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WATER QUALITY AND BENEFICIAL USE INVESTIGATION OF THE LOS ANGELES RIVER: PROSPECTS FOR RESTORED BENEFICIAL USES

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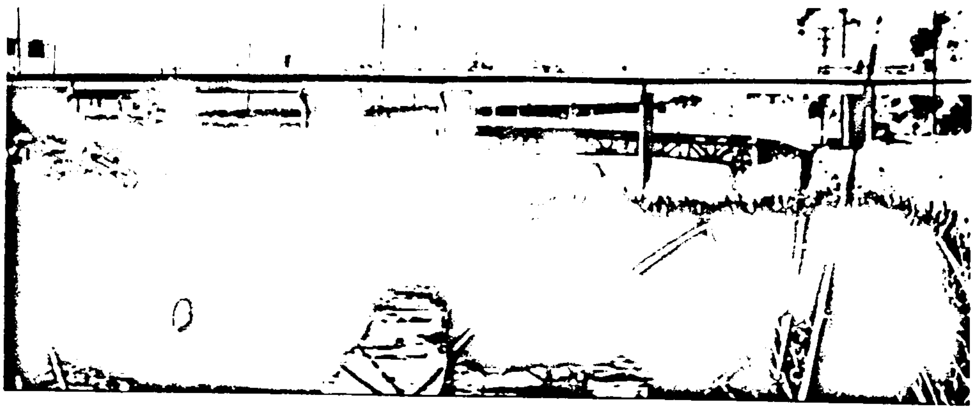

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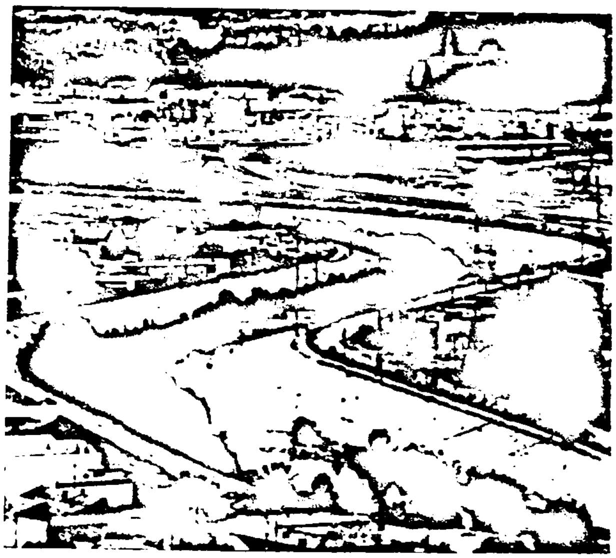

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WATER QUALITY AND BENEFICIAL USE INVESTIGATION OF THE LOS ANGELES RIVER: PROSPECTS FOR RESTORED BENEFICIAL USES

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ABSTRACT

The 52 mile Los Angeles River has six degraded and three lost beneficial uses due to its transformation into a flood control channel and deteriorated water quality. Currently, six uses occur in poor water quality, threatening the use and user. However, desire to restore beneficial uses, such as water supply, wildlife habitat, and recreation, is growing due to community awareness and availability of environmentally enhancing flood control technologies. Achievement of restoration requires improvement of specific water quality parameters. Monitoring results from 1988-1992 indicate: bacteriological >32,000 MPN/100ml, sporadically high biological oxygen demand, oil and gas 2.9 mg/l, nitrate as N, 10mg/l and phosphate as P, 2.8 mg/l. The wet regime, which averages 42 days per year, indicates detections of: Lindane, PCBs and twelve heavy metals River management requires knowledge of land use, water reclamation plant discharges, flow regimes, and channel surfaces. Land use analysis of thirteen sub-watersheds indicate that impacts are predictable and intensify downstream.

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ACKNOWLEDGEMENTS

I wish to thank all of my committee members, who taught me throughout my college years, the skills necessary to complete this thesis. I wish to thank Dr. Prem Saint for his contributions as committee chair and for his enthusiasm for learning and teaching, to which I aspire. I value the contributions of each agency which supplied information and data for my research, and especially appreciate the efforts of those agencies whose staff were more than willing to provide water quality data. In addition, I wish to thank Friends of the Los Angeles River for providing me a means to learn and study the river. Also, I would like to acknowledge Lewis Mac Adams, whose vision and respect for the river essentially became my thesis.

CHAPTER I

INTRODUCTION

The Los Angeles River, The Transformations

The Los Angeles River drains the mountains surrounding the coastal valleys and plains in the greater Los Angeles Metropolitan Area. The river's length is 52 miles, flowing through the San Fernando Valley, past downtown Los Angeles, to San Pedro Bay in Long Beach (Figure 1). The river was once a natural free-flowing stream which provided many beneficial uses such as water supply, groundwater recharge, recreation, wildlife, and fisheries--the river was an asset to the city. The Los Angeles area population grew and flood plains were urbanized. When the river occasionally flooded these areas, the river was perceived as a liability and the river was soon channelized in concrete. This change from a natural river to a flood control channel was the first transformation, which caused the loss of several beneficial uses (Figures 2a and 2b).

Political pressure from environmental and community groups, recent droughts and growing urban pressures initiated a movement to investigate ways to transform the river back into a resource with restored beneficial uses. During the late 1980s through the early 1990s, several political offices and local agencies were considering options to increase beneficial uses of the river, although the uses have been limited to recreation and water conservation. This is the beginning of the second transformation of the river. A change in the perception of the Los Angeles River is underway: the river is again being perceived as an asset rather than a liability.

Beneficial Use and Water Quality Problems

Apart from political and social challenges in transforming the Los Angeles River into a river which can provide opportunities for expanded beneficial uses, the greatest challenge

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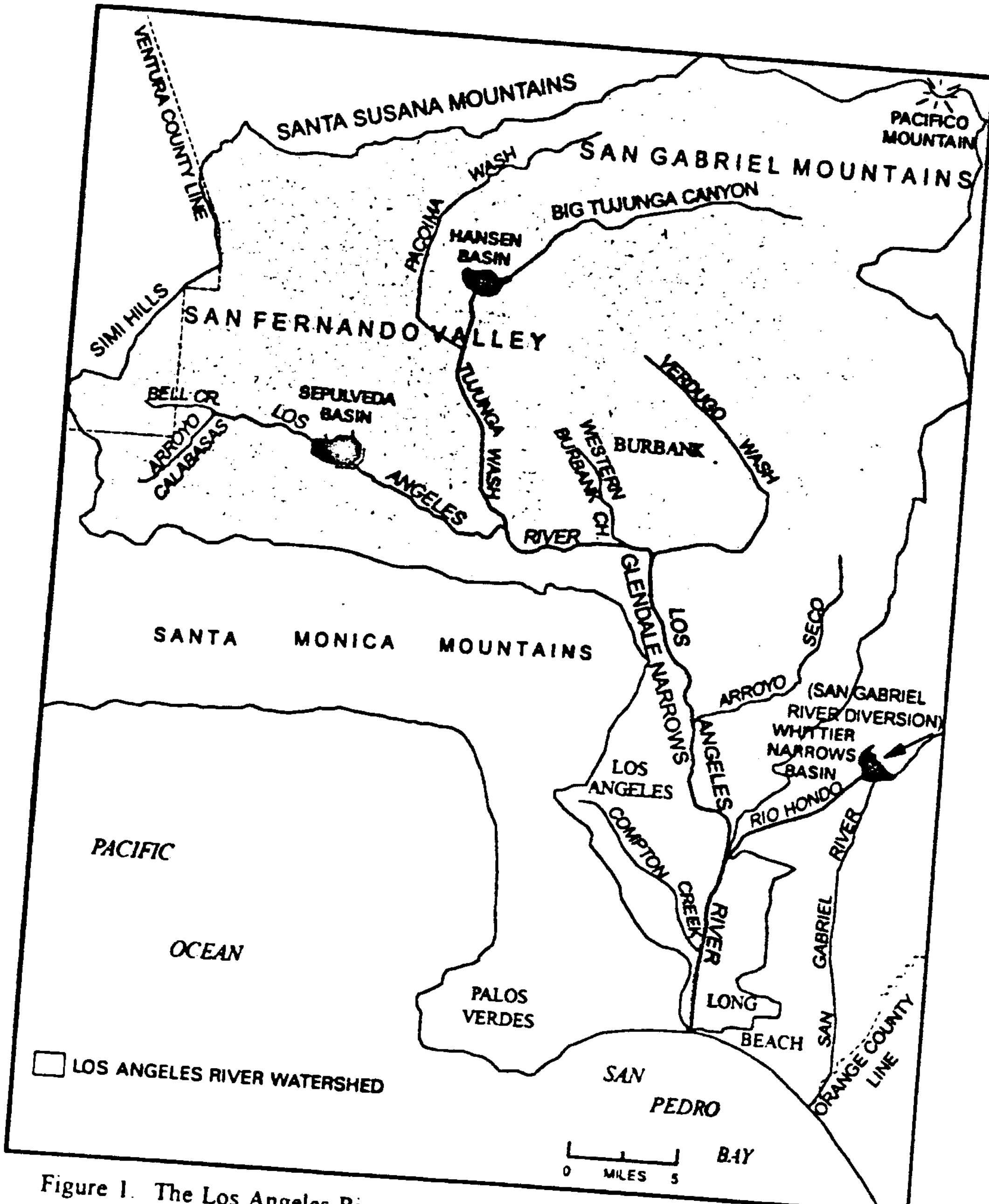

Figure 1. The Los Angeles River watershed. The river drains 832 square miles, making it the largest watershed in Los Angeles County.

Figure 2a. The Los Angeles River in Glendale Narrows at Los Feliz Bridge in 1932 (U.S. Army Corps of Engineers 1938). Before channelization with concrete, the river supported a rich diversity of plant life.

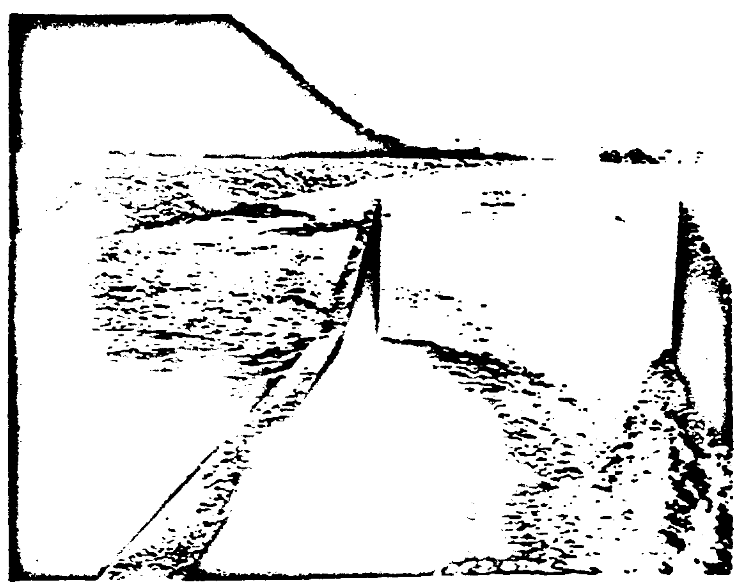

Figure 2b. The Los Angeles River at the same location as above after reinforcing banks with concrete and applying stone cobble bottom in 1938 (U.S. Army Corps of Engineers 1938). Channelization has significantly altered the river ecology.

is likely to be water quality management. Any resource development, such as water supply, recreation, habitat restoration, or aesthetic improvements, will require improvement of the river's water quality.

The U.S. Geological Survey (1965) defines water quality as "those traits that are distinctive to a body or supply of water in relation to some use — for example, drinking, irrigation of croplands, manufacturing, food processing, or recreation." The aspects of water quality which are important depend on the need or use for the water. However, regardless of need, quality of a water body can be rated as good or poor, using standards based on scientific data. On the Los Angeles River, water quality parameters which impact water usage include: dissolved minerals and organics, microorganisms, sediments, and urban trash. The water quality of the Los Angeles River has not been adequately studied in context of present or future uses.

Historical Perspectives on Beneficial Uses and Water Quality

The term "beneficial uses" is often used to describe waters being utilized by humans as well as by wildlife. The Federal Water Pollution Control Administration (FWPCA) (Interim Report, 1967) established criteria for major water uses: (1) aesthetics and recreation, (2) public water supplies, (3) fish, other aquatic life, and propagation of habitat, (4) agriculture, and (5) industrial water supplies. The California Regional Water Quality Control Board Los Angeles Region (IV) (RWQCB) recognizes 24 beneficial uses for water bodies in the region which includes Los Angeles and Ventura counties. These include: municipal and domestic water supply, agricultural supply, industrial service supply, industrial process supply, groundwater recharge, freshwater replenishment, navigation, hydropower generation, water contact recreation, non-contact water recreation, ocean commercial and sport fishing, warm freshwater habitat, cold freshwater habitat, preservation of areas of special biological significance, saline water habitat, wildlife habitat, preservation of rare and endangered species, marine habitat, fish migration, fish spawning, shellfish harvesting, estuarine, wetland, and aquaculture.

Beneficial uses are limited by and intrinsically tied to water quality. The study of water quality began with an emphasis on public health, but has shifted toward improving the quality of life for humans and wildlife. Hennigan et al (1969) described the historical development of water pollution control. In the past, the goals of most water pollution control programs were the prevention of communicable diseases through ingestion or body contact, prevention of fish kills, and elimination of nuisance conditions such as odors and trash. Post-World War II brought heavy industrialization and urbanization, and a greater concern about the quality of life. Both of these put more demands on water resources. With the growth of the environmental movement in the 1960s, the general public became aware of the sustained management of water resources. The result was the recognition of a limited water resource base and the ever-expanding need and demands, rising standards, and public insistence that effective action be taken to stop exploitation and degradation.

Emphasis in regulatory requirements has shifted over the years. Krenkel (1979) states that emphasis shifted from protection of public health to environmental protection. Regulatory requirements are based on water quality standards necessary to maintain and improve fisheries and aesthetic conditions in addition to consideration of the basic needs of the society. Hennigan et al (1969), called for more multi-disciplinary and interdisciplinary efforts in water resource research, including ecology, institutional reform, and public policy. They wrote "Water resource management and water quality management cannot be divorced and operated unilaterally very effectively. Stream flow regulation for water supply, recreation, power, flood control, and irrigation either is very dependent on quality control, or in the very operation itself, has a tremendous impact on water quality considerations." These ideas resulted in the designation of beneficial uses, whereby water use is inherently linked to water quality.

Pollutants limit the usability and safety of waters. Nemerow (1985) defines pollutants as too much of any given substance such that it renders the receiving water unusable in its existing state for its desired best usage. A study of water quality includes consideration of standards and tolerances that have been established (Hem 1989).

Water quality is considered in any discussion of beneficial uses. According to Krenkel and Novotny (1980), the intended use of water should its quality requirements and delineation of water allocated for specific uses is mandatory. Quality requirements can be defined as two respective terms; criteria or standards (U.S. EPA 1976). Criteria represent a constituent concentration or level associated with a degree of environmental effect upon which scientific judgment may be based. The term has come to mean a designated concentration of a constituent that, when not exceeded, will protect an organism, an organism community or a prescribed water use with an adequate degree of safety. Standards, on the other hand, use criteria as a basis for regulation or enforcement, but the standard may differ from criteria because of prevailing local natural conditions, economic considerations or desired safety. Establishing and meeting water quality criteria on the Los Angeles River allow the restoration of beneficial uses of the river. Thus, the achievement of safe water quality will allow attainable and sustainable beneficial uses to be established.

When water quality does not meet criteria for a beneficial use, the beneficial use is degraded. Other factors also can degrade beneficial uses, such as limited access to the river and poor resource management. The term "degraded beneficial use" is defined as an unused beneficial use or use occurring despite poor water quality. A potential beneficial use which does not occur because of some limiting factor is termed a "lost beneficial use."

Objectives and Methodology

This thesis examines beneficial uses of the Los Angeles River in the context of factors which influence the river environment and water quality. The objectives of this thesis are to:

1. Investigate the loss and degradation of beneficial uses of the Los Angeles River due to urbanization

2. Describe the present river environment and factors which affect the river environment

3. Analyze the river's water quality from 1988 to 1992, and determine existing and potential beneficial uses of the river in the context of water quality

A historical overview is presented to describe early beneficial uses of the river Historical information was obtained from historical accounts found in local history books and literature The historical perspective shows how the native Los Angeles River environment was transformed into its present environment

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CHAPTER II

TRANSFORMATION OF THE RIVER

Ian McHarg (1969), in his book *Design with Nature*, stated: "Can you find the river that first made the city? Look behind the unkempt industry, cross the grassy railroad tracks and you will find...". This statement could not be truer than in the case of the Los Angeles and its river. Los Angeles was first settled along the river and later the river was surrounded by industrial and commercial developments. Now much of the area is in decline, holding true to McHarg's statement.

Rivers have always been the sites of human settlement. The Los Angeles River is no different. Early Indian and Spanish settlements were located along the river near present-day downtown Los Angeles. The Spanish settlement was located in the river flood plain, and as a result was flooded twice before it was moved to higher ground. Agriculture and industry grew around this settlement and along the river. The river was an intrinsic part of the city.

A few decades later, however, the perception of the river changed: the river was no longer perceived as an intrinsic part of the city. The river flooded, became polluted and drier, and water supply came from other sources; the river no longer had a value and was all but forgotten. This completed the river's first transformation.

A half-century later a movement began, and today is gaining momentum, to return the Los Angeles River to a more natural state so that it may provide opportunities for humans as well as wildlife. If successful, the river would become a valuable part of the city. This would be the river's second transformation. By returning value back to the river does not mean transforming the river to exactly what it once was. Needless to say, it would be impossible. However, modifications to its physical structure and management would allow the river to be an important part of life in the Los Angeles area--completing the second transformation.

Human and Natural History of the Los Angeles River

The native Los Angeles River (prior to channelization and urbanization) had an extensive system of brackish and freshwater wetland habitats, coastal dunes, and riparian woodlands (Garrett 1993). A vast forest of sycamores, alders, willows, wild grape vines and bramble bushes grew between the highlands to the north (near downtown Los Angeles) and the seaport of San Pedro to the south (Johnston 1962).

There is evidence of people living in the valleys of the Los Angeles River system 10,000 to possibly as much as 30,000 years ago (Jorgensen 1982). The Tongva, of the southern California Shoshone Indians and the Chumash of the Hokan group, shared the southern California coastline and spread into the inland valleys at least 1,000 years ago. The Indians sought a dependable water supply. They settled near springs and tule marshes such as in the area of Encino in the San Fernando Valley. Other villages were located along canyons and streams, especially ones which had year-round water. Rainfall and spring-flows varied, and streams changed their courses so the people of the time were capable of adjusting to those changes in their environment.

Later, the European explore came. Don Gaspar de Portola' camped at a site on the east bank of a river near present-day North Broadway Bridge in downtown Los Angeles (Mann 1976). He named the river *Rio de Porciúncula*, and recorded it as being very suitable for a mission and a large settlement because water flowed year-round. Twelve years later a settlement called *El Pueblo de Nuestra Señora la Reina de Los Angeles de Porciúncula* was founded in the same location. The name of the settlement and the river was shortened to Los Angeles.

Governor Felipe de Neve, receiving approval from King Carlos III of Spain, gave the pueblos of California the right to the water of the rivers on which they were located (Guinn 1901). Soon the founders of Los Angeles constructed a primitive water distribution system. The system made use of a dam made of brush and poles placed in the Los Angeles River with a ditch, or *zanja*, to convey the water from the river to the

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fields and the plaza. Water for domestic use was taken from the *zanjas* in buckets and carried to the consumers by Indians.

In 1861, construction was completed of a new system of pipes, flumes, reservoir and dam. Water was diverted upstream for the settlement to use for domestic and irrigation needs (Figure 3). A large winter storm swept away the dam leaving the a water wheel and the flumes, and *zanjas* high and dry. A more elaborate system was built a year later, which consisted of a seven-foot-high dam on the river. The Los Angeles River supplied all of the water needs of the settlement. By 1888, the river was used to irrigate 10,987 acres (Hall 1888). Modifications and improvements to the system continued into the 20th century.

The source of the Los Angeles River was the mountains surrounding the San Fernando Valley. The agricultural water needs within the valley grew, which adversely affected downstream Los Angeles. The city defended its right to the river water through a State Supreme Court ruling in 1881 that allowed Los Angeles to succeed all rights of the former *pueblo* (Bowden, Edmunds, and Hundley 1982).

Los Angeles' water plant was situated at the point where all of the drainage from the San Fernando Valley would flow (Jorgensen 1982). The system used galleries and tunnels from which the city drew water. In a sense, water reclamation was occurring in the early 1900's as surface waters and groundwater. One out of every three gallons used for irrigation in the San Fernando Valley was reused, as it flowed through the Glendale Narrows.

The settlement soon grew. With the 1895-1904 drought in southern California, it became apparent that local water would not be sufficient to meet the needs of the growing city. As a result, in 1905, Los Angeles looked to the Owens Valley for more water. Until the water was delivered from the Owens Valley to Los Angeles in 1913,the Los Angeles River provided many beneficial uses, particularly the most sacred use, domestic water supply.

Although not a source of livelihood for Angelenos after 1913, the river still provided amenities for citizens. Susan Siegele (1982) quoted citizens who remember the river before the concrete:

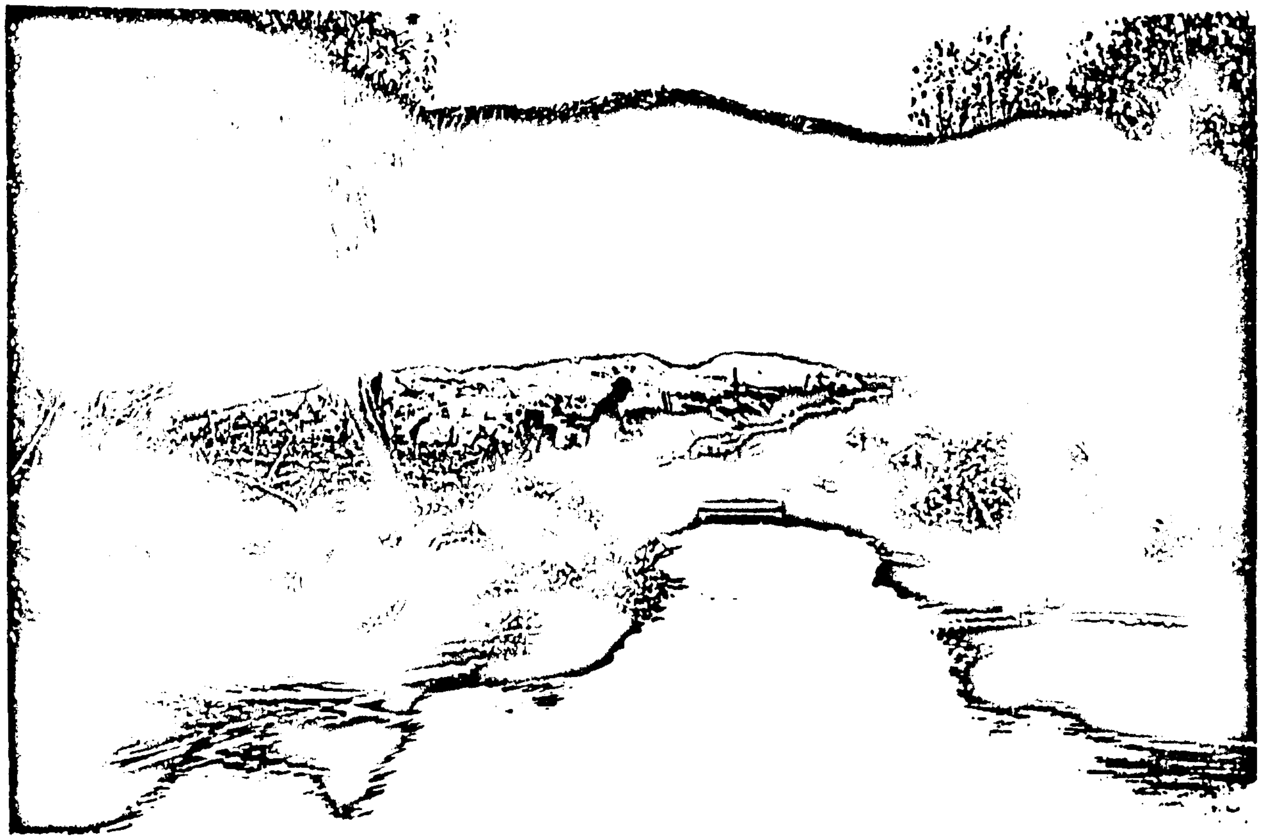


Figure 3. A *Zanjero* operates a gate on the Los Angeles River near Griffith Park, 1898 (Seaver Center, Los County Natural History Museum). The Zanja water supply system used ditches to deliver water for agricultural and municipal use.

Figure 4a. March 1938 flood near downtown Los Angeles. This flood was the most damaging flood to human settlement on the Los Angeles River.

Figure 4b March 1938, Tujunga Wash at Vineland Avenue, North Hollywood (U S Army Corps of Engineers).

provide for the control and conservation of flood, storm and other wastewaters of the district. Early bond issues financed the construction of dams. Debris dams were constructed and flood channel improvements were undertaken to confine the waters. Federal participation occurred through the U.S. Army Corp of Engineers (Corps), which became a leading force in the control of floods.

In the 1930s, the Comprehensive Plan was developed to control flooding and to conserve as much water as practicable, using debris basins, dams, and channelization. LACFCD submitted to the Los Angeles County Board of Supervisors in 1952 a report that investigated the best plan to control flood, storm and other wastewaters of the district and to conserve water for beneficial use (LACFCD 1952). The conclusion of the investigation found that the proper solution to these immediate problems will be realized upon completion of the Comprehensive Plan first developed in the 1930s. This continued the use of the Plan by the LACFCD, the Corps and the United States Department of Agriculture and the use of flood control dams, debris control basins, lined channels and bank protection, storm drains, and operation of spreading grounds. The Los Angeles County Department of Public Works (LACDPW) began administering LACFCD in 1985 LACDPW continued to pursue completion of the plan through the 1980s where it was 99 percent complete.

The Corps' role in flood control began in the late 1800s (Turhollow 1975). Demand for federal assistance increased in the Los Angeles basin with each flood. In 1936, the Corps' mission was modified to include the permanent supervision of future flood control projects. The 1938 flood resulted in federal legislation in 1938 and in 1941, which provided budgets for implementation of the Comprehensive Plan (Van Wormer 1991). The river was channelized and the majority of its length concrete-lined. Since then, the agencies implemented the Comprehensive Plan.

In 1938 the Corps prepared the report entitled, *Flood Control in the Los Angeles County Drainage Area*. The report cited that Los Angeles and its suburbs are "...under a more dangerous flood menace than any similar region in the United States."

Corps involvement in the Los Angeles River grew out of need for flood control as much as a need to put citizens to work during the post-Depression years. The Los Angeles District of the Corps employed 17,000 people, 90% of whom were obtained from relief rolls (Turhollow 1975). Paving of the river continued well into the 1960s.

In 1969 a U.S. Senate Resolution authorized the Los Angeles County Drainage Area Review studies (Corps 1992). A major finding of the study was the inadequacies of the Los Angeles River flood control system. The study also found that to improve flood protection, the river should be modified by raising the effective channel height by building parapet walls on 21 miles of existing levees of the Rio Hondo and lower Los Angeles River. In 1993 the project to build the parapet walls was in the design phase and the construction was expected to begin in 1995.

Beneficial Uses Lost

The beneficial uses of the river during the era of the Indians and Spanish were largely lost as flood control dykes were built and water was brought to the city from other watersheds. As the river was paved with concrete in the 1940s and 1950s, concern grew over the loss of the beneficial use of groundwater recharge. Regional water agencies in the coastal plain depended on rivers to recharge aquifers. According to the State Water Resources Board (1952), "As part of the channel improvement program, Los Angeles River has been lined to a point below its confluence with the Rio Hondo, with attendant reduction in percolation opportunity in the non-pressure area." In another report to the West Basin Water Association (1946), consulting engineer Harold Conkling stated that only an insignificant part of the stream discharge of the Los Angeles River now percolates the forebay. The groundwater levels dropped in the entire area since it was dependent on the Los Angeles River for years past.

Other portions of the flood control system have spreading grounds and reservoirs for water conservation. Only two water conservation structures are located on the Los Angeles River mainstem (Figure 5). The larger one, the Headworks spreading grounds, is operated by LADWP. Its operation is intermittent, depending on California Department of Health Services' regulatory activities and monitoring programs. A much smaller operation is the Dominguez Gap spreading grounds, which is operated by LACDPW. Water is diverted from the Los Angeles River to both of these facilities.

It is apparent that various other beneficial uses were lost or degraded. Table 1 is a compilation of beneficial uses before and after the river was concreted, using terminology adapted from RWQCB. RWQCB designations were used from the Los Angeles River

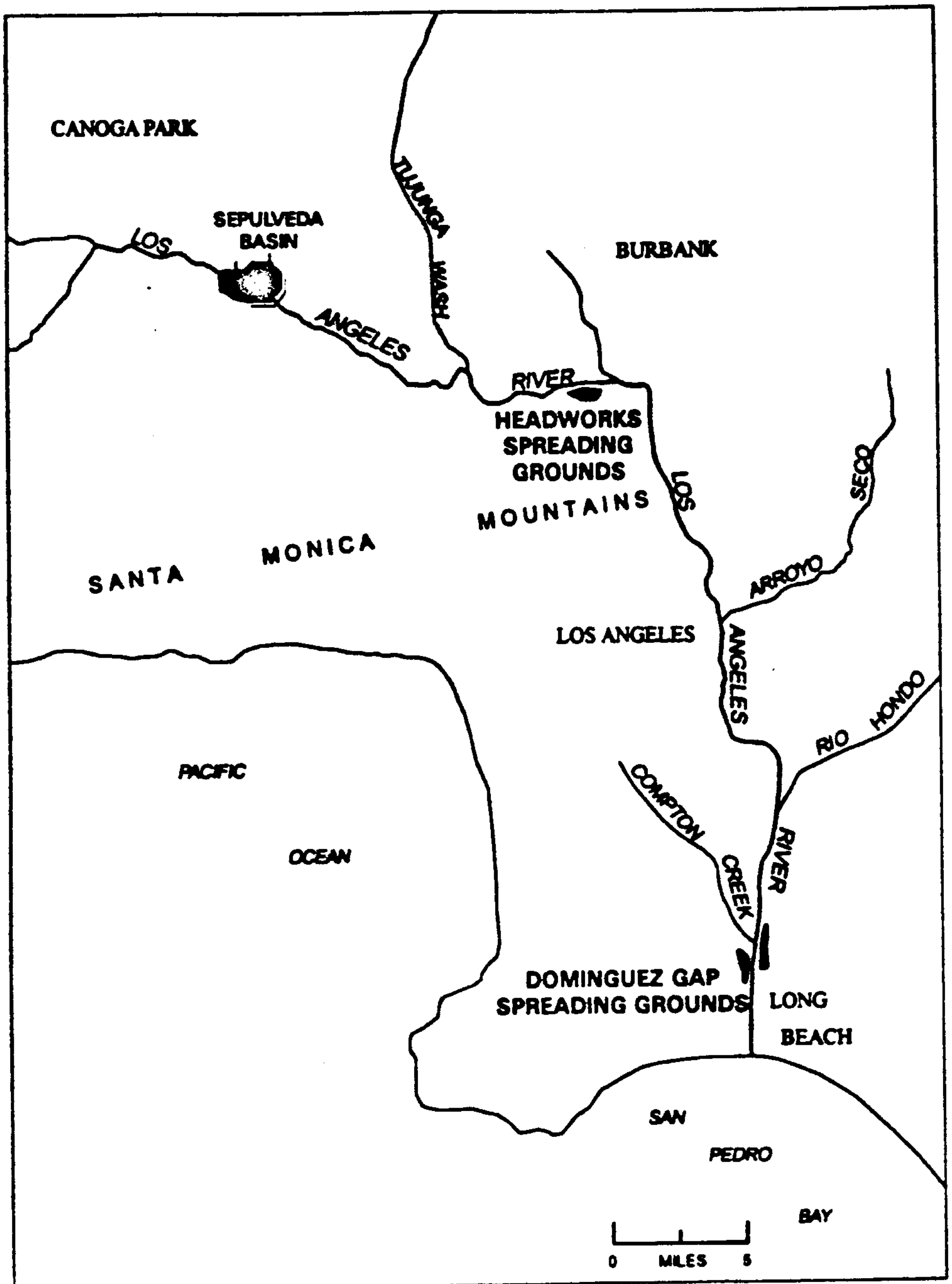


Figure 5. Location of Spreading Grounds on the Los Angeles River. These spreading grounds use water from the river.

The table shows how the present river environment has caused the loss or degradation of the beneficial uses of the Los Angeles River. Degraded beneficial uses can be grouped into two categories, sanctioned and unsanctioned. Sanctioned uses, such as groundwater recharge, are regulated and recognized by several controlling agencies. Unsanctioned uses, such as recreation and agriculture, are not allowed in the river bottom by agencies in designated areas, yet occur regularly.

Figure 6 is a graphic representation of the degradation of beneficial uses caused by the transformation of the river into a single-purpose flood control channel. Over time (the x-axis) the river was increasingly channelized and concreted, causing beneficial uses (the y-axis) to decrease. Note that beneficial uses are not eliminated, but are reduced in value (degraded) or in number (lost). Also note that channelization does not reach the maximum on the graph, taking into account the portions of the river that are not entirely concreted. Even if the entire river was concreted, some beneficial uses would still occur, albeit at a degraded level.

It may be useful to understand the processes which may have led to the first transformation, which caused the ensuing loss and degradation of the beneficial uses. The lining of the Los Angeles River seemed to take on facets other than flood control; the concrete proved to some that nature and her wild river could be tamed without regard to the river's natural endowment. This is exemplified in Turhollow (1975):

> "Thus, visitors to southern California should not be astonished at the sight of the immense, rock-lined or concrete "dry rivers" — but admire the perspicacity of their builders. The early Spanish settlers probably would not recognize these 'new' rivers, like the Los Angeles , but no doubt would appreciate the modifications"

While the Spanish might have appreciated the additional flood protection, they might have objected to the loss and degradation of beneficial uses which in their days included domestic water supply, agriculture, with high quality water.

Another element was the post-Depression economic need to provide jobs Over 17,000 people were employed by the Corps in the Los Angeles District alone Many public works projects were initiated in the post-Depression years This too may be a factor in the decision to taken on a Comprehensive Plan with zeal

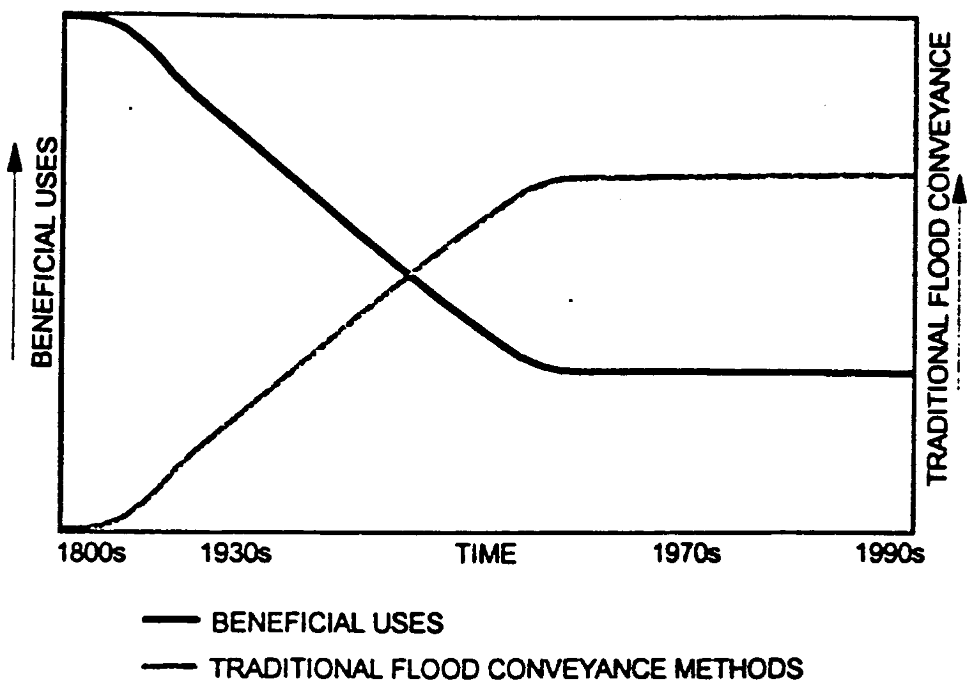


Figure 6. The Transformation Model. As flood conveyance projects are implemented, beneficial uses of rivers decrease.

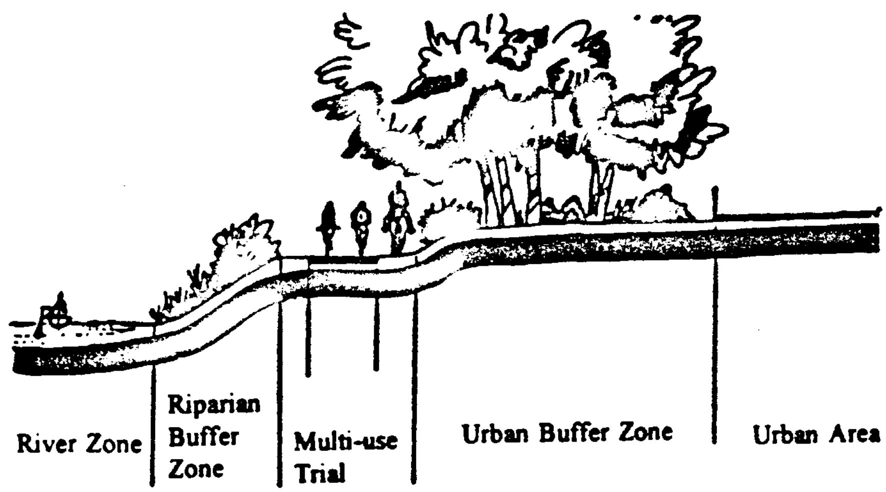


Figure 7. Common Design of Multi-use Channels. Designs such as this have been used in many places in the U.S. (National Park Service 1991).

Because of the efforts of the Friends of the Los Angeles River, a local community/ environmental organization, and growing wide-spread opposition to turning the river into another freeway, the plan slowly ran out of steam. Other similar ideas for transportation and other uses are routinely proposed.

Efforts to Restore Beneficial Uses on the Los Angeles River

Impetus to return the Los Angeles River to a more natural state began in the late 1980s with the formation of the Friends of the Los Angeles River. After years of media attention toward the "wild" concept, political support grew. As a result, several studies are completed or underway which, in some way, investigate the existing or potential resources of the river. They include:

- City of Los Angeles River Greenbelt Corridor Study
- Los Angeles County Natural History Museum Biological Inventory
- United State Army Corps of Engineers' Water Course Study (Recreational) on an 18-mile portion of the river
- United States Army Corps of Engineers' Water Supply and Conservation Study
- California Department of Water Resources, LACDPW, and Friends of the Los Angeles River Taylor Railroad Yard Multi-use study
- LACDPW Los Angeles River Master Plan
- Santa Monica Mountains Conservancy and Friends of the Los Angeles River Preliminary Integrated Upper Watershed Management Study
- Mountains Recreation and Conservation Authority Los Angeles River Parkway Project.

The Succession of River Transformations

River transformations can be considered a succession, where the river's importance to the city is lost and then returns. The importance of water quality is also a succession, varying directly with the transformation; being lessor important when the river has minimal beneficial use and more important when the river has maximized beneficial use. Figure 8 is a model which shows the urban river succession. The model begins with a river with many safe beneficial uses for humans, e.g. Indians and early Spanish settlements. Following down the model, the city is then founded on the river, but after several flood events, the river is viewed as a menace. Channelization caused the river to become a single-purpose feature, that is "a flood control channel." In addition, the river is no longer used as a primary water source, so water quality is less important. Urban development continues at a fast rate and water quality is further deteriorated. Later, lack of open space, urban stress, and droughts lead to a desire to restore beneficial uses of the river. Thus, water quality becomes very important. The last element of the succession is the restoration, which has not yet begun.

Controlling Water Quality

Urbanization is largely responsible for the flood problem and for water pollution. The imperviousness of urban areas increases runoff, thus even small rains may wash significant amounts of pollutants into surface waters (Krenkel and Novotny 1981). Thus, a logical solution to these problems lies in the urban areas themselves

Traditionally, flood control projects in southern California do not consider water quality, except for sediments, which have clogged channels and harbors. However, good resource management would consider water quality in flood control projects. The Federal Emergency Management Agency (FEMA) stated in a floodplain management report (FEMA 1991) that because the land and water resources of the floodplain and the flood-related problems and needs are highly varied, different strategies must be used to achieve desired objectives in different settings. Thus, if an objective is to improve the quality of the river, then flood control plans should be developed which consider this. The FEMA report lists several strategies to reduce flood damage. One strategy listed is land treatment measures whereby infiltration increases and runoff rate decreases (FEMA 1991). These methods, the report states, can be especially important in reducing erosion and the resulting amount of sediment and pollutants carried downstream.

Water Quality

Industrial businesses often settled near the channels for the purpose of discharging often

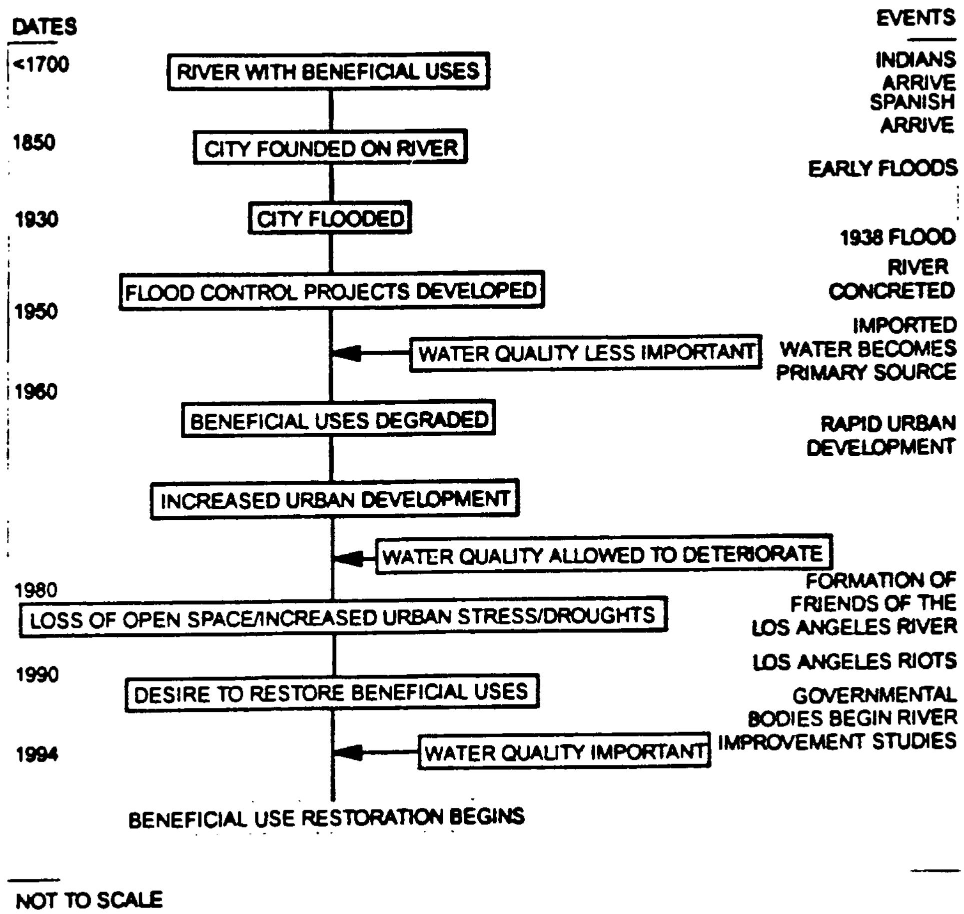


Figure 8. The Urban River Succession Model. Beneficial uses become degraded, and water quality deteriorates. Interest in restoring beneficial uses completes the succession.

polluted water. According to the California Regional Water Quality Control Board (RWQCB 1975), lower valley drainage courses have been the logical recipients of wastewaters from municipalities and industries to the detriment of sanitary conditions, aesthetics, and native flora and fauna. Public opposition to polluted waters has resulted in a correction of such overtly unsatisfactory conditions. In addition, public pressure for additional recreational use and aesthetic enjoyment of the waters increased, thereby expanding the recognized beneficial uses of many of these waters. The pattern, according to RWQCB, has been one of initial degradation, subsequent improvement of conditions, and eventual restoration, approaching complete recovery. This scheme is an example of the Urban River Succession Model presented in Figure 8.

Flood Control

Flood control is always the priority in river multi-objective planning because lives and property are at stake. However, flood control does not have to compromise beneficial uses. The paving of the Los Angeles River in the 1940s was largely responsible for the loss of beneficial uses. Today, many technologies provide an alternative to concrete (Table 2). Figure 9 is an application of the River Transformation model which shows the ideal situation, where flood control is maintained or improved, but is done by non-traditional means, using alternative flood control methods. In the model, as traditional flood conveyance methods are phased out, e.g., concrete channels, alternatives flood control methods are phased in. Meanwhile, beneficial uses increase on the river. The Transformation Models are a graphical representation of the Urban River Succession Model in Figure 8. These methods of flood control would enhance beneficial uses. If these methods are slowly implemented, then the need for traditional flood control conveyance would not be needed to the same extent and thereby can be phased out

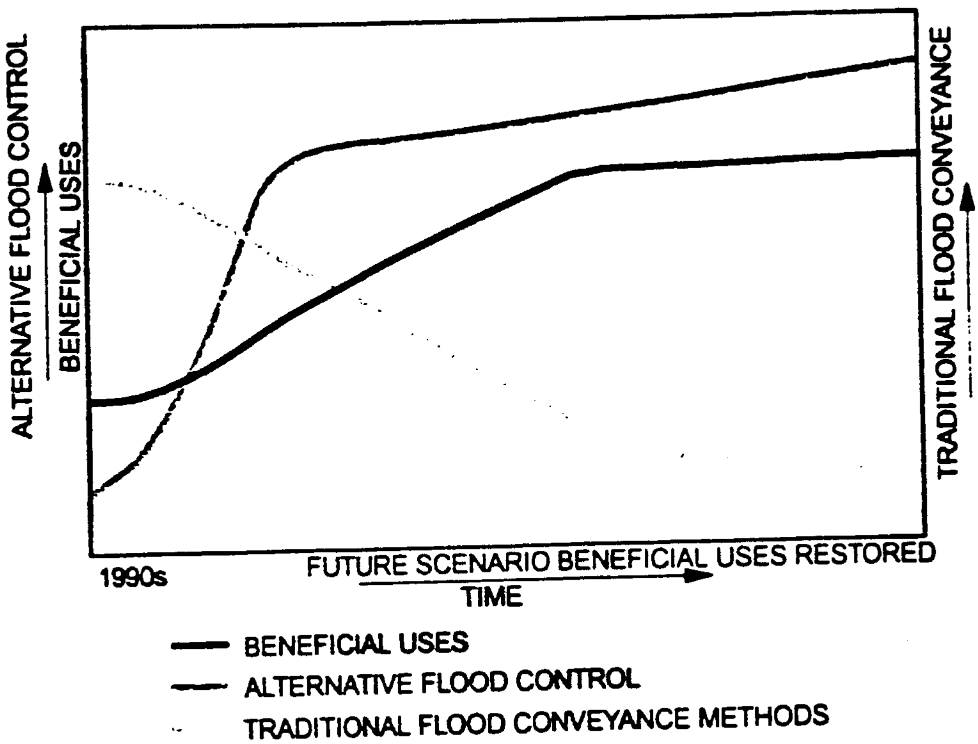


Figure 9. Ideal Transformation Model. As traditional flood conveyance methods are phased out and alternative methods are phased in, beneficial uses increase

Table 2. Flood control alternatives which would reduce need of concrete lining.

Use of permeable pavements in urban areas
On-site detention
Improved watershed management
Use of large storage areas such as gravel pits and parks
Wetland restoration
Storage in spreading grounds
Widening of the river

Source: Friends of the Los Angeles River, 1993

CHAPTER III

THE RIVER TODAY: WATERSHED AND RIVER CHARACTERISTICS

The Los Angeles River watershed is rimmed by the Transverse Ranges which include the San Gabriel Mountains, Santa Susana Mountains, Simi Hills, and Santa Monica Mountains (Figure 1, Chapter I). Tributaries emanating from these mountain ranges are the headwaters of the Los Angeles River. The river flows eastward through the San Fernando Valley, and then bends southward toward the ocean. The river crosses the coastal plain, passing over a gap in the Newport-Inglewood uplift, before reaching its final destination, the San Pedro Bay.

Physiography

The watershed drainage area, including the Rio Hondo drainage, is 832 sq miles.[1] The river begins at the confluence of Bell Creek and Arroyo Calabasas in the western San Fernando Valley (Figure 1). The Los Angeles River flows easterly from this point to the northeast end of the Santa Monica Mountains near Griffith Park. The river turns south as it enters Glendale Narrows, passes close to downtown Los Angeles, and flows across the coastal plain ending in San Pedro Bay. Calculated from U.S. Geological Survey maps, the river length is 52 miles with a designed capacity of 146,000 cubic feet per second (cfs) near its mouth (Corps 1992). Bridge crossings and confluences are commonly used to identify specific locations on the river, starting at the mouth of the river as mile zero (Figure 10).

The upper watershed is mountainous, containing steep-walled canyons with slopes greater

[1] Water can be diverted from the San Gabriel River watershed into the Los Angeles River via the Rio Hondo. The drainage area of the San Gabriel is 472 sq miles, giving a total of 1304 sq miles for the Los Angeles River system. The diversion to the Rio Hondo typically occurs during storm events.

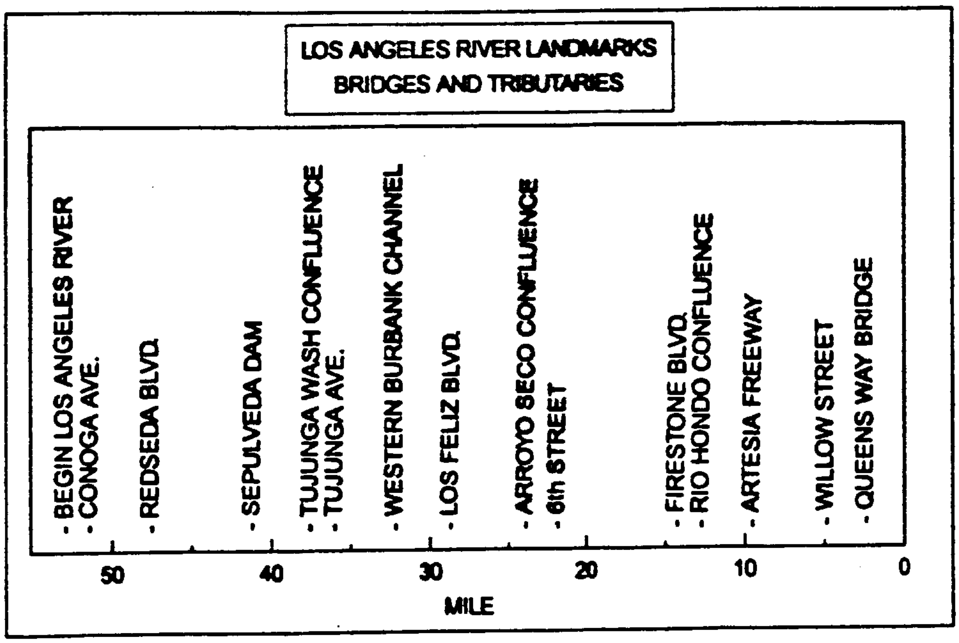


Figure 10. Bridges and Confluence Miles Upstream.

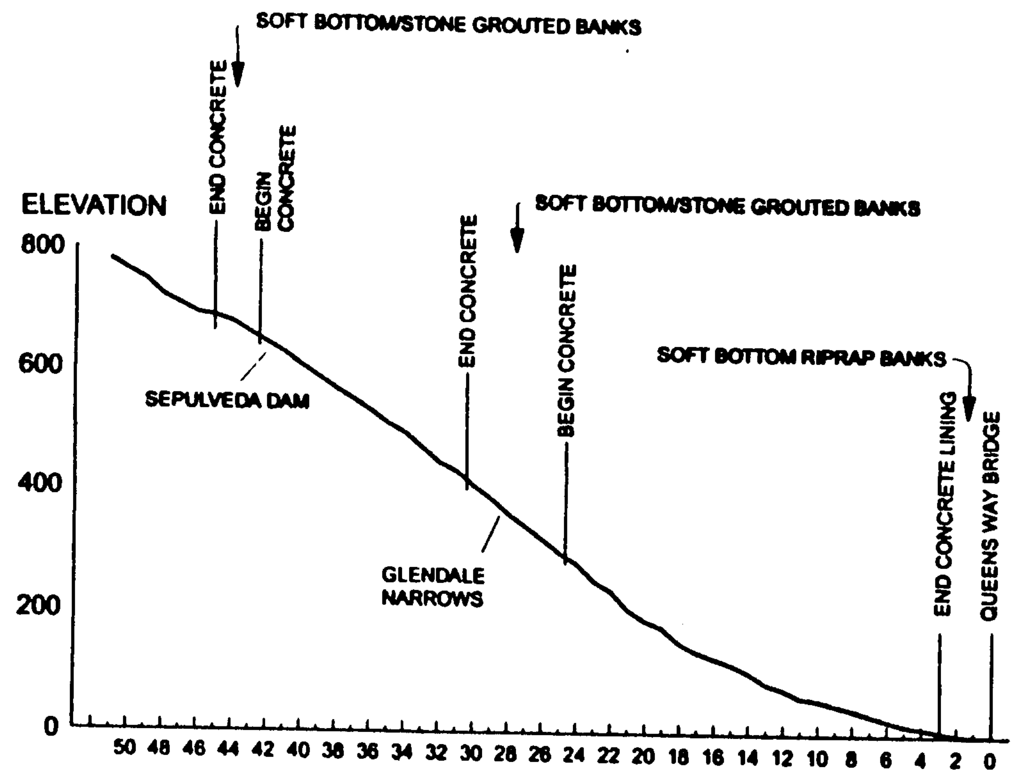


Figure 11. Profile of the gradient of the Los Angeles River. The river gradient is steepest in the San Fernando Valley and then levels out as it approaches the San Pedro Bay.

quality. The result is two distinct regimes, wet and dry. In general, inflows of the dry regime are consistent and inflows of the wet regime are variable (Figure 14).

Wet Regime. The wet regime is a result of precipitation during the winter months. The rainy season begins before mid-November and usually ends in March or early April (Bakker 1984). The river's hydrography tends to have a high peak during storms because of rapid runoff. This regime also includes periods of increased flows which can extend for months after an above-average rainy season.

Rapid runoff is a characteristic of the wet regime. Figure 15 shows hydrographs for the Los Angeles River above the Arroyo Seco confluence. Rapid runoff causes a very steep graph. Note that the peak flows occur over a three to ten hour period because of rapid runoff. Factors which contribute to rapid runoff are: 1) Steep gradients in the upper watershed, and 2) imperviousness and channelization of creeks in urban areas. Because rapid runoff in the wet regime is of short duration compared to the dry regime, the dry-regime is the dominant river condition.

Average days per year the river is in the wet regime can be calculated using average daily gaging station data. Typical precipitation events produce an average daily flow of at least 500 cfs. It is safe to assume that a flow of over 250 cfs is caused by a precipitation event because summer discharges have never exceeded 200 cfs. Thus, the wet regime is defined as when the river is above 250 cfs. Based on average daily gaging values from 1975 to 1992 at Wardlow Road from LACDPW, the river averages 42 days per year in the wet regime.

Dry Regime. The dry regime is characterized by a perennial flow, resulting from water reclamation plant (WRP) discharges, other permitted discharges (industrial), urban runoff, and rising groundwater. During the dry season, water from the local mountains does not typically flow into valley channels because the water infiltrates the alluvial sediments However, most urban areas have a minuscule, yet continuous flow of runoff into tributaries and the river.

The large volume of water flowing into the Los Angeles River is relatively recent A dependable flow of 100 cubic feet per second (cfs) developed in late 1986 For the past few years, the minimum flow of the river was 120 cfs (Figures 16a through 16g) Prior

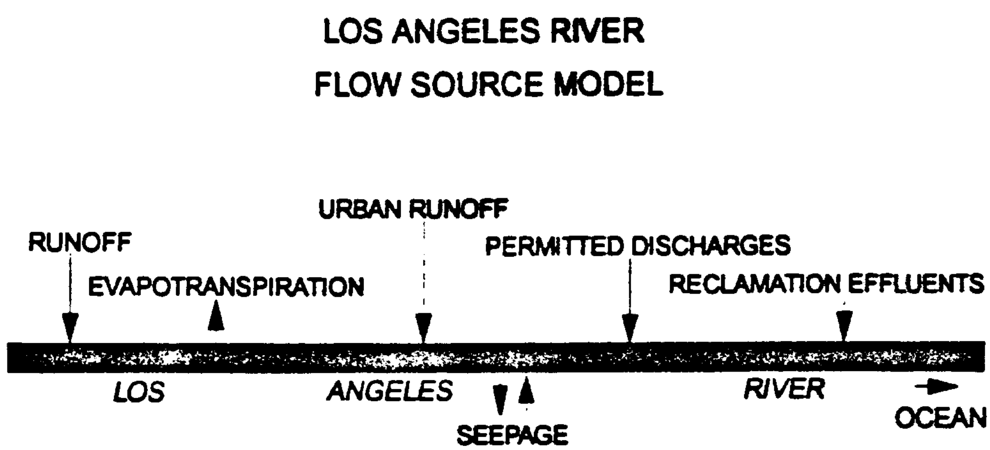


Figure 13. Flow Source Model for the Los Angeles River. The flow of the Los Angeles River is the result of various inflows.

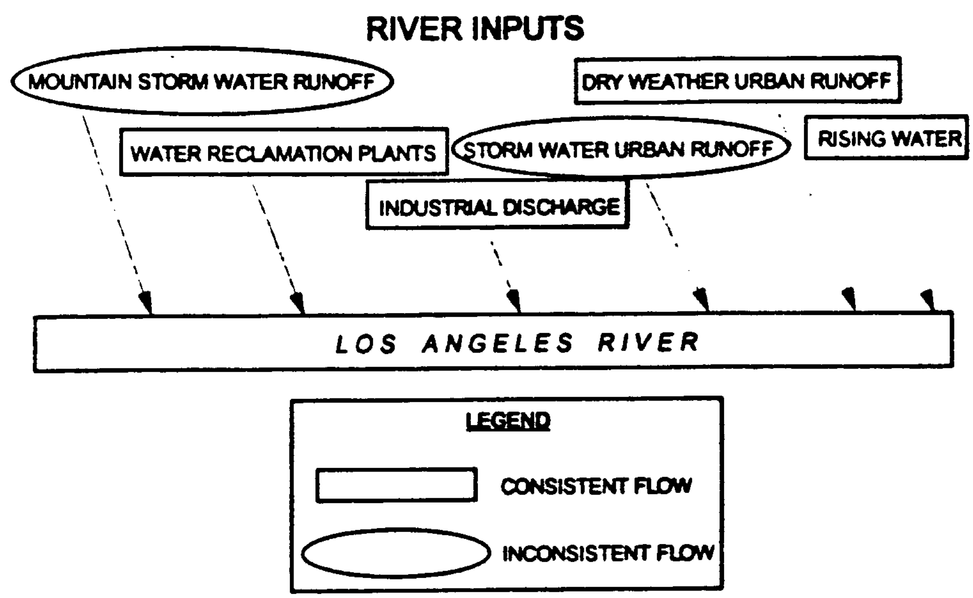


Figure 14. Inflows to the Los Angeles River consist of both consistent flow and inconsistent flow, both of which have various sources. To understand river dynamics, the inputs to the river must be recognized as the flow is the result of these impacts.

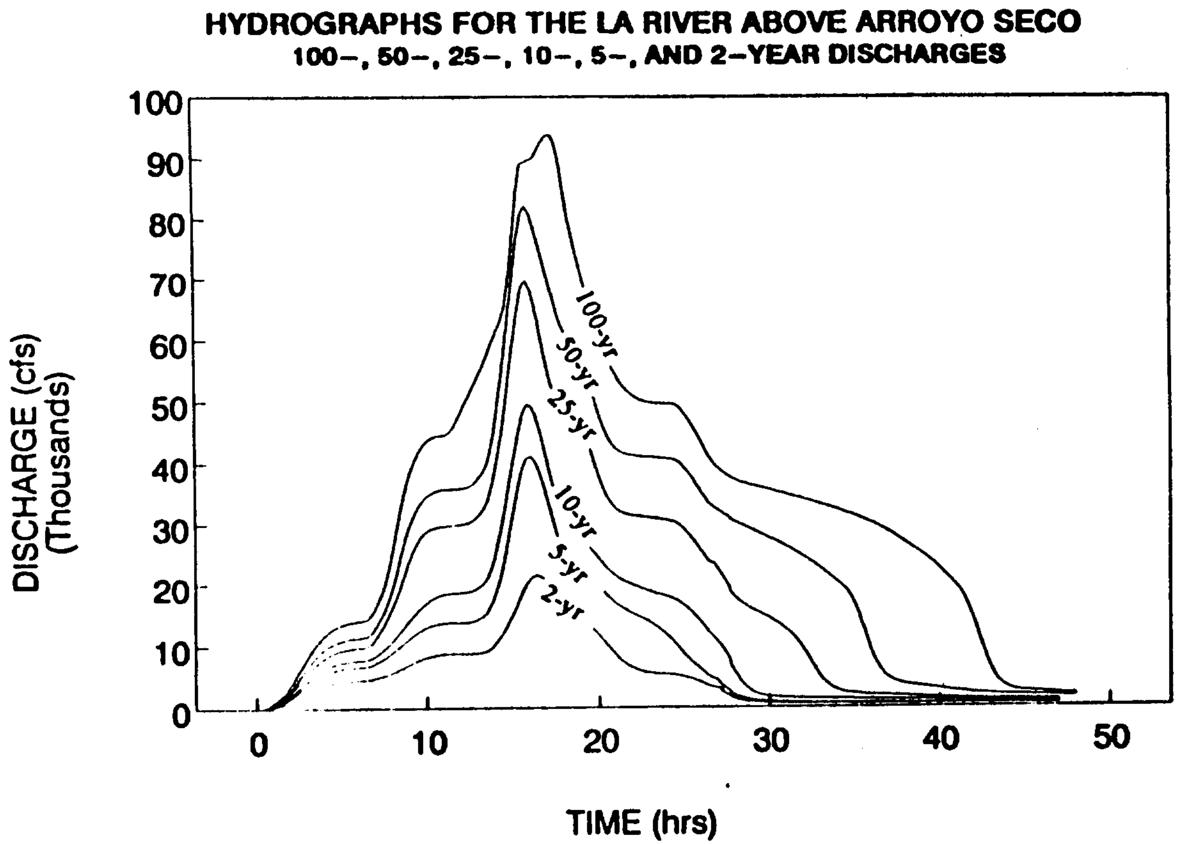


Figure 15. Hydrographs of the Los Angeles River above the Arroyo Seco Confluence. Rapid runoff causes the peak to be high and steep. (Adopted from U.S. Army Corps of Engineers)

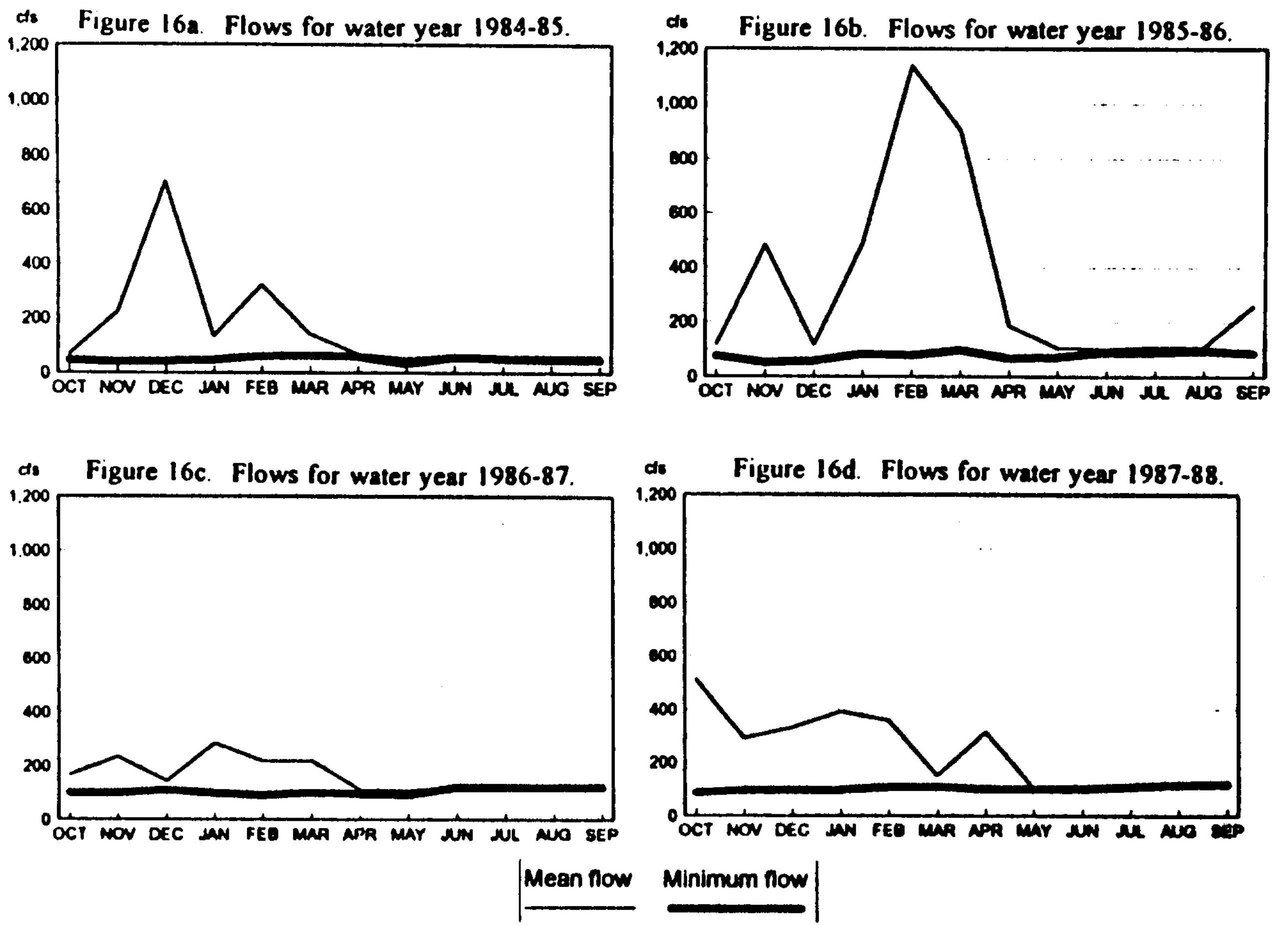


Figure 16. Los Angeles River Flow Characteristics at Wardlow Road, Long Beach.
(Data Source: Los Angeles County Department of Public Works.)

Figure 16e. Flows for water year 1988-89

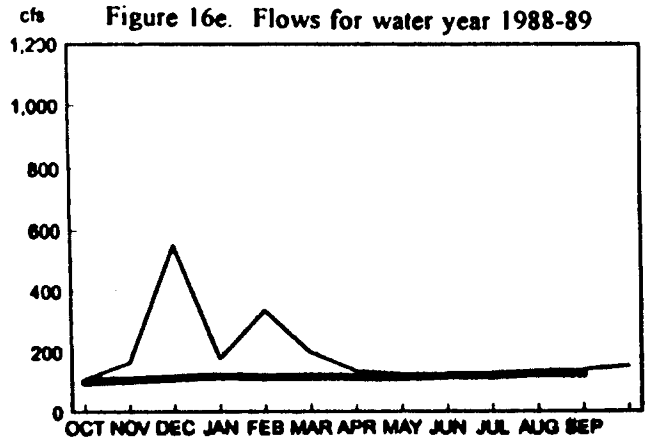


Figure 16f. Flows for water year 1989-90

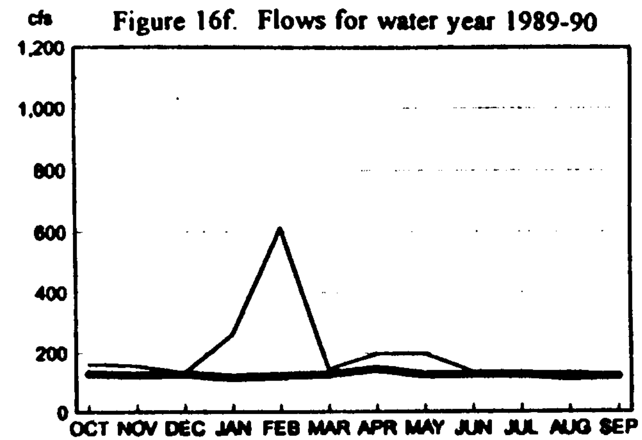
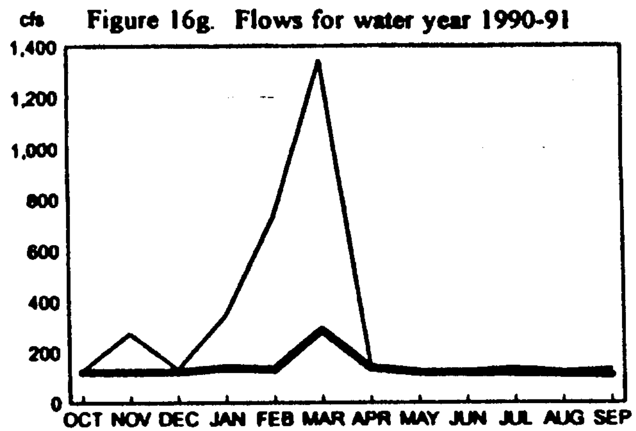


Figure 16g. Flows for water year 1990-91



Mean flow — Minimum flow

Data Source: Los Angeles County Dept. Public Works

Figure 16 Continued

to 1986, the minimum flow was less than 50 cfs (Figure 17).

The largest contributor to flows in the dry regime is the water reclamation plants (WRPs) along the river and some of its tributaries. Plant locations are plotted on a map in Figure 18; Table 3 shows plant discharge amounts.

Direct use of reclaimed water is increasing, which has an impact on the water flow of the Los Angeles River. The largest planned project is the East Valley Water Reclamation Project (Figure 18). The Project would reduce the amount of water discharged from the Tillman WRP (LADWP 1991). However, the Environmental Impact Report (1991) states that a baseline flow would be maintained; the amount was unspecified. Overall, the dry regime is likely to decrease, especially in summer, when the demand for reclaimed water is the highest.

Urban runoff is the result of over watering of landscape, outdoor washing, and other residential, municipal, and commercial water discharges. The Los Angeles River receives urban runoff during wet and dry periods from storm drains. Storm drains are known to carry pollutants to streams and wetlands and are contributors to urban water quality problems (Davenport et al, 1990). Urban runoff has long-term and short-term effects, including: destruction of aquatic habitat through sedimentation and chemical buildup in aquatic organisms and sediments, and related toxicity (Davenport 1990)

Historically, portions of the Los Angeles River flowed year-round without industrial or municipal discharges. According to a report to the governor entitled, *Irrigation in Southern California* (Hall 1888), the river's flow was 65 to 80 cubic feet per second (cfs) downstream of the San Fernando Valley, resulting from rising groundwater. It is difficult to measure the native flow today. The Upper Los Angeles River Watermaster Report (1992) attempts to measure rising water through the Glendale Narrows. The calculation involves measuring the base flow (non-storm flow) and subtracting permitted discharges. However, the methodology does not take into consideration urban runoff during dry periods and other possible unaccounted discharges. Thus, the result of the calculation is the quantity of unaccounted-for water. The portion that is rising groundwater remains unknown. Because of groundwater pumping, the flow is less than it was in 1888. However, after six years of drought, springs were observed by the author flowing through the channel invert in Glendale Narrows area (Figure 19). As the river passes downtown

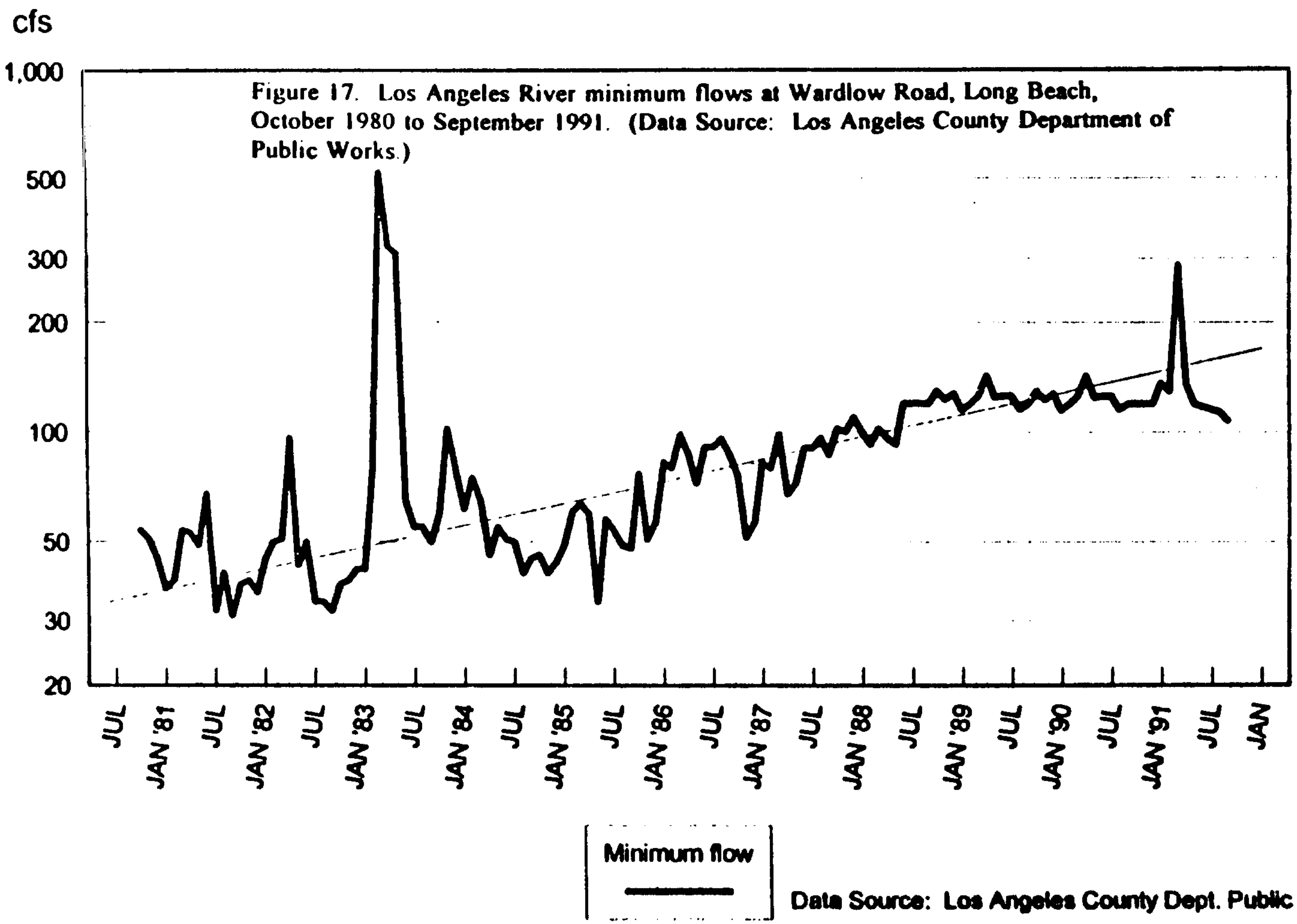


Figure 17. Los Angeles River minimum flows at Wardlow Road, Long Beach, October 1980 to September 1991. (Data Source: Los Angeles County Department of Public Works.)

Data Source: Los Angeles County Dept. Public Works

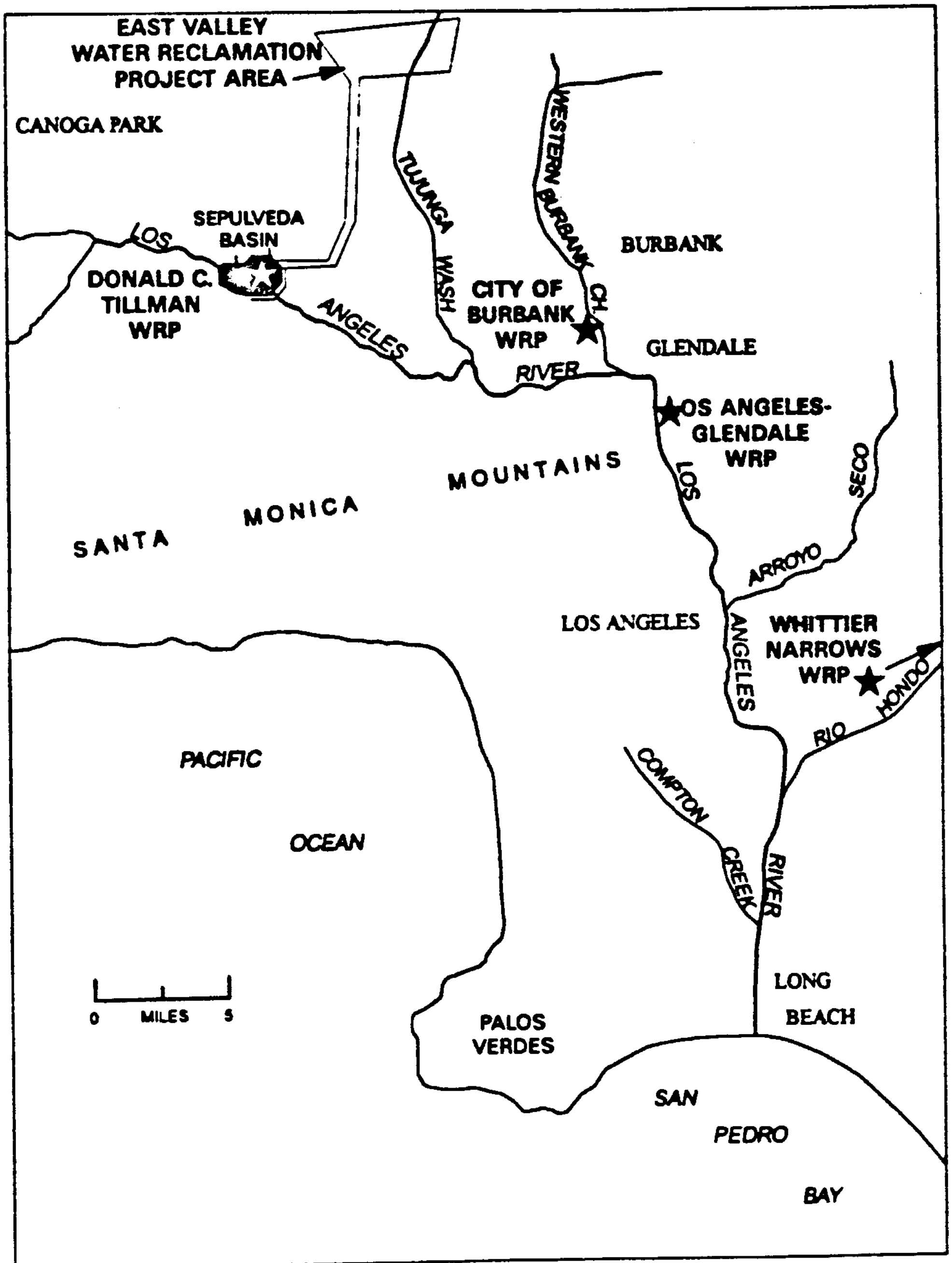


Figure 18 Location of Water Reclamation Plants in the Los Angeles River Watershed.

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Figure 19. Water issuing from a spring through concrete slabs in Glendale Narrows. Because of the springs in this area, the river bottom could not be sealed in concrete.

Table 3. Water reclamation plant (WRP) discharges to the Los Angeles River.

Water Reclamation Plant Data: October 1, 1990-September 30,1992	Typical Discharge (MGD)
Donald C.Tillman	39
Los Angeles-Glendale	13
City of Burbank	2.3
Whittier Narrows (via Rio Hondo)	< 1

Source: Upper Los Angeles River Area Watermaster, 1992.

Los Angeles and enters the coastal plain, the river would become an influent stream in the forebay, but the concrete lining prevents infiltration. This causes a continuous flow to the ocean.

Changes in Stream Environment Along the River

Today, two major factors influence environmental changes along the river course. One change is the variation of the channel invert surfaces from concrete bottom to soft bottom and the other is the discharge of reclaimed water.

The river is channelized in all but three portions. These soft bottom sections are located in Sepulveda Basin, Glendale Narrows, and at the estuary in Long Beach Figure 20 summarizes these changes by reach. The soft bottom allows riparian vegetation growth and supports diverse wildlife. Occasionally, the concrete sections will have small sandbars or cracks where vegetation can take root. The contrasting concrete and soft bottom sections have a significant impact on the river environment.

The second factor which influences the river environment is the presence of reclaimed water. Portions of the river, especially in the coastal plain, would normally be nearly dry However, the ever-present reclaimed water has made the river a perennial stream Vegetation, especially emergent plants, have proliferated in the soft bottom sections largely because these flows contain plant nutrients Reclaimed water is a dominant influence on the quality of the river waters. The impact of the reclaimed water on the

Because of the springs in this area, the river bottom could not be sealed in concrete

concrete sections is also considerable. A few species of birds frequent a concrete section near Long Beach which is covered by a sheet layer of water outside of the low-flow channel. This water layer provides a micro-habitat of algae and invertebrates, from which some birds forage (Garrett 1993).

The reclaimed water provides a consistent flow of water and offers hydrological stability to the river environment. Figure 14 is a schematic of inputs, showing river stretches that have a consistent flow. Seasonal flow rates can vary significantly, daily to annually. WRP discharges vary diurnally, seasonally and annually, but on a much smaller scale. This dampening effect has led to highly diverse riparian communities on the river.

Watershed Characteristics and Water Quality

Streams are the sum of the conditions of the watershed. Physical, hydrological, and land use characteristics of a watershed have direct impact on streams, therefore, the stream's water quality is the sum of these conditions.

According to the U.S. Environmental Protection Agency (USEPA 1977), seven factors affect runoff characteristics. They are:

- Soil Porosity - Infiltration is affected by actions which change the imperviousness of the soil; such actions include soil composition and surface pavement, thereby reducing infiltration.

- Drainage - Infiltration is assisted by drainage which retains runoff, thereby providing additional time for the water to infiltrate. Bogs, swamps and other surface areas (wetlands) provide temporary retention areas, thereby providing increased infiltration times and a reduction in the peak flows of small runoffs.

- Infiltration - Both velocity and quantity of runoff determine amount of water which can be infiltrated; a reduction in either of these factors increases the potential amount of water which will infiltrate into the ground.

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- Channelization - The velocity of water being drained from the area is a function of the distance over which it has to travel, the surface bed, and the size of the channel: by creating a channel which shortens the distance and reduces the surface roughness, one facilitates an increased velocity. The quantity of runoff is increased by an increase in the effective cross-sectional-area of the channel.

- Slope - The velocity of the runoff is directly related to the slope of the watercourse, as demonstrated in the Manning equation (velocity is a function of the square root of the slope). Any increase in the slope will therefore increase the velocity of the runoff from the area.

- Surface Roughness - The velocity of water running off an area is inversely proportional to the coefficient of roughness associated with the surface.

- Velocity - The quantity of water which can runoff from an area is a function of the velocity of the runoff (and therefore all those factors which affect velocity) and the cross-sectional area through which the runoff can occur.

Urbanization often results in physical alteration of the environment which brings changes to the hydrologic cycle (USEPA 1977), such as:

- Decreased soil porosity through compaction
- Elimination of surface areas which retain precipitation
- Increase in impermeable surfaces
- Construction of channel and storm sewers to carry off the excess surface water
- Increase in site slope due to terracing
- Decrease in vegetation thereby deceasing transpiration and interception
- Increase in the smoothness of surfaces

According to USEPA, these changes in an area's natural hydrologic balance can lead to serious impacts on water quality.

The early data on the relationship of land use and water quality in the United States, particularly urban uses, came during the 1960s, when concern grew over pollutants identified in runoff. Many studies were commissioned by USEPA for urban and non-urban watersheds throughout the country in the mid-1970s. The results of these studies have provided useful data. However, remaining unknowns about the problem and high costs of runoff treatment prevented federal funding, so EPA began the Nationwide Urban Runoff Program (NURP) in 1978 and produced a final report (USEPA 1983). Results included in the report showed expected runoff quality for various land uses.

Impacts on the River

Watersheds affect the river in many ways, from physical character to spatial relationship to the river. Impacts can be put into three general categories: physical character of the watershed, hydrological, and land use.

Physical Character of Watershed Physical character of a stream refers to the topography and geological structure of the area. For example, steep slopes of granite will yield lower total dissolved solids quality water than would relatively flat marine deposits high in calcium carbonates.

Hydrological Characteristics. Hydrological characteristics include factors such as precipitation, local geology, and human-made channel designs.

Land Use. Land use has long been recognized as a controlling factor in the water quality of a stream. Urban and agricultural developments can affect surface water and groundwater quality (Krenkel and Novotny 1980). The Urban Land Institute (1981) states that major problems of water resources protection are a result of urbanization and land development. Water resources are adversely affected by runoff increases, decreases in infiltration, and greater degree of erosion and sedimentation, flooding, runoff pollution, and discharge of sewage effluent.

Points of Impact. Sub-watersheds impact the river on two spatial regimes One spatial regime is contiguous impacts, via numerous storm drains or small channels The smaller and more disperse the discharge points are on the river, the quicker the assimilation of the discharged waters The other spatial regime is point impacts such as at confluences or water reclamation discharge points, where the sum of the sub-watershed characteristics

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impact the river at one point on the river. At these points, assimilation is more dependent on distance and time downstream from the discharge point. Table 4 shows the spatial regimes for each sub-watershed.

Table 4. Contiguous and point impacts of each sub-watershed.

Sub-watershed	Contiguous impact	Point impact
I	X	
II	X	
III	X	
IV		X
V		X
VI		X
VII	X	
VIII	X	
IX		X
X	X	
XI	X	
XII	X	
XIII	X	

Critical Points. Sub-watersheds with intensive urban land uses potentially have a high impact on the river. As discussed above, the sub-watershed's impact can be contiguous or point, so high impact sub-watershed will result in critical portions or critical points on the river. Critical portions of the river are located at sections adjacent to intensive land uses, such as industrial and commercial. Critical points are located at confluences, where the overall character of the sub-watershed impacts the river.

Methodology for Investigation

A fundamental need of a water quality study of the Los Angeles River is to understand the impact the watershed has on the river. To accomplish this, a land use and water quality analysis was performed on the Los Angeles River and its drainage by.

1 Grouping drainages along the river into sub-watersheds, showing their respective impact points on the mainstem

2. Assessing the land use character of each sub-watershed and its impact point

3. Comparing runoff water quality to expected quality based on the land use in the sub-watershed

The results of the comparison are presented in Chapter IV.

Data Sources

Data on land use and watershed boundaries were obtained from local agencies. The Los Angeles River watershed boundary was traced from Los Angeles County Flood Control District maps onto a land use map obtained from Los Angeles County Department of Regional Planning. Thirteen sub-watersheds were drawn based on natural watershed boundaries. To limit the number of sub-watershed to a manageable number, smaller watersheds were grouped if they had similar character based on terrain, aspect, and predominant land use ratio. The County land use map provided 9 land uses categories, but for the purposes of the water quality analysis, like categories were condensed, resulting in five categories.

Data showing the relationship of land use and water quality were obtained from several reports by the United Stated Environmental Protection Agency (USEPA), which has conducted several studies of the pollutants for three land use types -- residential, commercial, non-urban and sometimes industrial. Monitoring by USEPA tends to focus on the primary pollutants of concern, so comparisons with other parameters is not possible, and likely not a concern.

Nationwide Urban Runoff Program (NURP). Data were needed to evaluate the runoff for the Los Angeles River watershed. A widely recognized program is NURP, which was designed to provide information and methodologies for water quality planning efforts. The objectives of the program were to provide credible information for decision makers and support the planning and implementation of the 28 separate planning projects throughout the United States. The results of the program were combined into the Final Report issued in 1983.

NURP identified priority pollutants for which data were gathered from field monitoring to characterize urban runoff flows and pollutant concentrations and mass loadings. The resultant data represented a cross-section of regional climatology, land use types, slopes, soil conditions.

NURP's Final Report provided a data table of the mean concentrations for all sites by land use category. Although caution is needed in applying these results to one geographic area, the report states that site variability was shown to be very well represented. Thus, the table indicates the effect of land use on urban storm runoff pollutant discharges. Because the table is the best source of data, it was used to identify drainages in the Los Angeles River watershed which may be negatively impacting the river. Pollutants studied in NURP, and in this thesis, consist of copper, zinc, biological oxygen demand, lead, nitrate, and phosphorus.

Characteristics of Los Angeles River Sub-watersheds

The geographical character of each portion of the watershed impacts the river. By analyzing regions which have similar character, water quality impacts of land use can be better understood. Based on the local geography, i.e. physical, hydrological and cultural, the Los Angeles River watershed was divided into 13 sub-watersheds (Figure 21). For example, the sub-watershed titled, Southwest Valley (XIII), has a land use character distinct from the North Valley (I) in that it has a larger rural area and little industry. Its impact is contiguous along the western part of the Los Angeles River via small channels and storm drains. This division from the North Valley is based on field observations and land use data.

The area of each land use category was added and the percent of each land use by sub-watershed was calculated (Table 5). Figure 22 shows pie charts of land use for each sub-watershed. Table 4 shows the spatial impact, i.e., contiguous or point, for each of the sub-watersheds.

Following are descriptions of each watershed based on geological data from California Division of Mines and Geology Los Angeles Sheet (1991), U.S. Geological Survey topographic maps, (various dates), Los Angeles County Department of Regional Planning map (1993), and author observations.

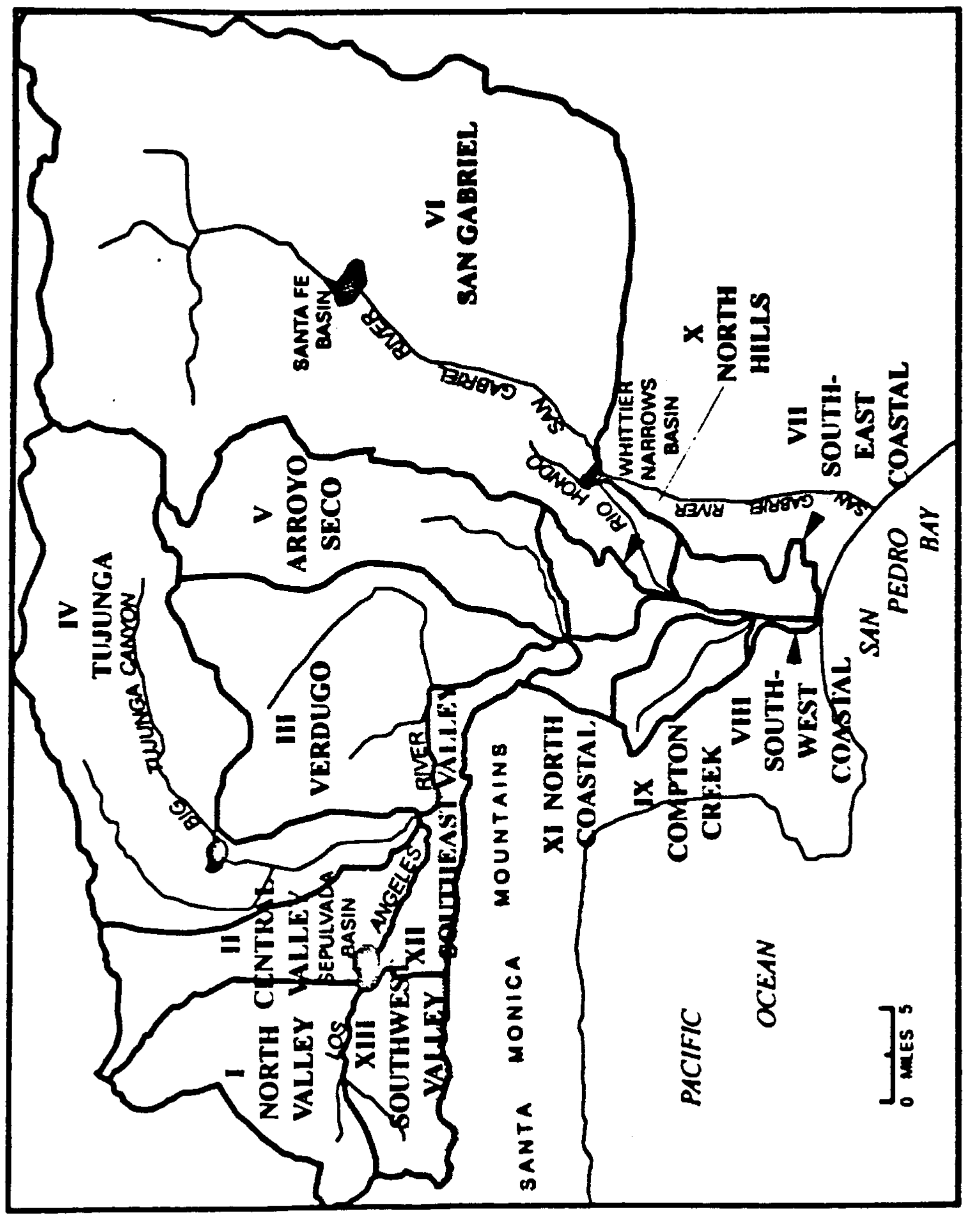

Figure 21. Sub-watersheds of the Los Angeles and San Gabriel Rivers. Lines show division of natural and human made watersheds boundaries

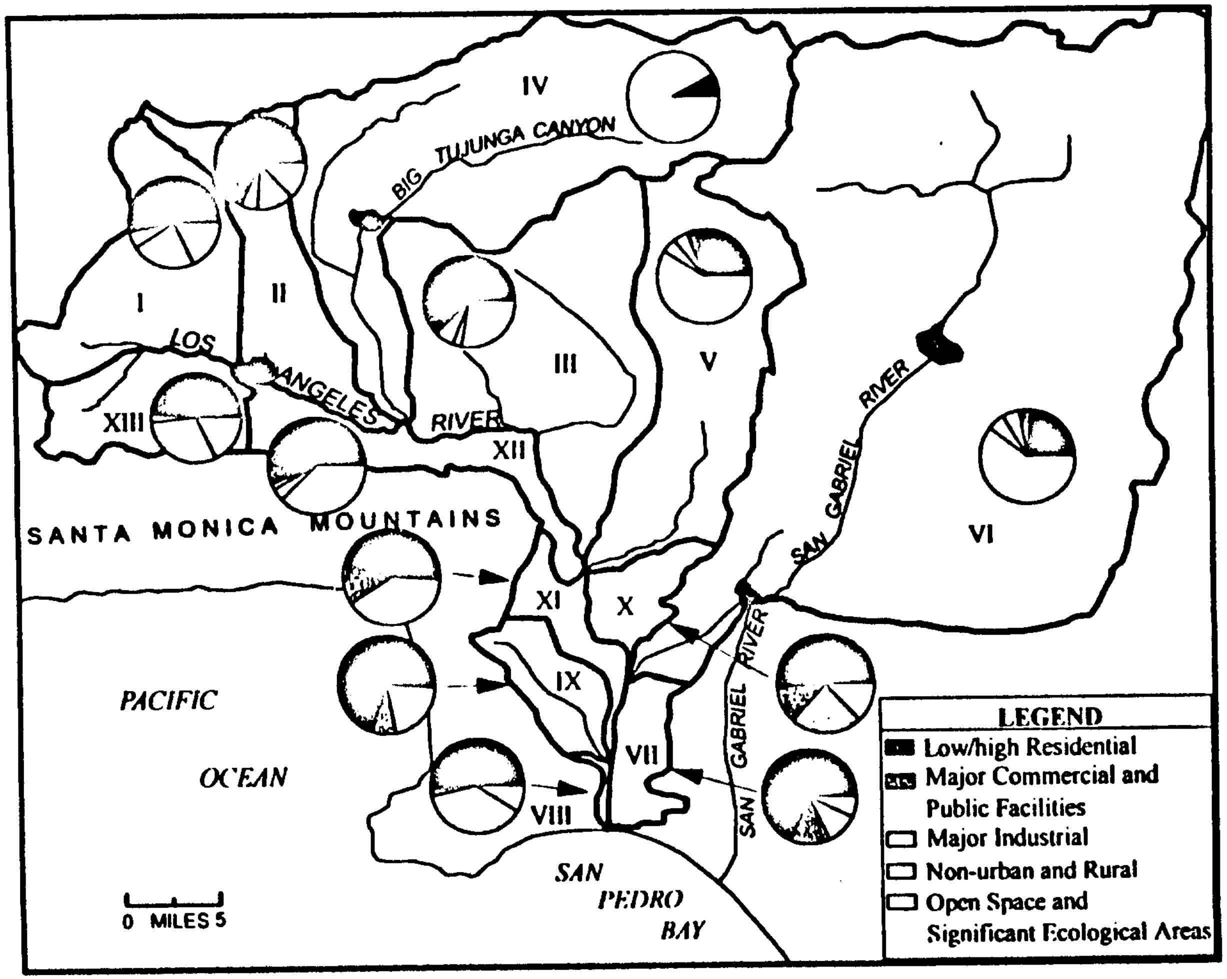

Figure 22. Percent Land Use Category for Sub-watersheds

Table 5. Percent land use for each sub-watershed.

Sub-watershed (percent)	Low/high Density Residential	Major Commercial/ Public Facilities	Major Industrial	Non-Urban and Rural	Open Space/ Significant Ecological Areas
I	49	4	6	23	18
II	57	11	8	13	13
III	54	8	7	3	28
IV	5	1	1	1	92
V	28	3	5	5	59
VI	24	4	6	6	61
VII	69	14	11	0	7
VIII	51	3	38	0	9
IX	70	8	21	0	1
X	51	12	24	0	13
XI	46	13	40	0	1
XII	50	6	2	4	38
XIII	39	10	3	31	18

I. North Valley. Located on the west side of the San Fernando Valley, this sub-watershed is bounded by the Simi Hills on the west and the Santa Susana Mountains on the north (Figure 1, Chapter 1). The hills and mountains are under 3,000 feet in elevation and contain canyons and broad areas of alluvium mostly in the valley. The mountainous areas contain mostly marine deposits with several other sedimentary rocks.

Streams emanate from the foothills and then cross the valley to the Los Angeles River A common characteristic of watersheds in southern California is debris flows. Many of the streams have debris basins. Drainage through the urban environment is via various culverts and concrete channels. This sub-watershed has a contiguous impact (Table 4) Reclaimed water discharges are not part of the local hydrology.

The North Valley is largely residential, followed by open space.

II. Central Valley. Much the same as North Valley (I), this sub-watershed is bounded by the Santa Susana Mountains to the north and by Bull Creek on the west The hills contains marine and non-marine sedimentary rocks, with alluvium filled valley.

The main drainage channel is Bull Creek and a portion of Pacoima Wash, which is diverted into Tujunga Wash. The Tillman Water Reclamation Plant is located in this sub-watershed. The tributary area of Bull Creek and the Los Angeles River is impacted by the reclaimed water discharges.

The majority of the area is residential, followed by open space. The percentage that is commercial and industrial is higher than in North Valley (I).

III. Verdugo. Verdugo Mountains is the center of this sub-watershed bounded by Tujunga and Arroyo Seco watersheds and the Los Angeles River. The range is about eight miles long and three miles wide with its highest peaks over 2,500 feet in elevation, composed of granitics, metamorphics, and marine rocks.

The largest drainage channel is Verdugo Wash which drains the northeast slope and the south slope of the Verdugo Mountains. Several other mountain drainages flow southwest off the mountain through urbanized areas and then into the Los Angeles River.

Quite similar to the Central Valley (II), Verdugo is mostly residential, however, a much higher percentage is open space, largely in the Verdugo Mountains.

IV. Tujunga. Bounded within the Big Tujunga, Little Tujunga, and Pacoima watersheds, this area contains the highest point in the Los Angeles River watershed proper, Pacifico Mountain at 7,124 feet located in the heart of the San Gabriel Mountains. Both igneous and metamorphic rocks make up the majority of the upper watershed, with some sedimentary rocks located near the mouth of the canyon. Alluvium makes up the lower portion of the watershed.

Mountain elevations are high enough to allow the accumulation of snow during winter. Steep slopes quickly carry snow-melt and rainfall to the streams. Historically, the mouths of these canyons are the site of large debris flows and flash flood. A series of dams are located upstream and Hansen Dam is located downstream. Alluvial fans allow groundwater recharge from the canyons to the valley bottom. Several spreading grounds are located in the area for groundwater recharge. Lower Tujunga Wash is a concrete

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lined channel from the Hansen Dam to the Los Angeles River, where the sub-watershed has a point impact.

Much of the Tujunga (IV) sub-watershed is within the Angeles National Forest, thus the overwhelming majority of the land use is open space or significant ecological areas. The primary focus of management within the National Forest is watershed protection. The remainder of the area is rural and residential. The overwhelming majority of this watershed is open space.

V. Arroyo Seco. Bounded on the north by the ridges of the San Gabriel Mountains, this watershed contains peaks over 5,000 feet in elevation. The upper watershed has a similar rock make-up as Big Tujunga Canyon, but the lower watershed contains only a narrow band of alluvium between some granitic rocks and marine deposits.

The main drainage feature is the Arroyo Seco which flows from the San Gabriel Mountains south to the Los Angeles River. Lofty hills border the stream through most of its length. The channel is mostly concrete or stone grouted after it enters the lowlands

The upper portion of the watershed is also located in the Angeles National Forest, giving the watershed a high amount of open space. The second largest land use is residential

VI. San Gabriel. The San Gabriel watershed stands alone as a major watershed, but is considered a sub-watershed because it drains into the Los Angeles River and San Gabriel River. The highest peak is Mount San Antonio at 10,064 feet above sea-level. The upper watershed contains much of the same rock types as in Big Tujunga Canyon, which is dominated by granitic rocks. The lower watershed contains a broad plain of alluvium

Drainage of this watershed into the Los Angeles River is controlled by Whittier Narrows Dam. Mountain runoff from San Gabriel River and other various channels flow into Whittier Narrows Dam basin. The Rio Hondo and San Gabriel River both continue south from the Dam (Figure 1, Chapter I). The Rio Hondo flows into the Los Angeles River approximately twelve miles upstream from San Pedro Bay, and the San Gabriel flows south to the ocean. Water flow characteristics are similar to the Tujunga Wash - - derived largely from mountain snow melt and debris flows. A comprehensive system of dams are used for flood control and water conservation. Spreading grounds are located in the valley and coastal plain.

The majority of the land area is within Angeles National Forest. Because the watershed contains the San Gabriel Valley, the open space areas is not an overwhelming percentage as in Tujunga (IV).

VII. Southeast Coastal. This sub-watershed is bounded by a drainage network constructed for urban development. Thus, its geologic structure has little impact on water quality. The topography varies from very flat, to bluffs of 50 feet high, to Signal Hill with an elevation of approximately 350 feet.

The hydrological features of this sub-watershed is largely anthropogenic. A storm drain network flows directly to the Los Angeles River. Nearly all of the drainages are through culverts. Because of the high river levee, many of the drains flow to pump stations which pump the water into the Los Angeles River. The pump stations prevent large size debris from entering the river.

The Southeast Coastal area contains the second largest percentage of residential, followed by commercial and industrial. Little rural space is found in the sub-watershed.

VIII. Southwest Coastal. Bounded by Dominguez channel on the west, this small drainage is similar to Southeast Coastal in that it is heavily urbanized. Little topographical change is notable.

The hydrological features are similar to the Southeast Coastal, but are more heavily impacted by industrial land uses.

This area has the highest industrial land use compared to the other sub-watersheds

IX. Compton Creek. This watershed is bounded by the Compton Creek drainage area, which is an extensive storm drain network, but also contains Dominguez Hills to the southwest, also heavily urbanized.

The main drainage feature is Compton Creek which is a concrete channel, except for its last two miles, which is soft bottom with grouted rock banks. The creek has a low

Drainage of the mountain slopes is though various channels, many ending in culverts. Debris flows appear not to be a problem.

About half of the area is residential followed by open space because Griffith Park is included in the area. A small percentage is commercial.

XIII. Southwest Valley. Bounded to the south by the north-slope of the Santa Monica Mountains, this area contains largely marine deposits with a short alluvial slope before meeting the Los Angeles River.

The topography is similar to Southeast Valley (XII), but on a larger scale. Debris basins are located on some channels.

This area contains the largest rural land use of all sub-watersheds, although it too is dominated by residential. Open space is a significant part of the area, followed by commercial.

Overall Land Use Trends

The data show that the sub-watersheds range in open space from 92% in the Tujunga sub-watershed to 1% in two of the coastal sub-watersheds (Table 5). Open space decreases from upstream to downstream, while commercial and industrial uses increase, with the maximum of 38% industrial area in the Southwest Coastal sub-watershed. Table 6 ranks the sub-watersheds with land use categories that have the most intensive impact on water quality.

Table 6. Sub-watershed ranked by percent of intensive type land uses.

Rank	Commercial/ Public Facilities	%	Industrial	%	Residential	%
1	**VII**	14	**XI**	40	**XI**	70
2	**XI**	13	VIII	38	**VII**	69
3	X	12	X	24	II	57
4	II	11	IX	21	III	54
5	XIII	10	**VII**	11	VIII	51

Bolding indicates those sub-watersheds which appear in three columns

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Watershed and Water Quality

Correlating water quality with upstream land use is not a new concept (Krenkel and Novotny 1980). Uncontrolled urban and watershore developments can easily result in a lowering of water quality (USEPA 1977). The source of this pollution can be traced to:

- Accumulation of dust and dirt trapped in the urban environment
- The residual product of automobiles, trucks and buses which are a source of suspended solids, chemical oxygen-demanding material, and heavy metals.
- Debris from litter in streets and other sources of organic material
- Runoff from construction sites
- Illegal discharges and dumping.

General Urban Runoff Characteristics. Since the discovery of the poor quality of urban runoff, several programs have been designed to quantify parameters (USEPA Executive Summary 1983). NURP concluded that :

- Heavy metals are by far the most prevalent priority pollutant constituents found in urban runoff
- Accumulation of dust and dirt trapped in the urban environment
- The residual product of automobiles, trucks and buses and as a source of suspended solids, chemical oxygen-demanding material, and heavy metals
- Debris from litter in streets and other sources of organic material
- Runoff from construction sites
- Illegal discharges and dumping

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highway rose and fell more rapidly than that in the undeveloped basins due to the impervious area of the highway. High metal concentrations were found in the soils within 100 feet of the highway and in the soil water infiltrating the soil zone. Chromium, copper, nickel and zinc concentration in the streams near the highway generally were above the maximum levels recommended by USEPA for the protection of aquatic life

Los Angeles River Runoff Characteristics Based on NURP. NURP data were chosen for comparing Los Angeles River runoff, because NURP results are commonly used by many other cities for planning purposes (this was the intent of the program). As part of NURP, Oltmann and Shulters (1989) studied runoff quality for four urban catchments in Fresno, California. This is of particular interest because this location is most similar in climate to Los Angeles as compared to the other cities in the study. Based on the USEPA, and Fresno results, the expected results for each parameter is listed in Table 7.

The land use character of the each sub-watershed dictates the vulnerability of the surface water. Table 8 is a listing of the sub-watersheds with land uses most vulnerable to the values in Table 7.

Table 7. Results of NURP for nationwide and Fresno, California average

Parameter	Residential NURP	Residential Fresno	Commercial NURP	Commercial Fresno	Industrial NURP	Industrial Fresno
Nitrate + nitrite (N) mg/l	0.7	0.4	0.6	0.4	N/M	0.6
Phosphorus mg/l	0.1	0.2	0.08	0.1	N/M	4.8
BOD mg/l	10.0	N/M	9.3	N/M	N/M	N/M
Lead µg/l	144	150	104	100	N/M	87
Copper µg/l	33	15	29	14	N/M	68
Zinc µg/l	135	120	226	180	N/M	520

Table 8. Ranking of watersheds with highest percent of two intensive land use categories.

Residential	Commercial/ Public Facilities	Industrial
XI	VII	XI
VII	XI	VIII
II	X	X
III	II	IX
VIII	XIII	VII

Areas with the highest intensity of land use will have the largest impact on the river Figures 23a through 23e show graphically each land use type and where it impacts the river. The graphs do not take into consideration area or runoff quantity, however, they help show how the river environment is impacted mile by mile, based on land use and its potential impact of water quality.

The first graph shows increasing contiguous impacts of residential land use, while point impacts tend to be lower land use. This is because the tributaries emanate from mountainous regions low in residential population. The effect of these point impacts are a buffer to the contiguous residential impacts and the water quality associated with residential land use.

Figure 23b indicates a slow but steady rise in commercial land use from upstream on the Los Angeles River downstream. In addition, Figure 23c indicates a marked increase of industrial land use.

Figure 23d indicates that rural development decreases significantly. The west end of the San Fernando Valley has the highest percentage, at 31 percent. The terminus of the river has less than 5 percent.

It is apparent from Figure 23e that the point source of the tributaries have a significant impact on the river. Most contiguous sub-watersheds have less than 50 percent open space, while all tributaries, except Compton Creek (IX), has greater than 50 percent open

Figure 23a-e. Percent land use for sub-watersheds draining into Los Angeles River by river mile. Contiguous impacts from sub-watersheds, denoted by line-bars and point impacts of tributaries denoted by squares.

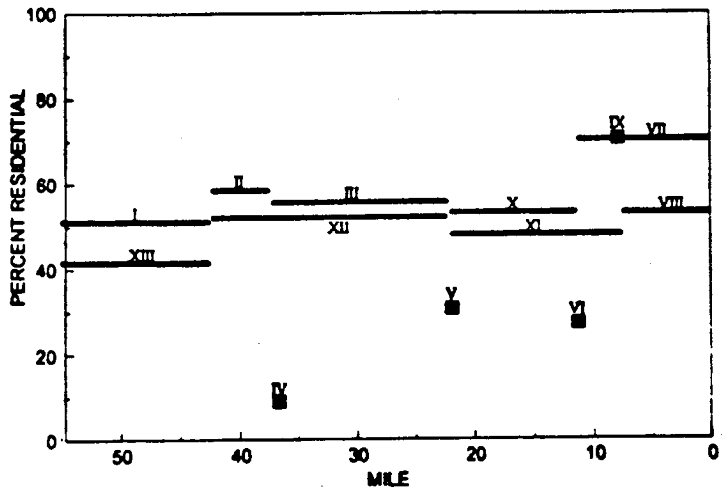

Figure 23a Residential land use increases downstream, however, all tributaries except for IX Compton Creek have smaller percentages.

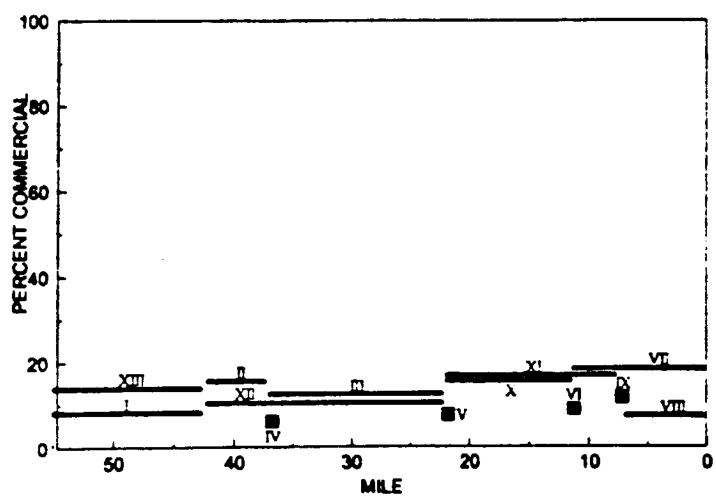

Figure 23b Commercial land use slowly increases downstream

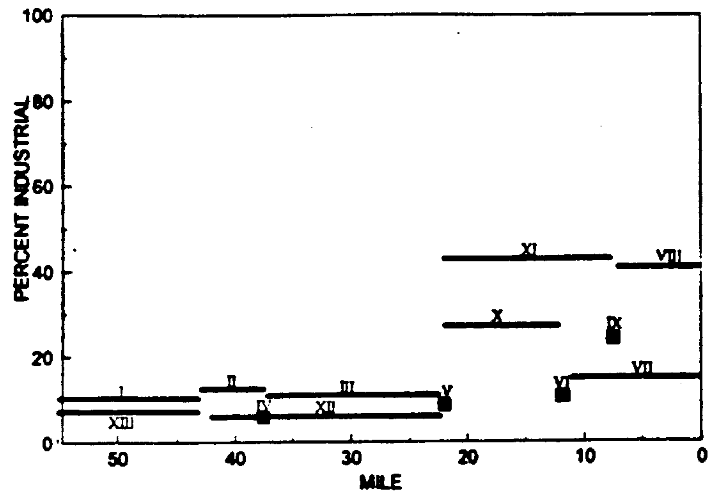

Figure 23c Industrial land use increases significantly near the end of the lower river

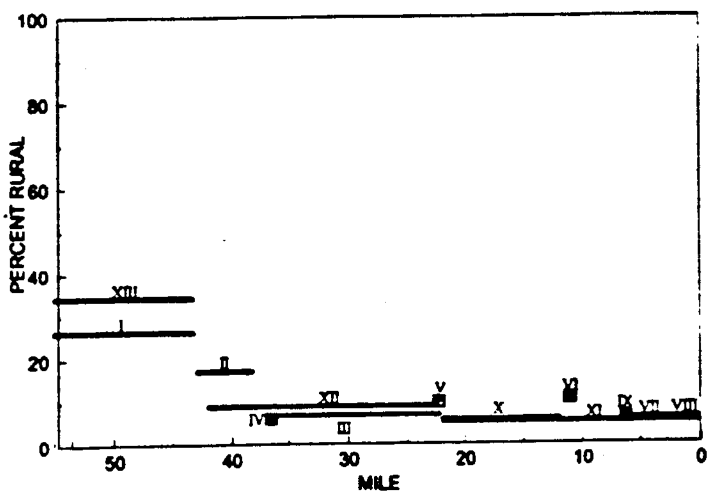

Figure 23d. Rural decreases significantly downstream

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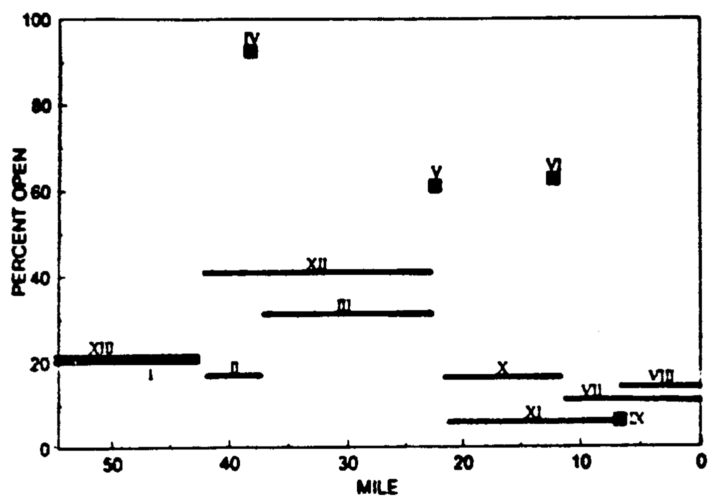

Figure 23e. Contiguous impacts of open space are higher mid-stream and in all tributaries except for IX Compton Creek.

space. Also, the lower Los Angeles River has much less open space than the upper.

It has been demonstrated that the watershed is the key to understanding and controlling water quality in a stream. An understanding of the watershed, including physical, hydrological, and cultural impacts can be used to evaluate water quality impacts. Once the watershed impacts are understood and controlled, river quality will also be improved

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CHAPTER IV

WATER QUALITY AND BENEFICIAL USE CRITERIA OF THE LOS ANGELES RIVER

Water quality plays an important role in human and environmental health. Periodic monitoring of a water body is common method to check the quality of water over time Water quality monitoring of the Los Angeles River is accomplished by several governmental agencies Overlapping jurisdictions, agency boundaries and mandates, make river monitoring and environmental protection complex To study the water quality of the entire river length, data from all possible agencies were gathered This chapter is a presentation and analysis of the data. Based on the results, two basic questions are addressed: What is the water quality of the Los Angeles River, and what beneficial uses are appropriate?

Water Quality and Beneficial Use Management

Two agencies perform the majority of the water quality monitoring and river system operation of the Los Angeles River. The California Regional Water Quality Control Board, Los Angeles Region IV (RWQCB) monitors the river and implements regulatory measures pursuant to the federal Clean Water Act and the California Porter-Cologne Water Quality Control Act (1969). The Los Angeles County Department of Pubic Works (LACDPW) also performs monitoring of surface waters, operates the flood control system, and maintains most of the flood control system including operations and pubic access to the Los Angeles River. The Corps does not monitor water quality, but operates portions of the river system.

California Regional Water Quality Control Boards are divided into nine regions throughout the state Los Angeles County and the Los Angeles River watershed is part of Region 4. RWQCB's primary duty is to protect the quality of the waters within the region for all designated beneficial uses. This is accomplished by formulating and adopting water quality control plans for specific ground or surface water basins and discharges (RWQCB 1993). RWQCB is responsible for regulating the activities and factors which affect or may affect the quality of the States waters (RWQCB 1975). The agency designates beneficial uses for the river, which can seldom be downgraded or removed from the list. Chapter V discusses the beneficial use designations by RWQCB

The agency designates beneficial uses of water bodies, sets water quality objectives, and adopts a water quality control plan to achieve objectives. The agency also performs annual water quality monitoring of nearly all the surface waters in the region.

Another facet of RWQCB's role in the water quality management of the Los Angeles River is its implementation of the National Pollutant Discharge Elimination System (NPDES) program and in particular the Stormwater NPDES program. The principal permittee for the Los Angeles County municipal stormwater NPDES permit is LACDPW and the local jurisdictions (cities) are the co-permittees (RWQCB letter to permittee June 17, 1993). RWQCB approved a program involving a stormwater monitoring program and Early Action Best Management Practice Plans in 1993. A successful program is expected to improve the water quality of the river.

LACDPW, incorporating the L.A. County Flood Control District, monitors the water quality of the river. Historically, this agency focused on waters used to recharge aquifers and for discharges to receiving waters (LACFCD 1981). With the NPDES program, LACDPW's role in water quality of the Los Angeles River has been expanded

Stormwater Quality Management

Research on methods to reduce pollution in runoff is growing. According to Urbonas and Stahre (1993), stormwater engineering and management has advanced more in the last 20 years than at any other time. Best Management Practices to enhance stormwater quality have proliferated and spread worldwide.

In 1987 the USEPA expanded the NPDES program to include municipal and industrial stormwater discharges as a result of the findings in a study titled the National Urban Runoff Program (Lee and Jones 1990). In California, the Stormwater NPDES program

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is implemented by the RWQCB which issues permits to stormwater dischargers. The Los Angeles River basin falls under the Los Angeles County municipal stormwater permit held by LACDPW. Various municipalities are the co-permitees under this permit. The NPDES Program requires monitoring and the implementation of best management practices in an effort to reduce pollution in runoff. Improved runoff quality is expected over the next few years as the efforts by municipalities are increased. The concepts presented in the land use section would be applicable to controlling pollution in runoff.

Data Collection

A significant amount of data is needed to make sound conclusions on the appropriate beneficial uses of a water body. Thus, all the data possible was gathered from eight local agencies. All parameters available from the 1988-92 study period were gathered.

Data Sources

Two key sources of data were the water reclamation plants (WRPs) and wastewater monitoring departments of various agencies. Agencies which conduct water quality monitoring of the river are listed in Table 9. Data results were from the laboratory analysis of field samples. Field sample locations varied with agency and depended largely on agency jurisdiction (Figures 24a and 24b). Water quality monitoring data were collected from the drought period 1988 through 1992. This allowed an investigation of the river when the watershed is dry, which is the prevailing condition. A total of over 50,000 data pieces were entered into a database for this study.

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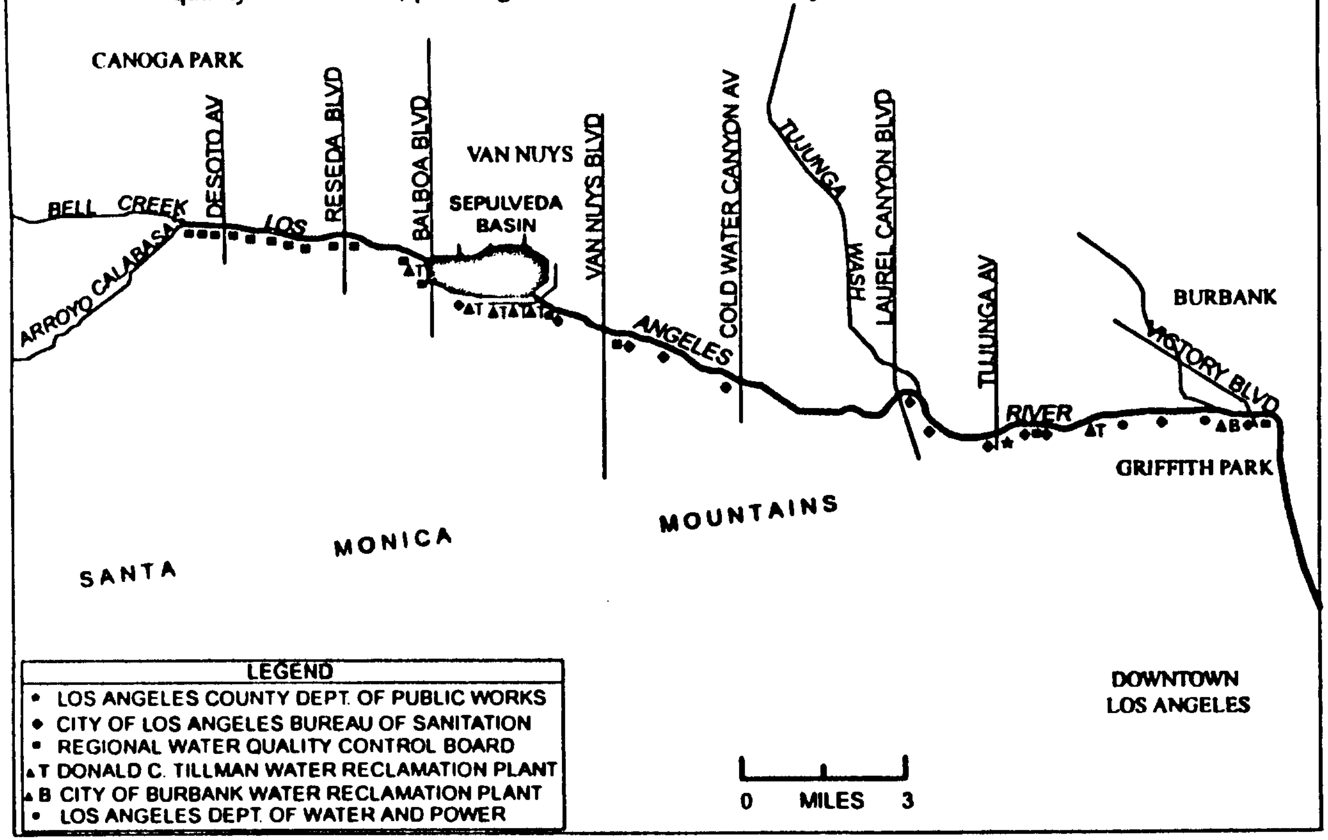
Table 9. Instream water quality monitoring by various agencies. Eight agencies regularly monitor the water quality of the Los Angeles River.

Agency	Physical		Inorganic		Organic	
	Stations	Period	Stations	Period	Stations	Period
Los Angeles County Department of Pubic Works	4	Monthly	6	Monthly	1	Quarterly
City of Los Angeles Bureau of Sanitation	19	Monthly	19 (3 Parameters)	Monthly	20 (Phenols)	Monthly
Regional Water Quality Control Board	5	Annually	5	Annually	11	Annually / Bi-annual
Donald C. Tillman WRP	3	Weekly	4	Bi-Annually	4	Bi-Annually
Los Angeles/ Glendale WRP	2	Weekly	N/M		N/M	
City of Burbank WRP	3	Weekly	3	Annually	N/M	
So Cal Coastal Water Research Project		Infrequent		Infrequent		Infrequent
Los Angeles Dept of Water and Power	4	Quarterly	4	Quarterly	4	Quarterly

Source: Agencies listed N/M = Not monitored

Figure 24a. Agency sample locations upper river. Agency sample location vary in quality and location, pubic agencies are limited to their jurisdiction.



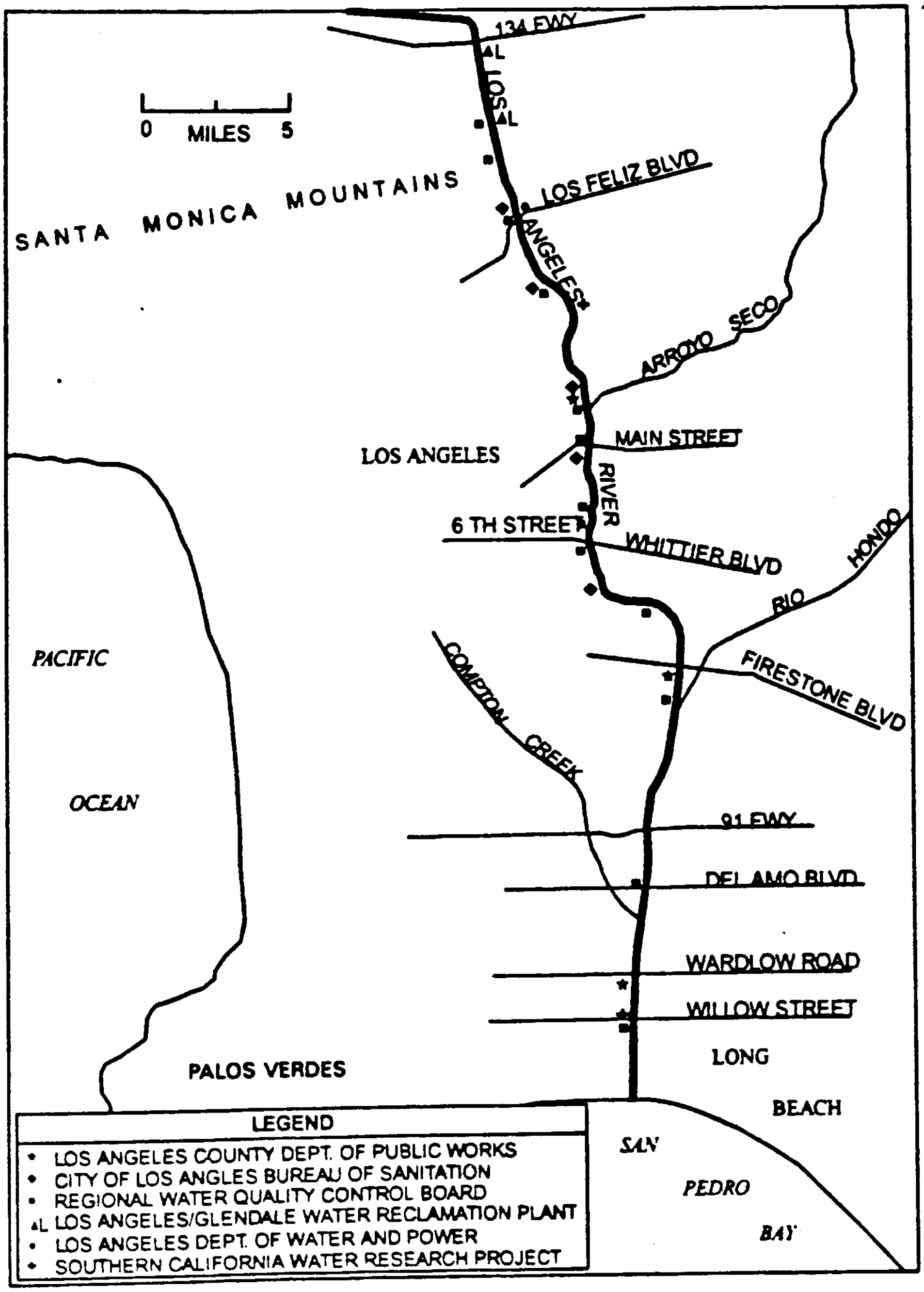


Figure 24b Agency sample locations lower river

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Data Analysis

Water quality data were categorized into the regime from which they were sampled Nearly all data was collected during the dry regime. Thus, this thesis focuses on the dry regime, which includes the four inflows as described in Figure 14: Reclaimed water discharges, industrial discharges, urban runoff, and rising groundwater. The dry regime is the most important regime to beneficial uses because it is present most often throughout the year. Wet regime results are discussed in the section following the dry regime analysis.

Data collected from agencies were entered into a database system designed for the specific purpose of analyzing the data. Most agencies had different sample points along the river, so sampling stations were assigned a letter code which indicated place-name, agency and river mile (River miles are designated from the mouth of the river upstream (Figure 25). The starting point (0 miles) is the Queensway Bridge in Long Beach.)

Inferential statistics was used to characterize the water quality of the Los Angeles River This is useful to draw conclusions about the characteristics of a large group from a small sample of that group (Gordon, Mc Mahon, and Finlayson 1992). This method is commonly used in environmental analysis where data are collected, described and related, and generalizations are made from the results This methodology provided a foundation for the discussion of potential beneficial uses of the river.

The sample station data were averaged for each agency and is presented in tables and graphics. The graphics are used to show temporal and spatial trends. The summarized data was compared to water quality criteria, which vary depending on the beneficial use For example, State of California drinking water standards were used for comparison purposes to assess quality of the water for municipal beneficial use Following the analysis of the data is a section which discusses beneficial uses which are acceptable based on the water quality data.

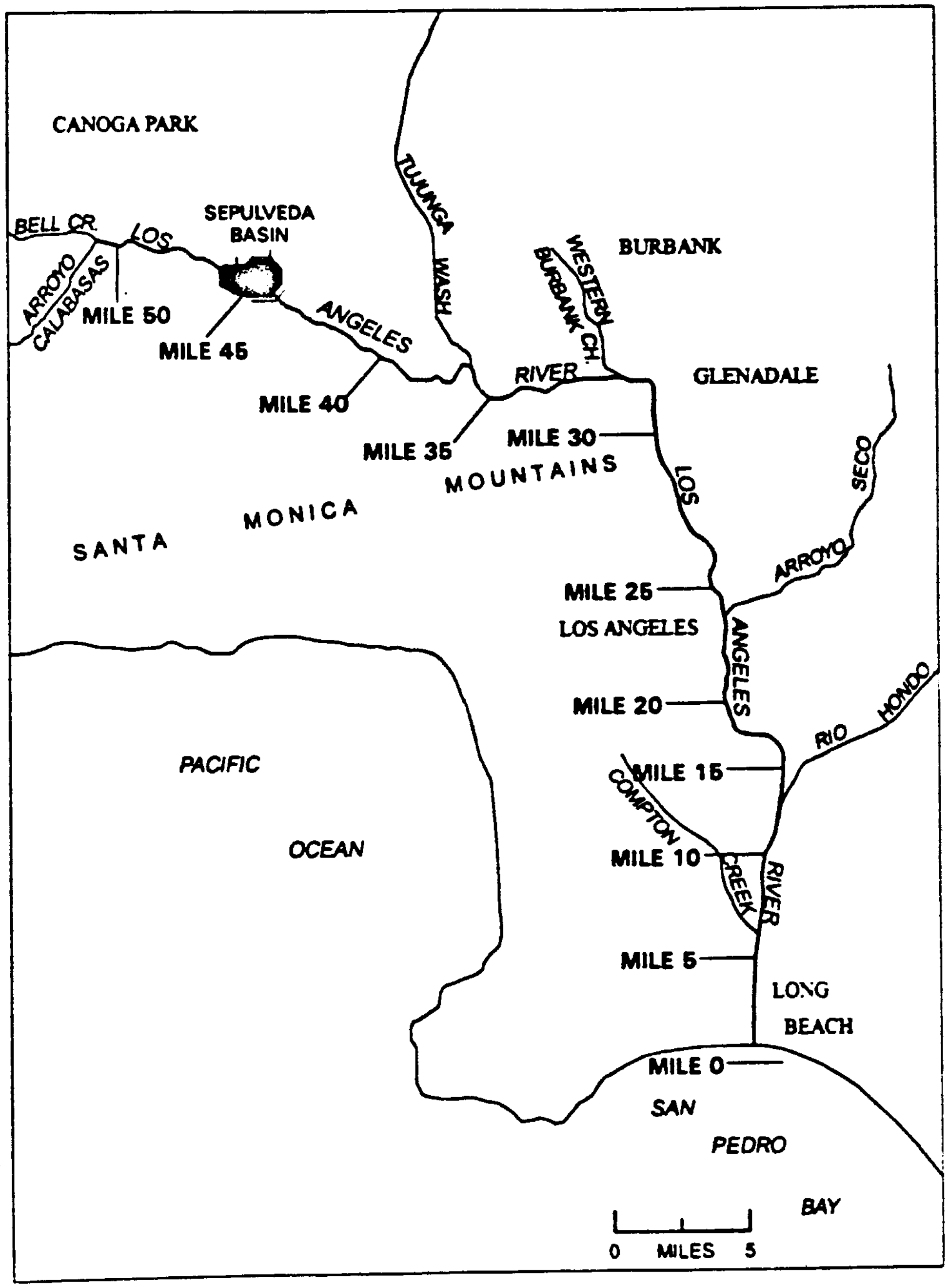

Figure 25 River Mile This figure is useful for comparing the water quality graph's river-mile to the location on the map

Dry Regime Water Quality Analysis Results

Water quality parameters that are below the accepted criteria have an impact ranging from health risk issues to the aesthetic issues. The analysis results of this section are useful to determine which parameters are at unacceptable levels. If these parameters are controlled in water quality control plans, then additional appropriate beneficial uses are attainable.

Dissolved Solids, pH, Oil and Gas

Treated municipal wastewater in southern California is often high in total dissolved solids (TDS). This condition has been exacerbated during the 1986-1992 drought. For instance, the city of Los Angeles increased its dependence on water from sources higher in TDS. Prior to the drought, Owens Valley and Mono Basin water with a TDS of 150 mg/l was used as a main source, but this source was cut in half during the late 1980's (MWD 1990). Make-up water was made available from the Colorado River Aqueduct with a TDS of 750 mg/l and the State Water Project with a TDS of 339 (Upper Los Angeles River Area Watermaster 1992). Drought conditions increased TDS levels in water supplies and as a result, discharges to the Los Angeles River through urban runoff and WRP discharges had elevated TDS concentrations.

Typical TDS values are shown in Table 10. However, TDS values can vary depending on local rainfall. Long periods of precipitation result in increased flow volume in the river which dilutes the dissolved solids. Although stormwater sampling results are scarce, TDS of under 500 mg/l is common during storm events.

Table 10. Electrical conductivity, TDS, pH, oil and gas values for the Los Angeles River.

Parameter	Tujunga Avenue	Arroyo Seco Confluence	Firestone Blvd.	Wardlow Street
Electrical Conductivity (µmhos/cm)	1068	1072	1052	1077
Total Dissolved Solids (mg/l)	641	643	651	669
pH Units	7.5	7.7	8.3	8.5
Oil and Gas (mg/l)	3.1	2.5	2.4	3.7

Source: Los Angeles County Department of Public Works

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The Donald C. Tillman Water Reclamation Plant (Tillman WRP) significantly impacts TDS concentration of the river. During the dry regime, the Tillman WRP discharges are significantly higher in quantity and lower in TDS than the river flow. This reduces pollutant concentrations. For example: a review of semi-annual data for electrical conductivity, provided by the Tillman WRP, shows that TDS in the river is reduced at the discharge point. TDS values were estimated using the electrical conductivity data (EC x 0.6) from two sample stations; one located upstream from the discharge points and one located downstream from the discharge points: the estimated TDS values were 804 (mg/l) and 514 (mg/l) respectively.

In addition, three samples were taken by the RWQCB above the WRP discharge point at De Soto Ave. The dates and results were: March 1990 - 1168 mg/l, May 1991 - 1328 mg/l, and December 1991- 886 mg/l. The average TDS value for WRP discharges at the plant is 596 (mg/l). Mixed water (WRP discharge and urban runoff) value is 641 mg/l

Although upstream data is extremely limited, these data indicate that the WRP dilutes urban runoff, thereby improving water quality in regard to TDS. Thus, the WRP largely dictates the water quality of the river. Unfortunately, insufficient data are available upstream of the Tillman WRP to determine its impact on other parameters. Reclaimed water discharges control the water quality of the river. A comprehensive review of individual parameters values is provided in the summary section on the effects of reclaimed water discharges.

TDS steadily increases, however slightly, downstream. This is most likely because of inflows of urban runoff with high TDS and possibly because of evaporation (Figures 26a and 26b). Figure 27 is a comparison of TDS values of the different types of water. There are steady increases in pH downstream but values remain in the neutral range.

Most rivers in the Pacific Southwest have a high alkaline character, mostly due to high evaporation rates. Thus, surface water supplies in southern California and the Los Angeles River exhibit this characteristic.

According to LACDPW data, oil and gas are detected often in the river. Field observations by the author indicate that oil and gas originate from crank case oil dumping into the storm drain system and sheet-wash from road surfaces and parking lots

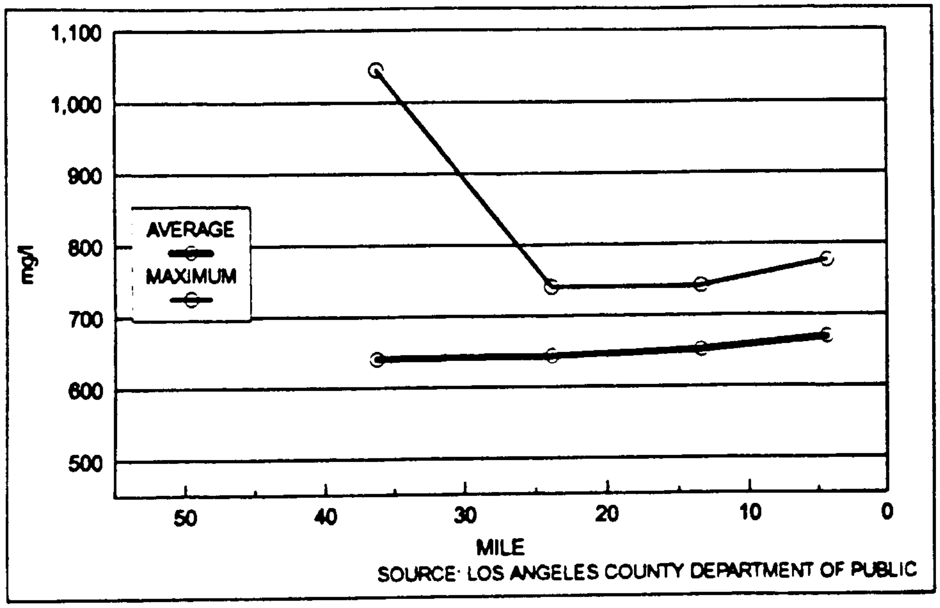

Figure 26a. Los Angeles River total dissolved solids average, May 1988-Jan 1992

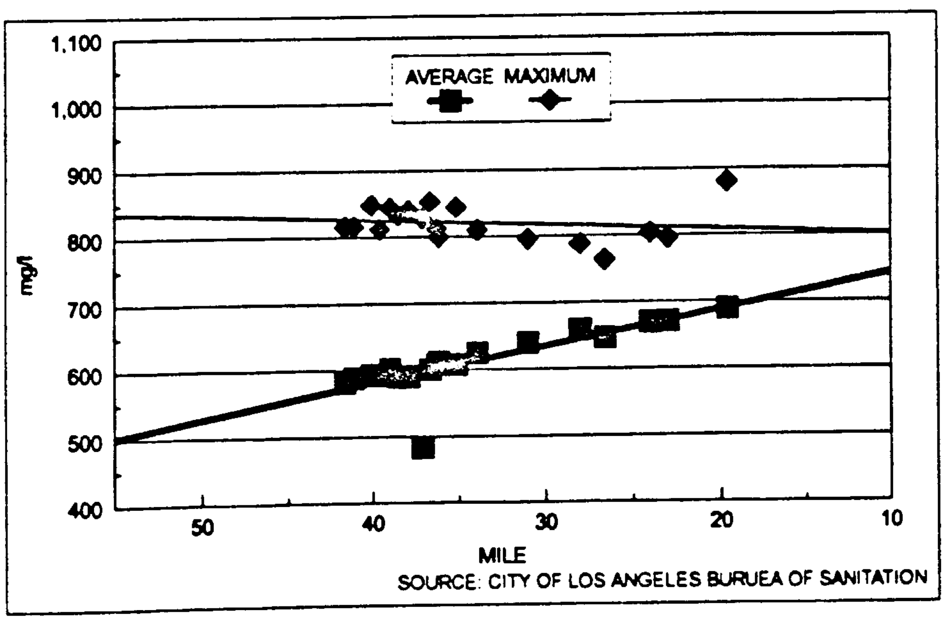

Figure 26b Los Angeles River total dissolved solids average, years 1989-1991

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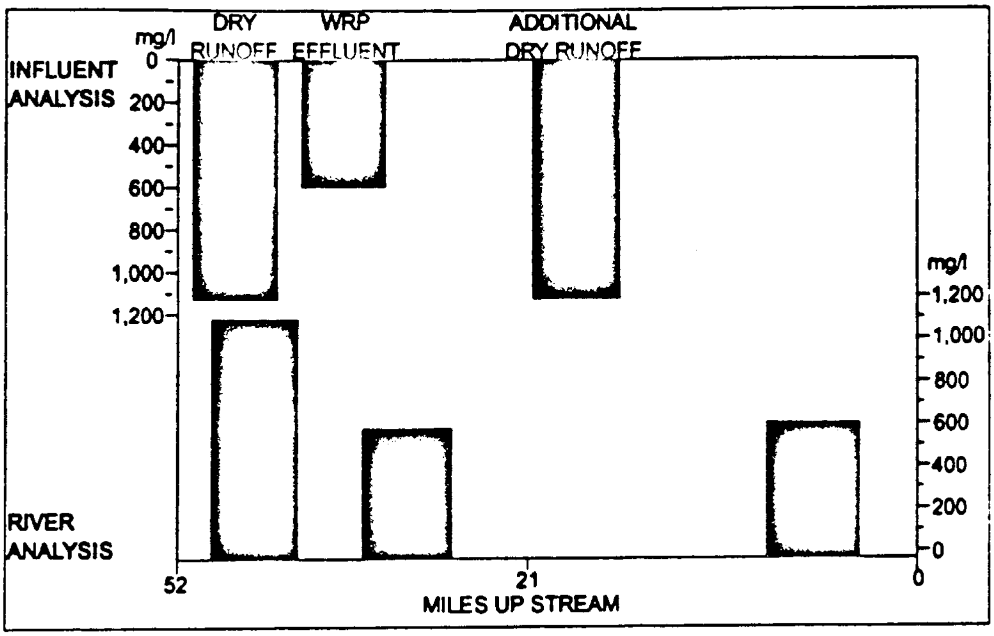

Figure 27. Total dissolved solids (TDS) of influent and receiving waters. Dry regime runoff is high in TDS, but is moderated by lower TDS effluent from water reclamation plants.

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Beneficial Use Assessmet. The maximum allowable limit for TDS in drinking water is 1000 mg/l with a recommended level of 500 mg/l, according to Secondary Drinking Water Standards - State of California Title 22. However, for wildlife, a TDS less than 5,000 mg/l is desirable. Standards for industrial uses vary significantly depending on use, but for many uses less than 300 mg/l is desirable. The river averages about 650 mg/l at the four LACDPW sample stations (LACDPW station locations: Wardlow Bridge, mile 4.35; Firestone Blvd Bridge, mile 13.38; Arroyo Seco confluence, mile 23.8; and Tujunga Ave. mile 36.25.) This concentration meets drinking water standards, but is outside the desirable levels for some industrial uses without additional treatment to reduce TDS. The river water is well within criteria for the propagation of wildlife.

There is little variation in pH levels and they are acceptable for most beneficial uses. The minimum and maximum recorded levels were 6.7 and 10.2 respectively. Acceptable pH ranges for industrial uses vary with the type of industry use (Hem 1989). A pH between 9 and 10 is usually acceptable as a maximum and a pH minimum of 6 is usually acceptable as a minimum for industrial uses. However, industrial boiler feed water requires a minimum pH of 8. For fish, a range between 6.5 and 9.0 is considered safe (European Inland Fisheries Advisory Commission 1978).

Oil and gas detections are undesirable for all beneficial uses. The maximum concentrations for body contact and non-body contact recreation is 2 mg/l and for wildlife 5 mg/l. The river concentration ranges between 2 mg/l and 5 mg/l. Oil concentrations in the 1 mg/l range have been shown to be toxic to fish (Hann 1972).

Nitrogen and Phosphorus

When nitrogen and phosphorus are discharged to a stream, they promote biological responses which may interfere with some desired uses of the water (Allen and Mancy 1972). Excessive growths of attached algae, resulting in high BOD and undesirable aesthetics, often occurs. Other elements and compounds are limiting factors to algal growths, however, most attention has been focused on nitrogen and phosphorus.

Nitrogen appears in various forms in aquatic environments. The forms of nitrogen is reflective on the aquatic environment (Krenkel, Novotny 1980). During anaerobic conditions, nitrate may be reduced to nitrogen gas or ammonia. During aerobic conditions, ammonia can be oxidized to nitrite and nitrate (Figure 28). Nitrate, and to a

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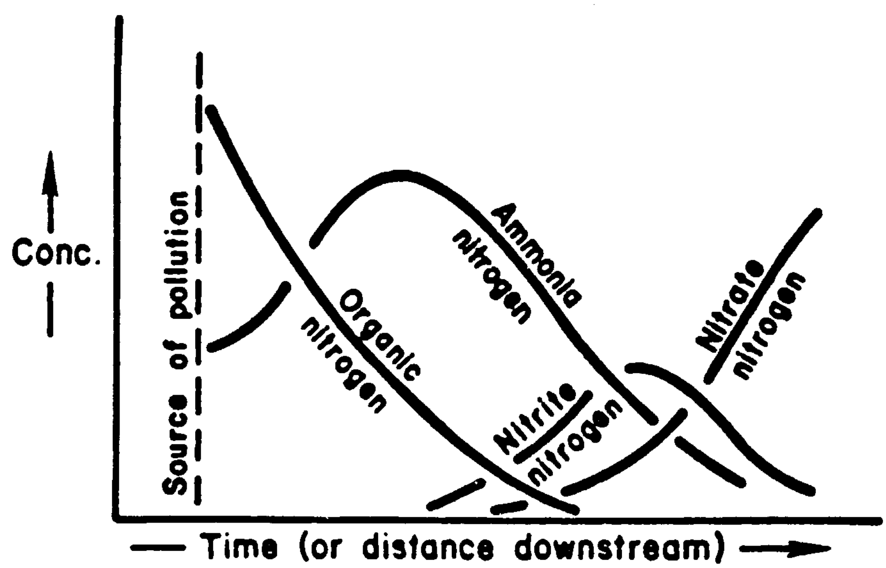

Figure 28. Nitrogen dynamics of streams. In typical streams, organic nitrogen and ammonia are transformed into nitrate. Source: Vesilind, Peirce and Weiner 1990

lesser extent ammonia, can be utilized by aquatic plants and algae.

Sources of nitrogen in surface waters include: municipal wastewater and fertilizers Nitrogen often occurs in polluted waters, but is seldom abundant in natural surface waters because of its value as a nutrient to plants (Hann 1972).

Ammonia is oxidized to nitrate in well aerated rivers. Aeration in the Los Angeles River occurs mostly in the soft bottom sections, while the concrete bottom sections have laminar flow. The two large reclaimed water discharge points from the Tillman and Los Angeles-Glendale WRPs are located at soft bottom sections of the river, thus allowing aeration. The Tillman WRP outfall has the shortest distance of soft bottom channel, which may inhibit oxidation of the ammonia.

The Tillman WRP main outfall is scheduled to be relocated in late 1994 The new discharge point will be just downstream of Sepulveda Dam and will discharge directly into the concrete channel This may alter the nitrogen dynamics, potentially delaying nitrification.

LACDPW has conducted monthly sampling for nitrate at four Los Angeles River locations and the City of Los Angeles Bureau of Sanitation (LABS) has conducted monthly sampling for nitrates at 18 sites. LACDPW had four Los Angeles River sites and LABS had 18. Figure 29a is a plot of nitrate values over distance. Each station is a composite of three years of monthly samples averaged for each agency. Average LACDPW value is 5.0 mg/l and LABS value is 10.5 mg/l, a steady state trend occurs in both data sets, however the averages vary significantly. Reasons for the variances between agency data may include: sample techniques, sample storage techniques and laboratory methodologies.

LACDPW data show a decrease in ammonia concentrations (Figure 29b) Insufficient number of data points fail to show nitrification dynamics, only general trends are shown LABS did not monitor for ammonia.

Phosphate occurs in increased amounts from fertilizer and detergent presence in waters A large proportion of the phosphorus in surface waters originates from municipal waste effluent Data from the three WRP along the Los Angeles River was

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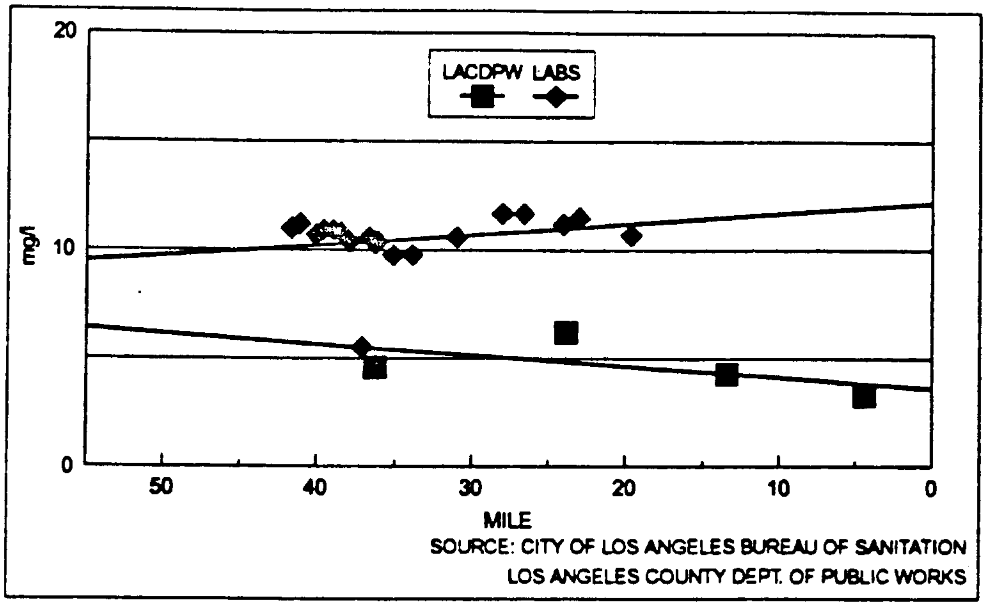

Figure 29a. Los Angeles River nitrate average, LACDPW May 1988-Jan 1992, LABS 1989-91.

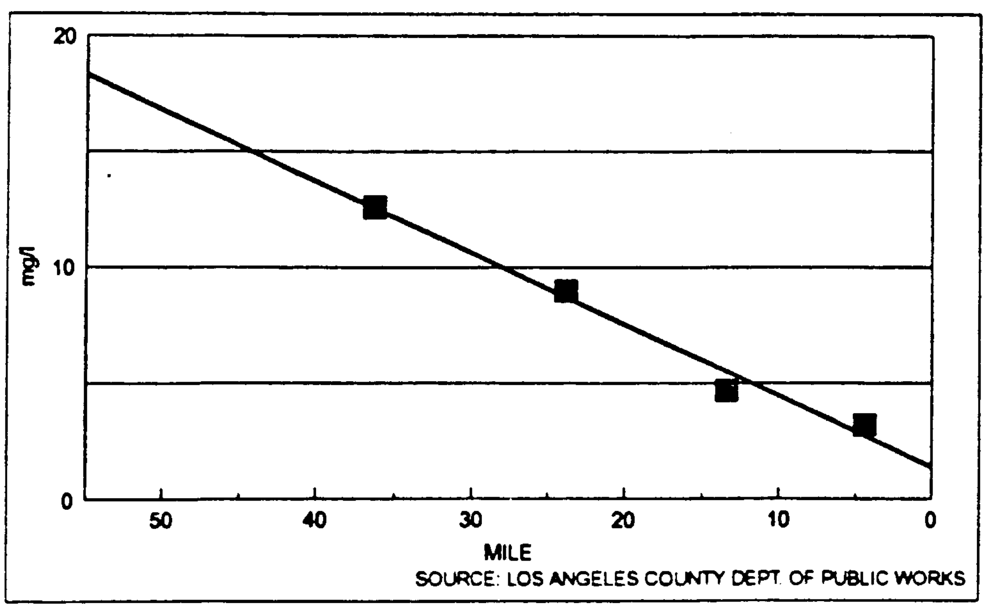

Figure 29b. Los Angeles River ammonia average, May 1988-Jan 1992

not available. Data from LACDPW showed phosphate levels averaging 2.8 mg/l. The average maximum of the four stations was 13.1 mg/l. Phosphate levels stay quite steady throughout the river length.

Beneficial Uses Assessment. High nitrate is tolerable for nearly all industrial processes except for food processing. However for drinking water supply, nitrate levels above 10 mg/l (as N) exceeds drinking water standards (USEPA, 1975). The river appears to approach this level, however inconsistent data and lack of adequate monitoring makes any conclusion unreliable.

Nitrogen is one of the two nutrients required for the growth of algae, the other is phosphorus (Allen and Mancy 1972). The quantity of phosphorus does not necessarily have a biological impact on surface waters since it must be in a biologically available form, such as orthophosphate (Krenkel and Novotmy 1980). Thus, river monitoring should include orthophosphate concentrations. The presence of nitrogen and phosphorus compounds create undesirable conditions by creating odors and rapid plankton growths. Beneficial uses, such as recreation, municipal and industrial water supply are hindered.

The Los Angeles River exhibits undesirable high nutrient loadings in most sections of the river. At times, the author has observed a continuous flow of algae globules from the concrete lined section to the estuary in Long Beach. The processes causing this phenomenon is not known, but is undoubtedly related to the nutrient levels discharged from the WRPs. Without further understanding of the nitrogen and phosphorus dynamics and its control, water quality control will not be attained and beneficial uses will be limited.

Eutrophication appears to be a problem on the river today. This has also been observed by the author at the estuary, especially in pools of water which become isolated from the main flow. These pools stagnate and produce strong odors, making the area undesirable for most uses. Reductions in nutrients may assist in improving the desirability of the estuary. Increasing the beneficial use of the river requires reduction of nutrients at the sources.

Biological Oxygen Demand

Biological oxygen demand (BOD) is used as a measure of the presence of organic materials which can support the growth of microorganisms (Stack 1972) BOD is a measure of oxygen required for biological and chemical oxidation.

Caution should be used when using BOD results for determining water characteristics. Stack (1972) states that BOD measurement is not a true quantitative entity in terms of water quality and translation of analytical information to the receiving waters is not a valid interpretation. In addition, Krenkel and Novotny (1980) state that the effects of many variables must be known before interpretation of the results can be made.

BOD levels in the river average about 5 mg/l. A high of 63.6 mg/l was detected in November 1991. The cause is not known. BOD discharge levels into the river were not available from all WRP. However, data from the Los Angeles-Glendale WRP showed that discharges are typically between <2.0 mg/l to 7.0 mg/l. Figure 30 shows the BOD levels along the river from LACDPW.

Beneficial Uses Assessment. The range of acceptable BOD for beneficial uses varies significantly. For example, BOD in drinking water is unacceptable, however, for wildlife propagation acceptable maximum concentrations are between 30 mg/l and 50 mg/l. Industrial uses usually require BOD values less than 10 mg/l. The river appears to have a typical BOD less than 10 mg/l. Closer monitoring and investigation of sources for the sporadic high BOD values should be performed. In addition, BOD and DO dynamics of the Los Angeles River are not well understood.

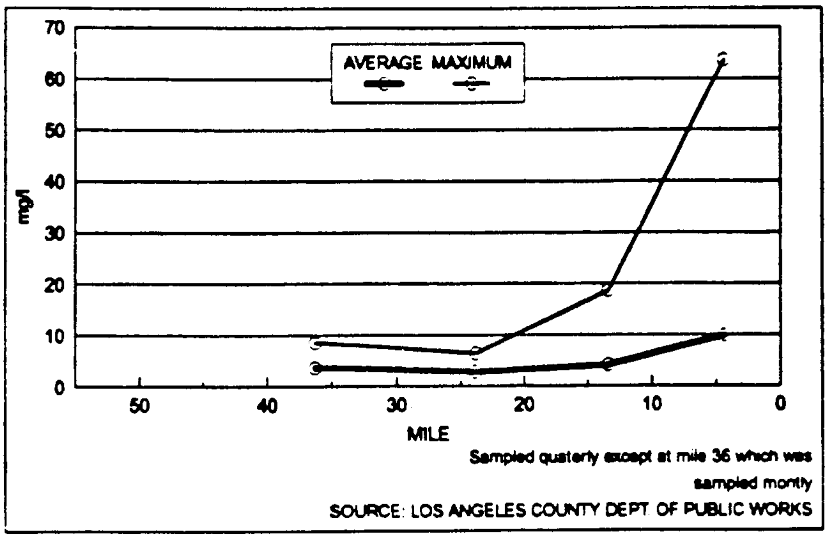

Figure 30. Los Angeles River Biological Oxygen Demand average, Jul 1988-Jan 1992

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<u>Bacteriological Quality</u>

Several indicator organisms are used routinely to monitor the presence of possible parthenogenic organisms in water. Krenkel and Novotny (1978), provide an overview of the use of bacteriological indices of water quality. They explain that indicator organisms are used to identify waters which have potential pathogens because it is not practical to monitor for all pathogens. For example, total coliform has been the most important indicator of sanitary or pathogenic conditions in waters. This group of bacteria was monitored on the Los Angeles River by LACDPW.

Bacteriological quality is often measured by fermenting bacteria collected from a water sample and doing a plate count. Values are expressed are the number of bacterial colonies counted per unit volume. A statistical analysis is also used resulting in the most probable number per unit volume (MPN/100ml) (Krenkel and Novotny 1980)

As organic food concentration increases in a stream, bacterial numbers increase (Nemerow 1985). In the Los Angeles River, high counts are most likely related to waste loadings from urban runoff and nutrient levels from WRPs. Monthly total coliform values from LACDPW averaged 36,000 to 96,200 for the period May 1988 through January 1992 (Table 11). The highest value recorded was 800,000 in October 1990 and several low values under 500 occurred in the winter and spring of 1990.

Tillman WRP monitors receiving waters as required by a National Pollution Discharge Elimination System (NPDES) permit issued by the RWQCB. Tables 12a and 12b summarize monitoring results for total coliform counts from two sampling periods

The first time period included three sample stations during the period January 1988 through September 1991. The station locations were revised in the second time period. from October 1991 through February 1993 (sample locations are described in the tables)

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Table 11. Bacteriological quality for the Los Angeles River.

Parameter (MPN/100ml)	Tujunga Avenue		Arroyo Seco		Firestone Blvd		Wardlow Rd	
	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Total Coliform	36,000	500,000	45,900	800,000	96,200	930,000	32,200	330,000
Fecal Coliform	3,000	30,000	1,900	23,000	14,300	230,000	6,700	93,000
Fecal Streptococci	4,000	80,000	1,800	13,000	1,300	17,000	1,900	16,000

Source: Los Angeles County Department of Public Works

Table 12a. Coliform sample results for receiving waters January 1988 through September 1991.

Parameter MPN/100ml	R-1 - 500 ft upstream		R-2 - 500 ft downstream		R-3 - 9 miles downstream	
	Avg	Max	Avg	Max	Avg	Max
Total Coliform	15,100	280,000	15,000	173,000	48,000	360,000

Source: Tillman Water Reclamation Plant

Table 12b Coliform sample results for receiving waters October 1991 through February 1993 (revised protocol)

Parameter MPN/100ml	R-4 - 1.5 miles upstream		R-5 - between lake and main outfalls		R-2 - 500 ft downstream of main discharge		R-6 - 0.75 miles downstream	
	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Total Coliform	24,800	420,000	4,700	20,000	5,500	100,000	5,500	100,000

Source: Tillman Water Reclamation Plant

During the first time period, the data table shows that R-1 has a slightly higher average than R-2, and R-3 is significantly higher. Again, it is likely that the WRP discharge is diluting urban runoff, which is high in total coliform. Downstream, at station R-3, a significant increase in total coliform is observed. This can be attributed to additional inflows from urban runoff into the river containing higher coliform levels and a time lag of bacterial growth downstream from the WRP. Thus, while the WRP is diluting urban runoff, it is providing additional nutrients for bacterial growth downstream.

Data from station R-1 may not be representative of the receiving-waters quality because of its proximity to the discharge point; a location where back-flow of reclaimed water could be occurring. Thus, the reduction of total coliform may be greater than available data suggests. Unfortunately, this reduction is apparently short lived, as R-3 shows significant increase in total coliform levels.

With the construction of Balboa Lake and the addition of discharge points along the river, a new sampling protocol began in October 1991. The lake, located in Sepulveda Basin, is a recreational lake which receives water from Tillman WRP. Excess water from the lake flows into the river. Under the revised sampling plan, R-1 was discontinued and two sample points were placed upstream of main discharge point, away from the back-flow problem zone and an additional sample station was placed 0.75 miles downstream from the main outfall. The second (revised plan) period shows very high total coliform at R-4, above both outfalls and a 75% reduction in total coliform downstream of the two discharges, (Table 12b).

Beneficial Use Assessment. Based on the above results, the river normally contains bacterial concentrations above all acceptable ranges for beneficial uses. The least stringent standard for bacterial quality is for wildlife propagation, which allows 1,000 bact/ml. Ninety-two percent of the 164 samples taken from May 1988 to January 1992 by LACDPW had results which were above the level acceptable for any other beneficial use.

WRP's along the Los Angeles River often use chlorine disinfection to control bacteria. Unfortunately, chlorination is complex and unpredictable in wastewater effluent (Chamber 1971). Levels of chlorination should extend to the desired level of coliform control. Research has shown that chlorine lowers BOD, however, the formation of chloramines can result in toxicity to fish (Zillich 1972). Chlorine residual is not allowed under the NPDES permit for WRP discharges.

Because nearly all samples are above acceptable levels, the river's water quality is unacceptable for all uses based on this parameter.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) in water is one of the most important measures of water quality (Stack 1972). The instantaneous concentration of DO is the result of many physical, chemical and biological factors. DO is a function of temperature, atmospheric pressure and the presence of other solutes (Allen and Mancy 1972). The solubility of oxygen in pure water at 25 degrees C is 8.4 mg/l. Uncontaminated surface waters are usually nearly saturated with oxygen. However, diurnal variations occur because of changes in photosynthetic activity.

Low DO may indicate excessive load of organic wastes which create a high BOD (Allen and Mancy 1972). Low dissolved oxygen has an adverse effect on aquatic life. DO averages range from 6.7 mg/l to 8.8 mg/l in the Los Angeles River. Variances in DO can be attributed to changes in the river sub-surface. The concrete sections exhibit laminar flow with less aeration, while the soft bottom sections have rapids that saturate the water with oxygen. In addition, algae and aquatic plants in the river add DO through photosynthesis.

Temperature is also an important factor, particularly for wildlife. Temperature affects the distribution of fishes (Moyle and Cech 1988). Warm water streams have temperatures that exceed 75 to 79 degrees F for extended periods of time. Common species in warm streams are smallmouth bass, green sunfish, catfish, and others small fishes. Cold water streams seldom exceed 75 to 79 degrees F. Trout is a common cold water stream species. Fish distribution is only partially dependent on temperature, however. Factors such as the presence of other species and stream gradient affect fish distribution.

Measurements of DO and temperature were made by the three WRPs on a regular basis. Data from the Tillman WRP is summarized because it is the farthest plant upstream to allow contrast of river with and without reclaimed water, (Tables 13a and 13b). Descriptions of the sample sites were described in the bacteriological quality section above.

Table 13a. Receiving water sample results for January 1988 through September 1991.

Parameter	R-1 - 500 ft upstream			R-2 - 500 ft downstream			R-3 - 9 miles downstream		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Temperature oF	67	48	80	69	48	90	N/M		
Dissolved Oxygen (mg/l)	6.7	1.4	10.0	6.7	3.7	13.2	N/M		

Source: Tillman Water Reclamation Plant. N/M = Not Monitored

Table 13b. Sampling results for receiving waters October 1991 through February 1993 (revised protocol).

Parameter	R-4 - 1.5 miles upstream			R-5 - between lake and main outfall			R-2 - 500 ft. downstream of main discharge			R-6 - 0.75 miles downstream		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Temperature oF	64	46	83	69	52	69	72	57	81	70	55	80
Dissolved Oxygen (mg/l)	8.8	2.9	15.3	7.3	4.9	9.8	6.9	3.6	9.2	7.8	3.5	11.6

Source: Tillman Water Reclamation Plant

Beneficial Use Assessment. The optimal DO concentration for nearly all beneficial uses including fisheries is 5 mg/l. Data collected from the Los Angeles River near the Sepulveda Basin averages above this amount. However, occasionally the concentrations fall below 5 mg/l with a low of 1.4 mg/l (It was noted that the sample time was 7:40 am when the photosynthesis rate is slow or non-existent. A sample taken at a later time of day may have provided a result with a high DO level). Of the 342 samples used in this report, (taken from January 1988 to February 1993) five percent had DO less than 5 mg/l. Thus overall, the portion of the river in Sepulveda Basin is close to being acceptable for most beneficial uses for this parameter. Because of lack of data, no other conclusions can be made about other portions of the river.

Anadromous fish, such as the endemic steelhead and Pacific lamprey, used to migrate from the ocean to the Los Angeles River and to Big Tujunga Wash. The migration took place after large storms while the water level remained high. The water temperature was between 32 and 55 degrees F (Swift 1993).

The WRPs provide a significantly warmer environment during the dry regime. However, these fish species would migrate after large winter storms, at a time when the volume of runoff is significantly higher than reclaimed water discharges. It is possible that water temperature is not a limiting factor of fish migrations. Loss of the supporting ecosystem, to the concrete channel and the invasion of non-native species probably play a more significant role in the loss of migratory fish.

<u>Minerals</u>

The majority of the mineral data available was from LACDPW. Table 14 contains averages of monthly data for four stations from May 1988 through January 1992. Note that all these sample locations are downstream of the Tillman WRP. Insufficient data was available upstream of the WRP discharge, making it difficult to assess the impact of the WRP on the river's mineral quantity. As discussed in the above section regarding TDS, the WRP does have a significant impact on mineral quality, apparently diluting urban runoff.

Table 14 Summary of minerals values for the Los Angeles River.

Parameter (mg/l)	Tujunga Avenue	Arroyo Seco Confluence	Firestone Blvd	Wardlow Street
Alkalinity	150	159.7	151.9	164.7
Calcium	54.4	63.1	63.0	64.7
Magnesium	21.4	21.6	21.9	24.8
Sodium	116.3	113.8	117.4	119.6
Potassium	14.8	13.6	13.1	12.8
Sulfate	166.3	155.5	163.8	163.0
Chloride	128.2	127.9	129.3	132.4
Fluoride	0.56	0.54	0.54	0.54
Boron	0.53	0.47	0.47	0.47

Source: Los Angeles County Department of Public Works

The river's mineral content reflects the high TDS, discussed above. Mineral concentration increases downstream, attributed to additional inflows to the river from urban runoff.

A historical account of the river's mineral quality is provided in Table 15. Monthly and semi-monthly dry-season data from 1932 was averaged for a station in Van Nuys (California Division of Water Resources 1933). The average flow in the summer of 1932 was 0.40 cfs, attributed to rising groundwater. No industry or waste discharges upstream of the Van Nuys station were reported to have occurred. LACDPW's Tujunga Avenue-sample-station was selected to compare the 1932 results with recent sampling.

Beneficial Use Assessment. High mineralization of the river results from urban runoff, but is moderated by WRP discharges. It appears that mineral concentration in the river decreases as a result of the WRP plant discharges. This, in effect, improves the water quality of the river for these parameters.

Table 15. Historical and recent Los Angeles River data from Van Nuys area

Parameter (mg/l)	April-November 1932	May-October 1989
Calcium (mg/l)	160	48
Sodium (mg/l)	113	106
Magnesium (mg/l)	67	19
Chloride (mg/l)	48	122
Sulphate (mg/l)	504*only two samples	142
Nitrate (mg/l)	13* only two samples	7
EC (µmhos/cm)	159	986
Average discharge (cfs)	0.40	approx. 60

Sources: 1932 data - Calif. Div. of Water Resources, Bul. 40-A, 1989 data - Los Angeles County Department of Public Works.

Heavy Metals

Some heavy metals commonly found in water, such as iron and manganese, pose no danger to aquatic life or humans below certain levels. They are usually associated with groundwater. In surface water, because of the presence of oxygen, they precipitate. When this occurs, it presents an aesthetic problem resulting from discoloration of the water.

Other metals can be toxic to humans, mammals, and aquatic life (Hann 1972). The concentration at which metals are toxic vary significantly. For example, arsenic ingestion in small quantities is dangerous because it can accumulate in animals. Arsenic can occur naturally in some waters, but normally enters streams from industrial wastes and agricultural runoff. The presence of a metal does not necessarily mean it is in a toxic form to cause biological damage. Many factors, such as pH and hardness, need to be considered before the toxicity of these metals is assessed.

Arsenic, barium, lead, nickel, and zinc are metals which are commonly detected in the Los Angeles River, (Table 16). Arsenic was detected at a maximum of 190 µg/l at the Firestone Blvd. sample station, but averaged between <10 to 10.7 µg/l. Barium consistently increases from upstream to downstream, with a maximum detected at 630 µg/l. Lead concentrations hovered near the detection limit of 10 µg/l, with several detections over 100 µg/l. Zinc detections were consistently high with all stations averaging over 100 µg/l.

Beneficial Use Assessment. The averages for the river meet the strictest water quality standards. The sporadic high concentrations of metals could impact beneficial uses. High

Table 16. Metals summary for the Los Angeles River

Parameter (µg/l)	Tujunga Ave. (max)		Arroyo Seco Confluence		Firestone Blvd.		Wardlow Rd	
	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Arsenic	<10	71	6.2	30.2	10.7	190	<10	37
Silver	<10	<10	<10	<10	<10	<10	<10	<10
Barium	19	60	30	260	37.9	290	52	630
Cadmium	<10	10	<10	<10	<10	<10	<10	12
Chromium	<30	30	<30	<30	<30	70	11.5	30
Chromium VI	<20	<20	<20	<20	<20	<20	<20	<20
Copper	<20	70	<20	30	<20	50	<20	30
Lead	11	120	11	140	<10	90	13.4	120
Mercury	<1	1	<1	1	<1	<1	<1	<1
Nickel	<10	60	10	60	11	40	11	30
Selenium	<5	9	<5	<5	<5	<5	<5	<5
Zinc	95.5	250	128	1120	122	2300	84	340
Iron	298	1900	196	980	193	660	372	2360
Manganese	31	80	53.2	220	39	240	<30	130

Source: Los Angeles County Department of Public Works

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levels may be detrimental to aquatic life and threatening to beneficial uses. More surveillance monitoring is needed to make conclusions on the effects of these sporadic high concentrations of metals. Comments on limiting values of metal concentrations are presented later.

Arsenic concentrations over 1000 µg/l is known to kill most fish species (Hann 1972) Because of the toxicity of arsenic, the drinking water standard in California is 50 µg/l (Title 22 Chap. 15). Based on LACDPW's data, the river is rarely above this level.

The drinking water standard for lead is 50 µg/l. A lead concentration over 100 µg/l would be lethal to fish (Krenkel and Novotny 1980). LACDPW monitoring results exceeded this level at three out of four stations.

Barium and nickel, and the other metals monitored had concentrations below the drinking water standards and the tolerances for most aquatic species. Iron and manganese seem to present no significant problems to water quality in the Los Angeles River.

<u>Volatile Organic Compounds</u>

Volatile organic compounds (VOCs) include such chemicals as solvents, fuels and byproducts of chlorination. The primary concern with respect to these compounds is in the area of groundwater resource management. However, surface waters are threatened by VOCs in the form of spills, dumping and runoff from contaminated surfaces. Many of these compounds at low concentrations volatilize quickly, especially in swift moving streams, so the threat of these compounds to rivers has not been as clearly defined as it has in groundwater. An exception to this is heavy amounts of oil and gas, which tend to float on the water often as a sheen. (See the section titled, Oil and Gas.)

VOCs are continually detected in the Los Angeles River at two locations (Figures 31a and 31b). The higher concentrations occurred in the Glendale Narrows area near Los Feliz Blvd., an area which is adjacent to groundwater contamination. Apparently, rising groundwater is a source of TCE and other VOCs. These compounds dissipate downstream fairly rapidly because large stones in the river aerate the water.

According to the Upper Los Angeles River Water Master Report (1992), the areas of groundwater contamination are within close proximity of the river (Figure 32).

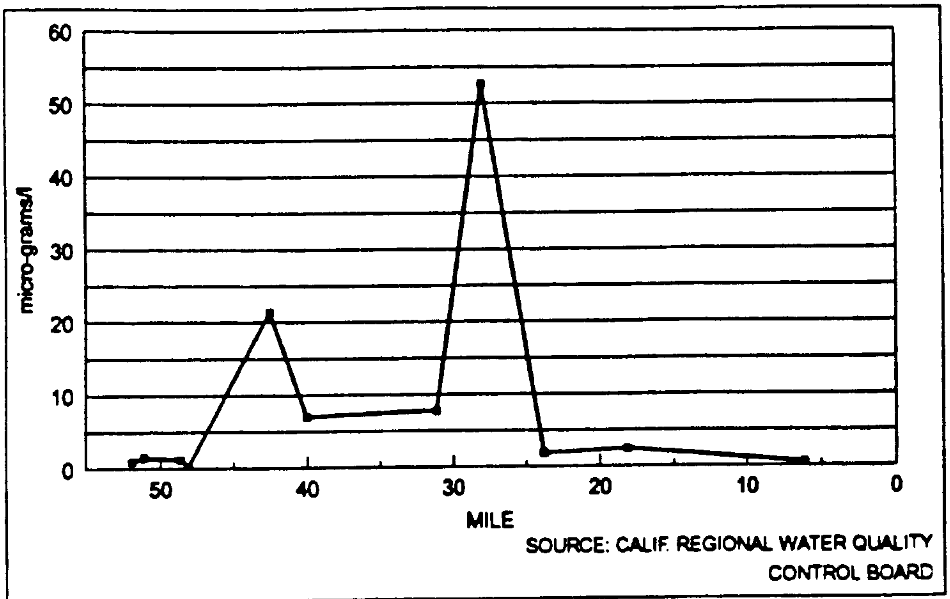

Figure 31a. Total volatile organic compounds in the Los Angeles River averaged from 1986-92. The highest peak occurs at the point where contaminated groundwater flows into the river. Most of these compounds volatize with aeration in the river bed.

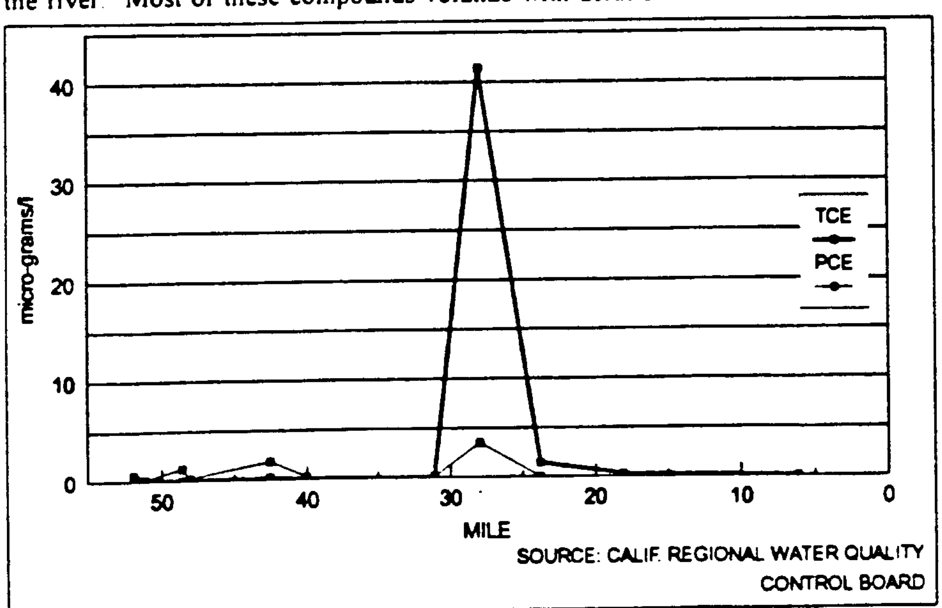

Figure 31b. Los Angeles River TCE and PCE averaged, 1986-92. These two compounds make up the majority of the contaminants from groundwater pollution at mile 28. They are seldom detected elsewhere in the river.

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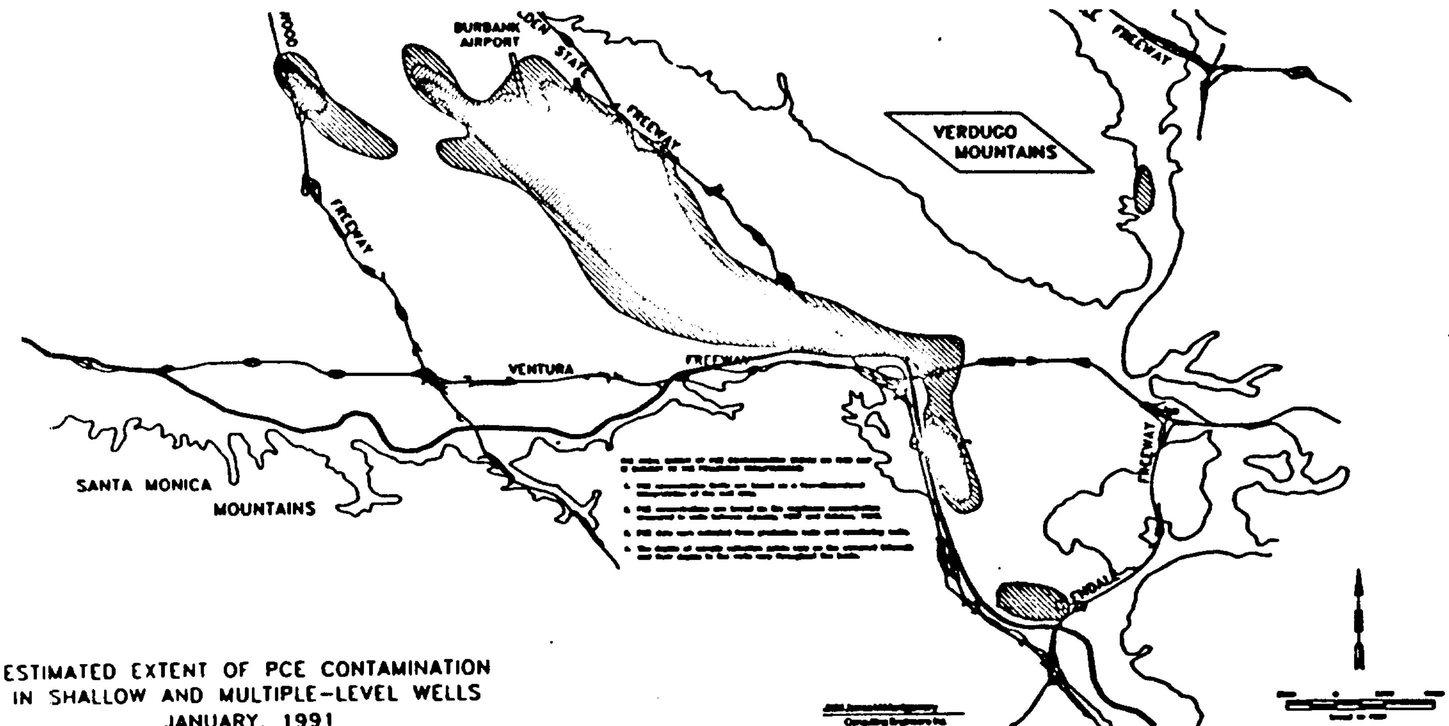
Figure 32. Existing groundwater contamination plume, San Fernando Valley. The point of entry of many volatile organic compounds in the river is near the contaminated groundwater plumes. (Los Angeles River Watermaster 1992)



The second area of VOC detections is near the Sepulveda Dam Basin The source of the contamination is not clear. The VOCs do not dissipate as rapidly as in the prior case probably because there may be multiple sources along the stream length.

Trihalomethanes are a byproduct of chlorination and are commonly associated with reclaimed waste water. Trihalomethanes increase significantly at the Tillman WRP outfall, and then dissipate farther downstream (Figure 33). All results are well below the drinking water standard of 100 µg/l.

Beneficial Use Assessment. Standards for VOC are not established for beneficial uses, except for municipal water supply. The river is well aerated, so low amounts of some VOCs dissipate quickly. The impacts to wildlife are not known, but any impact would occur near the seeps and springs which contain the high values of the groundwater contaminants or near the WRP outfalls.

Pesticides and Herbicides

LACDPW performed monthly analysis of pesticides and herbicides from May 1988 through January 1992 Detection limits varied, but were mostly 1 µg/l to 0.05 µg/l, depending on the chemical analyzed Of the 24 chemicals monitored, none of the samples were within detection limits (Table 17) except three pesticides were detected one to three times each, Aldrin, Heptachlor, and O,P-DDD with concentrations less than 0.02 µg/l Based on this data, the river is free of pesticides and herbicides during the dry regime However, it is important to reemphasize that these samples do not include any wet regime results, samples taken during storm events would have significantly different results (See following section titled Wet Regime Analysis Results.)

Beneficial Use Assessment During the dry regime, pesticides and herbicides which were monitored appear to have no impact on the river. However, it is important to note that only one sample, about one liter of water taken once a month, is not indicative of pesticide free water Rather the data shows that these chemicals tend not to be in the water continuously, thus, pesticide contamination is sporadic This is not the case for the wet regime, when runoff during storm events carry higher levels of pesticides (see section on wet regime) An accurate assessment of pesticide and herbicide impacts on the river environment depends on better characterization of bioaccumulation and residuals present after storm events.

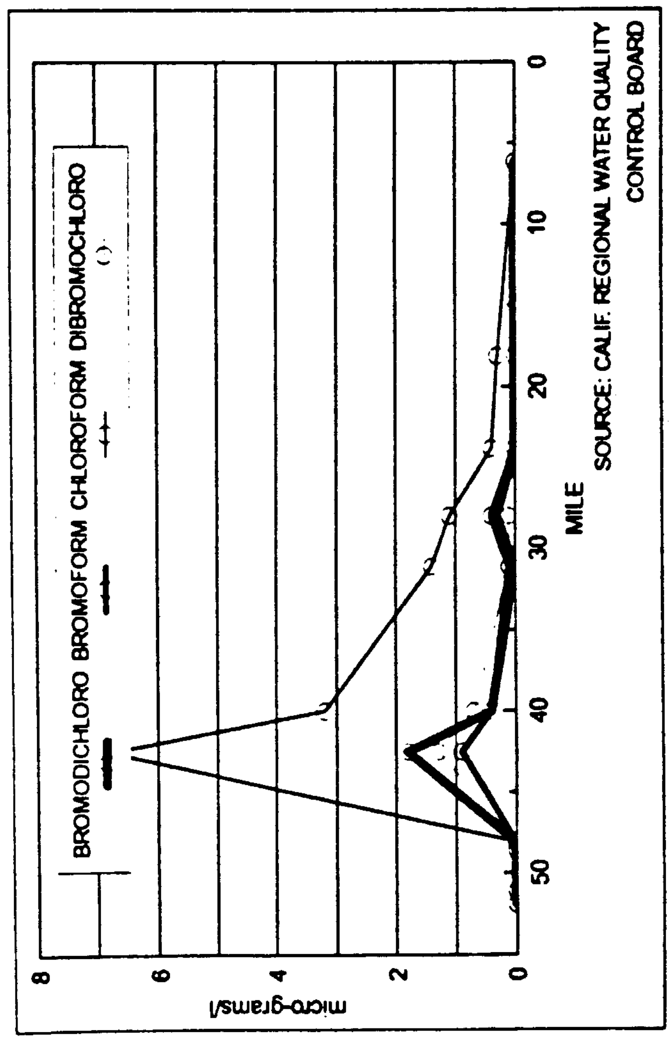


Figure 33 Los Angeles River averaged trihalomethanes values from 1986-92. The peak occurs at the water reclamation discharge point, the source, and then steadily decreases as they volatize.

Table 17. Pesticides and herbicides not detected.

Chlordane	Aroclor 1016	Dieldrin
P,P-DDD	Aroclor 1221	Endrin
P,P-DDT	Aroclor 1232	2,4-D
P,P-DDE (4 samples)	Aroclor 1242	2,4,5-TP
Endosul I	Aroclor 1248	Lindane
Endosul II	Aroclor 1254	A-BHC
Endo II SO4	Aroclor 1260	B-BHC
Toxaphene	Polychlronated	C-BHC
Heptachlor Epoxide	Methoxychlor	

Source: Los Angeles County Department of Public Works

<u>Phenols, Odors</u>

Phenols are common in industrial waste (Krenkel and Novotny 1980). They cause taste and odor problems in water and taste problems in fish. The USEPA recommends phenol concentrations less than 1µg/l for drinking water and aquatic life uses.

RWQCB performed annual sampling which included phenols, but none were detected. Results from LABS showed three detections in the two years of monthly monitoring of the river (detection limit of 100 µg/l). The WRP normally discharges phenols under 10 µg/l, except for one occurrence at 200 µg/l. The Los Angeles-Glendale WRP had a high detection of 35 µg/l. Phenol levels in the river appear to have no apparent adverse effect on any beneficial use.

Odors arise from organic and inorganic gases resulting from the decay of organic material, deoxygenation of rivers and lakes, and chlorination of water which may have been polluted by organic compounds (Stack 1972). Chemicals responsible for odors include halogens, sulfides, ammonia, phenols, various hydrogcarbons, organic compounds and pesticides. Odors can be controlled by preventing entry of these substances into receiving waters or by managing the water body using physical, chemical or biological techniques.

Although odors are not monitored, it is an important consideration if beneficial uses are

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to be expanded, especially if human contact and aesthetic beneficial uses are considered According to author observations, odors are often detected by people around the river.

Biotic Indicators

In early 1993, the Natural History Museum of Los Angeles released a biological inventory of the Los Angeles River. The report included a study on the diversity of species of algae. Algae can be used as an indicator of water quality. Anderson (1993) states in the report that algae associated with polluted water, *Scenedesmus* sp., *Euglena*, sp., *Oscillatoria* sp., and *Pediastrum* sp., were found at Willow Street. However, some clean-water algae, *Cladophora*, was also found at the site. It was recommended that future study should include regular chemical analysis of the water as well as algae identification by phycologists.

Mollusks are other indicators of water quality. Coney (1993) stated that the absence of an introduced bivalve pest, *Corbicula*, is indicative of serious water pollution problems One species, *Physa virgata*, flourish in the river because it can air breath and is able to withstand harsh conditions. In addition, it can restock the river from mountainous areas after a fish kill.

Swift and Seigel (1993) stated that extirpated native fish species, threespine stickleback (*Gasterostius aculeatus williamsoni*), Pacific lamprey (*Lampetra tridentata*, southern steelhead (*Oncorhynchus mykiss*), Pacific brook lamprey (*Lampetra pacificia*), speckled dace (*Rhinichthys osculus*) need strong improvement of water quality for them to exist in the river. They continue:

> "The problem could be as simple as excess nutrients (and concomitant increased algae biomass) using up too much oxygen, particularly at night, for fishes to thrive from dusk to dawn. The lack of aquatic insects and other organisms, except species like crayfish that can utilize air breathing, suggest this is one of the problems in the area."

They indicated that moderate improvements to water quality would allow the reestablishment of some native fish species.

Summary of Reclaimed Water Impacts

WRP discharges are the dominant factor influencing the water quality of the Los Angeles River today. Table 18 shows the trend of several parameters upstream and downstream of the Tillman WRP. The table is based on three to five samples from the Los Angeles River upstream and downstream of the Tillman WRP, and monthly samples from effluent The second column indicates changes in each parameter as the river flows past the discharge point. The third column indicates whether each parameter is detected in the plant effluent. Insufficient data, especially upstream of the WRP discharge point, makes it difficult to quantify the WRP discharge impact. In addition, detection levels may not be sensitive enough to detect changes.

Table 18 shows that some parameters increase in concentration because of the effluent, while other parameters decrease in concentration, possible due to dilution With additional data, it would be possible to verify which parameters detected in the river are in flux because of the effluent With this information, the impact of the effluent on the river would be better understood and the plant effluent could be chemically regulated to improve the quality of the river to meet the needs of beneficial uses.

Table 18. Effects of WRP discharge on the receiving waters near discharge point.

Parameter	Trend (3-samples)	Effluent detected	Parameter	Trend (5-samples)	Effluent detected
Arsenic	Increase	Yes	Total nitrogen	Increase	Yes
Cadmium	N/D	No	Ammonia (N)	Varied	Yes
Total chromium	Increase	Yes	Organic nitrogen	Varied	Yes
Copper	Varied	Yes	Nitrate nitrogen	Decrease	Yes
Lead	Decrease	Yes	Nitrite nitrogen	Varied	Yes
Mercury	Increase	Yes (rare)	Total phosphorus	Increase	Yes
Nickel	Decrease	Yes	MBAS	Varied	Yes
Zinc	Increase	Yes	COD	Varied	Yes
Cyanide	Increase	Yes (rare)	BOD	Increase	Yes
Phenolic compounds	N/D	Yes	Oil and grease	Varied	Yes
Aldrin and Dieldrin	N/D	No	Conductivity	Decrease	Detected
Endrin	N/D	Yes	Toxaphene	N/D	No
HCH	Varied	N/M	PCBs	N/D	No
Chlordane	N/D	No	DDTs	Increase	No

N/D = Not detected, Increase = On samples taken the same day, the station downstream of the discharge point showed an increased value for that parameter

Wet Regime Analysis Results

Overview of Stormwater Sampling

Stormwater monitoring involves several challenges. Factors which cause very large fluctuations in sampling results are storm duration, portion of rainy season, rainfall intensity, and length of dry period prior to storm. Pollutant concentrations will peak at different times on the hydrograph curve (Tomo, Marsalek, and Desbordes 1986), thereby, making sample timing critical during the storm event. Conclusive results from a stormwater monitoring program requires a sample program extending over several years to compensate for climatic variation of any given year. However, the nature of southern California climate is highly variability in seasonal totals. Annual precipitation may range from less than a third of the normal value to nearly three times normal (Ruffner and Bair 1974). Because of the high variability of the precipitation, runoff water quality will consequentially be highly variable in any given year.

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Stormwater has been monitored by LACDPW and by the Southern California Coastal Water Research Project (SCCWRP). LACDPW collected one to three samples during storm events from 1987 to 1992. SCCWRP collected samples during several seasons and reported findings in annual reports, so the data was not re-analyzed here. Following is a review the findings of SCCWRP and a general analysis and review of LACDPW data

Stormwater Characteristics

The USEPA's National Urban Runoff Program cites that a variety of pollutants including heavy metals, pesticides and nutrients are present in elevated concentrations in urban stormwater runoff (Lee and Jones 1990). Pitt and Field (1990) support that contaminants in urban stormwater are causing significant adverse impacts on the quality of surface waters in the U.S. It has been shown that runoff contributes amounts of BOD, COD, suspended solids and heavy metals to receiving waters (Hunter et al 1979).

Torno, Marsalek and Desbordes (1986) summarize the characteristics of urban runoff Their description is paraphrased as follows:

...Urban runoff contains...

Solids: inorganic and organic solids in particulate or colloidal form Suspended solids fraction induces turbidity, pollutant adsorption, benthal accumulation.

Oxygen demand: Organic and other oxidized material exerts oxygen demands.

Toxicity: Highly charged with heavy metals, hydrocarbons, pesticides and PCB's However, toxicity is dependent on pH, ionic strength and organic content.

Bacterial: Large concentrations of bacteria, viruses and pathogens

Nutrients: Phosphorous and nitrogen loadings accelerate eutrophication problems in quiescent reaches exerting subtoxic effects on aquatic organisms

Krenkel and Novotny (1980) further state that metal in water is usually related to cultural activities including sources such as automobiles, industrial production, mining, vector control, macrophyte and microphyte control.

Los Angeles River Data. A significant amount of stormwater quality data was available from SCCWRP who measured contaminants in the Los Angeles River during three periods; 1971-1972, 1979-1980, and 1985-1989 (SCCWRP 1986,1990). Suspended solids, oil and grease, metals, and chlorinated hydrocarbons were analyzed. In 1986, SCCWRP also measured other streams in southern California, including: the Santa Clara River, Calleguas Creek, Ballona Creek, Dominguez Channel and the San Gabriel River. The monitoring results of these streams were compared to each other. However, because of limitations of comparing different streams, no conclusions are possible except that stormwater runoff is becoming a significant factor in coastal pollution especially because of improvements in sewerage plant outfalls.

In 1987, SCCWRP measured the toxicity of Los Angeles River stormwater using a system called the Microtox™ Toxicity Analyzer System (1988). The system uses bacteria added to water samples to indicate toxicity of the water. This information is inferred as to toxicity to other aquatic organisms. The results showed that stormwater was generally less toxic than effluent from sewage treatment plants. Again no conclusions are possible because of the lack of sufficient data (SCCWRP Raco, 1993 personal communication)

LACDPW also sampled a few storms from 1987 to 1992 on the Los Angeles River at two sample sites. Only one sample was taken from each station located at Firestone Blvd and Wardlow Rd. No composite samples at different times on the hydrograph were taken.

Variations in instream contaminant concentrations make accurate quantification difficult because of the limitations of stormwater research. However, SCCWRP and LACDPW data does prove to be useful on a qualitative basis, helping to identify pollutants associated with stormwater in the river. Presence of chemicals does not necessarily constitute toxicity. Table 19 lists chemicals detected in the Los Angeles River by LACDPW and SCCWRP (1987) during storm events.

Table 19. Stormwater detections.

Parameter	LACDPW 1987-92	SCCWRP 1986-87	Parameter	LACDPW 1987-92	SCCWRP 1986-87
Arsenic	Yes	N/M	111,-Trichloroethane	Yes	N/M
Barium	Yes	N/M	Trichloroethene	Yes	N/M
Cadmium	No	Yes	Remainder of VOC list	No	N/M
Chromium	Yes	Yes	Aldrin	No	N/M
Copper	Yes	Yes	Lindane	Yes	N/M
Iron	Yes	N/M	Alpha, Beta, Delta-BHC	No	N/M
Lead	Yes	Yes	Chlordane	No	N/M
Lithium	Yes	N/M	DDTs	No	Yes
Manganese	Yes	N/M	Dieldrin	No	N/M
Mercury	Yes	N/M	Endosufan I, II, Sulfate	No	N/M
Nickel	Yes	Yes	Endrin	No	N/M
Selenium	Yes	N/M	Heptachlor	No	N/M
Silver	No	N/M	Heptachlor Epoxide	No	N/M
Zinc	Yes	Yes	Toxaphene	No	N/M
Oil and Grease	Yes	Yes	Arochlors	No	N/M
Petroleum Hydrocarbons	Yes	N/M	PCBs	N/M	Yes
Cyanide	No	N/M	Phenol	Yes	N/M
Organic Nitrogen	Yes	N/M	Silica	Yes	N/M

Source: Los Angeles County Dept of Public Works and Southern California Water Research Project Yes = Detected, No = Not detected, N/M = Not monitored

LACDPW also performed bacteriological analysis using several genera Fecal bacteria in stormwater comes from sources such as cats, dogs and rodents in city areas and from farm animals and wildlife in rural drainage (Geldreich and Kenner 1969) The results of LACDPW's 24 samples over a six-year period are as follows Total coliform (average/maximum) 800,000/5,100,000 MPN/100ml; fecal coliform 81,500/790,000 MPN/100ml; KF Streptococcus 78,000/330,000 CFU/100ml.

Chapter III discussed the results of U.S. Environmental Protection Agency (USEPA) stormwater monitoring program, titled Nationwide Urban Runoff Program (NURP). Also discussed was the mean values from the Nationwide program and a program under NURP for the city of Fresno, California. Table 20 presents a comparison of the results of NURP to LACDPW data.

Data for individual sub-watershed was not available in sufficient quantity so the only

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classification considered is mixed. Table 20 shows that the Los Angeles River stormwater values are higher than NURP and Fresno values for Nitrogen compounds, phosphorus and BOD. Copper and Zinc are within range of the other two studies, but lead is far below the others.

Most winter storms wash debris into the local channels and carry it to the beach (Figures 34a and 34b). LACDPW and the city of Long Beach are responsible for the removal of debris on beaches resulting from debris washed down the Los Angeles River during and after winter storms. In the 1992/93 season, over 7,000 tons were removed. Floating solids are a pollutant which contributes to water toxicity and severe aesthetic problems (Krenkel and Novotny 1980).

Impact on Beneficial Uses

It is apparent, despite limitations in sampling stormwater, that quality of the Los Angeles River during the wet regime is poor. This can be concluded without the Los Angeles River data presented above because enough evidence from other watersheds have concluded that elevated levels contaminants are common in stormwater runoff. Therefore, the water quality during storm events is not appropriate for beneficial uses. Fortunately, beneficial uses, such as recreation, are unlikely to take place during or immediately after storms.

Table 20. Comparison of NURP, Fresno and Los Angeles River stormwater data

Parameter	Residential NURP	Residential Fresno	Commercial NURP	Commercial Fresno	Industrial NURP	Industrial Fresno	Mixed land use LACDPW
Nitrate+ Nitrite-N mg/l	0.7	0.4	0.6	0.4	N/M	0.6	1.3
Phosphorus mg/l	0.1	0.2	0.08	0.1	N/M	4.8	1.4
BOD mg/l	10.0	N/M	9.3	N/M	N/M	N/M	16.3
Lead µg/l	144	150	104	100	N/M	87	8
Copper µg/l	33	15	29	14	N/M	68	20
Zinc µg/l	135	120	226	180	N/M	520	153

Figure 34a Compton Creek After Second Storm of Season. The channel is concrete lined upstream, debris is becomes caught in the foliage at the head of the soft-bottom

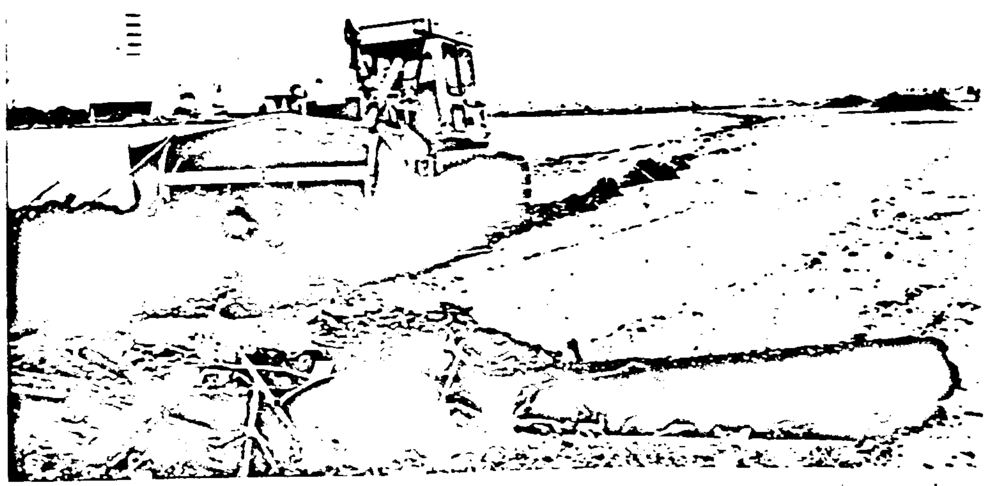

Figure 34b Long Beach After Winter Storms The Los Angeles River is a conduit for trash Better watershed management would help to alleviate this problem

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Improvement of stormwater quality is crucial in maintaining beneficial uses and increasing others. Successful implementation of the NPDES stormwater program along with implementation of structural (e.g. mechanical debris removal equipment) and non-structural (e.g. education programs) best management practices is needed to improve the overall quality of the river. Beneficial uses, such as fisheries and non-contact recreation, is contingent upon the success of improving urban runoff in both the wet and dry regimes

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CHAPTER V

ASSESSMENT OF WATER QUALITY AND BENEFICIAL USES

The following section summarizes the current water quality of the Los Angeles River and its various beneficial uses. Three steps are used to assess water quality and beneficial uses. First, the beneficial uses are listed in a table, including sanctioned and unsanctioned uses. Second, appropriate beneficial uses based on the water quality data presented are listed in a table. Third, the two tables are compared to show which beneficial uses are occurring despite poor water quality. The last table presents the water quality needed to maximize beneficial uses on the river. This is followed by a discussion of how water quality objectives can be designed to increase beneficial uses.

Assessment of Water Quality and Beneficial Uses on the Los Angeles River

Many existing beneficial uses are unauthorized, yet occur regularly or are not recognized by some agencies as a use despite its occurrence. Table 21 is a summary of all beneficial uses either recognized or observed by the author. A variety of activities which take place on the river are shown on Figures 35a through 35d.

Unfortunately, most of the uses in Table 21 are not acceptable based on water quality criteria. Table 22 summarizes the acceptable beneficial uses of the water in the Los Angeles River as it exists based on the data summarized in this report. If an important parameter occurs over the acceptable limit with regularity, it was categorized as unacceptable. Less important parameters and infrequent high-pollution occurrences were categorized as moderately acceptable. Additional treatment would increase the usability of the water in all cases.

Because unsanctioned beneficial uses occur on the Los Angeles River, whether

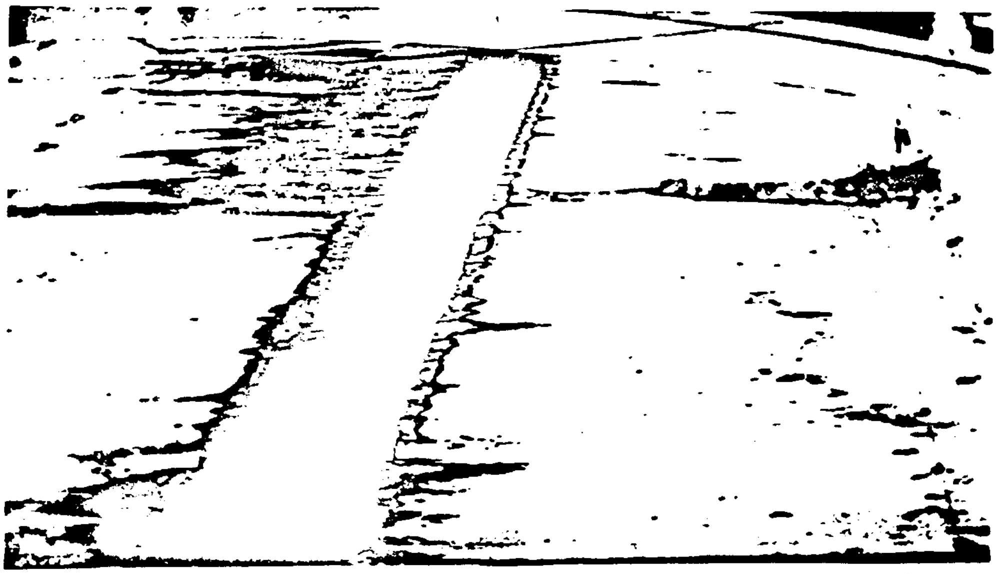

Figure 35a. An undressed man bathes and washes his clothes in the Los Angeles River near Downtown. The quality of the river is not appropriate for this use; however, uses such as this occur despite efforts to restrict it.

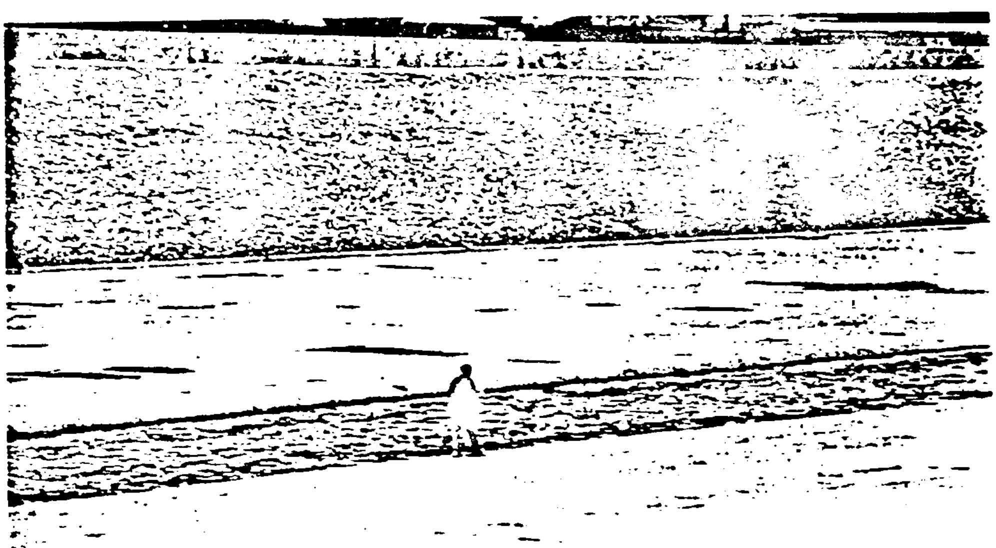

Figure 35b A man walks along the low-flow channel near South Gate Rivers have always attracted people.

Figure 35c. A man walks along the river bank in the southern San Fernando Valley in a restricted area.

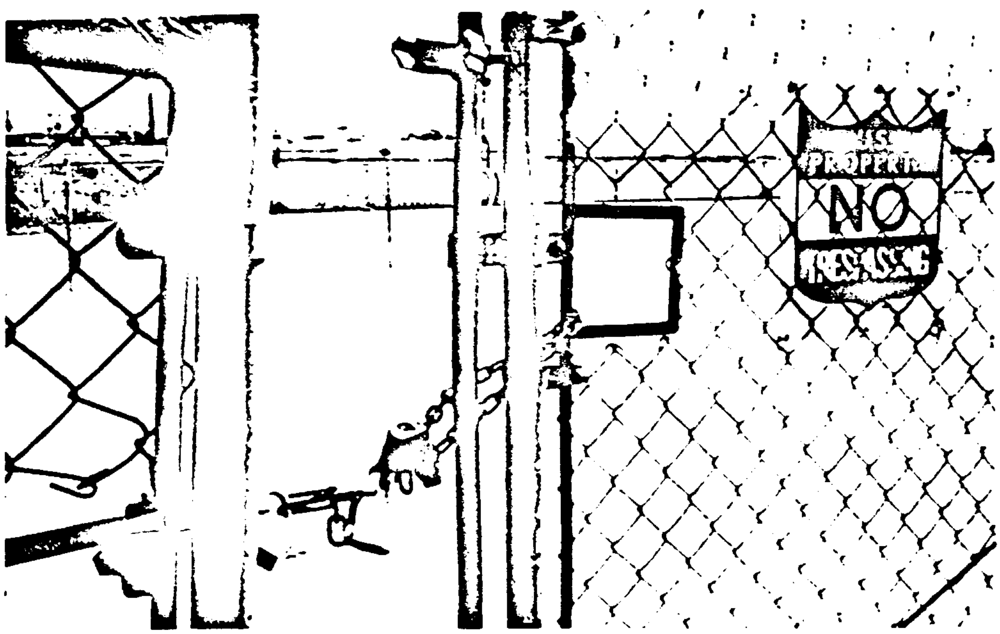

Figure 35d The man in 35c was walking behind this locked fence Despite warning signs of no trespassing, recreational activity occurs on the river regularly.

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Table 21. Recognized and observed uses of the Los Angeles River.

Beneficial uses	Existing	Intermittent	Potential
Municipal Water Supply (MUN)			A[1], R
Contact Recreation (REC1)		A	R
Non-contact Recreation (REC2)	A,R		
Warm Freshwater Habitat (WARM)	A[2]		R
Wildlife Habitat (WILD)	A		R
Fish Spawning/Migration (SPAWN)			A[3]
Industrial Service and Process (IND)			A
Agriculture (AGR)		A[4]	
Groundwater Recharge (GWR)	A,R		

Source: Author observations and RWQCB 1975 Basin Plan and subsequent amendments. Some beneficial use designations were modified. A, Author observations; R, RWQCB listing.

A[1] - Although not used for water supply, it is likely that some homeless people may use the river as water supply. In March 1993, a homeless person near Compton Creek was spotted by the author drinking creek water in a plastic jug.
A[2] - These uses occur at the various soft bottom sections.
A[3] - Restoration could lead to intermittent spawning of fish species, although some species, such as carp and catfish currently spawn (Garrett 1993).
A[4] - The river was used extensively for agriculture in the past. Today it is used occasionally for garden farms up to 1,500 sq. feet. Small vegetable plots have been observed at the estuary by the author and agencies in 1992 and in 1993.

Table 22. Acceptable beneficial uses of the Los Angeles River based on data presented in this study.

Beneficial uses	Acceptable	Moderately Acceptable	Unacceptable
Municipal Water Supply (MUN)			X
Contact Recreation (REC1)			X
Non-contact Recreation (REC2)			X
Warm Freshwater Habitat (WARM)			X
Wildlife Habitat (WILD)			X
Fish Spawning/Migration (SPAWN)			X
Industrial Service and Process (IND)		X	
Agriculture (AGR)		X	
Groundwater Recharge (GWR)		X	

appropriate with the existing water quality or not, it should be recognized as such, and water quality criteria for those uses are to be met. It is impossible to fully regulate public access and uses on the river, but if a use occurs with regularity and by a number of people, every effort should be made to improve the quality of the river to an acceptable level to protect public health.

Some beneficial uses of the Los Angeles River are regulated by LACDPW. Safety, liability and vandalism has caused the County to limit access to most of the river and much to the flood control system. Portions of this system, however, have recreational and water conservation beneficial uses. At a minimum, the river should have water quality to allow safe use for the existing beneficial uses. With improved water quality, existing beneficial uses in Table 23 become appropriate.

<u>Stormwater Quality and Beneficial Uses</u>

Geldreich, Kenner, and Van Donsel (1968), and Evans et al (1968) performed some early work on the presence of bacteria in stormwater. They concluded that stormwater can be a major source of intermittent pollution at bathing beaches and to water supply reservoirs opened to limited public recreational uses. They recommended regulation of pets on public beach areas and adequate garbage control plans and that stormwater drains be diverted away from beaches and reservoirs or treatment methods should be developed.

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Table 23. Potential beneficial uses with water quality improvements of Table 21.

Beneficial uses	Acceptable	Moderately Acceptable	Unacceptable
Municipal Water Supply (MUN)		X	
Contact Recreation (REC1)		X	
Non-contact Recreation (REC2)	X		
Warm Freshwater Habitat (WARM)	X		
Wildlife Habitat (WILD)	X		
Fish Spawning/Migration (SPAWN)		X	
Industrial Service and Process (IND)	X		
Agriculture (AGR)	X		
Groundwater Recharge (GWR)	X		

- Require water treatment.

Recent work by Urbonas and Stahre (1993) outlined available technologies to reduce contaminants such as bacteria. Great strides have been made in the 1980's in these technologies; but they concluded that many current technologies are not well tested and more research is needed.

Design of Water Quality Criteria for Beneficial Uses

Water quality criteria are designed so that the water quality is safe for the beneficial use. In some cases, a beneficial use will occur whether or not the water quality is safe for that use. For example, migratory birds forage and breed on the river, thus a beneficial use is wildlife propagation, even though the water quality is not appropriate for this use. If the water quality is improved to make the use of wildlife propagation appropriate then an objective is met. Alternately, if the water quality does not meet certain standards, other beneficial uses will be restricted. For example, boating will not be allowed on the river unless the water is safe for non-contact recreation. As a priority, the river should be made safe for all existing uses first, and then for additional beneficial uses. Additional beneficial uses might be viewed as a luxury, so emphasis should be on improving existing beneficial uses.

Nemerow (1985) describes the goals of pollution abatement in water as not absolutely clear. He states that idealists and preservationists push for pristine purity of all receiving waters and conservationists want reasonable management of resources. In addition he asserts, some streams would best be used primarily for drinking water while others for fishing. He concludes that most persons are united in attempting to maintain water quality at the highest level possible consistent with technical and economic limits.

Nemerow's ideas may not be applicable to rivers such as the Los Angeles. Most rivers in the eastern United States, for example, have a multitude of beneficial uses maintained throughout historical times (e.g., water supply, fisheries, navigation). The Los Angeles River in the early days of the city, had many beneficial uses (e.g. water supply, fisheries, agriculture), but all uses are either degraded or lost with implementation of flood control projects. A superficial examination of the uses today would show that water of the river need not be clean because the primary use of the river is flood control and beneficial uses are virtually non-existent. Thus, Nemerow's economic limit is easily met (except for the issue of coastal pollution). However, with a more thorough examination of the uses of the river today, including the unsanctioned uses, plus the community desire to revitalize the river, it becomes apparent that the flood control channel indeed needs higher quality water and economic limits of water quality improvement need to be increased. Therefore, it can be concluded that the economic limits need not be set with current acceptable uses, but should be set for the sanctioned and unsanctioned uses, and the potential uses which would be derived from water quality improvements. For example, the cost of installing a trash removal rack on the Los Angeles River might be determined to be too costly. It can be argued that trash removal would only improve the river aesthetically and may help the river habitat. No direct economic gain is realized by the trash rack. If the trash rack were installed as part of a new water conservation system, then the investment might payoff. Consequently, communities along the river might find a sense of pride living next to the river and possibly lead to tourist dollars and investors as part of the communities redevelopment. Most importantly, the river would again be benefiting people and the environment as it once did.

Water Quality Criteria Formulation. In most watersheds, especially ones which provide municipal water supply, a combination of watershed management, reservoir management and water treatment is needed to achieve the desired level of water quality. According the American Water Works Association (1991), controlling contaminants at their source of origin is the most fundamental way to prevent degradation of water quality in water-supply reservoirs and finished water. Unfortunately, because the Los Angeles River has been viewed as a flood control channel for the past 4 decades and not as a water source,

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the practice of managing land use to improve water quality has not been pursued. In other cities, where rivers are accessible and highly used for such uses as recreation and municipal water supply, the link between land use and water quality has been understood and good practices have occurred for many years. The American Water Works Association surveyed utilities which use surface waters and found the following percentage of water systems using the following watershed controls (Table 24). Water quality criteria can be designed for each specific beneficial use.

Table 24. Survey results of water systems which use surface waters.

Watershed Control	Percent
Watershed Entry Restrictions	38
Zoning Restrictions	29
Land Ownership Control	25
Prohibited Land uses	23
Informal Agreements with Land Owners	18
Formal Agreements with Land Owners	16

Source: American Water Works Association 1991

Case Example. The Anglian Water Authority (1980) has developed a basic approach to recognizing a wider range of river uses. The system included a list of all primary uses and criteria for specific use. Primary uses, in the first column of Table 25, are the general uses, which are then divided up into more specific uses or processes in the second column. Criteria for the items in the second column were prescribed. Criteria are specific levels of parameters acceptable for that use.

Table 25. The Anglian Water Authority's approach to recognizing a wider range of river uses.

Primary use	Uses for which criteria have been prescribed
Potable Water Supply	Direct to treatment Via impoundment
Fisheries	Anadromous Warm species Native Non-native
Industrial Supply	Cooling Process
Irrigation	Field crops Ornamentals/turf
Livestock watering	Livestock
Wildlife	Upstream mountainous Mid-stream Estuarine
Amenity/aesthetic appearance	High amenity Low amenity
Recreation	Contact Non-contact

Adopted from Anglian Water Authority (1980).

Instream Versus Offstream Beneficial Use

Long-range plans for expanded reclaimed water use will result in a reduction in the quantity of water discharged by the plants for use on other applications (Los Angeles Office of Water Reclamation 1990) Considerations which affect the river environment include both quantity and quantity of water discharged into the river, as these are directly related Water quality objectives need to be addressed to retain and enhance beneficial uses.

It can be argued that offstream reclaimed water uses, such as irrigation, may be a higher priority use because the water is used directly. However, this should not be done in a manner that jeopardizes the integrity of the river. By maintaining volume and quality in the river, beneficial uses would be derived instream and offstream, including instream uses such as recreation, wildlife, and economic developments. At the river terminus in Long Beach, offstream uses would be appropriate, uses such industrial and irrigation. Many heavy industries, including refineries are located in the area. With some treatment, some of this water could be used for industrial or processing water. Through watershed management to improve runoff quality, WRP discharges would become less important in guiding the quality of the river, so the quantity could be reduced.

<u>Water Quality Improvement Through Land Use Management</u>

Short-term and long-term management practices can be used to control pollution related to land use (Krenkel and Novotny 1980). Planning processes consider water resources in the area, determine the extent of pollution originating from non-point sources as compared to that from effluent outfalls, soil characterization, and the adequacy of existing and planned wastewater treatment facilities.

Several studies have shown that natural surfaces and vegetation may be effective at retaining pollutants as urban stormwater passes over them, thereby reducing impacts on receiving waters. Pratt, Mantle, and Schofield (1989) and many other researchers have found that permeable pavements effluent quality to be markedly better than in other urban areas with impermeable surfaces. In addition, flow reduction and peak discharge attenuation was achieved by using these techniques.

Beneficial uses are directly impacted by the waters of the river and the watershed from which the water originates. In a sense, the river is the sum of the watershed, therefore, the river is the telling feature of the landscapes environmental health.

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CHAPTER VI

ACHIEVING RESTORATION OF BENEFICIAL USES

The 52 mile Los Angeles River is in a deteriorated state that adversely impacts beneficial uses which are either degraded, unsafe, or have been eliminated. Beneficial use restoration would benefit the communities in the area as well as the environment. Restoration is achievable with watershed management and alternative flood control strategies.

The river once supported a variety of beneficial uses for Indians and settlers, and played an important role in the history of Los Angeles by being its primary source of water Due to periodic flooding, the river was transformed into a flood control channel resulting in the 39 miles out of its 52 mile-length completely channelized in concrete Channelizing was the result of the Comprehensive Plan initiated in the early 1930's by Los Angeles County Flood Control District (now Los Angeles County Department of Public Works (LACDPW)) and the federal government's participation through the U.S. Army Corps of Engineers (Corps). The post-Depression public works project came at a time when controlling or degrading the environment was largely acceptable to meet immediate needs Five years after completion in 1964, the Corps was authorized to study water resources in the project area and found the flood control system to be inadequate The addition of flood walls on the river looms in the late 1990s to address this inadequacy

The Los Angeles River is Transformed

The Transformation Model shows that as traditional flood conveyance methods are increasingly implemented, beneficial uses decrease (Figure 6) This process, with additional impacts from urbanization throughout the watershed, caused the degradation or loss of beneficial uses Table 26 is a list of beneficial uses which historically occurred

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on the river, but are now impacted. This change from a river which provided all of these beneficial uses to one which does not provide any high quality uses marks the river's First Transformation.

Table 26. Beneficial uses degraded or lost on the Los Angeles River.

Beneficial uses	Degraded	Unsafe	Lost
Municipal Water Supply			X
Contact Recreation		X	
Non-contact Recreation	X		
Warm Freshwater Habitat		X	
Wildlife Habitat		X	
Fish Spawning/Migration			X
Industrial Service and Process			X
Agriculture	X		
Groundwater Recharge	X		

The environment of the Los Angeles River is influenced by variation of the channel invert surfaces from concrete bottom to soft bottom, and by water reclamation plant discharges The soft bottom sections support riparian vegetation and wildlife, while the concrete sections are normally devoid of vegetation. Reclaimed water discharges help to support vegetation and dilute pollutants found in urban runoff. Urban runoff and discharges combined produce a year-round flow of over 120 cfs. This improves the river environment during the dry regime.

Impacts on the River Today

The wet regime is the result of a higher water level in the river due to precipitation Land use is the strongest controlling factor of this regime because the river is the sum of the conditions of the watershed Therefore, control of quantity and quality of inflows improves the quality of the river Land use analysis can be used to assist in the development of plans to control urban runoff pollution from the watershed Permitted discharges have been regulated for many years Urban runoff, however, remains unregulated -- flowing directly into the river without any treatment

A method to study the impacts along the river is to divide the watershed into sub-watersheds. Each sub-watershed has a distinct land use pattern and spatial impact on the river. For example, Tujunga sub-watershed has 92% open space and impacts the river at one point -- the confluence; while the Southeast Coastal sub-watershed has seven percent open space and has a contiguous impact. Land use types which increase along the river are commercial and industrial, with the maximum of 38% industrial area in the Southwest Coastal sub-watershed. In general, sub-watersheds in the lower river tend to have higher percentages of intensive land use practices, with Southeast Coastal and North Coastal having the most intensive (Figure 22). Results from studies, such as National Urban Runoff Program, indicate that urban runoff from intensive urban-type land is typically of poor quality, containing high levels of heavy metals, bacteria, pesticides, and nitrates. Therefore, runoff from the highly urbanized Los Angeles area is adversely impacting the river.

Water Quality

Water quality data from various agencies show that the river in the dry regime is free of many toxic substances often found in the wet regime. However, close monitoring is needed to detect sporadic unsafe levels. The dry regime is dominated by effluent from WRPs. The following parameters and averages, all stations from 1988-1992, are acceptable for most beneficial uses: total dissolved solids, 651 mg/l; pH, 8.0, dissolved oxygen, 7.4 mg/l; biological oxygen demand, <5 mg/l (sporadically high results common). silver, <10 µg/l, and 26 commonly monitored pesticides and herbicides, none detected. Volatile organic compounds are detected sporadically, but tend to volatilize out of the water rather quickly.

The following parameters and averages are considered beyond acceptable levels to allow beneficial uses to occur safely: oil and gas, 2.9 mg/l, nitrate as N, near 10 mg/l (related to high bacteriological counts and excess algae growths); phosphate as P, 2.8 mg/l. and bacteriological, >32,000 MPN/100ml. Twelve heavy metals are detected at varying levels amounts (majority <100 µg/l). However, sporadic high detections are common and may be detrimental to beneficial uses.

The wet regime is dominated by runoff which tends to have more heavy metals, pesticides and herbicides, and higher bacteriological levels. Data for the wet regime is limited and it is difficult to capture accurate results, thus, average values could not be determined accurately for most parameters. Data from 1988-1992 indicate that all heavy metals monitored were

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detected except for silver. Other chemicals detected include: 111,-trichloroethane, trichloroethene, Lindane, PCBs, and phenol. Bacteriological averaged 800,000 MPN/100ml. These results show that the water quality is not safe for any beneficial uses during the wet regime.

Poor water quality in the Los Angeles River is the result of negligent watershed management practices and the degradation of natural systems. Channelization transformed the river into a flood control feature in which water quality is not normally considered important. This is compounded by the loss of beneficial uses, which, if remained, would have ensured water quality protection. Unfortunately, today the river's water is not safe for most beneficial uses. Agencies with jurisdictions over the river should recognize unsanctioned uses. For example: homeless persons are often observed bathing and washing clothes in the river near downtown Los Angeles; and persons are often walking, riding or playing in and around the channel. Although these activities are illegal in places, they continue to occur. Because people have desire for these uses, river water which runs through a metropolitan area should always be safe for body contact to protect public health and to meet community needs. The RWQCB is charged with listing beneficial uses of the Los Angeles River and in 1994 will expand the list and assign objectives for these uses. Once objectives are set, every effort should be made to achieve safe water quality to protect public health for these uses.

Achieving Restoration of Beneficial Uses

The Los Angeles River has long been managed as a flood control channel. By changing its management to that of a river, the means to restore beneficial uses will be in place. Two environmental conditions need to be addressed if restoration is to take place. One is the methodology used for flood control. Channelization with concrete limits beneficial uses, therefore alternatives which enhance beneficial uses should be used. The other environmental condition to be addressed is water quality. Existing and potential beneficial uses are degraded because of unsafe water quality.

Alternative Flood Control Strategies

Beneficial uses need not be sacrificed for flood control. This can be accomplished with the implementation of alternative flood control strategies, which are well tested throughout the United States. Alternatives recommended by Friends of the Los Angeles River (1993) include: on-site detention, permeable pavements, improved watershed management, use of large and small detention basins, wetland restoration, spreading grounds, and river widening. The Federal Emergency Management Agency (1991) states that land treatment measures where infiltration is increased and the amount and rate of runoff is decreased can be especially important in reducing erosion and the resultant amount of sediment and pollutants carried downstream. The California Legislature recognized the close relationship among flood management and wetlands, fish, wildlife, and recreation (California Department of Water Resources 1980). The California Department of Water Resources adopted this policy, adding groundwater recharge. Implementation of these alternatives and policies would allow the restoration of beneficial uses.

According to the Corps, additional flood protection is needed on the lower Los Angeles River. Current plans call for parapet walls up to eight feet high along the river on the existing levees. However, other cities are successfully reducing the flood threat by instituting many alternatives. For example in Bellevue, Washington, the surface water management agency's goal is to preserve and enhance water resources. A City of Bellevue resolution states, "Engineering designs should improve the effectiveness of natural systems rather than negate, or replace them. Technological solutions should emphasize the use of non-structural or 'natural' engineering approaches. These approaches should be consistent with the natural resources and process, and preserve and enhance the natural features of Bellevue."

In Los Angeles, a similar approach is possible. A single agency with authority and expertise over the river and its watershed begins to find feasible methods to restore beneficial uses to the river. Flood control, environmental protection and enhancement, public access and water quality management are four fundamental factors addressed by such an agency. It is important to gain public support for such efforts and provide the appropriate agency with the resources and trained staff to protect the communities from floods while improving the condition of the river. Based on author observations, the general public is unaware of local rivers and their potential to benefit them. This is due to a widely held incorrect-perception that the Los Angeles River is solely a flood control channel constructed for that purpose. Little is known about the river's history, the natural soft bottom sections, and existing and potential beneficial uses.

Improving Water Quality

Because water quality is intertwined with beneficial uses, restoration cannot occur without

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a significant improvement. According to the AWWA (1991), nearly all variables should be targeted in watersheds to improve water quality. Listed are: turbidity and sediment, pH, nutrients, algae, bacteria, trihalomethane precursors, pesticides, other soluble and volatile organic compounds, heavy metals, and manganese.

Stream quality is the result of the inflows described in Figure 14. By studying this and the thirteen sub-watersheds of the river drainage area, water quality managers can predict impacts along sections of the river. This is a tool for accessing appropriate beneficial uses and for addressing water quality needs along the river. It is likely that if the most significant contributors of pollutants are controlled, beneficial uses limited by these will be restored. For example, only a few parameters in the dry regime are unacceptable: bacteriological, which is related to nitrates and phosphates; oil and gas; and occasionally high biological oxygen demand. The wet regime has additional pollution loads rendering beneficial uses unsafe, however this regime only occurs average 42 days per year. The priority for managing agencies is to firstly recognize the unsanctioned of uses of the river and make needed improvements and secondly be aware of the expansion of sanctioned uses in the future so that preparation can be made for additional water quality improvements.

Additional monitoring is not necessarily the answer, but better coordination of monitoring with specific goals is necessary. Agencies often do not share data. Better coordination of data-collection, storage and retrieval will increase the usefulness of the data. In addition, coordinating river monitoring is likely to be more cost effective.

Monitoring programs should have clear objectives. Key objectives of a monitoring program are to answer questions such as: implementation of beneficial uses, standards, sources of pollution, public perception of stormwater quality problems and effectiveness of stormwater management programs. Significant amounts of data are needed to make sound conclusions on the quality of the river and to understand the dynamics of water quality. With this understanding, sound decisions can be made regarding watershed and river management.

Eight governmental agencies perform regular river monitoring, each of which has distinct objectives. Yet, there is limited data to fully understand water quality dynamics. Coordination of monitoring plans would allow more efficient data collection and would allow the expansion of the monitoring program.

An encompassing study should be performed which includes data collection, analysis and conclusions, focusing on quality dynamics, pollution sources, and remedies to pollution. The most important element is action to improve the condition of the river.

Significantly more monitoring of stormwater is needed. Since SCCWRP no longer performs river monitoring, agencies and research groups should expand monitoring programs. Increased monitoring will result with the implementation of the NPDES program. In addition, a comprehensive study of stormwater effects on beneficial uses is recommended.

Benefits of Beneficial Uses Restoration

The loss of beneficial uses adversely affects general environmental quality, social well-being, and economic prosperity. A healthy river system in Los Angeles would provide additional clean water, provide riparian habitat with trees to improve air quality, would provide aesthetic improvement, and would allow restoration of wetlands.

Social well-being improves with restoration of beneficial uses. Appropriate unsanctioned beneficial uses would be allowed without restriction because the public health risks from poor water quality is eliminated. For example, non-contact recreation occurs without restriction, improving the quality of life for many communities. Community pride increases as the deteriorated water-front of the river is improved and revitalized. This is often the case with beach communities like Newport Beach's Balboa Peninsula or Long Beach's Shoreline Village.

Economic prosperity follows the restoration of beneficial uses. Dependable water supply increases, and business and work forces are attracted to the improved image of the area. The river becomes an attractive environment for tourism and money-generating recreation. Portions of the river can be used as boardwalks following the examples of San Antonio, Texas River Walk or Cleveland, Ohio renovated Cuyahoga River Flats Boardwalk.

Achieving the restoration of beneficial uses is the culmination of the Second Transformation of the Los Angeles River. The Los Angeles area is well on its way toward this goal. The city of Los Angeles, LACDPW, Corps, National Park Service,

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California Coastal Conservancy, Santa Monica Mountains Conservancy, have completed or are currently studying the Los Angeles River to find ways to improve the river, which result in enhanced beneficial uses.

The restoration of the Los Angeles River would mark the beginning of a new environmental ethic, where environmental tragedies of the early and mid-20th century are undone and urban culture recreates the city, only this time working with nature and becoming her champion.

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Southern California
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Annual Report • 1987

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This report was compiled on a Tandy 3000 HL personal computer with Microsoft Word (version 4.0), Aldus PageMaker (version 1.0a), and Jandel Sigma-Plot (version 3.1) software programs. Camera-ready pages were produced on a Hewlett-Packard LaserJet Series II printer.

Introduction

The primary objectives of the Southern California Coastal Water Research Project (SCCWRP) are to understand the sources, fates, and effects of contaminants entering the marine coastal environment. In order to emphasize each of these aspects, our report for this year is organized under four primary headings: Sources, Fates, Effects, and Communications.

As usual, the first article updates the contribution of contaminants to coastal waters by municipal wastewaters. A major event in late 1987 was the termination of the 7-mile sludge outfall in Santa Monica Bay, resulting in a 50% reduction of mass emissions during 1988. The inputs of contaminants from storm water in Los Angeles and Ventura Counties is described and compared with wastewater inputs. Aerial transport, storm water runoff, discharges of dredged material, industrial outfalls, and municipal wastewater effluents all represent significant sources of pollution. There is a tremendous amount of information on the mass emissions from municipal outfalls, but contributions from storm water, dredged material, or aerial sources are not understood well at this time. By sampling the sea-surface microlayer, SCCWRP investigators are finding the net result of contributions from aerial and floatable contaminants. Efforts to quantitate inputs from storm water will continue but will be restricted to the Los Angeles River, which contributes about 30% of the total volume to the Southern California Bight. Increased attention is required regarding the mass inputs and potential effects of aerial pollutants and contaminated dredged material.

Both oceanographic and geochemical studies will be covered under the heading of Fates, as physical and chemical factors control the distribution of contaminants in the coastal environment. The fate of discharged materials is obviously very important, but extremely difficult to assess. Environmental variability requires the collection of massive amounts of data to determine meaningful trends in the direction and magnitude of currents or the degree of sediment resuspension. Several reports were completed in the last year regarding actual and predicted distribution of discharged wastes. To aid in processing the numerous samples collected by SCCWRP scientists, the capabilities of the trace organics laboratory have been significantly expanded in the past year. The cornerstone of the laboratory is a Kratos Model MS25RFA gas chromatograph/mass spectrometer, which is capable of measuring picogram (10^{-12} gram) quantities of contaminants in samples. This piece of equipment was partially funded by a grant from the Los Angeles County Department of Harbors and Beaches.

Studies in the Effects section encompass a variety of projects including fish, invertebrates, and their larvae. Parameters measured include growth, reproduction, and survival. Research concerning the effects of contaminants on fish has been extended to different species in different locations. Results have confirmed SCCWRP's previous findings that increased contamination yields an increased frequency of micronuclei in the cells of affected fish. This past year SCCWRP scientists demonstrated that white croaker from contaminated areas of southern California exhibit impaired reproduction. We are taking advantage of a unique opportunity by measuring the rates of change in biota and chemistry around the terminated 7-mile sludge outfall. Also included in this section are studies about the effects of contaminated sediment on benthic species, an area that has been quite productive. These approaches will help us to understand the potential impacts of contaminated particles emanating from a range of coastal sources. The urchins and amphipods used in these studies are from southern California and they are appropriate for use in both acute and chronic effect studies. Better methods of measuring the toxicity of sediments and wastewater are being developed which will aid in interpreting and predicting impacts in the marine environment.

The communications we are attempting are of necessity quite diverse, ranging from presentations to interested groups to peer-reviewed publication in the scientific literature. Authors may need to view and prepare their data in three or more ways, but we feel this extra effort is required because dissemination of the knowledge obtained from the various projects to the public is an important function at SCCWRP. We plan to pursue all possible means of marine environmental education. SCCWRP has been involved with compiling information on regional monitoring for a case study on the Southern California Bight by the National Research Council (NRC). Recommendations from the NRC study suggest the design and implementation of a regional monitoring program. Quality assurance and comparability among laboratories in southern California has been handled in an excellent manner by two organizations called SCAMIT and SCECS, which you will learn more about in this report. We have also added some new and important projects during the last year that directly relate to our goals and will provide valuable information to the public of southern California and the scientific community.

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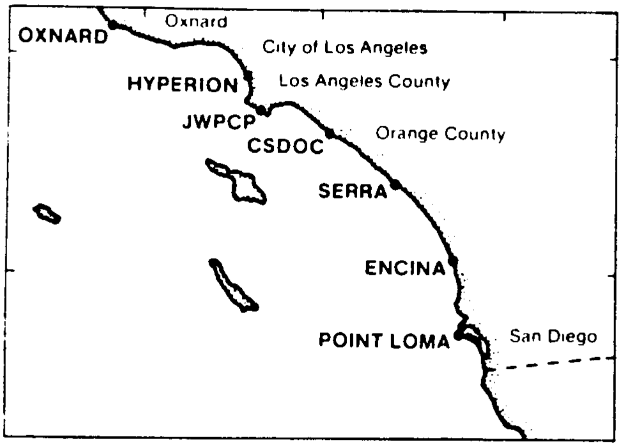
Sources



Outfall	Sponsor	Distance of Discharge Offshore (m)	Average Discharge Depth (m)
OXNARD	City of Oxnard	1,860	15
HYPERION	Los Angeles City Bureau of Sanitation	11,200 (7-mile) 8,300 (5-mile)	95 57
JWPCP	Los Angeles County Sanitation Districts	2,400 (90-in.) 3,660 (120-in.)	60 60
CSDOC	Orange County Sanitation Districts	7,250	60
SERRA	South East Regional Reclamation Authority	3,300	31
ENCINA	Encina Water Pollution Control Facility	2,400	45
POINT LOMA	City of San Diego	4,000	60

Figure 1. Locations of the seven dischargers summarized in this report.

Characteristics of Municipal Wastewaters in 1986 and 1987

Since 1971, wastewater treatment plants that discharge in the coastal waters of southern California have monitored general constituents (e.g., suspended solids, oil and grease, biological oxygen demand, and nutrients), trace metals, and some chlorinated hydrocarbons (DDT [includes six isomers] and polychlorinated biphenyls [PCBs; includes Aroclors 1242 and 1254]). This report summarizes the results of the monitoring data from the seven SCCWRP sponsors (Figure 1) for 1986 and 1987 and compares the results with those of past discharges.

Flow from these seven plants (Table 1) constitutes over 90% of the municipal discharges to the Southern California Bight. For the past 17 years, the combined contaminant emissions from these treatment plants have largely decreased despite steady annual increases in total flow (Table 2). Since 1971 the flow has increased by 32% (Figure 2), while suspended solids and biological oxygen demand (BOD) have been reduced by 48% (Figure 3).

The concentrations of effluent constituents and mass emissions for each of the seven plants for 1986 and 1987 are listed in Tables 3 and 4. Changes in trace contaminant concentrations from 1985, when we last summarized data, have shown some of the greatest decreases since monitoring began (Table 2). The combined flow increased by 27 million gallons per day (MGD; 37 x 10^9 L/yr) while suspended solids, BOD, and oil and grease emissions were reduced by 25, 40, and 38%, respectively. During the same period the emissions of trace metals were reduced by 20 to 50% (Figures 4a and 4b). The output of DDT remained about the same at 50 kg/yr, while PCBs

Table 1. Treatment and flows (in MGD) for seven outfalls for 1987. (Total flow was [1231 MGD]).

Plant	Advanced Primary	Secondary	Dilute Sludge
Hyperion	273	100	3
JWPCP	170	197	
CSDOC	112	140	
Point Loma	183		
Oxnard		18	
Encina	10[a]	10	
SERRA		15	
Total	748	480	3

[a] Primary (not advanced primary).

were reduced by about 60% to 250 kg/yr (Figure 5).

Silver emissions in the last two years are similar to other metals' emission and show about a 50% reduction between 1985 and 1987. However, the long-term trend is unlike any other contaminant. Silver emission doubled between the early 1970s and 1979, whereas most metals exhibited decreases for that same period. Although the cause of this increase was never determined, increased photographic and other industrial processes have been suggested as likely causes. Silver discharges dropped 25% between 1979 and 1980 but decreased only about 10% over the next five years (1980-1985).

Although the recent reductions have been large, the present levels are about equal to the early 1970 values. Silver will

Table 2. Combined mass emissions for 1971-1987 from seven municipal outfalls in metric tons per year except as noted.

Constituent	1971	1972	1973	1974	1975	1976	1977	1978
Flow								
L (10^9/yr)	1286	1274	1319	1336	1361	1419	1335	1402
MGD	931	922	955	967	985	1027	966	1015
Tot. Susp. Solids	288000	279000	270000	264000	287000	288000	244000	256000
BOD[c]	283000	250000	217000	222000	237000	259000	244000	237000
Oil & Grease	63500	60600	57400	54700	57400	59100	49000	49000
NH3-N	56600	39900	45900	37000	36600	37400	41200	39500
Ag	18	21	29	22	26	20	34	32
As				21	12	11	14	15
Cd	57	34	49	55	50	45	42	45
Cr	676	673	695	690	580	593	366	280
Cu	559	485	509	575	511	507	412	417
Hg				3	2	3	3	2
Ni	339	273	318	314	124	307	264	320
Pb	243	226	180	199	196	191	152	219
Se[d]				18	17	22	23	23
Zn	1880	1210	1360	1320	1142	1064	837	905
Tot. DDT[e] (kg/yr)	21700	6600	4120	2120	1990	1670	920	1110
Tot. PCB[e] (kg/yr)	8730	9830	4620	9390	6010	4310	2180	2510

[a]SERRA and Encina data first included.
[b]Discharge from Hyperion 7-mile outfall was terminated in November 1987.
[c]Hyperion 7-mile outfall data excluded.
[d]Data include only JWPCP, Hyperion 5- and 7-mile outfalls, and Point Loma.
[e]Values for 1971-75 are from SCCWRP's final report to the U.S. Enivironmental Protection Agency for Grant Nos. 801153 and R803707.

remain an important contaminant for municipal wastewater monitoring because effluents are responsible for more than 90% of anthropogenic inputs, and elevated levels in transplanted and natural mussels have shown that it is one of the best indicators of the presence of municipal outfalls.

Whereas the combined discharge to the bight has generally shown a steady increase in flow and decreases in contaminant emissions, individual outfall emissions have exhibited much greater annual variations. Examples of local fluctuations in emissions are the Hyperion 5- and 7-mile discharges.

Discharges from the Hyperion Treatment Plant to Santa Monica Bay over the last six years have shown some of the greatest increases and decreases in emissions since monitoring has been conducted. Between 1981 and 1983, the 5-mile discharge volumes increased by over 40 MGD (55 x 10^9 L/yr) and suspended solids mass emissions more than doubled between 1982 and 1985 (39,000 to 87,000 metric tons/yr). Most of the trace contaminants showed little increase in concentrations or mass emissions during this time.

Expansion and rehabilitation of facilities upstream and at the Hyperion plant since 1985 have

1979	1980	1981	1982*	1983	1984	1985	1986	1987*
1456	1516	1516	1567	1611	1622	1644	1691	1702
1054	1097	1097	1134	1166	1174	1190	1224	1231
243000	233000	226000	227000	247000	198000	205000	187000	162000
246000	260000	264000	269000	256000	230000	255000	184000	169000
45000	39000	37000	31900	36300	30200	34300	29300	26600
41200	42000	41000	44000	40600	40800	44200	43900	45600
42	31	28	26	26	25	27	22	15
15	11	12	9	10	18	16	12	12
42	40	33	21	24	16	17	15	10
237	275	187	203	164	140	110	88	60
359	336	339	286	247	252	240	205	135
3	2	2	1	1	1	1	1	<1
256	224	167	169	165	134	120	129	78
223	175	130	123	99	94	120	106	64
8	11	15	9	10	9	13	8	7
724	730	540	549	505	374	377	345	276
760	640	470	290	220	310	58	50	53
1190	1130	1250	860	1440	1340	820	480	250

Table 3. Average annual concentrations for 1986 and 1987 in milligrams per liter except as noted.[a]

Constituent	JWPCP 1986	JWPCP 1987	HYP5 1986	HYP5 1987	HYP7[b] 1986	HYP7[b] 1987	CSDOC 1986	CSDOC 1987
Flow								
L (10^9/yr)	503	506	542	518	5.4	4.7	329	348
MGD	364	366	392	375	3.9	3.4	238	252
Susp. Solids	82	73	77	58	13000[c]	12600[c]	49	47
Settl. Solids (ml/L)	0.4	0.3	1.1	0.8			0.8	0.4
BOD	100	108	148	116			76	76
Oil & Grease	10.2	11.1	21.3	15.2	687	694	10.1	12.8
NH3-N	40	37.9	16	16.2	377	486	25	25
Organic-N	8	7.4	7.54	6.4	511	554		
Total P	8.1	7.5	5.42	4.4	241	275		
MBAS	2.8	3.3	4.42	4.25			?	
Cyanide	0.02	0.02	0.017	0.027	0.07	0.078	0.001	<0.02
Phenol	1.6	2	0.038	0.041	0.15	0.098		
Turbidity (NTU)	58	52	50	43			27	26
Toxicity (TU)	1.03	1.14	1.03	1.1	17.8	28.3	0.26	0.45
Ag	0.008	0.008	0.017	0.010	0.43	0.231	0.012	0.01
As	0.007	0.007	0.009	0.008	0.29	0.352	0.004	0.004
Cd	0.004	0.002	0.009	0.006	0.72	0.659	0.004	0.004
Cr	0.058	0.052	0.036	0.014	4.65	3.6	0.027	0.021
Cu	0.052	0.042	0.12	0.057	13.2	9.35	0.083	0.075
Hg	0.0004	0.0003	0.0003	0.0001	0.034	0.024	0.0003	0.0002
Ni	0.059	0.051	0.113	0.056	2.5	1.56	0.033	0.03
Pb	0.055	0.046	0.051	0.043	3.24	1.79	0.023	0.01
Se	0.014	0.013	0.001	<0.005	0.053	0.038		
Zn	0.16	0.12	0.218	0.21	15.8	13.5	0.093	0.07
Total DDT (µg/L)	0.07	0.06	0.005	<0.02	0.14	<0.2	0.035	0.039
Total PCB (µg/L)	ND	ND	<0.1	0.007	4.87	0.39	1.38	0.708

[a]Abbreviations: MBAS, methylene blue activated substances; ND, not detected.
[b]Terminated November 1987.
[c]Total solids.

Table 4. Calculated annual mass emissions for 1986 and 1987 in metric tons per year except as noted.[a]

Constituent	JWPCP 1986	JWPCP 1987	HYP5 1986	HYP5 1987	HYP7[b] 1986	HYP7[b] 1987	CSDOC 1986	CSDOC 1987
Flow								
L (10^9/yr)	503	506	542	518	5.4	4.7	329	348
MGD	364	366	392	375	3.9	3.4	238	252
Susp. Solids	41200	36900	41700	30000	70200[c]	59200[c]	16100	16400
BOD	50300	54600	80200	60000			25000	26500
Oil & Grease	5130	5610	11500	7900	3710	3260	3320	4500
NO3-N	261	253	149	7				
NO2-N	10	15	60	135				
NH3-N	20100	19200	8670	8400	2810	2280	8220	8700
Organic-N	4020	3740	4080	3330	2760	2600		
Total P	4070	3790	2930	2280	1300	1290		
MBAS	1410	1670	2390	2200				
Cyanide	10	10	9	14	0.4	0.4	0.2	<7
Phenol	805	1010	21	21	0.8	0.5		
Ag	4	4	9	5	2	1	4	3
As	4	4	5	4	2	2	1	1
Cd	2	1	5	3	4	3	1	1
Cr	29	26	19	7	25	17	9	7
Cu	26	21	65	30	71	44	27	26
Hg	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1
Ni	30	26	61	29	14	7	11	10
Pb	28	23	28	22	18	8	7	3
Se	7	7	0.5	<3	0.3	0.2		
Zn	80	61	118	109	85	63	30	24
Total DDT (kg/yr)	35	30	3	<10	0.8	<1	12	14
Total PCB (kg/yr)	ND	ND	<54	4	26	2	454	250

[a]Abbreviations: MBAS, methylene blue activated substances; ND, not detected.
[b]Terminated November 1987.
[c]Total solids.

POINT LOMA		OXNARD		ENCINA		SERRA	
1986	1987	1986	1987	1986	1987	1986	1987
245	253	25	24	25	27	17	21
177	183	18.2	17.7	17.8	19.8	12.6	15.4
64	67	26.8	25.3	43.4	51.8	18.8	23.7
0.2	0.4	0.1	0.1	0.14	0.3	0.3	<0.3
106	100	25.5	22.6	52.9	63.0	12.6	13.7
21.6	20.3	3.7	3.9	9.35	6.6	1.3	1.5
24.2	24.3	8	6.2	20	21.3	15.6	6.4
		6	5.3				
10.7	7.52						
4.1	3						
0.010	0.009	0.022	0.007		<0.01	<0.01	0.06
0.006	0.005		0.021		0.001	<0.005	0.028
56	63	16.	16.1	31	34	6	7.2
1.23	1.43	0.17	0.07	1.14	0.94		
0.009	0.006	0.004	0.003	0.003	0.005	<0.01	0.003
0.004	0.004	0.004	0.003	0.001	0.001	0.003	0.01
0.009	0.004	0.007	0.003	0.001	0.008	<0.01	<0.01
0.02	0.008	0.008	0.003	0.002	<0.02		
0.05	0.047	0.072	0.047	0.029	0.04	0.019	0.01
0.0003	0.0002	0.0007	0.0002	0.0004	<0.001	0.0005	<0.001
0.05	0.017	0.058	0.051	0.006	0.02	0.008	<0.01
0.1	0.019	0.054	0.023	0.004	0.009	<0.03	0.04
0.002	0.002			ND			
0.09	0.059	0.063	0.069	0.065	0.10	0.34	0.104
ND	0.036	<0.1	<0.03	ND	ND		
ND	ND	<1	<0.2	ND	ND		

POINT LOMA		OXNARD		ENCINA		SERRA	
1986	1987	1986	1987	1986	1987	1986	1987
245	253	25	24	25	27	17	21
177	183	18.2	17.7	17.8	19.8	12.6	15.4
15600	16900	674	619	1070	1400	327	504
25900	25300	641	550	1300	1700	219	290
5280	5130	93	95	230	180	23	32
		143	160				
445		15	12				
5920	6100	201	150	492	580	270	136
		151	130				
2620	1900						
1000	760						
2	2	0.5	0.2		<0.3		1
			0.5		0.03		0.6
2	2	0.1	0.1	0.06	0.14	<0.2	0.06
1	1	0.1	0.1	0.02	0.03	0.05	0.21
2	1	0.2	0.1	0.01	0.22	<0.2	<0.2
5	2	0.2	0.1	0.05	<0.5		
12	12	1.8	1.2	0.71	1.1	0.33	0.21
0.1	0.1	0.02	0.01	0.01	<0.03	<0.008	<0.02
12	4	1.5	1.2	0.15	0.54	0.14	<0.2
24	5	1.4	0.6	0.10	0.24	<0.5	0.9
<1	<1					0.00	
22	15	1.6	1.7	1.6	2.7	5.92	2.2
<9	9	<3	<1				
<16	ND	<25	<5				

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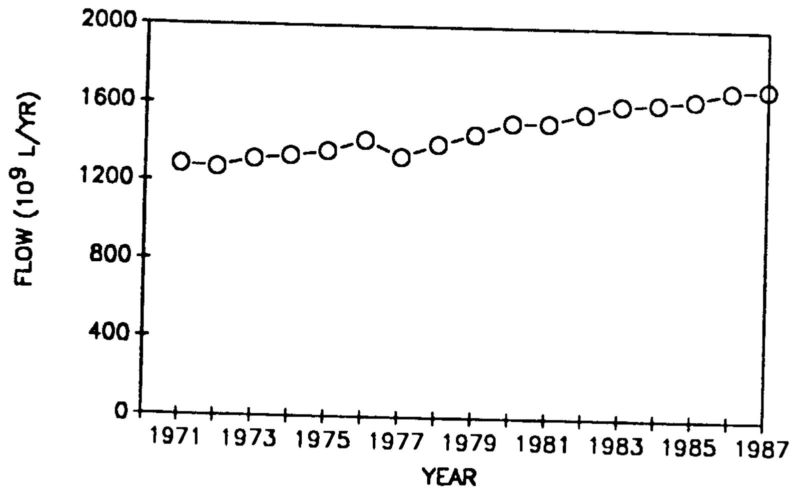

Figure 2. Combined annual flow from seven dischargers.

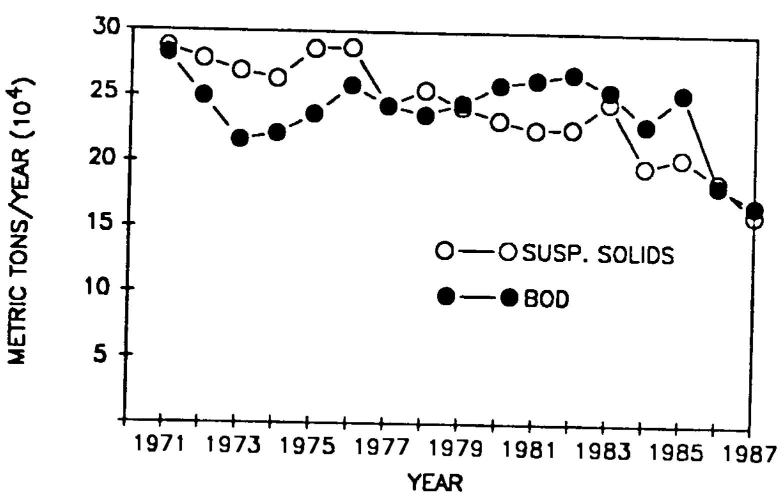

Figure 3. Combined BOD and suspended solids from seven dischargers.

reduced the 5-mile discharge by 30 MGD (48×10^9 L/yr) and the suspended solids by 57,000 metric tons/yr between 1985 and 1987. The latest data show that solids emissions are 15% lower than the 1971 emissions despite a 10% increase in flow.

The Hyperion 7-mile sludge outfall discharge has also undergone major changes in the past few years. Solids emissions increased 53% between 1985 and 1986 (44,000 to 70,000 metric tons/yr). Discharge was terminated in November 1987, and the solids are now transported to landfill. Although the outfall only operated for 10 months in 1987, it emitted 0.3% of the flow and 37% of the solids discharged by all municipal discharges to the bight. Its elimination will cause significant reductions in solids and trace metal annual inputs to the bight as of 1988.

The second largest discharge, the Joint Water Pollution Control Plant (JWPCP) outfalls at White Point, has continued to significantly reduce emissions. A steep decline in suspended solids occurred in 1984 after 200 MGD (276×10^9 L/yr) of secondary treatment was added in 1983. Between 1985 and 1987 suspended solids have been reduced an additional 15% and eight of the ten monitored metals have been reduced by 15 to 20%. Table 5 shows corrections for JWPCP 1985 data presented in SCCWRP's 1986 Annual Report.

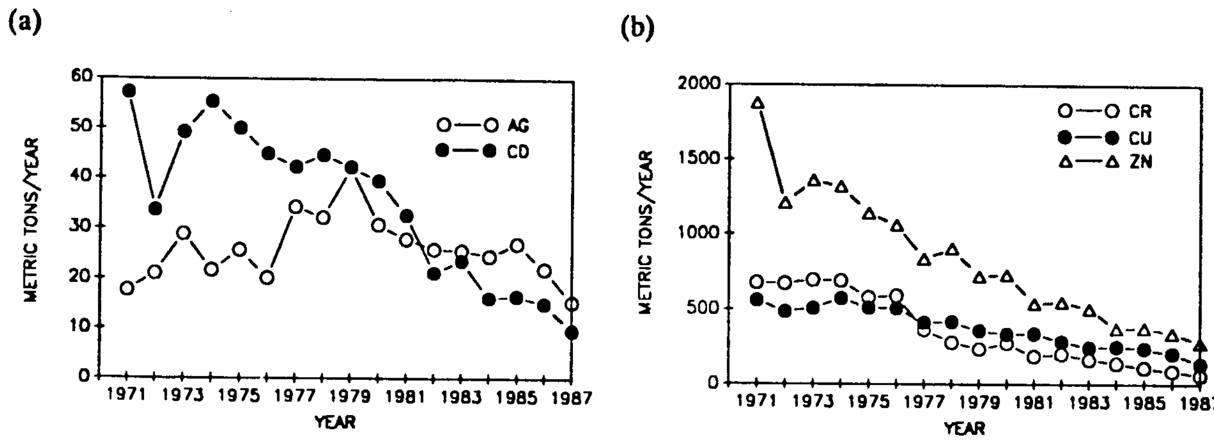

Figure 4. Emissions of (a) silver and cadmium, and (b) chromium, copper, and zinc to the Southern California Bight from seven dischargers from 1971 to 1987.

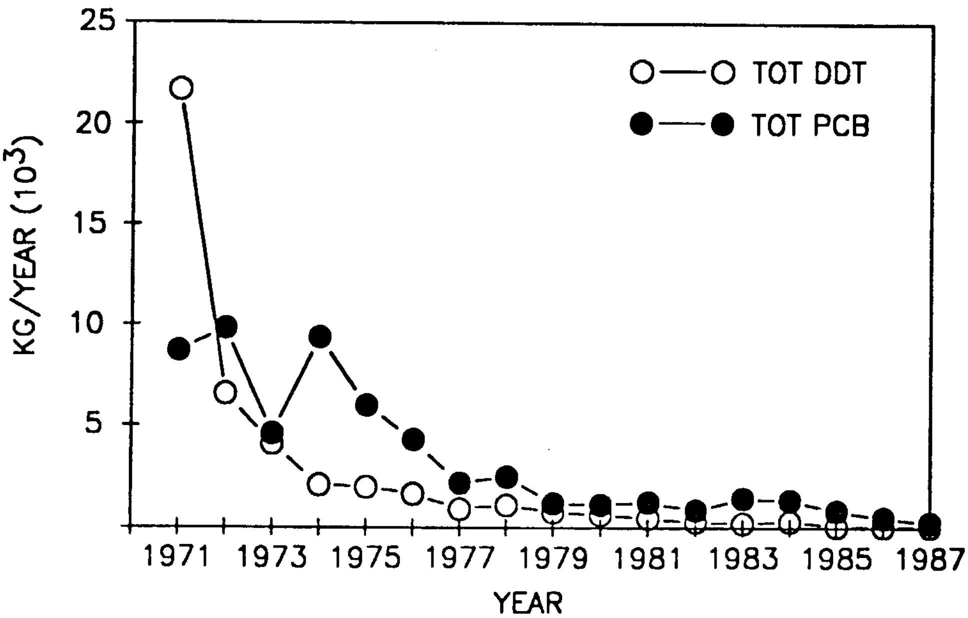

Figure 5. Output of DDT and PCBs to the Southern California Bight. Since 1985, the emission of DDT has remained about the same, but the output of PCBs has been reduced by about 60%.

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Table 5. Corrected 1985 data for JWPCP.

Constituent	Average Annual Concentration (mg/L except as noted)		Mass Emissions (metric tons/yr except as noted)	
	Reported	Corrected	Reported	Corrected
NO3-N	1.3	0.48	635	240
NO2-N	0.30	<0.05	150	<25
NH3-N	40.8	37.3	20400	18700
MBAS	5.7	4.1	2850	2050
Toxicity (TU)	2.25	1.30		
DDT	0.1 µg/L	0.07 µg/L	50 kg/yr	35 kg/yr
PCB	0.2 µg/L	0.02 µg/L	80 kg/yr	10 kg/yr
TICH	0.41 µg/L	0.26 µg/L	200 kg/yr	130 kg/yr

The County Sanitation Districts of Orange County (CSDOC) operate the third largest treatment plant in Southern California and reported the largest discharge of PCBs to the bight for each of the last nine years. They report a 60% reduction (660 to 250 kg/yr) between 1985 and 1987. It is not clear how much of this reduction is due to actual reductions in concentrations and how much is due to a change to a more standard method of analysis. For years CSDOC used a unique method of sample preparation for PCB analysis that apparently caused the samples to be prone to laboratory contamination, thus producing much higher values than U.S. Environmental Protection Agency (EPA) methods produced or that other laboratories were able to detect in CSDOC effluent. Since 1986 the CSDOC laboratory has switched to EPA methods.

The reductions in municipal outfall emissions increase the importance of other sources of anthropogenic inputs. To assess these other sources, SCCWRP is investigating runoff and aerial inputs and will be reporting on this information in future publications.

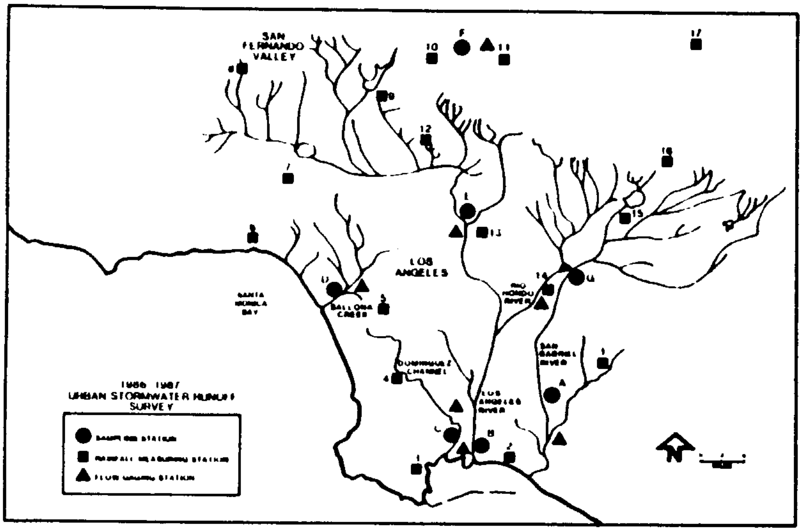

Figure 1. Los Angeles River Basin.

Storm Runoff in Los Angeles and Ventura Counties

One of SCCWRP's long-term projects is to update and improve past estimates of contaminant inputs to the Southern California Bight. By the summer of 1988, SCCWRP staff will have sampled storm runoff from the largest storm channels in four of the coastal counties of southern California.

On September 23-25, 1986, SCCWRP investigators collected 49 samples of storm runoff from eight sites in Los Angeles and Ventura Counties (Santa Clara River, Calleguas Creek, Ballona Creek, Dominguez Channel, Los Angeles River [Big Tujunga Wash, Fletcher Avenue Bridge, Willow Street Bridge], and San Gabriel River) (Figure 1). Each channel has a unique drainage basin, and most of the channels receive wastewater effluent from one or more municipal wastewater treatment plants, which contributes significantly to dry weather flows. Locations were chosen to provide safe sampling, to be used during adverse weather conditions, to provide access to the center channel of the flow, and to be downstream from the major sources of runoff contaminants.

The storm was very early in the rain season and was unpredicted. This made it difficult to take the samples as originally planned; however, low-flow, high-flow, and post-high-flow samples were obtained and concentrations of suspended solids, oil and grease, total extractable organics (TEO), trace metals, DDT, polychlorinated biphenyl compounds (PCBs), polynuclear aromatic hydrocarbons (PAHs), and *n*-alkanes were measured.

With these data, Henry A. Schafer and Richard W. Gossett were able to estimate mass emission of major runoff sources and compare the rates with previous runoff emission estimates and other sources of

Table 1. Flow-proportioned average concentrations and ranges of actual concentrations for storm runoff samples collected from the September 23-25 storm.

Constituent	LA River Willow	LA River Fletcher	LA River Tujunga	Ballona Creek	Santa Clara	Calleguas Creek	San Gabriel	Dominguez Channel	Hyperion 5-Mile[a]	Oxnard Plant[a]
	Station									
No. of samples	10	8	5	6	3	3	8	4	1985 AVE	1985 AVE
Flow (m^3/s)[b]										
Min	3	4		1		<1	2			
Max	240	65		140		2	122			
Susp. Sol. (mg/L)	645	246	229	755	1250	30	206	206		
Min	31	17	3	13	16	3	5	11		
Max	1850	1190	826	2500	1920	85	1080	76		
%Vol. Sol.										
Min	5	22	9	15	8	28	7	28		
Max	69	31	50	46	88	60	100	55		
Oil & Grease (mg/L)	10	3	1	15	3	2	5		29	4
Min	1	1	<0.1	2	1	0.2	0.2	0.2		
Max	22	11	1	36	7	2	8	3		
TEO (mg/L)	35	6	1	27	5	1	4			
Min	1	2	<0.1	2	1	0.4	0.4	0.7		
Max	103	29	4	60	8	2	12	5		
Cd (µg/L)	6	2		7			2		11	13
Min	<1	<1	<1	<1	<1	<1	<1			
Max	21	28		22	1		4			
Cr (µg/L)	45	11		67	56	2	31		60	11
Min	<3	<2	<2	<3	<2	<3	6			
Max	147	107	8	248	80	5	68			
Cu (µg/L)	182	96		267	69	18	86		197	57
Min	12	26	3	43	<2	3	17			
Max	512	667	28	860	106	46				
Ni (µg/L)	47	21		80	19	6	34		82	57
Min	13	12	<2	7	4	3	13			
Max	131	92	5	261	48	12	61			
Pb (µg/L)	264	71		530	88		120		88	285
Min	<8	24	<6	23	8	<9	23			
Max	607	345		1830	134		201			
Zn (µg/L)	718	299		1420	238	10	457		279	71
Min	21	116	2	172	7	6	80			
Max	1970	1360	47	4400	391	14	744			
DDTs (ng/L)	85	46		378	938	6	16		20	
Min	<1	21	3	1	8	1	<1	<1		
Max	169	249	12	1360	1570	10	35	9		
PCBs (ng/L)	291	108		267	162	14	57		102	<1000
Min	11	58	2	18	12	11	<1	15		
Max	695	352	41	632	250	19	75	34		
PAHs (µg/L)	36	2		24	1	0.02	1			
Min	<0.01	<0.01	<0.02	0.4	<0.01	<0.01	<0.01			
Max	120	18		76	2	0.14	1.6			
n-Alkanes (µg/L)	572	42	4	244	6	0.01	29			
Min	1	8	1	9	<0.01	<0.01	1	<0.01		
Max	1000	280	6	440	5		43	240		

[a]Based on 1985 monitoring data.
[b]To obtain units in cubic feet per second use the following formula: $ft^3/s = (m^3/s)/0.0283$.

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Table 2. Mass emission rates (metric tons) for several runoff constituents of the September 23-25, 1986, storm and average daily emissions from two ocean outfalls (1985 data).

Constituent	Station								
	LA River Willow	LA River Fletcher	LA River Tujunga	Ballona Creek	Santa Clara	Calleguas Creek	San Gabriel	Hyperion 5-Mile	Oxnard Plant
Tot. Vol. (L x 10^9)	11	7.7	0.0014	4.5	0.016	0.32	3.5	1.47	0.070
Susp. Solids	7100	1900	0.32	3400	20	9.7	720	238	2.3
Tot. Solids	10000	3200	0.67	6900	39	460	8400		
Oil & Grease	110	20	0.0009	67	0.045	0.74	17	43	0.030
TEO	380	44	0.0018	120	0.080	0.44	13		
Cd	0.064	0.013	ND[a]	0.030	ND	ND	0.0082	0.016	0.0009
Cr	0.50	0.088	ND	0.31	0.0009	0.0005	0.11	0.088	0.0008
Cu	2.0	0.74	ND	1.2	0.0011	0.0058	0.30	0.29	0.004
Ni	0.52	0.16	ND	0.36	0.0003	0.0022	0.12	0.12	0.004
Pb	2.9	0.55	ND	2.4	0.0014	ND	0.42	0.13	0.002
Zn	7.9	2.3	ND	6.4	0.0038	0.0031	1.6	0.41	0.005
Tot. DDTs (kg)	0.93	0.35	ND	1.7	0.015	0.002	0.056	0.030	
Tot. PCBs (kg)	3.2	0.83	ND	1.2	0.0026	0.0045	0.20	0.15	<0.07
Hexachlorobenzene (kg)	0.044	0.015	ND	0.015	ND	0.0001	0.0060		
Lindane (kg)	0.18	0.16	ND	0.086	0.0004	0.0008	0.022		
Tot. PAHs (kg)	400	15	ND	110	0.018	0.0056	4.0		
n-Alkanes (kg)	6300	320	0.0057	1100	0.41	0.0040	100		

[a]ND, Not detected.

contamination to the Southern California Bight. They also determined how the concentration and mass of contaminants varied throughout the storm to see if significant portions of the mass emissions were concentrated in a small part of the flow. Various sites were sampled to see how contaminant levels varied with land use. In addition, Schafer and Gossett measured concentrations of PAHs. For several channels, this was the first time that PAHs were measured; the molecular weight of the PAHs indicated that crankcase oil was present in the runoff.

Mass emissions and flow-proportioned mean concentrations were calculated for each sampling site. Mass emissions for each sampling period were first determined by multiplying the flow that occurred during the sampling period by the sample contaminant concentrations. Then the total storm emissions were computed by summing all of the interval mass emissions. The flow-proportioned mean concentrations were calculated by dividing the total mass emissions by the total flow.

Table 1 lists flow-proportioned mean contaminant concentrations and ranges for the sites sampled during this storm. The researchers found that the Santa Clara River and Calleguas Creek (both in Ventura County) had the highest and lowest concentrations of suspended solids, respectively. Generally, the Los Angeles River at Willow Street had the highest concentrations of hydrophobic (oil and grease, TEO, PAH, *n*-alkanes, PCBs, and DDT) contaminants. Exceptions occurred at Ballona Creek, which had 50% more oil and grease and a DDT concentration four times that of the Willow Street site, and at Santa Clara, which had a DDT concentration 11 times that of the Willow Street site. Trace metals concentrations were all highest at Ballona Creek followed by the Los Angeles River at Willow. Concentrations at Tujunga Wash were consistently below detection, while the other sites had roughly equal levels. Contami-

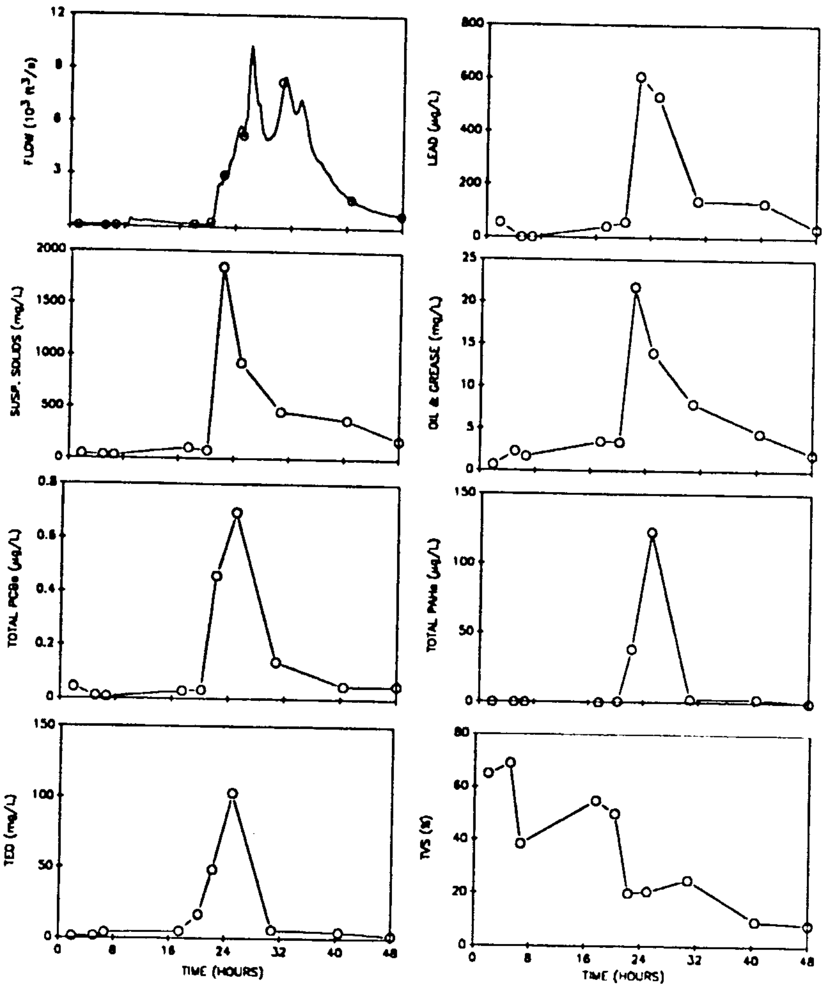

Figure 2. Flow and contaminant concentrations at the Los Angeles River at Willow Street during the storm on September 23-25, 1986. TVS, Total volatile solids.

Table 3. Flow-weighted mean concentrations of trace metals and chlorinated hydrcarbons in Los Angeles River storm runoff.[a]

Constituent (µg/L)	1971-72 Storm 1	1971-72 Storm 2	1979-80 Storm 1	1979-80 Storm 2	1979-80 Storm 3	1986-87 Storm 1
Ag	1.9	2.6	1.3	0.7	0.4	
Cd	16	9.3	1.6	8.7	1.8	5.8
Cr	86	80	140	120	52	45.4
Cu	120	140	110	110	44	182
Hg			1.8	0.4	0.2	
Ni	83	72	73	77	34	47.3
Pb	910	980	74	210	180	164
Zn	940	1100	760	450	230	718
Fe (mg/L)	10	25	68	57	28	
Mn	450	500	640	860	450	
DDT	0.93[b]		0.51	0.38	0.10	0.08
PCB	2.6[b]		0.35	0.47	0.12	0.29
Vol. (10^9 L)	1.4	7.2	2.8	21.8	14.5	11
Susp. Sol. (mg/L)			2700	1900	1500	645

[a]From Young et al. 1981.
[b]These values are the average measurements of the two storms.

nant concentrations along the Los Angeles River increased significantly from the upper to lower stations.

Table 2 shows the calculated flow-proportioned mass emissions. The Los Angeles River is the largest source of runoff to the Southern California Bight. The flow rate at the Willow site is about 30% greater than that at Fletcher and contaminant emissions are 3 to 10 times greater, which indicates that for all constituents except DDT, there is a consistent pattern of greatest emissions coming from the Los Angeles River, then Ballona Creek followed by Fletcher and San Gabriel. The remaining sample stations had minimal inputs.

Emissions from the San Gabriel River were underestimated because the flow data were available only from the Coyote Creek branch of the San Gabriel River. Therefore, estimates for that station could be low by a factor of 2 or more.

Figure 2 shows the flow and concentrations of suspended solids, oil and grease, TEO, lead, total PAHs, total PCBs, and volatile solids for the Los Angeles River during the 48 h of sampling. There were two peaks in flow that occurred about 6 h apart. Peak contaminant concentrations (except percent volatile solids) occurred at either hour 22 or 24, which was before the first peak in flow. Although the

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sample taken at hour 30 was at the second peak flow, the concentrations of all contaminants dropped. This may be due to a washout of contaminants.

The cumulative percent flow and cumulative percent emissions of suspended solids, oil and grease, chlorinated hydrocarbons, and combined trace metals for the Willow station and Ballona Creek are compared in Figure 3. Approximately 80% of the flow and suspended solids was discharged within 10 h. In general, the first 25% of flow produced 50% of the contaminant emissions, and when 50% of the flow had occurred, 75% of the contaminant emissions had occurred. This pattern is representative of the other sites studied.

As contaminant emissions from outfalls continue to decrease, runoff emissions become a more important source of marine inputs. Variations in runoff concentrations were not significantly different in the Los Angeles River between 1971 and 1979 except for lead and PCBs, which were reduced by factors of 6 and 8, respectively (Young et al. 1981). Table 3 shows concentrations for the five storms measured in 1971 and 1979 and the present 1986 results. Between 1979 and 1986 copper and lead concentrations increased by about a factor of 2, while suspended solids and chromium were reduced by two-thirds and one-half, respectively. The rest

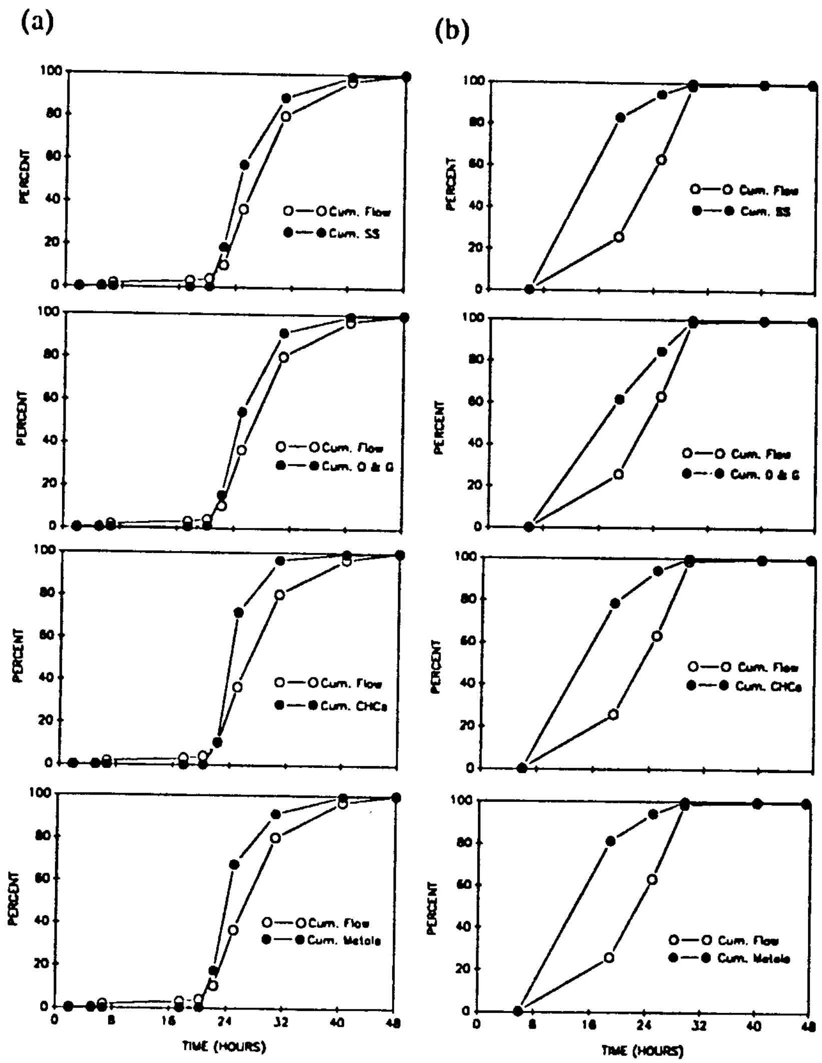

Figure 3. Cumulative percent flow and cumulative percent emissions of suspended solids (SS), oil and grease (O & G), chlorinated hydrocarbons (CHCs), and combined trace metals. (a) Los Angeles River at Willow Street. (b) Ballona Creek.

of the trace metals and PCBs varied by less than one-third. Levels of DDT changed the most; they were reduced by a factor of 4.

The highest concentrations of contaminants are associated with peak flows. Because the two Ventura sites were sampled while they had relatively low flow, these annual emission data may be less representative than those sites that were sampled during high flow. The two channels with the highest flows, Los Angeles River Willow and Ballona Creek, had the highest mean contaminant concentrations and consequently had the highest emissions of oil and grease, TEO, cadmium, chromium, copper, nickel, lead, zinc, PCBs, PAHs, resolved hydrocarbons, and *n*-alkanes.

Estimation of runoff should be viewed with the awareness of certain limitations. Factors that need further examination include annual variations in total rainfall within a drainage basin, the intentional retention of runoff for groundwater recharge, and diversions between drainage basin. These factors can combine to make each storm and year difficult to compare with other storms and years.

Acknowledgments

We appreciate the financial and field support that was provided by the Los Angeles Regional Water Quality Control board, especially A. Chartrand and M. Sowby. The Hyperion Laboratory kindly allowed us to use their facilities to measure oil and grease. We thank our fellow staff members who interrupted their work and sleep patterns to make this study possible.

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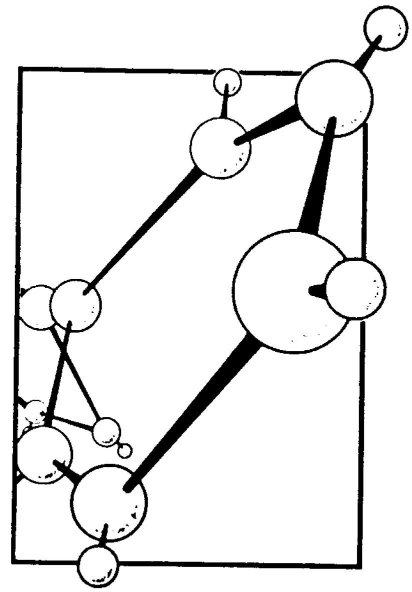
Polynuclear Aromatic Hydrocarbons in Waste Effluent and Sediments



In a previous annual report (SCCWRP 1987), SCCWRP scientists described early efforts to measure polynuclear aromatic hydrocarbon (PAH) concentrations in marine sediments from offshore southern California. The purpose of that survey was to determine the composition and concentration of PAHs in *surface* sediments at a variety of coastal sites presumed to be receiving hydrocarbon inputs. Here are results from a study by Robert P. Eganhouse and Richard W. Gossett of PAHs in final effluent from the Joint Water Pollution Control Plant (JWPCP; Los Angeles County) and sediments cored from the Palos Verdes Shelf.

PAHs are toxic substances that originate from a multitude of sources and exhibit a wide range of physico-chemical properties. Although globally distributed, they are typically found in greater abundance near urbanized coastal areas. The major sources of PAHs to coastal and estuarine environments are believed to be municipal waste discharges, urban runoff, and atmospheric particulates. Unfortunately, published information concerning the composition and concentrations of PAHs in municipal wastewaters, particularly in southern California, is extremely limited (Barrick 1982, Grzybowski et al. 1983). This makes it difficult to evaluate the importance of municipal waste discharges compared with other inputs of PAHs to the Southern California Bight. One of the objectives of the present study was to measure the concentrations of PAHs in the JWPCP's final effluent over the course of one year (1979). These data are used to estimate the mass emission rate of PAHs from this treatment plant as of 1979.

In addition to analyzing effluent samples, SCCWRP scientists examined sections of a sediment core collected from the Palos Verdes Shelf in connection with the County Sanitation District's coring program in 1981 (station 3C; 33°43.83 N, 118°24.01 W). Sediments from this core have been analyzed for elemental abundance, stable isotopic composition and molecular markers by Eganhouse and Kaplan (1988) and for a variety of inorganic and organic trace constituents by the County Sanitation District. Because the core is so well characterized, we felt it would provide an opportunity to estimate the accumulation rate of PAHs at station 3C.

Figure 1 illustrates the PAH composition of the JWPCP final effluent collected on October 15, 1979. This sample is generally representative of those taken in other months; however, some of the higher molecular weight PAHs found in low abundance in the October sample were not detected in effluent collected at other times during the year. The PAH distribution of the effluent is dominated by naphthalene, phenanthrene, and corresponding alkylated homologs. Higher molecular weight species (i.e., those having more than three fused rings) are in lower abundance. The alkyl homolog distributions (i.e., the relative abundances of parent and alkyl-substituted species) generally show a maximum for the C1- to

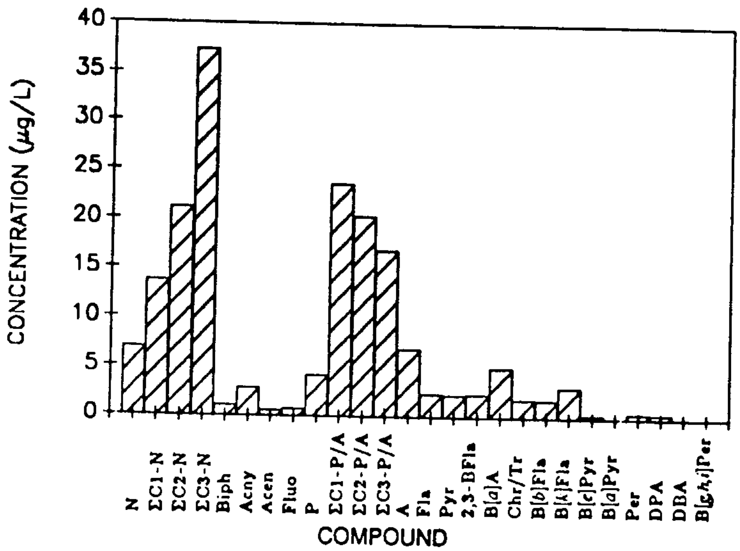


Figure 1. Distribution of PAHs in JWPCP final effluent, October 15, 1979. Abbreviations: N, naphthalene; Biph, biphenyl; Acny, accnaphthylene; Acen, acenaphthene; Fluo, fluorene; P, phenanthrene; A, anthracene; Fla, fluoranthene; Pyr, pyrene; B, benzo group; Chr/Tr, chrysene/triphenylene; Per, perylene; DPA, 9,10-diphenylanthracene; DBA, dibenzo[*a,h*]anthracene.

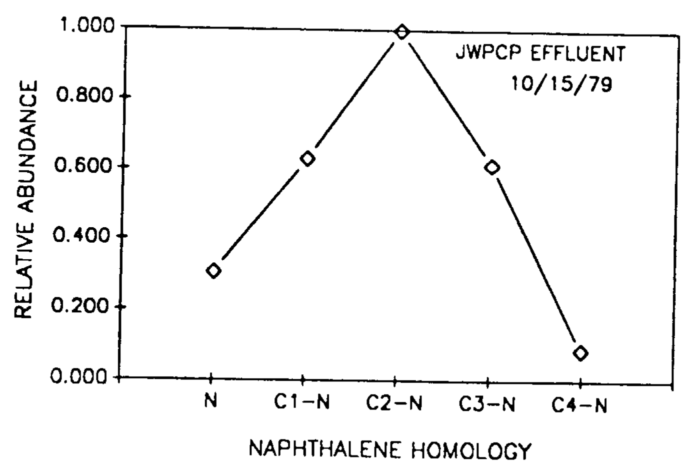


Figure 2. Alkyl homolog distribution of naphthalene series (C_nH_{2n-12}). N, Naphthalene.

C3-substituted naphthalenes and phenanthrene/anthracenes (Figure 2). In addition, the fluoranthene/pyrene series and other high molecular weight PAH groups exhibit dominance by the alkylated species. Together these results suggest that the PAHs found in the effluent samples are derived from fossil fuels, not combustion sources.

Table 1 provides a summary of the mean concentrations of PAHs in the effluents determined in this study along with data presented by Barrick (1982) for the Seattle METRO treatment plant (particulate concentrations) and Grzybowski et al. (1983) for waste effluent from Poland. Concentrations measured in the JWPCP effluent are approximately an order of magnitude greater than those determined for the METRO samples but generally fall within the range reported by Grzybowski et al. (1983). Some of this difference can be explained by the higher hydrocarbon concentrations of the California wastes. On average, the JWPCP hydrocarbon concentrations were five times greater than those reported for the Seattle METRO effluent. Despite the fact that the METRO plant receives inputs from storm water runoff, industrial contributions to the influent are relatively small. In contrast, the JWPCP receives substantial quantities of industrial wastes.

The JWPCP has monitored its effluent for the U.S. Environmental Protection Agency priority pollutants on an approximately quarterly basis since 1985. Non-detectable amounts have been reported for all PAHs except naphthalene and phenanthrene. In many cases, however, the reported detection limits are higher than the concentrations measured in this study.

There was an attempt by SCCWRP to measure priority pollutants in the JWPCP effluent in 1978. The only PAHs reported to be present at measurable concentrations were naphthalene (29 μg/L) and acenaphthene (7 μg/L). These concentrations are approximately 5 to 7 times higher than those observed for samples taken in 1979.

The variation in concentration of individual (or alkylated isomer groups of) PAHs found in all samples ranges from 46 to 74% (coefficient of variation), whereas the variation in total PAH concentrations (i.e., sum of 26 measured concentrations) is 53%. This is significantly greater than the variation in concentration of total hydrocarbons and extractable organics (Eganhouse and Kaplan 1982), possibly reflecting greater fluctuations of PAH inputs. Inspection of the data presented by Barrick (1982) indicates that similar levels of variation of individual PAH concentrations were observed in the Seattle effluent during 1978.

When the concentrations of total PAHs are applied to the mean monthly flows from the JWPCP, an annual mass emission rate of 110 metric tons is obtained. There are no known available data for other waste treatment plants or storm water drainage systems in southern California with which these figures can be compared for the year 1979. Recent studies at SCCWRP of a single storm in 1986 suggest that the total PAH emissions from the Los Angeles River during that event were 0.4 metric tons (see p. 13). More data are required to develop yearly estimates for this and other drainage systems in the southern California region.

Table 1. Concentrations of PAHs in municipal wastewater effluent.

Analyte	Mean Concentration (μg/L) This study[a]	Barrick (1982)[b]	Grzybowski et al. (1983)
Total hydrocarbons	16,300	3,000	NR[c]
Naphthalene	7.8	NR	NR
C1-naphthalenes	23.2	NR	NR
C2-naphthalenes	38.5	NR	NR
C3-naphthalenes	66.0	NR	NR
Phenanthrene	14.0	0.8	0.5-10.
Anthracene	0.9	NR	0.1-1.0
C1-phenanthrene/anthracenes	20.7	1.4	NR
C2-phenanthrene/anthracenes	20.5	1.6	NR
C3-phenanthrene/anthracenes	9.6	NR	NR
Fluoranthene	1.1	0.4	0.5-5.0
Pyrene	2.8	NR	11.-27.
Benz[*a*]anthracene	1.0	0.1	0.1-24
Chrysene/triphenylene	2.1	0.2	NR
Benzo[*e*]pyrene	0.5	0.1	1.-5.5
Benzo[*a*]pyrene	0.3	NR	0.6-6.5
Total PAH[d]	115.	NR	NR

[a]Measurements of unfiltered JWPCP effluent samples, 1979.
[b]Calculated values based on particulate concentrations in METRO effluent; exception: total hydrocarbons = particulate + dissolved.
[c]NR, Not reported.
[d]Total PAH is the sum of PAHs determined in this study.

Figure 3 depicts the distribution of PAHs found in sediments at a depth of 2 to 4 cm below the sediment-water interface at station 3C. The PAH composition is somewhat variable in different sections of the core, but the pattern shown here is fairly representative of those seen at other depths. In contrast to the effluent PAH composition (Figure 1), sedimentary PAH distributions are dominated by higher molecular weight species. Naphthalene, phenanthrene, and the corresponding alkylated homologs of these compounds were rarely seen and then only in low abundance. Because most of the hydrocarbons in this core down to depths of 24 cm are believed to be of sewage origin (Eganhouse and Kaplan 1988), it is likely that the lower molecular weight species so abundant in the effluent were lost via solubilization or biological degradation. The fact that the lower molecular weight species are not found in the uppermost section of the core indicates that alteration of the PAH assemblage occurs prior to

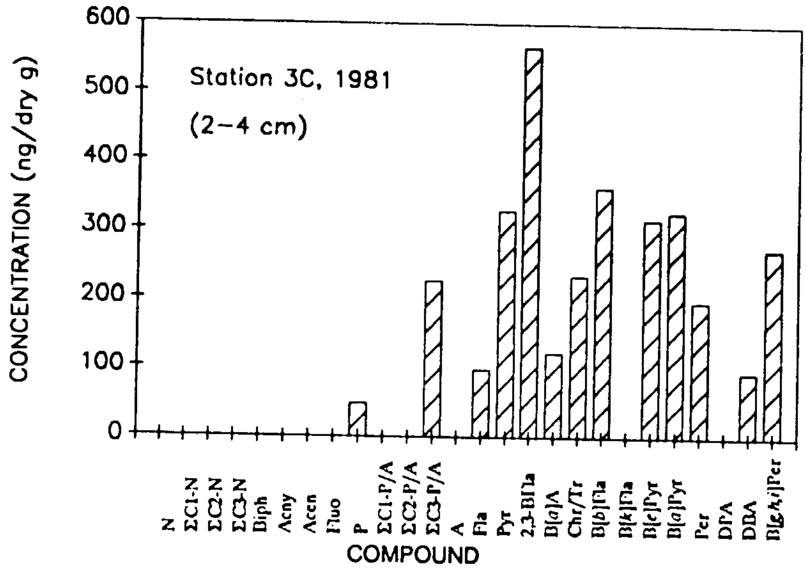


Figure 3. Distribution of PAHs in 2- to 4-cm section of sediment core at station 3C, 1981. Abbreviations are as in Figure 1.

sediment burial (i.e., in the water column and/or at the sediment-water interface).

Table 2 provides data for the sediment core along with results obtained from the literature. Although no measurements have yet been published for sediments from station 3C, Swartz et al. (1985) and Anderson and Gossett (1987) reported PAH data for whole grabs and surface sediments (0 to 2 cm), respectively, taken from the Palos Verdes Shelf in 1980 and 1986. Both surveys identified naphthalene and other lower molecular weight species at station 7C. The appearance of these relatively labile species at 7C and their absence at 3C may reflect differences in the sediment accumulation rates at these stations. Alkyl homolog distributions for the fluoranthene/pyrene series found in the highly contaminated sediment sections show maxima among the higher molecular weight alkylated species. This suggests that petroleum, not fossil fuel combustion products, is the dominant source of these PAHs.

A comparison of effluent particulate PAH/organic carbon ratios with those observed in the sediment sections suggests that even the higher molecular weight PAHs found in low abundance in the effluent may be subject to extensive removal during the sedimentation process. Whether this reflects desorption/dissolution, degradation, or some combination is unclear. The resistance of higher molecular weight PAHs to environmental alteration appears to depend, in part, on their physico-chemical speciation upon introduction to the environment (Readman et al. 1984, Gschwend and Hites 1981) with combustion-derived PAHs being more refractory than those occurring as petroleum residues. The present results are consistent with the hypothesis that the PAHs at station 3C are derived from petroleum.

Figure 4 illustrates the vertical concentration profile for total PAHs in the sediment core. Maximum concentrations are observed between depths (below the water-sediment interface) of 2 to 18 cm. With increasing depth below 18 cm, the PAH concentrations decline rapidly and appear to reach "background levels" at approximately 22 to 24 cm. At station 3C, the PAH distribution is similar to profiles observed for other waste-related contaminants, which typically exhibit a well-defined subsurface maximum at depths of 8 to 10 cm below the sediment-water interface (Eganhouse and Kaplan 1988, Stull et al. 1986). The appearance of high PAH concentrations over the same depth intervals as observed for other indicators of waste contamination (e.g., organic carbon and total hydrocarbons) strongly suggests that sewage is the dominant source of these compounds. The lack of a distinct subsurface maximum, however, indicates that changes in solids emissions alone (Eganhouse and Kaplan 1988) probably did not control accumulation rates of PAHs in these sediments.

Using tentative assignments for the ages of different depths of this core (Eganhouse and Kaplan 1988), one can calculate average accumulation rates of total and

Table 2. PAH concentrations in sediments of the Palos Verdes Shelf.

Compound	Concentration (ng/dry g) This study[a] (3C; 1981)	Swartz et al. (7C; 1985)	Anderson and Gossett (7C; 1986)
Naphthalene	--[b]	--	87
C1-naphthalenes	--	NR[c]	104
C2-naphthalenes	--	NR	415
C3-naphthalenes	--	NR	462
Biphenyl	--	NR	22
Acenaphthylene	--	160	57
Acenaphthene	--	NR	--
Fluorene	--	NR	16
Phenanthrene	--	290	197
Anthracene	--	623	52
C1-phenanthrene/anthracenes	--	NR	773
C2-phenanthrene/anthracenes	--	NR	1193
C3-phenanthrene/anthracenes	--	NR	701
Fluoranthene	17	294	157
Pyrene	127	838	401
2,3-Benzofluoranthene	149	NR	842
Benz[*a*]anthracene	36	1330	166
Chrysene/triphenylene	88	606	274
Benzofluoranthene	207	633	746
Benzo[*e*]pyrene	217	NR	317
Benzo[*a*]pyrene	212	NR	323
Perylene	105	NR	353
9,10-Diphenylanthracene	--	NR	4
Dibenz[*a,h*]anthracene	38	NR	NR
Benzo[*g,h,i*]perylene	205	NR	217
Total PAH	1,400	--	7,300
µg Total PAH/g organic carbon[d]	23.5	--	154.

[a]Data are for 0- to 2-cm section.
[b]Below detection limit.
[c]NR, Not reported.
[d]Elemental analysis from Eganhouse and Kaplan (1988).

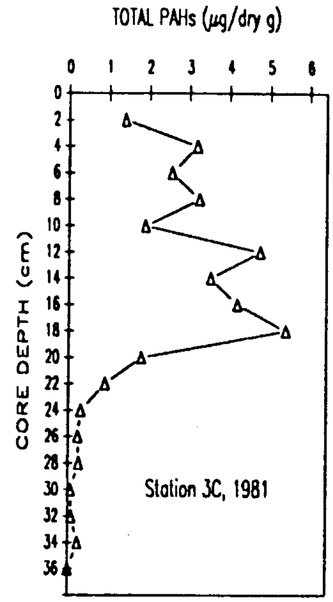


Figure 4. Vertical concentration profile of total PAHs at station 3C, 1981.

individual PAHs in the sediments. Table 3 presents estimated average accumulation rates based on such calculations. It is clear that the average accumulation rates of total PAHs for sections occurring after about 1950 (i.e., <24 cm) are an order of magnitude greater than those for the pre-1950 period. Moreover, the average accumulation rates appear not to have changed significantly during the three decades since 1950. The estimated accumulation rates for deeper sections of the core (i.e., >24 cm) are similar to those made by Gschwend and Hites (1981) for sediments near urban centers such as Boston Harbor and Buzzards Bay, MA. These are, nevertheless, at least an order of magnitude higher than those found at remote locations where sedimentary fluxes are dominated by atmospheric deposition. This suggests that even the deeper sections of the 3C core may have been heavily influenced by local inputs (including natural oil seepage) with direct atmospheric deposition playing only a minor role. Such a hypothesis is consistent with stable isotopic and molecular evidence at this site and in San Pedro Basin.

The results discussed here demonstrate the need for further study of municipal wastewater inputs of PAHs to the coastal ecosystem. In recent years, there has been a marked reduction in the mass emission rates of suspended solids, oil and grease, and other trace constituents from the JWPCP (Stull and Haydock 1988). It is, therefore, important to determine if similar reductions have occurred for PAH inputs. Because these toxic compounds appear to be accumulating in nearshore sediments at rates far in excess of "natural" fluxes, information regarding the bio-

Table 3. Average accumulation rates of PAHs in sediments at station 3C, 1981.

Depth Interval (cm)	Approx. Date Interval	Accumulation rate (ng cm^{-2} yr^{-1}) for: Fla	Pyr	B[*a*]A	Chr/Tr	B[*e*]Pyr	B[*a*]Pyr	Tot. PAH
0-8	1971-81	77	273	89	173	227	274	2640
8-14	1962-71	65	335	76	135	316	200	2970
14-24	1950-62	117	283	80	124	333	276	2870
24-34	1937-50	18	28	8	11	25	22	240
Boston Harbor[a]		37	39	19	23	14	17	NR[b]

[a]From Gschwend and Hites (1981).
[b]NR, Not reported.

geochemical fate and chemical speciation of sewage-derived PAHs is also of interest. Current evidence clearly indicates that the dominant source of PAHs to the JWPCP effluent (as of 1979) is petroleum. A large, but unknown, fraction of these PAHs appears to have been lost during the early stages of diagenesis. Hence, only the more resistant, higher molecular weight PAH species tend to accumulate in waste-impacted sediments. Whether the presence of these carcinogenic substances represents a threat to the health of indigenous marine life remains to be investigated.

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Current Flow Patterns in the San Diego Bight

During 1987, staff oceanographers Terry Hendricks and Niels Christensen developed methods to identify and quantify the flow patterns in the San Diego Bight. This information was required to ensure that the discharge from a proposed new ocean outfall would not contaminate the nearshore waters with bacteria.

A new ocean outfall may be constructed in the San Diego bight near the border with Mexico. Bathing water standards for total coliform bacteria must be met nearshore and in *Macrocystis pyrifera* kelp beds, so the treatment method, outfall design, and outfall location must be selected to meet these requirements. A variety of factors affects the presence of outfall-related bacteria in these protected waters. These include the concentration of bacteria in the effluent, the magnitude of the initial dilution, subsequent dilution by oceanic processes, die-off of the bacteria, and the rate and frequency of transport of wastewaters into the protected areas by ocean currents. The SCCWRP researchers were asked to quantify one element of this analysis: transport by ocean currents.

Figure 1 shows the study area. The indentation south of Point Loma and San Diego Bay forms the San Diego Bight. The dashed line extending offshore from the coast delineates the border with Mexico. The two solid lines near the border indicate possible alignments for the proposed outfall; the line extending offshore from Point Loma (terminating in a "vee") indicates the location of the existing outfall. The dashed line roughly paralleling the coast marks the offshore boundary of the area to be protected from bacterial contamination.

During 1986-87, Engineering Science obtained about one year of current meter data from the seven moorings indicated by the circles in Figure 1. Previous, but limited, measurements of currents in this area by SCCWRP (Hendricks 1981) have indicated that the presence of the bight introduces additional complexity into the coastal flow patterns. In view of this complexity, it would have been desirable to obtain information on the circulation in the middle and upper portion of the bight from additional current meter moorings. Unfortunately, this region lies within a U.S. Navy restricted area (indicated by the trapezoidal area in Figure 1).

The task faced by the SCCWRP researchers was to use this mass of current meter data to provide estimates of the frequency and rate of transport of wastewaters into the protected nearshore area for various possible termination locations of the proposed outfall. In order to do this, they developed the following five-step process.

(1) The currents were partitioned into two components--tidal (and shorter period fluctuations) and non-tidal flows. The latter dominate the transport between the proposed outfall terminus and the protected area; the former have the effect of additional dispersion superimposed on the flow.

(2) The non-tidal flows were examined for reoccurring patterns. Each observed flow pattern can be approximated as a combination of these elemental flow patterns.

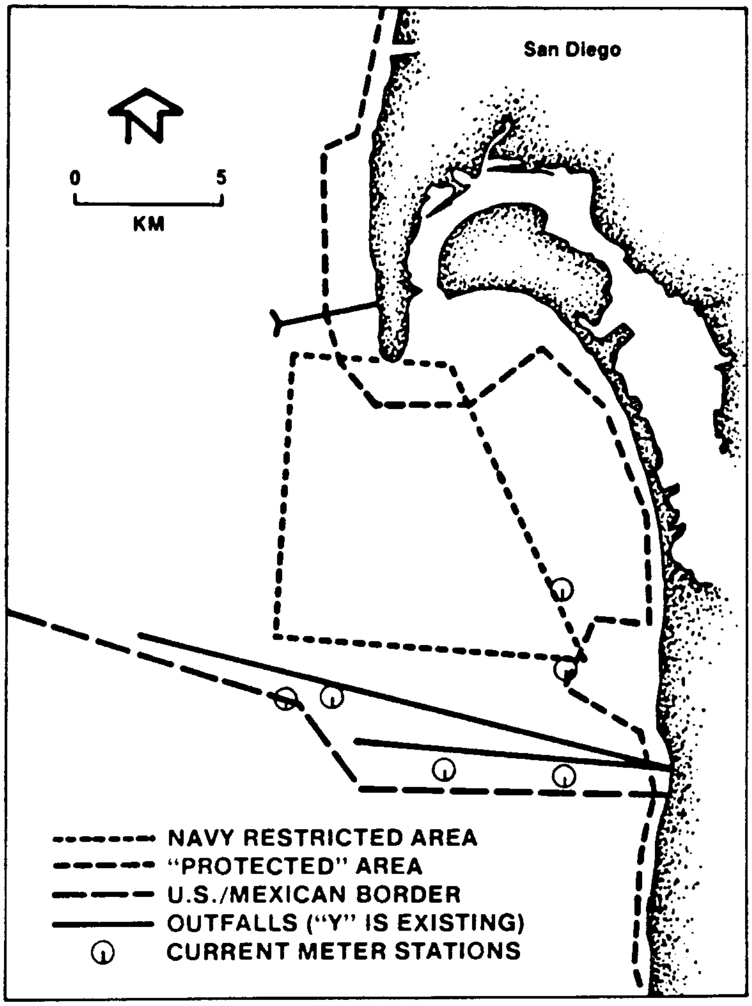

Figure 1. Study area.

(3) The variations in time for the strength of each elemental flow pattern were used to quantify the probability of occurrence for each composite flow pattern.

(4) The general characteristics of coastal flows were used in a numerical flow model to extend the composite flow patterns away from the current meter moorings and into other areas of the bight.

(5) The dispersion of wastewater associated with tidal (and shorter period) fluctuations was reintroduced to the transport estimates.

Through the use of this technique, it was possible to reduce the total of approximately 150,000 observations from the 10 meters used in the analysis to a few tens of circulation patterns, and to quantify the frequency of occurrence of each pattern.

A pair of velocity component (e.g., N-S and E-W) time-series was constructed from the speed-direction time-series for each current meter. A simple filter was applied to these series to remove fluctuations with tidal, or higher, frequency. Cross-correlation coefficients were then computed for each pair of the residual time-series. A mathematical technique, empirical orthogonal function (EOF) analysis, was used to identify statistically independent patterns in the correlations. For 10 current meters, and two components to the flow at each meter, 20 possible "elemental" flow patterns will be produced by this analysis. All the observed flows in the original time-series can be represented as a (time-varying) combination of these 20 elemental patterns. Up to this point, nothing has been gained by this analysis from the standpoint of reducing the number of observations required for the analysis.

It frequently happens, however, that most of the observed flows can be adequately represented as a combination of only a few of the elemental patterns. This turned out to be the case in the San Diego Bight. Two patterns, a more-or-less longshore flow and an eddy, were found to account for about 82% of the total observed variance (variability). Therefore, it was possible to approximate the observed flows as the combination of just two elemental flow patterns instead of the original 20.

So far, the flow patterns only describe the flows in the immediate vicinity of the current meter

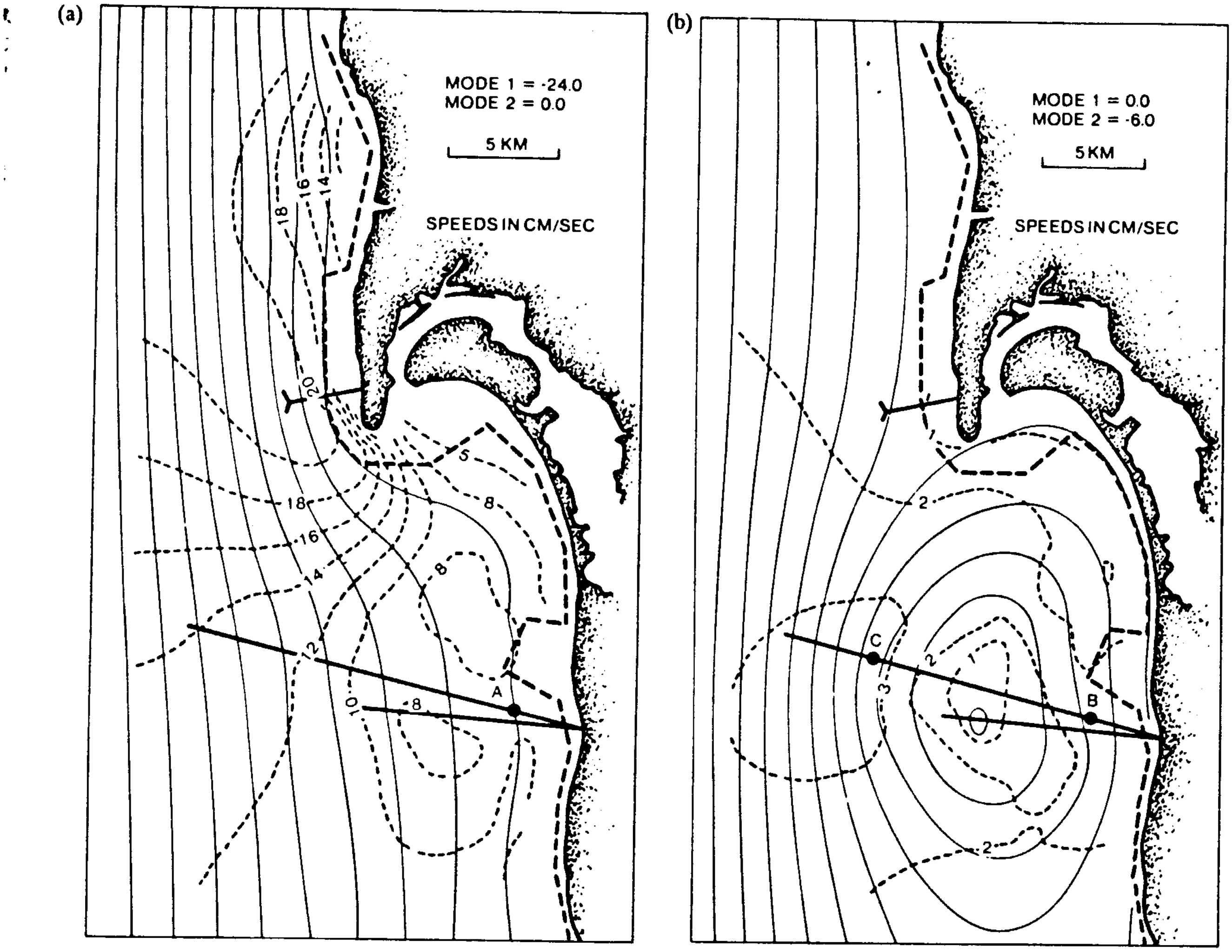

Figure 2. Two elemental flow patterns: (a) longshore flow and (b) eddy.

moorings. The presence of the coast can be expected to change the direction and strength of the currents from location to location, and it is necessary to estimate these variations to assess the frequency and rate of transport into the nearshore protected waters.

In order to do this, Hendricks and Christensen made a number of assumptions. First, they assumed that far offshore, the flow was essentially parallel to the general trend of the coastline. In addition, they noted that coastal flows frequently appear to be nearly in geostrophic balance--that is, the "force" associated with the earth's rotation is roughly balanced by the pressure gradients associated with the density stratification of the water column and the slope of the sea surface. They combined these assumptions with the requirement that the simulated flows reproduce the observed flows at each of the current meter moorings in a numerical model to simulate the circulation patterns over a larger area.

With these approximations, the circulations associated with the two elemental flow patterns identified from the EOF analysis are shown in Figures 2a (longshore flow) and 2b (eddy). In these figures, the light solid lines represent the trajectories of water as they move through the area. Where the lines are closer together, the currents move

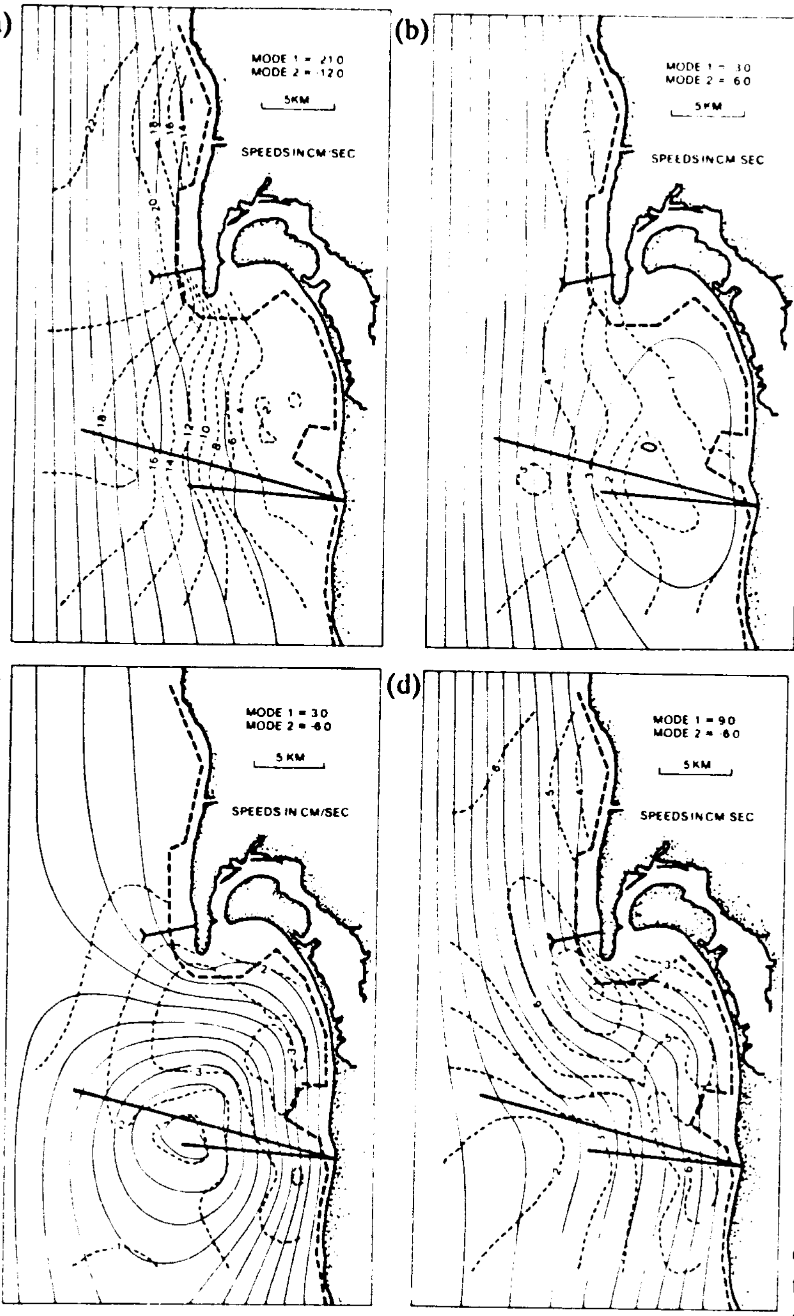

Figure 3. Four possible combinations of the two elemental flow patterns.

faster; where they are farther apart, the flows are weaker. From Figure 2a, it is immediately evident that if only the longshore flow pattern is present, wastewater discharged from the outfall offshore of point A will not come into contact with the protected area (actually, the dispersion associated with tidal motions still needs to be taken into account). On the other hand, only discharge from inshore of point B, or offshore of point C, in Figure 2b will impact the protected area. Thus these streamline diagrams provide a convenient method for analyzing the flow trajectories.

One should also note that these same trajectories exist whether the flow is strong or weak--only the rate and direction (e.g., upcoast/downcoast, clockwise/counterclockwise) of the flow depend on the magnitude and sign of the strength of the elemental flow.

As noted above, each of the observations during the course of the year-long study can be approximated as a simple combination of these two elemental patterns. Examples are shown in Figures 3a-3d for various strengths of the two elemental flow patterns. However, the strength of the contributions from each of two patterns will change during the passage of time and little would be gained by the previous analysis if a composite flow pattern must be generated for each observation time.

The time-series describing each of the elemental flow patterns can be generated from the original time-series for each current meter. It is convenient to describe the amplitude of each flow at each point in time in terms of the plot shown in Figure 4. In this plot, only a single point, corresponding to an amplitude of +10 and +5 for the two

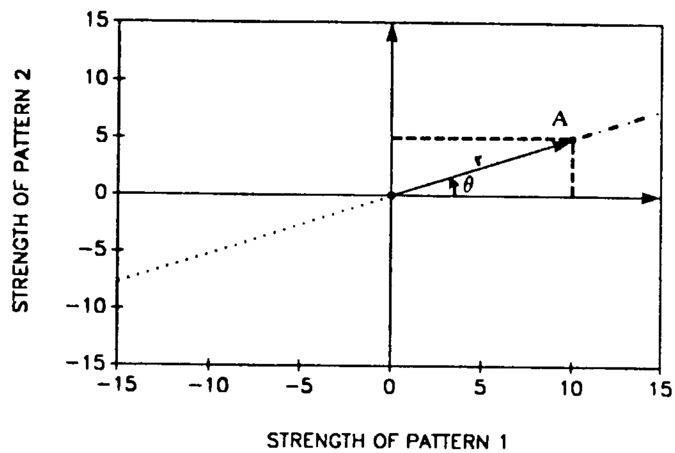

Figure 4. Representation of observations by the strength of the two patterns. Point A represents one observation in the time-series of observations.

components (respectively) is shown for clarity. However, the actual plot would contain as many points as there were observations in the original time-series used to compute the correlation coefficients.

The location of any point in this plot can be described in either rectangular coordinates (e.g., pattern 1, pattern 2), or by a radius and angle (as shown in Figure 4). The advantage of the latter approach is that all dots that lie along a line with the same angle have the same flow pattern and the same trajectory plot. The only difference between two flows lying at different distances from the origin along the line shown in Figure 4 is the strength (speed) of the flow. Moreover, dots lying along the same line extended through the origin also have the same trajectories--but with the flow in the opposite direction. Analysis also shows that dots lying close to this line have flow trajectories that are only slightly different from those lying on the line.

As a result, it is not only possible to substantially reduce the number of flow patterns that must be simulated, but to compute the probability of occurrence of each of the simulated flow patterns. Approximately 50 flow patterns were generated in the analysis (Figures 3a-3d represent 4 of the 50). This number was more than sufficient to describe the range of circulations contained in the original time series. Without this similarity analysis, it would have been necessary to generate more than 2600 flow patterns.

All the preceding analysis neglected the transport of wastewater by tidal currents. These motions were treated as a dispersion that is superimposed on the trajectories obtained from the previously described methods. The cross-shore component of the currents associated with tidal (and shorter period) motions (initially removed from the analysis) was used to compute this dispersion. It was found that the cross-shore distribution was essentially independent of time for elapsed times (i.e., the time since discharge from the outfall) of more than about 6 h. Approximately 50% of the time, the tidal motions would move the wastewater less than 0.5 km from the computed trajectory; about 90% of the time it would lie within 1 km of the trajectory; and virtually 100% of the time it would be within 2 km. These dispersion factors are easily applied to the trajectory diagrams to take into account the tidal motions.

The products of this study have been twofold. A new method has been developed to simplify the analysis of massive amounts of current meter data, and this method has been used to overcome the geographical constraints on the collection of oceanographic data required for siting the south San Diego outfall.

Acknowledgment

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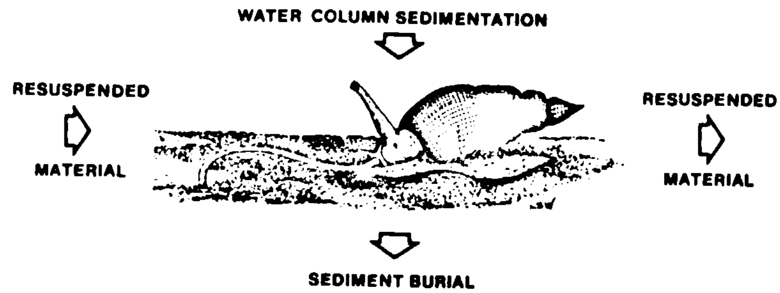

Figure 1. Possible sources of food to the benthic community.

Flux of Organic Material and Benthic Community Structure

Discharges from ocean outfalls are frequently accompanied by changes in the composition of the sediments and the abundance and structure of the animals living on and within the sediments. Staff oceanographer Terry Hendricks has been developing numerical simulation models to relate these changes to the characteristics of the effluent, the discharge system, and the receiving water environment (SCCWRP 1987).

These models attempt to predict the distribution, concentration, and accumulation of effluent and natural particles in the sediments around the outfall. Measurements of populations of benthic biota and organic content of the sediments showed an inverse relationship between these two variables (Hendricks 1985). In previous simulations, predictions of the distribution and concentration of organic material in the sediments were combined with this relationship in an attempt to provide estimates of the outfall-induced changes in the benthic community structure. The ability to predict community structure, as measured by the Infaunal Index, appeared to be better than the ability to predict concentrations of organic material in the sediments (Hendricks 1985). This was surprising because the biological predictions were based on the sediment organic content predictions.

Sediment trap studies conducted by Hendricks have provided a possible explanation for this paradox. It is assumed that the availability of food (e.g., organically enriched effluent particles) plays a role in regulating benthic community structure and abundance. This food may become available through sedimentation from the water column, accumulation in the sediments, or transport through the area by near-bottom currents (Figure 1).

The fluxes of resuspended material into sediment traps are generally one, or more, orders of magnitude greater than the rates of sedimentation from the water column or accumulation in the sediments. Thus the supply of organic matter to the benthic biota is likely to be dominated by the horizontal transport of organic matter by near-bottom currents. This flux of material, however, may have little relation to the concentration of organic material in the sediments.

In order to examine this hypothesis, Hendricks used the numerical simulation models SEDF2D and SEDR to simulate the deposition and the resuspension, transport, and accumulation of sediments, respectively. SEDR is an updated version of the model SEDP; SEDF2D and SEDP have been described previously (SCCWRP 1987). A by-product of the simulation process is an estimate of the transport fluxes of organically enriched outfall particles by the near-bottom currents.

Simulations were carried out for the Orange County (Newport Beach), City of San Diego (Point Loma), and Los Angeles County (White Point) outfall areas. Near-bottom transport fluxes were obtained for stations in each outfall area where Infaunal Index values were already available (Bascom 1979). Infaunal Index values for stations with comparable transport fluxes were combined into a composite value to reduce the natural variability.

The results for the Orange County and San Diego outfall areas are shown in Figure 2. At both sites, the Infaunal Index was inversely related to the flux of effluent material in the near-bottom waters. The Infaunal Index is observed to decrease by about 21 to 25 units for each 100 mg/cm² (bottom area) per year increase in near-bottom effluent particle transport flux. Although the two sites have approximately the same dependence on this flux, the natural (flux = 0) community structures are different. In the absence of any discharge, the expected Infaunal Index at the Orange County outfall is about 93; at the Point Loma site, it is about 77. The correlation coefficients for significant relationships at the Orange County and San Diego sites are -0.95 and -0.90, respectively, yielding 92 and 95% confidence levels.

Figure 3 shows the corresponding plot for the White Point area. Again a significant inverse correlation is observed ($r = -0.95$; $P < 0.02$). At this site, however, the reduction in Infaunal Index per unit near-bottom flux is only about one-quarter the rate at the other two sites. The reason for this difference is not known. Since the no-discharge Infaunal Index for the White Point area is estimated to be only about 57, it is possible that this substantially different assemblage of bottom dwellers responds differently than the communities at the other two areas. Alternatively, since the water column sedimentation and the accumulation fluxes are comparable in magnitude to the horizontal transport flux at this site (SCCWRP 1987), a more detailed estimate of the total flux of effluent material through the

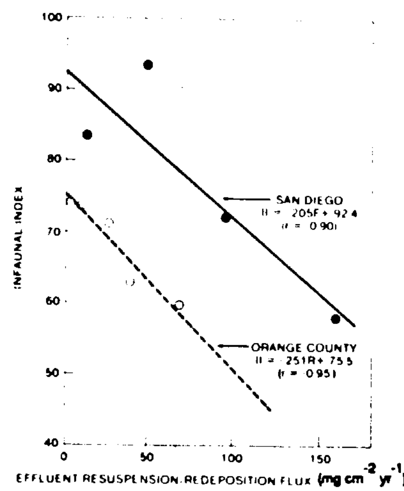

Figure 2. Infaunal Index values versus near-bottom flux for the City of San Diego and Orange County outfall areas.

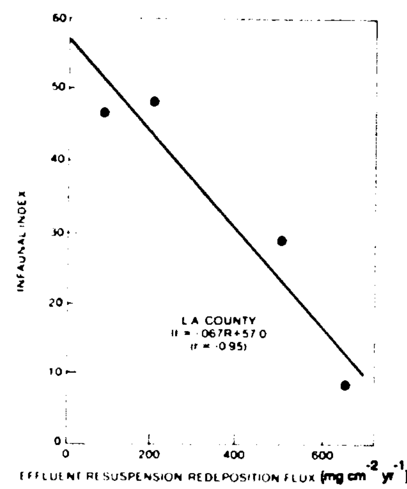

Figure 3. Infaunal Index values versus near-bottom flux for the Los Angeles County outfall area.

near-bottom environment may be required.

The correlation observed between Infaunal Index values and the (estimated) near-bottom transport of organically enriched particles is exciting because it offers the potential to estimate the effects on the benthic community structure associated with a discharge--and perhaps could assist in estimating the relative effects of toxicity and food supply on these assemblages. Additional work, including an explanation for the differences between White Point and the two other sites, will be required for this goal to be realized.

Acknowledgment

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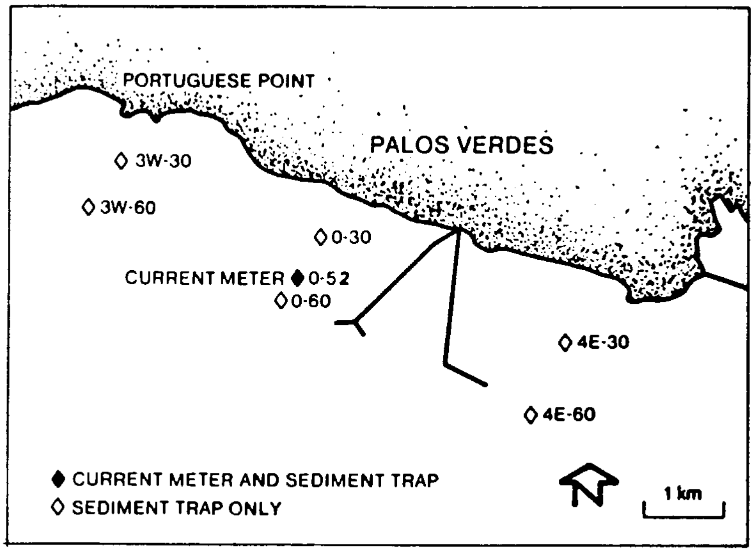

Figure 1. Current meter and sediment trap stations near the Los Angeles County outfall.

SCCWRP has been using sediment traps moored just above the sediment surface to obtain estimates of the rate of resuspension of sediment particles. Previous measurements in depths of water comparable with major outfalls (30 to 60 m) indicated resuspension flux rates that were one or more orders of magnitude greater than the accumulation rate of sediments (SCCWRP 1987). This difference in rates suggests that particles settling from the water column onto the sediments undergo a large number of resuspensions and redepositions before they become part of the "permanent" sediments. The dynamic nature of these surficial particles can substantially affect the distribution, concentration, and accumulation of effluent particles in the area around an ocean outfall.

Seasonal and Spatial Variations in Sediment Resuspension

In SCCWRP's 1986 Annual Report, Hendricks discussed some preliminary results from these sediment trap studies and the use of this data in a numerical simulation model (SEDP in SCCWRP 1987; the present, updated version is SEDR) of the resuspension, transport, and accumulation of effluent particles. That data represented a limited number of one-month observations from one or two locations in each of four outfall areas. Since that time, we have collected time-series of resuspension fluxes over a two-year period in the vicinity of the Orange County (Newport Beach) and Los Angeles County (White Point) outfalls. Measurements of the spatial variability in the resuspension rates and particle characteristics have also been made around the White Point outfalls during the summer of 1987. These measurements have provided new insight into sediment resuspension processes and have assisted in evaluating the validity of some of the assumptions contained in the simulation models.

Figure 1 shows the location of sediment trap moorings in the

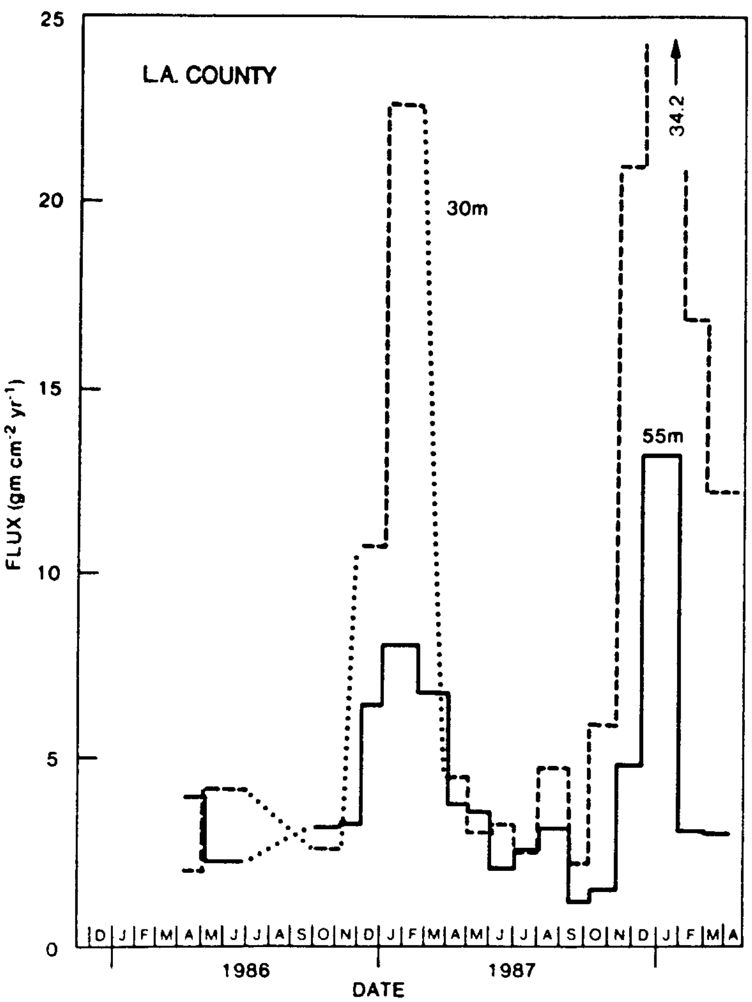

Figure 2. History of sediment trap fluxes near the Los Angeles County outfall at White Point. Dotted lines indicate no data.

White Point outfall area. Long-term time-series were collected at stations 0-30 and 0-52 (and/or 0-60); the remaining stations were only occupied during the summer and fall of 1987.

Figure 2 shows the fluxes of total particle mass collected during approximately one-month sampling periods beginning in April 1986 and extending to April 1988. The solid line represents the fluxes collected in 52 to 60 m of water; the dashed line represents the flux observed in 30 m.

The fluxes at both depths show a seasonal increase during the winter, with the greatest increase observed at the shallower depth. During both the 1986-87 and 1987-88 winters, the largest monthly flux was associated with the largest long-period swell during the winter. In summer, the fluxes collected at the 30- and 60-m depths are comparable. Wintertime fluxes vary from year to year. Maximum rates in the winter were about 23,000 and 34,000 mg cm^{-2} yr^{-1} during the two winters at a depth of 30 m, and about 8,000 to 12,000 mg cm^{-2} yr^{-1} at the 52- to 60-m depths. These rates are deceptive, however, since they are the average flux over the deployment period (typically 32 to 40 days), but most of the trapped particles were probably resuspended during the period of maximum swell (generally less than one day). Thus the "instantaneous" resuspension rates were probably at least an order of magnitude higher during the swell. The average fluxes over the two-year period were 10,600 and 4,400 mg $cm^{-2}\,yr^{-1}$.

The seasonal variations in the organic content of the material collected in the sediment traps are shown in Figure 3. Concentrations of organic material show an inverse relationship with the flux of total particle mass into the traps. The lowest concentrations occur in the winter; the highest in the spring-summer period. Since the net flow of near-bottom currents is upcoast and offshore flow, this change suggests that the inshore area may contribute a greater fraction of the material collected in the traps during the winter. Average total volatile solids (TVS) at both depths were about 10%.

Figure 4 shows the location of the two sediment trap moorings in the vicinity of the Orange County outfall. Figure 5 shows the seasonal variation in the flux of material into the traps at these stations from December 1985 until April 1988. In contrast to the observations in the White Point area, there is no clear seasonal signal. Average fluxes in 30 and 60 m of water are 2400 and 1100 mg $cm^{-2}\,yr^{-1}$, respectively. These fluxes are only about one-quarter the average fluxes in the White Point area.

The organic content of the material collected in the traps at the Orange County stations showed only a small seasonal effect. Again the highest concen-

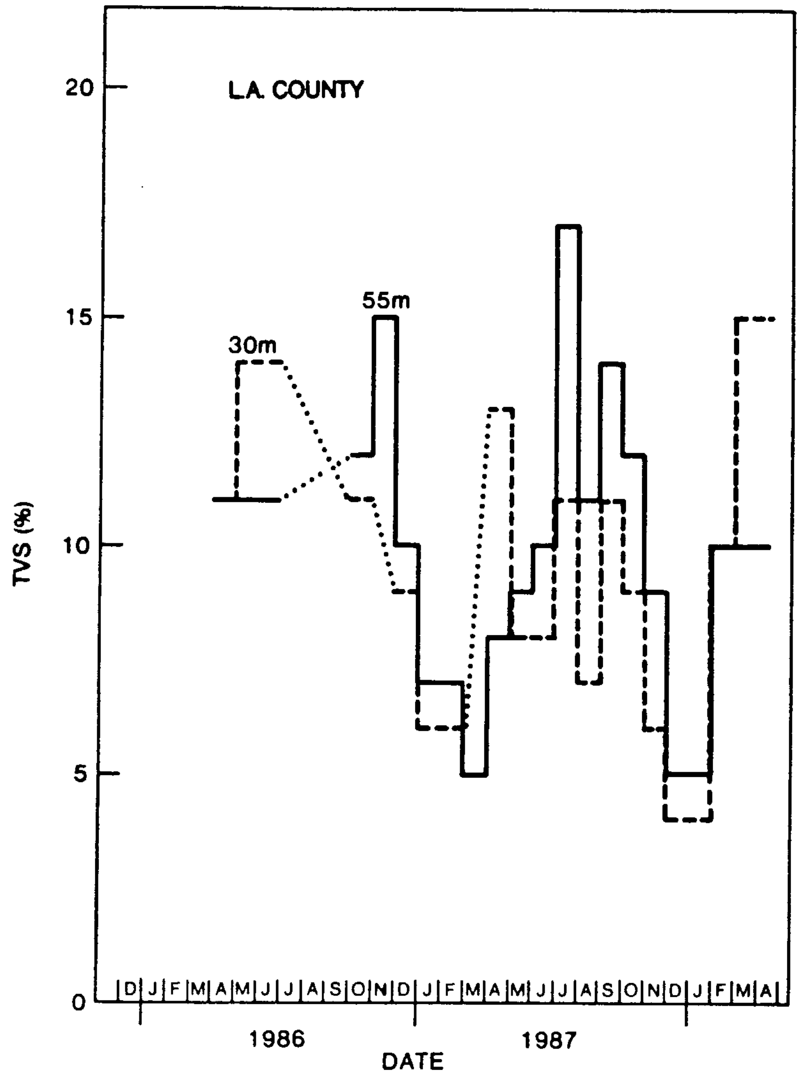

Figure 3. History of TVS collected in sediment traps near the Los Angeles County outfall. Dotted lines indicate no data.

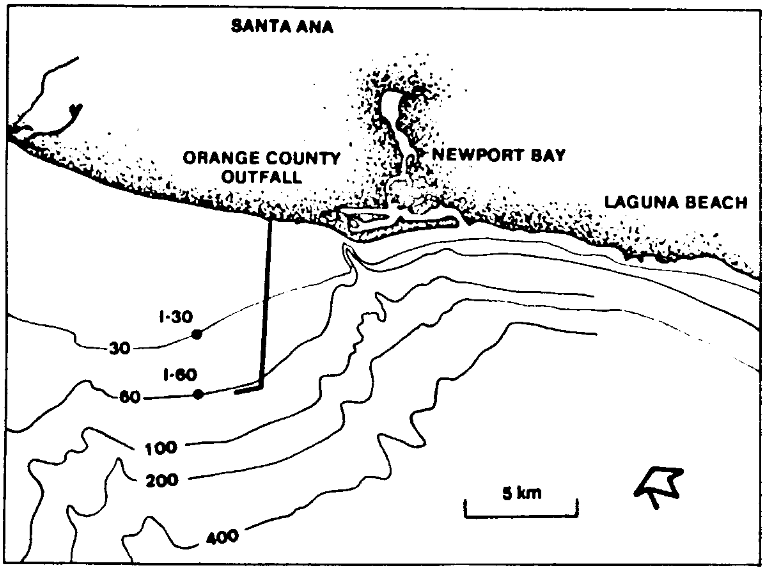

Figure 4. Locations of two sediment trap moorings near the Orange County outfall.

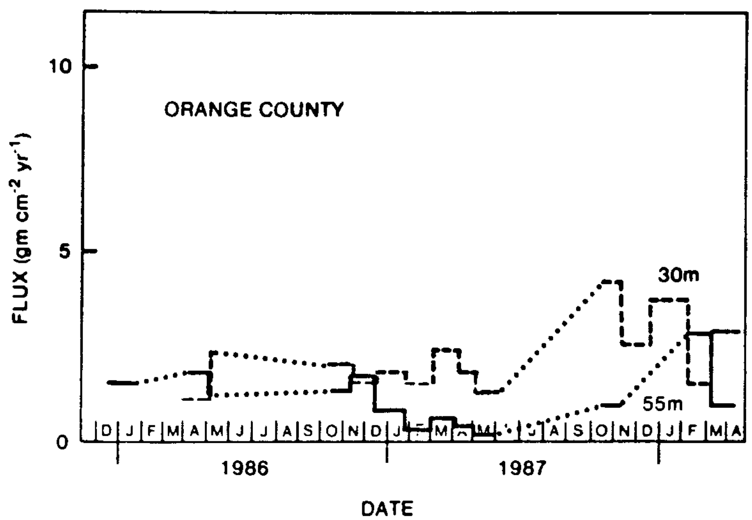

Figure 5. History of sediment trap fluxes near the Orange County outfall.

trations were observed in the summer. The average concentration of organic material in the traps (6%) was about 2 to 3 times that in the surface (0- to 2-cm depth) sediments (2 to 2.5%). This difference is consistent with differences observed in San Diego and Encina (Carlsbad) outfall areas.

Substantial differences in resuspension-redeposition fluxes have been observed between various outfall areas (e.g., White Point and Orange County, discussed above; and SCCWRP 1987). During the late spring to early fall of 1987, we deployed sediment traps at the 7 stations around the White Point outfalls shown in Figure 1 as part of a special study of sediment characteristics. One of the purposes of this deployment was to measure the spatial variability in sediment trap flux rates within a single outfall area.

Figure 6 shows the average resuspension-redeposition flux at each mooring for the period from May 1 until September 14. In 60 m of water, they ranged from about 2750 mg cm^{-2} yr^{-1} to about 3210 mg cm^{-2} yr^{-1}. This variation is within the normal range of variability between replicate traps ($\pm$ 30%). Along the "0" cross-shore transect, fluxes ranged from about 3060 mg cm^{-2} yr^{-1} in 30 m of water, to 4020 mg cm^{-2} yr^{-1} in 52 m, and about 2850 mg cm^{-2} yr^{-1} in 60 m of water-- again within normal variability.

There is, however, a significant, persistent, increase in flux at the station in 30 m of water just upcoast from Point Fermin. The source of this increased flux is unknown. A hint of increased flux rates is observed at the nearshore station near Portuguese Point. It was anticipated that increased fluxes might result from a local landslide in this area that terminates at the water's edge.

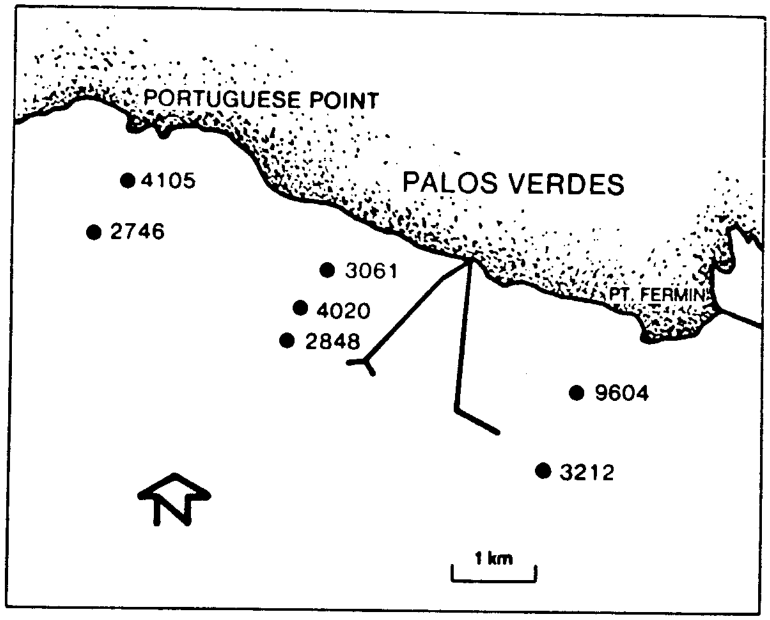

Figure 6. Apparent sedimentation flux (mg cm^{-2} yr^{-1}) for seven sediment traps near the Los Angeles County outfalls at White Point.

The fluxes into near-bottom sediment traps are substantially greater than net accumulation fluxes of material in the sediments. Significant variations in resuspension-redeposition fluxes occur between different regions of the coast, although they are relatively constant in 60 m of water over a 7- to 8-km section of the coast off White Point.

Large seasonal variations in the fluxes are observed in the White Point area in both 30 and 60 m of water. The increased fluxes are correlated with the presence of large-amplitude, long-period swells. In contrast, seasonal variations are negligible in both 30 and 60 m of water off Orange County.

The observed spatial and temporal variation in resuspension rates indicate that assumptions incorporated into the sedimentation/resuspension model set are only valid for selected areas and times (e.g., White Point in summer). Additional information on resuspension and redeposition mechanisms, the settling character of resuspension particles, and transport by near-bottom currents will be required to permit more universal simulations. Some of these questions will be addressed during the studies we have planned for the coming year.

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Table 1. Percentage of starry flounder with pleomorphic nuclei[a]

Station	% with NP rating 1	2	3	N
Berkeley	55	29	17	42
Oakland	65	22	13	23
San Pablo Bay	66	31	3	29
Vallejo	64	36	0	22
Santa Cruz	77	23	0	13
Russian River	97	3	0	29

[a]Abbreviations: NP, pleomorphic nuclei; N, sample size. Ratings: 1, <5% of erythrocytes were pleomorphic; 2, 5 to 50% of erythrocytes were pleomorphic; 3, >50% of erythrocytes were pleomorphic.

Micronuclei in Starry Flounder from San Francisco Bay

In this study, Jeffrey N. Cross of SCCWRP and Jo Ellen Hose of Occidental College quantified micronuclei in peripheral circulating erythrocytes of starry flounder (*Platichthys stellatus*) and correlated micronucleus frequencies with body burdens of chlorinated organic contaminants. The flounder were collected by otter trawl from four sites in San Francisco Bay and two sites along the outer coast of central California (Figure 1) during two sampling periods in the winter of 1986-87.

Micronuclei are small, secondary nuclei formed after chromosome breaks (Schmid 1976). They may arise spontaneously, but the induction of micronuclei above background levels is a sensitive indicator of genotoxic damage resulting from exposure to mutagens (Heddle et al. 1983).

Blood was collected from each fish immediately after capture, and smears were prepared on the ship. The smears were then stained in the laboratory, and the number of micronucleated erythrocytes per 1000 erythrocytes was determined. The erythrocytes were studied for degree of pleomorphism (loss of the usual elliptical shape of the nucleus) (Table 1) and for the presence of detached and attached micronuclei (Figure 2). If a pleomorphic nucleus had a projection greater than about one-fourth the nuclear diameter and the projection terminated in a chromatin mass, it was considered an attached micronucleus.

Micronuclei (detached and attached) and nuclear pleomorphism are manifestations of cytotoxicity. Detached micronuclei are formed after chromosomal breakage or spindle damage. Attached micronuclei and severe nuclear pleomorphism may be

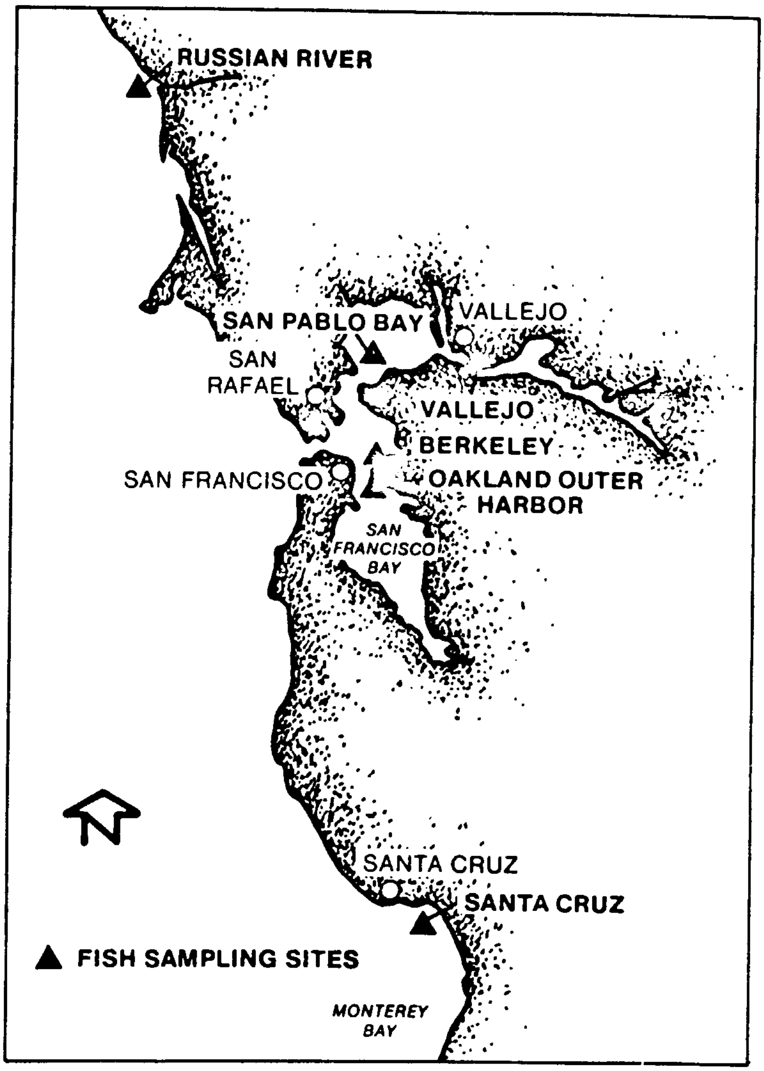

Figure 1. Map of the study sites.

the result of (1) chromosomal breakage or spindle damage, (2) destabilization of the nuclear membrane by certain chlorinated organics or intermediates of polynuclear aromatic hydrocarbon metabolism, or (3) agents that cause chromatin clumping (chromocenter formation) or margination (chromatin adhering to nuclear membrane).

Cross and Hose found that micronucleus frequencies were significantly higher among starry flounders collected within San Francisco Bay than among fish collected on the outer coast (Table 2). A significantly higher proportion of fish from the outer coast had no visible micronuclei. Within San Francisco Bay, there were no significant differences in micronucleus frequency. Fish with high micronucleus frequencies also had a high incidence of misshapen nuclei (nuclear pleomorphism).

In addition, micronucleus frequencies (1) were not significantly different among male starry flounders from the bay and the outer coast; (2) were significantly higher among females from the bay than among females from the outer coast; and (3) were positively correlated with fish size among females, but not among males, from San Francisco Bay stations.

The composition of organic contaminants in the livers of starry flounders was very similar among the four sites within San Francisco Bay and was slightly less similar between fish collected within the bay and on the outer coast (Figure 3). Fish from central San Francisco Bay had higher mean levels of contaminants than did fish from northern San Francisco Bay, and fish from the northern bay had higher mean levels than did fish from the outer coast (Table 3). Except for chlordane and lindane, contaminant concentrations were not correlated with fish size. Chlordane and lindane concentrations were higher in females collected in northern San Francisco Bay; these fish were generally smaller than females collected in the central bay.

The lack of compositional differences among fish from the different sites and the presence of fish with low organic contaminant concentrations at all of the sites suggest that (1) chlorinated hydrocarbons are present throughout the bay system and on the outer coast and (2) some starry flounders move throughout the bay and between the bay and the outer coast. In a review of data on chlorinated hydrocarbons in sediments and biota, Phillips and Spies (manuscript in review) concluded that some compounds, particularly polychlorinated biphenyls (PCBs), are widespread in the San Francisco estuarine system.

Micronucleus frequencies were not correlated with organic contaminant concentrations in this study. The results are consistent with the non-chromosome-breaking properties of DDTs and

Table 2. Starry flounder micronucleus frequencies per 1000 erythrocytes.[a]

Station	Mean	SD	Median	N	PROP
Berkeley	1.9	2.33	1.3	42	0.119
Oakland	1.5	2.06	0.5	23	0.348
San Pablo Bay	1.3	1.19	1.0	29	0.172
Vallejo	2.2	1.49	0.5	22	0.091
Santa Cruz	0.6	0.77	0.5	13	0.462
Russian River	0.4	0.74	0.0	29	0.655

[a]Abbreviations: SD, one standard deviation; PROP, proportion of zeros.

Table 3. Summary of starry flounder liver contaminant concentrations (µg/kg wet weight) by site. Data are means and one standard deviation (in parentheses).[a]

Station	N	Total DDT	Total Pesticides	Total PCB
Berkeley	18	202 (145)	50 (32)	422 (306)
Oakland	16	189 (120)	47 (34)	438 (312)
San Pablo Bay	14	161 (90)	48 (32)	110 (53)
Vallejo	14	160 (112)	30 (17)	110 (73)
Santa Cruz	4	73 (73)	119 (142)	89 (63)
Russian River	14	152 (245)	34 (44)	152 (253)

[a]N is the sample size; Total DDT is the sum of *p,p'*-DDE and *p,p'*-DDD; Total Pesticides is the sum of chlordane, dieldrin, heptachlorepoxide, and lindane;

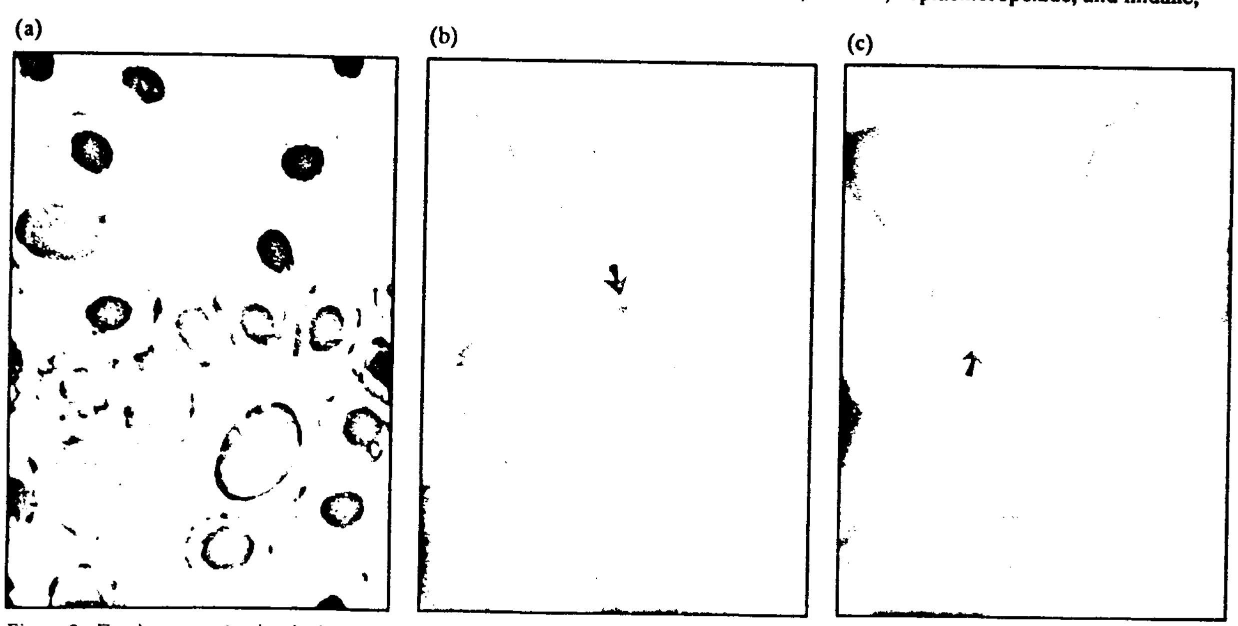

Figure 2. Erythrocytes (stained with May Grunwald-Giemsa) of starry flounder. (a) Sample from fish from the Russian River. Note the uniform elliptical appearance of the nuclei. White circles in the cytoplasm are artifacts. Magnification, X 5600. (b) One erythrocyte contains a detached micronucleus (arrow). Magnification, X 9450. (c) Sample from fish from San Pablo Bay shows an attached micronucleus (arrow). Many nuclei are pleomorphic. Magnification, X 9450.

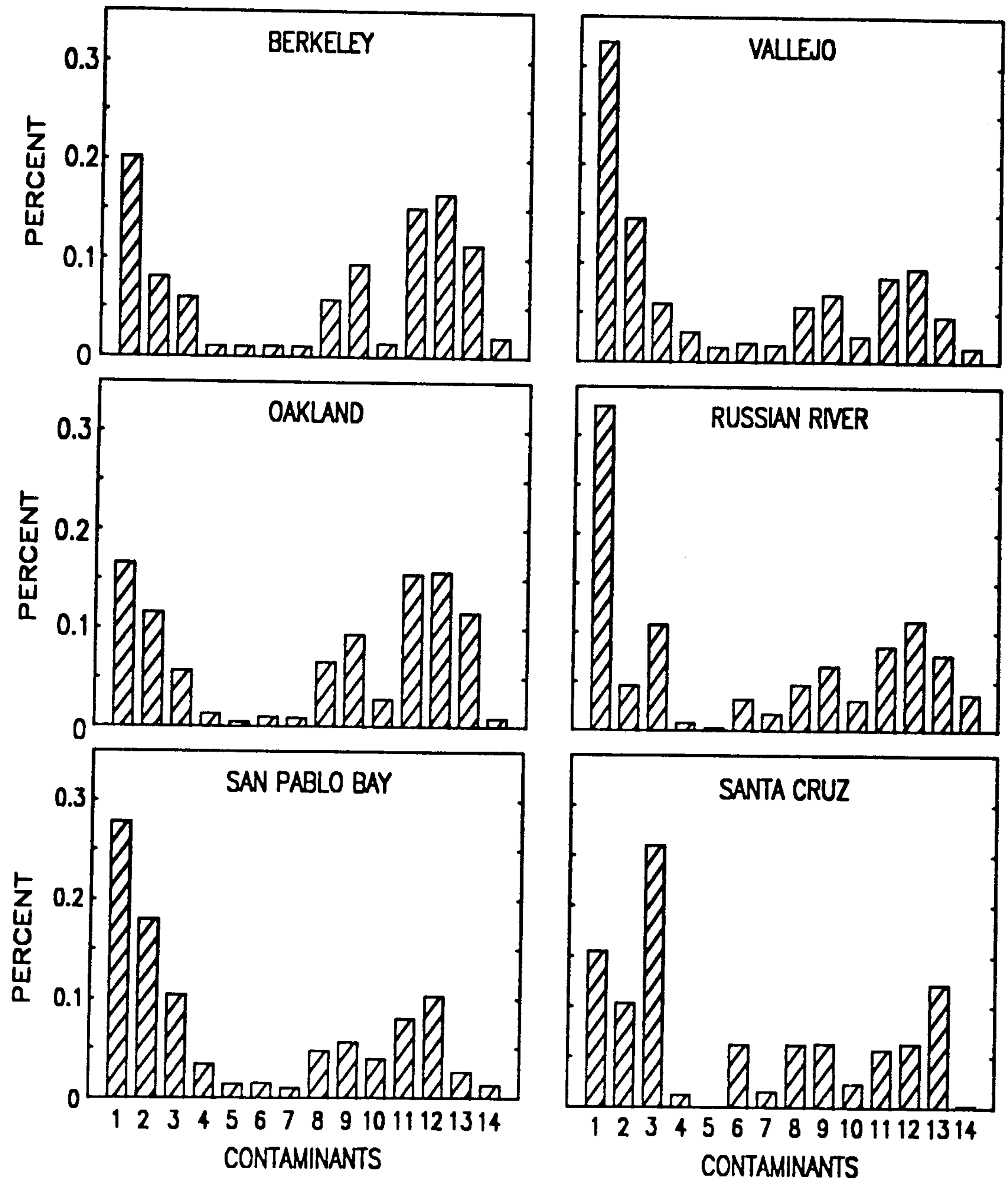

Figure 3. Normalized mean percentage of chlorinated hydrocarbons found in fish livers. Contaminant numbers on the abscissa are as follows: 1, *p,p'*-DDE; 2, *p,p'*-DDD; 3, dieldrin; 4, chlordane; 5, lindane; 6, heptachlorepoxide; 7, PCB44; 8, PCB101; 9, PCB118; 10, PCB128; 11, PCB138; 12, PCB153; 13, PCB180; 14, PCB206. PCB numbers indicate specific identities of the congeners (Ballschmiter and Zell 1980). Numbers increase with increasing molecular weight.

PCBs (Green et al. 1975, Heddle et al. 1983). It is well known from many mammalian and a few fish experiments that compounds such as metabolites of mutagenic polynuclear aromatic hydrocarbons (e.g., benzo[*a*]pyrene), mutagenic nitroaromatics and phenols, and carcinogenic volatile monoaromatics (benzene) enhance micronucleus formation (Schmid 1976, Hoofman and de Raat 1982, Heddle et al. 1983). These compounds were not measured in this study but are present in San Francisco Bay and may be responsible for the micronucleus frequencies observed.

Micronucleus frequencies of starry flounder from stations within San Francisco Bay (mean = 1.7‰, median = 0.5‰) were lower than micronucleus frequencies of white croaker (mean = 3.4‰, median = 2.5‰) and kelp bass (mean = 6.8‰, median = 4.3‰) from contaminated sites near Los Angeles (outer San Pedro Bay and eastern Palos Verdes Peninsula, respectively) (Hose et al. 1987).

Acknowledgments

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Chemical analyses were performed by Dr. R. Spies and D. Rice of Lawrence Livermore National Laboratory.

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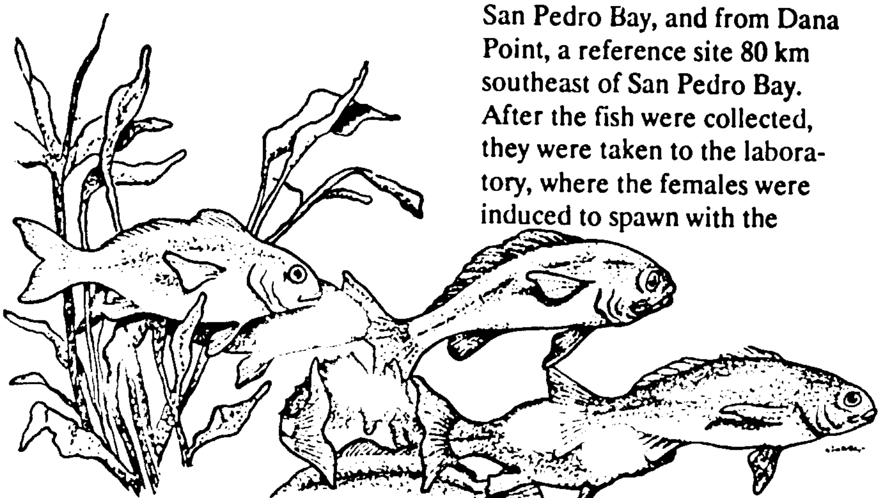


Impaired Reproduction in White Croaker off Southern California

The coastal waters off Los Angeles have received thousands of tons of domestic and industrial contaminants during the past 40 years. Exposure to these contaminants has been implicated in a decrease in catches of several species of sport and commercial fish. In this study, Jeffrey N. Cross of SCCWRP and Jo Ellen Hose of Occidental College examined white croaker (*Genyonemus lineatus*), an important sport and commercial fish inhabiting the coastal waters off Los Angeles, to determine if reproduction was impaired in fish from this contaminated region.

White croaker were collected from outer Los Angeles Harbor, a contaminated area in San Pedro Bay, and from Dana Point, a reference site 80 km southeast of San Pedro Bay. After the fish were collected, they were taken to the laboratory, where the females were induced to spawn with the hormone human chorionic gonadotropin. The resulting eggs were fertilized with sperm that was pooled from at least three males from the same locations as the females.

Statistical analysis showed that there was not a significant difference in the proportion of spawning females between the two locations. The ovaries from non-spawning fish were examined under a microscope, and the scientists found that non-spawning fish from Dana Point had hydrated oocytes, which indicates that they were maturing and spawning would occur soon. However, the non-spawning fish from San Pedro Bay had only yolky oocytes and remained unresponsive to the hormone injections.

Table 1 shows that white croaker from San Pedro Bay had higher concentrations of chlorinated hydrocarbons in their livers and gonads than the fish from Dana Point did. The San Pedro fish also produced fewer eggs and had lower fertilization rates.

At the beginning of the reproductive season, numbers of early oocytes were compared among females to account for potential differences in the timing of oocyte maturation at the two locations. Fish from San Pedro Bay produced fewer oocytes and had a greater number of these cells degenerating than the fish from Dana Point did (Table 1).

Concentrations of polychlorinated biphenyls (PCBs) were not significantly different between spawning fish from San Pedro Bay and the general population in that area. DDT concentrations in the ovaries of spawning fish from San Pedro Bay averaged 2.1 ppm (mg/kg wet weight), which was significantly less than the ovarian DDT concentrations (4.2 ppm) of fish from the general population in that area. None of the spawning fish from San Pedro Bay had ovarian DDT levels greater than 3.8 ppm, but in the general

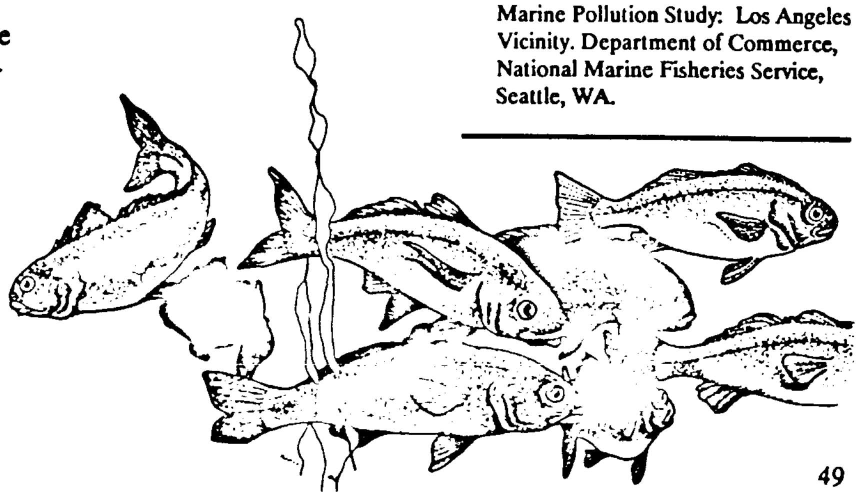
Table 1. Contaminant body burdens and reproductive success of female white croakers collected during December and January (1985-86) and spawned between January and March (1986). Data are mean ± standard deviation (sample size).

Measurement	San Pedro Bay	Dana Point
Body burdens[a]		
DDT - Liver (mg/kg wet)	1.52 ± 0.77 (19)	0.17 ± 0.07 (8)
DDT - Ovary (mg/kg wet)	2.10 ± 0.85 (19)	0.31 ± 0.18 (8)
PCB - Liver (mg/kg wet)	1.35 ± 1.34 (19)	0.03 ± 0.06 (8)
PCB - Ovary (mg/kg wet)	1.67 ± 1.02 (19)	0.16 ± 0.08 (8)
Reproductive success		
No. eggs spawned/female	67400 ± 62800 (21)	104500 ± 32000 (9)
%Fertilization	80 ± 16 (21)	93 ± 3 (6)
No. early oocytes/field	1.5 ± 0.6 (6)	2.7 ± 0.8 (6)
%Degenerated	15.0 ± 8.8 (6)	2.1 ± 2.4 (6)

[a]Abbreviations: DDT, total DDT (sum of DDD, DDE, and DDT); PCB, total PCB (sum of Aroclors 1242 and 1254).

population 38% of the fish had DDT levels greater than 3.8 ppm. Apparently, white croaker with ovarian DDT levels greater than 4 ppm do not spawn. In salmonid hatchery studies, Burdick and co-workers (1964, 1972) found there was a 3-ppm threshold for spawning. Although DDT concentrations are correlated with reproductive impairment, they are probably not the only cause of the effects found in this study. It has previously been found (Malins et al. 1986) that other contaminants (polynuclear aromatic hydrocarbons and trace metals) occur at high concentrations in sediments and fish from San Pedro Bay.

This study by Cross and Hose shows that white croaker inhabiting contaminated areas near Los Angeles have higher chlorinated hydrocarbon body burdens, greater early oocyte destruction and preovulatory degeneration, lower fertilization rates, and decreased egg production than do fish from the reference location. The mechanisms for reproductive impairment similar to that found in this study are not completely understood but may include a change in essential hormone levels, toxicity to developing gametes or nutritive cells, and generalized stress responses.



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This material has been presented at the Fourth International Symposium on Responses of Marine Organisms to Pollutants at Woods Hole Oceanographic Institution, Woods Hole, MA. For the original published article of this work, see *Mar. Environ. Res.* 24:185-188.

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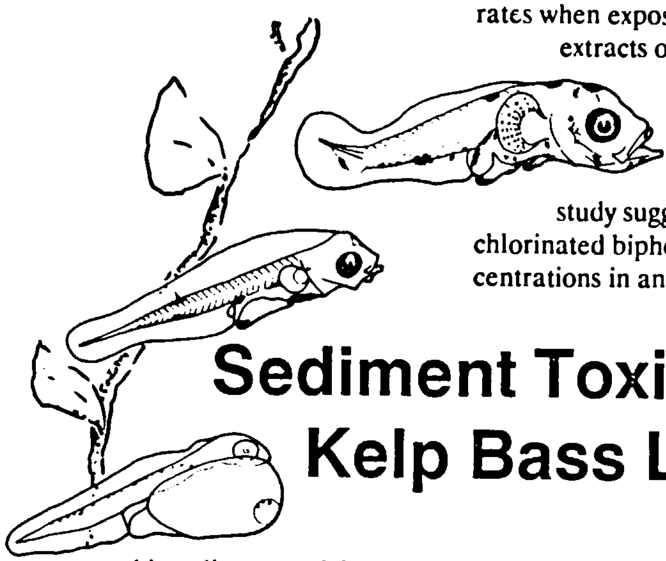

Sediment Toxicity to Kelp Bass Larvae

This sediment toxicity experiment by Dario W. Diehl (SCCWRP) and Jo Ellen Hose (Occidental College) focused on larval kelp bass (*Paralabrax clathratus*). Adults and juveniles are found in kelp beds and rocky reefs along the coast. They are a primary sport fish available throughout the year in the southern California region and become reproductively active in early summer. Kelp bass are very hardy fish, which makes them excellent laboratory animals. Some of these fish were spawning naturally after one year of captivity at Southern California Edison's research and development laboratory in Redondo Beach.

Kelp bass, like many other fish species, have larvae that develop in the water column during the spring and early summer. A previous study found that different species of fish larvae have different survival rates when exposed to seawater extracts of sediment from Charleston Harbor, SC (Hoss et al. 1974). Another study suggested that polychlorinated biphenyl (PCB) concentrations in anchovy larvae, *Engraulis mordax*, were dependent on the PCB concentrations in seawater and not on the PCB concentration in the food the larvae ingested (Scura and Theilacker 1977). For the present experiment the researchers tested the response of kelp bass larvae to sediments from four southern California coastal areas instead of seawater extracts.

Fish were captured from Catalina Island during the summer of 1986. Sediment was collected just prior to the experiment in the summer of 1987 from a relatively uncontaminated reference area (San Mateo Point), an industrialized harbor (Los Angeles), and two areas adjacent to large municipal wastewater outfalls (Orange County and Los Angeles County).

The static bioassay consisted of 5-gallon aquaria containing 2 cm of sediment and 15 L of filtered seawater. Control tanks contained only seawater. Five replicates of each sediment and seawater control were prepared. Water was changed carefully every 2 to 3 days, so little sediment resuspension occurred. One hundred and fifty 10-day-old yolk sac larvae were added to each aquarium. After 13 days, the surviving larvae were counted, weighed, microscopically measured, and examined for malformations. Larvae were fed daily with rotifers and brine shrimp nauplii during the experiment.

Chemical analysis showed that San Mateo Point is relatively clean, Orange County outfall is moderately contaminated, and Los Angeles Harbor and Los Angeles County outfall are fairly contaminated (Figure 1). Mean polynuclear aromatic hydrocarbon (PAH) concentrations were lowest at San Mateo Point (2 ng/g [ppb] wet weight) and highest in Los Angeles Harbor (2872 ppb). Mean PCB concentrations were lowest at San Mateo Point (2 ppb wet weight) and highest at Los Angeles

County outfall (345 ppb). Low levels of PAHs (47 ppb) and PCBs (18 ppb) were detected at Orange County outfall. Mean total DDT concentrations were lowest off Orange County and San Mateo Point (4 and 8 ppb wet weight, respectively). The highest level of DDT was found at Los Angeles County (2097 ppb) and Los Angeles Harbor had a moderate level (109 ppb) of DDT contamination.

Larval survival ranged from 11% in the control to 1.9% in Los Angeles Harbor sediment (Figure 2a). Larvae in Orange County, Los Angeles County, and Los Angeles Harbor sediment had statistically significant lower survival than those in San Mateo Point sediment. Survival of larvae in seawater control and reference area sediment were not statistically different and survival rates are typical of species with floating larvae. No statistical differences were found among the three contaminated areas.

Larval weight ranged from 0.93 mg in Orange County sediment to 0.57 mg in Los Angeles County sediment (Figure 2b). No statistical difference could be found among larvae from San Mateo Point, seawater, Orange County, Los Angeles County, and Los Angeles Harbor.

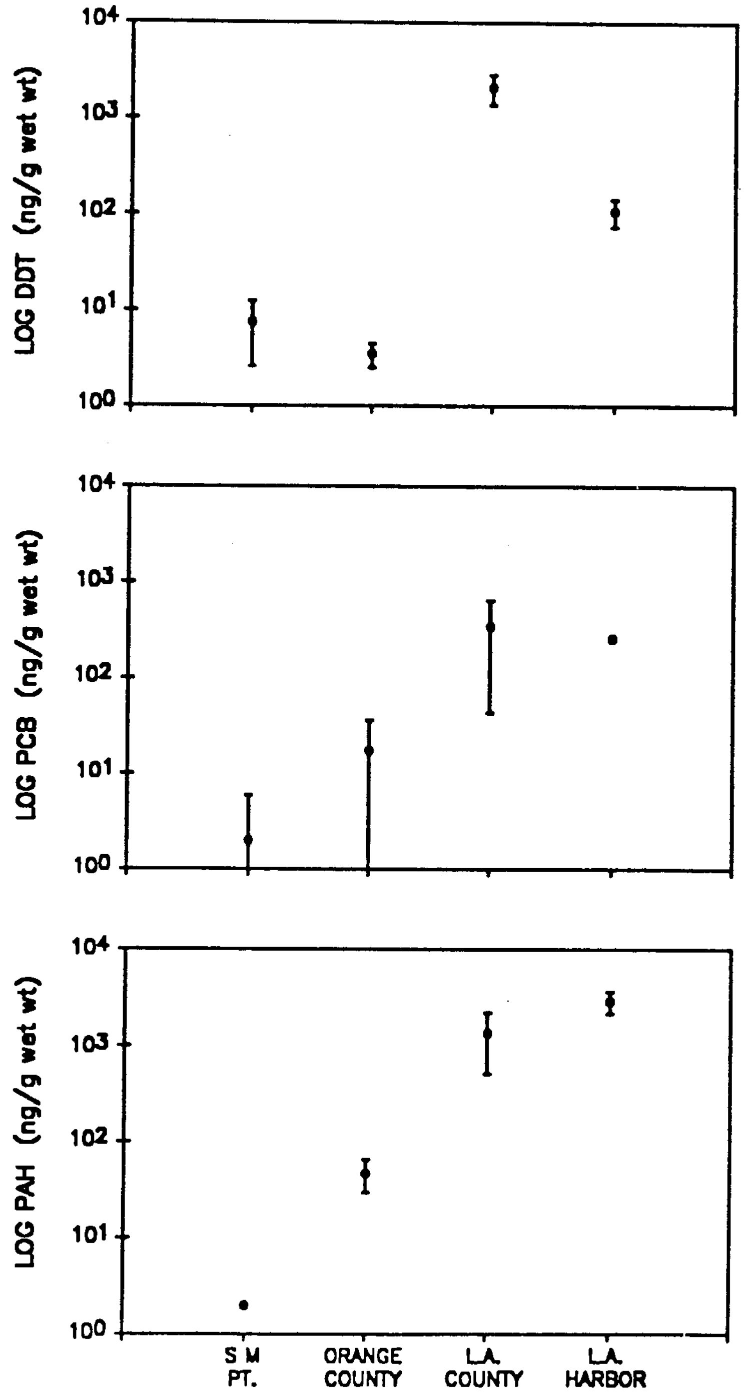

Figure 1. Organic contaminant concentrations in sediments from four southern California sites. Data shown are means; vertical lines indicate 95% confidence intervals. Note that data are plotted on a logarithmic scale.

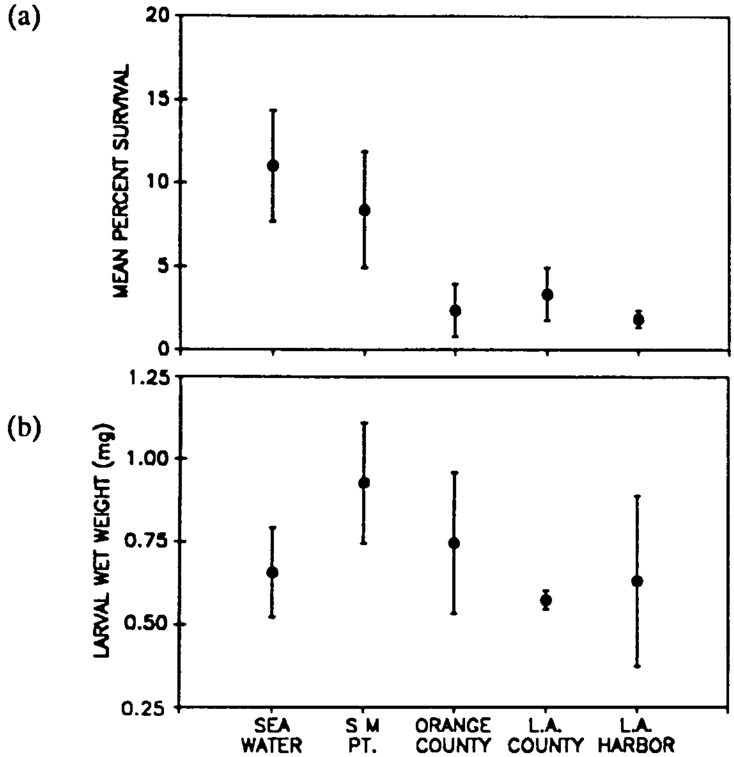

Figure 2. (a) Percentage of larval survival after 13-day exposure to seawater or sediment. Data shown are the means; vertical lines indicate 95% confidence intervals. (b) Weight of larvae after 13-day exposure to seawater or sediment. Data shown are the means; vertical lines indicate 95% confidence intervals.

Malformations were rarely observed. Only one malformed larva was observed during the experiment; it was exposed to sediment from Los Angeles Harbor (7.1% malformation rate). Larval mortality was so high in the contaminated sediments that the likelihood of deformed larvae surviving was slight.

These results suggest that even moderate levels of sediment contamination cause mortality among floating fish larvae. The moderate and higher levels were equally lethal to the larvae. Chronic toxicity (growth), however, was roughly proportional to sediment contamination. Further experiments need to be done to determine which contaminant caused mortality.

Kelp bass larvae have been successfully used in sea-surface microlayer bioassays (Cross et al. 1988) and appear to be promising candidates for sediment toxicity tests. Larval growth and survival endpoints are also used by the U.S. Environmental Protection Agency in their inland silverside (*Menidia beryllina*) bioassay for whole effluents (Heber et al. 1988). An advantage to the use of kelp bass over other indigenous species is that they have been induced to spawn outside of their natural reproductive period.

Acknowledgments

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Responses of Biota and Sediment to the 7-Mile Outfall Termination

In the SCCWRP 1986 Annual Report, the Hyperion Recovery Study was described briefly. At that time the researchers, Bruce E. Thompson of SCCWRP and John Dorsey of the Hyperion Treatment Facility, had started pre-termination sampling but did not report any data. Technical delays pushed back the projected date of shutoff, so the researchers postponed the sampling times accordingly. A revised sampling schedule is shown in Table 1. A third set of pre-termination samples was collected in the summer of 1987. Discharge from the Hyperion 7-mile sludge outfall was discontinued in November 1987, and quarterly post-termination sampling began in January 1988.

This report summarizes some of the data from the first set of pre-termination samples (February 1986), which show conditions in the bay under full sludge discharge.

Using dissolved sulfides in sediment interstitial (pore) water as an indicator of the sludge field, the scientists estimated that it exists mainly along the axis of the upper part of Santa Monica Submarine Canyon. Concentrations up to 284 mg/L of pore water were measured at the outfall terminus (Figure 1). Deep sediment cores, collected in October 1986, showed that the sludge field was about 50 cm deep, but cores collected in April 1988 showed that it was more than 140 cm deep.

Patterns similar to those in Figure 1 can be seen for such outfall-associated contaminants as polychlorinated biphenyl compounds (PCBs), polynuclear aromatic hydrocarbons (PAHs), and zinc (Figures 2a-2c), but peak concentrations were measured at sites deeper in the canyon, not at the outfall terminus. Additionally, elevated contaminant concentrations were measured farther from the outfall than sulfides were.

Infaunal indicator taxa such as the polychaete *Capitella capitata* were collected in highest abundances on the periphery of the sludge field; apparently, they are affected by high sulfide concentrations (Figure 1). Only about 10 species were collected from the sites near the outfall terminus. Most of these (mean, 655 organisms per square meter) were unusual polychaete taxa, such as *Ophryotrocha* spp. (three undescribed species), that are found only in highly contaminated areas. How they can exist in such areas is not understood. Exposures of most species to this sediment (see pp. 50, 58, and 65) caused death; however, another species found there, the gutless clam *Solemya reidi*, has biochemical mechanisms that can detoxify sulfide (Powell and Somero 1985).

Sites at intermediate distances from the outfall are dominated (abundance and biomass) by the clam *Parvilucina tenuisculpta* (560 organisms per square meter), and the reference sites are dominated by the ophiuroid *Amphiodia urtica* (760 organisms per square meter). *A. urtica* is the most abundant macrofaunal species at reference sites all along the southern California

Table 1. Schedule showing number of sites to be sampled at each time for each general category of samples. Discharge was terminated in November 1987.[a]

Tasks	Pre-Termination 1986 Feb. W	Pre-Termination 1986 Aug. Su	Pre-Termination 1987 Sept. Su	Post-Termination 1988 Jan. W	Post-Termination 1988 Apr. Sp	Post-Termination 1988 Aug. Su	Post-Termination 1988 Nov. F	Post-Termination 1989 Jan. W
Sediments								
Grain size & chemistry	17	17	17	17	17	17	17	17
Coring		3			10			10
Biology								
Infauna	17	17	17	17	17	17	17	17
Epifauna & fish (non-canyon sites)	12	12	12	12		12		12
Tissue chemistry (Dover sole & Ridge-back prawn)		6	6	6		6		6
Oceanography								
CTD/DO profile	6	6	6[b]	6		6		6
Current meters	1			3		3		3
Sediment traps	3			3		3		3

[a]Abbreviations: W, winter; Su, summer; Sp, spring; F, fall; CTD, conductivity/temperature/depth; DO, dissolved oxygen.
[b]CTD failed; data not collected.

Table 2. Concentrations (ng/g, wet weight; ppb) of DDTs and PCBs in tissues of two species (February 1986).

Area (No. of stations)	*Sicyonia ingentis* hepatopancreas DDT	*Sicyonia ingentis* hepatopancreas PCB	*Sicyonia ingentis* muscle DDT	*Sicyonia ingentis* muscle PCB	Dover sole liver DDT	Dover sole liver PCB	Dover sole muscle DDT	Dover sole muscle PCB
Outfall (9)[a]	990	2854	9	<47	972	2035	109	254
Transition (4)[a]					1714	2864	45	<40
Reference (Malibu) (4)[a]	1141	<838	11	<34	1686	<91	<14	<53
So. Cal. average of mainland shelf (38)[b]	655	568			440	368		

[a]Locations of stations are shown in Figure 2.
[b]Thompson et al. (1987).

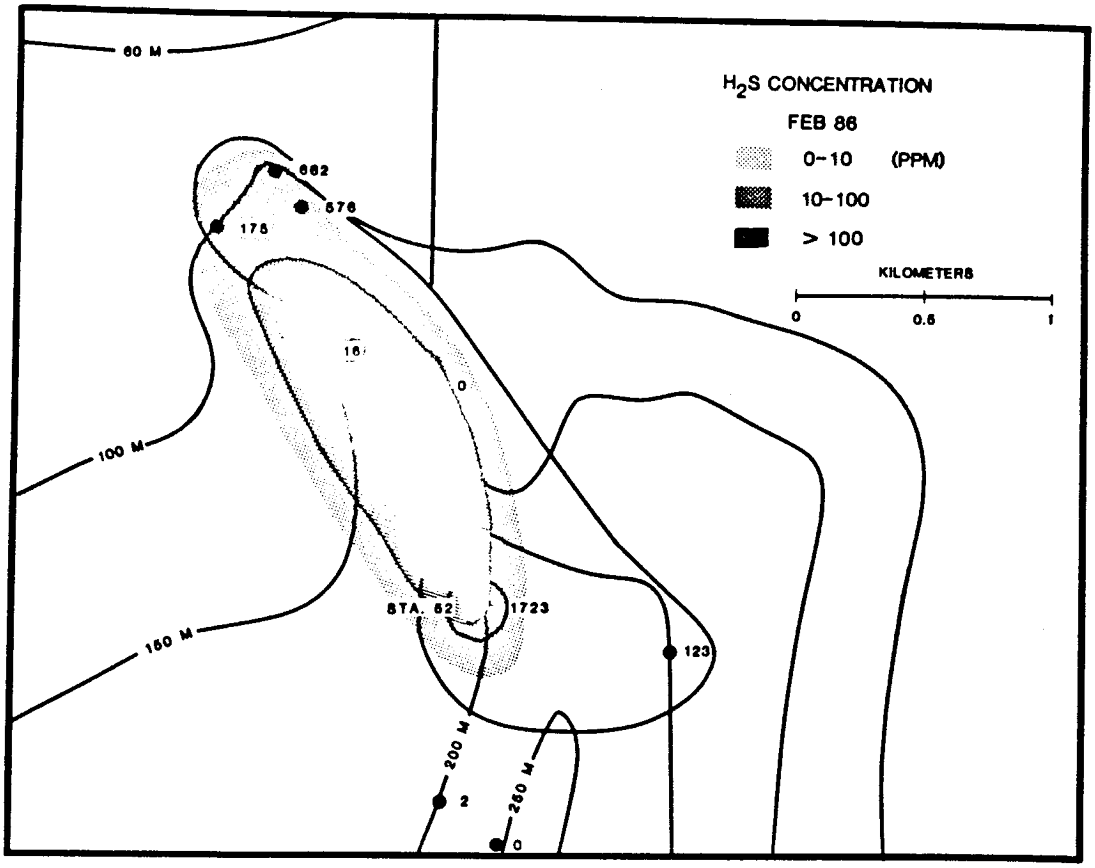

Figure 1. Plot of hydrogen sulfide (H_2S) concentrations measured in the sediments near the 7-mile outfall terminus. Numbers are numbers of the polychaete *C. capitata* (per grab) collected at each site (solid contours).

mainland shelf (Thompson et al. 1987). Similar patterns of species composition and abundance in Santa Monica Bay were shown by Bascom (1979) and Dorsey (in press).

Otter trawl catches contained similar species and abundances at sites near the outfall and at the reference sites. The prawn *Sicyonia ingentis* and the urchin *Lytechinus pictus* were the most abundant megabenthic invertebrates collected. These species were also reported to be the most abundant species all along the mainland shelf. The plainfin midshipman and stripetail rockfish were the most abundant fish collected in the trawls.

Contaminant concentrations in tissues of two species were measured. Table 2 shows that the highest PCB concentrations were in *S. ingentis* hepatopancreas and Dover sole livers collected near the outfall. Concentrations of DDT and other contaminants in muscle tissue were all low and showed no obvious outfall-related trends. These results show that only a small area (about 3 to 4 km²) was observably affected by sludge discharge.

During the April 1988 cruise, the scientists noticed that some of the canyon sites on the periphery of the sludge field had changed. At station 52 (Figure 1), pre-termination samples had the highest contaminant concentrations and the most *C. capitata*. In April, that station contained mostly *P. tenuisculpta* and *Pectinaria californiensis*, organisms more common in the

(a) (b) (c)

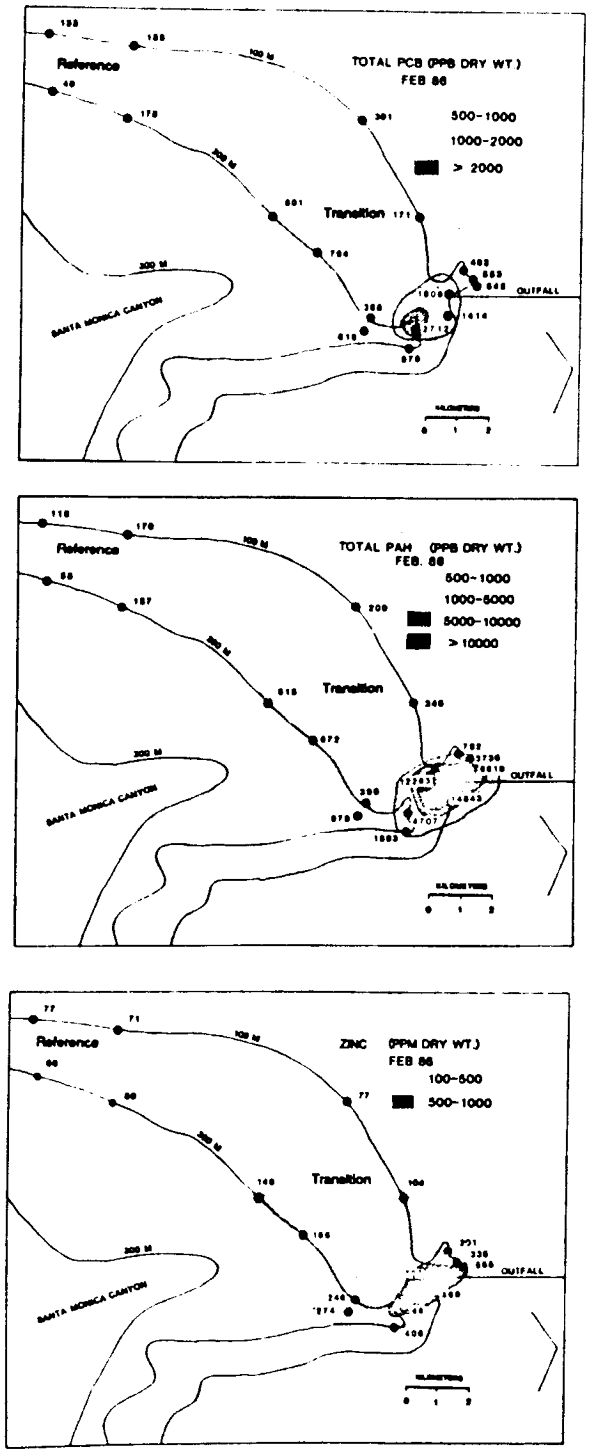

Figure 2. Plots of sediment contaminant concentrations measured near the 7-mile outfall terminus: (a) PCBs, (b) PAHs, and (c) zinc.

transition sites. Thus, it appears that recovery has begun at some sites on the periphery of the sludge field. Sites at the outfall terminus, however, were still as described above during February 1986.

Quarterly sampling will continue through next January (1989). Depending on the progress of recovery, sampling will probably continue semi-annually for another year. We expect that the transition sites and sites on the periphery of the sludge field will recover the fastest. As sediment conditions improve, more infaunal species normally found in reference areas will move into those areas. Recovery at the outfall terminus will probably take longer. Recovery at any site will be defined as occurring when parameters measured are not statistically different from those at the reference site.

Upon completion of analyses of all pre-termination samples, a summary of that information will be prepared. Researchers anticipate that will occur in the fall of 1988.

Acknowledgment

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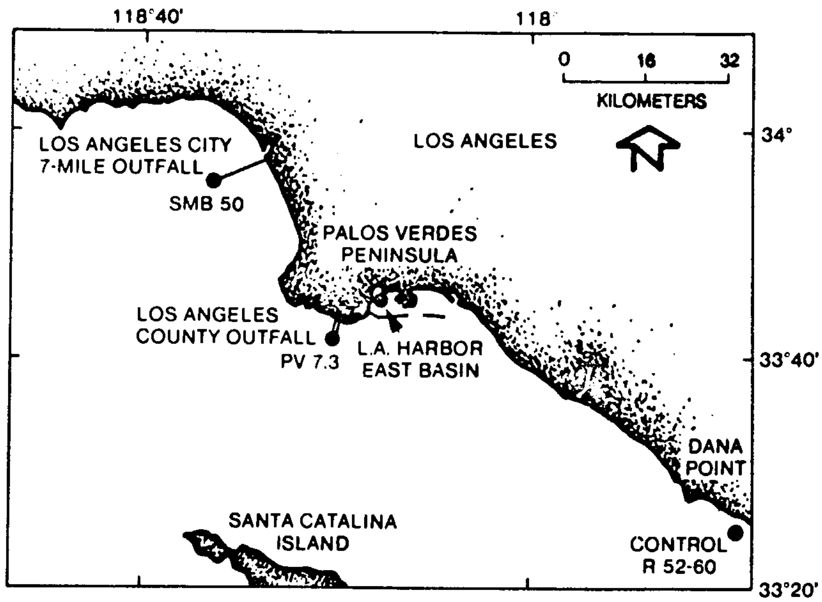

Figure 1. Sediment sampling sites.

Effects of Contaminated Sediments on Three Benthic Invertebrates

This paper summarizes three separate sediment exposure experiments conducted by Bruce E. Thompson, Steven M. Bay, and co-workers in laboratories at SCCWRP and California State University, Long Beach. Three different species of animals were used to test the same four sediment types: (1) SMB 50, sedimented sludge from near the Hyperion 7-mile outfall in Santa Monica Bay; (2) PV7.3, collected near the Palos Verdes outfall; (3) Los Angeles Harbor sediment taken from the East Basin; and (4) sediment collected near Dana Point, used as a control (Figure 1).

The sediment samples were collected with a Van Veen grab from which the top 5 cm was used. In the laboratory, they were homogenized by stirring, then sampled for analysis of sediment composition. Components analyzed were percent sand, percent total organic carbon (TOC), concentration of dissolved sulfides, chlorinated hydrocarbons (DDTs and polychlorinated biphenyls [PCBs]), polynuclear aromatic hydrocarbons (PAHs), and trace metals (Cd, Cr, Cu, Pb, and Zn) (Table 1). Sediment from SMB 50 had the highest levels of total organic carbon, sulfides, Cd, and Cu; PV7.3 had the highest concentrations of DDTs, PCBs, Cr, and Zn; and the harbor sediment contained the most PAHs and Pb. Although the reference sediment contained measurable quantities of most of these contaminants, they were an order of magnitude lower than the contaminants at the other sites and were within the range of reference values for this region (Thompson et al. 1987). The control sample also contained considerably less sand than the other samples.

Amphiodia urtica (brittlestar) is the most abundant infaunal organism in reference areas of the southern California mainland shelf, but it does not inhabit contaminated areas. This exposure was done to evaluate the sensitivity of *A. urtica* to contaminated sediments, to determine its usefulness as a test organism, and to determine an appropriate exposure system and endpoints for *A. urtica* in sediment toxicity testing. For this experiment, 10 individual ophiuroids were placed in each of three replicate aquaria containing each sediment type for 10 days in a static renewal exposure; the temperature was maintained at 15°C.

The mortality of *A. urtica* on each sediment type is shown in Figure 2. The control and harbor sediments had no mortalities. On PV7.3 sediment, only one organism in one tank died. All ophiuroids on the sludge sediment died. Thus, SMB 50 sediment (sludge) is acutely toxic to *A. urtica.*

Sicyonia ingentis (ridge-backed prawn) is one of the most abundant megafaunal species on the outer mainland shelf of southern California. It has been commercially harvested in a small fishery at Santa Barbara. This species was exposed to the four sediment types for 30 days at 12-15°C in a flow-through system in Dr. Donald J. Reish's laboratory at California State University, Long Beach. Ten adult prawns were used in each of three replicates of each sediment type. The parameters measured were mortality, growth rates (final-initial carapace lengths),

Table 1. Characteristics of sediments used in exposures.

Area	TOC (%)	Sand (%)	Dissolved Sulfides (mg/L)	Hydrocarbons (ng/g dry wt.) DDTs[a]	PCBs[b]	PAHs[c]	Metals (μg/g dry wt.) Cd	Cr	Cu	Pb	Zn
Control (Dana Point)	1.1	5.2	0.6	14	<59	<79	<0.56	32	18	<3.3	67
L.A. Harbor	2.8	38.0	0.3	763	1810	13642	2.2	110	132	194	410
PV7.3	4.3	29.1	23.6	13700	3484	4087	20	500	241	147	655
SMB 50	6.3	37.6	228.6	462	1118	5532	30	357	510	149	614

[a] DDTs include
o,p'-DDE
p,p'-DDE
o,p'-DDD
p,p'-DDD
o,p'-DDT
p,p'-DDT

[b] PCBs include
Aroclor 1242
Aroclor 1254

[c] PAHs include
Naphthalene
2-Methylnaphthalene
1-Methylnaphthalene
2,6-Dimethylnaphthalene
Other C2-naphthalenes
2,3,5-Trimethylnaphthalene
Other C3-naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Fluorene
Phenanthrene
C1-phenanthrene/anthracenes
C2-phenanthrene/anthracenes
C3-phenanthrene/antrhacenes
Anthracene
Fluoranthene
Pyrene
2,3-Benzofluorene
Benz[*a*]anthracene
Chrysene/Triphenylene
Benzo[*b*]fluoranthene
Benzo[*k*]fluoranthene
Benzo[*e*]pyrene
Benzo[*a*]pyrene
Perylene
9,10-Diphenylanthracene
Dibenz[*a,h*]anthracene
Benzo[*g,h,i*]perylene

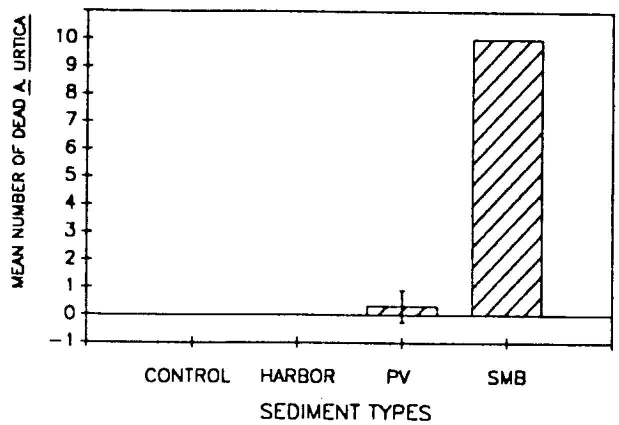

Figure 2. Mean (± standard deviation) mortality of *A. urtica* in each sediment after 10-day exposure. All brittlestars in SMB 50 died in all three replicates.

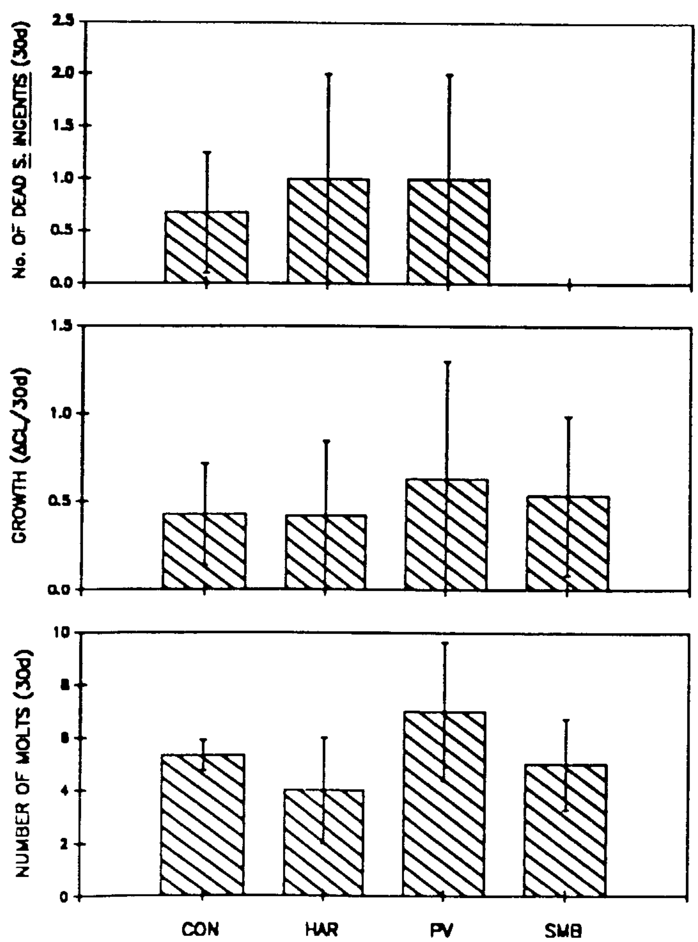

Figure 3. Mean (± standard deviation) mortality, growth, and number of molts for *S. ingentis* (n = three replicates; 10 prawns per replicate).

number of molts (counts of exoskeletons that were shed), and accumulation of contaminants in their hepatopancreas (Figures 3 and 4).

Prawns from PV7.3 sediment accumulated significant quantities of DDTs and PCBs; yet, no significant growth, mortality, or molt differences were found among prawns from any sediment type. The final trace metals concentrations in the hepatopancreas of prawns decreased from the initial concentrations and were similar among prawns from all four sediment types.

Lytechinus pictus (white sea urchin) is also one of the most abundant species on the mainland shelf off southern California. For this experiment, 15 urchins (diameter, 8 to 22 mm) were placed in each of three replicates of the four sediment types. They were exposed for 60 days in a flow-through system. The temperature was maintained at approximately 12°C throughout the exposure period. The parameters measured were mortality, growth rates (final-initial test diameter), gonad production (change in wet weight), and contaminant accumulation in urchin gonads (Figures 5 and 6).

No urchins on the control sediments died. On the harbor and PV7.3 sediments, only 1 and 3 urchins died, respectively, which was not significantly different from the controls. However,

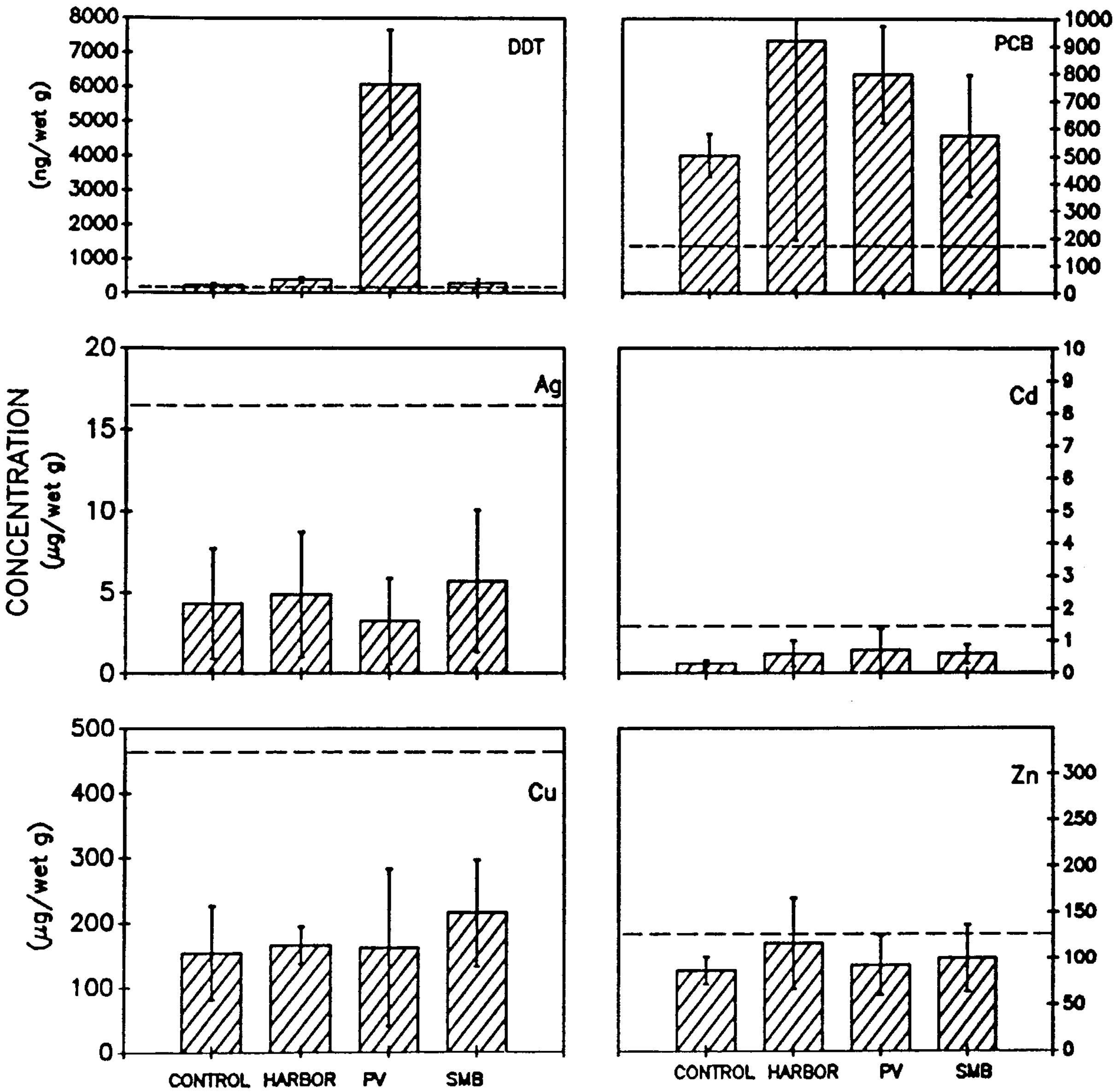

Figure 4. Mean (± standard deviation) contaminant concentrations in *S. ingentis* hepatopancreas after 30-day exposure in each sediment type. Dashed lines indicate initial concentrations.

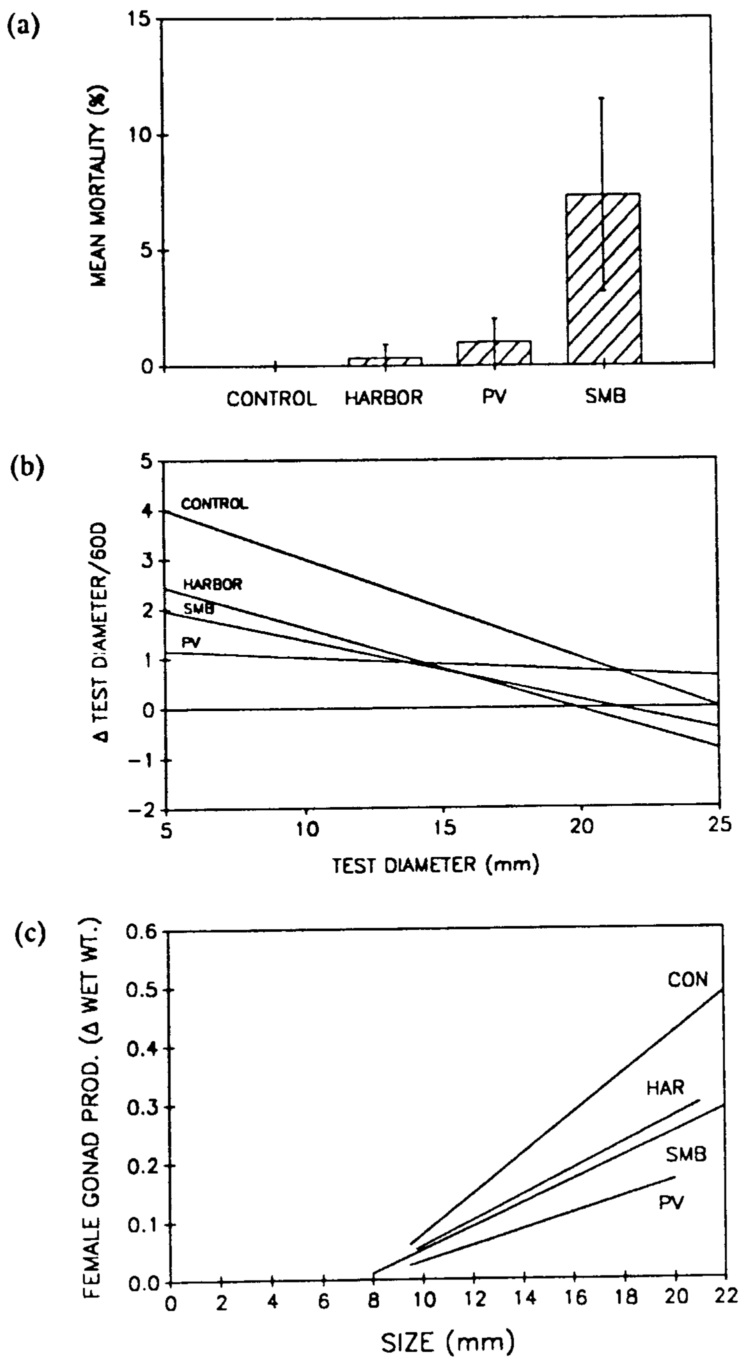

Figure 5. (a) Mean (± standard deviation) of *L. pictus* on each sediment type. (b) Size-growth regressions for *L. pictus* on each sediment type. (c) Size-gonad production regressions for *L. pictus* on each sediment type (n = three replicates; 15 urchins per replicate).

the urchins on the sludge sediment had significantly higher mortality than the control; about 49% of the SMB 50 urchins died. There were white bacterial mats on the surface of the sediment and a strong odor of sulfide.

For *L. pictus*, mortality rates in contaminated sediments were positively correlated with levels of dissolved sulfide, Cd, and Cu in the sediment and with Zn concentrations in the gonads. Hydrogen sulfide is suspected as the cause of the mortalities in the urchins.

Growth occurred in urchins from all sediment types, but the rate was significantly lower in urchins from contaminated sediments (Figure 5). In harbor and SMB 50 sediments, some urchins exhibited negative growth. Growth was inversely correlated with concentrations of PCBs, Cd, and Cr in sediments and DDTs in gonads.

Before exposure to contaminated sediments, urchin gonads accounted for approximately 2.3% of the wet body weight. There was a significant increase in gonad mass for urchins on all sediment types during the exposure because gametogenesis was apparently induced. After the 60-day exposure, gonad weight had increased to 11.3% wet body weight for the controls and 7% (the smallest increase) for the PV7.3 urchins. Female gonad production was significantly lower in SMB 50 and PV7.3 urchins than in the controls and

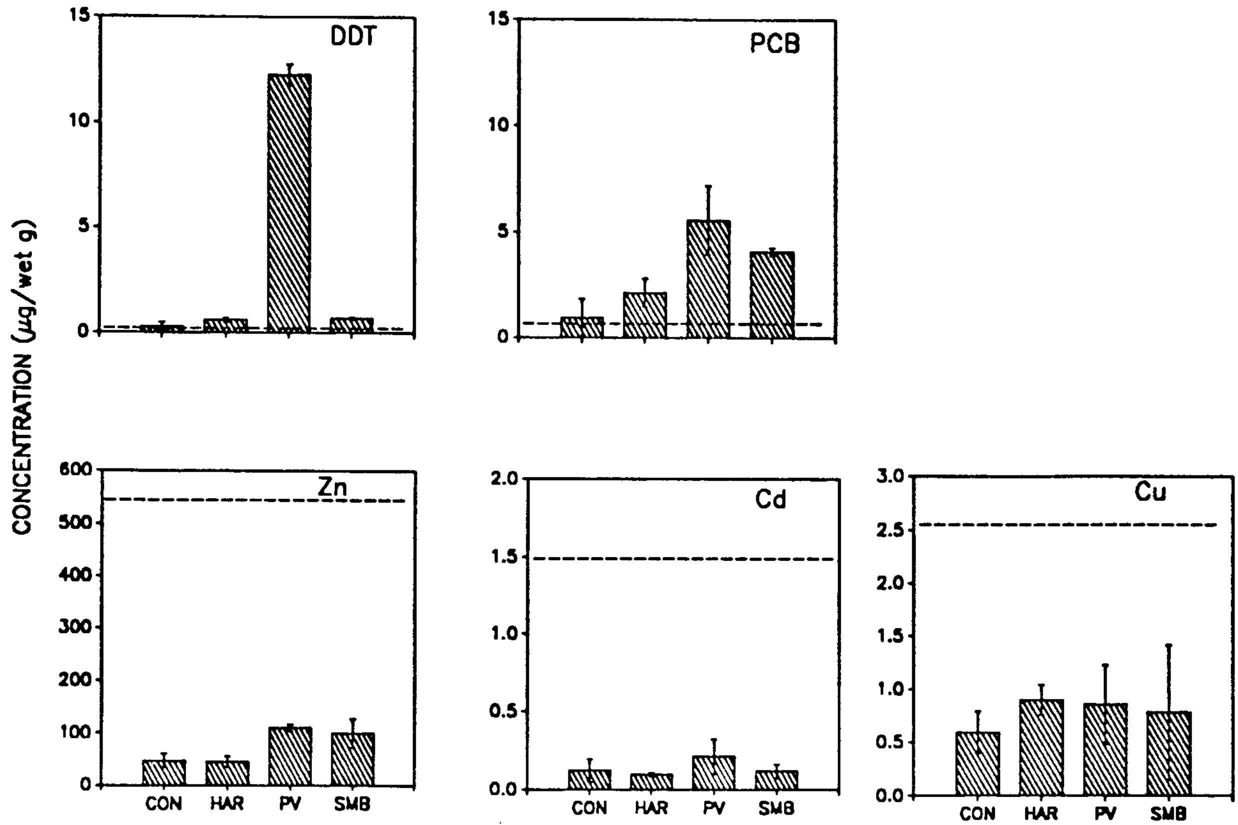

Figure 6. Mean (± standard deviation) contaminant concentration in *L. pictus* on each sediment type (n = three replicates; 15 urchins per composite sample). Dashed lines indicate initial concentrations.

was inversely correlated with sediment content of chlorinated hydrocarbons and trace metals.

The gonads of PV7.3 and SMB 50 urchins accumulated significant quantities of DDTs and PCBs; harbor urchins had a large increase in PCBs, but it was not significantly different from the control levels. As with *S. ingentis*, urchins from all four sediment types had a large decrease in Cd, Cu, and Zn concentrations.

Each of the three species exposed to contaminated sediments gave slightly different

Table 2. Summary of responses to contaminated sediments. A + indicates that a significant response was measured, - indicates that no significant response was measured, and NM indicates that the response was not measured.

Organism	Mortality	Growth	Gonad Production	Bioaccumulation
A. urtica	+	NM	NM	NM
S. ingentis	-	-	NM	+
L. pictus	+	+	+	+

responses (Table 2). Acute mortality occurred on SMB 50 sludge in *A. urtica* and *L. pictus*, but not *S. ingentis*. No significant chronic effects (growth or molt interruption) were observed in *S. ingentis*, but growth and gonad production were affected in *L. pictus*. Interestingly, accumulation of chlorinated hydrocarbons was observed in both *S. ingentis* and *L. pictus*, but in *S. ingentis* there were no measured effects. This demonstrates that measurement of bioaccumulation does not necessarily imply adverse effects. These results also show that both acute and chronic endpoints should be considered in evaluation of sediment toxicity.

The decrease in trace metals concentrations in both urchin gonads and prawn hepatopancreas is hard to explain. Since the decrease occurred in organisms from all four sediment types, including the control, it may simply reflect the dilution of trace metals in a growing tissue mass. It could indicate that the form of metals (in solution or on very fine particles) producing uptake in the field was not present in the exposure system.

In these exposures, it was not possible to ascribe causes of mortality, or impaired growth and gonad production to any one component in sediment. Effects may be due to any of the contaminants present, some unmeasured contaminant, or the additive nature of many contaminants. In addition, different contaminants may have different mechanisms of toxicity.

Exposures to separate contamination treatments (i.e., hydrogen sulfide only) are planned for this year. Size-specific mortality, growth, and reproduction rates are important terms in most population growth equations. Changes in any of these components probably translate into effects on populations. These exposure experiments are important to help achieve the goal of relating laboratory results to effects on populations in discharge-receiving areas.

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Reference

Thompson, B. E., J. D. Laughlin, and D. T. Tsukada. 1987. 1985 Reference Site Survey, C-221. Southern California Coastal Water Research Project, Long Beach, CA.

Toxicity of Contaminated Sediments to the Amphipod Grandidierella japonica

During the past several years, SCCWRP has been developing and evaluating methods useful for studying the toxicity of sediments in southern California. Reports elsewhere in this volume describe results obtained by using sea urchins (embryos and adults), shrimp, and fish larvae (see pp. 50, 58, and 70). In addition to these test systems, SCCWRP scientists Steven M. Bay and Darrin J. Greenstein have also been developing test methods with a local species of amphipod.

Short-term tests with marine amphipods have been widely used to assess sediment toxicity. This group of crustaceans contains species that burrow or build tubes in the sediment. Previous studies have demonstrated the sensitivity of amphipods to environmentally realistic levels of pollutants (Swartz et al. 1982). The most commonly used species, *Rhepoxynius abronius*, does not occur in high enough densities in southern California to be used in tests. This species is also stressed by the silty sediments characteristic of sewage outfall sites and other contaminated areas.

Initial toxicity studies with amphipods at SCCWRP have focused upon the species *Grandidierella japonica*. This is a tube-dwelling species common in intertidal and shallow estuarine areas of central and southern California. *G. japonica* has several characteristics that indicate its potential value in sediment toxicity studies. This species has a short generation time in laboratory culture (30 days at 19°C) and is tolerant of wide fluctuations in temperature, salinity, and sediment grain size.

Preliminary studies by Dr. Donald J. Reish of California State University, Long Beach (CSULB), demonstrated the utility of this species for sediment toxicity testing. With the assistance of Dr. Marion Nipper, a visiting environmental scientist from Brazil, Bay and Greenstein refined the acute test methods developed at CSULB and also developed a chronic test.

G. japonica was one of three test species used in a survey of sediment toxicity, contamination, and infauna funded by the California State Water Resources Control Board. All of the results from this project will be reported later, when the chemical and statistical analyses are complete. The effects of sediment from several highly contaminated sites in southern California on amphipod survival, reburial, and growth are reported here. To discriminate between pollutant effects and other environmental factors, the sediments were also analyzed for chemical composition, grain size, and organic carbon content.

Sediments were collected from a total of 11 southern California coastal areas (Figure 1). These sites included a relatively uncontaminated reference area, industrialized harbors, and areas adjacent to three large municipal wastewater outfalls. Sediment from the amphipod collection site in Newport Bay was collected for use as a control. A wide range of sediment texture and contamination levels was represented by these locations (Table 1).

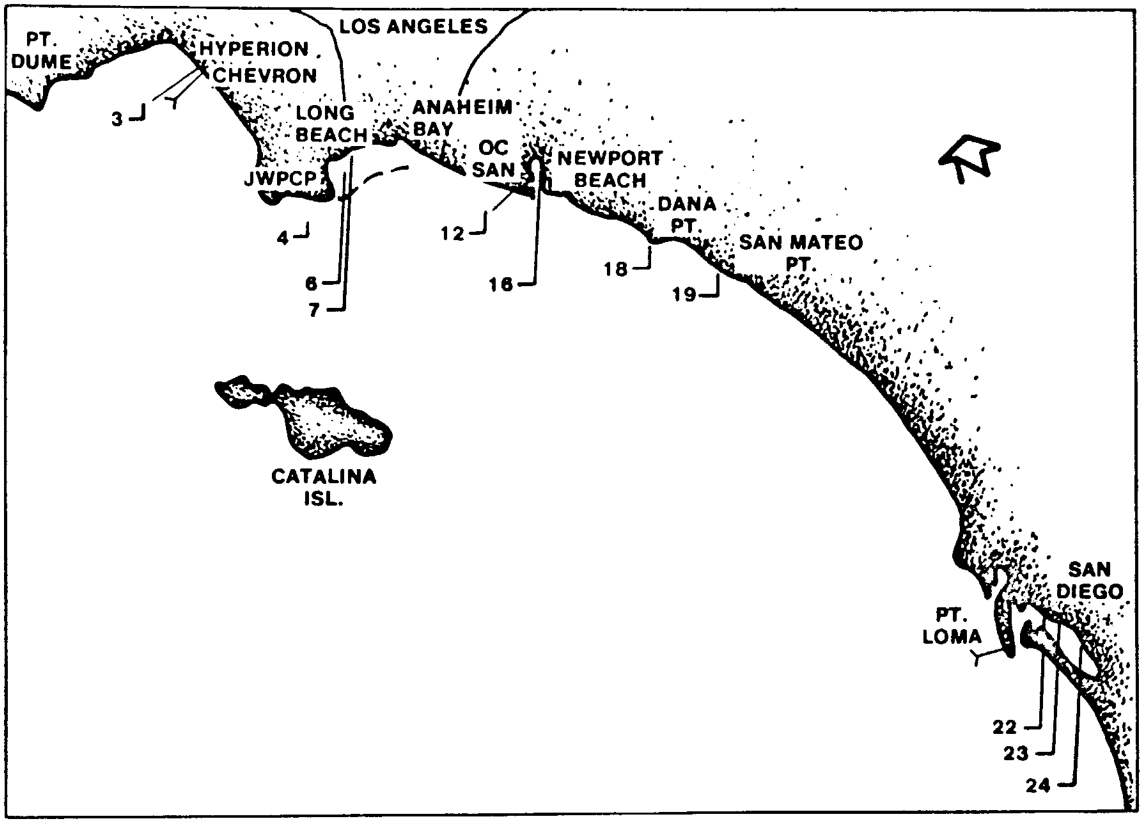

Figure 1. Location of sites examined in this study.

All bioassays were conducted by using flow-through conditions to minimize the effects of contaminants leaching into the water column. The exposure system consisted of 1-L polypropylene beakers containing a 2-cm layer of the test sediment.

G. japonica specimens were collected from Newport Bay. Acute (10-day exposure) bioassays were conducted with young amphipods which had not yet reached sexual maturity. This test was conducted at 15°C according to the procedure described by Swartz et al. (1985) for *R. abronius* and modified for a flow- through system. Animals were not fed during the test.

Bioassays were terminated after 10 days by passing the test sediments through a screen and counting the surviving amphipods. The number of surviving amphipods able to rebury within a 1-h period was also determined. The reburial test was intended to evaluate the organisms' condition, by observing if they responded normally to a favorable environment.

Chronic (28-day) toxicity tests with recently hatched amphipods were also conducted during this study. These tests were conducted on selected sediment types representing contamination from both sewage disposal and harbor activities.

Chronic tests were conducted at 19°C in a manner similar to the acute tests, except that newly released juveniles were used and food was given to the animals throughout the 28-day exposure period. Juvenile amphipods were obtained by

Table 1. Physical and chemical characteristics of sediments from study areas. All measurements were made at the start of each experiment.

Station	Location	Depth (m)	%TOC[a]	%Sand	Hydrocarbons (ng/g dry) PAH	DDT	PCB	Metals (μg/g dry) Cr	Cu	Pb	Zn
16	Newport Bay (control)	0	0.11	96.5	ND[b]	4	ND	2.5	1.9	4.1	13
3	Santa Monica Bay sludge outfall	157	10.5	53.4	20386	196	654	258	511	133	675
4	Palos Verdes Outfall	62	4.2	28.5	3209	5966	1548	326	213	112	630
6	L.A. Harbor E. Turning Basin	14	1.1	42.5	5310	88	217	50	82	64	211
7	L.A. Harbor L.A. River Mouth	5	4.3	40.7	9914	91	310	32	83	130	389
12	Orange Co. Outfall	60	0.55	77.4	90	7	55	19	24	12	62
18	Dana Pt. Marina	5	0.82	16.2	96	4	8	18	26	8.1	71
19	San Mateo Pt.	60	1.0	4.4	44	20	7	21	14	5.5	61
22	San Diego Bay NASSCO[c]	9	1.7	16.1	4711	10	208	64	214	60	321
23	San Diego Bay Chollas Creek	12	1.5	39.6	7625	30	188	37	132	70	235
24	San Diego Bay Seventh St.	8	1.7	37.6	12106	79	353	62	122	104	581

[a]TOC, Total organic carbon.
[b]Sample below detection limit for analysis.
[c]NASSCO, National Steel and Shipbuilding Company.

placing egg-laden females in petri dishes containing only seawater. Offspring released from the females 1 to 2 days before the test were used in the bioassays.

Amphipods were retrieved at the end of each experiment by passing the test sediment through a screen. The number and total body length of surviving animals were determined. Growth during the experiment was calculated by subtracting the animals' initial size (determined on a subset of the test population) from their final size.

The 10-day acute exposure produced reduced amphipod survival at most of the highly contaminated stations (Table 2). The lowest survival values were for animals exposed to sediment from the San Diego Bay and sludge outfall stations. The data from the sludge outfall site were highly variable, with survival ranging from 0 to 70% within the three replicates.

A statistically significant decline in acute survival was not found in sediment from Palos Verdes, even though high levels

Table 2. Amphipod survival, growth, and reburial following acute or chronic exposure to contaminated sediments. Values are mean ± standard error.

Station	Acute exposure		Chronic exposure	
	%Survival	%Reburial	%Survival	Growth (mm)
Newport Bay	88 ± 4	98 ± 2	62 ± 4	4.0 ± 0.6
Santa Monica Bay	34 ± 20	100 ± 0		
Palos Verdes Outfall	67 ± 5	93 ± 3	17 ± 4	0.6 ± 0.4
L.A. Harbor	48 ± 7	91 ± 3	40 ± 4	2.0 ± 0.8
L.A. River Mouth	88 ± 4	100 ± 0		
Orange Co. Outfall	77 ± 3	98 ± 2	60 ± 3	2.7 ± 0.6
Dana Pt. Marina	61 ± 5	94 ± 1		
San Mateo Pt.	84 ± 3	96 ± 4	49 ± 7	1.9 ± 0.7
NASSCO*	35 ± 5	89 ± 6		
Chollas Creek	68 ± 2	100 ± 0	45 ± 2	1.8 ± 0.3
Seventh St.	42 ± 6	97 ± 3		

*NASSCO, National Steel and Shipbuilding Company.

of chlorinated hydrocarbons were present. Reduced survival was found at stations having total polynuclear aromatic hydrocarbon (PAH) levels above 4,000 ng/g (ppb, dry weight), except for the Los Angeles River mouth and Dana Point Marina stations. Although the Los Angeles River site had substantial levels of hydrocarbon and metal contaminants, amphipod survival was unaffected. An unexpected result was the observation of moderate toxicity at the Dana Point Marina site. Sediment from this location had contamination levels similar to that from San Mateo Point and the Orange County outfall, where survival was greater.

No significant differences were found in the reburial activity of amphipods from the acute test. The lowest reburial percentage (88%) was at the Los Angeles Harbor site. These data indicate that the surviving *G. japonica* did not have reduced activity as the result of exposure to contaminated sediment.

Results from the chronic test of sediment from six locations are shown in Table 2. A different pattern of amphipod survival was observed compared with the acute test results. Survival at the Palos Verdes site was the only value significantly lower than the Newport Bay control value. Significant differences in amphipod growth were found for all of the sites tested, however. The greatest inhibition of growth was found at Palos Verdes, where the change in length during the test was only 16% that of the controls. These chronic test results contrast with the relatively small, acute effects seen for the Palos Verdes site. These data suggest that the high concentrations of chlorinated hydrocarbons or metals at this site may require chronic exposure before toxic effects are expressed or that the process of growth by molting in these crustaceans is very sensitive to the contaminants present at this site.

Significant differences in growth were found for amphipods in the remaining test sediments; these values were 46 to 69% of the control growth. An unexpected result that we found was the reduced growth of amphipods in the San Mateo Point sediment. Amphipod growth in the Orange County outfall sediment was greater than that at San Mateo Point, suggesting that the finer grain size or higher organic carbon content of the sediment may have had an important effect on the chronic test results.

This study has proven the usefulness of *G. japonica* as a sediment toxicity test organism. Both the acute and chronic test results have demonstrated the sensitivity of this species to environmentally realistic levels of sediment contamination. Results from these tests have also corresponded well to results obtained with chronic exposure of the white urchin, *Lytechinus pictus*, to the same sediments.

G. japonica is a suitable alternative to *R. abronius* for use in amphipod tests in southern California. The short life history of *G. japonica* also permits chronic tests with the measurement of sublethal responses such as growth and reproductive success, information necessary for determining the effects of contaminants on population size.

SCCWRP researchers are presently using chronic tests with this species in laboratory studies of the toxicity of individual PAH compounds. This work, also funded by the California State Water Resources Control Board, will further refine these amphipod test methods and produce a greater understanding of how factors such as PAH structure and sediment organic carbon content affect the toxicity of marine sediments.

Acknowledgment

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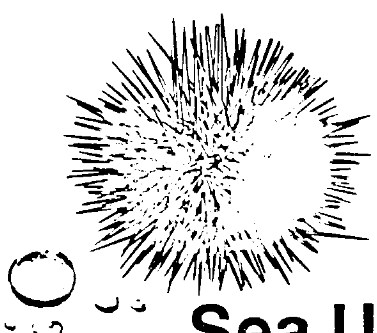

Sea Urchin Embryo Bioassay Methods For Use with Sediment Elutriates

The suitability of using sea urchin embryo and gamete test methods to assess the toxicity of sediment was evaluated during January-May of 1987. This project was funded by the National Oceanic and Atmospheric Administration (NOAA) as part of a nationwide comparison of several promising sediment bioassays. All participants in the project tested the same sediments, which were collected from sites in and around San Francisco Bay (Figure 1). The sites were selected based on previous studies to form a gradient of contamination, ranging from the control site at Tomales Bay to the most contaminated site at Oakland Inner Harbor. The general order of contamination was Oakland > Vallejo > Yerba Buena > San Pablo > Tomales Bay. The sites had various types of contamination, but high molecular weight polynuclear aromatic hydrocarbons (PAHs) were the dominant chemical group at the most contaminated sites (Table 1).

Steven M. Bay, Darrin J. Greenstein, Karen D. Englehart, and Valerie E. Raco performed SCCWRP's part of the project. Their goals were threefold: (1) to compare the biological responses between the stations, (2) to compare the results of several endpoints of the urchin bioassay, and (3) to compare the responses of three different species of urchins for one of the endpoints. Each of these goals was met with varying degrees of success.

Sea urchin embryo and gamete tests have been used at SCCWRP for many years for the testing of aqueous solutions, such as wastewater effluent and dissolved metal and organic contaminant solutions (Oshida et al. 1981). To provide an aqueous solution from the sediments, the scientists added clean laboratory seawater to the sediments and then allowed this to be stirred overnight. The sediment slurry was then centrifuged, and the overlying water (sediment elutriate) was removed for the assays.

Bay et al. used three species of urchins in this test: the purple urchin (*Strongylocentrotus purpuratus*), the white urchin (*Lytechinus pictus*), and the green urchin (*Strongylocentrotus drobachiensis*). These species were chosen to represent differences in geographic distribution and spawning season.

Four possible endpoints to the urchin assay were investigated. The first endpoint was fertilization success of sperm exposed to the elutriates. For this test, Bay and co-workers employed the methods of Dinnel et al. (1987). The second endpoint was normal embryo development after 48 h of exposure. This involved examining the embryos microscopically and rating their development. Subsamples of these embryos were also used for the third and fourth endpoints, the third being the production of the pigment echinochrome by the embryos. This test used the methods of Bay et al. (1983). The fourth endpoint was a microscopic examination of the embryos for cytologic/cytogenetic abnormalities. This part of the project was completed by Dr. Jo Ellen Hose of Occidental College using methods which she developed (Hose 1985). Only the 48-h development test was performed on the white and green urchins.

The sperm test showed results different from what was expected based on the relative degree of contamination at each station (Table 2). The elutriate samples from the Vallejo and Yerba Buena sites had significantly greater fertilization percentages than the other stations and the laboratory seawater control samples. The 48-h urchin development test showed few differences between stations; however, embryos from the Tomales Bay station had a significantly greater number of abnormalities than the other sites. The echinochrome pigment assay showed that exposure to elutriates from the Oakland, Vallejo, and San Pablo Bay sites resulted in significantly lower pigment production than that for Tomales Bay (Table 2).

The cytogenetic analysis produced the most responsive results and also had patterns which closely followed the contamination gradient. For most of the parameters examined, embryos exposed to Tomales Bay and San Pablo Bay elutriates usually were significantly less affected than those at the other sites (Table 3). The toxicity at Tomales Bay for the 48-h development test was not encountered in cytogenetic analysis, which suggests that the mechanism for the abnormal development was due to something other than genetic damage. The results of the white urchin test were similar to those for the purple urchins, with the Tomales Bay station having the greatest percentage of abnormally developed embryos. The green urchin test was completely unsuccessful as none of the fertilized eggs developed beyond the early cleavage stage. This was probably caused by stress resulting from their shipment from the East Coast.

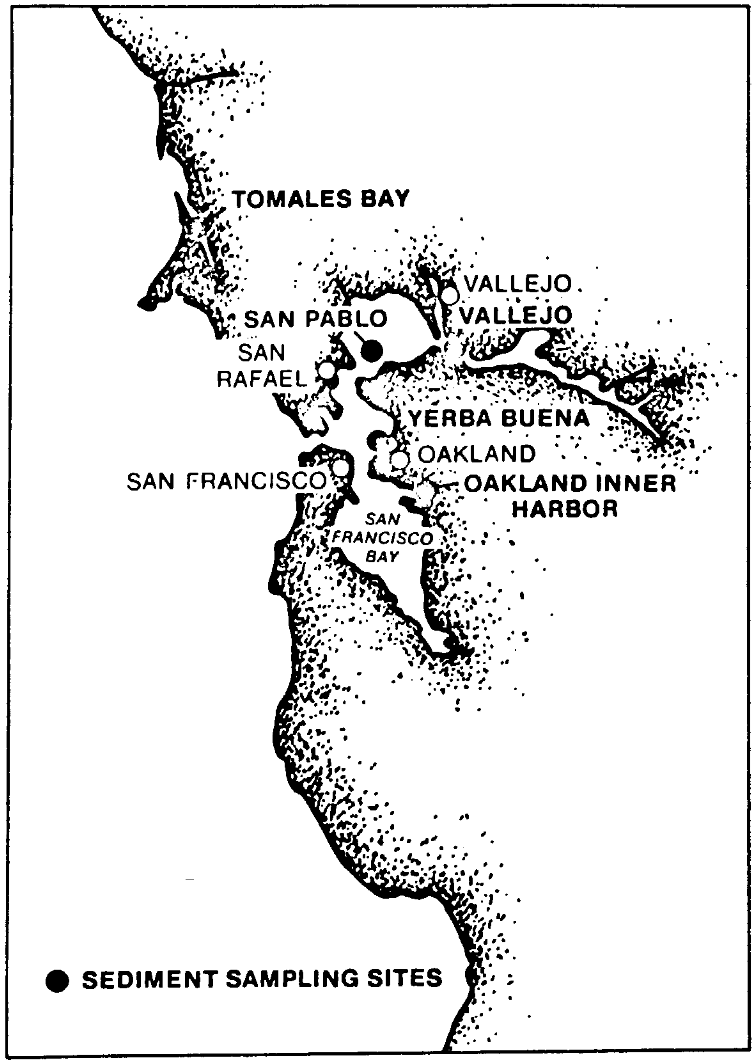

Figure 1. Locations of sediment sampling sites for this study.

One factor affecting the usefulness of an endpoint is the variability of the data between replicates. This variability was expressed as the coefficient of variation (CV, which is the standard deviation divided by the mean). For this project, the

Table 1. Chemical and physical characteristics from the five sediment sampling sites. Values are in dry weight. For each station $N = 3$.

Station	Hydrocarbons (ng/g)					Trace Metals (µg/g)									TOC[a] (mg/g)	Grain Size (%)		
	LPAH[b]	HPAH[c]	Total PCB[d]	Total DDT[e]	Other CHC[f]	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn		Sand	Silt	Clay
Tomales Bay																		
Mean	269	169	6	1	1	0.31	15.5	0.44	206	46.4	0.44	149	27.0	122	19.3	2	29	67
SE	23	22	2	1	1	0.11	1.3	0.02	30	10	0.04	24	6.8	8	0.3	<1	<1	2
San Pablo Bay																		
Mean	177	1215	23	9	4	0.61	16.6	0.29	179	57.7	0.26	116	28.0	135	12.4	4	46	47
SE	28	42	2	1	0.1	0.06	0.4	0.01	1	1.5	0.02	2	0.5	1	0.2	1	2	2
Yerba Buena																		
Mean	234	810	45	21	6	0.62	12.5	0.23	180	52.1	0.31	110	31.9	136	11.3	4	43	50
SE	17	7	23	2	1	0.03	1.4	0.01	3	5.4	0.03	5	2.2	7	0.5	2	3	3
Vallejo																		
Mean	155	462	42	24	9	0.36	18.4	0.44	182	41.6	0.34	120	53.9	126	10.2	37	31	24
SE	45	59	11	3	2	0.16	1.4	0.07	27	6.5	0.06	25	15.1	7	1.2	11	9	7
Oakland																		
Mean	600	4371	361	97	46	1.33	16.2	1.34	187	171	2.31	134	206	331	18.4	6	33	57
SE	139	623	33	26	2	0.11	0.8	0.22	3	8	0.54	2	11	24	0.5	2	4	4

[a] TOC, Total organic carbon.
[b] Sum of low molecular weight (2- and 3-ring) PAH compounds.
[c] Sum of high molecular weight (4- to 6-ring) PAH compounds.
[d] Sum of 2Cl-9Cl polychlorinated biphenyl compounds.
[e] Sum of *o,p'* and *p,p'* DDT, DDE, and DDD compounds.
[f] Sum of hexachlorobenzene, lindane, heptachlor, aldrin, heptachlor epoxide, alpha-chlordane, transnonachlor, and dieldrin.

Table 2. Percentage abnormal development, echinochrome pigment absorbance at 495 nm, and sperm test results (mean ± standard error).

Sample	%Abnormal	A_{495}	%Fertilized
Tomales Bay	25.5 ± 5.3	0.098 ± 0.002	73.9 ± 1.2
San Pablo Bay	17.9 ± 0.8 [a]	0.092 ± 0.003 [a]	66.8 ± 1.0
Vallejo	12.8 ± 0.9 [a]	0.089 ± 0.001 [a]	83.6 ± 5.7 [a]
Yerba Buena	14.2 ± 1.4 [a]	0.095 ± 0.002	91.3 ± 2.7 [a]
Oakland Harbor	15.0 ± 0.8 [a]	0.088 ± 0.002 [a]	68.8 ± 5.9

[a]Mean is significantly different from that at Tomales Bay (ANOVA, $P \leq 0.05$).

Table 3. Occurrence of mitotic and cytologic abnormalities (mean ± standard error) in purple sea urchin embryos exposed to sediment elutriates (for each sample, $N=5$).

Sample	Mitotic Index[a]	% Mitotic Abberations	Micronucleated Cells[b]	% Cytologic Abnormalities[c]
Tomales Bay	7.6 ± 0.5	6.1 ± 1.2	1 ± 1	0 ± 2
San Pablo Bay	8.0 ± 0.6	15.1 ± 3.1 [d]	16 ± 5	22 ± 6 [d]
Vallejo	6.2 ± 0.4	21.9 ± 2.2 [d]	8 ± 3	29 ± 8 [d]
Yerba Buena	6.0 ± 0.6	19.7 ± 4.8 [d]	6 ± 5	21 ± 6 [d]
Oakland Harbor	5.6 ± 0.5	30.1 ± 5.1 [d]	19 ± 14	14 ± 6 [d]

[a]Average number of mitoses per embryo.
[b]Number of micronucleated cells per 100 embryos.
[c]Percentage of embryos with at least one cytologic abnormality.
[d]Mean is significantly different than that at Tomales Bay (ANOVA, $P \leq 0.05$).

fertilization, percent abnormal development, and echinochrome production endpoints all had low CVs of less than 10%. The cytogenetic endpoints all had moderate to high CVs, ranging from 10 to 118%.

The identification of the specific contaminants responsible for the observed biological effects was not possible in this project because changes in individual contaminant concentrations were highly correlated with each other. However, PAHs seemed to be a likely cause of toxicity because of their high concentrations at the most contaminated sites and previous documentation of their genotoxicity to urchin embryos (Hose 1985).

In conclusion, while all of the endpoints were technically feasible and sensitive, examination of the embryos for mitotic aberrations and cytologic abnormalities was the most useful technique. The variability that was encountered with these endpoints may be reduced by examining more embryos per replicate.

The other bioassay tests of these sediment samples conducted under NOAA sponsorship included a mussel larvae test, amphipod tests with two species, and a polychaete test. Although a great diversity of responses was obtained from all of these tests, many of the responses seen with the sea urchin embryo test methods were also found by the other scientists. A technical report summarizing and evaluating all of the test results from this program is scheduled for production in 1988 by NOAA.

Acknowledgment

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Wastewater Toxicity Tests

Toxicity tests with sea urchin gametes and embryos have been used at SCCWRP since the late 1970s. This test system has been used effectively for measuring the toxicity of seawater, sewage effluent, and sediment extracts (this report). Several different responses can be measured with this test system including fertilization success of sperm, occurrence of abnormal embryonic development, and production of echinochrome pigment by developing embryos. Sea urchin bioassays were first used at SCCWRP to test the toxicity of sewage effluents in 1978 (Oshida et al. 1981). Effluent toxicity was measured again in 1982 and included samples from southern California's five largest ocean dischargers: Hyperion (City of Los Angeles), Joint Water Pollution Control Plant (JWPCP; Los Angeles County), Orange County, Point Loma (City of San Diego), and Oxnard (Oshida et al. 1983).

SCCWRP scientists Steven M. Bay, Darrin J. Greenstein, Valerie E. Raco, and Karen D. Englehart repeated these effluent tests in April and May of 1987, with the addition of test samples from two smaller treatment plants, Encina and South East Regional Reclamation Authority (SERRA) (located in San Diego and Orange Counties, respectively). In addition to the urchin bioassay, Bay and coworkers also performed the Microtox (Microbics Corp., Carlsbad, CA) bacterial luminescence test (Bulich 1982) on all of the effluents. The objective of this project was to see if a decrease in toxicity that would be expected after improvements in sewage treatment over the past few years could be detected. In addition, the researchers wanted to compare the relative sensitivities of the sea urchin and Microtox test endpoints to aid in their evaluation for routine use in effluent monitoring.

The samples used in this project were 24-h composites of final effluent collected by the dischargers as part of their routine chemical and biological monitoring. This allowed the SCCWRP scientists to compare their results with the measurements of effluent composition and fish toxicity gathered by the dischargers.

The sea urchin bioassay consisted of two parts with three separate endpoints, all performed by using gametes from the purple sea urchin, *Strongylocentrotus purpuratus*. The first part was the exposure of sperm to seawater dilutions of the effluent by using the methods of Dinnel et al. (1987). This was a 60-min test, with the endpoint being fertilization success of eggs added to the solution.

The other two endpoints were measured after a 48-h exposure of fertilized eggs to dilutions of effluent. After 48 h, purple sea urchin embryos normally attain the prism stage of development (Figure 1). Toxic effects were determined by measuring the percentage of normally developed 48-h embryos. The last endpoint evaluated was the amount of pigment echinochrome produced by the embryos. Toxic effects are expressed by a reduction in the amount of pigment present in an extract of an embryo subsample (Bay et al. 1983). The level of pigment in a sample was measured as light absorbance with a spectrophotometer.

The Microtox bioassay involved the exposure of luminescent marine bacteria to dilutions of the effluents. A sodium chloride solution was used as the

Figure 1. Normally developed sea urchin embryo at the 48-h prism stage.

diluent in this test. Toxicity was indicated by the loss of light output after 30 min of exposure.

The results from this study have been expressed as the percentage of change relative to the dilution water control, facilitating the comparison of results from different experiments and test methods. The effluent concentrations chosen for these tests were selected to include the no observable effect concentration (NOEC). This value is defined as the highest effluent concentration tested not resulting in a statistically significant toxic response. The NOEC value has been suggested to be the most appropriate way to describe bioassay results for monitoring purposes.

The results for each of the bioassay endpoints are shown in Table 1. Large differences in effluent sensitivity were found between the different test methods. A similar pattern of relative toxicity between effluent samples was indicated by each method, however. Toxicity was strongly related to differences in effluent

Table 1. Summary of data for all effluents, expressed as percentage of control value. Data marked with an * are significantly different from the controls. (Dunnett's $P \leq 0.05$). Note that different dilutions were tested for each sample.

Sample	%Fertilized	%Normal after 48 h	Echinochrome Absorbance[a]	Microtox
JWPCP				
0.05%				100
0.1%	39*	106	104	98
0.2%	36*	103	106	94
0.5%	1*	99	109	
1%	0*	94	110	
2%	0*	96	110	
4%	0*	17*	77	
Hyperion				
0.1%	83	101	93	97
0.2%	66*	104	99	96*
0.5%	39*	107	101	92*
1%	38*	101	107	86*
2%	34*	95	90	81*
4%	8*	96	97	
Orange Co.				
0.2%	58*	81*	79*	98
0.5%	40*	95	98	95*
1%	33*	108	98	89*
2%	5*	101	105	85*
4%	0*	78*	91	
8%	0*	1*	48*	
San Diego				
0.5%	51*	98	110	92
1%	17*	114	132	86*
2%	2*	88	130	78*
4%	1*	59	125	66*
8%	0*	0*	68*	57*
Oxnard				
2%	70*	110	125	94
4%	62*	105	140	91*
8%	40*	89	120	85*
Encina				
2%	58*	104	128	89
4%	25*	83	125	85*
8%	11*	6*	68*	83*
SERRA				
1%	103	110	46*	
2%	89*	105	105	
4%	87*	109	116	96
8%	77*	109	123	91*

[a] Echinochrome absorbance was measured at 495 nm.

Table 2. Effluent chemistry values from the actual effluent samples on which the bioassays were performed (unless otherwise noted) and annual averages for 1982. All units are micrograms per liter unless otherwise noted. Values for 1982 for Encina and SERRA effluents are omitted because we did not perform tests on them at that time.[a]

Constituent	JWPCP		Hyperion		Orange Co.		San Diego		Oxnard		Encina	SERRA
	1987	1982	1987	1982	1987	1982	1987	1982	1987	1982	1987	1987
Flow (MGD)	386	359	369	375	270	223	182	132	20	17	19[b]	15[c]
% Secondary	50	0	25	25	60	60	0	0	100	100	47	100
Susp. Solids (mg/L)	75	164	56	77	52	112	73	126	23	41	58[b]	20[c]
BOD (mg/L)	106	199	111	176	64	158	132	124	26	27	65[b]	11[c]
Ammonia-N (mg/L)	37.5	41.0	15.6	14.8	NA	24.0	23.4	24.2	4.9	13.9	19.5	7.2
Tot. phenol (mg/L)	1.8	2.53	0.048	0.062	NA	0.07	0.007	0.033	<0.02	0.012	0.001	<0.003
Arsenic	7	7	7	<5	NA	2	4	4	<5	11	<5	<5
Cadmium	1	11	12	10	2	16	<5	8	<10	10	7	<1
Chromium	61	190	3	90	17	70	<20	22	<10	8	<5	<50
Copper	44	128	67	140	60	218	50	133	52	28	22	40
Lead	46	81	30	50	20	80	<50	82	<70	26	1	140
Mercury	0.1	0.8	0.2	0.7	NA	0.2	0.5	0.4	<1	NA	<0.2	<1
Nickel	55	150	60	90	30	70	20	69	82	35	38	<40
Silver	8	11	12	20	11	16	<10	<2	<20	19	<1	<10
Zinc	110	510	320	180	70	200	62	292	58	NA	62	140
Cyanide	30	60	26	60	NA	40	5	7	11	<50	10	100
Tot. DDT	0.07	0.45	<0.02	0.06	NA	0.064	ND	0.081	<0.05	ND	ND	NA
Tot. PCB	ND	0.47	<0.1	<0.1	<0.5	1.77	ND	<0.001	<0.15	1.00	ND	NA
Tot. PAH[d]	<0.014	NA	0.024	NA	1.93	NA	<0.009	NA	<0.005	NA	<0.005	NA
96-h LC_{50}[e]	77	22	101	74	132	114	59[b]	96	>100[f]	77	130[g]	NA

[a]Abbreviations: NA, data not available; ND, not detectable or detection limit not available; MGD, millions of gallons per day; PCB, polychlorinated biphenyl; PAH, polynuclear aromatic hydrocarbon; LC_{50}, lethal concentration for 50% of the test organisms.
[b]Average for the month of May.
[c]Average for the month of April.
[d]Analysis done at SCCWRP.
[e]Fathead minnow bioassay, performed by the discharger.
[f]No mortality occurred at any of the dilutions, so LC_{50} cannot be calculated.
[g]Value for different day of same week.

flow at each treatment plant (Table 2). Effluent samples from plants having flows greater than 138 x 10^9 L/yr (100 million gallons per day) usually had much greater toxicity than did effluent from facilities with lower flows. This pattern is illustrated most clearly by the sperm test data (percent fertilized eggs).

The suspended solids content of the effluent samples also appeared to have an influence on the degree of toxicity. Among the larger treatment plants, effluent samples with the lowest suspended solids content (Hyperion and Orange County) generally elicited the least toxic response. Similar results were found for the smaller treatment plants. The Encina effluent sample had the highest suspended solids concentration and greatest toxicity of similar sized treatment plants.

The relationships between toxicity and flow or suspended solids illustrated by these results are to be expected because these parameters serve as general descriptors of the quantity of toxic chemicals likely to be present in the effluent. Large treatment plants (high flow) are often located near areas of increased industrial activity and the suspended solids in the effluent generally contain the highest concentrations of most contaminants. The concentrations of many toxic constituents were measured in these effluent

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Table 3. Comparison of NOEC for echinochrome data between 1982 and 1987 samples.

Discharger	NOEC (%Effluent) 1982	1987
JWPCP	0.2	>4
Hyperion	0.2	>4
Orange Co.	0.2	4
San Diego	1	4
Oxnard	7	>8

samples (Table 2). Multivariate statistical analyses are planned to help interpret these data, with the intent of determining which constituents are most closely associated with the toxicity observed.

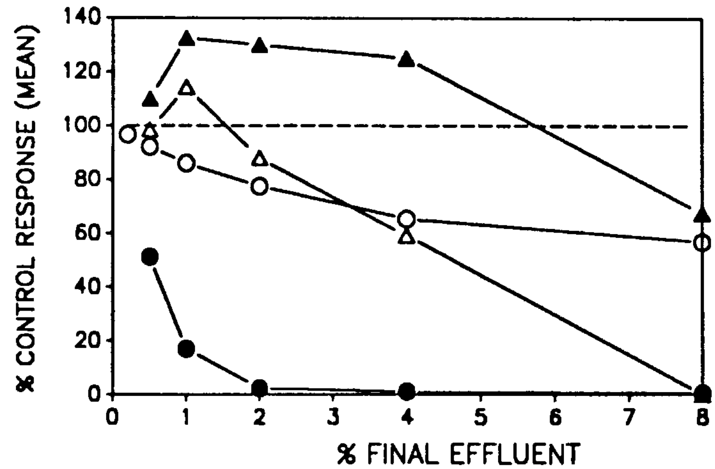

Figure 2. Results of Microtox and sea urchin sperm and embryo tests of Pt. Loma sewage effluent toxicity. The dashed line indicates the control response of 100%. Symbols: O, microtox; ●, sperm; △, % normal after 48 h; ▲, echinochrome.

Temporal changes in effluent toxicity can be identified by comparing these current test results to those from these researchers' 1982 survey, in which only echinochrome was measured (Table 3). The echinochrome data show that a decrease in toxicity has occurred for the effluent from the five treatment plants studied in 1982. Improvements in sewage treatment and source control practices appear to be responsible for these toxicity changes. Comparison of the current chemistry values with the annual averages for 1982 shows decreases in suspended solids, biological oxygen demand (BOD), and many chemical constituents (Table 2).

An important result of this study is the illustration of the diversity of effluent toxicity estimates that can be obtained through the use of different test methods. The variations in test sensitivity to effluent are demonstrated by a comparison of the various test results for the Point Loma effluent sample (Figure 2). For all of the effluents, the sperm test showed by far the greatest sensitivity to effluent; statistically significant reductions in fertilization at effluent concentrations below 1% were found for samples from the largest treatment plants.

The sperm test data cannot be used to determine the NOEC for many of the effluent samples because toxic effects were seen at every dilution tested. The inability to identify a NOEC for a given effluent in this study does not necessarily mean that that sample was the most toxic, since different dilutions were tested in many cases. The fertilization percentages show that the Oxnard and Encina effluents were among the least toxic, even though the NOEC was not bracketed by the concentrations chosen for the test.

The Microtox test also demonstrated toxic effects at low effluent concentrations. Although statistically significant effects were detected at very low concentrations, bacterial luminescence did not change as rapidly with increasing effluent concentration as did the sea urchin test endpoints (Figure 2). As a result, the relative sensitivity of effluent toxicity estimations from Microtox results is dependent upon the data analysis method. If relative toxicity is expressed in terms of the NOEC, the Microtox test is much more sensitive than the 48-h embryo test. If concentrations producing a 50% change (EC_{50}) are used to describe toxicity, the Microtox test is often less sensitive than the sea urchin sperm or embryo test.

The high sensitivity of the sperm and Microtox test methods is probably due to the rapidity of these methods, rather than to biological differences in contaminant susceptibility. Laboratory tests with individual contaminants usually show that the sperm and Microtox tests have similar or lower sensitivities compared with sea urchin embryo tests. The apparent reduced sensitivity of the sea urchin embryo test observed in this study was probably due to reductions in effluent contaminant levels during the exposure from volatilization and adsorption processes.

The State of California will require the use of sensitive marine bioassay tests for effluent monitoring by 1991. The State Water Resources Control Board is considering regulatory policy that would require effluents not to produce toxic effects in these tests at concentrations lower than the one resulting from initial dilution in the ocean. This effluent toxicity study provides an indication of the type of results which can be expected for future monitoring programs. The sperm test is one of the methods recommended by the U.S. Environmental Protection Agency for effluent testing and will probably be used in some monitoring programs in southern California. Results from the sperm tests by Bay et al. indicate that the proposed regulations would be exceeded by most of the effluents tested because toxicity was often found at levels below those produced by the treatment plants' assigned initial dilutions, which range from 0.6 to 1.2%.

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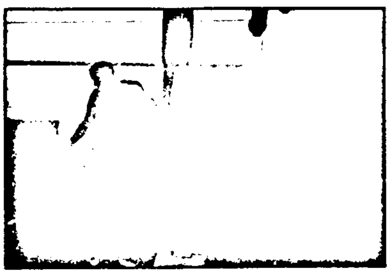
Communications



Sampling at Sea

Scientific research requires collecting various types of information to thoroughly understand oceanographic processes.

SCCWRP uses a variety of small ships and boats which are either made available by our sponsors contributing in cooperative projects or chartered from independent operators.

During the period ending December 31, 1987, our scientific staff conducted or participated in 133 cruises involving 402 man-days at sea. Usually this involved two or more persons (averaging three persons) at sea every working day.

Table 1 shows the distribution of effort by ship, date, and project. The dedication of Harold Stubbs and Dario Diehl, who start early and work long hours in sometimes rough seas, is much appreciated by all who have worked with them.

Table 1. Distribution of effort in 1987*

Date	Vessel	Activity	Location
January			
6	Sea-S-Dee	Service sediment collectors, CTD, & DHS trawls	White Point
7-9	Monitor III	Service current meters, sediment collectors, & CTD	Point Loma
15	Skiff	Hook & line - white croaker	Dana Point
21-23	Monitor III	Trawls & CTD	Point Loma
26	Enchanter IV	Service sediment collectors & CTD	Orange Co.
27, 28	Marine Surveyor	Trawls	Santa Monica Bay
February			
4	Marine Surveyor	Trawls - shrimp & urchins	Santa Monica Bay
11, 12	Monitor III	Retrieve current meters, sediment collectors, & CTD	Point Loma
20	Sea-S-Dee	Service sediment collectors & CTD	White Point
March			
1	Con-Suerte	Trawls	Dana Point
3	Marine Surveyor	Grabs	Santa Monica Bay & White Point
4	Enchanter IV	Service sediment collectors, CTD, & PAH	Orange Co.
5	Marine Surveyor	Grab	L.A. Harbor
6	Con-Suerte	Grabs	Dana Point
14, 18	Marine Surveyor	U/W TV	Santa Monica Bay
26	Marine Surveyor	Trawls	Santa Monica Bay
31	Sea-S-Dee	CTD & sediment collectors	White Point
April			
6	Enchanter IV	CTD & sediment collectors	Orange Co.
22	Marine Surveyor	Trawls	Deep Canyon Santa Monica Bay
23	Sea-S-Dee	Trawl for mysids	White Point
27	Marine Surveyor	Trawl for shrimp & urchins	Santa Monica Bay
30	Enchanter IV	CTD & sediment collectors	White Point

(continued)

(*Table 1 continued*)

Date	Vessel	Activity	Location
May			
1	Sea-S-Dee	CTD & sediment collectors	White Point
4-6	Seawatch	DHS trawls	White Point
11-15	Con-Suerte	DHS trawls	Dana Point
18-20	Sea-S-Dee	Coring	White Point
18-22	Con-Suerte	DHS trawls	Newport area
26-28	Sea-S-Dee	Trawls	White Point
June			
1	Sea-S-Dee	Current meters, CTD & sediment collection	White Point
1	Seawatch	Trawls	Malibu
2	Enchanter IV	CTD & sediment collection	Orange Co.
3, 4	Enchanter IV	DHS trawls	Lausen Knoll
8-12	Con-Suerte	DHS trawls	Sunset Beach
15-19	Con-Suerte	DHS trawls	Palos Verdes area
17, 18	Sea-S-Dee	Coring	Palos Verdes area
25	Con-Suerte	DHS trawls	Dana Point
28	Seawatch	Trawls	Malibu area
July			
1	Con-Suerte	Grabs for bioassay	Dana Point
2	Sea-S-Dee	Install current meters, grabs for bioassay, & CTD	White Point
7	Enchanter IV	Service sediment collectors & grab for bioassay	Orange Co.
8-10, 13-17, 20-24, 28	Con-Suerte	DHS trawls	Santa Monica Bay
28-30	Monitor III	Trawls	San Diego
August			
3	Sea-S-Dee	Service current meter & sediment collectors. Take CTD & collect mysids	White Point
17-21	Con-Suerte	DHS trawls	L.A. Harbor area
24-28	Con-Suerte	DHS trawls	Catalina

(*continued*)

(Table 1 continued)

Date	Vessel	Activity	Location
September			
3, 4, 8-10	Westwind	Hyperion 7-mile outfall termination	Santa Monica Bay
14	Sea-S-Dee	Service sediment collectors	White Point
16-18	Westwind	Microlayer sampling	Santa Monica Bay
19	Con-Suerte	SWRCB field sediments	Dana Point
20-23	Monitor III	SWRCB & EPA field sediments	San Diego
October			
9	Sea-S-Dee	Service sediment collectors & CTD	White Point
13	Sea-S-Dee	Sediment resuspension	White Point
15	Marine Surveyor	Trawls	Santa Monica Bay
22	Enchanter IV	Service sediment collector & CTD	Orange Co.
28, 29	Monitor III	Install sediment collectors & grabs	San Diego
29	Marine Surveyor	Grabs	7-mile Santa Monica
30, 31	Con-Suerte	Grabs & collect brittlestars	Dana Point, San Mateo Point
November			
2	Marine Surveyor	Grabs	7-mile Santa Monica
11	Sea-S-Dee	Service sediment collectors & CTD	White Point
19	Enchanter IV	Service sediment collectors & CTD	Orange Co.
24	Golden West	Longlines & trawls	L.A. Harbor
December			
1	Golden West	Longlines & trawls	L.A. Harbor
2, 3	Monitor III	Service sediment collectors & CTD	San Diego
14	Sea-S-Dee	Service sediment collectors & CTD	White Point
15	Whaler	Longlines	L.A. Harbor
21	Enchanter IV	Service sediment collectors & CTD	Orange Co.
22	Golden West	Trawl for white croaker	L.A. Harbor

[a]Abbreviations: CTD, conductivity/temperature/depth profiler; DHS, California Department of Health Services; PAH, polynuclear aromatic hydrocarbons; U/W TV, underwater television; SWRCB, State Water Resources Control Board; EPA, U.S. Environmental Protection Agency.

Historical Review of Monitoring in Southern California for the NRC

The National Research Council (NRC) determined that there was a national need for a comprehensive study of marine monitoring programs. Their study design included at least two case studies of specific regions of the United States where there were public concern and strong historical data bases on marine environmental monitoring. The Southern California Bight was selected as one such region, and SCCWRP scientists compiled a review of monitoring in the region.

Only those programs for which samples were taken at the same locations for at least three years were included in the study. Parameters that were used in the compilation were bacteriological contamination, water column quality, sediment contaminants and infauna, and epifauna including fish. Three primary categories of monitoring programs were noted during this study: (1) municipalities that discharge to the ocean, (2) power plants that are cooled with seawater, and (3) state and federal agencies that collect marine life to determine the dynamics of marine resources.

Historically, monitoring in California began in 1914 with the organization of the Department of Commercial Fisheries, whose responsibilities were to collect statistics; study fishing methods and processing; and learn about fishes, their habits, migrations, and spawning (Clark 1982). Many species were overfished during World War II to try to meet the increased demand for food. After the war, California's tremendous population growth increased water pollution and destruction of the aquatic habitat, and generally put a strain on all marine resources (Croker 1982).

The collapse of the sardine fishery in 1947 prompted the industry to propose and fund the Marine Research Committee (MRC). Revenue that was collected from taxes levied on the purchase or capture of certain species of fish went into the Fish and Game Preservation Fund. This money was dispensed by the MRC to finance research in developing the commercial fisheries of the Pacific Ocean and in developing marine products to be made available to Californians.

In 1948 the MRC established the California Cooperative Sardine Research Program to pursue research on physical and chemical oceanography, productivity, spawning and recruitment of sardines, availability of sardines to the fishery, fishing methods, and dynamics of the sardine population and fishery. In 1953, the program was renamed the California Cooperative Oceanic Fisheries Investigation (CalCOFI) to recognize the expansion of the sardine program to other species (Talbot 1973, Baxter 1982).

By 1960 the objectives of CalCOFI had been reformulated from understanding the sardine's behavior, availability, and abundance to understanding the factors that govern the abundance, distribution, and variations of pelagic marine fishes, emphasizing the oceanographic and biological factors affecting

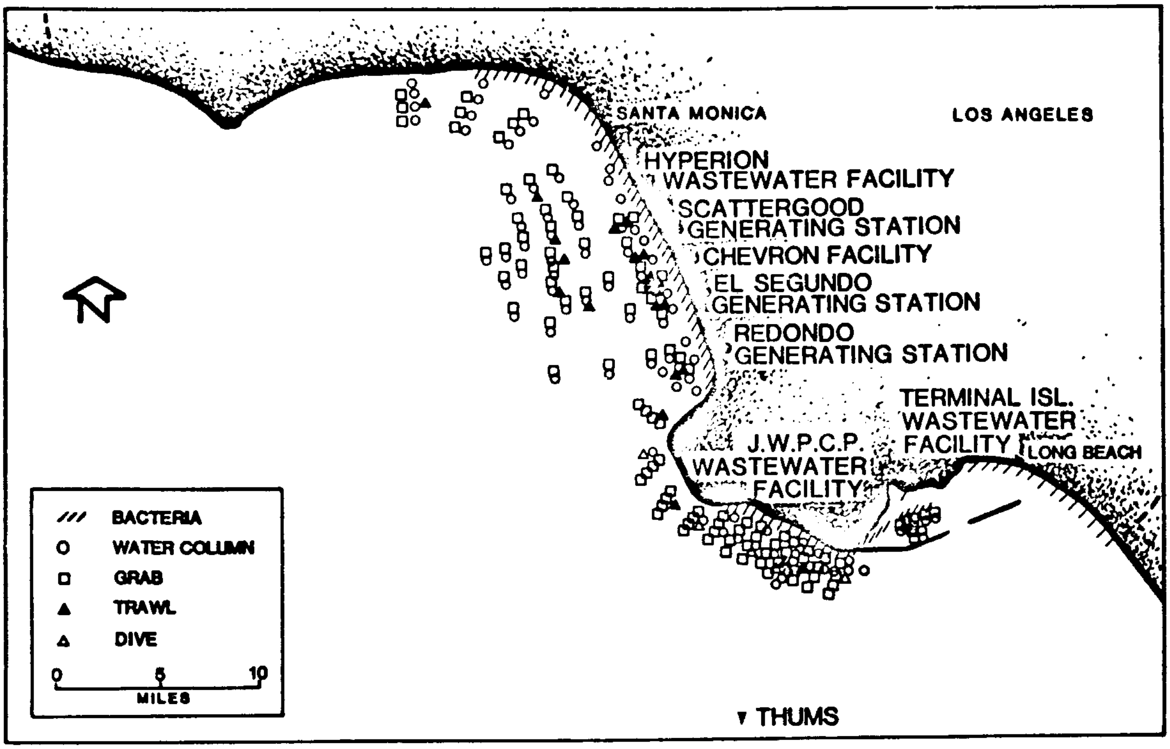


Figure 1. Monitoring efforts in Los Angeles County. Thums, Dump site for Texaco, Humble, Union, Mobil, and Shell Oil Companies.

sardines and their associates in the California Current system (Baxter 1982).

During this study for the NRC, SCCWRP scientists compiled short historical summaries of the activities related to marine monitoring conducted by the State of California and large municipal dischargers, including the Hyperion Wastewater Treatment Plant (City of Los Angeles), the Joint Water Pollution Control Plant outfall at Palos Verdes (County Sanitation Districts of Los Angeles County), CSDOC Treatment Plant No. 2 (County Sanitation Districts of Orange County), and the Point Loma Treatment Plant (City of San Diego). Also included were seven non-nuclear generating stations operated by San Diego Gas & Electric, Southern California Edison, and the Los Angeles Department of Water & Power. A list of monitoring activities and studies was compiled for the Southern California Edison San Onofre Nuclear Generating Station.

Marine monitoring objectives are to document short- and long-term effects of the discharge on receiving waters, sediment, biota, and beneficial uses of the receiving water; to determine compliance with National Pollution Discharge Elimination System (NPDES) permit terms and conditions; and to assess the effectiveness of toxic control programs.

To determine compliance with water quality standards, the receiving-water quality monitoring program must document water quality in the vicinity of the zone of initial dilution (ZID) boundary, at reference stations, and at areas beyond the ZID where discharge impacts might reasonably be expected. Monitoring must reflect conditions during all critical environmental periods.

Receiving-water monitoring comprises the following:

(1) *surf zone monitoring* to assess bacteriological conditions in

areas used for body-contact activities (such as swimming) and to assess aesthetic conditions for general recreational uses (such as picnicking),

(2) *nearshore monitoring* to assess bacteriological conditions in areas used for body-contact sports (such as scuba diving) and where shellfish or kelp may be harvested and also to assess aesthetic conditions for general boating and recreational uses,

(3) *water column monitoring* to determine if the applicant's discharge causes significant impacts on the water quality within the ZID and beyond the ZID as compared with reference stations, and

(4) *ocean current studies* to determine the potential for onshore transport of effluent and to aid in the predictions of effluent dilution and sediment accumulation.

Samples of bottom sediment are analyzed to assess the presence of pollutants and to evaluate the physical and chemical quality of the sediments.

Biological monitoring includes benthic biota monitoring to assess the presence of pollutants in organisms and to monitor the status of the benthic community; trawl sampling to assess the populations of demersal fish, to assess the bioaccumulation of toxic pollutants, and to determine whether a significant difference exists between those populations near the outfall diffuser and those in reference areas; rig fishing to monitor pollutant body burdens in fish consumed by man in order to determine whether the effects of the waste discharge may constitute a threat to public health; and kelp bed monitoring to assess the extent to which the discharge of wastes may affect the aerial extent and health of coastal kelp beds.

Municipal dischargers provide the greatest amount of monitoring data for the greatest cost. The four largest dischargers spend between $1 and 2 million per year on marine monitoring activities. Power plants spend an average of $105,000 per year, but the nuclear generating station at San Onofre requires an expenditure of $1.1 million per year, and an additional $6 million per year was given to the MRC for 10 years for a program designed to measure potential impacts of the station's discharge.

There are numerous specific monitoring programs, ranging from Santa Barbara to San Diego, compiled in this study. Copies of NPDES permits were obtained from the dischargers or the Regional Water Quality Control Boards. These permits provide much useful information including the name of the program, the reasons and objectives for monitoring, and a contact for the program. In addition to the specific monitoring programs, this compilation contains an extensive list of programs funded by dischargers and state and federal agencies that do not qualify as monitoring programs by the standards of this study because although many were conducted for several years, the same measurements at the same stations were not made. However, these programs still provide valuable reports on the physical, chemical, or biological characteristics of locations within the Southern California Bight.

Within the next year the final Southern California Bight case study and the NRC marine monitoring assessment should be available from their office in Washington, D.C. This will be a valuable analysis of the usefulness of monitoring measurements, and we look forward to their recommendations.

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Evaluation of Monitoring Methods

Monitoring of the marine environment to determine the effects of wastewater discharge has been conducted since the late 1950s in southern California. Currently, the four largest wastewater dischargers in the region spend over $4 million per year on mandated monitoring programs. These activities have produced an enormous amount of data that have seldom been evaluated. Regional analyses of all monitoring data have not been made.

Beginning about 1978, regulatory agencies, dischargers, and SCCWRP staff began discussing the possibility of a regional monitoring program. These discussions blossomed into a concept called ROMP--Regional Ocean Monitoring Program. Committees to determine sampling design and data management were established and made recommendations on how to set up such a program. Everyone agreed that regional monitoring should be established, but disagreement among regional, state, and federal regulators concerning who should administer the program essentially brought the discussions to a halt.

SCCWRP's role in the regional monitoring discussions was to coordinate the program and provide information necessary for making decisions about monitoring practices in the region. One of the main issues in regional monitoring is the selection of reference sites. SCCWRP felt that under current monitoring programs, the reference sites being sampled were not providing an adequate view of reference areas along the coast. To provide information about reference areas in the region, the 1985 Reference Site Survey was conducted (Thompson et al. 1987). Another issue was that of replication. SCCWRP and EcoAnalysis, Inc. (Ojai, CA) conducted analyses of power and precision of infaunal sampling and trawling (Bernstein et al. 1985, Cross 1983).

The subject of regional monitoring began to surface again in 1987 when the National Research Council (NRC) decided to investigate monitoring practices in the United States with the Southern California Bight as a case study (see p. 85; SCCWRP 1988, NRC [in press]).

The staff of SCCWRP fully agrees with the NRC's findings that regional monitoring is sorely needed in southern California. Setting up such a program will be very difficult. It is essential that all discharge agencies, regional and state boards, and the U.S. Environmental Protection Agency (EPA) agree to participate and to determine program structure and administration. It is also important that representatives of environmental organizations have opportunities for input in the development of the plan and review of progress.

In reviewing the National Pollution Discharge Elimination System (NPDES) monitoring programs of the major sewage dischargers for the NRC, we found that it is not possible to put together a comprehensive regional data base with that data.

By using offshore benthic monitoring programs as an example, different times, depths, numbers of replicates or composite samples, and different suites

Table 1. Partial listing of benthic parameters measured in 1987 southern California monitoring programs.[a]

Parameter		Oxnard	L.A. City Hyperion	L.A. County[b]	Orange County	San Diego Pt. Loma
	No. of sites:	7	39	18 (44)[c]	13 (40)[d]	18
	Depth (m):	16-20	18-150	23-305	30-304	16-83
Sediments						
Sulfides		S	A	-	Q (A)	Q
Grain size		S	A	-	Q (A)	Q
TVS		-	-	S	Q (A)	-
TOC		S	A	-	-	-
BOD		S	-	-	-	Q
Metals		S	A[e]	5 yr	Q[e] (A)	S[e]
DDTs		S	A	5 yr	Q (A)	S
PCBs		S	A	5 yr	Q (A)	S
PAHs		A	A	5 yr	Q (A)	S
Biology						
Infauna		S	S	S	Q (A)	Q
Trawls		S (3 sta.)	Q (6 sta.)	Q (12 sta.)	S (8 sta.)	S (6 sta.)
Tissue chemistry		A	A	-	S	-

[a]Abbreviations: A, annual; S, semiannual; Q, quarterly; -, not measured.
[b]The NPDES monitoring program was modified in 1988 to include more frequent sediment chemistry monitoring than these data indicate.
[c]An extended 44-station survey is to be conducted every 5 yr or after any major event. Trace chemistry is conducted at these times.
[d]Monitoring is done quarterly at 13 sites and annually at 40 sites.
[e]Metals, DDTs, PCBs, and PAHs are measured as priority pollutants.

of sediment contaminants are sampled in each monitoring program (Table 1).

Infaunal data are collected by all agencies, and all agencies participate in the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT), whose goal is taxonomic standardization. Species names submitted to the Ocean Discharge Evaluation System (ODES) may be consistent within a discharge agency, but there is no provision to merge species lists from two or more agencies and check for standardized species names so that a regional analysis of the data may be accomplished.

Similar problems exist for sediment data. For example, Hyperion, Orange County, and Point Loma are required to measure priority pollutants in sediments, but Los Angeles County is required to measure selected contaminants every five years. Point Loma does not measure total volatile solids (TVS) or total organic carbon (TOC). Although not shown in Table 1, some agencies measure two Aroclor mixtures (polychlorinated biphenyls [PCBs]) while others measure seven. The Southern California Environmental Chemists Society (see p. 91) was organized to standardize analytical chemistry methods which must also be addressed in a regional monitoring program. Not all dischargers use ODES. Therefore, data would have to be requested and verified manually. Most multivariate analyses cannot be performed with data sets that contain such gaps. Standardized regional monitoring could resolve these problems.

Many other technical issues must be resolved before regional monitoring can be established. A few of the important questions are the following:

(1) Which parameters are useful?

(2) How could compliance be determined for each parameter measured?

For example, for sediment contaminants, should the 95% confidence intervals of reference values, or toxicity limits be used as compliance criteria.

(3) How should reference sites be used in monitoring programs?

(4) How can we reconcile statistical significance with environmental significance?

(5) What additional information do we need to facilitate better monitoring decisions?

For example, analyses of power and precision for sediment and tissue contamination parameters have not been made for our region and would help guide decisions on replication, etc.

(6) Is it possible to define a balanced indigenous population?

(7) What if biological parameters are within compliance limits, but sediment parameters are not?

Some portion of the regional plan should be special studies to develop better approaches for determining which organism responses are best for use as early warning signals. Studies on sediment contaminants would be designed to develop better criteria for sediment impacts on biota.

SCCWRP hopes to assist in establishing a regional monitoring program by co-sponsoring a workshop to produce a consensus on the strategy for implementing such a program. Additional technical workshops will need to be held to work out details.

In anticipation of regional monitoring we have compiled a regional demonstration data base that includes permit monitoring data from the Hyperion Treatment Plant, Los Angeles County, Orange County, and Point Loma, as well as the 1985 Reference Site Survey data. It contains data from 93 sites at 30, 60, and 150 m sampled in the summer of 1985. This data base is available for use in addressing the numerous technical questions about regional monitoring, some of which are those listed above.

Most importantly, working together on the NRC case study produced a new spirit of cooperation and interest by southern California discharge agencies and regulatory agencies. That momentum should be carried forward towards a viable regional monitoring program.

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SCAMIT and SCECS: An Overview

The Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) was founded as a result of SCCWRP's original Taxonomy Standardization group, which was beginning to suffer from a lack of interest. SCAMIT was instituted in 1982 through a cooperative effort and renewed interest of taxonomists from SCCWRP, sanitation districts from Oxnard to San Diego, and local consulting agencies. Its primary functions are to develop a regionally standardized taxonomy and to disseminate taxonomic information.

Currently, SCAMIT has over 100 members throughout the world, including Mexico, Canada, Belgium, Great Britain, the West Indies, and the USSR. Many members are taxonomists by trade and study the local fauna for laboratories (such as SCCWRP) and consulting agencies, while others teach at universities or work in museums.

Each month, members meet at the Cabrillo Marine Museum in San Pedro, where the SCAMIT library of taxonomic literature and comprehensive listing of local marine invertebrates are stored for the members' use. Different taxonomic groups are chosen for study at each meeting, and representative species from that group are described on a voucher sheet and preserved in a reference collection. The monthly meetings give the members an opportunity to discuss and resolve problems in systematics, which ensures a standardized taxonomy. Members also receive a monthly newsletter that not only provides information concerning the meetings but also contains taxonomic descriptions, keys, and bibliographies.

In addition, SCAMIT hosts special workshops and lectures that are pertinent to taxonomic and ecological issues. Dr. J. L. Barnard is a world authority on gammaridian amphipods and has shared his expertise with SCAMIT at three workshops to date. SCAMIT members bring in specimens they are having problems assigning to a specific taxon and with the help of Dr. Barnard one of three things may be concluded.

(1) The specimen is a new undescribed species which needs to be described in the literature.
(2) The specimen is a currently described valid species.
(3) The systematics of that particular group is confused and needs more work.

At the workshops, SCAMIT members are able to work out taxonomic problems at a much accelerated pace than at their regular meetings.

Southern California Environmental Chemists Society

The Southern California Environmental Chemists Society (SCECS) was founded in 1985 by a group of chemists from municipal wastewater monitoring laboratories and SCCWRP. The purpose in forming SCECS was to promote communication among chemists who analyze environmental samples and to move toward standardizing analytical procedures. Up to this point, the diverse analytical methods and strategies used in monitoring and research programs were not always comparable. Also, it was apparent that the California State Water Resources Control Board and the Environmental Protection Agency would soon be requiring these laboratories to develop analytical capabilities for new classes of compounds (e.g., priority pollutants). Since most members had little experience doing this, it was felt that SCECS would help tremendously to provide an opportunity to interact with chemists who were developing similar methods. Thus the objectives of SCECS are to exchange scientific information on advances in analytical methodology, applications, and findings, and in general, to act as a medium for the improvement of chemical procedures and laboratory efficiency.

An important part of any chemistry program is quality assurance/quality control (QA/QC) and indeed a considerable amount of time and money is spent on QA/QC by analytical laboratories. SCECS also recognized this as an area in which its members needed to have a means of exchanging ideas and improving their understanding of how to manage a high-caliber QA/QC program. Laboratory managers have supported this need and consider time spent at SCECS meetings as an integral part of their QA/QC program; thus SCECS devotes much effort to this subject.

As of May 1988, SCECS had approximately 130 members including chemists from ocean monitoring laboratories and SCCWRP, as well as chemists and biologists from several private laboratories and other government agencies such as the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the South Coast Air Quality Management District, the California Department of Fish and Game, and the California Department of Agriculture.

Meetings are held every two months and the location rotates to different host laboratories so that members get a chance to experience laboratories other than their own. At each of these meetings specific subjects related to analytical techniques are discussed so that problems can be solved and helpful hints may be shared. Some of SCECS' goals include developing an ongoing intercalibration program, a standard reference material program, and a handbook of systematic analytical methods. SCECS members are currently compiling a manual for sample collection techniques which will aid those who often are not chemists themselves, but who are collecting environmental samples for chemical analysis.

SCAMIT and SCECS assure QA/QC for SCCWRP by integrating the thoughts of many scientists with common goals: standardization of their specialized fields, refinement or introduction of methods, and solutions to problems. Involvement with these organizations leads to improvement of SCCWRP methods by assuring constant refinement of procedures and review of methods used by other organizations. These two vital groups promote standardization of procedures among agencies conducting monitoring and research in their respective fields.

Readers interested in knowing more about SCECS or in joining the Society may contact the SCECS President, Richard Gossett, at (213) 435-7071. For information about SCAMIT membership, please contact Ann Martin at (213) 322-3131 (ext. 317).

New Projects

In addition to conducting studies that are funded by the SCCWRP sponsors, the SCCWRP staff also receives grants and contracts from other government agencies and private organizations. The information gathered through these projects helps in understanding the Southern California Bight, which is a benefit to all concerned. Recently, SCCWRP became involved with two new contracts, one from the U.S. Department of the Interior's Minerals Management service (MMS) and one from the American Petroleum Institute (API).

The Ocean Studies Institute (OSI; a consortium of the California State University campuses at Dominguez Hills, Fullerton, Long Beach, Los Angeles, Northridge, and Pomona) received a 30-month $333,000 contract from MMS to produce a graduate level textbook, which is tentatively titled *Ecology of the Southern California Bight: A Synthesis and Interpretation*. SCCWRP became part of the proposal to provide its expertise regarding the Southern California Bight.

Twenty-four scientists from the Pacific Northwest to Southern California will be contributing to the text which will contain chapters on various aspects of the Southern California Bight including physical oceanography, geochemistry and chemical oceanography, microbiology, phytoplankton, zooplankton, algae and marine spermatophytes, benthic invertebrates, fish, birds, marine mammals, major natural events, anthropogenic inputs and effects, complexity of governance, and ecosystem interrelationships. The project will also provide a current bibliography on the Southern California Bight to MMS, the result of a thorough literature search, which will list research done in the bight.

In addition to writing portions of the text, Murray Dailey (Director of OSI) will oversee the project as Program Manager, Jack W. Anderson (Director of SCCWRP) will aid the project as Publications Editor, and Donald J. Reish (Professor of Biology at California State University, Long Beach) will serve as Science Editor. A review board consisting of several scientists, all with well-known expertise in their respective fields, has been put together by the management team to ensure a high-quality text.

Jack W. Anderson of SCCWRP and Donald J. Reish of California State University, Long Beach, received a $100,000 contract for the first year of research from API to study the effects of produced waters on selected marine species through bioassays. In order to attain these goals, the principal investigators will develop methods for the collection, transport, and dilution of produced water samples; determine the chemical composition of produced water samples during specific time periods; compare mysids with five other organisms to evaluate test procedures and comparative sensitivities; and measure the toxicity of reference compounds and produced water samples with various salinities on five organisms. A second year of funding at approximately the same level is anticipated to complete the project.

Recent Contributions

1986

Brown, D. A., R. W. Gossett, G. P. Hershelman, C. F. Ward, A. M. Westcott, and J. N. Cross. 1986. Municipal wastewater contamination in the Southern California Bight: Part I - Metal and organic contaminants in sediments and organisms. *Mar. Environ. Res.* 18:291-310. C-204.

Cross, J. N. 1986. Epidermal tumors in *Microstomus pacificus* (Pleuronectedae) collected near a municipal wastewater outfall in the coastal waters off Los Angeles (1971-1983). *Calif. Fish Game* 72(2):68-77. C-199.

Jones, G. F., and B. E. Thompson. 1986. The ecology of *Adontyorhina cyclia* (Berry) on the southern California borderland. *Int. Rev. Ges. Hydrobiol.* 71:687-700. C-217.

Thompson, B. E., G. P. Hershelman, and R. W. Gossett. 1986. Contaminants in sediments of two nearshore basin slopes off southern California. *Mar. Pollut. Bull.* 17:404-409. C-218.

1987

Anderson, J., W. Birge, J. Gentile, J. Lake, J. Rodgers, Jr., and R. Swartz. 1987. Biological effects, bioaccumulation, and ecotoxicology of sediment-associated chemicals, pp. 267-296. *In* Fate and Effects of Sediment-Bound Chemicals in Aquatic Systems (K. L. Dickson, A. W. Maki, and W. A. Brungs, Eds.). Pergamon, New York. C-294.

Anderson, J. W., and R. W. Gossett. 1987. Polynuclear aromatic hydrocarbon contamination in sediments from coastal waters of southern California. Final Report to California State Water Resources Control Board. Southern California Coastal Water Research Project, Long Beach, CA. C-212.

Anderson, J. W., R. W. Gossett, C. F. Ward, and A. M. Westcott. 1987. Chlorinated hydrocarbon contamination in Dover sole from offshore Palos Verdes Peninsula. Final report to County Sanitation District of Los Angeles County. Southern California Coastal Water Research Project, Long Beach, CA. C-280.

Brown, D. A., S. M. Bay, D. J. Greenstein, P. Szalay, G. P. Hershelman, C. F. Ward, A. M. Westcott, and J. N. Cross. 1987. Municipal wastewater contamination in the Southern California Bight: Part II - Cytosolic distribution of contaminants and biochemical effects in fish livers. *Mar. Environ. Res.* 21:135-161. C-205.

Brown, D. A., R. W. Gossett, and S. R. McHugh. 1987. The occurrence of oxygenated metabolites of DDT and PCBs in marine sediments and organisms. *In* Oceanic Processes in Marine Pollution, vol. 1. Biological Processes and Wastes in the Ocean (J. M. Capuzzo and D. R. Kester, Eds.). Krieger, Melbourne, FL. C-202.

Cross, J. N. 1987. Demersal fishes of the upper continental slope off southern California. *Calif. Coop. Oceanic Fish. Invest. Rep.* 28:155-167. C-282.

Cross, J. N., J. T. Hardy, J. E. Hose, G. P. Hershelman, L. D. Antrim, R. W. Gossett, and E. A. Crecelius. 1987. Contaminant concentrations and toxicity of sea-surface microlayer near Los Angeles, California. *Mar. Environ. Res.* 23:307-323. C-299.

Hendricks, T. J. 1987. A study of sediment composition, transport, and deposition off Palos Verdes. Final report to County Sanitation Districts of Los Angeles. Southern California Coastal Water Research Project, Long Beach, CA. C-281.

Hendricks, T. J. 1987. Development of methods for estimating the changes in marine sediments as a result of the discharge of sewered municipal wastewater through submarine outfalls: Part I - Sedimentation flux estimation. Final report to U.S. Environmental Protection Agency. Southern California Coastal Water Research Project, Long Beach, CA. C-287.

Hendricks, T. J. 1987. Development of methods for estimating the changes in marine sediments as a result of the discharge of sewered municipal wastewater through submarine outfalls: Part II - Sedimentation simulations. Final report to U.S. Environmental Protection Agency. Southern California Coastal Water Research Project, Long Beach, CA. C-288.

Hendricks, T. J. 1987. In situ measurement of initial dilution at an ocean outfall. Final report to U.S. Environmental Protection Agency. Southern California Coastal Water Research Project, Long Beach, CA. C-286.

Hendricks, T. J. 1987. Measurements of the currents in San Gabriel Canyon and the estimation of the sedimentation rates around the proposed Orange County "deep" outfall. Final report to the National Oceanic and Atmospheric Administration. Southern California Coastal Water Research Project, Long Beach, CA. C-278.

Hendricks, T. J. 1987. Modeling of flow fields and effluent trajectories in the San Diego Bight. Final report to Engineering Science Inc. Southern California Coastal Water Research Project, Long Beach, CA. C-275.

Hose, J. E., J. N. Cross, S. G. Smith, and D. Diehl. 1987. Elevated circulating erythrocyte micronuclei in fishes from contaminated sites off southern California. *Mar. Environ. Res.* 22:167-176. C-279.

Jones, G. F., and B. E. Thompson. 1987. The ecology of *Cyclocardia ventricosa* (Gould, 1850) (Bivalvia:Carditidae) on the southern California borderland. *Veliger* 29:374-383. C-220.

MacDonald, C. D., and B. E. Thompson. 1987. Characteristics of a recreational fishery for Hawaiian spiny lobsters at the Midway Islands. *North Am. J. Fish. Manage.* 7:194-201. C-296.

Stubbs, H. H., D. W. Diehl, and G. P. Hershelman. 1987. A Van Veen grab sampling method. Technical Report. Southern California Coastal Water Research Project, Long Beach, CA. C-276.

Thompson, B. E., and G. F. Jones. 1987. Benthic macrofaunal assemblages of slope habitats in the southern California borderland. Allan Hancock Foundation Occasional Papers, New Series No. 7. Allan Hancock Foundation, Los Angeles. C-219.

Thompson, B. E., G. F. Jones, J. D. Laughlin, and D. T. Tsukada. 1987. Distribution, abundance, and size composition of echinoids from basin slopes off southern California. *Bull. South. Calif. Acad. Sci.* 86:113-125. C-295.

Thompson, B. E., J. D. Laughlin, and D. T. Tsukada. 1987. 1985 Reference site survey. Technical Report. Southern California Coastal Water Research Project, Long Beach, CA. C-221.

Presentations by SCCWRP Staff in 1987

Jack W. Anderson, Director

An overview of SCCWRP: The goals of the organization, results of past research projects and plans for future research.

Presented to:
Crossroads School, Santa Monica, CA. June 1987.
Business Roundtable of Redondo Beach, Redondo Beach, CA. June 1987.
Long Beach Yacht Club, Long Beach, CA. October 1987.
The Propeller Club, Long Beach, CA. November 1987.

Effects and bioaccumulation produced by exposure of the prawn, *Sicyonia ingentis*, and the urchin, *Lytechinus pictus*, to contaminated sediments. Society of Environmental Toxicology and Chemistry, Pensacola, FL. November 1987.

Steven M. Bay, Marine Biologist

Sediment assessment techniques using sea urchins. Western Society of Naturalists, California State University, Long Beach. December 1987.

Jeffrey N. Cross, Fish Biologist

Reproductive and hematologic indicators of stress in fishes from highly contaminated areas off southern California. Fourth International Symposium on Responses of Marine Organisms to Pollutants. Woods Hole, MA. April 1987.

Sea-surface microlayer. California Water Pollution Control Association Conference, San Diego, CA. April 1987.

Micronuclei in the peripheral erythrocytes of fish: A new monitoring technique. California Water Pollution Control Association Conference, San Diego, CA. April 1987.

Contaminant effects on southern California kelp bass (with J. E. Hose of Occidental College). Kelp Bass Symposium, Enhancement of Nearshore Fish Stocks: Status and Future. Cabrillo Marine Museum, San Pedro, CA. June 1987.

Occurrence of micronuclei in fish: A new toxicity test. Aquatic Habitat Institute, Berkeley, CA. November 1987.

Robert P. Eganhouse, Organic Geochemist

The fate of monoaromatic hydrocarbons in an oil-contaminated aquifer: Evidence for the importance of microbial activity (with T. Dorsey, C. Phinney, M. J. Baedecker, and I. Cozarelli). Geological Society of America National Meeting, Phoenix, AZ. October 1987.

Development of an Aroclor-based secondary calibration standard for the congener-specific determination of chlorobiphenyls in environmental samples. Southern California Coastal Water Research Project, Long Beach, CA. October 1987.

Fate of monoaromatic hydrocarbons in an oil-contaminated aquifer. University of California, School of Public Health, Environmental Science and Engineering Program. December 1987.

Tareah J. Hendricks, Physicist/Oceanographer

Los Angeles County Sediment Dynamics Workshop, Pomona, CA. October 1987.

Bruce E. Thompson, Benthic Ecologist

Problems in marine pollution research. Earth Day, Pierce College. April 1987.

Megabenthic assemblages of southern California mainland shelf, slope, and basins. Southern California Academy of Science, Annual Meeting, California State University, Los Angeles. May 1987.

Reference site survey, 1985. Seventh International Ocean Disposal Symposium, Nova Scotia, Canada. September 1987.

Biology of *Lytechinus pictus* in southern California. Western Society of Naturalists, California State University, Long Beach. December 1987.

1987 Management Chart

Commissioners

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T. D. Quinn (Alternate)
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Director

J. W. Anderson, Ph.D.

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R. W. Gossett
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G. P. Hershelman
P. Szalay
C. F. Ward
A. M. Westcott

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D. W. Diehl

Effects

Fisheries

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V. E. Raco
K. D. Englehart

Benthos

B. E. Thompson, Ph.D.
J. D. Laughlin
D. T. Tsukada
D. L. O'Donohue
R. L. Gonzales

Toxicology

S. M. Bay, M. S.
D. J. Greenstein
D. B. Compton

Administration

D. M. Wiley
L. D. Winter
K. D. Foreman
J. M. Nelson
S. R. Laughlin

This chart reflects SCCWRP personnel as of the publication date of this report.

COMMUNICATIONS

Financial Statements

Statement of Revenue

For January 1 through December 31, 1987

		Amount
Interest		$6,645.42
Aid from other Governmental Agencies		
Joint Powers Agreement:		
*County Sanitation District No. 2 of Los Angeles County		
City of Los Angeles	$236,810.00	
County Sanitation District No. 1 of Orange County	145,670.00	
City of San diego	89,880.00	
City of Oxnard	10,640.00	483,000.00
Associate Members:		
Encina Water Pollution Control Facility	10,640.00	
South East Regional Reclamation Authority	10,640.00	21,280.00
Contract Service:		
State Water Resources Board	14,000.00	
City of Los Angeles	11,553.88	
State Dept. of Health Services	68,621.26	
Engineering Science of Pasadena, CA	21,245.33	115,420.47
TOTAL		$626,345.89

*Proportionate share of budget in the amount of $217,000.00 was paid in June 1987.

Balance Sheet

For January 1 through December 31, 1987

	General Fund	Fixed Asset Group of Accounts
Assets		
Cash with Los Angeles County Treasurer	$20,021.33	
Imprest Cash	8,000.00	
Investments	0.00	
Equipment at Cost		$422,684.05
TOTAL	$28,021.33	$422,684.05
Liabilities and Fund Balance		
Encumbrances	$84,883.47	
Fund Balance	(56,862.14)	
Investment in Fixed Assets		$422,684.05
TOTAL	$28,021.33	$422,684.05

Analysis of Changes in Fund Balance

For January 1 through December 31, 1987

	Total General Fund	Less Encumbrances (Commitments)	Fund Balance Available
General Fund			
Balance at July 1, 1987	$120,590.64	$85,892.10	$34,698.54
Increase in Fund Balance available provided by decrease in commitments		(1,008.63)	1,008.63
Decrease in Fund Balance resulting from expenditures in excess of revenues	(92,569.31)		(92,569.31)
Balance December 31, 1987	$28,021.33	$84,883.47	$(56,862.14)
Fixed Asset Group of Accounts			
Balance July 1, 1987		$395,738.95	
Additions to Equipment		26,945.10	
Balance December 31, 1987		$422,684.85	

Statement of Expenditures and Encumbrances Compared with Appropriations

For January 1 through December 31, 1987

	Appropriation	Expenditure	Encumbrance	Total
Salaries and Benefits				
Salaries and Wages:				
Technicians		$297,406.52		
Management and Administration		76,089.32		
Benefits		47,663.44		
	$890,000.00	$421,159.28	—	$421,159.28
Services and Supplies				
Supplies, laboratory		14,233.85	8,263.30	
Services:				
Contractors		11,243.69		
Consulting Board		2,345.00		
Printing		15,409.86		
Research Contracts		71,490.00	2,121.93	
Computer		6.10	1,114.25	
Shiptime		22,894.14	10.00	
Travel		20,393.01	20.00	
Facilities:				
Office Rental		24,072.00		
Office Supplies		9,215.59	2,495.74	
Equipment Rental		18,205.72	46,644.48	
Communication		5,469.85		
Utilities		11,126.68		
Maintenance		10,819.50	17,774.00	
Other:				
Legal Services		1,031.50	420.00	
Accounting and Purchasing		10,028.03		
Insurance (Property/Liability)		21,851.25		
Miscellaneous		975.05		
	$411,200.00	$270,810.82	$78,863.70	$349,674.52
Fixed Assets				
Equipment	100,000.00	26,945.10	6,019.77	32,964.87
TOTAL	$1,401,200.00	$718,915.20	$84,883.47	$803,798.67

VOL 12

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Southern California
Coastal Water
Research Project Authority

646 West Pacific Coast Highway
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(213) 435-7071

VOL 12

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MONITORING SOUTHERN CALIFORNIA'S COASTAL WATERS

Panel on the Southern California Bight of the
Committee on a Systems Assessment
of Marine Environmental Monitoring

Marine Board
Commission on Engineering and Technical Systems
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1990

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the panel responsible for the report were chosen for their special competence and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

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The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Samuel O. Thier is president of the Institute of Medicine.

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The program described in this report is supported by Cooperative Agreement No. 14-12-0001-30416 between the Minerals Management Service of the U.S. Department of the Interior and the National Academy of Sciences, Contract No. P-32690 with six California municipalities, and State of California Contract No. 6-213-250-0 with the California State Water Resources Control Board. Federal agencies that actively worked with the authoring committee include the Environmental Protection Agency, Minerals Management Service, National Oceanic and Atmospheric Administration, and U. S. Army Corps of Engineers.

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Preface

PURPOSE

In 1987, the Marine Board of the National Research Council established the Committee on a Systems Assessment of Marine Environmental Monitoring. The committee's goal was to identify how monitoring contributes to environmental management, to determine why monitoring does not always produce useful information, and to recommend how more effective monitoring programs could be designed. The committee decided to carry out three case studies: the Chesapeake Bay, the Southern California Bight,[1] and particulate dispersion.

The following goals were established for this case study:

- to assess the design of monitoring programs in Southern California in terms of their technical components and linkages to relevant policy issues;

[1] The purpose of this case study was to conduct an overall review and assessment of marine monitoring in the Southern California Bight. Although there is a long tradition of monitoring in the bight, there is widespread concern that intensive monitoring activities are not efficient and that the information that results is not sufficiently used for decision making by governmental agencies. There is also concern that monitoring does not produce a readily accessible, coherent picture of conditions in the bight's marine environment. Accordingly, this study examines monitoring as a system that includes both institutional and technical aspects, then recommends possible improvements to this system. This study thus concentrates on the interface between technical or scientific issues and institutional and policy issues. It does not, other than for illustrative purposes, attempt to describe environmental impacts or actual conditions of marine waters and living resources in the bight.

• to use the assessment to develop guidance for future monitoring practice and institutional frameworks in the region; and

• to assess whether monitoring meets society's needs as manifested in regulations, public opinion, and scientific research.

In pursuit of these goals, this study accomplishes four main objectives:

1. it describes the natural environmental setting, including the physical setting and sources of environmental pollutants and habitat change;
2. it reviews the regulatory and institutional framework, including monitoring responsibilities in the government, academic, and public sectors;
3. it discusses the evolution of monitoring and current monitoring activities in the bight; and
4. it analyzes current monitoring practice in the context of the first three objectives and describes a conceptual framework for improved monitoring.

In combination, these objectives define the overall environmental, regulatory, historical, and institutional framework within which this study assesses monitoring in the bight. The emphasis is on systematic use by regulatory and management agencies of the data collected and not on the technical adequacy of individual collection activities.

METHODS

The Committee on a Systems Assessment of Marine Environmental Monitoring established a case study panel to pursue the goals and objectives described above. The case study panel performed much of its work through a series of fact-finding meetings held throughout Southern California to seek viewpoints from the monitoring community. A planning meeting was attended by panel members, representatives of the California state and regional water quality boards, the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration, municipal dischargers, and various research groups. This initial meeting achieved three results:

1. members identified important issues for the panel to investigate,
2. prepared a list of knowledgeable experts who would be invited to make presentations to the panel about these issues, and
3. specified background information needed for the panel's deliberations.

The Southern California Coastal Water Research Project prepared a report for the panel providing background information for each monitoring program in the bight, including detailed maps and data on sampling design, parameters sampled, sponsoring agency, relevant permits, and cost.

Experts invited to address the panel at subsequent fact-finding meetings were asked to make written and oral presentations. They were asked to consider specific questions about monitoring effectiveness and about their personal experiences with monitoring programs. As a result, the panel received information from experts knowledgeable about and experienced with a variety of issues, including fisheries management, the relationship of large-scale ecological processes to monitoring objectives, institutional relationships, public health, nonpoint sources of pollution, legal and regulatory requirements, wastewater treatment, thermal discharges from coastal power plants, public perceptions and interests, marine science, and monitoring design and implementation. In addition, some panel members made field visits in the region. At the conclusion of these fact-finding sessions, the panel held further meetings to discuss the structure and content of the case study report and to review and discuss draft material.

ORGANIZATION

This case study is organized into seven chapters:

Chapter 1 — The Southern California Bight provides a basic description of the geography, hydrology, water quality, climate, habitats, and natural resources of the area. It also describes land use patterns and economic activities.

Chapter 2 — Sources of Pollution and Habitat Change discusses major activities that result in pollution and habitat change, such as oil exploration and production, municipal and industrial wastewater discharges, power plant thermal discharges, stormwater and surface runoff, aerial fallout, and ocean dumping. It also contains a discussion of the characteristics of the resultant pollutants and their concentrations in the environment.

Chapter 3 — Regulatory Framework and Public Concerns sets forth the basic state and federal regulatory framework (water quality control, public health and safety, and natural resources protection) and the concerns and perceptions of the public about certain policy objectives for the bight.

Chapter 4 — Monitoring and Research Programs in the Southern California Bight discusses the relationship between research and monitoring and the general types of monitoring applied in studies of the bight. It characterizes the roles of government and of the private sector in these activities.

Chapter 5 — A Framework for the Analysis of Monitoring sets forth in general terms the theoretical objectives for a monitoring program and discusses in detail a conceptual framework that will ensure that the objectives are achieved.

Chapter 6 — Analysis of Monitoring Efforts examines specific aspects of certain monitoring efforts in the bight and evaluates the results in light of the conceptual framework and the societal expectations in Southern California. Recommendations for change are set forth in this chapter.

Chapter 7 — Conclusions and Recommendations sets forth the committee's conclusions and recommendations.

THE STUDY'S AUDIENCE

This study was requested by the parent Committee on a Systems Assessment of Marine Environmental Monitoring. Its findings and conclusions and the underlying discussion are an important source of information for the work of that committee. However, because of high interest in the condition of the environment and marine monitoring in Southern California this report will be of substantial interest to parties in that region.

Although environmental monitoring is most often considered to be within the exclusive domain of the scientific community, successful design and use of environmental monitoring depends on a system that reaches beyond scientists. The general public and interest groups have substantive questions about the condition of the marine environment that monitoring must address. Political leaders and policy makers need to make tough decisions about the allocation of monetary resources to particular control strategies, and monitoring results provide information upon which their success may be documented. Public and private managers must implement control programs and be able to predict as well as determine their success or failure on the basis of monitoring information. Finally, the scientific community is vital to the appropriate design and implementation of monitoring programs.[2]

This study, based on an examination of the monitoring system as a whole, makes recommendations about marine monitoring that respond to the needs and responsibilities of all these interests. Thoughtful consideration, debate, and (undoubtedly) modification can contribute to the evolution of marine monitoring in Southern California to make it a strong component of the overall program of environmental protection and restoration.

[2] The incorporation of relevant scientific knowledge in monitoring programs helps ensure that important questions will be properly addressed. Appropriate scientific analysis of monitoring results will also increase understanding of how the marine environment functions and responds to human impacts.

Acknowledgments

The Panel on the Southern California Bight would like to express its gratitude to a number of individuals whose assistance has been invaluable in the development of this report. The committee thanks Dr. Jerry M. Neff for his efforts as rapporteur. Appreciation is also conveyed to Jack Anderson and staff scientists at the Southern California Coastal Water Resources Project for providing the committee with the background document *A Historical Review of Monitoring in the Southern California Bight*, as well as a wealth of additional assistance. Brock Bernstein worked long and hard to shape the final report.

Many thanks also to the following individuals for their valuable input to the report: Blake Anderson of the Orange County Sanitation District, Gary Davis of the National Park Service, Dorothy Green of Heal the Bay, Robert Grove of Southern California Edison Company, Janet Hashimoto of the Region IX office of the Environmental Protection Agency, George Jackson of Scripps Institution of Oceanography, Burton Jones of the University of Southern California, Edward Liu of the Santa Ana Regional Water Quality Control Board, John McGowan of Scripps Institution of Oceanography, John Melbourn of the San Diego Department of Health Services, Richard Methot of the National Marine Fisheries Service, Robert Miele of the County Sanitation District of Los Angeles, John Mitchell of the Los Angeles Department of Public Works, Paul Papanek of the Los Angeles County Department of Health Services, John Stephens of Occidental College, and Ken Wilson of the California Department of Fish and Game.

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Executive Summary

With nearly 15 million people in the region, Southern California's coastal ocean[1] is coming under increasing environmental stress. There is little coastal space that is not subject to some form of development or resource utilization—including oil extraction, commercial and recreational fisheries, municipal and industrial wastewater discharge, ship traffic, and recreation.

There is in the region a broad public perception of environmental degradation. This is set against a backdrop of extraordinarily complex natural ecosystem processes that are not fully understood, extensive public and private efforts to protect and restore environmental systems, and great public concern for the environment.

Environmental management efforts have included numerous marine environmental monitoring programs. These efforts have been both extensive (for example, the long-term time-series resource assessments of the California Cooperative Oceanic Fisheries Investigation [CalCOFI]) and elaborately detailed, such as the monitoring programs for municipal waste water and electric power plants. The total amount of money and effort expended by public utilities, private industry, and government agencies in marine monitoring efforts in Southern California is conservatively estimated at well over $17 million annually.

[1] This report addresses the region known as the Southern California Bight, the oceanic region from Point Conception, California to Mexico and seaward from the coast to the California Current.

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As part of a larger assessment of marine environmental monitoring, the National Research Council analyzed the effectiveness of marine environmental monitoring in the Southern California Bight. The study committee found an extensive system of monitoring of environmental conditions in the bight, but also widespread concern that the system is not efficient and that its products are not sufficiently used for decision making.

The committee found that because monitoring in the bight is predominantly organized around discharge permits responding to water quality regulations, there is a fragmented approach to assessing environmental quality. There are deficiencies in monitoring for public health concerns and nonpoint discharges. Also, there are no existing formal mechanisms for integrating the wide array of monitoring activities and their findings; as a result, it is difficult—if not impossible—to present a coherent picture of the state of the bight as a whole. There is a glaring need for a regionwide monitoring system and for effectively reporting findings to the public, the scientific community, and policy makers.

In response to these findings, the committee recommends that a regional monitoring program be established that would address public health impacts, natural resources and nearshore habitat trends, nonpoint source and riverine contamination, and cumulative or areawide impacts from all contaminant sources.

A regional program should involve participation by the public and scientific communities at local, state, and federal levels and should include built-in mechanisms to communicate its conclusions to regulatory agencies and the public, the committee noted. It should also include review mechanisms and allow easy alteration or redirection of monitoring efforts, whenever justified by monitoring results or other information. Anticipated benefits from a regional program would include:

- *greater cost efficiency* through use of standardized sampling, analysis, data management, and coordination of effort;
- *ability to address specific questions* about environmental conditions and resources and to alter or redirect monitoring efforts as needed; and
- *more effective use of monitoring information* in decision making by ensuring better communication with and involvement by the public and scientific community.

Implementing a regional program will require coordination among local, state, and federal agencies and the integration of their regulatory, data, and management needs. Only through an integrated systemwide approach can important environmental and human health objectives identified by society be successfully attained: ensuring that it is safe to swim in the ocean and eat local seafood, providing adequate protection for fisheries and other living resources, and safeguarding the health of the ecosystem.

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The Southern California Bight

No system of marine monitoring exists in the abstract. Monitoring occurs in specific geographic regions that have particular qualities derived from their natural characteristics and processes. The marine environment in turn is affected by the human activities that take place in and adjacent to it. Understanding the strengths and weaknesses of monitoring in the Southern California Bight therefore requires a basic knowledge of the physical setting and human activity within it.

This chapter describes the physical setting of the Southern California Bight: its bathymetry, drainage basin, circulation and ocean-ography, climate, and hydrology. It also describes the natural habitats and resources of the region and the land use and economic activities of the adjacent coastal areas. Chapter 2 will describe in greater detail the sources and types of habitat change and pollutant loadings to the marine environment that stem from human activities in the bight.

PHYSICAL SETTING

The Southern California Bight is bounded on the north, east, and southeast by a long curve of the North American coastline extending from Point Conception in Santa Barbara County, southeast 357 mi to Cabo Colnett, Baja California in Mexico (Figure 1-1). It is bounded to the west by the California Current, which flows southeasterly approximately parallel to the coast and the edge of the continental shelf. The bight system includes more than 37,000 mi^2 of ocean and approximately 8,700 mi^2 of adjacent coastal areas draining into it.

Bathymetry

The bathymetry underlying the Southern California Bight has many features unique to the continental shelf surrounding the United States. For this reason the area was named "continental borderland" by Shepard and Emery (1941). Topographic features in the continental borderland and adjacent mainland drainage basin are summarized in Table 1-1.

The waters of the bight overlay an alternating series of 2,000- to 8,000-ft-deep basins and surfacing mountains that form 9 offshore islands or island groups and several large submerged banks and seamounts. Nearshore, 12 large submarine canyons influence movement of sediments and other materials deposited on the bottom. There are also 32 submarine canyons on the continental slope bordering the U.S. portion of the bight, including 20 canyons that cut into the mainland shelf (Emery, 1960). Offshore, there are 18 marine basins, 3 of which are essentially anoxic.

These submarine canyons and deep basins are important sites of accumulation of fine-grained sediments and particulate materials from land runoff, ocean discharges, and ocean dumping. An important feature throughout the bight is that deep water is close to shore. All slopes are steep, ranging from 5 to 15 percent. Island and mainland shelves are narrow, from less than 0.6-mi wide to a maximum of 12.5-mi wide. The mainland and island shelves constitute only about 11 percent of continental borderland area; marine basins cover about 80 percent of the borderland area.

The most important embayments of the mainland shelf are Santa Monica Bay and San Pedro Bay (separated from each other by the prominent and steeply sloping Palos Verdes Peninsula and shelf), San Diego Bay, and Todos Santos Bay in Baja California. Although no true estuaries penetrate the mainland coast, there are at least 26 wetland systems in coastal lagoons and at the mouths of transient streams and rivers in the U.S. portion of the bight (Figure 1-2)(Zedler, 1984). The total area of these coastal wetlands is only about 129 mi^2, an estimated 25 percent of the area they encompassed when the first Europeans arrived in Southern California in the late 1500s.

Drainage Basin

The onshore mainland drainage basin of the Southern California Bight, occupied by an ever-increasing human population of nearly 15 million, is a triangle-shaped, higher elevation extension of the offshore bathymetry. It consists of nearly equal areas of mountains and basins or plains (Table

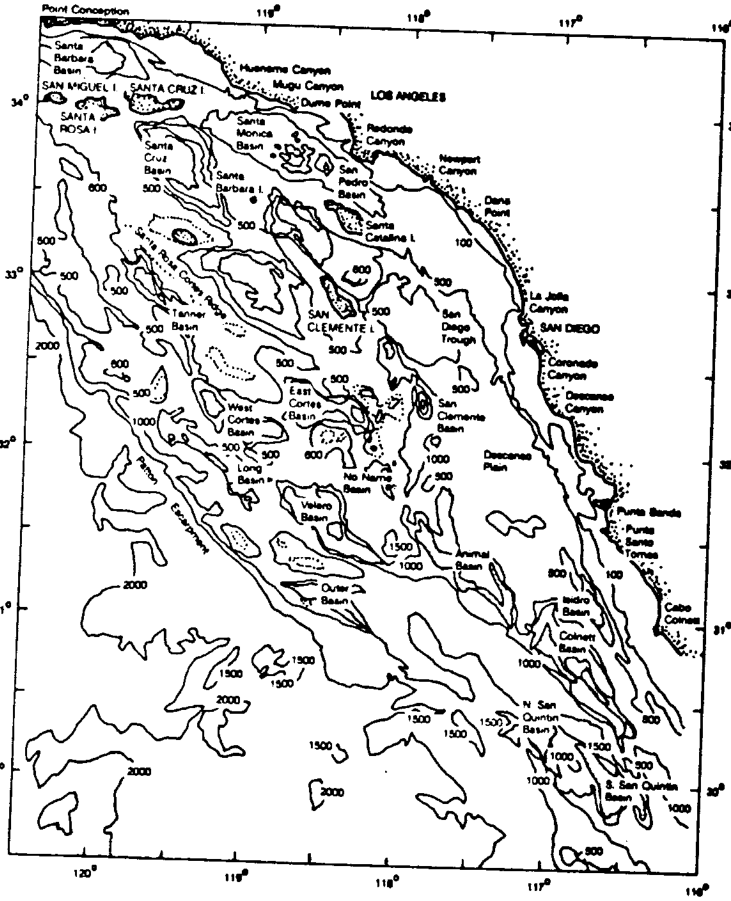

FIGURE 1-1 Bathymetry of the Southern California Bight, emphasizing its deep basins (shaded). Depth contours are shown in fathoms (1 fathom = 6 ft). SOURCE: Moore, 1969.

1-1). The rising shoreline is characterized by vertical scarps and wave-cut cliffs. There are as many as 20 raised marine terraces on land that are an extension of the 5 submerged terraces that lie at depths to 289 ft along the mainland shelf (Emery, 1960).

The drainage basin is bordered on the north by transverse (east-west ranges extending from Point Conception eastward along the Santa Monica,

TABLE 1-1 Topography and Bathymetry of the Southern California Bight Area

Feature	Area Mi²	Area % Total	% Borderland
Mainland			
mountains	4,600	10.0	—
basins and plains	4,090	9.0	—
Subtotals	8,690	19.0	—
Borderland			
islands	340	0.7	1.1
mainland shelf	1,890	4.1	6.2
island shelves	1,390	3.0	4.6
bank tops	2,420	5.3	8.0
basin and trough slopes	19,120	42.0	63.3
basin and trough floors	5,120	11.2	16.8
Continental slope	1,960	4.3	—
Abyssal seafloor	4,740	10.4	—
Subtotals	36,980	81.0	—
Totals	45,670	100.0	100.0

SOURCE: Emery, 1960.

San Gabriel, and San Bernardino mountains; and on the east by coastal ranges that continue southward down the length of the Baja Peninsula (SCCWRP, 1973). These mountain ranges separate the semiarid coastal plain from the very arid desert basins.

Because of the semiarid nature of the drainage basin and the highly seasonal pattern of annual precipitation, most of the rivers draining into the bight are small and are dry for much of the year. From north to south, the major rivers in the drainage basin are the Santa Clara, Los Angeles, San Gabriel, Santa Ana, San Luis Rey, San Diego, and Tijuana rivers (Figure 1-2). Much of the length of the Los Angeles and San Gabriel river beds and other major drainages are now lined with concrete. Most rivers have dams and debris basins constructed upstream to aid in flood control. In Southern California, there are separate systems to handle stormwater runoff and municipal wastewater flows.

Circulation and Oceanography

The western border of the Southern California Bight is marked by the California Current, which flows southeastward along the coast, continuing the clockwise geostrophic transport of water in the North Pacific Ocean (Figure 1-3). Water current regimes in the Southern California Bight are

FIGURE 1-2 Location of Southern California coastal wetlands and major rivers. SOURCE: Zedler, 1984.

complex and variable on seasonal and longer time scales. Only the general patterns will be described here. Because of the eastward indentation of the coast in the Southern California Bight, a surface counterclockwise gyre, the Southern California Eddy, breaks off the California Current and carries water northward through the central bight (Jones, 1971; Hickey, 1979). The eddy is usually well developed in summer and autumn and weak in winter and spring.

Closer to the shore along the mainland shelf, prevailing onshore (northwesterly) winds reverse this flow, resulting in a net alongshore surface flow toward the southeast at speeds of 1 to 3.3 cm/s (Lentz and Winant, 1979). Hendricks (1977) reported that the mean direction and velocity of water currents just below the thermocline are upcoast at 3 cm/s, and that this near-bottom current has a significant offshore component. Coastal currents reach maximum velocity in water depths of about 197 ft (Jackson, 1986). These complex nearshore currents are interrupted by coastal headlands and upwelling epicenters and respond to both regional and local land-sea breezes. During the afternoon, sea breezes are responsible for both cooling on land and shoreward movement of natural and man-made floating materials.

There is also a very nearshore circulation pattern caused by surf along

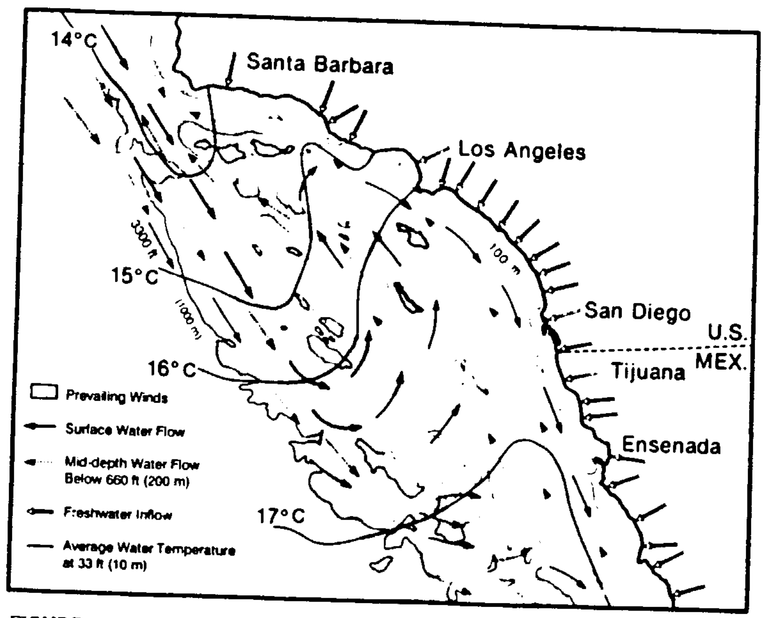

FIGURE 1-3 Patterns of nearshore bathymetry, wind, and ocean circulation in the Southern California Bight. SOURCE: Zedler and Nordby, 1986.

the beaches (Jones, 1971). The surf-driven current consists of transport alongshore inside the breaker zone to zones of outward-flowing water called "rip currents." The rip currents carry water transported inshore by the surf back offshore. This local circulation is important in beach erosion and nourishment and in transport of wastes from offshore discharges and stormwater runoff into and through recreational areas.

Below about 500 ft, there is a northwestward current flow of 25 cm/s or less inshore of the California Current (Figure 1-3). This water is of equatorial Pacific origin and has a higher temperature, salinity, and phosphate concentration and a lower oxygen concentration than the deep water in the California Current located at the same depth but farther offshore (Jones, 1971). This northward flow is weak but progressive through the deep basins and more vigorous along the mainland shelf and slope. Ordinarily, the northward countercurrent does not surface within the bight, except occasionally during the winter. This flow may surface nearshore off Los Angeles in late fall and winter and move northward as the Davidson Current, possibly as far as Vancouver Island, Canada, particularly during the periodic climatic anomalies known as "El Niño" events (described in detail later in this chapter). There is still some uncertainty about the continuity between the Davidson Current and the deep countercurrent in the bight (Hickey, 1979).

Because surface waters in the bight originate primarily from the south-flowing California Current, they are more nutrient-rich, less saline, and cooler (annual range 13° to 20°C) and undergo less seasonal temperature variation than nearshore surface waters at similar latitudes along the east coast (e.g., South Carolina and Georgia). Temperature drops with increasing water depth to about 4°C in the basins. Dissolved oxygen concentration also tends to decrease with depth, such that waters below the sill depths of the Santa Barbara, Santa Monica, and San Pedro basins are periodically or permanently anoxic (Emery, 1960). Due to anoxic conditions, bottom water and sediments in these basins are virtually devoid of higher life forms. The basins are major repositories for sediments and other particulate materials (including sludge) transported onto the shelf from the land and coastal waters.

Climate and Hydrology

The climate of Southern California is like that of the Mediterranean, with most of the precipitation occurring during winter months. Monthly mean temperature and precipitation for Los Angeles and San Diego are summarized in Table 1-2. Monthly mean temperatures in both cities vary by only about 10°C, though periodic extreme temperatures may range over about 35°C. Mean monthly precipitation ranges from near zero in June, July, and August to 2.0-3.3 in. (50 to 85 mm) in December, January, and February.

It is now clear that many environmental changes in the bight are connected more with long-term, low-frequency, interannual patterns than with seasonal cycles. Displacement of cool surface waters—including their inhabitants—in the bight by clear, nutrient-poor warm water is correlated with periodic warm-water events off the coast of Peru and in the tropical Pacific. These are the El Niño events, which occur several times per decade (e.g., 1976, 1979, 1982-1984, 1986-1987) and are characterized by warm water, a deeper surface-mixed layer, elevated sea levels, increased abundance of southern planktonic and pelagic organisms, alterations of benthic community structure, and degeneration of coastal kelp beds (Jackson, 1986). El Niño events and other long-term oceanographic changes also affect the weather in the bight. In some years (e.g., 1969 and 1982-1983) floods rule the coastal plain; in other years drought occurs (e.g., 1976-1977). In some years, there is a deep-penetrating, southerly ocean swell that mixes and resuspends mainland shelf sediments.

TABLE 1-2 Average Monthly Temperature and Precipitation in Los Angeles and San Diego, California

Parameter	Location	J	F	M	A	M	J	J	A	S	O	N	D
Temperature °C	Los Angeles	13	14	15	16	18	20	22	23	22	19	17	14
	San Diego	13	14	15	16	18	19	21	22	21	19	16	14
Precipitation mm	Los Angeles	60	85	60	30	6	2	0	0	7	13	26	79
	San Diego	51	55	40	20	4	1	0	2	4	12	23	52

SOURCE: Rudloff, 1981.

Crustal blocks between numerous faults move with alarming frequency, causing earthquakes. Oil and tar continuously ooze from shelf and island seeps, periodically creating large marine oil slicks. During some droughts, brush fires, fed by northeasterly Santa Ana winds, spew plumes of ash and soot onto the adjacent sea and coastal plain. Landslides and subsidence are common and predictable in certain hill and bluff areas. In short, the predominantly mild sunny climate of the Southern California Bight area does not reflect the major impacts of occasional meteorological and geological events.

Fresh water enters the bight from a variety of sources. Riverine runoff from rain and melting snow is very seasonal. Much of the water imported from Northern California through the California Aqueduct, from the high Sierra Mountains through the Owens Valley Aqueduct, and from the Colorado River through the Metropolitan Aqueduct (Table 1-3) eventually finds its way to the bight through land and subterranean runoff and discharges of waste water. The cost of wastewater disposal from municipal and industrial activities is 5 to 10 times the cost of supplying the water (World Bank, 1980). Disposal costs for agricultural drainage are about half those of water supply, unless treatment is required.

Because of the semiarid climate of the bight drainage basin, the volumes of water entering the bight from wastewater discharges are comparable to those from riverine and storm drain inputs. Because stormwater flow is more variable than wastewater flow, in dry seasons and years wastewater flow far exceeds that of storm water. For example, the mean treated wastewater flow to Santa Monica Bay between 1967 and 1982 was 346 million gal/day, with the annual mean increasing from 320 million in 1967 to 379 million gal/day in 1982 (Garber, 1987). Stormwater flow to Santa Monica Bay over the same period averaged 143 million gal/day and ranged from 51 million gal/day in 1972 to 400 million gal/day in 1969. However, nearly all of this stormwater flow occurred during and shortly after a few winter storms each year. Thus, the only continuous freshwater flow to the bight is treated municipal waste water. This includes primary, secondary, and tertiary treated sewage discharged directly to the ocean from coastal treatment plants and tertiary treated sewage discharged from inland treatment plants to Southern California rivers and streams. This pattern of freshwater input to coastal waters is quite different from that in much of the rest of the coastal United States, where riverine and stormwater flow far exceeds wastewater flow.

HABITATS AND NATURAL RESOURCES

Natural habitats and resources characteristic of the Southern California Bight include abundant deep water close to shore, extensive coastal

TABLE 1-3 Water Supply and Demand in Southern California

Parameter	1990	2010
Estimated population (millions)[a]	15.29	17.75
Water supply (millions of gal/day)		
local	1,955	1,955
reclaimed	143	152
Los Angeles Aqueduct	375	375
Colorado River	714	420
state water project	1,143	1,295
Total supply	4,330	4,147
Water utilization (millions of gal/day)		
residential	1,607	2,090
commercial	473	643
industrial	330	411
public[b]	411	464
agricultural	794	580
Total demand	3,615	4,188
Supply minus demand	+ 715	- 41
Per capita demand (gal/day)		
residential	105	118
commercial	31	36
industrial	22	23
public[b]	27	26
agriculture	52	30
Total per capita demand	237	233

[a]California Department of Finance data, assuming half of total increases in county projections will occur in coastal drainage area.
[b]Includes unaccounted for water.

SOURCE: California Department of Water Resources, 1987; Los Angeles Department of Water and Power, 1985-1986 Annual Report; State Water Contractors, Bay-Delta Hearings, June 1987, SWC Exhibit Numbers 3, 6, 13, 17, 76.

and offshore oil reserves, commercially or recreationally valuable fish and shellfish stocks, wildlife breeding and overwintering areas, kelp beds, beach and water recreation areas, and a climate tempered by the special oceanographic processes reviewed above.

As a result of the local oceanographic regime, particularly the Southern California Eddy, the bight is an enclave of communities of marine life specific to the area, except during El Niño years. It is also a trap for warm water and natural and anthropogenic materials entering the area from land, sea, and air.

Six species of seals and sea lions and the northernmost Pacific population of pelicans breed on several islands. Regional populations of porpoises occur in the bight, and the entire population of gray whales spends a portion of fall and winter there during its annual migration between the Bering Sea and Baja California.

Commercially exploitable stocks of anchovies, sardines, and mackerel spawn and grow primarily in the bight, as do bass, croakers, flatfishes, and rockfishes. Mariculture operations have been established in Agua Hedionda Lagoon in San Diego County (mussels and oysters) and in the Santa Barbara Channel (oysters, mussels, and scallops) (California Department of Health Services, 1988b). Deeper waters of the bight host a diversity of mesopelagic fishes that spend part of their life cycle in surface waters. The benthic fauna of the continental shelf, especially polychaetes and crustaceans, are very diverse and constitute an important food source for many fish species.

Rocky intertidal and subtidal areas, which cover large areas of the shoreline of the bight, host a rich diversity of epifauna (snails, mussels, crabs, etc.) and attached seaweeds. Beds of the giant kelp Macrocystis pyrifera, which attach to the bottom and can grow to over 164 ft in length, extend along the coast of the bight. There are 33 locations in the bight between Point Conception and San Diego where kelp beds are found at least periodically at water depths ranging from 20 to 65 ft. From the 1930s to 1979, individual kelp beds occupied up to 2,720 acres, with the total area occupied by kelp beds in the range of 12,000 to 15,000 acres (Foster and Schiel, 1985). The size and distribution of kelp beds varies spatially and temporally in response to changes in natural and anthropogenic conditions. Natural changes in surface water temperature and nutrient concentrations associated with El Niño events, and possibly with longer-term ocean warming trends, have resulted in declining kelp beds in some areas, and winter storms like those of 1983 and 1987 can devastate large kelp beds. These storms probably are the most important factor influencing the condition and areal extent of kelp beds, but human activities—such as kelp harvests, boat traffic, and possibly wastewater discharges at Palos Verdes and Point Loma—have also affected local giant kelp beds.

LAND USE AND ECONOMIC ACTIVITY

A combined U.S.-Mexico population of about 15 million people lives in, works in, and enjoys the coastal climate and resources in the drainage basin of the Southern California Bight. The population in this area has increased steadily since the 1890s.

Although once primarily an agricultural region, Los Angeles and adjoining counties now comprise the manufacturing, petrochemical, commercial, and aerospace center of western North America. There also are large military bases throughout the area. Accessible land space is now largely occupied by several hundred cities, hundreds of square miles of residential areas, highways, airports, and citrus groves.

Because of current land and water use practices, the entire region is heavily dependent on water diverted from northern and eastern California and the Colorado River system (Table 1-3) that would otherwise flow into the San Francisco Bay and delta area, Mono Lake, the Owens Valley east of the Sierra Mountains, and the Gulf of California. Water utilization in Southern California is projected to increase in the next 22 years due to an expected 16 percent increase in population, and despite a projected slight decrease in per capita consumption of water (Table 1-3). However, at the same time, total freshwater supply will decrease due to partial loss of water rights to the Colorado River. Disputes over other water sources continue, and these supplies are by no means assured for future use by Southern California. As a result, demand will be greater than supply by the year 2010, requiring increased conservation and on-site reclamation.

As described in "Climate and Hydrology," the base flow for most of the Southern California drainage system is now derived from treated waste water (see Chapter 2, Figure 2-2 for further detail). Secondary or tertiary treated sewage from inland treatment plants makes up much of the permanent flow of the Los Angeles, San Gabriel, Rio Hondo, and Santa Clara rivers in Los Angeles and Ventura counties. These discharges, as well as other NPDES-permitted (National Pollutant Discharge Elimination System) flows to the rivers are strictly regulated to protect water-contact recreational areas. However, storm drains and nonpoint source runoff to rivers are not regulated. Such flows may contain elevated concentrations of chemical contaminants and pathogens.

Highways are the principal basis of transportation in Southern California. Heavy manufacturing (metals, chemicals) is located near the coast and within convenient access to well-developed port facilities in Los Angeles, Long Beach, and San Diego harbors. The most active shipping, shipbuilding, and maintenance in western North America occurs in the combined complex of Los Angeles-Long Beach harbors; and military activities occur around Mugu Lagoon and Anaheim Bay (munitions), along the north San Diego County coastline (Camp Pendleton Marine Base), and at San Clemente Island (target practice). The harbors of Long Beach and San Diego were principal Pacific staging areas during World War II (1941-1945) and continue today as active naval and ship building bases.

Oil extraction has occurred for eight decades within and offshore of coastal city limits of Goleta, Carpinteria, Ventura, Oxnard, Santa Monica, Redondo Beach, Wilmington, San Pedro, Long Beach, Seal Beach, and Huntington Beach. Terminal Island and adjoining areas sank up to 30 ft (Allen, 1973) when oil was pumped out in the 1930s and 1940s. Offshore oil extraction from shore-based facilities began near the turn of the century along the Santa Barbara Channel and slightly later in southern Los Angeles and Orange counties. Oil production from offshore platforms began 35 years ago on nearby shelves (1 to 3 mi from shore) and now extends nearly to the shelf break. Proposals for more extensive offshore oil exploration and development in the bight are being hotly debated because many Southern Californians consider them a great potential pollution hazard to the marine environment. An extensive shore-based infrastructure has sprung up to support offshore oil production activities—including pipelines, refineries, produced water treatment facilities, and oil terminals.

Year-round commerce, fisheries, and marine recreation, combined with steady population growth, have resulted in constant development of harbors, marinas, and coastal home sites in Southern and Baja California. The region's 30,000 to 40,000 pleasure boats are concentrated primarily in Marina del Rey on Santa Monica Bay, in the new Los Angeles City Cabrillo Marina, in Alamitos Bay, Long Beach Marina, Huntington Harbor, Balboa-Newport harbors, northern San Diego Bay, and Mission Bay; and secondarily in marinas at Oceanside and Dana Point, and in Oxnard, Ventura, and Santa Barbara. Because pleasure boats are sources of fuel leaks and toxins from antifouling paints, they constitute a potential environmental problem that has not yet been quantified.

Fourteen coastal electric power plants in Southern and Baja California supply much of the region's power and recirculate nearly 11 billion gal/day of nearshore seawater, some of which controls circulation in harbors and marinas. Most generating plants operate on oil delivered by offshore tankers, and oil spills occasionally result from accidents involving tankers supplying fuel to plants in Southern and Baja California (e.g., Nishikawa-Kinomura et al., 1988). For example, in Los Angeles/Long Beach harbors where most of the tanker terminals are concentrated, an estimated 1.3 million gal of oil and fuels have been spilled since 1976; in the Santa Barbara Channel, since 1969 over 3.5 million gal of oil have been spilled from two oil platforms and a tanker collision. The San Onofre Nuclear Generating Station (SONGS) is the only nuclear plant on the coast of the bight.

Much of the region's 1.5 billion gal/day of raw sewage is collected via large-scale intercity networks of trunklines and transferred to 13 coastal Publicly Owned Treatment Works (POTWs) where effluent is subjected to primary, advanced primary, and in some cases secondary treatment and discharged to the ocean via submarine outfall diffusers at depths from 65 to 328 ft. Tertiary treatment currently reclaims almost 150 million gal/day of water, and there is a future potential to reclaim 0.5 billion gal/day. The reclaimed water is used for landscape irrigation, groundwater recharge, industrial processing, and control of saltwater intrusion into coastal aquifers. Storm water is completely separated from sewage in all major systems, but overflows occasionally occur. However, as discussed above, several POTWs discharge secondary or tertiary effluent to Southern California rivers for transport to the ocean. For example, the Los Angeles and San Gabriel rivers each receive about 100 million gal/day of treated waste water. Percolation of storm water into aging sewer lines during storms occasionally overwhelms the system, resulting in release of raw sewage to the bight.

The least developed areas of the bight include the northwesternmost 37-mi stretch of coast between Point Conception and Santa Barbara, the 12-mi coastline of Camp Pendleton in northern San Diego County, the central San Diego County coastline, the Cnannel Islands, and the Baja California coast south of Todos Santos Bay, near Ensenada.

In summary, there is little coastal space that has not been subject to construction, mineral extraction, or other forms of resource utilization. There is keen competition for coastal space, access, and resource utilization and, as a consequence, conflict among the many potential users. The California Coastal Commission, formed as a result of a 1969 ballot initiative, resolves conflicts related to multiple uses of the coastal zone.

SUMMARY

There are several natural and anthropogenic features of the Southern California Bight that are important for the consideration of environmental impacts and marine monitoring in the bight. The continental shelf throughout the bight is very narrow, and deep water exists near shore as a result of the bight's many submarine canyons and basins. The bight's western border is defined by the California Current, and the complex pattern of currents, eddies, and counter currents creates enclaves of indigenous biological communities. Many important environmental processes and changes are related more to long-term, low-frequency, interannual patterns than to yearly or seasonal cycles. The semiarid drainage basin of the bight receives sparse rainfall and much of the human activity in the area depends on imported water. As a consequence, many area rivers are dry much of the year, and wastewater flows constitute the only continuous freshwater input to the bight. Wastewater flows from treatment plants exceed natural flows from runoff and storms. Because waste water and storm water are managed by separate systems, however, the bight does not have the combined sewer overflow problems that characterize other coastal areas in the United States.

The Southern California Bight contains rich biological resources that support diverse commercial and recreational activities. In addition, many marine mammal species, including the entire gray whale population, spend part or all of each year in the bight.

Finally, as a result of Southern California's large population and attendant intense economic and recreational activity, there is little coastal space that has not been subject to construction, mineral extraction, or other forms of resource utilization. This activity has resulted in extensive habitat change and large and varied inputs of contaminants to the bight. These are reviewed in the next chapter.

2
Sources of Pollution and Habitat Change

Southern Californians have lived with contaminants and habitat change since before 1572, when Juan Cabrillo's ship entered the Bahia de Los Fuomos (Bay of Smokes, now Santa Monica Bay) and witnessed coastal Indians sealing their boats with tar from local oil seeps. Today, the ever-growing population of about 15 million has dramatically increased its utilization of marine resources and the types and amounts of contaminants produced and released to the Southern California Bight. These contaminants stem from sewage discharges, aerial fallout, land runoff, industrial and munitions disposal, dredged material disposal, and thermal enrichment. As a result, some of the bight's coastal waters and underlying sediments have become polluted and marine resources have been degraded.

This chapter describes the major human activities that have impacted the bight's marine environment and discusses in detail the various contaminants that may derive from these activities. They include wastes from petroleum exploration and production, radionuclides, pathogenic organisms, waste heat, organic matter, nutrients, trace metals, and synthetic organic chemicals. Since this chapter is intended to provide an overview of contamination, sources and amounts of contaminants—rather than their environmental impacts—are emphasized, followed by a brief overview of the regional and local environmental problems that have attracted public, regulatory, and scientific attention.

TABLE 2-1 Total Estimated Average Daily Wastewater Flows in 1984-1985 to the Southern California Bight from Seven Large Publicly Owned Sewage Treatment Plants

Outfall Name	Discharge (millions of gal/day)		
	Primary	Secondary	Sludge
Oxnard, Ventura County Sanitation Districts	None	18	None
Hyperion, Los Angeles City Bureau of Sanitation	292	97	4[a]
Joint Water Pollution Control Plant, Los Angeles County Sanitation Districts	183[b]	179	None
County Sanitation Districts of Orange County	94	138	None
South East Regional Reclamation Authority	12.5	None	None
Encina Water Pollution Control Facility	11	5	None
Point Loma, City of San Diego	156	None	None
Totals	742	443	4
Grand total			1,190

[a]Terminated, per court order, November 1987.
[b]Advanced primary, which removes 80 percent of solids (primary removes 60 percent).

SOURCE: SCCWRP, 1986a.

MAJOR SOURCES OF CONTAMINANTS

Sixteen municipal sewage treatment plants discharge partially treated sewage directly into the U.S. waters of the Southern California Bight. In addition, more than 230 million gal/day of treated sewage is carried by coastal rivers and storm drains from inland Publicly Owned Treatment Works (POTWs). In 1985, over 1.2 billion gallons of effluent were discharged daily into the bight's coastal waters by seven major municipal wastewater dischargers (Table 2-1 and Figure 2-1).

Over the years, major strides have been made to decrease the amounts of total solids and contaminants in the discharges, even as the total volume of sewage discharges has increased (Figure 2-2) (Southern California Coastal Water Research Project [SCCWRP], 1986a; Summers et al., 1987).

This has been accomplished primarily by a gradual but progressive shift over the last 100 years from discharge of raw sewage, to discharge of primary treated sewage, to discharge of advanced primary and secondary treated sewage (Figure 2-3); by a gradual phaseout of pipeline discharge of sludge; and, most important, by source control. In 1985, 62.4 percent of the total sewage from the seven major dischargers received primary treatment, 37.2

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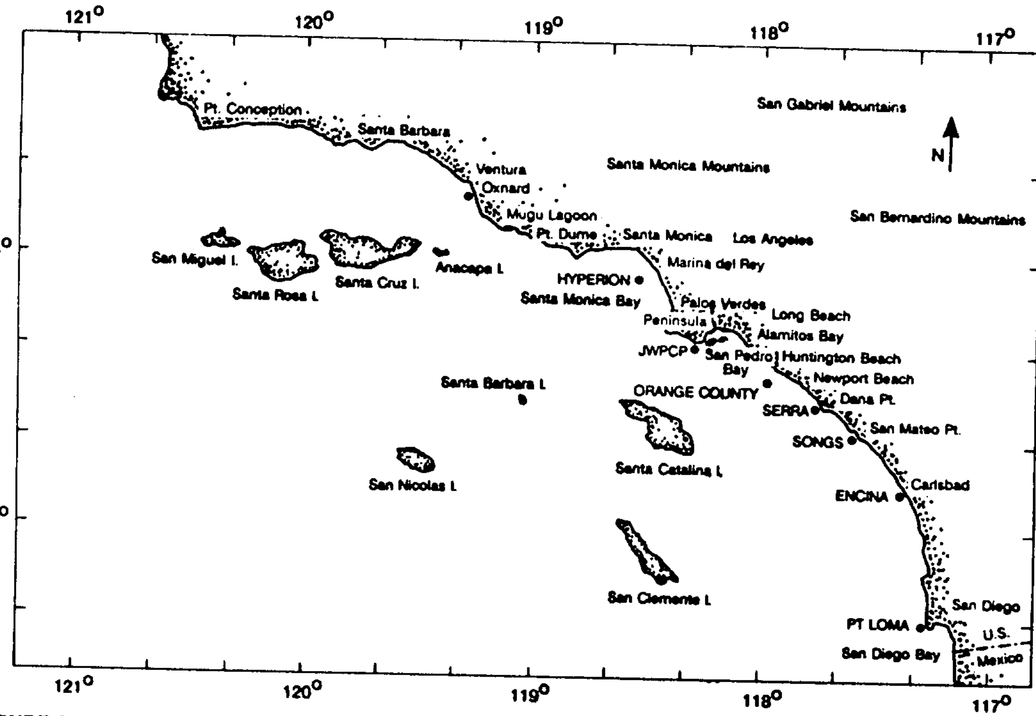

FIGURE 2-1 Major dischargers into the Southern California Bight.

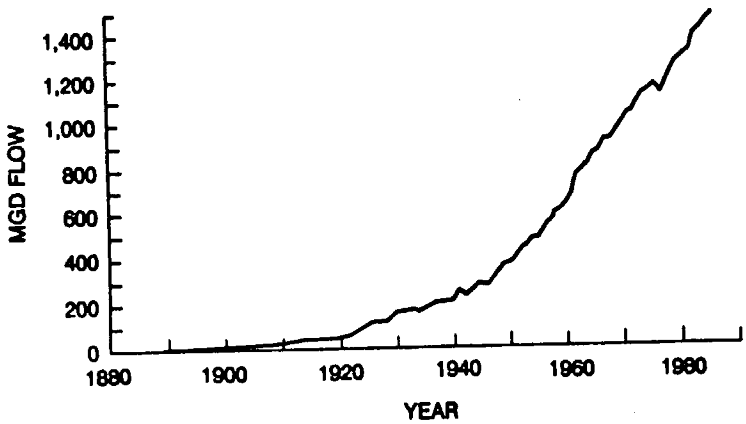

FIGURE 2-2 Municipal wastewater flow (millions of gallons per day) for the years 1890 to 1990 through sewage treatment facilities in Southern California that discharge treated wastewater to the Southern California Bight. SOURCE: Summers et al., 1987.

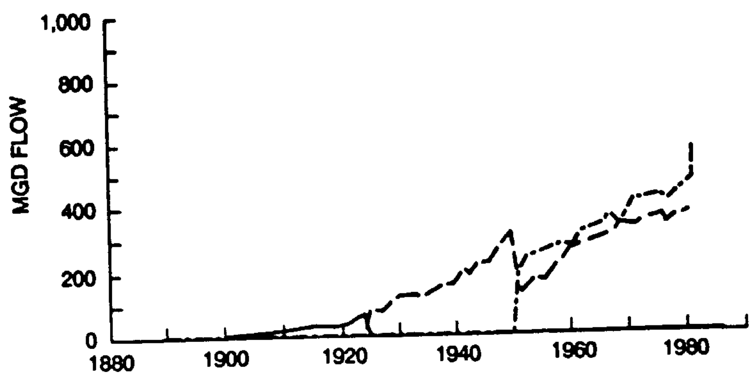

FIGURE 2-3 Annual municipal wastewater flow to the ocean (millions of gallons per day) by treatment level in Los Angeles County, California (raw, —; primary, - - -; secondary, -.-.-.). SOURCE: Summers et al., 1987.

percent received secondary treatment, and 0.4 percent was anaerobically digested sewage sludge, discharged from the Hyperion Treatment Plant.

The Hyperion Treatment Plant operated by the city of Los Angeles discharged sludge from 1957 through 1987 via an ocean outfall in 318 ft of water at the head of the Santa Monica submarine canyon in Santa Monica Bay. The County Sanitation Districts of Los Angeles discharges the liquid phase produced by dewatering sludge by centrifugation. Prior to 1983, this waste water contained high concentrations of solids (sludge). In 1983, new centrifuges with improved solids recovery (90 to 95 percent) came on line, resulting in a significant reduction in solids emissions. The Sanitation Districts of Orange County ceased discharging sludge to the ocean in 1984. The city of San Diego's Point Loma Treatment Plant discharged sludge to the ocean only during emergencies, when a pipeline to the Mission Bay drying beds was inoperative.

Most sewage sludge is now disposed of onshore. However, the shift from primary to secondary treatment results in a substantial increase (approximately double) in the volume of sludge generated. Although it has been suggested that various ocean disposal options may be reconsidered for handling increasing volumes of sludge (Conrad, 1985), ocean dumping is no longer an option. Other possible uses of sludge are composting, use in industrial processes, and landfill cover.

Because the Southern California Bight region is semiarid, design requirements for storm water and sanitary sewer-handling systems are quite different. As a consequence, storm drainage and sanitary sewer systems have been separate throughout the history of the region, unlike nearly all other major U.S. coastal urban areas. Surface runoff from land enters the bight through 150 natural streams (Figure 1-2) and 18 hydrologic units. In addition, there are several major channels in Los Angeles, Orange, and San Diego counties for stormwater runoff. In the Los Angeles County Flood Control District alone, there are 2,000 mi of underground drains, 500 mi of open channels, and 50,000 catch basins. Most of the surface water flow of 405 million gal/day (peak value) enters the bight from 20 major streams and channels, mostly in pulse inputs during winter storms. There are, in addition, hundreds of individual storm drains that discharge directly to the ocean.

Harbors and marinas are sources of local and, in some cases, regional contaminant inputs to the bight. For instance, a 1973 study (SCCWRP, 1973) indicated that 80,000 gal of antifouling paints containing 180 tons of copper were applied annually to many of the 35,000 recreational boats and numerous commercial and naval vessels that use these facilities. Most of this copper eventually dissolved into the water. In recent years, organotin compounds have largely replaced copper in antifouling paints, creating an even greater problem because of their high toxicity to marine animals. San Diego Bay and Los Angeles and Long Beach harbors are contaminated with organotins, with measured concentrations in the water column in the range of 0.02 to 0.93 mg/liter, and concentrations in sediments at least a hundredfold higher (Grovhoug et al., 1986). Many power boats and

TABLE 2-2 Estimated Annual Inputs (Metric Tons/Year) of Trace Metals to the Southern California Bight

Metal	Municipal[a] waste water 1976	Dry fallout 1975	Storm runoff 1971-1972	1972-1973	Thermal discharge 1977
Cadmium (Cd)	45	0.84	1.2	2.8	0.3
Chromium (Cr)	593	6.6	25	60	0.6
Copper (Cu)	507	31	18	42	2.1
Lead (Pb)	190	240	90	210	0.8
Mercury (Hg)	2.6	—	—	0.43	—
Nickel (Ni)	307	12	17	41	0.7
Silver (Ag)	20	0.06	1.1	2.6	—
Zinc (Zn)	1,060	150	101	240	1.8

[a]Before initiation of industrial wastewater source control.

SOURCE: Young et al., 1973, 1978.

submerged metal structures are equipped with sacrificial anodes designed to help prevent corrosion of submerged metal structures. These anodes leach aluminum, copper, and zinc.

Along the coast of the bight, there are 14 steam electricity generating stations that use sea water for once-through cooling. Total cooling-water flow from the plants is about 10.7 billion gal/day. The San Onofre Nuclear Generating Station (SONGS) alone has a base flow of about 2.4 billion gal/day. These flows introduce heat and small amounts of biocides (chlorine), radionuclides, and metals (Table 2-2) into the bight ecosystem. In addition, cooling-water intakes entrain large numbers of fish larvae and plankton and impinge adult fish and other marine organisms. During the special 316b study period from October 1978 through September 1980, Southern California Edison Company's eight coastal power plants impinged an average of 2.2 million fish per year, at an average total weight of 215,000 lbs (Herbinson, 1981). Fish impingement since this study period has averaged approximately half this amount. This is because surf perches, which made up a large percentage of fish impinged during the study period, decreased drastically in abundance during the El Niño periods of the 1980s and have only recently begun to reappear (K. P. Herbinson, Southern California Edison, Co., personal communication).

Other sources of contaminant inputs to the bight include more than 60 discharges permitted under the National Pollutant Discharge Elimination System (NPDES), from coastal industrial operations, more than 25 permitted discharges of produced water from offshore oil and gas platforms, spills, atmospheric fallout, and permitted ocean dumping of dredged material and drilling muds. The volumes of permitted discharges from coastal industries and offshore oil production platforms are small compared to wastewater discharges from municipal treatment plants. The Chevron refinery at El Segundo discharges about 6.5 million gal/day of treated brine and process water to Santa Monica Bay. Offshore oil or gas production platforms may (if permitted by NPDES) discharge up to about 0.25 million gal/day of produced water.

Inputs of various waste waters are not evenly distributed along the coast. Most of the inputs are located between Point Dume and San Mateo Point. They include approximately 82 percent of municipal wastewater effluents, 95 percent of discrete industrial wastewater discharges, 70 percent of power plant cooling water returns, and 71 percent of surface-water runoff. Oil and gas production and associated discharges occur in state and federal waters between Point Conception and Huntington Beach. Thus, there are large areas of the bight north and south of Los Angeles where discharges of waste waters to the bight are minimal.

CLASSES OF CONTAMINANTS

Oil Exploration and Production Wastes and Petroleum

Natural seeps along the coasts of Santa Barbara, Ventura, Los Angeles, and Orange counties intermittently or continuously discharge large quantities of oil and tar to nearshore waters of the bight. Fischer (1978) estimated that as few as 2,000 and as many as 30,000 metric tons (10 million gal) of oil enter the Santa Barbara Channel each year from natural seeps, the best known at Coal Oil Point. (By comparison, the 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska, leaked 11 million gal of oil into marine waters.) The intertidal zone at Goleta is chronically contaminated with oil and tar from this seep. One hundred years ago, the U.S. Fish Commission steamer *Albatross* dispatched an observer to report on a huge fish kill extending from Santa Barbara to San Diego. He counted thousands of pelagic and demersal fish on the Santa Monica Bay beach at Redondo, many of them smelling of petroleum, and suggested that the event was caused by seepage from offshore "oil springs."

The first offshore oil well in the world was drilled in 1898 from a wooden pier extending into the surf zone near Summerland, California. By the mid-1980s, more than 25,000 oil and gas wells had been drilled in U.S. coastal and outer continental shelf waters. In Southern California, a large number of oil and gas fields has been discovered along the coast, both in state waters and in federal lease tracts between Point Conception and Huntington Beach (Figure 2-4). Additional fields are now being developed in federal waters north of the bight between Point Conception and San Luis Obispo. As of July 31, 1987, a total of 318 exploratory and 633 development

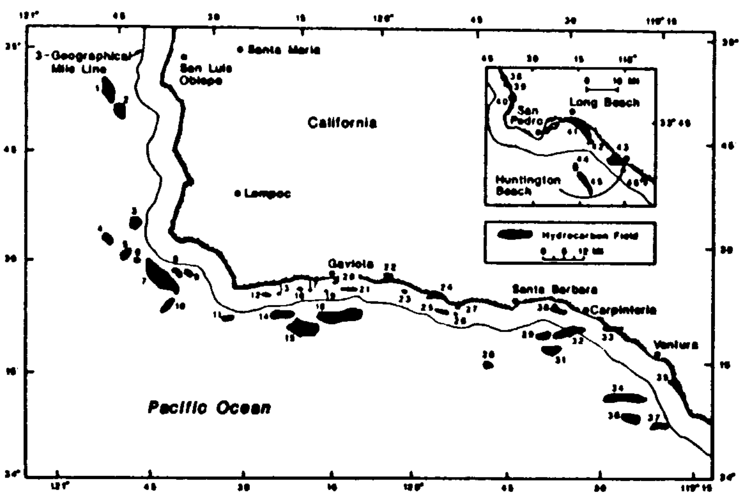

FIGURE 2-4 Major offshore oil and gas fields in state and federal waters of the Southern California Bight. Names of fields are 1, San Miguel; 2, Point Sal; 3, Point Pedernales; 4, unnamed 0443; 5, Bonito; 6, Electra; 7, Point Arguello; 8, Rocky Point; 9, Jalama; 10, Sword; 11, Government Point; 12, 13, Conception Offshore; 14, Sacate; 15, Pescado; 16, Cuarta Offshore; 17, Alegria Offshore; 18, Hondo; 19, Caliente Offshore; 20, Gaviota Offshore; 21, Moleno Offshore; 22, Capitan; 23, Naples Offshore; 24, Ellwood; 25, South Elwood Offshore; 26, 27, Coal Oil Point; 28, Santa Rosa; 29, Dos Cuadras; 30, Summerland Offshore; 31, Pitas Point; 32, Carpinteria; 33, Rincon Offshore; 34, Santa Clara; 35, West Montalvo; 36, Sockeye; 37, Hueneme; 38, Venice Beach; 39, Playa del Rey; 40, Torrance; 41, Wilmington; 42, Belmont Offshore; 43, Huntington Beach Offshore; 44, Beta Northwest; 45, Beta; 46, West Newport Offshore. SOURCE: MMS, 1987.

wells had been drilled in federal lease tracts off Southern California, most of them in the bight (Minerals Management Service [MMS], 1987).

As early as the 1920s, state fish and game wardens were frequently citing oil operations for beach spills and fish and shellfish kills. By the 1930s, these officers began reporting cooperation, cleanup, and adoption of preventive measures by the offshore oil industry to avoid oil spills. However, in large part because of the highly visible Santa Barbara Channel oil blowout of 1969, many people in Southern California consider offshore oil exploration and production to be a highly hazardous and polluting activity. In U.S. waters, spill records from offshore platforms show that of 5 billion barrels of oil produced on 41 million acres of offshore tracts leased in federal waters since 1954, 61,000 barrels were spilled (MMS, 1987), less than 0.001 percent of production.

During the 1950s and 1960s, marine life barely existed in the inner

Long Beach and Los Angeles harbors, due mainly to oxygen depletion resulting from the discharge of refinery waste waters directly into the inner harbors (Soule and Oguri, 1979; Reish et al., 1980). By the late 1960s, these inputs were reduced and partly diverted to the Los Angeles County sewage treatment plant at Carson, from which they were discharged with treated sewage off Palos Verdes. The harbors recovered, but their sediments remain heavily contaminated with petroleum hydrocarbons, metals, and other contaminants.

Today, many sources of petroleum hydrocarbon inputs to the ocean are recognized (National Research Council [NRC], 1985), and discharge of treated sewage may be a major source of aromatic and aliphatic hydrocarbons in coastal waters. Eganhouse and Kaplan (1982) estimated that the five largest municipal wastewater treatment plants in Southern California discharge a combined total of 17,400 metric tons per year of petroleum hydrocarbons to the Southern California Bight.

Dunn and Young (1976) measured elevated concentrations of the carcinogenic aromatic hydrocarbon, benzo(a)pyrene, in the mussel *Mytilus edulis* in Southern California. The highest concentrations occurred in mussels collected at harbor entrances. More recently, Anderson and Gossett (1986) confirmed that some Southern California harbor sediments and biota contain elevated concentrations of polycyclic aromatic hydrocarbons. Results of the National Oceanic and Atmospheric Administration's (NOAA) Mussel Watch Program reveal three locations in the bight where mussels contain elevated concentrations of total polycyclic aromatic hydrocarbons: San Diego Bay, Los Angeles Harbor, and Marina del Rey (Boehm et al., 1988). These high-molecular-weight aromatic hydrocarbons are derived from creosoted pilings, industrial (especially refinery) effluents, domestic sewage, oil spills, aerial fallout, and bilge water from ships, particularly crude oil tankers.

It is difficult, if not impossible, to construct a complete mass balance and describe long-term trends for all sources of inputs of petroleum hydrocarbons to the bight. However, inputs of petroleum hydrocarbons in treated sewage are known to have declined as the "oil and grease" fraction of the sewage declined during the last 15 years due to improved removal methods and implementation of source control and pretreatment programs. For the major treatment plants monitored by SCCWRP (1986a), oil and grease discharges decreased by approximately one-half, from 63,000 metric tons per year in 1971 to 34,300 metric tons per year in 1985.

Concentrations of total oil and grease in runoff from land and stormwater flows can be quite high. Gossett et al. (1985) estimated that the mass emission of oil and grease from the Los Angeles River was 28,600 metric tons in 1985. Some of this undoubtedly is derived from treated waste water discharged to the river by sewage treatment plants upstream.

Produced water containing up to 59 mg/liter total oil may be discharged to the ocean. If there were 25 platforms in the Southern California Bight, each discharging 0.25 million gal/day of produced water containing 50 mg/liter total oil, the amount of petroleum discharged each year from this source would amount to 450 metric tons, which is significantly less than the amount discharged from municipal wastewater outfalls in the bight. Refinery discharges have not been quantified but probably contribute a similar amount.

Radionuclides

During the 1940s, 1950s, and early 1960s, atmospheric testing of nuclear weapons by the United States, France, and the Soviet Union in the tropical Pacific, the southwest United States, and elsewhere led to the release of large amounts of radioisotopes into the atmosphere and to significant fallout of radionuclides throughout the Northern Hemisphere. There was considerable concern in California about contamination of leafy vegetable crops. Young and Folsom (1973) reported that in 1967 mussels and barnacles were contaminated with radio-manganese, cobalt, and zinc in a gradient extending from shore to far out to sea. By 1971, these radionuclides were no longer detectable in mussel tissues. Concentrations of plutonium and americium in mussels from the bight are not elevated above normal background values (Goldberg et al., 1978b). Two ocean dump sites designated in the bight for the disposal of radioactive wastes were used between 1947 and 1968. There is continued public concern about possible emissions of radionuclides to the bight from SONGS at San Clemente, and in treated sewage effluents. All discharges to the air and water from SONGS are monitored for radioactivity (Southern California Edison Company, 1987; see also Chapter 4). Sea water from the cooling-water outfall region contained natural background levels of potassium-40, but no radionuclides derived from the station. Ultratrace concentrations of cobalt-58, cobalt-60, silver-110, and cesium-137 derived from the station were detected in fish and invertebrates around the outfalls. Monitoring data from 1979 to 1985 revealed that concentrations of these radionuclides were not increasing over time in the animal tissues. The highest concentrations observed were only 1.8 percent of the levels that must be reported to the Nuclear Regulatory Commission.

Bacteria and Pathogens

Raw sewage was discharged directly into the Southern California Bight beginning before the turn of the century. However, it was not until the 1940s that public concern about the human health risks from pathogens associated with this discharge led to closure of beaches along Santa Monica Bay and in Orange County. During the late 1950s, these beaches were reopened to swimming as treatment practices improved and wastewater outfalls were diverted to deeper locations. Daily monitoring of bacteria has revealed that coliform counts at beach stations in Santa Monica Bay declined by several orders of magnitude between 1945 and 1964, and have since fluctuated around this lower level (Figure 2-5).

In spite of improvements elsewhere in the bight, significant bacterial contamination of swimming beaches persists south of San Diego. This is due to the discharge of raw sewage from Tijuana, Mexico, directly into the surf zone just south of the U.S.-Mexican border or into the Tijuana River, which empties into the bight just north of the border (Hickey, 1986). As a result, Border Field State Park and beaches as far north as Imperial Beach remain under quarantine. This problem persists despite the diversion of up to 13 million gal/day of sewage from Tijuana to the San Diego metropolitan sewer system, which occurred until 1986, when the Tijuana treatment facility came on line. San Diego now only treats emergencies (averaging less than 1 million gal/day). The total sewage flow for Tijuana has been estimated by the U.S. EPA and the International Boundary and Water Commission at between 32 and 38 million gal/day.Today, regulatory limits for coliforms in recreational waters are occasionally exceeded at some beaches following pump failures or overflows at treatment plants or flows into the stormwater drainage system due to infrequent heavy precipitation. Discharge of toilet wastes from recrea-tional vessels can be a major source of bacterial contamination in Newport Harbor and other marinas (Santa Ana Regional Water Quality Control Board, 1985). While regulatory limits have not been established for enteroviruses and other viral pathogens, the presence of such viruses in wastewater effluent and in sea water has been established (Morris et al., 1976).

Concern about pathogens in coastal waters of the bight has historically focused on beaches and the adjacent surf zone. However, increased use of offshore kelp beds by recreational and commercial divers prompted the State Water Resources Control Board to amend the California Ocean Plan to extend monitoring of surface waters for bacterial contamination to offshore kelp beds.

Thermal Discharges

The 14 coastal power plants along the U.S. and Mexican shore of the Southern California Bight generate a tremendous amount of excess heat annually. In 1972 coastal power plants generated an estimated 2 x 107 kw of excess heat (SCCWRP, 1973), and that amount is substantially higher at present. Much of this heat is discharged to the coastal zone

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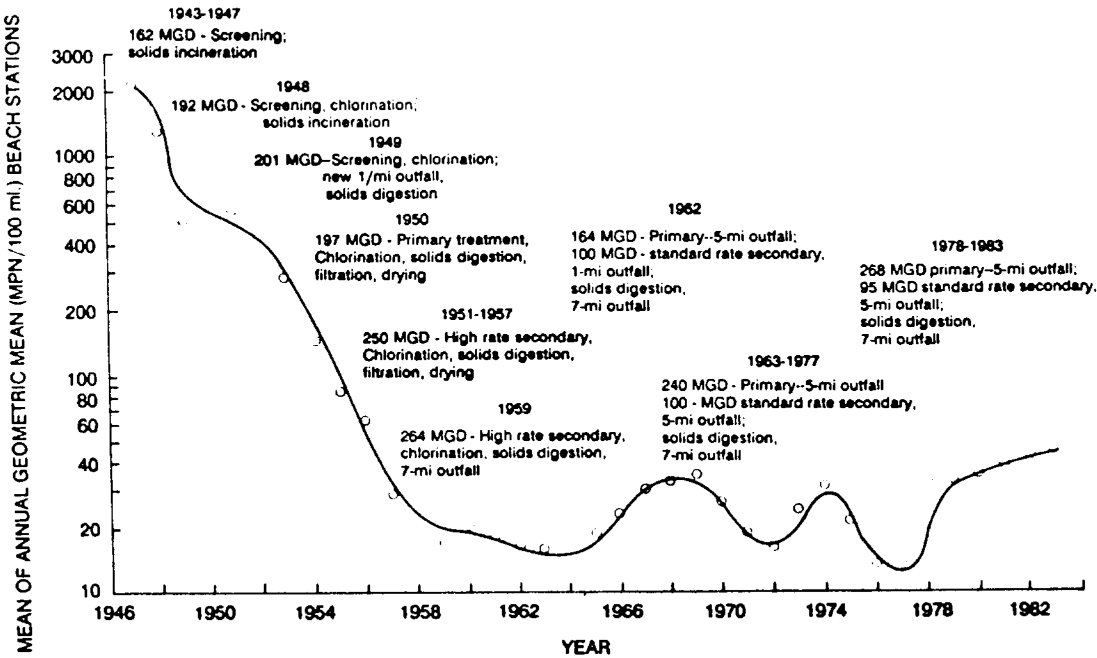

FIGURE 2-5 Counts of coliform bacteria at beach stations adjacent to the Hyperion sewage treatment plant between 1946 and 1983. SOURCE: Garber, 1987.

of the bight as waste heat in once-through cooling water. Approximately 10.7 billion gal/day of sea water is used by coastal power plants in the bight for once-through cooling water (personal communications, Southern California Edison Co., Los Angeles Department of Water and Power, San Diego Gas and Electric Company). This water may be discharged to the ocean at elevated temperatures, provided the temperature of the receiving water does not exceed 4C above ambient at 1,000 ft from the cooling-water discharge (California thermal plan [State Water Resources Control Board, 1975]). The potential effects of thermal discharge have been studied extensively and found to be either minimal or not extending beyond the immediate vicinity of the pipe (Southern California Edison Co., 1973). Traces of biocides and metals dissolved from the cooling coils are discharged (regulated by NPDES permits) with the cooling water.

Particulate Organic Matter and Solids

In lakes, estuaries, and poorly mixed marine basins, high concentrations of organic matter and inorganic nutrients from human and industrial wastes can stimulate bacterial and phytoplankton growth, leading to eutrophication and oxygen depletion. Oxygen depletion of the water can lead to severe damage to benthic and pelagic biotic communities (Rabalais et al., 1985).

The index most frequently used to indicate the tendency of a waste to cause oxygen depletion in the receiving water is the biological oxygen demand (BOD). BOD emissions to the bight have been estimated synoptically only once for all major sources—sewage, runoff, and industrial effluents (SCCWRP, 1973). However, new studies are under way. In 1971 and 1972, about 95 percent of the 297,000 metric tons of BOD discharged to the bight each year was from sewage. By 1985, BOD emissions from the seven major treatment plants had dropped to about 255,000 metric tons per year, and showed a substantial further decrease when ocean discharge of sewage sludge ceased.

It should be noted that since the early 1960s, sewage-derived BOD has been discharged directly to the ocean, not to bays, harbors, or estuaries (discharge of cannery wastes at Terminal Island ceased in 1978). Before that time, serious hypoxia in the bottom waters of Los Angeles and Long Beach harbors and San Diego Bay was nearly chronic. Since the 1960s, depressions in the concentration of dissolved oxygen in the sediments have always been minor in the open bight, even within offshore sewage discharge zones. Depressions of dissolved oxygen in the water column due to wastewater discharge have not been detected. Thus, little benefit to the dissolved oxygen resource is apparent from the substantial efforts to reduce BOD in sewage effluents. This issue merits further investigation.

The total suspended solids emissions in sewage from the seven major treatment plants have declined from 288,000 metric tons per year in 1971 to 205,000 metric tons per year in 1986, due in large part to the use of advanced primary treatment and the progressive shift to secondary treatment (SCCWRP, 1986a). These changes, along with source control, decreased chemical contaminants discharged to the bight (Figure 2-6). These improvements have not been without costs. They have resulted in increased loadings of sludge to landfills and could add to air pollution from sludge incineration in the future. Thus any regional approach to waste disposal options must ultimately consider the tradeoffs among air and water quality and land use.

A budget for suspended solids mass emissions to the bight from all sources has not been completed. Total suspended solids concentrations in stormwater flows have been monitored routinely for many years, but this information has not been synthesized and analyzed for long-term trends. In 1971 and 1972, the amount of suspended solids introduced in stormwater runoff was nearly equal to that introduced in municipal wastewater discharges (SCCWRP, 1973). The amount of suspended solids introduced in nonsewage industrial waste waters is much less than that introduced in sewage and stormwater. In the early 1980s, suspended solids discharged in waste water from five coastal refineries amounted to about 10,000 metric tons per year. By comparison, natural fluxes of suspended solids in the bight, mainly from erosion, are many-fold greater than those due directly to man's activities (Emery, 1960; Kolpack, 1987).

Dissolved Nutrients and Eutrophication

Various forms of nitrogen and total phosphorus are monitored routinely in municipal waste waters, but are rarely monitored in other effluents to the bight. The amount of ammonia nitrogen (the most useful form to phytoplankton) discharged in municipal waste water from the seven largest treatment plants, has not varied much over the years. Between 1971 and 1985, mass emission of ammonia ranged from 36,200 to 56,600 metric tons per year (SCCWRP, 1986a). Discharges of nitrate, nitrite, and organic nitrogen were much smaller and more variable. By comparison, discharges of ammonia in industrial waste water and runoff from land in 1971–1972 was estimated to be 9,500 and 440 metric tons, respectively (SCCWRP, 1973a).

Eppley (1986) compared the rate of input of ammonia and particulate organic nitrogen to the Southern California Bight in waste water to the rate at which these materials are generated by natural biological processes. The flux of ammonia and particulate organic nitrogen in municipal waste water is equivalent to the natural fluxes of these forms of nitrogen taking place under 772 mi^2 and 127 mi^2 of sea surface, respectively. Thus, it is likely

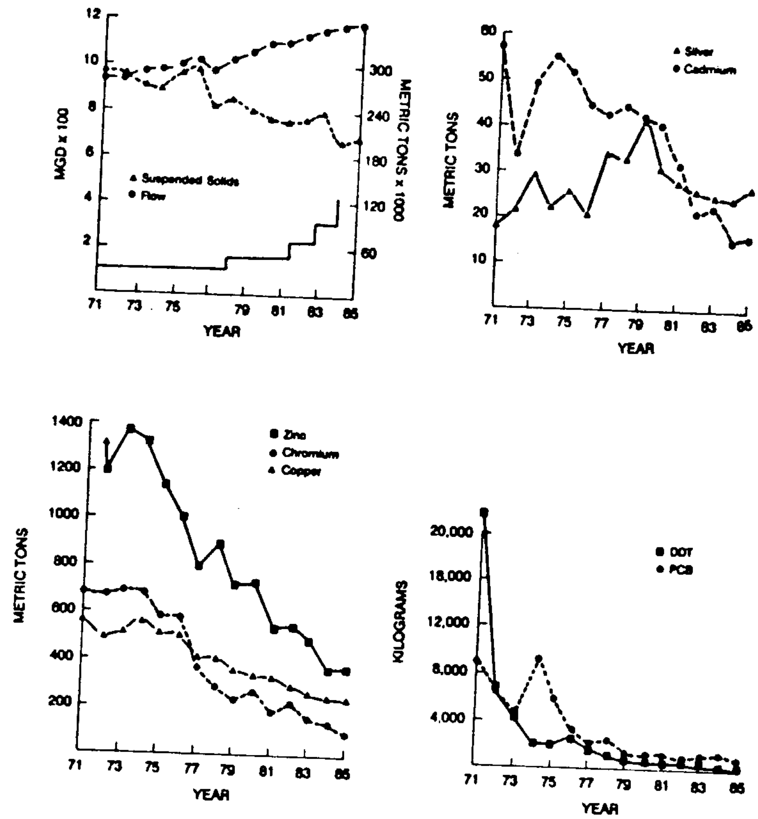

FIGURE 2-6 Mass emissions from seven large municipal sewage treatment plants discharging to the Southern California Bight, 1971 through 1985. SOURCE: SCCWRP, 1986a.

that growth of phytoplankton communities will be stimulated in the immediate vicinity of sewage and refinery outfalls if the waste water is allowed to mix into the near-surface euphotic zone. However, the likelihood of this occurring depends on the location of the outfall. For example, municipal wastewater outfalls discharge at approximately 197-ft depth, well below the thermocline. Refinery outfalls, in contrast, discharge into surface waters. Santa Monica Bay and other coastal waters of the bight have experienced several episodes of elevated ammonia concentrations and blooms of phytoplankton, possibly enhanced by wastewater discharges. Because the blooms

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are quite rare and wastewater discharges are continuous, it appears that factors other than these discharges play a more important role in causing blooms.

Dairy wastes, irrigation tailwaters, and urban lawn fertilizers in runoff can contribute to eutrophication in coastal estuaries and lagoons. High concentrations of nitrate in runoff water have been implicated in blooms of nuisance algae in Newport Bay (Santa Ana Regional Water Quality Control Board, 1987).

Trace Metals

There have been several attempts to estimate the fluxes of metals to the Southern California Bight from different sources. In studies performed in the 1970s, municipal waste water was found to be the major source of several metals (Table 2-2). In contrast, most of the lead entering the bight came from dry fallout from the atmosphere and stormwater runoff from land, derived primarily from combustion of leaded gasoline in automobiles. Garber (1987) found that from 1967 through 1982 the amounts of lead and mercury entering Santa Monica Bay in stormwater runoff were 40 and 52 percent, respectively, of the amounts entering the bay in municipal wastewater discharges. Garber also confirmed earlier conclusions that wastewater discharges were the major source of all other metals entering the bay. Dry or wet deposition of metal from brushfire smoke may be an additional source of metals in coastal waters (Young and Jan, 1977).

In the past 15 years, municipal sewage treatment plants have undertaken source control programs, enforced stringent pretreatment programs, and adopted procedures (including secondary treatment) that reduce the particulate emissions with which most metals are associated. As a result, the concentrations and mass emission rates of most metals have decreased dramatically in recent years (Figure 2-6). Mass emissions of several metals in sewage have decreased five- to sixfold between 1971 and 1985 (SCCWRP, 1986a). One exception is silver, for which the mass emission rate has increased from 17.7 metric tons in 1971 to 27 metric tons in 1985 (SCCWRP, 1986a).

The history of metal inputs to the bight from all sources is neatly recorded in layered sediments in its basins. They reveal that inputs increased annually through the late 1960s, then began decreasing, probably due to decreases in mass emissions of metals in sewage (Bruland et al., 1974).

Synthetic Organic Chemicals

Polychlorinated biphenyls (PCBs) and the pesticide DDT have been

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TABLE 2-3 Estimated Annual Emissions (Kilograms/Year) of Selected Chlorinated Hydrocarbons to the Southern California Bight from Different Sources

Source	Year	Total DDT	Dieldrin	Total PCBs
Municipal waste water[a]	1972	6,490	100	≈ 19,460
	1973	3,920	≤ 280	3,410
	1974	1,580	95	5,290
	1975	1,270	—	3,080
	1976	940	—	2,810
	1977	770	—	1,560
Harbor/industrial	1973-74	40	10	≤ 100
Antifouling paint	1973	< 1	—	< 1
Surface runoff	1971-72	100	20	190-280
	1972-73	320	65	250-830
Aerial fallout[b]	1973-74	1,400	—	1,100
Ocean currents	1973	≤ 7,000	—	≤ 4,000

[a]Values are lower than those in SCCWRP (1986) because fewer treatment plants were considered.
[b]Includes only the inner, nearshore zone of the bight (400 x 50 km).

SOURCE: Young and Heesen, 1978; Young et al., 1981.

monitored extensively in the bight ecosystem since the early 1970s. At that time, municipal waste water was the principal source of these contaminants (Table 2-3), with additional inputs from aerial fallout and surface runoff from land (Young et al., 1976). Garber (1987) reported that between 1967 and 1982, stormwater runoff contributed 7 percent of the total identifiable chlorinated hydrocarbons contributed by municipal waste water to Santa Monica Bay. The DDT came from a local manufacturer, which discharged its wastes into the Los Angeles County sewer system from 1947 to 1971 (Chartrand et al., 1985), and other pesticides and PCBs came from a variety of sources. Analysis of dated sediment cores from the Santa Barbara Basin revealed that deposition (and therefore discharge) of PCBs to the bight began about 1945 and deposition of DDT began about 1952 (Hom et al., 1974).

Gradients of DDT and its breakdown products in coastal mussels and sediments clearly point to the Los Angeles County outfalls as the major source of DDT (Figure 2-7). Body burdens of DDT in commercial fish also are highest off the Los Angeles metropolitan area and decline steadily from Southern California to Alaska, with slight elevations in fish from San Francisco Bay and Puget Sound (Malins et al., 1987; McCain et al., 1988). Among west coast mussels sampled in the NOAA National Status and Trends Program, those from the Los Angeles area had the highest body burdens of DDT (Matta et al., 1985; Boehm et al., 1988). In 1987, mussels from San Diego Bay contained the highest mean concentrations of PCBs along the west coast (2.1 ppm). Mussels from the Los Angeles

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area contained a mean of 0.72 ppm PCBs (Boehm et al., 1988). Mussels in the San Diego area have contained elevated concentrations of PCBs since at least 1976 (Farrington, 1983). The source of this contamination is uncertain.

In the 1970s, manufacture and use of DDT and PCBs in the United States were banned by the Environmental Protection Agency (EPA), and since that time emissions of these highly toxic contaminants to the U.S. environment have declined dramatically. With cessation of discharges of DDT to the Los Angeles County sewage treatment plant in 1971, emissions of DDT from the seven largest municipal wastewater plants dropped dramatically, from 21.7 metric tons in 1971 to 6.6 metric tons in 1972 (SCCWRP, 1986a). Emissions of DDT continued to drop each year and were about 58 kg in 1985. Discharges of PCBs reached a peak of 9.8 metric tons in 1972 and have declined gradually to 0.82 metric tons in 1985. This decline is reflected in the sediments of the anoxic Santa Barbara Basin (Hom et al., 1974).

By 1970, the California brown pelican had been driven almost to extinction in U.S. waters from eating DDT- and PCB-contaminated anchovies (Chartrand et al., 1985). Although still on the endangered species list, the bird has made a significant comeback in the 16 years since DDT was banned (Schreiber, 1980).

Much less attention has been paid to fluxes of other synthetic organic chemicals. There is evidence that several other pesticides are important contaminants in municipal waste and storm waters. The state mussel watch program has identified several hot spots of dieldrin, chlordane, and toxaphene in shallow coastal waters and bays. The pesticides aldrin, heptachlor, and heptachlor epoxide were found in tissues of mussels from coastal regions of northern Baja California (Gutierrez-Galindo et al., 1983), but not in mussels collected by the California Mussel Watch Program along the U.S. coast of the bight (Ladd et al., 1984). A possible source of these pesticides is the Tijuana raw sewage discharge at San Antonio de Los Buenos Creek.

Priority pollutant scans of sewage of the effluent in the monitoring programs of the major municipal dischargers have revealed a wide variety of chlorinated solvents and other synthetic organic chemicals. No attempts have been made to date to estimate the fluxes of these chemicals to the bight from different sources.

Ocean Dumping

Fourteen ocean dump sites designated for disposal of a wide variety of waste materials operated for various lengths of time between 1931 and 1973 in the Southern California Bight (Figure 2-8; Chartrand et al., 1985).

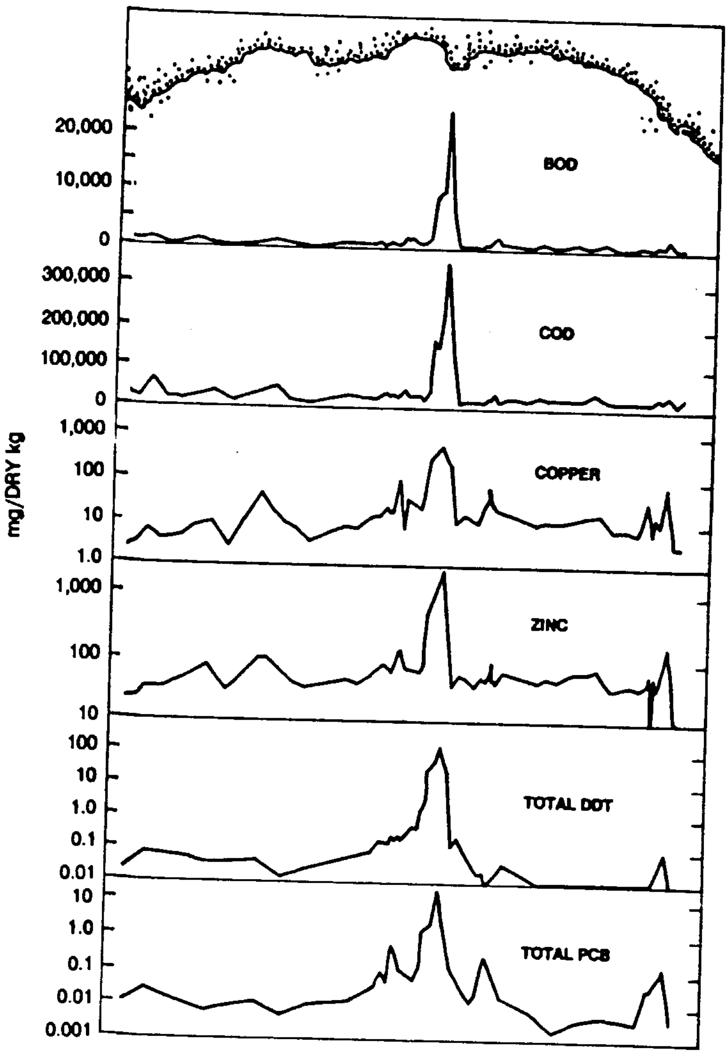

FIGURE 2-7 Variations in concentrations of six materials in surficial sediments from 77 stations along the 60-m isobath during spring and summer, 1978. The large peak is centered around the Palos Verdes discharge. Secondary peaks for some parameters are centered around the other major discharges. The major source of DDT is the Palos Verdes outfalls. SOURCE: Word and Mearns, 1979.

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Between 1947 and 1961, the California Salvage Company dumped a variety of liquid industrial wastes, including approximately 2,000 to 3,000 gal/day of an acid sludge containing DDT from Montrose Chemical Company, at Dump Site No. 1 located about 10 nautical miles north of Santa Catalina Island. In 1961, the Los Angeles Regional Water Quality Control Board began regulating ocean dumping off Los Angeles County and legal ocean dumping of DDT ceased. All legal ocean dumping at this site ceased in 1973. Chartrand et al. (1985) cite instances of illegal dumping of DDT-contaminated wastes off Palos Verdes in the 1970s.

Since 1977, four open-ocean locations have been designated by the EPA for use by the U.S. Army Corps of Engineers (COE) as interim disposal sites for dredged materials (P. Cotton, U.S. EPA Region IX, personal communication; 40 CFR 228 12A). Dump site LA-1 is off Port Hueneme, LA-2 is off Los Angeles and Long Beach harbors, LA-3 is off Newport Beach, and LA-5 is off Point Loma. Approximately 2 and 3 million yd^3 of dredged material from Los Angeles and Long Beach harbors and San Diego Harbor have been dumped at the LA-2 and LA-5 dump sites, respectively. This dredged material probably was contaminated with a wide variety of chemicals, but no monitoring is being performed to determine if chemicals are being leached from it.

EPA recently designated an ocean disposal site for oil well drilling muds and drill cuttings. The site is about 16 nautical miles from Long Beach Harbor and is near the center of the San Pedro Basin. It has been used by the THUMS Long Beach Company for disposal of drilling muds and cuttings generated during drilling from four islands in Long Beach Harbor.

OVERVIEW OF ENVIRONMENTAL PROBLEMS

Contaminant input, resource exploitation, and habitat modifications due to construction and other economic activity have led to a suite of environmental problems in the Southern California Bight. Some of them are regionwide, while others are relatively localized. It is beyond the scope of this case study to present a detailed review of all environmental problems, however, awareness of their diversity is important to understanding the monitoring programs described and analyzed in Chapters 4 through 6. The following sections therefore present a brief listing of major environmental problems in the bight, and describe two of them in more detail: DDT contamination and the transport of sewage contamination from Mexico into U.S. waters.

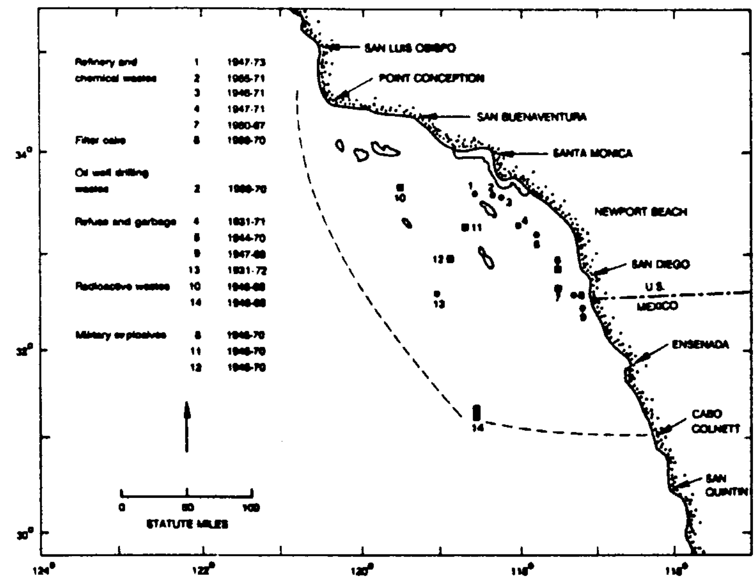

FIGURE 2-8 Ocean dump sites designated and used between 1947 and 1973. The THUMS dump site is near position 2. SOURCE: Chartrand et al., 1985.

Bightwide Environmental Issues

Many environmental problems from both human activity and natural processes in the bight extend throughout the entire bight or are extensive enough that they cross regulatory and legal boundaries. They include:

- impacts on fish and shellfish populations from commercial and sport fishing;
- impacts on fish populations from entrainment of larvae and impingement of adults by coastal power plants;
- large changes in fish populations (e.g., sardines) resulting from incompletely understood interactions between natural environmental changes and fishing activity;
- impacts on individual fish species from loss of nursery habitat due to construction and dredging;
- large changes in the areal extent of kelp beds resulting from natural environmental changes and contamination;

- regional changes in plankton populations due to nutrient enrichment by waste water;
- regional contamination of sediments and biota resulting from toxics in waste water, storm drain, and nonpoint source inflows;
- regional contamination of water resulting from pathogens in waste water, storm drain, and nonpoint source inflows; and
- cumulative effects that derive from the combination of regional and local impacts on specific resources.

DDT Contamination

One regional problem has attracted international attention. In 1967, high concentrations of DDT were reported in fish from California coastal waters (Risebrough et al., 1967). By 1970, it was known that the Montrose Chemical Company was disposing of large amounts of DDT via the Los Angeles County ocean sewage outfalls off Palos Verdes and by ocean dumping. During the next decade, numerous surveys documented the occurrence of the pesticide throughout the bight, south to Baja California, and far up coast to the north in many species of marine animals, including sea birds, seals, sea lions, and porpoises. Retrospective analyses of museum fish and dated sediment samples revealed that regionwide contamination began as early as 1950 (Chartrand et al., 1985). Until it was banned in the United States in the early 1970s, large amounts of DDT were used for agricultural and insect control. Some of the DDT reached the bight in aerial fallout, runoff from land, and municipal sewage (Young et al., 1976).

DDT continues to be used in Baja California and some of it continues to reach the bight in stormwater runoff. In recent years, large concentrations of DDT in mussels from Newport Bay have been reported (Santa Ana Regional Water Quality Control Board, 1985). These increased concentrations may be derived from agricultural soils being plowed or cleared for subdivision development and contaminating stormwater runoff. During the last decade, DDT emissions have been reduced a thousandfold (Figure 2-9) and contamination of intertidal organisms and fishes has declined (Matta et al., 1986). The widespread contamination that resulted from the combination of a large point source and many nonpoint source inputs dramatically illustrates the potential for localized problems to become regional problems over time.

U.S.-Mexico Sewage Contamination

The headwaters and mouth of the Tijuana River are in the United States, although 70 percent of its stream bed and drainage basin lie in

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the Mexican state of Baja California (Figure 2-10). The river has been used for disposal of raw sewage since the 1920s, and rapid population growth in the Tijuana area after World War II led to the quarantine of Imperial Beach (San Diego County) in 1959. The quarantine was lifted in 1962 after Tijuana completed its sewage system, but was reimposed in 1965 as the system failed repeatedly. As a stop-gap, an emergency pipeline was constructed to carry up to 13 million gal/day of sewage to the San Diego metropolitan system. By 1980, this pipeline was continuously at full capacity. Because of population pressures on both sides of the border, the pipeline agreement is currently being renewed on a year-to-year basis.

By the early 1980s, overflows, leakage, and failures at the Playas de Tijuana Treatment Plant and at other points in the sewer system led to multiple discharges of raw sewage (Figure 2-10)(Hickey, 1986), including the discharge of 1 million gal/day of raw sewage directly to the ocean less than 1 mile south of the Mexican border. In addition, raw sewage from some of the approximately 50 percent of Tijuana's population that is not sewered flows down open channels into the Tijuana River drainage. As a result, Border Field State Park and beaches as far north as Imperial Beach have remained under quarantine.

The regional contamination resulting from uncontrolled sewage flows from Tijuana provides a clear example of how environmental problems can cross regulatory and legal boundaries. As a result, in 1980 the San Diego County Department of Health Services, in cooperation with the San Diego Regional Water Quality Control Board and the U.S. State Department's International Boundary Commission, an agency formed by the U.S. and Mexican governments to deal with trans-border issues, implemented a monitoring program to determine the influence of Mexican sewage discharge on beaches in the border zone.

Local Environmental Problems

Many environmental problems in the bight are local; they are restricted to an area or time surrounding a specific identifiable disturbance or contamination source. Because they are easier to identify and monitor, these localized impacts are more completely understood than bightwide impacts. Localized impacts include:

- changes in benthic infauna around wastewater outfalls;
- changes in the makeup of fish communities around wastewater outfalls resulting from alterations in their food supply;
- contamination of sediments and biota in the immediate vicinity of wastewater outfalls;

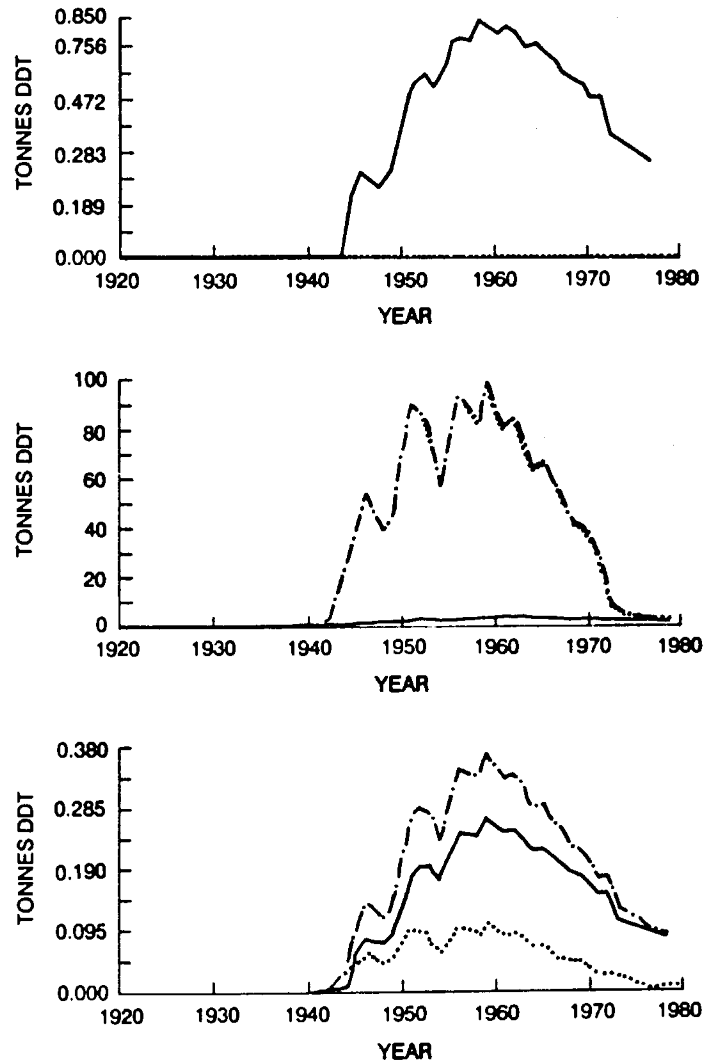

FIGURE 2-9 Total (—), nonpoint (-.-), and point source (...) estimated yearly input of DDT to the Southern California Bight from (a) Santa Barbara and Ventura counties, (b) Los Angeles, Orange, Riverside, and San Bernardino counties, and (c) San Diego County. SOURCE: Summers et al., 1987.

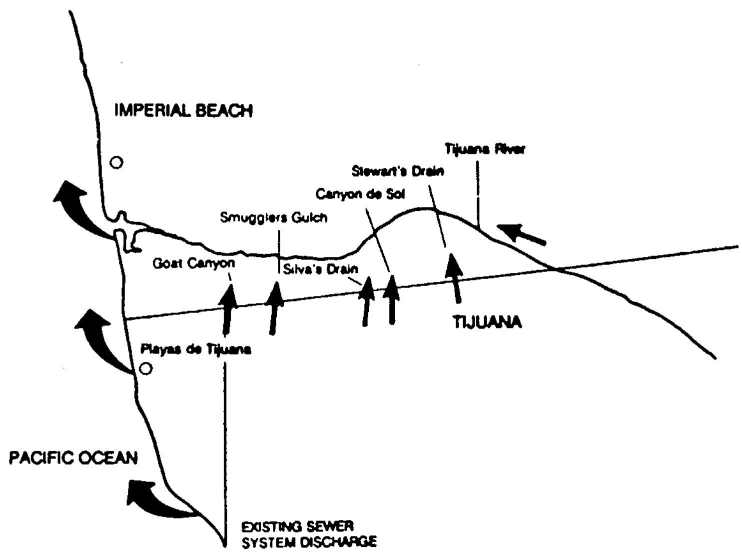

FIGURE 2-10 Locations where raw or partially treated sewage enters U.S. territory from Baja California, Mexico. SOURCE: Hickey, 1986.

- potential effects on kelp beds from the White Point and Point Loma wastewater outfalls and SONGS;
- effects on fish communities from heated power plant effluent;
- contamination of nearshore water in the immediate vicinity of storm drains;
- impacts on benthic communities from disposal of dredged material; and
- impacts on plankton populations resulting from SONGS' effects on nearshore circulation patterns.

SUMMARY

The sources of pollution in the Southern California Bight are quite varied and typical of those found in any highly urbanized coastal area of the United States, except that there are no major riverine inputs. Some of these sources are among the largest (sewage treatment plants) or most extensive (oil production) of their type found anywhere. The range of contaminants discharged is broad, and in some cases the volumes have been among the largest found in the country (for example, the historic DDT discharges through the Los Angeles County sewage treatment plant). In recent years, as a result of control strategies or changed production practices, the amounts of many contaminants discharged have declined dramatically. These reductions have resulted in decreased concentrations in the marine environment.

This great variety in sources and types of pollutants poses a formidable challenge for society as it seeks to impose appropriate controls on discharges to the marine environment. The statutory and regulatory system responsible for achieving these reductions is discussed in Chapter 3. In addition, the complexity of sources and pollutants has resulted in a set of intensive monitoring programs in the Southern California Bight, which are discussed in detail in Chapter 4.

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3
Regulatory Framework and Public Concerns

As public concerns over the condition of the nation's environment grew during the 1970s and 1980s, statutes were enacted to address them. This chapter discusses the major federal, California state, and international laws that address water quality and related issues, and the agencies responsible for implementing them. Many of the decisions made by these agencies in the context of the statutory requirements are based, in part, on information derived from the monitoring system in the Southern California Bight.

Public concern over water quality has not abated, and in many ways has grown sharper in recent years. Hearings held in 1988 on the California ocean plan provided a forum for restating these concerns as they relate to monitoring and are therefore summarized in this chapter.

REGULATORY SECTOR

State and federal agencies have regulatory authority over three types of environmental issues in the Southern California Bight:

1. water quality control,
2. public health and safety, and
3. natural resources protection and management.

Marine Water Quality

The two major federal laws that regulate marine water quality are the Federal Water Pollution Control Act Amendments of 1972 and 1987 (the Clean Water Act, as amended, or CWA), and the Marine Protection, Research and Sanctuaries Act (MPRSA) of 1972. The CWA regulates all discharges into navigable waters of the United States, from fresh waters through the estuaries, the territorial sea (0 to 3 nautical miles—hereafter called the 3-mi limit), the contiguous zone (3 to 12 nautical miles), and beyond (Figure 3-1). It covers pipeline discharges to estuaries, the territorial sea, and federal waters beyond the 3-mi limit. It also covers runoff from land and dumping of wastes (primarily dredged material) from vessels into estuaries. The MPRSA regulates the transportation and dumping of wastes in marine waters from the mean low-water line of the open coast to the outer limit of federal jurisdiction. Thus, the CWA covers pipeline discharges from coastal sewage treatment plants, electric power plants, and commercial and industrial operations to fresh and marine waters, as well as discharges from oil platforms in state and federal waters. The MPRSA covers any dumping of materials from barges or ships into the ocean, including incineration of hazardous wastes at sea.

An important difference between the two laws is that the CWA is a water pollution abatement law and as such is not required to consider effects on the air and land of abatement actions for water. MPRSA on the other hand requires evaluation and assessment of all potential water, air, and land impacts before an action (e.g., dump site designation) can be taken. Thus, pipeline discharge of sewage sludge is illegal under CWA.

The primary purpose of the CWA is to restore and maintain the chemical, physical, and biological integrity of U.S. water resources (Office of Technology Assessment [OTA], 1987). This was to be accomplished by a federal grant and loan program to help municipalities to build or upgrade sewage treatment plants and by pollution control programs with regulatory requirements for industrial and municipal discharges.

The Environmental Protection Agency (EPA) is the federal agency that administers the CWA. In the state of California, the pollution control provisions of the CWA are administered by the California State Water Resources Control Board and the regional water quality control boards under authority of the Porter Cologne Act (Water Code Sections 13000 et seq.).

Section 402 of the CWA authorizes the EPA to establish and administer the National Pollutant Discharge Elimination System (NPDES) permit program. All municipal and industrial facilities discharging directly into navigable waters are required to obtain a NPDES permit. Pollution control is implemented primarily by "end of the pipe" (effluent) limitations on specific conventional chemicals that may be present in the discharge. These limitations are based primarily on considerations of current available technology (technology-based limits). Recently, there has been a growing emphasis on basing permit limitations on consideration of the quality and

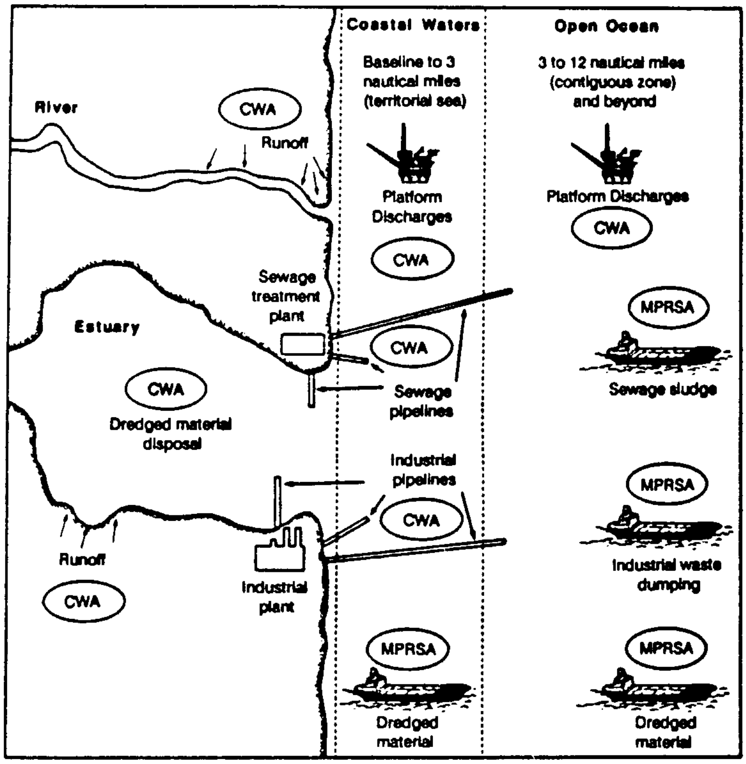

FIGURE 3.1 Jurisdictional boundaries of environmental laws affecting marine disposal.
SOURCE: Office of Technology Assessment, 1987.

uses of the receiving waters (water quality-based limits). Dischargers are required to report periodically on compliance with technology-based limits. In addition, if water quality-based limits are included in the permit and the discharge is to state waters, a monitoring program is required to ensure that water quality standards and requirements are met.

EPA issues permits for discharges outside state waters (beyond the 3-mi limit) and reviews NPDES permits issued by the regional water quality control boards. EPA is also the primary permitting authority for special permits identified by the CWA, such as section 301(h), which authorizes waivers from secondary treatment of effluent discharged into marine waters if water quality objectives to protect the marine environment can be met.

In the bight, the CWA is administered through the State Water Resources Control Board by four regional boards: Central Coast (Region 3), Los Angeles (Region 4), Santa Ana (Region 8), and San Diego (Region 9). The regional boards have primary responsibility for:

- developing and adopting waste discharge requirements (limits on the discharge of wastes to state waters),
- administering monitoring programs (used to determine compliance with permit requirements), and
- developing and adopting water quality control plans (basin plans) within their respective regions.

The state board determines state policy for water quality control and reviews the basin plans developed by the regional boards to ensure that they are consistent with state policy. The state board may also adopt statewide water quality control plans or policies, which supersede the regional basin plans if there is a conflict. Statewide plans and policies dealing with estuarine, coastal, and marine waters of California are:

- the California ocean plan (Water Quality Control Plan for Ocean Waters of California [State Water Resources Control Board, 1983]),
- the California thermal plan (Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California [State Water Resources Control Board, 1975]), and
- the enclosed bays and estuaries policy (Water Quality Control Policy for the Enclosed Bays and Estuaries of California [State Water Resources Control Board, 1974]).

Statewide and regional water quality control plans designate:

- beneficial uses to be protected,
- water quality objectives (limits or levels of water quality constituents for beneficial use protection), and
- implementation of a program for achieving water quality objectives (waste discharge requirements).

The designation of beneficial uses and water quality objectives constitute water quality standards for California. Waste discharge requirements are derived from the relevant basin or statewide plan.

The California ocean plan sets the scope for most of the discharge-related marine monitoring programs in the bight. The plan has been reviewed three times (1978, 1983, and 1987) and amended twice (1978 and 1983). Additional amendments were proposed in 1988 (State Water Resources Control Board, 1988). These amendments, as well as those to the CWA in 1977, 1981, and 1987 resulted in increased monitoring requirements for dischargers.

The regulatory process and the public are linked by the regional boards, which deal with regional and local regulatory issues. Board members are local residents and the staff deals directly with local governments, agencies, and dischargers. The boards hold hearings for discharge permits, and the staff (and, when appropriate, EPA—e.g., NPDES permits for discharges into federal waters) develop ocean monitoring programs, interpret monitoring results with respect to permit compliance, and inform the public.

The MPRSA, which regulates transportation of materials to be dumped in the ocean or incinerated at sea, authorizes EPA to designate and manage ocean dumping and incineration sites. EPA also evaluates ocean dumping criteria for all permits and issues permits for ocean disposal of materials other than dredged material. The U.S. Army Corps of Engineers (COE), under Title I, Section 103, administers the permit program for disposal of dredged material at ocean sites designated by EPA. However, EPA does have the authority to review applications for dredged material disposal permits. Both agencies must determine that the proposed dumping will not unreasonably endanger human health or the marine environment according to the ocean dumping criteria, and that ocean disposal is the best environmental option.

Section 404 of the CWA regulates discharge of dredged or fill material within the 3-mi limit and in estuaries and wetlands (Figure 3-1). The COE regulates such discharges, using guidelines they developed jointly with EPA (Office of Technology Assessment, 1987). Under Section 401 of the CWA, such discharges must be certified by the affected state as complying with applicable water quality criteria. In the event of a conflict between the state and COE, or outside of COE jurisdiction, the regional boards have independent authority under the California Water Code to regulate such discharges.

Under Title I, Section 107, of the MPRSA, the U.S. Coast Guard is responsible for surveillance and enforcement to prevent unlawful dumping of prohibited material, dumping outside designated ocean dump sites, and illegal transportation of material for dumping. Title I expressly prohibits the disposal of high-level radioactive wastes and chemical and biological warfare agents. Certain other materials are allowed only under certain circumstances.

Title II requires EPA and the National Oceanic and Atmospheric Administration (NOAA) to conduct research and monitoring to assess the environmental impacts of waste disposal.

Title III of MPRSA gives NOAA the authority to establish marine sanctuaries. Inland waters and marine areas as far offshore as the edge of the continental shelf can be designated as marine sanctuaries if such designation is determined necessary to preserve or restore the area for conservation, recreational, ecological, or aesthetic purposes. The Channel

Islands National Marine Sanctuary, located in the bight, is an example. Two international conventions address ocean dumping. The first is the London Dumping Convention (LDC), which was negotiated in 1972 and became effective in 1975. It requires that all signatory nations adopt marine disposal criteria that, at a minimum, are equivalent to and contain the basic constraints of those in the LDC. The United States, Mexico, and 59 other countries have ratified the LDC. In 1974, the MPRSA was amended so that all U.S. marine disposal criteria would be consistent with and contain all the basic constraints set forth in the LDC.

The second agreement, the International Convention for the Prevention of Pollution from Ships (1973 and protocols of 1978, known as MARPOL 73/78) regulates discharges from ships. Annex 1 (covering discharges of oil) and Annex 2 (covering discharges of bulk chemicals) have been ratified by the required number of nations and are in effect. Annex 3 (covering sewage discharges), Annex 4 (covering hazardous substances in packaged form), and Annex 5 (covering garbage) await approval. The U.S. Senate recently enacted the Marine Plastic Pollution Research and Control Act of 1987 (P.L. 100-200, Title II, Sections 2001 to 2305), which includes provisions of Annex 5 of MARPOL 73/78 and prohibits ships from dumping plastics anywhere in the ocean and from discharging garbage to the ocean within 12 mi of shore, including the bight. Ports will be required to provide garbage disposal facilities for ships, and ship captains will be required to keep a waste management log, which must be available to port officials.

Public Health and Safety

State and federal agencies with primary responsibility for public health and safety within the bight's waters and along its shores are the California State Department of Health Services (DHS), the county and municipal public health agencies, and the federal Food and Drug Administration (FDA). The California Health and Safety Code and the California Administrative Code authorize the DHS to supervise sanitation, healthfulness, and safety of public beaches and public water-contact sports areas. The main focus of DHS monitoring activities is marine recreational areas from the beach out to a depth of 30 ft or 1,000 ft from shore, whichever is farther (the surf zone), and coastal kelp beds. DHS has been relying on bacteriological standards developed in 1942 (total and fecal coliforms) to judge the safety of water bodies (California Department of Public Health, 1943). When standards are exceeded, DHS or local health officials may post warning signs or declare beach closures. Permanent warning signs have been posted in the vicinity of major storm drain outlets into Santa Monica Bay and near the U.S-Mexican border. Upper Newport Bay has been closed to water-contact sports since 1974 (Santa Ana Regional Water Quality Control Board, 1985).

Under present laws and regulations, DHS can close fishing and shellfishing areas because of bacterial contamination and the presence of paralytic shellfish poisoning (PSP) organisms in marine animals. Since 1978, upper Newport Bay has been closed to shellfish gathering for human consumption because of bacterial contamination from the bay drainage area (Santa Ana Regional Water Quality Control Board, 1985). A commercial shellfish growing operation in Agua Hedionda Lagoon in San Diego County is required by its state permit to cease harvesting for seven days after rain in excess of 0.25 inches due to bacterial contamination from the lagoon watershed (California Department of Health Services, April 7, 1988). The DHS has maintained that elevated fecal coliform levels in coastal waters and in shellfish meats at a mariculture operation in the Santa Barbara Channel have resulted from the intermittent impact of undisinfected sewage effluent from both the Goleta and Santa Barbara wastewater treatment plants. In 1987, the Goleta plant initiated disinfection of its effluent prior to discharge (California Department of Health Services, 1988b, letter to Pacific Seafood Industries).

There is no specific authorization under current law to close fishing and shellfishing areas due to chemical contamination. Until recently, there was no systematic sampling of edible tissues of fisheries products from the bight to evaluate potential effects on human health from chemical contamination. However, the DHS recently issued a health advisory warning against consumption of white croaker from the Santa Monica Bay, Palos Verdes Peninsula, and Los Angeles Harbor areas because of heavy DDT and PCB contamination.

The DHS is also overseeing a year-long assessment of chemical contamination of recreational and commercial fish sampled from 25 areas in the bight. More recently, experimental quantitative risk assessment methods have been used to evaluate suspected or potential human carcinogens in fishery products. Such methods may lead to estimates of health risks from levels of contamination well below current FDA action limits.

Monitoring for coliform or other enteric bacteria is also a part of all monitoring programs administered by the regional water quality control boards and EPA around municipal wastewater outfalls. This bacterial monitoring is intended to track the wastewater plume and evaluate possible hazards to the water contact recreation shorelines.

Natural Resource Protection and Management

Several state and federal resource agencies are involved in protecting and managing the natural resources of the Southern California Bight. The

California Department of Fish and Game, the National Marine Fisheries Service (NMFS) of NOAA, and the Fish and Wildlife Service (FWS) of the U.S. Department of the Interior (DOI) are all involved in protecting and managing living marine resources. Their activities include fish stock assessments and habitat protection. The State Lands Commission is responsible for leasing tidal and submerged lands out to the 3-mi limit for energy and mineral development, subject to the Public Trust Doctrine. The California Department of Fish and Game and the Department of Health Services issue permits for commercial shellfish growing, subject to review by the State Lands Commission. The DOI's Minerals Management Service (MMS) is responsible under the Outer Continental Shelf Lands Act of 1953 (OCSLA) for leasing energy and mineral rights in federal waters extending from the 3-mi limit to the outer limit (200 mi) of the Exclusive Economic Zone (EEZ).

Resource exploitation, management, and protection activities must comply with several federal regulations in addition to those dealing with water quality. The National Environmental Policy Act of 1970 (NEPA) requires that an environmental impact statement (EIS) be prepared for all proposed legislation and all major federal actions that could significantly affect the quality of the environment. Thus, the MMS prepares an EIS before leasing offshore tracts for oil and gas exploration. Although EPA is not required to prepare an EIS for ocean disposal site designations, its policy is to do so voluntarily for dump site and incineration site designations. EPA also prepared an EIS in 1977 when it proposed revisions to the ocean dumping regulations and criteria.

The Endangered Species Act of 1973 requires all federal and state agencies to ensure that any action they authorize, fund, or carry out will not jeopardize the existence of an endangered or threatened species or result in damage or destruction of critical habitat for such species. The act authorizes the NMFS and FWS to render a biological opinion about the potential effect of a proposed activity on endangered species. As part of the EIS process, one of these agencies, usually upon consultation with the California Department of Fish and Game, must attest that the proposed action is compatible with the Endangered Species Act.

The NMFS and FWS are empowered by the Marine Mammal Protection Act of 1972 to enforce a moratorium on the taking or importation of marine mammals and marine mammal products except by special permit from the Secretary of Commerce. The National Historic Preservation Act protects historic and prehistoric archaeological resources.

The Coastal Zone Management Act of 1972 (CZMA) administered by NOAA provides grants to coastal states to develop coastal management plans. It also provides for state review of federal actions, including leasing of tracts for oil development and designation of ocean dump sites in federal waters that might directly affect the coastal zone. Although the State Water Resources Control Board has primary authority to regulate water quality, the California Coastal Commission is responsible for reviewing federal actions for consistency with the state's coastal management plan. In this role, the commission has had a major influence on proposed oil and gas development activities on California's outer continental shelf.

Under the CZMA National Estuarine Reserve Research Program, the Secretary of Commerce may designate a state or estuary as a national reserve upon nomination for such designation by the state's governor. The Tijuana Estuary is the first estuary in the Southern California Bight to receive such status.

The California Coastal Commission controls development within the coastal zone by issuing permits and approving local development plans in accordance with the California Coastal Act of 1976. The California Coastal Conservancy is authorized to make grants to local governments to acquire and restore critical habitats, including coastal wetlands.

INTERAGENCY COOPERATION

Complex environmental problems may not fall neatly within the areas of responsibility of individual agencies. They may involve the responsibilities of several agencies, or none, and may cross jurisdictional boundaries. In delegating responsibility for regulatory activities in the bight to different state and federal agencies, the U.S. Congress and the state legislature have not always been able to anticipate such problems. As a result, agencies must deal with policy conflicts, gaps, and overlaps. In addition, monitoring and research results generated by one agency can relate to the statutory responsibility of another. There are several examples in the bight of interagency cooperation that has successfully resolved such conflicts, and a few are mentioned below.

The previous chapter described how the San Diego County Department of Public Health, the San Diego Regional Water Quality Control Board, and the U.S. State Department's International Boundary Commission cooperated on the design of a monitoring program to assess sewage contamination from Tijuana. In addition, the EPA's Region IX office cooperates with the U.S. Army COE and with the Regional Water Quality Control Boards in establishing discharge and disposal limitations and monitoring programs.

The California Cooperative Oceanic Fisheries Investigation (CalCOFI) program is a long-standing example of a joint monitoring and research program involving federal and state resource agencies and an academic institution. The State Water Resources Control Board and the California Department of Fish and Game have combined resources to establish a statewide Mussel Watch Program to monitor toxic contamination. This program complements NOAA's National Status and Trends Program. The NOAA Sea Grant programs (which receive matching funds from the state of California), the U.S. FWS, the Coastal Conservancy, and the California Department of Fish and Game have cooperated in coastal wetland restoration projects.

Responding to mounting public concern over the condition of Santa Monica Bay, the Southern California Association of Governments (SCAG), funded the Santa Monica Bay Study. The study's goal was to compile all data relevant to the bay, perform an overall assessment of the state of its marine environment, and develop an implementation plan for specific actions to improve it. The study's steering committee is a consortium of representatives from local and state governments, environmental and academic groups, federal agencies, and local dischargers. Ten local entities and the SWRCB (using Clean Water Act monies) are funding the study. The San Diego Regional Water Quality Control Board has initiated a similar program to address environmental problems in San Diego Bay.

PUBLIC CONCERNS FOR THE BIGHT

There is intense public interest and awareness about environmental quality in Southern California. As a result, the public has been very vocal in advocating strong and effective environmental protection policies for the Southern California Bight. A sampling of public concerns and perceived policy needs for the bight ecosystem can be gained from the October 1986 triennnial review of the California ocean plan (State Water Resources Control Board, 1987) and from the presentations of interested parties to the case study panel. The following points were made by representatives of citizen organizations:

- The California ocean plan (State Water Resources Control Board, 1987) needs clearer definitions of narrative terms such as "degrade." It is difficult to assess the information provided by monitoring in the context of such vague objectives.
- Not enough attention is being paid to nonpoint sources of contaminants entering the bight, such as stormwater drains and aerial fallout. The plan should consider placing monitoring requirements on these sources.
- There should be a shift from discharge standards and effluent limitations based on allowable concentrations of contaminants in receiving waters to standards and limitations based on mass emissions of contaminants. This would better reflect the loading of the marine environment.
- A more complete assessment of the cumulative effects of marine contamination is necessary.

- The plan should require monitoring of sediments and biota to better assess cumulative levels of contaminants and their associated effects.
- There should be more independent review and oversight of the monitoring programs performed by dischargers.
- Self monitoring should be eliminated and monitoring put in the hands of state agencies.
- There should be better analysis of monitoring data submitted to public agencies and better communication of that information to the public.
- An oceanic institute associated with local universities should be established to conduct regular monitoring currently performed by dischargers, to coordinate monitoring by other agencies, and to perform related research.
- Standardized bioassay protocols and bioaccumulation tests should be required to better assess the toxicity of effluents to marine life and the hazards of eating fishery products from coastal areas.

The public appears to expect monitoring activities to provide information that answers four basic questions:

1. Is it safe to swim in the ocean?
2. Is it safe to eat the local seafood?
3. Are fisheries and other living resources being adequately protected?
4. Is the health of the ecosystem being safeguarded?

These are the public expectations that the panel perceives drive the actual monitoring programs. However, monitoring is carried out within a broader societal context, which includes such issues as cost, the effects of competing uses on land, water, and air quality, and tradeoffs between short and long-term costs and benefits. The challenge is valid and useful to management decision making in that it provides information addressing public concerns.

SUMMARY

The regulatory framework in the Southern California Bight is indeed complex and far reaching. Successful implementation of monitoring programs often requires a high degree of cooperation among state and federal officials. The efficient design of a monitoring system that can meet the various objectives of regulatory interests and not impose unreasonable burdens on the regulated community is a formidable task. In succeeding chapters, the details of this system are discussed and its success at meeting these criteria assessed.

In part, the success of the regulatory program and the role that monitoring plays depend on public confidence. The public continues to question the efficacy of monitoring and the status of the marine environment. Subsequent chapters will offer suggestions about the technical design of monitoring programs that may address those questions.

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Monitoring and Research in The Southern California Bight

The relationship between research and monitoring activities in the Southern California Bight is complex, making it difficult to arbitrarily and consistently distinguish between the two. In this report, monitoring generally refers to repeated measurements taken to comply with specific regulations: research refers to measurement and experimental programs undertaken to answer more open ended questions. In the panel's view, monitoring and research are complementary activities that support each other and that both provide important information needed for resource management. Often the same agency will fund and/or direct both monitoring and research. Monitoring results have stimulated research programs, and research results have provided information that has been helpful in reducing impacts and refining monitoring requirements. In addition, research activities are often an integral part of monitoring programs in the bight.

Although this chapter reviews research and monitoring programs separately, it is important to remember the significant links and interactions between the two activities. These links exist because both monitoring and research are concerned with measuring and understanding processes of marine environmental change.

In general, monitoring in the bight is focused on four broad areas of concern:

1. the effects of effluent from municipal sewage treatment plants;
2. the effects of effluent from other sources, such as power plants, refineries, and nonpoint sources;

3. the status of resources such as fisheries and kelp beds; and
4. effects on public health from water contact sports.

Although these are useful organizing principles, in reality specific programs overlap the boundaries between them. Monitoring related to each of these four concerns is complemented by active research programs.

The main characteristic of research and monitoring activities in the bight is their broad diversity. Federal, state, and local agencies, along with universities and private industry, are active members of the research and monitoring community. This diversity stimulates innovation and careful evaluation of research and monitoring results, but it also makes coordination and integration of monitoring more difficult.

THE MONITORING SECTOR

The four monitoring areas described above reflect the existing regulatory environment (Chapter 3), with each kind of monitoring responding to a different set of laws, regulations, permits, and limitations. (A comprehensive review of past and present monitoring programs can be found in SCCWRP, 1988.) Effluent discharge and monitoring are controlled by National Pollutant Discharge Elimination System (NPDES) permits, which can contain effluent limitations (pertaining to the effluent) and water quality objectives (pertaining to the receiving waters). In California, these are determined by EPA, based on provisions of the Clean Water Act, as amended (CWA), and by the regional water quality control board issuing the permit, based on the California ocean and thermal plans (State Water Resources Control Board, 1975, 1987). Effluent limitations are specific numerical standards; water quality objectives include both numerical (Table B of the California ocean plan) and narrative standards (such as degradation of the environment).

The numerical effluent limitations are a combination of federal and California ocean plan (State Water Resources Control Board, 1987) regulatory requirements and are based primarily on consideration of current available technology (the technically or financially most feasible level of contaminant removal attainable). Effluent limitations may be stated as maximum acceptable concentrations of a constituent in the effluent or as the maximum allowable mass emission per day. For thermal effluents, for example, the maximum allowable difference in temperature between the effluent plume and the receiving waters at 1,000 ft from the outfall or diffuser is 4°C (California thermal plan [State Water Resources Control Board, 1975]). Compliance with such effluent limitations is determined directly by analysis of effluent at specified intervals.

The water quality objectives are also determined according to federal laws and regulations and California ocean plan requirements (State Water

Resources Control Board, 1987). They are numeric or narrative expressions of the maximum allowable changes in various environmental parameters that will not result in serious or long-term damage to the affected marine ecosystem. Numeric objectives define allowable concentrations of waste constituents after allowing for mixing within the zone of initial dilution (ZID), the region within a specified horizontal distance from the end of an outfall or any point along a discharge diffuser. The horizontal distance is usually equal to the water depth at the discharge. In contrast to establishing numeric objectives, demonstrating compliance with the narrative water quality objectives can be difficult. It is based on periodic monitoring of environmental conditions in the vicinity of the effluent discharge, and criteria used to measure compliance with these narrative objectives are often subjective and inferential.

In contrast to this system of effluent monitoring, resource monitoring is structured around compilation of commercial and sport catch statistics and studies of the status of particular stocks.

Routine health effects monitoring measures concentrations of bacterial indicators (e.g., coliforms) along beaches to determine whether to close sections of the coast to body contact sports.

The following sections describe monitoring activities related to the major sources of effluent and habitat change in the bight.

Municipal Discharges

There are 16 municipal wastewater dischargers operating under NPDES permits in the bight (Table 4-1). Of these, only the discharges in Goleta, Orange County, and Encina have received waivers under Section 301(h) of the Clean Water Act, as amended. Encina voluntarily relinquished its waiver in 1988. The largest of the 16 discharges are operated by the city of Los Angeles (Hyperion), the County Sanitation Districts of Los Angeles County (White Point), the County Sanitation Districts of Orange County, and the city of San Diego (Point Loma) (Southern California Coastal Water Research Project [SCCWRP], 1987). (Detailed histories of the regulatory actions and monitoring programs at each of these four large discharges can be found in SCCWRP, 1988.) In general, monitoring evolved from measurements of fecal contamination in the nearshore zone to more comprehensive assessments of environmental conditions over a broader area.

Table 4-1 summarizes the required monitoring programs at each municipal discharge in the bight. The wide variety in monitoring requirements among these discharges reflects differences in the size of each discharge, the levels of contaminants present, and the nature of the nearby marine environment (e.g., presence of kelp beds or other valued resources). In addition, permits were granted at different times, and their requirements reflect improvements in knowledge about the environment and changes in regulatory emphasis. Differences among monitoring programs also stem from the diverse orientations of the four regional water quality control boards that administer NPDES permits in the bight. These are the Central Coast, Los Angeles, Santa Ana, and San Diego regional boards. Boards differ in their staffing, level of experience, and responsiveness to local issues. As described in Chapter 3, the regional boards are relatively autonomous.

The current monitoring programs at two large municipal discharges, along with their historical contexts and existing permit conditions, are described in detail below. This will illustrate how monitoring has developed, as well as the relationship among regulatory requirements, public concerns, monitoring programs, and management decisions based on monitoring data.

County Sanitation Districts of Orange County

The County Sanitation Districts of Orange County (CSDOC) currently provide service to more than 2 million people in 23 of the county's 26 cities (CSDOC, 1987; SCCWRP, 1988). Two treatment plants, one at Fountain Valley and the other at Huntington Beach, process about 255 million gal/day of waste water. About 80 percent of the flow is from residential and commercial users, and 20 percent from industry. The effluent, consisting of about 40 percent primary treated and 60 percent secondary treated waste water, is discharged through an outfall 5 mi from shore in 200 ft of water off Huntington Beach.

The discharge at Orange County was initiated in the 1920s with screened effluent disposed of a short distance into the surf near the mouth of the Santa Ana River. In 1949, bacterial monitoring along the beach within 5 mi of the discharge was instituted at the request of the state health department. In the mid 1950s, expanded treatment facilities and a new outfall that discharged approximately 1 mi offshore were constructed. As a consequence, the monitoring program was expanded in 1960 to include offshore sampling of both the water column and sediments. In the late 1960s, sampling at additional nearshore stations was begun, and bacterial monitoring at shoreline stations was increased to 5 days per week.

In 1971, effluent was diverted from the old outfall 1 mi from shore to a new outfall 5 mi from shore. At this time, the Santa Ana Regional Water Quality Control Board designed a monitoring program to study the effects of the change. Additional parameters and stations were added to the existing monitoring program. The following year, monitoring of fish populations began with the addition of trawl sampling to the program.

The 1974 NPDES permit for the discharge increased the nearshore bacterial monitoring effort and required additional stations and parameters

TABLE 4-1 Monitoring programs of the 16 Municipal Wastewater Dischargers in the Southern California Bight

	Flow MGD	Bacteria	Water Column	Sediments/ Infauna	Epifauna/ Fish	Tissue Analysis	Histopathology	Mussel Cages	Kelp
Goleta (301h)	6.8	*1/week; 7 sta*	8 sta/ month	6 sta; 3 reps(ea); semiannually	2 sta annually	3 composites at 2 sta	no	no	no
Santa Barbara	11	*1/week; 5 sta	4 sta quarterly	8 sta semi-annually every 3rd year	fish, 5 sta semi-annually every 3rd year		no	no	no
Montecito	1.5	No	No	4 sta; odd years					
Summerland	0.15	No receiving water monitoring							
Oxnard	22.6	*1/week; 21 sta	7 sta quarterly	3 reps (ea); 7 sta semi-annually	3 sta semi-annually; 2 reps	2 sta; 3 reps; 1 spp annually	no	no	no
Los Angeles City, Hyperion	400	7sta/day plus 17 11 sta/ week	25 sta/ week	3 reps; 39 sta/ quarterly	6 sta quarterly	6 sta annually; 3 sta semiannually	no	no	no
County Sanitation Districts of Los Angeles County, JWPCP	360	7days/ week; 7 sta; 1/week; 5 sta	118 month	18 sta semiannually; 44 stations every 5 years	8-12 sta semiannually	12 sta quarterly			Diving 8 sta semi-annually
Los Angeles City, Terminal Island	20	1day/week; 3 sta	7 sta/ month	no	no	no	no	no	no

Avalon	0.4	1day/week; 5 sta; 1day/month	5/week	5 rep cores; 5 stations annually	no	no	no	no	no
County Sanitation Districts of Orange County (301h)	255	5days/ week; 17 sta	9/month 17/quarter	3 or 5 reps; 13 sta/quarter + 40 annually	2 rep trawls at 8 sta semiannually	12 sta semi-annually	60 fish per year	yes	no
Aliso (ALMA)	12	2days/ week; 16 sta	7 sta/ month	7 sed/year 5 rep/7 sta/year 1 rep/7 sta/year	no	no	no	no	annual aerial photo
SERRA	13.5	1/month; 31 sta	7 sta month	7 sta annually	no	no	no	no	no
Oceanside	11	1/month; 21 sta	7 sta annually	No additional monitoring if effluent meets standards					
Encina (301h, 85-88)	15	*1/week; 5 sta	11 sta/ month	6 sta annually; 5 reps	no	4 sta semi-annually	2 sta 3 composites annually	no	annual aerial photo
San Elijo	16.7	1/month; 2 sta	7 sta/ month	7 sta/sed 6 months metals & phenols; 7 sta/year biota 3 sta/year	no	no	no	no	qtrly aerial photo
San Diego City, Pt. Loma	180	*2days/week; 8 sta; 20 sta; month	20 sta/ month	18 sta/quarter; infauna-5 reps	no	no	no	no	annual aerial photo

*= sampling is more frequent in summer than in winter.
* sta=stations; reps=repetitions
SOURCE: Collected for the committee by SCCWRP.

in the offshore monitoring program. In particular, metals, phenols, biological oxygen demand (BOD), pesticides, and PCBs were to be measured in offshore sediments. In the late 1970s, this program was amended to reduce sampling for benthic biota to twice yearly instead of quarterly.

In 1978, the districts began operating an activated sludge facility at the first of their two treatment plants, and in 1983 at the second. These facilities improved the quality of the wastewater discharge.

In 1985, the Environmental Protection Agency (EPA) granted the CSDOC a 301(h) variance for a five-year waiver from the complete secondary treatment requirements of the CWA. An expanded monitoring program was required as a condition of the NPDES permit issued jointly by the Santa Ana Regional Water Quality Control Board and EPA Region IX (Table 4-2). EPA will use the monitoring data to assess whether the 301(h) permit should be renewed upon expiration, while the regional board will use them to determine compliance with the 1983 California ocean plan (State Water Resources Control Board, 1983). EPA must conduct a public hearing to consider any major changes to the permit conditions. If there is major opposition to such changes, they may not be allowed. Regional board action is also required for any substantive modification of the permit conditions.

As described above, the NPDES permit contains effluent limitations and water quality objectives. It also contains specific provisions and time tables for meeting the limitations of the permit and submitting various reports. The overall objectives of this 301(h) monitoring program, as specified by EPA (1987) and 40 CFR 125.62, are to:

- determine compliance with NPDES permit terms and conditions;
- document short- and long-term effects of the discharge on receiving waters, sediment, biota, and on beneficial uses of the receiving water; and
- assess the effectiveness of toxics control programs that limit discharge of toxic chemicals to the receiving waters.

To accomplish these objectives, the permit (No. CA0110604) specifies several kinds of monitoring (Table 4-2) and their objectives (Table 4-3).

City of Los Angeles

The city of Los Angeles' Hyperion treatment plant in Playa del Rey, with a design capacity of 420 million gal/day, is the largest sewage treatment plant discharging treated waste water to the bight (SCCWRP, 1988; John Dorsey, Hyperion Treatment Plant, personal communication). Planning is currently under way to double its capacity. The flow averages approximately 75 percent primary treated and 25 percent secondary treated waste water.

Treated wastes are discharged to Santa Monica Bay through an outfall

TABLE 4-2 Summary of the 301(h) Water Quality Monitoring Program Performed by the County Sanitation Districts of Orange County

Program element	Number of stations and frequency	Replicates/ station	Parameters measured
Beach coliforms	17 daily	1	Total coliforms (MPN/100 ml)
Water quality	9 monthly; 17 quarterly	1 each every 3 (or 6) m to bottom	Temperature, salinity, light transmission, total suspended solids, ammonia, coliforms, water color, dissolved oxygen, pH
Trawls (demersal communities)	8 semiannually	2	Fish/epifauna taxonomy, health, length/weight of 30 species
Benthic grabs	13 quarterly; 40 annually	Quarterly—infauna, 3 chemistry; annually—1 infauna, 1 chemistry	Infauna retained on 1 mm screen, grain size, oil, cyanide, sulfide, volatile solids, metals, extractable organics, pesticides, PCBs, volatile organics, total organic carbon
Bioaccumulation			
infauna	6 annually	5 g tissue total	Metals, synthetic organics, pesticides
fish	5 annually	20–60 specimens	Metals, synthetic organics, pesticides
epifauna	5 annually	5–58 specimens	Metals, synthetic organics, pesticides
Fish histopathology	8 semiannually	60 specimens	Liver histopathology, visual for tumors and lesions
Sport fishing survey	4 semiannually	As many as possible	Metals, synthetic organics, pesticides; liver histopathology, visual for tumors and lesions

terminating about 5 mi from shore in about 187 ft of water. Until November 1987, digested sludge and secondary effluent in a ratio of 1 to 3 were discharged through an outfall terminating nearly 7 mi offshore at the head of Santa Monica submarine canyon in about 300 ft of water. Periodically, during unusually high flows or in emergencies, chlorinated secondary effluent may be discharged through an outfall that terminates 1 mi from shore in 50 ft of water.

The city of Los Angeles began discharging raw sewage into Santa Monica Bay at Hyperion in 1894, and constructed a central outfall sewer in 1908. At the time, the area was relatively remote and there was minimal awareness about potential health hazards associated with the discharge of raw sewage. The State Department of Health began receiving complaints about fouled beaches in the vicinity of the discharge by 1912. As a result, an outfall was constructed in 1924 to carry screened effluent 1 mi offshore. However, a break in the outfall pipe 500 ft from shore, a growing urban population, and the need to bypass the screen during storm flows led to

TABLE 4-3 Objectives Specified in the NPDES Permit for the 301(h) Monitoring Program Performed by the County Sanitation Districts of Orange County.

Program element	Objectives
Beach and surf zone	Assess bacteriological conditions in areas used for water contact sports and shellfish harvest. Determine effectiveness of treatment to remove floatables that affect health and aesthetics.
Water column	Determine compliance with water quality objectives. Provide data to support interpretation of biology data.
Trawls (demersal communities)	Assess presence of balanced indigenous populations of demersal fish and benthic invertebrates.
Benthic grabs	Assess presence of balanced indigenous population of benthic invertebrates. Evaluate physical and chemical quality of the sediments.
Bioaccumulation (mussels, infauna, fish, epifauna)	Determine accumulation of toxic pollutants.
Fish histopathology	Assess prevalence of lesions, tumors, and liver abnormalities in local fish.
Sport fishing survey	Monitor uptake of pollutants in fish consumed by humans in order to determine impact on public health. Assess impacts on local fish populations.

repeated recontamination of Santa Monica Bay beaches. This caused the Department of Public Health to close beaches near Hyperion in Santa Monica Bay from 1946 to 1951 due to bacterial and grease contamination.

These continued problems with bacterial and aesthetic contamination led to legal action that resulted in construction of a larger outfall and a secondary treatment system in 1950 (Garber and Wada, 1988). Treated effluent and about 50 percent of the sludge were discharged to the bay, and reduced levels of contamination allowed the beaches to be reopened in 1951.

By 1952, growing public concern about contamination of Santa Monica Bay prompted comprehensive investigations by the Scripps Institution of Oceanography and the University of Southern California's (USC) Allan Hancock Foundation. The studies' objectives were to determine the bay's physical and biological conditions, sources and magnitude of pollution, and optimal design and location for deep-water outfalls. Based on data showing that bacterial contamination never traveled more than 5 mi along the beach in either direction from the outfall, a 5 mi-long effluent outfall was built in 1959. Prior to that, a 7 mi-long outfall had been built in 1957 to carry sludge to the head of Santa Monica Canyon.

Monitoring began coincident with the closure of public beaches in 1946, when routine daily surf and water column monitoring for coliforms was initiated by the Department of Public Health. This program was later incorporated into the monitoring mandated by the Regional Water Quality Control Board, and in 1956 was expanded to include additional water column and shoreline stations throughout the bay. This was the first such marine monitoring program in Southern California.

Hyperion's monitoring program was significantly enlarged in 1974, with the issuance of the plant's NPDES permit by the EPA and the state and regional water quality control boards. This permit required monitoring of infauna, some sediment chemistry, and water column bacteria. In 1980, the city signed a consent decree to cease sludge discharge to the ocean by February 15, 1986 (later extended to December 31, 1987). In 1982, the city of Los Angeles applied for a 301(h) waiver from the requirements to convert to secondary treatment, which EPA initially approved. The Los Angeles Regional Water Quality Control Board did not concur, and a waiver was not issued. However, in 1984 monitoring requirements under the existing NPDES permit were increased with the addition of trawling and replication at several benthic stations both within and outside the ZID of the 5-mi outfall. Hyperion received a new NPDES permit in 1987 that included a greatly expanded and modified monitoring program (Table 4-4).

The overall objectives of the Hyperion monitoring program differ somewhat from those of the Orange County program, partly because Hyperion is not operating under a 301(h) waiver. The overall objectives of this NPDES monitoring program are to:

- determine compliance with NPDES permit terms and conditions; and
- determine that state water quality standards are met (40 CFR 122.41[j] and 12.48[b].

As in Orange County's permit, subsidiary objectives are specified that generally parallel those described in Table 4-3. However, Hyperion's NPDES permit (No. CA0109991) contains one important difference. It incorporates language stating that the monitoring program may be modified based on information generated by the program. This is an important source of flexibility that is discussed in greater depth in Chapter 6. Specifically, the permit states:

> Once an adequate background database is established and predictable relationships among the biological, water quality, and effluent monitoring variables are demonstrated, it may be appropriate to revise the monitoring program. Revisions may be made under the direction of the EPA and the Regional Board at any time during the permit term, and may include a reduction or increase in the

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TABLE 4-4 Monitoring Program for Hyperion (1987)

Monitoring program	Parameters	Frequency
Shoreline water quality (17 stations)	Total and fecal coliforms, enterococcus, temperature, visual observations	Daily
Nearshore water quality (11 stations)	Total and fecal coliforms, enterococcus, temperature, DO, transmissivity profiles, visual observations	Weekly
	Above parameters plus suspended solids, oil and grease	Monthly
Offshore water quality (25 stations)	Profiles for DO, temperature, salinity, pH, visual observations	Weekly
Microlayer (12 stations)	Profiles for transmissivity and transparency; discrete samples for ammonia-nitrogen, suspended solids, TOC, oil and grease	Monthly
Sediment chemistry (39 stations)	Three replicate samples for oil and grease and TOC	3 times per year
(subset of 7 stations)	TOC, H_2S, oil and grease, grain size, 122 priority pollutants (one sample)	Annually
Sediment biology (39 stations)	Three replicate samples for above sediment parameters	Quarterly
(subset of 7 stations)	Macrofaunal community analysis (one sample)	Semiannually
		Quarterly
Demersal fish and macroinvertebrates (trawling) (6 stations)	Five replicates for macrofaunal community analysis	Quarterly
	Duplicate trawls for community analysis	Semiannually
Contaminants in sport fish (rig-fishing) (2 sites)	Three replicates for priority pollutants in tissues of hornyhead turbot and ridgebacked prawn	Semiannually
	Three replicate samples for priority pollutants in muscle of selected sport fish	

DO = dissolved oxygen; TOC = total organic carbon

(Table 4-4)

number of parameters to be monitored, the frequency of monitoring, or the number and size of the samples collected.

In addition to this permit language related to flexibility, the Hyperion program also includes a chemical sampling plan that allows monitoring resources to be used more efficiently. In the first year of the program, the entire list of priority pollutants is sampled in the effluent, the sediments, and selected organisms. In the second and third years, only those pollutants found during the first year are sampled for. Then in the fourth year, the entire list of pollutants is sampled for again. The rationale for this approach was to focus monitoring effort on those pollutants that occur in the effluent and the environment.

Coastal Power Plants

The history of monitoring of heated cooling water discharges from coastal electric power plants is much less involved than that for sewage discharges. Conventional generating stations on the shore of the bight were all completed before 1971. Between 1971 and 1973, thermal effects monitoring programs were required by the regional boards. Temperature profiles were measured in the water column; sediment grain size distribution was measured; and infauna, epifauna, plankton, and nekton communities in the vicinity of the outfalls were investigated. Some power plants continued these studies on their own through 1978, but others monitored only entrainment of fish in the water intakes. At the Encina generating station, a study of effects of thermal discharges on the giant kelp community was initiated in 1975 and continued through 1986.

In 1978, new NPDES permits were issued and annual monitoring programs were begun at most power plants (Table 4-5). As described below (see "The Research Sector"), the Southern California Edison Company (SCE) maintains an extensive program of special studies to develop information to supplement that gained through the monitoring programs.

San Onofre Nuclear Generating Station

The San Onofre Nuclear Generating Station (SONGS), located on the coast south of San Clemente, includes three units: Unit 1 was put in operation in 1968, and Units 2 and 3 came on line in 1985. The three reactors have enormous cooling-water requirements. The once-through seawater cooling system takes in approximately 6,300 m^3/s from nearshore intakes. The diffusers for Units 2 and 3 are unique to the bight. Each is approximately 0.6-mi long. In order to meet California thermal plan (State Water Resources Control Board, 1975) requirements, they were designed to entrain a volume of water 10 times the original discharge flow.

TABLE 4-5 NPDES Monitoring Programs at 10 Coastal Power Plants in the Southern California Bight[a]

Generating station	Max flow (MGD)[b]	Water column	Sediments	Infauna	Epifauna and fish	Kelp
Alamitos	1,270	12 stations	grain size; 5 stations	4 stations; 4 repetitions	7 stations; 2 repetitions	No
Ormond Beach	688	8 stations	7 stations	6 stations; 4 repetitions	6 stations; 2 repetitions	No
Long Beach	772	8 stations	grain size; 6 stations	6 stations; 4 repetitions	3 stations; 2 repetitions	No
Mandalay	255	15 stations	5 stations	5 stations; 4 repetitions	3 stations	No
Scattergood	495	12 stations	grain size; 4 stations	4 stations; 4 repetitions	2 stations; 2 repetitions	No
El Segundo	606	12 stations	No	4 stations	12 stations	No
Redondo Beach	1,140	16 stations	grain size; 7 stations	7 stations	6 stations; 2 repetitions	No

Huntington Beach	519	3 stations	Metals, organics and grain size; 6 stations	3 stations	3 stations; 2 repetitions	No
SONGS	3,268	Temp and transmissivity at 22 stations; DO[c] & pH at 4 stations quarterly. Metals 5 stations and chlorine 8 stations triannually	No	No	Fish, 9 stations bimonthly	Acoustic at 3 stations semi-annually
Encina	860	10 stations	No	No	No	Aerial photo

[a] Water column monitoring focuses primarily on temperature, dissolved oxygen, pH, and transmissivity, and does not include sampling for contaminants. Sampling at all plants except Huntington Beach and San Onofre is done semiannually, that is, once every two years. Huntington Beach is sampled every year during the summer, and San Onofre is sampled as indicated in the table. Also note that Huntington Beach and San Onofre, unlike the other plants, sample different numbers of stations for epifauna and fish.
[b] MGD = millions of gallons per day
[c] DO = dissolved oxygen

SOURCE: From SCCWRP, 1988.

The resultant plume is directed offshore and has been shown to severely influence nearshore circulation patterns in the vicinity of the plant.

Marine monitoring at SONGS has been more intensive than that at other coastal power plants. The programs carried out at SONGS have been unique in the bight in terms of the intensity of monitoring devoted to a single discharge.

Monitoring and special studies have been performed continuously at the site since 1963. In 1964, baseline environmental monitoring was performed prior to operation of Unit 1. These included profiles of temperature and water clarity in the water column; measurements of local ocean currents; and characterization of intertidal, subtidal hard bottom, and kelp communities.

In 1974 and 1976, monitoring determined the environmental effects of sand disposal and dredging for emplacement of the Units 2 and 3 outfalls. In 1976, the San Diego RWQCB issued NPDES permits, including receiving-water monitoring requirements, for all three units. Current NPDES monitoring requirements are summarized in Table 4-5.

Along with these NPDES monitoring requirements, SCE is obligated to carry out further monitoring by other agencies. Impingement of fish in the intakes is monitored for the California Department of Fish and Game. Periodic monitoring of radionuclides is required by the Nuclear Regulatory Commission. Most monitoring occurs within 6 mi of the plant, with reference stations at 30 or 37 mi. Direct radiation is monitored continuously; airborne radiation is monitored weekly; ocean water is monitored monthly; beach sand and bottom sediments are monitored twice a year; and tissues of nonmigratory marine animals are monitored quarterly.

In addition, the California Coastal Commission required Southern California Edison to form the Marine Review Committee. This independent committee was established in 1974 by the California Coastal Zone Conservation Commission (now called the California Coastal Commission) in response to controversy about, and as a condition of, the permit for discharge of cooling water from SONGS Units 2 and 3. The specific responsibility of the committee was to protect marine life and resources from potential or actual damage directly related to the design and operation of the cooling water system of Units 2 and 3. Its studies focused on four areas:

1. determining the effects of SONGS Unit 1 on the marine environment,
2. predicting the effects of Units 2 and 3 on the marine environment and recommending needed design changes in the cooling water system to the California Coastal Commission,

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3. determining the effects of SONGS Units 2 and 3 by performing both pre- and post-operational monitoring programs, and

4. investigating possible mitigation and enhancement measures for any damage encountered.

An important feature of the committee was its authority to make recommendations about operational and design changes to the cooling system, up to and including the construction of cooling towers.

The Marine Review Committee's program was noted for intense and comprehensive investigations, length of time committed to the study, and magnitude of total expenditures. Virtually all aspects of the marine environment near SONGS were investigated, including soft- and hard-substrate benthos, ichthyoplankton and adult fish, kelp beds, phytoplankton, zooplankton, epibenthic plankton, and the physical and chemical oceanography of the coastal zone. Investigations began in 1974, and study designs were, in most cases, firmly established by 1979. The resulting data sets cover eight years, and total expenditures for the program through production of the final report are estimated to be $47 million.

The committee's studies are unique among large monitoring programs in the bight in several important ways. First, the program was several times larger than any other monitoring program in the bight. Second, because the MRC was an independent entity, program designs could be adapted as needed. Third, monitoring plans were deliberately devised to detect predetermined amounts of change. Finally, repetitive, time series monitoring was integrated with modeling and research to constantly improve the ability of the monitoring programs to detect change.

Field work on nearly all projects was completed in December 1986, and final contractor reports were due in December 1987. The final report of the committee was scheduled for submission to the California Coastal Commission in 1989. Coincident with the end of the committee's studies, Southern California Edison began implementing procedures to make the committee's data available to investigators.

Oil Exploration and Production

There are few ongoing monitoring programs in the bight associated with oil exploration and production. This is partly because, except for platforms in the Santa Barbara Channel, the nearshore THUMS project in Long Beach, and the Aminoil project in Huntington Beach, there is no oil production in the nearshore regions of the bight. In addition, there are relatively few refineries along the coast discharging directly into the ocean. Finally, further exploration in the offshore regions of the bight has been delayed pending resolution of conflicts between the state and the federal government over oil and gas development policy for California's outer continental shelf.

EPA Region IX is considering the establishment of a monitoring program in the Santa Barbara Channel where extensive oil production occurs. The program's objectives will be to document production impacts from existing platforms and follow recovery after drilling ends. The THUMS project in Long Beach monitors a range of water column and sediment parameters at six stations. Sampling began before disposal. In the water column, salinity, temperature, pH, and dissolved oxygen are measured continuously, while heavy metals, oil and grease, suspended solids, cyanides, and organohalogens will be monitored quarterly during the first two years of the program. In the sediments, a range of parameters—including barium, EPA priority pollutants, grain size, petroleum hydrocarbons, and BOD—will be monitored semiannually. The Aminoil project in Huntington Beach measures grain size, barium, and heavy metals, and collects five replicate cores for infauna analysis at six sediment sites annually.

In Carpinteria, in the northern region of the bight, Chevron monitors water column, sediment, infauna, and epifauna parameters annually at four stations in the vicinity of the discharge from its wastewater treatment plant. The plant discharges 0.6 million gal/day of treated oil process waste. Water column variables measured include temperature, transmissivity, dissolved oxygen, pH, and ammonia. Sediment variables measured include sulfides, grain size, heavy metals, BOD, total organic carbon, total nitrogen, nitrate, oil and grease, and aromatic hydrocarbons. Infauna samples are identified to species, biomass is measured, and large epifaunal algae are identified.

Chevron also operates a refinery at El Segundo, in Santa Monica Bay. Organic matter is measured annually at two offshore sediment stations. In the water column, temperature, oil and grease, dissolved oxygen, and pH are measured monthly at four shore stations and two offshore stations.

Ocean Dumping and Dredge Disposal

There are no long-term ocean dumping monitoring programs for offshore sites in Southern California. Ocean dumping in the bight is currently limited to dredge material disposal. Two of the three active dredge dumpsites (LA2 and LA5) have only been sampled as part of the EIS/EIR process to designate them as permanent disposal sites. The first environmental survey of the third site (LA3) is currently in progress. The designation of LA2 and LA5 dump sites expired at the end of 1988, leaving only LA3 available to receive material from new projects. Routine ocean monitoring at the dump sites is under consideration by both EPA and the U.S. Army Corps of Engineers.

Dredge permit applications do not require monitoring at the dumpsite.

They do require chemical, bioaccumulation, and bioassay testing at the dredging site, in order to determine the suitability of the material for ocean disposal.

Nonpoint Sources

Nonpoint sources of contaminants are those that are diffuse or poorly defined. They include rainout or fallout from the air, surface runoff from land, and multiple small inputs, such as those from individual houses, businesses, and farms. Monitoring nonpoint source contamination is difficult precisely because it is so diffuse. It is technically challenging both to monitor such contaminant input and to clearly identify sources of elevated levels found in the environment.

Nonpoint sources are attracting greater attention from both regulatory agencies and the public, with most of this attention devoted to storm drains and riverine input. As a result of a steady decrease in the mass emissions from coastal wastewater treatment plants, mass emissions of some chemicals from stormwater runoff now approach those in effluents from coastal wastewater treatment plants (Table 4-6). As described in Chapter 1, precipitation in Southern California is highly seasonal. As a result, during dry periods a significant percentage of riverine flow can be composed of secondary and tertiary treated municipal wastewater from inland sewage treatment plants. Such inland treatment plants discharging to the Los Angeles or San Gabriel rivers may have flows in the range of 20 to 100 million gal/day.

As Garber (1987) points out, stormwater and riverine drainage enters the nearshore zone directly, while treated municipal wastewater is discharged 2 to 7 miles offshore, usually in deep water (about 100 ft). Potential impacts on recreational beaches may therefore be greater from land runoff than from offshore discharge of treated waste water.

In spite of these potential impacts, there is presently no mandated responsibility for monitoring land runoff. Individual county agencies responsible for stormwater systems may voluntarily perform such monitoring. For example, in Los Angeles County the County Department of Public Works monitors drainage facilities, and in Orange County such monitoring is performed by the County Environmental Management Agency. The only existing statutory basis for managing storm drainage systems is the NPDES permit program. However, agencies with overall management responsibility for stormwater drainage systems (e.g., Department of Public Works) are not now required to administer NPDES permits granted by other agencies for the multitude of individual discharges to the drainage system. There is thus no clear responsibility to monitor the drainage system itself or its discharges to the ocean.

TABLE 4-6 Estimated Average Emissions in Metric Tons Per Year of Several Constituents from the Los Angeles River and from the Two Largest Municipal Sewage Treatment Plants Discharging to the Southern California Bight

Constituent	Los Angeles River			JWPCP[a]	Hyperion[b]
	1971/1972	1979/1980	1984/1985		
Total extractable organics	---	6,400	28,600	7,860	13,200
Total aliphatics	---	---	270	---	---
Naphthalenes	---	---	0.29	---	---
Polynuclear aromatics	---	---	2.4	---	---
Total DDT	0.27	0.10	0.02	0.22	0.02
Total PCBs	0.75	0.09	0.01	0.21	< 0.12
Silver	< 1.0	< 1.0	< 1.0	4.5	12
Cadmium	3.7	1.2	< 1.0	3.8	8.2
Chromium	24	30	11	53	64
Copper	38	25	15	43	131
Iron	5,060	14,700	4,050	---	---
Manganese	137	188	78	---	---
Nickel	22	18	5.5	53	49
Lead	273	45	32	24	41
Zinc	153	139	81	131	151

[a]Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County, Palos Verdes, California.
[b]Hyperion Wastewater Treatment Plant, City of Los Angeles, Playa del Rey, California.

SOURCE: SCCWRP, 1986c.

Currently, nearly all NPDES-permitted discharges to drainage systems in the bight have strict effluent limitations and dischargers are required to do effluent monitoring. For example, all municipal wastewater treatment plants discharging to the river/stormwater system in Southern California measure priority pollutants in effluent semiannually and volatile organics quarterly. The 1987 amendments to the Clean Water Act require more monitoring of stormwater discharges.

The Los Angeles County monitoring program provides an example of the type of voluntary monitoring performed by agencies managing stormwater drainage systems in Southern California. Los Angeles County encompasses a drainage area of 4,100 mi^2 with a population in excess of eight million. Drainage of the area, primarily into the Southern California Bight, is provided by several rivers (such as the Los Angeles and San Gabriel rivers) and an extensive system of underground drains and open channels. The main flows to this system are from:

- precipitation;
- NPDES-permitted discharges of treated industrial and municipal wastewater;
- fire-fighting waste water (often containing high concentrations of contaminants);
- nuisance water (e.g., wash-down, excess lawn watering, etc.);
- accidental sewer overflows; and
- daily, weekly, and other periodic plant and site cleanup and wash down from business, commercial, and residential sources.

The Los Angeles County Flood Control District (since renamed the Los Angeles County Department of Public Works) began monitoring the drainage system in the 1930s because some of the runoff was used for groundwater recharge. In the mid 1960s, the water quality program was expanded to consider ocean disposal of stormwater runoff. The monitoring program was greatly reduced between 1984 and 1987, but much of it was reinstituted in 1988.

Water samples are collected during two to four storms per year from 20 stations along rivers, creeks, and drains. They are analyzed for inorganic minerals and pH, bacteria (total and fecal coliforms and enterococcus), total petroleum hydrocarbons, 12 heavy metals, total organic carbon, BOD, 8 volatile organic compounds, 15 pesticides, total suspended solids, and volatile suspended solids. Samples from the Rio Hondo Channel and San Gabriel River are also analyzed for priority pollutants.

Samples of dry weather (non-storm) flows are collected from 27 stations every month. These samples are analyzed for minerals, bacteria, total petroleum hydrocarbons, heavy metals, and oil and grease. Total organic carbon, BOD, and volatile organic compounds are analyzed quarterly or semiannually.

Shoreline Erosion and Beach Replenishment

The U.S. Army Corps of Engineers (COE) and the California Department of Boats and Waterways carry out the Coast of California Storm and Tidal Wave Program. This is intended to be a long-term program to develop baseline information on changes in beach profiles and ocean conditions along the California coast. The data will be used to monitor beach erosion and to assist in planning beach replenishment activities.

Approximately 60 sites between Oceanside and the U.S.-Mexican border were monitored semiannually between 1983 and 1988. Profiling efforts are expected to move to Orange and Los Angeles counties for the next five years. Semiannual monitoring of beach profiles in association with a sand bypass project at Oceanside Harbor has occurred since 1985 and may continue in the future.

A related program is carried out by the Ocean Engineering Research Group at the Scripps Institution of Oceanography, which monitors wave climatology at ten nearshore and offshore sites in Southern California. This project has collected over 10 years' worth of data for use by mariners and in coastal physical and oceanographic studies. The project is funded by the U.S. Army COE and the state of California.

Resource Monitoring

Resource monitoring is the responsibility of the California Department of Fish and Game, which collects information on sport and commercial fish catches and on exploitation of kelp beds in the bight. The present system of collecting catch information is straightforward and is described below, however the history of fisheries monitoring in California is long and complex. It is intimately associated with the California Cooperative Oceanic Fisheries Investigation (CalCOFI) program, which is unique for the spatial extent and consistency through time of its investigations into oceanography and fisheries biology. This history is summarized below and recounted in more detail in SCCWRP (1988).

Current Resource Monitoring

Commercial fishermen are required to report catch statistics to the Department of Fish and Game. Both fin and shellfish (e.g., abalone, sea urchins, lobsters) are included in these reporting requirements. Finfish catches have been monitored since 1918, and statistics currently include species caught and the location and weight of the catch. Daily logs of sea urchin and lobster catch numbers and locations have been reported for at least the last 10 years.

Commercial party-boat operators in the sport fishery are required to keep a log of the number and species of fish caught, number of anglers fishing, hours fished, and area fished. These records have been kept continuously by the Department of Fish and Game since 1935, with the exception of the five years during World War II (Young, 1969; Clark, 1982).

In 1975, the department initiated the Southern California Independent Sport Fishing Survey to monitor catches by recreational anglers. In 1979, the department, in collaboration with the National Marine Fisheries Service (NMFS), began a statewide program to monitor recreational catches. The objectives of these programs were to determine the magnitude and composition of the catch, to estimate effort expended by anglers and divers from private boats, and to assess the degree of compliance with state fishing laws (Wine, 1979).

Monitoring of artificial reefs began off Southern California in the late

1950s, in order to test the effectiveness of artificial reefs in increasing the availability of marine organisms and improving fishing. This program ended in 1964 and no formal studies were undertaken for 15 years, although reef building continued. In 1979, the Department of Fish and Game, in conjunction with Southern California Edison, began a six-year monitoring study of the development of marine life on the Pendelton Artificial Reef near the San Onofre Nuclear Generating Station. The objective was to develop a method of mitigating potential losses of kelp beds due to power plant operations. The success of this study resulted in an expanded program by the department to build and monitor artificial reefs throughout the Southern California Bight (Grant, 1987). This monitoring program is designed to identify the effects of important variables such as depth and reef topography on the biological communities that colonize reefs.

Historical Monitoring and the CalCOFI Program

Monitoring of marine fish and shellfish resources in the Southern California Bight has continued for more than 70 years. This monitoring has almost from the beginning been closely associated with research programs on fisheries. For this reason, the CalCOFI program is described here rather than in the research section below. In 1914, the California Department of Commercial Fisheries was established to collect fisheries statistics, develop improved methods for catching and processing fish, and study the life histories of commercially important fish and shellfish (Hewitt, 1988). Beginning in 1918, the Department of Commercial Fisheries collected catch data from commercial fishermen and fish dealers on species composition, weight, gear type, location, and intended commercial use. Much research was also performed during the 1920s and 1930s on fishery stock size, year class abundance, and fish distribution along the Pacific coast.

After World War II, state fishery agencies in California, Oregon, and Washington formed the Pacific Marine Fisheries Commission, and were later joined by fishery agencies in British Columbia. The commission's original focus was to study the Pacific sardine fishery, but when the fishery collapsed in 1947, it turned its attention to salmon, albacore, bottomfish, Dungeness crab, and shrimp (Croker, 1982).

After the sardine fishery collapsed, the California State legislature established the Marine Research Committee, composed of members from the commercial fishing industry and the California Department of Fish and Game. The committee set up a Fish and Game Preservation Fund to support research to improve the commercial marine fisheries of California and develop new commercial marine products.

In 1948, the committee established the California Cooperative Sardine Research Program. Its purpose was to study the distribution and natural history of sardines, their availability to the commercial fishery, fishing methods, and the physical, chemical, and biological oceanographic processes influencing sardine populations off California. The program included members from the California Department of Fish and Game, the Federal Bureau of Commercial Fisheries, Hopkins Marine Station, the California Academy of Sciences, and Scripps Institution of Oceanography. In 1953, the program was renamed the California Cooperative Oceanic Fisheries Investigation (CalCOFI) and was expanded to include consideration of species other than sardines. By 1960, CalCOFI's objectives had evolved to understanding factors governing abundance, distribution, and variations of pelagic marine fishes, emphasizing the oceanographic and biological factors affecting sardines and other marine life in the California Current system (Baxter, 1982).

The Fisheries Conservation and Management Act of 1976 (FCMA) gave the federal government management authority over commercial fisheries in the exclusive economic zone (the EEZ, 3 to 200 mi from shore), superseding the management role of the Marine Research Committee. The FCMA established regional fisheries management councils to develop plans for regulating harvesting of commercially valuable fish stocks and for controlling access of foreign fishing or processing vessels to U.S. territorial waters.

However, the NMFS, the California Department of Fish and Game, and Scripps decided in 1979 to continue CalCOFI as a long-term marine resources monitoring and research program (Radovich, 1982). The scope of and funding for the program have been greatly reduced in recent years (Figure 4-1). Fisheries and oceanographic data continue to be entered into the CalCOFI online data system at the Southwest Fisheries Center in La Jolla. This system contains a large-scale, multivariate time series of physical, chemical, biological, and meteorological data from approximately 40,000 stations and 300 cruises in the eastern North Pacific Ocean, collected since 1949.

Cooperation with scientists from Mexican institutions remains an important part of the CalCOFI program. This includes joint scientific symposia and cooperative studies of anchovy abundance and sardine spawning stocks. In addition, Mexico's fishery agency, the Secretatiat de Pesca, has expressed interest in funding a reestablishment of the CalCOFI time series transects in Mexican waters that were discontinued several years ago.

Kelp Bed Monitoring

Kelp beds along the California coast represent both a recreational and a commercial resource. Because of kelp's unique characteristics, separate programs have been instituted to monitor this resource. The California

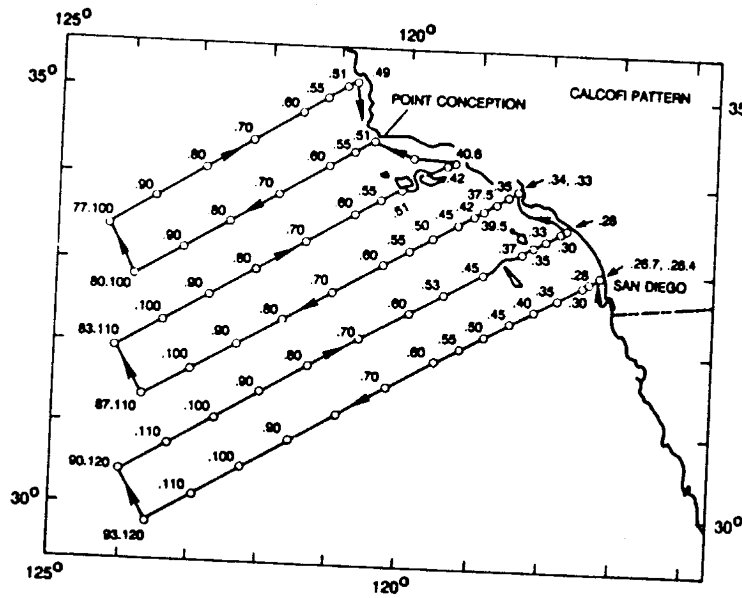

FIGURE 4-1 Location of the 1987 field survey stations sampled by CalCOFI during quarterly cruises. Station numbers and a typical cruise track are also shown.

Department of Fish and Game has conducted quarterly aerial surveys of kelp beds in Los Angeles County since 1974. Since 1987, these overflights have been extended south to San Onofre, near San Clemente. The goal of this program is to document fluctuations in bed size, and short-term studies have been conducted at the offshore islands and north of Los Angeles on special occasions.

In addition to these aerial surveys, diving surveys have been carried out since 1977 at five sites around the Palos Verdes Peninsula as part of the Nearshore Sportfish Habitat Evaluation Program. The goal is to increase understanding of kelp bed ecology.

In San Diego County aerial surveys have been carried out quarterly since 1967 by Dr. Wheeler North of the California Institute of Technology in Pasadena. These data are used by the six municipal dischargers in the county to fulfill NPDES monitoring requirements.

The Kelco Co. of San Diego compiles kelp harvest data by month and by kelp bed. However, only total annual values are available to the public due to lease agreements between Kelco and the state.

Noncommercial Resources

Another type of resource monitoring is mandated by Title III of the Marine Protection, Research and Sanctuaries Act (MPRSA) in the Channel Islands National Park. At the national park, long-term, time series monitoring is used to assess and maintain the ecological conditions (National Park Service, 1984). The main focus of the monitoring, much of it done with volunteers, is to determine the population dynamics and long-term environmental trends for key species of marine plants and animals in the park.

The National Estuarine Reserve Research Program of the Coastal Zone Management Act (CZMA) mandates research and monitoring programs in designated estuaries. In fiscal year 1988, the National Oceanic and Atmospheric Administration (NOAA) initiated a competitive grants program for studies in the 17 designated national estuarine reserves. The Tijuana River estuary is the only national estuarine reserve in the Southern California Bight area. Research and monitoring will be focused in five areas:

1. water management—the relationship between freshwater inflow and estuarine productivity;
2. sediment management—the effects of different types of sediments and sedimentation processes on estuaries;
3. nutrients and other chemical inputs—effects of anthropogenic inputs on estuaries;
4. coupling of primary and secondary productivity—nature of estuarine food webs and energy flows; and
5. estuarine fishery habitat requirements—values of estuaries as nursery areas for commercial and recreational species.

In the case of the Tijuana River estuary, these data will be extremely useful in influencing the design of sewage management strategies for Tijuana, Mexico (see "The U.S.-Mexican Sewage Contamination Problem," Chapter 2).

Water Quality Monitoring for Public Health

The California Health and Safety Code specifies that the State Department of Health Services is responsible for supervising sanitation, healthfulness, and safety of public beaches and public water contact areas of the state's bays and ocean waters. The State Department of Health Services may delegate some monitoring and enforcement activities to the county health services departments. When a public beach or water contact sports area fails to meet standards, the local health officer or the State Department of Health Services, after considering the causes of the failure, may post the area with warning signs or otherwise restrict use of the area until corrective action has been taken and the two following standards are met:

1. physical–no sewage sludge, grease, or other physical evidence of sewage discharge shall be visible at any time on any public beaches or contact sports areas; and
2. bacteriological–samples of water at a public beach or water contact sports area shall have a most probable number (MPN) of coliform bacteria less than 1,000 per 10 ml, provided that no more than 20 percent of the samples at any station in a 30-day period exceed 1,000 per 10 ml, and provided further that no single sample, when verified by a repeated sample taken within 48 hours, shall exceed 10,000 per 10 ml.

The monitoring programs performed by county health agencies in support of these management activities are of two types: (1) routine bacteriological sampling, and (2) bacteriological sampling following a waste discharge into recreational waters. Special studies are also carried out by county health agencies. However, there are no health monitoring programs targeted specifically at human health effects (e.g., gastroenteritis) related directly to water-contact sports.

Orange County has performed a monitoring program in recreational waters for several years. Los Angeles County is now monitoring routinely. In San Diego County, monitoring is performed along the shore at four sewage treatment plant ocean outfall sites: city of Oceanside, Encina Water Pollution Control Facility, San Elijo Water Pollution Control Facility, and city of San Diego. The outfall from the Point Loma Plant was constructed before kelp beds were included as water contact sports areas and the treatment plant is experiencing difficulty meeting bacterial standards at the outer perimeter of the kelp beds.

For over 30 years, the San Diego County Department of Health Services has performed beach and bay surveys annually. About 60 stations are usually sampled on these surveys. From three to five samples are collected at each station in April and May of each year. In addition, surveys of 40 stations, with a single sample from each station, are performed in early July and September. Many of these stations are interspersed with the shoreline stations sampled by the dischargers.

A routine weekly survey of water quality in Mission Bay was started in 1977 and continued through January 1987. The city of San Diego has replaced it with a more intensive monitoring program with more stations sampled more frequently. This monitoring program was initiated voluntarily by the city because of strong public concern about poor water quality. The data collected in all these monitoring activities is shared with the State Department of Health Services, regional water quality control boards, and other state and federal agencies concerned about recreational water quality.

National and Statewide Monitoring Programs

NOAA's National Mussel Watch Program and National Status and Trends Program represent national monitoring programs that have included sampling and measurement stations within the Southern California Bight. While the numbers of stations are too few to present a comprehensive picture of contaminant levels in the bight, they do provide a basis for making comparisons with contaminant levels in other parts of the country.

The original National Mussel Watch Program, developed by Dr. Edward Goldberg of Scripps and 10 other principal investigators, was first funded by EPA in 1976. Mussels and oysters were sampled at approximately 78 coastal and estuarine stations along the Atlantic, Gulf, and Pacific coasts of the United States in 1976, and again in 1977/1978. There were eight stations in the Southern California Bight. Mussel tissues were analyzed for six metals, three radionuclides, DDT (and its breakdown products), PCBs, and petroleum hydrocarbons (Goldberg et al., 1978a). Total funding for the program was about $400,000 per year. The national program was not continued past 1978, but several local programs were continued.

In 1984, NOAA's Ocean Assessments Division initiated the National Status and Trends Program that includes a National Benthic Surveillance Project and a Mussel Watch Project (NOAA, 1987). In the Benthic Surveillance Project, sediments and demersal fish have been collected annually since 1984 from 50 sites along the U.S. coast, including Alaska. In the Mussel Watch Project, mussel and oyster samples have been collected once each year since 1986 from 150 sites along the U.S. coast, including Alaska and Hawaii. Sediments are also collected at many of the Mussel Watch stations. There are 6 Benthic Surveillance stations and 16 Mussel Watch stations in the Southern California Bight (Figure 4-2). An extensive suite of metals (17), polynuclear aromatic hydrocarbons (18), pesticides (15), and PCBs is analyzed in the animal tissues and sediment samples. In addition, the fish are examined for diseases and histopathological lesions.

The overall objective of the National Status and Trends Program is to assess and document the status of coastal and estuarine environments. Specifically, the program is intended to define the geographic distribution of contaminant concentrations in biological tissues and in sediments from U.S. coastal and estuarine waters, determine temporal changes in those concentrations, and document biological responses to contamination (e.g., Malins et al., 1986). This information will be used to make decisions about the use and allocation of resources in the nation's coastal and estuarine regions.

Since 1976, the California Department of Fish and Game, under an interagency agreement with the California State Water Resources Control Board, has performed a Mussel Watch Program for monitoring marine and

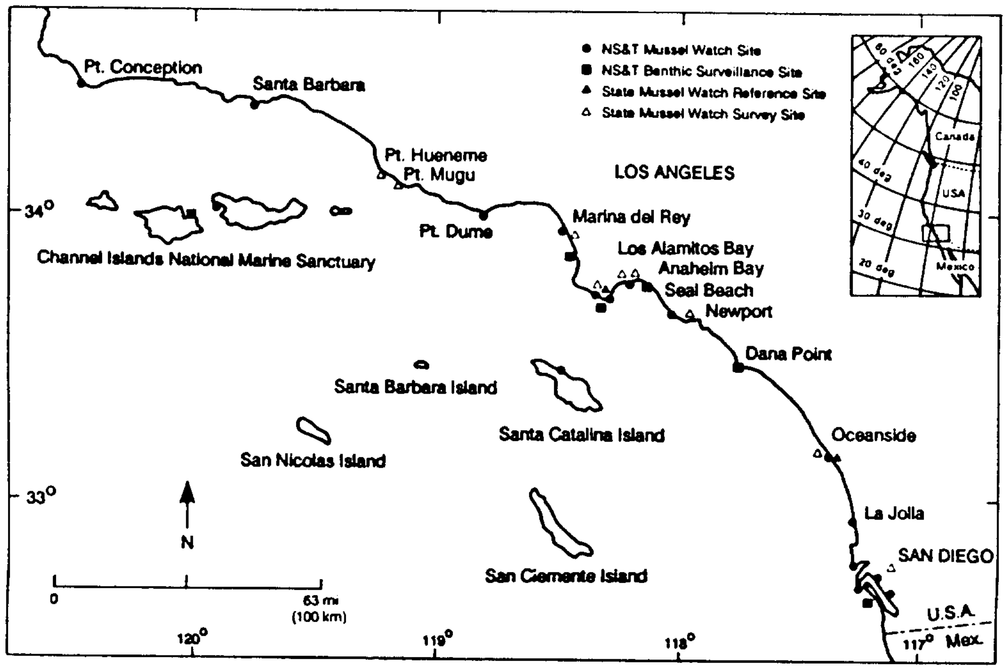

FIGURE 4-2 Locations of the NOAA National Status and Trends' Mussel Watch, and benthic surveillance sampling stations and the California Mussel Watch reference and survey sampling sites in the Southern California Bight. All California Mussel Watch Survey sites include several mussel sampling or transplant stations.

estuarine waters (Stephenson et al., 1987). Its purpose is to provide the state board and six coastal regional boards with an ongoing assessment of the geographic and temporal trends in levels of chemical contamination in coastal waters. The state's Mussel Watch Program is somewhat different than the national program in that it includes only five reference stations and several site-specific "hot spot" survey sites.

The latter may change from year to year. Resident mussels are used at the reference sites, but transplanted mussels or the Asiatic clam, *Corbicula fluminea*, are used at most site-specific stations. The two reference stations in the Southern California Bight are at Palos Verdes (Royal Palms State Park) and Oceanside. They are also National Mussel Watch sampling sites, providing an opportunity for intercalibration of results from the two programs. In 1986-1987, 11 site-specific surveys were performed in the Southern California Bight (Figure 4-2). These studies were performed at one or more locations inside harbors, marinas, or enclosed bays. All but two of the site-specific surveys were designed to collect baseline estuarine data. The survey in Los Angeles/Long Beach harbors was to document the levels of DDT, PCBs, and metals; the survey in San Diego Bay was intended to assess the level of contamination of PCBs, silver, copper, and zinc.

Citizen and Community Monitoring

Interest in the bight and its resources by community and environmental groups has extended to voluntary participation in monitoring and research programs. Three examples of these efforts have provided useful information.

Over 200 organizations and their personnel, mostly volunteers, monitor marine mammal strandings along the California coast as part of the Marine Mammal Stranding Network. The data generated by the Network are collected and managed by NOAA's Southwest Fisheries Center in La Jolla. Notification of strandings has been useful to scientists studying chemical contamination, diseases, and population trends of marine mammals (Seagars et al., 1986).

Volunteer reporting of physical evidence of sewage entering recreational waters has provided local health departments with timely information needed to determine whether to close recreational beaches and swimming areas.

Finally, annual volunteer beach cleanups coordinated by the California Coastal Commission have resulted in estimates of the type and quantity of plastic debris littering beaches. Such information has proven useful enough that the Center for Marine Education in Washington, D. C. plans to develop a uniform data reporting system for beach cleanups nationwide. These data will help in monitoring the magnitude of the plastic debris problem, as well as the effectiveness of source control and recycling programs. These efforts are supported officially, since Section 2204 of the 1987 Marine Plastic Pollution Research and Control Act directs the Secretary of Commerce, in cooperation with EPA, to encourage the formation of volunteer groups, to be designated as "Citizen Pollution Patrols," to assist in monitoring, reporting, cleanup, and prevention of ocean and shoreline pollution (1987 Marine Plastic Pollution Research and Control Act included as Title II in the U.S. Japan Fishery Agreement Approval Act of 1987).

Monitoring Expenditures

Marine monitoring programs are expensive, primarily due to staffing needs. Trained scientists and technicians are required to conduct field sampling, perform laboratory analyses, interpret resulting data, and write reports. Many activities involved in monitoring, such as benthic infaunal analysis and analytical chemistry, are labor-intensive. Tetra Tech (1984) estimated the costs to perform representative monitoring activities to be:

- $200 to $1,200 for a single benthic infaunal analysis, and
- $920 to $2,300 for a single priority pollutant scan of sediments.

These estimates are low compared to current rates, but they do show that monitoring is not cheap. In the Orange County 301(h) monitoring program, 300 benthic infaunal samples and 196 sediment chemistry samples are analyzed each year. Assuming that each benthic sample costs $600 and each chemistry sample costs $1,500 to analyze, the total cost per year to analyze these samples alone is $474,000.

Equipment and facilities that must be purchased are also costly. A good gas chromatograph, needed to measure PCBs, DDT, and other organic contaminants, may cost $10,000 to $50,000. An atomic absorption spectrophotometer, used to analyze metals, will have a similar cost. Research vessels equipped for accurate navigation and for collecting diverse sample types may cost $2,000 to $5,000 per day for an offshore vessel and $500 to $1,000 per day for a smaller vessel suitable for sampling close to shore.

Table 4-7 summarizes estimated costs incurred during the last five years in different types of monitoring in the Southern California Bight. This summary is incomplete, since it does not include several voluntary (nonmandated) monitoring programs and research efforts performed by different dischargers, environmental agencies, or universities. In addition, the costs of effluent monitoring activities are probably under-recorded, since they often are not consolidated with receiving water monitoring budgets.

Facilities and overhead costs for those aspects of monitoring performed

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TABLE 4-7 Estimated Costs for Monitoring Programs in the Southern California Bight

Program/location	Costs in thousands of dollars				
	1983	1984	1985	1986	1987
Waste treatment plants					
Point Loma	496	766	1,129	1,935	1,332
CSD Orange County	270	269	1,206	1,894	1,954
CSD Los Angeles County					
--required	350	373	351	434	750
--voluntary	450	503	479	522	350
Los Angeles City Hyperion	530	583	767	809	890
Aliso, South Laguna Beach	—*	43	44	33	34
Oxnard	—	—	103	214	277
SERRA, Dana Point	—	31	24	27	31
San Elijo	—	—	—	—	32
Encina	5	5	8	135	134
Goleta	14	17	47	170	270
El Estero	—	—	—	—	50
Electricity generating plants					
San Onofre nuclear plant, Southern California Edison, required and voluntary	1,100	1,100	1,100	1,100	1,100
San Onofre, Marine Review Committee	6,000	6,000	6,000	6,000	6,000
Southern California Edison, 7 generating stations					
--full program	540	540	540	540	540
--fish and bioassay	200	200	200	200	200
Scattergood Generating Station	—	—	12.5	12.5	—
Encina, San Diego Gas and Electric	—	—	—	—	25
Thermal outfalls	—	—	—	—	200
Redondo Harbor	—	—	—	—	20
Industrial discharges					
THUMS	—	—	—	—	—
Natural resources					
Channel Islands	—	—	—	—	45
CalCOFI (based on 60 days at sea, $9,000/ day ship time)	—	—	—	—	540
State mussel watch	325	328	331	334	340

TABLE 4-7 Continued

Program/location	Costs in thousands of dollars				
	1983	1984	1985	1986	1987
California Fish and Game					
Pendleton reef	—	—	—	—	280
1900s	—	—	—	—	530
pelagic fish	—	—	—	—	175
party boat survey	—	—	—	—	55
sportfish management	—	—	—	—	360
fishery assessment	—	—	—	—	800
Pacific Marine Fisheries committee recreational fishery statistics	—	—	—	—	250
Public health					
Long Beach	—	—	—	—	80
Orange County	—	—	—	—	150
San Diego	—	—	—	—	80
Total					17,874

*— data not available.

SOURCE: SCCWRP, 1988.

in-house by municipal wastewater treatment plants and industrial dischargers usually are not reported. While an accurate accounting of overhead costs is not available, these have been estimated to be equivalent to the direct costs, effectively doubling the total. Expenses incurred by county public works departments in monitoring chemicals in stormwater runoff are also not included in Table 4-7. Costs for the NOAA Status and Trends (Mussel Watch) monitoring of mussels, sediments, and fish in the bight are not included. (The estimated cost for sampling all stations in the bight and analyzing the samples is $175,000 per year.) Despite these omissions, the costs summarized in Table 4-7 do give a rough impression of the minimum level of expenses incurred in monitoring water quality, natural resources, and public health.

Table 4-7 reveals some important facts. Total estimated costs in 1987 for all monitoring in the bight are over $17 million. Because of the large budget of the Marine Review Committee's study of SONGS (ending in 1989), monitoring costs for the electric utilities are higher in this year than for the municipal wastewater treatment plants. Among the treatment plants, the most expensive monitoring program, at nearly $2 million per year, is the 301(h) monitoring program being performed by the County Sanitation Districts of Orange County. Total natural resource assessments cost about $3.3 million per year, while public health monitoring by the separate counties costs about $310,000 per year.

Of the total annual monitoring expenses of over $17 million in the Southern California Bight, nearly 80 percent are borne by the public sector. Much of the remainder is spent by the California Department of Fish and Game for marine resource monitoring.

Summary of Monitoring Activities

The review of monitoring activities in the Southern California Bight highlighted several important features that will be treated in more detail in the analysis of monitoring (Chapter 6). For the most part, monitoring is performed in response to permit requirements that regulate discharge activities. There are many agencies, federal, state, and local, involved in establishing standards and regulations under which these permits are administered. Despite the many agencies and programs, there is no overall coordination of monitoring in the bight. There is, however, cooperation among agencies that jointly regulate specific discharges such as the Hyperion outfall.

Individual monitoring programs are carefully carried out using state-of-the-art methods, and the quality of the resulting data is typically very high. Finally, Table 4-7 reveals that, with the exception of the recently ended Marine Review Committee program at San Onofre, the bulk of monitoring funds are devoted to measuring the effects of municipal wastewater discharge.

THE RESEARCH SECTOR

A great deal of research is performed in the bight by federal, state, and local agencies, and by universities and private industry. Some of this research is oriented specifically toward environmental problems (such as the effects of municipal wastewater outfalls) that are also addressed by monitoring programs. Other research is oriented toward more general issues in oceanography and marine ecology.

Research results can benefit monitoring programs by:

- increasing understanding of the marine environment and thereby enhancing the ability to predict, measure, and assess human impacts;
- identifying physical, chemical, or biological changes that are better indicators of pollution impacts than the parameters currently used in monitoring programs;
- providing information on the character and variability of natural processes in the marine environment that can be used as references against which to compare changes due to human activity;

• establishing a link or correlation between a parameter measured in a monitoring program and an adverse outcome of concern to society (e.g., link between fecal coliforms and disease);

• determining whether measurements made in monitoring programs provide meaningful assessments of the health of the marine environment and the nature of human impacts on it; and

• developing new techniques and instrumentation for use in monitoring programs.

The research sector is even more diverse than the monitoring sector, with a wide variety of programs that span the range from large-scale studies carried out by multidisciplinary research groups to narrowly focused studies performed by individual scientists. The following sections describe representative research activities sponsored by federal, state, and local agencies, universities, and private industry. This is not meant to be an exhaustive listing of programs and certainly does not come close to describing all the research carried out in the bight.

Federal Agencies

Marine research in the bight is sponsored by the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), the Minerals Management Service (MMS), the Department of Energy (DOE), and the Fish and Wildlife Service (FWS).

The NSF funds individual investigators as well as research programs and institutes at universities throughout the bight. This research is described more completely in the section below on university research.

NOAA funds several important programs in the bight. The National Status and Trends Program was described above as part of the monitoring sector. In addition, NOAA funds the National Marine Fisheries Service (NMFS) and the Sea Grant College Program.

NMFS performs studies of the biology of commercially important fish species and of the relationships between stocks of these species and the physical and chemical oceanography of the bight. Such studies include investigations of habitat requirements, reproduction, feeding biology, population dynamics, geographic distribution, and response to contaminants. NMFS is also an active participant in the CalCOFI program, which combines monitoring and research focused on commercial fisheries (see Historical Monitoring and the CalCOFI Program above). Because of its long history, archived samples from the CalCOFI program have proven valuable in studies of trends of contaminants such as DDT.

NOAA also funds the Sea Grant College Program, which is administered through the University of California. The federal Sea Grant legislation requires that at least one-third of the total federal funds received by each program be matched with local (nonfederal) funds. Since 1973, the state of California has made successive five-year commitments to provide up to two-thirds of the required matching funds (University of California, 1989). Sea Grant studies have addressed a wide variety of coastal problems, including, at present, the functioning of wetlands, physical processes in the coastal zone, aquaculture, marine products chemistry, and ocean engineering.

The U.S. EPA funds research targeted at specific environmental problems. This research is not extensive compared to that carried out by other agencies, since EPA's regional activities are predominantly enforcement related. As an example of such targeted research, EPA supported a study in 1980 to investigate fish catch and consumption among population subgroups in the Los Angeles area. The study was designed to furnish information useful in formulating local regulatory approaches, and was motivated by awareness that certain parts of the local population consume larger than average amounts of locally caught seafood containing elevated concentrations of DDT and PCBs (Puffer et al., 1982, 1983; Puffer and Gossett, 1983; Gossett et al., 1983). In addition, research carried out at the various EPA research laboratories is often relevant to environmental issues in the Southern California Bight.

The Pacific Outer Continental Shelf Region of the MMS funds an Environmental Studies Program (established in 1973) designed to provide basic information needed to make management decisions about the outer continental shelf (F. Piltz, personal communication; Piltz, 1990; MMS, 1990). Although most of this region lies outside the boundary of the bight, some portions of these studies are carried out inside it. Southern California region studies have investigated air quality, potential toxicity of oil to seabirds and marine mammals, adaptation of marine organisms to chronic exposure to petroleum hydrocarbons, and the effects of geophysical acoustic survey operations on important commercial fisheries. In addition, MMS has carried out large-scale reconnaissance of benthic hard- and soft-bottom communities and assessments of long-term changes in benthic communities in oil and gas development areas. Some MMS studies (e.g., Fauchald and Jones, 1978) are notable for their wide geographic coverage and commitment to long-term data collection.

The Ecological Research Division of DOE is sponsoring three regional studies in the bight. One of these, the California Basin Study (CaBS), begun in 1985, is a multidisciplinary effort to examine and understand the production, transport, and ultimate fate of biogenic particulates and the energy-related products (e.g., radionuclides) associated with them. One of the major goals of CaBS is to develop a carbon budget for the Southern California Bight that incorporates the contributions of bacteria, phytoplankton, and zooplankton.

The U.S. FWS Biological Services Program has performed an ecological inventory of the entire Pacific coast, including the bight. The FWS has published several reports on critical habitats within the bight, including kelp forests and coastal marshes, and has developed a series of profiles of environmental requirements for coastal fishes and invertebrates.

State Agencies

Marine research in the bight is sponsored by the California Department of Fish and Game, the Water Resources Control Board, and the Department of Health Services. In addition, state funds contribute to the support of the Sea Grant College Program.

The Marine Resources Branch of the Department of Fish and Game conducts research designed to protect and enhance specific fishery resources. The department has studied the effectiveness of artificial reefs in enhancing fish stocks and evaluated various methods for rehabilitating kelp beds. In addition, the department participates in funding the CalCOFI program, which investigates the biology of commercial fisheries.

The State Water Resources Control Board funds research specifically related to identifying environmental problems and developing water and sediment quality criteria and regulatory standards. For example, the board has supported a survey of PAH levels throughout the bight, followed by laboratory studies of PAH uptake and toxicity. The board has also requested studies of sediment transport and alternative methods of establishing sediment quality criteria.

The California Department of Health Services has examined levels of chemical contamination in fish caught in Santa Monica Bay and Los Angeles and Long Beach harbors. The results of this investigation will be useful to EPA and the Food and Drug Administration (FDA) in revising action limits for some highly nonpolar organic contaminants, such as DDT and PCBs. These are of special concern because of their high potential for bioaccumulation and toxicity.

Local Agencies

The single largest and most focused body of research on pollution problems in the bight is that performed by the municipal and regional sanitation agencies and the research organization they jointly fund, the Southern California Coastal Water Research Project (SCCWRP). In addition, local public health departments conduct research into the health effects of marine contamination and the regional water quality control boards carry out occasional studies targeted at the development of regulatory criteria.

The four major sanitation agencies in the bight all maintain active marine research programs that are beyond the activities mandated by their discharge permits. These four agencies are Los Angeles City, the County Sanitation Districts of Los Angeles County, the County Sanitation Districts of Orange County, and San Diego City. These agencies typically fund research on questions that are relevant to the management of their discharges and the understanding or mitigation of environmental impacts. They consider this research necessary to answer questions that are not addressed by mandated monitoring programs. Research has included both field and modeling studies of sediment transport and plume behavior, as well as investigations of nutrient dynamics in the water column, sediment toxicity, benthic community structure, and kelp bed ecology. In conjunction with SCCWRP, Los Angeles City is currently conducting an experimental study of the rate and character of ecological recovery around the city's sludge outfall, which suspended discharge operations in November 1987. In addition to these active research programs, all discharge agencies in the Southern California Bight belong to the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT). This organization works to ensure that all studies use a consistent, standardized, and up-to-date species list of marine invertebrates. This list has proved invaluable in regional analyses, which otherwise would have been impossible to perform. Discharge agencies also are active members of the Southern California Environmental Chemists Society (SCECS), which performs an analogous function for environmental chemistry.

SCCWRP was founded in 1969 with the aim of conducting both basic and applied marine research relevant to the discharge of municipal wastewater to the bight. At present, SCCWRP is supported by a yearly allocation from the seven major municipal dischargers in the bight, and to a lesser extent by contract funds from state and federal agencies. SCCWRP investigates generic problems of interest to all the dischargers, develops and refines new methods, and performs regional analyses that are beyond the scope of individual dischargers. SCCWRP's work has resulted in important additions to knowledge about the marine environment and improvements to monitoring practice. For instance, SCCWRP researchers have evaluated alternative methods for sampling benthic communities and developed the Infaunal Trophic Index for characterizing the degree of change in benthic communities. They have also investigated histopathological and biochemical indicators of pollutant stress in marine species, documented pollution induced changes in reproduction of key fish species, and monitored regional trends in the incidence of effects such as fin rot and tumors on fish. SCCWRP has performed a vital function because of its ability to collect and integrate data from all the municipal dischargers in the bight. As a result, SCCWRP has been able to complete significant analyses of bightwide patterns and trends in contamination and environmental change. The periodic SCCWRP Report series is available to the public on request.

County health departments and municipal governments in the bight have carried out periodic research studies to assess the likelihood of specific health effects from environmental contamination. For example, the Los Angeles County Department of Health Services has carried out lifeguard surveys in response to inquiries about the health of lifeguards.[1] These studies were stimulated in part by the finding that seven lifeguards in the Los Angeles area had developed cancer. The department is currently planning an additional epidemiological study of lifeguards that will focus on short-term health outcomes. Lifeguards were chosen as a sentinel group for monitoring possible adverse health outcomes due to marine pollution because they are more heavily and consistently exposed than the general public to contaminants in the ocean. The department is also investigating the relationship between consumption of ocean fish and concentrations of DDT, DDE, and PCBs in the milk of lactating mothers.[2] Another example of research performed by local agencies is the city of San Diego's study to assess health risks from the municipal wastewater discharge at Point

[1] In 1982, following notification that seven lifeguards in the Los Angeles area had developed cancer, Dr. Thomas Mack of the University of Southern California Cancer Surveillance Program undertook a study of cancer prevalence in Los Angeles County. He concluded that, although the number of cancer cases was higher than predicted, the elevation was not statistically significant. Neither was there evidence of a causal link between work as a lifeguard near Santa Monica beach and the subsequent appearance of cancer. In addition to these studies, investigations by the Department of Health Services have shown that industrial health claims demonstrate no clear pattern of illness in relation to where the lifeguards work. Prevalence of hepatitis A serology among lifeguards does not differ from control populations.

[2] Previous mammal studies showed that PCBs and DDT adversely affect neonatal development at doses that might be encountered by a small percentage of people eating contaminated fish from the bight (Allen and Barsotti, 1976). To address this concern, the Department of Health Services has selected approximately 50 post-partum breast-feeding women, predominantly from lower socioeconomic groups, as subjects in a study of the relationship between consumption of ocean fish and concentrations of DDT, DDE, and PCBs in breast milk. Preliminary results indicate that PCB concentrations (measured on a fat basis) are typically between 0.1 and 0.3 ppm. There are no values over 0.9 ppm. DDT is present in breast milk at concentrations from 1 to 5 ppm, with a few values over 10 ppm as measured on a lipid basis. It appears that the major source of PCBs in these women is the consumption of fishery products from the bight. However, there is an association between prior residence in Mexico or Central America and elevated (5 ppm or higher) concentrations of DDE in breast milk. All concentrations measured to date are well below the FDA action limits for whole milk (on a whole milk basis).

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Loma to recreational divers who use the Point Loma kelp bed or consume seafood caught there.[3]

The regional water quality control boards, which act independently of the state board, occasionally support research targeted at specific local problems. As one example, the Los Angeles board recently funded a study of contaminants in river runoff in the Los Angeles basin.

Universities

The are more than 200 academic institutions in the region of the Southern California Bight. Some of these have extensive and diverse marine research programs, while others may have only one or a few marine scientists active in particular specialties. The great number and wide variety of the academic marine research programs carried out in the bight make it impossible to review this work in detail. The following paragraphs therefore summarize only those programs that are large, well known, or have contributed significantly to knowledge about the marine environment and environmental effects.

The Scripps Institution of Oceanography of the University of California (UC) system carries out the largest and most varied set of marine research programs in the bight. Scripps is one of the largest oceanographic institutions in the country. It coordinates Sea Grant projects carried out by schools in the UC system and is a member of the University National Oceanographic Laboratory System (UNOLS), partially funded by the National Science Foundation. The research performed at Scripps is worldwide in scope and the institution maintains a fleet of oceangoing research vessels. However, a significant proportion of this work is focused on the California Current system and the Southern California Bight.

Scripps has several large research groups that focus on particular aspects of marine studies. The Food Chain Research Group's focus is the food web dynamics and biogeochemical cycles of plankton, and the nature of environmental effects on these. The Marine Life Research Group focuses on understanding the distribution and variability of the living resources of the California Current system. This research is carried out primarily

[3] Between June and September 1986, 346 recruited divers made 1,371 dives in the Pt. Loma kelp bed. Over 90 percent of the divers took seafood from the kelp bed and 25 percent of those who ate the seafood ate it raw. Raw seafood was consumed underwater by 18 percent of the divers. Twelve illnesses that fit the highly credible gastrointestinal symptoms (HCGI) as defined by EPA were reported. If all reported HCGI illnesses were genuine, then there were eight HCGI cases per 1,000 divers. The new EPA Water Contact Criteria that use enterococcus as the indicator organism for marine waters set a maximum allowable geometric mean enterococcus concentration that would permit an estimated 19 illnesses per 1,000 swimmers. The apparent health risk to divers in the Pt. Loma kelp bed is thus relatively low.

in conjunction with the CalCOFI Program. The Center for Coastal Studies emphasizes investigations of sedimentology and physical and chemical oceanography in the coastal zone. The goal of these studies is to increase the ability to assess and predict the effects of human activity in the coastal environment. In addition to these large groups, individual investigators at Scripps carry out research on the physical and chemical oceanography of the bight, as well as on the biology of kelp bed communities, fish populations, and other resources.

The University of California at Santa Barbara (UCSB) supports the Marine Science Institute and the Coastal Research Center. These research groups carry out basic and applied studies on specific marine resources such as kelp beds and fish stocks, as well as on more general problems such as the toxicity of pollutants. The Center for Remote Sensing and Environmental Optics is developing methods for applying remote sensing (i.e., satellite imagery) technology to the assessment of patterns and processes in the marine environment.

The University of Southern California (USC), a private institution in Los Angeles that is designated as a Sea Grant Institutional Program and is part of UNOLS, operates the Santa Catalina Island Marine Science Center. Historically, the USC Allan Hancock Foundation conducted pioneering programs emphasizing the coastal sedimentology and benthic ecology of the bight. USC has also conducted diverse applied studies, such as baseline inventories in marinas, harbors, and nearshore and continental shelf waters, and environmental assessments in support of the siting of the Hyperion Treatment Plant deepwater outfall and the Terminal Island Treatment Plant outfall. USC has also cooperated with the County Sanitation Districts of Los Angeles County in studies of the plume from the districts' White Point outfall. Other studies performed by USC researchers have examined the effects of oil seeps, the Santa Barbara oil spill, harbor dredging, and disposal of fish processing wastes.

The California State University (CSU) system, originally termed the State College system, is distinct from the University of California system. In the Los Angeles area, the State University system operates the Southern California Ocean Studies Consortium (SCOSC), which coordinates marine research, education, and community service programs at several state university campuses. The consortium recently completed a baseline biological survey for the Terminal Island dry bulk handling terminal in Los Angeles Harbor. Prior to and since the formation of SCOSC, faculty at CSU Long Beach have studied the effects of pollution on nearshore benthos and on reproduction of benthic invertebrates and have developed alternative bioassay/toxicity testing techniques. Faculty at CSU Fullerton and CSU Northridge have focused on the ichthyology of wetlands and embayments. Researchers at San Diego State University have performed studies of wetlands degradation and restoration and of the impacts of sewage from Mexico on the Tijuana estuary.

The California Institute of Technology (Cal Tech) supports the Environmental Engineering Program and the Environmental Quality Laboratory. Scientists in these two groups have been involved in the design of major wastewater outfalls in the bight and in developing design modifications for power plant cooling-water intakes that drastically reduced the numbers of fish taken in with the cooling water. In addition, Cal Tech scientists have studied the chemical and physical processes related to the movement and ultimate fates of discharged materials in the bight, have examined the chemistry of wastewater effluent, and investigated the fractionation of sewage sludge discharged to the ocean. For many years, Cal Tech also housed the Kelp Habitat Improvement Project, a long-term effort to understand the biology of kelp beds and enhance their survival and growth.

Notable among the research programs at small colleges in the bight is that at Occidental College, which has operated the R.V. *Vantuna* program for more than a decade. This ship-based program focuses on extensive otter trawling and diver ichthyological surveys, and on research on the effects of heated wastewater plumes from coastal power plants.

Private Industry

Private industries in the bight maintain research programs that are targeted at understanding the effects of specific discharges or other activities. With the exception of Southern California Edison's program, however, most of these are small and narrowly focused. Since 1972, the company has operated a research and development laboratory in Redondo Beach, and for many years supported a program of voluntary research termed the "Special Studies Program." These studies were carried out at SCE's initiative in order to:

- more clearly describe the effects of the company's permitted intake and discharge of power plant cooling water, and
- develop a greater understanding of the mechanisms underlying these effects.

Southern California Edison's research has included investigations of the effect of chlorinated discharges and thermal stress on various life stages of coastal fishes, fish behavior around cooling water intakes, the bightwide distribution patterns of ichthyoplankton and adult fishes, the biology of kelp beds, and remote sensing studies of surface-water temperature patterns throughout the bight. An unusual aspect of much of Edison's research is its emphasis on bightwide patterns and processes. For example, the company has attempted to determine whether its numerous coastal power plants, in the aggregate, have had any effect on larval and adult fish abundance and distribution in the bight. This orientation reflects the fact that Southern California Edison, unlike other dischargers, operates throughout the entire bight.

Research Successes

Research programs have contributed greatly to both the evolution of monitoring technology and to the mitigation of the impacts of human activity in the bight. These contributions are too numerous to list completely, but a few historical examples will indicate the breadth and importance of the relationship between research and monitoring programs in the bight.

For many years, scientists at USC's Allan Hancock Foundation carried out research on the biogeography of the bight. These studies described the fauna of the continental shelf and slope and the offshore basins. The resulting comprehension of zonation patterns was important in understanding the impacts of wastewater discharge. This information was also instrumental in determining the placement of outfalls and designing monitoring programs.

When Southern California Edison was first constructing coastal power plants in the bight, it worked closely with scientists and engineers at Cal Tech to redesign cooling water intakes to reduce the numbers of fish taken in with the cooling water (or impinged). Modeling and experimental studies showed that fish were disoriented by the vertical flow fields around intakes. As a result of this understanding, Southern California Edison fitted velocity caps to all intake structures. These velocity caps create a horizontal flow field around intakes, thus reducing the numbers of fish impinged by over 90 percent. Both the severity of the original problem and the efficacy of the velocity caps were documented by monitoring.

The diversion in 1971 of the County Sanitation Districts of Orange County's wastewater discharge from a shallow inshore outfall to a deeper outfall offshore provided a unique opportunity for research on both the recovery and disturbance of benthic communities. Gary Smith, of Scripps, studied the dynamics of community recovery at the old discharge site and the progress of disturbance effects at the new outfall site (Smith, 1974). The increased understanding of impact mechanisms that resulted from this study was extremely valuable in the continued improvement of monitoring around outfalls in the bight.

SUMMARY

Monitoring and research programs in the Southern California Bight are both diverse and intensive. They are carried out by a wide variety of federal, state, and local agencies, as well as by universities and private industry. Virtually every aspect of the marine environment is currently being monitored or otherwise investigated.

In many instances, research and monitoring activities have been closely coordinated, with research results being used effectively to improve and refine monitoring efforts. The active marine research community in Southern California has produced many innovations that have advanced the state of the art in marine monitoring. In addition, the large monitoring programs represent a valuable source of time-series data on the marine environment in the bight.

One of the most striking features of the monitoring and research system in the bight is the great number of programs carried out by an almost equally great number of agencies, universities, and industries. This has led to examples of interagency cooperation that could serve as a model for other regions facing similar problems. However, it has also led to fragmentation and a lack of integration, which has hampered monitoring efforts. These issues and others related to the technical design of monitoring programs will be dealt with in Chapters 5 and 6.

5
A Framework for the Analysis of Monitoring

The previous chapter documented the wide range of monitoring programs being carried out in the Southern California Bight. Because these programs can be evaluated from many different perspectives, it is important to clarify the criteria the panel used in its analysis of monitoring efforts. These criteria summarize the conceptual framework developed by the parent committee. They provide the basis for determining whether individual programs, as well as the monitoring system as a whole, are effective or not, and can be expressed as six questions:

1. Does monitoring address clearly stated management and societal objectives?
2. Does monitoring address the major environmental problems facing the bight?
3. Do the spatial and temporal scales of monitoring reflect those of the major environmental problems?
4. Are the technical design and implementation of monitoring of high quality? This includes proper statistical design of sampling and analysis, use of state-of-the art field and laboratory techniques, and adequate links to relevant research programs.
5. Do monitoring programs respond in a timely way to changing conditions and needs?
6. Are monitoring resources allocated effectively both within and among monitoring programs?

These criteria reflect the literature on monitoring (e.g., Holling, 1978;

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Green, 1979; Beanlands and Duinker, 1983; Fritz et al., 1980, National Research Council, 1986; Isom, 1986; Rosenberg et al., 1981; and Bernstein and Zalinski, 1983, 1986) and the experience of the panel members.

It is important to recognize that issues addressed by the evaluation criteria are not strictly technical. This is because monitoring is defined by and carried out within a complex context that includes the interests and information needs of the public and the regulatory agencies and the requirements (procedural and otherwise) of relevant laws and permits, as well as strictly scientific and technical concerns. The analysis of monitoring must therefore look as much at the interface between policy and technical issues as at the technical issues themselves.

The following sections address three areas that are especially relevant to the analysis of monitoring and that underlie the evaluation criteria:

- the importance of clear objectives,
- the role of technical design and its statistical component, and
- the necessity for identifying, evaluating, and prioritizing environmental problems.

THE IMPORTANCE OF OBJECTIVES

Monitoring programs are intended to produce information for quantifying and evaluating the effects of human activity on the marine environment. Monitoring is intended to provide decision makers with the information they need to make appropriate management decisions about how to protect the marine environment and its resources. Ideally, these information needs should be expressed as objectives that guide the design and implementation of monitoring programs.

The objectives that currently motivate monitoring programs in the bight can be loosely structured as a hierarchy. At the highest level are broad concerns about human health and the status of the ecosystem. Beanlands and Duinker (1983) make the point that objectives at this level often reflect sociopolitical values that cannot always be quantified or supported scientifically. This, however, does not necessarily lessen their importance or relevance as the basis of management and monitoring efforts. At the next level are the laws and regulations that embody these concerns as more specific objectives or requirements. At the next level are permits for individual discharges or other activities, which in some cases contain numerical monitoring criteria. Finally, the monitoring design itself is based on decisions about what, specifically, to measure, when, where, and how often to measure it, and about what degree of uncertainty in the final answer is acceptable. Ideally, each level should incorporate the content and intent of the preceding level. Westman (1985) has described an analogous hierarchy in terms of successively more specific and detailed goals, policies, strategies, and tactics.

As the foregoing discussion implies, clear objectives are crucial for both the monitoring and decision-making aspects of environmental management. For monitoring practitioners, they direct monitoring efforts toward the measurement of specific parameters and of specific amounts and rates of change. Without such clear objectives, it is impossible to effectively use such technical design tools as conceptual, numerical, and statistical models, and power and optimization analyses. For managers and regulators, they provide a standard against which environmental change can be measured in order to determine if corrective action is required. It is therefore necessary to completely specify objectives at each level of the hierarchy, from broad public concerns to specific, numerical criteria.

THE ROLE OF TECHNICAL DESIGN

Technical design involves making decisions about what to monitor; how, when, and where to take measurements; and how to analyze and interpret the resulting data. The parent Committee on a Systems Assessment of Marine Environmental Monitoring developed a design methodology that the panel used to structure its evaluation of this aspect of monitoring in the Southern California Bight (Figures 5-1 to 5-4) (National Research Council, 1990). Figure 5-1 shows that technical design must be considered in relation to the initial definition of goals and objectives and the ultimate effective dissemination of monitoring information. Figures 5-2 to 5-4 provide additional detail about the relationships among specific elements of the methodology.

The methodology summarized in Figures 5-1 to 5-4 reflects definite concepts about effective monitoring design and its benefits. These concepts are not the only ones that could have been used to structure an evaluation of the technical design of monitoring programs. They do, however, reflect many of the important themes that recur in the literature on monitoring design. The following is a summary of these concepts:

- Appropriate technical design ensures that data collection, analysis, and interpretation will address management needs and objectives. oTechnical design can be performed adequately only when objectives, problems, questions, or hypotheses are stated explicitly.
- Sampling, measurement, and analysis designs should be developed with the goal of detecting specific kinds and amounts of change.
- Predictions about the kinds and amounts of change expected should be derived from conceptual models that specify how particular human activities (causes) will lead to environmental impacts (effects).

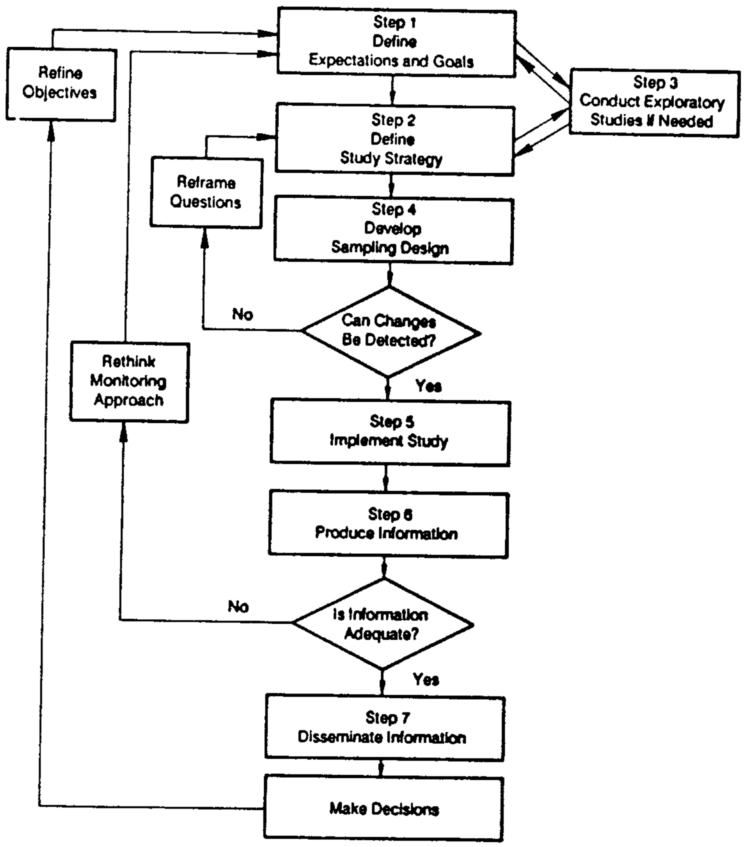

FIGURE 5-1 The elements of designing and implementing a monitoring program.

- Sampling and measurement designs should account for important sources of natural variability.
- Sampling and measurement designs should be evaluated beforehand to determine their ability to detect predicted changes.
- Analysis approaches should be selected before data collection to correspond to the statistical assumptions of the sampling design.
- Data base systems should make authorized versions of the data readily available to analysts and managers, and should provide easy access to a wide range of analysis, graphics, and reporting tools.

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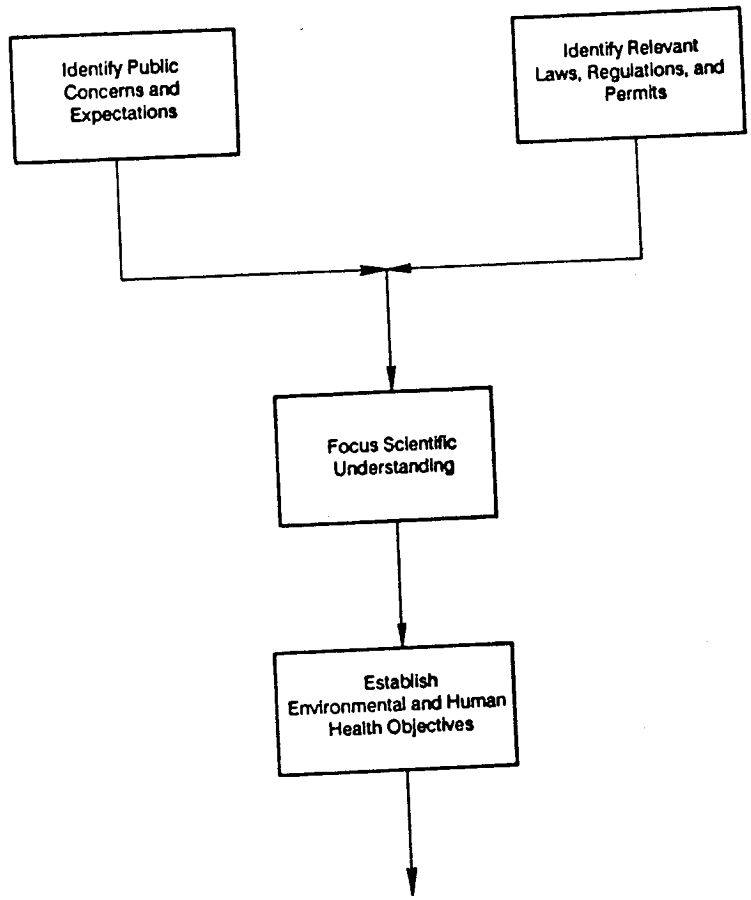

FIGURE 5-2 Step 1: Defining expectations and goals of monitoring.

The technical design process illustrated in Figures 5-1 to 5-4 furnishes a framework for translating broad questions and objectives into specific decisions about what to measure, where to measure it, and how many measurements to take. Using this framework as an evaluation tool enabled the panel to use a common set of standards in considering the technical design of monitoring programs in the bight.

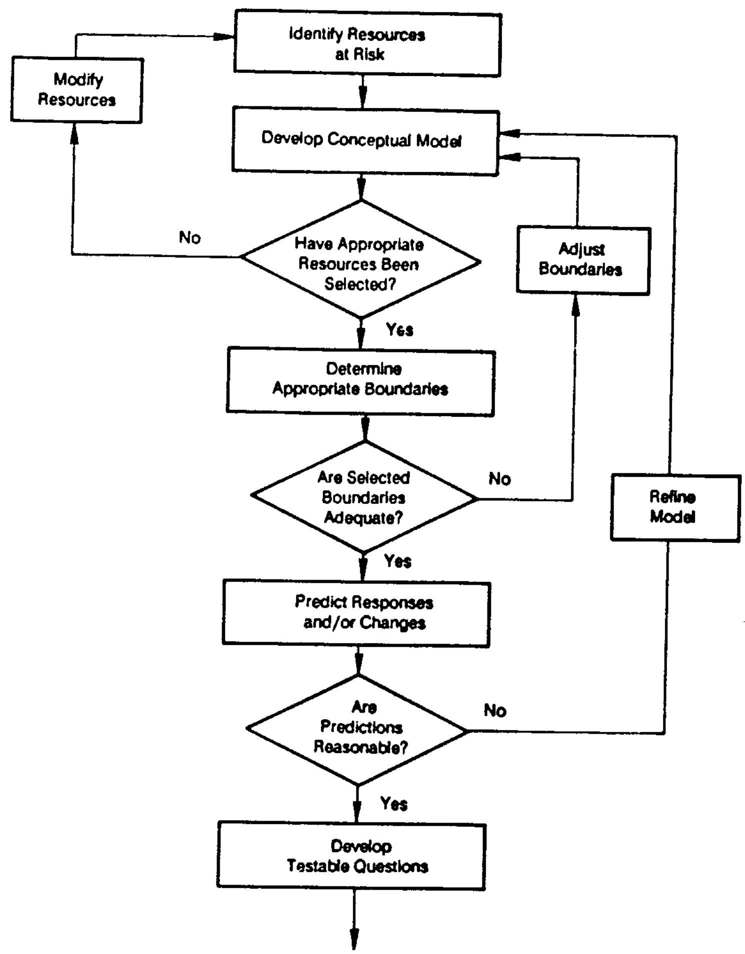

FIGURE 5-3 Step 2: Defining study strategy.

A FRAMEWORK FOR PRIORITIZING PROBLEMS

As stated previously, this case study is oriented toward examining the monitoring system in the bight as a whole. In addition to evaluating whether individual programs meet their objectives, this necessitates determining whether the entire collection of monitoring programs produces

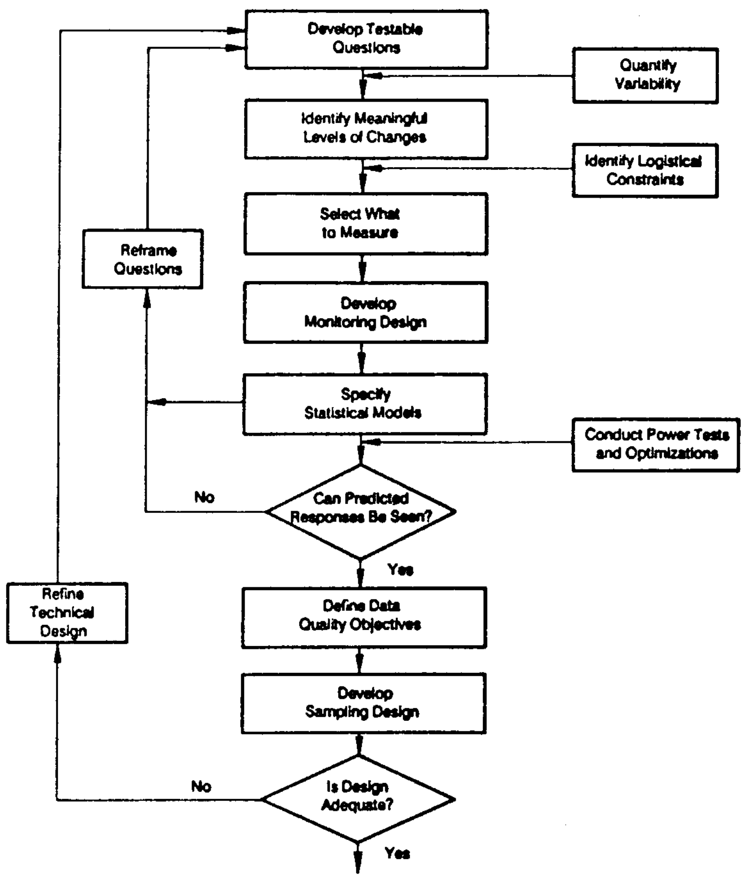

FIGURE 5-4 Step 3: Developing sampling and measurement design.

the information needed to satisfy both management and the public. The technical design methodology described above provided a means of structuring the analysis of individual programs. However, there was no similar framework available for the overall analysis of the monitoring system. The panel therefore adapted existing methods in order to perform a summary assessment of environmental impacts on resources in the bight. This assessment was intended to summarize the nature and severity of impacts on a range of important resources in the bight and was designed to help the panel address specific questions.

- Does monitoring address clearly stated management and societal objectives?
- Does monitoring address the major environmental problems facing the bight?
- Do the spatial and temporal scales of monitoring reflect those of the major environmental problems?
- Are monitoring resources allocated effectively both within and among monitoring programs?

The Assessment Framework

While many useful frameworks have been proposed for environmental assessments (see examples in Beanlands and Duinker, 1983; Westman, 1985; NRC, 1986), constructing one for monitoring in the bight in the context of the case study presented special difficulties. First, the goal of the assessment was to produce a synthetic overview that would aid in drawing conclusions about the entire monitoring system in the bight, both technical and institutional. This is in contrast to more typical assessments that focus only on identifying and quantifying the environmental impacts of individual projects. Second, the time available for developing this overview was necessarily short and the technical and financial resources available were limited. Third, there are extensive and diverse human and natural sources of perturbation in the bight and methods for characterizing multiple and cumulative impacts are not well developed. For example, effects on fish populations may derive from:

- coastal power plants–entrainment of larvae, impingement of adults;
- municipal wastewater outfalls–habitat alteration, changes in food supply, contamination;
- dredged material disposal–habitat alteration, contamination;
- storm runoff—contamination; and
- sport and commercial fishing–increased mortality.
- El Niños–changes in distribution and community structure, habitat alterations; and
- major storms–habitat alteration.

Such effects act on different spatial and temporal scales, and this adds to the challenge of understanding and portraying impacts.

To accommodate these constraints and difficulties, the panel used a combination of matrix and ad hoc assessment methods (Westman, 1985).[1]

[1] The matrix approach was adapted from a framework developed by Clark (1986) for identifying

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The assessment produced synoptic overviews that were useful in evaluating the overall pattern of monitoring in the bight. However, before reviewing the assessment products and explaining the supporting detail, it is important to understand the limitations of the matrix and ad hoc methods used. In most cases, the limitations of each method were somewhat balanced by the strengths of the other. The procedure described by Clark (1986) proceeds through a series of steps that specify:

- valued ecosystem components (VECs),
- marine constituents (both natural ecosystem parameters and anthropogenic contaminants) that cause changes in the VECs, and
- sources of natural and human-induced perturbation that create or cause changes in these constituents, which are linked in a matrix with specific VECs to show how they—along with contamination in the bight—affect marine resources (Figure 5-5).

The selection of perturbations, constituents, and VECs is necessarily somewhat arbitrary. Given the size of the bight and the multiplicity of resources and sources of impact, some selection among these was unavoidable. This selection reflects the values and biases of the panel, but the critical reviews by experts and scientists outside the panel were designed to balance competing points of view. However, there is no denying that other reviewers might have generated parameters that would have led to a different assessment.

The matrices do not specifically identify primary, secondary, and higher order interactions among perturbations, constituents, and VECs. This would be a severe shortcoming if the matrices were used as a stand-alone assessment method. In this case, however, the matrices were used as a cross check for the conclusions derived from the ad hoc approach and to enforce a degree of systematic thinking. While the matrices themselves do not specify interactions, they were discussed at length during preparation of the matrices and as part of the ad hoc approach.

The matrix products do not quantify effects and impacts. Rather Figure 5-5 scales two impact attributes, the potential influence of each source of perturbation and the degree of scientific certainty associated with this conclusion. This is similar to the scaling of impact magnitude and importance proposed by Leopold et al. (1971) in a similar matrix. This subjective scaling would be a major shortcoming if the panel's intent was to perform a damage assessment, a detailed project assessment, or a comparison of two or more alternative development scenarios. However, in

cumulative impacts. The ad hoc portion of the assessment (Rau and Wooten, 1980) consisted of brainstorming sessions with experts and critical review of the matrix products by individual scientists. The matrix products were modified a number of times to incorporate feedback from brainstorming sessions and individuals' reviews.

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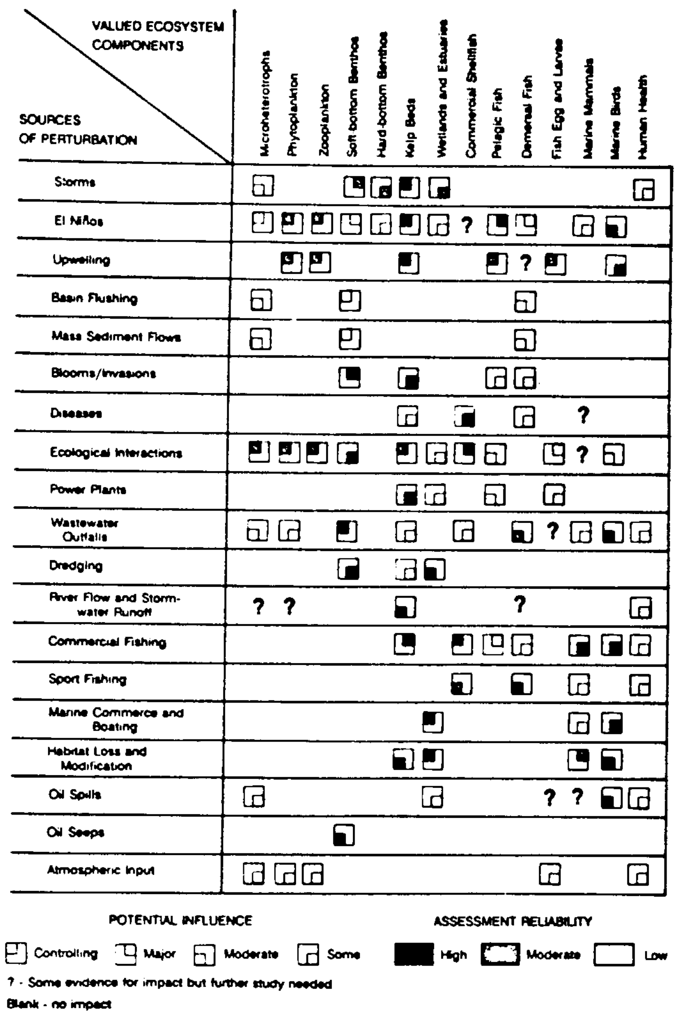

FIGURE 5-5 Impacts on the marine environment of the Southern California Bight. Individual cells of the matrix illustrate the presumed relative impact of each source on each component, along with the associated scientific certainty. Each column represents cumulative impacts on individual components; each row shows the effects of individual perturbations on all components. This figure was used to summarize and investigate ways of identifying and ranking impacts in the bight. SOURCE: After Clark, 1986.

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this case the panel's goal was to produce a high-level overview that would assist in comparing the overall pattern of impacts with the overall pattern and structure of monitoring programs. In addition, much of the background information used in both the matrix and ad hoc efforts was derived from extensive and quantitative research, monitoring, and modeling programs.

The overviews that resulted from the assessment lack detail about the nature of the effects they represent. Again, this is less of a problem given the panel's task. In fact, the high-level, summary character of the overviews was actually helpful in elucidating the weaknesses of the existing monitoring structure.

The ad hoc method depends on the collected experience and insights of the participants. As a result, conclusions are dependent not only on the selection of participants but also on their values and biases. Under the circumstances, the panel believed that enlisting the participation of a cross section of scientists from the bight region was the most efficient means of integrating the wealth of scientific and technical information available. Involving scientists of differing affiliations helped to balance individual values and biases. In addition, the matrix method helped to focus, systematize, and cross check each person's opinions and judgments.

No assessment method is perfectly objective. While quantitative models are increasingly valuable, even they depend on certain simplifying assumptions and often are challenged. Similarly, even a moderately sized monitoring program must make judgments about which aspects of the environment to measure or ignore, since it is impossible to measure everything. The panel used the assessment products to derive conclusions about the structure and focus of the monitoring system in the bight. The conclusions were judged to be robust enough to form the basis for conclusions and recommendations, even in light of the acknowledged limitations of the assessment methods used.

A Synoptic Overview

The matrix in Figure 5-5 is a useful heuristic tool. It shows that all ecosystem components are impacted by more than one kind of perturbation. It also shows that perturbations typically affect more than one ecosystem component. For example, storms affect soft benthos, kelp beds, and human health; wastewater outfalls affect soft benthos, microheterotrophs, and demersal fish populations.

Figure 5-5 helps categorize the types of monitoring programs in the bight. Some programs examine the effects of one perturbation on a single resource. These programs focus on one cell of Figure 5-5 and are called single-cell assessments. For example, the impingement sampling program carried out by the Southern California Edison Company is intended to assess the potential impacts of coastal power plants on pelagic fish populations. Other monitoring programs examine the effects of one perturbation on a range of resources. These programs focus on an entire row of Figure 5-5 and are called row assessments. For example, the 301(h) monitoring program around the Orange County wastewater outfall is designed to document the effects of the outfall on a range of resources, including soft benthos, water quality, and demersal fish populations. Monitoring programs that consider how several perturbations, acting together, affect a single resource would focus on an entire column of Figure 5-5 and are called column assessments. There are no examples of such programs in the bight, a fact which will be addressed in more detail in Chapter 6. Further, there are no coordinated monitoring programs in the bight that focus on the effects of two or more sources of perturbation on a range of related resources. Such a program, for example, might document the combined effects of fishing, power plants, and wastewater outfalls on demersal and pelagic fish populations.

Figure 5-5 also presents subjective judgments about the relative importance and degree of scientific certainty associated with each impact. For example, wastewater outfall impacts on soft benthos are more severe and extensive than those from dredging. As another example, it also shows that conclusions about kelp bed impacts are probably more reliable than those about effects on fish eggs and larvae. Such comparisons aid in analyzing existing monitoring programs by suggesting where further research would be more appropriate and useful than routine monitoring. As Chapter 6 makes clear, available financial and technical resources in the bight are not systematically allocated to research and monitoring on the basis of a comprehensive overview like the one in Figure 5-5.

As with Figure 5-5, Figure 5-6 is a useful heuristic tool that supplies insights about the structure of existing monitoring programs in the bight. It shows quite clearly that the impacts that are relatively well understood (e.g., coastal power plant plumes, disposal of coarse dredged material, nutrients, fine particles) are those whose scales are either less than or of the same order of magnitude as those of monitoring programs. It also demonstrates that, with the exception of the CalCOFI program, the temporal and spatial scales of individual monitoring programs are insufficient to resolve patterns of effects on larger scales. While the effects of scale are becoming a matter of concern to ecologists (Wiens, 1989), Figure 5-6 demonstrates that monitoring programs in the bight are not consistently designed with such scale effects in mind. As Wiens (1989) points out, these effects can be complex, and—if not considered carefully—". . . we may think we understand the system when we have not even observed it correctly."

Supporting Detail

As the first step in the matrix assessment procedure, the effects of the constituents on the VECs are identified (Figure 5-7), and the ways in which sources of perturbation cause changes in these constituents are then specified (Figure 5-8). This permits sources of perturbation to be linked (through changes in the constituents) directly to effects on VECs in a matrix (Figure 5-5). This in turn allowed the panel to summarize the effects of various human and natural processes on the VECs. Finally, the temporal and spatial scales of constituents and perturbations (Figure 5-6) are compared to the spatial and temporal scales of relevant monitoring programs.

Figure 5-7 qualitatively shows the effects of changes in marine constituents on valued marine ecosystem components. VECs include important ecosystem components and major fisheries, as well as demersal and pelagic fish life stages that occupy distinct habitats and might be affected differentially. Constituents are divided into physical oceanographic parameters (e.g., waves or temperature), and into floating, dissolved, suspended, and settleable categories. Figure 5-7 shows that specific constituents impact more than one VEC and that some VECs are affected by more than one constituent.

The constituents shown in Figure 5-7 were selected because they are typically measured in monitoring programs. Their division into floating, dissolved, suspended, and settleable categories reflects the fact that their association with particles of different sizes significantly influences the fates and effects of most contaminants. However, the selection and arrangement of these constituents is certainly not the only one possible. For example, rather than focusing on physical and chemical parameters, the constituents could include important dynamic processes, such as production, nutrient regeneration, the flux of organic matter, and recruitment and mortality.

Figure 5-8 furnishes the next link in the matrix-based assessment by showing which sources of perturbation affect which constituents. This then permits connecting sources of perturbation to effects on VECs. For example, the amount and distribution of fine particles and nutrients are affected by wastewater outfalls (Figure 5-8), and such changes can potentially affect the soft benthos (Figure 5-7). This suggests a potential mechanistic link between wastewater outfalls and effects on the soft benthos. Similarly, marine commerce and boating create floating debris (Figure 5-8), which affects marine birds (Figure 5-7). (These admittedly simplistic examples were chosen for illustrative purposes; the reader is encouraged to investigate other links suggested by Figures 5-7 and 5-8).

These two figures can be integrated to furnish a synoptic view of the impacts of both natural and human perturbations on the VECs. Thus, one

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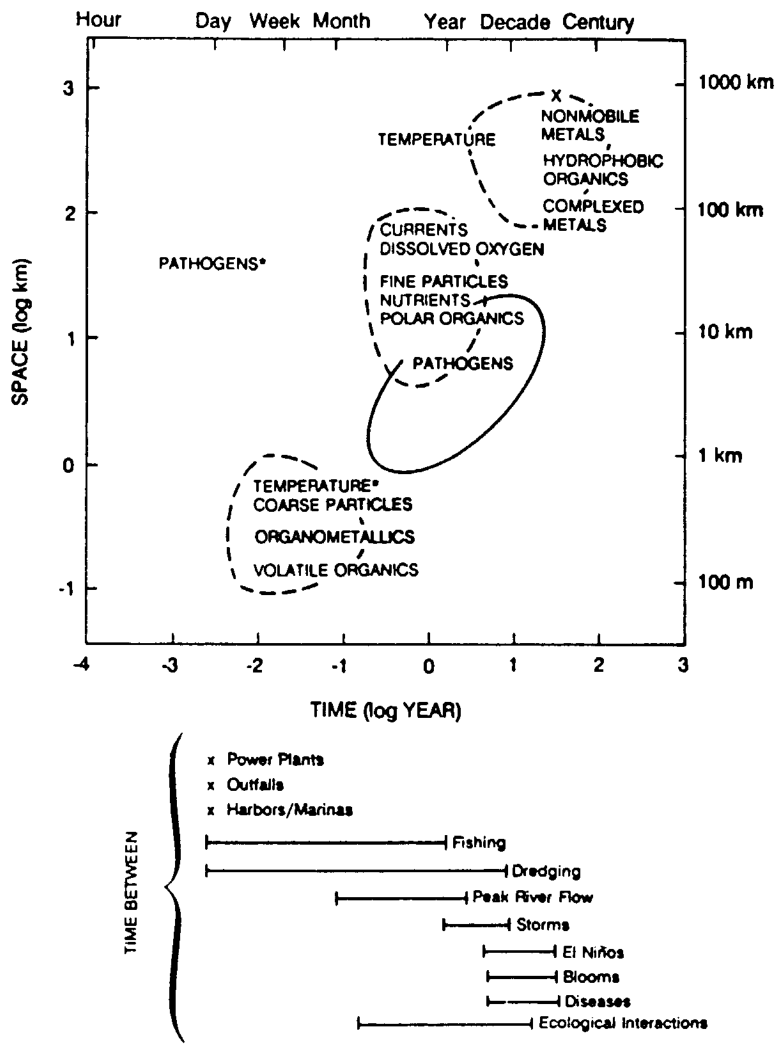
Hour
Day
Week
Month
Year
Decade
Century
1000 km
100 km
10 km
1 km
100 m
SPACE (log km)
TIME (log YEAR)
NONMOBILE METALS
TEMPERATURE
HYDROPHOBIC ORGANICS
COMPLEXED METALS
PATHOGENS*
CURRENTS
DISSOLVED OXYGEN
FINE PARTICLES
NUTRIENTS
POLAR ORGANICS
PATHOGENS
TEMPERATURE*
COARSE PARTICLES
ORGANOMETALLICS
VOLATILE ORGANICS
TIME BETWEEN
x Power Plants
x Outfalls
x Harbors/Marinas
Fishing
Dredging
Peak River Flow
Storms
El Niños
Blooms
Diseases
Ecological Interactions

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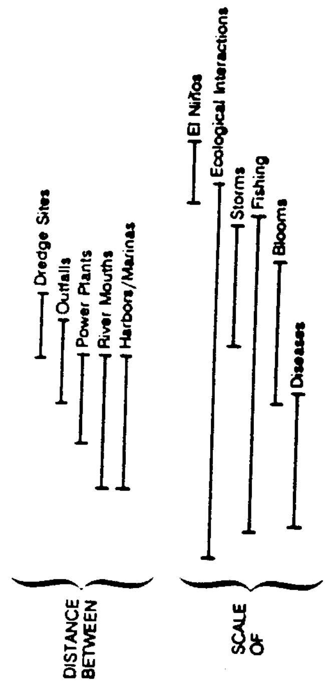

FIGURE 5-6 Characteristic temporal and spatial scales of important constituents and sources of perturbation. Constituents are the same as those in Figure 5-6, but have been abbreviated. "Temp *" refers to temperature changes from coastal power plants, and "Temp" to natural temperature changes (i.e., El Niño events). "Path *" refers to bacterial contamination from wastewater outfalls and storm runoff, and "Path" to pathogens from natural sources that cause diseases in urchins, fish, and other organisms. The abscissa represents a crude estimate of the half life or recurrence time of each constituent. The ordinate represents the spatial displacement likely to occur over that time, or the scale of activity. For example, nonmobile metals and hydrophobic organics are presumed to persist in the environment and spread much more widely than nutrients. The temporal and spatial boundaries of existing monitoring programs are outlined by a solid line, with the exception of the CalCOFI Program, whose parameters are indicated by an "X" in the upper right of the figure. Constituents with similar temporal and spatial scales are outlined with dotted lines. SOURCE: After Clark, 1986.

Marine Constituents \ Valued Ecosystem Components	Microheterotrophs	Phytoplankton	Zooplankton	Soft bottom Benthos	Hard bottom Benthos	Kelp Beds	Wetlands and Estuaries	Commercial Shellfish	Pelagic Fish	Demersal Fish	Fish Eggs and Larvae	Marine Mammals	Marine Birds	Human Health
OCEANOGRAPHIC														
Currents		●	●								●			
Winds		●	●								●			
Waves				●	●	●	●							
Temperature	●	●	●	●	●	●	●		●	●	●			
Dissolved Oxygen	●			●	●		●	●		●	●			
FLOATING														
Floating Debris												●	●	●
DISSOLVED														
Nutrients	●	●		●	●	●			●	●	●	●	●	
Volatile Organics	●	●									●			
Polar Organics	●	●	●								●			
Complexed Metals			●											
Organometallics			●											
SUSPENDED														
Fine Particles		●				●		●						
Coarse Particles					●	●		●						
Nutrients								●			●			
Pathogens						●		●		●		●	●	●
Hydrophobic Organics			●				●	●	●	●		●	●	●
Organometallics			●				●	●		●		●	●	
Nonmobile Metals							●							
SETTLEABLE														
Fine Particles				●	●		●							
Coarse Particles				●	●	●	●							
Nutrients				●	●					●				
Hydrophobic Organics				●	●		●							
Nonmobile Metals				●	●		●							

FIGURE 5-7 Major impacts of natural features of the ecosystem and anthropogenic contaminants on valued ecosystem components. The dots indicate that the listed constituent (left) is presumed to have a significant impact on that ecosystem component (top). Both direct and indirect impacts are included. Volatile organics include phenols and halomethanes; polar organics, PAH, DDT, and PCB. Nonmobile metals include lead and cadmium; complex metals—nickel and copper; organometallics—mercury, tin, selenium, and arsenic. Nutrients include both dissolved nutrients and nutrients associated with particles. Pathogens include those from both anthropogenic (e.g., coliforms) and natural (e.g., urchin disease) sources. Dissolved constituents are those less than .04 μm in size. Settleable constituents are defined operationally as those that settle to the bottom as a function of size and specific gravity. Valued ecosystem components include various parts of the food chain, communities associated with specific habitats (e.g., kelp beds), and important fisheries. Commercial shellfish include abalones, lobsters, and urchins. SOURCE: After Clark, 1986.

can start with VECs such as soft benthos or demersal fish populations, identify the constituents that affect them, and then trace these constituents back through their relationships with sources of perturbation to finally determine all the kinds of perturbations that affect these ecosystem components. The result of this process can be displayed as a matrix (Figure 5-5) that summarizes the impact of each kind of perturbation on each ecosystem component.

Figure 5-5 was constructed using other knowledge from the ad hoc method in addition to the mechanistic linkages shown in Figures 5-7 and 5-8. This points up shortcomings in the selection and organization of the constituents shown in Figure 5-7. For example, Figure 5-5 shows that sport and commercial fishing impact pelagic and demersal fish by directly removing individuals from the population. However, since Figure 5-8 does not include mortality as one of the marine constituents, Figures 5-7 and 5-8 do not combine to predict impacts on fish from fishing, an obvious failing. In addition, Figure 5-5 indicates that blooms, natural diseases, and especially ecological interactions have significant effects on the VECs. However, Figure 5-7 shows that none of these important sources of perturbation interact strongly with any of the constituents other than temperature and dissolved oxygen. The panel thus combined insights from both the matrix and ad hoc methods without rigidly adhering to the limitations of either.

Figure 5-5 is an informative way to organize existing knowledge about impacts on marine resources. However, the spatial and temporal scales of both perturbations and ecosystem processes vary widely and this information is necessary to evaluate the effectiveness of monitoring. The overall assessment framework therefore includes a means of organizing and comparing the temporal and spatial scales of constituents and perturbations. A preliminary approach is presented in Figure 5-6. The constituents are placed in a logarithmic time-space coordinate system based on crude estimates of their half-lives in the marine environment (for contaminants) or their typical scale of activity (for ecosystem features). The temporal and spatial range of existing monitoring programs is indicated, and the temporal and spatial scales of important perturbations shown along the x and y axes, respectively.

SUMMARY

This chapter presents the criteria and concepts used to organize the analysis of monitoring efforts reviewed in the next chapter. Six key questions made up the evaluation criteria used to assess both individual monitoring programs and the collection of monitoring programs in the bight. These questions addressed both the policy and technical aspects of monitoring,

MARINE CONSTITUENTS \ SOURCES OF PERTURBATION	Storms	El Niños	Upwelling	Basin Flushing	Mass Sediment Flows	Blooms/Invasions	Diseases	Ecological Interactions	Power Plants	Wastewater Outfalls	Dredging	River Flow and Runoff	Commercial Fishing	Sport Fishing	Marine Commerce and Boating	Habitat Loss and Modification	Oil Spills	Oil Seeps	Atmospheric Input
OCEANOGRAPHIC																			
Currents		●	●													●			
Winds	●															●			
Waves	●															●			
Temperature		●	●	●		●	●	●	●										
Dissolved Oxygen		●	●	●				●	●										
FLOATING																			
Floating Debris										●		●	●	●	●				
DISSOLVED																			
Nutrients	●	●	●	●	●					●		●							●
Volatile Organics										●		●			●		●		
Polar Organics										●		●			●		●		
Complexed Metals									●	●		●			●		●		●
Organometallics									●	●		●			●		●		
SUSPENDED																			
Fine Particles	●			●						●	●	●							
Coarse Particles	●								●	●	●	●							
Nutrients	●									●		●				●			
Pathogens																			
Hydrophobic Organics										●	●	●							
Organometallics									●	●	●	●							
Nonmobile Metals									●	●	●	●							●
SETTLEABLE																			
Fine Particles	●				●				●	●	●	●				●			
Coarse Particles	●				●				●	●	●	●				●			
Nutrients	●				●					●		●				●			
Hydrophobic Organics					●					●	●	●							
Nonmobile Metals					●				●	●	●	●							

FIGURE 5-8 Sources of major perturbations to the bight's marine ecosystem and their major impacts on marine constituents. The dots indicate that the listed perturbation (top) is presumed tc have a significant effect on the listed constituent (left). Both direct and indirect impacts are included. Perturbations include both human and natural sources of change. Basin flushing refers to the turnover of near-bottom water in offshore basins; mass sediment flows to sudden, large movements of sediment on the shelf; blooms or invasions to rapid increases in population levels of otherwise rare species (e.g., the echiuran *Listriolobus* or the kelp isopod *Pentidothea resecta*). Multiple sources of impacts of one kind (e.g., power plants, dredging) have been lumped to provide a consistent level of generality among perturbations. SOURCE: After Clark, 1986.

emphasizing the panel's focus on the functioning of the monitoring system as a whole.

Three areas that are especially relevant to the evaluation criteria were also discussed. Clear objectives are crucial in providing direction for monitoring design and implementation. An effective technical design then translates these objectives into decisions about what to monitor; how, when, and where to take measurements; and how to analyze and interpret the data. Finally, an overall assessment of environmental problems in the bight provides a framework for determining if all important questions are being addressed and whether monitoring resources are being allocated effectively.

6
Analysis of Monitoring Efforts

As described in Chapter 4, there exists a wide range of current and historical monitoring efforts in the Southern California Bight. Analyzing each of these in turn would be an unrealistic task, but examining only a few in detail might cause us to neglect important insights and patterns that could be derived from a broad survey. This review therefore identifies important conceptual issues, and illustrates them using examples from existing monitoring programs.

Many of these issues and examples identify shortcomings of the monitoring system and existing programs, and others stress positive developments. The analysis that follows emphasizes that monitoring efforts in Southern California are characterized by a commitment to technical excellence and continued evolution toward more sophisticated and effective planning and implementation. There is a broad consensus in the monitoring community that programs today are, in general, vastly improved over those in effect 10 or more years ago. This progress has highlighted remaining problems and has allowed attention to shift to broader concerns. The willing participation in this case study by all parts of the monitoring community is clear evidence of their interest in continuing to improve monitoring efforts.

This chapter focuses on four main topics:

1. institutional objectives and their limitations,
2. technical design and implementation,
3. technical interpretation and decision making, and

4. the overall allocation and organization of monitoring.

Judgments about monitoring's effectiveness in each of these areas are based on the criteria and concepts outlined in Chapter 5. This chapter discusses these concepts more extensively, in light of evidence from specific programs.

The panel's analysis of monitoring was based in large part on the written and verbal comments of invited speakers at the fact-finding sessions and further in-depth interviews with members of the monitoring community. The specific comments of these participants in the case study contributed to a consensus about the overall strengths and weaknesses of monitoring in the bight. This consensus is presented here as a series of statements and is amplified in the following sections.

The strengths of the monitoring system include:

- an established legal requirement for addressing environmental issues and problems;
- important contributions to environmental decision making;
- active links to ongoing research programs;
- innovative monitoring program designs and techniques;
- high-quality methods for collecting, analyzing, and interpreting data;
- raw monitoring data of high quality and integrity;
- large data sets that have greatly increased understanding of localized impacts, particularly of municipal wastewater discharges; and
- a few long-term data sets that are valuable for examining large-scale and long-term effects of human activities on the bight.

The weaknesses of the monitoring system include:

- poorly defined management objectives;
- poorly defined monitoring endpoints or decision criteria, especially for narrative water quality objectives;
- lack of explicit conceptual designs that link monitoring to specific hypotheses or paradigms about the ocean environment;
- inability to address regional or cumulative effects in the bight as a whole;
- sampling designs that do not take into account spatial and temporal scales of natural variability;
- reliance on a shotgun approach that measures many parameters, regardless of their relevance to operational, environmental, or public health decisions;
- rigidity that does not permit dropping redundant or outdated parameters, incorporating research with defined endpoints, or making adjustments in the light of new information;

- over-commitment of resources to well-understood problems;
- lack of a data management system containing a wide range of data types from all major monitoring programs;
- absence of synthesis that provides usable information to managers and other decision makers; and
- inability to effectively report the overall status of the resources and water quality in the bight to the public, the scientific community, and policy makers.

It should be emphasized that this consensus reflects the judgment of many people actively involved in designing, carrying out, and using the data from monitoring programs. Thus, in spite of the strengths mentioned above, and the fact that monitoring data have been used in decision making, there is evidence that the monitoring system could be more efficient, focused, and comprehensive.

INSTITUTIONAL OBJECTIVES AND THEIR LIMITATIONS

As described in Chapter 5, the objectives that motivate marine monitoring can be considered as a hierarchy or continuum. This begins with broad public concerns about public health and the status of marine resources; extends through laws, regulations, and permits; and ends with the specifications of individual monitoring programs. In Chapter 3 the public's concerns were reviewed in the section "Public Concerns for the Bight," while the laws that furnish the regulatory context for monitoring were reviewed in "The Regulatory Sector." Finally, the structure of effluent limitations and water quality criteria was described in Chapter 4 in "The Monitoring Sector."

These objectives influence the design of monitoring programs. They also influence the institutions that oversee the monitoring system. As a result, objectives are expressed explicitly in permits and other documents and implicitly in the behavior of the institutions that regulate monitoring. The following two sections address each of these aspects in turn.

Objectives

Because of the vast number of parameters that could be measured in the marine environment, monitoring programs require clear and precise objectives. The numeric effluent limitations and water quality criteria in discharge and other permits provide such precision. However, the narrative water quality criteria relating to unacceptable degradation or change do not furnish this level of precision. For example, the NPDES permit for the County Sanitation Districts of Orange County states that marine communities shall not be degraded. To monitor degradation in fish communities, a program could legitimately focus on any of the following parameters:

- diversity,
- species richness,
- community trophic structure,
- relative abundance of numerically dominant species,
- population sizes of numerically dominant species,
- population sizes of trophically important species,
- size-age relationships,
- reproductive potential as measured by gonad weight,
- mortality of one or more species,
- incidence of fin rot, tumors, and other abnormalities, or
- body burdens of specific contaminants.

Although these are all measurable parameters that may be indicators of degradation, they do not define it. To design a monitoring program with the objective of ascertaining "degradation," the term must be defined in a meaningful way. Thus, monitoring program objectives should be stated as clear, preferably quantitative, questions or null hypotheses: for example, a program could be designed to determine if the three most abundant fish species within 3 mi of the Orange County outfall had decreased in abundance by more than 50 percent from one year to the next. Such a decrease might be defined as a degradation of these fish populations.

One of the most comprehensive efforts to state monitoring objectives in Southern California is an Environmental Protection Agency (EPA) document titled *Objectives and Rationale for the County Sanitation Districts of Orange County 301(h) Monitoring Program*. For each program element, objectives of the relevant laws and regulations are stated, and sampling and analysis plans are specified. Objectives are precisely stated for influent, source control, effluent, and solids-handling monitoring. Although objectives for receiving-water monitoring are stated more clearly than ever before, they still contain no quantitative criteria for the kinds or amounts of change that should be monitored for. This is an important shortcoming because receiving-water monitoring focuses directly on determining whether human and ecosystem health objectives are being met.

This demonstrates that another level of detail is needed if monitoring in the bight is to consistently provide useful information. It should consist of specific descriptions of the kinds of changes, along with quantitative criteria about the amount of change, that should be monitored for. Hypothetical examples of such objectives, framed as null hypotheses, might be as follows:

- The operation of diffusers for the discharge of cooling water will not decrease the monthly average light transmission in the upcoast quarter of the adjacent kelp bed more than X percent below light transmission in the downcoast quarter of the kelp bed.

- The area around the sewage outfall outside the zone of initial dilution (ZID) exhibiting a change in benthic diversity of X percent or more shall not increase from year to year. Background diversity shall be defined as that found at reference stations A, B, and C.
- The long-term trend of DDT in the muscle tissue of adult Dover sole from the Palos Verdes Shelf shall not increase. Long-term shall mean a period of five years or more, and sampling shall be designed to detect a change in the long-term average of at least 5 percent.

These null hypotheses define a specific parameter and the amount of change to be measured. Before actual sampling begins, additional detail relating to confidence limits, background levels, and other factors must be decided. In the first hypothesis above, locations (surface, bottom, midwater, water column average), time scales (daily, weekly, monthly averages), and distribution of sampling stations must all be established. These decisions can be made with the support of the technical design tools outlined in Figures 5-1 to 5-4. In contrast to most objectives used as the basis of receiving-water monitoring, the three examples above provide the foundation for focused, efficient monitoring programs.

In contrast to other major monitoring programs in the bight, the Marine Review Committee (MRC) programs around the San Onofre Nuclear Generating Station (SONGS) were all designed with a specified probability of detecting definite amounts of change (Chapter 5). This policy was based on predictions of impacts and on a management decision that these amounts of change would be accepted as evidence of power plant impact.

There are two impediments to establishing this detailed level of objectives: (1) incomplete scientific knowledge (for example, an inability to establish source/receptor relationships), and (2) the institutional environment of monitoring. The environmental effects of all human activities cannot be predicted accurately. Where they cannot, objectives must necessarily remain more subjective, or research should be performed. In other cases, however, environmental effects are well enough understood that reasonably accurate predictions could be used to design more efficient monitoring programs. The changes that occur in the benthos around municipal waste discharges are a case in point. Changes in community composition, abundance, diversity, etc., have been well documented and could be used to develop more ecologically relevant and precise receiving-water objectives. Even where clearer and more quantitative objectives could be developed, however, there may be institutional constraints against implementing them.

For example, quantitative receiving water objectives could decrease regulatory flexibility if they were rigidly interpreted as a measure of compliance and automatically triggered management actions or litigation.

Despite these impediments, clearer monitoring objectives would result in beneficial gains in clarity, efficiency, and useful information. These gains would make the effort involved in developing them and integrating them into the regulatory framework worthwhile. In spite of these benefits, a danger of quantitative monitoring objectives is that they may be applied blindly, with little regard for naturally occurring effects. For example, between 1973 and 1977, there was a massive influx of the echiuran worm *Listriolobus* into benthic communities in the bight (Stull et aL, 1986). This organism's burrowing, respiratory, and feeding activities aerated and reworked sediments throughout the bight. In areas of wastewater impacts (particularly White Point on the Palos Verdes Shelf) these activities reduced apparent impacts from the Los Angeles County outfalL When the worm disappeared, impacts reappeared. Without awareness of this naturally occurring but anomalous and confounding event, the strict application of quantitative criteria would have led to the erroneous conclusion that impacts of wastewater outfalls had decreased and then increased.

Institutional Limitations

The statutory and regulatory framework within which monitoring is conducted in Southern California has evolved piecemeal over time, and as a result, deficiencies and inconsistencies exist within the institutional structure. These affect not only the way monitoring is carried out but also the quality of the information monitoring can produce. The most important of these limitations are:

- lack of attention to nonpermit activities that may have large environmental impacts;
- rigidity and lack of flexibility; and
- a piecemeal, permit-by-permit approach to problems that may actually be larger in scope.

These limitations will be discussed in turn and illustrated with specific examples.

Nonpermit Activities

The vast majority of monitoring in the bight is compliance monitoring; that is, it is required as a condition of obtaining a permit. The unstated assumption underlying this policy is that the permitting process addresses all aspects of discharges and other activities that potentially affect the environment. This is not always the case, however, since some large inputs of contaminants are not covered by permits. These include rivers, which contain runoff, treated municipal waste water, and upstream discharges; storm drains; fallout of airborne pollutants; and diffuse inputs of hydrocarbons and other contaminants from marinas and harbors.

Although rainfall is sporadic in Southern California, winter storms can dump 1 to 3 or more inches of rainfall within 24 hours, washing accumulated contaminants from streets, sidewalks, and other surfaces into rivers and storm drains, where they are carried out to the ocean. The river system in the Los Angeles basin (Figure 1-2) drains a watershed of over 4,100 mi^2. During a major storm, the Los Angeles River alone can discharge 65 billion gal of water during a 24-hour period. Additional runoff enters the ocean directly from storm drains. For example, 75 separate storm drains discharge into Mission Bay in San Diego. Many of the industries that discharge into rivers and storm drains operate under National Pollutant Discharge System (NPDES) permits, and there is some monitoring in the Los Angeles basin rivers. However, many river and storm drain inputs are not monitored, and the system as a whole is not managed as a source of contamination.

The bight is adjacent to urban areas that are major sources of air pollutants. Aerial fallout to the ocean surface constitutes a significant source of contaminants (e.g., Table 2-2). The many marinas and harbors are sources of hydrocarbons and other contaminants derived from bilge pumping, sewage discharge, fuel loading and transfer, marine construction and maintenance activities, and ship traffic. Therefore, it is clear that monitoring to satisfy permit requirements does not address all of the large inputs of pollutants to the bight.

Inflexibility

Because monitoring programs are typically defined in regulatory permits, it is difficult to alter them as knowledge accumulates. The lengthy public hearing process required for updating permits has occasionally deterred permittees from attempting to modify their monitoring programs. In addition, there is a natural reluctance to discard or modify parameters that have traditionally been measured, but which may now be outmoded. As a result, monitoring programs often include outdated or inappropriate measurements. Further, procedures that are experimental or in development have been incorporated as routine elements of monitoring, even though the data they produce are not adequate for decision making.

Oil and grease (a generic contaminant category including petroleum, synthetic, and biological "oily" materials) are measured throughout the water column as a part of several wastewater outfall monitoring programs. However, because most oil and grease float, and therefore are rarely found above detection limits in the water column, it is not cost effective to sample there. In addition, dissolved and dispersed oil and grease derive from many other sources, such as oil seeps, bilge pumping, aerial fallout, refinery effluents, stormwater runoff, and even from natural biological sources. Therefore, they are equivocal indicators, at best, of outfall impacts. It was suggested that floating grease balls, which can more directly be related to wastewater outfalls, would be a better indicator.

Biological and chemical oxygen demand (BOD and COD, respectively) have traditionally been measured as part of benthic monitoring programs around wastewater outfalls. These parameters were originally included in receiving-water monitoring programs because they were used by sanitary engineers to monitor in-plant sewage treatment processes. There was a consensus among practitioners in the bight that these parameters are less biologically relevant in an open ocean environment and therefore cannot be meaningfully interpreted. It was suggested that measuring organic carbon and carbon flux, ammonia-nitrogen, and total nitrogen would be more ecologically meaningful (see pages 28–29).

As a condition of their 301(h) permit, the County Sanitation Districts of Orange County are required to routinely measure a wide range of chemical contaminants, even though many of them are never found in effluent or sediments. This represents a large expenditure of resources where past experience has shown there is likely to be little contamination. In contrast, in Los Angeles City's Hyperion monitoring program, the search for chemical contamination is more focused. Priority pollutants in the effluent are measured monthly (quarterly for volatile organics), thus providing regular information about what is entering the environment. During the first monitoring year, all priority pollutants are measured in sediments, trawl-caught fish and invertebrates, and sport fish. Contaminants that were not found in the first year are not monitored during the second and third years. In the fourth year, the entire range of priority pollutants is measured again.

The city of San Diego is required to monitor suspended solids in the water column around the Point Loma wastewater outfall. However, because sampling stations are near the Point Loma kelp bed, the suspended solids samples sometimes contain larval crustaceans or pieces of kelp, seriously compromising the utility of this outfall plume indicator. More useful approaches here might be to measure light transmission or use sediment traps to determine fluxes of suspended particles in the water column.

The location of sampling stations can also be inappropriate. The sampling grid around the Point Loma outfall contains a southern control station that is of little or no use as a control because it is close to a dredged material disposal site and the sediments are predominantly extremely coarse sand. Even assuming that movement of material from the disposal site has not compromised the control station, the unusual sediments will necessarily be associated with a different benthic community, making meaningful comparisons with the outfall stations difficult if not impossible. At the northern end of the sampling grid, the city's permit required sampling a control station called B-2, located in 50 ft of water. This station was sampled for years, but was never used in analyses because there were no other stations at this depth. A transect had originally been planned at 50 ft, but all the stations, with the exception of B-2, were located in areas of rocky bottom, where benthic grab sampling was impossible. The city requested that it be allowed to stop sampling B-2 and instead add a control station at 150 ft. This would have been a more efficient use of resources because the sampling grid already included a transect at the 150-ft outfall depth, but lacked a control. Implementing this change in the sampling design required several years and a public hearing, at a cost of wasted sampling effort at B-2 and reduced ability to monitor impacts at 150 ft.

As part of its NPDES permit to discharge cooling water from coastal power plants, the Southern California Edison Company is required to monitor for thermal effects on marine resources despite the fact that nearly 20 years of studies have documented the limited nature of these effects. This example is indicative of the lack of clearly defined endpoints in monitoring studies, which hinder reallocation of monitoring resources to unresolved or more pressing issues.

Histopathology, tissue analysis for contaminants, and enterococcus measurements have been included as routine parts of monitoring programs, even though many participants in the case study believe they require more research and development before they can provide useful information. The panel stresses that these comments derived from a sincere desire to produce useful information and a frustration with requirements to perform studies whose results are ambiguous or uninterpretable.

Several unresolved issues apply to tissue chemistry studies. The basis of presentation of data has not been standardized, making it difficult to interpret and compare results. For example, data may be presented on a dry weight or lipid weight basis, with each method presenting a different picture of contaminant levels. The problem of confounding due to seasonal and reproductive cycles also has not been resolved. In the spring and summer, fishes' reproductive season, fats are mobilized and transferred from the liver to the gonads. This may affect contaminant levels not only in these tissues but in others as well (Cross et al., 1986). There may be differences in both the timing of reproductive cycles and in tissue chemistry between different species. However, because it is not possible to predict which species will be abundant enough for tissue chemistry studies at any one time, dischargers are allowed to sample species of opportunity. This means that no two dischargers consistently sample the same suite of species at the same time. It also means that the same discharger will sample different species in successive surveys. Given the unresolved issues related to seasonal cycles and interspecies differences, the lack of consistent target populations makes it extremely difficult to interpret tissue chemistry data and relate them to discharges.

The issues of standardization of measurement techniques, seasonal physiological changes, and inconsistent target species also plague histopathology studies. In addition, the interpretation of histological changes in marine organisms can be demanding and ambiguous, and it was suggested by several participants that this technique is not yet suitable for routine monitoring.

In contrast to these two examples of incompletely developed techniques being used as routine monitoring tools, the city of Los Angeles' Hyperion monitoring program includes a microlayer study that is explicitly experimental in design. The permit states that the first-year sampling results will be used to determine the scope and direction of future monitoring. It also defines first-year requirements of an otter trawl sampling program and stipulates that first-year data be used to refine the sampling design for subsequent years. In addition, Hyperion's permit includes specific language that allows for further flexibility as needed (see pages 63 and 65). These examples suggest that permits can be structured to be flexible and adaptable. This produces two important benefits. First, it allows for improving and refining monitoring programs as data become available. Second, it allows resources to be used more effectively by recognizing that some questions are more appropriately dealt with in a research context than in routine monitoring. Repeatedly collecting the same data over and over again is not always the best way to address unresolved questions about the utility of new technical methods.

The Southern California Edison Co. recognized this when it began its program of special studies in the marine environment (see Chapter 4). The special studies were explicitly experimental in nature because it was understood that it is often difficult to define research programs succinctly enough to make them part of routine monitoring. They produced information that was important in understanding and reducing impacts without becoming a part of routine monitoring activities. On the other hand, Edison personnel pointed out to the case study panel that they found the data from mandated monitoring programs based on conventional measurements to be of relatively little value in managing marine resources.

Permit-by-Permit Approach

The existing regulatory framework necessarily forces monitoring into a permit-by-permit approach to environmental problems in the bight. This results in monitoring programs that look at each activity in isolation from all others. Taking monitoring results at face value requires making two related and scientifically dangerous assumptions. The first is that there are no cumulative, overlapping, or interactive effects. The second is that the measurements taken to document the effects of a particular activity reflect that activity and no others. Neither of these assumptions is especially robust, as several examples will make clear.

The County Sanitation Districts of Orange County carry out a monitoring program around their wastewater outfall. Within or very near the sampling grid are other biological and physical/chemical patterns that interact with the effects of the outfall. On the eastern edge of the sampling grid is an active EPA interim-designated, dredged material disposal site for dredged material from upper Newport Bay. This dumpsite is in temporary use, and many of the contaminants found in the outfall effluent are also found in the dredged material. Just inshore of the outfall is the mouth of the Santa Ana River, which seems to be associated with a plume of modified sediments that affect benthic community patterns in the sampling grid. On the western edge of the sampling grid is a region of elevated contaminant levels of unknown origin. The permit-by-permit approach makes it more likely that these potentially confounding influences will be disregarded when designing a monitoring program for the Orange County outfall.

The city of Los Angeles and the County Sanitation Districts of Los Angeles and Orange counties all carry out fish trawling programs around the Hyperion, White Point, and Orange County wastewater outfalls, respectively. These sampling programs are used to independently assess the effects of each outfall on fish populations in the region of the outfall. However, it is likely that at least some portion of the studied fish populations moves throughout the entire area. This means that, for example, the monitoring program at White Point may actually also be measuring some effects of Hyperion and Orange County.

The city of Los Angeles' trawl sampling program in Santa Monica Bay is designed to document effects of the Hyperion outfall on fish populations. However, the Southern California Edison Company and Los Angeles Department of Water and Power also operate coastal power plants in Santa Monica Bay. Entrainment of large numbers of fish larvae by cooling water intakes and impingement of adults may affect fish population sizes and community structure in the bay. In addition, some of the species monitored in the trawling program may spend part or all of the juvenile phase of their life cycle in harbors and marinas in and around the bay. This example illustrates that patterns in fish populations (particularly population size and community structure) measured by the Hyperion monitoring program may actually reflect the effects of a suite of impacts, some of them occurring on other life stages than those targeted by the monitoring program. Other sources of effects were not incorporated into the design of the Hyperion trawling program despite the outfall's close proximity to coastal power plants; permitted and accidental discharges from oil refineries, stormwater drains, and nonpoint sources of pollution; marinas; and contaminated juvenile habitats.

The permit-by-permit approach to establishing monitoring programs also leads to important inconsistencies among monitoring programs. Some of these reflect the fact that permits were written at different times, with more recent permits incorporating more up-to-date knowledge. However, other inconsistencies reflect differences in approach or expertise among the regional water quality control boards and EPA Region IX personnel. As discussed more completely below, such inconsistencies make it difficult to develop an integrated view of impacts and trends in the bight as a whole.

Specific examples of inconsistencies among monitoring programs include the following:

- The city of Los Angeles has a flexible approach to measuring priority pollutants in sediments and organisms, whereas the County Sanitation Districts of Orange County measure priority pollutants regularly.
- Trawl sampling around wastewater outfalls is usually conducted quarterly or semiannually, but trawl sampling around coastal power plants is conducted every two months.
- The city of Los Angeles conducts offshore water quality sampling weekly because its discharge is near areas of intense water-contact recreational areas, whereas the County Sanitation Districts of Orange County conduct offshore water sampling monthly for some parameters and quarterly for others.
- No two dischargers consistently use the same organisms for tissue chemistry measurements.
- The city of San Diego is not required to conduct trawl, rig fishing, or tissue chemistry studies, although other dischargers are required to do so. However, trawls are performed on a voluntary basis to contribute to a regionwide assessment of fisheries resources.

TECHNICAL DESIGN AND IMPLEMENTATION

This section summarizes the extent to which monitoring programs in the Southern California Bight meet the criteria for technical design presented in Figures 5-1 to 5-4. The discussion is organized around

- the issues of statistical design of monitoring plans,
- the establishment of field and laboratory procedures that ensure valid, high quality measurements, and
- data management strategies.

Statistical Design

There is still room for improvement in how statistical tools—quantitative null hypotheses, statistical models, quantification and partitioning of variability, optimization analyses, and power tests, for example—are applied to program design. These tools are beginning to be applied to monitoring programs in the bight, and the EPA has produced 301(h) guidance documents that provide instructions for their use; however, lack of clear quantitative objectives prevents effective application. New monitoring tools can be properly applied only in the context of clear statements of management needs and the questions and/or hypotheses that reflect them. The following examples illustrate this point:

- Power tests can estimate the likelihood that a sampling plan will detect a change, such as an increase in the diversity of the benthic infaunal community of 0.1, 0.2, 0.3, 0.4, etc. Without guidance from regulations or ecological theory about what specific amount of change is important, it is still possible to perform power tests for a wide range of possible changes, then choose the sampling plan that is most likely to detect change (any change). However, a more useful approach would be to decide that a specific increase of 0.3, for example, is a strong indicator of outfall enrichment effects, then use power tests to design a sampling plan with a high probability of detecting that precise amount of change.
- Measurements of background variability can be extremely useful in designing efficient sampling plans. In spite of this, great time and expense could be wasted attempting to measure variability on all scales (e.g., feet to hundreds of miles and days to decades). However, if managers determine that only present effects within 6 mi of an outfall are of interest, other variability scales can be deemphasized. If managers are also interested in change from year to year, annual background variability would become relevant. If managers are interested in longer-term trends—more than 10 years, for example—then interannual variability on that time scale would become relevant.
- There has been discussion in the development of 301(h) monitoring plans about the proper number of "replicate" benthic grabs to take at each station. This discussion has used the results of technical design tools such as power analysis. Even these tools cannot resolve the issue because there is no one right number of replicates to collect. The proper number depends on the question(s) being asked, the amount of predicted change sampling

should detect, and the sources of variability that could obscure monitoring results.

This last point deserves further discussion because of the mistaken assumption that the same number of replicates is appropriate for all situations. As one example, if concern is focused on the difference in diversity inside and outside the ZID boundary at one point in time, then a different number of grabs at each station may be required than if the concern is about how the relationship between diversity inside and outside the boundary changes over five years. Further, if concern is focused on how diversity inside the ZID changes over five years in response to changes in the output of suspended solids, then another number of grabs might be appropriate.

Some of the deficiency in the consistent and proper use of technical design tools in monitoring programs in the Southern California Bight stems from the incorrect use of statistical concepts. Two such important concepts are "significance" and "replication."

Portions of permits and regulations state that a particular activity shall not cause a "significant" alteration, change, decrease, or degradation in some physical, chemical, or biological parameter. The California ocean plan (State Water Resources Control Board, 1987) defines a "significant" difference as "a statistically significant difference in the means of two distributions of sampling results at the 95 percent confidence level." The problem with this definition is that it provides no guidance in determining how large a change is of importance and should therefore be detected by a monitoring program. This is because virtually any change can be a statistically significant difference, depending on the intensity of sampling. Thus, a monitoring program with a low intensity of sampling will find only large changes to be statistically significant, while one with a high intensity of sampling could find even minuscule changes to be statistically significant. Permits and regulations should replace the word "significant" with another such as "meaningful" or "important" and then define the terms clearly.

There is an emphasis on replication in Southern California Bight monitoring programs but no equivalent awareness that replication has at least two different meanings, and that many aspects of a sampling plan can conceivably be replicated. Replication is loosely used to refer to the process of collecting repeated measurements, samples, or comparisons. However, in a stricter sense, it refers to the process of repeating entire experimental treatments. In addition, a sampling plan may have many levels of sampling, any and all of which may be repeated. For example, a monitoring program set up to determine whether benthic infaunal diversity inside the ZID is decreasing over time with respect to diversity outside the ZID might include:

- several stations inside the ZID,

- several stations outside the ZID,
- one or more "replicate" grabs at each station, and
- several sampling periods over time.

This sampling plan thus includes replicate grabs at each station, replicate stations within each area, and replicate times or surveys during which all stations are sampled. Depending on the resolution desired, technical design tools such as power and optimization analysis might indicate different numbers of "replicates" at each level of sampling (e.g., two grabs per station, five stations per area, and nine surveys over time). When different kinds of "replication" are not clearly distinguished, monitoring programs tend to emphasize repeated samples at a single place and time. A balance has to be struck between extensive replication of all samples and spreading limited sampling resources over other levels of a sampling plan.

Field and Laboratory Procedures

Many field and laboratory procedures are of commendable quality in Southern California monitoring, where an attempt is made to use state-of-the-art methods, particularly in the larger programs. In addition, an emphasis on improving monitoring methods has resulted in standardization of invertebrate taxonomy, benthic grab sampling techniques, and chemical analysis procedures. Monitoring programs at the municipal wastewater discharges benefit directly from research carried out at SCCWRP. New questions and new methods of sampling and analysis have been incorporated quickly into ongoing monitoring programs.

Although monitoring methods are state of the art, they may not always be adequate to address monitoring objectives. Such an example was described above with reference to tissue chemistry and histopathology studies. As another example, public health surveillance methods are not precise enough to detect brief episodes of mild illness among swimmers due to bacterial or viral agents in marine waters. In addition to the epidemiological problems, studies of putative viral agents are hampered by lack of culture techniques. There is growing recognition that there may well be a better indicator of fecal contamination than the coliforms (i.e., the enterococcus group), and health agencies are actively acquiring information to assess these new indicators. Because epidemiological studies are expensive to perform and marine epidemiological studies often yield equivocal results, especially when performed on a small-scale local basis, state and federal public health and water quality agencies have been reluctant to fund such studies.

Data Management

Data management is vitally important to monitoring efforts because it determines the final accessibility and utility of the data. Data management should include quality control procedures that ensure data accuracy at every step from initial collection to final analysis and reporting. It should also include methods for making the data readily available in usable formats to those responsible for analyzing and examining them. Another important but little-recognized aspect of data management is the importance of specifying data tabulation methods, structures, and handling procedures before a sampling program starts. This allows data to be collected and processed in ways that are appropriate to their final use, dissemination, and storage. This specification of data management procedures at the beginning of a program can save significant effort and money that would otherwise be spent correcting errors in raw data, analyses, and reports.

At present, there is a wide variety of approaches to marine monitoring data management in the bight. In spite of this variety, the panel found that the major monitoring programs all have well-developed and active systems for ensuring the accuracy and quality of their raw data. These data are continually reviewed and updated when necessary. The following examples are representative of data management approaches in the bight.

The 301(h) programs configure their data in the National Oceanographic Data Center (NODC) format and are now required to submit monitoring data to the EPA Ocean Data Evaluation System (ODES). ODES, designed to provide ready access to 301(h) data, has recently become fully operational and includes formal quality control procedures. However, not all historical outfall monitoring data are in digital format. For example, the Los Angeles County sanitation districts have computerized past monitoring data from the White Point outfall, whereas such data from the County Sanitation Districts of Orange County are available only in written reports.

Data from the California Cooperative Oceanic Fisheries Investigation (CalCOFI) program are in NODC format and are available in published data reports. The Southern California Edison Company maintains its own data base for a wide range of monitoring data. The National Marine Fisheries Service and the California Department of Fish and Game have fisheries monitoring data available on magnetic tape; however, these agencies do not maintain user-oriented data bases to provide access to these data. Scientists at the Scripps Institution of Oceanography monitor temperature and wave energy and provide these data on magnetic tape on request. Data from smaller studies (e.g., Los Angeles Harbor, Marina del Rey) are typically stored on floppy disks or on consultants' computer systems.

The city of San Diego and the County Sanitation Districts of Orange

County have initiated analogous programs to centralize and automate their in-house data management procedures. These systems provide computerized data entry functions that automatically perform quality control checks on a range of raw data. Validated data are stored in a centralized data base and a set of menu-driven options allow users to update and extract data. Additional menu options permit users to automatically produce standardized regulatory reports and automatically format data for submission to ODES. Finally, the systems incorporate links to a variety of analytical tools, such as spreadsheets and analysis and graphics software.

The taxonomic efforts of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) and the ODES data base represent important steps in setting consistent standards for standardization, quality control procedures, error checking, and digital formats for monitoring data. However, there is currently no easily accessible, user-oriented data base system to provide access to analysts interested in integrating data from several different kinds of studies. Such a system would greatly facilitate attempts to study regional and longer-term questions related to environmental effects in the bight.

There are two prototypes for such a system, each with its own strengths. These are the operational environmental data base developed by the Environmental Research Group of Southern California Edison and ODES. Both systems are unusual in that they include extensive quality control procedures and on-line documentation and are designed to permit data analysts to use menu-driven routines to readily extract data needed for analyses. Southern California Edison's system was designed to perform the following functions:

- store corrected and updated archival versions of important data sets so that all analysts access the same version of the data;
- store important data sets in a data base management system that provides the ability for easy extraction, updating, and manipulation of data;
- provide comprehensive on-line documentation of methods, error corrections, data characteristics and peculiarities, and publications for each data set;
- provide automated browse, search, retrieval, and reporting facilities;
- provide flexible links to the Statistical Analysis System (SAS) and other data analysis systems; and
- allow easy addition of novel data types to the system.

This system is fully operational and contains a wide variety of monitoring studies in standardized formats, thus facilitating comprehensive analyses. These studies currently include:

- benthic infauna and sediment data from monitoring programs at San Diego, Los Angeles city and county municipal wastewater outfalls;
- Southern California Coastal Water Research Project's (SCCWRP's) 198-ft (60-m) survey;
- Scripps' shoreline temperature data for the west coast of the United States, and wave energy and wave direction database;
- California Department of Fish and Game sportfish catch;
- National Marine Fisheries Service commercial fish catch data;
- benthic infaunal and sediment data from the Bureau of Land Management (BLM) study of the bight;
- complete impingement data for all Southern California Edison coastal power plants;
- data from bightwide ichthyoplankton studies and fish trawl studies performed for Southern California Edison; and
- selected Marine Review Committee studies.

This system is proprietary and is not accessible to scientists outside of Southern California Edison. It does, however, illustrate that such comprehensive databases can be constructed. The main strength of Southern California Edison's system is that it contains a wide range of data from biological and physical oceanographic studies that are bightwide in scope. The experience of constructing this database substantiated the fact that locating, acquiring, correcting, and standardizing disparate data sets is a significant effort.

The other system that points the way toward bightwide data management is ODES. ODES is intended as a national database to contain 301(h) monitoring data, which includes (among others) benthic infauna and sediment chemistry, otter trawl, water quality, and other data types. It includes a wide range of menus that assist users in extracting and combining data from different studies, in performing common types of analyses, and in creating maps and graphics. In addition, ODES provides for extracting raw data for analysis with other software packages.

Despite its strengths, ODES has shortcomings that restrict its utility and that must be corrected in any future system that successfully provides access to a range of monitoring studies. There is widespread dissatisfaction with ODES within the Southern California monitoring community. This dissatisfaction results from the difficult and labor intensive procedures required to format data for submission to ODES. It also stems from the lengthy wait required for feedback to requests for new species codes and answers to technical questions. There is therefore a long delay between the initiation of the submission process and the final availability of the data. Users of ODES have access only to the analysis and reporting routines that have been programmed into the system. While many of these are very useful, they do not cover the full variety of approaches required for a comprehensive analysis of monitoring data. Requests for additional analytical tools must wait until they can be programmed into the system, since ODES does not allow users to directly access other analysis systems. Users can, however, extract data from ODES and download them to their own computer systems. Another shortcoming is that when new data types are encountered, ODES must be reprogrammed to accept them, a process that can take several months. In contrast, data base systems that are designed for adaptability use table-driven data definition approaches to allow for rapid modification of data base structures.

ODES provides the ability to combine data from more than one study in order to perform regional or national analyses. However, in practice this capability is severely limited because ODES lacks an aggressive program to update data sets in the system and to standardize taxonomy among data sets. Experience in the bight has shown that such taxonomic updating and standardization is crucial if data sets are to retain their utility and if different studies are to be combined. Species names, particularly of benthic invertebrates, change continually over time as scientists adjust taxonomic affinities. Thus, for data sets to remain current, even historical data must be updated regularly. Taxonomic standards invariably differ among different studies. This is true even when efforts are made to use common standards. Thus, in order for data from two or more studies to be combined, careful attention must be paid to reconciling these superficial dissimilarities. As a result of the lack of such updating and standardization procedures, only analyses that do not depend on merging or matching species data can be performed with ODES. Such analyses include those using derived variables such as diversity indices, total abundance, numbers of species, or summaries of higher taxonomic groups.

TECHNICAL INTERPRETATION AND DECISION MAKING

The ultimate goal of monitoring is to provide data and information to support informed decision making. In this section, the technical interpretation of data obtained in monitoring programs and its use in decision making are addressed. Some examples show that monitoring data have been adequately interpreted and used in decision making. Overall, however, considering the effort that has been put into data collection, no comparable effort and expense has been devoted to translating that data into useful information and using it in decision making.

In spite of the shortcomings in the interpretation and decision-making process (reviewed below), it is important to recognize that monitoring information has played a significant role in many far-reaching management decisions in the Southern California Bight. Water quality and bacteriological monitoring data from Santa Monica Bay documented the severity and extent of nearshore contamination from sewage discharges in the 1940s and 1950s. These data helped make the case for construction of offshore outfalls in 1957 and 1959 that dramatically reduced nearshore sewage contamination.

In 1977, the California Department of Fish and Game closed the abalone fishery from Palos Verdes Point to Dana Point. This decision was based on monitoring surveys and catch data. As another example, scientists of NOAA's Ocean Assessments Division have used data from SCCWRP and the municipalities to evaluate environmental conditions relating to the body burdens of chlorinated hydrocarbons in coastal marine organisms (Mearns and O'Connor, 1984; Matta et al., 1986; and Mearns and Van Ness, 1987).

The inability of the city of San Diego's Point Loma wastewater treatment plant to consistently meet bacterial standards contained in the 1983 California ocean plan (State Water Resources Control Board, 1983) for offshore kelp beds contributed to a decision by the city to extend its outfall farther offshore. Earlier monitoring data generated by Southern California Edison Company showed that unacceptably large numbers of fish were being taken into cooling-water intakes of power plants. As a result, intakes were redesigned with velocity caps and other changes to reduce entrainment and impingement. Monitoring data were then used to confirm that the design changes were effective.

Data generated over the last eight years by the Marine Review Committee on the environmental impacts of SONGS will be used to make decisions about changes in the design or operation of the cooling-water system. These data will also be used to support the development of mitigation measures to offset impacts documented through monitoring. The recently released first-year report for the 301(h) monitoring program performed by the County Sanitation Districts of Orange County resulted in adjustments to the districts' permit. In addition, the data in the report suggested that no changes were needed in the waste discharge or treatment processes.

By far the greatest effort in data interpretation between the 1950s and the present has been the work of SCCWRP scientists. Starting with the 1973 report on conditions in the bight and implications for management (SCCWRP, 1973), their periodic reports and scientific journal publications have become internationally recognized. Although their work has included much more than evaluation of routine monitoring data, it has resulted in improved monitoring methods and in quality control activities that increase the reliability of the data. In fact, the scientific publications of the majority of SCCWRP scientists are cautious, if not silent, on interpretation of monitoring data with respect to regulatory actions. Instead, their interpretations generally focus on environmental conditions and, to a somewhat lesser extent, on possible impacts of pollutants.

On a smaller scale, the Channel Islands National Park monitoring program has generated data since 1981 from diving surveys at 14 stations, conducted primarily by volunteers. These data are used to make decisions about visitor access, harvesting of resources, and development of the park resource. As another example, the program conducted by Occidental College for Southern California Edison was originally related to monitoring the effects of waste heat discharge from coastal power plants. It has also yielded useful resource information on a sedentary reef fish community. This latter example demonstrates that if data were made available scientists would find monitoring programs useful for filling in information gaps about marine resources.

In many instances, the use of monitoring data is not as clearcut as in the examples just cited. In some cases, it is difficult to document whether decisions were based on monitoring results, particularly when decisions were made not to change existing procedures.

In some instances, disagreements about the interpretation of data can hamper the ability to make resource management decisions. For example, during the 1940s and 1950s, major differences of opinion among scientists working on sardines hindered implementation of the management measures needed to protect this fishery resource (Baxter, 1982). Scientists from the U.S. Bureau of Commercial Fisheries contended that year-class size was independent of the size of the spawning stock and that catch size therefore had no effect on stock size in subsequent years. California Department of Fish and Game scientists believed that there was a strong link between year-class size and spawning stock size. By the time the disagreement was resolved in 1966 in favor of the Department of Fish and Game, the fishery had collapsed.

Complicating such scientific uncertainty is the fact that the societal implications of resource decisions can be quite extensive. Thus, decisions based on limited data impose risks that managers have to weigh against expected benefits and the time constraints of required actions. For example, decisions involving the economic livelihood of fishermen who harvest pelagic fish stocks may require a decade to correct if the result of the decision is not as expected. In fact, a decade or more may sometimes be required to produce a signal sufficient to determine if the decision was correct.

In addition to scientific uncertainty, institutional limitations can limit the effective use of monitoring information in decision making. All too frequently, data reports sent to regulatory agencies are not subjected to thorough scrutiny and summarized for policy makers and the public. This is because the human resources and budgets of the regulatory agencies are inadequate to interpret the growing masses of data generated each year and translate them into information useful to environmental managers and policy makers.

Dischargers and other permittees often perform extensive analysis and interpretation of monitoring data. However, their reports are usually too lengthy and detailed to be readily accessible to policy makers and the public. In most cases, budgets earmarked for data analysis and interpretation by both the regulatory agencies and the permittees are judged inadequate. It was the consensus of the case study participants that monitoring data were incompletely synthesized and inadequately used in decision making. This is unfortunate because many monitoring reports contain extensive data sets that are not available in scientific journals even though they are peer reviewed to rigorous standards. In spite of this, some are suspect because the quality and quantity of the reviews are not documented. A statement at the beginning of such reports documenting the review process would have a favorable payoff in building confidence among the aware lay public who are trying to sort out technical issues. There are some exceptions to this generalization (for example, Matta et al., 1986) that provide both data, frequently from monitoring programs, and analysis of data. These are widely distributed and are cited in many regulatory documents such as the 301(h) decision documents.

Another institutional limitation derives from the differing responsibilities of the various regulatory agencies involved in managing monitoring activities. The EPA acts primarily as an enforcement and compliance agency. The state of California, through the State Water Resources Control Board has primary responsibility for the development of ocean policy in general, represented by the California ocean plan (State Water Resources Control Board, 1987). Evaluation of monitoring data is one part of the process of developing this policy and the specific regulatory actions intended to implement it. The state board establishes overall policy and the regional water quality control boards determine individual permit requirements.

Both the EPA and the regional boards believe that most monitoring programs are well planned, well executed, and yield data that are useful in demonstrating compliance and in documenting regulatory changes. The state board, however, has the additional responsibility of identifying beneficial uses of marine resources and establishing water quality objectives to protect those uses. The state board staff believe that the question, "Are beneficial uses being protected?" is of more fundamental importance than mere compliance, but that monitoring data are not presently adequate to answer this question. As explained in the next section, this may be because the available monitoring data are not sufficient to fully address this broader question and because the specific questions are not asked precisely enough to guide monitoring efforts.

OVERALL ORGANIZATION OF MONITORING

The preceding description and analysis of monitoring efforts in the Southern California Bight show that monitoring has achieved important successes. It has documented the extent of impacts from point sources such as power plants and wastewater outfalls. It has tracked the improvement of gross contamination in areas such as Los Angeles Harbor and the beaches of Santa Monica Bay. Longer-term studies, such as those carried out at the White Point outfall by the County Sanitation Districts of Los Angeles, have provided valuable insights into how human impacts interact with natural disturbances.

However, the same analysis shows that the existing monitoring system does not address all important sources of impacts (e.g., storm drains). In addition, Figure 5-5 shows that many important resources are affected by more than one kind of human or natural perturbation. In spite of this, there are no monitoring programs that focus on resources by integrating data about the cumulative effects of more than one kind of perturbation. This is because the monitoring system derives predominantly from a focus on regulating specific human activities, rather than managing natural resources. Finally, Figure 5-6 shows that many contaminants and other sources of change act on time and space scales much larger than those of the typical monitoring program. As a result, the existing monitoring system has difficulty resolving bightwide patterns of change that may be just as important as the localized impacts that are the current focus of monitoring.

In Chapter 5, four questions were identified as being especially pertinent to evaluating the overall success of monitoring in the bight. These were as follows:

- Does monitoring address clearly stated management and societal objectives?
- Does monitoring address the major environmental problems facing the bight?
- Do the spatial and temporal scales of monitoring reflect those of the major environmental problems?
- Are monitoring resources allocated effectively both within and among monitoring programs?

The foregoing analysis provides the basis for answering these questions. In each case, the summary answers below are focused on assessing the performance of the monitoring system as a whole, rather than on individual monitoring programs.

Objectives

As described previously, there are different kinds of objectives that motivate monitoring, from the broad concerns of the public to the detailed specifications of individual monitoring programs. These objectives can be classified as those pertaining to the effects of specific activities (e.g., dredging), to the overall status of important resources (e.g., kelp beds), and of the bight as a whole. Because of the institutional structure of the regulatory and permitting system, only the first of these is addressed in any detail by the existing monitoring system. In Figure 5-5, this can be represented as looking only at each row in isolation, ignoring both columns and the matrix as a whole.

While objectives relating to measuring and managing the impacts of individual activities may not always be clearly stated, they nevertheless are the unmistakable focus of permits and monitoring programs. In contrast, important concerns about the status of resources and the bight as a whole are not manifested in the more detailed objectives that structure monitoring programs.

Major Environmental Problems

There can be no arguing with the fact that monitoring addresses many of the major environmental problems facing the bight. However, it is also clear that the existing monitoring system cannot address other problems that are just as pressing. These include nonpermitted sources, such as storm drains and atmospheric input of contaminants. They also include cumulative impacts stemming from the action of more than one kind of human or natural perturbation on a single resource. Finally, the existing monitoring system cannot adequately assess the existence and importance of large-scale and long-term environmental trends in the bight.

The importance of these other environmental problems is a result of two major trends in the bight. First, increasing population and attendant utilization of marine resources have magnified the potential for cumulative and large-scale impacts. Sources of contamination and perturbation are more numerous and more closely spaced than in the past. Second, the existing monitoring and management system has been remarkably successful in removing gross pollution from the bight. As a result, concerns about cumulative impacts and subtle changes over time have become relatively more important.

Spatial and Temporal Scales

As a general rule of thumb, the spatial and temporal boundaries of a monitoring program should match those of the phenomena it is attempting to monitor. As Figure 5-6 shows, the spatial and temporal boundaries of existing monitoring programs match those of some but by no means all of the relevant processes in the bight. As a result, the existing monitoring system has only a limited ability to resolve trends and changes occurring on larger time and space scales. Such trends and changes can be natural, in which case they represent a moving background against which human impacts must be compared. Large-scale changes can also result from human impacts that by their nature cannot be restricted to one location (e.g., DDT contamination).

The CalCOFI program (e.g., Chelton et al., 1982) and the Bureau of Land Management study of benthic communities in the bight (e.g., Thompson and Jones, 1987) provide examples of the ability of larger-scale sampling programs to describe important patterns that cannot be detected by point-source monitoring programs. Because monitoring occurs throughout the bight, the existing monitoring system has the potential for measuring events on larger time and space scales. However, this potential cannot at present be fully realized because separate monitoring programs are not sufficiently coordinated and integrated.

Allocation of Monitoring Resources

Despite the large amount of time and money (at least $17 million per year) spent on monitoring in the bight, it is not possible to perform all the monitoring that would be desirable given unlimited resources. The available resources should therefore be allocated based on criteria that prioritize environmental problems and impacts. Such a process should be based in part on an overall assessment like that summarized in Figure 5-5. At present, this is not possible. Each monitoring program is developed independently, and its scope and cost are established in negotiations between the permittee and the regulatory agencies. As a result, some problems receive a disproportionate share of monitoring resources while others receive little or none.

SUMMARY

The analysis of monitoring in the Southern California Bight led to conclusions and insights about individual programs and about the monitoring system as a whole. In general, monitoring programs in the bight use state-of-the-art methods and produce accurate and reliable data. In addition, monitoring data have contributed to many important decisions related to pollution abatement and the management of natural resources. In general, monitoring has been successful in identifying and quantifying the impacts of such point-source activities as wastewater outfalls and coastal power plants.

In spite of these successes, the panel found several shortcomings, some related to the execution of individual programs and some to the institutional structure of the monitoring system as a whole. The most important of these were:

- poorly stated objectives that provided insufficient guidance for monitoring efforts;
- inability to monitor the effects of activities falling outside the existing permit structure;
- inflexibility that inhibits needed adaptability;
- overemphasis on a permit-by-permit approach to monitoring and environmental decision making, thus limiting the ability to monitor cumulative and large-scale impacts;
- insufficient use of statistical design tools in the development of sampling and measurement plans; and
- lack of a bightwide data management system to support integration and synthesis of data from different studies.

The panel performed a preliminary synoptic assessment of environmental problems in the bight. This assessment, combined with the analysis of individual programs, led to important conclusions about the structure of the overall monitoring system. Because the existing system focuses on individual permitted activities, it is unable to foster the higher level planning and coordination needed to assess cumulative and larger scale environmental problems. In addition, the focus on individual human activities makes it difficult to focus on important resources that are affected by more than one type of impact. As a result, it is difficult tc draw conclusions about the status of the bight as a whole and about whether beneficial uses of the marine environment are being protected.

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Conclusions and Recommendations

CONCLUSIONS

Current Monitoring Effort

1. The total amount of money and effort expended by public utilities, private industry, and government agencies in monitoring of water quality, natural resources, and public health in the Southern California Bight is extraordinarily large. A conservative estimate is that current annual expenses for monitoring far exceed $17 million (see Chapter 4).

2. Most water quality monitoring programs are organized around the outfalls of several large coastal municipal wastewater treatment plants and electric power generating stations and are elaborately detailed in their requirements.

3. The California Cooperative Oceanic Fisheries Investigation (CalCOFI) for natural marine resources in the California Current system and Southern California Bight has been unparalleled among marine resource monitoring programs in terms of its commitment to a long-term time-series assessment. However, station coverage has been reduced by budget cuts.

4. Significant sources of chemical and microbial contaminants contained in riverine and stormwater discharges to the bight have not been adequately monitored as part of the marine monitoring system in the bight.

Lack of Program Integration

5. There are no formal institutional mechanisms for integrating the findings from the different ongoing monitoring programs. This means that there is no mechanism for integrating the results from monitoring of various point sources with each other or with the findings of the resource or public health monitoring programs.

6. There is no system for interrelating the findings of various monitoring programs to present a coherent picture of the whole. This precludes evaluating the human impacts of bightwide human inputs in the context of natural variability, and thus it is difficult to evaluate whether corrective actions are effective.

7. There currently is no effective system for reporting findings of monitoring programs to the public, the scientific community, or policy makers.

8. The monitoring programs in specific permits have been designed to address small-scale discrete questions with little attention paid to the overall question of the status of natural resources and water quality of the Southern California Bight as a whole.

9. In the past, there have been recommendations for bightwide water quality, public health, and natural resource monitoring programs. These recommendations have not been implemented.

RECOMMENDATIONS

A Regional Approach

10. The questions of bightwide inputs and their impacts are growing in importance. Many of them could be addressed in a regional monitoring program. A regional program should be established that:

- addresses specific questions about the current environmental condition of the bight and the resources therein, including those associated with public health impacts, spatial and temporal trends in natural resources, nonpoint source and riverine contributions, nearshore habitat changes, and cumulative or areawide impacts of large and small point and nonpoint source inputs;
- incorporates standardized sampling, analysis, and data management methods;
- establishes a comprehensive data base management system for all monitoring and resource data in the bight, which could provide access to the historic and current data needed to perform comprehensive and bightwide analyses;

- can be facilitated through the coordination of local, state, and federal entities, which integrate their regulatory, data, and management needs and responsibilities to optimize the utilization of available resources;
- can be achieved largely through coordination, integration, and modification of existing efforts, rather than through the addition of another layer of monitoring in the bight;
- can be developed to involve the public and the scientific community as participants in the program;
- includes built-in mechanisms to ensure that its conclusions are effectively communicated to the public, the scientific community, and regulatory agencies; and
- includes mechanisms to require periodic review and to allow easy alteration or redirection of monitoring efforts when they are justified, based on the results of the monitoring or new information from other sources.

The effort to develop a regional program will need to address the needs of the agencies and parties involved in monitoring; synthesis of existing data and information in order to construct meaningful questions and null hypotheses; drafting of an organizational framework; drafting of a monitoring program; and allocating the financial resources required to carry out the program. If properly implemented, the benefits and the costs of a regional monitoring program can be shared by all sectors of society. However, it should also be noted that a regional approach ultimately has to consider the effects of competing uses on land, water, and air quality, and tradeoffs between short- and long-term costs and benefits.

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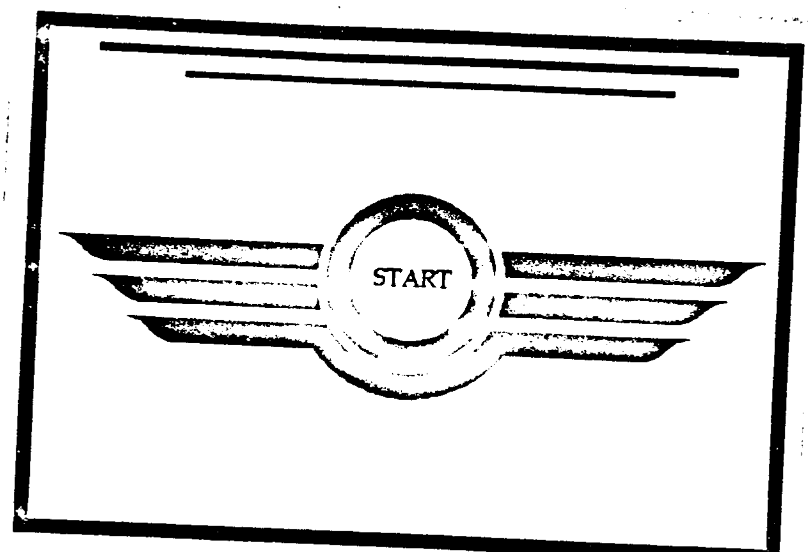

Toxicity of Stormwater Runoff in Los Angeles County

Previous studies of stormwater runoff by the Southern California Coastal Water Research Project produced estimated mass emission rates of solids and contaminants into the Southern California Bight (SCCWRP 1973, Young et al. 1980, SCCWRP 1988), but toxicity levels were never tested. Valerie Raco conducted this study to obtain estimates of stormwater runoff toxicity on marine life, to compare the water toxicity of different rivers (storm channels) during a single rainstorm, and to monitor a single river during a series of rainstorms during a one-year period.

The Microtox Toxicity Analyzer System was used to measure the toxicity of stormwater runoff samples by exposing luminescent marine bacteria to each aqueous sample and measuring changes in light output. The amount of light produced by the luminescent bacteria is an indicator of the general health of the bacteria, therefore the light is reduced when the bacteria are exposed to toxic solutions.

Samples of runoff water were collected from three storm channels in Los Angeles County: the Los Angeles River, San Gabriel River, and Ballona Creek (Figure 1), during four rainstorms in 1987 and analyzed for contaminant and toxicity levels. The Los Angeles River, which accounts for the largest flow in southern California (mean annual flow volume for 1983-1987 was 1.8 x 10^8 m^3 [1 m^3 = 35.31 ft^3]), drains west Los Angeles County from the San Fernando Valley, through downtown Los Angeles, to Long Beach. The San Gabriel River, which has the third largest flow in southern California (1.3 x $10^8 m^3$), drains southeastern Los Angeles County from the San Gabriel Mountains through the San Gabriel Valley to Long Beach. Ballona Creek, with the fourth largest flow (0.36 x 10^8 m^3), drains the western part of the City of Los Angeles. The drainage basins of the Los Angeles River, the San Gabriel River, and Ballona Creek encompass 2,110 km^2, 598 km^2, and 229 km^2 respectively. Both the Los Angeles and San Gabriel Rivers receive secon-

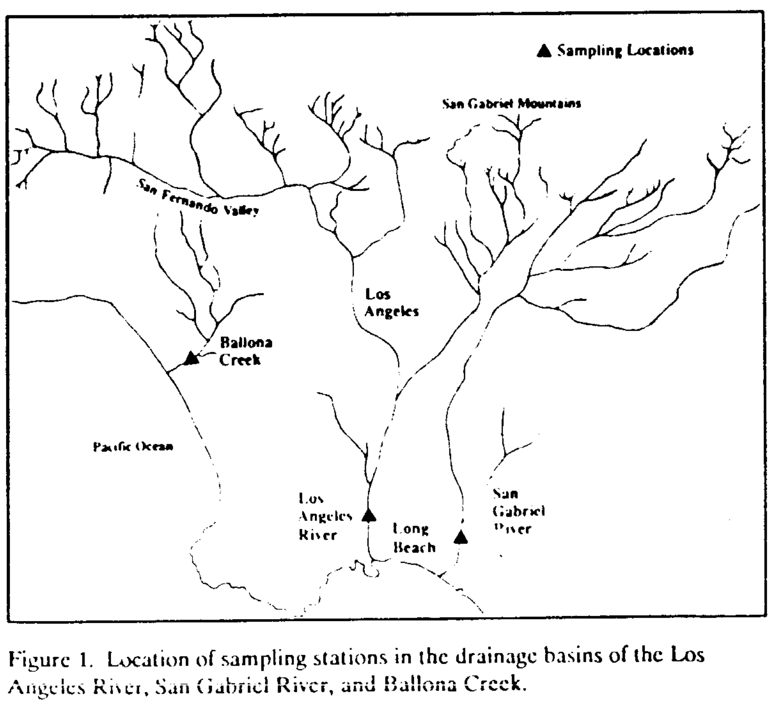

Figure 1. Location of sampling stations in the drainage basins of the Los Angeles River, San Gabriel River, and Ballona Creek.

dary and tertiary effluent from upstream municipal wastewater treatment plants throughout the year, but these discharges represent a minor flow component during storm runoff events.

Methods

Runoff samples were collected from the Los Angeles River, San Gabriel River, and Ballona Creek during rainstorms on January 4-5, March 21, October 22-23, and December 4-5, 1987. In this paper, the January runoff data is presented for all three storm channels, but only the Los Angeles River data are presented for the March, October, and December storms. Low-flow (non-storm) samples were also collected on October 31, 1986 from the Los Angeles River and Ballona Creek. The Los Angeles River collecting station was located at Willow Street in Long Beach, the San Gabriel River station was located at College Park Drive in Long Beach, and the Ballona Creek station was at Inglewood Boulevard in Los Angeles. Collecting stations were located as close to the mouth of each river as possible without encountering the tidal prism.

Runoff samples were collected during and sometimes immediately after each rainstorm. Toxicity testing was conducted within 2 days of sampling; samples were stored at 4°C until tested. Suspended solids in each sample were allowed to settle before a portion was removed for testing; if the sample remained turbid, it was centrifuged.

The Microtox Toxicity Analyzer System was used to

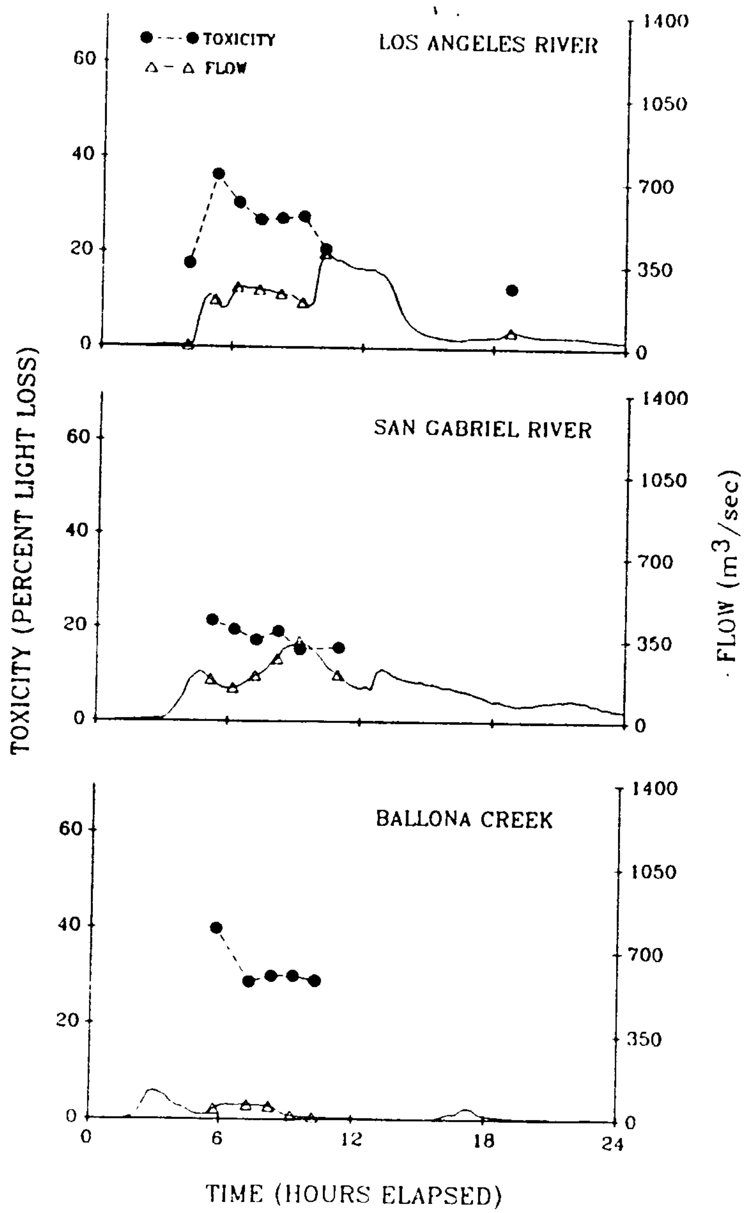

Figure 2. Runoff toxicity and flow rate for each of the rivers sampled during the January 4, 1987 rainstorm. The time axis represents the number of hours that elapsed after a time reference point before each storm.

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Methods

Runoff samples were collected from the Los Angeles River, San Gabriel River, and Ballona Creek during rainstorms on January 4-5, March 21, October 22-23, and December 4-5, 1987. In this paper, the January runoff data is presented for all three storm channels, but only the Los Angeles River data are presented for the March, October, and December storms. Low-flow (non-storm) samples were also collected on October 31, 1986 from the Los Angeles River and Ballona Creek. The Los Angeles River collecting station was located at Willow Street in Long Beach, the San Gabriel River station was located at College Park Drive in Long Beach, and the Ballona Creek station was at Inglewood Boulevard in Los Angeles. Collecting stations were located as close to the mouth of each river as possible without encountering the tidal prism.

Runoff samples were collected during and sometimes immediately after each rainstorm. Toxicity testing was conducted within 2 days of sampling; samples were stored at 4°C until tested. Suspended solids in each sample were allowed to settle before a portion was removed for testing; if the sample remained turbid, it was centrifuged.

The Microtox Toxicity Analyzer System was used to

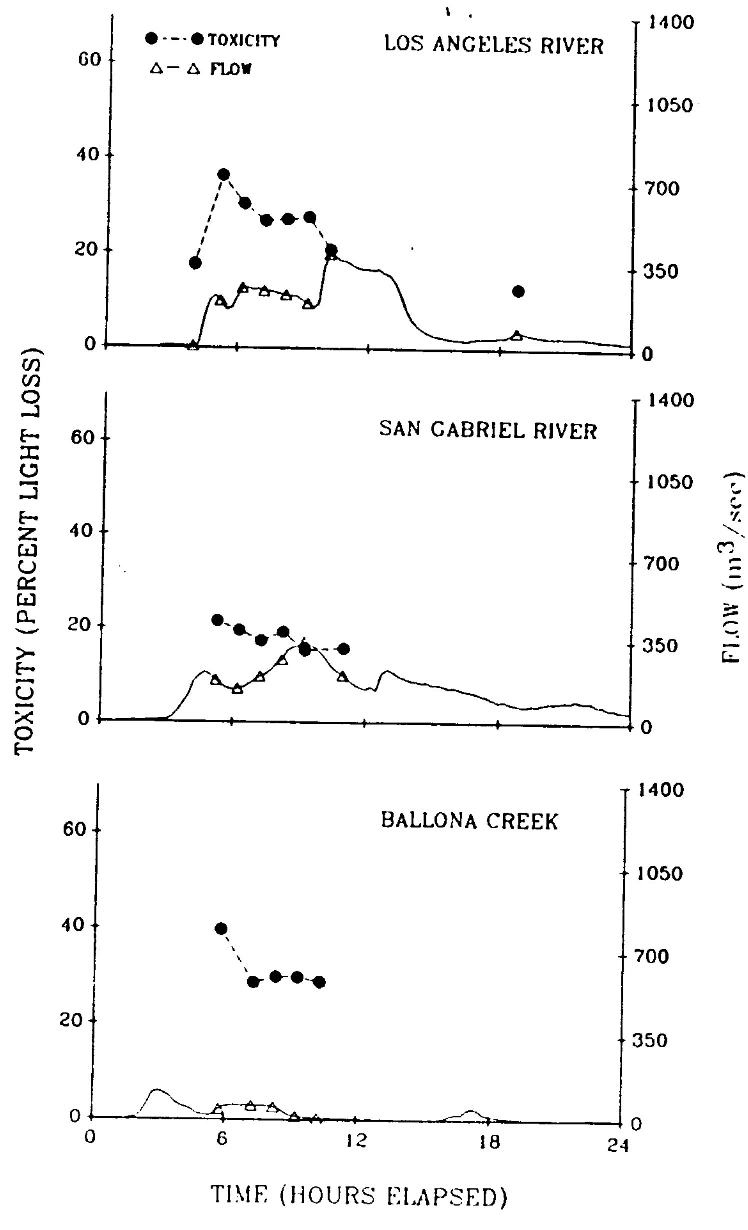

Figure 2. Runoff toxicity and flow rate for each of the rivers sampled during the January 4, 1987 rainstorm. The time axis represents the number of hours that elapsed after a time reference point before each storm.

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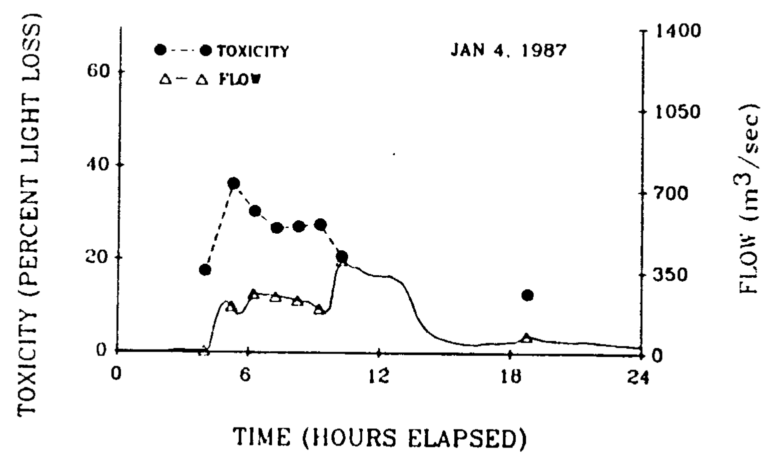
test runoff water toxicity as described by Bulich (1982). The Microtox procedure utilized freeze-dried marine bacteria *(Photobacterium phosphoreum)* which were reconstituted, diluted, and allowed to stabilize. All analyses were conducted at a salinity level of 20 ppt; all samples were adjusted to a salinity of 20 ppt by adding a concentrated sodium chloride solution to promote osmotic protection of the bacteria. Initial light produced by the bacteria was measured with the system's photometer and recorded. The samples and a control consisting of 20 ppt sodium chloride solution were then introduced to the Microtox bacteria, which diluted the samples to 45% of the original concentrations. After 30 min of exposure, light output was measured and recorded again. Toxicity levels were calculated by measuring the decrease in light output and normalized to the control.

Results

Toxicity results for the individual samples from each storm were plotted on graphs in relation to river flow rates in Figures 2 and 3; toxicity expressed as percent light loss (relative to the control) is graphed for the Microtox values. The toxicity of runoff collected during the January 4 rainstorm ranged from 13% to 36% light loss for Los Angeles River samples, 15% to 22% light loss for San Gabriel River samples, and 29% to 40% for Ballona Creek samples (Figure 2). Los Angeles River toxicity levels for all four storms ranged from 6% to 67% (Figure 3). It appeared that there was an elevated



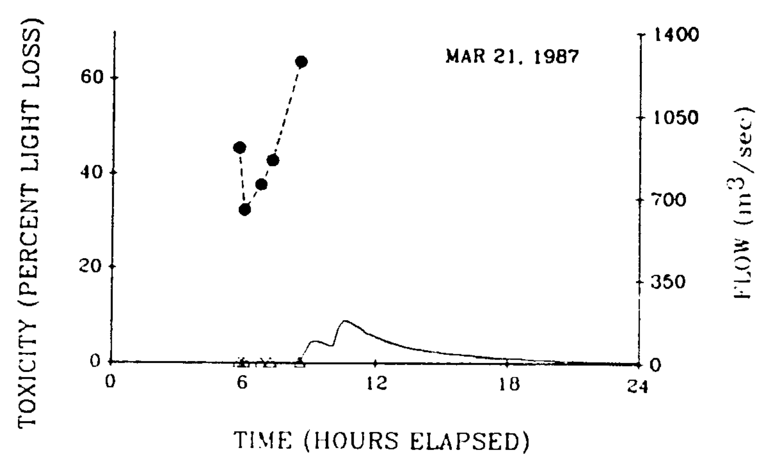


Figure 3. Runoff toxicity and flow rate of the Los Angeles River during four rain-
a time reference point before each storm.

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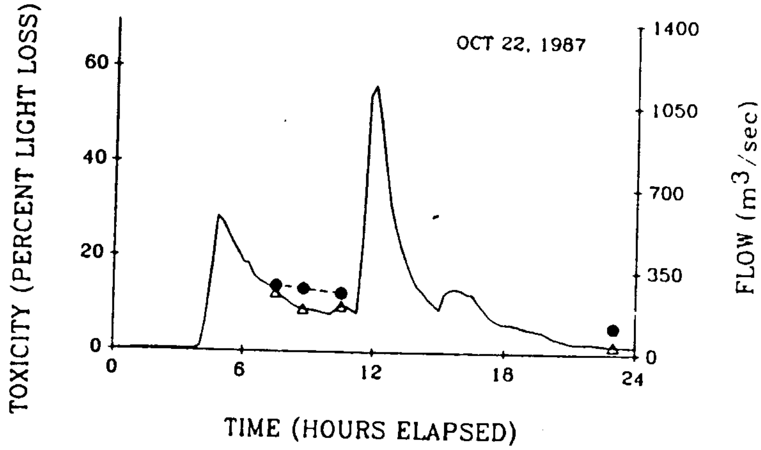

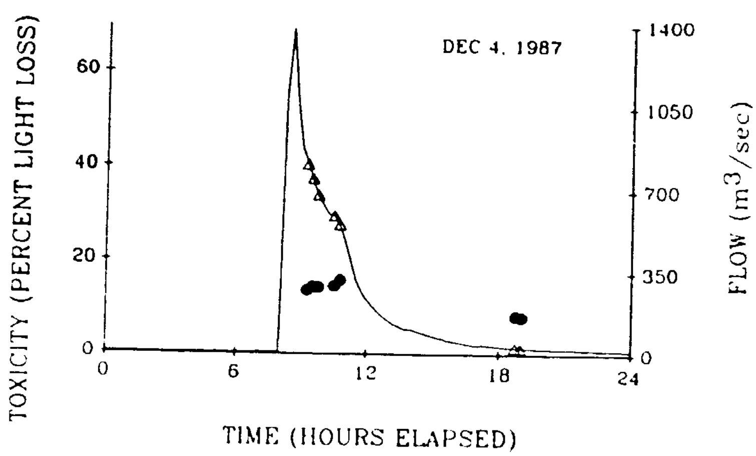

storms in 1987. The time axis represents the number of hours that elapsed after

level of toxicity in runoff waters at the beginning of the storms that roughly corresponded to the first peak of the flow rate; runoff toxicity generally decreased as the storms continued.

Because real-time measurements of flow rate were not available at the time of sampling, the important first peak in flow was missed at Ballona Creek during the January rainstorm and at the Los Angeles River during the March and October 1987 storms. However, March storm samples collected before the initial flow peak indicated that the toxicity changed rapidly and reached relatively high levels, which illustrates the importance of sampling during the initial phase of a rainstorm.

The Los Angeles River data presented in Figure 3 suggests that the maximum flow rate for the four storms had an inverse relationship with the maximum toxicity present; runoff from storms with larger flow rates generally had less toxicity than storms with lower flow rates. However, storm runoff sampled January 17, 1988 (data not presented in this paper) had a relatively low flow rate and low toxicity values.

The wide range of toxicity present at different sampling stations and during different storms is evident when comparing the toxicity data for each storm summarized in Figure 4. Mean toxicity levels for the storms was 18% for the San Gabriel River, 31% for Ballona Creek, and 13% to 45% for the Los Angeles River. The toxicity levels of the Los Angeles River and Ballona Creek for

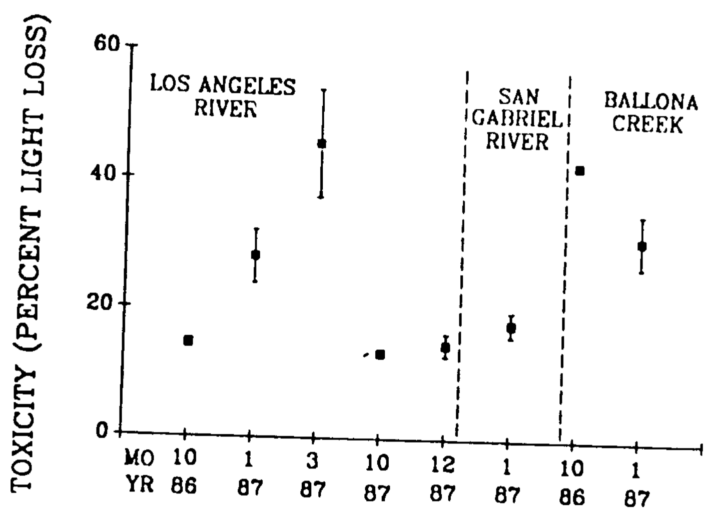

Figure 4. Stormwater toxicity levels (mean percent of light loss ±95% confidence intervals) for each storm sampled in 1987. Two low flow samples are included (October 31, 1986). Data collected after 90% of the total storm flow volume passed were not included in calculating the means.

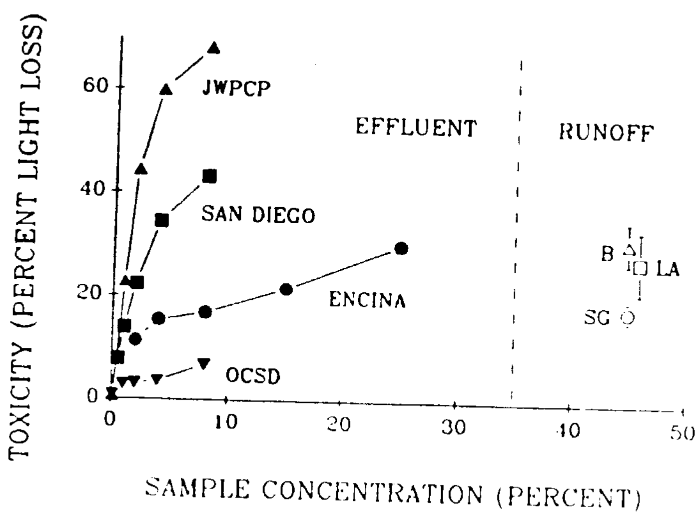

Figure 5. Comparison of wastewater effluent and runoff toxicity. Runoff data are means ±95% confidence intervals of all storms combined for each sampling station. Runoff data does not include low-flow sampling or samples taken after 90% of the total storm flow passed. Wastewater effluent toxicity was measured on 24 hr composite samples collected in 1987 or 1988.

January runoff samples were similar, while the San Gabriel River toxicity was much lower. This is probably a result of more commercial and industrial activity in the drainage basins of the Los Angeles River and Ballona Creek. However, the toxicity of the Los Angeles River low-flow sample (October 1986) was three times less than the Ballona Creek low-flow sample, possibly owing to the dilution of the Los Angeles River from the relatively clean tertiary effluent it receives. Due to insufficient sampling of the Los Angeles River during the March and October storms, trends that appear with respect to time (i.e. toxicity increases from October 1986 to March 1987, then decreases for October 1987) may be spurious.

Most southern California wastewater effluents seem to be more toxic than river runoff (Figure 5). When runoff and sewage effluent toxicities were compared, most effluent samples tested at much lower concentrations (≤25%) produced similar or greater Microtox effects than storm runoff samples tested at 45% concentrations.

Multivariate statistics were used to determine if runoff toxicity was related to the concentration of specific contaminants in the samples. A principal components analysis statistical procedure was used to reduce the number of variables by grouping those contaminants with highly correlated abundance patterns. Concentrations of suspended solids (SS), suspended volatile solids (SVS), trace metals, chlorinated hydrocarbons (CHCs), and chloroform extractables were included in this analysis. Polynuclear aromatic hydrocarbons (PAHs) were not included because they have not yet been measured.

Principal component analysis grouped the data into three factors: factor 1 was most highly correlated with concentrations of SS, SVS, Cr, Ni, and Cu; factor 2 had high correlations with the CHCs (total DDT, PCBs [Aroclors 1254 and 1242], and lindane), chloroform extractables, Pb, Zn, and Cu (almost equal to the correlation of Cu in factor 1); factor 3 was only highly correlated with Cd.

A multiple regression was performed on the principal component analysis scores versus the Microtox analysis results, which indicated that 59% of the runoff toxicity could be accounted for by changes in measured runoff characteristics. Factor 1 was the only contaminant group that had a significant correlation with toxicity (a subsequent principal component analysis on PAHs may yield different results). Within factor 1, toxicity increased with increases in SVS and decreases in SS, Cr, Cu, and Ni. Because the regression results indicated that toxicity decreased when Cr, Cu, and Ni concentrations increased, it is unlikely that the total concentrations of these trace metals were responsible for the observed toxicity. The results of principal component analysis indicate the SS or SVS content of storm runoff may substantially affect its toxicity, or that the runoff toxicity is strongly influenced by a type (e.g. PAH) of contaminant not yet measured.

Valerie Raco conducting Microtox analyses.

Discussion

This study provides information to help us understand the contribution of toxicity from stormwater into southern California marine waters. The data presented herein indicates that stormwater was generally less toxic than sewage effluent, and that runoff toxicity can vary substantially during a storm period, among a series of storms, and among runoff sampling stations.

Poor correlation between toxicity and conventional contaminant measurements calculated by principal components analysis indicate that toxicity should be measured directly by Microtox analysis or other bioassays to assess the biological impacts of stormwater runoff, instead of inferring toxicity from chemical measurements.

Continued research may provide information about which contaminants control the toxicity of stormwater and how these inputs affect nearshore organisms.

Acknowledgements

We thank Steven Bay, Dario Diehl, Richard Gossett, Darrin Greenstein, G. Patrick Hershelman, Jimmy Laughlin, Henry Schafer, Harold Stubbs, David Tsukada, Charles Ward, Skip Westcott, and Peter Szalay for helping to collect runoff water samples. Karen Englehart, Richard Gossett, G. Patrick Hershelman, Chuck Ward, Skip Westcott, and Peter Szalay are acknowledged for their assistance in extracting and analyzing trace contaminants.

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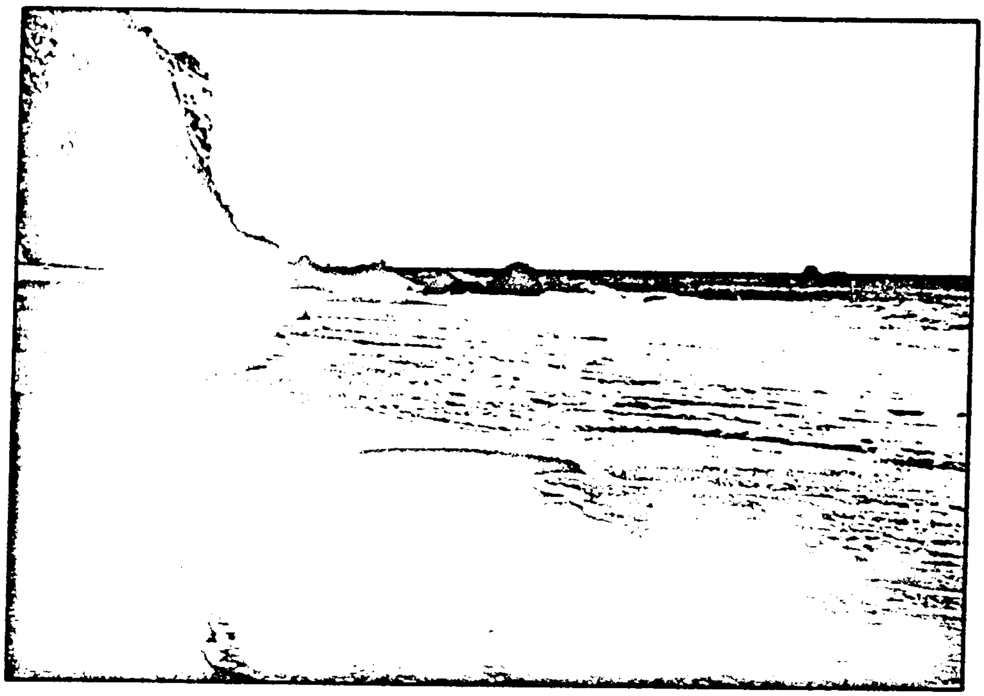

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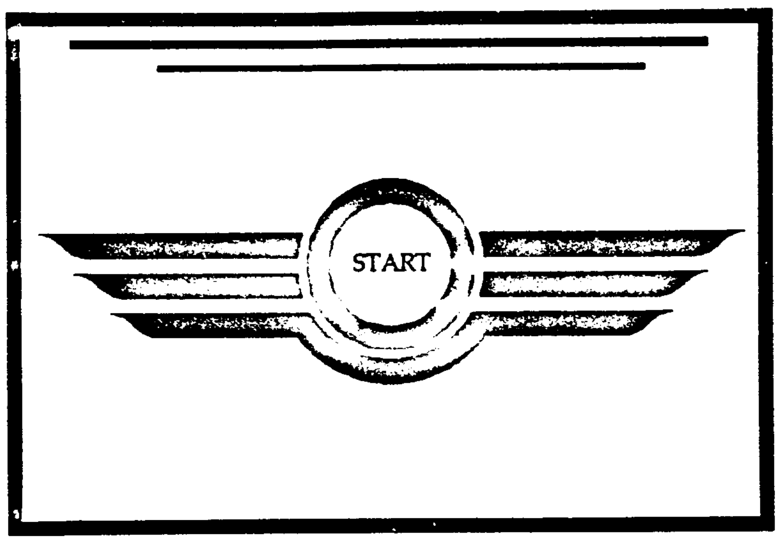

STUDY WORK PLAN FOR

SANTA MONICA BAY STORMWATER POLLUTANT REDUCTION STUDY

PREPARED FOR

CITY OF LOS ANGELES
WASTEWATER PROGRAM MANAGEMENT DIVISION
200 N. Main Street,
Room 600
Los Angeles, California 90012

DECEMBER 1987

PREPARED BY

ENGINEERING-SCIENCE
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8 January 1988

Mr. Stan Sysak
Wastewater Program Management Division
City of Los Angeles
200 N. Main Street, Room 600
Los Angeles, CA 90012

Dear Stan:

Enclosed please find three copies of the revised Project Work Plan for the Santa Monica Bay Stormwater Pollutant Reduction Study. This version reflects and incorporates comments made by your staff, the Hyperion staff, and Dr. Rainer Hoenike of the Regional Board. It incorporates all requests made by you for materials to be included for submission of the document to EPA for their review.

Upon approval of the Work Plan by EPA, Engineering-Science, Inc. (E-S) will provide a sufficient number of copies of the document to meet your internal and distribution needs.

The Project Work Plan document completes the first five tasks of the overall project work plan, as outlined in the revised document submitted to you by Mr. Phil Storrs on 12 August 1987, and reflected in the "Project Schedule and Management" section of the Work Plan. Upon contract approval, E-S will initiate plans for deploying equipment to collect rainwater runoff samples for analysis of target pollutant constituents. Other work tasks will follow in the progression described in the Project Work Plan.

E-S looks forward to working with you and your staff toward the successful completion of this project.

1/5/81

Cordially,

David W. Connally
Project Manager

Enclosures

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STUDY WORK PLAN FOR

SANTA MONICA BAY STORMWATER POLLUTANT REDUCTION STUDY

PREPARED FOR

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STUDY WORK PLAN

FOR

SANTA MONICA BAY
STORMWATER POLLUTANT REDUCTION STUDY

PREPARED FOR

CITY OF LOS ANGELES
WASTEWATER PROGRAM MANAGEMENT DIVISION
200 N. MAIN STREET, ROOM 600
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DECEMBER 1987

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BACKGROUND

On 19 February 1986 the City of Los Angeles (City) entered into an agreement with the Environmental Protection Agency (EPA) and the State of California in settlement of a lawsuit regarding violations by the City of its NPDES permit for wastewater discharges from the Hyperion Treatment Plant.

This agreement, as amended, termed the Consent Decree, placed several obligations on the City regarding waste treatment and cleanup. One of the terms of the consent decree was Item XIV, Stormwater Control Project, which required that funds be obligated for a stormwater discharge control project. Specifications and schedules were set forth in Appendix C of the Consent Decree. The City was directed to perform the study to "assess the nature and extent of discharges of pollutants from stormwater runoff from the Hyperion service area into Santa Monica Bay." The result of the study would be to recommend projects "to reduce effectively the discharge of such pollutants" into the Bay. The Consent Decree mandated that the City spend $3 million to implement control measures based on contractor recommendations and EPA approval.

The schedule for completion of the study was to be as follows:

Choose Project Manager	15 August 1987
EPA Approval	15 November 1987
Submit Work Plan and Budget	15 May 1988
EPA Review	15 August 1988
Submit Results and Alternatives	per study schedule
EPA Approval	90 days
Schedule to Implement Projects	90 days
Implement Projects	per schedule

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Engineering-Science, Inc. (ES) was chosen as the prime consultant to the City to perform the study. ES officially began work on the project on 7 September 1986. A work plan outline and budget were submitted to the City on 3 November 1987 for submission to EPA. The schedule associated with the ES proposal included:

Complete Data Review	March 1988
Complete Water Quality Sampling	September 1988
Land Use/Loading Summarization	September 1988
Project Identification	November 1988
Draft Report	December 1988
Final Report	February 1989

The schedule for the data review and water quality sampling components of the study have been accelerated slightly to take advantage of the 1987-88 Winter season. ES and its subcontractors have agreed to operate under a Letter of Agreement with the City, during negotiation of a final contract, in order to facilitate study initiation.

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INTRODUCTION

This Work Plan draws from information previously presented in ES's proposal and in a revised proposed work plan developed by ES to better define the tasks to be completed within the scope of work. The outline of this document corresponds closely with that revision. Major divisions include:

- o Summary of Available Data
- o Selection of Key Pollutants
- o Preliminary Pollutant Load Assessments
- o Selection of Detailed Study Areas
- o Proposed Monitoring Program
- o Use of Collected Data to Estimate Pollutant Loading
- o Identification of Pollutant Reduction Projects
- o Project Schedule and Management
- o Public Involvement

Input from several citizens groups and regulatory agencies suggested the need for more extensive collection and evaluation of offshore water quality data than is detailed in the work plan. Other comments were directed toward comparisons of pollutant loading by sewage discharges, other permitted discharges, and stormwater runoff. A suggestion to quantify the loading and relative impacts from stormwater and other inputs was also advanced. The approach and proposed sampling program developed for the work plan was deliberately restricted to collection of historical information and sampling of stormwater runoff that would provide information to give engineers and planners data needed to recommend the most effective control measures. A more extensive program to evaluate the toxicological effects and exposure pathways of the target pollutant materials once they entered the marine environment of Santa Monica Bay, or to comparatively quantify the effects of stormwater runoff, was deemed outside the scope of this study as mandated by the Consent Decree.

Discharge data for Hyperion Treatment Plant has been included in this report as a basis from which to quantitatively compare the relative importance of stormwater runoff constituents. Data from discharge

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monitoring at Hyperion exists for a number of years and is well-documented as a known level of input. Pollutant loading in stormwater runoff is a relative unknown in Santa Monica Bay. This study does not attempt to compare the relative impacts of stormwater runoff and sewage discharges, nor is it an indictment of Hyperion, which is a permitted discharge. A study currently in progress (MBC 1988) will attempt to quantify the impacts of sewage discharges and stormwater runoff in Santa Monica Bay.

SUMMARY OF AVAILABLE DATA

INTRODUCTION

Potential marine pollutants enter Santa Monica Bay via several pathways. These include advection of marine waters to the Bay from other areas (e.g. California Current, southern tropical waters during El Nino events), upwelling of deeper waters (especially near submarine canyon heads and southwest-aligned coastlines), aerial fallout, sewage discharges, surface runoff (from storm drains and natural streams and rivers), human marine activities (commercial and recreational boating, fishing, etc.), and the movement of contaminated marine life into the Bay from other areas.

The relative importance of these pathways varies with the pollutant of concern. During 1971-1972, surface stormwater runoff into Santa Monica Bay was estimated to contribute smaller amounts of most constituents examined than did municipal wastewater. Only iron emissions were greater in surface runoff. Nevertheless, except for large contributions of chemical oxygen demand (COD) and oil and grease by industrial discharges, surface runoff was considered to be the second most important source of most contaminants into the Bay (SCCWRP, 1973).

For the Southern California Bight in general, surface runoff emissions amounted to less than 10 percent of these contributed by municipal wastewater except for suspended solids, nitrates, iron, manganese, lead, and cobalt. These constituents are thought to have higher mass emission rates (kilograms or tonnes per year) in surface runoff than in municipal wastewaters (SCCWRP 1973). Lead in surface runoff in the Los Angeles River in 1979 had decreased by a factor of six relative to that found in 1971-1972 (presumably due to a decrease in the use of lead in gasoline). Total polychlorinated biphenyls (PCBs) had decreased by a factor of eight (presumably due to a ban on their use in open systems). In general, the mass emissions from surface runoff were an order of magnitude less than those found in municipal waste water, except for lead and zinc (Young et al. 1980). In 1985-1986, surface runoff from the Los Angeles River contributed greater mass emissions of suspended solids, lead, and zinc than did the Orange County Sanitation

Districts wastewater effluent (SCCWRP 1986). A continuing program of plant upgrading and secondary effluent treatment at Hyperion Treatment Plant (HTP) has reduced the loading of many of the pollutants of concern into Santa Monica Bay. In addition, the City of Los Angeles ceased discharges of treated sewage sludge into the Bay in late 1987, further decreasing the loading of potentially toxic constituents. As a result of these reductions, stormwater runoff loading is currently contributing a larger share of total pollutant loading to the Bay than it has in the past.

About 70 percent of the surface runoff in the Southern California Bight is the result of stormwater flows. The average annual flow from the storm drainage system into Santa Monica Bay is estimated to be 213 x 10^9 L/y, based on measured flows from Ballona Creek and extrapolated to include all storm channels draining into Santa Monica Bay (COWT, NRC 1984). During 1971-1972, the estimated storm flow of Ballona Creek was 26 x 10^9 L/y and the estimated dry flow was 15.7 x 10^9 L/y. The estimated storm flow of the Pico-Kenter drain was 1.2 x 10^9 L/y and the dry flow was estimated at 3.6 x 10^9 L/y. The storm flow of Malibu Creek was estimated at 3.4 x 10^9 L/y (SCCWRP 1973). Because stormwater runoff includes both street and land wash, it may include more trace contaminants than are found in municipal wastewater. Based on estimated mass emissions of constituents, the contribution of stormwater to the pollutant loading of Santa Monica Bay is thought to be substantial (COWT, NRC 1984).

Interest in the importance of stormwater runoff as a pollutant pathway to Santa Monica Bay has increased in recent years as environmental groups have pressed for removal of storm drain runoff from the beaches and surf and for better treatment of low flows and stormwater before it enters the ocean. These groups assert that stormwater runoff into Santa Monica Bay may represent a significant health hazard to that portion of the public which uses or resides near the Bay and to the marine life of the bay (Crow 1987).

A total of 24 storm drains discharge into Santa Monica Bay from the drainage area served by HTP (Hyperion Treatment Plant data, unpubl.). Although a considerable effort has been made to describe the nature of the wastewater that is discharged into the Bay by HTP and the effects of this wastewater on marine life, few studies have examined the nature of stormwater runoff. Those studies that have been conducted generally either have been conducted upstream in the storm drains or have monitored coliform along the beach. Little information exists on the constituents of stormwater for most storm drains or in the ocean.

SURFACE RUNOFF CONSTITUENTS

The importance of stormwater runoff as a pollution source to freshwater and marine receiving waters has long been recognized. Stormwater runoff typically consists of several major fractions: water, suspended solids, oil and grease, drifting macrodebris (human trash, plant debris), stream bed particulates (gravel and some human and organismal debris), and living organisms (including bacteria and small plants and animals). Most runoff studies have dealt with those components found in small parcels of water and these consist primarily of water, suspended solids, oil and grease, and bacteria. Most pollutants in stormwater runoff are associated with either the suspended solid fraction or the oil and grease fraction. The bacterial fraction is generally used as an indicator of the potential for human disease, as stormwaters may include septic tank overflows or sewerage system bypasses.

The relative abundance of the major constituents varies from region to region and is determined largely by the nature of the drainage basin and the intensity of the storm. Thus, concentrations of suspended solids are generally greater in runoff from natural or agricultural areas, whereas oil and grease are found in higher concentrations in areas draining transportation corridors and industrial areas. With the exception of silt and silt-associated constituents, stormwater in the Southern California Bight does not carry significantly higher or lower concentrations of constituents than does dry weather flow. Surface runoff is the primary source of beach sand supply (SCCWRP 1973).

Stormwater studies conducted in other regions have identified a number of basic constituents to stormwater runoff. These include sediment, heavy metals (lead, cadmium, copper, zinc, manganese, iron), and polynuclear aromatic hydrocarbons (PAHs; Hoffman et al. 1984, Ellis et al. 1986). In stormwater entering Narragansett Bay, Rhode Island, urban runoff accounted for 71 percent of the total inputs of higher molecular weight PAHs and 36 percent of the total PAHs (Hoffman et al. 1984). In the Los Angeles River, chlorinated hydrocarbon concentrations (i.e. DDT, PCB, and dieldrin) increased in a similar pattern with silt concentrations during storms, and decreased when storm flows subsided. Surface runoff throughout southern California during 1971-1972 accounted for about 1 percent of the amount of chlorinated hydrocarbons contributed to the coastal waters of southern California by municipal discharges (SCCWRP 1973).

Iron, manganese, and cobalt are natural constituents of surface runoff that are found in virgin soils (SCCWRP 1973). Other heavy metals accumulate near highways in proportion with the increasing traffic densities. Aerial deposition is the major source of metals entering the road drainage system. Urban deposition rates of zinc are greater than for lead. Zinc is primarily deposited as aerial fallout during storms whereas much lead is deposited directly from vehicular activities (Ellis et al. 1986). The oil and grease fraction is primarily composed of auto exhaust and derivatives, but petroleum hydrocarbons may have a variety of sources, including crude oil seepage (CRWQCB 1986). Although some kinds of PAHs occur naturally, most environmental PAHs result from combustion (e.g. forest fires and fossil fuels -- especially coal) and are deposited on land and water as aerial fallout. PAH concentrations are higher near highway and industrial land use areas than near commercial and residential areas. Some, however, are deposited directly from petroleum products, such as motor oil leakages. The kinds of PAHs occurring in urban runoff are similar to those found in aerial fallout but are dissimilar to those found in municipal effluents (Hoffman et al. 1984). Aerial fallout, surface runoff, and municipal wastewater are all sources of these pollutants entering the marine environment.

DYNAMICS OF STORMWATER RUNOFF EPISODES

Rainfall does not occur uniformly in space or time during a storm. For instance, rainfall does not occur equally over the drainage basin and several peaks in rainfall intensity may occur during a storm. Although stormwater runoff appears to follow a similar cycle to runoff intensity in the upstream drainage, the greatest runoff intensities occur after a time lag following the period of greatest storm intensity (Hoffman et al. 1984). This length of this lag will vary with the nature of the drainage and the intensity and quantity of rainfall occurring during the storm. If the drainage includes a significant quantity of nonabsorbent surfaces (i.e. streets, storm drains, parking lots), the lag time should be short, whereas if a significant amount of absorbent surface (i.e. porous soils) exists upstream, the lag time should be longer. Surface runoff volumes may represent 30 to 85 percent of the total incoming rainfall volume for the catchment basin, with losses resulting from surface characteristics, seasonal variation, and instrument limitations (Ellis et al. 1986).

There is some uncertainity concerning the importance of the length of the dry period preceding a storm in determining the amount of a given constituent that has built up prior to a storm. Higher levels of some runoff contaminants are often found in the first storms of a season, with lower levels in later storms ("first flush"; SCCWRP 1986). For instance, some constituents such as suspended solids are likely to occur in greater quantities after a long dry period. However, amounts of others, such as heavy metals and PAHs, appear to be unaffected by the antecedent dry period (Hoffman et al. 1984, Ellis et al. 1986). In addition, other factors associated with the dry period (i.e. chemical responses to temperature and light which may cause the loss of volatile materials to the atmosphere, or greater binding to other materials) or pre-storm conditions (i.e. winds which may carry airborne dust outside of the drainage basin) may influence this buildup (Hoffman et al. 1984).

Estimates of the relative importance of rainfall, runoff volume, and intensity in increasing metal loadings in runoff vary between studies (Hoffman et al. 1984, Ellis et al. 1986). Pollutant loadings (sediment and lead, cadmium, and manganese) in storm runoff from roadsides in England were most closely associated with total runoff volume and storm duration. The antecedent dry period and rainfall intensity were not important in controlling the removal of pollutants associated with particulates (Ellis et al. 1986). Concentrations of PAHs in storm drains in the Narragansett Bay, Rhode Island, watershed were most concentrated during the first or second flushes of the storm. Rainfall volumes and the length of the antecedent dry period were not correlated with the amount of PAHs in the runoff (Hoffman et al. 1984). In general, however, it appears that runoff volume is the most important factor controlling the loading of pollutants, with the preceding dry period and peak rainfall intensity controlling concentrations of pollutants (Athayde et al. 1982).

The constituents in stormwater runoff are not mobilized (i.e., released) equally during a storm. Some constituents are mobilized quickly and others are not mobilized until later (Hoffman et al. 1984, Ellis et al. 1986). The characteristic solubility and volatility of a compound contribute to the facility with which it is incorporated into the surface runoff of any particular storm. For instance, oil and grease are highly water-insoluble, and not likely to be flushed into the runoff unless the flow is sufficient to pick up particles with which they are associated (CRWQCB 1986). Suspended solids show a similar runoff pattern, as does both volume of runoff flow and high molecular weight PAHs which are associated with suspended solids. Some of these are enriched on small particles and some on large particles; these particles are differentially removed during a storm (Hoffman et al. 1984). Thus it is important to measure the quantity of each constituent mobilized at various parts of the storm cycle.

STORMWATER RUNOFF STUDIES IN THE SANTA MONICA BAY DRAINAGE BASIN

Several agencies and organizations have conducted or are conducting stormwater pollution or marine sampling programs that may measure stormwater pollution in Santa Monica Bay as a side benefit. These include the Los Angeles County Department of Public Works (Water Quality Division -- formerly Flood Control), Los Angeles County Health Department, Los Angeles City Department of Public Works (Hyperion Treatment Plant), Southern California Coastal Water Research Project (SCCWRP), the University of Southern California (Institute for Marine and Coastal Studies) and the Office of the Chief Administrative Officer of the County of Los Angeles (OCAOCLA). The Los Angeles County Department of Public Works and SCCWRP have collected samples in upstream portions of storm drains as well as at outlets. Both, as well as OCAOCLA, have measured a variety of constituents found in stormwater, with OCAOCLA conducting the most complete analysis of constituents. The Los Angeles County Health Department and the Hyperion Treatment Plant have monitored the inshore areas of the ocean in Santa Monica Bay for coliform bacteria. The University of Southern California (Soule and Oguri 1977) has sampled runoff at the mouth of Marina del Rey and SCCWRP has sampled runoff upstream in Ballona Creek; both sampled specifically during storms.

A report on investigations concerning reported cases of cancer in lifeguards and of the Pico-Kenter storm drain conducted by the Office of the Chief Administrative Officer of the County of Los Angeles (OCAOCLA 1981) described the characteristics of storm channel runoff of the Santa Monica Bay drainage. A wide variety of heavy metals and other toxic materials were measured in storm channels in this drainage. The storm channel water was dominated in yearly emission rate by total dissolved solids, chloride, sodium, sulphate, and chemical oxygen demand (COD). More than 250 components of each sample were assigned to polar and nonpolar groupings; the Ames test (Ames et al. 1987) showed the nonpolar grouping to be mutagenic, but no specific mutagen was found. Petroleum products, phthalate esters (in thinners, lacquers, and varnishes), and automobile coolant constituents (e.g. ethylene glycol esters and propylene glycol) were measured, and these are potentially mutagenic (COWT, NRC 1984).

The Waste Management Section, Water Quality Division of the Los Angeles County Department of Public Works (LACDPW) has examined the constituents of stormwater at the outlets of four storm drains since 1971 and upstream in Ballona Creek (Cheung 1987; Waste Management Section, LACDPW, unpubl. data). At present, storm drain outlets are sampled at Short Street (Santa Monica Canyon) and Pico (Kenter storm drain), and upstream on Ballona Creek at Sawtelle Avenue. The storm drains at Malibu Creek (sampled at Cross Creek Road) and Topanga Canyon (at Pacific Coast Highway) were also sampled before 1984. These stations are sampled quarterly for certain constituents and annually for a wide range of constituents (Cheung 1987). From 1974 to 1984 the full complement of constituents was sampled monthly. Recent surveys have not purposely sampled during storms. In general, flow data were not measured, but these data are kept by the Hydrology Department. After 1 January 1988 the Pico and Short Street outlets will be sampled more frequently and during storms (Cheung 1987).

The Recreational Health Program, Bureau of Environmental Protection, Los Angeles County Public Health Department, has sampled 13 stations along the beach in Santa Monica Bay during 1986 and 1987. These station extend from Pulga Canyon, Pacific Palisades, to Avenue I, Redondo Beach, and include the following storm drains: Pulga, Chautauqua, Santa Monica Pier, Pico-Kenter, Ashland, Windward, Marina del Rey swim area, Ballona Creek, Imperial Highway, Grand Avenue, 34th Place, Redondo Pier, and Avenue I. Each station was sampled about 50 m upcoast and 50 m downcoast from the outlet on a weekly schedule (Recreational Health Program, Bureau of Environmental Protection, Los Angeles County Public Health Department, unpubl. data). Samples were collected at the edge of the ocean and analyzed for total coliform, fecal coliform, and enterococcus. Samples were not collected at the storm drains for three to four days after a storm because of high coliform counts. These high coliform counts are often associated with nonhuman sources (i.e. horse corrals, soil bacteria, bird droppings) and the high counts rapidly decline to normal within a few days after a storm. Enterococcus is likely to be used more frequently in future studies because it is a better indicator of potential human contamination (Kebabjian 1987, pers. comm.).

Hyperion Treatment Plant has also conducted a similar monitoring program of the beach and storm drain outlets of Santa Monica Bay. Hyperion has collected water samples for 30 years from 17 beach stations and 8 offshore stations (along the 9 m isobath); storm drain outlets and areas of temporary special concern have also been sampled (Bartlett 1987, pers. comm.). Three additional stations were added in August 1987. Beach stations were located from Piedra Gorda Canyon to Malaga Cove and offshore stations from off Las Tunas Beach to off Hermosa Beach

(Hyperion Treatment Plant data, unpubl.). Beach stations have been sampled once daily and offshore stations once weekly. The Pico and Ballona Creek storm drains are monitored daily and several other storm drains (Entradero, Pulga Canyon, Sunset, Brook, Ashland, Market Street, Imperial Highway, Grand Avenue, and Avenue I) have been sampled Mondays, Wednesdays, and Fridays except when high dry weather flows occur, at which time they are sampled during high flows. Water quality is sampled at the surface and 2 m above the bottom (the latter since August 1987) at the nearshore stations; beach samples are taken by wading into the surf (Bartlett 1987, pers. comm.). In general, total coliform and enterococcus are the primary constituents measured, although fecal coliform is also measured at weekly intervals.

Bay mussels (Mytilus edulis) and California mussels (M. californianus) growing in Marina del Rey and Ballona Creek were examined for enteroviruses in 1975. The Ballona Creek mussels were also examined for total coliform and enterococci. Enteroviruses were found in both areas and coliform and enterococci counts were high at Ballona Creek. The source of this contamination was not discovered (Morris and Kim 1975).

POTENTIALLY IMPORTANT CONSTITUENTS FOR ANALYSIS

Stormwater samples have been analyzed for many conventional water quality parameters as well as those known to be important in municipal wastewater. In addition, other constituents have been suggested as being important, and ultimately a complete list of EPA priority pollutants could be examined. At present 126 pollutants are on this list. These include the following major classes: metals and inorganics; pesticides; PCBs and related compounds; halogenated aliphatics; ethers; monocyclic aromatics; phenols and cresols; phthalate esters; polycyclic aromatics; and nitrosamines and miscellaneous compounds. These pollutants are variously compartmentalized between the water (suspended solids or dissolved), sediments (organic or inorganic fractions), and biota (phytoplankton, zooplankton, macrophytes, benthos, fish, birds, and mammals) (Chapman et al. 1982). Some heavy metals and PAHs accumulate in the sea surface microlayer (i.e. upper 0.05 to 0.10 mm)

(CRWQCB and EPA 1987). Hence different fractions of the stormwater runoff should be examined to obtain the greatest concentrations of these constituents. In addition, the priority pollutants vary in their volatility, ability to accumulate in the environment, and their persistence (Chapman et al. 1982).

Because of the high cost of a complete analysis of EPA priority pollutants, the pollutants chosen for analysis should be ranked according to their persistence and potential harmful effects. Based on chemical properties and behavior, the most persistent, nonvolatile constituents that accumulate in the environment would be of most concern and hence should be targeted in monitoring studies. These include many of the metals and inorganics (arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc). Among the pesticides these include DDD, DDE, DDT, dieldrin, endrin, endrin, aldehyde, heptachlor, heptachlor epoxide, TCDD, and toxaphene. Six PCB arochlors and 2-chloronaphthalene also fall into this category. Only 2 of 22 halogenated aliphatics fall into this category; these are hexachlorobutadiene and hexachlorocyclopentadiene. Of the ethers, 4-chlorophenyl phenyl ether and 4-bromophenyl phenyl ether are potential target compounds by these criteria. Only one of 12 monocyclic aromatics (hexachlorobenzene) is a potential target. Pentachlorophenol and 2,4 -dimethylphenol are the most important of the phenol/cresol category. All phthalate esters and polycyclic aromatic hydrocarbons on the EPA list are persistent, nonvolatile, and accumulative as well as diphenyl nitrosamine, di-n-propyl nitrosamine, 3,3'-dichlorobenzidine, and 1,2-diphenylhydrazine (Chapman et al. 1982).

From the human health standpoint, human disease and disease indicators are important, along with potential carcinogens. Human disease indicators, such as total coliform, fecal coliform, and enterococcus, are frequently examined in water quality samples (Kebabjian 1987, pers. comm.). Coliform and fecal streptococcus (i.e. enterococcus) are common in fecal material and sewage and are generally not pathogenic. Fecal streptococci may survive better in coastal waters than coliform bacteria. Salmonella bacteria were the only pathogenic bacteria that were detectable in seawater near the Hyperion outfalls during 1974 and 1975 and these occurred in low abundance. Most bacteria causing infectious and enteric human diseases would be expected to enter the sea in municipal wastewater. Antibiotics produced by marine algae, diatoms, and fungi as well as competition from marine bacteria and selective predation by microorganisms contribute to the poor survival of enteric bacteria in the ocean (Kim 1975). Enteric viruses (e.g. poliovirus, coxsackie virus, echovirus, and the virus that causes infectious hepatitis) have been found in sewage effluent and these have been found in mussels in Marina del Rey and Ballona Creek. The virus that causes infectious hepatitis is the most dangerous and the most difficult to detect (Morris and Kim 1975).

Although many potential substances are carcinogenic to rats and mice, the normal exposure of humans to these carcinogens may be less than would be expected to cause cancers. In addition, the risk of acquiring cancer from the concentrations of many popularly-targeted carcinogens (at concentrations normally experienced by humans during their normal activities) may be much less than the risk associated with other substances that are normally encountered in daily activities (but which are less frequently recognized as carcinogens). A recent study (Ames et al. 1987) suggests that the conventional manner of ranking potential human carcinogens may be in error and hence may require re-evaluation. Based on their analyses, current levels of pesticide residues and water pollution may be of minimal concern relative to the background levels of natural substances. Nevertheless, until their method has gained wide acceptance, rankings of carcinogenicity of contaminants given by regulatory agencies should continue to be used, particularly since the health of the marine life is also at risk.

From the marine life standpoint those constituents that occur at acutely toxic concentrations would be of greater concern than those that cause sublethal effects, although these could also effect future generations of a species.

Additional compounds to be considered are dioxins, furans, and chlorophenols (Dahlgren 1987, pers. comm.). Dioxins are produced as a byproduct of defoliants, by incineration of PCB, and may occur in some waste oil (Dahlgren 1987, pers. comm.; Sims 1987, pers. comm.). Dioxins occur at parts per trillion levels in human adipose tissue. In addition, organic compounds of mercury and other metals are important contaminants as well as organophosphate, pyrethrate, and carbamate pesticides, phthalate esters (associated with plastics), and tetrachlorethane (a dry cleaning solvent).

MEASUREMENT OF PRECIPITATION AND SURFACE RUNOFF

The Los Angeles County Department of Public Works collects precipitation records at 300 stations in the County; three of these stations lie within the areas chosen for detailed study (See "Selection of Detailed Study Areas"). However, only the Civic Center gage includes 15-minute values and can therefore be used directly in modeling runoff events. Runoff gages with 15-minute sampling frequency are also maintained by the County. While historical records are available at eighteen sites within the study area, only six of these are currently maintained. Runoff is tabulated for daily mean values; 15-minute values must be computed by hand from punched gage records using rating tables.

The location and length of record for currently maintained stations are shown in Table 1.

In the early 1970s the then Los Angeles County Flood Control District estimated 100-year runoff values based on land use, impervious cover, slope, and area using the Modified Rational Method. While the results from this study would not be directly applicable to estimating runoff volumes from smaller storms, these raw data would provide useful input to a more storm-specific model.

STORMWATER POLLUTANT REDUCTION TECHNIQUES

Both structural and non-structural techniques will be considered in evaluating proposed projects to control pollutant runoff associated with stormwater transport. Traditionally, structural techniques (physically intercepting the runoff waters and treating them in some manner) have been favored by engineers and planners due, in part, to the ability to

TABLE 1

PRECIPITATION AND STREAMFLOW GAGES IN STUDY AREA

Precipitation or Flow	Station Name	#	Latitude	Longitude	Record Since
P*	LA Civic Center	716	34° 3' 9"	118°14'13"	1872
P	USC Campus	278	34° 2' 0"	118°18'46"	1929
P	Inglewood	116	33°57'53"	118°21'22"	1919
P	Topanga Patrol Sta		34° 5' 0"	118°36' 0"	?
P*	Burbank Valley Pump Plant		34°11' 0"	118°21' 0"	?
F	Santa Monica Cr. below Rustic Canyon		34° 1' 2"	118°31' 0"	1931
F	Santa Monica Cr. above Rustic Canyon		34° 1'48"	118°30'54"	1940
F	Rustic Canyon above Santa Monica Canyon		34° 1'48"	118°30'54"	1956
F*	Ballona Creek at Sawtelle	38	33°59'54"	118°24' 5"	1928
F*	Topanga Canyon above canyon mouth	54	34° 3'52"	118°35'10"	1930
F*	Sawtelle Westwood Channel above Culver	301	33°59'54"	118°24'54"	1951

* = 15-minute records available

better quantify the results of such actions. Some of the more prominent techniques used in past stormwater control efforts have included:

- o skimming of runoff surface to remove floating objects and oil and grease fractions
- o swirl or loop sections of conduit to promote settling of particulates in the flow
- o screens and filters to remove larger particulates
- o settling basins to remove particulates
- o detention basins to reduce overall runoff and promote groundwater recharge
- o wetland areas to filter stormwater flows in passage

Problems associated with these techniques have included low rates of successful removal of target fractions, restricted land availability for implementation, inability to handle water volumes associated with larger storms, contamination of groundwater resulting from recharge efforts, increasing urbanization in the target area, and technical difficulties with the control equipment.

Non-structural control techniques rely on urban planning, management practices, and increased regulatory measures to reduce the amounts of pollutant material available to be removed by stormwater runoff flows. These techniques include:

- o initiation or increase in frequency of vacuum street sweeping
- o restrictions on certain land uses
- o improved construction practices and requirements
- o increased enforcement practices by regulatory agencies
- o increased initiation and public awareness of monitoring programs for toxics and other illegally-discharged materials to deter violations

Problems associated with these techniques have included lack of operational effectiveness data, low or uncertain rates of pollutant reduction, public disinterest or refusal to comply with regulations, lack of committment to enforcement by regulatory bodies, and budget limitations.

Based on a review of the historical effectiveness of both structural and non-structural control technologies, the wide diversity of land uses in the study area, and the lack of any large concentration of a single land use, the solutions to the control of stormwater runoff into Santa Monica Bay will probably be a combination of structural controls intercepting stormwaters from large areas and areawide non-structual techniques. During the course of the project, these perceptions will be re-evaluated in light of more extensive land use mapping, data acquired during the monitoring phase, and evaluations of cost-effectiveness.

NATIONAL URBAN RUNOFF STUDIES

The National Urban Runoff Program was conducted by the EPA and local authorities between 1977 and 1982 to clarify the role of stormwater runoff as a pollution source. Twenty-eight locations across the national were selected to participate. Common data management procedures were established which permitted comparing the data at the end of the study. Some of the main conclusions were:

- It is possible to characterize stormwater quality by a quantity called the Event Mean Concentration (EMC). Using this parameter, storm events at a given site, as well as at different sites, can be compared. With relatively simple statistics it is possible to characterize both the storms and the resulting pollution.

- Log-normal statistical distributions adequately represent both the storm-to storm variations in pollutant EMCs at an urban site and site-to-site variations in the median EMCs which characterize individual sites.

- Heavy metals, especially copper, lead, and zinc are by far the most prevalent priority pollutant.

- The organic priority pollutants were detected less frequently and at lower concentrations than the heavy metals.

- Coliform bacteria are generally present at high levels.

- Total suspended solids (TSS) concentrations are fairly high compared to wastewater treatment plant discharges. In general, TSS contains more man-made products such as particles from tires and street surfaces and less biogenic particulates than does municipal sewage effluent.

- Nutrients are generally present in runoff but concentrations are not high compared to other sources.

- Although runoff volume and total pollutant load are generally highly correlated, little correlation was found between event mean concentrations and runoff volumes. At only thirty percent of the sites was a correlation found to be significant at the ninety percent level. Some sites showed positive correlations, indicating scouring, while others showed negative correlations. All in all, the variability among sites overwhelmed differences in EMC among different land uses or geographic regions.

The standard pollutants measured in the NURP study were total suspended solids, biochemical oxygen demand (BOD), COD, fecal coliform, total and soluble phosphorus, total Kjeldahl nitrogen, nitrite and nitrate nitrogen, total copper, total lead, and total zinc. In addition, the priority pollutants were examined at many of the sites. Event mean concentrations and coefficients of variation were given for the standard pollutants. In general, only ranges for the priority pollutants were given.

The main value of the NURP study is the developed methodology for sampling and analysis. Also, significant advances are being made in designing remedies to stormwater pollution such as detention basins which take advantage of statistical approaches.

An ongoing national program on urban runoff is being conducted by the U.S. Geological Survey. Results from this and other studies will be included as acquired.

STUDY WORK PLAN

This section details the work to be completed during the monitoring and evaluation phases of this study.

SELECTION OF KEY POLLUTANTS

Criteria for Selected Pollutants

Criteria include identification with adverse effects on human health or with adverse biological and aesthetic effects in Santa Monica Bay and on beaches, public concern, contribution of stormwater runoff loading versus total loading, implementability of controls, and cost of analysis (not a criterion for elimination). Recommendations were taken from evaluation of the historical literature, meetings with the City and other interested groups, and discussions with the project's toxicologist, Dr. James Dahlgren.

Target Pollutant List

	Analysis	
	Method	Cost
-Enterococcus	SM 910[a]	$ 25
(Particulate-associated)		
-suspended solids	SM 209C[a]	$ 10
-arsenic	206.3[b]	22
-mercury	245.5[b]	22
-silver	272.1[b]	40
-copper	220.1[b]	40
-cadmium	213.1[b]	40
-nickel	249.1[b]	40
-chromium	218.1[b]	10
-lead	239.1[b]	40
-zinc	289.1[b]	40
-dioxins	613[c]	400
-PAHs	610[c]	150
(Lipid soluble-associated)		
-oil and grease	413.2[b]	$ 60
-pesticides and PCBs	608[c]	80
-chlorophenoxy herbicides	8150[c]	125
	Total	$ 1,144

a Standard Methods for the Examination of Water and Wastewater
b EPA (1979)
c EPA (1982)

Pollutants Receiving Consideration

Laboratory analyses of the following pollutants were not performed for the listed reasons:

-Biochemical oxygen demand	-not a health hazard in open Bay waters
-Chemical oxygen demand	-not a health hazard in open Bay waters
-Total petroleum hydrocarbons	-picked up in oil and grease analysis
-Phthlate esters	-exposure path not through marine contact
-Chlorinated hydrocarbons	-soot; prevalent over wide areas
-Purgable organics	-exposure path not through marine contact
-Total coliforms	-Common in runoff from variety of sources
-Fecal coliforms	-Common in runoff from variety of sources

Recommendations of the Final Report may contain reduction measures for the pollutants not analyzed for, as listed above. Additionally, control measures recommended for those constituents on the analysis list will also be effective against the substances not tested for, as many of the latter are contained in the same water column fractions (particulate, lipid soluble).

PRELIMINARY POLLUTANT LOAD ASSESSMENT

Preliminary estimates of pollutant loads have been calculated using loading factors obtained from several sources. The results are presented in Table 2. In certain cases, the data were extrapolated from results of other studies. In particular, the following sources were used:

- The Final Report (Volume 1) of the Nationwide Urban Runoff Program (NURP) conducted by the EPA between 1977 and 1982. The loadings were calculated by multiplying the Event Mean

TABLE 2

PRELIMINARY ANNUAL POLLUTANT LOADINGS

	Source[a]	Surface Runoff Conc. (mg/L)	Surface Runoff Loading (kgs/acre-yr)	Surface Runoff Loading (metric tons)	Hyperion Treatment Plant Conc. (mg/L)	Hyperion Treatment Plant Loading (metric tons)
TSS	1	180	86.7	10,800	162	87,000
Arsenic	2W	0.020	0.0096	1.2	0.012	14
Cadmium	2WD	<0.003	<0.0014	<0.18	0.011	5.9
Chromium	2WD	<0.029	<0.014	<1.7	0.06	32
Copper	1	0.04	0.019	2.4	0.2	107
	2W	0.05	0.025	3.0		
	2D	0.015				
Lead	1	0.18	0.536	66.7	0.09	48
	2W	<0.040	<0.019	<2.4		
	2D	0.010				
Mercury	2WD	<0.0002	<0.0001	<0.012	0.0005	0.27
Nickel	2W	0.021	0.01	1.3	0.08	43
	2D	<0.01				
Silver	2WD	0.005	0.002	0.3	0.026	14
Zinc	1	0.20	0.096	12	0.28	150
	2W	<0.20		<12 0.096		
	2D	<0.10				
Oil/Grease	3	7.6	29	4603.7	15,600	
	4W	23	11.0	1370		
	4D	33.7		11609.3		
Pesticides/PCBs						
PCBs	2	<0.0001	0.0005	0.06	0.0002	.011
DDT					0.0001	.054
TICH					0.00013	.070

TABLE 2 (Continued)

	Source[a]	Surface Runoff Conc. (mg/L)	Surface Runoff Loading (kgs/acre-yr)	Surface Runoff Loading (metric tons)	Hyperion Treatment Plant Conc. (mg/L)	Hyperion Treatment Plant Loading (metric tons)
PAHs	5		0.00276	0.34		
Dioxin						
Chlorophenoxy Herbicides						
Enterococcus						
BOD	1	12		7205.8	120	
COD	1	82	40	4900		

a Sources:
1. Nationwide Urban Runoff Program; Athyade et al. (1982)
2. Los Angeles County DPW flood data (estimate from raw data to be revised).
3. Stenstrom Study.
4. SCCRWP (1973)
5. Hoffman et al. (1984)
W. Storm flow.
D. Dry weather flow.
S. Hyperion Treatment Plant effluent (1985); information will be updated as available for the final report.

Concentrations (EMC) by the estimated runoff volume for the whole study area.

- Water quality data from the Sawtelle Blvd. sampling station on Ballona Creek provide concentrations of pollutants taken during both dry and storm conditions. These data are from analyses of grab samples taken approximately monthly by the Los Angeles County Department of Public Works. Ballona Creek drains about 46 percent of the study area and is therefore quite representative of the whole study area, assuming no sanitary sewage overflows. (In many cases the concentrations of target pollutants were at or below the lower level of detectability and were reported only as less than a given amount.) The calculations of loadings were made as follows:

  Loading = Concentration x Rainfall x Runoff Coeff. x Area

  where,
  Loading = metric tons per year
  Rainfall = 375 mm per year
  Runoff coeff. = 0.32 (based on percent impervious surface)
  Area = 50,302 ha

A forthcoming statistical analysis of the concentration data from the County will help to update this information.

- The Southern California Coastal Water Research Project data (1973 and later) was used for some of the estimates such as oil and grease.

The preliminary pollutant data presented in Table 2 will be updated as additional information is obtained.

In order to make a preliminary pollutant load assessment, the pollutant loads from the surface runoff were compared to the annual loads from the Hyperion Treatment Plant effluent stream. This comparison is useful in judging the approximate relative impact of the surface runoff on an annual basis. Only the 1985 values for the effluent from the combined secondary and primary processes are shown, since the sludge stream will be directed elsewhere in the near future. If the sludge stream had been included, the relative impact of the runoff pollution would be even smaller.

The evaluation of overall importance of each pollutant was based partly on the following criteria:

Load in runoff more than 10 percent of amount discharged by Hyperion Treatment Plant for:

- o Oil and Grease
- o Total Suspended Solids

Load between 5 and 10 percent for:

- o Arsenic
- o Chromium
- o Lead

Load less than 5 percent for:

- o Cadmium
- o Copper
- o Mercury
- o Nickel
- o Silver

In the 1973 Southern California Coastal Water Research Project (SCCWRP) report, a comparison of pollutant sources for the entire Southern California Bight was presented. Also included were contributions from industrial wastes, vessels, ocean dumping, and aerial fallout. In many cases, the estimates were very rough and may no longer apply because of changes in regulations concerning PCBs, pesticides, and lead in gasoline. To the extent possible, these data will be updated to reflect current pollution sources in the Santa Monica Bay.

SELECTION OF DETAILED STUDY AREAS

Selection of areas for detailed study was based upon the need to characterize stormwater runoff characteristics and identify candidate areas for pollutant control of key pollutants. The methodology developed anticipates the need to identify pollutant loads by land use types occurring within the study region and to prescribe pollutant reduction techniques that are specific to varying land use types. Land use criteria for the City of Los Angeles were used in site selection. These criteria are included in Appendix A.

The methodology for selection of areas for detailed study included development of information on land use, drainage patterns, and availability of access to drains to collect stormwater data.

Candidate areas for detailed study were selected based upon the need to collect information on relatively homogeneous land use types that could be isolated for purposes of monitoring without a high degree of interference from other land use activities. These desirable characteristics included the need to identify a single location to monitor runoff volumes and stormwater pollutant values draining an area representative of the land use type. Land use and drainage maps and aerial photographs for areas within the study region were analyzed for candidate sites for detailed study by identification of areas satisfying the above criteria.

A series of candidate areas was identified for each of the five land use types to be evaluated (i.e. heavy industrial, light industrial, commercial, residential, and transportation). In addition, a monitoring location that would provide integrated information on the above land use types was sought. Preliminary monitoring locations were located based on drainage maps. All of the candidate areas for evaluation were located within the Ballona Creek watershed area, which constitutes approximately 46 percent of the drainage area and is the single largest stormwater input to Santa Monica Bay.

Each of the candidate areas was inspected to verify the land use types within the area drained, to identify monitoring locations, and to isolate any potential problems in data collection that may not have been apparent based upon the evaluation of land use and drainage maps and aerial photographs. The location of the monitoring station was identified in the field for each candidate area.

The candidate areas were screened against the selection criteria. Several of the candidate sites were deleted because of land use types that were not representative of the mapped classification, drainage

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patterns that did not correspond with mapped information, and problems in gaining access for field monitoring. The field inspection also identified potential problems in collecting representative samples of areas upstream due to incomplete mixing or in monitoring flow volumes at the confluence of several flow streams where backwater conditions may interfere with the accuracy of flow readings.

To increase the effectiveness of any proposed pollutant reduction measures or projects, the monitoring program will focus on data collection, analysis and control strategies that correlate these factors to specific land use types that produce the highest loadings, and concentrations of key pollutants. For instance, national studies have demonstrated that transportation facilities (e.g., highways) contribute high concentrations and a significant percentage of the loading of PAHs. By evaluating areas used for transportation for both the percent contribution to this loading and for potential control strategies, the most effective control projects for this pollutant are likely to be identified.

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Criteria used in choosing specific areas for study included:

1. Land uses specified in the request for proposal
2. Land uses deemed to contribute significant pollutant loading based on historical information
3. Location of an area of sufficient size to extrapolate to the overall study area
4. Area "representative" of citywide land use
5. Ability to sample a single land use from a single drain
6. Location within the Santa Monica Bay drainage area
7. Location within the City of Los Angeles, if possible.

The different land use types selected included residential, commercial, light industrial, and transportation. Criteria applicable to each site as listed above included the following:

- Residential — #s 1, 3, 4, 5, 6, 7
- Commercial — #s 1, 3, 4, 5, 6, 7
- Light Industrial — #s 1, 3, 4, 5, 6, 7
- Transportation — #s 2, 3, 4, 5, 6, 7

No Heavy Industrial land use sites that corresponded to the listed criteria were available in the City of Los Angeles. Alternate sites in other cities were investigated for conformance to the remaining criteria. These areas encompassed a number of small metal fabricating, metal plating, and similar industries that are potential sources for many of the target pollutants. None of the sites examined were suitable for monitoring due to:

- o inaccessibility of storm drainage in the candidate areas
- o non-availability of sampling locations collecting runoff from the industrial area only
- o lack of sufficient area at the candidate locations to make extrapolation to the study area realistic

Engineering-Science recommends that the Heavy Industrial land use be dropped from the study due to:

- o very low percent occurrence in the study area as compared to other land uses
- o lack of a suitable sampling area in the drainage basin
- o low probability of cost-effective treatment of stormwater runoff due to low level of accessibility to the runoff stream; most locations accessible by storm drains represent parcels of only 15 to 20 acres
- o City land use requirements mandate that Heavy Industrial areas must capture and treat storm runoff prior to releasing it to the storm drain system

The Transportation land use was added to those originally required in the Request for Proposal due to the importance of automobile transportation in the City region, the extensive area of the study basin covered by road and highway networks, and the importance of runoff pollutants from transportation land uses evident in the literature.

The locations of proposed study sampling locations are listed in Table 3.

The recommended Residential land use site is an area of mixed single-family and multi-family housing, and was deemed to be representative of overall study area residential land uses. Within the

TABLE 3

PROPOSED SAMPLING LOCATIONS

Land Use*	Location (N-E-S-W Bounds)	Area (Acres)	Access
Residential	West Adams (25th-St. Andrews-Jefferson-Arlington)	95	Manhole on Cimmaron
Commercial	Los Angeles (Olympic-Grand 12th-Figueroa)	38	Manhole on 12th
Light Industrial	Los Angeles (22nd-Main-Adams-Hope)	57	Manhole on Adams
Transportation	West Adams (I-10 Freeway [E]Western-[W]Crenshaw)	27	Manhole on Bronson
Combined Use**	Hancock Park Ballona Creek (covered)	9,750	Manhole on Windsor

* Using City of Los Angeles Land Use Criteria
** Location Collects from Several Land Use Types

selected area is a oil/gas production site, a potential source of contaminant runoff into the sample collection area. Communication with the operator of the site (UNOCAL) indicated that, for the past year, all surface runoff from the site has been retained on-site and reinjected into existing older wells on the property. Visual examination of the culvert below the production site showed no evidence of oil or grease discharges (dead vegetation, staining of the street pavement, etc.). The area was deemed suitable for use as the Residential land use study site. Other potentially suitable sites are available in Rancho Park and Culver City. The Rancho Park site is a primarily upper-class neighborhood of single-family homes that may not be representative of the study area. The Culver City site is more of an older middle-class area with all single-family dwellings.

The Combined Use area indicated in the table was chosen to provide a site to examine the physical mode of transport for the target pollutants. This concept will be more fully detailed in the section titled "Proposed Monitoring Program."

Locations of candidate and other sites examined are shown in Figure 1. Detailed maps of the proposed sites listed in the table above are included in Figures 2 through 5.

PROPOSED MONITORING PROGRAM

The proposed monitoring program encompasses both onshore and offshore sampling. The onshore program at the storm drain locations described above will be used to determine pollutant loading associated with the different land use types.

The offshore collection program will be used primarily to ascertain the presence of the target pollutants in offshore waters. No attempt will be made in this study to relate pollutant presence offshore with studies of the fates of these compounds in the marine environment.

Conceptual Sampling Plan

The sampling plan was designed to provide the information needed to characterize runoff and provide necessary input to engineers and planners for development of pollutant runoff reduction projects. This information included:

- o Spatial - where pollutants are coming from
- o Temporal - when pollutants are transported
  - -event (rainfall)
  - -season
  - -year
- o Physical - how pollutants are transported

Proposed Sampling Plan

Approach

Based on the design outlined above, the following sampling plan is proposed to gather the necessary planning and decision-making information:

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FIGURE 1

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FIGURE 2

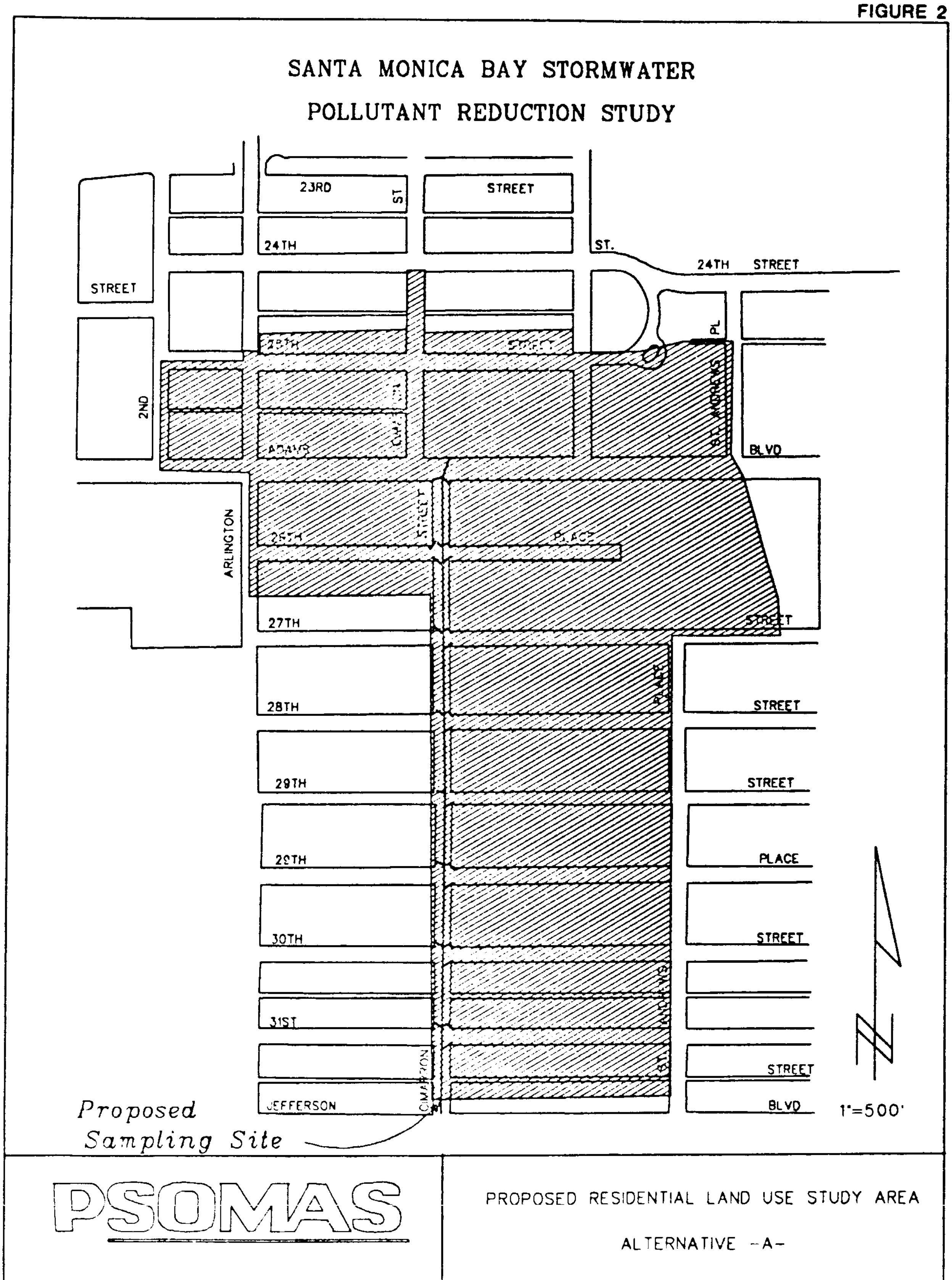

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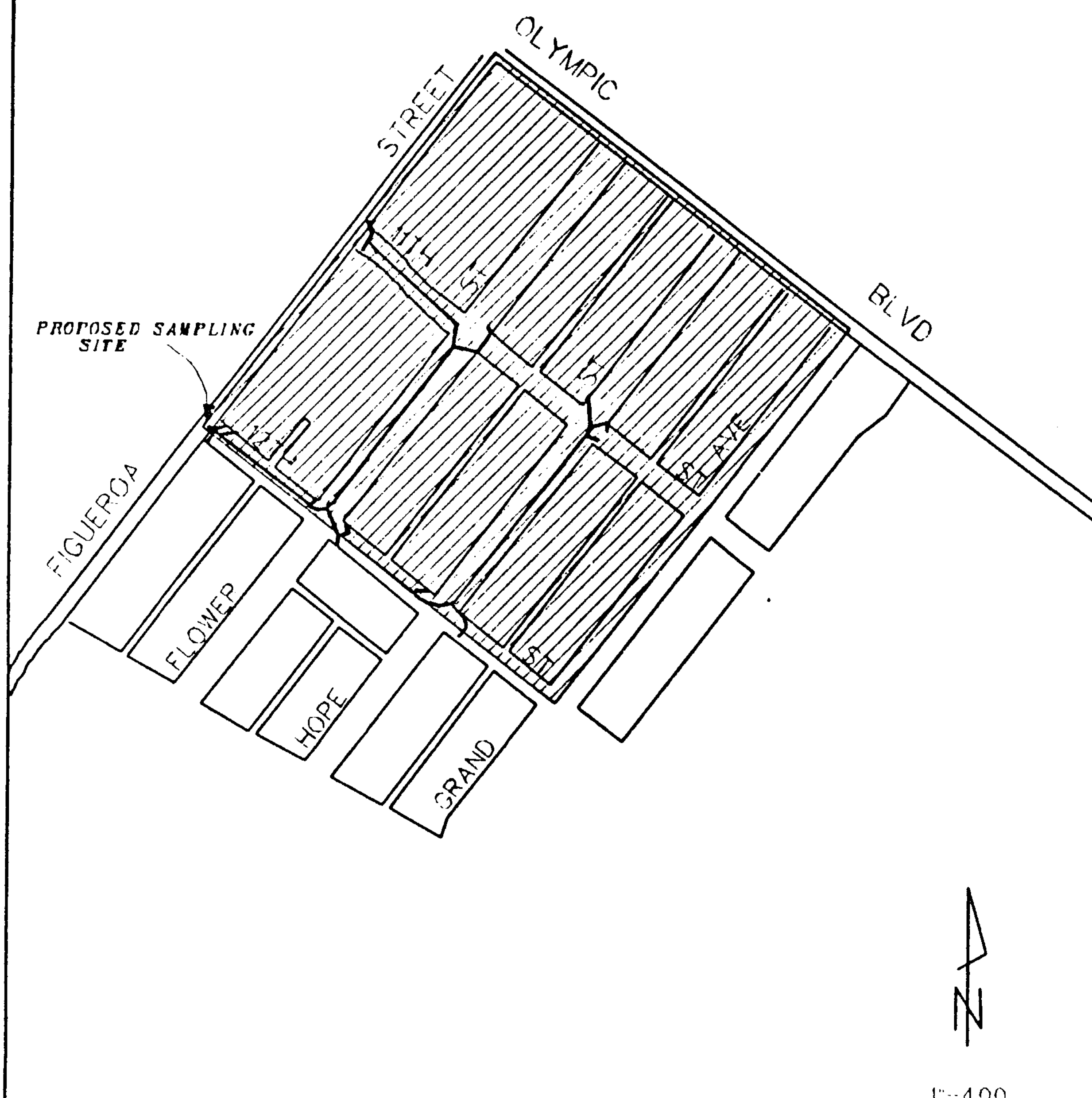
FIGURE 3

SANTA MONICA BAY
POLLUTANT REDUCTION STUDY



PSOMAS

PROPOSED COMMERCIAL LAND USE STUDY AREA

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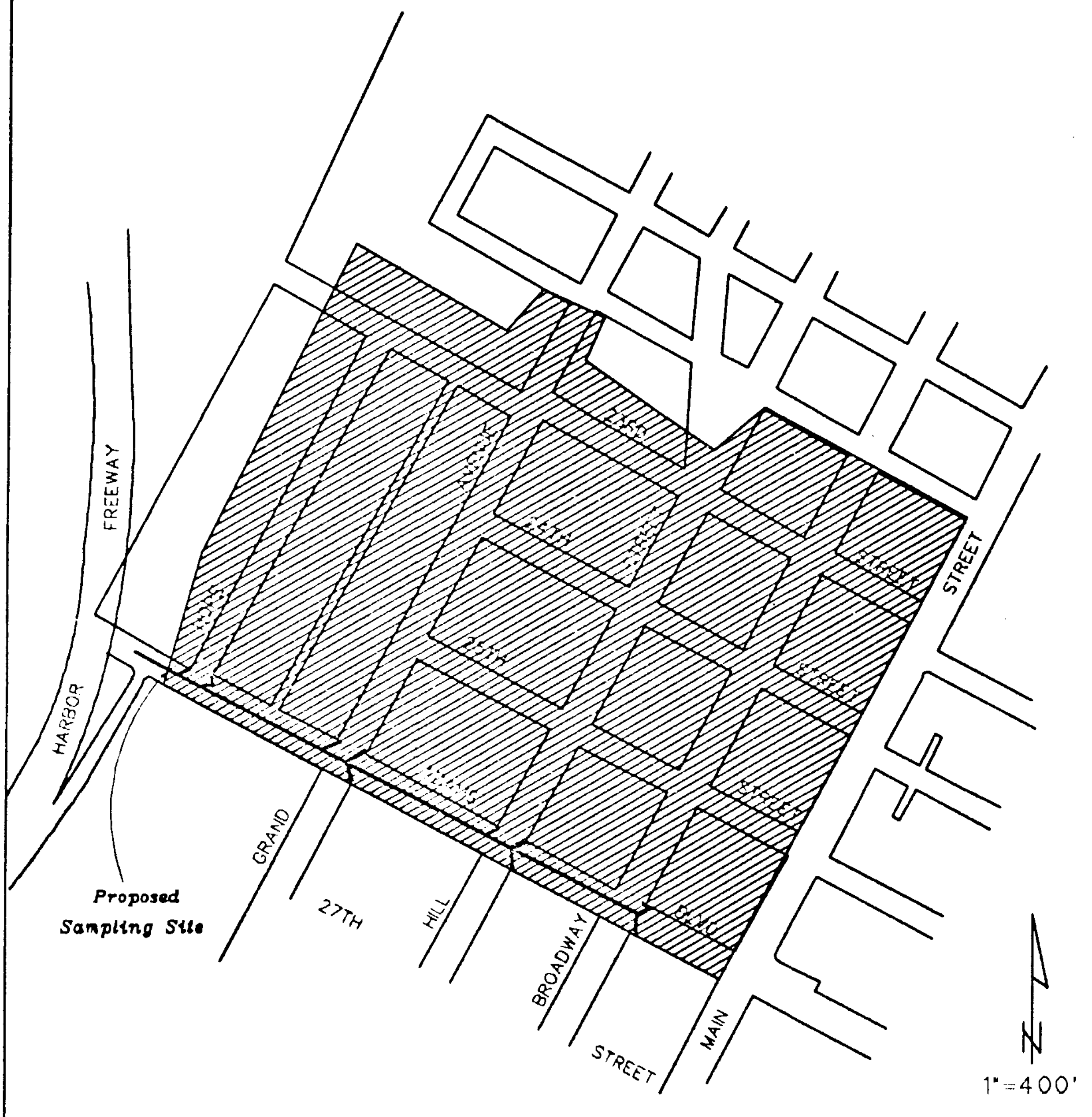
FIGURE 4

SANTA MONICA BAY STORMWATER POLLUTANT REDUCTION STUDY



PSOMAS

PROPOSED LIGHT INDUSTRIAL
LAND USE STUDY AREA

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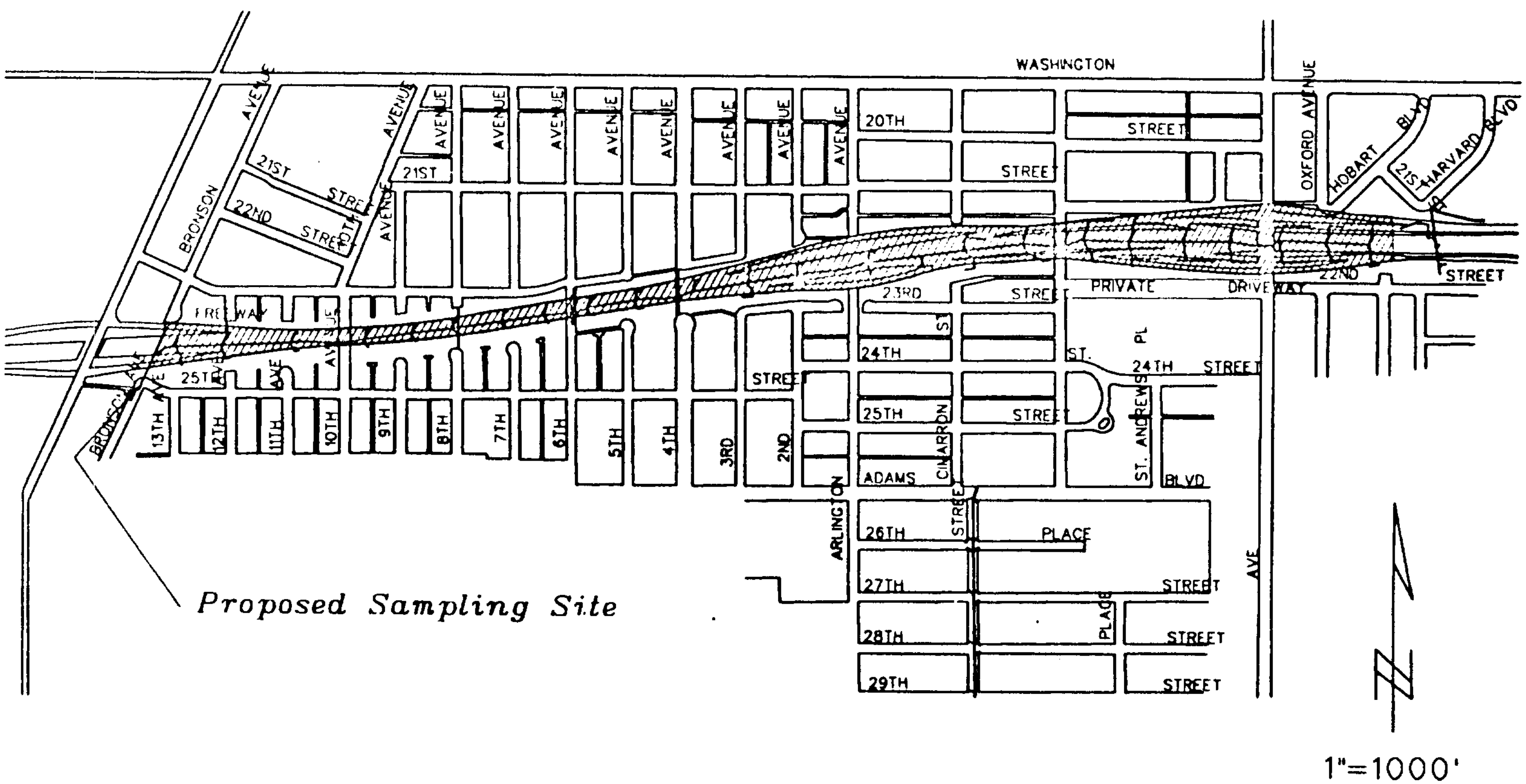
SANTA MONICA BAY STORMWATER POLLUTANT REDUCTION STUDY



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PROPOSED TRANSPORTATION CORRIDOR
LAND USE STUDY AREA

FIGURE 5

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- Spatial - comparison of runoff characteristics from different land use types

Land use types to be sampled during the study include:

- residential
- commercial
- light industrial
- transportation

- Temporal - hydrograph and "pollutograph" comparison to determine the time response of pollutant washoff to duration and intensity of rainfall:

    - Three storm events
        - first seasonal storm (see text below)
        - heavy midseason storm
        - late seasonal storm
    - dry season low flow - composite over 24 hours

- Physical - mode and location of transport as indicated in the table of sampling sites:

    - One station sampling from three discrete water column fractions
        - hydrophobic "floating" fraction (oil and grease, etc.)
        - midcolumn
        - particulate "bedload"

- Offshore - confirmation of pollutant presence

    - Seven stations, two water column levels (upper 1/4 meter, midwater)

Location of Offshore Sampling Stations

The location of monitoring stations for the offshore sampling program are as follows:

TABLE 4

OFFSHORE SAMPLING STATIONS

Station	Latitude	Longitude	Bottom Depth (m)	Sample Depth (m)
A	33°58'20"	118°28'25"	9	S,4
B	33°58' 0"	118°28' 3"	9	S,4
C	33°57'33"	118°27'30"	5	S,2
D	33°57'11"	118°27'22"	9	S,4
E	33°56'44"	118°27' 7"	9	S,4
F	33°57'27"	118°28' 2"	14	S,7
G	33°57'14"	118°28'29"	18	S,9

S - upper 1/4 meter

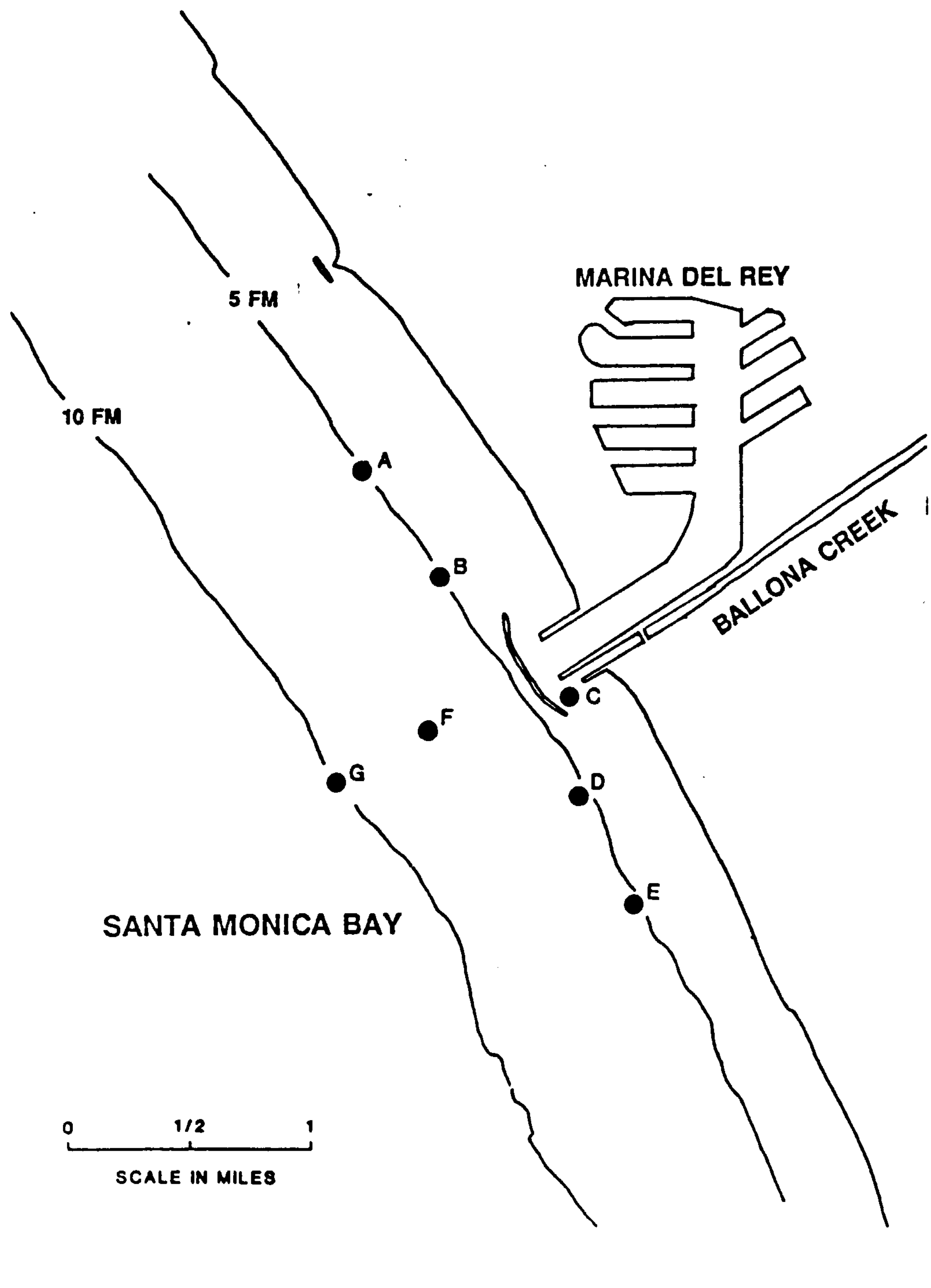
Station locations are presented in Figure 6.

Onshore station samples will be collected using automatic water collection pump samplers (ISCO or equivalent) to collect discrete samples at specified intervals. The samplers will be coupled with a flow-monitoring device programmed to activate the samplers based on a preprogrammed increase in flow rate within the storm drain resulting from rainfall runoff. The samplers themselves are time-programmable, allowing a fixed or variable time interval between sample collection. The sampling interval will be determined by examining historical duration/intensity data for rainfall events in the study area. A 15-30 minute interval is currently planned. Sufficient sample volume will be collected to provide water for all chemical analyses.

Offshore collections will use a manually-activated closing bottle device (Van Dorn or equivalent) to collect both near-surface (upper 1/4 meter) and midcolumn discrete samples. Only one sample at each depth from the seven proposed stations is planned. Collections will be made within two to three hours of the beginning of a storm to catch the expected maxima in pollutant concentrations, minimize influence of other runoff sources near the mouth of Ballona Creek, and complete sampling before the buildup of infiltration waters into the sewerage system that may result in sewage spills into Ballona Creek. The timing of offshore collections will necessarily be influenced by weather and safety considerations.

FIGURE 6

PROPOSED WATER QUALITY SAMPLING STATION IN STORMWATER POLLUTION REDUCTION STUDY



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Methodology

Offshore collections will be made within two to three hours of the beginning of the storm event, during the same period that runoff samples are being collected. As indicated by Table 4 and Figure 6, the offshore stations are concentrated off the mouth of Ballona Creek.

A conceptual example of sample collection strategy is depicted in Figure 7. The two curves represent volume of runoff flow and concentration of some pollutant in the flow. While runoff flow volume is expected to build over the initial period of the storm, some pollutant constituents are mobilized very quickly, and reach peak concentrations prior to the peak of runoff flow volume.

Collection of water samples from storm sewers will be initiated soon after the beginning of the rainfall event, as the flow meters monitoring runoff levels are triggered by the increase in flow and activate the samplers. Sample collection will continue until runoff flows drop to their pre-event levels. Bottles will be replaced as necessary to collect samples over the duration of elevated flows.

Volume of samples collected will be sufficient to satisfy requirements of the analyzing laboratory to complete testing using EPA or SM methodology (see "Selection of Key Pollutants"). The bottles contained in the ISCO samplers hold between 350 and 1,000 ml; more than one bottle may have to be filled for each sample to satisfy analysis requirements. Sampler servicing will be scheduled based on types of samples being collected, volume requirements, etc. Strict adherance to preservation techniques, handling, holding times, and other analysis protocols will be observed.

The figure also indicates a potential time sequence of samples chosen for analysis of target constituents. As suggested by the literature and indicated by the curve of runoff pollutant concentration versus time in Figure 7, many of the major pollutants are mobilized early in the storm event. It may be necessary to analyze a greater number of samples collected near the beginning of the rainfall event in order to best characterize the presence of such pollutants in the runoff stream. Analysis of fewer samples at longer intervals near the end of

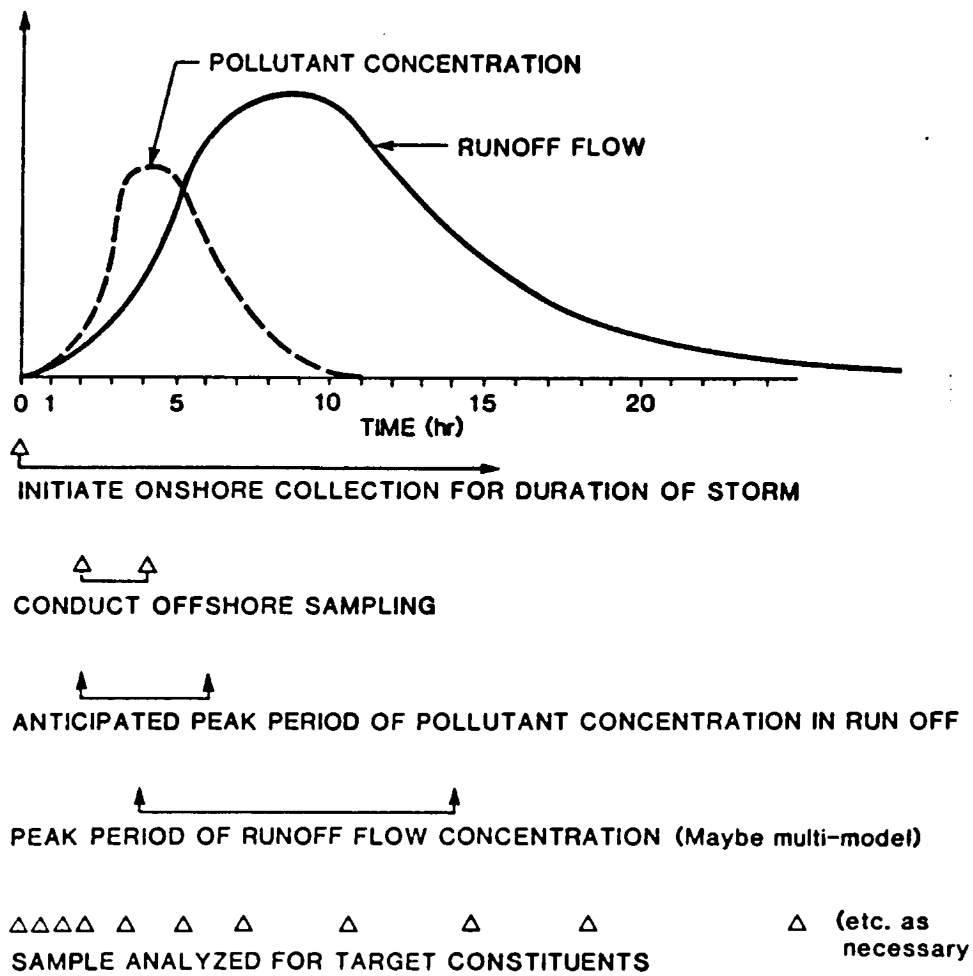


FIGURE 7. CONCEPTUAL RUNOFF AND POLLUTANT CONCENTRATION REPONSE FOR WINTER STORM SHOWING INITIATION OF SAMPLING MODES AND POTENTIAL SPACING OF SAMPLES ANALYZED FOR TARGET CONSTITUENTS

the event will assure that significant concentrations of such pollutants are not missed in assessing loading to the Bay during the storm.

Collection and analysis of runoff samples during three winter storms is currently planned. The absence of certain pollutant constituents during the first storm will be cause to eliminate their analysis in subsequent storms. Analysis for these constituents will again be conducted during summer low flow collections. Using this procedure, the limited laboratory budget can be directed toward constituents found frequently in runoff samples and requiring more extensive analyses.

Analysis of Samples

Analytical techniques for listed pollutants were detailed in the table of target constituents. Detection limits will be different for runoff samples and samples collected offshore because of the higher salinities associated with the latter.

During the first part of the sampling program, determination of pollutant constituents will be identical for all onshore and offshore monitoring locations. Results of the first sample collection may indicate that some constituents can be eliminated from further analysis on an individual land use or onshore/offshore basis.

Collection and analysis of water samples for Enterococcus group is complicated by the need for sterile equipment and methods during sampling. It is therefore impractical to collect Enterococcus samples via the automatic samplers deployed in the study area. Bacterial samples will be collected by hand, using appropraite sterile techniques, by technicians while servicing the samplers during the rainfall/runoff event. This will restrict the number of samples at each location, and will not allow for time-synchronous collections; however, the bacterial samples are deemed less important than other constituents due to their frequent occurrence in stormwater runoff and their low potential for effective control. Bacterial samples collected offshore will be handled in a similar manner, but will be collected only once at each sampling depth at each station.

First Seasonal Storm

The contract between Engineering-Science and the City of Los Angeles was not signed in sufficient time for sample collections during the first storm of the 1987-88 water season. Plans are being made to deploy samplers and collect runoff from the first storm during the fall of 1988, to determine the extent of pollutant concentrations in the "first flush" following the summer dry season.

POLLUTANT LOADING ESTIMATES

Characterization of Stormwater Hydrology

The study area has a rainfall pattern typical of the western coast, with dry summers and moderately wet winters. Rainfall from May through September is insignificant and the first major storms generally arrive in November.

Variations in rainfall due to topographic (land elevation) differences are minor in the immediate study area, but average annual precipitation is significantly greater in the Santa Monica Mountains than in the urbanized areas. Because the character of storms and annual variation are quite constant across the area of interest, point precipitation values for measured storms could be adjusted by the ratios of monthly or annual average precipitation for areas in which hourly precipitation values are unavailable.

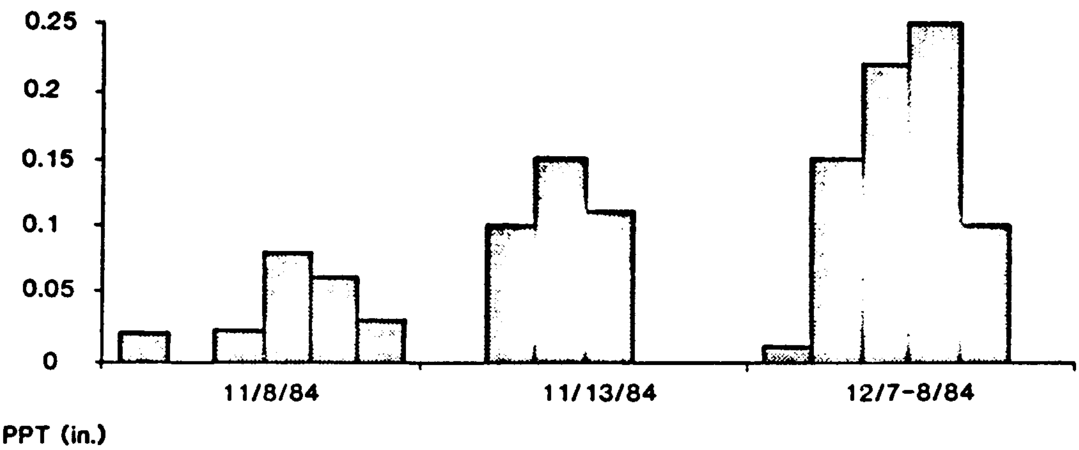
Precipitation characteristics of several storms as measured at the Los Angeles Civic Center are illustrated in Figures 8 through 10. The first figure shows hourly precipitation for the first significant rains of the 1984-85 water year, in November and December 1984. A two day December storm is illustrated in the second figure. Finally, the first three days of the significant storms in February 1986 are depicted in Figure 9.

Physical Parameters

The existing telemetered precipitation gage at Los Angeles Civic Center and the flow gage on Ballona Creek near Culver City provide almost 60 years of historical data in the detailed study area. Data

FIGURE 8

STORMS AT LOS ANGELES CIVIC CENTER



BARS REPRESENT ONE HOUR INCREMENTS
FROM BEGINNING OF STORM

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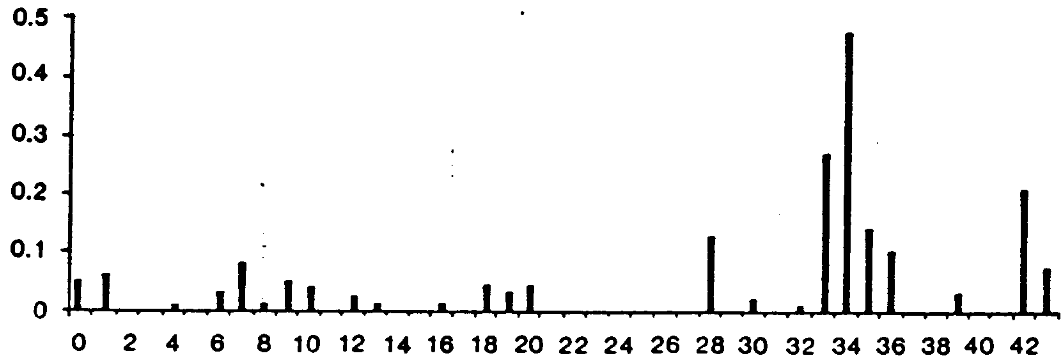
FIGURE 9

LATE DECEMBER STORM AT LOS ANGELES CIVIC CENTER



BAR REPRESENT ONE HOUR INCREMENTS
FROM BEGINNING OF STORM

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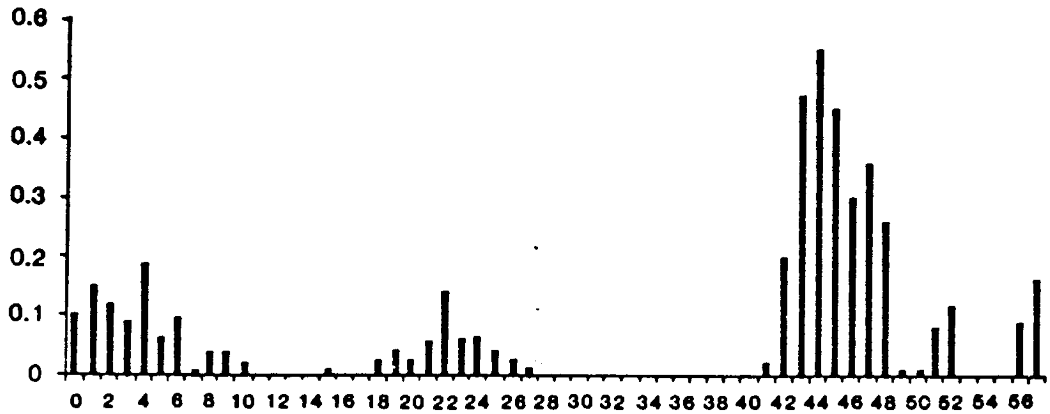
MAJOR STORM FEBRUARY 13-15, 1986 AT LOS ANGELES CIVIC CENTER



BAR REPRESENT ONE HOUR INCREMENTS FROM BEGINNING OF STORM

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from these gages will be supplemented by runoff flow information from the sampling stations established for this project. Specifically, during storm events precipitation may be measured at other locations within the detailed study area to establish the areal as well as temporal extent of the storm. Maximum storm intensity and duration is available directly from historical precipitation data, which are tabulated in 15-minute intervals.

Runoff rates at the five proposed monitoring stations will be estimated from theoretical stage-discharge relationships for open-channel flow. Exact runoff volumes at these sites will be computed from the resulting flow hydrographs, extended forward or backward in time as necessary to incorporate unmonitored flows. Runoff at sites outside the detailed study area will be estimated using the Modified Rational Method and by the Los Angeles County Department of Public Works. This method computes peak discharge as

$$Q = C \times I \times A$$

where Q is the peak discharge, C is the runoff coefficient, and I is the rainfall intensity over the time of concentration of the catchment area, and A is the drainage area. The runoff coefficient is a function of soil and land use type and of rainfall intensity. Flow hydrographs can then be estimated by transposing the measured hydrographs from locations with similar times of concentration, and checked against total flow computed from the total amount of precipitation received during the storm multiplied by the average runoff coefficient.

Characterization of Stormwater Quality

In accordance with the results from NURP, the best parameters for characterizing the stormwater quality are the event mean concentration and the coefficient of variation. The event mean concentration is calculated by dividing the total mass of pollutant in the runoff by the total volume of runoff. Event mean concentrations can be obtained in several ways:

(1) A flow-weighted composite can be analyzed directly for concentration.

(2) Discrete samples during the course of a storm event can be analyzed. From the concentrations and flows, a graph of mass flow vs. time is obtained which is then integrated for the total mass. This value is then divided by the total runoff volume.

For a given site, the EMCs for various storms are averaged assuming a log-normal distribution. The coefficient of variation is calculated by dividing the standard deviation by the mean. Collected data will be analyzed to determine if the assumption of log normality is valid. If it is not, non-parametric statistical methods will be used.

For some pollutants, the second method will be used to demonstrate how the pollution load varies over time for a given storm. This information may be useful in selecting a remedial strategy. Additional comparisons will also be made with various water quality standards.

Land Use and Water Quality Relationships

An analysis will be performed to determine whether parameters such as land use, impervious cover, or population can be correlated with the values for pollutant loadings. Statistical techniques similar to those presented in the NURP report will be used. One method involves normalizing the sites by dividing the site median concentration and its upper and lower 90-percent confidence limits by the average median value for the constituent in question. The sites can then be compared using a simple graphical procedure.

A comparison will be made between an estimate of total loadings for the entire study area extrapolating from both the Ballona Creek and from the single land use areas.

Modeling Methodology

The method of modeling pollutant loadings is derived from the stochastic screening model used in the National Urban Runoff Program report. The method relies on the fact that event mean concentrations (EMC), runoff volumes, and flows in receiving waters tend to be log-normally distributed; that, is the logarithms of the appropriate variables fit the normal distribution. The four variables normally considered in the model are:

1. Urban runoff flow
2. Urban runoff concentration
3. Streamflow in receiving waters
4. Stream concentration

The stochastic NURP model can be modified if event mean concentrations and/or runoff volumes fail to fit the log-normal distribution. Certain distributions other than log-normal can be modeled analytically, in that properties of the distribution of pollutant loadings can be found from the properties of the distributions of EMC and runoff volume. In the more general case, the distribution of loadings can be developed empirically using a simple Monte Carlo simulation of the EMC and runoff distributions, including appropriate correlations if these are found to be significantly different from zero. Goodness of fit could be ascertained using the Filliben correlation test (for normal or log-normal distributions) or the Kolmogorov-Smirnov test (for general distribution); normally at least fifteen to twenty observations are required to determine distribution parameters and goodness of fit.

The distributions of event mean concentrations will be developed from the results of the monitoring program, with the EMC for each storm event computed as the flow-weighted concentration observed in the tests. The distribution of runoff volumes for the detailed study area will be derived directly from measurements made during the study and from historical flow records of Ballona Creek. Elsewhere, flow distributions will be derived from runoff volumes computed using the modified rational approach described earlier. Event mean concentrations at other sites will be derived from the results of the land use and water quality study of the previous section.

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IDENTIFICATION OF POLLUTANT REDUCTION PROJECTS

Data collected during the monitoring phase will be combined with historical stormwater control information to identify appropriate pollutant reduction projects. Engineering-Science planners and engineers will work with the City of Los Angeles to reach a consensus on criteria for evaluation of alternatives. The procedure for identifying these projects will include:

- assess existing, operating structural stormwater control technologies for feasibility in the study area (area requirements, structural acceptibility, availability of land, etc.)
- eliminate technically non-feasible structural alternatives
- quantify effectiveness of pollutant reduction potential of remaining alternatives on several sizes of project application (volume handled, etc.)
- determine suitability of selected projects to control pollutant runoff from selected areas and land use types
- develop cost estimates for alternatives (document estimating techniques)
- categorize projects as to fundability within the $3 million mandated for control projects
- assess non-structural control options for feasibility
- eliminate technically non-feasible non-structural alternatives
- quantify pollutant reduction potential of remaining non-structural alternatives on a range of areal or statutory applications
- determine suitability of selected applications to control pollutant runoff from selected areas and land use types (effectiveness)
- develop cost estimates for implementation/enforcement of recommended alternatives (document estimating techniques)

- o examine pollutant reduction potential and costs for combined structural and non-structural projects, either by land use or for a specific area
- o rank recommended projects by:
  - effectiveness in reducing pollutant runoff
  - cost of implementation
  - combined effectiveness and cost
- o recommend projects on a specific land use or specific area basis

Recommendations for projects will also discuss the implications of costs related to maintenance requirements of selected techniques, proposed management/regulatory practices, and evaluation of the extent of reduction of pollutant loading into Santa Monica Bay.

PROJECT SCHEDULE AND MANAGEMENT

The study has been organized into a Work Plan and a Study Phase with a number of general tasks. These work plan phase tasks are:

Task 1 - Review and Evaluate Existing Data

The data that have been developed in the past on the quality and characteristics of Santa Monica Bay and storm runoff in the watershed are available from diverse sources. These include published reports, professional papers, and agency files. These data will be collated and evaluated for use in the subsequent tasks and to help determine what additional data will have to be collected in the monitoring program. A source list, annotated as necessary, will be compiled and incorporated as an appendix in the final project report.

Land use data and drainage system maps will be obtained from the City of Los Angeles and other agencies in the study area.

Task 2 - Identification of Key Pollutants

The objective of this task is to develop a list of pollutants that will be monitored during the project and that are likely candidates for control. The criteria for selection of these key pollutants will include:

- o Identification with adverse biological and aesthetic effects in the bay and on the beaches.
- o Identification with adverse effects on human health
- o Public concern
- o Ability to implement controls

Task 3 - Preliminary Pollutant Load Estimates

Land use in each drainage basin will be reviewed in relation to the available runoff and bay water quality data to provide a basis for preliminary estimates of pollutant generation rates in each land use category. These will be used to make preliminary estimates of mass pollutant loads (metric tons per year) for each of the key pollutants.

Task 4 - Selection of Areas for Detailed Study

One or more drainage areas will be selected for detailed study and for monitoring. The selection of the areas will be based on the preliminary land use analysis and pollutant load estimates. Other considerations will include the likelihood developing effective mitigation measures and the probable applicability of these measures to the entire study area.

Task 5 - Development of Project Work Plan

The work plan for the study phase of the project will define three main areas of work:

- o Monitoring of drainage system runoff and bay waters.
- o Problem analysis
- o Alternative project development

For the monitoring program, the work plan will delineate the locations of sampling points, sampling plans and schedules, parameters to be measured, methods of analysis of samples, sampling equipment, etc. The work plan has been prepared as a result of Task 5 above and is based on information developed by the first five tasks.

The remaining tasks of the Study Phase are:

Task 6 - Runoff and Receiving Water Monitoring

Monitoring of runoff from the drainage system will be done on a regular basis for dry weather flow and during rainfall events. To the extent possible sampling during rain events will be designed to catch the early part of the runoff on the leading slope of the storm hydrograph.

Sampling of water quality parameters in Santa Monica Bay will be done on a regular schedule and, consistent with safety, during or after storm to detect immediate effects of runoff from the watershed.

Task 7 - Land Use Analysis

Land use, topography, and street patterns in the study area will be digitized for entry into a computer data base. This will permit rapid analysis of areas, slopes, land use characteristics, runoff quality data, summary tabulations, etc., which will be needed for subsequent tasks.

Task 8 - Problem Identification and Analysis

The pollutant load estimates will be extended refined using the information gained from the monitoring and from the land use and drainage pattern analysis. These estimates coupled with information from limited field observation will be used to identify areas that contribute significant pollutant loads and in which there is a good probability of developing measures to reduce pollutant loads significantly.

Task 9 - Development of Projects

Projects and measures to reduce the pollutant loads identified in Task 8 will be formulated and evaluated. Criteria to be used in the evaluation will include:

- o Capital and operations costs in both the public and private sectors
- o Effectiveness in pollutant reduction

- o Environmental impact including the effects of alternative disposal of pollutants excluded front the drainage system
- o Relation of alternative controls or measures to other pollution control programs
- o Feasibility (legal, regulatory, technical, reliability etc.)
- o Public acceptance

The results of this task will be a prioritized list and discussions of possible structural and nonstructural controls with cost estimates.

Task 10 - Public Involvement and Meetings Support

This project and the recommended controls that will result from it are of high concern and interest to the public and to a number of government agencies. This task covers the efforts that will be made to obtain input from and to inform these groups.

Task 11 - Preparation of the Final Report

Task 12 - Project Management

The detailed schedule must take the following factors into consideration:

- o The storm season
- o Concurrent execution of the Study Phase Tasking
- o The organization of the project team

PUBLIC INVOLVEMENT

The public involvement program for this study has not yet been finalized. The subcontractor for this portion of the project (Renette Anderson and Associates) is currently providing support to the City in transferring information to the Pico-Kenter Task Force. The latter is acting in an advisory role for the conduct of this study. It is anticipated that public contacts and meetings may be required to disseminate the information and recommendations resulting from the monitoring and evaluation phases of the study. A more extensive public involvement program is envisioned at that time.

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APPENDIX A

GENERALIZED SUMMARY OF CITY OF LOS ANGELES
ZONING REGULATIONS

Land use designations used to select study sites for this project were taken as broad indicators of classes of zoning as expressed in the City of Los Angeles Planning and Zoning Code (Chapter 1 of the Los Angeles Municipal Code). A generalized summary of that code is included for reference in this Appendix.

The study sites chosen conformed to the zoning designations described below:

Land Use	Comparable City Designation	Brief Description
Residential	R4	Mixed single-family and ulti-unit homes (near 50% each), good condition; exteriors, lawns well-maintained, neighborhood age 20-40 yr
Commercial	C2	Retail and office, with associated parking
Light Industrial	MR1	Light manufacturing of various types of products (sewing machines, etc.), storage and repair of automobiles, manufacture and cleaning of clothing, small warehousing
Transportation	*	Freeway corridors, major highways, Los Angeles and other smaller airports

* No comparable City zoning designation; some overlap with City designation for parking buildings ("PB")

A more complete description of the individual study areas, including a breakdown by type and square footage of industry, percent of single and multi-family housing, etc. will be included in the Final Report.

GENERALIZED SUMMARY OF ZONING REGULATIONS
CITY OF LOS ANGELES

ZONE	USE	MAXIMUM HEIGHT		REQUIRED YARDS			MINIMUM AREA		MINIMUM LOT WIDTH	PARKING REQUIRED
		STORIES	FEET	FRONT	SIDE	REAR	PER LOT	PER DWELLING UNIT		
	AGRICULTURAL									
A1	AGRICULTURAL One-Family Dwellings-Parks Playgrounds Community Centers Golf Courses-Truck Gardening-Extensive Agricultural Uses	3	45 Ft.	20% lot depth 25 Ft. max.	25 Ft. Maximum 10% Lot Width 3 Ft. minimum	25% lot depth 25% Ft. max.	5 Acres	2½ Acres	300 Ft.	Two Spaces Per Dwelling Unit
A2	AGRICULTURAL A1 Uses						2 Acres	1 Acre	150 Ft.	
RA	SUBURBAN Limited Agricultural Uses One-Family				10 Ft. plus 1 Ft. 3-Stories-less than 70 Ft. width 10% lot width width 3 Ft. min.		17,500 Sq. Ft. (1)	17,500 Sq. Ft. (1)	70 Ft. (1)	Two Covered Spaces Per Dwelling Unit

GENERALIZED SUMMARY OF ZONING REGULATIONS
CITY OF LOS ANGELES

ZONE	USE	MAXIMUM HEIGHT		REQUIRED YARDS			MINIMUM AREA		MINIMUM LOT WIDTH	PARKING REQUIRED
		STORIES	FEET	FRONT	SIDE	REAR	PER LOT	PER DWELLING UNIT		
ONE FAMILY RESIDENTIAL										
RE 40	RESIDENTIAL One-Family Dwellings Parks Playgrounds Community Centers Truck Gardening	3	45 Ft.	20% lot depth	10 Ft. min. plus 1 Ft.- 3 stories	25% depth	40,000 Sq. Ft. (1)	40,000 Sq. Ft. (1)	80 Ft. (1)	Two Covered Spaces Per Dwelling Unit
RE 20							20,000 Sq. Ft. (1)	20,000 Sq. Ft. (1)	80 Ft. (1)	
RE 15				25% Ft. max.	10 Ft. max. 10% Lot width 5 Ft. min.- plus 1 Ft. 3 stories	25 Ft. max.	15,000 Sq. Ft. (1)	15,000 Sq. Ft. (1)	80 Ft. (1)	
RE 11					5 Ft. less than 50 Ft. width 3 Ft. min.		11,000 Sq. Ft. (1)	11,000 Sq. Ft. (1)	70 Ft. (1)	
RE9							9,000 Sq. Ft. (1)	9,000 Sq. Ft. (1)	65 Ft. (1)	
RS	SUBURBAN One-Family Dwellings- Parks- Playgrounds- Truck Gardening			20% lot depth 25 Ft. Max.	5 Ft., less than 50 Ft. 10% Lot With 3 Ft. Minimum	20 Ft.	7,500 Sq. Ft.	7,500 Sq. Ft.	60 Ft.	

GENERALIZED SUMMARY OF ZONING REGULATIONS

CITY OF LOS ANGELES

ZONE	USE	MAXIMUM HEIGHT: STORIES	MAXIMUM HEIGHT: FEET	REQUIRED YARDS: FRONT	REQUIRED YARDS: SIDE	REQUIRED YARDS: REAR	MINIMUM AREA: PER LOT	MINIMUM AREA: PER DWELLING UNIT	MINIMUM LOT WIDTH	PARKING REQUIRED
R1	ONE-FAMILY DWELLING RS Uses	3	45	20% lot depth 20 Ft. max.	Plus 1 Ft. 3 stories	15 Ft. Min.	5,000 Sq. Ft.	5,000 Sq. Ft.	50 Ft.	Two covered spaces per dwelling unit
RZ 2.5	RESIDENTIAL ZERO SIDE YARD Dwelling across not more than five lots (2) Parks-Playgrounds			10 Ft. Min.	None (3) or 3 Ft. plus 1 Ft.-3 stories	None (3) or 15 Ft.	2,500 Sq. Ft.	2,500 Sq. Ft.	30 Ft. with driveway, 25 Ft. w/o driveway	
RZ3							3,000 Sq. Ft.	3,000 Sq. Ft.	20 Ft.-flag curved or cul-de-sac	
RZ4							4,000 Sq. Ft.	4,000 Sq. Ft.		
RZ5							5,000 Sq. Ft.	5,000 Sq. Ft.		
RW1	ONE-FAMILY RESIDENTIAL WATERWAYS ZONE	2	30 Ft.	10 Ft. Min.	10% width 3 Ft. Min.	15 Ft. Min.	2,300 Sq. Ft.	2,300 Sq. Ft.	28 Ft.	

MULTIPLE RESIDENTIAL

RW2	TWO-FAMILY RESIDENTIAL WATERWAYS ZONE	3	45 Ft.	10 Ft. Min.	10% Lot Width 3 Ft. Minimum plus 1 Ft. each story over 2nd (4)	15 Ft. Min.	2,300 Sq. Ft.	1,150 Sq. Ft.	28 Ft.	Two covered Spaces per Dwelling Unit
R2	TWO-FAMILY DWELLING R1 Uses Two-Family	3	45 Ft.	20% lot depth 20 Ft. Max.	5 Ft., less than 50 Ft. 10% lot width 3 Ft. min. plus 1 Ft. each 3 stories	15 Ft. min.	5,000 Sq. Ft.	2,500 Sq. Ft.	50 Ft.	Two Spaces One Covered
RD 1.5	RESTRICTED DENSITY MULTIPLE DWELLING ZONE Two-Family Apartment Houses Multiple Dwellings	Height District No. 1 3 Stories 45 Ft.		15 Ft. Min.	5 Ft., less than 50 Ft. 10% lot width 3 Ft. min. plus 1 Ft. each story over 2, 16 Ft. max.		5,000 Sq. Ft.	1,500 St. Ft.	50 Ft.	One space each dwelling unit or less than three rooms, one and one-half spaces each dwelling unit or three rooms, two spaces each dwelling of more than three rooms, one space each quest room (first thirty).
RD2								2,000 Sq. Ft.		
RD3		Height District Nos. 2, 3 or 4 6 Stories 75 Ft. max.			5 Ft. or 10% lot width 10 Ft. Max.		6,000 Sq. Ft.	3,000 Sq. Ft.	60 Ft.	
RD4							8,000 Sq. Ft.	4,000 Sq. Ft.		

GENERALIZED SUMMARY OF ZONING REGULATIONS
CITY OF LOS ANGELES

ZONE	USE	MAXIMUM HEIGHT STORIES FEET	REQUIRED YARDS FRONT	REQUIRED YARDS SIDE	REQUIRED YARDS REAR	MINIMUM AREA PER LOT	MINIMUM AREA PER DWELLING UNIT	MINIMUM LOT WIDTH	PARKING REQUIRED
RD5	Restricted Density *(continued)*	Height District No. 1 3 stories 45 Ft.	20 Ft. Min.	10 Ft. Min.	25 Ft. Min.	10,000 Sq. Ft.	5,000 Sq. Ft.	70 Ft.	
RD6						12,000 Sq. Ft.	6,000 Sq. Ft.		
R3	MULTIPLE DWELLING R2 Uses Apartment Houses Multiple Dwellings Child Care (20 Max.)	Height District Nos. 1, 2, 3 or 4 6 stories 75 Ft.		5 Ft., less than 50 Ft. 10% lot width, 3 Ft. min., plus 1 Ft. each story above 2nd., 16 Ft. max.	15 Ft.	5,000 Sq. Ft.	800 to 1,200 Sq. Ft.	50 Ft.	One space each dwelling unit of less than three rooms, one and one-half spaces each dwelling unit or three rooms, two spaces each dwelling of more than three rooms
R4	MULTIPLE DWELLING R3 Uses- Churches- Schools- Child care	Unlimited (5)	15 Ft. key lots 10 Ft. min.		15 Ft. plus 1 Ft. each story above 3rd, 20 Ft. max.		400 to 800 Sq. Ft.	50 Ft.	One space each guest room (first thirty)

GENERALIZED SUMMARY OF ZONING REGULATIONS

CITY OF LOS ANGELES

ZONE	USE	MAXIMUM HEIGHT		REQUIRED YARDS			MINIMUM AREA		MINIMUM LOT WIDTH	PARKING REQUIRED
		STORIES	FEET	FRONT	SIDE	REAR	PER LOT	PER DWELLING UNIT		
R5	MULTIPLE DWELLING R4 Uses: Clubs-Lodges Hospitals Sanitariums							200 to 400 Sq. Ft.		

RESIDENTIAL FOOTNOTES

1. "H" Hillside or Mountainous Area designation may alter these requirements in the RA-H or RE-H Zones, subdivisions may be approved with smaller lots, providing larger lots are also included. Each lot may be used for only one single-family dwelling. See minimum width and area requirements below.

ZONE COMBINATION	MINIMUM TO WHICH NET AREA MAY BE REDUCED	MINIMUM TO WHICH LOT WIDTH MAY BE REDUCED
RA-H	14,000 Sq. Ft.	63 Ft.
RE9-H	7,200 Sq. Ft.	60 Ft.
RE11-H	8,800 Sq. Ft.	63 Ft.
RE15-H	12,000 Sq. Ft.	72 Ft.
RE20-H	16,000 Sq. Ft.	72 Ft.
RE40-H	32,000 Sq. Ft.	No Reduction

2. See Section 12.08 B1 of the Zone Code.
3. See Section 12.08 C4 of the Zone Code.
4. For two or more lots the interior side yards may be eliminated, but 4 Ft. is required on each side of the grouped lots. See Section 12.09.5C of Zone Code.

GENERALIZED SUMMARY OF ZONING REGULATIONS
CITY OF LOS ANGELES

ZONE	USE	MAXIMUM HEIGHT		REQUIRED YARDS			MINIMUM AREA PER LOT/UNIT	MINIMUM LOT WIDTH	LOADING SPACE	PARKING REQUIRED
		STORIES	FEET	FRONT	SIDE	REAR				
	COMMERCIAL									
CR	LIMITED COMMERCIAL Banks, Clubs, Hotels Churches, Schools, Business and Professional child care, parking areas, R4 uses	6	75 Ft.	10 Ft. min.	10 Ft. 10% lot width, 5-Ft. min. for corner lots; same as R4 for residential uses or adjoining an "A" or "R" Zone	15 Ft. plus 1 Ft. each story above 3rd	Same as R4 for Residential purposes Otherwise none		Hotels, Institutions, and with every building where lot abuts an alley Minimum Loading Space 400 Sq. Ft.	One space per 500 Sq. Ft. of area within all any lot.
C1	LIMITED COMMERCIAL Local retail stores Offices or Businesses, Hotels, hospitals and/or Clinics, Parking Areas-CR uses except churches, schools and museums R3 Uses				Same as R3 for for corner lots, lots, or residential uses or adjoining an "A" or "R" Zone	15 Ft. plus 1 Ft. each story above 3rd, 20 Ft. max. Residential uses or abutting an "A" or "R" Zone	Same as R3 for Residential purposes, except 5,000 Sq. Ft. per unit in C1-H Zones Otherwise None		Additional Space Required for Buildings containing more than 50,000 Sq. Ft. of floor area. None required for apartment buildings 30 units or less.	One space per 2000 Sq. Ft. of total floor area of medical service facilities.
C1.5	LIMITED COMMERCIAL C1 Uses-Department Stores, Theaters, Broadcasting Studios, Parking Buildings, Parks and Playground					Yards provided at lowest residential story Otherwise none	Same as R4 Residential purposes Otherwise none	50 Ft. for Residential use Otherwise none		

COMMERCIAL							
C2	COMMERCIAL C1.5 Uses-Retail Business with Limited Manufacturing, Auto Services Station and Garage, Retail Contractors Business, Churches, Schools, R4 Uses.	Unlimited (6)		None for Commercial buildings Residential uses-same as in R4 Zone Yards provided at lowest residential story	Same as R4 for residential purposes Otherwise None	Hospitals, Hotels, Institutions, and with every building where lot abuts an alley Minimum Loading Space 400 Sq.Ft. Required for Buildings containing more than 50,000 Sq.Ft. of floor area None required for buildings 30 units or less	One space per 500 Sq. Ft. of floor area within all buildings on any lot. One space per 200 Sq. Ft. of total floor area or medical service facilities
C4	COMMERCIAL C2 Uses-(With Exceptions, such as Auto Service Stations, Amusement Enterprises, Hospitals Second-Hand Business) R4 Uses						
C5	COMMERCIAL C2 Uses-Limited Floor Area for Light Manufacturing of the CM-Zone Type, R4 Uses						
CM	COMMERCIAL MANUFACTURING Wholesale Business, Storage Buildings, clinics, limited manufacturing, C2 Uses-Except Hospitals, Schools, Churches, R3 Uses			None for industrial or commercial buildings Residential Uses-same as in R4 Zone	Same as R3 for residential purposes Otherwise None		

GENERALIZED SUMMARY OF ZONING REGULATIONS

CITY OF LOS ANGELES

ZONE	USE	MAXIMUM HEIGHT		REQUIRED YARDS			MINIMUM AREA		MINIMUM LOT WIDTH	PARKING REQUIRED
		STORIES	FEET	FRONT	SIDE	REAR	PER LOT	PER DWELLING UNIT		
	INDUSTRIAL									
MR1	RESTRICTED INDUSTRIAL Uses first Permitted in CM Zone-Limited Commercial and Manufacturing Uses, Clinics, Limited Machine Shops, Animal Hospitals and Kennels			5 Ft. for lots 100 Ft. in depth or less, 15 Ft. for lots over 100 Ft. in depth	None for industrial or commercial buildings	None for industrial or commercial buildings	Same as R4 for watchman or caretaker dwellings (5)		Institutions, and with every building where lot abuts an alley	One space for each 500 Sq. Ft. of floor area in all buildings on any lot
MR2	RESTRICTED LIGHT INDUSTRIAL MR1 Uses-Addition Industrial Uses, Mortuaries, Agriculture				Residential Use-Same as in R4 Zone	Residential Uses-Same as in R4 Zone			Minimum Loading Space 400 Sq. Ft.	Must be located within 750 Ft. of building
M1	LIMITED INDUSTRIAL CM Uses-Limited Industrial and Manufacturing Uses-No "R" Zone Uses, No Hospitals, Schools, or Churches any enclosed C2 Uses	Unlimited (6)				Yards provided at lowest residential story			Additional required for buildings containing more than 50,000 Sq. Ft. of floor area	
M2	LIGHT INDUSTRIAL M1 and MR2 Uses-Additional Uses, Storage Yards of All Kinds, Animal Keeping-No "R" Zone Uses			None	Residential Uses-Same as in R5 Zone		Same as R5 Zone		None required for apartment buildings 30 units or less	
M3	HEAVY INDUSTRIAL M2 Uses-Any Industrial Uses-Nuisance Type-500 Ft. from any other Zone-No R" Zones Uses				None	None	None			

PARKING								
P	AUTOMOBILE PARKING-SURFACE AND UNDERGROUND Land in a "P" Zone may also be classified in "A" or "R" Zone Parking Permitted in lieu of Agricultural or Residential Uses			10 Ft. from where any combination of an "A" or "R" Zone with "P" Zone		None unless also in an "A" or "R" Zone		
PB	PARKING BUILDING Automobile Parking within without a Building "P" Zone Uses	(7)	0 Ft., 5 Ft. or 10 Ft. depending on zoning frontage and zoning cross street	5 Ft. plus 1 Ft. each story above 2nd if abutting or across street and frontage in "A" or "R" Zone	5 Ft. plus 1 Ft. each story above 2nd if abutting an "A" or "R" Zone	None None		

SPECIAL

TENTATIVE CLASSIFICATION
(T) Used in Combination with Zone Change Only-Delays Issuance or Building Permits until Subdivision or Parcel Map Recorded or other conditions met as required by City Council.

QUALIFIED CLASSIFICATION
(Q) Further restrictions on Property; used in Combination with Zone Changes Only (Except with RA, RE, RS or R1 Zones). Restricts Uses of Property and Assures Development Compatible with the Surrounding Property

DEVELOPMENT LIMITATION CLASSIFICATION
(D) Restricted absolute building heights, floor area ratio, percent of lot coverage and building setbacks

SUBMERGED LAND ZONE
(SL) Commercial Shipping - Navigation - Fishing - Recreation

FUNDED IMPROVEMENT CLASSIFICATION
(F) An Alternative means of Effecting Zone Changes and Securing Improvements (When No Subdivision or Dedications are Involved)

CP-7150 (4/85)

SUPPLEMENTAL USE DISTRICT: Established in Conjunction with Zone(s)	
G-Surface Mining O-Oil Drilling RPD-Residential Planned Development K-Equine Keeping CA-Commercial and Artcraft **FOOTNOTES:**	
(5) Sec. 12.17.5 B.9. (a) Dwellings considered as accessory to industrial use only (watchman or caretaker including family). (6) HEIGHT DISTRICT	
No. 1	Floor area of main building may not exceed three times the building area of the lot.
No. 1L	Same as No. 1 and maximum height - 6 stories or 75 Ft.
No. 1-VL	Same as No. 1 and maximum height - 3 stories or 45 Ft.
No. 1-XL	Same as No. 1 and maximum height - 2 stories or 30 Ft.
No. 2	Floor area of main building may not exceed six times the buildable area of the lot.
No. 3	Floor area of main building may not exceed 10 times the buildable area of the lot.
No. 4	Floor area of main building may not exceed 13 times the buildable area of the lot.
(7) MAXIMUM PB ZONE HEIGHTS	
No. 1	2 stories and roof
No. 2	6 stories
No. 3	10 stories
No. 4	13 stories

NOTE: ***This summary is only intended to be a guide; definitive information should obtained from the Department of Building and Safety.***

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SANTA MONICA BAY CHARACTERIZATION STUDY, 1993

April 1993

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SANTA MONICA BAY RESTORATION PROJECT

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CHAPTER 3: THE BIOLOGICAL SETTING

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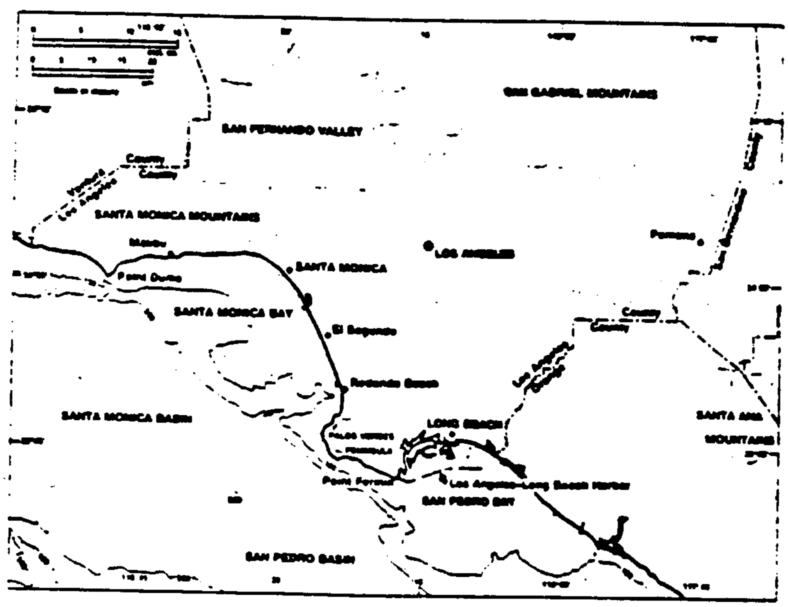

Figure 1-1. Santa Monica Bay and the greater Los Angeles Basin.

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CHAPTER 1
INTRODUCTION

Santa Monica Bay is an open embayment on the central part of the southern California coast which lies seaward of Los Angeles County (Figure 1-1). The Bay is bordered offshore by Santa Monica Basin, on each end by rocky headlands (Point Dume and the Palos Verdes Peninsula), and onshore by the Los Angeles Coastal Plain and Santa Monica Mountains.

Five hundred years ago the shores of Santa Monica Bay and the Palos Verdes Peninsula were probably inhabited by less than 10,000 native American Indians. These natives used the natural resources of the Bay for a variety of purposes, but there were so few of them that any impacts on the environment were probably not perceptible. From the time of European contact to the twentieth century human impacts on the environment remained relatively minor: much of the area remained undeveloped or was used for ranching. However, during the twentieth century the area became a major population and industrial center which increasingly imposed itself on the natural environment of the area.

Today Santa Monica Bay is a valuable natural resource that contributes to the local economy and enhances the quality of life for those who work or live in the area or visit it. The Bay supports a commercial party boat fishing industry and offers recreational fishing from piers, beaches and private boats. Approximately 500,000 tourists and local residents visit the beaches annually to surf, swim, and pursue the many recreational activities. This influx of visitors bolsters the local economy and constitutes an important source of revenue. Greater Los Angeles is the second largest metropolitan area in the United States, and is home to about 15 million people, nearly 6% the population of the United States (Hoffman 1992). This population uses the Bay not only for recreation, but also for domestic and industrial waste disposal. Multiple uses of a single resource inevitably lead to conflicts of interest and opinion.

PUBLIC CONCERN FOR THE BAY AND WATERSHED

Although concern for the condition of Santa Monica Bay and its watershed has increased dramatically during the last 25 years, solutions to some multiple-use conflicts were enacted long ago. For example, prior to 1884 raw sewage was discharged across the beach near the present Hyperion Treatment Plant and in the following decades nearshore discharges also contaminated the beaches with oil, grease, other floatables, and enteric bacteria. However, as the population and volume of discharge grew, sewage treatment was improved and discharge outfalls were moved further offshore into deeper water, so recreational use of the shore would not be affected. In 1935 the California Department of Fish and Game recognized the value of Santa Monica Bay for sport fishing and prohibited commercial fishing (by most methods) throughout the Bay. Public concern for the condition of Santa Monica Bay grew gradually after World War II and received a major impetus when the Federal Clean Water Act was established in 1972. The heightened awareness of the impacts of pollution which accompanied this legislation has resulted in public pressure to restore the natural state of the Bay.

In 1987 the Southern California Association of Governments (SCAG -Appendix A lists all acronyms used in this report) established the Santa Monica Bay Steering Committee and Santa Monica Bay Scientific Review Committee, and conducted public workshops at which issues and concerns about the Bay were aired. SCAG initiated one study to evaluate the state of Santa Monica Bay and another to guide the management of resources and problems in the Bay and its watershed. The studies were followed by the preparation of two State-of-the-Bay reports: Assessment of Conditions and Pollution Impacts (MBC 1988) and Management Framework (SCAG 1988). The information, findings, and recommendations of the two reports were publicized at a "State-of-the-Bay" conference in November 1988.

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Table 1-1. Bodies of water included in the National Estuary Program.

State	Body of Water
West Coast	
California	San Francisco Bay
California	Santa Monica Bay
Oregon	Tillamook Bay
Washington	Puget Sound
Gulf of Mexico	
Florida	Indian River Lagoon
Florida	Sarasota Bay
Florida	Tampa Bay
Louisiana	Barataria-Terrebonne Estuarine Complex
Texas	Corpus Christi Bay
Texas	Galveston Bay
East Coast	
Delaware	Delaware Inland Bays
Maine	Casco Bay
Massachusetts	Buzzard's Bay
Massachusetts	Massachusetts Bays
New Jersey, Pennsylvania, Delaware	Delaware Bay
New York	Peconic Bay
New York, Connecticut	Long Island Sound
New York/New Jersey	New York/New Jersey Harbor
North Carolina	Albemarle-Pamlico Sound
Rhode Island	Narragansett Bay
Atlantic Ocean	
Puerto Rico	San Juan Bay

Source: SMBRP, unpubl.

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THE NATIONAL ESTUARY PROGRAM

The National Estuary Program (NEP) was established by U.S. Congress in the Water Quality Act of 1987 and is administered by the United States Environmental Protection Agency (EPA). The purpose of the NEP is to create a conservation and management plan which will protect and enhance water quality in specific bodies of water (USEPA,OMEP 1987). In 1988 California Governor Deukmejian nominated Santa Monica Bay to be included in the NEP and in July 1988 the Bay became one of 21 bodies of water nationwide to be granted this status (Table 1-1).

Santa Monica Bay Restoration Project

Under sponsorship by EPA, State Water Resources Control Board (SWRCB), and State Environmental Affairs Agency (SEAA), the Santa Monica Bay Restoration Project (SMBRP) was established and mandated to meet the goals outlined by the NEP. A Management Conference was established to overview the activities of the Project and is being conducted by a Management Committee composed of representatives of 54 organizations, including Santa Monica Bay area Congressional and State legislative representatives, cities bordering Santa Monica Bay, Los Angeles County, regulatory and resource agencies, major dischargers, environmental and industry groups, and public interest groups. A Technical Advisory Committee (TAC) provides scientific and technical expertise to the Management Committee while a Public Advisory Committee (PAC) advises those affected by the Management Committee's recommendations and actions.

Comprehensive Conservation and Management Plan

The goal of the SMBRP is to develop a Comprehensive Conservation and Management Plan (CCMP) for the Bay which includes the following goals:

- To restore the beneficial uses of Santa Monica Bay and to protect present and future beneficial uses of the Bay. Beneficial uses include active and passive recreation, sport fishing, shellfish harvesting, and protection of marine habitat, including habitats for rare and endangered species and for fish spawning.

- To improve or eliminate discharges to the Bay that may adversely affect biologically sensitive sites, including wetlands, or important swimming and fishing areas.

- To improve water quality to a point where local marine species are not degraded and human health is not threatened.

To accomplish these goals, the SMBRP concentrates is in the process of building a consensus among all user groups; identifying the major environmental problems in Santa Monica Bay; and preparing a plan that can be implemented to protect the Bay and its resources.

PURPOSE AND OBJECTIVES OF THE STUDY

In 1990, the SMBRP adopted the "State of the Bay: Assessment of Conditions and Pollution Impacts" report (MBC 1988) as its preliminary characterization report. Since then the SMBRP has developed an outline of the CCMP, drafted Action Plan Elements to be addressed in detail in the Plan (Table 1-2), and has commissioned several studies to fill data gaps identified in the State of the Bay report. Meanwhile, the need to document present conditions in the Bay was recognized. In April 1992 MBC Applied Environmental Sciences was contracted to update the State of the Bay report.

The objectives of the present study are to update the State of the Bay Report and to provide a final characterization report for the Santa Monica Bay Restoration Project, emphasizing the tentative Action Plan Elements identified. The general aims of the update, like those of the original study, are to assess historic and present levels of pollution and to evaluate the impacts of that pollution in the study area. Specific goals include the following:

- to document what is and is not known about the condition of the Bay and its watershed, with an emphasis on the effects of pollution on human health and the marine environment;

- to determine inconsistencies in the literature regarding the condition and effects of pollution in the Bay and its watershed;

- to summarize the reviewed literature and evaluate conclusions from major documents and reports;

- to identify areas where additional research is needed to resolve inconsistent findings or to clarify appropriate clean-up measures; and,

- to prepare recommendations based upon this information.

STUDY APPROACH

The basic study approach was to collect, compile, review, summarize, and evaluate new information (collected between 1988 and 1992) relevant to the issues of concern. No field collections or measurements were made and few original analyses were performed. The original working bibliography of more than 1,000 citations was reviewed, leading to the identification of additional pertinent studies. Some of the information in this report was derived from published studies, but most of the recent data were collected from unpublished reports and personal communications from knowledgeable persons. Unpublished data from local agencies were integrated into existing figures and tables. However, the large number of studies and the quantity of data which have been generated precluded the inclusion of all information; only the more important references are actually cited.

HUMAN USES OF THE BAY

The developed area adjacent to Santa Monica Bay is important to southern California for its social, economic, and environmental resources. The Bay forms the western-most edge of much of the Los Angeles metropolitan area and is simultaneously a marine environment and a densely populated urban area. The kinds of human uses that occur at the interface between the Pacific Ocean and Los Angeles have varied over time, including:

- Recreation, Tourism, and Aesthetic Enjoyment
- Sport and Commercial Fishing
- Coastal Development
- Industrial Uses

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Table 1-2. Draft Action Plan Elements of the Comprehensive Conservation and Management Plan for Santa Monica Bay.

Action Plan Element	Discussion Chapters
I. REDUCE SOURCES OF POLLUTION	
A. Mass Emission Policy	5,6
B. Pollution Prevention Program	5,6
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C. Beaches and Intertidal Zones	3,8
D. Watersheds	3,6

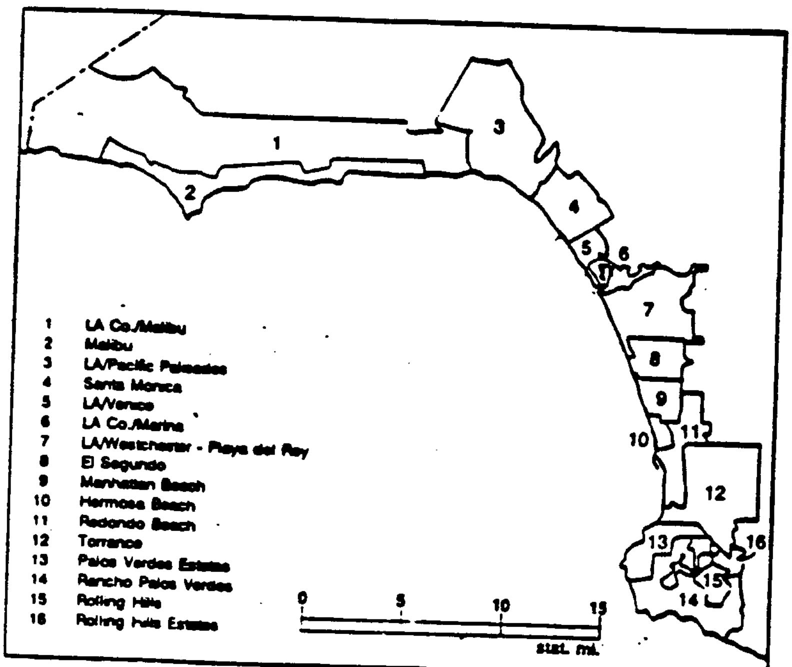

Figure 1-2. Local coastal jurisdictions in the Santa Monica Bay study area, 1992 (modified from MBC 1988).

These uses constantly compete with each other for the limited amount of land and water, resulting in the current patchwork of open space as well as commercial, residential, and industrial development. Some uses are mutually exclusive, others can coexist. Recreation, tourist facilities, and aesthetic features (views and mild climate) have a symbiotic relationship in which the elements reinforce one another; in contrast, some shipping and industrial uses are incompatible with fishing and recreational uses.

The following inventory of human uses in and adjacent to Santa Monica Bay emphasizes the social, environmental, and economic significance of these activities. When possible, the economic value is described. Coastal Santa Monica Bay includes the eleven incorporated cities adjacent to the Bay plus the communities of Playa del Rey, Westchester, Venice, Pacific Palisades (City of Los Angeles), and Marina del Rey (County of Los Angeles) (Figure 1-2). The eleven incorporated cities are El Segundo, Hermosa Beach, Manhattan Beach, Malibu, Palos Verdes Estates, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, Santa Monica, and Torrance. Malibu was incorporated in April 1991 and has a population of about 15,000. Major factors behind incorporation were the local residents' desire for low-growth policies and to block construction of a new county sewer system.

Recreational, Tourist, and Aesthetic Uses

Recreation features and activities can be natural or developed, commercially or non-commercially operated. Examples of the four possible combinations abound throughout the Bay area.

Natural Open Space

Undeveloped natural recreation areas are scarce along the predominantly urban coastline; pristine wildlife conditions no longer exist in the study area. Yet significant natural resources remain. The Ballona wetlands (between Marina del Rey and Playa del Rey at the mouth of Ballona Creek) is a surviving wetlands that contributes to recreation, tourism, and aesthetic enjoyment. Urban development has impacted the marsh in recent decades, but efforts to reestablish and enhance 151 acres of degraded wetlands habitat are being advanced (MBC 1988). Some relatively undisturbed marsh and riparian habitat is also found in the Malibu Creek drainage and the Santa Monica mountains offer a wide range of natural habitats, especially inland of the Malibu and Carillo coasts.

Developed Beach Facilities

The many miles of bathing beaches between Torrance and Point Dume almost define Santa Monica Bay for many persons. The 22 public beaches along the shore provided more than 46 million person-days of recreation in 1991. Activities include sunbathing, swimming, boating, and surfing as well as access to the nearshore waters for skin- and SCUBA-diving. Most of these beaches are at least partially developed, offering parking, restrooms, concessions, and rental equipment. The natural state of most of them is supplemented with imported sand and/or landscaping. The busiest beach in the County is the three-mile long Santa Monica Beach. Other developed natural recreation facilities include the beach bike path, which extends from Santa Monica to Redondo Beach, and several bluff-top parks overlooking the Bay.

Recreational use of Los Angeles County beaches increased sharply until the early 1980s, attendance peaking in 1983 at 79 million visitors. While the region's population and visitors to the area have increased steadily since then, beach attendance has decreased 56% since 1983

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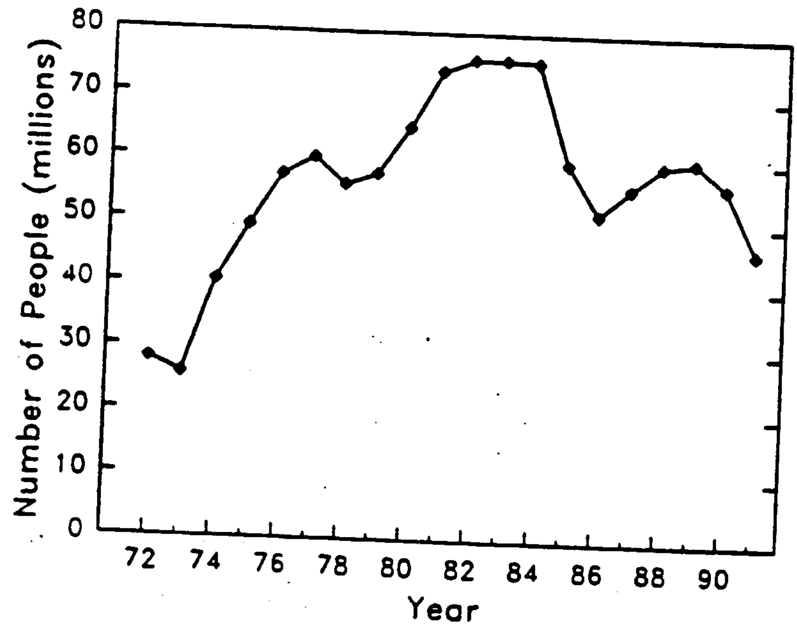

Figure 1-3. Beach attendance along Santa Monica Bay, 1972-1991 (LAC,DBH unpubl. data).

(Figure 1-3) (LAC,DBH 1987, 1992). Although changes in the weather account for annual fluctuations, the dramatic decline may indicate basic changes in recreational conditions at the beaches. In particular is public fear of water pollution, congestion, and lack of parking. For example, despite warm temperatures, beach attendance declined in late October and November 1987 following two sewage spills into the Bay from the Hyperion Treatment Plant (HTP) when some beaches were closed for up to seven days (LAC,DBH 1987). In 1991, beaches were closed on five occasions due to spills or overflows, and in 1992 beaches were closed at least eight times, including several days following contamination flowing from the storm drains created from the civil unrest in the spring of 1992.

Commercial

Commercial recreation opportunities range from bicycle and roller skate rentals, and "fun zone" arcades, to restaurants, bars, and art galleries. Most of these establishments capitalize on the pedestrian traffic attracted to the beach and some areas have evolved into recreation attractions of their own: Main Street and Santa Monica Pier in Santa Monica; Fisherman's Village in Marina del Rey; and King Harbor in Redondo Beach.

Tourist facilities and activities are abundant around Santa Monica Bay. Hotels, motels, apartments by the week, restaurants, shops, and conference facilities all cater to day visitors and out-of-town visitors. While neither the local economy nor the beach environment alone would attract tourism, in combination they create a powerful magnet for visitors. In addition, Los Angeles International Airport (LAX) is situated directly on Santa Monica Bay and it funnels a large percentage of its 48 million annual passengers into the Santa Monica Bay area for at least a portion of their stay.

Tourist services and attractions are not distributed evenly in the Bay area. Hotel development is centered around LAX, although small numbers of guest rooms and conference facilities are available in Santa Monica, Marina del Rey, El Segundo, Manhattan Beach, and Redondo Beach. An average of 9,372 guest rooms are available daily in the Santa Monica-LAX area, 10.4% of Los Angeles County's total (Pannell Kerr Forster 1992). The Santa Monica market has performed well despite the recession and is expected to remain strong even after the addition of two high-end hotel properties that are being added and will diversify the supply.

Demand in the LAX market has declined in recent years due to reductions in domestic and international tourism and in corporate travel. In addition, 700 new rooms were added to the market in 1991. Hotel supply in Los Angeles County outpaced demand by moderate levels: between 1986 and 1990 the daily average number of rooms available increased by 5%. Growth in new hotel rooms during the 1990s is expected to be at a slower rate than in the late 1980s due to the slow economy, cutbacks in corporate and leisure travel, escalating land prices and a more difficult development climate (Pannell Kerr Forster, 1992). There are few parcels of land left in the coastal area which are large enough to accommodate hotel-conference complexes (LAVCB 1988, pers. comm.).

Tourism is a powerful economic factor in the Bay area. Complete visitor data are not available for most jurisdictions, but a profile of Santa Monica's experience indicates the magnitude of visitor contributions to the local and regional economy. Santa Monica reports 2.5 million visitors annually, 64% of them day visitors. On average, day visitors spend $25 per day; overnight visitors staying in hotels spend $81 per day and constitute 15% of the city's visitor volume. Visitors who lodge with friends and relatives spend approximately $30 per day and make up about 20% of the total. In 1986 these visitors added $232 million and more than 3,000 jobs to Santa Monica's

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The sport fishery catch has some economic value as food, but fees paid to charter operators and other onshore expenditures have a much greater impact on the local economy. Expenditures on saltwater fishing in southern California totalled $536.3 million in 1989, 16% of which was on licenses and gear, 23% on boat related expenses, and 61% on trip-related expenses. Los Angeles County residents accounted for 37% of that total. About 465,000 of the 6.1 million households in Southern California coastal counties included at least one member who went sportfishing in 1989.

Los Angeles residents spend an average of $27.13 per fishing trip on tackle, food, lodging, boat fuel, boat fees, and gasoline. Shore anglers spend an average of $27.44 per fishing trip and party boat anglers spend an average of $72.76 per fishing trip. The average expenditures noted above, if applied to the totals counted by CDFG, would account for a total contribution to the local economy by sport anglers in Santa Monica Bay in excess of $3.6 million.

Recreational fishing facilities in the Bay area include piers at Malibu, Santa Monica, Venice, Manhattan Beach, Hermosa Beach, and Redondo Beach and a fishing barge off Redondo Beach. There are small craft harbors at Marina del Rey and at King Harbor in Redondo Beach. Fourteen artificial reefs designed to enhance marine life and improve sport fishing opportunities have been installed offshore at Malibu, Paradise Cove, Santa Monica, Marina del Rey, Manhattan Beach, Hermosa Beach, and Redondo Beach since 1958 and nine of these remain (Lewis and McKee 1989). Commercial passenger fishing vessels (party boats) can be taken at Marina del Rey, Malibu, and Redondo Beach. Party boats from Los Angeles, Long Beach Harbor also fish in the area.

Coastal Development in the Santa Monica Bay Area

Development of the Santa Monica Bay area is extensive: of the 67.6 mi^2 of land adjacent to the Bay (for which data exist) about 55% are devoted to residential uses; 14% commercial uses; 11% industrial uses; and 3% to transportation corridors (Table 1-3)(SCAG 1992a). Although 17% of the area are vacant, few sizable vacant parcels remain, the Hughes Playa Vista property is the largest.

Like the rest of the region, the Santa Monica Bay area is under pressure for living and working space; several regional employers in the area have fueled competition for the limited supply of coastal land. Density in areas adjacent to the Bay has increased in response to the demand for housing and business locations with coastal amenities.

For the most part land-use is regulated by the individual jurisdictions bordering the Bay and are specified in each cities' General Plan. The California Coastal Commission also regulates development in the Coastal Zone through Local Coastal Plans which are formulated by the jurisdictions in accordance with Commission policies and planning principles.

Coastal development itself is a major economic activity. The assessed valuation of property in jurisdictions around Santa Monica Bay ranged from $296 to $7,618 million in 1987 (Table 1-4) (LAC,AC 1988) and the full-market value of residential, commercial, and industrial properties in the area exceeded $30 billion. This figure does not include the value of publicly-held or otherwise tax exempt property such as libraries, schools and colleges, and parks and recreation facilities, nor does it include City and County of Los Angeles Plan areas, for which statistics were unavailable. Nevertheless, this indicator of private investment accounts for 9.7% of the Los Angeles County total.

economy and the city received $4.2 million in tax revenues generated by tourist expenditures. In total, Santa Monica garnered approximately 6.8% of the state's $3.4 billion tourist income (MBC 1987).

Noncommercial

The aesthetic features (especially marine) and favorable climate of Santa Monica Bay enjoy a worldwide reputation. These resources are an amalgam of natural and man-made features which have been achieved through merging of coastal themes with urban development.

The Santa Monica Bay shore offers numerous opportunities to appreciate physical beauty: broad beaches, boardwalks, and piers; vistas of Palos Verdes Peninsula, Malibu, and Santa Catalina Island; and a variety of public and private facilities and spaces. Local jurisdictions review proposed development plans in order to preserve and enhance existing aesthetic resources and scenic areas.

Aesthetic resources make an intangible but important contribution to the local economy. They tend to boost tourism and recreation and are closely tied to specific businesses such as television and motion picture filming, two staples of the regional economy.

Sport and Commercial Fishing

Fishing is one of the most fundamental human uses of the Bay and includes commercial passenger boat fishing (party boats), pier fishing, private boat fishing, scientific collecting, and limited commercial fishing. While sport fishing is allowed throughout the Bay, commercial fishing has been prohibited in about 62% of Santa Monica Bay proper to protect local fish populations, which could be depleted by a combination of both commercial and sport fishing. Commercial fishing for white croaker off Palos Verdes has been banned since 1989 due to white croaker contamination problems (Velez 1993, pers. comm.). Purse seining, gillnetting, and traps are prohibited in parts of the Bay east of a line between Malibu Point and Palos Verdes Point; thus commercial fishing activities there is restricted to hook-and-line fishing.

Commercial fishing activity in the rest of the Bay centers around gillnetting for California halibut west of Malibu and south of Palos Verdes Point, and purse seining for northern anchovy in the outer portions of the Bay (MBC 1985). Under Assembly Bill 2315, experimental gear permits are issued for round haul net fishing for live bait (Velez 1993, pers. comm.). Commercial catches from Santa Monica Bay are negligible. Limited commercial marine life collections are made for scientific and educational specimens and unauthorized commercial fishing and poaching may occur to some extent, although its magnitude is not known.

Although statistics are not available for Santa Monica Bay alone, 5.5 million sport fishing trips were made in southern California in 1989. It is estimated that 11% of those trips involved beach fishing, 22% involved pier fishing, 30% involved commercial passenger fishing vessels (CPFVs), and 37% involved private fishing boats (NMFS 1991). The sport fishery catch from Santa Monica Bay is monitored by the California Department of Fish and Game (CDFG). In 1987 the sport fishery catch (79,197 anglers) was dominated by Pacific bonito, chub (Pacific) mackerel, and barred sand bass (CDFG,MRD, unpub. data). In 1991-1992 the sport fishery of the Bay was dominated by chub mackerel, barred sand bass, and kelp bass (MBC, in prep.).

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Table 1-4. Assessed values of development within jurisdictions of the coastal Santa Monica Bay area, 1987.

Jurisdictions	Valuation $ in millions)
El Segundo	4,724
Hermosa Beach	1,002
LA/Venice	na
LA/LAX Westchester	na
LA/Pacific Palisades	na
LA/Malibu	na
LA/Playa Del Rey	na
LA/Marina Del Rey	na
Manhattan Beach	2,533
Palos Verdes Estates	1,284
Rancho Palos Verdes	2,571
Redondo Beach	3,690
Rolling Hills	296
Rolling Hills Estates	767
Santa Monica	5,863
Torrance	7,618
Total	30,348

Source: LAC, A-C 1988
na = Data not available

Table 1-3. Major land uses of local coastal jurisdictions within the Santa Monica Bay area, 1992.

Jurisdictions	Area (mi^2)					
	Comm.	Ind.	Res.	T/C	Vacant	Total
El Segundo	0.82	2.88	1.14	0.15	0.54	5.53
Hermosa Beach	0.23	0.01	0.62	0.07	0.15	1.08
LA/Venice	na	na	na	na	na	na
LA/LAX Westchester	na	na	na	na	na	na
LA/Pacific Palisades	na	na	na	na	na	na
LA/Malibu	na	na	na	na	na	na
LA/Playa Del Rey	na	na	na	na	na	na
LA/Marina Del Rey	na	na	na	na	na	na
Manhattan Beach	0.66	0.14	2.64	0.10	0.34	3.89
Palos Verdes Estates	0.20	0.00	3.08	0.07	1.38	4.73
Rancho Palos Verdes	0.51	0.06	7.22	0.18	5.34	13.31
Redondo Beach	1.14	0.35	3.08	0.16	0.37	5.09
Rolling Hills	0.04	0.00	1.94	0.01	1.05	3.04
Rolling Hills Estates	0.40	0.21	1.91	0.30	0.61	3.43
Santa Monica	1.70	0.51	4.76	0.42	0.42	7.81
Torrance	3.85	3.20	10.51	0.86	1.26	19.68
Total Area	9.55	7.36	36.90	2.33	11.45	67.59
Total Percent	14.1	10.9	54.6	3.4	16.9	

Source: SCAG 1992b
Comm. = commercial; Ind. = industrial; Res. = residential;
T/C = transportation corridor
na = Data not available

Table 1-5. Housing stock in the coastal Santa Monica area, 1987 and 1992.

Jurisdictions	Units 1987	Units 1992	Percent Difference
El Segundo	6,951	7,231	4.0
Hermosa Beach	10,012	9,743	-2.7
LA/Venice	20,530	16,354	-20.3
LA/LAX Westchester	19,236	8,098	-57.9
LA/Pacific Palisades	9,776	3,291	-66.3
LA/Malibu	7,371	7,570	2.7
LA/Playa Del Rey	1,496	8,235	450.5
LA/Marina Del Rey	4,756	5,513	15.9
Manhattan Beach	14,882	14,826	-0.4
Palos Verdes Estates	5,023	5,144	2.4
Rancho Palos Verdes	14,580	15,565	6.8
Redondo Beach	28,826	28,591	-0.8
Rolling Hills	664	676	1.8
Rolling Hills Estates	2,767	2,924	5.7
Santa Monica	47,843	47,976	0.3
Torrance	52,288	55,370	5.9
Total Coastal Units	247,001	237,107	-4.0
Total Los Angeles County Units	3,023,573	3,206,500	6.1
Percent of Total County	8.2	7.4	-0.8

Source: SCAG 1992a

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In addition to its ultimate assessed value, development contributes to local and regional economics during construction. Construction jobs and expenditures are a major segment of the southern California economy. Coastal development also supports the local economy through property taxes and development fees, which are used in part to fund recreation and open-space amenities that encourage still other economic benefits, primarily tourism.

The predominant human use in the Santa Monica Bay area is residential (Table 1-3). The Bay's recreation and air quality resources make it one of the most desirable sectors of the region in which to live: housing unit vacancies fall well below the County's 4% average in all but a few of the Bay jurisdictions. Except for the Palos Verdes Peninsula, the average household size is also below the Los Angeles County average, indicating a trend toward smaller, denser housing units (LAC,DRP 1987). The Bay area's housing stock is 7% of the Los Angeles County total (Table 1-5) (SCAG 1992b) and it houses 7% of the County's population, underlining the small household size along the coastal area. Torrance, Santa Monica, and Redondo Beach have the greatest number of housing units (Table 1-5) (SCAG 1992b). Between 1987 and 1992, the number of housing units increased 450% in Playa del Rey; the next highest rates of increase were Marina del Rey with 16% and Rancho Palos Verdes with 7% (Table 1-5). Pacific Palisades, Westchester, and Venice had fewer housing units in 1992 than in 1987, with decreases of 66, 58, and 20%, respectively.

Commercial and industrial land uses in the Santa Monica area contribute to the regional economy in terms of employment. In 1980 commercial and industrial land users in the Bay area provided 18% of the five-county region's jobs on only 4% of its land. These figures include inland portions of West Los Angeles, but exclude major job centers such as UCLA, Westwood, and Century City. Jobs within the Bay area are diffused throughout the 16 jurisdictions, although there are major concentrations in Santa Monica, South Bay, and at LAX. While the absolute numbers of jobs have changed since 1980, the general patterns have been reinforced through additional land development and employment growth.

Commercial and industrial land uses in the area support 17% of the region's retail jobs, 16% of financial jobs, 22% of business sector employment, 23% of service and entertainment jobs, 16% of professional workers, and 15% of public administration positions. The area also accommodates 20% of the region's manufacturing workers, 23% of transportation employment, and 18% of wholesale employment. This impact is augmented by the goods and services produced by the workers, which have regional, national, and international significance (Gordon 1988, pers. comm.).

Marine development in the Bay area includes piers, artificial reefs, and breakwaters. Commercial and industrial activities which depend on a coastal location are clustered in and around the small craft harbors and piers. Boat building and maintenance, fishing, and tourist facilities are coastal dependent commercial and industrial activities. However, electric power generating stations and an oil refinery must also be included as coastal-dependent, the former for cooling water and the latter for tanker access.

Secondary economic impacts from the Bay area's commercial and industrial activities emanate to the rest of the Los Angeles region. Employees from outside areas spend most of their income elsewhere, thus boosting sales and tax revenues there. Goods and services produced in the Bay area are often sold or consumed in other sectors of the region.

With the exception of the Playa Vista land holding, which is being planned for mixed-use development, the study area is at or near build-out. Future coastal development is limited by the

The Los Angeles County Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) discharges approximately 325 mgd of treated municipal wastewater onto the Palos Verdes Shelf. The JWPCP disposes of a mixture of 60% secondary- and 40% advanced primary-treated wastewater through two outfalls, 90- and 120-in. diameter, with a 72-in. diameter outfall for emergency backup. JWPCP is the processing facility for 5 upstream water reclamation plants located in Los Angeles County; these plants provide primary, secondary, and tertiary treatment for 150 mgd wastewater (Stull 1993, pers. comm.).

Each of these industrial/municipal uses impacts the economy in two ways. Each generates employment and goods for the local economy and each also provides a regional service with a high replacement value. Replacement costs for SCE's electrical generating stations at Redondo and El Segundo illustrate the magnitude of the economic value that major industrial uses for the study area and the region. Based on 1987 totals for capital investment, operations and maintenance expenses (including payroll and repairs), fuel expenditures, property taxes, and electricity sales, SCE estimates the power replacement value of its El Segundo station at $918,000,000, and for its Redondo station at $1,442,000,000 (SCE,SGD 1988).

HTP also represents a substantial replacement value, although no estimates are available. Some facilities might not be able to replace the loss of a Bay location or resource, at any cost. For example, loss of its marine terminal pipelines across the Bay could force Chevron to relocate to an area without transportation constraints.

Future impacts of industrial facilities on regional economics will depend on the amount of expansion and updating that occurs. LAX is the hub of a regional airport system, which is expected to grow to 65 million passengers annually by the year 2000 (CLA,DA 1992). HTP is being expanded and upgraded at present and is expected to remain the linchpin of Los Angeles' wastewater treatment system, whether or not additional capacity is added elsewhere. However, as additional land is unavailable, any expansions can only occur with more intensive use of existing land holdings and water resources, or through eminent domain.

Plans for further oil and gas development in and around Santa Monica Bay have changed in recent years. The Department of the Interior Lease Sale No. 95 Offshore Drilling Proposal for southern California, which would have made areas immediately west of Santa Monica Bay available for oil and gas exploration and development, has been dropped. Lease Sale No. 95 was originally slated for January 1990 but in June of that year President Bush deferred the sale until 1996 and in 1992, a moratorium was placed on offshore drilling and Lease Sale No. 95 was canceled. In addition, Occidental Petroleum's 22 year effort to drill for oil on the company's two acres of coastal property along Pacific Coast Highway ended in 1992. Occidental decided not to pursue the drilling plan any further and transferred ownership of the property to the City of Los Angeles (LA Times 1992).

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lack of available vacant land. Future growth, along with its primary and secondary economic benefits, will be restricted to scattered infill development, recycling, and redevelopment activities. Thus, significant expansion of the Bay area's economic position in the region is likely to result in a denser pattern of human activities and development.

Infrastructure constraints - the willingness of local jurisdictions to work together to fund and construct new streets, parking, and sewage treatment capacities - will also limit future growth,. Downzoning and other growth-curtailing planning and policy actions are now being considered in several local jurisdictions. Some of these proposals affect residential growth only, others address commercial growth, and some would impact all development. The outcome of these deliberations may freeze the present land use pattern and thus limit the area's current contribution to the regional economy.

Industrial Uses of the Bay Area

Industrial land use is found in all but two Bay area jurisdictions. El Segundo, Torrance, and Westchester-LAX-Playa del Rey contain industrial centers of 1,500 acres or more, while Santa Monica, Redondo Beach, and Manhattan Beach contain industrial centers of 250 to 500 acres (LAC 1987). Industrial uses also affect the marine environment directly through wastewater discharges and use of the ocean for transport.

The industrial/municipal activities that most impact the Bay are power generation, oil refining, and waste disposal. Most of the industrial facilities of concern are located nearshore, between Marina del Rey and Redondo Beach: the Los Angeles Department of Water and Power's Scattergood Generating Station; Southern California Edison's (SCE) El Segundo and Redondo Generating Stations; the Chevron USA's El Segundo Refinery; and the City of Los Angeles Hyperion Treatment Plant (HTP).

Los Angeles International Airport (LAX) is an industrial facility and aerospace-related manufacturing center which is located on the Bay but provide essential regional services; the airport relies upon its proximity to the Bay for safe flight paths exiting the airport.

The three power generation facilities use Bay water for condenser cooling and disposal of a small amount of treated effluent. Together, these plants circulate up to 238 billion gallons of seawater per day. Southern California Edison's plants generated $625.5 million worth of electrical energy sales to the region in 1987 (SCE,SGD 1988).

Chevron USA uses Santa Monica Bay to transport crude oil and refined petroleum products to and from its El Segundo Refinery. Small coastal lightening tankers load and off-load at the refinery using a three-berth offshore facility which connect the marine terminal to the refinery with subsea pipelines (Chevron USA 1988, pers. comm.). Small amounts of treated effluent are also discharged.

HTP discharges treated municipal wastewater at a distance of 5 miles from shore, relying on ocean water to dilute the effluent to safe levels. HTP disposes of a mixture of secondary- and primary-treated wastewater via a 5-mi long outfall pipe into the Bay. The 5-mi outfall discharges 60% secondary and 40% primary treated effluent. A 1-mi outfall is used for emergency purposes, to discharge chlorinated secondary treated effluent. A 7-mi outfall was used for sludge disposal until November 1987.

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CHAPTER 2
THE PHYSICAL SETTING

Santa Monica Bay is an open embayment on the southern California coast just west of Los Angeles, with natural boundaries which extend from Point Dume to Palos Verdes Point. For the purposes of this study, the Bay has been defined as extending from the Ventura-Los Angeles County Line (west of Point Dume) to Point Fermin (south of Palos Verdes Point) and offshore to water depths of about 1,650 ft (Figure 2-1).

Santa Monica Bay is a relatively small feature in a larger geographic region [the Southern California Continental Borderland (Emery 1960, SCCWRP 1973)] – the offshore, submerged lands from Point Conception, California to Cape Colnett, Baja California and seaward to the Patton Escarpment. Without the geological connotation, this region is known more commonly as the Southern California Bight, the seaward boundary of which is the California Current.

The study area consists of three regions: Santa Monica Bay itself; its natural watershed; and the wasteshed which drains to it (Figure 2-1). Santa Monica Bay includes the marine waters and seafloor of the area already defined. The watershed is that region of coastal land from which surface waters drain naturally to the Bay. The wasteshed is that area from which municipal wastes are collected before being treated and discharged to the Bay. The surface area of Santa Monica Bay is approximately 266 mi^2 and that of the combined watershed and wasteshed is approximately 1,380 mi^2. Most surface runoff from the wasteshed is carried to Los Angeles' Long Beach Harbor (east of the Palos Verdes Peninsula) but some is carried to the Bay.

The physical characteristics of the Santa Monica Bay ecosystem are determined primarily by the geology, climate, and oceanography of the region. Geological features provide the framework for the system within which climate and oceanography determine many natural environmental cycles.

GEOLOGY

The present configuration of the Southern California Continental Borderland is largely the result of the movement of the Pacific tectonic plate against the North American tectonic plate, the San Andreas fault marking the line of contact between the two. Many local features in the area result from block-faulting, a geological process in which large blocks of the earth's crust are thrown upwards or downwards. Offshore islands and banks represent upthrown blocks whereas basins represent downthrown blocks (Emery 1960). The Santa Monica Mountains were uplifted, then shifted to the West.

Santa Monica Bay is the submerged portion of the Los Angeles Coastal Plain, which extends southeast of the Santa Monica and San Gabriel Mountains, southwest of the San Bernardino Mountains, and north of the Santa Ana Mountains. The Los Angeles Basin lies beneath the Coastal Plain and the Bay and was formed as a downthrown block. Sediments eroded from the surrounding mountains have subsequently filled the basin to its present surface, near sea level (Terry *et al.* 1956, Emery 1960, Miller and Hyslop 1983). Sediments near the surface of the Basin have been deposited during the last 2 million years (BLM 1981).

Offshore of the Los Angeles Basin is the Santa Monica Basin, which is a downthrown block that has only been partially filled with eroded sediments; hence it is still a fairly deep marine basin. The shelf in Santa Monica Bay is partly the sediment-filled Los Angeles Basin and partly the sill that separates the Los Angeles and Santa Monica Basins. Bedrock lies much nearer the sediment surface beneath the sill than beneath the two basins (Emery 1960).

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The Palos Verdes Peninsula is an uplifted block that appeared as an island about 3 million years ago; it was later connected to the mainland as a result of sedimentation on the Coastal Plain (Reiter 1984). During ice ages, which occur about every 100,000 years, sea level drops as much as 425 ft because water is retained in polar glaciers (Covey 1984); during interglacial periods sea level rises, to present levels or higher. Most of the terraces which are obvious on the Palos Verdes Peninsula (and can be detected on the adjacent seafloor to water depths of 500 ft) were formed by wave erosion of the shore when sea level was at a different height for a considerable period of time. Terraces far above the shoreline on Palos Verdes Peninsula were probably exposed as a result of uplifting of the peninsula in recent geologic time.

The present continental shelf has only been submerged for the last 10,000 years and to the present depth for the last 3,000 years. During the peak of the last ice age (18,000 years ago), sea level was 384 ft lower than now (Nardin *et al.* 1981); this would have exposed the entire shelf and dry land would have extended as much as 12 mi offshore of the present shoreline.

Topography of Santa Monica Bay

Santa Monica Bay is characterized by a gently sloping (about 0.5°) continental shelf which extends seaward to the shelf break at a water depth of about 265 ft (Terry *et al.* 1956). At the break, the seafloor steepens along the continental slope but decreases again as the floor of the Santa Monica Basin is approached at a water depth of about 2,630 ft.

The shelf in the Bay ranges in width from a few hundred yards to about 12 mi (Figure 2-2). It is broadest off El Segundo, narrowest off Redondo Beach, and is transected by three submarine canyons: Dume Submarine Canyon across the northwestern shelf off Point Dume; Santa Monica Submarine Canyon 7 mi offshore of Ballona Creek; and Redondo Submarine Canyon, a few hundred yards off King Harbor. In this report the region between Santa Monica and Point Dume is called the Malibu Shelf and the region between the Ventura-Los Angeles County Line and Point Dume is called the Carillo Shelf.

The Palos Verdes Shelf extends from the southern edge of Redondo Canyon around the Palos Verdes Peninsula to Point Fermin and offshore to water depths of about 245 ft (SDWG 1988). The Palos Verdes Shelf ranges in width from about 1.2 to 4.6 mi, and is steeper than in the Bay proper. The shelf break is shallower but less pronounced; below the break the seafloor is relatively steep to the boundary of the study area at depths of 1,640 ft.

Shores

The shore of the study area is generally mountainous, with coastal cliffs between the Ventura County and Santa Monica and along the Palos Verdes Peninsula. Prior to development, the coast between the palisades at Santa Monica and Malaga Cove consisted of sand dunes; wetlands were abundant in the vicinity of Ballona Creek. At present approximately 50% of the shore of Santa Monica Bay is sandy, constituting the popular recreational beaches from Torrance Beach to Santa Monica and intermittently from there to Ventura County. The coast from Point Dume to Pulga Canyon consists of narrow, sandy beaches interrupted by rocky outcrops or short stretches of rocky shore. Along the Palos Verdes Peninsula the shore is largely cobble with some small sandy pocket beaches (Terry *et al.* 1956); these beaches comprise coarser sand than those along the rest of Santa Monica Bay and contain some cobble.

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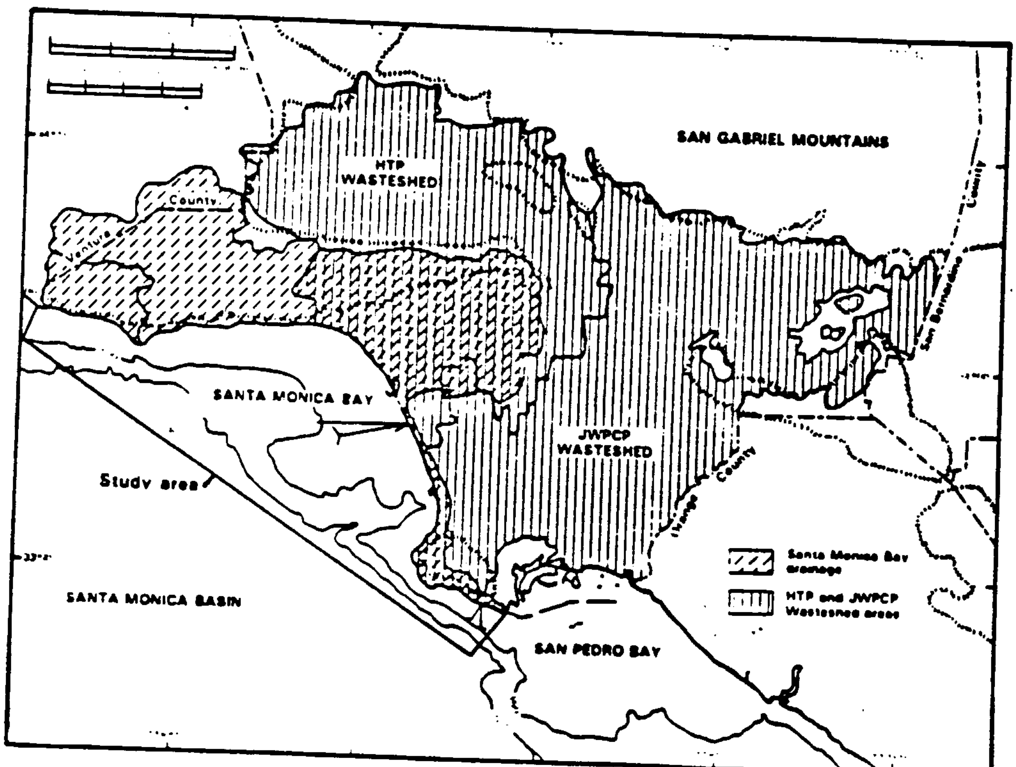

Figure 2-1. Santa Monica Bay study area, watershed, and wasteshed (modified from MBC 1988).

Since creeks in the Ballona Creek drainage were channelized in the 1930s, little sand is transported to the Bay from the coastal plain. In the past, occasional shifts in the course of the Los Angeles River to Santa Monica Bay probably replenished beach sand. Now the primary source of beach sand is cliff erosion (Woodell and Hollar 1991) with some inputs from runoff from the Santa Monica Mountains (Mitchell 1987, pers. comm.) and the Santa Clara River (Kolpack 1988, pers. comm.). A landslide at Portuguese Bend has been an important source of sediment to the Palos Verdes Shelf since 1956, contributing about 9 million MT of sediment (Stull 1988, pers. comm.); it has been particularly important since 1980 (SDWG 1988).

Sandy beaches are an extension of the intertidal zone, as they are formed by the combined action of wind and waves. The source of the sand on Santa Monica Bay beaches is bluff erosion and sediment carried from the watershed by coastal streams and rivers. Sand is transported longshore and is eventually lost into Redondo Canyon. In some locations, beaches have been augmented by nourishment projects which have added more than 24 million cubic meters of sand to the shoreline (Woodell and Hollar 1991).

Dunes depend on a supply of sand which is moved onshore by waves, then further inland across low-lying areas by frequent strong winds. Coastal dunes protect low-lying inland areas from ocean storms, but they may be completely eroded during a single winter storm and reformed during calmer periods. The El Segundo Dunes are the only significant dunes remaining in the Santa Monica Bay area.

Historical. Prior to development, the coast between the palisades at Santa Monica and Malaga Cove consisted mostly of sand dunes. Adjacent to Ballona Creek were wetlands with fine sediments. Occasional shifts in the course of the Los Angeles River to Santa Monica Bay through Ballona Creek probably replenished beach sand. Since the channelization of creeks in the Ballona Creek drainage in the 1930s, little sand has been transported to the Bay from the coastal plain. Now the only natural source of sand besides bluff erosion is in runoff from the Santa Monica Mountains (Mitchell 1987, pers. comm.) or from the Santa Clara River in Ventura County via longshore transport (Kolpack 1988, pers. comm.). The few remaining natural dunes are just west of Los Angeles International Airport (Sharp 1978).

The shoreline of Santa Monica Bay is gradually eroding because sea level is slowly rising. Early developments in the Santa Monica Bay coastal zone included the construction of commercial structures on beaches and in the littoral zone and, later, other projects to protect these investments from the impacts of natural events. The first efforts to rebuild eroding beaches began in 1930 with the establishment of the Los Angeles County Coastal Studies Division. Periodic surveys of the beaches began in 1933; there have been 36 surveys to date. As a result of many efforts to counteract the erosion process (construction of groins and beach replenishment), beaches along much of Santa Monica Bay are wider than in the past (Woodell and Hollar 1991).

Location and Jurisdiction. The beaches of the Santa Monica Bay study area are variously under the jurisdiction of the state, county, city, and private groups. State beaches are run by the California Department of Parks and Recreation and include Leo Carrillo, Westward, Point Dume, Corral, Malibu Lagoon (Surfrider Beach), Las Tunas, Topanga, and Will Rogers to the west of Santa Monica and Dockweiler, Manhattan, Redondo and Royal Palms south of there. Beaches, parks, and reserves falling under the jurisdiction of Los Angeles County include Nicholas Canyon Beach, Zuma Beach Park, Torrance Beach, Abalone Cove Beach, and Abalone Cove Ecological Reserve.

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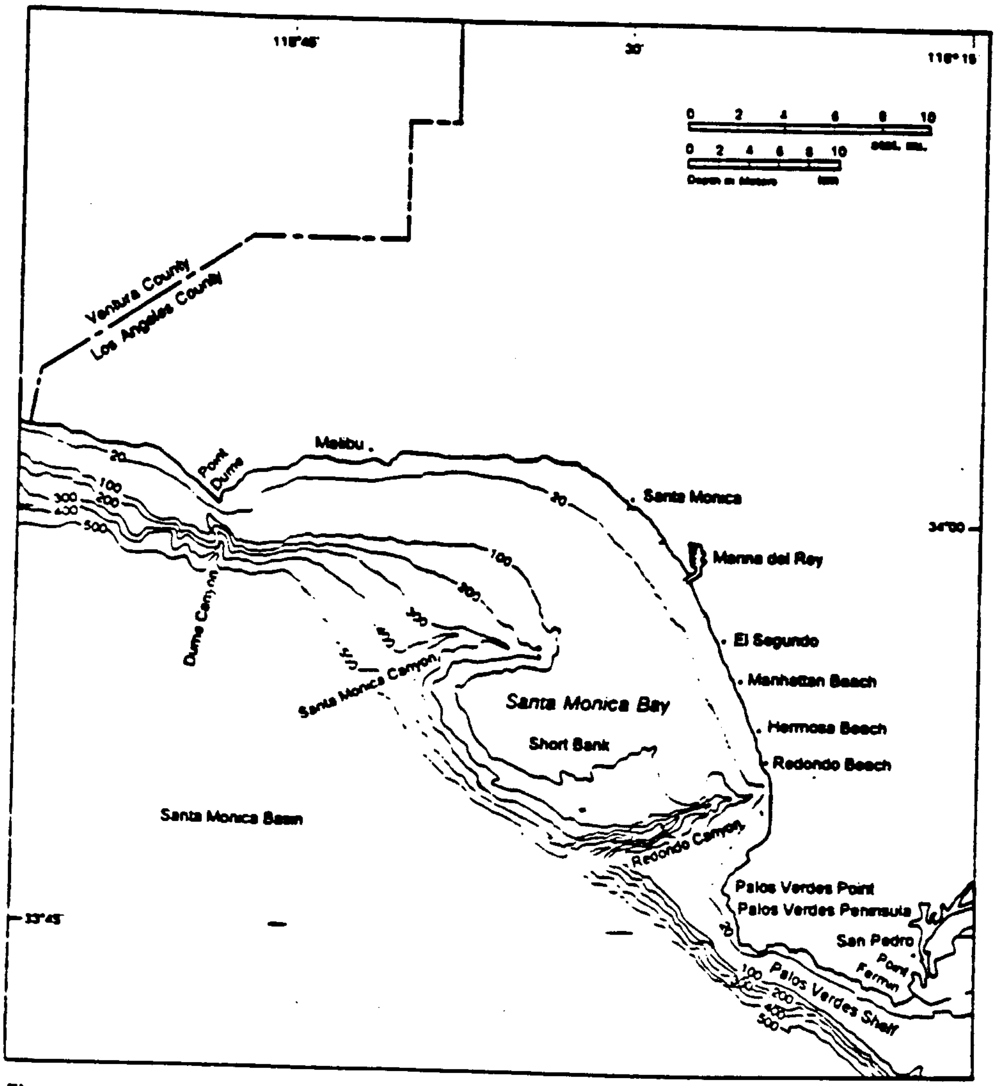

Figure 2-2. Topographic features of Santa Monica Bay (modified from MBC 1988).

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Soft-Bottom Sea Floor

The bottom type of the seafloor is largely a function of the water movement in the overlying water mass, although the proximity of the sediment source can be important. Coarse sand and gravel are found under swiftly moving water whereas fine silt and clay settle to the bottom in quiet water. In most parts of Santa Monica Bay the seafloor consists primarily of fine to moderately coarse, unconsolidated sediments. However, hard bottoms of bedrock, gravel, and phosphorite are found in some areas (Figure 2-3).

Unconsolidated (soft) sediments are classified on the basis of grain size into sand, silt, and clay fractions. In general, sediments grade from coarse nearshore to fine offshore; thus sediments on the shelf are sand whereas those on the slope are silt. Most nearshore sediments of Santa Monica Bay are olive green sands, which form an elongate bed which is broadest off Manhattan Beach and extending from Venice Beach to the central shelf (Terry *et al.* 1956). Sediments on the northwestern part of the Palos Verdas Shelf are generally coarser than those on the Santa Monica Shelf whereas those on the southern part of the shelf are finer (SDWG 1988).

Silty sand is found over much of the central plateau and on the Palos Verdes Shelf, but only in a narrow, nearshore band along Malibu and on the southern portion of the central shelf. Sandy silt is characteristic of the upper portion of the basin slope, much of the middle and deep depths off Malibu, and the outer portion of the central plateau. Deeper portions of the basin slope have silty sediments (Terry *et al.* 1956). Clay was a minor fraction of Santa Monica Bay sediments in the 1950s (Terry *et al.* 1956), but was more common in the 1970s (Bascom 1978).

Most sand on the shelf is fine quartz-feldspar that is being eroded from land, although small patches of relict red sand are found on the central plateau and south of Redondo Canyon (Terry *et al.* 1956). Relict red sands were deposited when the sea level was lower; they represent ancient beaches or sand dunes that have been reexposed. Much of the sand on the basin slope and the outer portions of the shelf are glauconite; shell sand occurs on some of the basin slopes.

Sediment composition and distribution change in time and place due to prevailing currents and storms. Winter storms move beach sand offshore to deeper (10 to 20 ft) water; in summer reduced wave intensity allows the sand to reaccumulate onshore (Grant and Shepard 1939). Currents generally move sand east along the Carillo Shelf toward Dume Canyon (Kolpack, 1988, pers. comm.), east along the Malibu Shelf, south along the central shelf toward Redondo Canyon, and north from Malaga Cove to Redondo Canyon (Grant and Shepard 1939). From time to time sand flows down Redondo Canyon and is lost to the nearshore system (Drake and Gorsline 1973). Numerous dikes, groins, and jetties have been constructed to help sand accumulate (Woodell and Hollar 1991). Sediments along the upper slopes of Santa Monica Canyon and the Palos Verdes Shelf occasionally slump into basins as a result of earthquakes and turbidity currents (Haner and Gorsline 1978, Gorsline *et al.* 1984, SDWG 1988).

Sediments are typically exposed to oxygen and any organic material is processed by aerobic infauna and bacteria which live in the sediments. However, if there is insufficient oxygen in the sediments for aerobic decomposers, anaerobic sulfur bacteria may dominate. These produce hydrogen sulfide which gives the sediments the odor typical of rotten eggs.

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City jurisdictions include beaches (Santa Monica, Venice, and Hermosa Beaches) and piers (Santa Monica Municipal, Venice Fishing, Manhattan Beach Municipal, Hermosa Beach Municipal, and Redondo Beach Municipal Piers). Seaside Lagoon at, and the Palos Verdes Estates Shoreline Preserve. Private beaches include Paradise Cove and Marina del Rey Public Beach. Private piers include Paradise Cove Pier, Redondo Sportfishing Pier, and Monstad Pier.

Rocky Intertidal. On coasts exposed to the full force of incoming waves, loose sediments have been stripped away leaving underlying bedrock exposed as rocky intertidal habitat. In the study area, natural rocky intertidal habitat is found along the Carrillo coast, on the Malibu coast from Point Dume to Paradise Cove, along occasional rocky patches from there to Big Rock Beach, and along the coast of Palos Verdes Peninsula. Reefs around Point Dume are primarily bedrock, but those on the Palos Verdes Shelf include cobble, which is less stable than bedrock. Jetties, groins and piers provide artificial intertidal hard-bottom habitat along the central Bay.

The rocky intertidal can be divided into four discrete zones (Hedgpeth and Hinton 1961, Carefoot 1977). The splash zone is above the high tide mark and is essentially terrestrial, although it is splashed by waves. The upper intertidal zone extends from the bottom of the splash zone to about mean high tide, and it is exposed to the air longer than it is under water. The middle intertidal zone extends from about mean high water to mean low tide mark; it is exposed and submerged for about equal periods of time. The lower intertidal extends from mean low tide to the subtidal and is submerged longer than it is exposed.

The demarcation of zones is also affected by the prevailing wave heights. In an area which is exposed to frequent and high waves, the upper zones are displaced upward and the boundaries between adjacent zones are blurred. In protected areas where the average wave height area is low, there is no splash zone and the other zones are marked distinctly.

Sandy Intertidal. Where the coast is not directly exposed to strong waves, sand accumulates to form beaches. The sandy intertidal is exposed to extremes in temperature, hydration, salinity, and movement. During high tides it is covered with cool salt water; on hot days during low tides it dries out and heats up rapidly. On rainy days when the tide is out it may be exposed to freshwater. Organisms in the sandy intertidal are also subjected to forceful wave shock and shifting sand with each high tide. Sandy beaches are less productive of plant and animal life than most other marine habitats and zonation is less apparent than on rocky shores.

Sandy beaches have relatively large spaces between sand grains which permits the ready flow of water and oxygen well below the sediment surface. Where the sand is coarse and wave action is great, fixed burrows are impossible to maintain and most inhabitants are small enough to live between the sand grains or, if larger, to quickly bury themselves in the loose sand.

The infaunal communities of the sandy beaches of Santa Monica Bay have not been studied in detail, but data from studies conducted at beaches at Point Dume (Patterson 1974, Straughan 1982), El Segundo (MBC 1982b,c), Torrance (Straughan 1977b), and King Harbor (Straughan 1977a,b) are available. Bight-wide, sandy intertidal habitats support three slightly different communities separated along geographic lines (Straughan 1982). All sites between Point Mugu and Palos Verdes Peninsula are similar.

Hard-Bottom Sea Floor

Exposed bedrock is found nearshore along the Carillo and Malibu coasts from the Ventura-Los Angeles County line to Pulga Canyon and from Malaga Cove to Point Fermin on the Palos Verdes Shelf. Exposed bedrock is also found offshore, on the central shelf (Short Bank) of the Santa Monica Shelf and in both Santa Monica and Redondo Submarine Canyons. Inshore rocky bottoms are similar in composition to those on land nearby; however, the offshore bedrock generally consists of siliceous shales with mudstone, siltstone, sandstone, and schist (BLM 1975).

Stream deposition and the erosion of rocky shore have formed nearshore gravel beds off Malibu and along the Palos Verdes Shelf. These gravels are primarily rounded pebbles of igneous rock but include metamorphic and sedimentary rock. Other gravel beds surround the exposed bedrock areas of Short Bank (Shepard and MacDonald 1938, Terry *et al.* 1956, Bascom 1978) and in Santa Monica Submarine Canyon (Bascom 1978). These presumably resulted from the erosion of outcrops at lower sea level stands or from stream deposition at that time.

Anthropogenic hard-bottom substrates in the study area include municipal wastewater outfall pipes (three from Hyperion Treatment Plant and four from the Joint Water Pollution Control Plant), as well as smaller outfall structures for generating stations and the refinery. Other artificial hard-bottom structures include jetties, breakwaters, groins, and artificial reefs.

Because subtidal, hard-bottom habitats support algal growth and attract sportfisheries species, the California Department of Fish and Game (CDFG) has constructed 14 artificial reefs in Santa Monica Bay since 1958. The first five were constructed of degradable materials (streetcars and automobiles) and have since disappeared. Nine artificial reefs (constructed since 1962 out of quarry rock, concrete, pier pilings, tires, and marine vessels) are expected to remain for much longer (Lewis and McKee 1989).

Topography of the watershed and wasteshed

The terrestrial environment bordering Santa Monica Bay consists of two major regions: 1) the watershed and 2) the wasteshed (Figure 2-1). The watershed is the region of coastal land that comprises the natural drainage area of the Bay (i.e., the land from which surface waters drain into the ocean). The natural drainage and its potential to carry pollutants into Santa Monica Bay makes the watershed important as it pertains to the Bay's environmental quality. The wasteshed is that land area from which municipal wastes originate before being treated at municipal waste treatment facilities which discharge to the Bay and hence is not a natural physical region. Much of the surface runoff in the wasteshed is carried to the Los Angeles-Long Beach Harbor area east of the Palos Verdes Peninsula but some is carried into Santa Monica Bay. The surface area of the combined watershed and wasteshed of Santa Monica Bay is approximately 1,380 mi^2; the watershed drains about 414 mi^2 (SMBRP 1992).

The topography of the terrestrial environment bordering Santa Monica Bay is dominated by the Santa Monica Mountains, the Los Angeles Coastal Plain, and the Palos Verdes Peninsula. Mountain peaks in the Santa Monica Mountains are up to 3,111 ft high (on the western border of the natural drainage) and in the Palos Verdes Hills up to 1,480 ft (Reiter 1984). However, most of the plain is less than 500 ft above sea level (Terry *et al.* 1956, CLADPW 1982).

Historically, the Los Angeles River occasionally emptied into Santa Monica Bay at Ballona Creek instead of into San Pedro Bay at Long Beach. This resulted from changes in the river's course during unusually heavy storms and is known to have occurred in 1815-1825, 1862, and

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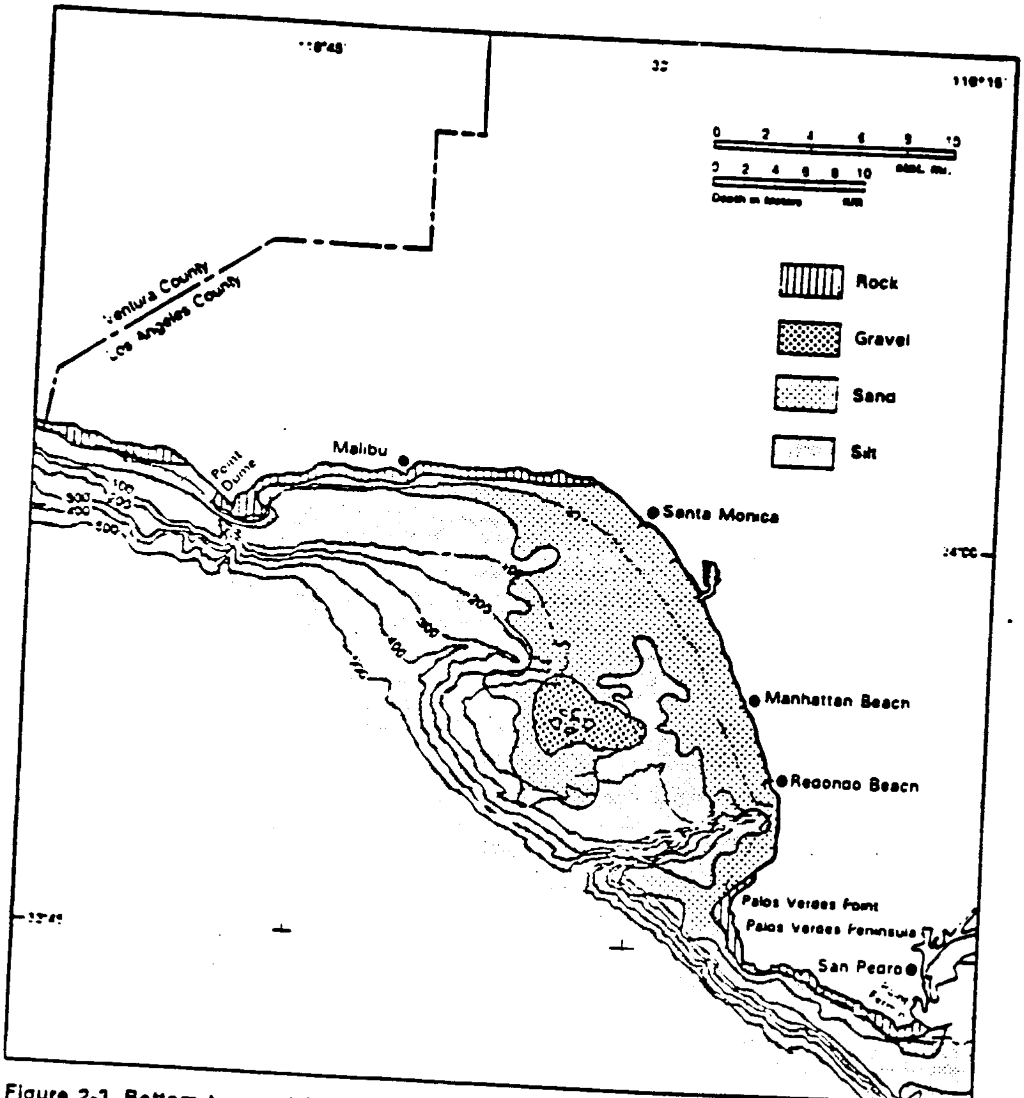

Figure 2-3. Bottom types of Santa Monica Bay (modified from MBC 1988).

Wind

Prevailing winds along the coast are from the west-northwest and wind speed is generally low throughout the year. At Santa Barbara Island, west of Santa Monica Bay, wind speed ranges from 6 to 8 mph in the fall to 10 to 12 mph during the spring, although gusts may reach 60 mph during the winter and spring (Kimura 1974). In summer sea breezes typically blow onshore in the morning as air over the land heats up, rises, and pulls cool air from the ocean (Miller and Hyslop 1983). At night offshore land breezes often develop as air over the land is pulled seaward as air over the warmer ocean rises.

During winter (but occasionally at other times) Santa Ana winds blow to the west off the deserts east of the Los Angeles Basin. These winds result from high pressure cells over the desert and enter the coastal zone through mountain passes. Santa Anas are very dry and hot as a result of compression as they drop in altitude, and gusts of 50 mph have been recorded. Santa Anas are responsible for dispersing dust and air-borne contaminants out over the ocean (Miller and Hyslop 1983).

OCEANOGRAPHY

Oceanographic conditions in the study area are largely a function of the California Current and other offshore currents, as modified by local topography and conditions.

Currents

Oceanic Currents

The California Current is a low-temperature, low-salinity, and nutrient-rich current that flows south along the California coast (Figure 2-4). It varies in velocity from year to year but is usually weakest in winter and spring (CLA,DPW and USEPA 1977). South of Point Conception, the California Current generally flows along the Patton Escarpment (100 mi offshore) and approaches the coast again near Cape Colnett, Baja California.

Off Baja California part of the California Current flows north into the Southern California Bight as the Southern California Countercurrent. Part of this countercurrent exits the Bight through the Santa Barbara Channel and rejoins the California Current while the rest flows south nearshore (CLA,DPW 1982). Beneath the surface water mass (i.e., from the surface to depths of about 820 ft) is a relatively high-temperature and high-salinity current called the California Undercurrent which flows to the north (CLA,DPW and USEPA 1977; Jackson 1986). This current surfaces nearshore north of Point Conception during the fall and winter and is known then as the Davidson Current.

Coastal Currents

Local currents are affected by local submarine topography, winds, and tides and are of two kinds: longshore currents which flow parallel to shore and cross-shore currents which move perpendicular to shore. Longshore currents are fastest near the surface; near-bottom they are slowed by seafloor friction. Off Palos Verdes and the seaward edge of Santa Monica Bay, longshore currents flow north at approximately 0.09 kn (CLA,DPW and USEPA 1977). However, surface currents with speeds up to 1.13 kn for several days have been measured on the Palos Verdes Shelf (SDWG 1988). Cross-shore currents flow shoreward or seaward near the surface and at depth; they are generally caused by surface wind forcing or by internal waves (Jackson 1986).

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1884 (Terry *et al.* 1956). When the Los Angeles River discharged through Ballona Creek, the natural drainage to Santa Monica Bay was much larger, including the San Fernando Valley and part of the San Gabriel Mountains. Because the Los Angeles River is now channelized, future discharges through the Ballona Creek are unlikely.

The area between Ballona Creek and present-day Beverly Hills was often a vast swamp (Johnston 1962, Reiter 1984); in fact, the Spanish word for swamp (*la cienega*) is given to a major boulevard in this region. During torrential rains in the winter of 1861-1862, the entire area from Los Angeles to the ocean, both toward San Pedro and toward Ballona, was a vast lake (Kuhn and Shepard 1981).

The natural drainage of the study area (Figure 2-1) follows the crest of the Santa Monica Mountains from the Ventura - Los Angeles County Line (and following a ridge to the sea in that area) to a point inland from Point Dume north of Lake Silverwood and from there east to Hollywood. From Hollywood it extends south and west across the Los Angeles plain to include the area east of Ballona Creek and north of the Baldwin Hills. South of Ballona Creek the natural drainage is a narrow coastal strip between Playa del Rey and the Palos Verdes Hills.

CLIMATE

Air Temperature

The climate of southern California is Mediterranean, characterized by warm, dry summers and mild, wet winters. Although less than half of the days of the year are cloudy, insolation (i.e., sunshine) is greatest from March to September. The sun heats the air, land, and water; in turn, the land and water heat the air. The average daily (24 hr) air temperature in the study area ranges from 45 to 72°F annually (SCCWRP 1973), being coldest in January and warmest in July. In summer the Los Angeles Coastal Plain is generally cooler than the nearby mountains and inland valleys due to the onshore flow of marine air (Miller and Hyslop 1983). Relative humidity is typically about 90% at night and about 60% during the day (Kimura 1974).

A temperature inversion often develops on the Los Angeles Coastal Plain during the summer. Cool coastal is air trapped beneath warm air at higher altitudes, resulting in hazy or smoggy air. Cool air over upwelling regions of the ocean often results in fog. During late spring and early summer, fog may deepen to several thousand yards, causing drizzles throughout the Coastal Plain (Miller and Hyslop 1983). At Los Angeles International Airport there are usually about 53 days of fog per year (Kimura 1974).

Rainfall

The average annual rainfall on the Coastal Plain is 12 to 13 in. but ranges from 4 to 25 in (SCCWRP 1973, Kimura 1974, Miller and Hyslop 1983). About 90% of the rainfall occurs between November and April (SCCWRP 1973). In winter cold-front storms typically come from the northwest; in summer tropical storms called chubascos occasionally come from the southeast. Most storms originate over the ocean as low pressure cells, but thunderstorms occasionally result from hot air rising over land (Kimura 1974, Miller and Hyslop 1983).

Surface currents in Santa Monica Bay are complex but those below the upper 100 ft flow north (Hickey 1988, pers. comm.). Surface currents along the Palos Verdes Shelf may flow northwest or south-southeast, at all depths and throughout the year. However, during the winter they tend to flow northwest and west-southwest below 150 ft; in summer they flow northeast and south-southeast near the surface (SCCWRP 1973).

Water sometimes enters Santa Monica Bay from the south, moving in a slow counterclockwise eddy. However, when the northward current is weakened, a clockwise gyre may develop. During these periods, a southward, longshore flow with speeds of 0.04 kn is induced (SCCWRP 1973, Hendricks 1980, CLA,DPW 1982). Recent studies suggest that the clockwise gyre may dominate on the shelf, except when it reverses for a few days at a time and inshore of the 70-ft isobath due to tidal action. The residence time of surface water (0-300 ft) in the Bay is estimated to be 3 to 4 days (Hickey 1988, pers. comm.).

Littoral Currents

Littoral currents move alongshore and adjacent to the shore, and are caused by breaking waves, as modified by shore topography. The littoral currents may move as much as 8 ft/sec and often transport beach sediments in a turbid layer which is denser than seawater and which may flow into submarine canyons as turbidity currents (Drake and Gorsline 1973). Point Dume and the offshore islands shelter much of Santa Monica Bay from most westerly and northerly storms. However, long period waves from southern storms may generate surf 10 to 15 ft high along the Malibu coast, reworking sediments to water depths of 250 ft (Haner and Gorsline 1978). On the Palos Verdes Shelf, storm waves can resuspend sediments to water depths of 150 ft (SDWG 1988).

Tides

Southern California has a mixed, semidiurnal tide, which is composed of two unequal high tides and two unequal low tides every 24 hr 50 min. In Santa Monica Bay the high and low tides generally differ by 3.7 ft, although spring tides may differ by 5.4 ft (NOS 1986). Tidal currents tend to flow onshore-offshore, but they achieve their greatest velocities alongshore (SCCWRP 1973). Down-canyon tidal flows in Santa Monica Submarine Canyon have been measured at 0.14 ft/sec and up-canyon velocities at 0.10 ft/sec (Hendricks 1980, CLA,DPW 1982). Similar flows probably occur in Dume and Redondo Submarine Canyons.

Upwelling

During prolonged northwesterly winds, nearshore surface water is transported offshore along coasts with a northwest-southeast orientation. In this process, known as upwelling, deep, oxygen-poor and nutrient-rich water comes to the surface to replace the surface water. In the study area upwelling is most likely to occur off the southwest portion of the Palos Verdes Shelf during the winter and spring (CLA,DPW and USEPA 1977).

Characteristics of Seawater

Natural seawater is characterized by a number of physical and chemical attributes, all of which vary seasonally as well as in irregular fashion. Key characteristics are described below, especially as they may be influenced by man's activities.

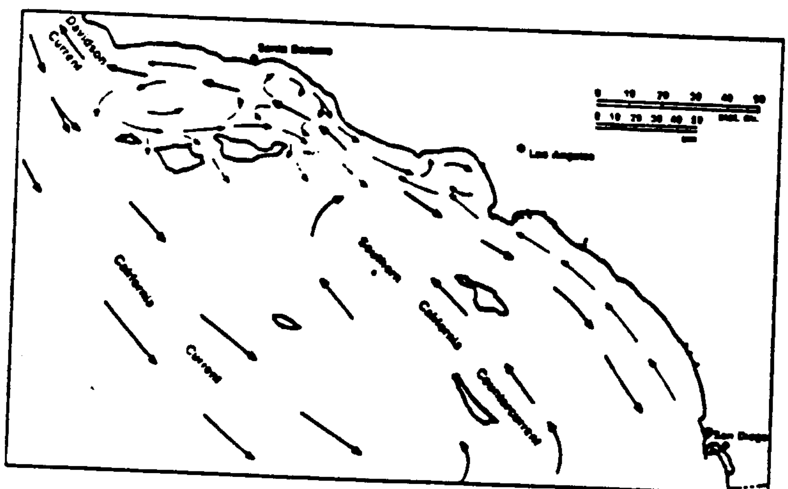

Figure 2-4. General ocean circulation of the Southern California Bight (modified from CLA,DPW and USEPA 1977).

Transparency to Light

As light penetrates the ocean it is reflected, absorbed, or scattered. The depth of light penetration is greatest in transparent waters and least in turbid waters. Water transparency (as measured by a standard Secchi disk) generally ranges from 20 to 50 ft in southern California. However, within a mile of stream deltas it may be less than 20 ft and off rocky areas it is often greater than 40 ft (AHF 1965, CLA,DPW and USEPA 1977). From 1956 to 1986 it ranged from 33 to 66 ft in Santa Monica Bay (Mearns 1987, pers. comm.).

Light penetration is especially important to photosynthesis (the process by which plants utilize carbon dioxide and water to produce, in the presence of light, organic matter and oxygen. Most photosynthesis occurs in the mixed layer, from the surface to water depths of about 33 ft. As light levels decrease photosynthesis decreases. The "compensation depth" refers to the depth at which light levels are so low that no net photosynthesis can occur; this depth marks the bottom of the "photic" zone.

Because inshore waters are generally more turbid, the photic zone may be less than 160 ft deep, whereas offshore it may extend deeper. Sunlight intersects the sea surface at a steeper angle in summer than in winter, this light penetrates more deeply in summer and the photic zone is deeper.

Hydrogen Ion Content (pH)

The pH of seawater over the shelf ranges from 7.5 to 8.6. High values result from photosynthesis which removes CO_2 from the water. Because photosynthesis decreases and net respiration increases with depth, CO_2 increases and hence pH decreases with depth (CLA,DPW and USEPA 1977).

Dissolved Oxygen

Oxygen is required for respiration (and thus life) of both plants and animals. As organic material decomposes, oxygen is used up, creating a biochemical oxygen demand (BOD). Dissolved oxygen (DO) levels are generally high near the surface as a result of input from the atmosphere and from photosynthesis; DO decreases with depth, as distance from the surface increases and photosynthesis ceases. The DO level near the sea surface is generally near saturation (approximately 5.5 ml/l), but saturation varies with temperature and salinity. At water depths of more than 200 ft, DO is usually about 2.8 ml/l, but is only 0.5 ml/l at depths of 1,640 ft along the slope of Santa Monica Bay. DO is virtually absent at the bottom of Santa Monica Basin (Emery 1960; BLM 1975; CLA,DPW and USEPA 1977; CLA,DPW 1982).

Inorganic Nonmetallic Materials/Nutrients

Nitrogen (ammonia, nitrite, nitrate), phosphate, and silicate are dissolved, inorganic materials which are required for photosynthesis and are called nutrients. Nutrients are especially important in the formation of amino acids (protein, nitrogen) and nucleic acids (phosphorous) as well as nonliving shells or tests (silicate).

Nutrient levels are generally low in the mixed layer and high in deeper water. This results from their utilization by phytoplankton in the photic zone and their regeneration by bacteria which are most abundant near the pycnocline. Nitrate is the predominant form of nitrogen found below the photic zone (Williams 1986).

Temperature

Horizontal differences in the temperature of seawater are due primarily to variations in the California Current and Countercurrent. Surface temperatures in the Southern California Bight range from about 52 to 73°F and are warmest (61 to 73°F) from July to December and coolest (52 to 63°F) from January to June (AHF 1965, CLA,DPW 1982; Bratkovich 1988, pers. comm.). Average annual surface water temperatures in Santa Monica Bay ranged from 60 to 65.8°F between 1956 and 1986 (Mearns 1987, pers. comm.).

Below 100 ft seasonal temperature patterns are different (Jackson 1986). At 200 ft temperatures range from 50 to 59°F and are warmest from October to March and coolest from April to September. At 500 ft temperatures are relatively constant at 47 to 50°F (AHF 1965, CLA,DPW and USEPA 1977).

Salinity

The major feature of seawater is the dissolved salts which produce its characteristic saltiness. Salinity is measured in parts per thousand (ppt), which refers to the amount of salt it contains. Most of the salt is common table salt, sodium chloride (NaCl); abundant ions in seawater include sodium (Na+), chloride (Cl-), sulfate (SO_4--), magnesium (Mg++), calcium (Ca++), potassium (K+), and bicarbonate (HCO_3-). Chloride comprises about 55% of the ions, sodium about 30%, and sulfate about 8%. The concentration of most of these ions is fairly constant and they are so abundant that even unusually high levels do not affect the overall salinity and hence are not considered contaminants.

Salinity in the California Current ranges from 33.5 to 34.1 ppt, whereas in the California Undercurrent it ranges from 33.4 to 34.6 ppt (CLA,DPW and USEPA 1977; Jackson 1986). The coastal waters of Santa Monica Bay are normally more saline during the summer due to evaporation of water and less saline in winter as a result of freshwater runoff. Salinity is usually less variable at greater depths.

Density and Stratification

The density of seawater is a function of its temperature and its salinity. Thus, layers of sharply different densities adjacent to one another (a pycnocline) can result from differences in temperature, salinity, or a combination of the two. If separated primarily by temperature, the pycnocline is also a thermocline; if separated primarily by salinity, it is also a halocline. Water above the pycnocline usually has little internal structure; it tends to be homogeneous and is called the mixed layer.

A pycnocline is a natural barrier to the exchange of water between the two layers. Wastewater is usually discharged below the pycnocline in order to prevent movement of the effluent into surface waters; except for oil and grease the plume is unlikely to reach the surface when the sea is stratified (CLA,DPW and USEPA 1977).

In Santa Monica Bay a thermocline often develops (from spring to fall) as a result of warm surface temperatures. In winter and spring there may also be a low-salinity lens at the surface which results from stream runoff. In summer a pycnocline occurs over the shelf at depths of about 35 ft When the surface temperature drops in the fall the density of the upper layer approaches that of the lower layer, the pycnocline breaks down. The mixed layer then extends into depths of 100 ft between December and March (Jackson 1986).

Event was in 1982-1983, with the previous large El Niño in 1957-1959. Events of lesser magnitude occurred in 1986-1987 and in 1991-1992 (Radovich 1961, Graham and White 1988, Kerr 1992).

During an El Niño marine organisms with more southern distributions occur in the Bight whereas cold water species become less abundant: pelagic red crabs were abundant offshore southern California in 1982 and 1983. During an El Niño the sport and commercial fisheries (and success) for pelagic species may increase dramatically.

In freshwater systems phytoplankton productivity is generally limited by the availability of phosphate. In the ocean, however, phytoplankton activity tends to be limited by the availability of nitrogen. Nutrients are replenished in the photic zone during upwelling or when the pycnocline breaks down in the winter; however, sewage and surface runoff may also add nitrogen and phosphate to local areas.

Trace Metals

Virtually all trace metals occur naturally in seawater. Among the more abundant are copper (Cu), manganese (Mn), zinc (Zn), cadmium (Cd), cobalt (Co), silver (Ag), nickel (Ni), and iron (Fe) (Williams 1986). Iron, manganese, and cobalt are abundant in the natural surface runoff from the Santa Monica Mountains (SCCWRP 1973).

Manganese and cobalt are typically more concentrated in surface waters than at depth, whereas the concentrations of cadmium, zinc, nickel, copper, and silver increase with depth. These patterns reflect both biological and chemical processes. For instance, iron is used by fish and other organisms to secure oxygen from the water and hence its concentration may be related to the abundance of organisms requiring it. Most trace metals are required for the growth of some organisms.

Organic Matter

Both particulate and dissolved organic compounds are found in seawater. The particulate phases are described as total particulate organic carbon, particulate organic nitrogen, and particulate organic phosphorus. Particulate organic materials are most abundant in the photic zone, less so with depth. Particulates adsorb trace metals and other contaminants; hence they are important in transporting these substances from the water column to the bottom (Williams 1986).

Dissolved organics include material from decaying organisms, their excretions and secretions, as well as synthetic materials produced by man. The major components are total dissolved organic carbon, dissolved organic nitrogen, and dissolved organic phosphorus. The concentrations of these components are high in the mixed layer and low at greater depths. For the most part materials are produced by phytoplankton in the photic zone and are broken down by bacteria at greater depths (Williams 1986).

El Niño Events

Every so often, with a quasiperiodicity of 3 to 5 years (Graham and White 1988), the oceanic environment of southern California changes dramatically as an El Niño Southern Oscillation (ENSO) event takes place. During an El Niño, the normal water mass off the California coast is replaced with water which is warmer, more saline, and lower in nutrients than usual. These conditions extend through the water column and may persist for months or years.

El Niños result from large-scale changes in the climate and oceanography of the Pacific Ocean as a whole. Normally tradewinds, which blow to the west north of the Equator, force water to pile up in the western Pacific. When the tradewinds weaken, seawater flows downhill (as a long-period wave) toward the eastern Pacific. When this wave encounters the Americas, it moves both north and south along the coast. Because currents in the North Pacific also decrease in strength, the south-flowing California Current is weakened and the warm-water mass from equatorial latitudes penetrates into the Southern California Bight. The most recent large El Niño

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CHAPTER 3
THE BIOLOGICAL SETTING

TERRESTRIAL ENVIRONMENTS

Terrestrial organisms in the study area are largely warm-temperate species of the California Wildlife Region (Brown and Lawrence 1965). The only life zone in the watershed is the Upper Sonoran life zone (Grinnell 1935); although the altitude lies within the range normally classified as Lower Sonoran, the temperatures are cooler and humidity is higher along the coast than in areas of similar altitude elsewhere in southern California.

Habitats and Plant Communities

The Santa Monica Bay watershed and its surrounding area includes a variety of terrestrial habitats and plant communities (often regarded as habitats because of the nature of the physical structure they provide to the habitat). Many of these would have occurred prior to European contact but several have developed since that time, particularly with urbanization. The Santa Monica Mountains alone have more than 860 species of flowering plants (Ikeda *et al.* 1991); the more urbanized areas of the watershed have many additional species, most of which are introduced.

Thirteen terrestrial habitats are found in the Santa Monica watershed (Figure 3-1) (Mayer and Laudenslayer 1988). Nine of these occur throughout the watershed: Eucalyptus, Valley Foothill Riparian, Coastal Scrub, Annual Grassland, Fresh Emergent Wetland, Riverine, Lacustrine, Orchard-Vineyard, and Urban. The four remaining habitats (Valley Oak Woodland, Coastal Oak Woodland, Mixed Chaparral, and Chamise-Redshank Chaparral) are specific to the Santa Monica Mountains.

Three of the ubiquitous habitats (Fresh Emergent Wetlands, Riverine, and Lacustrine) are wetlands habitats, two (Eucalyptus and Annual Grassland) consist primarily of introduced species, two (Orchard-Vineyard and Urban) result from human development, and two (Valley Foothill Riparian and Coastal Scrub) are entirely native to the area (Mayer and Laudenslayer 1988).

Valley Oak Woodland

The Valley Oak Woodland occurs exclusively in the western part of the Santa Monica Mountain portion of the study area (Mayer and Laudenslayer 1988), particularly in the Upper Malibu Creek Drainage. This habitat is dominated by valley oak, a deciduous oak 50-115 ft tall. The trees may be sparsely distributed as in a savannah or more densely distributed with partially closed canopies. It is best developed on deep, well-drained alluvial soils in valley bottoms. The Valley Oak Woodland habitat usually merges with the Annual Grassland habitat or near streams with the Valley-Foothill Riparian vegetation.

There is generally little recruitment of young valley oaks to this habitat to replace the older oaks which are being destroyed by urban and agricultural development. Most surviving stands in the state are from 100 to 300 years old, some reaching 400 years old. Valley Oak Woodland is important to mammals such as the gray fox, western gray squirrel, and mule deer, and for birds such as the redtail hawk, European starling, and California quail (Mayer and Laudenslayer 1988). At Malibu Creek State Park grasses have been planted to associate with Valley Oak Woodland in an effort to expand the potential habitat for valley oak (Danielsen and Halvorson 1990).

Coastal Oak Woodland

The Coastal Oak Woodland occurs in the Santa Monica Mountains, but not immediately near the coast (Mayer and Laudenslayer 1988). This habitat is dominated by coast oak and California walnut; the oak is evergreen and the walnut is deciduous. In moist sites, the trees are dense and form a closed canopy 15-70 ft high; in dry areas they are more widely spaced, forming a savannah. The understory ranges from lush, shade-tolerant shrubs and ferns beneath closed canopies to annual grassland in dry areas; shrubs from neighboring chaparral and coastal scrub communities may contribute to the understory (Mayer and Laudenslayer 1988).

This habitat can be further divided into a number of subhabitats based on understory plants (Allen 1990). The Coastal Oak Woodland community is best developed on moderately to well-drained soils which are moderately deep and have low to medium fertility. Coastal oak woodlands consist of slow-growing, long-lived trees that require 60-80 years to regenerate large mature trees; most stands consist of medium to large trees with a few saplings. This community has experienced an increased frequency of fires in recent years but coast oak generally survives fires. Important vertebrate species in this community include California quail, western gray squirrel, and mule deer (Mayer and Laudenslayer 1988).

Eucalyptus

The Eucalyptus habitat occurs throughout the watershed and wasteshed in disturbed, agricultural, or urban sites (Mayer and Laudenslayer 1988). This habitat is usually dominated by blue gum, to a lesser extent by red gum. Eucalyptus, or gum trees, were introduced into California from Australia in 1856. The structure of the habitat ranges from thickets of a single species with no understory to scattered trees with a well-developed shrubby understory. They are planted in rows to provide wind breaks or in groves for hardwood harvesting. Gum trees typically stand 87 to 133 ft high, but some reach a height of 264 ft. Understory plants range from annual grassland species in groves to coastal scrub or chaparral species; near streams, riparian plants may occur in the understory. They are also planted near orchards and vineyards. The allelopathic nature of gum tree litter prevents many other plants from developing in the understory. Gum trees regenerate rapidly following fires, reproducing vegetatively as well as by seeds. Most gum trees achieve 70-90% of their height in their first 15 years. Crows, ravens, and barn owls are common in the Eucalyptus habitat; the bark litter provides habitat for southern alligator lizards, gopher snakes, and woodrats. The habitat does not occur above 2,100 ft altitude (Mayer and Laudenslayer 1988).

Valley Foothill Riparian

The Valley Foothill Riparian habitat occurs throughout the watershed and wasteshed, in valleys, coastal plains, and foothills; next to low velocity streams on gravelly or rocky soils; and in association with annual grassland or oak woodland (Mayer and Laudenslayer 1988). This habitat is dominated by Fremont cottonwood, California sycamore, and valley oak; California sycamore is dominant in coastal areas of the Santa Monica Mountains. White alder is the dominant subcanopy tree but many shrubs (e.g., wild grapes, willows, poison oak) and herbaceous plants occur in the understory. The dominant species are deciduous. The canopy is about 100 ft high and coverage is 20-80%. Cottonwood trees become large mature trees at 20-25 years. Willows generally dominate in early stages of succession and, where there are good flows of silt, may persist indefinitely. The Valley Foothill Riparian habitat is important to many species of mammals, birds, reptiles, and amphibians (Mayer and Laudenslayer 1988).

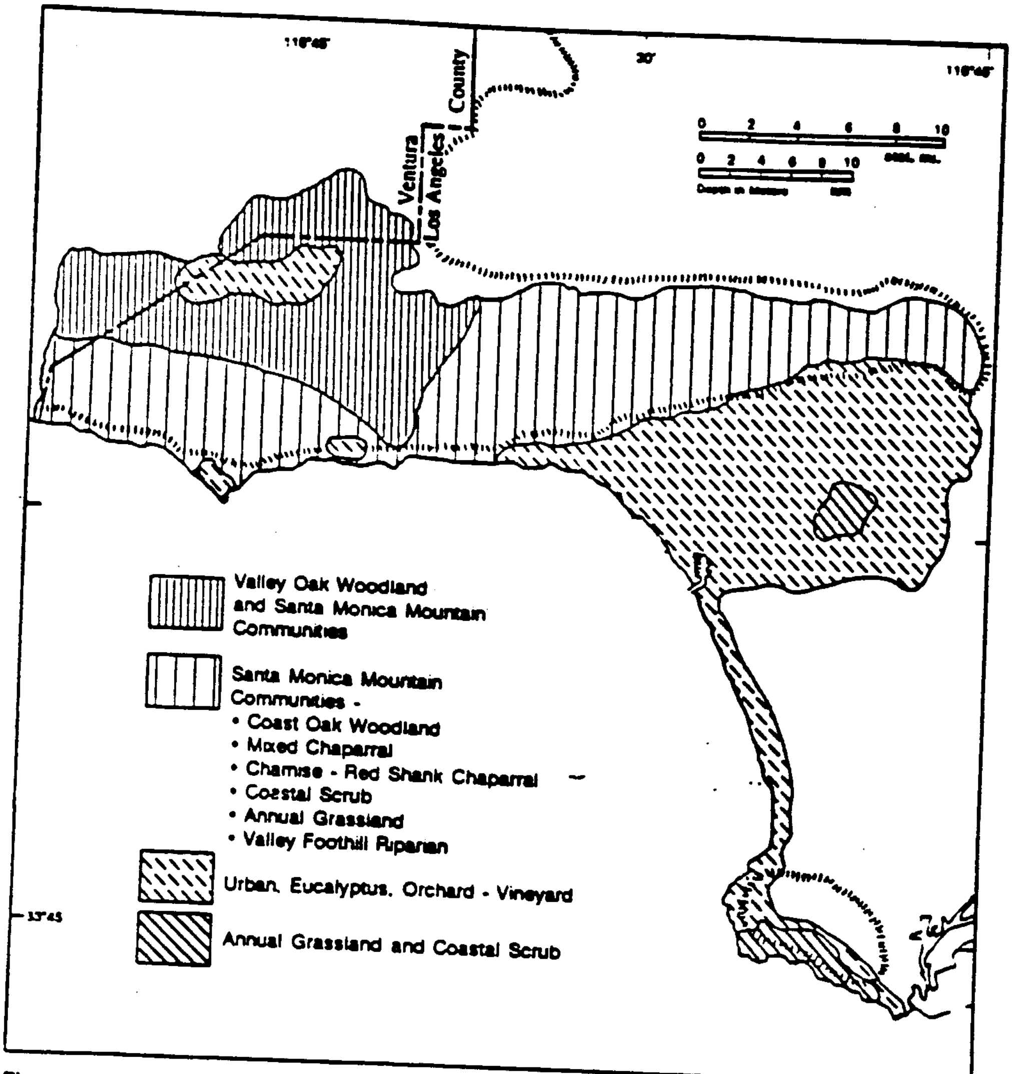

Figure 3-1. Major habitat areas of the Santa Monica Bay watershed.

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Annual Grassland

The Annual Grassland habitat occurs throughout the watershed and wasteshed. The habitat is found on flat plains to gently rolling hills. It consists of open grasslands dominated by annual grass and forb species (Mayer and Laudenslayer 1988). Most of the dominant species are introduced grasses (e.g., wild oats and red brome). Redstem filaree is a common forb in southern California annual grasslands and California poppy, the State Flower, is also found in this habitat. It often occurs as an understory in Valley Oak Woodlands and is found next to Coast Oak Woodland, Coastal Scrub, Valley Foothill Riparian, Fresh Emergent Wetlands, Orchard-Vineyard, and Eucalyptus habitats. Annual grasslands are generally found at lower elevations than Chamise-Redshank and Mixed Chaparral habitats. Seeds germinate following fall rains, grow slowly in winter but rapidly in spring as temperatures rise. During the summer the habitat can have a large amount of standing dead material if there is little grazing. The Annual Grassland habitat has replaced the pristine native grassland habitat in the area which was dominated by perennial bunchgrasses. Fall rains followed by extended dry periods encourage growth of deep-rooted forbs and grazing favors low-growing forbs. Important mammals in this habitat include black-tailed jackrabbit, California ground squirrel, and Botta's pocket gopher. Western meadowlark, turkey vulture, and American kestrel are common birds. Western fence lizard and western rattlesnake are important reptiles in this habitat (Mayer and Laudenslayer 1988).

Fresh Emergent Wetlands

The Fresh Emergent Wetlands habitat is found in localized areas throughout the watershed and wasteshed. It is dominated by erect, rooted water plants such as the perennial sedges, rushes, and cattails (Mayer and Laudenslayer 1988). The habitat is found on periodically flooded basins; thus the roots must do well in anaerobic silts and clays. This habitat naturally accumulates silt and over centuries is replaced by an upland community. It usually occurs in association with Riverine or Lacustrine habitats; its limit lies with the deepwater limit of emergent plants (usually at about a depth of 7 ft). This habitat is highly productive and provides food, cover, and water for many species of mammals, birds, reptiles, and amphibians, with some species utilizing the habitat for their entire life cycle. The endangered peregrine falcon utilize the habitat for feeding and roosting (Mayer and Laudenslayer 1988).

Riverine

The Riverine habitat consists of streams and rivers with intermittent or continually running water. This habitat occurs in a natural state primarily in the Santa Monica Mountains in the watershed; in the coastal plain the stream channels have been fixed as open concrete drainage channels with urban runoff rather than springwater constituting the stream flow. Most of the natural streams in the watershed are intermittent, with greatest flows in the winter. There are 28 stream drainage basins in the watershed (SMBRP 1992). Malibu Creek is the largest stream in the watershed and best represents this habitat. The habitat is usually found in association with Riparian, Lacustrine, and Fresh Emergent habitats. It usually arises at a spring in this area and runs down relatively steep canyons until the slope levels out, at which point the water becomes sluggish and may form pools (Mayer and Laudenslayer 1988). During this course, the floor of the stream changes from rocky to muddy; water temperature and turbidity increase and dissolved oxygen decreases down the stream course. In faster or upper-level streams, water moss and filamentous algae are attached to rocks, and stream insect larvae live on the underside of gravel in riffles or pools. In slower or lower-level streams mollusks and crustaceans replace the insects and emergent vegetation grows along the edge of the stream. Many insectivorous birds feed

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Mixed Chaparral

The Mixed Chaparral habitat is only found in the Santa Monica Mountain portion of the watershed. It is dominated by shrubs with stiff evergreen leaves (Mayer and Laudenslayer 1988). It generally occurs above the coastal scrub habitat and occurs predominantly on moist coastal or north- and east-facing slopes with Chamise-Redshank Chaparral on drier, south- and west-facing slopes. It usually is found on steep slopes with thin, well-drained rocky, sandy, or gravelly soils; soils in this habitat are deeper than in the Chamise-Redshank Chaparral. Shrubs range in height from 3 to 13 ft, occasionally to 19 ft, and form an impenetrable thicket of 80% cover. Dominant species include scrub oak, ceanothus (wild lilacs), and manzanita, with many other shrubs (e.g., laurel sumac, sugarbush, birch-leaf mountain mahogany, and toyon) also included in the community. Leaf litter may accumulate beneath the shrubs for years until consumed during a fire. The community is fire-adapted with large rootbases. Following a fire, annuals and perennials dominate for 1-3 yr until seedlings and root-crown shoots appear; the shrub canopies do not overlap until 10-30 yr after a fire. Wildlife species found in mixed chaparral are also found in chamise-redshank chaparral and coastal scrub (Mayer and Laudenslayer 1988).

Chamise-Redshank Chaparral

Chamise-Redshank Chaparral is found in isolated stands in the Santa Monica Mountains (Mayer and Laudenslayer 1988). Most stands in the study area are almost exclusively dominated by chamise with some redshank occurring at higher elevations (Raven and Thompson 1966). It occurs on steep slopes with thin, coarse soil. These stands are 3-7 ft in height but can reach 10 ft (Mayer and Laudenslayer 1988). There is no overstory or understory and canopy cover can reach 80%. It occurs primarily on dry, south- and west-facing slopes above the coastal scrub habitat. Near the coast other shrubs (e.g., laurel sumac, toyon, and ceanothus) are also found in this community along with white sage, black sage, and California buckwheat. As with mixed chaparral, chamise-redshank chaparral is fire-adapted. Annuals and perennials dominate for 1-3 yr following a fire until chamise and associated plants sprout from seedlings and roots. Chamise canopies do not overlap until 3-15 yr after a fire. Wildlife found in this habitat are also found in mixed chaparral and coastal scrub (Mayer and Laudenslayer 1988).

Coastal Scrub

Coastal Scrub Habitat occurs on well-drained clay, gravelly, and rocky soils and was the dominant habitat of the Los Angeles Coastal Plain prior to urban development. At present it is found on undeveloped slopes of the Santa Monica Mountains adjacent to the ocean, in drier areas at higher levels, and in the Palos Verdes Hills (Jaeger and Smith 1966). It lies within 20 mi of the ocean between the coastal dune habitat and the mixed chaparral, chamise-redshank chaparral, and coastal oak woodland habitats of slightly higher elevations. It is typical of steep, dry, south-facing slopes with sandy to shale soils but also occurs on moderate slopes and stabilized dunes. This community consists of low to moderate-sized shrubs (to a height of 7 ft) with a canopy cover of up to 100%. The dominant species in the community varies with moisture; California sagebrush, California buckwheat, purple sage, and chaparral yucca generally dominate in the Santa Monica Bay watershed. The community is fire-adapted and takes about 10 yr to recover following a fire. Unburned stands can survive intact for up to 60 yr. The community can invade disturbed areas (Mayer and Laudenslayer 1988). Air pollution has reduced the cover by native species in some areas of southern California (Westman 1979). The California ground squirrel is probably the most abundant, obvious mammal (Reiter 1984). The California gnatcatcher, a species of concern, is found exclusively in this habitat and endangered peregrine falcons include this as an important habitat (Mayer and Laudenslayer 1988).

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Conservancy was created at about the same time to acquire lands until the 70,000 acres necessary to complete the SMNRA could be completed; this acquisition is still in progress.

Endangered Species in the Watershed

Four species of flowering plants in the Santa Monica watershed are currently listed as rare, threatened, or endangered (Ikeda *et al.* 1991). The Santa Monica Mountains dudleya was listed as State Endangered in 1976. It is endemic to the Santa Monica Mountains where it has been found at less than 10 sites. It occurs on steep rocky areas along Malibu Creek. Lyon's pentachaeta has been listed by the California Native Plant Society. It occurs at less than 12 sites in the Santa Monica Mountains on the edge between annual grassland and chaparral communities. Conejo buckwheat was listed as State Rare in 1976. It occurs on dry rocky hillsides in coastal scrub and chaparral. Santa Susana tarweed was listed as State Rare in 1978. It grow on rocky outcrops in chaparral in the Santa Monica Mountains (Ikeda *et al.* 1991).

Federally endangered insect species in the study area include the Palos Verdes blue and El Segundo blue butterflies (CDFG 1992). Endangered birds in the watershed include American peregrine falcon (State and Federally Endangered), California gnatcatcher (Federally Proposed Endangered), and Belding's savannah sparrow (State Endangered).

Natural Variability

Fires

Many of the habitats in the Santa Monica Bay watershed are adapted to frequent fires. Plants in the chaparral and coastal scrub communities, in particular, have specialized methods by which to deal with what would ordinarily be a catastrophic event. Many perennial species, such as chamise, can resprout after the plant crown has been burned, and several species actually require that their seeds be exposed to the high temperatures of fires to germinate (Head 1989). Annual species have dispersal mechanisms which allow them to be transported long distances beyond the burned area (O'Leary 1989). Fire provides a means by which old growth and senescent plants are removed, making room for new individuals or new growth. The resulting ash, when carried by winter rains, provides nutrients to streams and coastal plains and wetlands (Faber *et al.* 1989). Fire also promotes greater diversity in the community, both among the plants and the animals which use them for food and shelter, by increasing the number of plant species available and providing more levels of habitat, such as open ground, opening-chaparral interfaces, and different age-class individuals. Fire also helps to maintain native plant communities by suppressing nonadapted, invasive, introduced plants (Wells 1990).

Drought

The climate of southern California is classified as Mediterranean, with mild, rainy winters and hot, dry summers. Near the coast, rainfall varies from about 10 to 20 in. per year, and temperatures range from highs of 68°F to 90°F in summer to lows of 37°F to 48°F, with infrequent frosts. Further inland, average rainfall is a little greater, up to 25 in. per year, and temperatures vary more, with summer highs up to 94°F (or over 100°F during a Santa Ana wind) and winters down to 29°F (Munz 1973). However, the distribution of rainfall, with most of it occurring in the cool, nongrowing season, requires that plants accomplish their warm-season growth during a period of little rainfall. Precipitation is also extremely variable from year to year, and periods of several consecutive years of below-normal rainfall result in extreme fire danger in the chaparral plant communities. Even within a normal-rainfall year, uneven distribution of the precipitation, with

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above this habitat and some water-associated birds are also found there (Mayer and Laudenslayer 1988).

Lacustrine

The Lacustrine habitat is found at several sites within the watershed and wasteshed. It consists of inland depressions or dammed streams that contain standing water and is often associated with riverine and fresh emergent wetlands habitats. The largest lakes in the watershed are Lake Sherwood and Malibu Lake. Light penetration is dependent on turbidity and oxygen levels may decrease with increasing depth. Dominant phytoplankton organisms consist of diatoms, desmids, and filamentous algae; other plants include duckweed and submerged algae and pondweeds. Rotifers, copepods, and cladocerans are important members of the zooplankton of lakes. Protozoa, hydras, snails, aquatic insects, and insect larvae also occur in lakes and ponds. Most lakes and ponds support fish populations (Mayer and Laudenslayer 1988).

Orchard-Vineyard

The Orchard-Vineyard habitat is sometimes found in rural areas of the watershed in the Santa Monica Mountains. It is an artificial, agricultural habitat that typically consists of a single tree (or in the case of grapes) vine species planted in rows with an open understory of low-growing grasses and herbaceous plants (Mayer and Laudenslayer 1988). In southern California dominant fruit and nut crops grown in orchards and vineyards include almonds, apples, apricots, avocados, dates, grapes, grapefruit, lemons, oranges, olives, and walnuts (Miller and Hyslop 1983). The habitat typically occurs in deep fertile soils and is sometimes irrigated. Individual orchards or vineyards may persist for about 40 yr, with replacement of orchard type resulting from a decline in market value or productivity. Deer, rabbit, and squirrels feed on orchard trees or their products (Mayer and Laudenslayer 1988).

Urban

The Urban habitat is found over much of the Santa Monica watershed south of the Santa Monica Mountains and over most of the wasteshed (Figure 3-1) (SMBRP 1992). It is also developed in the Thousand Oaks and Malibu areas and as residential areas near Point Dume and Topanga Canyon. Most of the habitat consists of single or multiple family residential areas but large areas of Santa Monica, Los Angeles, the Los Angeles Airport area, and El Segundo are put to commercial and industrial us (SMBRP 1992). Vegetation types include tree groves, street strips, shade trees and lawns, lawns, shrub cover, and demolition sites. Vegetation consists of a mixture of native and exotic species. Commercial and industrial areas often have little vegetation but nevertheless provide habitat for some species. Subhabitat types include downtown, urban residential, and suburbs. Rock dove, house sparrow, and European starling dominate the poorly vegetated downtown areas. Scrub jay, mockingbird, and house finch are the major birds in urban residential areas. Suburban areas approximate the natural environment and provide habitat to species from adjacent habitats. Air temperatures are generally warmer in urban areas and wind velocities lower, except where high-rise buildings are found (Mayer and Laudenslayer 1988).

Unique Areas and Habitats

Unique areas in the Santa Monica Mountains include the Santa Monica Mountains National Recreation Area (SMNRA) developed by Congress in 1978 to protect part of the mountains from further development (Ikeda *et al.* 1991). The Santa Monica Mountains

Wetlands are among the most productive ecosystems in the world. Productivity is related to several factors, including the efficient functioning of the grazing and detrital food chains. Additionally, periodic rise and fall of the tides and flooding in salt marshes bring nutrients from outside the system and keep the system oxygenated. Wetlands are now being recognized for their educational, recreational, and aesthetic values. Southern California wetlands are extensively used by bird watchers and other outdoor recreationists, and conservationist groups are taking increasingly important roles in their preservation and restoration.

Distribution

Ten brackish wetlands of varying size and state of naturalness are located along the edge of Santa Monica Bay: Trancas Lagoon, Zuma Beach Lagoon, Malibu Lagoon, Lower Topanga Canyon, Venice Canals, Ballona Lagoon, Oxford Flood Control Basin, Ballona Wetlands, Del Rey Lagoon, and El Segundo Dunes Wetlands (Figure 3-2). They range from small, seasonally-inundated river mouths, such as at Zuma Beach west of Point Dume, to the large Ballona Wetlands Complex at Marina Del Rey. A number of freshwater marshes occur within the watershed, such as Madrona Marsh (Torrance) and Upper Medea Creek (in the Malibu Creek drainage).

Ballona Wetlands Complex

Historically, the Los Angeles River occasionally emptied into Santa Monica Bay at Ballona Creek instead of into San Pedro Bay at Long Beach, as the river's course changed during unusually heavy storms that occurred between 1815 and 1825 and again in 1862 and 1884 (Terry *et al.* 1956). During that period, the drainage area of Ballona Creek (Los Angeles River) was considerably larger than at present, including the San Fernando Valley and part of the San Gabriel Mountains. The Los Angeles River is now channelized and future discharges through Ballona Creek are unlikely. The Venice Canals, Ballona Lagoon, Oxford Flood Control Basin, Ballona Wetlands, and Del Rey Lagoon are part of the historic Ballona Wetlands Complex.

The area between Ballona Creek and present-day Beverly Hills was often a vast swamp (Johnston 1962, Reiter 1984). During torrential rains in the winter of 1861-1862, the entire valley area from Los Angeles to the ocean, both towards San Pedro and toward Ballona, was a great lake (Kuhn and Shepard 1981). During periods when the Los Angeles River discharged into San Pedro Bay instead of into Santa Monica Bay, the areal extent of the Ballona wetlands was probably reduced, with greater marine influence.

In 1868 the Ballona Wetlands comprised 2,100 acres (Clark 1979). Development of Marina del Rey, the Venice canal system, and residential and commercial property, and the channelization of Ballona Creek reduced this area to less than 160 acres of habitat that can legitimately be called wetlands. Remnants of the Ballona Wetlands Complex include Ballona Lagoon, on the north side of the Marina channel; Del Rey Lagoon, to the south of Ballona Creek; Ballona Wetlands, the major marsh area, located north and south of Ballona Creek; Oxford Flood Control Channel on the north side of Marina del Rey; and the Venice Canals. The present remnant of the Ballona Wetlands Complex include mudflat, shallow subtidal, saltmarsh, brackish marsh, and freshwater marsh habitat (Schreiber 1981). Although estimates vary as to the total amount of extant habitat, about 10 to 15% of the original area (270 acres) can still be considered either degraded or nondegraded wetlands (Figure 3-3).

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most occurring during only one or two storms rather than spread more evenly over the season, will affect how much of the available moisture is able to soak into the soil. Native vegetation is most affected by the worst conditions than by the average (Clark 1992). Prolonged drought may predispose plants to diseases and disorders caused by opportunistic parasites (Brooks 1992).

Native plants deal with drought conditions (annual or cyclical) in various ways. Many species have hard or waxy-coated leaves to prevent evaporation or white, shiny, or fuzz-covered leaves to reflect light. Some species (drought-deciduous) drop their leaves during the hottest period of the year, or turn their leaves to avoid the direct rays of the sun (Head 1989). Deep root systems and water-storage capabilities are also present in many species. Physiological mechanisms are also employed, such as resistance of xylem embolism (Davis *et al.* 1992).

Wet Periods

Periods of greater-than-normal precipitation may adversely affect plants which are adapted to low-moisture conditions. Soil oxygen may be lowered, affecting the root systems or promoting the growth of infecting disease organisms. The absence of fires which are required for germination of seeds of some species may result in a shift of dominance by some species within the plant community.

WETLANDS HABITATS

Background

The California Coastal Act of 1976 defines wetlands as "land within the coastal zone which may be covered periodically or permanently with shallow water and includes saltwater marshes, freshwater marshes, open or closed brackish water marshes, swamps, mudflats, and fens."

Wetlands generally occur where the slope of the land is sufficiently flat to retain water for some length of time. Freshwater wetlands usually occur along streams or in depressions which may fill with rainwater (vernal pool). Marine wetlands develop where streams enter the ocean across low, flat coasts; they are characterized by freshwater or saltwater marshes and channels. If stream flow is sufficient some salt marshes alternate between fresh and saltwater. Thus, the dominant natural factors which affect wetlands habitats bordering the sea are variable salinities and the tidal cycle which alternately exposes and covers it with water. Marshlands are depositional in nature; because wave forces are minor, fine silts and clays accumulate. Thus, regardless of man's impact they are slowly filling in with fine sediments by natural forces.

Importance

Historically, the ecological importance of wetlands was overlooked and wetlands were only considered useful for reclamation for more "constructive" purposes. However, this outlook has changed dramatically because the vital ecological roles that wetlands served have been documented. Wetlands mitigate flooding and recharge groundwater; provide feeding and breeding habitat for fish, waterfowl and other wildlife; filter pollutants from sewage and agricultural runoff; and stabilize the biosphere by using carbon dioxide and producing oxygen. Energy flow patterns involve the direct consumption of green plants, such as eelgrass, by grazers and the breakdown and consumption of detritus, or organic debris, by bacteria and other organisms. The patterns are complex and often intertwine.

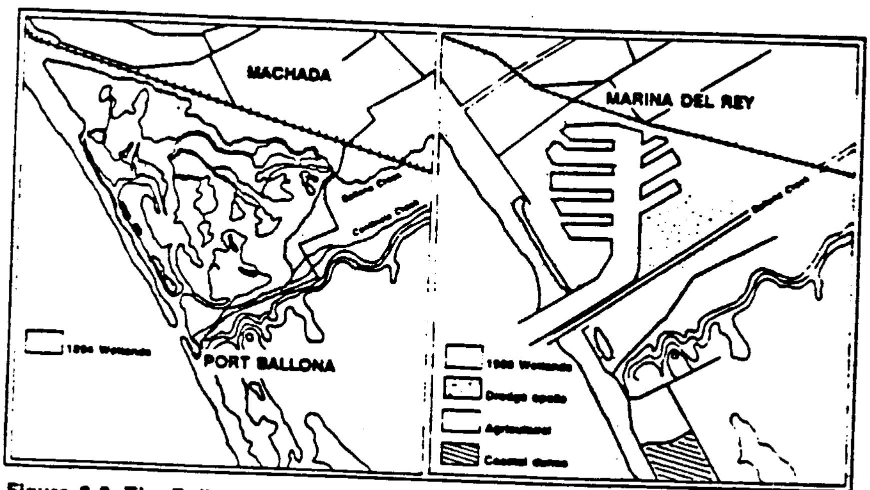

Figure 3-3. The Ballona Wetlands region in 1894 and 1988.

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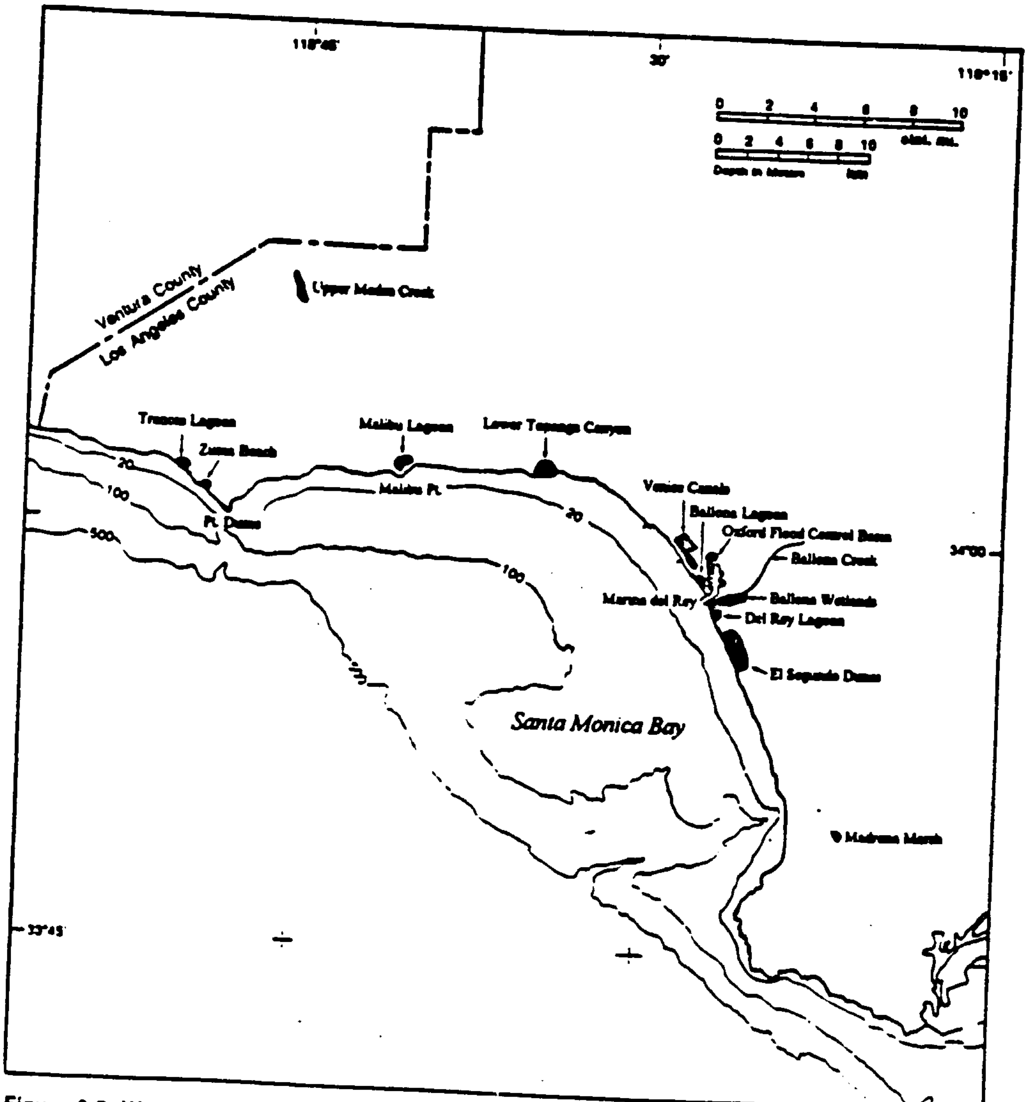

Figure 3-2. Wetlands of Santa Monica Bay study area.

the dominant saltmarsh plant; topographically it occurs lower than in other southern California saltmarshes with greater tidal influence. The saltmarsh is lacking in a low and middle marsh flora and has reduced the breeding, nursery, and foraging areas for fishes, birds, and reptiles.

There is a small pickleweed marsh at Malibu Lagoon, but this wetlands differs from the Ballona Wetlands Complex in that riparian woodland, with cottonwood and alder trees, and chaparral are found upstream (Dock and Schreiber 1981). Trancas Lagoon, Zuma Beach, and lower Topanga Canyon are less saline, and support a limited number of plant species. Their contributing creeks support riparian woodland species. El Segundo Dunes supports native dune species, but the native wetlands plants have been mostly replaced by invasive introduced species.

The endangered (state- and federally-listed) salt-marsh bird's beak, a low-growing annual, historically occurred in wetlands along the northern part of Santa Monica Bay. In other coastal wetlands of southern California and Baja California, it occurs at the landward edge of the salt marsh, where it is frequently disturbed. Introduced species often threaten to invade its habitat but no displacements have been documented (Zedler 1991).

Invertebrates

The shallow subtidal, marsh channel, and mudflat communities integrate the flow of energy through the wetlands. The marine invertebrates (primarily nematodes, annelids, crustaceans, and mollusks) in these environments recycle organics in the muds and are primary food sources for resident and transient fishes and shorebirds (Peterson 1975, Quammen 1980). Thus, the water and sediment quality and abundance of benthic invertebrates are likely to influence the distribution of higher trophic level organisms in the area.

The marine benthic invertebrate communities of the mudflats and tidal channels of the wetlands of Santa Monica Bay resemble those found in the sandy intertidal, but nematodes may be more abundant (Soule and Oguri 1985). Polychaetes, molluscs, and crustaceans dominate the invertebrate fauna of the Ballona Lagoon, however, oligochaetes are abundant in some places. Although the Ballona Wetlands are not well described, they are comparable to those of nearby Marina del Rey (Soule and Oguri 1987), Ballona Lagoon (Bakus 1975, Ford and Collier 1976), Playa Vista (Reish 1980), and other modified, shallow subtidal or mudflat embayments in southern California such as Sunset Bay, Anaheim Bay, and Upper Newport Bay. In these environments, combinations of physical and chemical stresses limit biological diversity, and community structure is dominated by hardy forms with life histories that are tolerant of the stressful conditions, whether natural or man-made (Kauwling and Reish 1975, McCall 1977, MBC and SCCWRP 1980, MBC and Marsh 1985, MBC 1986b). Several of the abundant species are indicators of organic enrichment and low dissolved oxygen. Ballona Lagoon may support the northern-most population of the fiddler crab on the west coast (Dorsey 1988, pers. comm.).

In the mid-1970s invertebrate assemblages of Ballona Lagoon were diverse and similar in species composition to those of the larger and more natural Tijuana Estuary, suggesting that the flora and fauna represented a reasonably natural and healthy assemblage of estuarine organisms. These conditions were attributed to adequate tidal exchange and flushing, despite the Lagoon's long and narrow configuration and restricted entrance (Ford and Collier 1976). In 1980-1982 the marine molluscan fauna of Ballona Lagoon was comparable in diversity and abundance to Mugu Lagoon and Mission Bay; the same species were present in all three saltmarshes, in approximately the same numbers (Ramirez 1981).

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Malibu Lagoon

Malibu Lagoon is located in the City of Malibu, west of the Malibu Pier and at the mouth of Malibu Creek. The full extent of the historical Malibu Lagoon-marsh system is unknown (Kraft 1978), but what remains probably represents only a small portion of the original marsh (CDPR 1978). In 1978, prior to restoration efforts, the natural resources consisted of 5 acres of open water, 10 acres of coastal saltmarsh, mudflats (area unknown), and 4 acres of riparian habitat. Most of the habitat reduction of the Malibu wetlands has resulted from the reclamation of habitat upcoast of Malibu Creek for mosquito control and housing developments such as Malibu colony (Kraft 1978).

Malibu Lagoon is a brackish water marsh, receiving most of its drainage from the Malibu Creek watershed with additional input from the Tapia Water Reclamation Facility (TWRF), located five miles upstream. The natural channel of Malibu Creek enters the ocean on the downcoast (southeast) side of Malibu Point and is normally open only during the winter rainy season. The sand bar which develops across the mouth is purposely breached by the Los Angeles County Department of Parks and Recreation for flood control purposes (CDPR 1978). As a result of the varying salinities, the species diversity is low compared to other coastal lagoons.

Water quality is a main concern in Malibu Lagoon. High nutrient loading makes the Lagoon susceptible to eutrophication, and coliform levels are frequently high due to various unidentified point and nonpoint sources of pollution, such as horse stables and septic tanks. The approved expansion of TWRF, which will increase the volume of freshwater input, may escalate the existing problems with the Lagoon entrance and water quality.

Biological Resources of Wetlands

Wetlands support a wide variety of plants and animals, and are populated by marine, estuarine, or freshwater organisms, depending upon the salinity of the water. Upstream wetlands are populated entirely by freshwater and terrestrial organisms. As a result of fine sediments and high organic content, wetlands support abundant bacteria (Pollock 1971). For the same reasons, oxygen concentrations in the sediment decrease rapidly with depth and reach zero within a few inches of the surface. Anaerobic bacteria in these zones produce hydrogen sulfide. Most of the Santa Monica Bay wetlands exhibit decreased biological diversity and productivity because of their degraded condition.

Plants

The present Ballona Wetlands Complex supports marine algae as well as marine and terrestrial flowering plants. Microalgae are abundant in the water column and on the sediments; the subtidal substrate (only in Basin D in Marina del Rey) supports eelgrass (Stephens *et al.* 1991) and sea lettuce occurs on mudflats. Immediately above the mudflats the saltmarsh plant assemblage consists of five species, dominated by one or more species of pickleweed. Upstream, the marsh grades into freshwater plant communities which include willows and freshwater marsh plants (Gustafson 1981). The higher areas of the wetlands and the adjacent sandy coastal strand and disturbed land contain 23 terrestrial plant species (Bakus 1975, Ford and Collier 1976).

Many marsh plant species which typify the pristine saltmarsh environments of southern California are absent from the Ballona Wetlands, possibly because of restricted water flow between the marsh and Ballona Creek proper (Gustafson 1981). Related factors (stagnation, salinity, and temperature fluctuations) have kept species density in the marsh low. Pickleweed is which occurred early in the century from Santa Barbara to San Diego, may also have contributed to their limited population size (Bent 1926). Since the clapper rail is a poor flyer, its natural immigration into Ballona is unlikely.

The same considerations probably also apply to the black rail, which occupies similar habitats (Grinnell *et al.* 1918). Early in the century the black-necked stilt bred at Playa del Rey (Willet 1933) and may have attempted to breed in the Ballona Wetlands during the summer of 1980 although no nests were found.

Mammals. Seventeen species of mammals are known to live in the wetlands complex and at least 21 more have occurred there in the past or forage in the area. Carnivores (including the introduced red fox), rodents, and rabbits are the most diverse groups (Friesen *et al.* 1981).

Endangered Species

Salt Marsh Bird's Beak. The salt marsh bird's beak was placed on the California and Federal Endangered Species Lists in 1978. It has suffered major population declines at all of the California coastal wetlands, and no longer occurs at any of the wetlands along Santa Monica Bay. The decline in numbers is due to loss of habitat (CNPS 1988).

Belding's Savannah Sparrow. The Belding's savannah sparrow depends on the upper saltmarsh habitat and is particularly abundant in areas dominated by pickleweed (Massey 1973, Zedler 1982), which it uses for foraging, breeding, and perching. This species is present year round in upper saltmarsh areas of the Ballona wetlands, but is limited to nesting territories between January and August (Dock and Schreiber 1981).

A beneficial, but short term, impact of placing dredge-spoil on the northern parcel of the Ballona wetlands during the construction of Marina del Rey was to increase the amount of suitable nesting habitat for Belding's savannah sparrows. Because of the long active breeding season and sensitivity to disturbance, human activity in this high marsh habitat may cause both habitat degradation and reproductive failure (Zedler 1982).

Territorial males have been observed on Playa del Rey and Ballona saltflats between 1973 and 1991, although there are no records of fledglings (Zembal 1992, pers. comm.). During the period from 1973 to 1987, the population was fairly stable, with 23 to 39 breeding pairs occurring in the wetlands each year (Table 3-1). Starting in 1990, the number of pairs started to decline, partly due to predation by introduced red foxes (Jurek 1992, pers. comm.) (Attempts have been made to trap and remove the foxes from the wetlands, but the program has encountered strong opposition from the animal-rights activists, to the extent that biologists were afraid to conduct surveys for fear of retaliation. Therefore, despite declining numbers of birds, surveys were not conducted in 1992.) The number of breeding pairs in the area may also be affected by changing habitat conditions, such as increased amounts of standing water during flooding and, in the case of the dredge spoil nesting site, a reduction in the quality and quantity of pickleweed habitat (Dock and Schreiber 1981).

California Least Tern. The California least tern is a summer visitor which breeds in southern California coastal habitat from late April to September. It builds its nests in shallow depressions in hard or soft dirt, dried mud, or sandy areas, usually on beaches or islands cleared of vegetation. The closest breeding site to any of the Bay wetlands is the Venice Beach site (Table 3-2).

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Nagano *et al.* (1981) identified 474 insect species from the Ballona Wetlands saltmarsh and estimated that as many as 1,200 may actually inhabit the region. On the basis of the presence of known indicator species, the Ballona region was characterized as a natural coastal saltmarsh and associated sand dune habitat. At least 10 of the species found have restricted coastal distributions, and destruction of Ballona Wetlands habitat could result in their elimination.

Vertebrates

Fishes. The Ballona Wetlands, primarily Ballona Lagoon, support a number of transient fish species but only nine resident species. The dominant species are the arrow goby, which lives commensally in burrows of other organisms in the intertidal zone; the mosquitofish, a freshwater species which was introduced to control mosquitos; and topsmelt, a pelagic marine species which moves in and out with the tides (Swift and Frantz 1981).

Marine lagoons and back bays in southern California serve as spawning and nursery grounds for resident species (such as several species of gobies, California killifish, Pacific staghorn sculpin, and possibly topsmelt) (Fitch and Lavenberg 1975) and as important nursery grounds for the California halibut (Haaker 1975). The importance of Ballona Lagoon and Marina del Rey to these species in the past is not known.

Rainbow trout (steelhead) and tidewater goby were present at Malibu Lagoon in the past, and those species might return there if the entrance to the ocean were kept open to improve water quality (WRA 1990). Topsmelt and gobies (and possibly other bay species) which occur in Marina del Rey probably also occur in the Oxford Flood Channel and the Venice Canals.

Amphibians and Reptiles. Three species of amphibians and six of reptiles are known from the Ballona Wetlands. Most of the amphibians are frogs and toads and most of the reptiles are lizards (MBC 1988). All are associated with freshwater areas in the wetlands.

Birds. Numerous terrestrial birds, shorebirds, and water fowl are found in the Ballona Wetlands Complex and Malibu Lagoon. However, diversity is greater at Malibu Lagoon because it is adjacent to riparian woodland and chaparral habitats. Most species in the Ballona Wetlands Complex are shore birds, perching birds, and waterfowl. Relatively few birds breed in the Ballona Wetlands Complex due to both human disturbances and limited habitat diversity (Dock and Schreiber 1981).

Two endangered species live and/or breed in the Ballona Wetlands: Belding's savannah sparrow and California least tern. The savannah sparrow is a year-round resident which forages and nests in pickleweed, while the least tern is present only during spring and summer, feeding in the shallow waters and nesting at nearby Venice Beach (Dock and Schreiber 1981, Atwood and Minsky 1983).

Two species of birds which have not been observed in the Ballona Wetlands in recent decades probably bred there early in the 19th century. The range of the light-footed clapper rail (a federally-listed endangered species) presently extends between the saltmarshes of northern Baja California and those of southern California. Clapper rail nesting was recorded in nearby Santa Monica marshlands early in the century (Grinnell and Miller 1944) and they have been found in various marshes in Los Angeles County (LFCRRT 1983). Their absence at Ballona may be a result of a lack of suitable nesting habitat, preferably cordgrass (Massey and Zembal 1979). Although it will nest in upper marsh areas, especially following flooding of lower marsh habitat, this habitat is generally lacking at Ballona. Overharvesting by museum collectors and hunters,

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Table 3-2. California least tern breeding data in the Ballona region, 1978-1992.

Year	Breeding Pairs		Fledgings	
	Venice Beach	Playa Del Rey	Venice Beach	Playa Del Rey
1978	60–75	25–30	75	30
1979	80–95	18–25	140	25
1980	157	na	240	0
1981	150	16	195	0
1982	170	na	na	na
1983	145	0	140	0
1984	83	0	94	0
1985	96	0	113	0
1986	104	0	113	0
1987	109	0	82	0
1988	165	0	192	0
1989	137	0	134	0
1990	206	0	279	0
1991	198	0	200	0
1992	229	0	245	0

Sources: CDFG, unpubl. data; Massey and Fancher 1989; Jurek 1992, pers. comm.

na = Data not available.

Table 3-1. Number of breeding pairs of Belding's savannah sparrow in the Ballona Wetlands, 1973-1991.

Year	Number of Breeding Pairs	Area
1973	23 [a,b]	Playa Del Rey
1977	27 [a,b]	Playa Del Rey
1979	39 [c]	Ballona
1980	28 [c]	Ballona
1981	23-26 [c]	Ballona
1986	32 [a,d]	Playa Del Rey
1987	29 [e]	Ballona
1990	12 [e]	Ballona
1991	5 [e]	Ballona

a Based on sightings of territorial males.
b Massey 1979
c Dock and Schreiber 1981
d Dembal, 1988, pers. comm.
e Jurek, 1992, pers. comm. (based on USF&WS data).

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Life zones are areas with distinct organisms with adaptations for special physical conditions (e.g., pressure, darkness). Life zone schemes usually divide the marine environment into pelagic (open-water) and benthic (bottom) environments, with these being further divided, usually by depth (Hedgpeth 1957, Allen and Smith 1988). Intertidal and estuarine environments are also included as separate categories (Hedgpeth 1957). Each of these environments can be divided into smaller habitat units, each characterized by particular physical attributes and a suite of specially adapted organisms.

The marine ecosystem is divided into the pelagic and benthic environments. The pelagic environment includes the entire water column from the surface to the bottom of the sea. Pelagic organisms typically meet their needs for food, space, and refuge in the water mass itself, with relatively little to no direct interaction with the underlying seafloor. Horizontally, the pelagic realm can be divided into two zones: neuritic and oceanic. The neuritic includes the water column that overlies the continental shelf. Oceanic zone includes all other open waters. The pelagic environment can be further divided vertically. Two life zones of the pelagic realm are represented in Santa Monica Bay: Epipelagic and Mesopelagic. The Epipelagic zone (euphotic zone) is part of the pelagic environment that is lighted; its lower boundary is the limit of light penetration and varies in depth with water clarity. The mesopelagic extends from the permanent thermocline and extends to about 1500 ft - the artificially defined deep boundary of the study area.

The benthic environment (Figure 3-4) has three major habitats based on substrate type (hard-bottom and soft-bottom) or the presence of kelp beds. Benthic communities generally show a change in composition along a gradient of water depth. The sublittoral zone (from shore to a depth of about 600 ft) is divided into inner shelf (5-100 ft), middle shelf (100-300 ft), and outer shelf (300-600 ft) zones (Allen 1982, Allen and Smith 1988); the mesobenthal zone extends from a depth of 600 to 1500 ft (the deepwater boundary of the study area) (Allen and Smith 1988). Kelp beds are only found in the inner shelf zone, where waters are warmer and with sufficient light for kelp growth. The term benthos is used variously to describe both the habitat and the organisms which live on or in the seafloor. Some organisms move about in the water column and feed or find refuge on the bottom; these are called demersal.

PELAGIC HABITATS

The pelagic habitat is the most obvious habitat in Santa Monica Bay, encompassing approximately 306 mi^2 (since it extends from the surface to depths of 1640 ft) and a total water volume of about 914 billion ft^3 (6,840 billion gal, using an average depth of 820 ft).

The pelagic environment varies on a fairly regular, seasonal basis as well as periodically. Temperature and phytoplankton production are two of the most important factors which affect the abundance of pelagic animals. Natural surface water temperatures in Santa Monica Bay range from 11.7°C to 22.0°C annually (EQA/MBC 1973). Seawater temperatures in the Bay are higher in late summer and fall and lower in the winter and spring. Stratification and increased light levels in spring and summer enhance phytoplankton production, which forms the basis for the pelagic food web and the bacteria which recycle waste products into nutrients.

Organisms of the pelagic habitat are planktonic or nektonic. Planktonic organisms are too small (or are otherwise unable) to swim against the prevailing currents and thus drift with the water mass. However, some are able to move vertically through the water, undertaking daily migrations to the surface (usually at night). Nektonic organisms are those which are large enough or strong enough to swim against prevailing currents; they can remain in one place or move to another at will. The largest of these (macronekton) are whales, sharks, and large fishes.

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Least terns commonly utilize the open waters of Ballona Creek and, to a lesser extent, Ballona Lagoon to forage for food, principally northern anchovy, topsmelt, various surfperches, killifish, and mosquitofish (CLTRT 1980). Topsmelt, killifish, and mosquitofish are probably principal items in the tidal channels, creeks, and lagoons of the Ballona Wetlands, whereas northern anchovy is most important in offshore waters. Breeding success is partially dependent on food availability (Massey 1972).

Western Snowy Plover. Snowy plovers nest on beaches and salt flats which have some vegetation, and feed on mud flats in the wetlands. Historically, snowy plovers nested on the beaches at Malibu and on a stretch between Santa Monica and Redondo Beach (Page and Stenzel 1981). A few snowy plovers winter on the beaches of Santa Monica Bay (Page *et al.* 1986). However, nesting in the area has not been observed since 1949. The number of breeding birds in the U. S. in 1988-1989 (roughly 7900 birds) was about 20% lower than 10 years earlier (Page *et al.* 1991). This observed decline has raised concern for the future of this species, and the process of listing as threatened or endangered has been initiated.

Natural Variability

Although there is little information on the natural variability of wetlands plants and invertebrates in the area, seasonal and interannual variation would be expected under most conditions. Phytoplankton (and other seasonal plants) are most abundant in the spring and least abundant in winter. In addition, the aquatic and saltmarsh organisms would vary in abundance with regard to the relative influence of freshwater (runoff) and seawater, which may vary either seasonally or interannually.

Intertidal zones are used as classrooms for amateur and professional naturalists. Rocky tidepools, in particular, are visited by school classes and casual beach-goers, and may be heavily impacted during extreme low tides. Fisherman collect mussels for bait and some ethnic groups collect limpets and abalone for food, thereby depleting the shoreline of these species in some areas.

SANTA MONICA BAY HABITATS

The biological community and the physical environment function together as an ecological system or ecosystem (Odum 1959). The term ecosystem is usually applied to naturally defined systems to describe systems with unique physical and biological attributes. The biological environment of Santa Monica Bay is not a naturally defined ecosystem but rather an integral part of the larger Southern California Bight and California Current ecosystems; the study area is artificially defined here as the Santa Monica Bay ecosystem, with that understanding.

The following section includes a description of the plants and invertebrates found in most habitats. The marine vertebrates of Santa Monica Bay and their responses to human activities are discussed in Chapter 9. A complete list of scientific and common names of species used in this report are given in Appendix C.

Most marine organisms found in Santa Monica Bay and its watershed are temperate species with geographic ranges extending far beyond the immediate area. The majority are members of the San Diegan Province, which extends from about Point Conception, California, to Magdalena Bay, Baja California Sur, but some belong to the Oregonian Province, which ranges from southern Canada to northern Baja California (Hubbs 1974, Allen and Smith 1988).

Pelagic Organisms

Phytoplankton. The major plants of the pelagic realm are phytoplankton (blue-green algae, flagellates, and diatoms) and their primary production forms the basis of the pelagic marine food web. Phytoplankton are found most abundantly in the photic zone, both nearshore and well offshore. Dinoflagellates (some of which are responsible for "red tides") are characteristic of waters over most of the shelf in Santa Monica Bay, while diatoms are typically more abundant in colder water. During upwelling diatoms may dominate the phytoplankton community; when upwelling ceases, dinoflagellates become dominant again (Mullin 1986).

In general, phytoplankton abundance is greatest in spring when nutrients are abundant in the mixed layer and there is ample sunlight. However, blooms may occur in the fall when stratification breaks down and nutrients enter the photic zone from below. Most phytoplankton blooms in Santa Monica Bay result in response to local conditions such as surface runoff, upwelling, and sewage discharges that increase nutrient levels. Primary production in the study area ranges from 75 to 175 g carbon/m^2/yr; that of the Santa Barbara channel is approximately 142 g carbon/m^2/yr (Eppley and Holm-Hansen 1986).

Invertebrates. Smaller invertebrates comprise most of the zooplankton whereas larger invertebrates are often important members of the nekton. The most abundant animals of the pelagic environment are the zooplankton, which are small animals which drift with the currents. Zooplankton includes protozoa, crustaceans (copepods, euphausiids or krill, and mysid shrimps), pelagic snails, polychaete worms, arrow worms, comb-jellies, and jellyfish. Zooplankton are typically less than an inch in size, but some jellyfish are over 6 ft long (Beers 1986).

Most zooplankton are primary consumers and eat phytoplankton. In turn, they are consumed by larger, secondary consumers. However, many zooplankters are secondary consumers themselves. Zooplankton are found throughout the water column, although certain species are characteristic of various depths. Mysids are typical of shallow, nearshore waters while euphausiids are typical of middle and upper layers of deep offshore water. Many planktonic crustaceans undertake a daily vertical migration, swimming to the surface at night and to deeper waters during the day.

Most zooplankton species reproduce several times in a single year, the life span of individuals being measured in weeks or months. Eggs are usually broadcast into the water and develop through a variety of larval stages to mature adults.

Zooplankton abundances typically increase immediately following plankton blooms, especially in spring; in fact, predation by zooplankton contributes to a decline of phytoplankton. However, a decline in phytoplankton is primarily caused by depletion of nutrients. The volume of zooplankton in the surface waters of the Southern California Bight generally range from 90 to 300 *ml*/100 m^3 (Mullin 1986). In 1980 zooplankton (mostly copepod) volumes in Santa Monica Bay ranged from 100 to 1,300 *ml*/1,000 m^3 (Kleppel *et al.* 1982).

The eggs and larvae of many invertebrates are planktonic, even though the adult stages may not be. These meroplankton may last for only a short period (days to months) before the larvae become nektonic or settle to the bottom. The pelagic nekton includes larger mobile invertebrates such as squid and shrimp. The most important large nektonic invertebrate is the California market squid, although the pelagic red crab and the jumbo squid may be abundant locally during El Niño periods. Ocean shrimp feed in the water column at night but rest on the bottom during the day.

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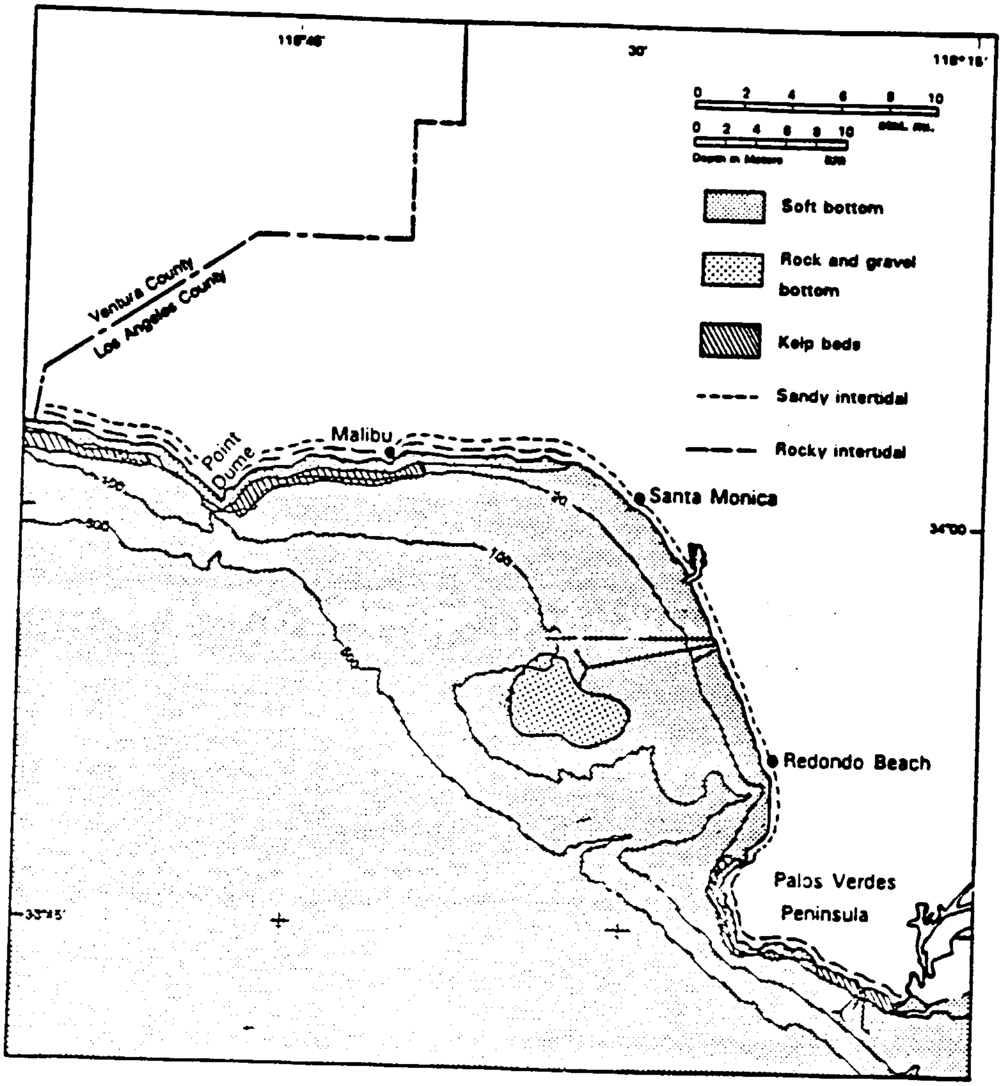

Figure 3-4. Major benthic and intertidal habitats of Santa Monica Bay.

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Because many zooplankters migrate between deep water during the day and the surface at night, zooplankton abundance in surface waters varies between day and night. Larger species such as euphausiids and mysids are generally more abundant in the surface waters of the Bay at night than during the day. Smaller species such as calanoid copepods do not migrate as much and day-night differences are less pronounced.

Intertidal Habitats

Organisms

Plants. Plants in the rocky intertidal display vertical zonation, with distinct species assemblages at different tidal levels, although the patterns may be disrupted by grazing, by dominant attached invertebrates, or by trampling. Lichens dominate in the splash zone, whereas the upper intertidal flora includes green algae such as sea felt and sea lettuce, brown algae (rockweeds), and various red algae. The middle intertidal includes a more diverse algal assemblage with foliose, filamentous, and coralline red algae and brown algae. The lower intertidal zone has red and brown algae as well as surfgrass (Hedgpeth and Hinton 1961, Dawson 1966).

Few plants are found in the sandy intertidal, although one-celled algae may be abundant on beaches with fine particle sizes (Pollock 1971). Benthic diatoms sometimes form a brownish green layer on sands where wave action is not too great and green algae, such as sea felt and sea lettuce, may occur on protected beaches where there is little sand movement. On the mudflats of backbays, cordgrass forms dense stands at the lower tidal level, while pickleweed dominates the upper level.

Where conditions are favorable for dune formation, above the high-energy intertidal zone, the sand may be sparsely vegetated with salt-tolerant sand verbena, silver beachweed, beach primrose, beach morning glory, salt bush and salt grass. Many introduced exotic plant species, such as Hottentot fig and sea fig (both known as iceplant), and sea rocket have taken over much of the extant dunes in southern California (Munz 1964, 1973). The vegetative cover helps to stabilize the dunes but is fragile. Its disturbance by vehicles and foot traffic may lead to eventual loss of the dune system.

Invertebrates. On rocky shores, only shelled species can live at the highest zones; soft-bodied forms cannot tolerate exposure to the air for very long. The splash zone is best characterized by periwinkles, barnacles, limpets, and rock lice. Periwinkles and limpets graze on diatom films, barnacles filter-feed when the tide is in, and rock lice are scavengers.

In the upper intertidal zone, species diversity increases with additional species of snails (periwinkles, turbans, limpets), attached bivalves, chitons, hermit crabs, and striped shore crabs. The upper limit of this zone is marked by California mussels and Pacific goose (or gooseneck) barnacles both of which are filter feeders and which are preyed upon by ochre starfish. A variety of sea anemones, snails (including black abalone), sea slugs, octopus, polychaetes, barnacles, isopods, crabs, shrimp, and brittle stars is also found here.

The lower intertidal is very similar to the subtidal; sponges, sea anemones, polychaetes, snails, sea slugs, attached bivalves, octopus, bryozoans, crustaceans (amphipods, isopods, shrimp, hermit crabs, crabs), sea stars, brittle stars, sea cucumbers, sea urchins, and tunicates are all abundant (Hedgpeth and Hinton 1961).

The production of phytoplankton (and secondarily of zooplankton) in the water column provides the primary basis of the food web that supports most of the larger organisms in the Bay.

Natural Variability

Phytoplankton assemblages in Santa Monica Bay are relatively distinct from those elsewhere in the Bight. Dinoflagellate abundance is higher in the Bay than in other areas along the coast. This has been attributed to high concentrations of ammonium, a result of nutrient regeneration at the bottom of the relatively broad shelf or from anthropogenic inputs. In addition, maximum phytoplankton production is at shallower depths (mostly less than 30 ft) in Santa Monica Bay than in other coastal and offshore areas of the Bight (Mullin 1986); it is greatest nearshore and decreases offshore. The distribution of bacterioplankton abundance parallels that of the phytoplankton (Azam 1986).

Most of the variability of plankton in Santa Monica Bay is natural (SCCWRP 1973), and its abundance may vary by an order of magnitude at periods of several years. Thus, in 1979 the concentrations of chlorophyll (a measure of total phytoplankton abundance) were less than one-tenth those in 1975 (Eppley 1986). During El Niño periods, phytoplankton productivity drops as the thermocline deepens and the availability of naturally occurring nutrients decreases (McGowan 1984). Cool surface waters are generally from the productive California Current whereas warm surface waters are generally from the less productive southern waters which move into the area during an El Niño.

Phytoplankton abundance in the Bay also varies seasonally, as a result of variations in light levels and nutrient availability. Primary production may vary by a factor of three between seasons. In general, phytoplankton abundance and production increase in spring as the sun moves higher in the sky and as stratification of the water column (from warming of surface waters) traps nutrients in the mixed layer. However, as phytoplankters deplete the nutrients, they become less abundant; predation by zooplankton also contributes to this decrease. A bloom may also occur in the fall when stratification breaks down and nutrients enter the photic zone.

Both spring and fall blooms are less pronounced in southern California than to the north; most local phytoplankton blooms are the result of local nutrient conditions from runoff, upwelling, and sewage discharge (Eppley and Holm-Hansen 1986). Upwelling in the Bay, particularly along the southern Palos Verdes Shelf, may lead to phytoplankton blooms which are dominated by diatoms rather than dinoflagellates (Eppley and Holm-Hansen 1986, Mullin 1986). In 1980 diatom abundance was sometimes high over Santa Monica and Redondo Submarine Canyons, suggesting upwelling there (Kleppel *et al.* 1982).

"Red tides" (which are typically dominated by dinoflagellates) sometimes develop in nearshore areas when warm temperatures, high light levels, abundant nutrients, and a shallow pycnocline occur together (Mullin 1986). Localized red tides occur almost every year, extensive ones less frequently. A red tide which developed in Santa Monica Bay in 1945 extended from San Luis Obispo to Los Angeles Harbor (Sommer and Clark 1946).

Zooplankton abundance also varies with oceanic conditions; it is generally low at high temperatures and high at low temperatures. Zooplankton abundance generally increases during a phytoplankton bloom (as during the spring) and decreases as phytoplankton abundance decreases. The abundance of microzooplankton in Santa Monica Bay generally parallels primary productivity (Eppley and Holm-Hansen 1986).

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Sandy beaches also provide foraging habitat for several species of shorebirds and nesting habitat for one endangered species, the California least tern. Western snowy plovers and willets are present on local beaches all year round; whimbrels, marbled godwits and sanderlings spend the winter only; and ruddy turnstones visit southern California beaches during spring and fall migrations (Garrett and Dunn 1981).

Marine Mammals. California sea lions sometimes haul out in rocky intertidal areas in Santa Monica Bay or rest on sandy beaches when sick or injured.

Importance

Beaches are the part of the marine ecosystem where the land meets the sea. As such, they present a unique and difficult environment for which a few species have become specially adapted. On sandy beaches, sand crabs and clams must cope with shifting sands (caused by waves) and with intermittent exposure to air during low tide. Species such as sand crabs and bean clams (also known as coquinas), move up and down with the tide, while others simply burrow deeper to avoid desiccation and predators. Pismo clams prefer the lower intertidal and are vulnerable only during the lowest tides. California grunion spawn in the sandy intertidal. All of these species are preyed upon at some time in their life cycle by other intertidal organisms, shorebirds, and humans.

Dunes provide protection for inland areas and serve as living and breeding areas for many species. Plants which have colonized dunes, in turn, act to stabilize the dunes, preventing them from blowing out during strong winds.

Rocky shores support a very different intertidal community. They provide points of attachment for algae which are primary producers and so are a source of algal as well as shell detritus. Rocky shores are the sole habitat for many species and they constitute nursery areas for the young of some fish and invertebrates.

Rare, Threatened, or Endangered species

California Least Tern. California least tern is a spring and summer visitor which breeds in southern California coastal habitat from late April to September. It builds its nests in shallow depressions in hard or soft dirt, dried mud, or sandy areas.

Historically, least tern nested on the upper reaches of sandy beaches along much of Southern California. As nesting habitat and suitable feeding grounds were lost and disturbance by humans increased (CLTRT 1980), terns made use of alternative sites (Dock and Schreiber 1981). California least terns formerly nested on salt- and mudflats at Playa del Rey in lieu of the larger and permanent site on Venice Beach. As a result of a program to protect least tern nesting grounds, the numbers of nesting pairs and fledglings at Venice Beach have almost tripled since 1984 (Table 3-2).

Breeding success of least terns varies greatly from colony to colony each year due to predation, unfavorable weather (CLTRT 1980), flooding (Dock and Schreiber 1981), and availability of food (Massey 1972). Least terns forage in the shallow, open waters of Ballona Creek, and to a lesser extent, Ballona Lagoon and Marina del Rey, principally for northern anchovy, topsmelt, surfperches, killifish, and mosquitofish (CLTRT 1980). Topsmelt, killifish, and mosquitofish are found in the tidal channels, creeks, and lagoons of the Ballona wetlands, whereas northern anchovy occurs in nearshore marine waters.

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The meiofauna, the smaller organisms of sandy beaches, is found in the upper sediment layers to a depth of several feet in coarse sand, to only 2 in. in fine sediment. Abundance is generally highest in coarse sands, but diversity is greater in fine sands. Similar species occur here as are found on the subtidal soft-bottom habitat.

The macrofauna of the sandy intertidal consists largely of polychaetes, bivalves, and crustaceans, the most obvious of which is the sand crab. This species is an important food for many surf zone fishes and is collected commercially for fishing bait. It filters particulate matter from the incoming waves but rapidly burrows deeper into the sand as the wave retreats.

The bloodworm is an infaunal polychaete which feeds on bacteria, microalgae, and meiofauna beneath the sand. Bean clams are abundant in some years; in other years they are rare. The pismo clam is a popular recreational species which is found on sandy beaches, and along with the little bean clam, extend subtidally. Populations of these two species appear to have declined over the past few years. The reasons are not clear, although recruitment has been very low, perhaps due to overfishing of parent stocks or habitat degradation (Shaw and Hassler 1989). The Pacific littleneck is found in coarse sand and gravel near rocky areas; this clam is also a popular recreational species. Although the status of this species is not known, it is subject to the same problems of overfishing and habitat degradation as Pismo and bean clams (Chew and Ma 1987). Amphipods are also important species on the intertidal sandy beach: beach hoppers (gammarid amphipods) live in burrows at low tide or under and around drift kelp (Hedgpeth and Hinton 1961). Further inland, on undisturbed, vegetated dunes, there are numerous species of insects, including the endangered El Segundo blue butterfly (WRA 1990).

Fishes. Rocky tidepool fishes are typically small and well-camouflaged. Woolly sculpin, opaleye, rockpool blenny, spotted kelpfish, and California clingfish are all found in the study area (Cross 1982a). The spotted kelpfish associates with turf algae, while the others are found where algae are not abundant. The rockpool blenny and California clingfish are most common in cobble areas whereas the woolly sculpin and opaleye are typical of fixed tidepools.

California grunion is a small, silvery fish, which deposits its eggs in the sandy intertidal zone. It spawns from late February to early September on the second night after a full moon, the so-called "grunion runs" of southern California beaches. Spawning occurs near the peak of the high tide during and just after high spring tides. Female grunion burrow tail-first into the sand and lay their eggs; males follow the females, wrap themselves around the females, and fertilize the eggs. They leave on succeeding waves and the eggs remain until the next spring tides two weeks later, when the eggs hatch and the larvae are carried out by waves. While buried on the beach, grunion eggs may be eaten by sand worms, isopods, flies, beetles and shorebirds (Fitch and Lavenberg 1971, USFWS 1985). Grunion may be caught (legally) by hand during the spawning season; they are taken incidentally in commercial nets along with other species (Fitch and Lavenberg 1971, USFWS 1985).

Several fishes live nearshore or in the surf zone. California corbina, barred surfperch, and shovelnose guitarfish all feed on sand crabs and are caught by sport fishermen. Surf fishermen often take California halibut as they move inshore to feed on grunion.

Shore Birds. Numerous shorebirds forage on crustaceans, mollusks, and polychaetes in the rocky intertidal zone. These include spotted sandpipers, willets, ruddy turnstones, black turnstones, surfbirds, wandering tattlers, black oystercatchers, Heermann's gulls, and western gulls (Jaeger and Smith 1966, MBC 1985). These species are most common locally during the winter; many migrate north in summer to breed.

Natural Variability

Under normal sea conditions, beaches exposed to wave surge erode or accrete in response to changing sea conditions. During winter storm events, beaches erode and sand is transported offshore. The resulting beach and nearshore profile are in equilibrium with the prevailing sea conditions. Typically, winter beaches are characterized by a steep beach face, relatively coarse sediment, and a sea cliff or winter berm (Anikouchine and Sternberg 1973). During summer much of the eroded sands is transported back to the beach by smaller waves (Bascom *et al* 1980) and the beach profile becomes less steep, with a smaller berm and finer sediments. During a severe storm, there may be insufficient sand on the beach to shape the equilibrium profile, and the upper beach dunes may be eroded to supply sand to the beach and nearshore zone. In winter 1982-83 there were four successive major storms with insufficient time between them for the beach to recover its stable protective profile (Armstrong 1991). Where the continental shelf is steep, waves cannot return sediment back to the beach after a severe storm and permanent erosion results (Woodell and Hollar 1991).

The coastline of Santa Monica Bay is naturally eroding because of the rise in sea level (more than 6 in. [15 cm] per century) (Woodell and Hollar 1991). The general long-term trend of shoreline erosion is very irregular and is punctuated by storm events, leading to a gradual, long-term trend of beach erosion. Major storm events during the last century which impacted Santa Monica Bay beaches occurred in 1905, 1915, 1926, 1931, 1939, 1941, 1952-53, 1957-58, 1972-73, 1077-78, 1982-83, and 1988. Recently, it has been recognized that these storms are associated with the El Niño-Southern Oscillation phenomenon.

Rocky intertidal habitats are subject to natural alteration by wave turbulence, inundation by sand, desiccation during hot, dry days, and freshwater dilution during rains. Storm surf damages these areas because they typically take the brunt of breaking waves; small cobbles are hurled about, damaging attached organisms. During winter the rocky intertidal is typically free of sand because beach sand is carried offshore; during summer, rocky intertidal areas may be covered with beach sand which is pushed ashore. Hot, dry weather subjects exposed organisms to desiccation and warms tide pools. During rain, attached organisms may be exposed to freshwater and tidepools may be affected by both freshwater and sediment carried in the runoff waters.

Thus, the abundance of intertidal organisms is expected to vary seasonally and interannually. Catastrophic destruction of individuals and habitat may occur at irregular intervals corresponding to major storms or dry periods. The natural variability of intertidal organisms in the Bay has not been quantified.

Soft-Bottom Habitats

The soft-bottom habitat is by far the most extensive benthic habitat in Santa Monica Bay. Most of the seafloor of the study area consists of unconsolidated (soft) sediments, which consist of mixtures of sand, silt, and clay (Figures 2-3, 3-4). Most of the energy entering this habitat is detrital fallout and phytoplankton from the water column, although detritus from surface runoff and sewage may be important.

Organisms

Plants. The few photosynthetic organisms that live on the soft-bottom habitat of the Bay include diatoms, blue-green algae, green algae, and flagellates which attach to sand grains or

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No studies have linked contamination of least tern food resources to reproductive success. However, since they prey on northern anchovy and topsmelt like the brown pelican, they may also have been impacted by the accumulation of chlorinated pesticides and PCBs in the 1970s.

Western Snowy Plover. The western snowy plover has recently been proposed for Federal threatened status (CDFG 1992). Its population has declined due to loss of beach nesting habitat in California (Garrett and Dunn 1981). Snowy plovers flock on the beach at Malibu and Hermosa Beach during winter but apparently do not nest there (Stenzel 1993, pers. comm.). The closest breeding colony is at Bolsa Chica in Orange County; other colonies nest at the Santa Clara River mouth, McGrath Lagoon and Mugu Lagoon in Ventura County, and some Channel Islands.

El Segundo Blue. The El Segundo blue is a subspecies of butterfly which inhabits (almost exclusively) dunes where its sole host plant, coastal wild buckwheat, is found (Emmel and Emmel 1973). It is presently limited to the dunes at the west end of LAX and Chevron USA's 1.6 acre butterfly preserve at the northwest corner of the refinery (Coonan 1992, pers. comm.). At one time the dunes encompassed 2,900 acres and included small seasonal pools and marshes; currently there are 338 acres of dunes, although potential enhancement sites are present within dunes owned by the airport and Chevron USA (WRA 1990). Attempts to protect the El Segundo blue from extinction have included protecting and propagating its host plant.

Wandering Skipper. The El Segundo Dunes are also inhabited by another rare butterfly, the wandering skipper. Wandering skipper larvae are restricted to one host plant, saltgrass. The decline in wandering skipper populations is due to loss of undisturbed beach dunes and coastal wetlands habitat (Zedler 1991). Thus, it is a valuable indicator of an ecosystem in continual decline. The wandering skipper has been a candidate for endangered status, and was listed in the Federal Register review of endangered or threatened invertebrate species (USFWS 1984).

Black Abalone. Black abalone are found in the intertidal and shallow subtidal of rocky shores from central Oregon to the southern tip of Baja California. Because they are large and easily noticed, they have been collected for food, beginning with the prehistoric coast-dwelling native Americans (Haaker *et al.* 1986). Indian middens along the southern California and Baja California contain great numbers of black abalone shells.

The black abalone population in southern California has been drastically reduced by commercial and sport harvesting as well as a mysterious "withering syndrome". Abalones also compete with sea urchins (which have increased along the coast) for the same food, brown algae. Collecting of black abalone has been banned in southern California from Palos Verdes Point to Dana Point and commercial harvesting is prohibited in Santa Monica Bay. The legal harvest size for black abalone is 5 in., but currently very few legal-sized animals are found in Santa Monica Bay (Harris 1992, pers. comm.).

Potential recovery strategies for black abalone include completely closing the fishery for up to 5 yr; continuing research on "withering syndrome" (evidence suggests that other abalone species may also be susceptible); and stricter enforcement of poaching regulations. Transplantion of larval or juvenile abalone onto Santa Monica Bay rocky beaches would not be practical until the cause of the withering syndrome is ascertained and until it can be demonstrated that transplantion actually works.

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Echinoderms (especially brittle stars) are also quite abundant and diverse. Brittle stars feed on detritus in the sediments or filter it from the water. Other less common invertebrate groups may be important at particular times or places. For instance, the spoonworm (an echiurid) is occasionally dense in some areas and is important in bioturbating sediments. Many benthic macrofaunal species have do not survive in contaminated areas, even though the sediment texture may be appropriate. Therefore, the benthic community composition differs with the degree of sediment pollution as well as with normal differences in sediment type.

Megafauna. The soft-bottom, invertebrate megafauna (excluding nektonic forms) of the Bay includes epibenthic sea stars, sea cucumbers, sand dollars, sea urchins, crabs, snails, and sea slugs. Being larger than the macrofauna, these species are less common and are spaced further apart. However, sand dollars and sea urchins often occur in very dense, single-species patches which limit the abundance of other species. Because they are larger, they often comprise the bulk of the biomass in an area. Most of these species feed on detritus and infaunal organisms. Sea cucumbers ingest sediments, sand dollars filter water, and sea urchins feed on detritus. However, moon snails, crabs, and the California sea slug are predatory.

Nektonic megafaunal species swim occasionally, but most spend much of their time on the bottom. Important invertebrate species include octopus, eastern Pacific bobtail (a squid), bay shrimp, ocean shrimp, and ridgeback rock shrimp.

Natural Variability

Sewage was discharged into the study area long before information on the infaunal communities of the area was available. The earliest large scale investigation of the infauna in the area was conducted (in 1952 to 1954) prior to operation of the HTP 5- or 7-mi outfalls. This study (Hartman 1956) did not sample sites off the Palos Verdes Peninsula, but included about 150 samples from the remaining portion of Santa Monica Bay. Six faunal assemblages were recognized, based mainly on physiographic differences in the habitat.

The above study was expanded into a survey of the entire Southern California Bight from 1957 to 1958 (CSWPCB 1959) which included stations on the Palos Verdes Shelf. Analyses of the data from this survey continued for years and these provide a background for impact studies (CSWQCB 1965, Jones 1969).

Historical information on the megafauna of Santa Monica Bay was not collected regularly nor is it comprehensive. The distribution of crabs and shrimp in the area are discussed by Wicksten (1984) on the basis of collections made prior to 1930. Qualitative comparisons of these data with those from 1958 to 1963 (Carlisle 1969) show little change in the species composition of Santa Monica Bay, but provide no information on abundance or fine scale distribution.

The abundance and distribution of individual species of the infauna and megafauna may vary seasonally and interannually, although most accounts of this are in studies concerned with human impacts. Most of this natural variability is difficult to separate from the variability associated with human impacts (Bernstein *et al.* 1984). However, any natural disturbance of the sediments or oceanographic changes, is likely to affect benthic soft-bottom invertebrate populations. For instance, a change in the species composition of the inshore megafauna assemblage of the Bight occurred after 1981, perhaps as a result of the 1982-1983 El Niño or because of severe winter storms in 1983 (SCCWRP 1936e). These events may also have been important in changing the composition of the infauna assemblages off Palos Verdes during this period (Swartz *et al.* 1986).

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move about on the surface of the sediments. These are most abundant on the inner shelf, at depths of less than 30 ft, where sufficient light reaches the bottom (Round and Hickman 1971). A few green, filamentous red, and small brown algae attach to worm tubes and cobbles on the bottom; these have the same light requirements as the one-celled plants and only occur in shallow water.

Meiofauna. The meiofauna are the smallest (less than 0.5 mm in. one dimension) infauna. Meiofauna (organisms which live in the sediments) includes small organisms such as one-celled protozoans, small roundworms (nematodes), small polychaetes and oligochaetes, copepods, gastrotrichs, flatworms, kinorhynchs, and tardigrades. These organisms are dense in aerobic sediments throughout the year, feeding on bacteria, one-celled plants, detritus, and other meiofauna. The meiofauna of the Bay has not been well studied, but organically-enriched sediments generally have higher proportions of nematodes and oligochaetes than normal sediments.

Macrofauna. The invertebrate macrofauna which are less than about 0.5 in. in one dimension are the dominant members of the soft-bottom infauna. The soft-bottom habitat of the shelf supports an extremely diverse (numbers of different species) and abundant (numbers of individuals) infauna. As many as 1,200 infaunal species have been reported from Santa Monica Bay (Dorsey 1988). Samples from uncontaminated sediments along the 200-ft isobath in the Bight averaged 71 species and 423 individuals in 0.1 m^2 of bottom sediment. However, because these animals are usually quite small, the biomass is small averaging 7.0 g/0.1 m^2 (Word and Mearns 1979). These values vary with depth and sediment type.

The infauna is usually dominated, in numbers of species and numbers of individuals, by polychaete worms. Polychaetes are soft-bodied, and may be free moving or sedentary. The free-moving ones generally crawl along the surface or burrow through the soft sediments like earthworms; sedentary forms move, but usually within a tube which they construct in or on the sediments. Most soft-bottom polychaetes feed on the bottom, engulfing sediments and digesting off the attached bacteria, or filter feed on bits of organic detritus in the water. A few polychaetes are predatory, feeding on other infauna. Polychaetes are important constituents in the diet of many demersal fish and are important in reworking (bioturbating) the sediments.

Crustaceans are usually the second most diverse and abundant group of soft-bottom infauna. Among this group of animals, amphipods are the most common, but others such as cumaceans, isopods, and ostracods are also important. Some species of amphipods and all of the benthic cumaceans and ostracods burrow in the sediments; some amphipods live in tubes while others, hide among debris. All of these crustaceans brood their eggs and hence do not have pelagic larvae; the males of many amphipods, cumaceans, and ostracods migrate up into the water column at night. Some crustaceans filter plankton and detritus from the water column and others feed on meiofauna, diatoms, and detritus in or on the sediments. Still others scavenge on dead organisms. Amphipods are particularly important prey for many demersal fishes (Allen 1982).

Mollusks are usually the third most diverse and abundant group of soft-bottom macrofauna. Bivalves (clams, mussels, etc.), snails, and sea slugs make up most of the molluscan portion of the benthos. Most bivalves are infaunal but scallops and mussels are epifaunal. Clams generally filter the water for bacteria, phytoplankton, and detritus but some species engulf sediments as they burrow. Snails and sea slugs tend to scrape material from the sediments or hard surfaces, but many are predatory, preying largely on clams and other snails by drilling holes through their shells.

abalone feed on drift kelp while sea urchins graze on macrophytes and diatoms. Many of the small crustaceans (amphipods, isopods, shrimp) eat algae but crabs, shrimp, lobsters, snails, sea slugs, polychaetes, and sea stars are carnivorous or omnivorous.

Abalone, California spiny lobster, yellow rock crab, Pacific rock crab, red sea urchin, and Pacific purple urchin are fished recreationally in shallow water and spot shrimp in deep water.

Natural Variation

Natural variations in the plant and invertebrate populations of subtidal hard-bottom areas occurs seasonally (particularly in shallow water) and during El Niño periods but these have not been well documented in the Bay. Studies of artificial reefs in the Bay indicate that the plant and invertebrate assemblages on newly-exposed hard substrates undergo a succession in dominant species and area coverage of epifaunal growth with increasing time (Carlisle *et al.* 1964). A red tide which occurred from San Luis Obispo to the Los Angeles Harbor in 1945 killed California spiny lobster and sheep crab, both hard-bottom species (Sommer and Clark 1946).

Additional factors which affect the shallow habitat include turbidity, sea urchin predation, water movement, temperature, and inundation by sand. Changes in the biota of a shallow reef may be seasonal or long-term. Turbidity and sea urchin predation reduce the algal growth whereas the turbulence, scouring, and inundation by sand affects the suitability of the habitat for sessile and crevice-seeking species. Seasonal changes are caused by differences in light intensity and temperature, which affect photosynthesis and may trigger spawning in a variety of organisms.

Annual inundation by sand is common in shallow areas; it may smother the existing biota, resulting in a bare surface when the sand is gone. As a newly exposed hard surface appears, the process of succession, from small sessile forms to a dense cover of macroalgae and mussels begins. Thus, shallow reefs may be almost constantly in an early state of development.

Kelp Beds

Kelp beds are an extension of the hard-bottom habitat. However, most hard bottom in the Bay is of low relief and the presence of kelp extends this relief to the sea surface. Giant kelp is probably the best known of the macroalgae It generally grows on hard, subtidal bottoms at depths of 20 to 70 ft, where the water is clear (Abbott and Hollenberg 1976). More than other macroalgae, giant kelp becomes a part of the habitat, providing food, shelter, nursery, or a point of reference for invertebrates and fishes.

Giant kelp is harvested to produce compounds such as algin, which is used in the manufacture of ice cream, cosmetics, and many other commodities. Kelp beds are also important for sport fishing, commercial harvesting of abalone and sea urchins, and recreational diving (North and Hubbs 1968).

Giant kelp has a complex life history which is normally completed in 12 to 14 months (Neushul and Haxo 1968). The mature kelp plant (a sporophyte) produces spores which are shed into the water column. When the spores settle and survive, they develop into a microscopic plant (a gametophyte) which produces eggs and sperm. The eggs and sperm unite to form a young sporophyte which grows to become a mature kelp plant. Kelp may live for more than five years (North 1968) and may grow as much as 12 to 20 in. per day, making it among the fastest growing plants known.

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Hard-Bottom Habitats

Hard-bottom substrate includes natural hard bottom and artificial reefs and structures. Hard-bottom habitats have a diverse and abundant assemblage of organisms that are often unique to the habitat. Reefs provide forage, shelter, and nesting sites for many animals. Hard-bottom in the photic zone is generally dominated by algal growth whereas that in deep water lacks algae altogether. Nearshore reefs may also provide habitat for giant kelp, which in turn provides habitat an additional diverse assemblage of organisms. Because of the diverse and abundant assemblage of unique organisms, reefs are important sites for recreational diving and fishing. Artificial structures, such as outfall pipes, artificial reefs, jetties, groins, and piers also provide hard-bottom habitat in Santa Monica Bay.

The rocky subtidal bottom off the Palos Verdes Peninsula is composed of sedimentary strata. Shale boulders and shelves are often isolated by reaches of sand and cobble. Reefs are more diverse, with two to four times higher vertical relief on the western side of the peninsula. The eastern rocky subtidal (12-18 m depth) is characterized by greater water turbidity and associated bottom sediment derived from the Portuguese Bend landslide. Most rock substrate is covered by a 1-2 cm layer of fine grained material and the surrounding soft bottom channels may have up to 20 cm of this sediment (Stull, pers. comm. 1993).

Organisms

Plants. Although, hard bottoms support diatoms and other one-celled plants, they are distinguished for their growth of kelps and other macroalgae. Macroalgae are anchored to the bottom with a root-like structure called a holdfast and reproduce in a complex system which produces both spore and gamet stages. In the study area macroalgae are only abundant along the Carillo and Malibu coasts, the Palos Verdes Peninsula, and artificial structures along the shore.

The major plants of the rocky subtidal in Santa Monica Bay are red and brown algae. Typically, the red algae form a low turf or understory of coralline, foliose, and filamentous forms from shore to the edge of the photic zone. Brown algae are generally larger and form an overstory; locally the feather-boa kelp is dominant nearshore while giant kelp dominates deeper areas of a reef (Quast 1968).

Invertebrates. Hard-bottom invertebrates include sessile and motile forms. Sessile forms are firmly attached to the surface of the rocks whereas motile forms move about on the reef or swim near the reef. Most hard-bottom invertebrates have planktonic larvae, although some amphipods and isopods brood eggs and larvae; sea squirts and sea anemones also reproduce asexually to form colonies.

The most obvious forms on this habitat are sessile species: mussels, barnacles, sponges, sea anemones, sea fans, tube worms, and sea squirts. Date mussels and piddock clams actually burrow into the rocks. Most of the sessile invertebrates feed by filtering plankton and detritus from the passing water mass. They are generally less abundant where macroalgae cover is high but are the dominant organisms elsewhere.

Most of motile invertebrates hide in crevices in the habitat or are protectively colored. Large species include abalone and other snails, octopus, shrimp, lobsters, and crabs. Smaller species include polychaetes, bivalves, snails, amphipods, and isopods. A variety of small motile forms live in and among the bases of the relatively large sessile species. Among the motile forms,

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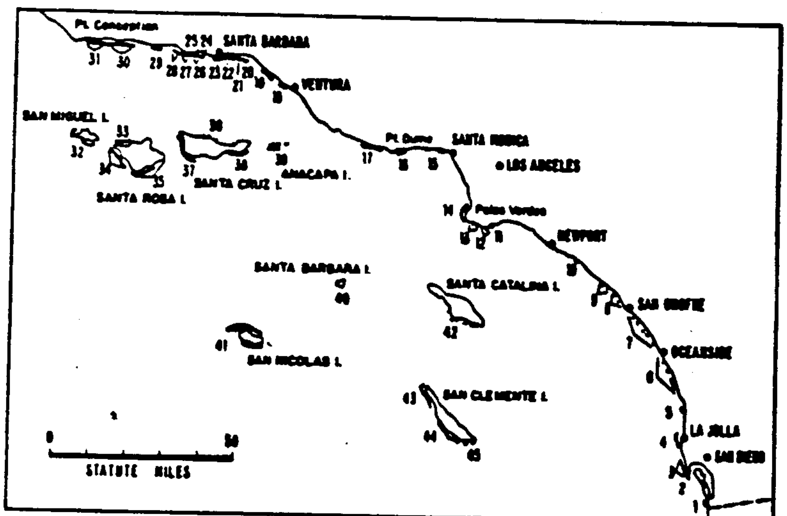

Figure 3-5. Kelp bed designations by the CDFG (CSWQCB 1964).

Mature giant kelp consists of a root-like holdfast, the stem-like stipes, and leaf-like blades. Gas-filled bladders at the base of each blade buoy up the plant, keeping the blades near the surface where light levels are maximal.

Giant kelp is found in the northeastern Pacific from Alaska to southern Baja California (Abbott and Hollenberg 1976). Not only are there replacement species along this latitudinal and temperature gradient, but within species there are strains which are adapted to particular temperature ranges. At present and in the recent past, giant kelp in Santa Monica Bay has been limited to rocky bottoms along Leo Carillo beach and the Malibu coast and along Palos Verdes Shelf (Figure 3-4).

The cover provided by California kelp beds provide protection and habitat for more of than 800 species of fishes and invertebrates, some of which are uniquely adapted for life in the beds. When kelp is absent from a reef, many of the associated invertebrates and fishes are also lacking.

Organisms

Plants. Many other algae associate with giant kelp, adding to the complexity and productivity of the habitat. These shrub or understory algae are similar to those found in other rocky bottoms at similar depths and include foliose, filamentous, and coralline red algae, smaller kelps and brown algae, and some green algae. In a dense bed, the canopy of kelp blades can actually limit the amount of light reaching the bottom so that understory algae (especially turf species) are less abundant. Feather-boa kelp is sometimes found on the inshore side of giant kelp, thus extending the bed shoreward (North 1976).

Invertebrates. The invertebrates found in kelp beds are similar to those found on hard-bottom environments without kelp. Because turf algae is often lacking, encrusting animals such as sponges, hydroids, sea fans, moss animals, and tunicates are more abundant. Pink abalone and California spiny lobster are often common in kelp beds, and red sea urchins and Pacific purple urchins are generally present. Several sponges, sea stars, and snails are unique to the holdfasts of giant kelp, as are file shells and warty sea cucumbers (Limbaugh 1955).

Kelp fronds become senile in about six months and individual blades deteriorate in one or two months; therefore, long-lived encrusting organisms like mussels and barnacles do not develop on them. However, some encrusting moss animals settle and form flat, white colonies that can completely cover a blade in three weeks. Broadtail isopods, carinate dovesnails, and kelp scallops are common on the stipes and many other invertebrates are found on the blades, though not exclusively (Limbaugh 1955).

Natural Variability

The history of kelp beds in the study area can be traced from records dating to 1911. Because kelp beds are licensed for harvesting each year they have been numbered by the California Department of Fish and Game (CDFG), which manages the resource (Figure 3-5). Beds 11, 12, 13, and 14 are located along the Palos Verdes Peninsula, between Point Fermin and Lunada Bay. Giant kelp has not been dense in this century along the sandy, central portion of Santa Monica Bay, although individual plants may have grounded there or grown on temporarily exposed rocks. Beds 15 and 16 are located between Santa Monica and Point Dume; Bed 16 is in the Mugu-Latigo Area of Special Biological Significance (CSWQCB 1979). In the early part of

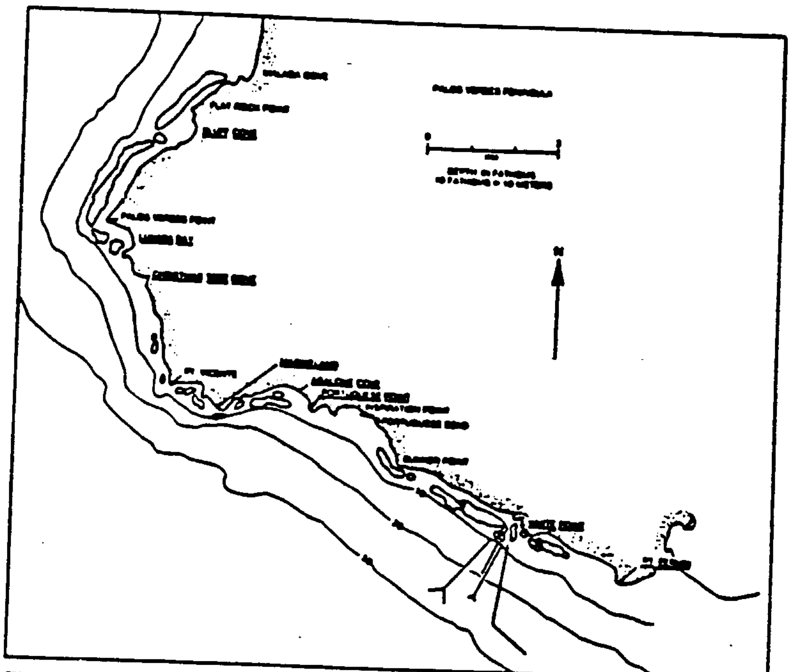
Figure 3-6. The kelp beds along Palos Verdes Peninsula in 1982 (MBC 1988)

this century, the Malibu coast beds extended from Point Dume to Santa Monica Canyon (Ulrey and Greeley 1928), but they now extend from Point Dume to Malibu.

From 1940 through 1974 the general trend in giant kelp was one of decline and appears to have been centered on the White Point outfall (North 1968). By 1959, following the strong El Niño Event of 1957 and 1958, kelp was almost completely gone; only small patches remained in Abalone Cove and at Portuguese Bend. By the fall of 1968 the last of these plants had perished (North 1970) and only transplanted kelp remained. Efforts to re-establish the Palos Verdes beds had begun in June 1967, initially with little success. During 1950-1960 as a result of increased urbanization, the marine environment became the disposal site for industrial and domestic waste. A decline in the size and number of productive kelp forests was documented during this time (Carter *et al.* 1985).

Between 1970 and 1977, the CDFG attempted to restart kelp at nine separate sites along the Palos Verdes Peninsula (Wilson *et al.* 1977). By 1975 kelp was thriving in Abalone Cove and was redeveloping in Bluff Cove (Figure 3-6). The total canopy area in 1982 was nearly what it was in the mid-1940s; it continued increasing, reaching a peak off Palos Verdes in mid-1987 which was 36% greater than recorded in 1911 (Neushul 1981). Kelp acreage was still high (617 acres) in early January 1988 (CDFG, unpubl. data), but as in 1983, storms in mid-January decimated the bed, severely reducing canopy cover. Storm decimation of the beds is a natural, ephemeral event with active regrowth following.

The history of Beds 15 and 16 in the western part of the Bay is not as well documented. Bed 15 (Figure 3-5) covered 182 acres in 1911 but has had a maximum canopy of 7 acres since 1935 (Neushul 1981). Between 1930 and 1980 the average cover was about 5 acres but kelp was often altogether absent (Harger 1983). Bed 16 in Paradise Cove is much larger and has been present continuously. In 1911 it covered 376 acres, but between 1959 and 1979 never exceeded 222 acres (Neushul 1981).

Causes of Natural Variability

The reasons for fluctuations in kelp bed canopy area and in health of the plants have been studied and argued for decades. Over-harvesting, recreational boating, waste discharge, storms, oil spills, turbidity, and warm water have all been identified as contributing to the disappearance or decline in kelp. To date no single cause has been identified and the luxuriant regrowth of kelp in areas from which it had disappeared has reassured many that declines are reversible. Many factors appear involved in the success or failure of any particular kelp bed, and neither natural nor contaminant related causes are of overwhelming importance.

Nutrient availability and storms seem to be the major natural factors which influence the health and survival of kelp. For a long time it was thought that warm summer temperatures and warm El Niño events caused the deterioration of giant kelp fronds. However, evidence indicates that lack of nutrients rather than warm temperature causes the summer degeneration (North 1983). The complicating factor is that in summer a density gradient (pycnocline) forms in nearshore waters, preventing nutrients (either natural or from sewage) from reaching surface waters. Thus, there may be both a yearly cycle in canopy extent and an irregular multi-year cycle which reflects El Niño influence.

Although low nutrient levels reduce canopy cover, they seldom result in the death of the plant. However, storms frequently do lead to complete loss of kelp. Whole beds may be uprooted during major storms and cast on or off shore. During the storms of winter 1987-1988 most kelp

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in the study area was lost. This repeated the 1983 winter storm decimation of beds in the study area (Wilson and Togstad 1983), and throughout southern California (Dayton and Tegner 1984) In both cases, high levels of growth followed.

Natural turbidity may also be important. Turbidity reduces light levels reaching the bottom and hence reduces plant growth. In addition, sediments settling to the bottom from turbid water may smother young plants or make the bottom unsuitable for settlement of sporophytes. Turbidity in near-bottom waters is greater in the eastern area of the peninsula primarily due to sediments from the Portuguese Bend landslide (Stull, pers. comm 1993). Since 1980 the landslide at Portuguese Bend has supplied more than seven times the suspended solids than the JWPCP outfall (SDWG 1988) and may have reduced kelp beds in the immediate area.

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Early Spanish and Mexican navigators had passed Santa Monica Bay, but did not land, possibly because they did not see the Indians' huts and the coves did not appear suitable for anchoring. Inland journeys of 1769 and 1774 also by-passed the coastal areas occupied by the Chumash, although they encountered some inland Gabrieleños settlements. Chumash villages were at the mouths of canyons (Robinson 1959); a Venturaño Chumash village named *Maliwu* was located near the present city of Malibu, which took its name from this village (Kroeber 1925, Johnston 1962). Gabrieleño villages were located throughout the Los Angeles Coastal Plain. Their villages were generally located on bluffs overlooking rivers or wetlands, some being located at Santa Monica (*Kuruvangna*), Los Angeles (*Wenot*), Culver City (*Sa'angna*), Redondo Beach (*Engnovangna*), and Palos Verdes Peninsula (*Masau*) (Kroeber 1925, Johnston 1962). In the late 1700s the Chumash Indians moved further inland using trails forged by explorers who had landed further north (Robinson 1959).

Little is known of the Venturaño Chumash, Fernandeño, or Gabrieleño Indians; their tribal names are unknown and their current names are derived from their later association with missions in the area San Buenaventura, San Fernando, and San Gabriel Mission (Kroeber 1925; Reiter 1984). Acorns were the staple food of all three tribes, but other plants and animals were also eaten. Coastal Chumash and Gabrieleños were skilled fishermen, the former using plank canoes and the latter using boats of made of rushes and tules. They fished for Pacific sardine, California halibut, lingcod, and tunas; hunted marine mammals such as dolphins, sea lions, seals, and sea otters; and gathered shellfish from the intertidal zone. In inland areas, they hunted deer, rabbits, and other small mammals (Johnston 1962). Indians made use of beach tar to waterproof their baskets and caulk their canoes.

SPANISH/MEXICAN PERIOD

The influx of Europeans in the late 1700s marked the beginning of the end of native Americans in the Los Angeles area. The Spanish occupation began in 1769 with the Portola expedition which founded Franciscan missions throughout California, the first being San Gabriel mission in 1771 (Josselyn *et al.* 1992). The missionaries encouraged the Indians to give up their traditional lifestyle and to live at the coastal missions but the stress of the mission routines and exposure to new diseases only hastened their demise. Some women practiced voluntary abortion rather than have their children grow up under such conditions (Robinson 1959). As the numbers of European and Mexican settlers increased, many natives deserted the area, and by 1852 there were approximately 3,700 "domesticated" Indians and 4,000 Europeans in southern California (Green 1980).

Several of the early explorers settled and purchased land in the Santa Monica Bay area. In 1775 Jose Bartolame arrived in Malibu with 240 colonists from Sonora, Mexico (Robinson 1959). He had a Spanish land grant for 13,000 acres which he called the Rancho Topanga Malibu Sequit and which was used primarily for cattle grazing. Bartolame cultivated a small area, planted a vineyard and cornfield, and built a mill, but after gold was discovered in the Sierra foothills in 1848, he sold Rancho Topanga. The three subsequent owners were a Frenchman, an Irishman, and a Puritan from New England who continued to raise cattle, the leading industry at the time.

In Santa Monica, Francisco Sepulveda purchased the majority of the land for cattle grazing (Robinson 1959). Other ranchos in the area included Rancho San Vicente y Santa Monica at Santa Monica, Rancho Rodeo de las Aguas at Beverly Hills, Rancho Ballona at Ballona Creek, and Rancho Sausal Redondo at Hermosa Beach (Josselyn *et al.* 1992).

CHAPTER 4

THE HUMAN POPULATION

During the last ice age (about 18,000 years ago) sea level was about 384 ft lower than at present (Nardin *et al.* 1981) and the continental shelf of Santa Monica Bay (which is presently submerged) would have been dry land and beach, probably backed by steep cliffs and rocky shores. Much of the land behind these cliffs was a broad, flat plain; Ballona Creek probably extended across this plain to enter what is now Redondo Submarine Canyon.

The land around Santa Monica Bay would have resembled that presently found near Monterey California, with forests of cypress and pine near the coast, brush and grasslands more inland, and riparian forests along the Ballona Creek drainage. In addition to the mammals and birds, which are still present, the area supported species which have since become extinct – mammoths, mastodons, giant ground sloths, sabertooth tigers, camels, and llamas.

Smoke from brush fires would have lingered in the valleys as "smog" and fallout from them would have contributed the same kind of "background" materials as they do today. The offshore oil seeps of today may have constituted tarpits near the mouth of Ballona Creek (at what is now Redondo Submarine Canyon). The sea was cooler and populated by marine life more typical of cooler waters than at present, and probably more abundant.

Sea level gradually rose, covering previously dry land, until the present sea level and coastline were attained about 3,000 years ago. Sandy beaches were the predominant shoreline during this period as the sea gradually progressed to higher levels across the plain; sea temperatures increased and the climate became warmer and drier.

THE NATIVE AMERICAN PERIOD

The earliest record of native Americans in the area is from about 6,000 years ago at Malaga Cove, although they were probably present much earlier (Reiter 1984). From 6,000 years ago to the 1700s, the area was populated largely by Indians with a hunting and gathering economy that emphasized plant foods such as seeds and acorns. Those living near the shore relied heavily on marine life for food.

Northern anchovy were more abundant, and large fishes, sea birds, and marine mammals which prey on anchovy may have been more abundant than at present (Soutar and Isaacs 1969). Hunting and fishing pressure increased with the native population and began to impact the plants and animals of the watershed, wetlands, and Bay. Some larger mammals may have been hunted to extinction and the food organisms along the shore were also probably impacted (Reiter 1984).

Although intermittent Spanish contact with the Indians occurred during the Cabrillo expedition of 1542 and the Vizcaino expedition of 1602, it was not until the late 1700s that the Venturaño Chumash, Gabrieleño, and Fernandeño Indians of the Santa Monica Bay watershed area had sustained contact with white men. The Gabrieleños lived from the Santa Monica Mountains south to the Aliso Creek Drainage in Orange County. The Fernandeños occupied the San Fernando Valley and the Santa Monica Mountains from the Topanga Canyon watershed east. The Venturaño Chumash were found west of the Topanga Canyon watershed to Ventura and inland to the Thousand Oaks area (Kroeber 1925). The entire Chumash population probably never exceeded 15,000 (Green 1980); less is known of the Gabrieleños, although their entire population was less than 5,000 in 1770 (Johnston 1962).

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selected San Pedro because it was better protected from winds, storms, and prevailing westerly swells (Marquez 1975).

By 1897 the population of Santa Monica had grown to approximately 2,000 people, twice that of 1875. With hopes of a shipping industry shattered, Santa Monica residents and entrepreneurs again tried to develop tourist and recreational opportunities. Since then, there has been opposition to large-scale industrial development (McQueen 1979).

1900 TO WORLD WAR II

The period from 1900 to 1920 was one of rapid population growth. Increases were especially pronounced between 1900 and 1905 when the population increased from 3,057 to 7,208 (136%), and again between 1910 and 1920 when it nearly doubled, from 8,700 to 15,000. These increases set the stage for dramatic regional growth and development between 1920 and World War II.

Establishment of the Douglas Aircraft Company (DAC) in the 1920s opened a new era for the Los Angeles area. Donald Douglas had moved to Santa Monica from the east coast to raise his children and to establish his own aircraft manufacturing company. With financing from David R. Davis, Douglas began work on an airplane which could fly coast to coast nonstop. With east coast associates, Douglas and his company received its first formal contract from the Navy in 1921. Douglas also secured the signatures of ten prominent Los Angeles businessmen on a $15,000 promissory note (Maynard 1962), and as the company grew, Douglas moved first to an abandoned movie studio in Santa Monica and in 1929 to Clover Field. The number of DAC employees increased from 20 in 1922 to 112 in 1924 (Maynard 1962) and at its wartime peak in 1944 DAC employed 160,000 persons in six plants. The firm manufactured 16% of all aircraft built in the U.S. between 1942 and 1945. Three of Douglas' plants closed in 1946, bringing employment down to 27,000, although there was an increase in sales during the Korean conflict in the 1950s. In the 1960s most of the company's operations were relocated to Long Beach.

The population of Santa Monica continued to grow substantially during this period, increasing from 15,000 to 37,000 between 1920 to 1930 (147%), from 37,500 to 53,000 (41%) between 1930 and 1940, and from 53,500 to 72,000 between 1940 and 1950 (35%) (USBC 1890-1970).

WORLD WAR II TO PRESENT

City of Santa Monica

The population of Santa Monica has increased dramatically since 1910 but the rate of increase was less after 1960 (Figure 4-1). In 1949 Santa Monica was characterized as a middle class community with a moderate degree of urbanization and little ethnic and social integration (McQueen 1979). Between 1950 and 1958, the population increased to 78,000, but residents were predominantly white, native-born American citizens. Ten percent of the population were foreign-born residents and 5% were non-white, predominantly black (90%) and Hispanic.

By 1990 the population of Santa Monica (including the City of Malibu) had increased to 98,388, 75% of whom were white, 14% Hispanic, 6.2% Asian, and 4.3% black. The median age of the residents was 37.9 years, significantly higher than the statewide median of 31.5. Santa Monica is home to a number of retired and senior citizens, 20.8% of whom are over 60 years old. Employment in Santa Monica increased dramatically between 1980 and 1990 (Figure 4-1) (MBC

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From the mid-1700s to the mid-1800s, inland vegetation was altered. Coastal scrub was converted to grassland as a result of burning and grazing (Johnston 1962). Smoke levels probably increased and bacteria from livestock entered streams draining to the sea. Without the Indians, intertidal organisms may have received a brief respite from fishing pressure, as the Europeans focused on fish, whales, and game. However, fishing and hunting pressure increased with firearms and better fishing methods, with marine mammals, seabirds, and water fowl probably the most affected (MBC 1988).

Although they occurred throughout history, major storms were first recorded in the 1800s. Storms from the southeast were common in the early 1800s and they often generated waves to 40 ft or higher (Kuhn and Shepard 1981).

EARLY STATEHOOD: 1850 TO 1899

In 1850, California became the 31st State. The collection of warm-water fish species in southern California in the 1850s suggest that El Niño events occurred during this time (Hubbs 1949). Extremely heavy rain fell in 1862 and from 1884 to 1891, causing the Los Angeles River to shift course between Ballona Creek and San Pedro (Kuhn and Shepard 1981). These storms probably affected beach erosion, offshore sedimentation, and coastal turbidity for months (MBC 1988).

Between 1864 and 1885 a whaling station was operated at Portuguese Bend (Sayers 1984) and by 1879 commercial and sport fishing had begun in Santa Monica Bay. Commercial landings at Los Angeles were dominated by pelagic and nearshore fishes (Jordan 1887).

Through the early 1870s the Santa Monica Bay region was largely open land used for cattle grazing, and very few Americans held land in the area. In 1872, 38,000 acres of Spanish Ranchos were purchased by New Englander Robert Baker, who hoped to develop a railroad terminus and shipping port. In 1875, when the local population was about 1,000, Baker sold two-thirds of his land to Senator John P. Jones of Nevada, who wanted to build a railroad to transport silver to ocean ports (Ingersoll 1908). Shortly thereafter the population began to grow, out of interest in Jones' plans and the emerging popularity of the area as an ocean resort. By 1877 the Comstock Crash forced Jones to sell the Los Angeles and Independence Railroad to Collis Huntington. The large ranchos were subdivided and sold to easterners and property values began to rise.

In 1878 the Southern Pacific Railroad dismantled the Santa Monica wharf, whereupon business declined. Santa Monica attempted to offset the loss of railroad and wharf resources by promoting its image as an ocean resort. This image was enhanced in 1886 with the construction of the luxurious Arcadia Hotel, which attracted people from all over the world. Santa Monica was also convenient for residents of Los Angeles and increasing numbers of people moved to Santa Monica and commuted to jobs in Los Angeles.

In 1891 Collis Huntington built a larger wharf in Santa Monica, intending to regain the shipping trade. Santa Monica and San Pedro vied for over five years as the location of a deep water port for the Los Angeles area, as the region had no natural harbor. The selected city would receive $3 million in federal funds to construct the new port. The Free Harbor League, an association of 400 members, supported San Pedro as the port site. Both public officials and private citizens feared that if located at Santa Monica, Collis Huntington and his Southern Pacific Railroad would dominate the port and form a monopoly. In 1897 the Army Board of Engineers

1988; SCAG 1991). In 1990 18.6% of the employed residents were in managerial, executive, and administrative positions (USBC 1990; CSM,PPD unpubl. data)

The income of Santa Monicans is also higher than the statewide average: in 1990 the mean household income in Santa Monica was $55,522, 20% higher than the state mean of $46,247. The number of housing units has increased at a slower rate than that of population or employment (Figure 4-1) (MBC 1988; SCAG 1991). Most Santa Monica residents rent; in 1990 only 26% of the 47,753 housing units in Santa Monica were owned by the occupant (USCB 1990; CSM,PPD unpubl. data). Rent control ordinances enacted in the 1980s have stabilized housing costs and apparently residents are reluctant to relocate from their current, low-cost homes.

Santa Monica continues to grow: the population is expected to increase 20% between 1990 and 2000 to approximately 104,683 persons (Figure 4-1) (USCB 1940, 1950, 1960, 1970; MBC 1988; SCAG 1991). A large percentage of residents continue to hold managerial, administrative and professional positions, but retail positions account for 13.6% of total employment (USCB 1990; CSM,PPD unpubl. data). The predominant land use is residential (61%), followed by commercial (22%), and industrial (6%) (Table 1-3) (SCAG 1992a). The tendency to keep industry to a minimum is still apparent: in 1991 9.8 million ft^2 were in commercial use and only 1.7 million ft^2 in industrial use (CSM 1991).

Education is important to the residents of Santa Monica: 87% are high school graduates and 70% have completed one or more years of college (USBC 1990; CSM,PPD unpubl. data).

Los Angeles County

In the past decade, many Los Angeles area businesses and industries have been bought by out-of-state and foreign companies. For example, in 1987 Pacific Southwest, Western, and Aircal airlines were taken over by U.S. Airgroup of Washington D.C., Delta of Atlanta, and American of Dallas, respectively. As of September 1992, 45.8% of the large downtown office buildings were foreign-owned (Cushman Realty Corp. 1992).

Trade is a major factor in this trend. The Ports of Los Angeles and Long Beach (located just outside the study area in San Pedro Bay) constitute the fastest growing major cargo center in the world. The value of import-export cargo going through the Ports increased from $35.4 billion in 1983 to $56.2 billion in 1985, and from $61.8 billion in 1986 to $1 trillion in 1990 (Leinberger 1988, Journal of Commerce 1990).

The population of Los Angeles County has increased rapidly since 1920 (Figure 4-2) (MBC 1988, SCAG 1991). As of 1990 Los Angeles County had a population of 8,863,164 (Figure 4-2), 57% of whom were white, 32% foreign-born, and approximately 11% black. Twenty-two percent of the residents were over 60 years (up from 13.3% in 1970) and the median age of 30.7 was very close to the statewide median of 31.5 years. Employment in the County has increased steadily, but at a lower rate in 1980-1990 than the population (Figure 4-2) (MBC 1988, SCAG 1991). The mean household income of Los Angeles County was $47,252, comparable to the statewide mean of $46,247 (USCB 1990).

The number of housing units in Los Angeles County has increased steadily since 1920, but at a much lower rate than either the population or employment (Figure 4-2) (MBC 1988, SCAG 1991). Los Angeles has a young homeowners market; 32% of households are headed by people under the age of 35, compared to 29% nationally. The national average for households with a college degree is 21%; Los Angeles is slightly higher with 24%. Managerial and

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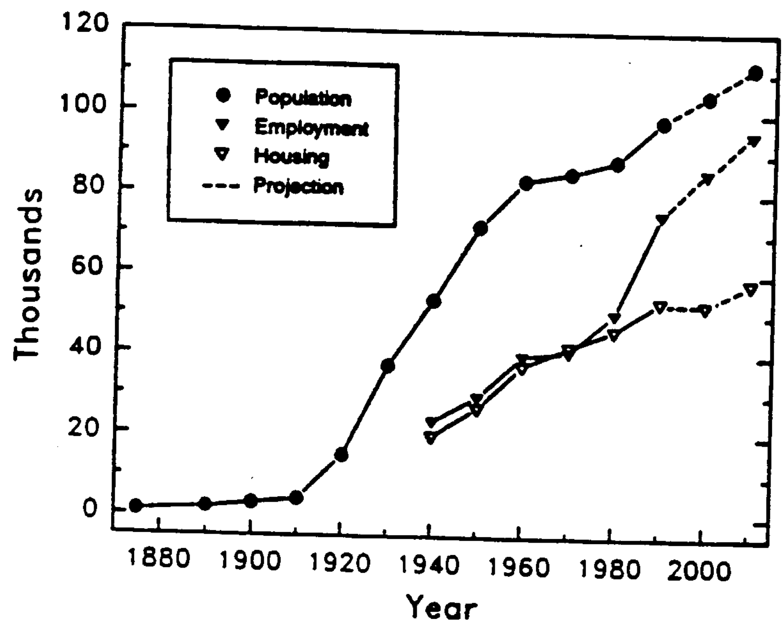

Figure 4-1. Population, housing, and employment trends in Santa Monica, 1875-2010 (data from MBC 1988; SCAG 1991; USBC, 1940, 1950, 1960, 1970, 1980, 1990).

professional positions are held by 27.5% of employed residents, while technical, administrative, and sales positions account for 32.3% (USCB 1990).

FUTURE PROJECTIONS

Housing in Los Angeles County is projected to increase by 879,538 units or 27.8% between 1990 and 2010, an increase which is close to the 28.3% increase projected for the population as a whole (Figure 4-2) (SCAG 1991). Housing in the Santa Monica Mountains area is projected to increase by 95.9% between 1984 and 2010. This increase is significantly higher than those projected for Central Los Angeles, Long Beach-Downey (10.5 and 21.9%, respectively), and for Los Angeles County as a whole (SCAG 1986).

The population of Los Angeles County is projected to increase by 2,514,032 or 28.3% between 1990 and 2010, an annual increase of 125,701 residents per year (Figure 4-2) (MBC 1988, SCAG 1991). The greatest increases will be in the Santa Monica Mountains and in East San Gabriel Valley, with increases of 84.3% and 56.8%, respectively. These projections are significantly higher than the 1.8 and 12.5% increases projected for Central Los Angeles and Long Beach-Downey (SCAG 1986).

The three basic components of population dynamics are births, deaths, and net migration. The first two components make up natural increases; net migration can be further separated into domestic migration (people moving to and from other parts of the nation) and foreign migration (including both legal and illegal immigration).

Immigration to California from elsewhere in the United States has eased due to the economy. In Los Angeles County there is an emigration of residents to surrounding counties. The major unknown is the rate of undocumented immigration from Mexico into southern California. In 1991 539,436 aliens were apprehended at the San Diego Zone of the Mexican border. The general rule is that for every apprehension at least two people enter the United States (Economic Development Corporation 1992).

Employment in Los Angeles County is projected to increase by approximately 1.2 million employees (25%) between 1990 and 2010 (Figure 4-2), a figure which is close to the projection of 26.2% for the City of Santa Monica (SCAG 1991). In recent years southern California has been shifting from a goods-producing, manufacturing economy into an information-based service economy. In 1991, the largest industry in the five-county Los Angeles area was business and management services (Calif. Employment Development Department 1992). The trend toward a service-based economy is expected to continue through the 1990s, then moderate between 2000 and 2010.

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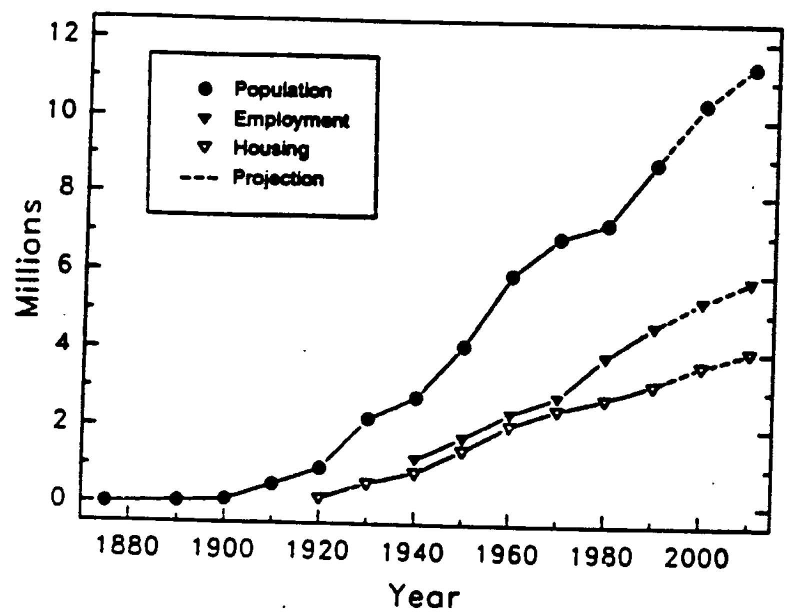

Figure 4-2. Population, housing, and employment trends in Los Angeles County, 1875-2010 (data from MBC 1988, SCAG 1991).

CHAPTER 5

POINT SOURCES OF CONTAMINATION

GENERAL CONSIDERATIONS

Numerous substances enter the waters of Santa Monica Bay via a variety of pathways. Some of these substances are neutral, some are beneficial, and some are detrimental to the Bay's environment. Some may not be particularly harmful alone but may have harmful synergistic effects when found with other substances. Those which have harmful effects on the ecosystem or on human health are generally considered to be contaminants or pollutants. "Pollutant" is often applied to contaminants resulting from human activities; these two terms are used interchangeably in this study. The effects of these contaminants on human health and on the ecosystem are discussed in subsequent chapters.

The point at which a body of water becomes contaminated differs for each contaminant and impact of concern (e.g., marine life, human health). The critical level for each contaminant is generally determined by scientific studies which test the toxicity or carcinogenicity of the contaminant against living organisms. Based on these studies regulations are made which restrict contaminant levels in input sources.

There is no single number or index by which the level of contamination of a water body can be measured; usually a water body is polluted in terms of some substances and perfectly normal as far as others go. The contamination of the body of water as a whole is determined by the diversity and levels of contaminants found but may also be determined by extremely high levels of specific substances alone. In general, unless a specific contaminant is extremely important (as with mercury in the Minimata disease of Japan; Eisler 1978), the degree of contamination of a body of water must be determined by comparison with other bodies of water with similar geographic and/or population settings.

Regulation of Contaminants

The U.S. Environmental Protection Agency (USEPA) has periodically issued ambient water quality criteria since 1969. The technical basis for water quality objectives are described in section 304(a) of the Federal Clean Water Act of 1977 and toxic pollutants are listed in section 307(a). The priority pollutant list includes about 126 substances and the list grows as more synthetic substances are developed and tested. Most of these substances are man-made compounds which have been shown to be toxic or carcinogenic, at least in laboratory animals. The EPA provides water quality criteria for 136 water contaminants; of these, 99 (73%) are priority pollutants and 50 (37%) are carcinogens. The remaining priority pollutants have not been studied sufficiently to define water quality criteria and standards at present (OWRS 1987).

The California Ocean Plan sets water quality objectives for contaminants discharged into the ocean off California from point and nonpoint sources. The plan sets criteria that apply to all discharges to the ocean off California excluding enclosed bays and estuaries (which are covered by the Enclosed Bays and Estuaries Policy) and thermal pollution (which is covered by the Thermal Plan). State-adopted numerical objectives have been set for 23 toxic materials and apply to all ocean discharges. Effluent limits have also been set for six other constituents or properties common in publicly-owned treatment works and industrial discharges but for which effluent guidelines were not established in sections 301, 302, 304, or 306 of the Federal Clean Water Act (CSWRCB 1990).

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The agencies which regulate contaminants in the study area and the pertinent regulations are described in SCAG (1988). In general, the U.S. Environmental Protection Agency (EPA) provides guidelines for water and air quality and human health. State agencies such as the California State Water Resources Control Board (CSWRCB), Regional Water Quality Control Board, Los Angeles Region (RWQCB,LAR); California Air Resources Board (CARB), and California Department of Health Services (CDHS) implement regulations prescribed in California law. Other state and federal agencies including the South Coast Air Quality Management District and the U.S. Food and Drug Administration, as well as city and county agencies also play important roles in regulating contamination in and around the Bay.

Physical/Chemical Processes

Most contaminants enter the marine environment by way of the water column. Once in the ocean the movement of contaminants is dictated by water turbulence, the direction and strength of currents, and the presence (or absence) of a pycnocline. The presence of a density gradient in the water column (pycnocline) restricts upward mixing of wastewater effluent and downward mixing of material discharged to the surface. The HTP and JWPCP sewage outfalls are located near the edge of the continental shelf, at the 200-ft depth contour. The HTP sludge outfall, which was inactivated in 1987, is located in about 300 ft of water, near the head of the Santa Monica Submarine Canyon. The configuration and location of these outfalls were designed to maximize dispersion and minimize transport of contaminants to the water surface or to the beach.

Drainage channels, on the other hand, provide a different input pathway, discharging into surface waters adjacent to the shoreline. Flow from these channels tend to form a freshwater surface layer, or lens, that is resistant to mixing with the underlying water.

The dilution and dispersion of dissolved or colloidal pollutants is entirely a function of the mixing and advection of water masses. Nutrients such as ammonia and phosphate are highly soluble and can be used to trace the dissolved component of sewage effluent plumes in the early stages of mixing. Dissolved contaminants can become associated with or transformed into particulates by the processes of sorption precipitation, and ion exchange. Sorption occurs more readily on fine-grained silts and clays than on coarse, sandy sediments. Fine suspended organic particles such as living or dead plankton and sewage particles have high sorption capacities, especially for dissolved organic contaminants. Trace metals absorb onto organic particles and iron or manganese oxyhydroxide phases, which form in oxygenated marine environments and coat the surfaces of particles.

The pathways followed by particle-bound contaminants are a function of particle density and current strength. Fine particles are easily transported by relatively slow currents; therefore they are easily dispersed. Studies of the distribution of suspended particulate material near the HTP 5-mi outfall indicate that the sewage plume rises rapidly from the discharge depth of 200 ft to about 66 ft below the water surface (Kolpack 1979). The initial direction of transport is toward the shoreline southeast of the outfall for most of the year, with wave action dispersing the plume over a large part of the Santa Monica shelf. Subsequent transport offshore occurs in well-defined zones near the sea surface.

Coarse-grained or dense particles are more resistant to transport. Sand accumulates on beaches because it is resistant to the wave energies that erode fine material. Similarly, coarse-grained material, which is resistent to turbulence and currents, accumulated near the HTP sludge outfall (Bascom *et al.* 1980). The settling of a particle onto bottom sediments does not mean that its journey is over. Stronger currents can rework the sediments, resuspending material and

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transporting it until the current velocity diminishes and the particles once again are deposited. Current velocities necessary for sediment resuspension in the vicinity of the JWPCP outfalls are often met (Hendricks 1976).

Water depth determines the susceptibility of sediments to resuspension by storm waves. Storm waves introduce energy that is proportional to their frequency and size. Although shallow water sediments are most affected, severe coastal storms can resuspend accumulated contaminant-laden particles from greater depths. Chemical concentrations in vertical sediment profiles on the Palos Verdes Shelf indicate that surface sediment losses in the nearshore region were induced or accelerated by several severe storms (Stull *et al.* 1986a). Recent studies have indicated that DDT-laden sediments are periodically resuspended in relatively shallow shelf areas, transported and redeposited elsewhere along the shelf (Hendricks 1987).

The accumulation rate and the physical mixing of surface sediments also influence the fate of particle-borne contaminants. The accumulation rate is a function of the rate of supply from both natural and anthropogenic sources and current velocities at the sediment-water interface. Mixing of the surface sediments can result from the activities of benthic organisms, a process called bioturbation. Both sediment accumulation and mixing act to bury freshly settled particles, thereby minimizing the potential for resuspension. Because benthic mixing derives from the activity of organisms, it is either absent or reduced in sediments with low abundances of benthic organisms. In a recent 301(h) waiver application (LACSD 1988), it is argued that decreases in solids discharged from the JWPCP outfalls could increase contaminant levels in surface sediments on the Palos Verdes Shelf by causing the recent depositional conditions (which have buried large amounts of DDT) to return to the (presumably historical) erosional environment. In this scenario the contaminated subsurface sediments from historical discharges would replace the less contaminated sediments from more recent discharges and would be available for resuspension. The combination of reduced sediment accumulation rate and enhanced benthic mixing (greater densities of organisms which resulted from decreased levels of contamination in surface sediments) were identified as the primary determinants of DDT distribution along the 200-ft depth contour on the Palos Verdes Shelf.

Several processes enhance the size of particles and thus the speed at which they sink through the water column. Flocculation is aggregation of colloidal material as freshwater mixes with seawater; differences in ionic strength (electrical charge) between fresh and salt water cause changes in the charges of the colloids and they attach to one another. Coagulation is the aggregation of particles brought about by physical contact. The higher the concentration of particles, the greater the chances of collision, and the greater the possibility of particle aggregation. Coagulation is probably an important process in the vicinity of sewage outfalls and storm drains where the concentration of particles, particularly particulates rich in organic matter, is high.

Pollutants can be incorporated into biologically produced particles such as fecal pellets, which are relatively large and sink quickly. It has been suggested that vertical transport by fecal pellets is an important mechanism for transporting particles to the sediments.

The behavior of oil spills illustrates the complex array of pathways and processes followed by a single kind of waste. Crude oil consists of a variety of organic compounds, a small fraction of which are soluble in water. The lighter, less dense fraction floats to the water surface, where it may be incorporated into particles (including organisms) and sink; volatilized into the atmosphere; or degraded by exposure to sunlight. Denser materials aggregate into tar balls that sink to the bottom, where they are subject to erosion, burial by accumulating sediments, or degradation by organisms. Oil and grease in sewage effluent tend to rise to the water surface and undergo similar processes.

Biological/Chemical Processes

Biological processes further complicate the fates of contaminants. Organisms can store contaminants, or can transform and decompose them through their metabolic processes. The microbially mediated degradation of organic matter is an oxidative process that transforms it into basic inorganic components (i.e., carbon dioxide, water, ammonia, orthophosphate). Biodegradation can also be a less drastic process that changes an organic contaminant to a more oxidized form that may be more or less toxic than the original compound. The chemical form of a contaminant can also be changed by the process of biotransformation, whereby a pollutant form is altered by an organism to make it less toxic to that organism. Biological processes also affect the fate of contaminants indirectly by altering environmental parameters. Degradation of organic matter lowers the pH (increasing the acidity), reduces the oxygen concentration and redox potential, and produces chemicals such as ammonia and sulfide that can impact aquatic life and interact with contaminants.

Degradation of Organic Matter

Many types of microorganisms derive energy by degrading organic matter, which also triggers changes in pH and redox potential in the environment. Marine aquatic systems are well-buffered by the presence of carbonate alkalinity, and relatively small changes in pH typically accompany organic matter degradation (seldom decreasing below a pH of 7). Changes in redox potential are more extreme. The degradation (i.e., oxidation) of organic matter by microorganisms requires the concurrent reduction of an electron acceptor, which in most environments is oxygen. If organic loading is sufficient and available oxygen has been consumed, nitrate, sulfate, and carbon dioxide are utilized sequentially as electron acceptors, producing reduced forms of these chemicals. The change in redox potential that accompanies organic matter degradation can change the oxidation state of some metals. Iron and manganese, which are present as insoluble oxyhydroxides under well-oxygenated conditions, are much more soluble in their reduced form. Moreover, metals that are sorbed to the surfaces of iron and manganese oxyhydroxides under well-oxygenated conditions may become mobilized as the phase undergoes dissolution in reducing environments. The reduction of sulfate is a particularly important process because sulfide is the degradation product. Many metals react with sulfide and precipitate as metal sulfides.

Bioaccumulation

The uptake and retention of chemical contaminants by organisms is called bioaccumulation. Chemical properties that make a particular contaminant more prone to bioaccumulation (i.e., that increase its solubility in fatty tissue) were described in the section on Chemical Properties and Behavior. Characteristics of organisms that result in high bioaccumulation potential include: 1) having a high fat content, 2) living on or near the bottom sediments, 3) filter-feeding on organic particles, and 4) being high on the food chain. Examples of such organisms include demersal fish (e.g., Dover sole), mussels and clams (filter feeders), and seals (high in fat and the top carnivore). Greater accumulation of a contaminant by organisms higher on the food chain is termed biomagnification. The accumulation of contaminants by the biota may result in biological effects to contaminated organisms or their predators.

Studies of the spatial distribution of hazardous substances in mussel tissues indicate that elevated concentrations of silver and chromium are found in the vicinity of the JWPCP and HTP outfalls, while elevated concentrations of lead and PCB are more widespread. Interpretation of fish bioaccumulation patterns indicates that the JWPCP and HTP outfalls may be major sources of PCB, but elevated tissue concentrations of PCB are found far from these outfalls because fish are mobile. The highest concentration of DDT in fish tissue occurs near the JWPCP outfall, a documented historical source. Spatial and temporal patterns in contaminant bioaccumulation in Santa Monica Bay are described in greater detail in Chapter 12.

Biotransformation of Contaminants

Microorganisms are responsible for most of the biotransformation or biodegradation of contaminants that occurs in the environment. Highly chlorinated hydrocarbons like PCB and DDT are relatively resistant to degradation, but are slowly degraded over time. DDT, a major contaminant in Santa Monica Bay, is slowly degraded to DDD and DDE. Measurements in sediments on the Palos Verde Shelf, described in Chapter 9, indicate that degradation of DDT is more rapid in shallow water than in deep water, as indicated by a comparison of DDE/DDT ratios. The redox potential may influence the rate of contaminant degradation. The degradation of anthracene and naphthalene (PAH) is not observed in sediments in the absence of oxygen. Under toxic conditions, these lower molecular weight PAH compounds are more susceptible to degradation than higher molecular weight PAH compounds.

The microbial synthesis of methylmercury is a good example of the process of biotransformation. The microbial synthesis of methylmercury and other organometallic compounds has advantages for cellular elimination because nonpolar compounds are more easily transferred across the cell membrane (Wood and Wang 1983). Unfortunately, these compounds are more easily bioaccumulated by higher organisms for similar structural reasons.

Sources of Contamination

Contaminants entering Santa Monica Bay may originate on land, in the air, or at sea outside of the Bay itself. The ultimate source of a contaminant, as used here, refers to the place at which it is introduced into the system that carries it to the ocean. The proximal source of a contaminant is the point or pathway by which it actually enters Santa Monica Bay. The ultimate source of most lead in the local environment was the leaded gasoline used in automobiles. After combustion, some lead entered the atmosphere and eventually landed on the ocean surface as aerial fallout -- a proximal source. Other lead particles adhered to material on streets and driveways and eventually entered Santa Monica Bay with storm runoff -- another proximal source.

The variety of ultimate sources of contaminants found in Santa Monica Bay is great, (Table 5-1) and it would be nearly impossible to identify all the possible sources for all the possible contaminants in the Bay. Knowledge of ultimate sources is especially important when source control programs are at issue, whereas knowledge of proximal sources helps to explain the distribution of contaminants in the Bay. There are two general kinds of proximal sources -- point sources and nonpoint sources -- although the distinction is sometimes difficult to make.

A point or discrete source is an identifiable place at which substances enter the receiving waters (usually continuously) and at which water quality samples can be taken repeatedly; it is usually a pipe or open drain built specifically to carry the waste material. Point sources include outfalls for municipal wastewater discharges, power plant cooling water discharges, and industrial waste effluent. All point sources which discharge to the Bay are issued National Pollutant

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Table 5-1. Ultimate sources of contaminants found in Santa Monica Bay.

Trace Metals:	
Dissipative decay of products containing the contaminant. Combustion of coal, residual oil, distillate oil, gasoline, and other fossil fuels.	
Cadmium:	Oil and gasoline combustion, batteries, pigments, plastics, synthetics, plating, galvanized pipe, photoelectric cells
Copper:	Oil and gasoline combustion, paint, electrical, building, automobiles, manufacturing, antifouling paint, pipes, roofing insecticides
Chromium:	Oil and gasoline combustion, Chemical industrial (Chromite, chromic acid, sodium dichromate), pigment, plating, protective coating
Lead:	Oil and gasoline combustion, paint, antifouling paint, lead metal, storage batteries, pigments, lead arsenate
Mercury:	Oil and gasoline combustion, industrial catalysts, agriculture, dental preparations, thermometers, barometers, electrical, paints, antifouling paint, pharmaceuticals, batteries
Nickel:	Stainless and heat-resistant steel, alloys, cast iron, electroplating, catalysts batteries, protective coating
Selenium:	Electronics, photographic uses, catalyst
Silver:	Chemical industry, electronics, plating, alloys
Tin:	Antifouling paint, pewter, plating, alloys
Zinc:	Oil and gasoline combustion, alloys, paint, pigment, plating, batteries, auto parts
Inorganic, Non-metallic Constituents:	
Chlorine:	Antifouling agent for generating stations, disinfectant
Phosphate:	Fertilizer, detergent
Nitrogen:	Fertilizer, refrigeration
Pesticides:	
DDT:	Montrose Chemical Corp., Torrance (past) agricultural application to: grains, vegetables, small fruits, grapes, nuts
Chlordane:	Private and industrial application to structures and vegetation; primary use for termite control
BHC/lindane:	Agricultural application to vegetables, grapes
Aldrin:	Agricultural application to vegetables
Dieldrin:	Agricultural application to vegetables, small fruits, hay
Endrin:	Agricultural application to cereals, vegetables
Heptachlor:	Agricultural application to vegetables, hay
Toxaphene:	Agricultural application to vegetables, grains, cereals
PCBs:	
Direct discharge from production facilities into holding reservoirs, receiving waters, municipal sewerage	
Decay of products releasing the contaminant to the environment: transformers (approx. 2150 lbs each); capacitors (approx. 25 lbs each); antifouling paint; plasticizers; lubricants; heat transfer fluids; hydraulic fluids; wax extenders; fluid in vacuum pumps; and compressors	
Other Organic Compounds:	
PAH:	Crude oil, fuel oil, crankcase oil; combustion releases contaminated soot which falls back on land
Phenol:	Phenolic resin, fuel-oil sludge inhibitor, solvent, rubber chemicals
Detergent:	Emulsifier, soap
BOD:	Organic material including human and animal waste and food refuse

Source: CSWRCB 1983, SCCWRP 1986a, Sax and Lewis 1987, Versar 1988.

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Discharge Elimination System (NPDES) permits by the Regional Water Quality Control Board with the concurrence of the U.S. Environmental Protection Agency.

A nonpoint or diffuse source is widespread, changing, or not identifiable; as such it may be difficult to sample. Nonpoint sources include aerial fallout, surface runoff, advective transport, ocean dumping, and boating and shipping activities. Aerial fallout and advection are clearly diffuse, whereas surface runoff and ocean dumping have some discrete aspects. Offshore petroleum activities which may occur in the area in the future also have point and nonpoint aspects. Offshore oil production platforms, for example, are required to have NPDES permits for the discharge of treated sewage, drilling muds, and cuttings; however, deckwash from a moving work boat is diffuse.

The Clean Water Act considers storm drains to be a nonpoint source of contaminants even though the effluent from a single drain can be sampled repeatedly. However, many channels drain to the Bay, resulting in a diffuse input of contaminants along the shore after a storm. At present, storm water is not treated and there are no facilities for storing it for later treatment. The operating and regulatory agencies have only limited power to control what is discharged into the drainage system upstream and little or no power to enforce effluent limitations or water quality objectives.

Los Angeles County and 89 cities in the Santa Monica Bay watershed have received NPDES permits requiring them to control pollution from urban runoff. In addition, industrial facilities and construction sites also receive general stormwater discharge permits. Operators and regulators must encourage source control programs (Best Management Practices) which reduce the likelihood of contaminants entering the system.

There are seven facilities in the study area with NPDES-permitted point discharges: three municipal waste treatment plants; three coastal generating stations; and one oil refinery (Figure 5-1). With the exception of the Joint Water Pollution Control Plant (JWPCP) outfalls at White Point on the Palos Verdes Peninsula, and the Tapia Water Reclamation Facility (TWRF) on Malibu Creek, these facilities discharge offshore in the south-central part of the Bay between Playa del Rey and Redondo Beach.

POINT SOURCES

Municipal Wastewater Treatment Plants

Municipal wastewater in the Los Angeles region includes sewered wastes from domestic, commercial, and industrial sources. Storm water runoff is collected in a separate system, although some infiltrates into sewers during exceptionally heavy rains. Residential sewage contains a variety of household cleaners and detergents; oil, grease, and solvents; food wastes; and enteric bacteria from human fecal waste. Commercial and industrial wastes include oils and grease, metals, and a variety of synthetic organic substances. About a 100 gal of sewage per capita per day is discharged into the study area (Barletta and Webber 1986; CLA,DPW 1988; Stull 1988, pers. comm.). Human fecal waste is produced at the rate of about 75 g (dry weight) – just under one-sixth of a pound – of solids per person per day (Bascom 1977).

Municipal wastes are collected by an extensive network of main and feeder sewers which drain into central treatment plants. The level of treatment which is attained can vary widely. Raw sewage (i.e., untreated sewage) is ordinarily not discharged to the ocean or any stream discharging into the ocean. Sewage is initially subjected to preliminary treatment, which consists

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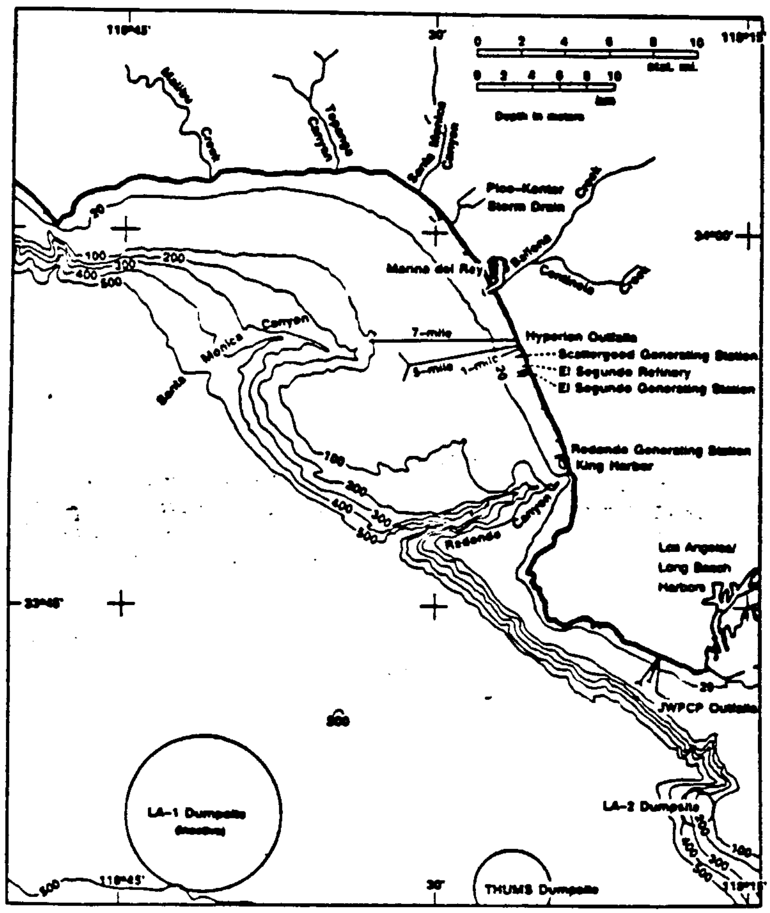

Figure 5-1. Major point and nonpoint sources in the Santa Monica Bay area.

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of screening, comminution (pulverization), and grit removal. Primary treatment consists of the removal of much of the suspended solids by sedimentation but not colloidal and dissolved matter. It does not include biological oxidation and usually consists of clarification with or without chemical treatment. At the end of this stage substantially all floating and settleable solids have been removed (Rogers *et al.* 1981).

Secondary treatment is defined by the U.S. EPA in terms of BOD-5, suspended solids, and pH, and is primarily a biological process (e.g., activated sludge) followed by settling that produces an effluent very low in solids, BOD, and sludge (Dorsey 1993, pers. comm.). Tertiary treatment (advanced waste treatment) includes the removal of nutrients (e.g., nitrogen and phosphorus compounds) and most of the remaining suspended solids. Finally, the effluent may be subjected to disinfection, whereby the effluent is treated with a disinfectant (e.g., chlorine or sulfur dioxide) to kill bacteria and viruses (Rogers *et al.* 1981, Dorsey 1993, pers. comm.).

The Clean Water Act (Public Law 92-500) of 1972 requires all domestic wastewater dischargers in the nation to achieve a minimum of secondary treatment. The effluent may have no more than 30 *mg/l* of biological oxygen demand (BOD) and of total suspended solids (TSS) (CLA,BE 1977). However, in 1977 Congress amended the Clean Water Act to add section 301(h) which provides for a NPDES permit with modified secondary treatment requirements (i.e., less than secondary). At present the Los Angeles County Sanitation Districts (LACSD) have been granted an evidentiary hearing after being denied a 301(h) waiver for the JWPCP discharge and judgment is pending. Hyperion Treatment Plant was denied a waiver and is presently upgrading their treatment to full secondary treatment, which is scheduled to be in place by 1998. Although full secondary treatment has not been attained by these dischargers, the quality of discharged wastewaters has improved greatly in recent years. This is the result of more stringent regulations with better enforcement; improved waste treatment technology and facilities; and better source control through education and enforcement.

Two municipal wastewater treatment plants discharge directly into Santa Monica Bay: Hyperion Treatment Plant (HTP) and Joint Water Pollution Control Plant (JWPCP). The Tapia Water Reclamation Facility (TWRF) discharges tertiary-treated wastewater into Malibu Creek.

Hyperion Treatment Plant

At one time raw sewage from the City of Los Angeles was used, untreated, for irrigation. The first ocean outfall was completed in 1894 and discharged across the beach near the present site of HTP. In 1907 a new outfall was constructed which discharged at a water depth of 16 ft. After the Los Angeles-Owens River Aqueduct was completed in 1913, much of the San Fernando Valley was annexed to the City of Los Angeles. Because of population growth and storm overflows in the 1920s, a screening plant and a new submarine outfall was built at HTP in 1925. In 1943, because of nearshore odors, discoloration, grease, and high levels of the bacteria E. coli (Dorsey 1993, pers. comm), the State Board of Health quarantined about 10 mi of beach from Hermosa Beach to Venice Beach. Soon an upgraded HTP was designed to implement full secondary treatment, with a high-rate activated sludge system, digestion, and sludge-drying facilities. HTP was placed on-line in 1950 and began discharging 193 mgd of chlorinated, secondary effluent through a 12-ft diameter concrete pipe one mile offshore, at a water depth of 50 ft (WSED 1982, CLA,DPW 1987; Dorsey 1988, 1993, pers. comm.).

Continued growth and the threat of beach contamination resulted in the construction of a 12-ft diameter pipe which discharges 5 mi offshore at a water depth of 190 ft. This pipe, built in 1959 and in full service by 1960, has a Y-shaped end with 83 diffuser ports (WSED 1982;

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Dorsey 1993, pers. comm.). HTP was also modified at this time to provide 100 mgd of activated-sludge, secondary treatment, and up to 420 mgd of primary treatment.

Beginning in 1950 an effort was made to recycle digested solids as fertilizer but this resulted in air pollution and was uneconomical to operate. The excess solids which could not be processed were discharged into nearshore shallow waters and created a water pollution problem. To rectify this, a 7-mi long 20 in diameter sludge pipe was constructed to discharge at the head of Santa Monica Canyon to a depth of 320 ft (WSED 1982). This pipe became operational in 1957 (Carlisle 1969, SCCWRP 1986b, CLA,DPW 1987) but use was discontinued in November 1987 (CLA,BE 1977; CLA 1987). At that time about 80% of the dewatered sludge was being transported to a landfill with the remaining 20% being treated by Chemfix, a chemical fixation process whereby the sludge is mixed with lime and silicate to produce a clay-like product (CLA 1987; Crosse 1988, pers. comm.).

By 1989, all sludge, now referred to as biosolids, was being recycled; none went to landfills. Presently, about 1,100-1,200 wet tons per day of biosolids are used as follows:

14% Dehydrated and combusted in HTP's cogeneration facility (Hyperion Energy Recovery System - HERS)

31% Directly injected into agricultural fields for crops not used for human consumption

39% Composted along with bulking materials (e.g., farm wastes, some green trimmings from the City) to produce a soil amendment for agriculture and horticulture

16% Chemically stabilized with lime and silicate to produce part of a clay-like substance used for covering landfills (Dorsey 1993, pers. comm.)

In 1988 HTP increased secondary treatment to 165 mgd from 90 mgd in 1985 (CLA,DPW 1988). This increase in secondary treatment is a direct result of the replacement of the air delivery system with a fine-bubble diffuser system, chemical addition to enhance capture of solids during the primary treatment phase, and development of innovative operating parameters which produced a high rate, secondary treatment operation (Dorsey 1993, pers. comm.) The improvements in the quality of effluent can be attributed to the Hyperion Interim Improvement Plan of 1986. The plan set compliance limitations which were revised in 1991 for BOD, total suspended solids, oil and grease, and settleable solids (CLA,DPW 1991). To achieve the 1991 levels, upgrades in chemical addition and aeration resulted in a 35% reduction of BOD in primary effluent, which allowed for an increase of up to 200 mgd of secondary effluent treatment (CLA,DPW 1991). HTP continues to decrease mass emissions of constituents in effluent discharged from the 5-mile pipe and in 1992 reached the 1998 mandated limitations for all constituents except BOD (Dorsey 1993, pers. comm.). The Hyperion Full Secondary Expansion Program is expected to be fully operational by 1998.

Influent Waters. As of 1990 the City of Los Angeles was treating wastewater of 3.5 million people over an area of 600 mi^2 (Figure 5-2). Most waste is processed at HTP but waste from San Pedro, Wilmington, and Terminal Island is processed at the Terminal Island Treatment Plant and discharged into outer Los Angeles Harbor (Barletta and Webber 1986). The wasteshed of HTP is about 480 mi^2.

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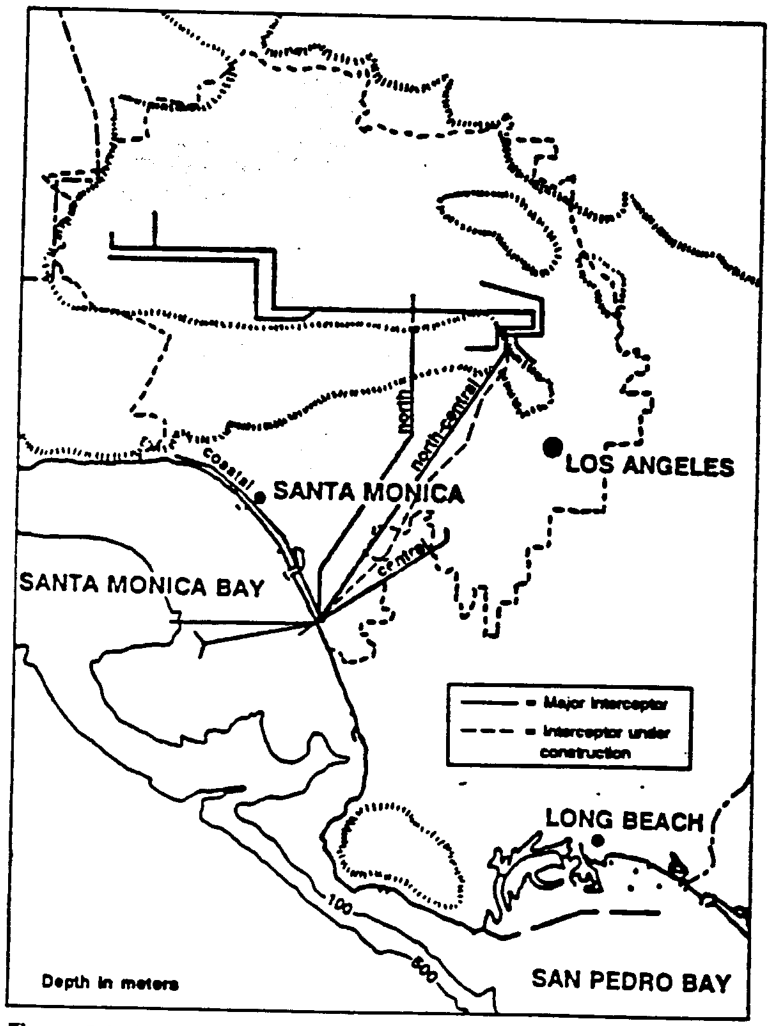

Figure 5-2. HTP watershed and influent collector lines (modified from CLA,DPW 1987 and 1993).

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HTP is supplied via four main collector lines (Figure 5-2). A new main sewer pipe, the North Outfall Replacement Sewer (NORS), was completed late in 1992 and is expected to be fully on-line by spring of 1993. When NORS goes on-line, the North Outfall Sewer (NOS) will be refurbished (Figure 5-2) (Dorsey 1993, pers. comm.). The influent sewage delivered by the present four tributary lines has remained fairly consistent since 1975, fluctuating annually due to wet and dry years. Influent sewage flow generally increases during heavy rainfall periods as surface runoff enters the system (Dorsey 1988, pers. comm.). About 85% of the influent sewage is domestic and about 15% is industrial (Crosse 1988, pers. comm.). Approximately 52% comes from the north collector, 35% from the north-central, and 6 to 7% each from the coastal and central collectors. Most constituents (i.e., potential contaminants) are also from the north outfall, followed by the north-central collector (CLA,DPW 1988).

In 1986 the total influent averaged 1.26 g/l of solids, about 75% dissolved and 25% suspended. The north-central line was the major contributor of phenols, cadmium, total chromium, nickel, sulfate, total identifiable chlorinated hydrocarbons (TICH), total pesticides, heptachlor, and lindane. The coastal line contributed most of the chloride, magnesium, and sodium, probably a result of saltwater intrusion into the outfall (CLA,DPW 1988).

Treatment. In 1991 HTP processed about 349 mgd of wastewater. Presently 60% of the flow receives secondary treatment and sludge digestion (CLA,DPW 1991; Dorsey 1993, pers. comm.). The influent is initially treated with chemicals to enhance the capture of solids and to control odors; the raw sewage is then screened and grit is removed. Next it is sent to primary settling tanks and from there to the secondary treatment system. In the secondary treatment system the primary effluent is pumped to aeration basins where oxygen and activated (biological) sludge are added to reduce the amount of organic matter. After four hours this effluent is pumped to secondary clarifiers which allow the activated sludge to settle out and be recycled. Of the secondary effluent, 30-40 mgd are recycled within the plant (mainly in the HERS process). The remaining effluent is blended with primary effluent and discharged from the 5-mile outfall (Dorsey 1993, pers. comm.). Most volatile organics are lost to the air during secondary treatment and metals (particularly chromium and copper) concentrations are reduced by adsorption to the particulates which are removed during treatment (Young 1978; Dorsey 1988, pers. comm.).

Mass emissions of most constituents have decreased in recent years due to improved chemical treatment and an increase in secondary treatment from 100 mgd in 1986 to 200 mgd in 1991. HTP expects to provide full secondary treatment by 1998, a project that is expected to cost $1.1 billion (CLA,DPW 1987; Biagi 1988, pers. comm.). The Hyperion Energy Recovery System (HERS) became fully operational in 1989 producing over 100 million kwhs of electricity and up to 28,000 tons of steam used for the energy recovery system (CLA,DPW 1988, 1989, 1990, 1991). By 1991 it produced 146 million kwhs, an increase of approximately 45% from 1988. Increases in the amount of electricity and energy recovery were due to improvements in on-line availability of turbines, generators, and the retrofitting of new gas burners into all of the combustion trains (CLA,DPW 1991).

Volumes Discharged. The volume of wastewater discharged from HTP has generally increased since 1950, when 193 mgd was discharged (Dorsey 1988, pers. comm.). During the first 6 years of operation, the combined flow from the 5- and 7-mile outfalls ranged from 261 to 283 mgd (Carlisle 1969); between 1974 and 1987 the combined flow averaged 371 mgd. During this period, flow from the 7-mile sludge pipe averaged 1.2% of the combined flow (Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986a; CLA,DPW 1987, 1988).

From 1987 to 1992 the total volume discharge from the 5-mile effluent pipe decreased from 375 mgd to 298 mgd (Figure 5-3 and Appendix D). In 1989 the flow increased slightly to 365 mgd then continued to decrease to the current level of 298 mgd in 1992. The average flow between 1988 and 1992 was 339 mgd, which is approximately 10 percent lower then the 1974-1987 period.

5-mile Effluent. The 5-mi outfall discharges a nonchlorinated mixture of primary and secondary effluent. This effluent is usually discharged by pumping during daily peak periods or storm flow; however, during low flow periods it is usually discharged by gravity (Dorsey 1988, pers. comm.). From 1974 to 1987 an average of 367 mgd of effluent was discharged from this outfall. This compares with an average discharge of 343 mgd for the period 1987 to 1992, a decrease of approximately 07% over the previous 13 year period (Figure 5-3 and Appendix D).

The lowest mass emission values for BOD, TSS, settleable solids, and oil and grease were recorded in the period 1987 to 1992 (Figure 5-4 and Appendix D). Peak values for these constituents reported in 1985 were caused by hydraulic overloading, increased influent flow, and construction at HTP, which resulted in a temporary reduction in the number of primary tanks in operation (SCCWRP 1986a; Dorsey 1988, pers. comm.).

Nitrate nitrogen was measured at 141 MT in 1974, however, no measurements were taken for the period 1975 through 1984. Levels for the remaining 8 year period ranged from a reported high of 273 MT in 1989 to a low of 110 MT in 1992, a decrease of approximately 60% (Figure 5-4 and Appendix D).

From 1974-1988, phenols decreased 96% from a high of 28 MT (Figure 5-4 and Appendix D). Mass emissions for phenols have remained relatively constant averaging 0.8 MT for the 5 year period 1988-1992. Mass emissions for cyanide have remained within a fairly consistent range from 14.0 to 6.6 MT since 1984, compared with a range of 94.2 to 25.0 MT in the preceding 10 year period.

Mass emissions for organic nitrogen, total phosphorus and detergents (MBAS) remained constant from 1975 through 1987. Levels for phosphorus elevated to 6,180 MT in 1985 but declined from there to the 1992 value of 2,530 MT. MBAS stabilized at approximately 1,500 MT in 1987, the last year measurements were available. Although ammonia nitrogen levels have fluctuated since 1974, the general trend indicates a gradual increase in mass emissions for this constituent, from a low in 1974 of 6,501, to the present high of 12,203 MT (Figure 5-4 and Appendix D).

In general, from 1974 to 1992 mass emissions of trace metals from the 5-mile outfall declined, with some metals displaying periods of fluctuation (Figure 5-4 and Appendix D). Overall, discharges of trace metals declined during the 1974-1992 period by the following percentages: silver (66%), arsenic (47%), cadmium (99%), chromium (97%), copper (82%), mercury (99%), nickel (92%), lead (96%), and zinc (69%) (Appendix D).

Total DDTs and PCBs were measured by different methods from 1974 to 1979 than from methods used during 1980 to 1987, therefore, reported values for the two periods may not be comparable. During the earlier period values were generally higher; however, DDT levels dropped sharply after 1976 and PCBs after 1978 (Figure 5-4). Since 1987, mass emissions for DDTs and PCBs have remained under the detection limits with the exception of trace amounts of DDT measured in 1991 (Figure 5-4 and Appendix D). The decline of DDTs and PCBs is credited to prohibitions placed on their use and production during the 1970s.

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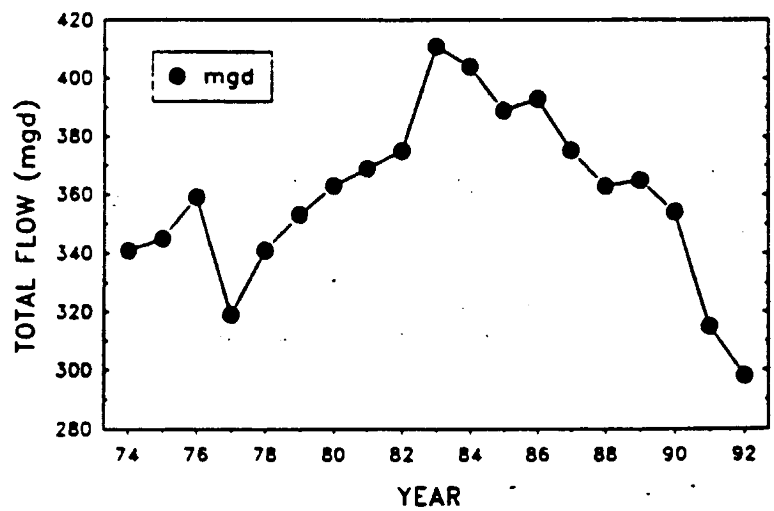

Figure 5-3. Average flow from the HTP 5-mile outfall, 1974-1992. (Data from Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; CLA,DPW 1987, 1988, 1989, 1990, 1991, 1992).

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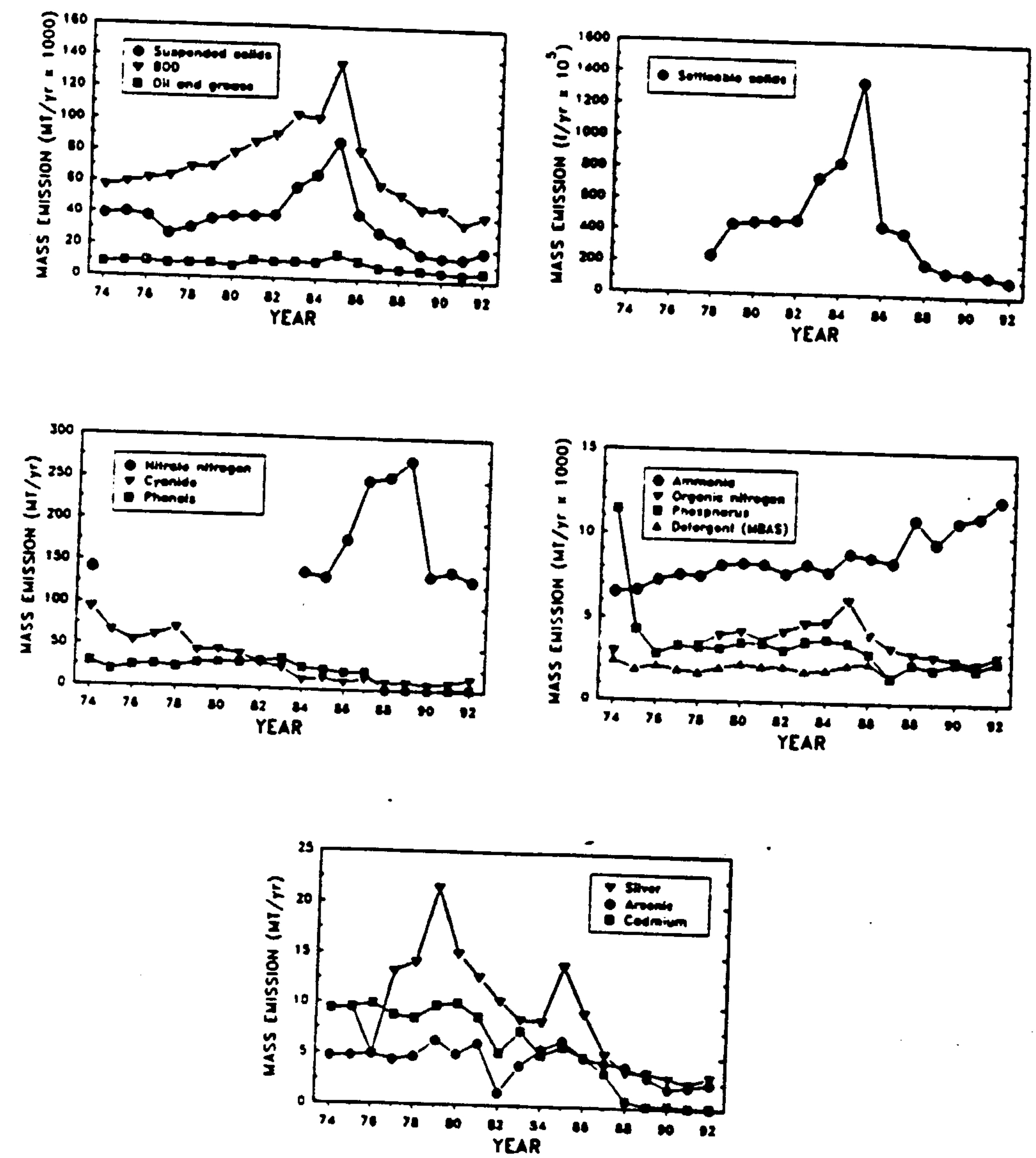

Figure 5-4. Annual mass emission rates of selected contaminates discharged from HTP 5-mile outfall from 1974-1992. (Data from Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; CLA,DPW 1987, 1988, 1989, 1990, 1991, 1992).

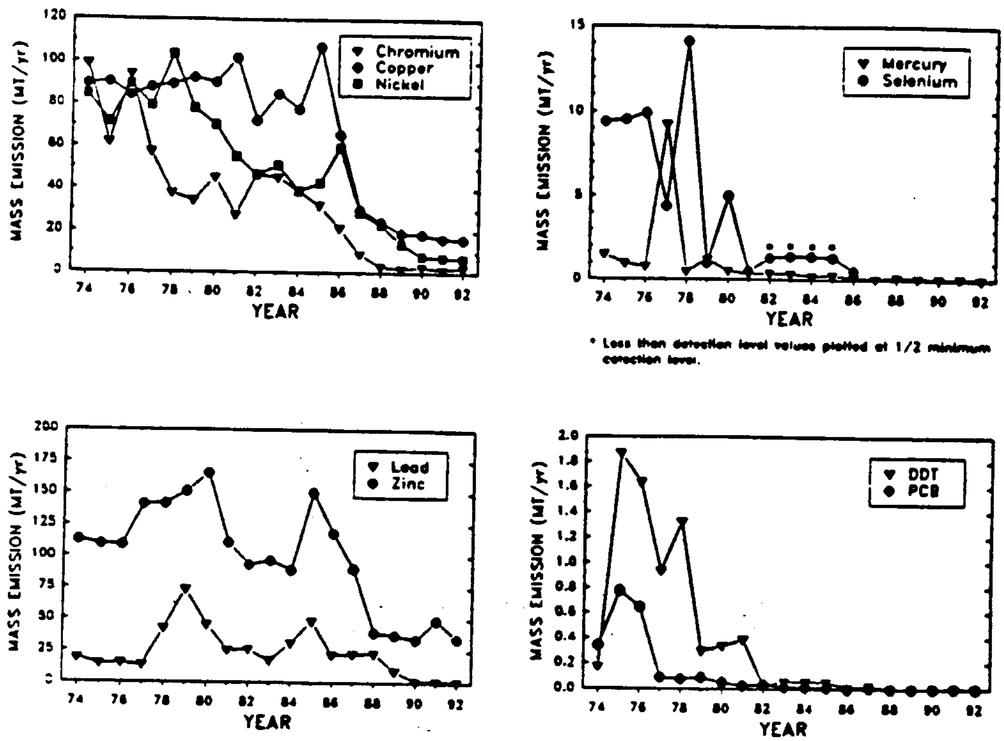

Figure 5-4. Cont.

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7-mile Effluent. Between 1974 and its discontinuation in November 1987, the 7-mi pipe discharged an average of 4.4 mgd of a mix of secondary effluent and digested sewage sludge. Annual mass emissions and concentrations of total suspended solids (TSS) averaged 50,030 MT from 1974 to 1985 while those of oil and grease averaged 2,687 MT (CLA,DPW 1988). TSS and oil and grease levels peaked in 1975 and were relatively constant since 1979 (Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; CLA,DPW 1988). BOD was not reported because no limits were set, but levels in sludge were generally high (Dorsey 1988, pers. comm.).

A complete scan of EPA priority pollutants in sludge from the 7-mi outfall in 1978 identified three volatile organics (1,2-trans-dichloroethylene; ethylbenzene; toluene) and two extractable organics (4-nitrophenol; phenol) which exceeded 10 ppb, the EPA mandated quantification limit (Young 1978).

Sludge Removal. Since the termination of the 7-mile sludge outfall in 1987, sludge wastes have been relegated to land disposal locations, for land applications, nonconsumption agriculture, chemical fixation for cover material at landfills, HERS, or landfill. All sludge is anaerobically digested and dewatered by centrifuge with polymer conditioning to 20% solids (CLA,DPW 1988). Quality assurance measures have been implemented by HTP to regulate and monitor contamination levels of sludge. Materials found hazardous must be disposed at an alternate disposal site that meets with California State codes regarding the disposal of contaminated material.

In November of 1987, all sludge was hauled to landfill sites for disposal, the most economical and flexible method of disposal at the time. By 1988 alternatives for sludge (biosolids) disposal resulted in 181 metric tons per day (MT/d) used for land application, 181 MT/d for cover material, (chemical fixation), 181 MT/d for HERS, and 590 MT/d relegated to landfill disposal, for a total of 1,134 MT/d. By 1989 biosolids disposal at landfills was halted. Disposal at alternative sites in 1992 accounted for 100% of all material with 31% for land applications, 39% for city composting, 16% for chemical solidification, and 14% for use by HERS, accounting for approximately 1,100-1,200 wet tons per day (Dorsey 1993, pers. comm.)

1-mile Effluent. Power outages or mechanical failures (which are usually associated with periods of heavy storm flow) occasionally cause effluent pumps to malfunction. When pump failure occurs, part of the 5-mile effluent is diverted to the 1-mile outfall. Since 1988 overflows into the 1-mile outfall have occurred 25 times, ranging from a high of 8 in 1988 to none in 1992 with an average of 5 bypasses per year (CLA,DPW 1988-1991). Such diversions to the 1-mile outfall are now rare, but when the need to divert occurs, the flow is split between the 1- and 5-mile outfalls with primary/secondary blend discharging to the 5-mile, and chlorinated secondary to the 1-mile (Dorsey 1993, pers. comm.).

Storm overflows. Increased inflow and infiltration into the North Outfall Treatment Facility during rainstorms occasionally necessitates discharges into Ballona Creek, although the facility can store about 1.1 million gal before this occurs. Such overflows presently receive primary sedimentation, two stages of screening, and chlorination at 40 *mg/l* (Crosse 1988, pers. comm.). The chlorination results in at least a four-order of magnitude bacterial kill (Crosse 1988, pers. comm.; Dorsey 1988, pers. comm.). However, there have been overflows in the past consisting of raw sewage (Sowby 1988, pers. comm.).

Ninety-four incidents of overflow discharges into Ballona Creek (and other storm drains) were recorded between 1965 and 1992 (Appendix H); none occurred in 1968, 1972, 1973, 1975, 1976, 1989, or 1991. Between 1965 and 1987, the average overflow lasted approximately 5.8 hr and discharged average of 4.6 million gal (Crosse 1988, pers. comm.). Between the years 1988 and 1991, three wastewater overflows entered Ballona Creek discharging an average of 3.4 million gal (Appendix H). On three consecutive days of heavy rain in February 1992, overflow discharges totaled 66 million gals with the average overflow lasting 9.2 hours (CLA,DPW, unpubl. data).

The primary reason for these overflows is the inability of the old NOS line to handle excessive water during storms. The new NORS line, completed in 1992 and due on-line in 1993, will be able to handle a total system flow to HTP of approximately 850 mgd (Figure 5-2). Presently HTP is unable to handle flows over 680 mgd, but interim projects scheduled for completion by spring of 1993 will enable the plant to receive system-wide flows to 850 mgd (Dorsey 1993, pers. comm.)

Permit Requirements. From 1979 to 1987 HTP discharges were subject to the requirements of an NPDES permit issued in 1979 that had expired in 1984. In 1987 a new permit was issued which established discharge limitations for 27 constituents in the 5- and 1-mile effluent and the 7-mile sludge discharge, which was terminated in 1987. Because the EPA could not sanction the discharge of sludge, standards specific to sludge were not set in the NPDES permit; therefore, the sludge discharge was subjected to full secondary treatment standards (Dorsey 1988, pers. comm.). The constituents included BOD (5-day), suspended solids, oil and grease, settleable solids, turbidity, toxicity concentration (chronic and acute), arsenic, cadmium, chromium (hexavalent), copper, lead, mercury, nickel, silver, zinc, cyanide, total chlorine (residual), ammonia (N), nonchlorinated phenolic compounds, chlorinated phenolic compounds, aldrin and dieldrin, chlordane and related compounds, DDT and derivatives, endrin, HCH, PCBs, and toxaphene. These limitations generally included 6-month median values and daily maximum values. The same limitations were set on gross constituents (total suspended solids, settleable solids, BOD, oil and grease, turbidity, and toxicity) as well as limitations on residual chlorine for all three outfalls (RWQCB,LAR 1987).

In 1991 limitations on BOD, suspended solids, oil and grease, and settleable solids for the 5-mile pipe were revised to comply with a consent decree between the EPA, Region IX, and the RWQCB, LAR. HTP is currently in compliance with the permit scheduling to reach full secondary treatment by 1998.

Compliance with standards. During the past eight years the number of noncompliance with the 1-mi effluent limit has decreased. In 1985 the effluent exceeded the daily maximum discharge limits on occasion for five parameters: fecal coliform, residual chlorine, beta-radiation, chromium, and toxicity. The 7-day mean limits on fecal coliform were also exceeded. In 1986 the daily discharge limits were exceeded for three constituents. Beta-radiation levels were too high for the year, residual chlorine during five months, and fecal coliform during one month. In 1987 the daily limits of residual chlorine were exceeded in two months and the six-month median for beta-radiation was exceeded for the year (RWQCB,LAR 1988). From 1988 to 1992 compliance with NPDES permit requirements were met for all overflows through the 1-mile effluent outfall (Dorsey 1993, pers. comm.)

The 5-mile effluent has been well within compliance with all standards established in HTP's NPDES permit since 1987. Presently all effluent constituents are meeting the standards for full secondary effluent that will be required in 1998 (Dorsey 1993, pers. comm.)

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Proposed Improvements. By 1998, HTP must be at full secondary treatment to comply with current NPDES regulations. In 1986, in order to comply with these regulations, HTP began the Interim Improvement Program to ensure that the highest quality of effluent was being discharged by the time the secondary treatment program was operational (CLA,DPW 1991). Recent improvements include a fifth pump in the effluent pumping plant and new maintenance facilities. Current construction includes a fully enclosed truck loading station to control odors, an intermediate pump station between primary and secondary systems, a cryogenic oxygen system and new secondary reactors and clarifiers for phase 1, and new headworks now in start-up (CLA,DPW 1991; Dorsey 1993, pers. comm.).

Proposed projects that will help HTP reach full secondary treatment by 1998 and increase the amount of effluent flow include; a dewatering centrifuge and anaerobic digester expansion for phase 1 and 1a respectively, medium and high pressure gas compressors, steam dryer for sludge dehydration, waste activated sludge thickening, and the expansion of cogeneration facilities to remain completely self sufficient. With current projects in construction and the proposal of future work HTP expects to be in full compliances of the 1987 consent decree to discharge full secondary treatment effluent.

Joint Water Pollution Control Plant

Until the 1920s most of the communities in Los Angeles County not serviced by HTP used cesspools and septic tanks. In the late 1920s the County Sanitation Districts were formed and White Point on the Palos Verdes Peninsula was selected as an ocean outfall site, partly because of its distance from the popular beaches of Santa Monica Bay.

The first Joint Disposal Plant was completed in 1928 and effluent was discharged into Dominguez Slough which flowed into Los Angeles Harbor. The ocean disposal of wastewater onto the Palos Verdes Shelf began in 1937 through a 5-ft diameter pipe; a 6-ft diameter pipe was added in 1947 (Rawn 1965). These outfalls discharged at water depths of 110 and 160 ft, respectively, and the initial flows were about 14 mgd each. A 7.5-ft diameter outfall, ending in a Y-shaped multiport diffuser at a water depth of 200 ft, was completed in 1956; in 1966 a 10-ft diameter pipe with a dog-legged, multi-port diffuser discharging at a 200 ft depth was added. The two diffusers are approximately 1.9 mi offshore (RWQCB,LAR 1977; Stull *et al.* 1986a).

Influent waters. The Los Angeles County Sanitation Districts Joint Outfall System (LACSD,JOS) presently treats the wastewater of 5 million people and more than 70,000 businesses and industries in a service area of approximately 583 mi^2 (Figure 5-5) (Stull 1993, pers. comm.). Approximately 30% of the influent sewage is treated to tertiary standards in upstream water reclamation plants and 70% is treated at the JWPCP in Carson (Horvath 1988, pers. comm.). The JWPCP provides advanced primary and partial secondary treatment for about 330 mgd of wastewater (Stull 1993, pers. comm.). About 15% of the influent sewage is industrial and about 85% domestic (Horvath 1988, pers. comm.).

Treatment. In 1983 the JWPCP began operating new secondary treatment facilities and by 1985 was treating an average of 179 mgd (SCCWRP 1986a). The wastewater was screened and grit removed prior to receiving advanced primary treatment, which included the addition of a polymer to remove suspended solids. Sixty percent of the effluent received pure oxygen secondary treatment while the rest was screened to remove grease and floatables. The combined flow was chlorinated and discharged. About 25% of the resulting sludge was sold as a soil amendment and the rest was hauled to the Puente Hills landfill (Stahl and Horvath 1988). Air disposal (via anaerobic digestion of sludge and subsequent combustion of the gas for energy

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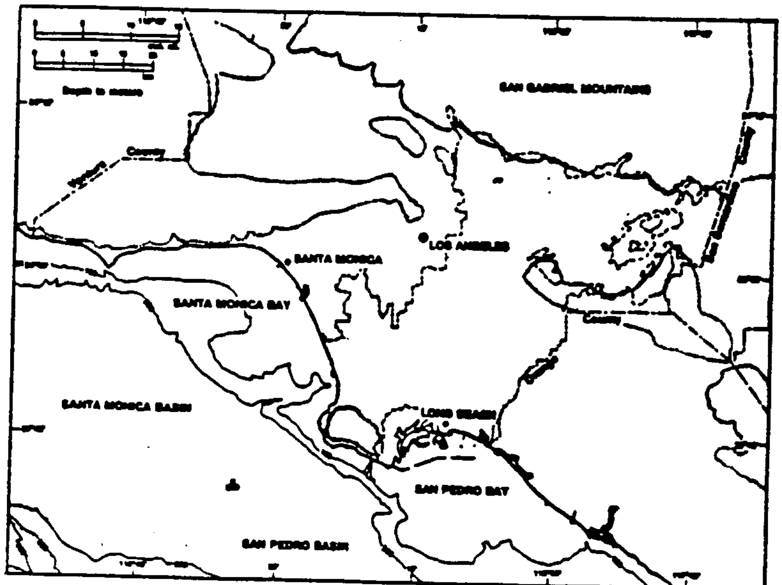

Figure 5-5. JWPCP watershed (modified from LACSD map G-m-450).

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production) increased from 26 to 35% between 1973 and 1985 (Horvath 1988, pers. comm.; Stull and Haydock 1988).

Volumes Discharged. From 1937 to 1970 the volume of municipal waste discharged from the JWPCP increased in approximate proportion to the population growth in its service area; it has remained relatively constant since 1970 (Figure 5-6 and Apppendix D) (Stull *et al.* 1986; Stull and Haydock 1988). From 1974 to 1987 JWPCP discharged an average of 356 mgd of effluent, with a peak flow of 382 mgd in 1989. In 1991 flow dropped by 12% to 330 mgd, the lowest recorded since 1977. This drop coincided with water conservation measures in response to the drought, as well as the economic recession (Stull 1993, pers. comm.). Projected flow for 1992 was 333 mgd, lower than the 1977 average flow. Data on flow for 1991 and 1992 suggest that drought conditions continued to impact the volume of final effluent (Appendix D).

In 1977 about 67% of the total effluent was discharged from the dog-leg outfall and 33% from the Y-shaped diffuser (RWQCB,LAR 1977). The 72-in. diameter outfall, which discharges at 160 ft depth, is on standby and may be used during heavy rains to provide hydraulic relief. The 60-in. diameter outfall which discharges at 110 ft depth is also on stand-by for extreme emergencies, although it has not been used in years (Stull 1993, pers. comm.).

In addition to the two main and two emergency ocean outfalls, JWPCP has 11 other discharge points; Harbor Lake, Dominguez Channel, Los Angeles River, and the Pacific ocean nearshore zone, used for extreme emergency relief (RWQCB,LAR 1991).

Effluent. The JWPCP improved effluent quality substantially between 1971 and 1981, partly through better source control and partly as a result of advanced technology – the use of polymers to help settle particulates, better sludge dewatering, and better screening techniques (Stull *et al.* 1986b).

Mass emissions recorded in the period 1987 to 1992 for BOD, TSS, settleable solids, and oil and grease were the lowest reported since 1974 (Figure 5-7 and Appendix D). From 1974-1992, phenols decreased 81%, from 1,582 to less than 300 MT. Cyanide levels declined 98% from a high of 206 in 1974 to 3 MT 1992. Although detergents (MBAS) fluctuated over the 19 year period, the overall trend declined (Figure 5-7 and Appendix D).

Mass emissions of organic nitrogen, total phosphorus, and ammonia nitrogen remained constant from 1974 to 1992, displaying little variability between years with 1992 values slightly lower than those in 1974 (Figure 5-7 and Appendix D).

In general, from 1974 to 1992 mass emissions of trace metals from the JWPCP outfall declined. Few metals displayed periods of high fluctuation; e.g., silver peaked in 1979 at 9.6, compared with a current value in 1992 of less than 2 MT; arsenic levels rose to 9.7 in 1984 before dropping to 1.9 MT in 1992 (Figure 5-7 and Appendix D). Overall, discharges of trace metals declined during the 1974-1992 period by the following percentages: silver (68%), arsenic (84%), cadmium (98%), chromium (98%), copper (95%), mercury (80%), nickel (87%), lead (98%), and zinc (95%) (Appendix D).

Total DDTs and PCBs were measured by different methods during 1974 to 1979 than from methods used 1980 to 1987, therefore, reported values for the two periods may not be comparable. During the earlier period values were generally higher; however, PCB levels dropped sharply after 1974 and to non detectable levels by 1987 where they have remained through 1992 (Figure 5-7 and Appendix D). DDTs experienced a more gradual decline and were further reduced

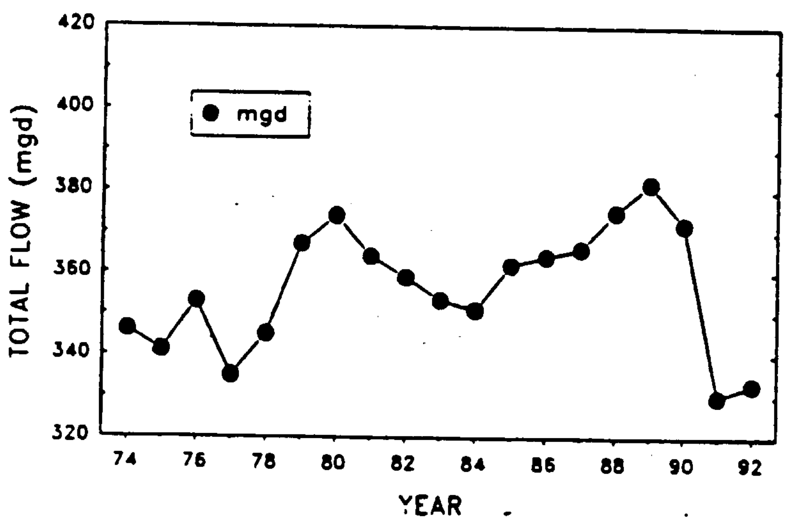

Figure 5-6. Average flow from JWPCP outfall, 1974-1992. (Data from Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; Stull 1988 pers. comm.; Horvath 1992 pers. comm.)

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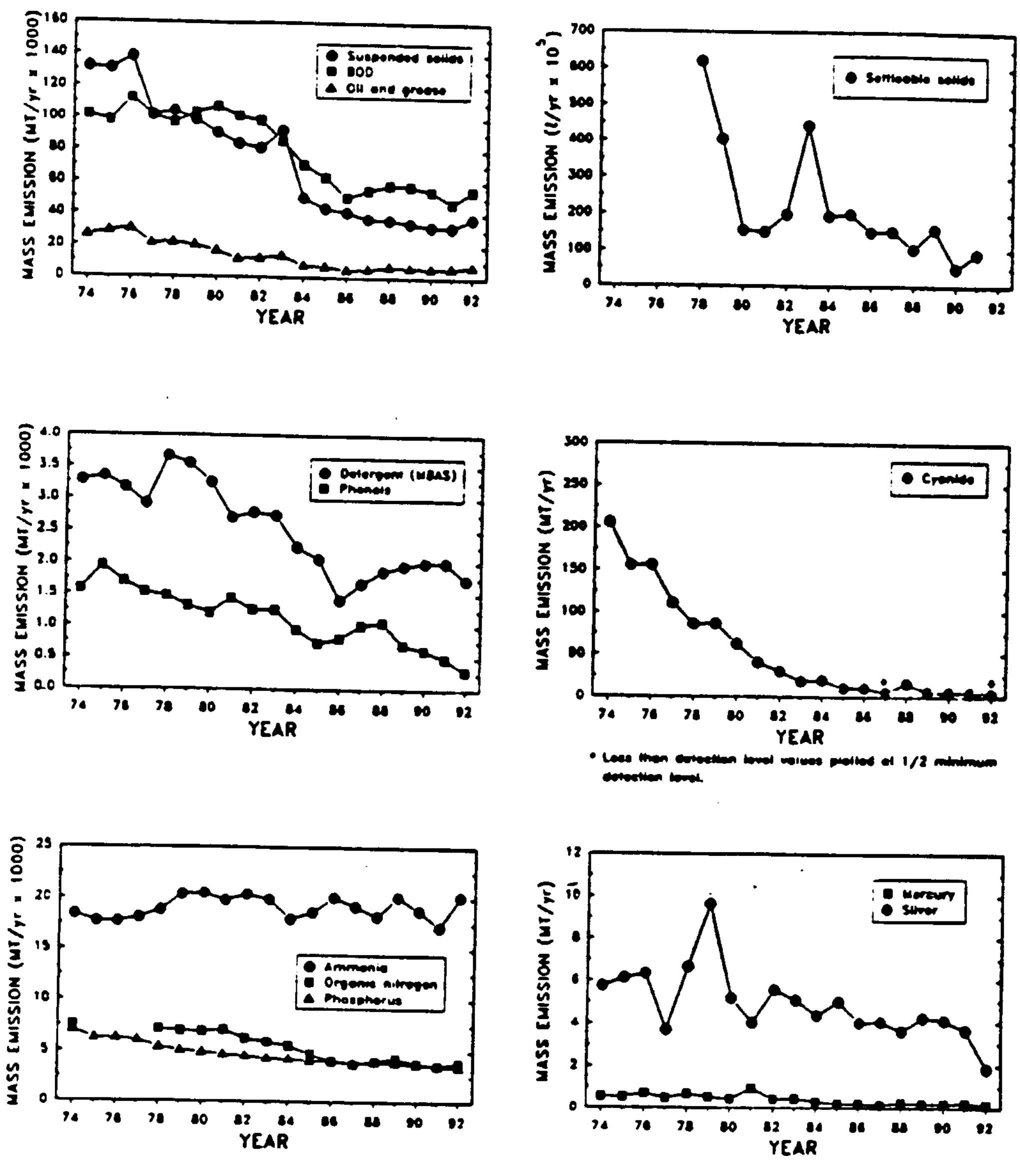
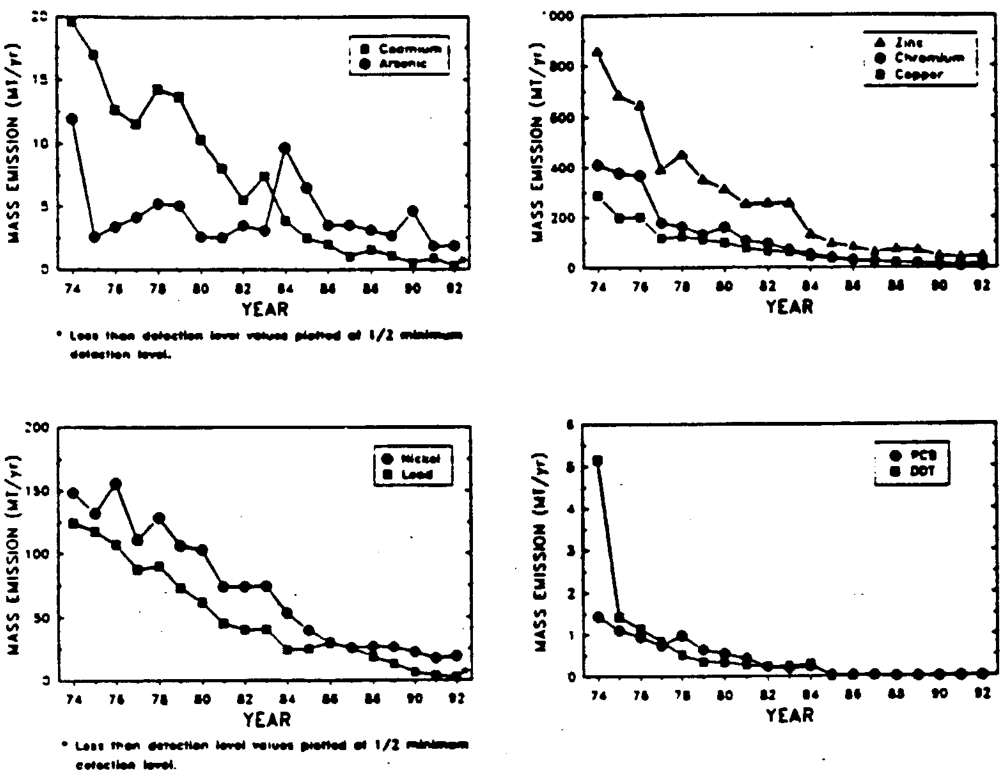


Figure 5-7. Annual mass emission rates of selected contaminates from JWPCP outfall 1974-1992. (Data from Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; Stull 1988 pers. comm.; Horvath 1992 pers. comm.)



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when the primary source (the Montrose Chemical Corporation) was identified and prohibited from dumping processing wastes into the JWPCP system (Chartrand 1988) (Figure 5-7 and Appendix D).

Permit Requirements. In 1991 the Regional Water Quality Control Board, Los Angeles Region (RWQCB,LAR), adopted a new NPDES permit for JWPCP which established discharge limitations (in concentrations) for 86 constituents. These include all of the major wastewater constituents, aquatic life toxicants, non-carcinogens, and carcinogens included in the 1990 California Ocean Plan, plus BOD. Many of the limits are more stringent than the Ocean Plan, and are based on either previous performance or practical quantitation limits. Limits for major constituents and aquatic life toxicants are provided for both concentrations and mass emissions, and are expressed for various time periods (e.g., 30-day, 7-day, daily, instantaneous, in various combinations) (Stull 1993, pers. comm.). The permit also includes limits and provisions for receiving waters established by the 1990 California Ocean Plan, which also sets limitations regarding secondary treatment of effluent.

Compliance with Standards. In the period 1983-1987 JWPCP effluent was in compliance with the California Ocean Plan limits except that daily concentration limits for suspended solids and chlorine were exceeded in 1983 and pH and turbidity in 1984 (RWQCB,LAR 1988). Presently JWPCP is unable to comply with these limitations regarding secondary treatment of effluent and until the 301(h) variance is resolved, or full secondary treatment is reached, must operate on interim limits set in a 1988 cease and desist order issued by the Board for secondary treatment. JWPCP's application for a variance to section 301(h) was denied in 1990 by the EPA Region IX, subsequently JWPCP requested and was granted a challenge to the denial. Dates for the challenge hearing are still pending (RWQCB,LAR 1991; Stull 1993, pers. comm.) A lawsuit was also filed in District Court by EPA seeking resolution of the secondary treatment issue (Stull 1993, pers. comm.).

Proposed Improvements. By 1995 LACSD will have finished construction of their sludge dehydration and thermal processing facilities (RWQCB,LAR 1988). Expansion is estimated to handle all sludge currently hauled off site to landfills, approximately 240 dry tons per day, and will be used for the energy recovery facility to generate electricity.

Tapia Water Reclamation Facility

The Las Virgenes Municipal Water District (LVMWD) was formed in 1958 and by 1965 construction of TWRF was completed with up to 500,000 gpd capacity. TWRF's capacity was expanded to 2 mgd after construction of sewer trunk lines were completed. Expansion in 1972 increased capacity to 8 mgd of effluent with solids handling capabilities of 4 mgd and at this time TWRF installed facilities to allow for water reclamation. Between 1972 and 1982 TWRF underwent area-wide facility upgrades, from the expansion to 8 mgd of hydraulic capacity, to the design and completion in 1982 of Rancho Las Virgenes with a capacity to handle 8 mgd of dewatered sludge. In 1984 filtration systems were installed and 1989 expansions allowed TWRF to increase capacity to 10 mgd. In 1991 construction began at TWRF and Rancho Las Virgenes that will allow for the handling of 16.1 mgd of influent and dewatered sludge (Gamble, 1992, pers. comm.).

In the past discharge of effluent to Malibu Creek was through percolation beds. The beds were removed from service after the installation of on site filters, however, periodic discharge to the percolation beds is required in summer months by CDFG to maintain the creek flow necessary to sustain fish populations in (RWQCB,LAR 1989).

Treatment. TWRF currently provides primary, secondary, and tertiary treatment of wastewater. Primary treatment includes coarse screening, grit removal, and primary sedimentation using rectangular clarifiers. Secondary treatment employs activated sludge with single-stage nitrification followed by secondary clarification. For tertiary treatment, coagulation chemicals are added and the water is flocculated, filtered, chlorinated and dechlorinated (RWQCB,LAR 1989). Tertiary treated wastewater is reclaimed and used for irrigation, dust control and fire suppression.

Sludge is currently being treated by aerobic digestion, screened, and either pumped to land injection farms, or dewatered in belt presses and hauled to landfills. Solids collected from coarse screening, grit removal, and sludge screening are hauled to landfills. Additional sludge incurred from expansion will undergo composting for use in landscape related activities.

Volumes Discharged. Flow from TWRF has averaged 2.7 mgd since 1974 with a maximum of 4.5 mgd discharged in 1978 (Figure 5-8, Appendix D). Over the last five years, flow has averaged 2.5 mgd. The trend of the previous five years has been fairly stable, though declining. This decline coincides with drought periods and subsequent water conservation measures.

Effluent. Emissions of total suspended solids, phosphorus, BOD, total nitrogen, detergent, chromium, copper, nickel, and zinc have generally been low but have erratic variation (Figure 5-9 and Appendix D). Copper emissions have increased slightly in recent years but appears to be part of this variation.

Permit Requirements. TWRF is subject to discharge requirements established in a 1985 NPDES permit, revised in 1989.

Wastewater discharge is limited to tertiary treated water with 30-day mean and daily maximum limits set for six constituents: BOD, suspended solids, oil and grease, residual chlorine, settleable solids, and turbidity. Eighteen other constituents, as well as EPA priority pollutants, are monitored and reported on a regular basis. Because Malibu Creek has relatively low dilution and is subject to human contact, discharged wastewater must be completely pathogen free (RWQCB,LAR 1989).

Proposed Improvements. By 1993-1994 TWRF is projected to be complete, with the capabilities to treat and discharge 16.1 mgd. Improvements in the plant consist primarily of expansion and upgrades to the current facility.

Industrial Dischargers

Industrial dischargers include three power generating stations; Scattergood, El Segundo, and Redondo, and the El Segundo Refinery.

The power generating stations use seawater from Santa Monica Bay to cool steam condensers. Cool seawater is pumped into the station, circulated through noncontact heat exchangers, and discharged at elevated temperatures. In addition to increased temperatures, the once-through cooling water may include treated wastewater which is nonhazardous as defined by state and federal regulations. The wastewater may include water-side boiler tube cleaning wastes, cooling water blowdown, and various low-volume wastes consisting of fireside boiler tube wash water, water purification wastes, boiler and evaporator blowdown, in-plant floor drainage, and rainfall runoff. Chlorine is also injected into the once-through cooling system (condensers) periodically to control biological growth (RWQCB,LAR 1985a,b,c; Karapetian 1988, pers. comm.).

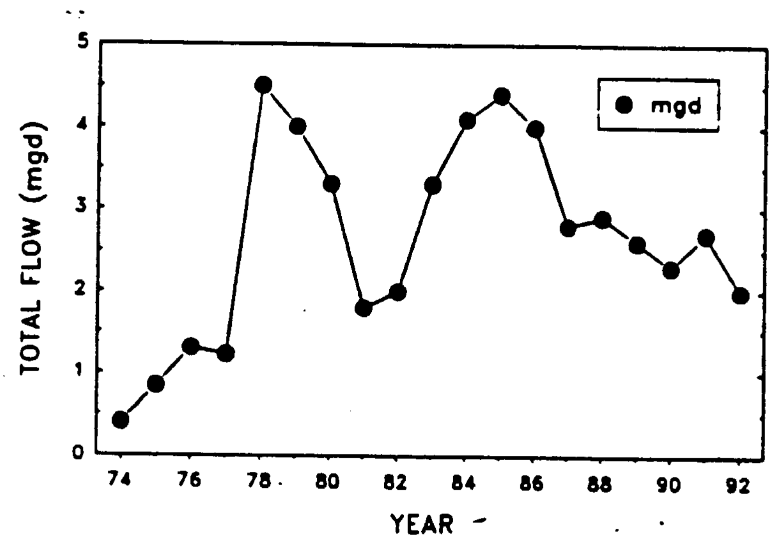

Figure 5-8. Average flow from TWRF 1974-1992. (Whitbeck 1992, pers. comm.)

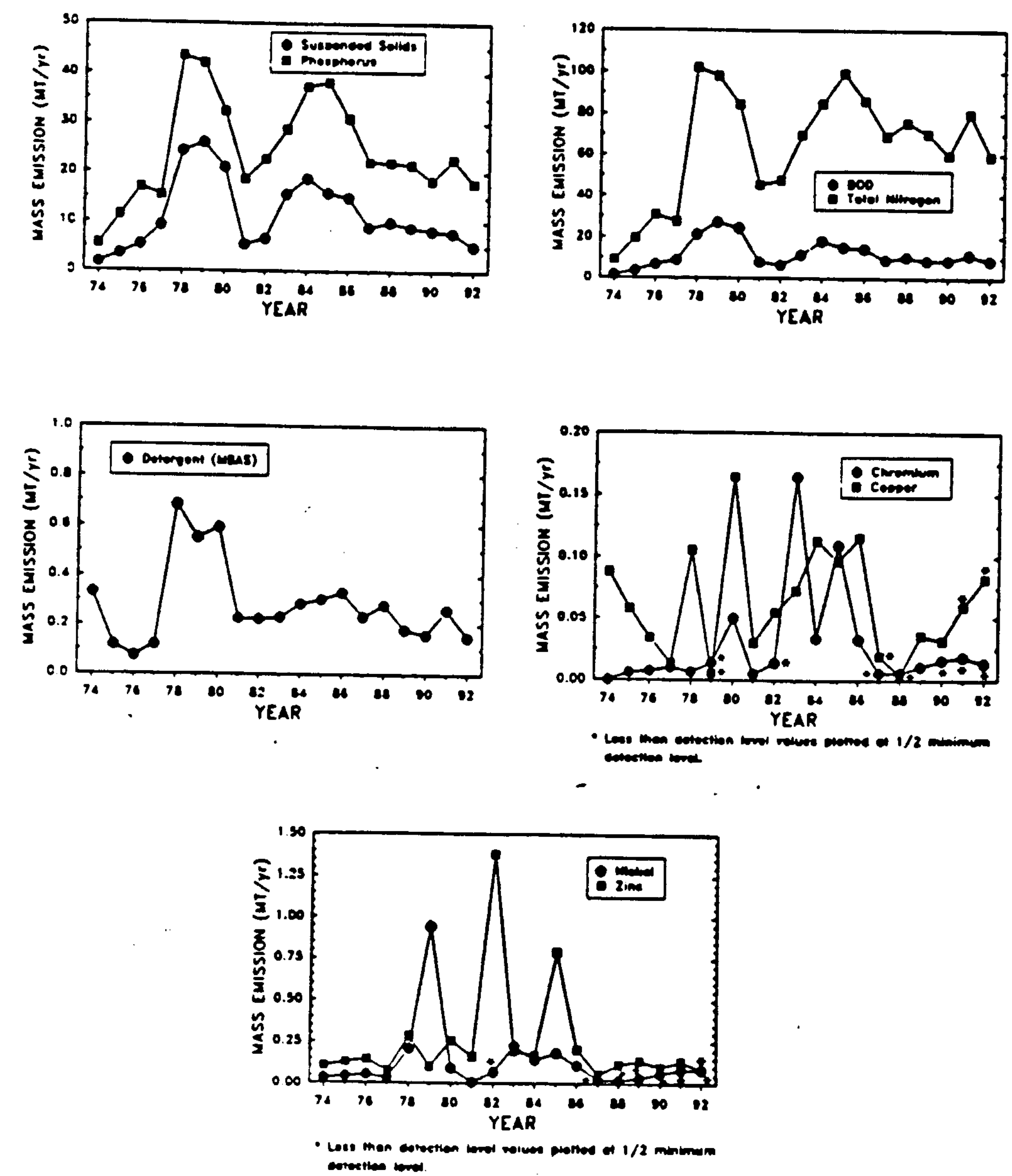

Figure 5-9. Annual mass emission rates of selected contaminates from TWRF 1974-1992. (Whitbeck 1992, pers. comm.)

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In addition, the following wastes could be discharged along with the once-through cooling water: wastewater from laboratory drains, metal cleaning wastes, treated wastewater from fuel pipeline hydrostatic testing, treated sanitary wastes, treated oil wastes, and groundwater. These wastes are held in settling basins before they are discharged to the ocean; residues from the basins are land disposed (RWQCB,LAR 1985a,b,c; Karapetian 1988, pers. comm.).

The growth of marine biofouling organisms in the discharge and intake conduits is periodically removed by recirculating a portion of the cooling water to achieve higher temperatures. These "heat treatments" kill fouling organisms as well as some fish and other nekton resident in the cooling water structures. Heat treatments are conducted every five to eight weeks and last two to four hours (RWQCB,LAR 1985a; Karapetian 1988, pers. comm.). Routine operation of generating station cooling systems may impinge and entrain a variety of marine organisms.

NPDES permits for generating stations limit constituents, as instantaneous and daily maximum or minimum levels or six-month median values. The regulated constituents include physical characteristics, metals, nonmetallic inorganics, toxicity, and radioactivity (RWQCB,LAR 1985a,b,c; 1991).

Concentration levels are measured in the discharged cooling water. However, because this water is unfiltered seawater, the same constituents are also found in the seawater entering the intake conduit. Calculations of mass emissions using cooling water flow and final discharge concentrations give unrealistically high values for these constituents. Therefore, the mass emissions given in the following sections are based on concentrations and flow from the retention basin discharge before it enters the cooling water effluent and reflects the mass emissions actually discharged by the plant itself. Chlorine is the only constituent added directly to the cooling water at another site in the system (Alcaino 1988, pers. comm.; Schumann 1988, pers. comm.). An earlier study of the cooling water discharge of power generating stations in southern California indicated that the transit through the plant increased intake (background) levels of trace metals by 0.21 ppb or less for each metal examined (Young *et al.* 1977). Thus the contribution of the cooling water discharge alone to trace metal concentrations appears to be very low.

Scattergood Generating Station

The Scattergood Generating Station (SGS) in Playa del Rey is owned and operated by the City of Los Angeles, Department of Water and Power. It consists of three fossil-fueled, steam-electric generating units and has been in operation since 1958 (LCMR,IRC 1979; RWQCB,LAR 1985a). The cooling water intake is located about 1,600 ft offshore, at a depth of 18 ft below the surface. The discharge to Santa Monica Bay is 1,200 ft offshore at a depth of 15 ft below the water surface (LCMR,IRC 1979; RWQCB,LAR 1985a; Karapetian 1988, pers. comm.).

Effluent. The maximum flow from Scattergood is about 500 mgd with the average flow about 322 mgd (RWQCB,LAR 1985a). For the last five years the flow from the retention basins to the cooling water averaged 0.16 mgd (CLA, DWP 1992, unpubl. data). The temperature of the discharge averages 80.7°F in winter and 82.4°F in summer. During normal operations the temperature differential is approximately 20°F. The maximum allowable discharge temperature during a heat treatment is 135°F, and averages approximately 120°F. Flow during heat treatments is about 75% of that during normal operations, with 50% being recirculated within the station. The difference between intake and discharge temperatures can range from 35 to 85°F. The flow from other in-plant waste streams accounts for less than 0.05% of the total discharge (RWQCB,LAR 1985a; Karapetian 1988, pers. comm.).

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Since 1987 Scattergood discharged an average of 1.6 MT of total suspended solids, and 0.32 MT of oil and grease to the once-through cooling water. Mass emissions of chromium and zinc have been measured in trace amounts during the 1988-1992 period (CLA,DWP 1992, unpubl. data). Emissions over the past five years have remained fairly consistent.

Permit requirements. The NPDES permit for the SGS discharge no longer includes limits for suspended solids, oil and grease, or BOD. Based on five years of monitoring data, limits for these constituents were determined by the RWQCB to be unnecessary (Karapetian 1988, pers. comm.).

El Segundo Generating Station

The El Segundo Generating Station in El Segundo is operated by the Southern California Edison Company (SCE) and consists of four stem-electric generating units. Units 1 and 2 have been in operation since 1955-1956 and Units 3 and 4 since 1963-1964 (LCMR and IRC 1979). Cooling waters for the two pairs of units have separate intake and discharge structures. Water for Units 1 and 2 is drawn from a water depth of 20 ft at the end of a conduit which extends 2,600 ft offshore and is discharged 1,900 ft offshore at a depth of 16 ft. Cooling water for Units 3 and 4 is drawn at a depth of 16 ft at the end of a conduit which extends 2,600 ft offshore and is discharged 2,100 ft offshore at a depth of 16 ft (LCMR,IRC 1979).

Effluent. From 1985 to 1987 the average flow through all units was 370 mgd; the flow through Units 1 and 2 averaged 106 mgd and through Units 3 and 4, 264 mgd. Discharge temperatures averaged 80°F for Units 1 and 2 and 85°F for Units 3 and 4 (Hertel 1988, pers. comm.). The average flow from the retention basins to the cooling water of all units was about 0.16 mgd in 1987 (Alcaino 1988, pers. comm.). The maximum temperature during a heat treatment is 125°F with the maximum difference between intake and discharge temperature during a heat treatment is 73.2°F (RWQCB,LAR 1985b).

Since 1989 emissions have averaged 3.4 MT of TSS and 1.7 MT of oil and grease. In 1991 the El Segundo Generating Station discharged about 4.8 MT of TSS, and 1.6 MT of oil and grease from the retention basin to the cooling water. Total flow from the El Segundo wastewater treatment plant in 1992 averaged less than 1 mgd, discharging approximately .07 MT of BOD, .09 MT of TSS, .03 MT of oil and grease, and 4,527 l/yr. of settleable solids (SCE 1992, unpubl. data).

Permit Requirements. Southern California Edison operates the El Segundo generating station under a NPDES permit issued in 1984, amended in 1985, and amended again in 1990 to include the objectives stated in the revised California Ocean Plan of 1988. Discharge limits for metal cleaning wastes, low volume wastes, and wastewater from treatment facilities must meet 30-day mean and daily maximum for: BOD, suspended solids, oil and grease, settleable solids, total copper, and total iron (RWQCB,LAR 1990).

Redondo Generating Station

The Redondo Generating Station, located in King Harbor, is operated by SCE and consists at present of four steam-electric generating units. Units 5 and 6 have been in operation since the early 1950s, and Units 7 and 8 since mid-1960. Units 1 to 4 went on-line in 1940 but were withdrawn from service in November 1986 (Curtis 1988, pers. comm.).

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Cooling water for the two pairs of units are drawn and discharged in separate cooling water systems. Cooling water for Units 5 and 6 is drawn into two intake conduits at a water depth of 20 ft within King Harbor and discharged at a depth of 25 ft, north of the Harbor and 1,600 ft offshore. Cooling water for Units 7 and 8 is drawn at a depth of 20 ft from a conduit extending 1,000 ft offshore at the entrance to King Harbor and discharged within the Harbor at a depth of 20 ft (RWQCB,LAR 1985c).

Effluent. From 1985 through 1987 the average flow through Units 5 and 6 was 227 mgd and through Units 7 and 8, 530 mgd. The average flow in 1987 from the retention basins to the cooling water of all units was about 1.2 mgd (Alcaino 1988, pers. comm.). The average discharge temperature for Units 5 and 6 was 85.7°F and that for Units 7 and 8, 83°F (Hertel 1988, pers. comm.). The maximum temperature during a heat treatment is 125°F, which represents an increase of 68.5°F, over intake temperatures (RWQCB,LAR 1985C).

In 1992 the Redondo Generating Station discharged about 3.4 MT of oil and grease, and 6.7 MT of total suspended solids to the cooling water from the on site retention basin, a decrease of 85-90% from 1990. An average of 74 MT of suspended solids and 32.8 MT of oil and grease have been discharged during the period 1988-1992 (SCE 1992, unpubl. data).

Permit Requirements. Redondo Beach Generating Station is currently operating under an NPDES permit issued in 1984, amended in 1985, and amended again in 1990 to include the objectives stated in the revised California Ocean Plan of 1988. Limits on effluent constituents for metal cleaning, and low volume wastes are set with a 30-day mean and daily maximum for suspended solids, oil and grease, total copper, and total iron (RWQCB,LAR 1990).

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El Segundo Refinery

Chevron USA's El Segundo Refinery has been in operation since 1911 and now manufactures various petroleum products, including gasoline, jet fuel, kerosene, solvent, coke, fuel oil, liquified petroleum gases, and propylene polymer. The refinery occasionally uses benzene and toluene in its processes, but these petroleum derivatives are manufactured elsewhere. Manufacturing processes used at the refinery include distillation, catalytic cracking, alkylation, isomerization, coking, catalytic reforming, hydrogenation, sulfur recovery, and blending. The refinery has a maximum production capacity of about 405,000 barrels per day, although the average production is about 240,000-290,000 barrels per day (RWQCB,LAR 1984; Chevron USA 1988, pers. comm.).

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Since the early 1970s the El Segundo Refinery has discharged treated wastewater through an outfall 500 ft offshore of the beach at Grand Avenue at a depth of approximately 20 ft (RWQCB,LAR 1984; Chevron USA 1988, pers. comm.). This discharge consisted of non-contact cooling water bleed-off, petroleum processing wastewater, treated boiler water, shallow recovery well groundwater, and stormwater runoff. All petroleum processing wastewater and shallow recovery well groundwater had been treated at an Effluent Treatment Plant (ETP) on the facility before being discharged.

In early 1993, Chevron announced plans to extend its wastewater pipeline two-thirds of a mile from the beach, effectively removing the last industrial discharger from the nearshore environment. The construction, which involves revamping an unused series of pipelines that stretch from the refinery to a tanker mooring, is expected to be completed within a year (LA Times 1993). The discharged effluent will still be processed through the ETP with treatment consisting of both primary and secondary processes including dissolved air flotation units, an equalization basin, and activated sludge (biological) units. Stormwater runoff is discharged after treatment in oil/water separators and induced air flotation units; if necessary, this can also be routed to the ETP for biological treatment. About 90% of this runoff may contain oil or other spilled contaminants (RWQCB,LAR 1984; Coonan 1993, pers. comm.).

Three tanks and an induced air floatation unit were constructed in 1988 as part of the Effluent Diversion Project to increase the residence time of the effluent during treatment. Two of the tanks have 7,140,000 gal capacities and one has a capacity of 2,940,000 gal (Chevron USA 1988, pers. comm.; Coonan 1993, pers. comm.).

Effluent. The refinery discharges 6 to 7 mgd of treated wastewater, with maximum discharges of up to 20 mgd and dry-weather flows of about 6.2 mgd (RWQCB,LAR 1984; Chevron USA 1988, pers. comm.; Dorsey 1988; Coonan 1993, pers. comm.). The most abundant constituents in the discharge are COD, BOD, and TSS, with average annual mass emissions of 1,760, 123, and 105 MT, respectively.

Permit Requirements. Chevron's NPDES permit limits a number of effluent constituents and includes 6-month medians, 30-day averages, and daily maximums for both dry and wet weather discharges. The regulated constituents include physical characteristics, metals, nonmetallic inorganics, organics, and toxicity (RWQCB,LAR 1984; Coonan 1993, pers. comm.). Settleable solids and turbidity do not have permit limitations but are monitored nevertheless (Chevron USA 1987; Coonan 1993, pers. comm.).

CHAPTER 6
NONPOINT SOURCES OF CONTAMINATION

While most of the contaminants found in Santa Monica Bay probably came from point sources and urban runoff (a nonpoint source), other nonpoint sources may also be a major factor. These include marine vessel activities, oil and hazardous material spills, dredging, ocean dumpsites, historically deposited sediments, advection, and aerial fallout.

MARINE VESSEL ACTIVITY

Small Craft Boating and Harbors

Although boats berthed elsewhere use Santa Monica Bay, most small boat traffic is concentrated in Marina del Rey and King Harbor. Marinas act as collecting basins for a variety of substances, including raw and chemically treated sewage, fish wastes, antifouling paint additives, oil and grease, wash water, and trash as well as surface runoff. During ebb tides or storms these contaminants enter the Bay through harbor entrances and porous breakwaters and jetties.

Marina del Rey

Marina del Rey was constructed between 1958 and 1962 from Ballona Wetlands. It includes about 403 acres of waterways (navigation channels and small craft berthing basins) and a similar amount of land-based support facilities. About one-third of the land is used by the Los Angeles County Department of Small Craft Harbors and two-thirds is leased to private entities (Soule and Oguri 1977).

About 6,000 boats can be harbored at Marina del Rey and hundreds more are in dry storage nearby: the number of boats berthed there increased from 5,500 in 1973 to 5,800 (SCCWRP 1973, Soule and Oguri 1992). The Marina includes four dry docks and two fuel docks (LACHP 1988, pers. comm.; MDRHMI 1988, pers. comm.). In addition to storm drains which empty directly into the Marina, tidal action carries storm water from Ballona Creek and Ballona Lagoon into Marina del Rey.

King Harbor

King Harbor was constructed between 1962 and 1968 (CCC 1987; Pitzer 1988, pers. comm.) and lies along the open coast between Hermosa Beach and the head of Redondo Canyon. It is surrounded by a porous breakwater which parallels the coast.

King Harbor includes about 110 acres of waterways and three small craft berthing basins. It has one fuel dock, two fishing piers, and berths for about 1,600 small boats (Straughan 1977a; Clemens 1988, pers. comm.; Pitzer 1988, pers. comm.). In 1973 there were about 1,400 boats in the harbor (SCCWRP 1973). Contaminants also enter King Harbor from surface runoff and the cooling water discharge of the Redondo Generating Station.

Commercial/Naval Shipping Activities

During the late 1800s Santa Monica served as the City of Los Angeles' deep water port. At present most commercial and naval shipping activities occur outside Santa Monica Bay, in the shipping lanes offshore, and in nearby Los Angeles and Long Beach Harbors (Figure 6-1).

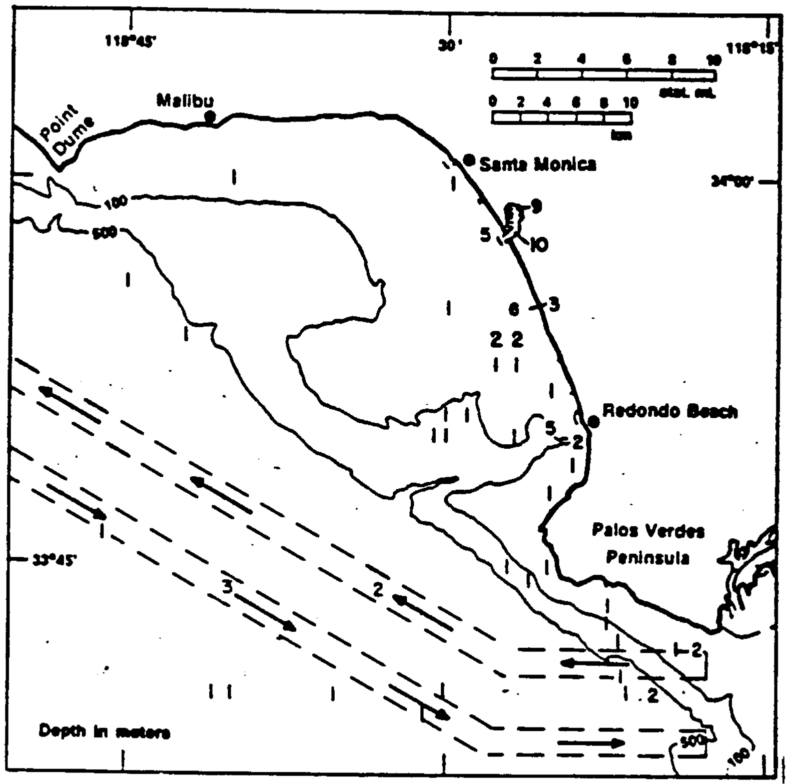

Figure 6-1. Shipping lanes and reported vessel spills (1973-1987 and 1991) in or near Santa Monica Bay area. (Numbers indicate number of spills; U.S. Coast Guard, Dept. Trans., unpubl. data).

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The entrance to Los Angeles Harbor is about 2.5 mi east of Point Fermin. In 1990, 7,013 vessels arrived at the Los Angeles-Long Beach Harbors, with over 1,000 of these tankers. Over 10,000 are expected to arrive in the year 2000 (USACOE/LAHD 1992). It is not known how many of these vessels pass by Santa Monica Bay, but it can be assumed that several thousand pass the Bay during the year. The coastwise shipping lane extends west of Point Fermin for 8.9 mi before turning northwest and running parallel to the 500-m isobath of Santa Monica Bay; it generally lies about 3.4 mi offshore of Santa Monica Bay (Figure 6-1).

Chevron USA maintains three submerged pipelines which extend from shore to a three-berth offshore tanker mooring facility in 42 to 66 ft of water. For the most part, these pipes transport crude oil and refined products (mostly gasoline and jet fuel) to tankers moored in the area (Chevron USA 1988, pers. comm.); refined product is occasionally off-loaded to the refinery.

Oil tankers cross the Bay from the coastal shipping lane to the moorings at a frequency of 10 to 20 tankers per month (O'Reilly 1988). In 1980 and 1985, about 305 and 310 vessels arrived at the moorings respectively (MMS,POCSR 1983). About 200 tankers arrived in 1986 but only 92 in 1987.

Trace Contamination from Marine Vessels

Trace pollutants from marine vessels include antifouling bottom paints, anticorrosion anodes, and fuel residues. Formerly, antifouling paints included copper, with trace amounts of mercury, arsenic, and PCBs; primers may contain zinc, chromium, and lead (SCCWRP 1973). In recent years tributyl tin (TBT) has been used in bottom paints as an antifouling agent. TBT is lethal (especially to mollusks) at parts per trillion levels. In 1984, 50 to 75% of pleasure craft used TBT paints and this percentage was probably higher for larger vessels (Soule and Oguri 1987). TBT-based paints are now banned on vessels less than 82 ft long that are not made of aluminum (CSG,MAP 1988).

Although its use is now restricted, much of the TBT paint from earlier applications has been sloughed, sanded, or scraped off boat bottoms, and may form a reservoir in the sediments of harbors and marinas. Because recreational vessels spend more time in port than large vessels and because their hulls are often scraped while in the water, small craft harbors may represent an important source of TBT (Soule and Oguri 1987).

In 1973 90% of the sail and power craft in Marina del Rey used sacrificial zinc anodes to control galvanic corrosion; some cadmium was also used. Each boat uses an estimated 4 to 5 kg/yr for this purpose (SCCWRP 1973). If similar usage rates occur today, the two marinas contribute about 30 to 38 MT of zinc per year to Santa Monica Bay.

Most of the fuel sold to recreational vessels is leaded gasoline (Bender 1988, pers. comm.). In 1973 it was estimated that the use of leaded fuel by vessels in Marina del Rey contributed about 0.55 MT/yr of lead to the environment (SCCWRP 1973). Spillage of oil and combustion of fuel by small craft introduced PAHs to the harbors. Higher than background levels of benzo(a)pyrene have been found in King Harbor (Puffer 1988, pers. comm.).

In 1971 the estimated mass emission of mercury to the Southern California Bight from vessel-related sources (bottom-paint) was greater than the total estimated mass emission of mercury from the municipal wastewater and surface runoff combined. The estimated PCB and copper emissions from this source were about half of the combined emission for wastewater and runoff. Hence, vessel-related contaminants may be a significant contaminant source (SCCWRP

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1973). At present the concentration of PCBs in antifouling paints is low but higher levels were found in older paints. Thus, the sediments in harbors may represent a reservoir which can release PCBs during dredging operations (Young and Heesen 1976).

OIL AND HAZARDOUS MATERIALS SPILLS

Potential Sources of Spills

The potential sources for spills and contamination from oil and other hazardous materials in the Santa Monica Bay area include small craft boating and harbors, commercial shipping activities, refinery transfer activities, offshore oil and gas operations, natural oil seeps, underground contamination at Los Angeles International Airport and El Segundo refinery, and accidents on land which could move into the Bay through its tributaries. Spills can be highly variable in size, and consist of very different substances. They are unpredictable, and are usually caused by unexpected problems or equipment failures. They can cause little or no problems to major damage, coating miles of shoreline. A spill on the order of the Exxon Valdez could impact an area from the Mexican Border to the Central coast. Spills in the watershed can move through drainage systems to reach wetlands, the intertidal communities, and finally the ocean. Spills on the ocean can evaporate into the air, coat the surface, suspend by emulsion into the water column, or sink to the bottom, depending on the properties of the substance spilled. Petroleum products may separate into different constituents, each reacting differently.

Boating and Commercial Shipping Spills

The U.S. Coast Guard lists at least 82 vessel spills in Santa Monica Bay between 1973 and 1987, with an average of 6 spills per year; the locations of 37 more spills were questionable (Appendix E) (U.S. Coast Guard, unpubl. data). The spills listed were almost exclusively of petroleum products, including automotive and aviation gasoline and jet fuel; 31% of the spills were fuel oil, 17% crude oil, and 17% miscellaneous oil products. Spills totalling just under 2,000 gal were recorded during this period; the median amount spilled was 2 gal and only two spills were greater than 100 gal. A tanker offshore El Segundo in 1977 spilled 1,000 gal of crude oil, most of which was recovered. In 1973, 370 gal of clarified oil were spilled from a recreational vessel in Marina del Rey.

In 59 of the 82 instances the vessel causing the spill was identified; 51% of these were recreational vessels, 29% tankers, and 14% fishing vessels. Twenty-four spills occurred in or near Marina del Rey, 17 were off El Segundo and Hermosa Beach, and 12 were in the commercial shipping lanes (Figure 6-1). More than 50% of these spills took place from 1973 to 1979.

In the past there have been occasional small spills and leaks at Chevron's offshore terminal, with only two larger spills. A tanker leak of crude oil in December 1980 was cleaned up and caused no apparent harm to beaches or marine life (Chevron 1988, pers. comm.).

In March 1991 a transport vessel's anchor snagged the offshore mooring complex at the Chevron El Segundo Refinery, resulting in a spill of 9,240 gals of a diesel oil/naphthalene mixture (MBC 1991a). At the time of the accident, an approaching low pressure weather front produced strong winds from the south-southeast, driving the floating oil to the north-northeast where it contacted the shore at Malibu. Beaches were closed to swimmers for a few days at Malibu and El Segundo during this period (Appendix I).

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Offshore Oil and Gas Operations

Offshore oil and gas operations generate contaminants from a variety of point and nonpoint sources. Crude oil may be leaked in small amounts during exploration and production drilling or spilled in large amounts in a blowout, a tanker accident, or a rupture of a submerged pipeline. Refined petroleum products may be leaked or spilled during routine transfer operations and in tanker accidents or pipe ruptures.

Trace metals and other synthetic compounds are found in drilling muds and a variety of metals, combustion by-products, and other substances resulting from the operation of heavy gasoline- and diesel-powered machinery on boats and platforms. Domestic wastes generated at drilling platforms and aboard work vessels are treated in self-contained treatment plants and discharged overboard. Although operators in the Federal Outer Continental Shelf (OCS) dispose of drilling muds and cuttings at sea under a general permit, those from State Lands operations must be barged ashore for land disposal.

At present the major oil and gas operation in Santa Monica Bay is tanker traffic to and from Chevron USA's refinery in El Segundo, the largest refinery in California with a capacity of 405,000 barrels/day. The refinery does not treat Federal OCS production. In the past spills or leaks occurred about once a year during offloading or onloading at the offshore terminal.

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Although oil and gas reserves are believed to occur on the Santa Monica Shelf, oil and gas development in or near Santa Monica Bay has been limited. It is estimated that the 40 tracts within the Bay have about 70 million barrels of oil and 90 billion ft^3 of gas.

By 1983 several lease plans had been considered which could affect Santa Monica Bay. Several alternatives were described in the draft Environmental Impact Statement (EIS) for the southern California lease offering, describing different drilling scenarios as well as potential risks (MMS,POCSR 1983; MBC 1988). However, by June of 1990, Federal OCS lease sale 95 was canceled. In addition, no leasing will occur in any other areas offshore of California before the year 2000. In the Santa Barbara area, 87 tracts will be offered for lease before January 1996, adjacent to areas currently in production (MMS,OCSNC 91). It is not clear what impact this new activity in the Santa Barbara area would have for the Santa Monica Bay.

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Natural Oil Seeps

Two natural oil seeps are known from Santa Monica Bay. One, with three seepage zones, is located about 2.3 mi off Redondo Beach, near the head of the Redondo Submarine Canyon; the other has two seepage zones and is located about 4.6 mi off Manhattan Beach. It is estimated that an average of about 10 barrels (420 gal) of oil from the seeps reach the surface each day; additional oil probably does not surface, either deteriorating or forming tar balls underwater. The daily flow (to the surface) is estimated to range from 2 to 18 barrels (84 to 756 gal) per day, but may be several times this amount during and after local earthquakes.

In calm weather surface oil slicks several miles long have been observed; in windy conditions the slicks dissipate rapidly. Surface oil generally drifts northward, towards shore, reaching the beaches from Redondo Beach to Malibu in 1 to 2 days. In 1971, 18 to 836 oil globules were found in a 2,500 ft^2 area of sand along Redondo Beach and Manhattan Beach; about 86% of these deposits originated from natural oil seeps (Marconsult 1971). More recent studies suggest that about 75% of the tar on Santa Monica beaches is from the Santa Barbara Channel (Hartman and Hammond 1981).

Natural oil from the vicinity of the La Brea Tar Pits also seeps into the Ballona Creek drainage system, contributing to contamination of the Creek and the Bay, especially during periods of low flow (Mitchell 1988, pers. comm.).

At least two accumulations of refined petroleum products have been identified adjacent to the shores of Santa Monica Bay. Although there is no evidence that any of these products have seeped into the Bay, their proximity to it has raised concern by the general public and regulatory agencies.

El Segundo Refinery

During its first 77 years of operation, a variety of oil and refined products had leaked into the ground beneath the El Segundo Refinery (Chevron USA), from surface spills, storage tanks, and leaking pipes. The refinery is located atop sand dunes, under which three aquifers or subterranean layers of groundwater are located in sand beds separated by relatively impervious layers of clay. The removal of drinking water from the aquifers has caused seawater intrusion (Waters 1988).

For several years, Chevron contractors drilled numerous delineation wells to identify the size and nature of the contaminated pool located in the aquifers. The results indicated that the pool contained about 252 million gal, primarily crude oil, gasoline, and jet fuel. Most of the petroleum contaminants had accumulated in the uppermost of three aquifers. Trace amounts had been found in the middle aquifer while the lowermost aquifers (the only one from which drinking water is extracted) appeared uncontaminated. Having identified the nature of the pool, Chevron began a program to recover as much of the pool as possible. 1988 estimates indicated that 50 to 70% of the materials could be recovered over the next 20 years (Waters 1988).

Los Angeles International Airport (LAX)

During the years LAX has been operating, jet fuel has leaked into the ground beneath the airport from underground pipes or from the 500,000 gal storage tanks. Initial investigations indicated that the contamination extended to a depth of 60 ft and included the uppermost aquifer (which is brackish from saltwater intrusion), but the full extent of contamination is unknown (Kelley 1988).

Since the initial reports, LAXFUEL, a nonprofit consortium of 50 commercial airlines serving 98% of airline operations at LAX, has initiated investigations to characterize the extent of contamination. Phase I and II groundwater investigations were completed between 1989 and 1991. A free-hydrocarbon recovery system was approved by the RWQCB and installed in September of 1991. Since that time, approximately 10,000 gals of free-hydrocarbon product has been recovered. LAXFUEL is currently modernizing and upgrading its bulk storage facility, and conducting Phase III groundwater contamination investigations (Speelmans 1992, pers. comm.).

Impacts of Spills

Impacts of oil or other hazardous material spills can reach all areas of the environment. Birds and marine mammals can be affected by a surface oil slick, by bioaccumulation in the food chain, or by direct toxicity from chemical spills. As spilled contaminants disperse through the water column, they can affect plankton, both plant and animal, as well as fish. They can also have toxic effects on kelp and other algal species which provide habitat for many animals in the Bay. When an oil spill sinks it coats the bottom and it can smother benthic communities that live in the

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sand and mud. Oil that washes up on the beaches or the intertidal zone can coat and smother species that dominate those areas. The California grunion, a fish that spawns on sandy beaches could be heavily impacted if a spill occurred during spawning season. Land spills, as well as ocean spills, could move into biologically sensitive wetlands, which are nursery areas for many species. Many of these areas do not have adequate baseline (pre-spill) information to determine the impacts on the communities and populations if a spill did occur (Lees 1992).

Following the 1991 spill at the Chevron USA offshore terminal, there were no observed impacts to California grunion spawning, sand crab populations, and the Santa Monica Bay artificial reef at Malibu (where the spill contacted the shore) nor were petroleum hydrocarbons found in beach sand; however, there was some mortality of mussels, spiny mole crabs, and possibly smooth turban snails (MBC 1991a).

In addition to the biological effects, there are aesthetic and economic effects for the human population. Large areas could be closed for recreational activities such as fishing, swimming, surfing, diving and sunbathing. This has an extended effect on businesses that depend on these activities. The fumes of a spill occurring, or moving ashore, in a heavily populated area could also result in health effects. Toxic materials could accumulate in sportfish species, and also cause residual health problems.

Risk of Future Spills

Current plans for oil and gas lease activity appear not to add any increased risk for future spills. However, if exploration and drilling resume, the risk will increase.

Commercial shipping is expected to increase for the near future. Los Angeles/Long Beach Harbors are expanding berthing facilities in their 2020 Plan to meet expected increases. In 1990, 7,013 vessels arrived at both ports, with over 1,000 of these tankers. Over 10,000 are expected to arrive in the year 2000 (USACOE/LAHD 1992). This will mean more traffic in the shipping lanes, with potential spills or accidents more frequent. It is not clear what number of these vessels transit the shipping lanes offshore of Santa Monica Bay.

The number of tankers loading and unloading at the El Segundo refinery has been steady for a number of years, however, Chevron recently received a permit to tanker from Santa Barbara to Santa Monica Bay. Currently none of these tankers has had a major spill, but should one occur, it could have a significant impact in the bay as evidenced by the Huntington Beach spill in 1990.

Prevention and Response to Oil and Hazardous Materials Spills

In 1990, the State of California passed the Lampert/Keene/Seestrand Oil Act (SB2240) in response to the Exxon Valdez and American Trader oil spills. The result of this law was to create an Oil Spill Prevention and Response (OSPR) group in the California Department of Fish and Game (CDFG). The goal of the Act is to increase inspection of facilities, transportation equipment and vessels, and to promulgate regulations defining these needs. This will provide for behavioral changes to increase preventative procedures and increase the ability to respond to a spill.

The law states that every oil plant, transporter, and vessel in state waters have contingency plans, preventative methodology, and containment equipment on hand in case of a spill. This must include a list of contacts for reporting and assistance and identification of rescue and rehabilitation groups. A Response Unit must be created to assist in a spill, if needed. OSPR

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provides for Natural Resources Damage Assessment methodology to be applied to determine what impacts occur during a spill, and to provide help with remediation efforts after the event. One function of OSPR is to identify sensitive biological areas that would be most affected by a spill, and provide this information to maximize efforts to keep these areas from being impacted.

The Santa Monica Bay is within two of the OSPR response areas. One extends from San Luis Obispo to Point Dume, with the OSPR Coordinator stationed in Santa Barbara. The other extends from Point Dume to Dana Point, with the OSPR Coordinator stationed in Long Beach (John Grant 1992, pers. comm.).

In addition to California legislation, the U.S. government passed the Oil Pollution Act of 1990 (OPA 90), which addresses spill prevention and response and contains requirements similar to California's SB2240. In addition, federal regulations are also being written to cover marine transfer facilities, bulk cargo carriers for oil landings in the ocean and mobile facilities, e.g., pipelines, railroad transport, and tank trucks. These are expected to be released in 1993, and will only cover specific types of oil and facilities. The regulations covering other types of hazardous materials have not yet been written.

The U.S. Coast Guard, Long Beach, has created a Port Area Committee, which is making contingency plans for the local area. These plans are pre-designed responses to spills of any size and type, from small up to the worst case scenario (Exxon Valdez size). The plans designate response actions and responsibilities for management, so implementation can be as rapid as possible.

A more general set of regulations exist under MARPOL, issued by the International Maritime Organization of the United Nations, effective in 1983. Regulation 26, Annex 1, MARPOL requires response plans for all ships of 400 Gross Tons (GT) or greater and bulk oil carriers of 150 GT or greater, and will be in effect in 1995 for existing ships. The regulation is presently in effect for ships under construction (Panagakos 1992, pers. comm.).

Local agencies, primarily fire departments, respond to spills occurring on land. They are trained in containment and response procedures and maintain a list of agencies to notify in case of storm drain contamination. Local laws are in effect requiring businesses to provide hazardous material inventories to response agencies, and also require containment methodology and response plans to be present on site. A regular inspection program provides enforcement of this legislation. Inspection and response programs are also undertaken by interested groups, e.g., Ballona Creek Task Force.

DREDGING

Dredged sediments are the only materials that may be dumped into the Southern California Bight in large quantities, however, they must meet Ocean Dumping Act requirements (USEPA 1988). The Army Corp of Engineers, RWQCB,LAR and the EPA regulate and manage all dredging and oceanic dumping.

Dredging is necessitated by the accumulation of sediments around harbor entrances which pose potential navigation hazards to vessels. Removal of this material has typically been done by hopper dredges, clam shell dredges or dragging. Dredged material can be used for beach replenishment, landfill in harbors, dumped at oceanic dumpsites, or disposed in sanitary landfill sites. Disposal of dredge material must meet specific criteria for each disposal type. Beach replenishment material must undergo chemical analysis and meet grain size limitations for the

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location of disposal. Ocean dump site material has to undergo chronic and acute toxicity analysis as well as chemical analysis for trace constituents and heavy metals (USEPA 1988).

Historical Dredging in Santa Monica Bay

Net sediment transport in Santa Monica Bay is to the south in the northern part of the Bay and to the north in the southern portion of the Bay with the accumulation of the majority of materials at the head of the Redondo Submarine Canyon (Woodel and Holler 1991). Two areas of concern in sediment buildup are the Marina del Rey entrance channel and King Harbor.

King Harbor is uniquely situated along the coast at the head of the Redondo Submarine Canyon. Sediment transport and accumulation around King Harbor varies with seasonal, tidal and long shore current patterns. In general, transport of sediments is downcoast with accumulation on the upcoast side of the Redondo breakwater. Sediments transported around the breakwater are deposited at the head of the Redondo Submarine Canyon where they move down and off the nearshore shelf (Terry *et al.* 1956).

Between 1960 and 1963 the original Ballona Wetlands was dredged to create Marina del Rey Harbor and was, at that time, the largest dredging project on the West Coast removing approximately 10.1 million yds^3 of dredged material. Since that time, occasional dredging is necessary due to sediment deposition in the entrance channel of Marina del Rey. This deposition is partially due to the position of a breakwater off shore and parallel to the coast which creates an area of calm water inside the breakwater that facilitates the build up of sediment. Urban run-off from Ballona Creek also deposits material at the mouth of the harbor entrance. Dredge activities since 1969 have produced 664,080 yds^3 of material, ranging from 298,000 yds^3 in 1969, to 17,000 yds^3 in 1992 (Woodel and Hollar 1991, Chang 1992, pers. comm.). Dredge spoils from 1969 to 1987 dredge operations were disposed on the beach directly down coast of the Harbor entrance. Records were not available to determine if any chemical analyses were done for the 1981 and 1987 activities.

Present Dredge Sites

King Harbor was dredged in 1990 for the removal of accumulated sediments inside the Harbor following storm activities. In 1990, 156,000 yds^3 of material was dredged and used for beach replenishment 0.5 mi south of the Harbor. No chemistry data are available for this project because it was deemed clean and met all grain size criteria for disposal (Chow 1992, pers. comm.). All earlier dredging activities at King Harbor were similar to the 1990 dredging operations (Chow 1992, pers. comm.).

In 1992 approximately 17,000 yds^3 were dragged from the entrance of Marina del Rey Harbor to downcoast of the entrance, where long shore currents transported the material downcoast. Beach and LA-2 dumpsite disposal were not viable alternatives due to high levels of lead and heavy metal contamination which probably originated in run-off from Ballona Creek (Chang 1992, pers. comm.). Future dredging activities will be handled by dragging, as needed, until appropriate disposal sites can be found or measured contamination levels are below EPA regulations (Chang 1992, pers. comm.).

OCEAN DUMP SITES

The dumping of unwanted material at sea has been practiced for centuries and has been regulated by federal law since 1886, originally to prevent navigational obstructions. EPA permitted ocean dumpsites are point sources in the sense that only specified amounts of specific materials can be disposed in a prescribed area. In practice, however, every load is not carefully monitored, and the kind and amount of material dumped may differ from what is permitted. In addition, "short-dumping" (i.e., dumping before the vessel reaches the designated site to save vessel time and money) of materials may be common. Accurate records of dumping activities at dumpsites are generally lacking.

Illegal dumping has occurred in the study area, but quantification of the kinds and amounts of materials dumped is almost impossible. The California Salvage Company illegally dumped industrial wastes off White Point on the Palos Verdes Peninsula on two occasions in 1968, but it is not known what or how much waste was dumped in the area (Chartrand *et al.* 1985).

Historical Dumping

Industrial wastes have been dumped into San Pedro Channel since the 1930s and continued more or less unregulated until 1967. Between 1967 and 1972 dredge spoils, oil refinery wastes, chemical wastes, filter cake, oil drilling wastes, refuse and garbage, radioactive wastes, and military explosives were dumped at 17 regulated dumpsites off Southern California (Figure 6-2). In 1972 the Marine Protection, Research, and Sanctuaries Act (Ocean Dumping Act) was enacted to regulate ocean dumping more closely and the disposal of hazardous materials (chemicals, munitions, bacteriological agents, etc.) at any offshore site was forbidden (Chartrand *et al.* 1985).

Prior to 1973 industrial wastes were dumped at a site (LA-1) in the San Pedro Channel, approximately 10 mi northwest of Santa Catalina Island in 2,500 ft of water (Figure 5-1). Between 1947 and 1960 the California Salvage Company dumped about 125 million gal of caustic and acid wastes from oil refineries and 2,000 to 3,000 gpd of acid sludge from the Montrose Chemical Company. This sludge contained DDT and it is estimated that over the years between 348 and 696 MT of DDT were dumped. Because of new oil refinery methods the total volume dropped from 1.2 million gal per month to 210,000 gal per month in 1961. Approximately 3 million gal of refinery wastes were dumped between 1961 and 1972 (Chartrand *et al.* 1985).

In 1961 the RWQCB,LAR began regulating ocean dumping, requiring that wastes be in containers which were perforated just before they were dumped. Between 1965 and 1972 about 0.8 million gal of aluminum chloride and 0.3 million gal of cyanide were dumped in the ocean. Solvents and acid wastes, beryllium, cesium, bromine, and film-processing materials were also included (Chartrand *et al.* 1985).

Between 1961 and 1964 the Pacific Ocean Disposal Company also dumped liquid and solid wastes at LA-1. Most liquid wastes were pumped directly overboard, but some liquid and the solid wastes were in containers. About 1.6 million gal of sodium hydroxide and 0.1 million gal of calcium fluoride were dumped; polymer acid sludge, acid wastes, nitric-hydrofluoric acid, paint and lacquer, and hydrolyzed aluminum chloride solution were also present (Chartrand *et al.* 1985).

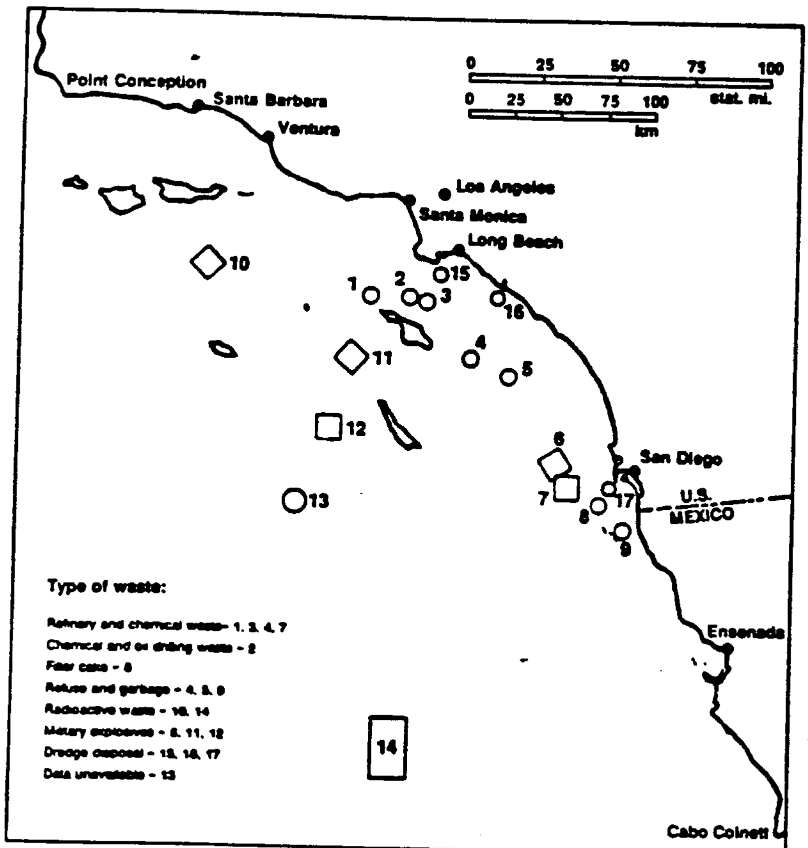

Figure 6-2. Designated ocean dumping sites in the Southern California Bight, 1931-1978 (modified from Chartrand *et al.* 1985).

The Texaco Humble Union Mobile Standard (THUMS) dumpsite is a 3 mi diameter circular site near the center of the San Pedro Basin at a water depth of 2,910 ft (Figure 5-1). The closest edge is approximately 8 mi from the study area. This site was designated by the EPA in 1985, for a period of three years, for the disposal of drilling muds and cuttings from THUMS' production operations in Long Beach Harbor. The drilling muds are similar to those approved by the EPA under a blanket permit for disposal in Outer Continental Shelf (OCS) waters (Chartrand *et al.* 1985). The THUMS dumpsite was in use for about one year (1986-1987), during which time about 50,000 barrels of drilling muds and cuttings were pumped from a barge as a slurry. THUMS did not reapply for an extension to the permit, allowing the site to become inactive (Otott 1988, 1992, pers. comm.).

LA-2 Dumpsite

At present there is one permitted dumpsite near, but outside of the study area (Figure 5-1) (Chartrand *et al.* 1985). This site may contribute to contamination of the Bay via advection but no estimates have been made of the amounts of material which might have moved toward shore.

The LA-2 dumpsite is a 1.1 mi diameter circle at a water depth of 600 ft, about 1.5 mi south of the study area (Figure 5-1). The site was given interim status by the EPA in 1977 for the ocean disposal of dredged materials (Rote 1985). Fine sediments which might be contaminated are tested in a laboratory bioassay before they can be dumped in the ocean, and if found to be toxic, are land-disposed.

The material dumped at LA-2 originates from maintenance and construction dredging in Los Angeles and Long Beach Harbors, which have multi-year permits for the disposal of dredged sediments. From 1978 to 1988 the U.S. Army Corps of Engineers issued permits for the disposal of 2.1 million yd^3 of dredged material at LA-2, but only 1.6 million yd^3 had been dumped. An average of about 180,000 yd^3 of material was dumped each year (USEPA 1988, Welch 1992, pers. comm.).

In 1989 SCCWRP estimated the quantity of material dumped and inputs of trace contaminants contained in disposed dredged material from 1984 to 1988. Six permit applications for dumping dredged material into LA-2, involving a total of 386,000 yd^3 were examined. Chemical data were available for only one dredge activity of 46,000 yd^3. It was assumed that the volume of dredged material discharged was equal to the amount permitted to be dumped in the application. Mass emission values were calculated from the available chemistry data and the total amount of sediments discharged. Due to the small size of the database it was difficult to determine exact mass emissions rates but a general trend can be distinguished. In general, the concentrations of contaminants in dredged materials is one-half to one-sixteenth those in municipal wastewater effluent. Although only limited chemical analysis of dredged materials has been conducted, dredge materials can reintroduce trace levels of constituents into the environment (SCCWRP 1989).

From January 1989 to March 1991 the LA-2 dumpsite was closed to dumping activities while an EIS was completed by the EPA (Cotter 1992, pers comm.). In March 1991, the LA-2 site was reopened under a new designation which allowed for continued dumping over a five year period. During this time potential environmental impacts will be monitored using current meter arrays, satellite imaging, and analysis of fisheries data. Continued use of the LA-2 dumpsite at the end of the five year period will be based on the environmental findings from this monitoring program. In the event EPA closes the LA-2 site, an alternative site must be designated within two years (Cotter 1992, pers. comm.). The EPA holds the final approval over permitting and can

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reassign the disposal of dredge material to land fills, beach restoration, and alternative ocean dump sites as needed (USEPA 1988).

Currently the Port of Long Beach has a five month contract ending in April 1993 for the disposal of approximately 710,000 yd^3 of dredged material at the LA-2 site. Other dredge contracts are planned for the Los Angeles and Port of Long Beach Harbors but anticipated dredged amounts are unknown at this time (Cotter 1992, pers. comm.).

ADVECTION

Advection is the transport of material by ocean currents. Prevailing currents not only disperse contaminants which are discharged into the Bay, but bring contaminants into the Bay from other areas. However, current patterns in the study area are complex and not well-known and very little effort has been expended in estimating the mass balance between contaminants entering and those leaving the Bay.

In general, water enters and exits at the seaward edge of the study area, along the 500-m isobath. Surface water generally enters from off Ventura County or Redondo Canyon and leaves at the same places or to the south, offshore of the Palos Verdes Peninsula. Recent studies suggest that a clockwise gyre is dominant seaward of the 20-m isobath (Hickey 1988, pers. comm.), but a counterclockwise gyre has been observed in Santa Monica Bay. Surface currents generally flow south off the Palos Verdes Peninsula, while below 90 m, water enters the study area from the south.

Oil slicks, contaminants in the surface microlayer, and other floatables are likely to be transported into the Bay by wind-generated currents and waves. Tar from the Santa Monica Channel is carried into the Bay by advection (Hartman and Hammond 1981). Contaminants form the Los Angeles-Long Beach Harbor may enter the Bay from the south, in the subsurface current which flows north along the Palos Verdes Shelf.

The sediments at nearby ocean dumpsites may constitute reservoirs of contaminants which, if resuspended, could be transported into the Bay in deep currents. However, the general pattern is for fine sediments to move offshore and into basins where they are deposited. Thus, the likelihood of significant amounts of contaminants moving against that natural gradient is remote.

Sea Surface Microlayer

Many anthropogenic substances, such as trace metals, chlorinated and petroleum hydrocarbons, and plastics, accumulate in the sea surface microlayer. Little information exists on the distribution of contaminants in the microlayer in Santa Monica Bay because effective sampling methods have only recently been developed (SCCWRP 1986d, Cross *et al.* 1988).

In general, trace metal and PAH concentrations in the microlayer are higher by orders of magnitude in inshore areas of harbors than in offshore areas (SCCWRP 1986d, Cross *et al.* 1988). Chlorinated hydrocarbons were not detected in offshore areas but occurred in low levels at King Harbor. Benzo(a)pyrene, a carcinogenic and mutagenic PAH, has been found in the microlayer of King Harbor (Puffer 1988, pers. comm.).

The dominant trace metals in the particulate phase of the microlayer in King Harbor were iron, manganese, and zinc with concentrations of 1,105; 20; and 12 $\mu g/l$. The most important

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metals in the dissolved phase at King Harbor were copper, zinc, and manganese with concentrations of 4.14, 3.44, and 2.97 µg/l; at White Point these were iron, zinc, and copper with concentrations of 4.48, 3.93, and 2.08 µg/l (SCCWRP 1986d).

Oil and grease concentrations in the microlayer were 1.04 µ/l on the Palos Verdes Shelf at White Point. Total PAH levels were 2.65 µ/l at King Harbor and 0.59 µ/l at White Point. Total DDT occurred at 11 µ/l at White Point (SCCWRP 1986d).

Water Column

Most contaminants enter the ocean dissolved in or carried by water. However, their concentrations are affected by circulation rates and patterns and are often low; rapid dilution of point discharges makes concentrations even lower. Impacts are usually observed only in biota carried along with the water mass and exposed for longer periods.

Debris

Natural and anthropogenic debris are most visible at the surface of the sea and at the shore. The distribution of debris is generally determined by wind or currents, and is not necessarily related to its origin. No estimates are available on the relative contributions of marine versus terrestrial sources, but tons of debris are removed annually from the shoreline of Santa Monica Bay. Much of this material, such as kelp, is natural and is removed for aesthetic reasons. Natural debris is eventually decomposed or consumed whereas man-made refuse, especially plastic, is persistent.

Ever increasing amounts of plastic debris are found at sea and on the shore. The average daily production of solid waste in Los Angeles County has increased from 10 lb per person in 1980 to 12 lb per person in 1988 (MBC 1988). Although data are not available, trends in the marine environment probably parallel those of land disposal.

Heat

In enclosed areas the addition of heated ocean water by power generating stations can cause severe impacts. In open coastal waters, waste heat seldom creates environmental problems. Waste heat from the three generating stations in Santa Monica Bay is detectable only in the nearshore surface waters between Dockweiler Beach and the Redondo Submarine Canyon (Figure 6-3).

The Thermal Plan prohibits a surface temperature elevation of more than 4°F above ambient following initial dilution and local power plants comply with this limitation (EQA/MBC 1973, IRC 1973). Areas of Santa Monica Bay which are affected by waste heat are actually smaller today than in 1973 because the availability of hydroelectric power from the Pacific Northwest has allowed most local power plants to operate below peak loadings. Two of the Redondo Generating Station's 8 units are now out of service, reducing the total potential for thermal pollution of the Bay.

Turbidity

Coastal waters are frequently murky, as a result of phyto- and zooplankton or of fine sediment suspended by nearshore turbulence. This natural phenomenon is often visible from the beach after a storm, when nearshore waters are brown, and offshore waters blue or blue-green.

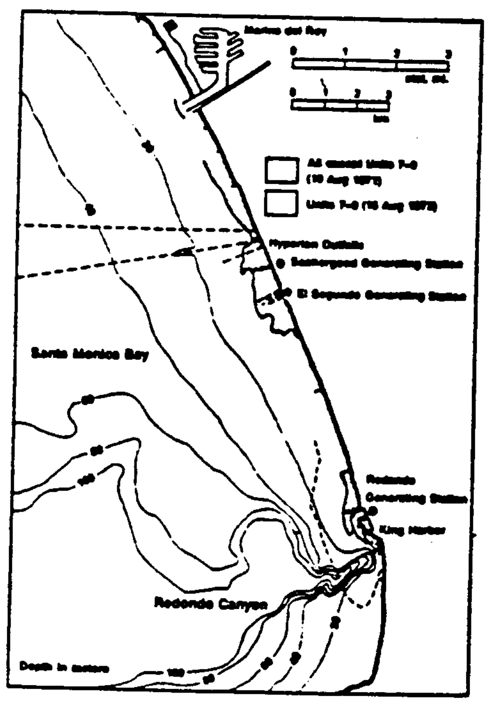

Figure 6-3. Maximum extent of 1F° above ambient thermal field from the Scattergood, El Segundo, and Redondo Generating Stations, August 1971 (Eliason and Foote 1972, EQA/MBC 1973).

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Both plankton and suspended sediments interfere with light penetration into seawater and restrict growth of seafloor plants.

Within a mile of shore, turbidity usually limits light penetration to less than 20 ft off sandy beaches and 20 to 40 ft off rocky shores (SCCWRP 1973). Off landslide areas at Portuguese Bend on the Palos Verdes Peninsula, turbidity is higher and light penetration less. Seaward of the surfzone, turbidity declines and light penetration increases.

Around the HTP 5-mile outfall the turbid plume caused by outfall particulates seldom reaches the surface; it usually remains below the thermocline, at depths of 65 to 100 ft (Kolpack 1979). Turbidity is highest near the ends of the outfalls but is rapidly reduced by dilution. Initially the plume moves southeast and toward shore, where it mixes with natural nearshore turbidity; it is then transported seaward by tidal currents.

Currents on the Palos Verdes Shelf are complex but primarily move along shore and toward the northwest. In the late 1970's, the turbidity plume from JWPCP outfalls rose to within 45 ft of the surface, and extended westward to Palos Verdes Point (Sweeney and Kaplan 1980). This plume most affected light transmission near-bottom, where it formed a flocculent particle layer (Meistrell and Montagne 1983).

Water transparency in the study area generally increased between 1956 and 1979 (Mearns 1980); a trend which continued off Palos Verdes through 1985 (Stull *et al.* 1987). Additional studies would be needed to determine whether the increase in water transparency was a function of water temperature or the decrease in particulates discharged.

Metals

Trace metals in the water column are found in two phases: dissolved and particulate. In the open ocean most metals are predominantly present in dissolved form, but in nearshore waters more are associated with particulates. Dissolved metals in marine waters are generally very low, even adjacent to outfalls (Katz and Kaplan 1981). Dissolved cadmium levels near the JWPCP outfall were about the same as those at control sites but chromium was elevated two-fold, nickel four-fold, and copper six-fold near the JWPCP outfalls (Young and Jan 1975).

Over 90% of the metals in wastewater of the study area associated with particles (Young and Jan 1975). Ninety percent of the particles in the HTP 5-mile effluent and 75% in the JWPCP effluent remain suspended for at least 3 hr and travel 6 mi or more before settling (Herring and Abati 1978). Metals concentrations on suspended particulates near JWPCP were elevated 8 (cadmium) to 65 (chromium) times over background levels. The average enrichment (over background) of mercury on particulate matter near the JWPCP outfall was 36-fold. When the HTP 7-mile outfall was in operation, mercury enrichment ranged from 36 to 191 times, averaging 49.

The concentration of organotin compounds (tri-, di-, and monbutlytin) have been measured in seawater from both Marina del Rey and King Harbor. In King Harbor, total organotin levels ranged from 0.171 to 0.480 ppb, with tributyl tin (TBT) levels between 0.021 and 0.060 ppb (Stallard *et al.* 1986). TBT and total organotins were both higher in Marina del Rey water, TBT reaching 0.470 ppb (Soule and Oguri 1987). Dissolved tin compounds were not detected outside of enclosed marinas.

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Inorganic Nonmetallic Nutrients

Nutrients are introduced to the photic zone in runoff, via upwelling and destratification of the water column, and by sewage disposal. They stimulate plant growth and are generally beneficial, although excessive algal growth can have deleterious effects. Nutrients in the water column are linked with those in sediments by cyclic chemical transformations. Nitrogen is found in numerous forms including ammonia, nitrate, organic nitrogen, and nitrogen gas (Valiela 1984). After advection and upwelling, sewage was the most important source of these materials.

Nitrogen is never available for long in the open ocean. Nitrate, nitrite, and ammonia uptake by plants is swift and prevents their accumulation in surface water. Both nearshore and offshore ammonium inputs were clearly visible along the HTP 5-mile outfall in Santa Monica Bay (Figure 6-4) (Eppley *et al.* 1979). Inshore, near the El Segundo Refinery outfall, surface waters showed elevated ammonium on 7 of 10 cruises between 1975 and August 1977. Elevated levels have not been measured there since August 1977 and even the highest observed levels pose no hazard to exposed organisms (Eppley 1986).

Toxic substances such as chlorine, sulfide, cyanide, and asbestos fibers are introduced with both sewage and runoff waters and by fallout or in solution from the air. Chlorine is generally introduced only as residual chlorine in sewage following its application as a disinfectant and is present in wastewater as chloramines. At present, HTP does not routinely chlorinate its 5-mile effluent (nor did it chlorinate its sludge), although it chlorinates overflows discharged through the 1-mile outfall. JWPCP routinely chlorinated its effluent from 1972 to 1985 during cold months when the thermocline is absent and year-round since September 1985 (Ackerman 1988, pers. comm.; Weisman 1992, pers. comm.). The discharge limit for chloramine is 0.3 mg/l - typically it is <0.1 mg/l (the detection limit) (Stull 1993, pers. comm.).

The three generating stations in the Bay use chlorine to control biofouling growth in cooling systems, but under normal circumstances none is discharged into the Bay. It is not known whether significant levels of by-products of chlorination, such as chloramines and bromamines, occur in this effluent.

Data on dissolved sulfides and cyanide are not available from the study area. Asbestos has not been monitored sufficiently in the study area to establish either distribution or input levels (MBC 1988).

Organic Contaminants

Contrary to popular belief, all organic materials are not contaminants. The input of natural, terrestrial organic material via rivers predates man's influence and is an essential part of the normal nutrient cycle. However, man has controlled the input of organics to the sea by diverting them to drainage channels or sewage waste streams. Basic measures of organic loading in waters and sediments include biochemical oxygen demand (BOD), chemical oxygen demand (COD), and organic carbon. These quantify organic matter in terms of oxidation demand or carbon content. In open water such as the study area, dissolved and particulate organic materials almost never depress available oxygen below levels safe for marine organisms on the continental shelf. Particulate organic material may, however, be present to excess.

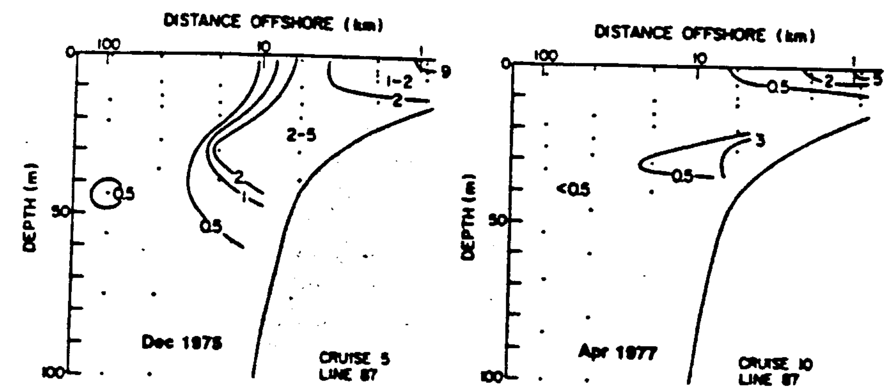

Figure 6-4. Concentrations of ammonium in ug-atoms/l from shore through mid-Santa Monica Bay parallel to the HTP outfalls in December 1975 and April 1977 (Eppley et al. 1979).

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Biological Pathogens

Bacteria, viruses, and protozoans are introduced into marine waters at sewage outfalls, bathing beaches, and storm drains. To minimize pathogens, sewage effluents which are discharged nearshore are treated (i.e., disinfected) with chlorine. Once introduced into the marine environment, pathogens are found both free in the water column and on particulates. Biological pathogens are discussed in more detail in Chapter 11.

AERIAL FALLOUT

Aerial fallout is a diffuse and potentially large source of contaminants which also derive from other sources. However, it is probably the least controllable source and possibly the most difficult to quantify. Relatively few studies have been conducted to assess the kinds and amounts of contaminants which enter the ocean via this path. Trace metals, chlorinated hydrocarbons, and PAHs (SCCWRP 1973, 1986a) have been identified in aerial fallout to the study area.

During the late 1960s zinc, lead, and manganese were the most abundant trace metals in rainfall in southern California. Bight-wide, it was estimated that the mass emissions of lead, mercury, and manganese in aerial fallout actually exceeded those from discrete sources. However, given the smaller area and the presence of two major sewage discharges, this is not likely to be true for Santa Monica Bay and the Palos Verdes Shelf. The mass emissions of copper and zinc in aerial fallout in the Bight were about the same as from discrete sources and those of iron and nickel were less (SCCWRP 1973). Levels of lead in aerial fallout were greater in the vicinity of Los Angeles than on the offshore islands.

Bight-wide, dry-weather fallout emissions of DDT and PCB in 1973-1974 were lower than those from municipal wastewater, about 1,300 and 1,500 kg/yr, respectively (SCCWRP 1973, Young and Heesen 1976). The highest fluxes of dry-weather aerial fallout of DDT in the Bight were at Santa Monica and Point Fermin where averages were estimated at 0.665 and 0.575 $\mu g/m^2$ per day, respectively. For comparison, Point Dume and Palos Verdes Point averaged 0.280 and 0.155 $\mu g/m^2$ per day, respectively (Young *et al.* 1976b). Based on the area of the present study and average fluxes at the four sites, the mass emission of DDT to Santa Monica Bay during that period was about 113 kg/yr.

Dry-weather PCB fluxes in 1974 were 0.650, 0.500, 0.190, and 0.052 $\mu g/m^2$ per day at Santa Monica, Point Fermin, Point Dume, and Palos Verdes Point, respectively (Young *et al.* 1976b). The mass emission to Santa Monica Bay during this period is estimated at 94 kg/yr.

DDT was manufactured at the Montrose Chemical Plant in Torrance; until 1972, Montrose disposed of DDT process wastes at the Palos Verdes Landfill on the Palos Verdes Peninsula. The flux of DDT from the air near the plant and landfill were 31 and 16 times higher, respectively, at Santa Monica, whereas the flux of Aroclor 1254 was about twice as great at the Montrose plant as at Santa Monica (Young *et al.* 1976b). The flux of both DDT and PCB to Santa Monica Bay was twice as high during Santa Ana wind conditions as during normal dry weather (Young and Heesen 1976). In 1986 chlorinated hydrocarbons in the sea surface microlayer were higher near Los Angeles than further offshore (SCCWRP 1986d), possibly reflecting aerial fallout.

Brush fires create pulses of trace metals to the atmosphere by mobilizing metals deposited on foliage. In 1975 smoke from a large brushfire in the Angeles National Forest was carried out over Santa Monica Bay and the aerial fallout of most metals increased. The fluxes of

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manganese, iron, and chromium were 6 to 8 times higher than normal; the area directly beneath the smoke cloud had by far the highest levels (Young and Jan 1975).

Airplanes departing Los Angeles International Airport fly directly over Santa Monica Bay. The combustion of jet fuel and gasoline probably contribute to the aerial fallout in this region. PAH and other hydrocarbons may be especially high in fallout below this air corridor although this has not been quantified. In addition, airplanes experiencing difficulties have been known to dump fuel over the ocean before attempting to land.

CHAPTER 7
URBAN RUNOFF

Urban runoff is probably the most important of nonpoint sources of contamination to Santa Monica Bay and has been the focus of much public, political, and scientific attention during the past five years. Surface runoff (consisting of stormwater and nuisance water) is transported to the Bay via the watershed's drainage channels (i.e., natural creeks and open or enclosed storm drains). Because surface runoff from urban areas generally transports more contaminants than natural creeks, surface runoff is generally called urban runoff.

In many parts of the country, the storm drain and sewer systems are combined into a single system. However, in southern California the storm drain system is separated from the sewage system because storms are infrequent and heavy in flow. Because urban runoff is not treated it may now be the most significant source of contamination to Santa Monica Bay. Surface runoff is discharged to the ocean via about 80 storm drains. Because there are so many drains and because the flow varies with the time of year, it has been difficult to quantify the kinds and amounts of total contamination.

Surface runoff probably constitutes an important source of trace metals, pesticides, and coliform bacteria. As the quality of sewage effluent has improved over the years, the relative contribution by storm drains has increased, even if its absolute contribution has remained the same.

DRAINAGES TO THE BAY

Drainage Area

The total natural drainage area of Santa Monica Bay comprises about 414 mi^2 (SMBRP 1992). In the north part of the Bay, the natural drainage follows the crest of the Santa Monica Mountains from just west of the Los Angeles-Ventura County Line to Hollywood; a small crest separates the drainage west of Point Dume from that to the east (Figure 7-1). From the Santa Monica Mountains it extends south to Ballona Creek and the Baldwin Hills and east to downtown Los Angeles. South of Ballona Creek, the natural drainage is a narrow coastal strip from Playa del Rey to Point Fermin on the Palos Verdes Hills.

Inland, urban runoff from most of the wasteshed of Santa Monica Bay (i.e., the area with sewer lines leading to Hyperion Treatment Plant and the Joint Water Pollution Control Plant) flows into the Los Angeles River, San Gabriel River, and Dominguez Channel, all of which drain into Los Angeles and Long Beach Harbors (Figure 2-1). Hence, while most of the sewage from the metropolitan area of Los Angeles County discharges into Santa Monica Bay, most of the urban runoff from the same area discharges into Los Angeles-Long Beach Harbor in San Pedro Bay.

Drainage Channels

Numerous storm drains (pipes or open channels) empty onto or across the beaches of the study area (Figure 7-1). There are at least 10 between the Los Angeles-Ventura County Line and Point Dume (Terry *et al.* 1956) and 68 between Big Rock Beach (east of Malibu) and Point Fermin; 37 of these are maintained by the Los Angeles County, Department of Public Works (LAC,DPW) and 31 by other organizations (LAC,DPW 1985). Along the Malibu and Palos Verdes coasts there are many small drains which collect runoff from a single street, parking lot, or small arroyo. Presently LAC,DPW is in the process of mapping drainage channels maintained by the cities in the study area (Hildebrand 1993, pers. comm.).

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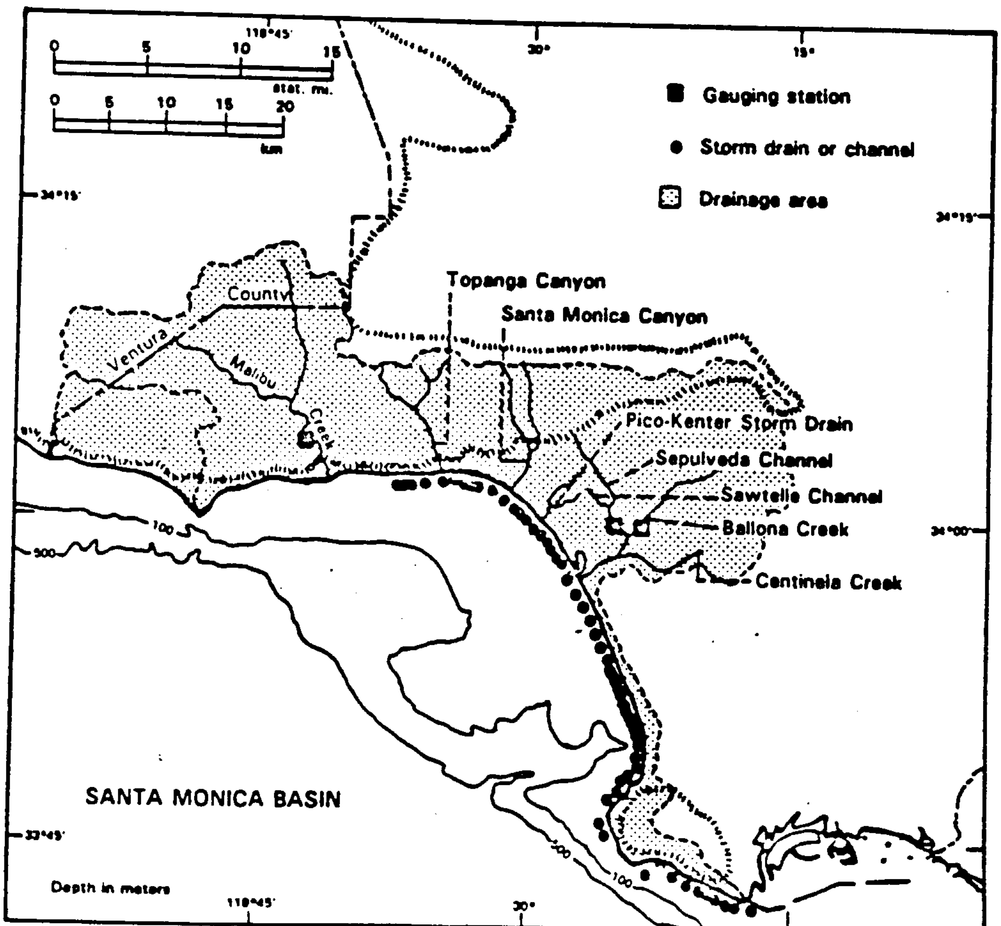

Figure 7-1. Present watershed and major drainage channels of Santa Monica Bay. Each dot represents one storm drain or channel (modified from LAC,DPW maps).

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Of the major drainage channels in the area, Ballona Creek (including Centinela Creek and Sepulveda Channel) is channelized; Pico-Kenter and Santa Monica Canyon are partially enclosed storm drains; while Malibu Creek and Topanga Canyon are natural creeks. Ballona Creek drains about 90 mi^2 and Malibu Creek drains about 103 mi^2 (LAC,DPW unpubl. data).

The water quality of Marina del Rey is influenced by point source and nonpoint source discharges which enter either the Marina or adjacent contiguous waters (Soule *et al.* 1992). Ballona Creek, Ballona Lagoon, and the Oxford Flood Control Basin collect runoff from urban areas which enters the Marina as a result of tidal exchange or storm water runoff (Soule *et al.* 1992). Oxford Street flood control channel is one of the smaller drainage channels in the watershed, however, it is important because it drains into the Marina through a tide gate. Although Ballona Creek flood control channel carries a much larger volume of water from a larger area than Oxford Street basin, Ballona Creek seems to have less of an impact on the Marina (Soule *et al.* 1992). Heavy wet weather flow will carry much of the debris into Santa Monica Bay, but during dry weather low flow, debris will enter the Marina on rising tides.

RUNOFF FLOW RATES

Surface runoff has two major components: rainfall and nuisance water (street runoff from domestic activities, irrigation water, and commercial and industrial discharges). In the dry season, from May to October, surface runoff consists primarily of nuisance water. In the wet months, from November to April, most of the surface runoff is from rainfall.

Annual Flow

The average surface runoff flow to Santa Monica Bay from all storm drains and creeks has been estimated at 143 to 153 mgd (NRC,COWT 1984; Garber and Wada 1988). However, flow rates vary widely by season, by year, and during a storm due to the amount of rainfall. Ballona Creek and Malibu Creek are the major channels in the drainage with gauging stations. However, because the gauging stations are located upstream, they do not measure the entire flow from either creek (Figure 7-1). Hence, the absolute flows are actually larger than indicated below. Santa Monica Creek and Sepulveda Channel also have gauging stations (Engineering Science 1987) but flow rates are not measured on a regular basis at these locations. The Topanga Canyon gauging station was destroyed during a storm in 1992 and at present there are no plans to replace this station (Hildebrand 1993, pers. comm.).

In normal (i.e., dry) years the annual flow in Ballona Creek is typically 2 to 10 times greater than that in Malibu Creek whereas in wet years the two flows are more comparable (Figure 7-2). For instance, in 1984 (a dry year), the Ballona Creek mean annual flow was 19 mgd whereas that of Malibu was 12 mgd (MBC 1988). Similarly, in the dry years of 1988 to 1991, the mean annual flow from Ballona Creek was 24 mgd whereas that of Malibu Creek was 10 mgd (LAC,DPW, unpub. data). In contrast, in 1983 (a very wet year) the flow in Ballona Creek was 81 mgd while that in Malibu Creek was 82 mgd. However, in some wet years the flow from Malibu Creek is higher than that of Ballona Creek. For instance, in 1969 the Malibu Creek flow was about 1.5 times that of Ballona Creek. Similarly, in 1992 (January to September) the average daily flow in Malibu Creek was almost twice that of Ballona Creek (LAC,DPW unpubl. data).

Flow rates for Topanga Creek were only available for 1989 (a dry year). Flows averaged 0.2 mgd in Topanga Creek while flows averaged 6 mgd and 15 mgd in Malibu and Ballona, respectively (LAC,DPW unpubl. data).

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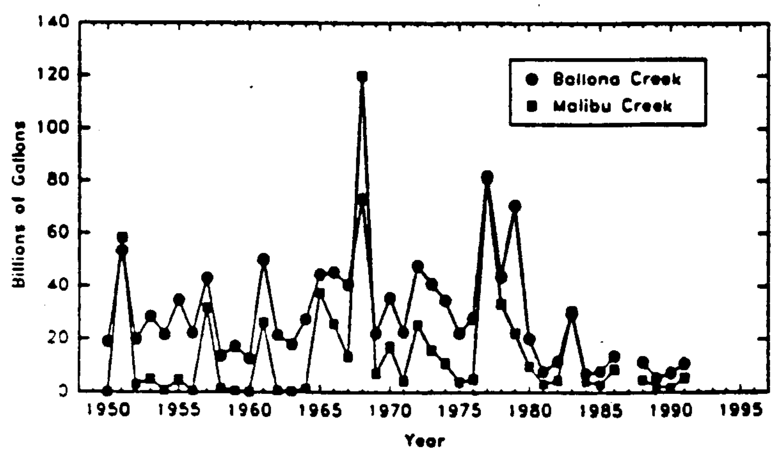

Figure 7-2. Annual flow from Ballona and Malibu Creeks for 1950-1991 (LAC,DPW unpubl. data).

Seasonal Flow

In addition to annual variation in flow there is seasonal variation between wet-weather (storm) and dry-weather months. In water year 1971-1972, wet- and dry-weather flows were estimated on the basis of instantaneous volumetric flows which were extrapolated to seasonal and annual flows for Ballona Creek, Pico-Kenter Storm Drain, and Malibu Creek (SCCWRP 1973). The annual flow during that period in Ballona Creek was about 10 times that of the Pico-Kenter Storm Drain or Malibu Creek, although only dry-weather flow was reported for Malibu Creek. In Ballona Creek wet-weather flow was 1.7 times greater than dry-weather flow, but in Pico-Kenter Storm Drain wet-weather flow was about 33% of dry-weather flow (SCCWRP 1973).

Based upon 1983 gauging station records, about 48% of the total flow in Ballona Creek and about 64% of it in Malibu Creek occurred during January and March. In 1984 about 39% of the total runoff in Ballona Creek was in December (LAC,DPW, unpubl. data). In 1991, 22% of the flow in Ballona Creek occurred in December and 65% occurred from January to March; however, in Malibu Creek about 15% occurred in December and 81% in January through March. Based on 1992 gauging station data for January through September, 86% of the total flow in Ballona Creek and about 88% in Malibu Creek occurred during January through March.

Storm Flows

Surface runoff is highest during and following storms and hence is usually highest during the winter. About 70% of the surface runoff in southern California occurs during storms (NRC, COWT 1984). During a storm in 1986, the peak flow in Ballona Creek was 275 times the dry weather flow (Schafer and Gosset 1988a).

CONSTITUENTS OF URBAN RUNOFF

Surface runoff carries large quantities of sediment, debris, and dissolved materials to the ocean. Many of these constituents are characteristic of natural runoff and do not pose a problem to the environment. However, some contaminants are potentially a threat to human health, impact the marine habitat, or affect the aesthetic qualities of the Bay. Three categories of pollutants found in stormwater/urban runoff are of concern in Santa Monica Bay because of their potential impact on the marine environment and human health. These include toxic compounds, biological pathogens, and litter. Naturally occurring nutrients and sediment from construction activities may also impact enclosed bodies of water such as wetlands or streams.

Existing monitoring programs conducted by LAC,DPW include regular dry weather and storm sampling at Ballona Creek, Pico-Kenter Drain, Malibu Creek, Santa Monica Canyon Channel, Topanga Canyon, and Dume Creek (Hildebrand 1993, pers. comm.). Several one-time studies have also examined levels of constituents in urban runoff from the area (LAC,OCAO 1981; Schafer and Gosset 1988b; UCLA and WCC 1992).

Sediment

Sediment naturally enters runoff during storms when rainwater flows over open areas. During the periods when the Los Angeles River discharged into Santa Monica Bay via Ballona Creek, storms probably transported large quantities of sediment to the Bay from the enlarged watershed area. However, even in the absence of a connection with the Los Angeles River, more sediment would have been transported in Ballona Creek prior to the construction of flood control channels during the early [illegible] of the 20th century (Terry *et al.* 1956) because the land in the drainage was less developed. Suspended sediments have not been measured in all surface runoff entering Santa Monica Bay, but aerial photographs of runoff plumes suggest that emissions are substantial, especially in natural drainages along the Malibu coast (Mitchell 1987, pers. comm.).

Mass emissions of silt are still highest in Ballona Creek. In water year 1971-1972, mass emissions of silt from Ballona Creek, Malibu Creek, and Pico-Kenter Storm Drain were estimated at 10,800, 1,000, and 700 MT, respectively. About 93% of the silt from Ballona Creek and about 71% from Pico-Kenter was discharged during storm flows (SCCWRP 1973). Sources of this silt include dust blown into the watershed by winds and sediments from upstream construction sites.

The soil in terrestrial areas adjacent to the Oxford Street flood control channel is highly contaminated with trace metals, pesticides and PCBs accumulated from earlier dumping or from World War II industrial contamination (Soule *et al.* 1992). During rainstorms, excavated soils erode and become suspended carrying pollutants into Marina del Rey harbor (Soule *et al.* 1992).

Naturally Occurring Dissolved Constituents

Naturally occurring compounds and metals dominate the dissolved solids in surface runoff. These constituents are abundant in surface runoff in both developed and undeveloped areas and are not considered to be harmful. Naturally occurring dissolved solids in surface runoff include calcium carbonate, bicarbonate, sulfate, chloride, calcium, sodium, magnesium, organic carbon, potassium, nitrate, nitrite, ammonia, iron, flouride, barium, and manganese, with traces of other metals. These constituents form the background environment to which contaminants or pollutants from human activities are added. Nevertheless some human activities in the watershed may increase concentrations and emissions of some of theses constituents.

From 1962 to 1982 the overall most abundant constituents from the five major drainage channels in the watershed were calcium carbonate, chloride, calcium, barium, and boron (Garber and Wada 1988). In 1983-1984 and 1989-1990 the major constituents of the surface runoff from Malibu Creek, Santa Monica Canyon, Pico-Kenter Storm Drain, Ballona Creek, and Centinela Creek were calcium carbonate, bicarbonate, sulfate, chloride, and calcium (Tables 7-1, 7-2) (LAC,DPW unpubl. data). The most abundant metallic ions were calcium, sodium, magnesium, and potassium. Dominant metals include iron, boron, and barium; abundant nonmetallic, inorganic constituents were chlorides and nitrates.

Constituent levels differ somewhat between drainage channels. In 1971-1972 mass emissions of most constituents were 5 to 10 times greater in Ballona Creek than in the Pico-Kenter storm drain or Malibu Creek (SCCWRP 1973). In 1983-1984 total dissolved solids (TDS) and the major constituents (calcium carbonate, bicarbonate, and sulfate) in surface runoff of Ballona and Malibu Creeks were comparable (MBC 1988). In 1989 mass emissions of constituents in surface runoff were generally higher in Ballona Creek than in Malibu Creek (Table 7-3) (M. Stenstrom, Univ. Calif., Los Angeles, unpubl. data; LAC,DPW, unpubl. data). This was due in part to a flow in Ballona Creek that was more than twice that of Malibu Creek. Sulfate was dominant in both creeks but chloride, calcium, and sodium followed in Ballona Creek whereas in Malibu Creek, the order of the last three constituents was reversed (i.e., sodium, calcium, and chloride).

Contaminants

Constituents of concern in urban runoff are generally the same as are limited in NPDES permits for point source discharges. Toxic compounds include organic chemicals and trace metals can be directly toxic to marine organisms or can accumulate in the tissues of marine

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Table 7-1. Average concentrations of constituents in surface runoff in creeks and storm drains entering Santa Monica Bay during 1983 and 1984.

Variable	Malibu Creek (n = 15)	Santa Monica Canyon (n = 15)	Pico-Kenter Stormdrain (n = 15)	Ballona Creek (n = 18)	Centinela Creek (n = 16)	Grand Mean
	Average Concentrations*					
High Concentration Constituents (mg/l)						
Total Dissolved Solids	907	764	625	664	514	695
Calcium carbonate	469	448	338	327	213	359
Bicarbonate	238	231	211	223	142	209
Sulfate	284	231	144	144	114	183
Chloride	83	61	85	89	91	82
Calcium	104	92	72	70	54	78
Sodium	89	55	66	81	80	74
COD	29	35	96	47	58	53
Magnesium	51	53	37	37	19	39
Total Organic Carbon	10	13	16	12	18	14
Low Concentration Constituents (mg/l)						
BOD	2.53	3.2	12.6	7.89	9.31	7.11
Potassium	4.41	3.97	4.87	3.66	6.91	4.76
Oil and Grease	-	-	4.54	2.16	2.65	3.12
Nitrate	3.19	2.92	2.56	1.57	1.52	2.35
Ammonia	0.42	4.33	0.64	0.84	0.27	1.3
Iron	1.05	2.03	1.56	0.31	0.82	1.16
Nitrite	0.24	0.02	5.05	0.06	0.02	1.08
Phosphate	1.71	0.61	1.03	0.73	0.64	0.94
Fluoride	0.65	0.66	0.54	0.69	0.57	0.62
Barium	0.09	0.52	0.17	0.07	0.18	0.21
Boron	-	-	0.11	0.12	0.2	0.14
Manganese	0.07	0.24	0.12	0.03	0.02	0.1
Trace Constituents (ug/l)						
Zinc	59.8	66.7	75.1	69.4	67.1	67.6
Nickel	29.5	171.6	35.6	13.5	19.8	54
Hexavalent chromium	<50.0	<50.0	<50.0	<48.1	<50.0	<49.6
Chromium	19.5	66.7	35.2	15.3	16.9	30.7
Copper	13.3	42	35	26	22.2	27.7
Lead	10	12.1	11.3	15.1	11.7	12
Silver	1.82	1.82	1.6	2.84	1.67	1.95
Cadmium	<1.3	<1.0	<1.1	<1.2	<1.0	<1.1
Mercury	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlorinated Hydrocarbons (ug/l)						
DDT	-	-	0.341	0.028	0.065	0.144
Endosulfan	-	-	0.285	0.039	0.01	0.111
Endrin	-	-	0.212	0.013	0.03	0.085
DDE	-	-	0.108	0.052	0.07	0.077
Lindane	-	-	0.029	0.088	0.04	0.052
DDD	-	-	0.099	0.012	0.015	0.042
Heptachlorepoxide	-	-	0.019	0.031	0.015	0.022
Dieldrin	-	-	0.015	0.015	0.01	0.014
Aldrin	-	-	-	0.017	0.01	0.013
Heptachlor	-	-	0.015	0.011	0.01	0.012
Bacteria (cells/ml)						
Total coliform	72	58	781	998	394	461
Fecal streptococcus	49	174	571	180	174	230
Fecal coliform	4	7	98	72	65	49

Source: Modified from LAC.DPW, unpubl. data.

*Average concentrations of constituents from the combined years of 1983 (a wet year) and 1984 (a dry year).

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Table 7-2. Average concentrations of constituents in surface runoff in creeks and storm drains entering Santa Monica Bay during 1989 and 1990.

Variable	Average Concentrations Malibu Creek (n = 19)	Santa Monica Canyon (n = 24)	Pico-Kenter Stormdrain (n = 24)	Ballona Creek (n = 24)	Centinela Creek (n = 24)	Grand Mean
High Concentration Constitituents (mg/l)						
Total Dissolved Solids	1263	925	2834	726	637	1277
Chloride	149	118	1283	111	172	367
Sulphate	512	265	278	178	100	267
Sodium	156	102	741	97	123	244
Calcium	136	113	109	91	59	102
Magnesium	77	64	114	40	25	64
Potassium	10	7	44	7	12	16
Low Concentration Constituents (mg/l)						
Total Organic Carbon	3.75	3.89	9.53	7.89	9.52	6.92
Oil and Grease	1.65	1.93	4.15	2.50	3.32	2.71
Nitrate	5.43	2.73	1.79	0.95	0.56	2.29
BOD	0.92	1.21	3.07	2.09	2.95	2.05
Phosphate	2.33	0.08	0.57	0.17	0.61	0.75
Fluoride	0.67	0.55	1.18	0.46	0.39	0.65
Iron	0.13	0.99	0.85	0.13	0.23	0.46
Ammonia	0.07	0.15	1.01	0.12	0.19	0.31
Boron	0.38	0.18	0.37	0.20	0.23	0.27
Nitrite	0.14	0.18	0.34	0.21	0.19	0.21
Trace Concentration Constituents (ug/l)						
Barium	37.1	57.1	108.1	56.0	75.0	66.7
Zinc	25.3	45.4	75.0	42.5	63.8	50.4
Lead	31.6	25.6	75.6	19.0	18.3	34.0
Manganese	8.7	31.9	74.4	9.0	24.2	29.6
Copper	8.9	11.3	37.1	12.7	14.2	16.8
Chromium	13.2	11.9	17.7	15.4	12.1	14.0
Hexavalent cnromium	10.5	10.0	10.0	10.0	10.6	10.3
Nickel	11.1	11.0	8.3	8.8	11.5	10.1
Cadmium	7.4	6.3	13.5	6.7	5.0	7.8
Silver	5.8	5.0	9.0	5.0	5.0	5.9
Mercury	0.5	0.5	0.5	0.5	0.5	0.5
Chlorinated Hydrocarbons (ug/l)						
Endosulfan	NA	NA	ND	ND	ND	
Endrin	NA	NA	ND	ND	ND	
Lindane	NA	NA	ND	ND	ND	
Heptachlorepoxide	NA	NA	ND	ND	ND	
Dieldrin	NA	NA	ND	ND	ND	
Aldrin	NA	NA	ND	ND	ND	
Heptachlor	NA	NA	ND	ND	ND	
Bacteria (cells/ml)						
Total Coliform	39	406	4288	389	932	1211
Fecal streptococcus	9	58	261	28	119	95
Fecal coliform	13	23	160	53	108	71

Source: Modified from LAC, DPW, unpubl. data.

NA = Not analyzed, ND = Not detected.

DDT, DDE, DDD - Data not available.

For bacteria levels, when parameter was recorded as >n for a particular month, n was used.

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Table 7-3. Mass emissions for Malibu and Ballona Creeks for 1983-1984 and 1989

	Malibu Creek				Ballona Creek				
	Total 83	Total 84	Total 89	Mean 83-84, 89	Total 83	Total 84	Total 89	Mean 83-84, 89	Grand Mean
Flow (billion l/yr)	114	16	9	46	112	27	21	53	50
Flow (mgd)	82	12	6	33	81	20	15	39	36
<u>High Emission Constituents (MT)</u>									
Calcium Carbonate	35672	9038	-	22355	31290	7376	-	19333	20844
Bicarbonate	20920	3423	-	12172	22913	4427	-	13670	12921
Sulfate	15100	6808	4091	8666	10952	4317	4076	6448	7557
COD	8500	346	-	4423	6167	1456	-	3812	4117
Chloride	7946	1484	1092	3507	8678	2118	2144	4313	3910
Calcium	8033	1945	1145	3708	6830	1520	2131	3494	3601
Sodium	6308	1802	1205	3105	7215	2048	2045	3769	3437
Magnesium	3779	1002	624	1802	3449	858	872	1726	1764
TOC*	3228	98	2	1109	1824	347	91	754	932
BOD**	478	44	-	261	1145	198	28	457	318
Potassium	354	85	94	178	358	97	162	206	192
Oil & Grease	-	-	9	9	383	-	29	206	105
Iron	544	0.5	0.5	182	71	12	2.16	28	105
Nitrate	247	101	3	117	155	24	30	70	93
Phosphate	164	40	18	74	119	6	4	43	59
Ammonia	25	1	0.4	9	221	3	1	75	42
Flouride	57	10	5	24	79	12	10	34	29
Boron	-	-	3	3	15	-	5	10	8
<u>Low Emission Constituents (MT)</u>									
Barium	25.29	0.6	0.21	8.70	8.15	2.07	1.05	3.76	6.23
Manganese	29.19	0.16	0.08	9.81	5.06	0.99	0.22	2.09	5.95
Nitrite	18.06	0.33	3.00	7.13	6.64	-	7.00	6.82	4.82
Zinc	10.04	0.13	0.09	3.42	9.33	2.62	0.51	4.15	3.79
Hexavalent chromium	5.69	0.82	0.13	2.21	5.62	1	0.21	2.28	2.25
Nickel	10.09	0.18	0.12	3.46	1.77	0.33	0.21	0.77	2.12
Chromium	5.33	0.16	0.13	1.87	1.82	0.55	0.29	0.89	1.38
Copper	2.68	0.18	0.05	0.97	3.67	0.76	0.12	1.52	1.24
Lead	1.14	0.16	0.69	0.66	1.22	1.09	0.51	0.94	0.80
Silver	0.45	0.02	0.05	0.17	0.61	0.07	0.10	0.26	0.22
Cadmium	0.23	0.02	0.04	0.10	0.15	0.05	0.11	0.10	0.10
Mercury	0.11	0.02	-	0.07	0.12	0.02	-	0.07	0.07

Source: Modified from LAC, DPW, unpubl. data

Note: Mass emissions for 1989 was calculated by adding monthly mass emissions. When parameter was not detected during a particular month, half the minimum detection level was used.
Selenium, aldrin, lindane, dieldrin, Heptachlor, heptachlorepoxide, Endosulfan, and Endrin were all not detected at Ballona Creek and not analyzed at Malibu in 1989.

BOD was not analyzed throughout 1989 at Malibu.
Data not available for DDE, DDD, and DDT in 1989.

* TOC - Total Organic Carbon
** BOD - Biochemical Oxygen Demand

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organisms and thus potentially cause adverse effects to the organisms or make them unfit for human consumption.

Contaminant levels in urban runoff are generally low, however, the more general categories of BOD and oil and grease as well as nutrients such as nitrates, ammonia, and phosphates are often abundant. For instance, in 1983-1984 mass emissions of contaminants (estimated from average concentrations in major channels) of BOD, oil and grease, ammonia, and phosphates were 1,514; 664; 277; and 201 MT/year, respectively (Table 7-4)(NRC,COWT 1984; LAC,DPW, unpubl. data). These constituents come from both natural and anthropogenic sources.

Trace metals are generally the next most abundant chemical contaminants. From 1962 to 1982 the major trace metal contaminants discharged to the Bay in urban runoff were zinc, lead, nickel, total chromium, copper, arsenic, selenium and mercury, with average mass emissions of 72.3, 17.9, 14.2, 12.4, 11.7, 2.9, 2.2, and 0.09 MT/year (Garber and Wada 1988). In 1983-1984 mass emissions of the dominant trace metals (estimated from average concentrations in major channels) contributed by urban runoff from major drainage channels in the watershed were 14.4, 11.5, and 10.6 MT/year for zinc, nickel, and hexavalent chromium, respectively (Table 7-4)(NRC,COWT 1984; LAC,DPW, unpubl. data). The dominant chlorinated hydrocarbons were total DDT, endosulfan, and endrin with estimated mass emissions of 31, 24, and 18 kg/year. A previous estimate of mass emissions based on the same flow but using constituent concentrations obtained from the Pico-Kenter Storm Drain during dry weather conditions produced somewhat different values (Table 7-4). Total dissolved solids, chloride, sodium, COD, calcium, BOD, potassium, boron, zinc, lead, and cadmium had higher values while sulfates, magnesium, oil and grease, nitrates, phosphates, manganese, nickel, chromium, copper, and silver were lower (NRC,COWT 1984).

As with other constituents, contaminant levels differ between drainage channels. In 1971-1972 mass emissions of most contaminants were 5 to 10 times greater in Ballona Creek than in the Pico-Kenter or Malibu discharges (SCCWRP 1973). In 1983-1984 Ballona Creek was higher in ammonia, oil and grease, and BOD while Malibu Creek was higher in phosphates, nitrates, and sulfates (Table 7-3)(LAC,DPW unpubl. data). In 1989 constituents that were more than 10 times higher in Ballona Creek than in Malibu were TOC, nitrates (M. Stenstrom, Univ. Calif., Los Angeles, unpubl. data; LAC,DPW, unpubl. data). Levels of phosphates and lead were higher in Malibu Creek. Pesticides were only measured in Ballona Creek and these were dominated by total DDT and lindane (MBC 1988).

In 1980 dry-weather flow from Pico-Kenter Storm Drain was scanned for the presence of about 600 compounds; 250 were subjected to Ames testing for possible mutagenic properties. Although some components were mutagenic, no specific mutagen was identified. Possible mutagens found in the discharge were petroleum products; phthalate esters from thinners, lacquers, and varnishes; and automobile coolant (ethylene glycol esters and propylene glycol) (LAC,OCAO 1981; NRC,COWT 1984). Mutagenic organic substances have also been found in other stormwater samples of the Los Angeles area (Garber and Wada 1988).

Biological Pathogens

Urban runoff also contributes bacteria and viruses to the marine environment. Pathogenic (disease-causing) forms may pose potential health risks to swimmers and waders. Indicators of potential human contamination include total coliform, fecal coliform, fecal streptococcus, and enterococcus bacteria. The concentrations of these bacteria is measured to indicate possible presence of pathogens of concern to humans (Greenberg *et al.* 1985). Pathogenic agents which

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Table 7-4. Comparison of mass emissions for Pico-Kenter Storm Drain and major drainage channels in Santa Monica Bay in the early 1980's.

Variable	Pico-Kenter* Estimate	Major Drainage** Channels
Flow (billion liters/yr)***	213	213
Flow (mgd)***	154	154
<u>High Emmission Constituents (MT/yr)</u>		
Total Dissolved Solids	180,000	147,969
Calcium Carbonate	-	76,507
Chloride	50,000	17,413
Bicarbonate	-	44,513
Sulfate	25,000	39,017
Sodium	30,000	15,784
COD	20,000	11,296
Calcium	19,000	16,676
Magnesium	4,000	8,364
BOD	4,500	1,514
Total Organic Carbon	-	2,910
Potassium	2,300	1,015
Oil and Grease	380	664
Nitrates	370	501
Ammonia	360	277
Iron	-	246
Nitrites	20	230
Phosphates	20	-
Flouride	-	132
Detergents (MBAS)	130	-
Boron	120	30
<u>Low Emission Constituents (Mt/yr)</u>		
Barium	-	43.8
Manganese	13	20.7
Zinc	20	14.4
Phenols	13	-
Nickel	6	11.5
Hexavalent Chromium	-	10.8
Chromium	2	6.5
Copper	2	5.9
Lead	4	2.8
Arsenic	3	-
Cyanide	2.1	-
Cadmium	2	0.2
Selenium	2	-

	Pico-Kenter Estimate	Major Drainage Channels
	213	213
	154	154
<u>Trace Constituents (kg/yr)</u>		
Silver	200	416
Mercury	20	213
DDT	-	31
Endosulfan	-	24
Endrin	-	18
DDE	-	16
Lindane	-	11
DDD	-	9
Heptachlorepoxide	-	5
Aldrin	-	3
Heptachlor	-	3
<u>Bacteria (billion cells/yr)</u>		
Total Coliform	-	9.81x10
Fecal Streptococcus	-	4.89x10
Fecal Coliform	-	1.04x10

Source: NRC,COWT 1984; LAC,DPW, unpubl. data.

*Based on mean concentrations at the Pico-Kenter Storm Drain during October 1980 and the estimated total surface runoff flow to Santa Monica Bay (NRC,COWT 1984).

**Based on average mean concentrations for Malibu Creek, Santa Monica Canyon, Pico-Kenter Storm Drain, Ballona Creek, and Centinela Creek during 1983 (a wet year) and 1984 (a dry year). (MBC 1988).

***Estimated average annual flow of surface runoff to Santa Monica Bay (NRC,COWT 1984) survive in seawater include viruses (hepatitis A and polio myletis), bacteria (*Staphylococcus, Salmonella,* and *Vibrio*), and a fungus (*Candida albicans*) (Kim 1975, Morris and Kim 1975, Dufour and Cabelli 1983).

Enteric bacteria are introduced via runoff in all drainage channels in the watershed. Enteric bacteria from Santa Monica Mountain streams (including Malibu Creek) and urban storm drains (including Ballona Creek) could pose a health risk to swimmers and waders in those areas.

In 1980 total coliform counts in dry-weather flow were highest in Centinela Creek while fecal coliform counts were highest in Pico-Kenter Storm Drain; lowest counts of both were in Ballona Creek (LAC,DPW unpubl. data). In 1983-1984 average concentrations of total coliform was highest in Ballona Creek; fecal coliform and fecal streptococcus was highest in Pico-Kenter Storm Drain.

In 1989 average concentrations of total coliform were more than 10 times higher in Ballona Creek than in Malibu Creek (Table 7-2)(LAC,DPW, unpubl. data). Average concentrations of total coliform, fecal streptococcus, and fecal coliform were highest in Pico-Kenter Storm Drain; the second highest concentrations were found in Centinela Creek.

Dry-weather coliform counts from the surf zone near storm drains during 1985-1987 were greatest near the Pico-Kenter and Pulgas Canyon Storm Drains. Elevated counts occurred throughout the surf zone of the Bay after storms but particularly near storm drains. The highest counts were off the Pico-Kenter Storm Drain and Ballona Creek (both sides); however, high counts were also found between Pulgas Canyon and HTP and off Torrance south of King Harbor (MBC 1988). Storms or extreme high tides carry fecal material washed off the jetties, such as dog, bird, and human feces, into the Marina (Soule *et al.* 1992).

Litter

Litter enters the Bay with surface runoff, via ocean currents, and as a result deliberate or accidental disposal into the ocean or onto beaches (Pruter 1987). Most is aesthetically unpleasing and some litter may represent a physical hazard; however, some may provide food and habitat for marine life. Plastics and metals degrade slowly and may persist indefinitely.

Creeks receive a large amount of debris such as yard clippings, Christmas trees, fast food plastic containers, waste motor oil, and aluminum cans. Trash and debris significantly affect the aesthetic quality of the seashore and may cause the death of fish, birds, and marine mammals that become entangled in or attempt to consume items of litter.

INFLUENCE OF STORMS ON CONTAMINANT LEVELS

The major constituents in dry- and wet-weather flows differ considerably. In general, suspended and settleable solids are greater during storms while dissolved solids (mostly salts) are greater in dry weather. Calcium, magnesium, sodium, potassium, hexavalent chromium, calcium carbonate, bicarbonate, nitrate, chloride, fluoride, and endosulfan have greater dry-weather mass emissions. The mass emissions of most metals, ammonia, phosphates, TOC, BOD, COD, oil and grease, heptachlor epoxide, and lindane are greater in wet weather. Thus, most of the annual input of metals and organics to the ocean occurs in storm flows whereas most salts enter in dry-weather flows (LAC,DPW unpubl. data). Salts can generally dissolve in a small amount of water whereas a sizeable flow is required to suspend and carry silt and organics.

Highest concentrations generally occur in channels with the greatest flows also making them the greatest sources of mass emissions (Schafer and Gossett 1988). Highest contaminant concentrations occurred near the peak flows and not at the first increase in flow (Schafer and Gossett 1988b).

High mass emissions generally occurred in months when flows were highest (Figure 7-3). In 1991 mass emissions of lead and oil and grease were highest in March when the flow was highest in both Ballona and Malibu Creek. In 1992 flows in Malibu Creek and Ballona Creek were highest in February and decreased in March. In general, mass emissions of lead and oil and grease varied in respect to flow, with highest emissions in February and decreasing at the same rate as flow in March and April. Mass emissions of lead were extremely high in January 1989 in both Ballona Creek and Malibu Creek when flow was relatively low. This may be the result of heavy rains that occurred in December 1988, prior to sampling. These high values in lead may also be due to a spike or illegal discharge, or an error in sample analysis, however, concentrations were high in all drainage channels during that time. During dry periods mass emissions showed little to no variation from month to month.

Runoff Dynamics During a Storm

The first storm of the season (or any storm which follows a dry period of several weeks or more) that significantly increases stream flow generally creates an immediate pulse in the concentrations of contaminants which accumulated in streets, gutters, and channels during dry weather, low-flow conditions (Engineering-Science 1987, MBC 1988). The highest contaminant concentrations occur near the peak flows, not at the first increase in flow (Schafer and Gossett 1988b). During a storm in 1986, peak flows in Ballona Creek occurred 24 hr after the rainfall began but concentrations of most constituents were highest 13 hr after the beginning of the storm (when flow was 40% of the peak flow). Maximum concentrations of the constituents at 13 hr were greater than the minimum levels (which generally occurred 24-42 hr after the storm began) by the following multipliers: DDT, 1,360; lead, 261; total suspended solids, 192; total pesticides, 162; chromium, 110; cadmium, 29; zinc, 26; nickel, 19; and oil and grease, 17 (Schafer and Gossett 1988b).

Comparison with other Watersheds

Compared to other drainage channels in Ventura and Los Angeles Counties, Ballona Creek stormwater had the highest levels of oil and grease, DDT, and trace metals in runoff samples from the first storm after the dry season in 1986 (Schafer and Gossett 1988b). Both the Los Angeles River and Ballona Creek had the highest mass emissions of the contaminants examined; this was the result of both having the highest flow and highest mean contaminant concentrations. Ballona Creek had both higher concentrations and higher mass emissions of DDT than the Los Angeles River (Table 7-5) and other locations sampled within the Southern California bight (Schafer and Gossett 1988b). Concentrations of oil and grease and trace metals, except copper and chromium, were higher in Ballona Creek than in the Los Angeles River but the higher flow at the Los Angeles River resulted in higher mass emissions there (Schafer and Gossett 1988b).

SOURCES OF CONTAMINANTS

Potential sources of contaminants in runoff include household and industrial wastes, accidental spills, sewer overflows, septic tank leaks, illegal and illicit connections, excess runoff and chemicals from landscape irrigation, rubbish, used crankcase oil, grease, food by-products,

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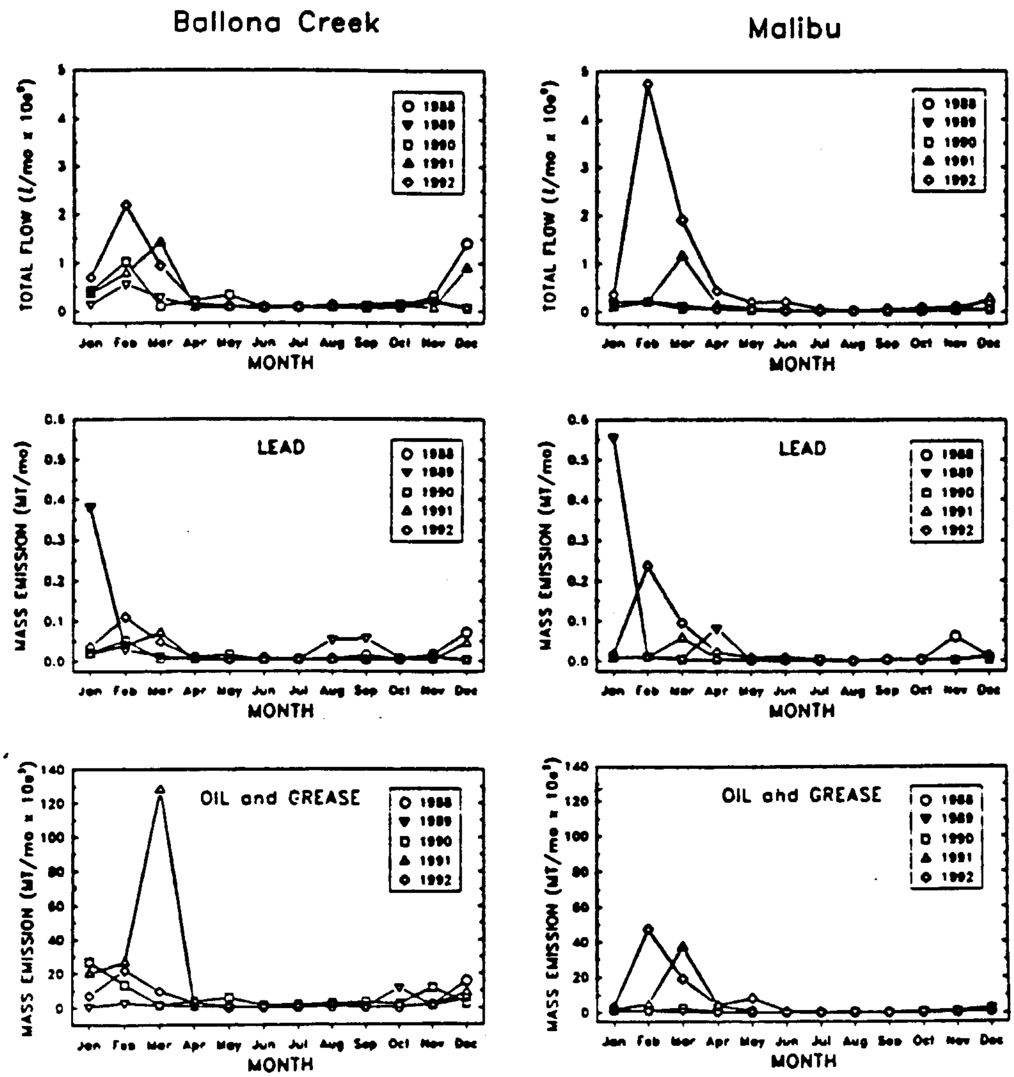

Figure 7-3. Average monthly flow and estimated mass emissions of lead and oil and grease in Ballona and Malibu Creeks, 1988-1992 (LAC,DPW, unpubl. data).

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Table 7-5. Flow and mass emissions of several runoff constituents in Ballona Creek (Santa Monica Bay Watershed) and the Los Angeles River (Los Angeles Harbor Watershed) during the September 23-25, 1986 storm.

Constituent	Station: Ballona Creek	Station: L.A. River Willow	Total	Station: Ballona Creek	Station: L.A. River Willow	Total
Total Volume (L x 10^9)	4.5	11		4.5	11	
High Constituents						
	Concentrations (mg/g)			Mass Emissions (MT)		
Total Solids	2030	1410	3440	6900	10000	16900
Sus. Solids	-	-	-	3400	7100	10500
TEOs	35.3	53.5	88.8	120	380	500
Oil & Grease	19.7	15.5	35.2	67	110	177
Zinc	1.88	1.11	2.99	6.4	7.9	14.3
Lead	0.706	0.408	1.114	2.4	2.9	5.3
Copper	0.353	2.8	3.173	1.2	2.0	3.2
Nickel	0.106	0.073	0.179	0.36	0.52	0.88
Chromium	0.003	0.07	0.073	0.31	0.5	0.81
Cadmium	0.090	0.009	0.099	0.030	0.064	0.094
Low Constituents						
	Concentrations (ug/g)			Mass Emissions (kg)		
n-Alkanes	324	887	1211	1100	6300	7400
Total PAHs	32.3	56.3	88.6	110	400	510
Total PCBs	0.353	0.451	0.804	1.2	3.2	4.4
Total DDTs	0.5	0.131	0.631	1.7	0.93	2.63
Lindane	0.025	0.025	0.05	0.086	0.18	0.266
HCBs	0.004	0.006	0.01	0.015	0.044	0.059

Source: Schafer and Gossett 1988

wash water, debris discarded on the street, animal droppings, and settled air pollutants. Street runoff carries the metal, rubber, and oil residues from highways, while garden runoff carries pesticides (Soule *et al.* 1992).

Enteric bacteria in Malibu Creek may also come from the TWRF, which has discharged into the creek since the late 1970s. As of 1987, about 90% of the treated effluent is recycled and sold during the summer but in the winter, most is discharged into Malibu Creek. The effluent received advanced secondary from the late 1970s to 1984 and has received tertiary treatment since then. The effluent has been below NPDES limits for coliform about 99% of the time. However, since the effluent is dechlorinated (after disinfection with chlorine) before being discharged to the creek, it is possible that regrowth may occur (Colbaugh 1988, pers. comm.). Coliform bacteria in Malibu Lagoon and Malibu Creek may be from this source but may also be from soil, lower animal wastes, septic tanks in the drainage, or from waterfowl (Sowby 1988, pers. comm.).

Most of the residential area along the coast west of Palisades is unsewered and sewage is disposed of in septic tanks. Tanks that are in disrepair may leak and may contaminate the ocean. High coliform counts have been noted in the area after storms. Many residents in the area do not believe that a new sewer system is necessary because septic tank problems have been less common in recent years. The coliform contamination in this area may also be from pets, wildlife, and birds (Stewart 1987).

CONTRIBUTION OF CONTAMINANTS BY LAND USE

Pollutant loadings are affected by various factors such as rainfall pattern, land use, and area of the drainage basin. There are 28 separate drainage basins within the Santa Monica Bay watershed (Figure 7-4). Each drainage area is unique due to topography and land use: the largest drainage areas are Ballona and Malibu Creek. Major types of land use include residential (single-family and multi-family), commercial, public, light industrial, other urban, and open areas (Figure 7-5). Open space is the primary land use in the Santa Monica Bay watershed with 57% of the total watershed area; it is followed by single-family and multi-family residential at 26% and 7%, respectively. Commercial and light industrial uses constitute the remaining 10% of the total watershed area (UCLA and WCC 1992).

The type of land use strongly influences the pollutant load: the more impervious area, the greater the runoff (UCLA and WCC 1992). The dominant form of land use, open space, has no impervious surface area whereas commercial land use has the highest (92%) impervious surface area. Thus, more runoff per unit area will result from commercial areas than from open areas. In single-family residential areas, an average of 35% of the surface is impervious. Since more land in the Santa Monica Bay watershed is devoted to residential use than commercial, residential accounts for a greater percentage of runoff pollutants (SMBRP 1992).

Among measured attributes, levels of TSS and COD were the highest in runoff from land-use areas in the Santa Monica Bay drainage basin, with TSS the dominant constituent (Table 7-6) (UCLA and WCC 1992). Oil and grease were the dominant constituent in runoff from multi-family residential, commercial, public, light industrial, and other urban areas; BOD in single-family residential areas and TKN in open areas. Single-family residential areas contribute the highest percentage of BOD, COD, total phosphorus, soluble phosphorus, TKN, nitrite and nitrate, copper, lead, and zinc. Open areas contribute the highest percentage of total suspended solids and multi-family residential areas contribute the highest percentage of oil and grease.

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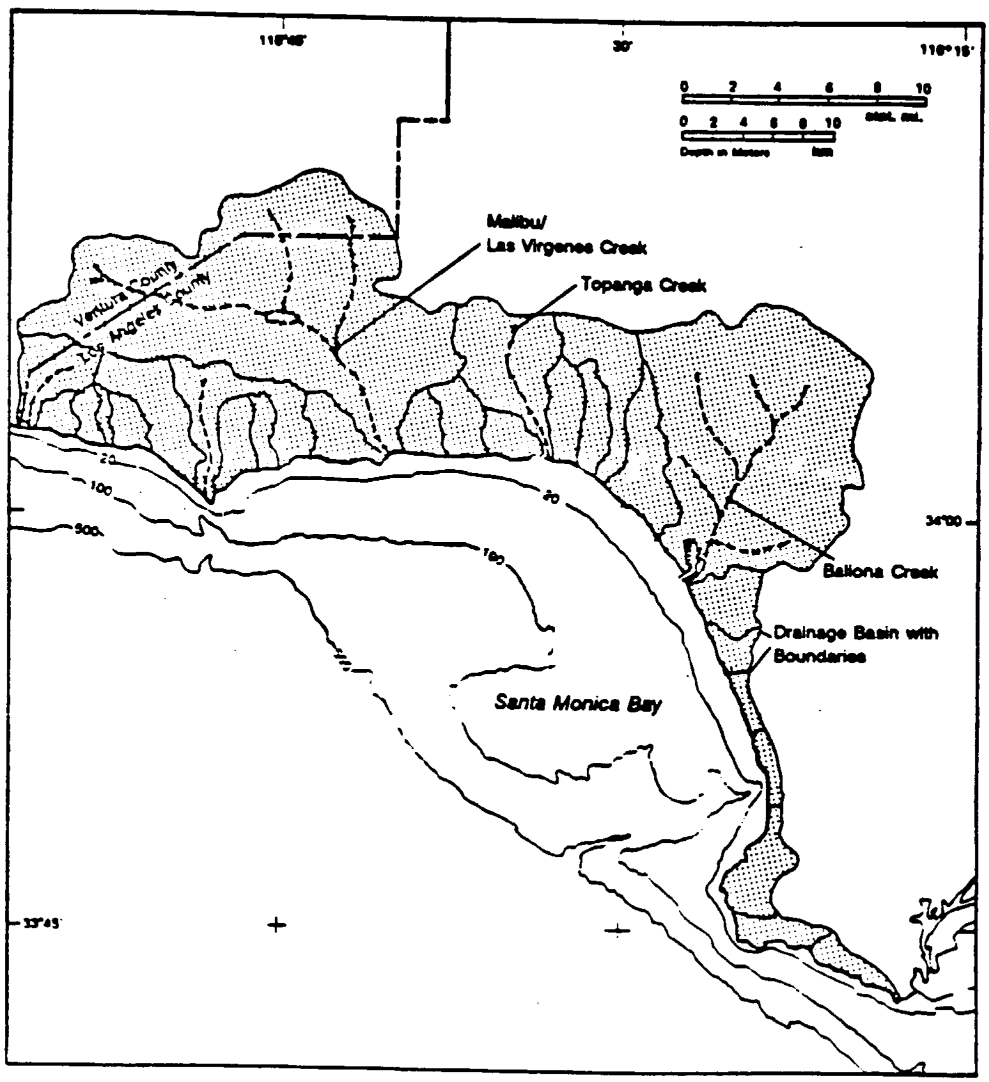

Figure 7-4. Drainage basins within the Santa Monica Bay watershed (modified from SMBRP 1992).

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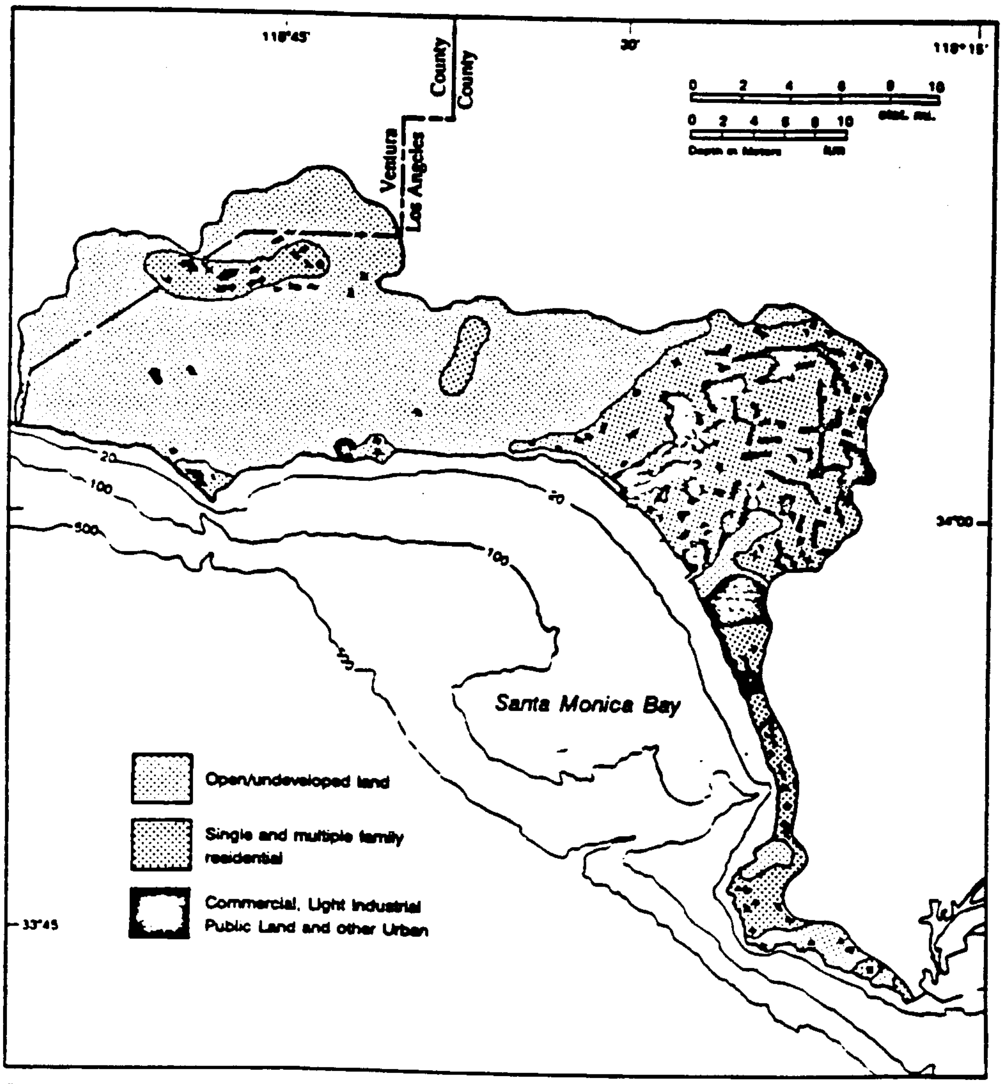

Figure 7-5. Land usage of the Santa Monica Bay study area (modified from SMBRP 1992).

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Table 7-6. Estimates of annual pollutant loadings for Santa Monica Bay drainage basins by land use.

Pollutant	Residential Fam. Single	Residential Fam. Multi	Commercial	Public	Light Industrial	Other Urban	Open	Unk.	Watershed Total
Pollutant Loadings (Metric Tons per Year)									
TSS	10,673	3,029	1,529	820	712	1,424	11,767	59	30,013
COD	5,152	1,875	765	410	356	881	2,281	37	11,757
BOD	626	216	119	64	55	102	48	4	1,234
Oil & Grease	110	317	187	100	87	149	0	6	957
TKN	158	35	17	9	8	16	67	1	311
NO2+NO3	68	14	10	5	5	7	35	0	145
Total Phosphate	31	9	4	2	2	4	12	0	64
Total Zinc	13	5	6	3	3	3	11	0	43
Total Lead	13	6	2	1	1	3	3	0	30
Soluble Phosphate	9	2	2	1	1	1	3	0	18
Total Copper	3	1	1	0	0	1	1	0	8
Percentage of Annual Pollutant Loadings									
TSS	35.6	10.1	5.1	2.7	2.4	4.7	39.2	0.2	100.0
COD	43.8	15.9	6.5	3.5	3.0	7.5	19.4	0.3	100.0
BOD	50.7	17.5	9.6	5.2	4.5	8.2	3.9	0.3	100.0
Oil & Grease	11.5	33.1	19.5	10.5	9.1	15.6	0.0	0.6	100.0
TKN	50.9	11.1	5.5	2.9	2.5	5.2	21.6	0.2	100.0
NO2+NO3	47.0	10.0	7.0	3.6	3.3	4.7	24.0	0.2	100.0
Total Phosphate	48.6	13.9	5.7	3.0	2.6	6.5	19.4	0.3	100.0
Total Zinc	29.7	12.6	13.6	7.3	6.3	5.9	24.3	0.2	100.0
Total Lead	43.6	21.5	6.5	3.5	3.0	10.1	11.4	0.4	100.0
Soluble Phosphate	50.0	10.2	8.3	4.5	3.9	4.8	18.3	0.2	100.0
Total Copper	42.7	17.6	7.5	4.0	3.5	8.3	16.1	0.3	100.0

Source: UCLA and WCC 1992.
TSS - Total Suspended Solids
COD - Chemical Oxygen Demand
BOD - Biochemical Oxygen Demand
TKN - Total Kjeldahl Nitrogen
NO2 + NO3 - Nitrite and Nitrate

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Single-family residential areas contributed approximately 50% of the annual load of the oxygen demand, and nutrient pollutants (Table 7-6). All other land use types contributed mostly to oil and grease; the largest contributors are from multi-family and commercial areas. The greatest percentage of copper, lead, and zinc is also from single family residential areas. TSS predominantly comes from open areas.

REGULATION OF CONTAMINANTS IN URBAN RUNOFF

Because there is no means of treating surface runoff at present, source control is the only way to reduce the levels of contamination in urban runoff.

NPDES Permits

In June 1990, the California Regional Water Quality Control Board, Los Angeles Region issued a NPDES permit for stormwater and urban runoff to the County of Los Angeles as principal permittee, and the cities in the Santa Monica Bay Watershed as co-permittees (Appendix F). The permit requires Los Angeles County and the 85 cities in the County to control pollution from urban runoff. To address the distinct problems associated with the control of stormwater/urban runoff pollution, a new approach has been initiated in the Santa Monica Bay watershed.

General Stormwater Discharge Permits

General stormwater discharge permits for industrial facilities and construction sites were issued by the State Water Resources Control Board in the summer of 1992. These stormwater/urban runoff permits provide a new regulatory framework which is considered practical and adaptable to the Los Angeles County drainage system's distinct structure. Programs developed under current stormwater permits emphasize pollution control through best management practices (BMPs) as opposed to conventional technology-driven water quality standards.

Best Management Practices

Studies conducted by the SMBRP have shown that land use practices are among the most identifiable causes of stormwater/urban runoff pollution. It is widely recognized that the elimination of diffuse "nonpoint" sources ultimately depends on successfully changing the long-standing habits and practices of people at work and in their communities. Therefore, among potentially effective BMP's, priority should be given to implementation of new land-use practices and to nonstructural control measures, in particular, public education and involvement programs.

Ozone Treatment

One potential technique for the treatment of urban runoff is to construct catch basins at the mouths of drainage channels and to treat runoff by ozone disinfection prior to discharging into the Bay. Ozone is used by the drinking water industry as an alternative to chlorine, and a pilot study demonstrating ozone disinfection was conducted for the SMBRP on the Kenter Canyon Storm Drain System in Santa Monica. Results showed that ozone was an effective dry-weather storm drain disinfectant (Greene 1992).

CHAPTER 8

IMPACTS - TERRESTRIAL, INTERTIDAL, AND WETLANDS HABITATS

TERRESTRIAL HABITATS

The native habitats of the Santa Monica Bay watershed have been greatly modified by the arrival of humans into the area. Native Americans used the natural resources such as plants and animals for shelter and food; they even practiced some fire control vegetation management. However, the impact was small compared to that from the first Europeans. Following California's statehood, some plant communities were more impacted than others. The first to be modified were the relatively flat native grasslands and the riparian areas along streams and rivers. Changes began with cattle grazing, clearing for fields, and damming of streams. Later, residential and commercial development, channelization of rivers and streams, introduction of non-native plant and animal species and production and use of toxic chemicals for industry and agriculture have all had their impact on native habitats.

About half of the area of the Santa Monica Bay watershed has been modified from native plant communities for agricultural and urban use (Figure 7-5). The impacts of development go beyond the actual area being used, as air and water carry material into previously pristine areas, and urban populations look for recreational locations away from the everyday congestion of the urban setting.

The growth of agriculture and trade resulted in the introduction of non-native species from Europe and other parts of the Americas for use as crops, other food, or for transportation. Many introductions were accidental (e.g., rats), but some were nonagricultural but concomitant with human civilization (e.g., cats). It will never be known how many native species were driven to extinction by introduced species taking over habitats or by the destruction of small or unique habitats. It is known that most of the native perennial bunch grasses are gone, along with many other annuals, insects, birds and mammals. At present there is concern about the remaining native habitats and steps are being taken to reduce the pressure from increasing population, to protect and restore native plant communities.

In southern California, the practice of fire suppression to prevent destruction of property has resulted in thick chaparral stands which have not burned for many years near populated areas. These stands are extremely susceptible to natural or man-induced fires, especially during Santa Ana wind conditions. Because of the accumulation of fuel, fires in these stands can burn extremely fast and hot. Urban sprawl has continued to intrude into these habitats, making control of fires necessary, but more difficult. The California Department of Parks and Recreation's policy now considers fire to be a natural element of the environment, and has begun prescribed burning in some units of the State Park System (Wells 1990). Other landholders, such as the Nature Conservancy, are taking similar steps.

Since they usually occur in the dry, hot season, large and severe fires can lead to widespread flooding, accompanied by high sediment loads in runoff from heavy winter rains. When combined with other man-made disturbances of the earth, such as road building and housing construction, flooding can result in destruction of property and loss of life.

Remediation

The Conservation/Open Space Element of Los Angeles County's General Plan (revised in 1979) includes the need "to protect...watershed, streams, and riparian vegetation to minimize water pollution, soil erosion, and sedimentation, maintain natural habitats, and to aid in ground water recharge." There are 65 significant ecological items in this element that are identified in a report entitled "Land Capability/Suitability Study, Los Angeles County General Plan Revision Program 1976" (Faber *et al.* 1989).

INTERTIDAL HABITATS

Impacts

Reduction of Sand Sources

Prior to the construction of flood control structures, heavy rains carried abundant sediment to the coast (Woodell and Hollar 1991). However, development in the Los Angeles basin has included measures to decrease the risk of flooding, along with water retention and diversion for agricultural and domestic use. Flood-control projects have reduced the rate and volume of flood runoff and its sediment load. As a result, some beaches downcoast of major streams or storm drains eroded; the sand which is lost offshore during high-wave events is not replenished naturally. Erosion now threatens coastal structures and beaches with less sand are less attractive for recreational activities.

Historically, the major sources of beach sand for Santa Monica Bay were bluff erosion and creeks and rivers which emptied into it: Calleguas, Malibu, Topanga and Ballona Creeks, and, occasionally, the Los Angeles River. Sand is lost to the system offshore and by longshore transport into Redondo Submarine Canyon. Estimates of transport rates vary, but in the 1960s a net transport of 246,000 yd^3/yr (188,000 m^3/yr) to the south was considered reasonable. Completion of the King Harbor North Breakwater has disrupted the loss to Redondo Submarine Canyon somewhat, although sediment still enters the Canyon from the south (Woodell and Hollar 1991). The development of housing and recreation facilities atop dunes has further reduced the amount of available sand (Casali *et al.* 1991).

Construction and beach renourishment projects have resulted in a coastal zone which is fairly stable, but which shows little resemblance to the beaches prior to man's intervention. The reduction of sand loss down Redondo Submarine Canyon, the construction of Marina del Rey and King Harbor, and the many piers and groins, have combined with beach nourishment to yield 14 miles of beaches which are now several hundred feet wider than they were previously (Woodell and Hollar 1991).

Groin, Jetty, and Pier Construction

One of the fundamental problems in the coastal zone is sand management: sand often erodes from desirable locations (for recreation and storm protection) and accumulates where it is not wanted (in harbor entrances, passes and inlets). The groins and jetties which are built to protect harbor entrances or to control erosion also affect longshore sediment transport. Sand accumulates on the upcurrent side of a structure perpendicular to the shoreline and erodes on the downcurrent side (Anikouchine and Sternberg 1973).

Structural methods of shoreline protection in the past, include the construction of more than 50 groins and jetties on Santa Monica Bay beaches. Many were specifically intended to help sand accumulate (Woodell and Hollar 1991).

Beach Nourishment

The primary nonstructural method of beach protection is beach nourishment, which often has only short-term success unless other measures are taken concurrently. Beach nourishment is only feasible (i.e., cost effective) where there is a nearby sand source. Most beach nourishment projects are initiated in response to navigational requirements to dredge and remove sand from harbor entrances.

Efforts to rebuild eroding beaches was begun in 1938 when nearly 1.8 million yd^3 of material from nearby dunes was placed onto the beaches (Shaw 1980). Since then more than 30 million yd^3 of material have been placed in the littoral zone (Woodell *et al.* 1990).

Almost 17 million yd^3 of material has been placed on Dockweiler State Beach since 1938 from the construction of the original Hyperion Treatment Plant. Since 1960 Dockweiler has also received more than 10 million yd^3 of material from construction and by-pass operations at Marina del Rey.

Dockweiler Beach is presently being nourished with sand from nearby dunes. In 1992, lead and other metals levels in sediments from Marina del Rey were found to be too high for beach nourishment. Materials dredged from the Marina were dumped offshore, to be distributed by longshore currents (Chang 1992, pers. comm.). More than 1.3 million yd^3 of sand from offshore sources have been deposited on Venice Beach and almost 2.6 million yd^3 on Redondo and Torrance Beaches (Woodell and Hollar 1991).

Especially large storms may even cause erosion of sand dunes. By replacing sand to the eroded dune, both beach and dune are nourished and maintained. Dune maintenance can stabilize a beach even where sand is lost to longshore transport (Walther 1991).

Urban Runoff

Urban runoff is a major source of contaminants which impacts intertidal marine organisms. Contaminants in seafood organisms can be transferred to man and result in adverse health effects. Filter-feeding intertidal organisms have a particularly high potential for bioaccumulating pesticides such as DDT, complex chlorinated hydrocarbons such as PCBs, and organometallic compounds such as methylmercury. In addition, most intertidal organisms are invertebrates and are less able than vertebrates to transform organic and metal contaminants to less toxic forms. Bacteria are discharged onto beaches from storm drains during periods of high flow, necessitating beach closures for short periods of time to protect human health.

Municipal Wastewater Discharges. Intertidal habitats are not exposed directly to contaminants discharged offshore, but they are exposed indirectly with every tidal cycle. Floatable materials from municipal effluent may reach the intertidal zone during onshore winds. Of particular concern are oily materials which rise to the surface, bearing lipid soluble contaminants (Word *et al.* 1984). These accumulate at the sea surface along with contamination from spills, boat bilge pumping, storm drain runoff, and natural oil seeps.

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The potential impacts of floatable materials on intertidal biota have not been examined from a community standpoint, although some air-water interface contaminant data are available (SCCWRP 1986d). The susceptibility of intertidal communities can be inferred from tissue toxicant concentrations in the California mussel; trace metals, DDT, and PCB levels were higher along the Palos Verdes Peninsula and near Marina del Rey than elsewhere in the study area.

Rocky intertidal communities in the Bay have not been well studied. Although intertidal algal distributions are adequately described. Data are available from prior to (Couch 1915, Goodman 1935), during (Dawson 1959, 1965; Widdowson 1971), and after (Thom and Widdowson 1978; Harris 1980, 1983) the period of peak contaminant discharge into the Bay. Reductions in algal cover and diversity on the Palos Verdes Peninsula were attributed to effluent from the JWPCP outfalls (Tetra Tech 1984). Algal communities impacted by sewage effluent resemble early successional stages and are dominated by opportunistic species with high reproductive potential (Murray and Littler 1978). Widdowson (1971), however, indicated that exposure to treated wastewater was less damaging than either human use (trampling) or exposure to air pollution. Although the exact cause is uncertain, a decrease in intertidal algae on the Palos Verdes Peninsula may have been related to direct treated wastewater exposure (Littler and Murray 1975) because the community has recovered with declining JWPCP mass emissions.

Thermal Discharges. The rocky intertidal biota on the breakwater at King Harbor is exposed to the thermal discharge from Redondo Generating Station. Studies indicate that the main determinant of community structure is tidal height, (EQA/MBC 1973; Straughan 1977a,c) although some data suggest a slight compression of the vertical zonation with organisms being found at lower than normal tidal heights (Straughan 1977a).

Marine Vessel Spills. The effects of oil spills from marine vessel traffic in the Bay have not been well studied. However, because spills are likely to encounter the beach, they may affect the eggs and newly hatched larvae of California grunion. Benzo(a)pyrene, (a PAH found in oil spills, industrial discharges, and aerial fallout), caused decreased hatching success and larval deformities in California grunion eggs collected from Redondo Beach. Such impacts would be detrimental to the survival of the fish if they occurred (Winkler *et al.* 1983). Benzo(a)pyrene does not cause tumors in marine fishes, but it does cause stress and makes them less resistant to parasites (Puffer 1988, pers. comm.). A spill of diesel and naphthalene offshore of El Segundo in 1991 did not affect intertidal organisms at Malibu, where it came ashore (MBC 1991a), and grunion were later observed to spawn normally on the Malibu coast.

Litter. Beach litter is both an aesthetic and an ecological problem. Birds may entangle themselves or ingest harmful substances and objects, and litter may smother organisms on beaches and in tidepools. Sharp objects are also dangerous to humans engaged in recreational activities. About 2,200 MT of litter were collected from beaches between San Pedro and the Los Angeles-Ventura County line excluding Santa Monica Beach from 1 July 1987 to 30 June 1988 by the Los Angeles County Department of Beaches and Harbors. About 690 MT were collected from Cabrillo Beach to Manhattan Beach; 681 MT from El Segundo to Venice; and 826 MT from Will Rogers State Beach to the Ventura-Los Angeles County border (Schumaker 1988, pers. comm.). From 1987 to 1992, an annual average of 3,400 MT of litter was collected from beaches in Santa Monica Bay excluding Santa Monica Beach (Isbitsky 1992, pers. comm.). Ten to 12 MT of litter are picked up from Santa Monica Beach each year (Rogers 1992, pers. comm.).

Contaminated Sediments Used in Beach Nourishment. Dockweiler Beach received more than 0.6 million yd^3 of material dredged from Marina del Ray during its construction. Heavy metals and other contaminants are known to be high in Marina del Rey sediments (Stallard *et al.*

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1986; Chang 1992, pers. comm.) and after USACE tests showed that heavy metal values were too high in Marina del Rey sediments for beach nourishment, the materials were disposed of nearshore.

Other Activities. The value of beaches for recreation and relaxation has resulted in the destruction and degradation of intertidal and dune ecosystems. Beach visitors walk on vegetation and intertidal organisms and leave litter which must be removed. Drift kelp is removed for aesthetic reasons, thus, interrupting the natural degradation of kelp and its reintroduction into the marine environment as a food for filter feeders. Beach hoppers (or sand fleas) depend on the salty dampness of the normal beach; they burrow into the sand under piles of seaweed during the day and come out at night to scavenge food. Beach isopods and kelp flies also help recycle decaying kelp and dead animals. Human foraging for edible intertidal organisms such as abalone, limpets, mussels, clams, and sea urchins may eliminate juvenile stages, leaving no individuals to grow to adulthood and reproduce.

Dunes are a fragile ecosystem which is easily disturbed by vehicle and foot traffic. Repeated disturbance kills the low-growing plants by exposing the fine root system to drying wind and sun. When vegetation is removed, the sand is exposed and becomes susceptible to transport further inland by strong winds. In addition to the direct loss of habitat, the dunes can no longer supply sand to eroding beaches or protect inland areas. Human intrusion also interrupts shorebird foraging and nesting. Inadvertent and deliberate disturbance of nesting and feeding of chicks and crushing or removal of eggs and nestlings has had a major impact on California least tern and Western snowy plover populations (Page and Stenzel 1981).

Remediation

Beach Profile Surveys

Beach profile surveys have been conducted sporadically by Los Angeles County Coastal Studies Division to study specific problem areas; they have not been used to study long-term, regional trends. However, a program is now underway to compare three recent surveys with several historical surveys, in light of the many erosion events and beach nourishments projects which have been conducted (Woodell and Hollar 1991).

California State Mussel Watch Program

The California State Mussel Watch Program has monitored contaminants in intertidal invertebrates near Santa Monica Bay beaches on an intermittent basis, a more consistent approach and thorough sampling program is needed to track patterns and trends of contaminants.

California Least Tern Habitat Restoration

California least terns nest on sandy beaches, however, they must be protected from human disturbance and introduced predators. The protected site at Venice Beach has been very successful, but additional space is needed to enhance continued population growth. An additional beach nesting site near the Ballona Wetlands complex was suggested to help the population expand by attracting first-time nesters.

In 1991, with funds from the SMBRP and USEPA, a 3.5 acre site with extant native vegetation was prepared on Dockweiler State Beach. A temporary enclosure fence was erected and plans were made for a permanent fence for the 1993 breeding season. Decoys and audio recordings of least tern calls were used to attract birds to the site. Although no terns nested on the site in 1992, there were several landings. The first year was considered to be a trial and plans now call to eventually expand the site to 5 acres (Baird 1992, pers. comm.). A California least tern nesting island at the west end of the Ballona Wetlands is also planned as part of the mitigation associated with the development of Playa Vista by Maguire-Thomas Partners.

Western snowy plover

The Western snowy plover is a threatened species (CDFG 1992) and restoration projects have been started. Snowy plovers have many of the same nesting habitat requirements as least terns, and restoration projects may target both species (Yoder 1993, pers. comm.).

Black Abalone Recovery Program

The black abalone population has decreased dramatically in Santa Monica Bay, probably as a result of extensive poaching, although the increase in sea urchin (which feed on the same resource, algae) population and "withering disease" may also have contributed. A recovery program could include planting young black abalone on rocky shores.

El Segundo Dunes Reserve

Dunes are a rapidly disappearing habitat which support a unique community of plants and animals. The remnant El Segundo Dunes are home to 11 threatened species, including the El Segundo blue, a Federal- and State-listed endangered butterfly. Restoration of the El Segundo Dunes and creation of a Dunes Habitat Preserve would halt the spread of invasive species and avoid further extinction of native species.

The dunes at the west end of Los Angeles International Airport (LAX) (most of which are owned by the airport) are the subject of a proposed El Segundo Dunes restoration program (WRA 1990). At present the vegetation is dominated by iceplant and acacia and the major goal is to reintroduce native vegetation. The area is inaccessible to the public (which should help) but an irrigation system would have to be installed and the non-native plants removed (WRA 1990).

Chevron USA maintains a 1.6-acre El Segundo blue butterfly preserve at the northwest corner of the El Segundo refinery (This site is not contiguous with the proposed El Segundo Dunes mitigation project west of LAX). The El Segundo blue recovery program involves ensuring that the butterfly's host plant, coastal wild buckwheat, is present and protecting the habitat from human intrusion.

The El Segundo Dunes fall under the jurisdiction of several entities: LAX owns 277 acres, 43 acres of which are relatively undisturbed; the Los Angeles Department of Water and Power owns 55 acres of right-of-way property; Chevron USA owns 1.6 acres, which have been set aside as a butterfly preserve; and the City of Manhattan Beach owns 4 acres.

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WETLANDS HABITATS

Impacts

Wetlands in Santa Monica Bay are threatened by the proximity of the large human population and its impact on the physical, chemical and biological characteristics of the wetlands. Specific factors are stream alteration, dredging and filling, modified water flow patterns, drought, urban runoff, sewage disposal, boating and shipping, encroaching housing and commercial development, introduced species, and the increased use of natural habitats for recreation.

Wetlands have been used as waterways and have been modified by dredging and filling for harbors and marinas. In several areas, the wetlands had been diked and used for duck hunting, oil production, and reclaimed water discharge by sewage processing facilities. More recently, the margins have been developed for residential and commercial purposes.

Development and Habitat Reduction

Most of the wetlands of Santa Monica Bay have already been highly modified by draining, dredging, filling, diking, and channelization to provide sites for port and harbor facilities, housing and commercial development, and farming. They have also been degraded by urban runoff, introduction of non-native species, and human disturbance, resulting in losses in biological diversity, productivity, and wetlands function. The loss of wetlands habitat is not unique to Santa Monica Bay.

Between the late 1800s and mid-1960s much of the wetlands of Los Angeles and Orange Counties was "reclaimed," with resulting losses in biological diversity, productivity, and function. Seventy-five percent of the coastal estuaries and wetlands in southern California have been destroyed or severely altered since 1900. Two-thirds of the 28 sizeable estuaries once found in southern California have been dredged or filled (CCZCC 1975).

Freshwater wetlands have also suffered: streams have been channelized and dammed and water appropriated to supply distant cities. Current water policy considers unused water to be a waste, thus from as far away as the San Joaquin-Sacramento River delta and the lower Colorado River water is transported to southern California for domestic and agricultural uses. Wetlands associated with those systems have been impacted by changes in water level and seasonal flow, as well as by damming, channelization, expanded agriculture, and livestock grazing. For example, about 3,000 acres (1,200 ha) of riparian vegetation are being lost along the lower Colorado River each year (Manci 1989). Water diversions have seriously impacted the commercial and sport freshwater fisheries in central California because of water draw-downs and salinization of a large part of the formerly freshwater delta (Rozengurt and Haydock 1991).

Ballona Wetlands Complex. In 1868 the Ballona Wetlands Complex covered as much as 2,100 acres (Clark 1979). By 1894, the area had been reduced to approximately 1,535 acres, from the present-day community of Venice on the north, southwest through La Ballona, inland to Machado and south to present-day Culver Boulevard (Figure 8-1). The area consisted of a broad marsh behind a long sand spit, with a narrow, ephemeral opening to the sea. The opening probably closed to the ocean during spring and summer, leaving a brackish lagoon until high winter inflow washed out the spit and exposed the marsh to tidal waters (Swift and Frantz 1981).

By about 1930 the major lagoons of the Ballona Wetlands had been drained and converted for agricultural use, oil and gas development, and to control and abate mosquitos and

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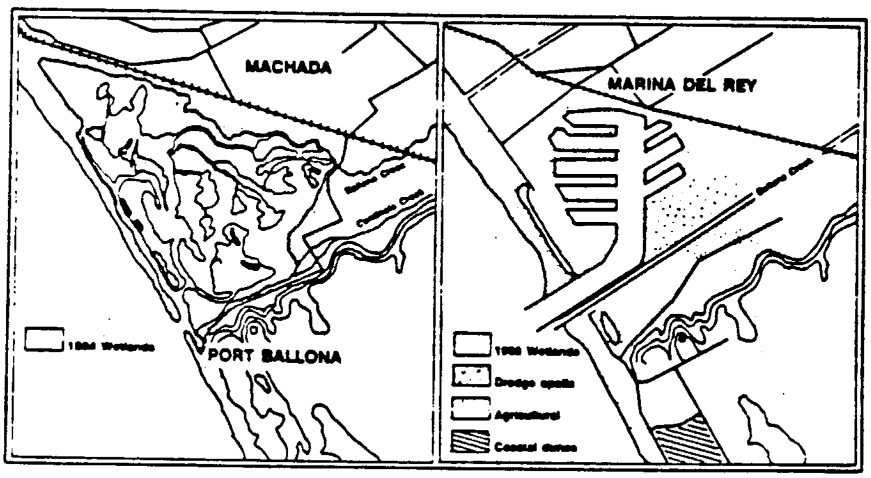

Figure 8-1. The Ballona Wetlands region in 1894 and 1988.

black gnats (Soule and Oguri 1977). From the 1930s to the 1950s roads and levees were built to access oil drilling pads and in the early 1960s, further reduction of the habitat resulted from dredging of Marina del Rey (Soule *et al.* 1992). Four-to 5-ft of dredge spoils were placed on northern section of wetlands that had been previously used for agriculture (Friesen *et al.* 1981).

By 1938 Ballona Creek, which was the principal freshwater source for the Ballona Wetlands Complex, was completely channelized as a flood control measure (Clark 1979). Channelization reduced the inflow of fresh water and nutrients to the marsh ecosystem and allowed the natural inlet to be blocked by sediments within two years. It also altered the natural salinity and depth regimes of the wetlands, leading to more-saline water and a deeper and more defined channel (Swift and Frantz 1981).

Introduced plants have become established in the Complex, altering the ecological balance and use of the marsh by native biota. Introduced species account for 40% (130 of 235) of all plant species in the saltmarsh area (Gustafson 1981) and much of the terrain is vegetated by introduced species such as gum (eucalyptus) trees and iceplant which are detrimental to the habitat as a whole and out-compete native species. Because of the continued disturbance, weedy species cover approximately 15% of the saltmarsh. A restoration project in progress at Ballona Lagoon, includes planting native salt marsh vegetation and removal of introduced species (Weiss 1993, pers. comm).

Malibu Lagoon. The full extent of the historical Malibu Lagoon-marsh system is unknown (Kraft 1978), but what remains probably represents only a small portion of the original marsh (CDPR 1978). In 1978, the natural resources consisted of 5 acres of open water, 10 acres of coastal saltmarsh, 4 acres of riparian habitat and mudflats (unknown). Most habitat reduction of the Malibu wetlands has resulted from the reclamation of habitat upcoast of Malibu Creek for mosquito control and houses (Kraft 1978).

The natural channel of Malibu Creek enters the ocean downcoast of Malibu Point. The sand bar which develops across the mouth is purposely breached by the Los Angeles County Department of Beaches for flood control purposes (CDPR 1978).

Urban Runoff

Significant quantities of floating trash and other urban debris are carried into Santa Monica Bay by way of Ballona Creek (Metz 1978) and much of it accumulates in the Ballona Wetlands Complex (Schreiber 1981). Debris and trash can temporarily limit light availability in the water column and cover saltmarsh habitat; styrofoam and plastic bags may be ingested by fish and birds.

During dry weather the low volume "nuisance" water brings grass clippings, motor oil, household pesticides, and drainage from roadway drips and accidental spills down-channel. When this flow reaches the tidal prism, debris and contaminants are deposited inside of the Marina jetty.

During wet weather, runoff carries bacteria into the wetlands and Marina del Rey and waters are considered unsafe for body contact during and for a few days following a storm (Soule *et al.* 1992). The sand bar at the entrance to the Marina may reduce circulation and flushing within, prolonging the period of contamination. Increased flow in Ballona Creek tends to carry the debris and contaminants as well as occasional sewage overflows from the HTP North Outfall Facility into Santa Monica Bay proper (Soule and Oguri 1986, 1987). As a result, sediments at the mouth of the Ballona Creek are more contaminated than those elsewhere in the vicinity of Marina del Rey (Soule and Oguri 1987). Stagnation and high nutrient input from urban runoff periodically cause algal blooms in Ballona Lagoon (Soule and Oguri 1977).

Organic enrichment due to wastewater overflows may account for low benthic community species diversity at the mouth of Ballona Creek, where the fauna is dominated by high numbers of nematode worms and the polychaete *Capitella capitata* (Soule and Oguri 1987). These organisms are highly opportunistic and characteristic of unstable, stressed environments, whether natural or anthropogenic. However, this area is also subject to excessive scour during storms, deposition during dry weather, and fluctuating salinity and temperature. The abundance of nematodes and *Capitella capitata* may also result from these natural perturbations. The benthic community in Ballona Lagoon is also affected by high organics, poor circulation, and storm run-off from the Venice canals.

The Oxford Flood Control Basin Marina del Rey are impacted by trace metals, pesticides and PCBs, apparently from sediments eroded during storms. Adjacent terrestrial areas are contaminated from earlier dumping and World War II industrial activities. Recent construction excavation may have exposed soils to erosion, as suggested by the increase in percentage of fine sediments in the Marina following heavy rainfall (Soule *et al.* 1992)

Many of the substances such as PCBs, pesticides, and heavy metals in urban runoff are toxic to marine organisms. Small amounts of several trace metals have been detected in the Marina, but these have been determined by the National Oceanographic and Atmospheric Administration (NOAA) to have low environmental effects. Concentrations of other metals (e.g., nickel and TBT) have been high in the past but are less concentrated now; concentrations of lead and zinc increase following heavy rainfall and decline during dry weather, indicating terrestrial sources. Copper concentrations have increased even during dry periods, suggesting its increased use as an antifoulant since the ban on TBT. Pesticides such as chlordane continue to be detected at high environmental effects levels (NOAA 1991b). The highest concentrations of chlordane have been at the mouth of the entrance channel, indicating that it has come from Ballona Lagoon (where there are many wooden structures which may have been treated for termite control). Levels were also high in the Oxford Flood Control Basin. Levels of DDT appear to be decreasing but still exceed the low environmental effects level at some locations in the Marina. Its metabolite DDE has increased in fish taken at the Fisherman's Village fish docks in the Marina's Main Channel (Soule *et al.* 1992)

Toxic materials may occur both in sediments and in the water column. Studies to determine levels of trace metals and organics in the marine environment are conducted by California State Mussel Watch (CSMW) primarily using California and bay (blue) mussels. Marina del Rey is the only CSMW site in northern Santa Monica Bay, but in 1981-1982, levels of PCBs in resident bay mussels from Marina del Rey were relatively high (1,000 ppb), indicating local PCB sources. Mussel transplant studies conducted in 1980 and in 1985-1986 also revealed high PCB levels (1,800 ppb in 1980 and 2,500 in 1985) in Marina del Rey (CSWRCB 1982, 1988). Marina del Rey mussels also had one of the highest lead concentrations measured in California (49 ppm), and had elevated zinc (340 ppm in 1980 and 833 ppm in 1986) and copper (13 ppm in 1980 and 112 ppm in 1986) concentrations as well. The lead concentration in Marina del Rey mussels was over 50 times those typically measured at uncontaminated coastal sites. Contaminants originating or accumulating in the Marina may flush into the Ballona Wetlands under normal conditions or from the wetlands into the Marina during wet periods.

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Transplanted and resident mussel tissues also had elevated concentrations of chlordane and dieldrin; total chlordane was the highest (780 ppb in transplants and 480 ppb in resident mussels) detected in the CSMW surveys. These data suggest a local source of the pesticide, because total chlordane in mussels from Palos Verdes was generally less than 50 ppb and from reference areas less than 10 ppb. The concentration of dieldrin was 91 ppb in 1980 transplant studies at Marina del Rey, although lower concentrations were measured in resident mussels from Marina del Rey (19 ppb) and the Palos Verdes Peninsula (6.5 to 11 ppb).

Marine Vessel Activity

Marina del Rey. The development of Marina del Rey drastically altered the original lagoon habitat. The shoreline was changed from natural muddy intertidal habitat to vertical concrete walls, although a small beach remains at the end of Basin D (Stephens *et al.* 1991). The Marina is, therefore, a wetlands only with respect to the shallow subtidal habitat which supports wetlands fish (and eelgrass in Basin D, prior to 1992). The amount of shallow bottom habitat was decreased by dredging (to 20 ft in the Main Channel and about 16 ft in the basins) and water circulation between the harbor and the ocean was increased. This alteration of habitat has no doubt decreased the abundance of lagoon species such as the arrow goby and California killifish, although this change has not been documented. It has probably also reduced the amount of nursery habitat for California halibut. Juveniles of this species generally develop in warmwater lagoons and hence the development of the Marina may have resulted in fewer adult halibut in the Bay.

The abundances of fish larvae and benthic-feeding fishes have declined in Marina del Rey since 1984. This may be the result of post-El Niño cooling but may also be related to TBT concentrations in the Marina. TBT is used as a biocide in antifouling paint and is more toxic to larvae than to adults (Soule and Oguri 1987). Since the use of TBT on small boats was banned in 1988, levels of TBT in the Marina have decreased three fold (Soule *et al.* 1992). Habitat disturbance may be responsible for the disappearance of the eelgrass beds from Basin D in 1991 (Soule *et al.* 1992)

Ballona Wetlands and Lagoon. The fish fauna of the remaining natural Ballona wetlands is less speciose and less diverse than coastal embayments such as Anaheim Bay (Lane and Hill 1975) and Newport Bay (Horn and Allen 1981), probably because only the shallow tidal channel habitat is present. In addition, flood gates and the shallow Ballona Creek Flood Control Channel separate the marsh from deeper water, interrupting the continuum from shallow marsh to the Bay. The limited number of flatfish collected in the Ballona wetlands suggest that it plays a limited nursery ground role compared to other southern California wetlands (Zedler 1982). The absence of goby eggs indicated that the Ballona wetlands are not even an important nursery for resident estuarine species, although Ballona Lagoon may be important nursery habitat for California killifish and topsmelt (Ford and Collier 1976).

TBT is present at some sites in Marina del Rey and Ballona Creek at levels (i.e., above 0.05 ppb) which are potentially toxic to mollusk larvae (Alzieu 1986). The reduction in mussel populations and crustaceans in Marina del Rey may be the result of TBT. Chronic exposure to and bioaccumulation of even low levels of TBT may have lethal or sublethal effects (Soule and Oguri 1987).

The degree to which TBT may impact shorebirds which forage on mollusks, crustaceans, polychaetes, or fish is unknown. However, reduction in the quality or quantity of these food

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resources could indirectly impact populations of waterbirds and shorebirds in the vicinity of Marina del Rey.

In 1988, unhatched eggs of California least terns from the Venice Beach nesting site had high levels of selenium, cadmium, and lead (Collins 1992); relatively high levels of lead have also been found in least tern feathers (Boardman and Collins 1992). Potentially dangerous levels of organochlorines, including DDT and its metabolites have also been found in least tern eggs and feathers (Boardman 1988). These levels are sufficiently high to cause concern for terns and other threatened species. California least terns feed on northern anchovy and topsmelt and they may be impacted by the accumulation of chlorinated pesticides and PCBs in the same way as the brown pelican.

Other Human Activities

Regulation of discharge of sewage by boats in the Marina has helped to reduce the levels of bacteria which are of concern to public health. There are occasional peaks of bacterial counts during dry weather, but overall, violations of Los Angeles County Department of Health Services standards were reduced in 1992 as compared to previous years (Soule *et al.* 1992).

Horse traffic, off-road vehicles, and human foot traffic have been noted in the Ballona wetlands, and these can cause lasting impacts by impeding or accelerating drainage and by altering elevations, thus affecting species abundance and composition (Zedler 1982). Noise from off-road vehicles or humans and domestic pets (Kraft 1978, Schreiber 1981) may affect locally breeding species such as the California least tern and Belding's savannah sparrow.

Insects in the Ballona Wetlands may also be affected by horse, human, and off-road traffic which compacts the soil, crushes insects, and destroys vegetation. The spread of introduced iceplant crowds out native plants required by some insects, while pesticides may eradicate native insects (Nagano *et al.* 1981).

Remediation

At present, the California Resources Agency (California Department of Fish and Game, Department of Foresty, etc.) is preparing a State Wetlands Conservation Plan (SWCP) through a cooperative, multi-organizational planning process. A draft outline was completed in 1992. The SWCP will identify and inventory wetlands and develop a state strategy for their protection and restoration. A regional wetlands agreement would take into consideration the special conditions of Santa Monica Bay wetlands resources.

The Santa Monica Bay Restoration Project funded a project to map and inventory all wetlands of the Santa Monica Bay watershed, and the report was produced in 1992 (Josselyn *et al.* 1992). The wetlands were evaluated and several sites were recommended for restoration, acquisition, creation, and/or best management practices (BMPs). Next priorities for these activities will be determined and an overall approach for protecting and enhancing wetlands resources of Santa Monica Bay will be adopted.

In 1990, the Port of Los Angeles (POLA) developed a Local Wetlands Mitigation Program, identifying 13 potential wetlands mitigation sites in the Los Angeles area (WRA 1990). Nine of the sites are in the coastal zone of Santa Monica Bay and one is in the watershed (Figure 8-2). One additional coastal site and one other watershed site were identified in the draft SMBRP Wetlands Inventory and Restoration Potential (Josselyn *et al.* 1992).

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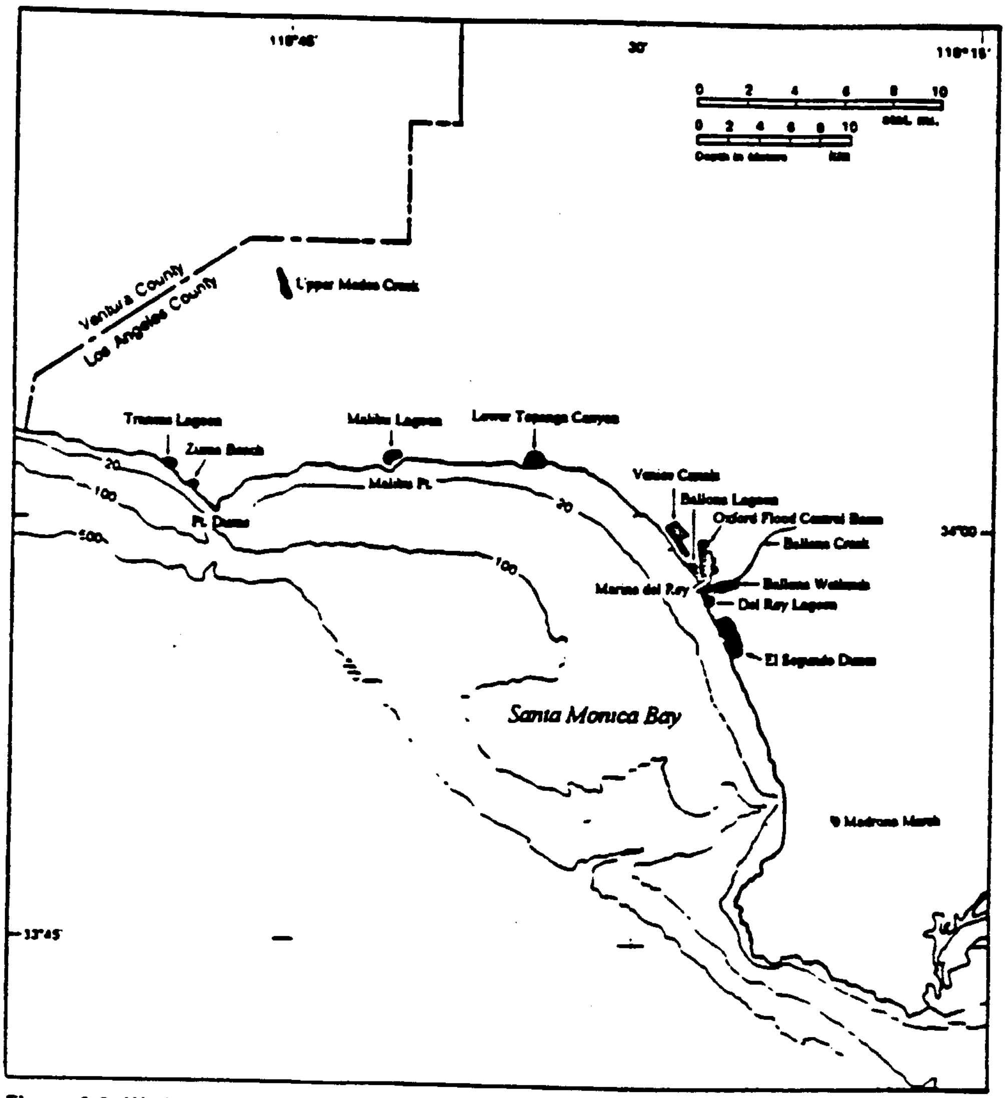

Figure 8-2. Wetlands of Santa Monica Bay study area.

Jurisdiction and Concerned Groups

Government. Many agencies maintain control over the wetlands in Santa Monica Bay, among them the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (USEPA), California Environmental Protection Agency (CalEPA), California Resources Agency, U.S. Fish and Wildlife Service, U.S. National Marine Fisheries Service, U.S. Soil Conservation Service, California State Department of Fish and Game, California Coastal Commission, California State Water Resources Control Board, Los Angeles Regional Water Quality Control Board, City of Los Angeles, Los Angeles Department of Parks and Recreation, and Topanga-Las Virgenes Resources Conservation District (TLVRCD).

The ecologic problems of wetlands involve numerous issues (habitat protection, point and nonpoint sources of pollution, land-use planning and resource management) which are too complex for any single agency to handle. Congress has enacted several programs to deal with wetlands, but the responsibility has often been relegated to the state level. In the face of budgetary shortfalls, the emphasis has been on eliminating duplication of effort and the EPA has become a facilitator rather than a manager or administrator of water pollution policies (Imperial *et al.* 1991). Under the National Estuary Program (NEP) the EPA identifies estuaries that are threatened by pollution, development, or overuse, and facilitates the preparation of comprehensive conservation and management plans (CCMP). The plans are implemented by the states using federal Coastal Zone Management (CZM) funding and are administered by the National Oceanographic and Atmospheric Administration (NOAA).

Private. The 16 acres of Ballona Lagoon is owned by several private individuals but is under the jurisdiction of the City of Los Angeles. Del Rey Lagoon (1 acre) is owned by the City of Los Angeles and Summa Corporation; Venice Canals (12 acres) are owned by the City of Los Angeles; Ballona Wetlands (232 acres) are owned largely by Maguire Thomas Partners; and El Segundo Dunes Wetlands habitat (less than 1 acre) is owned by the Los Angeles International Airport. Malibu Lagoon (36.1 acres) and lower Topanga Canyon (less than 1 acre) are owned by the California Department of Parks and Recreation.

Responsible agencies include the Soil Conservation Service, Topanga-Las Virgenes Resources Conservation District (TLVRCD), California Coastal Conservancy, and the California Coastal Commission. Oxford Flood Control Basin (10.5 acres) is controlled by Los Angeles County, Department of Public Works and the Zuma Beach Wetlands is controlled by the Los Angeles County Department of Beaches and Harbors. Trancas Lagoon (2 acres) is partly privately owned and restoration plans include expanding the Lagoon to the north of Pacific Coast Highway. The eight-acre Madrona Marsh has been designated as a significant ecological area by the County of Los Angeles and is owned by the City of Torrance. The proposed Upper Medea Creek restoration area (about 43 acres of riparian habitat along 2.2 mi of Medea Creek) is a tributary of Malibu Creek; much of the property along the creek is privately owned.

On-Going or Proposed Projects

Maguire Thomas Partners-Playa Vista Ballona Wetlands Project. In 1982 the California Department of Fish and Game conducted a Los Angeles County Local Coastal Plan status determination of the Ballona wetlands pursuant to Section 30411 of the California Coastal Act 1976. Purposes of the determination were to 1) define historical wetlands and their present status; 2) identify restoration within the area; 3) and assess the feasibility of restoring and enhancing

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wetlands. Their study area included the major marsh area and former agricultural parcels nearby. Their results indicated:

> "...that of the 510 acres within the study area, 478 acres were historically wetlands and 32 were historically uplands. ...of the 478 acres of historic wetlands, 151 acres are presently viably functioning wetlands. Of these 151 acres, 65 acres are essentially non-degraded and 86 are degraded. Additionally, 327 acres of historic wetlands have been so severely degraded that they no longer function viably as wetlands. Of these 327 acres, 51 acres are feasibly restorable and 276 acres may not be feasibly restored...(CDFG 1982)."

In 1984, Friends of Ballona Wetlands successfully challenged certification of a land-use plan by the California Coastal Commission (CCC) to allow the building of a roadway across the Ballona Wetlands and building of a residential development and golf course within the Wetlands. A settlement agreement was reached with the Commission and Maguire Thomas-Playa Vista (subsequent owners of the property) which downscaled the commercial development and eliminated development in contiguous wetlands, increased wetlands acreage through restoration, and restored mid-tidal flow.

Restoration of Ballona Wetlands was proposed in the Ballona Wetlands Habitat Management Plan (NAS 1986), prepared for the City of Los Angeles as part of the Local Coastal Program for the Ballona Wetlands. The plan included wetlands restoration and an interpretive and controlled access program. Under the plan, the Audubon Society would receive ownership of the property from Howard Hughes Properties and would manage restoration efforts with funds provided by them. This plan was later dropped and the property was sold to Maguire Thomas Partners (MTP), who acquired additional developable acreage through payment of $85 million and 70 acres in a land swap with the State of California; 60 acres were set aside for the wetlands (LA Times, 14 Sep 1991).

MTP developed a new plan, (agreed to by the Friends of Ballona Wetlands), to develop part of the property as Playa Vista, a residential-marina complex. The plan includes restoration of the saltwater marsh south of Ballona Creek, through restoration of tidal flow (the mid-tide plan developed by the National Audubon Society), dune restoration, creation of a freshwater marsh and riparian corridor upstream, and fish habitat enhancement in the proposed marina. A second enhancement plan - to reestablish full tidal action to all areas of the salt marsh - was proposed which would require the participation of other parties interested in receiving mitigation credits for tidal wetlands. In 1990 MTP applied for a permit for the first phase of the project (creation of the freshwater wetlands) and the permit was granted in 1991. However, it has not yet been signed by MTP-PV, although the draft EIR was recently submitted.

Ballona Lagoon. The California State Coastal Conservancy (CSCC) and the Ballona Lagoon Marine Preserve have been instrumental in assembling an enhancement plan for Ballona Lagoon which emphasizes improved water quality by enhancing circulation. Planting of native vegetation, fencing, and litter clean-up, along with reduced algal growth due to increased tidal exchange, would improve the aesthetics of the area (WRA 1990, Josselyn *et al.* 1992).

The City of Los Angeles, local landowners and the CSCC have approved a plan to develop Ballona Lagoon as the Ballona Lagoon Marine Preserve. The plan includes dredging, grading, bank replanting, sediment and oil and grease traps, and provisions for public access. Dredging would enhance the habitat for marine fish which are prey for the endangered California

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least tem. At present, adoption and implementation of the plan depends on assignment of the CEQA documents to either the City or the CSCC.

Some small enhancement projects are underway at Ballona Lagoon. Removal of debris and bank improvement has taken place at the southeast end of the Lagoon, and several property owners have removed exotic plant species and replaced them with native vegetation (Holderman 1992, pers. comm.). The Summa Corporation (which owns about a third of the Lagoon) has agreed to create a deep pool by dredging at the north end, although the project is pending because the private owners have not agreed to the plan for the other two-thirds of the Lagoon.

Other Projects. The Port of Los Angeles has investigated the potential for restoration of Del Rey Lagoon. Increased tidal flow would improve water quality, although local residents may object to the regular exposure of tidal flats. Improved tidal flow would increase the potential for flooding in the surrounding urban area. Pet waste control measures and banning the feeding of domesticated ducks would have to be enforced.

In 1990 the Oxford Flood Control Basin Task Force determined that enhancement possibilities for the Oxford Flood Basin were limited because of poor water quality, conflict with flood control uses of the basin, and limited wildlife potential.

Rehabilitation of the Venice Canals is currently being undertaken by the City of Los Angeles and work is due to be completed in 1993 (Josselyn *et al.* 1992).

The Malibu wetlands are within Los Angeles County Significant Ecological Area No. 5. The California Department of Parks and Recreation (CDPR) and others are developing a comprehensive plan for the Malibu Creek watershed which would include recommendations for the restoration of Malibu Lagoon (Michel 1992, 1993, pers. comm.). Enhancement of Malibu Lagoon as a brackish water marsh would probably include regulation of freshwater flow by retention or release from the Tapia Water Reclamation Plant and control of biological pollutants by the elimination of point and nonpoint sources. Tidal flushing is unlikely, as the flow volume is seldom sufficiently great to keep the mouth of the creek open to the ocean (WRA 1990).

Several projects have already begun at Malibu Lagoon, with funding from the CDPR and EPA. The tidewater goby was reintroduced into Malibu Lagoon in 1990, and has survived. Under EPA's Near Coastal Waters program, with funding from CalTrans as mitigation for construction of a replacement bridge across the Lagoon, a section of stream bank in the upper reaches of the Lagoon will be recontoured and revegetated to provide more goby habitat.

The CCSC wants to investigate effects of salinity changes on resident organisms; the effects of contamination from septic tanks on both water quality and organisms; and the effects of the water level in the Lagoon on the water table. At present, the CDPR breaches the berm to allow water to escape whenever the level in the Lagoon rises above 3.5 ft to avoid possible interaction with septic systems at the Malibu Colony. The long-term fate of the tidewater goby may depend, however, on restoration of a natural pattern of opening of the berm only during high-flow periods (Manion 1992, pers. comm.).

Wetlands which were linked to Malibu Lagoon historically but are not in the jurisdiction of the CDPR are found in the City of Malibu. The City has applied for grant funding to enhance or restore several small areas along with the larger Lagoon project (Manion 1992, pers. comm.).

CHAPTER 9

IMPACTS - MARINE INVERTEBRATES

PELAGIC RESOURCES

Because phytoplankton constitute the primary basis of the marine food web, impacts to the plankton populations of the Bay could seriously alter the abundance of other species.

Municipal Wastewater Discharges

In 1957 and 1959 the abundance of phytoplankton and zooplankton were higher within 2.2 mi of the HTP and JWPCP outfalls than at reference stations. When regular discharges ceased from the 1-mi outfall and began at the 5-mi outfall in the early 1960s, plankton abundance in Santa Monica Bay decreased in general, but the center of greatest abundance moved offshore (Figure 9-1). Because the 5-mi pipe discharges beneath the thermocline, nutrient enrichment of surface waters and phytoplankton enhancement only occurs when the wastefield surfaces (SCCWRP 1973).

In 1980 phytoplankton abundance and composition near the 5-mi outfall were not different from those at reference sites in the Bay. However, zooplankton were more abundant (the copepod (*Calanus pacificus* was dominant) near the discharge, but it is not known whether the increased abundance was due to population growth, entrainment, or migration (Kleppel *et al.* 1982).

Generating Station Impacts

The use of coastal water to cool electric generating stations contributes to losses of plankton (including larval stages of fish and invertebrates) and adult members of nearshore communities (Stephens *et al.* 1983). The mortality rate of plankton passing through the San Onofre Nuclear Generating Station was estimated at about 30% (USAEC 1973), that of zooplankton entrained at the Huntington Beach Generating Station was estimated at 28%. Intermittent chlorine injections (to prevent the accumulation of microbial slime inside of the pipes) temporally reduces photosynthesis by about 90%. Presumably the entrainment and chlorine treatment have a similar effect at Redondo, Scattergood, and El Segundo Generating Stations.

Refinery Impacts

High concentrations of ammonium were associated with a relatively consistent dinoflagellate bloom near the El Segundo Refinery discharge from 1975 to 1977. Ammonium levels and dinoflagellate abundance both decreased after 1977, but is not certain whether effluent from the El Segundo Refinery was actually responsible for conditions leading to this bloom (Eppley 1986).

Oil Spill Impacts

Oil slicks may cause a short-term reduction of light penetration and hence reduce photosynthesis in certain areas. These effects would last for a few days (Eppley 1986).

Urban Runoff Impacts

Storm runoff plumes can also enhance phytoplankton levels if the runoff contains elevated levels of nutrients. However, if suspended sediment concentrations are high, light penetration may

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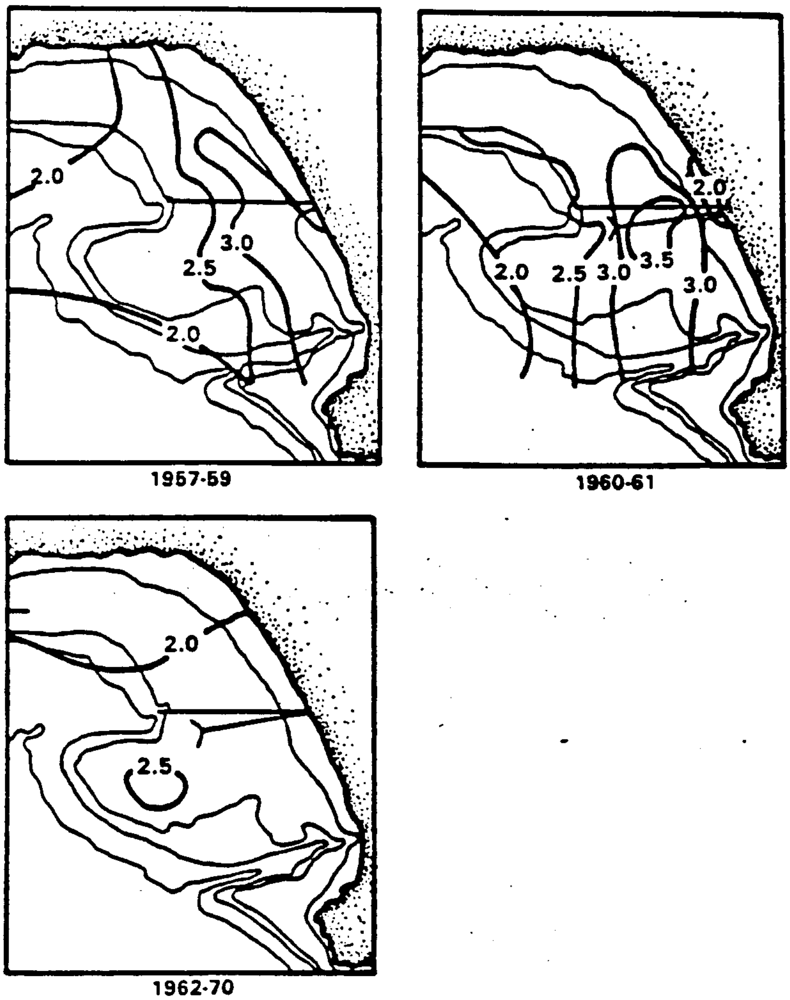

Figure 9-1. Distribution of phytoplankton and zooplankton in Santa Monica Bay during three discharge periods 1957-1959, 1960-1961, and 1962-1970 (SCCWRP 1973) Units in *ml*/1,500 *l*.

be reduced, leading to low photosynthesis and phytoplankton levels (Eppley 1986). Phytoplankton abundance in Santa Monica Bay increased dramatically in 1969, a year with exceptionally high surface runoff (SCCWRP 1973).

SOFT BOTTOM SEDIMENTS

Most contaminants are more concentrated and more readily measured in sediments than in the water column. Because contaminants usually bind to the surface of particulates, absolute levels are generally higher in fine sediments (which have a larger surface area per unit weight). Most studies of sediment concentrations in the study area have been near the HTP and JWPCP wastewater outfalls.

Contaminants in ocean sediments generally concentrate near point sources, whereas materials entering by way of aerial fallout are evenly distributed over the entire area. Once introduced, contaminants may be moved long distances with fine particles; most materials introduced into Santa Monica Bay are ultimately moved into offshore basins. Both the spatial and temporal distribution of contaminants are important and are described below.

Distribution by Contaminants

Treated wastewater discharges are the major source of toxic trace metals to the Southern California Bight (Young *et al.* 1978a). Cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc are most commonly studied. To assess man's impact on levels of metals, they must be measured at a reference site far from known inputs. In 1977 SCCWRP sampled and analyzed sediments from 71 sites in the Southern California Bight at water depths of about 200 ft, the depth at which most wastewater outfalls are located. On the basis of chemical and biological measurements, 29 of these sites were selected as reference stations (Word and Mearns 1979).

In 1985 levels were reexamined (Thompson *et al.* 1987) at 13 of the 1977 references sites to evaluate changes over time. There was no consistent trend in metals concentrations at these reference stations, some having increased and some having decreased: except for silver, most values were in the same general range in 1985 as they were in 1977.

Analysis of undisturbed core samples has also been used to estimate background metals levels (SCCWRP 1973, Galloway 1979). In this technique, a deep core of sediments is collected and sectioned horizontally and analyzed separately. Since sediment age increases with depth in the core, levels prior to human influence can then be determined.

Trace metal levels in surface sediments near the HTP and JWPCP outfalls are higher than levels found by Galloway (1979) in core-base sediments, but have generally decreased since 1985 (Table 9-1). In 1991 trace metals from near the 5-mi outfall were 0.8 to 9.6 times higher than core-base levels; those near the 7-mi outfall were 4 to 120 times higher and those near the JWPCP outfall (in 1990) were 11 to 81 times higher. Cadmium was the most enriched at all outfalls.

Elevated levels are not necessarily toxic to the local organisms. Ranges of toxicity have been developed by the National Oceanographic and Atmospheric Administration (NOAA) (Long and Morgan 1990) using data from spiked sediment bioassays, sediment-water equilibrium partitioning, the co-occurrence of fauna and contaminants in the field, and background levels. The resulting toxicity ranges are as follow: from threshold to the tenth percentile of effects is called the Effects Range-Low (ER-L), followed by the Effects Range-Medium (ER-M) and an Apparent

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Table 9-1. Effects levels, background, and concentrations of metals in sediment in Marina Del Rey, near HTP 5- and 7- mile outfalls and near JWPCP outfalls, 1985-1991. All values are in ppm.

Metal	Effects levels				MDR	
	ER-L	ER-M	AET	NRC	1990	1991
Cadmium	5	9	5	31	2.1	5.5
Chromium	80	145	nd	nd	70	68
Copper	70	310	300	136	399	410
Lead	35	110	300	132	325	575
Mercury	0.15	1.0	1.0	0.8	1.1	1.2
Nickel	30	50	nd	20	41	43
Zinc	120	270	260	760	491	640
Notes	a	a	a	b	c	c

Metal	Back-ground	Core-base	JWPCP 1985	JWPCP 1990
Cadmium	0.4	0.42	21.0	33.9
Chromium	5-40	53	804	581
Copper	10	21	529	386
Lead	2-29	6.2	112	237
Mercury	0.05	nd	nd	2.31
Nickel	nd	nd	nd	69
Zinc	nd	75	932	1051
Notes	d	e	f	f

Metal	Back-ground	Core-base	HTP 5-mi			
			1985	1989	1990	1991
Cadmium	0.4	0.22	4.0	2.9	3.5	2.1
Chromium	5-40	62	20	68	84	48
Copper	10	13	63	52	50	37
Lead	2-29	7	33	24	21	11
Mercury	0.05	nd	nd	0.29	0.44	0.18
Nickel	nd	nd	nd	23	19	14
Zinc	nd	57	107	90	98	63
Notes	d	e	g	g	g	g

Metal	Back-ground	Core-base	HTP 7-mi			
			1985	1989	1990	1991
Cadmium	0.4	0.22	44.0	37.2	33.4	26.3
Chromium	5-40	62	217	462	298	235
Copper	10	13	657	572	531	392
Lead	2-29	7	nd	164	140	122
Mercury	0.05	nd	nd	2.38	2.89	1.57
Nickel	nd	nd	nd	89	65	52
Zinc	nd	57	829	745	612	480
Notes	d	e	h	h	h	h

Notes and sources:

a. Effects levels: ER-L, ER-M: = Effects range low and medium; AET: Apparent effects threshold (Long and Morgan 1990)

b. National Research Council EPA Threshold Toxic Levels (NRC 1989)

c. Maximum values found in Marina Del Rey in October 1990 and May or October 1991 (Soule et al. 1992)

d. NOAA 1991a

e. Means of bottoms of Phleger core samples >20 cm taken within 6 mi of the outfalls (Galloway 1979)

f. ZID station (LACSD unpubl. data)

g. Averaged of levels found at ZID Stations Z1 and Z2 (CLA, DWP unpubl. data)

h. ZID Station E6 for 7-mi (CLA, DWP unpubl. data)

nd = no data

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Effects Threshold (AET). The National Research Council has also developed threshold toxic levels based on data from USEPA, the U.S. Geological Survey, and other sources (NRC 1989).

Mercury

In 1990, mercury levels were highest near the HTP 7-mile and JWPCP outfalls and surrounding areas (Figure 9-2). Mercury concentrations were also elevated (up to 1.2 ppm) in Marina del Rey (Soule *et al.* 1992), (Table 9-1).

In 1972 mercury levels in sediments were elevated as much as 100-fold over background levels (Eganhouse *et al.* 1976), the average enrichment on the Palos Verdes Shelf being 23-fold (Hershelman *et al.* 1981). In 1972 the highest levels in Santa Monica Bay proper were within 0.6 mi of HTP's 5-mi outfall, where they were elevated 14-fold, and near Redondo Submarine Canyon, where they were 18 times background. Concentrations in most of Santa Monica Bay were lower in 1990 than in 1970 except immediately adjacent to the outfalls. Mercury concentrations decreased approximately 50% near the 7-mi outfall between 1990 and 1991, from almost three times the effects levels to less than twice the effects levels (Table 9-1). Concentrations are still higher near the 7-mi outfall than near the 5-mi outfall.

On the Palos Verdes Shelf sediment mercury levels declined 46% at 100-ft stations, 38% at 200-ft stations, and increased 3% at depths cf 500 ft between 1973 and 1979, suggesting down-slope and offshore movement of contaminants (Stull and Baird 1985). Pre-1974 values may not be as accurate as recent values and the decrease may have been greater (Stull 1988, pers. comm.). Mercury levels on the Palos Verdes Shelf in 1990 were less than half those in 1972 except at the JWPCP outfalls. Concentrations deceased with distance north of the outfall and were below 1 ppm on most of the Palos Verdes Shelf the level at which effects are seen, (Table 9-1, Figure 9-2).

Cadmium

In 1986 cadmium concentrations exceeded 5 ppm (the level at which effects may occur) at stations close to the 5-mi outfall and in the 7-mi sludge field. They exceeded the average Bay value of 2.8 ppm in an ellipse about one mile wide and 2 mi long which included both outfalls. In 1990 and 1991 the ellipse of elevated levels was still centered on the 5- and 7-mile outfalls but its areal extent was smaller than in 1986 (Figure 9-3). Cadmium concentrations at the 7-mile outfall have been slowly decreasing since 1985 and were below the NRC threshold toxic level in 1991, although still above other effects levels (Table 9-1).

In 1977 cadmium levels off Palos Verdes exceeded average Bight values by about 36-fold (Hershelman *et al.* 1981). Between 1974 and 1980 concentrations and the area of very high concentrations both decreased. This trend continued, with an 48% decline in sediment cadmium concentrations near the JWPCP outfalls between 1980 and 1985 (LACSD, unpubl. data). The general trend of decreasing cadmium levels on the Palos Verdes Shelf appears to have continued into 1990, although at some shallow sites levels were higher in 1990 than in 1980. The highest levels on the Palos Verdes Shelf are near the JWPCP outfalls, but concentrations were above the NRC threshold toxic level of 31 ppm at only one sampling station (Figure 9-3).

Cadmium concentrations in Marina del Rey in 1991 were generally below 1 ppm, although they ranged as high as 5.5 ppm (Table 9-1).

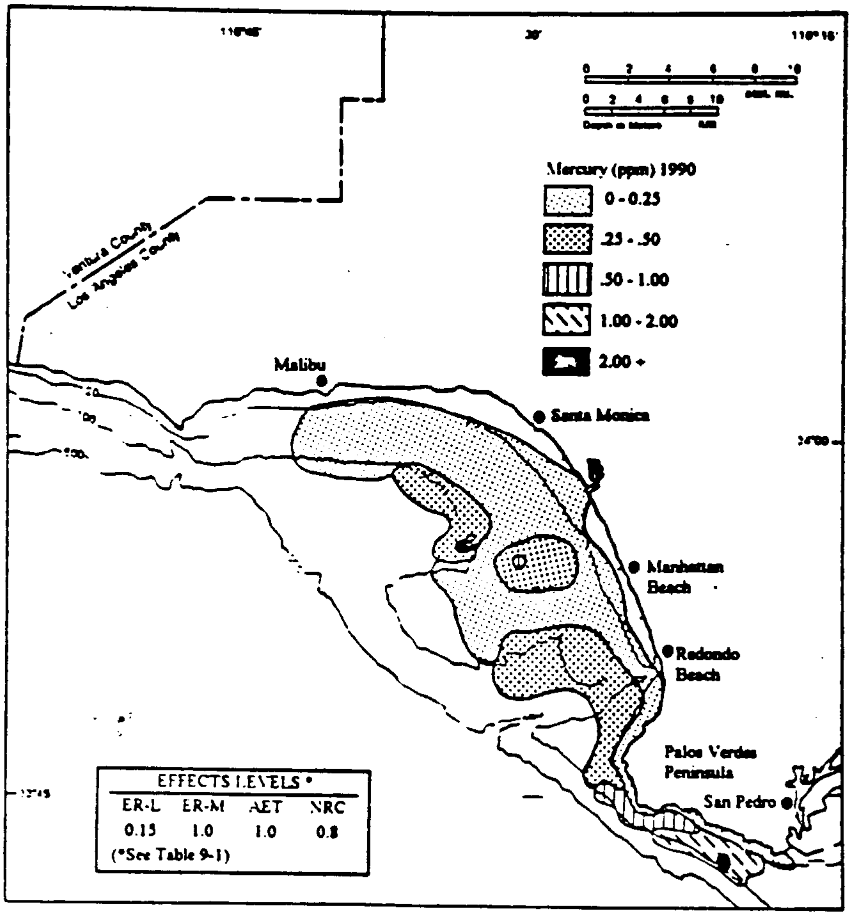

Figure 9-2. Mercury concentrations in surface sediments of Santa Monica Bay and Palos Verdes Shelf, 1990. Map contours contain areas of measurement. (Soule et al. 1992; CLA,DPW unpubl. data; LACSD unpubl. data).

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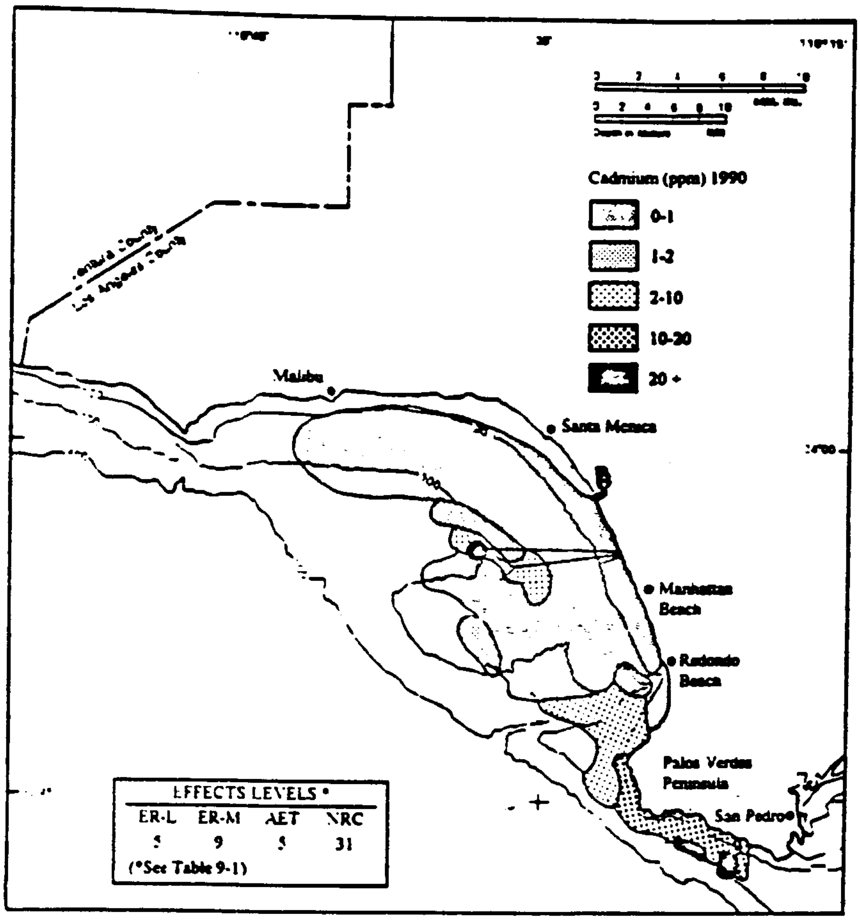

Figure 9-3. Cadmium concentrations in surface sediments of Santa Monica Bay and Palos Verdes Shelf, 1990. Map contours contain areas of measurement. (Soule *et al.* 1992; CLA,DPW unpubl. data; LACSD unpubl. data).

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Lead

In 1986, the concentrations of lead in sediments Bight-wide along the 200-ft isobath, averaged 32 ppm, five times background level (Word and Mearns 1979). In 1990 most levels in the Bay were below 20 ppm (Figure 9-4). In 1986 and 1990 the most concentrated lead values were in the Bay at the end of the 7-mi outfall. Elevated lead levels extended northwest of the 7-mi outfall (Figure 9-4) in both 1990 and 1991, although levels were only above effects levels near the 7-mi outfall (Table 9-1). In the Bay levels were lower overall and the area of elevated levels was smaller than in 1986.

Most sites in Marina del Rey in 1991 contained more than 100 ppm lead, over 10 times the levels in most of Santa Monica Bay (168 ppm in May, 152 ppm in October) and the highest levels exceeded toxic thresholds (Table 9-1). The average lead concentrations in Marina del Rey in 1991 were higher than average from 1984 to 1991 (Soule *et al.* 1992). Lead levels in Marina del Rey also generally increased between 1977 and 1987, a 3-fold increase in the entrance channel and a 10-fold increase at the mouth of Ballona Creek (Soule and Oguri 1987).

Lead concentrations in sediments near the JWPCP outfalls decreased by 59% between 1980 and 1985 (LACSD, unpubl. data), continuing the trend from 1974 to 1980 (Stull and Baird 1985), although values were still 23 times background at stations nearest the outfalls (Swartz *et al.* 1986; LACSD, unpubl. data). Vertical profiles of Palos Verdes Shelf sediments along the 200-ft isobath also show declines from earlier levels (Figure 9-5) (Stull *et al.* 1986a). Sediment lead concentrations decreased substantially on the Palos Verdes Shelf to below 100 ppm in 1990 except in sediments nearest the JWPCP outfalls (Figure 9-4). Highest concentration in 1990 was 237 ppm compared to 449 ppm in 1980 and 594 ppm in 1974. However, concentrations on much of the Palos Verdes Shelf remain above theoretical effect concentrations (Table 9-1).

The general trend over time appears to be a decline in sediment levels throughout the study area, except in Marina del Rey. This is probably a result of a decline in mass emissions from wastewater treatment plants and in aerial fallout. Nearshore sediments are gradually being cleansed of lead by resuspension and offshore transport.

Other Metals

Generally, the distributions of other metals are similar to those of mercury, cadmium, and lead. In 1990 copper concentrations were 5 to 10 times higher near the JWPCP outfalls than on the rest of the Palos Verdes Shelf; arsenic, chromium, and zinc were 4 times higher and nickel and silver, 2 times higher (LACSD unpubl. data). Copper concentrations are relatively high in Marina del Rey, but appear to be decreasing near the HTP and JWPCP outfalls (Table 9-1).

A notable exception to this pattern is that of the organic forms of tin, particularly tributyl tin (TBT). TBT has been used in the production of textiles, plastics, paints, fungicides, bactericides, and rodenticides since 1925 and in anti-fouling boat paint in the 1960s (Sax and Lewis 1987, Soule and Oguri 1987). However, because TBT is toxic to marine life it has been banned from use on vessels less than 50 ft long.

Present levels of TBT are linked to historical use on pleasure craft berthed in marinas. TBT values in Marina del Rey have decreased three orders of magnitude from 1,070 ppm in 1987 to 0.53 ppm in 1991 (Soule *et al.* 1992).

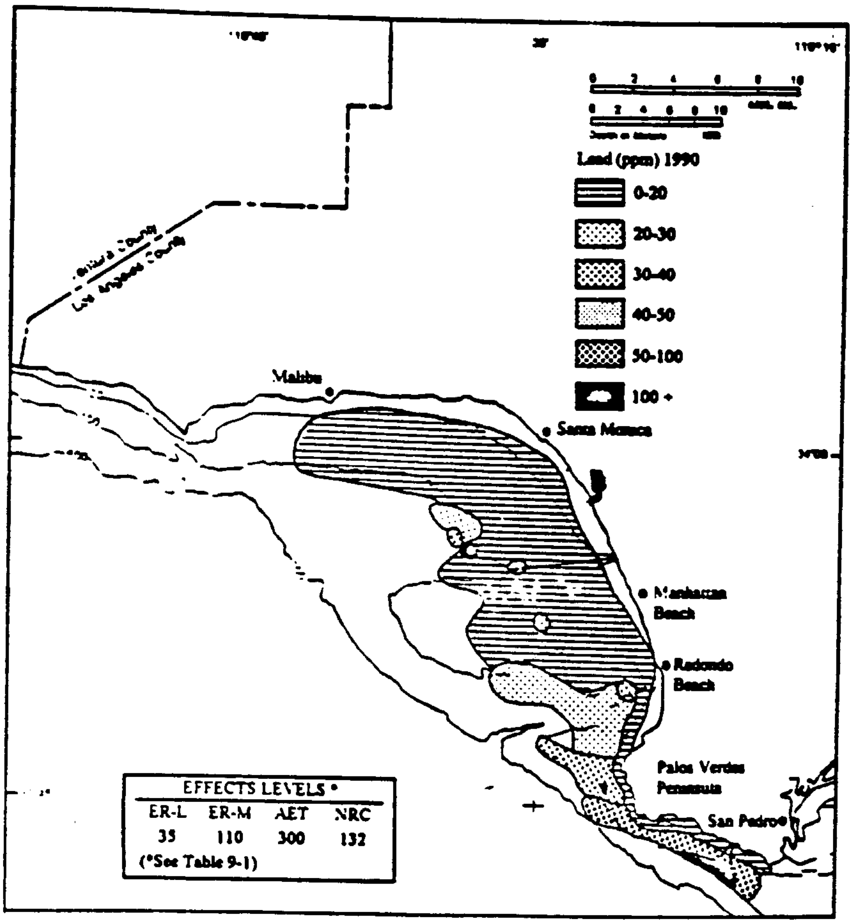

Figure 9-4. Lead concentrations in surface sediments of Santa Monica Bay and Palos Verdes Shelf, 1990. Map contours contain areas of measurement. (Soule *et al.* 1992; CLA,DPW unpubl. data; LACSD unpubl. data).

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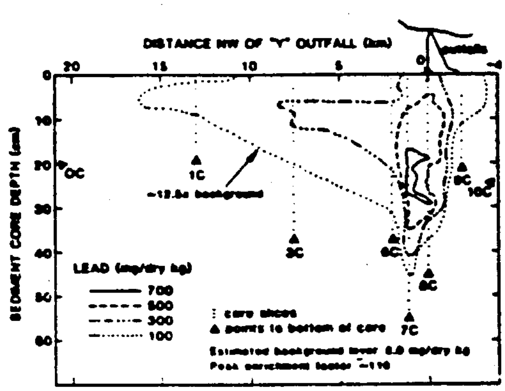

Figure 9-5. Lead stratigraphy along the 60 meter isobath on Palos Verdes Shelf. (Stull *et al.* 1986a, SDWG 1988).

Inorganic Nonmetallic Substances

Sediments act as a regeneration point for water column nutrients and as a sink for water column toxicants. Elemental nutrients (nitrogen, phosphorus, silicon) and toxicants (sulphur, chlorine) undergo changes in chemical form and distribution which may be further modified by man's activities. Inorganic nonmetallic substances may be essential parts of the marine system, but may be contaminants if especially excessive.

Organics Indicators

Total organic carbon (TOC) and organic nitrogen are measures of the amount of organic matter in sediments. In 1985, Bight-wide reference sites contained 0.2 to 1.5% TOC (Thompson *et al.* 1987), whereas in Santa Monica Bay, TOC was 6.4% at HTP's 7-mi outfall and 0.8% at the 5-mi outfall (CLA, DPW 1986). In the same year, values in Marina del Rey ranged between 1.0 and 10.1% and were highest at the mouth of Ballona Creek (Soule and Oguri 1986).

In 1990, TOC in Santa Monica Bay was again highest (4.7%) at HTP's 7-mi outfall with levels of 1.3 to 1.7% to the northwest, while most of the Bay sediments contained less than 1% (CLA, DPW, unpubl. data). After the termination of sludge disposal from the 7-mile outfall, TOC in the sludge field decreased from approximately 10% in 1986 to 8.5% in 1990 (SCCWRP 1992). On the Palos Verdes Shelf, levels were highest (5 to 8%) offshore of the outfalls, and decreased to 1 to 2% to the north. Levels in Marina del Rey in 1991 were generally 2 to 4% (Soule *et al.* 1992).

Treated sewage is a major source of nitrogen and elevated nitrogen values in sediments can be used to trace the transport and deposition of wastewater particulates. In 1977 organic nitrogen in sediments along the 200-ft isobath in the Southern California Bight averaged 0.11%, compared to the background level of 0.08%. The highest levels were in the vicinity of the HTP 5-mi (0.11%) and the JWPCP outfalls (0.81%) (Word and Mearns 1979), but in 1990 organic nitrogen levels were half the 1977 level near the JWPCP outfalls (Stull 1993, pers. comm.).

After termination of sludge disposal, organic nitrogen in the 7-mi sludge field decreased, from approximately 1.0% in 1986 to 0.08% in 1990 (SCCWRP 1992). Sediment levels of organic nitrogen also decreased on the Palos Verdes Shelf between 1971 and 1990. The highest levels (up to 0.4%) in 1990 were near the JWPCP outfalls, while most of the Shelf had levels below 0.2%. Organic nitrogen levels in Marina del Rey in 1991 were generally 0.1 to 0.2% (Soule *et al.* 1992).

Oil and Grease

In 1991, the highest levels of oil and grease in Santa Monica Bay were at the 7-mile outfall (4,400 ppm) and in 45 m of water off El Segundo (4,760 ppm) (CLA, DPW, unpubl. data). Levels higher than 400 ppm extended northwest and southeast of the 7-mile outfall while most sediments in the Bay contained less than 300 ppm. In 1989 and 1990 levels were even higher near the 7-mile outfall, 17,300 and 16,300 ppm, respectively.

The abundance of oil and grease near El Segundo in 1991 may have been due to a Chevron oil spill in March 1991, as levels in 1989 and 1990 were near average.

Oil and grease levels were high in Marina del Rey in 1991, as much as 8,700 ppm, although they were between 1000 and 2000 ppm in most areas (Soule *et al.* 1992). Oil and grease levels have always been high in Marina del Rey in the past, presumably from boating activities. In 1977 and 1978 values ranged from 1,000 to 7,000 ppm; in 1984 from 200 to 5,000 ppm; and in 1985 and 1987, up to 20,700 ppm. In 1987 concentrations within the Marina ranged from 1,000 to 4,250 ppm; the higher concentrations were near the mouth of Ballona Creek, suggesting runoff as the source (Soule and Oguri 1987).

In 1980, concentrations of oil and grease were 20,600 ppm at the JWPCP outfalls, but decreased to 1,020 ppm northward (Swartz *et al.* 1986). By 1983 concentrations had decreased to 6,860 ppm at the outfalls and to the north, around Palos Verdes Point, to 610 ppm. In those same years values at a reference site in northern Santa Monica Bay were 338 and 516 ppm, respectively.

PCBs

Polychlorinated biphenyls (PCBs) are among the most persistent and toxic of synthetic organic compounds. Over 200 congeners of PCB and a variety of mixtures have been produced; Aroclor 1254 was the most widely used locally. The manufacture of PCBs was limited in 1970 and their use restricted in 1972 to closed systems; manufacture of new PCBs was banned altogether in 1976.

PCBs are still concentrated in the sediments near municipal outfalls and in harbors, even though input levels have decreased with time (CSWRCB 1983). In 1976 it was estimated that 6 MT of Aroclor 1254 alone occurred on the 19 mi^2 of shelf surrounding the JWPCP outfalls (Young *et al.* 1976a).

In 1985, reference areas outside the study area had an average PCB concentration of 17.5 ppb – more than twice the average of 7.2 ppb in 1977 (Thompson *et al.* 1987), although the high levels have been attributed to a more refined analytical technique (Stull 1993, pers. comm.) In 1977 concentrations of PCBs in sediments from the 200-ft isobath of the Palos Verdes Shelf averaged 3,120 ppb, 69% which was Aroclor 1254. Concentrations of 10,890 ppb (60% 1254) were found near the JWPCP outfalls, but levels of both total and 1254 declined westward to 109 ppb (83% 1254) off Rocky Point (Word and Mearns 1979). By 1985, most of the Palos Verdes Shelf had PCB levels of less than 2,000 ppb. The highest levels (4,880 ppb) were again found offshore and to the north of the JWPCP outfalls (Stull 1988, pers. comm.). In 1990 PCB levels on most of the Palos Verdes Shelf were below 500 ppb, however, near the outfalls levels were 2,000 to 4,000 ppb, and up to 11,000 ppb in areas immediately adjacent (Figure 9-6).

In 1977, sediments contained an average of 157 ppb PCBs (81% 1254) in the vicinity of the HTP outfalls and along the 200-ft isobath. Levels were highest (up to 513 ppb, 80% 1254) near the outfalls; these values were four times the background off Point Dume (Word and Mearns 1979). In 1975 PCB concentrations as high as 10,000 ppb were measured in the sludge field below the 7-mi outfall.

By 1989 and 1990 PCB levels were below detection levels (20 ppb), in much of Santa Monica Bay, although in 1989 they were detected in a small area north and west of the 7-mi outfall. In 1990 levels were higher than in 1985 in an area near and southwest of the discharge (Figure 9-6). In 1991 the area of detected PCBs was larger than in 1990 in the same locations. Essentially all PCBs detected from 1989 to 1991 in Santa Monica Bay were Aroclor 1254.

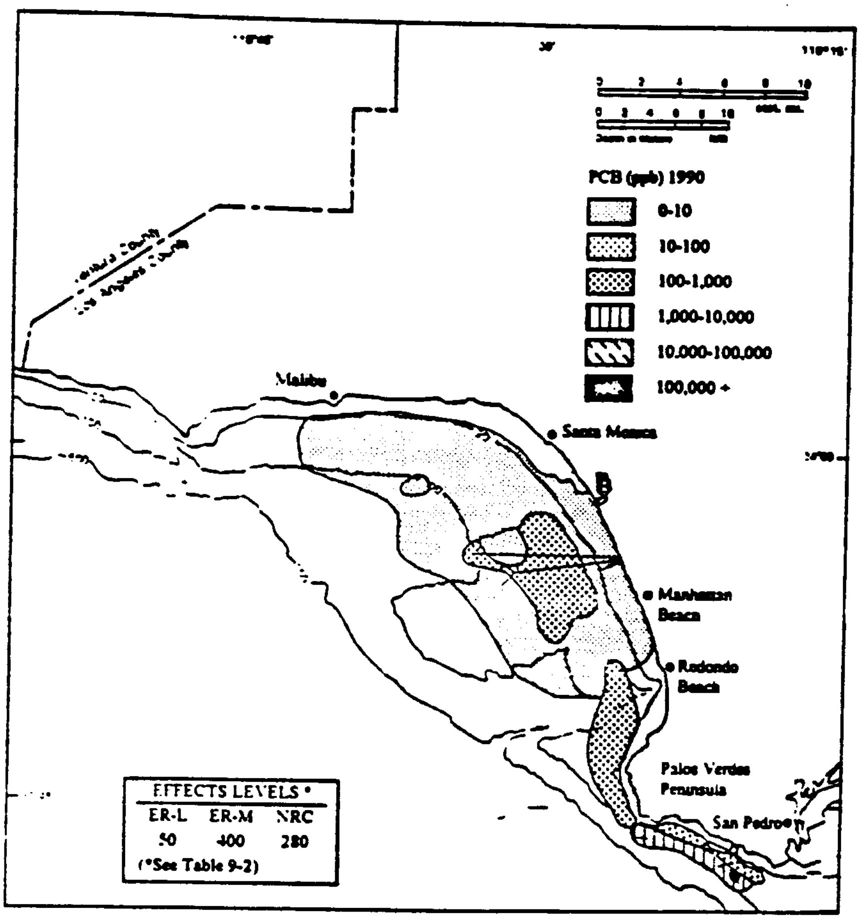

Figure 9-6. PCB concentrations in surface sediments of Santa Monica Bay and Palos Verdes Shelf, 1990. Map contours contain areas of measurement. (Soule et al. 1992; CLA,DPW unpubl. data; LACSD unpubl. data).

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In 1989 PCB concentrations were high (up to 330 ppb) in Marina del Rey where they previously had not been detected (Soule *et al.* 1992). Areas of high concentration varied between surveys, but were below detection levels by 1991. These PCBs may have been introduced at the result of grading projects in areas which were contaminated by industrial activity during World War II. Levels were up to six times toxic thresholds in May 1991 (Table 9-2).

The recent appearance of PCBs in Marina del Rey, and the increase in sediment concentrations from 1989 to 1990, and 1990 to 1991 indicate an upstream, historical source of PCBs.

DDT

Large amounts of DDT processing wastes were discharged through the JWPCP outfalls, resulting in especially high concentrations of DDT, DDD and DDE on the Palos Verdes Shelf. An estimated 1,700 MT of DDT were discharged between 1953 and 1970 – about 291 kg/day in 1970. The discharge of DDT processing wastes ceased in 1971, although DDT was manufactured until 1982.

In 1972 an estimated 200 MT of total DDT i.e., (DDT, DDD, and DDE) were contained in the upper foot of sediments in a 19 mi^2 zone around the JWPCP outfalls and 300 MT more on the surrounding shelf. In some places concentrations exceeded 200,000 ppb, the highest in shallow water northwest of the outfalls (MacGregor 1976, Young *et al.* 1976b).

Between 1971 and 1973 the concentration of DDT in surface sediments near the JWPCP outfalls ranged from 50,000 to over 200,000 ppb, however, in 1982 they averaged about 19,000 ppb. By 1985 most surface sediments on the Palos Verdes Shelf contained less than 10,000 ppb, although adjacent to the JWPCP outfalls, levels were as high as 65,000 ppb (Stull 1988, pers. comm.). Peak DDT levels (375,000 ppb) in 1985, were 12 in. below the surface (Figure 9-7), indicating that the heavy loading of the late 1960s and early 1970s has been buried.

By 1990 DDT levels on the Palos Verdes Shelf (Figure 9-8) had decreased somewhat, though not substantially since 1985. The highest concentrations are near the JWPCP outfalls, (up to 138,000 ppb), 10 times those on the shelf generally, and 100 times those to the north (CLA, DPW unpubl. data; LACSD unpubl. data).

In 1985 concentrations of DDT around the HTP outfalls decreased to the north and increased to the south, although levels near the 5- and 7-mi outfalls were higher than in the surrounding area. Values in Redondo Submarine Canyon are intermediate between those in Santa Monica Bay and the JWPCP area, suggesting that DDT has moved from the Palos Verdes Shelf into and across Redondo Submarine Canyon, and has mingled with inputs from HTP. In 1982 the mass emission rate from JWPCP was only 15 times that from HTP, yet the sediments off Palos Verdes contained 200 to 300 times more DDT than those around the HTP outfalls (Brown *et al.* 1984a).

DDT levels in Santa Monica Bay in 1990 and 1991 indicate that areas of high concentrations are slowly shrinking (Figure 9-8). Most of the "total" DDT found in Santa Monica Bay from 1988 to 1991 was DDE. DDT has only been detected twice since 1998: near the 5-mi outfall in 1988 and inshore of the 5-mi outfall in 1990, indicating that most DDT has degraded to the less toxic DDE (NRC 1989).

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Table 9-2. Effects levels and maximum concentrations (ppb dry weight) of pesticides in sediments in Marina Del Rey, near HTP 5- and 7-mile outfalls and near JWPCP outfalls, 1990-1992.

Pesticide	Effects levels			MDR	JWPCP	Hyperion	
	ER-L	ER-M	NRC			5-mi	7-mi
DDT	3	350	nd	136	138,000	75	146
PCB	50	400	280	300	10,913	90	125
Chlordane	0.5	6	20	436	nd	<50	<50
Notes	a	a	b	c	d	e	f

Notes and sources:

a. Effects levels: ER-L, ER-M: = Effects range low and medium (Long and Morgan 1990)

b. National Research Council EPA Threshold Toxic Levels (NRC 1989)

c. Maximum values found in Marina Del Rey in May or October 1991 (Soute et al. 1992)

d. ZID station, 1990 (LACSD unpubl. data)

e. Averaged of levels found in 1990 at ZID Stations Z1 and Z2 (CLA, DWP unpubl. data)

f. ZID Station E6 for (CLA, DWP unpubl. data)

nd = no data

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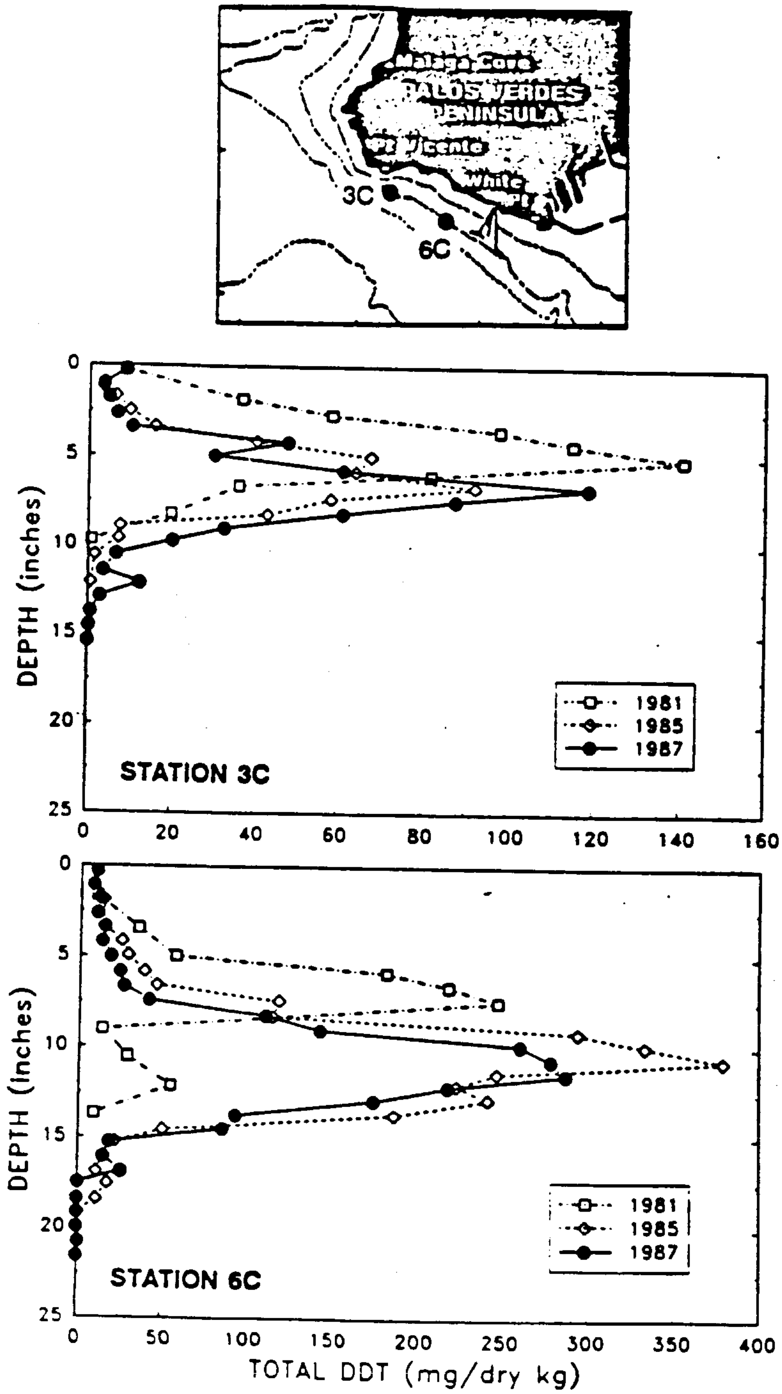

Figure 9-7. Concentration-depth profiles of total DDT at two stations along the 60 meter isobath 1982-1987 (modified from SDWG 1988)

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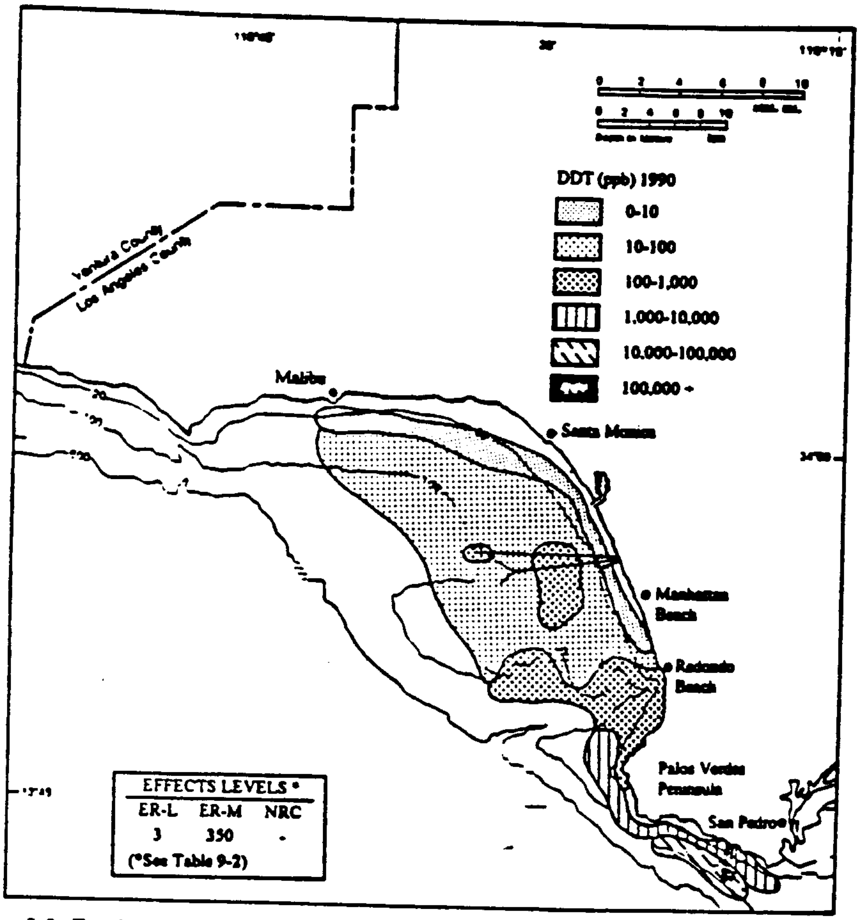

Figure 9-8. Total DDT concentrations in surface sediments of Santa Monica Bay and Palos Verdes Shelf, 1990. Map contours contain areas of measurement. (Soule *et al.* 1992; CLA,DPW unpubl. data; LACSD unpubl. data).

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Total DDT in Marina del Rey is above low effects levels (Table 9-2). Maximum levels decreased between 1990 and 1991, but increased between May 1991 and October 1991 after the spring rains, indicating upstream sources of DDT. The presence of DDT as well as DDE and DDD also suggests continued input (Soule *et al.* 1992).

In 1977 background sediment DDT levels averaged 30 ppb along the Bight-wide, 200-ft isobath (Word and Mearns 1979). When these same stations were resampled in 1985, the average DDT concentration had declined to 19.4 ppb (Thompson *et al.* 1987). In 100 ft of water DDT averaged 9.1 ppb, while in 500 ft of water it averaged 30.1 ppb, suggesting that DDT has moved offshore with time. Although levels in most of Santa Monica Bay have decreased with time, they remain above background levels.

Since 1971 mass emissions of DDT to the study area have decreased and degraded to DDD and DDE and moved offshore. Because contaminated sediments can be resuspended by storms and bioturbation, leading to the bioaccumulation of previously buried DDT or DDE, DDT continues to be of concern.

Other Pesticides

After DDT was banned, other pesticides were used and many of these are now found in the marine environment. Among the most common are aldrin, dieldrin, endrin, endosulfan, heptachlor, and isomers of BHC. In 1986, the concentrations of most of these in the vicinity of the HTP outfalls were less than 9 ppb. Gamma BHC, heptachlor epoxide, and endosulfan were most concentrated near the HTP 5-mi outfall, alpha BHC along the shelf break off Malibu, and dieldrin in Redondo Submarine Canyon. By 1991 most of these compounds were not detected in Santa Monica Bay, although 266 to 718 ppb of Beta BHC were found along the 45-m isobath.

Chlordane is a persistent insecticide which was used extensively in termite control until it was banned in 1988. Chlordane is high in Marina del Rey and may be increasing suggesting that it is continually being introduced (Soule *et al.* 1992). In 1991 all levels exceeded effects levels in Marina del Rey (Table 9-2).

PAHs

Polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) are related compounds which are present in crude oil and refined products and are released during combustion. Some are also released during the burning of non-petroleum substances in brush and forest fires. Concern about PAHs in the environment is fairly recent and their local abundance and distribution is not well known.

In 1984, the concentration of PAHs near the JWPCP outfalls was 560 ppb, at the HTP outfalls 370 ppb (Malins *et al.* 1987). In 1985 among sediments from 24 river mouths, harbors, and outfalls between Santa Monica Bay and San Diego, the least contaminated sample contained 150 ppb of PAHs. Sediments from the HTP 5-mi outfall contained 393 ppb PAHs, those from the 7-mi outfall 11,317 ppb, and those near the JWPCP outfalls 7,902 ppb (Anderson and Gossett 1986).

In 1985, 43 "reference" sites between Point Conception and San Diego averaged 32 ppb PAHs. Sites close to Los Angeles generally included 4 to 6 compounds, those further away only 1 or 2 compounds. A site in 100 ft of water west of Point Dume was one of the most contaminated, with 147 ppb PAHs (Thompson *et al.* 1987).

In 1987 sediment PAH at HTP 7-mile outfall were 20,000 ppb, higher than found in sites in Long Beach, Los Angeles, or San Diego harbors where values ranged from 4,700 to 12,100 ppb (SCCWRP 1989). Since the termination of sludge disposal at the 7-mi outfall, PAHs in the sludge field have decreased 50%, from approximately 10,000 to 5000 ppb (SCCWRP 1992).

In a nationwide survey, the highest levels of total PAH in California were found in San Diego Harbor (7,300 ppb) followed by San Francisco Bay (4,700 ppb) and San Pedro Bay (2,400 ppb) (NOAA 1991a). Sediment levels near Palos Verdes, in Santa Monica Bay, and in Marina del Rey were 1,100; 1,300; and 320 ppb, respectively.

Contaminated Sediments as Point Sources

Areas on Palos Verdes Shelf near HTP 5- and 7-mile outfalls, and in Marina del Rey sediments are sufficiently contaminated to be considered point sources of contamination themselves.

Most contaminants are more concentrated on the Palos Verdes Shelf than in Santa Monica Bay; they are especially high to the northwest and offshore of the JWPCP outfalls, and decrease with distance toward Redondo Submarine Canyon. Although DDT levels are decreasing in Santa Monica Bay, they remain elevated on the Palos Verdes Shelf. Lead concentrations have decreased, but are now higher in Marina del Rey than at the JWPCP outfalls.

Palos Verdes Shelf

Contaminated sediments deposited on the Palos Verdes Shelf in the recent past may be a primary source of contamination to Santa Monica Bay and of DDT and PCBs for the entire Southern California Bight (Mearns *et al.* 1991, SCCWRP *et al.* 1992). High levels of DDT, PCB, lead, and other trace metals accumulated near the JWPCP outfalls prior to the 1970s. The primary field of contaminated sediments in 1972 was about 19 mi^2 upcoast of the JWPCP outfalls (MacGregor 1976, Young *et al.* 1976a).

Although DDT levels were highest near the sediment surface in 1972, peak levels were about 6 in. below the sediment surface in 1981, and about 12 in. below the surface in 1987 (Figure 9-7) (SDWG 1988). Away from the outfalls (at Point Vicente) levels of DDT were shallower, 6 in. below the sediment surface in 1981 and 7 in. in 1987 (SDWG 1988). Lead shows a similar pattern: peak concentrations about 12 in. below the sediment surface near the outfall and about 2 in. below the surface 15 km upcoast of the outfalls (Figure 9-5) (Stull *et al.* 1986a, SDWG 1988).

Despite the burial, in 1990 DDT and PCB levels in white croaker and yellow rock crab tissue were still much higher on the Palos Verdes Shelf than at other locations in Santa Monica Bay indicating that the sediments are a source of contamination (SCCWRP *et al.* 1992). Bioturbation (the burrowing activities of infauna) may bring some of this contamination to the surface. In addition, some of these infauna may be preyed upon by fishes and larger invertebrates, thus introducing contamination into the food chain. Erosion especially at the edges of the field, may also remobilize the contaminants (SDWG 1988).

Recovery at the 7-Mile Outfall

Sludge from HTP was discharged from the 7-mile outfall from 1957 to 1987 resulting in a 20 mi^2 area of elevated contaminant concentrations centered along the axis of the upper part of Santa Monica Submarine Canyon. The sludge field was 50-100 cm deep (SCCWRP 1987)

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during the period of active sludge disposal. Sediments in the Canyon were characterized by extremely high organics and sulfides. By August 1990, the concentrations of most contaminants in the sludge field had decreased (SCCWRP 1992). DDT levels, on the other hand, decreased considerably at a nearby site although not in the sludge field.

Sulfide levels decreased rapidly within nine months after disposal abatement but remained higher than background levels. Organic carbon levels decreased 23%, nitrogen 29%, PCBs and PAHs about 49%, and trace metals 53 to 59%. In 1990 approximately 1 cm of clean sediment was found on the surface of the accumulated sludge. Based on the evidence of 1.5 yr of pre-abatement and 3 yr of post-abatement data recovery of the sludge field is estimated to take at least ten years, except for sulfide concentrations which may approach background by the end of 1994 (SCCWRP 1992).

Marina del Rey

Concentrations of the insecticide chlordane in Marina del Rey Harbor are as much as 100 times the "low effects" range (Soule *et al.* 1992). Although banned, chlordane continues to enter the Marina, either from continued use or from leaching from previously treated structures. DDT levels in Marina del Rey are sufficiently high to potentially impact larval and juvenile organisms. PCBs were found in the Marina between the October 1989 and May 1991, but were not detected in October 1991 (Soule *et al.* 1992).

Nickel concentrations are below low effects levels at most stations in the Marina while copper, lead, and zinc levels have fluctuated. Lead and zinc increase after heavy rainfalls, indicating terrestrial sources (Soule *et al.* 1992), lead levels in Marina del Rey are among the highest in Southern California (Mearns *et al.* 1991). Average copper levels in Marina del Rey have increased between October 1990 and October 1991, possibly because of copper based antifouling paint (Soule *et al.* 1992).

SOFT-BOTTOM BIOTA

Municipal Wastewater Discharges

Macrofauna

Large wastewater discharges into the sea have created "hotspots" of contamination and ecological imbalance, which generally expand with time as the discharge continues. They may contract if the discharge is stopped, its quality is improved, or if contaminated sediments are resuspended and flushed from the area. There is little evidence that wastewater effluent has approached shore in Santa Monica Bay since the discharge from HTP's 1-mi outfall was discontinued in 1960.

Early benthic investigations detected altered physical conditions in infaunal communities near outfalls in Santa Monica Bay. In 1957 the bottom near the JWPCP outfall was "foul" and lacked several important animal groups (Hartman 1959). As early as 1952, it was noted that infaunal community structure near the HTP 1-mi outfall was altered (Hartman 1956). Within 0.3 mi of the outfall was an impoverished zone, which was followed by an area of pollution-tolerant populations at 0.3 to 1.9 mi, and a zone of enrichment at 1.9 to 4.5 mi. High diversity and low density of species was noted at 4.5 to 7.9 mi and an unaffected bottom beyond 8 mi. This description exemplifies the benthic enrichment gradient described by Pearson and Rosenberg (1978) (Figure 9-9).

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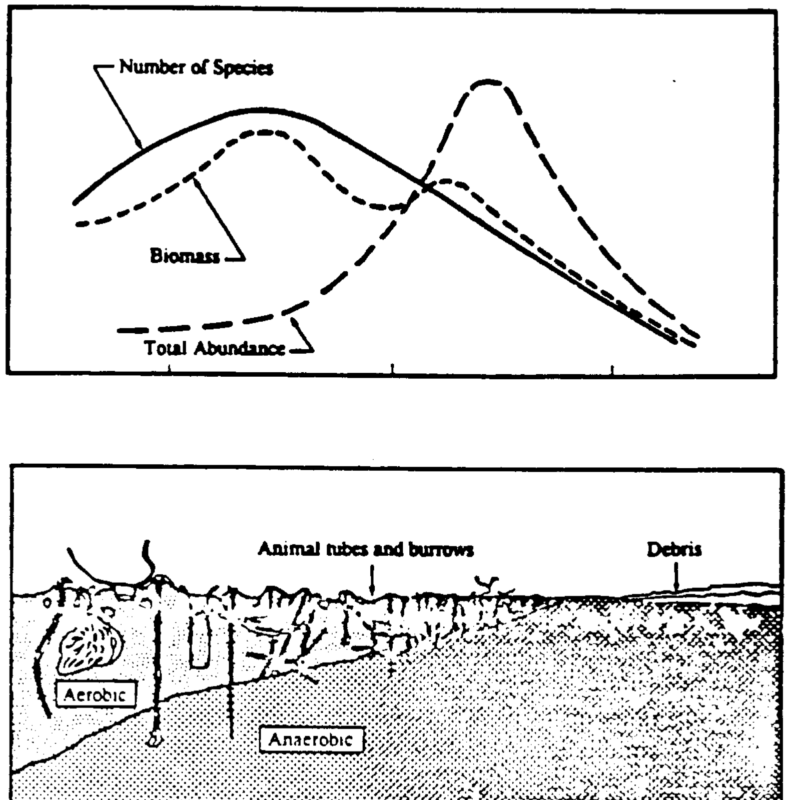

NORMAL	TRANSITION	POLLUTED	GROSSLY POLLUTED
Normal Infauna	Increased Abundance	Pollution Indicator Species	No Macrofauna

Figure 9-9. Generalized changes in fauna, sediment structure, and benthic community parameters along an organic enrichment gradient (Pearson and Rosenberg 1978).

The HTP 5-mi outfall became operational in 1961 and an area of impacted infauna began to develop around the discharge point. The 7-mi outfall became operational in 1957, and a degraded bottom community, (which corresponded to Hartman's 1952-1954 impoverished zone) developed. The affected area increased in the 1960s and 1970s, although the net trend has been downward (Hartman 1956, Tetra Tech 1981, Dorsey 1988). In 1985 an area of 11.5 mi^2 around the 5-mi and 7-mi outfalls supported an affected bottom community (Dorsey 1988), which corresponded to the first three zones observed by Hartman around the 1-mi outfall in 1952 to 1954. Thus, in the 31 years from 1954 to 1985, the area of bottom affected by the discharges declined by more than half, from 25 to 12 mi^2.

In 1977 the infaunal community in the study area was most degraded near the JWPCP outfalls and the HTP 7-mi outfall (Figure 9-10), as measured by the infaunal trophic index which evaluates the relative abundance of different infaunal assemblages (Bascom 1978). The general distribution of degraded and altered communities is very similar to that of many contaminants, including DDT and PCBs (Figures 9-6 and 9-8).

Comprehensive investigations of the infauna near the JWPCP outfalls were undertaken in 1972 and have continued to date. The infaunal community is most severely affected along a gradient of organic enrichment extending northwest of the outfalls along the Palos Verdes Shelf. In 1980 to 1981 the abundance and biomass of infauna were low about 2.5 mi north of the outfall, although at or slightly above 1977 reference station values. Diversity and numbers of species were also very low up to 2.5 mi north of the outfall.

The densities of the dominant species of infauna changed along a gradient extending 7 mi northwest of the outfalls at a depth of 200 ft (Tetra Tech 1984). The polychaete worms *Capitella* and *Schistomeringos*, which are indicators of degraded or polluted conditions, were most abundant near the outfall, while the clam *Parvilucina* (an indicator of mild pollution) and the polychaetes *Mediomastus* and *Tharyx* and the ostracod *Euphilomedes* (indicators of organically enriched, but not degraded areas) (Word *et al.* 1977) were more abundant away from the outfall.

Once the discharge of wastewater is stopped, the benthos recovers fairly quickly (Vesco and Gillard 1980). When regular discharge through the HTP 1-mi outfall was discontinued in 1961, the infauna in the area began to recover almost at once. Based on data collected between 1983 and 1987, the infauna near the 1-mi outfall can no longer be distinguished from that at similar depths elsewhere in the Bay (Dorsey 1988). HTP's 1-mi outfall was in a shallow, high-energy environment; recovery in deeper water (where most present outfalls are located) may proceed much more slowly (Smith 1988, pers. comm.).

HTP stopped disposing of sludge via the 7-mi outfall in November 1987. Quarterly sampling to determine the rate and direction of benthic recovery around the outfall was initiated in February 1986 (1.5 yr prior to termination) and continued until August 1990.

In 1986 indicator taxa such as the polychate *Capitella capitata* were most abundant in the contaminated area on the periphery of the sludge field, while sites in the sludge field near the outfall terminus were characterized by unusual polychaete taxa, such as *Ophryotrocha* spp., which are found only in highly contaminated areas (SCCWRP 1987).

After the termination of sludge discharge, the abundance of *Ophryotrocha* spp., initially increased, but they were nearly absent by August 1990 (SCCWRP 1992). Although *Capitella capitata* was only present in low abundance in the sludge field during discharge, it became the most abundance in this area within a year after discharge termination. By 1990 *Capitella capitata*

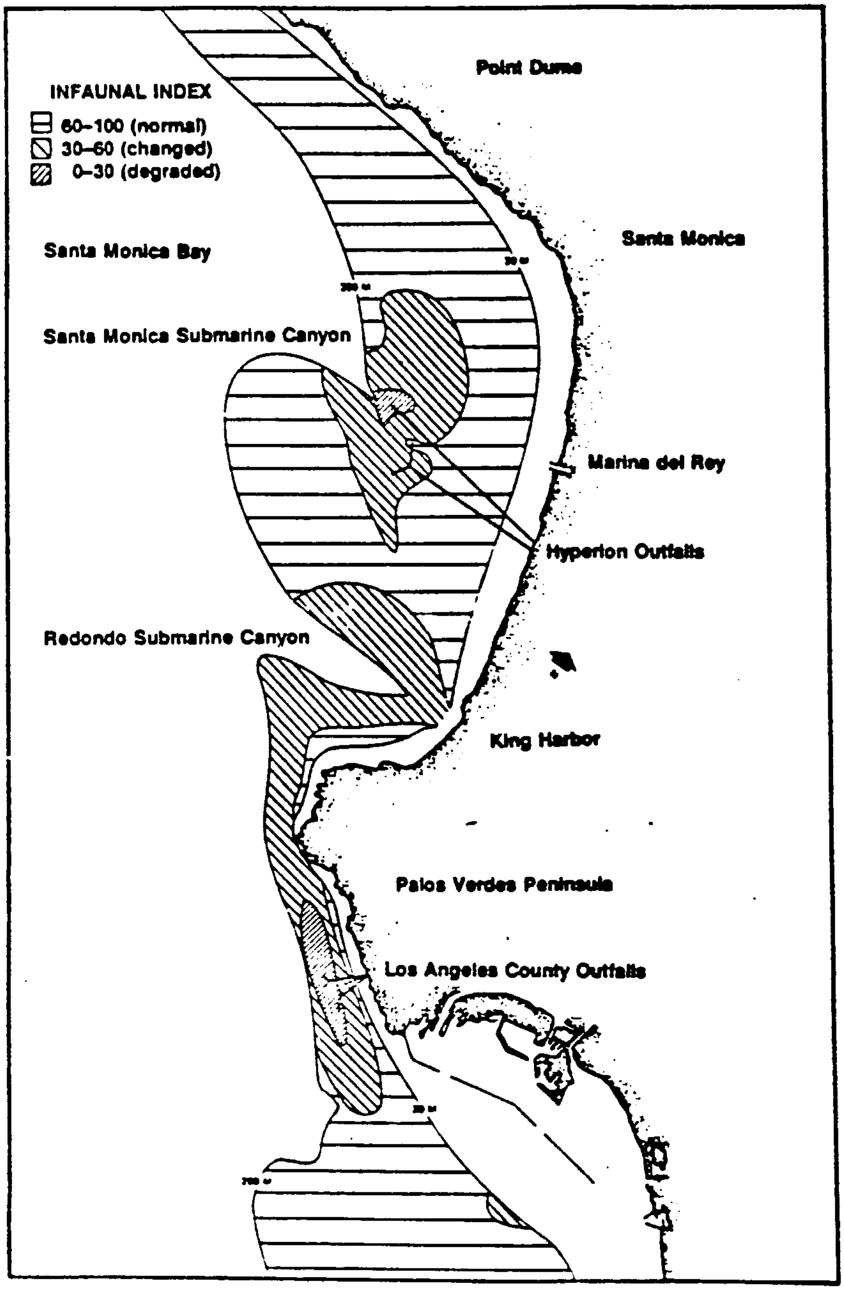

Figure 9-10. Location of normal, changed, and degraded areas in the study area as defined by changes in infaunal index, 1977 (Bascom 1978)

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abundance had decreased in all areas. Decreasing abundance of these two species indicates the gradual recovery of the sludge field. However, *Amphiodia urtica* an indicator of uncontaminated conditions and a species abundant in reference sites, to date have not become abundant in any of the contaminated areas (SCCWRP 1989).

Recovery also occurs when the discharge of pollutants is reduced, but not stopped. Between 1971 and 1981 the quality of the JWPCP effluent improved markedly and so did the infaunal community (Stull *et al.* 1986b), which is still recovering (Stull 1988, pers. comm.). Both the number of species and the Shannon Wiener diversity increased from 1972-1991, indicating general improvement in the Palos Verdes benthos (Stull 1992 pers. comm.).

Recovery of benthic assemblages was especially apparent following the reduction in input of DDT, PCBs, solids, trace metals, and various other contaminants from the JWPCP outfalls. Since 1972 the benthic community has become less characterized by pollution indicator species, has become more diverse, and has supported increasing abundances of microcrustaceans and echinoderms (Word and Striplin 1980) which were absent previously (SCCWRP 1973).

Recovery continued between 1980 and 1983; stations near the JWPCP outfall went from major degradation in 1980 to moderate degradation in 1983, changes which were attributed to improvements in the quality of the JWPCP effluent. However, natural environmental changes associated with the strong El Niño event of 1982-1983 may have also been involved (Swartz *et al.* 1986). The strong storms of that time period presumably resuspended contaminated surface sediments, especially near headlands such as the Palos Verdes Peninsula.

In 1973 large numbers of spoonworm *Listriolobus pelodes* settled on the Palos Verdes Shelf and by 1975 the center of the population was near the outfalls. The population declined by 1977 and the worms had all but disappeared by 1980 (Stull *et al.* 1986c). Although it is not certain whether their occurrence was due to chance or to the local environmental conditions, they had an important impact on the benthic community. Spoonworms form U-shaped burrows in the sediments, and their burrowing, feeding, and respiratory activities rework and aerate the sediments. On the one hand this bioturbation may improve physical, chemical, and biological characteristics of the sediments generally but it also exposes buried contaminants to the water column.

The areal extent of black sediments rich in hydrogen sulfide decreased during the spoonworm period, and the abundance of pollution-tolerant polychaetes, *Capitella capitata* and *Schistomeringos*, decreased as well. However, following the collapse of the spoonworm population, neither the species abundances nor the sediments returned to their previous states. The net improvement in sediment conditions during the period of high spoonworm density may have resulted from increased oxygenation of the surface sediments and a consequent decrease in free sulfide. Free sediment sulfide has been found to be the abiotic variable most strongly correlated with the infaunal community at outfall depths on the Palos Verdes Shelf (Greene and Smith 1975).

In 1989-1990 the numbers of species were lowest immediately adjacent to the HTP outfalls, but increased rapidly with distance from these disturbed areas; abundance was moderate around the 5-mi and high at the 7-mile outfall (CLA,DPW 1991). Diversity was lowest at the 7-mile outfall and increased with distance from the area, whereas it was moderate around the 5-mile outfall. Abundance and numbers of species were highest south of the outfalls at Short Bank, a habitat characterized by low-lying rock outcrops and heterogenous sediments.

Classification analysis of recent summer macrofauna data indicated five broad macrofaunal assemblages, which formed site groups associated with depth and proximity to the outfalls (Figure 9-11). Around the 5-mile outfall, two subgroups were delimited. One subgroup consisted of stations adjacent to the outfall, the other subgroup consisted of stations further from the outfall and represented macrofauna which are transitional between outfall and natural conditions (CLA,DPW 1991). The site group nearest the 7-mi sludge field was characterized by large numbers of individuals and low numbers of species, including several opportunistic, pollution-tolerant species.

Macrofauna assemblages also vary in composition along a strong depth gradient (from inner-shelf to upper-slope) and along natural sediment gradients, and with distance from the two outfalls, representing an environmental stress gradient (CLA,DPW 1991). Diversity and composition of the assemblages away from the outfalls were typical for southern California shelf communities.

The fluctuations in the size of the area impacted by the outfalls may result from the increase in numbers (species and individuals) of opportunistic species which respond quickly to small physical and chemical changes in the environment (CLA,DPW 1991). There are fewer opportunistic species around the 5-mi outfall, and species that were common away from it, (e.g., *Pectinaria californiensis*), have become common at the outfall. Pollution sensitive species such as *Amphiodia urtica*, however, are still sparse near the outfall but have invaded transitional areas between the outfalls and unaffected areas. During the period of sludge disposal, the polychate *Ophytrocha* dominated the field, but since about 1987, the abundance of this polychaete has diminished to nearly zero (CLA,DPW 1991).

Thus, in general, the abundances of opportunistic species are approaching background levels and overall diversity is incre ng. The area around the 5-mi outfall now supports a relatively natural composition of macrofauna, although sediments in the old sludge field are populated with a mix of "natural" and opportunistic species (CLA,DPW 1991).

The "degraded" area also persists around the JWPCP outfalls, although it is much smaller (in areal extent) than it was previously. The "changed" area has also contracted, gradually receding eastward on the Palos Verdes Shelf.

Megafauna

At water depths of 200 ft on the Palos Verdes Shelf, white sea urchins and other large echinoderms were uncommon (low population densities) between 1972 and 1979 compared to reference areas at the same depth (Word and Striplin 1980). Major megafaunal species were absent within several miles of the JWPCP outfalls in 1973, although they were present elsewhere in Santa Monica Bay (Mearns and Greene 1974). The diversity and abundance of echinoderms as a group were depressed near the JWPCP outfalls between 1971 and 1976 (Allen and Voglin 1976) and total invertebrate megafaunal biomass on the Shelf was only half that at stations in Santa Monica Bay between 1977 and 1982 (Moore *et al.* 1982). However, densities of the ridgeback rock shrimp were greatly enhanced.

In 1982 megafaunal biomass was about equal at sites on the Palos Verdes Shelf and at control sites in northern Santa Monica Bay (Table 9-3): however, in the vicinity of the HTP outfalls it was 3 to 4 times higher than at the reference sites (Cross 1982a). Between 1984 and 1986 enhanced biomass was most apparent south of the 5-mi outfall: while at the outfall itself the

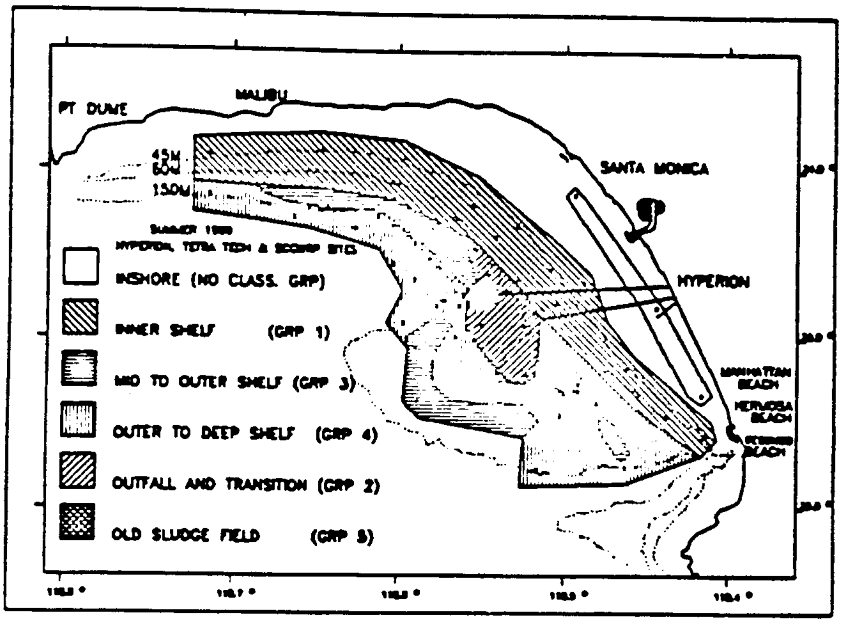

Figure 9-11. Map of site groups derived from classification of macrofaunal data from the HTP, Tetra Tech, and SCCWRP cruises in Summer 1989 in Santa Monica Bay (CLA,DPW 1991).

Table 9-3. Measures of megafaunal invertebrate community structures near Santa Monica Bay sewage outfalls and in northern Santa Monica Bay.

Location	Number of Individuals Mean ± S.D.	Number of Species Mean ± S.D.	Biomass (kg) Mean ± S.D.	Dominant Species
Northern Santa Monica Bay Reference	1018 ± 977	12.6 ± 2.5	5.4 ± 1.3	*Lytechinus pictus* *Astropecten verrilli* *Sicyonia ingentis* *Ophiura lutkeni*
HTP Outfall	1565 ± 757	18.7 ± 7.0	19.5 ± 9.0	*Astropecten verrilli* *Lytechinus pictus* *Parastichopus californiensis* *Sicyonia ingentis*
JWPCP Outfall	669 ± 316	12.4 ± 2.3	5.9 ± 2.3	*Astropecten verrilli* *Sicyonia ingentis* *Crangon nigromaculata* *Pleurobranchaea californica*

Source: Cross 1982a

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biomass was slightly lower than at the northern Santa Monica Bay control site (Johnson and Roney 1988).

By 1982 echinoderms (which had previously been lacking), were collected in the vicinity of the JWPCP outfalls, indicating a major change in the community structure since the early 1970s. Classification analysis of trawl-collected megafauna from throughout the Southern California Bight between 1971 and 1985 indicated that 1980 was a turning point on the Palos Verdes Shelf (SCCWRP 1986e). Prior to 1980 samples from Palos Verdes Shelf were separated from the "normal" mainland shelf group; whereas after 1980 samples from the Palos Verdes Shelf were grouped along with "normal" samples. Samples collected from depths of 120 to 520 ft in Santa Monica Bay, including those from near the HTP outfalls, were grouped with the reference stations during all years.

In 1989 and 1990 megafaunal communities exhibited a pronounced relationship to the HTP outfalls. Near the 5-mi outfall, diversity and the mean number of species were reduced (Figure 9-12)(CLA,DPW 1991). Spiny sand stars were most abundant at the outfall sites, possibly due to the abundance of prey whose populations were enhanced by organic enrichment. White sea urchins were present at offshore sites but not in the vicinity of the outfalls; in laboratory studies, both these species prefer clean sediments over contaminated sediments (Anderson et al. 1988).

During pre-abatement sampling at the 7-mi outfall, ridgeback rock shrimp and white sea urchin were the most abundant megafaunal invertebrates collected (SCCWRP 1989). Megafaunal species collected at the 300 ft depth contour differed between contaminated sites and the reference sites (SCCWRP 1989). In 1986-1987 (during active sludge discharge) the most abundant megafaunal species at the contaminated sites was the California sand star (SCCWRP 1989). Following discontinuation of sludge disposal the abundance of California sand star decreased below reference levels (SCCWRP 1989). White sea urchin was formerly most abundant at the reference sites and did not usually occur at the contaminated sites, it has not returned following sludge termination (SCCWRP 1989).

Industrial Discharge Impacts

Macrofauna

The shallow, subtidal bottom between Redondo Beach and El Segundo have been surveyed in connection with NPDES permits for three generating stations and the El Segundo Refinery industrial discharge. No effluent impact on the infauna has been demonstrated around either the El Segundo or Scattergood Generating Station discharges (IRC 1979, 1981, MBC 1991b); thermal effects and NPDES monitoring studies at the Redondo Generating Station have not indicated any effects of the discharge other than increased bottom turbulence (EQA/MBC 1973, MBC 1982a).

Turbulence associated with the discharge plume results in coarser bottom material near the discharge structure, and coarse sediments are inhabited by a somewhat different benthic community. Coarsening has also been observed at the intake structure, where mussel and barnacle shell fragments are flushed out during heat treatment of the conduits. These minor changes are only noticeable within 300 ft of the structures. Metals dissolved from the condenser tubes and chlorine used to control growth of clams and barnacles within the cooling water system do not have detectable effects on bottom communities.

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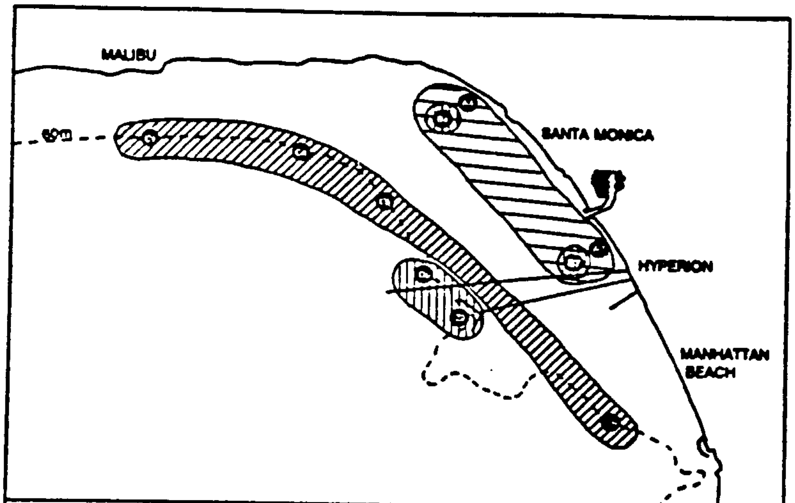

SITE GROUP		MEAN SPECIES	S.D.	MEAN NO. OF INDIVIDUALS	S.D.	SPECIES NAME	PERCENT ABUNDANCE
I	(horizontal hatching)	4.4	2.0	10.2	9.3	*Pyromaia tuberculata*	51.0
						Podochela lobifrons	28.2
						Astropecten verrilli	11.6
						Astropecten armatus	4.8
						Heterocrypta occidentalis	4.5
II	(vertical hatching)	3.9	1.9	827.0	781.7	*Astropecten verrilli*	98.7
						Luidia foliolata	0.4
						Sicyonia ingentis	0.4
						Parastichopus californicus	0.2
III	(diagonal hatching)	10.6	2.6	62.0	1125.0	*Lytechinus anamesus*	72.0
						Astropecten verrilli	9.5
						Ophiura luetkeni	7.1
						Ophiothrix spiculata	3.7

Figure 9-12. Trawl stations, site group locations, and community variables for invertebrate assemblages in Santa Monica Bay during 1989-1990 (CLA,DPW 1991).

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Infaunal sampling at El Segundo and Scattergood Generating Stations in 1991 indicated no effects from the discharge (MBC 1991b). Abundance and species richness have been greatest at stations along the 20-ft and 30-ft isobaths upcoast of the Scattergood Generating Station. Infaunal abundance and species richness patterns were closely associated with sediment grain size, suggesting that the sediments are the most important factor, but that the impact is not ecologically significant (MBC 1991b). Abundance, species richness, and diversity all generally decreased with increasing distance from the El Segundo Refinery discharge in 1990, indicating enhancement, if anything, due to the discharge (MBC 1990).

Megafauna

Diver-observed and trawl-caught megafauna along the 30-ft isobath were no different near the El Segundo Generating Station than away from it (IRC 1979, 1981). At water depths of 65 ft off Redondo Beach, white sea urchins were less abundant near the power plant discharge than in trawls taken off Manhattan Beach (MBC 1986a); however, few other species showed such a pattern.

Marine Vessel Activity Impacts

The soft benthos of Marina del Rey appears to have been impacted by marine vessel-related contaminants, in particular TBT from antifouling paints. Many mollusk species are virtually absent or are less abundant in areas where TBT levels are high than they would normally be expected (Soule and Oguri 1986, 1987).

HARD BOTTOM HABITATS

Municipal Wastewater Discharges

Treated wastewater can affect nearby rocky habitat through sedimentation, turbidity, and the toxicity of its metal and chlorinated organic components. In 1958 algal cover in rocky areas exposed to the JWPCP effluent was fairly normal at water depths of 10 and 33 ft, but almost no algae were found below 33 ft (CSWQCB 1964). In 1969 almost no algae were found at water depths of 50 to 75 ft from 2 mi upcoast to 2 mi downcoast of the outfalls and more than 0.4 in. of fine organic-rich sediment covered rock surfaces 1.3 mi upcoast of the discharge (Grigg and Kiwala 1970).

It appears that the area affected by the outfalls tripled between 1954 and 1969 and in 1966 the algal community at depths of 20 to 100 ft off Palos Verdes Point (8 mi upcoast of the JWPCP outfall) was modified as a result of exposure to wastewater (Strachan and Koski 1969). Partial recovery of the subtidal algal community (which coincided with decreases in the emission of particulates and toxicants from the JWPCP outfalls) was reported later (Grigg 1978, Meistrell and Montagne 1983), but significant increases in algal cover and diversity only occurred at sites farthest from the outfall (e.g., Palos Verdes Point). Algal populations and community structure near the outfalls were still impacted (Tetra Tech 1984).

In 1977 concentrations of metals and chlorinated hydrocarbons in the flocculent, near-bottom particulate layer off Palos Verdes Point were elevated above ambient. A concentration gradient (more metals and organics in this layer nearer the JWPCP outfalls) indicated that the outfalls were the source. Both positive and negative responses were noted: some populations apparently benefitted from outfall-derived nutrients, but overall the richness of the fauna increased as mass emission rates decreased. Exposed epifauna may have been affected indirectly by reductions in the availability of algal food and by the floc layer directly. By 1977, significant improvements had been observed compared to conditions in 1969, the greatest recovery being at Long and Palos Verdes Points (Grigg 1978).

The mass emissions of suspended solids from JWPCP in the 1990s is less than one-fifth the 1970 level, and it is no longer the source of particulates described by Grigg and Kiwala (1970) or Grigg (1978). Since 1978, the Portuguese Bend landslide, (located 3.5 miles west of the JWPCP outfall system), has been more active than before and through the 1980s, an average of 200,000 MT per year of slide debris were dislodged (City of Rancho Palos Verdes 1986), over five times that of JWPCP (Stull, pers. comm. 1993). The landslide sediments are released at the shoreline; whereas solids from JWPCP are discharged 2 to 4 km offshore in 60 m of water. Thus, while the rocky subtidal community of Palos Verdes Peninsula continues to be impacted by turbidity and sedimentation, the landslide has replaced JWPCP as the source of particulates. Reductions in mass emissions of trace constituents coincided with significant recovery of eastern sites from the 1970s to the mid-1980s (Stull, pers. comm. 1993).

The HTP outfall conduit provides additional hard-bottom substrate for both plants and animals to colonize, thereby creating positive impacts. Inshore portions of the 5- and 7-mi conduits are dominated by gorgonian corals and strawberry anemones, and the ballast rock provides crevices for cryptic species (Allen *et al.* 1976). In deeper water, low-relief rocky bottom near the shelf break has been examined with remote camera (Moore and Mearns 1980) and the hard substrates of the HTP outfalls by submersible (Allen *et al.* 1976). Plumose anemone was dominant on the pipe, however, it was not seen on the deep, low-relief rock bottom, despite its presence at equal depths elsewhere. The reasons for this and other differences between the communities in the two areas are not known, but may be related to the waste discharge. Although the outfall pipe supports a diverse and abundant epifauna, it is not the same as that of nearby natural rock areas.

The conduit does provide a habitat which attracts many fish and invertebrates, thereby making them popular sport fishing locations. Many species of rockfish are common near the 5-mi outfall terminus.

Industrial Discharge Impacts

No effects from the Redondo Generating Station effluent have been noted on rocky subtidal invertebrates in King Harbor. The widespread distribution of open coast algae in the harbor indicates good water circulation, which is at least partially due to the generating station intake and discharge (Straughan 1977).

Marine Vessel Activity Impacts

The substrate of groins, breakwaters, and jetties in shallow water near Marina del Rey may be subjected to the toxic effects of TBT on mussels, clams, and snails (Soule and Oguri 1986, 1987). TBT has been used in boat bottom-paint and because of its toxicity to mollusks, Marina del Rey has fewer species of mollusks than other areas where there are fewer marine vessels.

Fishery Impacts

Commercial fishing in the study area for California spiny lobster, rock crabs, and red sea urchin occurs primarily west of Malibu Point and south of Palos Verdes Point. Lobsters can only

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be fished from mid-October to mid-March (Schultze 1986), and commercial catches of lobster from the Bay have declined since 1955 (MBC 1985). However, total catch decreased in the early 1970s on the Palos Verdes Shelf and increased in the 1980s. Rock crab catches from this area were especially low in 1971, peaked in 1975, and have decreased since then. The red sea urchin fishery began on a large scale in 1976 and by 1981 had already been overharvested (Stull *et al.* 1987). It is not certain whether these fluctuations were due to natural causes, overfishing, loss of habitat (e.g., surfgrass nursery grounds for lobster), or pollution.

Recreational fishing for California spiny lobster, rock crabs, pink abalone, and rock scallop also occurs in the Bay, primarily by divers. The impact of this fishery has not been described, but the construction of artificial reefs in the Bay was intended to increase their habitat and thus fishing success.

ARTIFICIAL REEFS

A large number of unique and popular plants and animals utilize the hard-bottom, reef habitat. However, hard bottom is lacking in most of the study area and artificial reefs have been constructed to provide hard-bottom habitat. Originally, the justification for construction of artificial reefs was to enhance recreational fishing and diving, however, in recent years artificial reefs have also been used as mitigation for marine resources lost in coastal development projects (Wilson *et al.* 1990, Johnson *et al.* 1992).

Most of the nearshore area of Santa Monica Bay proper consists of sandy bottom and is devoid of natural reefs. Since 1958 the California Department of Fish and Game (CDFG) has constructed 14 artificial reefs in Santa Monica Bay. Five of the early reefs were constructed of streetcars, automobiles, and other degradable materials and have since disappeared. However, nine artificial reefs remain in the nearshore subtidal area from Malibu to Torrance Beach (Figure 9-13) (Lewis and McKee 1989). These are named as follows: Malibu, Topanga, Santa Monica, Santa Monica Bay, Marina del Rey Reef 1, Marina del Rey Reef 2, Hermosa Beach, Redondo Beach, and Palawan. Most are composed of quarry rock but Palawan Artificial Reef off Torrance Beach consists of the sunken liberty ship *Palawan* (Lewis and McKee 1989).

KELP BEDS

Wastewater discharges are thought to have contributed to the loss of giant kelp (*Macrocystis pyrifera*) near Los Angeles and San Diego (North and Schafer 1964). Kelp plants have been shown to be sensitive to many of the contaminants introduced by man, and although there are other sources, most of these in the study area are from treated wastewater (CSWQCB 1964). Aside from the coincidence that the Palos Verdes kelp beds began to degenerate shortly after the White Point discharge became operational in 1937 and spread outward from the outfall, there is a strong relationship between mass emissions through the JWPCP outfalls and kelp canopy coverage on the Palos Verdes Peninsula. Conversely, between 1974 and 1987 mass emissions of total suspended solids in the JWPCP effluent decreased by 72%, while the area of kelp coverage increased.

Kelp coverage along Palos Verdes has generally increased since the mid-1970s (Figure 9-14), although in 1983 and 1988 it suffered losses of 90% and 95%, respectively, due to extremely severe winter storms. Other beds in southern California suffered similar losses. Recovery of giant kelp was rapid at Palos Verdes: the surface canopy in 1989 was four times that in 1978. Between 1989 and 1992, kelp coverage has declined because of increased grazing pressure from expanding sea urchin populations. Some areas are essentially devoid of vegetation

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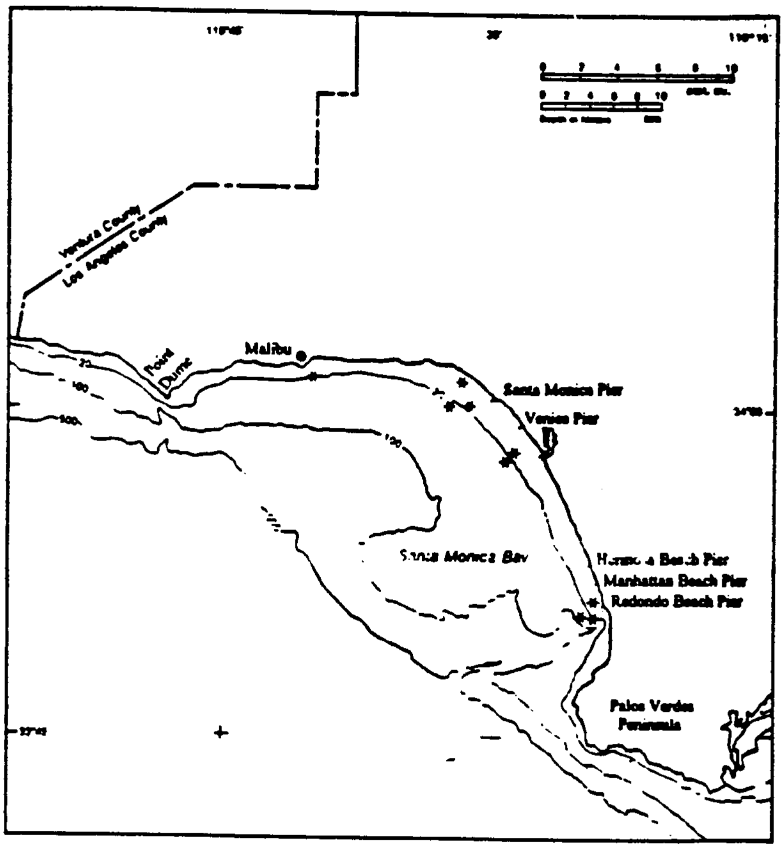

Figure 9-13. Artificial reefs in Santa Monica Bay (Lewis and McKee 1989)

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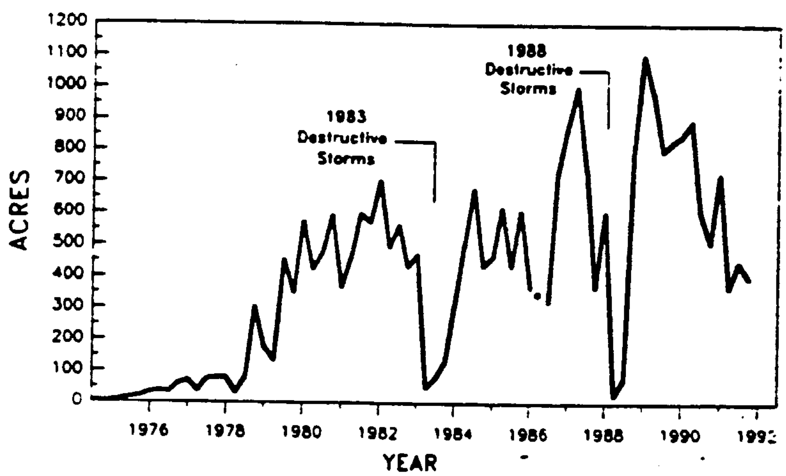

* No data available for second quarter of 1986.

Figure 9-14. Changes in the Palos Verdes Peninsula kelp canopy 1974 to 1992 (modified from CDFG, unpubl. data; LACSD, unpubl. data).

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because of sea urchins, although this appears to be a natural episodic event, unrelated to the discharge of treated wastewaters (Stull, pers. comm. 1993).

Toxic materials in wastewaters may harm kelp, but the accumulation of particulates on rock surfaces probably has the greatest impact. The small, young plants (sporophytes) which are contacted by the particulates are not only more sensitive than adults to toxic materials, but they do not settle and grow on rocks covered with a particulate film. In areas of heavy particle concentration the few sporophytes which settle are often on ridges which bottom currents sweep clear of sediment. Normally rocks in a well-developed kelp bed support large numbers of small sporophytes, which do not grow to maturity because the existing canopy keeps light levels too low for active photosynthesis. When adult plants die back because of summer nutrient limitations or are torn up by storms, light penetrates to the bottom and the sporophytes grow.

Turbidity and light reduction may also result from wastewater discharge and may affect kelp. Even though this would not prevent settlement of sporophytes, it might prevent their growth by reducing bottom light levels. At present there is not enough evidence to distinguish between these two effects, or to establish the role of toxic materials in kelp growth and survival in the study area. The strong relationship between JWPCP mass emissions and kelp die-off strongly suggests wastewater involvement, but it does not indicate which constituent is responsible.

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CHAPTER 10

MARINE VERTEBRATE RESOURCES

The marine vertebrates of Santa Monica Bay are important to the general public, especially to commercial and recreational fishermen as well as to recreational SCUBA divers. In the past, fish diseases have been an obvious indicator of contaminated areas. Sea birds, shore birds, and waterfowl are some of the most obvious members of the Santa Monica Bay fauna, and are important scavengers and foragers throughout the Bay. They are aesthetically and recreationally pleasing, and have shown some of the most striking responses to marine contamination. Marine mammals are important to Bay tourists, particularly whale watchers and party-boat fishermen; being near the top of the food web, they often accumulate high levels of contaminants.

FISHES

Distribution by Habitat

Pelagic

The most obvious and abundant pelagic nekton in the study area are bony fishes, species which typically school and are often migratory. Most pelagic fishes feed on copepods when small, on shrimp-like prey when larger, and on other fish as adults.

The dominant pelagic fishes in the study area are chub (or Pacific) mackerel, jack mackerel, northern anchovy, and Pacific sardine. These species make up most of the commercial wetfish fishery catch, the dominant commercial fishery in southern California. Oceanic species such as swordfish are important in the driftnet fishery and northern anchovy are caught in the bait fishery.

Some pelagic sport fishes such as yellowtail and Pacific barracuda are migratory species which move into the Bay in summer, and may be especially abundant during an El Niño period. Chub mackerel and Pacific bonito are commonly taken from piers and jetties as well as charter and private boats. In the 1980s chub mackerel and Pacific bonito accounted for about 27 and 13%, respectively, of the sport catch in the Bay proper, and 31 and 18% of that of the Palos Verdes Shelf (MBC 1985, Stull *et al.* 1987). Chub mackerel, Pacific barracuda, and Pacific bonito accounted for 29, 7, and 7%, respectively, of the recreational fish catch of Santa Monica Bay in 1991-1992 (MBC, in prep.).

Many neritic species occur in the Bay, including queenfish, jacksmelt, and topsmelt in shallow depths and shortbelly rockfish along the outer shelf. White seabass are important in the commercial set gillnet fishery (which will end in 1994) others are taken by recreational fishermen.

The deeper waters of the Bay support northern and Mexican lampfish, California smoothtongue, and Pacific hake. These species migrate between the surface waters at night and the deepwater mesopelagic zone below 300 ft during the day.

Many species are temporary members of the pelagic community. Vermilion rockfish, bocaccio, and sablefish feed in the water column at night but rest on or remain near the bottom during the day. White croaker and white seaperch school in the water column but feed on the bottom.

The eggs and larvae (ichthyoplankton) of many bony fishes are planktonic, even though the adult stages may not be. The planktonic stage lasts for a few weeks to months before the larvae transform into nektonic or demersal juveniles. Ichthyoplankton are of particular concern because of their relationship to the abundance of adults in particular fishing grounds. The most abundant fish larvae in an area are typically those of the most abundant adult species, but this is not always the case.

Sharks are the dominant cartilaginous fishes in the pelagic environment of Santa Monica Bay, with blue shark the most abundant, although thresher sharks, basking sharks, and others are seen occasionally. Most sharks feed on adult fish and squid but basking sharks feed on juvenile fish and euphausiids.

Soft-bottom

The soft-bottom habitat supports an abundant and diverse assemblage of demersal fishes which swim occasionally, but spend much of their time on the bottom. Flatfishes, rockfishes, sculpins, combfishes, and eelpouts make up most of the soft-bottom fish fauna. Different basic assemblages are found on the inner, the middle, and the outer shelf (SCCWRP 1973, Fay *et al.* 1978, Allen 1982). The inner shelf assemblage is dominated by speckled sanddab, the middle shelf by stripetail rockfish, and the outer shelf by slender sole (Allen 1982).

California halibut, California scorpionfish, barred sand bass, and white croaker are fished by sport fishermen. In the 1980s barred sand bass accounted for 8% of the sport fish catch off the Palos Verdes Shelf and 6% of that of the Bay proper (MBC 1985, Stull *et al.* 1987). In 1991-1992 they accounted for 11% of the recreational fish catch from piers, private boats, and commercial passenger fishing vessels (MBC, in prep.). Sablefish, Dover sole, and English sole are important in commercial fisheries to the north, although they are not fished in Santa Monica Bay.

Hard-bottom

The hard-bottom fish assemblage differs in composition with depth. Common shallow water families include the sea basses, surfperches, rockfishes, kelpfishes, sculpins, damselfishes, and wrasses. Important species locally include kelp bass, brown rockfish, pile perch, black perch, white seaperch, rubberlip seaperch, señorita, and opaleye (Carlisle *et al.* 1964; Stephens *et al.* 1984b; MBC 1987a; Dorsey 1988, pers. comm.). In deeper water, vermilion rockfish, bocaccio, cowcod, and flag rockfish dominate (Allen *et al.* 1976, Moore and Mearns 1980). Because these species occur off-bottom they are readily observed by divers or remote cameras; however, hard-bottom species such as kelpfishes, sculpins, and pipefishes are cryptic and hence difficult to see.

Hard-bottom fishes are pursued by divers on the Malibu and Palos Verdes Shelves and by anglers from shore, piers, and private or party boats. Because outfall pipes constitute hard substrate, party boat fishing is sometimes conducted along their length. Rockfishes and kelp bass are the most important hard-bottom sport fish in the Bay, rockfishes in deep water and kelp bass in shallow water. In the 1980s, rockfishes and kelp bass accounted for 43 and 6%, respectively, of the sport catch in the Bay proper and 17 and 10% of that of the Palos Verdes Shelf (Mearns 1977; MBC 1985, Stull *et al.* 1987). In 1991-1992 more kelp bass than rockfishes were taken by recreational anglers in Santa Monica Bay; kelp bass and rockfishes comprised 9 and 6%, respectively, of the catch during that period (MBC, in prep.).

Kelp-bed

The vertical complexity of kelp beds attracts many fishes which use the beds for schooling, shelter, and foraging. Kelp bass, black perch, rubberlip seaperch, opaleye, kelp rockfish, and olive rockfish are common in kelp holdfast zones. Yellowtail, white sea bass, rubberlip seaperch, halfmoon, and halfblind goby have been observed in the stipe region of the bed. Fishes of the kelp canopy include the topsmelt, kelp pipefish, kelp perch, giant kelpfish, kelp clingfish, and kelp gunnel.

Opaleye and halfmoon feed primarily on algae, whereas kelp bass, yellowtail, and white seabass eat fish and squid. The remaining species feed largely on crustaceans such as amphipods, copepods, mysids, crabs, and shrimp. The kelp bass is important in the sport fishery, comprising 10 and 6% of the catch of the Palos Verdes Shelf and Santa Monica Bay, respectively (MBC 1985, Stull *et al.* 1987). In 1991-1992 they comprised 9% of the recreational fish catch from Santa Monica Bay.

Natural Variability

The fish populations in Santa Monica Bay vary in size as a result of major climatological events and minor oceanographic and biological events. The species composition in fish assemblages also varies for similar reasons; although the effects of these natural events have only been described qualitatively.

The abundance of fish scales in sediments from basins off southern California indicates that populations of pelagic species have fluctuated greatly during the last 1,800 years (Figure 10-1) (Soutar and Isaacs 1969). Pacific sardine abundance has ranged from periods of high abundance lasting 20 to 200 years to periods of low abundance averaging 80 years in duration. Population peaks in the past were about twice those of the present century. However, fluctuations during the 19th century were similar in magnitude to those during this century: the low abundance of sardines since the 1940s is similar to that of the period between 1865 and 1885 (Soutar and Isaacs 1974).

Northern anchovy and Pacific hake populations did not crash as severely as did the Pacific sardine, but they have fluctuated greatly. The abundance of northern anchovy peaked about 1,500 years ago and has declined gradually since. Pacific hake has peak abundances about every 300 years, the last being about 250 years ago (Soutar and Isaacs 1969).

The abundance of these pelagic fishes combined was greater from 1900 to 1925 than anytime since (Soutar and Isaacs 1974). These long term changes may be related to variations in the California Current. During El Niño periods, warm-water species either recruit to the Bay from the south as larvae or move into the Bay as adults. Many species move into the area from their more typical habitat off Mexico (Radovich 1961, Mearns 1988).

Pelagic, warm-water, and migratory sport fish abundance increased in Santa Monica Bay during the 1957-1959 El Niño (Mearns *et al.* 1976). During the El Niños of 1978 and 1982-1983, several species of warm-water reef fishes recruited into King Harbor where they are still abundant (Stephens 1988, *pers. comm.*). Similarly, during 1985-1986 the shallow, demersal fish assemblage of the Palos Verdes Shelf had more warm-water species than it did in 1972-1973, a period of cold water (MBC 1987b).

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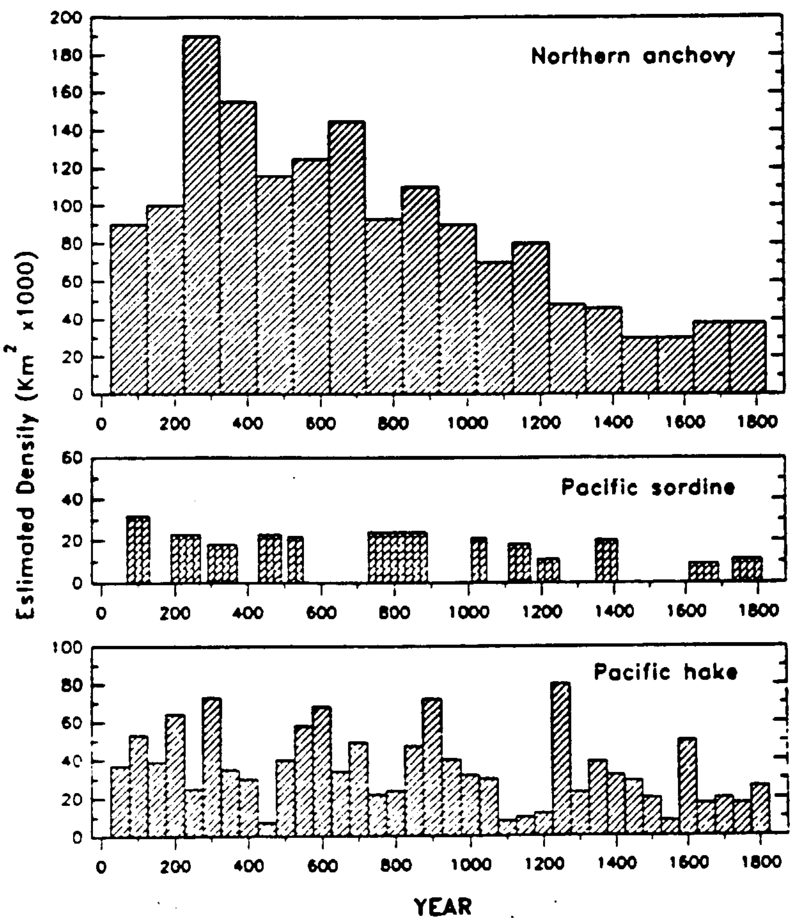

Figure 10-1. Minimum population estimates (based on scale abundance) in Santa Barbara Basin during the past 2,000 years for a) northern anchovy, b) Pacific sardine, and c) Pacific hake (Soutar and Isaacs 1969).

Cold water species are negatively affected during an El Niño event. The abundance of demersal fish in Santa Monica Bay was about one-third of normal during the 1957-1959 El Niño. This decrease coincided with the initiation of sludge discharge into Santa Monica Submarine Canyon (Carlisle 1969). Although the potential effect of sludge disposal cannot be discounted, the abundance of demersal fish did increase immediately after the El Niño.

During the 1982-1983 El Niño, many cool water soft-bottom species moved to deeper water in Santa Monica Bay (Love *et al.* 1986). Several coastal species disappeared from Marina del Rey, (presumably moving into the Bay proper) and these did not return until the water was cooler in 1986 (Soule and Oguri 1987). Apparently some cool-water species also recruited poorly during this period, possibly due to a decrease in zooplankton abundance (Love *et al.* 1986).

The development of kelp beds on the Palos Verdes Shelf during the late 1970s had little effect on the rocky-bottom fish fauna in general, but the abundance of kelp bass increased (Stephens *et al.* 1984b). Extreme wave turbulence destroys reef and kelp bed habitats and disrupts inshore sandy bottoms. Artificial rocky reefs in King Harbor were lost during a major storm of January 1988 (Stephens 1988, pers. comm.). Turbidity from storm runoff and landslides may linger for weeks or months, making the area unsuitable for many fish (Allen 1982). The movement of sand into tidepools during the summer reduces the amount of habitat for intertidal fishes.

Although a red tide in 1945 (from San Luis Obispo to Los Angeles Harbor) killed sharks, stingrays, and California halibut (Sommer and Clark 1946), no other red tides have caused major fish kills along the California coast in recent years (Bongersma-Sanders 1957).

Recruitment of juveniles to the Bay is not necessarily related to local spawning, primarily because most fishes have planktonic larvae. The coastal current regime during a spawning event may act to retain larvae spawned in the Bay, may carry them away, or may import larvae from outside the Bay.

Impacts

Municipal Discharge Impacts

Population Changes. The effects of wastewater discharges on the fishes of Santa Monica Bay were first studied after the discharge of sludge was initiated at the HTP 7-mi outfall in 1957. The abundance of most small, trawl-caught fishes in Santa Monica Bay declined in 1959, but returned to previous levels between 1960 and 1963 (Carlisle 1969). The decline probably resulted from poor recruitment of cool-water fishes during the El Niño Event of 1957-1959 (Mearns *et al.* 1976). Speckled sanddab appeared to be attracted to the 7-mi outfall, but yellowchin sculpin, California tonguefish, as well as the speckled sanddab were absent in the area near the terminus of the 5-mi outfall (Carlisle 1969).

From 1957 to 1975 the abundance and diversity of demersal fish were low around the 5- and 7-mi outfalls (Mearns *et al.* 1974, Allen and Voglin 1976, Mearns *et al.* 1976), but from 1976 to 1979 species richness, biomass, and individual fish size were greater in the sludge field than in reference areas. Underwater cameras showed that Pacific electric ray, white croaker, and shiner perch were abundant in the sludge field, the latter two apparently feeding in the sludge (Bascom *et al.* 1980). From 1984 to 1986 fish biomass was higher and fish abundance was generally high near the outfall stations while white croaker dominated the fish abundance near both outfalls although not in other offshore areas of the Bay (Johnson and Roney, 1988).

By the late 1980s, the number of fish per trawl in the contaminated zone near HTP 7-mi outfall were still below reference levels (SCCWRP 1989) and white croaker and Dover sole were the most abundant species collected (SCCWRP 1989). Immediately following termination of the sludge discharge fewer white croaker were collected at the contaminated sites, but sludge did not appear to impact fish communities at water depths of 200 m (SCCWRP 1989). The number of fish per trawl have not indicated any trends toward recovery.

Five demersal fish assemblages were described in Santa Monica Bay in 1989-1990 (Figure 10-2) (CLA,DPW 1991). The three offshore assemblages consisted of northern, mixed, and outfall site-groups; the two nearshore assemblages were separated by seasonal differences. Mean numbers of species and individuals were highest along the 60-m isobath, depressed in the vicinity of the outfalls, and lowest nearshore.

Flatfishes were the most abundant group; hornyhead turbot was the most widely distributed, California lizardfish the most abundant species near the outfalls. Contaminated sediments near HTP's 5-mi and terminated 7-mi outfalls may exclude, depress, or enhance the abundance of certain species (CLA,DPW 1991).

The distribution of fish species in Santa Monica Bay is also related to distribution of their prey. Changes in the composition of the benthic infauna can result in a change in the composition of demersal fish assemblages (Cross *et al.* 1985, MBC 1987b). Crustaceans (the preferred prey of most common demersal fish) are uncommon near the outfall sites. Fish that feed predominantly on benthic and epibenthic crustaceans are rare or absent from outfall sites (CLA,DPW 1991). Hornyhead turbot and English sole, on the other hand, feed primarily on infaunal polychaetes and mollusks (Allen 1982). Infauna near the outfalls were dominated by these invertebrates, thus those fish species were dominant there.

Between 1970 and 1976 the fauna of the Palos Verdes Shelf was more severely affected by wastewater discharge than that near the HTP outfalls. The abundance and diversity of demersal fish were low near the JWPCP discharges on the 200-ft isobath and were severely depressed at a depth of 450 ft, 0.6 to 1.2 mi northwest of the outfalls. Although fish biomass was enhanced at a depth of 450 ft near the discharge; hornyhead turbot, California tonguefish, plainfin midshipman, and yellowchin sculpin were rare or absent whereas white croaker, shiner perch, and curlfin sole were unusually abundant (Mearns *et al.* 1976, Allen 1982).

By 1985 and 1986 the demersal fish assemblage had changed from that characteristic of the early 1970s and some of the differences appeared to be related to improved effluent quality. Previously rare or uncommon species such as hornyhead turbot, California tonguefish, yellowchin sculpin, and plainfin midshipman were common whereas previously abundant species such as white croaker, shiner perch, and curlfin sole were absent or rare (MBC 1987b). Some of these shifts appear to be related to food availability; e.g., several species which fed on gammarid amphipods were absent when amphipods were uncommon during the mid-1970s whereas fish species which fed upon polychaetes were abundant when polychaetes were dominant (Allen 1982, Cross *et al.* 1985, MBC 1987a).

From 1988 to 1990 the fish fauna of the Palos Verdes Shelf changed little (LACSD 1992). At first, bigmouth sole was the most common species and slender sole the most abundant; in 1991 plainfin midshipman was the most abundant and most common species. Larvae of the most abundant species had settled on the Palos Verdes Shelf and thus most species were represented by several age-classes (LACSD 1992). Some species that feed on benthic microcrustaceans continue to be less abundant near the outfalls, but California tonguefish has been consistently

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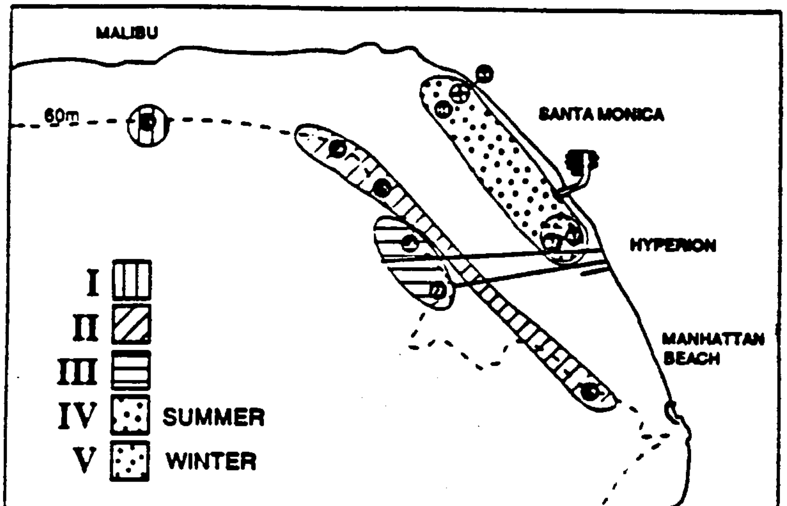

SITE GROUP	MEAN NO. OF SPECIES	S.D.	MEAN NO. OF INDIVIDUALS	S.D.	SPECIES NAME	PERCENT ABUNDANCE
I	11.9	1.7	210	90.8	Pacific sanddab	33.8
					Pacific argentine	21.9
					pink seaperch	13.3
					California tonguefish	8.4
II	11.6	2.3	142	72.2	Pacific sanddab	28.3
					yellowchin sculpin	18.9
					California lizardfish	10.2
					longspine combfish	8.1
					bigmouth sole	6.8
					pink seaperch	5.7
					hornyhead turbot	5.3
III	9.5	2.6	83	30.6	California lizardfish	24.6
					hornyhead turbot	15.1
					Pacific sanddab	14.6
					English sole	13.8
					gulf sanddab	10.4
IV	7.4	1.6	49	24.4	hornyhead turbot	28.4
					speckled sanddab	17.1
					California tonguefish	16.5
					white croaker	11.1
					California halibut	5.7
V	4.9	1.0	10.9	3.2	California tonguefish	26.3
					California halibut	17.5
					hornyhead turbot	17.5
					speckled sanddab	8.8
					fantail sole	7.3

Figure 10-2. Trawl stations, site group locations, and community variables for demersal fish assemblages in Santa Monica Bay during 1989-1990 (modified from CLA,DPW 1991).

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more abundant. Curlfin sole and shiner perch were abundant near the outfall in the early 1970s and were described as being "discharge-associated" (Allen 1982), but they are now rare or absent (LACSD 1992); whereas several species that were absent in the early 1970s are now present (Stull 1992 pers. comm.).

The HTP 5- and 7-mi outfalls function as artificial reefs, attracting many rocky bottom fishes. Schools and aggregations of fishes near the conduit in deep water may simply orient to the pipes, and may feed there. In shallow water, the ballast rock provides cover for rockfishes; shortbelly rockfish, vermilion rockfish, cowcod, and bocaccio are most common along deeper portions of the pipes (Allen *et al.* 1976).

Wastewater-related changes in intertidal fish populations have not been documented, although changes in the algae assemblage probably affect some fishes. Human disturbance has probably reduced intertidal fish populations throughout southern California (Cross 1982b).

Diseases and Abnormalities. Diseases and abnormalities in marine organisms have been related to pollution throughout the world (Sindermann 1979, Sindermann *et al.* 1980, Mix 1986). Diseases and abnormalities in marine organisms from southern California have been documented since the 1950s (Mearns and Sherwood 1977), although careful evaluations of the cause and effect relationships were not conducted until the early 1970s. Since then, many studies have surveyed the prevalence (i.e., percentage of a population affected) and geographic distribution of fish diseases and abnormalities. The major abnormalities that may be related to pollution in Santa Monica Bay include fin erosion, epidermal tumors, oral papillomas, and microscopic liver abnormalities.

Fin Erosion. Fin erosion is an obvious abnormality and has been linked to degraded marine environments throughout the world. It is characterized by the degeneration or absence of fins (Mearns and Sherwood 1974), but the causes are complex and may include chemical contamination, low dissolved oxygen, and secondary bacterial invasion (Sindermann *et al.* 1980). Although little is known about how the disease affects survival rates, it is less common in fish more than three years old (Cross 1985).

In 1969 to 1972 fin erosion in Dover sole was exceptionally high (42%) on the Palos Verdes Shelf and declined sharply both upcoast and downcoast from that area (Mearns and Sherwood 1974). The overall prevalence in Santa Monica Bay was 6%, but it was greater than 10% near the HTP outfalls and less than 2% elsewhere.

Fin erosion was found in 33 of 151 species (22%) from the study area and prevalence was 5% or greater in seven species: Dover sole (30%), greenstriped rockfish (14%), rex sole (13%), barred sand bass (9%), greenblotched rockfish (6%), and vermilion rockfish (5%) (Mearns and Sherwood 1977). The prevalence pattern of fin erosion in five species was similar to that in Dover sole: it peaked on the Palos Verdes Shelf (11 to 39%) and declined both upcoast and downcoast from that area (Sherwood 1978). Mearns and Sherwood (1974, 1977) and Sherwood (1978) concluded that fin erosion in fishes on the Palos Verdes Shelf is probably a result of the JWPCP effluent.

From 1971 to 1983, fin erosion was found in 29 fish species near the JWPCP outfalls: approximately 90% of all individuals with fin erosion were Dover sole (Cross 1985). The prevalence of fin erosion in Dover sole declined with increasing distance from the outfalls along both the 200- and 450-ft isobath. Within 0.6 mi of the outfalls prevalence was approximately 30%, whereas 14.4 mi from the outfalls it was close to 0.0%. The prevalence of fin erosion in Dover sole exhibited a fairly steady decline from 1971 to 1983. Values within 5.4 mi of the outfalls ranged from 51 to 81% in 1971-1972, and declined to less than 10% by 1983. The number of fish species with fin erosion near the JWPCP outfalls also declined, from 18 in 1971 to just 6 in 1983 (Cross 1985). Cross (1985) also concluded that this abnormality was the result of exposure to sediment contaminants. Fin erosion in Dover sole on the Palos Verdes Shelf was even lower (0.7%) in 1988. Within 0.6 mi of the outfall about 1.1% of the fish have the condition (Stull 1988, pers. comm.).

The extent of fin erosion has also declined over the years (Stull 1992, pers. comm.). In the 1970s most fins were completely lost, whereas in the 1980s and 1990s only a small section of the mid-dorsal fin was afflicted.

Fin erosion has been found in fishes from many other areas of the United States. Between 1967 and 1971 in Raritan, Lower, and Sandy Hook Bays (New York City), relatively high levels of fin erosion were found in four species bluefish 24%; summer flounder 16%; weakfish 11%; and winter flounder 8% (Mahoney *et al.* 1973). This condition was limited to inner portions of the New York Bight and was thought to be caused by bacteria in conjunction with environmental stress from chemical contamination (Mahoney *et al.* 1973). Fin erosion was found in two of 22 fish species from the highly contaminated Duwamish River in Puget Sound: 8% of the starry flounder and 0.5% of English sole. The abnormalities were attributed to an interaction of the genetic constitution of the organisms with multiple environmental variables, (such as chemical contaminants and physical factors), and mechanical injury (Wellings *et al.* 1976).

These studies confirm those from southern California which suggest that high prevalences of fin erosion are found only in highly contaminated areas, i.e., that the disease is induced by pollution. They also suggest that not all species are equally susceptible to fin erosion, although the reasons for different susceptibilities is not known.

Epidermal Tumors. Epidermal tumors appear as nodular growths on the skin and are most prevalent in flatfishes less than 3 years old. They have been found in several flatfish species on the west coasts of both Canada and the United States but have not been found in any species on the east coast of either country (Stich *et al.* 1977). They are thought to be caused by a unicellular parasite or a virus (Cross 1988). Epidermal tumors are frequently prevalent near urbanized areas (Sindermann 1979). Individuals with epidermal tumors exhibit reduced growth, increased mortality, and failure to participate in normal seasonal migrations (Stich *et al.* 1976, Campana 1983, Cross 1986).

Of 151 species examined from southern California between 1972 and 1975, only Dover sole was consistently affected with tumors (Mearns and Sherwood 1977). Tumors were most prevalent in Dover sole less than 120 mm standard length (SL) (Mearns and Sherwood 1977); 8% in Santa Monica and San Pedro Bays and about 5% on the Palos Verdes Shelf. Dover sole <120 mm SL were 34 times more abundant on the Palos Verdes Shelf than in Santa Monica Bay. Epidermal tumors were not seen in fish (fewer than 25 specimens) from Dana Point and Santa Catalina Island.

From 1969 to 1972, the prevalence of epidermal tumors in all size classes of Dover sole was highest (>2%) off Port Hueneme and in San Pedro Bay and ranged from 1 to 2% at other sites, (Mearns and Sherwood 1974, Sherwood and Mearns 1976).

Museum specimens from southern California as early as 1946 revealed that diseased Dover sole were found in relatively uncontaminated areas far from the Southern California Bight (Mearns and Sherwood 1976). Mearns and Sherwood (1977) concluded that epidermal

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papillomas are not related to discharges from southern California outfalls. The prevalence in juvenile fish was similar throughout the area; because juvenile fish were more abundant on the Palos Verdes Shelf, more juvenile fish with tumors were found there.

From 1971 to 1983, epidermal tumors were found in 15 species near the JWPCP outfalls (Cross 1988). Dover sole accounted for 93% of all individuals with tumors, largely fish less than 120 mm SL. The prevalence of the tumors decreased with increasing distance from the outfalls. The maximum prevalence (3.3%) was at a water depth of 200 ft within 0.6 mi of the outfalls; prevalence was less than 0.6% 14.4 mi from the outfalls. The prevalence of tumors within 5.4 mi of the outfalls declined temporally in the mid-1970s, but appeared to increase in the early 1980s (within 1.8 mi from the outfalls). The number of fish species with epidermal tumors near the JWPCP outfalls declined from 6 in 1971 to 1 in 1976 and remained at one or two through 1983.

In 1988 the prevalence of epidermal tumors near the JWPCP outfalls was 1.1% for small fish and 0.1% for large fish (Stull 1988, pers. comm.). In 1991, 2.1% of all Dover sole had epidermal tumors; 87% were <120 mm SL (Stull 1992, pers. comm.). Cross (1988) concluded that these epidermal tumors in Dover sole were directly related to the chemical contaminants in the sediments.

In 1986 2.8% of the Dover sole near the HTP 7-mi outfall had epidermal tumors, compared to an incidence rate of 1.5% in northern Santa Monica Bay (Johnson and Roney 1988), rates similar to those from this area in 1971 and 1972 (Mearns and Sherwood 1974). Epidermal tumors were not observed on fishes collected in 1987 to 1989 (CLA,DPW 1991).

Epidermal tumors have been found in young flatfishes from contaminated and uncontaminated areas on the west coasts of Canada and the United States. The highest prevalences (15 to 59%) in English sole were from contaminated areas near Vancouver, British Columbia; Bellingham, Everett, Seattle, and Aberdeen, Washington; and San Francisco, California (Cooper and Keller 1969, Stich *et al.* 1977). A prevalence of 54% was found in starry flounder from Bellingham, Washington. The prevalence of epidermal tumors in fishes from uncontaminated areas has generally been less than 1%, but a few high values have been observed: 30% in sand sole from the Queen Charlotte Islands, British Columbia; 23% in rock sole from the Bering Sea, Alaska; and 15% in flathead sole from the San Juan Islands, Washington (Miller and Wellings 1971, Stich *et al.* 1977, McCain *et al.* 1978). Thus, epidermal tumors may be unrelated to human pollution.

Oral Papillomas. Oral papillomas on fish from southern California were first reported in white croaker collected in 1956 within 1.4 mi from the HTP 1-mi outfall in Santa Monica Bay (Russell and Kotin 1957). The prevalence of oral papillomas in fish near the outfalls was approximately 3%, whereas none were found in fish from a reference area 48 mi away, suggesting that the papillomas may have resulted from exposure to a contaminant.

Between 1970 and 1976, the prevalence of oral papillomas in white croaker was less than 1% in Santa Monica Bay and on the Palos Verdes Shelf, less than 5% in San Pedro Bay, and 0% south of Oceanside (Mearns and Sherwood 1977). The prevalence of this disorder continues to be relatively low up to the present (Cross 1988, pers. comm.). Because of the low prevalence rates and their wide distribution, they do not appear to be related to municipal wastewater discharges (Mearns and Sherwood 1977).

Microscopic Liver Abnormalities. No microscopic abnormalities were found in livers of Dover sole from Dana Point in 1976, but those from the Palos Verdes Shelf had fatty vacuolations of cells, structural disarray, cellular degeneration, and increases in the numbers and sizes of melanin macrophage centers (Pierce *et al.* 1977). There was no evidence that the observed abnormalities were caused by pathogens or parasites and the authors suggested that they may have resulted from exposure to the chlorinated hydrocarbons DDT or PCBs.

From 1983 to 1984 Rosenthal *et al.* (1984) studied microscopic liver abnormalities in fishes from nine locations in southern California; yellowchin sculpin, California tonguefish, Pacific sanddab, longspine combfish, and California scorpionfish. Abnormalities were found in most fishes, but they were no more prevalent in contaminated areas than in reference areas. The prevalence of cellular vacuolation and hypertrophy (increased size) in California tonguefish was significantly different among locations. The authors concluded that liver abnormalities may be the result of widespread chlorinated hydrocarbon contamination.

In 1984 Malins *et al.* (1986) examined microscopic abnormalities in white croaker, hornyhead turbot, and California tonguefish from the HTP and JWPCP outfalls, Los Angeles Harbor, and Dana Point. Only in Los Angeles Harbor was the prevalence of one or more of the 11 abnormalities in white croaker substantially higher than at Dana Point. The prevalence of abnormalities in hornyhead turbot near the outfalls was similar to that at Dana Point. The prevalence of abnormalities in California tonguefish was similar near the outfalls and in Los Angeles Harbor.

The most serious liver abnormalities evaluated by Malins *et al.* (1986) included tumors and pretumorous conditions. Liver tumors were found in only three white croakers from the HTP outfalls (4%) and from Los Angeles Harbor (3%); pretumorous conditions were found in one white croaker from Los Angeles Harbor (2%).

Microscopic liver abnormalities are relatively widespread in fishes in contaminated and uncontaminated areas in the Southern California Bight. If they are the result of human contamination, it is unlikely that they can be related to specific sources. They may be related primarily to natural stresses, such as temperature, dissolved oxygen, and food availability.

Liver tumors and pretumorous conditions are also prevalent in fishes from other contaminated areas in the United States. The prevalences of tumors and pretumorous conditions in English sole frequently exceed 5 and 15%, respectively, in highly contaminated areas of Puget Sound (Malins *et al.* 1984, 1985a,b; Krahn *et al.* 1986; Becker *et al.* 1987). The highest (32 and 52%) prevalence in Puget Sound were in an area contaminated with creosote (Malins *et al.* 1985a,b). In Boston Harbor, the prevalence of liver tumors and pretumorous conditions in winter flounder collected near a major sewer outfall were 8% (Murchelano and Wolke 1985).

Other Conditions. Studies around Santa Monica Bay have indicated that fishes from contaminated areas may have impaired reproduction and chromosomal abnormalities (Cross and Hose 1988). Reproductive success in white croaker from San Pedro Bay was significantly less ($P \leq 0.05$) than at Dana Point. [Impaired reproduction was indicated by increased early oocyte destruction, lower batch fecundities, and lower fertilization rates.] Concentrations of total DDT and PCBs in liver and gonads were significantly higher ($P \leq 0.001$) in fish from San Pedro Bay than fish from Dana Point. These contaminants may have been partly or wholly responsible for the impaired reproduction in fish from Santa Monica Bay (Cross and Hose 1988).

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Hose *et al.* (1987) evaluated circulating erythrocyte micronuclei in the blood of fish from contaminated and reference areas in and near Santa Monica Bay. The frequency of micronuclei in kelp bass was 11 times higher at contaminated sites than at the reference site; micronuclei frequencies in white croaker were four times higher at the contaminated site than at the reference site. Although the frequency of micronuclei may be partly a function of blood cell kinetics, temperature, life history stage, and sex differences, the results also suggest a relationship between contaminant exposure and genotoxicity in fishes.

Industrial Discharge Impacts

As seawater is circulated through the cooling system of generating stations, planktonic larvae are entrained and some are killed. Studies in 1979-1980 estimated that about 3.4 billion fish larvae are entrained in the Redondo Generating Station each year. White croaker was the most abundant species overall, accounting for about 36% of the larvae, but the dominant species varies throughout the year (Connally *et al.* 1982). On the basis of average flows, about 2 billion and 1 billion larvae would have been entrained at the El Segundo and Scattergood Generating Stations, respectively.

The cooling water conduits function as artificial reefs. Intake conduits of the El Segundo and Redondo Generating Stations attract rocky-bottom and schooling species; the former utilize the riprap around the pipes for cover and the latter use the pipes as a point of reference (Helvey and Smith 1985). Both juveniles and adults are sucked into the conduits and killed by impingement on protective screens, by the physical habitat, or, by elevated temperatures during heat treatments. The most abundant species taken are nearshore pelagic or schooling demersal species. Between 1978 and 1980 approximately 71,000 fish/year were estimated to have been impinged at Redondo Generating Station, about 78,000/year at El Segundo Generating Station, and about 48,000/year at Scattergood Generating Station (Herbinson 1981, Damron 1988, pers. comm.). Queenfish accounted for about 48% of those at Redondo and 45% at El Segundo (Herbinson 1981); queenfish were the most abundant species impinged at Scattergood in 1986-1987 but surfperches were often dominant in the past (Damron 1988, pers. comm.). The numbers of fish impinged at all three stations has decreased since this period (Herbinson 1988, pers. comm.).

Fish impingement losses at Redondo Generating Station were the lowest in 1988 and 1989 since 1978, although they climbed again in 1990 and 1991 (MBC 1991b). In 1991 over 21,000 fish were impinged at Redondo Generating Station; blacksmith and white croaker accounted for 37% and 17% of the total (MBC 1991b). The decrease in 1988 and 1989 was due to a reduction in the number of circulating pumps in operation, which results in a lower current velocity at the intake (MBC 1991b).

Approximately 30,000 fish were impinged during heat treatments in 1991 at Scattergood and El Segundo Generating Stations (MBC 1991c). Over 90% of the fish impinged at El Segundo occur during heat treatments (Curtis 1992, pers. comm.). Blacksmith was the most abundant fish impinged at El Segundo whereas white croaker was most abundant at Scattergood (MBC 1991c). About 99% of the fish near generating station intakes are expected to survive for at least 5 years: a 10-fold increase in intake volume would reduce this to 82% (SCE 1982).

Urban Runoff Impacts

The potential impacts of surface runoff on fishes has not been studied specifically. The input of freshwater to inshore zones would cause fishes that cannot tolerate low salinities to move

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offshore temporarily. Turbidity from suspended sediments in stormwater may linger for days or weeks, and could cause decreased visibility and respiratory problems (Allen 1982). Contaminant effects are not known.

Marine Vessel and Harbor Development Impacts

The abundances of fish larvae and benthic-feeding fishes in Marina del Rey have decreased since 1984. These changes are probably the result of post-El Niño cooling but could be related to TBT concentrations in the Marina. TBT was used as a biocide in boat antifouling paint and is known to be more toxic to larvae than to adults (Soule and Oguri 1987).

The development of Marina del Rey drastically altered the original lagoon habitat. The amount of shallow bottom habitat was reduced whereas water exchange between the harbor and the ocean was increased. The abundance of lagoon species such as the arrow goby and California killifish undoubtedly decreased. The amount of habitat suitable as a nursery ground for California halibut was reduced. Juvenile halibut utilize warm-water lagoons for development (Kramer 1988, pers. comm.) and thus the development of the Marina may have resulted in fewer adult halibut in Santa Monica Bay. The construction of rock breakwaters and jetties at King Harbor and Marina del Rey provide habitat for many species (Stephens and Zerba 1981), thus benefitting rocky bottom fishes.

Commercial Fisheries. Sport and commercial catches are reported by block to the California Department of Fish and Game (Figure 10-3). Pelagic species have been the major component of the commercial purse seine and gillnet fisheries of southern California, however, those methods are prohibited in most of Santa Monica Bay (Figure 10-4). Commercial fishing for pelagic fish outside of the study area could impact sport fishing in the Bay.

Between 1934 and 1950 Pacific sardine accounted for over 50% of the annual commercial catch in the Bight. When the sardine population collapsed, the commercial fishery shifted first to jack mackerel and then, after 1969, to the northern anchovy. The crash of the Pacific sardine population appears to have been the result of a long-term population fluctuation pattern (Figure 10-1; Soutar and Isaacs 1969), although it may have been aggravated by intense fishing pressure (Browning 1980).

A moratorium on fishing for Pacific sardine and chub mackerel was implemented in the mid-1970s. By 1975 the chub mackerel population had recovered and by 1985 it was the major fishery in California, 83% from southern California in 1985 (CDFG 1986, 1987). Chub mackerel has been important in the catch from the Palos Verdes Shelf and Santa Monica Bay since 1978 (MBC 1985, Stull *et al.* 1987).

From 1969 to 1983 northern anchovy was generally the dominant fish in the southern California catch: prior to 1978 it accounted for about 90% of the wetfish fishery, but for only 42% since then (Stull *et al.* 1987). In part this shift reflects a poor market for anchovy and a better one for other pelagic species (CDFG 1987).

Gillnet fishing has increased in importance in California, although it is not allowed in the inner part of Santa Monica Bay. California halibut is fished on the Shelf west of Malibu Point and from Palos Verdes Point to Point Fermin. Halibut gillnets are set at depths less than 120 ft for California halibut (Vojkovich 1988, pers. comm.), and in 1986-1987 the CDFG observed about 34 sets per year in the Malibu Point-Point Dume area and about 22 sets per year in the Palos Verdes Point-Point Fermin area (McCormick 1988, pers. comm.). These observations represent about 1

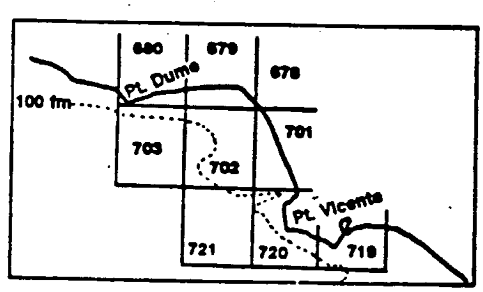

Figure 10-3. CDFG fish catch blocks for Santa Monica Bay (CDFG, unpubl. data).

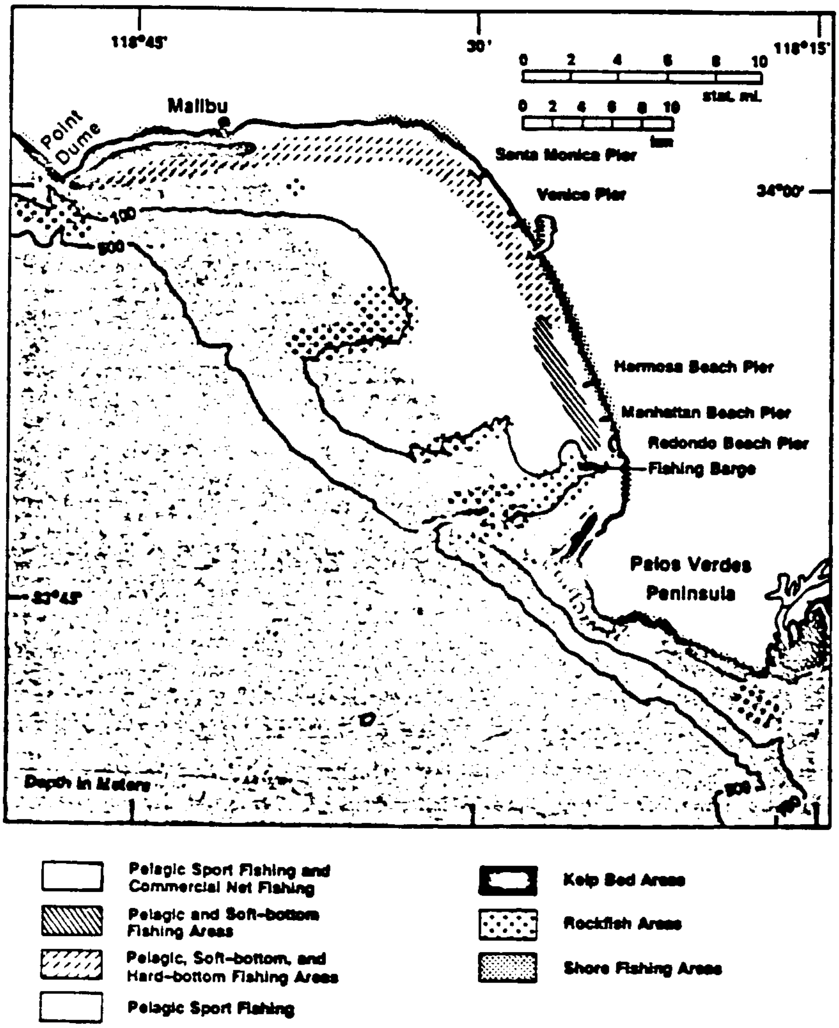

Figure 10-4. Fishing areas in and near Santa Monica Bay (based on Squire and Smith 1977, MBC 1988).

to 2% of the total fishing effort (Vojkovich 1988, pers. comm.); the actual fishing effort is probably 50 to 100 times greater. The annual catch of California halibut from southern California decreased 1976 to 1978, but has generally increased since then with a peak in 1985. In 1986 the minimum mesh size for gillnets was increased and a moratorium on the issuance of new permits for set gill nets and trammel nets was implemented (CDFG 1987).

White croaker are targeted with set gillnet on the Palos Verdes Shelf; the catch is sold fresh, primarily to ethnic markets in Los Angeles. Drift gillnet fishing for swordfish and pelagic sharks has not been observed in the study area (Vojkovich 1988, pers. comm.). The closures to net fishing in most of the Bay protect resident fishes from overfishing. However, commercial gillnetting for California halibut, (along with the recreational fishery and reduced nursery grounds), probably limits the halibut population in the Bay by intercepting adult halibut moving in from other areas.

Sport Fisheries. Sport anglers fish from beaches, piers and jetties, private boats, and commercial passenger fishing vessels (CPFV or party boats); divers use spears or their hands in shallow water to harvest fish and invertebrates (Squire and Smith 1977). Between 1981 and 1984 an average of 11,100,750 fish was taken per year in the Southern California Bight by an average of 1,551,000 sport fishermen (NFSP 1984, 1985).

Between 1985 and 1991 an average of 390,414 fish was taken from CPFVs in the study area. CPFV catches within Santa Monica Bay have dropped compared to previous years (Figure 10-5) (CDFG, unpubl. data), due in part to a shift in the fishery from deepwater to pelagic species following the 1982 El Niño (Gregory 1993, pers. comm.). The 1982-1983 El Niño provided exceptionally good sport fishing in the Bight (CDFG 1986) and in 1984 the catch was four times that in 1982. Chub mackerel, rockfishes, and Pacific bonito dominated the catches during these years (NFSP 1984, 1985).

The total sportfish catch has decreased in most of the study area since 1982, although it increased between Ocean Park and Redondo Beach reflecting the sport fishing near piers, jetties, and wastewater and generating stations outfalls (CDFG, unpubl. data). In 1973 nearly one-third of the entire catch of 3.7 million fish in the Southern California Bight was taken within 12.5 mi of the largest wastewater outfalls. Outfalls appeared to receive about 10 times more fishing pressure than the rest of the coast (Mearns 1977).

Most sport fishing in Santa Monica Bay is conducted nearshore or along the edges of submarine canyons and the Shelf (Figure 10-4). The area from Point Dume to Playa del Rey is fished for California halibut, kelp bass, barred sand bass, rockfishes, chub mackerel, Pacific bonito, white seabass, and Pacific barracuda. The area from Playa del Rey to Hermosa Beach is fished for Pacific bonito, California halibut, and Pacific barracuda. Vermilion rockfish, bocaccio, and chilipepper are taken along Redondo Submarine Canyon; along the shelf off Hermosa Beach; and in Santa Monica Submarine Canyon. Vermilion rockfish, olive rockfish, and bocaccio are caught off Point Dume (Squire and Smith 1977). The sport fishes most frequently caught in Santa Monica Bay in 1987 were Pacific bonito, chub mackerel, and barred sand bass (CDFG, unpubl. data). In addition to these species, the rockfish complex and kelp bass are also important on the Palos Verdes Shelf (Stull *et al.* 1987).

The sport catch per angler in Santa Monica Bay fell during World War II and did not reach pre-war levels until the early 1960s, except in 1957 (the largest on record) which was probably a result of the El Niño that year. The catch per unit effort (CPUE) peaked again in 1971-1972, decreased 1976-1977, peaked in 1979, and fell in 1982-1983, during another El Niño. CPUE has

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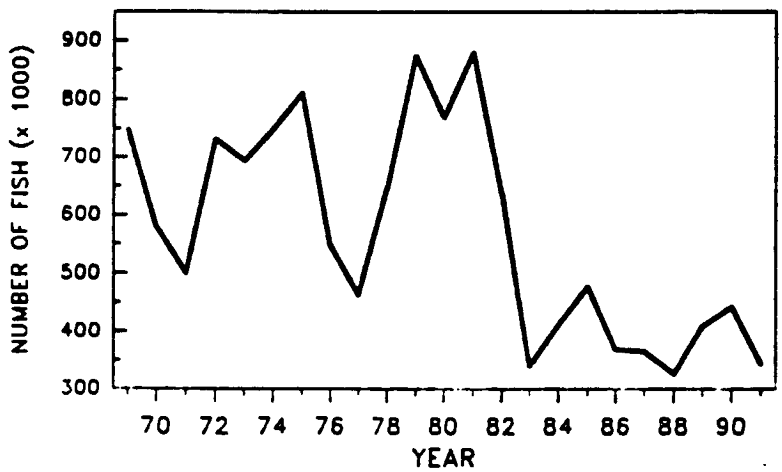

Figure 10-5. Total number of fish caught from commercial passenger fishing vessels for Santa Monica Bay and Palos Verdes Peninsula from 1969-1991 (CDFG, unpubl. data).

remained fairly low since 1982-1983; even the peak in 1989-1990 was low compared to catches prior to 1982 (Figure 10-6) (CDFG 1992, unpubl. data).

Fishing effort increases during an El Niño because the pelagic species which enter the area are highly prized. However, CPUE in Santa Monica Bay is usually greater during periods of cool, turbid water, when resident rockfishes dominate the catch. The general increase in CPUE from the 1940s to 1976 may have been a function of cooler water, but probably also reflects improvements in fishing gear and knowledge of fishing areas. Recent decreases reflect overfishing and oceanographic conditions (MBC 1985).

Total catch and CPUE along the Palos Verdes Shelf peaked in the late 1970s, but dropped to previous levels during the 1980s. From 1980 to 1985, catches of chub mackerel, California sheephead, kelp bass, barred sand bass, yellowtail, California scorpionfish, ocean whitefish, and Pacific bonito from the Shelf were greater than the 50-year average; whereas catches of California halibut, lingcod, white seabass, and rockfishes were lower than the average.

The catch of white croaker declined after 1985 when the California Department of Health Services (CDHS) posted warnings that it was contaminated with DDT and PCBs. The decline in California halibut catch may reflect the elimination of its estuarine nursery grounds (Stull *et al.* 1987) or the harvest of adults in the commercial fishery. Lingcod is a cool-water species which may have been excluded by the El Niño Event of the early 1980s.

Although pollution is often perceived as causing the decrease in sportfish abundance, this has not been demonstrated with certainty. Changes in the sport catch in Santa Monica Bay during 1957-1963 could not be linked to the HTP wastewater discharge (Carlisle 1969): the reduced catch of white croaker on the Palos Verdes Shelf in 1985 was related to CDHS-posted warnings (Stull *et al.* 1987). There has not been a fish kill in the Bay that can be attributed to pollution. Sublethal contamination would presumably affect fish behavior and lead to increased mortality by predators; however, diseased fish did not appear especially susceptible to predation by spiny dogfish or sablefish (SCCWRP 1974).

SEA BIRDS

Distribution by Habitat

Some seabirds feed in the pelagic realm and rest on land, but loons, grebes, scoters, California brown pelicans, gulls, and jaegers rest on the sea surface throughout the Bay. Shearwaters, fulmars, petrels, murres, puffins, and auklets are more oceanic and frequent the outer reaches of the Bay. California brown pelicans and terns (including the endangered California least tern) dive into the water from the air to catch fish; cormorants, murres, puffins, and auklets dive from the sea surface to pursue fish and zooplankton beneath the surface. Bonaparte's gulls congregate on the surface during the winter and feed on particulates and zooplankton.

Natural Variability

The abundance of seabirds, shorebirds, and waterfowl in Santa Monica Bay are highly seasonal. Bird diversity and abundance increase during the winter when migratory species arrive and decrease during the summer when they depart, leaving only resident species. Few species nest along the shores of the Bay; most use the Bay as either a stop over during migrations or for foraging.

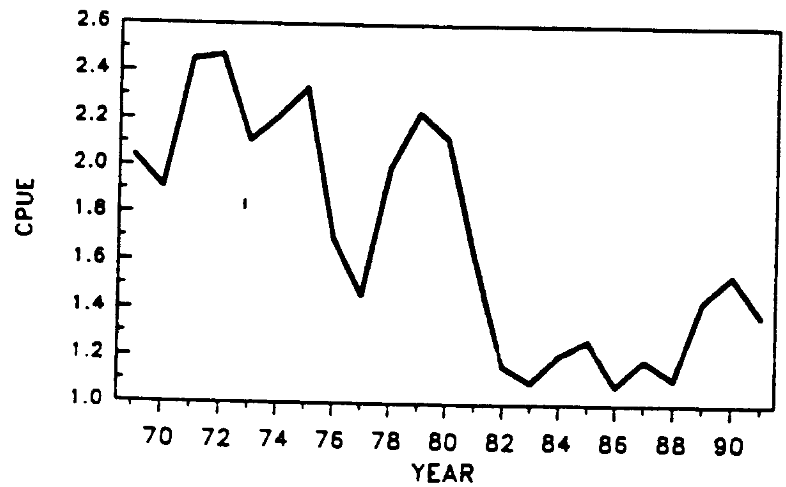

Figure 10-6. Catch per unit effort for commercial passenger fishing vessels for Santa Monica Bay and Palos Verdes Peninsula from 1969-1991. CPUE = numbers of fish divided by angler hours. (CDFG, unpubl. data).

Impacts

Municipal Discharge Impacts

Bonaparte's gulls and other species have been observed feeding near the JWPCP outfalls in winter, but the primary interaction of most seabirds with municipal wastewater is indirect via consumption of contaminated prey. DDT and PCBs increase in concentration up the food chain (i.e., they are biomagnified), being accumulated first in phyto- and zooplankton, then in northern anchovy, other fish, and finally in seabirds.

California brown pelicans nest on West Anacapa Island, Scorpion Rock (Santa Cruz Island), Santa Barbara Island, and Los Coronado Islands - all well removed from Santa Monica Bay. During the 1950s the reproductive success of brown pelicans declined and excessive eggshell thinning appeared to be the primary cause of reproductive failure (Risebrough *et al.* 1971). Research indicated that their eggshells were 26% thinner in 1962 than previously. By 1969 the eggshell thickness had decreased to 50% of pre-1943 values (Anderson and Hickey 1970).

Eggshell thinning was found to be a physiological response to high levels of DDT. Out of 300 eggs examined at the Anacapa breeding colony in 1969, only 12 were intact and DDE residues averaged 43 ppm (wet weight). Eggshell thinning results from DDE inhibition of an enzyme needed to transport calcium ions from the blood to the developing egg (Miller *et al.* 1975). DDT may also depress estrogen levels in birds, resulting in late breeding or the inability to lay more eggs if early clutches are destroyed (Peakall 1970).

In 1971 the use of DDT and the disposal of production wastes into sewers were banned (USEPA 1983). This resulted in a sharp decline of DDT input into coastal waters, and residual levels in the marine food web decreased substantially following the initiation of landfill disposal (Anderson *et al.* 1975, Risebrough *et al.* 1976, Ohlendorf *et al.* 1978, Risebrough *et al.* 1979). Ocean disposal of total DDT compounds decreased from 2,177 kg/year in 1971, to 721 kg/year in 1979 (Schafer 1980), to 50 kg/year in 1985 (SCCWRP 1986a) to 30 in 1987 (Stull 1988, pers. comm.). At the same time eggshell contamination and thinning were reduced (Anderson 1977), and by 1974, reproductive success of the California brown pelican had stabilized, although it was still lower than previously. Productivity has increased substantially since 1969, with peaks in 1975 and 1985 (Table 10-1) (Gustafson, in prep.).

Since California least tern feed upon similar fishes as the brown pelican (northern anchovy and topsmelt), they may also have been impacted by the accumulation of chlorinated pesticides and PCBs.

Other Impacts

Diving birds such as cormorants and scoters are occasionally impinged in generating station cooling waters (Curtis 1988, pers. comm.); however, this is a minor source of mortality to the species.

TBT may impact shorebirds which forage on mollusks, crustaceans, polychaetes, or fish by reducing the quality or quantity of these food resources in the vicinity of Marina del Rey; however, no studies have attempted to establish this connection.

Although human disturbances do not constitute a population-level impact at present, they could adversely affect brown pelican productivity. Such disturbances include deliberate mutilation,

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Table 10-1. Yearly mean population data for California Brown Pelicans nesting in the Anacapa Island area (West Anacapa Island and Scorpion Rock) and the Santa Barbara Island area (Santa Barbara Island and Sutil Island), 1969-1990.

Year	Nest Attempts	Young Fledged	Productivity
1969	750	4	0.005
1970	552	1	0.002
1971	540	7	0.013
1972	261	57	0.22
1973	247	34	0.14
1974	416	305	0.73
1975	292	256	0.88
1976	417	279	0.67
1977	76	39	0.51
1978	210	37	0.18
1979	1258	980	0.78
1980	2244	1515	0.68
1981	2946	1805	0.61
1982	1862	1175	0.63
1983	1877	1159	0.62
1984	628	530	0.84
1985	6194	7902	1.28
1986	7349	4601	0.63
1987	7167	4898	0.68
1988	2878	2500	0.87
1989	5959	3500	0.59
1990	2400 *	NC	NC

* Preliminary data.

Nest Attempts = a nest built by a pair of adult pelicans in an attempt to produce fledged young

Productivity = number of fledged per nest attempt

NC = not calculated

Source: Anderson and Gress 1983; Davis 1988, pers. comm.; Gustafson (in prep.)

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accidental hooking by commercial and sport fishermen, drowning in gillnets, disruption of nesting habitats by photographers and educational groups (Schreiber 1976, Anderson and Keith 1980), noise from aircraft and boats (Evans *et al.* 1979, Cooper and Jehl 1980, Jehl and Cooper 1980), and oil spills (Holmes and Cronshaw 1977). Population-level impacts could also result from overfishing of northern anchovy, the brown pelican's primary food source.

MARINE MAMMALS

Distribution by Habitat

California sea lions and northern elephant seals have been observed in outer parts of Santa Monica Bay (Bonnell *et al.* 1981, Dohl *et al.* 1981). California sea lions are common, and forage beneath the surface and in kelp beds for fishes and invertebrates.

Four species of baleen whales and eight species of toothed whales have been observed in the Bay. Gray whales, bottlenose dolphins, common dolphins, and Pacific white-sided dolphins are the most common species (Dohl *et al.* 1981; Shulman 1988, pers. comm.), and most sightings are within 9 mi of Point Dume or Point Vicente (Bonnell *et al.* 1981). Southerly migrating gray whales pass the Bay from December to February enroute to calving lagoons in Baja California; northerly migrating whales pass by the Bay from February to May enroute to feeding grounds in the Bering Sea (Dohl *et al.* 1981, Poole 1984). Although most gray whales cross the outer part of the Bay, juveniles have been seen north within 2 mi of shore from March to May (Figure 10-7).

Natural Variability

Because of their long lifespans and low reproductive potential, natural population changes in marine mammals generally occur slowly. Prior to human influence, food availability and disease were probably the major influences on marine mammal abundance.

Most strandings in Santa Monica Bay are of single animals. Autopsies of stranded animals indicate various causes of death, including parasites (in the liver, pancreas, and brain); cirrhosis of the liver and lung diseases (Ridgway and Johnston 1965; Ridgway and Daily 1972; Cowan *et al.* 1986; LACMNH, unpubl. data); traumatic injury such as boat propeller and gunshot wounds (Woodhouse 1984, Cowan *et al.* 1986); and entanglement with fishing gear (LACMNH, unpubl. data; NMFS, unpubl. data).

Impacts

Contaminant Impacts

Specimens of marine mammals (washed ashore in southern California) often have elevated levels of DDT and PCBs; in general, small nearshore species such as the California sea lion, common dolphin, and bottlenose dolphin have the highest levels (Britt and Howard 1983, Schafer *et al.* 1984). However, although the stranded marine mammals often have high tissue burdens of pesticides and PCB, data are insufficient to show a cause-and-effect relationship between the contaminant load and the stranding death.

Gray whales generally avoid embayments such as Santa Monica Bay because of the high turbidity due to runoff or waste discharges (Dohl *et al.* 1981). However, since gray whales seldom

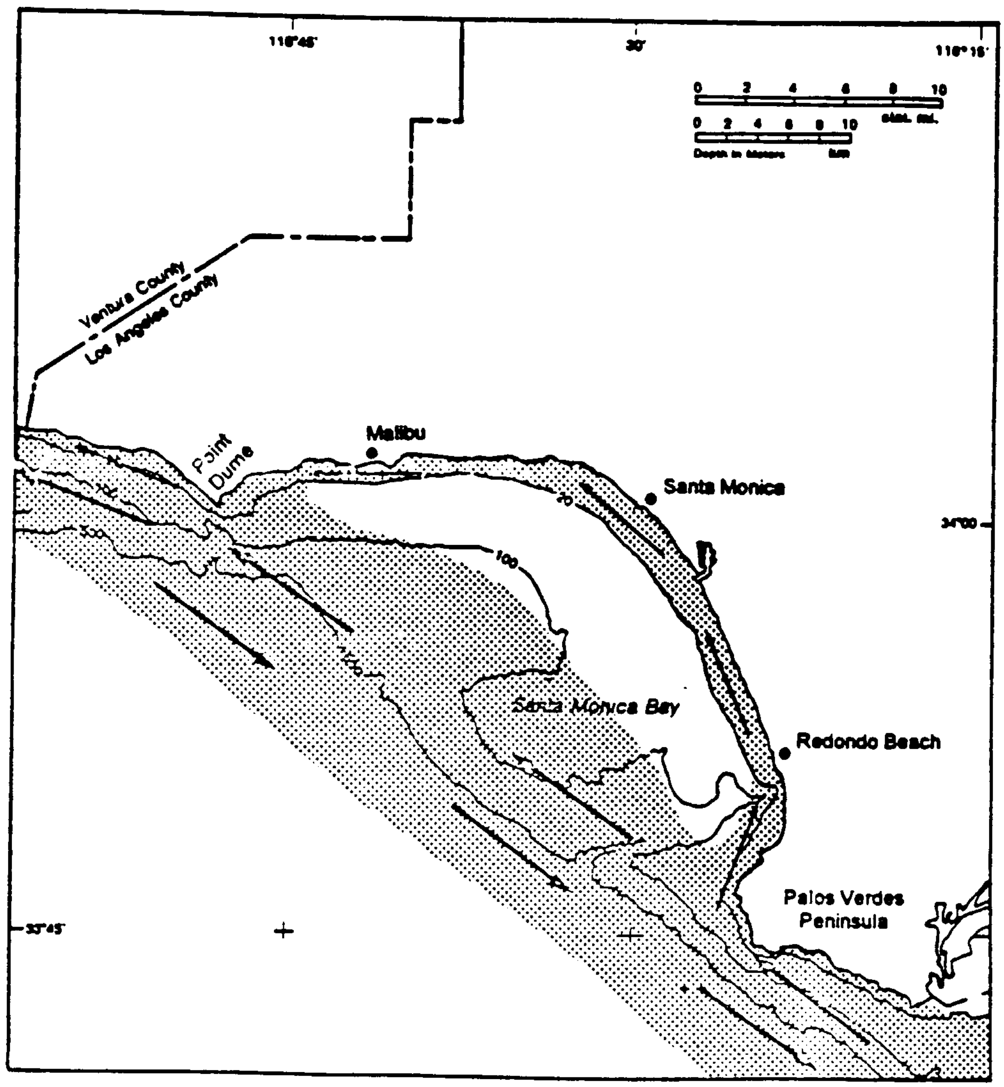

Figure 10-7. Generalized gray whale migration routes in the Santa Monica Bay area (modified from MBC 1988)

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feed during their migration, the bioaccumulation of contaminants from Santa Monica Bay is not likely.

Marine vessels and harbors

Marine mammals frequently interact directly with marine vessels. Marine vessels may collide with or harrass them. Vessel collisions are rare, (although many go unreported) but are the most detrimental impact of the encounters, since impacts may kill the animal. The most recent (reported) local collision was on 12 March 1988 when a tanker collided with one or two animals offshore the Palos Verdes Peninsula (Lewis 1988, pers. comm.).

Gray whales are frequently harassed by boaters who do not follow NMFS guidelines for whale watching. Human actions which interrupt whale behavior constitute "harassment" under the Marine Mammal Protection Act and the Endangered Species Act. Although violators can be prosecuted, enforcement is difficult and harassment hard to prove. Because of intensive local whale watching and concern that gray whales may be changing migrating habits as a result, the present guidelines may become official NMFS regulations in the near future (Jozwiak 1988, pers. comm.).

Vessel engine noise may cause short-term stress to individuals, although gray whales may have acclimated to human activity (BLM 1981). When approached by vessels whales often change their swimming course, and some researchers have suggested that the gray whale migration corridors are farther offshore than in previous years (Dohl *et al.* 1981, Reilly 1984, Shulman 1986).

Gray whales react more to cavitating propellers and sudden changes in engine speeds (Richardson *et al.* 1983) than to constant engine speeds (Dahlheim *et al.* 1984). Responses may include changing course, and/or altering swimming, diving and breathing patterns until the sound source is out of its hearing range (Malme *et al.* 1983, Richardson *et al.* 1983).

Fisheries Impacts

Marine mammals are occasionally caught in set gillnets. Since gillnetting became legal in the 1970s in southern California, California sea lions, common dolphin, bottlenose dolphin, and gray whales have been caught incidentally (NMFS, unpubl. data). The rate and number of entanglements of nontarget species are uncertain because: 1) fishermen may not report entanglements; 2) dead animals cut loose from the nets may not strand; and 3) the cause of death is not always possible to determine. Most deaths occur where gillnetting occurs, whereas strandings occur throughout the Bay because of the currents. There is no evidence that these entanglements have impacted any marine mammal populations (Lecky 1985).

In Santa Monica Bay gillnets are set along headlands between Point Dume and Malibu and from Palos Verdes Point to Point Fermin. From 1986 to 1988, at least six gray whales were caught in set gillnets; three near Point Dume and three along the Palos Verdes Peninsula. Four of the six were released by biologists or lifeguards; the outcomes of the other two were not determined.

Between 1983 and 1987 five gray whales which stranded in Santa Monica Bay either had gillnet around them or evidence which suggested that the cause of death was by gillnet (NMFS Stranding Network, unpubl. data).

Sea lions have been observed eating "hooked" sportfish and live bait used for chumming; there is also evidence that the catch rate slowed or stopped when sea lions were present (Scholl 1983). Partyboat operators are permitted to use nonlethal means (seal bombs or acoustical deterrents) to keep sea lions from interfering with fishing operations (Hanan 1988, pers. comm.).

Endangered Vertebrate Species

California brown pelican, California least tern, and Belding's savannah sparrow (of salt marshes) are federally-protected under the Endangered Species Act of 1973. The gray whale is a federally-protected marine mammal under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973.

CHAPTER 11

SWIMMING-RELATED HEALTH HAZARDS

The health risks of swimming in Santa Monica Bay derive from sources common to swimming in any body of water, such as drowning, ripcurrents, shark attacks, jellyfish stings, and injuries due to diving into shallow water. Drowning and diving injuries are typically associated with swimming anywhere, whereas ripcurrents, shark attacks, and jellyfish stings are generally limited to the ocean. In addition, biological pathogens and hazardous chemicals that are associated with large human populations and/or specific human activities may also pose a risk in certain areas. Because Santa Monica Bay lies adjacent to the largest population center on the West Coast, swimmers in the Bay are potentially exposed to biological pathogens and hazardous chemicals from urban runoff, accidental spills, and permitted municipal and industrial wastewater discharges.

Concern about the health risks of swimming in Santa Monica Bay has increased because of beach closures due to sewage spills and storm drain runoff. Thus, contamination of the Bay by microbial pathogens (i.e., bacteria and viruses) and toxic chemicals is recognized as a potential threat to human health. Articles in the press, which have increased public, scientific, and government awareness, may have fostered misconceptions about the magnitude of health risks by assigning causal roles to specific pollutants, specific sources, and specific human activities. However, a comprehensive study of the human health risks associated with Santa Monica Bay has not yet been performed.

This chapter first presents information on hazardous chemicals, then on microbial pathogens, and finally discusses public health approaches.

HAZARDOUS CHEMICALS

Bathers in Santa Monica Bay may be exposed to a variety of harmful chemicals resulting from improper disposal of household toxins; illegal disposal of motor oil, antifreeze, and battery acid into storm drains; and industrial discharges both into and "upstream" of the Bay. Depending on the nature of the contaminant, the duration of exposure, and the concentration at the point of contact, organic solvents and toxic chemicals may produce acute and long-term health effects such as sore throats, conjunctivitis, gastrointestinal illness, caustic burns, and even cancer. However, etiological relationships between chemical contamination and human health are difficult to establish because of the uncertainties in dose responses, contaminant sources and distribution patterns, differences between acute and long-term exposure, possible synergistic interactions of different compounds, and the long latency (possibly years) between exposure and subsequent disease, especially for cancer. Thus, very few studies have attempted to link human illness with chemical contamination of marine waters.

Hazardous Chemical Spills

Numerous chemical spills have occurred in the Santa Monica Bay watershed during the past several years. Some of these reached storm drains or creeks and were subsequently discharged to the ocean. Although such spills occasionally resulted in public health warnings, only one verified report of a chemical spill between 1986 and 1992 caused beach closures in Santa Monica Bay (Appendix I). On 16 March 1991, 9,240 gal of diesel oil mixed with naphthalene spilled from a tanker off the Chevron USA refinery at El Segundo (MBC 1991a). The spill resulted in beach closures at Surfrider Beach in Malibu on 24 March and between Imperial Highway and Grand Avenue on 29 March (LACDHS, unpubl. data).

Exposure Routes

Human health risks from chemical contamination may develop via several exposure routes. Direct water contact routes include absorption of contaminants through the skin, ingestion of contaminants along with seawater, and inhalation of volatilized contaminants (Brown *et al.* 1984). Exposure routes from contact with sediments include dermal absorption and ingestion of contaminated sediments.

Direct contact with contaminated seawater and/or sediments may occur during swimming, diving, wading, fishing barefoot, or playing in the surf zone. Dermal absorption and inhalation are potentially important routes for volatile organic compounds. While inadvertent ingestion of small quantities of seawater is likely to occur during any swimming activity, ingestion of sediments is unlikely to be significant except in children that exhibit pica behavior (i.e., abnormally high rate of soil ingestion).

BIOLOGICAL PATHOGENS

Direct water-contact activities (swimming, surfing, and skin-diving, etc.) and the consumption of raw molluscan shellfish are the major routes for the transmission of infectious diseases to man from the marine environment. Certain microorganisms native to the marine environment (for example, the genus *Vibrio*) occasionally cause human infections via both transmission routes (MBC 1988). Although pathogens from marine fauna may pose a human health risk, pathogens in the fecal wastes of ill persons and carriers are of most concern in the United States.

Such pathogens have accounted for most illnesses, resulted in the development of water quality standards, and led to the development of control technologies. These pathogens reach marine waters from municipal wastewater discharges, urban runoff, boat wastes, and swimmers. In small urban populations (less than about 40,000 people), the abundance of pathogens in the wastewater discharge varies with the numbers of ill or carrier individuals in the population, but in areas adjacent to large population centers, such as Los Angeles, the pathogen density remains fairly constant (McGee 1993 pers. comm.). In addition to pathogens derived from human wastes, the fecal matter of other vertebrates, particularly mammals, may also pose a threat to human health. Most biological pathogens are thought to be species specific (Atlas 1984), but the relative human health risk from pathogens derived from non-human sources is unknown.

Pathogens

Pathogenic bacteria, viruses, fungi, and protozoa all may occur in the nearshore waters of Santa Monica Bay and all could have adverse effects on swimmers. Pathogenic bacteria that have been found in the Bay include *Pseudomonas*, *Enterobacter/Citrobacter*, *Streptococcus*, *Escherichia coli*, *Klebsiella*, and marine *Vibrio* (Cabelli in MBC 1988). These pathogens cause a variety of human illnesses, ranging from skin infections, gastroenteritis, upper respiratory problems, and wound infections to pericarditis and spinal meningitis (Cabelli 1982).

Viral agents in recreational ocean waters have also been suspected of causing human illness (Cabelli *et al.* 1979, 1982; Gerba *et al.* 1979, 1985). Human-specific viruses such as hepatitis A, poliovirus, and Norwalk virus (which is suspected of causing gastroenteritis), have been found in marine waters (CDC 1987). Enteric human viruses are especially suspect in marine waters that receive municipal waste because they commonly escape secondary sewage treatment (Edmond *et al.* 1978) and because many persist for prolonged periods in the environment (Akin

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et al. 1971, Gerba and Schaiberger 1975, Melniek and Gerba 1980, Rao and Melniek 1986), thus increasing the potential for human exposure. However, no appropriate epidemiological study to discern a viral etiology in human illness has been conducted. Parasitic pathogens, such as *Cryptosporodium*, *Giardia*, and certain yeasts may also cause human illnesses (Atlas 1984).

Diseases

Numerous bacterial and viral pathogens have been recovered from human fecal wastes and municipal wastewater and potentially all of them could be transmitted back to man via contaminated shellfish and recreational waters. Because of the difficulty in conducting epidemiological studies, there is little, if any, evidence that these routes are significant in the transmission of infectious disease in the U.S. at present. There are, however, three exceptions: infectious hepatitis caused by hepatitis A virus; acute gastroenteritis caused by the Norwalk-like viruses; and pharyngo-conjunctivitis caused by adenovirus types 3 and 4 (Cabelli 1983a).

The most frequently reported waterborne disease in outbreak and epidemiological studies is acute gastroenteritis. Of the biological indicators examined in epidemiological studies conducted by the EPA, enterococcus levels in the water correlated best (r=0.75) with the rates of swimming-associated gastroenteritis (USEPA 1986). This relationship was recommended by the EPA as the marine recreational water quality criterion. The EPA also recommended a guideline of a geometric mean of 35 enterococci/100 ml, a value that corresponds to a predicted illness rate of about 19 cases of acute gastroenteritis per 1,000 swimmers (USEPA 1986).

Indicator Organisms

With the exception of areas adjacent to undisinfected waste discharges, human bacterial pathogens and enteric viruses are generally rare in the marine environment, which makes their enumeration and subsequent risk analysis difficult. Thus, to study the distribution and density of biological pathogens, researchers have used "indicator" organisms, which can be associated with the pathogens and may be more abundant. The indicators are easily-counted bacteria that are part of the normal intestinal flora of humans and some other animals. The rationale for their use is that their concentration in the environment is an indication of possible human fecal contamination and, hence, the potential for human disease (Atlas 1984).

Biotypes

At the turn of the century three bacterial species (*Escherichia coli*, *Streptococcus faecalis*, and *Clostridium perfringens*) were suggested as fecal indicators of water quality (Cabelli in MBC 1988). Each of these is found in human feces and none has appreciable extrafecal sources, although all three are found in the fecal wastes of other vertebrates. Because of procedural problems, each indicator system has been expanded to include biotypes that include non-fecal species.

The *E. coli* system was expanded to "total coliforms," which also includes three other genera, *Enterobacter*, *Citrobacter*, and *Klebsiella*. Although those organisms are not always found in human feces, they are usually abundant in sewage, presumably because they multiply there (Dufour 1976). The total coliform system was subsequently replaced with the "fecal coliform" system, more properly called thermotolerant coliforms because only those coliforms that ferment lactose at 44.5°C (as opposed to 35.0°C for total coliforms) are counted. Thermotolerant coliforms include *E. coli*, a portion of the *Klebsiella* biotype, and some extrafecal types (Dufour 1976).

The *Streptococcus faecalis* system was expanded to include *S. mitis* and *S. salivarius*, which are part of the oral flora; *S. equinus* and *S. bovis*, which are found primarily in the feces of mammals other than humans; and *S. faecalis* and *S. faecium*, which are found in the wastes of humans and other endotherms (Greenberg *et al.* 1992).

Because of the difficulties in discerning sources of contamination using specific biotypes, the ratio of fecal coliforms to fecal streptococci has also been used. A ratio greater than four indicates human fecal contamination, whereas a ratio less than 0.7 indicates contamination from non-human sources (Greenberg *et al.* 1992). Although this system has value in specific circumstances, differences between the two groups in terms of variable survival rates, responses to disinfection, and enumeration techniques limit its usefulness (Greenberg *et al.* 1992).

The enterococcus system is a sub-group of the fecal streptococci that is composed of *S. faecalis*, *S. faecium*, *S. avium*, and *S. gallinarum* (Greenberg *et al.* 1992). The enterococci group has proven to be a valuable indicator of fecal contamination in both fresh- and salt-water systems (Greenberg *et al.* 1992) and both enterococci and fecal coliform have been evaluated as indicators of gastroenteritis at public beaches (Cabelli *et al.* 1983, Dufour 1976). The best correlation between indicator concentration and general and acute gastrointestinal symptoms was seen for enterococci (Fattal *et al.* 1983), a relationship that is consistent with the observation that, with regard to their survival in seawater, fecal streptococci resemble the viruses more than the coliforms do. Current concepts of pathogenic risk from contact with bacteria-contaminated marine water are based on the indicator enterococcus (Cabelli *et al.* 1982).

Longevity

Viruses appear to be more resistant to environmental stress than bacterial indicators (Keswick *et al.* 1985) and they generally survive longer than human enteric bacteria in seawater and shellfish (Akin *et al.* 1971, Morris and Kim 1975, Gerba and Schaiberger 1975, Morris *et al.* 1976, Melniek and Gerba 1980, Rao and Melniek 1986). Mussels and other shellfish effectively concentrate bacteria and viruses and they have been used to examine pathogen die-off rates in seawater. Morris *et al.* (1976) found that viruses survived longer than total coliform bacteria in tissues of mussels near the Hyperion Treatment Plant (HTP) and Joint Water Pollution Control Plant (JWPCP) outfalls in 1975-1976 and enteroviruses have been detected in mussels collected from Ballona Creek and Marina del Rey (Morris and Kim 1975), which probably reflects the better survival of viruses than coliform bacteria in the ocean and shellfish.

Greater survival in the marine environment is also true of the Norwalk virus and of F male-specific coliphage, a virus that infects *E. coli* bacteria that have produced F pili. F male-specific coliphage survive chlorination and natural salinity better than either coliforms or enterococci (Cabelli in MBC 1988). Because of this, F-male specific coliphage has been suggested as an indicator of human fecal contamination (Cabelli in MBC 1988). However, Gold *et al.* (1990, 1991, 1992) found that F-male specific coliphage was a poor indicator of human enteric viruses in Santa Monica Bay.

Because many viruses appear to survive longer in seawater than bacterial indicators of fecal pollution, viruses may be present in sufficient number to produce illness after the indicators become undetectable. Thus, the potential health risks from human enteric viruses may be greater than that predicted by the bacterial indicators. This emphasizes the need for more sensitive indicators for human fecal contamination, particularly for known pathogens.

California Ocean Plan Bacterial Standards

To limit the risk of human infection from biological pathogens from municipal sewage, the California Ocean Plan (COP) has instituted the following objectives for bacterial indicators for shoreline and nearshore areas (CSWRCB 1990):

1) Water samples from each sampling station shall have a total coliform density of less than 1,000 cfu (colony forming units) per 100 ml, provided that not more than 20% of the samples at any station, in any 30-day period exceed 1,000 cfu/100 ml; and providing further that no single sample, when verified by a repeat sample taken within 48 hours exceed 10,000 cfu/100 ml.

2) Water samples for fecal coliform densities are based on a minimum of not less than five samples for any 30-day period per sampling station. For fecal coliform, geometric means shall not exceed 200 cfu/100 ml and less than 10% of the total samples during any 60-day period shall exceed 400 cfu/100 ml.

The COP also states that in waters where shellfish may be harvested for human consumption, the median total coliform density shall not exceed 70 cfu/100 ml, and not more than 10% of the samples shall exceed 230 cfu/100 ml (CSWRCB 1990).

Although enterococcus density standards have not been developed, California has adopted the following enterococcus guidelines for shoreline and nearshore stations when the total or fecal standards have been exceeded: a geometric mean of 24 cfu/100 ml for any 30 day period and a geometric mean of 12 cfu/100 ml for any six-month period, based on at least five samples per month (CSWRCB 1990). If a shore station consistently exceeds one of these bacterial objectives, the COP requires a sanitary survey to determine the source of the contamination. However, the protocol for such a survey has not been developed.

Sources and Distribution of Biological Pathogens

Fecal waste is the primary source of most human-specific biological pathogens, and several sources of fecal wastes could lead to infectious disease among users of the Bay. These include treated wastewater discharges, urban runoff, sewage spills into storm drains, small boat waste discharges, bathers, and marine fauna. Although the risk of disease from human fecal contamination is paramount, it is important to emphasize that the relative importance of pathogens from non-human sources is not known.

Wastewater from sewage treatment facilities may be a potentially large source of human fecal contamination to bathers in Santa Monica Bay. Treated wastewater is discharged directly to the Bay from both the HTP and the JWPCP outfalls, which discharge offshore, and indirectly from the Tapia water reclamation facility (TWRF), which discharges into Malibu Lagoon via Malibu Creek. The relative importance of the offshore sources and their impact on the health of bathers depends upon the transport of associated pathogens shoreward to bathing beaches. Both HTP and JWPCP regularly monitor bacterial indicators at offshore, nearshore, and shoreline sites throughout the Bay and in the past 10 years there has been no evidence from microbial indicators that sewage from the effluents has reached the beach. Occasionally high bacterial counts at shoreline stations is a result of other sources of contamination, such as storm drains, shorebirds, and bathers.

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Hyperion Treatment Plant

HTP began monitoring total coliform levels at shoreline stations near the 1-mi outfall in the 1940s. Between 1947 and 1959 total coliform levels along shore decreased dramatically (Figure 11-1), due to improved treatment and because the 1-mi outfall was extended to 5 mi offshore in 1957 (WSED 1982, Garber and Wada 1988). Increases in bacterial densities at shoreline stations between 1959 and 1974 were probably due to urban runoff via storm drains, especially those in the north with large drainage basins (MBC 1988).

The present HTP monitoring program was initiated in 1974 and is focused on recreational waters of Santa Monica Bay. HTP monitors 17 shoreline stations between Topanga and Torrance Beaches (Figure 11-2), 11 nearshore stations located 1,000 ft from shore, and several stations along Ballona Creek and at the Pico-Kenter Storm Drain in the city of Santa Monica. Shoreline samples are collected and analyzed daily for total coliforms and enterococci and at least five times per month for fecal coliforms. Nearshore samples are analyzed for all three indicators four or five times per month (CLA,DPW 1992). In addition to the shoreline and nearshore stations, HTP also monitors bacterial densities associated with plume tracking and microlayer investigations.

The results of the present monitoring program indicate that levels of indicator bacteria (and presumably microbial pathogens) continue to decline in the receiving waters. All nearshore samples have been in compliance with indicator bacterial levels since 1987, suggesting that HTP's 5-mi outfall is not the source of occasionally high bacterial counts in the Bay. This trend is due primarily to improved treatment: new digesters, chemical additives (ferric chloride and polymer), sludge dewatering, and an increase in the amount of flow receiving secondary treatment. The trend should continue as the plant is scheduled for full secondary treatment by 1998 (CLA,DPW 1992).

Although densities of bacterial indicators are generally low at nearshore stations, water quality limits have been exceeded in recent years at several shoreline sites, most frequently those near storm drains. Thus, the major sources of bacterial contamination at the surf zone appear to be urban runoff, sewage overflows to storm drains, and marina activities, rather than the HTP effluent.

Joint Water Pollution Control Plant

JWPCP regularly monitors bacterial indicators in the nearshore waters of the Palos Verdes Peninsula. Between 1972 and 1982 total coliform counts were made at seven shoreline and five nearshore stations near White Point (Figure 11-3). Over that period, total coliform counts decreased at all stations except one, and those high values were attributed to a colony of California sea lions. The decrease in coliform levels is attributed to improvements in treatment (Figure 11-4).

Because elevated subsurface counts had been measured during previous interruptions in chlorination (Stull 1992, pers. comm.), the chlorination facilities and procedures at JWPCP were modified in 1987 and 1988 to meet more stringent requirements. Chlorine dosage was increased and from 1988 to 1990 a backup chlorination station was constructed for use on primary effluent when the main facility was inoperative. In 1991 another standby disinfection facility was constructed for use in the secondary waste treatment system.

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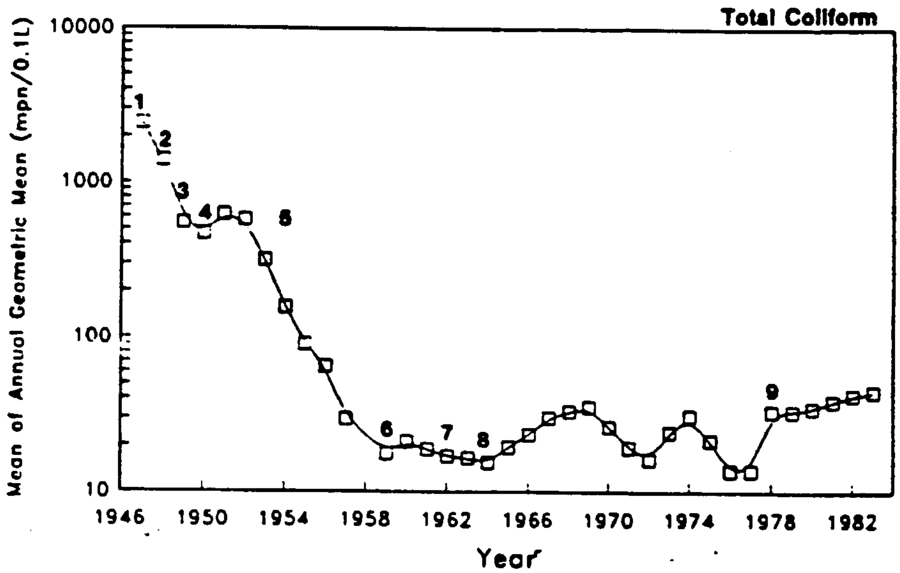

1 1943-1947: screening, solids incineration
2 1948: 182 MGD - screening, chlorination, solids incineration
3 1949: 201 MGD - screening, chlorination, new 1 mi outfall, solids digestion
4 1950: 201 MGD - screening, chlorination, new 1 mi outfall, solids digestion
5 1951-1957: 250 MGD - high rate secondary, chlorination, solids digestion, filtration drying
6 1958: 254 MGD - high rate secondary, chlorination, solids digestion, 7 mi outfall
7 1962: 184 MGD - primary - 5 mi outfall, 100 MGD - standard rate secondary, 1 mi outfall, solids digestion, 7-mi outfall
8 1963-1977: 240 MGD primary - 5 mi outfall, 100 MGD standard rate secondary, 5 mi outfall, solids digestion, 7 mi outfall
9 1978-1983: 283 MGD primary - 5 mi outfall, 85 MGD standard rate secondary, 5 mi outfall, solids digestion, 7 mi outfall

Figure 11-1. Temporal trend in total coliform bacteria at Santa Monica Bay shoreline. Values are mean of annual geometric mean in mpn/100 ml (Garber and Wada 1988).

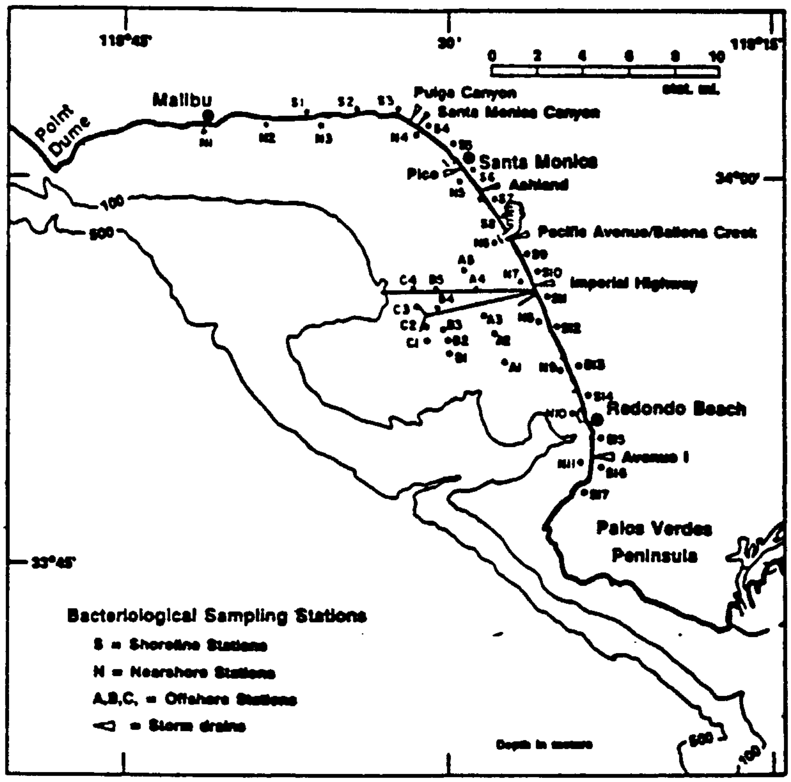

Figure 11-2. HTP bacteriological sampling stations in Santa Monica Bay.

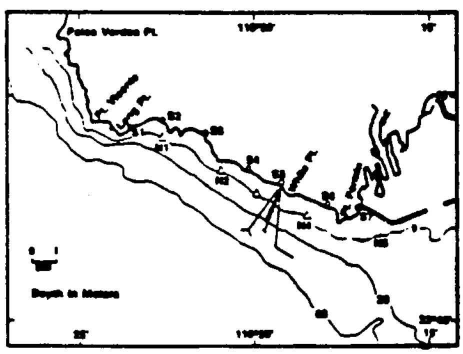

Figure 11-3. JWPCP shoreline (S) and nearshore (N) bacteriological stations on the Palos Verdes Shelf.

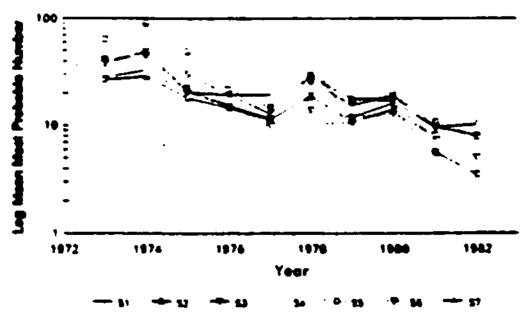

Figure 11-4. Temporal trends in total coliform bacteria densities at Palos Verdes shoreline stations 1972-1982. Values are log mean mpn/100 ml (modified from LACSD, unpubl. data).

These improvements resulted in further decreases in bacterial densities at both shoreline and nearshore stations. In 1991 total coliform densities exceeded 1,000 cfu/100 ml on less than 0.6% of the sampling days at the seven shoreline stations (Stull 1992, pers. comm.). No surface or subsurface coliform limits were exceeded at the nearshore stations, although near-bottom samples occasionally exceeded the limits at some stations. Since total coliform counts have been continuously lower than standards for fecal coliform, fecal coliform measurements have not been required since 1988. JWPCP began monitoring enterococcus levels in December 1991, and all counts since then have been at or near detection limits at all stations.

Although chlorination appears to have reduced levels of indicator bacteria at both shoreline and nearshore stations, the efficacy of chlorination in reducing viral concentrations has never been determined. Furthermore, the potential for toxic effects on marine life from extensive chlorination has not been adequately addressed (Gold 1993 pers. comm.).

Urban Runoff

More than 68 storm drains discharge into Santa Monica Bay between Ventura County and Point Fermin. The majority of these storm drains convey appreciable run-off to the Bay only intermittently, but during periods of heavy rainfall they may carry high concentrations of biological pathogens as well as chemical contaminants from a variety of residential and industrial sources. Although storm drains may constitute point sources at the site of entry into the Bay, the contaminants that they convey derive from a variety of non-point sources, making monitoring and regulation of storm drain effluents difficult. Bacterial pathogens may be transported to the Bay when stormwater overflows into sewage lines, causing sewage to flow into the storm drain system. These overflows cause the most extensive human fecal contamination of Santa Monica Bay. However, high indicator bacteria levels and human enteric viruses have been found in storm drains even during dry weather (CLA,DPW 1988, 1990, 1991, 1992; Gold *et al.* 1990, 1991, 1992). Because most storm drains in the Bay discharge directly into the surf zone, and because of the high levels of contamination that have been found in storm drain runoff, surf zone areas near storm drains are considered high risk areas to swimmers, especially during rain storms.

Dry-weather Flow. Monitoring recently conducted by HTP indicates that high levels of indicator bacteria in the Bay are usually associated with flowing storm drains (CLA,DPW 1988, 1990, 1991, and 1992). For example, since at least 1987 indicator levels at Stations S3, S6, S11, and S16 (Figure 11-2) have exceeded one or more of the Ocean Plan standards. Each of these stations is adjacent to a storm drain: Station S3 is just north of the Pulga Storm Drain; Station S6 is midway between the Pico-Kenter and Ashland Storm Drains; Station S11 is just south of the Imperial Storm Drain; and Station S16 is just south of the Avenue I Storm Drain. High counts have also been recorded at Station S9, which is adjacent to Marina Del Rey and Ballona Creek, and at Stations S14 and S15, which are adjacent to King Harbor in Redondo Beach (CLA,DPW 1988, 1989, 1990, 1991, and 1992). When high levels of bacterial indicators were recorded at the shoreline stations, low levels were recorded at nearshore stations, suggesting that the HTP outfall was not the source of bacterial contamination at the shoreline.

Because high levels of indicator bacteria in the Bay are consistently found near storm drains, the Santa Monica Bay Restoration Project (SMBRP) conducted a series of studies to assess storm drain contamination of the Bay (Gold *et al.* 1990, 1991, 1992). These studies examined storm drain runoff at several sites throughout Santa Monica Bay and they provide the most recent analysis of dry-weather biological contamination from urban runoff.

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The first study was conducted over a period of nine weeks during August and September 1989. Samples were collected at the Pico-Kenter and Ashland Storm Drains in the city of Santa Monica, which have had high densities of indicator bacteria in the past (CLA,DPW 1987, 1988, 1989, 1990, 1991, 1992). At each site, samples were taken from inside the drains and from the surf zone at several sites at ankle and chest depths. These samples were analyzed for total and fecal coliforms and enterococcus densities. Human enteric viruses and F-male specific coliphage densities were analyzed in samples taken from the storm drains. In addition, viral seeding experiments were conducted to determine the effectiveness (i.e., percent of recovery) of the enumeration methods and to test for possible toxic effects of the storm drain effluent on the viruses (Gold *et al.* 1992). In 1990 and 1991, the sampling program was expanded to include the Pico-Kenter Storm Drain; the Herondo Storm Drains, which are located just north of King Harbor in Redondo Beach; and several sites within Malibu Lagoon (Gold *et al.* 1991, 1992). Ankle and chest-deep samples were taken only near the Pico-Kenter Storm Drain. The 1991 study was also designed to evaluate the effectiveness of the 600-ft pipeline extension at the Pico-Kenter Storm Drain, which was completed in August 1991, in dispersing the effluent beyond the surf zone. The densities of bacterial indicators were evaluated on whether they exceeded "excessive limits" or "levels of concern," which were defined as 1,000 cfu/100 ml for total coliform, 200 cfu/100 ml for fecal coliform, and 24 cfu/100 ml for enterococcus (Gold *et al.* 1990, 1991, 1992).

In 1989, 1990, and 1991 all three bacterial indicators exceeded levels of concern in virtually all samples taken from the Pico-Kenter Storm Drain (Figures 11-5 and 11-6). In general, densities of bacterial indicators decreased with depth and distance along the shoreline. In 1989 most surf zone samples taken 10 yd from the storm drain exceeded limits on 100% of the sampling days, but chest-depth samples exceeded limits much less frequently (Figure 11-5, Gold *et al.* 1990). The geometric means of bacterial densities further demonstrate the decrease in the concentrations of bacterial indicators with distance from the storm drain (Figure 11-7). Pico-Kenter Storm Drain samples in 1989 had mean bacterial levels nearly one-hundred times greater than levels of concern, but levels of all three indicators in ankle-deep water were approximately one order of magnitude lower than storm drain samples and levels in chest-deep water were approximately two orders of magnitude lower. Bacterial densities in 1989 also exceeded levels of concern at a station 150 yd from the storm drain. However, during the 1989 sampling, HTP recorded bacteria levels below levels of concern at Station S6, 200 yd south of Pico-Kenter (CLA,DPW 1990), suggesting that the extent of bacterial contamination may be limited to within 150 to 200 yd from the storm drain.

Densities of all three bacterial indicators in 1991 were three to five times higher in the Pico-Kenter drain than the Herondo drain, and one to two orders of magnitude higher than at Malibu Lagoon. In the Pico-Kenter Storm Drain, densities of all three indicators exceeded levels of concern in all 13 samples. However, in the surf zone, levels of concern were infrequently exceeded at the ankle- or chest-deep stations. The results from the 1991 dispersion study were very different from that conducted in 1990 (Gold *et al.* 1991, 1992), in which bacterial levels of concern were frequently exceeded at ankle and chest-deep stations up to 100 yd from the drain (Figure 11-6). Furthermore, for all three indicators, at nearly every surf zone station, the geometric means in 1991 were significantly lower than the means in 1990. Thus, the 600-ft extension to the Pico-Kenter Storm Drain, when functioning properly, appears to be effective in reducing the densities of indicator bacteria in the surf zone, where the potential for human exposure is greatest (Gold *et al.* 1992).

The distribution pattern in and around the Ashland Storm Drain was similar to that seen at Pico Kenter: levels of concern for all three bacterial indicators were exceeded in nearly 100% of the 15 storm drain samples and least frequently at the chest-depth stations (Figure 11-8).

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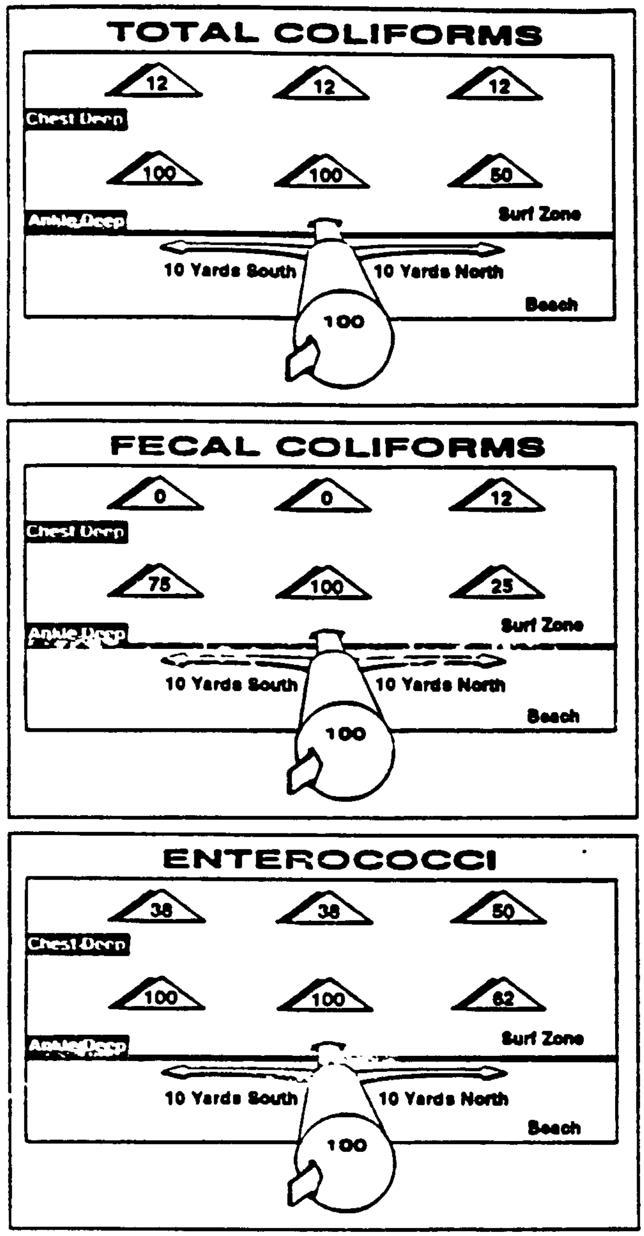

Figure 11-5. Percentage of sampling days where excessive levels of bacterial indicators were exceeded near the Pico-Kenter Storm Drain in August and September 1989 (excessive levels: total coliforms = 1,000 cfu/100 ml, fecal coliforms = 200 cfu/100 ml, enterococci = 24 cfu/100 ml). Triplicate samples were collected for eight days from the surfzone and on 15 days from the storm drain (Gold *et al.* 1990).

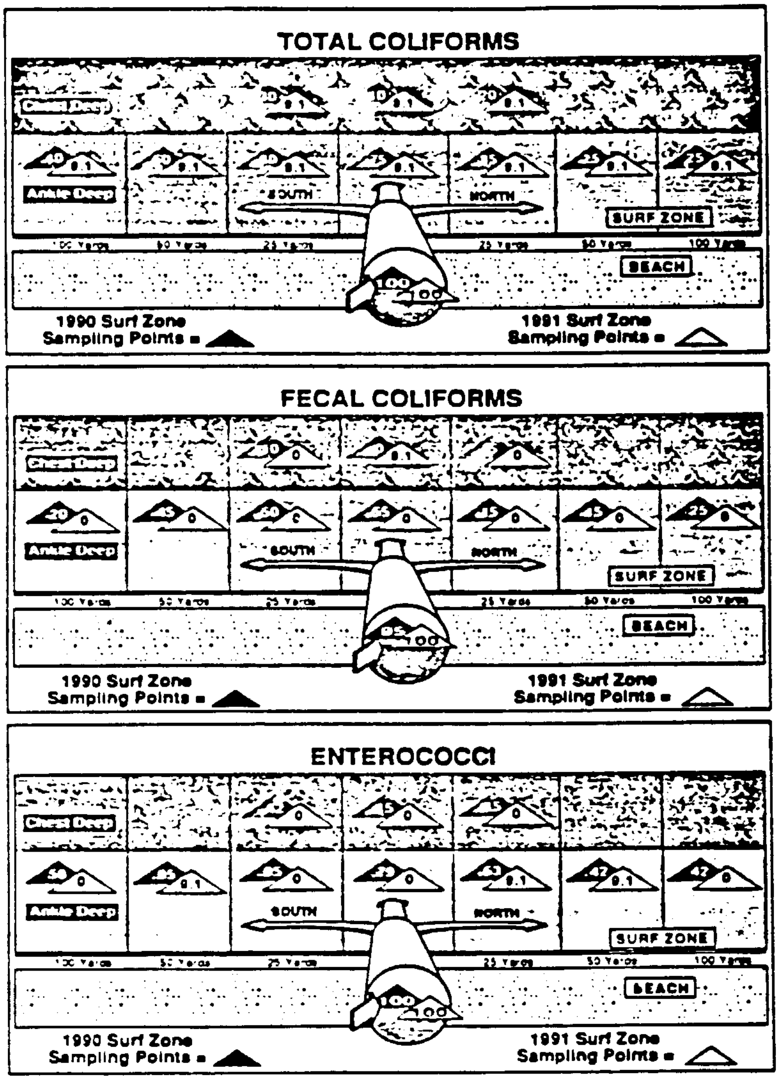

Figure 11-6. Percentage of sampling days where excessive levels of bacterial indicators were exceeded near the Pico-Kenter Storm Drain in 1990 and 1991 (excessive levels: total coliforms = 1,000 cfu/100 ml, fecal coliforms = 200 cfu/100 ml, enterococci = 24 cfu/100 ml). (Gold *et al.* 1992).

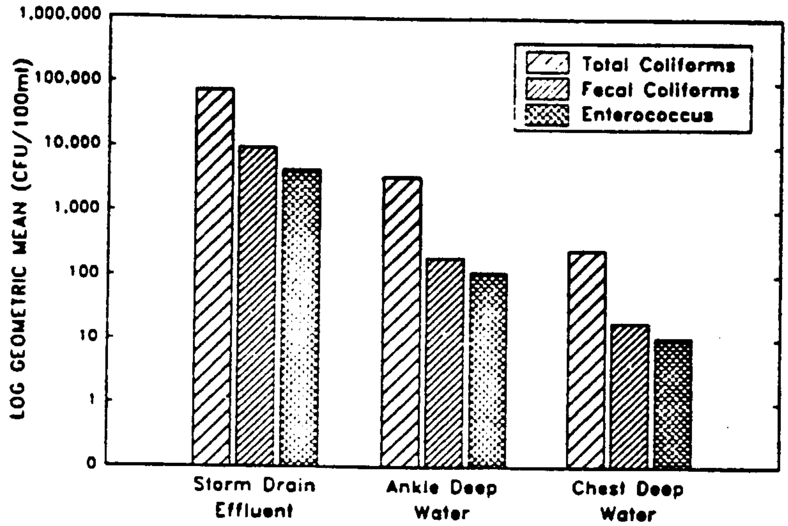

Figure 11-7. Geometric means of bacterial indicator densities (cfu/100 ml) near the Pico-Kenter Storm Drain in August and September 1989. Values were calculated from data collected on eight sampling days with three replicates per station (Gold *et al.* 1990).

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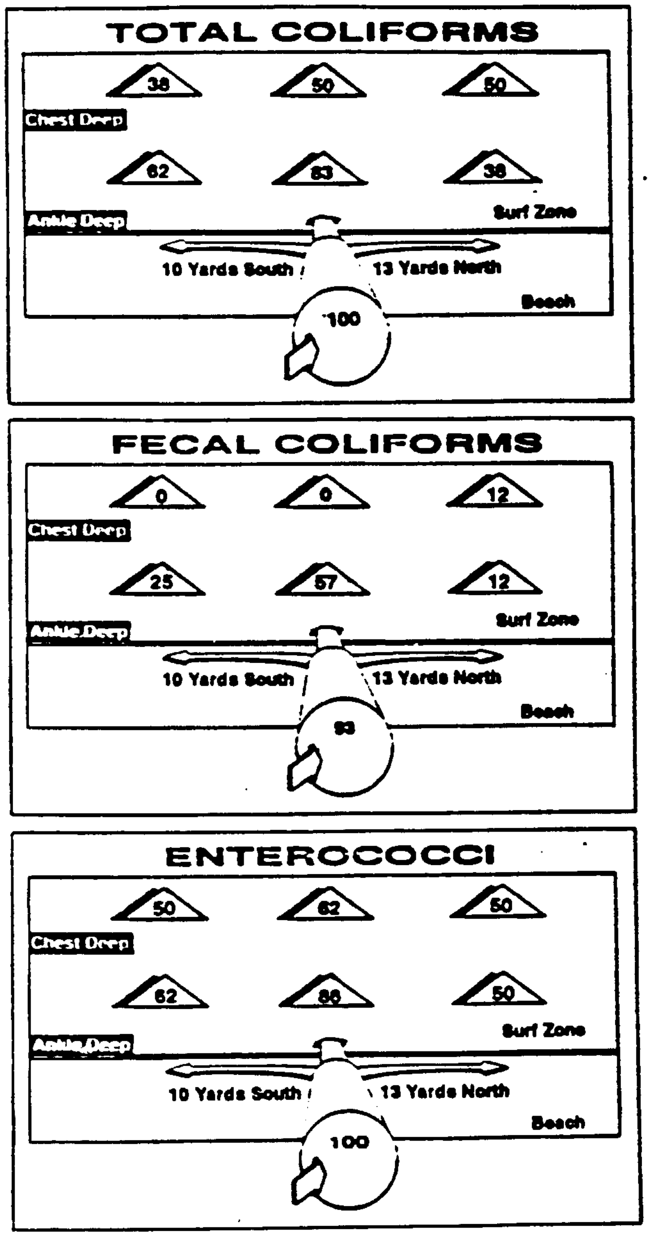

Figure 11-8. Percentage of sampling days where excessive levels of bacterial indicators were exceeded near the Ashland Storm Drain in August and September 1989 (excessive levels: total coliforms = 1,000 cfu/100 ml, fecal coliforms = 200 cfu/100 ml, enterococci = 24 cfu/100 ml). Triplicate samples were collected for eight days from the surfzone and on 15 days from the storm drain (Gold et al. 1990).

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Bacterial densities at ankle-depth were not as high as those at the Pico-Kenter site, but all three indicators exceeded levels of concern in most samples.

Human enteric viruses were found in both the Pico-Kenter and Herondo Storm Drains (Gold *et al.* 1990, 1992). However, no viruses were detected in any of the samples taken from the Ashland Storm Drain, even in the seeded samples (recovery of spiked viruses was 0%), suggesting that there were significant interferences in the collection or identification processes (Gold *et al.* 1990, 1992). Thus, the lack of viruses in the Ashland Storm Drain is not evidence of their absence. The presence of enteric viruses in the Pico-Kenter and Herondo Storm Drains indicates that human fecal waste was present in the runoff during the majority of the sampling period. The viruses were identified as Coxsackie B, which can cause gastroenteritis and on rare occasions, pericarditis and meningitis (Gold *et al.* 1992). Possible sources of the human fecal contamination detected in the storm drains include leaky sewer lines, overflows from blocked sewers, illegal inputs, or the local homeless population (Gold *et al.* 1992).

At all sites in Malibu Lagoon, the mean densities of all three bacterial indicators exceeded levels of concern. Densities were especially high in Malibu Creek, upstream of the main Lagoon. Furthermore, enteric viruses were found at all three sampling sites in the Lagoon, suggesting the presence of human fecal contamination. TWRF discharges tertiary-treated waste water into Malibu Creek approximately 6 mi upstream from the Lagoon and is a potential source of fecal contamination. However, levels of bacterial indicators in samples taken from the facility's effluent were very low during the study period and remained so throughout 1992 (LVMWD unpubl. data). Thus, the plant does not appear to be a direct source of fecal contamination, which confirms indications in 1987 when only a single human enteric virus was detected in TWRF's effluent during 25 days of sampling (James M. Montgomery Engineers 1988). Possible sources of human fecal input to Malibu Lagoon include the Malibu Colony Septic system, campers, picnickers, temporary residents, and illegal discharges from mobile homes or recreational vehicles (Gold *et al.* 1992).

The density of F-male specific coliphage was monitored to examine its usefulness as an indicator of human enteric viruses in marine waters polluted with human sewage. Coliphage densities were ten times higher at the Pico-Kenter Storm Drain than at the Ashland Storm Drain in 1989, but the data were extremely variable and there was not enough information available on human fecal inputs to explain the higher density at Pico-Kenter (Gold *et al.* 1990). Furthermore, there was no correlation between the densities of coliphage and bacterial indicators, nor between coliphage densities and the presence of enteric viruses. Thus, F-male specific coliphage is apparently a poor predictor of the presence or absence of human enteric viruses.

The ongoing monitoring studies conducted by HTP, JWPCP, and TWRF and the studies conducted by Gold *et al.* (1990, 1991, 1992) have established that the largest potential threat to swimmers in Santa Monica Bay from human pathogens is from urban runoff, particularly at the Pico-Kenter and Herondo Storm Drains and in the Malibu Creek/Malibu Lagoon drainage system, where the presence of human fecal contamination has been detected. Although there are several areas of potential fecal input into these drainage systems, it is important to emphasize that the source or sources of the sewage has not been determined conclusively at any site. Furthermore, an epidemiological study, which would evaluate the impact of human sewage on swimmers, has not been conducted in Santa Monica Bay. The first step in reducing the potential for human health risks associated with swimming in waters contaminated with fecal waste is to carry out a sanitary survey, which would identify and reduce or eliminate the sources of fecal contamination. However, until the criteria and methods for such studies are developed, the public should continue to be informed about the potential risks of swimming in contaminated areas.

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Wet-weather flow. Because of the relationship among wet weather, storm drains, and high bacterial counts, regulatory agencies distinguish between wet- and dry-weather sampling; HTP has defined wet weather as the day of rain plus the two subsequent days. Bacterial monitoring studies conducted by HTP from July 1989 through June 1990 (CLA,DPW 1991) indicate that total coliform, fecal coliform, and enterococcus densities all increase during wet weather, especially at stations closest to storm drains (Figure 11-9). For example, in 1989-1990, densities of all three indicators were highest during wet weather at Station S3, which is adjacent to the Pico-Kenter Storm Drain, and at Stations S8 and S9, which are on either side of Marina Del Rey and Ballona Creek (Figure 11-2).

The effect of runoff on the densities of bacterial indicators in the Bay can be demonstrated by examining wet-weather vs. dry-weather days in which bacterial indicator standards were exceeded. For instance, between July 1989 and June 1990, total coliform levels exceeded standards on at least one day at every HTP station (Table 11-1, CLA,DPW 1991). Levels were particularly high between the Pulga Canyon Storm Drain and the Imperial Highway Storm Drain (Stations S3 through S11, Figure 11-2), an area that drains a large portion of Los Angeles County (Figure 7-1), and on either side of King Harbor in Redondo Beach (Stations S14 and S15). Fecal coliform and enterococcus levels were also higher during wet weather, but the difference between wet- and dry-weather days for fecal coliform and enterococcus were much less than that for total coliform. Although high levels of any one of these indicators by themselves is not necessarily indicative of fecal contamination, high levels of all three indicators at a single location suggests human fecal input.

The extent of contamination around a storm drain depends on local rainfall, runoff from the surrounding area, and the interval between storms. For example, densities of all three bacterial indicators were highest during periods of peak rainfall in Los Angeles between July 1989 and June 1990 (Figure 11-10) (CLA,DPW 1991). Bacterial densities are usually highest during the first few months of the rainy season and tend to decrease as the season progresses. This pattern is known as the "first flush" and it assumes that coliform-bearing materials accumulate throughout the dry season. For the same reason, bacterial densities may also be particularly high during the first few hours of a rain that follows an extended dry period. Densities of bacterial indicators (and presumably human pathogens) may remain high for three or four days following the initial runoff (Figure 11-11), during which time swimmers are at greatest risk (CLA,DPW 1991).

Sewage Spills and Overflows

When sewage spills in Santa Monica Bay occur, they are usually a result of heavy rainfall or construction near sewer lines. Spills have lasted anywhere from an hour to several days and they may carry large volumes of sewage to the Bay through local storm drains. Although overflows cannot be predicted, there is usually enough time to warn the public about impacted areas and thus minimize exposure to potential pathogens.

Unusually high inflow and/or infiltration occasionally requires the North Outfall Treatment Facility of HTP to discharge into Ballona Creek or other storm drains. In the past some of these overflows have consisted of raw, untreated sewage (Sowby 1988, pers. comm.), but normally the sewage receives primary sedimentation, two stages of screening, and chlorination at a concentration of 40 mg/l (Crosse 1988, pers. comm.; Dorsey 1988, pers. comm.). A new sewer line and associated upgrades, which will virtually eliminate these discharges, are scheduled for completion in 1993-1994 (CLA,DPW 1992).

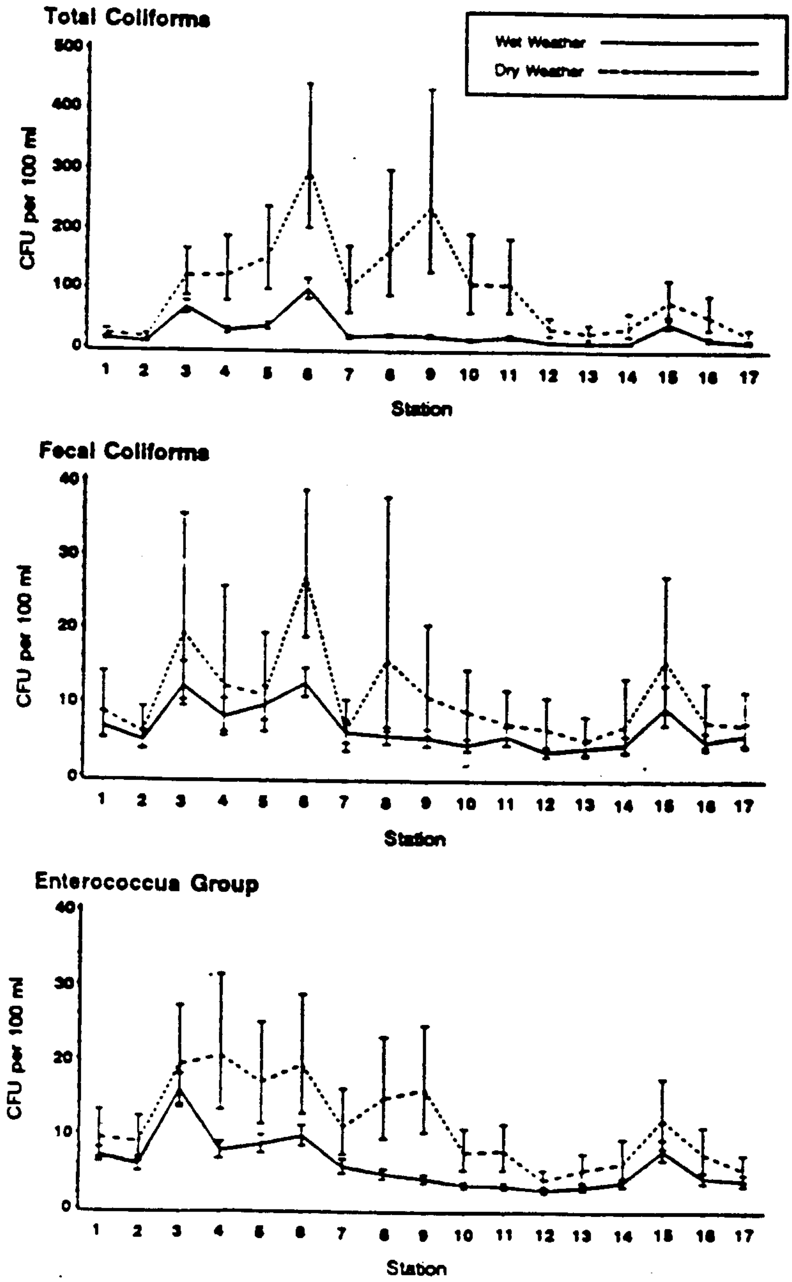

Figure 11-9. Annual geometric means for indicator bacteria collected from HTP shoreline stations during wet and dry weather, sampling year 1989-1990; error bars represent two standard errors (CLA,DPW 1991).

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Table 11-1. Percentage of wet and dry weather days where excessive levels of bacterial indicators were exceeded at the HTP shoreline stations (excessive levels: total coliforms = 1,000 cfu/100 ml, fecal coliforms = 200 cfu/100 ml, enterococci = 12 cfu/100 ml) (CLA,DPW 1991).

Station	Total Coliforms >1,000 CFU/100 mL		Fecal Coliforms >200 CFU/100 mL		Enterococcus >12 CFU/100 mL	
	Wet	Dry	Wet	Dry	Wet	Dry
1	1	0	0	0	36	28
2	1	<1	0	<1	34	22
3	9	3	2	<1	57	56
4	14	2	2	<1	58	31
5	17	1	2	0	50	33
6	24	5	9	2	55	37
7	20	<1	0	<1	42	21
8	27	<1	6	0	44	15
9	31	<1	2	0	45	12
10	23	2	1	0	37	10
11	21	4	2	<1	31	11
12	7	<1	0	0	19	9
13	7	<1	0	<1	24	13
14	12	2	2	0	22	15
15	10	1	1	<1	40	29
16	9	1	2	0	31	19
17	2	<1	0	<1	22	17

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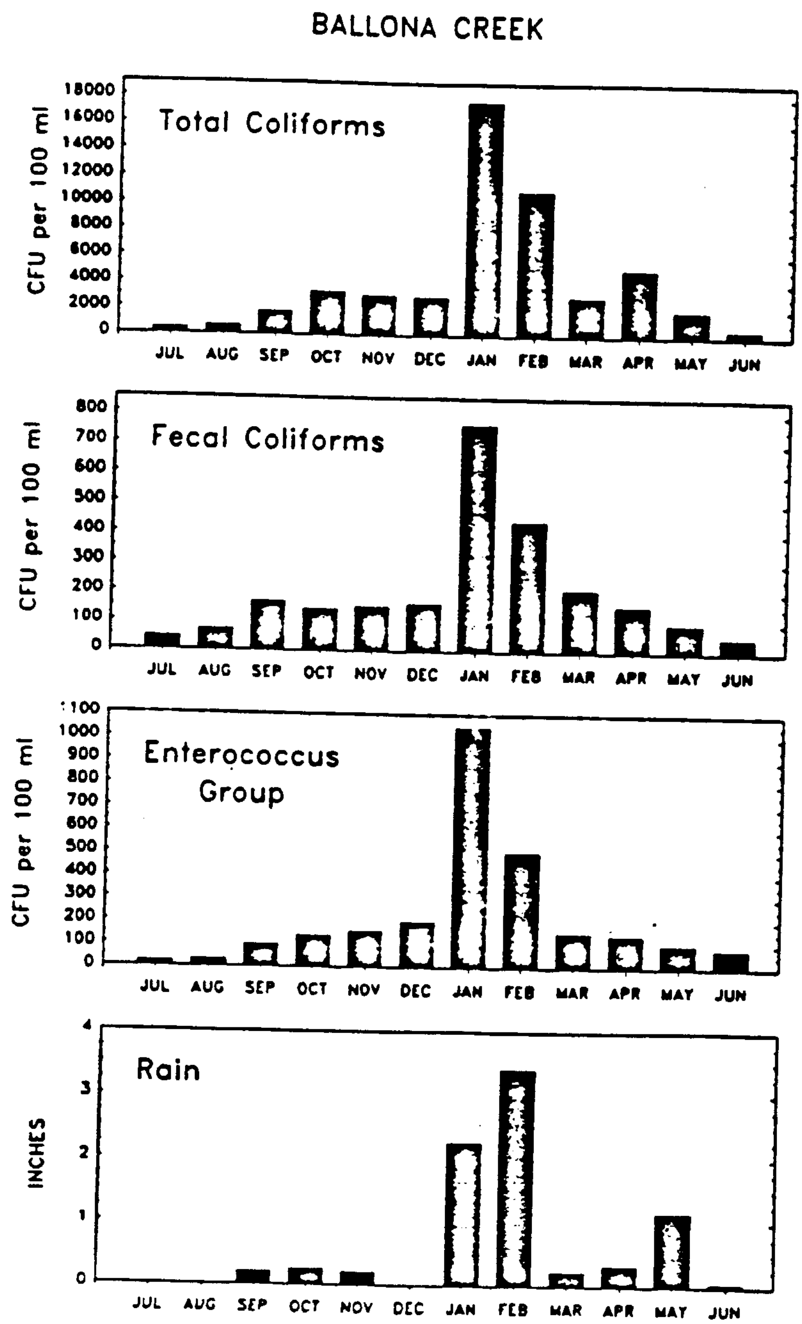

Figure 11-10. Monthly geometric means of indicator bacteria measured in Ballona Creek at Pacific Avenue, sampling year 1989-1990; rain data are in total inches per month (CLA,DPW 1991).

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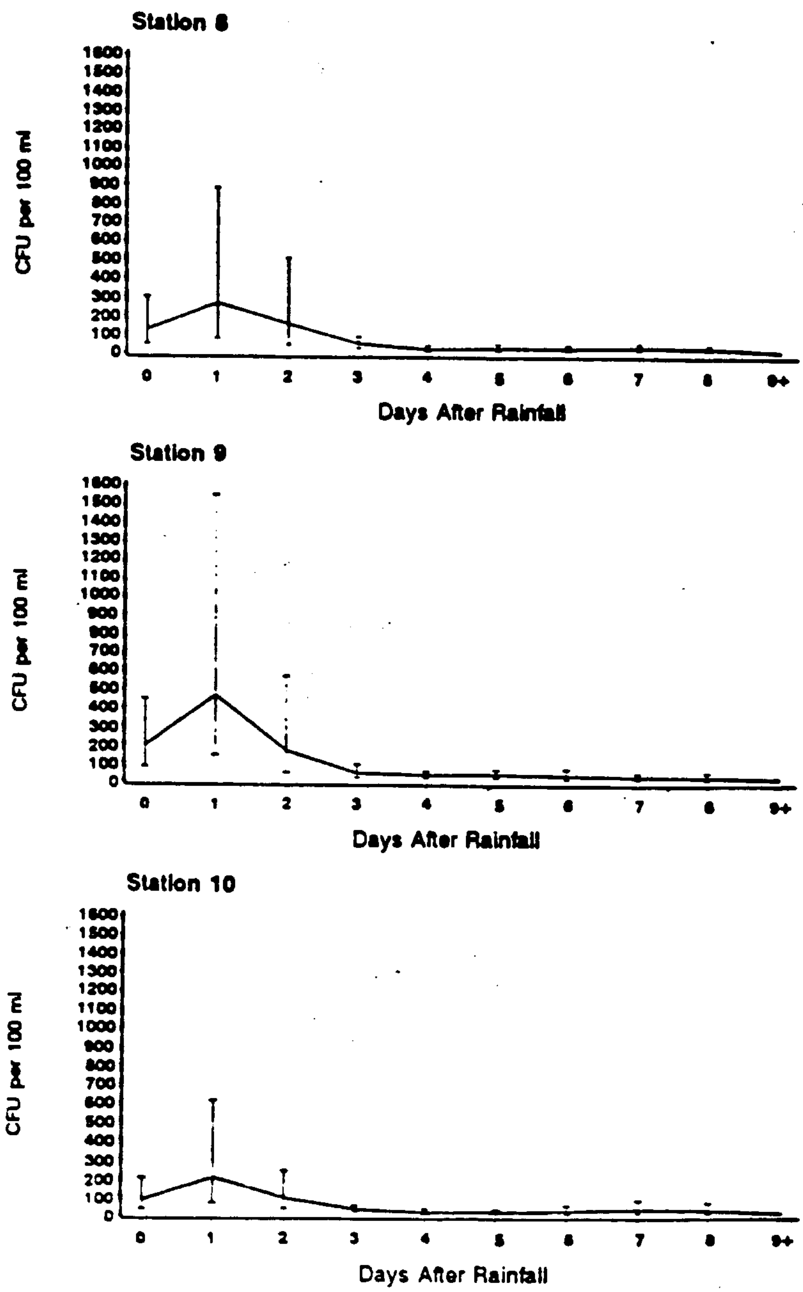

Figure 11-11. Bacterial counts on the days following rain at HTP shoreline stations S8, S9, and S10 (CLA,DPW 1991).

Between January 1987 and September 1992, at least 26 sewage overflows were recorded that resulted in beach closures (Appendix I). Most of these were the result of excess storm water in collector lines leading to HTP, although, some sewage has been released from septic tanks and coastal restaurants. The largest of the spills occurred on 10 February 1992 when heavy rains caused the discharge of over 66 million gallons of partially treated sewage into Santa Monica Bay. Because of the high bacterial levels, beaches were closed along the entire Los Angeles County coast for 11 days (Appendix I).

Small Boat Wastes

The overboard discharge of wastes from boats, particularly those berthed in the marinas, may present a risk of infectious disease to people that use recreational resources in the immediate vicinity. However, because of the small numbers of individuals who contribute to this source and their intermittent nature, the risks are not predictable by fecal indicators or pathogen levels in the water. Therefore, the conventional water quality guidelines and standards do not apply. The recognized solution is to restrict body-contact activities in the immediate vicinity of marinas and to enforce regulations that prohibit sewage discharges from boats. However, since enforcement is often difficult, education of recreational boat users about the potential hazards of sewage discharge is also essential.

Bathers

At least two epidemiological studies have related swimming-associated illness and bather density in areas of poor water exchange (Fattal *et al.* 1986, Calderone and Dufour, pers. comm.). Although there appears to be a health risk to swimmers from other bathers in the area, the extent of the risk is unpredictable and not amenable to usual control technology. The levels of *Staphylococcus aureus*, a potential human pathogen that has been found to be a good predictor of illness in freshwater, correlate well with bather density and could be used to identify such situations (Fattal *et al.* 1986, Calderone and Dufour 1988, pers. comm.). However, the link between *S. aeureus* density and illness has not been established in marine waters.

Marine Fauna

Fecal wastes from marine mammals, water fowl, and shorebirds may contain bacteria (notably *Salmonella*) pathogenic to humans. Although the infectious dose for *Salmonella* is very high, heavy contamination of the water could produce disease among swimmers or consumers of shellfish. The impacts on swimmers of pathogens from non-human sources has not been examined, except for swimmer's or clam-digger's itch, a problem caused by a bird shistosome (MBC 1988). Because bacterial indicators originate from several sources other than human feces and because most viruses are thought to be species-specific (Atlas 1984), water contaminated with non-human feces would probably have to markedly exceed bacterial indicator limits before a significant risk of human illness would result.

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Public Health Approaches

Beach Closures and Warnings

Santa Monica Bay beaches are closed when high indicator bacteria levels are linked to sewage spills or when there are other health-risk concerns.

Santa Monica Bay beaches were closed to swimmers 39 times from January 1987 through September 1992 (Appendix I). Beach closures ranged from three in 1990 to 10 in 1987, with eight from January through September 1992. Most closures lasted from one to three days, but the longest closure lasted for 42 days in 1987, due to high densities of bacterial indicators that apparently resulted from an excessive bird population at Marina del Rey Beach.

Most closures were for a small segment of the beach, usually near a storm drain, but some extended beyond the study area. Three closures during this period extended from the Ventura-Los Angeles County Line to the Long Beach City border; these closures occurred on 22 and 31 October, 1987, and on 10 February, 1992, and lasted for 6, 12, and 11 days, respectively. These closures were due to sewage discharges of 2.7, 4.1, and 66.1 million gal, respectively from the North Outfall Treatment Facility resulting from heavy rains.

Epidemiology

To assess the potential risk to human health from swimming in Santa Monica Bay, it would be necessary to conduct an epidemiological study, which would evaluate the impact of pathogenic organisms or toxic chemicals on swimmers. However, such a study has not been conducted for Santa Monica Bay. Adequate chemical data are lacking for intertidal and shallow subtidal areas near storm drains and sewage overflow points, which are the primary areas of concern in the Bay other than possible unknown spill sites. However, as a result of the ongoing monitoring conducted by HTP, JWPCP, and TWRF and recent studies by Gold *et al.* (1990, 1991, 1992), there appears to be sufficient evidence from biological data that an epidemiological study is warranted. Such a study has been designed and proposed by Dr. Robert Haile and it has been approved and recommended for implementation by the Santa Monica Bay Restoration Project Management Committee (Gold 1993 pers. comm.).

The first step in reducing the potential for human health risks associated with swimming in waters contaminated with fecal waste is to carry out a sanitary survey, which would identify and reduce or eliminate the sources of fecal contamination. However, until the criteria and methods for such studies are developed, the public should continue to be informed about the potential risks of swimming in contaminated areas.

Risk Analysis

Procedure. Health risks to swimmers from microbial contamination in Santa Monica Bay was predicted according to the method of Cabelli *et al.* (1983b) in 1988 (MBC 1988). This analysis was based on sewage-contaminated waters which, considering the results of Gold *et al.* (1990, 1991, 1992), appears to be a valid, conservative risk assessment (Gold 1993 pers. comm.). Sampling days were first segregated into two groups, wet and dry, based on the mean enterococcus levels for the 17 shoreline stations sampled by HTP. The risk of acute gastroenteritis was estimated for wet and dry days using enterococcus data. Values of enterococci-based risks were evaluated for multiple stations to describe spatial patterns of contamination and risk.

The Cabelli method for evaluating risk is based on a regression equation between enterococcus density in swimming water and the rate of swimming-associated cases of acute gastroenteritis (Cabelli 1983b). "Swimming" is defined as the exposure of upper-body orifices to the water and illness rates are predicted from measurements of enterococcus levels in bathing water. The log to the base 10 of the median enterococcus level (median number per 100 ml) is entered into the regression equation obtained from epidemiological studies that were conducted at other locations:

$$Y = 12.17 \text{ (log Median)} + 0.02$$

where:

Y = the predicted number of illnesses/1000 swimmers.

If the geometric mean of enterococcus counts from at least ten days is used to represent enterococcus levels, the predicted rate is equivalent to the illness rate that would not be exceeded on half the days during the swimming season. From a public health point of view, this is not a protective prediction. When there are sufficient data points, the 90th percentile enterococcus level can, with some mathematical reservations, be entered into the equation to obtain an approximation of the predicted illness rate that will not be exceeded on 90% of the days during the time period represented.

Cabelli calculated the risk of swimming-associated acute gastroenteritis from the illness-indicator relationship in the above equation (MBC 1988) using the 50th and 90th percentile enterococcus levels for each shoreline station during wet and dry weather (Table 11-2). The values in Table 11-2 may be viewed as the predicted swimming-associated rates of gastroenteritis that would not be exceeded on 50% and 90% of the days, respectively. During dry weather, the predicted 50th percentile rates for all stations were less than that accepted by the EPA enterococcus guidelines; this was also true for most of the stations during wet weather.

Assumptions and Uncertainties. Most of the uncertainty in microbial risk assessment is related to the sources of the indicators, particularly those that are unpredictable or not related to human fecal contamination. Enterococci or coliforms reaching the beaches of Santa Monica Bay could derive from several sources, including off-shore municipal wastewater outfalls, sewage spills, urban runoff, discharges from pleasure boats, marine and shore fauna, and the bathers themselves.

Untreated discharges from pleasure craft and fecal contamination from bathers may pose a risk of swimming-associated illness, but these discharges are small relative to the number of contributing individuals. Therefore, the risk may not be predictable using bacterial indicator guidelines.

One major uncertainty in calculating risk from stormwater runoff results from the occurrence of indicator bacteria unrelated to human fecal inputs, notably those from the feces of other endotherms. These extraneous bacteria confound the relationship between the indicator and actual pathogens. For stormwater discharges that contain nonhuman fecal wastes but little of human origin, the risk of illness may be markedly overstated by the enterococcus or coliform levels in the water. However, since the survival rate of some human enteric viruses may be greater than that of the indicator bacteria, health risks may be understated in some areas.

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Table 11-2. Enterococcus levels and predicted swimming-associated gastroenteritis rates at HTP shoreline (S) stations in Santa Monica Bay in 1987 (MBC 1988).

	Dry Weather (111 days)[a]				Wet Weather (97 days)[a,b]			
	Enterococci/ 100 mL		AGI/1,000 persons[c]		Enterococci/ 100 mL		AGI/1,000 persons[c]	
	Percentile		Percentile		Percentile		Percentile	
Station	50th	90th	50th	90th	50th	90th	50th	90th
S1	3	15	6	14	11	82	13	24
S2	2	11	4	13	7	61	11	22
S3	9	23	12	17	22	224	17	29
S4	7	16	11	15	20	95	16	24
S5	7	22	11	16	20	113	16	25
S6	9	24	12	17	22	172	17	27
S7	4	10	8	12	21	127	16	26
S8	3	9	6	12	19	200	16	28
S9	2	13	4	14	20	92	16	24
S10	2	12	4	13	22	242	17	29
S11	2	14	4	14	12	58	13	22
S12	1	6	0	10	11	75	13	23
S13	1	7	0	11	9	61	12	22
S14	1	7	0	10	9	82	12	24
S15	4	16	8	15	14	67	14	23
S16	1	11	0	13	9	85	12	24
S17	1	11	0	13	9	42	12	20

Source: CLA,DPW, unpub. data

a Defined from log-probability plot (MBC 1988) by day of the 17-station GM enterococcus levels. Cut-off of 5.5 CFU/100 mL.

b Includes spills and unexplained events leading to 17-station GMs in excess of 5.5.

c Predicted from equation (Cabelli 1980). Swimming-associated acute gastroenteritis (AGI) rate/1,000 persons:

$$y = 12.17 \log x + 0.2$$

where:

y = predicted swimming-associated rate for acute gastroenteritis
x = GM enterococcus level/100 mL.

d Assumes, with reservations, that the equation developed from GMs can be used with 50th and 90th percentile values. 90th percentile rate can be thought of as the rate which will not be exceeded on 90% of the days during bathing season.

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Finally, it must be realized that recreational water quality criteria may not apply under certain conditions such as unusually high levels of illness in the population whose wastes potentially contaminate the resource.

Recreational Water Quality Standards

As noted above, viruses survive longer in seawater and shellfish than do human enteric bacteria, which suggests that the risk of swimming-associated illness may be greater than suggested by the indicators. However, because of the problems in identifying an etiological relationship between water-borne pathogens and human illness and because of the lack of a mechanism for swimming-associated illness surveillance, there has never been a reported outbreak of a specific illnesses associated with swimming in Santa Monica Bay.

Cabelli (in MBC 1988) suggested that a predicted illness rate of 17 to 18 cases of swimming-associated gastroenteritis per 1,000 swimmers corresponds to a dry-weather recreational water quality standard of a 90 percentile limit of 25 to 30 enterococci/100 ml. A somewhat crude interpretation of this limit is that this is the rate that will not be exceeded on more than 10 percent of the days during the swimming season. The decision as to whether this risk is acceptable or not is properly one of policy.

With regard to Santa Monica Bay, the predicted rate probably overstates the actual one to the extent that the sources of enterococci are often non-human wastes. Even if a worst case situation is assumed (i.e., all the enterococci derive from human fecal sources), the predicted rates are appreciably less than those accepted by the USEPA guideline and the corresponding enterococcus limits are attainable. Moreover, the implementation of these limits as interim guidelines or standards should provide an impetus for the conduct of the monitoring, research, and epidemiological programs needed to better assess and manage risks.

A better operating procedure for dealing with events leading to unusually high enterococcus levels that are linked with high total or fecal coliform levels at multiple stations is needed. The response to sewage spills in the absence of stormwater runoff is a relatively simple problem; the potentially affected beaches are temporarily closed until the bacterial standard is achieved. At present there is no epidemiological database regarding the risk of swimming-associated illness from biological pathogens; this information is needed. In addition, an indicator system that is more reflective of human fecal wastes or sewage than the present system is needed. Until these are available, the current practice of issuing health advisories concerning swimming at beaches near storm drains after rainfall should continue. Based on recent studies by Gold *et al.* (1990, 1991, 1992) and ongoing monitoring by HTP (CLA,DPW 1987, 1988, 1990, 1991, 1992), bathers should stay at least 200 yards away from storm drains during dry weather and refrain from swimming during and immediately (two to three days) after rain storms.

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CHAPTER 12
HEALTH HAZARDS OF SEAFOOD CONSUMPTION

Marine environments adjacent to heavily populated urban areas may be exposed to a variety of chemical contaminants from anthropogenic sources, including pesticides such as dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), chlordane, dieldrin, as well as heavy metals such as arsenic, mercury, silver, selenium, and lead. Marine organisms living in impacted areas may also be exposed to the same contaminants through direct water contact soon after discharge from a point source, or through contact with sediments in which contaminants have accumulated over time. Human health may in turn be at risk if animals exposed to contaminants are consumed. The contaminants that pose the greatest risk to human health from consumption of seafood are those that "biomagnify" or increase "up the food chain." The degree of accumulation in aquatic organisms depends on the type of food chain, on the availability and persistence of the contaminant in the environment, and especially on the physical and chemical properties of the contaminant. The most extensively studied and tractable contaminants in Santa Monica Bay are heavy metals, PCBs, and DDT and its by-products.

CONTAMINANTS OF CONCERN AND DISEASES

Many trace metals are important in animal nutrition, where, as micronutrients, they play an essential role in tissue metabolism and growth. The essential trace metals include cobalt, copper, chromium, iron, manganese, nickel, molybdenum, selenium, tin, and zinc (Rand and Petrocelli 1985). However, the optimum concentration range for trace metals is usually very narrow and severe imbalances in their availability can contribute to poor health, retarded growth, and death. Some non-essential trace metals, such as lead, cadmium, and mercury, also can be toxic at concentrations commonly found in marine sediments and natural waters.

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Uptake of metals in invertebrates and fishes can occur through contact with contaminated sediments and waters or through ingestion of contaminated food. Heavy concentrations of trace metals in the environment can pose a health risk to humans that eat seafood from the contaminated area. The mechanisms of accumulation and storage of trace metals in aquatic animals are diverse, varying with chemical form of the metal, mode of uptake, and animal species (Luoma 1983). However, many aquatic animals are able to excrete a higher than normal proportion of their metal intake under contaminated conditions and thus maintain trace metal concentrations in the body at a normal level (Phillips 1980). A major exception to this pattern is mercury, which is readily bioaccumulated when it is in the organic form of methylmercury (Phillips 1980). Thus, the idea of bioaccumulation, where the highest trophic levels contain the highest toxin concentrations, does not hold for most heavy metals (Rand and Petrocelli 1985). For this reason, sediments generally contain higher concentrations of heavy metals than are present in aquatic organisms.

PCBs are a class of synthetic chlorinated organic chemicals that were used in many industrial products (e.g., hydraulic fluids, plasticizers, adhesives, and paper coatings) from 1929 to 1971. Beginning in 1970, their use was voluntarily restricted by the Monsanto Chemical Company to closed electrical systems in the mid-1970s (Cordle *et al.* 1978). Because of their toxic properties, a partial ban was imposed on PCB use and manufacture in 1976 [Section 6(e) of the Toxic Substance Control Act (TSCA)]. In 1979, TSCA regulations were finalized to prohibit their use in heat transfer systems used for the manufacture of food, drugs, and cosmetics. After 1 July 1984, PCBs were no longer allowed for use in electrical equipment. After distribution in the Santa

Monica Bay environment from stormwater, and sewage inputs, PCBs may be absorbed and accumulated by seafood organisms. Consumption of fish and shellfish (including freshwater species) represents the major pathway of human exposure to PCBs today.

Although PCBs have low toxicity in short-term exposures, they are of public health concern because of their persistence and their long-term toxic effects in humans and other animals (Calabrese and Sorenson 1977; Kurzel and Cetrulo 1981; Rogan *et al.* 1986). The low short-term toxicity of PCBs means that a massive dose would be required to cause death or other severe health effects from short-term exposures. Such extreme doses are unlikely to occur under environmental conditions. However, a series of smaller doses over a long period of time (e.g., decades) may cause toxic effects on skin and liver tissue, including liver cancer. A variety of reproductive effects of PCBs have been demonstrated in humans and other animals (e.g., mink, chickens, monkeys, rats). For example, in Michigan and North Carolina infants born to women that were heavy consumers of PCB-contaminated fish exhibited a reduced size at birth, poor muscle tone, and behavioral deficiencies (Jacobson *et al.* 1985, Rogan *et al.* 1986). Because PCBs are lipophilic, long-term exposure to PCBs may result in high concentrations in breast milk (Schwartz *et al.* 1983; Jacobson *et al.* 1984; Humphrey 1987, 1988). Recently, the Los Angeles County Health Department, the California Department of Health Services, and the Office of Environmental Health Assessment conducted a comprehensive study of concentrations of PCBs, DDT, dioxin, and dibenzofurans in breast milk of women in Los Angeles County. The report from this study is currently being prepared.

In the 1960s and early 1970s, the Montrose Chemical Company dumped tons of the insecticide DDT into the Palos Verdes Shelf via the JWPCP outfalls (Chartrand 1988). Although DDT has been banned in the U.S. since 1972, high levels are still found in the sediments near the JWPCP outfall (NOAA 1991a), which themselves now act as source of DDT contamination for demersal organisms. Like PCBs, DDT and related compounds are readily accumulated in animal tissues and tend to persist once uptake has occurred. Although there is some concern that DDT and related compounds may cause premature birth in humans (Kurzel and Cetrulo 1981), the evidence for potential toxic effects in humans concerns primarily liver and pancreatic cancer (Garabrant *et al.* 1992). USEPA (1985) concluded that DDT, DDD, DDE, and dicofol, a DDT-related pesticide, are probable carcinogens (cancer-causing chemicals) based on evidence from experiments with rats, mice, and other animals. The extent to which these substances are carcinogenic to humans remains unknown because appropriate epidemiologic data for calculating carcinogenic potency are lacking. As with PCBs, DDT and related chemicals may occur in high concentrations in breast milk of females that consume large amounts of DDT-contaminated fish, but appropriate studies to show health effects in infants are not yet available. Nonetheless, Rogan *et al.* (1986) demonstrated a positive correlation between DDE concentration in breast milk and slow reflexes in infants.

SOURCES OF CONTAMINANTS

The contaminants that may be taken up by animals in Santa Monica Bay originate from many potential sources. Sewage treatment facilities discharge an enormous volume of wastewater to the Bay. Although all sewage that enters the Bay, aside from occasional leaks and overflows, has undergone primary, secondary, or tertiary treatment, sewage outfalls historically have been considered the principal sources of contaminants to the Bay. However, with improvements in effluent quality during the past two decades, sediments near the outfalls that were previously exposed to contaminants may now be the principal source of many contaminants. Other sources include coastal generating stations, oil refineries, and storm drains, which deliver a variety of

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contaminants, particularly during periods of heavy rainfall or sewage overflows. The specific constituents originating from these sources are discussed in Chapter 5.

DISTRIBUTION OF CONTAMINANTS IN MARINE ORGANISMS

The amount of a contaminant that is bioaccumulated by an organism depends on several factors, including the chemical characteristics of the contaminant, its concentration in the marine environment, and the characteristics of the organism. For example, the chemicals that have the highest potential for bioaccumulation are least soluble in water. Such compounds are highly soluble in fats and oils and tend to be retained in tissues once they enter organisms. These same chemicals generally have a high affinity for organic particles and tend to concentrate in bottom sediments. Chemicals with a high potential for bioaccumulation include pesticides such as DDT, complex chlorinated hydrocarbons such as PCBs, and organo-metallic compounds such as methylmercury. Highly soluble or volatile compounds such as chloroform have a very low potential for bioaccumulation, even when highly concentrated.

Organisms with a high bioaccumulation potential generally have characteristics such as 1) high fat content, 2) live on or near the bottom sediments, 3) filter-feed on organic particles, and 4) are high on a food chain (i.e., top carnivores). Examples of such organisms include Dover sole and other flatfish species (demersal fishes), mussels and clams (filter feeders), and seals (high fat and top carnivores).

Invertebrates

Except for mussels, contaminant levels in invertebrates from Santa Monica Bay have not been well studied. Data on mussel contamination levels have been generated primarily by the California State Mussel Watch (SMW) Program, a periodic assessment that has been conducted since 1977 by the State Water Resources Control Board (SWRCB). The program uses both blue (= bay) and California mussels to assess spatial and temporal trends in the contamination of native and transplanted organisms. Mussels are good indicators of environmental contamination because they are filter feeders, and therefore ingest small organic particles and associated contaminants. Mussels are also attached to a substrate and as such provide a better indication of localized conditions than motile organisms, such as fishes.

Other invertebrates that have been assessed for tissue contamination include yellow rock crab, ridgeback rock shrimp (= ridgeback prawn), black abalone, California spiny lobster, and giant rock scallop; species names are listed in Appendix C.

Spatial Patterns

Metals. In 1979, the SMW Program conducted an intensive survey of resident intertidal mussels in Santa Monica Bay. The distributions of metals in mussels showed distinct patterns that related to metal sources and to fate processes in the Bay. For example, the mussels at Royal Palms, on the Palos Verdes Peninsula, had the highest tissue levels of silver in the study area (about 6 times those at Point Dume); intermediate and relatively constant levels of tissue silver were measured at locations in central and southern Santa Monica Bay (Figure 12-1). The high silver levels in Royal Palms mussels probably resulted from contamination from the JWPCP outfalls.

In contrast, lead contamination of mussels had a very different pattern in the Bay, with the highest concentrations being measured along the central inshore Bay from Playa del Rey to

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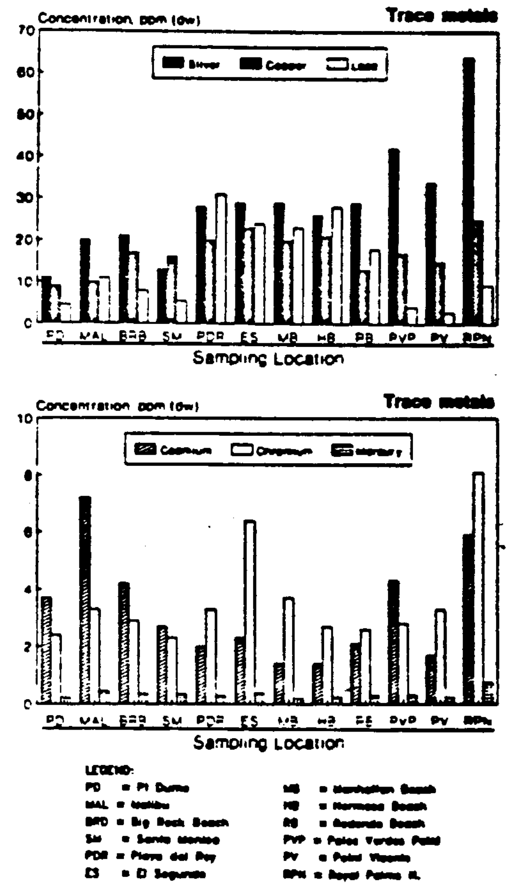

Figure 12-1. Regional variations in concentrations of trace metals in resident sea mussels (*Mytilus* spp.) from Santa Monica Bay, 1979 (CSWRCB 1982).

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Redondo Beach. This pattern suggests that the major lead sources were probably urban surface runoff and marinas. One of the highest lead concentrations measured in resident mussels (49 ppm at Marina del Rey) was about 50 times the lead concentrations typically found at uncontaminated coastal sites.

Brown *et al.* (1986) and Thompson *et al.* (1987a) measured hepatopancreatic concentrations in ridgeback rock shrimp and found that copper, zinc, and cadmium had very different spatial patterns (Figure 12-2). Concentrations of copper and zinc in shrimp from Santa Monica Bay were less than, or similar to, concentrations of these metals in shrimp from adjacent coastal areas. In contrast, cadmium was highly elevated in shrimp from northern and central Bay sites, but not in shrimp from the Palos Verdes Shelf, possibly reflecting the high degree of cadmium complexing with organic matter near that outfall (MBC 1988).

Analyses of edible tissue of six invertebrate species collected near the JWPCP outfalls from 1974 to 1976 indicated that most metals, including those of greatest concern relative to human health (lead, mercury, and cadmium), were not substantially elevated above reference areas (Jan *et al.* 1977). For most of the species and metals tested, the concentrations in outfall organisms ranged from 1 to 3 times the control levels. The only metal showing substantial bioaccumulation in outfall organisms was chromium, which was elevated about 10 times reference levels in edible tissues of scallops and abalone. These data suggest relatively minor bioaccumulation of metals in these species, since sediment metal concentrations near the outfalls were elevated from 16 to 36 times control areas.

Organic Compounds. Resident mussels from a few sites in Santa Monica Bay have been analyzed for tissue concentrations of organic chemicals. From 1932 to 1983, mussels from Royal Palms on the Palos Verdes Peninsula contained about 1,400 ppb total DDT (Ladd *et al.* 1984). This value was over 6 times the total DDT concentration in mussels from a reference area off Oceanside and over 140 times the levels at northern California reference sites such as Trinidad Head. High DDT levels have also been reported for giant rock scallop, black abalone, and California spiny lobster collected from the Palos Verdes Peninsula (Young *et al.* 1978). Most of the total DDT present in animal tissues is in the form of DDE, with lesser amounts of DDD and very small amounts of DDT, suggesting that there has not been a recent input of the parent compound. Most pesticides other than DDT (e.g., chlordane, endrin, aldrin, endosulfan, heptachlor, and toxaphene) do not have elevated concentrations in animals from Santa Monica Bay (SCCWRP 1992, CSWRCB unpubl. data).

Data for ridgeback rock shrimp collected in 1982 (Brown *et al.* 1986) and 1985 (Thompson *et al.* 1987a) indicate widespread DDT contamination in this species throughout the Southern California Bight (Figure 12-3). In particular, shrimp from Santa Monica Bay displayed highly elevated tissue levels when compared with adjacent coastal areas. The highest mean DDT concentration (49,000 ppb) was measured in shrimp from near the JWPCP outfall at White Point (Figure 12-3), which were over 370 times the mean DDT concentration in shrimp from Imperial Beach. Shrimp from Malibu and HTP outfall areas also had high DDT concentrations in hepatopancreas tissue, with mean values exceeding 10,000 ppb (Figure 12-3). These data suggest that, in addition to the large source of DDT near the JWPCP outfall, the HTP outfall or perhaps other sources such as runoff from the Malibu watershed, may have contributed to the DDT contamination in northern Santa Monica Bay.

The historically high levels of contaminants in sediments and animal tissue at the Palos Verdes Peninsula prompted the Santa Monica Bay Restoration Project (SMBRP) to conduct a study on the distribution of PCBs and DDT in yellow rock crab to assess the extent of

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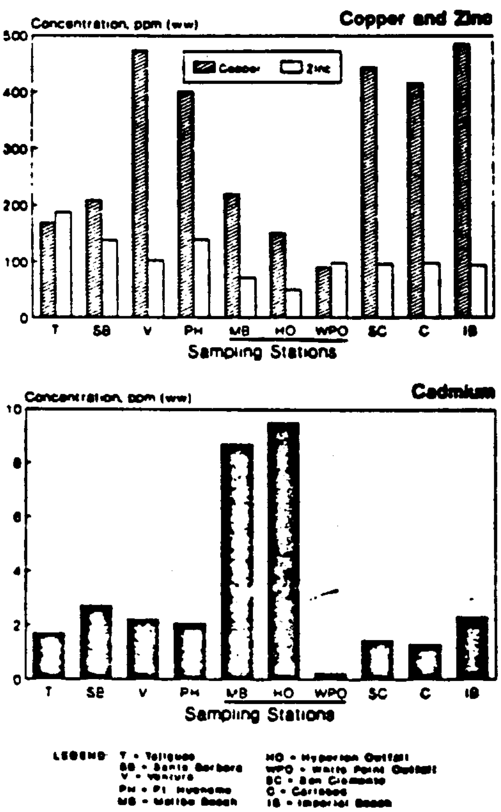

Figure 12-2. Regional variations in concentrations of trace metals in hepatopancreas of ridgeback rock shrimp (*Sicyonia ingentis*) from the Southern California Bight, 1982-1985 (Brown *et al.* 9186, Thompson, unpubl. data).

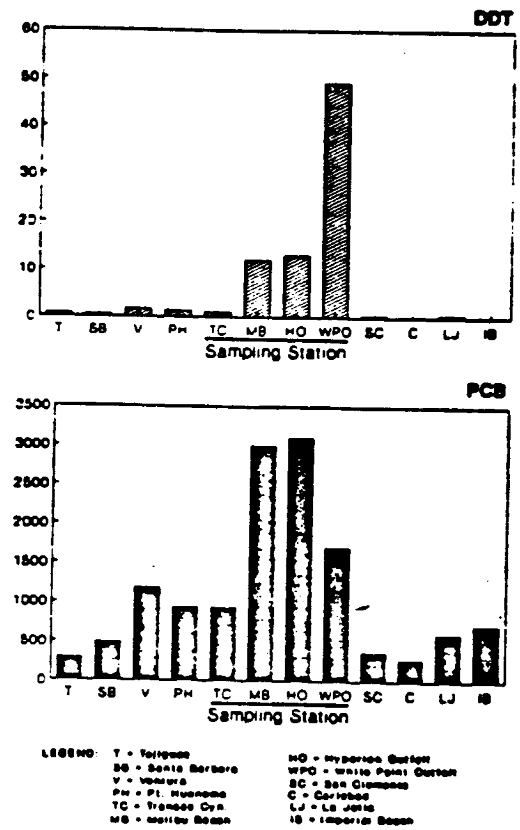

Figure 12-3. Regional variations in concentrations of DDT and PCB in hepatopancreas of ridgeback rock shrimp (*Sicyonia ingentis*) from the Southern California Bight, 1983-1985 (Brown *et al.* 9186, Thompson, unpubl. data).

contamination in the animals near the JWPCP outfall (SCCWRP *et al.* 1992). The mean DDT concentration in the muscle of yellow rock crab taken from White Point in 1990 (31 ppb) was an order of magnitude greater than from crabs collected at Dana Point (Figure 12-4). Over 90% of the total DDT at both sites was in the form of DDE, suggesting that there has been no recent input of the parent compound, but that sediments near the outfall are still contaminated with DDT by-products. PCB levels (Figure 12-5) were about three times higher in yellow rock crab taken from White Point (9.1 ppb) than those from Dana Point (2.7 ppb) (SCCWRP *et al.* 1992).

In mussels, the spatial distribution of PCBs is similar to that seen for DDT and its constituents. In 1990, PCB concentrations were 150 ppb in mussels from Royal Palms, while tissue levels at Oceanside were 54 ppb (CSWRCB unpubl. data). Levels at Santa Monica (65 ppb) and Malibu (70 ppb) were similar to those at Oceanside and other sites in southern California (CSWRCB unpubl. data). In contrast, ridgeback rock shrimp hepatopancreatic PCB contamination was highest in northern and central Santa Monica Bay near Malibu Beach and the HTP outfall, where concentrations exceeded 3,000 ppb in 1983-1985 (Figure 12-3; Brown *et al.* 1986, Thompson unpubl. data). The PCB levels in Santa Monica Bay shrimp were about 10 times the levels at Tajiguas, the most northerly site sampled. Brown *et al.* (1986) found similar patterns of hepatopancreatic concentrations of PCBs and DDT in armed box crabs from Santa Monica Bay. The most likely source of PCB contamination in northern Santa Monica Bay is effluent from the HTP outfall.

Temporal Trends

Metals. Data from the SMW Program indicate temporal trends in contaminant levels because the same sites have been sampled through time with consistent methods. The only SMW site in Santa Monica Bay with good temporal data is at Royal Palms, on the Palos Verdes Peninsula. Royal Palms mussel tissue show a substantial decline in lead contamination since 1977 and evidence of lower chromium levels (Figure 12-6). However, copper, silver and cadmium display no apparent declines during the period of 1977 to 1983. With the exception of copper, all of the metal levels in Royal Palms mussels remain considerably higher than those measured at Oceanside, a relatively uncontaminated downcoast site. Data collected in 1990 show that lead concentrations at Royal Palms have continued to decrcase, but concentrations of other metals in 1990 were similar to those in 1982-1983 (CSWRCB unpubl. data).

Recently, SCCWRP (1992) analyzed HTP monitoring data to determine the effects of sludge that had been discharged through HTP's 7-mi outfall since 1957. Sludge discharge was terminated in November, 1987, and data collected since that time was used to assess the impacts of sludge discharge on contaminant levels in marine organisms in the impacted area and the recovery of organisms following sludge discharge cessation. This summary provides a good database for analyzing recent temporal trends in contamination levels near the outfall.

SCCWRP (1992) analyzed tissues of ridgeback rock shrimp and Dover sole from the 100-m isobath at a "contaminated" site surrounding the discharge, a reference site approximately 10 km west of the discharge, and a transition zone between the two areas. The concentrations of trace metals in hepatopancreas tissue in ridgeback rock shrimp from contaminated sites changed very little from 1986 through 1988 (Figure 12-7; SCCWRP 1992). Copper and silver concentrations decreased slightly after sludge termination, but zinc and cadmium showed no appreciable changes. Although sludge abatement had little effect on metals contamination, concentrations of all metals in shrimp tissue from the outfall area were similar to those from animals taken elsewhere on the southern California mainland shelf (SCWWRP 1992).

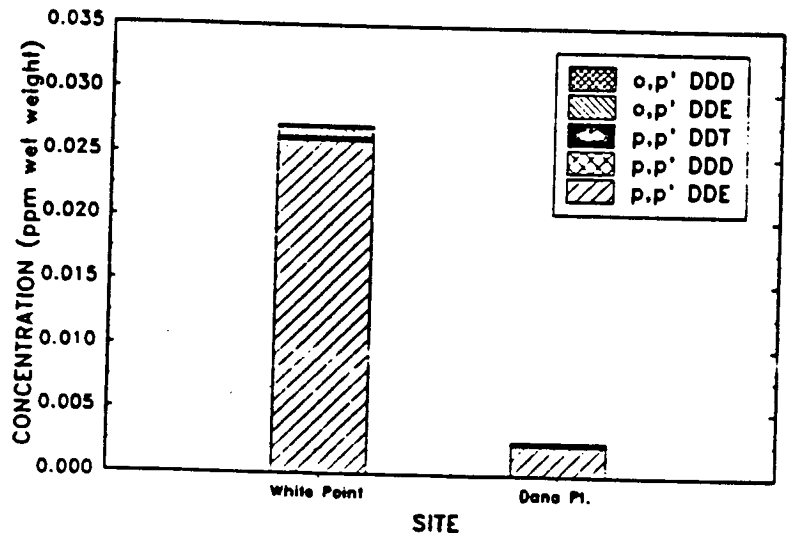

Figure 12-4. Mean concentrations of total DDT in composites of muscle tissue of yellow rock crab (*Cancer anthonyii*) collected from White Point and Dana Point, 1990 (SCCWRP *et al.* 1992)

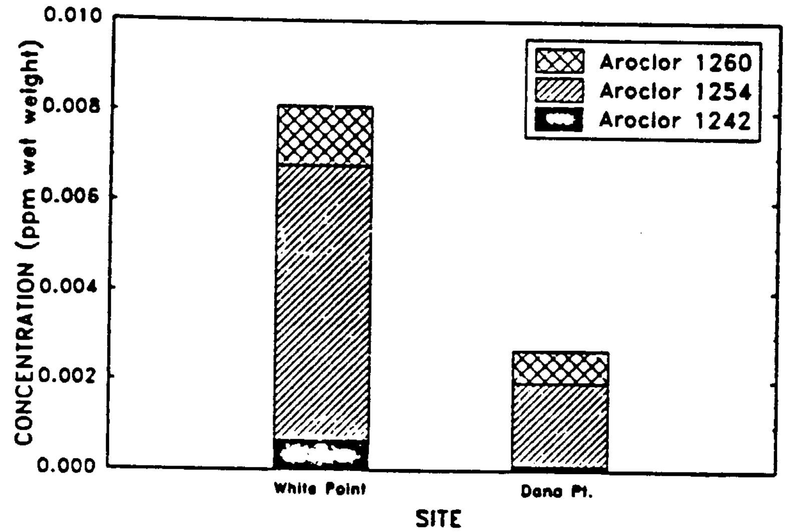

Figure 12-5. Mean concentrations of total PCB (Aroclors 1242 + 1245 + 1262) in composites of muscle tissue of yellow rock crab (*Cancer anthonyii*) collected from White Point and Dana Point, 1990 (SCCWRP *et al.* 1992)

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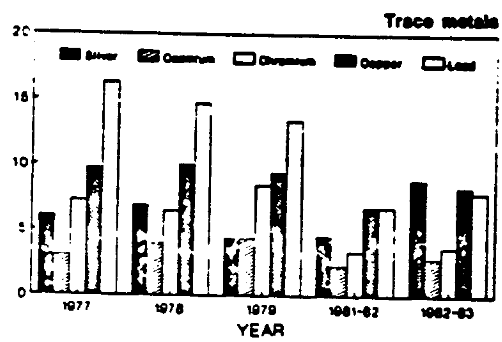

Figure 12-6. Temporal variation in concentrations of trace metals in resident mussels at Royal Palms State Beach on the Palos Verdes Peninsula, 1977-1983 (Stephenson *et al.* 1979, Ladd *et al.* 1984).

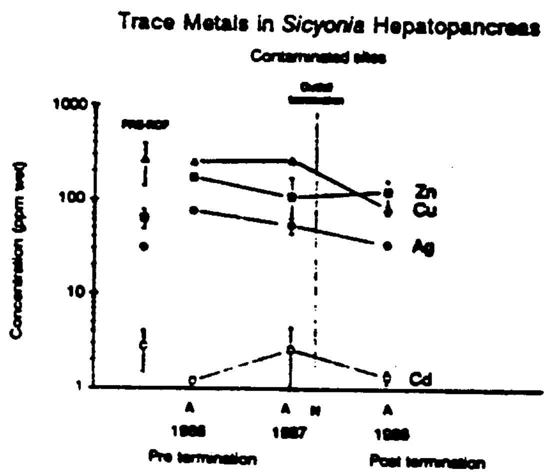

Figure 12-7. Concentrations of trace metals in hepatopancreas of ridgeback rock shrimp (*Sicyonia ingentis*) from contaminated sites near the HTP 7-mile outfall, 1986-1988 (SCCWRP 1992)

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Organic Compounds. Levels of DDT and PCBs in mussels collected from the Palos Verdes Peninsula have declined substantially since 1971 (Figure 12-8). In 1982-83, concentrations of PCBs and DDT were only about 12% and 7%, respectively, of the concentrations measured in 1971. Concentrations of both contaminants from mussels collected in 1990 (CSWRCB unpubl. data) were similar to those in 1982-1983 (Ladd *et al.* 1984). Thus, PCB and DDE levels in Palos Verdes mussels have remained fairly constant since about 1977.

The decrease in DDT and PCB levels at Palos Verdes is also evident in yellow rock crab body burden levels. Heesen and McDermott (1974) showed widespread DDT contamination of yellow crab muscle in 1971 and 1972. Total DDT concentrations were highest in crabs from the Palos Verdes Shelf, ranging from 500 to 2,100 ppb in edible tissue (Heesen and McDermott 1974). In 1990, mean DDT levels in yellow rock crab taken from White Point averaged 31 ppb (SCCWRP 1992). Thus, it appears that DDT levels in crabs from the Palos Verdes Peninsula have greatly decreased in the last 15 or 20 years.

PCB contamination of crabs was much more uniform throughout the Bay in the early 1970s. The overall range was 400 to 1,900 ppb PCBs in 1972, with maximum concentrations in crabs from central Santa Monica Bay near the HTP 5-mi outfall (Heesen and McDermott 1974). By 1990, PCB levels had decreased greatly, with a mean value of 9.1 ppb in yellow rock crab taken at White Point (SCCWRP 1992).

In 1986-1987 SCCWRP (1992) found that concentrations of PCBs in shrimp hepatopancreas from the contaminated areas near HTP's 7-mi outfall were high compared to levels in animals from the reference site (Figure 12-9). PCB levels decreased in shrimp from the impacted area in 1987, and by 1990 levels were similar to those of the reference site (Figure 12-9). This trend correlates well with levels of PCBs in the sediments in the study area (SCCWRP 1990). Although the data are somewhat variable, it appears that sludge abatement in 1987 eliminated, or at least decreased, a potentially large source of PCBs to Santa Monica Bay, which subsequently reduced PCB uptake in shrimp near the 7-mi outfall.

In contrast to PCB levels, the concentration of DDT in ridgeback rock shrimp hepatopancreas did not decrease from 1986 to 1990 (Figure 12-10) (SCCWRP 1992). However, with the exception of 1988, DDT levels from 1986 through 1990 remained below 1,000 ppb in animals taken near the outfall terminus. These values are much lower than those collected in 1983-1985, when hepatopancreas levels were greater than 10,000 ppb (Brown *et al.* 1986, Thompson *et al.* 1987a). The high DDT values in 1988 are difficult to explain, but higher values at the reference site suggest that previously contaminated sediments may be periodically exposed through tectonic activity or storms, or that sources other than the 7-mi outfall are present, such as urban runoff through local storm drains.

Fishes

Studies of fish contamination in Santa Monica Bay have emphasized contaminants in edible muscle and liver tissue. The edible muscle tissue is important because it represents the contaminants that could be passed on to humans. However, liver body-burden levels are indicative of the total range of contaminants entering the fish because of the role the liver plays in regulation and storage of toxic chemicals (Fowler 1982). Consideration of contaminants in both edible muscle and liver tissue can therefore provide an assessment of the potential human health impacts as well as the health of fishes.

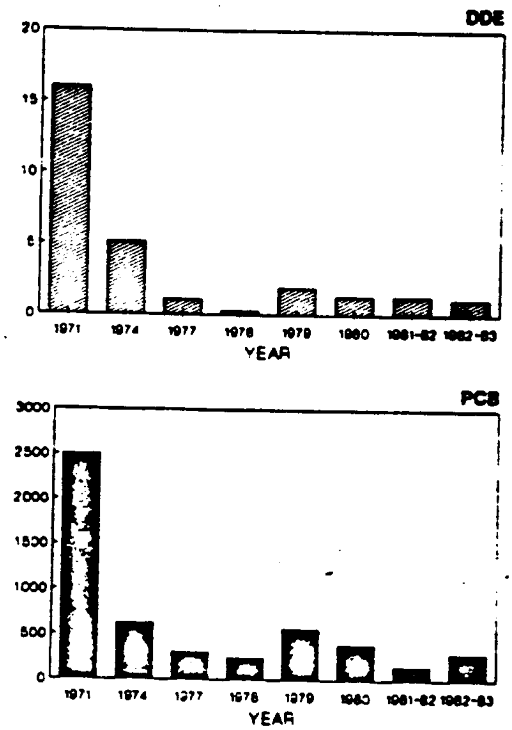

Figure 12-8. Temporal variation in concentrations of DDE and PCB in resident mussels at Royal Palms State Beach on the Palos Verdes Peninsula, 1971-1983 (Stephenson *et al.* 1980, Ladd *et al.* 1984).

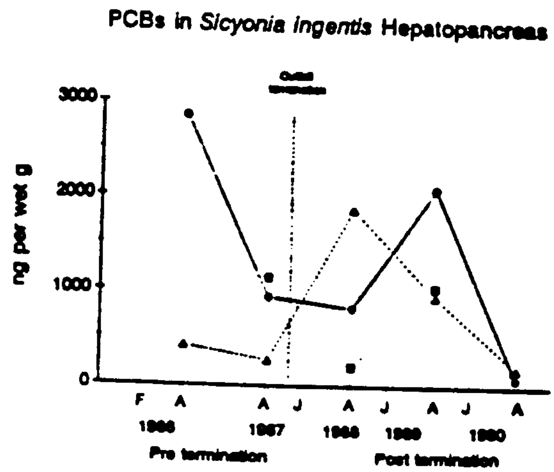

Figure 12-9. Concentrations of PCB in hepatopancreas of ridgeback rock shrimp (*Sicyonia ingentis*) from contaminated (circles), transition (squares), and reference (triangles) sites near the HTP 7-mile outfall, 1986-1988 (SCCWRP 1992)

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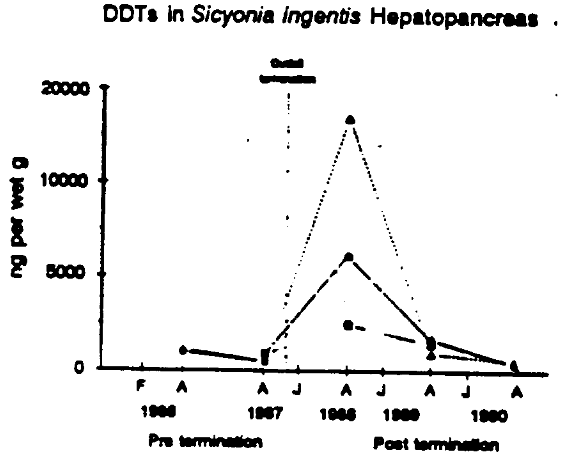

Figure 12-10. Concentrations of DDT in hepatopancreas of ridgeback rock shrimp (*Sicyonia ingentis*) from contaminated (circles), transition (squares), and reference (triangles) sites near the HTP 7-mile outfall, 1986-1988 (SCCWRP 1992)

Demersal fishes are preferred as indicators of contamination because they live in close contact with bottom sediments, often feed on benthic organisms, and are not generally migratory. Contaminants in fishes with these characteristics can be related to localized sources with confidence.

Spatial Patterns

Metals. In general, metals concentrations in edible muscle and liver tissue in fishes from Santa Monica Bay have not been elevated substantially above the levels observed in fishes from reference areas such as the Santa Barbara Channel, Santa Catalina Island, Point Dume, and Dana Point (DeGoeij *et al.* 1974, McDermott *et al.* 1976, Sherwood *et al.* 1978, Young *et al.* 1978, Young *et al.* 1980, Jenkins *et al.* 1982, Brown *et al.* 1986). Brown *et al.* (1986) and Thompson (unpubl. data) found that liver concentrations of copper, cadmium, and zinc were frequently lower in fish near the HTP and JWPCP outfalls than in fish from a number of relatively uncontaminated reference areas along the California coast (Figure 12-11). The low levels near the outfalls may result from reduced availability of the metals as a result of complexing with organic sewage material or from the inhibitory effects of organic contaminants on the retention of metals.

Organic Compounds. Most studies of organic compounds in fishes from Santa Monica Bay have dealt with PCBs and DDT and its by-products in muscle and liver tissue, although a few have considered other organic contaminants, primarily EPA priority pollutants (Young and Heesen 1977; Gossett *et al.* 1982, Gossett *et al.* 1983a, b; Malins *et al.* 1987). An early (1971 to 1972) study of DDT in Santa Monica Bay in Dover sole (Young *et al.* 1976a) found that concentrations of DDT were highest near the JWPCP (White's Point) outfalls and rapidly declined both upcoast and downcoast from that location (Figure 12-12). Values in Santa Monica Bay were 2 to 36 times higher than the value observed at Point Dume. A similar pattern was also seen for DDT levels in livers of several demersal species in 1982 and 1985 (Brown *et al.* 1986, Thompson *et al.* 1987a). These studies show the DDT discharged in the 1960s and 1970s into the Palos Verdes sediments continues to bioaccumulate in the tissues of fishes that inhabit the area.

The distribution of PCBs in Santa Monica Bay fishes is also usually highest at Palos Verdes, but fishes from other areas in the Bay often contain elevated levels. In 1982 and 1985, Brown *et al.* (1986) and Thompson *et al.* (1987a) found that liver concentrations of PCBs were highest near the JWPCP and HTP outfalls in four demersal fishes: Pacific sanddab, California scorpionfish, yellowchin sculpin, and longspine combfish. Although values generally declined both upcoast and downcoast from these two locations, unusually high concentrations in Pacific sanddab were found at Point Dume and Imperial Beach. Concentrations in Pacific sanddab from Santa Monica Bay ranged from 0.4 to 1.4 times the value at Point Dume. Concentrations in California scorpionfish from Santa Monica Bay ranged from 3 to 4 times the value at Dana Point. The more uniform distribution pattern of PCBs in the Bay reflects the numerous sources of this contaminant.

In 1991, the Office of Environmental Health Hazard Assessment (OEHHA) and the Department of Health Services (DHS) conducted a comprehensive study of chemical contaminants in fishes collected in southern California (Pollock *et al.* 1991). This report provides an excellent database for examining the distribution of contaminants in local fishes. Several fish species from twelve sites in Santa Monica Bay were included in this study. DDT and PCB levels in fish caught at stations in Santa Monica Bay and at Dana Point (reference) were examined for Pacific bonito, chub mackerel, California halibut, kelp bass, California scorpionfish, several species of surfperches, queenfish, and white croaker (Table 12-1).

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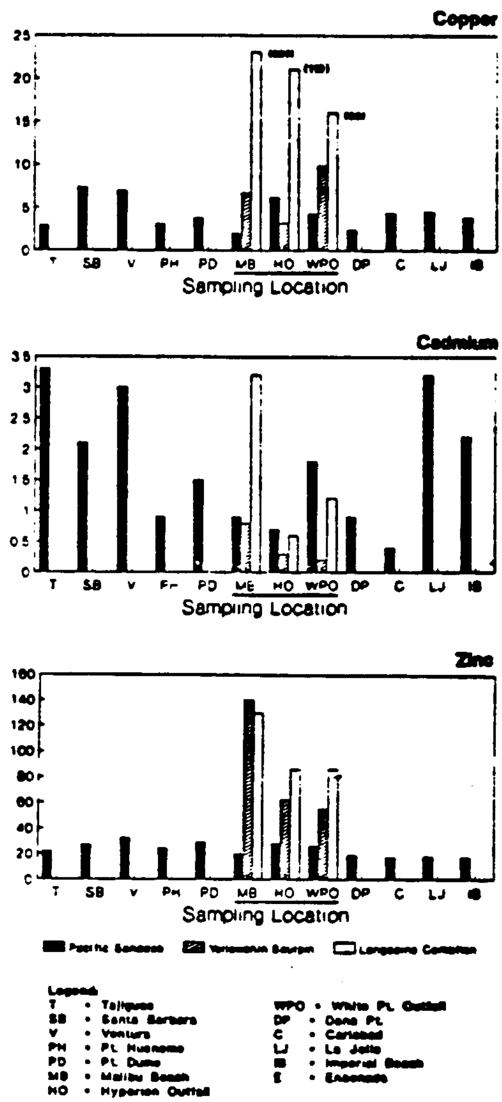

Figure 12-11. Regional variation in concentrations of selected metals in the livers of Pacific sanddab (*Citharichthys sordidus*), yellowchin sculpin (*Icelinus quadriseriatus*), and longspine combfish (*Zaniolepis latipinnis*) from the Southern California Bight, 1982-1985 (Brown *et al.* 1986, Thompson unpubl. data).

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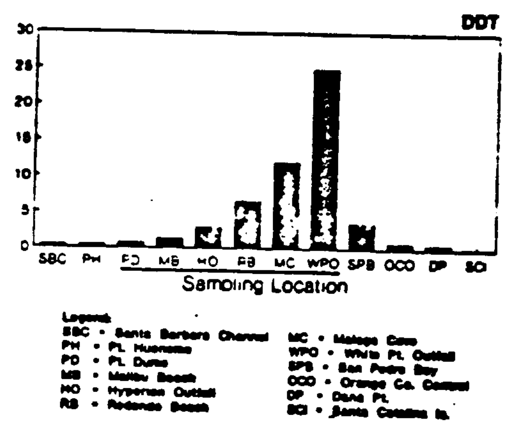

Figure 12-12. Regional variation in concentrations of total DDT in muscle tissue of Dover sole (*Microstomus pacificus*) from the Southern California Bight, 1970-1971 (Young *et al.* 1976b).

Table 12-1. Geometric mean concentrations of total DDT and PCB (ppb wet weight) in edible tissue of several fish species in 1987 at sites throughout southern California (compiled from Pollock *et al.* 1991)

Species	Site: PD	MP	M	SM	VB	MD	RP	RB	PV	Pt.V	WP	DP
DDT												
Pacific Bonito	25	48	30	21	24	11	21	43	18	32	31	5
Pacific Mackerel	7	10	19	7	12	18	12	9	14	26	19	5
Kelp Bass	14	ND	16	ND	24	16	ND	ND	44	32	126	23
California scorpionfish	14	ND	ND	ND	9	8	11	12	33	41	154	ND
California Halibut	4	16	7	7	ND	7	ND	8	ND	ND	ND	10
Surfperches	14	9	ND	ND	ND	40	35	42	70	45	29	7
Queenfish	114	191	164	139	93	37	90	43	95	70	141	62
White Croaker	201	27	506	74	44	54	ND	ND	253	2641	2099	6
PCBs												
Pacific Bonito	11	15	19	11	9	5	5	17	8	13	14	2
Pacific Mackerel	3	10	2	3	3	9	3	0	6	13	9	4
Kelp Bass	9	ND	5	ND	11	2	ND	ND	20	9	14	ND
California scorpionfish	7	ND	ND	ND	3	1	8	2	10	2	41	ND
California Halibut	2	0	2	0	ND	0	ND	2	ND	ND	ND	5
Surfperches	9	3	ND	ND	ND	10	20	21	16	17	29	0
Queenfish	25	294	38	10	34	16	11	15	14	19	24	17
White Croaker	236	23	757	64	53	45	ND	ND	61	498	252	1

ND = No Data

Legend:

PD = Point Dume
MP = Malibu Pier
M = Malibu
SM = Santa Monica Pier
VB = Venice Beach
MD = Marina Del Rey
RP = Redondo Pier
RB = Redondo Beach
PV = PV Northwest
PT.V = Pt. Vicente
WP = White Point
DP = Dana Point

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The distribution and concentrations of contaminants in the fishes examined depends on the mobility, feeding habits, and metabolism of individual species (Table 12-1). For instance, Pacific bonito and chub mackerel are biologically similar in that they are pelagic fishes that migrate over a large area of the ocean (Eschmeyer *et al.* 1983). DDT and PCB levels are low in Pacific bonito and chub mackerel from all sites and it does not appear that contaminant concentrations in these fishes are site specific (Pollock *et al.* 1991). Kelp bass had high DDT levels at White Point and slightly high levels at Palos Verdes-Northwest, but levels were low in kelp bass caught throughout the rest of Santa Monica Bay. California halibut is a demersal ambusher (Allen 1982) that might be expected to have high contaminant levels due to its close contact with sediments and its trophic position. However, DDT levels were very low in California halibut at all sites where it was collected, possibly reflecting the consistently low lipid concentrations found in this species (Pollock *et al.* 1991) or because adults primarily feed on pelagic, non-resident northern anchovy (Allen 1982). California scorpionfish and the surfperches had elevated DDT levels at most stations on the Palos Verdes Peninsula, but levels generally were low throughout Santa Monica Bay.

The most elevated DDT levels were found in queenfish and white croaker (Table 12-1) (Pollock *et al.* 1991). Site-specific DDT levels for both species were almost always the highest levels found for all fishes analyzed. Similar to other species with elevated contaminant levels, the highest DDT concentrations in white croaker and queenfish were found at stations on the Palos Verdes Peninsula. White croaker from Point Vicente and White Point had the highest DDT levels of any fishes in the study area, with mean concentrations of 2,641 and 2,099 ppb, respectively. In addition to high DDT levels in fishes from Palos Verdes, contaminated white croaker and queenfish were also found in northern Santa Monica Bay at Point Dume, Malibu Pier, Malibu, and Santa Monica Pier.

PCB levels in fishes analyzed by Pollock *et al.* (1991) were low for most species (Table 12-1). However, PCB levels in queenfish and white croaker were markedly elevated compared to the other fishes analyzed. Levels were particularly high in queenfish from Malibu Pier and in white croaker from Point Dume and Malibu and from Point Vicente and White Point. The HTP and JWPCP outfalls are the most likely sources of PCBs in northern Santa Monica Bay and Palos Verdes, respectively, but the more uniform distribution of PCBs (compared to DDT) in fishes throughout the Bay suggests that there are probably several sources of this contaminant.

It should be mentioned that the levels of chlordane were very low in most fishes throughout the study area (Pollock *et al.* 1991). Only white croaker, surfperches, California corbina, and queenfish had total chlordane levels above the method detection limit.

In 1992, the SMBRP conducted a study on the contamination of seafood in Santa Monica Bay (SCCWRP *et al.* 1992). Although not a risk assessment, the study was designed to provide information for management decisions regarding subsistence, recreational, and commercial fisheries in the area. White croaker was most extensively analyzed because of the historically high levels of chlorinated hydrocarbons found in this species (Table 12-1) and because it is one of the most commonly caught seafood species in Santa Monica Bay (Wine 1979). White croaker were collected from 11 sites along the southern California coast in September 1990 and tissue composites were analyzed for lead, selenium, and several chlorinated hydrocarbons including PCBs, DDT, and chlordane.

The distribution of PCBs in white croaker tissue (Figure 12-13) (SCCWRP *et al.* 1992) suggest that the most heavily contaminated area in 1990 was off the Palos Verdes Peninsula. At all three Palos Verdes stations (Palos Verdes North, South, and White Point), the mean

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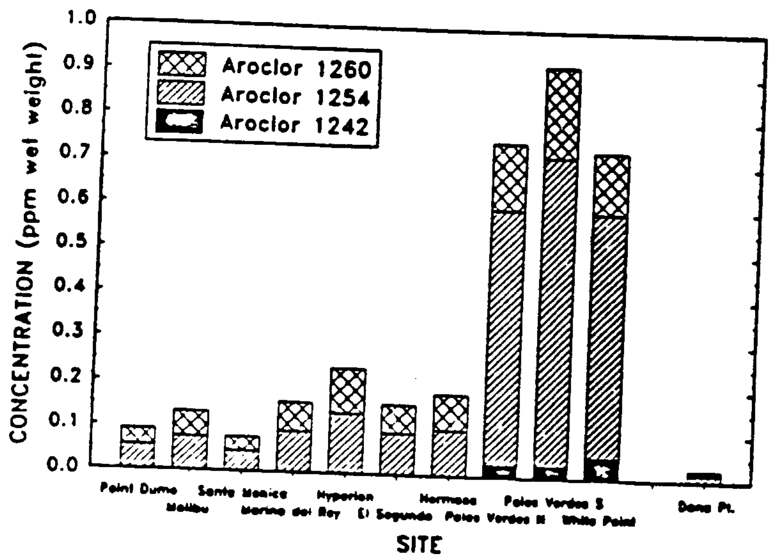

Figure 12-13. Mean concentrations of total PCB (Aroclors 1242 + 1245 + 1262) in composites of muscle tissue of white croaker (*Genyonemus lineatus*) collected from coastal sites in southern California, 1990 (SCCWRP *et al.* 1992)

concentration of total PCBs was two to three times higher than at any other station in Santa Monica Bay and more than 30 times higher than the Dana Point reference site. This is similar to the DDT distribution pattern in white croaker tissue in which DDT levels in fish collected from the Palos Verdes sites were as much as 85 times higher than those collected from Santa Monica Bay. Thus, in 1990 the distribution of PCBs and DDT in white croaker were highly elevated in fish taken from Palos Verdes, but in contrast to the 1987 survey (Pollock *et al.* 1991) contaminant levels were not elevated in white croaker from northern Santa Monica Bay. Both these studies confirmed the results of Young *et al.* (1976a) and Gossett *et al.* (1983b), that the JWPCP outfall area is the primary source of DDT and PCB contamination in fishes in the Southern California Bight.

Temporal Trends

Metals. The temporal distribution of metals in Santa Monica Bay fishes has not been extensively studied, and long term trends are available for only a few species. One of the best surveys in recent years was conducted by SCCWRP (1992) for Dover sole near the HTP outfall to study the effects of sludge abatement in 1987. Concentrations of zinc, copper, cadmium, and silver were all low at "contaminated" sites near the outfall from 1986 through 1988 and only silver concentration decreased following sludge abatement (Figure 12-14). The concentrations of all metals analyzed in dover sole were equal to or less than the southern California average of the mainland shelf (SCCWRP 1992).

Organic Compounds. In general, the concentrations of DDT and PCBs in the muscle tissue of fishes collected in Santa Monica Bay and off the Palos Verdes Peninsula have decreased over the last 20 years (McDermott-Ehrlich *et al.* 1977, 1978; Sherwood *et al.* 1978; Smokler *et al.* 1979; LACSD 1988; Young *et al.* 1988b, Pollock *et al.* 1991, SCCWRP *et al.* 1992). Because of the historically high levels of these contaminants found in white croaker, and because of the extensive database that exists for this species, the temporal changes in DDT and PCB levels in white croaker are outlined below.

Between 1980 and 1990, DDT levels in white croaker from Santa Monica Bay have decreased or remained relatively constant, with the highest levels measured in 1981 from fish taken at Malibu (Figure 12-15) (SCCWRP *et al.* 1992). However, off the Palos Verdes Shelf, DDT levels have been consistently the highest of anywhere in the Southern California Bight (NOAA 1991b). Since the dumping of DDT was terminated in 1971-1972, the concentration of this contaminant in sediments surrounding the JWPCP outfall has declined (NOAA 1991a). The change in DDT levels in Palos Verdes sediments reflects the bioaccumulation in white croaker. For instance, in 1971, the mean DDT concentration in white croaker from the Palos Verdes Shelf averaged 39,000 ppb (Young *et al.* 1978), but had decreased to 7,629 ppb by 1980 (Schafer *et al.* 1984). There was no apparent change in DDT levels between 1981 and 1987 (Pollock *et al.* 1991). In 1990, DDT levels from white croaker collected at three sites on the Palos Verdes Peninsula averaged 11,580 ppb (Pollock *et al.* 1991), which was a significant increase from 1987 levels. This increase may have resulted from shifting sediments off the Palos Verdes Shelf, which could have exposed old reservoirs of DDT or possibly to differences in the biological condition of the fish at the time of analysis. Since PCBs and DDT tend to accumulate in the fatty tissue, differences in reproductive condition or annual migrations of white croaker may have contributed to the apparent increase from 1987 to 1990, but it is unlikely that there has been any "new" source of DDT to the area.

PCB levels in white croaker from Malibu and Point Dume have decreased since 1987, which may reflect the termination of sludge disposal from the HTP outfall in 1987 (SCCWRP 1992). However, PCB levels in white croaker at other locations throughout Santa Monica Bay have

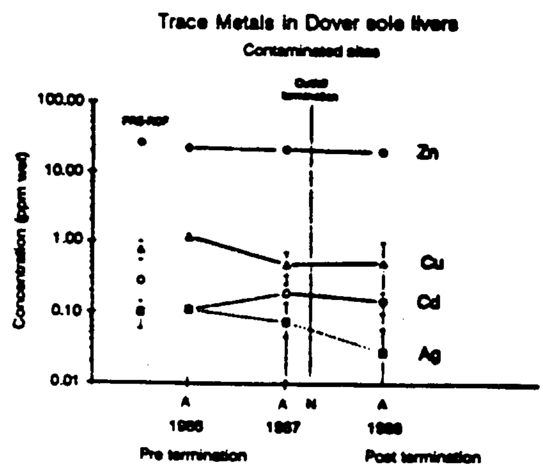

Figure 12-14. Concentrations of trace metals in liver tissue of Dover sole (*Microstomus pacificus*) from contaminated sites near the HTP 7-mile outfall, 1986-1988 (SCCWRP 1992).

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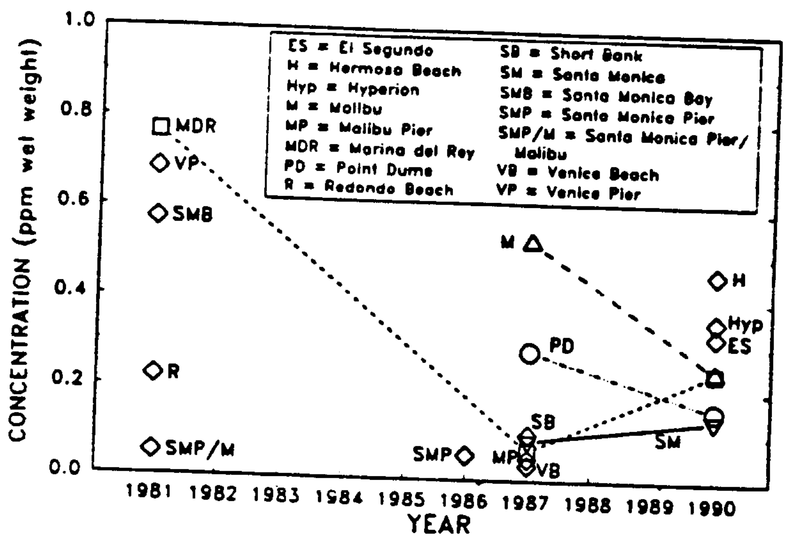

Figure 12-15. Mean concentrations of total DDT in muscle tissue of white croaker (*Genyonemus lineatus*) collected from Santa Monica Bay, 1981-1990 (data from Gossett *et al.* 1983, Risebrough 1987, Pollock *et al.* 1991, SCCWRP *et al.* 1992)

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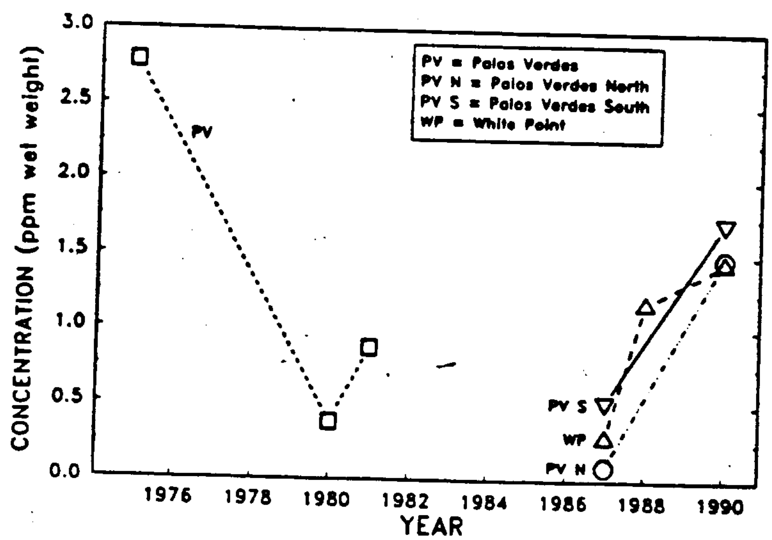

Figure 12-16. Mean concentrations of total PCB in muscle tissue of white croaker (*Genyonemus lineatus*) collected from Palos Verdes Shelf, 1975-1990 (data from Young *et al.* 1978a, Schafer *et al.* 1984, Gossett *et al.* 1983, Risebrough 1987, Pollock *et al.* 1991, SCCWRP *et al.* 1992)

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changed little since 1981. On the Palos Verdes Shelf, PCB levels decreased markedly in white croaker tissue from 1975, when the average concentration was 2,780 ppb (Young *et al.* 1978), to 1980 when tissue levels averaged 383 ppb (Figure 12-16) (Schafer *et al.* 1982). These results reflect the decrease of PCB in Palos Verdes sediments (NOAA 1991a). In 1987, PCB levels in white croaker muscle (Pollock *et al.* 1991) were similar to those in 1980, but by 1990 levels at several locations had increased to approximately 1,500 ppb (SCCWRP *et al.* 1992). It is unlikely that there has been any recent input of PCBs through the JWPCP outfalls, but the apparent increase in white croaker PCB levels from 1987 through 1990 may have been due to seasonal differences in lipid content of white croaker or perhaps to the shifting of sediments on the Palos Verdes Shelf, which may have exposed old beds of the contaminant. The fact that PCB levels have not decreased since the early 1980s reflects the persistence of this contaminant over time and suggests that the Palos Verdes sediments act as a source.

SEAFOOD CONSUMPTION

Because of the persistence of contaminants in some fishes caught in Santa Monica Bay and the Palos Verdes Shelf, and because of the growing public concern over the consumption of seafood from the area, the SMBRP funded a seafood consumption study, which was conducted in 1991 and 1992 (MBC in prep.) to determine the amount and type of seafood that is being eaten from the Bay. The last seafood consumption study of Santa Monica Bay was conducted in 1980 (Puffer *et al.* 1981, 1982). However, since that time the health risks of consuming seafood from the Bay may have changed due to changes in seafood availability, species preference, and ethnic composition of the fishing population.

Recreational Fish Catch

In the 1992 study (MBC in prep.), surveyors identified 72 seafood species that were caught by recreational anglers during the summers of 1991 and 1992. The species caught in greatest abundance were chub mackerel, barred sand bass, kelp bass, white croaker, and Pacific barracuda. Chub mackerel was the most abundant fish caught from piers, private boats, and party boats, accounting for 51.9, 24.0, and 23.3% of the total catch, respectively. Of the fish caught from piers, white croaker was the second most abundant species, accounting for 18.2% of the total catch, followed by jacksmelt, and surfperches. Barred sand bass was the second most abundant species caught from party boats, accounting for 20.2% of the total, followed by kelp bass (16.4%) and Pacific barracuda (13.2%). Of the species caught from private boats, white croaker was the second most abundant species (16.6%) followed by barred sand bass (8.8%), kelp bass (8.5%), and Pacific barracuda (5.9%). Much fewer species were caught by beach anglers, but of these, sea mussels and Pacific purple urchin together accounted for nearly 90% of the total catch.

Demographic Profile of Santa Monica Bay Anglers

The demographic profile of the anglers that catch and consume seafood species from the Bay is used to determine the relative risks of different ethnic groups of eating contaminated seafood. In 1980, Puffer *et al.* (1981, 1982) found that the anglers in the Los Angeles area consisted mainly of caucasians (42%), followed by blacks (24%), Mexican-Americans (16%), Oriental/Samoans (13%), and "others" (5%). Of these 88% were male, primarily between the ages of 18 and 40. Similar to 1980, the majority (44%) of the anglers in 1991 and 1992 were white. However, the second most abundant anglers were hispanic (25%), followed by blacks (10%); Filipinos, Koreans, Chinese, Vietnamese, and "others" each accounted for less than 7% of the

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total fishing population in the Bay. In 1991 and 1992, 86% of the anglers were male and most were between the ages of 25 and 45.

Seafood Consumption Rates

The health risks of consuming contaminated seafood from the Bay depends on the frequency and magnitude of food consumed and on the level of contaminants present in the consumed species. In the 1980 seafood consumption study, Puffer *et al.* (1981) found that, of the species caught by recreational anglers, California halibut, Pacific bonito, chub mackerel (listed as Pacific mackerel in Puffer *et al.* 1991, 1982), and opaleye were consumed the most. On average, anglers consumed 4.3, 1.9, 1.1, and 0.5 kg/person/month, respectively. White croaker was the fifth most abundantly consumed species, with anglers consuming an average of 0.4 kg of white croaker per person per month (Puffer *et al.* 1981).

The surveys conducted in 1991 and 1992 (MBC in prep.) suggest that the consumption habits of recreational anglers that fish in the Santa Monica Bay area have changed little in the last 10 years and that the differences that do exist probably reflect species availability. In 1991 and 1992, the species that anglers consumed the most were chub mackerel, Pacific barracuda, barred sand bass, and Pacific bonito. The "other" group, which consisted of Middle Easterners, Samoans, and Cambodians had the highest consumption rates, followed by blacks and Filipinos. However, the "other" group consumed virtually no white croaker, whereas blacks and Filipinos consumed the most.

Health Warning Awareness. To determine the effectiveness of health warnings posted by the Department of Health Services concerning the consumption of fish from Santa Monica Bay, recreational anglers in Santa Monica Bay were asked whether they were aware of the health warnings, and if so, what effect have they had on seafood consumption (MBC in prep.). Of the 925 individuals questioned in the 1991 and 1992 surveys, nearly 50% said that they were not aware of the health warnings (Table 12-2). Of the anglers that were aware of the warnings (468 individuals), 46% (217 individuals) said they had stopped eating some fish, 25% (115 individuals) said they ate less of all fish, 19% (87 individuals) said they stopped eating all fish, and 10% (49 individuals) said they ate less of some fish.

RISK ASSESSMENT

Approach

The first step in the risk assessment process is to define toxic hazards posed by the chemical contaminants in selected seafoods of Santa Monica Bay. The hazard and dose-response assessments result in the choice of the critical health effects on which to base the subsequent steps in the risk analysis. For example, the health effect of concern may be selected because it is the most severe adverse effect identified in the hazard assessment. Because cancer is a severe disease that may be initiated by relatively low levels of exposure to toxic chemicals, it is usually the health effect chosen for evaluating risks of any potentially cancer-causing chemical.

Contaminants of Concern

Information on concentrations of toxic chemicals in tissues of invertebrates and fishes of Santa Monica Bay was presented in previous chapters. The contaminants of greatest concern

Table 12-2. Responses of recreational anglers to seafood consumption warnings posted in Santa Monica Bay, 1991-1992 (MBC in prep).

Warnings Effect	Racial/Ethnic Category									
	Black	Korean	Filipino	Vietnamese	Chinese	Hispanic	Japanese	White	Other	Total
Total "No"	52	10	20	2	13	99	27	222	12	457
Total "Yes"	43	14	36	5	9	78	34	243	6	468
Eat Less of All Fish	16	4	11	2	1	22	8	50	1	115
Eat Less of Some Fish	3	3	3	1	1	8	1	29	0	49
Stopped Eating All Fish	8	0	6	0	1	14	6	51	1	67
Stopped Eating Some Fish	16	7	16	2	6	34	19	113	4	217
Total	95	24	56	7	22	177	61	465	18	925

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relative to potential human health effects are DDT and PCBs. These contaminants exhibit the following characteristics (MBC 1988):

- High persistence in the aquatic environment
- High bioaccumulation potential
- Suspected as potential cause of cancer in humans based on mammalian bioassays
- Known sources of contaminant within Santa Monica Bay
- High concentrations in previous samples of both fish and invertebrates from various locations within the Bay.

Based on the data presented earlier, concentrations of metals in samples of fish muscle tissue from Santa Monica Bay are not sufficiently high to pose a problem. Chlordane and selected metals (lead, silver, cadmium, chromium, and mercury) in shellfish may pose a human health hazard, but data for edible tissues of harvested species are very limited. Therefore, subsequent steps in this risk assessment focus on PCBs and DDT (and related compounds).

Chemical Intake from Seafood Consumption

Because the seafood consumption study of Santa Monica Bay (MBC in prep.) has not yet been completed and because catch/consumption patterns undoubtedly vary over time, precise estimates of exposure to contaminated seafood have not yet been made. However, two studies (MBC 1988, Pollock *et al.* 1991) have analyzed the potential risks of eating seafood from Santa Monica Bay. In MBC (1988), a range of estimates of consumption was used to derive a range of contaminant doses for each of the selected seafood species and geographic locations. Risk estimates presented in a later section are related to a range of consumption values.

The calculated doses of total DDT and total PCBs from consumption of contaminated seafood correspond to selected consumption rates as follows (MBC 1988): a low estimate equal to the national average consumption of estuarine fish and shellfish (6.5 g/d = about 2 meals/mo), the 90th percentile value for each species [85.2 g/d = 22 meals/mo for white croaker, 334 g/d = 88 meals/mo for Pacific bonito; Puffer *et al.* 1981, 1982], and the 90th percentile value for all species combined (225 g/d = 59 meals/mo). The average serving of fish was assumed to be 0.25 lb (= 114 g). These consumption values were selected only for illustration purposes, and to develop the relationships between risk and consumption presented below. Estimates of average per capita consumption of fish and shellfish by the U.S. population generally range from 6.5 to 20.4 g/day (Pastorok 1988). Most estimates include fish and shellfish (mollusks and crustaceans) in marine, estuarine, and fresh waters, but marine species form the bulk of consumed items. Most estimates also include commercially harvested fisheries products. Also, estimates of average U.S. consumption do not account for subpopulations in coastal areas that may consume large quantities (>20 g/day) of locally caught fish or shellfish.

Risk Characterization

Estimates of excess cancer risk associated with long-term consumption of seafood from Santa Monica Bay (MBC 1988) were derived from estimates of toxic potencies for the selected contaminants (i.e., PCBs, total DDT) and chemical intake by sport fish consumers. It should be noted that consumption of fish and shellfish (including commercial products) is the major route of exposure of humans to PCBs (USFDA 1984, Humphrey 1987). In contrast, exposure of humans to DDT and related compounds occurs through a variety of foods and, in some subpopulations (e.g., farmers, pesticide applicators), through use of pesticides. When interpreting the risk estimates presented below, remember that they represent approximate (order of magnitude) estimates of a plausible upper limit to lifetime cancer risk for the specific chemicals and exposure conditions (i.e., a selected seafood species, harvest location, and consumption rate). The real health risks may be much lower than those shown. Because an individual's chance of having cancer is influenced by factors other than PCB and DDT exposure via seafood consumption (e.g., cigarette smoking, hereditary factors), the risk estimates presented below represent additional risks associated only with the exposure route of concern (i.e., ingestion of seafood from Santa Monica Bay).

Cancer Risk Estimates

The potential upper-limit risks of cancer associated with consuming selected seafood species from some areas of Santa Monica Bay (MBC 1988) are shown in Figures 12-17 and 12-18. The plausible-upper-limit risk is shown as a function of consumption rate to illustrate the relative importance of consumption rate and to allow evaluation of risks based on various consumption rates. Each shaded area in the figure is based on the range of total concentration of PCBs and DDT (including DDD and DDE) in muscle tissue for the species and locations noted. Data on contaminant concentrations in edible fish tissue were available for several locations (Figures 12-17 and 12-18), including frequently used fishing piers and several offshore areas Santa Monica Bay; a party boat fishery; the Palos Verdes Peninsula (PV); trawl transects T-3 and T-5 within 5 km of the JWPCP outfall sampled by Los Angeles County Sanitation District; and the JWPCP outfall area (WP), which may not normally be used by recreational anglers. Each shaded area (Figures 12-17 and 12-18) represents information for two or more locations with the same general range of risk (i.e., high, medium, or low). A separate line is not shown for each location because the risk estimates are not precise and individual replicate data to test for statistical differences among areas were not available.

To interpret Figures 12-17 and 12-18, choose a consumption level (on the horizontal axis) that corresponds to the average frequency of the seafood species in the diet. The consumption rate is the average consumption rate for a 70-year lifetime, but exposures for less than 70 years can easily be calculated. For example, if it is assumed that the seafood of interest is eaten once per month (i.e., one 0.25-lb serving per month) for only 7 years, then the average lifetime (70 years) consumption rate is one-tenth (7 divided by 70) the short-term rate, or 0.025 lb/month. Find the region of the shaded area for the fishing location of interest that corresponds to the consumption rate selected. Then read the range of risk estimates (on the vertical axis) that corresponds to the selected consumption rate and harvest area. Comparisons with health risks from other foods and common activities can be made using Figure 12-19 (also refer to the section, Comparison of Santa Monica Seafood Risks with Other Risks).

Based on the risk analysis by PTI in MBC (1988), consumption of seafood from the JWPCP outfall area and the surrounding areas of the Palos Verdes Peninsula poses the greatest risk of cancer from total DDT and PCBs combined. Total DDT accounted for more than about 35% of the total cancer risk associated with total DDT and PCBs in white croaker at only the Palos Verdes Peninsula area. Consumption of white croaker from areas offshore of Hermosa Beach also posed a relatively high risk. Cancer risks associated with consuming white croaker from offshore Santa Monica Bay (Figure 12-17) were moderate relative to other study areas; nevertheless, they were about the same as risks associated with the consumption of white croaker representing the average contamination at six Los Angeles Harbor sites combined (including party boat samples

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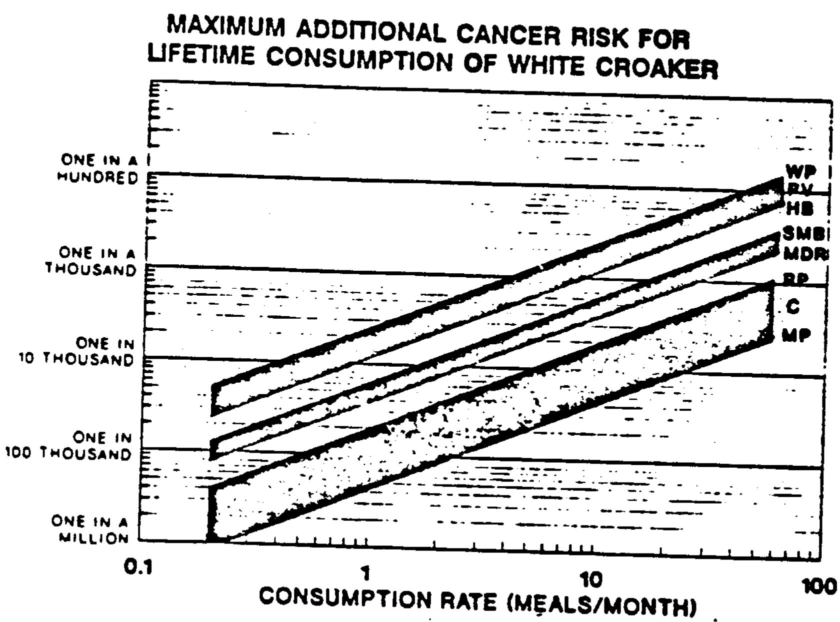

Legend:

WP = White Point 1980
PV = Palos Verdes 1985
SMB = Santa Monica Bay/ LA Harbor 1980; Venice Pier 1985
MDR = Marina Del Rey 1980; Venice Pier 1980
RP = Redondo Piers 1980
HB = Hermosa Beach 1985
C = Control-Orange County Dana Point 1980
MP = Malibu/Santa Monica Piers 1980

Figure 12-17. Upper-limit estimates of lifetime cancer risk (based on an average lifetime of 70 years) from total DDT plus total PCB in white croaker (*Genyonemus lineatus*) from southern California. One meal = 0.25 lb = 114 g (MBC 1988).

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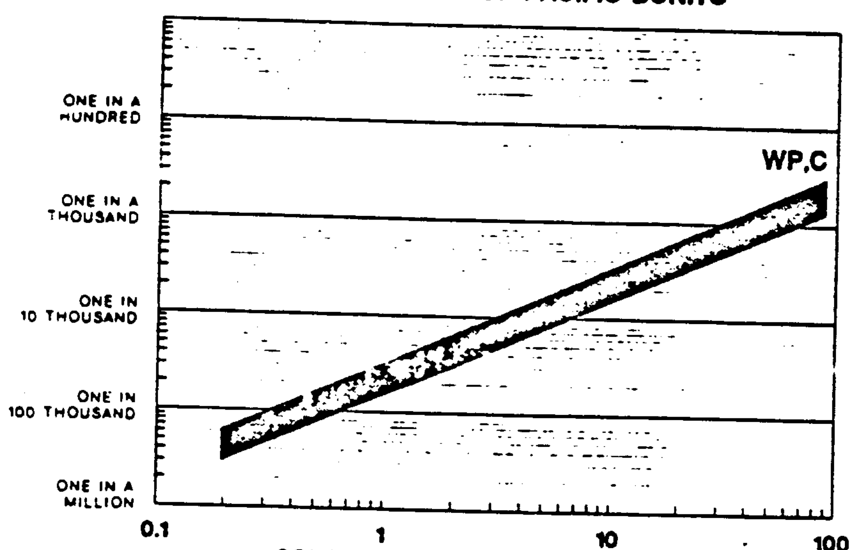
MAXIMUM ADDITIONAL CANCER RISK FOR LIFETIME CONSUMPTION OF PACIFIC BONITO



Legend:

WP = White Point 1980

C = Control-Orange County Dana Point 1980

Figure 12-18. Upper-limit estimates of lifetime cancer risk (based on an average lifetime of 70 years) from total DDT plus total PCB in Pacific bonito (*Sarda chiliensis*) from southern California. One meal = 0.25 lb = 114 g (MBC 1988).

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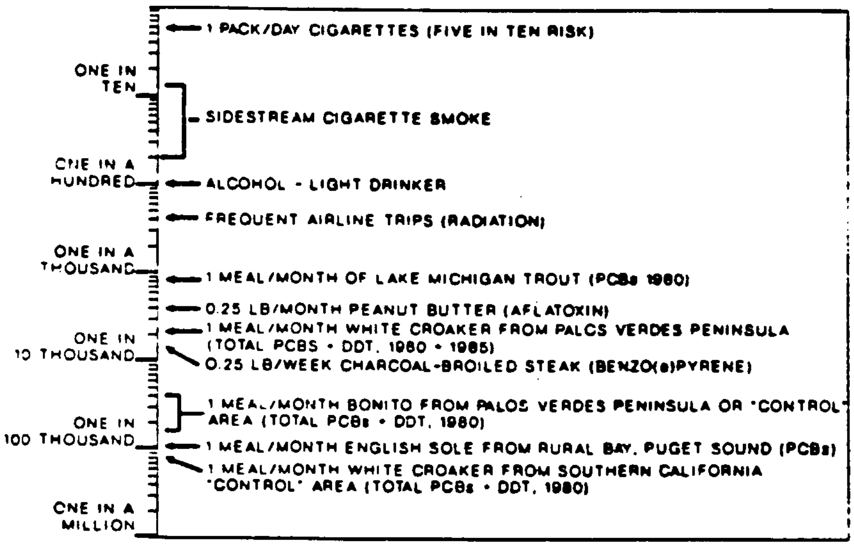

All risk estimates were taken from Wilson and Crouch (1987) except: peanut butter, English sole, trout, steak (Pastorok et al. 1986); sidestream cigarette smoke (Papanek 1988, pers. comm.); white croaker and bonito (present study).

Average annual risk estimates from Wilson and Crouch (1987) were multiplied times the uncertainty factor given by the authors to convert them to upper-limit estimates and by a factor of 70 years to convert them to lifetime risks. Data were not available to calculate cancer risk estimates associated with swimming in Santa Monica Bay.

Figure 12-19. Upper-limit estimates of lifetime cancer risk (based on an average lifetime of 70 years) for various activities (MBC 1988).

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analyzed by Gossett *et al.* (1983a)]. Marina del Rey and the Venice and Redondo Piers also presented moderate risk levels relative to other areas. The lowest risk levels for croaker occurred at the Malibu/Santa Monica Piers, which exhibited risk estimates slightly lower than the control areas at Orange County and Dana Point.

The relative risk of consuming Santa Monica Bay seafood as estimated by PTI in MBC (1988) is similar to that estimated by Pollock *et al.* (1991). For instance, Pollock *et al.* (1991) estimated that the excess lifetime risk of consuming white croaker from White Point was 1 in 1,000 (1.0×10^{-3}), which is the same as that estimated by MBC 1988 (Figure 12-17). However, the two risk assessments cannot be compared directly because of differences in PCB and DDT contaminant levels, the PCB carcinogenic potency factors, and theoretical seafood consumption rates.

Pollock *et al.* (1991) developed site-specific recommendations for seafood consumed from several areas in Santa Monica Bay and the Palos Verdes Shelf (Table 12-3), and species-specific recommendations for the most frequently caught and consumed fishes in the area (Table 12-4); recommendations were based on contaminant levels in fishes collected in 1987 (Pollock *et al.* 1991), where one meal consists of six oz (170 g) of fish. The recommendations are meant to provide guidance to anglers as an indication of how often to fish in an area and how often to eat a specific fish species caught at a site (Pollock *et al.* 1991).

Summary of Assumptions and Uncertainties

Faced with the many uncertainties and assumptions in risk assessment, an estimate of the plausible upper-limit to cancer risk was derived above to evaluate potential human health effects related to consumption of contaminated fish. A similar approach is commonly used by EPA and other agencies as the basis for environmental regulations. This ensures that health risks will not be underestimated. Although the absolute risk may often be overestimated by as much as 1,000 times (or even 10,000 times in some circumstances), the plausible-upper-limit approach is appropriate to ensure adequate protection of human health. Assumptions inherent in this risk assessment are summarized in MBC (1988).

Because of the differences in habitat, feeding habits, and trophic position, white croaker and Pacific bonito were selected in MBC (1988) to represent a wide range in assessing the health risks associated with consuming seafood from the Bay. White croaker are probably more indicative of specific areas of the Bay because of their limited movements and benthic feeding habits. In contrast, Pacific bonito are highly mobile species. Consequently, major differences in contamination of white croaker among areas are found, whereas little spatial variation in contamination of Pacific bonito is expected.

In the analyses on which Figures 12-17, 12-18, and 12-19 were based, the effect of cooking on contaminant concentrations was not taken into account. The effect of cooking on the ultimate health risk from a mixture of chemicals (including any transformation or degradation products produced by heating) is not completely understood. Some studies have shown decreases in concentrations of lipid-soluble organic compounds such as DDT and PCBs following pan-frying, broiling, or baking of fish fillets (Smith *et al.* 1973; Skea *et al.* 1981; Puffer and Gossett 1983).

Because of the limitations of risk assessment, emphasis should be placed on relative risk comparisons. For example, comparisons among fishing areas are valuable for developing perspectives for environmental advisories such as guidance on choices of fishing location and

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Table 12-3. Site-specific seafood consumption recommendations for several locations in Santa Monica Bay, based on 1987 contaminant levels (Pollock et al. 1991).

Site	Fish Species	Recommendation*
Marina Del Rey Redondo Beach Santa Monica Pier Venice Pier Venice Beach Dana Point	All Species	No Restrictions
Redondo Pier	Corbina	One meal every two weeks
Malibu Pier	Queenfish	One meal a month
Short Bank	White croaker	One meal every two weeks
Malibu Point Dume Point Vicente Palos Verdes-Northwest	White croaker	Do not consume
White Point	White croaker	Do not consume
	Cal. scorpionfish Rockfishes Kelp bass	One meal every two weeks+

* One meal is about six ounces

\+ Consumption recommendation is for all the listed species combined.

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Table 12-4. Species-specific seafood consumption recommendations for several fish species of Santa Monica Bay, based on 1987 contaminant levels (Pollock *et al.* 1991).

Fish Species	Contamination Group	Recommendation*
White Croaker	HIGH	Avoid Consumption
Corbina Queenfish Surfpeches Cal. scorpionfish	MODERATE	Consume not more than one meal every two weeks
Black croaker Barred Sand Bass Rockfishes Kelp bass	LOW	Consumption not restricted
Pacific bonito Mackerel Pacific sanddab Pacific Barracuda Opaleye Halfmoon Halibut	LOWEST	Consumption not restricted

* One meal is about six ounces

+ Consumption recommendation is for all the listed species combined.

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target species by individual anglers. Statistical differences in PCB and DDT concentrations in fish tissue among fishing areas were demonstrated by Gossett *et al.* (1983a). Nevertheless, caution should be exercised in interpreting upper-limit risk estimates presented in Figures 12-17 and 12-18. Contaminant concentration differences on the order of those between Hermosa Beach and the JWPCP outfall area or between the Redondo Piers and the offshore Santa Monica Bay station are likely to be nonsignificant. Thus, risk estimates for these pairs of areas (and other pairs of areas differing by a similar magnitude of contamination) in Figure 12-17 should be considered as roughly equal.

Comparison of Santa Monica Bay Seafood Risks with Other Risks

Are Santa Monica Bay seafoods hazardous to your health? Although this question is on the minds of many scientists, environmental managers, and anglers, it is impossible to provide a simple answer. The answer to this question depends on five factors: 1) the location of interest (e.g., outer bay vs. the outfall areas vs. fishing piers), 2) the species of interest (open-water species vs. bottom species), 3) the chemicals responsible for contamination, 4) seafood consumption rate, and 5) the risk level considered "acceptable" or tolerable by an agency or the individual consumer. Despite our best efforts, society will never achieve a world of "zero-risk," especially relative to food quality (e.g., see Ames 1983).

Despite the limitation of this assessment (many of which are inherent in any risk assessment), the data are adequate to support the conclusion that significant risks of potential health effects may result from relatively high consumption of bottomfish and lipid-rich species harvested from certain locations within the study area. Concentrations of total DDT and PCBs in fish from within the study area are clearly elevated above "background" concentrations at control sites.

To aid interpretation of the risk estimates presented above, health risks from consumption of other foods and from other common activities are presented in Figure 12-19 [based mainly on data in Pastorok *et al.* (1986) and Wilson and Crouch (1987)]. Against a background of an average lifetime risk on the order of 2 to 3 in 10 (20 to 30%) per individual for all cancers from all causes, an additional lifetime cancer risk of one in a million or less is generally considered tolerable by environmental regulatory agencies (Travis *et al.* 1987). An additional lifetime cancer risk above about one in a thousand is generally considered unacceptable. Risk levels on the order of one in ten thousand to one in one-hundred thousand have often led to development of environmental regulations on chemical releases and exposure of humans. Regulatory decisions regarding contamination of food products have sometimes been based on risk levels up to 1 in 1,000 to 1 in 100.

Although the potential health risks of eating fish from Santa Monica Bay are high in some cases (Table 12-4), other foods and activities may pose substantial risks (greater than 1 in 1,000). Considering that the usable protein content of Santa Monica Bay fish, steak, and peanut butter are roughly similar, substitution of the latter two protein sources for locally harvested fish may not substantially reduce cancer risk.

CHAPTER 13
SUMMARY, STATUS AND TRENDS

The information presented in Chapters 1 through 12 describes in detail the sources of contamination to and the nature of developments in the study area; the distribution of contaminants and developments in space and time; and the actual impacts which are known or suspected to have resulted from the contamination, development, and use of Santa Monica Bay.

This chapter emphasizes the major trends of concern and those issues which have given rise to the Action Plan Elements being developed by the Santa Monica Bay Restoration Project (Table 13-1). Like the body of the report, this chapter includes three major topics (sources, distribution, and impacts of contamination) which are arranged in that order. The sources of contaminants will be addressed by Action Plan Elements IA, IB, and ID of Table 13-1. These elements deal with mass emissions, pollution prevention, and municipal and industrial discharges.

POINT SOURCES

Point sources relate primarily to Action Plan Element ID of Table 13-1, Municipal and Industrial Discharges. Seven facilities operate point sources of contamination and potential impacts to Santa Monica Bay under NPDES permits.

Generating Stations

The three generating stations use seawater to cool condensers, discharging it back to the Bay at somewhat elevated temperatures. Redondo, Scattergood, and El Segundo Generating Stations have all been operating for more than 20 years. No long-term, widespread impacts have been attributed to the thermal waste from them, individually or collectively. The small amounts of contaminants which originate in the plant are generally well below the NPDES-permitted limitations and do not constitute a threat to the local biota.

Each year a seemingly large number of plankton (one to two billion) are entrained into the cooling water flow, where they are usually assumed to suffer in excess of 99% mortality. However, despite the large numbers, there is no indication that these losses have affected the local population size even though individual units at the plants have been operating for 20 to 40 years. White croaker generally suffer the greatest entrainment losses and yet they are also among the most abundant offshore species.

Adult fishes are also impinged and killed on protective screens across the intake conduit. These losses, as much as 78,000 individuals per year at El Segundo, also seem high; but the most commonly impinged species - queenfish - is also among the most common species offshore; thus no population-level impact can be ascribed to the stations.

Oil Refinery

Chevron USA operates an NPDES-permitted ocean outfall from its El Segundo refinery which discharges an average of about 8 million gallons of wastewater to the Bay each day. Chevron's on-site treatment facility became operational in the 1970s and has been upgraded several times since then. At present operational wastes are fully treated before being discharged; storm runoff is treated in oil/water separators with induced air flotation units.

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Table 13-1. Draft Action Plan Elements of the Comprehensive Conservation and Management Plan for Santa Monica Bay.

Action Plan Element
I. Reduce Sources of Pollution
A. Mass Emission Policy
B. Pollution Prevention Program
C. Comprehensive Stormwater/Urban Runoff Management Program
D. Municipal and Industrial Discharge
E. Prevention and Response to Oil and Hazardous Materials Spills
F. Remediate Contaminated Sediments
II. Protect the Public from Health Risks Associated with Swimming and Consuming Seafood from the Bay
A. Ensure that Bay Seafood is Safe to Consume
B. Reduce Human Health Risks Associated with Swimming in Bay Waters
III. Restore, Protect and Manage Habitats and Watersheds
A. Marine Ecosystem
B. Wetlands
C. Beaches and Intertidal Zones
D. Watersheds

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The most abundant constituents in the present effluent are COD, BOD, and TSS, with annual mass emissions of about 1,800, 125, and 100 MT, respectively. The effluent has only exceeded permitted limitations on three occasions in the last 7 years. At present the wastewater outfall discharges in about 20 ft of water, less than 200 ft from shore. However, Chevron is in the process of relocating the outfall to a point 3,500 ft from shore in approximately 60 ft of water.

Wastewater Treatment Plants

Hyperion Treatment Plant (HTP) and Joint Water Pollution Control Plant (JWPCP) are among the four largest municipal wastewater treatment plants in southern California; both discharge treated domestic sewage to the study area. In the past these discharges were unquestionably the major point sources of contamination to Santa Monica Bay. However, effluent concentrations and mass emissions from both facilities have declined significantly since the early 1970s, following the creation of the USEPA and enactment of the Clean Water Act.

Hyperion Treatment Plant

HTP treats wastewater from most of the City of Los Angeles' 3.5 million persons and tens of thousands of businesses and industries.

The flow from HTP's 5-mile outfall has generally increased over the years, from about 200 million gallons per day (mgd) in 1950 to over 400 mgd in 1983. However, the flow has declined steadily since 1983, to just under 300 mgd in 1992 (Figure 13-1). Between 1974 and 1987 (when it was discontinued) an average of 4.4 mgd of mixed secondary effluent and digested sewage sludge was discharged to the head of Santa Monica Submarine Canyon through HTP's 7-mile outfall.

Mass emissions of key organics indicators (suspended solids, BOD, and settleable solids) through the 5-mile outfall also increased steadily through the mid-1980s, peaked in 1985 and have declined since then (Figure 13-2). The mass emission of BOD, for example, was about 140,000 metric tons (MT) in 1985 but has been below 50,000 MT since 1988.

Mass emissions of nutrients were relatively stable from the mid-1970s to the mid-1980s, at which time they decreased sightly (Figure 13-2). The increase in ammonia is attributed to treatment improvements, digestion which converts nitrates to ammonia.

Mass emissions of most trace metals declined between 1974 and 1986, although the annual variability was great (Figure 13-2). Since 1988 mass emissions have been consistently low, in some cases not detectable.

The mass emissions of DDT and PCBs declined dramatically in the late 1970s, displaying a 3-5 year lag behind legislative source control which limited their use and manufacture (Figure 13-2). Mass emissions have been very low (sometimes undetected) since 1982.

The general decline in the mass emissions of most contaminants between 1974 and 1986-87 reflect source control of various sorts; the dramatic decreases in 1987-1988 coincide with better solids removal (suspended and settleable solids) to which the contaminants bind.

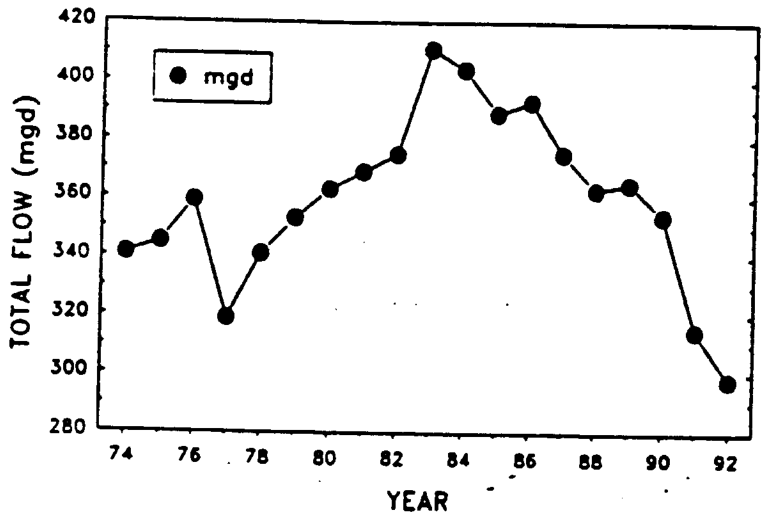

Figure 13-1. Average flow from the HTP 5-mile outfall, 1974-1992. (Data from Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; CLA,DPW 1987, 1988, 1989, 1990, 1991, 1992).

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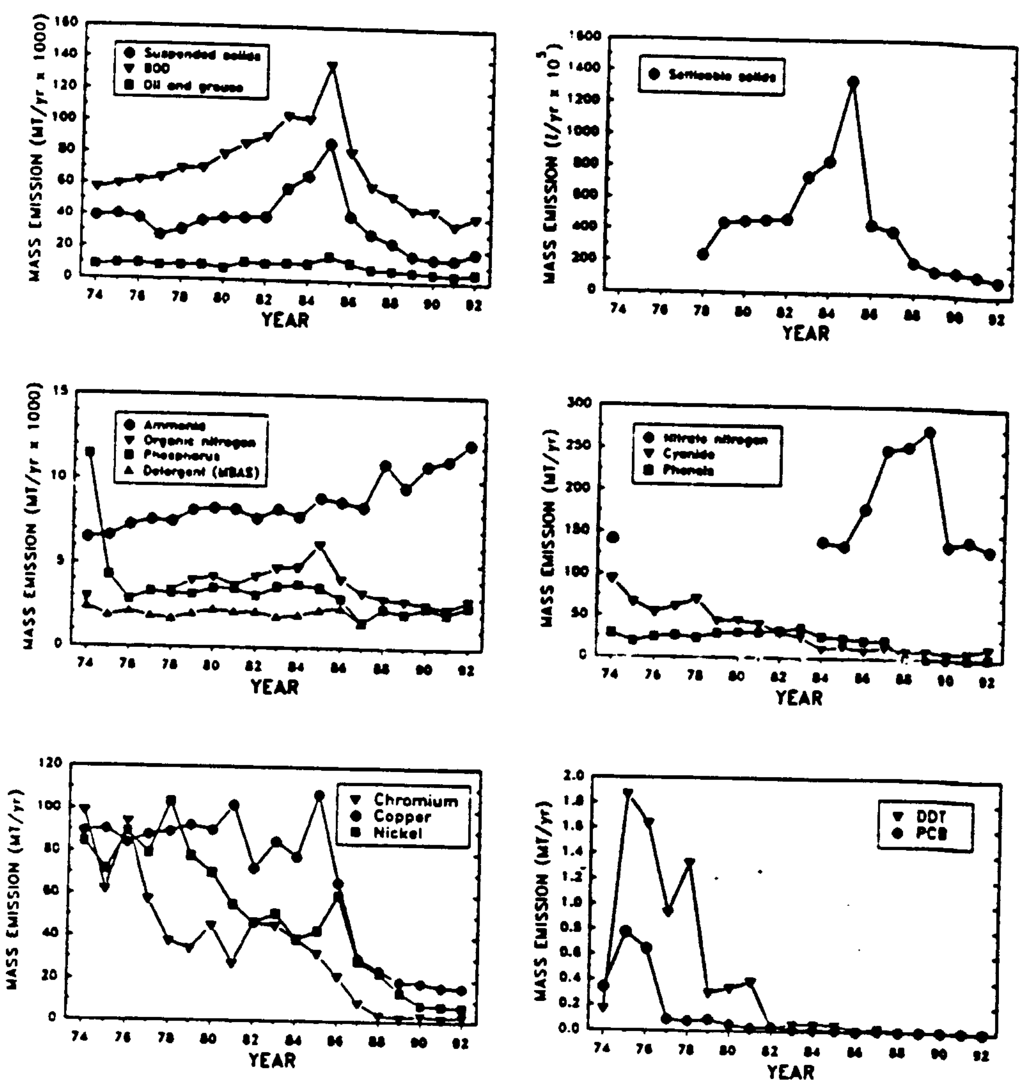

Figure 13-2. Annual mass emission rates of selected contaminates discharged from HTP 5-mile outfall from 1974-1992. (Data from Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; CLA,DPW 1987, 1988, 1989, 1990, 1991, 1992).

Joint Water Pollution Control Plant

(JWPCP) treats wastewater from a population of about 5 million people and 70,000 businesses and industries, most of Los Angeles county which is not serviced by HTP.

Flow from JWPCP to the Palos Verdes Shelf generally increased from about 340 mgd in the mid-1970s to about 370 mgd in the late 1980s (Figure 13-3). In 1991 and 1992 the flow declined and averaged 330 mgd.

Mass emissions of key organics indicators (suspended solids, BOD, and settleable solids) from JWPCP decreased steadily from 1974 to 1982, exhibited a spike in 1983, and continued to decline (although not as quickly as earlier) from 1984 to 1990. Mass emissions increased slightly in 1991 and 1992 (Figure 13-4).

Mass emissions of ammonia remained almost unchanged from 1974 to 1992, whereas organic nitrogen and phosphorus declined steadily from the mid-1970s to 1985, and have been stable since then (Figure 13-4).

Mass emissions of most trace metals declined steadily between 1974 and the late 1980s. There are indications that the mass emission rates have reached a plateau and will not decline more without major changes in the treatment process (Figure 13-4).

The mass emissions of DDT from JWPCP decreased 80% between 1974 and 1975, reflecting a lag with respect to the cessation of its disposal to the treatment system in 1971 (Figure 13-4). DDT levels have been very low since 1985 and often are not detected. The mass emissions of PCBs declined steadily between 1974 and 1985 and have also been very low (sometimes undetected) since then.

The very gradual, but steady, decline in mass emissions of most contaminants from JWPCP in the last 20 years reflect better source control as well as improved treatment technology, especially solids removal.

Tapia Water Reclamation Facility (TWRF)

TWRF provides primary, secondary, and tertiary treatment for as much as 10 mgd. Sludge is treated by aerobic digestion and either pumped to land-injection farms, or dewatered and disposed at land-fills.

TWRF's NPDES permit allows only tertiary-treated and completely pathogen-free wastewater to be discharged to Malibu Creek. The flow to Malibu Creek has averaged 2.7 mgd since 1974 and 2.5 mgd over the last five years.

NONPOINT SOURCES OF CONTAMINANTS

Nonpoint sources relate primarily to Action Plan Element I-A and I-B of Table 13-1, mass emission and pollution prevention measures. Nonpoint sources of contamination are, by definition, diffuse, unpredictable, and difficult to quantify. In the past runoff was strictly considered a nonpoint source, However, recent legislation now treats storm drains as point sources in the sense that they require NPDES permits. Although effluent does enter the receiving waters at a single point, they will always be nonpoint in the sense that contaminants enter the storm drain in a diffuse, irregular, and unpredictable (i.e. nonpoint) manner.

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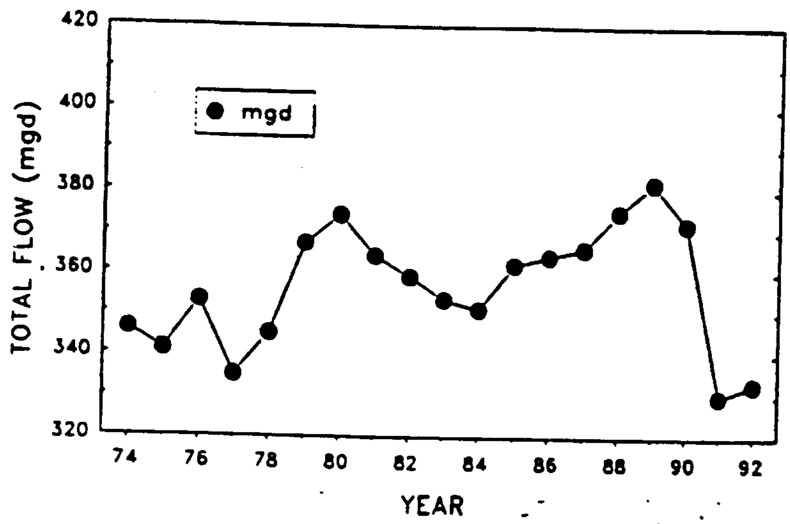

Figure 13-3. Average flow from JWPCP outfall, 1974-1992. (Data from Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; Stull 1988 pers. comm.; Horvath 1992 pers. comm.)

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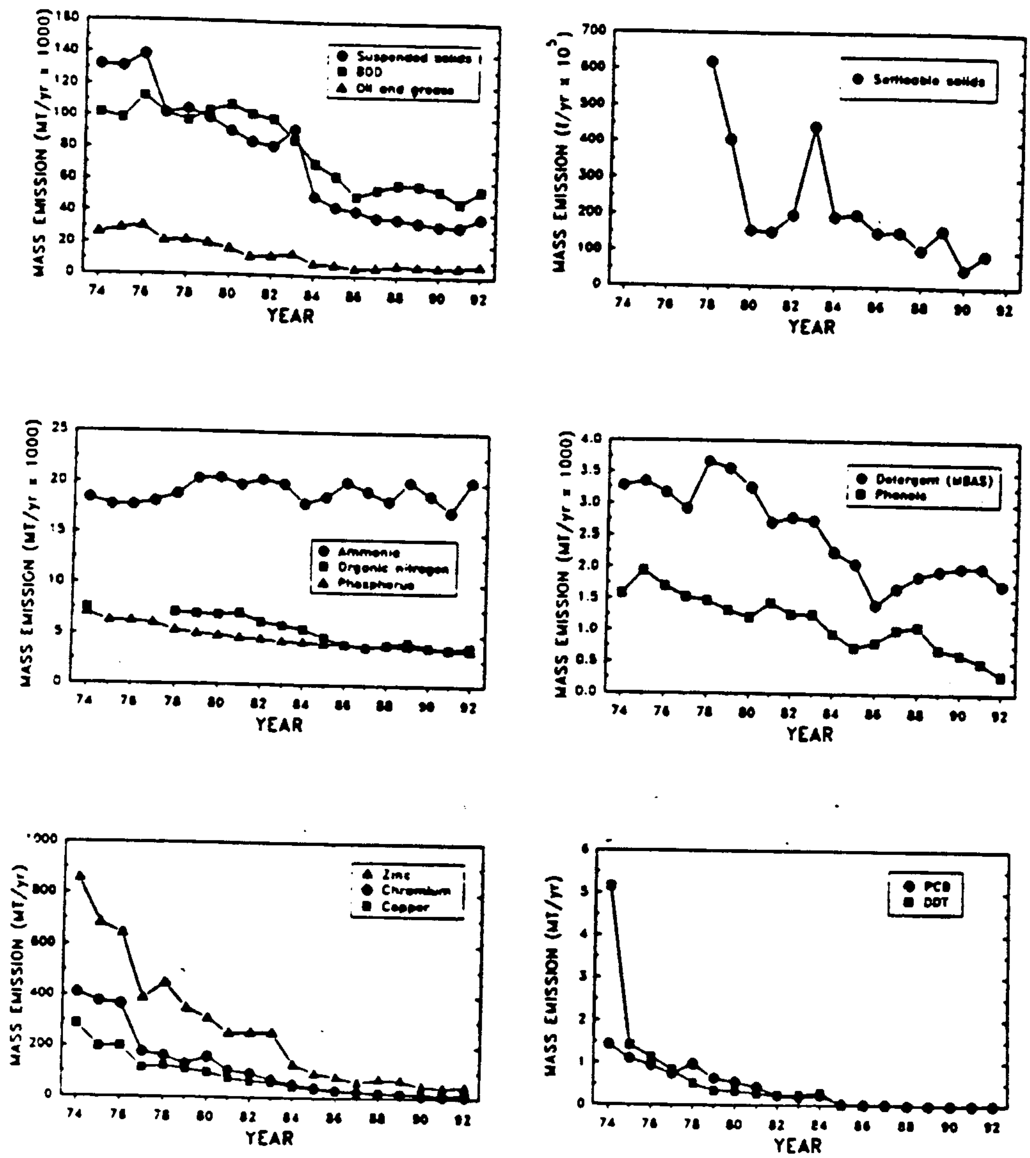

Figure 13-4. Annual mass emission rates of selected contaminates from JWPCP outfall 1974-1992. (Data from Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; Stull 1988 pers. comm.; Horvath 1992 pers. comm.)

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Marine Vessel Activities

Contaminants which enter the waters of Santa Monica Bay through the operation of marine vessels includes oil and refined petroleum products; antifouling paint additives (zinc, chromium, copper, mercury, arsenic, PCBs, and tributyl tin); trace metals from sacrificial anodes; lead from leaded marine fuel; PAHs from the combustion of fuel; and human enteric wastes.

The most remarkable fact about this potential contamination is that it is nonpoint and virtually impossible to quantify. Except for the enteric bacteria which result from illegal discharges of holding tanks or toilets, most derive from normal operation of the source vessels. Stricter enforcement of regulations will help reduce the input, as will careful evaluation of the use and effects of specific substances. Thus, TBT was banned from use on small vessels which are moored in confined marinas for long periods of time. TBT is still being released as old paint is scraped or sloughed off, but new sources are not being added.

Oil and Hazardous Materials Spills

This section relates directly to Action Plan Element IE, prevention of and response to oil and hazardous waste spills to Santa Monica Bay. Because there are no large, commercial ports and few large commercial vessels in the study area, the risk of oil spills from tankers or ruptured fuel tanks in the study is relatively low.

Spills are required to be reported to the US Coast Guard, which recorded an average of 6 spills per year from 1973 to 1987. These totaled less than 2,000 gal, and were primarily fuel oil and crude oil. The largest spill in that period of time was 1,000 gal of crude oil from a tanker offshore El Segundo and most of it was recovered. In 1991 approximately 9,000 gal of diesel-based cutting oil spilled from a ruptured pipeline off El Segundo; some of this product reached shore in Malibu, although no serious impacts were reported.

For comparison, it has been estimated that an average of about 10 barrels (420 gal) of oil from natural submarine oil seeps off Redondo Beach and Manhattan Beach reach the surface each day. Additional amounts do not reach the surface, either deteriorating or forming tarballs.

In 1990, the Lampert/Keene/Seestrand Oil Act (SB2240) was passed. Among other things the Act established an Oil Spill Prevention and Response (OSPR) group within the California Department of Fish and Game. OSPR is now engaged in establishing baseline data and enforcing development of contingency plans by every oil facility, transporter, and vessel in State waters.

Dredging and Dumpsites

The dumping of unwanted and hazardous waste materials at sea has been largely prohibited since 1972, although some illegal activities have taken place since then. However, none of the 15 formerly permitted dumpsites in southern California is in the study area. It is virtually impossible to estimate what kinds and amounts of materials have accumulated on-bottom, much less what fraction may some day be resuspended or dissolved and enter the ecosystem.

At present dredged materials from Los Angeles and Long Beach Harbors are dumped at a permitted site (LA-2) which is just outside the study area. From 1978 to 1988 an average of about 180,000 cubic yards per year of dredged material was disposed of at LA-2. LA-2 was recently re-opened for use, but no contaminated materials will be permitted to be dumped.

Theoretically materials from LA-2 could move into Santa Monica Bay, but no estimates have been made of this potential.

Aerial Fallout

Aerial fallout is probably the most diffuse contaminant source and the most difficult to quantify. Studies in the 1960s and 1970s indicated that the mass emissions of lead, mercury, and manganese from aerial fallout might exceed those from point sources. However, only a few studies of aerial fallout have been conducted locally in the last 15 years.

Knowledge of the emission rates in aerial fallout is academic, however, since the only way to regulate aerial fallout is by the application of source control measures at the site(s) where the contaminants enter the atmosphere. The levels of lead in aerial fallout undoubtedly decreased after the use of leaded gasoline was restricted, just as the mass emissions of DDT to Santa Monica Bay decreased after DDT process wastes were no longer disposed of at landfills on Palos Verdes Peninsula.

Storm and Urban Runoff

Material in this section relates to Action Plan Element IC of Table 13-1, comprehensive stormwater and urban runoff management program. Unlike some metropolitan areas, the City and County of Los Angeles have separate sewage and storm drain systems. The sewage system is too small to handle the uncommon, but sometimes torrential rains, although storm runoff does infiltrate and overload the sewage system on occasion. Overflows of sewage caused by storm runoff may result in raw, untreated sewage entering Santa Monica Bay through storm drains.

Legislation now treats storm drains as point sources (the effluent does enter at a single point), but they will always be nonpoint in the sense that contaminants enter the storm drain in a diffuse, irregular, and unpredictable (i.e. nonpoint) manner. Thus, until the flow in major storm drains is retained and treated, there is no effective way to control contaminant levels except by upstream source control – i.e. policing all sites where contaminants enter the drainage.

The kinds and amounts of contamination in storm/urban run-off to Santa Monica Bay were estimated for the major drainages in 1983, 1984, and 1989 (Table 13-2). However, it is not possible to accurately extrapolate the results of just a few surveys (usually conducted during periods of high runoff) to the many small drains and various flow conditions which prevail through the year and study area.

Above all else, these studies confirm that many contaminants remain high in storm/urban runoff. Thus, as wastewater treatment becomes more effective and mass emissions decrease from them, the relative contribution of contaminants via runoff have become greater, even though the absolute amounts have not increased.

Storm/urban runoff is somewhat unique in that it contributes indicator bacteria to the nearshore of Santa Monica Bay (Table 13-2). Bacteria from HTP and JWPCP do not ordinarily reach shore, where the potential threat to humans engaged in direct body-contact activities is greatest. However, numerous studies have confirmed that bacteria are abundant in stormwater and are most concentrated in the vicinity of stormdrains and the mouths of streams to the Bay.

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Table 13-2. Mass emissions for Malibu and Ballona Creeks for 1983-1984 and 1989

	Malibu Creek				Ballona Creek				
	Total 83	Total 84	Total 89	Mean 83-84, 89	Total 83	Total 84	Total 89	Mean 83-84, 89	Grand Mean
Flow (billion L/yr)	114	16	9	46	112	27	21	53	50
Flow (mgd)	82	12	6	33	81	20	15	39	36
<u>High Emission Constituents (MT)</u>									
Calcium Carbonate	35672	9038	-	22355	31290	7376	-	19333	20844
Bicarbonate	20920	3423	-	12172	22913	4427	-	13670	12821
Sulfate	15100	6808	4091	8666	10952	4317	4076	6448	7557
COD	8500	346	-	4423	6167	1456	-	3812	4117
Chloride	7946	1484	1092	3507	8678	2118	2144	4313	3910
Calcium	8033	1945	1145	3708	6830	1520	2131	3494	3801
Sodium	6308	1802	1205	3105	7215	2048	2045	3769	3437
Magnesium	3779	1002	624	1802	3449	858	872	1726	1764
TOC*	3228	98	2	1109	1824	347	91	754	932
BOD**	478	44	-	261	1145	198	28	457	316
Potassium	354	85	94	178	358	97	162	208	192
Oil & Grease	-	-	9	9	383	-	29	208	105
Iron	544	0.5	0.5	182	71	12	2.16	28	106
Nitrate	247	101	3	117	155	24	30	70	93
Phosphate	164	40	18	74	118	6	4	43	59
Ammonia	25	1	0.4	9	221	3	1	75	42
Flouride	57	10	5	24	79	12	10	34	29
Boron	-	-	3	3	15	-	6	10	8
<u>Low Emission Constituents (MT)</u>									
Barium	25.29	0.6	0.21	8.70	8.15	2.07	1.05	3.76	6.23
Manganese	29.19	0.16	0.08	9.81	5.06	0.99	0.22	2.09	5.95
Nitrite	18.06	0.33	3.00	7.13	8.64	-	7.00	8.82	4.82
Zinc	10.04	0.13	0.09	3.42	9.33	2.62	0.51	4.15	3.79
Hexavalent Chromium	5.69	0.82	0.13	2.21	5.62	1	0.21	2.28	2.25
Nickel	10.09	0.18	0.12	3.46	1.77	0.33	0.21	0.77	2.12
Chromium	5.33	0.16	0.13	1.87	1.82	0.55	0.29	0.89	1.38
Copper	2.68	0.18	0.05	0.97	3.67	0.76	0.12	1.52	1.24
Lead	1.14	0.16	0.69	0.66	1.22	1.09	0.51	0.94	0.80
Silver	0.45	0.02	0.05	0.17	0.61	0.07	0.10	0.26	0.22
Cadmium	0.23	0.02	0.04	0.10	0.15	0.05	0.11	0.10	0.10
Mercury	0.11	0.02	-	0.07	0.12	0.02	-	0.07	0.07
<u>Bacteria (trillion cells/yr (cell x 10^{12}))</u>									
Total Coliform	13991	132	146	4756	103163	84120	5295	84193	34474
Fecal Streptococcus	17747	49	19	5938	48985	-	523	24754	13465
Fecal Coliform	1384	7	13	468	16297	1800	490	6196	3332

Source: LAC, DPW, unpubl. data

Note: Mass emissions for 1989 was calculated by adding monthly mass emissions. When parameter was not detected during a particular month, half the minimum detection level was used. Selenium, aldrin, lindane, dieldrin, Heptachlor, heptachlorepoxide, Endosulfan, and Endrin were all not detected at Ballona Creek and not analyzed at Malibu in 1989.

BOD was not analyzed throughout 1989 at Malibu.

Data not available for DDE, DDD, and DDT in 1989.

* TOC - Total Organic Carbon

** BOD - Biochemical Oxygen Demand

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As in the case of aerial fallout, the only effective way to reduce contaminant input via storm/urban runoff is to impose stricter upstream source control measures. While the upstream sources of some contaminants have been identified (at least generally) the exact upstream sources of bacterial contamination have not.

DISTRIBUTION OF CONTAMINANTS

This section contains material which relates to Action Plan Element I-F of Table 13-1, remediation of contaminated sediments. Most contaminants reach Santa Monica Bay in an aqueous medium; a few are dissolved in water but most are attached to particulates which are suspended in water. Once in the Bay the organic or inorganic particulates are re-distributed to some extent, but tend to settle out of suspension and accumulate on-bottom according to two basic criteria: close to their point of entry, and in depositional environments (quiet water where contaminant-bearing particulates settle out of suspension). The so-called "hotspots" of contamination reflect these criteria.

In Santa Monica Bay hotspots are found in the vicinity the HTP and JWPCP outfalls, in embayments such as Marina del Rey, King Harbor, and Ballona Lagoon, and (temporarily) at the mouths of streams and stormdrains. Hotspots began to develop around wastewater outfalls as soon as the outfalls became operational: in 1937 at the JWPCP outfalls on the Palos Verdes Shelf; in 1951 at the HTP 5-mile outfall; and in 1957 at the HTP 7-mile sludge outfall to Santa Monica Submarine Canyon.

Especially high levels of DDT and PCBs were discharged through the JWPCP outfalls until the mid-1970s, several years after the discharge of process wastes to the sewage system was discontinued. However, JWPCP has continued to discharge less-than-secondary treated effluent since then and solids in the (cleaner) effluent have settled out of suspension to cover the highly contaminated sediments. DDT and PCB levels are now highest 6 to 12 inches beneath the sediment surface and are almost undetectable at the surface. While this may have temporarily sequestered the contaminants and kept them from being incorporated into the food web, they remain in the area and are potentially available to be resuspended and reintroduced into the ecosystem.

Fortunately, hotspots of chemical degradation can and do recover once the input of contaminants is curtailed or reduced. This has been observed world-wide and in the study area, as the contaminated sediments are resuspended (through bioturbation or water motion) and are carried by ocean currents out of the area.

In 1987 HTP ceased discharging sludge into Santa Monica Submarine Canyon and in 1988 the sludge field was as much as 140 cm (4.6 ft) deep. Indicators of organic enrichment and contaminant levels were elevated over an area of 20 mi^2 However, sediment sulfide levels decreased within nine months after the discharge was terminated and were only slightly above background values. Within a year organic carbon values decreased 23%, nitrogen 29%, PCBs and PAHs about 48%, and trace metals from 53 to 59%. DDT concentrations actually increased, however, perhaps as surface materials were removed, exposing underlying deposits. By 1990 1 cm of cleaner sediment had covered the sludge.

The mouths of streams and storm drains into Santa Monica Bay constitute point sources which probably create temporary hotspots of contamination. Although appropriate time-series studies have not been conducted just offshore of drains to confirm this, it is expected that the hotspots would only last (in the Bay itself) for a few days after the input has ceased. The concentrations of organic and inorganic substances (for example, oil and grease from roads and parking lots) would be reduced through dilution and dispersion, aided by the stream flow itself as well as the wave energy and currents in the nearshore environment. The reduction in bacterial concentrations would accelerate because of the natural die-off of the organisms in seawater.

Marina del Rey, King Harbor, and Ballona Lagoon are not only depositional locales, but include the mouths of streams or drains which discharge runoff. Thus contamination levels are affected by both criteria for hotspots. Fortunately, they are all relatively small and contaminated sediments can (theoretically) be dealt with readily; in fact some accumulations of toxic substances have probably been removed during maintenance dredging at Marina del Rey and King Harbor.

Contaminant levels in Marina del Rey have fluctuated in recent years, possibly because they derive from nonpoint, and therefore unregulated, sources. Even though its use is banned, for example, the insecticide chlordane is highly concentrated; it may be leeching out of previously treated wooden structure. The limited exchange with the Bay proper reduces the likelihood that existing levels will be reduced by dilution or dispersion.

HABITAT IMPACTS

The impacts summarized in this section provide information which relates to Action Plan Elements IIIA-IIID of Table 13-1, to restore, protect, and manage habitats and watersheds.

Subtidal Benthos

Infaunal assemblages were used to evaluate the "health" of the seafloor even before analytical chemistry was used to monitor contaminant levels directly. Both scientists and lay persons are usually more interested in the effects of pollution on the living resources than in the chemical concentrations themselves. Because the contaminants can be passed up the food web to humans, there is also an indirect concern for their own well-being.

The infaunal assemblages which have inhabited the sediments around HTP and JWPCP outfalls reflect the contamination levels in those sediments. They also reflect the improvements in sediment quality which have taken place during the last 20 years.

As early as 1952 the area around HTP's 1-mi outfall supported infaunal assemblages which were progressively degraded with proximity to the discharge. The assemblage was unaffected 8 mi from it; enrichment characterized the infauna at 1.9 to 4.5 mi away; and within 0.3 mi of the outfall was an impoverished zone. In 1957, the bottom near JWPCP outfalls on the Palos Verdes Shelf was described as "foul" and lacking several important animal groups.

In 1977 benthic communities throughout the study area were characterized using the "Infaunal Index" as being normal, changed, or degraded (Figure 13-5). Eighteen and a half mi^2 of bottom surrounding the HTP outfalls were considered changed, and within this area, 1.2 mi^2 (around the HTP 7-mile outfall) were considered degraded; no degraded communities were observed near the 5-mi outfall. Approximately 33 mi^2 around the JWPCP outfalls on the Palos Verdes Shelf and extending north past Redondo Submarine Canyon were changed, 3.5 mi^2 immediately adjacent to the outfalls were degraded.

By 1991 only 9 mi^2 of bottom in the vicinity of the HTP outfalls were considered "affected" and less than 1 mi^2 next to the (now unused) 7-mile sludge outfall was considered degraded. These represent a 50% reduction in the total area affected by HTP effluents; by 1991 diversity of

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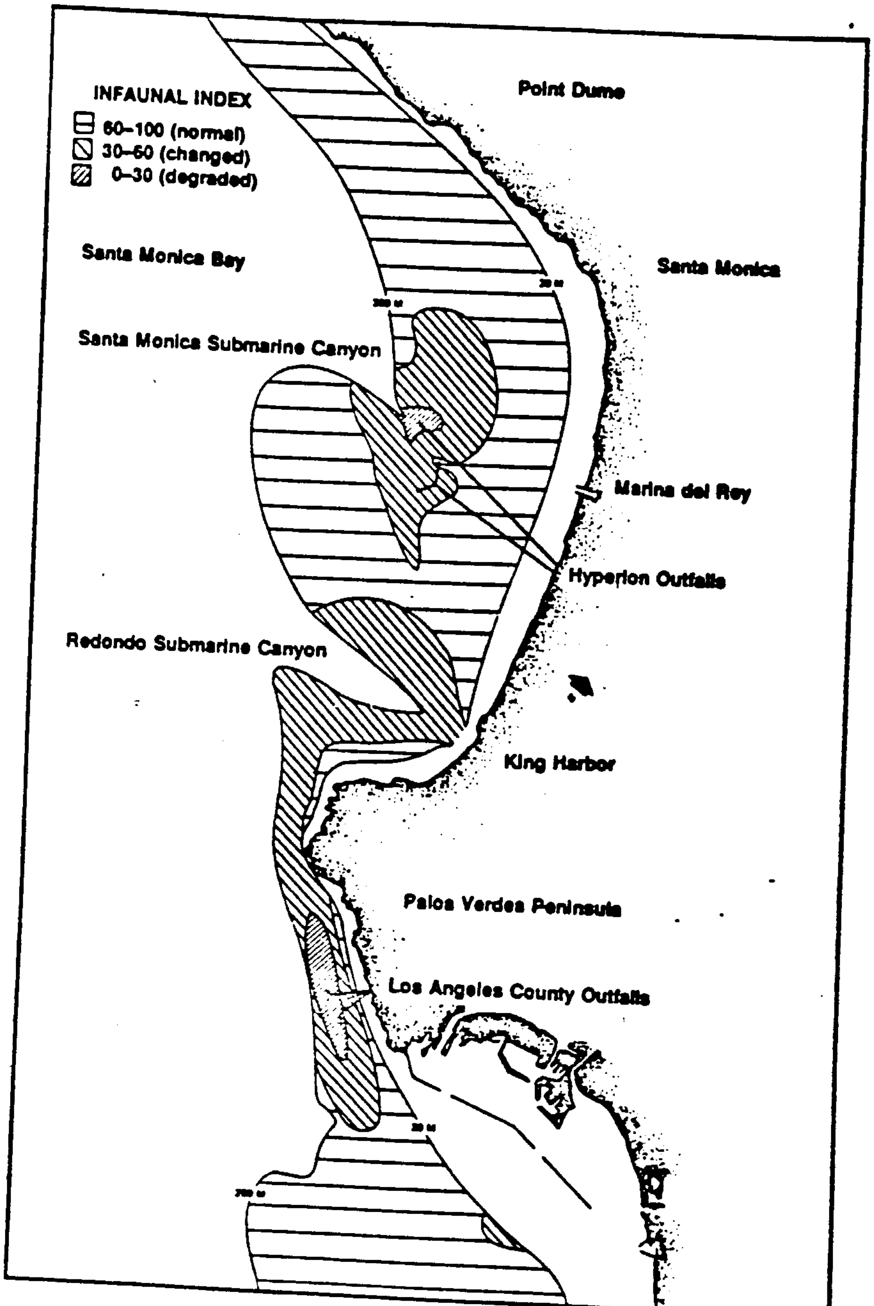

Figure 13-5. Location of normal, changed, and degraded areas in the study area as defined by changes in infaunal index, 1977 (Bascom 1978)

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the infauna had improved throughout the area, just since 1985. All these improvements are attributed to the reduction of mass emissions from HTP: abatement of sludge disposal from the 7-mile outfall, and improved effluent quality from the 5-mile outfall.

Demersal Fish Assemblages

Between 1957 and 1975 the abundance and diversity of demersal fishes were low near both HTP outfalls, but from 1976 to 1979 species richness, biomass, and the size of individual fish were all greater in the 7-mile sludge field than in reference areas. From 1984 to 1986 biomass and abundance were generally high near the outfalls and white croaker was the dominant species, although it was not elsewhere in the Bay. In 1989 and 1990 the numbers of species and individuals were both depressed in the vicinity of the outfalls.

Although the above community-wide measures do not indicate clear recovery at either outfall, examination of individual species suggests that replacement often takes place according to individual species prey preferences. Crustaceans (which are the preferred prey of most common demersal fish) are uncommon near outfalls and so also are species which feed on them. Hornyhead turbot and English sole feed primarily on infaunal polychaetes and mollusks, which dominate near outfalls, and those fish species are also often dominant near outfalls.

Between 1970 and 1976 the abundance and diversity of demersal fishes near the JWPCP outfalls on the Palos Verdes Shelf were severely depressed, however, by 1985 and 1986 the assemblage was showing marked signs of recovery. Previously rare or uncommon species were becoming common while previously abundant species (indicators of outfalls) were becoming less common. These changes coincided with improvement in JWPCP's effluent quality and in changes in the availability of infaunal prey (crustaceans vs. polychaetes) which the fish consumed.

Beaches and Rocky Intertidal Habitats

Prior to development, the coast between Santa Monica and the Palos Verdes Peninsula consisted primarily of sand dunes and sandy beaches, which were moved around by air and water currents. Beach sand is naturally moved offshore by longshore currents; sediment needed to replenish the beach sand lost down submarine canyons was replenished by rivers and creeks flowing into Santa Monica Bay. Dunes behind the beach also supplied sand and provided a buffer between the shoreline and inland development.

The development of coastal structures impacted longshore sediment transport and channelization of drainages reduced the sediment input. These factors, along with rising sea level, have combined to redistribute the available material and erode local beaches to the point that recreation and coastal development are threatened.

Beach nourishment has ameliorated the condition in some places: more than 30 million yd^3 of material have been placed on beaches in Santa Monica Bay since 1938, much excavated from nearby dunes and construction projects or dredged from Marina del Rey. Recently, however, sediments in Marina del Rey were found to be too contaminated with lead and other metals for beach nourishment. Therefore, dredged material has been dumped offshore, to be distributed by longshore currents. Shoreline erosion and accretion continue to be studied in search for methods to protect and restore the beaches of Santa Monica Bay.

Beaches provide habitat for certain species which are of special concern specifically because of the loss of habitat in southern California. The Federal government lists the California

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least tern and the El Segundo Blue (butterfly) as endangered and the Western snowy plover as threatened. California least terns and Western snowy plovers both nest on beaches and salt flats which have been heavily developed and used for recreation. The El Segundo Blue is severely imperiled, as it is restricted to sand dunes where its host plant is found. Other species are being studied because their numbers are declining: the wandering skipper butterfly is another dune inhabitant and the black abalone is found on rocky shores.

Projects underway to protect the California least tern include providing appropriate and undisturbed nesting habitat near suitable foraging areas. One such site at Venice Beach has been very successful, even though it is located on a well used beach. Other potential nesting sites are being identified to further expand the least tern population, including one in the Ballona Wetlands and one at Dockweiler Beach. No projects have been implemented or proposed for Western snowy plover; however, since its nesting requirements are similar to those of the California least tern, future restoration projects may be designed for both.

Efforts to protect the El Segundo Blue have included preserving a small dune area near the western end of LAX and maintaining the population of the butterfly's host plant, the coastal wild buckwheat. Restoration of additional dunes and halting the spread of invasive plants (which displace the buckwheat) will help survival of this species.

More than 50 million people visit the beaches of Santa Monica Bay each year. The beaches between Santa Monica and Redondo Beach receive the heaviest use, as they are most accessible to inland populations. Beaches and rocky intertidal tidepools are used as classrooms by students and naturalists; they also provide bait for fishermen and food for some ethnic groups.

As human use of the beaches and waters of Santa Monica Bay increases, so does trash and the need for beach clean-up, including (unfortunately) the removal of natural debris such as drift kelp which is a natural part of the marine nutrient cycle. The increase in the user population has also meant more marine vessel spills and greater contamination from urban runoff. Floatable materials may impact intertidal species such as California grunion which lay their eggs on beaches. Contaminants may also find their way into the food web, potentially impacting the entire ecosystem.

Kelp Beds

Kelp beds along the Palos Verdes Peninsula began to decrease in size shortly after the first JWPCP outfall became operational in 1937; degeneration began near the outfall site at White Point and spread outward from there. There has been a strong inverse relationship between kelp coverage and mass emissions of total suspended solids (TSS) from JWPCP, and when TSS levels declined between 1974 and 1987, kelp coverage increased. However, the impact of large, destructive storms cannot be discounted as a major factor, as was clear in 1983 and 1988 (Figure 13-6).

Wetlands

Wetlands are covered periodically or permanently with shallow water, and include freshwater, saltwater and brackish water marshes, swamps, and mudflats. Marine wetlands develop where streams enter the ocean across a low, flat coasts and are modified by variable salinities and the tidal cycle. Wetlands help mitigate flooding, filter and recharge groundwater, and provide feeding and breeding habitat for fish and waterfowl. In the past, wetlands were

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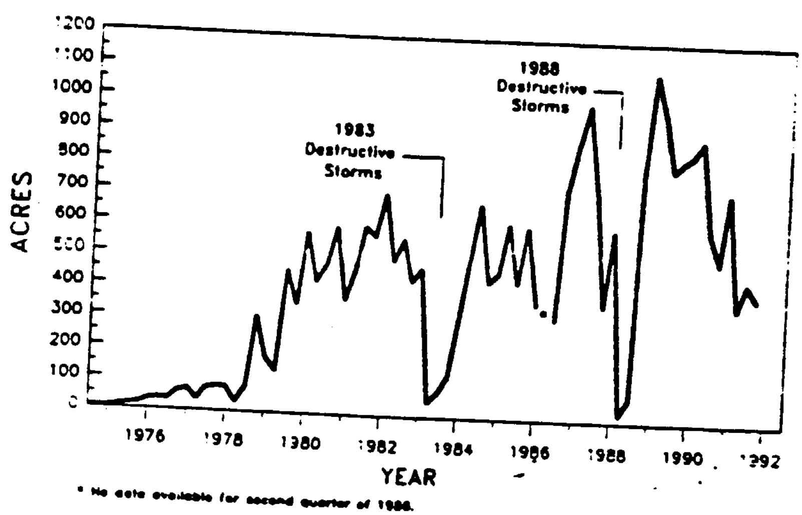

Figure 13-6. Changes in the Palos Verdes Peninsula kelp canopy 1974 to 1992 (modified from CDFG, unpubl. data; LACSD, unpubl. data).

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considered useful only for more "constructive" purposes. Recently the ecological role and importance of wetlands has been recognized.

Ten brackish wetlands occur along the edge of Santa Monica Bay, the largest of which are the Ballona Wetlands Complex (Ballona Wetlands, Ballona Lagoon, Del Rey Lagoon, Oxford Flood Control Basin, and the Venice Canals) and Malibu Lagoon. At one time the Ballona Complex comprised 2,100 acres of wetlands. The development of Marina del Rey, the Venice Canals, and other residential and commercial properties; the draining for agricultural use and to control insect pests; and the channelization of Ballona Creek have reduced the wetlands to less than 160 acres. The 40-acre Malibu Lagoon, at the mouth of Malibu Creek, is also a remnant of a previously larger system. Most wetlands in the study area have reduced biological diversity and productivity because of their degraded condition.

Restricted water flow, which results in poor water quality (high levels of nutrients and/or contaminants), is the main concern at most sites. Additional adverse impacts include the lack of shallow water habitat, disruption of upstream flow, introduction of non-native plants and animals, debris and bacteria from urban runoff, human recreational over-use, and the presence of domestic pets.

The wetlands of Santa Monica Bay support a variety of marine and terrestrial biota; however, many of the species characteristic of pristine saltmarshes of southern California are lacking. Vegetation is often sparse and includes or is dominated by introduced species which have little functional value. The salt-marsh bird's beak (a Federally- and State-listed plant) is no longer found in the area. Belding's savannah sparrow (a State-listed endangered species) is a year-round resident of saltmarshes, foraging and nesting in pickleweed, a dominant plant of the upper marsh. The population of this sparrow was low but stable until 1990, when it began to decline, in part because of predation by introduced red foxes. Attempts to remove the foxes have met with limited success. Other "listed" birds which have not been seen for some time (due to the absence of cordgrass) are the light-footed clapper rail (Federally- and State-listed endangered) and the black rail (State-listed as threatened). The black-necked stilt, a species of concern, has not nested recently in the local wetlands.

Animal communities in the sediments, lagoons, and channels of local wetlands are also less diverse than in the past and some of the most abundant invertebrates found now are indicators of stressed conditions. Some fish species (for example rainbow trout) no longer occur although the tidewater goby was recently reintroduced to its original habitat at Malibu Lagoon. California least tern (State- and Federally-listed) forage in the waters of several of the Bay wetlands.

Although several plans have been developed to preserve and restore the wetlands of Santa Monica Bay, prior attempts have often been confused by the complex issues and often conflicting goals of the regulatory agencies. The extant wetlands have been inventoried (for the Santa Monica Bay Restoration Project) to serve as a basis for a general approach to protection and enhancement. The Port of Los Angeles has developed a Local Wetland Mitigation Program which identifies those wetlands available for mitigation projects. Successful implementation of any of the plans will depend on dedicated individuals and adequate funding.

Restoration at Malibu Lagoon has begun with the regulation of freshwater flow and reintroduction of the tidewater goby. Future plans include reduction of nutrient inputs, recontouring and revegetation of the intertidal habitat, and restoration of former wetlands in the City of Malibu. Rehabilitation of the Venice Canals has also begun and plans have been approved

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to enhance Ballona Lagoon, including removal of debris and exotic vegetation and replacement with native species. Construction of the Playa Vista residential-marina complex depends on development of plans to restore the Ballona Wetlands. The plans are to include: restoration of tidal flow; construction of saltwater marsh, dunes, a freshwater marsh, and a riparian corridor; and fish habitat enhancement in the proposed marina. Suggestions for enhancement of Del Rey Lagoon include increased tidal flow to achieve better water quality.

SWIMMING RISKS

The material summarized below relates to Action Plan Element IIB of Table 13-1, concern for the human health risks associated with swimming in Santa Monica Bay. Concern about the health risks from hazardous chemicals and biological pathogens to swimmers in Santa Monica Bay derives primarily because beaches have been closured due to sewage spills and storm drain runoff. There are no documented (verified) cases of disease or illness which were caused by microbial pathogens or toxic chemicals in the Bay.

Bathers in Santa Monica Bay may be exposed to a variety of harmful chemicals which may produce acute and long-term health effects. However, because etiological relationships between chemical contamination and human health are difficult to establish, health risk analyses of swimming in Santa Monica Bay have focused primarily on biological pathogens.

Pathogenic bacteria that have been found in the Bay include *Pseudomonas*, *Enterobacter/Citrobacter*, *Streptococcus*, *Escherichia coli*, *Klebsiella*, and marine *Vibrio*. These can cause human illnesses ranging from skin infections, gastroenteritis, upper respiratory problems, and wound infections, to pericarditis and spinal meningitis. Human-specific viruses such as hepatitis A, poliovirus, and Norwalk virus have also been found in marine waters and recently Coxsackie B viruses were found in storm drains that discharge to Santa Monica Bay.

The primary source of most human-specific biological pathogens is human fecal waste from treated wastewater discharges, urban runoff, sewage spills, small boat waste discharges, and the bathers themselves. The risk of disease from human fecal contamination is paramount; the relative importance of pathogens from non-human sources is not known.

There has been no evidence (microbial indicator) that the waste fields from HTP or JWPCP have reached shore in the past 10 years, a result of improved treatment and offshore discharges. The largest source of bacterial pathogens to nearshore bathers in Santa Monica Bay is probably urban runoff via storm drains and stormwater overflows into sewage lines (which force untreated sewage back into storm drains, then to the Bay). Because most storm drains discharge directly into the surf zone and because high indicator bacteria counts have been found in storm drain runoff, the surf zone near storm drains is a high risk area, especially during rain storms.

High indicator bacteria levels and human enteric viruses have also been found in storm drains during dry weather. Recent studies in Santa Monica Bay provide evidence of dry-weather biological contamination of urban runoff. Samples from the Pico-Kenter, Ashland, and Herondo Storm Drains and Malibu Lagoon were analyzed for densities of "indicator" bacteria (total and fecal coliforms and enterococcus) and human enteric viruses. Samples were taken variously from inside the drains and from the nearby surf zone at ankle and chest depths. Densities of bacterial indicators were classified as exceeding "excessive limits" or "levels of concern".

In 1989, 1990, and 1991 all three bacterial indicators exceeded levels of concern in generally decreased with water depth and distance from the Drain (Figure 13-7). In 1989 bacterial counts from Pico-Kenter were nearly one-hundred times greater than levels of concern.

All three indicator levels were approximately one order of magnitude lower in ankle-deep water than in storm drains and two orders of magnitude lower in chest-deep water than in the drains. A similar pattern was seen at the Ashland Storm Drain. Bacterial densities were markedly lower in the surf zone, but levels of concern were frequently exceeded up to distances of 150 yd from the Pico-Kenter Drain. In 1989 HTP recorded bacteria levels below levels of concern at a station 200 yd south of Pico-Kenter, suggesting that bacterial contamination may be limited to within 150 to 200 yd from the Storm Drain.

Bacterial densities near Pico-Kenter were much lower in 1991 than in 1990 (Figure 13-7), suggesting that the 600-ft extension to the Drain (which was added in August 1990) reduces bacterial densities in the surf zone.

Human enteric viruses were found in the Pico-Kenter and Herondo Storm Drains and in Malibu Lagoon, indicating that human fecal waste was present in the runoff even during dry weather. Possible sources of the human fecal contamination include leaky sewer lines and septic systems; overflows from blocked sewers; campers, picnickers, or the local homeless population; and illegal discharges from mobile homes or recreational vehicles.

The extent of contamination around storm drains depends on local rainfall, runoff from the surrounding area, and the interval between storms. Densities of all three bacterial indicators were highest during periods of peak rainfall in Los Angeles between July 1989 and June 1990 (Figure 13-8). Bacterial densities are usually highest during the first few months of the rainy season and during the first few hours of a single storm and tend to decrease thereafter.

These ongoing studies have established that the largest potential threat to swimmers in the Bay is from human pathogens in urban runoff, especially at the Pico-Kenter and Herondo Storm Drains and in the Malibu Creek/Malibu Lagoon drainage system.

To assess the potential swimming risk quantitatively it is necessary to conduct an epidemiological study and there appears to be sufficient evidence from biological data to warrant one. Such a study has not been conducted for Santa Monica Bay, although one has been designed and proposed by Dr. Robert Haile, and approved and recommended by the Santa Monica Bay Restoration Project Management Committee.

CONTAMINATED SEAFOOD

The material summarized below relates to Action Plan Element IIA of Table 13-1, concern that seafood collected from Santa Monica Bay is safe to consume.

Marine environments adjacent to heavily populated areas may contain many chemical contaminants. Organisms (including humans) may contact these contaminants through direct water contact or through contact with contaminated sediments. Human health may be at risk through direct contact and by consuming contaminated species. The most extensively studied and tractable contaminants in Santa Monica Bay are heavy metals, PCBs, and DDT and its derivatives.

Historically wastewater outfalls were the principal source of contaminants to the Bay. Recent improvements in effluent quality may have changed this: the sediments contaminated

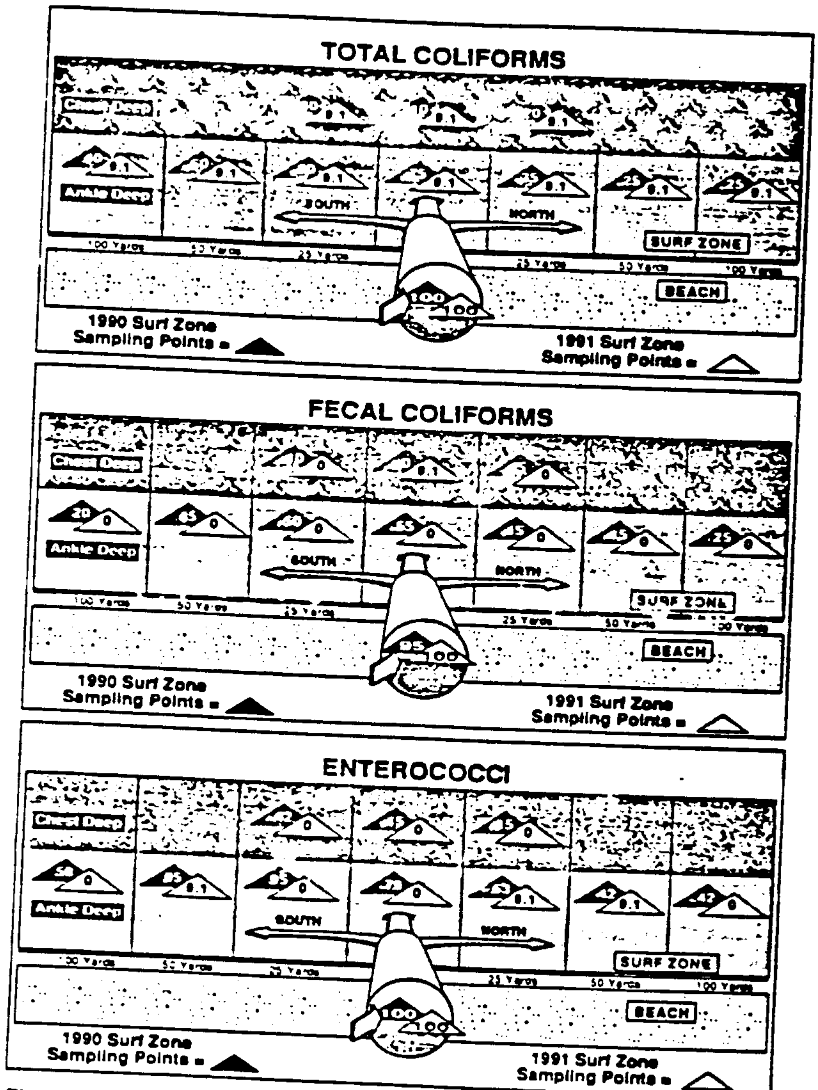

Figure 13-7. Percentage of sampling days where excessive levels of bacterial indicators were exceeded near the Pico-Kenter Storm Drain in 1990 and 1991 (excessive levels: total coliforms = 1,000 cfu/100 ml, fecal coliforms = 200 cfu/100 ml, enterococci = 24 cfu/100 ml). (Gold et al. 1992).

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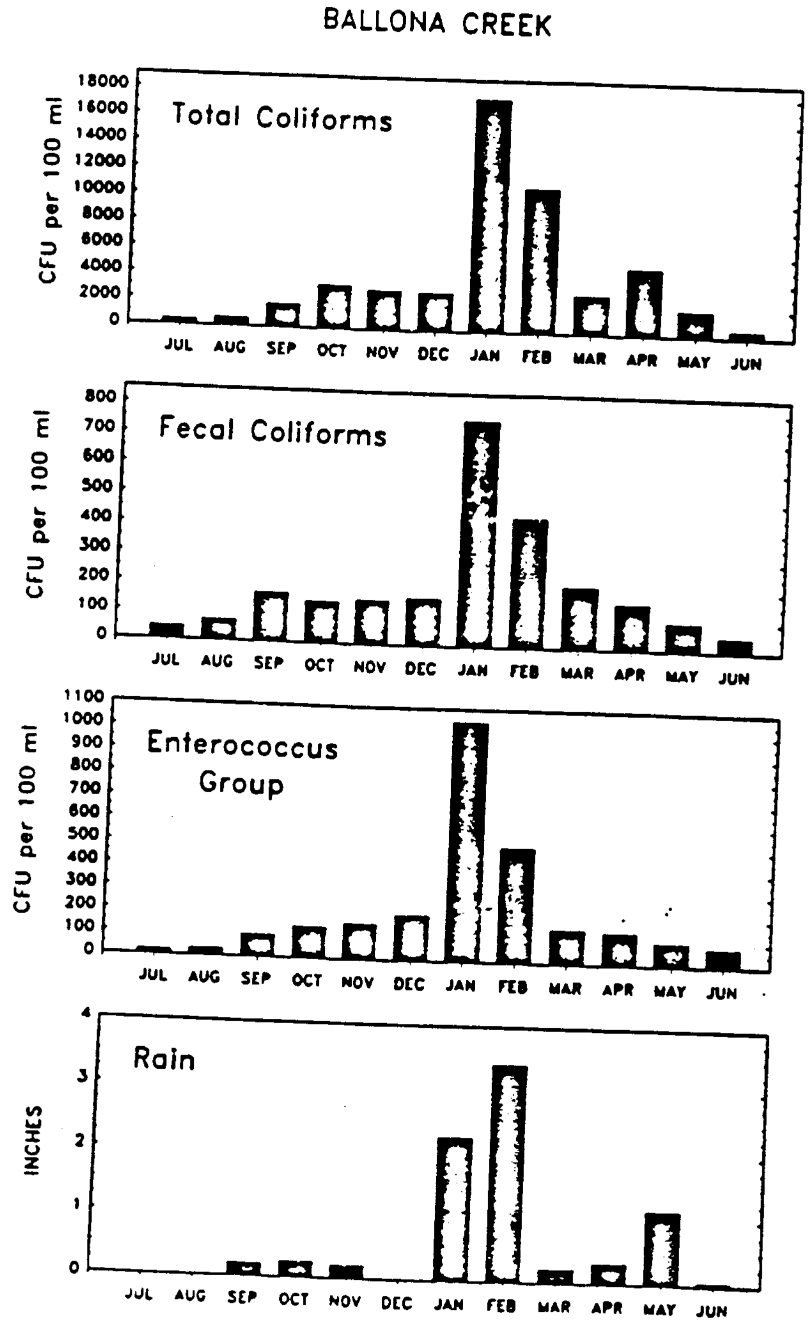

Figure 13-8. Monthly geometric means of indicator bacteria measured in Ballona Creek at Pacific Avenue, sampling year 1989-1990; rain data are in total inches per month (CLA,DPW 1991).

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previously may now constitute a principal source of contaminants along with urban runoff via storm drains, particularly during periods of heavy rainfall or sewage overflows.

In general, metal levels in edible tissue of fishes and invertebrates from near the JWPCP and HTP outfalls in the last ten years have not been substantially elevated over those at reference sites elsewhere in southern California. Since sediments near the outfalls often contain high metal concentrations, actual bioaccumulation and biomagnification of metals in the species studied appear to be minor. Thus seafood consumption does not appear to pose an appreciable health risk from metals contamination.

Organic contaminants such as PCBs and DDT (and DDD and DDE) present the greatest risk to individuals that consume seafood from Santa Monica Bay. High levels of these contaminants in the sediments around the JWPCP and HTP outfalls reflect the massive discharges that occurred in the 1960s and early 1970s. Over the past 25 years several species (especially filter-feeding invertebrates and demersal fishes) from contaminated areas have exhibited very high body-burden levels of PCBs and DDT. Body-burden levels in the late 1970s were much lower than those in the late 1960s, reflecting the ban on dumping these contaminants in the early 1970s.

Body-burden levels of PCBs and DDT have been about the same (at particular sites) throughout the Bay since about 1982, reflecting the persistence of these contaminants over time and suggesting that historically contaminated sediments now constitute a source. The PCBs and DDT discharged to the Palos Verdes Shelf in the 1960s and 1970s continue to bioaccumulate in the tissues of fishes and invertebrates in area.

Because of the persistence of PCBs and DDT in fishes from the Palos Verdes Shelf and northern Santa Monica Bay, the Office of Environmental Health Hazard Assessment (OEHHA) conducted a comprehensive study and risk assessment in 1991. OEHHA measured body burden levels of several contaminants (including PCBs and DDT) in fishes from the Bay and assessed the potential health hazards of consuming the contaminated species.

White croaker is generally the most contaminated fish in the Bay, especially those from highly-contaminated areas such as the Palos Verdes Shelf. The theoretical excess lifetime cancer risk from consumption of white croaker from the Palos Verdes Shelf is approximately 1 in 1,000, based on a theoretical consumption rate of about one 6 oz (170 g) meal per week (23 g/day). Other relatively contaminated species are California corbina, queenfish, surfperches, and California scorpionfish. Pacific bonito, chub mackerel, Pacific sanddab, Pacific barracuda, opaleye, halfmoon, and halibut are less contaminated.

OEHHA also developed (on the basis of 1987 data) site-specific recommendations for seafood consumption from areas of Santa Monica Bay and the Palos Verdes Shelf (Table 13-3) and species-specific recommendations for the most frequently caught and consumed fishes (Table 13-4). OEHHA points out that the inclusion of seafood in the diet is strongly encouraged as a general recommendation. Tables 13-3 and 13-4 reference fishes caught locally and are meant to indicate how often to fish an area and how often to eat specific species from each site.

A recent SMBRP-funded study to determine seafood consumption patterns of anglers that fish in Santa Monica Bay will describe consumption patterns by ethnic group and will identify those groups that are most at risk from consuming contaminated seafood from the Bay. The report will also report angler consumption rates, which may be used to calculate actual health risks rather than those formulated from theoretical consumption rates.

Table 13-3. Site-specific seafood consumption recommendations for several locations in Santa Monica Bay, based on 1987 contaminant levels (Pollock *et al.* 1991).

Site	Fish Species	Recommendation*
Marina Del Rey Redondo Beach Santa Monica Pier Venice Pier Venice Beach Dana Point	All species	No Restrictions
Redondo Pier	California corbina	One meal every two weeks
Malibu Pier	Queenfish	One meal a month
Short Bank	White croaker	One meal every two weeks
Malibu Point Dume Point Vicente Palos Verdes-Northwest	White croaker	Do not consume
White Point	White croaker	Do not consume
	California scorpionfish Rockfishes Kelp bass	One meal every two weeks+

* One meal is about six ounces (170 g).

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Table 13-4. Species-specific seafood consumption recommendations for several fish species of Santa Monica Bay, based on 1987 contaminant levels (Pollock *et al.* 1991).

Fish Species	Contamination Group	Recommendation*
White croaker	HIGH	Avoid Consumption
California corbina Queenfish Surfperches California scorpionfish	MODERATE	Consume not more than one meal every two weeks
Black croaker Barred sand bass Rockfishes Kelp bass	LOW	Consumption not restricted
Pacific bonito Chub mackerel Pacific sanddab Pacific barracuda Opaleye Halfmoon California halibut	LOWEST	Consumption not restricted

* One meal is about six ounces (170 g).

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APPENDIX A

List of Acronyms

Appendix A. List of Acronyms. Santa Monica Bay Characterization Study, 1993.

AHF	University of Southern California, Allan Hancock Foundation
BHC	Benzene hexachloride
BLM	United States Department of Interior, Bureau of Land Management
BMPS	Best Management Practices
BOD	Biochemical oxygen demand
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CCC	California Coastal Commission
CCMP	Comprehensive Conservation and Management Plan
CDFG	California Department of Fish and Game
CDFG,MRO	California Department of Fish and Game, Marine Resources Division
CDFG,OSPR	California Department of Fish and Game, Oil Spill Prevention and Response
CDHS	California Department of Health Services
CDPR	California Department of Parks and Recreation
CEG	Coastal Ecology Group
CEPA	California Environmental Protection Agency
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CLA,BE	City of Los Angeles, Bureau of Engineering
CLA,DA	City of Los Angeles, Department of Airports
CLA,DPW	City of Los Angeles, Department of Public Works
CLA,DWP	City of Los Angeles, Department of Water and Power
CLA,EMD	City of Los Angeles, Environmental Monitoring Division
CLTRT	California Least Tern Recovery Team
CNPS	California Native Plant Society
COD	Chemical oxygen demand
CPFV	Commercial Passenger Fishing Vessel
CPUE	Catch per unit effort
CRWQB,LAR	California Regional Water Quality Control Board, Los Angeles Region
CSCC	California State Coastal Conservancy

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Appendix A (Cont).

CSG,MAP	California Sea Grant, Marine Advisory Program
CSM,PPD	City of Santa Monica, Program and Planning Department
CSM,SMPPD	City of Santa Monica, Program and Planning Department
CSWPCB	California State Water Pollution Control Board
CSWQCB	California State Water Quality Control Board
CSWRCB	California State Water Resources Control Board
CWA	Clean Water Act (of 1972)
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved oxygen
EIS	Environmental impact statement
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Agency
EQA	Environmental Quality Analysts, Inc.
FDA	Food and Drug Administration
FWS	Fish and Wildlife Service (see also USFWS)
HCH	Hexachlorocyclohexane
HERS	Hyperion Energy Recovery System
HTP	Hyperion Treatment Plant
IRC	Intersea Research Corporation
JWPCP	Joint Water Pollution Control Plant
kg	Kilogram
km	Kilometer
LAC,A-C	Los Angeles County, Auditor-Controller
LAC,DBH	Los Angeles County, Department of Beaches and Harbors
LAC,DPW	Los Angeles County, Department of Public Works
LAC,DRP	Los Angeles County, Department of Regional Planning
LAC,MNH	Los Angeles County Museum of Natural History

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LAC,OCAO	Los Angeles County, Office of Chief Administrative Officer
LACSD	Los Angeles County Sanitation Districts
LAX	Los Angeles Airport
LFCRRT	Lightfooted Clapper Rail Recovery Team
m	Meter
MBAS	Methylene blue activated substance (e.g. detergent)
mgd	Million gallons per day
ml	Milliliters
MMS,OCSNC	Minerals Management Service, Outer Continental Shelf National Compendium
MMS,POCSR	Minerals Management Service, Pacific Outer Continental Shelf Region
MOA	Memorandum of Agreement
MPN	Most probable number
MT	Metric ton (1000 kg)
MTP	Maguire Thomas Partners
MTP-PV	Maguire Thomas Partners-Playa Vista
NAS	National Audubon Society
NEP	National Estuary Program
NEPA	National Environmental Protection Act
NFSP	National Marine Fisheries Service, National Fishery Statistics Program
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEL	"No Observed Adverse Effect Level"
NOEL	"No Observed Effects Level"
NPDES	National Pollutant Discharge Elimination System
NRC,COWT	National Research Council, Committee on Ocean Waste Transportation
NWP	Nation Wide Permits
OCS	Outer continental shelf
PAC	Port Area Committee
PAH	Polycyclic (or polynuclear) aromatic hydrocarbon
PCB	Polychlorinated biphenyl
POLA	Port of Los Angeles

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Appendix A (Cont).

ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand, also 0/00
PSP	Paralytic shellfish poisoning
RfD	Reference dose
RWQCB,LAR	Regional Water Quality Control Board, Los Angeles Region (see CRWQCB)
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Water Research Project
SCE	(The) Southern California Edison Company
SCE,SGD	Southern California Edison, Steam Generation System
SCUBA	Self-contained underwater breathing apparatus
SDWG	Sediment Dynamics Workshop Group
SL	Standard length; in fish, from the snout to the base of the tail
SMB	Santa Monica Bay
SMBRP	Santa Monica Bay Restoration Project
SMNRA	Santa Monica National Recreation Area
SMW	State Mussel Watch
SWCP	State Wetlands Conservation Plan
TBT	Tributyl tin
THUMS	Texaco Humble Union Mobile Standard
TICH	Total identifiable chlorinated hydrocarbon
TLVRCO	Topanga-Las Virgines Resources Conservation District
TOC	Total organic carbon
tpd	Tons per day
TSCA	Toxic Substance Control Act
TSS	Total suspended solids
TVS	Total volatile solids
USACE	United States Army Corps of Engineers
USACOE/LAHD	United States Army Corps of Engineers/Los Angeles Harbor Department
USEPA	United States Environmental Protection Agency

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Appendix A (Cont).

UCLA & WCC	University of California at Los Angeles and Woodward-Clyde Consultants
USCB	United States Census Bureau
USFWS	United States Fish and Wildlife Service
WCC	Woodward-Clyde Consultants
WSED	Wastewater Systems Engineering Division
ww	Wet weight

APPENDIX B

Glossary

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208 PLANNING	Authorized under Section 208 of the 1972 amendments to the Federal Water Pollution Control Act to control non-point source pollution.
AEROBIC	Living, active, or occurring only in the presence of oxygen.
ALDRIN	A cyclodiene insecticide which is extremely toxic from skin absorption.
ALGAE	A group of chiefly aquatic nonvascular plants which lack flowers and produce organic compounds by the process of photosynthesis. Includes one-celled algae such diatoms and dinoflagellates as well as multicellular seaweeds and kelps.
AMPHIPOD	A small (most are well under an inch long) shrimp-like crustacean of the order Amphipoda. Sand fleas are a common example.
ANAEROBIC	Living, active, or occurring in the absence of oxygen. Some bacteria live only in the absence of oxygen and in the course of normal respiration produce the hydrogen sulfide which is characteristic of anoxic sediments.
ANNELID	Any of a phylum (Annelida) of segmented worms, including polychaetes.
ANOXIC	Lacking oxygen; said of water or sediment.
ANTHROPOGENIC	Made or caused by man; said of substances such as DDT or effects such as elevated water temperatures.
AQUIFER	An underground rock, sand, or gravel formation that yields water.
AROMATIC	A class of (often persistent) organic compounds characterized by at least one benzene ring.
ASSEMBLAGE	A group of species that occur together. See Community.
ADVECTION	The horizontal movement of air.
BACTERIOPLANKTON	Planktonic bacteria
BAITFISH	Small, schooling pelagic fish (such as anchovy) which are preyed upon by larger game fish and hence are used as bait by sport fishermen.
BENEFICIAL USE	Water protected under the Porter-Cologne Act including domestic, municipal, agricultural and industrial water; power generation; recreation; navigation; and preservation of fish, wildlife, and aquatic resources.
BENTHIC	Living on or in the sea floor.

BENTHOS	The bottom of the ocean; also, collectively, the biota living on or in the bottom.
BEST MANAGEMENT	Steps by which water quality is protected, usually from nonpoint sources such as agriculture, construction, mining, logging or urban runoff. These steps can also be applied to point source waste discharges.
BIOACCUMULATION	The accumulation of a substance (usually a contaminant) in the tissues of an organism.
BIOASSAY	A test which measures the lethal or sub-lethal effects of a substance (or composite mixture) on living organisms or tissues.
BIOCHEMICAL OXYGEN DEMAND (BOD)	The amount of oxygen used by organic matter in water. High levels of BOD can remove oxygen needed to support fish and aquatic life.
BIODEGRADATION	A biochemical (i.e. conducted by living organisms) process by which complex substances are broken down into simpler ones; said especially of toxic substances which are detoxified by the process.
BIOMAGNIFICATION	The accumulation of a substance (usually a contaminant) at greater tissue concentrations in successively higher-level consumers with increasingly higher contaminant levels as prey are consumed up the food chain.
BIOMASS	The weight of living tissue, of an organism or a group of organisms. Often includes the weight of non-living material (such as a snail's shell) which was produced by the organism(s).
BIOTA	The plants and animals found in a particular environment.
BIOTURBATION	Disruption of sediment caused by animal activity.
BIVALVE	A mollusk having two shells hinged together, as the oyster, clam, or mussel.
CARBON DIOXIDE (CO2)	A colorless, odorless, incombustible gas present in the atmosphere and formed during respiration.
CARCINOGENIC	Having the capacity to cause cancer.
CATCH PER UNIT EFFORT (CPUE)	The numbers or pounds of organisms which are collected in a standard sampling or fishing effort.
CETACEAN	Whales, dolphins, and porpoises, all of which are sometimes placed in the order Cetacea.
CHLORDANE	An insecticide and fumigant (for termites) which is toxic by ingestion, inhalation, and skin absorption.
CHLORINATED HYDROCARBONS	Organic compounds that contain chlorine and have toxic properties in varying amounts; pesticides and solvents such as DDT, DDD, DDE, and PCB.

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CHLOROPHYLL	The pigment which makes most plants green and enables them to produce organic substances in the process of photosynthesis.
CLEAN WATER ACT	The federal water quality control law governing surface waters establishing water quality objectives, waste discharge standards, and the NPDES permit process; also called the Federal Water Pollution Control Act, amended.
CLEAN WATER GRANT	Apportioned under Clean Water Act for upgrading or constructing publicly-owned and operated sewage treatment facilities.
COLIFORM	Relating to, resembling, or being the colon bacillus bacteria.
COMMUNITY	All plants and animals living in a particular place or habitat and which interact with one another. Some scientists use the term assemblage to denote a community when interactions among the species cannot be defined.
CONDUCTIVITY	A measure of salinity in water determined by conduction of electricity; generally related to the chloride ion concentration (or chlorinity).
CONTAMINANT	An unnatural (man-made) substance found in the environment or a naturally occurring substance or compound which is found in unnaturally high concentrations; a health hazard; a pollutant.
CORALLINE	Consisting of or containing deposits of calcium carbonate which would include any of the various corallike animals or calcareous algae.
CRUSTACEAN	An animal belonging to a class or phylum of organisms (Crustacea) which have a hard exoskeleton and jointed legs and body; includes crabs, lobster, amphipods, and shrimp.
CUBIC FEET PER SECOND (cfs)	The flow of water past a given point over time at the equivalent of 449 gal/min or 1.98 acre-ft/day.
DBCP (dibromochloropropane)	A pesticide and fungicide extensively used until banned in 1977 as a suspected carcinogen.
DDT (dichlorodiphenyl-trichloroethane)	A toxic insecticide banned in 1970 but still widely found in water and fish samples.
DEMERSAL	On or near the sea floor.
DETRITUS	Fine, disaggregated particles of inorganic and organic material (i.e. dead plant and animal matter), either in suspension on settled on the bottom of a water body. Forms the basis of an extensive food web in the ocean.
DIATOM	Any of a class (Bacillariophyceae) of minute planktonic unicellular or colonial algae with silicified skeletons.

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DIELDRIN	An insecticide toxic by ingestion, inhalation, and skin absorption. It is carcinogenic. Its use is now restricted to nonagricultural applications.
DINOFLAGELLATES	Important plantlike elements of plankton having two flagella.
DIOXIN	2,3,7,8-tetrachlorodibenzo-p-dioxin, a contaminant of a herbicide, banned by the FDA for most purposes after ten years of use. It was also a contaminant in defoliants used in Vietnam (agent orange). It is a carcinogen, a teratogen, and a mutagen.
DISINFECTION	Process where effluent is treated with a disinfectant (e.g. chlorine) to kill bacteria and viruses.
DISSOLVED OXYGEN (DO)	Oxygen (parts per million) which is dissolved in water; the source of most oxygen used by plants and animals in their normal respiration. The dissolved oxygen in seawater replenished by exchange with the air or produced by plants during photosynthesis.
DIVERSITY	A parameter of ecological communities which describes the relationship between the number of species and their abundance.
ECHINODERM	An invertebrate animal having radial symmetry and belonging to the phylum Echinodermata. Includes starfish and sea urchins.
ECOSYSTEM	The sum of all plants, animals, and non-living components of a particular defined area. A given kelp bed may be viewed as an ecosystem, but it is also part of the larger coastal or Bay ecosystem.
EFFLUENT	The material which flows out of a pipe or facility into a water body (or another larger pipe). Wastewater which has undergone treatment to remove pollutants.
EL NIÑO	An aperiodic change in the oceanic climate of the Pacific whereby warm, low-nutrient water flows east along the Equator, north along the west coast of North America and south along South America. The condition lasts for several months or 2-3 years, causing a change in the biota and climate of an area.
EMBAYMENT	A body of water forming an indentation of the shoreline, larger than a cove but smaller than a gulf.
ENDOSULFAN	An insecticide which is toxic by ingestion, inhalation, and skin absorption. Use is restricted.
ENDRIN	A stereoisomer of dieldrin, used as an insecticide to control crop insects and mites. It is a carcinogen, and toxic by inhalation and skin absorption.
ENTERIC	Relating to the intestines.
ENTEROCOCCUS	Any of a genus (*Streptococcus*) of nonmotile, usually parasitic, gram-positive bacteria occurring in the intestine that divide only in one plane and which occur in pairs or chains.

EPIBIOTA	Organisms living on the surface of the seafloor.
EPIDERMAL TUMORS	Tumors located in the outer, nonvascular, layer of the skin.
EPIFAUNA	Benthic animal living on the surface of bottom material.
EROSION	Deterioration of earth or rock by water, glaciers, winds, and waves.
ERYTHROCYTE	One of the red cells of the blood.
ESTUARY	The coastal portion of a river mouth where the fresh, river water mixes with the saltwater of the ocean. The degree of mixing and layering (fresh water tends to float on top of the sea water) depends on tidal conditions, river flow, and local currents. Estuaries typically support a biota which can tolerate varying salinities and therefore differ from marine and freshwater biotas.
EUPHAUSIID	Any of an order (Euphausiacea) of usually luminescent, shrimp-like crustaceans which are important components of plankton; also known as krill.
EUTROPHIC	Describing a situation in which excess nutrients have led to excessive plant growth; when the plants die and decompose, dissolved oxygen is used up, making the water uninhabitable by animals. Erosion, sewage discharges, fertilizers and detergents speed the process.
FAUNA	The animal life of a community, habitat, or ecosystem.
FECAL COLOFORM (bacteria)	A class of bacteria which are found in the intestinal tracts of mammals, including man. Fecal coliform bacteria are not dangerous themselves, but their abundance is measured in water as an indication of raw sewage and thus the potential for the presence of pathogenic organisms.
FEDERAL WATER POLLUTION CONTROL ACT, as amended	Original title of Clean Water Act.
FLOOD CONTROL BASIN	An area to temporarily hold water to prevent flooding of lands downstream.
FLORA	The plant life of a community, habitat, or ecosystem.
FOLIOSE	Describes having leaves of a specified number or type, or a thin leaflike stratum or layer.
FORB	Any herb that is not a grass or grasslike.
FOOD WEB	A symbolic description of the interdependence of the organisms of a community, based on who eats whom.
GENOTOXIC	Any substance that is toxic to a specific plant or animal as a group.
GEOCHRONOLOGICAL	Relating to the chronology of the earth as indicated by geological data.

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GEOSTROPHIC	Current flow resulting from the deflective forces caused by the rotation of the earth.
GILLNET	A curtainlike net, suspended vertically in the water for the purpose of entrapping fish by their gills.
GROIN	A small jetty extending from the shore to prevent beach erosion.
GROUNDWATER	Water in the spaces between soil and rock particles; water under the subsurface from which wells and springs are fed.
HABITAT	A particular place or environment which supports a particular assemblage of organisms. Most habitats are described in terms of physical parameters such as sediment type and water depth, but the concept also includes chemical attributes of the water column and living components (a mussel, for example, provides a place for other organisms to attach).
HAZARDOUS WASTE	A waste or combination of wastes, which may cause or contribute to death or serious illness or pose a potential hazard to human health or the environment.
HEPATOPANCREAS	A glandular organ of a crustacean that combines the digestive functions of the vertebrate liver and pancreas.
HEPTACHLOR	A persistent cyclodiene chlorinated hydrocarbon insecticide, toxic by ingestion, inhalation, and skin absorption. Use has been restricted and discontinued except for termite control.
HEPTACHLOREPOXIDE	Insecticide, a degradation product of heptachlor.
HERBICIDE	A substance which is capable of killing or stunting the growth of plants.
HERBIVORE	An animal that eats plants.
HYDROCARBON	An organic compound composed of the elements hydrogen and carbon; natural gas, coal, and petroleum are important naturally occurring hydrocarbons.
INDICATOR	An organism or ecological community so strictly associated with particular environmental conditions that its presence is indicative of the existence of these conditions.
INDIGENOUS	Native, or belonging to a particular region or local ecosystem; said of plants and animals as well as of humans.
INFAUNA	Collectively, the invertebrates that live in, beneath, and just at the surface of unconsolidated soft sediments.
INSECTICIDE	A substance which is capable of killing insects, either by direct application or by ingestion.
INSOLATION	Solar radiation.

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INTERTIDAL	That portion of the shore or structures in the ocean which is between high and low tide levels; the substrate and organisms in the intertidal are alternately covered by seawater and exposed to the air.
KILOGRAM (kg)	A standard metric unit of weight (mass) equivalent to 1,000 grams or about 2.2 pounds.
KILOMETER (km)	A standard metric unit of length (distance) equivalent to 1,000 meters or about 0.6 mile.
LARVA	A young or juvenile stage (of some species) which differs in basic body form from that of the adult; the plural is larvae.
LINDANE	A pesticide (hexachlorocyclohexane) consisting chiefly of the gamma isomer of BHC, which is toxic by ingestion, inhalation, and skin absorption. Its use is restricted.
LIPID	Substances that are soluble in nonpolar organic solvents and includes fats and oils; along with proteins and carbohydrates are major structural components of living cells.
LITER (*l*)	A standard metric unit of volume, equivalent to 1,000 cubic centimeters or 0.26 gal.
MEIOFAUNA	Very small (less than about 0.5 mm) organisms found in sediments.
MEROPLANKTON	Planktonic eggs and larvae of invertebrates and fish.
METABOLISM	The sum total of all chemical processes which go on in an organism and give it life; the major kinds of metabolism include the breakdown of some substance and the synthesis of others.
METER (m)	A standard metric unit of length or distance, the equivalent of about 3.3 feet or 1.1 yard.
METRIC TON (MT)	A standard metric unit of weight (mass), the equivalent of 1,000 kilograms, 2,200 pounds, or 1.1 English tons.
MICROGRAM (μg)	A metric unit of weight which equals one millionth of a gram.
MICROLAYER (Sea Surface)	The very thin, upper surface layer of the ocean, at which organic substances, toxicants, and pathogens accumulate at greater concentrations than in the water column itself.
MILLIGRAM (mg)	A metric unit of weight which equals one thousandth of a gram.
MILLIGRAMS PER LITER (mg/*l*)	Concentration of a substance in water equaling 0.001 g in 1,000 *ml* of water. Approximate equivalent - parts per million.
MILLION GALLONS PER DAY (mgd)	Measure of water or wastewater flow equal to about 0.5 cubic feet per second or 3.78 million liters per day.

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MOLLUSC(K)	An invertebrate animal which belongs to the phylum Mollusca and which has an unsegmented body and usually with a hard outer shell. Includes clams, mussels, snails, chitons, squid, and nudibranchs.
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)	Standards for waste discharges from point sources to surface waters (rivers, lakes, bays, oceans, etc.) controlled by state or federal agencies under provisions of Clean Water Act.
NEKTON	Free-swimming aquatic animals, independent of wave and current action.
NEMATODE	Elongated cylindrical worms (round worms) of the phylum Nematoda parasitic in animals or plants or free-living in soil sediments or water.
NEOPLASM	A tumor-like area of (abnormal) cell growth; a new growth of tissue serving no physiological function.
NERITIC	Relating to the region of shallow water (over the continental shelf) adjoining the seacoast.
NITRATE	Ion containing nitrogen and oxygen; its excess in water will stimulate the growth of algae.
NONPOINT SOURCE	A widespread, diffuse, or unidentifiable source of contaminants that comes from more than one point which cannot be controlled or easily monitored; it therefore does not involve an NPDES permit.
NUISANCE WATER	A component of surface runoff which includes street runoff from domestic washdown and irrigation water but not rainfall.
NUTRIENTS	Elements necessary for plant growth. Nitrogen and phosphorous are the most common. Excess nutrients in surface waters stimulate plant and algae growth.
OLIGOCHAETE	An annelid worm of the class Oligochaeta; these are more common on land (e.g. earthworms) than in the sea.
OMNIVORE	A consumer which eats many types of foods, including both plants and animals.
ORGANIC	In the chemical sense, a compound that contains one or more atoms of the element carbon (not applied to simple carbon compounds such as carbon dioxide or cyanide); more generally, produced by, derived from, or having to do with organisms.
PAPILLOMA	A benign tumor due to overgrowth of the epithelial tissue on papillae of vascular connective tissue.
PARTS PER BILLION (ppb)	Number of units per billion units. (e.g. μg/kg)
PARTS PER MILLION (ppm)	Number of units per million units. (e.g. mg/kg)
PELAGIC	Of, in, or pertaining to the water column as opposed to the bottom of the ocean.

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PERCOLATION	Movement of water through rock or soil.
PESTICIDE	Any substance which is used to control (usually by killing) pests, including insecticides, herbicides, algicides etc.
pH	A measure of the acidity or alkalinity of a fluid which ranges from 1 to 14. A pH of 7.0 is neutral, while 3 is very acidic and 12 is very alkaline (basic).
PHENOL	Aromatic organic compounds in which one or more hydroxy groups are attached directly to the benzene ring.
PHYTOPLANKTON	Small (generally one-celled) drifting plants including blue-green algae, flagellates and diatoms.
PINNIPEDS	A seal or sea lion, both of which are sometimes placed in the order or suborder Pinnipedia.
PLANKTON	Generally relatively small organisms which drift passively with currents, and are unable to swim against them.
POINT SOURCE	A single source from which contaminants enter the receiving water body; usually a discharge pipe or structure which is regulated under an NPDES permit.
POLLUTANT	In general, the same as a contaminant, i.e. some substance present in an environment at unnatural concentrations or levels. Some persons define a pollutant as a contaminant which has an adverse impact on the environment or which comes from an anthropogenic source.
POLYCHAETE	An annelid worm of the class Polychaeta; these are found only in the ocean.
POLYCHLORINATED BIPHENYLS (PCBs)	An extremely toxic group of industrial chemicals used in capacitors, transformers, and carbonless paper. Manufacture of this product was banned in 1976 and its use discouraged.
PORTER-COLOGNE WATER QUALITY CONTROL ACT	1970 California law defining water rights and pollution control programs.
PRELIMINARY TREATMENT	Initial stage of sewage treatment which includes screening, pulverization, and grit removal.
PRIMARY TREATMENT	Sewage treatment which includes the removal of much of the suspended solids by sedimentation but not colloidal and dissolved matter. It does not include biological oxidation and usually consists of clarification with or without chemical treatment.
PRIMARY CONSUMER	Animals that eat plants.
RAW SEWAGE	Untreated sewage.
REGIONAL WATER QUALITY CONTROL BOARDS	Nine regional boards in California that plan and enforce water quality standards within their boundaries.

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RESIDENCE TIME	The estimated, average time that a water parcel spends in a confined or semi-confined region before being exchanged with the open ocean.
RESPIRATION	The collective metabolic processes by which an organism converts stored chemical energy into physical energy in order to remain alive; involves the use of oxygen and the production of carbon dioxide.
RIPARIAN	Area next to a river; bank of a stream.
RUNOFF	Water that is not absorbed into the ground and hence which flows into streams or other bodies of water, or into a drain or sewer.
SALINITY	The standard measure of the "saltiness" of seawater, measured as the weight of salts (primarily sodium chloride) per unit of water and expressed as parts per thousand or grams per liter. The salinity of normal seawater is between 33 and 35 ppt.
SEAWATER INTRUSION	A condition that occurs when seawater enters an aquifer near the coast, generally resulting from the removal of freshwater via wells.
SECONDARY CONSUMER	Animals that eat other animals, particularly primary consumers.
SECONDARY TREATMENT	Sewage treatment that includes the reduction of organic material and solids by bacterial decomposition; about 85% of the BOD and suspended solids are removed. It consists primarily of clarification followed by a biological process to produce sludge.
SEDIMENTATION	Deposition or settlement of suspended matter in water, wastewater, or other liquids.
SESSILE	Permanently attached, not free to move about.
SHELLFISH	Molluscs (such as oysters, clams, and abalone) and crustaceans (such as crab and lobster) which have a hard outer shell or exoskeleton and are of sport or commercial interest.
SLUDGE	The solid material which settles, or is precipitated, out of sewage during the treatment process.
SPOROPHYTE	A young plant developed from a spore
STATE WATER RESOURCES CONTROL BOARD	State agency responsible for water rights and pollution control.
STRATIFIED	Occurring in distinct layers, separated by a sharp difference in some parameter. In the ocean, where the layers are of different densities, the boundary is called a pycnocline. If the difference is in temperature, the sharp difference, the pycnocline, is also a thermocline; if in salinity, it is also a halocline. Freshwater tends to float on top of saltwater and warm water on top of cold water.

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SUCCESSION	Unidirectional change in the composition of an ecosystem or ecological community as the competing organisms modify the environment.
SUSPENDED SOLIDS	Organic and inorganic material which is in suspension in seawater or in a waste effluent.
SYNERGISTIC	Having the capacity to work together such that the total effect is greater than the sum of the individual effects.
TEMPERATE	The region between the Tropic of Cancer and the Arctic Circle or between the tropic of Capricorn and the Antarctic Circle; the biota associated with this region.
TERTIARY TREATMENT	Sewage treatment that includes the removal of nutrients (e.g. nitrogen and pholphorus compounds) and most of the remaining suspended solids.
THERMOCLINE	A boundary layer in a thermally stratified body of water that separates upper, warmer, less dense water from lower, colder, denser water.
TOTAL DISSOLVED SOLIDS (TDS)	Solids that are able to pass through a filter but which remain following evaporation; generally consist of salts.
TOXAPHENE	A chlorinated camphene insecticide, toxic by ingestion, inhalation, and skin absorption. Most uses are prohibited; widely used and persistent; used on cotton, tomatoes, and many field crops.
TOXIC	Lethal or damaging to humans or other living animals such as plants, pets, fish, and wildlife.
TRACE METAL	Metallic elements such as cadmium, chromium, lead, nickel, silver, and zinc which occur naturally in "trace" amounts in ocean water. They are of concern because 1) their concentrations may be increased through man's activities; 2) they do not degrade; 3) their concentration may be biomagnified through the food chain; and 4) they may be toxic at high concentrations, even though many are required for the normal functioning of organisms.
TRACER	A chemical (or bacterium) used to track the transport and fate of contaminants from a particular source.
TUNICATE	Any marine chordate having a saclike body enclosed in a thick membrane or tunic.
TURBIDITY	Water cloudiness; determined by the amount of material (living and non-living) which is suspended in a parcel of water. High turbidity reduces the penetration of light.
WASTE DISCHARGE REQUIREMENTS	Waste discharge conditions adversely affecting waters of state and regulated by the Regional Water Quality Control Board and sometimes the State Water Resources Control Board.
WASTEWATER RECLAMATION	A process where pollutants are removed so that the water can be reused.
WASTESHED	The land area encompassing the service area of a municipal wastewater treatment plan.

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WASTEWATER	Sewage; a combination of water-carried wastes and liquid from industrial plants, residences, and commercial buildings.
WATERSHED	The total land from which rain water drains into a particular stream, drain, or body of water; the drainage basin.
WETFISH	Fish that are packed in a can first and then cooked; pelagic wetfish in southern California include small schooling species such as Pacific sardine, northern anchovy, chub (=Pacific) mackerel, and jack mackerel, all of which are harvested by purse seine.
WETLANDS	A collective term which describes areas where permanently or frequently wet conditions produce particular plant and animal communities; includes saltmarshes, freshwater marshes, and tidal mudflat habitats.
ZOOPLANKTON	Small drifting animals. See plankton.

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APPENDIX C

List of Common and Scientific Names.

Appendix C. List of Common and Scientific Names. Santa Monica Bay Characterization Study.

Common Name	Scientific Name
abalone	*Haliotis spp.*
American kestrel	*Falco sparverius*
amphipod	Amphipoda
anemone	Anthozoa
annelid	Annelida
armed box crab	*Mursia gaudichaudii*
arrow goby	*Clevelandia ios*
arrow worms	Chaetognatha
auklet	Alcidae, unid.
barnacle	*Balanus spp.*
barnacle	*Chthamalus spp.*
barnacle	Cirripedia
barred sand bass	*Paralabrax nebulifer*
barred surfperch	*Amphistichus argenteus*
basking shark	*Cetorhinus maximus*
bat ray	*Myliobatis californica*
bay shrimp	*Crangon spp.*
beach bloodworm	*Euzonus mucronata*
beach hopper	Talitridae
beach morning glory	*Convolvulus soldanella*
beach primrose	*Camissonia (Oenothera) cheiranthifolia*
bean clam	*Donax gouldi*
Belding's savannah sparrow	*Passerculus sandwichensis beldingi*
bigmouth sole	*Hippoglossina stomata*
black abalone	*Haliotis cracherodii*
black oystercatcher	*Haematopus bachmani*
black perch	*Embiotoca jacksoni*
black rail	*Laterallus jamaicensis*
black turnstone	*Arenaria melanocephala*
blacksmelt	*Bathylagus spp.*
blackspotted bay shrimp	*Crangon nigromaculata*
blacktail jackrabbit	*Lepus californicus*
black-necked stilt	*Himantopus mexicanus*
blood worm	*Glycera dibranchiata*
blue shark	*Prionace glauca*
blue whale	*Balaenoptera musculus*
blue (= bay) mussel	*Mytilus edulis*
bluefish	*Pomatomus saltatrix*
bocaccio	*Sebastes paucispinis*
Bonaparte's gull	*Larus philadelphia*
Botta's (valley) pocket gopher	*Thomomys bottae*
bottlenose dolphin	*Tursiops truncatus*
brittle star	*Amphiodia urtica*
brittle star	Ophiuroidea, unid.
broadtail isopod	*Paracerceis spp.*
brokenspine brittle star	*Ophiura lutkeni*
brown algae	Phaeophyta
brown pelican	*Pelecanus occidentalis occidentalis*
brown rockfish	*Sebastes auriculatus*
bryozoan	Ectoprocta
cabezon	*Scorpaenichthys marmoratus*
California brown pelican	*Pelecanus occidentalis californicus*
California buckwheat	*Eriogonum fasciculatum*
California clingfish	*Gobiesox rhessodon*
California corbina	*Menticirrhus undulatus*

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Common Name	Scientific Name
California gnatcatcher	*Polioptila californica*
California ground squirrel	*Spermophilus (= citellus) beecheyi*
California grunion	*Leuresthes tenuis*
California gull	*Larus californicus*
California halibut	*Paralichthys californicus*
California killifish	*Fundulus parvipinnis*
California least tern	*Sterna antillarum browni*
California lizardfish	*Synodus lucioceps*
California mussel	*Mytilus californianus*
California poppy	*Eschscholzia californica*
California sagebrush	*Artemisia californica*
California sandstar	*Astropecten verrilli*
California scorpionfish	*Scorpaena guttata*
California sea cucumber	*Parastichopus californicus*
California sea lion	*Zalophus californianus*
California sea slug	*Pleurobranchaea californiensis*
California sheephead	*Semicossyphus pulcher*
California smoothtongue	*Leuroglossus stilbius*
California spiny lobster	*Panulirus interruptus*
California tonguefish	*Symphurus atricauda*
carinate (= keeled) dovesnail	*Alia carinata*
cattail	*Typha latifolia*
chaparral candle yucca	*Yucca whipplei*
chilipepper	*Sebastes goodei*
chiton	Polyplacophora
chub (= Pacific) mackerel	*Scomber japonicus*
cladoceran	Cladocera
comb jellies	Ctenophora
common dolphin	*Delphinus delphis*
common murre	*Uria aalge*
conejo buckwheat	*Eriogonum crocatum*
copepod	*Calanus pacificus*
cordgrass	*Spartina foliosa*
cormorant	*Phalacrocorax spp.*
cowcod	*Sebastes levis*
crustacean	Crustacea
cumacean	Cumacea
curlfin sole	*Pleuronichthys decurrens*
Dall's porpoise	*Phocoenoides dalli*
damselfish	Pomacentridae, unid.
date mussel	*Lithophaga spp.*
diatoms	Bacilliophycea
Dover sole	*Microstomus pacificus*
dudleya	*Dudleya cymosa marcescens*
eastern brown pelican	*Pelecanus occidentalis carolinensis*
eastern Pacific bobtail squid	*Rossia pacifica*
echinoderm	Echinodermata
eelgrass	*Zostera marina*
El Segundo blue butterfly	*Euphilotes battoides allyni*
encrusting bryozoan	*Membranipora spp.*
English sole	*Pleuronectes (= Parophrys) vetulus*
euphausiid	Euphausiacea, unid.
fantail sole	*Xystreurys liolepis*
feather-boa kelp	*Egregia menziesii*
fine-lined lucine (clam)	*Parvilucina tenuisculpta*
flag rockfish	*Sebastes rubrivinctus*
flathead sole	*Hippoglossoides elassodon*
fragile sea urchin	*Allocentrotus fragilis*
frog	*Hylidae and Ranidae*
giant kelp	*Macrocystis angustifolia Macrocystis pyrifera*

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Appendix C (Cont).

Common Name	Scientific Name
giant rock scallop	*Crassidoma gigantea*
gigantic plumose anemone	*Metridium gignteum*
Gould beanclam (coquina)	*Donax gouldii*
gray sandstar	*Luidia foliolata*
gray whale	*Eschrichtius robustus*
grebe	Podicipedidae, unid.
greenblotched rockfish	*Sebastes rosenblatti*
greenling	Hexagrammidae, unid.
greenstriped rockfish	*Sebastes elongatus*
Gulf sanddab	*Citharichthys fragilis*
gull	*Larus spp.*
halfblind goby	*Lethops connectens*
halfmoon	*Medialuna californiensis*
harbor porpoise	*Phocoena phocoena*
harbor seal	*Phoca vitulina*
Heermann's gull	*Larus heermanni*
hermit crab	Paguridea
hornyhead turbot	*Pleuronichthys verticalis*
Hottentot fig	*Mesembryanthemum edule*
ice cream cone worm	*Pectinaria californiensis*
ice plant	*Mesembryanthemum spp.*
jack mackerel	*Trachurus symmetricus*
jacksmelt	*Atherinopsis californiensis*
jaeger	*Stercorarius spp.*
jellyfish	Scyphozoa
kelp	*Macrocystis spp., Egregia menziesii*
kelp bass	*Paralabrax clathratus*
kelp clingfish	*Rimicola muscarum*
kelp flies	Coelopidae
kelp gunnel	*Ulvicola sanctaerosae*
kelp perch	*Brachyistius frenatus*
kelp pipefish	*Syngnathus californiensis*
kelp rockfish	*Sebastes atrovirens*
kelp scallop	*Leptopecten latiauratus*
kelpfishes	*Gibbonsia spp.*
krill	Euphausiacea
large beach hopper	*Megalorchestia californiana*
laurel sumac	*Rhus larina*
light-footed clapper rail	*Rallus longirostris levipes*
limpets	*Acmaea spp.*
lingcod	*Ophiodon elongatus*
lizard	*Iguanidae, Scincidae, Teiidae, and Anguidae*
longspine combfish	*Zaniolepis latipinnis*
loon	*Gavia spp.*
Lyon's pentachaeta	*Pentachaeta lyonii*
marbled godwit	*Limosa fedoa*
Memphill fileclam (file shell)	*Limatula hemphilli*
Mexican fiddler	*Uca crenulata*
Mexican lampfish	*Triphiturus mexicanus*
minke whale	*Balaenoptera acutorostrata*
mollusk	Mollusca
moonsnail	Naticidae, unid.
mysid	Mysidae, unid.
mysid shrimp	Mysidacea
nematode	Nematoda
nematode	Nematoda, unid.
northern anchovy	*Engraulis mordax*
northern elephant seal	*Mirounga angustirostris*
northern fulmar	*Fulmarus glacialis*
northern lampfish	*Stenobrachius leucopsarus*

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Appendix C (Cont).

Common Name	Scientific Name
northern right whale dolphin	*Lissodelphis borealis*
ocean shrimp	*Pandalus jordani*
ocean whitefish	*Caulolatilus princeps*
ochre starfish	*Pisaster ochraceus*
octopuses	*Octopus spp.*
olive rockfish	*Sebastes serranoides*
opaleye	*Girella nigricans*
ostracod	*Euphilomedes spp.*
ostracod	Ostracoda
Pacific argentine	*Argentina sialis*
Pacific barracuda	*Sphyraena argentea*
Pacific bonito	*Sarda chiliensis*
Pacific electric ray	*Torpedo californica*
Pacific goose barnacle	*Pollicipes polymerus*
Pacific hake	*Merlucclus productus*
Pacific littleneck	*Protothaca staminea*
Pacific purple urchin	*Strongylocentrotus purpuratus*
Pacific rock crab	*Cancer antennarius*
Pacific sand dollar	*Dendraster excentricus*
Pacific sanddab	*Citharichthys sordidus*
Pacific sardine	*Sardinops sagax*
Pacific spiny brittle star	*Ophiothrix spiculata*
Pacific staghorn sculpin	*Leptocottus armatus*
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
Palos Verdes blue butterfly	*Euphilotes battoides allyni*
pelagic red crab	*Pleuroncodes planipes*
pelagic snail	*Janthina spp.*
peregrine falcon (American)	*Falco peregrinus anatum*
periwinkle	*Littorina spp.*
pickleweed	*Salicornia spp.*
pickleweed	*Salicornia virginica*
piddock clam	Pholadidae, unid.
pile perch	*Rhacochilus (= Damalichthys) vacca*
pink abalone	*Haliotis corrugata*
pink seaperch	*zalembius rosaceus*
pipefish	Syngnathidae, unid.
pismo clam	*Tivela stultorum*
plainfin midshipman	*Porichthys notatus*
polychaete	*Capitella capitata*
polychaete	*Mediomastus*
polychaete	*Schistomeringos*
polychaete	*Tharyx spp.*
polychaete worms	Polychaeta, unid.
puffin	*Fratercula spp.*
pygmy sperm whale	*Kogia breviceps*
queenfish	*Seriphus politus*
rainbow (= steelhead) trout	*Oncorhynchus mykiss (formerly Salmo gairdneri)*
red algae	Rhodophyta
red fox	*Vulpes fulva*
red sea urchin	*Strongylocentrotus franciscanus*
rex sole	*Errex (= Glyptocephalus) zachirus*
ridgeback rock shrimp (= ridgeback prawn)	*Sicyonia ingentis*
rock crab	*Cancer spp.*
rock lice	*Ligia spp.*
rockfish	*Sebastes spp.*
rockpool blenny	*Hypsoblennius gilberti*
rockweed	*Pelvetia spp.*
rotifer	Rotifera
roundworm	Nematoda, unid.
rubberlip seaperch	*Rhacochilus toxotes*

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Appendix C (Cont).

Common Name	Scientific Name
ruddy turnstone	*Arenaria interpres*
sablefish	*Anoplopoma fimbria*
salt bush	*Atriplex spp.*
salt grass	*Distichlis spicata*
saltmarsh bird's beak	*Cordylanthus maritimus ssp. maritimus*
sand crab	*Emerita analoga*
sand flea	Talitridae
sand sole	*Psettichthys melanostictus*
sand verbena	*Abronia maritima*
sanderling	*Calidris alba*
sandflat elbow crab	*Heterocrypta occidentalis*
Santa Susana tarweed	*Hemizonia minthornii*
scale insect	*Haliaspis spartina*
scoter	*Melanitta spp.*
sculpin	Cottidae, unid.
sea bass	Serranidae, unid.
sea cucumber	Holothuroidea
sea fan	Gorgonacea, unid.
sea felt	*Enteromorpha spp.*
sea fig	*Mesembryanthemum chilense*
sea lettuce	*Ulva spp.*
sea moss	Bryozoan, unid.
sea rocket	*Cakile maritima*
sea slug	Nudibranchia
sea squirt	Ascidiacea, unid.
sea star (sand star)	*Astropecten armatus, A. verrilli*
sea urchin	*Strongylocentrotus spp.*
senorita	*Oxyjulis californica*
shark	*Elasmobranchiomorphi* (= *Chondrichthyes, Elasmobranchii*)
shearwater	*Puffinus spp.*
sheep crab	*Loxorhynchus grandis*
shiner perch	*Cymatogaster aggregata*
shortbelly rockfish	*Sebastes jordani*
shortfin pilot whale	*Globicephala macrorhynchus*
shovelnose guitarfish	*Rhinobatos productus*
shrimp	Natantia
silky axinopsid (clam)	*Axinopsida serricata arvilucina*
silver beachweed	*Ambrosia (Franseria) chamissonis*
slender sole	*Eopsetta (= Lyopsetta) exilis*
small beach hopper	*Traskorchestia traskiana*
speckled sanddab	*Citharichthys stigmaeus*
sperm whale	*Physeter macrocephalus*
spider crab	*Podochela lobifrons*
spiny dogfish	*Squalus acanthias*
spiny sandstar	Astropecten armatus
sponge	Porifera
spoonworm	*Listriolobus pelodes*
spot shrimp (= spot prawn)	*Pandalus platyceros*
spotted kelpfish	*Gibbonsia elegans*
spotted sandpiper	*Actitus macularia*
squid	Teuthoidea
starry flounder	*Platichthys stellatus*
stingray	Dasyatididae, unid.
storm-petrel	*Oceanodroma spp.*
striped shore crab	*Pachygrapsus crassipes*
stripetail rockfish	*Sebastes saxicola*
summer flounder	*Paralichthys dentatus*
surfbird	*Aphriza virgata*
surfgrass	*Phyllospadix spp.*

Appendix C (Cont).

Common Name	Scientific Name
swordfish	*Xiphias gladius*
tern	*Sterna spp.*
thresher shark	*Alopias vulpinus*
tidewater goby	*Eucyclogobius newberryi*
toad	*Pelobatidae and Bufonidae*
topsmelt	*Atherinops affinis*
toyon	*Heteromeles arbutifolia*
tuberculate pear crab	*Pyromaia tuberculata*
tule	*Scirpus spp.*
tunicate	Ascidiacea
turban	*Tegula spp.*
turkey vulture	*Cathartes aura*
vermilion rockfish	*Sebastes miniatus*
walleye surfperch	*Hyperprosopon argenteum*
wandering skipper	*Panoquina errans*
wandering tattler	*Heteroscelus incanus*
warty sea cucumber	*Parastichopus parvimensis*
weakfish	*Cynoscion regalis*
western fence lizard	*Sceloporus occidentalis*
western gull	*Larus occidentalis*
western meadowlark	*Sturnella neglecta*
western mosquitofish	*Gambusia affinis*
western snowy plover	*Charadrius alexandrinus nivosus*
western sycamore	*Platanus racemosa*
western (southern Pacific) rattlesnake	*Crotalus viridis helleri*
whale	Cetacea
whimbrel	*Numenius phaeopus*
white alder	*Alnus rhombifolia*
white croaker	*Genyonemus lineatus*
white sea bass	*Atractoscion nobilis*
white sea urchin	*Lytechinus pictus (= L. anamesus)*
white seaperch	*Phanerodon furcatus*
wild buckwheat	*Eriogonum parvifolium*
wild lilac	*Ceanothus spp.*
willet	*Catoptrophorus semipalmatus*
willow	*Salix spp.*
winter flounder	*Pleuronectes (= Pseudopleuronectes) americanus*
woolly sculpin	*Clinocottus analis*
wrasse	Labridae, unid.
yellow rock crab	*Cancer anthonyi*
yellowchin sculpin	*Icelinus quadriseriatus*
yellowtail	*Seriola lalandi*

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APPENDIX D

Concentrations and Mass Emissions of Contaminants from Wastewater Treatment Plants.

Appendix D-1. Average concentrations of constituents in the HTP 5-mi effluent, 1974-1992.

Year	1974	1975[a]	1976	1977	1978[b]	1979	1980	1981	1982	1983	1984	1985
Flow (mgd)	341	345	359	319	341	353	363	369	375	411	404	389
liters/day x 10(6)	1291	1306	1359	1207	1291	1336	1374	1397	1419	1556	1529	1472
GENERAL CONSTITUENTS (mg/l)												
Total Suspended Solids	83	86	77	82	86	75	77	77	77	102	118	102
Settleable solids (ml/l)					0.5	0.9	0.9	0.9	0.9	1.3	1.5	2.5
BOD (5-day)	121	125	125	145	148	144	156	180	178	183	183	254
Oil and Grease	18	20	20	10	10	10	14	22	20	10.0	10	20
Nitrate Nitrogen	0.3										<0.5	<0.5
Ammonia Nitrogen	13.8	13.9	14.9	17.2	15.9	18.7	16.5	16.1	14.9	14.5	14.0	16.9
Organic Nitrogen	6.2				7.3	8.2	8.4	7.3	8.2	8.4	8.7	11.5
Total Phosphorus	24.3	9.0	5.7	7.6	8.8	6.5	7.1	6.6	6.0	6.5	6.8	8.7
Detergent (MBAS)	5.1	3.9	4.3	4.2	3.0	4.1	4.9	4.1	4.1	3.2	3.5	4.2
Cyanide (CN)	0.20	0.14	0.11	0.14	0.15	0.09	0.09	0.06	0.09	0.04	0.02	0.03
Phenols	0.06	0.04	0.06	0.06	0.05	0.06	0.05	0.05	0.05	0.064	0.047	0.045
TRACE METALS (mg/l)												
Silver	0.020	0.020	0.010	0.030	0.030	0.044	0.030	0.025	0.020	0.015	0.015	0.028
Arsenic	0.010	0.010	0.010	0.010	0.010	0.013	0.010	0.012	<0.005	0.007	0.010	0.012
Cadmium	0.020	0.020	0.020	0.020	0.018	0.020	0.020	0.017	0.010	0.013	0.009	0.011
Chromium	0.210	0.130	0.190	0.130	0.080	0.070	0.090	0.054	0.090	0.080	0.070	0.080
Copper	0.190	0.190	0.170	0.200	0.190	0.190	0.180	0.200	0.140	0.150	0.140	0.200
Mercury	0.0032	0.0020	0.0015	0.0210	0.0010	0.0025	0.0010	0.0007	0.0007	0.0006	0.0004	0.0006
Nickel	0.180	0.150	0.180	0.180	0.220	0.160	0.140	0.108	0.090	0.090	0.070	0.080
Lead	0.040	0.030	0.030	0.030	0.090	0.150	0.090	0.050	0.050	0.030	0.056	0.080
Selenium	0.020	0.020	0.020	0.010	0.030	0.002	0.010	0.001	<0.005	<0.005	<0.005	<0.006
Zinc	0.240	0.230	0.220	0.320	0.300	0.310	0.330	0.217	0.180	0.170	0.160	0.280
CHLORINATED HYDROCARBONS (ug/l)												
Total DDT	0.72	1.63	1.30	0.20	0.10	0.18	0.10	0.05	0.09	0.03	0.03	0.02
Total PCB	0.[illegible]8	3.92	2.31	2 13	2.82	0.[illegible]2	0.67	0 78	<0.1	<0.2	<0.2	0.1

Appendix D1 (Cont).

Year	1986	1987	1988	1989	1990	1991	1992[c]	Survey Totals n	Mean	Std. Dev.	C.V.
Flow (mgd)	393	375	383	365	354	315	298	10	300	29	8
liters/day x 10(6)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	1301	112	8
GENERAL CONSTITUENTS (mg/l)											
Total Suspended Solids	78	88	40	33	30	33	36	10	73	32	44
Settleable solids (ml/l)	0.5	0.5	0.4	0.3	0.3	0.3	0.2	15	0.8	0.6	72
BOD (5-day)	151	110	106	90	93	83	83	10	140	43	31
Oil and Grease	21.3	15	14	13	11	10	12	10	18	5	29
Nitrate Nitrogen	0.3	0.5	0.5	0.8	0.3	0.3	0.3	10	0.3	0.2	62
Ammonia Nitrogen	18.0	18.2	21.9	19.0	22.3	25.8	24.7	10	17	4	21
Organic Nitrogen	7.8	6.4	5.9	5.8	5.4	5.5	5.9	16	7.3	1.6	22
Total Phosphorus	5.4	2.9	4.7	4.1	5.0	4.7	5.1	18	8.9	4.4	64
Detergent (MBAS)	4.4	2.8						14	4.0	0.8	14
Cyanide (CN)	0.02	0.03	0.02	0.02	0.01	0.02	0.03	10	0.07	0.06	83
Phenols	0.04	0.04	0.00	0.00	0.00	0.00	0.00	10	0.04	0.02	52
TRACE METALS (mg/l)											
Silver	0.017	0.010	0.007	0.007	0.006	0.006	0.006	10	0.018	0.011	89
Arsenic	0.009	0.008	0.008	0.008	0.004	0.006	0.006	10	0.008	0.003	38
Cadmium	0.009	0.007	0.001	0.0004	0.001	0.0003	0.0002	10	0.011	0.008	70
Chromium	0.040	0.017	0.009	0.004	0.006	0.004	0.005	10	0.070	0.061	87
Copper	0.121	0.058	0.048	0.038	0.038	0.038	0.033	10	0.132	0.067	50
Mercury	0.0003	0.0001	0.0003	0.0002	0.0002	0.0002	0.00004	10	0.002	0.005	240
Nickel	0.110	0.056	0.048	0.028	0.018	0.017	0.014	10	0.102	0.084	83
Lead	0.040	0.043	0.046	0.018	0.003	0.003	0.001	10	0.047	0.037	79
Selenium	0.001							13	0.006	0.010	119
Zinc	0.218	0.174	0.079	0.074	0.069	0.113	0.070	10	0.186	0.088	44
CHLORINATED HYDROCARBONS (ug/l)											
Total DDT	[d]	<0.02	0	0	0	0.003	0	10	0.24	0.47	196
Total PCB	0.02	<0.1	0	0	0	0	0	10	0.77	1.27	164

a. For Chlorinated Hydrocarbons Project Values: Analyses of two 1-week composite samples of each effluent.
b. Project value for DDT based on 52 weekly composites.
c. Values for 1992 based on data January to October extrapolated to 12 months.
d. DDD, DDE, and DDT (p,p and o,p) were all <0.02.
Source: Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986a; CLA, DWP 1987, 1988, 1989, 1990, 1991, 1992; Cressey, R. 1992 HTP, pers. comm.

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Appendix D-2. Annual mass emissions of constituents in the HTP 5-mi effluent, 1974-1982.

Year	1974	1975[a]	1976	1977	1978[b]	1979	1980	1981	1982	1983	1984	1985
Flow (mgd)	341	345	350	319	341	353	363	369	375	411	404	389
liters/day x 10(6)	1291	1306	1350	1207	1291	1336	1374	1397	1419	1556	1529	1472
GENERAL CONSTITUENTS (MT/yr)[d]												
Total Suspended Solids	39101	40813	38189	27324	31092	36578	38815	38253	38891	57910	65880	57091
Settleable solids (l/yr x 10(6))					236	438	451	459	486	738	837	1344
BOD (5-day)	57003	59576	61906	63902	69723	70225	79238	86153	91180	103908	102139	139802
Oil and Grease	8480	9532	8919	8373	8951	8266	7021	11215	10301	10785	10806	18585
Nitrate Nitrogen	141										140	134
Ammonia Nitrogen	6501	6625	7241	7580	7480	8144	8276	8207	7967	8233	7814	8821
Organic Nitrogen	2968				3439	3999	4213	3721	4248	4753	4856	6180
Total Phosphorus	11448	4290	2827	3349	3203	3170	3561	3517	3108	3668	3786	3601
Detergent (MBAS)	2403	1859	2133	1851	1896	1899	2257	2100	2124	1828	1848	2257
Cyanide (CN)	94.2	66.7	54.8	61.7	70.7	43.8	45.1	40.8	31.1	25.0	11.2	14.9
Phenols	23.3	10.1	24.8	26.4	23.6	29.3	30.1	30.8	32.1	36.3	36.2	34.2
TRACE METALS (MT/yr)												
Silver	9.4	9.5	8.0	13.2	14.1	21.5	15.0	12.7	10.4	8.5	8.4	14.9
Arsenic	4.7	4.5	5.0	4.4	4.7	6.3	5.0	6.1	1.3	4.0	5.8	6.4
Cadmium	9.4	9.5	9.8	8.8	8.5	9.8	10.0	8.7	5.2	7.4	5.0	5.9
Chromium	96.9	62.0	94.2	57.3	37.7	34.1	45.1	27.5	46.8	45.4	39.1	32.2
Copper	89.5	90.9	84.3	88.1	89.5	82.7	90.3	102.0	72.5	85.2	78.1	107.5
Mercury	1.8	1.0	0.7	0.3	0.5	1.2	0.5	0.4	0.4	0.3	0.2	0.3
Nickel	84.8	71.5	89.3	79.3	103.6	78.0	70.2	56.1	40.8	61.1	39.1	43.9
Lead	18.8	14.3	14.5	13.2	42.4	73.2	45.1	25.5	25.9	17.0	30.7	46.4
Selenium	9.4	9.5	9.9	4.4	14.1	1.0	5.0	0.5	1.3	1.4	1.4	1.3
Zinc	113	110	109	141	141	151	165	111	89	87	89	150
CHLORINATED HYDROCARBONS (MT/yr)												
Total DDT	0.339	0.777	0.846	0.088	0.075	0.088	0.080	0.025	0.031	0.017	0.017	0.011
Total PCB	[illegible]	1.868	1.640	[illegible]	1.330	0.330	0.326	0.487	0.026	0.067	0.056	0.064

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Appendix D2 (Cont).

Year	1986	1987	1988	1989	1990	1991	1992 [c]	Survey Totals n	Mean	Std. Dev.	C.V.
Flow (mgd)	393	375	363	365	354	315	298	19	360	29	8
liters/day x 10(6)	1488	1420	1374	1382	1340	1192	1128	19	1361	112	8
GENERAL CONSTITUENTS (MT/yr) [d]											
Total Suspended Solids	41263	29845	24573	19840	14672	14361	18773	19	30822	18137	40
Settleable solids (l/yr x 10(6))	434	396	201	151	147	131	99	18	435	332	76
BOD (5-day)	81984	80080	64161	45383	45482	36120	41006	19	70829	25229	36
Oil and Grease	11565	7779	7021	6556	5380	4352	5828	19	8878	2819	30
Nitrate Nitrogen	179	249	264	273	136	143	132	10	178	57	32
Ammonia Nitrogen	8687	8401	10983	9581	10906	11228	12203	19	8868	1806	19
Organic Nitrogen	4126	3321	2950	2824	2941	2393	2893	19	3721	999	27
Total Phosphorus	2948	1624	2349	2053	2467	2086	2530	19	3448	2080	60
Detergent (MBAS)	2400	1469						14	2023	269	13
Cyanide (CN)	9.2	14.0	9.0	9.1	6.9	9.4	14.5	19	33.2	26.3	79
Phenols	20.8	21.5	0.5	0.4	0.2	0.5	2.1	19	19.9	12.4	62
TRACE METALS (MT/yr)											
Silver	9.2	5.2	3.5	3.5	3.0	2.5	3.2	19	9.0	5.2	57
Arsenic	4.8	4.4	4.0	3.0	2.0	2.2	2.5	19	4.3	1.5	36
Cadmium	4.9	3.4	0.7	0.2	0.3	0.1	0.1	19	5.7	3.5	66
Chromium	21.7	9.0	3.0	2.0	2.9	1.8	2.5	19	34.8	29.3	84
Copper	85.7	30.1	24.8	19.2	18.6	16.5	18.3	19	66.4	33.1	50
Mercury	0.2	0.1	0.2	0.1	0.1	0.1	0.02	19	0.8	2.1	233
Nickel	59.7	23.9	23.1	14.1	7.8	7.4	9.9	19	50.5	30.1	60
Lead	21.7	22.4	22.9	9.1	1.2	1.1	0.7	19	23.6	18.3	78
Selenium	0.5							13	4.8	4.9	100
Zinc	118	90	40	37	34	40	34.9	19	90	43	43
CHLORINATED HYDROCARBONS (MT/yr)											
Total DDT	0	0.006	0	0	0	0.001	0.0	19	0.11	0.22	197
Total PCB	0.011	0 026	0	0	0	0	0.0	19	0.39	0.80	189

a. For Chlorinated Hydrocarbons Project Values: Analyses of two 1-week composite samples of each effluent.
b. Project value for DDT based on 52 weekly composites.
c. Mass Emmissions for 1992 based on data from January to October extrapolated to 12 months.
d. Less than values calculated at 1/2 minimum detection level.
Source: Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984, SCCWRP 1986a; CLA, DWP 1987, 1988, 1989, 1990, 1991, 1992; Cressey, R. 1992 HTP, pers. comm.

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Appendix D-3. Average concentrations of constituents in the JWPCP effluent, 1974-1992.

Year	1974[a]	1975[b]	1976	1977	1978[c]	1979	1980	1981	1982	1983	1984	1985
Flow (mgd)	346	341	353	335	345	367	374	364	359	353.3	351	362
liters/day x 10(6)	1310	1291	1336	1268	1306	1389	1416	1378	1359	1337	1329	1370
GENERAL CONSTITUENTS (mg/l)												
Total Suspended Solids	278	278	234	220	219	196	178	167	164	180	103	87
Settleable solids (ml/l)					1.3	0.8	0.3	0.3	0.4	0.9	0.4	0.4
BOD (5-day)	213	200	231	220	204	204	206	202	199	178	148	139
Oil and Grease	56	61	63	46	46	40	32	23	25	25	10	14
Nitrate Nitrogen (NO3-N)	0.16										<0.10	0.48
Ammonia Nitrogen	30	36	30	30	40	40	40	30	41	41	37	37
Organic Nitrogen	15.7				14.9	13.7	13.4	14.0	12.5	12.0	11.4	8.4
Total Phosphorus	14.7	13.2	12.8	13.0	11.2	9.9	9.4	9.2	9.1	8.8	8.8	8.2
Detergent (MBAS)[d]	0.65	7.10	9.60	8.30	7.70	7.00	6.29	5.37	5.01	5.80	4.83	4.10
Cyanide (CN)	0.43	0.33	0.32	0.24	0.18	0.17	0.12	0.08	0.06	0.04	0.04	0.02
Phenols	3.31	4.13	3.48	3.30	3.06	2.80	2.33	2.85	2.83	2.57	1.96	1.46
TRACE METALS (mg/l)												
Silver	0.012	0.013	0.013	0.008	0.014	0.019	0.010	0.008	0.011	0.010	0.009	0.019
Arsenic	0.025	<0.011	0.007	0.009	0.011	0.010	0.005	0.005	0.007	0.008	0.020	0.013
Cadmium	0.041	0.036	0.026	0.025	0.030	0.027	0.020	0.016	0.011	0.015	0.008	0.008
Chromium	0.86	0.80	0.75	0.38	0.34	0.26	0.31	0.21	0.16	0.14	0.11	0.08
Copper	0.80	0.42	0.41	0.25	0.26	0.22	0.19	0.15	0.13	0.13	0.09	0.07
Mercury	0.001	0.001	0.001	0.001	0.001	0.001	0.0008	0.0018	0.0008	0.0009	0.0006	0.0004
Nickel	0.31	0.28	0.32	0.24	0.27	0.21	0.20	0.15	0.15	0.15	0.11	0.08
Lead	0.26	0.25	0.22	0.19	0.19	0.15	0.12	0.09	0.08	0.08	0.06	0.06
Selenium	0.012	<0.013	0.011	0.016	0.010	0.013	0.010	0.029	0.012	0.013	0.013	0.011
Zinc	1.79	1.45	1.32	0.84	0.84	0.89	0.80	0.80	0.51	0.52	0.27	0.19
CHLORINATED HYDROCARBONS (ug/l)												
Total DDT	3.01	2.33	1.92	1.52	2.04	1.25	1.06	0.84	0.45	0.38	0.48	0.07
Total PCB	10.8	10.95	2.93	2.46	1.76	1.02	0.66	0.64	0.47	0.61	0.63	0.02

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Appendix D3 (Cont).

Year	-1986	1987	1988	1989	1990	1991	1992[f]	Survey Totals n	Mean	Std. Dev.	C.V.
Flow (mgd)	364	366	375	382	372	330	333	19	356	15	4
liters/day x 10(6)	1378	1385	1419	1446	1408	1249	1260	19	1348	57	4
GENERAL CONSTITUENTS (mg/l)[e]											
Total Suspended Solids	82	73	70	65	83	70	65	19	180	80	53
Settleable solids (ml/l)	0.3	0.3	0.2	0.3	0.1	0.2		14	0.4	0.3	75
BOD (5-day)	100	108	112	109	106	103	89	19	102	80	31
Oil and Grease	10	11	14	12	12	13	14	19	28	18	65
Nitrate Nitrogen (NO3-N)	0.52	0.80						8	0.3	0.2	72
Ammonia Nitrogen	40	38	36	38	37	38	37	19	36	2	4
Organic Nitrogen	8.0	7.4	7.3	8.2	7.4	7.9	7.0	18	10.7	3.1	29
Total Phosphorus	8.1	7.5	7.8	7.3	7.2	7.9	8.2	19	8.5	2.4	26
Detergent (MBAS)[d]	2.80	3.30	3.60	3.70	3.80	4.40	3.14	19	8.2	1.5	30
Cyanide (CN)	0.02	<0.02	0.03	0.01	0.01	0.01	<0.012	19	0.11	0.13	118
Phenols	1.80	2.00	2.04	1.33	1.21	1.07	0.54	19	2.3	0.9	41
TRACE METALS (mg/l)											
Silver	0.008	0.006	0.007	0.006	0.006	0.006	<0.007	19	0.010	0.004	39
Arsenic	0.007	0.007	0.008	0.006	0.008	0.004	0.003	19	0.008	0.006	69
Cadmium	0.004	0.002	0.003	0.002	0.001	0.002	<0.001	19	0.014	0.013	91
Chromium	0.06	0.06	0.04	0.03	0.02	0.02	<0.035	19	0.24	0.27	112
Copper	0.05	0.04	0.04	0.04	0.03	0.03	0.03	19	0.17	0.18	97
Mercury	0.0004	0.0003	0.0005	0.0004	0.0004	0.0005	<0.0005	19	0.001	0.000	88
Nickel	0.06	0.05	0.05	.05	0.04	0.04	0.03	19	0.15	0.10	68
Lead	0.06	0.06	0.038	0.025	0.012	0.006	<0.009	19	0.10	0.08	83
Selenium	0.014	0.013	0.012	0.013	0.013	0.014		18	0.013	0.006	41
Zinc	0.16	0.12	0.14	0.13	0.09	0.09	0.08	19	0.55	0.51	89
CHLORINATED HYDROCARBONS (ug/l)											
Total DDT	0.07	0.09	0.004	0.002	0.002	0.009	0.006	19	0.82	0.94	115
Total PCB	0	0	nd	nd	nd	nd	nd	19	1.72	3.34	184

a. For Total PCB, the average concentration for January to September was 4.72; for October to December, 29.1.
b. For Chlorinated hydrocarbons Project values: Analyses of two 1-week composite samples of each effluent.
c. Project value for DDT based on 52 weekly composites.
d. MBAS is Methylene blue active substances.
e. Less than values calculated at 1/2 minimum detection level.
f. 1992 values are estimates based on January to February data.
Sources: Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; Stull 1988, pers. comm.; Horvath 1992, pers. comm.

Appendix D-4. Annual mass emissions of constituents in the JWPCP effluent, 1974-1992.

Year	1974[a]	1975[b]	1976	1977	1978[c]	1979	1980	1981	1982	1983	1984	1985
Flow (mgd)	346	341	353	335	345	367	374	364	359	353.3	361	362
liters/day x 10(6)	1310	1291	1336	1268	1306	1388	1416	1378	1359	1337	1329	1370
GENERAL CONSTITUENTS (MT/yr)												
Total Suspended Solids	131830	130986	138501	101818	104381	88889	90838	83980	81339	82094	48846	43610
Settleable solids (l/yr x 10(6))					620	406	155	151	186	443	184	200
BOD (5-day)	101816	88480	112507	101818	97232	103432	107472	101581	88698	85660	70798	63014
Oil and Grease	26338	25926	30480	21336	21925	20230	18637	11717	12151	13637	7759	7002
Nitrate Nitrogen (NO3-N)	72										24	240
Ammonia Nitrogen	18403	17713	17703	18050	18827	20331	20461	19783	20335	19870	17942	18664
Organic Nitrogen	7806				7102	6946	6824	7040	6200	6667	6528	4701
Total Phosphorus	7027	6210	6242	6017	5338	5016	4857	4626	4508	4285	4267	4101
Detergent (MBAS)[d]	3274	3345	3170	2916	3670	3549	3250	2700	2782	2733	2246	2080
Cyanide (CN)	206	155	156	111	66	86	82	40	30	19	10	10
Phenols	1582	1946	1697	1527	1466	1318	1204	1433	1265	1256	846	730
TRACE METALS (MT/yr)												
Silver	8.7	5.1	6.3	3.7	6.7	8.8	5.2	4.0	5.8	5.1	4.4	5.6
Arsenic	12.0	2.8	3.4	4.2	5.2	5.1	2.6	2.8	3.5	3.1	0.7	6.5
Cadmium	19.8	17.0	12.7	11.8	14.3	13.7	10.3	6.0	5.5	7.4	3.9	2.8
Chromium	411	377	306	178	182	130	160	106	84	70	53	40
Copper	287	186	200	118	124	112	88	77	63	62	43	34
Mercury	0.5	0.5	0.7	0.5	0.7	0.5	0.4	0.8	0.4	0.4	0.3	0.2
Nickel	148	132	156	111	129	108	103	74	74	75	53	40
Lead	124	118	107	88	91	74	82	46	40	41	24	25
Selenium	8.7	3.1	5.4	7.4	4.8	6.6	5.2	14.0	6.1	6.5	6.3	5.5
Zinc	856	683	644	389	448	360	310	251	253	254	131	86
CHLORINATED HYDROCARBONS (MT/yr)												
Total DDT	1.44	1.10	0.94	0.73	0.97	0.83	0.54	0.42	0.22	0.16	0.23	0.04
Total PCBs	5.16	5.16	1.43	1.14	0.84	0.52	0.34	0.27	0.23	0.25	0.31	0.01

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Appendix D4 (Cont).

Year	1986	1987	1988	1989	1990	1991	1992[f]	Survey Totals n	Mean	Std. Dev.	C.V.
Flow (mgd)	364	366	375	382	372	330	333	19	356	15	4
liters/day x 10(6)	1378	1385	1419	1446	1408	1249	1260	19	1349	57	4
GENERAL CONSTITUENTS (MT/yr)											
Total Suspended Solids	41238	36912	36265	34303	32377	31913	37540	19	73620	37736	51
Settleable solids (l/yr x 10(6))	151	152	104	158	51	91		14	220	158	72
BOD (5-day)	50288	54609	58024	57524	54478	46958	64654	19	79948	23655	30
Oil and Grease	6029	6562	7149	6388	6064	6109	7453	19	13764	8594	62
Nitrate Nitrogen (NO3-N)	281	253						5	170	113	66
Ammonia Nitrogen	20115	19164	18239	20160	18810	17233	20219	19	19052	1072	6
Organic Nitrogen	4023	3742	4036	4327	3803	3548	3870	19	5325	1457	27
Total Phosphorus	4073	3792	3948	3874	3711	3548	3439	19	4681	1038	22
Detergent (MBAS)[d]	1408	1869	1866	1863	2004	2006	1733	19	2543	709	28
Cyanide (CN)	10	5	10	5	5	5	3	19	54	62	115
Phenols	806	1011	1067	702	622	488	287	19	1123	441	39
TRACE METALS (MT/yr)											
Silver	4.0	4.0	3.6	4.2	4.1	3.8	1.8	19	4.9	1.6	33
Arsenic	3.5	3.5	3.1	2.6	4.8	1.8	1.6	19	4.3	2.6	61
Cadmium	2.0	1.0	1.8	1.1	0.5	0.9	0.3	19	7.0	6.3	90
Chromium	30	26	19	19	9	7	10	19	119	131	110
Copper	26	21	19	16	16	13	16	19	51	77	86
Mercury	0.2	0.2	0.3	0.2	0.2	0.2	0.1	19	0.4	0.2	54
Nickel	30	28	28	29	22	17	19	19	72	48	66
Lead	30	25	19	13	9	4	3	19	49	40	80
Selenium	7.0	6.6	6.2	6.7	6.6	6.5		18	6.5	2.3	35
Zinc	80	61	73	69	46	42	46	19	267	244	91
CHLORINATED HYDROCARBONS (MT/yr)											
Total DDT	0.04	0.03	0.002	0.001	0.001	0.004	0.005	19	0.40	0.45	114
Total PCB	0	0	nd	nd	nd	nd	nd	19	0.82	1.58	192

a. For Total PCB, the average concentration for January to September was 4.72; for October to December, 29.1.
b. For Chlorinated hydrocarbons Project values: Analyses of two 1-week composite samples of each effluent.
c. Project value for DDT based on 52 weekly composites.
d. MBAS is Methylene blue active substances.
e. Less than values calculated at 1/2 minimum detection level.
f. Mass emissions for 1992 are extrapolated to 12 months based on January to October data.
Sources: Mitchell and McDermott 1975; Schafer 1976, 1977, 1978, 1980, 1982, 1984; SCCWRP 1986c; Stull 1988, pers. comm.; Horvath 1992, pers. comm.

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Appendix D-5. Average concentrations of constituents in the TWRF effluent, 1974-1992.

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Flow (mgd)	0.4	0.84	1.3	1.22	4.5	4.0	3.3	1.8	2.0	3.3	4.1	4.4
liters/day x 10(6)	2	3	5	6	17	15	12	7	8	12	16	17
GENERAL CONSTITUENTS (mg/l)												
Total Suspended Solids	3.0	3.0	3.0	5.5	3.0	4.7	4.8	2.2	2.4	3.4	3.3	2.8
Settleable solids	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Oil and Grease	1.7	0.4	0.7	1.2	<1.2	1.2	2.1	1.8	<1	<1	<1	<1
BOD (5-day)	3.0	3.0	3.7	6.2	3.4	4.9	6.3	3.2	2.3	2.5	3.2	2.8
Total Nitrogen	18.00	18.80	17.10	18.21	18.40	17.75	18.83	18.18	17.18	16.25	18.02	18.37
Phosphorus (PO4-P)	10.0	8.7	9.4	8.1	7.0	7.8	7.1	7.5	8.2	6.3	6.8	6.3
Detergent (MBAS)	0.80	0.10	0.04	0.07	0.11	0.10	0.13	0.09	0.08	0.05	0.05	0.06
Cyanide (CN)		<0.001	<0.004	0.008	<0.002	0.008	0.0014	0.024	0.020	<0.003	<0.050	<0.050
Phenols	<0.050	<0.010	<0.030	0.010	0.010	0.011	<0.002	0.006	<0.004	<0.001	<0.100	NA
TRACE METALS (mg/l)												
Silver		0.001	0.010	0.017	<0.002	<0.002	0.003	0.001	<0.010	0.008	0.018	0.050
Arsenic		0.002	0.003	0.020	0.003	<0.001	<0.001	0.010	<0.010	<0.040	<0.001	0.018
Cadmium	0.007	0.007	0.004	0.003	0.002	<0.010	0.006	0.001	<0.010	0.020	0.004	0.004
Chromium		0.005	0.004	0.009	0.001	<0.005	0.011	0.002	<0.010	0.038	0.008	0.010
Copper	0.160	0.050	0.019	0.008	0.017	<0.002	0.038	0.012	0.020	0.018	0.020	0.010
Mercury		0.0002	0.0004	0.001	<0.001	<0.001	0.0002	<0.002	<0.002	<0.001	<0.002	<0.002
Nickel	0.060	0.036	0.030	0.018	0.033	0.170	0.020	0.003	<0.050	0.049	0.025	0.030
Lead	0.033	0.051	0.018	0.028	0.007	<0.020	0.040	0.018	<0.100	0.043	0.024	0.020
Zinc	0.160	0.110	0.080	0.044	0.046	0.018	0.058	0.065	0.500	0.042	0.030	0.130

Appendix D5 (Cont).

Year	1986	1987	1988	1989	1990	1991	1992 [a]	Survey Totals: n	Mean	Std. Dev.	C.V.
Flow (mgd)	4.0	2.8	2.9	2.6	2.3	2.7	2	19	2.7	1.2	40
liters/day x 10(6)	15	11	11	10	9	10	8	19	10	4.8	40
GENERAL CONSTITUENTS (mg/l)											
Total Suspended Solids	2.7	2.3	2.5	2.5	2.8	2.1	1.9	19	2.1	1.9	32
Settleable solids	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19	–	–	–
Oil and Grease	<1	<1	<1	<1	<1	<1	<1	19	9.5	9.7	153
BOD (5-day)	2.8	2.3	2.8	2.4	2.7	3.1	2.8	19	8.2	1.9	30
Total Nitrogen	15.60	17.82	18.88	19.55	18.78	21.41	17.88	19	17.4	1.8	9
Phosphorus (PO4-P)	5.8	5.7	5.5	6.0	5.8	9.1	5.4	19	7.1	1.8	21
Detergent (MBAS)	0.06	0.06	0.07	0.06	0.06	0.07	<0.06	19	0.1	0.1	130
Cyanide (CN)	<0.050	0.008	0.007	<0.050	0.012	<0.04	<0.01	18	0.005	0.007	153
Phenols	0.300	<0.008	<0.005	<0.100	0.031	<0.01	<0.01	19	0.010	0.086	263
TRACE METALS (mg/l)											
Silver	0.005	<0.004	0.003	0.002	<0.005	<0.010	<0.009	18	0.007	0.012	189
Arsenic	<0.050	<0.001	0.004	<0.010	<0.005	<0.030	<0.011	18	0.003	0.005	186
Cadmium	0.002	<0.006	<0.003	<0.003	<0.005	<0.005	<0.004	19	0.002	0.005	153
Chromium	0.006	<0.003	<0.003	0.003	<0.010	<0.010	<0.008	19	0.005	0.009	186
Copper	0.021	<0.010	<0.002	0.010	0.010	<0.032	<0.05	19	0.022	0.038	184
Mercury	<0.002	<0.001	<0.0002	<0.001	<0.002	<0.0002	<0.200	18	0.0001	0.0002	281
Nickel	0.020	<0.014	<0.010	0.010	<0.040	<0.045	<0.06	19	0.027	0.039	147
Lead	0.030	<0.011	<0.030	<0.030	0.002	<0.010	<0.008	19	0.017	0.017	104
Zinc	0.037	<0.029	0.029	0.039	0.032	0.036	<0.06	19	0.078	0.112	143

a. Values for 1992 are based on data from January to October extrapolated to 12 months.
Sources: Los Virgenes Municipal Water District; Whitbeck, S. 1992, TWRF, LVMWD, pers. comm.

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Appendix D-6. Annual mass emissions of constituents in the TWRF effluent, 1974-1992.

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Flow (mgd)	0.4	0.84	1.3	1.22	4.5	4.0	3.3	1.8	2.0	3.3	4.1	4.4
liters/day x 10(6)	2	3	5	6	17	15	12	7	8	12	16	17
GENERAL CONSTITUENTS (MT/yr) [b]												
Total Suspended Solids	1.7	3.5	6.4	9.3	34.2	30.0	21.0	5.5	6.8	18.5	10.7	18.8
Settleable solids	0.03	0.06	0.09	0.06	0.31	0.28	0.23	0.12	0.14	0.23	0.28	0.30
Oil and Grease	0.94	0.46	1.20	2.02	3.73	0.83	0.57	3.88	1.38	2.28	2.83	3.04
BOD (5-day)	1.7	3.5	6.6	6.8	21.1	27.1	24.2	6.9	6.4	11.4	18.1	18.2
Total Nitrogen	6.8	19.5	30.7	27.3	102.0	98.1	84.5	46.2	47.5	80.5	85.1	80.5
Phosphorus (PO4-P)	5.5	11.3	16.9	15.3	43.5	42.0	32.4	18.7	22.7	28.7	37.4	38.3
Detergent (MBAS)	0.23	0.12	0.07	0.12	0.08	0.86	0.59	0.22	0.22	0.23	0.28	0.30
Cyanide (CN)	0.00	0.001	0.004	0.01	0.01	0.04	0.01	0.08	0.08	0.01	0.14	0.15
Phenols	0.29	0.01	0.03	0.02	0.08	0.08	0.005	0.01	0.01	0.002	0.28	0.00
TRACE METALS (MT/yr)												
Silver	0.00	0.001	0.02	0.03	0.01	0.01	0.01	0.002	0.01	0.03	0.11	0.30
Arsenic	0.00	0.002	0.01	0.03	0.02	0.003	0.002	0.02	0.01	0.09	0.003	0.06
Cadmium	0.004	0.01	0.01	0.01	0.01	0.03	0.02	0.002	0.01	0.09	0.02	0.02
Chromium	0.00	0.01	0.01	0.01	0.01	0.01	0.06	0.006	0.01	0.16	0.03	0.11
Copper	0.09	0.09	0.03	0.01	0.11	0.01	0.16	0.03	0.06	0.07	0.11	0.10
Mercury	0.00	0.0002	0.001	0.002	0.003	0.003	0.0005	0.002	0.003	0.002	0.008	0.008
Nickel	0.03	0.04	0.06	0.03	0.21	0.94	0.09	0.01	0.07	0.22	0.14	0.18
Lead	0.02	0.06	0.03	0.06	0.04	0.06	0.15	0.04	0.14	0.20	0.14	0.12
Zinc	0.10	0.13	0.14	0.07	0.29	0.10	0.26	0.16	1.38	0.19	0.17	0.79

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Appendix D6 (Cont).

Year	1986	1987	1988	1989	1990	1991	1992 [a]	Survey Totals n	Mean	Std. Dev.	C.V.
Flow (mgd)	4.0	2.8	2.9	2.6	2.3	2.7	2	10	2.7	1.2	46
liters/day x 10(6)	15	11	11	10	9	10	8	10	10	4.6	46
GENERAL CONSTITUENTS (MT/yr) [b]											
Total Suspended Solids	14.9	8.9	10.0	9.0	8.3	7.8	8.2	10	11.4	7.1	62
Settleable solids	0.26	0.19	0.20	0.18	0.16	0.19	0.17	10	0.18	0.08	45
Oil and Grease	2.79	1.93	2.00	1.80	1.59	1.87	1.86	10	2.72	2.15	79
BOD (5-day)	14.4	8.8	10.4	8.8	8.8	11.9	5.9	10	11.7	6.8	58
Total Nitrogen	86.2	68.9	78.8	70.2	59.9	79.9	59.3	10	64.1	27.7	43
Phosphorus (PO4-P)	30.9	22.9	22.0	21.8	18.4	22.9	17.9	10	24.8	10.4	42
Detergent (MBAS)	0.33	0.23	0.28	0.18	0.10	0.28	0.15	10	0.28	0.17	60
Cyanide (CN)	0.14	0.02	0.03	0.09	0.04	0.07	0.02	10	0.06	0.06	109
Phenols	1.86	0.01	0.01	0.18	0.10	0.02	0.02	10	0.14	0.36	262
TRACE METALS (MT/yr) [b]											
Silver	0.03	0.01	0.01	0.01	0.01	0.02	0.01	10	0.03	0.07	212
Arsenic	0.14	0.00	0.02	0.02	0.01	0.06	0.02	10	0.03	0.04	134
Cadmium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	10	0.02	0.02	126
Chromium	0.03	0.01	0.01	0.01	0.02	0.02	0.01	10	0.03	0.04	150
Copper	0.12	0.02	0.00	0.04	0.03	0.06	0.06	10	0.06	0.04	70
Mercury	0.006	0.002	0.0004	0.002	0.003	0.0004	0.33	10	0.020	0.078	385
Nickel	0.11	0.03	0.02	0.04	0.06	0.08	0.08	10	0.13	0.21	160
Lead	0.17	0.02	0.06	0.05	0.01	0.02	0.01	10	0.07	0.06	82
Zinc	0.20	0.09	0.12	0.14	0.10	0.13	0.06	10	0.24	0.32	131

a. Mass Emissions for 1992 are extrapolated to 12 months.
b. Less than detection level values calculated at 1/2 detection level for plotting.
Sources: Los Virgenes Municipal Water District; Whitbeck, S. 1992 TWRF, pers. comm.

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APPENDIX E

Type and Size of Spills of 500 Gallons or more in Santa Monica Bay Area. 1973-1987, 1991.

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Appendix E. Type and size of spills of 500 gallons or more in Santa Monica Bay, 1973-1987 and 1991.*

Year	Amount (gal) Spilled	Amount (gal) ecovered	Type of Spill	Source Type**		Primary Cause	Contributing Cause
1976	200000	0	Not elsewhere specified	NV	Land Facility	Unintentional Discharge	ATT
1984	42000	0	Caustic soda solution	NV	Land Facility	Structure Failure	Corrosion
1984	33600	0	Oil, fuel	V	Freight Ship	Structure Failure	Collision
1979	28000	0	Oil: Clarified	V	Fishing Boat	Equipment Failure	EWR
1974	21000	21000	Oil, Crude	NV	OPN	Equipment Failure	Unknown
1974	15000	0	Not elsewhere specified	NV	Land Facility	ID	Unknown
1976	12000	0	Gasoline, Aviation (4.86g Pb/gal)	NV	Land Facility	Equipment Failure	Unknown
1991	9240	0	Diesel oil and Napthalene	NV	Pipeline	Structure Failure	Anchor impact
1978	8000	0	Oil, Crude	NV	Land Facility	Unknown	Unknown
1980	6300	6090	Oil: Crude	V	Tanker Ship	Unintentional Discharge	Unknown
1975	5000	0	Gasoline, Aviation (4.86g Pb/gal)	NV	LVN	Unknown	Unknown
1977	5000	0	Jet fuel	NV	Air Craft	Equipment Failure	Unknown
1978	4500	0	Oil, Crude	NV	Land Facility	Equipment Failure	Unknown
1983	4200	0	Oil, Crude	NV	OPN	Equipment Failure	Unknown
1983	4200	0	Oil: Crude	NV	Land Facility	Structure Failure	WTH
1976	4000	0	Hydrochloric acid	NV	LVN	CS	NEC
1977	4000	0	Oil, fuel	NV	Rail Road Equip.	Structure Failure	CNC
1977	4000	0	Oil, fuel	NV	Rail Road Equip.	CS	Collision
1983	3780	0	Sulfuric acid	NV	Land Facility	Structure Failure	Unknown
1975	3500	3500	Oil, misc: Mineral seal	NV	LVN	Unintentional Discharge	Unknown
1979	3360	0	Oil, fuel	NV	Land Facility	Equipment Failure	SEC
1983	3150	0	Oil: Crude	NV	OPN	Equipment Failure	CUT
1983	3000	0	Not elsewhere specified	NV	Land Facility	Equipment Failure	MNT
1973	2400	0	Jet fuel (Kerosene, heavy)	NV	NEC	Structure Failure	Collision
1982	2100	0	Oil, misc: Absorption	NV	Unknown	Unknown	Unknown
1984	2100	0	Oil, misc: transformer	NV	OPN	Structure Failure	Unknown
1976	2000	0	Distillates: Flashed feed stocks	NV	OPN	Equipment Failure	Unknown
1976	2000	0	Jet fuel	NV	OPN	Equipment Failure	Corrosion
1980	2000	0	Oil: Crude	NV	Tanker Truck	CS	NEC
1980	2000	0	Oil: Crude	NV	Land Facility	Equipment Failure	DEF
1980	2000	0	Oil: Crude	NV	LVN	CS	NEC
1981	2000	0	Not elsewhere specified	NV	OMF	Equipment Failure	PFG
1981	2000	0	Gasoline, Aviation (4.86g Pb/gal)	NV	Tanker Truck	CS	Collision
1981	2000	0	Not elsewhere specified	NV	Land Facility	Equipment Failure	Unknown
1984	1680	0	Oil, fuel	NV	OPN	Structure Failure	Corrosion
1982	1470	0	Not elsewhere specified	NV	NEC	NS	NEC
1977	1260	0	Oil, Crude	NV	OPN	Structure Failure	DEF
1978	1260	0	Oil, fuel	V	Freight Ship	Equipment Failure	Unknown
1976	1200	0	Gasoline, Auto (4.23g Pb/gal)	NV	LVN	CS	NEC
1979	1050	0	Oil, Crude	NV	Unknown	Unknown	Unknown
1974	1000	0	Hydrochloric acid	NV	Land Facility	Equipment Failure	DEF
1974	1000	1000	Oil, Crude	V	Tanker	Unintentional Discharge	NEC
1976	1000	1000	Oil, Crude	NV	LVN	CS	NEC
1977	1000	1680 ***	Oil, Crude	V	Tanker Ship	Equipment Failure	Valve
1979	1000	0	Oil, fuel	V	TNKB	Unintentional Discharge	Unknown
1979	1000	0	Oil, Crude	NV	Unknown	Unknown	Unknown
1981	1000	0	Oil, misc: Spray	NV	Land Facility	Unintentional Discharge	Unknown
1984	1000	0	Jet fuel (Kerosene, heavy)	NV	Land Facility	Equipment Failure	Unknown
1976	850	0	Oil, Crude	NV	Land Facility	ID	SAB
1981	850	800	Oil: Crude	V	Tanker	Unintentional Discharge	Unknown
1979	840	0	Not elsewhere specified	NV	Land Facility	Unintentional Discharge	ATT
1976	700	700	Oil, fuel	V	USCG	Unintentional Discharge	ATT
1979	630	0	Benzene	V	Tanker Ship	Unintentional Discharge	TOP
1981	630	630	Oil, fuel	V	Freight Ship	Unintentional Discharge	ATT
1985	630	0	Oil, fuel	V	POTH	Unintentional Discharge	TRN
1984	600	0	Gasoline, Aviation (4.86g Pb/gal)	NV	LVN	CS	PFG
1974	500	490	Oil, Crude	NV	OPN	Equipment Failure	DEF
1974	500	500	Oil, fuel	NV	LVN	Equipment Failure	SEC
1978	500	0	Chlorine	NV	OMF	Unknown	Unknown
1979	500	0	Oil, Crude	NV	Unknown	Unknown	Unknown
1979	500	0	Not elsewhere specified	NV	ONP	Unknown	Unknown
1981	500	0	Oil, fuel	NV	Unknown	Unknown	Unknown

Source U.S. Coast Guard, Dept. of Transportation, Washington D.C., unpublished data.

* Data not available for 1987 to 1990, only partial data for 1991.

** NV = Non Vessel; V = Vessel

*** As recorded in USCG data.

Information was not available for definitions of some codes used for vessel type and causes.

Note. In 1976, 10,000 lbs of Cyclohexenyltrichlorosilane were spilled from a land facility with none recovered.

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APPENDIX F

National Pollutant Discharge Elimination System Permits.

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STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

ORDER No. 90-079

NPDES NO. CA0061654 (CI 6948)

WASTE DISCHARGE REQUIREMENTS
STORMWATER/URBAN RUNOFF DISCHARGE
for
LOS ANGELES COUNTY
and
CO-PERMITTEES

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The California Regional Water Quality Control Board, Los Angeles, (Regional Board) finds :

1. The County of Los Angeles, in cooperation with the following cities : Agoura Hills, Beverly Hills, Culver City, El Segundo, Hermosa Beach, Inglewood, Los Angeles, Manhattan Beach, Rancho Palos Verdes, Redondo Beach, Rolling Hills Estates, Rolling Hills, Santa Monica, Torrance, West Hollywood, and Westlake Village, has submitted a report of waste discharge (NPDES permit application) dated March 15, 1990 for issuance of waste discharge requirements for the County of Los Angeles and other cities tributary to Los Angeles County (excluding Antelope Valley) under the National Pollutant Discharge Elimination System. (NPDES Permit No. CA0061654).

2. The discharges consist of surface runoff generated from various land uses in all the hydrologic drainage basins which discharge into water courses flowing into water bodies in Los Angeles County. The quality of these discharges varies considerably and is affected by land use, basin hydrology and geology, season, and the frequency and duration of storm events. The constituents of concern and significance in these discharges are: total and fecal coliform and enterococci bacteria, total suspended solids, biochemical oxygen demand, oil and grease, heavy metals, nutrients, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, pesticides and herbicides, and petroleum hydrocarbons.

3. The objective of this permit is to develop a timely, comprehensive, and cost-effective stormwater pollution control program to minimize pollutants in urban runoff/stormwater discharges to water bodies in Los Angeles County.

4. Due to the complexity and networking of drainage facilities within and tributary to Los Angeles County, the county and adjacent areas discharging storm water into Los Angeles County are divided and prioritized into five drainage basins for the implementation of the permit. The owners/operators of all facilities impacting stormwater quality will be ultimately a party to these waste discharge requirements. The County of Los Angeles together with the cities identified above, the initial parties filing for the system-wide permit, are 'Permittees', with the County of Los Angeles as the 'Principal Permittee' and the rest as 'Co-Permittees'. All other cities and recognized entities such as Caltrans, college/university campuses, hospitals, parks, agricultural areas, real estate developments and waste disposal facilities identified in this Order, are designated 'Co-Participants'. A 'Co-Participant' will be a 'Co-Permittee' upon becoming an active party to the permit.

   Attachments 1 and 2 show, respectively, the list of cities and a partial list of entities designated as Co-Participants for this permit. The list of entities will be revised as necessary.

5. The County of Los Angeles, as the 'Principal Permittee', will obtain the cooperation of 'Co-Participants' to become 'Co-Permittees'. The Regional Board has the discretion and authority to require non-cooperating cities and/or entities to become 'Co-Permittees' or obtain individual stormwater discharge permits, pursuant to 40 CFR 122.26 (a).

6. Los Angeles County as the 'Principal Permittee' is the permit coordinator responsible for general administration of this Order, and coordinating cooperation by 'Co-Permittees', including but not limited to the implementation of local self-monitoring programs and Best Management Practices, and the preparation and submittal of reports required by this Order.

7. Los Angeles County obtains its authority to :

   - control pollutants in stormwater discharge
   - prohibit illegal discharges and control spills
   - require compliance and carry out inspections

of drainage facilities in the County of Los Angeles from the Los Angeles County Flood Control Act and various county ordinances which address industrial wastes and waste discharges within the unincorporated areas of Los Angeles County and contract cities. 'Co-Permittees' with the status of incorporated cities have various forms of legal authority in place, such as charters, State Code provisions for General Law cities, city ordinances and applicable portions of Municipal Codes and the State Water Code, to regulate stormwater/urban runoff discharges.

8. The division and prioritization of Los Angeles County and adjacent areas into five drainage basins for program implementation are based on hydrological characteristics of the watersheds, perceived importance and beneficial uses of water bodies, and the existence of an adequate infrastructure for program implementation. The five drainage basins are :

I	:	Santa Monica Bay Drainage Basin
II	:	Upstream Los Angeles River Drainage Basin, to and including Sycamore Canyon Channel (San Fernando Valley);
III	:	Upper San Gabriel River (San Gabriel Valley) Drainage Basin.
IV	:	Lower Los Angeles River Drainage Basin
V	:	Lower San Gabriel River Drainage Basin; and Santa Clarita Valley Basin.

Attachment 3 shows a map of Los Angeles County with the boundary delineations of the five drainage basins.

Attachment 4 shows Co-Participant cities in Los Angeles County (and their respective populations).

[Note: Detailed maps of the Los Angeles County storm drain system with boundary delineations of drainage basins are available for review at the Regional Board Office.]

9. A number of studies on stormwater/urban runoff pollution in the permit areas has been conducted by agencies such as the City of Los Angeles, the Southern California Coastal Water Research Project and the Southern California Association of Governments. These studies indicate stormwater/urban runoff contributes significantly to the deterioration of the quality of water bodies in Los Angeles County.

The University of California at Los Angeles, under the sponsorship of the Santa Monica Bay Restoration Project, is currently compiling and summarizing data and information on stormwater/urban runoff discharges for the Santa Monica Bay watershed.

10. The Los Angeles County Department of Public Works has an active surface water quality monitoring program in the permit area, comprising twenty-eight monitoring stations located at principal storm drains and water conservation facilities. The Surface Water Quality Monitoring Program comprises the collection and analysis of dry weather water samples for general minerals, pesticides, total petroleum hydrocarbons, heavy metals and bacteria (total and fecal coliform, KF streptococci and enterococci). Volatile organic constituents are tested semi-annually at selected stations. Stormwater runoff is monitored three to four times annually at twenty-one stations for minerals, pesticides, heavy metals (total and dissolved), bacteria, total and organic suspended solids, oil and grease, biochemical oxygen demand, total organic carbon and volatile organics.

11. The Los Angeles County Department of Public Works and some cities have on-going activities that reduce stormwater/urban runoff pollutant loads. These activities include periodic catch-basin cleaning and street sweeping, public information on proper disposal of household hazardous waste, and emergency responses to reports of illegal dumping, illicit disposal, illegal connections, and industrial waste spills. The Los Angeles County Department of Public Works also participates and coordinates action with local, State, and Federal agencies responding to spills and illegal dumping reports that threaten surface waters.

12. The Regional Board currently regulates industrial process and point source non-process wastewater and stormwater discharges to storm drain systems through NPDES permits. Point source discharges including stormwater will continue to be regulated by the Regional Board. An information system will be developed and maintained to update pollutant loadings to designated

drainage facilities and water bodies from permitted point source discharges.

13. The State Water Resources Control Board (State Board) adopted a Water Quality Control Policy for the Enclosed Bays and Estuaries of California on May 16, 1974. The policy provides that the discharge of industrial process waters to enclosed bays and estuaries shall be prohibited. Storm water and urban runoff are not considered industrial process waters for the purpose of that policy.

14. The State Board adopted a revised Water Quality Control Plan for Ocean waters of California (Ocean Plan) on March 22, 1990, which amended the Plan adopted on September 22, 1988. The Plan contains water quality objectives for the coastal waters of California.

15. The Regional Board adopted a revised Water Quality Control Plan for the Los Angeles River Basin (Basin Plan) on November 27, 1978. The Basin Plan incorporates the Ocean Plan, and contains water quality objectives for the basin, including the beneficial uses of water bodies.

16. The beneficial uses of water bodies in Los Angeles County and their tributary streams include contact water recreation, non-contact water recreation, wildlife habitat, preservation of rare and endangered species, marine habitat, estuarine habitat, fish migration, fish spawning, industrial service and process supply, agricultural water supply, shellfish harvesting, navigation, commercial and sport fishing, and groundwater recharge.

17. Section 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act of 1972 to require the Environmental Protection Agency (EPA) to establish regulations for stormwater/urban runoff discharge under the National Pollutant Discharge Elimination System (NPDES).

18. The Federal Clean Water Act allows EPA to delegate its NPDES permitting authority to States with an approved environmental regulatory program. The State of California is one of the delegated States. The Porter-Cologne Act (State Water Code) authorizes the State Board, through its Regional Boards, to regulate and control the discharge of pollutants into waters of the state and tributaries thereto.

19. Although Water Code Section 13263 (a) requires that waste discharge requirements issued by Regional Boards shall include provisions to implement water quality based objectives, numerical water quality standards

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are not provided in this Order. Information is not available to establish appropriate numerical limits, and determine locations where permittees shall be made accountable. The requirements in this Order will provide the necessary information while concurrently achieving reductions in pollutant loads to water bodies from stormwater/urban runoff discharges. Numerical water quality objectives will be developed by Board staff for consideration in the permit renewal process and utilized for the evaluation of Best Management Practices.

20. Due to the significance of the Los Angeles County Stormwater/Urban Runoff Program, the Regional Board, in recognition of the need for public involvement and participation in the development and implementation of an effective program will conduct at a minimum an annual workshop, prior to approving plans submitted by Permittees, to solicit comments and to inform the public of the progress of the program. Comments presented will be referred to Los Angeles County for response.

21. Stormwater/urban runoff discharges to drainage facilities that cross County boundaries and Regional Board jurisdictions, and which are regulated under NPDES permits, are the regulatory responsibility of those agencies issuing the permits.

22. The issuance of waste discharge requirements for this discharge is exempt from the provisions of the California Environmental Quality Act (CEQA); Chapter 3 (commencing with Section 21100) of Division 13 of the Public Resources Code in accordance with Water Code Section 13389.

The Board has notified the Permittees and interested agencies and persons of its intent to issue waste discharge requirements for this discharge and has provided them with an opportunity to submit their written views and recommendations.

The Board, in a public hearing, heard and considered all comments pertaining to the discharge and to the tentative requirements.

This Order shall serve as a National Pollutant Discharge Elimination System permit pursuant to Section 402 of the Federal Clean Water Act, or amendments thereto, and shall take effect at the end of ten days from the date of its adoption provided the Regional Administrator, EPA, has no objections.

IT IS HEREBY ORDERED that the Permittees, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, and the provisions of the Clean Water Act as amended and regulations and guidelines adopted thereunder, shall comply with the following:

1.0 COMPLIANCE

1.1 The Permittees and Co-Permittees shall comply with the requirements contained in this Order according to the following schedule:

	DRAINAGE BASIN	STARTING DATE FOR COMPLIANCE WITH REQUIREMENTS
I.	Santa Monica Bay	July 1, 1990
II.	Upper Los Angeles River (San Fernando Valley)	July 1, 1992
III.	Upper San Gabriel River (San Gabriel Valley)	July 1, 1992
IV.	Lower Los Angeles River	July 1, 1993
V.	Lower San Gabriel River and Santa Clarita Valley	July 1, 1993

2.0 REQUIREMENTS - YEAR 1

2.1 For each Drainage Basin, prepare and submit to the Regional Board within 12 months of the starting date for compliance, according to the schedule under 1.1:

2.1.1 Water quality data and flow data from 1980 to the present to facilitate identification of sources of pollutants present in discharges from the prioritized drainage basin. "Drainage areas" in the drainage basin are to be reported and the "drainage areas" associated with each drainage basin clearly identified.

For purposes of stormwater/urban runoff, a "drainage area" is defined as a subdivision of a drainage basin which is unique in land use patterns, and pollutant characteristics and loadings.

2.1.2 The 90th percentile value for the water quality parameters, (i) Total Suspended Solids (TSS), and (ii) Oil and Grease, from the data set of all wet weather samples collected from 1980 to the present. These data will be used to establish guidance for early action control of stormwater pollution.

The 90th percentile for a given water quality parameter is defined as the concentration value exceeded in ten percent of the samples of the reference data set.

2.1.3 Additional information of a qualitative nature that would contribute to isolating and identifying sources of problems. Such information should include but not be limited to visual observations of factors exacerbating stormwater contamination, principal land use classifications and Standard Industrial Code (SIC) categories of facilities in "drainage areas", and a description of soils, dumps, landfills, waste disposal sites and Resource Conservation and Recovery Act (RCRA) facilities associated with each area.

2.1.4 Monthly precipitation data from rain gauge stations, relevant to the drainage basin, for the years 1980 to the present, and an estimate of the area of impervious surfaces (including paved areas and building roofs) within each "drainage area".

2.1.5 Documentation of existing procedures to detect and address illegal discharges and illicit disposal practices.

2.1.6 Documentation of existing practices and improvement plans to control pollutants in stormwater/urban runoff from construction sites.

2.1.7 Documentation of existing stormwater/urban runoff management practices and existing Best Management Practices (BMPs) for the control of pollutants in discharges from residential, commercial and industrial areas.

For purposes of this permit, a Best Management Practice is defined as a stormwater quality management practice that has been demonstrated to reduce stormwater/urban runoff constituents of concern in studies in the United States and elsewhere, or a stormwater/urban runoff quality management practice that can significantly control stormwater/urban runoff pollution.

2.1.8 Plan with schedule of implementation, for approval by the Executive Officer, of early action BMPs.

For purposes of this permit, an early action BMP is defined as an existing stormwater/urban runoff quality management practice that is optimized to the maximum extent practicable (MEP) in efficiency for the control of stormwater runoff pollution, such as improving the frequency of storm drain catchment basin cleaning or the stricter enforcement of existing regulations, or a BMP that is not specific to stormwater/urban runoff constituents or "drainage area" in its constituent removal capacity and can be applied on a system-wide basis, such as public outreach and educational programs.

For purposes of this permit, maximum extent practicable means to the maximum extent possible, taking into account equitable considerations of synergistic, additive and competing factors, including but not limited to gravity of the problem, fiscal feasibility, public health risks, societal concern, and social benefits.

The Principal-Permittee, in the submittal of plans and schedules to the Executive Officer, shall demonstrate that public input has been obtained.

For purposes of this permit, public input is demonstrated by, (i) disseminating the notice of availability of plans for review and comment, to the public at large, environmental groups, Federal, State and local officials and other interested parties, and (ii) addressing concerns expressed by the public.

The Board may modify the plans in response to public input received at the Board during its comment/review period. Permittees are required to implement the original or modified plan on approval by the Executive Officer.

2.1.9 A workplan for the development of a stormwater/urban runoff monitoring program, for approval by the Executive Officer, to include but not be limited to the following information :

- listing of constituents and parameters to be monitored and the rationale for their choice.
- listing of monitoring locations and the rationale for their choice.
- listing of sampling methodology of choice and frequency of sampling for both wet weather and dry weather flow.
- supplementary information that influences the design of the monitoring plan.

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The Principal-Permittee, in the submittal of the workplan to the Executive Officer, shall demonstrate that public input has been obtained.

2.1.10 Documentation that each Permittee, individually and/or jointly, through the establishment of a joint powers authority or a stormwater utility, possesses adequate legal authority to operate and manage stormwater/urban runoff quality management programs, and/or plans to obtain the necessary legal authority to regulate illegal discharges and illicit disposal practices into storm drains, and to prosecute violators.

3.0 REQUIREMENTS - YEAR 2

3.1 For each Drainage Basin, prepare and submit to the Regional Board, for approval by the Executive Officer, within 24 months of the starting date of compliance, according to the schedule under 1.1:

3.1.1 A monitoring program based on the approved workplan. This program shall be designed to:

- detect accurately the constituents and parameters of concern, in discharges indicated in the workplan, and to identify their possible sources.
- identify illegal dischargers and/or locations of illicit disposal practices.

Monitoring reports for this program shall be submitted according to the format and frequency to be approved by the Executive Officer.

3.1.2 Plan with schedule of implementation for additional BMPs, judged appropriate for each city or drainage basin, to control pollutants from residential, commercial and industrial sites to the maximum extent practicable.

Both structural and non-structural BMP measures are to be evaluated at the MEP standard. Examples of non-structural measures include catch basin cleaning, street sweeping and public education, while controls such as detention/retention basins, first flush diversions, grassy swales and porous pavements are examples of structural measures.

3.1.3 Plan with schedule of implementation of procedures to detect and eliminate illegal discharges and illicit disposal practices.

3.1.4 Plan with schedule of implementation of measures to control pollutants in surface runoff from construction sites.

The Principal Permittee, in the submittal of plans and schedules (items 3.1.2, 3.1.3, and 3.1.4) to the Executive Officer shall demonstrate that public input has been obtained. The Board may modify the plans in response to public input received at the Board during its comment/review period. Permittees are required to implement the original or modified plans on approval by the Executive Officer.

3.2 Evidence of satisfactory progress of implementation of plan and schedule for early action BMPs.

3.3 Evidence of all requisite legal authority to regulate illegal discharges and illicit disposal practices to drainage facilities, and to prosecute violators.

4.0 REQUIREMENTS - YEAR 3

4.1 For each Drainage Basin, submit to the Regional Board, within 36 months of the starting date of compliance, according to the schedule under 1.1, the following:

4.1.1 Evidence of satisfactory progress of implementation of plan and schedule for early action BMPs and additional BMPs.

4.1.2 Evidence of implementation and progress of procedures to detect and eliminate illegal discharges and eliminate illicit disposal practices.

4.1.3 Evidence of implementation and progress of measures to control pollutants in surface runoff from construction sites.

5.0 EXPIRATION AND RENEWAL

5.1 This Order expires on June 18, 1995.

5.2 The Permittees shall file a report of waste discharge (ROWD), not later than 180 days before the expiration date, as application for reissuance of waste discharge requirements. This report of waste discharge shall include but not be limited to the following:

5.2.1 Summary of the results of the monitoring program.

5.2.2 Summary of BMPs implemented and evaluations of their effectiveness.

5.2.3 Summary of procedures implemented to detect illegal discharges and illicit disposal practices and an evaluation of their effectiveness.

5.2.4 Summary of measures implemented to control pollutants in surface runoff from construction sites and an evaluation of their effectiveness.

5.2.5 Evaluation of the need for additional BMPs, source control, and/or structural control measures.

5.2.6 Proposed plan of stormwater/urban runoff quality management activities that will be undertaken during the term of the next permit.

I, Robert P. Ghirelli, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an order adopted by the California Regional Water Quality Control Board, Los Angeles Region, on June 18, 1990.

ROBERT P. GHIRELLI, D.Env.
Executive Officer

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ATTACHMENT 1

LIST OF CO-PARTICIPANT CITIES

Agoura Hills
Arcadia
Avalon
Baldwin Park
Bellflower
Beverly Hills
Burbank
Cerritos
Commerce
Covina
Culver City
Downey
El Monte
Gardena
Glendora
Hawthorne
Hidden Hills
Industry
Irwindale
La Habra Heights
La Mirada
La Verne
Lawndale
Long Beach
Lynwood
Maywood
Montebello
Norwalk
Palos Verdes Estates
Pasadena
Pomona
Redondo Beach
Rolling Hills Estates
San Dimas
San Gabriel
Santa Clarita
Sant Monica
Signal Hill
South Gate
Temple City
Torrance
Walnut
West Hollywood
Whittier

Alhambra
Artesia
Azusa
Bell
Bell Gardens
Bradbury
Carson
Claremont
Compton
Cudahy
Diamond Bar
Duarte
El Segundo
Glendale
Hawaiian Gardens
Hermosa Beach
Huntington Park
Inglewood
La Canada Flintridge
Lakewood
La Puente
Lancaster
Lomita
Los Angeles
Manhattan Beach
Monrovia
Monterey Park
Palmdale
Paramount
Pico Rivera
Rancho Palos Verdes
Rolling Hills
Rosemead
San Fernando
San Marino
Santa Fe Springs
Sierra Madre
South El Monte
South Pasadena
Thousand Oaks
Vernon
West Covina
Westlake Village

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ATTACHMENT Z

LIST OF ENTITIES (PARTIAL LIST)

Caltrans
Army Corps of Engineers
Railroad Rights of Way
Federal Hospitals
The State University System
University of California Campuses
National Forest Service
Federal Military Facilities

[This list will be updated during the permit process to indicate actual identity of agencies and entities.]

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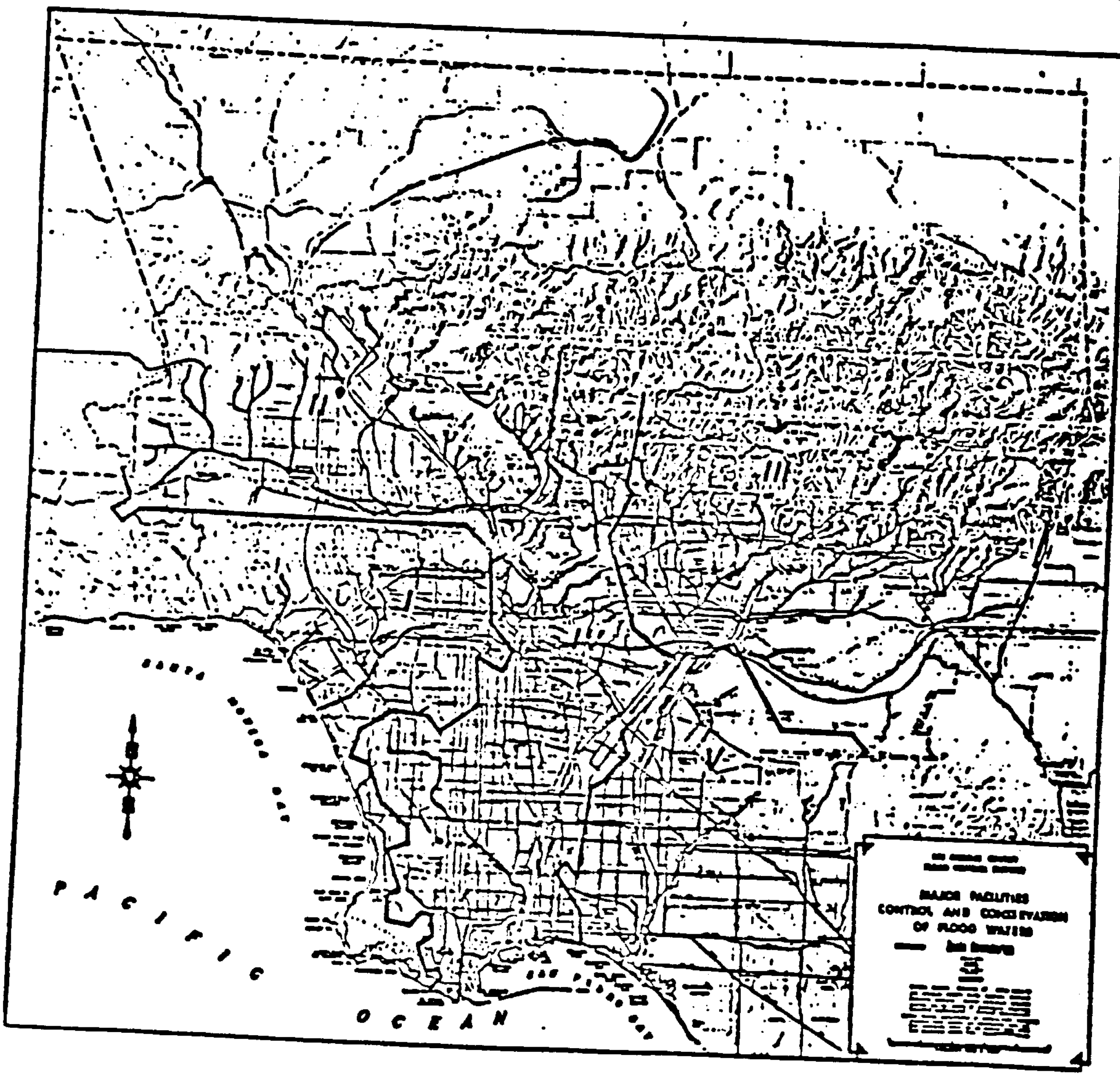
ATTACHMENT 3

DELINEATIONS OF DRAINAGE BASIN BOUNDARIES FOR LOS ANGELES COUNTY



ATTACHMENT 2

CITIES (AND POPULATIONS) TRIBUTARY TO DRAINAGE BASINS

Santa Monica Bay

Agoura Hills	19,000	Rancho Palos Verdes	46,000
Beverly Hills	34,000	Redondo Beach	64,700
Culver City	40,950	Rolling Hills	2,090
El Segundo	15,750	Rolling Hills Estates	7,875
Hermosa Beach	19,750	Santa Monica	96,500
Inglewood	102,300	Thousand Oaks	104,400
Los Angeles	3,400,500	Torrance	142,200
Manhattan Beach	35,300	West Hollywood	38,400
Westlake Village	8,025	Palos Verdes Estates	15,000

Upper Los Angeles River

Burbank	93,800	Glendale	166,100
Hidden Hills	1,950	Los Angeles	3,310,057
San Fernando	20,700		

Upper San Gabriel River

Alhambra	74,900	Arcadia	49,100
Azusa	38,250	Baldwin Park	63,300
Bradbury	930	Claremont	36,550
Covina	43,250	Diamond Bar	74,120
Duarte	21,350	El Monte	95,400
Glendora	47,400	Industry	370
Irwindale	1,230	La Canada Flintridge	20,800
La Habra Heights	5,450	La Puente	33,550
La Verne	30,500	Monrovia	34,000
Montebello	58,200	Monterey Park	64,600
Pasadena	132,200	Pomona	119,000
Rosemead	47,700	San Dimas	32,500
San Gabriel	34,900	San Marino	13,800
Sierra Madre	11,250	South El Monte	18,700
South Pasadena	24,500	Temple City	31,900
Walnut	26,400	West Covina	94,200

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(CONTINUED)

Lower Los Angeles River

Alhambra	74,900	Bell	28,250
Bell Gardens	38,300	Carson	88,800
Commerce	11,700	Compton	93,000
Cudahy	20,700	Downey	86,800
El Segundo	15,750	Gardena	50,900
Glendale	166,100	Hawthorne	67,400
Huntington Park	51,200	Inglewood	102,300
La Canada Flintridge	20,800	Lakewood	76,500
Lawndale	27,300	Lomita	20,300
Los Angeles	3,400,500	Lynwood	53,700
Maywood	24,650	Montebello	58,200
Monterey Park	64,600	Palos Verdes Estates	15,000
Paramount	44,450	Pasadena	132,200
Pico Rivera	57,300	Rancho Palos Verdes	46,000
Redondo Beach	64,700	Rolling Hills	2,090
Rolling Hills Estates	7,875	Signal Hill	8,150
South Gate	79,200	South Pasadena	24,500
Torrance	142,200	Vernon	80

Lower San Gabriel River

Artesia	14,950	Bellflower	60,900
Cerritos	58,400	Downey	86,800
Hawaiian Gardens	12,350	La Habra Heights	5,450
Lakewood	76,500	La Mirada	42,600
Long Beach	419,800	Norwalk	90,800
Paramount	44,450	Pico Rivera	57,300
Santa Clarita	115,700	Santa Fe Springs	16,400
Signal Hill	8,150	Whittier	74,100

Population estimates are taken from Report 89 E-1 published by the State of California Department of Finance.

The cities of Avalon (Pop: 2,490), Lancaster (Pop: 82,200), and Palmdale (Pop: 45,850) which are within Los Angeles County are not part of this permit.

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APPENDIX G

Dischargers into Santa Monica Bay.

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Appendix G. Dischargers in Santa Monica Bay (RWQCB,LAR unpubl. data).

Agency Name	Facility Name	Flow (mgd)
So Cal Edison	Redondo Generation Station	1143.00
Los Angeles, City of DWP	Haynes Generating Station	1014.71
So Cal Edison	El Segundo Generating Station	606.00
Los Angeles, City of DWP	Scattergood Generating Station	495.78
Los Angeles, City of DWP	Hyperion Treatment Plant	420.00
Los Angeles County Sant. Dist.	JWPCP, Carson	420.00
Los Angeles, City of DWP	Harbor Generating Station	380.00
Union Pacific Resources Co	Wilmington and Terminal Island	165.80
Unocal Corp	Los Angeles Refinery	40.00
Unocal Corp	Carson Refinery	39.12
Pacific Texas Pipeline	Marine Terminal & Storage Fac.	33.40
Los Angeles, City of DWP	Terminal Island Treatment Plant	30.00
Star Kist Foods	Plant No 1	28.80
Chevron U.S.A. Inc	El Segundo Refinery	19.80
Las Virgenes MWD	Tapia Park Plant, NPDES	18.10
Mobil Oil Corp	Torrance Refinery	16.00
Stocker Resources, Inc	Inglewood Oil Fd., Baldwin Hills	7.56
Hermosa Beach Investment Co	Hermosa Beach Strand Hotel	7.20
Arco	Watson Refinery	4.32
United Food Processors	Terminal Island Plant	4.07
Franciscan Promenade	Franciscan Ceramics	3.60
US Navy	Long Beach Naval Shipyard	3.17
Texaco Refining & Marketing Inc	Los Angeles Plant (Wilmington)	2.88
Pan Pacific Fisheries	Plant No 1 & 2, Terminal Island	2.74
GATX Tank Storage Terminals Co	Carson Terminal – NPDES	2.60
Rhone-Poulenc Basic Chemical Co	Dominguez Indust. Chem. Plant	2.30
United States Borax & Chem Corp	Wilmington Plant	2.23
Santa Monica, City of	Arcadia Drinking Wtr. Trt. Plant	1.85
Metropolitan Stevedore Co	Pier G. Berth 212, LB Harbor	1.71
Channel Gateway Ltd Partnership	Channel Gateway	1.50
Chiat/Day, Inc	Chiat/Day, Inc	1.40
Ultramar Inc	Marine Term, Berth 164	1.20
Four Corners Pipeline Co	Long Beach Marine Term 2	1.08
Arco C.Q.C. Klm, Inc	Arco C.Q.C. Klm, Inc	1.04
Monterey Park, City of	GW-Fern Well	0.93
Caltrans	Century and San Diego Freeway	0.86
Las Virgenes MWD	GW-Tapia Groundwater Discharge	0.80
Unocal Corp	Tank Leak-Unocal SS #1120	0.72
Los Angeles, City of DWP	Alamitos Barrier Proj. Unit 2 & 3	0.65
Texaco Refining & Marketing Inc	Carson Sulfur Recovery Plant	0.65
Cushman Investment & Dev. Corp	Landmark Square	0.60
Los Angeles, City of DWP	Marine Tank Farm, Harbor Steam	0.60
Howard Hughes Properties	Tank Leak-Culver City Facility	0.58
BP North America Petroleum Inc	San Pedro Marine Terminal	0.60
International Light Metals Corp	Torrance Facility	0.60
Los Angeles County DWP	Malibu Mesa WW Recl, NPDES	0.60
Scharff Werner G.	GW-Werner Scharff	0.50
Chevron U.S.A. Inc	San Pedro Marine Terminal	0.43
Western Fuel Oil Co	San Pedro Facility	0.41
Texaco Refining & Marketing Inc	Tank Leak-Texaco Service Station	0.38
General Telephone Co of CA	Tank Leak-Malibu Facility	0.34
Los Angeles, City of DWP	Olympic Tank Farm, Skim Pond	0.30
Mobil Oil Corp	Tank Leak-Mobil SS #11-FRN	0.29
Cochran (342 South) Avenue	342 S. Cochran	0.29
CWD Cloverdale Associates	328 Cloverdale Apartments	0.29
Lerner Building & Mgt. Co	Village on Canon	0.29
Defense Logistics Agency	Defense Fuel Sup. Terminal Is.	0.28
Harbor Cogeneration Company	Harbor Cogeneration Company	0.27
GATX Tank Storage Terminals Co	Los Angeles Harbor Terminal	0.26
Hayworth Associates	Hayworth Associates	0.25
Project West Corporation	818 South Burnside	0.25
DMG, Ltd	Office Building	0.25
Wilshire Landmark II	Wilshire Landmark II	0.23
Mercury Casualty Company	Home Office Building	0.22
Praxair, Inc	Linde Division, Wilmington	0.22

Appendix G (Cont).

Agency Name	Facility Name	Flow (mgd)
W & M Partners Development Corp	Watt City Center	0.22
Southwest Marine, Inc	San Pedro Yard	0.21
Shell Oil Co	Mormon Island Marine Terminal	0.20
Rohm and Haas Southern Calif.	Borden Chemical	0.19
Mobil Oil Corp	Southwestern Terminal–Area I	0.15
Riverbanks Bulk Water	Deionized Water, Wilmington	0.15
Southern California R.T.D.	Tank Leak–Division 7	0.15
CWD Detroit Associates	618 S. Detroit Apartments	0.14
Malibu Grand Prix	Tank Leak–Malibu Grand Prix	0.14
North Oakhurst Partnership	GW–North Oakhurst Partnership	0.14
Unisys Corporation	Tank Leak–Memorex Corp	0.14
Frank Pickett	Tank Leak–Pickett Service Stat.	0.13
Mobil Oil Corp	HT–Vernon Facility	0.13
Unocal Corp	Tank Leak–Unocal SS #6021	0.12
California Sulphur Co	Sulfur Pelletizing, Wilmington	0.11
Los Angeles County DWP	Big Rock Mesa Drainage Facility	0.11
Cal Fed Enterprises	Thayer Ltd	0.10
Dorchester Partners	Dorchester Partners	0.10
Las Virgenes MWD	GW–Irrigation Well–Westlake	0.10
Los Angeles, City of DWP	Harbor Steam Plant, Skim Pond	0.10
Park Mile Associates	Lowy Plaza	0.10
Wilshire West Inc	Wilshire West Inc.	0.10
Wilshire Westwood Associates	Wilshire Westwood Associates	0.10
Alvarado Grand Plaza	Alvarado Grand Plaza	0.09
University of Southern California	Institute For Marine & Coastal	0.09
Il Mook Kang	Maplewood Apartments	0.08
Center for Early Education	School	0.08
Arco T.S. & Four Corners Pipe	Long Beach Marine Term 3	0.07
Clark–Swall, Ltd	Clark–Swall, Ltd	0.07
Clinton Partnership	Clinton Partnership	0.07
Howard Hughes Properties	Tank Leak–Lot 2	0.07
Trillium Woodland Hills	Office Building	0.07
Burke Company, The	Edoco Technical Products	0.07
Los Angeles, City of DWP	Alamitos Barrier Proj. Unit 1	0.07
Los Angeles, City of DWP	West Coast Barrier Proj. 8	0.06
Beverly Springs Medical Center	Beverly Hot Springs	0.06
Los Angeles, City of DWP	Harbor Steam Plant, N Skim Tank	0.06
Los Angeles, City of DWP	West Coast Barrier Proj. 6	0.06
Los Angeles, City of DWP	Dominguez Gap Barrier Proj. 3	0.06
Unocal Corp	Los Angeles Terminal West	0.06
Culver City Unified Sch. Dist.	Culver City Natatorium	0.06
Los Angeles, City of DWP	West Coast Barrier Proj. 7	0.06
Los Angeles, City of DWP	Dominguez Gap Barrier Proj. 1 & 2	0.06
Redman Equipment & Mfg Co	Torrance Heat Exchanger Mfg & Rp	0.06
Todd Shipyards Corporation	Ship Build & Repair, LA Harbor	0.06
Atochem North America, Inc	Detergent Man–Carson	0.06
Delta Towers Joint Venture	Century Plaza Towers, Offices	0.05
Four Corners Pipeline Co	Marine Terminal, Berth 121, LB	0.05
Gardena, City of	Primm Memorial Swimming Pool	0.05
GATX Terminals Corporation	Bulk Chem. Store, Berth 70, SP	0.05
GATX Terminals Corporation	Berth 172, L.A. Marine Terminal	0.05
Inglewood, City of	Centinela Swim Pool, 700 Warren	0.05
Inglewood, City of	Fuel, Wash & Steam Clean Fac.	0.05
Kim Bong – Hwan	GW–Korean Youth Center	0.05
Los Angeles, City of DWP	West Coast Barrier Proj. 3 & 4	0.05
Petro Diamond Terminal Company	Marine Terminal, Berth 83, LB	0.05
Pine Realty, Inc	Gateway West Bldg, LA	0.05
Reef U S A Fund II Corp	Century Square Shopping Center	0.05
Reynolds Metal Company	Torrance Extrusion Plant	0.05
Third and Fairfax Plaza Assoc	Office Building	0.05
Wickland Properties	Wilmington Marine Terminal	0.05
Wilmington Liq. Bulk Terminals	Petroleum & Chemical Terminal	0.05
Northrop Corp	Aircraft Mfg, Hawthorne	0.05
Los Angeles, City of DWP	West Coast Barrier Proj. 2	0.04
Richard Ellis / Yarmouth Group	Tank Leak–May Co. Site	0.04

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Appendix G (Cont).

Agency Name	Facility Name	Flow (mgd)
Los Angeles, City of DWP	West Coast Barrier Proj. 5	0.04
Los Angeles, City of DWP	West Coast Barrier Proj. 1	0.04
Voi-Shan Aerospace Products	Tank Leak	0.04
Airesearch Manufacturing Co	Torrance Facility	0.04
Amakasu Investment Co	Wilshire Renaissance Apts.	0.04
H R Capital-North Doheny	West Hollywood Facility	0.04
Honeywell Inc	Tank Leak-Honeywell Inc	0.04
Mcgregor Co., The	4141 Wilshire Blvd. Associates	0.04
Tiger Co	GW-Tiger Co.	0.04
Two Rodeo Associates	Two Rodeo Associates	0.04
Westlake Kingstown Ltd	Westlake Kingstown Ltd	0.04
Arco Petroleum Products Co	Tank Leak-Arco Station #6028	0.03
Nakano Koar Inc	Tank Leak-Nakano Koar Partner	0.03
Unocal Corp	Tank Leak-Unocal SS #1715	0.03
Unocal Corp	Tank Leak-Unocal SS #0832	0.03
Unocal Corp	Tank Leak-Unocal SS #1715	0.03
Westwood Gateway II Ltd	Tank Leak-Breninvest Property	0.03
Coastfed Properties	The Casden Co	0.03
Los Angeles Times	Times Mirror Parking Structure	0.03
Arco Petroleum Products Co	Tank Leak-Arco Station #5080	0.03
Arco Petroleum Products Co	Tank Leak-Arco Station #6171	0.03
Douglas Aircraft Co	Torrance Facility	0.03
Morton Salt Co	Morton Salt Co	0.02
Astani Marco H.	GW-40 Units Apartments	0.02
Tracinda Corporation	Corp. Headquarters	0.02
Unocal Corp	Tank Leak-Unocal SS #3659	0.02
Unocal Corp	Tank Leak-Unocal SS #5317	0.02
Unocal Corp	Tank Leak-Unocal SS #0981	0.02
Arco Petroleum Products Co	Tank Leak-Former Arco #1361 NPDES	0.02
Jack Slomoric	Office Building-1026 Robertson	0.02
Jack Slomoric	Office Building-1030 Robertson	0.02
American Home Mortgage Corp	Tank Leak-Former Gasoline S.S.	0.02
Los Angeles County Medical Assoc	1930 W. 8th St. Cl 6933	0.02
Masseline Manor	Masseline Manor Apartment	0.02
Mobil Oil Corp	Tank Leak-Mobil SS #11-FC8	0.02
Suresh Manibhai	701 W. P.C.H. Cl 6941	0.02
Thrifty Oil Co	Tank Leak-Thrifty Oil #023	0.02
Unocal Corp	Tank Leak-Unocal SS #2326	0.02
Maguire Thomas Partners, Inc	The Gas Company Tower	0.01
Shell Oil Co	Tank Leak-Shell Oil Property	0.01
Arco Petroleum Products Co	Tank Leak-Arco Station #1946	0.01
Exxon Co, USA	Tank Leak-Exxon SS #3733	0.01
Altadena Texaco Market	Tank Leak-Altadena Texaco Mkt.	0.01
Los Angeles County DWP	GW-Dominguez Gap Barrier 7A	0.01
Milton Meyer & Co	Milton Meyer & Co	0.01
Arco T.S. & Four Corners Pipe	Long Beach Marine Term 1	0.009
Cal-Four Capital Thayer Assoc	Office Building	0.009
Bee Chemical Co./Morton Intl	Tank Leak-Bee Chemical Co	0.007
Los Feliz Associates	Villas Apartments	0.007
Pacific Bell	Tank Leak-Inglewood Veh. Maint.	0.007
Peter Giorganni	Peter Giorganni	0.007
Elixir Industries	Tank Leak-Elixir Industries	0.006
Beverly Connection, Ltd	Shopping Mall	0.006
Centerwest Wilshire-Glendon	Tank Leak-Center West	0.006
Glenfed Development Corp	Sunset Apartment	0.006
Green's Ready-Mixed Concrete	Ready-Mixed Concrete Plant	0.006
Hara Co	New Wilshire	0.006
HBWC Ltd	HBWC Ltd	0.006
House Ear Institute	House Ear Institute	0.006
Hyatt Hotel Corp	Hyatt House at LA Intl. Airport	0.006
Lake View Mansion Partnership	Apartment	0.005
Los Angeles Free Clinic Inc	Los Angeles Free Clinic	0.006
Ogden Avenue Associates, Ltd	Ogden Avenue Associates, Ltd	0.005
Pangiossian Development Corp	Panglossian Development Corp	0.005
Sheldon M Gordon Co	Ma Maison Hotel	0.006

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Appendix G (Cont).

Agency Name	Facility Name	Flow (mgd)
State Farm Mutual Auto Ins Co	Insurance Office, Westlake Vill.	0.006
Refiners Marketing Company	Terminal Is. Tank Farm, Lube Oil	0.004
Federal Employees Dist. Co	LA Discount Dept. Store	0.004
Kinneloa Irrigation Dist.	GW-K3 Water Well	0.003
Central Associates	Central Bank Office Building	0.003
Mobil Oil Corp	Tank Leak-Mobil SS #11-EBK	0.003
Texaco Refining & Marketing Inc	Tank Leak-Texaco Station Aband.	0.003
Los Angeles Unified School District	Tank Leak-Lincoln Medi Magnet	0.002
San Pedro Marine, Inc.	Berth 74, San Pedro	0.002
Aggie Cal.	Basin H Boat Repair Facility	0.001
Al Larson Boat Shop	Al Larson Boat Shop	0.001
GBW Properties Inc	Real Estate Developer	0.001
General Telephone Co. of Calif	Tank Leak-Santa Monica Cleanup	0.001
Jan Development Co	Reno Apartments	0.001
Los Angeles County DWP	Municipal Storm Sewer System	0.001
Mobil Oil Corp	Tank Leak-Mobil SS #11-KWL	0.001
Northrop University	Data Processing School	0.001
San Pedro Boatworks	Berth 44 Outer Harbor	0.001
Windward Yacht & Repair Inc	Yacht Repair, Marina Del Rey	0.001
Abraham Moradzudeh & Sam Shaou	Abraham Moradzudeh & Sam Shaou	0.001
Beverly Mercedes Place, Ltd	Beverly Mercedes Place	0.001
Northrop Corp	Aircraft Mfg, El Segundo	0.001
Real Property West Inc	Pacific Financial Center	0.001
Cerritos Yacht Anchorage, Inc	Berth 205C	0.0002
Koll Co., The	GW-550 Hope St. Building	0.0001

Source: Modified from RWQCB, LAR 1992 unpubl. data

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APPENDIX H

Recorded Sewage Overflows into Ballona Creek, 1965-1992.

Appendix H. Recorded sewage overflows into Ballona Creek, 1965-1992.

Date	Flow Duration (Hr)	Total Flow (mg)	Peak Flow Rate (mgd)	Date	Flow Duration (Hr)	Total Flow (mg)	Peak Flow Rate (mgd)
11/22/65	1.7	[a]	[a]	03/04/83	12.6	0.62	1.7
12/29/65	6.0	[a]	[a]	03/05/83	8.5	0.28	0.7
11/07/66	2.5	[a]	[a]	03/06/83	3.5	0.12	0.7
11/21/67	1.5	[a]	[a]	03/07/83	3.0	0.10	0.7
11/22/67	3.2	[a]	[b]	03/08/83	2.5	0.06	0.7
01/25/69	14.6	21.8	59.3	03/12/83	2.0	0.06	0.7
02/23/69	3.5	0.8	7.4	03/18/83	1.5	0.06	0.7
11/29/70	7.2	9.9	69.3	03/19/83	2.0	0.08	0.7
12/24/71	2.0	0.2	5.3	09/15/84	2.5	0.59	1.7
01/07/74	15.4	[a]	[a]	10/20/84	0.5	[c]	[c]
06/17/77	5.1	2.4	19.4	11/17/84	0.5	[c]	[c]
12/28/77	3.8	0.8	8.5	11/22/84	1.0	0.28	6.5
12/30/77	3.0	0.7	8.5	11/24/84	2.0	0.34	4.3
01/17/78	8.5	10.7	66.0	11/28/84	1.0	0.23	4.3
02/10/78	9.5	7.8	59.3	12/19/84	6.7	0.05	1.2
03/01/78	14.0	60.4	49.8	12/22/84	1.0	0.04	1.9
03/02/78	13.5	11.0	34.4	12/31/84	0.8	[c]	[c]
03/04/78	19.2	43.2	89.8	01/05/85	1.7	0.11	1.8
03/05/78	13.0	17.1	40.3	01/12/85	2.3	0.50	7.2
03/06/78	11.2	1.2	5.3	01/19/85	1.0	0.50	1.2
01/06/79	5.5	3.2	18.5	02/02/85	1.5	0.02	0.5
01/15/79	6.5	3.5	21.2	02/16/85	1.0	0.09	1.2
01/16/79	1.5	0.3	6.4	02/18/85	2.5	0.02	0.2
03/27/79	9.5	12.1	53.0	02/23/85	1.5	0.04	0.5
03/28/79	3.5	1.0	14.3	03/02/85	2.1	0.22	4.5
02/14/80	1.5	0.1	2.1	03/09/85	1.5	0.02	0.2
02/15/80	17.8	19.9	69.0	07/12/85	–	0.01	[c]
02/16/80	15.8	37.8	110.0	07/20/85	1.0	0.03	1.0
02/17/80	13.5	12.9	49.5	07/22/85	0.1	[c]	[c]
02/18/80	18.5	16.9	37.1	07/28/85	1.7	0.04	0.5
02/22/30	9.8	2.0	12.2	08/02/85	2.5	[c]	[c]
02/23/80	7.2	1.3	6.4	09/06/85	0.5	[c]	[c]
03/02/80	9.8	9.3	44.0	09/21/85	1.8	0.10	2.4
03/03/80	11.0	2.4	10.1	01/30/86	4.4	0.80	4.8
03/14/82	1.3	0.1	2.1	01/31/86	4.6	0.82	3.6
03/17/82	5.2	2.3	21.2	02/14–15/86	8.2	10.23 [d]	30.6
11/30/82	5.0	1.52	12.7	02/19/86	6.5	1.89	7.5
02/02/83	6.4	0.34	1.7	03/08/86	5.2	2.31	18.5
02/05/83	2.0	[a]	[a]	03/15/86	2.9	0.56	7.0
02/27/83	5.8	0.42	2.4	03/16/86	9.8	24.28	171.0
02/28/83	3.0	0.06	0.7	09/25/86	0.4	0.000 [d]	20.9
03/01/83	20.8	9.77	15.4	10/22–23/86	2.4	2.78 [d]	41.0
03/02/83	20.3	7.17	13.4	10/31/87	7.0	4.11 [d]	31.6
03/03/83	17.0	1.67	4.3				

Source: CLA, DPW, unpubl. data.
Note: No record available for 1968, 1972, 1973, 1975, and 1976.
No overflow recorded in 1981.

a = Insufficient data to calculate.
b = No record due to power failure.
c = Flow immeasurably small.
d = Stored 1,000,000 gallons in holding tanks.

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APPENDIX I

Los Angeles County Beach Closures 1986-1992.

Appendix I. Los Angeles County beach closures, 1986-1992 (LAC,DHS unpubl. data).

LOS ANGELES COUNTY BEACH CLOSURES 1986 - 1992

Date Closed	No. of Days	Location	Cause
03/20/86	2	Redondo Pier to ¼ mile southward.	Sewage discharge under Redondo Pier.
09/26/87	2	Temescal Storm Drain to Sunset Storm Drain.	Sewage discharge due to sewage pump failure.
10/07/87	1	100 yds. north and south of Santa Monica Canyon Storm Drain.	Sewage discharge due to blocked sewer line. 100 gallons.
10/22/87	6	½ mile north of Sunset Storm Drain to ½ mile south of the Bel Air Bay Club.	Sewage discharge due to pump failure.
10/22/87	6	Ventura County border to Long Beach City border.	Sewage discharge at North Outfall Treatment Facility, due to heavy rains. 2.7M gallons.
10/22/87	42	Marina Del Rey Beach.	Excessive bird population leading to elevated bacterial levels.
10/30/87	13	Temescal Storm Drain to Sunset Storm Drain.	Unknown.
10/31/87	12	Ventura County border to Long Beach City border.	Sewage discharge at North Outfall Treatment Facility, due to heavy rains. 4.11M gallons.
11/25/87	5	Temescal Storm Drain to Sunset Storm Drain.	Unknown.
12/01/87	3	Temescal Storm Drain to Sunset Storm Drain.	Sewage discharge due to unknown sewer system failure. Approximately 2K gallons.
12/30/87	3	Pulga Canyon Storm Drain to Santa Monica Canyon Storm Drain.	Unknown.
06/03/88	1	¼ mile either side of Pulga Storm Drain.	Sewage discharge due to sewage pump failure.
07/06/88	1	¼ mile either side of Sunset Storm Drain.	Sewage discharge due to line blockage.
09/15/88	2	Santa Monica Pier south to Pico/Kenter Storm Drain.	Suspected sewage discharge from Santa Monica Pier Storm Drain.
10/07/88	1	Pico/Kenter Storm Drain to ¾ miles southward.	Possible diesel fuel flow from Pico/Kenter Storm Drain.
11/10/88	3	Venice Pier to Grand Ave. Storm Drain.	Sewage discharge into Ballona Creek due to sewer line blockage.
12/12/88	3	Sunset Storm Drain to Temescal Storm Drain.	Sewage discharge due to sewage pump failure.

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Appendix I (Cont.)

LOS ANGELES COUNTY BEACH CLOSURES
1988 - 1992

Date Closed	No. of Days	Location	Cause
01/23/89	3	200 yds. north and south of Santa Monica Pier.	Small sewage discharge under Santa Monica Pier.
03/06/89	3	King Harbor south ¼ mile to Ainsworth Court.	Sewage discharge due to restaurant sewer line blockage.
05/02/89	2	Venice Pier to Imperial Ave. Storm Drain.	Sewage discharge into Ballona Creek due to sewage pump failure. 100K gallons.
09/26/89	3	¼ mile either side of Ashland Storm Drain.	Sewage discharge of unknown origin into Ashland storm drain. Est. less than 500 gallons.
11/20/89	1	½ mile either side of Pulga Storm Drain.	Sewage discharge due to pump failure caused by tripped circuit breaker. Est. 1.5K gallons.
12/13/89	2	Sunset Storm Drain to Temescal Storm Drain.	Sewage discharge due to pump failure caused by faulty air check valve at pump station 639. Approximately 6.5K gallons.
02/17/90	4	Entire Los Angeles County coastline from Topanga Canyon Storm Drain to Palos Verdes Point.	Discharge of primary treated sewage from North Outfall Treatment Facility, due to heavy rains. Approximately 7.6M gallons.
9/19/90	9	Santa Monica Pier south to Ashland storm drain. Reopened Ashland to Hart St. on 9/21/90.	Possibly caused by construction on the Pico/Kenter storm drain. Release of accumulated debris. Not sewage related.
12/10/90	4	King Harbor south to Pearl Street extended (appx. ¼ mi. north and south of Redondo Pier)	Small sewage leak from 12" main.
02/28/91	14	Topanga Canyon Blvd. south to Palos Verdes Point. Closure reduced to Marina Del Rey entrance channel south to the El Segundo city line and Marina Del Rey on 3/5/91.	Discharge of 2.31M gallons partially treated sewage at the North Outfall Treatment Facility due to heavy rains.
03/01/91	13	Topanga Canyon to the Ventura County border. Closure reduced to Topanga Canyon to Malibu Creek on 3/6/91.	Washout of private sewage treatment systems due to heavy rains.
03/24/91	1	Surfrider Beach, Malibu.	Diesel fuel spill.
03/29/91	2	Grand Ave. north to Imperial Highway.	Diesel fuel spill.

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Appendix I (Cont.)

LOS ANGELES COUNTY BEACH CLOSURES
1988 - 1992

Date Closed	No. of Days	Location	Cause
11/21/91	4	Imperial Highway storm drain, one mile north and south.	Sewer line break at Hyperion Treatment plant resulting in flow of sewage into Imperial Hwy. storm drain and 2K gallons of sewage into ocean. Partially reopened 11/22/91.
02/10/92	11	Entire L.A. County coastline, from Ventura County of Long Beach City.	Discharge of 66.12M gal. partially treated sewage at the North Outfall Treatment Facility due to heavy rains. Partially reopened 2/19/92 from MDR entrance channel to Cabrillo Beach.
05/02/92	3	Dockweiler Beach, ½ mile north to 1 mile south of Marina Del Rey entrance channel and Marina Del Rey Beach.	High Bacteria counts detected in Ballona Creek, most likely caused by a small sewage discharge which occurred when a contractor accidently drilled into a sewer line. This coincided with civil disturbances in Los Angeles and as a precautionary measure beaches were closed.
05/16/92	1	Redondo Beach Pier, south to Ruby St. (appx. ¼ mile).	Leaking sewer line under the Redondo Beach Pier. Quantity unknown.
07/29/92	1	Redondo Beach Pier, south to Ruby St. (appx. ¼ mile).	Leaking sewer line under the Redondo Beach Pier. Quantity 50 - 75 gallons.
08/15/92	3	Rose Ave. south to Imperial Highway (appx. 4 miles).	High bacteria counts originating from sewage in upper Ballona Creek, source unknown. Coastline reopened 8/18/92 and Marina Del Rey Beach reopened 8/19/92.
08/17/92	3	Redondo Beach Pier, south to Knobhill Ave. (appx. ¾ mile)	Leaking sewer line under the Redondo Bch. Pier due to vandalism. Amount and duration unknown.
09/04/92	1	Avenue 23, Los Angeles, south to Imperial Highway. (appx. 2½ miles).	High bacteria counts detected in Ballon Creek, source unknown, with the potential to affect adjacent beaches.
09/16/92	1	Pico Blvd. south to Windward Ave. (appx. 2 miles).	Collapsed sewer line discharging into Ashland Storm Drain.

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Santa Monica BAY Restoration PROJECT

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Ozone Disinfection and Treatment of Urban Storm Drain Dry-Weather Flows:

A Pilot Treatment Plant Demonstration Project on the Kenter Canyon Storm Drain System in Santa Monica

VOL 12

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VOL 12

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EXECUTIVE SUMMARY

The Pico-Kenter Canyon storm drain has become the archetype for assessing the problems and possible solutions that can be associated with many of the urban storm drains in the Santa Monica Bay region. While known events of chemical contamination are few, the drain has long been known to be contaminated with indicator bacteria such as Total and Fecal Coliforms. More recently, the consistent identification of Human Enteric Viruses, F-male Specific Coliphage, and high densities of Enterococcus bacteria have indicated that a potentially serious public health threat exists. The City of Santa Monica, with the assistance of the Santa Monica Bay Restoration Project (SMBRP), the United States Environmental Protection Agency (EPA), and the UCLA Laboratory of Biomedical and Environmental Sciences (LBES), recently completed an evaluation of ozone for the treatment of dry-weather storm drain flows. The primary goals of this study were to establish if ozone could be used to disinfect the water that typically flows from the Pico-Kenter storm drain and determine if some known hazardous chemical contaminants were present at significant levels.

Recently, ozone has become renowned in the drinking water industry as an alternative to chlorine that rapidly disinfects water while forming few halogenated by-products. This study demonstrated that ozone was an effective disinfectant, reducing bacterial and viral populations by 3-5 log (99.9 to 99.999% of the microbes killed or inactivated). In many of the 438 effluent samples, coliform concentrations were sufficiently reduced to qualify the water for reclamation projects such as landscape irrigation along the Santa Monica Freeway, suggesting a possible useful role for the treated effluent. Ozonation by-products (aldehydes) were detected in the plant effluent at low (<100 PPB) concentrations. No significant increases in halogenated by-products, or mutagenicity, were observed following ozone disinfection. During a test of the ozonation process, twelve organic chemicals were added to the influent water and the effluent monitored. While some refractory compounds passed through the pilot facility intact, the concentrations of most were reduced.

In comparison to State Ocean Plan Water Quality Objectives and Federal Drinking Water Maximum Contaminant Levels, the primary hazardous chemical constituents in the influent storm drain water were metals (primarily copper and lead) and polynuclear aromatic hydrocarbons (PAHs). While lead levels were significantly above both standards, the concentration of copper was well under drinking water standards. The mean observed level of six major PAHs were approximately equal to their proposed phase V drinking water MCL standard (100-400 ng/L or PPTr). Isolated samples were found to contain organic contaminants, such as ortho-xylene and the pesticide chlordane. This did not appear to be a pervasive problem and can be attributed to isolated events that cannot be anticipated and will only be prevented through an informed and concerned public.

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While the metal content of the water cannot be reduced using ozone, this study found that high concentrations of some organics, including PAHs, can be reduced during the ozonation process. This remediation probably occurs by oxidation and hydroxylation to less hazardous forms. Irregardless of further ozonation investigations, additional more sensitive and definitive PAH analyses are warranted in future studies of the storm drain water and sediments.

Based on the results of this investigation, the City of Santa Monica is investigating construction of a disinfection facility that would reclaim high quality water for landscape irrigation, use low quality for sewer flushing, and disinfect the remainder prior to releasing it into the Santa Monica Bay. Construction of the proposed facility would be encouraged by the support of the Santa Monica Bay Restoration Project in goal definition and consensus building among the member and non-member agencies.

Summary Conclusions

1) Ozone at moderate doses (10-20 mg/L) was an extremely effective disinfectant of dry-weather storm drain flows.

2) Bacterial and viral levels were reduced 3-5 log (99.9% to 99.999% of the microbes killed or deactivated).

3) Much of the effluent was sufficiently disinfected to meet the landscape irrigation standard of 23 coliforms per 100 ml.

4) Based on California Ocean Plan Water Quality Objectives, heavy metals and polynuclear aromatic hydrocarbons appear to be the primary contaminants of concern in the pilot plant effluent.

5) While ozone disinfection by-products were detected (aldehydes), their concentration was low and, in contrast to what would be expected from disinfection by chlorination, no increase in mutagenicity was observed following ozonation.

Summary Recommendations

1) The SMBRP should encourage further evaluation of the ozone disinfection process, by promoting the City of Santa Monica in its effort to design and construct a full scale facility.

2) Since construction and operation of the proposed facility will require interagency consent and permitting, the City of Santa Monica solicits the continued assistance of the SMBRP in consensus building, policy direction, and technical support.

3) Further investigations into the use of the ozone technology should include provisions for the evaluation of Advanced Oxidation Processes (AOPs), using hydrogen peroxide and ozone, for the control of organic pollutants such as PAHs.

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INTRODUCTION

In contrast to the success achieved in controlling point sources of water pollution, storm drains and other non-point sources of pollution remain a significant threat to the environmental and public health of our national waterways (GAO 1990 and Water-2000 1991). The popular perception of these conveyances is expressed by the antiquated, but still prevalent, descriptive phrase "storm sewers", suggesting a pipe that conveys wastewater to a treatment facility that purifies the water into a non-polluting effluent. However the Civil Engineer knows, and the public is being educated to the fact, that storm drains are only tubes meant to rapidly convey rainfall to a nearby lake, river, or bay, without significant treatment to remove the pollutants that maybe present.

Rain falling in urban areas becomes contaminated by scavenging pollutants such as Polynuclear Aromatic Hydrocarbons (PAHs) even before reaching the ground (Tsai et al, 1991). The runoff is further contaminated by passing through fields or lawns that contain fertilizers, pesticides, and decaying organic matter. Urban areas are also significant sources of additional pollutants including construction site suspended solids, transportation-derived metals, particulates, oils and previously deposited aerial fallout. Even hazardous substances, which may be present at outdoor storage and manufacturing facilities, find their way into storm drain water. While urban runoff, groundwater infiltration, and National Pollutant Discharge Elimination System (NPDES) permitted facilities, produce a steady stream of contaminated water, spills and illegal releases of hazardous chemicals continue to regularly occur with potentially disastrous implications (SCAG 1988). Additional sources of urban storm drain pollutants include illegal sewer and floor drain connections, sanitary sewer overflows, swimming pool drainage, lawn over-watering, human and pet fecal matter, vehicular and structural washdown, leaking cooling systems, and automotive repair shop off-site drainage.

A second aspect of the storm drain pollution problem, is attempting to economically deal with the volume of water that must be conveyed. In many regions of the United States, precipitation is evenly spaced throughout the year and undeveloped land is relatively affordable. In these areas, management practices, such as open spaces and park-like detention basins, can help to detain water on-site, provide additional area for infiltration, and reduce the stormwater pollutant loading (Davenport 1990). Unfortunately, in Southern California rainfall and runoff are observed on one or two dozen days each winter and the large percentage of impervious surface assures that a immense volume of water must be processed in an exceedingly short time. Furthermore, the high value of land in Southern California ensures that little open space remains for the installation of treatment or detention facilities, especially when usage is limited to few dozen days per year and the adjacent developed areas might become susceptible to periodic flooding.

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The City of Santa Monica, California, located just west of Los Angeles, is an extreme example of a populated urban community with a resident population of 86,900 (1990 census), a significantly larger business population, and a surface area of only 8.147 square miles. Santa Monica was founded in 1875 and is mainly zoned for residential and commercial use, with confined industrial areas. The municipal infrastructure is well developed and most of the storm drain system was constructed prior to 1960. Since then, numerous multistory buildings, parking lots, roofs, roadways and other impervious surfaces have been added, covering an estimated 70% of the total municipal surface area and exceeding the drainage capacity of the system. Eight, of the fourteen storm drains in the City, discharge onto municipal beaches, while the remaining six drains pass through adjacent portions of Los Angeles before entering Santa Monica Bay. Although originally constructed to seasonally empty into the ocean, accretion of beach sand has resulted in some drains discharging directly onto public beaches where trash and other debris accumulates and ponding occurs. Several of these areas have been identified as major sources of biological and chemical contamination during both wet (rainy) and dry-weather conditions. While incidents of chemical contamination are few, the drainage water often contains high levels of indicator organisms that pollute the adjacent marine environment and are associated with human and animal fecal input (PLC 1988).

The Kenter Canyon, Pico Boulevard, and Santa Monica Freeway or Caltrans (California Department of Transportation) storm drains all terminate under Pico Boulevard at The Promenade, entering a concrete lined channel before spilling onto the beach. The latter two are completely within the City of Santa Monica and join approximately one kilometer upstream of the beach, but have significantly different source characteristics and should be considered independently. The Kenter Canyon Storm drain enters Santa Monica along its northeast boundary, after having drained canyon, suburban and commercial areas of Los Angeles City. Two thirds of the total Kenter Canyon drainage area of 6.28 square miles is in the City of Los Angeles. Approximately one third of the total City of Santa Monica area is discharged at the combined three drain outlet. While the California Department of Transportation is responsible for the Santa Monica Freeway drain, the Pico and Kenter Canyon drains are maintained and operated by the Los Angeles County and City Departments of Public Works and City of Santa Monica Department of General Services.

The dry and wet weather flow, from the Pico-Kenter Canyon storm drain outfall, primarily consists of water conveyed by the Kenter Canyon storm drain. During dry weather, the Pico and Caltrans drains usually contain little water and the flow is generally less than a few thousand gallons per day. In contrast, the Kenter Canyon Storm drain has a dry-weather flow estimated at between one hundred thousand and three million gallons per day (SCCWRP 1973), most of which enters Santa Monica from the upper drainage basin. Low flows during this study were normally estimated at between one and three hundred thousand gallons per day (70-210 GPM). During a significant storm, this stream swells to an estimated hundred million gallons per day, fills the enclosed 10 by 12 foot Kenter Canyon storm drain, and lifts manhole covers.

For decades, the effluent from the mouth of the Kenter Canyon storm drain has formed large ponds on the beach, where young children would play away from the surf, and wildlife would find a source of freshwater. Over a dozen years ago, the outfall became suspect as a source of carcinogens which may have affected the health of lifeguards stationed near it. Since then, the Pico-Kenter has become one of the most heavily investigated storm drains in the country. The beach adjacent to it is now posted to warn bathers to avoid the area and storm drain water in general.

While the evidence of chronic chemical contamination is mixed, it appears that few recognized hazardous contaminants are present in significant concentrations (PCR 1988). Among those that are present, most are found in low concentrations and at levels that are comparable to other storm drains (SCAG 1988b). Assuming a five fold initial dilution, and comparing the mean values reported in State of the Bay report (SCAG 1988b) with the 1990 California Ocean Plan, several pesticides exceeded the water quality objectives given in the Plan. In particular, the DDT, DDE, and DDD group was several hundred times above the 1990 objectives. The endrin and endosulfan (including heptachlor) groups also exceeded objectives by 6 to 20 times. Copper was determined to be at about six times the water quality objectives while lead, chromium, zinc, and nickel were all slightly above their respective goals. Significant spills of hydrocarbons, probably vehicular fuels, were observed in the outfall in September 1980, December 1985, and September 1986, and caused beach closures and the posting of warning signs (PCR 1988).

The problem of microbial contamination in the Pico-Kenter effluent is more clear than that of chemical contamination and has warranted significant attention from various agencies and advocacy groups. Biological standards are based on the enumeration of benign indicators, such as enterococcus and total and fecal coliform bacteria, because of the difficulty in estimating the number of human pathogenic (disease causing) organisms, such as enteric viruses. Unfortunately, as was extensively reviewed in the State of the Bay report (1988b), all of the standard indicators have sources other than human fecal material. The California Ocean Plan standards for total coliform organisms can be summarized as 1,000 bacteria per 100 ml of water, yet this group of microbes are common constituents of soil and vegetation and are prevalent in the urban runoff found in storm drains. The criterion for fecal coliform and enterococcus bacteria are 200 and 24 organisms per 100 ml. respectively. Both of these groups are prevalent in the intestinal tract of endotherms and would be anticipated in the runoff from communities with large pet populations or where birds bathe and roost, as is observed in the beach ponds below the Pico-Kenter outfall. Not surprisingly, the Pico-Kenter outfall, even with ocean dilution, frequently exceeds the standards for these indicator bacteria. However, due to the prevalence of non-human sources, the presence of these indicator bacteria in storm drain effluent has been minimalized and not used as evidence of a public health threat for exposure to pathogenic organisms. The recent detection of human enteric virus in the mouth of the Kenter Canyon storm drain (Gold et al. 1990), indicates that a defined public health threat may indeed exist and that the storm drain low-flow may warrant treatment to control human pathogenic organisms.

In response to concerns for the public and environmental health, the City of Santa Monica has participated on commissions and undertaken studies and projects, with the goal of reducing exposure to contaminated storm drain effluents. The Cities of Santa Monica and Los Angeles have joined with Los Angeles County in directing the combined Pico-Kenter dry-weather effluent through a by-pass pipe, 600 feet into the ocean in an effort to reduce the exposure of terrestrial organisms to contaminants. As part of this project, the Consortium has also installed hydrocarbon sensors that warn authorities in case of a significant fuel spills. The Cities have begun construction of a temporary diversion to pump the dry-weather flow into a sanitary sewer for eventual treatment at the Hyperion Sewage Treatment Facility. The City of Santa Monica also commissioned a treatment orientated preliminary assessment for the Pico, Caltrans, and Kenter Canyon Storm Drains which concluded that chlorination could be successfully used to disinfect the dry weather flow (JMM 1987). However, chlorine is a hazardous chemical with significant storage and transportation risks. In addition, the chlorine gas disinfection process, requires long contact times, forms many carcinogenic disinfection by-products, and ocean release of the chlorinated water would require a dechlorination step. Furthermore, the proposed facility would have been placed on a heavily used public beach, adjacent to resort hotels, and would probably have encountered significant resistance from local environmental and neighborhood advocacy groups.

Recently, ozone has become renowned in the drinking water industry as an alternative to chlorine, that rapidly disinfects water while forming few halogenated, and toxicologically potent, by-products (Tate 1991). Unlike chlorine, ozone is generated from air or oxygen at the time of use and does not require the storage or transport of hazardous chemicals. During an emergency, electrical generation of ozone terminates and the ozone rapidly reverts back to oxygen. The process of ozonating water is easily monitored using off gas and effluent monitors, so that the dosage can be instantaneously increased to meet the challenge of contaminated material entering the treatment stream. The dissolved ozone residual in the plant effluent, rapidly degrades and introduces little environmental hazard. Off-gas ozone is rapidly returned to oxygen by passage through a heated metal catalyst.

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The City of Santa Monica, with the assistance of the Santa Monica Bay Restoration Project (SMBRP), the United States Environmental Protection Agency (EPA), and the University of California Laboratory of Biomedical and Environmental Sciences (LBES), recently completed an evaluation of an ozonation pilot plant for the treatment of dry-weather storm drain flows. The major goal of this study was to determine if ozone could be used to disinfect the water that typically flows from the Pico-Kenter Canyon storm drain. Unlike drinking water, the storm drain effluent is high in suspended solids and organic carbon, factors that might be expected to significantly reduce the efficacy of ozone disinfection. Secondarily, this study was also intended to develop a comprehensive and long-term analysis of chemical constituents in both the influent and treated water and their variability. This information could then be used to determine if construction of a full scale facility was warranted, which pollutants would be amenable to treatment at the proposed plant, and what process train the facility should incorporate.

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METHODS

A. Location, Design and Operation of the Ozone Pilot Plant

This project was facilitated, by the placement of the Santa Monica Municipal Bus Yard over the Kenter Canyon storm drain near the corner of 5th Street and Olympic Boulevard in Santa Monica. This facility provided security, utilities, and supportive staff that assisted in maintenance activities. Operation of the pilot plant began in November 1989 and continued through December of 1990, but was intermittent during June, July, and August due to organic contamination that was eventually traced to the rupture of a sanitary sewer into an upstream catch basin. Sampling was occasionally suspended due to plant modifications or monitoring device failures. Generally three sample runs were conducted during each day of operation. Each run consisted of an influent/effluent sample pair with the treated sample collected after a time delay sufficient to allow the influent sample plug to reach the effluent port. This time delay was equivalent to the contactor tower volume (12 gallons) divided by the flow rate (1- 6 GPM) which yielded delays of 2 to 12 minutes. Feed gas flow ranged from 2-18 Standard Cubic Feet per hour (SCFH) with an ozone concentrations of up to 4.5%. Effluent dissolved ozone residuals of up to 10 mg/L (PPM) were observed. Although dosages of up to 40 mg/L (PPM) ozone were delivered, operation was generally in the 5-20 PPM range.

In general, all materials exposed to ozone were constructed of either stainless steel, polyvinyl chloride (PVC), borosilicate glass, or teflon. Swagelock® fittings and valves were utilized for lines smaller than ½ inch, while PVC valves were used on the water lines. Most of the samples were collected with the flow design shown in figure 1 and the schematic plant configuration shown in figure 2. The daily operating schedule commenced with provision of compressed gas and warming up of the ozone generation and monitoring systems. Compressed air was prepared using a Dayton Speedaire® oil-less air compressor (model 3Z852) equipped with aftercooler, air filter, and relief valve. Later in the study, standard cylinders of industrial grade compressed oxygen were obtained from the Liquid Air Corporation. The use of compressed oxygen, rather than air, doubled the ozone production in the influent gas and effectively doubled the applied dose, but does not significantly influence the disinfection process or basic treatment parameters. For all but the largest ozone facilities, generation from air is more economical than first separating oxygen from air. The submersible pump (Goulds #3885) was secured in a large plastic housing, with 1.5 mm aluminum mesh screen, lowered into the storm drain, upstream of a temporary weir, and the screened water pumped to the surface and into a 110 gallon polyethylene holding tank. Once the level in the tank reached the return overflow, water was pumped through an Ace-50 swimming pool-type pump through an RMC-145 flow meter (1-9 GPM) and into the top of the contactor tower.

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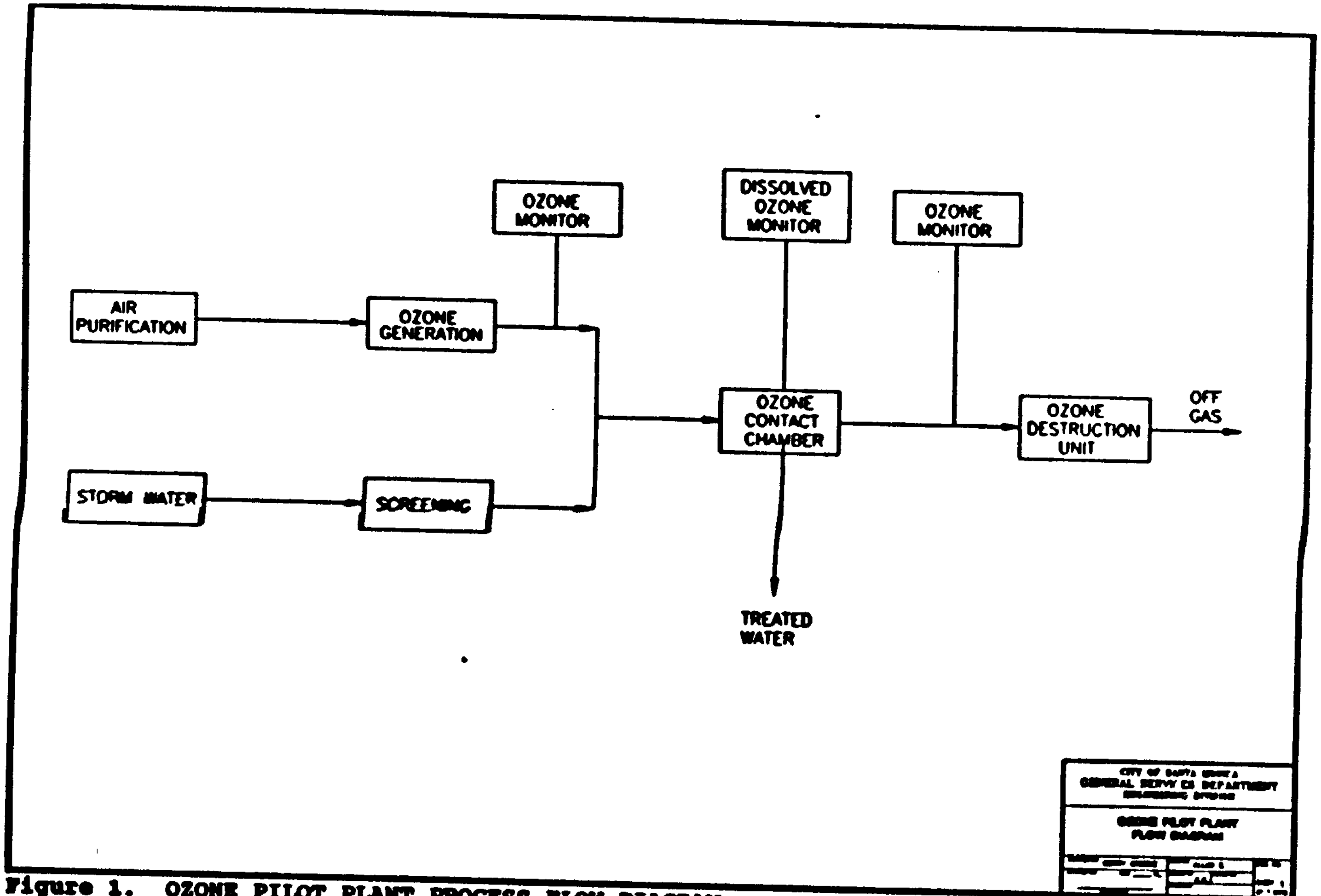

Figure 1. OZONE PILOT PLANT PROCESS FLOW DIAGRAM.

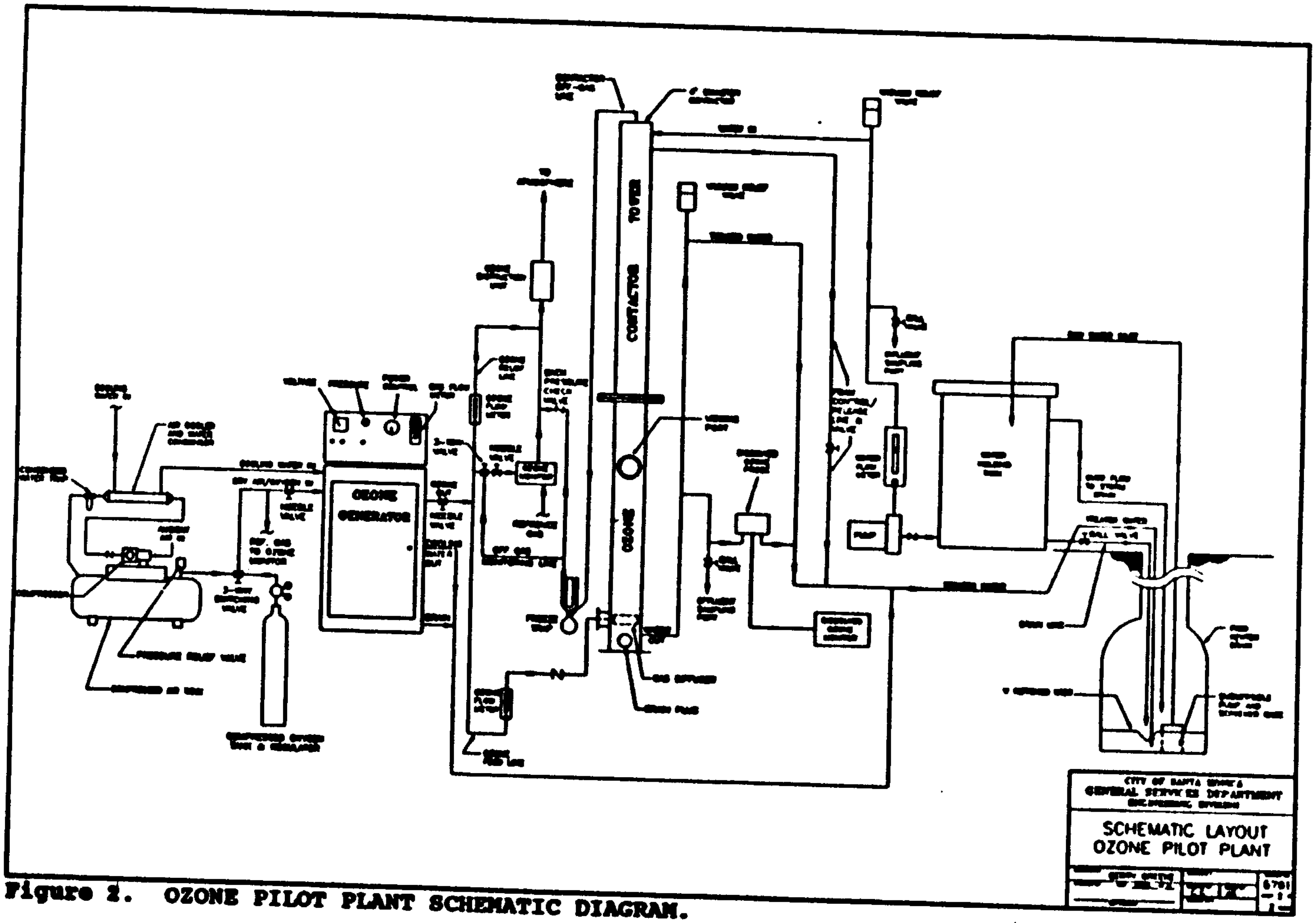

Figure 2. OZONE PILOT PLANT SCHEMATIC DIAGRAM.

The contactor tower, ozone generator, and flow meters were generously supplied by the Hankin Ozone Company of Scarborough, Canada and San Francisco, California. The stainless steel contactor tower was composed of two section with a 10 cm inside diameter and total height of 6 meters. The gas flow meters were rotameter type and calibrated to deliver the specified flow (1-18 scfh) with the 6 meter water head pressure. The ozone generator was a Hankin dual Ozotec® lab unit with cabinet. The bulk of the feed-gas leaving the ozone generator was passed through the flow meter and into the bottom of the contactor tower through a cylindrical ceramic diffuser (bubbler) to increase transfer efficiency. A side stream from the generator could be passed through a 3-way valve to a PCI HC® ozone gas monitor, which determines ozone concentration on the basis of UV light absorbance. After the flows of water and gas were initiated, the process was monitored and allowed to stabilize for at least 15 minutes prior to each sample collection. Samples were taken as influent/effluent pairs, with an appropriate delay for flow through the treatment train. The delay was determined based on the assumption that the influent water would travel through the tower as a plug. An Orbisphere dissolved ozone probe was installed adjacent to the effluent sampling port and operated based on the manufacturer's instructions. During each sampling period, the dissolved ozone residual was recorded twice. Following treatment, the pilot plant effluent was returned to the storm drain downstream of the weir.

The tower off-gas was passed through a water vapor trap, a check valve, and then the remaining ozone was catalytically reverted to oxygen by passage through a Carulite® 200 (Carus Corp.) manganese dioxide ozone kill unit. The water vapor trap was a Dewar type condenser (Ace glass # 5964-14), with Claisen adapter (Ace Glass # 5055-10), and 50 ml boiling flask. It was utilized, as described below, to prevent water vapor from passing into the ozone gas monitor. Prior to pilot plant installation, the vapor trap was tested in a by-pass loop between the generator and gas monitor to insure that the device would not directly influence ozone concentration. No difference in ozone gas concentration was observed after passage through the trap. During normal operation, the trap condenser was filled with a dry-ice/butanol mixture and the contactor tower off-gas passed in through the adapter side arm. While water, and sloughed off ice crystals, collected in the boiling flask, the off-gas would pass through the condenser where the water vapor would freeze out. Between the vapor trap and back pressure/check valve, a "T" led to the three-way valve and into the ozone gas monitor. During the sample run time delay, the 3-way valve was switched between influent and off-gas lines, the flow rate adjusted, and the ozone concentrations recorded. Normally, both ozone feed- and off-gas concentrations were measured twice per sample. The difference between these two values was used to calculate the absorbed or consumed ozone dose. If foam was noted in the vapor trap, holding tank or influent sampling port, sampling was generally suspended and the tower either drained or the top of

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the tower "skimmed" via a foam release line and valve. When foam was present, the tower was observed to pressurize and water would be forced out, shortening the contact time and interfering with dosage estimation.

At the conclusion of each sampling day, the ozone generator was turned off, the ozone off-gas concentration allowed to fall to background, and the tower and holding tanks drained. The submersible pump and screen were then removed from the drain and the screen cleaned. The ozone generator, flow meters, and monitors were maintained as per manufacturers recommendations. On several occasions the tower was not promptly drained and the check valves failed. The ozone unit would then require extensively cleaning, after which it would take several days for the full ozone generating potential to return. This is probably associated with water vapor in the generator dielectric and illustrates the need for dry feed gas. The catalyst in the off-gas kill unit was also noted to "combust" organics when, during an incidental test of a sensor, water contaminated with gasoline (50-100 PPM) passed through the contactor tower and began reacting in, and melting, the plexiglass kill unit. During spiking tests, when the influent water was artificially contaminated, the effluent was collected in barrels and subsequently passed through a carbon filter (organics spiking tests), or chlorinated and dechlorinated (virus spikes), prior to release back to the drain. Following the summer 1990 sewage shut down, the ozone transfer efficiently was observed to be greatly reduced and the diffuser was eventually found to be contaminated with organic matter. The diffuser was subsequently cleaned in concentrated sulfuric acid and found to operate more efficiently then during earlier parts of the project.

B. Sampling Design

The sampling design basically followed that given in the Project Quality Assurance Plan which was approved by Kent Kitchingman of the EPA in November of 1989. Most of the deviations from the proposed plan were related to the additional analyses that were undertaken at the request of the project review board. Some changes were the result of concerns with the external certified laboratory analyses and are more fully elaborated in appendix A (Quality Control and Assurance Report). The basic goal of the analytical design was to identify those water quality and disinfection parameters which most substantially influenced the treatment process. In particular, we were concerned with those parameters which could be effectively monitored and controlled in a full-scale automated facility. The secondary goal was to identify known hazardous chemicals, in both the plant influent and effluent, and determine if they would constrain future operations or induce significant public health or environmental harm.

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Because the storm drain environment can be subjected to relatively small plugs of contaminants moving through the system, this study analyzed pre- and post-ozonation sample pairs, with an appropriate contact-time delay between them. The analyses were split into physical, biological, and chemical groupings. The physical analyses were performed at the pilot plant site and at the University of California Los Angeles (UCLA) Laboratory of Biomedical and Environmental Sciences (LBES). Biological analyses were performed at the site and at a certified contract laboratory. Chemical analyses were undertaken at UCLA and at the certified laboratory. While the intent of using both research and contract labs was to insure the quality of the results from the University labs, several difficulties arose in interpreting the contract laboratory results, which are elaborated in appendix A. Since this study was primarily concerned with disinfection, the staff utilized the minimal media Most Probable Number (MPN) method to analyze each of the 438 sample pairs for the number of total and fecal coliform organisms. The certified lab performed 48 duplicate coliform analyses and all of the Enterococcus analyses.

While the analytical chemical methods were chosen to provide a thorough screen of emissions into the Santa Monica Bay, the individual analyses were selected for specific secondary purposes. The concentrations of the individual metal analytes, including sodium, calcium, and magnesium, were critical to evaluating the potential usefulness of the water for reclamation. The formation of hexavalent chromium during ozone treatment was a concern of the SMBRP steering committee. Total Organic Carbon (TOC) can be correlated to bacterial counts and may be a indicator of sanitary contamination. Chlorinated pesticides, like DDT, have previously been detected in this drain and were a likely source of health or environmental risk that could be compared to previously published data. Volatile organic analysis was used to screen for gasoline components and previously reported chlorinated solvents, but also estimated the concentration of short chain aldehydes, a known ozonation by-product. The semi-volatile, or base-neutral acid extractable (method 625), analysis was included to screen for heavier hydrocarbons, such as polynuclear aromatic hydrocarbons (PAHs), and other significant, but non-traditional contaminants.

C. Analytical Methods

The analytical methods followed those given in the Project Quality Assurance (QA) Plan which was approved by Kent Kitchingman of the EPA and the other project officers in November of 1989. Following the validation described in appendix A, the duplicate sample spiking concentrations were reduced in several of the methods, in order to facilitate interpretation of the analytical results at the low contaminant levels observed during this study.

The analyses can be split into process, physical, chemical and biological groups. Among the process analyses, were the various flowmeters and ozone monitors previously described. Rotameter-type flowmeters were checked daily for accumulations of oil or debris that would inhibit free travel of the metering ball, and cleaned as needed. Water and gas flow rates were always verified immediately prior to, during, and following each sampling run. The gas and water ozone monitors were both solid state and self calibrating. The monitors were maintained as recommended by their manufacturers and repaired when indicated by the monitor or by questionable performance. The gas monitor generally failed catastrophically, while the dissolved ozone monitor failed both catastrophically and occasionally by degraded performance over the matter of a few hours. During occasions of degraded performance, the collected samples were discarded and repeated after repairs were completed.

The physical analyses included temperature, pH, conductance, turbidity, settleable solids, suspended solids, dissolved solids and total solids. The measurement of conductance was initiated in mid-January, 1990, using an ICM model 71250 portable, temperature correcting, conductivity meter and the analysis conformed to EPA Method 120.1 (EPA 1983). Fresh calibration standards were prepared monthly and the unit calibrated before each analysis. The measurement was taken within 15 minutes of sample collection, from the one liter samples used for pH, temperature, settleable solids and turbidity analyses, which were collected in polycarbonate graduated cylinders. The measurement of pH was initiated using a pocket meter, but by January, analyses were being made using a portable ICM model 41250 unit. Commercial prepared temperature corrected buffer solutions were used to calibrate the unit before each sample. Measurement was made within 15 minutes of sample collection, from the 1 liter sample, and conformed with EPA method 150.1 (EPA 1983). Temperature was measured using a standard glass laboratory thermometer that was checked weekly against a precision thermometer. Measurement was made within 15 minutes of sample collection from the 1 liter sample and conformed to EPA method 170.1 (EPA 1983), except that the thermometer was not mercury filled. This deviation did not appear to influence the results.

Turbidity measurements began in early January 1990 and were made using a Monitek model 21PE Nephelometer. The unit was calibrated between samples and the initial measurement was made within 15 minutes of sample collection. Influent samples exceeding 100 NTU were diluted until the desired working range was reached. The corresponding effluent sample was then identically diluted. Although method 180.1 was followed, two notable analytical difficulties arose. First the 1-10 and 10-100 NTU scales did not completely overlap i.e. a sample could read greater than 10 units on the lower scale, but less than 10 on the higher range. Careful analysis of standards indicated that both scales were in error by about 10% on a 10 NTU sample, with the error decreasing to 0% for values below 8 and above 15 NTU. Analyses that were observed to be within this range, were estimated from the readings on one or the other scale and the paired sample measured on the same scale. The second problem related to effluent samples which were observed to form gas bubbles on the wall of the turbidity cuvette. After "bumping" the bubbles free, the turbidity was found to be lower. It appeared that micro bubbles of dissolved ozone/oxygen aggregated or came out of solution during the delay between repeated sample analysis. Unfortunately, it is unknown whether the reduction in turbidity is due to aggregation of micro bubbles or settling of suspended material. Both of these difficulties are not expected to effect a full scale treatment facility and only trivially corrupt the results of this analysis.

After the completion of the above physical test, the remainder of the 1 liter samples were used to determine the quantity of settleable solids in poly carbonate Immhoff cones as per EPA method 160.5. It should be noted that occasionally material would settle on the walls of the cone, but not fall to the bottom. Usually a rapid rotation of the cone would cause much of the material to dislodge and fall downward for inclusion in the measurement.

The analysis for total solids (total residue, Method 160.3), dissolved solids (filterable residue, method 160.1) and suspended solids (non-filterable residue, method 160.2) followed basic EPA methodology except that the volume in the latter analysis varied between 50-1000 ml based on passage through the filter, rather than the anticipated residue weight. Residue measurements were made at LBES using a 1.25 liter sample collected in a clear Wheaton media bottle. After collection, the bottle was chilled on blue ice and transported to LBES for processing. Residue samples were generally processed within 6 hours of collection, although approximately 10% of the samples required up to 12 hours for completion, due to scheduling conflicts. Samples held for more than 4 hours were refrigerated until analysis was undertaken. All samples were allowed to dry overnight in a standard laboratory oven. Poor balance performance during the first 3 weeks led to unreliable results and required that the balance be repaired. Enumerations during this period are accurate to only about 10 mg. rather than the 1 mg observed during the bulk of the study.

The analytical chemistry methodologies employed during this study were Inductively Coupled Plasma Atomic Emission Spectrometric (ICP-AES) analysis of metals (EPA method 200.7), hexavalent chromium (EPA method 218.5 modified for ICP-AES analysis), total organic carbon (EPA method 415.2), organochlorine pesticides (EPA method 608), purgeable or volatile organics (modified from EPA method 624) and extractable or semi-volatile organics (modified from EPA method 625). The first three methods are taken from Methods for Chemical Analysis of Water and Wastewater (EPA-600/4-79-020 rev. March 1983), while the latter three are from Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater (EPA-600/4-82-057). As anticipated in our QA plan, several changes were undertaken to better utilize our instruments in the low analyte concentration ranges which were observed during this study. These changes were minor and primarily served to increase and evaluate our sensitivity in the observed matrix.

The analysis for metals was conducted by Mr. Leon McAnulty, a senior staff technician at the Laboratory of Biomedical and Environmental Sciences of UCLA, using a research grade simultaneous Inductively Coupled Plasma-Atomic Emission Spectrometer (ICP-AES), with a 1.5 meter focal length. Samples collected during 1989 were analyzed with a meinhard nebulizer, while samples collected after that time were analyzed using the more sensitive ultrasonic nebulizer. Since acid digestions using ultra-high purity acids, new acid washed fleakers, and milli-q water, resulted in unacceptable levels of metal contamination, digestions were undertaken only on those samples that had greater than 100 mg/L of suspended solids. The detection limits reported in appendix B (Data Summary and Comparison to Relevant Standards) were determined using the method of the International Union of Pure and Applied Chemistry.

The primary change in the hexavalent chromium method (218.5) was analysis by the ICP-AES, rather than graphite AA, in order to utilize the sensitive ultrasonic nebulizer. Sample preparation was undertaken by project staff. During early March, the author became aware that hexavalent chromium blanks were contaminated at around 7 PPB. While this was above the method detection limit of 5 PPB, it was below the Ocean Plan Water Quality Objective (with 5:1 initial dilution) of about 10 PPB and did not warrant the significant time and financial expenditures required to find and replace the contaminant source. Reported values are not adjusted.

Because of equipment scheduling conflicts the analysis for Total Organic Carbon (method 218.5) could not begin until late December. Samples collected prior to this time were acidified and refrigerated, then analyzed, out of holding time compliance. The carbon concentrations in these non-compliance samples were typical of values seen during most of the study and were included in the data base. TOC analyses were undertaken by project staff under the supervision of the QA officer. Some samples containing high dissolved solids (salt) concentrations gave erroneous results due to chloride interferences and were excluded from the data base.

The delays encountered in performing organochlorine pesticides analyses was one of the more significant frustrations of the project. Fortunately, the purchase of a service agreement ensured that it was not one of the more costly aspects. Upon initiating the laboratory phase of this project, the Varian 3500 gas chromatograph with dual electron capture detectors was found to be severely malfunctioning. After a dozen service visits, the unit was returned to Varian and completely refurbished. It was only after a second certified lab unit failure, that the detector insulation was found to degrade over time. Following the return and evaluation of the GC in mid-April, pesticide analyses were begun, using both DB-5 and DB-1701 30 meter capillary columns hooked in parallel through a chromafit zero dead volume Y splitter, and integrated on a Spectrophysics 4270. Analyses was made using 4,4'-dibromooctafluorobiphenyl (DBOFBP) as an internal standard and hexabromobenzene as a surrogate. The choice of hexabromobenzene was made due to the unavailability of dibutyl-chlorendate, but it was found to be a poor substitute. The compound precipitated out of the spiking solution during freezer storage, then was slow to re-enter solution when returned to room temperature. This information became available after many analyses were completed and the bulk of the pesticide samples had been extracted. Fortunately, the recoveries from spiked samples indicate that extraction efficiencies were generally good. Sample extraction from the complex and organically rich matrix, was accomplished through the use of centrifuging and glass wool filtering. Concentration was performed using a combination of hot water baths, tube and block heaters. After analyses had begun, it was determined that alumina (neutral super III) clean-up was routinely required. Even with this step, most samples contained a significant number of false positives that would appear on one or the other, but not both, chromatograms. As discussed in appendix A, sample spikes were prepared using surplus EPA QA samples diluted to about the CLP detection limit. The extracted samples were stored at about -20C until analysis, at which time they received alumina clean-up and were reconstituted to a volume of 1 ml. Due to the delays in starting this analysis, one fourth of the total number of pesticide samples were analyzed out of holding time compliance.

The analysis of volatile compounds was performed at the Institute of Geophysics and Planetary Physics under the direction of Mr. Edward Ruth, a senior staff technician with over 4 years experience with the GC/MS and an extensive analytical chemistry background. The analysis was conducted using a Tekmar purge and trap unit with cryofocusing interface to a Finnigan gas chromatograph with DB-624 capillary column and mass spectrometer. The analysis was a hybrid of the 624 wastewater and 524 drinking water methods, using a 25 ml water volume to increase sensitivity. Six hazardous substance list compounds were also simultaneously analyzed and the results are included in the data summary appendix. The surrogate spiking compound, 4-Bromofluoro-benzene, was utilized during the analysis and the priority pollutants quantified by addition of three internal standards to the water sample.

The extraction of semi-volatile (method 625) compounds was performed at LBES by the QA officer. The only substantial change in methodology, was the combining of acid and base neutral extracts prior to concentration and analysis as a single GC/MS extract. The results given in the QA supplement (appendix A) demonstrate the validity of this modification. Extraction was conducted in groups of eight: 3 sample pairs, a travel blank and a spiked duplicate

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sample. As with the pesticide extraction, centrifugation and filtering was required to separate the aqueous/organic emulsion. A third "humic" layer formed between the two normal layers and was returned to the separatory funnel between extractions. Spikes were at either 20 or 40 PPB rather than the 100 PPB used in the method description. The analysis of extractable compounds was performed at the Institute of Geophysics and Planetary Physics under the direction of Mr. Edward Ruth using a Finnigan gas chromatograph with a DB-5 capillary column and mass spectrometer detector. Each sample contained 6 extraction surrogates and 6 internal standards.

During the brief spiking study, organic test compounds of interest were prepared at various concentrations, in 50 ml of acetone, then mixed into the holding tank just prior to beginning the treatment process. Methanol was originally used as the diluting solvent, but was found to have a significant ozone demand as a free radical scavenger. After the treatment process had run for approximately 10 minutes and was nearing equilibrium, normal influent and effluent samples pairs were taken for biological and chemical analyses. The effluent water was held in holding tanks and slowly pumped through granulated activated carbon (GAC) to remove the offending spiked compounds before being release back to the storm drain. The chemical analysis was performed using liquid-liquid micro-extraction and the pesticide method analytical instrumentation. To summarize the method, 30 ml of water was combined with 2 ml of hexane and vigorously (vortex) mixed for 1 minute. The organic layer was removed using fresh disposable pasteur pipettes and added to the 1 ml mark on an autosampler vial. The internal standard (DBOFBP) and a few anhydrous sodium sulfate crystals (to prevent water from contaminating the GC) were added to the extract, which was then analyzed. Since funding for the spiking study was not provided for in the agreement, it was not included or cleared in the QA/QC plan, but was described to the project review board and SMBRP technical advisory committee. Due to the carrier solvent, TOC analyses are only available for the pre-spike influent waters.

Information regarding the methodology for the mutagenicity extraction and assay can be obtained from the project QA officer or Dr. John Froines of the UCLA School of Public Health. The basic method called for resin extraction of influent and effluent waters, followed by extraction and concentration in hexane and acetone. The extracts were serially diluted and plated, following the EPA Interim Procedures for Conducting the Ames Mutagenicity Test (EPA 1983). Extractions and mutagenicity analyses were undertaken by staff under the direction of Dr. John Froines.

The bacteriologic analyses were undertaken by project staff working at the pilot plant site and by the certified laboratory. The methodology proposed in appendix B of the pre-project Quality Assurance plan was followed with minor adjustments for correct bracketing of the bacteria numbers and collection of the effluent

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samples in recently emptied dilution bottles. All of the 438 samples collected during this study were analyzed by project staff for the most probable number (MPN) of total and fecal coliform organisms in both the influent and effluent water. The analysis was undertaken using the Minimal Media Ortho-nitrophenyl-beta-D-galactopyranoside 4-Methyl Umbelliferyl-beta-D-Glucuronide method, also referred to by the specific generic name of Minimal Media O-MUG or MMO-MUG as in the EPA final ruling on its use (EPA, 1989). The supplier was Environetics (formerly Access Analytical) which markets the product under the Colilert® brand name. Briefly, a potentially contaminated water sample, is mixed, in a test tube with a sterile powder consisting of growth media, the two sugar dye complexes listed above, and antibiotics to inhibit the growth of competing organisms. The tube is then sealed, mixed and incubated at 36°C for 24 hours. Coliform organisms produce the enzyme beta-galactosidase, which cleaves the ONPG sugar dye complex, causing the culture to become yellow. Similarly, _Escherichia coli_, the primary fecal coliform, produces the enzyme beta-glucuronidase, which cleaves MUG releasing a greenish fluorescent dye that is clearly visible under ultraviolet light.

Using the same statistical methods developed for the Multiple Tube Fermentation (MTF) method, it is them possible to take the results from the MMO-MUG analysis and estimate the number of total and fecal coliform organisms per volume of the original sample. The certified laboratory initially used the Membrane Filtration (MF) method 9222A-E (APHA 1989) for total and fecal coliform analyses, but shifted to the MMO-MUG method mid-way through the project. The enterococcus analyses were only undertaken by the certified laboratory which always used the membrane filtration standard method 9230 A,C (APHA 1989). While the results were decipherable, the project QA officer found that the bacterial analyses from the certified laboratory were frequently erroneous and that their results required some interpretation. This difficulty is further elaborated in appendix A.

The virus spiking study was conducted by Charles McGee and staff of the Sanitation Districts of Los Angeles County on June 5, 1990, using a modification of Standard Method 9510-B (APHA 1989). Attenuated, vaccine strain type 1, poliovirus was added to about 85 gallons of water pumped from the storm drain into the surface holding tank. The tank was then mixed for about 5 minutes prior to being pumped into the treatment system. Influent samples were taken at the beginning and termination of each run. Effluent samples were collected after 20, 40, and 60 gallons of seeded water had been treated. The quantity of virus in the samples was determined at the County Sanitation Districts Laboratory. Samples were assayed on Buffalo Green Monkey Kidney cells using the plaque forming unit technique (EPA 1984).

RESULTS

The database is fully summarized and tabulated in appendix B, and includes comparisons to drinking water standards and California Ocean Plan standards and objectives. The following results are taken from the database, and appendix B, and consists of that information which the author believes is most pertinent to this report and future research and policy issues. Since the intent of the study was to provide research information, the reported values are often well below normal CLP (Contract Laboratory Program) reporting levels and the concentrations and detection limits should be judiciously noted. Both the arithmetic and geometric means were calculated, and if the geometric was less than about 75% of the arithmetic mean, the data was assumed to be skewed and the log normal distribution and geometric statistics are both reported. The observation of skewed data is common in the environmental field (APHA, 1989) and the use of the log normal distribution acts to decrease the overwhelming influence that a small number of high samples can have on the overall sample group. As an extreme example, the sanitary sewage spill resulted in water with an ozone demand that exceeded the generating capacity of the pilot plant and high bacterial counts were observed in the effluent. The overall project arithmetic mean and 90th percentile for the total coliform count in the disinfected water were 7,600 and 13,200 organisms per 100 ml. respectively, while the log-normal or geometric values were only 160 and 5,600. While the geometric mean is only 2.1% of the arithmetic mean, the high values converge in each distribution. Skewed data were prevalent in the metals, biological and "significantly" detected organics, but the distribution was normal among the remaining organics where "noise" below the detection limit predominated.

The mean absorbed, or effective, ozone dose was around 12.5 mg/L (PPM), although exposures of twice that concentration were occasionally utilized. Although higher values are often used to control specific problems such as color, taste, odor or chemical contamination, the drinking water industry typically disinfects with ozone concentrations below 5 mg/L (Tate, 1991). The geometric mean of the effluent water ozone residual was 0.31 mg/L, although many samples of greater than 2 mg/L were produced. Dissolved ozone rapidly degrades and residuals will drop within a few minutes of treatment. Since ozone is not used to provide distribution system disinfection, it is not closely monitored in the water industry.

Among the physical parameters, the ozone treatment appears to have caused an increase in temperature and decrease in pH. The former result was due to the compression of air during the first part of the study, and was not observed after switching to bottled oxygen. The maximal temperature increase was about 1.5°C and should not be sufficient to constrain the release of the effluent. The mean pH was normally reduced from 8.1 to 7.8 and the value of

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well ozonated effluent water was generally a half pH unit below that of the influent. Only a few of the influent samples exceeded the Ocean Plan Water Quality Objective of 6.0-9.0 pH units and none of the effluent samples were in violation.

Ozonation had little effect on solids or conductance which are primarily inorganic characteristics. The geometric mean of both influent and effluent dissolved solids (690 mg/L) and conductance (1070 µmho/cm) were about 80% of the arithmetic mean and the data approximated a normal distribution. The geometric mean of suspended (22 mg/L) and settleable (<0.1 ml/L) solids were both significantly below the Ocean Plan Water Quality Objectives and about 20% of the arithmetic mean, indicating that the data were highly skewed. The data for suspended solids is plotted on a log scale in figure 3. The plots of both influent and effluent data are virtually identical, indicating that ozone had little influence on this parameter. The results are characterized by normally low values punctuated by brief periods of contamination, when values would rise above the 240 mg/L objective. At concentrations between 60 and 240 mg/L the Ocean Plan calls for a reduction in suspended solids to no more than 60 mg/L. At levels above 240 mg/L the source is required to remove 75% of the suspended material. The skewed distribution is primarily associated with brief upstream events (construction and sewer break) when values rose to levels 100 times greater than the Water Quality Objectives.

The influence of ozone on turbidity was difficult to assess, since freshly treated water contained light scattering micro-bubbles, while settling could be expected to occur in seasoned samples. Paired samples checked 10-20 minutes after collection, generally showed a slight (10-20%) decrease in turbidity, but it would be speculative to suggest that ozone was the causative agent. Color was not monitored during the study, but it was visually evident that ozonation decreased the orange brown color associated with the dissolved humic and fulvic acids that result when water passes through decaying organic matter. In Myrtle Beach, South Carolina highly organic influent water containing 150-450 color units, is reduced to as little as 5 units using ozone doses of up to 10 mg/L (Ferguson, Gramith and McGuire, 1991).

Bacterial and viral analyses conclusively demonstrated that ozone was an extremely effective disinfectant of storm drain dry-weather flow, reducing microbial counts by a geometric mean of 3.4 log (99.96%). The remainder of the biologic results will be elucidated in the discussion section in conjunction with a discussion of the goals and conclusions of this study.

The Total Organic Carbon (TOC) content of the influent and effluent waters ranged from 2.2 mg/L, the day after a rain storm, to 124 mg/L when the sewer break was flowing maximally. While most values were between 7 and 30 mg/L, the mean TOC level was 19 mg/L and the distribution was only slightly skewed. While ozone can

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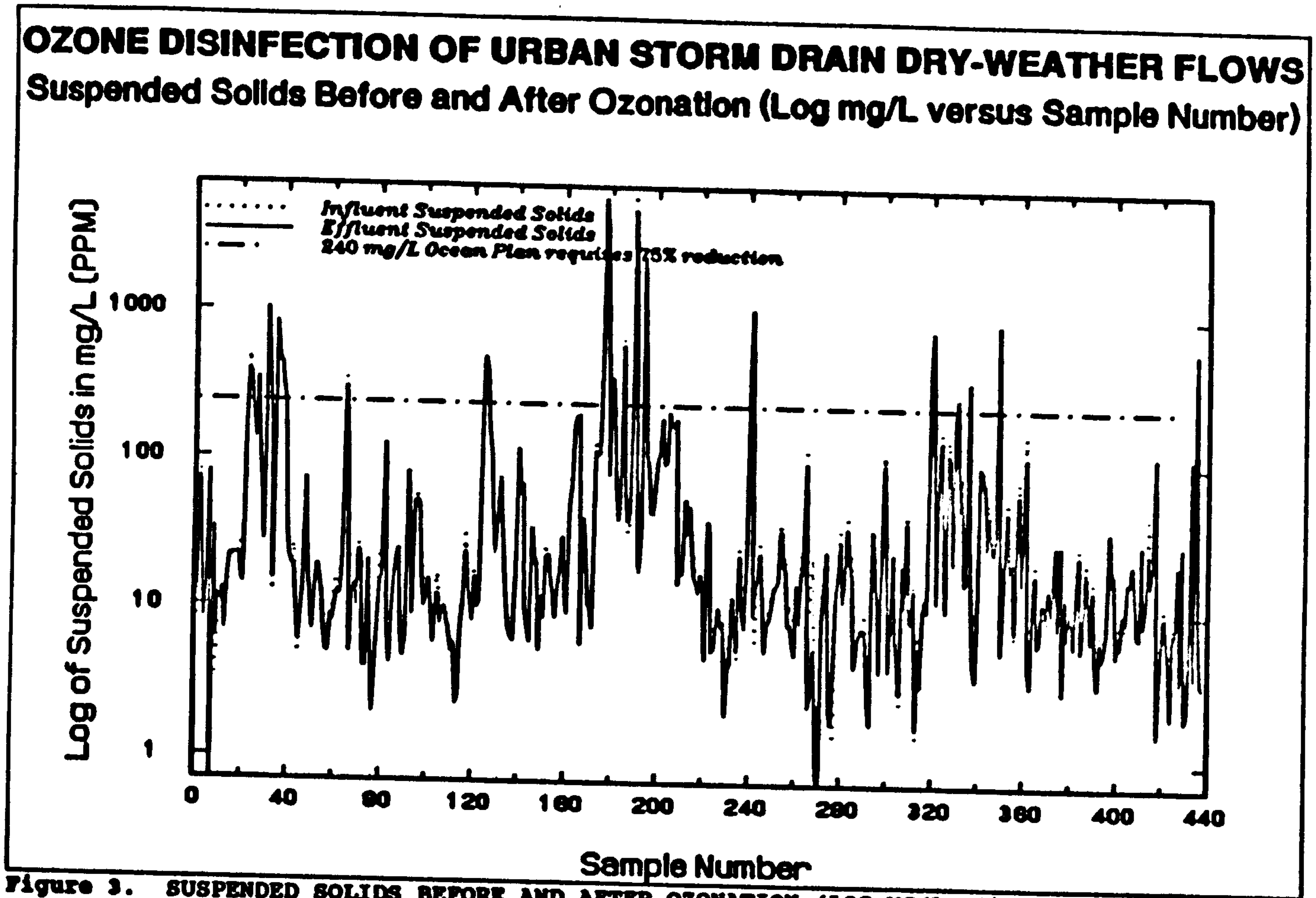

Figure 3. SUSPENDED SOLIDS BEFORE AND AFTER OZONATION (LOG MG/L VERSUS SAMPLE NUMBER).

mineralize moderate levels of some organic compounds (Glaze and Kang 1988), the high TOC levels observed in this study assure that most was consumed in breaking cellular material and humic and fulvic matter into simpler organic units. As observed in this study, this would not result in a net TOC decrease. While the source and treatment variability assure that the data is widely scattered, the regression lines in figure 4 show that ozone demand increased, and observed ozone residuals decreased, with TOC concentration as would be intuitively expected.

There were significant differences between the arithmetic and geometric mean concentrations of most metals, especially the heavy or non "salt" metals. The "salt" metals, such as calcium, magnesium, sodium, phosphorus, silicon, and potassium, were generally in the mid to high PPM levels, normally distributed, and are not regulated. In contrast, the industrially valuable metals, such as aluminum, iron, manganese, chromium, lead, titanium and molybdenum were normally at low concentrations, which episodically rose orders of magnitude higher resulting in a skewed distribution. Many of these elements are toxic and closely regulated. The mean concentration of selenium, which is both an essential element and highly toxic, was below the drinking water standard of 10 PPB, but numerous samples above this level were observed. The highest observed value of 112 µg/L was well below the Instantaneous Maximum Ocean Plan Water Quality Objective, with 5:1 dilution, of 750. Barium, nickel, and silver were always well below standards. The mean values of arsenic and cadmium were well under the Ocean Plan and drinking water standards, but occasionally samples exceeded one or both sets of limitations. Mean chromium, copper, lead and zinc concentrations exceeded Ocean Plan Water Quality Objectives and will be subject to further discussion in later sections of the report. While the results from the hexavalent chromium analyses are complicated by contamination in the reagents, both the arithmetic and geometric mean, before (31 and 12.9 µg/L respectively) and after (29 and 11.7 µg/L) ozonation, show that no increase in concentration was observed.

Only 4 organochlorine pesticides were detected among the 86 sample pairs analyzed. The high concentrations of both lindane (γ-HCH or hexachlorocyclohexane) and endosulfan I were about 30 ng/L (PPTr) or just slightly above our detection limit and about half of the Contract Laboratory Program detection/reporting limits. Both high values were an order of magnitude below Ocean Plan Water Quality Objectives. Heptachlor is a contaminant in chlordane, that has a double bond instead of a chlorine and hydroxyl group. It was only detected in the three samples having the largest chlordane concentrations and its detection is obviously incidental. The sample containing the highest chlordane concentration also included heptachlor at 2.5 times the 30 day Ocean Plan objective of 36 PPTr.

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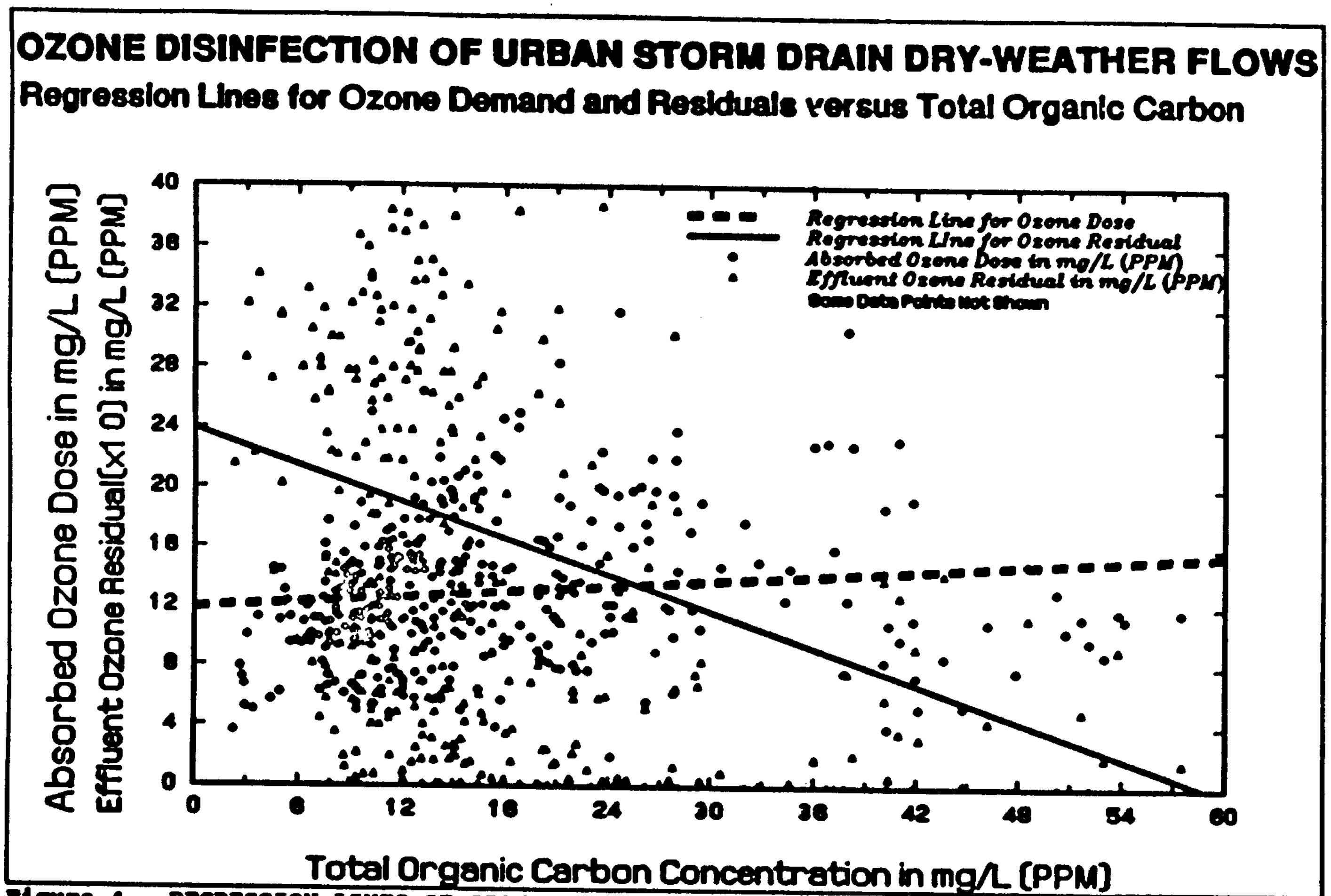

Figure 4. REGRESSION LINES OF OZONE DEMAND AND RESIDUAL WITH TOC CONCENTRATIONS.

The detection of the pesticide chlordane, was the only significant finding among the pesticide analyses. This compound was used against termites and ants and was sprayed or injected adjacent to residential foundations. While now recognizedas a probable human carcinogen, it was commercially available early in the decade and manufactured until 1988. The pesticide was first detected on 12/14/89 and concentrations diminished during the next two weeks. Following an intense rain storm, no additional detections were obsarved. The arithmetic mean concentration in the plant influent was 133 ng/L and in the effluent 59 ng/L. The influent geometric mean was 0.86 ng/L, while the effluent value was 0.78 ng/L. The 30 day Ocean Plan objective for chlordane is 1.15 ng/L (PPTr). In the most contaminated sample, an ozone dose estimated at between 15-20 mg/L, with no residual, reduced the chlordane concentration from 5700 PPTr to about 1900 PPTr. While it is impossible to accurately estimate the efficiency of removal, ozone appeared to significantly reduce the concentration of chlordane in the plant effluent. This is especially evident at the highest chlordane concentrations when it made up a significant fraction of the TOC. As pesticide concentrations decreased toward the detection limit, and chlordane became a smaller fraction of the carbon pool, the removal efficiency appeared to drop. Although speculative and based on trace concentrations (given in ng/L or PPTr) and few data points, ozone may have also reduced heptachlor (90, 30, and 24 to 55, 24, and not detected) and Endosulfan I (30 to 24) concentrations, but probably not lindane (34, 26, and 21 to 28, 27, and <20), which is an extremely stable compound.

The analysis of volatile organic compounds showed that the maximum observed values were mostly more than an order of magnitude below either drinking or Ocean Plan standards, and the means were generally less than 1 µg/L (PPB). The primary exceptions to this assertion, is that one sample contained ortho xylene at levels in the 1,000 to 100 PPB range, which was sufficiently high to saturate the detector and invalidate the accuracy of the results. By the time the instrument was returned to service, the samples were of little value due to volatilization. The second exception was that butanone, 2-hexanone, and 4-methyl-2-pentanone were all observed in the ozonated effluent at less than 4 PPB as maximum observed values. Standards do not exist for these compounds. The drinking water ozonation process is known to form aldehydes, ketones, and carboxylic acids, generally in the low PPB to PPTr range (Glaze et al., 1989), and the detection of these compounds is to be expected. Among the other observed ozonation by-products were aliphatic aldehydes such as hexanal, heptanal, octanal etc., which appeared individually in the 10-50 PPB range. There are no water standards for aldehydes, but they are found in fermented beverages (wines).

With the exception of Polynuclear Aromatic Hydrocarbons (PAHs or PNAHs) and phthalates, the results from the base-neutral-acid extractable or semi-volatile analyses were inconsequential. The maximal value of most compounds was orders of magnitude below any

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Ocean Plan or drinking water standards and less than 1 µg/L (PPB). Benzyl alcohol, naphthalene, 2-methylnaphthalene and nitrobenzene had maximal values in the 1-5 PPB range, but means of less than 0.5 µg/L. Benzoic acid was detected at 13, but the mean value was less than 4 PPB. Cresols (methyl phenols) were detected in the spiking run, probably as contaminants of one of the spiked compounds. Phthalates were occasionally detected at levels over 100 PPB, but the mean values were generally in the low PPB levels. These plasticizers are ubiquitous in surface waters and laboratories, and with the exception of bis 2-ethylhexyl phthalate, the values observed in this study are not untypical of the results seen in laboratory extractions. In the case of bis 2-ethylhexyl phthalate, the high value of 122 µg/L was well above the 30 day Ocean Plan dilution objective of 17.5 PPB, but the arithmetic and geometric mean were only 12 and 7.1 PPB respectively. These values are noticeably above the Phase V proposed drinking water maximum contaminant level (MCL) of 4 µg/L.

The most significant finding among the extractable analyses, was the level of Polynuclear Aromatic Hydrocarbons or PAH's. The California Ocean Plan treats PAH's as a group and the objective is based on the sum of 13 PAHs that are commonly analyzed. The Ocean Plan 30 day average, with a 5:1 dilution, requires that the sum of these 13 PAHs remain below 0.044 µg/L. The sum of the maximum observed values, for each PAH analyte, was 17 PPB and was associated with samples containing significant amounts of suspended sediment. The arithmetic and geometric means of both the influent and effluent streams ranged from 1.9 to 1.3 µg/L (PPB) indicating that a normal distribution existed and that levels were about 35 times the Ocean Plan Water Quality Objective. The sum of the mean travel blank PAH concentrations was equal to 0.22 PPB.

The results of the mutagenicity study are shown in table 1 and clearly reveal that the ozonation process did not form mutagens as measured by this extraction method and test. While ozone could conceivably be cleaving large mutagens into small volatile mutagens, that are lost during extraction, the results clearly show that mutagenicity was lower in the effluent for all Salmonella strains with, or without, S9 activation (a mammalian enzyme that makes some PAHs more mutagenic). This observation is in agreement with many of the papers cited in the review by Noot et al. (1989).

Three sets of spiking runs were conducted during the latter phases of the project. In the first chemical study, available extractable compounds were added to the influent water then pre- and post-ozonation samples were analyzed using the standard GCMS method (625). The results for 2 sample runs are given in table 2 and clearly indicate that chemical remediation did occur when the contaminants were present in significant concentrations.

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Table 1. AMES ASSAY RESULTS FOR OZONATED STORM DRAIN WATER.

Salmonella Strain	± S9	Influent Slope[1]	Effluent Slope[1]
TA 98	w/o S9	1498 ± 337	1165 ± 322
	w S9	2304 ± 496	2130 ± 397
TA 100	w/o S9	4655 ± 2718	3672 ± 1994
	w S9	8072 ± 2970	6153 ± 2958

[1] Slope of mean number of revertants per liter of sample water for five sample pairs with standard error.

Table 2. CHEMICAL SPIKING STUDY 1, VALUES IN µg/L (PPB).

Spiked Compound	MDL	Sample Pair 348		Sample Pair 349	
		Influent	Effluent	Influent	Effluent
2-Chloro Naphthalene	.19	.69	<MDL	.42	.078
4-Methyl Phenol	.59	71.	.64	29.	<MDL
Naphthalene	.10	7.8	.103	10.6	.072
Phenol	.91	21.	.21	2.6	.31
Pyrene	.10	39.	2.1	40.	.79
1,2,4-Tri-methylbenzene	NA	20.	.88	3.6	ND

In the second chemical study, 7 halogenated compounds were spiked into the treatment stream and samples taken before and after ozonation. The compounds were chosen as examples of a halogenated solvent (1,1,1-Trichloroethane), surrogate gasoline-like components (Benzyl Chloride or α-Chlorotoluene and 124-Trichlorobenzene), PAHs (9,10-Dibromoanthracene) and halogenated pesticides (Aldrin and Lindane). Calibration standards were prepared in milli-q water, then both standards and samples were extracted as described in the methods section. The calibration standards and samples were then analyzed using the pesticide analytical equipment, and the results are given in table 3. While no explanation for the anomalous increase in TCE concentrations is available, it is notable that the concentrations of most other compounds decreased. In retrospect, this was especially impressive given the relatively high concentrations of Benzyl Chloride.

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Table 3. CHEMICAL SPIKING STUDY 2, VALUES IN µg/L (PPB).

Spiked Compounds	Sample354		Sample355		Sample356		Sample 357	
	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff
1,1,1-TCEthane	6.2	8.2	6.0	9.4	6.2	9.0	7.1	9.2
Benzyl Chloride	460	122	440	172	470	86	520	220
1,2,4-TCBenzene	10.8	.70	9.6	.83	9.8	.66	8.0	.98
Lindane	8.9	8.5	10.2	8.9	10.	8.5	13.7	12.8
Aldrin	7.4	ND	6.0	.43	6.8	.11	7.1	.012
9,10-DBAnthrac.	74	66	132	100	150	115	200	150

The third spiking study examined the disinfection of virus (attenuated polio) by ozone and was generously undertaken by the Los Angeles County Sanitation District. This study was conducted on June 5, 1990, just prior to the time when the sanitary sewage spill overwhelmed operations. While a negligible loss of virus occurred due to toxicity (20% reduction), each of three replicates taken during three separate sample runs, showed viral reductions of 99.96% (3.8 log) or greater. Bacterial kill during these runs was unusually low and ranged between 1.7 and 3.6 log. Significant turbidity was observed during two of the three runs (8, 98, and 80 NTU). The applied ozone doses were moderately high at 15, 19 and 15 mg/L (PPM) and dissolved ozone residuals were negligible.

An analysis of the sediments contained behind the storm drain weir was undertaken and although this evaluation did not relate directly to the use of ozone, it does have implications for the disposal of sludge that might accumulate in a treatment facility. Coarse sediments were collected on 2/13/90 and both fine and coarse sediments were taken on 6/21/90. The extracts was analyzed for organochlorine pesticides and semi-volatile compounds and the estimated concentrations are given in table 4. The reporting of 4,4'-DDE should be viewed with suspicion, since the levels detected were at the limit of quantification, the extract contained numerous interfering peaks, and neither DDD nor DDT were detected. The levels of polynuclear aromatic hydrocarbons detected in the storm drain sediments is both significant and predictable given our knowledge of combustion particulates and aerial deposition.

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Table 4. CONTAMINANTS IN STORM DRAIN SEDIMENTS mg/gram (PPM).

Chemical Constituents	2/13 coarse		6/21 coarse		6/21 fine	
	WET	DRY	WET	DRY	WET	DRY
TOC (by combustion)	1.6%	2.0%	1.01%	1.12%	6.3%	14.2%
4,4'-DDE	.0043	.0054	.0040	.0044	.0129	.029
Acenaphthene	.052	.064	ND	ND	ND	ND
Acenaphthylene	.0142	.018	ND	ND	ND	ND
Anthracene	.17	.21	.024	.026	.24	.54
Benz(a)Anthracene	.33	.41	.145	.160	1.00	2.3
Benzo(a)Pyrene	.15	.19	.090	.099	.97	2.2
Benzo(b)Fluoranthen	.87	1.09	.29	.32	2.2	4.9
Benzo(ghi)Perylene	ND	ND	.027	.30	2.2	4.9
bis(2-ethylhexyl) phthalate	.44	.55	.28	.30	ND	ND
Butyl Benzyl Phthal	.040	.050	ND	ND	ND	ND
Chrysene	1.48	1.8	.38	.42	2.0	4.4
Dibenzo(ah)Anthrace	ND	ND	.051	.056	.21	.48
Dibenzofuran	.070	.087	ND	ND	.19	.43
Diethyl Phthalate	.026	.032	ND	ND	.046	.105
Di-n-ButylPhthalate	.65	.81	.149	.160	.55	1.24
Di-n-OctylPhthalate	.084	.104	.126	.138	.18	.41
Fluoranthene	2.6	3.2	.38	.41	2.4	5.4
Fluorene	.110	.137	.042	.047	.75	1.7
Indeno(1,2,3,4-cd) Pyrene	ND	ND	.074	.081	.86	1.9
2-Methyl Naphthalen	.029	.036	.15	.17	.72	1.6
Naphthalene	.016	.020	.053	.58	.19	.426
Phenanthrene	3.0	3.8	.30	.33	2.3	5.2
Pyrene	1.9	2.3	.31	.34	2.6	5.8
Σ PAH's	10.7	13.3	2.2	2.4	18.	40.
Σ Ocean Plan PAHs	8.0	10.0	1.7	1.9	15.	35.

DISCUSSION

The primary goal of this project was to demonstrate whether ozone would be an effective disinfectant for dry-weather storm drain flows, particularly those of the Kenter Canyon drain. The secondary goal was to characterize the variance, in concentration, of some low flow pollutants and determine whether the observed levels would inhibit disinfection or be beneficially reduced during ozonation. Others goals were to define the important treatment parameters, develop a prototype process train, estimate the cost of treatment, and elucidate the operational response to a sudden influx of contaminants. The answers to these questions would determine whether the project should continue beyond the pilot plant phase and what goals to set for that expanded facility.

The pilot plant study proved that ozone was extremely efficient in disinfecting the Pico Kenter Canyon storm drain dry-weather flow. As summarized in table 5, the overall reduction in bacterial numbers was over two and half log, or three and half log based on the more representative geometric mean. Furthermore, these statistics severely under-report disinfection for at least three reasons: First, the plant was not always operated optimally, many runs were performed to compare the relative importance of contact time and ozone concentration or some other parameter; Second, less than half of the samples were prepared using oxygen, rather than air, as the feed gas, so that during the first half of the study applied ozone dosages were relatively low; Third, the analytical method is insensitive to counts of less than two, so that 100% disinfection is still reported in the database as a most probable number of 2 organisms per 100 ml. As seen in figures 5, 6, and 7, disinfection was greatest during the latter phase of the project and a full scale facility should be able to maintain a 5 log (99.999%) reduction in bacterial and viral numbers, based on total coliform counts. Finally, while this study analyzed benign indicator bacteria counts, it should be noted that ozone has been used against a variety of pathogens (Ferguson, Gramith and McGuire 1991) and, while a few species are relatively resistant (Ferguson et al. 1990), the vast majority succumb to ozone more rapidly than other common disinfectants.

Table 5. REDUCTION IN MICROBIAL COUNTS FOLLOWING OZONATION.

Micro Organism Type	Arithmetic		Geometric	
Total Coliform	2.4 log	(99.6%)	3.5 log	(99.97%)
Fecal Coliform	2.5 log	(99.7%)	3.4 log	(99.96%)
Enterococcus sp.	2.9 log	(99.9%)	3.4 log	(99.96%)
Polio Virus (Vaccine Strain)	3.5 log (99.97%)			

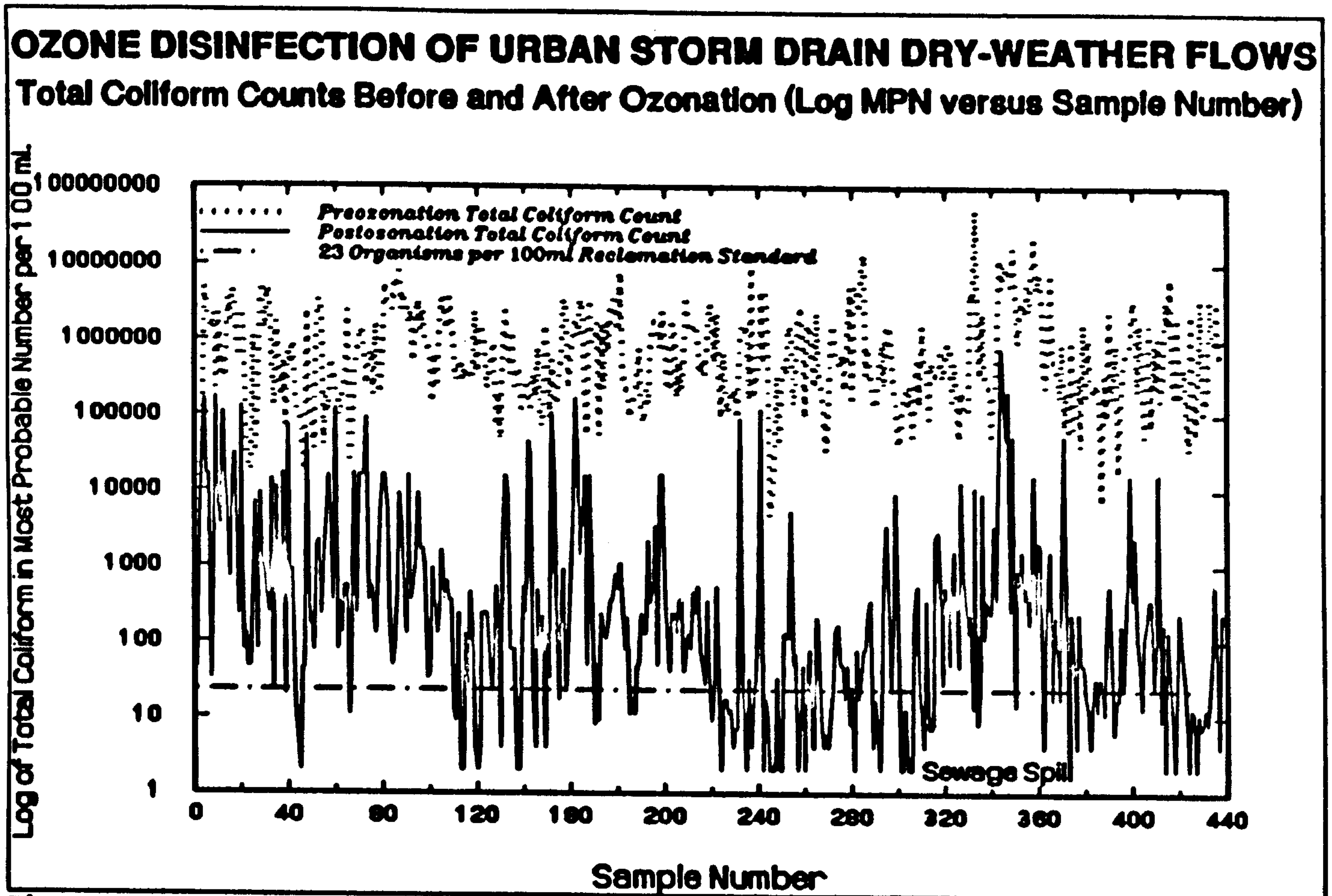

Figure 5. TOTAL COLIFORM COUNTS BEFORE AND AFTER OZONATION (LOG MPN VS SAMPLE NUMBER).

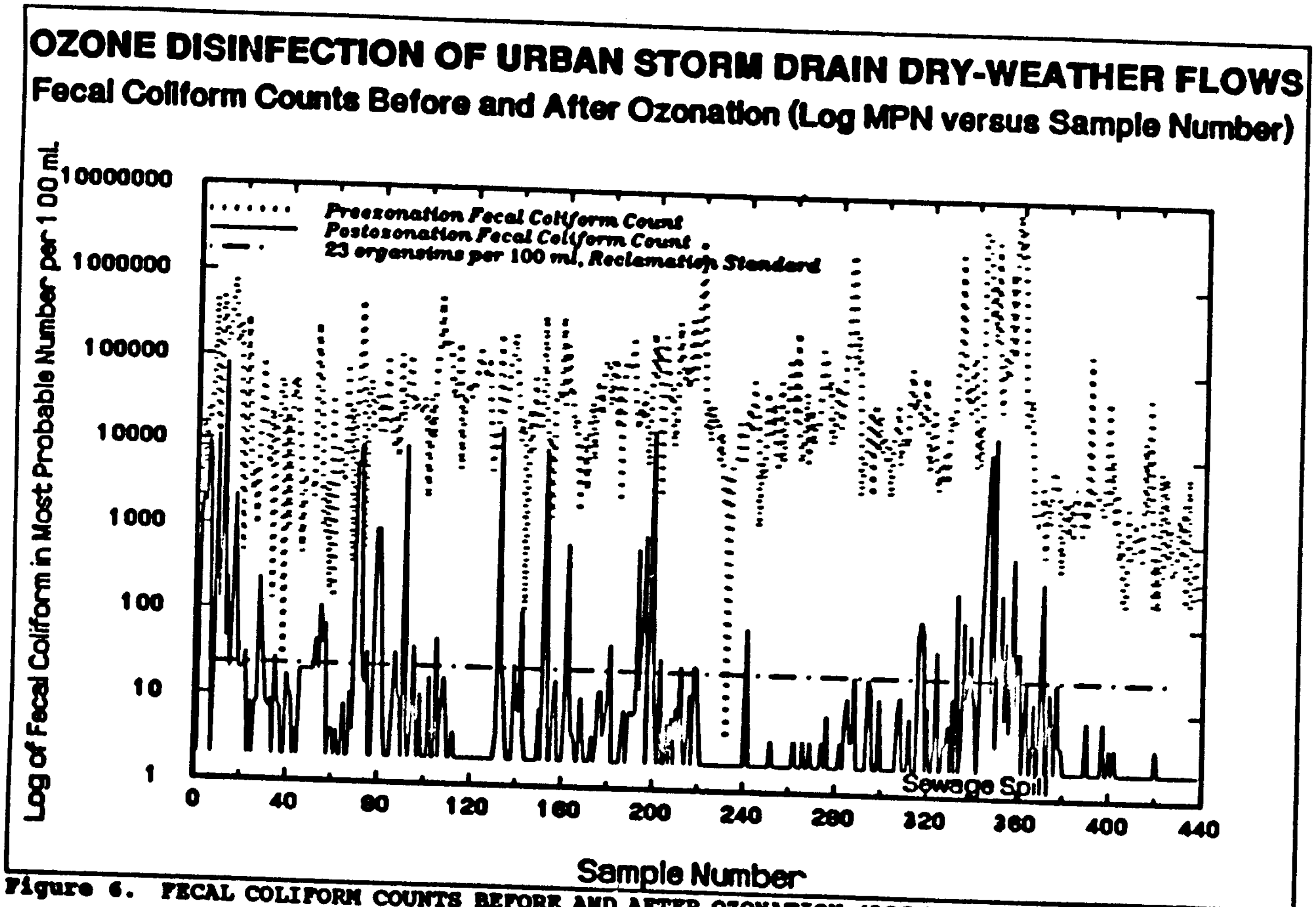

Figure 6. FECAL COLIFORM COUNTS BEFORE AND AFTER OZONATION (LOG MPN VERSUS SAMPLE NUMBER).

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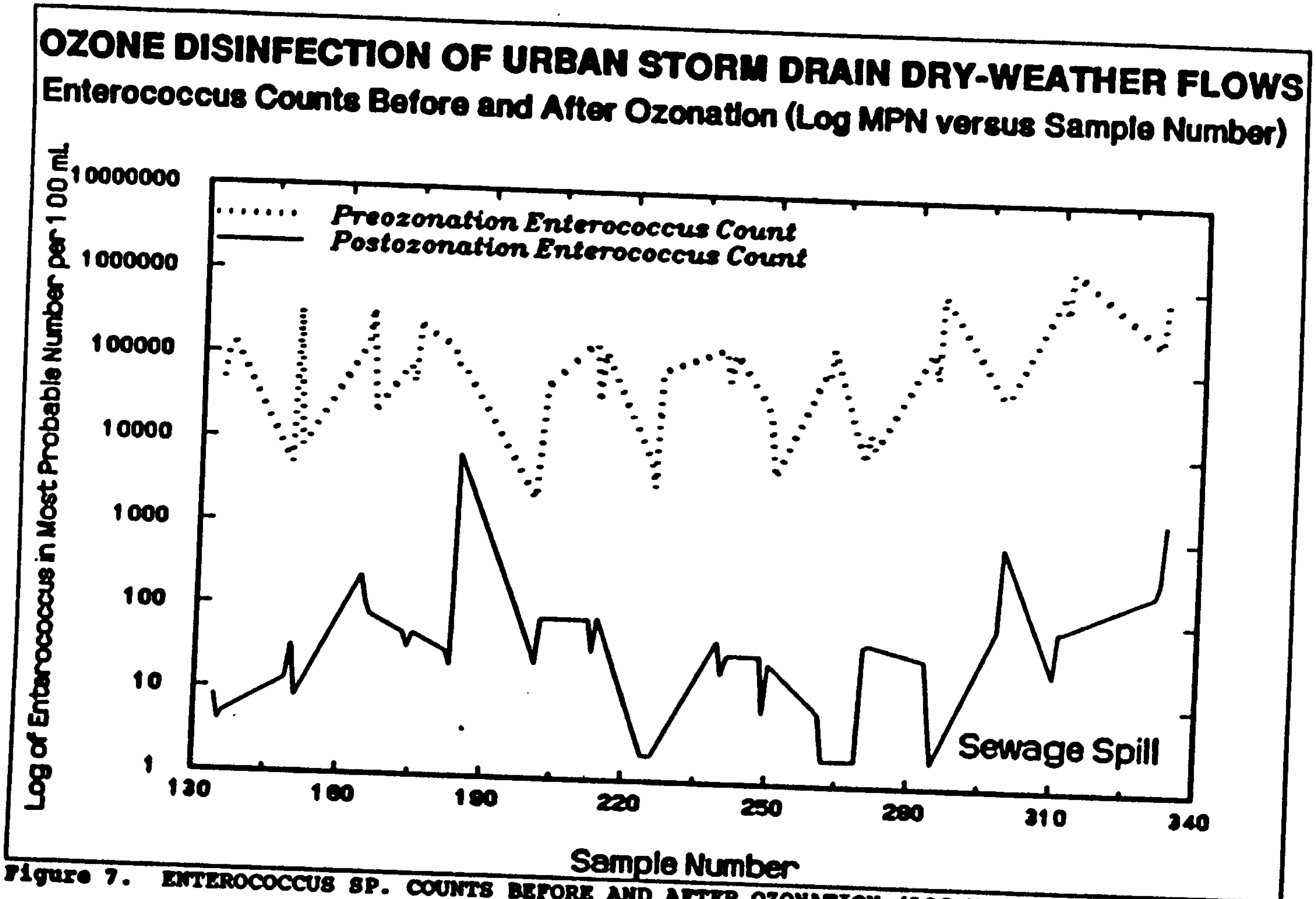

Figure 7. ENTEROCOCCUS SP. COUNTS BEFORE AND AFTER OZONATION (LOG MPN VS SAMPLE NUMBER).

Major economies of scale exist in sizing air preparation and ozone generation equipment and a full scale facility of this type should probably be sized at 5 to 10 times the anticipated mean ozone demand. The major variable expense of treatment, is the electrical ozone generation costs, which is directly proportional to the quantity of ozone produced and consumed and few penalties exist for over designing this aspect of the treatment train. While the pilot phase demonstrated that bacterial numbers were often reduced 5-6 log, a full-scale efficiently operated facility should be able to consistently achieve a 4.5 to 5 log reduction in bacterial counts. This compares with the experience of the drinking water industry which, while using more rigorous filtration processes, is able to achieve a 7-8 log bacterial reduction (Ferguson et al. 1990) using an ozone dose of only 4 mg/L.

The highly variable concentration of contaminants in the flow have confounded the statistical analyses of the parameters that influenced the disinfection process. Intuitively ozone dose and residual would be expected to correlate with disinfection. Contact time also appeared to correlate with disinfection, however, the exposures in this project were relatively short (2-6 minutes) and other research suggests that little correlation exists for periods greater than six minutes (Ferguson et al. 1990). While pH decreased with degree of disinfection, this is probably an artifact of ozonation rather than a direct contribution to sterilization. Total organic carbon was normally inversely proportional to disinfection efficacy, especially at high TOC concentrations. Since ozone indiscriminately reacts with both organismic and inanimate carbon, as the proportion of the latter increases, the amount of ozone acting on microbial carbon must correspondingly decrease. Turbidity, settleable solids, and suspended solids were generally correlated with each other, but appeared to have risen from both inorganic and organic sources. Disinfection generally continued, albeit at lower efficiencies, in the presence of inorganic material, such as was present when extensive upstream concrete cutting flushed large quantities of loamy sediments into the storm drain. In contrast, when the sanitary sewer ruptured into the drain, turbidity, solids and TOC all increased significantly and disinfection was reduced to one or two log. Fortunately these periods were exceptional and disinfection normally proceeded efficiently.

The treatment of storm drain water is hampered by two major constraints. First the integrity of the storm drain as a means of rainfall conveyance must not be hindered. Second, contamination is periodic, erratic and concentrations may change by orders of magnitude over a few moments. The variability was particular evident amongst the solids (Total Solids, Suspended Solids, Dissolved Solids, and Settleable Solids), bacterial, and metal contaminants, but instances also occur among the organic analytes. Chlordane (and heptachlor), lindane, endosulfan and o-xylene were each observed as single spill events and were probably released by a household or small business. While both chlordane and o-xylene were at significant concentrations during these periods, it is unlikely that these random events could have been anticipated. While a typical wastewater treatment facility would receive these individual releases diluted by volumes of wash water and organic sludge, a low- or base-flow storm drain treatment facility would be confronted by a significantly modified and contaminated flow. The proposed storm drain facility would require a smart process train capable of distinguishing between the normal water, that can be treated during the primary disinfection process, and heavily contaminated water that should be directed elsewhere. Depending on the costs, type of contamination, and societal goals, this second path could include on-site treatment, but would probably be more economically decontaminated at a wastewater facility where dilution and additional treatment processes would moderate the spill event.

The chronic Kenter Canyon low flow chemical contamination appears to be limited to some heavy metals and polynuclear aromatic hydrocarbons (PAHs). While an actual initial dilution factor (assumed to be 5:1) would need to be determined to calculate the exact limitations, table 6 indicates that the concentrations of several metals warrant concern. Fortunately, most of the high heavy metals concentrations came from only a few of the almost 200 samples analyzed, and their exclusion would have significantly reduced the mean concentrations. Excluding PAHs, these few easily detected samples, and the described hexavalent chromium contamination, only lead and copper appear to violate the Ocean Plan Objectives for ocean release of the water.

While the recent elimination of leaded gasoline may well bring emissions of this element under standards, a few years will be required to test the hypothesis. Copper represents a more difficult regulatory quagmire. While the mean concentration of copper was about 4 times the Ocean Plan Objectives, it is only one 30th of the drinking water MCL. While no one would advocate that the water is potable, we are faced with the dilemma that water fit to drink from the standpoint of copper contamination, could not be released to the ocean. Given the overall environmental benefits of disinfection, copper would be a prime candidate for regulatory relief if construction of the ozone facility is contemplated.

The major chronic organic contaminants were the polynuclear aromatic hydrocarbons (PAHs) which consist of variously linked benzene rings and include several known and probable human carcinogens. The California Ocean Plan treats PAHs as a group with the water quality objective being based on the sum of thirteen that are commonly analyzed. The Ocean Plan 30 day average for the sum of these 13 is 8.8 ng/L (PPTr) which, with a 5:1 dilution, is equal to an effluent objective of 0.044 µg/L (PPB). The arithmetic and geometric means of both the influent and effluent streams ranged from 1.9 to 1.3 µg/L (PPB) suggesting a normal distribution and indicating that levels were 35 times the Ocean Plan Water Quality

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Table 6. MEAN CONCENTRATIONS OF HEAVY METAL ANALYTES, IN µG/L, DURING STUDY AND COMPARISON TO REPRESENTATIVE WATER STANDARDS.

Analyte Name	Analyte Concentration During the Study			Ocean Plan Objective 5:1 Dilution Assumed		Drink-ing Water MCL
	Mean Values		Maxi-mum	6 Month Median Value	Instan-taneous Maximum	
	Normal	Geomet				
Arsenic	24	13	730	33	465	50
Cadmium	2.8	2.8	16	5	50	10
Chromium+6	31	13	1020	10	100	50
Copper	38	32	136	8	170	1000
Lead	90	42	740	10	100	15
Nickel	6.4	3.6	47	25	250	100
Selenium	7.8	2.2	112	75	750	10
Silver	0.6	0.3	14	3.4	41	50
Zinc	100	82	700	80	1160	5000

Objective. The sum of the mean travel blank PAH concentrations was equal to 0.22 PPB. In the proposed phase V drinking water regulations, the EPA plans to set maximum contaminant levels (MCLs) for 7 of the PAHs specified in the Ocean Plan. For each of these 7 PAHs, the mean value observed during this study was slightly less than the proposed MCL. Furthermore, the sum of the seven proposed drinking water MCLs (1.6 µg/L) was essentially equal to sum of the observed project means (1.9 to 1.3 µg/L) for the 13 PAHs listed in the Ocean Plan Objectives. Consequently, for PAHs we again face the regulatory dilemma that water meeting proposed drinking water maximum contaminant levels would be prohibited for ocean release.

Polynuclear aromatic hydrocarbons are associated with combustion processes and are commonly found in the particulates emitted by diesel engines. These vehicular emissions are also significant sources of metals such as lead and chromium (Manahan 1984). Although the pilot plant was located in the municipal bus yard, the runoff from the yard enters a second storm drain and the chronic contaminant concentrations observed in this study are probably attributable to basin-wide aerial deposition of particulates. This soot, which settle in street side curbs throughout the drainage basin, is probably carried by urban runoff into the storm drains and is unlikely to be effectively controlled in the immediate future. Water treatment technologies for the control of these chronic contaminants, at the mean concentrations observed in this study, include reverse osmosis/ultrafiltration and granulated activated carbon and are extremely costly with other potentially hazardous waste streams. Given the concentration of pollutants in the sediment (table 4), it is likely that much of the observed contamination was due to the submersible pump transporting sediments into the system. Future undertakings should explicitly segregate the sediments and utilize an alternative decontamination strategy, which may require some degree of administrative relief.

A secondary question relates to how the facility responds to chemical contamination and whether any chemical remediation of organic compounds would be observed. Given that metals cannot be "degraded", only isolated and removed, there were few instances in which to observe the action of ozone on hazardous substances. While the o-xylene event could not be analyzed due to saturation of the GCMS detector (the effect of air stripping would also have complicated the results), the chlordane spill provided an exciting validation that remediation does occur. At the highest concentration, 70% of the influent chlordane was apparently degraded to other, probably more polar and less toxic, compounds. This percentage dropped with influent concentration and was less than 40% when a storm washed out the contaminated sediments. The apparent loss in efficacy, with lower contaminant concentration, correlates with the simplistic concept of ozone randomly attacking and cleaving carbon macromolecules into less complex compounds that may still be susceptible to ozone directed attack.

When ozone susceptible compounds are present in the PPM level, and make up a significant fraction of the TOC, ozonation would be a meaningful remediation technology, but at sub-PPB levels in a PPM carbon soup, the removal efficacy could well be inconsequential. Automation and staging of the ozone treatment process should facilitate a rapid response to the challenge of an increase in TOC or drop in ozone residuals. Based on the results of this study, it appears that the concentration of many (trimethyl benzene, aldrin, phenol) compounds can be significantly (> 95%) reduced during disinfection. Others, such as benzyl chloride, naphthalene, 9,10-dibromoanthracene, and pyrene, are less reactive, but are still degraded when present in high concentrations. Finally some recalcitrant compounds, such as lindane and 1,1,1-trichloroethane are apparently resistent to ozone directed attack.

While the disinfection results exceeded expectations and the monitoring program found the water to be only modestly contaminated by chemicals, the question of disinfection by-products remains unresolved. The monitoring program detected mid PPB levels of aliphatic aldehydes, such as hexanal, heptanal, etc., compounds which are typical of ozone disinfection and whose environmental hazard at these levels are unknown. However, it is encouraging that in the Microtox® test, toxicity (EC$_{50}$) decreased with increasing carbon chain length from 1 PPM with formaldehyde to 5

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mg/L for acetylaldehyde, 300 mg/L for butanal and almost 2 gr/l (PPTh) for Benzylaldehyde (Kaiser and Ribo, 1988). The smaller, more volatile, aldehydes are also likely to be stripped with the off-gas into a catalytic ozone destruction unit which is highly reactive with aldehydes and other volatile organics. As discussed in the methods section, this reaction is exothermic and a thermocouple must be included to monitor the unit for combustion. It is also clear that ozone disinfection formed few, if any, of the halogenated byproducts seen with disinfection by chlorine, chlorine dioxide and chloramines (Jacangelo et al. 1989). While all disinfection processes produce by-products, ozone and peroxzone (ozone combined with hydrogen peroxide) produce fewer mutagens then chlorine related processes (Noot et al 1989). Furthermore, as shown in table 1, ozonation clearly did not increase the mutagenicity of the dry-weather storm drain water.

The results obtained during this project, conclusively show that ozone was an effective disinfectant for the low-flow storm drain water. While ineffective in removing metals and trace organic contaminants, ozone disinfection appeared to produce few hazardous by-products, is amenable to automation, and has some chemical remediation properties. Based on the results of this study, it appears that disinfected water can be produced which meets the 23 coliform organisms per 100 ml standard and could be made available for landscape irrigation purposes as part of an integrated treatment and reclamation facility. The project-wide mean metal concentrations are within the guidelines suggested for trace elements in irrigation waters (CWQC 1968) for most metals on any soil. The only exceptions were molybdenum which, at the level found in this study could cause illness in ruminants, and boron which is well within the standard for use on fine textured soils. The other contaminants would not be expected to negatively impact the relatively hardy plants that tolerate growth along freeways.

A potential full-scale process train is diagrammed in figures 8 and 9 and could be based on construction adjacent to a section of storm drain or at a central locality with laterals carrying the flow from adjacent drains. The first station would be an automated trash rack to remove trash during low-flow, first flush, and light storm conditions. Water in excess of treatment system pumping capacity would pass through the 1/4 inch screen and be routed to the ocean through an overflow. The sluice gates (local and remote) and trash rack would be controlled by ultrasonic level detectors. Once the water had been de-trashed, redundant submersible pumps would bring the influent water to surface level and into a filtering device such as a back pressure activated auto strainer with 100 micron filter. After filtering, the water would be monitored for flow rate, pH, conductivity, turbidity, TOC, and probably selected heavy metal ions, such as chromium and iron. Based on these results, the water would be tentatively categorized for potential end uses. Water low in contaminants would go through

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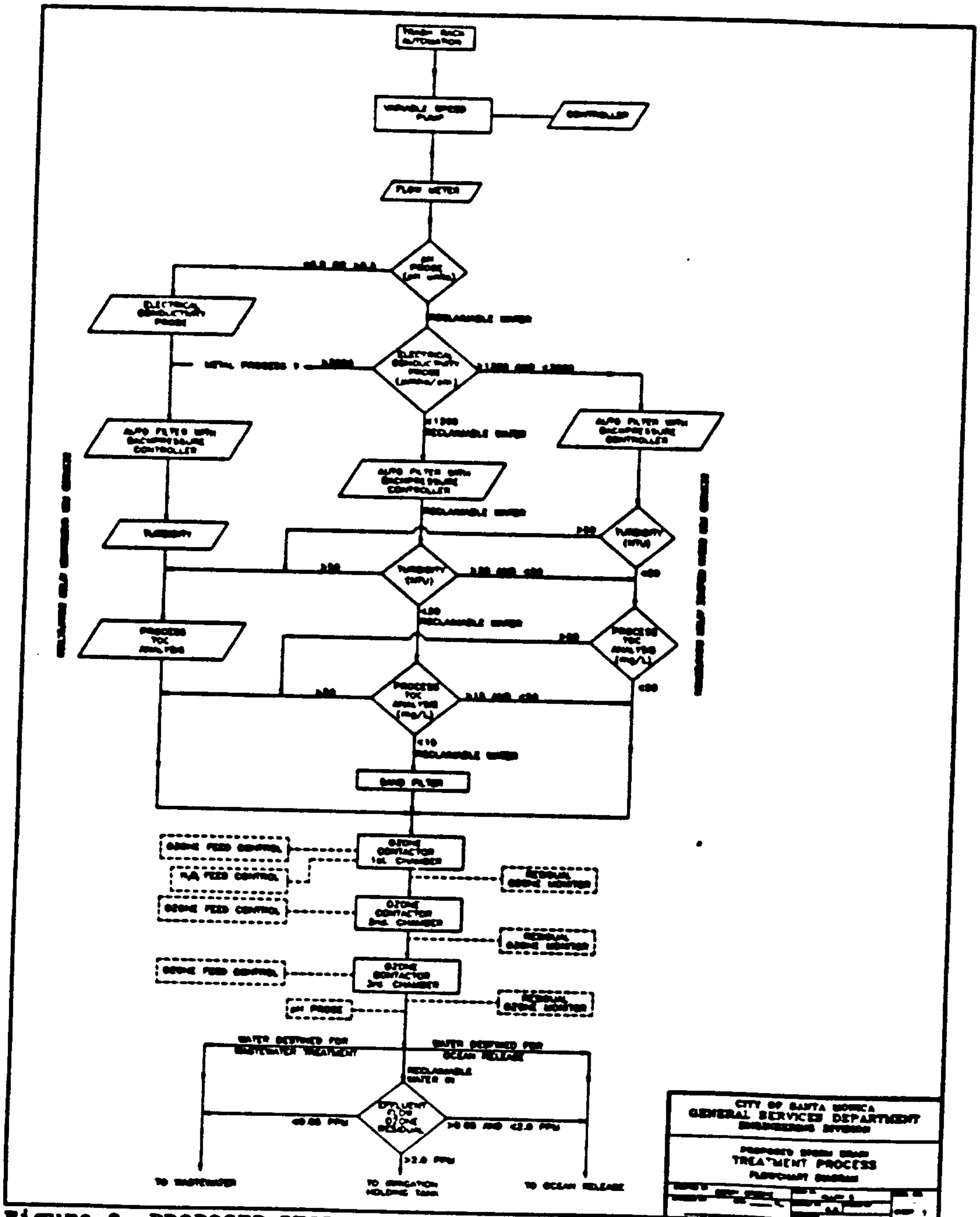

Figure 8. PROPOSED STORM DRAIN TREATMENT PLANT PROCESS FLOWCHART.

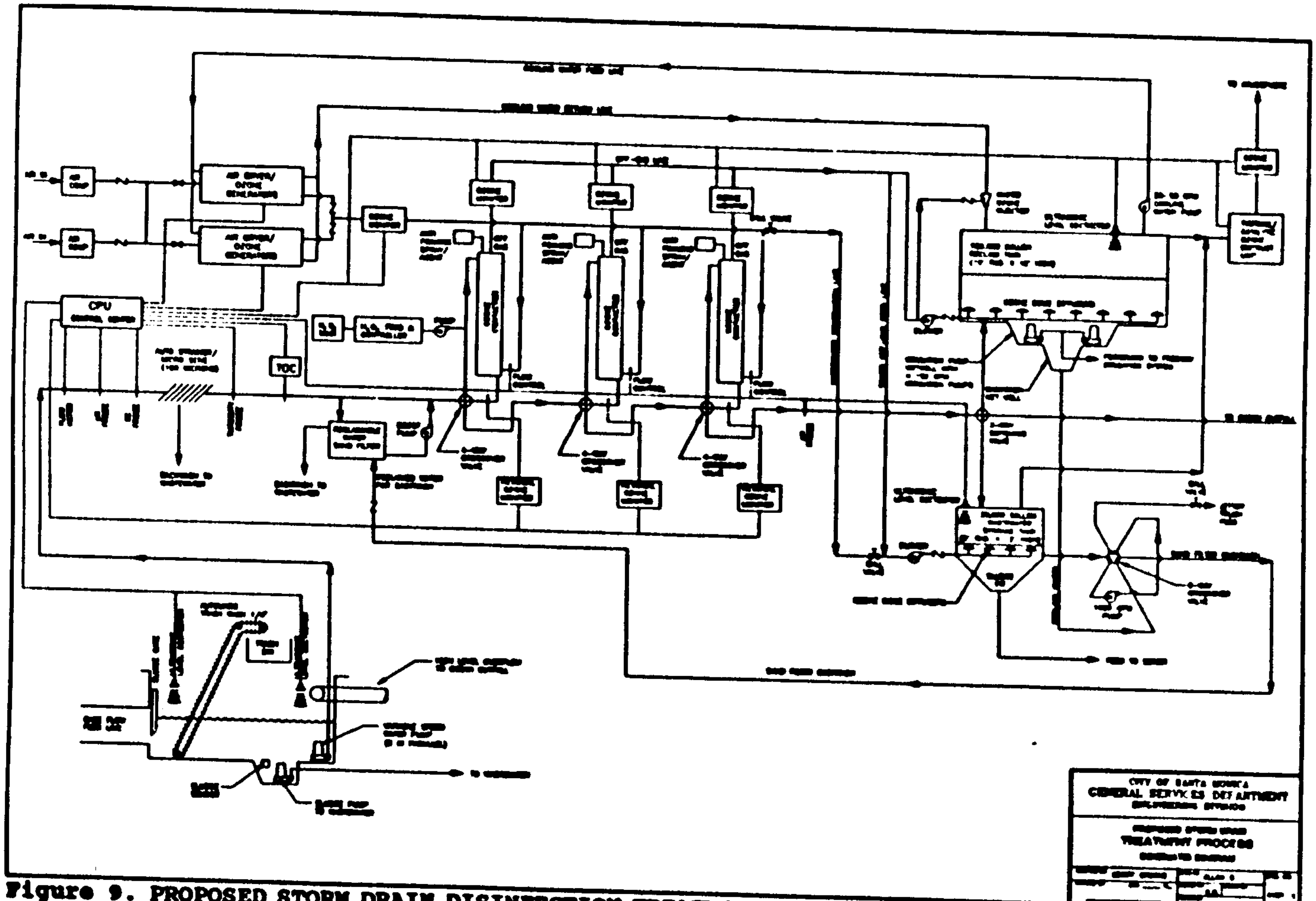

Figure 9. PROPOSED STORM DRAIN DISINFECTION TREATMENT PLANT SCHEMATIC PROCESS FLOW DIAGRAM.

a sand filter with the intention of using the water for irrigation. Water that was moderate in contamination, or in excess of landscape needs, would be slated for ocean release. The most contaminated water could be directed to the sewer or used for sewer flushing.

Following sand filtration of the reclaimable water and characterization of the lower quality waters, the next step would be ozonation in a multichamber system. The separate towers permit maintenance and monitoring of the dissolved ozone residuals and off-gas concentrations. The addition of ozone would be correlated with tower effluent ozone concentrations and influent TOC. Assuming a design consisting of three sequential towers, the residuals would be monitored after each chamber. In response to low residuals, ozone gas flow or generation would increase to some optimum higher production point and be directed to the depressed chamber and its upstream companion. Finally, based on the cumulative sensor parameters, water would be directed one of three effluent streams: the storm drain and ocean; an irrigation reclamation holding tank; or a wastewater holding tank for sewer flushing. The reclamation holding tank would also be the source of backwash water for the sand filters and cooling water for the ozone generators and compressors. The contactor tower off-gas would be passed through both reclamation and wastewater holding tanks to maintain a disinfectant residual, with the off-gas from the tanks passing through the catalytic ozone destruction unit. An auxiliary line would be available to directly feed ozone into the wastewater holding tank if chemical remediation appeared to be warranted.

Initially, the bulk of the treated water would be directed back to the storm drain for ocean release. Later, as reclamation became more significant, only water that was in excess of reuse demand or highly conductive (salty) would be directed back to the drain. Water that was low in conductivity, turbidity, TOC and moderate in pH would be directed for landscape irrigation purposes if, it also contained a significant ozone residual. Water that failed the irrigation and ocean release criteria, such as water that was high in metals, organic matter, or turbidity, would be directed to the holding tank for contaminated or wastewater. The tank overflow and any water used in flushing sewers would then be directed to a typical wastewater treatment facility, but would arrive substantially diluted. Only the dry-weather flow that is within the wastewater treatment facility's capacity and requiring full treatment would receive it. The bulk of the dry-weather flow would receive only the warranted disinfection treatment before being reclaimed or released to the ocean. Finally, water that is highly contaminated and unacceptably for disposal to the sewer system because of metal content, gasoline, or oil and grease, could be held and treated by specific measures such as oil skimming, ozonation, or ion exchange, to reduce the contamination to acceptable levels. Thus the water would be treated in a manner appropriate to the degree of contamination observed.

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The proposed treatment plant off-gas effluent stream is a potential source of cross-media contamination and it was therefore desirable to estimate the level of some contaminants that are likely to be released from the process train. In a study of automotive exhaust from traditional and oxygenated fuels, Hoekman (1992) calculated emissions in terms of milligrams of combustion by-products per mile driven, providing an easily understood standard for comparison. Estimates of treatment plant off-gas emissions of ozone, volatile organic carbon (VOC's), carbon dioxide, and carbonyl (aldehyde-like) compounds were prepared using best (manufacturer's claims), reasonable (generally observed), and worst (poor emission control performance) case scenarios. Based on the data from 6 late model California cars (1986 to 1990), the reasonable case scenarios resulted in 24 hour estimated emissions equivalent to between 10 and 20 miles of driving. With the exception of carbon dioxide, which is fixed at around 14 miles, the best case emissions estimates were less than 1 mile and worst case estimates were less than 160 miles. Therefore, the most likely estimate of treatment plant air emissions are about equivalent to one local commuter trip and represent an insignificant contribution to the local air quality problems.

While bacterial regrowth of the ozonated water in the irrigation pipeline is likely to occur, the bacteria are unlikely to include human pathogens and should not support replication of human enteric virus. The landscape irrigation system will initially require regrowth monitoring and it may become necessary to consider periodic flushing with heavily ozonated (or passed through a solid chlorinator) water with disposal to a modest injection well near the upstream terminus of the irrigation system.

SUMMARY AND CONCLUSIONS

The results proved that ozone was an extremely effective disinfectant and at doses in the range of 10-20 mg/liter was capable of reducing bacterial and viral populations by 3-5 log (99.9 to 99.999% of the microbes killed or inactivated) with contact times of less than 6 minutes. While high organic carbon (TOC) or suspended solids (turbidity) reduced the efficacy of ozonation, the process was not neutralized and samples high in inorganic solids were readily disinfected. In many effluent samples, coliform concentrations were sufficiently reduced to qualify the water for use in reclamation projects such as landscape irrigation along the Santa Monica Freeway, suggesting a possible useful purpose for the treated effluent. While ozonation by products, such as aldehydes, were detected in the plant effluent, their concentration was low (mid PPB range) and many would also be present in a chlorinated effluent. No significant increase in halogenated by-products or mutagenicity was observed following ozone disinfection. As a test of the ozonation process, a dozen hazardous organic chemicals were added to the influent water and the effluent monitored. While the four most refractory compounds passed through the facility unchanged, the concentrations of the other eight were greatly reduced during the disinfection process.

The primary hazardous chemical constituent in the influent water were metals, primarily copper, lead, zinc and chromium which are not removed by ozonation and polynuclear aromatic hydrocarbons which are at extremely low concentrations. Isolated samples did contain organic contaminants, such as ortho-xylene and the pesticide chlordane, but this did not appear to be a pervasive problem and can be attributed to isolated events that cannot be anticipated and will only be prevented through an informed and concerned public. Data on the degradation of PAH's by ozone was mixed. The mean effluent sum of PAHs was 80% of the mean influent sum value, but during the first spiking study, when concentrations of Naphthalene and Pyrene were hundreds of time higher than normal, concentrations were reduced by <95%. This suggests that PAHs, and probably many other organics, are only degraded when their proportion of the total organic carbon becomes substantial in relationship to the large bacterial and biological carbon content. With the exception of some metals, the mean concentration of most of the chemical contaminants were below the levels allowed in drinking water, and only a few contaminants were above California Ocean Plan Water Quality Objectives.

In contrast to bacterial counts which were generally high and consistently present, sediments and suspended solids were generally low, then would suddenly, and unpredictably, rise to levels hundred of times greater than the mean value. This often appeared to coincide with increased dry-weather flows, which would resuspend deposited material, so that increased per gallon treatment demand coincided with higher flow rates through the treatment system.

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RECOMMENDATIONS

The positive results from this study have lead the City of Santa Monica to consider construction of a full scale ozone based treatment facility, presently planned for construction near the Santa Monica Pier. While numerous institutional barriers will need to be surmounted, before a commitment to begin construction can be made, City staff is confident that any negative attributes will be greatly offset by the positive environmental outcome. The proposed facility is expected to be automated and intelligent with the capability to remove trash from all of the dry-weather flows and a least part of the first flush of wet-weather storm runoff.

In the proposed treatment train, after filtration, the influent dry-weather flows would be process monitored for parameters such as conductivity, turbidity, pH, and total organic carbon, the water would then ozonated, and the effluent retested for pH and ozone residual. Based on these parameters the effluent would be directed to the most appropriate disposition. Water that is low in conductivity (salts and metals), filtered and well disinfected (high ozone residual) would be slated for reclamation purposes. Initially, this could consist of a test section of the Santa Monica Freeway and other public works projects. If successful and warranted by the quantity and quality of the effluent, this project could then be expanded to other sections of the freeway. The bulk of the water, which is not initially needed for reclamation, would be screened, disinfected and released to the ocean. Filter backwash water and plant effluent water that is high in organic content (nominally 50 PPM as TOC) would be routed to a holding tank where oil water separators would remove floating contaminants. The contents of this tank could be utilized in municipal jetter trucks which use a high pressure stream to flush out sanitary sewers, thus routing the contaminated water to the facility traditionally designated to deal with water containing a high organic content. Water that is sufficiently high in organic content (perhaps 200 PPM) or heavy metals (based on detection with ion specific electrodes) would be investigated to determine if the contaminants would endanger downstream facilities and then either treated on-site or appropriately disposed of.

If the proposed Santa Monica facility is successful, the potential exists that the dry-weather flows from several of the adjacent storm drains could be transferred, through a new coastal interceptor, to a single treatment plant near the Santa Monica pier. The effluent from this hypothetical facility could then be distributed for use in public works projects, irrigation of neighboring freeways, released under the pier and into the ocean, or pumped into the adjacent Moss Avenue sewage pumping station for eventual treatment at the Los Angeles City Hyperion Facility.

The primary constraint on development of this facility is for the various agencies to determine the level of treatment which is compatible with the various effluent goals. As an example, the content of heavy metals and PAHs could occasionally exceed Ocean Plan Objectives for ocean release of the effluent. However, the reduction in uncontrolled and microbial emissions would be greatly reduced by construction of the facility. The reclaimed water will contain contaminants, but freeways are already the primary source of these pollutants and the landscaping flora has apparently adapted to a soil containing high concentrations of heavy metals and particulates. The treatment facility solids and sludge stream will need to be disposed of. While Santa Monica will be able to deal with "trash" from the screening process, the filter backwash, sediments, and sludge would require further processing. Assuming that ocean release is unacceptable, Santa Monica is faced with the costly choice of de-watering and disposing of the material or directing it to the sanitary sewer and perhaps being considered as an industrial point source. The cost of becoming a point source, that is treating nonpoint contaminants, may be prohibitively expensive, especially if aerial deposition is the primary source of contamination and two thirds of the drainage basin is in another jurisdiction. Unfortunately, it is possible that concerns regarding the unknown disposal costs of the these waste streams may prevent treatment of a known and potentially significant biohazard. While testing, evaluating, and operating this prototype facility, it is important that all parties be prepared to deal with some unanticipated excursions. It is vital that the known public health "big" picture remain consistently clear and not become distorted over contaminant variability and episodic spill events.

The various arms of the Santa Monica Bay Restoration Project can expedite the development of the proposed facility by continuing to contribute its group expertise on the individual policy issues. The advice of the technical advisory committee, has already been invaluable in directing the progression of this study and will hopefully continue to participate in designating the major contaminants and waste streams of concern. The public advisory committee has volunteered to translate this report into a format that can be understood and supported by the general public and will continue to reduce the level of storm drain pollution by educating the populace. Finally, the management committee and foundation wield significant authority and prestige among responsible agencies and regulators. As a consensus forming group, its support represents an essentially neutral opinion regarding the broad environmental good of the Santa Monica Bay Region. While Santa Monica gratefully acknowledges the support of the SMBRP in funding the demonstration project, the City requires the continued support and influence of the Santa Monica Bay Restoration Project to successfully commission and evaluate the proposed facility.

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OZONE DISINFECTION AND TREATMENT OF
URBAN STORM DRAIN DRY-WEATHER FLOWS

A PILOT TREATMENT PLANT DEMONSTRATION PROJECT ON THE KENTER
CANYON STORM DRAIN SYSTEM IN SANTA MONICA

TECHNICAL AND DATA APPENDICES

APPENDIX A

QUALITY CONTROL AND ASSURANCE REPORT

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SUMMARY

Given the scope and resources of this project, the quality assurance and control were generally excellent. The primary QA/QC failure was associated with analyses conducted out of holding time compliance primarily for pesticide and TOC analyses. Lesser problems also developed in interpreting the results from the outside (state certified) laboratory, poor choice of pesticide internal standard, and contamination in the hexavalent chromium reagents. None of these difficulties compromised the analytical value of the data. To the contrary, the analytical accuracy of the analyses exceeded that anticipated in the project Quality Assurance Plan and, with only two exceptions, significantly more analyses were undertaken, then were originally planned.

A summary of the compliance and analytical information is given in Table A1. The only reductions, from the proposed number of analyses, were among the purgeable and mutagenicity assays. This was necessitated by a doubling in anticipated analytical cost of the mutagenicity work and was approved by the project review board. The other additional analyses were financed by a combination of unmatched municipal funds, lower personnel costs, and reduced costs of the bacterial analyses. The number of analyses performed by the certified laboratory remained unchanged. Differences between the sample number collected and number included in the database were generally due to analytic problems such as salt in TOC analyses, and detector saturating concentrations of ortho-xylene in the purgeable analyses. The ozone pilot plant spiking studies and sediment sample results are contained in the text and were incompatible with inclusion in the database. The complete database, draft report, and alternative database formats have been submitted to, and should be available through, the EPA Oceanographic Data Evaluation System (ODES) network. The Data is available from the author in ODES, ASCII, and Dbase III+ formats.

ANALYTICAL QUALITY CONTROL PROCEDURES

Methodological problems that occurred during the project are included in the main report, this appendix is primarily devoted to describing the efforts undertaken to insure and demonstrate the accuracy and quality of the data obtained during the study.

The electrical conductivity meter was calibrated prior to each analysis using a 1,000 µmho/cm standard prepared using a calcium chloride solution as specified by the manufacturer. Samples were collected in polycarbonate Immhoff cones and any that measured above 3,000 µmho/cm were compared to a 10,000 µmho/cm standard. Fresh standards were prepared monthly and compared to the "expired" standards to insure that they agreed to within 5%. The meter was temperature corrected and the readout was directly recorded.

The pH meter was calibrated daily using pH 7 and 10 buffers corrected for the anticipated water temperature. The buffers were obtained from Fisher Scientific and were within expiration date. The calibration was checked just prior to use, or when the water temperature differed from the expected by more than 2°C.

Temperature was measured using a standard glass laboratory thermometer, that was checked weekly against a precision thermometer.

The nephelometer (turbidimeter) was calibrated between samples using a 40 or 5.0 NTU Amco® AEPA-1 standard. As discussed in the methods section, the 0-1, 1-10 and 10-100 scales did not completely overlap. Sample pairs that fell between the scales were compared on the same scale and could be accurately estimated up or down 1 NTU. The accuracy of the instrument and analyst was also checked using an EPA Turbidity Quality Control Sample (Lot WS 289). The 1.00 NTU sample read 1.02 on the 0-1.0 scale and 0.95 on the 1-10 scale, as compared to performance evaluation mean of 1.05 with 95% confidence interval ranging from 0.81 to 1.29. The 5.0 NTU sample was read as 5.5 NTU while the performance mean was 4.94 with a 95% confidence interval of 4.26 to 5.62 NTU. Since the samples were always measured as influent/effluent pairs, any error introduced by the scale misalignment would affect both samples and introduce a relatively neutral bias.

Immhoff cones are standardized at the factory and no calibration of the settleable solids analysis is possible.

The accuracy of the analyses for total solids (total residue, Method 160.3), dissolved solids (filterable residue, method 160.1) and suspended solids (non-filterable residue, method 160.2) were confirmed using EPA Residue Quality Control Samples (Lot RES 489). The results are given in Table A2.

Table A1. SAMPLING AND COMPLIANCE NUMERICAL ASSESSMENT BY METHOD.

Analysis Name	# of Samples		# in Extraction Compliance	Number in Analytical Compliance	Samples Added to Database
	Planned	Taken			
Total Coliform	360	438	N/A	438	438
Fecal Coliform	360	438	N/A	436	436
Metals-ICP	96	208	N/A	156-193	156-193
Chromium +6	96	96	95	95	95
TOC (wet)	312	438	N/A	425	425
Organochlorine Pesticides	72	86	86	64	86
Volatile Organics	24	22	N/A	20	20
Extractable Organics	18	21	21	21	21
Resin Accumul. Mutagenicity	6	5	N/A	N/A	5
Electrical Conductance	Not planned	332	N/A	332	332
pH	N/P	438	N/A	401	401
Temperature	N/P	430	N/A	430	430
Turbidity	N/P	349	N/A	349	349
Settleable Solids	N/P	438	N/A	438	438
Total Solid	N/P	435	N/A	435	435
Dissolved Solids	N/P	435	N/A	435	435
Suspended Solids	N/P	434	N/A	434	434
Off-gas O3	N/P	387	N/A	387	387
Dissolved Ozone Residual	N/P	430	N/A	430	430
Virus Spike	N/P	3	N/A	N/A	N/A
Sediments	N/P	3	N/A	N/A	N/A
Chemical Spike	N/P	6	6	6	N/A

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Table A2. EVALUATION OF EPA RESIDUE QUALITY CONTROL STANDARDS.

Analyte	True Value	Inter Lab. Mean	Standard Devia-tion	Tech. #1	Tech. #2	95% Con-fidence Interval
Dissolved Solids #1	408	411	27.0	455	381	361-470
Dissolved Solids #2	287	290	21.7	319	287	247-333
Suspended Solid #1	31.5	31.5	1.82	28.8	31.2	27.7-35.1
Suspended Solids #2	278	267	8.70	255	259	250-284
Total Solids #1	439	442	29.1	443	391	384-500
Total Solids #2	565	557	37.4	551	526	490-632

The use of the sensitive ultrasonic nebulizer, presented a metals analysis quality assurance problem, since the standard inductively coupled plasma QC samples (ICP-19 and ICP-7) were far too concentrated. Secondly, the report included with these QC samples (Lot WP988) did not include interlaboratory mean, standard deviation and 95% confidence interval for each metal. The analyst responded by diluting the ICP standards 1:50 and 1:500 respectively. The QA officer has taken interlaboratory data from trace metal analysis by atomic absorption (Water Pollution Control Sample Trace Metal I Lot WP287) and prepared table A3. The concentration of metals in the diluted ICP standards were mostly at 200 μg/L, while the interlaboratory comparison was for samples containing 100 μg/L for most metals (Al was at 500, V was at 250, Cd and Se were at 25). The 95% confidence interval in table A3 have therefore been normalized to 200 PPB. With the exception of those metals not analyzed in the interlaboratory study, it appears that the results obtained in this study are comparable to those expected using graphite furnace atomic absorption analysis.

Two samples were collected in duplicate, one being handled by project staff, while the second was sent to a certified laboratory (International Technology) for analysis. As shown in table A4, the results for sample 200B are in reasonable agreement, with the exception of magnesium, which is at concentrations only four times their detection limit. Less correlation is observed in sample 331A, especially for arsenic, chromium, lead, and selenium, which were in significantly lower concentrations in the commercial lab results.

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While it is impossible to determine the source of disagreement at this time, this sample was noted by project staff to have required the most acid, during digestion, of any sample prepared, and included matter that was not digestible. A lab that prepared water samples in bulk, could easily have under-prepared this sample resulting in undissolved particulate matter, that would have escaped analysis.

Because hexavalent chromium is subject to valence changes during transport and handling, quality control is generally performed using samples prepared at the user laboratory. Both staff and the commercial laboratory experienced methods development problems due to contamination in the reagents. Staff, with review board approval, choose to tolerate the 7 ppb level of contamination rather than suffer the expense of locating the source. The commercial lab eventually located and replaced their contaminated reagents. Based on the method of standard additions, staff found that recovery of Cr_{+6} averaged 70%. Five of the six samples analyzed by both laboratories were in basic agreement, while the sixth was reported at 45 PPB by staff while the certified lab reported 6 μg/L. A sample collected 90 minutes earlier, contained a moderate (32 PPB) concentration of total chromium. The project arithmetic and geometric mean trivalent chromium concentrations were 14.4 and 3.5 μg/L respectively.

Quality control was integral to the project Total Organic Carbon (TOC) analysis. Following instrument warm up, staff injected both 100 and 10 PPM standards and would proceed to the laboratory blank only if agreement was within 2%. If the blank was at less than 0.5 mg/L, the analysis would proceed, otherwise, the unit was recalibrated using a 5 to 7 injection standardization, then rechecked as above. If sample pairs differed by more than 10%, they were re-injected to verify variation or until a majority showed that an error had occurred during the initial injections. With the exception of samples collected during the long resin runs, sample pairs were normally in agreement. As shown in Table A5, little agreement was observed in the split samples sent for commercial analysis. Initially this was traced to the samples not being acidified and purged of carbon dioxide by the certified labs. Following this discovery, the samples were reanalyzed and the results are reported here. Samples 200 and 332 were collected during resin accumulation runs, when each type of analysis was undertaken and sampling could require 30 or more minutes. In both cases the effluent TOC sample agreed with the commercially tested sample and neither of those agreed with the influent sample. This disagreement is undoubtedly a sampling artifact associated more with coordinating sampling during the resin runs and demonstrates the variability of the flow. Although both laboratories were using the same model of instrument, efforts to improve the analytical correlation were unsuccessful during the latter part of the study. In an effort to verify internal quality assurance, the author did find that if the instrument ran too long between samples, or dilute samples followed more concentrated ones, high results were observed.

Table A3. EVALUATION OF METAL ANALYTES QUALITY CONTROL STANDARDS. All analyte concentrations are given in µg/L (PPB), n=15.

Analyte	ICAP-19 1:50 True Value	Normalized 95% Confidence Interval (Atomic Absorption)	Project Results	
			Mean	Stand. Dev.
Aluminum	200 ICAP7	170.8-234.0	228	28.4
Arsenic	200	160.0-236.0	208	14.3
Barium	200	NA	202	10.7
Beryllium	200	177.4-220.0	198	5.2
Boron	200	NA	186	60.7
Cadmium	200	169.6-221.6	201	9.0
Calcium	200	NA	262	28.3
Cobalt	200	173.6-224.0	198	6.2
Chromium	200	168.8-230.0	199	6.7
Copper	200	188.8-218.0	200	8.5
Iron	200	165.4-236.0	207	8.8
Magnesium	200	NA	195	10.4
Manganese	200	176.8-218.0	195	7.4
Molybdenum	200	NA	200	9.5
Nickel	200	176.0-226.0	206	9.9
Lead	200	170.2-230.0	203	10.5
Potassium	2000	NA	2840	640
Selenium	200	139.2-226.4	204	13.9
Silicon	106	NA	120	14.9
Silver	200	NA	200	9.2
Titanium	200	NA	197	8.5
Vanadium	200	176.0-225.6	193	8.2
Zinc	200	178.0-222.0	200	9.2

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Table A4. INTERLABORATORY METAL ANALYTES COMPARISON.
All analyte concentrations are given in µg/L (PPB).

Analyte	Detection Limit		Sample 200B		Sample 331A	
	SM	IT	SM	IT	SM	IT
Arsenic	6.4	10	13	<10	160	<10
Barium	0.2	200	76	<200	169	200
Cadmium	1.1	5	2	<5	7	<5
Calcium	5.2	5000	41200	61000	53800	44000
Chromium	1.0	10	5	10	31	20
Lead	4.9	3	32	40	79	27
Magnesium	0.4	5000	11400	21000	16000	21000
Nickel	1.5	40	7	<7	17	<40
Selenium	5.0	5	<5	<5	53	7
Silver	0.2	10	3	<10	5	<10
Sodium	29	5000	77500	95000	126000	120000
Zinc	0.5	20	100	140	280	270

Table A5. INTERLABORATORY TOTAL ORGANIC CARBON COMPARISON IN MG/L.

Sample #	Santa Monica Results	Commercial Laboratory Results
134A	8.3	12
149A	9.2	10
164A	7.9	8
174A	13.9	12
200A	13.9 (resin run)	21
213A	25	19
248A	23	29
285A	13.6	29
298A	25	37
311A	20	33
332A	72 (resin run)	46

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Although pesticide analyses were delayed due to instrumental failure, few quality control problems were encountered. During the initial phase of the study, samples were spiked using EPA Water Pollution Quality Control Sample, Chlorinated Hydrocarbon Pesticide III (Lot WP185) at the designated concentration. As presented in table A6, the results were well within the interlaboratory acceptance criteria, even though the samples were all analyzed out of holding time compliance. During the second half of the pesticide analyses, samples were spiked with EPA WQPQCS CHP I (Lot WP385), but at 1/20th the concentration used for the acceptance criteria. In both cases, quality control protocols call for spikes to be added to laboratory water rather than the more challenging field samples utilized here. The results from 13 (=n) spiked samples is presented in table A7. The acceptance criteria was taken from the report issued with the sample, but divided by 20 to normalize for the concentrations used in this series. While some of the mean recoveries were low, this is to be expected given the dilute concentrations spiked and utilization of the difficult storm drain matrix.

Table A6. HIGH CONCENTRATION PESTICIDE QUALITY CONTROL SAMPLES. Results taken from seven samples (n=7) and are given in ng/L (PPTr).

Analyte	True Value of Spiked Samples	EPA Accept.Criteria		Project Results	
		Mean Range	s	Mean	s
ß-BHC	2000	780-2600	640	1440	180
Heptachlor epoxide	2000	1130-2630	410	1470	121
Endosulfan I	2000	1140-2820	490	1500	123
Endosulfan II	10000	2200-17100	6100	5600	710
Endrin Aldehyde	10000	mean 8280	3540	4200	960

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Table A7. LOW CONCENTRATION PESTICIDE QUALITY CONTROL SAMPLES. Results taken from 13 samples (n=13) and are given in ng/L (PPTr).

Analyte	True Value of Spiked Samples	Acceptance Crit.		Project Results	
		% Recovery	S	% Recovery	S
Heptachlor	100	42-122	20	62	11.9
Aldrin	100	34-111	21	49	11.3
4,4'-DDE	100	30-145	28	34	9.0
Dieldrin	100	36-146	38	39	10.1
4,4'-DDD	500	31-141	140	32	70
4,4'-DDT	500	25-160	180	30	56

Thirteen of the 14 pesticide samples analyzed by both staff and the certified laboratory, were negative for all analyzed pesticides. Sample 284A was determined by the contract lab to contain Endosulfan Sulfate at their detection limit of 100 PPTr. Since the staff analysis did not detect this pesticide at 20 ng/L, the certified lab was requested to verify the analysis and send copy of the pertinent chromatograms. While the detection was "confirmed" by the certified lab, the project QA officer's review of the chromatograms found a false positive. This determination is based on the pre- and post-sample standard injections of Endosulfan sulfate which had a retention time of 23.03 minutes, while the suspect sample peak was observed at 22.93 minutes. As shown in table A8, 3 spiked samples were shipped to the certified lab, with their mean recovery being comparable to those observed by project staff (table A7).

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Table A8. CONTRACT LABORATORY RECOVERY OF SPIKED PESTICIDES. Results are given in ng/L (PPTr).

Analyte/Sam.#	Det.Lim.	200AS	224A	260AS	$\bar{X}$ Recovery
Spiking Level	ng/L	200	200	400	N/A
Aldrin	50	100	100	100	42%
α-BHC	50	200	200	300	92%
β-BHC	50	100	200	200	67%
Γ-BHC	50	200	200	300	92%
δ-BHC	50	200	200	300	92%
4,4'-DDD	100	100	100	100	42%
4,4'-DDE	100	100	80	200	47%
4,4'-DDT	100	100	80	200	47%
Dieldrin	100	100	200	400	83%
Endosulfan I	50	100	200	200	67%
Endosulfan II	100	100	100	<200	<50
Endo. Sulfate	100	ND	100	300	42%
Endrin	100	100	200	200	67%
Heptachlor	50	100	100	100	42%
Hep. Epoxide	50	100	200	300	75%

As proposed in the project quality assurance plan, laboratory control standards were utilized to verify the analytical results for the analysis of purgeable compounds. The mean, standard deviation and range of recoveries, were all well within the EPA 624 method acceptance criteria and shown in table A9, with a comparison to the results obtained during this study. Because of the difficulty in reliable spiking low concentrations of purgeable compounds, no spiked samples were prepared for the certified laboratory.

Table A9. EVALUATION OF PURGEABLE LABORATORY CONTROL STANDARDS. Results taken from 3 samples (n=3) and are given in µg/L (PPB).

Analyte	Acceptance Criteria		Project Results	
	Range of Mean	S	Mean	S
Benzene	3,04-5.20	1.38	4.19	0.25
Bromodichloromethane	2,02-5.60	1.28	3.96	0.07
Bromoform	2,28-6.22	1.08	3.95	0.26
Bromomethane	D-8.24	3.58	4.16	0.50
2-Butanone	N/A	N/A	3.81	0.04
Carbon Disulfide	N/A	N/A	3.77	0.61
Carbon Tetrachloride	3.44-4.70	1.04	4.02	0.07
Chlorobenzene	3,28-5.48	1.26	4.02	0.09
Chloroethane	1,68-8.08	2.28	4.30	0.33
2-Chloroethyl Vinyl Ether	D-10.8	5.18	2.77	1.70
Chloroform	2,74-4.84	1.22	3.78	0.18
Chloromethane	D-9.18	3.96	3.94	0.19
Dibromochloromethane	2,76-5.32	1.22	4.00	0.12
1,1-Dichloroethane	2,84-5.70	1.02	3.87	0.05
1,2-Dichloroethane	2,86-5.48	1.20	3.87	0.04
1,1-Dichloroethene	0,74-8.46	1.82	3.88	0.33
trans-1,2-Dichloroethene	2,72-5.70	1.82	3.88	0.33
1,2-Dichloropropane	0,76-7.24	2.76	3.95	0.09
cis-1,3-Dichloropropene	0,20-7.80	3.16	4.78	0.12
trans-1,3-Dichloropropene	1,32-6.48	2.08	3.17	0.02
Ethyl Benzene	3,48-5.34	1.50	3.81	0.18
2-Hexanone	N/A	N/A	3.85	0.40
Methylene Chloride	D-8.20	1.48	3.68	0.22
4-Methyl-2-Pentanone	N/A	N/A	3.94	0.07
Styrene	N/A	N/A	3.91	0.19

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Table A9 contd. EVALUATION OF PURGEABLE LABORATORY CONTROL STDS. Results taken from 3 samples (n=3) and are given in µg/L (PPB).

Analyte	Acceptance Criteria		Project Results	
	Range of Mean	S	Mean	S
1,1,2,2-Tetrachloroethane	2.70-5.44	1.48	4.00	0.12
Tetrachloroethene	3.40-5.32	1.00	4.03	0.10
Toluene	3.32-5.34	0.96	4.11	0.28
1,1,1Trichloroethane	2.74-6.02	0.92	3.93	0.10
1,1,2Trichloroethane	2.86-5.42	1.10	3.91	0.08
Trichloroethene	3.72-5.34	1.32	4.01	0.11
Trichlorofluoro-methane	1.78-6.30	2.00	3.81	0.84
Vinyl Acetate	N/A	N/A	3.58	0.54
Vinyl Chloride	D-8.70	4.00	3.97	0.18
o-Xylene	N/A	N/A	3.87	0.16

As with the other major analyses, the method 625 semi-volatile or extractable analysis was initiated using EPA Water Pollution Quality Control Samples spiked into duplicate field collected samples at the designated concentration of 100 µg/L (PPB). Three spiked samples were prepared using both GC/MS Base Neutral II (Lot WP586) and GC/MS Acids (Phenols) (Lot GAC489). As shown in tables A10 the mean and standard deviation were well within the reported acceptance criteria for all compounds except 2-Methyl-4,6-dinitrophenol, which appears to be due to a typographical error since the standard deviation (S=93.2) is twice the range of the mean (53-100). It should also be noted that combining, and simultaneously analyzing, the base neutral and acid extracts, a method modification used during this project, produced no discernable analytical artifacts, even with the vary concentrated spiked quality control samples.

During the second phase of the quality control assessment, three duplicate samples were spiked with all of the method 625 analytes, at either 20 or 40 µg/L. The resulting values were multiplied by 5 or 2.5 respectively and compared to method acceptance criteria, which are based on the spiking of laboratory water at 100 µg/L, and are presented in tables A11. As previously suggested, 2-Methyl-4,6-dinitrophenol appears to exceed criteria due to a typographical error. Three other compounds, 2-Chloronaphthalene, Hexachlorobenzene, and 2,4,6-Trichlorophenol, are slightly out of acceptance criteria for the standard deviation.

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Table A10. EVALUATION OF HIGH CONCENTRATION SEMI-VOLATILE QUALITY CONTROL STANDARDS. Results from 3 samples and are in µg/L (PPB).

Analyte	Acceptance Criteria		Project Results	
	Range of Mean	S	Mean	S
Acenaphthene	60.1-132.3	27.6	73	1.8
Anthracene	43.4-118.0	32.0	86	1.44
Benzo(b)fluoranthene	42.0-140.4	38.3	97	3.3
Benzo(a)pyrene	31.7-148.0	39.0	101	3.1
Benzo(ghi)perylene	D-195	58.9	106	23.
Benzyl Butyl Phthalate	D-139.9	23.4	90	4.6
Bis(2-ethylhexyl) Phthalate	28.9-136.8	41.1	81	3.8
4-Bromophenyl-phenyl Ether	64.7-114.4	23.0	87	1.7
4-Chloro-3-methylphenol	40.8-127.9	37.2	98	4.4
2-Chlorophenol	36.2-120.4	28.7	84	0.36
4-Chlorophenyl-phenyl Ether	38.4-144.7	33.4	85	1.6
Chrysene	44.1-139.9	48.3	95	1.7
Dibenzo(a,h) anthracene	D-199.7	70.0	147	3.5
1,4-Dichlorobenzene	37.3-105.7	32.1	67	2.0
2,4-Dichlorophenol	52.5-121.7	26.4	102	5.1
2,4-Dimethylphenol	41.8-109.0	26.1	86	1.5
Dimethyl Phthalate	D-100.0	23.2	69	4.0
2,4-Dinitrophenol	D-172.9	49.8	121	2.3
Fluoranthene	42.9-121.3	32.8	91	2.7
Fluorene	71.6-108.4	20.7	72	2.7
Hexachloroethane	55.2-100.0	24.5	75	3.1
2-Methyl-4,6-dinitrophenol	53.0-100.0	93.2	138	5.9
Naphthalene	35.6-119.6	30.1	56	6.4

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Table A10 contd. EVALUATION OF HIGH CONCENTRATION SEMI-VOLATILE QUALITY CONTROL STANDARDS. Results from 3 samples and are in µg/L.

Analyte	Acceptance Criteria		Project Results	
	Range of Mean	S	Mean	S
Nitrobenzene	54.3-157.6	39.3	90	4.1
2-Nitrophenol	45.0-166.7	35.2	113	6.4
4-Nitrophenol	13.0-160.5	47.2	113	8.0
Pentachlorophenol	38.1-151.8	48.9	100	2.2
Phenol	16.6-100.0	22.6	50	1.22
2,4,6-Trichlorophenol	52.4-129.2	31.7	111	1.24

Given that acceptance criteria are normally based on 7 laboratory water extractions at higher concentrations, these variances do not warrant concern. Finally, sample 200A was collected in duplicate and both were spiked with 40 µg/L. They were then analyzed by either staff or the certified laboratory. The results are given in tables A12 and show a general agreement at levels above the CLP detection limits of 10 to 50 PPB. Sample 260A was analyzed by the contract laboratory and reported to contain 2-methyl phenol (o-Creosol) at 19 µg/L, while a duplicate analyzed by staff did not confirm the finding. The QA officers review of the contract labs analysis concurs with their findings. Since the two labs were in disagreement, only the staffs findings were reported in the report. However if this value had been included, the most significant change would have been in the total maximum value of phenols, which would have risen to 34 PPB while the Ocean Plan standard, with 5:1 dilution, is 150.

The quality assurance and quality control for the resin accumulation and ames assays were undertaken by staff under the direction of Dr. J. Froines. They generally followed EPA protocols and utilized blanks and controls. Further information on the specific efforts and results of those efforts can be obtained by contacting the author or Dr. Froines of the University of California at Los Angeles, School of Public Health.

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Table A11. EVALUATION OF LOW CONCENTRATION SEMI-VOLATILE QUALITY CONTROL STANDARDS. Results from 3 samples and are in µg/L (PPB).

Analyte	Acceptance Criteria		Project Results	
	Range of Mean	S	Mean	S
Acenaphthene	60.1-132.3	27.6	94	18
Acenaphthylene	53.5-126.0	40.2	98	15
Aniline	N/A	N/A	8.9	6.8
Anthracene	43.4-118.0	32.0	88	16
Azobenzene	N/A	N/A	120	22
Benzidine	N/A	N/A	27	54
Benzo(a)anthracene	41.8-133.0	27.6	98	14.5
Benzo(b)fluoranthene	42.0-140.4	38.3	104	19
Benzo(k)fluoranthene	25.2-145.7	32.3	84	22
Benzo(a)pyrene	31.7-148.0	39.0	93	17
Benzo(ghi)perylene	D-195	58.9	114	34
Benzoic Acid	N/A	N/A	76	59
Benzyl Butyl Phthalate	D-139.9	23.4	108	13.8
bis(2-chloroethoxy) methane	49.2-164.7	34.5	97	16
bis(2-chloroethyl) ether	42.9-126.0	55.0	90	14.9
bis(2-chloro-isopropyl) ether	62.8-138.6	46.3	86	8.3
bis(2-ethylhexyl) Phthalate	28.9-136.8	41.1	81	3.8
4-Bromophenyl-phenyl Ether	64.7-114.4	23.0	87	1.7
4-Chloroaniline	N/A	N/A	26	23
4-Chloro-3-methylphenol	40.8-127.9	37.2	98	4.4
2-Chloronaphthalene	64.5-113.5	13.0	97	24
2-Chlorophenol	36.2-120.4	28.7	102	11.4

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Table A11 contd. EVALUATION OF HIGH CONCENTRATION SEMI-VOLATILE QUALITY CONTROL STANDARD. Results from 3 samples and are in µg/L.

Analyte	Acceptance Criteria		Project Results	
	Range of Mean	S	Mean	S
4-Chlorophenyl-phenyl Ether	38.4-144.7	33.4	85	1.6
Chrysene	44.1-139.9	48.3	98	19
Dibenzo(a,h) anthracene	D-199.7	70.0	112	33
Dibenzofuran	N/A	N/A	103	30
1,2-Dichlorobenzene	48.6-112	30.9	65	11
1,3-Dichlorobenzene	16.7-153.9	41.7	61	10.6
1,4-Dichlorobenzene	37.3-105.7	32.1	67	2.0
3,3'-Dichlorobenzidine	8.2-212.5	71.4	33	24
2,4-Dichlorophenol	52.5-121.7	26.4	107	18
2,4-Dimethylphenol	41.8-109.0	26.1	86	1.5
Diethyl Phthalate	D-100	26.5	89	8.3
Dimethyl Phthalate	D-100.0	23.2	69	4.0
2,4-Dinitrophenol	D-172.9	49.8	121	2.3
2,4-Dinitrotoluene	47.5-126.9	21.8	119	21
2,6-Dinitrotoluene	68.1-136.7	29.6	110	22
Di-n-octyl Phthalate	18.6-131.8	31.4	107	12.2
Fluoranthene	42.9-121.3	32.8	117	22
Fluorene	71.6-108.4	20.7	93	14.4
2-Fluorobiphenyl (Surrogate)	N/A	N/A	22	6.9
2-Fluorophenol (Surrogate)	N/A	N/A	13.7	1.9
Hexachlorobenzene	7.8-141.5	24.9	109	28
Hexachlorobutadiene	37.8-102.2	26.3	65	21
Hexachlorocyclo-pentadiene	N/A	N/A	62	23

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Table A11 contd. EVALUATION OF HIGH CONCENTRATION SEMI-VOLATILE QUALITY CONTROL STANDARD. Results from 3 samples and are in µg/L.

Analyte	Acceptance Criteria		Project Results	
	Range of Mean	S	Mean	S
Hexachloroethane	55.2-100.0	24.5	56	10.9
Indeno(1,2,3-cd) pyrene	· D-150.9	44.6	108	30
Isophorone	46.6-180.2	63.3	93	12.9
2-Methyl-4,6-dinitrophenol	53.0-100.0	93.2	125	22
2-Methylnaphthalene	N/A	N/A	125	43
2-Methylphenol	N/A	N/A	84	11.0
4-Methylphenol	N/A	N/A	81	11.9
Naphthalene	35.6-119.6	30.1	90	26
2-Nitroaniline	N/A	N/A	142	46
3-Nitroaniline	N/A	N/A	98	65
4-Nitroaniline	N/A	N/A	142	43
Nitrobenzene	54.3-157.6	39.3	102	17
Nitrobenzene-d5 (Surrogate)	N/A	N/A	24	7.9
2-Nitrophenol	45.0-166.7	35.2	121	24
4-Nitrophenol	13.0-160.5	47.2	36	36
N-Nitrosodimethylamine	N/A	N/A	59	5.5
N-Nitrosodi-n-propylamine	13.6-197.9	55.4	90	14.5
N-Nitrosodiphenylamine	N/A	N/A	160	65
Pentachlorophenol	38.1-151.8	48.9	137	25
Phenanthrene	65.2-108.7	20.6	106	16
Phenol	16.6-100.0	22.6	55	6.5
Phenol-d6 (Surr)	N/A	N/A	10.4	1.12
Pyrene	69.6-100.0	25.2	96	12

Table A11 contd. EVALUATION OF HIGH CONCENTRATION SEMI-VOLATILE QUALITY CONTROL STANDARD. Results from 3 samples and are in μg/L.

Analyte	Acceptance Criteria		Project Results	
	Range of Mean	S	Mean	S
4-Terphenyl-d14(Sur)	N/A	N/A	25	7.5
2,4,6-Tribromophenol (Surrogate)	N/A	N/A	27	7.6
1,2,4-Trichlorobenzene	57.3-129.2	28.1	73	17
2,4,5-Trichlorophenol	N/A	N/A	100	20
2,4,6-Trichlorophenol	52.4-129.2	31.7	129	34

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Table A12. INTERLABORATORY SEMI-VOLATILE QUALITY CONTROL EVALUATION. Results are given in µg/L (PPB).

Analyte	Certified Laboratory			Project Results	
	D.L.	Conc.	% Recov	Conc.	% Recov
Acenaphthene	10	37	92	44	110
Acenaphthylene	10	35	88	44	110
Anthracene	10	32	80	29	73
Azobenzene	10	33	82	58	145
Benzidine	10	ND	<25	43	107
Benzo(a)anthracene	10	32	80	38	96
Benzo(b)fluoranthene	10	31	78	40	101
Benzo(k)fluoranthene	10	29	72	33	82
Benzo(a)pyrene	10	30	75	35	88
Benzo(ghi)perylene	10	28	70	37	92
Benzoic Acid	50	ND	<DL	ND	<DL
Benzyl Alcohol	10	37	92	42	106
Benzyl Butyl Phthalate	10	15	38	39	97
bis(2-chloroethoxy) methane	10	38	95	41	102
bis(2-chloroethyl) ether	10	40	100	43	108
bis(2-chloro-isopropyl) ether	10	36	90	36	89
bis(2-ethylhexyl) Phthalate	10	31	78	43	108
4-Bromophenyl-phenyl Ether	10	31	78	47	118
4-Chloroaniline	10	ND	<25	6.0	15
4-Chloro-3-methylphenol	10	41	102	36	89
2-Chloronaphthalene	10	34	85	48	120
2-Chlorophenol	10	37	92	43	108

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Table A12 contd. INTERLABORATORY SEMI-VOLATILE QUALITY CONTROL EVALUATION. Results are given in µg/L (PPB).

Analyte	Certified Laboratory			Project Results	
	D.L.	Conc	% Recov	Conc	% Recov
4-Chlorophenyl-phenyl Ether	10	ND	<25	4.7	12
Chrysene	10	32	80	40	99
Dibenzo(a,h) anthracene	10	30	75	37	92
Dibenzofuran	10	44	110	27	67
1,2-Dichlorobenzene	10	26	65	32	81
1,3-Dichlorobenzene	10	22	55	30	76
1,4-Dichlorobenzene	10	24	60	32	81
3,3'-Dichlorobenzidine	20	ND	<50	16	40
2,4-Dichlorophenol	10	36	90	41	103
2,4-Dimethylphenol	10	36	90	40	99
Diethyl Phthalate	10	ND	<25	37	92
Dimethyl Phthalate	10	ND	<25	34	85
2,4-Dinitrophenol	50	ND	<DL	29	71
Di-n-butyl Phthalate	10	18	45	49	122
2,4-Dinitrotoluene	10	28	70	48	121
2,6-Dinitrotoluene	10	39	98	39	97
Di-n-octyl Phthalate	10	26	65	37	92
Fluoranthene	10	32	80	58	145
Fluorene	10	38	95	42	106
Hexachlorobenzene	10	31	78	59	147
Hexachlorobutadiene	10	24	60	37	93
Hexachlorocyclo-pentadiene	10	ND	<25	23	57
Hexachloroethane	10	18	45	28	70
Indeno(1,2,3-cd) pyrene	10	25	62	38	94

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Table A12 contd. INTERLABORATORY SEMI-VOLATILE QUALITY CONTROL EVALUATION. Results are given in µg/L (PPB).

Analyte	Certified Laboratory			Project Results	
	D.L.	Conc.	% Recov	Conc.	% Recov
Isophorone	10	40	100	34	86
2-Methyl-4,6-dinitrophenol	50	ND	<DL	51	126
2-Methylnaphthalene	10	46	115	73	182
2-Methylphenol	10	35	88	32	80
4-Methylphenol	10	34	85	29	73
Naphthalene	10	36	90	50	126
2-Nitroaniline	50	ND	<DL	56	139
3-Nitroaniline	50	65	162	46	115
4-Nitroaniline	50	69	172	54	135
Nitrobenzene	10	41	102	46	115
2-Nitrophenol	10	34	85	49	121
4-Nitrophenol	50	66	165	ND	<DL
N-Nitrosodimethylamine	10	ND	<25	25	62
N-Nitrosodi-n-propylamine	10	40	100	103	260
N-Nitrosodiphenylamine	10	40	100	34	85
Pentachlorophenol	50	ND	<DL	63	159
Phenanthrene	10	34	85	50	124
Phenol	10	42	105	21	53
Pyrene	10	31	78	36	91
1,2,4-Trichlorobenzene	10	30	75	39	97
2,4,5-Trichlorophenol	50	ND	<DL	46	115
2,4,6-Trichlorophenol	10	38	95	69	173

A major emphasis of this study, was the estimation of bacterial numbers. All of the bacterial densities are expressed in terms of the most probable number per 100 ml of water. While some of the certified laboratory analyses actually used a membrane filtration method (primarily the enterococcus analyses), the distinction is irrelevant for the purposes of analyzing the results. Routine quality control followed the recommendations of the manufacturer Environetics (formerly Access Analytical), and included weekly culturing of Pseudomonas aeruginosa (a non coliform organism), the total coliform bacteria Klebsiella pneumoniae, and the primary fecal coliform microbe Escherichia coli.

During the project, 48 influent/effluent pairs were analyzed by both project staff and the contract laboratory for both total and fecal coliform organisms. The contract lab also analyzed their 48 pairs for fecal streptococcus as shown in table A13. Thus, 192 pair-wise comparisons can be made between the staff and contract laboratory analyses. Early in the study (see sample #173-175), the project QA officer became disturbed with discrepancies in the outcomes of these comparisons. Initially, the contract laboratory responded by adding additional blue ice to further chill the samples or by supplying more sturdy sample collection containers. However, these changes were generally short lived and even with frequent remainders from the QA officer, shortages occurred.

In order to define the source of these errors, EPA Microbiological Quality Control Samples were utilized. The Escherichia coli (lot series 121589), or fecal coliform, sample was diluted 1:99, then 7 sterile dilution bottles were inoculated with 1 ml from the first dilution bottle. Two of these seven were analyzed by each of the three staff members who performed the bulk of the bacterial analyses. The remaining seventh bottle was then poured into the whirl bag sample container and shipped to the certified laboratory marked as a spiked sample (300AS1). The analysis for total coliform was conducted using a Klebsiella pneumoniae quality control sample (lot series 060989) prepare in an identical fashion and marked as sample 300AS2. For both analyses the staff samples were all well within the 95% confidence interval for MMO-MUG type analyses. In the case of total coliforms, the staff mean was 490,000 organisms per 100 ml, compared to the EPA mean reported value of 510,000. The sample analyzed by the contract lab was reported to contain 2,400,000 organisms per 100 ml, and was outside of the 95% confidence interval. The results for fecal coliform were similar. The mean staff MPN was 320,000, with all enumeration in 95% confidence interval, while the EPA mean was 350,000 organisms per 100 ml. The certified laboratory analysis returned a value of 70,000 and was outside of the acceptance criteria confidence interval. It was also noted that after these results were reported back to the contract lab, the remaining analyses (sample numbers ≥310) more closely correlated with the results obtained by staff.

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Table A13. INTERLABORATORY BACTERIAL ANALYSES. Results are in terms of Most Probable Number (MPN) per 100 ml.

Sample Number	Total Coliform		Fecal Coliform		Enterococcus
	Santa Mon.	Cont. Lab	Santa Mon.	Cont. Lab	Cont. Lab
134A	350,000	700,000	35,000	70,000	49,000
134B	79	33	14	11	8
135A	1,300,300	460,000	92,000	79,000	110,000
135B	79	49	4	4	4
136A	240,000	490,000	92,000	49,000	130,000
136B	79	<2	27	23	5
149A	1,600,000	230,000	17,000	13,000	4,900
149B	4	<2	<2	6	13
150A	920,000	70,000	350,000	7,000	330,000
150B	130	1,100	8	14	33
151A	92,000	230,000	24,000	4,300	7,900
151B	33	310	2	4	8
164A	3,500,000	490,000	22,000	11,000	130,000
164B	1,400	13,000	4	49	230
165A	2,400,000	230,000	11,000	22,000	350,000
165B	3,300	7,900	4	22	110
166A	210,000	2,800,000	1,700	7,600	23,000
166B	16,000	13,000	<2	5	79
173A	1,700,000	46,000	54,000	7,900	79,000
173B	240	<2	4	<2	49
174A	220,000	79,000	54,000	11,000	49,000
174B	130	8	<2	2	33
175A	1,700,000	33,000	24,000	3,300	230,000
175B	110	8	4	<2	49
182A	350,000	330,000	17,000	9,500	130,000
182B	350	790	<2	2	31

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Table A13 contd. INTERLABORATORY BACTERIAL ANALYSES. Results are in terms of Most Probable Number (MPN) per 100 ml.

Sample Number	Total Coliform		Fecal Coliform		Entero-coccus
	Santa Mon.	Cont. Lab	Santa Mon.	Cont. Lab	Cont. Lab
183A	220,000	110,000	54,000	7,900	79,000
183B	79	110	<2	2	21
184A	220,000	230,000	2,300	7,900	79,000
184B	210	490	<2	5	7,000
200A	790,000	79,000	170,000	33,000	2,200
200B	350	26	17	2	33
201A	220,000	490,000	24,000	23,000	11,000
201B	130	79	4	<2	23
202A	220,000	790,000	2,700	49,000	49,000
202B	41	22	2	<2	79
212A	1,600,000	490,000	92,000	46,000	170,000
212B	460	4,900	27	33	79
213A	1,700,000	230,000	54,000	49,000	33,000
213B	240	1,300	4	22	33
214A	920,000	330,000	160,000	22,000	130,000
214B	540	490	2	5	84
224A	92,000	130,000	35,000	22,000	7,000
224B	2	<2	<2	<2	2
225A	700,000	490,000	22,000	2,200	3,300
225B	17	5	<2	<2	<2
226A	160,000	230,000	24,000	700	79,000
226B	17	8	<2	<2	2
239A	350,000	49,000	22,000	7,900	150,000
239B	34	70	<2	5	49
240A	350,000	79,000	35,000	13,000	64,000
240B	260	<2	330	49	20

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Table A13 contd. INTERLABORATORY BACTERIAL ANALYSES. Results are in terms of Most Probable Number (MPN) per 100 ml.

Sample Number	Total Coliform		Fecal Coliform		Entero-coccus
	Santa Mon.	Cont. Lab	Santa Mon.	Cont. Lab	Cont. Lab
241A	4,600,000	1,300,000	17,000	79,000	140,000
241B	120,000	110	79	4	33
248A	350,000	230,000	54,000	14,000	35,000
248B	34	220	<2	2	33
249A	40,000	330,000	24,000	17,000	23,000
249B	2	49	2	5	7
250A	220,000	79,000	17,000	4,900	4,900
250B	<2	13	<2	2	27
260A	95,000	130,000	24,000	7,000	79,000
260B	<2	5	<2	<2	8
261A	1,700,000	490,000	280,000	22,000	70,000
261B	33	14	<2	7	7
262A	1,600,000	1,100,000	17,000	49,000	170,000
262B	79	14	4	5	2
269A	35,000	33,000	24,000	3,300	7,900
269B	6	8	4	<2	<2
270A	92,000	79,000	22,000	22,000	17,000
270B	4	23	2	5	46
271A	920,000	490,000	39,000	22,000	11,000
271B	11	46	<2	2	49
283A	2,400,000	4,900,000	170,000	79,000	170,000
283B	17	23	<2	5	33
284A	9,200,000	7,900,000	2,200,000	130,000	79,000
284B	31	79	8	8	8
285A	14,000,000	9,500,000	2,400,000	790,000	790,000
285B	79	49	13	17	2

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Table A13 contd. INTERLABORATORY BACTERIAL ANALYSES. Results are in terms of Most Probable Number (MPN) per 100 ml.

Sample Number	Total Coliform		Fecal Coliform		Entero-coccus
	Santa Mon.	Cont. Lab	Santa Mon.	Cont. Lab	Cont. Lab
298A	240,000	220,000	11,000	17,000	49,000
298B	140	22	<2	<2	79
299A	140,000	49,000	17,000	7,900	49,000
299B	9,200	1,700	13	21	790
300AS1	320,000*	70,000	320,000*	70,000	<2
300AS2	490,000**	2,400,000	<2	<2	<2
310A	1,600,000	1,300,000	64,000	33,000	790,000
310B	11	33	<2	2	23
311A	540,000	490,000	110,000	33,000	490,000
311B	4	11	<2	<2	79
312A	540,000	790,000	35,000	79,000	1,700,000
312B	350	230	8	7	79
331A	4,600,000	17,000,000	110,000	49,000	220,000
331B	240	79	14	2	230
332A	3,500,000	11,000,000	110,000	33,000	790,000
332B	13	220	<2	2	330
333A	54,000,000	22,000,000	2,400,000	790,000	790,000
333B	11,000	790	240	330	1,700

* Sample 300AS1 is the mean of 540,000; 170,000; 240,000; 240,000; 540,000; & 170,000. EPA mean is 350,000; 95% CI 1,100,000-110,000.
** Sample 300AS2 is the mean of 920,000; 350,000; 170,000; 240,000; 1,100,000 & 170,000. EPA mean is 510,000; 95% CI 1,400,000-130,000.

In summary, all of the analyses in the Quality Assurance Plan were carefully evaluated to insure the quality of the results. Most of the analyses and analysts demonstrated their competence through the use of EPA Water Quality Control Samples. While any individual analysis maybe outside of the 95% confidence interval around the true value, there is no indication of any bias or significant inaccuracy. The data acquired by the project staff is of generally excellent quality and many of the primary conclusions of the study would not have been possible without the conscientious efforts of each analyst individually, and more importantly, as an analytical team.

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URBAN STORM DRAIN DRY-WEATHER FLOWS

A PILOT TREATMENT PLANT DEMONSTRATION PROJECT ON THE KENTER CANYON
STORM DRAIN SYSTEM IN SANTA MONICA

TECHNICAL AND DATA APPENDICES

APPENDIX B

DATA SUMMARY AND COMPARISON TO RELEVANT STANDARDS

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TABLE B1a-1. EVALUATION OF PILOT PLANT PROCESS PARAMETERS BEFORE AND AFTER OZONATION.

Pilot Plant Operating Process Parameter	units[1]	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Water Flow Rate	GPM	3.1	1.11	4.5	2.9	1.48	4.8	NA	NA	NA	NA	NA	NA
Gas Flow Rate	SCFH	12.9	3.4	17.	12.3	1.35	18.	NA	NA	NA	NA	NA	NA
Influent Ozone	Wt.%	2.7	1.09	4.1	2.4	1.7	4.7	NA	NA	NA	NA	NA	NA
Off-gas Ozone	Wt.%	NA	NA	NA	NA	NA	NA	.61	.53	1.29	.32	4.7	2.3
Absorbed Ozone	mg/L	NA	NA	NA	NA	NA	NA	13.0	4.9	19.	12.0	1.48	20.
Ozone Residual	mg/L	NA	NA	NA	NA	NA	NA	1.47	1.60	3.5	.31	16.	11.0

TABLE B1b-1. PILOT PLANT PROCESS PARAMETERS.

Physical Analysis or Analyte Name	Units[1]	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Water Flow Rate	GPM	NA	0.5	NA	1.0	8.0	438	NA	NA
Gas Flow Rate	SCFH	NA	2.0	NA	4.0	18.	438	NA	NA
Influent Ozone	Wt.%	NA	.005	NA	.34	5.1	387	NA	NA
Off-gas Ozone	Wt.%	NA	.005	NA	<MDL	2.2	387	NA	NA
Absorbed Ozone	mg/L	NA	NA	NA	3.6	38.	414	NA	NA
Ozone Residual	mg/L	NA	.005	NA	<MDL	7.8	430	NA	NA

[1]Units are Gallons Per Minute (GPM), Standard Cubic Feet per Hour (SCFH), Weight Percent (Wt.%), and mg/L (PPM).

TABLE B2a-1. EVALUATION OF PILOT PLANT PHYSICAL PARAMETERS BEFORE AND AFTER OZONATION.

Physical Analysis Name	units	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Temperature	°C	18.5	1.7	20.7	18.2	1.10	20.5	18.8	1.8	21.1	18.6	1.10	21.0
pH	units	8.1	.29	8.5	8.1	1.04	8.5	7.8	.32	8.2	7.8	1.04	8.2
Conductance	µmho/c	1310	2200	4100	1070	1.5	1900	1300	2100	4000	1070	1.5	1900
Turbidity	NTU	83	370	550	22	3.5	110	71	250	390	21	3.5	106
SettleableSolid	ml/L	.52	5.3	7.3	<LOQ	6.6	2.1	.52	5.0	6.9	<LOQ	6.6	2.2
SuspendedSolids	mg/L	103	500	740	22	4.0	129	97	440	660	19	4.2	122
DissolvedSolids	mg/L	870	1650	3000	690	1.6	1250	900	1700	3100	710	1.7	1500
Total Solids	mg/L	1010	1800	3300	780	1.7	1500	1010	1800	3300	780	1.7	1500

TABLE B2b-1. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYSES.

Physical Analysis Name	Units	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Temperature	°C	NA	-10	NA	14.0	24.4	430	NA	NA
pH	units	NA	NA	NA	7.1	9.6	401	6.0 - 9.0	6.5 - 8.5
Conductance	µmho/c	NA	NA	NA	470	36000	332	NA	1600
Turbidity	NTU	0.1	0.3	NA	2.3	5800	349	75	0.5
SettleableSolid	ml/L	NA	.20	NA	<LOQ	78	438	1.0	NA
SuspendedSolids	mg/L	1.2	4.0	NA	0.6	6540	434	60	NA
DissolvedSolids	mg/L	3.0	10.0	NA	190	30000	435	NA	NA
Total Solids	mg/L	3.0	10.0	NA	280	31000	435	NA	NA

TABLE B3a-1. EVALUATION OF BACTERIAL AND ORGANIC CARBON ANALYSES WITH OZONE TREATMENT.

Bacterial Group and Multiplier or Total Organic Carbon Analysis	units[1]	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Total Coli.$x10^6$	MPN	1.49	3.4	5.9	.520	4.5	3.6						
Total Coli.$x10^3$	MPN							7.6	4.4	13.2	.160	160	5.6
Fecal Coli.$x10^3$	MPN	160	670	1020	19	7.8	260	.520	4.2	5.9	.007	7.2	.088
Enterococc.$x10^3$	MPN	190	310	590	69	4.8	510	.250	1.04	1.6	.030	5.9	.290
Total Organic C	mg/L	19	16	40	15	1.9	35	19	15	38	16	1.8	34

TABLE B3b-1. BACTERIAL AND TOC QUALITY ASSURANCE PARAMETERS, AND STANDARDS, BEFORE AND AFTER OZONATION.

Bacterial Group and Multiplier or TOC Analysis	Units[1]	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Total Coli.$x10^3$	MPN	NA	2	<LOQ	<LOQ	54000	438	5.	One
Fecal Coli.$x10^3$	MPN	NA	2	<LOQ	<LOQ	7900	436	1.	None
Enterococc.$x10^3$	MPN	NA	2.	<LOQ	<LOQ	1700	47	0.12	None
Total Organic C	mg/L	.07	.20	<1.5	2.2	124	425	25 as Oil/G	NA

[1]Units are Most Probable Number of organisms per 100 ml of water (MPN) and mg/L (PPM).

TABLE B4a-1. EVALUATION OF METAL ANALYTES (METHOD 200.7) BEFORE AND AFTER OZONATION.

Chemical Analyte Name	units[1]	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Aluminum	µg/L	1230	4100	6500	390	2.8	1470	1370	4100	6600	380	3.2	1700
Arsenic	µg/L	23	56	95	10.2	3.8	61	25	58	100	13.1	3.2	63
Barium	µg/L	68	45	127	61	1.5	104	73	56	145	62	1.7	120
Beryllium	µg/L	.13	.41	.66	.090	1.29	.51	.16	.43	.71	.107	1.30	.19
Boron	µg/L	1170	1010	2500	870	2.1	2300	1120	830	2200	760	3.8	4200
Cadmium	µg/L	2.7	2.6	6.0	2.0	2.0	6.3	2.8	3.1	6.7	2.8	2.2	6.7
Calcium	mg/L	50	43	105	45	1.48	74	44	29	81	40	1.45	64

TABLE B4b-1. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Chemical Analyte Name	Units[1]	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Aluminum	µg/L	19	65	28	125	31000	156	NA	1000
Arsenic	µg/L	6.4	21	9.2	<MDL	730	193	33	50
Barium	µg/L	.20	.67	.75	25	400	193	NA	1000
Beryllium	µg/L	.06	.20	<.01	<MDL	3	193	NA	Prop. 1
Boron	µg/L	21	70	134	<MDL	6500	156	NA	NA
Cadmium	µg/L	1.1	3.7	1.00	<MDL	16	193	5	10
Calcium	mg/L	.005	.017	.018	20.4	540	193	NA	NA

[1] Concentrations are in gr/L (PPTh), mg/L (PPM), µg/L (PPB), ng/L (PPTr), and pg/L (PPQ).

TABLE B4a-2. EVALUATION OF METAL ANALYTES (METHOD 200.7) BEFORE AND AFTER OZONATION.

Chemical Analyte Name	units[1]	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Chromium	µg/L	14.4	70	104	3.5	4.0	20	21	95	144	2.2	4.7	22
Chromium (+6)	µg/L	31	107	170	12.9	2.6	43	29	102	160	11.7	2.6	41
Cobalt	µg/L	10.2	10.0	23	7.1	2.3	23	11.2	10.8	25	8.1	2.2	24
Copper	µg/L	34	22	62	29	1.7	59	38	24	68	32	1.7	66
Iron	µg/L	1490	5100	8000	470	3.0	1900	2100	5900	9600	600	3.3	2800
Lead	µg/L	59	82	164	33	3.2	148	89	127	250	42	3.8	240
Lithium	µg/L	28	11.5	43	27	1.45	42	28	11.4	42	26	1.5	45

TABLE B4b-2. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Chemical Analyte Name	Units[1]	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Chromium	µg/L	.98	3.3	1.6	<MDL	700	193	10	50
Chromium (+6)	µg/L	6.0	20	4.0	<MDL	1020	95	10	50
Cobalt	µg/L	2.6	8.7	3.2	<MDL	92	193	NA	NA
Copper	µg/L	1.3	4.3	2.0	7.0	136	193	8	1000
Iron	µg/L	.75	2.5	14.0	60	40000	193	NA	300
Lead	µg/L	4.9	16	6.4	<MDL	740	193	10	15 as Ave.
Lithium	µg/L	.10	.33	1.8	10	72	193	NA	NA

[1]Concentrations are in gr/L (PPTh), mg/L (PPM), µg/L (PPB), ng/L (PPTr), and pg/L (PPQ).

TABLE B4a-3. EVALUATION OF METAL ANALYTES (METHOD 200.7) BEFORE AND AFTER OZONATION.

Chemical Analyte Name	units[1]	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Magnesium	mg/L	14.5	4.5	20	14.1	1.32	20	14.0	5.3	21	13.2	1.48	22
Manganese	µg/L	45	74	139	27	2.4	84	43	81	146	21	2.8	81
Molybdenum	µg/L	79	84	190	34	4.8	260	35	49	97	13.8	4.5	100
Nickel	µg/L	6.3	7.6	16	3.6	2.8	16	6.4	7.8	16	3.6	2.8	16
Phosphorus	µg/L	1900	1240	3500	1500	2.1	4000	2000	1400	3700	1600	1.78	3500
Potassium	mg/L	11.9	5.8	19	10.7	1.7	22	11.4	5.0	18	10.2	1.7	20
Selenium	µg/L	7.8	13.6	25	2.2	4.0	18	6.7	17	29	1.3	3.9	12.4

TABLE B4b-3. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Chemical Analyte Name	Units[1]	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Magnesium	µg/L	0.4	1.3	2.1	940	41000	193	NA	NA
Manganese	µg/L	.013	.043	.13	<MDL	535	193	NA	NA
Molybdenum	µg/L	2.4	8.0	4.9	<MDL	380	193	NA	50
Nickel	µg/L	1.5	5.0	1.25	<MDL	47	193	NA	NA
Phosphorus	µg/L	51	170	69	<MDL	9900	193	25	Prop. 100
Potassium	mg/L	.131	.440	.490	.62	55	193	NA	NA
Selenium	µg/L	5.0	16.7	7.8	<MDL	112	193	75	10

[1]Concentrations are in gr/L (PPTh), mg/L (PPM), µg/L (PPB), ng/L (PPTr), and pg/L (PPQ).

TABLE B4a-4. EVALUATION OF METAL ANALYTES (METHOD 200.7) BEFORE AND AFTER OZONATION.

Chemical Analyte Name	units	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Silicon	mg/L	11.8	2.3	14.8	11.5	1.29	16	10.9	2.4	13.9	10.5	1.45	17
Silver	µg/L	0.6	1.6	2.6	.29	1.7	1.6	.51	1.25	2.1	.29	1.7	1.47
Sodium	mg/L	144	78	240	132	1.50	220	126	82	230	102	2.8	390
Strontium	µg/L	350	260	690	320	1.48	520	330	320	740	290	1.5	490
Tin	µg/L	58	74	150		6.9		74	65	160	59	1.9	133
Titanium	µg/L	24	66	108	8.3	3.1	39	28	83	135	6.4	3.9	42
Vanadium	µg/L	11.4	12.0	27	9.2	1.7	19	12.2	13.5	30	9.2	1.9	22
Zinc	µg/L	86	93	200	61	2.1	160	100	80	200	82	1.8	170

TABLE B4b-4. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Chemical Analyte Name	Units	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Silicon	µg/L	6.9	23	5.9	940	22000	193	NA	NA
Silver	µg/L	.14	.47	1.9	<MDL	14	193	3.4	50
Sodium	mg/L	.029	.097	.103	59	28000	193	NA	NA
Strontium	µg/L	.14	.47	.38	142	2600	193	NA	NA
Tin	µg/L	7.0	23	11.0	<MDL	576	193	NA	NA
Titanium	µg/L	.32	1.07	.88	<MDL	590	193	NA	NA
Vanadium	µg/L	.95	3.2	1.6	<MDL	101	193	NA	NA
Zinc	µg/L	.47	1.6	2.9	13	700	193	80	5000

TABLE B5a-1. EVALUATION OF PESTICIDES (METHOD 608) ANALYTES BEFORE AND AFTER OZONATION.

Pesticide or Chemical Analyte Name	units are ng/L or PPTr	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Aldrin	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
α-BHC (α-HCH)	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
β-BHC (β-HCH)	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
δ-BHC (δ-HCH)	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Γ-HCH (Lindane)	ng/L	.94	5.1	7.5	.122	1.86	1.49	.64	4.2	6.0	.072	1.7	1.05
Chlordane	ng/L	133	670	990	.86	7.2	23	59	234	360	.78	6.2	17
4,4'-DDD	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
4,4'-DDE	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND

TABLE B5b-1. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Pesticide or Chemical Analyte Name	ng/L or PPTr	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Aldrin	ng/L	NA	20	ND	ND	ND	86	0.11	NA
α-BHC (α-HCH)	ng/L	NA	20	ND	ND	ND	86	Σ HCHs 20	NA
β-BHC (β-HCH)	ng/L	NA	20	ND	ND	ND	86	Σ HCHs 20	NA
δ-BHC (δ-HCH)	ng/L	NA	20	ND	ND	ND	86	Σ HCHs 20	NA
Γ-HCH (Lindane)	ng/L	NA	20	ND	ND	34	86	Σ HCHs 20	4000
Chlordane(tech)	ng/L	NA	200	ND	ND	5700	86	ΣChlor0.115	NA
4,4'-DDD	ng/L	NA	20	ND	ND	ND	86	Σ DDTs 0.85	NA
4,4'-DDE	ng/L	NA	20	ND	ND	ND	86	Σ DDTs 0.85	NA

TABLE B5a-2. EVALUATION OF PESTICIDES (METHOD 608) ANALYTES BEFORE AND AFTER OZONATION.

Pesticide or Chemical Analyte Name	units are ng/L or PPTr	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
4,4'-DDT	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Dieldrin	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Endosulfan I	ng/L	.35	3.2	4.5	.040	1.45	.67	.26	2.4	3.3	.037	1.40	.60
Endosulfan II	ng/L	<LOQ	NA	<LOQ	<LOQ	NA	<LOQ	<LOQ	NA	<LOQ	<LOQ	NA	<LOQ
Endosu. Sulfate	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Endrin	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Endrin Aldehyde	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Heptachlor	ng/L	2.2	11.3	17	.19	2.2	2.3	1.33	7.4	10.8	.134	1.9	1.7

TABLE B5b-2. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Pesticide or Chemical Analyte Name	ng/L or PPTr	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
4,4'-DDT	ng/L	NA	20	ND	ND	ND	86	Σ DDTs 0.85	NA
Dieldrin	ng/L	NA	20	ND	ND	ND	86	0.2	NA
Endosulfan I	ng/L	NA	20	ND	ND	30	86	ΣEndo.s 45	NA
Endosulfan II	ng/L	NA	20	ND	ND	<LOQ	86	ΣEndo.s 45	NA
Endosu. Sulfate	ng/L	NA	20	ND	ND	ND	86	ΣEndo.s 45	NA
Endrin	ng/L	NA	20	ND	ND	ND	86	10	200
Endrin Aldehyde	ng/L	NA	20	ND	ND	ND	86	NA	NA
Heptachlor	ng/L	NA	20	ND	ND	90	86	ΣHept.s 3.6	NA

TABLE B5a-3. EVALUATION OF PESTICIDES (METHOD 608) ANALYTES BEFORE AND AFTER OZONATION.

Pesticide or Chemical Analyte Name	units are ng /L or PPTr	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Heptac. Epoxide	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Methoxychlor	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Mirex	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Toxaphene	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
PCB-1016,1221	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
PCB-1232,1242	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
PCB-1248	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
PCB-1254,1260	ng/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND

TABLE B5b-3. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Pesticide or Chemical Analyte Name	ng/L or PPTr	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Heptac. Epoxide	ng/L	NA	20	ND	ND	ND	86	ΣHept.s 3.6	NA
Methoxychlor	ng/L	NA	20	ND	ND	ND	86	NA	NA
Mirex	ng/L	NA	20	ND	ND	ND	86	NA	NA
Toxaphene	ng/L	NA	1000	ND	ND	ND	86	1.05	5000
PCB-1016,1221	ng/L	NA	300	ND	ND	ND	86	Σ PCBs0.095	NA
PCB-1232,1242	ng/L	NA	300	ND	ND	ND	86	Σ PCBs0.095	NA
PCB-1248	ng/L	NA	300	ND	ND	ND	86	Σ PCBs0.095	NA
PCB-1254,1260	ng/L	NA	300	ND	ND	ND	86	Σ PCBs0.095	NA

TABLE B6a-1. EVALUATION OF VOLATILE ORGANIC ANALYTES (METHOD 624) WITH OZONATION.

Volatile Organic Cmpds. Analyte or Chemical Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Benzene	µg/L	.051	.034	.095	.050	1.03	.094	.040	.038	.089	.040	1.04	.087
Bromodichloro-methane	µg/L	.049	.063	.126	.047	1.06	.127	.068	.107	.21	.064	1.09	.190
Bromoform	µg/L	.19	.34	.63	.16	1.22	.51	.25	.44	.81	.21	1.27	.64
Bromomethane	µg/L	.085	.16	.30	.076	1.13	.26	.18	.20	.44	.17	1.17	.42
Butanone	µg/L	1.14	.96	2.4	.96	1.5	2.4	4.4	3.8	9.2	3.0	2.4	11.1
Carbon Disulfide	µg/L	.22	.25	.55	.20	1.18	.49	.17	.18	.40	.16	1.14	.37

TABLE B6b-1. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Volatile Organic Cmpd. Chemical Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Benzene	µg/L	.030	.100	.019	<LOQ	.143	20	29.5	1
Bromodichloro-methane	µg/L	.070	.20	ND	<MDL	.25	20	Σ HMETH 13	Σ THMs 100
Bromoform	µg/L	.100	.300	2.0	<MDL	1.6	20	Σ HMETH 13	Σ THMs 100
Bromomethane	µg/L	.080	.25	.011	<MDL	.73	20	Σ HMETH 13	NA
Butanone	µg/L	.120	.35	.092	.145	3.7	20	NA	NA
Carbon Disulfide	µg/L	.060	.20	.144	.047	1.18	20	NA	NA

TABLE B6a-2. EVALUATION OF VOLATILE ORGANIC ANALYTES (METHOD 624) WITH OZONATION.

Volatile Organic Cmpds. Analyte or Chemical Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Carbon Tetrachloride	µg/L	.001	.004	.006	.001	.002	.003	ND	ND	ND	ND	ND	ND
Chlorobenzene	µg/L	.004	.007	.013	.004	1.01	.012	.002	.003	.006	.002	1.00	.006
Chloroethane	µg/L	ND	.002	.003	ND	1.00	.001	.012	.031	.052	.012	1.03	.051
2-Chloroethyl-vinyl Ether	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	µg/L	.107	.072	.20	.104	1.07	.20	.105	.063	.19	.104	1.06	.19
Chloromethane	µg/L	.30	.36	.75	.26	1.26	.69	.29	.32	.70	.26	1.21	.32

TABLE B6b-2. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Volatile Organic Cmpd. Chemical Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Carbon Tetrachloride	µg/L	.08	.25	.001	<MDL	<MDL	20	4.5	0.5
Chlorobenzene	µg/L	.03	.30	.001	<MDL	<MDL	20	2850	30
Chloroethane	µg/L	.09	.30	ND	<MDL	<MDL	20	NA	NA
2-Chloroethyl-vinyl ether	µg/L	0.6	2.0	ND	<MDL	<MDL	20	NA	NA
Chloroform	µg/L	.045	.15	.018	<MDL	.25	20	650	Σ THMs 100
Chloromethane	µg/L	.06	.21	.110	<LOQ	1.21	20	Σ HMETH 13	NA

TABLE B6a-3. EVALUATION OF VOLATILE ORGANIC ANALYTES (METHOD 624) WITH OZONATION.

Volatile Organic Cmpds. Analyte or Chemical Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Dibromochloro-methane	µg/L	.24	.67	1.09	.16	2.3	.71	.17	.34	.61	.138	1.23	.48
1,1-Dichloro-ethane	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloro-ethane	µg/L	.028	.038	.077	.028	1.04	.078	.020	.035	.065	.019	1.04	.065
1,1-Dichloro-ethene	µg/L	.002	.005	.008	.002	1.00	.009	ND	.001	.001	ND	ND	ND
trans 1,2-Dichloroethene	µg/L	ND	.001	.002	ND	1.00	.002	ND	ND	ND	ND	ND	ND

TABLE B6b-3. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Volatile Organic Cmpd. Chemical Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Dibromochloro-methane	µg/L	.08	.25	.004	<MDL	3.0	20	Σ HMETH 13	Σ THMs 100
1,1-Dichloro-ethane	µg/L	.08	.25	ND	<MDL	<MDL	20	NA	NA
1,2-Dichloro-ethane	µg/L	.08	.25	.021	<MDL	<LOQ	20	650	0.5
1,1-Dichloro-ethene	µg/L	.08	.25	ND	<MDL	<MDL	20	36000	6.0
trans 1,2-Dichloroethene	µg/L	.08	.25	.001	<MDL	<MDL	20	NA	NA

TABLE B6a-4. EVALUATION OF VOLATILE ORGANIC ANALYTES (METHOD 624) WITH OZONATION.

Volatile Organic Cmpds. Analyte or Chemical Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Dichloromethane	µg/L	1.44	3.9	6.5	.73	1.8	2.8	.59	.43	1.14	.55	1.27	1.11
1,2-Dichloro-propane	µg/L	.001	.003	.005	.001	1.00	.004	.001	.002	.003	ND	1.00	.002
cis 1,3-Dichloropropene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans 1,3-Dichloropropene	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	µg/L	.24	1.00	1.5	.102	1.46	.79	.146	.59	.90	.081	1.34	.57
2-Hexanone	µg/L	.039	.18	.26	.030	1.14	.22	.63	1.17	2.1	.42	1.6	1.6

TABLE B6b-4. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Volatile Organic Cmpd. Chemical Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Dichloromethane	µg/L	.08	.25	4.6	<MDL	18	20	2200	Proposed 5
1,2-Dichloro-propane	µg/L	.004	.015	ND	<MDL	.011	20	NA	NA
cis 1,3-Dichloropropene	µg/L	.045	.15	ND	<MDL	<MDL	20	44	0.50
trans 1,3-Dichloropropene	µg/L	.08	.25	ND	<MDL	<MDL	20	44	0.50
Ethyl Benzene	µg/L	.015	.05	.006	<MDL	4.5	20	20500	680
2-Hexanone	µg/L	.09	.30	ND	<MDL	.79	20	NA	NA

TABLE B6a-5. EVALUATION OF VOLATILE ORGANIC ANALYTES (METHOD 624) WITH OZONATION.

Volatile Organic Cmpds. Analyte or Chemical Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
4-Methyl-2-Pentanone	µg/L	.64	.96	1.9	.47	1.6	1.6	1.6	1.47	3.5	1.31	1.7	3.5
Styrene	µg/L	.087	.15	.28	.079	1.14	.27	.17	.34	.61	.135	1.26	.52
1,1,2,2-Tetrachloroethane	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Tetrachloroethene	µg/L	.026	.034	.070	.026	1.03	.069	.018	.018	.041	.019	1.02	.040
Toluene	µg/L	.31	.35	.76	.27	1.28	.75	.30	.38	.79	.26	1.30	.76
1,1,1-Trichloroethane	µg/L	.036	.038	.085	.035	1.04	.085	.029	.034	.073	.028	1.03	.071

TABLE B6b-5. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Volatile Organic Cmpd. Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
4-Methyl-2-Pentanone	µg/L	.08	.25	.002	<MDL	3.2	20	NA	NA
Styrene	µg/L	.017	.050	.050	<MDL	.43	20	NA	NA
1,1,2,2-Tetrachloroethane	µg/L	.06	.20	ND	<MDL	<MDL	20	6000	1
Tetrachloroethene	µg/L	.05	.15	.007	<MDL	.122	20	500	5
Toluene	µg/L	.017	.05	.25	<MDL	1.09	20	420000	NA
1,1,1-Trichloroethane	µg/L	.005	.015	.020	<MDL	.138	20	2700000	200

TABLE B6a-6. EVALUATION OF VOLATILE ORGANIC ANALYTES (METHOD 624) WITH OZONATION.

Volatile Organic Cmpds. Analyte or Chemical Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
1,1,2-Trichloroethane	µg/L	.006	.025	.038	.005	1.02	.035	.006	.028	.041	.007	1.03	.043
Trichloroethene	µg/L	.006	.011	.020	.007	1.01	.022	.005	.006	.013	.005	1.01	.013
Trichlorofluoromethane	µg/L	.061	.046	.120	.060	1.04	.120	.052	.027	.087	.052	1.03	.087
Vinyl Acetate	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Vinyl Chloride	µg/L	.005	.023	.034	.005	1.02	.033	.001	.005	.007	.001	1.01	.008
ortho-Xylene	µg/L	2.4	10.6	16.	.28	2.4	2.8	2.9	12.7	19.	.27	2.5	4.1

TABLE B6b-6. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Volatile Organic Cmpd. Chemical Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
1,1,2-Trichloroethane	µg/L	.08	.25	ND	<MDL	<LOQ	20	220000	Proposed 5
Trichloroethene	µg/L	.05	.15	ND	<MDL	<MDL	20	135	5
Trichlorofluoromethane	µg/L	.11	.35	.105	<MDL	<LOQ	20	NA	NA
Vinyl Acetate	µg/L	.09	.30	ND	<MDL	<MDL	20	NA	NA
Vinyl Chloride	µg/L	.06	.20	ND	<MDL	<LOQ	20	18	NA
ortho-Xylene	µg/L	.015	.05	.010	<MDL	147.	20	NA	1750

TABLE B7a-1. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Acenaphthene	µg/L	.22	.99	1.49	.089	1.45	.58	.20	.80	1.23	.096	1.41	.70
Acenaphthylene	µg/L	.005	.012	.021	.005	1.01	.021	.015	.051	.080	.014	1.05	.076
Aniline	µg/L	ND	.001	.002	ND	1.00	.002	ND	ND	ND	ND	ND	ND
Anthracene	µg/L	.034	.052	.101	.033	1.05	.097	.112	.34	.55	.082	1.23	.41
Azobenzene	µg/L	ND	ND	ND	ND	ND	ND	.013	.050	.077	.012	1.05	.072
Benzidine	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	µg/L	.063	.18	.29	.052	1.15	.26	.072	.17	.29	.061	1.15	.27

TABLE B7b-1. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Acenaphthene	µg/L	.096	.32	ND	<MDL	4.6	21	NA	NA
Acenaphthylene	µg/L	.084	.28	ND	<MDL	.23	21	Σ PAHs .044	NA
Aniline	µg/L	1.05	3.5	ND	<MDL	<MDL	21	NA	NA
Anthracene	µg/L	.105	.35	.008	<MDL	<LOQ	21	Σ PAHs .044	NA
Azobenzene	µg/L	.096	.32	ND	<MDL	<LOQ	21	NA	NA
Benzidine	µg/L	39	129	ND	<MDL	<MDL	21	0.34	NA
Benzo(a)anthracene	µg/L	.093	.31	.043	<MDL	.73	21	Σ PAHs .044	Proposed 0.1

TABLE B7a-2. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Benzo(b)fluor-anthene	µg/L	.19	.26	.52	.17	1.20	.48	.18	.27	.52	.16	1.20	.47
Benzo(k)fluor-anthene	µg/L	.132	.20	.39	.118	1.16	.36	.133	.22	.41	.118	1.18	.37
Benzo(a)pyrene	µg/L	.15	.23	.44	.137	1.18	.41	.130	.24	.44	.112	1.18	.38
Benzo(g,h,i)-perylene	µg/L	.22	.49	.85	.17	1.33	.68	.16	.39	.66	.123	1.27	.52
Benzyl Alcohol	µg/L	.42	.80	1.44	.29	1.5	1.19	.49	.78	1.49	.36	1.5	1.29
bis(2-chloro-ethoxy) methane	µg/L	.002	.007	.010	.002	1.01	.011	.019	.064	.101	.017	1.06	.094

TABLE B7b-2. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Benzo(b)fluor-anthene	µg/L	.16	.55	.040	<MDL	1.17	21	Σ PAHs .044	Proposed 0.2
Benzo(k)fluor-anthene	µg/L	.17	.58	.068	<MDL	.90	21	Σ PAHs .044	Proposed 0.2
Benzo(a)pyrene	µg/L	.110	.36	.027	<MDL	1.06	21	Σ PAHs .044	Prop. 0.2
Benzo(g,h,i)-perylene	µg/L	.22	.74	ND	<MDL	2.2	21	Σ PAHs .044	NA
Benzyl Alcohol	µg/L	.73	2.4	ND	<MDL	3.2	21	NA	NA
bis(2-chloro-ethoxy) methane	µg/L	.39	1.31	ND	<MDL	.28	21	220	NA

TABLE B7a-3. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
bis(2-chloro-ethyl) ether	µg/L	ND	.002	.003	ND	1.00	.003	ND	ND	ND	ND	ND	ND
bis(2-ethylhex-yl) phthalate	µg/L	11.7	19.	35.	7.1	2.5	25.	12.8	26.	46.	6.5	2.7	26
bis(2-chloro-isopropyl)ether	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
4-Bromophenyl phenyl ether	µg/L	ND	NA	ND	ND	NA	ND	.070	.23	.37	.053	1.18	.31
Butyl benzyl phthalate	µg/L	1.00	1.00	2.3	.82	1.5	2.1	1.16	1.39	2.9	.88	1.6	2.6

TABLE B7b-2. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
bis(2-chloro-ethyl) ether	µg/L	.21	.69	ND	<MDL	<MDL	21	0.22	NA
bis(2-ethylhex-yl) phthalate	µg/L	.071	.24	.37	<MDL	122	21	17.5	Proposed 4
bis(2-chloro-isopropyl)ether	µg/L	.124	.41	ND	<MDL	<MDL	21	6000	NA
4-Bromophenyl phenyl ether	µg/L	.93	3.1	ND	<MDL	<LOQ	21	NA	NA
Butyl benzyl phthalate	µg/L	.18	.60	.037	<MDL	5.6	21	NA	NA

TABLE B7a-4. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
4-Chloroaniline	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
2-Chloronaph-thalene	µg/L	.055	.17	.27	.045	1.14	.24	.009	.024	.040	.009	1.02	.039
4-Chlorophenyl phenyl ether	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Chrysene	µg/L	.148	.18	.38	.137	1.15	.37	.141	.15	.34	.131	1.14	.34
Dibenzo(a,h)-anthracene	µg/L	.19	.41	.71	.146	1.28	.58	.16	.41	.68	.119	1.28	.53
Dibenzofuran	µg/L	.18	.76	1.16	.086	1.39	.65	.16	.59	.92	.093	1.34	.59

TABLE B7b-4. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
4-Chloroaniline	µg/L	.76	2.6	ND	<MDL	<MDL	21	NA	NA
2-Chloronaph-thalene	µg/L	.19	.63	ND	<MDL	.69	21	NA	NA
4-Chlorophenyl phenyl ether	µg/L	.42	1.39	ND	<MDL	ND	21	NA	NA
Chrysene	µg/L	.103	.34	.042	<MDL	.71	21	Σ PAHs .044	Prop. 0.2
Dibenzo(a,h)-anthracene	µg/L	.24	.79	ND	<MDL	1.8	21	Σ PAHs .044	Proposed 0.3
Dibenzofuran	µg/L	.086	.29	ND	<MDL	3.5	21	NA	NA

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TABLE B7a-5. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
1,2-Dichloro-benzene	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
1,3-Dichloro-benzene	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
1,4-Dichloro-benzene	µg/L	.001	.004	.006	.001	1.00	.006	ND	NA	ND	ND	NA	ND
3,3'-Dichloro-benzidine	µg/L	.028	.130	.19	.023	1.11	.17	.010	.045	.067	.009	1.04	.063
Diethyl phthalate	µg/L	1.8	6.0	9.5	.61	2.1	3.1	1.6	5.7	8.9	.50	2.0	2.7

TABLE B7b-5. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
1,2-Dichloro-benzene	µg/L	.120	.40	ND	<MDL	<MDL	21	Σ DCBs 25500	NA
1,3-Dichloro-benzene	µg/L	.127	.42	ND	<MDL	<MDL	21	Σ DCBs 25500	NA
1,4-Dichloro-benzene	µg/L	.123	.42	ND	<MDL	<MDL	21	ΣDCBs25500 or 900	5.0
3,3'-Dichloro-benzidine	µg/L	1.00	3.3	ND	<MDL	<MDL	21	45	NA
Diethyl phthalate	µg/L	.090	.299	.054	<MDL	28	21	165000	NA

TABLE B7a-6. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Dimethyl phthalate	µg/L	.040	.127	.20	.35	1.11	.18	.077	.20	.34	.063	1.17	.30
Di-n-butyl phthalate	µg/L	1.35	.54	2.0	1.29	1.26	2.1	2.2	2.0	4.8	1.8	1.7	4.4
2,4-Dinitro-toluene	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
2,6-Dinitro-toluene	µg/L	ND	NA	ND	ND	NA	ND	.004	.019	.028	.004	1.02	.028
Di-n-octyl phthalate	µg/L	.73	.62	1.5	.64	1.38	1.47	.75	.67	1.6	.66	1.39	1.5

TABLE B7b-6. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Dimethyl phthalate	µg/L	.096	.32	ND	<MDL	.71	21	4100000	NA
Di-n-butyl phthalate	µg/L	.090	.30	1.5	.44	6.9	21	17500	NA
2,4-Dinitro-toluene	µg/L	.87	2.9	ND	<MDL	<MDL	21	13	NA
2,6-Dinitro-toluene	µg/L	.88	2.9	ND	<MDL	<MDL	21	NA	NA
Di-n-octyl phthalate	µg/L	.097	.32	.036	.087	2.3	21	NA	NA

TABLE B7a-7. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Fluoranthene	µg/L	.16	.17	.37	.150	1.14	.36	.117	.123	.27	.111	1.11	.27
Fluorene	µg/L	.017	.033	.059	.016	1.03	.058	.031	.067	.117	.029	1.06	.111
Hexachloro-benzene	µg/L	ND	NA	ND	ND	NA	ND	.014	.063	.095	.013	1.06	.087
Hexachloro-butadiene	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Hexachlorocyclo-pentadiene	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
Hexachloro-ethane	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND

TABLE B7b-7. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Fluoranthene	µg/L	.092	.30	.020	<MDL	.59	21	75	NA
Fluorene	µg/L	.093	.31	ND	<MDL	.35	21	Σ PAHs .044	NA
Hexachloro-benzene	µg/L	.90	3.0	ND	<MDL	<MDL	21	.00105	Proposed 1
Hexachloro-butadiene	µg/L	.95	3.2	ND	<MDL	<MDL	21	70	NA
Hexachlorocyclo-pentadiene	µg/L	2.0	6.5	ND	<MDL	<MDL	21	290	Proposed 50
Hexachloro-ethane	µg/L	.20	.67	ND	<MDL	<MDL	21	12.5	NA

TABLE B7a-8. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Indeno(1,2,3,4-cd)pyrene	µg/L	.18	.42	.72	.139	1.28	.57	.146	.36	.60	.112	1.25	.48
Isophorone	µg/L	.021	.034	.065	.020	1.03	.064	.007	.020	.032	.007	1.02	.031
2-Methyl-naphthalene	µg/L	.33	1.40	2.1	.120	1.5	.96	.21	.84	1.29	.105	1.42	.73
Naphthalene	µg/L	.112	.26	1.8	.092	1.19	.37	.15	.53	.83	.095	1.31	.55
2-Nitroaniline	µg/L	.027	.125	.19	.022	1.10	.064	.002	.011	.016	.002	1.01	.016
3-Nitroaniline	µg/L	ND	NA	ND	ND	NA	ND	.004	.018	.027	.004	1.02	.027
4-Nitroaniline	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND

TABLE B7b-8. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Indeno(1,2,3,4-cd)pyrene	µg/L	.88	2.9	ND	<MDL	<MDL	21	NA	Proposed 0.4
Isophorone	µg/L	.148	.49	ND	<MDL	<MDL	21	750	NA
2-Methyl-naphthalene	µg/L	.19	.62	ND	<MDL	6.4	21	NA	NA
Naphthalene	µg/L	.102	.34	.011	<MDL	2.3	21	NA	NA
2-Nitroaniline	µg/L	.93	3.1	ND	<MDL	<MDL	21	NA	NA
3-Nitroaniline	µg/L	.71	2.4	ND	<MDL	<MDL	21	NA	NA
4-Nitroaniline	µg/L	.99	3.3	ND	<MDL	<MDL	21	NA	NA

TABLE B7a-9. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Nitrobenzene	µg/L	.070	.26	.41	.051	1.19	.31	.107	.16	.32	.097	1.14	.29
N-Nitrosodi-methylamine	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
N-Nitrosodi-n-propylamine	µg/L	.004	.020	.029	.004	1.02	.029	ND	NA	ND	ND	NA	ND
N-Nitrosodi-phenylamine	µg/L	.030	.092	.147	.027	1.08	.135	.038	.110	.18	.033	1.09	.16
Phenanthrene	µg/L	.29	.93	1.48	.17	1.43	.84	.070	.076	.17	.068	1.07	.16
Pyrene	µg/L	.31	.28	.67	.28	1.21	.63	.15	.138	.33	.145	1.12	.33

TABLE B7b-9. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Nitrobenzene	µg/L	.80	2.7	ND	<MDL	<LOQ	21	24	NA
N-Nitrosodi-methylamine	µg/L	.74	2.5	.18	<MDL	<MDL	21	36	NA
N-Nitrosodi-n-propylamine	µg/L	.40	1.32	ND	<MDL	<MDL	21	NA	NA
N-Nitrosodi-phenylamine	µg/L	.124	.41	ND	<MDL	.49	21	12.5	NA
Phenanthrene	µg/L	.096	.32	.010	<MDL	4.3	21	Σ PAHs .044	NA
Pyrene	µg/L	.103	.34	.021	<MDL	1.18	21	Σ PAHs .044	NA

TABLE B7a-10. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
1,2,4-Tri-chlorobenzene	µg/L	ND	NA	ND	ND	NA	ND	.003	.012	.019	.003	1.01	.019
Benzoic acid	µg/L	3.2	2.4	6.2	2.5	2.0	7.2	3.9	2.9	7.6	3.2	1.7	7.6
4-Chloro-3-methylphenol	µg/L	.019	.080	.123	.017	1.07	.110	ND	NA	ND	ND	NA	ND
2-Chlorophenol	µg/L	.012	.028	.048	.012	1.03	.047	.010	.032	.050	.009	1.03	.049
2,4-Dichloro-phenol	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND

TABLE B7b-10. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks $\bar{X}$	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
1,2,4-Tri-chlorobenzene	µg/L	.21	.69	ND	<MDL	<MDL	21	NA	NA
Benzoic acid	µg/L	2.4	8.0	.36	<MDL	12.9	21	NA	NA
4-Chloro-3-methylphenol	µg/L	.41	1.37	ND	<MDL	<MDL	21	Σ ClPhenols 5	NA
2-Chlorophenol	µg/L	.40	1.33	ND	<MDL	.134	21	Σ ClPhenols 5	NA
2,4-Dichloro-phenol	µg/L	.73	2.4	ND	<MDL	<MDL	21	Σ ClPhenols 5	NA

TABLE B7a-11. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
2,4-Dimethyl-phenol	µg/L	.136	.45	.72	.090	1.29	.51	.018	.066	.103	.016	1.06	.095
2,4-Dinitro-phenol	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
2-Methyl-4,6-dinitrophenol	µg/L	.047	.15	.24	.038	1.13	.21	ND	NA	ND	ND	NA	ND
2-Methylphenol	µg/L	.068	.26	.40	.049	1.19	.31	.018	.031	.058	.018	1.03	.058
4-Methylphenol	µg/L	.24	.62	1.03	.15	1.41	.79	.109	.17	.33	.097	1.16	.32
2-Nitrophenol	µg/L	.024	.062	.104	.023	1.06	.100	.005	.022	.032	.005	1.02	.031
4-Nitrophenol	µg/L	.33	1.39	2.1	.127	1.5	.97	ND	NA	ND	ND	NA	ND

TABLE B7b-11. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
2,4-Dimethyl-phenol	µg/L	.48	1.6	ND	<MDL	2.1	21	Σ Phenols 150	NA
2,4-Dinitro-phenol	µg/L	2.0	6.6	ND	<MDL	<MDL	21	20 or Σ Phenol 150	NA
2-Methyl-4,6-dinitrophenol	µg/L	1.6	5.4	ND	<MDL	<MDL	21	1100 or Σ Phenol 150	NA
2-Methylphenol	µg/L	.53	1.8	ND	<MDL	1.12	21	ΣPhenol 150	NA
4-Methylphenol	µg/L	.59	2.0	ND	<MDL	2.1	21	ΣPhenol 150	NA
2-Nitrophenol	µg/L	.76	2.6	ND	<MDL	.21	21	ΣPhenol 150	NA
4-Nitrophenol	µg/L	3.0	9.9	ND	<MDL	6.4	21	ΣPhenol 150	NA

TABLE B7a-12. EVALUATION OF SEMI-VOLATILE ORGANIC ANALYTES BEFORE AND AFTER OZONATION.

Physical Analysis or Chemical Analyte Name	units are µg/L or PPB	Ozone Pilot Plant Influent Water						Ozone Pilot Plant Effluent Water					
		Normal Distribu.			Geometric Dist.			Normal Distribu.			Geometric Dist.		
		$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%	$\bar{X}$	σ	90%
Pentachloro-phenol	µg/L	.074	.25	.40	.056	1.19	.31	.015	.069	.103	.013	1.06	.094
Phenol	µg/L	.20	.140	.38	.19	1.12	.37	.149	.143	.33	.141	1.13	.33
2,4,5-Tri-chlorophenol	µg/L	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND
2,4,6-Tri-chlorophenol	µg/L	.008	.029	.046	.008	1.03	.044	.015	.062	.094	.013	1.06	.087
Σ Phenols	µg/L	1.16	NA	5.6	.76	NA	3.8	.34	NA	1.1	.31	NA	1.06
Σ Chlor Phenols	µg/L	.113	NA	.62	.093	NA	.51	.045	NA	.25	.035	NA	.23
Σ PAHs	µg/L	1.9	NA	6.6	1.6	NA	5.4	1.6	NA	5.2	1.27	NA	4.4

TABLE B7b-12. QUALITY ASSURANCE STATISTICAL EVALUATION AND SELECTED STANDARDS FOR OZONATION ANALYTES.

Physical Analysis or Analyte Name	Units µg/L or PPB	MDL 3σ	LOQ 10σ	Travel Blanks X	Minimum Sample Value	Maximum Sample Value	Sample Number N Pairs	Ocean Plan Standard 5:1 Dilu.	Drinking Water Standard
Pentachloro-phenol	µg/L	1.9	6.2	ND	<MDL	<MDL	21	Σ ClPhenols 5	NA
Phenol	µg/L	.91	3.0	.029	<MDL	<MDL	21	ΣPhenol 150	NA
2,4,5-Tri-chlorophenol	µg/L	1.7	5.6	ND	<MDL	<MDL	21	Σ ClPhenols 5	NA
2,4,6-Tri-chlorophenol	µg/L	.70	2.3	ND	<MDL	<MDL	21	1.45 OR ΣCl Phenols 5	NA
Σ Phenols	µg/L	NA	NA	.029	<MDL	15.0	21	ΣPhenol 150	NA
Σ Chlor Phenols	µg/L	NA	NA	ND	<MDL	1.9	21	ΣClPhenol 5	NA
Σ PAH's	µg/L	NA	NA	.22	<MDL	17.	21	Σ PAHs .044	NA

OZONE DISINFECTION AND TREATMENT OF
URBAN STORM DRAIN DRY-WEATHER FLOWS

A PILOT TREATMENT PLANT DEMONSTRATION PROJECT ON THE KENTER CANYON STORM
DRAIN SYSTEM IN SANTA MONICA

TECHNICAL AND DATA APPENDICES

APPENDIX C

GLOSSARY

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Base Flow See Dry-weather Flow.

By-products Incidental products (chemicals) that are formed during a process, such as water disinfection, many of which are undesirable, but difficult to prevent from being formed.

Chlordane A technical (commercial) grade of chlorinated pesticide which contains many similar compounds that vary slightly in the number and placement of chlorines. Included in the mixture is heptachlor a pesticide that is sold in a more pure form. Chlordane was a popular and widely available pesticide for use in foundations for the control of ants and termites. Over the last 20 years it use has become more restricted and is now unavailable for use in the United States.

Chlorine Chlorine gas has been widely used for destroying disease causing organisms and can be credited with preventing many human epidemics. Recent studies have shown that it also generates many hazardous by-products. In this report chlorine disinfection refers to treatment by chlorine gas, chloramines, chlorine dioxide and other similar treatment compounds.

Coliform A group of bacteria that ferment lactose (milk sugar) and includes several genera in the Enterobacteriaceae family, such as Arizona, Citrobacter, Enterobacter, Escherichia, and Klebsiella. While some genera are found in animal intestines, many are also found free-living in soils and other media. For decades, total coliform organism counts have been used as an indicator of the effectiveness of disinfection of drinking water.

Dilution See Initial Dilution.

Disinfection A term originally used to describe methods used to remove or inactivate infectious or disease causing organisms, but also used to refer to the control of microscopic organisms in general.

Dry-weather Flow The flow observed from storm drains during the dry season and several days after storms. While the relative source contributions varies significantly, the flow is assumed to be composed of infiltration (leaks into the storm drain from groundwater or septic systems), runoff from lawns and other residential sources (pools, car washing, etc.), NPDES permitted facilities, and illegal floor drains, maintenance activities, and sewer connections. Many other sources have been observed.

Enteric virus As used here, see Human Enteric Virus.

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<u>Enterococcus bacteria</u> A subset of <u>Streptococcus</u> bacteria including S. <u>fecallis</u>, S. <u>faecium</u>, S. <u>avium</u>, S. <u>bovis</u>, S. <u>equnius</u>, and S. <u>gallunarum</u>, which have been isolated from the feces of mammals and birds.

<u>Fecal Coliform</u> A subset of the Coliform bacteria group, characterized by the ability to ferment lactose at elevated temperatures (> 39°C). <u>Escherichia coli</u> and some strains of <u>Klebsiella</u> make up this group and the former is commonly found in mammalian and avian feces. While generally a beneficial constituent of the human intestinal tract, the presence of fecal coliform in water maybe an indicator of sewage contamination and the presence of pathogenic (disease-causing) organisms.

<u>F-male Specific Coliphage</u> A virus that attacks and replicates exclusively in a specific (F-male) type of Coliform bacteria. Coliphage are indicative of fecal contamination and may be a good indicator of chlorine disinfection efficacy.

<u>Geometric</u> As used here, this refers to a statistical method whereby the logarithmic value (base 10) is calculated and used to estimate the mean and standard deviation. This method, which is commonly applied in bacteriology and to a lesser degree in environmental analysis, acts to reduce the statistical effect of unusually high events (spills) on the overall mean and standard deviation.

<u>Halogenated Compounds</u> Chemicals that contain Chlorine, Bromine, Fluorine or Iodine. Many are biologically hazardous.

<u>Heptachlor</u> A chlorinated pesticide that is available in a relatively pure form and found in pesticide mixtures such as Chlordane.

<u>Human Enteric Virus</u> Any virus found to replicate in humans and be present in the human digestive system. Many types are pathogenic (disease-causing) in humans.

<u>Humic Acids</u> Colloidal organic material derived from decomposing plant and animal matter. It often induces a brown color when dispersed in water and can exert a significant disinfectant demand during disinfection. Humic and Fulvic matter are believed to be significant sources of mutagen precursors in chlorinated water.

<u>Initial Dilution</u> is the process which results in the rapid and irreversible turbulent mixing of wastewater with ocean water around the point of discharge.

<u>Mutagens</u> Chemicals and processes that cause a change or mutation in the genome (DNA) of an organism. Some mutagens are also carcinogens, causing mutations that disrupt normally cellular growth and result in the rapidly cellular proliferation generically referred to as a cancer.

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NTU National Turbidity Units. A standardized scale based on the ability of matter in water to scatter incident light at a ninety degree angle. Comparable to Formazin or Jackson Turbidity Units (FTU or JTU).

O-xylene (1,2-Dimethyl Benzene) is present in gasoline and may be used as a solvent, but is less hazardous than benzene.

Ozone is a gas composed of three atoms of oxygen, while the oxygen humans breathe consists of only two atoms. Simplistically, ozone tends to "degrade" back to molecular oxygen, but the third oxygen atom may react with other compounds, especially organics with double bonded carbons. This process effectively attacks microbial membranes and kills the organism (bacteria).

PAH's or **PNAH's** are Polynuclear Aromatic Hydrocarbons and are essentially compounds containing multiple (commonly 3-5) benzene rings (6-carbons forming a ring with each carbon bonded to a hydrogen and the adjacent carbons). Benzene and many of the PAH's have been identified as mutagens and are likely carcinogens. They are formed during combustion processes and have been associated with soot and particulates from diesel engines among other sources. The list of compounds included in "Total PAH's" varies among regulators and analysts and care should be taken in making comparisons among different sources.

Pathogen An organism (normally microscopic) that cause diseases in other organisms (generally vertebrates and commonly humans).

Polio and **Polio virus** The common name and causative agent of the disease Poliomyelitis which is characterized by inflammation of brain stem and spine and results in loss of muscle control or death. During this study noninfectious or vaccine type polio virus were used to investigate disinfection efficiency.

TOC or **Total Organic Carbon** refers to an analytical chemical method to detect carbon atoms from sources that were of biologic (living) sources. This would include carbon from oil and hydrocarbon fuels such as gasoline

Total Coliform See Coliform.

Water Reclamation The treatment, transportation, and use of wastewater for a direct beneficial or controlled use that would not otherwise occur. While not technically a wastewater, storm drain dry-weather flows can exhibit many of the same undesirable qualities.

Wet-Weather Flows The relatively high flows from storm drains that occur during and after storms as water is conveyed away from areas in the upstream areas.

START

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THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

ANNUAL REPORT FOR THE FISCAL YEAR

July 1, 1988, to June 30, 1989

Carl Boronkay
General Manager

Compiled and edited by
S. H. Landsman

LOS ANGELES, CALIFORNIA
1989

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FIGURES

LIST OF ABBREVIATIONS

Abbreviation	*Term*
AB	Assembly Bill
AOR	Automation Overview Report
Aqueduct	Colorado River Aqueduct
Bay Delta	San Francisco Bay/Sacramento-San Joaquin Delta Estuary
CAD	Computer Aided Drafting
Calleguas	Calleguas Municipal Water District
Cal OSHA	California Occupational Safety Health Act
CAP	Central Arizona Project
CBT	Computer Based Training
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
COA	Coordinated Operating Agreement
Coastal	Coastal Municipal Water District
CRAPRP	Colorado River Aqueduct Pump Rehabilitation Program
CRW	Colorado River Water
CVP	Federal Central Valley Project
DBP	disinfection by-products
Delta	Sacramento-San Joaquin Delta
DFG	California Department of Fish and Game
DHS	California Department of Health Services
Diemer plant	Robert B. Diemer Filtration Plant
DOM	dissolved organic matter
DPW	Los Angeles County Department of Public Works
DSOD	California Division of Safety of Dams
DWP	Los Angeles Department of Water and Power
DWR	California Department of Water Resources
Eastern	Eastern Municipal Water District
EDD	California Employment Development Department
EDP	Electronic Data Processing
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
EOC	Los Angeles Headquarters Emergency Operations Center

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LIST OF ABBREVIATIONS

Abbreviation	*Term*
EPA	United States Environmental Protection Agency
ETS	Electronic Timesheet System
FSD	Fallbrook Sanitary District
GAC	Granular Activated Carbon
GE	General Electric
gwh	gigawatt hour
HPC	heterotrophic plate count
HR	House Resolution
Imperial	Imperial Irrigation District
Jensen plant	Joseph Jensen Filtration Plant
KCWA	Kern County Water Authority
kv	kilovolt
KWB	Kern Water Bank
kwh	kilowatt hours
Las Virgenes	Las Virgenes Municipal Water District
LIMS	Laboratory Information Management System
maf	million acre feet
MCL	maximum contaminant level
Metropolitan	Metropolitan Water District of Southern California
mgd	million gallons per day
mg/l	milligrams per liter
MIB	2-methylisoborneol
Mills plant	Henry J. Mills Filtration Plant
ml	[illegible]
MRL	[illegible] Reporting Level
MWDOC	[illegible] Water District of Orange County
OCWD	[illegible] Water District
PEROXONE	[illegible] peroxide and ozone combination
PERS	[illegible] Retirement System
PINS	[illegible] Information System
PPD	[illegible] Document
RCF	[illegible] Construction Fund

LIST OF ABBREVIATIONS

Abbreviation	*Term*
Reclamation	United States Bureau of Reclamation
S	Senate Bill
SANDAG	San Diego Association of Governments
SAWPA	Santa Ana Watershed Project Authority
SCA	Senate Constitutional Amendment
SCAG	Southern California Association of Governments
SCE	Southern California Edison
SDCWA	San Diego County Water Authority
Skinner plant	Robert A. Skinner Filtration Plant
SWC	State Water Contractors
SWP	State Water Project
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
THM	trihalomethane
VOC	volatile organic compound
WAPA	Western Area Power Administration
Western	Western Municipal Water District of Riverside County
Weymouth plant	F.E. Weymouth Filtration Plant
WRSF	Water Rate Stabilization Fund
µg/L	micrograms per liter

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[illegible]

[illegible]
E. L. [illegible]
[illegible] MWD

Vice Chairman
A. Michael Stolle
Las Virgenes MWD

Secretary
E. L. Aufdenkamp
Coastal MWD

DIRECTORS
June 30, 1989

Robert J. Abernethy
Los Angeles

Charles D. Barker
West Basin MWD

James H. Blake
Fullerton

Doyle F. Boen
Eastern MWD

Marvin Brewer
Torrance

Timothy F. Brick
Pasadena

Harold E. Cosner
West Basin MWD

William F. Davenport
MWD of Orange County

Anne W. Dunihue
Chino Basin MWD

Douglas W. Ferguson
Central Basin MWD

Marilyn L. Garcia
Los Angeles

John Garthe
Santa Ana

Edward A. Girard
Chino Basin MWD

Michael Glazer
Los Angeles

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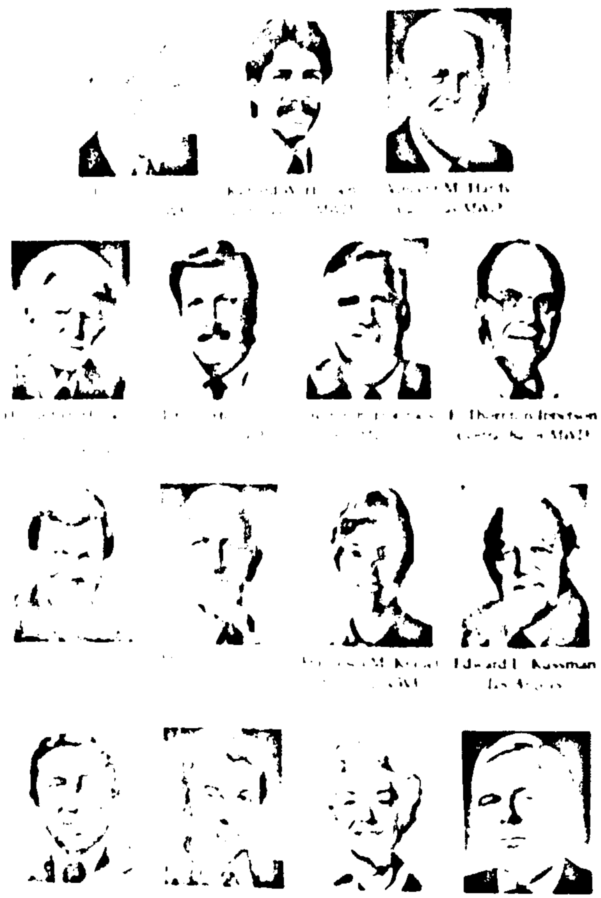

E. Thornton Ibbetson
Central Basin MWD

Edward L. Kussman
Los Angeles

Michael D. Madigan
San Diego CWA

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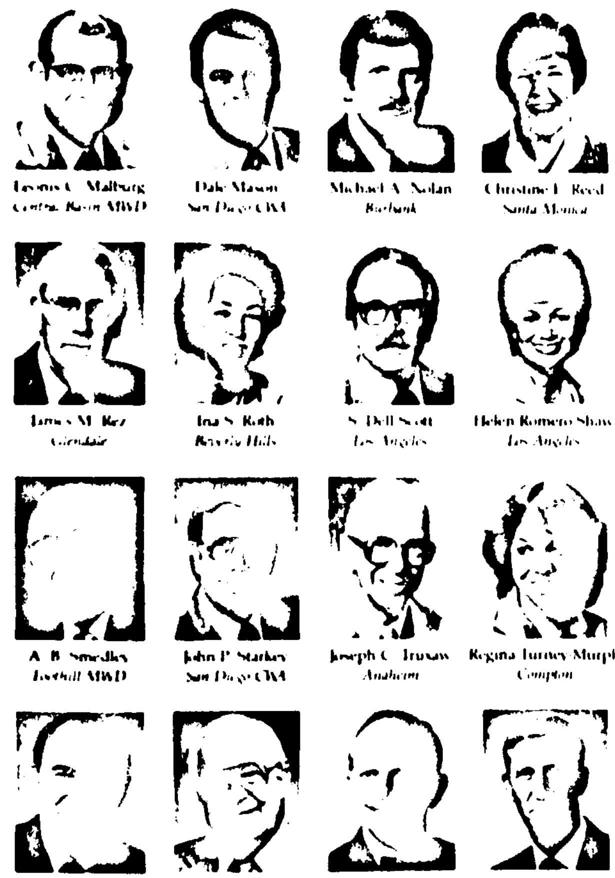
DIRECTORS
June 30, 1989



Leonis C. Malburg
Central Basin MWD

Dale Mason
San Diego CWA

Michael A. Nolan
Burbank

Christine E. Reed
Santa Monica

James M. Rez
Glendale

Ina S. Roth
Beverly Hills

S. Dell Scott
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Helen Romero Shaw
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A. B. Smedley
Foothill MWD

John P. Starkey
San Diego CWA

Joseph C. Trusaw
Anaheim

Regina Turney Murph
Compton

Carl E. Ward
Calleguas MWD

Kenneth H. Witt
MWD of
Orange County

Frank S. Wyle
Los Angeles

Doude Wysbeek
San Fernando

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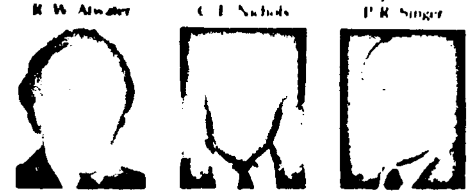
...FICERS

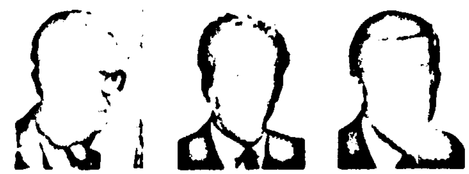
Assistant Gen. Manager
R. R. Baird

DISTRICT MANAGERS

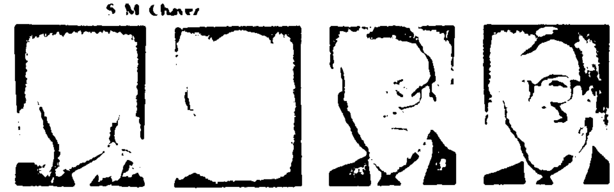
Director of Resources R. W. Atwater	*Chief Engineer* C. L. Nichols	*Chief of Operations* P. R. Singer



Director of Planning F. W. Horne	*Director of Personnel* E. J. Alva	*Director of Administrative Services* G. K. Mitchell



Director of Right of Way and Land S. M. Chavez	*Director of Finance* G. D. Leddy	*Director of Public Affairs* T. M. Spencer



Director of Water Quality M. J. McGuire	*Executive Secretary* K. E. Dorff	*Administrator of State Water Project Matters* R. W. Schempp	*Administrator of Conservation & Water Management* T. H. Quinn

BOARD OF DIRECTORS
As of June 30, 1989

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MEMBERS OF THE BOARD

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San Diego County Water Authority	John F. Hennigar
San Diego County Water Authority	Dale Mason
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Santa Ana	John Garthe
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Torrance	Marvin Brewer
Upper San Gabriel Valley Municipal Water District	Howard H. Hawkins
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West Basin Municipal Water District	Harold E. Crozier
West Basin Municipal Water District	E. L. Balmer
Western Municipal Water District of Riverside County	Lois B. Krieger

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MEMBERS OF STANDING COMMITTEES
JUNE 30, 1989

[illegible]

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Preston B. Hotchkis
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Carl J. Kymla
Mark Lainer
S. Dell Scott
John P. Starkey
A. Macneil Stelle
Regina Turney-Murph
Carl E. Ward

ROLL OF DIRECTORS

JUNE 30, 1989

ANAHEIM

A. W. Franz[illegible]*	March 1, 1929, to April 11, 1930
O. E. Stew[illegible]	April 18, 1930, to April 12, 1935
E. P. Ha[illegible]	May 3, 1935, to June 14, 1960
Charles A. P[illegible]	July 12, 1960, to May 8, 1972
Keith A. M[illegible]	June 13, 1972, to May 29, 1979
JOSEPH [illegible]	August 17, 1979, to

BEVERLY HILLS

Paul E. Schwab*	March 1, 1929, to June 19, 1931
George R. Barker*	June 19, 1931, to August 2, 1935
Arthur Taylor*	August 2, 1935, to August 2, 1951
Lloyd F. Fischer*	August 17, 1951, to December 2, 1977
Ellen Stern Harris	January 10, 1978, to March 10, 1981
Nicholas H. Contanos	March 10, 1981, to September 1, 1981
Mel Oldom	January 11, 1983, to February 14, 1984
INA S. ROTH	February 14, 1984, to

BURBANK

Harvey E. Bruce*	March 1, 1929, to February 11, 1933
James E. Norwood*	March 10, 1933, to April 30, 1943
	May 9, 1947, to October 13, 1953
[illegible]*	May 11, 1943, to May 9, 1947
[illegible]	[illegible] to June 13, 1961
[illegible]	[illegible] to June 1, 1965
MICHAEL A. [illegible]	June 11, 1985, to

[illegible] MUNICIPAL WATER DISTRICT

R[illegible]	January 10, 1961, to August 22, 1969
CARL E. WA[illegible]	September 16, 1969, to
[illegible]	October 14, 1980, to

[illegible] BASIN MUNICIPAL WATER DISTRICT

Milo D[illegible]	November 23, 1954, to November 23, 1983
[illegible]	November 23, 1954, to November 30, 1959
Frank H. [illegible]	November 23, 1954, to April 10, 1973
[illegible]	November 23, 1954, to November 30, 1963

E. THORNTON IBBETSON	December 8, 1959, to
William H. Kent*	October 10, 1961, to April 7, 1977
Carl Fossette*	March 13, 1973, to May 30, 1986
DOUGLAS W. FERGUSON	June 14, 1977, to
LEONIS C. MALBURG	July 8, 1986, to

CHINO BASIN MUNICIPAL WATER DISTRICT

A. C. Reynolds	February 12, 1952, to March 12, 1963
Ray W. Ferguson	March 12, 1963, to December 31, 1980
Carl B. Masingale*	March 10, 1981, to August 9, 1984
John G. Gilday	September 11, 1984, to February 15, 1985
EDWARD A. GIRARD	March 12, 1985, to
ANNE W. DUNIHUE	September 20, 1988, to

COASTAL MUNICIPAL WATER DISTRICT

C. C. Cravath*	August 14, 1942, to January 22, 1957
LYNNDON L. AUFDENKAMP	January 22, 1957, to
James E. O'Connor*	December 7, 1976, to July 1, 1979
JOHN KILLEFER	January 12, 1982, to

COMPTON

C. A. Dickison*	July 17, 1931, to January 20, 1933
William H. Foster*	January 20, 1933, to June 28, 1935
Warren W. Butler*	June 28, 1935, to January 24, 1980
REGINA TURNEY-MURPH	March 11, 1980, to

EASTERN MUNICIPAL WATER DISTRICT

Irvin H. Farrar*	August 31, 1951, to March 1, 1982
DOYLE F. BOEN	March 9, 1982, to

FOOTHILL MUNICIPAL WATER DISTRICT

Nelson Hayward*	February 8, 1955, to July 4, 1959
Conrad R. Fanton*	November 10, 1959, to November 2, 1964
A. B. SMEDLEY	April 13, 1965, to

FULLERTON

Walter Humphreys*	April 10, 1931, to January 19, 1945
H. H. Kohlenberger*	July 27, 1945, to March 7, 1959
Hubert C. Ferry*	February 23, 1960, to February 8, 1983
Norman L. De Vilbiss	February 8, 1983, to April 12, 1988
JAMES H. BLAKE	August 23, 1988, to

GLENDALE

W. Turney F[illegible]*	March 1, 1929, to November 27, 1931
Samuel G. M[illegible]*	November 27, 1931, to January 13, 1933
(See also [illegible])	
Frank P. [illegible]	January 13, 1933, to August 31, 1934
Bernard [illegible]	August 31, 1934, to April 23, 1937
Herman N[illegible]	June 4, 1937, to August 27, 1954
[illegible]	September 28, 1954, to June 10, 1958
Norman C. [illegible]*	June 10, 1958, to June 9, 1970
Lauren W. [illegible]*	June 9, 1970, to May 21, 1972
William H. [illegible]*	June 13, 1972, to July 13, 1976
C. E. [illegible]	July 13, 1976, to July 13, 1988
JAMES M. [illegible]EZ	August 23, 1988, to

LAS VIRGENES MUNICIPAL WATER DISTRICT

Earle [illegible]	December 13, 1960, to March 26, 1963
A. Marion McBride*	March 26, 1963, to May 11, 1965
A. MACNEIL STELLE	June 8, 1965, to October 23, 1967
	March 11, 1975, to
Whitney P. Reeve*	December 19, 1967, to March 11, 1975

LONG BEACH

Newland M. Reid*	April 10, 1931, to January 27, 1933
W. M. Cook*	January 27, 1933, to April 30, 1943
Gus A. Walker	April 30, 1943, to December 31, 1976
Lloyd C. [illegible]*	May 9, 1947, to June 30, 1979
Samuel C. F[illegible]	October 9, 1979, to March 12, 1985
IDA FRANCES LOWRY	March 12, 1985, to

LOS ANGELES

[illegible] R. [illegible]*	March 1, 1929, to February 4, 1930
[illegible] R. R[illegible]*	March 1, 1929, to October 28, 1947
W. P. W[illegible]*	March 1, 1929, to January 10, 1947
[illegible]*	November 1, 1929, to September 15, 1933
[illegible]*	November 5, 1929, to August 29, 1930
W. [illegible] H[illegible]*	February 28, 1930, to July 21, 1933
[illegible]*	August 29, 1930, to July 2, 1937
Walter A. Ha[illegible]	January 20, 1933, to January 4, 1935
D. W. [illegible]*	January 20, 1933, to September 3, 1955
Perry H. Greer*	July 21, 1933, to August 14, 1950
[illegible] H. F[illegible]*	October 13, 1933, to November 19, 1960
[illegible]*	January 11, 1935, to October 22, 1947

Louis S. Nordlinger*	August 13, 1937, to June 8, 1940
Joseph Jensen*	August 16, 1940, to February 3, 1944
	March 8, 1946, to July 8, 1974
Ransom W. Chase*	March 14, 1947, to February 11, 1975
Gordon B. Crary*	March 14, 1947, to November 8, 1959
Howard D. Mills*	March 14, 1947, to March 17, 1965
W. R. Fawcett	May 13, 1952, to November 27, 1953
Luther C. Anderson	January 12, 1954, to February 11, 1975
Noah Dietrich*	November 8, 1955, to November 23, 1970
Ferdinand Mendenhall*	July 29, 1958, to October 8, 1974
Ben P. Griffith*	August 9, 1960, to June 7, 1961
Pietro Di Carlo*	February 14, 1961, to November 7, 1967
William S. Peterson*	February 14, 1961, to August 10, 1979
Aubrey E. Austin, Jr.*	February 28, 1961, to May 13, 1975
Albert F. Bush*	November 14, 1961, to February 11, 1975
John W. Luhring	January 16, 1962, to August 8, 1967
Joseph M. Quinn*	May 14, 1968, to September 18, 1973
B. Walter Hicks	May 8, 1973, to August 20, 1974
Samuel B. Nelson*	September 18, 1973, to October 9, 1984
Katherine B. Dunlap	August 20, 1974, to September 11, 1984
Jerry Godell	October 8, 1974, to October 9, 1984
EDWARD L. KUSSMAN	October 8, 1974, to
Herman Leavitt	February 11, 1975, to August 19, 1975
Yolanda M. Nava	February 11, 1975, to September 14, 1976
S. DELL SCOTT	February 11, 1975, to
Willie J. Stennis	May 13, 1975, to December 31, 1978
Mladin Zarubica	August 19, 1975, to March 16, 1981
Soledad S. Garcia	September 14, 1976, to September 11, 1984
MARK LAINER	November 13, 1979, to
Mark Nathanson	April 14, 1981, to September 11, 1984
MICHAEL GLAZER	September 11, 1984, to
HELEN ROMERO SHAW	September 11, 1984, to
MARILYN L. GARCIA	October 9, 1984, to
Rachel Levin	October 9, 1984, to April 4, 1989
FRANK S. WYLE	October 9, 1984, to
ROBERT J. ABERNETHY	April 4, 1989, to

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Glenn P. Allen	December 11, 1951, to December 17, 1986
W. B. Hellis*	August 19, 1955, to February 9, 1975
William J. Teague	February 11, 1969, to October 10, 1972
Robert R. Dowling	September 14, 1971, to May 11, 1976
Doyle Miller	October 10, 1972, to October 31, 1987

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CARL J. KYMLA	[illegible] 1973, to
Philip J. R[illegible]	[illegible] 1975, to December 8, 1978
Gerald E. P[illegible]	[illegible] 11, 1976, to December 11, 1988
M. ROY K[illegible]	September 13, 1977, to
KENNETH [illegible]	October 11, 1981, to
WILLIAM [illegible]	January 13, 1987, to

PASADENA

[illegible]	March 1, 1929, to August 27, 1952
Morris S. [illegible]	September 16, 1952, to October 10, 1961
Robert E. [illegible]	January 16, 1962, to October 27, 1966
Don C. M[illegible]	January 10, 1967, to October 26, 1975
Karl V. [illegible]	December 9, 1975, to April 11, 1980
Martin G. Smith	July 8, 1980, to June 11, 1985
TIMOTHY F. ERICK	June 11, 1985, to

SAN DIEGO COUNTY WATER AUTHORITY

Fred A. Heilbron*	January 10, 1947, to February 14, 1973
F. L. Burkholder*	January 24, 1947, to April 6, 1953
Richard S. Holmgren	August 11, 1953, to February 19, 1963
J. William Fisher*	April 12, 1955, to October 11, 1955
[illegible]*	August 20, [illegible], to October 20, 1986
[illegible]*	February 2[illegible], 196[illegible], to July 8, 1965
HARRY GRIFFEN	February 19, 1963, to
George R. Henderson*	August 13, 1964, to November 29, 1964
Ralph E. Graham	September 14, 1971, to January 14, 1975
	August 17, 1979, to June 29, 1982
Raymond F. [illegible]*	September 18, 1973, to May 14, 1979
Lloyd E. [illegible]	November 20, 197[illegible], to December 31, 1980
John M. [illegible]	January 14, 1975, to December 31, 1986
JOHN E. S[illegible]	January 13, 1981, to
MICHAEL [illegible]	August 18, 1982, to
FRANCES [illegible]	November 8, 1983, to
JOHN [illegible]	November 18, 1986, to
[illegible]	January 13, 1987, to

SAN FERNANDO

[illegible]	[illegible] 14, 1971, to August 21, 1984
[illegible]	[illegible] 21, 1984, to August 8, 1986
[illegible]	[illegible] 9, 1986, to

SAN MARINO

Harry L. Hellner*	March 1, 1929, to September 29, 1933
John H. Ramboz*	September 29, 1933, to November 18, 1960
Howard A. Miller*	January 10, 1961, to April 26, 1975
Preston Hotchkis*	June 10, 1975, to September 10, 1986
PRESTON B. HOTCHKIS	March 10, 1987, to

SANTA ANA

S. H. Finley*	March 1, 1929, to April 10, 1942
A. H. Allen*	April 10, 1942, to December 10, 1968
Howard W. Crooke*	December 10, 1968, to September 1, 1977
JOHN GARTHE	November 8, 1977, to

SANTA MONICA

George H. Hutton*	March 1, 1929, to January 16, 1931
Arthur A. Weber*	January 16, 1931, to October 12, 1934
William H. Carter*	February 15, 1935, to March 13, 1936
Edmund S. Gillette*	June 12, 1936 to January 8, 1937
Arthur P. Creel*	January 8, 1937, to March 3, 1941
Samuel G. McClure*	March 21, 1941, to November 14, 1947
(See also Glendale entry)	
Samuel J. Crawford*	December 5, 1947, to September 15, 1959
Mark T. Gates*	January 12, 1960, to July 12, 1972
Francis X. Coppen	August 16, 1972, to December 9, 1980
Robert Gottlieb	December 9, 1980, to December 8, 1987
CHRISTINE E. REED	March 8, 1988, to

THREE VALLEYS MUNICIPAL WATER DISTRICT

Hugh W. Stiles*	December 8, 1950, to December 31, 1961
Arthur H. Cox	January 16, 1962, to April 16, 1974
William C. Leech	April 16, 1974, to February 9, 1982
William H. Koch	February 9, 1982, to February 12, 1985
Mel Harper	February 12, 1985, to February 18, 1986
RICHARD W. HANSEN	June 10, 1986, to

TORRANCE

John Dennis*	March 17, 1931, to April 14, 1933
J. R. Jensen*	April 14, 1933, to December 31, 1933
Charles T. Rippy*	January 19, 1934, to August 8, 1950
George W. Stevens	September 22, 1950, to June 13, 1961
George A. Bradford	June 13, 1961, to October 13, 1964
George Vico	November 17, 1964, to August 13, 1968

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Ben Haggott*	[illegible] to November 14, 1982
(See also West [illegible])	
MARVIN BREWE[illegible]	[illegible] to

[illegible] VALLEY MUNICIPAL WATER DISTRICT

J. Emel [illegible]	April 9, 1953 to January 30, 1964
HOWARD [illegible]	April 9, 1963 to
Frank [illegible]	March 10, 1964 to March 10, 1970
Robert [illegible]	March 10, 1970 to December 31, 1970
Travis [illegible]	January 12, 1971 to December 31, 1978
BURTON [illegible]	January 9, 1979 to

WEST BASIN MUNICIPAL WATER DISTRICT

Robert L. Nestar*	August 20, 1948 to October 21, 1968
Ben Haggott*	March 10, 1953 to October 8, 1966
(See also Torrance entry)	
W. C. Farquhar*	August 19, 1955 to July 13, 1976
J. N. Tabon	August 9, 1960 to April 9, 1963
Louis J. Alexander*	August 13, 1963 to March 30, 1972
CHARLES D. BARKER	September 10, 1963 to
Lane C. Mason*	November 12, 1965 to February 12, 1984
Lester E. Carlson*	October 8, 1974 to September 2, 1988
E. L. Rabner*	August 19, 1976 to May 23, 1980
HAROLD E. CROZIER	October 25, 1986 to

WESTERN MUNICIPAL WATER DISTRICT OF RIVERSIDE COUNTY

Howard Backer*	December 14, 1954 to July 13, 1976
LOIS B. KELLER	August 13, 1976 to

Notes:
*Deceased
**Current Directors are shown in capital letters.

STAFF

June 30, 1989

GENERAL MANAGER DEPARTMENT

General Manager .... C. Boronkay
Assistant General Manager .... R. B. Baird
Assistant General Manager .... R. W. Balcerzak
Assistant General Manager .... M. B. Holburt
Legislative Representative .... R. E. Corley

LEGAL DEPARTMENT

General Counsel .... F. Vendig
Assistant General Counsel .... K. L. Tachiki

AUDIT DEPARTMENT

Auditor .... M. W. Hondorp
Assistant Auditor .... L. W. Lindhout

EXECUTIVE SECRETARY DIVISION

Executive Secretary .... K. E. Dorff

ENGINEERING DIVISION

Chief Engineer .... C. E. Nichols, Jr.
Assistant Chief Engineer .... G. M. Snyder
Principal Engineer .... W. P. Lundy
Principal Engineer .... M. S. Chan
Principal Engineer .... A. M. Whitsett
Principal Engineer .... G. J. Hazel
Principal Engineer .... G. F. Horowitz
Principal Engineer .... E. N. D'Alessandro
Principal Engineer .... L. L. Treadway
Principal Engineer .... D. C. Gledhill

RESOURCES DIVISION

Director of Resources .... R. W. Atwater
Principal Engineer .... A. Sienkiewich
Senior Engineer .... A. Hassani

OPERATIONS DIVISION

Chief of Operations	P. R. Singer
Assistant Chief of Operations	C. F. Voyles
Region Operations Manager	D. D. Newkirk
Region Operations Manager	R. W. Hurc
Region Operations Manager	M. L. Sien
Principal Engineer	V. L. Haller
Operations Services Manager	W. F. Mancinelli
Control Systems Manager	W. G. Kervahn

PLANNING DIVISION

Director of Planning	F. W. Horne
Senior Engineer	D. R. Froelich
Advance Planning Manager	D. L. Adams

ADMINISTRATIVE SERVICES DIVISION

Director of Administrative Services	G. K. Mitchell
Assistant Director	R. E. Kennedy
Manager, Purchasing and Stores	R. K. Savoie
Office Services Manager	D. Soto
Headquarters Services Manager	R. J. Lantieri
Manager, Information Systems	K. R. Sommerville
Manager, Data Processing	T. D. Harman

PERSONNEL DIVISION

Director of Personnel	E. J. Alva
Assistant Director	G. F. Ivey
Principal Personnel Analyst	G. J. Bryant
Principal Personnel Analyst	J. M. Mallory

PUBLIC AFFAIRS DIVISION

Director of Public Affairs	T. M. Spencer
Senior Assistant Director	J. Lundgren
Senior Assistant Director	J. Malinowski
Principal Government Relations Representative	E. L. Ungerman

RIGHT OF WAY AND LAND DIVISION

Director of Right of Way and Land	S. M. Chavez
Assistant Director	W. E. Vazzana
Manager, Right of Way and Land	H. J. Dearing
Manager, Right of Way and Land	F. Aranda

FINANCE DIVISION

Director of Finance	G. D. Leddy
Assistant Director	L. H. Becker
Manager, Financial Services	R. R. Campbell
Controller	D. I. Furukawa
Treasurer	R. D. Sjoberg

WATER QUALITY DIVISION

Director of Water Quality	M. J. McGuire
Associate Director of Water Quality	E. G. Means
Water Purification Engineer	M. D. Buehler
Water Quality Laboratory Manager	M. K. Davis

STATE WATER PROJECT MATTERS

Administrator of State Water Project Matters	R. W. Schempp
Principal Engineer	P. A. Teigen
Principal Engineer	R. C. Clemmer

CONSERVATION & WATER MANAGEMENT

Administrator of Conservation & Water Management	T. H. Quinn
Water Conservation Manager	E. J. Thornhill
Principal Engineer	M. D. Moynahan

... to prepare it for welding

Foreword

Coping with a third consecutive dry year and studying ways to meet increasing future water demands were Metropolitan's primary concerns during fiscal year 1988-89. Although new water supplies were secured, analyses still indicated potential problems in the next century.

By augmenting dependable supplies of Colorado River water (CRW), Metropolitan improved long-term water reserves for Southern California's urban coastal zone. At mid-fiscal year, Metropolitan entered into an historic agreement with Imperial Irrigation District (Imperial), creating a $237-million water conservation program. The innovative water-saving program will improve Imperial's irrigation efficiency and supplement Southern California's future CRW supplies.

Under the agreement with Imperial, Metropolitan will pay Imperial about $92 million to build conservation facilities near the Salton Sea, while another $23 million will cover Imperial's indirect costs such as the loss of hydroelectric revenues. Metropolitan also will underwrite operating and maintenance costs totaling $14 million over the contract's first five years, and $3.1 million for each of the following 35 years. In return, Metropolitan gains approximately 100,000 acre-feet of conserved CRW per year, which will meet the annual water needs of approximately 1 million people. The water comes directly from the conservation program and does not impact agricultural supplies to Imperial farmers.

Another 100,000 acre-feet of water will be realized annually from lining the All-American Canal and Coachella branch of the All-American River. In October 1988, Congress approved Senate Bill 795, introduced by Senator Alan Cranston and cosponsored by Senator Pete Wilson, authorizing the canal lining. Metropolitan and other California agencies with CRW contracts will pay the costs to line the 66 miles of earthen-lined canals. Practically, however, only Metropolitan possesses the resources to cover the lining costs, estimated at $150 million to $200 million. Because only water saved through conservation will be added to the urban supply, the canal lining will not negatively affect farmers, and may indeed provide benefits through increased efficiency and reduced maintenance costs.

Additional measures to expand water supplies were pursued during the fiscal year. Metropolitan presented the results of its preliminary studies defining the need for additional reservoir storage space at a community meeting in Hemet where [illegible] potential reservoir sites are located. New reservoir capacity would permit Metropolitan to import more water during wet years.

Equally important, Metropolitan continued a wide-scale conservation campaign for Southern California's third consecutive dry year. Although Metropolitan's [illegible] were sufficient to meet Southern California's 1989 summer needs, the [illegible] population and dwindling supplies make conservation essential for the area. Among the campaign's components were an [illegible] media and public education program using television, radio and billboards; suggested local anti-waste ordinances, including landscape irrigation restrictions; distribution of plumbing fixture retrofit devices; and an expanded conservation credits program to help retail water purveyors finance water-saving projects. Metropolitan's long-term conservation goal is a savings of [illegible] acre-feet of water per year within the next 20 years.

Threats to Southern California's water reserves, however, came from the State Water Resources Control Board (SWRCB), which released a draft allocation plan in November 1988. The SWRCB plan calls for large releases of fresh water through the Sacramento-San Joaquin Delta (Delta) estuary and into the ocean to ostensibly improve fishery habitat. Currently, the Delta provides about two-thirds of California's fresh water.

If implemented, Southern California's State Water Project (SWP) deliveries from the Delta would be limited to 1985 levels in most years, despite the [illegible] population and reduced Colorado River supplies. The plan also means Southern Californians would be forced to implement stringent water [illegible] SWRCB has not shown that the region can achieve [illegible]. Metropolitan challenged the proposal and after [illegible] SWRCB withdrew the proposal and will resubmit a [illegible]. The plan concludes the first phase of hearings on the [illegible] Delta.

[illegible] the Delta plan [illegible] that it does not forthrightly advocate [illegible] that can increase water supplies and protect [illegible] even more acute in light of a Metropolitan report [illegible] $3 billion worth of new water facilities over the [illegible] September 1988, the review noted that existing [illegible] expanding and improving while new plants [illegible] reservoirs developed, and new pipelines to deliver [illegible]

The study's major findings include: population will increase 35 percent within Metropolitan's service area over the next two decades; water usage, while increasing 24 percent at the same time, will grow more slowly due to conservation and declining agricultural use; all five of Metropolitan's water treatment plants and much of its distribution system will operate at or near capacity during peak water demand periods; treatment capacity, increasing in the service area by 880 million gallons per day by the year 2000, could double to 4.5 billion gallons per day by 2030; more stringent water quality standards could reduce some treatment plants' capacities; more than 500,000 acre-feet of new reservoir will be needed by 2000, 1.1 million acre-feet by 2030, to fulfill seasonal, carryover, and emergency storage requirements; and, while Metropolitan's wholesale price of untreated water is expected to increase only slightly by 2010, its wholesale price of treated water used in homes and businesses will rise from its current $230 per acre-foot to $320 per acre-foot (in 1988 dollars).

In fiscal year 1988-89, water rates remained stable for the fourth consecutive year. By implementing its rate stabilization fund, Metropolitan's Board of Directors held rates at $197 per acre-foot and $230 per acre-foot for untreated and treated water, respectively; $153 and $186 for interruptible untreated and treated water, $591 and $624 for emergency untreated and treated water; and $84 for reclaimed water.

To finance planned improvements and expansions, Metropolitan's Board of Directors authorized a negotiated sale of $215 million in waterworks general obligation bonds, the largest issue in Metropolitan's history. Sale proceeds will be used to continue financing Metropolitan's $2.8 billion capital improvement program.

In another record year for water sales, revenues rose $32 million over last fiscal year, totaling $425 million on water deliveries of 2,095,079 acre-feet, up nine percent over last year's record deliveries. Revenues of $19 million were earned from the recovery of hydroelectric power, $1 million more than the previous fiscal year. *Ad valorem* property taxes, levied on all property within Metropolitan, earned revenues of $73 million, up $1.5 million from last fiscal year.

Secured property tax rates for fiscal year 1988-89 continued to fall slightly to 0.0110 of property value, Metropolitan's lowest rate in 54 years. These rates are in keeping with a 1984 policy calling for Metropolitan taxes to continue representing a decreasing percentage of its total revenue. Tax revenues are used to pay voter-approved debt service related to financing facilities.

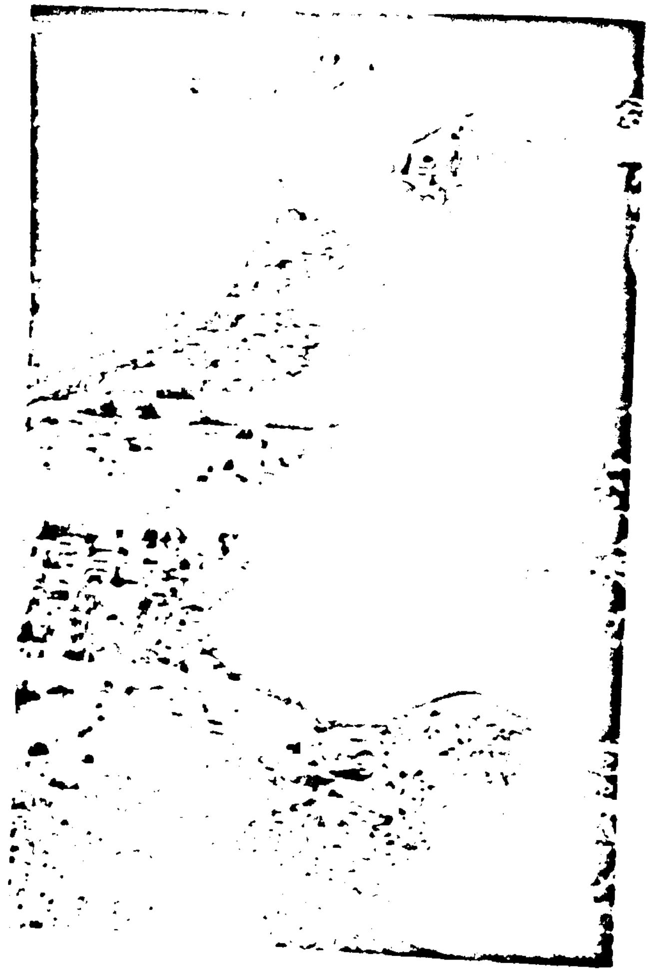
Metrop[illegible] ing water demands. Na[illegible] exceeding $71 million were award[illegible] the fiscal year. Eleven construct[illegible] $2,038,726 were completed and six [illegible] were valued at an estimated 470 [illegible] included Robert A. Skinner Plant [illegible] water demands in San Diego and [illegible] water reservoir with a floating [illegible]

[illegible] of the fiscal year included the [illegible] capacity to 1,700 cubic feet [illegible] Pressure Control Structure to deliver [illegible] Metropolitan's distribution [illegible] No. 1 and the Robert B. Diemer

[illegible] an extensive five-year program [illegible] at its Colorado River Aqueduct [illegible] to their original efficiency is [illegible] savings worth over two million dollars [illegible] an additional operating [illegible] The F.E. Weymouth Filtration Plant is also [illegible] project. Over an estimated five [illegible] or modernizing flow

[illegible] Water Awareness Week, Metropolitan sponsored [illegible] implications of the current global [illegible] Scientists speculate that even a few [illegible] temperatures could have a profound [illegible] water resources. In California [illegible] precipitation leading to diminished

A Metropolitan Patroller records water use on one of over 300 member-agency revenue meters.



...ew provides a glimpse ...Colorado River

XXVII

CHAPTER 1

WATER SUPPLY

The Metropolitan Water District of Southern California (Metropolitan) was incorporated in 1928 to provide Southern California's coastal plain with a supplemental water supply. Municipal and industrial demand consume approximately 90 percent of Metropolitan-supplied water, with the remaining 10 percent being used for agricultural activities.

Metropolitan's service area spans 5,200 square miles, consisting of 27 member agencies: 14 cities, 12 municipal water districts, and the San Diego County Water Authority. Metropolitan currently supplies about half of the water used within its service area and is expected to deliver nearly all of the anticipated increase in future demands.

Southern California water supplies are obtained either locally or imported, vary widely from wet years to dry years, and are affected by multi-year periods of drought conditions. Metropolitan's two sources of imported water are the Colorado River Aqueduct, which diverted 1.18 million acre-feet (maf) in fiscal year 1988-89, and the State Water Project, which furnished 1.0 maf. Because of its lower cost and availability to Metropolitan, Colorado River water (CRW) continues as the primary supply source. Metropolitan's total dependable supply from the Colorado River and the State project equals only 1.65 maf per year.

Colorado River Supply

Entitlements

Metropolitan signed a contract with the United States Secretary of the Interior in the early 1930s for an allotment of 1.212 maf of CRW per year. Additionally, three California agricultural contractors signed with the Secretary, and maintain priority over Metropolitan for their CRW entitlement. In 1963, California lost a portion of its entitlement to the State of Arizona by U.S. Supreme Court decision. However, Colorado River sys[illegible] issued by the Secretary of th[illegible] Interior in 1931 [illegible] impact for 15 years. In March 1985 [illegible] Project (CAP) began supplying wat[illegible] to Arizona [illegible] from Lake Havasu. This reduce[illegible] Metropolit[illegible] supply to less than 550,000 acre-fe[illegible] per year [illegible] priority Indian and miscellaneous right[illegible] (3,000 [illegible] losses (50,000 acre-feet) further lower this [illegible] feet per year.

The Aqueduct System

The [illegible] Aqueduct was initially completed in 1941. Over th[illegible] to keep pace with increasing water needs, Metropoli[illegible] the Aqueduct to accommodate a full capacity of more than one mil[illegible] per year, which equals more than one billion gallons per day.

The Aqueduct spans 242 miles of desert and mountain ranges between its Lake Havasu intake and its terminal reservoir, Lake Mathews, near Riverside. Originally designed to convey an eight-pump flow of 1,605 cubic feet per second (cfs), the Aqueduct can actually carry flows 15 percent higher. The system currently delivers the dependable water supply as well as more than 500,000 acre-feet of surplus water when available. During the 1988-89 fiscal year, 1.2 maf of water was diverted from Lake Havasu into the Aqueduct. The average flow was 1,657 cfs, 103 percent of the Aqueduct design capacity.

To reach Metropolitan's service area, CRW rises 1,367 feet via five pumping plants. The W. P. Whitsett Pumping Plant, on Lake Havasu's western [illegible] elevates water from the lake 291 feet to Gene Wash Reser[illegible] Gene Pumping Plant raises the CRW an[illegible] Gene Reservoir to Copper Basin Reservoir [illegible] the Aq[illegible] point. The water then flows by gravity app[illegible] Iron Mountain Pumping Plant where it is ele[illegible] Mountains. Rolling another 147 miles, the [illegible] Pumping Plant which raises the water 438 [illegible] the water arrives at the Hinds Pump[illegible] plant elevates the water 441 feet [illegible] to bring the water the remaining [illegible] at Lake Mathews.

Each [illegible] pump[illegible] usly with eight pumps, a ninth [illegible] and provides additional or emer[illegible] nine-pump flow, the Aqueduct can carry [illegible] capacity, or 1,850 cfs. Because [illegible] each pump's capacity now exceeds [illegible] capacity.

Colorado River Water Supply Conditions

Colorado River runoff continued below average for a second consecutive year. End-of-year reservoir storage declined by about 3.8 maf from a year ago, reflecting the June 1 forecast of average runoff into Lake Powell of 47 percent for the April-to-July snowmelt period (Table 5).

As shown in Table 1, Lake Powell inflow reflected the drought conditions experienced in the Upper Colorado River Basin.

Table 1

Inflow to Lake Powell

(Million Acre-feet)

Inflow Source	Fiscal Year 1986-87	1987-88	1988-89
Green River at Green River, Utah	4.7	3.4	2.2
Colorado River near Cisco, Utah	7.0	3.9	2.9
San Juan River near Bluff, Utah	3.5	1.3	1.0
Miscellaneous	0.8	0.6	0.2
Total Inflow to Lake Powell	16.0	9.2	6.3

The river's gauged flow at Lees Ferry, Arizona, a few miles downstream of Lake Powell, was 7.7 maf for the fiscal year. This gauge lies just upstream of the Paria and Colorado River confluence. Downstream of the Paria is the Colorado River Compact point, where Upper Colorado River Basin releases to the Lower Basin are determined.

Releases from Lake Mead totaled 9.2 maf. CRW deliveries in the Lower Basin were 5.11 maf to California, including 1.18 maf to Metropolitan and 3.87 maf to the agencies supplying irrigation water; 2.08 maf to Arizona, 0.16 maf to Nevada; and 1.94 maf to Mexico.

Colorado River Aqueduct Power Requirements

Power required for Aqueduct pumping operations is delivered through a Metropolitan-owned transmission system consisting of 310 miles of high-voltage (230-kilovolts) power lines connecting the pumping plants to the Western Area Power Administration (WAPA) system and the Southern California Edison Company (SCE) system. WAPA's system delivers Metropolitan's power from Hoover Power Plant and the Parker Power Plant.

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TABLE 2

ELECTRIC ENERGY AVAILABLE AT HOOVER AND PARKER POWER PLANTS

Fiscal Year 1988-89

	(Kilowatt-hours)
Hoover Power Plant	
Total Hoover Energy	4 245 751 000
Total Hoover Energy Available to Metropolitan	1 231 206 000
Parker Power Plant	
Total Parker Energy	484 029 049
Total Parker Energy Available to Metropolitan	237 142 000

Total energy needed to divert the 1,185,803 acre-feet of water from Lake Havasu this fiscal year was 2.4 billion kilowatt-hours (kwh), and as shown in Table 3, the Hoover and Parker Power Plants provided 61.4 percent of the total.

To supplement the Hoover and Parker power resources, Metropolitan purchases power from different suppliers under various power contracts and agreements implemented since June 1987. Almost all of the supplemental power involved economy off-peak energy purchases: 13.5 percent were SCE purchases, and the remaining 86.5 percent came from various suppliers, including Arizona Public Services Company, Salt River Project, California Department of Water Resources (DWR) and WAPA's Navajo Project.

TABLE 3

METROPOLITAN'S ELECTRIC ENERGY USE

Fiscal Year 1988-89

Energy Source	Kilowatt-hours	Percentage of Total Energy Requirement
Hoover Power Plant	1 231 206 000	51.49
Parker Power Plant	237 142 000	9.92
Edison Benefit Energy	215 485 363	9.01
Exchange (SCE)	(27 764 000)	(1.16)
Supplemental Energy Purchases*	735 276 330	30.75
TOTAL	2 391 345 693	100.00

Note:

*Suppliers include Edison, California Department of Water Resources, Western Area Power Administration Navajo Project, Salt River Project and Arizona Public Services Company

Table 7 summarizes this fiscal year's total power costs for Aqueduct pumping operations. The composite of the supplemental power costs represents SCE's average power rate of 23.3 mills kilowatt-hour, and the other suppliers' average rate of 17.2 mills kilowatt-hour, with the difference providing substantial economic benefits. The operating conditions of the interconnected systems and the energy market usually dictate such supplemental purchases. For fiscal year 1988-89, the supplemental power cost savings totaled approximately $3.8 million.

Power Management

Boulder Canyon Project Administration

Staff attended the annual Boulder Canyon Project Contractor's meeting with WAPA and the Bureau of Reclamation (Reclamation). Items discussed included year-end Hoover energy accounting, proposed changes for administrative and operating procedures, progress on the uprating of Hoover generating units, Hoover-Mead substation consolidation, and status of the Hoover power rate and repayment studies.

Staff continues to work with WAPA concerning the cost estimates and methodology employed in WAPA's repayment studies. Based upon Metropolitan's recommendations, WAPA refined its final repayment analysis which significantly reduced its proposed rate adjustment on Metropolitan's current cost for Hoover power.

Sale of Metropolitan's Hoover-Mead Transmission Lines

A transmission line sales agreement between WAPA and Metropolitan was executed on August 29, 1988. Under the agreement, Metropolitan's two 230-kv transmission lines between Hoover Power Plant and Mead Substation were sold to WAPA for $3.5 million. All ownership rights in the lines as well as the property on which the lines reside were transferred to WAPA on the above date. Metropolitan's Hoover power is delivered at the Mead Substation interconnection with Metropolitan's transmission system. Under the agreement, WAPA is obligated to provide Metropolitan with 320 megawatts of transmission capacity between Hoover and Mead when needed in the future.

District-Edison Contracts

New administrative procedures were developed and implemented per the District-Edison 1987 Service and Interchange Agreement. These procedures cover energy scheduling, dispatching, transmission, metering arrangement, accounting, and billing. Staff continues to monitor conformity with this agreement's operational and monetary aspects to maximize the operational flexibility of the Aqueduct and minimize Metropolitan's overall power costs.

A letter was prepared and submitted to Edison requesting that negotiations be initiated between Metropolitan and Edison for an interconnection agreement for Metropolitan's Etiwanda power plant, construction of which is scheduled for 1991. Staff expects that the proposed interconnection agreement will be accomplished through an amendment of Metropolitan's current contract with Edison.

District-State Contracts

As required under the District-State Coordination Agreement, staff completed and submitted to the California Department of Water Resources (DWR) Metropolitan's estimate of its Aqueduct power operation for calendar year 1989 and indicated that no surplus Aqueduct energy will be available to sell to DWR nor will any energy be available for exchange.

Pursuant to the terms of Metropolitan's marketing contract with DWR, a letter agreement was executed specifying the unit rate to be applied for the sale of energy from Metropolitan's Phase I hydroelectric power plants to DWR during the six-year period from January 1, 1989 through December 31, 1994. Under the agreement, Metropolitan will receive 40 mills per kilowatt hour (kwh) during 1989, escalated by 3 percent per year during the succeeding five years. During this period, it is estimated that Metropolitan will receive an average of approximately 8.4 million dollars per year for the next six years.

Purchase Agreement for Supplemental Power

Aqueduct pumping demands can exceed Metropolitan's base-load energy resources available from Hoover and Parker power plants and Edison's benefit energy by up to one billion kwh of supplemental power annually. To supplement these base-load resources, staff has negotiated and signed economy energy agreements with WAPA, DWR, Salt River Project Agricultural Improvement and Power District, Arizona Electric Power Cooperative, Inc., Arizona Public Service, Nevada Power Company, Tucson Electric Power Company, and the city of Glendale. These agreements allow Metropolitan to purchase supplemental power for Aqueduct pumping on an hour-to-hour basis, depending on the power market conditions existing at the time.

Impact on Supply—The Central Arizona Project

While the Secretary has not yet limited Metropolitan's CRW diversions, CRW diversions by CAP increased to about 610,000 acre-feet this year. It is projected that diversions will total [illegible] acre-feet next fiscal year from CAP's Hayden-Rhodes, Salt-Gila, and Tucson Aqueducts.

Now scheduled for a 1991 completion, 87 miles of the Tucson Aqueduct are completed, with three pumping plants fully operational and six under construction. Construction is proceeding on five miles of pipeline and tunnel to deliver water to Tucson, and a contract has been awarded to build an eight-mile pipeline to serve the San Xavier Indian Reservation. A contract for an Aqueduct regulating reservoir will be awarded next fiscal year.

New Waddell Dam will serve as CAP's major regulatory storage facility. Three tunnels that will act as inlet, outlet, and diversion works for the reservoir have been excavated. With foundation excavation nearing completion, a contract to erect the dam embankment will be awarded next fiscal year. The new Waddell Pump Generation plant is under construction with operation to begin in 1994. Figure 3 shows where the major CAP facilities are located.

Colorado River Floodway

Metropolitan staff continued participating in a Colorado River Floodway Task Force created to advise the Secretary and Congress on issues related to establishing a floodway from Davis Dam to the southerly international boundary. In determining the floodway boundary, the Task Force adopted design criteria and mapping procedures. The floodway will encompass the area required to carry the one-in-one-hundred-year river flow or 40,000 cfs, whichever is greater. The one-in-one-hundred-year river flow has been determined to range from slightly greater than 35,000 cfs to nearly 50,000 cfs in different river reaches. Floodway boundary mapping was under way at fiscal year end.

State Water Project Supply

To meet its future demands, Metropolitan signed the first contract with DWR in 1960 leading to the State Water Project's (SWP) construction. Initially, the contract called for Metropolitan's ultimate water entitlement to be 1.5 maf per year, but later amendments raised this to 2.0115 maf per year. Metropolitan's entitlement equals half of the 4.218 maf per year contracted by all 30 SWP contractors. Metropolitan's contract with DWR reaches it maximum annual entitlement in 1990.

The SWP was designed so that additional conservation facilities to augment yield could be constructed as delivery demands increased. However, due largely to opposition from various sectors since the first conservation facilities were finished in 1967, no additional conservation facilities have been built. The total demand for State project water has been increasing since then, and two drought periods have also stressed the system (see Table 10). In the past, Metropolitan has received its maximum CRW entitlement to meet its needs. However, due to increasing demands and reduced Colorado River supplies, in the future Metropolitan will use greater amounts of State water than before. To enable Metropolitan to receive larger amounts of State project water, the California Aqueduct's East Branch is being enlarged. This project's status follows:

TABLE 4

EAST BRANCH IMPROVEMENT/ENLARGEMENT

As of June 30, 1989

STATUS	PROJECT
Complete	• Raise [illegible] lining [illegible] length of East Branch* • Construct [illegible] siphons • [illegible] foundation work at Pearblossom Pumping Plant and Devil Canyon Power Plant
Near Completion	• Raise [illegible] siphons • Design Devil Canyon Power Plant penstock shutoff valve
Construction Begun	• Check structure modification — Alamo to Pearblossom • Enlarge Devil Canyon Power Plant — fabrication and installation units 3 and 4 • Enlarge Pearblossom Pumping Plant — fabrication and installation units 7, 8, and 9
Contract Awarded	• Furnish and install second penstock at Devil Canyon Power Plant
Contracts Out for Bid	• Pearblossom Pumping Plant • Mojave Siphon Power Plant — turbines, generators and governors
Continuous	• Design — Mojave and Antelope Siphons • Design — Mojave Siphon Power Plant • Design — modifications to check structures from Pearblossom to Mojave Siphon Power Plant • Develop second afterbay at Devil Canyon Power Plant

Notes:

*A portion of the East Branch canal lining from Alamo to Pearblossom may have to be raised an additional foot pending hydraulic testing upon completion of the East Branch Enlargement.

Metropolitan first began receiving State project water in 1972 at Castaic Reservoir, the California Aqueduct's West Branch terminus. Under its contract, Metropolitan paid the State nearly $195 million before taking its first water delivery. Each of the 30 SWP contractors proportionately pays project costs based on the sizing of facilities required to deliver water to their respective areas. Metropolitan, located at the project termini, pays approximately two-thirds of all costs. Metropolitan's payments to DWR for State project water reached $232 million during the fiscal year, for a cumulative total of $2.32 billion through June 30, 1989 (Table 11).

Power for Pumping State Project Water

The SWP power supply system is managed and operated by the DWR. The major goals of DWR's power program are: (1) maximizing the benefits from existing SWP power resources, (2) developing and maintaining alternate energy sources thereby reducing dependence on power purchased from utilities, (3) securing transmission resources to efficiently supply power to SWP facilities and to provide access to areas where low cost power can be obtained, and (4) minimizing the impact on the SWP when major contractural arrangements expire in 2004.

The three largest sources of SWP energy are hydroelectric energy, exchange energy, and coal-fired energy. SWP hydroelectric energy resources include the Hyatt and Thermalito hydroelectric plants and on-aqueduct power recovery plants. Exchange energy is provided through contractual arrangements with SCE. Coal-fired generation is obtained from unit No. 4 at the Reid Gardner Power Plant in Southern Nevada. These energy sources accounted for 90 percent of the total SWP energy requirements in 1988. Other sources of SWP energy are purchases from a variety of public and investor-owned utilities, geothermal power, and wind generated power. Figure 2 shows the SWP energy resources for 1988.

The overall SWP energy mix is subject to annual variations, because precipitation amounts can vary substantially from year-to-year directly affecting both hydroelectric generation and pumping demands. The locations of SWP power resources and major transmission facilities are shown in Figure 4. Table 12 contains actual and projected energy and costs for 1988, 1990, and 1995.

Metropolitan's Share of SWP Power Costs

Metropolitan's average net power cost for pumping SWP water in 1988 was $99 per acre-foot for a total cost of $79 million. The projected pumping power cost for 1995 is $114 per acre-foot, with a total annual cost of $172 million.

Mojave Siphon Power Plant

Discussions were carried out between DWR and the State Water Project Contractors regarding the sizing, construction schedule, and cost allocation for the proposed Mojave Siphon Power Plant on the East Branch of the California Aqueduct. DWR recommended construction of a power plant having three 8 megawatt turbines, each rated at a maximum flow of 960 cfs. This design will allow the entire flow of the enlarged East Branch to pass through the power plant. Plant construction is expected to be completed by 1994, at a total estimated cost of approximately $38 million. The project will be financed through the sale of water system revenue bonds and repaid over a 35-year period.

South Geysers Power Plant

DWR presented a Geothermal Facilities Operation Plan to the State Water Contractors which describes DWR's long range plan for development, operation, and use of SWP geothermal facilities. These facilities include Bottle Rock and South Geysers power plants, the Francisco, Rorabaugh, and Binkley mineral leases, and associated well structures and equipment. Of specific interest is the South Geysers plant, originally designed as a 55 MW facility but which was never completed due to an inadequate steam supply. In March 1988 a plan was approved that calls for accepting bids for leasing the steam resource and the existing structure at South Geysers, and sale of most of the plant equipment. Currently, DWR is in the process of accepting bids on these resources separately or in combination.

Reid Gardner

Reid Gardner unit No. 4 is jointly owned by DWR which is entitled to 94 percent of the Unit's 250 MW output, and the Nevada Power Company (NPC). In March 1988 a settlement was reached in a long-running arbitration between DWR and NPC which involved the interpretation of each party's obligation for receipt of minimum coal deliveries from coal suppliers. The settlement, known as Memorandum of Agreement No. 56, set forth the minimum coal delivery obligations for both parties, established a common stockpile for coal at Reid Gardner, and provided for NPC to make a series of payments to DWR totalling approximately $12.4 million.

SWP Power Cost Computer Models

Staff implemented a plan to use computer models to track SWP power costs. DWR currently utilizes computer programs to model the operation of the California Aqueduct and associated project facilities. These models are used for a variety of purposes including scheduling water flows, balancing energy loads and resources, and allocating power costs among the contractors. The ability to use these programs will allow staff to more closely monitor SWP power operations and costs.

Issues Affecting Water Supply

Forecasting Agricultural Water Use

Metropolitan and the Colorado River Board of California have developed techniques for projecting agricultural CRW use in California outside Metropolitan's service area. As both techniques underestimated actual use in calendar year 1988, a consultant has begun refining Metropolitan's

forecasting model. Had Metropolitan's CRW use been limited in calendar year 1988, 65,000 acre-feet of unused agricultural priority water could have been scheduled for diversion by use of monthly forecasts.

Colorado Ute Indian Water Rights Settlement

Legislation to settle outstanding water rights claims between the Ute Mountain Ute and the Southern Ute Indian tribes and parties in Colorado was signed by the President. As introduced, House Resolution (HR) 2642 and Senate Bill (S) 1415 would have authorized the tribes to enter into water-use contracts to sell, exchange, lease, or dispose of water tributary to the Colorado River. Metropolitan and the States of California, Arizona, and Nevada sought bill amendments to prohibit off-reservation, out-of-state use of this water. As passed by Congress, the legislation prohibits sales, exchanges, leases, uses, or other disposal of water into or in the Lower Colorado River Basin unless water held by non-Federal, non-Indian holders of water could be marketed under State law, Federal law, interstate compacts, or international treaty. Such a determination would be subject to a Federal court's final order or pursuant to an agreement among the seven Colorado River Basin states.

Salinity Control

Implementation of the Colorado River Salinity Control Program continues, meeting numeric criteria for total dissolved solids concentration below Hoover and Parker Dams and at Imperial Dam adopted by each of the Colorado River Basin states. Numerous projects to prevent agricultural, point, and diffuse sources of salinity from entering the Colorado River or its tributaries have been completed or are under development by the Departments of the Interior and Agriculture. Projects in the Grand and Paradox Valleys and Lower Gunnison Basin and the Dolores Project and Meeker Dome areas of Colorado, the Uinta Basin in Utah, the Big Sandy River area in Wyoming, and Las Vegas Wash in Nevada remove 157,000 tons of salt annually. Another 1.1 million tons of salt per year must be removed by the year 2010 to meet Imperial Dam's numeric criterion.

San Francisco Bay/Delta Hearing

The State Water Resources Control Board's (SWRCB) three-year-long hearing process to review its 1978 water rights decision 1485 (D-1485) and related water quality control plans for the San Francisco Bay (Bay) and the Central Valley basins fell behind schedule this year.

Phase I concluded on February 1, 1988, and Phase II was scheduled to begin in July 1988. Prior to Phase II, the SWRCB was to issue a draft Water Quality Control Plan for Salinity in the San Francisco Bay/Delta Estuary (Plan) and draft Pollutant Policy Document (PPD). During

Phase II, the SWRCB was to receive comments on these draft documents. However, the draft Plan and draft PPD were not completed and publicly released until November 3, 1988.

In the drafts, SWRCB staff rejected or disregarded most of the Phase I recommendations of Metropolitan, the State Water Contractors (SWC), DWR, and other water agencies. The major concerns over the SWRCB staff recommendations include:

- The draft Plan would limit SWP and federal Central Valley Project (CVP) Sacramento-San Joaquin Delta (Delta) exports to 1985 levels.
- The draft Plan would hold the amount of water pumped at the Edmonston Pumping Plant to the 13 Southern California SWP contractors to the 1985 levels of 790,000 acre-feet annually (660,000 acre-feet for Metropolitan, about one third of its contracted entitlement).
- Additional Northern California water, above 1985 levels, could be pumped only during wet and above normal water years for off-stream surface storage and conjunctive use programs.
- The draft Plan would call the viability of the Coordinated Operations Agreement (COA) between DWR and the United States Bureau of Reclamation (Reclamation) into question.
- The draft Plan doubled Metropolitan's projected water conservation levels in its service area to one maf per year by the year 2010. No information submitted or discussed during Phase I justified such large projected savings.
- The Plan, based on very poor evidence of added benefits, would have greatly increased the amount of Delta outflow (1.5 maf) from April through July dedicated to fish and wildlife. A combination of water released from upstream reservoirs and SWP and CVP export curtailments accounted for the increase.
- The draft Plan specifically rejected the current D-1485 fish and wildlife Delta standards and the current resource management programs being implemented as unreasonable.
- Based on preliminary DWR staff analysis, it appeared that the Bulletin 160-87 plans for increasing SWP yield (Delta facilities, Los Banos Grandes Reservoir, interim CVP water purchases, and the Kern Water Bank groundwater storage) would not be feasible under the proposed draft Plan.
- The draft PPD would have left urban water agencies using Delta water completely responsible financially for trihalomethane (THM) treatment by recommending that "reasonable alternatives" other than treating THM sources be used; and
- The draft Plan would have required that Central Valley reservoir operating procedures be changed to release additional water from April through July.

SWRCB staff, in the draft documents, did not suggest specific outflow standards for San Francisco Bay but recommended further research and monitoring toward possible future outflow standards.

Finally, the draft Plan proposed a "California Water Ethic" as its major philosophical approach to solving the State's future water needs. Essentially, the "Ethic" called for Southern California to use less water to solve California's complex water resources problems. While Metropolitan places high priority on additional conservation efforts, conservation alone does not solve Southern California's future water needs. The SWRCB approach proved quite different from DWR's statewide water plan (Bulletin 160-87) in which conservation, fish and wildlife, and water management, along with new State project facilities, are all proposed to meet California's future growing water needs.

Subsequent to the release of the draft Plan and draft PPD, Metropolitan and other parties filed petitions with the SWRCB to reopen Phase I of the hearing, to set aside the two draft documents, and to schedule a special workshop in January 1989. The latter allowed participants to submit estimates of time needed to prepare and present additional evidence to respond to the draft documents' proposals and assumptions.

The SWRCB held the workshop and later directed its staff to develop a new schedule and work plan for the Bay-Delta hearing process. It also eliminated flows and export limits from the Plan and included objectives for salinity and possible water temperature only; export limits and flow requirements would be considered later during the water rights hearing. Workshops to facilitate greater interaction among the SWRCB staff and DWR and other interested parties will be held to help provide SWRCB staff the necessary data and analysis of impacts to revise the draft plan. A revised draft Plan and PPD are expected in late 1989. An overall Bay-Delta hearing proceedings completion date is not known.

California Urban Water Agencies Delta Drinking Water Study

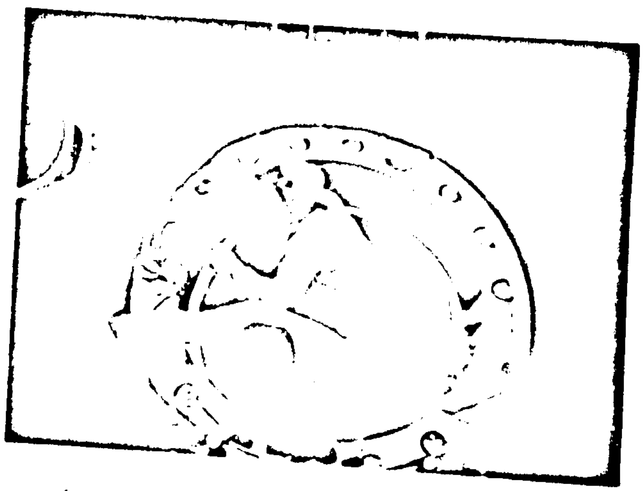
Brown and Caldwell Consulting Engineers completed the final report on a two-year study evaluating alternatives to protect Delta drinking water quality. This study was funded by nine urban water agencies, including East Bay Municipal Utility District, Los Angeles Department of Water and Power, San Diego County Water Authority, city of San Francisco, Santa Clara Valley Water District, city of San Diego Water

Department, Municipal Water District of Orange County, Alameda County Water District, and Metropolitan.

The report concludes that constructing new water facilities would significantly improve the quality of Delta drinking water by dramatically reducing levels of dissolved solids and organic compounds that form THMs during water treatment. Of the six alternatives studied, the Peripheral Canal provides the most cost-effective way of improving Delta drinking water quality.

State Water Project Fishery Mitigation

In July 1985, negotiations began between DWR and the California Department of Fish and Game (DFG) over a new fishery agreement. This is required under the December 30, 1986 Banks Pumping Plant Fishery Mitigation Agreement before DWR can operate the plant at full capacity of 10,300 cfs. To improve the Delta fish population by offsetting direct fish losses at the Banks Pumping Plant, the 1986 agreement called for funding mitigation projects such as hatcheries, fish screens, and physical transfer of fish from Clifton Court Forebay back into the Delta.



Painters apply coal-tar epoxy coating to a turbine during shutdown of Venice Hydroelectric Power Plant

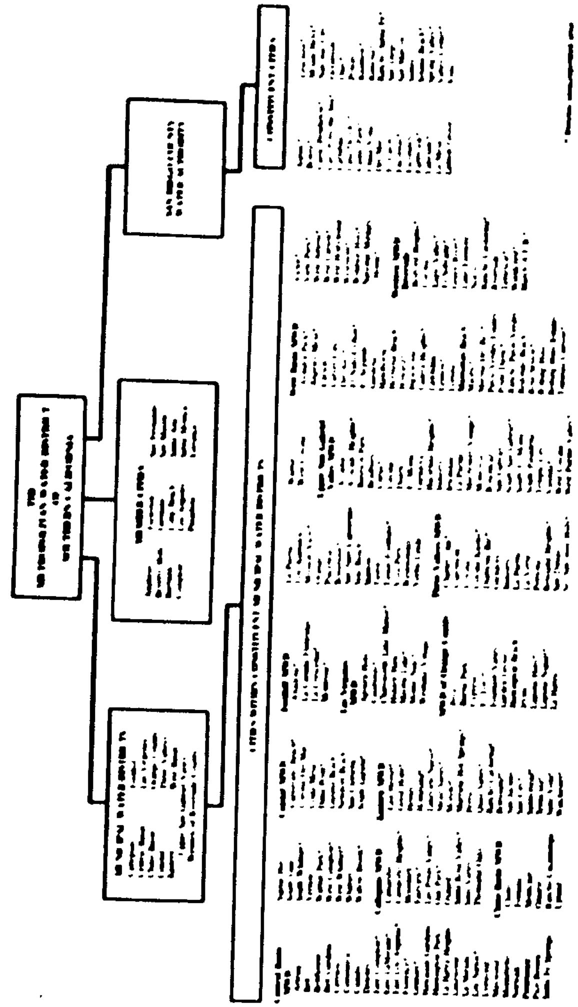
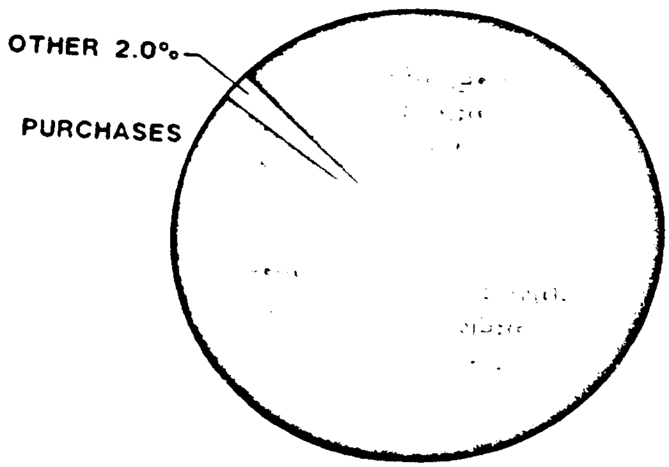


Figure 1. Composition of the Metropolitan Water District of Southern California



1988

7.4 BILLION KWH TOTAL AVAILABLE ENERGY

Figure 2. State Water Project Electric Resource Mix

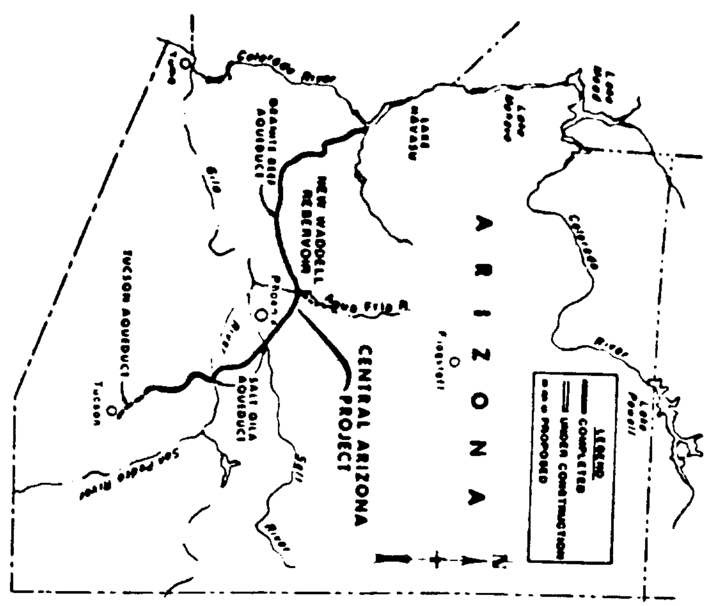


Figure 3. Central Arizona Project

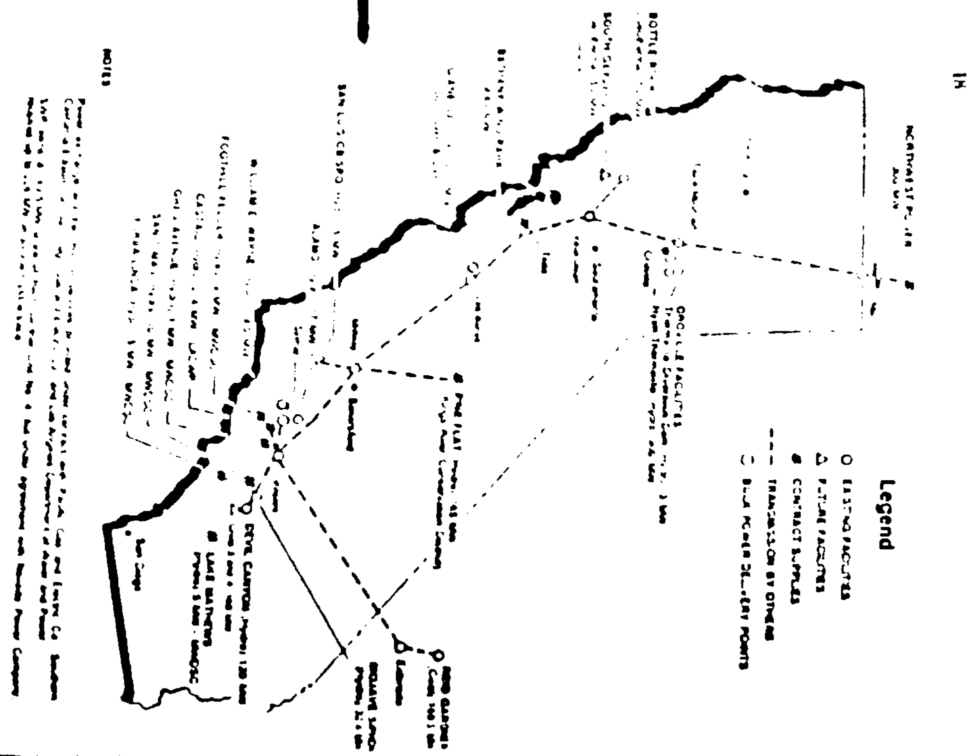


Figure 4 State Water Project Power Facilities

TABLE 5
STORAGE IN COLORADO RIVER RESERVOIRS
(Acre Feet)

Reservoirs	Gross Capacity	Total Usable Capacity Above Lowest Outlet	Water in Storage on June 30, 1989: Usable Storage	Percent of Total Usable Capacity	Storage Above Minimum Power Head	Storage Above Rated Power Head	Change in Storage Since June 30, 1988
Upper Basin							
Fontenelle	345,400	344,800	260,000	75	65,000	26,200	231,000
Flaming Gorge	3,789,000	3,749,000	2,956,000	79	2,723,000	1,894,000	-292,000
Blue Mesa	940,800	829,500	675,000	81	593,900	425,600	162,000
Morrow Point	117,200	117,000	112,000	96	37,100	32,200	-1,000
Crystal	25,300	17,600	17,000	97	6,400	3,100	--
Navajo	1,709,000	1,696,400	1,399,000	82	--	--	164,000
Powell	27,000,000	25,002,000	21,557,000	86	17,431,000	12,129,000	-2,317,000
Subtotal	33,926,700	31,756,300	26,976,000	85	20,856,400	14,510,100	-2,053,000
Lower Basin							
Mead	28,537,000	26,159,000	21,552,000	82	11,528,000	7,899,000	-1,828,000
Mohave	1,818,500	1,810,000	1,774,000	98	1,556,500	586,000	77,000
Havasu	648,000	619,400	603,000	97	163,600	--	-3,000
Subtotal	31,003,500	28,588,400	23,929,000	84	13,248,100	8,485,000	-1,754,000
Total	64,930,200	60,344,700	50,905,000	84	34,104,500	22,995,100	-3,807,000

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TABLE 6
PLANT ENERGY USE

[illegible]

Plant	Pump Hours	Energy Use	Station Service	Water Diverted
	[illegible]	[illegible]	[illegible]	Acre-Feet
Whitsett	[illegible]	414 [illegible]	[illegible] 316	1 185 703
Gene	[illegible]	441 [illegible]	5 472 622	
Iron Mtn.	[illegible]	212 822 [illegible]	2 629 174	
Eagle Mtn.	[illegible]	621 [illegible]	2 [illegible] 355	
Hinds	[illegible]	641 [illegible]	2 [illegible] 937	
Total	[illegible]	2 33[illegible]	[illegible] 264	1 185 703

Total Colorado River Aqueduct Energy Use (kwh)

[illegible]	2 33[illegible]
[illegible]	[illegible] 64
[illegible]	[illegible]
[illegible]	2 3[illegible] 345 6[illegible]

TABLE 7
ENERGY COST FOR PUMPING COLORADO RIVER WATER

[illegible]

Energy Source	Cost ($)	Average Cost per Acre-Foot Diverted at Whitsett Intake ($/Acre-Foot)
[illegible]	[illegible]	
[illegible]	[illegible]	15.97
[illegible]	[illegible]	5.63
[illegible]	[illegible]	36.33
[illegible]	[illegible]	
Total	23 5[illegible]	19.88*

Note:

* [illegible] 215 [illegible] kwh of Benefit Energy plus Exchange Energy with [illegible]

TABLE 8
HISTORY OF METROPOLITAN ENERGY USE

(Kilowatt hours)

Operating Year (June 1-May 31)	Hinds	Parker	Glen Canyon	Edison	Mohave	Total
1938-39	42 848 400					42 848 400
1939-40	227 368 669					227 368 669
1940-41	143 064 984					143 064 984
1941-42	44 017 660					44 017 660
1942-43	60 017 059					60 017 059
1943-44	82 247 841					82 247 841
1944-45	91 709 105					91 709 105
1945-46	123 081 428					123 081 428
1946-47	133 567 956					133 567 956
1947-48	291 060 715					291 060 715
1948-49	322 377 526					322 377 526
1949-50	356 573 150					356 573 150
1950-51	333 188 278					333 188 278
1951-52	436 497 338					436 497 338
1952-53	245 559 840	106 563 861				352 123 701
1953-54	188 555 562	313 911 487				502 467 049
1954-55	494 543 293	309 158 579				803 701 872
1955-56	591 818 318	240 557 612				832 375 930
1956-57	886 594 514	228 920 983				1 115 515 497
1957-58	782 923 439	344 134 852				1 127 058 291
1958-59	915 031 459	296 260 814				1 211 292 273
1959-60	1 239 926 323	262 475 757		49 299 179		1 551 701 259
1960-61	1 322 302 890	250 847 552		531 690 327		2 104 840 769
1961-62	1 111 164 408	226 714 509		706 533 264		2 044 411 181
1962-63	1 288 224 496	239 851 631		670 159 619		2 198 015 746
1963-64	1 289 797 301	234 190 543		604 756 952		2 178 744 498
1964-65	1 312 499 097	211 094 582	286 448 600	537 389 594		2 347 391 873
1965-66	1 289 868 361	210 116 245	328 356 000	344 000 000		2 172 340 606
1966-67	1 293 545 542	216 719 338	169 409 200	674 893 325		2 354 567 405
1967-68	1 275 118 352	209 316 617	157 666 000	543 268 034		2 185 388 703
1968-69	1 281 328 330	213 317 866	255 192 600	563 019 477		2 312 878 273
1969-70	1 309 500 582	208 919 322	49 626 930	821 929 208		2 389 976 042
1970-71	1 289 125 697	215 653 464		910 725 653		2 415 504 814
1971-72	1 285 114 849	220 867 717		973 793 122		2 479 775 688
1972-73	1 272 549 941	212 336 395	32 435 484	769 054 383		2 286 376 203
1973-74	1 248 781 774	227 442 806	49 139 785	904 840 000		2 430 204 365
1974-75	1 246 248 014	234 124 706	200 198 925	319 600 000		2 000 171 645
1975-76	1 293 466 752	231 649 808			17 216 800	1 542 353 360
1976-77	1 359 469 444	209 579 194		407 620 000*	20 030 160	1 996 648 098
1977-78	1 155 147 387	207 835 790		812 620 023**	18 719 600	2 194 322 500
1978-79	1 243 505 702	206 910 950		2 811 200	3 841 600	1 457 069 452
1979-80	1 392 744 887	265 148 569		4 560 640		1 662 454 096
1980-81	1 450 274 619†	317 178 703		2 417 120		1 769 870 442
1981-82	1 256 021 261	229 291 138		137 750 000***		1 621 064 399
1982-83	1 015 883 381	241 214 269		102 250 000***		1 359 347 650
1983-84	1 869 123 790	439 251 018				2 308 374 808
1984-85	2 175 826 778	433 251 904				2 609 078 682
1985-86	2 241 138 815	435 357 644				2 676 496 459
1986-87	2 302 108 552	406 352 676				2 708 461 228

Notes:

* Includes 21 000 000 kwh of exchange energy arranged for by Dudley Ridge Water District and supplied by DWR energy suppliers (SCE).

** Includes 544 000 000 kwh of exchange energy arranged for by DWR and supplied by DWR's energy suppliers Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E).

*** Exchange energy arranged for by DWR, supplied by DWR's energy suppliers (PG&E, SCE, and SDG&E), and delivered to Metropolitan using SCE's transmission facilities.

† Includes 56 662 113 kwh of secondary energy.

TABLE 8

HISTORY OF METROPOLITAN ENERGY USE •

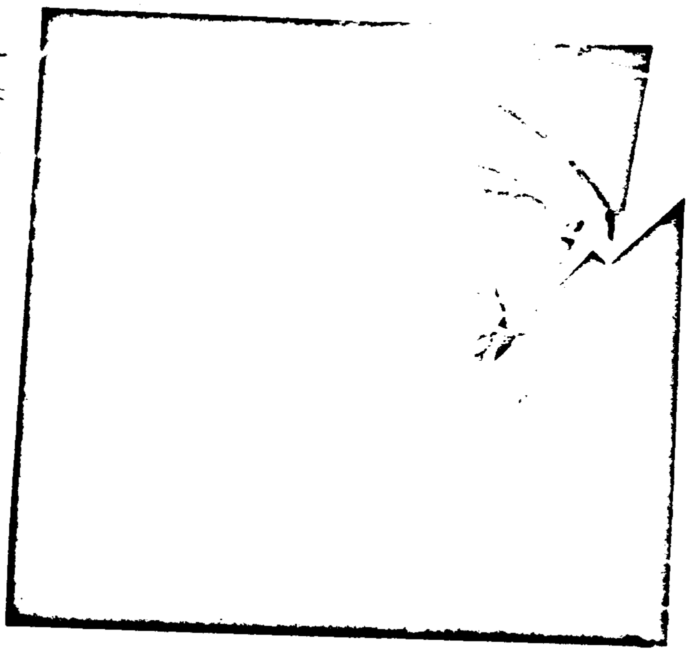

TABLE 9

STORAGE IN STATE WATER PROJECT RESERVOIRS

(Thousand Acre feet)

	GROSS CAPACITY	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		GROSS STORAGE AS OF JUNE 30														
Reservoirs																
Oroville	3,540	3 470	2 420	1 200	3 331	3 328	3 118	3 112	3 490	3 491	3 234	2 684	3 230	2 612	2 239	3 111
San Luis (State share)	1,068	795	629	535	1 049	938	1 032	610	345	1 059	862	819	1 004	641	886	478
Pyramid	171	163	164	168	162	168	165	162	158	154	160	157	158	158	161	161
Castaic	324	164	237	[illegible]	309	298	297	249	318	291	166	226	251	248	264	256
Silverwood	75	60	59	57	63	64	67	70	64	[illegible]	66	68	66	68	63	70
Perris	132	100	91	80	103	105	108	81	95	112	124	[illegible]	112	[illegible]	122	96
Total	5,310	4 752	3 600	2 111	5 017	4 901	4 781	4 286	4 470	5 184	4 612	4 015	4 821	3 856	3 737	4 174

TABLE 10

STATE WATER PROJECT DELIVERIES

(Thousand Acre feet)

	MAXIMUM ENTITLEMENT	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
		DELIVERIES OF ALL TYPES OF WATER TO SWP CONTRACTORS AS OF JUNE 30														
Delivery Areas																
Feather River	40	21	8	8	12	12	8	17	9	9	<1	<1	<1	<1	1	1
North Bay	67	6	7	7	7	6	7	7	6	1	2	4	4	5	9	29
South Bay	188	124	157	79	106	129	134	139	129	104	103	116	124	134	137	160
San Joaquin	1,355	1 082	1 247	735	540	1,168	1 483	1 529	1 507	937	1 064	1 273	1 136	1 318	1 163	1 292
Coastal	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Southern California	2,498	444	664	550	305	812	466	758	790	931	467	591	809	973	884	1 096
Total	4,218	1 677	2 083	1 379	970	2 127	2 098	2 450	2 441	1 982	1 637	1 964	2 073	2 430	2 194	2 578

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TABLE 11

CHARGES, PAYMENTS, AND CREDITS UNDER THE STATE WATER AND DEVIL CANYON-CASTAIC CONTRACTS FOR 26 YEARS

FISCAL YEAR	CONSERVATION (DELTA) Capital	CONSERVATION (DELTA) Minimum Charge	TRANSPORTATION Capital	TRANSPORTATION Minimum Charge	TRANSPORTATION Variable	[illegible] COSTS	DELIVERY STRUCTURES	DEVIL CANYON CASTAIC	SUBTOTALS	(CREDITS)	TOTALS	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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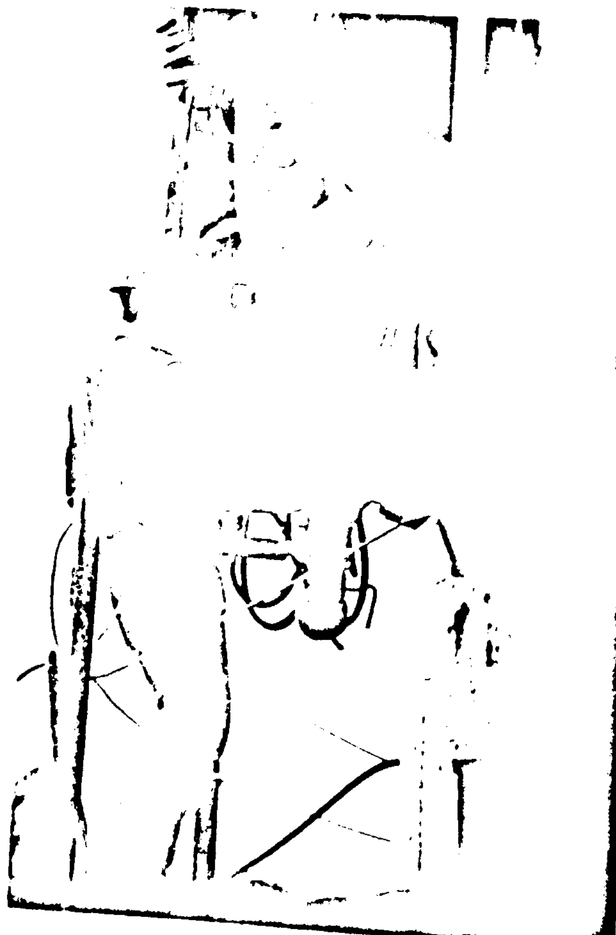
1982-83	14 247 106	6 416 512	53 580 275	41 245 605	13 764 049		7 234	[illegible]	[illegible]		[illegible]	[illegible]
1983-84	[illegible]	6 154 562	73 098 046	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1984-85	12 105 567	8 014 799	68 307 001	[illegible]	6 322 525			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1985-86	12 737 649	10 699 907	57 996 458	180 881 347	1 876 906			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1986-87	14 048 419	11 558 148	57 301 538	141 058 759	7 498 487			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1987-88	15 220 698	12 090 974	58 156 929	138 857 747	7 528 655	8 519 661		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1988-89	16 564 007	11 945 462	58 845 142	148 186 503	98 511	16 051 924		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
								9 785 559	[illegible]	[illegible]	[illegible]	[illegible]
TOTALS	165 565 673	92 554 301	[illegible]	[illegible]	95 099 735	61 732 761	4 210 207	126 642 917	2 559 125 439	(240 017 235)	2 319 088 704	

TABLE 12

STATE WATER PROJECT ACTUAL AND ESTIMATED ENERGY RESOURCES AND ENERGY COSTS***

Resources	1988 gwh	1988 $1000	1988 mills/kwh	1990 gwh	1990 $1000	1990 mills/kwh	1995 gwh	1995 $1000	1995 mills/kwh
Hyatt Thermalito	1,259	23,327	19	1,655	23,170	14	2,143	25,716	12
SWP Recovery Plants									
Gianelli	161	4,037	25	142	3,550	25	158	3,950	25
Alamo	24	805	33	25	750	30	115	3,450	30
Devil Canyon	591	14,770	25	937	23,425	25	1,208	30,200	25
W. E. Warne	298	7,440	25	368	9,200	25	440	11,000	25
Castaic	473	11,817	25	629	15,725	25	669	16,725	25
San Luis Obispo	—	—	—	—	—	—	30	750	25
Pine Flat	127	9,119	72	318	11,130	35	387	13,158	34
Metropolitan Hydro	179	9,646	54	197	7,486	38	260	11,700	45
Thermalito Diversion Dam	21	613	29	23	751	33	23	759	33
Mojave Siphon	—	—	—	—	—	—	98	5,194	53
SCE Exchange*	2,336	—	—	1,674	—	—	1,354	—	—
Reid Gardner Unit No. 4	1,632	87,340	54	1,440	83,520	58	1,261	97,097	77
Bottle Rock	140	19,068	136	123	22,912	186	151	25,368	168
TERA Power Corp (Wind)	4	368	85	6	513	85	6	408	68
CRA Energy Purchases	—	—	—	424	7,208	17	913	20,086	22
Energy Purchases	196	3,030	15	1,425	25,194	18	702	17,550	25
Total Resources	7,441	191,380	26	9,386	234,534	25	9,918	283,111	29
Sales	1,693	42,424	25	880	31,117	35	—	—	—
SWP Pumping Energy Requirements**	5,748	148,956	26	8,506	203,417	24	9,918	283,111	29
Unit Transmission Cost	—	—	3	—	—	5	—	—	5
Effective Unit Cost	—	—	29	—	—	29	—	—	34

Notes:
* Net energy gained from Southern California Edison Co. under 1979 DWR-SCE Power Contract and 1981 Capacity Exchange Agreement
** Does not include engergy deliveries to SCE pursuant to 1979 Power Contract and 1981 Capacity Exchange Agreement
***Includes allowance for future cost escalation



... installed in Newhall Tunnel ... into the tunnel.

CHAPTER 2

Delivering Metropolitan's Water Supplies

The Distribution System

Stretching about 200 miles along the Pacific Ocean, Metropolitan's service area runs from Oxnard to the Mexican border, and inland in some places for about 70 miles. It extends into six counties: San Diego, San Bernardino, Riverside, Orange, Los Angeles, and Ventura. Metropolitan delivered approximately 2.2 million acre-feet (maf) of water in fiscal year 1988-89, an average of almost 2 billion gallons each day.

The initial delivery point for Colorado River water (CRW) into Metropolitan's distribution system is Lake Mathews, while Castaic Lake and Devil Canyon provide delivery points for State project water. Utilizing 775 miles of pipeline, five filtration plants, eight reservoirs, numerous regulating structures, and 14 hydroelectric power recovery plants, Metropolitan supplies its member agencies, which subsequently deliver water to homes, industries, and agricultural users. Table 13 shows each filtration plant's location and capacity.

System and area control operators can remotely control any one of several hundred valves and monitor changes in water levels and pressure, thus regulating system flows. More sophisticated computerized control systems are being developed and integrated into the Area Control Centers to provide even greater monitoring and control.

Metropolitan delivers water to member agencies through 345 service connections located throughout the distribution system. Each connection usually consists of a turnout valve, turnout structure, and metering facility.

When a member agency requests a new or modified service connection, Metropolitan normally provides plans, specifications, equipment, and materials, then helps construct the connections.

TABLE 13

METROPOLITAN DISTRIBUTION SYSTEM
FILTRATION PLANTS

Plant	Process	Current Design Capacity Million gallons/day (mgd)
Jensen plant, Granada Hills	Filter State Project Water	400
Weymouth plant, La Verne	Filter Blend CRA/State Project Water	400
Skinner plant, Winchester	Filter Blend CRA/State Project Water	320
Diemer plant, Yorba Linda	Filter Blend CRA/State Project Water	400
Mills plant, Riverside	Filter State Project Water	75

This fiscal year, Metropolitan completed three new major service connections, made significant modifications to one connection, and enlarged another's capacity.

Service Connection LA-30, on the Sepulveda Feeder, was completed on March 29, 1989. This new connection has a design capacity of 100 cubic feet per second (cfs) and provides additional service to Los Angeles Department of Water and Power's Marina del Rey, Los Angeles Airport and Los Angeles Harbor areas.

Construction was completed May 18, 1989 on Service Connection CB-16, an untreated water service connection on the Rialto Pipeline, which will provide a design flow of [illegible] cfs to the Cucamonga County Water District's new water treatment plant.

Service Connection CB-12 was completed in August 1988, and provided water deliveries that same month to test the new Chino Basin Municipal Water District treatment plant. Full service began in September 1988.

On June 5, 1989, staff completed installing a 78-inch butterfly valve at DWCV-4, an untreated water service connection off the second barrel of the Colorado River Aqueduct (Aqueduct). As a result, Metropolitan can now isolate flows to the Desert Water/Coachella Valley's Service Connections DWCV-4A through 4D and the Whitewater hydroelectric power plant without affecting Aqueduct flow.

A treated water service connection on the Lower Feeder for the city of Brea, OC-29, was enlarged in December 1988. This service connection originally had a design capacity of 10 cfs; the expansion now provides treated water at a design capacity of 15 cfs.

Operational Planning

Metropolitan has a well designed, flexible water distribution system. Numerous pipelines distribute water to different portions of the system. While weighing each water supply's availability and the effect on State Water Project (SWP) operations, staff plans activities to maximize delivery of the least costly water. Continually deciding on increases and decreases in the quantities taken from each source, staff determines the extent to which terminal reservoir storage should be utilized to most efficiently accommodate demand changes. Plans are developed weekly and reviewed daily.

During the year, Metropolitan's Operations Planning staff continued to participate in the development and review of Colorado River and SWP operations. During the first eight months of the year, California's water supply situation was deteriorating and it appeared that Californians would suffer a third year of continuous drought throughout the State. While Southern California's situation was buffered by the U.S. Secretary of Interior's approval for Metropolitan to divert up to 1.3 maf of CRW through Metropolitan's Aqueduct, numerous SWP contractors were facing serious supply shortfalls. In February 1989, facing mandatory contractor cutbacks by the SWP, Metropolitan reduced its order for State project water by 200,000 acre-feet to approximately 1.17 maf. During March 1989, above-average rainfall was received in the Northern California region resulting in the recovery of State conservation reservoirs. The State approved all SWP contractor orders and eliminated the proposed reduction in the agricultural water deliveries.

Although the water supply situation remained poor throughout most of the year, Metropolitan continued delivering water to its member public agencies at record levels. By carefully monitoring Southern California's water supply situation, Metropolitan continues to develop strategies that minimize the potential for delivery shortfalls to member public agencies.

Shutdowns and Service Interruptions

Metropolitan's water operations also involve filtration plant, pipeline, or reservoir shutdowns and planned service interruptions. This year, major shutdowns and interruptions included:

- The Foothill Feeder from Castaic Lake to Magazine Canyon was shut down from November 29, 1988, to March 17, 1989, so that the Newhall Tunnel could be sealed with a 19-foot diameter, 1 2-inch thick welded steel liner. The liner was installed from the Newhall Siphon to Magazine Canyon Shaft (See "Maintaining and Improving the Distribution System" page 32)

- On November 9, 1988, the State Department of Water Resources (DWR) reported a break on the SWP's East Branch at the Mojave Siphon, upstream of Silverwood Lake. The East Branch was shut down and investigations indicated the break was caused by corrosion failure of the prestressing wire that reinforces the pipe. By utilizing Metropolitan's distribution system's flexibility, overall deliveries to member agencies remained unaffected. Deliveries through the East Branch resumed on November 27, 1988.

- Two concrete panels collapsed on the San Diego Canal near the Lake View Pipeline. Collapsed panels are not uncommon and occur particularly in areas of settlement or high groundwater. Metropolitan forces replaced the panels and restored service within 72 hours of the March 2, 1989, incident.

- On March 6, 1989, a shutdown of the Box Springs Feeder was made at DWR's request to examine a potential leak located near the turn-out structure on the State system. Further inspection revealed two major breaks and considerable corrosion on exposed portions of the prestressing steel wire. Metropolitan staff, in cooperation with DWR, restored the line's structural integrity and service was returned to affected member agencies on March 11, 1989. DWR later affected permanent repairs through an emergency contract.

- The West Valley Feeder was shut down March 28, 1989, to allow an [illegible] with Calleguas Municipal Water District to modify [illegible] on CA-2. The modification included install[illegible] butterfly valve on CA-2's discharge manifold.

Ensuring Deliveries—Emergency Preparedness

Operations remained [illegible] three earthquakes during the fiscal year:

- June 10, 1988, located near Gorman, California; registered a magnitude of 5.2 on the Richter Scale, causing major damage to DWR's Edmonston Pumping Plant switchyard.
- December 3, 1988, located near downtown Pasadena, California; registered 4.5.
- January 16, 1989, located eight miles south of Malibu, California; registered 5.0.

During each of the quakes, Metropolitan's Emergency Operations Center (EOC) was activated. Located in the most earthquake-resistant area of the Los Angeles Headquarters Building, the EOC's primary purpose is to assimilate system status from the Eagle Rock System Control Center and inform and coordinate damage assessment teams. The EOC also maintains communications with local media and offices of emergency services.

Optimizing the System—Power Recovery

Adding 14 hydroelectric power plants to the distribution system in recent years has increased Metropolitan's ability to minimize or recover some of the energy costs required in CRW and State project water pumping operations. As shown in Table 14, these hydroelectric power recovery plants produced a total of 356,020,600 kilowatt-hours (kwh) this fiscal year. Although power plant inspection and maintenance continued throughout the year, careful rerouting of system flows minimized generation loss.

Water Deliveries and Sales

Water sales for fiscal year 1988-89 totaled 2,095,078 acre-feet, up 9 percent over last year. Of the total sales, 64 percent was treated water, 35 percent untreated water, and sales of reclaimed water constituted the remainder. Monthly water sales varied from approximately 116,622 acre-feet in February 1989 to a high of 221,775 acre-feet in June. The June 1989 sales figure established not only a new sales record for that month, but the highest monthly sales record in Metropolitan's history. In this fiscal year, new monthly water sales records were set in nine out of the 12 months.

Table 15 summarizes water use by Metropolitan's member agencies, while Tables 16 through 18 detail the types of water deliveries made to the member agencies during the past fiscal year and over the last 48 years.

Approximately 63,000 acre-feet of water were sold under the temporary in-lieu program. The program enhances conservation of imported supplies by substituting Metropolitan deliveries with water produced by local sources, thus providing greater water storage for future use.

Groundwater replenishment was generally suspended from July to November 1988 due to water supply constraints, then re-established in December 1988 through April 1989. In May 1989, replenishment deliveries were again curtailed to ensure the filling of Lake Mathews Reservoir. Groundwater replenishment deliveries totaled 106,941 acre-feet.

The Interruptible Water Service Program encourages member agencies with reservoirs or groundwater basin supplies to hold water in reserve. When a member agency maintains reservoir or underground facilities capable of compens... for Metropolitan service interruption ...r reductions, it may p... the interruptible portion of its water su... at a lower rate. M... that replenish groundwater basin... spreading ... are also eligible. Similarly, member agencies ... buy ... deliveries made from surplus supplies at ... reduced ... In M... Metropolitan's Board of Directors determ... that all ... requests for interruptible water deliveries du... the ... could be met. Table 19 shows a 40-year hist... of ... member agencies for underground replenishme...

During N...ber 1988, in response to the State's continuing dry conditions, Metropolitan for the first time issued the required one-year advance notice to agricultural water users participating in the Interruptible Water Service Program that Metropolitan could be required to curtail service. The one-year advance notice allows agricultural users to adjust cropping patterns before interruption. However in April 1989 improved supply conditions enabled Metropolitan to cancel the notice.

Maintaining the Systems

The Aqueduct System

Colorado River Aqueduct pump plant personnel involved with the plants 24 ... carefully plan, coordinate, and execute flow ... and provide consistent pumping at ... responsibility for continually monitoring and ... and power dispatching operations.

... involving a wide spectrum of skills ... specialized Aqueduct pump mechan... overhaul major electrical and hydrau... pumps, and electrical motors, wh... maintain power transmission lines a... sand from the Aqueduct and ... flows to reduce aquatic plant growth ... carrying capacity.

Maint... the Distribution System

... fiscal year included:

- ... was installed over the Palos Verde... helps maintain an adequate lev... foreign material intrusion into the ...

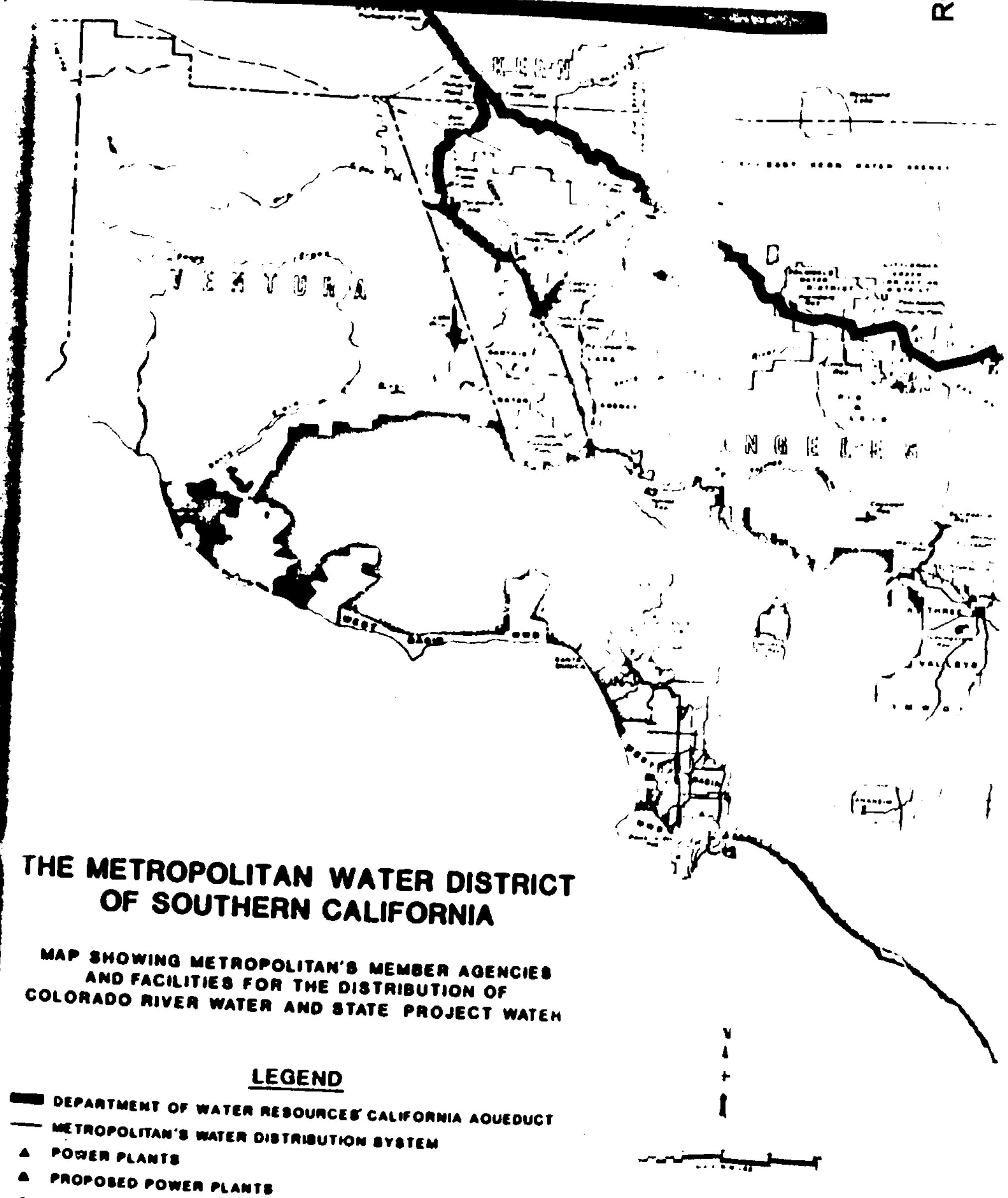


Figure 5. Met...tan's Member Agencies and Facilities for the Distribution of ...orado River Water and State Project Water

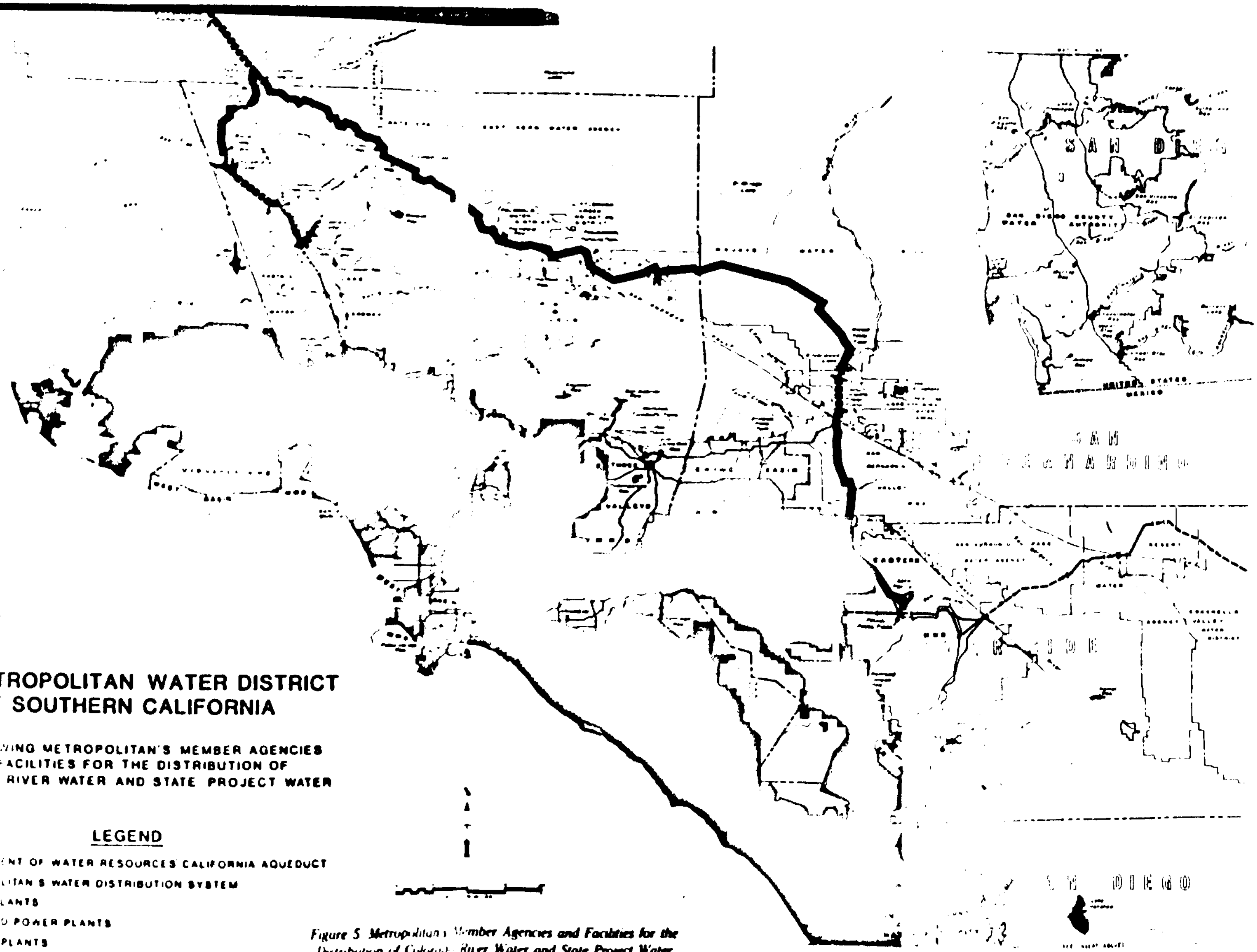
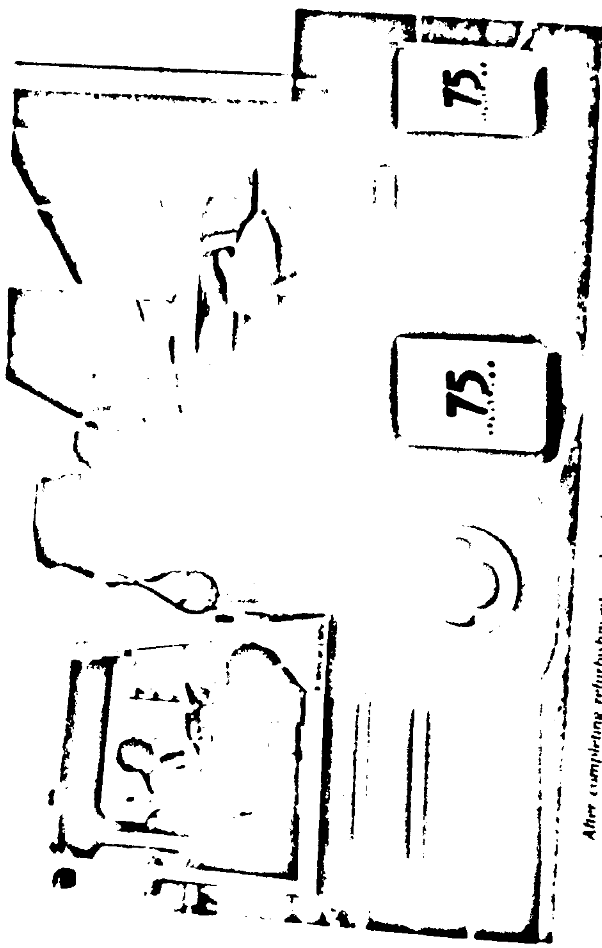


Figure 5 Metropolitan's Member Agencies and Facilities for the Distribution of Colorado River Water and State Project Water



After completing refurbishment work at LaVerne, an impeller and shaft assembly are ... one of Metropolitan's pump plants

- The Foothill Feeder Lining Project was started at the end of November 1988 and continued until mid-March 1989. Spanning 2,940 feet, the 19-foot diameter, welded steel liner was installed to prevent crude petroleum from continuing to seep into the tunnel from the surrounding oil-bearing strata. Since completing the liner installation and reactivating the Joseph Jensen Filtration Plant, no trace of petroleum odor or oil sheen has been evident in the plant's source water or anywhere throughout the plant.

- Installation of a security monitoring system at Pleasants Peak communication facility was completed in February 1989. Closed circuit television monitoring equipment was installed and placed in operation at the Eagle Rock and Soto Street facilities.

- The Board granted authorization in May 1989 to proceed with the preliminary design phase of the new Operations Control and Maintenance Center at Garvey Reservoir.

- Diemer Modification Project work included installing various piping, chlorine, and flow metering systems designed to increase the Robert B. Diemer Filtration Plant capacity.

Rehabilitating An Aging System

Colorado River Aqueduct Pump Rehabilitation Program

A 1985 evaluation of the condition of the five major pumping units that bring CRW to Metropolitan's service area revealed that many of the units installed during the original construction of the Colorado River Aqueduct were nearing the end of their useful life. As a result, last year Metropolitan began an extensive five-year program to rehabilitate each of the nine pump units at all five pumping plants. Restoring all the pump units to their original efficiency should result in approximately a 6 percent power or $2 million annual savings, based on delivery of 550,000 acre-feet of CRW. Transformer rehabilitation should generate an additional operating efficiency savings of approximately $88,000 annually.

Project Description

Each of the five pumping plants contains nine pump units and was designed to operate continuously with eight pumps. The ninth pump, serving as a spare and intended to permit maintenance without interrupting plant service, was also included to provide additional pumping capacity during peak periods.

Each pump unit consists of four major components (electric motor, centrifugal pump, suction valve, and discharge valve) and various auxiliary systems and equipment. The horsepower, rotational speed, pump size, and impeller shape are engineered to provide pumping capacity of approximately 200 cfs. Figure 7 identifies the components of a unit.

The size and scope of the Aqueduct Pump Rehabilitation program includes: (1) designing and purchasing equipment, and replacing up to 35 bronze impellers, including one spare impeller for each pumping plant, (2) rehabilitating pump motors, discharge valves, pump system components, and bearings, (3) replacing motor temperature instruments at all pumping plants, (4) replacing vibration monitoring instrumentation, (5) installing acoustic flowmeter transducers in delivery lines at all plants and totalizing flowmeters at two plants, and (6) rehabilitating 11 main transformers at four plants.

Project Schedule

Planned in nine phases, the Colorado River Aqueduct Pump Rehabilitation Project (CRAPRP) will be completed in 1992. Phase I was concluded in July 1988 and included Unit No. 5 at Intake, Unit No. 1 at Gene, Unit No. 3 at Iron Mountain, Unit No. 3 at Eagle Mountain, and Unit No. 1 at Hinds.

During the 1988-89 fiscal year, Phases II and III of the CRAPRP were completed. Phase II ran from September 6, 1988, to February 29, 1989. Phase III was started March 6, 1989, and completed on June 29, 1989.

Project Management

During Phase II, staff determined that the system used for documenting the time, equipment, and resources of the identified 800 individual tasks for each project phase was inadequate for the project's needs. Because of this, staff consolidated task progress sheets, used during Phases I and II to identify each step of the 800 repair procedures, to simplify tracking costs and project schedule development. Additionally, a new project scheduler program was implemented. Weekly coordination meetings were held as Phase II and III work progressed to adjust the schedule, as required, and plan remaining work.

In order to maintain the Phase II and III schedules, Metropolitan contracted for supplemental laborers, as was done in Phase I, to work with its crews at the pump plants and Metropolitan's shops in La Verne. The supplemental laborers included machinists, welders, and millwrights.

As with Phase I, the first major task facing the crews during Phases II and III involved installing a bulkhead in the discharge pipeline of each unit being worked on in that phase. Once installed, the bulkheads allowed

the other units on the affected delivery line to resume normal operations while preventing back flow into the plant and protecting the crews during the pump rehabilitation work.

Prior to the complete disassembly of each unit, alignment and tolerance checks were made and recorded to determine proper clearances. Workers removed the pump impeller assembly from the pump bowl and shipped it to Metropolitan's shops in La Verne. The new impellers were check balanced and corrected as required. Figure 8 outlines the major work completed on the pump and discharge valves.

While shop work was in progress, desert crews sandblasted then coated the pump bowls, and installed vibration monitoring probes and computerized monitoring equipment. Discharge valve bowls and plug valves were also sandblasted then coated. To provide additional protection to the plug and housing, corrosion protection devices were installed on the discharge valve plugs at Eagle Mountain and Hinds. Replacement stationary seal rings were bored in place in preparation for final impeller assembly installation.

Figure 9 outlines the major work completed on the motors. The main and pilot exciters were shipped to La Verne where they were cleaned, machined, balanced, and electrically tested. All rotors and stators were inspected, solvent cleaned, repaired, coated, and electrically tested.

Rehabilitation of the final General Electric transformer for Gene Bank 1 and the first of four Iron Mountain Bank 1 transformers was completed this year by McGraw Edison. The remaining three General Electric transformers at Iron Mountain are scheduled for rehabilitation by McGraw Edison during next fiscal year. For refurbishment, the transformer units are disassembled and the coils removed from the old core. Before the coils are reinstalled into the new core, the old core is structurally modified. The core and coil assembly is placed in an oven for three weeks to dry completely, then is tested and returned to service.

Testing and Evaluation

At the end of each phase, engineers, technicians, consultants, and workers conducted performance testing at each plant. Before starting a motor, a preliminary check ensures a free-running unit. Once the pump and motor have passed the checkout phase, performance testing begins. Over 270 measurements are taken to obtain data on suction and discharge pressure, vibration, flow, temperature, and electrical energy use.

Evaluation of the repairs made to the units during the first three phases revealed that repairs and modifications prevented future unit outages and increased Aqueduct flow by approximately 40 cfs.

Phase IV, scheduled to begin on August 28, 1989, will involve Intake Unit No. 1, Gene Unit No. 6, Iron Mountain Unit No. 2, Eagle Mountain Unit No. 6, and Hinds Unit No. 3.

F. E. Weymouth Filtration Plant Rehabilitation

The F. E. Weymouth Filtration plant was constructed in 1941, and expanded in both 1949 and 1962. In 1967 and 1973, modifications modernized the plant to filter State project water and helped rehabilitate the chlorination system, roads, and parking areas. But operating problems in the areas where the plant was not rehabilitated had been increasing due to equipment aging. Consequently, a study was undertaken to develop a plan for all work required to maintain operating reliability, improve process control, automate the plant, and bolster energy management. All equipment was inspected, the operating and maintenance history reviewed, and test and evaluations made prior to the final recommendations.

The study showed that some of the equipment was worn, vibrated too much, and required excessive maintenance, calibration, and part replacement. Equipment maintenance and repair posed a major problem due to the unavailability of spare parts. In addition, some of the old equipment is incompatible with plant automation.

Based on the detailed study, a modification program consisting of 30 projects was approved in late May 1985. Basically, all projects are concerned either with instrumentation, modernizing flow measurement devices, or handling emergencies to ensure noninterruptible service. Specifying the time required for the modification work proved extremely difficult because scheduling required plant shutdowns and close coordination with plant operations. But the project work was estimated to be accomplished over a five-year period. Metropolitan personnel oversee the design and purchase of materials and equipment and construction of the modification work.

During the fiscal year Metropolitan personnel continued with the design work, equipment and materials procurement, and installation and construction work at the plant. Of the 23 individual projects at the beginning of the fiscal year, six have been completed. Engineering design has been completed and the required equipment has been delivered or ordered for eight of the projects; construction is progressing for three of those projects. Design work is nearing completion for the remaining eight projects.

TABLE 14

HYDROELECTRIC POWER RECOVERY PLANTS

1987/89 Production

Power Plant	Design Capacity (Megawatts)	1988-89 Production (kwh)	1987-88 Production (kwh)
Greg Avenue	1 0	5,040,000	4,809,600
Lake Mathews	4 9	38,880,000	32,670,000
Foothill Feeder	9 0	35,616,000	52,968,000
San Dimas	9 9	64,242,000	41,310,000
Yorba Linda	5 1	32,196,000	30,732,000
Sepulveda Canyon	8 6	44,061,600	50,262,000
Venice	10 1	21,816,000	34,056,000
Temescal	2 8	19,992,000	20,829,000
Corona	2 8	19,644,000	20,493,000
Perris	7 9	20,772,000	19,395,000
Rio Hondo	1 9	10,180,000	11,434,000
Coyote Creek	3 1	17,805,000	17,118,000
Red Mountain	5 9	24,840,000	8,730,000
Valley View	4 1	936,000	7,644,000
		356,020,600	352,450,600

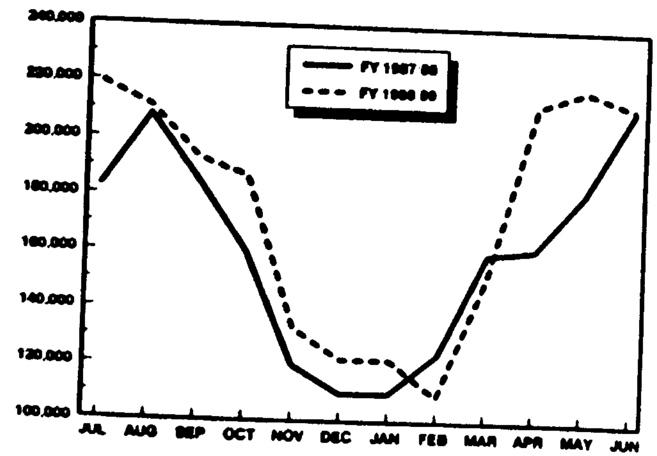


Figure 6. Monthly Water Demand

TABLE 15
WATER USE BY METROPOLITAN'S MEMBER AGENCIES
Fiscal Year 1988-1989
(Acre-Feet)

Member Agencies	Local Production	Adjusted Local Supply*	Metropolitan Deliveries: Direct Deliveries	Metropolitan Deliveries: Replenishment Deliveries**	Metropolitan Deliveries: Total Deliveries	Total Water Use
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Las Virgenes MWD	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Long Beach	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Los Angeles	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
MWD of Orange County	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Pasadena	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
San Diego CWA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Fernando	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
San Marino	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Santa Ana	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Santa Monica	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Three Valleys MWD	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Torrance	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Upper San Gabriel Valley MWD	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
West Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Western MWD of Riverside County	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	1 786 073	1 826 676	1 968 679	140 211	2 108 890	3 795 355

Notes:
* Adjusted for inter-member agencies' water transfers and includes reclaimed wastewater and MWD's Replenishment deliveries.
** Replenishment deliveries benefit other member agencies in the same groundwater basin.
[illegible]

TABLE 16
WATER DELIVERIES TO MEMBER AGENCIES
Fiscal Year 1988-89
(Acre-Feet)

Water Deliveries	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Fiscal Year Totals
Untreated Temp. In-Lieu Repl.													
Anaheim	—	—	—	—	—	—	—	—	29.7	2.1		—	31.8
Los Angeles	—	—	—	—	—	—	—	—	2 304.9	17 533.4	3 028.4	—	22 866.7
San Diego	—	—	—	—	—	—	—	—	1 345.3	4 417.0	715.8	—	6 478.1
TOTAL	—	—	—	—	—	—	—	—	3 679.9	21 952.5	3 744.2	—	29 376.6
Treated Temp. In-Lieu Repl.													
Anaheim	—	—	—	—	—	—	—	—	815.5	2 762.1	440.7	—	4 018.3
Central Basin MWD	—	—	—	—	—	—	—	—	100.0	110.0		—	210.0
Fullerton	—	—	—	—	—	—	—	—	369.5	1 421.4	241.3	—	2 032.2
Las Virgenes MWD	—	—	—	—	—	—	—	—	44.0	44.0	31.1	—	119.1
Long Beach	—	—	—	—	—	—	—	—	—	175.0		—	175.0
Los Angeles	—	—	—	—	—	—	—	—	7 092.1	4 780.6	195.1	—	12 067.8
MWD of Orange County	—	—	—	—	—	—	—	—	2 142.6	6 023.4	571.6	—	8 737.6
Pasadena	—	—	—	—	—	—	—	—	550.0	1 100.0	180.0	—	1 830.0
Pomona Valley MWD	—	—	—	—	—	—	—	—	128.3	282.5	40.2	—	451.0
San Diego CWA	—	—	—	—	—	—	—	—	—	—	7.3	—	7.3
San Fernando	—	—	—	—	—	—	—	—	217.8	286.6	41.6	—	545.8
Santa Ana	—	—	—	—	—	—	—	—	45.0	236.0	60.7	—	341.7
West Basin MWD	—	—	—	—	—	—	—	—	984.3	1 156.4	373.4	—	2 514.1
TOTAL	—	—	—	—	—	—	—	—	13 060.9	18 378.6	2 182.8	—	33 630.3
Untreated Noninterruptible													
Anaheim	383.0	221.5	578.7	532.8	1 652.0	1 566.7	750.4	512.4	875.4	922.5	1 180.1	1 332.3	10 524.8
Chino Basin MWD	1 928.6	2 295.8	2 706.5	2 394.6	2 269.7	1 825.4	950.3	584.3	737.8	1 376.0	1 639.3	1 550.9	20 241.2
Eastern MWD	506.0	(87.0)	34.2	(324.7)	(417.3)	(441.9)	(314.1)	(193.8)	520.7	386.4	1 186.7	233.2	[illegible]
Los Angeles		—			1 100.0	—	—		—		8 294.8	14 525.9	23 920.7
MWD of Orange County	804.4	761.4	664.0	606.4	429.8	386.0	324.3	200.7	551.2	856.1	820.8	827.2	7 232.3
Pomona Valley MWD	1 804.5	1 760.3	1 443.2	1 378.7	969.8	982.5	1 333.3	1 165.6	1 136.2	1 551.0	1 770.1	1 898.3	17 193.5
San Diego CWA	26 634.3	26 873.4	24 996.2	20 240.7	13 440.0	8 697.4	10 614.4	10 220.3	22 620.9	22 353.4	41 401.3	28 815.0	254 915.3
Western MWD - Riverside	3 978.6	1 738.6	1 568.2	1 795.6	873.4	726.4	675.8	560.8	923.2	3 027.5	1 695.3	1 947.2	19 490.6
TOTAL	36 019.4	33 564.0	31 981.0	26 624.1	20 317.4	13 742.5	14 351.4	13 030.3	27 381.4	30 472.9	58 623.0	49 130.0	353 237.8

TABLE 16 (Continued)

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1988-89

(Acre-Feet)

Water Deliveries	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Fiscal Year Totals
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Upper San Gabriel Valley MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
West Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Western MWD – Riverside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Untreated Interruptible													
Anaheim	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Central Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chino Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Eastern MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Los Angeles	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 16 (Continued)

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1988-89

(Acre-Feet)

Water Deliveries	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Fiscal Year Totals
Untreated Interruptible (Cont.)													
Pomona Valley MWD	19.0	22.0	21.0	16.2	6.1	4.0	4.3	3.1	8.9	12.3	10.0	14.1	[illegible]
San Diego CWA	17,203.0	16,884.1	16,672.5	14,498.2	9,333.6	8,313.1	6,962.6	6,502.3	9,348.5	12,701.2	14,955.0	16,810.3	149,554.0
Upper San Gabriel Valley MWD	–	–				5,365.0	9,321.1	9,410.9	10,667.5	6,078.1	1,782.7	550.1	43,186.0
Western MWD – Riverside	3,016.3	2,886.3	2,740.7	3,387.3	1,525.2	1,270.1	601.4	1,427.6	2,660.5	2,279.7	2,277.6	2,501.3	26,656.2
TOTAL	38,300.5	35,173.8	32,230.2	30,986.6	13,453.9	24,567.8	30,743.0	30,110.3	27,726.9	31,606.0	26,734.2	34,512.4	363,153.0
Treated Interruptible													
Anaheim	607.0	600.0	503.5	208.7	545.3	74.9	5	4	888.7	951.0	389.4	312.3	3,550.5
Burbank	500.0	500.0	500.0	500.0	500.0	500.0	500.0	580.0	500.0	500.0	500.0	500.0	6,800.0
Calleguas MWD	1,064.1	984.6	1,224.9	1,016.2	1,275.5	1,211.9	875.0	858.6	984.2	1,382.1	912.9	1,097.7	12,800.2
Central Basin MWD	2,758.5	2,091.6	2,121.5	2,064.7	1,909.4	1,841.9	1,888.3	1,097.1	1,089.9	2,243.6	2,070.7	2,091.2	26,920.3
Coastal MWD	20.2	5.7	15.5	18.1	10.8	17.8	3.7	9.6	2.9	7.8	11.2	17.6	[illegible]
Compton	20.0	20.0	20.0	20.0	20.0	30.0	20.0		38.5	20.0	–	3.5	250.0
Eastern MWD	1,122.6	1,057.7	853.0	683.6	352.3	233.4	128.5	92.0	207.9	495.2	886.2	879.7	7,802.9
Foothill MWD	40.0	40.0	20.0	19.0	10.0	7.0	12.0	11.0	0.0	0.0	8.0	9.0	162.0
Fullerton	23.0	2.8	19.5	5	7.3	1.2	3.6	6	3.9	8.9	14.1	0.9	95.1
Glendale	805.0	785.0	708.0	630.0	456.0	400.0	400.0	460.0	513.0	552.0	604.0	675.0	[illegible]
Las Virgenes MWD	100.0	100.0	100.0	100.0	500.0	500.0	500.0	500.0	500.0	500.0	800.0	800.0	5,300.0
Long Beach	400.0	400.0	400.0	400.0	500.0	100.0	360.0	500.0	500.0	500.0	500.0	500.0	5,300.0
Los Angeles	6,487.4	6,408.1	5,756.7	5,628.1	2,140.0		–	–	–		–	–	26,438.3
MWD of Orange County	3,287.6	3,763.0	2,906.2	2,450.3	2,395.7	1,810.9	1,530.0	2,052.3	2,160.7	2,610.0	3,215.6	4,145.3	[illegible]
Pasadena	2,152.2	1,880.6	775.0	328.0	420.4	–	–	–		956.6	1,485.0		8,300.0
Pomona Valley MWD	104.0	104.0	94.0	52.0	47.0	31.0	10.0	10.0	42.0	52.0	62.0	104.0	[illegible]
San Diego CWA	9,224.4	9,469.7	9,556.7	8,171.9	5,061.5	3,992.4	3,225.5	3,141.3	4,574.0	6,794.6	7,400.5	8,758.5	[illegible]
Santa Ana	300.6	300.0	300.7	450.6	450.7	451.1	450.3	450.6	450.5	301.5	300.7	300.0	4,520.1
Torrance	600.0	600.0	300.0	300.0	300.0	310.0	200.0	300.0	300.0	600.0	600.0	600.0	5,300.0
West Basin MWD	3,203.4	3,383.4	3,248.3	3,458.8	3,180.9	3,209.3	3,083.9	2,811.6	2,850.0	2,986.2	2,867.3	3,005.7	37,269.6
Western MWD – Riverside	3,755.9	3,112.8	2,528.1	2,102.5	1,627.2	1,377.2	640.1	556.6	1,652.7	1,578.0	1,509.9	1,797.8	[illegible]
TOTAL	38,086.7	35,098.6	31,752.4	28,601.8	21,288.0	16,083.2	13,798.4	13,952.5	17,745.7	22,470.1	23,980.1	25,607.2	286,472.7

TABLE 16 (Continued)

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1988 89

(Acre-Feet)

Water Deliveries	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Fiscal Year Totals
Reclaimed													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Water Delivery Summary													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Reclaimed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GRAND TOTAL	219 864.1	210 433.2	197 295.2	188 551.1	120 446.4	120 731.8	123 106.4	114 329.1	156 784.4	216 314.6	220 389.0	220 844.6	2 108 889.0
Fiscal Year to Date (Cumulative)													
Untreated Spreading	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Treated Spreading	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Untreated Full Service	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Treated Full Service	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Untreated Interruptible	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Treated Interruptible	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Reclaimed	49.6	1 466.5	2 175.5	1 366.3	1 619.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
SUBTOTAL	219 864.1	430 297.3	627 592.5	816 143.6	936 690.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
TOTAL OTHER DELIVERIES					171.0	411.0	569.3	569.0	664.0	664.0	664.0	664.0	
ACCUMULATED GRAND TOTAL	219 864.1	430 297.3	627 592.5	816 143.6	936 861.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
PERCENT OF TOTAL	10	10	9	9	6	6	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

TABLE 16 (Continued)

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1988 89

(Acre-Feet)

Water Deliveries	July	Aug	Sept	Oct	Nov.	Dec.	Jan	Feb	Mar	Apr	May	June	Fiscal Year Totals
Member Agencies' Total Deliveries													
Anaheim	2 480.3	2 165.0	1 900.9	1 775.8	1 915.1	1 726.3	870.2	611.1	2 350.3	4 204.3	2 697.3	3 125.4	25 802.0
Burbank	2 372.9	2 321.1	2 166.2	1 876.8	1 801.2	1 527.8	1 566.2	1 320.0	1 448.5	2 071.4	2 081.8	2 201.8	22 775.5
Beverly Hills	1 436.7	1 446.0	1 275.6	1 282.2	1 065.3	1 048.1	1 329.7	883.5	1 116.8	1 315.5	1 344.2	1 369.3	14 593.7
Compton	362.6	548.2	491.2	470.1	381.2	431.2	361.5	304.9	381.4	428.5	442.5	562.0	5 132.7
Calleguas MWD	11 627.1	11 136.6	9 880.4	9 608.3	6 698.1	5 129.8	5 285.9	5 130.7	7 030.8	8 429.6	10 591.8	13 050.2	104 153.1
Chino Basin MWD	3 220.5	3 446.2	3 554.8	3 122.0	2 882.2	3 402.7	6 180.3	3 881.2	4 164.3	4 550.7	4 829.4	5 120.7	46 350.0
Central Basin MWD	10 799.3	11 127.5	8 961.0	8 075.2	6 667.8	13 853.7	15 792.8	14 786.2	7 782.5	14 471.3	10 958.1	17 667.7	141 019.1
Coastal MWD	4 661.6	4 626.0	4 146.1	3 864.2	2 980.0	2 646.0	2 527.3	2 498.6	2 796.6	4 286.5	4 210.3	4 518.2	43 802.8
Eastern MWD	6 562.8	6 385.8	5 641.3	4 088.3	2 475.0	1 939.1	1 716.8	1 411.9	2 589.0	3 961.8	5 412.1	6 758.4	48 490.3
Foothill MWD	1 410.5	1 243.9	1 054.8	1 036.6	716.9	643.5	567.5	499.4	682.5	956.2	970.6	1 164.8	10 891.2
Fullerton	1 858.2	1 872.5	1 560.2	1 341.3	761.4	688.7	521.3	462.9	1 453.3	2 639.0	1 606.2	1 579.8	16 212.8
Glendale	2 718.6	2 799.5	2 652.0	2 604.6	1 840.2	1 861.5	1 679.7	1 580.7	1 939.0	2 469.5	2 732.4	2 617.0	27 555.0
Las Virgenes MWD	2 472.0	2 390.1	2 189.5	1 678.4	1 400.2	1 490.5	1 348.1	1 016.2	969.9	2 058.4	2 298.9	2 401.5	22 032.7
Long Beach	4 384.4	4 874.6	4 407.9	4 010.1	3 188.5	3 379.5	3 332.3	3 051.8	3 190.7	4 214.1	4 366.6	4 690.1	47 788.0
Los Angeles	21 520.5	18 264.6	22 335.5	33 410.0	8 154.6	8 047.4	8 187.7	6 821.5	16 913.7	35 781.4	27 761.5	22 982.3	230 148.5
MWD of Orange County	26 980.2	21 523.5	25 138.1	20 434.7	14 406.1	11 643.1	12 018.9	10 142.2	15 974.2	25 474.3	24 909.6	27 314.1	244 095.0
Pasadena	3 154.7	2 798.3	2 409.8	2 441.6	1 380.5	1 324.4	902.7	801.2	1 341.1	2 568.6	2 660.2	2 709.1	23 928.2
Pomona Valley MWD	8 562.1	8 350.1	7 404.2	6 128.8	4 255.0	3 464.4	3 172.7	2 831.8	3 849.1	5 391.3	6 929.1	8 014.8	68 365.2
San Diego CWA	63 931.1	63 111.3	59 351.6	51 339.7	34 758.5	28 963.6	28 337.6	27 372.2	45 224.3	56 076.7	72 769.1	61 601.9	592 215.8
San Fernando	10.9			113.5	266.8	232.0	245.0	229.1	217.8	206.6	41.4	1.9	1 645.0
San Marino	17.5	1.4	7.2	22.7			1.3		39.7	64.3	75.9	103.0	333.0
Santa Ana	1 681.0	1 647.7	1 589.9	1 338.5	847.8	803.0	876.5	909.7	1 205.1	1 551.0	1 579.0	1 787.4	15 815.6
Santa Monica	823.4	865.8	872.8	780.3	695.2	736.1	741.6	591.2	777.7	886.6	976.9	1 163.0	9 882.6
Torrance	1 867.5	1 930.8	1 705.5	1 641.7	1 796.2	1 751.9	1 719.0	1 515.4	1 923.2	2 162.4	2 352.1	2 318.0	22 803.7
Upper San Gabriel Valley MWD	1 584.1	1 467.7	1 210.7	958.0	740.0	6 052.7	10 000.1	10 019.7	11 516.0	7 021.4	2 962.1	1 746.2	55 279.3
West Basin MWD	18 736.4	18 642.1	17 419.1	16 883.5	14 793.3	14 556.6	14 369.9	12 230.3	14 236.3	15 761.8	16 456.0	16 896.1	190 685.2
Western MWD — Riverside	12 665.6	9 459.5	7 961.7	1 931.9	4 423.3	3 689.6	2 237.8	2 772.3	5 464.8	7 360.8	6 212.9	7 696.1	71 860.3
GRAND TOTAL	219 864.1	210 433.2	197 295.2	188 551.1	120 446.4	120 731.8	123 106.4	114 329.1	156 784.4	216 314.6	220 389.0	220 844.6	2 108 889.0

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TABLE 17
WATER DELIVERIES FOR 48 YEARS

Water Deliveries	1941-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	Total
Treated Water											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pasadena	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Diego CWA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Fernando	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Marino	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Santa Ana	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Santa Monica	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Three Valleys MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Torrance	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Upper San Gabriel Valley MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
West Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Western MWD of Riverside Co	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Treated Water	13 702 529	975 177	940 660	912 172	1 062 125	1 119 443	1 144 804	1 248 737	1 322 482	1 355 347	23 783 476

TABLE 17 (Continued)
WATER DELIVERIES FOR 48 YEARS
(Acre Feet)

Water Deliveries	1941-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	Total
Untreated Water											
Anaheim	46 093	9 570	9 260	10 534	10 556	12 377	6 783	11 646	10 070	12 597	139 506
Central Basin MWD	1 736 085	6 495	29 999	2 436	1 500	40 625	21 495	44 501	34 542	44 001	1 961 679
Chino Basin	277 510	34 382	36 794	26 894	26 362	29 761	35 322	33 958	36 025	46 354	583 362
Eastern MWD	829 905	36 164	33 936	27 665	11 362	1 377	1 336	425	1 359	2 644	946 175
Fullerton	2 567										2 567
Los Angeles										91 758	91 758
MWD of Orange County	3 139 807	86 207	72 186	33 032	23 954	47 130	62 089	48 837	71 251	30 799	3 615 292
San Diego CWA	6 532 579	236 329	281 181	148 256	239 230	288 615	330 875	361 182	357 725	410 947	9 186 919
Three Valleys MWD	133 616	8 013	6 731	6 255	7 950	8 805	9 957	9 915	16 977	17 313	225 532
Upper San Gabriel Valley MWD	216 144	34 690	59 150	31 534	14 829		3 000	25 000	37 570	43 186	465 103
West Basin MWD	2 498										2 498
Western MWD of Riverside Co	611 761	35 983	33 413	27 584	28 867	26 371	30 138	37 397	33 201	46 147	910 862
Total Untreated Water	13 528 565	487 833	562 650	314 190	364 610	455 061	500 995	572 861	598 720	745 768	18 131 253
Reclaimed Water											
Coastal MWD	—	—				216	740	689	416	569	2 630
Las Virgenes			—	—		91	295	1 501	1 994	2 920	6 801
Long Beach	—							187	226	571	984
MWD of Orange County	—							1 949	2 860	3 715	8 524
Total Reclaimed Water						307	1 035	4 326	5 496	7 775	18 939
San Gabriel River Unit Deliveries	44 165	—									44 165
Special Contracts	532 556	1	2			60	41	3	5		532 668
Nonreimbursable Construction Water	13 700	587	987	207	1 210	874	305	1 503	670	694	20 737
Total Treated Water	13 702 529	975 177	940 660	912 172	1 062 125	1 119 443	1 144 804	1 248 737	1 322 482	1 355 347	23 783 476
Total Untreated Water	13 528 565	487 833	562 650	314 190	364 610	455 061	500 995	572 861	598 720	745 768	18 131 253
Grand Total	27 821 515	1 463 598	1 504 299	1 226 569	1 427 945	1 575 745	1 647 180	1 827 430	1 927 373	2 109 584	42 531 238
Annual Change (Percent)			3	-18	16	10	5	11	5	9	

TABLE 18
AGRICULTURAL WATER DELIVERIES

(Acre Feet)

Water Deliveries	1956-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	Total
Treated Water											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Treated Water	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Untreated Water											
Anaheim	586	194	[illegible]	126	115	118	[illegible]	94	64	41	[illegible]
Chino Basin MWD	20 363	[illegible]	588	[illegible]	444	444	198	[illegible]	459	[illegible]	21 818
Eastern MWD	[illegible]	16 218	20 132	16 646	[illegible]	[illegible]	1 338	425	1 359	2 911	[illegible]
Fullerton	23										21
MWD of Orange County	401 441	31 036	33 541	6 291	14 360	13 661	24 191	[illegible]	25 395	12 [illegible]	578 849
San Diego CWA	1 411 575	86 111	51 754	44 429	61 [illegible]	59 613	62 027	65 334	[illegible]	61 554	1 951 264
Three Valleys MWD	28 544	141	179	124	141	152	141	[illegible]	168	14	29 893
Western MWD of Riverside Co.	433 862	21 [illegible]	21 892	19 154	21 916	19 436	21 444	21 [illegible]	19 [illegible]	25 [illegible]	631 742
Total Untreated Water	2 9[illegible]	141 [illegible]	134 821	89 [illegible]	[illegible]	94 861	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	146 [illegible]	182 459	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 19
WATER USED FOR UNDERGROUND REPLENISHMENT

(Acre Feet)

Member Agencies	Type of Replenishment	1949-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	Total
Anaheim	Temp. in Lieu	14 [illegible]	[illegible]			15 143	9 [illegible]					
Burbank	Temp. in Lieu	6 727	4 323							4 615	3 850	78 787
Calleguas MWD	Temp. in Lieu	2 464		—								11 050
Central Basin MWD	Temp. in Lieu	19 963	9 554							1 620		4 084
	Spreading	2 049 342	8 495	30 000	2 436	8 222	3 238			1 565	210	42 152
	Injection	66 797	4 107	4 859	5 198	1 501	40 625	21 495	44 501	34 542	44 001	2 274 938
Chino Basin MWD	Temp. in Lieu	14 771	5 317			4 024	4 724	4 610	6 958	6 538	5 599	113 414
	Spreading	44 263	15 565	19 042	13 188	61	84					20 233
Coastal MWD	Temp. in Lieu	671	190			13 777	12 188	16 330	13 609	15 636	7 407	177 005
Compton	Temp. in Lieu	496	442	—	—	354	701			411		2 327
Eastern MWD	Spreading	567	—	—		340	1,200					2 478
Foothill MWD	Temp. in Lieu	1 470	—	—								567
Fullerton	Temp. in Lieu	13 271	8 418	—	—		326	—				1 796
Glendale	Temp. in Lieu	5 550	4.094	—		9 501	2 927			2 770	2 412	37 299
Las Virgenes MWD	Temp. in Lieu		—	—	—	1 501	992			1 125		13 262
Long Beach	Temp. in Lieu	8 492	1 926	—						474	120	594
Los Angeles	Temp. in Lieu	5 443	4 596	—		6 022	848			1 361	175	18 524
	Spreading	79 542	9 713	—	—		4 951				35 335	57 325
MWD of Orange Co.	Temp. in Lieu	45 471	16 470	—								84 255
	Spreading	2 467 787	32 490	32 336	20 765	27 775	11 955			11 613	8 737	122 021
Pasadena	Temp. in Lieu	11 170	1 280			4 547	29 819	31 779	27 126	38 752	10 761	2 696 162
San Diego CWA	Temp. in Lieu			—			4 039			910	1 830	19 229
San Fernando	Temp. in Lieu	—		—	—	—		24 018			6 465	30 503
Santa Ana	Temp. in Lieu	3 707	1 686	—	—						546	546
	Spreading	17	—	—	—	1 243	529			653	342	8 160
Santa Monica	Temp. in Lieu	7 353		—		—	—					17
	Injection	2 267	1 188	554	2 141	467						7 820
Three Valleys MWD	Temp. in Lieu	7 444	3 502	—	—	1 845	131		2 251	1 822		12 199
Torrance	Temp. in Lieu	2 742	2 028		—	4 109		—			451	15 506
Upper San Gabriel Valley MWD					—	3 439	1 700					9 909
	Temp. in Lieu	1 002										
	Spreading	260 308	34 690	59 150	31 534	14 828	206					1 208
West Basin MWD	Temp. in Lieu	15 879	3 994			7 165	4 581	3 000	25 000	37 570	43 186	509 266
	Injection	476 700	30 988	28 282	36 710	38 257	34 738	25 730	31 602	1 230	2 514	35 363
										31 522	29 257	763 784
Total		5 656 067	212 759	174 223	111 972	164 127	193 599	102 944	151 045	194 429	203 218	7 164 383

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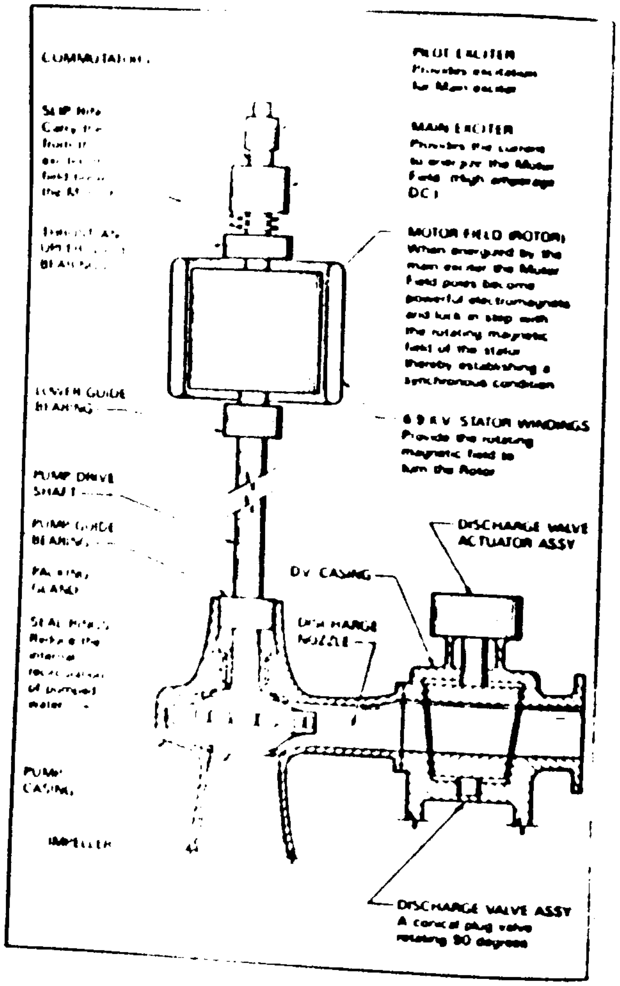


Figure 7. Components of a Pump Unit

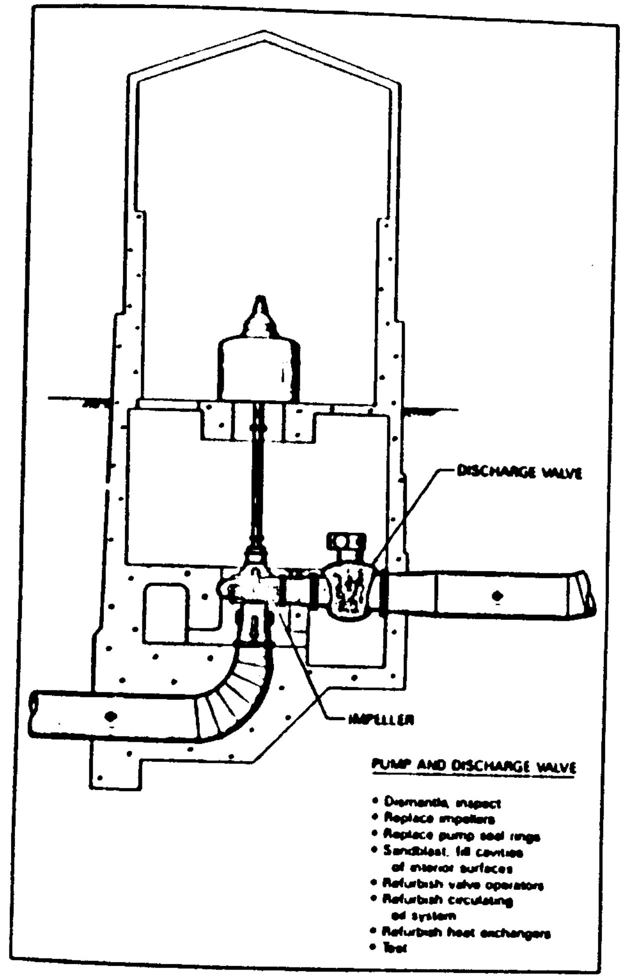
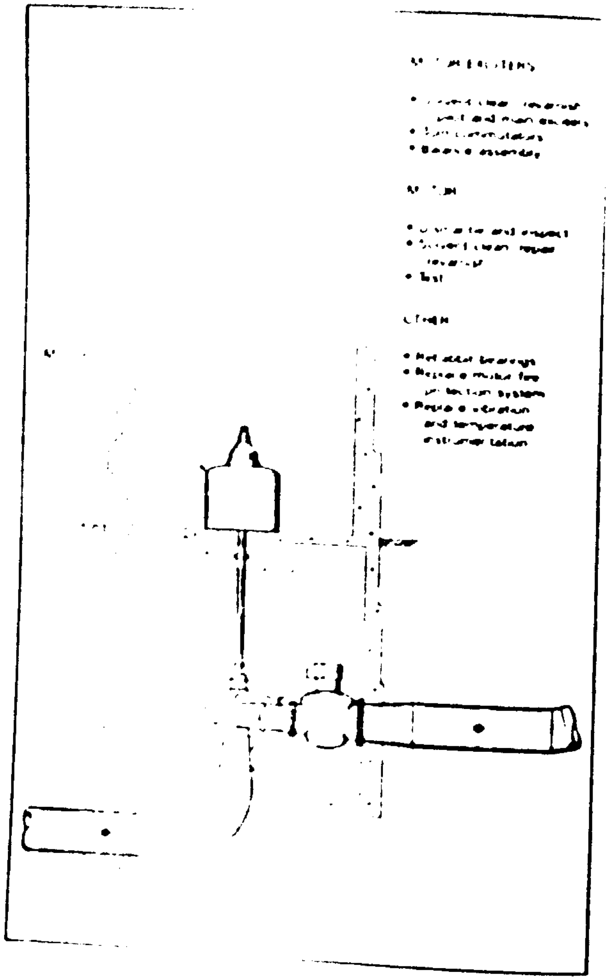
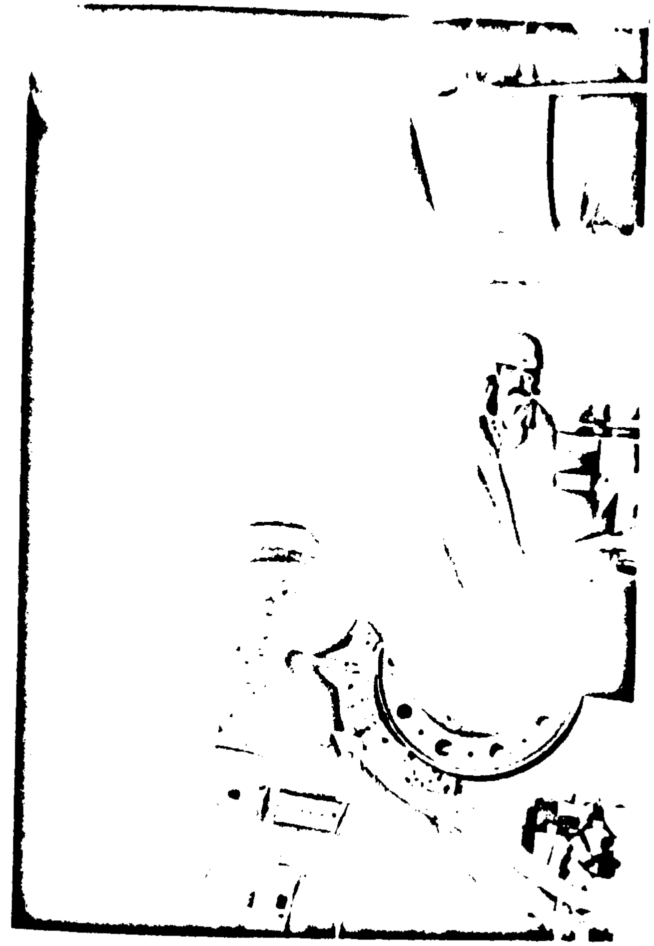


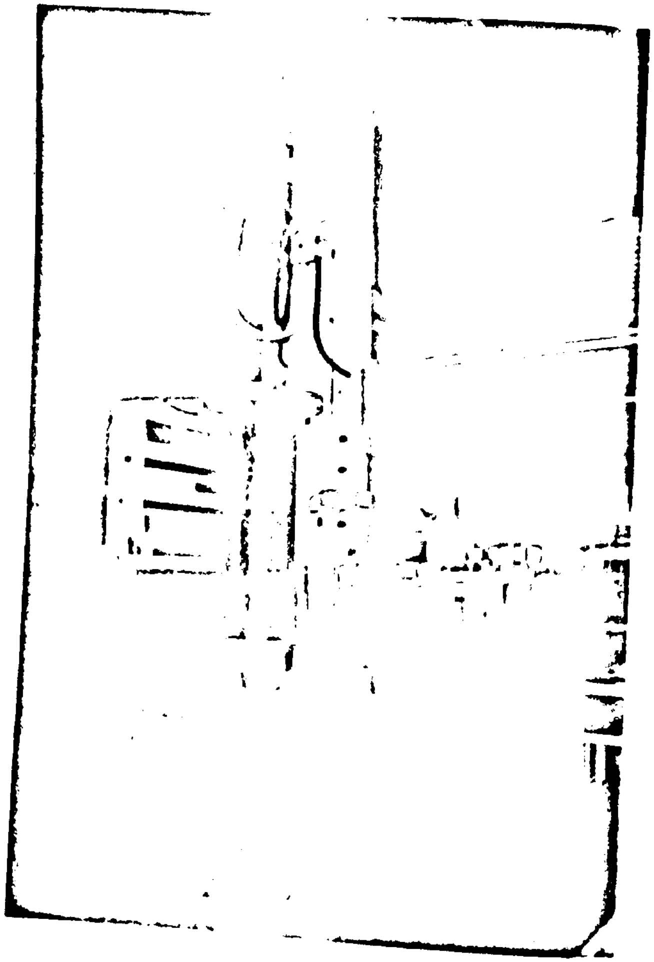
Figure 8. Rehabilitating a Pump and Discharge Valve



... Pump Motor



An intermediate shaft gets installed at one of Metropolitan's pump plants



... rehabilitation program.
... a final alignment check

CHAPTER 3

Water Supply Management and Development

Colorado River Water

During the year, Metropolitan exchanged 56,506 acre-feet of Desert Water Agency (Desert) and Coachella Valley Water District (Coachella) State project entitlement water with an equal amount of Colorado River water (CRW) from its predelivery account, drawing it down to a balance of 436,236 acre-feet by June 30, 1989. Metropolitan did not predeliver CRW to Desert and Coachella for Coachella Valley groundwater basin storage during the year.

Also during the year, 65 acre-feet of San Bernardino Valley Municipal Water District State project water was delivered to Metropolitan for an equal amount of CRW extracted from Lake Havasu by the Havasu Water Company.

State Project Water

State Water Contractors

Metropolitan, together with 27 other State Water Project (SWP) water contractors, formed State Water Contractors, Inc. (SWC) to further its members' common interests. SWC mainly conducts its work through the various committees which regularly meet to study and offer solutions to problems arising from the California Department of Water Resources' (DWR) management of the SWP. The following are the major committees and some of the matters in which they are involved:

- The *Future Water Supply Committee* works on the State's plans for developing and maintaining an SWP water supply that includes Sacramento-San Joaquin Delta (Delta) water management programs, Los Banos Grande Reservoir, and interim and long-term water purchases

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- The Kern ... [illegible] ... itself with all financial ... affecting the SWP ... allocating costs among ... contractors. ... the reports of the Technical Accounting ...
- The ... [illegible] ... composed of the DWR Contr... and ... firms representing the contra... project accounting procedures. ... the evaluation of DWR's pro... costs from the contractors.
- ... [illegible] ... watches areas which may need amen... contracts. Currently this committee is exam... a further contract amendment covering local ...
- ... [illegible] ... reviews DWR's activities in develop... ... SWP yield. Presently the Kern Water ...
- ... [illegible] ... provides DWR with the ben... experience in operations and main... ... is examining the California ... at Arroyo Pasajero.
- ... [illegible] ... ongoing right-of-wa... SWP facilities. Currently th... ... Enhancement and the plan...
- ... [illegible] ... look at power supplies an... ... includes evaluating th... supply costs.
- ... [illegible] ... relating to each contractor... committee is reviewing tw... SWP entitlement among ... Water District in the San ... Agency to increase its water ... relinquish some of its entitle...
- ... [illegible] ... reviews and assists DWR in ... working with DWR to develop ... costs of purchasing interim ... water contracts to allow ... for the purchases as an ... Delta Water Charge. DWR is evaluating

several water purchase sources including the Federal Central Valley Project (CVP) and a permanent agreement to purchase water from Yuba County.

Future Water Supply

DWR is actively planning to acquire further water supplies to increase SWP yield. Without additional water and facility construction to store the water the SWP will, in the very near future, be unable to meet water requests from the water contractors even in high or average rainfall years. The following are some of the most significant projects DWR is now examining.

- **Delta Facilities**—In the North Delta, DWR is seeking to provide a more efficient path for Sacramento River water through the Delta, reducing the water quality and fisheries problems currently associated with reverse flows. As the initial phase of the North Delta improvements, DWR proposes to increase the South Fork Mokelumne River flow capacity which will also provide flood control benefits for the surrounding Delta islands. In the West Delta, DWR, committed to meeting certain water quality standards, recommends constructing water conveyance facilities to the western portion of Sherman Island. Alternatively, DWR proposes to purchase island property and convert it to wildlife habitat. The South Delta's main problem lies in its channels' limited capacity, which leads to channel scouring when the SWP and CVP are maximizing their pumping simultaneously at a low San Joaquin River flow or at low tide. The low water levels also contribute to the poor South Delta water quality. Numerous alternatives are being studied, among them a modified Clifton Court Forebay gate, dredging in the channels, and a levee setback or enlargement of Clifton Court Forebay together with the channel enlargements. Other facilities which may be included in this project are various tidegate structures or a siphon at Tom Paine Slough, and connecting the CVP with Clifton Court Forebay.
- **Los Banos Grandes Reservoir**—An off-stream reservoir similar conceptually to San Luis Reservoir, this Reservoir is intended to store excess Delta flows, available primarily in the winter, for subsequent project use. DWR is currently refining its feasibility studies and will shortly be proceeding with the Federal and State environmental study process. A final Environmental Impact Report/Environmental Impact Statement (EIR/EIS) is expected in late 1991.
- **Article 10(h) Water**—Negotiations pursuant to Article 10(h) of the Coordinated Operating Agreement between the U.S. Bureau of Reclamation (Reclamation) and California, are continuing. Under the proposed agreement, Reclamation will provide an interim SWP water

supply of appro... feet per year. In turn, D... will wheel app... feet of CVP water. DWR a... Reclamation ... the environmental process a... a final EIR ... issued in mid-1991.

- Yuba Co... Yuba County Water Agency ha... begun ne... an interim water supply of up 200,000 a... the SWP from Yuba County Wat... Agency ... Reservoir.

Arvin-Edison Water Storage and Exchange Program

Arvin-Edison Water Storage District, a Kern County CVP contractor, and Metropolitan have proposed entering into a program whereby Metropolitan would ... a portion of its SWP entitlement to Arvin-Edison for storage in its groundwater basin. When needed, Metropolitan would then take Arvin-Edison's CVP surface water supply from the Delta and Arvin-Edison would pump the previously stored groundwater. The program would not adversely impact SWP operations or other SWP contractor entitlement deliveries.

DWR Business Information System

In developing a business information system, DWR plans to replace the present data processing system used in managing the SWP. The SWC has retained the two contractor auditing firms of Ernst & Whinney and Arthur Young to ensure that SWC needs for DWR information are handled by the new system. A joint report was prepared and transmitted to DWR ... The auditors will participate on DWR's internal ... staff to ensure that SWC needs will be considered ... and will provide assistance to DWR if required.

California Water ... Legislation

Legislation ... 1989 to reduce the SWP obligation to the C... ...bursing DWR for funds spent on recreation a... ...ancement facilities. In return, DWR will regul... ...transfers from the SWP to the California W... ...der of the obligation.

Suisun Marsh

The Montezu... Structure became operational in October 1988 and ... ...ed the control of Suisun Marsh salinity levels. Ad... ...plete the project, such as modifying the levees and ... be done in the coming year.

...P Financing

...n December 1988, DWR sold $9 million in Central Valley Project Water ...stem Revenue Bonds, Series E, to cover the reserve requirements for ...0 million bond issue Series D, sold in June 1988 to repay construction ...ts of various SWP facilities including the East Branch Enlargement. ...e Series E bonds are non-tax exempt since they are to be invested ...d held in trust over the life of the Series D bonds.

In March 1989, DWR sold $160 million in Central Valley Project Water System Revenue Bonds, Series F, to defease a portion of the Central Valley Project Power Facilities Revenue Bonds, Series G, which were for the Reid Gardner Project construction. This defeasance will reduce the debt service obligation of the SWP contractors by a present value of $12.2 million.

Regional Water Resources

Efforts to Expand the Use of Groundwater and Reservoir Storage

Member agencies received program assistance to expand current groundwater production to meet future regional needs. Expanded use of Southern California's groundwater and surface water storage is being accomplished through technical assistance to member agencies in five primary areas: water rates, local projects, cooperative conjunctive-use studies with member agencies, legislative and regulatory advocacy, and research and development funding.

Water Rates—Seasonal Storage Service

The Board of Directors has approved a permanent version of the Tem...rary In-lieu Program called the Seasonal Storage Service Program. ...offering water at a greatly reduced rate from October through April ...h year, the program provides incentives for member agencies to ...imize use of their local storage resources. The program is expected ...ead to the development of increased local production capacity by ...structing additional production, well-head treatment, spreading, and ...er facilities. Regional benefits include enhancing Metropolitan's ...ity to capture excess surface flows from both the State Water Project ...d the Colorado River and improving the region's capability to use ...re groundwater and reservoir storage during sustained droughts ...d emergencies.

Ground[illegible] Storage Programs

Chino Basin [illegible] Storage Program

Metropolitan [illegible] and held two public hearings for the [illegible] posed Chino [illegible] program. Comments made during the review focused primarily [illegible] program's influence on basin groundwater levels and groundwater [illegible], which has been deteriorating for many years and is predicted [illegible] continue to do so even without implementing the proposed program. The draft EIR helped alert local agencies to the groundwater quality problem's potential magnitude.

Metropolitan is assisting local Chino Basin agencies in developing approaches to improve basin management practices and deal with existing poor quality groundwater conditions. In this regard, Metropolitan has agreed to jointly fund a groundwater quality improvement study in the lower Chino Basin with the Santa Ana Watershed Project Authority (SAWPA). Also in response to a SAWPA "White Paper," the Chino Basin Municipal Water District and the Chino Basin Watermaster are attempting to expand the study to include the whole basin and incorporate groundwater quality monitoring. Additional efforts include jointly funding both a groundwater quality improvement study with the city of Pomona and the Santa Ana River Nitrogen study with numerous local and regional agencies. The most significant related effort, however, is the current development of Metropolitan's Seasonal Storage Program.

In the [illegible] additional basin management practices and improvement [illegible] developed, local agencies are acting individually [illegible] better use their groundwater resources. Metropolitan [illegible] participate with local agencies through its existing Chino [illegible] Storage Account, in which it has stored more than [illegible] Chino Basin Cyclic Storage Account which contains [illegible] state project water.

Calleguas Groundwater Study

Metropolitan and C[illegible] Municipal Water District (Calleguas) completed a draft report [illegible] improve groundwater resource use in the North Las Posas B[illegible] adjacent groundwater basins. A hydrogeologic evaluation [illegible] groundwater modeling study indicate that North Las Posas Basin [illegible] substantial storage capacity and that recharge and extraction are [illegible] feasible. Alternative means of replenishment and extraction were identified for staged expansion of existing facilities and development of new facilities. Analysis of the alternatives revealed that conjunctive-use programs would work effectively with application of Metropolitan's new seasonal storage service.

In related efforts, Metropolitan also provided technical assistance to [illegible]ct and store imported water in other Calleguas area groundwater [ba]sins. Working jointly with Calleguas and the city of Oxnard, Metropolitan initiated a small scale pilot injection test on the Oxnard Plain. Oxnard [pl]ans to use Metropolitan's new seasonal storage service to finance the project.

San Jacinto Basin Groundwater Storage Project

Metropolitan and Eastern Municipal Water District (Eastern) are jointly participating in a demonstration of groundwater spreading and storage in the San Jacinto Groundwater Basin. The project will involve groundwater recharge in the San Jacinto River bed and developing a groundwater model to assess quantitative and qualitative responses associated with conjunctive-use operations in the San Jacinto Basin. While coordinating the modeling study's joint funding options with Eastern and SAWPA, Metropolitan also is assisting Eastern in developing a phased construction plan for the recharge basins and a comprehensive groundwater monitoring plan to evaluate test operations. Eastern completed design of the spreading basin facilities connecting pipelines and monitoring wells and, at fiscal year end, had obtained all but one of the permits required for the project to proceed.

Conjunctive-Use Studies and Programs

Metropolitan and the Upper San Gabriel Municipal Water District are studying expanded use of the Main San Gabriel Basin under the *Main San Gabriel Conjunctive-Use Program*. A modeling study completed by a consultant demonstrated that the basin can physically accommodate significantly increased replenishment and extraction operations. Metropolitan assisted local basin agencies in reviewing the U.S. Environmental Protection Agency's (EPA) proposed plans to deal with extensive groundwater contamination under the Federal Superfund program. At fiscal year end, staff was formulating various conjunctive-use alternatives that would be compatible with EPA's program. Metropolitan also assisted the Main San Gabriel Watermaster with his appeal to the State Water Resources Control Board (SWRCB) to deny a permit for solid waste disposal in a gravel pit located in the basin's recharge area.

Under the *Raymond Basin Conjunctive-Use Study*, Metropolitan and the [city] of Pasadena have agreed to study the conjunctive use opportunities [in] the Raymond Basin. A consultant began collecting data describing [basi]n characteristics including basin geology, existing spreading facilities, [its] current operations of the basin's producers, and water quality [con]ditions in the basin. After completing a draft report on basin conditions [an]d background information, the consultant began identifying and [eva]luating conjunctive-use alternatives that will lead to better groundwater management in the [illegible] tives are being discussed [illegible] all of the basin wa[illegible] [illegible] which should be consid[illegible] further in Phase [illegible]

Metropolit[illegible] [illegible] Municipal Water District (Three Vall[illegible] and the cit[illegible] [illegible] studying expansion of La Verne's us[illegible] the Live Oa[illegible] [illegible] *Oak Conjunctive-Use Feasibility St*[illegible] A draft re[illegible] [illegible] geology consultant describes the bas[illegible] characteris[illegible] [illegible] condition. The parties are now formu[illegible] ing alterna[illegible] [illegible] recharge and extraction of imported water in light of the [illegible] institutional setting.

The [illegible] *Use Program* covers Metropolitan and Three Valleys evaluation of conjunctive use possibilities for the Glendora Basin high nitrate concentrations that have limited the city of Glendora's ability to produce groundwater. A basin management plan could allow Glendora to substitute local groundwater for imported Metropolitan water during drought years. A consultant is collecting and analyzing pertinent background information.

In coordination with the city of Glendale and the Crescenta Valley County Water District, Metropolitan is investigating means to increase Verdugo Basin groundwater production through the *Verdugo Basin* [illegible] Work progressed on developing an analytical model to evaluate the basin response to various conjunctive-use opportunities. [illegible] completed a conceptual model of the basin and is [illegible] model using historic data. Parameters to be [illegible] conductivity, specific yield, and boundar[illegible]

Metr[illegible] [illegible] to expand San Fernando Bas[illegible] conjunc[illegible] [illegible] that produce water from the bas[illegible] The EPA [illegible] [illegible] agencies to clean up contaminat[illegible] ground[illegible] [illegible] fund program. Conjunctive-u[illegible] scenari[illegible] [illegible] the clean up activities are bei[illegible] reviewed.

Water Exchan[illegible]

Sev[illegible] [illegible] arranged during the ye[illegible] tan a[illegible] [illegible] agreement between Metropo[illegible] of the late[illegible] Agency (SGPWA) to the Secreta[illegible] Metropolita[illegible] approved, the agreement perm[illegible] like amount [illegible] acre-feet per year of CRW for SGPWA with [illegible] water. This agreement provid[illegible] politan mor[illegible] otherwise receive and gives Metr[illegible] [illegible] water.

[illegible]scellaneous Projects

[illegible]etropolitan may establish a wheeling agreement with the Castaic [illegible] Water Agency (Castaic) through approximately seven miles of [illegible]ropolitan's Foothill Feeder. The agreement would allow Castaic to [illegible]ver part of its State project water entitlement to areas where Castaic [illegible] experiencing unprecedented growth through unused capacity in Metropolitan's system. Metropolitan would benefit by receiving revenue [illegible] its unused pipeline capacity. The price for wheeling the water is currently being evaluated and negotiations are underway with Castaic.

Metropolitan's role as a regional agency in groundwater management was presented at the Groundwater Information Management Workshop sponsored by the U.S. Geologic Service and at the Interstate Conference on Water Policy. Based on presentations and panel discussions, Metropolitan's activities place it at the forefront of establishing strategies for groundwater information management and sharing. While the smaller agencies were concerned with using computers to efficiently record and report data, the larger agencies focused on quality control in collecting and interpreting groundwater information.

Staff prepared a report on the Groundwater Remediation Activities in Southern California. Readily available information was collected and analyzed for 21 of the groundwater basins in Metropolitan's service area, described in individual basin profiles. Two major trends emerged: (1) an increasing number of groundwater contamination problems are being identified and (2) achieving successful groundwater remediation is increasingly difficult.

Metropolitan formed and hosted several meetings of the Groundwater Advisory Committee. The committee is composed of Metropolitan's management, groundwater resources staff, groundwater managers, and independent consultants from throughout Metropolitan's service area. At their bi-monthly meetings, participants evaluate and discuss political, managerial, water quality, and economic trends that impact regional groundwater production and management.

A research project was set up with the Orange County Water District [illegible]develop a practical and cost-effective method to remove nitrate [illegible]amination from groundwater. Biological denitrification is especially [illegible]ctive because it degrades nitrate into harmless compounds and does [illegible] require costly brine disposal facilities. Promising laboratory results [illegible] denitrification with a bench-top column colonized by autotrophic [illegible]eria led to the development of a pilot-scale laboratory test treatment [illegible] which will use local wellwater spiked with nitrate. To date, major [illegible]lusions find that hydrogen-based denitrification can be readily [illegible]ated and maintained under laboratory conditions and that nutrient[illegible]s found in typically high-nitrate groundwater will probably support

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microbes with the [illegible] of phosphate. These findings constitute an important [illegible] consideration for both wellhead and in situ processes.

Metropolitan [illegible] three-year sponsorship of the University of California at Los Angeles [illegible] Engineering Research Center (ERC) which will highlight [illegible] cross-disciplinary solutions to hazardous waste problems. The ERC focuses research efforts on the most beneficial proposals in the areas of soil and groundwater remediation, treatment and disposal, and [illegible] risk evaluation. Metropolitan considers the ERC an excellent [illegible] for transferring technology between different sectors and exploring [illegible] to expand new technological applications.

Report No. [illegible] is progressing and will update groundwater quality conditions and project the impact of proposed legislation, including examination of Superfund-type sites on groundwater in Metropolitan's service area. After gathering data from every available source, including the EPA Superfund data base, staff will now use the data to evaluate groundwater conditions in the service area. The report will be released during [illegible].

The State Division of Safety of Dams completed its review of the Morris Dam seismic evaluation which was prepared as required under the agreement with Los Angeles County to transfer ownership of Morris Dam and Reservoir to it. Among other things, the review concludes that the dam should be stable during the maximum credible earthquake on the Sierra Madre fault and would sustain a full reservoir without uncontrolled [illegible]. It is now planned to complete the Agreement's remaining steps so that Morris Dam may be promptly transferred to the County.

Local Projects Program

The original Local Projects Program was initiated in late 1981, deferred in 1983 due to Metropolitan's [illegible] constraints, and reactivated and revised in early 1986. Under the [illegible] Program, Metropolitan provides financial support to [illegible] develop local water supply projects that reduce demand for Metropolitan's imported supplies. Metropolitan contributes to qualifying projects [illegible] an equivalent amount of [illegible] energy cost for pumping [illegible] water. This amount may change yearly subject to a minimum payment of $75 per acre-foot. The contribution for fiscal year 1988-89 was $75 per acre-foot, which will remain the same next fiscal year.

The financial contribution is transferred to a member agency through a Joint Participation Agreement in which Metropolitan guarantees to purchase a project's yield at a rate equaling the sum of Metropolitan's reclaimed water or other appropriate rate and the annually adjusted

avoided energy cost. Metropolitan then sells the yield back to the member agency at the reclaimed water or other appropriate rate, thereby transferring to the project a net contribution by Metropolitan equal to the annually adjusted avoided energy cost. Under the program, Metropolitan has participated in two groundwater reclamation projects and [illegible] wastewater reclamation projects with a combined total ultimate yield of [illegible] acre-feet per year. Currently, 15 projects with a total estimated yield of 33,500 acre-feet per year are in various stages of review.

Original Program

In 1982, Metropolitan entered into a Letter of Intent to participate in the SAWPA-sponsored *Arlington Basin Groundwater Desalter Project*. In October 1988, Metropolitan executed a Joint Participation Agreement with Western Municipal Water District of Riverside County and SAWPA to develop the project. Under this project, approximately 6,300 acre-feet per year of high-salinity groundwater from the Arlington Basin will be desalted for local use. SAWPA awarded contracts for the desalination equipment and well construction. The project will involve extraction wells, organics-removal facilities, desalting facilities and connections to local water distribution systems. When the project is completed, Metropolitan will retain a right to 61,000 acre-feet of groundwater in the Arlington Basin.

Revised Program

During the fiscal year, two projects were approved and Joint Participation Agreements were executed. Joint Participation Agreements for two additional projects, approved in the previous year, were also negotiated and executed.

The *Lakewood Water Reclamation Project* Joint Participation Agreement has been executed. The project is sponsored by the Central Basin Municipal Water District (CBMWD) and is owned and operated by the city of Lakewood. The project would deliver approximately 400 acre-feet per year of tertiary-treated reclaimed water from the Los Angeles County Sanitation District's Los Coyotes Water Reclamation Plant through the city of Cerritos' reclamation system for landscape irrigation.

The *South Laguna Reclamation Expansion Project* Joint Participation Agreement also has been executed. Sponsored by Coastal Municipal Water District, this project will be owned and operated by the South Coast Water District (South Coast). The project expands South Coast's existing South Laguna Reclamation Project to which Metropolitan contributed capital funds under the original program. The expansion project will produce approximately 700 acre-feet per year of additional reclaimed water from the Aliso Water Management Agency's Coastal Treatment Plant for park, golf course, residential greenbelt, school yard, and highway landscaping irrigation.

The *Fallbrook R[illegible]* Joint Participation Agreemen[illegible] executed Own[illegible] by the Fallbrook Sanitary District ([illegible]D). the project is [illegible] San Diego County Water Authority (SD[illegible]A). The project [illegible] to 1,200 acre-feet per year of tertiary-tr[illegible]ed reclaimed [illegible] Water Reclamation Plant No. 1 for irri[illegible]on of freew[illegible] golf courses, and nurseries within the comm[illegible]ty of Fallbrook and the cities of Oceanside and Carlsbad.

The *[illegible] Reclaimed System Extension Project* Joint Particip[illegible]on Agreement has been executed between Metropolitan, Las Virgenes M[illegible]cipal Water District (LVMWD) acting individually, and LVMWD and Triunfo County Sanitation District acting as a joint venture. The extension project, owned by the joint venture and operated by LVMWD, will produce approximately 700 acre-feet per year of reclaimed water from the joint venture's Tapia Water Reclamation Facility for landscape irrigation. The Expansion Project is an addition to the joint venture's existing Las Virgenes Reclamation Project to which Metropolitan contributed capital funds under the original program.

Of the 15 projects currently under review for inclusion in the program, the following five projects are in advanced review stages. These five projects with a total ultimate yield of 3,722 acre-feet per year, are expected to be approved by Metropolitan's Board of Directors next fiscal year.

Negotiations continued with the *Buena Sanitation District* for the proposed SDCWA-sponsored Shadowridge Reclamation Project. The project [illegible] approximately 350 acre-feet per year of reclaimed water from [illegible] Water Reclamation Plant for golf course and [illegible]

An [illegible] *Expan[illegible]* [illegible] evaluation of the *Glendale Reclam[illegible]* Glendale [illegible] city of Glendale was complet[illegible] politan [illegible] participation agreement with Me[illegible] imately [illegible] expansion project would yield app[illegible] Glendale [illegible] reclaimed water from the Los Ange[illegible] [illegible] park, and landscape irrigat[illegible]

Staff [illegible] for the prop[illegible] Ramona Municipal Water Dist[illegible] this project [illegible] *Santa Maria Reclamation Project*. W[illegible] receive abo[illegible] [illegible] water distribution system wou[illegible] Maria Water R[illegible] of reclaimed water from the Sa[illegible] would then be [illegible] raw water-reclaimed water ble[illegible] golf course and [illegible] irrigation and potentially for futu[illegible]

Discussions are [illegible] with the Trabuco County Water Distr[illegible] for the proposed *[illegible] Reclamation Expansion Project* sponsor[illegible] by the Municipal Water District of Orange County. The project wou[illegible]

[illegible]oduce approximately 672 acre-feet per year of tertiary-treated reclaimed [illegible]ter from the Trabuco Wastewater Reclamation Plant for landscape and [illegible]lf course irrigation.

Metropolitan and the city of San Diego are discussing the proposed [illegible]DCWA-sponsored San Pasqual Aquaculture Project which would supply [illegible]pproximately 600 acre-feet per year of reclaimed water through an [illegible]novative treatment process using water hyacinths. The reclaimed water [illegible]ould be used for landscape and nursery irrigation purposes.

Miscellaneous Local Projects

A survey was performed to determine the amount of reclaimed water use in Southern California. The survey documented 43 existing or under-construction reclamation projects in Southern California which will ultimately deliver approximately 197,000 acre-feet per year of reclaimed water. This represents an increase of 27 percent over the 155,000 acre-feet per year of re-use documented by a 1986 study.

Metropolitan and CBMWD jointly agreed to conduct an implementation study to develop a project providing reclaimed water along the Century Freeway and to six neighboring communities for landscape irrigation purposes. The implementation study, conducted by HYA Consulting Engineers, will identify a project, a lead agency, service area boundaries, institutional arrangements, capital facilities, preliminary costs, and the available financial alternatives.

Program staff is participating on the Bay Delta Reclaimed Water Sub-Work Group Committee organized by DWR at SWRCB's request. SWRCB asked the committee to compile a report which defines water reclamation and estimates the State's potential reclaimed water use by year 2010.

Two draft reports examining the potential for groundwater storage [illegible]rograms were prepared. The "Background Information for a Mojave [illegible]Water Agency Groundwater Storage and Exchange Program" explores [illegible]he feasibility of storing water in the Mojave River Groundwater Basin, [illegible]nd the "Background Information for an Antelope Valley Basin Ground-[illegible]ater Storage Program" examines the possibility of storing water in the [illegible]ntelope Valley Basin.

CHAPTER 4

Water Quality

…gislation and Regulations

The U.S. Environmental Protection Agency (EPA) and the State of California Department of Health Services (DHS) have been actively promulgating regulations under the federal Safe Drinking Water Act (SDWA) Amendments of 1986. Additionally, the California legislature …duced a number of water-quality-related bills.

On August 18, 1988, the EPA proposed a revised maximum contaminant level (MCL) for lead, a new standard for copper, and monitoring and public notification requirements for both. Compliance monitoring in the distribution system for lead and copper standards was originally proposed, but the EPA is now considering requiring monitoring at the homeowner's tap, which could significantly impact water utilities. The final regulation is expected in winter 1990.

The EPA proposed drinking water standards for 30 organic and eight inorganic chemicals on May 22, 1989. These 38 substances are among the 83 chemicals for which the SDWA requires regulation. Metropolitan had submitted comments at the public hearing in July 1988. The final regulation is expected January 1991.

The EPA finalized the Surface Water Treatment Rule (SWTR) and the Total Coliform Rule on June 29, 1989, establishing filtration and disinfection requirements for surface water systems, a revised MCL for total coliforms, and coliform monitoring requirements.

At the State level, monitoring and compliance regulations for organic chemicals became final on January 3, 1989. The DHS finalized MCLs for … chemicals on February 28, for 10 more on April 3, and for three more between January and July 1989. Through the Ad Hoc Committee of the California-Nevada Section of the American Water Works Association (AWWA), Metropolitan reviewed numerous DHS drafts of the State's version of the SWTR.

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Metropolitan ... for the California legislature's att... to pass a water ... and State primacy bill. Assembl... Byron Sher ... 21 on December 5, 1988. This bill ... amendment ... compromise among interested parties ... currently ... the legislature.

California ... attempted several times to incorporate p... agencies ... utilities into the warning requirements of the Safe Drinking Water and Toxic Enforcement Act (Proposition 65). Although the current bill ... 65 authored by Senator Kopp, is encounter-ing little opposition as it moves through the legislature, a similar bill was vetoed by Governor George Deukmejian last year.

In its 1988 session, the California legislature passed a bill establishing an environmental laboratory accreditation program, effective January 1, 1989. Under this legislation, public water system tests that are required by law must be performed by accredited laboratories. For currently certified laboratories, the accreditation requirement begins when the existing certificates expire. The renewal process will now cover a period of two years instead of three and will be self supporting through accreditation fees. Metropolitan is ... accreditation for its five treatment plant ... Water Quality Laboratory.

General Water Quality

Metropolitan ... of the DHS primary standards and EPA MCL ...

For the ... solids ... the fiscal year average of total dissolved ... from ... at Lake Havasu increased ... (Figure ... 1987-88 to 560 mg/L in 1988-... 10 year ... approximately 60 mg/L below ...

As shown ... Joseph Jensen ... TDS value for the influent to the ... TDS concentration ... plant) was 334 mg/L—the highest ... yearly increase ... years and the fourth consecutive ... Branch of the ... State project water from the West ... December ... at Castaic Lake. However, from ... came from the ... water used by the Jensen plant ... Aqueduct. This ... of Water and Power's Los Angeles ... lower than the ... averaged approximately 100-150 mg ... water.

As seen in ... East Branch water ... average TDS concentration ... TDS value recorded ... Lake, 350 mg/L, was the highest ... since Metropolitan began using ...

... Branch water. For treated water at the five filtration plants, the ...ghted average TDS value was 456 mg/L – the second consecutive yearly ...ease and the second highest TDS concentration in the past seven years.

...ince Metropolitan changed to chloramines, the bacteriological quality ...water in Metropolitan's distribution system has remained excellent ...shown in Table 20, distribution-system samples tested by the ...mbrane-filter technique for coliform bacteria produced monthly ...rages ranging from less than 0.001 to 0.028 coliforms per 100 milliliters ...falling considerably below the DHS standard, which allows a monthly ...rage of up to one coliform/100 ml.

Because nitrification again occurred in several locations within Metropolitan's distribution system and finished-water reservoirs, Metro-politan formulated a comprehensive plan to reduce nitrification occurrence and impact in its facilities and those of its member agencies. The primary nitrification control strategies to be implemented in the next fiscal year include temporarily converting to free chlorination and increasing the ratios of chlorine to ammonia when using chloramines.

In May 1989, a memorandum on the "Criteria for Accepting Treated Groundwater into Metropolitan's System" was issued, defining the criteria that member agencies must meet if they propose to send treated groundwater through Metropolitan's distribution system.

The laboratory information management system (LIMS) has been completely implemented, and the system has received most of the samples that entered the laboratory after December 1988. Successful LIMS demonstrations and interaction with the water quality data base were conducted in October 1988 and June 1989. Improvements in the system's operation are now being considered.

Trace Constituents

...n November 1988, Metropolitan analyzed source waters and filtration-...nt effluents for 16 metals (Table 23). All concentrations of primary ...d secondary standard metals were substantially lower than the MCLs. ...ough a new primary MCL of 1 mg/L became effective for aluminum ...February 25, 1989, aluminum concentrations in Metropolitan's source ...ers and filtration-plant effluents have historically been much lower ...n that value.

...etropolitan continued quarterly monitoring of source and treated ...ers for volatile organic compounds (VOCs) at the sample sites listed ...able 24. The EPA set MCLs for eight VOCs in 1988 and for an additional ...n in 1989. As required by the EPA and DHS, Metropolitan also ...itored for a number of unregulated VOCs. Table 24 lists the regulatory ...rmation and minimum reporting levels (MRLs) for the VOCs. Except

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for trihalometha[illegible] [illegible] regulated or unregulated V[illegible] were detected [illegible] list the results of other anal[illegible] of Metropoli[illegible]

As in p[illegible] [illegible] monitored pesticides and agricul[illegible] chemic[illegible] [illegible] waters (Table 28). The revised Stat[illegible] Califor[illegible] [illegible] Regulations (Title 22), effective Jan[illegible] 1989 [illegible] [illegible] monitoring for six pesticides (lind[illegible] endri[illegible] [illegible] Silvex) that were regulated b[illegible] [illegible] has one year of consecutive quarterly d[illegible] [illegible] three years for lindane, endrin, toxaphene, and me[illegible] [illegible] will satisfy part of the requirement. Quarterly monit[illegible] 2,4-D and Silvex began in March 1989. Quarterly monitoring of five [illegible] pesticides for which MCLs had been set, as well as eight unregulated pesticides, began in June 1989. Table 28 lists the regulatory information and MRLs for pesticides and agricultural chemicals. Except for the unregulated pesticide Dacthal, no pesticides or agricultural chemicals were detected in any of Metropolitan's supply sources.

A consultant began work to determine radon levels in water from 200 wells located within the major groundwater basins in Metropolitan's service area. In addition, selected homes that receive 100 percent groundwater will be tested to determine ambient air and tapwater radon levels. The study, to be completed in August 1989, will provide data to address the upcoming federal radon regulations. Such regulations may impact the planning of Metropolitan's conjunctive use programs as well [illegible] demands if member agencies should abandon wells [illegible]

THMs and Other Disinfection By-Products (DBPs)

Metrop[illegible] of 0.10 [illegible] comply with the EPA and DHS MC[illegible] annual [illegible] As shown in Table 29, the running average [illegible] distribution system's four quarte[illegible]

To a[illegible] monit[illegible] Metropolitan expanded the THM requir[illegible] DBPs. Five analytical fractions we[illegible] haloce[illegible] haloacetic acids (HAAs), fo[illegible] chloral[illegible] chloral hydrate, cyanog[illegible] formalde[illegible] and acetaldehyde. DB[illegible] The THM [illegible] and State project water blend[illegible] by the HAA[illegible] fraction of DBPs formed, follow[illegible] and th[illegible] [illegible]triles or chloral hydrate (Tables [illegible] or were not de[illegible] [illegible] were formed at very low levels [illegible] and acetaldehyde were occasionall[illegible]

WATER QUALITY

d[illegible]ted in State project source water and were found to incre[illegible] distribution system. Also, higher levels of cyanogen chlorid[illegible] d[illegible]ted when using chloramine disinfection than were present w[illegible] chlorine disinfection.

Additionally, in June 1989, Metropolitan completed a two-year n[illegible]nwide study for the DHS and the EPA on the occurrence of these s[illegible] 21 DBPs, and is completing a treatment and control study of these c[illegible]pounds for the EPA. The largest DBP fractions were composed of THMs (national median of TTHM sums = 39 μg/L) and HAAs (national median of HAA sums = 19 μg/L). Study results also showed that utilities using free chlorine as a disinfectant typically exhibited higher DBP levels than utilities using chloramines, with the exception of the DBP cyanogen chloride. Utilities employing ozone had higher levels of the nonhalogenated DBPs formaldehyde and acetaldehyde. Also, the presence of bromide in source waters shifted the distribution of some DBPs from chlorinated to brominated species.

The results of these studies may enable utilities to predict the particular DBPs formed as a result of source-water quality, seasonal factors, and treatment processes. In addition, the results will help both the EPA to define the best available technology to set DBP regulations and the water utility industry to select treatment processes to meet DBP regulations.

In February 1989, the final report on "Optimization and Economic Evaluation of Granular Activated Carbon for Organic Removal" was finished and submitted to the AWWA Research Foundation (AWWARF). This completed a two-year bench- and pilot-scale study by Metropolitan and James M. Montgomery, Consulting Engineers, Inc. (Montgomery), on the use of granular activated carbon (GAC) to lower THM and other DBP levels. In summary, GAC adsorption proved expensive as a means to control THMs. Metropolitan's capital cost to use GAC, based on a capacity of 2,970 million gallons per day (mgd), would be $730 and $[illegible] million to meet future THM MCLs of 50 μg/L and 5 μg/L, respectively.

[illegible]th Montgomery's assistance and an AWWARF grant, pilot-scale [illegible] continued to evaluate the effectiveness of ozone and PEROXONE, [illegible] combination of hydrogen peroxide and ozone for removing taste and [illegible] compounds, inactivating microorganisms, and controlling DBPs. [illegible]lts obtained this year indicate that PEROXONE was significantly [illegible] effective than ozone alone in controlling taste and odor compounds, [illegible]ically 2-methylisoborneol (MIB) and geosmin.

[illegible] equivalent removals of MIB and geosmin, the ozone dosage required [illegible] PEROXONE at the optimum hydrogen peroxide/ozone ratio equaled [illegible]ximately half that needed for ozone alone. Preoxidation with [illegible]OXONE or ozone, each followed by chloramines, was found to

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effectively limit ... THMs and other DBPs. Finally, ... PEROXONE ... ozone ratio of 0.3 or less) and ... were found ... units against *Giardia muris*, bacte... viruses ... coliform and heterotrophic plate c... bacteria ... will continue through 1990, evalua... the impact ... changes on the ozone and PEROXO... processes ... most efficient process train over tim...

A demo... oxidation facility with a capacity of 5.5 mgd is being ... evaluate the ozone and PEROXONE treatment processes ... first phase concluded in January 1989, a five-month ... study reviewed worldwide ozone technology and recommended ... approach for the demonstration plant. The design phase, which began in January 1989, is expected to be completed by October 1989. The ... oxidation demonstration project should confirm the results of the pilot-plant studies, evaluate processes and equipment for the country's first large-scale application of PEROXONE for surface water treatment, and provide the information necessary to retrofit Metropolitan's plants with ozone/PEROXONE. Critical issues to be addressed include ozone dosage, hydrogen peroxide/ozone ratio, contact time, and application methods and locations. Also, investigators will determine the impacts of ozone and PEROXONE on existing downstream conventional treatment processes. The 12-month construction phase of the project, if approved by the Board of Directors, is expected to begin in March 1990.

Pathogen Monitoring Program

... were collected from Metropolitan's source and ... tested for the bacterium *Legionella* by an outside lab... Legionnaires' disease, an acute respiratory illness ... the like illness. *Legionella* was not d... source or finished-water samples.

In Ja... ...tered a collaborative study with the University ... Hampshire to detect enteric viruses in water ... technology represents a significant improve... for detecting viruses, as it is less expensive ... In this one-year study, samples will be ... and finished-water sites are analyzed ... probes and the traditional virus detection ... will be important for documenting Metropolitan ... as recommended in the SWT... *Giardia* ...

Metropolitan ... University of California, Irvine (UCI) to evaluate a ... detection procedure, "Colilert," which may identify ... more rapidly than currently used

...niques. In this one-year project, UCI will study Colilert's technique ...simultaneously detecting total coliforms and *E. coli*.

Reservoir Management

...kes Mathews and Skinner were once again affected by growths of ... blue-green algae that produce the malodorants MIB and geosmin. ... stem the growth of the taste- and odor-producing algae *Phormidium* ... and *Oscillatoria curviceps*, helicopters applied 86 tons of copper sulfate ... the lakes' shallow-water areas during the 1988 taste and odor season. As in past years, Metropolitan's divers conducted regular on-site inspection and sampling. Because of the efficient monitoring program and effective copper sulfate treatments, MIB and geosmin production remained low throughout the 1988 taste and odor season. Lake Perris, a California Department of Water Resources terminal reservoir for East Branch State project water, experienced very high levels of taste and odor compounds this season. Geosmin levels as high as 450 µg/L were produced during planktonic algae blooms. Consequently, water used by Metropolitan had to be withdrawn from the lakes' lower depths, where geosmin levels were much lower.

A testing program was initiated to determine whether chlorination effectively controls San Diego Canal algae growths, which reduce the canal's flow capacity. Previous work demonstrated that copper sulfate was ineffective.

Treatment-Plant Studies

In May 1989, a memorandum was issued entitled "Uniform Approach to Filtration-Plant Design Criteria," which defined process criteria for a "standard" Metropolitan filtration-plant process train. These criteria will be used in expanding existing plants, designing new plants, and reviewing the capacity ratings of existing plants.

... January 1989, Phase I studies, conducted jointly with the consulting ... CH2M Hill, Inc., began for the Robert B. Diemer Filtration Plant (...ner plant) uprating and the Henry J. Mills Filtration Plant (Mills ...t) expansion. The Phase I studies will evaluate existing plant facilities, ...s plant operation, and develop capacity ratings for the existing plants. ... results will be used in Phase II, which will evaluate the process ...rovements required to permanently uprate and maximize the Diemer ...'s rated capacity and will develop process design criteria for the ...her expansion of the Mills plant.

... April 1989, consultants Metcalf & Eddy completed the washwater ...mation study, and issued reports covering the results for the Jensen, ...ner, and Weymouth filtration plants.

In a related project, a pilot study was started in April 1989 to evaluate the Diemer plant [illegible] of filter air binding, which may limit the plant's uprated capacity. This study will evaluate the impacts of air binding on the filtration process with respect to supersaturation of dissolved air in the [illegible] entering the plant and the physical configuration [illegible] Diemer's filters.

In February 1989, staff began compiling a comprehensive data base of filtration performance (from 1982 to the present) at all of Metropolitan's filtration plants. These historical performance data bases will facilitate the plants' operation, upgrade, and conceptual design.

A project was initiated in June 1989 to determine whether Metropolitan's filtration plants will comply with the SWTR provisions that deal with water quality instrumentation, monitoring, and addition of coagulants to filter backwash water.

In December 1988, a Jensen plant study was finished, evaluating Jensen's filters with respect to turbidity removal, filter run length, headloss, and media condition. Results indicated that filter performance has declined over the past five to 10 years and that the filter media no longer meet Metropolitan's design specifications. To ascertain whether all of Jensen's filter media should be replaced, and to determine the optimal media configuration, a one-year test using four full-scale filters will begin at the Jensen plant in late 1989.

In April and May 1989, Jensen plant filter media were disrupted by hydraulic conditions created in the filter beds by operating the plant at high [illegible]. Recommendations were made to further [illegible] and develop a solution.

Operational Activities

A special data acquisition and transfer system utilizing microcomputers and specialized [illegible] developed to partially address the extensive SWTR filtration plant and water quality monitoring requirements. Each filtration plant laboratory is now equipped with a microcomputer, and plant personnel are evaluating software. A data transfer system for centralizing information within Metropolitan for assembly and submission to the DHS is expected to be operational by next fiscal year.

As required by the Federal National Pollutant Discharge Elimination System, 92 monitoring reports were prepared and presented to the Regional Water Quality Control Board concerning discharges of Metropolitan's water, wastewater, and sludge.

Assistance to Others

Metropolitan confirmed and recommended corrective measures to the City of Burbank, the Rowland Heights Water District, and the Municipal Water District of Orange County for nitrification problems occurring in their distribution systems or finished water storage reservoirs. Throughout the year, other member agencies and subagencies received assistance in resolving water quality degradation problems.

Approximately 100 people attended a seminar workshop presented by Metropolitan staff for two member agencies, the San Diego County Water Authority and the West Basin Municipal Water District, on the impact of nitrification on water quality and the effectiveness of nitrification control strategies.

Metropolitan organized and implemented regular meetings of the Member Agency Water Quality Directors to encourage information exchanges on water quality and regulatory matters between Metropolitan and its member agencies and subagencies.

Electric conduit work is done during the shutdown of the Venice Hydroelectric Power Plant

TABLE 20

BACTERIOLOGICAL EXAMINATIONS OF METROPOLITAN'S DISTRIBUTION SYSTEM

[illegible]

Membrane Filter Method

(100 ml Samples)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Mills Plant	Distribution System Summary: Total Number of Samples	Number of Positive Samples	No. Samples with 4 or more Colonies	% Samples with 4 or more Colonies	Total Number of Colonies	Avg. No. of Colonies per Sample
[illegible]	[illegible]	[illegible]	[illegible]	44	14	837	0	0	0.00	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	41	19	1,111	2	1	0.09	14	[illegible]
September	[illegible]	[illegible]	128	37	16	940	0	0	0.00	0	0.000
October	52[illegible]	283	136	31	15	992	0	0	0.00	0	0.000
November	435	233	127	28	15	838	0	0	0.00	0	0.000
December	484	215	131	22	16	868	3	0	0.00	0	0.000
January	485	224	128	38	14	889	0	0	0.00	0	0.000
February	484	214	119	17	12	846	1	0	0.00	0	0.001
March	554	253	135	39	10	991	4	1	0.10	28	0.028
April	480	247	128	36	16	907	1	0	0.00	1	0.001
May	566	328	152	33	18	1,097	1	0	0.00	0	0.000
June	501	328	133	22	17	1,001	0	0	0.00	0	0.000
Total	6,033	3,134	1,590	378	182	11,317	9	2	—	44	—
Annual Average	503	261	132	32	15	943	0.0008*	0.0002*	<0.02	–	0.004*

Note:
[illegible] coliforms to total number of samples

TABLE 21

BACTERIOLOGICAL EXAMINATIONS OF METROPOLITAN'S FILTRATION PLANT INFLUENTS

Fiscal Year 1966-67

Multiple Fermentation Tube Method (MPN*)

Month	Weymouth Plant Influent: Number of Samples	Percent of Samples Positive	Median MPN	Diemer Plant Influent: Number of Samples	Percent of Samples Positive	Median MPN	Jensen Plant Influent: Number of Samples	Percent of Samples Positive	Median MPN	Skinner Plant Influent: Number of Samples	Percent of Samples Positive	Median MPN	Mills Plant Influent: Number of Samples	Percent of Samples Positive	Median MPN
July	15	100.0	13	13	100.0	9	20	40.0	<3	15	86.7	29	13	84.6	13
August	19	94.7	17	17	82.4	4	23	87.0	240	23	56.5	7	17	100.0	22
September	15	100.0	33	15	100.0	39	21	81.0	93	19	78.9	33	16	87.5	32
October	16	87.5	15	16	93.8	17	21	52.4	<3	16	93.8	130	15	100.0	23
November	16	100.0	48	16	100.0	65	20	50.0	<2	18	83.3	20	15	100.0	49
December	15	80.0	180	16	81.2	135	21	47.6	<2	20	95.0	12	16	93.8	22
January	16	100.0	170	16	100.0	240	22	81.8	4	20	90.0	21	14	92.9	16
February	16	100.0	49	16	100.0	50	19	42.1	<2	15	86.7	13	13	91.7	[illegible]
March	18	100.0	74	16	100.0	80	19	57.9	2	29	44.8	<2	7	85.7	7
April	16	100.0	48	16	100.0	60	19	100.0	4	53	96.2	8	16	93.8	3
May	19	100.0	24	21	100.0	23	22	40.9	<2	29	70.8	17	17	76.5	8
June	16	100.0	67	17	100.0	30	24	45.8	<2	30	93.3	22	17	88.2	8
TOTAL	197			195			251			287			175		
Annual Average	16	97.0	48	16	96.4	44	21	60.6	<3	24	87.6	18	15	[illegible]	[illegible]

Note:
*Most Probable Number of Coliform Bacteria per 100 ml Sample

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TABLE 22

BACTERIOLOGICAL EXAMINATIONS OF METROPOLITAN'S FILTRATION PLANT EFFLUENTS

[illegible]

Month	Weymouth Plant No. of Samples	Weymouth Plant Percent Positive	Diemer Plant No. of Samples	Diemer Plant Percent Positive	Jensen Plant No. of Samples	Jensen Plant Percent Positive	Skinner Plant 1 No. of Samples	Skinner Plant 1 Percent Positive	Skinner Plant 2 No. of Samples	Skinner Plant 2 Percent Positive	Mills Plant No. of Samples	Mills Plant Percent Positive
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
October	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	0	[illegible]	0	[illegible]	[illegible]
November	16	0	16	0	15	0	23	0	23	0	15	0
December	17	0	16	0	16	0	25	0	25	0	16	0
January	16	0	16	0	19	0	24	0	24	0	14	0
February	16	0	16	0	15	0	25	0	25	0	12	0
March	18	0	16	0	18	0	30	0	31	0	10	0
April	16	0	16	0	40	0	30	3.3	29	0	16	0
May	19	0	22	0	33	0	30	0	30	0	18	0
June	[illegible]	[illegible]	[illegible]	0	26	0	30	0	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	201	0	200	0	249	0	301	0.3	301	0	182	0

TABLE 23

ANALYSIS OF TRACE METALS IN METROPOLITAN WATER SUPPLIES

Fiscal Year 1988-89

Values in Micrograms per Liter

SOURCE WATERS: Colorado River Water (columns 1–3); State Project Water (columns 4–6); Blended Water (columns 7–10)

Metal	Maximum Contaminant Level	Detection Limits	Source 1 [illegible]	Source 2 [illegible]	Source 3 [illegible]	Source 4 [illegible]	Source 5 [illegible]	Source 6 [illegible]	Source 7 [illegible]	Source 8 [illegible]	Source 9 [illegible]	Source 10 [illegible]	Filtration Plant Effluents: Weymouth Plant	Diemer Plant	Jensen Plant	Skinner Plant 1	Skinner Plant 2	Mills Plant
Aluminum	1000	5	20	58	74	72	113	8[illegible]	3[illegible]	164	[illegible]	129	110	113	79	194	225	115
Arsenic	50	1	2	2	2	2	3	3	1	2	2	2	2	2	2	2	2	2
Barium	1000	5	138	148	157	39	46	39	44	104	87	104	97	108	35	111	109	44
Cadmium	10	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	50	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	1000*	10	ND	ND	25	15	ND	ND	13	10	[illegible]	12	ND	ND	ND	ND	ND	ND
Iron	300*	20	ND	47	90	95	145	87	23	239	88	134	ND	ND	ND	ND	ND	ND
Lead	50*	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lithium		10	35	34	34	ND	ND	ND	ND	24	21	25	25	25	ND	25	26	ND
Manganese	50*	5	8	6	10	12	11	10	9	21	8	12	ND	ND	ND	ND	ND	ND
Mercury	2	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum		2	6	6	6	2	ND	ND	2	5	5	6	6	5	3	6	5	ND
Selenium	10	1	3	3	2	ND	ND	ND	ND	2	1	2	2	2	ND	2	[illegible]	ND
Silver	50	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Strontium		20	910	900	910	300	225	220	220	665	585	665	660	670	3[illegible]	685	660	225
Zinc	5000*	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

* [illegible] standard based on consumer acceptance rather than health considerations.

** [illegible] fiscal year averages; the other results are from samples taken in November 1988.

*** ND = None detected.

WATER QUALITY

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TABLE 24
VOLATILE ORGANIC COMPOUNDS
Quarterly Results
Micrograms per Liter (µg/l)

Location	Compound Detected	Aug 1988	Sept 1988	Nov 1988	Mar 1989	June 1989
Source Waters						
[illegible]	[illegible]	ND	ND	ND	0.23	ND
[illegible]	[illegible]	ND	ND	ND	ND	ND
[illegible]	[illegible]	ND	ND	ND	ND	ND
[illegible]	[illegible]	ND	1.2	0.94	7.8	1.3
[illegible]	[illegible]	ND	ND	ND	0.24	ND
[illegible]	[illegible]	ND	0.48	0.24	3.1	2.3
Filtration Plants						
[illegible]	[illegible]	ND	59	61	32	47
[illegible]	[illegible]	ND	68	86	30	65
[illegible]	[illegible]	ND	12	17	12	5.4
[illegible]	[illegible]	ND	75	53	45	71
[illegible]	[illegible]	NA	NA	NA	36	51
[illegible]	[illegible]	ND	67	52	29	54

Regulatory Information and Minimum Reporting Levels

Compound	CDHS Action Level (µg/l)	CDHS Taste and Odor Threshold (µg/l)	CDHS MCL (mg/l)	USEPA MCL (mg/l)	CDHS DLR (µg/l)	Metropolitan Minimum Reporting Levels: Aug 1988 (µg/l)	Sept 1988 (µg/l)	Nov 1988 (µg/l)	Mar 1989 (µg/l)	June 1989 (µg/l)
[illegible]					0.50	0.5	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.1	[illegible]
[illegible]					0.50	0.1	0.1	0.1	[illegible]	[illegible]
[illegible]					0.50	0.1	0.1	0.2	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]			[illegible]		0.50	0.1	0.1	0.5	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.2	0.2	0.5	[illegible]
[illegible]					5.0	2.0	1.0	1.0	1.0	[illegible]
[illegible]					5.0	1.0	1.0	1.0	1.0	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.1	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.1	[illegible]
[illegible]					0.01	0.01	0.01	0.01	0.01	[illegible]
[illegible]					0.02	0.01	0.01	0.01	0.02	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]			[illegible]		0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.2	0.2	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]			[illegible]		0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]			[illegible]		0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.2	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	[illegible]

TABLE 24 (Continued)
VOLATILE ORGANIC COMPOUNDS
Quarterly Results
Micrograms per Liter (µg/l)

Compound	CDHS Action Level (µg/l)	CDHS Taste and Odor Threshold (µg/l)	CDHS MCL (mg/l)	USEPA MCL (mg/l)	CDHS DLR (µg/l)	Metropolitan Minimum Reporting Levels: Aug 1988 (µg/l)	Sept 1988 (µg/l)	Nov 1988 (µg/l)	Mar 1989 (µg/l)	June 1989 (µg/l)
[illegible]					0.50	0.1	0.1	0.1	[illegible]	[illegible]
[illegible]					0.50	0.1	0.1	0.1	[illegible]	[illegible]
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			0.0005		0.50	0.1	0.1	0.1	0.5	0.5
[illegible]										
[illegible]			0.680		0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			0.680		0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					5.0	1.0	1.0	1.0	1.0	1.0
[illegible]	40.0				5.0	1.0	1.0	1.0	1.0	1.0
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			0.001		0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			0.005		0.50	0.1	0.1	0.1	0.5	0.5
[illegible]	100.0				0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.5	0.5	0.5	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			0.200	0.20	0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			0.032		0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			0.005	0.005	0.50	0.1	0.1	0.1	0.5	0.5
[illegible]	150.0				0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]					0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			0.0005	0.002	0.50	0.1	0.1	0.1	0.5	0.5
[illegible]			1.750		0.50	0.1	0.1	0.1	0.5	0.5

CDHS = California Dept. of Health Services ND = Not Detected NA = Not Analyzed
USEPA = U.S. Environmental Protection Agency NQ = Not Quantified
DLR = Detection limit for purposes of reporting MCL = Maximum Contaminant Level
# = The MCL for total trihalomethane (four compounds) is 0.10 mg/l

TABLE 25

METHYLENE-BLUE ACTIVE SUBSTANCES (MBAS) METROPOLITAN SOURCE WATERS

[illegible] May 1989

Location	Surfactants* mg/L
[illegible] Pumping Plant	<0.1
[illegible]	<0.1
[illegible]	<0.1
[illegible]	<0.1
[illegible]	<0.1
[illegible]	<0.1
[illegible]	<0.1

[illegible] 0.5 mg/L, a secondary standard [illegible]

TABLE 26

RESULTS OF GROSS ALPHA RADIOACTIVITY ANALYSES

[illegible] Mead and Havasu

[illegible]

Sample Month	Lake Mead Surface	Lake Mead at Takeout Depth	Lake Mead near Bottom	Lake Havasu at MWD Intake
July	[illegible]	[illegible]	1.0±1.1	0.6±1.5
August	[illegible]	[illegible]	1.5±0.7	2.0±0.8
September	[illegible]	[illegible]	2.5±1.5	1.3±1.2
October	[illegible]	[illegible]	2.3±1.6	1.8±0.8
November	[illegible]	[illegible]	4.0±1.7	5.9±2.0
December	[illegible]	[illegible]	1.9±1.1	3.1±0.6
January	[illegible]	[illegible]	2.7±0.4	0.8±1.6
February	[illegible]	[illegible]	2.0±0.9	2.4±1.3
March	[illegible]	[illegible]	3.0±1.1	1.6±2.3
April	[illegible]	[illegible]	Not Sampled	1.7±3.1
May	[illegible]	[illegible]	3.1±1.7	3.2±1.7
June	[illegible]	[illegible]	2.2±1.6	1.3±1.5
Average	[illegible]	[illegible]	2.6±1.2	2.1±1.5

[illegible] reported as ± 1.96 standard deviations [illegible] 15 picocuries per liter [illegible] for gross alpha radioactivity is [illegible]

TABLE 27

ANALYSIS OF METROPOLITAN WATER SUPPLIES

Fiscal Year 1988-89 Averages*

Unweighted Averages

CONSTITUENT	SYMBOLS AND UNITS	SOURCE WATERS: Lake Havasu near Whitsett Intake	San Joaquin Tunnel West Portal	Lake Skinner	Castaic Lake*	Silverwood Lake	Lake Perris	Lake Mathews	FILTRATION PLANT EFFLUENTS: Weymouth Plant	Diemer Plant	Jensen Plant	Skinner Plant 1	Skinner Plant 2	Mills Plant
Silica	SiO_2 mg/L	9.2	8.9	8.9	18.7	14.0	7.1	9.7	10.4	10.6	18.4	9.4	9.5	14.0
Calcium	Ca mg/L	70	69	68	30	22	18	53	58	58	30	53	53	22
Magnesium	Mg mg/L	26.5	26	26	15	16.5	14.5	22.5	23.5	24	14.5	22.5	23	16
Sodium	Na mg/L	78	78	77	64	77	58	76	77	77	67	76	77	79
Potassium	K mg/L	4.0	4.1	4.0	4.0	4.0	3.7	3.9	3.9	3.9	4.0	3.9	3.9	3.9
Carbonate	CO_3 mg/L	0	1	0	1	0	2	1	0	0	4	0	0	5
Bicarbonate	HCO_3 mg/L	160	159	159	122	100	96	137	144	144	120	138	139	96
Sulfate	SO_4 mg/L	225	223	222	55	43	39	164	184	185	57	165	166	45
Chloride	Cl mg/L	66	64	64	83	121	82	79	77	76	85	81	82	119
Nitrate	NO_3 mg/L	0.75	0.6	0.55	1.55	2.15	0.15	0.45	1.0	1.0	1.55	0.5	0.5	2.4
Fluoride	F mg/L	0.28	0.28	0.29	0.30	0.10	0.13	0.22	0.22	0.21	0.27	0.17	0.17	0.08
Boron	B mg/L	—	0.10	0.12	0.38	0.18	0.19	0.12	0.13	0.13	0.37	0.12	0.14	0.16
Total Dissolved Solids	mg/L	560	553	550	334	350	273	479	506	507	340	481	484	356
Total Hardness as $CaCO_3$	mg/L	282	279	277	136	123	105	225	241	242	135	225	226	124
Total Alkalinity as $CaCO_3$	mg/L	131	131	130	101	82	81	115	118	118	105	113	114	87
Free Carbon Dioxide	CO_2 mg/L	1.6	1.1	1.3	2.3	1.4	0.8	1.0	1.7	1.7	0.9	2.0	2.0	0.6
H^+ Concentration	pH	8.24	8.39	8.32	8.02	8.11	8.43	8.37	8.15	8.16	8.36	8.06	8.06	8.48
Specific Conductance	µmho/cm	882	882	880	591	648	510	796	832	832	623	800	804	655
Turbidity	NTU	1.41	0.71	1.1	1.3	2.1	0.63	2.0	0.12	0.12	[illegible]	[illegible]	0.13	0.11
Temperature	°C	20	20	18	14	16	19	19	18	19	14	19	20	18
Percent State Project Water		0	0	0	71	100	100	28	20	20	[illegible]	28	[illegible]	[illegible]

*Castaic Lake sampled at Jensen plant influent. Jensen plant was using 100% Los Angeles Department of Water and Power water from December [illegible]

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TABLE 28

PESTICIDE AND AGRICULTURAL CHEMICALS

Quarterly Results

Micrograms per Liter (µg/1)

Location	Compound Detected	November 1988	March 1989	June 1989
Source Waters				
[illegible]	None	ND	ND	ND
[illegible]	None	ND	ND	ND
[illegible]	None	ND	ND	ND
[illegible]	None	ND	ND	ND
[illegible]	None	ND	ND	ND
[illegible]	None	ND	ND	ND
Filtration Plants				
[illegible]	None	ND	ND	ND
[illegible]	None	ND	ND	ND
[illegible]	None	ND	ND	ND
[illegible]	None	ND	ND	ND
[illegible]	[illegible]	ND	ND	0.2
[illegible]	None	ND	ND	ND

Regulatory Information and Minimum Reporting Levels

COMPOUND	CDHS ACTION Level µg/l	CDHS MCL mg/l	USEPA MCL mg/l	CDHS DLR µg/l	Montgomery Labs MDL Nov 1988 µg/l	IT Analyt MDL Mar 1989 µg/l	MWD MRL June 1989 µg/l
Organochlorine Pesticides							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

WATER QUALITY

TABLE 28 (Continued)

PESTICIDE AND AGRICULTURAL CHEMICALS

Quarterly Results

Micrograms per Liter (µg/1)

COMPOUND	CDHS ACTION Level µg/L	CDHS MCL mg/L	USEPA MCL mg/L	CDHS DLR µg/L	Montgomery Labs MDL Nov 1988 µg/L	IT Analyt MDL Mar 1989 µg/L	MWD MRL June 1989 µg/L
Organophosphorus Pesticides (cont)							
[illegible]					1.0		
[illegible]	0.001			1.0	0.5	NA	NA
[illegible]					1.0	NA	1.4
[illegible]						NA	NA
[illegible]							
[illegible]					NA	NA	5.0
[illegible]					1	NA	NA
[illegible]					20	NA	NA
[illegible]	14.0				2.5	NA	NA
[illegible]	140.0				1.0	NA	0.5
[illegible]					0.5	NA	0.5
[illegible]	75.0				0.5	NA	NA
[illegible]					0.5	NA	NA
[illegible]	160.0				5.0	NA	NA
[illegible]					15.0	NA	NA
[illegible]					10.0	NA	NA
[illegible]					5.0	NA	NA
[illegible]		0.02		2.0	1.0	NA	NA
[illegible]	80.0				NA	NA	0.2
[illegible]	30.0				1.0	NA	NA
[illegible]					1.0	NA	NA
[illegible]					0.20	NA	NA
[illegible]					1.0	NA	NA
[illegible]					0.5	NA	0.5
[illegible]		0.010		1.0	0.5	NA	0.2
[illegible]		0.02		[illegible]	NA	NA	2.0
[illegible]					5.0	NA	NA
Organochlorine Pesticides							
[illegible]							
[illegible]	0.010				NA	NA	0.20
[illegible]			2.0	NA	NA	0.50	
[illegible]					NA	NA	0.50
[illegible]		0.1	0.1	100	0.5	1.0	0.50
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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NR

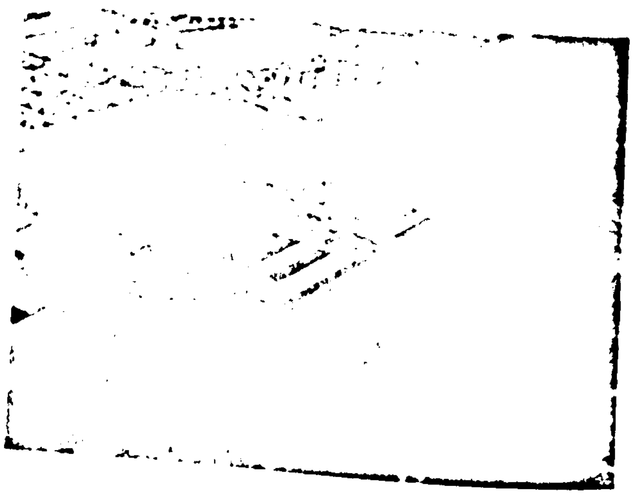
TABLE 28 (Continued)

PESTIC DE AND AGRICULTURAL CHEMICALS

Quarterly Results

Micrograms per Liter (μg/l)

COMPOUND	CDHS ACTION Level μg/l	CDHS MCL MG/L	USEPA MCL mg/l	CDHS DLR μg/l	Montgomery Labs MDL Nov 1988 μg/l	IT Analyt MDL Mar 1989 μg/l	MWD MDL Apr 1989 μg/l
Carbamate Pesticides (cont)							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



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WATER QUALITY

TABLE 29

QUA ERLY RESULTS OF TOTAL TRIHALOMETHANE MONITORING

Fiscal Year 1988 89

Micrograms per Liter (μg/l)

Sample Location	August 1988	November 1988	February 1989	May 1989	Annual Average
Distribution System					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average	65	81	56	67	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

... ND = None Detected   NR = None Reported

... consecutive quarters of data were not available

TABLE 30
DISINFECTION BY-PRODUCTS, PART 1

TABLE 31
DISINFECTION BY-PRODUCTS, PART 2
Quarterly Results
[illegible]

Location	Haloacetic Acid Sum Aug 1988	Haloacetic Acid Sum Nov 1988	Haloacetic Acid Sum Feb 1989	Haloacetic Acid Sum May 1989	Chloral Hydrate Aug 1988	Chloral Hydrate Nov 1988	Chloral Hydrate Feb 1989	Chloral Hydrate May 1989	Cyanogen Chloride Aug 1988	Cyanogen Chloride Nov 1988	Cyanogen Chloride Feb 1989	Cyanogen Chloride May 1989	Total Organic Halogen (TOX) Aug 1988	Total Organic Halogen (TOX) Nov 1988	Total Organic Halogen (TOX) Feb 1989	Total Organic Halogen (TOX) May 1989	Formaldehyde Nov 1988	Formaldehyde Feb 1989	Acetaldehyde Nov 1988	Acetaldehyde Feb 1989
CM 1	18	17	18	27	5.1	4.0	3.6	4.4	0.2	0.2	NR	[illegible]	250	200	180	220	4.7	ND	5.0	ND
Garvey Effluent	20	22	11	24	3.0	3.2	3.4	3.6	1.5	2.4	NR	[illegible]	140	170	110	130	7.2	1.8	5.3	2.0
San Joaquin Influent	14	18	9.6	20	2.3	4.9	2.5	3.3	1.4	1.3	NR	3.4	120	150	92	130	4.6	1.1	3.1	1.3
San Joaquin Effluent	20	9.5	16	24	2.8	0.35	2.4	1.9	0.3	2.5	NR	1.5	210	180	180	200	3.2	ND	2.1	ND
WB 3	15	18	9.4	14	1.1	0.80	2.9	0.95	1.5	2.4	NR	2.0	170	170	95	170	4.7	1.3	3.1	1.2
WB 23	13	18	11	14	0.95	0.79	3.1	0.93	1.3	2.6	NR	2.9	170	170	100	150	4.6	1.6	3.1	1.7
Diemer Influent	NA	NA	NA	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	1.8	ND
Diemer Effluent	12	18	8.7	26	2.3	2.9	2.2	4.2	0.9	0.6	NR	4.1	180	150	94	150	3.4	ND	2.7	ND
Jensen Influent	NA	NA	NA	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	4.0	ND	ND	ND
Jensen Effluent	13	18	21	14	0.98	0.96	3.0	0.72	1.0	1.9	NR	2.0	170	190	120	120	4.6	1.3	2.7	ND
Mills Influent	NA	NA	NA	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND
Mills Effluent	6.3	10	8.1	24	0.30	0.46	1.0	2.4	0.9	0.6	NR	7.0	61	94	72	190	3.3	ND	2.1	1.3
Skinner 1 Influent	NA	NA	NA	NA	ND	0.23	ND	0.78	NA	NA	NA	NA	NA	NA	NA	NA	5.2	ND	2.6	NR
Skinner 1 Effluent	18	19	12	22	5.9	4.6	2.8	3.3	1.7	1.9	NR	4.2	170	130	110	170	7.1	1.6	4.2	1.6
Skinner 2 Influent	NA	NA	NA	NA	ND	0.29	ND	0.90	NA	NA	NA	NA	NA	NA	NA	NA	4.4	ND	2.6	ND
Skinner 2 Effluent	15	16	8.6	20	4.7	3.4	1.5	2.7	1.6	1.2	NR	4.1	150	130	98	170	5.2	1.0	3.8	1.0
Weymouth Influent	NA	NA	NA	NA	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND
Weymouth Effluent	12	17	9.6	20	2.7	5.0	2.4	3.0	[illegible]	1.5	NR	3.7	130	140	93	130	5.5	nd	3.4	1.4

ND = Not Detected NA = Not Analyzed NR = Not Reported

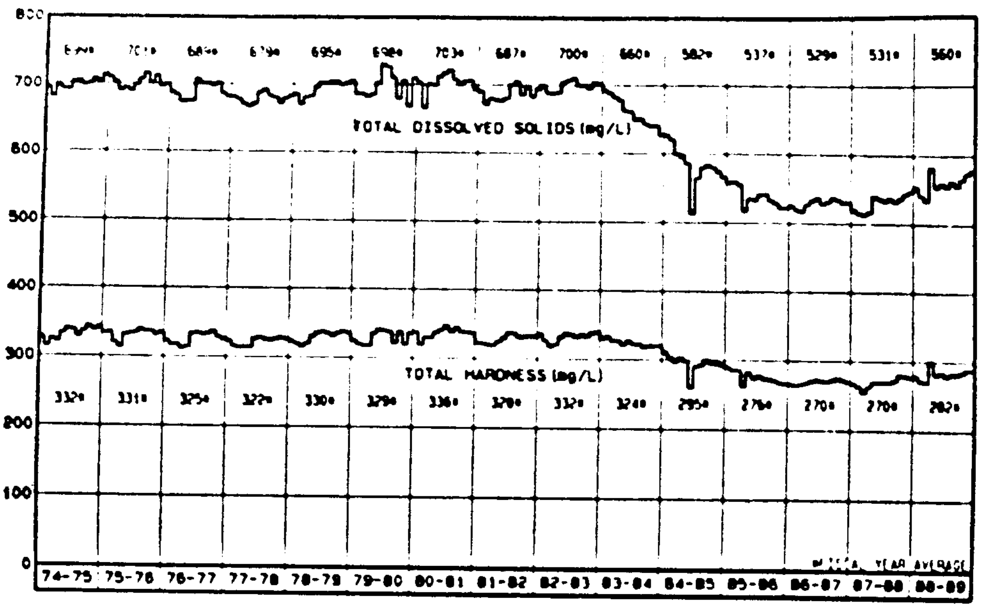

Figure 10 Chemical Quality of Colorado River Water at Whitsett Intake Pumping Plant

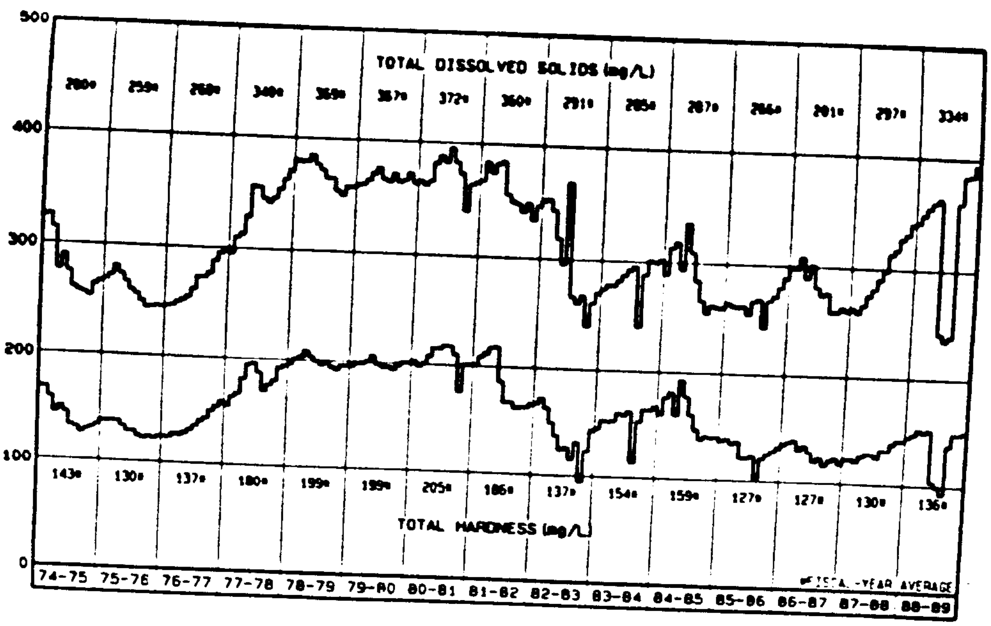

Figure 11 Chemical Quality of Edmund G. Brown California Aqueduct Water, West Branch

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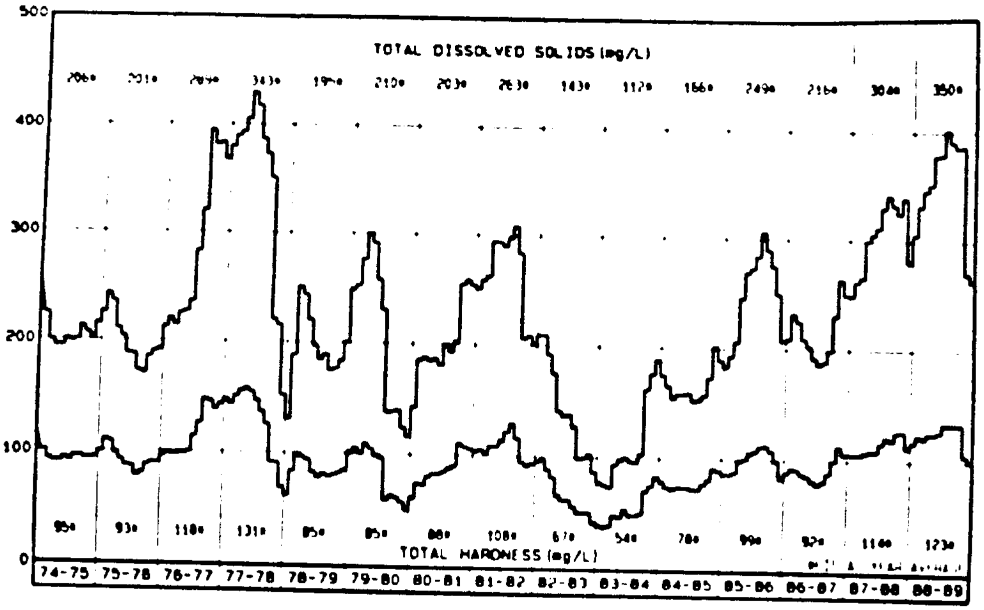
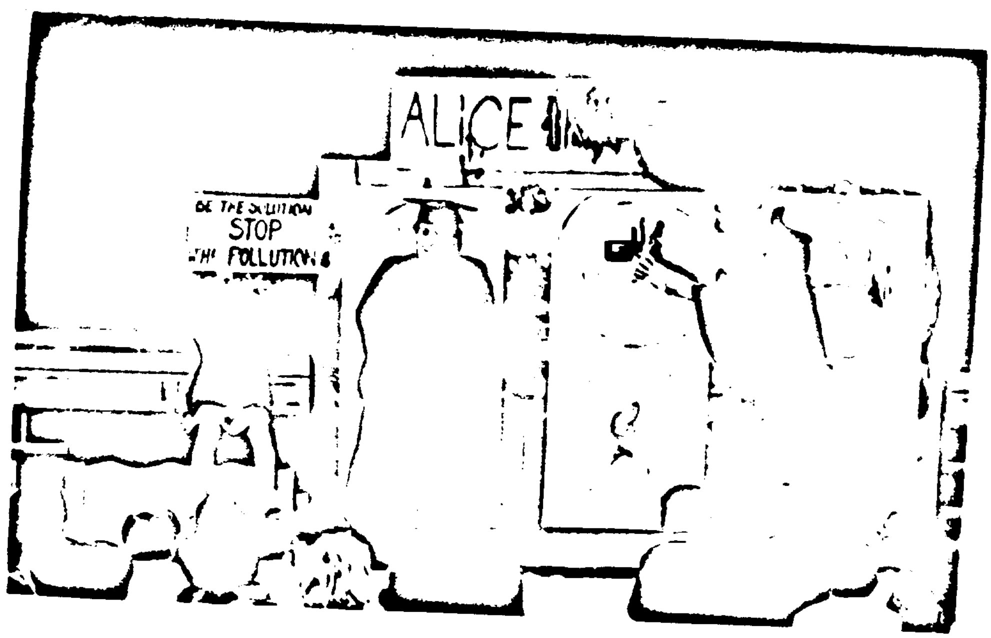


Figure 12 Chemical Quality of Edmund G. Brown California Aqueduct Water, East Branch



Programs designed for school assemblies teach children important lessons about ensuring healthful water quality

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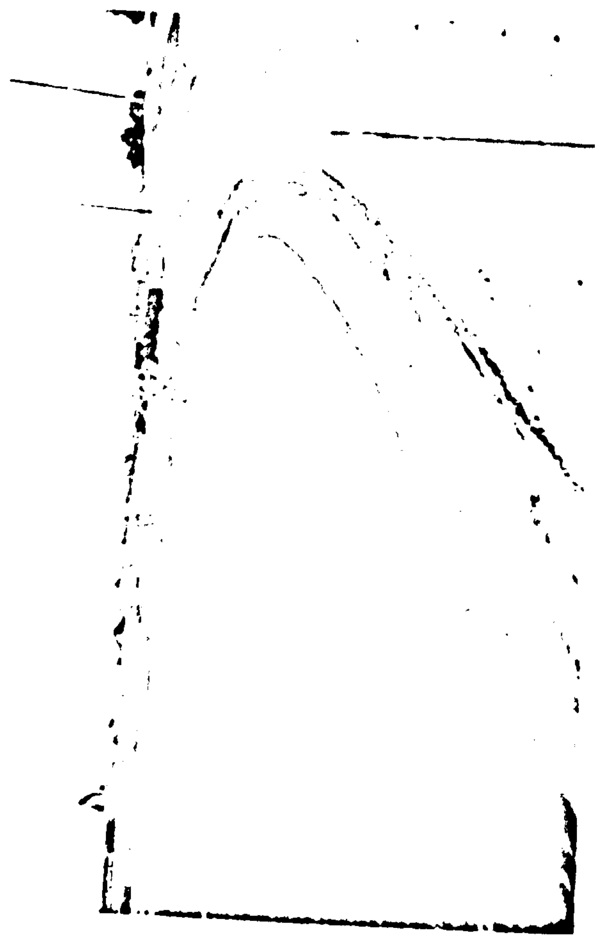

A contractor prepares grading for additional retention basins at the Henry J. Mills Filtration Plant in Riverside

CHAPTER 5

Planning

Advance Planning Activities

System Overview Study

The Distribution System Overview Study (Report No. 971) was published and distributed in October 1988, and is a guideline for planning transmission, storage, treatment, and distribution facilities. The population within Metropolitan's service area is projected to increase from 14.5 million to 18.2 million, or 25 percent, over the next 20 years. By the year 2010, the demands on Metropolitan are expected to increase from the present use of more than 2 million acre-feet (maf) to almost 3 maf, primarily in treated water demands. In addition, new facilities and modifications to existing facilities will be necessary to meet these growing demands, to comply with more stringent Federal and State drinking water standards, and to maintain high standards of reliability throughout the growth period.

Area Studies and Facility Plans

Based on needs identified in the Distribution System Overview Study, area studies and facility plans are being conducted to evaluate key facilities in greater planning detail. Area water demand studies and facility plans are designed to determine the required facilities, estimate the capacity of those facilities, evaluate alternatives, and establish a project time-line and budget. The studies underway include expansion of the Henry J. Mills (Mills plant) and Robert A. Skinner (Skinner plant) Filtration Plants and construction of an Inland Feeder, an Eastside Reservoir, an Orange County treatment plant, and a Perris treatment plant. To effectively coordinate the planning and engineering work, multi-divisional task forces have been formed for each study.

Mills Area Study

Located in Riverside County, the Mills plant began service in 1978 with a capacity of 75 million gallons per day (mgd). The plant's first expansion was under construction this past year and will be placed int... rvice in the summer of 1989, doubling the Mills plant's total capacity. H... ever, Metropolitan's supplemental water demands are projected to i... crease by approximately 65 percent by 2010, and based on these pro... tions, the Mills plant will likely require expansion again in the mid-1990s.

Perris Area Study

The Distribution System Overview Report identified the need for a new treatment plant near Lake Perris to meet the increasing water demands in Riverside County and to supplement Mills plant activities. An area study to identify the location, size, and schedule for a new Perris treatment plant was initiated in June 1988.

After initially screening 26 potential treatment plant sites, staff selected five sites in an area south of Lake Perris for further analysis. Preliminary geotechnical assessments and reconnaissance level environmental studies have been conducted on the five sites. An engineering evaluation to determine the technical and operational feasibility of each site is currently underway.

South Riverside San Diego Area Study

The San Diego Canal and the Skinner plant serve the south Riverside San Diego area. The San Diego Canal, which currently has a capacity of 1,200 cubic feet per second (cfs), is being expanded to 1,70... cfs. The Skinner plant capacity is also being expanded, from 320 m... to 520 mgd. Both expansions are scheduled for completion in 1991.

According to studies conducted in 1986 by Metropolitan and the ... Diego County Water Authority (SDCWA), the expanded facilities w... adequately meet water demands until the year 2000 or beyond. However, the latest forecasts issued by the Southern California Associati... Governments (SCAG) and the San Diego Association of Governm... (SANDAG) indicate increasing population projections for sou... Riverside and San Diego counties. Water demand projections ind... that additional treatment and conveyance facilities will be ne... around 1997.

Currently underway, a study identifying near-term and long-range f... ity plans for the area is being closely coordinated with area mem... agencies to identify opportunities for joint operations and poter... groundwater development in southern Riverside County. Metropol... is also participating in SDCWA's Optimal Storage Study that will iden... ways to optimize reservoir facility use in San Diego County. This a... study is also coordinated with the Perris San Jacinto treatment pl... study and the Eastside Reservoir study.

Inland Feeder Study

Due to steadily growing water demands and projected reductions of Colorado River water deliveries, an Inland Feeder is needed to bring more State project water into Metropolitan's service area by the year 2000. Under study for some time, this facility has been an important element of Metropolitan's system development plans. The Inland Feeder will be a raw water conduit that will convey State project water from the expanded California Aqueduct East Branch to the Colorado River Aqueduct near San Jacinto. Through this feeder, Metropolitan can avail itself of additional State project or exchange water required to meet member agency needs starting in the year 2000. Furthermore, it will enhance system reliability by connecting major aqueduct systems and enable Metropolitan to blend State project and Colorado River supplies throughout greater portions of the service area.

The Inland Feeder Study originally identified 17 alternative alignments for the Inland Feeder. During the fiscal year, reconnaissance studies reviewed these alternative alignments, determining the relative merits of individual alignments and identifying five to be evaluated further. Reconnaissance studies included hydraulic analyses and seismic risk assignments of each alignment, biological land use and cultural resources surveys to support required California Environmental Quality Act (CEQA) documentation, and an operating analysis of deliveries through the Inland Feeder according to available State project supplies. Each of the five alignments consists of a series of tunnels and pipelines extending 35 to 40 miles in length. The routes transverse two counties, six water districts, and 18 cities.

Central Pool Augmentation and Water Quality Project

This project, which evolved from the south Orange County Study, will augment service to Metropolitan's central service area (Los Angeles, Ventura, and Orange counties) via additional conveyance and treatment capacity.

Project components include a second outlet tower at Lake Mathews, a pipeline tunnel into Orange County through the Santa Ana Mountains, and a new filtration plant located either at Lake Mathews or in south Orange County. This plant will relieve the Robert B. Diemer Filtration Plant (Diemer plant) of a large portion of its Orange County load, enabling it to serve other parts of the central service area. The new plant is expected to be on-line by 1998.

San Joaquin Reservoir Improvement Project

Located in Newport Beach, the San Joaquin Reservoir is a 3,000 acre-foot finished water reservoir jointly owned by Metropolitan and several-

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local agencies. In recent years, frequent episodes of high bacteria counts have caused periodic bypassing of the facility. This project aims to improve reservoir water quality and to better integrate the water into Metropolitan's distribution system. Alternatives under consideration include: (a) a new filtration plant to treat reservoir effluent, (b) various types of reservoir covers, (c) replacing a new pipeline from the Diemer plant to the service connections at the Coastal Junction delivery point, (d) abandoning the reservoir, and (e) continuing operating the reservoir as at present.

Eastside Reservoir Study

Metropolitan has identified the need to virtually double its reservoir capacity in the next 40 years. Reconnaissance studies, initiated in 1987, have identified up to 19 alternative reservoir sites which either singly or in combination could meet this need. The reservoir sites have been evaluated against various engineering, cost, environmental, and operational criteria. From these studies, five potential sites have been selected for evaluation during detailed feasibility studies, which will include preparing an Environmental Impact Report (EIR). The five alternative sites, all in Riverside County, include the potential expansion of Lake Perris, a reservoir at Potrero Creek south of the city of Beaumont, a reservoir at the Domenigoni Valley southwest of the city of Hemet, the expansion of Lake Skinner, and the expansion of Vail Lake. These alternatives will be further evaluated and reduced in number near the end of 1989. During the studies, coordinated surface reservoir and groundwater operations also will be evaluated. Groundwater storage is expected to meet a portion of the total storage need.

Detailed land use studies indicate that several of the potential reservoir sites could be subjected to strong land development pressures during the study period. As a result, Metropolitan's Board of Directors authorized funding in November 1988 and again in May 1989 to acquire options or to purchase properties where development pressures could eliminate a site before reservoir studies could be completed. Negotiations to purchase lands have been initiated at the Domenigoni Valley and Potrero Creek sites. Studies are scheduled for completion in mid-1991 at which time a final reservoir site will be selected.

Weymouth Lake Mathews Area Study

Over the next 25 years, the Chino Basin area within western San Bernardino County is expected to continue its rapid population growth, projected to double by the year 2010, causing a corresponding rise in municipal and industrial water demands. These demands will substantially increase raw and treated water delivery requirements within the Weymouth Lake Mathews service areas. An Area Study currently underway will determine the scheduling for the Rialto Pipeline paralleling,

the need for the Chino Valley Pipeline, and expansion of F.E. Weymouth Filtration Plant (Weymouth plant). During the fiscal year, hydraulic evaluations of the existing raw water conveyance lines and the Weymouth plant were conducted. In addition, alternatives for increasing raw and treated water to the Chino Basin area have been initiated.

Water Quality, Supply and Demand Studies

Water Supply and Demand Models

The *MWD-MAIN water demand forecasting model*, originally developed for the U.S. Army Corps of Engineers and later calibrated for use by Metropolitan, is used within Metropolitan's service area. In forecasting demands, the model incorporates numerous demographic, econometric, and climatic variables, including the number and types of housing units (single- and multiple-family dwellings), housing density, housing values, and employment levels for more than 200 different industrial and commercial sectors. It also accounts for changes in water and waste water rates and various types of water conservation programs. The model provides disaggregated water demand forecasts for four major water-use categories: residential, commercial, industrial, and public/unaccounted. Additionally, these forecasts are further disaggregated into very specific water use categories to better understand the service area's water-use characteristics.

During 1988-89, four technical improvements were made in the model. First, its commercial and industrial water-use coefficients were updated to reflect a special recovery of water use by 3,000 commercial and industrial establishments in Metropolitan's service area. Second, the population, housing, employment, and land-use projections were updated to encompass the 1988 revisions made to regional growth plans by SCAG and SANDAG. Third, the residential demand equations were revised per a special study of 1,250 households in five southern California communities. Finally, the water conformation assumptions are being updated to indicate implementation of "best management practices" throughout the state.

Since climate influences water use, Metropolitan continued developing the *METROWATFORE model* to supplement the MWD-MAIN model to estimate *variations in water demands due to climate swings*. The demand fluctuation caused by weather variation has been estimated to be about 8 percent above and below the total normal MWD-MAIN model demand projection, at the 90 percent confidence level.

A short-term *monthly demand forecast model* was developed in 1988-8 that includes a population trend, a seasonal component for capturing the characteristic monthly water-use pattern, and climatic variables to show the effect of specific month-to-month rainfall and heat conditions. The monthly model explains more than 97 percent of the month-to-month demand variation, and allows staff to estimate short-term future demands and storage levels for various temperature and rainfall scenarios.

Used during the DROUGHT '88 campaign, the demand forecasting model showed that regional water use decreased by about 90,000 acre-feet during the 1988 summer months, an approximate 7 percent savings.

Staff developed a *computerized distribution system flow model* to route water through Metropolitan's delivery system and to assist in identifying the need for future system improvements and their scheduling. Specific projects now being analyzed include the Eastside Reservoir, Inland Feeder, and South Orange County Treatment Plant.

Regional Population and Water Demand Studies

In early 1989, SCAG adopted its Growth Management Plan, with revised forecasts of year 2010 population, housing, and employment within a six-county Southern California planning area. SANDAG had adopted its Series 7 forecasts in 1988. Metropolitan's staff has incorporated the revised forecast results into the MWD-MAIN water demand studies and facility planning. The key findings are that by the year 2010:

(1) the population of Metropolitan's service area will increase from the present 14.5 million to 18.2 million with two-thirds of the increase due to births over deaths,

(2) the number of housing units will increase from 2.8 million to 3.4 million,

(3) total employment will increase from 4.2 million to 5.0 million,

(4) the increase in population, housing, and employment will create a need for an additional 1 maf of water to meet municipal and industrial demands, and

(5) the demands on Metropolitan could increase by 700,000 acre-feet per year depending on weather conditions and Los Angeles Aqueduct supplies.

Water Resources Data (PINS)

Staff has developed a computerized data base and retrieval system called the Planning Information System (PINS). PINS contains data on

Metropolitan's daily system flows and monthly water sales, daily rainfall and temperature data, local water production, groundwater quality, and water supplies to Metropolitan, as well as population and demographic statistics. Accessible to all divisions, PINS data files are part of Metropolitan's corporate data base and provide data for analyzing seasonal and annual water demand forecasts, future delivery system requirements, and the Finance Division's annual water rate recommendations.

PINS software development is now 80 percent complete, and will be finished during the next fiscal year. PINS currently contains 3 million records of information, approximately 1 million additional records of information will be added every year.

Water Quality Studies

Metropolitan currently provides 55 percent of all the water used annually within its service area. Local ground and surface water and the Los Angeles Aqueduct meet the remaining demand.

However, the future availability of local water is affected by groundwater quality conditions and changing regulatory requirements. Metropolitan is now collecting data to update its 1986 Report No. 969, "Groundwater Quality and Its Impact on Water Supply in the Metropolitan Water District Service Area," a reconnaissance assessment of groundwater conditions. Beyond providing assessment of current groundwater quality conditions and changes since 1986, this updated study will evaluate how new and proposed water quality standards potentially affect groundwater availability. Study results will further define the supplemental water needs from the Colorado River and State Water Project.

Environmental Studies

Garvey Reservoir Operations and Maintenance Facility

Pursuant to CEQA, a Negative Declaration was prepared regarding constructing a new operations and maintenance facility on the Garvey Reservoir property. The new facility will accommodate additional administrative, operations, and maintenance activities of the Los Angeles Section staff. The Board of Directors approved the Negative Declaration on May 9, 1989. Final CEQA documents were subsequently filed with the appropriate State and local agencies.

Joseph Jensen Filtration Plant Expansion

Staff completed a Negative Declaration for the facilities needed to expand the Jensen plant's existing capacity of 350 mgd to a total capacity of

750 mgd. This expanded capacity will meet above-normal, peak-week demand for supplemental treated water in the Jensen service area. The Board of Directors approved the Negative Declaration on March 14, 1989, and the final documents were filed with the appropriate State and local agencies.

Environmental Documents in Preparation

At year's end, staff were actively involved in preparing seven EIRs. A Draft EIR was completed for the San Joaquin Reservoir Improvement Project. As CEQA requires, this document was transmitted for public review.

Notices of Preparation were completed and published for the Central Pool Augmentation and Water Quality Project, Arvin-Edison Water Storage and Exchange Program and Eastside Reservoir Study. A Notice of Preparation is a CEQA document that advises the public of an agency's decision to prepare an EIR. It solicits public comments on the EIR's scope and contents, and initiates the CEQA compliance process for the proposed project.

Environmental reconnaissance studies were initiated for the Perris Area Study, South Riverside-San Diego Area Study, and Inland Feeder Study. These preliminary investigations will help identify the scope of environmental compliance requirements for subsequent actions, develop project schedules and cost estimates, screen alternatives, modify project plans to mitigate significant adverse effects, and expedite the environmental compliance process for recommended alternatives.

Conservation and Water Management

Arvin-Edison Water Storage and Exchange Program

During the past year, Metropolitan and the Arvin-Edison Water Storage District (Arvin-Edison), a Federal Central Valley Project contractor in Kern County, progressed considerably in implementing the Arvin-Edison Water Storage and Exchange Program. Under this program, Metropolitan can accumulate an underground reservoir of about 800,000 acre-feet by storing available State project water in the groundwater basin underlying Arvin-Edison. During future dry years, Metropolitan would receive, through exchange, water that would otherwise be delivered to Arvin-Edison, increasing available dry-year supplies by about 100,000 acre-feet annually.

During 1989, progress was made on numerous difficult implementation issues. Responding to concerns of other State Water Contractors,

Metropolitan and Arvin-Edison agreed to develop their program such that it would not cause greater shortages of entitlement water available from the State Water Project (SWP). Working closely with the State Department of Water Resources (DWR), the two entities extensively studied the program's potential impacts and developed procedures to assure that program operations would not adversely affect other contractors. Based on the DWR studies, the Arvin-Edison program will allow DWR to deliver more than 1,000,000 additional acre-feet of water to Metropolitan in the future without negatively impacting deliveries of entitlement water to others.

In cooperation with Arvin-Edison and the U.S. Bureau of Reclamation (Reclamation), Metropolitan has also developed an approach to supplement the water rights permit held by Reclamation—a difficult step necessary for the program's ultimate implementation. In Kern County, the program will generate significant economic benefits but also raises local concerns about an agreement with urban Southern California. Thus, a series of public meetings are underway to provide information about program operations and benefits and to resolve the concerns of local residents, landowners, and others. Despite recent progress, a full program implementation may take more than two years.

Completed environmental documentation for the project is expected in spring 1990, with final design and facility construction to follow. Meanwhile, Metropolitan and Arvin-Edison have developed an interim program to allow for water storage while the long-term program is finalized.

Water Conservation

Regional Urban Water Management Plan

In 1983, the California Legislature passed the Urban Water Management Planning Act, AB 797. The Act required most retail urban water suppliers to prepare water management plans documenting existing and future water management activities, including water conservation. Although Metropolitan was not obligated to prepare a plan, it did so to assist its member agencies in developing their plans.

Per the Act, plans face revision after five years. During the year, work began on revising Metropolitan's Regional Urban Water Management Plan. The revised regional plan, which will be completed in 1990, will provide the framework for Metropolitan's future water management activities, as well as assist Metropolitan's members and sub-agencies in revising their plans.

Conservation Credits Program

To encourage member agencies to undertake aggressive water conservation programs, Metropolitan introduced the Conservation Credits

Program (CCP). CCP provides financial incentives for implementing conservation projects with verifiable water savings. Under CCP, Metropolitan will pay the lesser of one half of a conservation project cost or an amount per acre-foot of water saved based on the avoided cost of SWP aqueduct pumping, subject to a minimum pumping cost of $75 per acre-foot.

In 1989, Metropolitan and the city of Pasadena initiated the first CCP project. Under this pilot project, Pasadena will survey indoor and outdoor water use at 2,400 single-family homes to determine water savings potential and to implement appropriate conservation measures. A second program with Pasadena was initiated to distribute low-flow showerheads and toilet displacement kits to the entire city, or 34,000 single-family residences. This program is expected to save approximately 4,990 acre-feet of water during the project's five-year span.

In another CCP project, Metropolitan and the city of Santa Monica will replace high-flow toilets and showerheads in existing residences with ultra-low-flow toilets and showerheads. This will be the first such program implemented in Metropolitan's service area. Approximately 25 percent of the bathrooms in Santa Monica will be retrofitted over a five-year period, with a $100 rebate provided to homeowners for each bathroom retrofitted. To help finance the program, a surcharge of $0.50 per month will be levied on non-participants for each bathroom not retrofitted. Water use in participating households is expected to drop by about 70 gallons per day.

Metropolitan is entering into agreements with Municipal Water District of Orange County and its sub-agency, Irvine Ranch Water District, to conduct residential pilot water conservation studies in Orange County. Approximately 4,000 homes will be retrofitted with low-flow showerheads and toilet displacement devices, and complete indoor-outdoor home water surveys will be conducted on an additional 1,000 homes to determine the potential for large-scale water savings using these techniques.

Metropolitan and its member agencies are currently studying a variety of other proposals. The San Diego County Water Authority has proposed a large-turf water audit program, while the city of Los Angeles' Department of Public Works has submitted a proposal to retrofit 100,000 single-family homes with low-flow showerheads and toilet displacement devices.

Landscape Water Conservation

Metropolitan's third California Irrigation Management Information System (CIMIS) weather station was installed at Three Valleys Municipal Water District's treatment plant in Claremont. It joins the Irvine and

Hollywood Hills stations installed last year. A contract was also signed to install a CIMIS weather station at Mount Olivette Reservoir in the city of Santa Monica. Additionally, DWR has placed seven CIMIS weather stations within Metropolitan's service area.

To encourage using CIMIS weather data to schedule irrigation of large landscaped areas and improve irrigation systems, Metropolitan contracted with the University of California Cooperative Extension, the Ventura County Resource Conservation District (VCRCD), and the Irrigation Association to train irrigators of large landscaped areas. The training's purpose is to help irrigators evaluate their irrigation systems efficiency and apply CIMIS weather data to help schedule irrigations. About 300 irrigators were trained by the University and VCRCD during the year. Altogether, 1,500 of the largest turf irrigators in Metropolitan's service area will be trained to help them substantially reduce water use.

Residential Water Conservation Pilot Projects

Metropolitan's consultant project manager, Brown and Caldwell, Consulting Engineers, has completed the field survey work on several pilot projects, including residential water audits and a residential leak detection program. Initial results indicate that the pilot studies successfully demonstrated that these measures could be effective in saving water and money. Metropolitan will receive a final report once Brown and Caldwell has completed its analysis of study results.

TABLE 32
AREA AND POPULATION OF MEMBER AGENCIES
As Of June 30, 1989

Constituent	Area in Square Miles	POPULATION 1970 Census	POPULATION 1980 Census	POPULATION Jan. 1, 1989* Estimated
Anaheim	44.9[illegible]	166 4[illegible]	221 847	244 300
Beverly Hills**	5.[illegible]6	33 416	32 367	34 300
Burbank	17.14	88 871	84 625	93 800
Calleguas MWD	348.[illegible]0	222 400	344 [illegible]30	459 035
Central Basin MWD	[illegible]	1 152 [illegible]0	1 241 936	1 368 649
Chino Basin MWD	242.24	22[illegible] [illegible]0	345 8[illegible]3	533 4[illegible]
Coastal MWD	59.[illegible]	[illegible]	170 231	201 560
Compton**	7.[illegible]1	78 54[illegible]	81 286	93 000
Eastern MWD	533.4[illegible]	[illegible]	133 6[illegible]9	293 034
Foothill MWD	2[illegible]	87 [illegible]0	77 [illegible]44	85 2[illegible]
Fullerton	22.[illegible]4	85 [illegible]87	102 034	111 700
Glendale**	3[illegible]	132 [illegible]64	139 [illegible]60	166 100
Las Virgenes MWD	12[illegible]	13 [illegible]0	33 423	54 444
Long Beach	4[illegible]	358 879	361 334	4[illegible]9 800
Los Angeles**	46[illegible]	2 8[illegible]1 8[illegible]1	2 966 763	3 400 500
MWD of Orange County	5[illegible]1.2[illegible]	871 [illegible]00	1 233 745	1 485 540
Pasadena**	22.60	112 951	119 374	132 200
San Diego CWA	1 4[illegible]5.84	1 276 [illegible]	1 776 851	2 345 654
San Fernando	2.37	16 57[illegible]	17 731	20 700
San Marino	3.7[illegible]	14 177	13 307	13 800
Santa Ana	2[illegible].4[illegible]	155 710	203 713	237 300
Santa Monica	8.05	88 289	88 314	96 500
Three Valleys MWD	133.30	266 100	359 [illegible]61	456 680
Torrance**	19.54	134 968	131 497	142 200
Upper San Gabriel Valley MWD	143.7[illegible]	651 600	669 677	754 015
West Basin MWD	165.[illegible]1	721 400	732 609	818 439
Western MWD of Riverside Co.	5[illegible]	249 [illegible]00	332 957	454 429
TOTAL	5 [illegible]37.8[illegible]	10 226 639	12 017 108	14 516 367

Note

*A different method was used to estimate 1989 population. The estimate was based on the Southern California Association of Governments' detailed disaggregation of the Department of Finance and county planning agency population data.

**Areas tabulated for these cities are exclusive of areas annexed to the cities which, for Metropolitan purposes, are included within the area of a constituent Municipal Water District. The total areas now within the present boundaries of the cities involved are rounded to the nearest 100th of a square mile.

TABLE 32 (Continued)
AREA AND POPULATION OF MEMBER AGENCIES
As Of June 30, 1989

Constituent	Area in Square Miles
ANAHEIM	
Area exclusive of portion within MWD of Orange County	45.02
Area within MWD of Orange County	0.01
Total area of City of Anaheim	45.03
BEVERLY HILLS	
Area exclusive of portion within West Basin MWD	5.06
Area within West Basin MWD	.64
Total area of city of Beverly Hills	5.70
COMPTON	
Area exclusive of portions within Central Basin MWD and West Basin MWD	
Area within Central Basin MWD	7.81
Area within West Basin MWD	2.35
Total area of city of Compton	.01
	10.17
GLENDALE	
Area exclusive of portion within Foothill MWD	30.36
Area within Foothill MWD	.23
Total area of city of Glendale	30.59
LOS ANGELES	
Area exclusive of portions within West Basin MWD, Las Virgenes MWD, and Central Basin MWD	461.90
Area within West Basin MWD	4.25
Area within Las Virgenes MWD	2.64
Area within Central Basin MWD	.01
Total area of city of Los Angeles	468.80
PASADENA	
Area exclusive of portions within Foothill MWD and Upper San Gabriel Valley MWD	22.60
Area within Foothill MWD	.37
Area within Upper San Gabriel Valley MWD	.18
Total area of city of Pasadena	23.15
TORRANCE	
Area exclusive of portion within West Basin MWD	19.54
Area within West Basin MWD	1.95
Total area of city of Torrance	21.49

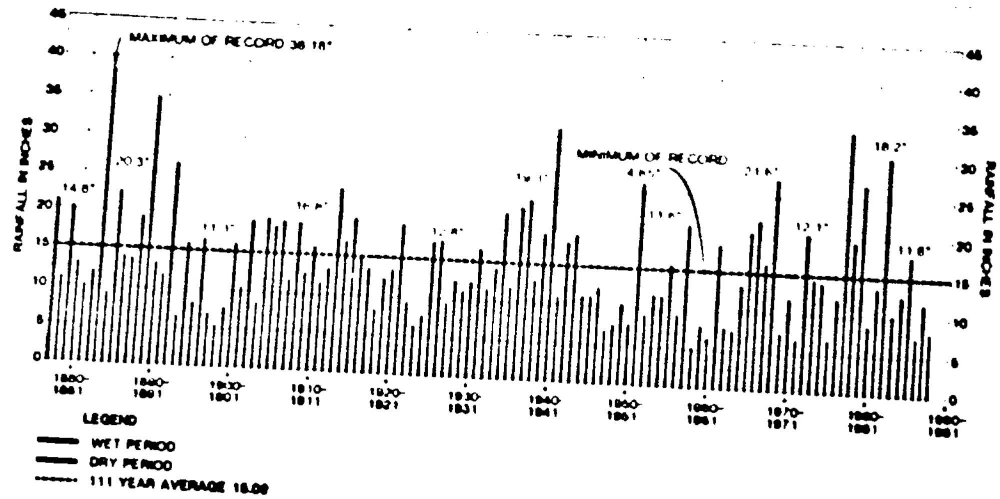


Figure 13 112-Year History of Average Annual Rainfall

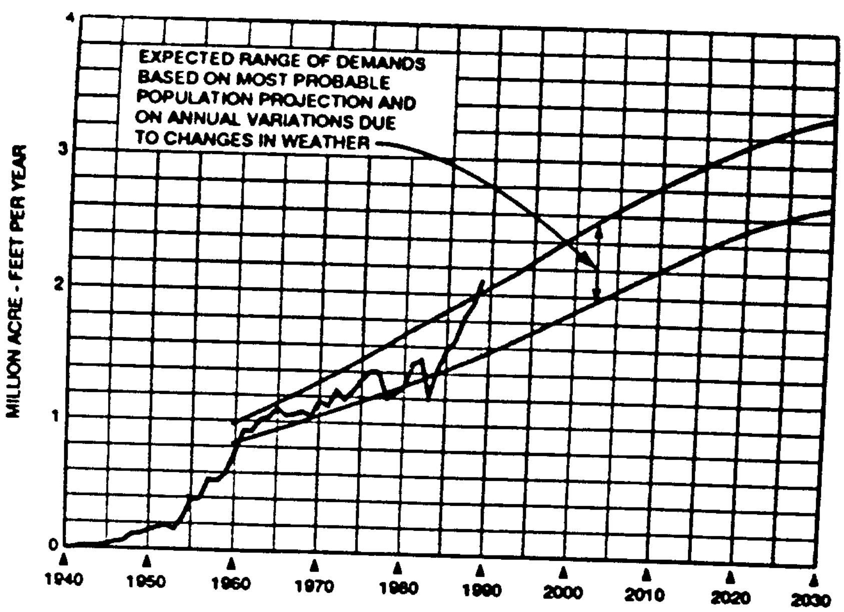
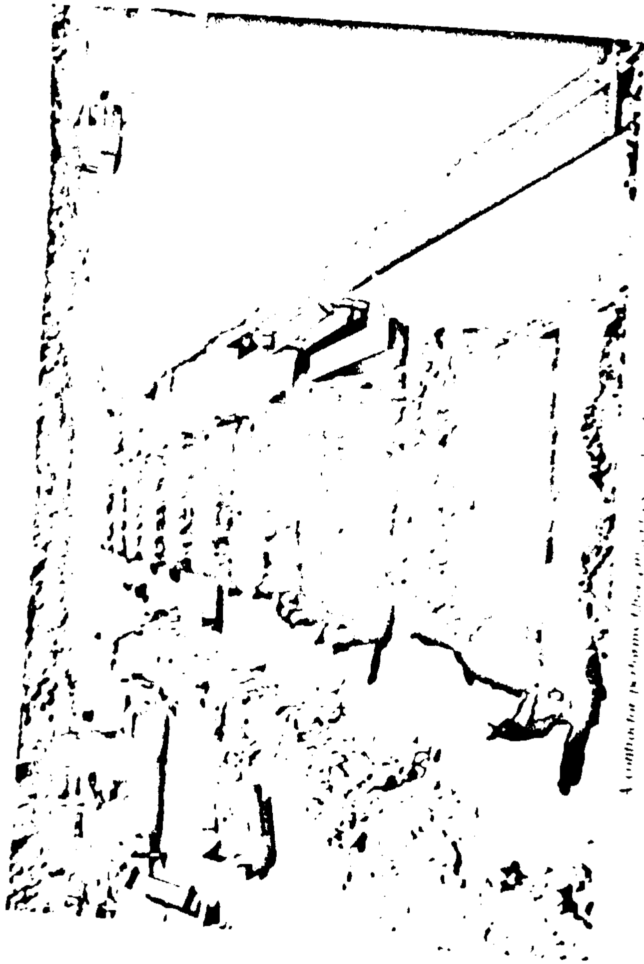


Figure 14 Total Projected Water Demand to be Met by Metropolitan



CHAPTER 6

Engineering

During fiscal year 1988-89, Metropolitan continued the third major engineering design and construction period in its history. The expanded work program answers the need to expand or modify existing facilities and to construct new facilities to meet increasing water demands in Metropolitan's service area. The 1988-89 engineering work program was based on facility requirements specified in the Planning Division's System Overview Study and those that meet anticipated State and Federal water quality standards. Design and construction programs dealt with water transportation, purification, storage, and distribution facilities, and included rehabilitation, expansion, modification, and new-construction work.

Under the expanded work program, both Metropolitan staff and outside consultants conducted a number of studies relative to project alternatives and feasibility and system design capacities.

Major ongoing activities included dam and reservoir investigations and surveillance, office automation, substructure investigations, corrosion control, materials evaluation, and metallurgy studies. Other significant programs under way during the year involved seismicity investigations and response, pipeline relocations, service connection constructions and refittings, and records of survey for pipeline and aqueduct survey maps.

The consulting firm of Touche Ross & Company completed a study and prepared a report examining Engineering Division staffing requirements and the division's operational strategies. The report provides recommendations for increasing production and improving operational efficiency and supports the current and planned increased use of professional consultants and temporary personnel to assist Engineering staff members during peak work-load periods.

Capital Projects

Capital expenditures for fiscal year 1988-89 totaled more than $54 million, an increase of about $25 million over the previous year. This figure covers work performed under contract and by Metropolitan, and includes

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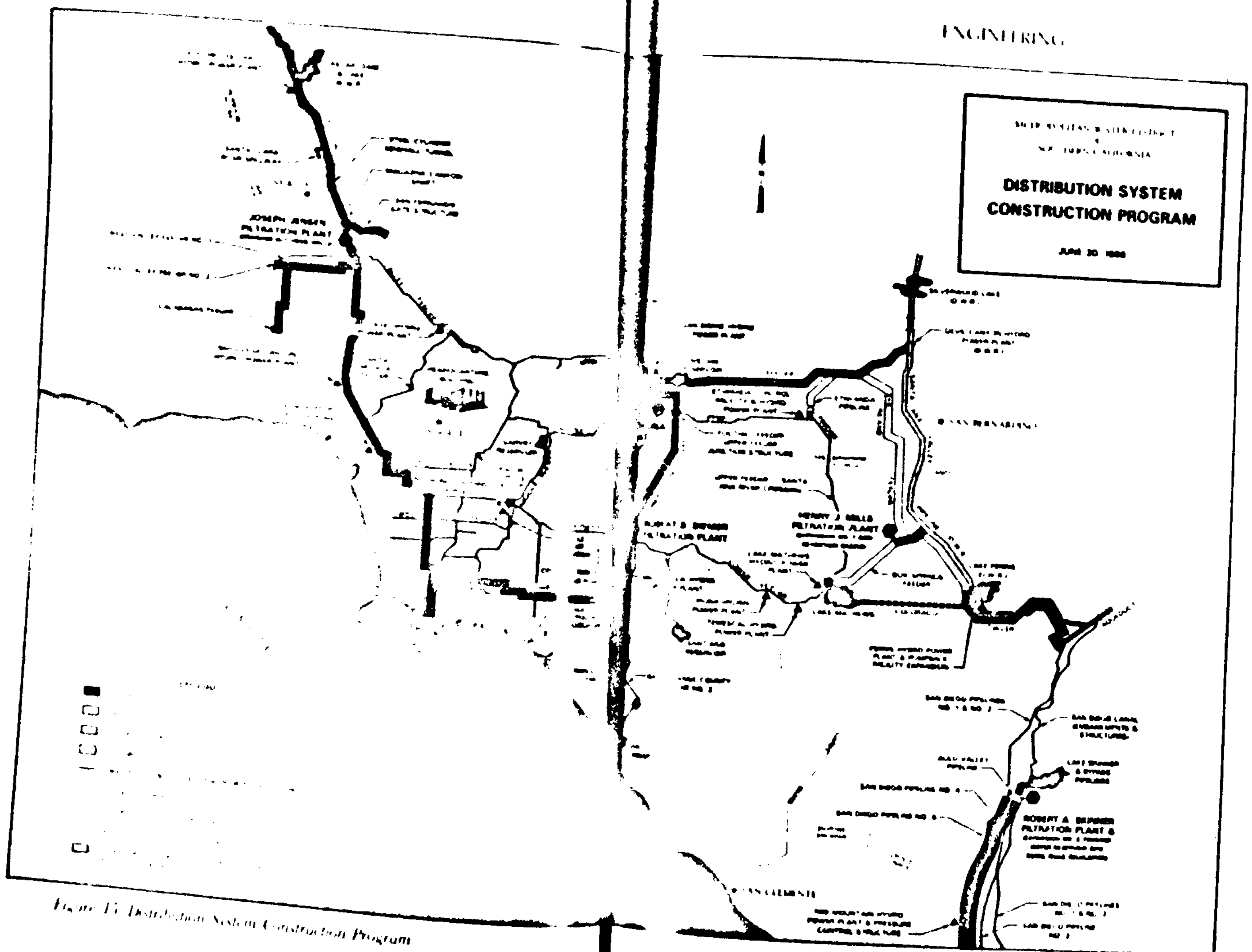


Figure 15 Distribution System Construction Program

equipment and right of way procurement, design, contract administration, inspection, and general administration. Metropolitan's existing and proposed facilities and pipelines are shown in Figure 15, while Table 3? summarizes projects in various design and construction stages.

Construction

Outside Contracts

During the fiscal year 17 construction contracts covering modifications, betterments, and expansions to existing facilities were in progress. Contractor earnings under these contracts totaled $20,532,361 during the fiscal year.

Additionally, the Board of Directors or the General Manager awarded nine construction contracts valued in excess of $71 million. Included in these contracts was the construction of Expansion No. 3 to the Robert A. Skinner Filtration Plant (Skinner plant), the Skinner plant's finished water reservoir and additional retention basins at the Henry J. Mills Filtration Plant (Mills plant). Eleven construction contracts were completed during the fiscal year with gross contractor earnings of $29,318,726. At fiscal year-end, six construction contracts valued at an estimated $70.8 million were progressing. Capital construction projects in progress at various times during the fiscal year included:

- Skinner Plant Expansion No. 3 — To better handle San Diego County's growing water demands, Metropolitan's existing facilities, including the Skinner plant, are being improved and expanded. This 200 million gallon per day (mgd) plant expansion will increase plant output from 340 mgd to 540 mgd and involves filtration modules, flocculation basins, chemical mixing and storage facilities, plant control units, and washwater reclamation facilities. Kiewit Pacific Company was awarded the construction contract at a bid price of $45.1 million in April 1989. Completion of this expansion project is presently scheduled for April 1991. Essentially, only mobilization operations were accomplished during the fiscal year.
- Finished Water Reservoir — Included in the major expansion of Skinner facilities, a 340-acre-foot finished water storage reservoir with a floating synthetic rubber cover will be constructed to improve supplies to the San Diego County Water Authority. This reservoir will ensure adequate disinfection contact time. A construction contract exceeding $20.5 million was awarded to Kiewit Pacific Company in May 1989; mobilization operations were progressing at fiscal year-end. All work required under the contract is currently scheduled for completion during February 1991.

- **Borel Road Relocation** — Relocating a portion of Borel Road was required for the Skinner plant expansion and construction of the finished water reservoir. McGrew Construction Co. completed relocation operations during December 1988.
- **Mills Plant Expansion No. 1** — Costing about $13.3 million, the 75-mgd expansion to the existing Mills plant was completed during June 1989. Prime contractor on the project was Dillingham Construction, N. A., Inc.
- **Retention Basins at Mills plant** — In connection with the Mills plant expansion, a $1.584 million contract to modify existing retention basins and construct additional retention basins was awarded to G. A. MacDonald Construction. This work will upgrade the plant's existing reclamation system to handle the increased water flow from the plant. Construction operations began in November 1988 and were 95 percent complete by the end of the fiscal year.
- **Floating Cover for Palos Verdes Reservoir** — Installation of this one-million-square-foot floating synthetic-rubber cover over the Palos Verdes Reservoir was completed during July 1988 by Gulf Seal Corporation at a final construction cost of $3,850,559.
- **Newhall Tunnel Liner** — Approximately 3,000-linear-feet of the existing Newhall Tunnel needed impervious steel lining to prevent continued seepage of crude oil into the water being transported from Lake Castaic to the Joseph Jensen Filtration Plant (Jensen plant). Installation of the 236-inch-diameter steel cylinders was completed by J. F. Shea Co., Inc. during May 1989 at a construction cost of $8,844,325.
- **Middle Feeder Relocation** — Part of the existing 83-inch-diameter Middle Feeder was relocated to accommodate construction of the proposed State Route 105 (Century Freeway). Advanco Constructors, Inc. completed relocating 1,100-linear-feet of pipeline during July 1988 at a cost of $1,478,595. This project is reimbursable by the State of California.

Details of various miscellaneous construction contracts awarded, in progress, or completed during the fiscal year are shown in Table 34. These projects consisted entirely of repairs and modifications to existing facilities and were located throughout Metropolitan's distribution network.

Metropolitan Construction

Major construction projects in progress during fiscal year 1988-89 by Metropolitan forces included rehabilitating Colorado River Aqueduct pump plant systems; structural modifications to the East Valley Feeder to improve operational reliability, facilitate maintenance and protect valves, installing operator-assisted automated control systems for the existing Mills filtration plant (Module No. 1) and the Mills expansion (Module No. 2), the Robert B. Diemer Filtration Plant (Diemer plant) and the Skinner plant (Modules Nos. 1, 2, and 3) and refurbishing F. E. Weymouth Filtration Plant (Weymouth plant) equipment to maintain operating reliability, improve water quality and energy management and automate the plant. Although design work is still under way to modify the Diemer plant to increase capacity, some construction work was also in progress during the year.

Engineering Design

Extensive design work was undertaken during the fiscal year. The following are major projects in design during the year:

- San Diego Canal Enlargement — The San Diego Canal will be enlarged to a 1,700 cubic feet per second (cfs) capacity to help meet the projected demand for San Diego County and the south part of Riverside County. The project will include raising canal banks and linings, weir walls, walkways, structure walls, and headwalls, and replacing radial gates where necessary to gain additional flow capacity. Design work was completed at fiscal year-end.
- Etiwanda Facilities — The Etiwanda Pipeline and Pressure Control Structure are being designed to deliver additional State project water from Devil Canyon into Metropolitan's distribution system. (The additional water will be made available by the California Aqueduct East Branch enlargement.) Extending about six miles from the Rialto Pipeline to the Upper Feeder in the Fontana area, the pipeline will contain a design capacity of 1,000 cfs and an inside diameter of about 12 feet. To control the pipeline's water flow, a pressure control structure and 450 acre-foot regulating reservoir are also being designed. Under the Etiwanda project, a 20-megawatt turbine-generator power plant is being designed to recover energy which would otherwise be wasted through the pressure control structure. The pressure control structure, power plant, and reservoirs will be located in the Rancho Cucamonga area. Design work on the pipeline and pressure control structure is scheduled to be completed by about February 1990, on the power plant, by June 1991.
- Jensen Filtration Plant Expansion No. 1 — The Jensen plant will be expanded from the existing 350-mgd capacity to a 750-mgd capacity to join with the Diemer and Weymouth plants in meeting increased water demands in Metropolitan's Central Pool area. Construction will include additional structures, mixing and settling basins, filter units, retention basins, a 50-million-gallon finished

water reservoir, and an additional 33-mgd washwater reclamation plant to handle expanded Jensen plant flow. Completed design on all phases of this project is expected by September 1990.

- Diemer Filtration Plant Modifications — The Diemer plant will be modified to increase plant capacity from the current 600 mgd to about 710 mgd to help meet the increasing Central Pool area water demands. The modifications will include raising the height of the launders and rejection weirs at the settling basins, adding equipment, enlarging service lines for the chlorination and chemical feed system, and expanding the washwater reclamation facility to accommodate the increased plant capacity. The design work is scheduled to be finished by January 1990.
- Weymouth Washwater Reclamation Plant Enlargement — Currently, the facility is undersized for treating Weymouth washwater when the plant is operating at high capacity. This enlargement project consists of constructing additional facility capacity, upgrading equipment in the north washwater reclamation facility module, and adding two sludge retention tanks. Design work should be completed by October 1989.
- Ozonation Demonstration Project — Under this project, a demonstration plant will be constructed at the Weymouth facility for verifying the technical feasibility and determining cost effectiveness of treating water with ozone or PEROXONE followed by chloramines. This project represents an effort to refine water quality in Metropolitan's systems to meet anticipated State and Federal water quality standards. Complete design work is expected by October 1989.
- Foothill Feeder Control Structure Expansion No. 1 — This structure will be expanded to 1,700 cfs to supply additional water from Lake Castaic to the expanded Jensen plant. The expansion will include installing valves in two existing branch lines. Design work should be completed about March 1990.
- During fiscal year 1987-88, preliminary design work was progressing on the Chino Valley Pipeline which will provide treated water to the Chino Basin service area under a conjunctive-use program. This year, design work was delayed while additional studies were conducted regarding Chino Basin conjunctive-use requirements.

Other design projects included Lake Skinner Bypass Pipelines Nos. 2 and 3 to provide operational flexibility during problem taste and odor episodes, expanding the Skinner plant administration building, constructing a maintenance building and expanding the existing administration building at the Mills plant, building vibration monitoring systems for hydroelectric plants, removing and replacing underground storage tanks throughout Metropolitan, and refurbishing Weymouth plant systems and equipment. (Design work was progressing on only portions of the underground storage tanks and Weymouth refurbishment projects – remaining portions of these projects are in construction phases.)

Service Connections

The reimbursable service connection program is an ongoing activity (See Table 13). Of six service connection projects under way during the year, three were under design by consultants and will be constructed by outside contractors. Metropolitan reviewed agency designs and provided construction inspection and cost monitoring.

During the year, two of the larger service connection projects in preliminary design were Service Connection LA-35 at the Jensen plant and enlargement of Service Connection OC-60 at the Diemer plant. LA-35 will connect Metropolitan's Foothill Feeder to the Los Angeles Department of Water and Power to increase water supply reliability. The OC-60 enlargement will help meet increasing water demands in southern Orange County.

Continuing Projects

Studies

Significant studies conducted during the year included a technical and operational feasibility study of possible sites for a new treatment plant near Lake Perris and a study of alternatives for improving San Joaquin Reservoir water quality and for better integrating the reservoir water into Metropolitan's distribution system. Of particular interest, studies were performed on water desalination processes and the technical and financial viability of constructing a seawater desalting plant in Southern California. Studies also were performed on possible energy sources for powering desalination processes including new generation nuclear power, fossil fuel, and coal. The nuclear studies focused on the modular, high-temperature, gas-cooled reactor concept.

Major studies conducted relative to system design capacities were a water distribution study for the Mills plant and Perris Reservoir sites, a flow test of the East Orange County Feeder No. 2 for the Central Pool Augmentation Project, and a test of the Weymouth plant's hydraulic capacity.

Investigation and Surveillance of Dams and Reservoirs

The ongoing surveillance program monitored the safety and structural performance of Metropolitan's 14 dams and reservoirs. This included daily inspections by operating personnel at all facilities and semiannual inspections by Metropolitan's dam safety engineers in which California Division of Safety of Dams (DSOD) engineers frequently participated. Seepage flows, piezometric pressures, and horizontal and vertical movements were and continue to be monitored and analyzed for each dam. During strong shaking from earthquakes, seismic acceleration time histories were also recorded instrumentally and analyzed. This fiscal year, five earthquakes of sufficient magnitude occurred to start the strong-motion accelerographs at various sites. None of Metropolitan's dams or reservoirs was damaged during any of these five earthquake episodes. Engineering reports were periodically provided to the DSOD, summarizing routine surveillance activities, periodic inspections, and analysis of all data collected from each dam.

The DSOD has formally concurred with the consultants' final conclusions that Morris Dam is stable and should be able to sustain the maximum credible earthquake shaking without uncontrolled loss of stored reservoir water. Document preparation is progressing to finalize the transfer of ownership of Morris Dam to the Los Angeles County Department of Public Works.

Office Automation

Computer use grew during the fiscal year, with applications for all facets of engineering design and construction. In construction administration, computers continued to help monitor construction contract progress, perform administrative tasks, and analyze survey data. Electronic surveying instruments and programs that perform survey calculations were used in field surveying. Additionally, two systems for monitoring and reporting dam and reservoir safety were implemented. One system completely automates collecting and processing settlement data while the other collects and processes piezometric data.

Both the Formtek and Auto computer-aided-drafting (CAD) systems helped prepare drawings for ongoing design projects and planning studies. Numerous programs to automate design-drawing production and improve CAD operator productivity continued to be developed.

Touche Ross & Company began reviewing engineering automation and information processing requirements to assist in selecting and implementing applications to improve engineering activity efficiency and effectiveness.

Staff began implementing a mainframe-based project management system which will help staff better manage projects and resources. This system offers managers current task-level information regarding project status and resource utilization.

Substructure Investigations

Substructure investigations review and analyze proposed utility and improvement projects to determine if they will interfere with existing and proposed Metropolitan facilities. During the fiscal year, staff received and answered 1,151 letters from outside agencies and developers regarding proposed new construction or modifications to existing facilities, and 225 notifications from the city of Los Angeles of proposed construction activities. Staff also reviewed 6,028 teletype notifications from "Underground Service Alert," a nonprofit computerized service notifying participating members of planned excavations or construction activities at or near their underground facilities. Additionally, approximately 404 street right-of-way notices to vacate were processed to ensure continued access to existing Metropolitan facilities.

Corrosion Control

Field Investigations

The ongoing program of monitoring and mitigating corrosion throughout Metropolitan's water transmission, storage, and distribution systems continued. Electrolysis and close interval potential surveys were completed on the Calabasas, Long Beach, and Torrance pipelines and the Lower, Middle, and Upper Feeder pipelines.

Staff monitored and maintained existing cathodic protection systems on a regularly scheduled basis. Several existing systems were modified and refurbished as required. New deep well anode cathodic protection systems were installed to provide corrosion protection for portions of the Inglewood Lateral and Rialto Pipeline. To mitigate the corrosive effects of cathodic interference from several petroleum conveying pipelines, a new deep-well anode cathodic protection system also was installed on the Second Lower Feeder.

Materials Evaluations and Research and Development

To stay current with new materials technology, materials evaluations continued, including short- and long-term testing of protective coatings, adhesives, linings, sealants, metal alloys, and other materials used for construction and maintenance.

Research and development projects undertaken this year included evaluating the effects of modified orthophosphate-based, potable-water corrosion inhibitors on reducing or eliminating the amounts of lead that can be leached from copper plumbing joined with lead tin solders. Testing was initiated to determine effects of chloramine-treated waters on elastomeric materials used in valves, meters, pumps, and back-flow prevention devices.

Data obtained from materials evaluations and research and development form the basis for materials selection and technical information for Metropolitan, its member agencies, and other water utilities.

Metallurgy

Failure analyses were conducted in both the metallurgical laboratory and the field to determine reasons for equipment failures at various locations. Resultant metallurgical evaluations have led to improved materials specifications, and modifications to operating parameters for both existing and proposed equipment.

In the metallurgical laboratory, complex metallurgical evaluations involving metal characterization (both destructive and nondestructive), failure analysis, alloy identification, and quality control can be performed. These capabilities are used by both the Engineering and Operations Divisions.

Seismic Investigations and Response Program

The Emergency Preparedness Task Force continued to coordinate Metropolitan's Earthquake Preparedness and Emergency Response Programs with those of State, counties, local cities, public and private utilities, and member agencies.

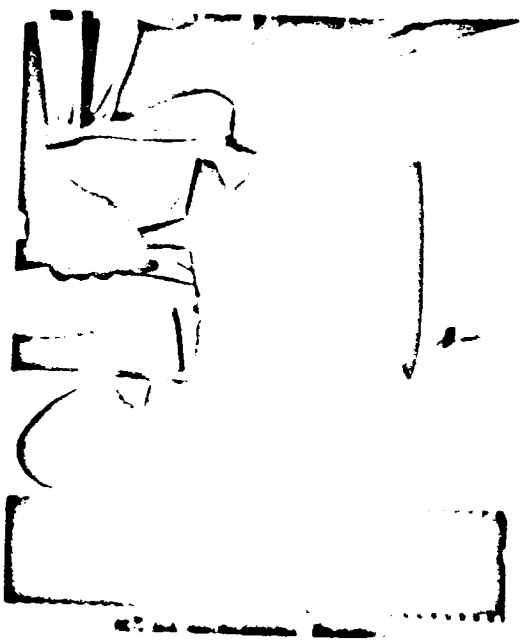
Several projects have been initiated under a long-range program to minimize the effect of a large seismic event. Consulting structural engineering firms analyzed the original maintenance shops at Metropolitan's La Verne facility and the Los Angeles Headquarters two-story buildings. Reports were prepared addressing proposed seismic upgrading to ensure these facilities continued functioning following a major earthquake.

Record of Survey Program

During the year, six Records of Survey covering 16 miles of pipeline and aqueduct rights-of-way were filed with County Records. Approximately 55 percent complete, this program monuments and records survey maps for public record.

Professional Consultant Activity

To keep pace with its accelerated fiscal year work program, Metropolitan relied on many outside sources to supplement its permanent work force. Professional consultants contributed significantly to this effort, and professional consultant activity increased about 61 percent from the previous fiscal year. As of June 30, 1989, 236 consultant agreements were in effect for services including feasibility studies, analyses, design, rehabilitation, program development and implementation, advertising, drafting, personnel training, forecasting, office automation, and administrative and clerical support work. Expenditures under these agreements totaled about $6,200,000; most of the services were engineering related.



Ensuring that slide gates can operate freely is a part of the maintenance process.

TABLE 33
ENGINEERING PROJECTS
DESIGN

Facility	Project	Status as of June 30, 1989	Estimated Completion Date	Cost as of 6-30-89 ($1,000s)	Total Project Cost ($1,000s)
DISTRIBUTION SYSTEM	San Diego Canal – Expansion No. 3	Final Design Complete, Construction Contract Award Scheduled July 1989	[illegible] 1991	4,161	4[illegible]
	Etiwanda Pipeline	Final Design in Progress, Construction Contract Award Scheduled February 1990	September 1991	2,253	51,000
	Etiwanda Control Facility	Final Design in Progress, Construction Contract Award Scheduled April 1990	September 1991	869	17,000
	Etiwanda Power Plant	Preliminary Design in Progress	April 1993	630	24,500
	Palos Verdes Feeder – Install Corrosion Protection	Preliminary Design in Progress	July 1991	5	1,600
	Santa Ana Cross Feeder – Relocate for City of Santa Ana Storm Drain Enlargement	Preliminary Design in Progress	June 1990	28	[illegible]
	Santa Ana Cross Feeder – Relocate for Freeway 5-55 Interchange Reconstruction (1)	Final Design in Progress, Construction to Start August 1989	January 1990	[illegible]	[illegible]
	East Orange County Feeder No. 2 – Relocate for Freeway 5-55 Interchange Reconstruction (1)	Preliminary Design in Progress	February 1991	7	8[illegible]
	Orange County Feeder – Relocate for [illegible] Landfill Expansion by the County Sanitation District of Los Angeles County (1)	Final Design in Progress, Construction Contract Award Scheduled November 1989	December 1990	[illegible]	3,4[illegible]
FILTRATION PLANTS					
Weymouth Plant	Oxidation Demonstration Plant	Final Design in Progress, Construction Scheduled to Start April 1990	February 1991	[illegible]	8,[illegible]
	Modify Water System	Final Design in Progress, Construction Scheduled to Start October 1989	August 1990	425	45[illegible]
	Replace Water Quality Instruments	Final Design in Progress, Construction Scheduled to Start September 1989	July 1990	28	[illegible]

(1) Reimbursable Project

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TABLE 33 (Continued)

ENGINEERING PROJECTS

DESIGN

Facility	Project	Status as of June 30, 1989	Estimated Completion Date	Cost as of 6-30-89 ($1,000s)	Total Project Cost ($1,000s)
FILTRATION PLANTS					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	August [illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	March [illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	February [illegible]	[illegible]	[illegible]
Jensen Plant	Expansion No. 1	Preliminary Design in Progress	March 1991	[illegible]	[illegible]
	Finished Water Reservoir No. 2	Preliminary Design in Progress	March 1991	[illegible]	[illegible]
Diemer Plant	Washwater Reclamation Plant	Final Design in Progress; Construction Scheduled to Start May 1990	April 1991	36	[illegible]
Skinner Plant	Administration Building Expansion	Design in Progress; Construction Contract Award Scheduled for July 1990	February 1991	21	800
	Install Permanent Chlorination System at Outlet Tower	Final Design in Progress; Construction Scheduled to Start January 1991	April 1991	23	825
	Bypass Pipelines Nos. 2 and 3	Preliminary Design in Progress	August 1991	220	6 500
Mills Plant	New Maintenance Building and Administrative Building Expansion	Design in Progress; Construction Contract Award Scheduled for May 1990	March 1991	51	2 500

TABLE 33 (Continued)

ENGINEERING PROJECTS

DESIGN

Facility	Project	Status as of June 30, 1989	Estimated Completion Date	Cost as of 6-30-89 ($1,000s)	Total Project Cost ($1,000s)
GENERAL	Garvey Reservoir Operations and Maintenance Center	Preliminary Design and Environmental Studies in Progress	To be Determined	61	4 100
	Garvey Reservoir: Replace Irrigation Water Line	Preliminary Design and Environmental Studies in Progress	To be Determined	1	400
	Garvey Reservoir Operations Control Systems Center	Preliminary Design and Environmental Studies in Progress	To be Determined	[illegible]	750
	Hydroelectric Power Plants (Except Greg Avenue) Phases I and II: Install Vibration Monitoring System	Final Design in Progress; Construction Scheduled to Start November 1990	June 1991	13	475
	Anaheim Lake: Construct Facilities for Delivering State Project Water for Groundwater Recharge[1]	Preliminary Design in Progress	To be Determined	5	2 800
	All Facilities: Replace Underground Storage Tanks Phase I	Final Design Complete; Construction Scheduled to Start October 1989	December 1989	340[2]	2 600[2]
	All Facilities: Replace Underground Storage Tanks Phase II	Final Design in Progress; Construction Contract Award Scheduled August 1990	November 1990	340[2]	2 600[2]
	Los Angeles Headquarters and Pasadena Satellite Facility: Replace Telephone Switch (L.A.) and Install Telephone System (Pasadena)	Final Design in Progress; Construction Scheduled to Start March 1990	April 1990	91	980
	Los Angeles Headquarters: Install Fire Safety and Security Systems	Final Design Complete; Construction Contract Award Scheduled for August 1989	January 1990	71	675
	Los Angeles Headquarters: Install Emergency Generator	Final Design in Progress; Construction Contract Award Scheduled for April 1990	February 1991	0	300
	Los Angeles Headquarters: Replace Precast Concrete Sunscreen	Preliminary Design in Progress	March 1991	27	1 300

(1) Reimbursable Project

(2) Includes Costs for Phases I Through III

TABLE 33 (Continued)

ENGINEERING PROJECTS

DESIGN

Facility	Project	Status as of June 30, 1989	Estimated Completion Date	Cost as of 6-30-89 ($1,000s)	Total Project Cost ($1,000s)
GENERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SERVICE CONNECTIONS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	August [illegible]	[illegible]	[illegible]

(1) Reimbursable Project

TABLE 33 (Continued)

ENGINEERING PROJECTS

CONSTRUCTION IN PROGRESS

Facility	Project	Contractor	Start Date	Percent Complete 6-30-89	Contract Cost ($1,000s)	Estimated Completion Date	Cost as of 6-30-89 ($1,000s)	Estimated Project Cost ($1,000s)
DISTRIBUTION SYSTEM	East Valley Feeder - Structure Modifications	MWD	July 1986	75		December 1989	1,566	3,500
	Upper Feeder Santa Ana River Crossing - Recoat Structural Components	Lundeen Coatings Corporation	April 1989	50	348	November 1989	100	400
AQUEDUCT SYSTEM	All Pumping Plants - Replace 36 Bronze Impellers, and Purchase up to One Spare Impeller for Each Plant	MWD	Nov. 1987	75	-	June 1992	4,388	6,515
	All Pumping Plants - Replace Thermometers and Temperature Recorders in Control Rooms	MWD	Jan. 1984	60	-	April 1992	278	460
	All Pumping Plants - Install 480 Volt Station Power Supply Systems	MWD	July 1986	90	—	June 1990	118	325
	Eagle Mountain, Hinds, Gene, and Iron Mountain Pumping Plants - Rehabilitate Main Transformer	Outside Contractors	Feb. 1985	80	1,600	January 1990	1,453	1,755
	All Pumping Plants - Install External Heat Exchangers on Bank No. 1 220 kv Transformers	MWD	Oct. 1989	60	—	April 1990	535	850
	All Pumping Plant - Replace Motor Protection Relays on Units 4, 5, and 6	MWD	Jan. 1988	80	—	July 1993	11	130
	Mile 12 Siphons - Install Acoustic Flowmeters	MWD	Sept. 1988	95	—	October 1989	388	425

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TABLE 33 (Continued)

ENGINEERING PROJECTS

CONSTRUCTION IN PROGRESS

Facility	Project	Contractor	Start Date	Percent Complete 6-30-89	Contract Cost ($1 000s)	Estimated Completion Date	Cost as of 6-30-89 ($1 000s)	Estimated Project Cost ($1 000s)
ACQUEDUCT SYSTEM	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
FILTRATION PLANTS								
[illegible] Plant	[illegible]	MWD	[illegible]	[illegible]		December [illegible]	[illegible]	[illegible]
	[illegible]	MWD	[illegible]	[illegible]		February 1991	2 [illegible]	[illegible]
	Replace [illegible] Equipment and Instrumentation [illegible] Building [illegible]	MWD	[illegible] 1988	[illegible]		February 1991	291	[illegible]
	Replace Water Sampling [illegible]	MWD	Feb 198[illegible]	70		April 1990	289	290
	Replace Chlorine Solution Manifold and Feed Lines	MWD	April 1988	40		April 1990	110	270
Jensen Plant	Security Improvements	Honeywell Inc	Mar 1989	40	448	July 1990	117	205
	Replace Chemical Feed Pumps	MWD	May 1988	25		May 1990	242	180
	Install Chemical Flowmeters	MWD	May 1988	25		May 1990	101	130
Diemer Plant	Automatic Computer-Assisted Control System	MWD	Nov 1987	80		April 1990	4 981	5 700
	Replace Sludge Pumps	MWD	May 1988	50		December 1989	194	[illegible]
	Plant Modifications	MWD	May 1989	25		April [illegible]	[illegible]	[illegible]

TABLE 33 (Continued)

ENGINEERING PROJECTS

CONSTRUCTION IN PROGRESS

Facility	Project	Contractor	Start Date	Percent Complete 6-30-89	Contract Cost ($1 000s)	Estimated Completion Date	Cost as of 6-30-89 ($1 000s)	Estimated Project Cost ($1 000s)
FILTRATION PLANTS (cont.)								
Skinner Plant	Expansion No. 3	Kiewit Pacific Co	May 1989	2	40 166	May 1991	7 411	50 000
	Finished Water Reservoir	Kiewit Pacific Co	June 1989	1	20 541	February 1991	1 972	26 000
	Modules 1 and 3 Influent Flowmeters	MWD	Nov. 1987	30	–	November 1989	53	110
	Install Automatic Computer Assisted Control on Modules 1, 2, and 3	MWD	Apr. 1987	85	–	October 1989	957	1 400
	Install Chemical Flowmeters on Modules 1, 2, and 3	MWD	July 1987	90	–	November 1989	89	130
Mills Plant	Modifications and Additional Retention Basin	G. A. MacDonald Company	Dec. 1988	95	1 584	August 1989	2 010	2 000
	Automatic Computer-Assisted Control System	MWD	May 1989	10	–	March 1990	869	2 000
	Sanitary Waste System	MWD	May 1989	90	–	August 1989	44	120
GENERAL	All Facilities: Replace Underground Storage Tanks Phase I	Tait & Associates, Inc	Jun. 1989	75	144	October 1989	340	2 600 [2]
	Distribution System: Install Discharge Monitoring Analyzers	MWD	Feb. 1988	10	–	March 1990	98	500

[2] Includes Costs for Phases I Through III

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R0049219

TABLE 33 (Continued)

ENGINEERING PROJECTS

[illegible]

Facility	Project	Contractor	Start Date	Percent Complete 6-30-89	Contract Cost ($1,000s)	Estimated Completion Date	Cost as of 6-30-89 ($1,000s)	Estimated Project Cost ($1,000s)
SERVICE CONNECTIONS [illegible]								
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* (Member Agency Administering Contract)
(1) Reimbursable Project

TABLE 33 (Continued)

ENGINEERING PROJECTS
CONSTRUCTION COMPLETED

Facility	Project	Contractor	Start Date	Completion Date	Contract Amount ($1,000s)	Total Project Cost ($1,000s)
DISTRIBUTION SYSTEM	Middle Feeder: Relocate to Accommodate Freeway 105 in the City of Paramount	Constructors, Inc.	Nov. 1987	July 1988	1,479	1,900
	Foothill Feeder: Install Liner in Newhall Tunnel	J. F. Shea Co., Inc.	March 1988	May 1989	8,855	10,700
	East Valley Feeder: Perform Structural Modifications	MWD	July 1986	May 1989	—	3,500
	Orange County Feeder: Relocate at Fullerton Creek (1)	KEC Company*	May 1988	November 1988	—	525
	West Orange County Feeder: Relocate for City of Anaheim Storm Drain Improvements**	Ameron, Inc. (Alabama) / S. A. Healy Company	July 1988 / December 1988	December 1988 / January 1990	171 (Both Contracts)	450
AQUEDUCT SYSTEM	Eagle and Hinds Pumping Plant: Replace Vibration Monitoring System	MWD	November 1986	November 1988		185
	Intake, Gene and Iron Mountain Pumping Plants: Replace Vibration Monitoring Systems	MWD	November 1986	December 1988		470
	Palos Verdes Reservoir: Replace Paving	Madison Paving, Inc.	July 1988	October 1988	172	325
	Intake, Gene, and Iron Mountain Pumping Plants: Replace Vibration Monitoring Systems	MWD	January 1988	December 1988	-	470
FILTRATION PLANTS						
Weymouth Plant	Install Flow Transmitters and Automate The North Plant of the Washwater Reclamation Facility	MWD	October 1988	March 1989	-	115
	Install Slide Motor Operators in Mixing and Settling Basins 1-4	MWD	June 1988	March 1989	—	175
	Install Vertical Turning Lathe in Machine Shop	MWD	October 1988	December 1988		550

* Orange County Environmental Agency is Administering Contract
** Construction Administered by City of Anaheim
(1) Reimbursable Project

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TABLE 33 (Continued)
ENGINEERING PROJECTS
CONSTRUCTION COMPLETED

Facility	Project	Contractor	Start Date	Completion Date	Contract Amount ($1,000s)	Total Project Cost ($1,000s)
FILTRATION SYSTEM						
[illegible] Plant	[illegible]	MWD	January 1988	July 1988		[illegible]
	[illegible]	MWD	November 1988	March 1989		[illegible]
Skinner Plant	[illegible]	MWD	May 1989	June 1989		[illegible]
Mills Plant	Construct [illegible]	[illegible] Construction N.A., Inc.	August 1987	June 1989	11,232	23,0[illegible]
SERVICE CONNECTIONS	Second Lower Feeder - Construct [illegible] (1)	[illegible] & Sons	March 1988	June 1989	245	[illegible]
	[illegible] - Construct [illegible] (1)	MWD	December 1987	August 1988		[illegible]
	Colorado River Aqueduct - Construct [illegible]	MWD	December 1987	April 1989		418
	Middle Feeder - Construct [illegible] (1)	MWD	December 1987	June 1988		485
GENERAL	Los Angeles Headquarters - Repaint Building Exterior	Xios Painting Company	June 1988	October 1988	51	632
	Sepulveda Canyon Control Facility - Recoat Storage Tank Interiors	United Federal Construction, Inc.	May 1988	June 1989	890	[illegible]
	[illegible] and [illegible] Power Plants - Construct Air Release Structures	MWD	July 1988	December 1990		100
	Palos Verdes Reservoir - Install Floating Cover	Gulf Star Corporation	September 1987	July 1988	3,757	5,255
	Palos Verdes Reservoir - Replace Paving	Madison Paving, Inc.	July 1988	October 1988	172	325

(1) Reimbursable Project

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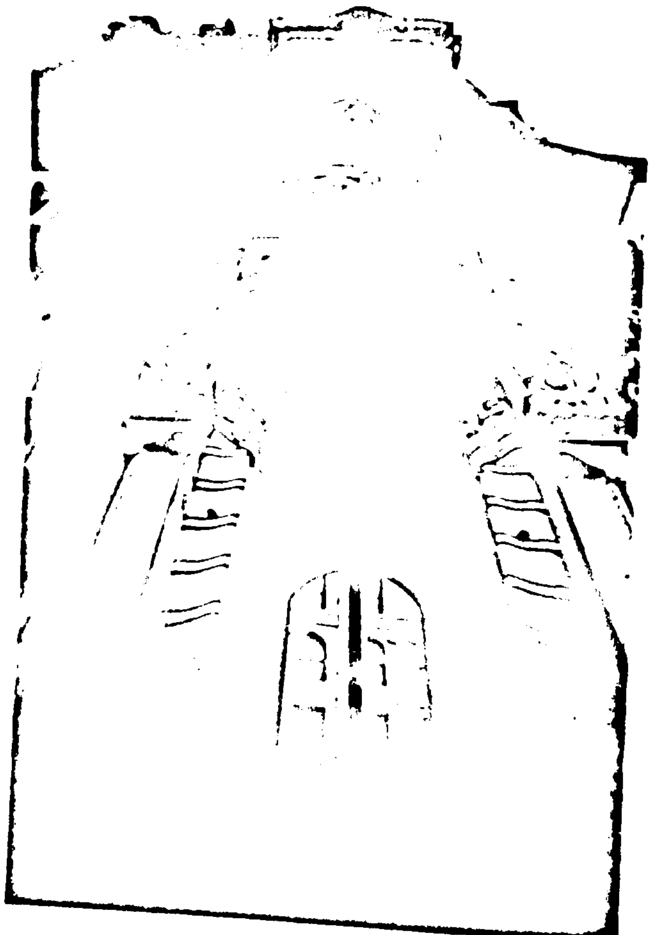
TABLE 34
MISCELLANEOUS CONTRACTS

Project	Contractor	Contract Cost	Awarded	Completed
Repaint Interior Storage Tanks - Sepulveda Canyon	United Federal Construction, Inc	$889,802	4-88	6/23/89
Repaint Exterior - L.A. Headquarters Building	Xios Painting Company	51,000	5-88	10/31/88
Replace Paving - Palos Verdes Reservoir	Madison Paving, Inc	172,004	6-88	10/28/88
Reroof Shop and Warehouse Building - Diemer Plant	Dave Wiltshire	49,986	7-88	11/3/88
Security Improvements - Jensen Plant	Honeywell, Inc	103,300 (Bid Amount)	10-88	67%
Repave Dike Roadway - Lake Mathews	R.J. Noble Company	53,891	11-88	4/7/88
Repaint Bridge Crossing - Santa Ana River	Lundeen Coating Corporation	347,619 (Bid Amount)	2-89	21%
Reroof Maintenance Service Building - Skinner Plant	TEC Systems, Inc	25,300	3-89	4/11/89
Remove and Replace Underground Tanks - Phase I	Tait Associates, Inc	144,147 (Bid Amount)	5-89	0%



The decorative entrance to Metropolitan's first headquarters still beautifies downtown Los Angeles

CHAPTER 7

Legal

Metropolitan's legal staff represents Metropolitan, its Board of Directors, officers, and occasionally employees, in litigation and administrative proceedings. The staff provides the Board [and] Metropolitan officers with legal advice and written opinions, and [re]views contracts and other documents. Additionally, the staff follows [lit]igation and administrative proceedings to which Metropolitan is not [a] party but whose outcome could affect Metropolitan or the resources [o]n which it depends. By closely monitoring State and federal legislative proposals, staff recommends positions Metropolitan should take, if any.

Litigation

Water Matters

Chino Basin MWD v. City of Chino, et al

In November 1988, three agencies holding water rights in the Chino groundwater basin under a 1978 water rights adjudication filed a motion seeking, among other things, to invalidate a trust storage agreement Metropolitan had executed with the Chino Basin Watermaster in 1986. The agreement allows Metropolitan to store groundwater in Chino Basin in exchange for imported water Metropolitan delivers through Chino Basin Municipal Water District to the city of Ontario and Cucamonga County Water District.

The San Bernardino Superior Court, supervising administration of that [ad]judication, upheld the validity of Metropolitan's agreement in a tenta[tiv]e decision issued on May 11, 1989. Proceedings to finalize that ruling [we]re pending at fiscal year's end.

Imperial Irrigation District v. SWRCB

On July 8, 1988, the Imperial County Superior Court denied Imperial [Irr]igation District's (Imperial) motion for a new trial on the ade[quacy of] the State Water Resources Control Board's (SWRCB) 1984 Decision 1600. [Th]at Decision ruled that Imperial was wasting water it diverts from the

Colorado River. Imperial filed a notice of appeal on August 8, but [illegible] not filed the record on appeal by fiscal year end. The Court of App[illegible] ruled in 1986, in an earlier Imperial appeal, that SWRCB had jurisdict[illegible] to determine whether Imperial is wasting water.

Mono Basin Water Rights Litigation

During the year, major developments occurred in the five cases challenging the city of Los Angeles' rights to export approximate[illegible] 100,000 acre-feet of water annually from Mono Basin streams in the eastern Sierra Mountains. These cases are important to Metropolitan since Los Angeles will replace losses in that supply by purchasing additional water from Metropolitan.

Three of the cases assert Mono Lake public trust obligations and have been coordinated for trial by the El Dorado Superior Court. On June 15, 1989 that court issued a temporary restraining order directing Los Angeles to hold all of its Mono Basin diversions in storage there until the court would rule on requests from the National Audubon Society and others for a temporary injunction that would reduce Los Angeles' Mono Basin supply to 50,000 acre-feet through March 31, 1990. At Los Angeles' request, Metropolitan submitted staff declarations to the court describing potential impacts on Metropolitan of that type of injunction.

The two remaining cases assert California Fish and Game Code obligations to maintain fish flows below Los Angeles' dams and other diversion facilities in streams that flow into Mono Lake.

On January 26, 1989, the Court of Appeal ruled that SWRCB must revise Los Angeles' water rights licenses to include those obligations. Metropolitan and other water agencies supported Los Angeles' unsuccessful request to the California Supreme Court for review of that ruling. At the fiscal year end, the cases were pending before the Sacramento Superior Court to determine specific directions to SWRCB.

SWRCB advised that it would initiate Mono Lake public trust proceedings in conjunction with its mandated proceedings to add fish flow requirements for the Mono Lake tributary streams to Los Angeles' water rights licenses. SWRCB accordingly filed a request in mid-June 1989 to stay the three Mono Lake cases until it completes its proceedings. In late June, SWRCB distributed a draft work plan that indicates those proceedings will last three years.

Laughlin River Tours, Inc., et al. v. Bureau of Reclamation, et al.

Plaintiff John T. Talley, an operator of river tour boats in the vicinity of Laughlin, Nevada, sought in federal district court in Las Vegas, Nevada, both a temporary restraining order and a preliminary injunction to require

the U.S. Bureau of Reclamation (Reclamation) to release 10,000 cubic feet per second of water continuously from Davis Dam to facilitate river navigation. Both those applications were denied. Plaintiff complains that the river in this reach is non-navigable during certain times of the year due to Reclamation's limited water releases. Plaintiff alleges that under the Boulder Canyon Project Act, a first priority is accorded to navigation improvement and that the U.S. Secretary of the Interior is failing to adhere to that priority by regulating the river in a manner favorable to water users and power generation. The States of Arizona, California, and Nevada, as well as the Los Angeles Department of Water and Power, Metropolitan, and the Arizona Power Authority, have all intervened in this action. The Regional Director of the Lower Colorado River Region denied the administrative request by Laughlin to release water from Davis Dam for the sole purpose of facilitating navigation, a decision affirmed by the Commissioner of Reclamation. The federal district court will now review that administrative determination.

Coachella Valley Water District v. Metropolitan, et al.

In February 1989, the Coachella Valley Water District (Coachella) filed an action in the federal district court for the Southern District of California to challenge the validity of the Imperial Irrigation District-Metropolitan Water Conservation Agreement. Under the Agreement's terms, Imperial would undertake conservation measures intended to conserve 100,000 acre-feet of water per year, and agree to reduce its diversion from the Colorado River by a like amount. In return, Metropolitan would pay Imperial the costs of conserving that water. Coachella, through its lawsuit, asserts that under the law governing Colorado River water (CRW) use and allocation, it has a prior right, to the extent it can be put to beneficial consumptive use, to water conserved by Imperial. The suit was served on Metropolitan and others in May of 1989. The parties have agreed to extend the time to respond in the lawsuit while settlement discussions continue.

Environmental Defense Fund, et al. v. East Bay MUD

The Environmental Defense Fund, Sacramento County, and others have pursued this action for 17 years. The action's apparent purpose is to prevent the East Bay Municipal Utility District (EBMUD) from taking delivery of American River water from the Federal Central Valley Project's Folsom South Canal under a 1970 Reclamation water supply contract.

Trial began in the Alameda Superior Court on March 6, 1989. On June 12, the court issued a 139-page "preliminary tentative decision" for review and comments by the parties. When finalized, that decision will represent a significant development in establishing rules for applying the public trust doctrine to water rights issues, and in recognizing the importance of public health aspects of water supplies.

The tentative decision recognizes that California's public trust doctri requires balancing in stream flow needs and water supply diversion nee on the basis of economic, technological, and other feasibility factors ar reasonable use considerations. It also places major emphasis on th importance of protecting public drinking water supplies from public healt risks. More specifically, it concludes that American River water has muc better public health characteristics than does Sacramento-San Joaqui Delta water.

The tentative decision provides a physical solution which would allow EBMUD to proceed with its plans to divert 150,000 acre-feet of American River water from the Folsom South Canal, but would impose several significant conditions. Those conditions include Lower American River flows twice as large as previously recommended by the SWRCB.

The conditions also include a 60,000 acre feet annual storage reserve for fishery needs, a requirement that the water be used only for municipal purposes within EBMUD's service area, EBMUD funding of viable fishery and riparian habitat in the Lower American River, and appointing a special master to administer the physical solution.

Indian Claims and Litigation

Metropolitan, et al. v. United States, et al. (Indian Boundary Litigation)

The United States Supreme Court granted Metropolitan's petition for certiorari from the Ninth Circuit's decision ordering the case dismissed on the basis that the United States was immune from suit. In June of 1988, Metropolitan, along with Coachella, the States of Arizona and California, filed their brief on the merits. The United States and the tribes filed their briefs in mid August. In June 1989, the Supreme Court, evenly divided, affirmed the Ninth Circuit's dismissal of the lawsuit. The tribes will not receive any additional CRW as a result of this decision. Rather, another forum must be found to finally determine the Indian reservation boundaries.

Soboba Band of Mission Indians v. United States

On or about June 27, 1986, the United States filed a cross-motion for summary judgment to limit the tribe's claim to damages to pre-August 13, 1946, damages actually incurred based on crops that the tribe would have grown on up to 286 acres of reservation land and for the permanent diversion of water from 86 acres of land. This latter determination, the United States contends, should be based on the diminution in value of reservation land before and after 1946, or the difference in value before and after the alleged permanent deprivation of water. That deprivation is alleged to be in part due to the effect on local aquifers by Metropolitan's San Jacinto Tunnel construction. The tribe in its motion for summary

judgment had apparently requested an award of approximately $63 million. The Claims Court in June 1989 denied the cross motion of the United States and will allow the tribe to claim post-1946 damages. The case will now be scheduled for trial. If damages are awarded to the Sobobas, the United States might assert a claim against Metropolitan for reimbursement for a portion thereof. An action on behalf of the Sobobas could also possibly be brought for monetary damages or for a determination of the Sobobas' water rights or both.

Miscellaneous Matters

MWD v. NRC Construction; NRC Construction v. MWD

In September 1988 this case was settled by agreement under which Metropolitan received a total sum of $100,000 from NRC Construction. The dispute arose out of the construction of Metropolitan's Water Quality Laboratory located at the F. E. Weymouth Filtration Plant in La Verne, California. During construction, various disputes arose regarding the quality of work, specification, interpretation, and inspection procedures, and the failure of NRC Construction as general contractor to follow written directives. Metropolitan first withheld a progress payment and then suspended work on July 17, 1984. When NRC Construction took the position that the suspension constituted contract termination, and refused to complete the project, Metropolitan finished the project under separate contracts and filed suit against NRC Construction. NRC Construction filed a cross-complaint against Metropolitan for breach of contract and quantum meruit. By reason of the settlement, the parties have dismissed their respective cross-actions and this suit is now ended as to Metropolitan.

MWD v. Voith-Hydro, Inc.; Allis-Chalmers Corporation, et al.

Metropolitan reached a settlement in the suit it filed in June 1988 against Voith Hydro, Inc. (Voith), the contractor, as successor-in-interest to Allis-Chalmers Corporation, which supplied the turbine generator units for Metropolitan's Red Mountain and Valley View Power Plants. Metropolitan paid a total of $2,000,147 for the two turbine generator units. The Red Mountain Power Plant was plagued by a series of runner failures necessitating repeated tear-downs, repair, and re-assembly, and the current runner is considered unreliable and needs a newly designed replacement. The Valley View Power Plant also failed upon initial start up and was beset by repeated operating and control problems which have been remedied. Various and difficult contractual and evidentiary disputes arose between the parties which necessitated the litigation, particularly with regard to causation of the Red Mountain Power Plant runner failures. Under the settlement, Metropolitan dismissed its suit in exchange for the supply of a newly-designed runner for the Red Mountain Power Plant, the installation of that new runner by Voith forces, and a payment to Metropolitan by Voith in the sum of $50,000. This litigation is now closed.

Internal Matters

Staff was involved in various cases in which damages were claimed for death, personal injury or property damage, principally resulting from accidents involving motor vehicles. Staff also represented Metropolitan in various personnel matters involving disciplinary issues or discrimination claims.

Administrative Proceedings

State Water Resources Control Board Activities — Bay Delta Hearings

SWRCB San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay Delta) water quality and water rights proceedings continued. In these proceedings, SWRCB will develop a document setting forth pollutant policy for waters of the State, adopting a water quality control plan identifying beneficial uses of Bay Delta waters, and determining reasonable levels of protection for those uses. It also will hold a water rights hearing to determine the need to condition water rights as a means to protect those beneficial uses. A wide variety of interests are represented in the hearings including the operators of State and federal water projects, State and federal fish, wildlife, and other resources agencies, agricultural and municipal/industrial water users, both in export areas and within the watershed, and environmental and other special interest groups. Metropolitan participates in concert with State Water Contractors, Inc. (SWC), an organization comprised of public entities with contracts for water delivery from the State Water Project (SWP).

In November 1988, SWRCB released a draft Water Quality Control Plan (WQCP) which effectively could have limited Metropolitan's supply of State project water to its 1985 supply level. Similar restrictions would have been imposed on other urban and agricultural water agencies relying on the Delta for their water supplies. However, as the result of petitions filed by Metropolitan and other parties, with SWRCB identifying numerous legal, factual, and policy errors in the draft WQCP, SWRCB withdrew the draft, revised its procedural work plan for the remainder of the proceeding and began preparing a revised draft WQCP.

Hearings on the pollutant policy document are scheduled to begin in October 1989, and it is anticipated that a revised draft WQCP will also be released in October, with hearings to commence thereon in mid-November 1989. SWRCB plans to adopt a final WQCP in July 1990 and the final pollutant policy document in August 1990. Adoption of that document will be followed by a scoping session and a water rights

hearing to review whether any water rights should be conditioned as a means of implementing the WQCP or otherwise protecting beneficial uses of Bay Delta waters.

The finally adopted WQCP and water rights decision could substantially impact the SWP's ability to store water and to export water from the Delta. This could in turn decrease the amount of water available for delivery to Metropolitan under its SWP contract. Nearly every urban area statewide and scores of agencies delivering water for agricultural purposes could also face reductions in available water from the Bay Delta watershed.

State Water Resources Control Board Activities — Emergency Drought Hearings

SWRCB held a series of hearings to determine the State water supply situation for 1988 (the second of two consecutive inadequate rainfall years) to establish contingency plans for a potential dry 1989, and to determine possible steps which water supply agencies could take to mitigate the impacts of a continued drought. Presentations were made by Reclamation, California Department of Water Resources (DWR), a number of other State agencies, agricultural, municipal, and industrial water users, including Metropolitan, and environmental interest groups. SWRCB issued a draft resolution containing its findings and determinations, which received substantial negative comment. Subsequently, SWRCB announced that it was indefinitely postponing any further proceedings on the drought hearings.

Interpretation of Shortage Provision of Metropolitan's State Water Contract

A controversy currently exists between Metropolitan, other State contractors, and DWR staff regarding water allocations under the various State water contracts in times of water shortage. Metropolitan currently relies on the SWP for approximately 50 percent of its supplies. In 1989, Metropolitan requested approximately 1,100,000 acre-feet of water from SWP; it had a right to request 1,961,000 acre-feet. Metropolitan contributes towards SWP's cost of conserving water on its right to receive water as distinct from its actual water delivery request.

The controversy relates to whether Metropolitan, in times of shortage, should, after certain initial deficiencies imposed on SWP agricultural users, be allocated available water based on its actual request or based on the amount of water it has a right to receive. Metropolitan ... that this water should be allocated on the basis of its right ... Such a basis enhances the reliability of the SWP's ... to Metropolitan.

Discussions on this matter are continuing with other State contractors and DWR.

SWRCB Imperial Irrigation District Water Conservation Proceedings

SWRCB adopted a 46 page order on September 7, 1988, implementing its 1984 Decision 1600 which ruled that Imperial is wasting water it diverts from the Colorado River. The order directed Imperial to initiate a program by the end of 1988 that will conserve an additional 100,000 acre-feet annually by January 1, 1994.

Imperial accordingly entered into a water conservation agreement with Metropolitan in December 1988 for a 35-year program to conserve that amount of water annually in Imperial Valley for Metropolitan's use. The agreement is subject to satisfaction of several conditions by the end of 1989.

Shasta Dam Storage Releases

In July 1988 and June 1989, Metropolitan, along with SWC, DWR and the Association of California Water Agencies filed memoranda with SWRCB in support of a Reclamation petition to rescind a waste discharge order of the Central Valley Regional Water Quality Control Board.

That order would establish a significant precedent by allowing regional boards to regulate Shasta Dam water storage releases into the Sacramento River as waste discharges, although SWRCB already regulates those discharges under water rights permits. The precedent could precipitate similar regional board regulation of other storage reservoirs such as those of the State Water Project.

On June 22, 1989, SWRCB directed its staff to initiate water rights proceedings to resolve the underlying factual issues. However, it had not determined by fiscal year end the manner in which it would rescind the regional board order.

Legislation

All legislation introduced in the California Legislature was examined to determine its interest to Metropolitan. Staff prepared a digest and recommendations as aids in reporting to the Board of Directors and others those items requiring a policy determination.

During the first half of the 1989-90 Legislative session, several bills were introduced dealing with the San Francisco Bay Delta Estuary. Three bills, Assembly Bill (AB) 2210, SCA 24 and SCA 28, sought to expand the existing statutory protection for water uses in the Bay Delta watershed. Metropolitan's Board opposed these measures since in each instance, the added protection would reduce the reliability of Metropolitan's SWP supplies.

The Board supported AB 1442, introduced by Assemblyman William Baker. This bill provides that monies the State General Fund currently owes the State Water Resources Development System, which includes the SWP, for project recreation and fish and wildlife enhancement benefits are to be offset against monies the System owes the California Water Fund (Fund). The bill also provides that future monies owed for recreation and fish and wildlife enhancement benefits would be used to reduce the Fund obligation. Two other measures, AB 609 and AB 610, introduced by Assemblyman Byron Sher, also dealt with Fund repayment. AB 609 requires the Legislature to annually review all reimbursements to the Fund to determine for what purpose the funds so reimbursed are to be used and AB 610 requires the SWP to reimburse the entire $432,800,000 owed the Fund by July 1, 1994. The Board opposed AB 610 and took no position on AB 609.

Metropolitan supported several measures dealing with water conservation. AB 325, authored by Assemblyman Steve Clute, would require cities and counties in California to adopt a resolution or ordinance on appropriate landscaping to further water conservation. AB 1571 and AB 1572, authored by Assemblywoman Maxine Waters, would provide State financial assistance for, or State participation in, constructing and improving local water storage and conveyance facilities. Senate Bill (SB) 1520, authored by Senator Robert Presley, would set new flushing standards for water closets for dwellings constructed after January 1992, while a similar bill, AB 2355 by Assemblyman Bill Filante, also would set stricter standards for water closets and associated flushometer valves.

Of several water quality bills, Metropolitan was particularly concerned with AB 2102, authored by Assemblyman Lloyd Connelly. This measure would require public water systems to notify consumers if the running annual average of quarterly samples for trihalomethanes (THMs) exceeds 25 parts per billion. The current primary drinking water standard for THMs is 100 parts per billion. The Board opposed this bill since it would require public notification even if THM levels lie significantly below the current primary drinking water standard and, therefore, would create confusion and undermine the public's confidence in its water supplies. The Board supported AB 21, authored by Assemblyman Sher, which would establish primacy for the State of California, under the federal Safe Drinking Water Act. The bill also would establish additional reasonable standard-setting requirements for maximum contaminant levels and recommended public health levels.

The Board also opposed AB 1767, authored by Assemblyman Moo[illegible]. This bill prohibits the Department of Health Services director from issuing an order requiring covering or draining a reservoir owned by a public water system unless no other alternative is technically feasible. If enacted, this measure could prevent installing reservoir covers even though a cover might best preserve water quality and ensure public safety.

[illegible]

Southern Californians long for plenty of winter snow to guarantee substantial spring runoff.

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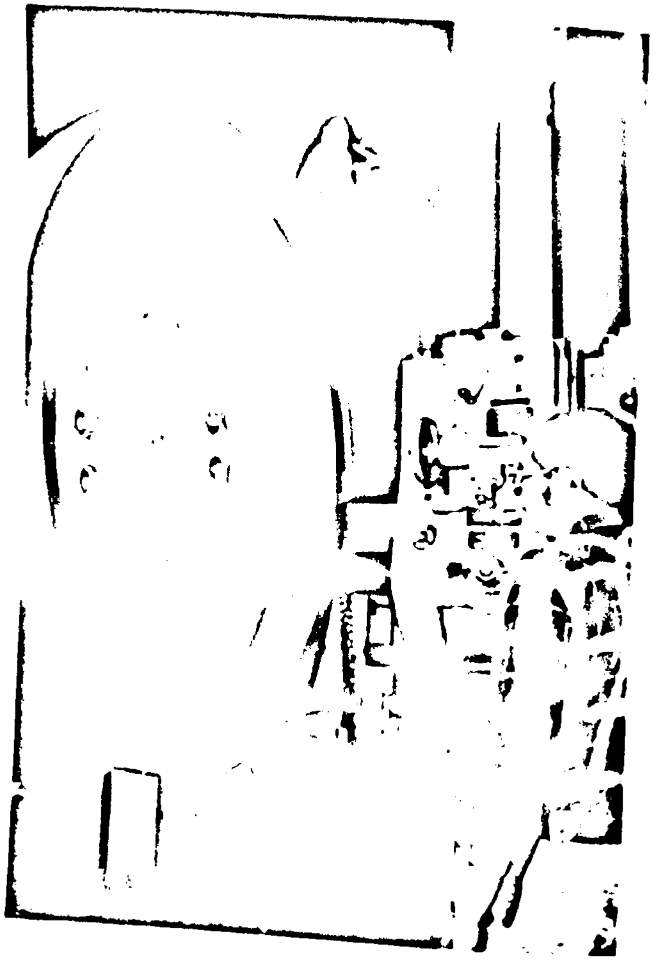

Metropolitan assists others, such as by working on an impeller for the State Water Project.

CHAPTER 8

Finance

[illegible]neral Obligation Bond Sale

In June 1989, Metropolitan sold $215 million in Waterworks General Obligation Bonds, Election 1966, Series C, to raise needed capital funds. A negotiated sale occurred on June 15, 1989, after only 15 working days [of] preparation, and such sale was recommended to the Board to take [ad]vantage of the lowest rates available to insurers in the last 10 years. The [b]onds were sold at a net interest cost of 6.53 percent and a true interest [cost] of 6.65 percent. At the time of the sale, the 25-year index for AAA-rated G.O. bonds stood at 6.85 percent, the AA 20 G.O. bond index at 6.88 percent. Rating agencies rated the issue AAA/Aaa.

With the sale's proceeds, Metropolitan can continue funding its expansion program into 1991. Metropolitan's average cost of capital, including this sale, remains below 7 percent, noteworthy considering the credit markets' volatile nature over the last decade.

Long-Range Finance Strategy

In 1986, staff prepared a Long Range Finance Plan to identify the most [co]st-effective means of financing Metropolitan's capital improvement plan. During this fiscal year, staff developed a Strategic Finance Plan that [ad]dressed both Metropolitan's updated capital financing requirements [an]d how the future construction program will impact total costs and [fut]ure water rates. Staff continued developing and analyzing financing [tech]niques to lessen Metropolitan's future cost of capital while preserving financial integrity. The updated plan identifies [illegible] [strateg]ies for meeting Metropolitan's long range capital [illegible] year 2010.

[St]aff projects that capital improvements and [illegible] [distr]ibution and treatment systems through the [illegible] billion in 1989 dollars or $4.5 billion in escalated [illegible] recommends funding these expenditures [illegible]; however, projections indicate a possible [illegible] [capac]ity by 1997. To reduce bonding requirements [illegible] various financing methods to the Board during the year. Acting on [illegible] recommendations, the Board approved a revised pay-as-you-go prog[illegible], a revised working capital policy, and creating a Revolving Constru[illegible] Fund (RCF) during the year.

The Board authorized a pay-as-you-go objective of 20 percent of [illegible] construction program. This measure coupled with revenue bond s[illegible] should completely finance the construction program.

The new working capital policy sets a ceiling of $130 million for work[illegible] capital purposes through fiscal year 1993-94. The increased financ[illegible] flexibility now available to Metropolitan through short-term debt authority should hold working capital at this level for the next five years. Staff will periodically review working capital levels and water sales experience to ensure that Metropolitan can cover potential revenue shortfalls. To comply with statutory, bond covenant, contractual, and rating requirements, the revised policy will maintain sufficient funds; it also will help Metropolitan adjust to changing circumstances such as back-to-back annual water sale deficiencies.

In January 1989, the Board established the RCF with a $100 million loan from the Water Rate Stabilization Fund (WRSF). When bond funds are unavailable, the RCF balance would be expended on capital programs. The RCF would then be reimbursed from security sale proceeds. Using the RCF will enable Metropolitan to better time market entry for security sales and realize economic savings of up to 1.5 percent (the difference in interest rates between invested funds and long-term borrowed funds).

1989-90 Budget

Staff [illegible] Metropolitan's 1989-90 budget in a program-budg[illegible] format [illegible] statements of accomplishments, objectives and the [illegible] resources needed to continue a high standar[illegible] of service [illegible] member agencies. With the program-budg[illegible] format [illegible] division consolidates its activities and cost in an intern[illegible] evaluate performance against Metropolitan goals.

The 1989-90 [illegible] include optimally using Metropolitan's facilities, expanding [illegible] of Metropolitan's distribution system, upgrading and [illegible] treatment facilities, increasing dependable water supplies and [illegible] programs to reduce demands on Metropolitan's system, upgrading water quality standards, rehabilitating Colorado River Aqueduct [illegible] pumps with minimal service interruptions, and continuing to automate Metropolitan work activities. These expenditures are estimated to be $562 million in 1989-90.

FINANCE

[illegible]89-90 Revenue Requirements and Water Rates

In December 1988, the General Manager submitted [illegible] [illegible]surance Committee an estimate of total revenues [illegible] [illegible]es for fiscal year 1989-90, as determined under the Board's [illegible] [illegible]e policy. The General Manager recommended and the [illegible] [illegible]proved using up to $22 million from the WRSF to [illegible] [illegible]sts, and that revenues derived from 1989-90 water [illegible] at least [illegible]58 million. This formed the basis for setting the [illegible] water rates.

In January 1989, the General Manager submitted a recommendation [illegible] no change in water rates to the Water Problems Committee, leaving the rates unchanged since 1984. Following a public hearing, the Board adopted rates for 1989-90 as follows:

Noninterruptible		Interruptible		Emergency		Reclaimed
Untreated	Treated	Untreated	Treated	Untreated	Treated	
$197	$230	$153	$186	$591	$624	$84

Metropolitan's water pricing structure contains four service classes: noninterruptible, interruptible, emergency, and reclaimed. Noninterruptible service includes water sold for domestic, municipal, and other purposes, while interruptible service meets all noncontinuous demands, including groundwater replenishment and agricultural uses. Water sold for agricultural purposes at interruptible rates is provided only when not needed for municipal and industrial uses. Under certain conditions, such as temporary water shortages, interruptible water delivery can be reduced or discontinued. Agencies purchasing interruptible water must be able to sustain an interruption by using their local storage supplies. If they cannot, agencies may avoid customer service loss by purchasing water for domestic and municipal purposes, but at the substantially higher emergency rate. Reclaimed water (nonpotable water with limited uses) is sold at Metropolitan's lowest rate. Metropolitan's reclaimed water comes from rights received through financial participation in member agencies' [illegible]l reclamation projects.

[illegible]n Revenue

[illegible]entified as an objective in the long-range financ[illegible] [illegible]or more new sources of firm revenue will help [illegible] [illegible]ble water revenues as Metropolitan taxes and [illegible] [illegible]ne. During the year, staff compiled a report that [illegible] a firm revenue charge collected as a service [illegible] [illegible]ber agencies, and how a service charge would [illegible] [illegible]erential right to purchase water, the offset [illegible] [illegible]ctions, and changes in working capital req[illegible]

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Staff considered several factors in allocating a projected service charge among the member agencies. These included water demands, service connection capacity, acreage, population, and assessed valuations. Various levels of service charges were examined based on amounts collected sufficient to meet Metropolitan's total fixed costs, total capital costs, revenue bond debt service, or a combination of revenue bond debt service plus pay-as-you-go construction. The report illustrated how a service charge could be established at various levels and allocated among the member agencies under different methods.

Alternatively, staff investigated the relative merits of phasing in a water standby charge on individual land parcels within Metropolitan's service area. Imposed annually, the standby charge would be shown as a line item on county tax statements. The charge per parcel would be established by the Board; it may be allocated on such bases as acreage, land use, benefits received from the construction program, or the quantity of water used in the parcel's service area. Parcel information is gathered through each County Assessor's Parcel Number (APN) which is uniquely assigned to every parcel within the State. Extracting, modifying, and analyzing the APN data available from each County Assessor requires specialized technical expertise. A consultant assisted in continued studies of a standby charge revenue mechanism.

Investment Operations

State law requires Metropolitan's Treasurer to submit annually a statement of investment policy to the Board. The statement describes the Treasurer's investment authority, practices, and limitations, as established by the Government Code and Board policy. In order of importance, Metropolitan's basic investment policy's objectives are safety of principal, liquidity, and yield.

Interest earnings totaled $52 million, an increase of approximately $15 million over fiscal year 1987-88. At year end, the return on investments ranged from 7.5 percent to 10.5 percent with average weighted days to maturity of 215.7 days.

Examination of Metropolitan Bonds Held for Safekeeping and Escheatment of Coupons not Presented for Payment

A physical inventory of bearer bonds held for safekeeping by Bankers Trust Company in New York and Security Pacific National Bank in Los Angeles was performed using bank personnel. The two financial institutions are expected to resolve the minor discrepancies noted.

Financial Systems Automation

As one of its objectives, the Finance Division works through automation to deliver prompt financial information to respond to queries and to more readily support the decision-making process. Automated systems provide a means to capture, develop, store, and deliver this needed information. Staff is developing various systems within the division and also is creating various corporate information systems.

During the year, staff installed a local area network within the division, enhanced the *Electronic Timesheet System* (ETS), and implemented a general ledger query system. The query system will allow network users to access information from the general and appropriation ledgers. Work progressed on developing an enhanced cost accounting and budgeting system; testing an investment management system to assist the Treasurer in making, monitoring, and reporting investment decisions; and maintaining information through an on-line system on vendors who do business with Metropolitan.

Staff began testing the *Investment Management System*, which is designed to assist with analyzing, tracking, reporting, and accounting for Metropolitan's investment portfolio. Program coding and the system's initial testing phase have been completed.

Installed within the division this year, a *local area network* allows sharing of microcomputer resources, such as printers and software. The network will facilitate developing a financial data base integrating information related to investments, cash accounting, general ledger accounting, and accounts receivable records. All network users may review general ledger information via an application that was implemented during the year. In the near future, staff plans to activate the General Ledger and Cash systems in the network environment.

Electronic Timesheet System

The ETS was enhanced during the year to permit tracking of labor hours against work tasks. The new ETS captures data at more detailed levels than did its predecessor. Additionally, it will allow for full integration with the proposed Cost Accounting System. The staff also is revising the electronic approval process to improve ease and efficiency of use.

During the year, a more efficient on-line Vendor System replaced the manual method of maintaining information on Metropolitan's vendors. The information supports Metropolitan's purchasing and accounts payable functions. Eventually, the Vendor System will be a subsystem of the new Procurement System.

In September 1987, the Automation Overview Report (AOR) identified the Cost Accounting System and the reporting of cost information as needing improvement. The AOR recommended addressing this as a major application within the corporate information system. Additionally, the AOR encouraged improving the budget process and the current budget system in the areas of data accuracy, procedures, and systems.

The limiting factor with the current cost system is the cost accounting structure and the systems that relate to it, including budget, operating equipment, and labor. During the summer of 1988, a task force including staff from several divisions began reviewing the chart of accounts and the cost accounting structure. Its goal: to develop an integrated perspective and understanding of the information requirements of systems for cost, budget, project management, and other related systems, and to devise a flexible yet consistent structure. Phase 1, which provided a data model and requirements overview, was completed in November 1988. The second phase was initiated to further define the proposed system's data, interface, and processing requirements.

The second phase has been completed with the task force defining the requirements for a comprehensive cost and budget data structure. This structure and the related data model represent a significant portion of the "corporate data base" and a major milestone for the task force. With this proposed structure, staff can begin addressing many of the problems the original AOR identified.

Automation of Transmitting Payroll Information

The software necessary to electronically transmit payroll data to Security Pacific National Bank via computer was developed and successfully tested. Staff expects to put this process in production by December 1989.

Automation of Stop Payment Procedures

During the year, a system allowing computers to place stop payments on Metropolitan checks was implemented. This electronic method will reduce the cost of placing stop payments on checks by 50 percent. In addition, the length of time in which a stop payment may remain in place without being renewed was doubled.

Physical Inventory of Central Stores

The Controller's Branch annually performs a physical inventory of the Central Stores to verify the accuracy of Metropolitan's perpetual inventory records. In recent years, this occurred at an interim date (in March or April) to allow enough time to complete the inventory testing prior to fiscal year end.

The 1988-89 Central Stores inventory was taken as of April 30, 1989. A report was issued summarizing the results of the physical inventory counting process and quantified the reduction in inventory value based on the results of that counting. The report contained several recommendations for improving the physical inventory process. Staff concluded, after certain reconciliation procedures were performed, that the statistically projected total inventory value was, within a high degree of probability, approximately $8,557 less than the recorded inventory values (0.1 percent of the total inventory).

Operating Equipment

The 1988 operating equipment inventory is nearing completion. In conjunction with the inventory and to facilitate automating the inventory process in 1990, bar code tags were designed and attached to all operating equipment. Staff also developed new transfer reporting procedures for equipment.

Benefits Administration

Section 89 Compliance

Staff spent considerable time researching, collecting data, and running preliminary tests for legal counsel in preparation for compliance with Internal Revenue Service Code Section 89 requirements. Section 89 requires testing employee benefit plans that provide tax-favored benefits to "highly compensated" employees.

Deferred Compensation

Metropolitan administers a deferred compensation plan for its employees' benefit according to Section 457 of the Internal Revenue Code of 1986. This plan enables employees to defer portions of their compensation until retirement, disability, or death. The Director of Finance administers the plan, the Plan Coordinator maintains participation records, and the Treasurer invests the deferred funds in security [illegible]. As of June 30, 1989, the plan balance was $16.2 million compared to $13.6 million on June 30, 1988. Employees deferred [illegible] the fiscal year and investments yielded an average return of [illegible] percent.

Savings Plans

In accordance with Section 401(k) of the Internal Revenue Code, Metropolitan established two additional deferral arrangements to [illegible] employees (referred to as Savings Plans I and II). The Director of Finance [illegible]

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administers the plans and the Treasurer acts as Trustee. Amounts deferred are transferred each payday to a third-party broker who invests them in authorized investment vehicles as each participant directs. Employees deferred a total of $601,743 in fiscal year 1988-89. Enrollment in the various plans increased 11 percent over last year, raising total enrollment to 931 participants.

Several provisions in the 1986 Tax Reform Act, which became effective January 1, 1989, necessitated plan amendments. The revisions proved technical in nature, were approved by the Board of Directors, and did not significantly affect Metropolitan's plan administration. The major changes reflect more rigid distribution requirements and revised limitations on the amounts participants can invest.

Pursuant to the Tax Reform Act of 1986 relating to Metropolitan's 401(k) Saving Plans I and II, the anti-discrimination test was modified for the plan years beginning after December 31, 1988, to further limit the disparity between elective deferrals made by "highly and non-highly compensated employees." The actual deferred percentage of the "highly compensated employees" (as defined by IRS) has been adjusted downward to ensure regulatory compliance.

Risk Management

The Risk Manager consulted with Resources Division personnel regarding insurance and indemnity related to water conservation negotiations and with Operations Division and Legal Division personnel regarding the Orange County Volunteer Emergency Preparedness Organization and Municipal Water District of Orange County programs.

The Risk Manager also completed an Annual Report on Risk Management, and audited the transactions reports for subrogated property losses.

Balance Sheet Highlights

Cash & Marketable Securities

Cash and marketable securities totaled $694 million and $613 million at June 30, 1989 and 1988, respectively, as shown in the following table.

TABLE 35

CASH AND INVESTMENT SCHEDULE

June 30, 1989 and 1988
(Dollars in Thousands)

	June 30 1989	June 30 1988
Cash and cash equivalents	$ [illegible]	$ 1,257
U.S. Treasury securities	[illegible]	259,040
GNMA's	[illegible]	4,468
Federal agency securities	112,[illegible]	60,269
State agency securities	25	20
Bankers' acceptances	33,875	91,114
Prime commercial paper	84,364	72,441
Negotiable certificates of deposit	101,922	107,105
Repurchase agreements	16,643	12,093
Local Agency Investment Fund	5,000	5,000
Total cash and investments	$694,189	$612,807
Less:		
Restricted portion	288,494	212,799
Employee deferred compensation fund	15,988	13,421
Unrestricted cash and governmental marketable securities	$389,707	$386,587

Cash and marketable securities are held under separate accounts (funds) to accomplish specific activities in accordance with special regulations, bond covenants, and Board policies. The funds are classified under general headings as "unrestricted" and "restricted." After necessary fund transfers are made to comply with bond covenants, the Board has complete discretion over the magnitude and use of unrestricted funds. Restricted funds are non-discretionary in use and pay for debt service on Metropolitan bonds and capital costs under the State Water Contract. In addition to unrestricted and restricted funds, Metropolitan maintains other funds as follows (also see Table 36):

- Revenue Bond Construction Fund
- 1966 Bond Construction Fund
- Revolving Construction Fund
- San Joaquin Reservoir Fund
- Deferred Compensation Fund

Plant and Equipment

Before accumulated depreciation, plant and equipment increased $68 million over 1988, to $1.4 billion in 1989, after depreciation, primarily because of construction program expenditures for water distribution and treatment plant facilities.

Participation Rights in State Water Facilities

Participation rights reflect unamortized capital expenditures made under the State Water Contract. Since Metropolitan does not own the State Water Project (SWP), the capitalized payments represent intangible rights (assets). The participation rights are amortized as Metropolitan receives State project water. For the fiscal year ending June 30, 1989, the asset account increased $118 million before amortization to $945 million net of amortization. This increase was directly associated with the revised costs for each State Water Contract component cost.

Deferred Water Rights

Metropolitan and other agencies have entered into several water exchange, storage, and reclamation project agreements, which reliably supplement Metropolitan's Colorado River and State project water supplies. Metropolitan is also actively pursuing other agreements both within and outside its service area, to provide additional water supplies.

The exchange and storage agreements generally provide for advance water delivery during periods when surplus flows and inexpensive energy for pumping are available. The reclamation project agreements effectively furnish Metropolitan funding to construct or improve reclamation facilities by local agencies to produce subpotable water for agricultural and industrial uses.

Cost associated with these agreements have been recorded as deferred charges and are amortized to the cost of water as the rights are exercised. At June 30, 1989 and 1988, deferred water rights totaled approximately $16 million and $17 million, respectively, based on volumes of 715,000 and 757,000 acre-feet respectively, as of such dates.

Bonded Debt

On June 30, 1989, $879 million in Metropolitan bonds was outstanding, consisting of $365 million in revenue bonds and $514 million in general obligation bonds (Table 37). Principal payments in 1988-89 reduced bonded debt by $16 million. Table 42 contains a five-year summary of Metropolitan's revenue bond coverage. The weighted average cost of all bonded debt outstanding, exclusive of the 1989 Series G general obligation bonds, was 5.57 percent at year end with an average bond life of 17 years.

Commitments and Contingencies

To provide power for transportation within the SWP system, the State Department of Water Resources (DWR) has financed construction of certain off-aqueduct power facilities. Construction on one such facility, the South Geysers Geothermal Power Plant, was suspended in 1987 pending

procurement of a steam supply sufficient to operate the plant at planned capacity. During the year ended June 30, 1989, DWR officials decided to dispose of the plant assets, if possible, by leasing the steam field and plant site, and selling the power plant equipment. As a result, Metropolitan's management determined, per provisions of Financial Accounting Standards Board Statement No. 5, that Metropolitan had incurred a contingent loss which must be recognized for financial reporting purposes. Therefore, the portion of unamortized participation rights attributable to the South Geysers Project, totaling $22 million, was written off as of June 30, 1989. Additionally, the estimated present value of $55 million of Metropolitan's remaining obligations to the State for debt service costs of South Geysers Project was recorded as a contingent liability.

Equity

Equity on June 30, 1989, stood at $2.1 billion, compared to $2.0 billion on June 30, 1988. The increase reflects net income of $115 million and $2 million more in contributions from member agencies to aid construction. Of retained earnings, $68 million was designated at fiscal year end for pay-as-you-go construction to reduce future debt requirements and to preserve revenue bond debt capacity.

Statement of Operations Highlights—Accrual Basis

Water Sales and Power Recoveries

Revenues of $425 million from water sales increased $32 million over last year (Figure 16). Water deliveries of 2,095,079 acre-feet rose 171,256 acre-feet over fiscal year 1987-88, marking the fifth consecutive year of record water sales. Hydroelectric power sales generated revenues of $19 million, $1 million more than the previous year.

Interest and Other Income

Interest earnings increased by $12 million for a total of [illegible] fiscal year 1988-89, reflecting higher interest rates on [illegible] Other income equaled $7 million, an increase of $1 [illegible] principally due to Metropolitan's sale of surplus [illegible]

Taxes and Annexation Income

As shown in Tables 40 and 41 and Figure 17, the total valuation of property subject to taxation for Metropolitan purposes was $597 billion in August 1988, representing a 5.7 percent increase over August 1987. Beginning in fiscal year 1988-87, unitary values for State Assessed utility properties were valued separately and excluded from the total taxable assessed valuations. The unitary value results in an average county-wide tax rate for property operated as a unit in a primary function. Therefore, the individual county determines an estimated revenue (tax) for Metropolitan's bond debt service accounts at a specified dollar amount which it remits to Metropolitan.

Proposition 13, adopted by voters in 1978, does not limit taxes levied by Metropolitan to pay voter-approved bonded debt, including payments under the State Water Contract and debt service requirements for Metropolitan general obligation bonded debt. Ad valorem property taxes and annexation charges collected on all property within Metropolitan totaled $73 million during 1988-89. For the fiscal year, Metropolitan's secured property tax rate was .0110 percent of assessed value; the unsecured rate was .0112 percent. This equals 4.4 cents and 4.5 cents per $100 of assessed value, respectively, as defined before Proposition 13, with assessed value recorded at one quarter of full value. Table 39 summarizes the tax rates over the past five years and Figure 18 shows regular tax levies.

Since 1978, Metropolitan has required newly annexing areas to pay charges on a cash basis. Prior to 1978, annexing areas could amortize their annexation fees over 30 years, and most areas chose this option. These areas must make essentially equal annual payments to Metropolitan until the debt is fully amortized. As a result, the applicable annexation tax rate varies yearly due to changes in the area's assessed valuation. Annexation charges levied this year totaled $6 million; total estimated future annexation charges amount to $28 million. Fiscal year income from cash annexations was $14 million.

Metropolitan does not record annexation receivables unless full amortization can be accomplished within 50 years following the amortization date by applying an annual tax rate of 0.1875 percent of assessed valuation or less, assuming that the annexed area's assessed valuation remains constant. As of June 30, 1989, annexation receivables of $46 million, including uncollected interest of $18 million, were not reflected as assets nor included in Metropolitan's equity.

Operating Expenses

Net operating expenses of $218 million increased $5 million over the previous year, reflecting State Water Contract credits totaling $25 million.

Depreciation and amortization expenses increased $19 million to $1.1 billion, because DWR increased the Water System Revenue Bond Surcharge charges. The amount of Participation Rights amortized is based on the total projected annual water deliveries divided into the total associated cost base. Bond interest expense, net of $5 million interest capitalized, was $46 million, a decrease of approximately $4 million.

Net Income

For fiscal year 1988-89, net income decreased $46 million to $115 million. The decline resulted primarily from recording a $76 million loss for financial reporting purposes attributable to the State's planned abandonment of the South Geysers Geothermal Power Plant.

Debt Service Coverage

Debt service coverage on the outstanding revenue bonds for fiscal year 1988-89 was:

TABLE 36

DEBT SERVICE COVERAGE ON OUTSTANDING REVENUE BONDS

For the Fiscal Year 1988-89
(Dollars in Millions)

	Accrual Basis*
Water and Power Sales	$ 443
Net Operation and Maintenance Expense	218
Net Operating Revenues	225
Revenue Bond Debt Service	26
Debt Service Coverage Ratio	8.49x

Note:
X = Times
* Any differences are due to rounding

Net Direct and Overlapping Bond Debt

Presented in Table 44 is a statement of direct and overlapping tax-supported bonded indebtedness within Metropolitan's boundaries on June 30, 1989, as prepared by California Municipal Statistics, Inc. Net direct and overlapping bonded debt totaled $10 billion, which amounts to a per capita debt of $673. As of June 30, 1989, Metropolitan's gross direct "general obligation" bonded debt stood at $514 million, which is approximately 0.09 percent of Metropolitan's 1988-89 assessed valuation of $553 billion (after deducting approximately $44 billion incremental assessed value associated with redevelopment agency activity).

Cash Flow Highlights (Cash Basis)

Cash Receipts

The following three sections contain dollar amounts based upon the cash basis of accounting, which reflects transactions only when cash is received or disbursed. Conversely, the dollar amounts shown for the Balance Sheet and Statement of Operations are recorded on an accrual basis of accounting. This manner of accounting indicates financial transactions are recorded when revenues are earned and expenditures are incurred, irrespective of actual receipt or disbursement during the fiscal year accounting period.

Cash receipts from water sales for fiscal year 1988-89 were $418 million. Tax receipts equaled $74 million and other revenues $64 million, for a total of $556 million, compared to an annual budget estimate of $462 million. This was mainly due to increased water sales which were $72 million over budget. Sales were 362,760 acre-feet over budget for the fiscal year.

Expenditures

Expenditures for the fiscal year totaled $446 million. This compared with an annual budget estimate of $449 million. Total net disbursements were $3 million below budget, mainly due to the following:

- SWP capital, OMP&R, and off-Aqueduct costs were lower than anticipated due to revised billings;
- State Water Control variable power costs were lower than anticipated after adjusting the variable cost component for prior year transportation charges; and
- Additional power credits were received from DWR due to changes in Los off-Aqueduct costs as well as bonded debt service coverage from prior years.

Cash-On-Hand at End of the Fiscal Year

Total cash on hand at fiscal year end equaled $555 million, excluding construction and trust funds totaling $139 million. Of this amount, $164 million was in restricted funds, with $25 million designated for self-insurance, and $68 million was in the Pay-As-You-Go Fund. Funds in the Water Rate Stabilization and Treatment Surcharge Stabilization Funds totaled $173 million and $20 million, respectively, and are designated to reduce future water revenue and treatment revenue requirements.

The July 1, 1988, working capital requirement, in accordance with current Board policy, was $105 million. On June 30, 1989, surplus funds of

$5 million and $6 million were transferred from the Water [illegible] Remainder Fund to the WRSF and Water Treatment Surcharge Stabilization Fund, respectively, in accordance with Board policy established in Metropolitan's Administrative Code.

Over the next decade, to the year 2000, staff is projecting use of all funds available in the water rate stabilization funds to mitigate water rate increases. The base noninterruptible and interruptible water rates are projected to increase over the period by less than 5 percent per year, assuming a complete draw down of the stabilization fund. The treatment surcharge is estimated to rise over the 10-year period at a rate slightly above the projected inflation rate, which is assumed to be 5 percent per year, taking into the account the use of PEROXONE or ozone to meet the anticipated revisions in the federal water quality regulations.

REVENUES FROM WATER SALES
ACCRUAL BASIS
(DOLLARS IN MILLIONS)

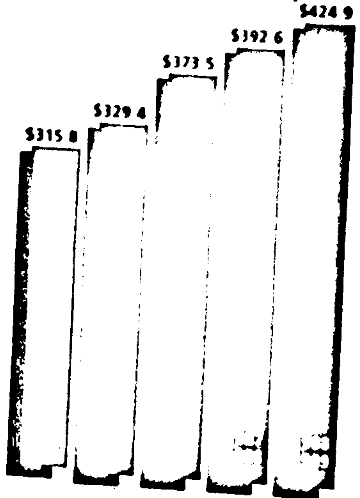

Figure 16

ASSESSED VALUATIONS
(DOLLARS IN BILLIONS)

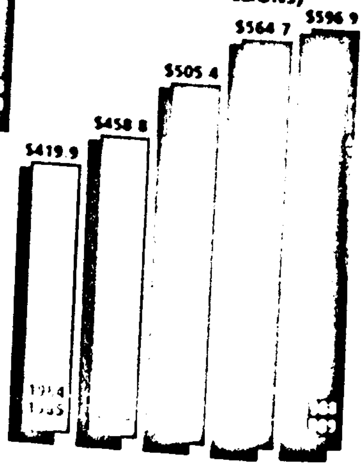

Figure 17

REVENUES FROM TAX LEVIES
ACCRUAL BASIS
(DOLLARS IN MILLIONS)

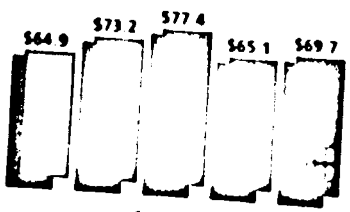

Figure 18

TABLE 37

FUND BALANCES
June 30 [illegible]
(Dollars in [illegible])

	19[illegible]	[illegible]
UNRESTRICTED FUNDS		
For Working Capital Purposes		
General Fund	$ [illegible]	$ [illegible]
Water Revenue Remainder Fund*	[illegible]	[illegible]
Designated for Other Purposes		
Pay As You Go Fund**	68,043	0
Water Rate Stabilization Fund	172,701	251,296
Water Treatment Surcharge Stabilization Fund***	19,741	13,219
Total Unrestricted Funds	$ 389,707	$ 386,587
RESTRICTED AND TRUST FUNDS		
Revenue Bond Reserve Fund	$ 18,433	$ 18,433
Revenue Bond Interest & Principal Funds	11,744	10,940
General Obligation Bond Interest Principal & Redemption Funds	21,771	19,126
State Contract Fund	54,586	51,047
Operation & Maintenance Fund	57,707	51,429
1966 Bond Construction Fund	21,139	60,498
Revolving Construction Fund†	101,309	0
Revenue Bond Construction Fund	596	316
Trust Funds††	1,209	930
Total Restricted and Other Funds	$ 288,494	$ 212,799
Employee Deferred Compensation Fund	$ 15,988	$ 13,421
Total Funds at End of Year†††	$ 694,[illegible]	$ 612,[illegible]

Notes

* Includes $25,000,000 designated for emergency repairs and [illegible] March 31, 1989 and June 30, 1988. For fiscal year ended June 30, [illegible] these purposes was $20,000

** This fund was initiated in December of 1988 with the [illegible] capital improvement program from operating funds [illegible]

*** The Water Treatment Surcharge Stabilization Fund [illegible]

† The Revolving Construction Fund was established with [illegible] transfer of $100,000,000 from the Water Rate Stabilization [illegible]

†† Includes balances in the trust accounts portion [illegible]

††† Total Funds are exclusive of refunding escrow trust [illegible] $90,777,133 held in Waterworks Refunding Revenue [illegible] Bond Escrow Trust Funds, respectively for 1989 [illegible] [illegible]05,033 held in Waterworks Refunding Revenue Bond [illegible] Escrow Trust Funds, respectively for 1988

TABLE 38
FIVE-YEAR SUMMARY OF WATER RATES
(Per Acre-Foot)

For the Period	Noninterruptible: Untreated	Noninterruptible: Treated	Interruptible: Untreated	Interruptible: Treated	Emergency: Untreated	Emergency: Treated	Reclaimed
7/1/84–6/30/85	$1[illegible]7	$229	$153	$185	$59[illegible]	$623	$84
7/1/85–6/30/86	192	224	148	18[illegible]	586	618	84
7/1/86–6/30/87	197	230	153	186	591	624	84
7/1/87–6/30/88	197	23[illegible]	153	186	591	624	84
7/1/88–6/30/89	197	23[illegible]	153	186	591	624	84

TABLE 39
FIVE-YEAR SUMMARY OF SECURED PROPERTY PERCENTAGE TAX RATES

Fiscal Year Ended June 30	Bond Service	State Contract	Total
1985	0.0081	0.0075	0.0156
1986	0.0100	0.0064	0.0164
1987	0.0079	0.0069	0.0148
1988	0.0070	0.0042	0.0112
1989	0.0067	0.0043	0.0110

TABLE 40
ASSESSED VALUATIONS, PERCENTAGES, AND VOTE ENTITLEMENTS

Constituent Areas	Date of Entry	First Year Taxable	Assessed Valuations August 1988-89	Assessed Valuations August 1987-88	Percentages* 1988-89	Percentages* 1987-88	Vote Entitlements* 1988-89	Vote Entitlements* 1987-88
Anaheim	12/06/28	$ [illegible]644 41[illegible]	$ 12 143 [illegible] 545	$ [illegible]376 [illegible]	2 [illegible]4	1 81	6[illegible]	1008
Beverly Hills	12/06/28	60 92[illegible] 41[illegible]	6 191 312 345	5 612 [illegible]1 476	1 0[illegible]	99	616	558
Burbank	12/06/28	21 470 280	5 294 171 613	4 9[illegible] 949 741	0 89	8[illegible]	518	479
Glendale	12/06/28	76 160 945	7 081 869 951	6 436 348 088	1 19	1 14	692	628
Los Angeles	12/06/28	1 801 655 535	133 829 420 151	125 513 139 880	22 52	22 23	11 110	12 274
Pasadena	12/06/28	117 760 505	5 866 789 939	5 519 8[illegible] 644	0 99	98	573	541
San Marino	12/06/28	14 484 990	1 092 693 391	992 822 868	0 18	18	107	97
Santa Ana	12/06/28	20 201 805	8 888 270 251	7 614 743 131	1 50	1 36	872	750
Santa Monica	12/06/28	62 [illegible] 225	6 364 571 048	5 904 659 441	1 01	1 05	600	584
Fullerton	02/27/31	11 556 160	5 212 593 101	4 911 613 335	0 8[illegible]	8[illegible]	508	478
Long Beach	02/27/31	185 5[illegible]6 045	14 343 511 476	13 733 215 763	2 41	2 41	1 4[illegible]	1 342
Torrance	02/27/31	24 289 800	7 159 498 2[illegible]	7 335 421 814	1 30	1 30	[illegible]	[illegible]
Compton	06/23/31	10 748 495	1 011 081 415	1 078 841 703	0 [illegible]	[illegible]	[illegible]	[illegible]
Coastal MWD	06/15/42	10 256 915	18 782 [illegible] 630	17 768 445 114	3 18	3 15	1 8[illegible]	[illegible]
San Diego County Water Authority	12/17/46	226 320 190	91 991 404 442	89 889 675 825	15 3[illegible]	15 92	8 [illegible]	8 [illegible]
West Basin MWD	02/23/48	161 813 905	46 055 104 435	43 613 826 929	[illegible]	[illegible]	4 [illegible]	4 [illegible]
Three Valleys MWD	[illegible]	66 5[illegible]	16 028 979 365	14 91[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Eastern MWD	[illegible]	[illegible]6 919 [illegible]	9 4[illegible] 304	8 148 54[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]9 612 1[illegible]	18 5[illegible] 23[illegible]	16 6[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	2[illegible]	75 [illegible] 216	72 8[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]4 [illegible] 41[illegible]	3 [illegible]49 838 [illegible]	[illegible]919 2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	1 1[illegible]	38 957 216 346	38 [illegible]16 024 416	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	16[illegible] 945 930	15 153 304 716	13 820 538 24[illegible]	2 52	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible] 92[illegible] 500	4 800 976 213	4 142 5[illegible] 018	0 8[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	8[illegible]	20 153 083 989	19 142 585 3[illegible]	3 3[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	8[illegible]4 [illegible]	22 607 515 28[illegible]	21 739 8[illegible] 024	3 74	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	32 051 0[illegible]5	[illegible]	4[illegible] 94[illegible] 9[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			596 865 933 764	564 6[illegible] 8[illegible]	100 [illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]				
[illegible]			596 900 258 958	564 692 806 2[illegible]				

* [illegible] are based upon County Auditors' certified valuations after deductions for Home Owners' [illegible]

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Tab

TABLE 41

ASSESSED VALUATION OF PROPERTY SUBJECT TO TAX LEVY BY METROPOLITAN*†

August of Each Fiscal Year

Fiscal Year	Property Within MWD	Property Outside MWD (Excluded Areas)	Total Property
[illegible]	$ [illegible]		$ [illegible]
[illegible]	[illegible]	[illegible]	[illegible]
1982-83**	[illegible]	[illegible]	314 129 654 882
1983-84**	[illegible]	[illegible]	351 135 259 907
1984-85**	[illegible]	[illegible]	379 168 157 242
1985-86**	[illegible]	[illegible]	419 855 347 899
1986-87**	[illegible]	[illegible]	458 782 [illegible] 816
1987-88**	[illegible]	[illegible]	505 419 661 679
1988-89**	[illegible]	[illegible]	564 642 816 227
			598 800 358 958

Notes:
* As certified by the [illegible]
† Before [illegible]
[illegible] exemptions, valuations of which, since the creation thereof [illegible] direct taxation by Metropolitan [illegible]
[illegible] shall be at 100 per cent [illegible] 25 per cent [illegible] the Revenue and Taxation Code, assessed [illegible] as reported for prior years.

TABLE 42

SUMMARY OF LONG-TERM DEBT

June 30, [illegible]

(Dollars in Thousands)

Category of Debt	Amount Authorized	Amount Issued	Amount Outstanding
1931 Authorization - General Obligation Bonds	$220 [illegible]	$ 220 [illegible]	$ [illegible]
1956 Authorization - General Obligation Bonds	77 400	77 400	
1966 Authorization - General Obligation Bonds*	850 000	585 000	511 640
1974 Authorization - Revenue Bonds**		372 500	365 590
Total Bonded Debt		$ 1 254 900	$879 480
Purchase of First San Diego Aqueduct***			1 223
Total Long Term Debt †			$880 703

Notes:
* Includes $96 470 000 Waterworks Refunding General Obligation Bonds, Issue of 1986, to advance refund $81 220 000 of Waterworks Bonds, Election 1966, Series F.
** Includes $147 500 000 Waterworks Refunding Revenue Bonds, Issue of 1978, to advance refund $144 770 392 of Waterworks Revenue Bonds, Issue of 1975 and 1976, and $163 545 000 Waterworks Refunding Revenue Bonds, Issue of 1986, to advance refund $143 110 000 of Waterworks Revenue Bonds, Issue of 1983.
*** Title to the First San Diego Aqueduct is vested in the United States Government and will be transferred to the District in 1995 upon completion of reimbursement to the Government for the cost of the aqueduct.
† Exclusive of any unamortized bond premium and/or discount as of June 30, 1989.

TABLE 43

FIVE-YEAR SUMMARY OF OPERATIONS ACCRUAL BASIS

(Dollars in Thousands)

	1985	1986	1987	1988	1989
Water and Power Revenue	$332 307	$348 [illegible]	$ [illegible]	[illegible]	[illegible]
Operating Expense*	151 382	183 [illegible]	[illegible]	[illegible]	[illegible]
Net Operating Revenue	180 925	164 3[illegible]	[illegible]		
Revenue Bond Debt Service**	(27 599)	(27 5[illegible])	[illegible]		
Bond Anticipation Notes**	(5 040)	[illegible]			
Balance Available for Other Purposes	$148 286	$136 [illegible]	$ [illegible]		
Revenue Bond/Note Coverage	5 54X	5 95X	[illegible]		

Notes:
* Excludes depreciation of Metropolitan assets and am[illegible] contract capital costs
** Scheduled debt service
X = Times

TABLE 44
DIRECT AND OVERLAPPING BONDED DEBT
(Dollars in Millions)

	At June 30, 1989	
	% Applicable	Bonded Debt(1)
[illegible] and Authorities	94.6	$ 1,44[illegible]
[illegible] Authorities	99.8	196
[illegible] Authorities	96.4	29[illegible]
[illegible] Authorities and Board of Education	63.5	163
[illegible] Authorities	67.6	76
[illegible] Bernardino County Authorities and Superintendent		
[illegible] and Authorities	40.5	[illegible]6
[illegible] Authorities and Open Space Park [illegible]	99.9	599
[illegible] and Authorities	99.9	[illegible]
[illegible] and Authorities	100.0	226
[illegible] Authorities	99.6	255
[illegible] Authorities	100.0	152
[illegible]	various	1,403
[illegible] Water	98.0	216
[illegible]		
[illegible] Improvement Districts	100.0	71
[illegible]	100.0	299
[illegible] 41, 42, 43 and 44	100.0	166
[illegible]	100.0	204
[illegible]	various	641
[illegible] Authorities	99.5	103
[illegible] Authorities	99.9	63
[illegible]	various	683
[illegible]	various	924
[illegible]	various	253
[illegible] BONDED DEBT	various	997
[illegible]		$ 9,719
[illegible]		497
[illegible]		$ 9,222
[illegible]		$ 514
[illegible]		41
TOTAL [illegible] BONDED DEBT		$ 473
[illegible] BONDED DEBT		$10,233
[illegible]		$ 9,695
Ratios to Assessed [illegible] $[illegible] 142,227.4		
Gross Direct Debt [illegible]	[illegible]%	
Net Direct Debt [illegible]	[illegible]%	
Gross Total Debt	[illegible]%	
Net Total Debt	[illegible]%	

(1) Totals not exact due to [illegible]. Debt instruments included are general obligation bonds, lease revenue bonds and [illegible] other supported by the general fund, 1915 Act special assessment bonds and [illegible] assessment bonds. Excluded are enterprise revenue bonds, tax allocation bonds [illegible] revenue bonds, tax and revenue anticipation notes and non bonded capital lease obligations.

(2) These bonds are classified as self-supporting since they are bonds that are funded from enterprise revenues and not from property tax revenues.

(3) Portions of general obligation bonds allocable to the City of San Diego, which are funded from local enterprise revenues and not from property taxes.

(4) After deducting $44,565,654,060 redevelopment tax allocation increment.

TABLE 45
SUMMARY OF RECEIPTS AND EXPENDITURES
Cash Basis
(Dollars in Thousands)

	FISCAL YEAR	
	1988-89	1987-88
Receipts from Water Sales	418,471	$366,947
Power Recoveries	19,029	17,109
Total Operating Revenues	437,500	404,056
MWD O&M Expenditures(1)	(130,108)	(119,266)
SWC OMP&R Costs(2)	(63,167)	(70,552)
SWC Off Aqueduct O&M Costs	(29,688)	(26,950)
Net Operating Revenues	214,537	187,288
Revenue Bond Debt Service	(26,832)	(26,385)
Funds Available for Other Purposes	187,705	160,903
Other Receipts		
Interest on Investments - Net	47,311	36,699
Other Receipts (Expenditures) - Net	6,716	5,776
Pay As You Go Construction - Net(3)	(10,979)	0
SWC Capital Cost - Paid by Current Year Operations	(63,653)	(55,093)
SWC Off Aqueduct Capital Costs - Net	(41,641)	(35,076)
Other Costs	(230)	(235)
Funds Available from Current Year	125,229	112,974
Tax Receipts	73,571	71,535
1931 General Obligation Bond Debt Service	(582)	(1,501)
1966 General Obligation Bond Debt Service	(39,461)	(39,765)
SWC Capital Costs - Paid by Current Year Taxes	(33,528)	(30,269)
Balance Available from Current Year	125,229	112,974
Balance Available from Prior Years	612,807	[illegible]
Redemptions		
1975 Revenue Bonds(4)	(30)	
1976 Revenue Bonds(5)	[illegible]	
Construction Costs - Net(6)	[illegible]	
Funds Available at End of Year	$[illegible]	
Revenue Bond Debt Service Coverage		

[illegible]

(1) Includes MWD O&M expenditures, net of reimbursements and [illegible]
(2) Includes all State Water Contract OMP&R and variable power [illegible]
(3) The Pay As You Go Fund was established by the Board in [illegible] expenditures. Prior to December 1988, Metropolitan [illegible] Fund moneys. Therefore, those earlier expenditures are [illegible] years. The amount report is net of reimbursements [illegible]
(4) The 1975 Revenue Bonds were called for redemption on [illegible]
(5) The 1976 Revenue Bonds were called for redemption on [illegible]
(6) Net of reimbursements to construction accounts.

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CHAPTER 9

Support Functions

Human Resources Management

Recruitment and Selection

The total number of Metropolitan's budgeted permanent positions increased by 68 to a total of 1,593 positions in fiscal year 1988-89. Staff continued in its efforts to enhance recruitment through the use of advertising, consulting services, and targeted recruitment sources to assure that qualified minorities and women were informed of all employment opportunities. During the fiscal year, 142 permanent positions and 166 temporary positions were filled, and at fiscal year end, Metropolitan's payroll comprised 1,569 permanent employees. The following is a five-year summary of Metropolitan's permanent employees.

End of Fiscal Year	Employees
1984-1985	1,330
1985-1986	1,374
1986-1987	1,416
1987-1988	1,506
1988-1989	1,569

Metropolitan employees are eligible to receive service pins after one year of service, and on every subsequent fifth anniversary. At three Service Award luncheons, hosted by the Chairman of the Board and the General Manager, 68 employees with 20 or more years of service were honored.

Assisted by the California Employment Development Department (EDD) in Los Angeles, the Summer Student Employment P[illegible] from increased minority and female employment [illegible] and resources to recruit and screen qualified candidates [illegible] while the Personnel Division supplied timely [illegible] clearances. The program employed a total of [illegible]

Classification, Compensation and Employee Insurance

Annually a salary survey of 11 agencies is conducted to obtain prevailing wage rates in the local labor market. In addition, other agencies have been utilized during specialized surveys to obtain data on managerial classifications. Staff also surveys various agencies on employee benefits to collect data used during bargaining unit negotiations.

Job audits ensure that Metropolitan's wage policy applies uniformly and that positions are classified appropriately. During the fiscal year, 54 job audits were conducted and numerous job descriptions revised to reflect current duties and responsibilities. New classifications were implemented as required.

Metropolitan employees receive a benefits package that includes medical, dental, and group term life insurance. They also maintain the option of enrolling in other insurance programs such as disability, accidental death and dismemberment, and cancer and intensive care.

Several changes occurred in medical insurance with the consolidation of three of Metropolitan's more prominent health carriers into one fee-for-service indemnity plan, "PERS CARE." In addition, another carrier with substantial enrollment, First Farwest, became insolvent. Employees subjected to these changes were given the opportunity to choose an alternate health carrier.

Employee Relations

The second year of the two-year agreement with Metropolitan's Employees Association became effective June 25, 1989. Changes include the following:

1. Salary increases of 5 percent,

2. An increase in Metropolitan's monthly contribution to medical insurance premium rates to $125 for employee only, $227 for employee plus one dependent, and $314 for employees with two or more dependents,

3. The amount of group life insurance for nonmanagement employees increased to $20,000, and

4. The choice to receive the Preretirement Optional Settlement 2 Death Benefit in lieu of the lump sum basic death benefit becomes available to spouses of employees deceased on or after July 1, 1989. For these survivors of active employees who die at or after age 50, this option provides a survivor's allowance calculated as if the employee had died while retired and had elected the most advantageous retirement benefit option.

...etirement Counseling

Designed to assist employees plann... ...re-retirement counseling seminar was ... ...eir spouses. Public Employee Retirem... ...enefits, Social Security benefits, estate pla... ...al planning, deferred compensation, ...nd other miscellaneous benefits were disc... ...ultants, resource experts, and Metropolitan empl...

Liability Claims Administration

The Liability Claims and Subrogation Program works to ensure equitable disposition of liability claims against Metropolitan under its self-insured program, to minimize economic loss experience as a result thereof, and to facilitate recovering damages to Metropolitan resulting from outside third-party negligence.

Employee Training and Education

Metropolitan expanded its Human Resource Training Section, adding a staff member to design and implement a human resource development program covering basic skills; management skills; and leadership, supervisory, and advanced management skills. Approximately 1,450 requests were received to attend more than 54 of the program workshops available. In addition to these program courses, 50 first-line supervisors participated in an eight-month training program; 145 employees received training in writing, editing, time management, meeting management, delegation, leadership and presentation skills, and six managers attended the University of Southern California's Professional Manager Program.

A computer program to assist Metropolitan in adapting to the increasing ...ultural diversity of its workforce was purchased and implementation ...egun.

Metropolitan's Tuition Reimbursement Program ... ...l-time employees with a minimum of six ... ...continue their formal education. Under th... ...tion, book, and lab fees are reimbursed ... ...de of "C" or better per course. The ... ...ponsibility for deciding the taxability of ... ...ase-by-case basis, working closely with ... ...blish precedents and policies. Nearly 200 ... ...r education through the program this ...

...he second phase of the New Employ... ...esigned, and 150 new employees attend...

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sessions during the fiscal year. Additionally, the section established data bases for the tuition reimbursement program, training vendors and materials, training enrollments, and scheduling.

Equal Employment Opportunity

A primary function of the Equal Employment Opportunity section has been the revision, implementation and monitoring of Metropolitan's Affirmative Action Plan. Now known as the Equal Employment Opportunity Program, the new plan is a more expansive program consistent with current laws, regulations, and guidelines.

Another critical function of this section involves processing and resolving discrimination complaints. In addition to internal complaints and inquiries, complaints from the U. S. Equal Employment Opportunity Commission, the California Department of Fair Employment and Housing, the U. S. Office of Federal Contract Compliance Programs, and the U. S. Civil Rights Commission are received and investigated. Technical assistance is provided to all employees in the work environment.

In reference to Metropolitan's statistics and procedures for recruitment and selection, staff has responded to several special requests from various entities that monitor equal employment opportunity, such as the Contract Compliance Unit of the Department of Fair Employment and Housing.

Throughout the year, Metropolitan was involved with various governmental and professional organizations, charitable functions, and community groups associated with equal employment opportunity.

The Equal Employment Opportunity Officer held regular meetings of the section's Advisory Committee, comprised of representatives from various minority organizations, the Vietnam Era Veterans Association, Metropolitan's Women's Association, and labor groups. Through the committee, members address relevant issues and exchange pertinent information on equal employment opportunity and affirmative action.

Environmental Safety and Health

Metropolitan's Environmental Safety and Health Program is promulgated on the California Occupational Safety and Health Act (OSHA) of 1973. The program assures compliance with standards of this act to ensure a safe and healthy work environment to prevent industrial illness and injury.

A multi-disciplinary Safety and Health staff effectively implements this program to train employees in safety and health practices, provide engineering, mechanical and physical safeguards to the maximum extent possible, and furnish appropriate personal protective equipment and

instruction on its application and maintenance. [illegible] surveys and investigations to determine corrective [illegible] necessary to eliminate unsafe workplace conditions.

This program has significantly advanced in [illegible] hygiene to evaluate conditions of potential hazard [illegible] and biological agents in the work environment [illegible] workplace ergonomics, material hazard control, and [illegible] construction safety consultation and compliance [illegible] projects by Metropolitan forces and major contract projects by various contractor services, and comprehensive training to heighten employee awareness of safety and health interests.

Metropolitan's accident experience comparison from January 1, 1988 to December 31, 1988, reflected 135 recordable injuries, 50 of which resulted in 1,082 lost work days and 748 restricted days. On average for a three-year period, employees experienced 119 recordable injuries, 46 of which resulted in 1,191 lost work days and 294 restricted duty days.

Based on this information, the following incident rates (Table 46) were computed and are compared to the U. S. Bureau of Labor Statistics rates for 1987 for the water supply industry.

TABLE 46

ACCIDENT INCIDENTS

	1988	1987	Average	Industry
Total Recordable Injuries/Illnesses	7.76	7.51	7.44	13.02
Lost Workday Cases*	2.87	2.03	2.88	6.20
Non Fatal Cases w/o Lost Workdays	4.88	5.97	4.56	6.86
Lost Workdays**	105.15	85.75	92.83	119.00

Note

Incident Rate = $\frac{\text{Number of Injuries/Illnesses} \times 200{,}000}{\text{Total Number of Hours Worked}}$

200,000 = Average Work Year in Hours for 100 Employees

* The lost workday cases rate includes cases which incurred a [illegible] duty workday

**The lost workdays rate includes lost and/or restricted [illegible]

Protective Services

Metropolitan's Protective Services Program provides professional [illegible] protection from natural, technological, and human threats [illegible] During the fiscal year, staff began implementing security [illegible] at the Joseph Jensen Filtration Plant, completed implementation of the site-specific security plan for the F. E. Weymouth Filtration Plant, initiated a program to identify and correct problems related to illegal uses of Metropolitan land, completed installing security systems at Pleasants Peak, Eagle Rock, and Soto Street facilities, established effective liaison and coordination with other key public safety and emergency service agencies, and maintained program emphasis on prevention, investigation, and consultation.

Detailed plans regarding response to emergency conditions at all of Metropolitan's facilities were developed and tested. Special emphasis was placed on Los Angeles Headquarters and City of Los Angeles requirements pertaining to emergency response capability.

Burns International Security Services continued to provide excellent contract guard services at Los Angeles Headquarters and selected field locations. All guards received ongoing training relative to emergency response, crime prevention, and public relations.

For incident management purposes, staff partially implements contingency plans via a limited Emergency Information System.

TABLE 47

SELECTED PROTECTIVE SERVICES ACTIVITIES

	1988-89	1987-88
Incident Investigations	267	223
Pre Employment Investigations (including temporary & contract employees)	483	444
Administrative Investigations	23	31
Inspections	374	230
Courtesy Reports	520	325
Reported On Site Hazards	865	1,025
Trespassers Contacted/Escorted	734	1,116
Security Awareness Sessions	45	0
Security Improvement Recommendations	65	32
Consultations	84	43
Contacts with Outside Agencies	456	340

Workers' Compensation

Ensuring equitable claims disposition against Metropolitan under its self-insured program, the Workers' Compensation Program also minimizes economic loss experienced as a result thereof. In fiscal year 1988-89, 159 Workers' Compensation claims were filed compared to 126 in 1987-88.

Medical

The Medical Section protects Metropolitan employees by placing them in jobs for which they are medically fit without significant risk to themselves or co-workers. As shown in Table 48, staff accomplishes this goal through pre-placement medical evaluations which match the person with the job and vice versa, periodic medical surveillance to ensure that employees remain medically fit to effectively perform their job duties, job transfer evaluations to obtain all necessary medical data prior to transfer, audiometric testing for employees exposed at or above OSHA limits, and Return-to-Work evaluations to assess employee' ability to safely perform their jobs after serious or extended illness or injury.

To help employees become more responsible for their own health, staff educates employees to use available health services, emphasizing lifestyle changes designed to maintain health and prevent chronic illness. These goals are accomplished through individual employee counseling, wellness activities, and employee assistance services. A formalized Employee Assistance Program is currently being implemented. In addition, the executive physical program has been expanded to offer eligible employees the option of participating in community wellness activities in lieu of an annual examination.

TABLE 48

EMPLOYEE PARTICIPATION IN MEDICAL ACTIVITIES

Selected Medical Activities	1988-89	1987-88
Pre Placement Medical Evaluations	285	[illegible]
Medical Section Visits by Employees	1039	[illegible]
Audiometric Testing	236	[illegible]
Class I Drivers	78	[illegible]
Return to Work Evaluations	90	[illegible]
Periodic Medical Surveillance	971	
The Medical Group	[illegible]	
New Health Center	41	
Wellness Reimbursement	17	

Administrative Services

Purchasing

During the fiscal year, Metropolitan obtained $40,653,584 in materials, equipment, and services required for operation, maintenance, and minor construction in addition to purchasing large items under formal contracts. This total amount does not include electrical costs for water pumping or formal construction contract costs. The number of purchase orders issued increased about 8 percent over last fiscal year, with a total increase over the past two fiscal years of approximately 20 percent.

In other activities, an auction of used vehicles and assorted equipment reaped a total of $86,560 and sale by sealed bids of salvage material and surplus stock accrued $291,557. Colorado River and State project water treatment required purchasing 6,909 tons of liquid chlorine, 5,171 tons of liquid caustic soda, 5,072 tons of liquid alum, 1,471 tons of polymer, 1,206 tons of ammonia, and 211 tons of copper sulfate. This equals a 13 percent increase over last year's total chemical use.

Staff began customizing the Procurement System, a mainframe-based system which will automate creating, processing, and tracking purchase requisitions, purchase orders, and contracts, handle bid processing and analysis, and allow on-line receipt of material. Initial efforts have been focused on the Vendor, National Institute of Government Purchasing (NIGP) Commodity Code, and Stock Item sub-systems. The Vendor sub-system provides extensive information on vendors from both a Purchasing and Accounts Payable viewpoint, while the NIGP Commodity Code furnishes a cross-reference between vendors/bidders and the commodities they supply. Finally, the Stock Item sub-system allows maintenance and inquiry of stock items and links stock items to NIGP commodity classes and to the vendors that provide these commodities.

Procurement System use will be phased in to allow users access to sub-systems as they are completed, while development continues on the rest of the system. Throughout the fiscal year, Purchasing staff has used a microcomputer-based Automated Vendor/Bidder Commodity file system and Automated Bid Analysis system.

Warehousing

During the year, Metropolitan entered into three new annual agreements, totaling $69,350, for diskettes, respirators, and PVC pipe and fittings. This represents a 38 percent increase over the previous fiscal year's new agreements, and brings the number of Central Stores agreements to 32. Such agreements cost effectively reduce paperwork, labor, and procurement time over individual order processing.

Increasing $0.6 million over last fiscal year, inventory value of Central Stores stock at fiscal year end totaled $6.3 million. Total transactions (including transfers, issues, receipts, and debits) rose 10 percent during the fiscal year. As part of Metropolitan's continuing effort to eliminate and salvage excess and unusable personal property, staff sold 2,546 items of such materials and equipment, for a total value of $291,557. Items sold included scrap metal, office equipment and supplies, heavy equipment, and shop machines. This represented an increase of 2,498 items and $271,605 over the amount disposed of during the previous fiscal year.

Last fiscal year's use of drawer-type cabinets at Lake Skinner for rapid, over-the-counter issuing of small inexpensive items has been expanded to three additional outlying warehouses, which are now 80 percent converted to this system. The method has proven cost effective, reduces paperwork, and helps eliminate errors caused by repetitious issue procedures.

Office Automation

Metropolitan's office automation goal is to provide computer users with access to corporate applications and office functions on the central computer system. To that end staff implemented an Office System to handle daily office tasks such as sending and receiving electronic mail, sending notes and messages, scheduling meetings, and maintaining daily calendars. By fiscal year end, 200 employees were using the Office System with approximately 40 new users being trained monthly.

The original Automation Overview Study identified the need to provide on-line reference material. Toward the fiscal year end staff activated a pilot program using General Instructions (Metropolitan's policy and procedures documents) to evaluate a specific on-line reference package for the ease of both entering material and extracting it. Originators of various frequently-referenced materials determined how easy it was to enter documents, and other staff judged the ability to extract the information. The pilot program is expected to continue into the first quarter of next fiscal year.

Staff also implemented a Document Management System. Designed by a consultant to search for all types of documents, the system is currently tailored towards work progressing on the San Francisco Bay-Sacramento-San Joaquin Delta (Bay Delta) Hearings. The system will likely serve as a prototype of a generic document management system that can be adapted to meet any division's needs.

A project team was formed to investigate and analyze Metropolitan's costing needs and define the requirements of an appropriate costing system. What will evolve is a Cost/Chart of Accounts/Budget System.

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During the fiscal year, the team defined the entity diagram, delineating the system's heart and the relationship between the parts (see Chapter 8). Emphasis will be placed on the Budget portion during next fiscal year.

Microcomputer Training

Metropolitan continues to provide its computer users with in-house training, using a combination of instructor-led classroom courses, microcomputer and mainframe computer-based-training, and video courses. Classroom courses consist of basic, intermediate, and advanced curricula for various software products; data base concepts and design for the intermediate-level microcomputer user, and specialized curricula for support personnel within each division. During the fiscal year, the training program was expanded to cover the newly installed Office System, and staff began developing classroom instruction to support application training for users of Metropolitan's corporate on-line systems.

Data Processing

During the last quarter of the fiscal year, Metropolitan implemented a disaster recovery program. Defined by a task team of Metropolitan staff and an outside consultant, the plan ensures that, in case of emergency, staff will follow specific guidelines to recover previously identified key applications on Metropolitan's mainframe computers. Last fiscal year, the task team had interviewed certain division heads to identify and agree upon Metropolitan's key applications. This program produced a disaster recovery manual that provides a concise, highly structured format and identifies the personnel, policies, procedures, and provisions needed for a comprehensive data recovery plan. To ensure that the manual's information remains relevant, the plan was placed under a maintenance contract for annual updating.

To better meet the needs of the increasing numbers of users of Metropolitan's central computers, the Data Processing and Information Systems branches changed towards fiscal year end. Applications programming staff, previously a part of Data Processing, was transferred to Information Systems. As a result, Data Processing has become the technical operational arm of Metropolitan's information system, responsible for keeping the mainframe computer operating, installing and monitoring new mainframe software, troubleshooting user connectivity and operational problems, and monitoring system activity and response time.

Headquarters Services

The Los Angeles Headquarters Building again sustained minor cracks to drywall, plaster, and acoustical ceiling tiles when an earthquake shook

Pasadena in February 1989. As it had in 1987 [illegible] did comparable damage. Metropolitan employed [illegible] repairs with minimal effort and no disruption of [illegible]

Staff developed three new data bases for use by the Headquarters Services group. An Internal Shipping and Tracking data base allows users to keep abreast of packages and equipment sent through internal mails and to determine the status of the package or equipment in transit. For those participating in Metropolitan's Rideshare Program, the carpool parking data base maintains better control of assigned spots. Lastly, a Facility Management data base is being created to track, report, and project office space use in the Los Angeles Headquarters Building.

Office Services

A growing number of individuals have requested over the last few years the ability to merge text and artwork electronically for such things as treatment and hydroelectric plant operations manuals, pamphlets; various handbooks (i.e., timekeeping, communications, accounting for operating equipment, reports), and others. To meet that demand, Metropolitan will be installing a computer network capable of processing publishing and page artwork now being sent to outside vendors. During the fiscal year, staff developed a detailed plan and schematic for installing this network which is due during the first quarter of next fiscal year. The equipment will be compatible with existing systems both inside and outside Metropolitan.

Metropolitan augmented its computer graphics imaging system by providing needed support for creating maps and illustrations. The expanded software increases the number of type styles available, allows the mixture of typefaces on the same illustration, and rotates type for complicated artwork. Using this software greatly reduces artist design time since the old software created type only on a horizontal plane. With this software, staff can more easily devise maps, water quality charts, schematics for operational manuals, and illustrations for Planning and Water Conservation programs. This fiscal year, staff produced conceptual drawings of the Etiwanda Power Plant and the Desalination Plant projects, the Lake Skinner Operations Manual, and the Corona Hydro Power Plant Manual.

Communications

Formed last fiscal year, a management-level task team assessed Metropolitan's automation needs given the rapidly changing work environment and steadily increasing workloads. Investigation results were published in the Automation Overview Report that discussed Metropolitan's existing communications network and its limitations for accommodating growth and future communication needs. The report disclosed the need for network enhancements that would provide improved disaster recovery capability and backup systems for the existing voice and data networks.

This year, Metropolitan developed a three-year communications strategy to support its business plans, control system, and information system requirements and their impact on Metropolitan's communications system. The plan was developed jointly by Arthur Young's Telecommunications Consulting Group and Metropolitan staff, and consists of conceptual and physical network designs and organizational support structure, estimated costs, and a three-year, phased implementation plan.

Public Affairs

California's continuing drought and the proposed allocations of Bay Delta waters dominated public awareness campaigns and water-related issues during fiscal year 1988-89.

With California entering its third consecutive critically dry year, Metropolitan renewed vigorous attempts to promote water conservation among consumers. A television advertising campaign ran District-wide from mid-July through September. The broadcasts were augmented by live presentations featuring conservation that appeared at county fairs and home and garden shows throughout Metropolitan's service area.

Following the original dissemination of more than 200,000 tent cards, a second conservation card was developed for distribution through the California Restaurant Association. Additionally, mirror stickers encouraging conservation were produced and dispersed via member agencies and several hotel and motel chains. *WaterScape*, a publication dedicated to conservation, reached a specially targeted audience.

Water Awareness Week ran May 1 through 7 this fiscal year, and was followed by a new water conservation advertising campaign based upon conservation becoming a way of life in Southern California. Using the theme, "Be Water Tight," the campaign incorporated television, radio, and outdoor billboards.

The State Water Resources Control Board (SWRCB) issued a draft water distribution plan for the Bay Delta, which generated substantial interest from the media and the public. Following its considerable involvement throughout the Bay Delta hearings, Metropolitan conducted a series of briefings for legislators, county supervisors, and city council members on the important need to modify the plan. Soon thereafter, SWRCB announced that it would redraft its original proposal.

Continuing negotiations between Metropolitan and the Imperial Irrigation District (Imperial) successfully forged an agreement for a dynamic water conservation effort in the Imperial Valley. Major media outlets statewide covered the story in-depth.

Government Relations

Metropolitan gained support for a water conservation proposal to line the All American Canal, with more than 80 cities, counties, business organizations, water agencies, and water associations indicating their backing. Combined tours of the Colorado River Aqueduct (Aqueduct) and the State Water Project (SWP) were conducted throughout the year for Federal, State, and local officials and their staff members to enhance understanding of these systems.

Staff arranged briefings for officials when concerns were raised regarding specific proposals, such as the impact of the Chino Basin Groundwater Storage Program on Chino's milk producers. A series of public meetings were conducted throughout Metropolitan's service area to discuss the importance of groundwater exchange proposals.

To maintain open communications and good relations with associations and organizations impacted by water issues, staff participated in the County Supervisors' Association of California annual conference, worked with chambers of commerce legislative committees, undertook grassroots efforts in Orange County regarding construction of transmission and filtration facilities, and made presentations to mayors and city councils regarding Southern California's 1989 water supply.

Community Relations

Strengthening public knowledge regarding the Aqueduct and SWP, the community relations staff continued its facilities inspection program as directors sponsored 40 Aqueduct and 11 SWP tours. The General Manager hosted another 12 Aqueduct and one SWP tour. Special and one-day tours numbered 20 for the fiscal year. Nearly 2,400 individuals were guests on these tours, while another 6,300 visited various filtration plants.

Staff planned and coordinated two Directors Emeritus luncheons and the annual Directors' Workshop; planned and participated in National Water Resources Association Municipal Caucus activities, the Association of California Water Agencies Public Affairs Committee, and the Southern California Water Conference Program Committee; assisted in planning and conducting the American Water Works Association annual conference held this year in Los Angeles; and participated in Colorado River Water Users Association activities, chairing the Public Affairs and Exhibits

committees. Additionally, staff participated in a joint association agency effort by chairing the Public Affairs Committee for the kickoff event of Water Awareness Week in the state capitol.

The Speakers Bureau was expanded to 53 participants. Members reached a total audience of about 16,000 people at a wide variety of club, association, society, chamber, and other appearances.

Publications

Throughout the year, more than 4,540 individuals and organizations asked to be added to the mailing list for Metropolitan's external publications, *Aqueduct* and *Focus*. Staff also sent extra copies of *Aqueduct* and *Focus* upon request to farmers along the Sacramento River, chambers of commerce, the city of Los Angeles wastewater management division, and realtors. Permission to reprint articles from both periodicals were received from and granted to numerous outside organizations and publications.

Employees were further advised about the SWRCB draft plan and other pertinent issues through the internal bulletin, *Watermark*. A brochure, "You Can Make a Difference," was updated to carry the theme that water conservation must become part of the Southern California lifestyle. Incorporating Metropolitan's new "Be Water Tight" conservation slogan, materials were developed that included a revised version of "25 Ways to Save Water," a redesigned plastic bag for fair presentations, plant tags, bumper stickers, and a postage meter mark displaying the slogan.

In addition to the regularly scheduled publications, more than 463,000 pieces of literature were distributed through exhibits, display racks, speaking engagements, Metropolitan's member agencies, and mail and telephone requests.

Media

While the drought held considerable media attention during the fiscal year, staff also attained expansive media coverage regarding the All-American and Coachella Canal linings, Metropolitan Imperial negotiations, trihalomethanes, Metropolitan's continuing program to cover water storage reservoirs, groundwater storage, Metropolitan finances, the lining of the Newhall Tunnel, and the Vail Lake enlargement.

Also receiving media attention were issues such as water rates, Metropolitan's reduction in SWP deliveries for 1989, record water-demand days in April, a U.S. Supreme Court ruling on Colorado River Indian water rights litigation, and the death of Board Chairman E. L. Balmer.

Throughout the year, staff provided info... and conservation in general and about sp... tan's affiliation with the California Coun... nomic Balance, upon request. Comprehensive... with the General Manager by the *Los Ang...* media outlets.

Education Programs

Elementary school students in the fourth and sixth grades gain early understanding about water resources through the "Admiral Splash" and "Water for Ursa" programs, respectively. Staff held orientation sessions for 878 teachers to receive program materials. Teachers throughout the Metropolitan service area were sent Metropolitan's *Splash* newsletter. Versions of the "Home Information Leaflets" that are part of the fourth- and sixth-grade classroom kits were translated into the Tagalog, Chinese, Vietnamese, Korean, and Cambodian languages.

Additionally, education staff made presentations at assemblies and other gatherings, reaching nearly 11,000 elementary school children. Materials were developed for the planned high school program which will begin in fall 1989. Metropolitan also continued its involvement in the Adopt-A-School program with El Sereno and Van Gogh elementary schools in Los Angeles County. Hands-on water science experiments were conducted at schools throughout the service area.

A 1989 "Water Is Life" calendar, featuring artwork created by elementary school students, was printed and distributed. Metropolitan also sponsored 10 stage performances of "Alice in Waterland" at area schools and prepared an activity package for elementary schools to use during Water Awareness Week.

Staff consulted with officials at Bonita High School and Van Gogh Elementary School regarding proposed drought tol... gardens at the schools.

Films and Exhibits

A new videotape, "Waterwise Gardening: B... Water," was funded in part by Metropolitan ... Films in cooperation with the American W... California Nevada Section. This video was sup... and selected subagencies throughout the se...

Metropolitan's film-loan program continued ... primarily by schools throughout the six countie... operates.

Throughout the year, Metropolitan presented live shows at major county fairs and home shows, and further reached the public with displays exhibited at malls, expos, and commercial locations. Metropolitan also provided xeriscape exhibits in various locations. For Water Awareness Week, a large outdoor display was erected at the State Capitol Building in Sacramento. Staff assisted the city of Glendale with a conservation exhibit and helped dedicate the conservation garden at the Los Angeles County Arboretum.

Right of Way and Land

Acquisition

Right of way acquisition activity focused on obtaining fee, permanent easement, and temporary easement property rights for the San Diego Canal Enlargement project, which extends approximately 17 miles from the San Jacinto area to Lake Skinner in western Riverside County. By the end of the fiscal year, two fee and 50 temporary easement purchases were consummated for this project.

Additional acquisitions, involving the Etiwanda Pipeline project, Detention Peak Microwave Site, and several miscellaneous easements containing exchanges for alternate access rights were completed. In the city of Fontana, one fee acquisition of 5.90 acres for the Etiwanda Pipeline project was acquired through Heritage Village and cost $1,746,000. Additionally, one permanent easement for access to Metropolitan's Detention Peak Microwave Site was closed this period. Staff provided acquisition services consisting of title encumbrance review, lease review, escrow coordination, and agreement review during negotiations for the Searl Ranch lands, which are included in the potential Eastside Reservoir Site in the Domenigoni Valley. Numerous property owners were contacted for entry permits for geotechnical survey purposes along the Etiwanda Pipeline alignment, the South Orange County Treatment Plant alternate sites, and the Domenigoni Valley, Potrero Creek and Vail Lake potential sites for the Eastside Reservoir. Division staff also monitored an independent contractor's acquisition of 400 entry permits for environmental observation purposes, 248 of which were acquired by fiscal year end at five potential Eastside Reservoir sites.

Approximately 122 parcels remain to be acquired for pending or completed projects, including San Diego Canal Enlargement (embankments and structures) project, Etiwanda Pipeline, San Diego Pipeline No. 4, Auld Valley Pipeline, Santa Monica Feeder, Corona Hydroelectric Plant, and Lower Feeder Service Connection. Advance acquisition

activities, including property owner conta[illegible] and [illegible] record and tract map surveillance and appraisal are continuing for [illegible] within potential Eastside Reservoir and South Orange County [illegible] Plant locations. A total of 62 fee, permanent easement, and [illegible] easement parcels were acquired for Metropolitan use this fiscal year. Table 50 shows the details of the year's right-of-way acquisition projects.

Land Management

Real Property Branch personnel are managing 152 separate secondary-use agreements on Metropolitan's fee-owned properties. Metropolitan collected approximately $273,630 in revenue from these uses, an increase of $9,530 over last fiscal period. Staff issued easements for secondary uses over Metropolitan's properties to governmental agencies, public utilities, and private individuals. Such easements usually apply to street widening, underground utilities, alternate access, and slope maintenance.

Metropolitan joined forces with various governmental agencies and utility companies in granting authority for special use of its properties for emergency purposes. Staff authorized fire department helicopter water pickup and landing sites at Lake Mathews and Lake Skinner, which will be used for water drop practice and/or emergency use.

The general construction boom in Southern California has created the need to grant easements to others for the above mentioned uses. Throughout the year, the Real Property Branch processed 75 to 100 documents, many of which are temporary in nature.

Occasionally, Metropolitan leases private property. Operating and maintaining Metropolitan's facilities requires staff to lease office space for government relations and legislative representatives in Washington, D.C., Sacramento, and Orange and Imperial Counties. To date, 12 leases permit Metropolitan to use private property for its needs. These leaseholds amount to approximately $32,000 annually.

Surplus Property

Surplus property sales activity stayed exceptionally low this fiscal period as staff concentrated on acquisition to expand existing or new Metropolitan facilities. Staff also participated in the planning [illegible] for proposed Metropolitan facilities.

Metropolitan sold one surplus parcel, [illegible] approximately [illegible] acres of land, for $9,000 in cash. Through [illegible] process staff publicly auctioned Metropolitan's F. E. Weymouth [illegible] Basin surplus Parcels H15-2-1, 3, and 7. The property placed on the market at its appraised value of $10,750,000 contains about 67.3 net acres of land and was sold for $13,550,000. However, the sale was never completed due to alleged

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municipal considerations which made the transaction too expensive for development. A thorough analysis of this sale has begun. Staff is also reviewing Metropolitan's overall surplus property marketing policies and will present its findings to the Board of Directors' Land Committee for review.

At fiscal year end, the eight promissory notes secured by deeds of trusts on properties previously sold were in effect. The fixed interest rates for these deeds of trust range from 10 to 12¼ percent. The principal balance of the notes outstanding at the end of the period amounted to $848,683, while the principal and interest payments received during the fiscal year amounted to $177,256.51. Metropolitan collected full payment on three promissory notes. Staff prepared full reconveyance documents for recording.

Relocation Assistance

No relocation assistance benefits were processed during the fiscal year, however staff is conducting preliminary surveys during project conceptual stages to determine the potential magnitude of displacing persons, farms, and businesses and replacement property availability.

Staff responded to inquiries related to relocation assistance and, furthermore, reviewed new legislation affecting relocation benefits and eligibility.

Real Estate Appraisal and Land Use Activities

Staff assisted contractors doing work for Metropolitan and the appraisal section, and completed appraisal reports for lesser valued parcels, rental rate surveys, and rental valuations for Metropolitan's use. Additionally, staff appraisers provided appraisal expertise and opinions along with recommendations to the General Manager and the Legal Department.

Staff Appraisals

Staff appraised 14 easement crossings and conducted four rental surveys, which will aid in determining market (economic) rental rates for tenant-occupied parcels. Right of Way personnel also completed 73 appraisals of fee and easement property rights for the San Diego Canal Enlargement Project. To update unsettled acquisition valuations, staff completed 18 re-appraisals of these parcels.

A preliminary value estimate was developed for the Planning Division on a 57 acre potential reservoir site east of the Robert B. Diemer Filtration Plant. Staff appraised two surplus parcels located along the Colorado River Aqueduct-Val Verde Tunnel, near Mead Valley, in Riverside County, as well as the Searl Ranch Property which includes 41 parcels and

... 346± acres (net) valued at $27,000,000 ... ...ty for advanced acquisition for a port... ...alley Reservoir site, near Hemet. Sta... ...t rental rates for 34 leases, licenses ... ...2 permanent easement parcels adjacen... ...nds, involving about 19.53 acres, for a ...

...ndependent Appraisals

Staff appraisers reviewed two appraisal reports submitted by outside ...gencies, which involved partial takings for lateral road crossing easements. One taking was by Caltrans to widen San Fernando Road, State Sign Route 126, across Metropolitan's Foothill Feeder in the city of Santa Clarita (Newhall). The other allowed the County of San Bernardino to cross the Yorba Linda Feeder, on a parcel in Chino Hills near the Phillips Ranch.

Staff conducted scoping and pre-submission conferences with all independent fee appraisers retained to perform acquisition appraisals as well as reviewed six appraisal reports submitted by independent appraisers. Staff also conducted a disposition appraisal review of independent appraisals on the Bolsa Chica Desalinization Plant Site, Huntington Beach, California, and an analysis of municipal assessments on an independent appraisal of F. E. Weymouth Sludge Basin surplus parcels.

Administrative and Consulting

Metropolitan entered into contracts with 20 independent fee appraisers regarding required land acquisitions and potential sales of surplus properties. One of the contracts calls for the appraisal of three potential spreading basins for the Arvin-Edison Water Storage District in Kern County, south of Bakersfield. An executive briefing was prepared on the proposed purchase of a land option at Potrero Creek Estates within the future Eastside Reservoir study area.

Land Use Studies

Staff completed several special land-use stud... ...d implementing potential projects:

- A preliminary estimate of both the original ... ...f 39 parcels (354+ acres) was developed ... ...-mile length of the Foothill Feeder, from C... ...oad. With this information, Metropolitan ... ...hare of the wheeling charge for joint pipel... ...elp staff determine the pro-rata share o... ...mposed by the County of Los Angeles.

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- An updated valuat... of 96 privately owned condominiums overlooking the San ... reservoir was reviewed. Staff determined the likelihood of ... in property values due to the prospect of Metropolit... the reservoir to conform with water quality standards.

- A b... was prepared for a requested early termination of ... lease. GTE Sprint leased an area of Metropolitan's H... Plant fee Parcel 1640-1-1 for a microwave radio facility.

Annexation

... ed six annexations to Metropolitan, increasing the service area by 5,4?32 acres. Riverside County experienced four annexations: two to Eastern Municipal Water District (Eastern)—(Thirty-Sixth and Thirty-Eighth Fringe Areas), and two to Western Municipal Water District (Western)—(Twenty-First and Twenty-Second Fringe Areas). One annexation occurred in Ventura County to Calleguas Municipal Water District (Calleguas)—(Calleguas Annexation No. 28) and one annexation occurred in Los Angeles County to Las Virgenes Municipal Water District (Las Virgenes)—(Hidden Hills Annexation 87-1). The annexation charges totaled $375,122.30.

The city of San Diego annexed one area, which added 435.55 acres to Metropolitan. As of June 30, 1989, Metropolitan's total service area encompassed 5,137.89 square miles, increasing 1.47 square miles over last fiscal year.

The Board granted informal approvals for concurrent annexation of two areas to Western and Metropolitan, four to Eastern and Metropolitan, ... to Calleguas and Metropolitan. The Board granted formal ... for five concurrent annexations: Twenty-First and Twenty-... Areas to Western and Metropolitan, Fortieth Fringe Area ... Metropolitan, Calleguas Annexation No. 28 to Calleguas ... and Hidden Hills Annexation 87-1 to Las Virgenes ... tan.

... 30 redevelopment projects to determine their effect on ... tax base and facilities. Staff processed and paid 216 property ... for a total tax payment of $60,118.17. The total tax payment ... additional tax assessment on Metropolitan for $41,017.84, ... the Board of Equalization's review of all taxable government ... Angeles County. Also included were the escaped assessments ... 1983-84 amounting to $2,029.75. Staff further paid street ... maintenance assessments of $11,085.50 on Metropolitan ... located within its boundaries.

...atement of Change of Boundaries

On December 30, 1988, Metropolitan ... Statement of Change of Boundaries with the County ... the six counties ... luded within Metropolitan's service area. ... summarizes ... changes in Metropolitan's member ... boundaries during the previous calendar year which changed Metropolitan's overall boundaries.

Automation

The changing work environment has led staff to increase their personal use of microcomputers, which decreased the duplication of efforts in specific areas, and saved man-hours. Staff also has enhanced their work's quality.

Most divisional staff is now computer literate. Staff is aware of, and is benefiting from, specialized software programs tailored to real estate and management applications.

TABLE 49

TAXES AND ASSESSMENTS PAID

Fiscal Year 1988-89

Location	Number of Tax Parcels		Payment
Taxes Paid on Property Outside Metropolitan			
Clark County, Nevada	3		$ 6,514.49
Mohave County, Arizona	2		731.48
Los Angeles County, California			
1988-89 Tax Assessments	52	(38,972.67)	
Adjusted 1988-89 Tax Assessments	(2)	(15.42)	
1983-84 Escaped Assessments	(9)	(2,029.75)	
Total Los Angeles County			41,017.84
Riverside County, California	1?3		8,405.58
San Bernardino County, California	4?		3,448.78
TOTAL TAXES PAID	21?		$ 60,118.17
Street Lighting and Maintenance Assessments Paid on Property Within Metropolitan			
City of Los Angeles, California	18		9,003.03
City of South Gate, California	55		2,026.35
Orange County, California	2		56.12
TOTAL ASSESSMENTS PAID	75		$ 11,085.50
GRAND TOTAL Taxes and Assessments Paid			$ 71,203.67

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TABLE 50

RIGHT OF WAY ACQUISITION

Fiscal Year 1988-89

Location	Parcels Acquired	Acres Fee	Acres Permanent Easement	Acres Temporary Road Easement	Cost
Foothill Feeder	1		0.51		$ 0*
Middle Feeder	1		0.98		0**
[illegible] Feeder	1		0.01		0**
[illegible]	2		0.58		0***
[illegible]	1		5.90		1,746,000
[illegible] Feeder	1		0.02		0*
East [illegible] Feeder	1		0.23		0†
West [illegible] Feeder	1		1.51		0†
San Diego Canal	50			120.07	326,582
	2	0.19			725
Detention Peak Microwave Site	1		0.19		500
R. A. Skinner Filtration Plant	1	0.01			700
TOTAL	63	0.20	9.93	120.07	$2,074,507

Notes:

* [illegible] Easement granted to provide substitute access rights due to development

** [illegible] Easement granted in exchange for alternate access

*** [illegible] Price obligation per agreement with City of Norwalk

† [illegible] Access agreement with State of California

TABLE 51

STATEMENT OF CONSTRUCTION, [illegible] AND OTHER COSTS

June 30, 1989

	CRA Construction	Distribution Construction	Other Construction	Total
Completed Features				
Parker Power Plant Dam	$12,995,418.82			$ [illegible]
Power Recovery Plants		[illegible]		[illegible]
Other Dams & Reservoirs		[illegible]		[illegible]
Water Transportation Facilities	—	909,14[illegible],113.01		909,144,113.01
Pumping Plants & Facilities	64,239,517.73			64,239,517.73
Treatment Plants & Facilities	—	218,341,149.18		218,341,149.18
Power Lines & Communications	6,521,439.28			6,521,439.28
Miscellaneous Features			40,951,617.26	40,951,617.26
Subtotal	83,756,375.83	1,303,512,576.20	40,951,617.26	1,428,220,569.29
Preliminary Organization			5,571,000.74	5,571,000.74
Interest Original Constr			36,232,889.05	36,232,889.05
Interest During Constr	934,551.00	26,437,976.00	1,830,164.00	29,202,691.00
Unused Energy Original Constr			2,790,868.25	2,790,868.25
Subtotal	934,551.00	26,437,976.00	46,424,922.04	73,797,449.04
Total Comp. Features	84,690,926.83	1,329,950,552.20	87,376,539.30	1,502,018,018.33
Work in Progress				
Cost of Work in Progress	9,241,471.82	124,349,266.42	8,663,677.77	142,254,416.01
Interest During Constr	1,064,982.00	13,282,606.00	1,455,267.00	15,802,855.00
Total Work in Progress	10,306,453.82	137,631,872.42	10,1[illegible]8,944.77	158,057,271.01
Right of Way				
Completed Features	1,440,415.19	28,838,524.16	(4,000.[illegible])	[illegible]
Current Construction	—	6,102,986.37		[illegible]
Right of Way Deposits	—	579.00		[illegible]
Interest During Constr	—	3,095,000.00		[illegible]
Total Right of Way	1,440,415.19	38,037,089.53	[illegible]	[illegible]
Other Costs				
San Joaquin Res. Trust Agent	—		[illegible]	[illegible]
Feasibility Studies, Reimbursables, etc	—		[illegible]	
Construction Deposits	—			
Customer Deposits	—		[illegible]	
Total Other Costs	—		[illegible]	[illegible]
Total Cost to Date	96,437,795.84	1,505,619,514.15	[illegible]	

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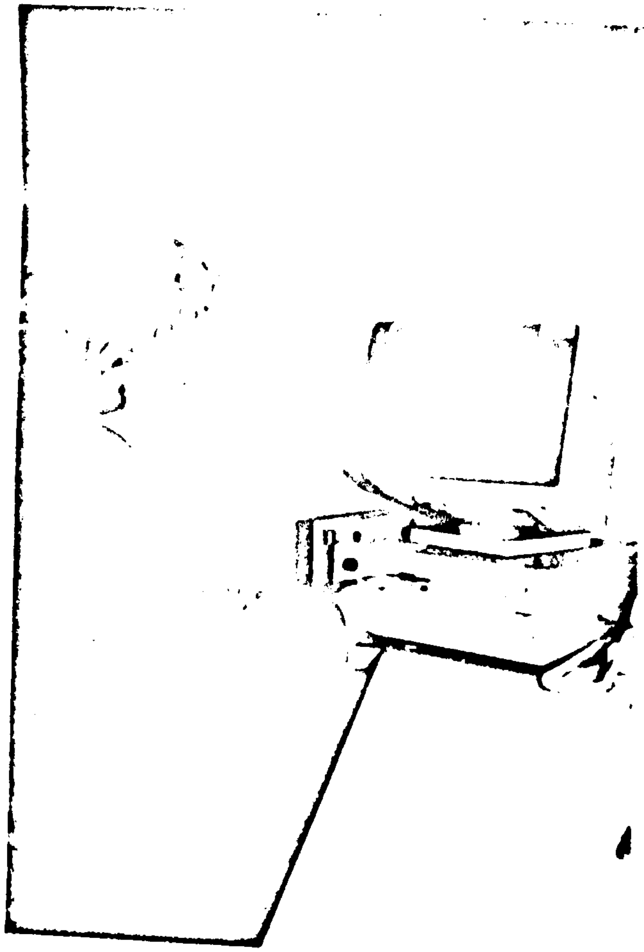

An internal auditor prepares for an audit of one of Metropolitan's automated systems

CHAPTER 10

Internal Audit

Metropolitan's Audit Department performs internal auditing activities consisting of financial and compliance audits, as well as miscellaneous reviews or special audits. The Auditor reports directly to the Board of Directors through the Audit Subcommittee of the Finance and Insurance Committee. He works closely with Metropolitan staff, but is independent of Metropolitan's general management.

Internal audit assignments are usually selected by the Auditor and are occasionally requested by the Board of Directors or management. Performance of detailed audit testing is preceded by appropriate planning and coordination with management or staff. Upon completion of all significant audit assignments, a report is issued to the Board of Directors and copies are provided to management. In accordance with internal auditing standards, the typical audit report outlines the objectives and scope of the work performed, the audit findings noted, and any recommendations for corrections or improvements which the Auditor feels are warranted in the circumstances. In addition to internal audit assignments, the Auditor and his staff provide substantial assistance to Metropolitan external auditor in conducting quarterly financial audits and the year-end audit required by the California Government Code and Metropolitan bond covenants.

During fiscal year 1988-89, the Audit Department issued a variety of reports pertaining to financial, compliance, electronic data processing (EDP), or special auditing matters. Aside from the aforementioned assistance provided to the external auditors, major assignments completed and reported on during the year included (in chronological order of issuance):

- EDP Application Review—Bond Inventory System, dated July 29, 1988.
- EDP Application Review—Payroll System, dated November 22, 1988.
- Review of Payment Procedures for Engineering Consultants, dated April 13, 1989.

- Review of Metropolitan's Hydroelectric Power Program, dated April 27, 1989
- Review of Metropolitan Bond Records and Controls, dated April 21, 1989
- Review of April 1989 Physical Inventory of Central Stores, dated June 26, 1989
- Review of Metropolitan's Fiscal 1989-90 Annual Budget, dated June 30, 1989

The results of these audits, together with management's responses to the Auditor's recommendations, are discussed in detail with the Audit Subcommittee. The Audit Subcommittee met four times during fiscal year 1988-89.

In addition to the aforementioned assignments, a number of other meaningful assignments were completed during fiscal 1988-89 for which formal audit reports were not prepared. Instead, management and appropriate staff were provided with copies of memoranda summarizing the results of these reviews for their information and possible action. The following assignments fell into this category.

- Update Review of Bank and Check Reconciliation Systems.
- Survey Review of Automated Expense Reporting System.
- Review of Single Audit Act Compliance for Fiscal 1987-88.

At June 30, 1989, the following significant financial assignments, exclusive of EDP and many smaller assignments, were in progress:

- Review of the Official Statement for Metropolitan's 1989 Series "G" General Obligation Bonds
- Survey Audit of Reimbursables Section Activities.
- Review of Water Rate Adjustments Credits
- Review of District's Disaster Contingency Planning
- Review of October 1988 Operating Equipment Inventory.

In some instances, completion of these assignments was delayed due to other work priorities or other factors. All are expected to be completed during fiscal 1989-90.

In addition to the preceding assignments, Audit Department personnel participated in many other short-term or recurring assignments throughout the year. Recurring assignments include reviews of the Monthly Financial Reports, audits of submitted directors' and department heads' expense claims; audits of selected employees' expense claims; quarterly reviews of water inventory and deferred water rights computations and quarterly reviews of Budget vs. Cost Reports.

During fiscal year 1988-89, audit personnel also reviewed drafts of Metropolitan's comprehensive Annual Financial Report for the fiscal year ended June 30, 1988; tested the accuracy of the 1988-89 tax levy documentation; reviewed Metropolitan's compliance with its June 30, 1988, fund requirements, reviewed new overhead rate calculations that were effective July 1988; reviewed selected petty cash funds at Headquarters; reviewed quarterly lobbying reports which are required by the Fair Political Practices Act to be filed with the State, tested various work orders for propriety and compliance with Metropolitan's procedures; and reviewed security activities on a quarterly basis for matters having audit implications.

While the results of these recurring or short-term assignments were generally satisfactory, written comments on such reviews, including recommendations, if appropriate, are often provided to management or staff for their information and possible action.

Among the more significant of corporate-wide systems development projects that the department's EDP auditors are involved with include: (1) the Cost Accounting System; (2) the Procurement System, and (3) the Water Accounting and Classification Invoicing System. In addition, the EDP auditors are currently monitoring and testing the development of the following Finance Division systems: (1) the Investment Management System, (2) the Local Area Network, and (3) Accounts Receivable.

As a result of almost continuous involvement by the EDP auditors in various systems development activities, specific computer application reviews were not performed to the level anticipated during the year. While internal audit involvement in the development and testing of new automated financial systems remains a top priority, the review of some of the key computer applications is also a priority objective for the next year.

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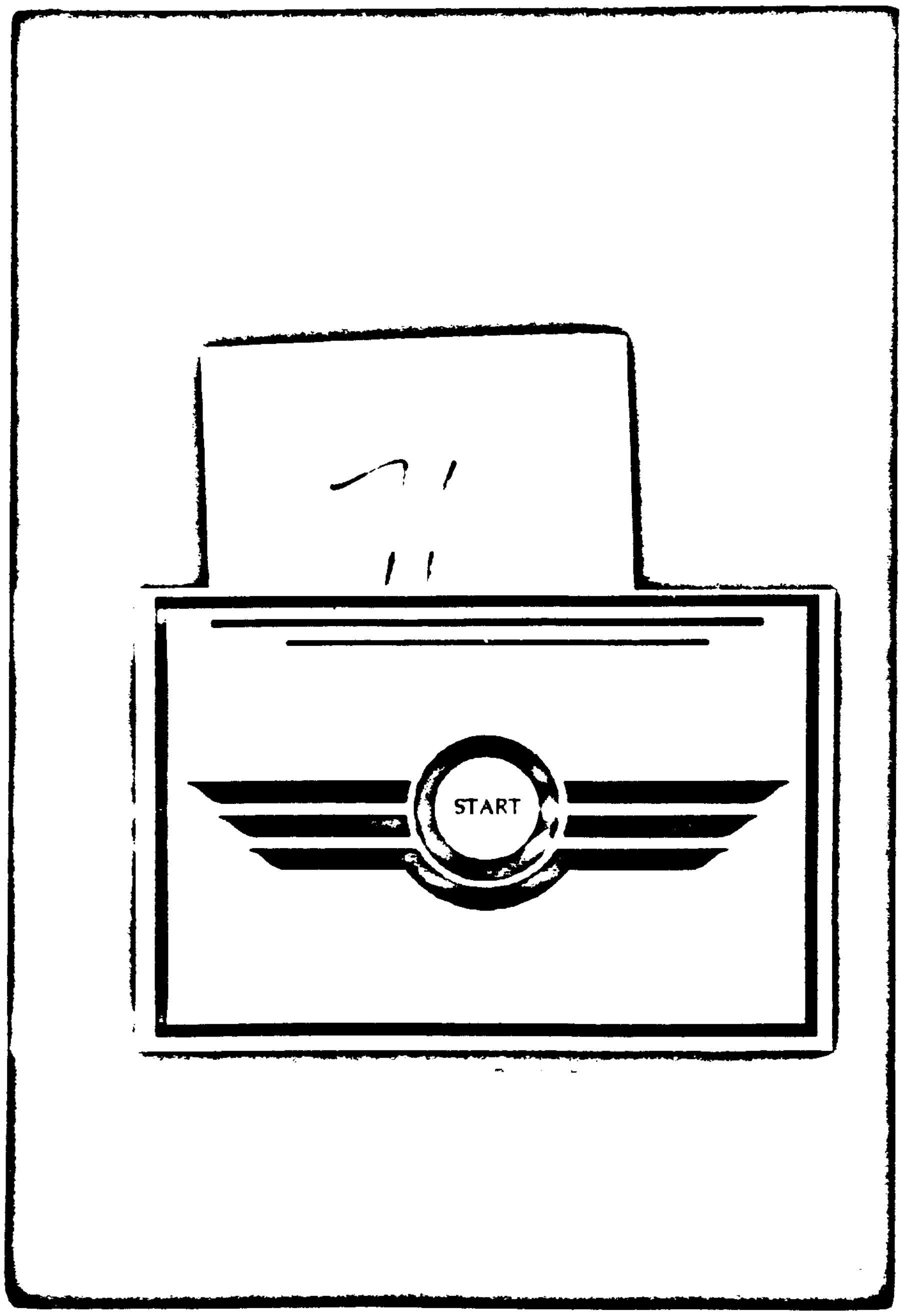

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THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

ANNUAL REPORT FOR THE FISCAL YEAR

July 1, 1989, to June 30, 1990

Carl Boronkay
General Manager

Compiled and edited by
S. H. Landsman

LOS ANGELES, CALIFORNIA
1990

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Drought conditions cause reservoir storage to shrink with each dry year (Frontispiece)

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TABLES

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FIGURES

LIST OF ABBREVIATIONS

Abbreviation	*Term*
AB	Assembly Bill
Aqueduct	Colorado River Aqueduct
AOC	assimilable organic carbon
Arvin Edison	Arvin Edison Water Storage District
AWWA	American Water Works Association
Bay Delta	San Francisco Bay/Sacramento San Joaquin Delta
Calleguas	Calleguas Municipal Water District
CAP	Central Arizona Project
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
Coachella	Coachella Valley Water District
CRAPRP	Colorado River Aqueduct Pump Rehabilitation Program
CRW	Colorado River water
CVP	Federal Central Valley Project
DBP	disinfection by products
DFG	California Department of Fish and Game
DHS	California Department of Health Services
Diemer plant	Robert B. Diemer Filtration Plant
DSFM	Distribution System Flow Model
DSOD	California Division of Safety of Dams
DWR	California Department of Water Resources
Eastern	Eastern Municipal Water District
EDF	Environmental Defense Fund
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
EOC	Los Angeles Headquarters Emergency Operations Center
EPA	U.S. Environmental Protection Agency
FETCA	Field Employees and Technical Crafts Association
GAC	granular activated carbon
GIS	Geographical Information System
HAA	haloacetic acid
Imperial	Imperial Irrigation District

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LIST OF ABBREVIATIONS

Abbreviation	Term
Jensen plant	Joseph Jensen Filtration Plant
kv	kilovolt
kwh	kilowatt hours
LIMS	Laboratory Information Management System
maf	million acre feet
MBAS	methylene blue active substance
MCL	maximum contaminant level
Metropolitan	Metropolitan Water District of Southern California
mgd	million gallons per day
mg/l	milligram per liter
M&I	municipal and industrial
MIB	2-methylisoborneol
Mills plant	Henry J. Mills Filtration Plant
ml	milliliter
MRL	minimum reporting level
MWDOC	Municipal Water District of Orange County
OCWD	Orange County Water District
OSHA	Occupational Safety Health Act
Palo Verde	Palo Verde Irrigation District
pCi/l	picocuries per liter
PEROXONE	hydrogen peroxide and ozone combination
PERS	Public Employees Retirement System
PINS	Planning Information Systems
Reclamation	U.S. Bureau of Reclamation
RG-6	[illegible] Unit No. 6
RPHLs	recommended public health levels
SB	[illegible]
SANDAG	San Diego Association of Governments
SAWPA	Santa Ana Watershed Project Authority
SCAG	Southern California Association of Governments
SCE	Southern California Edison
SDCWA	San Diego County Water Authority

LIST OF ABBREVIATIONS

Abbreviation	Term
SDG&E	San Diego Gas & Electric
SIG	System Information Graphics
Skinner plant	Robert A. Skinner Filtration Plant
SWC	State Water Contractors
SWP	State Water Project
SWRCB	State Water Resources Control Board
TCR	Total Coliform Rule
TDS	total dissolved solids
THM	trihalomethane
T&O	taste and odor
VOC	volatile organic compound
WAPA	Western Area Power Association
Weymouth plant	F.E. Weymouth Filtration Plant
WQCP	Water Quality Control Plan

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June 30, 1990

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A. [illegible] Selle
Las Virgenes MWD

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Coastal MWD

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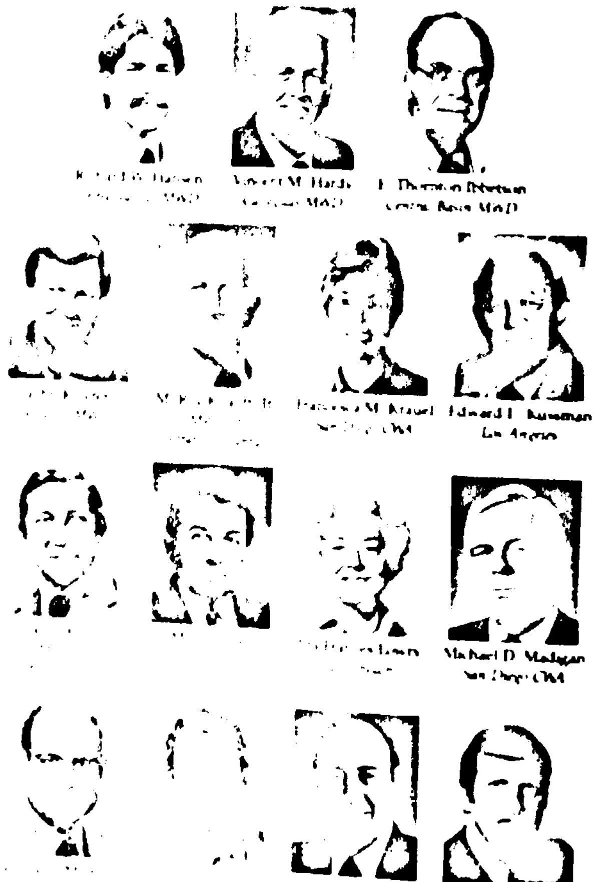

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Los Angeles

Michael D. Madigan
San Diego CWA

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MWD of
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Los Angeles

Doude Wysbeek
San Fernando

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Auditor

Assistant
Gen. Manager
R. B. Baird

Assistant
Auditor
L. W. Lindhout

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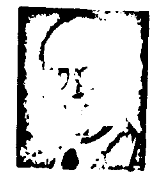
Chief
Engineer
C. E. Nichols

Chief of
Operations
P. R. Singer

Director of
Planning
F. W. Horne

Director of
Personnel
E. J. Alva



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G. K. Mitchell

Director of
Right of Way
and Land
S. M. Chavez

Director of
Finance
G. D. Leddy

Director of
Public Affairs
T. M. Spencer

Director of
Water Quality
M. J. McGuire

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Administrative
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G. F. Ivey

Director of
State Water Project
& Conservation
T. H. Quinn

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As of June 30, 1990

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Vice Chairman	Burton E. Jones
Vice Chairman	A. Macneil Stelle
Secretary	L. L. Auldenkamp

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Los Angeles	Michael Glazer
Los Angeles	Helen Romero Shaw
Los Angeles	Marilyn L. Garcia
Los Angeles	Robert J. Abernethy
Los Angeles	Frank S. Wyle
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Municipal Water District of Orange County	William F. Davenport
Municipal Water District of Orange County	John V. Foley
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San Diego County Water Authority	Michael D. Madigan
San Diego County Water Authority	John P. Starkey
San Diego County Water Authority	Francesca M. Krauel
San Diego County Water Authority	Dale Mason
San Diego County Water Authority	Herbert H. Stickney
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San Marino	John T. Morris
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Upper San Gabriel Valley Municipal Water District	John E. Maulding
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West Basin Municipal Water District	Harold E. Crozier
West Basin Municipal Water District	Charles L. Stuart
Western Municipal Water District of Riverside County	Lois B. Krieger

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JUNE 30, 1990

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Regina Turney-Murph
Carl E. Ward

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...ORS

...90

...M

A. W. Fr...	... 1929, to April 11, 1930
O. E. St...	... 18, 1930, to April 12, 1935
E. P. H...	May ... 1935, to June 14, 1960
Ch...	July 12, 1960, to May 8, 1972
K...	June 13, 1972, to May 29, 1979
JOSEPH ...	August 17, 1979, to

BEVERLY HILLS

Paul E. Schwab*	March 1, 1929, to June 19, 1931
George R. Barker*	June 19, 1931, to August 2, 1935
Arthur Taylor*	August 2, 1935, to August 2, 1951
Floyd E. Fischer*	August 17, 1951, to December 2, 1977
Ellen Stern Harris	January 10, 1978, to March 10, 1981
Nicholas H. Cominos	March 10, 1981, to September 1, 1981
Mel Odom	January 11, 1983, to February 14, 1984
INA S. ROTH	February 14, 1984, to

BURBANK

Harvey E. Bruce*	March 1, 1929, to February 11, 1933
James L. Norwood*	March 10, 1933, to April 30, 1943
	May 9, 1947, to October 13, 1953
Frank C. Tillson*	May 14, 1943, to May 9, 1947
Walter H. Long*	October 13, 1953, to June 13, 1961
Earle C. Bl...	June 13, 1961, to June 11, 1985
MICHAEL A. NOLAN	June 11, 1985, to

...ALLEGUAS MUNICIPAL WATER DISTRICT

...	January 10, 1961, to August 22, 1969
...	September 16, 1969, to
...	October 14, 1980, to June 30, 1990

...N MUNICIPAL WATER DISTRICT

	November 23, 1954, to November 23, 1983
	November 23, 1954, to November 30, 1959
	November 23, 1954, to April 10, 1973
	November 23, 1954, to November 30, 1963

E. THORNTON IBBETSON	December 8, 1959, to
William H. Kent*	October 10, 1961, to April 7, 1977
Carl Fossette*	March 13, 1973, to May 30, 1986
DOUGLAS W. FERGUSON	June 14, 1977, to
LEONIS C. MALBURG	July 8, 1986, to

CHINO BASIN MUNICIPAL WATER DISTRICT

A. C. Reynolds	February 12, 1952, to March 12, 1963
Ray W. Ferguson	March 12, 1963, to December 31, 1980
Carl B. Masingale*	March 10, 1981, to August 9, 1984
John G. Galday	September 11, 1984, to February 15, 1985
Edward A. Girard	March 12, 1985, to May 31, 1990
ANNE W. DUNIHUE	September 20, 1988, to

COASTAL MUNICIPAL WATER DISTRICT

C. C. Cravath*	August 14, 1942, to January 22, 1957
LYNNDON L. AUFDENKAMP	January 22, 1957, to
James E. O'Connor*	December 7, 1976, to July 1, 1979
JOHN KILLEFER	January 12, 1982, to

COMPTON

C. A. Dickison*	July 17, 1931, to January 20, 1933
William H. Foster*	January 20, 1933, to June 28, 1935
Warren W. Butler*	June 28, 1935, to January 24, 1980
REGINA TURNEY-MURPH	March 11, 1980, to

EASTERN MUNICIPAL WATER DISTRICT

Irwin E. Farrar*	August 31, 1951, to March 1, 1982
DOYLE F. BOEN	March 9, 1982, to

FOOTHILL MUNICIPAL WATER DISTRICT

Nelson Hayward*	February 8, 1955, to July 4, 1959
Conrad R. Fanton*	November 10, 1959, to November 2, 1964
A. B. SMEDLEY	April 13, 1965, to

FULLERTON

Walter Humphreys*	April 10, 1931, to January 19, 1945
H. H. Kohlenberger*	July 27, 1945, to March 7, 1959
Hubert C. Ferry*	February 23, 1960, to February 8, 1983
Norman L. De Vilbiss	February 8, 1983, to April 12, 1988
JAMES H. BLAKE	August 23, 1988, to

[illegible]

W. Turney Fox*	[illegible] to November 27, 1931
Samuel G. McClure* (See also [illegible])	[illegible] 27, 1931, to January 13, 1933
Frank P. [illegible]*	[illegible] 13, 1933, to August 31, 1934
Bernard [illegible]	August 31, 1934, to April 23, 1937
Herman [illegible]*	June 4, 1937, to August 27, 1954
Paul [illegible]	September 28, 1954, to June 10, 1958
Norman [illegible]	June 10, 1958, to June 9, 1970
Lauren W. [illegible]*	June 9, 1970, to May 21, 1972
William H. [illegible]*	June 13, 1972, to July 13, 1976
C. E. [illegible]	July 13, 1976, to July 13, 1988
JAMES [illegible]	August 21, 1988, to

LAS VIRGENES MUNICIPAL WATER DISTRICT

Earle Brookins	December 13, 1960, to March 26, 1963
A. Myron McBride*	March 26, 1963, to May 11, 1965
A. MACNEIL STEELE	June 8, 1965, to October 23, 1967
	March 11, 1975, to
Whitney P. Reeve*	December 19, 1967, to March 11, 1975

LONG BEACH

Nowland M. Reid*	April 10, 1931, to January 27, 1933
W. M. Cook*	January 27, 1933, to April 30, 1943
Guy A. Walker	April 30, 1943, to December 31, 1976
Lloyd C. Leedom*	May 9, 1947, to June 30, 1979
Samuel C. Rae	October 9, 1979, to March 12, 1985
IDA FRANCES LOWRY	March 12, 1985, to

LOS ANGELES

John R. Haynes*	March 1, 1929, to February 4, 1930
John R. R[illegible]*	March 1, 1929, to October 28, 1947
W. P. W[illegible]*	March 1, 1929, to January 10, 1947
John G. B[illegible]*	[illegible] 1, 1929, to September 15, 1933
[illegible]	[illegible] 5, 1929, to August 29, 1930
W. L. H[illegible]*	[illegible] 28, 1930, to July 21, 1933
[illegible]*	[illegible] 29, 1930, to July 2, 1937
[illegible]	[illegible] 20, 1933, to January 4, 1935
[illegible]*	[illegible] 20, 1933, to September 3, 1955
[illegible] H. [illegible]*	[illegible] 21, 1933, to August 14, 1950
[illegible]*	[illegible] 13, 1933, to November 19, 1960
[illegible]*	January 11, 1935, to October 22, 1947

Louis S. Nordlinger*	August 13, 1937, to June 8, 1940
Joseph Jensen*	August 16, 1940, to February 3, 1944
	March 8, 1946, to July 8, 1974
Ransom W. Chase*	March 14, 1947, to February 11, 1975
Gordon B. Crary*	March 14, 1947, to November 8, 1959
Howard D. Mills*	March 14, 1947, to March 17, 1965
W. R. Fawcett	May 13, 1952, to November 27, 1953
Luther C. Anderson	January 12, 1954, to February 11, 1975
Noah Dietrich*	November 8, 1955, to November 23, 1970
Ferdinand Mendenhall*	July 29, 1958, to October 8, 1974
Ben P. Griffith*	August 9, 1960, to June 7, 1961
Pietro Di Carlo*	February 14, 1961, to November 7, 1967
William S. Peterson*	February 14, 1961, to August 10, 1979
Aubrey E. Austin, Jr.*	February 28, 1961, to May 13, 1975
Albert F. Bush*	November 14, 1961, to February 11, 1975
John W. Luhring	January 16, 1962, to August 8, 1967
Joseph M. Quinn*	May 14, 1968, to September 18, 1973
B. Walter Hicks	May 8, 1973, to August 20, 1974
Samuel B. Nelson*	September 18, 1973, to October 9, 1984
Katherine B. Dunlap	August 20, 1974, to September 11, 1984
Jerry Gotdell	October 8, 1974, to October 9, 1984
EDWARD L. KUSSMAN	October 8, 1974, to
Herman Leavitt	February 11, 1975, to August 19, 1975
Yolanda M. Nava	February 11, 1975, to September 14, 1976
S. DELL SCOTT	February 11, 1975, to
Willie J. Stennis	May 13, 1975, to December 31, 1978
Mladin Zarubica	August 19, 1975, to March 16, 1981
Soledad S. Garcia	September 14, 1976, to September 11, 1984
MARK LAINER	November 13, 1979, to
Mark Nathanson	April 14, 1981, to September 11, 1984
MICHAEL GLAZER	September 11, 1984, to
HELEN ROMERO SHAW	September 11, 1984, to
MARILYN L. GARCIA	October 9, 1984, to
Rachel Levin	October 9, 1984, to April 4, 1989
FRANK S. WYLE	October 9, 1984, to
ROBERT J. ABERNETHY	April 4, 1989, to

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Glenn P. Allen	December 11, 1951, to December 17, 1986
W. B. Hellis*	August 19, 1955, to February 9, 1975
William J. Teague	February 11, 1969, to October 10, 1972
Robert R. Dowling	September 14, 1971, to May 11, 1976
Doyle Miller	October 10, 1972, to October 31, 1987

CARL J. KY[illegible]	[illegible] 1973, to
Philip J. R[illegible]	December 9, 1975, to December 8, 1978
Gerald [illegible]	May 11, 1976, to December 31, 1988
M. RO[illegible] KN[illegible]T, JR	[illegible] 13, 1977, to
KENNETH [illegible] WITT	[illegible] 13, 1981, to
WILLIAM E. DAVENPORT	[illegible] 13, 1987, to
JOHN V. FOLEY	[illegible] 22, 1989, to

PASADENA

Franklin Thomas*	March 1, 1929, to August 27, 1952
Morris S. Jones*	September 16, 1952, to October 10, 1961
Robert B. Diemer*	January 16, 1962, to October 27, 1966
Don C. McMillan*	January 10, 1967, to October 26, 1975
Karl A. Johnson	December 9, 1975, to April 11, 1980
Martin Goldsmith	July 8, 1980, to June 11, 1985
TIMOTHY F. BRICK	June 11, 1985, to

SAN DIEGO COUNTY WATER AUTHORITY

Fred A. Heilbron*	January 10, 1947, to February 14, 1973
J. L. Burkholder*	January 24, 1947, to April 6, 1953
Richard S. Holmgren	August 11, 1953, to February 19, 1963
J. William Fisher*	April 12, 1955, to October 11, 1955
Hans H. Doe*	August 20, 1959, to October 20, 1986
Paul Beermann*	February 19, 1963, to July 9, 1963
HARRY GRIFFEN	February 19, 1963, to
George R. Henderson*	August 13, 1963, to November 29, 1964
Ralph E. Graham	September 14, 1971, to January 14, 1975
	August 17, 1979, to June 28, 1982
Raymond [illegible]	September 18, 1973, to May 14, 1979
[illegible]	[illegible] 1973, to December 31, 1980
John M. [illegible]	[illegible] 14, 1975, to December 31, 1986
JOHN [illegible]	[illegible] 13, 1981, to
MICHAEL [illegible]	[illegible] 18, 1982, to
FRANCES [illegible]	[illegible] 8, 1983, to
[illegible]	[illegible] 18, 1986, to October 31, 1989
[illegible]	[illegible] 13, 1987, to
[illegible]	[illegible] 14, 1989, to

SAN FERNANDO

[illegible]	[illegible] 11, 1971, to August 21, 1984
[illegible]	[illegible] 21, 1984, to August 8, 1986
[illegible]	[illegible] 9, 1986, to

SAN MARINO

Harry L. Hellner*	March 1, 1929, to September 29, 1933
John H. Rambur*	September 29, 1933, to November 18, 1960
Howard A. Miller*	January 10, 1961, to April 26, 1975
Preston Hutchins*	June 10, 1975, to September 10, 1986
Preston B. Hutchins	March 10, 1987, to March 13, 1990
JOHN T. MORRIS	March 13, 1990, to

SANTA ANA

S. H. Finley*	March 1, 1929, to April 10, 1942
A. H. Allen*	April 10, 1942, to December 10, 1968
Howard W. Crooke*	December 10, 1968, to September 1, 1977
JOHN GARTHE	November 8, 1977, to

SANTA MONICA

George H. Hutton*	March 1, 1929, to January 16, 1931
Arthur A. Weber*	January 16, 1931, to October 12, 1934
William H. Carter*	February 15, 1935, to March 13, 1936
Edmond S. Gillette*	June 12, 1936, to January 8, 1937
Arthur P. Creel*	January 8, 1937, to March 3, 1941
Samuel G. McClure* (See also Glendale entry)	March 21, 1941, to November 14, 1947
Samuel J. Crawford*	December 5, 1947, to September 15, 1959
Mark T. Gates*	January 12, 1960, to July 12, 1972
Francis A. Gaplen	August 18, 1972, to December 9, 1980
Robert Gottlieb	December 9, 1980, to December 8, 1987
CHRISTINE E. REED	March 8, 1988, to

THREE VALLEYS MUNICIPAL WATER DISTRICT

Hugh W. Stiles*	December 8, 1950, to December 31, 1961
Arthur H. Cox	January 16, 1962, to April 16, 1974
William C. Leech	April 16, 1974, to February 9, 1982
William H. Koch	February 9, 1982, to February 12, 1985
Mel Harper	February 12, 1985, to February 18, 1986
RICHARD W. HANSEN	June 10, 1986, to

TORRANCE

John Dennis*	March 17, 1931, to April 14, 1933
J. R. Jensen*	April 14, 1933, to December 31, 1933
Charles T. Rippy*	January 19, 1934, to August 8, 1950
George W. Stevens	September 22, 1950, to June 13, 1961
George A. Bradford	June 13, 1961, to October 13, 1964
George Vico	November 17, 1964, to August 13, 1968

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Ben Haggott* (See also West Basin MWD entry)	August [illegible] to November 14, 1982
MARVIN BREWER	March [illegible] to

UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT

J. Excel Chinamon*	April 9, 1963 to January 30, 1964
Howard H. Hawkins	April 9, 1963 to December 31, 1969
Frank E. Vallee	March 10, 1964 to March 10, 1970
Robert J. Reichert*	March 10, 1970 to December 31, 1970
Jonas L. Minnick	January 12, 1971 to December 31, 1978
BURTON E. JONES	January 9, 1979 to
JOHN E. MAULDING	January 9, 1980 to

WEST BASIN MUNICIPAL WATER DISTRICT

Robert E. Austin*	August 20, 1948 to October 21, 1948
Ben Haggott* (See also Torrance entry)	March 30, 1951 to October 8, 1956
W. C. Farquhar*	
E. A. Lucas	August 19, 1955 to July 13, 1976
Louis J. Alexander*	August 9, 1960 to April 9, 1963
CHARLES D. BARKER	August 13, 1963 to March 30, 1972
Lauer C. Matson*	September 10, 1963 to
Lester E. Carlson*	November 12, 1968 to February 12, 1984
E. L. Balmer*	October 8, 1974 to September 2, 1980
HAROLD E. CROZIER	August 10, 1976 to May 23, 1980
CHARLES E. STUART	October 25, 1980 to
	July 11, 1980 to

WESTERN MUNICIPAL WATER DISTRICT OF RIVERSIDE COUNTY

Howard [illegible]	December 11, 1964 to July 13, 1976
LOIS B. KREGER	August 13, 1976 to

Notes

*Deceased

**Current Directors [illegible] capital letters.

STAFF

June 30, 1980

GENERAL MANAGER DEPARTMENT

General Manager	C. Boronkay
Assistant General Manager	R. B. Baird
Assistant General Manager	R. W. Balcerzak
Assistant General Manager	D. L. Georgeson
Executive Assistant to the General Manager	N. G. Taylor
Legislative Representative	R. E. Corley

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Assistant General Counsel	K. L. Tachiki

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Assistant Auditor	L. W. Lindhout

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Executive Secretary	K. E. Dorff

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Assistant Chief Engineer	G. M. Snyder
Principal Engineer	W. P. Lundy
Principal Engineer	M. S. Chan
Principal Engineer	A. M. Whitsett
Principal Engineer	G. J. Hazel
Principal Engineer	G. F. Horowitz
Principal Engineer	A. Hassani
Principal Engineer	L. L. Treadway
Principal Engineer	D. C. Gledhill

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Senior Engineer	D. R. Froelich
Advance Planning Manager	D. C. Man
Manager, Environmental Affairs	R. L. Soltz

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Assistant Chief of Operations ... C. F. Voy
Assistant Chief of Operations ... J. W. Malinows
Regional Operations Manager ... D. D. Newkirk
Regional Operations Manager ... R. W. Hur
Regional Operations Manager ... M. L. Ste
Principal Engineer ... V. L. Haller
Control Systems Manager ... W. G. Kervahn

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Assistant Director ... R. E. Kennedy
Manager, Information Systems ... K. R. Sommerville
Manager, Data Processing ... T. D. Harman
Manager, Communications ... T. J. Rankin

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Assistant Director ... S. C. Green
Manager, Personnel ... G. J. Bryant
Manager, Human Resources & Development ... J. M. Mallory

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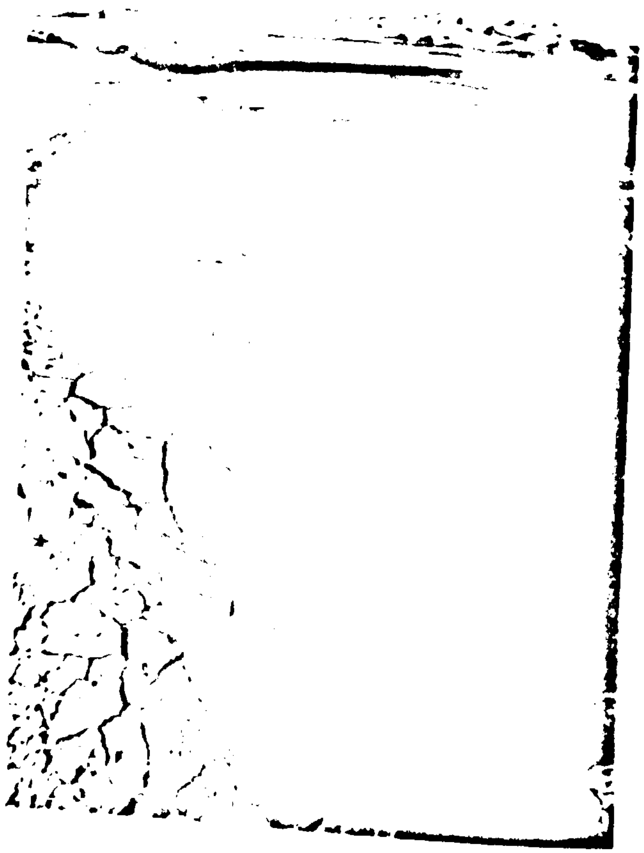
Principal Engineer ... R. C. Clemmer
Principal Engineer ... W. F. Mancinelli



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Foreword

With Southern California facing its fourth consecutive drier-than-normal year, Metropolitan continued its increased efforts toward ensuring future water supplies through additional water storage and water conservation agreements, by supporting reclamation projects, and by accelerating its conservation awareness programs.

Metropolitan authorized preliminary design of an innovative storage and transfer project that will provide additional water for Southern California. The project, between Metropolitan and the Arvin-Edison Water Storage District, will allow some of Metropolitan's unneeded supplies in wet years to be stored by Arvin-Edison in an underground aquifer in the San Joaquin Valley. In later dry periods, Arvin-Edison will use the underground reserve to irrigate crops. In exchange, water supplies that otherwise would be delivered to the agricultural district's farmers from federally operated storage reservoirs will be delivered to Metropolitan.

Supporting local water reclamation projects is another way Metropolitan ensures sufficient future supplies for cities and agricultural areas. Two reclamation projects that together will produce nearly 4 billion gallons of water annually for landscape irrigation purposes in Orange County were approved by the Board; one with the Moulton Niguel Water District, and the other with the city of San Clemente, the Tri-Cities Municipal Water District, and the Coastal Municipal Water District. A third project, the Trabuco Water Reclamation project in Orange County, will yield 260 million gallons of water per year; a fourth, with the City of Glendale, will produce nearly 196 million gallons of water to irrigate Glendale Forest Lawn Memorial Park.

In heightened conservation efforts, Metropolitan's Board of Directors called on municipal governments to adopt drought ordinances to help reduce the threat of water shortages and adopted a special rebate program aimed at rewarding communities and water agencies that cut back water usage by more than 5 percent. The Board also approved a $2,000,000 advertising campaign aimed at reducing water use in Southern California on a continuing basis by creating public awareness and providing valuable tips on how to curtail water use. The campaign, primarily radio and television commercials, is planned for the summer months when people are more conscious of the need for conserving water.

Furthering its involvement in the conservation effort, for the very first time, Metropolitan joined a private firm in calling for water use reductions. At fiscal year end, Metropolitan and Wells Fargo Bank launched a $3.4-million water conservation campaign "Helping California save water for a future we can all bank on." Aimed at saving more than 65 billion gallons of water over the summer, it includes not only radio, television, and billboard advertising but distribution of 1 million water conservation kits. Wells Fargo will distribute 70 percent of the kits at its 167 Southern California branches, the remainder will be disseminated by Metropolitan and its 27 member agencies.

Not stopping at its efforts on earth, Metropolitan is looking into outer space for assistance. Sophisticated analysis of photographs taken 450 miles above the earth will help plot outdoor water use patterns and guide Metropolitan to important water conservation opportunities in urban landscaping. The information will also be particularly useful in ongoing water allocation hearings before the State Water Resources Control Board.

Making sure that local water sources remain uncontaminated, Metropolitan, the Environmental Defense Fund, and local water agencies filed lawsuits during the year aimed at blocking a controversial garbage dump expansion in the San Gabriel Valley, seeking to reverse a ruling by the State Water Resources Control Board. The ruling would allow the Azusa Land Reclamation Company to dump more than 30 million tons of municipal garbage in gravel pits overlying the groundwater basin that provides drinking water for 1 million people. Metropolitan, EDF, and the local water agencies feared that the protective plastic liners installed at the dump would eventually leak, contaminating the groundwater basin which provides 90 percent of the valley's drinking water.

Metropolitan continues in the forefront on high standards of water quality, undertaking a six-month study of the occurrence of radon in Southland groundwater supplies in anticipation of an Environmental Protection Agency limit on radon expected later this year. The EPA advised that the maximum contaminant level (MCL) will be set somewhere between 200 and 2,000 pico Curies per liter (pCi/L). Findings from the study ranged from 93 to 1,538 pCi/L, with the majority of sites having radon levels between 200 and 500 pCi/L, indicating there could be significant impact on available water supplies in Southern California the more stringent the MCL.

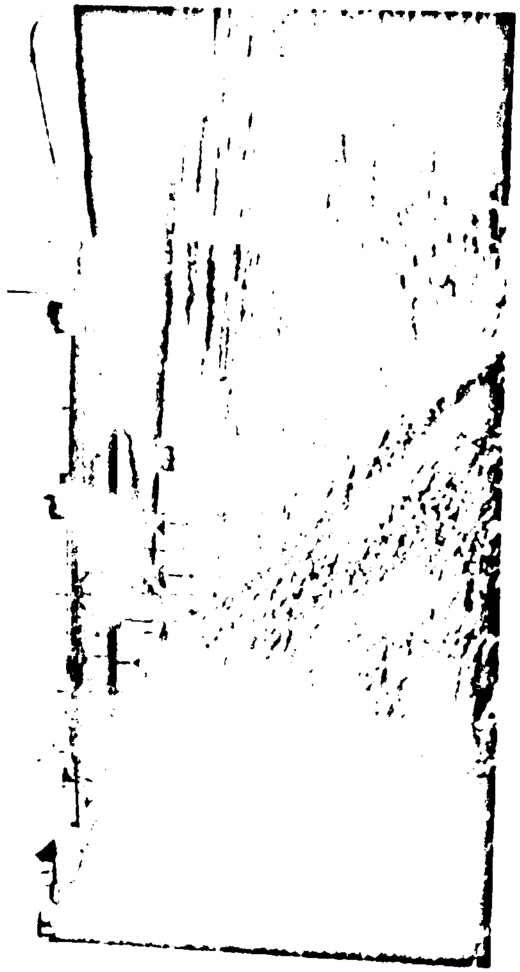
Water rates remained stable for the fifth consecutive year, keeping untreated and treated water at $197 per acre-foot and $230 per acre-foot respectively, interruptible untreated and treated water at $153 and $186, emergency untreated and treated water at $591 and $624, and reclaimed water at $54. A new class of service, Seasonal Storage, was added this year. Priced at $115 for untreated water and $135 for treated, Metropolitan hopes to encourage agencies to purchase water from October through April and

store it for summer use during peak demand on Metropolitan. This fiscal year, 18 member agencies took advantage of seasonal storage rates, buying 320,000 acre-feet, and staff estimates that about one-third would be used during the summer of 1990.

In yet another record year for water sales, revenues rose $62 million over last fiscal year, totaling $487 million on water deliveries of 2,511,375 acre-feet, up 19.8 percent over last year's record deliveries. Revenues from the recovery of hydroelectric power remained the same as last year at $19 million. The net amount of taxes for 1989-90 totaled $81.9 million.

Metropolitan's major expansion program moved forward throughout the year. Nineteen construction contracts with a total cost of $58,344,969 were in progress. The Board of Directors awarded 13 new construction projects with a value exceeding $129 million; 3 construction contracts were completed at a total cost of $2,160,529, and 16 contracts progressing at year end were valued in excess of $198 million. The major projects under construction during the fiscal year included Skinner Filtration Plant Expansion No. 3 and Finished Water Reservoir, enlargement of San Diego Canal, and Etiwanda Pipeline, Control Facility, and Reservoir. Major projects in design phases during the fiscal year included Jensen Plant Expansion No. 1, Foothill Feeder Pressure Control Structure Expansion, Diemer Plant Modifications, and the Etiwanda Power Plant.

Metropolitan continued rehabilitating its aging Colorado River Aqueduct pumping system, completing Phases IV and V during the fiscal year. Metropolitan staff also continued rehabilitation work at the F.E. Weymouth Filtration Plant, with completion anticipated during the next fiscal year.



Greater water conservation will be achieved by lining the earthen All American Canal and Coachella Branch

CHAPTER 1

Water Supply

Incorporated in 1928, the Metropolitan Water District of Southern California (Metropolitan) provides a supplemental water supply for Southern California's coastal plain. Municipal and industrial demand consumes approximately 90 percent of Metropolitan-supplied water; the remaining 10 percent is used for agricultural purposes and to prevent seawater intrusion into coastal groundwater basins.

Metropolitan's service area covers 5,200 square miles and 27 member agencies, which consist of 14 cities, 12 municipal water districts, and the San Diego County Water Authority (SDCWA) as shown in Figure 1 at the end of this chapter. Currently supplying more than half of the water used within its service area, Metropolitan is expected to deliver nearly all of the anticipated increase in future water demands.

Obtained either locally or imported, Southern California water supplies vary widely from wet years to dry years and are affected by multi-year periods of drought conditions. For imported water, Metropolitan relies on the Colorado River Aqueduct (Aqueduct), which diverted 1.24 million acre-feet (maf) in fiscal year 1989-90, and the State Water Project (SWP) which furnished 1.32 maf. As Metropolitan's total dependable supply from these two sources is projected to equal only 1.75 maf in 1995, various initiatives are being undertaken to increase that supply.

Colorado River Supply

Entitlements

In 1930, Metropolitan signed a contract with the Secretary of the Interior (Secretary) to receive Colorado River water (CRW). By annexing SDCWA's service area in 1946, Metropolitan's contractual CRW entitlement increased to 1.212 maf per year. However, Metropolitan lost some entitlement dependability in 1985 when the Central Arizona Project (CAP) began supplying water to central Arizona. This caused provisions of Colorado River reservoir operating criteria issued by the Secretary in 1970 to become effective. Annually, the Secretary determines whether sufficient water is available to satisfy water requests from contractors in Arizona, California, and Nevada. California's basic CRW apportionment is limited to 4.4 maf per year by a 1963 U.S. Supreme Court decision. Agencies supplying irrigation water hold a higher priority to reasonable beneficial use of 3.85 maf per year, less the amount of water made available to Metropolitan under its Water Conservation Agreement with Imperial Irrigation District (Imperial). Furthermore, water use by holders of higher priority Indian and miscellaneous rights (30,000 acre-feet) and conveyance losses (50,000 acre-feet) reduce Metropolitan's dependable supply delivered into the coastal plain. Metropolitan estimates that its dependable supply will increase from 476,110 acre-feet in 1990 to 576,110 acre-feet by 1996 as Imperial Valley water conservation projects are completed.

The Aqueduct System

Initial facilities on the voter approved Aqueduct were completed in 1941. As water needs increased, Metropolitan had expanded Aqueduct facilities by 1961 to a capacity of more than 1 maf per year, which equals more than 1 billion gallons per day.

The Colorado River Aqueduct covers 242 miles of desert terrain and mountain ranges between its Lake Havasu intake and its terminal reservoir, Lake Mathews, near Riverside. The Aqueduct, originally designed to accommodate an eight-pump flow of 1,605 cubic feet per second (cfs), can convey flows 15 percent higher. This sufficiently delivers the dependable water supply plus more than [illegible] acre-feet of surplus CRW when available. During the 1989-90 fiscal year, 1,243,064 acre-feet of water was diverted from Lake Havasu into the Aqueduct. The average flow was 1,720 cfs, 107 percent of the original Aqueduct design capacity.

Five pumping plants elevate CRW a total of 1,617 feet, taking it over several mountain ranges. The Whitsett pumping plant, on Lake Havasu's western shore, elevates water from the lake 291 feet to Gene Wash Reservoir located two miles inland. The Gene pumping plant raises the CRW an additional 303 feet to Copper Basin Reservoir, the Aqueduct's major flow control point. The water flows by gravity approximately 63 miles to the Iron Mountain pumping plant, where it is raised another 144 feet. After flowing another 41 miles, the water reaches the Eagle Mountain pumping plant which boosts it 438 feet. Following a 16-mile gravity flow, the water arrives at the Hinds pumping plant and is elevated 441 feet. The water continues by gravity the remaining 116 miles to Lake Mathews.

Each pumping plant was designed to operate continuously with eight pumps; a ninth pump facilitates maintenance and repairs and provides additional pumping capacity. With a nine-pump flow, the Aqueduct can carry flows 15 percent higher than design capacity, or 1,850 cfs. Because of modifications to pump and motor units, each pump's capacity now exceeds its original 200-cfs design capacity.

Colorado River Water Supply Conditions

Colorado River runoff continued below average for a third consecutive year. End-of-year reservoir storage declined by about 5 maf from a year ago, reflecting the June 1 forecast of runoff into Lake Powell of 31 percent of average for the April-to-July snow-melt period.

As shown in Table 1, Lake Powell inflow reflected the dry conditions experienced in the Upper Colorado River Basin.

TABLE 1

Inflow to Lake Powell
(Million Acre feet)

Inflow Source	Fiscal Year 1987-88	1988-89	1989-90
Green River at Green River, Utah	3.4	2.2	1.9
Colorado River near Cisco, Utah	3.9	2.9	2.2
San Juan River near Bluff, Utah	1.3	1.0	0.7
Miscellaneous	0.6	0.2	0.2
Total inflow to Lake Powell	9.2	6.3	5.0

The river's gauged flow at Lees Ferry, Arizona, a few miles downstream of Lake Powell, was 8.0 maf for the fiscal year. This gauge lies just upstream of the Paria and Colorado River confluence. Downstream of the Paria is the Colorado River Compact point, where Upper Colorado River Basin releases to the Lower Basin are determined.

Releases from Lake Mead totaled 9.0 maf. CRW deliveries in the Lower Basin were 5.2 maf to California, including 1.2 maf to Metropolitan and 3.9 maf to the agencies supplying irrigation water; 2.3 maf to Arizona; 0.2 maf to Nevada; and 1.7 maf to Mexico including saline waters bypassed to the Santa Clara Slough.

Colorado River Aqueduct Power Requirements

Power required for the Aqueduct pumping operations is delivered through a Metropolitan-owned transmission system consisting of 310 miles of high-voltage (230 kilovolt) power lines connecting the pumping plants to the Western Area Power Administration (WAPA) system and the Southern California Edison Company (SCE) system. WAPA's system delivers Metropolitan's share of power from Hoover and Parker Power Plants, shown in Table 2.

TABLE 2

ELECTRIC ENERGY AVAILABLE AT HOOVER AND PARKER POWER PLANTS

Fiscal Year 1989-90

	(Kilowatt-hours)
Hoover Power Plant	
Total Hoover Energy	4 067 847 000
Total Hoover Energy Available to Metropolitan	1 205 476 000
Parker Power Plant	
Total Parker Energy	469 699 522
Total Parker Energy Available to Metropolitan	230 545 000

This fiscal year, a total of 2.4 billion kilowatt-hours (kwh) of energy was needed to divert the 1,243,064 acre-feet of water from Lake Havasu. As shown in Table 3, the Hoover and Parker Power Plants provided 59.0 percent of the total energy required.

TABLE 3

METROPOLITAN'S ELECTRIC ENERGY USE

Fiscal Year 1989-90

Energy Source	Kilowatt-hours	Percentage of Total Energy Requirement
Hoover Power Plant	1 205 476 000	49.51
Parker Power Plant	230 545 000	9.47
Edison Benefit Energy	219 139 828	9.00
Exchange	24 [illegible] 000	1.02
Supplemental Energy Purchases*	754 629 485	31.00
TOTAL	2 434 567 313	100.00

Note

*[illegible] ... Project, Arizona Public Services Company, and the T[illegible]

To augment the Hoover and Parker power resources, Metropolitan and SCE integrated their electric systems under the District-Edison 1987 Service and Interchange Agreement. The agreement improves electric service reliability, conserves resources, and helps optimize efficiency for both parties. Specific benefits include energy interchanges and exchanges, supplemental energy purchases, and use of surplus generating capacity.

To secure the required energy for pumping operations, Metropolitan purchased supplemental power under various power contracts and agreements. Almost all of the supplemental power was "economy, off-peak energy" from various suppliers, including Arizona Public Services Company, Salt River Project, WAPA's Navajo Project, and the Tucson Electric Power Company.

Tables 4 and 5 summarize this fiscal year's total power use and costs for Aqueduct pumping operations. The composite of the supplemental power costs represents SCE's average power rate of 29.5 mills/kwh, and the other suppliers average rate of 16.7 mills/kwh. Such supplemental power rate differences provide substantial economic benefits by minimizing Metropolitan power costs. For fiscal year 1989-1990, the supplemental power cost savings totaled approximately $8.9 million.

TABLE 4

PLANT ENERGY USE

Fiscal Year 1989-90

Plant	Pump-Hours (Hours)	Energy Use (kwh)	Station Service (kwh)	Water Diverted (Acre feet)
Whitsett	61,910	423,187,481	898,861	1,243,064
Gene	66,265	447,553,908	5,706,434	—
Iron Mt	68,198	219,421,779	2,782,495	—
Eagle Mt	68,214	638,198,352	2,626,666	—
Hinds	68,208	653,158,477	2,164,007	—
Total	332,795	2,381,519,997	14,178,463	1,243,064

Total Colorado River Aqueduct Energy Use (kwh):

Total Pumping Energy Use	2,381,519,997
Add Total Station Service	14,178,463
Add Transmission Losses	38,868,853
Total System Energy Use	2,434,567,313

Power Management

Boulder Canyon Project Administration

Metropolitan staff continued participating in meetings with other Boulder Canyon Project Power Contractors, WAPA, and the United States Bureau of Reclamation (Reclamation). Significant meetings attended included WAPA's 1990 Hoover Power Repayment Study, financial analysis of the Boulder Canyon Project, proposed changes on Boulder Canyon Project Power Contractors' Conservation and Renewable Energy Programs, and Hoover energy scheduling and accounting.

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TABLE 5

ENERGY COST FOR PUMPING COLORADO RIVER WATER

[illegible]

Energy Source	Cost ($)	Average Cost per Acre-Foot Diverted at Whitsett Intake ($/Acre-Foot)
[illegible]		
[illegible]	[illegible]	[illegible]5.59
[illegible]	[illegible]	[illegible]3.96
[illegible]	13,[illegible]	33.89
[illegible]	[illegible]	
[illegible]	24,[illegible]	[illegible]9.47*

[illegible]

[illegible] Benefit Energy plus Exchange Energy with SCE [illegible]

WAPA refunded approximately $9 million to Metropolitan, equaling Metropolitan's portion of funds that WAPA received from the Hoover power contractors which exceeded Boulder Canyon Project needs during the first 50 years (1937-1987).

WAPA has accepted Metropolitan's two-year progress report of its conservation and renewable energy program. The submission was required under the Hoover Power Plant Act and Section 9 of Metropolitan's Hoover Contract. The report described the progress made on rehabilitating Metropolitan's pumping plants during the last two years.

District [illegible]

Pursuant [illegible] Edison 1987 Service and Interchange Agreement [illegible] submitted to SCE Metropolitan's energy loads and [illegible] year 1989 through 2000. The submissions included [illegible] and estimated available Aqueduct power resources. Aqueduct [illegible] unused energy available to the SWP and benefit [illegible] deliver to Metropolitan.

Staff has also been [illegible] a preliminary interconnection agreement with SCE for Metropolitan's [illegible] Etiwanda Power Plant which is scheduled for operation in 1994. Under the proposed agreement, SCE would perform the necessary engineering, design, procurement, and construction of the interconnection facilities required to connect Metropolitan's Etiwanda Power Plant to SCE's electric transmission system.

Metropolitan-State Contracts

Per the provisions of the Power Coordination Agreement between Metropolitan and the California Department of Water Resources (DWR), staff completed and submitted to DWR Metropolitan's estimate of its Aqueduct power operation for the 1990 calendar year. Metropolitan anticipated that no surplus Aqueduct energy will be available to sell to DWR nor that any energy will be available for exchange.

On December 27, 1989, the San Diego Gas and Electric Company (SDG&E) submitted to the California Energy Commission a Notice of Intent (NOI) to construct a 460-megawatt combined cycle power plant at one of six possible California locations, including the Sun Desert site near Blythe, California. Metropolitan has been closely following the NOI process as it pertains to the Sun Desert location because of its potential obligation to supply cooling water from its Colorado River entitlement and its stake in DWR's acquiring viable and economic power resources. If SDG&E constructs the plant at the Sun Desert site before the year 2000, Metropolitan would be obligated, under an amended 1974 Letter of Intent, to annually provide 17,000 acre-feet of cooling water from its CRW entitlement through the year 2033. The letter of intent also obligates SDG&E to allow DWR to participate in the project up to 110 megawatts. DWR has notified SDG&E of its intent to participate in the NOI process.

Purchase Agreements for Supplemental Power

Pumping demands on the Aqueduct exceeded Metropolitan's base-load energy resources available from Hoover and Parker Power Plants and SCE's benefit energy in 1989-1990 by up to 750 million kwh. To supplement these base-load resources, the General Manager has executed new Economy Energy Agreements with WAPA, city of Burbank, and city of Pasadena in addition to existing Economy Energy Agreements with DWR; Salt River Project Agricultural Improvement and Power District; Arizona Electric Power Cooperative, Inc.; Arizona Public Service; Nevada Power Company; Tucson Electric Power Company; and city of Glendale. Due to the power market's dynamic nature, staff continually seeks opportunities to negotiate additional supplemental power resources for pumping on the Aqueduct at the lowest price. Metropolitan's history of energy use is listed in Table 6.

Impact on Supply — The Central Arizona Project

While the Secretary has not yet limited Metropolitan's CRW diversions, CAP CRW diversions increased to about 830,000 acre-feet this year. It is projected that diversions will total 1.15 maf next fiscal year from the CAP's Hayden-Rhodes, Salt-Gila, and Tucson Aqueducts.

TABLE 6

HISTORY OF METROPOLITAN ENERGY USE

Operating Year (June 1–May 31)	Hoover	Parker	Glen Canyon	Edison	Mohave	Total
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Fiscal Year (July 1–June 30)	Hoover	Parker	Edison Benefit	Edison Exchange	Supplemental Energy Purchases	Total
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Tucson Aqueduct construction has been completed, with three of its pumping plants fully operational and six under construction. Nearly four miles of pipeline and tunnel to deliver water to Tucson have been finished. Water deliveries to the city are expected to begin at the end of 1991 following construction of a water treatment plant. The Pima Reservoir, an operational reservoir off the Black Mountain Pipeline, has been completed. Construction of the eight-mile Black Mountain Pipeline to serve the San Xavier Indian Reservation and others is under way.

New Waddell Dam will serve as the CAP's major regulatory storage facility. Construction continued on tunnels that will act as inlet, outlet, and diversion works for the reservoir. With foundation excavation completed, erection of the dam embankment will begin early next fiscal year. Construction of the New Waddell Pump Generation Plant continued. Reservoir operation is scheduled to begin in 1994. Figure 3 shows the location of major CAP facilities.

Colorado River Floodway

Metropolitan staff continued participating in the Colorado River Floodway Task Force created to advise the Secretary and Congress on issues related to establishing a floodway from Davis Dam to the southerly international boundary. The floodway will encompass the area required to carry the one-in-one-hundred-year river flow or 40,000 cfs, whichever is greater. The Task Force adopted its report to the Secretary and Congress near fiscal year end. The report includes recommendations on means to restore and maintain the floodway, the necessity for additional floodway management legislation, whether specific cases of economic hardship resulting from impacts of the 1983 runoff on property outside the floodway should be compensated, and the potential application of the floodway on Indian lands.

State Water Project Supply

To meet future demands, Metropolitan signed the first contract with DWR leading to construction of the SWP in 1960. Although the initial contract called for an ultimate water entitlement of 1.5 maf per year for Metropolitan, later amendments raised this to 2.0115 maf per year. This is nearly one-half of the 4.218 maf per year contracted for by all 30 SWP contractors. Metropolitan's contract with DWR reached its maximum annual entitlement in 1990.

The SWP was designed so that additional conservation facilities to augment yield could be constructed as delivery demands increased. However, due largely to opposition from various sectors, no additional

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conservation facilities have been built since the first ones were finished in 1967. The total demand for State project water has been increasing since then and two drought periods have also stressed the system as shown in Tables 8 and 9. In the past, Metropolitan has received its maximum CRW entitlement to meet its needs. However, due to increasing demands and reduced Colorado River supplies, Metropolitan will be using greater amounts of State project water than before. To enable Metropolitan to receive larger amounts of State project water, the California Aqueduct's East Branch is being enlarged. Table 7 shows the project's status.

Metropolitan first began receiving State project water in 1972 at Castaic Reservoir, the California Aqueduct's West Branch terminus. Under its contract, Metropolitan paid the State nearly $195 million before taking its first water delivery. Each of the 30 SWP contractors proportionately pays project costs based on the sizing of facilities required to deliver water to their respective areas. Located at the project termini, Metropolitan pays approximately two-thirds of all costs. Metropolitan's DWR payments for State project water reached $248 million during the fiscal year, for a cumulative total of $2.57 billion through June 30, 1990, shown in Table 10.

Power for Pumping State Project Water

Operating as an electric utility since 1983, DWR manages the SWP power system consistent with the following principles: (1) maximizing the benefit from existing SWP resources, (2) developing and maintaining alternate energy sources to provide flexibility in meeting water delivery requests and to reduce dependence on power purchased from utilities, (3) securing transmission resources to efficiently supply power to SWP facilities and to provide access to areas where low-cost power can be obtained and (4) minimizing the impact on the SWP when major contractual arrangements expire in 2004.

Hydro[illegible] provides the largest SWP energy share. Hydroelectric res[illegible] Hyatt-Thermalito generating plants, and the Gianelli[illegible] Castai[illegible] Alamo, Devil Canyon, Warne, and Mojave [illegible] In 1989 hydroelectric energy accounted for [illegible] 42 percent of the total resources. Coal-fired [illegible] Gardner Unit No. 4 (RG4) Power Plant in South[illegible] [illegible] source of SWP energy. DWR's [illegible] million kwh. Exchange energy, a third [illegible] provided through contractual arrange[illegible] million kwh. Figure 4 at the end of the [illegible] source mix for 1989. Figure 5 shows the [illegible] and major transmission facilities.

[illegible] varies annually because precipitation [illegible] from year to year, directly affecting both [illegible] pumping demands. Table 12 lists projected [illegible] 1990, 1995, and 2000.

TABLE 7

EAST BRANCH IMPROVEMENT/ENLARGEMENT

As of June 30, 1990

PROJECT	STATUS
Complete	• Raising East Branch of canal lining* • Big Rock Siphon construction • R. C. Box Siphons 1, 2, & 3 construction • Parallel nine additional pipe siphons construction
Near Completion	• Devil Canyon Power Plant - Initial contract • Pearblossom Power Plant - Initial contract • Check structure modification - Pearblossom to Mojave Siphon Power Plant
Construction Begun	• Check structure modification - Alamo to Pearblossom • Devil Canyon Power Plant - Fabrication and manufacturing of Units 3 and 4 • Pearblossom Pumping Plant - Fabrication and manufacturing of Units 7, 8, and 9 • Furnish and install second penstock at Devil Canyon Power Plant
Contract Awarded	• Pearblossom Pumping Plant - Completion contract • Devil Canyon Power Plant - Completion contract • Mojave Siphon Power Plant - Turbines, generators, and governors
Contracts Out for Bid	• Mojave Siphon Power Plant - Initial contract
Continuous	• Design - Mojave and Antelope Siphons • Design - Mojave Siphon Power Plant • Develop second afterbay of Devil Canyon Power Plant • Design Devil Canyon Power Plant penstock shutoff valve

Notes

*A portion of the East Branch canal lining from Alamo to Pearblossom may have to be raised an additional foot pending hydraulic testing upon completion of the East Branch Enlargement.

Metropolitan's Share of the SWP Power Costs

Metropolitan's total power cost for pumping State project water in 1989, excluding cost adjustments for previous years, was approximately $104 million or $90 per acre-foot. The projected total pumping power cost for 1990 is $123 million or $90 per acre-foot.

South Geysers Power Plant

The 1989 SWP Geothermal Facilities Operation Plan describes DWR's long-range plan for developing, operating, and using SWP geothermal facilities. Consistent with this plan, DWR accepted bids to sell the South Geysers generating equipment, the steam resource, and the power plant building. In April 1990 four major lots of generating equipment were sold for $5.5 million. The remaining lots of equipment at South Geysers will be used as spares at SWP facilities. Efforts continue to market the steam field. The current outlook for the South Geysers plant building is to use it as a general archive and storage facility for the State of California.

Bottle Rock Power Plant

The DWR owned and operated Bottle Rock Power Plant is a geothermal facility located in the Geysers area of Northern California with an original design capacity of 55 megawatts. Due to a lower than anticipated steam supply, the Bottle Rock plant output has historically been considerably less than its rated capacity. As of March 1989 the plant was only generating about 8 megawatts, with expectations of continued decreased generation annually.

To increase plant steam production, DWR and the Northern California Power Agency (NCPA) reworked three wells in April 1990 with disappointing results. The costs and benefits of the redrilling effort are being equally shared by DWR and NCPA. NCPA has expressed interest in leasing the steam field and power plant, but no decision has been made. DWR is also considering shutting down the plant if a leasing arrangement cannot be negotiated.

Reid Gardner

RG4 is jointly owned by DWR and the Nevada Power Company (NPC). DWR is entitled to 90.4 percent of RG4's 250 megawatt output. During a scheduled plant outage in April and May of 1990, RG4's deteriorating concrete cooling tower was demolished and connections to a new wooden cooling tower were completed. In addition, the RG4 steam turbine was modified [illegible] the unit's output by 15 megawatts. DWR and NPC will [illegible] benefits and costs. Legal action is being taken [illegible] $13 million in damages to replace the structure [illegible] cooling tower.

Devil Can[illegible]

[illegible] the Devil Canyon Power Plant. Two 80- [illegible] added, bringing the plant's total gross [illegible]. The enlarged power plant should [illegible] Afterbay, with a storage capacity of [illegible] the Devil Canyon site. Benefits of the [illegible] include significant cost savings [illegible] reserve capacity and benefits [illegible] on peak energy production is

Issues Affecting Water Supply

Forecasting Agricultural Water Use

Metropolitan and the Colorado River Board of California have developed techniques for projecting agricultural CRW use in California outside Metropolitan's service area. As both techniques underestimated actual use in calendar year 1988, a consultant continued efforts to refine Metropolitan's forecasting model. Had Metropolitan's CRW use been limited in calendar year 1989, no unused agricultural priority water would have been available since use exceeded the 3.85 maf available under the first three priorities.

Salinity Control

Implementation of the Colorado River Salinity Control Program continues, meeting numeric criteria adopted by each of the Colorado River Basin states for total dissolved solids concentration below Hoover and Parker Dams and at Imperial Dam. Numerous projects to prevent agricultural, point, and diffuse sources of salinity from entering the Colorado River or its tributaries have been completed or are under development by the Departments of the Interior and Agriculture. Projects in the Grand Valley, Lower Gunnison Basin, and the Meeker Dome areas of Colorado, the Uinta Basin in Utah, the Big Sandy River area in Wyoming, and Las Vegas Wash in Nevada remove 168,500 tons of salt annually. Another 1.4 million tons of salt per year must be removed by the year 2010 to meet the numeric criterion at Imperial Dam.

San Francisco Bay-Delta Hearing

The State Water Resources Control Board (SWRCB) maintains regulatory authority over water quality and water rights within the State of California. The SWRCB's actions and decisions can significantly impact the SWP's facility operations and water supply reliability.

In July 1987, the SWRCB began regulatory review of its 1978 Water Rights Decision 1485 (D-1485) along with related water quality control plans for the San Francisco Bay-Sacramento-San Joaquin Delta Estuary (Bay/Delta) and the Central Valley water basins. After some delays, the SWRCB now projects adoption in late 1990 of the Water Quality Control Plan (WQCP) covering salinity in the Bay/Delta; the entire process will be completed in late 1992 with adoption of a water rights decision.

Metropolitan is coordinating its Bay/Delta Hearing involvement through State Water Contractors, Inc. (SWC). This effort consists of preparing testimony before the SWRCB and documents supporting Metropolitan and SWC's recommendations. During the 1989-90 fiscal year, this effort was directed towards analyzing the revised drafts of the heavily criticized 1988 draft WQCP. The SWRCB held workshops to receive public comments on the revised WQCP in February 1988 and scheduled hearings on the revised WQCP for August 1988.

In broad terms, the SWC is examining the revised draft WQCP assumptions and proposals from three directions:

- Are the directives in the Racanelli Decision being followed for water rights and water quality?
- Is there a reasonable balance of beneficial water uses among fish, wildlife, municipal, agricultural, and other purposes with supporting scientific evidence?
- Are pollution sources and adequate protection for drinking water quality addressed?

As part of the process, solutions must be found for the multiple existing Bay-Delta problems. SWC is supporting a broad examination and consideration of all options, including isolated Delta transportation facilities with appropriate guarantees.

State Water Project Fishery Mitigation

In July 1988, DWR and the California Department of Fish and Game (DFG) began discussions toward negotiating a new fishery agreement to mitigate SWP overall impacts on the Delta fishery. This new agreement is required by the December 30, 1986, Banks Pumping Plant Fishery Mitigation Agreement before DWR can operate the plant with four additional pumps at the full capacity of 10,300 cfs. The 1986 agreement was entered into to offset the direct losses of fish at the Banks Pumping Plant by funding mitigation projects such as hatcheries, fish screens, and physical transfer of fish from Clifton Court Forebay back into the Delta. It did not account for other [illegible] fishery caused by the SWP. Since discussions began, [illegible] in the negotiations with the hope of also [illegible] DFG for impacts caused by the Central Valley Pr[illegible]

In April [illegible] agreement detailing a procedure to initiate [illegible] expected to speed up negotiations since it [illegible] specific problems or species one at a time. [illegible] agreement will be completed at the [illegible]

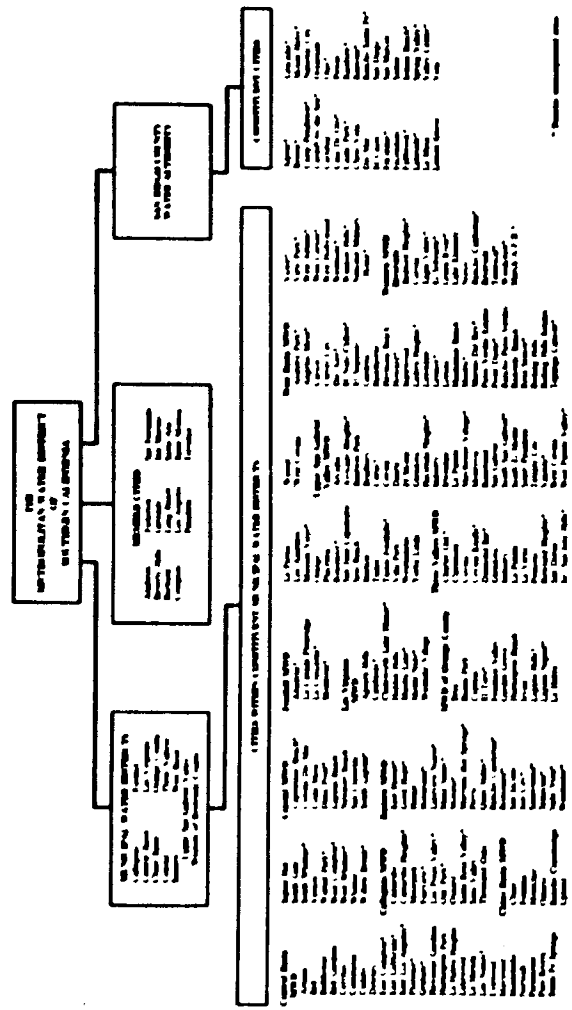
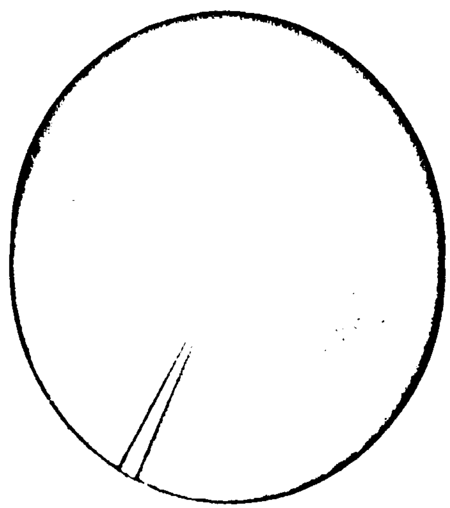


Figure 1. Composition of the Metropolitan Water District of Southern California



1989

8.4 BILLION KWH TOTAL AVAILABLE ENERGY

Figure 2. State Water Project Electric Energy Resource Mix

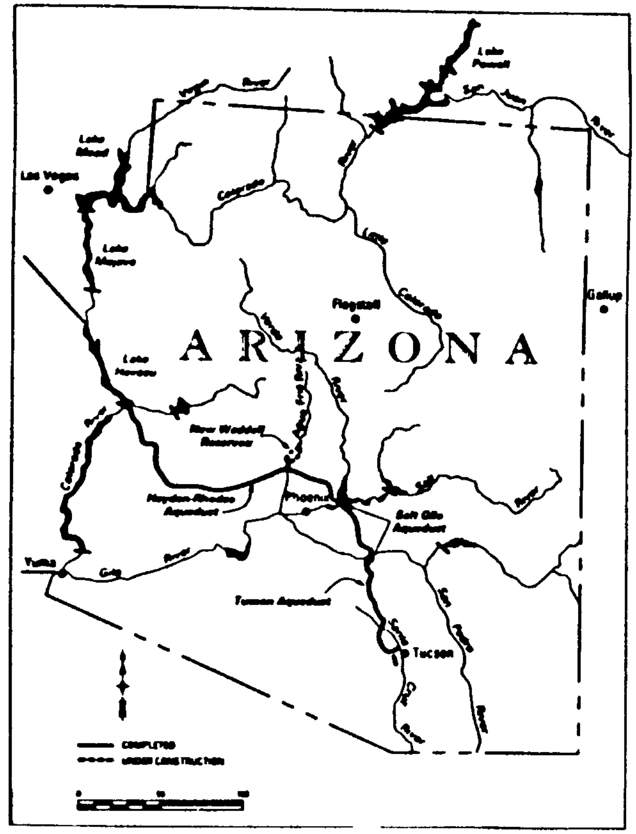


Figure 3. Central Arizona Project

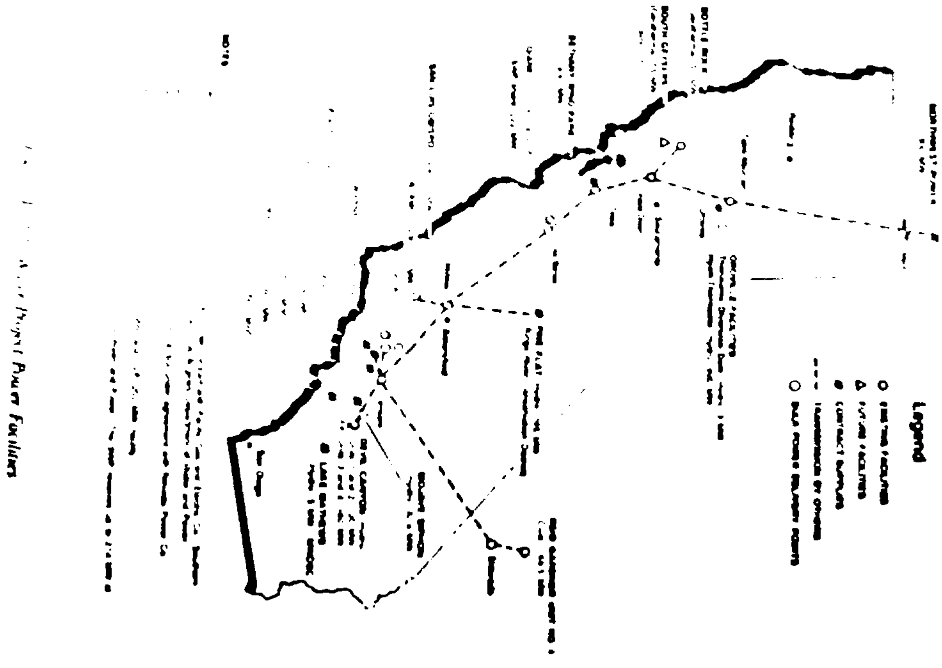


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TABLE 8

STORAGE IN COLORADO RIVER RESERVOIRS

(Acre Feet)

Reservoirs	Gross Capacity	Total Usable Capacity Above Lowest Outlet	Water in Storage on June 30, 1990: Usable Storage	Percent of Total Usable Capacity	Storage Above Minimum Power Head	Storage Above Rated Power Head	Change in Storage Since June 30, 1989
Upper Basin							
Fontenelle	345,400	344,800	282,000	82	87,000	48,200	22,000
Flaming Gorge	3,789,000	3,749,000	3,040,000	81	2,807,000	1,978,000	84,000
Blue Mesa	940,800	829,500	680,000	82	598,900	430,600	5,000
Morrow Point	117,200	117,000	112,000	96	37,100	32,200	—
Crystal	25,300	17,600	16,000	91	5,400	2,100	-1,000
Navajo	1,709,000	1,696,400	1,367,000	81	—	—	-32,000
Powell	27,000,000	25,002,000	17,853,000	71	13,727,000	8,425,000	-3,704,000
Subtotal	33,926,700	31,756,300	23,350,000	74	17,262,400	10,916,100	-3,626,000
Lower Basin							
Mead	28,537,000	26,159,000	20,415,000	78	10,391,000	6,762,000	-1,137,000
Mohave	1,818,500	1,810,000	1,553,000	86	1,335,500	365,000	-221,000
Havasu	648,000	619,400	575,000	93	135,600	—	-28,000
Subtotal	31,003,500	28,588,400	22,543,000	79	11,862,100	7,127,000	-1,386,000
Total	64,930,200	60,344,700	45,893,000	76	29,124,500	18,043,100	-5,012,000

TABLE 9
STORAGE IN STATE WATER PROJECT RESERVOIRS
(Thousand Acre-feet)

Reservoirs	Gross Capacity	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 10
STATE WATER PROJECT DELIVERIES
(Thousand Acre-feet)

Delivery Areas	Maximum Entitlement	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
		Deliveries of all types of water to SWP contractors as of June 30														
Feather River	40	8	8	12	12	8	17	9	9	<1	<1	<1	<1	1	1	1
North Bay	67	7	7	7	6	7	7	6	1	2	4	4	5	9	29	28
South Bay	188	157	79	106	129	134	139	129	104	101	116	124	134	137	160	138
San Joaquin	1,355	1 247	735	540	1 160	1 483	1 529	1 507	937	1 064	1 271	1 136	1 318	1 163	1 292	1 093
Coastal	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Southern California	2 498	664	550	305	812	466	758	780	931	467	591	809	971	884	1 096	1 451
Total	4 218	2 083	1 379	970	2 127	2 098	2 450	2 441	1 982	1 637	1 984	2 071	2 430	2 194	2 578	2 711

TABLE 11
CHARGES, PAYMENTS, AND CREDITS UNDER THE STATE WATER AND DEVIL CANYON-CASTAIC CONTRACTS FOR 27 YEARS
(Dollars)

Fiscal Year	Conservation (Delta) Capital	Conservation (Delta) Minimum Charge	Transportation Capital	Transportation Minimum Charge	Transportation Variable	[illegible] Costs	Delivery Structures	Devil Canyon-Castaic	Subtotals	(Credits)	Totals	Accumulated Totals
1968-69			30 673 757	2 369 334		27 558 520			60 601 319		60 601 319	60 601 319
1969-70			26 452 982	1 678 024		6 751 185	1 993 837		36 876 028		36 876 028	97 477 347
1970-71			30 161 433	2 443 328		4 851 461	1 196 325		38 654 547		38 654 547	136 131 893
1971-72	793 130	190 399	46 029 430	4 696 534	19 581		41 000		51 770 082	(1 398 821)	50 371 261	186 503 155
1972-73	1 705 299	472 203	52 129 409	8 144 724	990 235		632 499	3 556 686	67 639 135	(14 223 829)	53 415 306	239 918 461
1973-74	2 641 639	609 986	45 819 842	7 895 486	1 186 272		19 747	7 220 621	65 393 593	(12 210 525)	53 183 068	293 101 529
1974-75	3 697 709	924 582	45 079 514	9 266 076	2 234 175		18 417	7 285 624	68 506 047		68 506 047	361 607 576
1975-76	4 453 130	1 268 300	43 898 117	13 484 079	4 711 720		308 091	6 952 362	75 075 807		75 075 807	436 683 383
1976-77	5 454 632	1 137 423	44 416 998	12 362 756	3 977 163			6 699 542	74 049 914		74 049 914	510 733 297
1977-78	6 524 008	1 667 203	45 013 794	15 901 631	4 750 827		13 137	7 061 898	81 012 498	(19 160 560)	61 851 938	572 585 235
1978-79	7 579 284	2 315 730	45 935 131	17 808 192	8 492 921			6 999 207	89 130 265	(2 314 432)	86 815 833	659 401 068
1979-80	8 635 392	3 299 862	47 175 444	23 415 348	1 652 083			7 309 848	91 487 977	(1 657 335)	89 830 642	749 231 710
1980-81	11 739 549	5 036 758	58 788 166	17 317 783	8 154 120			7 272 795	108 309 171	(10 461 314)	97 847 857	847 079 567
1981-82	15 705 488	6 731 991	54 501 522	22 835 858	10 135 834		7 234	6 931 899	116 849 826		116 849 826	963 929 393
1982-83	14 247 106	6 436 512	53 580 275	41 245 605	13 764 049			7 003 006	136 276 553	(3 729 599)	132 546 954	1 096 476 347
1983-84	11 770 952	6 154 562	73 098 046	75 172 846	12 498 291			7 357 130	186 051 827	(31 537 158)	154 514 669	1 250 991 016
1984-85	12 105 581	8 014 299	68 307 001	119 083 669	6 322 525			8 151 441	221 990 522	(41 136 763)	180 853 759	1 431 844 775
1985-86	12 737 849	10 699 907	57 396 458	140 383 347	1 876 306			8 260 705	231 354 372	(23 635 157)	207 719 215	1 647 563 990
1986-87	14 048 419	11 558 148	57 301 538	141 058 759	7 498 481			8 346 601	239 811 952	(17 904 859)	221 907 093	1 869 471 083
1987-88	15 220 698	12 090 974	58 156 929	138 851 747	7 528 655	6 519 663		8 992 213	247 366 879	(29 426 530)	217 940 349	2 087 411 432
1988-89	16 504 002	13 945 462	58 845 142	148 186 503	98 533	16 051 924		9 285 559	262 917 125	(31 240 353)	231 676 772	2 319 088 204
1989-90	18 011 483	15 086 553	59 756 280	149 963 911	4 197 064	17 861 454	425 000	9 009 877	274 317 622	(26 216 497)	248 101 125	2 567 189 329
TOTALS	183 583 156	107 640 854	1 110 518 696	1 112 795 460	100 096 799	79 594 215	4 655 207	133 702 814	2 833 443 081	(266 253 732)	2 567 189 329	

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TABLE 12

STATE WATER PROJECT ACTUAL AND ESTIMATED ENERGY RESOURCES AND ENERGY COSTS*

	Calendar Year 1990			1995			2000		
	gwh	$1000	mills/kwh	gwh	$1000	mills/kwh	gwh	$1000	mills/kwh
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Reid Gardner Unit No. 4	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bottle Rock	1 4[illegible]	80 [illegible]	62	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TEXA Power Corp. (Wind)	93	19 4[illegible]	2[illegible]		[illegible] 440		[illegible]	[illegible]	[illegible]
Additional Firm Resources	3	290	85	3	24	68	1	[illegible]4	68
CRA Energy Purchases				876	52 540	60	1 752	[illegible]	[illegible]
Energy Purchases	1 750	42 920	25	915	[illegible] 270	30	915	[illegible] 120	43
Total Resources	9 279	241 358	27	144	[illegible] 340	[illegible]	464	4[illegible] 560	98
Sales	1 361	41 900	32	10 018	322 970	32	10 972	4[illegible] 870	42
SWP Pumping Energy Requirements***	7 918	203 458	26	39					
Unit Transmission Cost			3	9 980	322 970	32	10 972	4[illegible] 670	42
Effective Unit Cost			29			3			2
						35			44

Notes:

* Includes allowance for future cost escalation

** Net energy gained from Southern California Edison Co. under 1979 DWR-SCE Power Contract and 1981 Capacity Exchange Agreement

*** [illegible]

One of Metropolitan's divers is ready to take bacteriological samples from the San Joaquin Reservoir.

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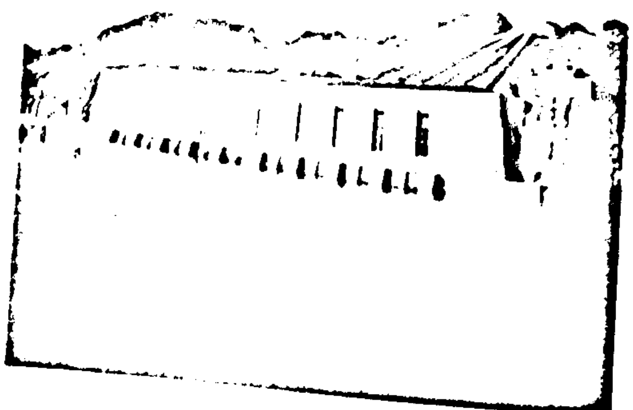

... Metropolitan at the ... on Lake Havasu

CHAPTER 2

Delivering Metropolitan's Water Supplies

The Distribution System

Stretching 200 miles along the Pacific Ocean, Metropolitan's service area extends from Oxnard to the Mexican border and inland in some places for about 70 miles through six counties: San Diego, San Bernardino, Riverside, Orange, Los Angeles, and Ventura. In fiscal year 1989-90, Metropolitan's system met historical record-setting demands and delivered about 2.5 million acre-feet (maf) of water, averaging 2.27 billion gallons per day.

Our dependence on imported water is satisfied by the Colorado River Aqueduct (Aqueduct), described in Chapter 1, and the State Water Project (SWP) operated by the Department of Water Resources (DWR). State project water is transported from the Sacramento-San Joaquin Delta through the central valley to Southern California. State project water is introduced to Metropolitan's distribution system through the SWP's West Branch to Castaic Lake in the Santa Clarita Valley and through the East Branch to Silverwood Lake in the San Bernardino Mountains.

Utilizing 775 miles of pipeline, five filtration plants, eight reservoirs, numerous regulating structures, and 14 hydroelectric power recovery plants, Metropolitan delivers water to its member agencies, which subsequently supply homes, industries, and agricultural users. Table 13 shows each filtration plant's location and capacity.

Due to deteriorating water quality caused by nitrification, Metropolitan temporarily changed the disinfectant leaving the treatment plants from chloramine to free chlorine starting on June 26, 1989, at the Henry J. Mills Filtration Plant (Mills plant), and on July 10, 1989, at the Robert B. Diemer (Diemer plant), Joseph Jensen, Robert A. Skinner, and F. E. Weymouth (Weymouth plant) filtration plants. All of Metropolitan's treatment plants returned to chloramine disinfection on August 7, 1989.

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TABLE 13

METROPOLITAN DISTRIBUTION SYSTEM — FILTRATION PLANTS

Plant	Process	Current Design Capacity Million gallons/day (mgd)
[illegible]	[illegible] State project water	400
[illegible]	[illegible] State project water	400
[illegible]	[illegible] State project water	320
[illegible]	[illegible] State project water	400
[illegible]	[illegible] project water	150

System and Area Control Operators remotely control several hundred valves associated with the filtration plants, distribution system, and hydroelectric power plants and simultaneously monitor changes in water levels, flows, and pressure throughout the system. More sophisticated computerized control systems are being designed to provide more en[illegible] [illegible] capabilities and will replace obsolete equipment [illegible] operation.

[illegible] are made through 347 service connections located [illegible] system. Each connection usually consists of [illegible] structure, and metering facility. Whe[illegible] a member [illegible] modified service connection, Metro[illegible] politan [illegible] structs it.

This [illegible]

Service [illegible] completed two major service connections [illegible] Mills plant [illegible] located immediately downstream of the [illegible] feeder has a design capacity of 125 cubic feet per second [illegible] the Western Municipal Water District of Riverside [illegible]

Construction [illegible] tion OC-63, with a design capacity of 20 cfs, located on [illegible] County Feeder and serving the Irvine Ranch Water District [illegible] completed in March 1990.

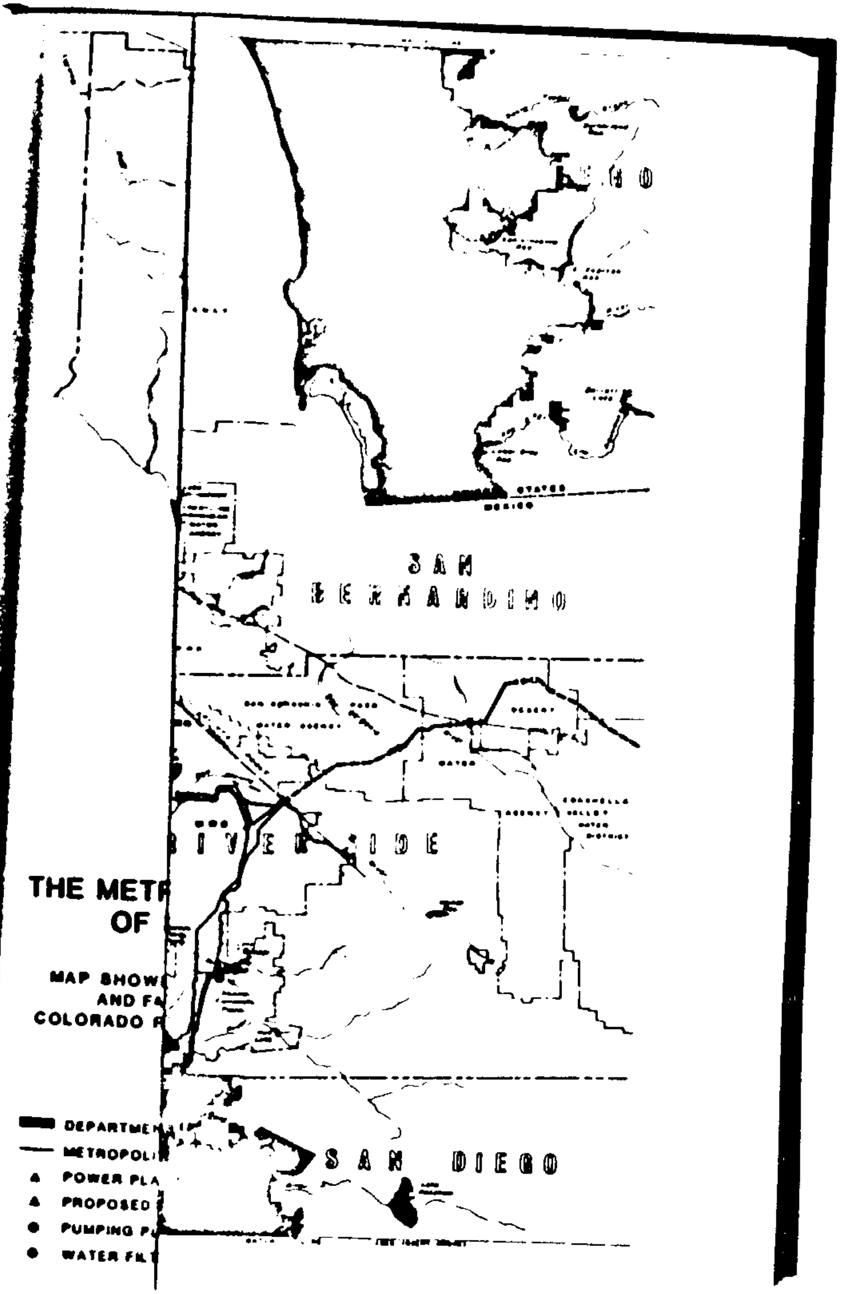


TABLE 13

METROPOLITAN DISTRIBUTION SYSTEM — FILTRATION PLANTS

Plant	Process	Current Design Capacity Million gallons/day (mgd)
[illegible] plant [illegible]	Filter State Project water	400
[illegible] plant [illegible]	Filter [illegible] State project water	400
[illegible] plant [illegible]	Filter [illegible] State project water	320
[illegible] plant [illegible]	Filter [illegible] State project water	400
M[illegible] plant [illegible]	Filter State Project water	150

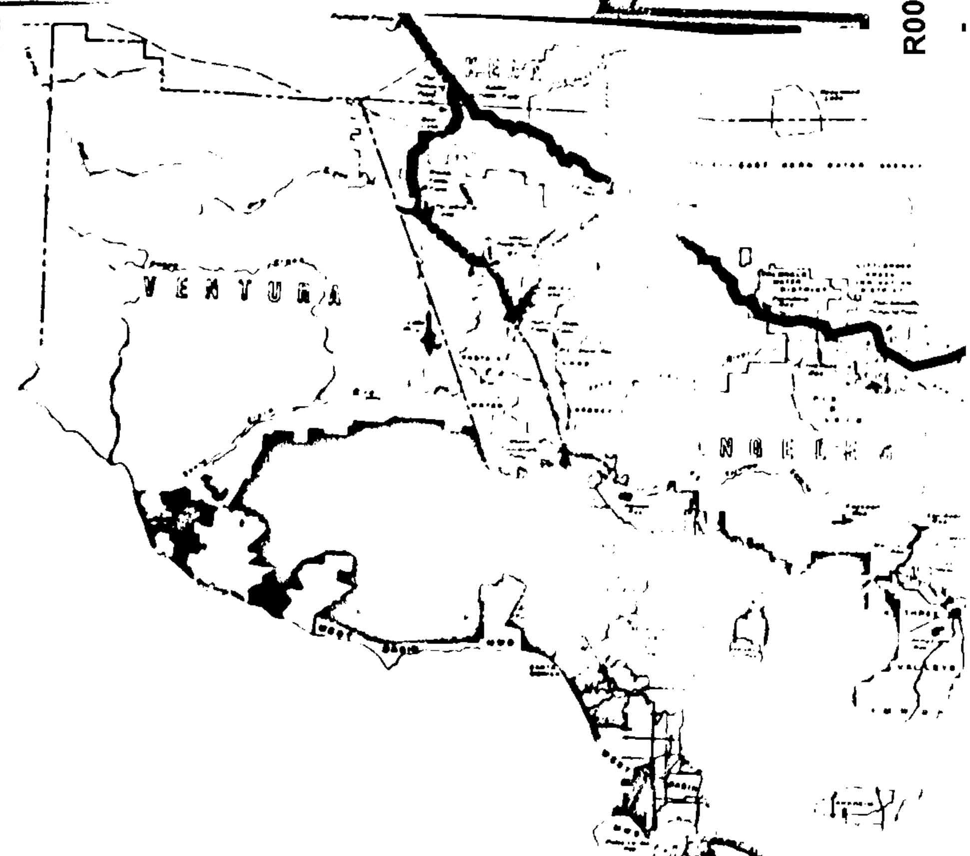
System and Area Control Operators remotely control several hundred valves associated with the filtration plants, distribution system, and hydroelectric power plants and simultaneously monitor changes in water levels, flows, and pressure throughout the system. More sophisticated computerized control systems are being designed to provide more enhanced monitoring and control capabilities and will replace obsolete equipment [illegible] in operation.

Deliveries [illegible] made through 347 service connections located through[illegible] the distribution system. Each connection usually consists of a [illegible] structure, and metering facility. When a member agency [illegible] modified service connection, Metropolitan normally [illegible] constructs it.

This fiscal year Met[illegible]ted two major service connections.

Service Connection WR-24[illegible] located immediately downstream of the Mills plant on the Box Sp[illegible] feeder has a design capacity of 125 cubic feet per second (cfs) and [illegible] the Western Municipal Water District of Riverside County, and

Construction of Service Connection OC-63, with a design capacity of 20 cfs, located on the East Orange County Feeder and serving the Irvine Ranch Water District, was completed in March 1990.



THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

MAP SHOWING METROPOLITAN'S MEMBER AGENCIES AND FACILITIES FOR THE DISTRIBUTION OF COLORADO RIVER WATER AND STATE PROJECT WATER

LEGEND

- DEPARTMENT OF WATER RESOURCES' CALIFORNIA AQUEDUCT
- METROPOLITAN'S WATER DISTRIBUTION SYSTEM
- ▲ POWER PLANTS
- ▲ PROPOSED POWER PLANTS
- ● PUMPING PLANTS
- ● WATER FILTRATION PLANTS

Figure 5. Metro[illegible] Member Agencies and Facilities for Distribution of [illegible] River Water and State Project W[illegible]

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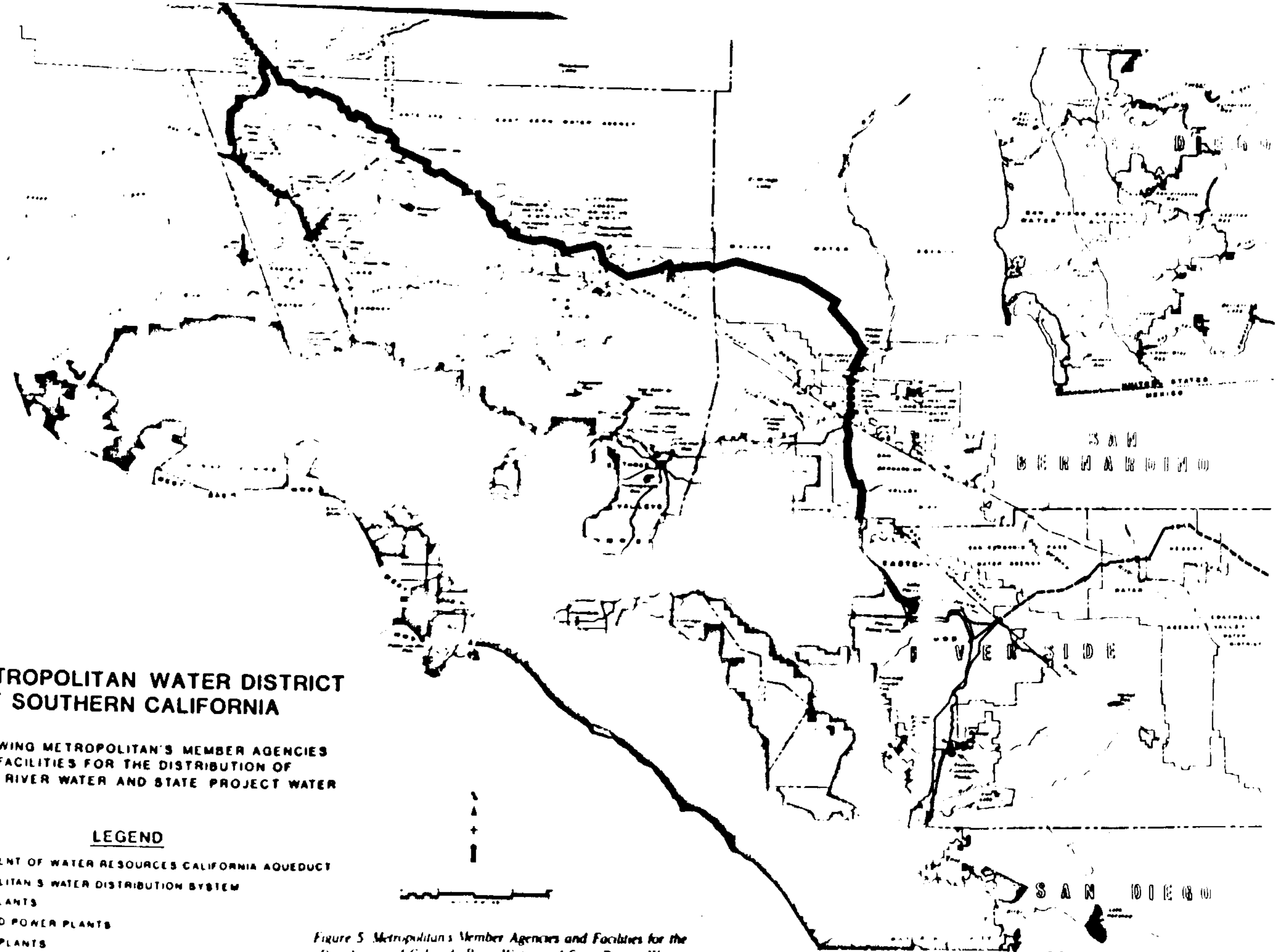

TH METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

HOWING METROPOLITAN'S MEMBER AGENCIES
ND FACILITIES FOR THE DISTRIBUTION OF
ADO RIVER WATER AND STATE PROJECT WATER

LEGEND

RTMENT OF WATER RESOURCES CALIFORNIA AQUEDUCT
METROPOLITAN'S WATER DISTRIBUTION SYSTEM
PLANTS
LED POWER PLANTS
NG PLANTS
R FILTRATION PLANTS

Figure 5. Metropolitan's Member Agencies and Facilities for the Distribution of Colorado River Water and State Project Water

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... a buckle in the ... oil seepage

Operational Planning

Metropolitan has a well-designed, flexible water distribution system involving numerous pipelines. Operations are planned to maximize delivery of the least costly water while weighing each water supply's availability and the effect on SWP and Aqueduct operations. Staff continually decides on quantity fluctuations taken from each source, and the extent to which terminal reservoir storage should be utilized to most efficiently accommodate demand changes. During the past year, Metropolitan's Operations Planning staff continued participating in developing and reviewing Colorado River and SWP operations. Due to a fourth year of continuous drought in California, the State imposed a 50 percent deficiency on agricultural deliveries in 1990; none were imposed on municipal or industrial contractors. Southern California's situation was further buffered by Metropolitan's ability to divert 1.243 maf of Colorado River water (CRW) during the fiscal year.

Metropolitan continued record-level deliveries to its member agencies, establishing monthly water sales records for nine out of the 12 months and delivering a total of 2,511,375 acre-feet during the fiscal year. By carefully monitoring Southern California's water supply situation, Metropolitan continues to develop operational strategies that minimize possible delivery shortfalls to its member agencies.

Seasonal Storage Service

In July 1989, Metropolitan's Board of Directors adopted a new service class known as seasonal storage. The three principal goals of seasonal storage service are to (1) achieve greater conjunctive use of imported and local water supplies, (2) encourage construction of additional local production facilities, and (3) reduce member agencies' dependence on Metropolitan summer deliveries. Generally, this discounted-rate service is to be offered October through April. To accomplish the goals, agencies are expected to store any water purchased under seasonal storage service for production at a time more advantageous to Metropolitan. Storage can occur in surface reservoirs or in groundwater basins either directly or by in-lieu means.

During fiscal year 1989-90, 18 of Metropolitan's 27 member agencies took advantage of seasonal storage service, which was available for the entire October 1 through April 30 period. Approximately 320,000 acre-feet were sold at seasonal storage rates, with about 133,000 acre-feet for direct groundwater replenishment, 95,000 acre-feet for in-lieu groundwater replenishment, and 91,000 acre-feet for reservoir storage. Staff estimates that about one-third of this total would be produced during the summer of 1990 to help offset the peak demand on Metropolitan.

"Drought Action Plan '90"

By spring 1990 it [illegible] that Southern California was into the [illegible] consecutive [illegible]. Anticipated supplies from Metropolitan's sources [illegible] well below normal and held the potentia[illegible] possib[illegible] projected demands. In response, Metropoli[illegible] Board of Directors approved "Drought Action Plan '90" in April [illegible]

The Drought Action Plan '90 goal [illegible] conserve 200,000 acre-feet of w[illegible] in calendar year 1990. It utilized $100 per acre-foot rebates as incentiv[illegible] to be credited to the accounts of member agencies that successfully redu[illegible] total water demands by more than 5 percent compared to adjusted 19[illegible] total water demands. Rebate crediting began June 1, 1990, and will continue through the summer. In the program's first month, approximately $241,[illegible] was credited to the member agencies.

Shutdowns and Service Interruptions

Filtration plant, pipeline, and reservoir shutdowns and planned service interruptions constitute another dimension of Metropolitan's water operations. This year, major shutdowns and interruptions included:

- On November 28, 1989, Garvey Reservoir was taken out of service and dewatered. During inspection, a 300-foot crack was found on the southwest slope near the junction with the reservoir's floor. The reservoir remains out of service.
- [illegible] Devil Canyon from December 1989 to [illegible] Metropolitan conducted maintenance and repairs to [illegible] Reservoir, and the San Dimas Power Pla[illegible] [illegible] Pipeline was shut down and dewater[illegible]
- [illegible] Feeder was shut down March 27, 1990, fro[illegible] Control Structure to San Joaquin Res[illegible] [illegible] Connection OC-63, providing water to t[illegible]
- [illegible] Feeder was shut down for four da[illegible] [illegible] Feeder Structure Modification Proje[illegible] [illegible] the last five years. The East Vall[illegible] [illegible] Calleguas Conduit, was purchase[illegible] [illegible] District in 1971 and was original[illegible] [illegible] vacuum, air-release, and shut-off valv[illegible] [illegible] surrounding structures. In March 19[illegible] [illegible] the $3.5 million rehabilitation pr[illegible] [illegible]

- The Santiago Lateral was shut down on May 18 and 24, 1990, for 12 hours each day to remove and replace the 24-inch butterfly valve at Service Connection A-8. The valve failed to seat properly, and did not completely shut off water flow to accommodate the city of Anaheim Hills performing work downstream.

Ensuring Deliveries—Emergency Preparedness

Operations remained normal following the February 28, 1990, Upland earthquake that measured 5.6 on the Richter Scale. Assigned personnel proceeded to Metropolitan's Emergency Operations Center (EOC) which, during an emergency, functions as the central point for evaluating the field's damage assessment reports. Located at Los Angeles Headquarters, the EOC is activated when an earthquake measuring at least 4.0 on the Richter Scale occurs in Metropolitan's service area.

In the event of an earthquake, Metropolitan's Emergency Response Plan requires that designated emergency field personnel proceed to their preassigned locations. According to the plan, the field's damage assessment reports are communicated to the Eagle Rock System Control Center and relayed to the EOC.

To ensure that its emergency preparedness efforts are current with industry trends, Metropolitan is reviewing its existing Emergency Response Plan and evaluating its entire emergency preparedness program.

Optimizing the System—Power Recovery

Adding 14 hydroelectric power plants to the distribution system in recent years has increased Metropolitan's ability to minimize or recover some of the energy costs required in the pumping operations of CRW and State Project water. As shown in Table 14, these hydroelectric power recovery plants produced a total of 404,498,600 kilowatt-hours (kwh) this fiscal year. Although power plant inspection and maintenance continued throughout the year, strategically realigning the distribution system flows minimized generation loss.

During the fiscal year, the Yorba Linda, San Dimas, and Sepulveda Canyon hydroelectric power plants were retrofitted with new Kingsbury thrust bearings. Early test results of the upgraded thrust bearings indicate reduced operating temperatures and less wear, resulting in extended operating periods.

Water Deliveries and Sales

Water sales for fiscal year 1989-90 totaled 2,511,375 acre-feet, increasing 19.8 percent over last fiscal year. Of total sales, 58 percent was treated water and 41 percent untreated water, with sales of reclaimed water constituting the remainder. Month[illegible] sales varied from approximately 150,[illegible] feet in February [illegible] to a high of 266,710 acre-feet in July 1989. The [illegible] established not only a sales record for the month of July, but the h[illegible] monthly sales [illegible] in Metropolitan's history.

Table 13 summar[illegible] water use by Metropolitan's member agencies. [illegible] ure 6 shows water demand by month. Tables 16 through 18 detail the t[illegible] of water deliveries made to the member agencies during the past [illegible] year and over the last 49 years.

The Interruptible Water Service Program encourages member agencies with reservoirs or groundwater basin supplies to hold water in reserve. A member agency with reservoir or underground facilities capable of compensating for Metropolitan service interruptions or reductions may purchase the interruptible portion of its water supply at a lower rate. Member agencies that replenish groundwater basins by spreading or injecting are also eligible. Similarly, member agencies may buy water for agricultural purposes from surplus supplies at the reduced interruptible rate. Table 14 shows a 50-year history of water delivered to member agencies for underground replenishment.

In July 1989, responding to the State's continuing dry conditions, Metropolitan issued the required one-year advance notice to agricultural water service users that Metropolitan may be required to curtail service in whole or in part beginning January 1991. The one-year advance notice allows [illegible] cropping patterns before interruption and helps [illegible] meet the domestic and municipal needs [illegible]

[illegible]ing the Systems

Maint[illegible]

[illegible]tribution System and Filtration Plan[illegible]

Main[illegible] regulat[illegible] Projects [illegible] [illegible]quire considerable time because [illegible] agencies, and operating restrictior [illegible] year included.

- The M[illegible] treatm[illegible] in July [illegible] 75 mgd [illegible] which was completed and commenc[illegible] and Western Municipal Water Distr[illegible] provides the service area an addition[illegible]

- Construction and installation was completed in August 1989 on the computerized control system at the Diemer plant. Started in 1982, this project required extensive rewiring of plant controls and installation of computerized equipment.

- The Operations Division, Field Services Section, coordinated in October 1989 with the Engineering Division and Corrosion Control Section to develop and schedule a systematic inspection program of all prestressed concrete pipe within Metropolitan's distribution system.

- November 14, 1989, marked the start of the first of six 14-day San Diego Canal Enlargement shutdowns. Deliveries to San Diego were maintained by ensuring an adequate storage level in Lake Skinner and utilizing San Diego Pipelines Nos. 1 and 2.

The Aqueduct System

Aqueduct pump plant personnel, involved with the plants' 24-hour operations, carefully plan, coordinate, and execute flow changes to meet supply requirements and maintain consistent pumping at each plant. They are responsible for continuous surveillance and control of pumping plant and power dispatching operations.

Additionally, skilled maintenance work must be performed regularly. Specialized Aqueduct pump mechanics repair, maintain, install, replace, and overhaul major electrical and hydraulic equipment such as valve regulators, pumps, and electrical motors. Lineworkers install, repair, and maintain more than 340 miles of power transmission lines and equipment. Workers routinely remove sand from the Aqueduct and inject liquid chlorine into the Aqueduct flow to reduce aquatic plant growth, thereby maintaining efficient water carrying capacity.

Rehabilitating An Aging System

Colorado River Aqueduct Pump Rehabilitation Program

Five major pumping plants lift CRW over several mountain ranges to transport the water to Metropolitan's service area. A 1985 evaluation of the pumping units' conditions revealed that many of the original units installed were nearing the end of their useful life. As a result, in February 1988, Metropolitan began an extensive five-year program to rehabilitate each of the nine pump units at all five pumping plants. Restoring all the pump units to their original efficiency should reduce power use by 6 percent, representing an annual savings of approximately $2.0 million.

This estimate is based on ... 550,000 acre-feet of CRW. Trans... rehabilitation should ... additional operating efficiency ... of approximately $...

Project Descripti...

Each of the ... plants has nine pump units and was des...ned to operate ... with eight pumps. The ninth pump, serving as a spare, ... intended to permit maintenance without interrupting plant service ... to provide additional pumping capacity during peak periods.

Each pump unit consists of four major components (electric motor, centrifugal pump, suction valve, and discharge valve) and various auxiliary systems and equipment. The horsepower, rotational speed, pump size, and impeller shape provide a pumping capacity of approximately 200 cfs.

The size and scope of the Colorado River Aqueduct Pump Rehabilitation Program (CRAPRP) includes:

1. Designing and purchasing equipment and replacing up to 35 bronze impellers, including one spare impeller for each pumping plant.
2. Rehabilitating pump motors, discharge valves, pump system components, and bearings.
3. Re... ...perature instruments at all pumping plants.
4. ...ing instrumentation.

... transducers in delivery lines at ... ...ers for Intake and Hinds pump...

Proj...

Pla... this pr... 1989 ... will be completed in 1992. Phase IV ... and completed on December ... and was finished on April 19, 19...

Project Ma...

The new ... utilized dur... as Phase IV ... the remaining ... implemented during Phase III, w... coordination meetings were he... in order to monitor, track, and pl...

To maintain the Phase IV and V schedules, Metropolitan contracted for supplemental laborers, as in Phases I through III, to work with Metropolitan crews at the pumping plants and at shops in La Verne. The supplemental laborers included machinists, welders, and millwrights.

As with Phases I through III, the first major task facing the crews during Phase IV and V was installing a bulkhead in the discharge pipeline of each unit being worked on in that phase. Once installed, the bulkheads allowed the other units on the affected delivery line to resume normal operation while preventing back flow into the plant and protecting the crews during the pump rehabilitation work.

Testing and Evaluation

At the end of each phase, performance testing was completed at each plant. Engineers, technicians, and consultants worked for several days to perform the tests. Before starting a motor a preliminary check is made to ensure a free-running unit. Once the pump and motor have passed the checkout phase, performance testing begins. Over 270 measurements are taken to obtain data on suction and discharge pressure, vibration, flow, temperature, and electrical energy usage.

Evaluating repairs made to the units during the first five phases revealed that modifications prevented future outages of the units and increased Aqueduct flow by approximately 60 cfs.

Colorado River Aqueduct Transformer Rehabilitation Project

The remaining four General Electric 230-kilovolt (kv) transformers at Iron Mountain Bank No.1, including the spare transformer, were refurbished by McGraw-Edison this fiscal year. This completes a total of 12 230-kv Bank No. 1 transformers and three spares that have been rehabilitated at Gene, Eagle Mountain, Iron Mountain, and Hinds pumping plants during the last three years. The fourth spare is a newer model that did not require refurbishment. The transformer rehabilitation project targeted the original 230-kv transformers installed in the late 1930s. Transformer rehabilitation includes disassembling and refurbishing the primary and secondary coils, modifying the core structurally, drying, and testing before being returned to service.

Rehabilitation of the remaining 13 230-kv Bank No. 2 transformers, including the newer spare, is being studied to justify rehabilitation costs.

F.E. Weymouth Filtration Plant Rehabilitation

The Weymouth plant was constructed in 1941 and expanded in 1949 and 1962. In 1967 and 1973, modifications modernized the plant for State project water filtration and for rehabilitative work on the chlorination system,

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roads, and parking areas. Op[illegible] problems in the areas where t[illegible] plan was not rehabilitated had [illegible] increasing due to the equipme[illegible] age. Consequently, a study [illegible] to develop a plan for all work n[illegible] to maintain operati[illegible] improve process control, autom[illegible] the plant, and impr[illegible] management. All equipment was insp[illegible] the operating [illegible] history reviewed, and tests and evalu[illegible] were made prior to the final recommendations.

The study indicated that some equipment is worn out, has excessive vibration, and requires excessive maintenance, calibration, and parts replacement. A major problem with the maintenance and repair of the equipment is the availability of spare parts. In addition, some of the old equipment is not compatible with plant automation.

Based on the detailed study, a modification program consisting of 34 projects was approved in late May 1985. Generally, all projects are concerned either with plant process equipment instrumentation, modernizing flow measurement devices, water quality monitoring, or handling emergen[illegible] uninterruptible service. Specifying the time required for the [illegible] proved difficult because scheduling required plant shut[illegible] with plant operations. But the project work [illegible] over a five-year period. Metropolit[illegible] the design and purchase of materials and [illegible] of the modification work.

[illegible] Metropolitan personnel continued with the des[illegible] and materials, and installation and co[illegible] individual projects were complet[illegible] remain. Engineering design has be[illegible] has been delivered or ordered [illegible] for five of those projects. Des[illegible] remaining two projects. It is now ant[illegible] completed in fiscal year 1991.

TABLE 14

HYDROELECTRIC POWER RECOVERY PLANTS

1988 90 Production

Power Plant	Design Capacity (Megawatts)	1989-90 Production (kwh)	1988-89 Production (kwh)
Greg Avenue	1.0	4,872,000	5,040,000
Lake Mathews	4.9	36,816,000	38,880,000
Foothill Feeder	9.0	48,792,000	35,616,000
San Dimas	9.9	62,136,000	64,242,000
Yorba Linda	5.1	28,806,000	32,196,000
Sepulveda Canyon	8.6	55,077,600	44,061,600
Venice	10.1	40,707,000	21,816,000
Temescal	2.8	20,280,000	19,992,000
Corona	2.8	19,548,000	19,644,000
Perris	7.9	24,975,000	20,772,000
Rio Hondo	1.9	10,388,000	10,180,000
Coyote Creek	3.1	13,863,000	17,805,000
Red Mountain	5.9	30,894,000	24,840,000
Valley View	4.1	7,344,000	936,000
TOTAL		404,498,600	356,020,600

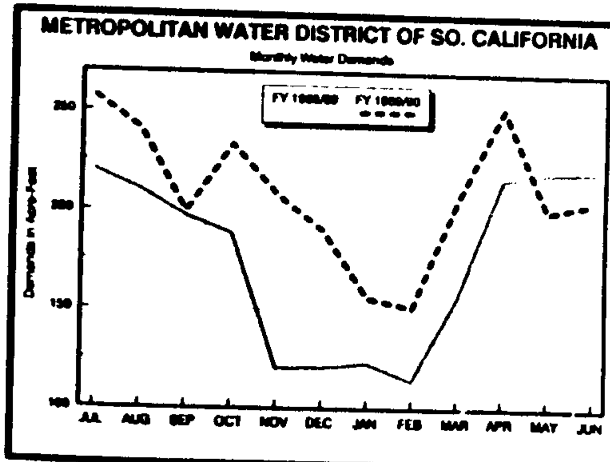

Figure 6. Monthly Water Demand

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TABLE 15

WATER USE BY METROPOLITAN'S MEMBER AGENCIES

[illegible]

(Acre Feet)

Member Agency	[illegible]	Adjusted Local Supply*	Metropolitan Deliveries: Direct Deliveries	Replenishment Deliveries**	Total Deliveries	Total Water Use
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MWD of Orange County	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pasadena	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Diego CWA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Fernando	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Marino	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Santa Ana	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Santa Monica	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Three Valleys MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Torrance	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Upper San Gabriel Valley MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
West Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Western MWD of Riverside County	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	1 622 538	1 672 816	2 305 875	194 787	2 500 662	3 978 661

Notes

* Adjusted for inter-member agency water transfers and [illegible]

** [illegible]

*** [illegible]

TABLE 16

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1989 90

(Acre Feet)

Water Deliveries	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Fiscal Year Totals
Untreated Temp. In-Lieu Repl.													
Anaheim	-	-	-	1 297.0						180.7			1 477.7
Los Angeles	-	-	-							377.5			377.5
Central Basin MWD	-	-	-	6 776.1	6 827.5	211.7	2 091.2		9 561.6	11 471.2			36 525.1
Chino Basin MWD	-	-	-	7 282.3						19 324.2			26 6[illegible].5
MWD of Orange County	-	-	-	5 812.5	1 921.3	91.5	185.2	1 039.1	8 507.8	14 911.2			27 959.2
San Diego CWA	-	-	-	3 235.1	5 147.9	1 988.4	4 113.2	4 086.5	4 413.8	20 504.1			86 421.8
Upper San Gabriel Valley MWD	-	-	-	2 220.7	11.2	2 351.4	1 111.0	15 545.2	13 782.1	22 611.8			56 428.0
TOTAL	-	-	-	24 121.9	13 233.9	6 611.8	8 282.6	19 455.4	38 641.9	89 441.3			197 806.0
Treated Temp. In-Lieu Repl.													
Anaheim	-	-		1 518.9	1 485.3	1 160.0	1 605.7	1 164.1		231.2			7 189.2
Calleguas MWD	-	-		1 419.6	531.0	384.8	262.7	291.2	395.4	513.6			3 799.8
Central Basin MWD	-	-		1 056.3	1 109.1	1 044.6	911.6	844.8	881.6	(1 878.6)			4 117.2
Coastal MWD	-	-				257.1	99.5	49.0	61.4	(60.6)			348.5
Compton	-	-			80.1	167.5	99.0	98.7	91.2	(301.7)			36[illegible].1
Foothill MWD	-	-	-	40.2	72.3		11.2	36.7	101.4	105.3			36[illegible].1
Las Virgenes MWD	-	-				21.1	186.7	343.6	268.9	100.0			1 720.9
Long Beach	-	-		690.0	615.0	464.0	291.0	396.0	507.0	111.0			3 043.0
Los Angeles	-	-		11 283.6	10 510.3	5 211.2	4 412.7	7 086.1	11 216.4	8 979.5			58 650.8
MWD of Orange County	-	-	-	2 664.9	2 689.1	3 314.6	3 240.2	2 115.8	2 247.7	811.5			11 342.7
San Diego CWA	-	-		162.9	5 795.0	2 135.3	1 518.2	2 735.5	2 681.7	1 631.6			16 666.2
San Fernando	-	-		794.0	250.5	235.1	77.6	57.0		(270.6)			651.6
Santa Ana	-	-	-	627.0	892.0	780.0	1 121.0	811.1					4 243.1
Santa Monica	-	-								693.0			693.0
West Basin MWD	-	-		219.2	219.7	269.2	250.3	183.1	256.3	(166.4)			1 228.4
TOTAL	-	-	-	19 885.6	24 268.4	15 447.5	16 331.4	16 360.1	18 819.9	10 598.4			119 807.9
Untreated Noninterruptible													
Anaheim	18.0	232.7	572.8	870.3	756.5	838.3	985.1	96.2	1 017.1	1 264.8	37.6	166.9	7 396.3
Chino Basin MWD	3 184.1	3 174.3	2 791.6	899.3	773.1	185.1	550.5	98.8	61.4	552.7	16.4	4 985.9	17 273.8
Eastern MWD	661.4	299.4	50.2	(140.5)	(414.6)	898.6	(19.4)	248.2	(459.2)	(38.7)	34.1	132.5	(143.2)
Los Angeles				-	18 795.2	21 582.6	21 583.6	18 269.2	21 280.4	14 751.7	19 249.1	19 958.3	155 250.1
MWD of Orange County	886.8	865.5	724.0	587.7	651.5	722.2	804.6	564.5	604.8	584.8	872.2	823.6	8 610.2
Pomona Valley MWD	2 221.9	2 080.1	1 748.7	1 677.4	1 681.0	866.8	734.1	1 160.7	1 506.4	1 507.6	1 810.4	1 930.9	18 901.8

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TABLE 16 (Continued)

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1989-90

(Acre-Feet)

Water Deliveries	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Fiscal Year Totals
Untreated Noninterruptible													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Treated Noninterruptible													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 16 (Continued)

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1989-90

(Acre-Feet)

Water Deliveries	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Fiscal Year Totals
Untreated Interruptible													
Anaheim	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Central Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chino Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Eastern MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Los Angeles	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MWD of Orange County	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pomona Valley MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Diego CWA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Western MWD – Riverside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	82 989.2	64 789.0	51 120.8	35 472.2	17 395.7	11 706.6	4 734.5	4 249.7	7 376.2	9 095.6	16 248.5	19 568.9	324 746.9
Treated Interruptible													
Anaheim	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Burbank	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Calleguas MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Central Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Coastal MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Compton	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Eastern MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Foothill MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fullerton	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Glendale	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Las Virgenes MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Long Beach	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Los Angeles	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MWD of Orange County	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pasadena	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pomona Valley MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
San Diego CWA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Santa Ana	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Torrance	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
West Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Western MWD – Riverside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	73 648.5	57 265.2	38 140.4	22 991.8	19 538.0	14 237.0	9 536.9	7 581.5	10 058.7	9 371.6	11 895.7	12 764.5	286 971.8

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TABLE 16 (Continued)

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1989-90

(Acre-Feet)

Water Deliveries	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Fiscal Year Totals
Reclaimed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Water Delivery Summary	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GRAND TOTAL	256,950.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fiscal Year to Date (Cumulative)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUBTOTAL	256,950.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

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TABLE 16 (Continued)

WATER DELIVERIES TO MEMBER AGENCIES

Fiscal Year 1989-90

(Acre-Feet)

Water Deliveries	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Fiscal Year Totals
Fiscal Year to Date (Cumulative) (Cont.)													
TOTAL OTHER DELIVERIES	—	—	—	—	—	4	5	6	7	7	7		
ACCUMULATED GRAND TOTAL	256,950.2	497,565.3	696,903.2	930,235.9	1,138,480.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
PERCENT OF TOTAL	10	10	8	9	8	8	6	6	8	10	8	8	
Member Agencies' Total Deliveries													
Anaheim	2,782.5	2,284.7	1,953.5	4,950.8	3,126.6	2,856.2	3,133.0	2,286.1	1,523.1	2,057.3	959.5	2,381.4	29,474.7
Burbank	2,455.3	2,399.3	2,140.0	1,908.3	1,859.6	1,771.1	1,591.6	1,401.8	1,855.7	1,986.1	1,862.1	2,071.7	23,216.6
Beverly Hills	1,534.7	1,481.4	1,390.9	1,295.5	1,255.6	1,184.7	1,092.1	954.3	1,142.1	1,053.1	1,718.9	1,241.7	14,867.0
Compton	643.0	591.3	431.9	285.1	49.0	944.5	489.3	448.0	507.1	446.0	343.4	375.2	5,536.4
Calleguas MWD	12,485.0	11,013.2	10,368.3	10,674.8	9,605.7	9,356.8	6,860.1	5,942.0	8,085.0	6,278.9	11,517.3	8,940.9	111,086.0
Chino Basin MWD	6,979.2	6,795.3	6,566.8	10,530.5	2,632.1	1,495.1	1,626.7	1,312.3	1,928.3	21,940.6	2,725.6	5,652.2	70,164.6
Central Basin MWD	18,447.0	11,411.1	9,406.1	14,022.6	14,431.3	8,309.9	8,980.9	6,004.0	17,478.4	18,776.8	8,552.5	13,829.1	49,629.7
Coastal MWD	5,270.7	5,709.0	4,918.5	4,121.3	3,938.5	3,839.1	2,924.9	2,669.0	3,056.9	3,280.9	4,381.7	4,452.1	48,242.6
Eastern MWD	7,995.7	7,722.3	6,549.6	4,781.9	3,358.8	2,918.1	1,889.4	1,862.1	3,042.1	3,530.1	5,405.4	6,966.6	56,120.1
Foothill MWD	1,480.6	1,371.3	1,032.1	916.9	895.8	882.4	688.3	542.0	775.9	636.1	734.9	929.9	10,886.2
Fullerton	1,772.9	1,797.9	1,466.9	1,014.7	790.0	720.4	699.8	817.1	1,895.0	1,141.5	1,129.3	1,257.1	14,510.6
Glendale	3,115.8	3,108.3	2,797.6	2,322.8	2,250.7	2,149.7	2,102.7	1,751.0	2,230.6	2,057.4	2,436.2	2,556.8	28,847.6
Las Virgenes MWD	2,754.6	2,811.5	2,554.5	1,795.2	2,026.3	1,823.1	1,771.6	1,420.0	1,825.7	1,426.4	2,112.5	2,349.4	24,670.8
Long Beach	4,997.4	5,318.1	4,353.7	4,955.9	4,536.2	4,292.7	3,786.6	3,442.8	4,243.0	4,167.2	3,603.5	3,365.6	51,062.7
Los Angeles	25,342.4	30,240.5	18,052.1	42,322.1	40,535.2	34,716.1	30,888.6	30,448.8	39,137.3	34,317.0	32,537.2	26,089.9	385,085.2
MWD of Orange County	38,758.7	29,960.6	22,754.2	28,462.8	24,217.5	21,951.7	16,448.2	16,507.0	26,008.1	32,127.3	19,382.1	21,956.6	298,014.8
Pasadena	3,530.5	3,571.0	3,032.6	2,308.7	2,278.2	1,768.8	1,458.6	977.8	1,556.5	1,670.1	2,330.2	2,669.9	26,902.9
Pomona Valley MWD	9,688.3	9,457.7	7,964.6	6,619.5	6,069.1	5,188.8	3,917.8	3,316.1	4,076.2	4,844.0	6,592.8	8,062	75,876.9
San Diego CWA	67,192.7	67,440.5	61,276.0	58,549.2	55,911.6	54,782.6	40,326.4	35,316.6	49,081.3	63,754.1	61,510.1	58,143.1	672,844.2
San Fernando	—	7	—	312.0	274.6	254.7	93.1	70.7	—	—	—	1.6	1,007.4
San Marino	150.8	101.6	142.4	122.6	185.4	139.3	110.2	122.4	94.8	134.9	63.6	58.8	1,426.8
Santa Ana	1,563.1	1,509.5	1,682.6	2,079.9	2,090.8	2,121.7	2,048.8	1,957.7	1,207.7	1,201.4	1,342.7	1,422.16	20,228.1
Santa Monica	1,148.2	1,007.3	945.2	771.4	805.9	824.2	1,059.5	1,133.8	1,282.2	1,225.3	778.2	709.0	11,690.2
Torrance	2,454.3	2,411.7	2,184.4	1,991.3	1,967.0	1,887.9	1,638.9	1,526.8	1,837.5	1,832.6	2,082.5	2,008.7	23,803.6
Upper San Gabriel Valley MWD	1,602.5	1,788.6	1,424.7	3,445.6	1,123.4	3,286.1	2,520.0	14,315.0	14,771.9	23,761.6	1,158.3	1,249.3	70,397.0
West Basin MWD	19,258.8	17,814.3	16,629.9	15,605.4	15,095.0	15,012.3	13,434.9	12,244.5	14,343.8	14,185.3	15,144.6	17,489.6	186,023.2
Western MWD — Riverside	13,745.5	11,496.4	8,216.8	7,585.3	6,882.9	6,463.3	4,035.4	2,350.2	3,812.0	5,094.8	10,309.2	9,014.1	89,005.9
GRAND TOTAL	256,950.2	240,615.1	199,337.9	233,332.7	208,244.8	180,499.3	155,975.5	151,179.9	208,573.1	252,416.8	200,414.1	205,122.4	2,500,661.8

TABLE 17

WATER DELIVERIES FOR 49 YEARS

(Acre feet)

Water Deliveries	1941-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	To Date
Treated Water											
Anaheim	[illegible]	[illegible]	7 356	25 347	20 296	16 592	9 027	[illegible]	13 205	19 550	449 238
Beverly Hills	[illegible]	[illegible]	13 278	[illegible]	[illegible]	14 578	14 791	[illegible]	[illegible]	14 867	351 775
Burbank	[illegible]	[illegible]	18 654	[illegible]	[illegible]	22 325	[illegible]	[illegible]	[illegible]	[illegible]	465 773
Calleguas MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	96 325	[illegible]	[illegible]	1 524 622
Central Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	93 189	[illegible]	100 359	97 219	[illegible]	[illegible]
Chino Basin MWD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	44 156	42 446	43 211	41 378	[illegible]
Compton	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3 962	5 151	[illegible]	[illegible]
Eastern MWD	[illegible]	[illegible]	[illegible]	[illegible]	27 491	26 428	[illegible]	[illegible]	45 846	[illegible]	238 428
Foothill MWD	[illegible]	[illegible]	8 276	[illegible]	[illegible]	[illegible]	10 672	10 461	10 891	[illegible]	834 769
Fullerton	[illegible]	14 881	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16 362	16 213	[illegible]	[illegible]
Glendale	[illegible]	[illegible]	21 846	[illegible]	[illegible]	21 448	21 995	20 812	27 555	28 840	449 876
Las Virgenes MWD	[illegible]	16 351	13 443	[illegible]	15 768	15 489	16 089	17 572	19 119	20 820	272 481
Long Beach	[illegible]	42 156	42 049	[illegible]	[illegible]	[illegible]	[illegible]	44 557	46 727	49 778	1 398 075
Los Angeles	[illegible]	34 417	25 819	[illegible]	46 552	81 855	[illegible]	144 262	138 391	165 959	2 621 312
MWD of Orange County	[illegible]	144 464	111 459	[illegible]	[illegible]	171 810	186 209	230 844	279 579	227 386	[illegible]
Pasadena	[illegible]	17 181	[illegible]	15 862	22 726	[illegible]	[illegible]	[illegible]	23 928	[illegible]	[illegible]
San Diego CWA	533 28[illegible]	134 474	155 906	[illegible]	145 551	[illegible]	[illegible]	172 206	181 268	191 520	1 963 451
San Fernando	914	33	80		57	429	854	2 016	1 645	[illegible]	7 025
San Marino	71	56	1	18	48	152	1 017	598	331	1 427	3 744
Santa Ana	319 504	13 909	12 087	15 762	15 591	14 089	15 021	15 832	15 816	20 228	457 845
Santa Monica	413 025	11 386	11 576	[illegible]	9 496	9 321	11 886	11 015	9 883	11 690	510 079
Three Valleys MWD	441 314	41 165	34 713	43 737	46 042	44 756	48 444	49 024	50 712	56 861	756 788
Torrance	449 427	15 849	14 569	[illegible]	19 044	17 072	20 590	20 134	22 802	23 804	642 433
Upper San Gabriel Valley MWD	29 013	8 825	6 867	[illegible]	10 025	10 255	10 432	13 319	12 093	13 969	121 055
West Basin MWD	3 332 769	156 619	166 142	182 811	184 521	172 862	185 713	191 936	190 685	186 023	4 952 103
Western MWD of Riverside Co	15 191	17 141	12 500	11 651	16 752	19 693	23 154	22 367	31 714	33 856	221 825
Total Treated Water	14 677 706	940 660	912 172	1 062 125	1 119 443	1 144 804	1 248 737	1 322 682	1 355 347	1 464 980	25 248 456

TABLE 17 (Continued)

WATER DELIVERIES FOR 49 YEARS

(Acre feet)

Water Deliveries	1941-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	To Date
Untreated Water											
Anaheim	55 663	9 260	10 534	10 556	12 377	6 783	11 666	10 070	12 597	9 925	149 431
Burbank	—	—	—	—	—	—	—	—	—	378	378
Central Basin MWD	1 742 580	29 999	2 436	1 500	40 625	21 495	44 501	34 542	44 001	49 531	2 011 210
Chino Basin MWD	311 892	36 794	26 894	26 362	29 761	35 322	33 958	36 025	46 354	70 165	653 527
Eastern MWD	866 069	33 936	27 865	11 362	1 377	1 336	425	1 359	2 646	3 419	949 594
Fullerton	2 567	—	—	—	—	—	—	—	—	—	2 567
Los Angeles	—	—	—	—	—	—	—	—	91 758	219 106	310 864
MWD of Orange County	3 226 014	72 186	33 032	23 954	47 130	62 089	48 837	71 251	30 799	65 495	3 680 787
San Diego CWA	6 768 908	281 181	148 256	239 230	288 615	330 875	361 182	357 725	410 947	475 271	9 662 190
Three Valleys MWD	141 629	6 731	6 255	7 950	8 805	9 917	9 935	16 977	17 331	19 016	244 548
Upper San Gabriel Valley MWD	250 834	59 150	31 534	14 829	—	3 000	25 000	37 570	43 186	56 428	521 531
West Basin MWD	2 498	—	—	—	—	—	—	—	—	—	2 498
Western MWD of Riverside Co	647 744	33 413	27 584	28 861	26 371	30 178	37 357	33 201	46 147	55 350	966 212
Total Untreated Water	14 016 398	562 650	314 190	364 610	455 061	500 995	572 861	598 720	745 768	1 024 083	19 155 336
Reclaimed Water											
Central Basin MWD	—	—	—	—	—	—	—	—	—	357	357
Coastal MWD	—	—	—	0	216	740	689	416	569	865	3 495
Las Virgenes	—	—	—	—	91	295	1 501	1 994	2 920	3 843	10 644
Long Beach	—	—	—	—	—	—	187	226	571	1 285	2 269
MWD of Orange County	—	—	—	—	—	—	1 949	2 860	3 715	5 195	13 719
San Diego CWA	—	—	—	—	—	—	—	—	—	53	53
Total Reclaimed Water	—	—	—	—	307	1 035	4 326	5 496	7 775	11 598	30 537
San Gabriel River Unit Deliveries	44 165	—	—	—	—	—	—	—	—	—	44 165
Special Contracts	532 557	2	—	—	60	41	3	5	—	1	532 669
Nonreimbursable Construction Water	14 287	987	207	1 210	874	305	1 503	670	694	782	21 519
Total Treated Water	14 677 706	940 660	912 172	1 062 125	1 119 443	1 144 804	1 248 737	1 322 682	1 355 347	1 464 980	25 248 456
Total Untreated Water	14 016 398	562 650	314 190	364 610	455 061	500 995	572 861	598 720	745 768	1 024 083	19 155 336
Grand Total	29 285 113	1 504 299	1 226 569	1 427 945	1 575 745	1 647 180	1 827 430	1 927 373	2 109 584	2 501 444	45 032 682
Annual Change Percent			18%	16%	10%	5%	11%	5%	9%	19%	

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TABLE 18
AGRICULTURAL WATER DELIVERIES
(Acre Feet)

Water Deliveries	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	Total
Treated Water											
Anaheim	4 4[illegible]	1[illegible]	76	178	133	135	115	99	51	81	5 474
Calleguas MWD	[illegible]	8 566	6 010	7 84[illegible]	8 699	8 044	9 502	8 610	9 801	10 728	141 043
Central Basin MWD	[illegible]	84	32	46	65	44	48	51	140	382	2 389
Eastern MWD	[illegible]	9[illegible]	15	6 318	10 182	6 075	5 965	5 797	7 001	6 055	49 973
Fullerton	[illegible]	192	159	[illegible]	[illegible]	170	134	97	95	77	11 820
Los Angeles	[illegible]	1 745	1 445	2 187	3 830						227 632
MWD of Orange County	[illegible]	814	620	1 5[illegible]	2 045	3 414	3 297	3 193	4 251	4 859	81 995
San Diego CWA	191 774	49 [illegible]	39 620	48 5[illegible]	42 120	40 8[illegible]	41 822	38 887	45 370	43 802	582 120
Santa Ana	204	166	145	130	144	76	53	13	8		941
Three Valleys MWD	375										375
Torrance		86	147	326	216	150					925
West Basin MWD	16 682	498	521	600	590	170	302	441	552	471	20 829
Western MWD of Riverside Co	30 061	13 316	8 322	6 6[illegible]	9 249	10 024	11 685	12 936	21 501	16 026	141 743
Total Treated Water	559 295	75 552	57 212	74 569	76 050	69 041	74 923	69 744	88 780	82 282	1 227 458
Untreated Water											
Anaheim	782	135	126	135	118	76	94	66	41	51	1 624
Chino Basin MWD	20 680	588	307	404	498	398	364	459	175	118	23 996
Eastern MWD	625 121	20 732	16 646	7 621	1 377	1 336	425	1 359	2 933	3 561	681 113
Fullerton	23										23
MWD of Orange County	432 479	33 541	6 791	14 360	13 667	24 193	16 118	25 395	12 805	8 582	587 431
San Diego CWA	1 477 906	57 754	46 429	63 307	59 613	62 027	65 004	57 670	63 554	74 713	2 027 977
Three Valleys MWD	28 677	179	124	147	152	143	163	168	140	115	30 008
Western MWD of Riverside Co	661 133	21 892	19 154	21 916	19 436	21 404	23 096	19 905	25 806	29 435	863 177
Total Untreated Water	3 046 801	134 821	89 077	107 890	94 861	109 577	105 269	105 022	105 454	116 577	4 015 349
Grand Total	3 606 096	210 373	146 289	182 459	170 911	178 624	180 192	174 770	194 234	198 858	5 242 806

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TABLE 19
WATER USED FOR UNDERGROUND REPLENISHMENT
(Acre Feet)

Member Agencies	Type of Replenishment	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	Total
Anaheim	Temp in Lieu	46 094			15 149	9 079			4 615	3 850	11 795	90 582
Burbank	Temp in Lieu	11 050									6 000	17 050
Calleguas	Spreading										378	378
Central Basin MWD	Spreading	2 464							1 620		1 717	5 801
	Temp in Lieu	29 517			8 222	3 238			1 565	210	22 098	64 850
	Spreading	2 055 837	30 000	2 436	1 501	40 625	21 495	44 501	34 542	44 001	49 531	2 324 469
	Injection	70 904	4 859	5 198	4 024	4 724	4 610	6 958	6 538	5 599	5 756	119 170
Chino Basin MWD	Temp in Lieu	20 088			61	84					26 157	46 990
	Spreading	59 828	19 042	13 180	11 777	12 188	16 330	13 609	15 636	7 407	26 617	197 622
Coastal MWD	Temp in Lieu	861			354	701			411		349	2 676
Compton	Temp in Lieu	938			340	1 200					450	2 928
Eastern MWD	Temp in Lieu										2924	2 924
	Spreading	567										567
Foothill MWD	Temp in Lieu	1 470				326					559	2 355
Fullerton	Temp in Lieu	19 689			9 501	2 927			2 770	2 412	1 880	39 179
Glendale	Temp in Lieu	9 644			1 501	992			1 125		7 000	20 262
Las Virgenes MWD	Temp in Lieu								474	120		594
Long Beach	Temp in Lieu	10 418			6 022	848			1 061	175	8 043	26 567
Los Angeles	Temp in Lieu	10 039				4 951				35 335	73 283	123 608
	Spreading	89 255										89 255
MWD of Orange Co	Temp in Lieu	61 941			27 775	11 955			11 613	8 737	49 634	171 655
	Spreading	2 500 277	32 336	20 765	4 547	29 819	31 779	27 126	38 752	10 761	31 027	2 727 189
Pasadena	Temp in Lieu	12 450				4 039			910	1 830	8 000	27 229
San Diego CWA	Temp in Lieu					24 018				6 485		30 503
San Fernando	Temp in Lieu									546	652	1 198
Santa Ana	Temp in Lieu	5 393			1 243	529			653	342	9 343	17 503
	Spreading	17										17
Santa Monica	Temp in Lieu	7 353			467						693	8 513
	Injection	3 455	554	2 141	1 845	131		2 251	1 822		3	2 202
Three Valleys MWD	Temp in Lieu	10 946			4 109					451	712	16 218
Torrance	Temp in Lieu	4 770			3 439	1 700					5 000	14 909
Upper San Gabriel Valley MWD	Temp in Lieu	1 002				206						1 708
	Spreading	294 998	59 150	31 534	14 828		3 000	25 000	37 570	43 186	56 428	565 694
West Basin MWD	Temp in Lieu	19 873			7 165	4 581			1 230	2 514	10 028	45 391
	Injection	507 688	28 282	36 710	38 257	34 736	25 730	31 600	31 522	29 257	25 050	788 834
Western MWD of Riverside Co	Temp in Lieu										1 376	1 376
Total		5 868 826	174 223	111 972	164 127	193 599	102 944	151 045	194 429	203 218	442 481	7 606 864

5994

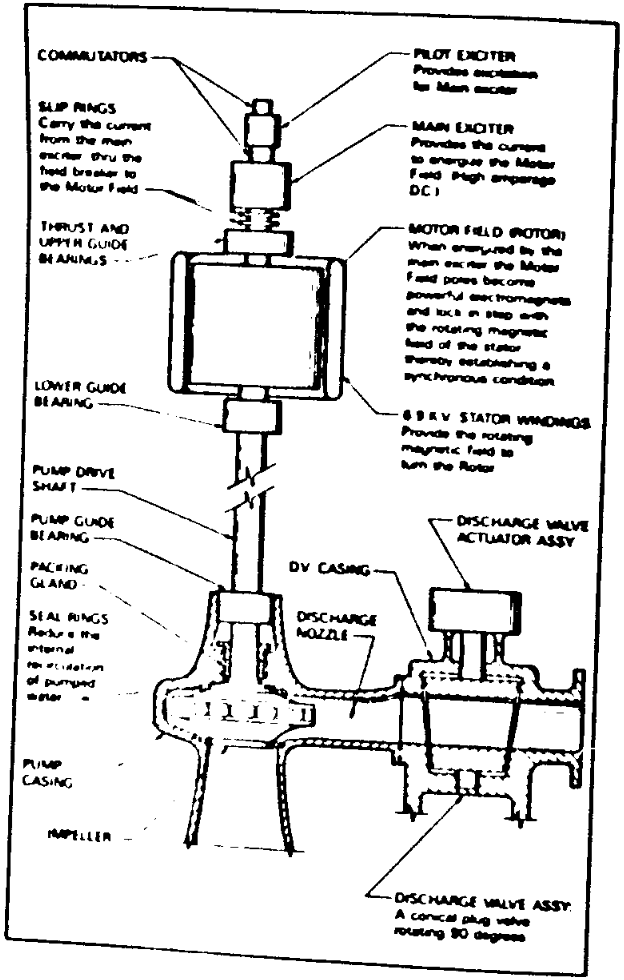


Figure 7. Components of a Pump Unit

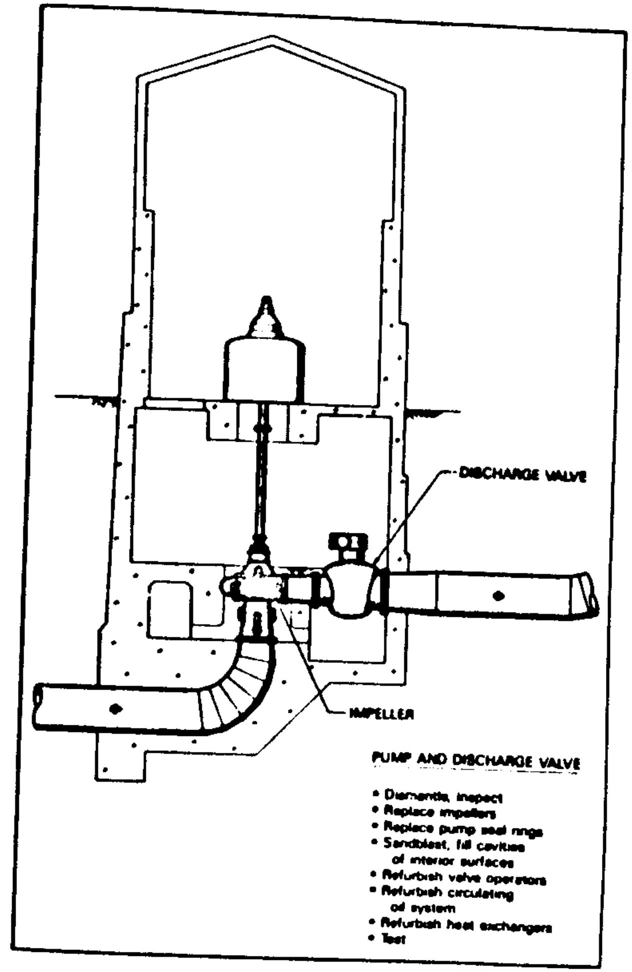
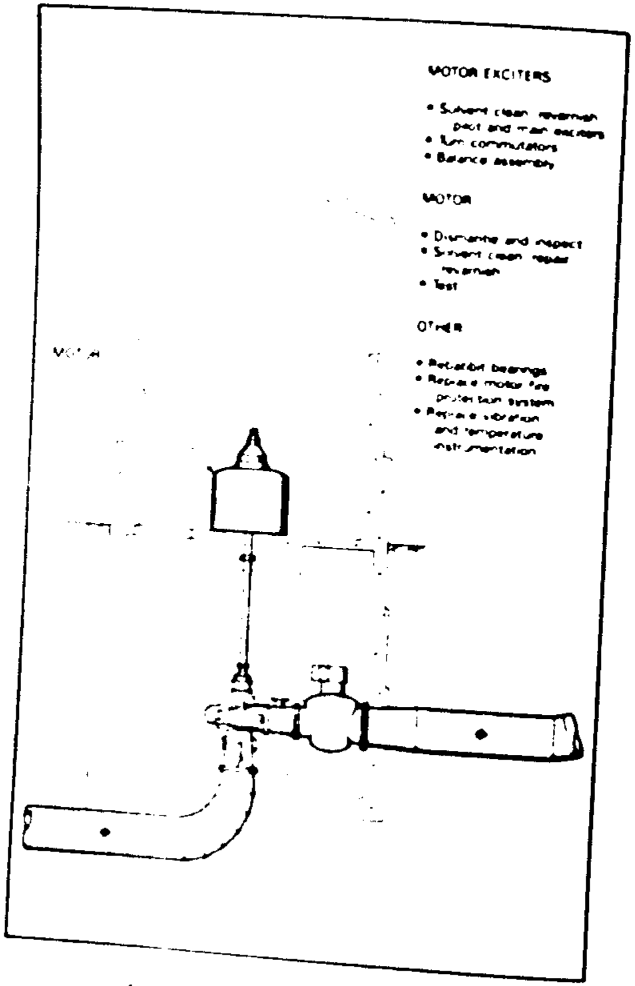
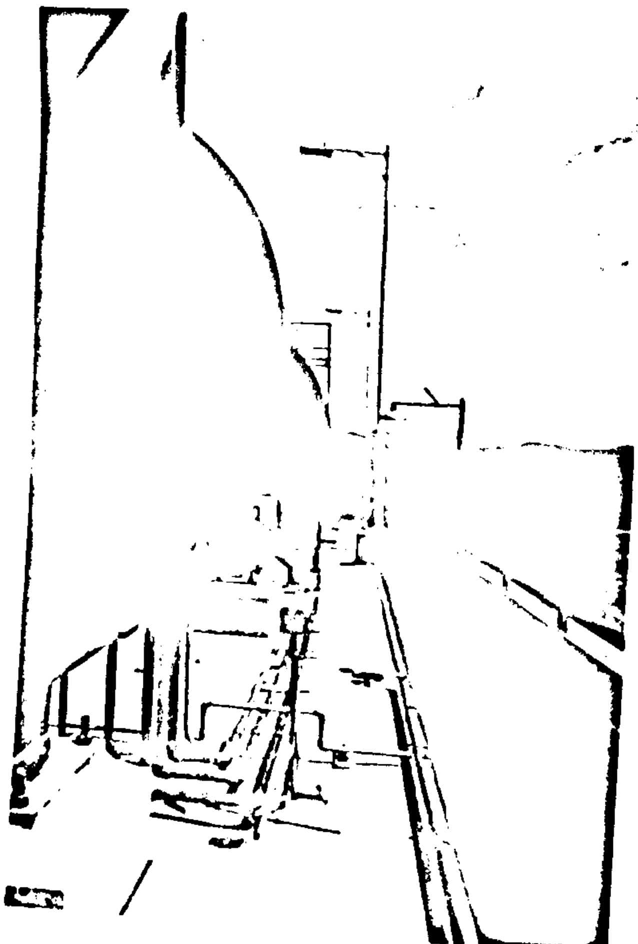


Figure 8. Rehabilitating a Pump and Discharge Valve



[illegible] a Pump Motor

Getting a head start on water issues thanks to Metropolitan's educational programs, these students at Brentwood School learn new lessons in geography.



New 55,000-gallon tanks at the Robert B. Diemer Filtration Plant safely store sodium hydroxide used to reduce pipeline corrosion.

CHAPTER 3

Water Supply Management and Development

Colorado River Water

With forecasts of insufficient State project supplies during future dry periods and Metropolitan's loss of half of its dependable Colorado River water (CRW) supplies, numerous water supply management and development programs are being undertaken. Although Metropolitan can expect to receive more than its dependable supply when surplus water is available or the agencies supplying irrigation water do not fully use their allocation, Metropolitan is working to develop additional supplies.

All American Canal and Coachella Branch Lining

Title II of Public Law 100-675 authorized the Secretary of the Interior (Secretary) to enter into agreements with the California agencies holding CRW delivery contracts to fund two canal lining projects: concrete lining of 28 miles of the All American Canal and concrete lining of 38 miles of the Coachella Branch. The U.S. Bureau of Reclamation (Reclamation) continued work toward publishing draft Environmental Impact Statements/Environmental Impact Reports (EISs/EIRs) next fiscal year on the canal lining projects.

To test the feasibility of lining the canals while they are operating, Reclamation awarded a contract to Kiewit Pacific Company last fiscal year to shape the canal prism and place a polyvinyl chloride and geotextile liner and concrete cover in 1.5 miles of the Coachella Branch. Subsequent complications in this first-ever underwater placement attempt required testing equipment modifications this fiscal year. Upon successfully completing the test, the contractor modified the equipment and will continue construction early next fiscal year. Metropolitan, Coachella Valley Water District (Coachella), and Reclamation are underwriting this demonstration project through an advance funding agreement.

Water Conservation Agreement with Imperial Irrigation District

This fiscal year, Metropolitan concluded negotiations with Imperial Irrigation District (Imperial), Coachella, and Palo Verde Irrigation District (Palo Verde) on agreements gaining Coachella and Palo Verde's approval of the Imperial-Metropolitan Water Conservation Agreement. Coachella had filed a complaint last fiscal year in Federal district court seeking to enjoin implementation of the Conservation Agreement. Coachella believed that Imperial was required to conserve water with or without Metropolitan funding and that such water should be available to it first under beneficial use priorities outlined in CRW water delivery contracts.

Under the Approval Agreement signed by the four agencies, Imperial is making available the water conserved by two Conservation Program Projects at no cost to Metropolitan. These two projects constitute the Augmentation Program and are estimated to conserve 6,110 acre-feet per year. Projects have been substituted into the Conservation Program so that the total water available equals 106,110 acre-feet annually. Should the Secretary require reduced use to offset use exceeding 3.85 million acre-feet, Metropolitan would reduce using conserved water at Coachella's request if Imperial did not exercise its option to do so. Coachella and Palo Verde would also reduce their diversions on a proportionate basis. If Metropolitan reduced its use of conserved water by certain amounts, the minimum term of the Conservation Agreement would be extended for a specified period. Imperial, Coachella, and Palo Verde would implement a public awareness water conservation program in any year in which Metropolitan might have to reduce its use of conserved water. These agencies would cooperate with Metropolitan in developing East Mesa groundwater resources in Imperial County.

Under a Supplemental Approval Agreement between Metropolitan and Coachella, Coachella would limit its net Colorado River diversions to 450,000 acre-feet per year except under limited circumstances. Coachella would not request that Metropolitan reduce its use of conserved water unless Imperial's net diversions exceeded certain amounts.

With project substitution, the capital costs of the conservation program in 1988 dollars are estimated to total $97.8 million, the indirect costs $23 million, and the annual direct costs $2.6 million upon full implementation. The three agreements' terms extend for a minimum of 35 years after full implementation of the conservation program, and continue until terminated.

With the approval agreements executed, Imperial began implementing the conservation program halfway through the fiscal year. By fiscal year end, 28 miles of canal were concrete lined, half day deliveries of irrigation water were taking place, and distribution system automation work was

progressing. Also, Z Reservoir design, the Plum-Oat Lateral Interceptor Canal siting, and on-farm water conservation plan preparation were under way.

Exchange Water Contracts

During the year, Desert Water Agency (Desert) and Coachella exchanged 57,010 acre-feet of State project entitlement water with Metropolitan for an equal amount of CRW from Metropolitan's advance delivery account. Metropolitan delivered 34,308 acre-feet of water to Desert and Coachella for Coachella Valley groundwater basin storage. The account balance on June 30, 1990, was 413,529 acre-feet, a reduction of 22,700 acre-feet during the fiscal year.

Also during the year, 59 acre-feet of San Bernardino Valley Municipal Water District State project water was delivered to Metropolitan for an equal amount of CRW extracted from Lake Havasu by the Havasu Water Company.

State Project Water

State Water Contractors

Metropolitan, together with 27 other State Water Project (SWP) water contractors, formed State Water Contractors, Inc. (SWC) to further its members' common interests. SWC mainly works through committees which regularly meet to study and offer solutions to problems arising from the California Department of Water Resources' (DWR's) SWP management. The following are the major committees and some of the matters in which they are involved:

- The Future Water Supply Committee works on the State's plans for developing and maintaining an SWP water supply that includes Sacramento-San Joaquin Delta (Delta) water management programs, Los Baños Grandes Reservoir, Kern Water Bank, and interim and long-term water purchases.
- The Joint Audit-Finance Committees concern themselves with all financial issues affecting the SWP, including procedures for allocating costs among the contractors. This committee also receives the reports of the DWR Technical Accounting Committee.
- The Contract Issues Committee watches areas which may require water service contract amendments. Currently, this committee is examining a contract amendment covering local projects.

- The Groundwater Committee mainly reviews DWR's activities in developing groundwater programs as SWP yield. At present, the Kern Water Bank program is being monitored.
- The Operations and Maintenance Committee provides DWR with the benefit of the water contractors' experience in operations and maintenance items. It is now examining the California Aqueduct sedimentation problem at Arroyo Pasajero.
- The Design and Construction Committee examines ongoing right-of-way acquisition and design and construction of SWP facilities. Currently, this committee is following the East Branch Enlargement and the planning of Los Baños Grandes Reservoir.
- The Energy and Power Issues Committees look at power supplies and cost allocations of power facilities, including evaluating the geothermal power plants and energy supply costs.
- The Table A Committee explores matters relating to each contractor's State project water entitlement.
- The Interim Water Purchase Committee reviews DWR's activities in acquiring interim water supplies. Working with DWR to develop an equitable method of collecting the associated costs, the contractors amended the water contracts to allow DWR to bill such water purchases as an operating cost in the Delta Water Charge. DWR is evaluating several sources of water purchase including the Central Valley Project (CVP) and a permanent agreement to purchase water from Yuba County.

Future Water Supply

DWR is actively planning to acquire further water supplies to increase SWP's yield. Without additional water and facilities to store it, the SWP will, in the very near future, be unable to meet requests from water contractors even in high or average rainfall years. The following are some of the most significant projects DWR is now examining.

- Delta Facilities. In the North Delta, DWR wants to provide a more efficient path for Sacramento River water through the Delta, thus reducing the water quality and fishery problems currently associated with reverse flows. In the initial phase of the North Delta improvements, DWR proposes to increase the South Fork Mokelumne River flow capacity which will also provide flood control benefits for the surrounding Delta islands. In the West Delta, DWR, committed to meeting certain water quality standards, recommends constructing water conveyance facilities to the western portion of Sherman Island. Alternatively, DWR proposes to purchase island

property and convert it to wildlife habitat. The South Delta's main problem lies in the channels' limited capacity which leads to channel scouring when the SWP and CVP are maximizing their pumping simultaneously with a low San Joaquin River flow or a low tide. The low water levels also contribute to the poor South Delta water quality. Numerous alternatives are being studied, among them a modified Clifton Court Forebay gate, channel dredging, and a levee setback or enlargement of Clifton Court Forebay together with the channel enlargements. Other possible project activities include installing tidegate structures, adding a siphon at Tom Paine Slough, and connecting the CVP with Clifton Court Forebay. Draft EIRs/EISs are expected in late 1990.

- Los Baños Grandes Reservoir—An off-stream reservoir similar conceptually to San Luis Reservoir, this reservoir is intended to store excess Delta flows, available primarily in the winter, for subsequent project use. DWR is currently refining its feasibility studies and will be proceeding with the Federal and State environmental processes. A Draft EIR EIS is expected in late 1990.
- Article 10(h) Water—Negotiations pursuant to Article 10(h) of the Coordinated Operation Agreement between Reclamation and DWR are continuing. Under the proposed agreement, Reclamation will provide an interim SWP water supply of approximately 150,000 acre-feet per year. In turn, DWR will wheel approximately 150,000 acre-feet of CVP water. DWR and Reclamation have initiated the environmental process and a final EIR/EIS should be issued in mid-1991.
- Yuba County Water—DWR and Yuba County Water Agency have been negotiating an interim water supply in the amount of up to 130,000 acre-feet per year for the SWP from Yuba County Water Agency's New Bullards Bar Reservoir.

Arvin-Edison Water Storage and Exchange Program

Arvin-Edison Water Storage District (Arvin-Edison), a Kern County CVP contractor, and Metropolitan may enter into a program whereby Metropolitan would deliver a portion of its SWP entitlement to Arvin-Edison for groundwater basin storage. When needed, Metropolitan would then take Arvin-Edison's CVP Delta surface water supply and Arvin-Edison would pump the previously stored groundwater. The program would not adversely impact SWP operations or other SWP contractors' entitlement deliveries.

DWR Business Information System

In developing a business information system, DWR plans to replace the present data processing system used in SWP management. The contractors have retained the auditing firm of Ernst & Young to ensure that the new system handles SWC needs for DWR information. The auditors are par ticipating on DWR's internal committee to ensure that system designers will consider SWC's needs. The auditors will provide assistance to DWR if required.

California Water Fund Offset Legislation

Legislation passed in September 1989 and signed by the governor reduces the SWP obligation to the California Water Fund by reimbursing DWR for funds spent on recreation and fish and wildlife enhancement facilities. In return, DWR will regularly schedule reimbursement transfers from the SWP to the California Water Fund for the remainder of the obligation.

Suisun Marsh

The Montezuma Slough Control Structure became operational in October 1988 and helped control salinity levels in the Suisun Marsh. Additional work to complete the project, such as modifications to the levees and boat locks, will be done in the coming year.

SWP Financing

In March 1990, DWR sold $100 million in CVP Water System Revenue Bonds, Series G, to (1) reimburse DWR for funds previously expended for SWP construction and planning costs, (2) fund a portion of the Debt Service Reserve Account, and (3) pay interest on the Series G Bonds to December 1, 1990, and pay costs of issuing the Series G Bonds.

DWR Technical Accounting Committee

The Technical Accounting Committee, chaired by the DWR Controller and including representatives of the auditing firms representing the water contractors, examines problems concerning SWP accounting and financing procedures. The main problem before the committee is resolving DWR's procedure for collecting SWP replacement costs from the contractors.

Water Conservation and Management

Best Management Practices

In response to SWRCB's 1988 Draft Water Quality Control plan, the Urban Water Conservation Task Force, which is comprised of representatives from urban water suppliers and various public interest groups, has been meeting to define and develop Best Management Practices (BMPs) for water

conservation. Metropolitan staff has played an important role on the task force and in developing the BMPs. Upon adoption by the coalition's membership, the BMPs will be submitted to SWRCB as publicly developed guidelines and standards for urban sector water conservation. The BMPs would be submitted through a Memorandum of Understanding in which the urban water suppliers and the various public interest groups would be the primary signatory parties.

Conservation Credits Program

In 1988, Metropolitan's Board of Directors adopted the Conservation Credits Program (CCP) to assist its member agencies in aggressively implementing conservation programs. Under CCP, Metropolitan's member agencies receive a financial incentive for conservation programs with verifiable savings. Metropolitan pays the lesser of one-half the program's cost or an amount per acre-foot of water saved times a flat rate of $154 per acre-foot.

Projects are selected for implementation based on anticipated effectiveness, verifiable results, economics, and financial need. Metropolitan staff may evaluate a program on its innovative merits to encourage development of new methods and technology.

To date, Metropolitan has funded a total of eight projects in its service area. These projects are anticipated to save 7,730 acre-feet per year, a total of 43,125 acre-feet over the lives of the projects. Because many of these initial projects are pilot in nature, the final total yields may vary from anticipated savings. This data will be used in developing future CCP standards and guidelines. Metropolitan's total financial commitment in fiscal year for 1989-90 was $3,454,150.

Regional Urban Water Management Plan

In 1983, the California Legislature passed the Urban Water Management Planning Act (Assembly Bill 797). The act required most urban water agencies to prepare a water management plan. Although exempted from the act's provisions, Metropolitan did prepare a Regional Urban Water Management Plan (RUWMP) for its own internal planning purposes and to assist its member agencies and sub-agencies in preparing their required plans.

This year, as in 1984-85, Metropolitan has prepared a RUWMP and this revised plan will be a significant part of Southern California's water management and conservation program planning. The RUWMP will document Metropolitan's existing and proposed water management programs, and provide a framework for a 10-year water management and conservation program.

Southern California Water Energy Conservation Partnership

During the year Metropolitan joined with Southern California Edison, Southern California Gas Co., and the Los Angeles Department of Water and Power to form the Southern California Water Energy Partnership (Partnership). This group serves to combine these agencies' efforts to conserve water and energy and to increase environmental protection and the quality of life in Southern California.

The agencies have agreed that where their mutual interests coincide they will cooperate in planning, funding, and implementing joint water energy conservation programs. Initially, the Partnership will implement a pilot toilet flapper retrofit program. The goal is to retrofit 32,000 Southern California homes.

CIMIS Program

Metropolitan continued its Southern California expansion of the California Irrigation Management Information System (CIMIS) program. The CIMIS program consists of two components, the CIMIS weather station network and the audit training module, and is intended to monitor and reduce growth in outdoor water usage. Metropolitan has provided CIMIS Audit training to 350 large landscape irrigators to teach them how to evaluate their irrigation systems efficiently, identify poor irrigation practices, and use the CIMIS weather data to schedule irrigation frequency and volume. This program is administered by the University of California Cooperative Extension in Los Angeles, Orange, Riverside, San Bernardino and San Diego Counties. The Ventura County Resource Conservation District administers the program within Metropolitan's service area in Ventura County.

Water Exchanges

Arvin-Edison—Metropolitan Water Storage and Exchange Program

During the past year Metropolitan and Arvin-Edison continued the joint effort to implement the Arvin-Edison Metropolitan Water Storage and Exchange Program. Under this program Metropolitan will be able to store about 800,000 acre-feet of SWP water in the groundwater basin underlying Arvin-Edison. During future shortage years, Metropolitan will receive, through the California Aqueduct, Arvin-Edison's CVP water. Arvin-Edison will, in turn, pump the water previously stored by Metropolitan to meet their demands. This will increase available dry-year supplies by about 10,000 acre-feet annually.

Significant progress was made on the EIR/EIS during 1989-90. The EIR/EIS was submitted to Reclamation for review. The public comment period is expected to be completed in December 1990. Adoption of the EIR/EIS by Metropolitan's and Arvin-Edison's Boards of Directors is scheduled for March 1991.

During 1990, Reclamation filed for a Change-in-Use Permit from SWRCB on behalf of Arvin-Edison. This permit will allow CVP water to be used in urban Southern California in exchange for Metropolitan's SWP entitlement water previously stored in the Arvin-Edison groundwater basin. SWRCB will convene a hearing on this permit in late 1990.

Metropolitan is continuing to work with DWR and the other SWC members to develop procedures to assure that the exchange program operations will not adversely affect the other SWP contractors.

Because 1990 has been a critically dry year, the Interim Arvin-Edison Metropolitan Water Storage and Exchange Program was not used this year. However, the Interim Program will be extended in the event an opportunity arises to put water in storage before the long-term program is finalized.

Groundwater and Regional Water Resources

Groundwater Resources

Throughout the year Metropolitan worked with its member agencies to protect and improve utilization of local groundwater resources. Groundwater represents roughly one-third of the annual water supply available to communities in Metropolitan's service area. Aquifers provide valuable storage of local and imported water vital to meeting seasonal, drought, and emergency demands. However, widespread contamination threatens existing groundwater production and is the primary obstacle to expanded conjunctive use. Metropolitan's activities focused on accomplishing the following objectives:

- Increased importation of surplus water through conjunctive use of groundwater storage.
- Increased groundwater production capacity.
- Protection and improvement of groundwater quality.
- Reduced peak demands on Metropolitan.

Actions taken toward accomplishing these objectives include:

Cooperative Groundwater Studies

Metropolitan participated with member and local agencies in 15 cooperative studies to maximize groundwater resource utilization. Reconnaissance-level reports identifying conjunctive-use opportunities in the Main San Gabriel Basin, the North Las Posas Basin, the Glendora Basin, the Raymond Basin, and the Live Oak Basin were completed. The remaining studies are in progress.

Metropolitan and local agencies formed the Chino Basin Water Resource Management Task Force. The Task Force's goal is to develop basin management practices that improve groundwater quality and expand conjunctive use. The Task Force established funding mechanisms, defined specific goals and initiated consultant investigations. Concurrently, Chino Basin agencies expanded local production capacity. New wells were drilled to quality for increased interruptible service and to offset declining agricultural pumping.

Metropolitan and Eastern Municipal Water District (Eastern) are jointly participating in a project to demonstrate spreading and storage of State Project water in the San Jacinto Groundwater Basin. Metropolitan assisted Eastern in developing a two-year replenishment test. The University of California at Riverside was retained to design and implement a groundwater monitoring program. Meanwhile, Eastern obtained all necessary permits and initiated construction of spreading basins in the San Jacinto River bed, connecting pipelines and nearby monitoring wells. Phased replenishment deliveries are scheduled to start in the fall. Development of a basin groundwater model was initiated through the services of the University of California at Los Angeles (UCLA). Model predictions will help guide future basin fill and extraction operations.

Research and Development

The city of Oxnard developed an innovative groundwater injection and recovery project and received technical support from Metropolitan. Oxnard successfully injected and stored imported water in the Oxnard Plain Groundwater Basin. Wells that had previously been shut down because of high total dissolved solids content were retrofitted. The wells were then operated to inject imported water during the winter of 1989-90 and to pump that water from groundwater storage during the following summer high demand period. The project showed the feasibility of recovering and serving high quality imported water injected into poor quality groundwater zones. Seasonal Storage Service pricing incentives offered by Metropolitan and Calleguas Municipal Water District (Calleguas) helped make the project cost effective. At year end, Calleguas and Metropolitan were

developing plans for another injection project that could eventually use 300,000 acre-feet of available storage capacity in the nearby North Las Posas Basin.

Metropolitan participated with the Orange County Water District (OCWD) in researching and developing biological procedures to remove nitrates from well water. The initial laboratory phase of investigation demonstrated promising applications for the autotrophic denitrification process. If perfected, this new technology would eliminate costly brine disposal associated with traditional reverse osmosis and ion exchange technology. The agencies are coordinating plans for a second phase of field testing on a production well.

Research conducted at UCLA and supported by Metropolitan led to advances in understanding contaminant transport processes in groundwater and in developing waste minimization technology for hazardous substances.

Regulatory and Legislative Advocacy

Metropolitan assisted member agencies in reviewing development proposals for solid waste landfill projects. Because landfills are potential sources of groundwater contamination, they require careful planning and management. Metropolitan identified certain sites as unsuitable and recommended improved design features for other projects to protect irreplaceable groundwater resources and major distribution pipelines from contamination. The following projects were investigated during the fiscal year: the Azusa Landfill, the North San Diego County Landfill, the North Orange County Landfill, Sunshine Canyon Landfill, and the Los Angeles County Solid Waste Management Plan. In finding the Azusa site unsuitable, Metropolitan, the Upper San Gabriel Valley Municipal Water District and other local agencies filed suit with the State Water Resources Control Board (SWRCB) to stop project expansion.

SWRCB began reviewing its Subchapter 15, Discharge of Waste to Land Regulations, which provide the criteria for developing and operating all California solid waste landfills. Metropolitan actively participated in strengthening the regulations to protect water quality. The review process continues into next fiscal year.

Metropolitan participated in the American Water Works Association Technical Advisory Group in reviewing proposed Federal legislation and regulations that would protect and expand groundwater use.

Groundwater Storage

This fiscal year, assignments totaling 28,725 acre-feet of the city of Ontario's and Cucamonga County Water District's Chino Basin safe yield water were executed. The groundwater was assigned to Metropolitan under its Trust

Storage Agreement with the Chino Basin Watermaster in exchange for delivery of equal quantities of imported water. Metropolitan is holding its Trust Storage water in the Chino Basin to use during shortages.

Metropolitan's Water Rates—Seasonal Storage Service

The Board of Directors approved a new class of water service, Seasonal Storage Service, on July 11, 1989. Under this program, water rates are discounted for water purchased from Metropolitan during specified periods and placed into groundwater or reservoir storage.

Seasonal Storage Service encourages member agencies to store Metropolitan's water when imported supplies are abundant and use the water during periods when Metropolitan's capability to provide service is less certain. The program encourages coordinating local storage resource operations with those of Metropolitan's and the State's importation facilities.

In brief, the regional benefits expected from the local development encouraged by Seasonal Storage Service are:

1. Storage of Metropolitan's water in the winter months of October through April better utilizes available imported supplies.
2. Increased local water production in droughts and peak-demand periods increases available supplies for non-groundwater agencies while providing adequate supplies for the agencies overlying groundwater basins.
3. The program decreases demands on Metropolitan's system during the summer months and increases system use during the low-demand season when facilities would otherwise be underutilized.
4. Increased local water production in the summer months lessens the drawdown of Metropolitan and State storage allowing higher carryover storage volumes to be held for droughts.
5. Seasonal regulation by local agencies extends the adequacy of Metropolitan's delivery system, ultimately leading to cost reductions for distribution system additions.
6. Improved local production capabilities could add to regional supplies following an earthquake.

OCWD established its Conjunctive Use Well Construction Program in response to the financial incentives available through Metropolitan's Seasonal Storage Service. Under the program, OCWD financially assists its

member agencies with new well construction. The OCWD goal is construction of 40 to 50 new wells by its member agencies to increase basin production capacity from 280,000 to 380,000 acre-feet annually.

Miscellaneous Projects

Report No. 991

Progress continued on Report No. 991, "Groundwater Quality and Its Impact on Water Supply in Metropolitan's Service Area." A database was developed that includes over 400,000 active groundwater quality values for approximately 3,400 municipal wells. Special software to use the data were developed and installed. At year end, work progressed on developing reporting formats and coordinating preliminary findings regarding groundwater quality in 15 major basins.

Brackish Water Study

Metropolitan began studying the potential water supply benefits associated with desalting brackish groundwater in its service area. The study would identify the quantity of brackish groundwater available, existing treatment technology, and production costs.

Morris Dam and Reservoir

A new draft lease was negotiated allowing the U.S. Navy to continue using the Morris Dam and Reservoir property. The lease reflects plans to transfer Morris Dam and Reservoir to the Los Angeles County Department of Public Works during the upcoming fiscal year. The existing lease expired on June 30, 1990. Under the County's ownership, the dam and reservoir will be operated to maximize flood control and water supply benefits. As a result, the Navy will no longer experience stable reservoir water surface levels. The new lease is expected to be finalized in the upcoming fall months. Metropolitan also prepared an agreement with the County to train County employees to operate Morris Dam to facilitate a smooth transition of ownership and to provide continuity in project operation.

Reclaimed Water and Local Resources

Development

Under the Local Projects Program (LPP), Metropolitan financially supports local agencies that develop water supply projects that reduce demands for Metropolitan's imported supplies. Metropolitan provides a

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financial contribution for each acre-foot of water produced by a qualifyin reclamation project. The financial contribution is transferred to a membe agency through a Joint Participation Agreement in which Metropolita guarantees to purchase the project yield at a rate equal to the sum o Metropolitan's reclaimed water rate and the LPP contribution. Metropol tan then sells the yield back to the member agency at the reclaimed wate rate or other appropriate rate, thereby giving the project a net contribution equal to the LPP contribution.

The original Local Projects Program was initiated in late 1981, deferred in 1983 due to Metropolitan's financial constraints, and reactivated and revised in early 1986. Under the original program, Metropolitan provided capital funding for reclamation projects. With the 1986 program revisions Metropolitan contributed the avoided energy cost for pumping an equivalent amount of water through the SWP. The contribution to qualifying projects for fiscal year 1989-90 was $75 per acre-foot.

To meet the reclaimed water goal of 200,000 acre-feet of LPP water by the year 2000, staff members examined the adequacy of the energy-based LPP incentive. They determined that an LPP contribution of $154 per acre-foot would help facilitate goal implementation by more equitably sharing the costs of reclaiming water. The $154 per acre-foot contribution is based on Metropolitan's avoided costs to convey, treat, and distribute water and includes considerations of reliability and service area needs. This contribution is subject to a three to five year periodic review by the Board.

Under the original LPP, Metropolitan participated in two wastewater reclamation projects and one groundwater reclamation project with a combined ultimate yield of 9,000 acre-feet per year. Twelve wastewater reclamation projects and one groundwater reclamation project with a combined total ultimate yield of about 30,225 acre-feet per year are included in the 1986 revised LPP. Four of these wastewater reclamation projects were added this fiscal year. Currently, 15 projects with a total estimated yield of 49,714 acre-feet per year are in various stages of review.

Original Program

In 1982, Metropolitan entered into a Letter of Intent to participate in the Arlington Basin Groundwater Desalter Project (Project) sponsored by the Santa Ana Watershed Project Authority (SAWPA). The Joint Participation Agreement with Western Municipal Water District of Riverside County and SAWPA was executed in October 1988. Under this Project, approximately 6,100 acre-feet per year of high-salinity groundwater from the Arlington Basin will be desalted for local use. The Project will consist of extraction wells, organics removal facilities, reverse osmosis desalting facilities, and connections to the local water distribution systems. Currently under construction, the project will be operational in August 1990.

Revised 1986 Program

During the fiscal year, four projects were negotiated and Joint Participation Agreements were executed to provide a minimum LPP contribution of $75 per acre-foot.

The *Shadowridge Reclaimed Water System* Joint Participation Agreement between Metropolitan, the San Diego County Water Authority (SDCWA), and Buena Sanitation District (BSD) was executed in September 1989. The system will produce up to 375 acre-feet per year of tertiary-treated reclaimed water from BSD's Shadowridge Water Reclamation Plant to irrigate greenbelts and golf courses. BSD will own and operate the Shadowridge Reclaimed Water System.

The *Glendale Water Reclamation Expansion Project* Joint Participation Agreement between Metropolitan and the city of Glendale was executed in October 1989. The project will deliver approximately 600 acre-feet per year of tertiary-treated reclaimed water from the Los Angeles/Glendale Water Reclamation Plant for landscape irrigation. While the expansion project will be owned and operated by the city of Glendale, the reclamation plant is owned and operated by the city of Los Angeles.

The *Trabuco Canyon Reclamation Expansion Project* Joint Participation Agreement between Metropolitan, Municipal Water District of Orange County (MWDOC), and Trabuco County Water District was executed in November 1989. The project expands Santa Ana Mountain County Water District's (SAMCWD) existing Trabuco Canyon Reclamation project to produce approximately 700 acre-feet per year of additional reclaimed water for golf course and landscaping irrigation. This project will be owned and operated by SAMCWD.

The *Los Angeles Greenbelt Project* Joint Participation Agreement between Metropolitan and the Board of Water and Power Commissioners of the city of Los Angeles Department of Water and Power was executed in January 1990. The project will produce approximately 1,600 acre-feet per year of reclaimed water for landscape irrigation and will be operated by the city of Los Angeles Department of Recreation and Parks and the Department of Public Works.

Of the 15 projects currently under review for inclusion in LPP, four projects are in advanced stages of review. The following four projects, with a total ultimate yield of 19,600 acre-feet per year, are expected to be approved by Metropolitan's Board of Directors early next fiscal year.

- The proposed Santa Maria (Ramona) Reclamation Project will produce approximately 1,600 acre-feet per year of reclaimed water from the proposed Santa Maria Water Reclamation Plant for golf course and landscape irrigation. Sponsored by SDCWA, this project will [illegible] owned by the Santa Maria Water District.

- The proposed Molton Niguel Reclamation Project will produce abo[illegible] 8000 acre feet per year of reclaimed water for golf course a[illegible] landscape irrigation. MWDOC will be the sponsor, and the Molt[illegible] Niguel Water District the purveyor.

- The proposed San Clemente Reclamation Project will produce abou[illegible] 4000 acre feet per year of reclaimed water by expanding the existin[illegible] Advanced Wastewater Treatment facility. The reclaimed water wi[illegible] then be used to irrigate parks, golf courses, freeway areas, and greenbelts throughout the city of San Clemente's service area. This project is sponsored by Coastal Municipal Water District and will be owned and operated by the city of San Clemente.

- The proposed Rancho California Reclamation Project will produce approximately 6000 acre feet per year of tertiary-treated reclaimed water from the Rancho California treatment plants for landscape and golf course irrigation. The project is sponsored by Eastern and will be owned and operated by the Rancho California Water District.

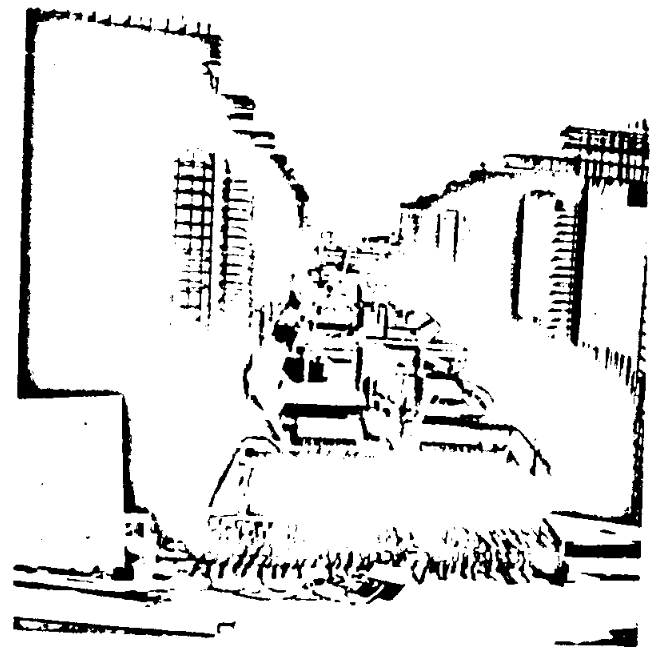
Other Activities

Metropolitan and Central Basin Municipal Water District conducted a study to formulate a project to provide reclaimed water along the Century Freeway and in six neighboring communities for industrial and landscape irrigation purposes. The Feasibility Study and Implementation Plan prepared by HYA Consulting Engineers, identified the service area boundaries, potential users, institutional arrangements, capital facilities, preliminary [illegible] available financial alternatives. The Plan outlines a reclam[illegible] which would serve approximately 4,000 acre-feet per year [illegible]

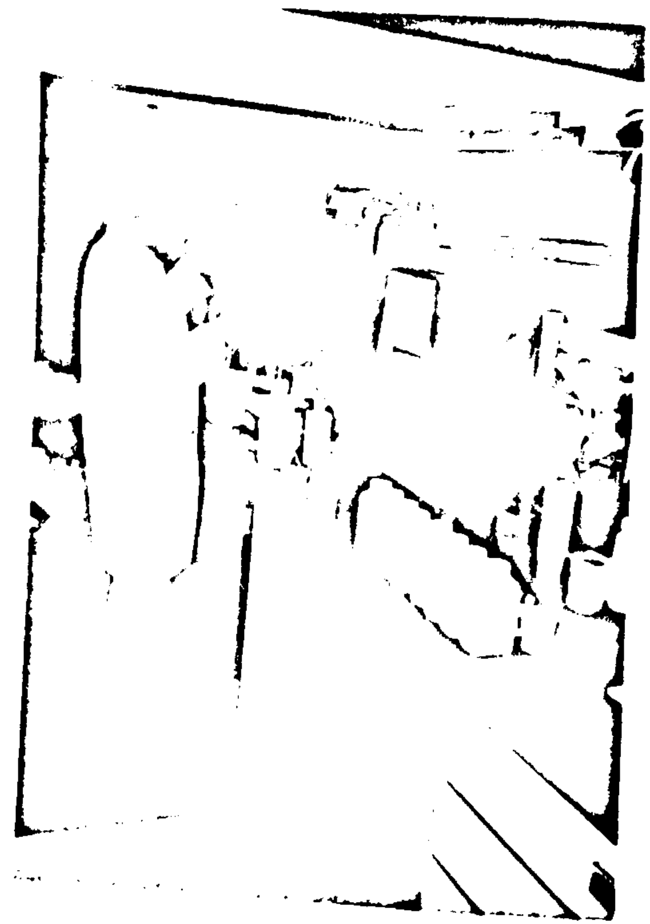
Metrop[illegible] West Basin Municipal Water District (WBMWD) initiated a [illegible] use of reclaimed water within WBMWD's service area. [illegible] conducted by HYA Consulting Engineers will identify po[illegible] reclaimed water supply alternatives develop a [illegible] and perform preliminary cost analyses.

LPP staff is par[illegible] on the San Francisco Bay Sacramento-San Joaquin Delta Es[illegible] Delta) Reclaimed Water Sub-Work Group Committee organized by DWR at SWRCB's request. The Work Group is preparing a rep[illegible] SWRCB that will estimate the State's potential reclaimed water use for the Bay Delta hearing process and will describe management practices and implementation and legislative needs for reclamation projects.

LPP staff is also participating on the State Water Conservation Coalition Reclamation Re-use Task Force organized by the Southern California Water Committee and the Committee for Water Policy Consensus, collectively known as the State Water Conservation Coalition. The Task Force is preparing a report on water reclamation in the State to present to SWRCB for use in the Bay Delta hearings.



Filter beds take shape at the Robert A. Skinner Filtration Plant expansion project.



Analyst determines ammonia-nitrogen concentrations in Metropolitan's treated water

CHAPTER 4

Water Quality

Legislation and Regulations

Considerable legislative and regulatory activity related to drinking water quality issues occurred during the 1989-90 fiscal year. Numerous regulations were proposed or promulgated by the U.S. Environmental Protection Agency (EPA) and the State of California Department of Health Services (DHS). In addition, the California legislature passed several bills affecting water utilities.

At the Federal level, Strawman rules—outlines of key regulatory concepts—were released for the disinfectant disinfection by-product (D/DBP) rule and the groundwater disinfection rule in September 1989 and April 1990, respectively. Metropolitan submitted comments to the EPA on the Strawman rules.

Additionally, the public water system primacy regulations were revised to incorporate the 1986 Safe Drinking Water Act amendments and became final on December 20, 1989.

The EPA is expected to issue final regulations for maximum contaminant levels (MCLs), monitoring, and public notification requirements for lead and copper in mid-1991. Also, the EPA's regulation for Phase II contaminants, which is expected to be finalized in January 1991, will establish MCLs and MCL goals for 30 organic and eight inorganic compounds and add 110 unregulated contaminants for monitoring purposes.

At the State level, public notification regulations for lead became final in February 1990. Additionally, final monitoring requirements for 48 unregulated contaminants were issued in March 1990. To assist the EPA in determining whether standards need to be set, these unregulated contaminants must be monitored quarterly for one year. DHS proposed MCLs for 12 synthetic organic chemicals on August 1, 1989. These regulated contaminants must be monitored quarterly for one year and, if none are found, may subsequently be monitored once every two years.

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Responding to a recent State regulation, Metropolitan prepared and m[illegible] available to the general public its first annual water quality report [illegible] assisted its member agencies in preparing their reports.

On April 3, 1990 DHS proposed surface water filtration requireme[illegible] which are expected to be finalized in January 1991. Metropolitan commen[illegible] on the proposed regulations at a June 13, 1990, public hearing.

Also, through the Ad Hoc Committee of the California-Nevada Sectio[n] of the American Water Works Association (AWWA), Metropolitan beg[an] reviewing drafts of the State's Total Coliform Rule (TCR) in June 1990.

During the year, the California legislature considered numerous drinking water quality issues. Assembly Bill 21, which provides for State primacy in making and enforcing stricter drinking water regulations, became effective on January 1, 1990. This bill significantly impacts water utilities, as it establishes recommended public health levels (RPHLs) for contaminants in water. These health-based standards require water utilities to evaluate contaminant reduction methods when the RPHLs are exceeded. Metropolitan is providing technical input to DHS on setting RPHLs.

General Water Quality

Metropolitan continued to meet all of DHS' primary standards and EPA's MCLs for drinking water.

For the [illegible] consecutive year, the fiscal-year average of total dissolve[d] solids (TDS) in Colorado River water (CRW) at Lake Havasu increased, rising from [illegible] milligrams per liter (mg/L) in fiscal year 1988-89 to 589 mg/L in fiscal year 1989-90, as shown in Figure 10. This TDS value is the highes[t] concentration in the past [illegible] years and is 19 mg/L below the 10-year averag[e] of 608 mg/L. Metropolitan continues to participate in the Colorado Riv[er] Basin Salinity Forum Work Group addressing concerns about future TD[S] increases.

As shown in Figure 11, the average TDS value for State project wate[r] from the California Aqueduct's West Branch at Castaic Lake was 351 mg/L—the highest TDS concentration in the past eight years and the fift[h] consecutive yearly increase. As seen in Figure 12, the average TDS for East Branch water from Silverwood Lake, 303 mg/L, was 47 mg/L lower than the 1988-89 fiscal year average. However, this value is the third-highest TDS average recorded during the 17 years since Metropolitan began using East Branch water. For treated water at the five filtration plants, the weighted average TDS value was 443 mg/L, a slight decline of 16 mg/L from the previous year's average of 459 mg/L.

The bacteriological quality of water in Metropolitan's system continues to be excellent. As shown in Tables 20, 21, and 22, distribution samples tested by the membrane filter technique for coliform bacteria produced monthly averages ranging from less than 0.001 to 0.054 coliforms per 100 milliliters (ml), falling considerably below the DHS standard of 1 coliform/100 ml. Beginning on December 31, 1990, total coliforms will be reported as a percentage of positive samples per the TCR, rather than as a monthly average of coliform colonies, as is currently required.

Metropolitan contracted with the University of California, Irvine, to evaluate the new coliform detection product's usefulness in complying with the TCR. Results of analyses indicated that whereas the new commercially available products (Colilert and Coliquik) were effective for detecting total coliforms, they underestimated the presence of *Escherichia coli*, a specific member of the coliform group the TCR regulates.

In July 1989 and again in May 1990, the disinfectant in the distribution systems of Metropolitan and its member agencies was changed for a one-month period from chloramines to free chlorine to control nitrification. As an additional nitrification control strategy, the chlorine-to-nitrogen weight ratio in Metropolitan's distribution system was increased from 3:1 to 5:1, by reducing the total ammonia-nitrogen concentration from 0.5 to 0.3 mg/L, beginning in August 1989. Increasing this ratio reduces the amount of free ammonia, which nitrifying bacteria require for growth. Collectively, these strategies have significantly reduced nitrification in the distribution systems of Metropolitan and its member agencies. Metropolitan also initiated a comprehensive one-year laboratory study, beginning in November 1989, to determine the disinfectant conditions necessary to prevent nitrifier growth.

The environmental laboratory accreditation program (ELAP) became effective on January 1, 1989. Under this program, analytical tests required by law for public water systems must be performed by accredited laboratories. For currently certified laboratories, the accreditation requirement begins when the existing certificates expire. As part of ELAP, the Water Quality Laboratory conducted quality performance evaluation analyses in May 1990 for general mineral and physical parameters, trace metals, volatile organic compounds (VOCs), pesticides, herbicides, trihalomethanes (THMs), and other DBPs.

In May 1990, the Occupational Safety and Health Administration promulgated a new standard entitled "Occupational Exposures to Hazardous Chemicals in Laboratories," which requires water utilities to implement a chemical hygiene plan by January 31, 1991. Metropolitan's Environmental Safety and Health Section has hired Clayton Environmental to assist in developing and implementing this plan.

The Digital Equipment Corporation (DEC) Varian laboratory informat[illegible] management system (LIMS) was completely implemented. Since increas[illegible] regulatory activity has required more analyses, a study to upgrade [illegible] current computer system's capacity was initiated. Additionally, becau[illegible] the DEC Varian software has been discontinued and full software supp[illegible] will no longer be available, other LIMS software packages are bei[illegible] evaluated.

In June 1989, staff from Arthur D. Little, Inc., returned to the Wat[illegible] Quality Laboratory and trained eight staff members for the flavor-profil[illegible] panel. Operations Division staff from the treatment plants also received introductory training in flavor profile analysis.

Trace Constituents

In November 1989, Metropolitan analyzed source waters and filtration plant effluents for 16 metals (Table 23). All concentrations of primary and secondary standard metals were substantially lower than DHS standards for filtration plant effluents.

Metropolitan monitored VOCs for one quarter at the sample locations listed in Table 24. Except for THMs, no VOCs were detected. Metropolitan has now completed four quarters of required monitoring, and, though required to monitor for VOCs every two years, will monitor VOCs twice each year to address the public's concerns.

In February 1990, Metropolitan completed the four consecutive quarters of required monitoring for pesticides and herbicides in source and treated waters. As shown in Table 25, none of the pesticides or herbicides for which analysis was done was detected.

Metropolitan [illegible] quarter of monitoring for base neutral and acid extractable [illegible] compounds in source and treated waters. None was detected as shown in Table 26. Tables 27 through 29 list the results of other analyses on Metropolitan's waters.

Metropolitan's [illegible] the Southern California radon survey. Black and Veatch, Inc., submitted its final report in January 1990. The study provided information on radon levels in groundwater to address upcoming federal regulations, which [illegible] probably establish the radon MCL between 200 and 500 picoCuries per liter (pCi/L). Although most wells tested had radon levels in this range, approximately 86 percent of the wells tested would exceed an MCL set at 200 pCi/L. By comparison, Metropolitan's source water radon levels are typically less than 10 pCi/L. If member agencies should abandon wells containing radon levels above the MCL, this could impact Metropolitan's conjunctive-use program planning and increase water demands on Metropolitan.

THMs and Other DBPs

Metropolitan continued to comply with the EPA and DHS MCL of 0.10 mg/L for total THMs. As shown in Table 30, the running annual average calculated from the distribution system's four quarterly averages was 0.066 mg/L. In the third and fourth quarters of 1989, Metropolitan continued to monitor for haloacetic acids (HAAs); haloacetonitriles; haloketones; chloropicrin; chloral hydrate; cyanogen chloride; 2,4,6-trichlorophenol; formaldehyde; and acetaldehyde in the distribution system. In general, DBP production increased with temperature and percent of State project water. The THMs constituted the largest fraction of DBPs based on weight, followed by HAAs as shown in Tables 31 and 32. The level of brominated DBPs increased as the percent of State project water increased in the blend because State project water contains a higher bromide concentration than does CRW [a result of seawater intrusion into the Sacramento-San Joaquin Delta Estuary (Delta)]. Metropolitan discontinued monitoring for these and other DBPs after the fourth quarter of 1989 to develop analytical methods for detecting ozone DBPs for the oxidant pilot plant and ozone by-product studies.

A draft report by the California Department of Water Resources (DWR), prepared with Metropolitan's review, demonstrates that agricultural drainage into the Delta is contributing approximately 45 percent of the State project water THM formation potential. These data have provided the impetus for the California legislature and DHS to request that the State Water Resources Control Board and the DWR find solutions to minimize DBP precursors from saltwater intrusion and agricultural drainage.

Five consecutive quarters of THM monitoring in Metropolitan's desert pumping plants' domestic treatment systems, completed in November 1989, indicate that all systems would have difficulty in meeting a new THM standard if it were set at 0.05 mg/L. A study currently being conducted by Brown and Caldwell Consultants will evaluate the treatment systems and recommend improvements to ensure compliance with the new regulations.

Metropolitan's Water Quality Division staff continued to manage and provide technical support for an AWWA D/DBP Technical Advisory Workgroup (TAW). The D/DBP TAW is providing input into the EPA's D/DBP and Groundwater Disinfection rules.

Through the D/DBP TAW's efforts, with analytical assistance from Metropolitan and funding from the AWWA, James M. Montgomery, Consulting Engineers, Inc. (Montgomery), is developing mathematical models to predict the types and amounts of DBPs that a utility may experience based on its raw-water characteristics and operational treatment practices. These models will allow a utility to investigate alternative treatments to control DBPs. In a related effort, Malcolm Pirnie, Inc., which originally developed a model for predicting THM formation, is determining wh[illegible]ther Metropolitan's member agencies will be able to comply with [illegible]ure disinfection and DBP regulations. Member agencies unable to meet [illegible]ure regulations may rely on Metropolitan to provide more treated wa[illegible]r.

In November 1990 bench-scale testing was initiated to evaluate the impact of optimized coagulation on THM precursor removal in State project water and CRW. THM formation potential test results indicated that high doses of alum (up to 100 mg/L), together with a cationic polymer, reduced THM precursors by 28 percent in State project water and 30 percent in CRW when the pH was not adjusted after alum addition.

Metropolitan is one of five utilities providing additional funding and analytical support for a project awarded by the AWWA Research Foundation (AWWARF) to the University of North Carolina to identify ozone DBPs and their occurrence in North America.

Pathogen Monitoring

In November 1990 Metropolitan contracted with the University of New Hampshire for a one-year study to develop gene probe methods for rapidly mon[illegible] viruses in Metropolitan's source waters. As part of the study, the University of Arizona is analyzing split samples by the [illegible] Albuquerque and Metropolitan will analyze them [illegible] gene probe procedure. To date, more and [illegible] has been observed between the gene-probe [illegible]

In De[illegible] Univer[illegible] initiated a collaborative study with th[illegible] Cryp[illegible] gene probes to detect *Giardia* an[illegible] These te[illegible] as common waterborne pathogens detection [illegible] decrease analysis time for pathogen [illegible] fluorescent antibody procedures.

Reservoir Manage[illegible]

Lakes Mathews [illegible] blue green algae [illegible] affected by extensive growths of benthic and geosmin. In Lake M[illegible] odorants 2-methylisoborneol (MIB) (T&O) producer, *Pho[illegible]* appearance of a new taste-and-odor began earlier in the season and lasted longer than in previous years. To stem this alga's growth, 3[illegible] tons of copper sulfate were applied to the lake. Diver inspections and laboratory experiments indicated that *Phormidium* is different from other T&O producers found in Metropolitan's source waters in that it grows at greater depth (up to 75 feet) and is more resistant to copper sulfate. To prevent the growth of T&O-producing *Oscillatoria* spp. in Lake Skinner, 105 tons of copper sulfate were effectively applied to the shallow areas. At Castaic Lake, geosmin levels as high as

250 nanograms per liter were produced by a surface bloom of a planktonic blue-green alga, *Anabaena* spp. Consequently, water used by Metropolitan had to be withdrawn from lower depths of the lake, where geosmin levels were much lower.

Metropolitan contracted with Paul Beatty and Associates to evaluate using grass carp for controlling aquatic plants and algae in its source waters and canals. The consultant indicated that grass carp would be ineffective in Metropolitan's source waters.

The U.S. Department of Agriculture completed a two-year study, partially funded by Metropolitan, to develop immunodiagnostic procedures to rapidly detect MIB and geosmin in environmental samples. Although antibodies to these compounds were successfully developed, the technique's sensitivity was too low to adequately detect these odorants in water without preconcentration.

Chlorination continued to be effective in controlling attached algae growths and biofilm formation in the San Diego Canal.

San Joaquin Reservoir (SJR), a 3,000-acre-foot, uncovered, finished-water reservoir serving communities in southern Orange County, was removed from service on three occasions (for a total of 34 days) because of elevated coliform activity in service connections receiving water from SJR. An Environmental Impact Report is being prepared to address options for improving SJR's water quality.

Oxidation Demonstration Project

With partial funding from the AWWARF and technical assistance from Montgomery, pilot-scale testing continued to evaluate the effectiveness of ozone and PEROXONE (the combination of ozone and hydrogen peroxide) for controling T&O compounds, microorganisms, and DBPs. Montgomery is preparing a report detailing the results obtained during the two-year pilot study, which was completed in June 1990, and it will become available from the AWWARF in early 1991.

Key issues examined during the study's second year included evaluating the impact of bromide in State project water on the production of brominated DBPs by ozone and PEROXONE, the production and removal of assimilable organic carbon (AOC), and the importance of ozone residuals in predicting the amount of *Giardia* cyst inactivation. With regard to the bromide issue, ozonation of State project water (dosed with added bromide to simulate severe saltwater intrusion into the Delta) yielded significant levels of bromoform and dibromoacetic acid. Ozone with ammonia addition or treatment with PEROXONE resulted in substantially lower levels of these compounds. In contrast, unamended State project water treated with PEROXONE produced higher bromate levels than it did when treated with ozone. The AOC analyses showed that without a secondary disinfectant added, the dual-media filter bed developed a biofilm capable of reducing AOC, formaldehyde, and selected brominated organic DBPs. However, when a secondary disinfectant was added before the filters, biodegradation of these undesirable compounds did not occur. Finally, disinfection results consistently demonstrated that ozone residual is the key to achieving adequate levels of inactivation of viruses and Giardia. These data were used to provide input to the EPA in developing disinfection regulations for ozone.

A 5.5-million-gallon-per-day (mgd) demonstration-scale plant is being constructed to further evaluate the ozone and PEROXONE treatment processes. The design phase of the project, completed in December 1990, was followed by a five-month bid-and-award period to select a construction contractor. The oxidation demonstration project's objectives are to confirm the results of the pilot-scale studies, evaluate processes and equipment, and provide the information necessary to retrofit Metropolitan's filtration plants with ozone/PEROXONE. The project staff expects that the ozone generation system and contactors will be on line by November 1991.

Treatment Plant Studies

Major emphasis was placed on developing and implementing an action plan to meet the upcoming Surface Water Treatment Rule (SWTR), which affects all Metropolitan filtration plants, including the desert pumping plants' domestic treatment facilities. The plan's key components include evaluating the filtration plants' process reliability, optimizing their washwater reclamation systems, developing emergency disinfection and operations plans, and evaluating the plants' pathogen removal capabilities.

In April and May 1990, conceptual design studies, conducted with the assistance of CH2M Hill, Inc., were completed for the Robert B. Diemer Filtration Plant (Diemer plant) uprating and the Henry J. Mills Filtration Plant (Mills plant) expansion. The Diemer plant study recommended improving the flash mixing, flocculation, and filtration processes to increase the design nameplate capacity from 400 to 518 mgd. The Mills study suggested modifications to improve the plant's reliability and performance. Recommendations for expanding the Mills plant included installing pumped-injection flash mixers, paddle-type flocculators, and tri-media filters.

Assisted by CH2M Hill, Inc., Metropolitan's staff initiated conceptual design studies in April 1990 for the new Central Pool Augmentation Filtration Plant and for uprating the F. E. Weymouth Filtration Plant (Weymouth plant). These studies will evaluate unit process requirements and recommend design criteria for the new plant and determine possible modifications to the Weymouth plant.

In June 1990, Metropolitan contracted with Montgomery to evaluate unit processes and recommend design criteria for a proposed filtration plant capable of treating water from Lake Perris. Adverse water quality conditions periodically experienced in the lake, including microbiological contamination from body contact and severe T&O episodes, could require enhanced ozone/PEROXONE feed capabilities and granular activated carbon (GAC) in addition to full conventional treatment.

A one-year study was initiated at the Mills plant in June 1990 to evaluate ferric chloride's effectiveness and feasibility as a coagulant for eventual use by Metropolitan.

In April 1990, groundwater from below and adjacent to the finished-water reservoir at the Joseph Jensen Filtration Plant (Jensen plant) was removed (and subsequently treated with ion exchange to meet discharge requirements) to prevent possible damage to the reservoir caused by a significant drawdown of water to meet water demands during a planned shutdown.

In June 1990, a treatment facility consisting of an oil-water separator and two 2,000-pound GAC absorbers was installed at the Magazine Canyon shaft to treat hydrocarbon-contaminated water, which began entering the Jensen plant from the Newhall Tunnel. The treatment reduced concentrations of organic contaminants to below detectable levels so the water could be returned to the Magazine Canyon shaft.

As part of the SWTR action plan, a tracer test was conducted at the Mills plant in October 1989 to determine hydraulic detention times, which will be used to assess the plant's ability to meet disinfection requirements. Results of the tracer test indicated that baffling would have to be installed to prevent the substantial hydraulic short-circuiting occurring in the flocculation basins.

Tracer studies were also conducted within the finished-water reservoirs at the Weymouth, Jensen, and Mills plants to determine actual hydraulic detention times. The results indicated that short-circuiting of flow occurs to varying degrees in all three reservoirs. This information will prove useful for future reservoir operation and for the design of additional facilities to provide sufficient disinfection contact time following chloramine addition.

Operational Activities

More than 60 monitoring reports were prepared and submitted to regulatory agencies concerning Metropolitan's water, waste water, and sludge discharges to comply with the 13 discharge permits or Board Orders issued to Metropolitan by the California Regional Water Quality Control Boards and other agencies. In addition, applications for four permit renewals were submitted, one special discharge permit was obtained, and more than 25 dechlorinations were conducted as part of various dewatering activities. Surveys conducted to identify unpermitted discharges from Metropolitan's facilities indicated that many new permits are needed.

Assistance to Others

Metropolitan provided analytical assistance with nitrification problems and recommended corrective measures to the city of Garden Grove, the Foothill Municipal Water District, and the Municipal Water District of Orange County. Throughout the year, other member agencies and subagencies received assistance in resolving water quality degradation problems.

Metropolitan organized and implemented regular meetings of the Member Agency Water Quality Directors to encourage information exchanges between Metropolitan and its member agencies and subagencies on water quality and regulatory matters.

Water Quality Publications and Presentations

During the fiscal year, Water Quality Division staff members were responsible as authors (or co-authors) for 11 feature articles published in professional journals such as [illegible] and [illegible] *[illegible] Science and Technology, Applied [illegible]* [illegible] the *Journal of Water Supply Research and Technology* [illegible] *Journal*. Water Quality Division personnel were also principal or secondary authors of 13 papers presented at professional conferences and symposia, including the AWWA's Annual Conference, Water Quality [illegible] Conference, and California-Nevada Section meetings, [illegible] Ozone Association's Pan American Committee Conference, [illegible] the Annual Meeting of the American Society for Microbiology.

TABLE 20
COLIFORM CONTENT OF METROPOLITAN'S DISTRIBUTION SYSTEM
Fiscal Year 1989-90
Membrane Filter Method
(100 ml Samples)

Month	Number of Samples Examined at Each Metropolitan Laboratory					Distribution System Summary					
	La Verne Water Quality Lab	Diemer Plant	Jensen Plant	Skinner Plant	Mills Plant	Total Number of Samples	Number of Positive Samples	No. Samples with 4 or more Coliforms	Pct. Samples with 4 or more Coliforms	Total Number of Coliforms	Avg. No. of Coliforms per Sample
July	419	260	128	27	16	850	0	0	0.000	0	0.000
August	570	310	162	31	18	1,091	0	0	0.000	0	0.000
September	488	263	200	24	15	990	3	1	0.101	53	0.054
October	512	272	224	18	16	1,042	2	0	0.000	2	0.002
November	503	293	136	17	16	965	0	0	0.000	0	0.000
December	475	272	144	19	14	924	0	0	0.000	0	0.000
January	485	310	152	14	13	974	2	0	0.000	2	0.002
February	428	279	128	13	13	861	1	0	0.000	1	0.001
March	468	353	136	15	17	989	0	0	0.000	0	0.000
April	475	315	117	18	16	941	1	0	0.000	1	0.001
May	523	350	152	21	18	1,064	5	3	0.282	20	0.019
June	449	403	128	26	17	1,023	3	1	0.098	11	0.011
Total	5,795	3,680	1,807	243	189	11,714	17	5	—	90	—
Average	483	307	151	20	16	976	0.0015*	0.0004*	0.043*	—	0.008*

Note
*Ratio of total number of positive samples (or coliforms) to total number of samples

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TABLE 21

COLIFORM CONTENT OF METROPOLITAN'S FILTRATION PLANT INFLUENTS

Fiscal Year [illegible]

Multiple Fermentation Tube Method (MPN*)

Month	Weymouth Plant Influent			Diemer Plant Influent			Jensen Plant Influent			Skinner Plant Influent			Mills Plant Influent		
	Number of Samples	Percent of Samples Positive	Median MPN	Number of Samples	Percent of Samples Positive	Median MPN	Number of Samples	Percent of Samples Positive	Median MPN	Number of Samples	Percent of Samples Positive	Median MPN	Number of Samples	Percent of Samples Positive	Median MPN
July	[illegible]	[illegible]	[illegible]	[illegible]	87.5	24	[illegible]	[illegible]	[illegible]	[illegible]	96.8	[illegible]	16	100.0	41
August	[illegible]	100.0	23	19	100.0	30	21	[illegible]	[illegible]	30	93.3	235	18	88.9	23
September	16	93.8	12	16	100.0	23	21	[illegible]	[illegible]	30	90.0	25	15	93.3	17
October	17	100.0	11	17	94.1	23	23	[illegible]	34	29	82.8	5	16	87.5	11
November	17	100.0	27	18	100.0	40	29	[illegible]	14	29	93.1	7	16	100.0	8
December	17	88.2	79	18	88.9	95	31	100.0	30	29	86.2	8	10	90.0	36
January	18	100.0	79	30	93.3	85	31	100.0	28	31	87.1	13	12	100.0	26
February	16	100.0	40	28	100.0	85	28	100.0	20	28	89.3	30	14	100.0	30
March	17	100.0	130	31	100.0	110	31	96.8	7	31	100.0	30	17	88.2	7
April	17	100.0	80	30	100.0	75	22	100.0	20	28	89.3	8	16	100.0	8
May	19	100.0	30	31	96.8	50	30	96.7	8	30	83.3	13	17	88.2	7
June	16	100.0	30	30	100.0	43	30	66.7	4	30	90.0	25	17	88.2	7
TOTAL	204			284			322			356			184		
Average	17	97.5	30	24	97.2	46	27	92.5	20	30	90.2	19	15	93.5	14

Note

*MPN = Most probable number of coliform bacteria per 100 ml sample

TABLE 22

COLIFORM CONTENT OF METROPOLITAN'S FILTRATION PLANT EFFLUENTS

Fiscal Year 1989-90

Membrane Filter Method

(100 ml Samples)

Month	Weymouth Plant		Diemer Plant		Jensen Plant		Skinner Plant 1		Skinner Plant 2		Mills Plant	
	No. of Samples	Percent Positive	No. of Samples	Percent Positive	No. of Samples	Percent Positive	No. of Samples	Percent Positive	No. of Samples	Percent Positive	No. of Samples	Percent Positive
July	14	0	16	0	17	0	31	0	31	0	16	0
August	19	0	19	0	38	0	30	0	30	0	18	0
September	16	0	16	0	19	0	30	0	30	0	15	0
October	17	0	17	0	23	0	29	0	29	0	16	0
November	17	0	18	0	58	0	29	0	28	0	16	0
December	17	0	18	0	47	0	30	0	30	0	14	0
January	18	0	30	0	31	0	31	0	31	0	13	0
February	16	0	28	0	28	0	28	0	28	0	13	0
March	17	0	31	0	31	0	31	0	31	0	17	0
April	17	0	30	0	27	0	29	0	29	0	16	0
May	19	0	31	0	31	0	30	0	30	0	18	0
June	16	0	30	0	30	0	30	0	30	0	17	0
TOTAL	203	0	284	0	380	0	358	0	357	0	189	0

TABLE 23

ANALYSIS OF TRACE METALS IN METROPOLITAN WATER SUPPLIES

Fiscal Year 1989-90 Averages*

Micrograms per Liter (µg/L)

Metal	Maximum Contaminant Level	Detection Limit	Source Waters										Filtration Plant Effluents					
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aluminum	[illegible]	[illegible]	8[illegible]	58	64	45	[illegible]	58	22	[illegible]	64	93	154	144	75	214	190	139
Arsenic	50	[illegible]	3	2	3	2	2	2	2	2	3	2	2	2	2	2	2	2
Barium	1000	5	172	140	150	44	39	37	51	82	96	96	81	101	37	110	98	42
Cadmium	10	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	50	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	1000**	10	ND	ND	41	ND	ND	ND	ND	19	24	15	12	12	ND	ND	10	ND
Iron	300**	20	75	79	61	6[illegible]	449	141	21	249	112	61	ND	ND	ND	ND	ND	ND
Lead	50	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lithium		10	40	31	36	ND	ND	ND	ND	20	19	24	20	19	ND	21	21	ND
Manganese	50**	5	11	10	8	8	35	16	11	22	12	10	ND	ND	ND	ND	ND	ND
Mercury	2	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum		2	7	6	[illegible]	2	2	2	2	5	4	5	4	4	2	5	4	2
Selenium	10	1	2	2		ND	ND	ND	ND	1	1	1	1	1	ND	1	1	ND
Silver	50	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Strontium		20	940	895	905	240	175	175	230	540	530	620	550	575	240	595	580	175
Zinc	5000**	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

*For results below the detection limit, the averages were calculated by assuming a value of one half the detection limit.

**Secondary standard based on consumer acceptance rather than health considerations. Applicable to filtration plant effluents only.

ND = None detected

TABLE 24

VOLATILE ORGANIC COMPOUNDS

Fiscal Year 1989-90

Micrograms per Liter (µg/L)

Location	Compound Detected	February/March 1990
Source Waters		
Jensen influent	None	ND
Devil Canyon afterbay	None	ND
Lake Havasu near intake	None	ND
Lake Mathews headworks	THMs	0.98
Lake Perris	None	ND
Lake Skinner outlet conduit	THMs	0.71
Filtration Plants		
Diemer Plant Effluent	THMs	64
Jensen Plant Effluent	THMs	65
Mills Plant Effluent	THMs	10
Skinner Plant 1 Effluent	THMs	27
Skinner Plant 2 Effluent	THMs	27
Weymouth Plant Effluent	THMs	58

Regulatory Information and Minimum Reporting Levels

COMPOUND	DHS Action Level (µg/L)	DHS Taste and Odor Threshold (µg/L)	DHS MCL (mg/L)	EPA MCL (mg/L)	DHS DLR (µg/L)	MWD MRL June 1990 (µg/L)
Benzene			0.001	0.005	0.5	0.5
Bromobenzene					0.5	0.5
Bromochloromethane					0.5	0.5
Bromodichloromethane				#	0.5	0.1
Bromoform				#	0.5	0.1
Bromomethane					0.5	0.5
n-Butylbenzene					0.5	0.5
sec-Butylbenzene					0.5	0.5
tert-Butylbenzene					0.5	0.5
Carbon tetrachloride			0.0005	0.005	0.5	0.5
Chlorobenzene			0.030		0.5	0.5
Chloroethane					0.5	0.5
bis (2-Chloroethyl) ether						5.0
2-Chloroethylvinyl ether					1.0	1.0
Chloroform				#	0.5	0.1
Chloromethane					0.5	0.5
2-Chlorotoluene					0.5	0.5
4-Chlorotoluene					0.5	0.5
Dibromochloromethane				#	0.5	0.1
Dibromochloropropane (DBCP)			0.0002		0.01	0.01
1,2-Dibromoethane			0.00002		0.02	0.02
Dibromomethane					0.5	0.5
1,2-Dichlorobenzene	130.0	10			0.5	0.5
1,3-Dichlorobenzene	130.0	20			0.5	0.5
1,4-Dichlorobenzene			0.005	0.075	0.5	0.5
Dichlorodifluoromethane					0.5	0.5
1,1-Dichloroethane	5.0				0.5	0.5
1,2-Dichloroethane			0.0005	0.005	0.5	0.5
1,1-Dichloroethane			0.006	0.007	0.5	0.5

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TABLE 24 (Continued)

VOLATILE ORGANIC COMPOUNDS

Fiscal Year 1989-90

Micrograms per Liter (µg/L)

COMPOUND	DHS Action Level (µg/L)	DHS Taste and Odor Threshold (µg/L)	DHS MCL (mg/L)	EPA MCL (mg/L)	DHS DLR (µg/L)	MWD MRL June 1990 (µg/L)
cis-1,2-Dichloroethylene	6.0					
trans-1,2-Dichloroethylene	10.0				0.5	0.5
1,2-Dichlorobenzene	5.0				0.5	0.5
1,3-Dichlorobenzene					0.5	0.5
2,2-Dichloropropane					0.5	0.5
1,1-Dichloropropene					0.5	0.5
cis-1,3-Dichloropropene &			0.0005		0.5	0.5
trans-1,3-Dichloropropene					0.5	0.5
Ethylbenzene			0.680			
Hexachlorobutadiene					0.5	0.5
Isopropylbenzene					0.5	0.5
p-Isopropyltoluene					0.5	0.5
Methyl ethyl ketone					0.5	0.5
Methyl isobutyl ketone					5.0	1.0
Methylene chloride	40.0				5.0	1.0
Naphthalene					0.5	0.5
n-Propylbenzene					0.5	0.5
Styrene					0.5	0.5
1,1,1,2-Tetrachloroethane					0.5	0.5
1,1,2,2-Tetrachloroethane			0.001		0.5	0.5
Tetrachloroethylene			0.005		0.5	0.5
Toluene	100.0				0.5	0.5
1,2,3-Trichlorobenzene					0.5	0.5
1,2,4-Trichlorobenzene					0.5	0.5
1,1,1-Trichloroethane			0.200	0.20	0.5	0.5
1,1,2-Trichloroethane			0.032		0.5	0.5
Trichloroethylene			0.005	0.005	0.5	0.5
Trichlorofluoromethane	150.0				0.5	0.5
1,2,3-Trichloropropane					0.5	0.5
1,2,4-Trimethylbenzene					0.5	0.5
1,3,5-Trimethylbenzene					0.5	0.5
Vinyl chloride			0.0005	0.002	0.5	0.5
Xylenes, meta, ortho & para			1.750		0.5	0.5
[illegible]					0.5	0.5

DHS = California Department of Health Services
EPA = U.S. Environmental Protection Agency
MCL = Maximum contaminant level
# = The MCL for total trihalomethane (four compounds) is 0.10 mg/L
ND = Not detected
DLR = Detection limit for purposes of reporting
MRL = Minimum reporting level

TABLE 25

PESTICIDE AND HERBICIDE CHEMICALS

Fiscal Year 1989-90

Quarterly Results

Location	Compound Detected	August 1989	November 1989	February 1990
Source Waters				
Jensen Influent	None	ND	ND	ND
Devil Canyon afterbay	None	ND	ND	ND
Lake Havasu near intake	None	ND	ND	ND
Lake Mathews headworks	None	ND	ND	ND
Lake Perris	None	ND	ND	ND
Lake Skinner outlet conduit	None	ND	ND	ND
Filtration Plants				
Diemer Plant Effluent	None	ND	ND	ND
Jensen Plant Effluent	None	ND	ND	ND
Mills Plant Effluent	None	ND	ND	ND
Skinner Plant 1 Effluent	None	ND	ND	ND
Skinner Plant 2 Effluent	None	ND	ND	ND
Weymouth Plant Effluent	None	ND	ND	ND

Regulatory Information and Minimum Reporting Levels

COMPOUND	DHS ACTION Level µg/L	DHS MCL mg/L	EPA MCL mg/L	DHS DLR µg/L	MRL Feb 1990 µg/L
Organochlorine Pesticides:					
Alachlor	(LQ=0.2)				0.1
a-BHC	0.7				0.02
b-BHC	0.3				0.02
d-BHC					0.02
g-BHC (Lindane)		0.004	0.004	0.4	0.02
Chlordane	0.1			0.1	0.1
Chlorothalonil					0.05
4,4-DDD					0.01
4,4-DDE					0.01
4,4-DDT					0.01
Endrin		0.0002	0.0002	0.01	0.01
Heptachlor	0.01			0.01	0.01
Heptachlor epoxide	0.01			0.01	0.01
Methoxychlor		0.1	0.1	100.0	0.1
Toxaphene		0.005	0.005	0.5	0.5
Organophosphorus Pesticides and Triazine Herbicides					
Atrazine		0.003		1.0	0.4
Bromacil					5.0
Diazinon	14.0				0.5
Dimethoate	140.0				0.5
Malathion*	160.0				1.0
Molinate		0.02		2.0	0.5
Prometryn					0.5
Simazine		0.010		1.0	0.2
Thiobencarb		0.07		0.8	0.90**
Organochlorine Herbicides:					
Bentazon		0.018		2.0	0.5
2,4-D		0.1	0.1	100.0	0.5
2,4,5-TP (Silvex)		0.01	0.01	1.0	0.2
2,4,5-T					0.2
Miscellaneous Pesticides:					
Glyphosate***	700.0				5.0

ND = Not detected
MCL = Maximum contaminant level
LQ = Limit of quantification
DLR = Detection limit for purposes of reporting
* Malathion was analyzed in February 1990 only
** Metropolitan's Water Quality Laboratory was approved by the DHS at this MRL for analysis of thiobencarb
*** Analyzed by North Coast Laboratories in February 1990
DHS = California Department of Health Services
EPA = U.S. Environmental Protection Agency
MRL = Minimum reporting level

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TABLE 26

BASE/NEUTRAL AND ACID EXTRACTABLE ORGANIC COMPOUNDS

Fiscal Year 1989-90

Quarterly Results

Location	Compound Detected	February 1990
Source Waters		
[illegible]	[illegible]	[illegible]
Filtration Plants		
[illegible]	[illegible]	[illegible]

Regulatory Information and Minimum Reporting Levels

COMPOUND*	DHS ACTION LEVEL (µg/L)	MRL (µg/L)	COMPOUND*	DHS ACTION LEVEL (µg/L)	MRL (µg/L)
Base/Neutral Compounds			Base/Neutral (Cont.)		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Acid Extractable Compounds		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Hazardous Substances (Included in BNA analysis)		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

TABLE 27

METHYLENE-BLUE ACTIVE SUBSTANCES (MBAS) METROPOLITAN SOURCE WATERS

Samples collected in November 1989

Location	Surfactants* mg/L
Lake Havasu near Whitsett Intake Pumping Plant	<0.1
San Jacinto Tunnel, West Portal	<0.1
Lake Mathews Effluent	<0.1
Silverwood Lake Effluent	<0.1
Lake Perris (surface)	<0.1
Lake Skinner Effluent	<0.1
Castaic Lake Effluent at Jensen Plant Influent	<0.1

Note

*The maximum contaminant level for MBAS foaming agents is 0.5 mg/L, a secondary standard based on consumer acceptance rather than health considerations.

TABLE 28

RESULTS OF GROSS ALPHA RADIOACTIVITY ANALYSES

Special Sampling Program: Lakes Mead and Havasu

Fiscal Year 1989-90

(picoCuries per Liter*)

Sample Month	Lake Mead Surface	Lake Mead at Takeout Depth	Lake Mead near Bottom	Lake Havasu at MWD Intake
July	2.6±2.0	3.8±1.0	1.6±1.8	2.0±2.0
August	3.7±0.9	2.8±0.8	2.3±2.2	3.2±1.2
September	2.1±2.0	5.5±2.4	8.0±2.9	1.1±0.4
October	5.0±2.1	3.4±2.2	0.6±1.7	Not Analyzed
November	1.6±1.8	1.4±0.7	0.7±1.3	1.2±0.8
December	3.7±1.8	3.3±1.8	3.7±2.1	Not Analyzed
January	2.4±1.8	2.8±1.8	2.5±1.8	1.4±1.6
February	0.8±1.5	2.7±1.8	1.7±1.8	1.0±1.6
March	4.8±2.1	4.5±2.2	3.9±2.0	5.0±2.4
April	<0.2±1.4	1.7±1.8	2.0±1.9	4.3±1.5
May	2.5±1.2	2.2±0.7	1.2±1.2	3.1±1.3
June	3.8±2.1	3.0±1.9	3.3±2.0	0.6±1.5
Average	2.8±1.7	3.1±1.6	2.6±1.9	2.3±1.4

Note

*Results include instrument counting variability reported as ± 1.96 standard deviations (95 percent confidence level). The maximum contaminant level for gross alpha radioactivity is 15 picoCuries per liter.

R0049320

TABLE 29

GENERAL MINERAL AND PHYSICAL ANALYSIS OF METROPOLITAN WATER SUPPLIES

Fiscal Year 1989-90 Averages

CONSTITUENT	UNITS	SOURCE WATERS							FILTRATION PLANT EFFLUENTS					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Percent State Project Water		0	0	0	100	100	100	34	28	32	100	34	32	100

TABLE 30

QUARTERLY RESULTS OF TOTAL TRIHALOMETHANE MONITORING

Fiscal Year 1989-90

Micrograms per Liter (µg/l)

Sample Location	August 1989	November 1989	February 1990	May 1990	Annual Average
Distribution System					
[illegible]	64	59	75	79	68
[illegible]	72	67	80	78	74
[illegible]	71	68	77	90	77
[illegible]	60	67	73	64	67
[illegible]	56	59	56	65	59
[illegible]	61	67	72	77	69
[illegible]	55	70	66	75	67
[illegible]	56	65	58	78	59
[illegible]	48	57	69	66	60
[illegible]	52	60	NC	66	NQ
[illegible]	66	56	76	118	89
[illegible]	50	57	62	60	59
[illegible]	4.4	5.3	27	6.4	11
[illegible]	52	60	41	77	58
[illegible]	45	55	60	60	57
[illegible]	48	61	75	61	57
[illegible]	50	67	57	79	63
[illegible]	50	70	NCR	NCR	NQ
[illegible]	52	63	NCR	NCR	NQ
[illegible]	56	68	41	NC	NQ
[illegible]	58	77	72	76	71
[illegible]	50	60	68	76	69
[illegible]	65	65	79	74	71
[illegible]	52	62	87	62	71
[illegible]	66	75	87	64	81
[illegible]	87	61	42	69	69
[illegible]	74	70	50	78	68
[illegible]	62	57	75	73	57
[illegible]	62	56	58	61	60
[illegible]	NC	59	44	80	NQ
[illegible]	66	60	66	61	69
[illegible]	56	56	80	65	59
[illegible]	78	65	68	103	84
[illegible]	70	68	45	40	56
[illegible]	52	56	56	69	51
[illegible]	74	67	70	75	72
[illegible]	77	67	72	92	77
[illegible]	76	70	64	80	71
[illegible]	64	61	58	75	60
[illegible]	77	65	73	72	72
[illegible]	70	54	61	78	66
[illegible]	76	68	74	68	72
[illegible]	72	67	73	70	71
[illegible]	76	64	73	68	70
[illegible]	76	68	73	66	71
Quarterly Average	62	64	61	76	
Running Annual Average	61	57	64	66	
Filtration Plants					
[illegible] Influent	0.55	1.3	0.70	0.71	0.81
[illegible] Effluent	63	56	70	82	63
[illegible] Influent	ND	ND	0.16	ND	ND
[illegible] Effluent	74	63	68	71	69
[illegible] Influent	ND	ND	ND	ND	ND
[illegible] Effluent	5.6	6	29	8	12
[illegible] 1 Influent	24	0.16	ND	29	13
[illegible] 1 Effluent	59	63	48	67	58
[illegible] 2 Influent	28	0.39	0.10	32	15
[illegible] 2 Effluent	56	48	33	63	50
[illegible] Influent	0.48	1	0.90	0.46	0.71
[illegible] Effluent	61	57	32	68	55

Notes:

* Distribution system terminus ND = None detected NC = Not collected

NQ = Not quarterized (four consecutive quarters of data were not available)

NCR = Not collected (reservoir out of service)

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TABLE 31

DISINFECTION BY-PRODUCTS, PART 1

Fiscal Year 1989 90

Quarterly Results

Micrograms per Liter (µg/L)

[illegible]

1607

TABLE 32

DISINFECTION BY-PRODUCTS, PART 2

Fiscal Year 1989 90

Quarterly Results

Micrograms per Liter (µg/L)

Location	HALOACETIC ACID SUM		CHLORAL HYDRATE		CYANOGEN CHLORIDE		TOTAL ORGANIC HALOGEN (TOX)		FORMALDEHYDE	ACETALDEHYDE
	Sept 1989	Nov 1989	Sept 1989	Nov 1989	Sept 1989	Nov 1989	Sept 1989	Nov 1989	Sept 1989	Sept 1989
CM-1	26	26	4.5	4.2	0.32	ND	200	200	3.3	ND
Garvey Effluent	29	25	3.5	3.4	2.5	2.2	150	160	5.9	ND
San Joaquin Influent	25	20	3.4	2.5	3.5	1.5	150	130	3.2	ND
San Joaquin Effluent	22	21	1.5	2.3	0.30	0.39	180	190	ND	ND
WB-3	23	18	1.3	1.1	3.5	2.7	170	140	ND	ND
WB-23	23	18	1.2	1.0	2.8	2.5	160	140	ND	ND
Diemer Effluent	25	18	4.0	2.4	1.9	0.82	150	140	3.3	ND
Jensen Effluent	23	17	1.2	0.88	2.3	1.4	160	130	ND	ND
Mills Effluent	7.5	8.4	0.45	0.35	1.6	1.5	53	60	ND	ND
Skinner 1 Effluent	27	25	6.0	4.8	3.1	2.0	160	150	5.3	ND
Skinner 2 Effluent	25	20	4.6	3.2	2.9	1.4	140	140	4.7	ND
Weymouth Effluent	24	20	3.4	2.8	2.5	1.2	160	140	3.5	ND

ND = Not Detected

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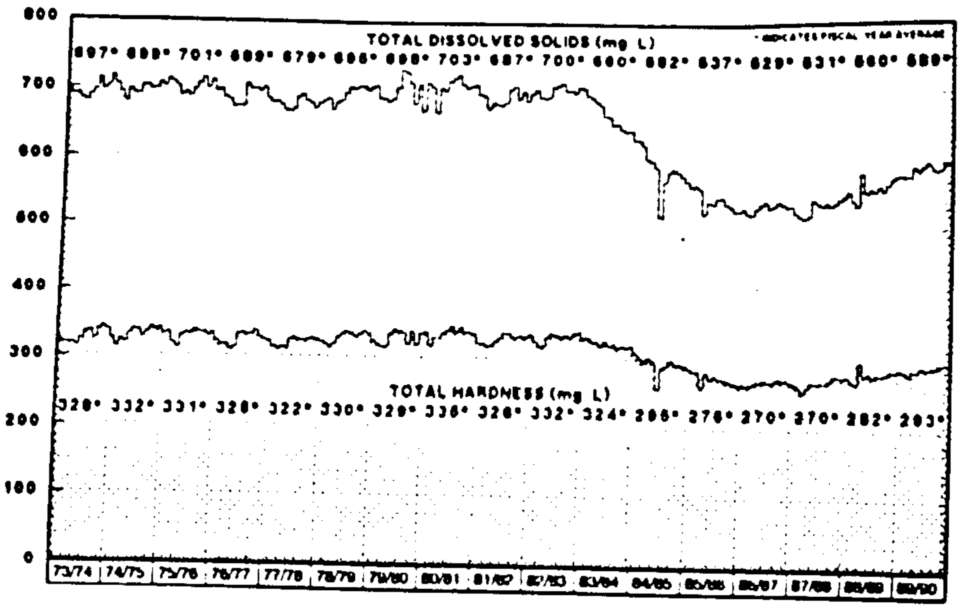

Figure 10 Chemical Quality of Colorado River Water at Whitsett Intake Pumping Plant

1 6018

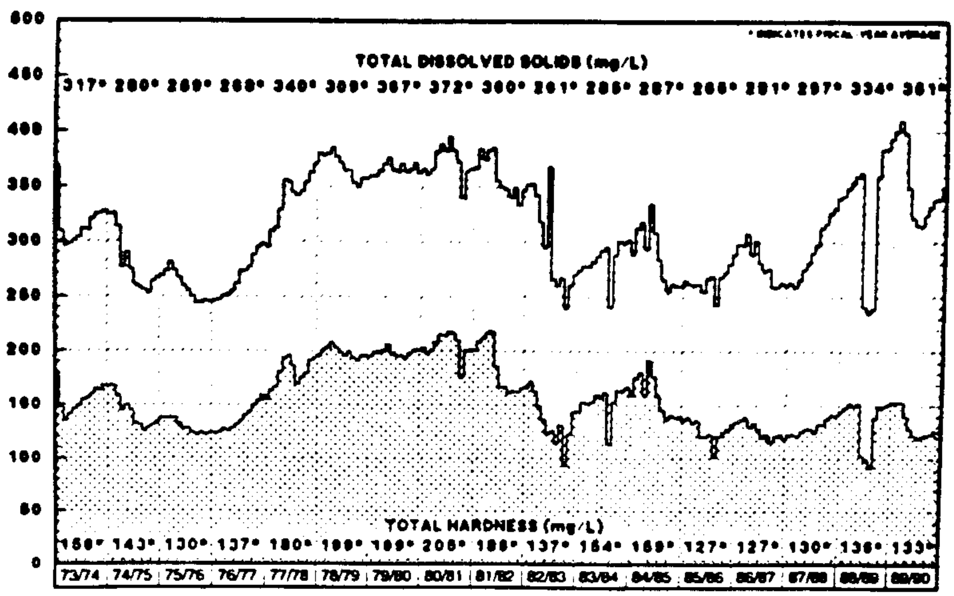

Figure 11 Chemical Quality of Edmund G. Brown California Aqueduct Water, West Branch

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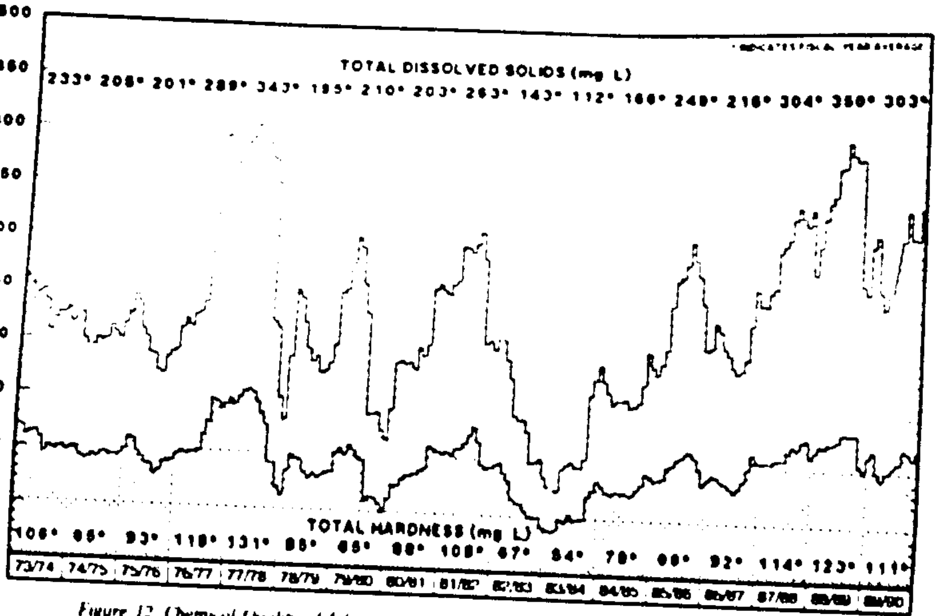

Figure 12 Chemical Quality of Edmund G. Brown California Aqueduct Water, East Branch

1 60-19

Counting coliform bacteria in water is among the standard tests performed in Metropolitan's laboratories.

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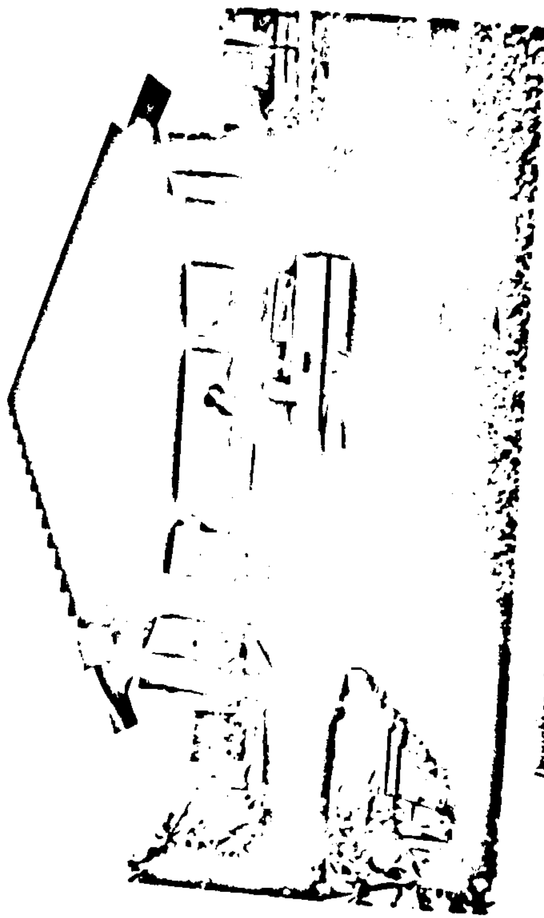

Drought-resistant plants flourish at this specially landscaped garden [illegible] Municipal Water District of Riverside County

CHAPTER 5

Planning

Advance Planning Activities

Area Studies and Facility Plans

Metropolitan's Report No. 971, the Distribution System Overview Study, outlined a plan of system improvements needed to meet Metropolitan's service area's future water quality and quantity requirements. A series of area studies and facility plans currently underway further evaluates and defines key facilities. These include the Central Pool Augmentation and Water Quality Project, Eastside Reservoir, Inland Feeder, Mills Area Study, Perris San Jacinto Area Study, San Diego Pipeline No. 6, and West Valley Area Study. Staff from Planning, Engineering, Operations, Water Quality, Resources, State Project Matters, and Right of Way have formed project study teams to facilitate coordination of all the area studies and facility plans. Corresponding environmental documentation is proceeding in each area.

Eastside Reservoir

For the past year, staff has been studying and preparing an EIR on five potential reservoir sites in western Riverside County to determine the feasibility of additional reservoir storage in the Metropolitan system. During this year, studies have included the collection and analysis of environmental, social, operational, cost, water quality, and engineering data to screen and reduce the total number of reservoir alternatives under consideration. Based on the information gathered to date, the Potrero Creek, Domenigoni Valley, and Vail reservoir sites have emerged as the most viable alternatives and are being studied in more detail. Results of the Lake Perris and Lake Skinner site studies will be presented in the EIR; however, neither is expected to be selected as a result of the feasibility study.

Beyond studying potential reservoir sites, staff conducted a refined assessment of reservoir storage needs and groundwater storage capability. These studies indicate that groundwater storage can meet a portion of the total storage need and that operating the reservoir within the delivery system, by temporarily storing imported deliveries in the reservoir, can facilitate groundwater basin deliveries. These studies also note that reservoir operation substantially increases the reliability of all imported supply sources by providing added capability to store imported supplies during the winter season when supplies are more abundant and aqueduct capacity is available.

During these studies, staff extensively evaluated potential mitigation sites and developed preliminary information regarding these sites' economic viability and acceptability. Using a habitat productivity model, staff quantified the effectiveness of the mitigation areas. The model compares overall habitat quality by measuring the habitat's physical characteristics as well as its ability to support various plant and animal species.

The Draft Feasibility Report and EIR are scheduled to be completed by February 1991; the final EIR will be submitted in July 1991.

Inland Feeder

The Inland Feeder will be a raw water conduit that will convey State Project water from the California Aqueduct's expanded East Branch to the Colorado River Aqueduct near San Jacinto. This facility is needed by the late 1990s to enable Metropolitan to optimally use State water supplies. It also will enhance system reliability by linking two of Metropolitan's main aqueduct systems and allow a more uniform blend of State and Colorado River water through much of Metropolitan's system.

The Inland Feeder Study is currently evaluating four alternative alignments. Each alignment encompasses a series of tunnels and pipelines that extend 40 to 50 miles. During the fiscal year, technical feasibility and environmental evaluations were begun and will continue into next fiscal year. The evaluations conducted include a preliminary geotechnical feasibility study of the tunnel portions, preliminary portal and spoil site evaluations, and a preliminary pipeline feasibility study. Environmental surveys were also initiated during the fiscal year in preparation for California Environmental Quality Act (CEQA) and National Environmental Protection Act (NEPA) documentation. The surveys are being conducted for sensitive habitat and species, and cultural and archeological resources. The draft EIR will be issued for public review next fiscal year.

Central Pool Augmentation and Water Quality Project

This project, which evolved from the South Orange County Area Study completed in 1988, will evaluate the facilities necessary to augment treated water service to Metropolitan's central service area (Los Angeles, Ventura, and Orange Counties). Lake Mathews provides the project's source water, which will be treated and conveyed into south Orange County, relieving the Robert B. Diemer Filtration Plant (Diemer plant) of much of its existing

demand. This will enable the Diemer plant to serve other parts of the central service area. The project will also enhance groundwater storage in the Main San Gabriel, Central, and West Basins.

Project components include a second outlet tower at Lake Mathews, a pipeline or pipeline tunnel conveyance system into south Orange County, and a new regional treatment plant located either near Lake Mathews or in south Orange County. Project completion is scheduled for 1998.

At the fiscal year beginning, staff had identified three potential treatment plant sites in south Orange County, one potential site near Lake Mathews, and several feasible lake outlet and conveyance system alternatives to meet the project's objectives. As staff members initiated the environmental documentation and analysis, they also conducted land-use studies to monitor development pressures which could threaten the feasible alternatives. Staff also continued to evaluate the technical feasibility of the alternatives based on planning refinements in related projects. The environmental and ongoing technical evaluations indicated that certain alternatives were indeed threatened, therefore another plant site near Lake Mathews and related conveyance system components were added to the study. Two of the three south Orange County sites were dropped from further consideration due to hydraulic and geotechnical constraints. The draft Environmental Impact Report (EIR) for the project is approaching completion and will be released for public review next fiscal year.

Mills Area Study

The proposed expansion of the Henry J. Mills Filtration Plant (Mills plant) in western Riverside County should meet regionally approved population forecasts and serve communities now using untreated water. Completed in summer 1989, the first Mills plant expansion doubled the plant capacity to 150 million gallons per day (mgd). This area study is being coordinated with the Perris San Jacinto Treatment Plant study to determine the capacity and timing required for the second Mills expansion. A capacity of about 300 mgd appears likely.

Perris San Jacinto Treatment Plant

This study is identifying the need, location, size, and schedule for a new treatment plant in the Perris Valley/San Jacinto Valley area of western Riverside County. Proposed facilities, including a new regional treatment plant and raw water conveyance pipelines, are planned to meet the increasing water demands and supplement activities at both the Mills and Robert A. Skinner Filtration Plants, and are being coordinated with the planning for the Inland Feeder and Eastside Reservoir facilities.

Reconnaissance studies, initiated in 1988, originally identified 26 potential treatment plant sites. By the fiscal year start, staff had screened the candidate sites down to five within the Perris Valley. However, as proposed developments threatened these sites' availability, additional sites were considered. During the year, five more sites in the San Jacinto Valley were evaluated.

Staff conducted detailed ranking evaluations of the facility alternatives, including technical feasibility, compatibility with the Inland Feeder and Eastside Reservoir systems, geotechnical and right-of-way investigations of plant sites and pipeline routes, cost estimates, and potential impacts to cultural and biological resources. Three sites will be included in the environmental documentation process. Also, due to strong land development pressures, staff began evaluating development activities and the potential need to secure properties where development could eliminate sites prior to final environmental documentation.

San Joaquin Reservoir Improvement Project

A 3000 acre-foot treated water reservoir near Newport Beach, the San Joaquin Reservoir is jointly owned by Metropolitan and several local agencies. As the reservoir has experienced periods of poor water quality, the improvement project is evaluating alternatives to improve water quality stored in and served from the reservoir and to better integrate the reservoir into Metropolitan's distribution system. Final environmental documentation was prepared during the fiscal year, including the EIR and the Plan Selection Report.

South Riverside San Diego Area Study

By identifying long range facility needs for south Riverside and San Diego Counties, this study looks to integrate Metropolitan's supplies with local storage plans and operations. Due to the area's rapid growth and increasing water demands, analysis has determined a need for San Diego Pipeline No. 6. The proposed pipeline, with a 500-cubic-foot-per-second capacity, will convey raw water. Staff has identified four alternate routes based on reconnaissance level engineering and environmental investigations, and has begun engineering feasibility studies and environmental field work.

Metropolitan is closely coordinating this study with area member agencies to identify opportunities for joint operations and potential groundwater development in southern Riverside County, and is also participating in San Diego County Water Authority's Optimal Storage Study to identify ways to optimize San Diego County reservoir facility use. This area study is also coordinated with the Perris San Jacinto Treatment Plant Study and the Eastside Reservoir Study.

West Valley Area Study

To determine the demands and identify the facilities needed to serve water in Ventura and western Los Angeles Counties, the West Valley Area Study initially identified nine alternative water conveyance alignments, which are now being evaluated. Preliminary technical feasibility studies and reconnaissance-level environmental surveys were started this year.

Seismic Risk Assessment of Local Water Production

This study assesses the availability of local supplies after a major movement along the San Andreas Fault. A seismic model was used to examine the vulnerability of local water production facilities (groundwater extraction wells) within Metropolitan's service area. The seismic analysis indicated that approximately 50 percent of groundwater extraction wells (or about 600,000 acre-feet per year of local water production) are located in areas of high ground-shaking intensities (Mercalli intensity 8 or more) where structural damages and underground pipeline breakages are expected. Additionally, the analysis found that approximately 40 percent of the extraction wells (about 500,000 acre-feet per year of local water production) are located in high liquefaction potential areas. These percentages are not additive because ground shaking and liquefaction areas overlap considerably. The data indicates that about 60 percent of the wells will be exposed to either high-intensity ground shaking or liquefaction.

Currently, a consultant is studying the probable damages to local water production facilities and Metropolitan's distribution system and the time needed for service restorations. Damages will be expressed in terms of typical failures or failure modes, and, given the damage scenarios, repair times will be estimated. The study will be completed by the end of summer 1990, and will provide information about emergency storage needs for the Eastside Reservoir Study.

Water Resources Data (PINS)

Staff has developed a computerized data base and retrieval system known as the Planning Information System (PINS). PINS contains data on the Metropolitan's daily system flows and monthly water sales, daily rainfall and temperature, local water production, groundwater quality, and Colorado River and State Water Project storages and supplies to Metropolitan as well as population and other demographic statistics. As part of Metropolitan's corporate data base, PINS data files are accessible to all divisions.

PINS is used for several types of studies. The distribution system flow data is used in facility planning studies by analyzing historic flow patterns and projecting when specific facilities will be operating at capacity. Water demand forecasts require the extensive use of climate, population, demographic data, and historic water-use patterns. The water-use modules, which includes data on Metropolitan's monthly water deliveries, are employed by the Planning and Finance Divisions to project water use and perform water-rate analyses. Additionally, the local water-use data has been applied by the Operations and Resources Divisions to evaluate how Metropolitan programs impact local water use and opportunities for conjunctive-use and coordinated operations.

Water Supply and Demand Studies

Urban Demands

The MWD-MAIN water demand forecasting model, originally developed for the U.S. Army Corps of Engineers Institute for Water Resources and later calibrated for use by Metropolitan's water demand consultant, is used to project municipal and industrial (M & I) water use within Metropolitan's service area. In forecasting M & I water demands, the model incorporates numerous demographic variables, including number and types of housing units, housing densities, population, and employment for over 200 industrial and commercial sectors, economic parameters including household income, housing value, price of water, and climatic data. The model also accounts for the effectiveness of urban water conservation programs. Water demands are disaggregated into four major use categories: residential, commercial, industrial, and public unaccounted. Additionally, these forecasts are further disaggregated into very specific categories to better understand the service area's water use characteristics.

During the past two years, four technical improvements were made to the model. First, its commercial and industrial water-use coefficients were updated based on an extensive Metropolitan water-use survey of over 3,000 service area commercial and industrial establishments. Second, the population, housing, employment, income, and land-use projections were updated to encompass the 1989 revisions made to the regional growth plans by the Southern California Association of Governments (SCAG) and the Series 7 forecasts of the San Diego Association of Governments (SANDAG). Third, the residential econometric demand models were revised based on specific Southern California agency water-use data. These new residential demand models were verified per a detailed Metropolitan household water-use study conducted to determine water-use behavior and characteristics of 1,000 households in five Southern California communities. Finally, the water conservation assumptions were revised to incorporate the 1981 and 1982 California building codes requiring low water-using fixtures in new construction, public education, and changes in retail level prices from 1980 to 1990. Metropolitan also is examining the

effectiveness of various "Best Management Practices" on further reducing service area water demands. Projected M & I water demands, under normal weather conditions, are expected to be 3.86 million acre-feet (maf) in year 2000 and 4.34 maf in year 2010. This compares to a current M & I use of 3.4 maf. These demands include the effectiveness of current conservation programs which are expected to reduce demands by 7 percent in year 2000 and 11 percent in year 2010.

Agricultural Demands

To project total regional water demands, agricultural water-use projections must be added to the MWD-MAIN's M & I demands. Metropolitan has conducted a special study on the service area's projected agricultural water use. In fiscal year 1988-89, agricultural water use in Metropolitan's service area was 384,000 acre-feet per year, or 10 percent of the total regional water use, with 194,000 acre-feet provided by Metropolitan. This yielded an annual gross crop value of about $2.0 billion. In total, agriculture contributes upwards of three times the crop value or $6.0 billion to the region.

The dairy industry in Riverside and San Bernardino Counties accounts for the largest category of agricultural activity in terms of crop values. Nursery products found throughout Metropolitan's service area run second. The largest amount of irrigated acreage is devoted to tree crops followed by row crops. With continued urbanization, agricultural water use is projected to decline to 310,600 acre-feet per year by year 2010, or 7 percent of total demands. Of this, Metropolitan is projected to provide 153,000 acre-feet per year; the remainder will come from local supplies.

Total Demands

The total regional decrease under normal weather conditions is projected to increase from a current annual use of 3.8 maf to 4.2 maf by year 2000 and 4.7 maf by year 2010. During periods of low rainfall and higher temperatures, demands would be greater than under normal weather conditions.

Distribution System Flow Model

A computerized system designed to route water through Metropolitan's distribution system, the Distribution System Flow Model (DSFM) evaluates the need and timing for future system expansion. Recently the model helped determine the amount of additional groundwater storage of Metropolitan's supplies that would be possible with the proposed Eastside Reservoir and Inland Feeder. Results indicated upwards of 300,000 acre-feet of additional storage may be achieved. Together with the DSFM, the System Information Graphics (SIG) program has been developed to graphically display the distribution system flow model results on a computer screen.

Short-term Demand Forecast Model

The short-term monthly water demand forecast model was developed to track water use in one-to-two year time frames given a set of population growth and climatic scenarios. It helps both the Planning and Operations Divisions to forecast the highest probable water demands on Metropolitan's system due to unusual climatic conditions. Model improvements include: (1) a climate "generator" was developed based on observed climate data to provide the possible rainfall and temperature extremes and their probability of occurrence; (2) models have been restructured to discern urban and agricultural water use; and (3) fully automated-and-interactive demand forecasting models for various member agencies have been constructed.

Drought '90 Water Use

As part of Metropolitan's Drought '90 campaign, staff obtained daily and monthly water-use data from key agencies. The data helped determine the effectiveness of Metropolitan and member agency conservation efforts. Company water use by these agencies for May, June, and July for 1990 and 1989 showed 8, 6, and 5 percent reductions respectively. Using the short-term demand forecast model to adjust for population growth and climate effects, staff estimated conservation savings of 6, 12 and 9 percent for May, June, and July over last year. The estimated agricultural savings in Metropolitan's service area would be 19,000, 40,000, and 35,000 acre-feet respectively for these three months. This monitoring program will continue through fall of next fiscal year to determine the conservation campaign's full effectiveness.

Regional Population and Water Demand Studies

The California Department of Finance has released its January 1, 1990, population estimates for the State of California, cities, and counties. Statewide population in 1990 is estimated to be 29.5 million, up 800,000 from the 1989 population of 28.7 million. Based on this data, along with supplemental data from county planning agencies, Metropolitan's 1990 population estimate is 14.9 million, an annual increase of about 373,000 over 1989's 14.5 million. Metropolitan's share of California's growth holds constant at about 50 percent.

In early 1989, SCAG adopted its Growth Management Plan, revising the population, housing, and employment forecasts for year 2010. SANDAG also adopted its revised Series 7 demographic and land-use forecasts in 1988. Together, these revised projections of demographic, economic, and land-use data for the six-county Southern California planning area have

been incorporated into the MWD-MAIN water demand forecasting model and facility planning studies. Key findings are:

(1) population will increase from 14.9 million to 18.2 million in year 2010, with two-thirds of the increase due to births over deaths;

(2) number of occupied housing units will increase from 5.2 million to 6.8 million in year 2010;

(3) persons per household will decline from 2.85 to 2.69 in year 2010;

(4) employment will increase from 7.1 million to 9.2 million persons in year 2010;

(5) employment is projected to grow at faster rates than population, indicating the percent of persons in the work force will be increasing; and

(6) growth rates of population, housing, employment, and income are greater in the inland Riverside and San Bernardino Counties compared to the other parts of Metropolitan's service area.

To assess how regional growth affects water demands, staff has been examining economic and demographic data such as population, house building activity, jobs, personal income, wages, and value of goods and services (economic output) in Metropolitan's service area. In a special study of population undercounts and undocumented immigrants, the Center for Continuing Study of the California Economy has determined that the 1990 Census population undercount in Metropolitan's service area could be about 601,000, occurring primarily in Los Angeles and San Diego Counties.

With the upcoming 1990 Census results, significant revisions are expected in the forecasting models regional governments use to project demographics. The regional governments will also be updating their land-use inventories to correspond with the 1990 Census.

Water Supply Data

Daily flow, storage, and water-delivery information covering the past six years have been entered into a computerized data base. With the historic and updated information, staff can closely monitor the use of Metropolitan's treatment plants, pipelines, and storage facilities and provide an early warning when flows approach system capacity. SIG will graphically display the information for easier interpretation. Currently, the data base is being expanded to include information from Metropolitan's distribution system control centers.

Water Use in Future Annexations

At the Board of Directors' request, staff identified the areas likely to seek future annexations to Metropolitan. These annexations would consist of "island areas" in west Riverside and San Diego Counties, the remaining part of the Oxnard Plain in southern Ventura County, and minor expansion of the easterly boundaries in San Diego County. Collectively, these areas would add about 2 percent to Metropolitan's land area over the next 50 or so years, and may increase demands on Metropolitan by up to 66,000 acre-feet per year by year 2010. Staff is working closely with the Board of Directors and member agencies to review water use in proposed annexation areas.

Environmental Studies

At fiscal year's end, staff was preparing 11 EIRs and three major environmental support studies. Environmental staff also led in establishing and coordinating two significant task forces to improve environmental performance in pertinent Metropolitan activities.

San Joaquin Improvement Project

Staff completed a Final EIR and Plan Selection Report for the San Joaquin Reservoir Improvement Project. This project would improve the quality of drinking water served from San Joaquin Reservoir and better integrate the reservoir into the Metropolitan's distribution system.

Arvin-Edison Water Storage and Exchange Program

To satisfy the provisions of both State and Federal environmental laws, staff prepared a joint Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the Arvin-Edison Water Storage and Exchange Program. Under this program, new facilities will be constructed to store up to 1 maf of water in the Arvin-Edison Water Storage District (Arvin-Edison). This water would be delivered to Arvin-Edison during wet periods in exchange for Arvin-Edison's Central Valley Project supplies to be delivered to Metropolitan during dry periods. The EIR/EIS will be submitted for public review next fiscal year.

Service Connection LA-35

Environmental Branch staff prepared a Negative Declaration and acquired a permit from the California Department of Fish and Game for Service Connection LA-35. This service connection will provide a permanent source of raw water to the Los Angeles Department of Water and Power at its Granada Hills facility. Final documents were filed with the appropriate State and local agencies.

Joseph Jensen Filtration Plant Expansion

An Addendum to the Negative Declaration for the Joseph Jensen Filtration Plant Expansion was prepared to address revisions to project plans made subsequent to the existing environmental documents. Construction will proceed as scheduled.

Environmental Compliance Handbook

To update specific procedures for the orderly review and completion of environmental requirements associated with both State and Federal laws, staff revised General Instruction 6A and prepared a complementary handbook for use by Metropolitan staff. This handbook also clarifies responsibility for compliance with applicable Government Code provisions.

Alternatives Report, Mills Area Study

To satisfy CEQA provisions as they relate to developing and analyzing alternative means to meet project objectives, staff identified and evaluated alternative treatment plant sites to accomplish Mills Area Study objectives. These studies will be used to complete an EIR for the proposed Mills plant expansion.

Regulatory Compliance Review Program

A regulatory task force was formed from the Engineering, Operations, Personnel, Planning, and Water Quality Divisions with representation from the Legal Department. The task force will make recommendations to management on measures to maintain compliance with health, safety, and environmental laws; to minimize major risk to the environment or public; and to prevent the imposition of civil and criminal responsibility on Metropolitan or its employees when statutory or regulatory requirements are violated.

At year's end, the task force agreed on program objectives and approach, and adopted an internal process to achieve consensus during program development. Further, the task force hired the consulting firm Dames & Moore to assess major risks at all Metropolitan facilities and to determine line-unit responsibilities for regulatory compliance. This work, to be completed next year, is the first of three steps leading to development of a Metropolitan environmental audit program. Steps two and three, implementing regulatory compliance and audit procedures for each line unit or division and implementing periodic oversight audits, also will be completed next year.

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Air Quality Task Force

In April, Environmental Branch staff formed the Air Quality Regulat Compliance Committee to monitor and respond to proposed air-qua rules and legislation, and to develop procedures to comply with adop rules and laws. The committee is composed of representatives fr Engineering, Operations, Water Quality, Resources, Planning, Personn and Administrative Services Divisions with representation from the Le Department.

GIS Database

Staff retained Keller Environmental Associates to collect data for an environmental data geographical information system (GIS) study of Metropolitan's service area. The information will be integrated into a computerized GIS data base and used to evaluate the environmental effects of projects throughout Metropolitan's service area.

Environmental Documents in Preparation

During the past year, the CEQA compliance process was initiated for three projects as Notices of Preparation were completed and published for the Central Pool Augmentation and Water Quality Project, Eastside Reservoir Project, and the Mills plant expansion. These notices advise the public of an agency's intent to prepare an EIR and solicit comments regarding the type of information the EIR should include. Metropolitan's policy in each of these projects is to avoid and minimize impacts as a first priority, then mitigate to the extent practicable for unavoidable impacts. Advance mitigation is used as appropriate to ensure project schedules.

Environmental reconnaissance studies were undertaken for the Skinner Landfill Expansion, Perris Treatment Plant, and Westside Conveyance projects. These preliminary investigations will help identify the scope of environmental compliance requirements, develop project schedules and cost estimates, screen alternatives, modify project plans to mitigate significant adverse effects, and expedite the environmental compliance process for recommended alternatives.

To help conserve water, homeowners perform such simple tasks as replacing worn-out faucet washers and installing low-flow faucet heads.

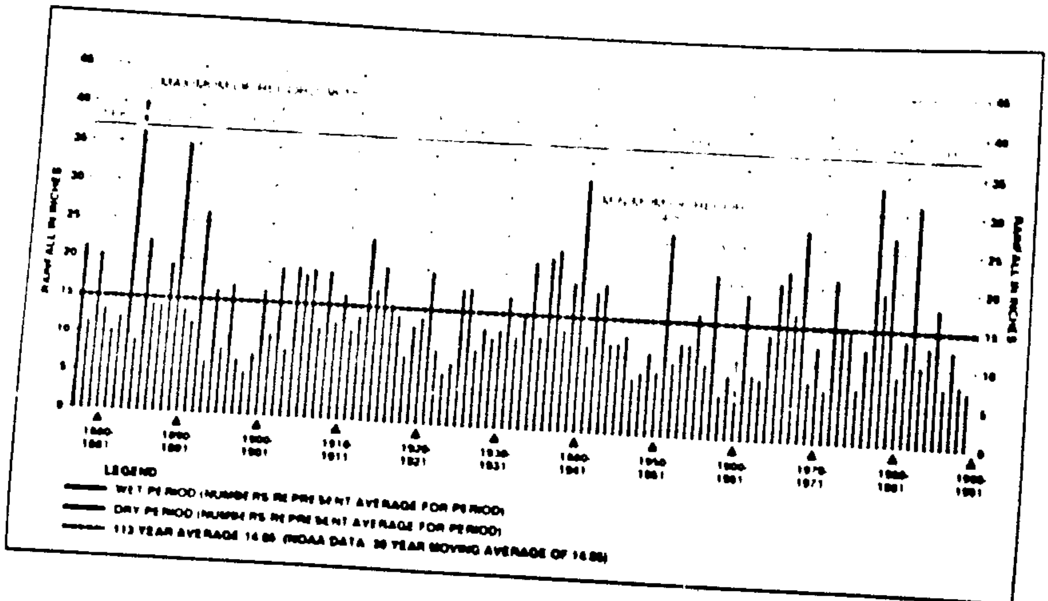

Figure 13 113-Year History of Average Seasonal Rainfall (Measurements Taken at Los Angeles Civic Center)

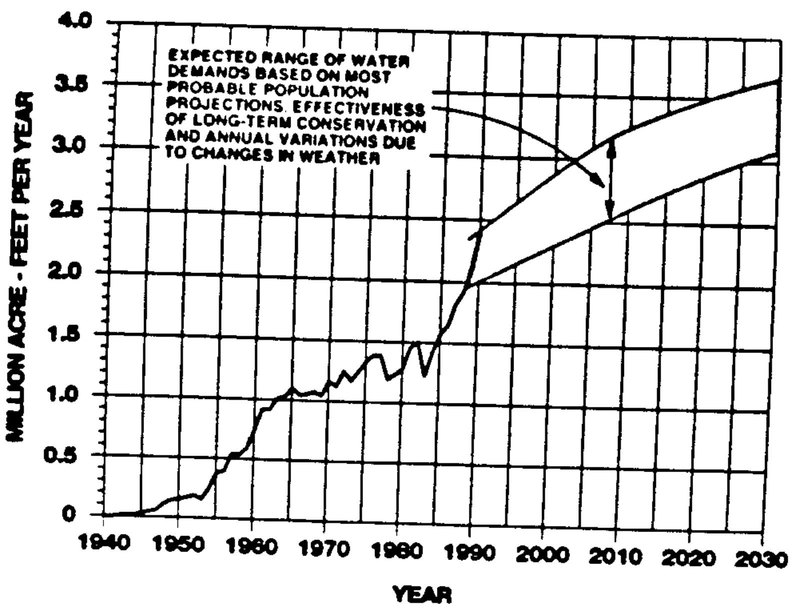

Figure 14 Total Projected Water Demand in Metropolitan's Service Area

TABLE 33

AREA AND POPULATION OF MEMBER AGENCIES

As Of June 30, 1990

Constituent	Area in Square Miles	POPULATION 1970 Census	POPULATION 1980 Census	POPULATION Jan. 1, 1990* Estimated
Anaheim**	44.91	166,408	221,847	247,8[illegible]
Beverly Hills**	5.06	33,416	32,367	34,3[illegible]
Burbank	17.14	88,871	84,625	95,3[illegible]
Calleguas MWD	348.58	222,400	344,030	471,500
Central Basin MWD	178.99	1,152,700	1,241,936	1,387,170
Chino Basin MWD	242.24	279,600	345,813	580,000
Coastal MWD	59.11	140,300	170,231	215,324
Compton**	7.81	78,547	81,286	93,400
Eastern MWD	533.69	69,600	133,679	324,389
Foothill MWD	21.60	83,600	79,744	86,365
Fullerton	22.14	85,987	102,034	111,700
Glendale**	30.36	132,664	139,060	174,800
Las Virgenes MWD	121.91	13,900	33,423	55,185
Long Beach	49.79	358,879	361,334	419,800
Los Angeles**	461.90	2,811,801	2,966,763	3,433,600
MWD of Orange County	541.23	871,000	1,233,745	1,515,376
Pasadena**	22.60	112,951	119,374	133,900
San Diego CWA	1,420.21	1,276,000	1,776,851	2,435,200
San Fernando	2.37	16,571	17,731	20,650
San Marino	3.75	14,177	13,307	13,650
Santa Ana	27.43	155,710	203,713	236,000
Santa Monica	8.05	88,289	88,314	96,900
Three Valleys MWD	133.30	266,100	359,161	462,900
Torrance**	19.54	134,968	131,497	142,500
Upper San Gabriel Valley MWD	143.71	651,600	669,677	764,200
West Basin MWD	165.71	721,400	732,609	829,520
Western MWD of Riverside Co	508.82	249,200	332,957	496,611
TOTAL	5,141.95	10,226,639	12,017,108	14,878,040

Note

*Estimate based on California Department of Finance January 1, 1990, estimates. Numbers will be revised when 1990 Census becomes official.

**Areas tabulated for these cities are exclusive of areas annexed to the cities which, for Metropolitan purposes, are included within the area of a constituent Municipal Water District. The total areas now within the present boundaries of the cities involved are rounded to the nearest 100th of a square mile.

TABLE 33 (Continued)

AREA AND POPULATION OF MEMBER AGENCIES

As Of June 30, 1990

Constituent	Area in Square Miles
ANAHEIM	
Area exclusive of portion within MWD of Orange County	44.91
Area within MWD of Orange County	0.01
Total area of city of Anaheim	44.92
BEVERLY HILLS	
Area exclusive of portion within West Basin MWD	5.06
Area within West Basin MWD	0.64
Total area of city of Beverly Hills	5.70
COMPTON	
Area exclusive of portions within Central Basin MWD and West Basin MWD	7.81
Area within Central Basin MWD	2.35
Area within West Basin MWD	0.01
Total area of city of Compton	10.17
GLENDALE	
Area exclusive of portion within Foothill MWD	30.36
Area within Foothill MWD	0.23
Total area of city of Glendale	30.59
LOS ANGELES	
Area exclusive of portions within West Basin MWD, Las Virgenes MWD, and Central Basin MWD	461.90
Area within West Basin MWD	4.25
Area within Las Virgenes MWD	2.64
Area within Central Basin MWD	0.01
Total area of city of Los Angeles	468.80
PASADENA	
Area exclusive of portions within Foothill MWD and Upper San Gabriel Valley MWD	22.60
Area within Foothill MWD	0.37
Area within Upper San Gabriel Valley MWD	0.18
Total area of city of Pasadena	23.15
TORRANCE	
Area exclusive of portion within West Basin MWD	19.54
Area within West Basin MWD	1.95
Total area of city of Torrance	21.49

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CHAPTER 6

Engineering

During fiscal year 1989-90, the Engineering work program focused on continuing last year's projects to expand or rehabilitate existing or construct new major facilities for water treatment, distribution, and storage. These facilities will help meet the heightened demands on Metropolitan due to increasing regulatory requirements and rapid population growth in Southern California. The ongoing major-facility projects under construction this year included Robert A. Skinner Filtration Plant (Skinner plant) Expansion No. 3; Skinner Finished Water Reservoir; the San Diego Canal enlargement; expansion of the Weymouth and Diemer Washwater Reclamation Plants, the Etiwanda Pipeline, Control Facility, and Reservoir, and modifications to existing and construction of new retention basins at the Henry J. Mills Filtration Plant (Mills plant). The ongoing major-facility projects in design during the year included the Joseph Jensen Filtration Plant (Jensen plant) Expansion No. 1, expansion of the Foothill Feeder Pressure Control Structure, and modifications to the Robert B. Diemer Filtration Plant (Diemer plant). Other major ongoing projects included the Etiwanda Power Plant and the Orange County Feeder relocation.

During the year, many new engineering projects were initiated, most involved continuing efforts to comply with tighter State and Federal drinking water quality standards, increased concern with containment and safe handling of potentially hazardous substances, and improving internal telecommunications. In the water quality improvement effort, construction progressed on the Oxidation Demonstration Plant, and an investigative study began for a large-scale program to retrofit the filtration plants with ozonation facilities. Also during the year, the seismicity investigation and upgrade program expanded to include new studies and design work.

Capital Projects

Capital expenditures for fiscal year 1989-90 engineering activities totaled nearly $103 million, an increase of about $4.5 million over fiscal year 1988-1989. This figure covers capital work performed under contract and by Metropolitan, and includes equipment and right-of-way procurement, design, inspect[illegible] [illegible]d contract and general administration. Metrop[illegible] existing and r[illegible] [illegible]d facilities and pipelines are shown in Figure 15[illegible] Tables 34 a[illegible] [illegible]mmarize projects in various design and constr[illegible] stages.

Con

[illegible]struction contracts were in progress throughout the [illegible] year at a cost totaling $58,344,969; they are listed in Table 35. Thirteen [illegible] construction contracts were awarded by the Board during the year at a value exceeding $129 million. Three construction contracts, at a cost of $2,100,529, were completed during the fiscal year. At fiscal year end 16 construction contracts, valued in excess of $198 million, were progress[illegible]ing. Details of the major construction projects in progress during the year follow.

- Skinner Filtration Plant Expansion No. 3 — Construction of this 200-million-gallon-per-day (mgd) expansion to the existing 340-mgd Skinner plant continued through the fiscal year by the contractor, Kiewit Pacific Company, under a $48.1 million contract. The expansion [illegible] 52 percent complete by fiscal year end with all [illegible] currently scheduled for completion during May 1991.
- [illegible] Reservoir — Work continued on the 340-acre-[illegible]servoir and floating synthetic rubber cover. At [illegible] contractor, Kiewit Pacific Company, had [illegible] percent of the $20.5 million contract with [illegible] scheduled for March 1991.
- San Die[illegible] Enlargement — Enlarging approximately 18 mi[illegible] of the existing San Diego Canal, extending from San Jacinto Tun[illegible] to Lake Skinner, comes as part of Metropolitan's program to expa[illegible] facilities to provide greater water deliveries required by the San Die[illegible] County Water Authority. A $30.7 million construction contract [illegible] awarded to Kiewit Pacific Company in July. By fiscal year end [illegible] expansion project was approximately 61 percent complete, w[illegible] completion expected in August 1991.
- Oxidation D[illegible] Plant — This state-of-the-art 5.5-mgd wa[illegible] treatment p[illegible] the existing F. E. Weymouth Filtration Pl[illegible] (Weymouth pla[illegible] study large scale application of PEROXO[illegible] and ozone in water treatment processes. In March 1990, Me[illegible] Construction Engineers, Inc., was awarded a contract for $12.2 millio[illegible] Completion is scheduled in June 1991.
- Weymouth Washwater Reclamation Plant Expansion — Basically, th[illegible] expansion project involves constructing a 22-mgd water reclamati[illegible] plant and a 33-mgd coal removal flowsplitting structure, and modi[illegible]ing the existing 11-mgd washwater reclamation plant. The existi[illegible]

facilities do not have sufficient capacity to treat washwater when the Weymouth plant is operating at high capacity. In March 1990, a $7.7 million contract was awarded to C. W. Roen Construction Company. It is scheduled for a June 1991 completion.

- **Diemer Washwater Reclamation Plant Expansion** — Construction of this 25-mgd washwater reclamation facility is part of the Diemer filtration plant expansion. During June 1990, Kaweah Construction Co. was awarded a construction contract at a bid price of $6.7 million to expand the reclamation facility. The contract should be completed during October 1991.
- **Etiwanda Pipeline, Control Facility, and Reservoir** — These facilities are required to accept additional water deliveries available due to the expansion of the State Water Project's East Branch and then incorporate these increased deliveries into the existing distribution system. Two construction contracts were awarded near the close of the fiscal year; however, no construction had been started by fiscal year end. The Etiwanda Control Facility and Reservoir, required to regulate water flow into the system, will consist of a distribution and control facility and a 450-acre-foot reservoir. In May 1990, a contract to construct the control facility and reservoir was awarded to Advanco Constructors for a bid amount of $22.4 million. This contract is currently scheduled for completion during March 1992. A second Advanco Constructors contract, awarded in June 1990 at a bid price of $43.6 million, covers construction of 6.15 miles of 144-inch-diameter welded steel pipeline, including valve, meter, and relief structures, extending between the Rialto Pipeline and the Upper Feeder. The pipeline should be constructed by mid-1992.
- **Orange County Feeder Relocation** — In December 1989, Barnard Construction Co., Inc., received a contract for a bid price of $3.4 million to relocate approximately 5,800 feet of existing 46-inch-diameter pipeline owned by the Pomona-Walnut-Rowland Joint Water Line Commission and approximately 5,900 feet of existing Orange County Feeder Pipeline. These relocations, required per a Los Angeles County Sanitation District landfill project, are reimbursable by the county. This relocation project is scheduled for completion during December 1990.
- **Retention Basins at Mills Plant** — In August 1989, G. A. MacDonald Construction Company, Inc., completed modification of existing and construction of additional retention basins at the Mills plant at a construction cost of $1,634,763.

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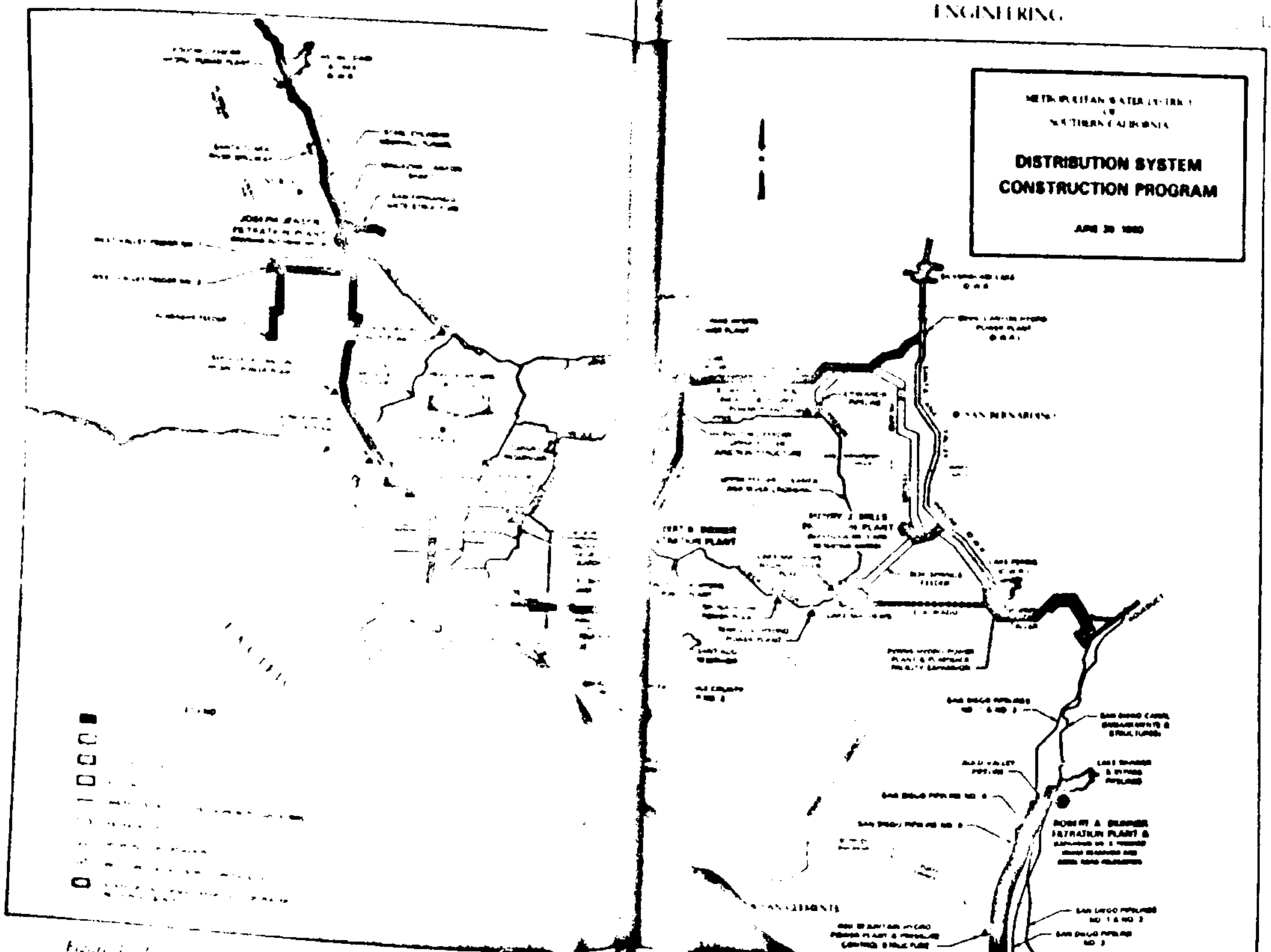

Figure [illegible] Construction Program

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Design

The major facility projects in design phases during the fis[illegible] year included

- Jensen Plant Expansion No. 1 — The Jensen plant capacity [illegible] be expanded from 350 mgd to 750 mgd to help meet increasing [illegible] quality requirements and demands in Metropolitan's Central Po[illegible] area in conjunction with Diemer and Weymouth plant operations. The expansion work will include constructing additional structures: mix[illegible]ing and settling basins, filter units, retention basins, a 50-million-[illegible] finished water reservoir, and an additional 33-mgd washwater recla[illegible]mation plant. All design phases are scheduled to be completed by March 1991.

- Foothill Feeder Pressure Control Structure Expansion — The Foothill Feeder Control Structure regulates the water flow from Lake Castaic to the Jensen plant. Once the Jensen plant is expanded, it will have the capacity and requirement for additional Lake Castaic water. To meet the increased requirement, the pressure control structure will need to be expanded from the current 900 cubic feet per second (cfs) capacity to about 1,500 cfs. The control structure expansion will consist of installing sleeve and butterfly valves, pipe fittings, and related equipment. Design work is expected to be completed in October 1991.

- Diemer Plant Modifications — With a planned plant capacity increase [illegible] mgd to about 710 mgd, the Diemer plant enlargement will [illegible] increasing water quality requirements and Central Po[illegible] [illegible] conjunction with Jensen and Weymouth plant oper[illegible] [illegible] will include raising the height of the la[illegible] [illegible] at the settling basins, adding equipm[illegible] [illegible] for the chlorination and chemical feed s[illegible] [illegible] the washwater reclamation facility. The des[illegible] work sho[illegible] completed by January 1991.

- Etiwanda P[illegible] Plant — This proposed 19.5-megawatt capacity pow[illegible] plant will be [illegible] in Rancho Cucamonga to recover ener[illegible] that would otherwise be wasted through the Etiwanda Contr[illegible] Structure. The projected annual power generation for the first 10 yea[illegible] of operation is about [illegible] million kilowatt-hours, and the projecte[illegible] annual gross income from the plant's power generation is abo[illegible] $7,000,000. Design is scheduled for completion in mid-1992.

- Filtration Plant Ozonation Retrofitting — This project is one of severa[illegible] to be implemented under Metropolitan's Trihalomethane Action Pla[illegible] for reducing trihalomethane formation in drinking water. In this proj[illegible]ect, the five filtration plants will be retrofitted with oxidation systems using ozone or PEROXONE processes. Design work on this project is expected to be completed by July 1991.

Design was completed on various smaller-scale filtration plant projects. [illegible]hey include Skinner plant control room modifications and administra[illegible]tion building expansion, control system installations for Mills plant mod[illegible]ules Nos. 1 and 2, and rehabilitation of Weymouth plant equipment. Design [illegible]egan during the year on filter media replacements for Jensen plant filtra[illegible]tion systems.

Numerous distribution system projects were in design. Design was continued from last year on Skinner Bypass Pipelines Nos. 2 and 3 to provide operational flexibility during problem taste-and-odor episodes. Also, design was ongoing to relocate East Orange County Feeder No. 2 to accommodate the new Freeway 5/55 Interchange. An engineering study was under way to examine constructing a bypass canal in the Lake Mathews area to reduce potential lake pollution and provide emergency delivery capacity from Lake Mathews to the Lower and Upper Feeders. Design was completed for the following distribution system projects: installing chlorine solution lines and feed systems at Skinner East and West Bypass Pipelines and Bypass Pipeline No. 2 to eliminate taste-and-odor problems through periodic chlorination; replacing carbon dioxide cylinders within fire protection systems and rehabilitating controls at Units 1, 2, and 3 of the Colorado River Aqueduct (Aqueduct) pumping plants; relocating the Santa Ana Cross Feeder to accommodate a city of Santa Ana storm drain enlargement project; and modifying overhead bridge crane controls at Aqueduct pumping plants.

During the year, the previous study and design program for bulk storage containment measures expanded to include investigating, identifying, and recommending prevention measures for potential hazardous-substance spills and for implementing measures to safely handle potentially hazardous substances at Metropolitan facilities, including filtration and pumping plants, reservoirs, and maintenance areas. As a result of studies completed to date, design began for replacing caustic soda tanks at the Diemer plant.

Engineering design was completed during the year on the following telecommunications systems: (1) a telephone switch replacement and data networking equipment for Los Angeles Headquarters, (2) a telephone system for the Pasadena facility, (3) a CBX switch for the Weymouth plant, (4) ROLM-net for all facilities (a software program that provides alternate call-routing capability), and (5) PhoneMail systems for nine facilities.

Other projects in design during the year included hydroelectric plant vibration monitoring systems and enlargement of the chemical unloading facility located in the Lake Mathews area to accommodate increased chlorine delivery and storage requirements, as well as numerous miscellaneous projects. Design was completed for Phase III of the program to replace underground storage tanks at various Metropolitan facilities.

Continuing Projects

Corrosion Control

The ongoing program of monitoring and mitigating corrosion throughout Metropolitan's water transmission, storage, and distribution systems continued. Electrolysis surveys were completed on the Auld Valley and Lakeview Pipelines, the Burbank and Compton Laterals, and the West Orange County and West Coast Feeders. Also, surveys were conducted on portions of the Rialto Pipeline and the Santa Monica, Yorba Linda and East Orange County No. 2 Feeders. Corrosion was mitigated through regular maintenance and monitoring of existing cathodic protection systems and design and installation of several new systems. Projects included installing an impressed-current cathodic-protection system on the Lake Mathews forebay and headworks and the Mills plant influent gates and reservoir effluent structure. Deep-well anode groundbeds were installed to protect portions of the Orange County Feeder and West Valley Feeder No. 2.

Materials Evaluations and Research and Development

Restrictions placed on materials by government regulating agencies resulted in testing of several new products. Short- and long-term testing was conducted on protective coatings, adhesives, linings, sealants, and other materials used for construction and maintenance. Additionally, staff began evaluating how concentrated ferric chloride affected construction materials at the Mills plant, and an extensive report on the corrosion rates of metal alloys in Metropolitan's waters was completed. Test methods included accelerated weatherometer testing, infrared spectroscopy of test samples, and cathodic disbonding tests. Research and development projects included designing a new materials testing facility which will be operated in conjunction with the Oxidation Demonstration Plant, including cost analysis, process equipment product survey and acquisition, and design and construction of an ozone contact tower for diffuser and hydrodynamic studies. Data obtained from materials evaluations and research and development form the basis for materials selection and technical information for Metropolitan, its member agencies, and other water utilities.

Metallurgy

Failure analyses were conducted in both the metallurgical laboratory and the field to determine why equipment failed at various locations throughout Metropolitan's system. These included metallurgical inspection and failure analyses of hazardous materials containment, conveyance, and pumping equipment. Several power plant inspections were conducted and procedures recommended for weld repairs, heat treatments, and chemical cleaning and passivation. Also, ultrasonic testing procedures for inspecting and evaluating chlorine evaporators for flaws and corrosion were devised and implemented. Metallurgical evaluations by the metallurgy laboratory are used by both the Engineering and Operations Divisions and member agencies.

Investigations and Surveillance of Dams and Reservoirs

The ongoing surveillance program continued monitoring the safety and structural performance of the existing 14 dams and reservoirs in Metropolitan's system. This included daily inspections by operating personnel at all facilities and semiannual inspections by Metropolitan's dam safety engineers. Engineers from the California Division of Safety of Dams (DSOD) frequently participated in the dam inspections. Seepage flows, piezometric pressures, and horizontal and vertical movements were and continue to be monitored and analyzed for each dam. Seismic acceleration time histories are also recorded instrumentally and analyzed whenever any dam undergoes strong shaking during an earthquake. The Upland earthquake and some of its aftershocks, which occurred during this fiscal year, were of sufficient magnitude to activate strong-motion accelerographs at various sites. None of Metropolitan's dams or reservoirs were damaged by the Upland earthquake sequence.

Engineering reports were periodically provided to DSOD summarizing the results of all routine surveillance activities, periodic inspections, and analysis of all data collected from each dam.

The DSOD completed its review of plans and specifications on the 340-acre-foot treated water reservoir for the Skinner plant. DSOD gave final project approval in October 1989, and construction was subsequently started. Intensive liaison activities were, and continue to be, maintained between the DSOD, the outside geotechnical consultants, and Metropolitan's design and construction staff.

A ruling was obtained from the DSOD that the 450-acre-foot Etiwanda Reservoir does not fall under State jurisdiction, principally because its general configuration places most of the reservoir below the adjacent natural grade.

Staff reviewed the consultant's feasibility studies of the Eastside Reservoir siting. Numerous field and office reviews were made and liaison was maintained with the DSOD regarding all technical issues pertaining to that planned storage facility.

Subsequent to groundwater surfacing in the backyards of some Garvey Reservoir area homes, divers discovered a crack in the reservoir's bottom. As a result, the reservoir was taken out of service and drained in November 1989. An intensive effort was mounted to discover the cause of the ground cracking and to devise appropriate repair measures. Several consultants were retained to investigate the situation and to help design effective repairs.

Independently. DSOD retained Dr I M Idriss, Dr Clarence Allen, a
Mr J C Sciandrone as a consulting board to advise on all matters pertain
to incident causes and to the effectiveness of the proposed repairs. It is
anticipated that the repairs will be completed and the reservoir return
to service in summer 1991

Seismic Inspections, Investigations, and Upgrade Program

Biannual earthquake inspections were initiated by the Emergency Preparedness Task Force at Metropolitan facilities The investigations focused on the anchorage or lateral bracing of pipes, equipment, and electrical panels Preliminary design has been completed for seismic upgrading of several structures, and is nearing completion for lateral bracing of the discharge pipelines at the five Aqueduct pumping plants and for seismic upgrading of the plants themselves Design was completed on a seismic upgrade of part of the La Verne auto repair and utility shop and continues on the remainder Consultants have completed the preliminary seismic upgrade design for the two-story portion of the Headquarters Building and for the maintenance shop building at the La Verne facility A geotechnical consultant is preparing an investigative report on the stability of the slope directly behind the diversion structure at the San Jacinto Tunnel's west portal

Records of Survey

During the fiscal year four Records of Survey documents, covering four miles of pipeline and rights-of-way were filed with County Records Approximately 57 percent complete this program monuments and records survey maps for public record The survey maps are an accurate record of Metropolitan rights of way and land holdings. The work is currently completed using electronic surveying equipment and computer-aided engineering and drafting programs

Office Automation

A new Intergraph Computer Aided Design and Drafting system wa
acquired this fiscal year This sophisticated computer system will help auto
mate the design and drafting process of engineering projects in the ne
future The two initial phases of implementation—training an
standardization—have begun and will continue through fiscal yea
1990-91 A mainframe based project management system was als
implemented this year The system interfaces with the Electronic Time She
System to obtain up-to-date labor data Engineering managers and proje
engineers have access to project management reports via a terminal at the
desks The reports are interactive, which allows individuals to precisel
select the information they need to monitor and control the portions
the projects for which they are responsible Currently under way is a
enhancement to electronically retrieve cost data. This will provide complete

cost-monitoring capabilities within the Engineering Division. Computers continued to automate the collecting, processing, and analyzing of engineering data as well as to help perform administrative tasks.

Substructure Investigations

Substructure investigations review and analyze proposed utility and improvement projects to determine if they will interfere with existing and proposed Metropolitan facilities. During the fiscal year, staff received and answered 1,005 letters from outside agencies and developers regarding new construction that affected Metropolitan's existing and/or proposed facilities and rights-of-way, and 2,034 notifications and plans of proposed construction activities for the city of Los Angeles and Bureaus of Engineering and Street Maintenance. Also, 311 "Street Right-of-Way Vacation" notices were processed to ensure continued rights-of-access for operation and maintenance of existing Metropolitan facilities.

Service Connections

Under the reimbursable service connection program, which is an ongoing activity, 22 projects were under way during the year. The major projects in design stages included LA-35 to increase water supply from the Foothill Feeder to the Los Angeles area, in coordination with the Los Angeles Department of Water and Power; OC-64 to provide low-flow capability in the Santiago Aqueduct; EM-18 to supply additional water service from San Diego Pipeline No. 2 to the Rancho California area; enlarging EM-17 to increase water supply from the Auld Valley Pipeline to the Perris area, EM-12 to provide water service from the Mills plant to Moreno Valley; and USG-9 to furnish additional water service from the Middle Feeder to the Baldwin Park area. The major projects under construction included CenB-30 to provide water service from the Lower Feeder to the Santa Fe Springs area, CM-13 to supply water service from the Orange County Feeder to the Newport Beach area, and WR-24D to furnish water from the Sepulveda Feeder to the west part of Los Angeles.

Professional Consultant Activity

Fiscal year 1989-90 was another very busy year at Metropolitan. In order to meet project schedule requirements under the accelerated work program, Metropolitan continued to rely on many outside professional consultants to assist with projects requiring technical expertise. Professional consultant activity increased about 34 percent from fiscal year 1988-89, and 381 consultant agreements were active as of June 30, 1990. The heaviest uses were experienced by the Planning and Engineering Divisions, primarily with respect to drought and water conservation, water quality improvement, and facility expansion and construction for meeting the increasing demands on Metropolitan due to population growth. Fiscal year 1989-90 expenditures under the active agreements totaled about $21,561,811.

TABLE 34

ENGINEERING PROJECTS IN DESIGN

Facility	Project	Status as of June 30, 1990	Estimated Project Completion Date	Cost as of 6-30-90 ($1,000s)	Total Project Cost ($1,000s)
AQUEDUCT SYSTEM	[illegible]	Preliminary Design in Progress	February 1992	65	300
	[illegible]	Preliminary Design in Progress	March 1992	24	3 400
	[illegible]	Final Design Complete; Construction Contract Award Scheduled for July 1990	To be Determined	22	625
DISTRIBUTION SYSTEM	[illegible] Pipeline	Design Complete; Construction Contract Award to Advance Construction in June 1990 ($41 654 520); Construction Scheduled to Start August 1990	June 1992	4 9[illegible]	51 000
	Etiwanda Power Plant	Preliminary Design Complete; Final Design Scheduled to Start July 1990	October 1991	887	25 700
	Palos Verdes Feeder - Install Corrosion Protection	Final Design in Progress; Construction Contract Award Scheduled for January 1991	December 1991	160	1 600
	Santa Ana Cross Feeder - Relocate for City of Santa Ana Storm Drain Enlargement [1]	Final Design in Progress; Construction Scheduled to Start November 1990	December 1990	136	200
	East Orange County Feeder No. 2 - Relocate for Freeway 55 Interchange Reconstruction [1]	Final Design in Progress; Construction Contract Award Scheduled for April 1991	November 1991	354	830
	San Jacinto Tunnel West Portal - Construct Seismic Modifications	Preliminary Design in Progress; Construction Contract Award Scheduled for November 1991	August 1992	14	1 500

(1) [illegible]

TABLE 34 (Continued)

ENGINEERING PROJECTS IN DESIGN

Facility	Project	Status as of June 30, 1990	Estimated Project Completion Date	Cost as of 6-30-90 ($1,000s)	Total Project Cost ($1,000s)
FILTRATION PLANTS					
All Plants	Chemical Containment Program	Study in Progress	January 1991	232	15 000
	Preliminary Ozonation Engineering Study	Study in Progress	December 1990	15	5 000[1]
Weymouth Plant	Construct Corrosion Material Test Lab	Final Design in Progress; Construction Scheduled to Start August 1990	March 1991	2	675
Jensen Plant	Expansion No. 1	Final Design in Progress; Construction Contract Award Scheduled for July 1991	July 1994	3 780	129 000
	Finished Water Reservoir No. 2	Final Design in Progress; Construction Contract Award Scheduled for August 1991	December 1994	74	21 000
Diemer Plant	Washwater Reclamation Plant	Final Design Complete; Construction Contract Award Scheduled for August 1990	October 1991	1 142	10 500
Skinner Plant	Administration Building Expansion	Design Completed; Construction Contract Award Scheduled for January 1991	August 1991	128	1 650
	Install Permanent Chlorination System in Outlet Tower	Final Design in Progress; Construction Scheduled to Start January 1991	September 1991	78	625
	Bypass Pipelines Nos. 2 and 3	Final Design in Progress; Construction Scheduled to Start November 1990	April 1992	1 494	12 000
	Secondary Containment for Chemicals and Hazardous Substances	Final Design in Progress; Construction Scheduled to Start September 1990	November 1990	3	100
Mills Plant	New Maintenance Building and Administration Building Expansion	Design in Progress; Construction Contract Award To be Scheduled	To be Scheduled	264	3 800

(1) Study Only

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TABLE 34 (Continued)

ENGINEERING PROJECTS IN DESIGN

Facility	Project	Status as of June 30, 1990	Estimated Project Completion Date	Cost as of 6-30-90 ($1,000s)	Total Project Cost ($1,000s)
RESERVOIRS	[illegible]	[illegible]	[illegible]	[illegible]	25,000
	[illegible]	Studies in Progress	To Be Determined	[illegible]	400
	[illegible]	[illegible] in Progress	December 1992	[illegible]	650
	[illegible]	Preliminary Design in Progress	May 1991	14	300
	[illegible]	Preliminary Design in Progress	To Be Determined	[illegible]	2,800
LOS ANGELES HEADQUARTERS	Install Emergency [illegible]	Final Design Complete, Construction Contract Award Scheduled for August 1990	February 1991	64	150
	Replace Precast Concrete Sunscreens	Final Design in Progress, Construction Contract Award Scheduled for April 1991	October 1991	27	1,450
POWER PLANTS	Install Fire Safety and Security System	Design Complete, Construction Contract Award [illegible] in August 1990 ($441,800), Construction Scheduled to Start October 1990	To Be Determined	90	675
	Hydroelectric Power Plants (Except Greg Avenue Phases I and II) Install Vibration Monitoring Systems	Final Design in Progress, Construction Scheduled to Start May 1991	October 1991	16	475
	Temescal and Corona Power Plants, Construct Air Release Structures	Final Design in Progress for Corona, Construction Scheduled to Start November 1990 (Temescal Complete)	December 1990	232	300

TABLE 34 (Continued)

ENGINEERING PROJECTS IN DESIGN

Facility	Project	Status as of June 30, 1990	Estimated Project Completion Date	Cost as of 6-30-90 ($1,000s)	Total Project Cost ($1,000s)
GENERAL	Central Stores Stock—Conical Plug Valves	Final Design Complete Material Procurement in Progress	October 1990	33	1,200
	Coastal Plain Facilities—Install Digital Microwave Network	Final Design Complete, Construction Contract Award Scheduled for July 1990	March 1992	2	3,225
	Soto Street Maintenance Center Replacement	Studies in Progress	To Be Determined	73	To Be Determined
SERVICE CONNECTIONS (1)	Foothill Feeder Pressure Control Structure Expansion	Final Design in Progress, Construction Scheduled to Start April 1992	June 1992	48	4,100
	Foothill Feeder—Construct LA 35 to LA Aqueduct Treatment Plant	Final Design in Progress, Construction Schedule to be determined	To Be Determined	37	4,600 (50% Reimbursable)
	Santiago Lateral—Construct OC 64	Final Design in Progress, Construction Scheduled to Start January 1991	June 1991	4	250
	San Diego Pipeline—Construct EM 10	Preliminary Design in Progress	To Be Determined	1	450
	Middle Feeder—Construct USG 9	Preliminary Design in Progress	May 1991	7	445

(1) Reimbursable

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TABLE 35

ENGINEERING PROJECTS UNDER CONSTRUCTION

Facility	Project	Contractor	Start Date	Percent Construction Complete 6-30-90	Contract Cost ($1,000s)	Estimated Project Completion Date	Cost as of 6-30-90 ($1,000s)	Estimated Project Cost ($1,000s)
DISTRIBUTION SYSTEM	[illegible]	[illegible]	Aug. 1989	[illegible]	[illegible]	August 1991	[illegible]	41,000
	[illegible] Control Facility and Reservoir	[illegible] Construction	June 1990	6	[illegible]	March 1992	4,091	45,000
	Orange County Feeder [illegible]	[illegible] Construction Co., Inc.	Feb. 1990	2	[illegible]	December 1990	20	4,600[(1)]
	East Valley Feeder - Structure Modifications	MWD and Outside Contractors	Mar. 1986	75		September 1990	1,675	3,500
	Santa Margarita Pipeline	Various	July 1989	75	Various Amounts	June 1991	[illegible]	47,000 Metropolitan's share of joint funding
AQUEDUCT SYSTEM	All Pumping Plants - Replace 38 Bronze Impellers and Purchase up to One Spare Impeller for Each Plant	MWD	Nov. 1987	75		June 1992	5,029	6,515
	All Pumping Plants - Replace Thermometers and Temperature Recorders in Control Rooms	MWD	Jan. 1984	60		September 1992	307	460
	All Pumping Plants - Install 480 Volt Station Power Supply System	MWD	July 1986	90		August 1991	118	325

(1) This cost is reimbursable and includes costs to other participating agencies.

TABLE 35 (Continued)

ENGINEERING PROJECTS UNDER CONSTRUCTION

Facility	Project	Contractor	Start Date	Percent Construction Complete 6-30-90	Contract Cost ($1,000s)	Estimated Project Completion Date	Cost as of 6-30-90 ($1,000s)	Estimated Project Cost ($1,000s)
AQUEDUCT SYSTEM (Cont.)								
	All Pumping Plants – Install External Heat Exchangers on Bank No. 1 230 KV Transformers	MWD	Oct. 1988	70	–	July 1991	633	850
	All Pumping Plants – Replace Motor Protection Relays on Units 4, 5, and 6	MWD	Jan. 1986	60	–	July 1993	8	130
	All Pumping Plants – Replace 165 Surge Capacitors on Main Pump Motors and Transformers	MWD	Jan. 1986	30	–	Beyond 1992	2	150
FILTRATION PLANTS								
Weymouth Plant	Washwater Reclamation Plant Expansion	C.W. Roen Construction Co.	April 1990	7	7,773	June 1991	1,820	9,200
	Replace Longitudinal Scraper Drive Assemblies in Settling Basins Nos. 3 and 4	MWD	Feb. 1989	50	–	April 1991	449	490
	Modify Sparger Systems in Filter Buildings Nos. 1 and 2	MWD	April 1990	20	–	May 1991	81	170
	Install Backwash Turbidimeters in Filter Bldgs. Nos. 1 and 2	MWD	May 1990	5	–	February 1991	99	155

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TABLE 35 (Continued)

ENGINEERING PROJECTS UNDER CONSTRUCTION

Facility	Project	Contractor	Start Date	Percent Construction Complete 6-30-90	Contract Cost ($1,000s)	Estimated Project Completion Date	Cost as of 6-30-90 ($1,000s)	Estimated Project Cost ($1,000s)
FILTRATION PLANTS (Cont.)								
Weymouth Plant	Oxidation Demonstration Plant	Meri... Construction Engineers, Inc	May 1990	3	12,204	June 1991	3,602	19,600
	Modify Water System	MWD	Mar 1989	10		June 1991	580	850
	Replace Water Quality Instruments	MWD	Sept 1989	25		August 1991	65	150
	Construct Washwater Pipe Extension to Wash water Reclamation Plant Influent	MWD	Feb 1990	50		August 1990	571	580
	Construct Interface Modifications at Wash water Reclamation Facility	MWD	Feb 1990	3		March 1991	117	2,100
Jensen Plant	Security Improvements	Honeywell Inc	Mar 1989	91	101	August 1990	101	205
Diemer Plant	Plant Modifications	MWD	May 1989	75		April 1992	2,676	5,825
Skinner Plant	Expansion No. 3	Kiewit Pacific Co	May 1989	80	48,190	June 1991	393	68,450
	Finished Water Reservoir	Kiewit Pacific Co	June 1989	80	20,541	March 1991	16,471	20,800
	Modules 1 and 3 Influent Flocculation	MWD	Nov 1987	75		January 1991	53	110
	Control Room Modifications	MWD	May 1989	98		August 1990	393	550
	Install Automatic Computer Assisted Control Systems	MWD	May 1989	70		September 1991	1,361	2,000

TABLE 35 (Continued)

ENGINEERING PROJECTS UNDER CONSTRUCTION

Facility	Project	Contractor	Start Date	Percent Construction Complete 6-30-90	Contract Cost ($1,000s)	Estimated Project Completion Date	Cost as of 6-30-90 ($1,000s)	Estimated Project Cost ($1,000s)
FILTRATION PLANTS (Cont.)								
Mills Plant	Secondary Containment for Chemicals and Hazardous Substances	MWD	April 1990	40	—	July 1990	9	160
LOS ANGELES HEADQUARTERS	Install Network Cabling System	Optec, Inc	May 1990	99	261	July 1990	729	2,463
	Replace Telephone Switch (L.A.) and Install Telephone System System (Pasadena)	MWD	Jan 1990	90	—	July 1990	721	980
GENERAL	Distribution System—Install Discharge Monitoring Alarms	MWD	Feb 1990	98	—	September 1990	29	500
	All Facilities Replace Underground Storage Tanks Phase II	M.H. Lee Co (Scheds. I, III & IV)	Nov 1989	93	260	October 1990	247	2,600[1]
		IT Corporation (Sched. II)	Nov 1989	81	342	August 1990	282	2,600[1]
	Mobile Chlorination Unit 3	MWD	Jan 1990	40	—	March 1990	197	720
	Various Facilities Data Networking	MWD[2]	May 1990	99	—	March 1992	729	2,463
	Upgrade CBX at Weymouth Plant and Install ROLM net at 11 Facilities	MWD	Feb 1990	70	—	September 1990	96	350

[1] Includes cost for Phases I through III

[2] MWD is performing majority of work, however outside contractors will perform some portions

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TABLE 36
ENGINEERING PROJECTS — CONSTRUCTION COMPLETED

Facility	Project	Contractor	Start Date	Completion Date	Contract Amount ($1,000s)	Total Project Cost ($1,000s)
DISTRIBUTION SYSTEM	[illegible]	[illegible]	[illegible]	[illegible]	148	400
	[illegible]	MWD	August 198[illegible]	January 19[illegible]		590
AQUEDUCT SYSTEM	[illegible]	[illegible]	February 198[illegible]	June 198[illegible]	Various Amounts	1,755
	[illegible] Install [illegible] Fremantle	MWD	September 1988	October 1989		4?
FILTRATION PLANTS						
Weymouth Plant	Install Computer-Assisted Automatic Plant Control	MWD	October 1985	July 1989		2,600
	Replace Pneumatic Equipment and Instrumentation in Filtration Building No. 2 and Washwater Reclamation Plant	MWD	January 1988	May 1990		175
	Secondary Containment for Chemicals and Hazardous Substances	MWD	May 1990	June 1990		100
	Replace Water Sampling Pumps	MWD	February 1987	July 1989		250
	Replace Chlorine Solution Manifold and Feed Lines	MWD	April 1989	March 1990		270
Jensen Plant	Install Lab Particle Counter	MWD	July 1989	November 1989		220
	Replace Chemical Feed Pumps	MWD	May 1989	February 1990		300
	Install Chemical Flowmeters	MWD	May 1989	March 1990		130
	Secondary Containment for Chemicals and Hazardous Substances	MWD	May 1990	June 1990		100

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TABLE 36 (Continued)
ENGINEERING PROJECTS — CONSTRUCTION COMPLETED

Facility	Project	Contractor	Start Date	Completion Date	Contract Amount ($1,000s)	Total Project Cost ($1,000s)
FILTRATION PLANTS (Cont.)						
Diemer Plant	Install Automatic Computer-Assisted Control System	MWD	November 1983	August 1989	—	5,700
	Replace Sludge Pumps	MWD	May 1989	December 1989	—	250
	Secondary Containment for Chemicals and Hazardous Substances	MWD	May 1990	June 1990	—	100
Skinner Plant	Install Automatic Computer-Assisted Controls on Modules 1, 2, and 3	MWD	April 1987	October 1989	—	1,400
	Install Chemical Flowmeters on Modules 1, 2, and 3	MWD	July 1987	October 1989	—	130
Mills Plant	Modifications and Additional Retention Basins	G. A. MacDonald Construction Co.	December 1988	August 1989	1,584	2,000
	Sanitary Waste System	MWD	May 1989	August 1989	—	120
GENERAL	All Facilities—Replace Underground Storage Tanks—Phase I	Tait & Associates, Inc.	June 1989	May 1990	144	2,600[1]
SERVICE CONNECTIONS [2]	Mills Plant—Construct WR 24D	KEC Contractors	September 1988	October 1989	(3)	350
	Rialto Pipeline—Construct CB-16	MWD	December 1989	August 1989	—	1,270
	Venice Pressure Control Structure Inlet—Construct LA 30	MWD	October 1988	July 1989	—	995
	Lower Feeder—Construct CenB 30	Schuler Engineering Corp.	February 1989	October 1989	(3)	36[illegible]
	Orange County Feeder Extension—Construct CM-13	Pascal & Ludwig	April 1989	February 1990	(3)	26[illegible]

(1) Includes Costs for Phases I through III
(2) Reimbursable
(3) Outside agency is administering contract

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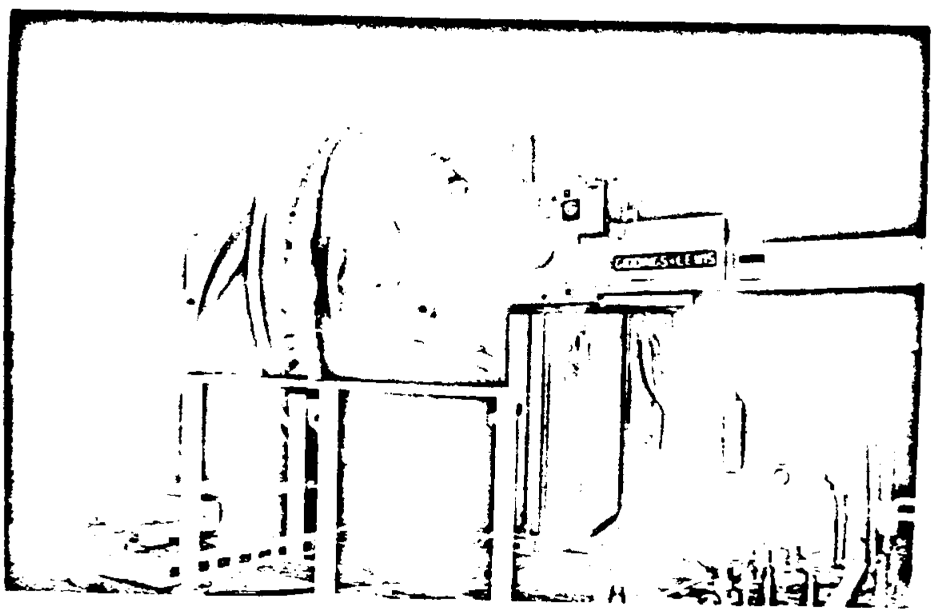
TABLE 37
MISCELLANEOUS CONTRACTS

Project	Contractor	Contract Cost	Awarded	Percent Completed
Security Improvements [illegible] Jensen [illegible]	[illegible]	$[illegible]	[illegible]	91
Repair [illegible]	[illegible]	$[illegible]	[illegible]	100 (11 3 89)
Remove and Replace [illegible] Phase [illegible]	[illegible] Associates [illegible]	$[illegible]	[illegible]	100 ([illegible] 4 90)
Safety and Security Systems [illegible] Headquarters	[illegible]	$4[illegible]7 8[illegible]	8 8[illegible]	[illegible]
Remove and Replace Underground Tanks Phase II Scheds [illegible]	[illegible] Company	$268 7[illegible]	8 89	9[illegible]
Remove and Replace Underground Tanks Phase II Sched [illegible]	IT Corporation	$141 928	8 89	8[illegible]
Remove and Replace Filter Media Jensen Plant	Kiewit Pacific Company	$330 000	2 90	0
Network Cabling System Los Angeles Headquarters	Optec Inc	$260 000	2 90	99
Modifications to Overhead Bridge Cranes Colorado River Aqueduct Pumping Plants	General Hoist Corporation	$587 440	6 90	0



[illegible] special services section machines this impeller from [illegible]

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Board Chairman Lois B. Krieger presides over discussion at a lively Board of Directors meeting

CHAPTER 7

Legal

Metropolitan's legal staff represents Metropolitan, its Board of Directors, officers, and occasionally employees, in litigation and administrative proceedings. The staff provides the Board and Metropolitan officers with legal advice and written opinions, and reviews contracts and other documents. Additionally, the staff follows litigation and administrative proceedings to which Metropolitan is not a party, but whose outcome could affect Metropolitan or the resources on which it depends. By closely monitoring State and Federal legislative proposals, staff recommends positions Metropolitan should take, if any.

Litigation

Water Matters

Azusa Landfill Litigation

Metropolitan participated in State Water Resources Control Board (SWRCB) hearings supporting a petition by the Main San Gabriel Basin Watermaster to set aside a Los Angeles Regional Water Quality Control Board Order. That order allowed a major expansion of the Azusa Land Reclamation Company's municipal waste landfill in the San Gabriel Groundwater Basin's (Basin's) water recharge area. The California Departments of Water Resources (DWR) and Health Services (DHS), along with overlying water service agencies, locally elected legislators and other officials, and environmental and community groups also supported the Watermaster's petition.

The Basin provides drinking water supplies for nearly 1 million people within that portion of Metropolitan's service area. Additionally, Metropolitan stores imported water in the Basin and is actively studying a cooperative program for substantially expanding that storage.

Evidence adduced at the hearings indicated that the landfill expansion seriously threatens major contamination of the groundwater supplies and aquifers. The U.S. Environmental Protection Agency has already placed portions of the Basin on the National Superfund Priority List ... is currently formulating a billion-dollar remedial program, most of ... ch must be financed by local entities.

Nevertheless, SWRCB upheld the Regional Board's approval of the l... ... expansion with some modifications, including a conditional $20.5 m... ...on proposal by the landfill operator's parent entity, Browning Ferris Indus...es.

On November 8, Metropolitan, along with the Upper San Gabriel Valley Municipal Water District and the Environmental Defense Fund (EDF), filed an action in the Los Angeles Superior Court to rescind SWRCB's approval of the landfill expansion. The court consolidated the case with a similar action filed concurrently by the Watermaster. The actions assert that SWRCB's approval of the landfill expansion violates its duties under California's Water Quality Control Act, Solid Waste Management Act, and Environmental Quality Act (CEQA), as well as due process and other procedural requirements.

On April 20, 1990, the court rejected both actions. It ruled that SWRCB properly weighed conflicting needs for waste disposal and water supply and that the record indicates that any resulting groundwater impairment is reasonably remote. Additionally, the court ruled that the need for an Environmental Impact Report (EIR) on the expansion had not been adequately raised during the SWRCB proceedings and that SWRCB had nevertheless considered environmental issues.

Metropolitan and the other petitioners are appealing the Superior Court judgment, and a Court of Appeal ruling is expected within the next year.

Chino Basin ... Management Litigation

On July 31, 19..., the San Bernardino Superior Court issued a statem... of decision denying a motion by four Chino Valley water purveyo... challenging the validity of Metropolitan's groundwater storage exchan... agreement with the Chino Basin Watermaster and other aspects of t... Watermaster's management program.

Among other things, the decision holds that Metropolitan's agreeme... with the Watermaster fully complies with the letter and spirit of the 19... Chino Basin groundwater management judgment, and properly an... adequately safeguards the rights of the parties to that judgment. Th... decision also recognizes Metropolitan's right to participate in an... proceeding under that judgment that affects Metropolitan's real an... substantive interests without becoming a party to the judgment.

LEGAL

Imperial Irrigation District v. SWRCB

During the fiscal year, Imperial Irrigation District (Imperial) and SWRC... filed their respective briefs with the Court of Appeal in Imperial's continuing challenge of the validity of SWRCB's 1984 Water Rights Decision 1600. That decision concluded that Imperial's failure to develop and implement an adequate plan for reducing major losses in its Colorado River diversions violated the California Constitution's reasonable use requirements.

Expected to hear argument on the appeal in late 1990, the Court of Appeal previously upheld SWRCB's jurisdiction to adjudicate the reasonableness of Imperial's water management practices. The current appeal asserts that SWRCB did not comply with evidentiary and procedural requirements in issuing Decision 1600.

Mono Basin Water Rights Litigation

The Court of Appeal and the El Dorado Superior Court issued opinions and orders that significantly reduce the city of Los Angeles' 100,000 acre-feet Mono Basin water rights; these orders prevented Los Angeles from exporting any water from Mono Basin this past year. As a result, a substantial portion of the 155,000 acre-feet increase in Los Angeles' purchase of water from Metropolitan this fiscal year was used to offset this loss.

The Superior Court has issued preliminary injunctions that require Los Angeles to release substantial amounts of water for fishery purposes into Mono Basin streams that flow into saline Mono Lake, and to refrain from exporting any water from the basin until the Mono Lake level increases several inches.

In late June 1990, the Superior Court began lengthy evidentiary hearings to reconsider terms for extending the lake level preliminary injunction. Metropolitan's General Manager, Director of Planning, and Chief of Operations provided testimony describing the Mono Basin exports' importance to Metropolitan's service area.

Both preliminary injunctions are intended to maintain estimated fish flow and lake-level requirements until SWRCB completes a more precise re-evaluation, expected by the end of 1992, of Los Angeles' Mono Basin water rights licenses.

Coachella Valley Water District v. Metropolitan et al.

On January 26, 1990, the Coachella Valley Water District dismissed this action which challenged the validity of the Imperial/Metropolitan Conservation Agreement, with prejudice.

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American River Litigation

In December 1989, the Alameda County Superior Court finalized its decision in the American River litigation which EDF initiated 17 years earlier as *EDF v. East Bay Municipal Utility District* (East Bay). Of particular interest to Metropolitan, the decision applies the public trust doctrine by balancing instream flow uses with competing water supply needs, and concludes that providing high quality drinking water is a significant public policy objective in that balancing process.

The decision allows East Bay to export up to 150,000 acre-feet of water annually from the river under East Bay's Federal Central Valley Project water supply contract. However, the decision conditions that export on maintaining substantial instream flows. It also includes a physical solution to implement the decision, reserves continuing jurisdiction, and appoints a watermaster to aid in administering the physical solution.

Laughlin River Tours, Inc., et al. v. Bureau of Reclamation et al.

On December 29, 1989, the federal district court denied the request of Laughlin River Tours, Inc., for releases of water from Davis Dam for the sole purpose of facilitating Colorado River navigation. The claim for damages by Laughlin against the Federal government is still pending.

Indian Claims and Litigation

Arizona v. California III

After the U.S. Supreme Court affirmed the dismissal of *Metropolitan et al. v. United States et al.* (Indian boundary litigation), Metropolitan, joined by the States of Arizona and California and the Coachella Valley Water District, filed a motion to re-open *Arizona v. California* for the limited purpose of finally determining the boundaries and their attendant water rights, if any, of three Indian reservations along the lower Colorado River. The Supreme Court granted the motion and appointed a Special Master to hear the dispute and make recommendations to the Supreme Court.

Soboba Band of Mission Indians v. United States

This case has now been set for trial in February 1991 with regard to the damages issues. If damages are awarded to the Sobobas, the United States may possibly assert a claim against Metropolitan for reimbursement for a portion thereof. Additionally, an action on behalf of the Sobobas could possibly be brought for monetary damages or for a determination of the Sobobas' water rights or both.

Miscellaneous Matters

Mission Viejo Company v. MWD, et al.

This Los Angeles County Superior Court action asserts violations of CEQA and other statutes in purchasing properties for the proposed Eastside Reservoir, particularly the Searl Ranch property. It was brought by private developer Mission Viejo Company against Metropolitan, the Board of Directors, each individual Board member, and two staff members. On July 24, 1989, a preliminary injunction sought by plaintiff was denied. Causes of action against individual directors and staff members were severed and are currently the subject of a tentative judgment for dismissal. The remaining cause of action for writ of mandate has been ordered coordinated with a companion Riverside County Superior Court action (*Faulkner v. MWD*). The parties have engaged in extensive discovery pending designation of a trial court and trial date.

Faulkner, et al. v. MWD

On October 24, 1989, 22 individuals, subsequently reduced to 16 individuals, claiming to be resident owners of various land parcels located in or around the Domenigoni Valley in close proximity to the Searl Ranch properties, filed a petition for writ of mandate against Metropolitan in Riverside County Superior Court alleging violations of CEQA and other statutory provisions. That action is now at issue, extensive discovery has proceeded, and that action has been coordinated with a companion Los Angeles County Superior Court action for trial. The parties are continuing with discovery and await the designation of a trial court and trial date.

Mission Viejo Company v. Searl, MWD, et al.

On August 8, 1989, Mission Viejo Company filed and served its amended complaint in Riverside County Superior Court against the sellers of the Searl Ranch property and Metropolitan for specific performance, constructive trust, etc. with regard to the Searl Ranch properties. Discovery is proceeding and trial is set for November 1990.

Mission Viejo Company v. MWD, et al.

In addition to the pending lawsuits already described, on or about December 29, 1989, Mission Viejo Company filed a government tort claim against Metropolitan, all persons who were members of the Board of Directors in May 1989, and two staff members, claiming damages according to proof for Metropolitan's alleged tortious interference with contract in its purchase of the Searl Ranch property for the proposed Eastside Reservoir. Metropolitan denied the claim on February 9, 1990. By stipulation and agreement with Metropolitan, Mission Viejo Company has until September 9, 1990, to file suit on those alleged claims.

MWD v. Cucamonga Development Company et al.

This is an action in eminent domain filed by Metropolitan on December 12, 1989, to take a parcel of property consisting of approximately 80.51 acres located in the city of Rancho Cucamonga. Metropolitan obtained an Order for Possession of the property on December 27, 1989, and, based on an independent appraisal, deposited $8,767,500 with the court as compensation for the parcel. A trial-setting conference is scheduled for August 24, 1990. The parties have not yet exchanged valuation data; therefore, it is uncertain what amount, if any, beyond the deposit the defendant will demand.

Garvey Reservoir Leak

Due to an October 1989 leak at Garvey Reservoir, approximately 37 claims for personal injury and property damages have been submitted to Metropolitan by the city of Monterey Park and homeowners residing near the reservoir. Nineteen of those claims have been denied; nine are still under investigation; two offers have been submitted; and Metropolitan is prepared to submit offers to five additional homeowners as soon as they provide final estimates of property damage. Metropolitan offered to settle the claims submitted by Monterey Park, which denied the offer; there is one new claim. Of the 19 claims denied, 13 were denied because the claimants did not specify the extent of their damages; thus, Metropolitan was unable to act on those claims. The 45-day period for responding to such claims expired in May 1990.

Nine of the claimants live on Ransom Way in Monterey Park, and Metropolitan engineers have been unable to determine whether there is a causal connection between the Garvey Reservoir leak and their claimed damage. As a result, those claimants were notified that Metropolitan was still investigating their claims and, within 90 days from the notice date, Metropolitan would make a decision about those claims. To date, no one has accepted any of Metropolitan's offers.

Employees Association of The Metropolitan Water District of Southern California Local 1902, AFSCME, AFL-CIO v. The Metropolitan Water District of Southern California et al., Case Nos. BC 003912 and BS 001327

Near the end of the fiscal year, Metropolitan was served with a complaint for injunctive relief and was also served with a petition for writ of mandate in the above matters. Later, an amended petition was served. The Employees Association (Association) alleged that Metropolitan was committing unfair labor practices in its handling of a petition from a group of employees who wish to split from the Association and form a new employee organization. The petitioning group, made up primarily of maintenance, operations, and crafts workers located at Metropolitan's field facilities and calling itself the Field Employees and Technical Crafts

[Ass]ociation (FETCA), filed a petition signed by more tha[n] ... [th]e employees in the job classifications that it hoped to ... [Metro]politan's Employee Relations Officer determined, as ... [M]etropolitan's Administrative Code, that the group was an ... [u]nit" and scheduled an election to determine whether FETCA or the Ass[oci]ation will represent the unit.

The Association alleged that Metropolitan and certain named defendants dominated, interfered with, and encouraged the formation of FETCA in order to divide the Association and in retaliation for the Association's recent affiliation with the American Federation of State, County, and Municipal Employees. The complaint seeks a temporary and permanent injunction. The petition seeks damages, including punitive damages of $1 million, and an order enjoining Metropolitan from recognizing the new group for 12 months. The Los Angeles Superior Court denied the Association's request for a Temporary Restraining Order, and its request for a Preliminary Injunction. A tentative settlement resulting in dismissal of this action has been reached and will be presented to the Metropolitan's Board for approval on September 11, 1990.

Internal Matters

Staff was involved in various cases in which damages were claimed for death, personal injury, or property damage, principally resulting from accidents involving motor vehicles. Staff also represented Metropolitan in various personnel matters involving disciplinary issues or discrimination claims.

Administrative Proceedings

State Water Resources Control Board Activities—Bay Delta Hearings

The SWRCB San Francisco Bay-Sacramento-San Joaquin Delta Estuary (Bay-Delta) water quality and water rights proceedings continued.

In these proceedings, SWRCB will (1) develop a document ... [p]ollutant policy for waters, (2) adopt a water quality control plan ... [b]eneficial uses of Bay/Delta waters and determining reasonable ... [p]rotection for those uses, and (3) hold a water rights hearing ... [t]he need to condition water rights as a means to protect those ... [u]ses. A wide variety of interests are represented in the hearing ... [t]he operators of State and Federal water projects; State and Federal ... [w]ildlife, and other resources agencies; agricultural and municipal ... water users, both in export areas and within the watershed; and environmental and other special interests. Metropolitan particip...

concert with the State Water Contractors (SWC), a nonprofit corporation made up of public entities with State Water Project (SWP) water delivery contracts.

In January 1990, SWRCB released a partial Revised Draft Water Quality Control Plan (WQCP) for the Bay Delta that discussed alternative water quality objectives proposed by the parties to this proceeding and by SWRCB staff, and held hearings on this partial draft in February 1990.

A full Revised Draft WQCP was released in June 1990 which contains a variety of proposed water quality objectives. The WQCP does not include the large freshwater outflow objectives that were contained in SWRCB's November 1988 Draft WQCP, which was withdrawn as a result of petitions filed by Metropolitan and others. The withdrawn flow objectives, based on fisheries' purported needs, will instead be considered in the proceeding's water rights phase. However, the Revised Draft WQCP still contains objectives that, if adopted, could cause the loss of as much as 2 million acre-feet of water available for municipal, industrial, and agricultural purposes.

The SWRCB adopted its Pollutant Policy Document on June 21, 1990. That document is intended to set policy to prevent pollution in the Bay Delta as a guide for the San Francisco Bay and Central Valley regional boards in amending plans for their respective regions' basin plans.

The ultimate WQCP and water rights decision could have a substantial impact on SWP's ability to store and export Delta water. This could, in turn, decrease the amount of water available for delivery to Metropolitan under its SWP contract. Nearly every California urban area and scores of agencies delivering water for agricultural purposes could also face reductions in available water from the Bay Delta watershed.

Shasta Dam Storage Releases

On May 2, 1990, SWRCB adopted a water rights order which imposed additional terms and conditions on the U.S. Bureau of Reclamation's (Reclamation's) permits and licenses to divert and store water at its Shasta Dam and Keswick Dam facilities. The terms and conditions are intended to improve temperature conditions in the Sacramento River below Shasta Dam for fall run Sacramento River salmon.

The water rights proceeding followed SWRCB's rescission of a similar order by the Central Valley Regional Water Quality Control Board issued as a waste discharge order under its water quality authority. Reclamation—supported by Metropolitan, SWC and others—had successfully argued that the regional board's order was beyond its water quality authority and was a matter more properly before SWRCB under its water quality authority.

Both Reclamation and the Central Valley Project Water Association h... filed actions seeking to invalidate SWRCB's order asserting that the ord... (1) violates CEQA because it was issued without a completed EIR an... (2) violates California Water Code sections 1253 and 1257 because SWRC... modified Reclamation's permits without considering and balancing th... relative benefit and public interest in consumptive water uses. Reclamation... action was filed in Federal court, the water association's in State cour...

Legislation

All legislation introduced in the California Legislature was examined to determine matters of interest to Metropolitan. Staff prepared a digest and recommendations as aids in reporting to the Board of Directors and to others those items requiring a policy determination.

Metropolitan supported several water conservation measures during the 1989-90 session, some of which were enacted by the Legislature prior to the session's end. Assembly Bill (AB) 325 (Statutes of 1990, Chapter 1145), authored by Assembly Member Steve Clute, requires DWR to appoint and work with an advisory task force to adopt a model water-efficient landscape ordinance which local agencies could then utilize. This measure would encourage and facilitate local agencies to adopt landscaping ordinances which would reduce demand on Metropolitan. Senate Bill (S) 1520 (Statutes of 1990, Chapter 809), authored by Senator Robert Presley, excludes from income any rebate a taxpayer receives from a local water agency as reimbursement for installing a low flush toilet, thus encouraging consumers to participate in low flush toilet rebate programs. AB 2355 (Statutes of 1989, Chapter 1029), authored by Assembly Member Bill Filante, sets stricter standards for water closets and associated flushometer valves. In time, these lower water-use facilities should reduce per capita water demands in Metropolitan's service area, particularly in new growth areas.

Of several water quality bills, Metropolitan was particularly concerned with AB 2158 (Statutes of 1990, Chapter 1182), authored by Assembly Member Jim Costa. The bill as enacted places all public water systems that have 15 or more connections under DHS's regulatory authority and requi... public water systems with 200 or more connections to pay $.50 for ea... connection. The $.50 fee is repealed as of July 1, 1991. After that date, pub... water systems will pay a fee based on the costs of service provided b... the DHS to the particular system. Metropolitan opposed S 65 (Statutes of 1990, Chapter 407) authored by Senator Quentin Kopp, amending t... Safe Drinking Water and Toxic Enforcement Act of 1986 to include publ... agencies, which include water utilities, under the warning and som... discharge requirements. S 65 will be on the November 1990 general election ballot as Proposition 141. If passed, water utilities will be required to warn their customers of chemicals in their water that are known to cause cancer or reproductive toxicity. Additionally, water utilities would not be allowed to use certain chemicals at "unsafe" levels and would have to either find replacement chemicals, lower the chemical's level or remove the chemical from their systems.

A package of bills intended to protect wetlands were introduced during the Legislative session's second half. The Board opposed some of those bills — S 2530 authored by Senator Milton Marks, AB 4231 authored by Assembly Member Byron Sher and AB 4327 authored by Assembly Member Phillip Isenberg — because they would impose additional restrictions, requirements, and costs on operating agencies, far exceeding existing Federal and State statutes or other measures necessary to protect wetlands. The Board adopted a position urging that the bills be amended to eliminate redundant permission and unreasonable mitigation requirements and to conform with Federal guidelines. The bills were not enacted during the 1989-90 session but are expected to be introduced again during the 1991-92 Legislative session.

Voice and data communications travel between Metropolitan's ... strategically placed microwave towers.

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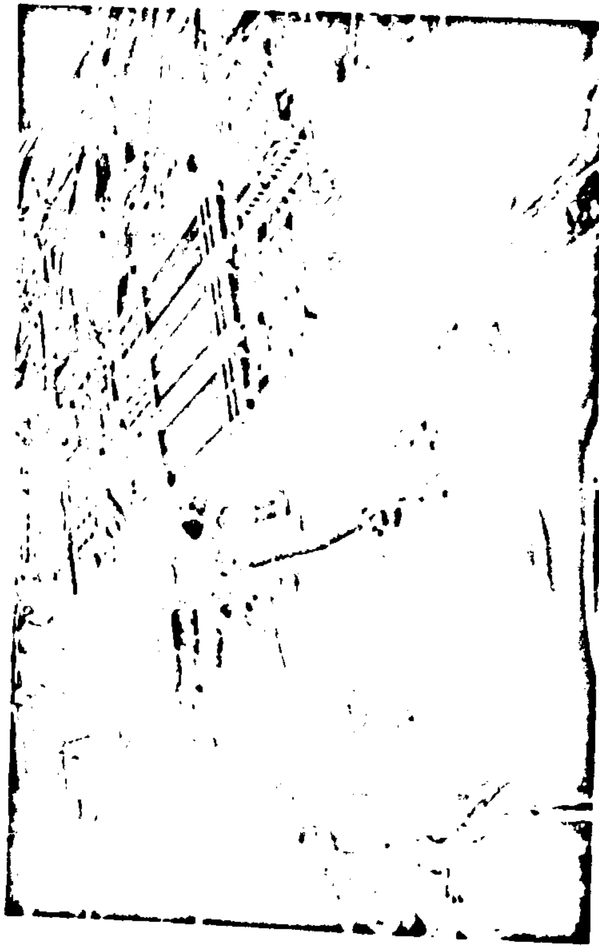

Expansion at the Robert A. Skinner Filtration Plant will increase output by 200 million gallons per day to meet San Diego and Riverside Counties' growing needs.

CHAPTER 8

Financial Planning and Operations

Long-Range Financial Plan Strategy

Throughout the fiscal year, staff continued analyzing financial techniques to determine whether a more cost-effective means than presently strategized for financing Metropolitan's capital improvement plan may be advantageous. Current projections indicate that capital improvements and additions to the water distribution and treatment systems through the year 2010 will cost $4.3 billion in 1990 dollars, or $6.0 billion in escalated dollars after taking into account the construction schedule. The Finance Plan Strategy recommends financing these expenditures primarily from a combination of security sales and pay-as-you-go financing. The securities would include fixed- and variable-rate revenue bonds and commercial paper offerings.

Developing a new source of firm revenue would reduce reliance on variable water revenues as future Metropolitan taxes and water rate stabilization fund balances decline. During the year, staff continued reviewing charges as a firm revenue source. A consultant compiled information on parcel data from Metropolitan's six-county service area during the year; a model data base is being constructed to provide information on future revenue that could be derived from various levels of stand-by charges.

By law, Metropolitan's revenue bond debt capacity is limited to an amount equal to its equity as shown on its balance sheet. To confirm [illegible] revenue bond capacity will exist to finance the Capital [illegible] staff projected Metropolitan's financial statements and [illegible] each year to the year 2000 using an updated Consumer [illegible] The analysis, which took into account the Board's 20 percent [illegible] objective, reconfirmed that the projected revenue bond debt [illegible] Metropolitan's projected equity.

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In January 1989 the Board established the Revolving Construc[illegible] Fund (RCF) with a $100 million transfer from the Water Rate Stabilizat[illegible] Fund (WRSF). The RCF currently finances Metropolitan capital works [illegible]ich general obligation bond proceeds cannot be used. In 1993 the fu[illegible] [illegible]ll be closed and the $[illegible] million plus interest will be transferred to the WRSF.

Selection of Financial Advisor

[illegible] year Metropolitan sent requests for proposals to financial firm[illegible] consideration as financial advisor. Staff received requests for p[illegible] from 12 firms and conducted interviews with six. The firm of [illegible] Partners Inc. was selected to provide financial advisory services.

1990-91 Annual Budget

Metropolitan's budget for 1990-91 is $628 million. Projected revenue sources for the fiscal year are $444 million from water sales, $77 million from ad valorem taxes, $53 million from interest income, and $20 million from power sales. WRSF will be used to fund expenditures not covered by operating revenues.

Metropolitan's budget is organized in a program format which provides clear statements of accomplishments, objectives, and the cost of resources needed to continue the high standard of service Metropolitan provides its member agencies. With this format, each department and division consolidates its activities and costs in an interrelated document to evaluate performance against Metropolitan's goals.

The 1990-91 budget's major objectives include pursuing opportunities to increase dependable water supplies and formulate programs to reduce demands on Metropolitan's system, upgrading water quality, efficiently using existing facilities, expanding the distribution system's capacity, upgrading and enlarging water treatment facilities, rehabilitating Colorado River Aqueduct pumps with minimal service interruptions, and continuing the automation of work activities.

To monitor the budget throughout the fiscal year, Metropolitan p[illegible] a monthly variance analysis to track actual receipts and expenditures [illegible] the budget.

1990-91 Revenue Requirements and Water Rates

In December 1989, the General Manager submitted to the Fina[illegible] and Insurance Committee an estimate of total revenues required fro[illegible] water sales for fiscal year 1990-91 as determined under the Board's propo[illegible] rate policy. This formed the basis for setting 1990-91 water rates. In [illegible]ary 1990 the General Manager recommended no change in water rat[illegible] the Water Problems Committee, leaving the rates unchanged since 19[illegible].

FINANCIAL PLANNING AND OPERATIONS

Following a public hearing, the Board adopted the [illegible] per acre-foot for 1990-91 as follows:

Noninterruptible		Interruptible		Emergency		Reclaimed	Seasonal Storage	
Untreated	Treated	Untreated	Treated	Untreated	Treated		Untreated	Treated
$197	$230	$153	$186	$591	$624	$84	[illegible]	[illegible]

Metropolitan's water pricing structure contains five service classes: noninterruptible, interruptible, emergency, reclaimed, and seasonal storage.

Noninterruptible service includes water deliveries for domestic and municipal purposes, including groundwater replenishment, in-lieu groundwater replenishment, and storage, and is not subject to reduction or interruption. Interruptible service includes water deliveries for agricultural purposes in addition to the primary uses identified for noninterruptible service, but is subject to reduction or interruption upon notice. Agencies purchasing interruptible water for other than agricultural purposes must demonstrate the ability to sustain an interruption by using stored supplies not normally required for local area service. Alternatively, an agency unable to sustain an interruption may purchase emergency water at a higher rate. Water may be delivered for agricultural purposes when supplies are surplus to domestic and municipal demands.

Reclaimed water (nonpotable water with limited uses) is sold at Metropolitan's lowest rate. Through financial participation in member agencies' local reclamation projects, Metropolitan acquires rights to reclaimed water.

Seasonal storage service is discounted to encourage member agencies to purchase and place into local groundwater storage and surface reservoirs water available during the off-peak winter months. The agencies thereby reduce treatment demands on Metropolitan during on-peak summer months.

1989-90 Tax Levy

Metropolitan levies taxes each year to pay debt service on its general obligation bonds and a declining portion of the capital costs [illegible] its contract with the State for water. Installments are also collec[illegible] Metropolitan area annexations prior to June 6, 1978. The net [illegible] for 1989-90 totaled $81.9 million. Assessed valuations within Metropolitan's six-county service area amounted to $671.7 billion, an [illegible] percent over 1988-89.

Charges and Payments Under the State Water Contract

Metropolitan is one of 30 participants contracting with the State for a system to provide water throughout California. Metropolitan is obligated to pay part of the cost of system construction and operation through the year 2035 regardless of the quantities of water available. For fiscal year 1989-90, Metropolitan paid $248.1 million, or 67 percent, of the State Water Project (SWP) costs.

Indirect Cost Allocation Plan

Staff assembled data for the Indirect Cost Allocation Plan (ICAP) for fiscal year 1989-90 to update the ICAP overhead rate. The ICAP identifies the cost components to be included in establishing an acceptable indirect cost rate for federal cost reimbursement purposes. The new rate also is used as a provisional indirect cost rate for applicable projects in the subsequent fiscal year.

Establishment of the Iron Mountain Landfill Closure/Postclosure Maintenance Fund

Metropolitan operates a solid waste landfill facility at its Iron Mountain Pumping Plant, and therefore is subject to regulations under Government Code Section 66796.22. This statute requires landfill operators to evidence their financial ability to pay the closure and postclosure maintenance costs of their facilities. Last year, based on draft regulations, Metropolitan satisfied the Government Code's requirements by disclosing to the California Integrated Waste Management Board (CIWMB) the estimated costs of closure and postclosure maintenance of its landfill facility and certifying its ability to meet such costs.

In August 1989, the CIWMB issued amended regulations requiring Metropolitan to establish a separate funding mechanism to insure that sufficient monies will be available to pay the estimated costs of closure and postclosure maintenance of its solid waste site. Staff recommended establishing a separate enterprise fund to be invested and held by Metropolitan. The fund basically offers protection equivalent to a third-party trust fund, thereby assuring that all costs will be covered. Upon Board approval and adoption of the required resolution, $3.4 million, the engineering estimate of the costs (in 1990 dollars) for closure in the year 2030 and the postclosure period ending in the year 2045, was transferred to this newly established fund.

Revised Statement of Investment Policy

The Annual Statement of Investment Policy for 1990 was revised to reflect three changes:

(1) The portion of the portfolio that can be invested in repurchase and reverse repurchase agreements was reduced from 50 to 20 percent.

(2) The Treasurer was authorized to extend investment maturities beyond the standard two-year maximum term for the Iron Mountain Trust Fund.

(3) Qualified institutions with which the Treasurer may execute transactions were identified, each of which will be sent, and must acknowledge receipt of, Metropolitan's Statement of Investment Policy of investment objectives and parameters.

Banking Issues

An interim securities custodial agreement was executed on April 6, 1990, with Security Pacific National Bank (SPNB's) trust department following dissolution of SPNB's operational safekeeping unit. A request for proposals for permanent custodial services and other banking services should be issued by fall 1990. Staff is being trained on a new system which electronically notifies the custodian that a security has been purchased or sold with subsequent updating of the custody account. The system also enables the Treasurer to review the securities held in safekeeping.

In cooperation with SPNB, an audit is being conducted of Metropolitan's bearer bonds held for safekeeping at SPNB, Los Angeles, and Banker's Trust Company, New York. Upon completion, the exchange and co-paying functions performed by Banker's Trust will be consolidated into SPNB. Electronic transmission of payroll data to SPNB was fully implemented in October. Automated payroll deposits for crediting employee accounts at SPNB and other banks is now completed.

Deferred Compensation and Savings Plans

Metropolitan administers a deferred compensation plan for its employees' benefit according to Internal Revenue Code Section 457. This plan enables employees to defer portions of their compensation until retirement, disability, or death. The Director of Finance administers the plan, the Plan Coordinator maintains participation records, and the Treasurer invests the deferred funds in Metropolitan-authorized instruments. As of June 30, 1990, the plan balance was $18.8 million compared to $16.2 million on June 30, 1989. Employees deferred $2,017,638 for the fiscal year and investments yielded an average return of 8.943 percent.

In accordance with Section 401(k) of the Internal Revenue Code, Metropolitan maintains two additional deferral arrangements to benefit eligible employees (referred to as Savings Plans I and II). The Director of Finance administers the plans and the Treasurer acts as Trustee. Amounts deferred are transferred each pay day to a third-party broker who invests them in authorized investment vehicles as each participant directs. Employees deferred a total of $820,366 in fiscal year 1989-90. Enrollment in the plans increased 22 percent over last year, raising total enrollment to 1,137 participants. An employer-matching contribution for Plan I began in January 1990. Metropolitan contributions totaled $74,367.

At the Trustee's request, the Audit Department performed a limited review of the activities in Savings Plans I and II for calendar year 1988. Based upon the review's overall results, the existing internal controls over the Plans' records and documents are considered adequate and related accounting and administrative policies and procedures required to maintain such records are functioning properly in all significant respects.

Risk Management

The Risk Manager is developing a program to comply with the U.S. Environmental Protection Agency regulations which impose financial responsibility conditions on owners of underground storage tanks and, with Imperial Irrigation District's (Imperial's) insurance representatives, is setting up a system to ensure mutual compliance with the risk, insurance, and indemnity provisions of the Metropolitan Imperial agreement.

Accounting Operations

During the fiscal year, Finance's automation program continued contributing to operational effectiveness as new microcomputer and local area network based applications were implemented and staff continued to maintain and operate numerous applications vital to its daily operations.

Annual Tax Levy

The annual tax levy process involves accumulating assessed valuations from the Counties of Los Angeles, San Diego, Orange, Riverside, San Bernardino, and Ventura. The information and Metropolitan's annual tax levy requirement are processed to determine the tax levy rates that will be used to assess property owners in the counties. This information is presented to the Board of Directors each August for its approval, and then sent to each of the six counties for inclusion in their property tax bills. The process includes developing tables that list assessed valuations for

each of the geographical areas covered by Metropolitan's [illegible] This information is used to determine the number of directors [illegible] that each member agency has on the Board of Directors.

Inventories

Staff annually performs a Central Stores physical inventory to verify the accuracy of Metropolitan's perpetual inventory records. In recent years this occurred in March or April to allow enough time to complete the inventory testing prior to fiscal year end. The 1989-90 Central Stores inventory was completed by March 23, 1990. The Controller issued a report summarizing the results of the physical inventory counting process and quantified the reduced inventory value based on the counting results. The report contained several minor recommendations for improving the physical inventory process. Staff concluded, after certain reconciliation procedures were performed, that the statistically projected total inventory value was, within a high degree of probability, approximately $49,053 less than the recorded inventory values, or less than 1 percent of the total inventory.

Final results of the 1988 Operating Equipment Inventory were released. A biennial physical inventory of operating equipment verifies the accuracy of Metropolitan's equipment inventory records. The physical inventory resulted in a write-off of 363 pieces of equipment, with an original cost of $566,623, and a net book value of $101,784. The net write-offs as a percentage of the total net value of the operating equipment, over $12 million, is minor (less than 1 percent).

To improve the accuracy and timeliness of the 1990 operating equipment inventory, efforts are under way to revise the counting procedures and develop new programs used to process and report the inventory results. During the 1990 physical inventory, staff will also prototype, at selected locations, the bar code scanning system currently under testing.

Invoice Processing

A study was undertaken to develop methods for streamlining requisition and invoice processing. A joint task force of Operations, Purchasing, and Accounts Payable staff met and made 34 recommendations that were approved by management. A deadline of December 1, 1990 was set for implementing the recommendations. The study's [illegible] recommendation was to install a draft system for use by [illegible] which allows them to procure materials and one-time services [illegible] than $500 and pay the vendor directly. This draft system will [illegible] reduce the number of small payments that Accounts Payable [illegible] and improve vendor relationships. Verification controls are [illegible] oped to guard against system abuses.

Major inroads were made to improve Metropolitan's relationship with consultants. Staff analyzed the payment procedures and found that the growth of consultant contracts over the past five years exceeded Metropolitan's ability to process the invoices in a timely fashion. To correct the problem (1) An automated tracking system was installed that produces reports showing the status of invoices, and flagging invoices that exceed the agreement total, (2) written guidelines were developed for agreement administrators on how to process consultant invoices and how disagreements are to be handled, and (3) in an effort to provide feedback to agreement administrators on their payment record, an Accounts Payable report was produced on the average number of days required per agreement to pay an invoice for the last six months of 1989. Reports were then run quarterly for the remainder of the fiscal year, showing that the total processing time has been reduced from 25 to an average of 12 days.

Balance Sheet Highlights

Cash & Marketable Securities

Cash and marketable securities totaled $955 million and $694 million at June 30, 1990, and 1989, respectively, as shown in Table 39.

Cash and marketable securities are held under separate accounts (funds) to accomplish specific activities in accordance with special regulations, bond covenants, and Board policies. The funds are classified under general headings as "unrestricted" and "restricted." After necessary fund transfers are made to comply with bond covenants, the Board has complete discretion over the magnitude and use of unrestricted funds. Restricted funds are earmarked for payment of debt service on Metropolitan bonds and capital charges under the State Water Contract. In addition to unrestricted and restricted funds, Metropolitan maintains other funds as follows (also see Table 40):

- Revenue Bond Construction Fund
- 1966 Bond Construction Fund
- Revolving Construction Fund
- San Joaquin Reservoir Fund
- Deferred Compensation Fund
- Excess Earnings Fund
- Iron Mountain Trust Fund

Plant and Equipment

Before accumulated depreciation, plant and equipment increased $158 million over 1989 to $1.5 billion in 1990, after depreciation, primarily because of construction program expenditures for water distribution and treatment plant facilities.

Participation Rights in State Water Facilities

Participation rights reflect unamortized capital expenditures made under the State Water Contract. Since Metropolitan does not own the SWP, the capitalized payments represent intangible rights (assets). The participation rights are amortized as Metropolitan receives State project water. This fiscal year, the asset account increased $91 million before amortization to $982 million. This increase was directly associated with the revised costs for each State Water Contract component cost.

Deferred Water Rights

Metropolitan and other agencies have entered into several water exchange, storage, and reclamation project agreements, which reliably supplement Metropolitan's Colorado River and State project water supplies. Metropolitan is also actively pursuing other agreements both within and outside its service area to provide additional water supplies.

The exchange and storage agreements generally provide for advanced water delivery during periods when surplus flows and inexpensive energy for pumping are available. Under reclamation agreements Metropolitan funds a share of the construction or improvement of reclamation facilities by local agencies. Reclamation plants produce subpotable water for agricultural and industrial uses.

Costs associated with these agreements have been recorded as deferred charges and are amortized to the cost of water as the rights are exercised. At June 30, 1990, and 1989, deferred water rights totaled approximately $16 million for both years, based on volumes of 649,000 and 715,000 acre-feet respectively.

In addition to the above programs, Metropolitan and Imperial approved a major conservation program that will help improve Imperial's outdated distribution system. In all, 106,000 acre-feet of water a year will be made available for Metropolitan's use by 15 Metropolitan financed conservation projects. As of June 30, 1990, Metropolitan has deferred charges of [illegible] million for this program. Over the first 40 years of the program [illegible] year 2029 — nearly 4 million acre-feet (maf) of water will be made [illegible] to Metropolitan.

Bonded Debt

On June 30, 1990, $1.078 billion in waterworks bonds was outstanding, consisting of $361 million in revenue bonds and $717 million in general obligation bonds. Principal payments by Metropolitan in 1989-90 reduced bonded debt by $17 million. Table 42 contains a five-year summary of Metropolitan's revenue bond coverage. The weighted average cost of all bonded debt outstanding, including the 1989 Series G general obligation bonds, was 5.65 percent with an average bond life of 17 years.

Commitments and Contingencies

To provide power for transportation within the SWP system, the State Department of Water Resources (DWR) issued bonds to construct two off-aqueduct power facilities. Construction on the South Geysers Geothermal Power Plant was suspended in 1987 pending procurement of a steam supply sufficient to operate the plant at planned capacity. During the year ended June 30, 1989, DWR officials decided to dispose of the plant assets, if possible, by leasing the steam field and plant site and selling the power plant equipment.

Additionally, the Bottle Rock Geothermal Power Plant's steam supply has been steadily declining in recent years. This fiscal year, DWR determined it to be more economical to either suspend operations at this facility indefinitely or to contract with a private entity for plant operations, rather than continue operations under the present conditions. Regardless of the option selected, it is unlikely DWR will receive any significant future benefits from power generation at the Bottle Rock facility.

Because of these contingencies and a reading of Financial Accounting Standards Board Statement No. 5, Metropolitan has decided to recognize losses on these two geothermal facilities. The portion of unamortized participation rights attributable to the South Geysers Project, totaling $21.5 million, was written off as of last fiscal year. Similarly, the portion of unamortized participation rights attributable to the Bottle Rock facility, totalling $11.8 million, were written off as of June 30, 1990. Additional losses on the Off Aqueduct Power Facilities (OAPF) were recorded in the amounts of $115.8 and $55 million for the years ended June 30, 1990, and 1989, respectively. These additional losses represent the present value of Metropolitan's remaining obligations to the State through the year 2024 for the debt service costs of the South Geysers project and the Bottle Rock facilities which are now reflected as long term obligations on Metropolitan's balance sheet.

Equity

Equity on June 30, 1990, rose to $2.2 billion, compared to $2.1 billion on June 30, 1989. The increase reflects net income of $[illegible] million, $1 million in contributions from member agencies to aid construction, and $4 million in annexation commitments. Of retained earnings, $[illegible] million was designated at fiscal year end, $90 million was reserved, and the remaining $1.7 billion was undesignated.

Statement of Operations Highlights— Accrual Basis

Water Sales and Power Recoveries

Revenues of $487 million from water sales increased $62 million over last year (Figure 16). Water deliveries of 2.5 maf rose 416,000 acre-feet over fiscal year 1988-89, marking the sixth consecutive year of record water sales. Hydroelectric power sales generated revenues of $19 million.

Interest and Other Income

Interest earnings increased $24 million to $75 million during fiscal year 1989-90, reflecting higher interest rates and larger operating balances. Other income equaled $4 million, principally due to Metropolitan's sale of surplus lands and new annexation commitments which, since 1978, are paid in lump sum rather than on installment.

Taxes and Annexation Income

As shown in Tables 43 and 44 and Figure 17, the total valuation of property subject to taxation for Metropolitan purposes was $672 billion in August 1989, representing a 12.5 percent increase over August 1988. Beginning in fiscal year 1988-89, unitary values for State-assessed utility properties were valued separately and excluded from the total taxable assessed valuations. The unitary value results in an average county-wide tax rate for property operated as a unit in a primary function. Each County determines a specified amount which it remits to Metropolitan as its share of unitary value-based taxes.

Proposition 13, adopted by voters in 1978, does not limit taxes levied by Metropolitan to pay voter-approved bonded debt, including payments under the State Water Contract and debt service requirements for Metropolitan general obligation bonded debt. Ad valorem property taxes, annexation charges, and allocated county-wide taxes on utilities collected on all property within Metropolitan totaled $90 million during 1989-90. For the fiscal year, Metropolitan's secured property tax rate was 0.0121 percent of assessed value, the unsecured rate was 0.0110 percent. This equals 4.8 cents and 4.4 cents per $100 of "assessed value" respectively, as defined before Proposition 13 with assessed value recorded at one-quarter of full value. Table 46 summarizes the tax rates over the past five years, and Figure 18 shows regular tax levies.

Annexation charges levied this year totaled $6 million and total estimated future annexation charges amount to $25 million. Fiscal year income from cash annexations was $0.4 million.

Metropolitan does not record annexation receivables unless full amortization can be accomplished within 50 years following the amortization date by applying an annual tax rate of 0.0075 percent of assessed valuation or less, assuming that the annexed areas assessed valuation remains constant. As of June 30, 1990, annexation receivables of $45 million, including uncollected interest of $17 million, were not reflected as assets nor included in Metropolitan's equity.

Operating Expenses

Net operating expenses of $273 million increased $55 million over the previous year, reflecting State Water Contract credits totaling $9 million. Depreciation and amortization expenses increased $7 million to $123 million, because DWR increased the OAPF charge components. The amount of participation rights amortized is based on the total projected annual water deliveries divided into the total associated cost base. Bond interest expense, net of $7 million interest capitalized, was $57 million, an increase of approximately $11 million.

Net Income

For fiscal year 1989-90, net income decreased $37 million to $78 million. The decline resulted primarily from recording a $127.6 million OAPF loss attributable to the State's planned abandonment of the SWP South Geysers and Bottle Rock Geothermal Power Plants.

Debt Service Coverage

Debt service coverage on the outstanding revenue bonds for fiscal year 1989-90 was:

TABLE 38

DEBT SERVICE COVERAGE ON OUTSTANDING REVENUE BONDS
For the Fiscal Year 1989 90
(Dollars in Millions)

	Accrual Basis*
Water and Power Sales	$ 506
Net Operation and Maintenance Expense	273
Net Operating Revenues	233
Revenue Bond Debt Service	26
Debt Service Coverage Ratio	8.79X

Note
X = Times
* Any differences are due to rounding

Net Direct and Overlapping Bonded Debt

Table 47 presents a statement of direct and overlapping tax-supported bonded indebtedness within Metropolitan's boundaries on June 30, 1990, as prepared by California Municipal Statistics, Inc. Net direct and overlapping bonded debt totaled $11 billion, which amounts to a per capita debt of $733. As of June 30, 1990, Metropolitan's gross direct general obligation bonded debt stood at $717 million, which is approximately 0.12 percent of Metropolitan's 1989-90 assessed valuation of $619 billion (after deducting approximately $52 billion incremental assessed value associated with redevelopment agency activity).

Cash Flow Highlights (Cash Basis)

The following contain amounts based upon the cash basis of accounting which summarizes cash receipts and expenditures. Conversely, the amounts shown for the Balance Sheet and Statement of Operations are recorded on an accrual basis of accounting. This accounting procedure reflects both cash and non-cash transactions occurring in the fiscal year accounting period.

Cash Receipts

Cash receipts from water sales for fiscal year 1989-90 were $494 million. Tax receipts equaled $87 million and other receipts $68 million, for a total of $649 million, compared to an annual cash basis budget estimate of

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$530 million. This was mainly due to drought conditions which increased water sales by 641,000 acre-feet over budget for the fiscal year. The receipts exceeded the budget estimate in total by $119 million.

Expenditures

Expenditures for the fiscal year totaled $543 million. This compared with an annual budget estimate of $562 million. Total net expenditures were $19 million below budget, mainly due to:

- Metropolitan operations and management expenditures were under the budget estimate due to a reimbursement of $9.0 million from the U.S. Bureau of Reclamation.
- Payments under a preliminary agreement with Imperial were budgeted to be paid in January and July of 1990, but because of a delay in reaching a final agreement only one payment was made in the fiscal year.
- Additional power credits were received from DWR due to changes in 1990 Off-Aqueduct costs. DWR bonded debt service coverage in excess of cash disbursement for debt service was returned to Metropolitan.

Cash-On-Hand at End of the Fiscal Year

Total cash-on-hand at fiscal year end equaled $674 million, excluding construction and trust funds totaling $281 million. Of this amount, $174 million was restricted, $25 million was designated for self-insurance, and $53 million was set aside in the Pay-As-You-Go Fund. Funds in the WRSF and Water Treatment Surcharge Stabilization Fund totaled $289 million and $23 million, respectively, and are designated to reduce future water revenue and treatment revenue requirements.

In accordance with current Board policy, the July 1, 1990, working capital requirement was $105 million with an additional $5 million for Imperial indirect payments. On June 30, 1990, surplus funds of $106 million and $14 million were transferred from the Water Revenue Remainder Fund to WRSF and Water Treatment Surcharge Stabilization Fund, respectively, per Board policy.

Over the next decade, the base noninterruptible and interruptible water rates are projected to increase by about 10 percent per year, assuming a utilization of the stabilization fund. The treatment surcharge is estimated to rise over the 10-year period at a rate of about 12 percent per year, taking into account the use of PEROXONE or ozone to meet the anticipated revisions in expanding treatment facilities and other enhanced treatment processes needed to meet Federal and State water quality regulations.

REVENUES FROM WATER SALES
ACCRUAL BASIS
(DOLLARS IN MILLIONS)

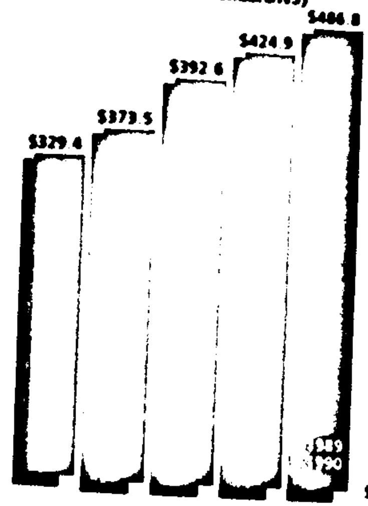

Figure 16

ASSESSED VALUATIONS
(DOLLARS IN BILLIONS)

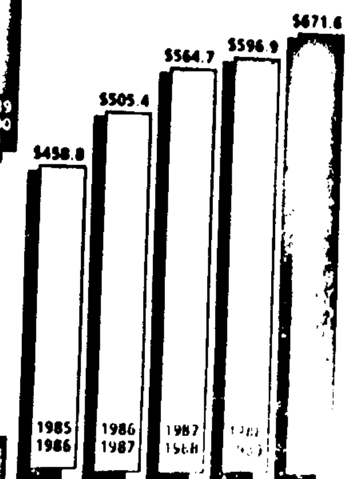

Figure 17

REVENUES FROM TAX LEVIES
ACCRUAL BASIS
(DOLLARS IN MILLIONS)

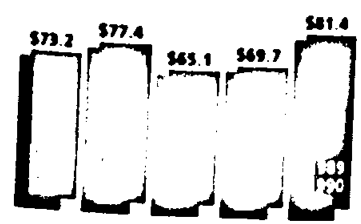

Figure 18

TABLE 39

CASH AND INVESTMENT SCHEDULE

June 30, 1990 and 1989

(Dollars in Thousands)

	June 30, 1990					June 30, 1989	
	Category			Carrying	Market	Carrying	Market
	1	2	3	Amount	Value	Amount	Value
U.S. Treasury Securities	$ 391,046			$ 391,046	$ 391,882	$ 336,936	$ 338,180
U.S. Guarantees GNMAs	9,908			9,908	9,819	4,179	4,071
Federal Agency Securities	120,358			120,358	121,724	112,530	119,730
State Agency Securities	29			29	29	24	24
Prime Bankers Acceptances	154,313			154,313	157,516	33,875	34,673
Prime Commercial Paper	187,580			187,580	188,277	84,364	84,364
Negotiable Certificates of Deposit	70,273			70,273	70,273	101,922	101,922
Repurchase Agreements Held in safekeeping at Federal Reserve		12,082		12,082	12,330[(1)]	16,643	16,957[(1)]
Total	$ 933,507	$ 12,082	$	945,589	951,650		
Local Agency Investment Fund State of California				10,000	10,000	5,000	5,000
Total Investments				955,589	$ 961,650	695,413	$ 704,919
Add							
Cash-Demand Deposits				(1,021)[(2)]		(1,872)[(2)]	
Time Deposits				100		640	
Total Cash and Investments				954,668		694,189	
Less							
Restricted Cash and Investments				438,337		288,494	
Employee Deferred Compensation Fund				18,531		15,988	
Current and Unrestricted Cash and Investments				$ 497,800		$ 389,707	

Notes

(1) Repurchase agreements are collateralized by government marketable securities which have market values as shown.

(2) Credit balances result from the investment of cash totaling $1,362,000 and $2,112,000 in repurchase agreements at June 30, 1990 and 1989, respectively.

TABLE 40

FUND BALANCES

June 30, 1990 and 1989

(Cash Basis)

(Dollars in Thousands)

	1990	1989
UNRESTRICTED FUNDS		
For Working Capital Purposes		
General Fund	$ 10,072	$ 6,722
Water Revenue Remainder Fund(1)	122,501	122,500
Designated for Other Purposes		
Pay As You Go Fund	52,897	68,043
Water Rate Stabilization Fund	289,582	172,701
Water Treatment Surcharge Stabilization Fund	22,748	19,741
Total Unrestricted Funds	$ 497,800	$ 389,707
RESTRICTED AND TRUST FUNDS		
Revenue Bond Reserve Fund	$ 18,433	$ 18,433
Revenue Bond Interest & Principal Funds	11,971	11,744
General Obligation Bond Interest Principal & Redemption Funds	26,405	21,771
State Contract Fund	55,500	54,586
Operation & Maintenance Fund	62,023	57,707
1966 Bond Construction Fund	151,831	21,139
Revolving Construction Fund	103,232	101,309
Revenue Bond Construction Fund	309	596
Other Trust Funds(2)	8,632	1,209
Total Restricted and Other Funds	$ 438,336	$ 288,494
Employee Deferred Compensation Fund	$ 18,531	$ 15,988
Total Funds at End of Year(3)	$ 954,667	$ 694,189

Notes

(1) Includes $25,000,000 designated for emergency repairs and claims.

(2) Includes balances in the trust accounts portion of the General Fund, San Joaquin Revenue Fund, Excess Earnings Fund, and Iron Mountain Trust Funds.

(3) Total Funds are exclusive of refunding escrow trust funds. Table excludes $152,796,616 and $89,394,333 held in Waterworks Refunding Revenue Bond and Waterworks Refunding General Obligation Bond Escrow Trust Funds, respectively for 1990. Table excludes $154,918,216 and $[illegible] held in Waterworks Refunding Revenue Bond and Waterworks Refunding General Obligation Bond Escrow Trust Funds, respectively for 1989.

TABLE 41
SUMMARY OF LONG-TERM DEBT
June 30, 1990
(Dollars in Thousands)

Category of Debt	Amount Authorized	Amount Issued	Balance Outstanding
1931 Authorization – General Obligation Bonds	$220 000	$ 220 000	$ 1 750
1956 Authorization – General Obligation Bonds	77 400	77 400	0
1966 Authorization – General Obligation Bonds*	850 000	800 000	714 810
1974 Authorization – Revenue Bonds**		372 500	361 325
Total Bonded Debt		$ 1 469 900	$1 077 885
Purchase of First San Diego Aqueduct***			998
Total Long Term Debt †			$1 078 883

Notes

* Includes $96,470,000 Waterworks Refunding General Obligation Bonds, Issue of 1986 to advance refund $91,220,000 of Waterworks Bonds, Election 1966, Series F. Additionally, includes sale of $215 million of Waterworks General Obligation Bonds, Election 1966, Series G, issued in July 1989.

** Includes $141,500,000 Waterworks Refunding Revenue Bonds, Issue of 1978 to advance refund $144,710,392 of Waterworks Revenue Bonds Issue of 1975 and 1976 and $161,545,000 Waterworks Refunding Revenue Bonds, Issue of 1986 to advance refund $143,110,000 of Waterworks Revenue Bonds Issue of 1983.

*** Title to the First San Diego Aqueduct is vested in the United States Government and will be transferred to Metropolitan in 1995 upon completion of reimbursement to the Government for the cost of the aqueduct.

† Exclusive of any unamortized bond premium and/or discount as of June 30, 1990.

TABLE 42
FIVE-YEAR SUMMARY OF OPERATIONS — ACCRUAL BASIS
(Dollars in Thousands)

	1986	1987	1988	1989	1990
Water and Power Revenue	$348 274	$375 846	$410 134	$443 463	$506 015
Operating Expense*	183 920	174 148	212 995	218 469	273 178
Net Operating Revenue	164 354	201 698	197 139	224 994	232 837
Revenue Bond Debt Service**	(27 592)	(22 940)	(26 468)	(26 482)	(26 491)
Bond Anticipation Notes**	(25)	(10)	0	0	0
Balance Available for Other Purposes	$136 737	$178 748	$170 671	$198 512	$206 346
Revenue Bond/Note Coverage	5.95X	8.79X	7.45X	8.49X	8.79X

Notes

* Excludes depreciation of Metropolitan assets and amortization of capitalized State Water Contract capital costs

** Scheduled debt service

X = Times

TABLE 43
ASSESSED VALUATIONS, PERCENTAGES, AND VOTE ENTITLEMENTS

Constituent Areas	Date of Entry	First Year Taxable	Assessed Valuations August 1989-90	Assessed Valuations August 1988-89	Percentages* 1989-90	Percentages* 1988-89	Vote Entitlements* 1989-90	Vote Entitlements* 1988-89
Anaheim	12/06/28	$ 7 694 410	$ 13 271 621 738	$ 12 143 017 545	1.98	2.03	1 304	1 190
Beverly Hills	12/06/28	60 921 410	6 946 757 009	6 191 332 345	1.03	1.04	691	616
Burbank	12/06/28	27 470 280	5 947 331 651	5 294 173 673	0.89	0.89	584	518
Glendale	12/06/28	76 160 945	8 027 479 623	7 083 869 951	1.20	1.19	787	692
Los Angeles	12/06/28	1 801 655 535	149 164 989 993	133 829 420 151	22.21	22.42	14 650	13 110
Pasadena	12/06/28	117 760 505	6 452 011 786	5 864 789 939	0.96	0.98	632	573
San Marino	12/06/28	14 484 990	1 257 216 930	1 092 693 391	0.19	0.18	123	107
Santa Ana	12/06/28	20 201 805	9 721 734 577	8 886 270 251	1.45	1.49	956	872
Santa Monica	12/06/28	62 896 225	6 780 721 414	6 064 571 048	1.01	1.02	672	600
Fullerton	02/27/31	11 556 140	5 794 390 576	5 212 593 103	0.86	0.87	566	508
Long Beach	02/27/31	105 576 045	15 359 647 599	14 343 511 476	2.29	2.40	1 506	1 403
Torrance	02/27/31	24 289 800	8 729 312 370	7 759 498 277	1.30	1.30	856	759
Compton	06/23/31	10 738 495	1 108 074 164	1 017 081 455	0.16	0.17	105	96
Coastal MWD	06/15/42	10 256 915	20 977 869 843	18 782 233 630	3.12	3.15	2 072	1 853
San Diego County Water Authority	12/17/46	226 320 190	103 530 032 120	91 991 404 442	15.41	15.41	10 098	8 951
West Basin MWD	07/23/48	161 813 905	50 657 559 499	46 055 104 435	7.54	7.72	4 983	4 522
Three Valleys MWD	11/15/50	66 577 600	18 119 073 156	16 028 979 365	2.70	2.69	1 761	1 552
Eastern MWD of Riverside County	07/25/51	18 979 960	11 755 637 260	9 409 002 304	1.75	1.58	1 138	[illegible]
Chino Basin MWD	11/26/51	79 612 160	21 748 379 982	18 563 916 231	3.24	3.11	2 118	[illegible]
MWD of Orange County	11/26/51	262 195 310	87 600 126 953	75 962 275 716	13.04	12.73	8 562	[illegible]
Foothill MWD	01/15/53	74 854 430	3 575 252 375	3 138 838 741	0.53	0.53	345	[illegible]
Central Basin MWD	[illegible]	1 119 738 260	42 463 232 947	38 957 276 346	6.32	6.53	[illegible]	[illegible]
Western MWD [illegible]	[illegible]	161 945 930	17 862 163 673	15 153 304 716	2.66	2.54	[illegible]	[illegible]
[illegible]	[illegible]	13 923 500	5 776 681 794	4 800 976 213	0.86	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	81 345 020	23 127 434 502	20 153 083 989	3.44	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	834 220 704	25 387 524 601	22 607 515 287	3.78	[illegible]	[illegible]	[illegible]
[illegible]		32 051 075	541 789 794	495 029 764	0.08	[illegible]	[illegible]	[illegible]
			671 683 835 929	596 885 833 784	100.00	100.00		
			15 722 732	14 525 174				
			$ 671 699 558 661	$ 596 900 358 958				

* [illegible] based upon County Auditors' certified valuations after deductions for Home Owners' Property and Business [illegible]

TABLE 44
ASSESSED VALUATION OF PROPERTY SUBJECT TO TAX LEVY BY METROPOLITAN(1)
As of Each Fiscal Year

Fiscal Year	Property Within MWD	Property Outside MWD Excluded Areas	Total Property
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

TABLE 45
FIVE-YEAR SUMMARY OF WATER RATES
(Per Acre Foot)

For the Period		NONINTERRUPTIBLE Domestic, Reservoir and Replenishment		INTERRUPTIBLE Domestic, Reservoir Replenishment and Agriculture		SEASONAL STORAGE		EMERGENCY Domestic		RECLAIMED
		Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	
7/1/85	6/30/86	$192	$224	$148	$180	N-A	N-A	$586	$618	$84
7/1/86	6/30/87	197	230	153	186	N-A	N-A	591	624	84
7/1/87	6/30/88	197	230	153	186	N-A	N-A	591	624	84
7/1/88	6/30/89	197	230	153	186	N-A	N-A	591	624	84
7/1/89	6/30/90	197	230	153	186	$115	$135	591	624	84

TABLE 46
FIVE-YEAR SUMMARY OF SECURED PROPERTY PERCENTAGE TAX RATES

Bond Service	State Contract
0.0100	0.0064
0.0079	0.0069
0.0070	0.0042
0.0067	0.0043
0.0079	0.0042

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TABLE 47
DIRECT AND OVERLAPPING BONDED DEBT
(Dollars in Millions)

	At June 30, 1990	
	% Applicable	Bonded Debt*
Los Angeles County and Authorities	94.4	$ 1,468
Orange County and Authorities	99.8	191
San Diego County Authorities	96.4	301
Riverside County Authorities and Board of Education	66.1	302
Ventura County Authorities and Superintendent of Schools	68.6	71
San Bernardino County Authorities and Superintendent of Schools	41.3	121
City of Los Angeles and Authorities	99.9	740
City of San Diego, Authorities and Open Space Park District	99.9	184
City of Long Beach and Authorities	100.0	220
City of Anaheim and Authorities	99.8	269
City of [illegible] and Authorities	100.0	149
Other Cities and City Authorities	various	1,485
Los Angeles County Flood Control District and Certificates of Participation	95.9	195
Municipal Water District of Orange County, Water Facilities Corporation and Improvement District #1	100.0	68
Irvine Ranch Water District and Improvement Districts	100.0	324
San Diego County Water Authority and Certificate of Participation	99.9	117
Santa Margarita Water District #1, #2, #3, and #4	100.0	295
Other Water Districts	various	709
Los Angeles Unified School District and Authorities	99.6	109
San Diego Unified School District and Authorities	99.9	62
Other School Districts and School Authorities	various	693
Community Facilities Districts	various	1,269
Other Special Districts	various	237
1915 Act Bonds (Estimated)	various	1,067
TOTAL GROSS OVERLAPPING BONDED DEBT		$10,646
Less: Self-supporting Bonds**		586
TOTAL NET OVERLAPPING BONDED DEBT		$10,060
METROPOLITAN WATER DISTRICT		
TOTAL GROSS DIRECT BONDED DEBT		$ 717
Less: Self-supporting Bonds***		58
TOTAL NET DIRECT BONDED DEBT MWD		$ 659
TOTAL GROSS DIRECT AND OVERLAPPING BONDED DEBT		$11,363
TOTAL NET DIRECT AND OVERLAPPING BONDED DEBT		$10,719

Ratios to Assessed Valuation of $619,039,312,327†

Gross Direct Debt (MWD)	0.12%
Net Direct Debt (MWD)	0.11%
Gross Total Debt	1.84%
Net Total Debt	1.73%

NOTES

* [illegible]

** [illegible]

*** [illegible]

† [illegible]

TABLE 48
SUMMARY OF RECEIPTS AND EXPENDITURES
(Cash Basis)
(Dollars in Thousands)

	FISCAL YEAR	
	[illegible]	[illegible]
Receipts from Water Sales	$4[illegible]	$416,4[illegible]
Power Recoveries	18,452	19,029
Total Operating Revenues	512,0[illegible]7	437,500
MWD O&M Expenditures(1)	(143,831)	(130,108)
SWC OMP&R Costs(2)	(78,499)	(63,167)
SWC Off Aqueduct O&M Costs	(26,877)	(29,688)
Net Operating Revenues	262,830	214,537
Revenue Bond Debt Service	(26,930)	(26,832)
Funds Available for Other Purposes from Operations	235,900	187,705
Interest on Investments - Net	72,805	47,311
Other Receipts (Expenditures) - Net	(5,025)	6,716
Pay As You Go Construction - Net(3)	(49,199)	(10,979)
SWC Capital Cost - Paid by Current Year Operations	(65,681)	(63,653)
SWC Off Aqueduct Capital Costs - Net	(41,236)	(41,641)
Other Costs	(225)	(230)
Remaining Funds from Operations	147,337	125,229
Tax Receipts	86,684	73,571
1931 General Obligation Bond Debt Service	(514)	(582)
1966 General Obligation Bond Debt Service	(50,362)	(39,461)
SWC Capital Costs - Paid by Current Year Taxes	(35,808)	(33,528)
Balance Available from Current Year	147,338	125,229
Balance Available from Prior Years	694,189	612,807
Bond Proceeds	211,215	
1975 Revenue Bonds(4)	(105)	(30)
1976 Revenue Bonds(5)	(10)	(35)
Construction Costs - Net(6)	([illegible])	([illegible])
Funds Available at End of Year	$[illegible]	$6[illegible]
Revenue Bond Debt Service Coverage(7)	[illegible]	[illegible]

Notes

(1) Includes MWD O&M expenditures, net of reimbursements, and [illegible]

(2) Includes all State Water Contract OMP&R and variable power costs [illegible]

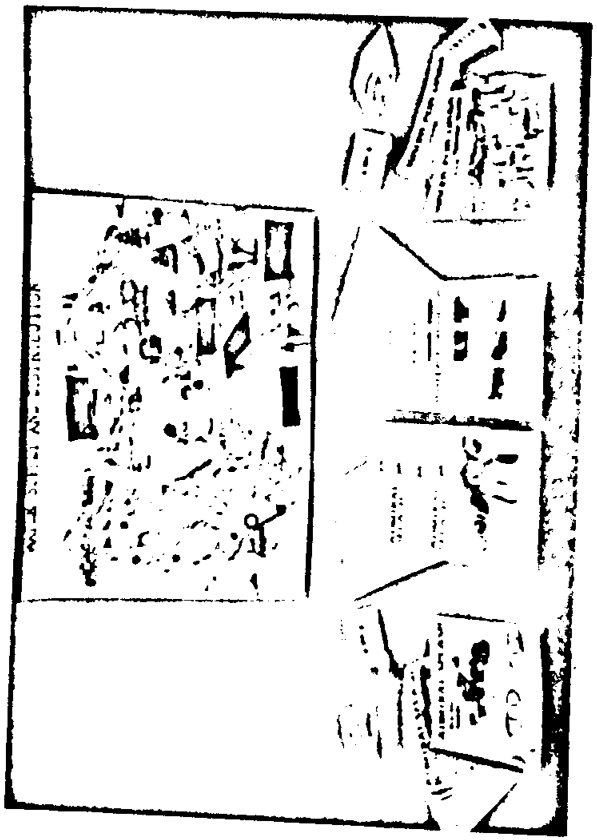
(3) The Pay As You Go fund was established by the Board in December 1988 [illegible] expenditures. Prior to December 1988, Metropolitan funded a lesser level of [illegible] its General Fund moneys. Those earlier expenditures are not identified in [illegible]

(4) The 1975 Revenue Bonds were called for redemption on January [illegible]

(5) The 1976 Revenue Bonds were called for redemption on July 1, 1986.

(6) Net of reimbursements to construction accounts.

(7) Calculated in accordance with revenue bond resolutions by dividing [illegible] operation revenues using actual dollar amounts on a cash basis.



Metropolitan produces a myriad of materials to help teach elementary school students about water issues

CHAPTER 9

Support Functions

Human Resources Management

Recruitment and Selection

During fiscal year 1989-90, the number of Metropolitan's budgeted permanent positions increased by 109 to a total of 1,702 positions; the number of permanent employees increased to 1,667. Personnel staff filled 268 permanent positions and 209 temporary positions. Additionally, staff continued enhancing recruitment through advertising, consulting services, and expanded use of targeted recruitment sources to ensure that qualified minorities and women received employment information. Job Fair participation also attracted many qualified candidates, and thousands of inquiries were received by the Job Information Line on the PhoneMail system. To implement more timely and cost-effective selection processes, staff drafted procedures to use eligibility lists next fiscal year.

The following is a five-year summary of the number of permanent employees on Metropolitan's payroll.

End of Fiscal Year	Number of Employees (Actual)
1985-1986	1,371
1986-1987	1,416
1987-1988	1,506
1988-1989	1,569
1989-1990	1,667

Metropolitan employees are eligible to receive servic[illegible] of service, and on every subsequent fifth-year anniver[illegible] fiscal year, 72 employees with 20 or more years of ser[illegible] at a total of three Service Award luncheons hosted b[illegible] the Board and the General Manager.

Metropolitan's Summer Student Employment Program employed 61 students, including an increase in minority and female employment. Assistance was provided by the State's Employment Development Department in Los Angeles which again supplied staff and resources to recruit and screen qualified candidates for this program. Metropolitan's Personnel staff was also able to provide timely medical and security clearances for the program.

Classification, Compensation, and Employee Insurance

To obtain information on prevailing wages and benefits, the annual salary survey of 11 agencies was conducted. This and other survey information enabled Metropolitan to establish wages and benefits competitive with those in the local labor market.

Job audits continued to be a tool to ensure that Metropolitan uniformly applies its wage policy and classifies its positions appropriately. During the fiscal year, staff conducted 15 job audits resulting in the update of numerous job descriptions and implementation of new job classifications to reflect current duties and responsibilities. Additionally, consultants Becker and Bell, Inc., performed job audits for the engineering, electronic, and hydroelectric technicians and the communications series.

The Metropolitan employees' benefit package includes medical, dental, and group term life insurance. Employees also may enroll in other insurance programs such as disability, accidental death and dismemberment, and cancer and intensive care.

Health Fairs were conducted at five Metropolitan facilities during the Public Employees Retirement System (PERS) Open Enrollment period (May 1-31) for medical insurance. Representatives from most of the medical insurance carriers participated in the Health Fairs, providing informational materials and answering questions. Delta Dental, Metropolitan's dental insurance carrier, also participated. Meetings were held by Employee Benefits staff at seven Metropolitan facilities to offer employees open enrollment information and answer questions about medical insurance and other employee benefits.

Employee Relations

Effective October 1, 1989, new Memoranda of Understanding were signed, implementing three-year agreements with Metropolitan's Management and Professional Association, the Field Supervisors and Professional

Personnel Association, and the Association of [illegible] Individual contracts also became effective for [illegible] The agreements included:

1. **Salary increases of 4.5 percent** effective June 24, [illegible] **effective June 23, 1991.**

2. **An increased Metropolitan** contribution for medical insurance **rates: (a) $140 for employees only, (b) $264** for employees with one **dependent, and (c) $353 for employees** with two or more dependents **during the first contract year. During the** contract's second year, **Metropolitan's contribution will be based on 80** percent of the PERS-**CARE rate, and during the third year,** on 85 percent of the PERS-CARE **rate.**

3. **A change in the group life insurance benefit for unrepresented employees, employees represented by the Management and Professional Employees Association, and employees represented by the Association of Confidential Employees from 100 percent of annual salary with a maximum of $50,000 to a full 100 percent of annual salary, effective January 1, 1990.**

4. **A long-term disability (LTD) insurance benefit for unrepresented employees, employees represented by the Field Supervisors and Professional Personnel Association, and employees represented by the Association of Confidential Employees, effective January 1, 1990. LTD insurance provides a benefit of $1,000 per month (but not to exceed 60 percent of the employee's monthly salary) 180 days after the employee's disability begins and extends to a maximum of 2-1/2 years.**

5. **A matching contribution by Metropolitan** in the amount of 50 cents **for each dollar contributed to Metropolitan's 401(k)** savings plan, effective **January 1, 1990. The maximum contribution** for the year ending **December 31, 1990, will be 1 percent** of salary and for the year ending **December 31, 1991, the maximum contribution** will be 2 percent. **Commencing January 1, 1992, the maximum** matching contribution will **be 3 percent.**

Liability/Property Administration

The Liability Claims and Subrogation Program works [illegible] **disposition of liability claims against Metropolitan** and [illegible] **program, to minimize economic loss as a result** thereof [illegible] **recovering damages to Metropolitan** resulting from [illegible] **negligence. Staff processed 132 liability** claims and 59 [illegible] **fiscal year 1989-90.**

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Employee Training and Education

The Human Resource Training Section conducted 64 internal training classes covering basic skills, management skills, supervisory skills, and leadership. Approximately 913 employees participated. Beyond these programs, three four-day Project Management Workshops were held during the fiscal year involving 20 employees per workshop. Three workshops, involving approximately 58 employees, in Creating High Performance Teams were held at the request of the Management Development Club. A Team Achievement workshop also was held at Gene Village for 18 employees.

To provide a wider spectrum of available developmental resources, the Training Section purchased self-study video courses in writing skills and computer literacy, the two highest enrollment requests for the 1989-90 fiscal year. These are now available at Headquarters, and at field locations where formal workshops are impractical.

Metropolitan's Tuition Reimbursement Program financially assists full-time employees with a minimum of six months service who wish to continue their formal education. Under the program, 85 percent of tuition, books, and lab fees are reimbursed if the employee receives a grade of "C" or better per course. More than 300 applications were processed during this fiscal year.

During the second day of the New Employee Orientation Program, staff processed 179 new employees.

Equal Employment Opportunity

During the fiscal year, staff continued implementing and monitoring Metropolitan's Equal Employment Opportunity Program (Program) to assure compliance with current laws, regulations, and guidelines. Additionally, efforts to revise and enhance the existing Program continued.

Contract-initiated compliance procedures relative to Metropolitan's contractors and consultants were developed during this fiscal year. This effort's primary purpose was to ensure the participation of minorities and females as prime or subcontractors on construction contracts.

Another critical function of this section involves processing, investigating, and resolving internal discrimination complaints, as well as those received from the U. S. Equal Employment Opportunity Commission, the State of California Department of Fair Employment and Housing, the U. S. Office of Federal Contract Compliance Programs, and the U. S. Civil Rights

Commission. This year, 10 complaints were ... assistance and counseling concerning equal ... compliance was made available to all employees ... received individual counseling.

Responding to special requests from various ... employment opportunity, such as the Contract ... Department of Fair Employment and Housing, staff provided Metropolitan's statistics and procedures for recruitment and selection.

Throughout the fiscal year, Metropolitan was involved with various governmental and professional organizations, charitable functions, and community groups associated with equal employment opportunity.

The Equal Employment Opportunity Officer held regular meetings with the Equal Employment Opportunity Advisory Committee, comprised of representatives from Metropolitan's various minority organizations, the Vietnam Era Veterans Association, Metropolitan's women's association, and the employee bargaining units. This committee provides a forum for members to address relevant issues and obtain pertinent information on equal employment opportunity and affirmative action.

Environmental Safety and Health

Metropolitan's Environmental Safety and Health Program, which conforms to the California Occupational Safety and Health Act (OSHA) of 1973, is designed to promote a safe and healthy work environment and prevent industrial illness and injury.

Environmental Safety and Health issues were addressed through monthly safety training, industrial hygiene and construction safety support activities, and individual work group training sessions.

During the fiscal year, the Environmental Safety and Health staff continued to identify and evaluate health hazard situations, recommend and implement policies and procedures, and monitor work environments. Additionally, staff identified and assessed chemical, biological ... ical hazards throughout Metropolitan work areas and ... ment of proposed changes to Federal, State, and local ... Metropolitan's Environmental Safety and Health Program.

Metropolitan's accident experience in calendar ... 157 recordable injuries, 69 of which resulted in ... 424 restricted work days. Over a three-year period, Metropolitan ... 102 recordable injuries annually, 78 of which resulted ... days and 294 restricted duty days.

Based on this information, the following incident rates were computed and are compared to the Bureau of Labor Statistics rates for 1987 for the water supply industry

TABLE 49

ACCIDENT INCIDENTS

	1989	1988	Water Supply Industry
Total Recordable Injuries/Illnesses	8 99	7 76	12 36
Lost Workday Cases*	5 04	2 87	6 06
Non Fatal Cases w/o Lost Workdays	3 95	4 88	6 30
Lost Workdays**	126 42	105 15	138 00

Note

$$\text{Incident Rate} = \frac{\text{Number of Injuries/Illnesses} \times 200\,000}{\text{Total Number of Hours Worked}}$$

(200 000 = Average Work Year in Hours for 100 Employees)

* The lost workday cases rate includes cases which incurred a lost and/or restricted duty workday

** The lost workdays rate includes lost and/or restricted modified duty workdays

Protective Services

The Protective Services Program provides ongoing professional, quality protection for Metropolitan assets from natural, technological, and human threats. During the fiscal year, staff completed most of the Joseph Jensen Filtration Plant (Jensen Plant) security improvements; completed site-specific security plans for Lake Mathews, Lake Skinner, and the Robert B. Diemer Filtration Plant; expanded the program begun last year to identify and correct problems related to illegal use of Metropolitan lands; continued and expanded liaison with key public safety and emergency service organizations within Metropolitan's service area; and completed several specific-hazard contingency plans to protect Metropolitan facilities during a disaster or civil emergency.

Duber Security began providing contract guard services at the Los Angeles Headquarters Building (Headquarters) and selected field locations. Most of the security personnel employed under the previous Burns International Security Services contract were retained in the new contract, generating little loss of specialized training in emergency response due to the change.

Metropolitan's Protective Services Program emphasizes three broad areas of service: prevention, investigation, and consultation. This has resulted in reduced threats to Metropolitan's resources through greater involvement by its employees. The impact of these collective activities is reflected in Table 50.

TABLE 50

SELECTED PROTECTIVE SERVICES ACTIVITIES

	1989 [illegible]	[illegible]89
Incident Investigations	[illegible]	[illegible]
Pre-employment Investigations (including contract and temporary employees)	[illegible]	[illegible]
Administrative Investigations	10	23
Inspections	236	374
Courtesy Reports	344	520
Reported On Site Hazards	1,217	865
Trespassers Contacted/Escorted	304	734
Security Awareness Sessions	62	45
Security Improvement Recommendations	41	65
Consultations	72	84
Contacts with Outside Agencies	555	456
Informal Agreements with Outside Agencies	3	0

Medical

The Medical Section safeguards Metropolitan employees by placing them in jobs for which they are medically fit without significant risk to themselves or to co-workers. As shown in Table 51, this goal is accomplished through pre-placement medical evaluations matching individuals with jobs, periodic medical surveillance to ensure that employees remain medically fit to effectively perform their job duties, compliance with OSHA requirements, job transfer evaluations to ascertain medical fitness to perform new duties, audiometric testing for employees exposed at or above OSHA limits, and return-to-work evaluations to assess employees' abilities to safely perform their jobs after serious or extended illness or injury.

Attempts are made to educate employees to become responsible for their own health by becoming informed consumers of available health services and by emphasizing lifestyle changes designed to [illegible] and prevent chronic illness. These goals were accomplished [illegible] employee counseling, wellness activities, and employee [illegible]. A formalized Employee Assistance Program was imple[illegible] 1989. In addition, the Executive Physical Program [illegible] eligible employees the option of participating in [illegible] activities in lieu of an annual examination.

TABLE 51

EMPLOYEE PARTICIPATION IN MEDICAL ACTIVITIES

Selected Medical Activities	1989-90	1988-89
Pre placement Medical Evaluations	259	285
Medical Section Visits by Employees	1,376	1,039
Audiometric Testing	392	298
Class I Drivers	47	28
Return to work Evaluations	85	90
Periodic Medical Surveillance	328	971
Executive Medical Evaluations		
The Medical Group	38	71
New Health Center	41	41
St Johns Medical Center	—	3
Wellness Reimbursement	17	17
Job Transfers	N/A	85
Mercury Testing	—	27

Administrative Services

Purchasing

During the fiscal year, Metropolitan obtained $42,759,531 in materials, equipment, and services required for operation, maintenance, and minor construction in addition to purchasing large items under formal contracts. This total amount does not include electrical costs for water pumping or formal construction contract costs. The number of purchase orders increased about 13 percent over last fiscal year, with a total increase over the past two fiscal years of approximately 21 percent.

In other activities, an auction of used vehicles and assorted equipment brought a total of $72,368 and sale by sealed bids of salvage materials and surplus stock accrued $68,322. Colorado River and State project water treatment required purchasing 6,920 tons of liquid chlorine, 6,652 tons of liquid caustic soda, 5,349 tons of liquid alum, 3,682 tons of polymer, 595 tons of ammonia, and 576 tons of copper sulfate. This equals a 19 percent increase over last year's total chemical use.

Staff continued customizing the Procurement ... system which will automate creating, processing ... requisitions, purchase orders, and contracts ... analysis, and allow on-line receipt of material. ... were directed toward implementing the automated ... portions of this system.

Procurement system use will continue to be phased in to allow users to access sub-systems as they are completed, while development continues on the remainder of the system.

Warehousing

Decreasing $0.2 million over last fiscal year, inventory value of Central Stores stock at fiscal year end totaled $6.1 million. Total transactions (including transfers, issues, receipts, and debits) rose 8 percent during the fiscal year. Surplus stock and salvage items sold included office equipment, books, tires, wooden pallets, shop equipment and machines, and scrap metals. This represents a decrease of $203,235 from the amount disposed of during the previous fiscal year.

Last year's use of drawer-type cabinets for rapid, over-the-counter issuing of small, inexpensive items has been expanded to two additional warehouses, including the Gene Camp facility and Central Stores, which are now 25 percent converted to this system, and should be fully converted in fiscal year 1990-1991. This method saves money, reduces paperwork, and helps eliminate errors caused by repetitious issue procedures.

Headquarters Services

To accommodate new employees and relieve overcrowding at Headquarters, Metropolitan has conducted a major long-term and short-term office space allocation program, which includes the F.E. Weymouth Filtration Plant (Weymouth Plant) and Headquarters modification ... The ... increase has required leasing two floors (25,000 square feet) ... in Pasadena to accommodate 114 employees ... Administrative Services' Purchasing Branch ... in January 1990.

Metropolitan concluded negotiations on an additional ... of office space in the Pasadena building to ... additional employees from Headquarters and ... additional space needs until spring 1991 for ... Pasadena.

During a six-week period from March through April, the Headquarters floor arrangements were reconfigured to satisfy Los Angeles City Fire Code requirements. This reconfiguring included widening fire escape routes to 48 inches and removing obstacles such as tables and copiers from elevator lobbies and bookcases and file cabinets from aisles. When reinspected by the Los Angeles Fire Department, the building met Fire Code standards.

Office Services

During the fiscal year, staff expanded its services to accommodate the move of the Right of Way and Land and Finance Divisions and the Purchasing Branch to the Pasadena office facilities. This included placing a mail clerk at the facility to distribute and pick up mail and revising and updating 11 different business forms for Purchasing so that bids and other documents would be delivered directly to the Pasadena facility.

Staff converted Controller documents, deeds, and easements documentation into a micrographic retrieval system to protect these vital records from continued handling. A back-up copy of the film is stored in an off-site vital records storage vault. Staff also converted the deferred compensation hard copy files to the micrographic retrieval system to eliminate continued file growth and maintain an audit trail of compensation plan statements.

To meet the demand of reproducing reports and meeting deadlines, Metropolitan upgraded its in-house copying capabilities by installing three new state-of-the-art high-speed duplicators.

Fleet Management

During the last quarter of the fiscal year, 149 vehicles were added to the fleet at a cost of $2,184,566. An auction of 91 used vehicles netted $137,358. Future auctions will be held quarterly.

Regulation XV and the Trip Reduction Program require that employers reduce the number of vehicles commuting to the work site by promoting ridesharing participation through employee incentives.

Metropolitan's new Trip Reduction Plan has adopted a more aggressive approach toward reaching previously established goals by implementing several new policies. Among these are the Guaranteed Ride Home, which makes a Metropolitan vehicle available to any ridesharing participant in case of emergency or if required to work late. Several shuttle services have been initiated to provide efficient transportation and peripheral parking between Headquarters and other Metropolitan facilities, such as the Jensen plant, Weymouth plant, and Pasadena offices. A new service shuttles employees using public transportation (Amtrak at Union Station or the Blue Line at Pico Station).

Information Syst[illegible]

Office Automation

The automated Office System, in place [illegible] 450 users performing tasks such as sending [illegible] scheduling meetings, and maintaining daily [illegible] bulletin board informs staff of support services [illegible] and helpful hints on using the system. During the fiscal year, the office system became available to field locations.

A centralized Helpdesk was established in Information Systems to assist users in solving problems encountered while using office automation equipment. To track problems and associated solutions, a problem management system was developed and provides a repository for future reference.

The conversion from Wang to IBM workstations was completed, making it possible for users to access internal and outside information from a single workstation, saving the cost of leased equipment needed to access outside data.

Phase 2 of the Procurement System was implemented, permitting requisition of materials, products, and services through an on-line system. Routing of requisitions for review and approval is now done electronically, providing substantial time savings.

A program to account for all water in Metropolitan's distribution system and to produce invoices for water sold has been completed. Testing and implementation of this program will continue into the next fiscal year. The program enables auditing of all water distribution and invoicing transactions, as well as automatically enforcing invoice approval processes by both Operations and Finance Divisions. These and other features reduce errors, diminish the effort required to produce invoices and capture planning data, and create flexibility to accommodate new conservation programs.

Communications

Last year, Arthur Young Consulting and staff [illegible] three-phase communications plan. This year, [illegible] mented. State-of-the-art telephone systems were [illegible] ters and the Weymouth plant, producing [illegible] greater reliability, route optimization in case of [illegible] and improved disaster recovery capability. Al[illegible] all Metropolitan facilities.

Metropolitan's data network is being upgraded to meet future interconnectivity requirements between major computer systems. The increased capacity will support high data transmission volumes, water control systems, video teleconferencing, geographical information systems, and electronic data interchange systems. As part of the upgrade, a fiber-optic cabling system was installed at Headquarters and additional systems are scheduled for Weymouth and Gene facilities; these increase capacity, improve connectivity to user workstations, and support the new local area networks at Headquarters and planned for the Weymouth plant. Installing such new technologies as voice-mail, telemanagement software, digital microwave data network, and satellite systems provide the tools necessary to enhance, process, and manage Metropolitan's evolving communications network and user requirements.

Data Processing

The ability to support the expanding network of end-users of host computer services was substantially improved by installing an upgraded IBM Disk Storage System and Communications Controller as well as an Uninterruptible Power Source that will prevent data loss caused by power outages. Also, nearly 400 workstations were installed at Headquarters and at all field locations.

Preliminary plans for the Network Operations Center (NOC) recommended in the Strategic Communications Plan were completed. Phase I of the NOC plan was initiated in May 1990. The NOC will be located in a remodeled area of the Computer Operations Center on the seventh floor of Headquarters and will provide central performance monitoring of the communication network so that a reliable, continuous flow of information is maintained between users and the host computer.

Public Affairs

As California moved into its fourth year of drought, staff focused on providing information about water supply and management, drought conditions, and conservation and reclamation.

The $2-million water conservation campaign, "Be Water Tight," continued throughout the summer of 1989. Live performances at county fairs, school assemblies, and community functions augmented this campaign. Bumper stickers, restaurant tent cards, and conservation brochures were incorporated into Metropolitan's most far-reaching water conservation effort at that time.

May was declared Water Awareness Month [illegible] the water awareness of 30 million Californi[illegible] tens of thousands of brochures, magnet[illegible] materials for its member agencies and sub[illegible] Metropolitan's participation in Water Percepti[illegible] May. Co-sponsored with the Los Angeles Depar[illegible] this program drew business leaders from throu[illegible]

Water Awareness Month activities set the [illegible] ambitious $2.6-million conservation campaign for th[illegible] campaign designed to reinforce the need for water con[illegible] a way of life in Southern California. Television [illegible] advertising began in June. Working with Wells Fargo [illegible] conservation kits and literature were distributed through bank branch[illegible]

Government Relations

Staff provided local, State, and Federal officials with information needed for the decision-making processes in which they are involved. Activities included inspecting water facilities on the Colorado River and in Northern California, and participating in legislative briefings, scoping sessions, and conferences.

Issues addressed in detail by staff included siting of the proposed Eastside Reservoir, Garvey Reservoir repair and future operations, Metropolitan's opposition to expanding a controversial Azusa garbage dump which overlays a groundwater basin, the Central Pool Augmentation Project, and the effects of the drought.

Additionally, staff coordinated community breakfasts and luncheons. Opportunities to develop contacts, present Metropolitan's position on issues, and respond to special interest inquiries were gained by attending minority leadership conferences and industry and commerce conferences.

Community Relations

Staff coordinated and conducted inspection trips sponsored [illegible] of the Board of Directors and by the General Mana[illegible] [illegible] director-sponsored Colorado River Aqueduct (Aqueduc[illegible] Water Project (SWP) tours, the General Manager spon[illegible] Aqueduct and two SWP tours. There were 18 special [illegible] during the fiscal year. These included two special to[illegible] the Arizona state legislature and for executives of Ari[illegible] and associations who visited Southern California [illegible] [illegible]an's structure. A new directors' tour to Northern Cal[illegible] [illegible]nd conducted. Numerous groups, largely student[illegible] [illegible]tan's filtration plants. The total number of persons [illegible] during the year exceeded 10,000.

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May was declared Water Awareness Month, a statewide ... the water awareness of 30 million Californians. Metrop... tens of thousands of brochures, magnets, bumper stick... materials for its member agencies and subagencies. Staff ... Metropolitan's participation in Water Perception '90, a seminar h... May. Co-sponsored with the Los Angeles Department of Water and ... this program drew business leaders from throughout the metropolita...

Water Awareness Month activities set the stage for an even mo... ambitious $2.6-million conservation campaign for the summer of 1990, a campaign designed to reinforce the need for water conservation to become a way of life in Southern California. Television, radio, and outdoor advertising began in June. Working with Wells Fargo Bank, special conservation kits and literature were distributed through bank branches.

Government Relations

Staff provided local, State, and federal officials with information needed for the decision-making processes in which they are involved. Activities included inspecting water facilities on the Colorado River and in Northern California, and participating in legislative briefings, scoping sessions, and conferences.

Issues addressed in detail by staff included siting of the proposed Eastside Reservoir, Garvey Reservoir repair and future operations, Metropolitan's opposition to expanding a controversial Azusa garbage dump which overlays a groundwater basin, the Central Pool Augmentation Project, and the effects of the drought.

Additionally, staff coordinated community breakfasts and luncheons. Opportunities to develop contacts, present Metropolitan's position on issues, and respond to special interest inquiries were gained by attending minority leadership conferences and industry and commerce conferences.

Community Relations

Staff coordinated and conducted inspection trips sponsored by members of the Board of Directors and by the General Manager. There were 38 director-sponsored Colorado River Aqueduct (Aqueduct) and eight State Water Project (SWP) tours; the General Manager sponsored another eight Aqueduct and two SWP tours. There were 18 special and one-day tours during the fiscal year. These included two special tours for members of the Arizona state legislature and for executives of Arizona water agencies and associations who visited Southern California to investigate Metropolitan's structure. A new directors' tour to Northern California was planned and conducted. Numerous groups, largely students, toured Metropolitan's filtration plants. The total number of persons visiting Metropolitan during the year exceeded 10,000.

Staff assisted in planning, coordinating, and implementing meetings of the National Water Resources Association's Municipal Caucus and of the Southern California Water Conference and chaired the Public Affairs Committee and served on the Exhibits Committee of the Colorado River Water Users Association. Community relations activities at meetings of the Association of California Water Agencies, the California Water Resources Association, the National Water Resources Association, and the Colorado River Water Users Association were planned and conducted. Staff participated in forming the Colorado River Resources Coalition, an organization representing water users, farmers, municipalities, and power distributors working together to better inform the public and Congress of the Colorado River's many economic, industrial, and environmental values.

Two Directors' Emeritus luncheons, designed to update former Metropolitan directors on current issues, and a Directors' Workshop were planned and coordinated, and two Public Information Liaison Committee meetings were held to keep public affairs staff of member agencies and subagencies apprised of current activities.

Metropolitan's Speakers Bureau members spoke to more than 29,000 persons during the year. The most requested topic was the continuing drought. To publicize the Speakers Bureau, a brochure was developed that includes a request-for-speaker form. To provide updates to members, quarterly meetings were held, and two training sessions were conducted for new speakers. Staff developed a Speakers Bureau workbook to provide an overview of Metropolitan's history and issues past, present, and future.

Education Programs

Metropolitan's elementary program was distributed through in-services to 951 fourth- and sixth-grade teachers. These educators, new to the program, plus those who were resupplied with materials this year, taught the "Admiral Splash Water for Less" programs to approximately 90,000 students during the 1989-90 school year. The kindergarten through sixth grade assembly programs were rewritten and presented to some 15,300 students. Hands-on water science experiments were conducted with approximately 1,600 students during the year.

Three high school water education programs, "Water Quality," "Water Highways," and "Water Economics," were developed and produced. The units were presented to 83 teachers during the first month of availability. Implementation of the high school program officially begins during the 1990-1991 school year. The Water Quality unit was featured in a segment of the local CBS evening news in May 1990.

"Geography of Water" materials were introduced [illegible] four through eight, and approximately 2,000 teachers [illegible]. Teacher evaluations have been positive.

Staff conducted two college-credit classes, one for elementary and one for high school teachers, with a total of 100 educators participating. Topics covered included hydroelectric generation, water quality, water distribution, water politics and conservation. Teacher feedback was extremely positive.

Publications

Articles included in *Aqueduct*, Metropolitan's tri-yearly magazine, and *Focus*, its bimonthly newsletter, reflected the serious issues facing Metropolitan and the entire water industry today: urban and agricultural water use, long- and short-term water storage agreements, water quality regulations, environmental issues, water marketing, and conservation, among others. Several requests to reprint articles were granted to local, national, and international publications. Subjects included the drought, bottled water, growth, and water quality.

An education programs brochure was developed for use on Metropolitan inspection trips. "The Pacesetters," a brochure detailing the structure of the Board of Directors, and various water quality and conservation brochures were updated. The conservation newsletter *WaterScape* and the bimonthly internal *People* were also produced.

More than 500,000 pieces of literature, in addition to the regularly scheduled publications, were distributed through the exhibits program, display racks, speaking engagements, and member agencies' mail and phone requests.

Media

The drought continued to draw major interest from local, regional, state, national, and international media. Staff assisted radio and television stations with their efforts to produce water awareness programming. Drought stories promoted by Metropolitan news releases included the request for drought ordinances from the cities within the [illegible] and the possible wheeling of water into northern Ventura and Santa Barbara Counties.

The election of Lois Krieger as Chairman of the Board of Directors to complete the term of late Chairman E. L. Balmer was an historic [illegible] and produced wide interest.

Following the San Francisco Bay area earthquake, staff responded to media requests that centered on Metropolitan's ability to withstand a major quake and how repairs would be accomplished and water service restored.

News conferences were held to explain Metropolitan's position in attempting to block the expansion of the controversial Azusa garbage dump and to cover the historic signing of the agreement with Imperial Irrigation District (Imperial).

The discovery of a leak in the Garvey Reservoir floor also drew media attention. Public meetings, press conferences, and an opinion survey were conducted.

Additionally, information was provided to media outlets regarding the State Water Resources Control Board's San Francisco Bay Sacramento-San Joaquin Delta hearings, the seasonal storage program, the Eastside Reservoir project and related land acquisition, water reclamation, and water quality issues.

Staff also participated in visits to major Northern California newspapers. As a result of these meetings, several favorable editorials were published recognizing Metropolitan's and all of Southern California's efforts in water conservation and the positive action taken by Metropolitan in negotiating proposed agreements with Imperial and the Arvin-Edison Water Storage District.

Special inspection trips to the Imperial Valley, the Colorado River, and Mono Lake were conducted for local reporters.

Right of Way and Land

Acquisition

Right of Way activity reflected the increasing number of projects ranging from those still in planning stages to those certified for construction. Staff began acquiring parcels for the Etiwanda Pipeline connecting the Foothill Feeder to the Upper Feeder and traversing the cities of Fontana and Rancho Cucamonga. Although construction of the San Diego Canal enlargement is almost complete, nine additional temporary construction easements were acquired.

The major acquisition during the year was the 4,197-acre Searl Ranch, one of the sites under consideration for the Eastside Reservoir, for $26,500,000. Consultants working with staff provided mapping, title, and escrow coordination, document review, and administration of assigned leases subsequent to acquisition. Two additional parcels located within potential Eastside Reservoir sites also were acquired. One parcel comprising 227 acres was bought for $5,250,000 and the other, comprising 9.89 acres,

was purchased for $164,000. Additional prope[illegible] or appraised for acquisition. In addition to [illegible] several easements were obtained to preserve acc[illegible] surrounding land is developed.

Entry permits for pre-bid inspections were acquired [illegible] by the Etiwanda Pipeline. To assist project planning, staff obtained numerous entry permits for observation and geotechnical purposes on potential sites for the Eastside Reservoir, Lake Perris Treatment Plant and Reservoir expansion, and Eastside Reservoir mitigation. Staff also monitored the acquisition of 811 entry permits obtained by consultants in connection with site studies for the Inland Feeder and San Diego Pipeline No. 6.

During the last several months of the fiscal year, staff has been obtaining entry permits for observation of the Westside Conveyance Study project. Involving 185 parcels of land, the project consists of six study routes from Lake Castaic in north Los Angeles County, through the Santa Clarita Valley to the city of Fillmore, and south to the city of Thousand Oaks. Entry permits for observation purposes also are being obtained for the proposed Lake Mathews Treatment Plant, to be located west of Lake Mathews and east of Highway 15 in the Corona area of Riverside County, consisting of 23 parcels of land.

Advance acquisition activities are continuing for properties within potential sites of the Eastside Reservoir, South Orange County Treatment Plant, Westside Conveyance Project, Palo Verde Irrigation District, and various environmental mitigation areas. These activities include property owner contact, search of public records, tract map surveillance, mapping, title search, appraisal, writing of legal descriptions, and obtaining entry permits for observation and geotechnical purposes.

A total of 24 fee, permanent easement, and temporary easement parcels were acquired by direct negotiation with property owners. Table [illegible] lists the year's right of way acquisition projects.

Surplus Property

Surplus property sales activity remained low this [illegible] concentrated on acquisition and advance acquisition [illegible] tan sold one surplus parcel, containing approximately [illegible] for $27,000 cash. At fiscal year end, eight promissory note[illegible] of trust on properties previously sold were in effect. [illegible] of trust secure notes bearing fixed interest rates of 12[illegible] principal balance of the notes outstanding at the end [illegible] amounted to $778,559, while the principal and inte[illegible] ceived during the fiscal year amounted to $175,411.

Land Management

Currently, Real Property staff is administering 161 separate secondary uses of Metropolitan's fee property, generating $307,811 in revenue from these uses, an increase of $34,181 over last fiscal period. These secondary uses are granted to governmental agencies, public utilities, and private individuals, by granting easements or issuing licenses, leases, or entry permits for uses ranging from street widening, underground utilities, agriculture, or access. During last fiscal year, the property acquired for the proposed Eastside Reservoir included six existing leases which produce an annual revenue of $72,000.

Conversely, Metropolitan must occasionally lease private property for satellite offices, to operate and maintain its facilities, or for office space for its governmental representatives in Washington, DC, Sacramento, and Orange and Imperial Counties. There are seven such leases in effect, totaling $493,604 in annual rent payments.

Real Estate Appraisal and Land-Use Activities

Staff coordinated and reviewed appraisal work performed by contractors, and completed rental valuations for Metropolitan's use. Additionally, staff appraisers provided appraisal consultation services to the Planning, Engineering, and Operations Divisions, the General Manager, and the Legal Department.

Staff Appraisals

Staff conducted appraisals of secondary use, permanent pipeline, and temporary construction easements, and conducted rental surveys to aid in determining market rental rates for tenant-occupied parcels. Also completed were appraisals of fee interests required for Metropolitan projects, as well as fee interests of surplus properties. Staff prepared a planning-level cost analysis of a potential environmental mitigation area for the proposed Eastside Reservoir, westerly of Temecula. This mass appraisal involved 19 parcels totaling 5,665 acres of raw land. An update survey of vacant potential residential subdivision land sales, in the coastal Orange County area, was conducted by appraisal staff to review any market changes which would bear on the possible disposal of Metropolitan's Bolsa Chica property.

Independent Consultant Appraisers

Staff negotiated and processed 39 contracts to retain the services of independent real estate appraisers to value private ownerships comprising over 25,000 acres of land at the Domenigoni Valley, Vail Lake, and Potrero

Creek potential reservoir sites. Scoping and pr[illegible] were conducted with all independent consult[illegible]. Additionally, staff reviewed appraisal reports su[illegible] appraisers.

Standard general conditions were developed for attachment to appraisal contracts for acquisition appraisals. Special instructions were prepared to inform independent consultant appraisers of government code and evidence code requirements. Staff developed a final draft of division appraisal report procedures, which address staff appraisals and include descriptions of the minimum requirements for the various types of appraisal reports and consultations the division provides.

To facilitate the real estate appraisal and due diligence investigations of 18 separate ownerships to protect lands at potential Eastside Reservoir sites, staff retained the services of private consulting engineers to perform environmental, civil, and cost engineering services.

Land-Use Studies

A highest and best use feasibility study of property located within the potential Domenigoni Reservoir site was completed as a part of the Eastside Reservoir Study. The analysis investigated the property's potential susceptibility to the threat of development.

Staff completed a cost and planning study of vacant land surrounding the chemical unloading facility (CUF) for possible acquisition to provide a buffer zone to protect other uses in the area from the potential nuisance of CUF activities. The cost and planning study involved a land use feasibility study, land value range estimation, and acquisition cost estimation.

Staff completed an office availability study in the Pasadena, San Dimas, and La Verne areas of Los Angeles County.

Annexation

Eight annexations to Metropolitan were completed and processed increasing the service area by 1,724.52 acres. Seven annexations became effective in Riverside County; one became effective in Ventura County to Calleguas Municipal Water District. Total annexation charges amounted to $1,414,592.

Metropolitan's Board of Directors granted formal approval for 11 concurrent annexations and gave informal approval for [illegible] annexations.

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The city of Oceanside was able to annex one area, comprised of 876.46 acres, without Board approval because of its automatic annexation privilege. Metropolitan's total service area, as of June 30, 1990, consisted of 5,141.94 acres, an increase of 4.05 square miles from the previous year.

Staff reviewed 40 redevelopment projects to determine if either Metropolitan's facilities or tax base would be affected. Staff processed and paid 221 property tax statements for a total tax payment of $59,887, including an additional tax assessment of $1,315. This resulted from acquiring Parcel No. 145-1-25 for the portion of Eastside Reservoir property lying outside Metropolitan's boundaries. Also included were the escaped assessments for fiscal year 1983-84 amounting to $2,029. Street lighting and maintenance assessments of $10,035 on Metropolitan properties located within its boundaries were paid.

Statement of Change of Boundaries

Metropolitan filed the annual Statement Change of Boundaries with the State Board of Equalization and the County Assessors of the six counties in which Metropolitan's service area boundaries extend. Filed on December 29, 1989, the statement indicates any changes in the boundaries of Metropolitan's member agencies which amended Metropolitan's service boundaries during the previous calendar year.

Automation

Increased reliance on microcomputers and computer network systems to centralize data, decrease duplication of data and effort, and increase efficiency led to installing new hardware and software systems. These systems encompass word processing, mapping, real estate data spreadsheets, and legal description programs. To ensure the systems' efficient use, an on-going training program has been implemented to keep staff informed of and skilled in the use of new hardware and software.

The Information Retrieval System, a data base designed last year to provide essential facts and figures relevant to each Metropolitan-purchased parcel, has been completed and staff has formed a team to continuously update and improve the data base.

Survey and Legal Description Approval

This fiscal year, a Licensed Land Surveyor was added to staff to expedite the processing of legal descriptions set forth on documents used in acquisition and leasing. The surveyor processed 164 documents in addition to reviewing ALTA surveys of prospective acquisitions submitted by Metropolitan surveyors. He also established guidelines for legal descriptions and

maps for public agencies, corporations, an[illegible] permanent or temporary easements, leases, [illegible] politan property.

Project Management

Anticipating future growth, the consulting group of [illegible] conducted a study of the Right of Way and Land Division's automation needs to document current responsibilities and develop a man loading forecast. The study provided a timeline for 45 capital projects, identified five-year work force needs, suggested opportunities for both multi-division project management and exclusive Right of Way and Land Division project management, provided estimates of mapping capacity and appraisal capacity, and suggested historical data storage and retrieval methods. These recommendations are currently being reviewed for implementation.

TABLE 52

RIGHT OF WAY ACQUISITION

Fiscal Year 1989-90

Location	Parcels Acquired	Acres Fee	Acres Permanent Easement	Acres Temporary Road Easement	Cost
Eastside Reservoir	3	4,434.60			$ 31,914,000
Middle Feeder	2		0.42		0*
San Diego Canal	9			33.83	84,835
Upper Feeder	1		0.78		0*
Etiwanda Pipeline	7	1.89	1.76	[illegible]	2[illegible]8,820
San Diego Pipeline No. 3	1		0.05		
West Orange County Feeder Extension	1		0.08		
TOTAL	24	4,436.49	2.[illegible]		

Notes

* No consideration. Easement granted to provide su[illegible]

TABLE 53
TAXES AND ASSESSMENTS PAID
Fiscal Year 1989-90

Location	Number of Tax Parcels		Payment
Taxes Paid on Property Outside Metropolitan			
Clark County, Nevada	3		$ 6,546.64
Mohave County, Arizona	2		770.98
Los Angeles County, California			
1989-90 Tax Assessments	51	36,928.25	
Adjusted 1989-90 Tax Assessments	1*	15.03	
1983-84 Escaped Assessments	9*	2,029.75	
Total Los Angeles County			38,973.03
Riverside County, California			
1989-90 Tax Assessments	113	8,945.68	
Acquisition for Eastside Reservoir	2	1,315.92	
Total Riverside County			10,261.60
San Bernardino County, California	52		3,334.23
TOTAL TAXES PAID	233		$ 59,886.48
Street Lighting and Maintenance Assessments Paid on Property Within Metropolitan			
City of Los Angeles, California	18		7,423.60
City of South Gate, California	55		2,581.72
Orange County, California	1		30.38
TOTAL ASSESSMENTS PAID	74		$ 10,035.70
GRAND TOTAL Taxes and Assessments Paid			$ 69,922.18

NOTES

*Adjusted and escaped assessments involve tax parcels already counted

TABLE 54
STATEMENT OF CONSTRUCTION, RIGHT [illegible] AND OTHER COSTS
(Accrual Basis)
June 30, 1990

	CRA Construction	Distribution Construction	Other Construction	TOTAL
Completed Features				
Parker Power Plant & Dam	$12,995,418			$ 12,995,418
Power Recovery Plants		96,241,507		96,241,507
Other Dams & Reservoirs		101,479,048		101,479,048
Water Transportation Facilities		906,619,603		906,619,603
Pumping Plants & Facilities	65,891,615			65,891,615
Treatment Plants & Facilities		234,433,178		234,433,178
Power Lines & Communications	6,521,439			6,521,439
Miscellaneous Features			41,854,103	41,854,103
Subtotal	85,408,473	1,338,773,338	41,854,103	1,466,035,915
Preliminary Organization Expense			5,571,000	5,571,000
Interest: Original Constr			36,232,889	36,232,889
Interest, During Constr	983,724	32,374,253	1,950,314	35,308,291
Unused Energy				
Original Constr			2,790,868	2,790,868
Subtotal	983,724	32,374,253	46,545,072	79,903,049
Total Comp. Features	86,392,197	1,371,147,591	88,399,175	1,545,938,964
Work in Progress				
Cost of Work in Progress	10,261,240	185,967,318	7,912,175	204,140,733
Interest, During Constr	1,702,861	12,511,700	2,089,798	16,304,359
Total Work in Progress	11,964,101	198,479,018	10,001,972	220,445,092
Right of Way				
Completed Features	1,440,415	28,997,072	[illegible]	[illegible]
Current Construction	—	46,802,219		[illegible]
Right of Way Deposits	—	3,397,606		[illegible]
Interest, During Constr		3,095,[illegible]		[illegible]
Total Right of Way	1,440,415	82,291,[illegible]	[illegible]	[illegible]
Other Costs				
San Joaquin Res. Trust Agmt				
Feasibility Studies, Reimbursables, etc	—			
Construction Deposits	—			
Customer Deposits			[illegible]	
Total Other Costs			[illegible]	
Total Cost to Date	$99,796,714	$1,651,9[illegible]	[illegible]	[illegible]

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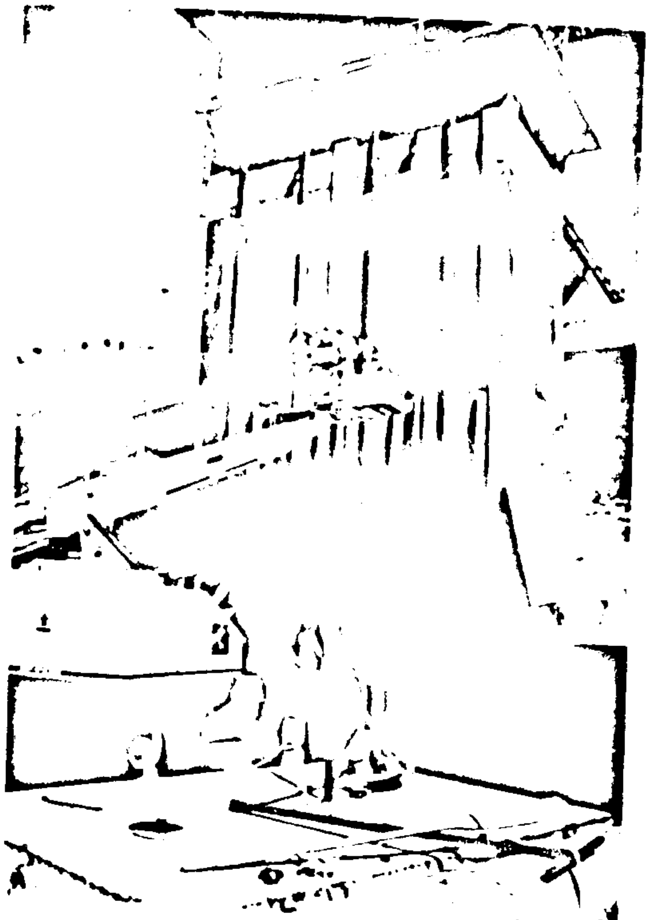

During a Lake Mathews shutdown, workers perform scheduled maintenance to replace valve stems and add cathodic protection to the gate valves.

CHAPTER 10

Internal Audit

Metropolitan's Audit Department performs internal financial and compliance audits as well as miscellaneous reviews or special audits. The Auditor reports directly to the Board of Directors through the Audit Subcommittee of the Finance and Insurance Committee. He works closely with Metropolitan staff, but is independent of general management.

Internal audit assignments are usually selected by the Auditor and are occasionally requested by the Board of Directors or management. Detailed audit testing is preceded by appropriate planning and coordination with management or staff. Upon completing all significant audit assignments, a report is issued to the Board of Directors and copies are provided to management. In accordance with internal auditing standards, the typical audit report outlines the objectives and scope of the work performed, the audit findings noted, and any recommendations for corrections or improvements which the Auditor feels are warranted in the circumstances. Beyond internal audit assignments, the Auditor and his staff provide substantial assistance to Metropolitan's external auditor in conducting quarterly financial audits and the year-end audit required by the California Government Code and Metropolitan bond covenants.

During fiscal year 1989-90, the Audit Department issued a variety of reports pertaining to financial, compliance, electronic data processing (EDP), and special auditing matters. Aside from the aforementioned assistance provided to the external auditors, major assignments completed and reported on during the year included (in chronological order of issuance):

- Review of Metropolitan Bond Records and Controls—Follow-up Procedures, dated August 31, 1989.
- Compliance with IRS Restrictions on the Use of Revenue Bond Proceeds for Hydroelectric Facilities, dated October 31, 1989 (joint letter with General Counsel).
- Review of October 1989 Inventory of Gene Stores Warehouse, dated November 28, 1989.

- Review of Transmission of Payroll Automatic Deposit to Security Pacific National Bank, dated November 28, 1989.
- Review of Reimbursable Taxes Section Functions, dated December 28, 1989
- Review of Biennial Inventory of Operating Equipment as of September 30, 1988, dated January 19, 1990.
- Limited Review of the 401(k) Savings Plans, dated January 22, 1990.
- Review of March 1990 Physical Inventory of Central Stores, dated May 22, 1990
- Review of Metroplitan Compliance with the Federal Single Audit Act, dated May 23, 1990.
- Review of the 1990-91 Annual Budget, dated May 25, 1990.

The results of these audits, together with management's responses to the Auditor's recommendations, are discussed in detail with the Audit Subcommittee. The Audit Subcommittee met four times during fiscal year 1989-90.

In addition to the aforementioned assignments, a number of other meaningful assignments were completed during fiscal 1989-90 for which formal audit reports were not prepared. Instead, when applicable, management and appropriate staff received summaries of the results of these reviews for their information and possible action. The following assignments fell into this category:

- Review of the Official Statement for Metropolitan's 1989 Series "G" General Obligation Bonds.
- EDP Review of the Finance Division's Local Area Network (LAN).
- Review of Treasurer's Proposal to Replace Canceled Checks with a Bank Microfilm System.
- Compliance Review of Insurance Certificates Required for Construction Contracts and Consultant Agreements.
- Review of Security Contract Compliance.
- Review of the General Manager's Quarterly Reports to the Land Committee.

INTERNAL AUDIT

At June 30, 1990, the following significant financial a[illegible] of EDP and many smaller assignments, were in pro[illegible]

- Review of Water Rate Adjustments Credits
- Review of Metropolitan's Disaster Contingency Planning
- Survey and Review of Local Projects Programs
- Review of Selected Construction Contracts

In some instances, completion of these assignments was delayed due to other work priorities or other factors. All are expected to be completed during fiscal year 1990-91.

In addition to the preceding assignments, Audit Department personnel participated in many other short-term or recurring assignments. Recurring assignments include reviews of the Monthly Financial Reports, audits of submitted directors' and department heads' expense claims, audits of selected employees' expense claims, quarterly reviews of water inventory and deferred water rights computations, and quarterly reviews of Budget vs. Cost Reports.

During fiscal year 1989-90, audit personnel also reviewed drafts of Metropolitan's comprehensive Annual Financial Report for the fiscal year ended June 30, 1989; tested the accuracy of the 1989-90 tax levy documentation; reviewed Metropolitan's compliance with its June 30 and December 31, 1989, minimum fund requirements; reviewed quarterly lobbying reports which are required by the Fair Political Practices Act to be filed with the State; tested various work orders for propriety and compliance with Metropolitan's procedures, and reviewed security activities on a quarterly basis for matters having audit implications.

While the results of these recurring or short term as[illegible] generally satisfactory, written comments on such revi[illegible] recommendations, if appropriate, are often provided to [illegible] staff for their information and possible action.

Among the more significant of corporate-wide s[illegible] projects with which the department's EDP auditors we[illegible] fiscal 1989-90 include the Accounts Payable System [illegible] System, and the Water Accounting and Classification Fi[illegible] In addition, the EDP auditors are currently monitoring [illegible] development of the Investment Management System a[illegible] Expense System for the Finance Division. The EDP audit[illegible] a significant amount of time during the year working on [illegible] and security issues pertaining to the Wide Area Network in [illegible] the Finance Division LAN in particular.

As a result of turnover and almost continuous involvement by the EDP auditors in various systems development activities, specific computer application reviews were not performed to the level anticipated during the year. While internal audit involvement in the development and testing of new automated financial systems remains a top priority, the review of some of the key computer applications is also a priority objective next year.

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Santa Monica
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VOL 12

ASSESSMENT OF STORM DRAIN SOURCES OF CONTAMINANTS TO SANTA MONICA BAY

VOLUME I

Annual Pollutant Loadings to Santa Monica Bay from Storm Water Runoff

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May 1993

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VOL 12

ASSESSMENT OF STORM DRAIN SOURCES OF CONTAMINANTS TO SANTA MONICA BAY

VOLUME I

ANNUAL POLLUTANTS LOADINGS TO SANTA MONICA BAY FROM STORMWATER RUNOFF

by

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May 1993

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PREFACE AND ACKNOWLEDGMENTS

This report represents Volume I from a series of four volumes of reports which form the basis of a pollution assessment and monitoring plan for Santa Monica Bay. Volume I describes storm drainage system land use statistics, catchment areas, existing water quality monitoring data, rainfall data, NPDES permit information for existing permits to storm drains, and contaminant mass emission estimates, based upon land use modeling. Volume II reviews sampling techniques, including sampling equipment, and other aspects associated with sampling such as a quality assurance plan. Volume III presents the proposed monitoring plan. Volume IV addresses best management practices as they apply to the Santa Monica Bay area. The first draft of this volume was issued in February, 1992.

The contract was performed by UCLA and Woodward-Clyde Consultants (WCC). Professor Michael K. Stenstrom of the Civil and Environmental Engineering Department, UCLA and Eric Strecker from WCC's Portland office were the project managers. There were several key individuals from both UCLA and WCC who assisted with the project; they include Sim-Lin Lau and Kenneth Wong (UCLA) and Lou Armstrong, Gail Boyd, Carol Forrest, and Joan Kersnar (WCC).

The contractors are grateful for the assistance of many individuals. The Santa Monica Bay Project and LA Regional Water Quality Control Board staffs were most helpful. We extend our special thanks to Dr. Guang-yu Wang, Ms. Catherine Tyrrell, Dr. Rainer Hoeinke and Mr. Xavier Swamikannu. Several public agencies were very helpful in providing data and information to us. The Los Angeles County Department of Public Works and the Southern California Association of Governments (SCAG) provided catchment area and land use data, respectively. We are also indebted to the members of the Technical Advisory Committee of the Santa Monica Bay Project and others who reviewed and commented on our draft reports.

ABSTRACT

This report describes the collection of data and land use information to estimate pollutant loads to Santa Monica Bay from stormwater runoff. A pollutant load is calculated by multiplying the flow rate or discharge of water by a pollutant concentration. The type of land use influences the pollutant load by either increasing or decreasing the fraction of impervious surface area (the higher the impervious area, the larger the runoff). The quality of stormwater runoff may also vary by land use. Therefore, pollution loading from a particular watershed can be formulated as a function of the areas of each of the various land use types that form it. Given this, a simple pollutant load model can be developed such that the sum of the products of the runoff from each land use type times the concentrations associated with each land use type equals the total load. The generic equation is of the form:

$$\Sigma M_a X_a = Y$$

where:

- X_a is the estimated runoff generated from land use "a"
- M_a is the estimated concentration for land use "a"
- Y is the calculated total load
- Σ is the summation over all land uses

To estimate the pollutant loadings of stormwater runoff from the Santa Monica Bay catchments, a form of the above equation was used. The methodology is similar to the methodology developed under the EPA's Nationwide Urban Runoff Program (NURP, EPA 1983), and was adapted to a simple spreadsheet model. This model uses available local data for rainfall, land use, and drainage area characteristics. It differs from the NURP methodology in that it uses different land use specific runoff pollutant concentrations for different land use types, where NURP used the same pollutant concentrations for all land use types.

The following steps are used in computing the annual pollutant loadings and concentrations:

- Organize rainfall data into storm events. The storm events data are then analyzed to estimate average storm volume, storm intensity, storm duration, time between storms, and number of storms per year. Spatial variability in rainfall between catchments is accounted for by calculating a rainfall correction factor to scale the storm statistics to from a single rain gage to all the catchment. Data from small rainfall events not expected to produce runoff (less than 0.1 inches) are eliminated.

- Determine land use characteristics. The drainage basins are divided into a series of catchments and the land use acreage is tabulated for each catchment. This was accomplished by use of a GIS system, where land use areas were calculated within the delineated catchments. For each land use type, the percentage of impervious area is used to estimate the runoff coefficient, the ratio of runoff to rainfall.

- Determine average storm and annual runoff. Total volumes and flow rates for each catchment are estimated by combining rainfall statistics, rainfall correction factors, runoff coefficients, and drainage area.

- Determine the pollutant concentration associated with each land use. The data collected by NURP were compared to local data by comparing the frequency distributions for both data sets. It was found that the 90th percentile concentration data from NURP (i.e. concentrations that were 90% higher than the rest) were approximately equivalent to the median concentrations (50% higher than the rest) collected in the Santa Monica Bay area.

- Multiply the runoff volumes by concentration. Concentrations of water quality parameters typically found in urban runoff, obtained from the NURP database, are multiplied by the runoff volumes to yield average annual pollutant loads for each land use area in each catchment.

- Calculate total loads. Total loads for each catchment are calculated by summing the loads for each of the land uses. The average concentration for each catchment is then estimated by dividing the total load for the catchment by the total runoff from the catchment.

The above methodology indicates that significant pollutant loads are coming from residential areas. This does not mean that residential areas are necessarily more polluted than other areas, but instead that, given the large amount of residential area in the Santa Monica Bay area, it contributes the most runoff. It does however suggest that cleaning up the residential areas a small amount will have the same affect in reducing loads as cleaning up a dirty industrial area a lot.

This report (Volume I) provides the information basis for the development of Volume III (monitoring plan development) and Volume IV (best management practices) of this project.

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1.0
INTRODUCTION

Annual pollutant loadings are influenced by the spatial and temporal rainfall pattern, the total area of the drainage basin, and the distribution of different land use types in the drainage basin. The type of land use influences the total volume of runoff by either increasing or decreasing the fraction of impervious surface area (the higher the impervious area, the larger the runoff) and, as a result, the pollutant loads.

A number of studies have been conducted to investigate the concentration and loadings of a variety of pollutants in stormwater runoff. Urban runoff pollutant concentrations and loadings were studied in depth by the US Environmental Protection Agency's (US EPA) Nationwide Urban Runoff Program (NURP). WCC directed and completed a number of studies for the EPA under this program. The NURP program included the coordination of urban runoff pollutant studies at 65 urban sites across the United States, which included monitoring of over 2,000 storm events. In addition to the site-specific reports produced during this study, EPA published the Final Report of the Nationwide Urban Runoff Program (US EPA, 1983). The report summarized the findings of the research and presented a methodology for predicting pollutant loads from urban watersheds using a statistical approach. Other related studies conducted for US EPA include the analysis of detention basins for control of urban stormwater runoff quality (US EPA, 1986) and the development of a probabilistic, statistical methodology for predicting pollutant loadings and concentrations from stormwater runoff and their impacts on rivers and streams (US EPA, 1984). The oil and grease information used in this report is based heavily upon the work by Stenstrom et al. (1984) and Fam et al. (1987)

The Federal Highway Administration (FHWA) study analyzed the characteristics of pollutant loadings and concentrations found in highway runoff. This study involved the analysis of highway data collected from 31 highway sites throughout the United States and included approximately 1,000 storm events (Driscoll et al., 1990). As part of the study, a methodology for predicting pollutant loads and concentration from highways and street surfaces was developed (FHWA, 1987).

A small pollutant load study was presented in the State of the Bay report (SCAG, 1988). This study evaluated at loads from Ballona Creek, Malibu Creek, and the Pico-Kenter storm drain. The study calculated loads by using flow data and pollutant concentrations from 1983-84. The analysis is limited since only two years of flow data were used; furthermore, one year was very wet and the other year was dry. An addition limitation is the use of averaged dry and wet weather concentration data. This would tend to under predict the concentrations of the pollutants studied because wet weather concentrations tend to be higher than dry weather concentrations for most contaminants.

The goal of this study is to estimate the annual loads to Santa Monica Bay, in such a way that they can be used to easily identify catchments with the largest expected contribution of each pollutant. The catchments can be prioritized based on pollutant loadings and/or concentrations, and this information can be useful to others who might wish to prioritize the catchments on the basis of the receiving water's ability to assimilate the discharge. Monitoring sites and types and locations of best management practices (BMPs) can be targeted at those catchments having the highest levels of pollutant concentrations and loadings and the greatest potential for improvement. In addition to aiding in the

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To estimate the pollutant loadings of stormwater runoff from the Santa Monica Bay catchments, a modified version of the methodology developed under the US EPA's Nationwide Urban Runoff Program (US EPA, 1983) was adapted to a simple spreadsheet model. This model uses available local data for rainfall, land use, and drainage area characteristics. It differs from the NURP methodology in that it uses different land use specific runoff pollutant concentrations for different land use types, where NURP used the same pollutant concentrations for all land use types. The loadings for each of the catchments were calculated by multiplying the volume of runoff for each area with its associated land use concentrations. The loadings for each drainage basin were calculated by summing the results from contributing catchments.

2.1 RAINFALL STATISTICS

Average annual rainfall statistics were used to calculate the estimated pollutant loadings to the receiving waters for an "average" year. The amount of rainfall that the watershed receives annually, however, is quite variable from year to year. Hence, the pollutant loadings can vary appreciably from year to year.

In the Santa Monica Bay watershed, rainfall is measured at rain gage stations operated by the National Weather Service (NWS) and by local flood control and water supply districts including the Los Angeles County Department of Public Works (LACDPW). Table 1 lists those gages selected for detailed analyses in this study because of location, record completeness, and the availability of data in electronic format from the NWS. For each of these stations, the location (latitude and longitude), elevation, period of record, record completeness (in percent), and average annual rainfall are shown in the table. Figure 1 shows the location of gages in operation during 1988-89.

The rainfall record at the Los Angeles Airport (Station 5114) was analyzed to determine wet and dry seasons at Santa Monica Bay. The average monthly rainfall volumes and subtotals for each season are shown in Table 2, and the seasonal variation in rainfall is shown graphically in Figure 2. Based on average monthly rainfall volumes, the period from November through April is defined as the wet season and the remaining period is defined as the dry season for the study area. The wet season receives over 93 percent of the annual rainfall, as shown in Table 2. The analyses that follow focus on the wet season.

To illustrate the annual variation in rainfall, the wet season rainfall totals for selected gages are tabulated as shown in Table 3. The average wet season rainfall for the Los Angeles Airport gage is 10.72 inches with a standard deviation of 5.42 inches. Figure 3 shows the time series plot of the wet season rainfall for this gage. The horizontal lines in the figure represent the record average and one standard deviation above and below the average. Annual variations that have occurred at the other stations are similar.

To compute average runoff volumes at the site, data on rainfall duration, intensity, volume, and time between storms are required. Detailed analysis of the rainfall record of hourly data is performed using a statistical analysis program developed for the US EPA (US EPA,

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development of a stormwater quality management program, estimates of the annual pollutant load of the cumulative discharges to waters of the United States are required for Part 2 of the National Pollution Elimination System (NPDES) Stormwater Permit Application for municipalities. A description of the procedures used to estimate pollutant loads must also accompany the permit application.

This brief report summarizes the methodology and results of pollutant loading calculations for the Santa Monica Bay watershed. The general methodology, land use characteristics, water quality parameters, and intermediate results used to calculate the pollutant loadings are presented in the next section. Data collected by the various monitoring agencies were brought together and placed into a single ASCII data set. Summaries of the annual pollutant loading calculations by land use type and by drainage basins are given in the third section. The last section contains conclusions and recommendations based on these results.

Two appendices are provided. Appendix A summarizes the land use and annual pollutant loadings by catchment. Appendix B describes the collected data and a program provided to help sort the data for specific locations and parameters. A summary of the average dry and wet weather contaminant concentrations for 22 selected locations is also included in the Appendix B.

To estimate the pollutant loadings of stormwater runoff from the Santa Monica Bay catchments, a modified version of the methodology developed under the US EPA's Nationwide Urban Runoff Program (US EPA, 1983) was adapted to a simple spreadsheet model. This model uses available local data for rainfall, land use, and drainage area characteristics. It differs from the NURP methodology in that it uses different land use specific runoff pollutant concentrations for different land use types, where NURP used the same pollutant concentrations for all land use types. The loadings for each of the catchments were calculated by multiplying the volume of runoff for each area with its associated land use concentrations. The loadings for each drainage basin were calculated by summing the results from contributing catchments.

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Table 1. Rain Gages Near Santa Monica Bay Watershed

Station Name	NWS I.D. Number	LACDPW I.D. Number	Latitude	Longitude	Elevation (feet)	Period of Record	Percent Complete	Average Annual Rainfall (Inches)
Bel Air Hotel	619	10A	34°05'11"	118°26'45"	540	1948-84	91	16.7
Birmingham General Hospital	818	—	34°11'–"	118°30'–"	—	1948-77	92	13.93
Burbank Valley Pumping Plant	1194	749B	34°11'11"	118°20'54"	655	1948-89	96	14.7
Chatsworth Reservoir	1682	23B	34°13'44"	118°37'18"	900	1948-89	91	14.19
Lechuza Patrol Station	4867	352B	34°04'38"	118°52'47"	1620	1948-89	93	20.97
Long Beach Airport	5085	662D	33°49'–"	118°09'–"	34	1968-89	86	14.22
Los Angeles Airport	5114	734C	33°56'25"	118°23'44"	105	1948-89	98	12.03
Los Angeles Civic Center	5115	716	34°03'09"	118°14'13"	306	1948-89	95	14.55
Sepulveda Dam	8092	465C	34°10'06"	118°28'11"	683	1948-89	91	14.13
Signal Hill	8230	415	33°47'49"	118°10'03"	140	1948-89	92	10.94

Sources: National Weather Service (NWS) and Los Angeles County Department of Public Works (LACDPW) rain gage record summaries.

Table 2. Seasonal Rainfall for Los Angeles Airport.
(Station 5114)

Month	Rainfall (inches)	Percent of Annual Total
Wet Season		
November	1.62	13.7
December	1.62	13.6
January	2.73	23.0
February	2.33	19.7
March	1.91	16.1
April	0.87	7.3
Wet Season Total	11.08	93.3
Dry Season		
May	0.14	1.2
June	0.03	0.2
July	0.01	0.1
August	0.11	1.0
September	0.21	1.8
October	0.28	2.4
Dry Season Total	0.79	6.7
Annual Total	11.88	100.0

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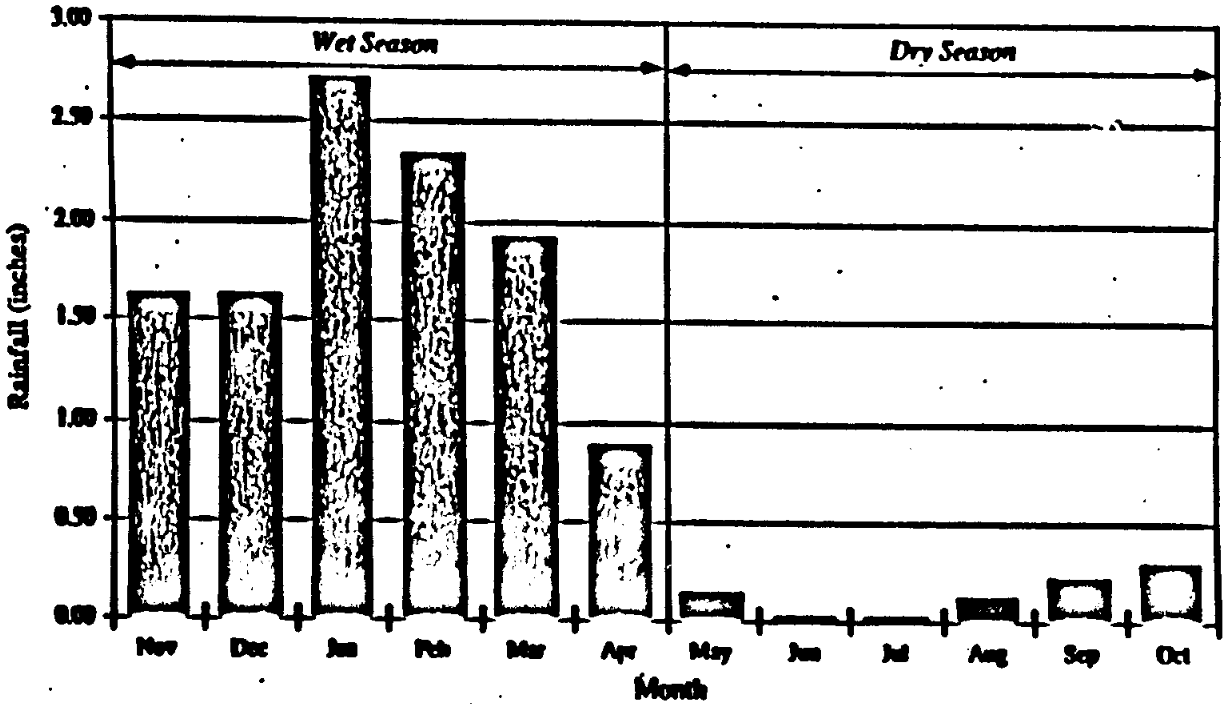


Figure 2. Average Monthly Rainfall at Los Angeles Airport.
(Station 5114)

(All values in inches)

Water Year	Station 4867	Station 0619	Station 5115	Station 5114
1949	12.32	9.14	7.12	7.04
1950	18.40	13.58	9.50	8.95
1951	10.74	8.38	6.97	8.91
1952	10.54	21.25	25.14	18.42
1953	—	—	8.81	8.04
1954	20.33	17.49	11.54	11.70
1955	13.99	13.33	10.34	9.07
1956	19.25	17.96	15.12	12.66
1957	12.95	12.28	8.41	8.31
1958	25.08	25.20	19.11	16.81
1959	7.76	9.14	4.95	4.95
1960	13.59	10.69	7.74	8.74
1961	7.76	6.44	4.54	4.17
1962	30.30	26.47	18.49	17.48
1963	12.64	8.85	7.75	8.63
1964	8.96	7.33	6.40	5.18
1965	12.67	13.06	12.97	9.57
1966	26.41	18.97	17.99	12.06
1967	17.23	22.84	21.38	12.85
1968	14.98	15.61	15.11	13.58
1969	37.73	24.38	26.26	15.45
1970	15.14	9.38	7.39	5.28
1971	17.93	4.15	12.04	9.43
1972	10.30	8.43	6.94	8.93
1973	25.70	22.85	20.39	15.25
1974	20.80	—	14.33	10.50
1975	11.90	5.80 (b)	12.93	10.36
1976	6.30	4.90	6.52	3.36
1977	8.90	7.90	6.04	6.22
1978	41.00	42.70	30.63	25.74
1979	23.10	14.90	18.91	13.98
1980	32.00	10.40	25.53	20.05
1981	13.70	—	8.66	8.30
1982	11.40	—	9.78	12.44
1983	43.20	—	29.33	24.03
1984	10.40	—	6.62	6.38
1985	8.90	—	11.39	8.28
1986	27.40	—	16.97	17.85
1987	7.70	—	4.58	4.05
1988	14.70	—	8.62	6.40
1989	11.60	—	7.76	6.57
1949-1989 Statistics				
Number of Years with Data	40	29	41	41
Minimum (inches)	6.30	4.15	4.54	3.36
Maximum (inches)	43.20	42.70	30.63	25.74
Average (inches)	17.22	14.76	12.95	10.72
Standard Deviation (inches)	9.45	8.38	7.16	5.42
Coefficient of Variation	0.55	0.57	0.55	0.51

(a) For storms with more than 0.10 inches and inter-event time of 6 hours during November through April.
(b) Value not used in statistics due to missing data.
"—" indicates no data.

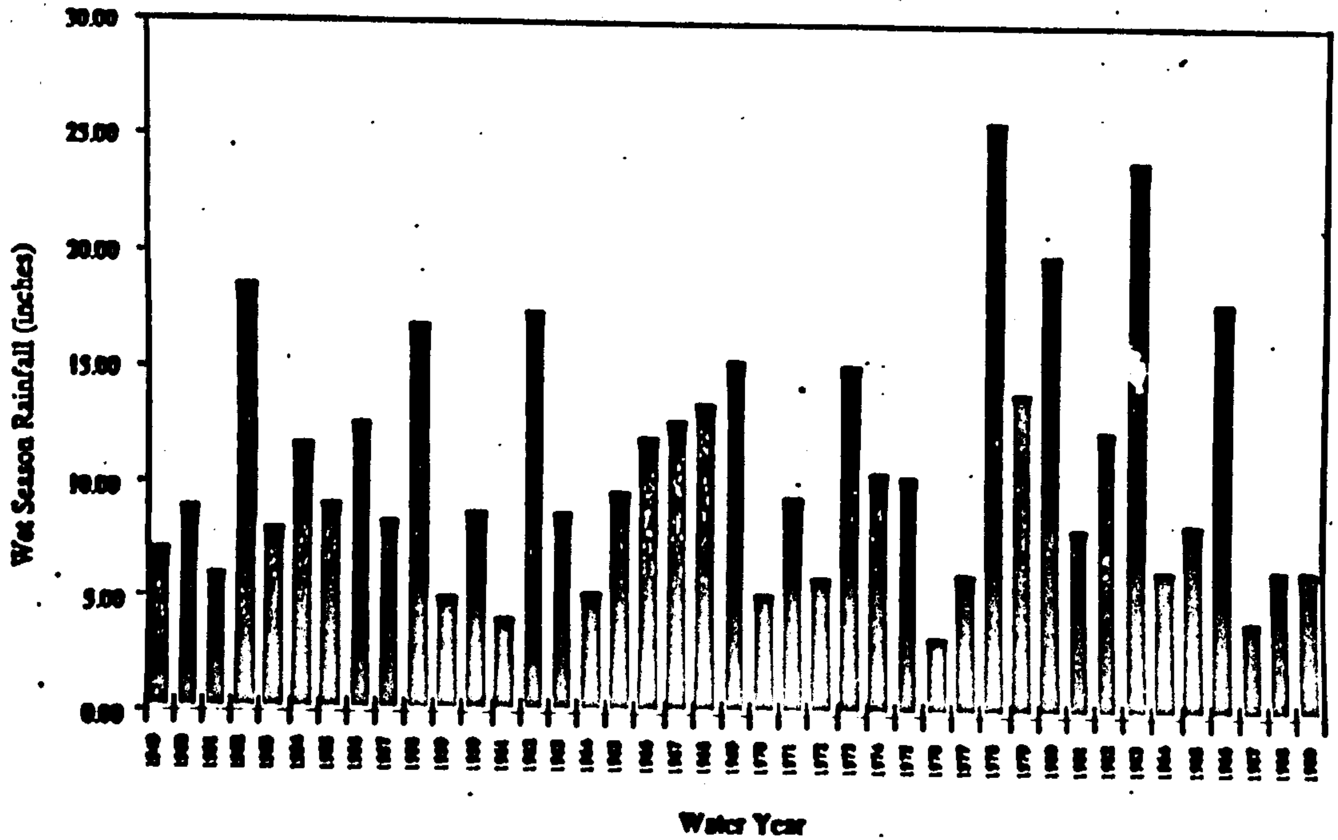


Figure 3. Wet Season Rainfall at Los Angeles Airport
(Station 5114)

1980) and updated by WCC for the US EPA and FHWA in 1989. The procedure used in the Synoptic Rainfall Analysis Program (called SYNOP) segregates the hourly rainfall record into discrete storm "events" by defining the number of consecutive dry hours that separate events (inter-event time). Then, for each "event," the total volume, duration, average intensity, and interval between storm event midpoints are computed. SYNOP performs a standard statistical analysis to compute the mean, standard deviation, and coefficient of variation for all of the event statistics.

Because only those rainfall events which produce runoff are of interest in this study, the minimum storm volume analyzed to produce average storm statistics is set at 0.10 inches. Therefore, all storm "events" with a volume of less than 0.10 inch are removed from the analyses based on evidence that these smaller events generally do not generate significant runoff volumes. A 6-hour inter-event time is also used to define the discrete storm "events". That is, hours of rainfall separated by 6 or more hours of dry weather are considered to be parts of separate events. These parameters have been used in other studies conducted by WCC in the Los Angeles area and in a national rainfall analysis prepared by WCC for US EPA (US EPA,1989). All computations are conducted for the wet season, a 6-month period ending on April 30 of the indicated year. The entire period of record is used for each of the gages, excluding partial years associated with the starting and ending dates of the records.

The results of the analyses for all storms in the period of record for the selected Santa Monica Bay rain gages are summarized in Table 4. The statistics shown in this table include storm volume, intensity, duration, and time between storm events (delta) averaged over all storms used in the analyses. The coefficients of variation for each of the summary statistics are also shown. For the Santa Monica Bay watershed, the average wet season storm volume varies from 0.67 to 1.09 inches with an average intensity of 0.061 to 0.101 inches per hour and duration of 10.5 to 14.2 hours. The time between storms varies from 198 to 258 hours (or 8 to 11 days) during the wet season. Approximately 16 storm events occur on average during each wet season.

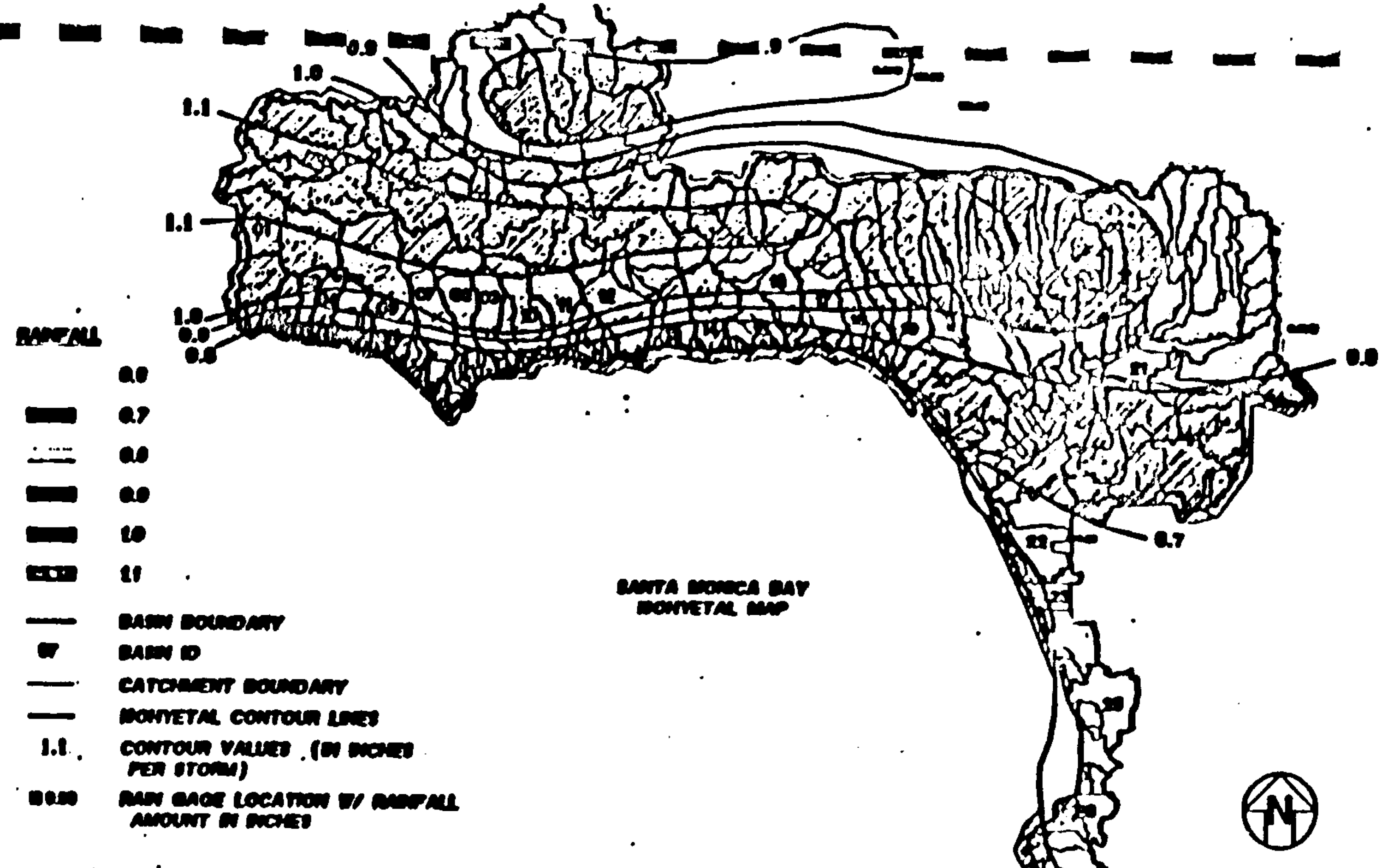
There is a strong spatial variation in rainfall due to topographic influence in the Los Angeles area, which leads to uneven rainfall amounts over basins in the Santa Monica Bay area. Isohyetal maps (maps with contour lines of equal rainfall amounts) provide a good tool for identifying these rainfall patterns. The LACDPW publishes isohyetal maps of annual rainfall totals in the study area in its annual hydrologic reports. The 1988-89 seasonal total isohyetal map is shown in Figure 4. An isohyetal map of the 50-year, 24-hour rainfall event is also available from LACDPW and is shown in Figure 5. Figure 6 shows an isohyetal map of average storm volumes developed from the storm event analyses and the patterns found in the above mentioned isohyetal maps.

To assign rainfall characteristics to each catchment delineated for the Santa Monica Bay watershed, the statistics for one gage, the Los Angeles Airport gage, are used as the point-of-reference for all locations. Rainfall correction factors are used to scale the rainfall volumes for each catchment to reflect spatial variations within the watershed. The rainfall correction factor is essentially a modeling tool that allows a single reference gage to be used as input data. For each catchment rainfall volumes are calculated as the reference gage volume multiplied by the correction factor spatial variability in rainfall that occurs between catchments throughout the Bay drainage area. The rainfall correction factors for average storm volumes are computed using the Los Angeles Airport gage average storm volume of 0.68 inches as the basis. These factors are combined with the isohyetal map shown in Figure 6 to assign rainfall correction factors to each catchment. The results are shown in Figure 7. Average storm duration and number of storms per season do not vary as greatly as storm volumes and were assumed constant for all catchments.

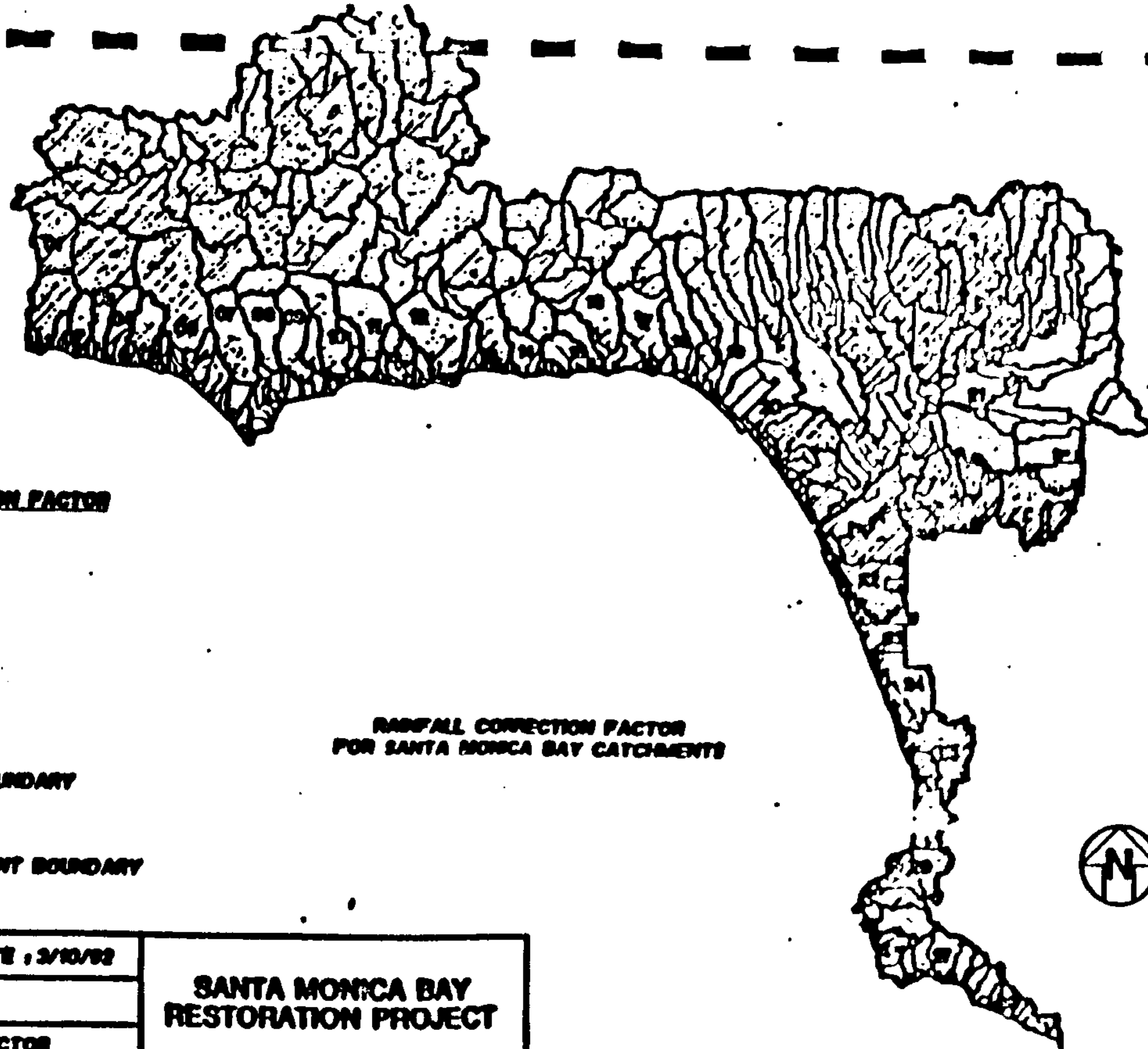
Table 4. Wet Season Storm Statistics (a)

STATION	PERIOD OF ANALYSIS (water years)	STORM VOLUME (inches/storm)		STORM INTENSITY (inches/hour)		STORM DURATION (hours/storm)		TIME BETWEEN STORMS (hours)	
		Average	Coef of Var	Average	Coef of Var	Average	Coef of Var	Average	Coef of Var
0619	1948-1980	1.06	1.22	0.084	0.66	12.5	0.85	209	1.32
0818	1948-1976	0.98	1.22	0.068	0.74	14.2	0.92	258	1.25
1194	1948-1989	0.88	1.31	0.067	0.69	13.0	0.89	231	1.20
1602	1948-1989	0.80	1.27	0.063	0.69	14.0	0.91	230	1.22
4067	1948-1989	1.09	1.17	0.101	0.73	11.3	0.87	198	1.35
5085	1977-1989	0.67	1.05	0.061	0.79	11.3	0.71	221	1.10
5114	1948-1989	0.68	1.16	0.062	0.72	12.0	0.83	221	1.23
5115	1948-1989	0.81	1.18	0.067	0.69	12.8	0.87	221	1.21
8092	1948-1989	0.96	1.26	0.069	0.74	13.5	0.89	238	1.23
8230	1948-1989	0.69	1.07	0.074	0.73	10.5	0.88	219	1.36
Minimum		0.67		0.061		10.5		198	
Maximum		1.09		0.101		14.2		258	
Average		0.87		0.072		12.5		225	

(a) For storms having more than 0.10 inches of precipitation with a 6-hour inter-event time during November through April.



JOB NO. 9151040F	DATE : 3/10/92	SANTA MONICA BAY RESTORATION PROJECT
FIGURE NO. 6		
ISOHYETAL MAP		



RAINFALL CORRECTION FACTOR
FOR SANTA MONICA BAY CATCHMENTS

RAINFALL CORRECTION FACTOR

	1.0
	1.2
	1.3
	1.5
	1.6

— BASIN BOUNDARY

07 BASIN ID

— CATCHMENT BOUNDARY

JOB NO. 9151040F	DATE : 3/10/92	SANTA MONICA BAY RESTORATION PROJECT
FIGURE NO. 7		
RAINFALL CORRECTION FACTOR		

2.2 LAND USE CHARACTERISTICS

Parameters used to compute the rainfall-runoff relationship and pollutant concentrations are based on land use categories. Land use data and acreage breakdown is available from the Southern California Association of Governments. The data were collected in 1987 by AIS under contract with Southern California Edison as part of a comprehensive coastal inventory. The land uses were photo interpreted then mapped. The complete data set covers approximately the area from Point Arguello to the United States/Mexico border and about 5 miles inland. The following categories are used:

- Single-family residential areas including duplexes and group quarters,
- Multi-family residential areas including mobile homes,
- Commercial areas including wholesale and retail trade and general services,
- Public lands including government offices and schools,
- Light industrial areas including manufacturing facilities,
- Other urban areas not included under the other categories,
- Open spaces including parks and undeveloped lands, and
- Unknown land use classification.

Drainage basins are defined as areas that drain to Santa Monica Bay and are made up of several smaller catchments. The land use acreage for each catchment are provided in Appendix A (Table A-1). Summaries for the drainage basins and the entire watershed are given in Tables 5 and 6. Open space represents the primary land use in the watershed (57 percent of the total watershed). Single-family residential areas represent the largest developed area (26 percent of the total watershed). Seven percent of the total watershed consists of multiple-family residential land use. Other urban land uses including commercial and light industrial uses constitute the remaining 10 percent of the total watershed area. As shown in Table 6, drainage basins 1 through 19 are more than 65 percent open, whereas drainage basins 18 through 28 are mostly urbanized (residential, commercial and/or industrial). Drainage basin 23 has the largest percentage of commercial/industrial land use (81 percent) and drainage basin 24 has the largest percentage of residential land use (85 percent).

The land use acreage for each catchment are used to determine the impervious area and runoff coefficient for each catchment. Impervious areas are those portions of a catchment where infiltration of rainfall cannot take place and surface runoff occurs. The overall average ratio of runoff to rainfall is the runoff coefficient which is used to convert rainfall data to estimates of runoff volume and runoff flow rate.

Prior studies (US EPA, 1983; FHWA,1987), which developed and analyzed rainfall-runoff characteristics using very large databases for both urban areas and highways, have indicated that the runoff volume and rate (and hence, the runoff coefficient) are strongly related to the fraction of impervious surface area within a predominantly urban watershed. The relationship used in this analysis to convert rainfall to subsequent runoff (the runoff coefficient) is based on the results from those studies. The equation expressing this relationship is (FHWA, 1987):

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Table 5. Land Use and Hydrology for Santa Monica Bay Drainage Basins.

DRAINAGE BASIN	LAND USE	LAND USE PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERVIOUS	RUNOFF COEFFICIENT Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVERAGE ANNUAL VOLUME (CU FT)	AVG ANN STORM RUNOFF (AF/YR)
Basin 01	Single-family	0	0	40	0.30		0.0	0	0	0
	Multi-family	0	0	60	0.50		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	100	2,302	0	0.10		67.4	2,462,800	43,913,000	985
	Unknown	0	1	65	0.54		0.0	0	0	0
	Basin Total	100	2,303	0	0.10		67.4	2,462,800	43,913,000	985
Basin 02	Single-family	3	45	40	0.30		3.4	84,000	864,000	20
	Multi-family	0	0	60	0.50		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	2	25	80	0.66		1.2	48,000	684,000	16
	Open	95	1,360	0	0.10		30.4	434,000	6,764,000	166
	Unknown	0	1	65	0.54		0.0	1,000	16,000	0
	Basin Total	100	1,428	3	0.12		33.1	522,000	8,311,000	182
Basin 03	Single-family	5	80	40	0.30		3.7	68,000	1,051,000	20
	Multi-family	0	0	60	0.50		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	1	0	80	0.66		0.4	26,000	348,000	0
	Open	94	1,080	0	0.10		6.3	351,000	5,326,000	122
	Unknown	0	0	65	0.54		0.0	0	0	0
	Basin Total	100	1,165	3	0.12		10.4	414,000	6,424,000	153
Basin 04	Single-family	4	45	40	0.30		3.3	33,000	683,000	30
	Multi-family	0	0	60	0.50		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	96	1,132	0	0.10		6.0	366,000	5,600,000	120
	Unknown	0	0	65	0.54		0.0	1,000	16,000	0
	Basin Total	100	1,176	3	0.11		10.3	400,000	6,136,000	140
Basin 05	Single-family	7	200	40	0.30		3.0	201,000	2,416,000	35
	Multi-family	0	0	60	0.50		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	93	1,582	0	0.10		34.3	591,000	9,420,000	237
	Unknown	0	0	65	0.54		0.0	0	0	0
	Basin Total	100	2,014	3	0.12		38.6	792,000	11,872,000	272
Basin 06	Single-family	10	600	40	0.30		10.7	784,000	22,576,000	280
	Multi-family	0	0	60	0.50		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	1	80	80	0.66		4.6	302,000	2,912,000	67
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	89	6,000	0	0.10		24.3	2,160,000	24,000,000	784
	Unknown	0	14	65	0.54		0.4	22,000	352,000	8
	Basin Total	100	6,842	5	0.14		39.3	3,111,000	50,444,000	1,138

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Table 3. *Land Uses and Hydrology for Santa Monica Bay Drainage Basins (cont'd).*

DRAINAGE BASIN	LAND USE	LAND USE PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERVIOUS	RUNOFF COEFFICIENT Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVERAGE ANNUAL VOLUME (CU FT)	AVG ANN STORM RUNOFF (AF/YR)
Basin 07	Single-family	8	477	42	0.39		64.4	972,000	9,153,000	210
	Multi-family	0	0	68	0.58		0.0	0	0	0
	Commercial	1	44	92	0.74		3.1	[illegible]	[illegible]	45
	Public	2	124	80	0.66		8.1	204,000	2,104,000	119
	Light Industrial	0	0	91	0.74		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	89	5,437	0	0.10		90.8	2,025,000	33,400,000	[illegible]
	Unknown	0	11	65	0.56		0.1	29,000	464,000	11
	Basin Total	100	6,101	6	0.14		77.2	3,073,000	49,146,000	1,129
Basin 08	Single-family	30	703	42	0.39		32.2	883,000	14,128,000	324
	Multi-family	0	13	68	0.58		0.6	22,000	262,000	8
	Commercial	0	6	92	0.74		0.3	14,000	224,000	5
	Public	0	7	80	0.66		0.4	16,000	240,000	6
	Light Industrial	0	0	91	0.74		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	77	2,596	0	0.10		20.3	818,000	13,088,000	300
	Unknown	0	1	65	0.56		0.1	2,000	37,000	1
	Basin Total	100	3,367	10	0.17		43.8	1,746,000	27,936,000	642
Basin 09	Single-family	9	190	42	0.39		5.6	223,000	3,568,000	82
	Multi-family	0	0	68	0.58		0.0	0	0	0
	Commercial	0	0	92	0.74		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.74		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	91	2,039	0	0.10		16.3	649,000	10,384,000	238
	Unknown	0	1	65	0.56		0.0	2,000	37,000	1
	Basin Total	100	2,229	4	0.12		22.0	874,000	13,984,000	321
Basin 10	Single-family	3	102	42	0.39		2.1	124,000	1,984,000	46
	Multi-family	0	0	68	0.58		0.0	0	0	0
	Commercial	0	0	92	0.74		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.74		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	97	2,664	0	0.10		32.2	1,280,000	20,480,000	470
	Unknown	0	3	65	0.56		0.1	5,000	80,000	2
	Basin Total	100	2,770	5	0.11		36.4	1,409,000	22,544,000	518
Basin 11	Single-family	6	289	42	0.39		7.3	289,000	4,624,000	106
	Multi-family	0	2	68	0.58		0.1	3,000	48,000	1
	Commercial	1	24	92	0.74		1.3	53,000	848,000	19
	Public	5	286	80	0.66		10.4	414,000	6,624,000	152
	Light Industrial	0	0	91	0.74		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	89	3,816	0	0.10		32.6	1,299,000	20,784,000	477
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	4,288	7	0.13		51.6	2,064,000	33,024,000	755
Basin 12	Single-family	8	5,694	42	0.39		189.6	7,629,000	122,264,000	2,776
	Multi-family	1	283	68	0.58		18.0	716,000	11,456,000	263
	Commercial	1	420	92	0.74		27.6	1,098,000	17,568,000	403
	Public	0	245	80	0.66		19.7	782,000	12,672,000	291
	Light Industrial	1	404	91	0.74		27.8	1,106,000	17,696,000	406
	Other Urban	2	1,304	80	0.66		69.3	2,760,000	44,288,000	1,017
	Open	88	64,571	0	0.10		566.1	22,630,000	361,920,000	8,309
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	73,202	7	0.15		927.4	36,529,000	590,844,000	13,565

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Table 5. Land Uses and Hydrology for Santa Monica Bay Drainage Basins (cont'd).

DRAINAGE BASIN	LAND USE	LAND USE PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERVIOUS	RUNOFF COEFFICIENT R_v	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVERAGE ANNUAL VOLUME (CU FT)	AVG ANN STORM RUNOFF (AFYR)
Basin 13	Single-family	16	353	42	0.39		18.5	436,000	6,686,000	153
	Multi-family	0	0	68	0.58		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	84	1,893	0	0.10		54.9	593,000	9,458,000	218
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	2,246	7	0.13		73.4	1,009,000	16,144,000	371
Basin 14	Single-family	15	488	42	0.39		14.7	286,000	3,574,000	213
	Multi-family	0	0	68	0.58		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	1	26	80	0.66		1.2	48,000	768,000	18
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	84	2,649	0	0.10		35.1	921,000	14,724,000	338
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	3,157	7	0.13		50.0	1,333,000	24,000,000	371
Basin 15	Single-family	3	67	42	0.39		3.0	70,000	1,204,000	30
	Multi-family	0	0	68	0.58		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	97	1,887	0	0.10		48.3	641,000	9,776,000	224
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	2,054	1	0.11		51.3	690,000	11,040,000	253
Basin 16	Single-family	12	1,487	42	0.39		56.0	2,153,000	34,422,000	790
	Multi-family	0	0	68	0.58		0.0	0	0	0
	Commercial	0	0	92	0.76		0.0	0	0	0
	Public	0	0	80	0.66		0.0	0	0	0
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	88	11,169	0	0.10		108.0	4,300,000	68,848,000	1,581
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	12,606	5	0.13		162.1	6,453,000	103,200,000	2,371
Basin 17	Single-family	13	603	42	0.39		30.3	817,000	13,072,000	300
	Multi-family	1	43	68	0.58		3.0	119,000	1,904,000	44
	Commercial	0	16	92	0.76		0.9	26,000	368,000	13
	Public	1	32	80	0.66		2.7	106,000	1,696,000	39
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	3	140	80	0.66		9.0	317,000	5,072,000	116
	Open	81	4,017	0	0.10		26.3	1,666,000	23,124,000	301
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	4,899	16	0.17		71.3	2,940,000	46,448,000	1,063
Basin 18	Single-family	28	582	42	0.39		28.6	1,140,000	18,240,000	419
	Multi-family	0	0	68	0.58		0.0	0	0	0
	Commercial	0	4	92	0.76		0.3	11,000	176,000	4
	Public	1	30	80	0.66		2.0	74,000	1,184,000	27
	Light Industrial	0	0	91	0.76		0.0	0	0	0
	Other Urban	1	26	80	0.66		1.4	84,000	864,000	26
	Open	68	1,836	0	0.10		34.7	587,000	9,392,000	216
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	2,523	16	0.21		46.3	1,896,000	30,336,000	696

Table 5. Land Uses and Hydrology for Santa Monica Bay Drainage Basins (cont'd).

DRAINAGE BASIN	LAND USE	LAND USE PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERVIOUS	RUNOFF COEFFICIENT Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVERAGE ANNUAL VOLUME (CU FT)	AVG ANN. STORM RUNOFF (AF/YR)
Basin 19	Single-family	24	2,316	42	0.30		70.3	3,257,000	58,312,000	1,360
	Multi-family	0	26	60	0.50		1.5	60,000	960,000	22
	Commercial	1	63	92	0.74		3.5	138,000	2,205,000	51
	Public	0	22	80	0.66		1.6	63,000	1,008,000	23
	Light Industrial	0	0	91	0.74		0.0	0	0	0
	Other Urban	0	32	80	0.66		2.5	112,000	1,792,000	41
	Open	74	7,227	0	0.10		72.5	2,880,000	46,208,000	1,061
	Unknown	0	0	65	0.54		0.0	0	0	0
	Basin Total	100	10,333	11	0.18		161.3	6,413,000	102,608,000	2,356
Basin 20	Single-family	48	4,282	42	0.30		111.8	4,770,000	76,304,000	1,752
	Multi-family	21	1,800	60	0.50		76.3	3,026,000	48,576,000	1,115
	Commercial	6	540	92	0.74		39.2	1,163,000	18,602,000	427
	Public	3	234	80	0.66		10.5	411,000	6,608,000	154
	Light Industrial	0	26	91	0.74		1.2	46,000	724,000	17
	Other Urban	2	215	80	0.66		9.1	362,000	5,792,000	133
	Open	19	1,731	0	0.10		13.6	542,000	8,672,000	199
	Unknown	0	1	65	0.54		0.0	2,000	32,000	1
	Basin Total	100	8,831	44	0.41		261.3	10,284,000	164,608,000	3,779
Basin 21 first-half	Single-family	48	32,573	42	0.30		951.9	37,894,000	606,304,000	13,919
	Multi-family	19	12,806	60	0.50		560.4	22,225,000	355,600,000	8,163
	Commercial	9	5,804	92	0.74		323.6	12,881,000	206,096,000	4,731
	Public	3	2,002	80	0.66		95.3	3,804,000	60,864,000	1,397
	Light Industrial	4	2,906	91	0.74		159.3	6,347,000	101,552,000	2,331
	Other Urban	4	2,692	80	0.66		110.6	4,400,000	70,400,000	1,616
	Open	14	9,196	0	0.10		74.6	2,967,000	47,472,000	1,090
	Unknown	1	756	65	0.56		14.0	557,000	8,912,000	205
	Basin Total	100	68,185	50	0.43		2,306.0	91,875,000	1,457,200,000	33,452
Basin 21	Single-family	46	38,849	42	0.30		1,130.3	44,602,000	713,632,000	16,383
	Multi-family	18	14,976	60	0.50		659.4	26,231,000	420,896,000	9,643
	Commercial	8	6,644	92	0.74		373.8	14,851,000	237,616,000	5,455
	Public	4	3,040	80	0.66		149.9	5,966,000	95,464,000	2,191
	Light Industrial	4	3,571	91	0.74		181.5	7,222,000	115,552,000	2,653
	Other Urban	4	2,939	80	0.66		134.3	5,381,000	86,096,000	1,976
	Open	17	13,874	0	0.10		115.6	4,602,000	73,632,000	1,690
	Unknown	0	756	65	0.56		14.0	557,000	8,912,000	205
	Basin Total	100	83,387	46	0.44		2,769.2	109,424,000	1,750,964,000	40,196
Basin 22	Single-family	34	1,582	42	0.30		38.3	1,530,000	24,500,000	560
	Multi-family	3	130	60	0.50		4.8	190,000	3,040,000	70
	Commercial	3	136	92	0.74		6.2	247,000	3,952,000	91
	Public	4	179	80	0.66		7.3	292,000	4,672,000	107
	Light Industrial	1	26	91	0.74		1.2	48,000	768,000	18
	Other Urban	42	2,120	80	0.66		87.3	3,476,000	55,616,000	1,277
	Open	17	847	0	0.10		5.3	210,000	3,360,000	77
	Unknown	0	1	65	0.56		0.0	0	0	0
	Basin Total	100	5,006	50	0.48		150.3	5,986,000	95,776,000	2,199
Basin 23	Single-family	11	182	42	0.30		4.4	172,000	2,000,000	60
	Multi-family	1	22	60	0.50		0.8	34,000	406,000	11
	Commercial	2	36	92	0.74		1.6	65,000	1,040,000	36
	Public	1	10	80	0.66		0.4	16,000	256,000	6
	Light Industrial	9	153	91	0.74		5.2	207,000	3,312,000	76
	Other Urban	72	1,170	80	0.66		48.2	1,916,000	30,704,000	705
	Open	6	100	0	0.10		0.6	26,000	416,000	10
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	1,644	73	0.60		61.3	2,441,000	38,824,000	897

Table 5. Land Uses and Hydrology for Santa Monica Bay Drainage Basins (cont'd).

DRAINAGE BASIN	LAND USE	LAND USE PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERVIOUS	RUNOFF COEFFICIENT R.	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVERAGE ANNUAL VOLUME (CU FT)	AVG ANN. STORM RUNOFF (AF/YR)
Basin 24	Single-family	79	2,164	42	0.39		52.3	2,884,000	33,344,000	765
	Multi-family	3	149	60	0.58		5.4	314,000	3,424,000	79
	Commercial	6	161	92	0.74		7.4	394,000	4,704,000	108
	Public	6	163	80	0.66		6.3	309,000	4,304,000	99
	Light Industrial	0	0	91	0.74		0.0	1,000	16,000	0
	Other Urban	0	11	80	0.66		0.4	[illegible]	[illegible]	7
	Open	3	76	0	0.10		0.3	[illegible]	240,000	6
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	2,727	46	0.43		72.8	3,895,000	46,330,000	1,064
Basin 25	Single-family	67	2,900	42	0.39		78.3	2,794,000	44,704,000	1,026
	Multi-family	11	491	60	0.58		17.7	703,000	11,240,000	258
	Commercial	5	216	92	0.74		9.9	394,000	6,304,000	145
	Public	9	380	80	0.66		15.9	632,000	10,112,000	232
	Light Industrial	0	14	91	0.74		0.6	26,000	416,000	10
	Other Urban	5	196	80	0.66		8.0	319,000	5,104,000	117
	Open	3	119	0	0.10		0.7	30,000	480,000	11
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	4,327	51	0.46		131.0	4,898,000	78,364,000	1,799
Basin 26	Single-family	72	3,303	42	0.39		80.9	3,417,000	54,672,000	1,255
	Multi-family	4	319	60	0.58		7.9	313,000	5,008,000	115
	Commercial	1	62	92	0.74		2.9	114,000	1,824,000	42
	Public	3	144	80	0.66		5.9	233,000	3,728,000	86
	Light Industrial	0	16	91	0.74		0.7	28,000	404,000	11
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	19	933	0	0.10		5.8	230,000	3,680,000	84
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	4,827	37	0.36		109.1	4,336,000	69,376,000	1,593
Basin 27	Single-family	40	1,512	42	0.39		38.5	1,458,000	23,328,000	536
	Multi-family	3	72	60	0.58		2.6	104,000	1,664,000	38
	Commercial	2	65	92	0.74		3.0	120,000	1,920,000	44
	Public	3	73	80	0.66		3.0	118,000	1,888,000	43
	Light Industrial	1	22	91	0.74		1.0	40,000	640,000	15
	Other Urban	0	0	80	0.66		0.0	0	0	0
	Open	54	2,016	0	0.10		12.0	498,000	7,968,000	183
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	3,760	22	0.25		58.7	2,333,000	37,360,000	857
Basin 28	Single-family	47	1,080	42	0.39		26.4	1,052,000	16,832,000	386
	Multi-family	3	41	65	0.58		1.5	58,000	928,000	21
	Commercial	1	14	92	0.74		0.6	25,000	400,000	9
	Public	2	54	80	0.66		2.3	90,000	1,440,000	33
	Light Industrial	0	0	91	0.74		0.0	0	0	0
	Other Urban	5	107	80	0.66		4.4	175,000	2,800,000	64
	Open	46	1,055	0	0.10		6.4	264,000	4,224,000	98
	Unknown	0	0	65	0.56		0.0	0	0	0
	Basin Total	100	2,344	27	0.30		41.6	1,664,000	26,464,000	608
Watershed Total	Single-family	26	78,198	42	0.39		2,040	81,201,000	1,299,216,000	29,826
	Multi-family	7	20,496	65	0.58		799	31,822,000	509,152,000	11,689
	Commercial	2	6,401	92	0.74		471	18,745,000	299,920,000	6,885
	Public	3	8,380	80	0.66		252	10,052,000	160,832,000	3,692
	Light Industrial	2	4,800	91	0.74		219	8,725,000	139,600,000	3,205
	Other Urban	3	8,710	80	0.66		376	14,979,000	239,344,000	5,495
	Open	57	168,240	0	0.10		1,331	52,983,000	847,760,000	19,462
	Unknown	0	977	65	0.56		16	621,000	9,936,000	228
	Watershed Total	100	295,228	24	0.27		5,504	219,110,000	3,505,760,000	80,482

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Table 6. Land Use Breakdown by Drainage Basin.

DRAINAGE BASIN	RESIDENTIAL acreage	RESIDENTIAL percentage	COMMERCIAL/INDUSTRIAL acreage	COMMERCIAL/INDUSTRIAL percentage	OPEN/UNDEVELOPED acreage	OPEN/UNDEVELOPED percentage	percentage
01	0	0%	1	0%	7,202	5%	100%
02	46	3%	22	2%	1,360	1%	95%
03	58	5%	8	1%	1,043	1%	94%
04	46	4%	0	0%	1,132	1%	96%
05	132	7%	0	0%	1,882	1%	93%
06	669	10%	96	1%	6,098	4%	89%
07	477	8%	187	3%	5,437	4%	89%
08	776	23%	15	0%	2,596	2%	77%
09	190	9%	1	0%	2,039	1%	91%
10	102	3%	3	0%	3,664	2%	97%
11	241	6%	230	5%	3,816	3%	89%
12	6,046	9%	2,375	3%	61,871	41%	88%
13	353	16%	0	0%	1,893	1%	84%
14	488	15%	20	1%	2,649	2%	84%
15	67	3%	0	0%	1,987	1%	97%
16	1,457	12%	0	0%	11,149	7%	88%
17	726	15%	216	4%	4,017	3%	81%
18	922	33%	65	2%	1,836	1%	65%
19	2,551	24%	147	1%	7,837	5%	74%
20	6,190	69%	1,016	11%	1,731	1%	19%
21	53,044	64%	16,368	20%	13,874	9%	17%
22	1,715	34%	2,474	49%	847	1%	17%
23	204	12%	1,337	81%	103	0%	6%
24	2,313	85%	338	12%	76	0%	3%
25	3,393	78%	814	19%	119	0%	3%
26	3,772	77%	222	5%	933	1%	19%
27	1,584	42%	160	4%	2,016	1%	54%
28	1,134	48%	176	7%	1,035	1%	44%
Total	88,694	33%	26,291	10%	150,243	100%	57%

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$$RV = 0.007\,IMP + 0.1$$

where: RV = runoff coefficient
IMP = impervious area (expressed as a percentage).

In this study, the percentage of impervious surface area for a given land use category is taken or estimated from the Santa Monica Bay Drainage Basin - Drainage Area Characteristics (Los Angeles County Department of Public Works). For land use types not reported, an average of similar categories was taken. The Public and Other Urban categories were an average of the Multi-family and Commercial impervious surface values. The Unknown category was an average of the Single Family, Multi-family, Light Industry, Open and Commercial impervious surface values.

Table 7 lists the percentage of impervious surface area and runoff coefficient for each of the land use categories used in the Santa Monica Bay watershed. These values range from 0% impervious (runoff coefficient of 0.10) for open spaces and 92 percent impervious (runoff coefficient of 0.74) for commercial land uses. An average impervious area of 65 percent is used for areas with unknown land uses.

2.3 RUNOFF VOLUME

Storm runoff volumes and flow rates are calculated from the rainfall statistics and land use characteristics presented above. The Santa Monica Bay watershed is broken into 28 drainage basins, all of which drain directly to Santa Monica Bay. Each drainage basin is then made up of several smaller catchments. The computations are made for each catchment in the watershed and summed to produce the runoff data for each drainage basin and the entire watershed. The catchment data are included in Appendix A (Table A-1) and are summarized in Table 8. Average storm runoff was calculated by multiplying the average storm rainfall by the appropriate runoff coefficients. The annual average storm runoff was then calculated by multiplying the average storm runoff by the average number of storms per year. The amount of runoff from a drainage basin is primarily influenced by the size of the drainage basin. Drainage basins 12 and 21 represent 58 percent of the total watershed area and contribute an estimated 62 percent of the average annual runoff to Santa Monica Bay.

The computed runoff volumes can be compared to stream flow data to determine the validity of the method and parameters. Stream flow data are available for three gages located in the Santa Monica Bay watershed along Ballona, Topanga and Malibu Creeks. Information on the location, drainage area, period of record, and average annual stream flow is given in Table 9. The monthly average stream flow at each gage are summarized in Table 10. As shown in the table, the wet season total represents the majority of stream flow at each gage.

Table 11 shows a comparison of the wet season total stream flow at each gage and the computed storm runoff volume for the corresponding drainage basin. Because the stream gages are located within each drainage basin and measure a smaller drainage area than that used in the computations, the computed storm runoff volumes are adjusted in proportion to the drainage areas. As seen by the percent difference between the adjusted storm runoff and the recorded average wet season stream flow, the computed storm runoff volume for Topanga Creek is 48 percent less than the recorded stream flow.

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Table 7. Land Use Characteristics.

LAND USE CATEGORY	PERCENT IMPERVIOUS (a)	RUNOFF COEFFICIENT (b)
Single-family	42	0.39
Multi-family	68	0.58
Commercial	92	0.74
Public	80	0.66
Light Industrial	91	0.74
Other Urban	80	0.66
Open	0	0.10
Unknown	65	0.56

(a) Based on Los Angeles County Department of Public Works. NPDES Permit No. CA0061654, Attachment 1, Santa Monica Bay Drainage Basin, Drainage Area Characterization.

(b) Estimates based on percent imperviousness and runoff coefficient relationship given in FHWA (1990).

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Table 8. Land Uses and Hydrology for Santa Monica Bay Watershed.

DRAINAGE BASIN	PERCENT OF TOTAL ACREAGE	TOTAL BASIN ACREAGE	PERCENT IMPERVIOUS	RUNOFF COEFFICIENT Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVERAGE ANNUAL VOLUME (CU FT)	AVG. ANN. STORM RUNOFF (AF/YR)
01	2.7	7,203	0	0.10	0.80	67	2,682,000	42,912,000	985
02	0.5	1,428	3	0.12	0.80	13	522,000	8,352,000	192
03	0.4	1,108	3	0.12	0.80	10	414,000	6,624,000	153
04	0.4	1,178	2	0.11	0.80	10	408,000	6,528,000	149
05	0.8	2,014	3	0.12	0.80	19	742,000	11,872,000	272
06	2.6	6,862	5	0.14	0.80	79	3,153,000	50,448,000	1,158
07	2.3	6,101	6	0.14	0.80	77	3,073,000	49,168,000	1,129
08	1.3	3,387	10	0.17	0.80	44	1,746,000	27,936,000	642
09	0.8	2,229	4	0.12	0.06	22	874,000	13,984,000	321
10	1.4	3,770	1	0.11	0.80	35	1,409,000	22,544,000	518
11	1.6	4,288	7	0.15	0.80	52	2,058,000	32,928,000	755
12	26.5	70,292	7	0.15	0.80	927	36,929,000	590,864,000	13,565
13	0.8	2,246	7	0.15	0.80	25	1,009,000	16,144,000	371
14	1.2	3,157	7	0.15	0.80	39	1,555,000	24,880,000	571
15	0.8	2,054	1	0.11	0.80	17	690,000	11,040,000	253
16	4.8	12,606	5	0.13	0.80	162	6,455,000	103,280,000	2,371
17	1.9	4,959	10	0.17	0.80	71	2,840,000	45,440,000	1,043
18	1.1	2,823	16	0.21	0.80	47	1,866,000	29,856,000	686
19	4.0	10,535	11	0.18	0.80	161	6,418,000	102,688,000	2,358
20	3.4	8,937	44	0.41	0.80	258	10,288,000	164,608,000	3,779
21	31.4	83,287	48	0.44	0.80	2,749	109,434,000	1,750,944,000	40,196
22	1.9	5,036	55	0.48	0.80	150	5,986,000	95,776,000	2,199
23	0.6	1,644	72	0.60	0.80	61	2,441,000	39,056,000	897
24	1.0	2,727	48	0.43	0.80	73	2,895,000	46,320,000	1,064
25	1.6	4,327	52	0.46	0.80	123	4,898,000	78,368,000	1,799
26	1.9	4,927	37	0.36	0.80	109	4,336,000	69,376,000	1,593
27	1.4	3,760	22	0.25	0.80	59	2,335,000	37,360,000	857
28	0.9	2,344	27	0.29	0.80	42	1,654,000	26,464,000	606
Total	100.0	263,228	24	0.27	0.80	5,504	219,110,000	3,505,760,000	80,482

Table 9. Streamflow Gages in Santa Monica Bay Watershed.

Station Name	Station I.D. Number	Latitude	Longitude	Drainage Area (square miles)	Period of Record	Average Annual Streamflow (acre-feet)
Ballona Creek near Culver City	11103500	33°59'54"	118°24'05"	89.5	1928-78	30,060
Malibu Creek at Crater Camp near Calabasas	11105500	34°04'40"	118°42'03"	105.0	1931-79	16,870
Topanga Creek near Topanga Beach	11104000	34°03'52"	118°35'10"	18.0	1930-79	4,320

Source: U.S. Geological Survey stream gage record summaries.

Table 10. Seasonal Streamflow

MONTH	STREAMFLOW (ACRE-FEET) Ballona Creek	Malibu Creek	Topanga Creek
Wet Season			
November	2,990	560	130
December	4,430	1,210	340
January	5,980	4,610	1,160
February	6,190	4,220	1,280
March	4,300	4,220	1,020
April	2,000	1,230	270
Wet Season Total	25,890	16,050	4,200
Dry Season			
May	770	340	60
June	540	170	20
July	590	90	10
August	650	70	10
September	790	80	10
October	830	70	10
Dry Season Total	4,170	820	120
Annual Total	30,060	16,870	4,320

Table 11. Streamflow and Storm Runoff Comparison.

	Ballona Creek (Basin 21)	Malibu Creek (Basin 12)	Topanga Creek (Basin 16)
STREAM GAGE DATA			
Drainage area (square miles)	89.5	105	18
'et season streamflow (acre-feet)	25,890	16,050	4,200
COMPUTED STORM RUNOFF			
Total basin area (square miles)	130.1	109.8	19.7
Wet season storm runoff computed for total basin (acre-feet)	40,200	13,560	2,370
Wet season storm runoff adjusted for gage drainage area (acre-feet)	27,650	12,970	2,170
COMPARISON			
Difference between adjusted storm runoff and recorded streamflow (acre-feet)	1,760	-3,080	-2,030
Percent difference between adjusted storm runoff and recorded streamflow	7%	-19%	-48%

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The computed storm runoff volumes for Malibu Creek are 19 percent less than the recorded average wet season stream flow. Part of this error may be due to the fact that the model is only calculating runoff and does not consider base flow (base flow is any flow that is not derived from rainfall, such as flow from point sources).

The Ballona Creek computed storm runoff volumes are 7 percent higher than the recorded stream flow. A possible source of error in this comparison is that the stream gage data encompasses a drainage area of 89.5 square miles while the storm runoff is computed for a 130.1 square mile drainage area then adjusted for comparison. The drainage area in the model is slightly larger because it includes catchments which are downstream of the gaging station. Other errors in the runoff calculations are probably due to the simplicity of the model and the use of lumped parameters. These results indicate that the runoff coefficients and rainfall parameters reasonably represent actual conditions.

2.4 WATER QUALITY PARAMETERS

Key water quality parameters that are of concern to urban nonpoint source runoff and required for Part 2 of the NPDES Stormwater Permit Application are included in this study. The water quality parameters that are included in this study consist of total suspended solids (TSS); 5-day biochemical oxygen demand and chemical oxygen demand (BOD_5 and COD); nutrients (total Kjeldahl nitrogen (TKN) and nitrite-nitrate nitrogen (NO_2+NO_3) and total and soluble phosphorus); total metals (copper, zinc, and lead), and oil and grease.

The following is a brief description of the pollutants used in the model:

- **Total Suspended Solids (TSS).** The term "suspended solids" is descriptive of the organic and inorganic particulate matter which is of a size and type that allows the particles to stay suspended in water. The sediment load in a water body is influenced by a number of factors including but not limited to: particle size, stream flow, climate, geology, and vegetation of each drainage system. The conditions under which suspended sediments are considered a pollutant is a matter of definition. In general, suspended solids are considered a pollutant when they significantly exceed natural concentrations and have a detrimental effect on water quality and/or beneficial uses of the water body. Suspended sediments are often used as a surrogate for other contaminants which bind easily with fine particulate matter, including heavy metals. Open areas are assigned the highest concentrations for TSS in the model.

- **Oxygen Demand.** Oxygen demand refers to the amount of oxygen that will be consumed by biological or chemical reactions involving organic compounds. In general, moderately high dissolved oxygen content is necessary for the maintenance of healthy aquatic ecosystems. The relationship of oxygen-consuming discharges to the amount of dissolved oxygen in a receiving water body, therefore, is fundamental to the maintenance of environmental quality in natural water bodies. The oxygen demand parameters are about equal for all the land use areas, except BOD_5 for Open areas. This is probably due to pollutants such as fertilizers, animal wastes and other organics.

  Biochemical Oxygen Demand (BOD). The BOD test provides an indirect measure of the quantity of biologically degradable organic matter in water in terms of the amount of oxygen required by microorganisms to oxidize it to carbon dioxide and

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water. The decomposition of biodegradable materials by natural soil and water bacteria draws upon the dissolved oxygen resources of a water body. This process is countered by natural re-aeration processes that all water bodies possess to varying degrees. Significant reductions in dissolved oxygen concentrations can result when the demand rate exceeds the rate of replenishment through re-aeration.

Chemical Oxygen Demand (COD). The COD test provides a more rapid measure of oxygen demand. The consumption of oxygen from a strongly oxidizing chemical agent is measured by this test. As a result, it typically measures appreciably higher levels of oxygen demand than will be produced by biological decomposition because it oxidizes some organic compounds that are not biodegradable, and may also react with inorganic compounds as well. In urban stormwater, for example, COD levels are typically found to be about 8 times greater than BOD levels.

Nutrients. Nutrients are necessary for the growth and support of biota in natural water systems. Excessive quantities can result in the over-stimulation of biological growth and the creation of objectionable water quality conditions. Runoff from fertilized areas and discharges of sewage or industrial wastes are frequently sources of significant quantities of nutrients. Other sources include urban stormwater runoff and direct atmospheric deposition to water body surfaces. In general, the most important nutrient factors causing an acceleration in algal production are nitrogen compounds and phosphorus. Again, the Single Family has the highest concentration of nutrients. This is probably due to pollutants such as fertilizers, animal wastes and other organics. The high value for TKN can be attributed to the increased amount of foliage entering stormwater from this land use type.

Nitrogen. Among the potential major point sources of nitrogen which enter water bodies are municipal and industrial waste waters, and septic tank and feed-lot discharges. It is unlikely that the latter two are significant contributors to the system. Nonpoint sources of nitrogen include lawn fertilizers, leachate from waste disposal in dumps or sanitary landfills, atmospheric fallout, nitrite discharges from automobile exhausts and other combustion processes, and natural sources such as mineralization of soil organic matter, and farm-site fertilizers and animal wastes. Many water treatment methods have no significant effect on nitrate removal from water (Dunne and Leopold, 1978).

Two forms of nitrogen have been analyzed extensively in stormwater runoff water quality studies. These are nitrite plus nitrate ($NO_2 + NO_3$), and total Kjeldahl nitrogen (TKN). The latter, named after the analytical test procedure, provides a measure of ammonia and organic nitrogen forms that are present. The former ($NO_2 + NO_3$) provides a measure of the inorganic nitrogen. Both NO_3 and TKN are analyzed in this study.

Phosphorus. Phosphorus is used by algae and higher aquatic plants and may be stored in excess of use within plant cells. With decomposition of plant cells, some phosphorus may be released immediately through bacterial action for recycling within the biotic community, while the remainder may be deposited with sediments. Much of the phosphoric material that combines with the consolidated sediments within the bottom of a water body is bound permanently, with a low likelihood of being recycled into the water column.

Phosphorus enters waterways from many of the same sources as nitrogen. Domestic sewage contains significant concentrations of phosphorus, which is

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contributed by detergents and human wastes. Primary and secondary treatment processes remove only about 20 to 30 percent of this element from sewage (Dunne and Leopold, 1978). Fertilizers and the erosion of soils rich in phosphorus can also be a potential source.

Two forms of phosphorus have been routinely analyzed in stormwater runoff water quality studies. These include total phosphorus (TP) and soluble phosphorus (SP). This study analyzes both of these parameters.

- **Metals.** Heavy metals such as copper, lead, and zinc are naturally released in very small quantities by the weathering of exposed soils and mineral deposits, corroding metal surfaces, decomposing paints, and certain corrosion-control compounds. Heavy metals tend to have comparatively low solubilities and are often mobilized by forming soluble complexes with humic materials or by becoming attached to clay particles.

  These metals are present in the biosphere as trace elements and are micronutrients necessary for plant and animal growth. Heavy metals are of concern because elevated concentration levels of soluble forms in natural water bodies can produce toxic effects in biota. Sources include domestic and industrial point-source discharges, urban stormwater runoff, and direct atmospheric deposition. In this study copper (Cu), lead (Pb), and zinc (Zn) have been chosen for analysis because stormwater runoff water quality studies conducted at other urban locations have indicated that these metals are almost always present, and are at concentrations which tend to be elevated, relative to other heavy metals. They also can be used as surrogates for other heavy metals, as they tend to display similar transport characteristics. Copper and lead are often associated with automotive emissions and leaks which is possibly why they are higher in the Santa Monica Bay area. Industrial and Commercial areas are assigned the largest concentration of zinc.

- **Oil and Grease.** Oil and grease is a prevalent constituent in urban runoff. In a study of oil and grease concentrations in urban runoff in Richmond, California, Stenstrom et al. (1984) found that oil and grease concentrations in runoff from commercial properties and parking lots are about three times higher than from residential and open areas. The NURP program did not address oil and grease. Due to the very limited data base on oil and grease concentrations, it was not possible to accurately model this constituent. Accurately measuring oil and grease is very difficult, especially due to its affinity for coating sampling bottles. Eganhouse and Kaplan (1981) measured oil and grease concentrations in the Los Angeles River and found that concentrations were generally lower during storm events than during dry flows. The State of the Bay report (SCAG, 1988) estimated that urban runoff accounted for about 3 percent of the total input of oil and grease to the Bay. The oil and grease concentrations are the same for all land use types except the Open and Single Family categories, which are lower (Stenstrom et al., 1984).

To quantify the pollutant characteristics of runoff from a given area and the surrounding vicinity, it is desirable (and sometimes possible) to use site-specific data or local data. However, the data set must be extensive enough to adequately characterize urban runoff water quality from each land use type. When extensive amounts of data are not available, as is the case for Santa Monica Bay, an alternative approach is to use the NURP database for characterizing typical runoff concentrations.

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2.5 LOCAL DATA COLLECTION

One of the tasks of this project was to assemble all the available runoff water quality data. In this way an additional source of data beyond the NURP data would be available for accessing inputs to Santa Monica Bay. In theory this data could be more accurate than NURP data because they were collected from inputs to the Bay, as opposed to many different runoff sources. It was also planned to make the data available for other Santa Monica Bay Restoration Project purposes

Data collection was begun in 1990 and completed in 1991. At the beginning of the collection process all agencies that routinely monitor or have monitored stormwater runoff (point source data were excluded from the goals of this project, since the data are accessible by other means) were contacted either by telephone or letter. A total of 15 potential data sources were found.

After identifying the data sources an assessment of the quantity and quality of the data was made. Of the 15 original sources 9 were deemed to be suitable for inclusion. The other six sources were not included because the data were too few in number, collected by unconventional techniques, duplicative of other sources, or collected at points not discharging into Santa Monica Bay. Most data were collected in machine-readable format; some data, such as the data from SCCWRP were coded from printed material. It is important to note that data gathered from a variety of sources such as those contributing to this data set are less reliable that data collected from a single source or data collected through a sampling program with quality assurance (QA) and quality control (QC) programs. No rigorous analysis of the data was performed. If the parties responsible for collecting the data introduced errors, then they will also exist in this combined data set. Table 12 shows the sources of data. Further information on each source is provided in Appendix B, along with other material describing the data set.

Many of the data sources contained data collected from several places. There were a total of 47 different locations. Table 13 shows the locations. They are coded by longitude and latitude. Two sources have missing locations and are unavailable. Many of the various locations were collected from source 11 through US EPA STORET records. The location name shown in the table is the most accepted name known to us, although some agencies have different names for specific locations. There is no standard naming convention for the locations.

A data set was constructed of all the records and integrated with SAS (1985) on the UCLA IBM 9000/900 computer. The SAS program was used to calculate various statistics as well as to divide the data into subsets, such as data collected under dry and wet weather conditions. All parameters were coded by STORET number. A separate data set is included which can be used to decode the STORET numbers into water quality parameters. Table 14 shows a subset of the STORET codes used later in the text of the report. There are a total of over 11,000 STORET codes.

The locations were not correlated to any particular rain gauge, flow gauge or discharge location. This is because the data were collected by several agencies who had no reason to perform a systematic monitoring plan. Furthermore, much of the data was collected for purposes other than accessing inputs to Santa Monica Bay.

Table 15 shows the number of observations at each sample location. Also included are the periods of observation, number of parameters monitored, and number of observations below detection limits. The earliest observations were made in 1967. The most recent were made at the end of 1990. The reason there are no observations in 1991, even though the

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Table 12. Sources of Data.

Source Number	Title and Description of Source	Status
1	Santa Monica Bay Stormwater Pollutant Reduction Study. City of Los Angeles and Engineering Science.	Included
2	Coliform Database by SAIC	Excluded
3	Surface Water Quality Survey - Los Angeles Regional Water Quality Control Board.	Included
4	Discharges from Storm Drains to Santa Monica Bay -- Dept. of Health Services, County of LA	Included
5	An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses from Two Storm Drains -SMBRP	Included
6	Stormwater Runoff Program -- SCCWRP	Included
7	National Pollutant Discharge Inventory - NOAA	Excluded
8	NPDES Monitoring Reports -- RWQCB	Excluded
9	Search for Mutagens and Carcinogens in Pico Kenter Storm Drain -- Los Angeles County	Excluded
10	Ozone Pilot Plant -- SMBRP and City of Santa Monica.	Included
11	Los Angeles County Dept. of Public Works Surface Water Quality Monitoring Program	Included
12	Deposition and Processing of Airborne Pollutants-National Parks Service	Included
13	California Mussel Watch	Excluded
14	Hyperion Treatment Plant Coliform Data City of Los Angeles	Excluded
15	Los Angeles River Loadings of Trace Metals and Synthetic Organics - US E.P.A.	Included

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Table 13. Sampling Locations.

Location Code	Latitude	Longitude	Station Name
1	34.06444	118.3547	BALLONA CREEK
2	34.04222	118.2661	FIGUEROA ST. & 12TH ST.
3	34.02694	118.2728	ADAMS & HOPE ST.
4	34.05083	118.3272	WINDSOR BLVD 300FT N. OF 12TH ST.
5	34.02917	118.3147	CIMARRON ST. & 29TH ST.
6	34.03481	118.3313	BRONSON AVE.
7	34.04278	118.6833	MALIBU CREEK @ CROSS CREEK RD
8	34.08472	118.7117	M[illegible]BU CREEK @ SALVATION ARMY CAMP
9	34.04111	118.5800	TO[illegible]NGA CANYON CREEK U/S OF PCH(~1000')
10	34.02833	118.5178	SANTA MONICA CANYON @ PCH
11	33.98500	118.4125	CENTINELA CREEK @ CENTINELA AVE.
12	33.99000	118.4108	BALLONA CREEK @ INGLEWOOD AVE.
13	33.99222	118.4067	BALLONA CREEK @ SEPULVEDA CHANNEL
14	33.99222	118.4072	SEPULVEDA CHANNEL @ BALLONA CREEK
15	34.01528	118.4264	SAWTELLE CHANNEL ABOVE SEPULVEDA CHANNEL
16	34.01556	118.4267	SEPULVEDA CHANNEL ABOVE SAWTELLE CHANNEL
17	34.01611	118.3892	BENEDICT CANYON CHANNEL @ BALLONA CREEK
18	34.02306	118.3675	JEFFERSON BLVD DRAIN @ BALLONA CREEK
19	34.03333	118.3742	LA CIENAGA BLVD DRAIN @ BALLONA CREEK
20	34.03833	118.3678	BALLONA CREEK @ FAIRFAX AVE.
21	34.00556	118.4908	PICO-KENTER OUTFALL
22	33.99667	118.4842	ASHLAND AVE STORM DRAIN OUTFALL
23	33.96083	118.4583	BALLONA CREEK OUTFALL
24	34.00889	118.4956	SANTA MONICA PIER STORM DRAIN OUTFALL
25	33.93056	118.4358	IMPERIAL HWY STORM DRAIN OUTFALL
26			AINSWORTH STORM DRAIN OUTFALL
27	33.83611	118.3894	AVENUE I STORM DRAIN
28	34.02806	118.5189	SANTA MONICA CANYON STORM DRAIN OUTFALL
29	34.03813	118.5414	PULGA CANYON STORM DRAIN OUTFALL
30	33.99667	118.4842	ASHLAND AVE U/S OF OUTFALL
31	34.00639	118.4911	PICO-KENTER U/S OF OUTFALL
32			DEER CANYON CREEK
33	34.04592	118.9055	LA CHUSA CANYON CREEK
34	34.03856	118.8425	TRANCAS CANYON CREEK
35	34.02426	118.7865	RAMIREZ CANYON CREEK
36	34.03466	118.7435	SOLSTICE CANYON CREEK
37	34.03353	118.7326	CORRAL CANYON CREEK
38	34.03778	118.6481	CARBON CANYON CREEK
39	34.00556	118.4908	PICO-KENTER DRAIN
40	34.09184	118.5686	UPPER SANTA YNEZ CANYON CREEK
41	33.99667	118.4022	BALLONA CRK @ SAWTELLE BLVD
42	33.98500	118.4119	CENTINELA CRK @ CENTINELA BLVD
43	34.70000	118.7331	CORAL CANYON CRK @ PCH
44	34.00056	118.8056	DUME CRK @ ZUMA BEACH
45	34.02917	118.5158	SANTA MONICA CANYON CHANNEL @ SHORT ST.
46	33.99222	118.4072	SEPULVEDA CHANNEL @ CULVER BLVD
47	33.87245	118.33232	I-405 FREEWAY @ REDONDO BEACH BLVD

Note: Blank Latitude and Longitude means missing data

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Table 15. General Description of the Completed Data Set

Table 14. Storet Code Desription

Storet Code	Storet Parameter Description
1027	Cadmium, Total (µg/L as Cd)
1042	Copper, Total (µg/L as Cu)
1051	Lead, Total (µg/L as Pb)
1092	Zinc, Total (µg/L as Zn)
310	BOD, 5 Day, 20°C (µg/L)
340	COD, 0.25 N $K_2Cr_2O_7$ (µg/L)
403	pH, Lab, Standard Unit (SU)
515	Residue, Total Filtrable (Dried at 105°C) (µg/L)
550	Oil and Grease (Soxhlet Extraction) Total, Rec., (µg/L)
608	Nitrogen, Ammonia, Dissolved (µg/L as N)
615	Nitrite Nitrogen, Total (µg/L as N)
620	Nitrate Nitrogen (µg/L as N)
650	Phosphate, Total (µg/L as PO_4)
680	Carbon, Total Organic (µg/L as C)
95	Specific Conductance (µmhos/cm @ 25°C)
31505	Coliform, Tot, MPN, Confirmed Test, 35°C (Tube 31506)
530	Residue, Total Nonfiltrable (µg/L)
31615	Fecal Coliform, MPN, EC Med, 44.5°C (Tube 31614)
610	Nitrogen, Ammonia, Total (µg/L as N)
31616	Fecal Coliform, Mbr Filter, M-FC Broth, 44.5°C
70507	Phosphorus, in Total Orthophosphate (µg/L as P)
31673	Fecal Streptococci, Mbr Filt, KF Agar, 35°C, 48 hours

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Table 15. General Description of the Completed Data Set.

LOCATION NAME	Location Code	Number of Data Points	Number Below Detection	Number of Different Parameters	Earliest Date	Most Recent Date
ADAMS & HOPE ST.	3	846	439	73	26-Feb-81	25-Nov-81
AINSWORTH STORM DRAIN OUTFALL	26	27	0	3	21-Jul-86	18-Sep-86
ASHLAND AVE STORM DRAIN OUTFALL	22	25	0	3	21-Jul-86	18-Sep-86
ASHLAND AVE U/S OF OUTFALL	30	44	0	3	30-Aug-89	29-Sep-89
AVENUE I STORM DRAIN	27	27	0	3	21-Jul-86	18-Sep-86
BALLONA CREEK	1	[illegible]	771	86	28-Nov-70	24-Jul-81
BALLONA CREEK @ FAIRFAX AVE	20	[illegible]	1123	130	16-Oct-74	5-Dec-90
BALLONA CREEK @ INGLEWOOD AVE	12	3076	417	167	28-Nov-70	6-Feb-90
BALLONA CREEK @ SEPULVEDA CHNL	13	39	38	39	11-Dec-86	11-Dec-86
BALLONA CREEK OUTFALL	20	25	0	3	21-Jul-86	18-Sep-86
BALLONA CRK @ SAWTELLE BLVD	41	14441	1218	125	20-Nov-67	5-Dec-90
BENEDICT CYN CHNL @ BALLONA CREEK	17	39	39	39	20-Apr-87	20-Apr-87
BRONSON AVE.	6	643	333	73	27-Feb-81	23-Nov-81
CARBON CYN CREEK	38	1	0	1	25-Mar-82	25-Mar-82
CENTINELA CREEK @ CENTINELA AVE.	11	1593	345	86	16-Apr-69	23-Jun-87
CENTINELA CRK @ CENTINELA BLVD	42	1656	977	39	11-May-88	7-Sep-90
CIMARRON ST. & 29TH ST.	5	721	609	73	28-Feb-81	25-Nov-81
CORAL CYN CRK @ PCH	43	133	34	19	10-Jan-90	11-Jul-90
CORRAL CYN CREEK	37	1	0	1	25-Mar-82	25-Mar-82
DEER CYN CREEK	32	1	0	1	25-Mar-82	25-Mar-82
DUME CRK @ ZUMA BEACH	44	40	7	20	11-May-88	16-Jun-88
FIGUEROA ST. & 12TH ST.	2	701	573	73	27-Feb-81	14-Apr-81
IMPERIAL HWY STORM DRAIN OUTFALL	25	27	0	3	21-Jul-86	18-Sep-86
I-405 FREEWAY @ REDONDO BEACH BLVD	47	380	34	12	11-Jan-81	19-Mar-81
JEFFERSON BLVD DRAIN @ BALLONA CREEK	18	39	35	39	11-Jun-87	11-Jun-87
LA CHUSA CYN CREEK	33	1	0	1	25-Mar-82	25-Mar-82
LA CIENAGA BLVD DRAIN @ BALLONA CREE	19	39	39	39	11-Jun-87	11-Jun-87
MALIBU CREEK @ CROSS CREEK RD	7	1266	722	172	15-Dec-86	5-Jun-90
MALIBU CREEK @ SALVATION ARMY CAMP	8	80	80	41	23-Dec-86	3-May-88
PICO-KENTER DRAIN	39	3308	360	8	30-Nov-89	19-Nov-90
PICO-KENTER OUTFALL	21	45	26	31	11-Apr-71	18-Sep-86
PICO-KENTER U/S OF OUTFALL	31	1723	954	61	11-May-88	7-Sep-90
PULGA CYN STORM DRAIN OUTFALL	29	27	0	3	21-Jul-86	18-Sep-86
RAMIREZ CYN CREEK	35	1	0	1	25-Mar-82	25-Mar-82
SANTA MONICA CYN @ PCH	10	38	39	39	23-Dec-86	23-Dec-86
SANTA MONICA CYN CHNLL @ SHORT ST.	45	988	382	36	11-May-88	7-Sep-90
SANTA MONICA CYN STORM DRAIN	28	27	0	3	21-Jul-86	18-Sep-86
SANTA MONICA PIER STORM DRAIN	24	27	0	3	21-Jul-86	18-Sep-86
SAWTELLE CHNL ABOVE SEPULVEDA CHNL	15	80	79	41	23-Jun-87	14-Apr-88
SEPULVEDA CHNL @ BALLONA CREEK	14	284	279	148	11-Dec-86	6-Feb-90
SEPULVEDA CHNL @ CULVER BLVD	46	1307	617	47	11-May-88	7-Sep-90
SEPULVEDA CHNL ABOVE SAWTELLE CHNL	16	80	80	41	23-Jun-87	14-Apr-88
SOLSTICE CYN CREEK	36	1	0	1	25-Mar-82	25-Mar-82
TOPANGA CYN CREEK U/S OF PCH(~1000')	9	2034	485	77	23-Dec-86	7-Sep-90
TRANCAS CYN CREEK	34	1	0	1	25-Mar-82	25-Mar-82
UPPER SANTA YNEZ CYN CREEK	40	1	0	1	25-Mar-82	25-Mar-82
WINDSOR BLVD 500FT N. OF 12TH ST.	4	391	318	73	27-Feb-81	27-Sep-81

data was obtained from the agencies in 1991, is probably the lag between collection, analysis and reporting. The full data set includes the detection limits when they were reported, the sampling technique (e.g. grab, composite, flow-weighted composite, etc.). Sampling technique, flow rate and mass emissions were included in the data set if they were provided. Few flow rates were provided and this is most likely because of the difficulty in measuring stormwater and dry weather flows.

Approximately 90% of the collected observations were coded as to wet or dry weather conditions. In order to classify the remaining observations, the date of collection and the occurrence of rainfall were noted. All of the USGS rainfall gauges in the runoff area were used. If 5 or more of the gauges showed rainfall more than 0.1 inch, the observation was classified as wet weather; otherwise it was classified as dry weather.

Table 16 shows selected data for locations that had sufficient data to perform a statistical evaluation. They are included to illustrate how the parameters for the model were selected. The parameters shown in Table 16 were selected because they match the NURP parameters used in the model, and therefore could be used to compare the Santa Monica Bay drainage area to the national averages (NURP). Refer to Table 14 to determine the units of the parameters shown in Table 16.

The left hand most columns of Table 16 show the parameter concentrations occurring at specific probabilities. For example, at Ballona Creek at Inglewood, the cadmium concentration was less than 1.175 ug/L 25% of the time, less than 2.24 ug/L 50% of the time, less than 6.98 ug/L 75% of the time, and less than 21.94 ug/L 90% of the time. The probability concentrations are more robust than the mean concentrations and are frequently more useful in comparing one data set to another.

For this study, local data were inadequate for use in the model due to the limited amount of data available. However, it was possible to use the available data for comparison with the NURP data. The NURP database includes estimated concentrations for several different land use types, including residential, commercial, mixed, and open. By comparing the median site concentrations (50% probability) of the available Santa Monica Bay data, to the concentration distribution of NURP data, the most representative NURP data can be selected for use in the model.

A comparison of the NURP site median results and actual data collected in the Santa Monica Bay watershed are presented in the plots included as Figure 8. The graphs in Figure 8 present the probability distribution of pollutant concentrations (the median value of the event mean concentrations at each site) in urban runoff at the Santa Monica Bay sites, while the NURP land uses represent the distribution of the site median concentration for the various sites tested. The data used for comparison are from sampling station 41 (Ballona Creek at Sawtelle Blvd.) and sampling station 12 (Ballona Creek at Inglewood Ave.). These two stations were chosen for comparison because they had the most data points for comparison. It should be noted, however, that a significant portion of the Santa Monica Bay data were collected as grab samples while most of the NURP data were collected as composite samples. As shown in the graphs, the spread of the data for the Santa Monica Bay locations is quite large. However, the concentration medians of the Santa Monica Bay data generally fall in the upper range of the NURP site median concentrations. Therefore, for the purposes of this study, the 90th percentile values of the NURP data are used to estimate pollutant concentrations for Santa Monica Bay. By using these concentration values, this study is assuming that the Santa Monica Bay watershed has more stormwater pollution than 90% of the other urbanized areas in the United States. These concentrations are shown in Table 17. Possible reasons for pollutant concentrations being higher in the Santa Monica Bay area are:

Table 16. Parameter Statistics for Selected Locations (wet weather conditions)

Ballona Creek (1)						Percentile			
Parameter (STORET)	N	MEAN	MAX	MIN	STD DEV	25%	50%	75%	90%
Total Coliform (31505)	9	154444	620000	0	194686	30000	60000	230000	620000
Oil and Grease (550)	9	8222.22	23000	0	8227.86	1000	8000	14000	23000
Total Organic Carbon (680)	9	37444.4	106000	0	32573.4	2500	21000	36500	106000

Ballona Crk at Inglewood (12)						Percentile			
Parameter (STORET)	N	MEAN	MAX	MIN	STD DEV	25%	50%	75%	90%
Cadmium, Total (1027)	30	8.42267	26	0	7.5337	1.175	2.25	6.98	21.94
Copper, Total (1042)	30	116.237	860	37.8	172.921	41.5	86.05	116.25	352.3
Lead, Total (1051)	30	1065.22	7140	0	1792.82	92	310.5	1454.75	2939
Zinc, Total (1092)	30	938.7	4640	82	1285.3	264.75	377	889.75	3936
Total Coliform (31505)	19	941179	7.00E+06	0	1623106	60000	2.30E+05	6.30E+05	2.40E+06
Chemical Oxygen Demand (340)	17	264412	8.86E+05	3.00E+04	235045	66500	152000	437000	621200
Total Dissolved Solids (515)	26	351833	2.50E+06	1.30E+04	473467	96250	199000	383000	934100
Total Suspended Solids (530)	6	1744500	5741000	53000	2228119	67250	925500	3497750	5741000

Ballona Crk at Fairfax (20)						Percentile			
Parameter (STORET)	N	MEAN	MAX	MIN	STD DEV	25%	50%	75%	90%
Cadmium, Total (1027)	6	5	8	3	2.36643	3	4	8	8
Copper, Total (1042)	3	176.667	300	110	106.927	110	120	300	300
Lead, Total (1051)	2	495	640	350	205.061	350	495	640	640
Zinc, Total (1092)	3	560	1250	110	606.712	110	320	1250	1250
BOD 5 (310)	6	22333.3	38000	12000	12339.6	12000	17000	38000	38000
Fecal Coliform (31616)	3	7733.33	12200	5000	3900.43	5000	6000	12200	12200
pH (403)	40	7.115	7.8	6.5	0.348293	6.9	7.05	7.3	7.79
Total Suspended Solids (530)	14	133571	402000	57000	116658	60000	108000	128000	402000
Ammonia Nitrogen (610)	6	410	620	180	197.383	180	430	620	620
Nitrate Nitrogen (620)	6	1796.67	3000	1150	932.967	1150	1240	3000	3000
Specific Conductivity (95)	42	395.333	1190	56	329.801	86.5	170	369.75	943

Ballona Crk at Sawtelle (41)						Percentile			
Parameter (STORET)	N	MEAN	MAX	MIN	STD DEV	25%	50%	75%	90%
Cadmium, Total (1027)	38	14.5789	30	1	14.5789	3	5	30	30
Copper, Total (1042)	19	41.1789	120	19	28.1813	20	31	50	88
Lead, Total (1051)	18	95.9722	500	10	131.849	47.625	50	86.25	410
Zinc, Total (1092)	19	367.895	1000	60	269.095	230	310	520	980
BOD 5 (310)	62	13516.1	45000	2000	9157.53	6000	12000	17000	25700
Fecal Coliform (31616)	28	46025	430000	500	89435.9	5525	13500	33250	137000
Chemical Oxygen Demand (340)	42	70761.9	132000	15000	29438.5	52250	69000	92000	111300
pH (403)	70	6.97257	8.31	5.8	0.514657	6.57	7	7.4	7.82
Total Suspended Solids (530)	34	152529	476000	34000	97963	89500	134000	191000	210000
Oil and Grease (550)	34	17552.9	540000	0	96502.2	2000	4000	4500	10000
Ammonia Nitrogen (diss. 608)	34	532.5	1500	10	486.069	92.5	445	907.5	1300
Ammonia Nitrogen (610)	40	344.25	1630	0	461.253	0	118.5	582.5	1090
Nitrite Nitrogen (615)	10	342	1000	60	381.774	92.5	90	602.5	1000
Nitrate Nitrogen (620)	58	1282.55	4290	0	1210.05	307.5	900	1782.5	3280
Total Organic Carbon (680)	18	24955.6	42000	13500	9036.93	19300	24000	28625	42000
Total Ortho Phosphorus (70507)	21	298.571	910	10	233.887	90	260	425	676
Specific Conductivity (95)	80	264	2100	65	349.681	98.5	154.5	236.75	636.2

I-405 and Redondo Beach (47)						Percentile			
Parameter (STORET)	N	MEAN	MAX	MIN	STD DEV	25%	50%	75%	90%
Chemical Oxygen Demand (340)	31	181806	724000	23000	192502	53000	111000	220000	535600
Total Dissolved Solids (515)	32	123281	461000	16000	119989	45250	83500	158730	357100
Total Suspended Solids (530)	33	1292576	1.58E+07	18000	3611894	41000	102000	256500	3936000

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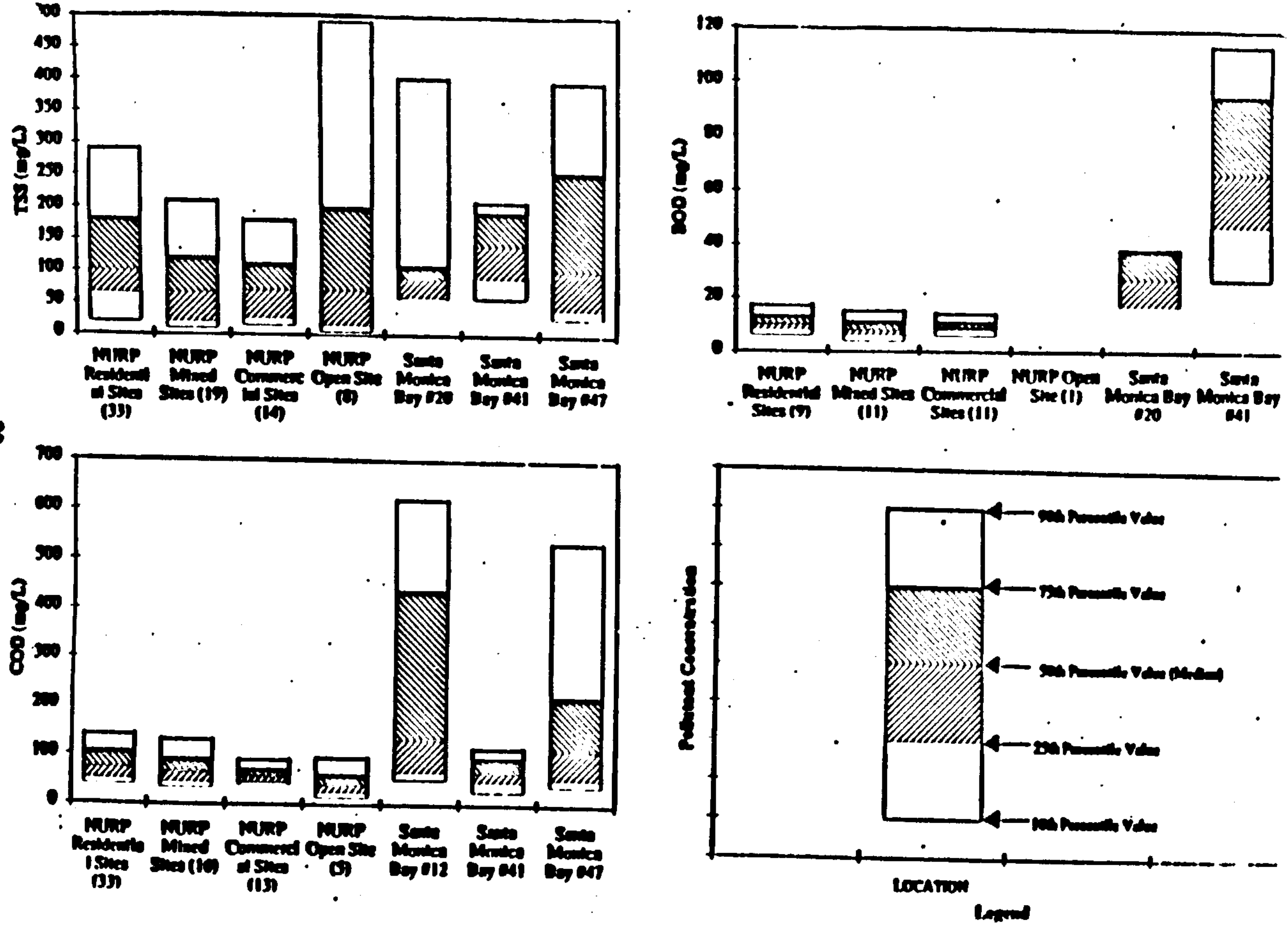

Figure 8. Plots of Pollutant Concentrations.

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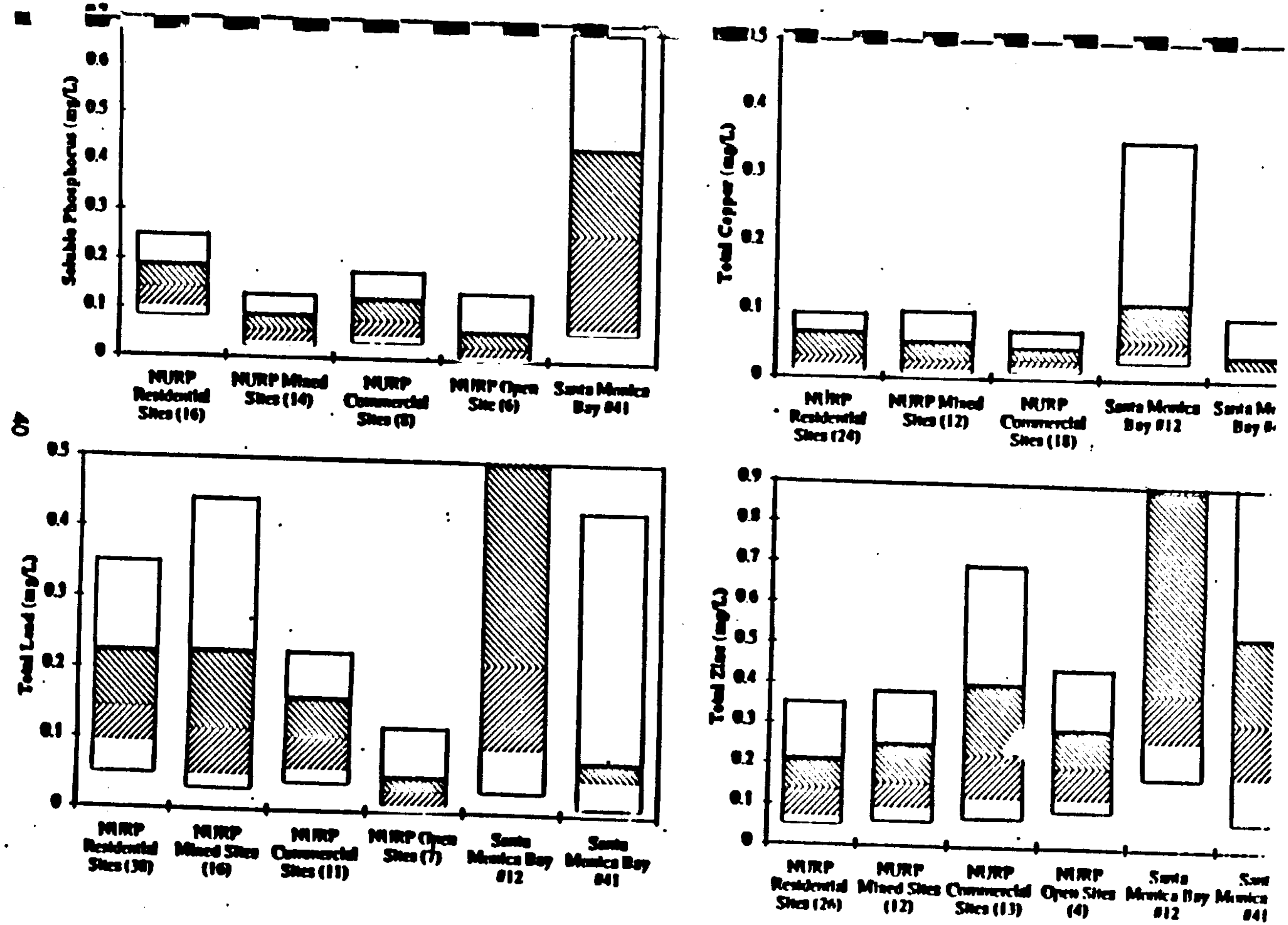

Figure 8. **Plots of Pollutant Concentrations (cont'd).**

Table 17. Water Quality Characteristics

LAND USE	POLLUTANT CONCENTRATION (MG/L) (a)										
	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil and Grease
Single-family	290	17	140	0.850	0.230	4.300	1.850	0.095	0.350	0.350	3
Multi-family	210	15	130	0.620	0.130	2.400	1.000	0.100	0.440	0.380	22
Commercial	180	14	90	0.430	0.180	2.000	1.200	0.072	0.225	0.694	22
Public	180	14	90	0.430	0.180	2.000	1.200	0.072	0.225	0.694	22
Light Industrial	180	14	90	0.430	0.180	2.000	1.200	0.072	0.225	0.694	22
Other Urban	210	15	130	0.620	0.130	2.400	1.000	0.100	0.440	0.380	22
Open	490	2	95	0.520	0.140	2.800	1.450	0.055	0.140	0.440	0
Unknown	210	15	130	0.620	0.130	2.400	1.000	0.100	0.440	0.380	22

(a) 90th percentile values for median event mean concentrations for each site in a land use category (EPA 1983); data for commercial sites used for public, light industrial, other urban and unknown land uses.

1. The longer dry period between storms which allows a larger build up of pollutants.

2. Air pollution levels (and therefore airfall deposition of pollutants) in the Los Angeles Basin are probably higher than other urban areas.

It should be noted that the concentration used for lead may be high for present conditions. The values used in this study are based on the analyses of samples collected during NURP. Much of the stormwater quality data for the Santa Monica Bay watershed was also collected during this period. Decreased use of leaded gasoline may have reduced lead concentrations in stormwater runoff.

Oil and grease concentrations are taken from Silverman et al. (1988). These estimates are developed from stormwater runoff studies conducted in the San Francisco Bay area. Average concentrations of oil and grease determined for residential, commercial/industrial and undeveloped areas are shown in Table 17. Undeveloped areas contribute little oil and grease to stormwater runoff, whereas developed areas having large impervious areas and high vehicular use contribute a disproportionate fraction of oil and grease loadings.

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Using the previously described methodology for predicting runoff volumes and pollutant concentrations from individual land use areas, pollutant loadings and average concentrations can be calculated for each catchment in the watershed. Appendix A contains detailed tables of the calculations performed in this study including land use and hydrology (Table A-1) and pollutant loadings and concentrations (Table A-2). The drainage basins can be categorized in the following way:

Drainage basins 1-19 make up the North Bay.

Drainage basins 20-22 make up West Los Angeles.

Drainage basins 23-28 make up the South Bay.

To aid in analyzing the results of the modeling, rankings based on pollutant loads and concentrations were calculated. The rankings are based on the model results and are not based on other factors, such as coastal resources, which may also be important. The overall rankings assume that all the pollutants are weighted equal. This assumption is reasonable given that the affects of the modeled pollutants on the environment in Santa Monica Bay are not fully understood. The results are summarized in two formats: by land use categories and by drainage basins.

3.1 SUMMARY BY LAND USE

The annual pollutant loadings from each land use category are presented in Tables 18 and 19. Table 18 reports the loads for each land use in each basin. Table 19 reports the results for the total watershed in pounds per year, as a percentage of total, and in kilograms per hectare per year (KG/HA/YR). A ranking of the land use categories based on annual pollutant loadings (mass) was developed and is shown in Table 20. A ranking of 1 corresponds to the highest average annual pollutant loading for a given pollutant and a ranking of 8 corresponds to the lowest average pollutant loading for the pollutant. Ranking of the average of individual rankings for each land use category provides an overall ranking assuming equal weighting of each pollutant. A ranking of land use by pollutant concentration is not presented because the concentration data by land use was used as input data. As shown in the above tables, single-family residential contribute approximately 50 percent of the annual load of the oxygen demand and nutrient pollutants. The single family land use also ranks first in annual loads of metals. This does not mean that single family residential areas have a higher concentration of metals, but instead that, given the large amount of residential area in the Santa Monica Bay area, it contributes the most runoff. The modeling results also show that the largest load of TSS comes from open areas, and the biggest contribution of oil and grease is from the multi-family and commercial areas. The overall ranking shows that residential areas and open areas contribute the largest loads to Santa Monica Bay. These results may be misleading however, unless one considers the fact that these two land uses comprise 90 percent of the total watershed and contribute 82 percent of the total runoff.

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Table 18. Annual Pollutant Loadings of Santa Monica Bay Drainage Basins by Land Use.

DRAINAGE BASIN	LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR) TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
Basin 01	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,313,120	8,360	204,546	1,397.32	375.18	7,202.30	3,883.79	147.30	373.18	1,170.14	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	1,313,120	8,360	204,546	1,397.32	375.18	7,202.30	3,883.79	147.30	373.18	1,170.14	0
Basin 02	Single-family	26,647	917	2,836	48.86	13.40	[illegible]	99.22	2.13	16.50	16.50	302
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	9,823	644	3,306	26.64	5.59	103.13	43.97	4.30	11.50	16.35	815
	Open	207,304	847	40,340	220.30	50.31	1,106.25	614.31	22.30	50.31	186.41	0
	Unknown	210	19	130	0.62	0.13	2.40	1.00	0.10	0.44	0.99	22
	Basin Total	222,474	2,434	83,317	301.43	70.53	1,821.70	704.00	32.83	87.84	223.80	1,120
Basin 03	Single-family	30,704	1,336	9,513	97.70	36.99	392.17	123.70	0.46	25.70	25.70	204
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	3,347	220	1,940	9.20	1.98	23.97	14.89	1.20	6.50	8.70	300
	Open	162,860	661	31,420	171.80	46.30	826.80	479.37	16.19	46.30	148.82	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	184,913	3,861	43,881	281.60	61.34	1,294.20	620.33	28.14	78.44	173.80	324
Basin 04	Single-family	20,000	800	7,374	44.16	12.90	203.42	96.12	4.84	20.19	20.19	186
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	172,811	790	28,000	180.45	40.46	973.20	514.34	20.31	40.44	146.80	0
	Unknown	210	19	130	0.62	0.13	2.40	1.00	0.10	0.44	0.99	22
	Basin Total	180,250	1,808	41,102	229.24	62.70	1,218.62	611.46	24.85	60.20	170.04	170
Basin 05	Single-family	48,725	2,805	21,130	126.26	37.72	648.70	270.13	14.20	52.01	52.01	403
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	280,350	1,361	55,100	297.87	82.67	1,652.40	864.26	32.46	82.67	299.82	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	333,113	3,746	72,335	424.22	120.30	2,302.26	1,136.30	46.61	126.48	313.04	403
Basin 06	Single-family	227,398	22,371	169,952	687.57	188.34	3,577.30	1,452.04	74.42	374.22	374.22	2,806
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	28,704	2,946	34,367	74.30	22.75	363.71	281.52	22.89	40.52	104.22	4,081
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,069,022	4,323	208,223	1,220.86	302.50	4,851.26	3,122.84	118.27	262.50	800.26	0
	Unknown	4,816	330	2,358	11.83	2.86	52.76	21.90	2.30	0.67	0.35	404
	Basin Total	1,334,130	30,330	334,497	1,993.26	524.31	8,843.12	4,826.39	205.77	626.86	1,300.40	6,041

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Table 18. Annual Pollutant Loadings of Santa Monica Bay Drainage Basins by Land Use (cont'd).

DRAINAGE BASIN	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
Basin 07	Single-family	[illegible]	9,716	[illegible]	485.31	843.89	2,457.43	1,887.30	94.30	380.84	380.84	1,715
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	32,122	1,731	11,861	32.83	32.13	345.80	647.48	0.83	37.46	85.39	2,784
	Public	28,773	4,332	30,137	130.31	28.27	647.48	288.49	20.31	72.84	224.88	2,122
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	991,426	4,847	192,321	1,852.16	283.27	[illegible]	2,913.80	111.30	283.27	890.39	0
	Unknown	6,073	433	2,347	17.97	3.77	69.54	71.95	2.90	17.73	11.91	677
	Basin Total	[illegible]	20,411	316,263	1,347.89	810.83	[illegible]	4,446.20	280.64	[illegible]	4,411.31	12,176
Basin 08	Single-family	283,843	64,999	123,321	749.95	228.77	2,792.86	1,422.36	83.83	288.80	288.80	2,647
	Multi-family	4,616	330	2,834	13.43	2.86	82.76	21.98	2.30	0.67	8.36	484
	Commercial	2,318	996	1,359	6.82	2.83	37.98	16.79	1.04	3.18	9.71	386
	Public	2,096	310	1,349	6.44	2.70	29.98	17.89	1.88	3.37	38.40	330
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	396,982	1,619	78,881	438.86	113.31	2,266.10	1,773.86	44.31	113.31	386.11	0
	Unknown	470	30	290	1.24	0.26	4.13	2.00	0.70	0.11	0.76	44
	Basin Total	862,699	17,383	208,135	1,186.14	348.23	6,175.36	2,864.36	133.83	430.16	804.36	3,813
Basin 09	Single-family	64,616	2,780	31,395	169.40	58.71	888.13	412.32	31.77	77.89	77.89	688
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	317,736	1,377	61,606	337.21	90.79	1,815.75	940.30	38.47	90.70	283.33	0
	Unknown	470	30	290	1.24	0.26	4.80	2.00	0.20	0.11	0.76	44
	Basin Total	382,794	8,113	93,060	537.83	146.73	2,776.46	1,304.33	87.83	169.86	364.86	712
Basin 10	Single-family	38,031	2,306	17,344	103.32	30.30	832.77	239.22	11.77	43.57	43.57	372
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	624,609	2,338	121,803	666.57	179.86	3,301.13	1,804.52	70.34	179.86	582.75	0
	Unknown	1,049	75	649	3.10	0.65	11.99	9.00	0.30	2.20	1.90	110
	Basin Total	663,679	4,730	139,796	773.48	210.68	4,125.90	2,053.73	82.41	224.62	628.01	482
Basin 11	Single-family	83,743	4,969	46,428	243.43	72.19	1,281.71	634.22	27.43	101.87	101.87	886
	Multi-family	639	46	380	1.86	0.39	7.19	3.60	0.30	1.32	1.14	66
	Commercial	9,832	761	4,766	22.77	9.33	105.82	43.83	3.81	11.82	36.78	1,068
	Public	74,480	5,791	37,330	177.88	34.46	837.34	486.40	38.78	98.88	387.89	8,304
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	636,801	2,596	123,306	674.86	181.71	3,434.29	1,882.84	71.39	181.71	371.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	804,366	14,083	206,130	1,122.90	328.29	5,816.44	2,978.21	132.72	289.88	897.13	11,306
Basin 12	Single-family	2,388,594	132,987	1,095,183	6,049.33	1,963.88	32,637.77	14,472.86	903.16	2,737.86	2,737.86	22,488
	Multi-family	150,340	10,731	93,006	443.36	93.01	1,777.83	715.43	71.34	344.70	371.86	18,730
	Commercial	197,482	13,380	98,741	471.36	197.48	2,194.34	1,316.85	78.99	248.85	781.40	24,137
	Public	142,446	11,879	71,323	340.39	143.45	1,882.73	949.64	38.38	178.86	840.21	77,610
	Light Industrial	198,921	18,672	99,460	475.30	198.32	2,318.33	1,326.14	79.57	248.85	786.86	24,313
	Other Urban	580,815	41,487	289,532	1,714.79	289.36	6,457.89	2,765.79	278.88	1,216.85	1,851.80	68,847
	Open	11,874,933	45,306	2,347,181	11,752.99	3,164.37	63,383.33	32,772.76	1,263.10	3,164.37	9,844.84	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	14,613,430	272,319	3,964,366	21,847.82	6,111.36	111,263.22	54,318.36	2,349.33	8,107.82	16,853.32	868,914

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Table 18. Annual Pollutant Loadings of Santa Monica Bay Drainage Basins by Land Use (cont'd).

DRAINAGE BASIN	LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR): TSS	BOD5	COD	Total P	Soluble P	TKN	NO3+NO2	Total Cu	Total Pb	Total Zn	Oil & Grease
Basin 13	Single-family	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,387.37	[illegible]	30.40	845.40	845.40	1,347
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	1,785	[illegible]	308.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	410,841	8,231	144,483	661.43	[illegible]	[illegible]	1,618.13	[illegible]	[illegible]	[illegible]	1,347
Basin 14	Single-family	[illegible]	9,954	[illegible]	[illegible]	[illegible]	2,317.78	[illegible]	[illegible]	[illegible]	[illegible]	1,557
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	[illegible]	671	4,317	[illegible]	[illegible]	[illegible]	97.31	[illegible]	[illegible]	[illegible]	[illegible]
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	[illegible]	[illegible]	173,710	[illegible]	[illegible]	[illegible]	2,473.17	[illegible]	[illegible]	[illegible]	2,812
Basin 15	Single-family	[illegible]	[illegible]	11,881	67.10	[illegible]	[illegible]	[illegible]	7.80	27.43	27.43	237
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	1,221	[illegible]	317.47	[illegible]	1,700.43	[illegible]	[illegible]	[illegible]	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,501.27	41.80	113.10	[illegible]	237
Basin 16	Single-family	[illegible]	[illegible]	[illegible]	1,827.76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,451
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	[illegible]	[illegible]	2,230.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,891.81	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	2,730,364	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,451
Basin 17	Single-family	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Multi-family	[illegible]	1,784	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.80	[illegible]	[illegible]	[illegible]
	Commercial	[illegible]	[illegible]	3,147	[illegible]	[illegible]	[illegible]	41.57	[illegible]	[illegible]	[illegible]	[illegible]
	Public	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	311.83	[illegible]	[illegible]	[illegible]	70.51	[illegible]
	Light Industrial	0	0	0	0.00	-0.00	0.00	0.00	0.00	.0.00	0.00	0
	Other Urban	[illegible]	4,731	61,777	[illegible]	41.18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Open	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	318.73	[illegible]	[illegible]	[illegible]
Basin 18	Single-family	[illegible]	[illegible]	[illegible]	[illegible]	384.77	[illegible]	2,107.31	[illegible]	[illegible]	[illegible]	3,477
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	[illegible]	[illegible]	[illegible]	4.73	[illegible]	[illegible]	13.19	[illegible]	[illegible]	7.43	[illegible]
	Public	[illegible]	[illegible]	[illegible]	31.79	13.31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	31,331	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Open	[illegible]	[illegible]	[illegible]	[illegible]	32.11	[illegible]	[illegible]	[illegible]	32.11	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3,113.86	151.86	[illegible]	[illegible]	[illegible]

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Table 18. Annual Pollutant Loadings of Santa Monica Bay Drainage Basins by Land Use (cont'd).

DRAINAGE BASIN	LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR) TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
Basin 19	Single-family	914,798	32,636	461,626	2,461.30	788.42	13,364.34	2,835.78	379.46	1,308.57	1,308.57	9,463
	Multi-family	12,590	899	7,794	37.57	7.79	143.88	59.95	6.80	26.38	22.78	1,319
	Commercial	24,320	1,930	13,410	59.30	24.32	375.78	161.47	9.93	31.40	58.70	3,804
	Public	11,331	881	3,863	37.87	11.33	135.90	78.34	4.53	44.16	43.09	1,383
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	22,501	1,579	14,340	69.30	14.33	288.34	111.91	11.19	49.24	43.33	2,462
	Open	1,413,983	2,771	374,141	1,382.36	486.80	8,579.93	4,184.25	108.71	486.80	1,288.70	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	2,401,828	64,757	886,183	4,374.78	1,351.11	23,438.33	16,433.90	490.03	1,428.57	2,578.46	73,463
Basin 20	Single-family	1,367,415	88,159	600,131	4,807.84	1,778.81	28,273.47	8,723.17	467.38	1,600.33	1,600.33	64,346
	Multi-family	637,880	48,304	394,384	1,880.81	394.36	7,380.57	3,803.57	303.36	1,334.77	1,132.78	68,730
	Commercial	309,173	16,399	101,366	499.80	309.17	2,324.14	1,394.46	83.67	361.47	809.46	28,366
	Public	75,180	3,847	37,590	179.40	75.18	638.33	801.30	30.87	60.97	309.86	9,100
	Light Industrial	8,773	643	4,137	19.76	8.77	91.93	39.16	3.31	10.34	31.50	1,011
	Other Urban	75,959	3,436	47,822	234.36	47.82	888.18	361.71	36.17	159.15	157.43	7,886
	Open	266,368	1,883	91,469	281.61	78.82	1,316.30	783.37	39.79	78.82	328.39	0
	Unknown	670	50	260	1.24	0.26	4.00	2.00	0.70	0.91	0.76	44
	Basin Total	2,634,117	134,961	1,379,360	7,894.82	1,983.90	33,196.72	14,836.36	836.51	3,386.73	4,307.83	184,881
Basin 21	Single-family	10,980,469	643,683	3,380,916	32,184.13	9,466.52	162,813.84	78,867.83	3,997.88	13,323.39	13,323.39	113,591
	Multi-family	4,063,316	333,108	2,884,939	13,760.44	2,884.94	53,397.33	22,307.22	2,220.72	9,771.18	8,438.74	486,339
	Commercial	2,316,725	180,190	1,136,363	3,534.40	2,316.73	25,741.39	15,444.83	526.69	2,895.91	8,932.36	283,135
	Public	684,172	53,313	363,884	1,634.41	684.17	7,401.91	4,361.15	373.67	855.22	2,437.86	83,621
	Light Industrial	1,141,346	88,787	570,773	2,727.83	1,141.35	12,484.84	7,618.31	484.62	1,426.93	4,401.39	130,522
	Other Urban	923,261	66,347	571,362	2,725.82	571.34	10,331.33	4,396.46	430.46	1,336.43	1,678.86	96,723
	Open	1,453,467	3,379	281,460	1,341.61	415.88	8,300.95	4,398.71	863.88	415.88	1,304.44	0
	Unknown	116,976	8,348	72,352	349.06	72.35	1,333.72	534.55	55.06	244.93	211.49	12,244
	Basin Total	22,779,332	1,379,206	11,384,610	60,660.93	12,334.25	[illegible]	139,133.07	8,133.11	30,793.50	40,849.84	1,213,413
Basin 21	Single-family	12,934,232	797,627	6,320,285	37,881.37	11,361.86	191,635.17	82,447.60	4,333.80	15,598.31	15,598.31	133,699
	Multi-family	8,808,719	393,480	3,418,160	16,343.84	3,418.16	63,956.79	26,332.00	2,633.30	11,342.88	9,868.16	577,164
	Commercial	2,671,841	207,748	1,335,321	6,380.82	2,671.84	39,671.34	17,806.94	1,066.42	3,338.50	10,378.35	326,461
	Public	1,673,021	83,457	836,510	2,363.33	1,673.02	11,923.45	7,133.47	429.31	1,341.28	4,137.89	131,347
	Light Industrial	1,398,720	861,227	649,480	3,108.98	1,398.72	14,422.44	8,409.47	819.57	1,433.46	3,808.86	108,737
	Other Urban	1,129,108	80,410	695,770	3,333.33	695.97	12,904.57	5,376.70	537.57	2,361.73	2,043.14	108,387
	Open	2,351,176	9,107	436,840	2,391.13	663.76	12,573.29	6,667.86	282.01	663.70	2,023.26	0
	Unknown	116,976	8,348	72,352	349.06	72.35	1,333.73	554.55	55.06	244.93	211.49	12,244
	Basin Total	26,573,093	1,641,833	13,379,096	72,262.07	21,809.81	337,340.19	164,800.36	8,720.43	36,606.41	40,287.36	1,457,699
Basin 22	Single-family	441,377	28,770	213,869	1,383.81	380.45	6,343.86	2,813.30	144.57	532.62	532.62	4,866
	Multi-family	39,048	3,040	24,480	117.31	24.48	488.64	169.23	16.90	53.53	72.36	4,177
	Commercial	44,424	3,455	22,212	108.33	44.42	493.88	266.16	11.77	55.53	171.38	5,430
	Public	22,518	4,883	26,399	120.46	22.52	283.53	288.12	21.01	65.46	283.49	6,619
	Light Industrial	8,433	671	4,317	20.62	8.43	98.50	57.35	2.43	10.79	32.39	1,083
	Other Urban	729,376	52,896	451,818	2,153.40	451.82	8,326.73	3,473.33	367.32	1,628.22	1,319.82	78,411
	Open	102,811	420	30,504	109.11	20.28	507.25	204.26	11.54	20.28	92.33	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	1,418,304	89,467	781,570	3,925.94	901.40	17,093.61	7,406.46	804.86	2,305.72	2,433.57	98,806
Basin 23	Single-family	81,389	3,857	34,780	188.33	46.21	789.40	337.19	34.80	61.89	61.89	591
	Multi-family	6,305	486	4,257	18.39	4.80	74.34	28.56	3.10	13.43	11.77	681
	Commercial	11,801	900	3,845	27.83	11.80	130.50	77.84	4.48	14.61	48.57	1,439
	Public	2,378	234	1,439	6.57	2.38	31.97	18.38	1.15	3.89	11.80	282
	Light Industrial	37,230	2,976	18,615	88.94	37.23	413.67	248.39	14.89	46.54	143.54	4,589
	Other Urban	402,646	28,763	249,370	1,188.83	249.37	4,601.82	1,917.46	191.78	843.68	728.64	42,104
	Open	12,720	52	2,466	13.31	3.64	72.74	37.57	1.43	3.64	11.43	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	534,990	36,314	306,425	1,495.61	352.35	6,083.83	2,664.42	233.79	987.40	1,013.45	48,787

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Table 18. Annual Pollutant Loadings of Santa Monica Bay Drainage Basins by Land Use (cont'd).

DRAINAGE BASIN	LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR) TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
Basin 24	Single-family	603,577	28,400	201,527	1,769.96	[illegible]	8,954.80	2,852.32	977.23	728.82	728.82	8,297
	Multi-family	44,304	2,307	27,790	132.57	37.80	813.19	313.83	31.38	94.88	81.25	4,706
	Commercial	22,578	4,113	26,439	226.32	32.88	597.33	252.52	31.15	66.10	200.57	6,463
	Public	48,381	2,763	24,191	113.38	48.38	577.57	222.34	19.38	69.48	188.34	2,913
	Light Industrial	380	14	90	0.43	0.18	2.80	1.30	0.07	0.32	0.89	22
	Other Urban	2,777	270	2,326	11.15	2.34	42.77	17.80	1.80	7.91	6.03	306
	Open	7,344	20	1,604	7.79	2.10	41.87	21.73	0.82	2.10	6.59	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	761,240	46,797	273,826	2,163.83	664.26	10,679.43	4,782.12	262.40	890.71	1,314.80	23,343
Basin 25	Single-family	809,812	47,400	380,847	2,372.80	697.94	12,804.50	2,164.76	263.22	977.12	977.12	8,375
	Multi-family	147,312	10,577	91,317	435.31	91.32	1,465.83	702.44	70.34	289.87	266.93	15,404
	Commercial	70,863	8,512	38,433	169.28	70.86	787.37	472.42	28.35	88.50	273.32	8,861
	Public	113,800	8,841	86,834	371.84	113.57	2,382.99	727.79	43.47	143.89	438.26	13,093
	Light Industrial	4,876	304	2,336	11.17	4.88	81.86	31.18	1.87	9.85	18.83	572
	Other Urban	66,936	4,781	41,437	197.42	41.44	784.99	318.74	31.87	140.25	121.12	7,812
	Open	14,688	60	2,840	13.39	4.30	83.93	43.47	1.88	4.30	13.19	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	1,227,957	77,334	621,083	3,473.72	1,024.10	18,641.88	7,490.80	444.87	1,667.15	2,107.86	83,867
Basin 26	Single-family	990,177	58,843	477,997	2,902.11	853.57	14,481.28	6,316.30	304.28	1,190.90	1,190.90	10,343
	Multi-family	65,577	4,891	40,837	193.90	40.86	720.80	312.75	31.37	137.81	118.84	6,800
	Commercial	20,504	1,995	10,252	48.98	20.50	237.82	126.09	6.30	20.63	79.86	2,506
	Public	41,906	3,299	20,953	180.11	41.91	488.83	279.28	16.76	52.38	161.57	8,122
	Light Industrial	8,316	406	2,608	12.46	5.22	97.95	30.77	2.09	6.53	20.11	637
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	112,810	480	21,833	119.30	32.17	643.40	333.23	13.84	32.17	101.12	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	1,326,050	68,433	574,300	3,377.89	994.22	16,836.83	7,413.21	395.32	1,449.31	1,673.60	28,300
Basin 27	Single-family	421,613	26,715	203,577	1,320.76	263.46	6,351.09	2,699.40	128.11	588.84	588.84	4,363
	Multi-family	21,833	1,539	13,309	64.43	13.51	240.40	103.92	10.30	48.72	39.40	2,206
	Commercial	21,363	1,679	10,791	51.36	21.38	239.81	143.88	8.63	26.98	83.31	2,638
	Public	21,223	1,491	10,613	80.70	21.22	235.81	141.49	8.49	26.53	81.83	2,994
	Light Industrial	7,394	360	2,597	17.19	7.19	79.94	47.86	2.88	8.59	27.74	679
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	243,825	995	47,372	288.75	69.46	1,392.38	721.23	37.57	69.46	210.94	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	737,260	31,186	281,318	1,671.30	406.43	8,449.73	3,844.37	195.57	604.73	960.05	12,739
Basin 28	Single-family	284,836	17,570	167,362	880.46	282.79	4,319.98	1,844.64	99.86	287.91	287.91	3,183
	Multi-family	12,170	860	7,504	35.93	7.83	139.69	57.86	5.80	28.80	22.80	1,275
	Commercial	4,496	380	2,248	10.74	4.30	49.86	29.96	1.80	5.63	17.34	880
	Public	16,187	1,299	8,094	38.87	16.19	178.86	107.91	6.47	20.23	62.41	1,570
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	26,721	3,623	22,732	108.41	22.73	419.86	178.86	17.40	76.94	66.43	3,867
	Open	124,360	508	24,111	131.57	35.53	710.63	368.81	15.06	35.53	111.67	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Basin Total	468,771	23,476	211,880	1,210.21	360.37	6,019.18	2,483.36	143.37	531.73	647.39	10,883

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Table 19. Annual Pollutant Loadings of Santa Monica Bay Watershed by Land Use.

LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR)										
	TSS	BOD5	COD	Total P	Soluble P	TKN	(NO2+NO3)	Total Cu	Total Pb	Total Zn	Oil&Grease
Single-family	23,529,451	1,379,313	11,399,805	68,966	20,784	340,005	150,102	7,790	20,990	20,990	261,010
Multi-family	6,677,270	476,940	4,133,954	19,714	4,130	70,312	31,797	3,100	13,990	12,003	699,324
Commercial	3,371,409	262,220	1,685,780	8,054	3,371	37,400	22,476	1,309	4,214	12,999	412,900
Public	1,807,913	140,615	901,958	4,319	1,800	20,000	12,053	723	2,300	6,971	230,947
Light Industrial	1,509,260	122,052	784,622	3,709	1,500	17,436	10,462	620	1,902	6,090	191,796
Other Urban	3,130,877	224,205	1,903,110	9,267	1,909	35,873	14,907	1,095	6,577	5,600	320,035
Open	25,941,000	105,805	3,029,540	27,530	7,412	140,239	76,767	2,912	9,412	23,299	0
Unknown	138,906	9,300	80,465	385	81	1,409	671	62	273	196	15,651
Watershed Total	66,166,345	2,720,347	23,920,202	141,903	40,002	605,702	319,223	18,036	65,003	93,710	2,110,241

LAND USE	PERCENTAGE OF ANNUAL POLLUTANT LOADINGS										
	TSS	BOD5	COD	Total P	Soluble P	TKN	(NO2+NO3)	Total Cu	Total Pb	Total Zn	Oil&Grease
Single-family	35.6	50.7	43.8	48.6	50.0	56.9	47.0	42.7	43.6	29.7	11.5
Multi-family	10.1	17.5	15.9	13.9	10.2	11.6	10.0	17.6	21.5	12.6	33.1
Commercial	5.1	9.6	6.5	5.7	8.3	5.5	7.0	7.5	6.5	13.6	19.5
Public	2.7	5.2	3.5	3.0	4.5	2.9	3.8	4.0	3.5	7.3	10.5
Light Industrial	2.4	4.5	3.0	2.6	3.9	2.5	3.3	3.5	3.0	6.5	9.1
Other Urban	4.7	8.2	7.5	6.5	6.0	5.2	4.7	8.5	10.1	5.9	15.6
Open	39.2	3.9	19.4	19.4	18.3	23.6	24.0	16.1	11.4	24.3	0.0
Unknown	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.4	0.2	0.6
Watershed Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

LAND USE	UNIT AERIAL POLLUTANT LOADINGS (KG/HA/YR)										
	TSS	BOD5	COD	Total P	Soluble P	TKN	(NO2+NO3)	Total Cu	Total Pb	Total Zn	Oil&Grease
Single-family	376	22.	191	1.10	0.92	5.57	2.40	0.12	0.45	0.45	4
Multi-family	405	29	250	1.19	0.25	4.62	1.93	0.19	0.85	0.73	42
Commercial	446	35	220	1.06	0.45	4.95	2.97	0.10	0.36	1.72	54
Public	390	30	193	0.95	0.39	4.35	2.60	0.16	0.49	1.50	40
Light Industrial	440	30	220	1.05	0.40	4.08	2.93	0.10	0.55	1.09	54
Other Urban	429	30	203	1.27	0.27	4.90	2.80	0.20	0.90	0.70	45
Open	190	1	30	0.23	0.08	1.01	0.57	0.02	0.06	0.17	0
Unknown	300	25	220	1.09	0.23	4.20	1.73	0.10	0.77	0.67	39
Watershed Total	200	11	100	0.60	0.17	2.90	1.33	0.08	0.28	0.40	9

Table 20. Land Use Pollutant Loading Ranking.

LAND USE	RANKING BASED ON POLLUTANT LOADINGS *											
	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease	Overall Ranking
Single-family	2	1	1	1	1	1	1	1	1	1	4	1
Multi-family	3	2	3	3	3	3	3	2	2	4	1	2
Commercial	4	3	5	5	4	4	4	5	5	3	2	4
Public	6	5	6	6	6	6	6	6	6	5	5	6
Light Industrial	7	6	7	7	7	7	7	7	7	6	6	7
Other Urban	5	4	4	4	5	5	5	4	4	7	3	5
Open	1	7	2	2	2	2	2	3	3	2	8	3
Unknown	8	8	8	8	8	8	8	8	8	8	7	8

* 1=highest mass loading; 8=lowest mass loading.

3.2 SUMMARY BY DRAINAGE BASIN

Tables 21 through 23 summarize results of the pollutant loadings model for each drainage basin. These tables report the results in pounds per year, percentage of total loadings, and average pollutant concentrations in milligrams per liter (mg/L).

In a fashion similar to the summary by land uses, a ranking of the drainage basins was developed using both average annual pollutant loadings and concentrations. The results are given in Tables 24 and 25. For this ranking, a ranking of 1 corresponds to the highest average annual loading (or concentration) for a given pollutant and a ranking of 28 corresponds to the lowest average annual loading (or concentration) for the pollutant. As shown in Table 24, the two largest drainage basins (12 - Malibu Creek and 21- Ballona Creek) contribute the largest pollutant loads to Santa Monica Bay (about 65 percent when combined). It should be noted however, that these two basins also contribute approximately 67 percent of the total runoff. When looking at the pollutant concentrations, calculated as the load divided by the total runoff, these two basins rank 8th and 18th respectively. A closer inspection of the concentration rankings (Table 25) reveals that drainage basins 24 through 28, in the urbanized southern section of the watershed, have the highest average annual pollutant concentrations, whereas drainage basins 1 through 5, in the undeveloped northern section of the watershed, have the lowest concentrations.

Table 26 is a comparison of the loads model for Ballona and Malibu Creeks in the State of the Bay report and this loads model. The Ballona Creek comparison shows that the model predicts higher pollutant mass loads to the Bay at reduced flow rates. This discrepancy is possibly a result of the fact that the State of the Bay model used concentration data which was an average of wet weather and dry weather data. The one exception to this would be the lead value which is approximately an order of magnitude higher.

The Malibu creek comparison shows that the flows used in the model are approximately 74 percent lower than the flow used in the State of the Bay report. As a result, it is very difficult to compare the results of the two models. The comparison would tend to suggest, however, that the BOD, COD, and copper data are approximately equal and that the lead and zinc data are high. Oil and Grease data was not presented for Malibu Creek in the State of the Bay report. The model results would not predict flow contributions from any point sources on either Ballona or Malibu Creek. The possible contributions to both flow rates are reported in Section 4.

3.3 SOURCES OF UNCERTAINTY

The average pollutant loading estimates presented above are based on limited data and should be viewed as preliminary. Actual pollutant loadings are anticipated to be highly variable. Factors influencing actual pollutant loadings include:

- Number and intensity of storms
- Length of dry period before storms
- Land use characteristics
- Basin activities including construction and accidental spills

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Table 21. Annual Pollutant Loadings from Santa Monica Bay Watershed.

DRAINAGE BASIN	POLLUTANT LOADINGS (POUNDS PER YEAR)										
	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
01	1,313,129	5,360	254,586	1,394	375	7,504	3,896	147	375	1,179	0
02	232,474	2,424	53,517	293	79	1,524	758	33	98	222	1,129
03	184,912	2,041	42,881	239	65	1,254	620	26	77	175	534
04	189,089	1,608	41,102	229	63	1,219	611	25	68	175	178
05	333,113	3,746	77,223	435	120	2,302	1,135	47	135	313	453
06	1,324,130	20,550	334,497	1,883	535	9,845	4,827	209	628	1,360	6,841
07	1,243,684	20,451	316,202	1,748	510	9,086	4,556	201	597	1,411	12,178
08	662,699	17,383	206,135	1,198	342	6,176	2,865	133	439	694	3,812
09	382,794	5,115	93,060	528	147	2,779	1,355	57	170	364	712
10	663,679	4,739	139,498	773	211	4,126	2,099	83	225	608	482
11	804,366	14,083	206,120	1,123	338	5,816	2,979	133	389	997	11,198
12	14,613,430	272,319	3,964,346	21,848	6,111	111,265	54,318	2,550	8,108	16,083	165,914
13	410,881	8,251	114,483	861	187	3,446	1,628	72	228	406	1,247
14	629,366	12,466	173,716	997	284	5,190	2,475	110	345	643	2,812
15	322,042	2,563	69,050	385	105	2,049	1,031	41	113	296	237
16	2,730,364	45,154	709,497	4,064	1,140	21,285	10,212	441	1,355	2,644	6,451
17	1,061,560	25,275	320,863	1,776	488	8,883	4,210	211	711	1,185	15,133
18	644,354	22,536	229,851	1,343	389	6,840	3,114	152	524	736	6,473
19	2,401,028	64,787	756,185	4,375	1,251	22,458	10,433	490	1,629	2,578	17,663
20	2,638,837	154,961	1,299,540	7,095	1,989	33,197	14,857	935	3,587	4,308	124,651
21	26,975,093	1,641,535	13,379,098	72,262	21,010	337,740	154,900	9,720	36,698	49,288	1,457,699
22	1,418,954	89,447	761,970	3,926	992	17,096	7,486	565	2,306	2,424	98,056
23	524,990	36,314	306,425	1,496	353	6,085	2,659	234	988	1,013	49,727
24	761,340	46,797	373,806	2,164	654	10,679	4,782	262	960	1,215	23,745
25	1,227,957	77,554	621,053	3,474	1,024	16,642	7,491	445	1,667	2,108	53,967
26	1,236,050	68,453	574,300	3,377	994	16,827	7,413	395	1,449	1,676	25,389
27	737,260	31,158	289,318	1,678	497	8,490	3,848	196	687	960	12,759
28	498,771	23,478	211,880	1,219	349	6,019	2,683	145	532	648	10,803
Total	66,166,345	2,720,547	25,920,202	141,983	40,602	685,782	319,223	18,056	65,085	95,710	2,110,241

Table 22. Distribution of Pollutant Loadings from Santa Monica Bay Watershed.

DRAINAGE BASIN	PERCENTAGE OF ANNUAL POLLUTANT LOADINGS										
	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
01	2.0	0.2	1.0	1.0	0.9	1.1	1.2	0.8	0.6	1.2	0.0
02	0.4	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1
03	0.3	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.0
04	0.3	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.0
05	0.5	0.1	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.3	0.0
06	2.0	0.8	1.3	1.3	1.3	1.4	1.5	1.2	1.0	1.4	0.3
07	1.9	0.8	1.2	1.2	1.3	1.3	1.4	1.1	0.9	1.5	0.6
08	1.0	0.6	0.8	0.8	0.8	0.9	0.9	0.7	0.7	0.7	0.2
09	0.6	0.2	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.4	0.0
10	1.0	0.2	0.5	0.5	0.5	0.6	0.7	0.5	0.3	0.6	0.0
11	1.2	0.5	0.8	0.8	0.8	0.8	0.9	0.7	0.6	1.0	0.5
12	22.1	10.0	15.3	15.4	15.1	16.2	17.0	14.1	12.5	16.8	7.9
13	0.6	0.3	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.1
14	1.0	0.5	0.7	0.7	0.7	0.8	0.8	0.6	0.5	0.7	0.1
15	0.5	0.1	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.0
16	4.1	1.7	2.7	2.9	2.8	3.1	3.2	2.4	2.1	2.0	0.3
17	1.6	0.9	1.2	1.3	1.2	1.3	1.3	1.2	1.1	1.2	0.7
18	1.0	0.8	0.9	0.9	1.0	1.0	1.0	0.8	0.8	0.8	0.3
19	3.6	2.4	2.9	3.1	3.1	3.3	3.3	2.7	2.5	2.7	0.8
20	4.0	5.7	5.0	5.0	4.9	4.8	4.7	5.2	5.5	4.5	5.9
21	40.8	60.3	51.6	50.9	51.7	49.2	48.5	53.8	56.4	51.5	69.1
22	2.1	3.3	2.9	2.8	2.4	2.5	2.3	3.1	3.5	2.5	4.6
23	0.8	1.3	1.2	1.1	0.9	0.9	0.8	1.3	1.5	1.1	2.4
24	1.2	1.7	1.4	1.5	1.6	1.6	1.5	1.5	1.5	1.3	1.1
25	1.9	2.9	2.4	2.4	2.5	2.4	2.3	2.5	2.6	2.2	2.6
26	1.9	2.5	2.2	2.4	2.4	2.5	2.3	2.2	2.2	1.8	1.2
27	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.1	1.0	0.6
28	0.8	0.9	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 23. Average Concentrations from Santa Monica Bay Watershed.

DRAINAGE BASIN	AVERAGE POLLUTANT CONCENTRATIONS (MG/L)										
	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
01	490	2	95	0.520	0.140	2.800	1.490	0.055	0.140	0.440	0
02	446	5	103	0.563	0.151	2.921	1.453	0.063	0.187	0.426	2
03	447	5	104	0.578	0.158	3.032	1.499	0.063	0.185	0.423	1
04	464	4	101	0.562	0.154	2.970	1.500	0.060	0.168	0.428	0
05	449	8	104	0.587	0.162	3.105	1.531	0.063	0.183	0.422	1
06	420	7	106	0.598	0.170	3.125	1.532	0.066	0.199	0.432	2
07	405	7	103	0.569	0.166	2.999	1.484	0.065	0.194	0.460	4
08	380	10	110	0.687	0.196	3.540	1.642	0.076	0.252	0.398	2
09	438	6	107	0.604	0.168	3.182	1.551	0.065	0.194	0.417	1
10	471	3	99	0.549	0.150	2.931	1.484	0.059	0.160	0.432	0
11	391	7	100	0.546	0.165	2.829	1.449	0.065	0.189	0.485	5
12	396	7	107	0.592	0.166	3.015	1.472	0.069	0.220	0.436	4
13	400	8	114	0.656	0.185	3.418	1.615	0.071	0.227	0.403	1
14	405	8	112	0.642	0.183	3.341	1.593	0.071	0.222	0.414	2
15	467	4	100	0.550	0.153	2.972	1.496	0.069	0.164	0.430	0
16	423	7	110	0.630	0.177	3.300	1.583	0.068	0.210	0.410	1
17	374	9	113	0.626	0.172	3.150	1.484	0.074	0.251	0.418	5
18	346	12	123	0.720	0.209	3.648	1.670	0.082	0.281	0.395	3
19	374	10	110	0.682	0.195	3.502	1.627	0.076	0.254	0.402	3
20	237	15	126	0.690	0.193	3.229	1.445	0.091	0.349	0.419	12
21	247	15	122	0.661	0.192	3.009	1.417	0.089	0.336	0.451	13
22	237	15	127	0.656	0.166	2.858	1.252	0.094	0.385	0.405	16
23	215	15	126	0.613	0.145	2.495	1.090	0.096	0.405	0.416	20
24	263	16	129	0.748	0.226	3.092	1.653	0.091	0.332	0.420	8
25	251	16	127	0.710	0.209	3.400	1.531	0.091	0.341	0.431	11
26	285	16	133	0.779	0.229	3.804	1.711	0.091	0.335	0.387	6
27	316	13	124	0.719	0.213	3.622	1.649	0.084	0.294	0.411	5
28	302	14	128	0.738	0.211	3.642	1.624	0.088	0.322	0.392	7
Total	302	12	118	0.649	0.185	3.132	1.458	0.082	0.297	0.437	10

Table 24. Drainage Basin Ranking by Pollutant Loadings.

DRAINAGE BASIN	RANKING BASED ON POLLUTANT LOADINGS * TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease	Overall Ranking
01	8	21	15	15	15	14	13	16	19	13	28	16
02	26	26	26	26	26	26	26	26	26	26	21	26
03	28	27	27	27	27	27	27	27	27	27	23	27
04	27	28	28	28	28	28	28	28	28	28	27	28
05	24	24	24	24	24	24	24	24	24	24	25	24
06	7	15	10	10	10	10	9	12	13	10	15	10
07	9	16	12	12	11	11	11	13	14	9	12	12
08	17	17	18	18	18	16	17	18	17	18	18	19
09	23	22	23	23	23	23	23	23	23	23	22	23
10	16	23	21	21	21	21	21	21	22	21	24	21
11	13	18	19	19	19	19	16	19	18	15	13	18
12	2	2	2	2	2	2	2	2	2	2	2	2
13	22	20	22	22	22	22	22	22	21	22	20	22
14	19	19	20	20	20	20	20	20	20	20	19	20
15	25	25	25	25	25	25	25	25	25	25	26	25
16	3	9	6	5	5	5	5	7	8	4	17	7
17	12	12	11	11	13	12	12	11	11	12	10	11
18	18	14	16	16	14	15	15	15	16	17	16	15
19	5	7	5	4	4	4	4	5	6	5	9	4
20	4	3	3	3	3	3	3	3	3	3	3	3
21	1	1	1	1	1	1	1	1	1	1	1	1
22	6	4	4	6	8	6	7	4	4	6	4	5
23	20	10	13	14	16	17	19	10	9	14	6	14
24	14	8	9	9	9	9	10	9	10	11	8	9
25	11	5	7	7	6	8	6	6	5	7	5	6
26	10	6	8	8	7	7	8	8	7	8	7	8
27	15	11	14	13	12	13	14	14	12	16	11	13
28	21	13	17	17	17	18	18	17	15	19	14	17

* 1=highest mass loading; 28=lowest mass loading.

Table 25. Drainage Basin Ranking by Pollutant Concentrations.

DRAINAGE BASIN	RANKING BASED ON AVERAGE POLLUTANT CONCENTRATIONS *											Overall Ranking
	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease	
01	1	28	28	28	28	27	23	28	28	4	28	28
02	7	24	23	23	25	24	22	24	22	11	18	25
03	6	23	21	21	22	18	16	22	23	12	20	22
04	4	25	24	24	23	20	15	25	25	10	25	24
05	5	22	20	20	21	16	13	23	24	13	24	21
06	10	20	19	18	13	15	12	18	18		17	17
07	13	19	22	22	17	22	18	19	19	2	13	20
08	16	12	11	8	7	6	5	12	12	25	16	9
09	8	21	18	17	18	13	11	20	20	17	23	19
10	2	27	27	20	26	23	19	27	27	6	27	27
11	15	18	25	27	20	26	24	21	21	1	10	23
12	14	16	17	19	19	19	21	16	16	5	12	10
13	11	14	13	12	11	8	6	14	14	23	21	12
14	12	15	15	15	12	10	9	15	15	19	19	13
15	3	26	26	25	24	21	17	26	26	9	26	26
16	9	17	16	14	13	11	18	17	17	21	22	16
17	18	13	14	15	14	14	20	13	13	16	11	14
18	19	10	9	4	6	3	2	10	10	26	14	6 (tie)
19	17	11	12	9	8	7	6	11	11	24	15	10
20	24	4	6	7	9	12	25	4	3	19	4	6 (tie)
21	26	5	10	10	10	17	26	7	5	3	3	6
22	27	6	4	11	10	25	27	2	2	22	2	11
23	28	7	7	16	27	28	28	1	1	18	1	15
24	23	1	2	2	2	2	3	6	7	14	6	1
25	25	2	5	6	5	9	14	5	4	6	5	3
26	22	3	1	1	1	1	1	3	6	26	8	2
27	20	9	8	5	3	5	4	9	9	20	9	5
28	21	8	3	5	4	4	7	8	8	27	7	4

* 1=highest concentration; 28=lowest concentration.

Table 26. Comparison of Model Results with the State of the Bay Report (using 83-84 average data)

Parameter	State of the Bay	Model	Difference	Percent Difference
Ballona Creek				
Flow (Ac-Ft/yr)	56,750	40,200	-16,550	-29
BOD (lb/yr)	1,477,300	1,641,500	164,200	11
COD (lb/yr)	8,385,300	13,379,100	4,993,800	60
Copper (lb/yr)	4,900	9,700	4,800	98
Lead (lb/yr)	2,500	36,700	34,200	1,368
Zinc (lb/yr)	13,100	49,300	36,200	276
Oil and Grease (lb/yr)*	787,600	1,457,700	670,100	85
Malibu Creek				
Flow (Ac-Ft/yr)	52,700	13,570	-39,130	-74
BOD (lb/yr)	574,200	272,300	-301,900	-53
COD (lb/yr)	9,730,600	3,964,300	-5,766,300	-59
Copper (lb/yr)	3,100	2,550	-550	-18
Lead (lb/yr)	1,400	8,100	6,700	479
Zinc (lb/yr)	11,200	16,100	4,900	44

◆ NPDES discharges are not included and may contribute as much as 1,600 and 7,8000 acre-ft/yr to the measured flows for Ballona and Malibu Creeks, respectively.

* only 1983 data available for oil and grease

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Deviations of any of these factors from average conditions will result in variations in the annual pollutant loads. Factors specifically influencing the results for Santa Monica Bay include the following:

- Only storm flows were considered in the analyses; base flows, illicit connections, and illegal dumping may contribute to pollutants loads. Also, only storms with 0.1 inches of rain were considered in this study.
- Uneven rainfall patterns over a particular basin was estimated and based on catchment boundaries, i.e. uneven rainfall within a catchment was not considered.
- Existing BMPs were not co...dered; any water quality improvements due to these BMPs were not modeled.
- Flows and concentrations were based on typical values of percent imperviousness and runoff concentrations.
- The Santa Monica Bay water quality data was collected by grab samples whereas the NURP data used for comparison were collected as composite samples. Also, the NURP data were site median concentrations whereas the Santa Monica data were event median concentrations.
- The land use data was collected in 1987 and may no longer be valid in some areas. Also, for some of the categories such as Other Urban, which consists of urban areas not distinguishable by aerial photography, and Unknown percent impervious values were estimated.

Also, it should be noted that the pollutant concentration levels selected for this study are higher than values seen from other stormwater studies. The values selected for the model were based on the few data available for Santa Monica Bay. The concentration values should be adjusted after more extensive monitoring to better reflect actual pollutant runoff concentrations.

The impact of potential errors in the water quality parameter estimates, land use or area estimates, is linear. The model is linear in the parameters. Therefore a hypothetical 5% error in a water quality parameter would have a 5% error when the parameter is used in the model calculations.

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4.0 COMPARISONS TO POINT SOURCES

It is interesting to compare the wet weather flow rates to the dray weather flow that results from permitted discharges. There are a number of permitted dischargers that are allowed to discharge their effluent directly into one or more storm drains. Two examples of allowable practices are the discharge of cooling tower blow-down or bleed-off (a portion of circulating cooling water is purposefully discharged and replaced with tap water to prevent salt build-up), and ground dewatering (pumping of shallow groundwater to prepare sites for construction. Normally these flows are not contaminated and are not though to pose a problem. There is a concern that these low flows may flush accumulated materials in the storm drains to the ocean, or may mask an illegal discharge.

In order to determine the magnitude of permitted flows to storm drains, a database of the Los Angeles Regional Water Resources Control Board's permits was created. The database was then used to develop total discharge estimates. Table 27 shows the results of the database development. The maximum allowable flow to Ballona Creek, from these permits is approximately 1,410,000 gallons per day, or approximately 2.18 cu ft/sec. This flow rate is negligibly small during an average storm event (see Table 7) but can impact the overall yearly discharge. For Malibu Creek the permitted discharges may be as much as 15% of the flow measured in the State of the Bay report, or more than 50% of the predicted flows (model results).

The discharges represented in Table 27 are maximums. There may have been no discharge during the periods reviewed; the permit represents the maximum allowable discharge.

No comparisons to large treatment plant discharges (e.g. Hyperion) were made, since they were beyond the scope of this study. Such comparisons would be useful and could be helpful in determining the benefits of both increased treatment plant removal efficiency and stormwater best management practices.

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Table 27. Summary of NPDES Permits to Stormwater Drains.

Permit Number	Permittee Name	Reporting Period	Average Flow Rate (gpd)	Average TSS Mass (lb/day)	Average BOD Mass (lb/day)	Average O&G Mass (lb/day)	Average Temp (oF)	Discharge Type	Receiving Water	C
1786	Cochran (342)			NO REPORTS FILED				Groundwater dewatering	Ballona Creek	Los A
52710	Federal Employees Distributing Company	1/90 - 12/90	1,000	0.15	0.02	0.02	80	Cooling tower bleed off	Ballona Creek	Los A
52807	Pacific Management Company	1/90 - 12/90	4,000				72	Cooling tower bleed off	Ballona Creek	Los A
53074	Reef USA Fund II	1/90 - 12/90	1,000	0	0	0	70	Groundwater seepage	Ballona Creek	Holl
53091	Mark Wilshire Associates	1/90 - 12/90	2,390	0.07	0.31	0.07	70	Cooling tower bleed off	Ballona Creek	Los A
53139	Culver City Unified School District	4Q 90	4,000	2.23	0	Not Reported	80	Backwash waste	Ballona Creek	Culv
53163	Delta Towers Joint Venture	1/90 - 6/90	1,400		0.01	0.07	79	Subsoil drainage	Ballona Creek	Los A
53163	Delta Towers Joint Venture	1/90 - 12/90	1,400	0	0	0		Groundwater seepage	Ballona Creek	Los A
53228	Cedars-Sinai Med.	1/90 - 11/90	30,000	0	0	0		Subsoil drainage	Ballona Creek	Los A
53261	R & B Enterprises	1/90 - 12/90	900	0.21	0.64	0.64		Subsoil drainage	Ballona Creek	Los A
53279	Wilshire Highland Bldg.	1/90	2,000	0.07	<0.01	<0.02	66	Subsoil drainage	Ballona Creek	Los A
53287	Pine Realty - Gateway West	1/90 - 12/90	10,000	0	0	0		Groundwater seepage & reflect	Ballona Creek	Los A
53490	Holiday Inns, Inc.	1/90 - 12/90	800	0.22	0.04		70	Swimming pool drainage	Ballona Creek	Los A
53503	Coldwell Banker Real Estate Services	1/90 - 12/90	2,000	0.06	0.02	0.07	70	Subsoil drainage	Ballona Creek	Los A
53503	Topa	1/90 - 12/90	2,000	0	0	0		Groundwater seepage	Ballona Creek	Los A
53511	Howard David Ltd & Fintch Bldg Mngmt Corp	1/90 - 12/90	900	0.11	0.15	0.07	75	Cooling tower bleed off	Ballona Creek	Los A
53532	Nationwide Theatres	1/90 - 12/90	600	0	0	0		Cooling tower bleed & Subsoil drainage	Ballona Creek	Los A
53996	City of Los Angeles	1/90 - 12/90	36,200	0	0	0		Cooling tower bleed off	Ballona Creek	Los A
[illegible]	City of Santa Monica	1/90 - 12/90	373,000	422.6			71	Plant backwash waste	Ballona Creek	Los A
5412[illegible]	Century Towers	1/90 - 12/90		NO DISCHARGE				Swimming pool drainage	Ballona Creek	Los A
54305	Holiday Inns, Inc	1/90 - 12/90	500	0.02	0.01		75	Groundwater seepage, pool backwash	Ballona Creek	Holl
54453	University of Southern California	1/90 - 12/90	5,000				84	Backwash waste	Ballona Creek	Los A
54861	Harbor Inc.	1/90 - 12/90	1,400					Cooling tower bleed & Subsoil drainage	Ballona Creek	Los A
54887	Scottish Rite Cathedral Assn.	1/90 - 12/90	700	0	0	0		Cooling tower bleedoff	Ballona Creek	Los A
54909	City of Inglewood	1/90 - 12/90		NO DISCHARGE				Vehicle wash water, service area rainfall	Ballona Creek	Ingl
55361	Universal Properties, Inc.	4/90 - 6/90	1,800				76	Cooling tower bleed off	Ballona Creek	Beve
55409	The Salvation Army	7/90 - 12/90	20,000	0	0	Not Reported	80	Backwash waste	Ballona Creek	Los
55638	Westin Hotels, Inc	1/90 - 12/90	1,572	17.53	0.0[illegible]		80	Backwash waste	Ballona Creek	Los
55708	Jilco Industries	1/90 - 12/90	1,800	0.19	0.0[illegible]	0.0[illegible]	67	Groundwater, cooling water, fountain	Ballona Creek	Beve
56707	Great Western Savings & Loan	1/90 - 12/90	3,090	0	0	0		Gradwater seepage, no additive	Ballona Creek	Beve

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Table 27. Summary of NPDES Permits to Stormwater Drains (cont'd).

Permit Number	Permittee Name	Reporting Period	Average Flow Rate (gpd)	Average TSS Mass (lb/day)	Average BOD Mass (lb/day)	Average O&G Mass (lb/day)	Average Temp. (o F)	Discharge Type	Receiving Water	City
58297	Wilshire Blvd. Office Bldg.	1/90 - 12/90	2,000	0	0	0		G water seepage, cooling-tower bleed.	Ballona Creek	Los Angeles
59602	City of Inglewood	1/90 - 12/90	NO DISCHARGE					Swimming pool drainage	Ballona Creek	Inglewood
59382	Realty Center Management	1/90 - 12/90	50,000	0	0	0		Groundwater seepage	Ballona Creek	Los Angeles
59404	Carolco Pictures	1/90 - 12/90	50,000	0	0	0	73	Cooling tower and groundwater	Ballona Creek	Los Angeles
59421	City of Beverly Hills	4/90 - 12/90	40,097	0	0	0	61	Groundwater seepage	Ballona Creek	Beverly Hills
59722	L.A. County Museum of Nat. History	1/90 - 3/90	NO DISCHARGE					Groundwater seepage, ponded rainfall	Ballona Creek	Los Angeles
59765	Coastfed Properties	3rdQ & 4thQ 90	300	0	0	0		Groundwater seepage	Ballona Creek	Beverly Hills
59781	Museum Terrace Apartments	1/90 - 12/90	1,500	0.14	0.06	0.06	70	Subsoil drainage	Ballona Creek	Los Angeles
59803	Cal-Fed Capital Thayer Associates	1/90 - 12/90	900	0.02	0.05	0.03	72	Groundwater waste	Ballona Creek	Los Angeles
59889	The Carden Company	1/90 - 12/90	65,000				64	Groundwater seepage	Ballona Creek	Los Angeles
60062	Marcello Manor Apartments	1/90 - 9/90	9,000	0.7	0.33	0.15	70	Groundwater seepage	Ballona Creek	Los Angeles
60062	Marcelline Man.	1/90 - 12/90	9,000	0	0	0		Groundwater dewatering	Ballona Creek	Los Angeles
60143	Wilshire Westwood Associates	1/90 - 6/90	100	0.12			68	Subsoil drainage	Ballona Creek	Los Angeles
60143	Wilshire Westwood Assn.	1/90 - 12/90	100	0	0	0		Groundwater dewatering	Ballona Creek	Los Angeles
60186	Center for Early Education	1/90 - 12/90	75,000					Groundwater dewatering	Ballona Creek	Los Angeles
60239	Bracton Corporation	7/90 - 9/90					70	Groundwater waste	Ballona Creek	Los Angeles
60259	Hare Corp.	1/90 - 9/90	5,000	0	0	0		Groundwater dewatering	Ballona Creek	Los Angeles
60381	Lake View Mansion Partnership	1/90 - 12/90	100				74	Groundwater waste	Ballona Creek	Los Angeles
60411	Third and Fairfax Plaza Associates	10/90 - 12/90	15,053			0.01	73	Groundwater waste	Ballona Creek	Los Angeles
60542	Parkside Assn.		NO DISCHARGE (PERMIT INACTIVE)					Treated groundwater during construction	Ballona Creek	Los Angeles
60623	Two Rodeo Assn.	12/90	30,000	0	0	0		Groundwater dewatering	Ballona Creek	Beverly Hills
60640	Huntley Drive Assn. (Sheldon M. Gordon)	1/90 - 12/90	5,000	0	ND	ND		Groundwater dewatering	Ballona Creek	Los Angeles
60658	Los Angeles Free Clinic	1/90 - 12/90	1stQ - 150	Not Reported		1stQ - <0.006	60	Groundwater dewatering	Ballona Creek	Los Angeles
60763	Tracinda Corporation	1/90 - 12/90						Groundwater seepage	Ballona Creek	Beverly Hills
60763	MGM/UA Comm.	1/90 - 12/90	22,000	0.6411809	0.3975322	0.4213474644		Groundwater seepage	Ballona Creek	Beverly Hills
60810	Dorchester	5/90 - 12/90	100,000	0	0	Not Reported		Groundwater - no additives	Ballona Creek	Los Angeles
60879	Westwood Gateway	1/90 - 11/90	23,110	Not Reported		<0.96		Treated groundwater from chlorinated org. solvent	Ballona Creek	Los Angeles
61115	Howard Hughes	1/90 - 11/90	7,200	Not Reported		0.24		Treated groundwater	Ballona Creek	Los Angeles
61123	Jan Development		NO DISCHARGE REPORTED						Ballona Creek	Los Angeles
61140	Jack Slomovic - 01	1/90 - 12/90	17,400	0	0	0		Groundwater dewatering	Ballona Creek	Los Angeles
61150	Jack Slomovic - 02	1/90 - 12/90	17,400	0	0	0		Groundwater - no additives	Ballona Creek	Los Angeles
61221	Abraham Moradzadeh Sunshore		6,952 NO DISCHARGE					-	Ballona Creek	Los Angeles

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Table 27. Summary of NPDES Per..., to Stormwater Drains (cont'd).

Permit Number	Permittee Name	Reporting Period	Average Flow Rate (gpd)	Average TSS Mass (lb/day)	Average BOD Mass (lb/day)	Average O&G Mass (lb/day)	Average Temp. (o F)	Discharge Type	Receiving Water	City
61239	Miracle Mile HR-Capital	6/90 - 12/90	2,200	0	0	0		Groundwater dewatering (treated)	Ballona Creek	Los Angeles
61247	Beverly Mercedes Plaza		6,978	NO DISCHARGE				-	Ballona Creek	Los Angele
61263	Alvarado Grand Plaza		6,950	NO REPORTS					Ballona Creek	Los Angele
61271	Project West Corp.	7/90 - 12/90	25,000	0	0	0		Groundwater dewatering	Ballona Creek	Los Angele
61506	Ogden Ave. Assn.	1/90 - 9/90		NO DISCHARGE				Groundwater dewatering	Ballona Creek	Los Angele
61531	WBM Partners Develop Corp.	7/90 - 9/90		NO DISCHARGE REPORTED				Groundwater	Ballona Creek	Los Angele
61557	Hayworth Assn.	7/90 - 10/90		NO DISCHARGE REPORTED					Ballona Creek	Los Angele
61603	Wilshire West Inc.	3rd & 4thQ 90	16,580	0	0	ND		Groundwater dewatering	Ballona Creek	Los Angele
61662	Glenfed Develop.	9/90 - 12/90		NO DISCHARGE				Wastewater - underground drainage	Ballona Creek	Los Angele
61735	CWD Detroit Assn.			NO RECORD OF DISCHARE				Groundwater dewatering	Ballona Creek	Los Angele
61743	CWD Cloverdale Assn.			NO RECORD OF DISCHARE				Groundwater dewatering	Ballona Creek	Los Angele
61751	Peter Giorgianni	1/90 - 9/90		NO DISCHARGE				Groundwater dewatering	Ballona Creek	Los Angele
61803	Pangloveian Assn.			NO REPORTS FILED				Groundwater dewatering	Ballona Creek	Los Angele
61832	House Ear Institute	8/90 - 12/90	1,890					Groundwater waste	Ballona Creek	Los Angele
61875	Westlake Kingston	4thQ 90	17,200	0	0	ND		Groundwater dewatering	Ballona Creek	Beverly Hill
61883	McGregor Co.	1/90 - 12/90		NO DISCHARGE				Groundwater dewatering	Ballona Creek	Los Angele
61891	Clinton Partnership	7/90 - 12/90	33,120	0	0	0		Groundwater dewatering	Ballona Creek	Los Angele
61948	S. Doheny HR-Capital	9/90 - 11/90	7,200	0	0	ND		Groundwater dewatering (Treated)	Ballona Creek	Los Angele
62154	Clark Swall Ltd.		7,801	NO REPORTS FILED				Groundwater dewatering	Ballona Creek	Los Angele
			1,412,995	445.87118	2.1375322	1.801347464				
50014	Las Virgenes MWD	1/90 - 12/90	7,000,000	0	0	0	78	Wastewater discharge	Malibu Creek	Malibu
53112	State Farm Auto Inc.	1/90 - 12/90	11,224	0	0	0	74	Cooling tower bleedoff	Malibu Creek	Westlake Vill
			7,011,224	0	0	0				
00372	GBW Properties	1/90 - 12/90	2,402	Not Reported		0.04		Groundwater dewatering	Marina del rey	Marina del r
54009	Windward Yacht & Repair			NO DATA SUBMITTED				Boat washing waste water	Marina d.r. Hbr	Marina del r
57027	Stecher Resources (discharge in Feb, May only)	2/90 - 12/90	86,000 & 7,055	Not Reported		2.31 & 0.29			Centinela Creek	Inglewood
57657	L.A. County DWP-1	1/90 - 12/90		NO DISCHARGE						Los Angele
57711	L.A. County DWP-2	1/90 - 12/90		NO DISCHARGE						Los Angele

Table 27. Summary of NPDES Permits to Stormwater Drains (cont'd).

Permit Number	Permittee Name	Reporting Period	Average Flow Rate (gpd)	Average TSS Mass (lb/day)	Average BOD Mass (lb/day)	Average O&G Mass (lb/day)	Average Temp. (in F)	Discharge Type	Receiving Water	City
57771	L.A. County DWP-3,4	1/90 - 12/90		NO DISCHARGE						Los Angeles
58076	L.A. County DWP-8 (011 & 014)	1/90 - 12/90	21,496 & 18,715		Not Reported	2.08 & 2.34	64	Control of Saltwater Intrusion	Pacific Ocean	Los Angeles
57894	L.A. County DWP-5	1/90 - 12/90		NO DISCHARGE						Los Angeles
57959	L.A. County DWP-6	1/90 - 12/90		NO DISCHARGE						Los Angeles
58017	L.A. County DWP-7	1/90 - 12/90		NO DISCHARGE						Los Angeles
61085	L.A. County DWP-9	1/90 - 12/90		NO DISCHARGE						Los Angeles
370	City of Los Angeles	1/90 - 12/90	290,909,091					Cooling tower runoff	SM Bay	Los Angeles
34615	Milton Meyer		5,881					Groundwater dewatering		
59412	Amir Devel.		6,000	3.67				Groundwater dewatering seepage		
61357	Los Feliz Assn.									
61379	Unocal # 0981									
61475	Unocal # 1715									
60708	Unocal # 2325									
61468	Unocal # 0932									
61522	Arco Petroleum									
61611	L.A. County Medical Assn.									
60593	DMG, Ltd	3rd Q. 90	205,000	<0.1	0	<2.00				
59943	Pacific Design		6,755					Leaky tank		
60054	General Telephone									
60160	Wilshire Glendon							Leaky tank		
59617	General Telephone									
59706	Sunlin Corp.									
60402	Howard Hughes									
60771	American Home		6,851					Leaky tank		
60828	Texaco Refining									
60411	Third & Fairfax									
60488	Hamant Devel.									
60674	Texaco Refining									
61107	Unocal # 1715									

As noted in the introduction, estimates of the annual loads can be used to identify catchments with the largest expected pollutant loads, site stormwater quality monitoring stations, and select types of and locations for applying source control and structural BMPs. Estimates of the annual pollutant load of the cumulative discharges to waters of the United States are also required for Part 2 of the application for NPDES Stormwater Permits for municipalities. It should be noted, however, that areas which contribute a large quantity of runoff, often times are identified as being the largest pollutant load source. This is not an indication that the area is excessively polluted, just that it contributes a large quantity of stormwater to the receiving water body. This point becomes apparent when dealing with large open areas.

Based on the estimates of annual pollutant loads, the model shows that, overall, single-family residential areas contribute the largest loads of pollutants to the Bay. Again, this due to the large area that this land use makes up. However, higher concentrations of oxygen demand and nutrients are also associated with single-family residential areas. Therefore, public education and awareness about stormwater pollution may be considered as a Best Management Practice (BMP) for residential areas.

The loads model also shows that the urbanized South Bay and West Los Angeles drainage basins (20 through 28) have high loads as well as high concentrations of pollutants. These areas should also be targeted in the stormwater monitoring program and BMP design. Basin 21 (Ballona Creek) had the overall highest pollutant load ranking, although this can be misleading due to its size. Basins 24-28 had the highest 5 pollutant concentration rankings, in respective order. This indicates that these areas may require more structural and pollutant abatement oriented BMPs and should be considered candidates for early action BMP programs.

Beyond the general BMPs mentioned above an Illicit discharge and Illegal dumping elimination program should be considered for the highly urbanized basins.

Although some data are available, hydrologic and water quality data collected in the stormwater monitoring program should be used to update the estimates of annual pollutant loadings with site-specific data. A monitoring program that helps characterize the pollutant concentrations associated with the various land uses should be developed. Stream stations, which drain mixed land uses should also be monitored to help calibrate the model. A model such as this one is only as good as its input data, and the more data available for calibration the better. It is also recommended that the results of this model be used for comparison with and, where appropriate, to update the status and trends of pollutant loading to Santa Monica Bay.

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ABBREVIATIONS AND SYMBOLS

Abbreviation	Definition
BNAs	Base/Neutral and Acid Extractables
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
N	Elemental Nitrogen
P	Elemental Phosphorous
PAHs	Polyaromatic Hydrocarbons
PCBs	Polychlorobiphenyls
SS	Suspended Solids
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TPHs	Total Petroleum Hydrocarbons
TS	Total Solids
TSS	Total Suspended Solids
VOCs	Volatile Organic Compounds

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8.0 APPENDIX A

This appendix describes the land use, hydrology and annual pollutant loadings by catchments for the Santa Monica Bay Watershed.

TABLE A-2
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
01	ARSEQ1	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	98	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	2,169.08	0	0.10	1.6	21.5	857,000	23,712,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	2,169.08	0	0.10	1.6	21.5	857,000	23,712,000
	ARSEQ2	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	98	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	2,912.09	0	0.10	1.6	28.9	1,150,000	[illegible]
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	2,912.09	0	0.10	1.6	28.9	1,150,000	31,400,000
	ARSEQ3	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	98	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	1,904.27	0	0.10	1.3	15.4	612,000	8,792,000
		Unknown	0	0.05	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,904.32	0	0.10	1.3	15.4	612,000	8,792,000
	SMB1	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	98	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	99	28.59	0	0.10	1.3	0.3	11,000	376,000
		Unknown	1	0.23	65	0.54	1.3	0.0	0	0
		Catchment Total	100	28.82	0	0.10	1.3	0.3	11,000	376,000
	SMB2	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	98	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	127.71	0	0.10	1.3	1.0	[illegible]	600,000
		Unknown	0	0.02	65	0.54	1.3	0.0	0	0
		Catchment Total	100	127.73	0	0.10	1.3	1.0	[illegible]	[illegible]
	SMB3	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	98	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	40.72	0	0.10	1.3	0.3	12,000	182,000
		Unknown	0	0.15	65	0.54	1.3	0.0	0	0
		Catchment Total	100	40.87	0	0.10	1.3	0.3	12,000	182,000
	SMB4	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	98	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	97	7.11	0	0.10	1.3	0.1	2,000	32,000
		Unknown	3	0.20	65	0.54	1.3	0.0	0	0
		Catchment Total	100	7.31	3	0.11	1.3	0.1	2,000	32,000

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TABLE A-2
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
SB	SMB10	Single-family	29	8.79	42	0.39	1.2	0.3	20,000	300,000
		Multi-family	0	0.00	68	0.51	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	71	21.44	0	0.10	1.2	0.3	6,000	96,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	30.12	12	0.15	1.2	0.4	26,000	394,000
	SMB11	Single-family	46	18.20	42	0.39	1.2	0.5	21,000	344,000
		Multi-family	0	0.00	68	0.51	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	36	14.10	80	0.66	1.2	0.7	28,000	440,000
		Open	18	7.22	0	0.10	1.2	0.1	2,000	32,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	39.53	46	0.43	1.2	1.3	51,000	816,000
	SMB12	Single-family	13	6.07	42	0.39	1.2	0.3	7,000	112,000
		Multi-family	0	0.00	68	0.51	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	10	4.36	80	0.66	1.2	0.3	9,000	144,000
		Open	77	35.36	0	0.10	1.2	0.3	11,000	176,000
		Unknown	0	0.02	65	0.56	1.2	0.0	0	0
		Catchment Total	100	46.03	13	0.19	1.2	0.7	27,000	432,000
	SMB3	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.51	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	18.67	0	0.10	1.2	0.1	6,000	96,000
		Unknown	0	0.01	65	0.56	1.2	0.0	0	0
		Catchment Total	100	18.68	0	0.10	1.2	0.1	6,000	96,000
	SMB4	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.51	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	37.40	0	0.10	1.2	0.4	17,000	272,000
		Unknown	0	0.01	65	0.56	1.2	0.0	0	0
		Catchment Total	100	37.41	0	0.10	1.2	0.4	17,000	272,000
	SMB7	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.51	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	22.91	0	0.10	1.2	0.3	10,000	160,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	22.91	0	0.10	1.2	0.3	10,000	160,000
	SMB8	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.51	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	77.22	0	0.10	1.2	0.4	22,000	352,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	77.22	0	0.10	1.2	0.4	22,000	352,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

TABLE A-1
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB9	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	99	37.08	0	0.10	1.2	0.3	11,000	176,000
		Unknown	1	0.41	65	0.56	1.2	0.0	1,000	16,000
		Catchment Total	100	37.49	1	0.11	1.2	0.3	12,000	192,000
	SMCK	Single-family	3	22.67	42	0.39	1.2	0.4	16,000	256,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	3.01	80	0.66	1.2	0.2	6,000	96,000
		Open	96	621.45	0	0.10	1.2	6.7	267,000	4,272,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	647.13	1	0.11	1.2	7.3	289,000	4,624,000
	WLWCL1	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	240.20	0	0.10	1.2	1.8	71,000	1,136,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	240.20	0	0.10	1.2	1.8	71,000	1,136,000
80	LALB1	Single-family	1	11.20	42	0.39	1.2	0.4	14,000	224,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	99	932.60	0	0.10	1.2	7.5	299,000	4,784,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	943.80	0	0.10	1.2	7.9	313,000	5,008,000
	SMB13	Single-family	10	2.76	42	0.39	1.2	0.1	4,000	64,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	10	2.80	80	0.66	1.2	0.2	7,000	112,000
		Open	81	22.55	0	0.10	1.2	0.3	9,000	144,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	28.11	12	0.16	1.2	0.5	20,000	320,000
	SMB14	Single-family	24	9.97	42	0.39	1.2	0.3	12,000	192,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	10	3.97	80	0.66	1.2	0.2	8,000	128,000
		Open	66	27.27	0	0.10	1.2	0.2	8,000	128,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	41.21	18	0.22	1.2	0.7	28,000	448,000
	SMB15	Single-family	17	4.36	42	0.39	1.2	0.1	5,000	80,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	83	21.92	0	0.10	1.2	0.2	6,000	96,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	26.28	7	0.15	1.2	0.3	11,000	176,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF R_v	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CF)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	SMB 16	Single-family	39	19.17	42	0.30	1.2	0.4	22,000	282,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	61	29.43	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.56	1.2	0.2	9,000	144,000
							1.2	0.0	0	0
		Catchment Total	100	48.60	37	0.21	1.2	0.6	31,000	426,000
	SMB 17	Single-family	99	8.30	42	0.30	1.2	0.3	31,000	374,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	1	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.07	65	0.56	1.2	0.0	0	0
							1.2	0.0	0	0
		Catchment Total	100	8.39	41	0.30	1.2	0.3	31,000	374,000
04	LACHU1	Single-family	0	0.00	42	0.30	1.2	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	326.06	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.56	1.2	0.7	265,000	4,340,000
							1.2	0.0	0	0
		Catchment Total	100	326.06	0	0.10	1.2	0.7	265,000	4,340,000
	LACHU3	Single-family	8	7.83	42	0.30	1.2	0.2	9,000	144,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	92	89.08	0	0.10	1.2	0.0	0	0
		Unknown	0	0.01	65	0.56	1.2	0.7	26,000	416,000
							1.2	0.0	0	0
		Catchment Total	100	96.94	3	0.12	1.2	0.9	35,000	560,000
	SMB 18	Single-family	72	13.30	42	0.30	1.2	0.4	22,000	260,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	28	5.04	0	0.10	1.2	0.0	0	0
		Unknown	0	0.07	65	0.56	1.2	0.0	2,000	34,000
							1.2	0.0	0	0
		Catchment Total	100	18.31	31	0.31	1.2	0.4	24,000	294,000
	SMB 19	Single-family	10	24.62	42	0.30	1.2	0.7	28,000	440,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	90	211.61	0	0.10	1.2	0.0	0	0
		Unknown	0	0.73	65	0.56	1.2	1.6	62,000	3,088,000
							1.2	0.0	1,000	16,000
		Catchment Total	100	236.42	4	0.13	1.2	2.3	92,000	3,472,000
05	ENCRL1	Single-family	0	0.00	42	0.30	1.2	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	1,976.96	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.56	1.2	8.7	346,000	5,536,000
							1.2	0.0	0	0
		Catchment Total	100	1,976.96	0	0.10	1.2	8.7	346,000	5,536,000

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TABLE A-1
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMCL2	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	74.34	0	0.10	1.3	0.6	24,000	384,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	74.34	0	0.10	1.3	0.6	24,000	384,000
	SMCL3	Single-family	11	36.77	42	0.39	1.2	0.3	20,000	384,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	89	237.46	0	0.10	1.2	1.0	41,000	656,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	274.23	5	0.13	1.3	1.3	60,000	960,000
	SMB20	Single-family	16	5.61	42	0.39	1.2	0.2	6,000	96,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	84	30.43	0	0.10	1.2	0.2	9,000	144,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	36.04	7	0.13	1.3	0.4	15,000	240,000
	SMB21	Single-family	21	11.71	42	0.39	1.2	0.3	14,000	224,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	79	44.30	0	0.10	1.3	0.3	13,000	208,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	56.01	9	0.16	1.2	0.7	27,000	432,000
	SMB22	Single-family	19	14.03	42	0.39	1.2	0.4	14,000	224,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	81	58.68	0	0.10	1.2	0.4	16,000	256,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	72.71	8	0.16	1.3	0.8	34,000	544,000
	SMB23	Single-family	30	14.12	42	0.39	1.2	0.4	14,000	224,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	70	33.35	0	0.10	1.2	0.3	10,000	160,000
		Unknown	0	0.04	65	0.54	1.2	0.0	0	0
		Catchment Total	100	47.51	13	0.19	1.2	0.7	26,000	416,000
	SMB24	Single-family	4	1.99	42	0.39	1.2	0.1	2,000	32,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	96	46.46	0	0.10	1.2	0.3	14,000	224,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	48.45	2	0.11	1.2	0.4	16,000	256,000

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BASIN CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
SMB30	Single-family	7	2.39	42	0.30	1.2	0.1	3,000	46,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	93	22.85	0	0.10	1.2	0.3	[illegible]	[illegible]
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	24.14	3	0.13	1.2	0.3	13,000	[illegible]
SMB31	Single-family	67	22.56	42	0.30	1.2	0.3	[illegible]	[illegible]
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	33	[illegible]	0	0.10	1.2	0.1	2,000	32,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	33.93	28	0.30	1.2	0.3	20,000	320,000
SMB32	Single-family	39	20.04	42	0.30	1.2	0.6	23,000	264,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	61	31.43	0	0.10	1.2	0.3	9,000	144,000
	Unknown	0	0.09	65	0.56	1.2	0.0	0	0
	Catchment Total	100	51.77	16	0.21	1.2	0.6	32,000	313,000
SMB33	Single-family	30	18.19	42	0.30	1.2	0.3	21,000	204,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	70	41.79	0	0.10	1.2	0.3	22,000	302,000
	Unknown	0	0.09	65	0.56	1.2	0.0	0	0
	Catchment Total	100	59.92	13	0.19	1.2	0.6	33,000	[illegible]
SMB34	Single-family	34	6.74	42	0.30	1.2	0.2	8,000	128,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	66	13.15	0	0.10	1.2	0.1	4,000	64,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	19.89	14	0.20	1.2	0.3	12,000	192,000
STEEP1	Single-family	0	0.00	42	0.30	1.2	0.0	0	0
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	100	170.31	0	0.10	1.2	1.4	[illegible]	[illegible]
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	170.31	0	0.10	1.2	1.4	36,000	[illegible]
STEEP2	Single-family	5	4.23	42	0.30	1.2	0.1	2,000	[illegible]
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	95	81.36	0	0.10	1.2	0.6	24,000	384,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	85.39	2	0.11	1.2	0.7	28,000	464,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF R.	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
06	SMB33	Single-family	39	25.73	42	0.39	1.2	0.3	31,000	[illegible]
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	61	41.71	0	0.10	1.2	0.3	12,000	[illegible]
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	66.44	16	0.21	1.2	1.1	43,000	[illegible]
	SMB36	Single-family	46	50.78	42	0.39	1.2	1.3	39,000	[illegible]
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	54	58.59	0	0.10	1.2	0.4	77,000	372,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	109.47	19	0.23	1.2	1.0	76,000	1,316,000
	SMB37	Single-family	8	10.23	42	0.39	1.2	0.3	12,000	[illegible]
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	92	124.77	0	0.10	1.2	0.9	37,000	[illegible]
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	135.00	3	0.12	1.2	1.2	49,000	[illegible]
	SMB38	Single-family	32	14.62	42	0.39	1.2	0.4	17,000	272,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	68	31.01	0	0.10	1.2	0.3	9,000	144,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	45.63	13	0.19	1.2	0.7	26,000	416,000
	SMB39	Single-family	46	22.86	42	0.39	1.2	0.7	26,000	414,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	51	25.70	0	0.10	1.2	0.2	8,000	128,000
		Unknown	3	1.25	65	0.54	1.2	0.1	2,000	32,000
		Catchment Total	100	49.50	31	0.34	1.2	0.8	36,000	576,000
	SMB40	Single-family	21	13.72	42	0.39	1.2	0.4	16,000	256,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	73	46.28	0	0.10	1.2	0.3	14,000	224,000
		Unknown	6	3.63	65	0.56	1.2	0.2	6,000	96,000
		Catchment Total	100	63.63	13	0.19	1.2	0.9	36,000	576,000
	SMB41	Single-family	64	161.50	42	0.39	1.2	4.7	187,000	2,992,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	36	90.97	0	0.10	1.2	0.7	27,000	432,000
		Unknown	1	1.95	65	0.54	1.2	0.1	3,000	48,000
		Catchment Total	100	254.42	27	0.29	1.2	5.5	217,000	3,472,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
SMB42	Single-family	41	222.76	42	0.39	1.2	2.9	253,000	2,400,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	2	11.34	80	0.66	1.2	0.4	22,000	202,000
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	55	301.37	0	0.10	1.2	1.4	54,000	864,000
	Unknown	0	0.67	65	0.54	1.2	0.0	1,000	16,000
	Catchment Total	100	537.34	20	0.24	1.2	3.4	333,000	3,712,000
SMB43	Single-family	40	37.86	42	0.39	1.2	1.1	44,000	704,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	30	25.73	80	0.66	1.2	1.3	50,000	800,000
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	27	23.40	0	0.10	1.2	0.2	7,000	112,000
	Unknown	2	1.61	65	0.54	1.2	0.1	3,000	41,000
	Catchment Total	100	84.96	43	0.39	1.2	2.6	104,000	1,664,000
SMB44	Single-family	40	50.77	42	0.39	1.2	1.5	58,000	928,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	2	1.59	80	0.66	1.2	0.1	4,000	64,000
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	55	64.76	0	0.10	1.2	0.5	19,000	304,000
	Unknown	0	0.79	65	0.54	1.2	0.0	0	0
	Catchment Total	100	117.11	19	0.23	1.2	2.0	81,000	1,296,000
SMB45	Single-family	30	20.07	42	0.39	1.2	0.6	23,000	368,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	64	42.42	0	0.10	1.2	0.3	13,000	208,000
	Unknown	6	4.17	65	0.54	1.2	0.2	7,000	112,000
	Catchment Total	100	66.66	17	0.22	1.2	1.1	43,000	688,000
TRANC1	Single-family	1	48.80	42	0.39	1.5	1.5	58,000	944,000
	Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
	Commercial	0	0.00	92	0.74	1.5	0.0	0	0
	Public	1	43.26	80	0.66	1.5	2.7	106,000	1,696,000
	Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
	Open	98	4,702.43	0	0.10	1.5	43.7	1,741,000	27,856,000
	Unknown	0	0.00	65	0.54	1.2	0.0	0	0
	Catchment Total	100	4,794.49	1	0.11	1.5	47.9	1,906,000	30,496,000
TRANC2	Single-family	0	7.37	42	0.39	1.2	0.2	8,000	128,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	91	68.79	0	0.10	1.2	0.5	20,000	320,000
	Unknown	0	0.00	65	0.54	1.2	0.0	0	0
	Catchment Total	100	76.16	4	0.13	1.2	0.7	28,000	448,000
TRANC3	Single-family	1	2.45	42	0.39	1.5	0.1	3,000	48,000
	Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
	Commercial	0	0.00	92	0.74	1.5	0.0	0	0
	Public	0	0.00	80	0.66	1.5	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
	Open	99	291.42	0	0.10	1.5	2.8	113,000	1,808,000
	Unknown	0	0.00	65	0.54	1.5	0.0	0	0
	Catchment Total	100	294.87	0	0.10	1.5	2.9	116,000	1,856,000

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TABLE A-4
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	TRANC4	Single-family	31	32.39	42	0.39	1.2	0.9	28,000	480,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	49	31.78	0	0.10	1.2	0.3	9,000	164,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	64.27	21	0.25	1.2	1.2	47,000	833,000
	TRANC5	Single-family	4	3.39	42	0.39	1.2	0.1	4,000	64,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	96	80.60	0	0.10	1.2	0.7	27,000	432,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	84.08	2	0.11	1.2	0.8	31,000	496,000
	TRANC6	Single-family	25	39.45	42	0.39	1.2	1.2	44,000	704,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	75	120.61	0	0.10	1.2	0.9	36,000	576,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	160.33	10	0.17	1.2	2.0	82,000	1,312,000
07	SMB50	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	68	3.97	0	0.10	1.2	0.0	1,000	16,000
		Unknown	32	1.89	65	0.56	1.2	0.1	3,000	48,000
		Catchment Total	100	5.85	21	0.25	1.2	0.1	4,000	64,000
	SMB51	Single-family	83	41.66	42	0.39	1.2	1.2	48,000	768,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	17	8.77	0	0.10	1.2	0.1	3,000	48,000
		Unknown	1	0.56	65	0.56	1.2	0.0	1,000	16,000
		Catchment Total	100	50.99	26	0.34	1.2	1.2	52,000	832,000
	SMB52	Single-family	62	221.80	42	0.39	1.2	3.5	141,000	2,256,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	1	3.34	92	0.74	1.2	0.1	3,000	48,000
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	35	67.53	0	0.10	1.2	0.3	20,000	320,000
		Unknown	2	4.75	65	0.56	1.2	0.2	8,000	128,000
		Catchment Total	100	305.42	28	0.30	1.2	4.3	172,000	2,752,000
	SMB53	Single-family	64	11.97	42	0.39	1.2	0.3	16,000	256,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	29	5.42	0	0.10	1.2	0.0	2,000	32,000
		Unknown	7	1.29	65	0.56	1.2	0.1	2,000	32,000
		Catchment Total	100	18.64	31	0.32	1.2	0.4	18,000	288,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	SMB34	Single-family	87	22.97	42	0.39	1.2	1.0	28,000	600,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	12	4.43	[illegible]	0.10	1.2	0.0	1,000	16,000
		Unknown	1	0.27	[illegible]	0.54	1.2	0.0	1,000	14,000
		Catchment Total	100	26.06	37	0.36	1.2	1.0	40,000	640,000
	SMB35	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	31	1.95	0	0.10	1.2	0.0	1,000	16,000
		Unknown	69	4.37	65	0.54	1.2	0.2	7,000	112,000
		Catchment Total	100	6.30	45	0.42	1.2	0.2	8,000	128,000
	SMB36	Single-family	60	25.52	42	0.39	1.2	0.7	28,000	464,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	36	15.49	0	0.10	1.2	0.1	3,000	50,000
		Unknown	3	1.43	65	0.54	1.2	0.1	2,000	27,000
		Catchment Total	100	42.44	27	0.29	1.2	0.9	35,000	574,000
	SMB37	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	73	8.72	0	0.10	1.2	0.1	3,000	48,000
		Unknown	27	3.23	65	0.54	1.2	0.1	5,000	80,000
		Catchment Total	100	11.95	18	0.22	1.2	0.3	8,000	128,000
	SMB38	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	8.30	0	0.10	1.2	0.1	2,000	33,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	8.30	0	0.10	1.2	0.1	2,000	33,000
	SMB39	Single-family	35	4.37	42	0.39	1.2	0.1	2,000	30,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	65	7.83	0	0.10	1.2	0.1	2,000	33,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	12.10	15	0.20	1.2	0.2	5,000	111,000
	SMB40	Single-family	75	7.66	42	0.39	1.2	0.2	9,000	144,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	25	2.49	0	0.10	1.2	0.0	1,000	16,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	10.15	32	0.32	1.2	0.2	10,000	160,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	ZUMA1	Single-family	2	42.52	42	0.39	1.6	1.6	61,000	1,040,000
		Multi-family	0	0.00	68	0.55	1.6	0.0	0	0
		Commercial	2	35.41	92	0.78	1.6	2.6	102,000	1,648,000
		Public	7	124.30	80	0.66	1.6	8.1	324,000	5,184,000
		Light Industrial	0	0.00	91	0.78	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	89	1,637.19	0	0.10	1.6	16.4	654,000	10,464,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	1,839.42	6	0.16	1.6	28.6	1,146,000	18,336,000
	ZUMA2	Single-family	0	0.00	42	0.39	1.5	0.0	0	0
		Multi-family	0	0.00	68	0.55	1.5	0.0	0	0
		Commercial	0	0.00	92	0.78	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.78	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	100	912.36	0	0.10	1.5	9.1	364,000	5,824,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	912.36	0	0.10	1.5	9.1	364,000	5,824,000
	ZUMA3	Single-family	1	15.96	42	0.39	1.5	0.6	25,000	366,000
		Multi-family	0	0.00	68	0.55	1.5	0.0	0	0
		Commercial	0	0.00	92	0.78	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.78	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	99	2,393.99	0	0.10	1.5	22.3	894,000	14,376,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	2,409.95	0	0.10	1.5	22.8	919,000	14,544,000
	ZUMA4	Single-family	38	172.93	42	0.39	1.3	2.0	208,000	2,300,000
		Multi-family	0	0.00	68	0.55	1.3	0.0	0	0
		Commercial	2	7.45	92	0.78	1.3	0.4	17,000	272,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.78	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.60	1.3	0.0	0	0
		Open	60	268.74	0	0.10	1.3	2.0	80,000	1,280,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	449.42	16	0.22	1.3	5.3	297,000	4,752,000
90	RAMIRZ1	Single-family	1	11.46	42	0.39	1.3	0.4	16,000	240,000
		Multi-family	0	0.00	68	0.55	1.3	0.0	0	0
		Commercial	0	0.00	92	0.78	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.78	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	99	1,661.96	0	0.10	1.3	13.4	534,000	8,544,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,673.42	0	0.10	1.3	13.8	549,000	8,784,000
	RAMIRZ2	Single-family	8	9.83	42	0.39	1.2	0.3	11,000	176,000
		Multi-family	0	0.00	68	0.55	1.2	0.0	0	0
		Commercial	0	0.00	92	0.78	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.78	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	92	113.71	0	0.10	1.2	0.9	34,000	544,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	123.54	3	0.12	1.2	1.1	45,000	720,000
	RAMIRZ3	Single-family	27	46.28	42	0.39	1.2	1.3	53,000	848,000
		Multi-family	0	0.00	68	0.55	1.2	0.0	0	0
		Commercial	0	0.00	92	0.78	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.78	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	73	123.44	0	0.10	1.2	0.9	37,000	592,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	169.72	11	0.18	1.2	2.3	90,000	1,440,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	BAMB24	Single-family	3	2.59	42	0.39	1.2	0.1	2,000	41,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	97	98.60	0	0.10	1.2	0.7	20,000	404,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	101.19	1	0.11	1.2	0.8	22,000	312,000
	BAMB25	Single-family	31	28.30	42	0.39	1.2	0.7	18,000	400,000
		Multi-family	11	8.02	68	0.56	1.2	0.3	14,000	204,000
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	58	44.57	0	0.10	1.2	0.3	22,000	200,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	76.27	20	0.34	1.2	1.4	53,000	850,000
	SMB41	Single-family	89	37.83	42	0.39	1.2	0.8	31,000	494,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	92	0.66	1.2	0.0	0	0
		Open	9	2.74	0	0.10	1.2	0.0	1,000	16,000
		Unknown	2	0.61	65	0.54	1.2	0.0	1,000	14,000
		Catchment Total	100	30.34	30	0.37	1.2	0.8	33,000	524,000
	SMB42	Single-family	95	171.31	42	0.39	1.2	3.0	189,000	3,168,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	4	7.45	80	0.66	1.2	0.4	25,000	240,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	1	2.02	0	0.10	1.2	0.0	1,000	16,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	180.78	43	0.40	1.2	3.4	214,000	3,424,000
	SMB43	Single-family	61	253.04	42	0.39	1.2	4.4	277,000	2,832,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	3	6.34	92	0.74	1.2	0.3	14,000	224,000
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	37	91.73	0	0.10	1.2	0.7	27,000	432,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	251.11	28	0.29	1.2	5.5	318,000	3,488,000
	SMB44	Single-family	100	7.80	42	0.39	1.2	0.2	8,000	128,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	7.80	42	0.39	1.2	0.2	8,000	128,000
	SMB45	Single-family	99	6.25	42	0.39	1.2	0.2	7,000	112,000
		Multi-family	0	0.00	68	0.56	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	1	0.05	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	6.30	42	0.39	1.2	0.2	7,000	112,000

TABLE A-1
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB711	Single-family	28	25.67	42	0.39	1.2	0.4	22,000	281,000
		Multi-family	8	4.86	65	0.58	1.2	0.3	8,000	128,000
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	67	41.72	0	0.10	1.2	0.5	13,000	202,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	62.05	16	[illegible]	1.2	1.0	36,000	608,000
	SMB712	Single-family	57	12.48	42	0.39	1.2	0.4	28,000	240,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	43	9.42	0	0.10	1.2	0.1	3,000	48,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	22.10	24	0.26	1.2	0.4	11,000	281,000
	SMB713	Single-family	71	44.95	42	0.39	1.2	1.2	32,000	522,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	29	18.40	0	0.10	1.2	0.1	4,000	96,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	63.33	30	0.31	1.2	1.4	36,000	622,000
	SMB72	Single-family	69	3.60	42	0.39	1.2	0.1	4,000	64,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	31	1.65	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	5.25	29	0.30	1.2	0.1	4,000	64,000
	SMB73	Single-family	38	98.13	42	0.39	1.2	2.8	113,000	1,808,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	61	154.61	0	0.10	1.2	1.2	46,000	736,000
		Unknown	0	0.73	65	0.56	1.2	0.0	1,000	16,000
		Catchment Total	100	253.47	16	0.21	1.2	4.0	160,000	2,560,000
	WAL001	Single-family	15	7.80	42	0.39	1.2	0.2	9,000	104,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	85	44.71	0	0.10	1.2	0.5	13,000	208,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	52.51	6	0.14	1.2	0.6	22,000	312,000
	WAL002	Single-family	3	0.71	42	0.39	1.2	0.0	1,000	16,000
		Multi-family	0	0.00	65	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	97	20.86	0	0.10	1.2	0.2	6,000	96,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	21.57	1	0.11	1.2	0.2	7,000	112,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
	WALCH[illegible]	Single-family	33	37.80	42	0.39	1.3	0.5	33,000	313,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	77	80.50	0	0.10	1.3	0.7	27,000	482,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	111.30	20	0.17	1.3	1.3	30,000	844,000
	WALCH4	Single-family	1	0.62	42	0.39	1.3	0.0	1,000	16,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	99	62.77	0	0.10	1.3	0.5	19,000	304,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	63.39	0	0.10	1.3	0.5	20,000	320,000
	WALCH[illegible]	Single-family	94	92.41	42	0.39	1.3	2.7	107,000	1,712,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	6	6.10	0	0.10	1.3	0.0	2,000	32,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	98.51	39	0.37	1.3	2.7	109,000	1,744,000
80	ZBCON1	Single-family	3	44.12	42	0.39	1.3	1.4	55,000	880,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	98	1,569.50	0	0.10	1.3	14.9	593,000	9,488,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	1,613.62	1	0.11	1.3	16.3	648,000	10,368,000
	ZBCON2	Single-family	32	50.50	42	0.39	1.3	1.7	68,000	1,104,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	68	109.80	0	0.10	1.3	1.0	38,000	608,000
		Unknown	0	0.43	65	0.54	1.2	0.0	1,000	16,000
		Catchment Total	100	160.37	13	0.19	1.3	2.7	108,000	1,728,000
	SANT4	Single-family	58	85.49	42	0.39	1.3	2.5	94,000	1,504,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	41	60.21	0	0.10	1.3	0.4	20,000	320,000
		Unknown	0	0.55	65	0.54	1.2	0.0	1,000	16,000
		Catchment Total	100	146.25	25	0.27	1.3	3.0	115,000	1,840,000
80	BRYNL1	Single-family	0	1.42	42	0.39	1.3	0.0	2,000	32,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	206.68	0	0.10	1.3	2.5	98,000	1,568,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	208.09	0	0.10	1.3	2.5	100,000	1,600,000

TABLE A-2

TABLE A-1
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
	BEYTAC2	Single-family	8	18.40	42	0.39	1.3	0.6	22,000	264,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	92	202.06	0	0.10	1.3	1.6	65,000	1,040,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	220.34	4	0.13	1.3	2.2	84,000	1,400,000
	LATIO1	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	694.40	0	0.10	1.3	8.6	224,000	3,584,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	694.40	0	0.10	1.3	8.6	224,000	3,584,000
	LATIO2	Single-family	35	24.40	42	0.39	1.3	0.7	28,000	448,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	64	44.78	0	0.10	1.3	0.3	13,000	208,000
		Unknown	1	0.52	65	0.54	1.3	0.0	1,000	16,000
		Catchment Total	100	69.70	15	0.21	1.3	1.1	42,000	672,000
	SMBT75	Single-family	56	43.76	42	0.39	1.3	1.3	51,000	816,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	40	31.20	0	0.10	1.3	0.3	9,000	144,000
		Unknown	3	2.62	65	0.54	1.3	0.1	4,000	64,000
		Catchment Total	100	77.44	25	0.26	1.3	1.6	64,000	1,024,000
	SMB11	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	99	24.18	0	0.10	1.3	0.2	7,000	112,000
		Unknown	1	0.29	65	0.54	1.3	0.0	0	0
		Catchment Total	100	24.47	1	0.11	1.3	0.2	7,000	112,000
	SMB12	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	38.54	0	0.10	1.3	0.3	11,000	176,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	38.54	0	0.10	1.3	0.3	11,000	176,000
	SCLST1	Single-family	1	23.63	42	0.39	1.5	0.5	28,000	288,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	99	2,247.30	0	0.10	1.5	20.9	832,000	13,312,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	2,260.93	0	0.10	1.5	21.4	852,000	13,632,000

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TABLE A-4
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	SOLST2	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	72.53	0	0.10	1.3	0.5	21,000	304,000
		Unknown	0	0.00	65	0.54	1.2	0.0		0
		Catchment Total	100	72.53	0	0.10	1.3	0.5	21,000	304,000
11	CORAL1	Single-family	2	45.82	42	0.39	1.3	1.6	65,000	1,040,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	98	2,025.11	0	0.10	1.3	38.5	750,000	12,000,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	2,070.93	1	0.11	1.3	[illegible]	815,000	13,040,000
	CORAL2	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	201.26	0	0.10	1.3	1.4	63,000	842,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	201.26	0	0.10	1.3	1.4	63,000	842,000
	MARIE1	Single-family	0	0.39	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	20	60.90	80	0.66	1.3	3.3	120,000	2,044,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	80	247.43	0	0.10	1.3	2.0	78,000	1,204,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	308.73	16	0.21	1.3	5.3	200,000	3,324,000
	MARIE2	Single-family	0	3.81	42	0.39	1.3	0.1	2,000	40,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	90	32.50	0	0.10	1.3	0.2	10,000	160,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	36.30	5	0.13	1.3	0.3	13,000	200,000
	MARIE3	Single-family	77	35.36	42	0.39	1.3	1.0	41,000	684,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	3	1.47	80	0.66	1.3	0.1	2,000	40,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	20	8.80	0	0.10	1.3	0.1	2,000	40,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	45.63	35	0.34	1.3	1.2	47,000	763,000
	MARIE4	Single-family	15	10.93	42	0.39	1.3	0.3	22,000	280,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	85	63.73	80	0.66	1.3	2.1	128,000	2,080,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	74.66	74	0.62	1.3	2.4	150,000	2,320,000

TABLE A-2
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	MARIB3	Single-family	17	9.93	42	0.39	1.2	0.3	11,000	176,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	37	20.50	80	0.66	1.2	0.5	20,000	304,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	46	25.96	0	0.10	1.2	0.3	22,000	352,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	54.41	31	0.34	1.2	1.1	42,000	672,000
	PUERC1	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	484.33	0	0.10	1.2	3.3	231,000	3,694,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	484.33	0	0.10	1.2	3.3	231,000	3,694,000
	PUERC2	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	37.33	0	0.10	1.2	0.3	11,000	176,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	37.33	0	0.10	1.2	0.3	11,000	176,000
	PUERC3	Single-family	11	17.31	42	0.39	1.2	0.3	20,000	320,000
		Multi-family	0	0.30	68	0.58	1.2	0.0	0	0
		Commercial	2	3.57	92	0.74	1.2	0.3	8,000	128,000
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	87	141.96	0	0.10	1.2	1.1	43,000	688,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	164.34	7	0.15	1.2	1.8	71,000	1,136,000
	SMEB3	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	25.76	0	0.10	1.2	0.3	11,000	176,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	25.76	0	0.10	1.2	0.3	11,000	176,000
	SMEB4	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	20.59	0	0.10	1.2	0.2	9,000	144,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	20.59	0	0.10	1.2	0.2	9,000	144,000
	SMEB5	Single-family	4	1.48	42	0.39	1.2	0.0	2,000	32,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	96	36.14	0	0.10	1.2	0.2	11,000	176,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	37.62	2	0.11	1.2	0.3	13,000	208,000

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TABLE A-4
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	SMB86	Single-family	30	17.17	42	0.39	1.2	0.3	20,000	200,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	70	40.92	0	0.10	1.2	0.3	12,000	102,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	58.09	13	0.19	1.2	0.3	32,000	312,000
	SMB87	Single-family	15	22.34	42	0.39	1.2	0.7	20,000	404,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	1	0.75	90	0.74	1.2	0.0	2,000	22,000
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	85	131.97	0	0.10	1.2	1.0	30,000	604,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	155.25	7	0.15	1.2	1.7	61,000	1,072,000
	SMB88	Single-family	40	20.71	42	0.39	1.2	0.6	24,000	204,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	16	7.57	90	0.74	1.2	0.4	17,000	272,000
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	41	19.57	0	0.10	1.2	0.1	8,000	96,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	48.22	23	0.33	1.2	1.2	47,000	512,000
	SMB89	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	26.26	0	0.10	1.2	0.3	8,000	128,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	26.26	0	0.10	1.2	0.2	8,000	128,000
	SMB90	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	51	44.86	80	0.66	1.2	2.3	88,000	1,408,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	49	42.56	0	0.10	1.2	0.3	12,000	208,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	87.42	41	0.39	1.2	2.3	101,000	1,616,000
	SMB91	Single-family	3	1.22	42	0.39	1.2	0.0	1,000	16,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	90	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	97	40.94	0	0.10	1.2	0.3	12,000	192,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	42.16	1	0.11	1.2	0.3	13,000	208,000
	SMB92	Single-family	45	42.80	42	0.39	1.2	1.2	38,000	608,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	12	11.66	90	0.74	1.2	0.6	25,000	404,000
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	42	39.79	0	0.10	1.2	0.3	12,000	192,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	94.26	30	0.31	1.2	2.2	80,000	1,600,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	WINCN1	Single-family	4	31.35	42	0.39	1.3	0.3	12,000	[illegible]
		Multi-family	1	2.80	68	0.58	1.3	0.1	3,000	48,000
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	10	25.40	80	0.66	1.3	1.3	[illegible]	[illegible]
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	85	219.44	0	0.10	1.3	1.6	[illegible]	1,040,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	254.31	16	0.17	1.3	3.3	131,000	2,094,000
13	[illegible]1	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	3	71.61	80	0.66	1.3	3.8	153,000	2,432,000
		Open	97	2,822.79	0	0.10	1.3	16.3	649,000	10,304,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	2,894.40	3	0.12	1.3	20.1	801,000	12,816,000
	[illegible]2	Single-family	30	207.57	42	0.39	1.3	7.2	286,000	4,540,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	6	41.40	92	0.74	1.3	2.3	95,000	1,504,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	59	383.50	0	0.10	1.3	3.1	126,000	1,900,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	632.47	31	0.30	1.3	12.7	507,000	8,113,000
	COLDK1	Single-family	12	114.35	42	0.39	1.6	4.4	176,000	2,816,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	2	14.92	80	0.66	1.6	1.0	39,000	624,000
		Open	86	793.74	0	0.10	1.6	7.9	313,000	5,001,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	923.01	6	0.14	1.6	13.3	528,000	8,441,000
	COLDK2	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	924.93	0	0.10	1.6	9.2	365,000	5,840,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	924.93	0	0.10	1.6	9.2	365,000	5,840,000
	COLDK3	Single-family	8	150.57	42	0.39	1.6	5.8	232,000	3,712,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	92	1,801.66	0	0.10	1.6	17.9	712,000	11,392,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	1,952.23	3	0.12	1.6	23.7	944,000	15,104,000
	COLDK4	Single-family	3	21.30	42	0.39	1.5	0.6	22,000	352,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	95	282.07	0	0.10	1.5	2.6	104,000	1,664,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	297.46	3	0.12	1.5	3.2	126,000	2,016,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	COLDK3	Single-family	32	149.40	42	0.39	1.5	2.4	204,000	2,434,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	68	314.60	0	0.10	1.5	2.9	117,000	1,372,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	464.09	14	0.19	1.5	5.3	321,000	3,321,000
	BARCKC1	Single-family	4	24.31	42	0.39	1.5	0.8	25,000	300,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	96	622.50	0	0.10	1.5	5.8	301,000	3,904,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	644.81	3	0.11	1.5	6.7	326,000	4,204,000
	ELVRO1	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	1,436.12	0	0.10	1.3	11.4	463,000	7,392,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	1,436.12	0	0.10	1.3	11.4	463,000	7,392,000
	GATEB1	Single-family	7	34.32	42	0.39	1.3	1.1	40,000	600,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	93	475.79	0	0.10	1.3	3.8	152,000	2,440,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	510.11	3	0.12	1.3	4.9	194,000	3,136,000
	LEKER1	Single-family	4	68.32	42	0.39	1.6	2.6	105,000	1,600,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	96	1,600.81	0	0.10	1.6	16.0	636,000	10,170,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	1,671.13	3	0.11	1.6	18.6	741,000	11,836,000
	LEETT1	Single-family	6	98.30	42	0.39	1.5	2.6	162,000	2,372,000
		Multi-family	2	28.56	68	0.58	1.5	1.9	77,000	1,222,000
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	3	34.50	80	0.66	1.5	2.4	134,000	2,144,000
		Open	88	1,413.24	0	0.10	1.5	12.2	524,000	8,384,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	1,604.20	7	0.15	1.5	22.0	877,000	14,032,000
	LEDRO1	Single-family	25	454.00	42	0.39	1.3	20.6	819,000	13,104,000
		Multi-family	1	41.30	68	0.58	1.3	1.9	77,000	1,232,000
		Commercial	3	102.62	92	0.74	1.3	6.1	244,000	3,904,000
		Public	0	23.91	80	0.66	1.3	0.7	30,000	484,000
		Light Industrial	0	17.40	91	0.74	1.3	1.1	42,000	672,000
		Other Urban	5	199.54	80	0.66	1.3	10.6	423,000	6,768,000
		Open	76	3,290.11	0	0.10	1.3	26.6	1,064,000	16,928,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	4,321.06	14	0.19	1.3	67.4	2,642,000	43,072,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CF)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	LOBOC1	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.13	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	1,726.67	0	0.10	1.6	17.3	687,000	[illegible]
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	1,726.80	0	0.10	1.6	17.3	687,000	[illegible]
	LOBOC2	Single-family	0	0.04	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	89.31	0	0.10	1.6	0.9	35,000	[illegible]
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	89.35	0	0.10	1.6	0.9	35,000	[illegible]
	LOBOC3	Single-family	16	64.93	42	0.39	1.6	2.5	[illegible]	[illegible]
		Multi-family	0	0.00	65	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	84	352.71	0	0.10	1.6	3.5	139,000	[illegible]
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	417.64	7	0.15	1.6	6.0	239,000	[illegible]
	LVIRG2	Single-family	13	148.86	42	0.39	1.3	4.7	185,000	[illegible]
		Multi-family	0	0.00	65	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	1	13.97	80	0.66	1.3	0.8	34,000	[illegible]
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	6	72.41	80	0.66	1.3	3.9	154,000	2,464,000
		Open	79	905.99	0	0.10	1.3	7.3	291,000	4,656,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	1,142.30	13	0.18	1.3	16.7	664,000	10,624,000
	LVIRG3	Single-family	2	30.00	42	0.39	1.3	0.9	38,000	[illegible]
		Multi-family	0	0.00	65	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	1	8.66	80	0.66	1.3	0.5	18,000	[illegible]
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	3	47.06	80	0.66	1.3	2.6	102,000	1,632,000
		Open	94	1,317.19	0	0.10	1.3	10.6	423,000	6,768,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	1,402.90	4	0.13	1.3	14.6	581,000	[illegible]
	LVIRG4	Single-family	3	88.80	42	0.39	1.5	3.1	124,000	1,984,000
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	11.36	92	0.74	1.5	0.8	31,000	[illegible]
		Public	1	16.91	80	0.66	1.5	1.0	41,000	[illegible]
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	14	406.34	80	0.66	1.5	25.0	994,000	[illegible]
		Open	82	2,325.95	0	0.10	1.5	21.7	866,000	[illegible]
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	2,834.46	13	0.19	1.5	51.6	2,061,000	[illegible]
	LVIRG5	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	371.27	0	0.10	1.6	3.7	147,000	2,352,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	371.27	0	0.10	1.6	3.7	147,000	2,352,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
	LVRO1	Single-family	1	31.30	42	0.39	1.3	1.0	30,000	624,000
		Multi-family	0	0.00	65	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	99	3,143.30	0	0.10	1.3	25.5	1,577,000	25,372,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	3,175.10	0	0.10	1.3	26.5	1,604,000	25,976,000
	MALIBU1	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	929.47	0	0.10	1.6	9.3	391,000	6,264,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	929.47	0	0.10	1.6	9.3	391,000	6,264,000
	MALIBU2	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	99.39	0	0.10	1.6	1.0	30,000	484,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	99.39	0	0.10	1.6	1.0	30,000	484,000
	MALIBU3	Single-family	1	11.35	42	0.39	1.6	0.4	23,000	372,000
		Multi-family	0	0.00	65	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	99	990.85	0	0.10	1.6	9.9	384,000	6,204,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	1,002.20	0	0.10	1.6	10.3	411,000	6,576,000
	MALIBU4	Single-family	1	0.82	42	0.39	1.6	0.0	1,000	16,000
		Multi-family	0	0.00	65	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	99	81.62	0	0.10	1.6	0.8	20,000	322,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	82.44	0	0.10	1.6	0.8	21,000	338,000
	MALIBU5	Single-family	9	257.35	42	0.39	1.3	4.8	262,000	4,202,000
		Multi-family	0	3.67	65	0.58	1.3	0.3	11,000	176,000
		Commercial	1	22.84	92	0.74	1.3	1.0	76,000	1,216,000
		Public	1	30.47	80	0.66	1.3	1.0	41,000	654,000
		Light Industrial	0	11.51	91	0.74	1.3	0.7	27,000	432,000
		Other Urban	0	7.35	80	0.66	1.3	0.4	16,000	254,000
		Open	91	2,572.82	0	0.10	1.3	22.1	882,000	14,322,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	2,906.21	5	0.13	1.3	24.3	1,304,000	21,214,000
	MEDEA1	Single-family	2	38.27	42	0.39	1.3	2.0	42,000	672,000
		Multi-family	2	38.91	65	0.58	1.3	1.4	38,000	608,000
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	3	35.86	80	0.66	1.3	1.9	76,000	1,216,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	93	1,242.79	0	0.10	1.3	10.8	408,000	6,528,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,341.83	5	0.13	1.3	14.6	576,000	9,216,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (AF)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	MEDEA2	Single-family	3	30.80	42	0.39	1.3	0.5	21,000	301,000
		Multi-family	14	53.38	68	0.58	1.3	2.5	90,000	1,344,000
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	1.80	80	0.66	1.3	0.1	2,000	32,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	4	34.90	80	0.66	1.3	0.5	22,000	312,000
		Open	80	314.84	0	0.10	1.3	2.5	101,000	1,614,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	391.23	14	0.20	1.3	6.2	237,000	3,603,000
	MEDEA3	Single-family	46	1,099.77	42	0.39	1.3	34.6	1,570,000	25,014,000
		Multi-family	1	34.62	68	0.58	1.3	0.8	31,000	496,000
		Commercial	2	46.36	92	0.74	1.3	2.5	110,000	1,760,000
		Public	3	73.35	80	0.66	1.3	3.0	131,000	2,080,000
		Light Industrial	2	46.13	91	0.74	1.3	2.5	110,000	1,760,000
		Other Urban	3	64.83	80	0.66	1.3	3.2	140,000	2,240,000
		Open	44	1,049.98	0	0.10	1.3	8.5	357,000	5,592,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	2,391.13	28	0.30	1.3	54.7	2,390,000	36,144,000
	MEDEA4	Single-family	21	412.80	42	0.39	1.3	20.9	906,000	9,536,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	79	1,508.19	0	0.10	1.3	14.9	599,000	8,728,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,920.99	9	0.16	1.3	35.8	1,134,000	18,144,000
	PCMDO1	Single-family	5	130.34	42	0.39	1.3	4.4	178,000	2,888,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	95	2,443.79	0	0.10	1.3	19.7	784,000	12,544,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	2,573.13	3	0.12	1.3	24.1	961,000	15,344,000
	TOTVY1	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	4	251.90	80	0.66	1.6	9.9	395,000	6,324,000
		Open	96	3,795.85	0	0.10	1.6	38.6	1,539,000	24,624,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	4,047.75	3	0.12	1.6	48.6	1,935,000	30,960,000
	TOTVY10	Single-family	16	88.70	42	0.39	1.6	3.4	137,000	2,192,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	1	7.59	80	0.66	1.6	0.5	21,000	336,000
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	83	472.01	0	0.10	1.6	4.7	186,000	2,976,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	568.30	8	0.15	1.6	8.6	344,000	5,504,000
	TOTVY11	Single-family	0	2.70	42	0.39	1.6	0.1	6,000	96,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	1	8.36	80	0.66	1.6	0.3	14,000	224,000
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	99	827.31	0	0.10	1.6	8.2	327,000	5,232,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	838.37	1	0.10	1.6	8.7	347,000	5,552,000

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LAND USE AND RUNOFF SUMMARY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	POTVY12	Single-family	86	317.38	42	0.39	1.6	22.3	489,000	7,824,000
		Multi-family	0	0.85	68	0.58	1.6	0.0	2,000	32,000
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	14	50.31	0	0.10	1.6	0.3	20,000	320,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	368.54	36	0.33	1.6	22.2	511,000	8,176,000
	POTVY2	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	760.05	0	0.10	1.6	7.7	308,000	4,928,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	760.05	0	0.10	1.6	7.7	308,000	4,928,000
	POTVY3	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	683.40	0	0.10	1.6	6.8	271,000	4,334,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	683.40	0	0.10	1.6	6.8	271,000	4,334,000
	POTVY4	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	202.64	0	0.10	1.6	2.0	80,000	1,280,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	202.64	0	0.10	1.6	2.0	80,000	1,280,000
	POTVY5	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	76.44	0	0.10	1.6	0.8	30,000	480,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	76.44	0	0.10	1.6	0.8	30,000	480,000
	POTVY6	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	178.84	0	0.10	1.6	1.8	71,000	1,136,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	178.84	0	0.10	1.6	1.8	71,000	1,136,000
	POTVY7	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	173.67	0	0.10	1.6	1.7	69,000	1,104,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	173.67	0	0.10	1.6	1.7	69,000	1,104,000

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TABLE A-1
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF R.	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	POTVY8	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	4,251.11	0	0.10	1.6	42.2	1,680,000	26,880,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	4,251.11	0	0.10	1.6	42.2	1,680,000	26,880,000
	POTVY9	Single-family	0	40.36	42	0.39	1.6	1.6	62,000	992,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	91	424.33	0	0.10	1.6	4.3	168,000	2,688,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	465.09	4	0.13	1.6	5.5	230,000	3,680,000
	RUSSL1	Single-family	25	486.74	42	0.39	1.5	14.7	584,000	9,344,000
		Multi-family	0	8.21	68	0.58	1.5	0.4	16,000	251,000
		Commercial	0	0.34	92	0.74	1.5	0.0	1,000	16,000
		Public	1	22.83	80	0.66	1.5	1.4	56,000	896,000
		Light Industrial	15	270.98	91	0.74	1.5	18.6	742,000	11,872,000
		Other Urban	3	84.48	80	0.66	1.5	3.3	133,000	2,128,000
		Open	57	1,005.28	0	0.10	1.5	9.3	372,000	5,952,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	1,766.10	37	0.29	1.5	47.9	1,904,000	30,464,000
	SCHSE1	Single-family	3	8.30	42	0.39	1.5	0.2	8,000	128,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	97	280.41	0	0.10	1.5	3.1	204,000	3,264,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	333.81	0	0.10	1.5	3.3	212,000	3,392,000
	SLEEP1	Single-family	15	57.43	42	0.39	1.6	2.2	88,000	1,424,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	85	314.36	0	0.10	1.6	3.1	124,000	1,984,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	371.79	7	0.14	1.6	5.3	213,000	3,408,000
	STOKE1	Single-family	1	26.72	42	0.39	1.6	0.6	26,000	416,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	99	2,873.92	0	0.10	1.6	28.6	1,139,000	18,224,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	2,900.64	0	0.10	1.6	29.3	1,165,000	18,640,000
	TRSUN1	Single-family	1	25.15	42	0.39	1.6	0.6	23,000	368,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	99	1,099.96	0	0.10	1.6	11.0	438,000	7,008,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	1,125.11	1	0.10	1.6	11.6	461,000	7,376,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	TRUN2	Single-family	30	892.48	42	0.39	1.5	31.5	834,000	11,004,000
		Multi-family	8	231.77	68	0.58	1.5	8.6	342,000	8,481,000
		Commercial	6	182.22	92	0.74	1.5	22.5	498,000	7,894,000
		Public	6	124.96	80	0.66	1.5	7.7	306,000	4,880,000
		Light Industrial	3	67.41	91	0.74	1.5	4.7	185,000	2,960,000
		Other Urban	1	21.53	80	0.66	1.5	1.3	53,000	844,000
		Open	42	837.46	0	0.10	1.5	7.7	306,000	4,904,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	1,976.02	36	0.33	1.5	64.0	2,547,000	40,752,000
	TRUN3	Single-family	6	68.88	42	0.39	1.5	2.4	94,000	1,504,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	1	22.04	92	0.74	1.5	2.0	38,000	608,000
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	92	971.47	0	0.10	1.5	9.0	360,000	5,760,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	1,060.39	4	0.13	1.5	12.3	492,000	7,872,000
	TRUN4	Single-family	6	26.00	42	0.39	1.5	0.9	38,000	608,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	94	394.78	0	0.10	1.5	3.7	146,000	2,336,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	420.78	3	0.12	1.5	4.6	184,000	2,944,000
	TRUN5	Single-family	3	19.73	42	0.39	1.5	0.7	28,000	448,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	97	583.61	0	0.10	1.5	5.4	216,000	3,456,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	603.34	1	0.11	1.5	6.1	244,000	3,904,000
	TRUN6	Single-family	13	203.40	42	0.39	1.6	7.9	313,000	5,008,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	87	1,376.37	0	0.10	1.6	13.7	544,000	8,704,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	1,579.76	5	0.14	1.6	21.5	857,000	13,712,000
	TRUN7	Single-family	1	34.43	42	0.39	2.0	0.6	22,000	352,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	99	2,544.41	0	0.10	1.6	25.4	1,012,000	16,288,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	2,578.84	6	0.10	1.6	26.0	1,035,000	16,640,000
13	CRBCN1	Single-family	8	106.44	42	0.39	2.0	3.3	133,000	2,128,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.06	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	92	1,393.13	0	0.10	1.3	10.4	413,000	6,608,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	1,499.62	3	0.12	1.3	13.8	546,000	8,736,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CF3)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB101	Single-family	38	18.14	42	0.39	1.2	0.5	21,000	384,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	62	28.86	0	0.10	1.2	0.2	9,000	144,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	47.20	16	0.21	1.2	0.7	30,000	480,000
	SMB102	Single-family	14	9.58	42	0.39	1.2	0.3	11,000	176,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	86	61.26	0	0.10	1.2	0.5	18,000	288,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	70.84	6	0.14	1.2	0.7	29,000	464,000
	SMB103	Single-family	97	17.43	42	0.39	1.2	0.5	20,000	320,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	3	0.52	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	17.95	41	0.38	1.2	0.5	20,000	320,000
	SMB104	Single-family	98	31.33	42	0.39	1.2	0.9	36,000	576,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	2	0.69	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	32.02	41	0.38	1.2	0.9	36,000	576,000
	SMB105	Single-family	81	52.97	42	0.39	1.2	1.5	61,000	976,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	19	12.60	0	0.10	1.2	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	65.57	34	0.33	1.2	1.6	65,000	1,040,000
	SMB93	Single-family	46	27.71	42	0.39	1.2	0.5	20,000	320,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	54	28.44	0	0.10	1.2	0.2	6,000	96,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	56.15	20	0.23	1.2	0.7	26,000	416,000
	SMB94	Single-family	7	28.86	42	0.39	1.2	0.8	32,000	512,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	93	376.94	0	0.10	1.2	2.8	112,000	1,792,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	405.80	3	0.12	1.2	3.6	144,000	2,304,000

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TABLE [illegible]

LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CF)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB95	Single-family	78	54.41	42	0.30	1.2	2.6	63,000	1,008,000
		Multi-family	0	0.00	60	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	22	15.42	0	0.10	1.2	0.1	3,000	48,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	69.83	33	0.33	1.2	2.7	66,000	1,056,000
	SMB96	Single-family	17	16.76	42	0.30	1.2	0.5	19,000	304,000
		Multi-family	0	0.00	60	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	83	82.65	0	0.10	1.2	0.6	24,000	384,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	99.41	7	0.13	1.2	1.1	43,000	688,000
14	LPLCN1	Single-family	5	55.14	42	0.30	1.5	2.0	80,000	1,280,000
		Multi-family	0	0.00	60	0.50	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	2	29.66	80	0.66	1.5	1.2	48,000	768,000
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	94	1,122.27	0	0.10	1.5	10.5	419,000	6,704,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	1,207.07	3	0.12	1.5	13.7	547,000	8,752,000
	LPLCN2	Single-family	21	149.37	42	0.30	1.2	4.3	173,000	2,768,000
		Multi-family	0	0.00	60	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	79	564.97	0	0.10	1.2	4.2	169,000	2,704,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	714.34	9	0.16	1.2	8.6	342,000	5,472,000
	LTLPL1	Single-family	3	20.20	42	0.30	1.5	0.7	28,000	448,000
		Multi-family	0	0.00	60	0.50	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	97	700.91	0	0.10	1.5	6.6	262,000	4,192,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	721.11	1	0.11	1.5	7.3	290,000	4,640,000
	SMB106	Single-family	100	51.80	42	0.30	1.2	1.5	60,000	960,000
		Multi-family	0	0.00	60	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	51.80	42	0.30	1.2	1.5	60,000	960,000
	SMB107	Single-family	26	40.52	42	0.30	1.2	1.2	47,000	752,000
		Multi-family	0	0.00	60	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	74	114.43	0	0.10	1.2	0.9	34,000	544,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	154.95	11	0.15	1.2	2.0	81,000	1,296,000

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TABLE A-1
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	SMB108	Single-family	64	23.41	42	0.39	1.2	0.7	27,000	432,000
		Multi-family	0	0.00	48	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	36	13.26	0	0.10	1.2	0.1	4,000	64,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	36.67	27	0.29	1.2	0.8	31,000	496,000
	SMB109	Single-family	41	21.26	42	0.39	1.2	0.6	28,000	448,000
		Multi-family	0	0.00	48	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	59	30.18	0	0.10	1.2	0.2	6,000	96,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	51.44	17	0.22	1.2	0.8	34,000	544,000
	SMB110	Single-family	50	23.93	42	0.39	1.2	0.4	16,000	256,000
		Multi-family	0	0.00	48	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	50	13.84	0	0.10	1.2	0.1	4,000	64,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	37.79	21	0.25	1.2	0.5	20,000	320,000
	SMB111	Single-family	71	40.65	42	0.39	1.2	1.4	56,000	896,000
		Multi-family	0	0.00	48	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	29	20.87	0	0.10	1.2	0.1	6,000	96,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	61.52	30	0.31	1.2	1.6	62,000	992,000
	SMB112	Single-family	55	38.93	42	0.39	1.2	1.1	48,000	720,000
		Multi-family	0	0.00	48	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	45	31.41	0	0.10	1.2	0.2	8,000	144,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	70.34	23	0.25	1.2	1.4	54,000	864,000
	SMB113	Single-family	61	25.43	42	0.39	1.2	0.7	28,000	464,000
		Multi-family	0	0.00	48	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	39	16.34	0	0.10	1.2	0.1	2,000	80,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	41.76	26	0.28	1.2	0.9	34,000	544,000
16	PENA1	Single-family	0	1.88	42	0.39	1.2	0.0	2,000	32,000
		Multi-family	0	0.00	48	0.50	1.2	0.0	0	0
		Commercial	0	0.00	92	0.76	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	481.85	0	0.10	1.2	2.6	142,000	2,272,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	482.73	0	0.10	1.2	2.6	144,000	2,304,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	PEDR1	Single-family	4	15.30	42	0.39	1.2	0.4	18,000	281,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	96	411.15	0	0.10	1.2	2.1	323,000	1,961,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	426.45	1	0.11	1.2	2.5	341,000	2,254,000
	SMB114	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	22.73	0	0.10	1.2	0.2	7,000	112,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	22.73	0	0.10	1.2	0.2	7,000	112,000
	SMB115	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	48.96	0	0.10	1.2	0.4	15,000	240,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	48.96	0	0.10	1.2	0.4	15,000	240,000
	SMB121	Single-family	43	8.26	42	0.39	1.2	0.2	10,000	160,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	57	10.76	0	0.10	1.2	0.1	3,000	40,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	19.02	18	0.23	1.2	0.3	13,000	200,000
	SMB122	Single-family	39	3.36	42	0.39	1.2	0.1	4,000	64,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	61	14.89	0	0.10	1.2	0.1	4,000	64,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	18.25	6	0.15	1.2	0.2	8,000	128,000
	SMB123	Single-family	54	4.55	42	0.39	1.0	0.1	4,000	64,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	46	3.94	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	8.49	23	0.26	1.0	0.1	5,000	80,000
	SMB124	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	100	18.48	0	0.10	1.2	0.1	5,000	80,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	18.51	0	0.10	1.2	0.1	5,000	80,000

TABLE A-4
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CF?)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	SMB 125	Single-family	0	0.00	40	0.39	1.5	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	0.00	90	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	100	22.39	0	0.10	1.5	0.2	7,000	112,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	22.39	0	0.10	1.5	0.2	7,000	112,000
	SMB 126	Single-family	0	0.00	40	0.39	1.5	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	0.00	90	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	100	14.31	0	0.10	1.5	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	14.31	0	0.10	1.5	0.1	4,000	64,000
	SMB 127	Single-family	15	2.12	40	0.39	1.5	0.1	2,000	32,000
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	0.00	90	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	85	11.97	0	0.10	1.5	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	14.09	6	0.14	1.5	0.2	6,000	96,000
	SMB 128	Single-family	36	7.14	40	0.39	1.5	0.2	8,000	128,000
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	0.00	90	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	64	12.49	0	0.10	1.5	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	19.63	15	0.21	1.5	0.3	12,000	192,000
	TUNA1	Single-family	3	24.30	40	0.39	1.5	0.8	31,000	496,000
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	0.00	90	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	97	[illegible]	0	0.10	1.5	7.3	292,000	4,672,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	[illegible]	3	0.11	1.5	8.1	323,000	5,168,000
36	BROOK1	Single-family	0	0.00	40	0.39	1.5	0.0	0	0
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	0.00	90	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	100	172.65	0	0.10	1.5	1.3	51,000	816,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	172.65	0	0.10	1.5	1.3	51,000	816,000
	[illegible]	Single-family	43	223.96	40	0.39	1.5	4.5	179,000	2,864,000
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	0.00	90	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	57	267.35	0	0.10	1.5	1.6	62,000	992,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	491.31	18	0.22	1.5	6.1	241,000	3,856,000

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LAND USE AND RUNOFF [illegible] FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	GARAP1	Single-family	3	41.38	42	0.39	1.6	1.6	64,000	1,804,000
		Multi-family	0	0.00	60	0.52	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	97	1,184.37	0	0.10	1.6	11.7	468,000	7,408,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	1,225.75	1	0.11	1.6	13.3	532,000	8,313,000
	GRNLF	Single-family	1	8.51	42	0.39	1.6	0.3	33,000	288,000
		Multi-family	0	0.00	60	0.52	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	99	596.47	0	0.10	1.6	5.9	304,000	2,776,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	604.98	1	0.10	1.6	6.2	340,000	3,064,000
	HONDO1	Single-family	3	14.42	42	0.39	1.6	0.6	26,000	404,000
		Multi-family	0	0.00	60	0.52	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	97	469.97	0	0.10	1.6	4.7	186,000	2,976,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	484.39	1	0.11	1.6	5.3	213,000	3,382,000
	GTTNG1	Single-family	11	131.50	42	0.39	1.6	3.1	208,000	3,240,000
		Multi-family	0	0.00	60	0.56	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	89	1,025.81	0	0.10	1.6	10.2	405,000	6,400,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	1,157.34	5	0.13	1.6	13.3	608,000	9,720,000
	GTTNG2	Single-family	5	47.77	42	0.39	1.6	1.2	46,000	724,000
		Multi-family	0	0.00	60	0.56	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	95	857.40	0	0.10	1.6	8.5	300,000	5,424,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	905.17	2	0.12	1.6	9.7	363,000	6,148,000
	GTTNG3	Single-family	37	98.70	42	0.39	1.6	2.1	135,000	1,962,000
		Multi-family	0	0.00	60	0.52	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	83	378.72	0	0.10	1.6	3.2	150,000	2,400,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	484.42	7	0.15	1.6	4.9	273,000	4,344,000
	RDRCK1	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	60	0.52	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	378.17	0	0.10	1.6	2.7	225,000	3,600,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	378.17	0	0.10	1.6	2.7	225,000	3,600,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF R•	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB 129	Single-family	77	[illegible]	42	0.39	1.5	0.4	17,000	372,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	[illegible]	0.66	1.5	0.0	0	0
		Open	23	4.37	0	0.10	1.5	0.0	1,000	16,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	[illegible]	32	0.32	1.5	0.5	18,000	288,000
	[illegible]	Single-family	0	0.38	42	0.39	1.6	0.0	1,000	16,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	601.12	0	0.10	1.6	0.0	237,000	3,792,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	601.50	0	0.10	1.6	6.0	238,000	3,808,000
	TPNGA1	Single-family	14	208.49	42	0.39	1.6	8.1	321,000	5,136,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	86	1,252.69	0	0.10	1.6	12.4	495,000	7,920,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	1,461.18	6	0.14	1.6	20.5	816,000	13,056,000
	TPNGA2	Single-family	34	63.39	42	0.39	1.6	2.4	97,000	1,552,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	[illegible]	0.66	1.6	0.0	0	0
		Open	66	120.31	0	0.10	1.6	1.2	48,000	768,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	183.87	14	0.20	1.6	3.6	145,000	2,320,000
	TPNGA3	Single-family	22	284.13	42	0.39	1.6	11.1	441,000	7,056,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	[illegible]	0.66	1.6	0.0	0	0
		Open	78	1,034.93	0	0.10	1.6	10.3	409,000	6,544,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	1,321.06	9	0.16	1.6	21.3	850,000	13,600,000
	TPNGA4	Single-family	78	188.38	42	0.39	1.6	4.0	159,000	2,544,000
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	[illegible]	0.66	1.6	0.0	0	0
		Open	22	28.79	0	0.10	1.6	0.3	12,000	192,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	133.17	33	0.33	1.6	4.3	171,000	2,736,000
	TPNGA5	Single-family	21	201.86	42	0.39	1.5	7.3	292,000	4,672,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	[illegible]	0.66	1.5	0.0	0	0
		Open	79	760.38	0	0.10	1.5	7.1	282,000	4,512,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	962.23	9	0.16	1.5	14.4	574,000	9,184,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CF3)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	TPNGA6	Single-family	4	78.42	42	0.39	1.5	2.8	110,000	1,740,000
		Multi-family	0	0.00	68	0.52	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	70	0.66	1.5	0.0	0	0
		Open	96	1,726.34	0	0.10	1.5	36.1	640,000	10,240,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	1,804.76	2	0.11	1.5	38.8	750,000	12,000,000
	TPNGA7	Single-family	21	52.21	42	0.39	1.3	1.5	60,000	960,000
		Multi-family	0	0.00	68	0.56	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	79	191.22	0	0.10	1.3	1.4	57,000	912,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	243.43	9	0.16	1.3	3.0	117,000	1,872,000
77	PARKR1	Single-family	43	159.36	42	0.39	1.3	4.6	184,000	2,944,000
		Multi-family	3	12.41	68	0.56	1.3	0.5	22,000	352,000
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	7	26.46	80	0.66	1.3	1.2	48,000	768,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	47	177.75	0	0.10	1.3	1.3	53,000	848,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	374.34	29	0.26	1.3	7.7	307,000	4,912,000
	QUARY1	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.56	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	326.42	0	0.10	1.6	3.2	208,000	3,328,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	326.42	0	0.10	1.6	3.2	208,000	3,328,000
	SMB130	Single-family	7	1.84	42	0.39	1.3	0.1	2,000	32,000
		Multi-family	0	0.00	68	0.56	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	93	24.42	0	0.10	1.3	0.2	7,000	112,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	26.26	3	0.13	1.3	0.2	9,000	144,000
	SMB131	Single-family	95	49.11	42	0.39	1.3	1.6	57,000	912,000
		Multi-family	0	0.00	68	0.56	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	5	2.64	0	0.10	1.3	0.0	1,000	16,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	51.75	40	0.38	1.3	1.6	58,000	928,000
	SMB132	Single-family	100	20.66	42	0.39	1.3	0.6	24,000	384,000
		Multi-family	0	0.00	68	0.56	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	20.66	42	0.39	1.3	0.6	24,000	384,000

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[illegible]

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF R*	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SYNEZ1	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	93	0.74	1.6	0.0	0	0
		Public	0	0.00	50	0.46	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	50	0.46	1.6	0.0	0	0
		Open	100	1,304.34	0	0.10	1.6	22.2	511,000	8,176,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	1,304.34	0	0.10	1.6	22.2	511,000	8,176,000
	SYNEZ2	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	3	1.79	68	0.58	1.6	0.1	4,000	64,000
		Commercial	0	0.00	93	0.74	1.6	0.0	0	0
		Public	0	0.00	50	0.46	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	50	0.46	1.6	0.0	0	0
		Open	97	64.95	0	0.10	1.6	0.7	26,000	416,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	66.84	2	0.11	1.6	0.8	30,000	480,000
	SYNEZ3	Single-family	20	480.76	42	0.39	1.3	12.4	302,000	3,032,000
		Multi-family	2	30.83	68	0.58	1.3	1.2	72,000	1,144,000
		Commercial	1	14.67	93	0.74	1.3	0.9	21,000	340,000
		Public	1	37.34	50	0.46	1.3	1.1	26,000	416,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	7	167.70	50	0.46	1.3	7.9	313,000	5,008,000
		Open	72	1,633.01	0	0.10	1.3	13.1	321,000	5,136,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	2,333.11	13	0.21	1.3	37.3	1,040,000	16,633,000
	TILLER1	Single-family	9	31.30	42	0.39	1.6	1.2	48,000	768,000
		Multi-family	3	8.50	68	0.58	1.6	0.5	20,000	320,000
		Commercial	0	0.00	93	0.74	1.6	0.0	0	0
		Public	0	0.00	50	0.46	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	1.60	50	0.46	1.6	0.1	4,000	64,000
		Open	88	301.84	0	0.10	1.6	3.0	119,000	1,904,000
		Unknown	0	0.00	65	0.54	1.6	0.0	0	0
		Catchment Total	100	343.71	6	0.14	1.6	4.8	191,000	3,056,000
16	PULGA1	Single-family	62	632.68	42	0.39	1.3	18.3	767,000	12,272,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	93	0.74	1.3	0.0	0	0
		Public	0	0.00	50	0.46	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	2	19.83	50	0.46	1.3	1.0	40,000	640,000
		Open	36	368.79	0	0.10	1.3	2.9	116,000	1,856,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,021.30	27	0.29	1.3	23.2	923,000	14,768,000
	ENB120	Single-family	69	112.34	42	0.39	1.2	3.3	130,000	2,080,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	93	0.74	1.2	0.0	0	0
		Public	3	5.09	50	0.46	1.2	0.2	10,000	160,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	50	0.46	1.2	0.0	0	0
		Open	28	44.80	0	0.10	1.2	0.2	13,000	208,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	161.93	30	0.32	1.2	3.8	153,000	2,448,000
	ENB124	Single-family	64	34.26	42	0.39	1.2	1.0	40,000	640,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	0	0.00	93	0.74	1.2	0.0	0	0
		Public	0	0.00	50	0.58	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	50	0.46	1.2	0.0	0	0
		Open	36	19.08	0	0.10	1.2	0.1	6,000	96,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	53.34	27	0.29	1.2	1.1	46,000	736,000

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[illegible] FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB135	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	100	23.60	0	0.10	1.3	0.3	20,000	100,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	23.60	0	0.10	1.3	0.3	20,000	100,000
	TEMES1	Single-family	10	262.34	42	0.39	1.5	2.1	200,000	2,540,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	4.46	92	0.74	1.5	0.3	11,000	774,000
		Public	2	38.57	80	0.66	1.5	1.6	64,000	1,004,000
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	6.44	80	0.66	1.5	0.4	16,000	204,000
		Open	87	2,371.32	0	0.10	1.5	11.1	442,000	7,072,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	2,341.13	6	0.14	1.3	16.4	724,000	11,344,000
19	MNDLV1	Single-family	21	484.34	42	0.39	1.5	17.9	714,000	11,424,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	7.37	80	0.66	1.5	0.4	10,000	201,000
		Open	79	1,830.23	0	0.10	1.5	17.2	683,000	10,860,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	2,321.84	9	0.16	1.5	35.6	1,417,000	22,672,000
	RIVAS1	Single-family	14	95.86	42	0.39	1.3	3.0	120,000	1,920,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	6	44.37	80	0.66	1.3	2.4	94,000	1,504,000
		Open	80	557.00	0	0.10	1.3	4.5	179,000	2,864,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	697.23	11	0.18	1.3	9.9	393,000	6,281,000
	RUSTC1	Single-family	0	0.00	42	0.39	1.6	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.6	0.0	0	0
		Commercial	0	0.00	92	0.74	1.6	0.0	0	0
		Public	0	0.00	80	0.66	1.6	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.6	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.6	0.0	0	0
		Open	100	1,491.47	0	0.10	1.6	14.2	589,000	9,424,000
		Unknown	0	0.00	65	0.56	1.6	0.0	0	0
		Catchment Total	100	1,491.47	0	0.10	1.6	14.2	589,000	9,424,000
	RUSTC2	Single-family	8	303.46	42	0.39	1.5	5.0	236,000	3,776,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	92	1,809.20	0	0.10	1.5	18.5	737,000	11,792,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	2,112.66	3	0.12	1.5	24.4	973,000	15,568,000
	RUSTC3	Single-family	97	294.25	42	0.39	1.2	9.7	385,000	6,178,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	3	9.84	92	0.74	1.2	0.5	20,000	352,000
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	304.09	43	0.40	1.2	10.2	405,000	6,530,000

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TABLE A-2
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	[illegible]	Single-family	[illegible]	576.17	42	0.39	1.5	6.4	284,000	4,064,000
		Multi-family	0	0.00	60	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	[illegible]	1,642.37	0	0.10	1.5	15.3	680,000	9,728,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	2,218.54	4	0.13	1.5	21.7	962,000	13,792,000
	SMB 136	Single-family	59	40.33	42	0.39	1.3	1.2	47,000	702,000
		Multi-family	0	0.00	60	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	41	28.37	0	0.10	1.3	0.2	8,000	120,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	68.70	25	0.27	1.3	1.4	55,000	818,000
	SMB 137	Single-family	12	4.33	42	0.39	1.3	0.1	3,000	50,000
		Multi-family	0	0.00	60	0.58	1.3	0.0	0	0
		Commercial	1	0.53	92	0.74	1.3	0.0	1,000	16,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	87	32.60	0	0.10	1.3	0.2	20,000	300,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	37.34	6	0.14	1.3	0.4	24,000	364,000
	SMB 138	Single-family	32	11.82	42	0.39	1.3	0.3	24,000	354,000
		Multi-family	0	0.00	60	0.58	1.3	0.0	0	0
		Commercial	0	0.01	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	68	24.83	0	0.10	1.3	0.3	7,000	112,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	36.76	14	0.19	1.3	0.5	31,000	466,000
	SMB 142	Single-family	73	279.13	42	0.39	1.3	6.4	281,000	4,046,000
		Multi-family	0	0.00	60	0.58	1.3	0.0	0	0
		Commercial	5	16.63	92	0.74	1.3	0.5	22,000	312,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	22	65.74	0	0.10	1.3	0.5	20,000	304,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	371.50	35	0.34	1.3	7.3	304,000	4,664,000
	[illegible]	Single-family	78	877.30	42	0.39	1.3	25.7	1,025,000	16,400,000
		Multi-family	3	34.87	60	0.58	1.3	1.5	60,000	900,000
		Commercial	3	29.72	92	0.74	1.3	1.6	60,000	1,040,000
		Public	3	32.40	80	0.66	1.3	1.6	60,000	1,000,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	13	149.82	0	0.10	1.3	1.1	44,000	704,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,123.34	40	0.37	1.3	31.6	1,287,000	20,112,000
	[illegible]	Single-family	87	88.77	42	0.39	1.3	2.6	100,000	1,600,000
		Multi-family	0	0.00	60	0.58	1.3	0.0	0	0
		Commercial	8	8.33	92	0.74	1.3	0.3	20,000	288,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	5	5.46	0	0.10	1.3	0.0	2,000	32,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	102.56	44	0.40	1.3	3.1	122,000	1,904,000

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TABLE A-2
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
[illegible]	[illegible]	Single-family	89	544.34	42	0.39	1.2	15.5	630,000	10,044,000
		Multi-family	9	54.53	68	0.58	1.2	2.4	94,000	1,504,000
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	2	13.00	0	0.10	1.2	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	611.77	43	0.40	1.2	18.2	727,000	11,633,000
	[illegible]	Single-family	3	18.93	42	0.39	1.0	0.8	11,000	176,000
		Multi-family	50	304.85	68	0.58	1.0	16.7	428,000	6,848,000
		Commercial	5	23.36	92	0.74	1.0	1.1	44,000	704,000
		Public	12	61.56	80	0.66	1.0	2.5	100,000	1,600,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	3	14.66	80	0.66	1.0	0.6	24,000	384,000
		Open	30	97.34	0	0.10	1.0	0.6	24,000	384,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	505.33	57	0.50	1.0	15.8	630,000	10,048,000
	[illegible]	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	91	68.79	92	0.74	1.2	5.5	251,000	3,416,000
		Public	0	0.26	80	0.66	1.2	0.0	1,000	16,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	9	6.52	0	0.10	1.2	0.0	2,000	32,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	75.57	84	0.68	1.2	5.5	154,000	2,464,000
	[illegible]	Single-family	61	1,172.90	42	0.39	1.0	28.4	1,132,000	18,112,000
		Multi-family	15	287.00	68	0.58	1.0	10.3	411,000	6,576,000
		Commercial	1	16.43	92	0.74	1.0	0.8	30,000	480,000
		Public	4	83.12	80	0.66	1.0	3.4	135,000	2,160,000
		Light Industrial	0	7.47	91	0.74	1.0	0.3	14,000	224,000
		Other Urban	10	183.32	80	0.66	1.0	7.5	299,000	4,784,000
		Open	8	161.12	0	0.10	1.0	1.0	40,000	640,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	1,914.53	46	0.44	1.0	51.8	2,061,000	32,976,000
	[illegible]	Single-family	100	226.00	42	0.39	1.0	5.3	211,000	3,408,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	226.00	42	0.39	1.0	5.3	211,000	3,408,000
	[illegible]	Single-family	74	96.40	42	0.39	1.0	2.3	93,000	1,488,000
		Multi-family	17	21.77	68	0.58	1.0	0.8	31,000	496,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	9	11.41	80	0.66	1.0	0.5	19,000	304,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	129.67	50	0.45	1.0	3.6	143,000	2,288,000
	[illegible]	Single-family	5	27.38	42	0.39	1.2	0.8	32,000	512,000
		Multi-family	54	457.21	68	0.58	1.2	18.9	751,000	12,016,000
		Commercial	36	98.78	92	0.74	1.2	5.3	210,000	3,360,000
		Public	2	13.94	80	0.66	1.2	0.7	27,000	432,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	3	14.75	0	0.10	1.2	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	611.06	69	0.59	1.2	25.7	1,024,000	16,384,000

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TABLE A-2

TABLE A-2
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF R.	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	[illegible]	Single-family	20	38.92	42	0.39	1.0	0.9	77,000	592,000
		Multi-family	73	142.03	68	0.58	1.0	2.1	283,000	3,341,000
		Commercial	3	5.44	90	0.74	1.0	0.3	38,000	444,000
		Public	0	0.86	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.64	91	0.74	1.0	0.0	1,000	14,000
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	4	8.30	0	0.10	1.0	0.1	2,000	28,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	195.33	61	0.53	1.0	4.4	351,000	4,041,000
	BUNDY1	Single-family	16	81.33	42	0.39	1.3	2.9	177,000	1,572,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	90	0.74	1.3	0.0	0	0
		Public	1	7.17	80	0.66	1.3	0.4	30,000	290,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	2	10.77	80	0.66	1.3	0.6	25,000	400,000
		Open	80	399.34	0	0.10	1.3	2.7	140,000	2,344,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	498.34	20	0.17	1.3	7.1	301,000	4,524,000
	BUNDY2	Single-family	42	61.80	42	0.39	1.3	2.2	89,000	1,424,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	90	0.74	1.3	0.0	0	0
		Public	5	7.34	80	0.66	1.3	0.4	16,000	251,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	53	78.73	0	0.10	1.3	0.7	29,000	484,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	147.39	21	0.25	1.3	3.4	134,000	2,176,000
	BUNDY3	Single-family	63	183.48	42	0.39	1.3	3.8	230,000	3,600,000
		Multi-family	10	22.34	68	0.58	1.3	1.0	42,000	672,000
		Commercial	1	1.15	90	0.74	1.3	0.1	3,000	48,000
		Public	6	14.28	80	0.66	1.3	0.8	28,000	480,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.92	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	222.17	47	0.43	1.3	7.6	303,000	4,810,000
	KENTR1	Single-family	65	633.61	42	0.39	1.3	20.9	790,000	12,602,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	90	0.74	1.3	0.0	0	0
		Public	0	0.71	80	0.66	1.3	0.0	2,000	32,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	35	342.57	0	0.10	1.3	3.8	110,000	1,760,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	976.86	27	0.29	1.3	22.7	902,000	14,400,000
	KENTR2	Single-family	51	144.43	42	0.39	1.3	4.2	167,000	2,572,000
		Multi-family	24	67.34	68	0.58	1.3	3.0	114,000	1,824,000
		Commercial	15	40.91	90	0.74	1.3	2.3	90,000	1,440,000
		Public	3	8.74	80	0.66	1.3	0.4	17,000	272,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	7	21.09	0	0.10	1.3	0.2	6,000	96,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	282.54	53	0.47	1.3	9.9	394,000	6,324,000
	KENTR3	Single-family	78	408.20	42	0.38	1.3	12.7	504,000	8,064,000
		Multi-family	3	11.87	68	0.58	1.2	0.5	18,000	304,000
		Commercial	1	6.32	90	0.74	1.2	0.3	14,000	224,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	18	102.63	0	0.10	1.3	0.3	28,000	480,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	254.33	26	0.34	1.3	14.3	560,000	8,704,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	KENTRA	Single-family	25	253.59	42	0.30	1.2	10.3	411,000	6,576,000
		Multi-family	32	460.77	48	0.38	1.2	19.9	792,000	12,672,000
		Commercial	19	287.26	82	0.74	1.2	14.7	586,000	9,376,000
		Public	2	25.90	80	0.46	1.2	1.3	51,000	816,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	4.58	80	0.46	1.2	0.3	14,000	224,000
		Open	22	322.38	0	0.10	1.2	2.4	96,000	1,536,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	1,446.21	51	0.46	1.2	48.9	1,950,000	31,200,000
	LA4798	Single-family	80	268.42	42	0.30	1.0	6.3	251,000	4,016,000
		Multi-family	11	37.31	48	0.38	1.0	1.3	53,000	848,000
		Commercial	4	13.71	82	0.74	1.0	0.6	30,000	480,000
		Public	0	0.00	80	0.46	1.0	0.0	0	0
		Light Industrial	5	15.79	91	0.74	1.0	0.7	29,000	464,000
		Other Urban	0	0.00	80	0.46	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	337.23	48	0.44	1.0	9.0	364,000	5,728,000
	SMB 139	Single-family	0	0.00	42	0.30	1.2	0.0	0	0
		Multi-family	0	0.00	48	0.38	1.2	0.0	0	0
		Commercial	0	0.00	82	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.46	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.46	1.2	0.0	0	0
		Open	100	63.36	0	0.10	1.2	0.5	18,000	288,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	63.36	0	0.10	1.2	0.5	18,000	288,000
	SMB 140	Single-family	0	0.00	42	0.30	1.2	0.0	0	0
		Multi-family	0	0.00	48	0.38	1.2	0.0	0	0
		Commercial	0	0.00	82	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.46	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.46	1.2	0.0	0	0
		Open	100	28.36	0	0.10	1.2	0.2	8,000	128,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	28.36	0	0.10	1.2	0.2	8,000	128,000
	SMB 141	Single-family	0	0.00	42	0.30	1.2	0.0	0	0
		Multi-family	0	0.00	48	0.38	1.2	0.0	0	0
		Commercial	0	0.00	82	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.46	1.2	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.46	1.2	0.0	0	0
		Open	99	70.78	0	0.10	1.2	0.5	21,000	336,000
		Unknown	1	0.99	65	0.54	1.2	0.0	2,000	32,000
		Catchment Total	100	71.77	1	0.11	1.2	0.6	23,000	368,000
	SMB 143	Single-family	4	2.58	42	0.30	1.0	0.1	3,000	48,000
		Multi-family	90	60.57	48	0.38	1.0	2.3	93,000	1,504,000
		Commercial	0	0.00	82	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.46	1.0	0.0	0	0
		Light Industrial	2	1.35	91	0.74	1.0	0.1	2,000	32,000
		Other Urban	0	0.00	80	0.46	1.0	0.0	0	0
		Open	3	1.80	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	94.57	46	0.57	1.0	2.6	104,000	1,664,000
21	SM11021	Single-family	64	826.57	42	0.30	1.2	24.3	966,000	15,456,000
		Multi-family	22	281.74	48	0.38	1.2	12.3	494,000	7,904,000
		Commercial	6	72.48	82	0.74	1.2	4.0	159,000	2,544,000
		Public	4	50.64	80	0.46	1.2	2.5	99,000	1,584,000
		Light Industrial	2	23.02	91	0.74	1.2	1.8	70,000	1,120,000
		Other Urban	1	18.67	80	0.46	1.2	0.9	36,000	576,000
		Open	0	0.26	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	1,291.71	[illegible]	0.47	1.2	43.9	1,826,000	[illegible]

TABLE A-5
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
[illegible]	Single-family	2	2.36	42	0.39	1.2	0.1	3,000	48,000
	Multi-family	90	228.82	68	0.58	1.2	8.3	220,000	3,520,000
	Commercial	2	3.31	92	0.74	1.2	0.2	7,000	112,000
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	5	7.15	91	0.74	1.2	0.4	16,000	256,000
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	1	0.74	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	241.60	69	0.59	1.2	8.2	246,000	3,936,000
[illegible]	Single-family	29	158.72	42	0.39	1.2	4.6	182,000	2,928,000
	Multi-family	56	466.86	68	0.58	1.2	20.3	806,000	12,896,000
	Commercial	11	87.98	92	0.74	1.2	4.8	192,000	3,072,000
	Public	9	71.63	80	0.66	1.2	3.5	140,000	2,240,000
	Light Industrial	0	3.41	91	0.74	1.2	0.2	8,000	128,000
	Other Urban	5	28.86	80	0.66	1.2	1.2	47,000	752,000
	Open	2	30.82	0	0.10	1.2	0.1	5,000	80,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	831.44	66	0.56	1.2	34.7	1,382,000	22,112,000
[illegible]	Single-family	53	1,309.61	42	0.39	1.0	28.3	1,126,000	18,016,000
	Multi-family	17	370.77	68	0.58	1.0	13.3	531,000	8,496,000
	Commercial	5	113.20	92	0.74	1.0	5.3	210,000	3,360,000
	Public	4	94.94	80	0.66	1.0	3.8	153,000	2,448,000
	Light Industrial	6	139.10	91	0.74	1.0	5.9	236,000	3,776,000
	Other Urban	8	178.25	80	0.66	1.0	7.3	290,000	4,640,000
	Open	6	136.73	0	0.10	1.0	0.8	34,000	544,000
	Unknown	0	0.00	65	0.56	1.0	0.0	0	0
	Catchment Total	100	2,313.31	54	0.46	1.0	64.3	2,580,000	41,280,000
[illegible]	Single-family	63	157.46	42	0.39	1.2	4.6	182,000	2,912,000
	Multi-family	4	9.73	68	0.58	1.2	0.4	17,000	272,000
	Commercial	9	22.34	92	0.74	1.2	1.2	49,000	784,000
	Public	5	11.32	80	0.66	1.2	0.4	22,000	352,000
	Light Industrial	16	40.12	91	0.74	1.2	2.3	88,000	1,408,000
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	3	7.36	0	0.10	1.2	0.1	2,000	32,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	248.33	56	0.49	1.2	8.8	360,000	5,760,000
[illegible]	Single-family	100	28.15	42	0.39	1.2	0.7	27,000	432,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	0	0.00	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	28.15	42	0.39	1.2	0.7	27,000	432,000
[illegible]	Single-family	65	272.19	42	0.39	1.2	7.0	314,000	5,024,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	35	143.64	0	0.10	1.2	1.1	43,000	688,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	415.83	27	0.29	1.2	8.8	357,000	5,712,000
[illegible]	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	11	9.71	91	0.74	1.2	0.5	21,000	336,000
	Other Urban	75	63.59	80	0.66	1.2	3.1	125,000	2,000,000
	Open	13	11.21	0	0.10	1.2	0.1	3,000	48,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	84.51	71	0.60	1.2	3.8	149,000	2,384,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF R.	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	B4242	Single-family	0	0.00	40	0.39	1.2	0.0	0	0
		Multi-family	7	6.59	68	0.58	1.2	0.3	11,000	176,000
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	33	30.93	91	0.74	1.2	1.7	65,000	1,001,000
		Other Urban	39	35.83	80	0.66	1.2	2.7	101,000	1,578,000
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	82.34	83	0.64	1.2	4.7	187,000	2,992,000
	B4243	Single-family	11	28.83	40	0.39	1.2	0.9	25,000	800,000
		Multi-family	25	66.51	68	0.58	1.2	2.9	114,000	1,824,000
		Commercial	3	4.71	92	0.74	1.2	0.5	18,000	288,000
		Public	30	77.34	80	0.66	1.2	3.8	152,000	2,432,000
		Light Industrial	7	19.46	91	0.74	1.2	1.1	43,000	688,000
		Other Urban	20	54.42	80	0.66	1.2	2.7	106,000	1,696,000
		Open	6	17.13	0	0.10	1.2	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	270.43	60	0.54	1.2	11.7	461,000	7,440,000
	B426	Single-family	46	80.86	40	0.39	1.2	2.3	92,000	1,472,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	8	13.19	92	0.74	1.2	0.7	29,000	464,000
		Public	1	1.19	80	0.66	1.2	0.1	2,000	32,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	31	53.55	80	0.66	1.2	2.6	105,000	1,680,000
		Open	14	24.34	0	0.10	1.2	0.2	7,000	112,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	172.13	53	0.46	1.2	5.9	235,000	3,760,000
	B461	Single-family	76	652.40	40	0.39	1.2	18.9	754,000	12,064,000
		Multi-family	6	47.83	68	0.58	1.2	2.1	82,000	1,312,000
		Commercial	6	53.40	92	0.74	1.2	2.9	117,000	1,872,000
		Public	12	100.95	80	0.66	1.2	3.8	197,000	3,152,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	854.46	51	0.43	1.2	28.0	1,150,000	18,400,000
	B467	Single-family	80	368.90	40	0.39	1.2	10.7	426,000	6,816,000
		Multi-family	3	11.85	68	0.58	1.2	0.5	20,000	320,000
		Commercial	13	60.66	92	0.74	1.2	3.3	133,000	2,128,000
		Public	1	3.32	80	0.66	1.2	0.2	6,000	96,000
		Light Industrial	3	15.36	91	0.74	1.2	0.8	34,000	544,000
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	460.09	51	0.45	1.2	15.6	619,000	9,904,000
	B4681	Single-family	91	430.06	40	0.39	1.0	9.9	395,000	6,320,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.86	92	0.74	1.0	0.0	1,000	16,000
		Public	0	30.39	80	0.66	1.0	1.6	64,000	1,024,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	450.21	45	0.41	1.0	11.6	466,000	7,344,000
	B4682	Single-family	80	188.65	40	0.39	1.0	4.8	191,000	3,056,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	10	23.18	92	0.74	1.0	1.1	42,000	672,000
		Public	1	2.30	80	0.66	1.0	0.1	4,000	64,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	234.83	48	0.43	1.0	6.0	237,000	3,792,000

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TABLE A-1
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	[illegible]	Single-family	80	2,254.36	42	0.39	1.0	84.6	3,772,000	34,722,000
		Multi-family	3	84.14	60	0.52	1.0	2.1	123,000	1,944,000
		Commercial	2	44.35	92	0.74	1.0	2.0	81,000	1,296,000
		Public	3	84.75	80	0.66	1.0	2.5	130,000	2,301,000
		Light Industrial	5	134.54	91	0.74	1.0	4.3	290,000	4,600,000
		Other Urban	1	35.44	80	0.66	1.0	1.3	54,000	928,000
		Open	2	61.40	0	0.10	1.0	0.4	25,000	399,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	2,705.42	47	0.42	1.0	71.3	3,337,000	[illegible]
	[illegible]	Single-family	80	251.84	42	0.39	1.3	6.0	320,000	3,120,000
		Multi-family	9	28.57	60	0.52	1.3	1.4	53,000	880,000
		Commercial	11	33.90	92	0.74	1.3	2.0	80,000	1,280,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	319.31	50	0.44	1.3	11.4	453,000	[illegible]
	[illegible]	Single-family	7	34.98	42	0.39	1.3	1.3	46,000	736,000
		Multi-family	0	0.00	60	0.52	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	93	454.32	0	0.10	1.3	2.7	146,000	2,336,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	493.30	3	0.13	1.3	4.0	192,000	3,072,000
	[illegible]	Single-family	58	380.33	42	0.39	1.5	21.0	838,000	13,408,000
		Multi-family	0	0.00	60	0.52	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.35	80	0.66	1.5	0.0	1,000	16,000
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	42	421.32	0	0.10	1.5	3.9	156,000	2,496,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	1,001.90	24	0.27	1.5	25.0	996,000	[illegible]
	[illegible]	Single-family	59	1,459.36	42	0.39	1.3	44.0	1,769,000	28,424,000
		Multi-family	16	383.83	60	0.52	1.3	17.9	714,000	11,424,000
		Commercial	6	151.40	92	0.74	1.3	9.0	366,000	5,760,000
		Public	2	53.10	80	0.66	1.3	2.8	113,000	1,808,000
		Light Industrial	4	92.04	91	0.74	1.3	5.5	221,000	3,536,000
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	12	295.18	0	0.10	1.3	2.4	95,000	1,520,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	2,469.41	47	0.43	1.3	82.6	3,302,000	52,872,000
	[illegible]	Single-family	38	131.04	42	0.39	1.3	3.3	142,000	2,340,000
		Multi-family	12	42.82	60	0.52	1.3	2.0	78,000	1,248,000
		Commercial	0	0.53	92	0.74	1.3	0.0	1,000	16,000
		Public	14	47.33	80	0.66	1.3	3.3	102,000	1,632,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	1	3.36	80	0.66	1.3	0.2	7,000	112,000
		Open	37	131.46	0	0.10	1.3	1.1	42,000	672,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	[illegible]	35	0.36	1.3	9.3	364,000	[illegible]
	[illegible]	Single-family	70	238.40	42	0.39	1.0	3.3	133,000	2,128,000
		Multi-family	25	49.75	60	0.52	1.0	1.8	71,000	1,136,000
		Commercial	3	3.36	92	0.74	1.0	0.2	10,000	160,000
		Public	3	3.23	80	0.66	1.0	0.2	9,000	144,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	[illegible]	51	0.45	1.0	5.6	223,000	3,568,000

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BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	B1304	Single-family	74	340.30	42	0.39	1.0	8.2	328,000	5,341,000
		Multi-family	20	94.12	68	0.58	1.0	3.4	135,000	2,160,000
		Commercial	5	21.61	92	0.74	1.0	1.0	39,000	624,000
		Public	1	2.78	80	0.66	1.0	0.2	6,000	96,000
		Light Industrial	1	2.73	91	0.74	1.0	0.1	5,000	80,000
		Other Urban	0	0.05	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	461.79	50	0.45	1.0	12.9	513,000	[illegible]
	B1306	Single-family	86	175.71	42	0.39	1.0	4.2	169,000	2,704,000
		Multi-family	4	8.64	68	0.58	1.0	0.3	12,000	192,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	7	13.30	91	0.74	1.0	0.7	28,000	448,000
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	3	5.64	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	203.42	46	0.42	1.0	5.3	210,000	3,360,000
	B131	Single-family	63	323.35	42	0.39	1.0	7.8	311,000	4,976,000
		Multi-family	19	97.39	68	0.58	1.0	3.3	139,000	2,224,000
		Commercial	9	44.13	92	0.74	1.0	2.0	81,000	1,296,000
		Public	7	36.00	80	0.66	1.0	1.5	60,000	960,000
		Light Industrial	1	6.51	91	0.74	1.0	0.2	12,000	192,000
		Other Urban	0	0.94	80	0.66	1.0	0.0	2,000	32,000
		Open	2	8.11	0	0.10	1.0	0.1	2,000	32,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	516.34	54	0.46	1.0	13.2	607,000	9,712,000
	B132	Single-family	42	277.67	42	0.39	1.2	8.1	321,000	5,136,000
		Multi-family	36	233.14	68	0.58	1.2	11.0	438,000	7,008,000
		Commercial	9	61.15	92	0.74	1.2	3.4	134,000	2,144,000
		Public	1	4.01	80	0.66	1.2	0.2	8,000	128,000
		Light Industrial	8	52.32	91	0.74	1.2	2.9	115,000	1,840,000
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	2	13.31	0	0.10	1.2	0.1	5,000	80,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	661.62	60	0.52	1.2	25.6	1,021,000	16,336,000
	B132041	Single-family	0	3.41	42	0.39	1.2	0.1	4,000	64,000
		Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
		Commercial	47	510.46	92	0.74	1.2	28.1	1,110,000	[illegible]
		Public	1	8.17	80	0.66	1.2	0.5	18,000	288,000
		Light Industrial	35	378.49	91	0.74	1.2	20.8	830,000	13,280,000
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	17	190.19	65	0.56	1.2	7.5	299,000	4,784,000
		Catchment Total	100	1,081.72	87	0.71	1.2	57.0	2,270,000	36,320,000
	B132042	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
		Multi-family	0	0.21	68	0.58	1.2	0.0	0	0
		Commercial	7	30.38	92	0.74	1.2	1.6	66,000	1,056,000
		Public	23	102.19	80	0.66	1.2	5.0	200,000	3,200,000
		Light Industrial	70	309.40	91	0.74	1.2	17.0	678,000	10,848,000
		Other Urban	0	0.45	80	0.66	1.2	0.0	1,000	16,000
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	442.33	89	0.72	1.2	23.7	945,000	15,120,000
	B132043	Single-family	24	697.30	42	0.39	1.2	20.3	806,000	12,896,000
		Multi-family	33	973.31	68	0.58	1.2	42.1	1,679,000	[illegible]
		Commercial	21	603.67	92	0.74	1.2	33.2	1,322,000	[illegible]
		Public	10	288.36	80	0.66	1.2	14.5	578,000	9,248,000
		Light Industrial	7	213.57	91	0.74	1.2	11.5	460,000	7,360,000
		Other Urban	3	95.30	80	0.66	1.2	4.8	192,000	3,072,000
		Open	3	80.42	0	0.10	1.2	0.4	15,000	240,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	2,924.51	60	0.56	1.2	127.0	5,054,000	80,864,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	[illegible]	Single-family	72	723.11	42	0.39	1.3	21.0	[illegible]	23,576,000
		Multi-family	14	140.36	68	0.58	1.3	6.1	241,000	3,834,000
		Commercial	9	89.95	92	0.74	1.3	5.0	197,000	3,153,000
		Public	2	17.82	80	0.66	1.3	0.5	33,000	528,000
		Light Industrial	3	33.85	91	0.74	1.3	1.9	74,000	1,184,000
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,004.99	53	0.46	1.3	34.7	1,361,000	[illegible]
	[illegible]	Single-family	37	233.45	42	0.39	1.3	3.1	[illegible]	[illegible]
		Multi-family	63	401.47	68	0.58	1.3	17.3	690,000	11,040,000
		Commercial	11	67.35	92	0.74	1.3	3.7	147,000	2,352,000
		Public	7	44.50	80	0.66	1.3	2.2	88,000	[illegible]
		Light Industrial	1	6.59	91	0.74	1.3	0.4	14,000	224,000
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	1	8.64	0	0.10	1.3	0.0	2,000	32,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	634.30	67	0.57	1.3	26.4	[illegible]	17,[illegible]
	[illegible]	Single-family	77	623.89	42	0.39	1.3	18.1	720,000	11,520,000
		Multi-family	16	125.59	68	0.58	1.3	5.4	216,000	3,456,000
		Commercial	1	4.43	92	0.74	1.3	0.3	10,000	160,000
		Public	1	4.70	80	0.66	1.3	0.3	13,000	208,000
		Light Industrial	3	22.34	91	0.74	1.3	0.7	29,000	464,000
		Other Urban	0	2.97	80	0.66	1.3	0.2	8,000	128,000
		Open	4	31.78	0	0.10	1.3	0.2	9,000	144,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	809.40	46	0.42	1.3	25.3	[illegible]	[illegible]
	[illegible]	Single-family	54	230.57	42	0.39	1.5	8.4	333,000	5,328,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	46	194.61	0	0.10	1.5	1.5	72,000	1,152,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	425.41	23	0.26	1.5	10.2	405,000	6,480,000
	[illegible]	Single-family	93	230.41	42	0.39	1.5	8.4	333,000	5,328,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	7	17.35	0	0.10	1.5	0.2	7,000	112,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	248.16	39	0.37	1.5	8.6	340,000	5,440,000
	[illegible]	Single-family	59	402.53	42	0.39	1.0	9.7	381,000	6,[illegible]
		Multi-family	6	40.77	68	0.58	1.0	1.5	58,000	928,000
		Commercial	7	46.12	92	0.74	1.0	2.1	84,000	1,344,000
		Public	9	58.76	80	0.66	1.0	2.4	96,000	1,536,000
		Light Industrial	18	122.65	91	0.74	1.0	5.7	226,000	3,616,000
		Other Urban	0	0.35	80	0.66	1.0	0.0	0	0
		Open	1	9.23	0	0.10	1.0	0.1	2,000	32,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	681.21	59	0.51	1.0	21.5	854,000	13,664,000
	[illegible]	Single-family	61	593.85	42	0.39	1.3	23.7	943,000	15,[illegible]
		Multi-family	25	241.42	68	0.58	1.3	11.3	449,000	7,184,000
		Commercial	7	66.65	92	0.74	1.3	4.0	158,000	2,528,000
		Public	3	27.35	80	0.66	1.3	1.3	53,000	848,000
		Light Industrial	1	7.34	91	0.74	1.3	0.5	18,000	288,000
		Other Urban	2	20.46	80	0.66	1.3	1.0	41,000	656,000
		Open	1	12.37	0	0.10	1.3	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	969.37	54	0.47	1.3	37.0	1,471,000	23,536,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	B1567	Single-family	1	2.15	42	0.39	1.0	0.1	2,000	22,000
		Multi-family	19	57.85	68	0.58	1.0	2.1	63,000	1,521,000
		Commercial	15	45.56	92	0.74	1.0	2.1	83,000	1,528,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	37	84.32	91	0.74	1.0	2.5	98,000	1,884,000
		Other Urban	2	5.36	80	0.66	1.0	0.2	9,000	166,000
		Open	47	145.40	0	0.10	1.0	0.9	26,000	576,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	310.84	44	0.41	1.0	7.8	312,000	4,092,000
	B1571	Single-family	24	280.83	42	0.39	1.3	8.3	304,000	5,104,000
		Multi-family	23	272.79	68	0.58	1.2	11.7	442,000	7,461,000
		Commercial	8	100.57	92	0.74	1.2	5.5	220,000	3,130,000
		Public	6	68.80	80	0.66	1.3	3.6	134,000	2,144,000
		Light Industrial	2	28.16	91	0.74	1.3	1.1	44,000	704,000
		Other Urban	3	35.42	80	0.66	1.3	1.3	50,000	800,000
		Open	35	410.50	0	0.10	1.2	5.1	204,000	1,804,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	1,187.40	41	0.39	1.3	34.3	1,364,000	21,834,000
	B15710	Single-family	17	18.87	42	0.38	1.3	0.6	23,000	366,000
		Multi-family	54	62.41	68	0.58	1.3	2.9	117,000	1,872,000
		Commercial	28	37.42	92	0.74	1.3	1.6	66,000	1,064,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	108.34	70	0.59	1.3	5.1	206,000	3,296,000
	B1572	Single-family	22	288.44	42	0.38	1.3	9.8	371,000	6,284,000
		Multi-family	56	599.95	68	0.58	1.2	28.3	1,079,000	16,464,000
		Commercial	6	61.89	92	0.74	1.2	3.4	136,000	2,176,000
		Public	4	45.39	80	0.66	1.2	2.2	89,000	1,424,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	1	8.94	80	0.66	1.2	0.4	17,000	272,000
		Open	1	14.38	0	0.10	1.2	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	1,064.09	61	0.53	1.2	41.9	1,606,000	26,616,000
	B1573	Single-family	30	301.83	42	0.38	1.3	3.2	126,000	2,016,000
		Multi-family	43	220.50	68	0.58	1.3	10.5	409,000	6,544,000
		Commercial	9	45.57	92	0.74	1.3	2.7	108,000	1,728,000
		Public	3	13.80	80	0.66	1.3	0.7	28,000	448,000
		Light Industrial	14	70.57	91	0.74	1.3	4.2	167,000	2,672,000
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	11	57.46	0	0.10	1.3	0.5	18,000	288,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	507.42	61	0.53	1.3	21.5	856,000	13,696,000
	B1574	Single-family	26	485.76	42	0.39	1.3	25.6	620,000	9,920,000
		Multi-family	44	831.42	68	0.58	1.3	80.9	2,347,000	34,752,000
		Commercial	15	284.59	92	0.74	1.3	37.6	700,000	11,200,000
		Public	1	23.41	80	0.66	1.3	0.7	28,000	448,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	14	274.86	0	0.10	1.3	2.2	88,000	1,408,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	1,899.56	55	0.49	1.3	75.0	2,983,000	47,728,000
	B1575	Single-family	18	479.68	42	0.39	1.3	22.2	325,000	5,680,000
		Multi-family	54	1,382.02	68	0.58	1.3	59.9	2,344,000	38,176,000
		Commercial	24	575.67	92	0.74	1.3	34.3	1,367,000	21,872,000
		Public	1	25.67	80	0.66	1.3	1.4	54,000	864,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	2	57.46	0	0.10	1.3	0.5	18,000	288,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	2,540.50	64	0.57	1.3	109.3	4,330,000	69,600,000

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TABLE A-4

TABLE A-4
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
B3576	Single-family	76	473.84	42	0.39	1.3	14.9	393,000	9,401,000
	Multi-family	13	80.16	68	0.58	1.3	2.7	149,000	2,364,000
	Commercial	7	44.73	92	0.74	1.3	2.7	105,000	1,696,000
	Public	4	26.57	80	0.66	1.3	1.4	57,000	913,000
	Light Industrial	0	1.57	91	0.74	1.3	0.1	5,000	80,000
	Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
	Open	0	0.00	0	0.10	1.3	0.0	0	0
	Unknown	0	0.00	65	0.56	1.3	0.0	0	0
	Catchment Total	100	627.41	51	0.43	1.3	22.9	910,000	14,540,000
B3577	Single-family	24	319.32	42	0.39	1.3	16.3	650,000	10,400,000
	Multi-family	13	206.74	68	0.58	1.3	9.2	346,000	5,534,000
	Commercial	11	144.67	92	0.74	1.3	9.0	396,000	6,336,000
	Public	2	26.54	80	0.66	1.3	1.4	36,000	594,000
	Light Industrial	1	11.17	91	0.74	1.3	1.1	43,000	684,000
	Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
	Open	48	603.72	0	0.10	1.3	4.9	195,000	3,120,000
	Unknown	0	0.00	65	0.56	1.3	0.0	0	0
	Catchment Total	100	1,336.16	35	0.33	1.3	42.0	1,705,000	27,296,000
B3578	Single-family	24	380.84	42	0.39	1.3	11.5	451,000	7,216,000
	Multi-family	18	263.84	68	0.58	1.3	22.3	491,000	7,856,000
	Commercial	8	120.10	92	0.74	1.3	7.3	281,000	4,500,000
	Public	0	0.00	80	0.66	1.3	0.0	0	0
	Light Industrial	5	78.60	91	0.74	1.3	4.7	187,000	2,992,000
	Other Urban	5	67.90	80	0.66	1.3	3.6	144,000	2,304,000
	Open	40	601.84	0	0.10	1.3	4.8	193,000	3,088,000
	Unknown	0	0.00	65	0.56	1.3	0.0	0	0
	Catchment Total	100	1,491.61	36	0.37	1.3	44.0	1,751,000	28,016,000
B3579	Single-family	70	874.40	42	0.39	1.3	37.5	1,498,000	[illegible]
	Multi-family	12	164.97	68	0.58	1.3	9.3	372,000	4,672,000
	Commercial	11	136.93	92	0.74	1.3	8.2	331,000	5,300,000
	Public	1	14.30	80	0.66	1.3	0.8	30,000	480,000
	Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
	Open	6	74.42	0	0.10	1.3	0.6	24,000	384,000
	Unknown	0	0.00	65	0.56	1.3	0.0	0	0
	Catchment Total	100	1,251.30	40	0.44	1.3	44.4	1,764,000	28,224,000
B4640A	Single-family	30	91.82	42	0.39	1.3	2.6	105,000	1,680,000
	Multi-family	62	188.48	68	0.58	1.3	8.6	341,000	5,456,000
	Commercial	8	24.23	92	0.74	1.2	1.6	64,000	864,000
	Public	0	0.70	80	0.66	1.3	0.0	1,000	16,000
	Light Industrial	2	7.34	91	0.74	1.2	0.4	16,000	256,000
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	0	0.00	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	322.07	63	0.54	1.2	13.0	312,000	8,372,000
B4640C	Single-family	50	58.43	42	0.39	1.2	1.7	68,000	1,088,000
	Multi-family	2	2.71	68	0.58	1.2	0.1	5,000	80,000
	Commercial	26	28.76	92	0.74	1.2	1.1	46,000	736,000
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	20	26.26	91	0.74	1.2	2.0	77,000	1,232,000
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	0	0.00	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	117.36	66	0.56	1.2	4.9	196,000	3,136,000
B3677	Single-family	33	188.11	42	0.39	1.0	4.4	173,000	2,768,000
	Multi-family	7	38.31	68	0.58	1.0	1.4	55,000	880,000
	Commercial	3	16.28	92	0.74	1.0	0.7	30,000	480,000
	Public	0	0.79	80	0.66	1.0	0.0	1,000	16,000
	Light Industrial	4	23.26	91	0.74	1.0	1.1	42,000	672,000
	Other Urban	17	95.99	80	0.66	1.0	3.9	156,000	2,496,000
	Open	35	185.21	0	0.10	1.0	1.2	48,000	768,000
	Unknown	0	0.00	65	0.56	1.0	0.0	0	0
	Catchment Total	100	549.35	39	0.37	1.0	12.7	505,000	8,080,000

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TABLE A3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	B77	Single-family	81	264.70	42	0.39	1.0	4.9	197,000	3,152,000
		Multi-family	5	21.39	60	0.58	1.0	0.5	30,000	480,000
		Commercial	20	84.17	92	0.74	1.0	4.3	172,000	2,752,000
		Public	6	23.00	80	0.66	1.0	1.0	39,000	624,000
		Light Industrial	9	36.47	91	0.74	1.0	1.7	67,000	1,072,000
		Other Urban	1	4.44	80	0.66	1.0	0.2	7,000	112,000
		Open	8	36.70	0	0.10	1.0	0.1	5,000	80,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	403.44	60	0.52	1.0	13.0	517,000	8,272,000
	B170	Single-family	79	1,157.57	42	0.39	1.2	30.0	1,314,000	21,024,000
		Multi-family	6	84.10	60	0.58	1.2	3.6	144,000	2,304,000
		Commercial	14	197.60	92	0.74	1.2	10.9	422,000	6,752,000
		Public	2	23.39	80	0.66	1.2	1.1	44,000	704,000
		Light Industrial	0	0.34	91	0.74	1.2	0.0	1,000	16,000
		Other Urban	0	3.30	80	0.66	1.2	0.1	5,000	80,000
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.13	65	0.54	1.2	0.0	0	0
		Catchment Total	100	1,466.13	51	0.43	1.2	46.0	1,941,000	31,056,000
	B171	Single-family	82	872.32	42	0.39	1.0	21.1	840,000	13,440,000
		Multi-family	7	68.81	60	0.56	1.0	2.5	99,000	1,584,000
		Commercial	5	53.42	92	0.74	1.0	2.3	91,000	1,456,000
		Public	3	37.34	80	0.66	1.0	1.1	45,000	720,000
		Light Industrial	3	26.36	91	0.74	1.0	1.2	49,000	784,000
		Other Urban	0	1.46	80	0.66	1.0	0.1	2,000	32,000
		Open	1	8.11	0	0.10	1.0	0.1	2,000	32,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	1,051.39	46	0.43	1.0	28.3	1,128,000	18,048,000
	B181	Single-family	91	711.52	42	0.39	1.0	27.3	683,000	10,928,000
		Multi-family	1	7.12	60	0.58	1.0	0.2	10,000	160,000
		Commercial	0	0.09	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	8	65.72	91	0.74	1.0	3.0	120,000	1,920,000
		Other Urban	0	0.10	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	784.93	46	0.42	1.0	30.5	813,000	13,040,000
	B184	Single-family	32	54.45	42	0.39	1.2	1.6	63,000	1,008,000
		Multi-family	20	34.32	60	0.58	1.2	1.5	60,000	960,000
		Commercial	5	8.56	92	0.74	1.2	0.5	20,000	320,000
		Public	13	21.61	80	0.66	1.2	1.1	42,000	672,000
		Light Industrial	12	20.43	91	0.74	1.2	1.1	45,000	720,000
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	18	30.32	0	0.10	1.2	0.2	9,000	144,000
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	170.71	53	0.47	1.2	6.0	239,000	3,824,000
	B186	Single-family	78	55.59	42	0.39	1.0	1.3	52,000	832,000
		Multi-family	4	2.56	60	0.58	1.0	0.1	4,000	64,000
		Commercial	4	2.60	92	0.74	1.0	0.1	5,000	80,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	17	12.33	0	0.10	1.0	0.1	3,000	48,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	72.07	38	0.36	1.0	1.6	64,000	1,024,000
	[illegible]	Single-family	81	53.36	42	0.39	1.2	1.6	62,000	992,000
		Multi-family	19	12.50	60	0.58	1.2	0.5	21,000	336,000
		Commercial	0	0.00	92	0.74	1.2	0.0	0	0
		Public	0	0.00	80	0.66	1.2	0.0	0	0
		Light Industrial	0	0.30	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	0	0.00	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	66.06	47	0.43	1.2	2.1	83,000	1,328,000

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TABLE B-3

TABLE A-3

LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	BLLNA1	Single-family	42	50.56	42	0.39	1.3	1.6	64,000	1,004,000
		Multi-family	51	61.82	68	0.58	1.3	2.9	113,000	1,640,000
		Commercial	7	8.30	92	0.74	1.3	0.5	20,000	320,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	121.17	50	0.51	1.3	5.0	[illegible]	3,164,000
	BLLNA10	Single-family	100	61.76	42	0.39	1.3	1.8	71,000	1,126,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	61.76	42	0.39	1.3	1.8	71,000	1,126,000
	BLLNA11	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	100	34.96	91	0.74	1.3	0.2	35,000	531,000
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	34.96	91	0.74	1.3	[illegible]	35,000	531,000
	BLLNA12	Single-family	20	2.77	42	0.39	1.3	0.1	3,000	40,000
		Multi-family	0	0.00	68	0.58	1.3	0.0	0	0
		Commercial	77	10.50	92	0.74	1.3	0.6	24,000	384,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	4	0.60	91	0.74	1.3	0.0	1,000	16,000
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	14.07	82	0.67	1.3	0.7	28,000	440,000
	BLLNA13	Single-family	3	1.57	42	0.39	1.3	0.0	2,000	22,000
		Multi-family	3	1.42	68	0.58	1.3	0.1	2,000	22,000
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	94	48.18	80	0.66	1.3	2.4	94,000	1,504,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.2	0.0	0	0
		Catchment Total	100	51.17	79	0.65	1.3	2.5	98,000	1,548,000
	BLLNA14	Single-family	100	19.04	42	0.39	1.0	0.5	18,000	288,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	19.04	42	0.39	1.0	0.5	18,000	288,000
	BLLNA15	Single-family	91	222.03	42	0.39	1.0	3.0	117,000	1,872,000
		Multi-family	6	8.65	68	0.58	1.0	0.3	22,000	352,000
		Commercial	3	3.74	92	0.74	1.0	0.2	7,000	112,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	234.42	43	0.41	1.0	3.4	136,000	2,176,000

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TABLE [illegible]
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CF)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	BLLNA16	Single-family	50	14.57	42	0.39	1.0	0.4	14,000	224,000
		Multi-family	4	1.21	68	0.58	1.0	0.0	2,000	32,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	46	13.85	80	0.66	1.0	0.4	20,000	320,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	29.57	61	0.52	1.0	1.0	36,000	634,000
	BLLNA17	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	100	18.34	0	0.10	1.0	0.1	5,000	80,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	18.34	0	0.10	1.0	0.1	5,000	80,000
	BLLNA18	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	100	89.41	0	0.10	1.0	0.6	22,000	352,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	89.41	0	0.10	1.0	0.6	22,000	352,000
	BLLNA19	Single-family	25	400.30	42	0.39	1.0	9.7	396,000	6,376,000
		Multi-family	2	28.92	68	0.58	1.0	1.0	41,000	656,000
		Commercial	2	30.33	92	0.74	1.0	1.8	72,000	1,152,000
		Public	6	98.85	80	0.66	1.0	4.0	161,000	2,576,000
		Light Industrial	3	34.75	91	0.74	1.0	2.5	100,000	1,600,000
		Other Urban	22	343.81	80	0.66	1.0	14.2	563,000	9,008,000
		Open	40	633.76	0	0.10	1.0	2.9	156,000	2,496,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	1,602.33	30	0.37	1.0	37.2	1,479,000	23,664,000
	BLLNA2	Single-family	96	81.57	42	0.39	1.0	2.0	79,000	1,264,000
		Multi-family	1	0.64	68	0.58	1.0	0.0	1,000	16,000
		Commercial	3	2.59	92	0.74	1.0	0.1	4,000	64,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	84.80	46	0.40	1.0	2.1	84,000	1,344,000
	BLLNA20	Single-family	6	2.15	42	0.39	1.0	0.1	2,000	32,000
		Multi-family	86	20.57	68	0.58	1.0	1.0	41,000	656,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	7	2.57	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	23.30	61	0.53	1.0	1.1	44,000	704,000
	BLLNA3	Single-family	90	138.59	42	0.39	1.3	4.4	174,000	2,784,000
		Multi-family	10	15.50	68	0.58	1.3	0.7	28,000	448,000
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	154.11	45	0.41	1.3	5.1	202,000	3,232,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
BLLNA4	Single-family	41	34.72	42	0.39	1.2	1.6	63,000	1,008,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	15	19.12	92	0.74	1.2	1.1	43,000	688,000
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	21	18.39	91	0.74	1.2	1.6	63,000	1,008,000
	Other Urban	23	20.73	80	0.66	1.2	1.5	60,000	960,000
	Open	0	0.00	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	111.14	80	0.54	1.2	5.3	229,000	3,664,000
BLLNA6	Single-family	40	32.70	42	0.39	1.2	1.5	61,000	976,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	22	18.08	92	0.74	1.2	0.7	29,000	464,000
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	35	37.46	91	0.74	1.2	2.1	82,000	1,312,000
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	4	4.61	0	0.10	1.2	0.0	1,000	16,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	107.43	63	0.54	1.2	4.3	173,000	2,768,000
BLLNA7	Single-family	0	0.00	42	0.39	1.2	0.0	0	0
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	100	34.78	91	0.74	1.2	1.4	54,000	864,000
	Other Urban	0	0.01	80	0.66	1.2	0.0	0	0
	Open	0	0.00	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	34.79	91	0.74	1.2	1.4	54,000	864,000
BLLNA8	Single-family	16	47.86	42	0.39	1.2	1.4	55,000	880,000
	Multi-family	0	0.36	68	0.58	1.2	0.0	1,000	16,000
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	11	33.43	91	0.74	1.2	1.9	74,000	1,184,000
	Other Urban	73	223.70	80	0.66	1.2	11.0	437,000	6,992,000
	Open	0	0.32	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	305.41	75	0.63	1.2	14.3	567,000	9,072,000
BLLNA9	Single-family	28	30.46	42	0.39	1.2	0.6	25,000	388,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	73	51.16	91	0.74	1.2	3.2	127,000	2,032,000
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	0	0.00	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	71.62	78	0.63	1.2	3.8	151,000	2,420,000
BLNA5	Single-family	31	68.79	42	0.39	1.2	2.7	108,000	1,728,000
	Multi-family	13	21.00	68	0.58	1.2	1.0	40,000	640,000
	Commercial	30	35.55	92	0.74	1.2	2.0	78,000	1,248,000
	Public	0	0.16	80	0.66	1.2	0.0	0	0
	Light Industrial	17	28.45	91	0.74	1.2	1.7	67,000	1,072,000
	Other Urban	0	0.25	80	0.66	1.2	0.0	0	0
	Open	0	0.00	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	163.30	63	0.54	1.2	7.4	293,000	4,688,000
BLLNA12	Single-family	76	57.71	42	0.39	1.2	1.7	67,000	1,072,000
	Multi-family	0	0.00	68	0.58	1.2	0.0	0	0
	Commercial	0	0.00	92	0.74	1.2	0.0	0	0
	Public	0	0.00	80	0.66	1.2	0.0	0	0
	Light Industrial	24	18.46	91	0.74	1.2	1.0	40,000	640,000
	Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
	Open	0	0.00	0	0.10	1.2	0.0	0	0
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	76.17	54	0.47	1.2	2.7	107,000	1,712,000

LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CY)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	BNDCT1	Single-family	40	701.86	40	0.39	1.5	25.4	2,012,000	24,192,000
		Multi-family	0	0.00	60	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	60	1,061.93	0	0.10	1.5	9.9	596,000	6,324,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	1,763.79	17	0.21	1.5	35.4	2,608,000	31,326,000
	BNDCT2	Single-family	97	259.16	40	0.39	1.5	8.7	343,000	3,520,000
		Multi-family	0	0.00	60	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	3	7.33	0	0.10	1.5	0.1	3,000	48,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	266.49	41	0.38	1.5	8.7	346,000	3,564,000
	BNDCT3	Single-family	95	330.37	40	0.39	1.5	8.0	301,000	3,316,000
		Multi-family	0	0.00	60	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	1	0.90	80	0.66	1.5	0.1	2,000	32,000
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	4	6.19	0	0.10	1.5	0.1	2,000	32,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	346.24	40	0.38	1.5	8.2	305,000	3,380,000
	BNDCT4	Single-family	51	177.35	40	0.39	1.5	6.4	254,000	4,096,000
		Multi-family	0	0.00	60	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	2	6.84	80	0.66	1.5	0.4	16,000	256,000
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	47	160.57	0	0.10	1.5	1.5	60,000	960,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	343.06	23	0.26	1.5	8.3	332,000	5,312,000
	BNDCT5	Single-family	28	190.99	40	0.39	1.5	6.9	250,000	3,024,000
		Multi-family	21	142.00	60	0.58	1.5	7.0	277,000	4,432,000
		Commercial	15	105.44	92	0.74	1.5	6.3	254,000	4,000,000
		Public	6	42.86	80	0.66	1.5	2.3	91,000	1,456,000
		Light Industrial	6	38.37	91	0.74	1.5	2.3	91,000	1,456,000
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	24	166.10	0	0.10	1.5	1.5	58,000	928,000
		Unknown	0	0.00	65	0.56	1.5	0.0	0	0
		Catchment Total	100	685.62	50	0.45	1.5	25.2	1,001,000	16,016,000
	BNDCT6	Single-family	52	342.65	40	0.39	1.2	9.0	396,000	6,336,000
		Multi-family	14	100.08	60	0.58	1.2	6.9	273,000	4,368,000
		Commercial	11	71.88	92	0.74	1.2	4.9	158,000	2,528,000
		Public	2	10.84	80	0.66	1.2	0.5	21,000	336,000
		Light Industrial	2	11.62	91	0.74	1.2	0.6	25,000	400,000
		Other Urban	3	17.57	80	0.66	1.2	0.9	35,000	560,000
		Open	7	48.36	0	0.10	1.2	0.4	15,000	240,000
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	664.37	53	0.47	1.2	23.2	923,000	14,000,000
	CCAM	Single-family	46	334.13	40	0.39	1.2	9.4	374,000	5,984,000
		Multi-family	30	213.06	60	0.58	1.2	12.2	486,000	7,776,000
		Commercial	22	83.92	92	0.74	1.2	4.6	184,000	2,944,000
		Public	4	28.19	80	0.66	1.2	1.2	49,000	784,000
		Light Industrial	0	0.00	91	0.74	1.2	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.2	0.0	0	0
		Open	0	0.40	0	0.10	1.2	0.0	0	0
		Unknown	0	0.00	65	0.56	1.2	0.0	0	0
		Catchment Total	100	714.70	59	0.52	1.2	27.5	1,092,000	17,472,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	CNTLA1	Single-family	26	237.30	42	0.39	1.0	3.5	132,000	2,112,000
		Multi-family	5	20.42	65	0.55	1.0	0.7	26,000	464,000
		Commercial	11	66.14	92	0.74	1.0	3.9	121,000	1,936,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	6	31.25	91	0.74	1.0	1.5	58,000	928,000
		Other Urban	11	26.97	80	0.66	1.0	1.6	65,000	1,040,000
		Open	22	81.25	0	0.10	1.0	0.5	20,000	320,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	377.42	51	0.46	1.0	10.7	425,000	6,800,000
	CNTLA2	Single-family	63	200.40	42	0.39	1.0	4.9	188,000	3,001,000
		Multi-family	0	0.00	65	0.55	1.0	0.0	0	0
		Commercial	1	2.40	92	0.74	1.0	0.1	4,000	64,000
		Public	1	2.32	80	0.66	1.0	0.1	4,000	64,000
		Light Industrial	26	84.52	91	0.74	1.0	3.9	153,000	2,448,000
		Other Urban	9	28.53	80	0.66	1.0	1.2	48,000	768,000
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	318.77	50	0.51	1.0	10.1	402,000	6,432,000
	COLDW1	Single-family	77	531.90	42	0.39	1.3	19.3	768,000	12,288,000
		Multi-family	0	0.00	65	0.55	1.3	0.0	0	0
		Commercial	0	0.00	92	0.74	1.3	0.0	0	0
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	23	162.49	0	0.10	1.3	1.5	60,000	960,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	694.39	32	0.32	1.3	20.8	828,000	13,248,000
	COLDW2	Single-family	97	402.31	42	0.39	1.3	14.6	581,000	9,296,000
		Multi-family	0	0.00	65	0.55	1.3	0.0	0	0
		Commercial	3	10.45	92	0.74	1.3	0.7	29,000	464,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	1	2.47	0	0.10	1.3	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	413.23	43	0.40	1.3	15.3	611,000	9,776,000
	CULVER1	Single-family	48	169.21	42	0.39	1.3	5.5	219,000	3,504,000
		Multi-family	12	40.86	65	0.55	1.3	2.1	84,000	1,344,000
		Commercial	2	6.17	92	0.74	1.3	0.3	14,000	224,000
		Public	6	20.44	80	0.66	1.3	1.2	46,000	736,000
		Light Industrial	30	116.54	91	0.74	1.3	6.4	255,000	4,080,000
		Other Urban	3	10.37	80	0.66	1.3	0.5	20,000	320,000
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	363.57	64	0.55	1.3	16.0	638,000	10,208,000
	DDC11	Single-family	20	42.97	42	0.39	1.3	2.0	79,000	1,264,000
		Multi-family	51	104.53	65	0.55	1.3	7.3	291,000	4,656,000
		Commercial	29	57.81	92	0.74	1.3	5.2	209,000	3,344,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	207.33	70	0.59	1.3	14.5	579,000	9,264,000
	DDC111	Single-family	73	1,653.43	42	0.39	1.3	52.0	2,072,000	33,152,000
		Multi-family	12	261.06	65	0.55	1.3	12.2	481,000	7,808,000
		Commercial	8	169.90	92	0.74	1.3	10.1	403,000	6,448,000
		Public	1	23.25	80	0.66	1.3	1.2	49,000	784,000
		Light Industrial	2	53.73	91	0.74	1.3	3.2	128,000	2,048,000
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	4	86.16	0	0.10	1.3	0.7	28,000	448,000
		Unknown	0	0.00	65	0.56	1.3	0.0	0	0
		Catchment Total	100	2,251.43	49	0.44	1.3	79.6	3,168,000	50,688,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	BDC113	Single-family	51	425.30	42	0.39	1.3	23.7	945,000	8,720,000
		Multi-family	42	350.46	65	0.58	1.3	34.9	671,000	16,724,000
		Commercial	3	28.80	92	0.74	1.3	1.8	30,000	944,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	4	34.39	0	0.10	1.3	0.3	12,000	102,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	837.3	53	0.47	1.3	33.3	1,287,000	20,392,000
	BDC114	Single-family	51	1,270.40	42	0.39	1.3	42.1	1,715,000	37,440,000
		Multi-family	30	663.94	65	0.58	1.3	48.4	1,600,000	25,728,000
		Commercial	12	322.84	92	0.74	1.3	30.3	767,000	12,272,000
		Public	1	30.82	80	0.66	1.3	1.8	71,000	1,136,000
		Light Industrial	3	82.57	91	0.74	1.3	3.3	126,000	2,016,000
		Other Urban	1	36.34	80	0.66	1.3	0.9	35,000	560,000
		Open	1	28.44	0	0.10	1.3	0.2	9,000	144,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	2,441.93	54	0.50	1.3	104.4	4,331,000	69,296,000
	BDC1	Single-family	34	759.00	42	0.39	1.3	23.9	950,000	15,200,000
		Multi-family	39	309.15	65	0.58	1.3	18.7	743,000	11,888,000
		Commercial	4	60.44	92	0.74	1.3	3.6	144,000	2,304,000
		Public	0	0.00	80	0.66	1.3	0.0	0	0
		Light Industrial	7	99.46	91	0.74	1.3	5.9	236,000	3,776,000
		Other Urban	3	37.43	80	0.66	1.3	2.0	79,000	1,264,000
		Open	0	1.75	0	0.10	1.3	0.0	1,000	16,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,317.34	56	0.40	1.3	54.1	2,153,000	34,448,000
	FRANK1	Single-family	9	73.97	42	0.39	1.5	2.7	107,000	1,712,000
		Multi-family	0	0.00	65	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	0	0.00	80	0.66	1.5	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	88	698.72	0	0.10	1.5	6.5	259,000	4,144,000
		Unknown	3	20.99	65	0.54	1.5	1.1	44,000	704,000
		Catchment Total	100	793.68	6	0.14	1.5	10.3	410,000	6,560,000
	GROC1	Single-family	31	101.34	42	0.39	1.0	2.3	91,000	1,456,000
		Multi-family	40	130.31	65	0.58	1.0	4.7	187,000	2,992,000
		Commercial	9	27.36	92	0.74	1.0	1.2	50,000	800,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	20	64.34	0	0.10	1.0	0.4	16,000	256,000
		Unknown	0	0.60	65	0.54	1.0	0.0	1,000	16,000
		Catchment Total	100	323.97	48	0.44	1.0	8.6	[illegible]	[illegible]
	LA1177	Single-family	50	1,306.66	42	0.39	1.2	37.0	1,509,000	24,144,000
		Multi-family	16	438.01	65	0.58	1.2	17.3	696,000	11,136,000
		Commercial	8	207.84	92	0.74	1.2	11.4	456,000	7,296,000
		Public	3	61.35	80	0.66	1.2	3.0	121,000	1,936,000
		Light Industrial	3	84.47	91	0.74	1.2	3.0	119,000	1,904,000
		Other Urban	6	166.77	80	0.66	1.2	7.2	287,000	4,592,000
		Open	16	421.82	0	0.10	1.2	3.1	125,000	2,000,000
		Unknown	0	0.11	65	0.54	1.2	0.0	0	0
		Catchment Total	100	2,604.50	47	0.43	1.2	83.3	3,313,000	53,008,000
	MDRZ71	Single-family	3	28.12	42	0.39	1.0	0.5	19,000	304,000
		Multi-family	11	86.10	65	0.58	1.0	3.1	123,000	1,968,000
		Commercial	7	51.38	92	0.74	1.0	2.4	94,000	1,504,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	40	303.93	80	0.66	1.0	15.7	625,000	10,000,000
		Open	11	85.96	0	0.10	1.0	0.5	21,000	336,000
		Unknown	20	154.13	65	0.54	1.0	5.4	213,000	3,408,000
		Catchment Total	100	761.62	67	0.57	1.0	27.3	1,095,000	17,520,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
MORAO1	Single-family	25	233.19	42	0.39	1.5	8.5	237,000	3,592,000
	Multi-family	1	7.81	68	0.58	1.5	0.4	15,000	240,000
	Commercial	0	0.00	92	0.74	1.5	0.0	0	0
	Public	0	0.00	80	0.66	1.5	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
	Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
	Open	74	677.41	0	0.10	1.5	6.3	251,000	4,014,000
	Unknown	0	0.00	65	0.56	1.5	0.0	0	0
	Catchment Total	100	917.72	11	0.18	1.5	15.1	603,000	9,444,000
MT318	Single-family	30	482.70	42	0.39	1.0	18.4	532,000	8,513,000
	Multi-family	20	329.31	68	0.58	1.0	31.8	471,000	7,536,000
	Commercial	7	94.37	92	0.74	1.0	4.3	172,000	2,752,000
	Public	3	38.45	80	0.66	1.0	1.3	55,000	880,000
	Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
	Other Urban	37	584.98	80	0.66	1.0	18.8	650,000	10,604,000
	Open	3	44.83	0	0.10	1.0	0.2	11,000	176,000
	Unknown	0	0.00	65	0.56	1.0	0.0	0	0
	Catchment Total	100	1,437.94	61	0.53	1.0	46.9	1,866,000	29,836,000
MT400	Single-family	2	3.10	42	0.39	1.0	0.1	3,000	48,000
	Multi-family	82	126.86	68	0.58	1.0	4.9	194,000	3,104,000
	Commercial	1	1.50	92	0.74	1.0	0.1	3,000	48,000
	Public	0	0.00	80	0.66	1.0	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
	Other Urban	0	0.02	80	0.66	1.0	0.0	0	0
	Open	15	24.46	0	0.10	1.0	0.2	8,000	96,000
	Unknown	0	0.00	65	0.56	1.0	0.0	0	0
	Catchment Total	100	163.17	58	0.51	1.0	5.2	206,000	3,296,000
PANPC1	Single-family	42	1,998.17	42	0.39	1.3	62.8	2,502,000	40,032,000
	Multi-family	19	914.74	68	0.58	1.3	42.8	1,702,000	27,232,000
	Commercial	6	276.15	92	0.74	1.3	16.5	656,000	10,496,000
	Public	1	41.52	80	0.66	1.3	2.2	88,000	1,408,000
	Light Industrial	4	183.70	91	0.74	1.3	11.1	441,000	7,056,000
	Other Urban	0	23.09	80	0.66	1.3	1.2	49,000	784,000
	Open	27	1,264.32	0	0.10	1.3	10.2	406,000	6,496,000
	Unknown	0	0.00	65	0.56	1.3	0.0	0	0
	Catchment Total	100	4,701.69	41	0.39	1.3	146.3	5,844,000	93,504,000
BDORD1	Single-family	59	453.36	42	0.39	1.3	14.6	574,000	9,184,000
	Multi-family	10	77.82	68	0.58	1.3	3.6	145,000	2,320,000
	Commercial	24	183.27	92	0.74	1.3	11.1	440,000	7,040,000
	Public	2	15.46	80	0.66	1.3	0.8	33,000	528,000
	Light Industrial	5	36.07	91	0.74	1.3	2.2	86,000	1,376,000
	Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
	Open	0	0.00	0	0.10	1.3	0.0	0	0
	Unknown	0	0.00	65	0.56	1.3	0.0	0	0
	Catchment Total	100	772.11	60	0.51	1.3	32.1	1,278,000	20,448,000
SAWTL1	Single-family	37	1,030.46	42	0.39	1.2	29.9	1,190,000	19,024,000
	Multi-family	26	724.80	68	0.58	1.2	31.7	1,261,000	20,176,000
	Commercial	7	204.91	92	0.74	1.2	11.3	449,000	7,184,000
	Public	14	397.82	80	0.66	1.2	19.5	778,000	12,448,000
	Light Industrial	3	88.86	91	0.74	1.2	3.3	137,000	2,192,000
	Other Urban	3	78.63	80	0.66	1.2	3.9	156,000	2,496,000
	Open	11	313.34	0	0.10	1.2	2.3	94,000	1,504,000
	Unknown	0	0.00	65	0.56	1.2	0.0	0	0
	Catchment Total	100	2,818.72	35	0.40	1.2	101.8	4,064,000	64,064,000
SEPUL1	Single-family	8	178.34	42	0.39	1.5	6.2	247,000	3,952,000
	Multi-family	0	4.34	68	0.58	1.5	0.2	9,000	144,000
	Commercial	0	0.00	92	0.74	1.5	0.0	0	0
	Public	0	0.00	80	0.66	1.5	0.0	0	0
	Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
	Other Urban	11	241.53	80	0.66	1.5	15.3	607,000	9,712,000
	Open	81	1,792.44	0	0.10	1.5	16.7	664,000	10,624,000
	Unknown	0	0.00	65	0.56	1.5	0.0	0	0
	Catchment Total	100	2,216.21	12	0.19	1.5	38.4	1,527,000	24,432,000

LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
	SEPUL2	Single-family	59	484.34	42	0.39	1.5	34.3	566,000	9,061,000
		Multi-family	0	0.06	68	0.58	1.5	0.0	0	0
		Commercial	3	20.83	92	0.74	1.5	0.6	26,000	414,000
		Public	17	122.66	80	0.66	1.5	7.3	281,000	4,496,000
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	3	22.14	80	0.66	1.5	1.5	47,000	752,000
		Open	19	143.69	0	0.10	1.5	1.5	46,000	736,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	793.47	43	[illegible]	1.5	34.3	966,000	15,461,000
	SEPUL3	Single-family	38	411.42	42	0.39	1.3	11.9	473,000	7,000,000
		Multi-family	23	250.41	68	0.58	1.3	10.1	430,000	6,880,000
		Commercial	13	139.80	92	0.74	1.3	7.7	306,000	4,896,000
		Public	12	126.52	80	0.66	1.3	6.2	247,000	3,952,000
		Light Industrial	8	80.11	91	0.74	1.3	4.4	177,000	2,832,000
		Other Urban	5	53.98	80	0.66	1.3	2.7	109,000	1,744,000
		Open	1	10.63	0	0.10	1.3	0.1	3,000	48,000
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	1,073.19	64	0.53	1.3	43.0	1,747,000	27,952,000
	SEPUL1	Single-family	73	443.35	42	0.39	1.0	10.7	427,000	6,832,000
		Multi-family	20	124.57	68	0.58	1.0	4.5	179,000	2,864,000
		Commercial	4	21.85	92	0.74	1.0	1.0	40,000	640,000
		Public	2	12.94	80	0.66	1.0	0.5	20,000	320,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	1	8.15	80	0.66	1.0	0.3	13,000	208,000
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.01	65	0.54	1.0	0.0	0	0
		Catchment Total	100	610.69	50	0.43	1.0	17.1	679,000	10,864,000
	STONE1	Single-family	23	337.28	42	0.39	1.5	11.8	473,000	7,568,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	0	0.00	92	0.74	1.5	0.0	0	0
		Public	5	74.44	80	0.66	1.5	4.6	182,000	2,912,000
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	73	1,066.99	0	0.10	1.5	9.0	395,000	6,320,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	1,464.95	13	0.19	1.5	26.4	1,050,000	16,800,000
	STONE2	Single-family	59	161.86	42	0.39	1.5	5.9	234,000	3,744,000
		Multi-family	0	0.00	68	0.58	1.5	0.0	0	0
		Commercial	3	6.98	92	0.74	1.5	0.5	19,000	304,000
		Public	16	40.20	80	0.66	1.5	3.0	120,000	1,920,000
		Light Industrial	0	0.00	91	0.74	1.5	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.5	0.0	0	0
		Open	21	57.60	0	0.10	1.5	0.5	21,000	336,000
		Unknown	0	0.00	65	0.54	1.5	0.0	0	0
		Catchment Total	100	273.64	41	0.39	1.5	9.9	394,000	6,304,000
	STONE3	Single-family	0	0.00	42	0.39	1.3	0.0	0	0
		Multi-family	22	57.42	68	0.58	1.3	2.7	107,000	1,712,000
		Commercial	5	12.59	92	0.74	1.3	0.8	31,000	496,000
		Public	74	195.35	80	0.66	1.3	10.4	413,000	6,608,000
		Light Industrial	0	0.00	91	0.74	1.3	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.3	0.0	0	0
		Open	0	0.00	0	0.10	1.3	0.0	0	0
		Unknown	0	0.00	65	0.54	1.3	0.0	0	0
		Catchment Total	100	265.37	78	0.63	1.3	13.8	551,000	8,816,000
	WATER	Single-family	39	16.17	42	0.39	1.0	0.4	16,000	256,000
		Multi-family	1	0.51	68	0.58	1.0	0.0	1,000	16,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	59	24.30	91	0.74	1.0	1.1	44,000	704,000
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	41.00	71	0.60	1.0	1.5	61,000	976,000

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TABLE A-3

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CF)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
22	BS13A	Single-family	61	226.72	42	0.39	1.0	3.1	222,000	1,882,000
		Multi-family	36	98.34	68	0.58	1.0	1.6	85,000	880,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	3	3.90	80	0.66	1.0	0.2	7,000	112,000
		Open	30	30.35	0	0.10	1.0	0.3	30,000	300,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	368.36	40	0.36	1.0	4.0	304,000	3,184,000
	BS13C	Single-family	30	800.86	42	0.38	1.0	34.5	578,000	8,348,000
		Multi-family	0	0.73	68	0.58	1.0	0.3	14,000	204,000
		Commercial	2	34.75	80	0.74	1.0	1.6	43,000	1,808,000
		Public	3	82.57	80	0.66	1.0	2.3	86,000	1,374,000
		Light Industrial	1	28.84	91	0.74	1.0	1.3	47,000	782,000
		Other Urban	62	1,209.96	80	0.66	1.0	81.6	2,083,000	30,841,000
		Open	2	43.84	0	0.10	1.0	0.2	11,000	174,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	2,026.39	67	0.57	1.0	114	2,832,000	43,433,000
	BS241	Single-family	34	882.31	42	0.39	1.0	39.4	772,000	12,252,000
		Multi-family	4	84.74	68	0.58	1.0	3.0	121,000	1,574,000
		Commercial	4	100.50	92	0.74	1.0	4.6	184,000	2,044,000
		Public	5	126.16	80	0.66	1.0	3.3	206,000	2,376,000
		Light Industrial	0	0.39	91	0.74	1.0	0.0	1,000	16,000
		Other Urban	36	861.06	80	0.66	1.0	28.3	1,404,000	22,444,000
		Open	17	416.14	0	0.10	1.0	2.6	108,000	1,644,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	2,372.30	53	0.47	1.0	78.1	2,791,000	44,454,000
	SMB144	Single-family	91	32.33	42	0.39	1.0	0.4	31,000	496,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	9	3.33	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	35.34	38	0.36	1.0	0.4	32,000	512,000
	SMB145	Single-family	44	10.26	42	0.39	1.0	0.2	10,000	160,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	56	12.91	0	0.10	1.0	0.1	3,000	40,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	23.17	19	0.23	1.0	0.3	13,000	200,000
	SMB146	Single-family	19	10.63	42	0.39	1.0	0.3	10,000	160,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	81	44.84	0	0.10	1.0	0.3	11,000	174,000
		Unknown	0	0.05	65	0.54	1.0	0.0	0	0
		Catchment Total	100	55.54	8	0.16	1.0	0.5	21,000	334,000
	SMB147	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	3	0.89	80	0.66	1.0	0.0	1,000	16,000
		Open	97	25.30	0	0.10	1.0	0.2	6,000	96,000
		Unknown	0	0.01	65	0.54	1.0	0.0	0	0
		Catchment Total	100	26.19	3	0.12	1.0	0.2	7,000	112,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB 148	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	3	1.36	80	0.66	1.0	0.1	2,000	32,000
		Open	97	39.26	0	0.10	1.0	0.4	28,000	340,000
		Unknown	0	0.77	65	0.54	1.0	0.0	0	0
		Catchment Total	100	40.61	3	0.11	1.0	0.4	31,000	372,000
	SMB 149	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	3	1.38	80	0.66	1.0	0.0	2,000	32,000
		Open	97	40.13	0	0.10	1.0	0.3	30,000	300,000
		Unknown	1	0.34	65	0.54	1.0	0.0	0	0
		Catchment Total	100	41.57	3	0.12	1.0	0.3	32,000	332,000
	SMB 150	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	2	0.95	80	0.66	1.0	0.0	2,000	32,000
		Open	98	35.08	0	0.10	1.0	0.2	14,000	224,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	36.03	1	0.11	1.0	0.4	16,000	256,000
	SMB 151	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.03	80	0.66	1.0	0.0	0	0
		Open	100	31.07	0	0.10	1.0	0.2	8,000	128,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	31.09	0	0.10	1.0	0.2	8,000	128,000
	SMB 152	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	2	1.35	80	0.66	1.0	0.1	3,000	32,000
		Open	98	62.78	0	0.10	1.0	0.4	18,000	240,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	64.13	2	0.11	1.0	0.4	21,000	272,000
	SMB 153	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	11	3.87	80	0.66	1.0	0.1	3,000	48,000
		Open	89	23.84	0	0.10	1.0	0.1	3,000	48,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	34.71	9	0.16	1.0	0.1	6,000	96,000
20	BC402	Single-family	34	149.16	42	0.39	1.0	3.6	144,000	2,304,000
		Multi-family	5	21.34	68	0.58	1.0	0.5	31,000	496,000
		Commercial	8	35.36	92	0.74	1.0	1.6	65,000	1,040,000
		Public	2	9.52	80	0.66	1.0	0.4	16,000	256,000
		Light Industrial	26	113.36	91	0.74	1.0	2.3	207,000	3,312,000
		Other Urban	6	26.25	80	0.66	1.0	1.1	43,000	681,000
		Open	20	87.30	0	0.10	1.0	0.5	22,000	352,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	442.74	55	0.48	1.0	11.3	521,000	8,448,000

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LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

TABLE A-2
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	[illegible]	Single-family	1	2.45	42	0.39	1.0	0.1	2,000	48,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	92	201.38	80	0.66	1.0	8.3	[illegible]	[illegible]
		Open	7	15.57	0	0.10	1.0	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	219.40	76	0.62	1.0	8.4	[illegible]	[illegible]
	[illegible]	Single-family	3	20.40	42	0.39	1.0	0.7	[illegible]	[illegible]
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.40	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	97	[illegible]	80	0.66	1.0	[illegible]	[illegible]	[illegible]
		Open	0	0.31	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	[illegible]	79	0.65	1.0	30.4	[illegible]	[illegible]
34	[illegible]	Single-family	80	[illegible]	42	0.39	1.0	[illegible]	[illegible]	[illegible]
		Multi-family	2	32.84	68	0.58	1.0	3.2	47,000	[illegible]
		Commercial	5	99.97	92	0.74	1.0	4.1	[illegible]	[illegible]
		Public	8	157.40	80	0.66	1.0	2.6	[illegible]	[illegible]
		Light Industrial	0	0.40	91	0.74	1.0	0.0	1,000	16,000
		Other Urban	1	20.34	80	0.66	1.0	0.4	17,000	272,000
		Open	4	82.34	0	0.10	1.0	0.4	15,000	240,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	[illegible]	47	0.43	1.0	44.3	[illegible]	[illegible]
	[illegible]	Single-family	85	28.48	42	0.39	1.0	0.7	28,000	448,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	14	4.79	80	0.66	1.0	0.2	7,000	112,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	2	0.51	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	33.78	47	0.42	1.0	0.9	35,000	560,000
	[illegible]	Single-family	71	253.77	42	0.39	1.0	6.1	[illegible]	[illegible]
		Multi-family	13	47.35	68	0.58	1.0	1.7	[illegible]	[illegible]
		Commercial	9	31.38	92	0.74	1.0	1.4	57,000	912,000
		Public	6	22.47	80	0.66	1.0	0.9	[illegible]	[illegible]
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	[illegible]	52	0.46	1.0	10.2	[illegible]	[illegible]
	[illegible]	Single-family	74	15.90	42	0.39	1.0	0.4	25,000	240,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	23	4.90	92	0.74	1.0	0.2	[illegible]	[illegible]
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	3	0.56	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	21.36	52	0.46	1.0	0.6	34,000	544,000
	[illegible]	Single-family	94	17.39	42	0.39	1.0	0.4	17,000	272,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	6	1.07	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	18.46	40	0.37	1.0	0.4	17,000	272,000

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BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CF)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	[illegible]	Single-family	94	77.34	42	0.39	1.0	0.4	77,000	372,000
		Multi-family	0	0.00	65	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.06	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	5	[illegible]	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	81.35	40	0.36	1.0	0.4	[illegible]	372,000
	[illegible]	Single-family	96	8.32	42	0.39	1.0	0.3	8,000	128,000
		Multi-family	0	0.00	65	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	4	0.32	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	8.64	40	0.36	1.0	0.3	8,000	128,000
	[illegible]	Single-family	96	204.57	42	0.39	1.0	3.1	[illegible]	[illegible]
		Multi-family	4	8.31	65	0.58	1.0	0.3	11,000	182,000
		Commercial	2	4.95	92	0.74	1.0	0.3	9,000	144,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	1	1.45	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	223.28	44	0.40	1.0	3.6	304,000	[illegible]
	SMB 161	Single-family	92	10.23	42	0.39	1.0	0.3	10,000	160,000
		Multi-family	0	0.00	65	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	4	0.44	80	0.66	1.0	0.0	1,000	16,000
		Open	4	0.45	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	11.16	42	0.36	1.0	0.3	11,000	176,000
	SMB 162	Single-family	96	17.73	42	0.39	1.0	0.4	17,000	272,000
		Multi-family	0	0.00	65	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	4	0.70	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	18.43	40	0.36	1.0	0.4	17,000	272,000
	SMB 163	Single-family	98	15.08	42	0.39	1.0	0.4	15,000	240,000
		Multi-family	0	0.00	65	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.06	80	0.66	1.0	0.0	0	0
		Open	2	0.31	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	15.39	41	0.36	1.0	0.4	15,000	240,000
	SMB 164	Single-family	95	21.17	42	0.39	1.0	0.5	20,000	320,000
		Multi-family	0	0.00	65	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	5	1.08	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	22.25	40	0.36	1.0	0.5	20,000	320,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB 165	Single-family	95	24.39	42	0.39	1.0	0.6	24,000	284,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	5	1.27	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	26.16	40	0.36	1.0	0.6	24,000	284,000
	SMB 166	Single-family	93	14.39	42	0.39	1.0	0.3	14,000	224,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	4	0.54	80	0.66	1.0	0.0	1,000	16,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	3	0.42	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	15.39	42	0.39	1.0	0.4	15,000	240,000
	SMB 167	Single-family	96	13.31	42	0.39	1.0	0.4	13,000	208,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	4	0.50	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	13.90	40	0.36	1.0	0.4	13,000	208,000
	SMB 168	Single-family	71	61.32	42	0.39	1.0	1.5	59,000	944,000
		Multi-family	9	7.83	68	0.58	1.0	0.3	11,000	176,000
		Commercial	18	15.70	92	0.74	1.0	0.7	29,000	464,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	2	1.33	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	85.98	53	0.47	1.0	2.5	99,000	1,584,000
	SMB 169	Single-family	94	22.59	42	0.39	1.0	0.5	22,000	352,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	6	1.33	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	23.92	40	0.37	1.0	0.6	22,000	353,000
	SMB 170	Single-family	97	4.44	42	0.39	1.0	0.1	4,000	64,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	3	0.16	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	4.60	41	0.38	1.0	0.1	4,000	64,000
	SMB 171	Single-family	90	17.62	42	0.39	1.0	0.4	17,000	272,000
		Multi-family	7	2.37	68	0.58	1.0	0.0	2,000	32,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.05	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	3	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	19.04	44	0.40	1.0	0.5	20,000	304,000

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TABLE [illegible]

LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
	SMB 172	Single-family	35	27.51	42	0.38	1.0	0.7	26,000	416,000
		Multi-family	45	35.44	68	0.58	1.0	1.3	51,000	816,000
		Commercial	18	14.36	92	0.74	1.0	0.7	26,000	416,000
		Public	0	0.00	88	0.46	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	88	0.46	1.0	0.0	0	0
		Open	2	1.18	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	78.43	62	0.54	1.0	2.6	103,000	[illegible]
	SMB 173	Single-family	44	22.44	42	0.38	1.0	0.3	12,000	192,000
		Multi-family	56	26.30	68	0.58	1.0	0.6	23,000	368,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	88	0.46	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	88	0.46	1.0	0.0	0	0
		Open	0	0.03	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	48.77	57	0.50	1.0	0.9	35,000	560,000
25	B1 1105	Single-family	67	1,864.01	42	0.38	1.0	48.4	1,814,000	29,024,000
		Multi-family	10	284.67	68	0.58	1.0	8.7	385,000	6,160,000
		Commercial	6	167.42	92	0.74	1.0	7.7	306,000	4,896,000
		Public	10	283.38	88	0.46	1.0	10.9	432,000	6,912,000
		Light Industrial	1	14.80	91	0.74	1.0	0.6	26,000	416,000
		Other Urban	5	131.89	88	0.46	1.0	5.4	214,000	3,424,000
		Open	2	61.57	0	0.10	1.0	0.4	15,000	240,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	2,781.84	53	0.46	1.0	80.1	3,192,000	51,072,000
	B1 407	Single-family	98	118.85	42	0.38	1.0	2.9	114,000	1,824,000
		Multi-family	5	6.59	68	0.58	1.0	0.3	9,000	144,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	88	0.46	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	88	0.46	1.0	0.0	0	0
		Open	0	0.01	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	125.45	43	0.40	1.0	3.1	123,000	1,968,000
	B4 530	Single-family	54	226.57	42	0.38	1.0	5.9	228,000	3,648,000
		Multi-family	21	91.70	68	0.58	1.0	3.3	131,000	2,096,000
		Commercial	3	9.83	92	0.74	1.0	0.5	16,000	256,000
		Public	22	97.83	88	0.46	1.0	4.0	159,000	2,544,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	88	0.46	1.0	0.0	0	0
		Open	1	4.35	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	429.56	57	0.49	1.0	13.5	537,000	8,592,000
	SMB 174	Single-family	0	0.02	42	0.38	1.0	0.0	0	0
		Multi-family	2	1.56	68	0.58	1.0	0.1	2,000	32,000
		Commercial	20	17.15	92	0.74	1.0	0.8	31,000	496,000
		Public	0	0.00	88	0.46	1.0	0.0	0	0
		Light Industrial	0	0.06	91	0.74	1.0	0.0	0	0
		Other Urban	78	56.59	88	0.46	1.0	2.3	91,000	1,456,000
		Open	0	0.06	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	75.86	82	0.46	1.0	3.1	124,000	1,984,000
	SMB 175	Single-family	0	0.00	42	0.38	1.0	0.0	0	0
		Multi-family	66	27.56	68	0.58	1.0	1.0	40,000	640,000
		Commercial	0	0.01	92	0.74	1.0	0.0	0	0
		Public	0	0.00	88	0.46	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	19	8.05	88	0.46	1.0	0.3	13,000	208,000
		Open	15	6.35	0	0.10	1.0	0.0	2,000	32,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	42.13	60	0.53	1.0	1.4	55,000	880,000

[illegible]

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CF)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB176	Single-family	78	662.54	42	0.39	1.0	16.0	630,000	10,200,000
		Multi-family	11	94.80	68	0.58	1.0	2.4	136,000	2,176,000
		Commercial	3	21.61	92	0.74	1.0	1.0	39,000	624,000
		Public	3	24.59	80	0.66	1.0	1.0	41,000	664,000
		Light Industrial	0	0.80	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.52	80	0.66	1.0	0.0	1,000	16,000
		Open	6	47.33	0	0.10	1.0	0.3	13,000	202,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	852.13	45	0.41	1.0	21.8	867,000	13,872,000
26	[illegible]	Single-family	71	792.91	42	0.39	1.0	20.2	763,000	12,208,000
		Multi-family	4	48.57	68	0.58	1.0	1.5	58,000	928,000
		Commercial	0	0.79	92	0.74	1.0	0.0	1,000	16,000
		Public	3	37.12	80	0.66	1.0	1.5	60,000	960,000
		Light Industrial	1	25.59	91	0.74	1.0	0.7	29,000	464,000
		Other Urban	0	0.80	80	0.66	1.0	0.0	0	0
		Open	20	237.32	0	0.10	1.0	1.4	56,000	896,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	1,114.77	36	0.33	1.0	24.3	967,000	15,472,000
	[illegible]	Single-family	81	531.21	42	0.39	1.0	13.8	511,000	8,176,000
		Multi-family	12	81.13	68	0.58	1.0	2.9	114,000	1,824,000
		Commercial	0	0.80	92	0.74	1.0	0.0	0	0
		Public	5	35.43	80	0.66	1.0	1.5	58,000	928,000
		Light Industrial	0	0.80	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.80	80	0.66	1.0	0.0	0	0
		Open	1	9.31	0	0.10	1.0	0.1	2,000	32,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	657.28	47	0.42	1.0	17.3	687,000	10,992,000
	[illegible]	Single-family	83	205.90	42	0.39	1.0	6.9	275,000	4,400,000
		Multi-family	6	19.62	68	0.58	1.0	0.7	28,000	448,000
		Commercial	11	37.73	92	0.74	1.0	1.7	68,000	1,088,000
		Public	0	0.80	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.80	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.80	80	0.66	1.0	0.0	0	0
		Open	0	0.80	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	263.25	49	0.44	1.0	9.3	372,000	5,952,000
	[illegible]	Single-family	62	751.50	42	0.39	1.0	18.2	724,000	11,584,000
		Multi-family	0	0.80	68	0.58	1.0	0.0	0	0
		Commercial	0	0.80	92	0.74	1.0	0.0	0	0
		Public	0	0.88	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.80	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.80	80	0.66	1.0	0.0	0	0
		Open	38	484.35	0	0.10	1.0	2.8	112,000	1,792,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	1,236.23	26	0.28	1.0	21.0	836,000	13,376,000
	[illegible]	Single-family	66	101.33	42	0.39	1.0	2.4	97,000	1,552,000
		Multi-family	0	0.80	68	0.58	1.0	0.0	0	0
		Commercial	0	0.80	92	0.74	1.0	0.0	0	0
		Public	6	9.10	80	0.66	1.0	0.4	18,000	288,000
		Light Industrial	0	0.80	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.80	80	0.66	1.0	0.0	0	0
		Open	28	42.92	0	0.10	1.0	0.3	11,000	176,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	153.15	32	0.32	1.0	3.1	122,000	1,952,000
	[illegible]	Single-family	75	196.84	42	0.39	1.0	6.7	267,000	4,272,000
		Multi-family	0	0.80	68	0.58	1.0	0.0	0	0
		Commercial	0	0.80	92	0.74	1.0	0.0	0	0
		Public	0	0.80	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.80	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.80	80	0.66	1.0	0.0	0	0
		Open	25	91.93	0	0.10	1.0	0.6	23,000	368,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	264.77	30	0.32	1.0	7.3	290,000	4,640,000

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TABLE A-[illegible]
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	B79617	Single-family	91	193.00	42	0.39	1.0	4.7	306,000	3,976,000
		Multi-family	0	0.00	60	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	8	16.21	80	0.66	1.0	0.7	28,000	414,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	1	3.10	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	213.00	44	0.41	1.0	5.4	333,000	4,401,000
	MT12911	Single-family	100	19.33	42	0.39	1.0	0.3	16,000	204,000
		Multi-family	0	0.00	60	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	19.33	42	0.39	1.0	0.3	16,000	204,000
	MT12912	Single-family	97	14.82	42	0.39	1.0	0.4	16,000	204,000
		Multi-family	0	0.00	60	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	3	0.52	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	15.34	41	0.38	1.0	0.4	16,000	204,000
	MT1290[illegible]	Single-family	100	20.37	42	0.39	1.0	0.7	28,000	448,000
		Multi-family	0	0.00	60	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.02	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	20.39	42	0.39	1.0	0.7	28,000	448,000
	MT34	Single-family	89	60.38	42	0.39	1.0	1.3	60,000	958,000
		Multi-family	0	0.00	60	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	11	7.29	0	0.10	1.0	0.0	2,000	32,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	67.67	37	0.36	1.0	1.3	62,000	984,000
	SMB183	Single-family	39	26.36	42	0.39	1.0	0.6	28,000	400,000
		Multi-family	26	17.37	60	0.58	1.0	0.6	28,000	480,000
		Commercial	34	22.75	92	0.74	1.0	1.0	42,000	672,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	1	0.58	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	67.06	65	0.54	1.0	2.3	92,000	1,472,000
	SMB185	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	90	45.49	60	0.58	1.0	1.6	65,000	1,040,000
		Commercial	2	0.85	92	0.74	1.0	0.0	2,000	32,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	8	3.99	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	50.33	63	0.55	1.0	1.7	68,000	1,088,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CF)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB 187	Single-family	82	232.14	42	0.39	1.0	3.2	137,000	2,002,000
		Multi-family	9	14.57	68	0.58	1.0	0.5	21,000	324,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	6	9.43	80	0.66	1.0	0.4	15,000	240,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	3	2.36	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	261.70	45	0.41	1.0	4.1	164,000	2,434,000
	SMB 191	Single-family	100	31.76	42	0.39	1.0	0.8	31,000	496,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	31.76	42	0.39	1.0	0.8	31,000	496,000
	SMB 192	Single-family	99	71.44	42	0.39	1.0	1.7	69,000	1,104,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	1	0.91	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	72.35	41	0.39	1.0	1.7	69,000	1,104,000
	SMB 193	Single-family	62	57.57	42	0.39	1.0	1.4	55,000	880,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	38	35.24	0	0.10	1.0	0.2	9,000	144,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	92.81	26	0.28	1.0	1.6	64,000	1,024,000
	SMB 194	Single-family	46	25.23	42	0.39	1.0	0.6	22,000	352,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	54	27.35	0	0.10	1.0	0.2	7,000	112,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	50.58	19	0.23	1.0	0.7	29,000	464,000
	SMB 195	Single-family	69	48.85	42	0.39	1.0	1.0	38,000	604,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	31	22.12	0	0.10	1.0	0.1	4,000	64,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	70.97	29	0.30	1.0	1.1	42,000	668,000
	SMB 201	Single-family	54	32.33	42	0.39	1.0	0.8	30,000	480,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	39	23.74	80	0.66	1.0	1.0	38,000	604,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	7	4.31	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	60.34	54	0.46	1.0	1.8	71,000	1,136,000

TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	SMB302	Single-family	100	20.11	42	0.39	1.0	0.3	18,800	284,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	0	0.00	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	20.11	42	0.39	1.0	0.3	18,800	284,000
	SMB303	Single-family	82	59.46	42	0.39	1.0	1.4	57,000	912,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	17	12.67	80	0.66	1.0	0.5	20,000	320,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	1	0.56	0	0.10	1.0	0.0	0	0
		Unknown	0	0.16	65	0.54	1.0	0.0	0	0
		Catchment Total	100	72.79	46	0.43	1.0	2.0	77,000	1,232,000
37	ALTMR1	Single-family	44	419.73	42	0.39	1.0	10.1	404,000	6,464,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	2	22.84	80	0.66	1.0	0.9	37,000	592,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	53	506.97	0	0.10	1.0	3.1	125,000	2,000,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	944.46	21	0.24	1.0	14.2	566,000	9,056,000
	BRKTN1	Single-family	38	163.10	42	0.39	1.0	3.9	157,000	2,512,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	1,000	16,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	5	22.06	91	0.74	1.0	0.6	22,000	351,000
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	59	251.81	0	0.10	1.0	1.6	62,000	998,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	427.37	39	0.33	1.0	6.1	242,000	3,872,000
	ELNDK1	Single-family	49	113.30	42	0.39	1.0	2.7	108,000	1,704,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	51	116.86	0	0.10	1.0	0.7	25,000	404,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	230.15	21	0.24	1.0	3.3	134,000	2,180,000
	MT1800	Single-family	62	24.00	42	0.39	1.0	0.6	22,000	355,000
		Multi-family	0	0.00	68	0.58	2.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	38	14.58	0	0.10	1.0	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	38.54	26	0.28	1.0	0.7	27,000	433,000
	PD1140	Single-family	17	33.39	42	0.39	1.0	0.8	32,000	512,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	6	12.42	92	0.74	1.0	0.6	23,000	368,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	76	142.61	0	0.10	1.0	0.9	37,000	592,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	194.42	13	0.19	1.0	2.3	92,000	1,472,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL CORRECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	FD131	Single-family	53	54.42	42	0.39	1.0	1.3	22,000	352,000
		Multi-family	8	7.91	68	0.58	1.0	0.3	11,000	176,000
		Commercial	0	0.00	92	0.76	1.0	0.0	0	0
		Public	4	3.86	80	0.66	1.0	0.2	6,000	96,000
		Light Industrial	0	0.00	91	0.76	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	35	35.54	0	0.10	1.0	0.2	9,000	144,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	101.73	31	0.31	1.0	2.0	96,000	1,541,000
	FD1686	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	57	18.00	68	0.58	1.0	0.6	26,000	416,000
		Commercial	0	0.00	92	0.76	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	43	13.36	0	0.10	1.0	0.1	3,000	48,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	31.43	39	0.36	1.0	0.7	29,000	464,000
	FD237	Single-family	67	128.50	42	0.39	1.0	3.1	122,000	1,952,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	1	1.82	92	0.76	1.0	0.1	3,000	48,000
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	31	14.57	0	0.10	1.0	0.1	4,000	64,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	144.90	36	0.36	1.0	3.3	129,000	2,064,000
	FD243	Single-family	65	171.53	42	0.39	1.0	4.1	165,000	2,640,000
		Multi-family	4	11.11	68	0.58	1.0	0.4	16,000	256,000
		Commercial	3	7.84	92	0.76	1.0	0.3	14,000	224,000
		Public	3	6.90	80	0.66	1.0	0.4	14,000	224,000
		Light Industrial	4	9.83	91	0.76	1.0	0.3	18,000	288,000
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	21	54.97	0	0.10	1.0	0.3	14,000	224,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	261.28	30	0.37	1.0	6.1	241,000	3,856,000
	FD699	Single-family	45	221.36	42	0.39	1.0	2.9	117,000	1,872,000
		Multi-family	5	12.19	68	0.56	1.0	0.5	20,000	320,000
		Commercial	2	5.30	92	0.76	1.0	0.3	10,000	160,000
		Public	2	6.26	80	0.66	1.0	0.5	10,000	160,000
		Light Industrial	0	0.00	91	0.76	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	46	223.38	0	0.10	1.0	0.5	28,000	448,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	268.27	26	0.28	1.0	4.7	186,000	2,976,000
	FORTU1	Single-family	25	113.26	42	0.39	1.0	2.7	109,000	1,744,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.76	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	75	333.25	0	0.10	1.0	2.1	82,000	1,312,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	446.51	11	0.17	1.0	4.8	191,000	3,056,000
	SMB204	Single-family	84	65.10	42	0.39	1.0	1.6	63,000	1,008,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.76	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.76	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	16	12.63	0	0.10	1.0	0.1	3,000	48,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	77.73	35	0.34	1.0	1.7	66,000	1,056,000

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BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN STORM VOLUME (CU FT)
	SMB206	Single-family	10	4.30	42	0.39	1.0	0.1	4,600	64,000
		Multi-family	0	0.00	68	0.56	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	90	39.54	0	0.10	1.0	0.2	30,000	360,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	43.84	4	0.13	1.0	0.3	34,000	394,000
	SMB211	Single-family	5	14.96	42	0.39	1.0	0.4	14,000	224,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	10	28.22	92	0.74	1.0	1.3	70,000	1,120,000
		Public	11	31.25	80	0.66	1.0	1.3	51,000	816,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	71	202.27	0	0.10	1.0	1.3	55,000	880,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	284.73	22	0.26	1.0	4.4	183,000	2,900,000
	SMB213	Single-family	24	20.40	42	0.39	1.0	0.7	26,000	404,000
		Multi-family	41	31.35	68	0.58	1.0	0.8	31,000	496,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	3	2.65	0	0.10	1.0	0.0	1,000	16,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	53.19	30	0.43	1.0	1.5	60,000	964,000
	SMB214	Single-family	7	5.12	42	0.39	1.0	0.1	5,000	80,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	93	66.61	0	0.10	1.0	0.4	16,000	256,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	71.73	3	0.12	1.0	0.5	21,000	336,000
	SMB216	Single-family	37	28.06	42	0.39	1.0	0.7	27,000	432,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	63	47.97	0	0.10	1.0	0.3	12,000	192,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	76.03	16	0.21	1.0	1.0	39,000	624,000
	SMB217	Single-family	47	24.87	42	0.39	1.0	0.4	24,000	384,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	53	28.03	0	0.10	1.0	0.1	7,000	112,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	52.90	20	0.24	1.0	0.5	31,000	496,000
20	SMB23	Single-family	49	108.57	42	0.39	1.0	2.6	105,000	1,680,000
		Multi-family	7	14.92	68	0.58	1.0	0.5	21,000	336,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	44	99.08	0	0.10	1.0	0.4	24,000	384,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	222.57	25	0.27	1.0	3.5	150,000	2,400,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF R•	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG ANN. STORM VOLUME (CU FT)
	FD10061	Single-family	25	31.94	42	0.39	1.0	0.3	31,000	496,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	23	26.28	80	0.66	1.0	0.7	27,000	432,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	63	81.71	0	0.10	1.0	0.5	20,000	320,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	139.93	20	0.26	1.0	1.5	78,000	1,241,000
	FD10062	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	7	3.51	80	0.66	1.0	0.1	6,000	96,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	93	44.54	0	0.10	1.0	0.3	11,000	176,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	48.05	6	0.14	1.0	0.4	17,000	272,000
	FD122	Single-family	40	118.85	42	0.39	1.0	2.0	114,000	1,824,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	2	6.00	80	0.66	1.0	0.3	11,000	176,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	57	168.21	0	0.10	1.0	1.0	42,000	672,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	293.06	18	0.22	1.0	4.3	167,000	2,672,000
	FD269	Single-family	57	235.42	42	0.39	1.0	5.7	227,000	3,632,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	2	9.76	80	0.66	1.0	0.4	15,000	240,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	2	8.00	80	0.66	1.0	0.4	14,000	224,000
		Open	39	163.06	0	0.10	1.0	1.0	40,000	640,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	416.24	27	0.30	1.0	7.4	296,000	4,736,000
	SMB318	Single-family	37	27.45	42	0.39	1.0	0.7	26,000	416,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	63	46.02	0	0.10	1.0	0.3	11,000	176,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	73.47	16	0.21	1.0	0.9	37,000	592,000
	SMB319	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	100	205.64	0	0.10	1.0	0.7	26,000	416,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	205.64	0	0.10	1.0	0.7	26,000	416,000
	SMB320	Single-family	0	0.00	42	0.39	1.0	0.0	0	0
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	4	0.31	80	0.66	1.0	0.0	1,000	16,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	96	6.82	0	0.10	1.0	0.0	2,000	32,000
		Unknown	0	0.00	65	0.56	1.0	0.0	0	0
		Catchment Total	100	7.13	3	0.12	1.0	0.1	3,000	48,000

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TABLE A-3
LAND USES AND HYDROLOGY FOR SANTA MONICA BAY CATCHMENTS

BASIN	CATCHMENT	LAND USE	PERCENT OF TOTAL	LAND USE ACRES	PERCENT IMPERV	RUNOFF COEFF Rv	RAINFALL COLLECTION FACTOR	AVERAGE STORM RUNOFF (CFS)	AVERAGE STORM VOLUME (CU FT)	AVG. ANN. STORM VOLUME (CU FT)
	SMB221	Single-family	6	5.00	42	0.39	1.0	0.1	2,000	88,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	94	81.87	0	0.10	1.0	0.5	20,000	320,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	86.86	3	0.13	1.0	0.6	25,000	400,000
	SMB222	Single-family	40	101.84	42	0.39	1.0	4.3	170,000	2,[illegible]
		Multi-family	3	11.44	68	0.58	1.0	0.4	16,000	256,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.45	80	0.66	1.0	0.0	2,000	32,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	6	26.80	80	0.66	1.0	0.6	25,000	400,000
		Open	46	107.87	0	0.10	1.0	1.0	41,000	656,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	260.20	26	0.35	1.0	6.6	261,000	4,176,000
	SMB223	Single-family	79	180.49	42	0.39	1.0	3.6	204,000	3,264,000
		Multi-family	3	5.30	68	0.58	1.0	0.1	3,000	48,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	8	30.32	80	0.66	1.0	0.4	18,000	288,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	11	25.46	0	0.10	1.0	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	236.97	41	0.36	1.0	3.3	135,000	2,[illegible]
	SMB224	Single-family	67	220.40	42	0.39	1.0	2.9	314,000	[illegible]
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	8	22.25	92	0.74	1.0	0.4	25,000	400,000
		Public	4	6.59	80	0.66	1.0	0.3	11,000	176,000
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	0	0.00	80	0.66	1.0	0.0	0	0
		Open	21	26.80	0	0.10	1.0	0.2	9,000	144,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	279.32	36	0.37	1.0	4.1	361,000	[illegible]
	SMB225	Single-family	81	204.37	42	0.39	1.0	3.0	220,000	3,520,000
		Multi-family	8	22.56	68	0.58	1.0	0.5	16,000	256,000
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	10	25.75	80	0.66	1.0	0.6	26,000	416,000
		Open	0	0.01	0	0.10	1.0	0.0	0	0
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	252.71	48	0.43	1.0	4.1	264,000	[illegible]
	SMB226	Single-family	25	37.36	42	0.39	1.0	0.7	26,000	416,000
		Multi-family	0	0.00	68	0.58	1.0	0.0	0	0
		Commercial	0	0.00	92	0.74	1.0	0.0	0	0
		Public	0	0.00	80	0.66	1.0	0.0	0	0
		Light Industrial	0	0.00	91	0.74	1.0	0.0	0	0
		Other Urban	60	67.24	80	0.66	1.0	2.8	110,000	1,760,000
		Open	15	16.56	0	0.10	1.0	0.1	4,000	64,000
		Unknown	0	0.00	65	0.54	1.0	0.0	0	0
		Catchment Total	100	111.51	50	0.51	1.0	3.5	140,000	2,240,000

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
ARZEQ1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	419,594	3,713	81,380	441.38	110.34	2,397.48	1,341.46	47.10	110.34	376.78	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	419,594	3,713	81,380	441.38	110.34	2,397.48	1,341.46	47.10	110.34	376.78	0
ARZEQ2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	863,849	2,376	200,163	397.33	260.37	3,317.43	1,666.17	63.30	260.37	306.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	863,849	2,376	200,163	397.33	260.37	3,317.43	1,666.17	63.30	260.37	306.40	0
ARZEQ3	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	299,440	1,323	34,093	317.99	83.41	1,713.33	504.69	33.43	83.41	299.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	299,440	1,323	34,093	317.99	83.41	1,713.33	504.69	33.43	83.41	299.86	0
SMB1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,344	22	1,844	3.72	1.34	20.78	15.94	0.40	1.34	4.84	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,344	22	1,844	3.72	1.34	20.78	15.94	0.40	1.34	4.84	0
SMB2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	18,405	76	3,407	18.74	3.32	104.31	33.06	2.09	3.32	16.71	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	18,405	76	3,407	18.74	3.32	104.31	33.06	2.09	3.32	16.71	0
SMB3	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,575	24	1,139	6.34	1.64	33.57	17.30	0.46	1.64	3.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,575	24	1,139	6.34	1.64	33.57	17.30	0.46	1.64	3.38	0
SMB4	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	180	1.04	0.20	8.40	2.90	0.11	0.26	0.84	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	979	4	180	1.04	0.20	8.40	2.90	0.11	0.26	0.84	0

VOL 12

1 6220

VOL 12

1 6221

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible] 10	Single-family	[illegible]	370	[illegible]	5.40	2.30	42.97	28.49	0.95	2.30	2.30	20
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,934	22	370	3.12	0.84	14.79	8.40	0.33	0.84	2.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	[illegible]	[illegible]	11.61	2.34	56.75	37.18	1.28	4.34	4.74	20
[illegible] 11	Single-family	[illegible]	287	[illegible]	17.84	5.26	98.23	38.32	1.80	7.34	7.34	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,775	420	2,637	17.38	2.44	67.13	27.98	2.90	22.31	20.43	616
	Open	979	4	190	1.04	0.26	5.60	2.90	0.11	0.26	0.88	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	12,940	780	6,763	36.22	8.16	162.97	69.49	4.80	30.93	28.63	676
[illegible] 12	Single-family	[illegible]	110	979	5.95	1.75	30.88	12.94	0.44	2.45	2.45	21
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	1,881	130	1,169	2.54	1.17	21.34	8.99	0.90	2.06	3.42	298
	Open	3,344	32	1,044	2.72	1.04	30.79	16.94	0.40	1.04	4.84	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,303	276	3,192	11.24	4.46	83.43	37.87	2.17	7.34	10.70	319
[illegible]	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,934	22	370	3.12	0.84	14.79	8.40	0.33	0.84	2.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,934	22	370	3.12	0.84	14.79	8.40	0.33	0.84	2.44	0
[illegible]	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	8,323	34	1,614	8.83	2.34	47.56	24.63	0.93	2.34	7.67	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,323	34	1,614	8.83	2.34	47.56	24.63	0.93	2.34	7.67	0
[illegible]	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,596	20	849	2.20	1.40	27.36	14.09	0.33	1.40	4.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,596	20	849	2.20	1.40	27.36	14.09	0.33	1.40	4.40	0
[illegible]	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	11,261	46	2,110	11.95	3.22	64.35	33.32	1.26	3.22	18.11	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	11,261	46	2,110	11.95	3.22	64.35	33.32	1.26	3.22	18.11	0

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB9	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,384	22	1,844	2.72	1.54	20.78	23.84	0.60	1.54	4.84	0
	Unknown	710	15	730	0.02	0.13	3.40	1.00	0.10	0.44	0.31	22
	Catchment Total	3,394	37	3,174	6.33	1.67	23.17	24.84	0.70	1.98	5.22	22
SMCR	Single-family	4,634	372	2,320	11.50	4.00	68.74	29.31	1.13	2.00	2.00	48
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	1,309	60	779	3.72	0.78	14.30	0.00	0.00	2.64	2.35	132
	Open	130,725	236	28,340	128.73	37.35	767.20	394.84	14.67	37.35	177.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	136,421	698	28,343	134.04	43.13	830.14	422.41	14.79	43.84	125.26	180
WLWCL1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	24,762	142	6,740	24.89	9.93	189.44	182.57	3.90	9.93	31.22	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	24,762	142	6,740	24.89	9.93	189.44	182.57	3.90	9.93	31.22	0
LALIS1	Single-family	4,057	236	1,998	11.89	2.90	68.13	28.24	1.33	4.90	4.90	42
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	146,393	598	28,382	155.36	41.83	836.33	423.20	16.43	41.83	201.43	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	150,450	833	30,341	167.25	44.33	894.64	451.04	17.76	46.72	206.33	42
SMB13	Single-family	1,339	61	380	2.40	1.00	17.39	7.39	0.36	1.40	1.40	12
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	1,460	305	989	4.54	0.91	16.79	6.59	0.70	2.02	2.44	184
	Open	4,406	18	864	4.48	1.26	25.18	23.84	-0.49	1.26	2.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,204	391	2,333	11.41	3.17	59.13	37.43	1.57	3.36	6.81	196
SMB14	Single-family	2,477	204	1,679	10.10	2.00	51.34	22.18	1.14	4.20	4.20	36
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	1,579	120	1,020	4.95	1.84	19.38	7.20	0.60	2.52	3.84	176
	Open	3,917	16	789	4.16	2.12	22.36	11.59	0.44	1.12	2.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,073	340	3,477	19.20	5.16	93.13	41.77	2.38	8.03	10.75	212
SMB15	Single-family	1,409	65	679	4.25	1.35	22.40	8.34	0.47	1.38	1.38	15
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,936	32	579	3.12	0.84	24.79	8.69	0.33	0.84	2.84	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,344	97	1,260	7.26	2.09	36.37	17.04	0.80	2.19	4.20	15

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 16	Single-family	6,375	374	2,878	18.69	2.90	94.32	48.87	2.09	7.09	7.09	66
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	18	854	4.66	1.36	25.18	12.84	0.49	1.36	3.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	10,781	392	3,732	23.36	4.75	119.70	61.71	2.54	8.05	11.65	66
SMB 17	Single-family	3,137	187	1,539	9.34	2.75	47.36	20.33	1.04	3.33	3.33	33
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,137	187	1,539	9.34	2.75	47.36	20.33	1.04	3.33	3.33	33
LACFU1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	129,746	330	25,133	137.40	37.07	741.41	283.94	14.36	37.07	116.31	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	129,746	330	25,133	137.40	37.07	741.41	283.94	14.36	37.07	116.31	0
LACFU2	Single-family	2,606	153	1,289	7.64	2.25	38.67	16.64	0.83	3.12	3.12	27
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	22,730	52	2,448	13.51	3.64	72.74	37.67	1.43	3.64	11.43	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	25,336	205	3,727	21.15	5.89	111.41	54.31	2.26	6.76	14.56	27
SMB 18	Single-family	4,347	255	2,098	12.74	2.75	64.45	27.73	1.42	2.26	2.26	46
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	480	2	85	0.52	0.14	2.80	2.45	0.06	0.14	0.46	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,836	257	2,183	13.26	2.89	67.25	30.18	1.48	2.39	2.60	46
SMB 19	Single-family	8,114	476	3,977	23.78	4.90	120.30	51.76	2.66	9.77	9.77	84
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	20,843	126	5,900	32.73	8.81	176.36	91.38	3.46	8.81	22.70	0
	Unknown	210	15	150	0.62	0.13	2.40	1.00	0.10	0.46	0.50	22
	Catchment Total	29,160	617	10,027	57.13	13.84	299.06	144.03	6.22	19.04	33.07	106
SNCNL1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	189,404	601	22,844	179.78	48.40	964.82	501.30	30.01	48.40	152.12	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	189,404	601	22,844	179.78	48.40	964.82	501.30	30.01	48.40	152.12	0

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
BNCNL2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	11,731	48	2,378	22.47	3.36	67.15	34.77	1.32	3.36	10.55	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	11,731	48	2,378	22.47	3.36	67.15	34.77	1.32	3.36	10.55	0
BNCNL3	Single-family	8,506	320	3,838	16.14	4.75	81.83	28.12	1.80	4.44	4.44	37
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	28,874	82	2,592	21.30	5.74	114.71	50.40	2.26	5.74	18.03	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	36,380	402	6,430	37.44	10.44	196.54	94.52	4.06	12.34	24.47	37
SMB 20	Single-family	1,730	102	820	5.10	1.50	25.78	11.00	0.57	2.10	2.10	38
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	18	854	4.66	1.26	25.18	13.04	0.49	1.26	3.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,143	120	1,674	9.77	2.76	50.96	24.13	1.06	3.36	6.06	38
SMB 21	Single-family	4,087	238	1,808	11.90	3.50	60.15	27.84	1.30	4.80	4.80	42
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,345	26	1,324	6.75	1.82	36.37	18.83	0.71	1.82	5.73	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	10,432	264	3,132	18.65	5.32	96.52	46.71	2.01	6.71	10.61	42
SMB 22	Single-family	4,536	272	2,238	13.59	4.00	65.74	29.52	1.52	5.60	5.60	48
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	8,873	26	1,709	9.35	2.52	50.36	26.05	0.59	2.52	7.91	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	13,449	298	3,947	22.94	6.51	116.10	55.66	2.11	8.11	13.51	48
SMB 23	Single-family	4,536	272	2,238	13.59	4.00	65.74	29.52	1.52	5.60	5.60	48
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,996	20	909	2.20	1.40	27.90	14.09	0.55	1.40	4.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	9,532	292	3,147	15.78	5.40	94.72	44.06	2.07	6.99	9.99	48
SMB 24	Single-family	880	34	280	1.70	0.58	3.90	2.70	0.19	0.70	0.70	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,553	28	1,329	7.27	1.86	38.17	20.28	0.77	1.86	6.16	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,434	62	1,609	8.97	2.44	47.76	22.98	0.96	2.44	6.85	0

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

		POLLUTANT LOADINGS (POUNDS PER YEAR)										
CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 30	Single-family	849	51	420	2.55	0.75	12.70	5.55	0.30	1.05	1.05	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,906	20	900	5.20	1.40	27.90	14.40	0.33	1.40	4.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,763	71	1,360	7.74	2.15	40.57	20.03	0.63	2.45	5.45	0
SMB 31	Single-family	5,216	306	2,516	15.30	4.50	77.84	33.57	1.71	6.50	6.50	54
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	190	1.04	0.28	5.00	2.90	0.11	0.28	0.81	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,195	310	2,706	16.33	4.78	82.93	36.17	1.82	6.57	7.17	54
SMB 32	Single-family	6,865	391	3,317	30.33	3.75	98.82	42.52	2.18	8.84	8.84	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0
	Open	4,806	18	854	4.08	1.36	25.18	13.04	0.49	1.36	3.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	11,671	409	4,172	34.21	7.00	124.00	55.56	2.66	9.20	12.80	60
SMB 33	Single-family	6,085	257	2,958	17.84	5.25	90.23	28.82	1.99	7.34	7.34	63
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	5,875	24	1,120	6.24	1.64	33.57	17.39	0.44	1.64	5.28	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	11,960	281	4,077	24.07	6.89	123.80	46.21	2.43	9.02	12.62	63
SMB 34	Single-family	2,318	136	1,119	6.70	2.00	34.37	14.79	0.76	2.00	2.00	24
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,958	8	280	2.08	0.36	11.19	5.00	0.22	0.36	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,277	144	1,399	8.87	2.36	45.56	20.14	0.98	2.36	4.46	24
STEEP 1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	25,928	110	5,221	28.34	7.40	151.81	79.69	2.82	7.40	24.18	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	25,928	110	5,221	28.34	7.40	151.81	79.69	2.82	7.40	24.18	0
STEEP 2	Single-family	1,849	55	699	4.25	1.25	21.48	9.24	0.47	1.75	1.75	15
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	11,351	48	2,578	12.47	3.36	67.15	34.77	1.32	3.36	10.55	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	13,199	103	2,778	16.72	4.61	88.63	44.01	1.79	5.11	12.30	15

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 35	Single-family	[illegible]	[illegible]	4,337	[illegible]	7.74	[illegible]	57.30	2.94	[illegible]	[illegible]	[illegible]
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,573	26	1,139	6.34	1.68	32.57	17.39	0.66	1.68	2.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	[illegible]	[illegible]	[illegible]	9.42	[illegible]	[illegible]	3.60	[illegible]	[illegible]	[illegible]
SMB 36	Single-family	[illegible]	[illegible]	[illegible]	30.11	14.74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	177
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	34	3,614	[illegible]	2.38	47.36	[illegible]	0.93	2.38	7.47	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	[illegible]	[illegible]	[illegible]	17.12	301.06	[illegible]	6.33	23.01	[illegible]	177
SMB 37	Single-family	3,477	[illegible]	1,579	16.19	[illegible]	51.36	[illegible]	1.14	4.20	4.20	36
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	94	3,512	[illegible]	5.18	[illegible]	53.61	[illegible]	[illegible]	16.27	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	378	5,101	[illegible]	8.17	[illegible]	75.79	3.17	[illegible]	[illegible]	36
SMB 38	Single-family	4,826	[illegible]	2,370	14.44	4.28	73.84	31.42	1.61	[illegible]	[illegible]	31
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	[illegible]	[illegible]	4.66	1.26	25.10	[illegible]	0.49	1.26	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	307	[illegible]	18.11	[illegible]	[illegible]	44.46	2.11	[illegible]	[illegible]	31
SMB 39	Single-family	[illegible]	442	[illegible]	[illegible]	6.40	111.71	[illegible]	2.47	0.00	0.00	[illegible]
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,917	16	[illegible]	4.16	[illegible]	[illegible]	11.59	0.44	[illegible]	[illegible]	0
	Unknown	420	20	260	1.24	0.26	4.00	2.00	0.20	[illegible]	[illegible]	44
	Catchment Total	11,870	[illegible]	4,446	[illegible]	[illegible]	[illegible]	[illegible]	3.11	11.00	[illegible]	[illegible]
SMB 40	Single-family	4,626	[illegible]	[illegible]	[illegible]	4.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,835	[illegible]	[illegible]	7.27	1.96	39.17	[illegible]	0.77	1.96	6.36	0
	Unknown	1,259	90	779	2.72	0.71	14.39	0.00	0.00	2.64	2.29	[illegible]
	Catchment Total	12,730	[illegible]	4,347	[illegible]	6.73	[illegible]	[illegible]	[illegible]	16.19	[illegible]	[illegible]
SMB 41	Single-family	[illegible]	3,576	[illegible]	[illegible]	46.71	[illegible]	[illegible]	17.35	[illegible]	[illegible]	[illegible]
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	22,319	34	2,543	14.05	3.75	75.54	30.12	1.40	3.75	11.87	0
	Unknown	679	45	390	1.86	0.39	7.19	3.00	0.30	1.32	1.14	[illegible]
	Catchment Total	[illegible]	3,573	29,112	174.71	50.84	[illegible]	387.79	[illegible]	[illegible]	[illegible]	[illegible]

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	44,914	2,633	21,683	231.64	38.72	685.97	284.52	34.71	84.31	84.31	483
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	3,557	[illegible]	2,978	9.45	2.56	43.56	28.36	1.34	4.56	23.36	484
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	28,439	[illegible]	2,126	2.06	7.33	251.85	78.34	2.57	7.53	23.74	0
	Unknown	710	15	730	9.62	0.13	3.40	1.00	0.10	0.44	0.38	22
	Catchment Total	75,320	3,064	[illegible]	[illegible]	50.36	983.41	392.16	38.36	97.33	93.34	970
[illegible]	Single-family	22,734	747	6,135	37.57	18.59	189.85	81.52	4.18	19.39	19.39	132
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	8,593	[illegible]	4,606	21.48	8.59	99.72	59.35	3.80	11.34	34.67	1,099
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,427	34	664	3.44	0.98	39.34	18.14	0.38	0.98	3.88	0
	Unknown	679	45	390	1.36	0.39	7.10	3.00	0.20	1.57	1.14	46
	Catchment Total	35,799	1,506	11,706	64.33	31.33	313.73	154.43	8.46	28.93	54.38	1,277
[illegible]	Single-family	16,807	983	8,114	49.26	14.49	189.20	107.21	3.31	28.38	28.38	176
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	719	86	380	1.72	0.72	7.59	4.80	0.39	0.98	2.77	88
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	8,303	28	1,804	8.87	2.66	33.16	27.33	1.84	2.66	0.35	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	26,129	1,079	10,277	60.83	17.87	310.33	139.34	6.84	32.04	31.41	263
[illegible]	Single-family	6,665	391	3,377	19.53	3.75	98.82	42.52	2.11	8.04	8.04	69
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,365	26	1,334	6.75	1.82	36.37	18.83	0.71	1.82	3.73	0
	Unknown	1,449	105	979	4.34	0.91	16.79	6.99	0.79	3.08	2.66	154
	Catchment Total	14,496	522	5,361	30.63	8.47	151.86	68.35	3.60	12.96	16.43	223
TRANC1	Single-family	17,896	1,882	8,283	88.11	14.74	283.50	100.06	8.60	28.63	28.63	177
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	19,865	1,403	9,532	46.34	19.06	211.83	137.10	7.43	23.83	73.51	2,330
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	852,408	2,679	365,363	904.80	243.35	4,578.90	2,522.40	95.40	243.35	768.43	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	888,169	5,964	383,046	1,000.25	277.32	5,334.23	2,758.50	108.90	284.01	890.57	2,507
TRANC2	Single-family	2,378	136	1,119	6.79	2.00	34.37	14.70	0.76	2.80	2.80	24
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	9,702	40	1,978	10.39	2.30	38.06	38.58	1.30	2.30	8.79	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	12,110	176	3,013	17.19	4.30	90.33	43.76	1.86	5.00	11.59	24
TRANC3	Single-family	869	51	420	2.55	0.75	12.89	5.35	0.28	1.05	1.05	9
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	35,326	226	10,726	58.71	15.81	316.15	163.72	6.21	15.81	49.68	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	36,195	277	11,146	61.26	16.56	329.04	169.26	6.49	16.86	50.73	9

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

TABLE A-3

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

		POLLUTANT LOADINGS (POUNDS PER YEAR)										
CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
TRANC4	Single-family	21,811	643	2,316	22.27	9.49	163.27	70.34	3.61	13.39	13.39	114
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,606	20	254	4.88	1.26	25.11	13.04	0.49	1.26	3.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	26,417	663	2,570	26.85	10.75	188.43	83.38	4.10	14.65	17.35	114
TRANC5	Single-family	2,155	48	260	2.40	1.00	17.39	7.39	0.38	1.40	1.40	12
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	32,219	84	2,863	14.80	3.74	75.34	39.12	1.48	3.78	11.87	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	34,374	132	3,123	17.43	4.74	92.73	46.51	1.86	5.18	13.27	12
TRANC6	Single-family	12,329	761	6,426	39.07	11.49	197.64	85.03	4.57	16.09	16.09	126
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	17,626	72	3,417	18.71	2.04	100.72	52.16	1.08	5.04	15.03	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	29,955	833	9,843	57.77	13.53	298.36	137.19	5.65	21.13	31.12	132
SMB30	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	480	2	96	0.52	0.14	2.80	1.43	0.05	0.14	0.44	0
	Unknown	679	45	390	1.84	0.39	7.19	3.00	0.30	1.32	1.34	66
	Catchment Total	1,159	47	486	2.36	0.53	9.99	4.43	0.35	1.46	1.78	66
SMB31	Single-family	23,909	815	6,715	40.77	11.59	206.33	88.73	4.36	16.79	16.79	144
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,600	6	285	1.36	0.42	8.30	4.35	0.16	0.42	1.32	0
	Unknown	219	15	130	0.62	0.13	2.80	1.80	0.10	0.44	0.38	22
	Catchment Total	25,728	836	7,130	42.75	12.14	217.43	94.87	4.62	17.65	18.49	166
SMB32	Single-family	40,257	2,305	20,724	119.75	25.22	688.21	280.44	22.30	40.31	40.31	420
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	840	42	270	1.30	0.54	0.00	2.00	0.22	0.67	2.00	66
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	9,792	40	1,590	10.30	2.10	51.06	20.98	1.30	2.00	2.79	0
	Unknown	1,579	120	1,579	4.96	1.04	19.11	7.99	0.90	3.52	3.04	176
	Catchment Total	52,468	2,507	22,932	136.39	29.40	684.95	301.21	23.50	46.30	63.32	664
SMB33	Single-family	4,057	208	1,858	11.00	3.50	68.15	25.88	1.33	4.80	4.80	42
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	380	1.84	0.28	3.60	2.50	0.11	0.28	0.80	0
	Unknown	420	30	250	1.34	0.36	4.10	2.00	0.20	0.11	0.76	44
	Catchment Total	5,456	272	2,488	14.17	4.04	70.54	30.78	1.64	6.86	6.33	86

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
SMB 34	Single-family	11,011	645	3,316	22.57	8.49	262.57	70.24	2.61	22.79	22.79	114
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	2	95	0.52	0.14	2.30	1.43	0.05	0.14	0.04	0
	Unknown	210	15	130	0.42	0.13	2.40	1.00	0.10	0.44	0.32	22
	Catchment Total	11,711	662	3,541	23.41	8.76	266.47	72.69	2.76	23.37	24.11	136
SMB 35	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	2	95	0.52	0.14	2.30	1.45	0.05	0.14	0.04	0
	Unknown	1,440	105	979	4.34	0.91	16.79	6.99	0.70	2.09	2.06	134
	Catchment Total	1,931	107	1,004	4.86	1.05	19.31	8.44	0.75	2.23	2.10	134
SMB 36	Single-family	8,403	490	4,207	24.03	7.34	224.80	53.61	2.75	10.14	10.14	87
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,441	30	473	2.60	0.70	13.99	7.34	0.27	0.70	2.20	0
	Unknown	420	20	260	1.24	0.26	4.10	2.00	0.20	0.88	0.76	44
	Catchment Total	11,271	333	4,791	28.47	8.30	243.39	63.33	3.23	11.72	13.10	131
SMB 37	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,469	6	285	1.96	0.42	8.30	4.35	0.16	0.42	1.52	0
	Unknown	1,049	75	649	2.10	0.65	11.99	5.00	0.30	2.20	1.90	110
	Catchment Total	2,518	81	934	4.46	1.07	20.34	9.34	0.46	2.63	3.32	110
SMB 38	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	180	1.84	0.35	2.60	2.90	0.11	0.35	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	979	4	180	1.84	0.35	2.60	2.90	0.11	0.35	0.44	0
SMB 39	Single-family	1,449	85	699	4.35	1.35	31.40	9.24	0.47	1.35	1.35	18
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	180	1.84	0.35	2.60	2.90	0.11	0.35	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,428	89	851	4.39	1.53	37.80	12.14	0.58	2.03	2.43	18
SMB 40	Single-family	2,606	183	1,239	7.64	2.25	38.67	14.64	0.25	3.15	3.15	37
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	2	95	0.52	0.14	2.30	1.45	0.05	0.14	0.04	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,096	185	1,334	8.16	2.39	41.47	16.09	0.31	3.29	3.19	37

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
ZUMA1	Single-family	38,535	1,304	9,893	33.21	16.34	379.38	130.15	6.77	22.73	22.73	185
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	38,525	3,441	9,363	44.25	18.53	205.84	123.54	7.41	23.16	71.43	3,304
	Public	38,373	4,533	38,137	178.21	38.27	647.46	281.49	23.11	72.84	204.68	7,122
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	330,304	1,307	62,080	379.11	91.49	1,829.74	947.54	35.94	91.49	307.53	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	413,837	8,344	109,372	571.46	164.32	3,062.33	1,571.60	72.43	210.22	606.36	8,341
ZUMA2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	178,217	727	34,332	189.13	50.92	1,011.38	327.38	20.00	50.92	100.03	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	178,217	727	34,332	189.13	50.92	1,011.38	327.38	20.00	50.92	100.03	0
ZUMA3	Single-family	4,443	391	3,317	10.53	2.75	98.52	42.52	2.11	8.04	8.04	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	435,793	1,771	84,103	468.35	120.94	2,478.52	1,283.67	48.40	123.04	299.33	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	440,437	2,161	87,320	479.89	129.60	2,577.44	1,326.19	50.57	131.08	307.37	60
ZUMA4	Single-family	87,984	3,397	27,576	300.86	48.96	809.31	300.70	18.98	69.84	69.84	600
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	3,051	238	1,570	7.30	3.06	33.97	30.30	1.33	3.83	11.79	374
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	38,100	160	7,904	41.57	11.19	222.82	113.91	4.40	11.19	28.37	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	180,180	3,795	37,100	318.73	64.21	1,117.11	303.99	24.60	84.86	110.90	973
BANRZ1	Single-family	4,347	286	2,098	12.74	2.75	64.45	27.73	1.42	3.35	3.35	48
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	281,451	1,037	50,609	277.46	74.70	1,494.80	773.44	29.35	74.70	204.77	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	285,797	1,322	52,706	290.20	77.45	1,558.45	801.41	30.77	78.05	208.12	48
BANRZ2	Single-family	2,187	187	1,539	9.34	2.75	47.26	20.33	1.04	3.85	3.85	33
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	16,647	68	3,227	17.67	4.76	95.12	49.26	1.87	4.76	14.85	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	18,834	255	4,766	27.01	7.50	142.38	69.59	2.91	8.60	18.79	33
BANRZ3	Single-family	15,358	980	7,414	45.01	13.34	227.72	97.97	5.03	18.54	18.54	159
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	18,115	74	3,512	19.22	5.18	103.52	53.61	2.03	5.18	16.27	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	33,473	974	10,926	64.24	18.42	331.23	151.58	7.06	23.71	34.80	159

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SAMB24	Single-family	849	51	420	2.35	0.73	22.59	2.33	0.30	1.86	1.86	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	14,199	28	2,733	15.07	4.06	61.34	42.22	1.39	4.06	12.73	0
	Unknown	0	0	0	0.00	0.00	0.00	.70	0.00	0.00	0.00	0
	Catchment Total	15,048	109	3,173	11.42	4.81	94.03	47.34	1.66	4.11	13.80	0
SAMB23	Single-family	8,114	476	3,977	22.76	6.90	130.30	51.76	2.66	9.79	9.79	84
	Multi-family	2,934	210	1,819	8.67	1.82	23.57	22.59	1.40	6.16	2.52	256
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0
	Open	6,363	26	1,224	6.75	1.82	26.57	18.53	0.71	1.82	3.72	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	17,416	711	6,904	30.21	10.43	190.23	84.18	4.77	17.77	20.12	303
SMB41	Single-family	8,503	257	4,377	26.30	7.74	232.19	57.30	2.94	10.84	10.84	93
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	2	85	0.52	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	710	15	190	0.62	0.13	2.40	1.00	0.10	0.44	0.31	22
	Catchment Total	9,643	344	4,561	27.47	8.01	238.39	59.73	3.10	11.42	11.66	115
SMB42	Single-family	57,574	3,343	27,008	168.17	40.46	850.72	264.01	18.70	69.34	69.34	594
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,098	210	1,340	6.44	2.70	30.96	17.90	1.08	2.37	10.40	230
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	2	85	0.52	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	60,162	3,575	28,433	175.13	43.30	883.49	283.44	19.83	72.16	80.09	823
SMB43	Single-family	51,209	2,897	24,700	180.35	44.31	900.49	237.19	16.80	61.80	61.80	501
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	2,518	306	1,390	6.82	2.52	37.06	36.70	1.01	3.15	9.71	288
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	13,319	24	2,543	14.88	3.70	75.54	30.12	1.40	3.70	11.57	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	67,026	3,236	28,342	170.37	50.51	864.01	283.09	18.20	66.12	83.48	836
SMB44	Single-family	2,318	126	1,119	6.70	2.00	34.37	34.79	0.76	2.80	2.80	24
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,318	126	1,119	6.70	2.00	34.37	34.79	0.76	2.80	2.80	24
SMB45	Single-family	2,028	119	979	3.85	1.75	20.08	12.94	0.66	2.45	2.45	21
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,021	119	979	3.85	1.75	20.08	12.94	0.66	2.45	2.45	21

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO3+NO2	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB711	Single-family	8,316	266	3,513	23.29	4.30	77.34	22.57	1.71	6.29	6.29	84
	Multi-family	1,679	120	1,809	4.96	1.04	30.11	7.59	0.80	3.52	3.04	176
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,775	36	1,139	6.34	1.61	22.57	17.30	0.66	1.60	2.28	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	12,770	430	4,096	26.46	7.21	130.10	44.43	3.17	11.49	14.61	250
SMB712	Single-family	4,347	255	2,088	12.94	3.75	64.45	27.73	1.42	2.35	2.35	43
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,089	0	255	1.36	0.42	8.39	4.26	0.16	0.42	1.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,813	261	2,343	14.30	4.17	72.84	32.07	1.59	3.67	6.34	43
SMB713	Single-family	30,044	803	7,374	44.16	12.99	223.42	96.12	4.94	18.19	18.19	156
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,936	22	570	3.12	0.84	16.79	8.09	0.33	0.84	2.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	33,006	835	7,944	47.28	13.83	240.21	104.21	5.27	19.02	20.83	156
SMB73	Single-family	1,139	65	260	3.40	1.80	17.19	7.30	0.36	1.40	1.40	12
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,139	65	260	3.40	1.80	17.19	7.30	0.36	1.40	1.40	12
SMB75	Single-family	22,744	1,919	15,807	98.97	28.23	483.51	208.36	10.73	38.32	38.32	239
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	22,522	92	4,367	23.90	6.43	128.70	66.45	2.53	6.43	28.23	0
	Unknown	210	15	130	0.62	0.13	2.40	1.00	0.10	0.44	0.31	22
	Catchment Total	45,476	2,026	20,304	123.49	34.79	614.61	276.53	13.35	44.39	66.12	261
WAL001	Single-family	2,606	153	1,259	7.64	2.35	28.67	16.64	0.85	2.35	2.35	37
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,365	26	1,204	6.75	1.82	26.37	10.83	0.71	1.82	5.72	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,973	179	2,463	14.40	4.17	55.04	26.47	1.57	4.17	8.06	37
WAL002	Single-family	290	17	140	0.85	0.25	4.30	1.85	0.09	0.25	0.35	3
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,936	22	570	2.12	0.84	16.79	8.09	0.33	0.84	0.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,227	39	709	2.97	1.09	21.09	10.14	0.42	1.19	2.99	3

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
WALCN2	Single-family	9,273	844	4,476	27.18	7.59	137.49	59.15	3.04	11.19	11.19	96
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	23,219	84	2,543	14.03	2.78	75.54	20.13	1.48	2.78	11.57	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	7.30	0.00	0
	Catchment Total	32,472	848	7,039	41.21	11.77	213.03	86.27	4.52	14.57	23.06	96
WALCN4	Single-family	280	17	140	0.85	0.35	4.30	1.25	0.00	0.35	0.35	3
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	9,302	38	1,894	9.87	2.46	33.16	27.53	1.04	2.46	8.35	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	9,572	55	2,043	10.72	2.81	37.43	28.34	1.14	3.01	8.70	3
WALCN5	Single-family	31,005	1,818	14,946	90.88	26.73	459.73	197.79	10.16	37.42	37.42	221
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	180	1.04	0.28	8.40	2.90	0.11	0.28	0.83	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	31,984	1,822	15,126	91.92	27.01	468.33	200.69	10.27	37.70	38.30	221
ENCON1	Single-family	10,037	934	7,004	46.71	13.74	224.31	101.87	5.22	19.25	19.25	165
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	390,236	1,185	54,780	208.11	82.95	1,689.07	859.16	32.59	82.95	260.71	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	396,273	2,119	63,884	254.83	96.69	1,913.38	960.83	37.81	102.19	279.95	165
ENCON2	Single-family	10,994	1,172	9,632	50.60	17.34	296.46	157.53	4.85	34.15	34.15	297
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	18,605	76	3,087	18.74	5.32	106.31	85.06	2.09	5.32	16.71	0
	Unknown	710	15	190	0.62	0.13	2.40	1.00	0.10	0.44	0.38	22
	Catchment Total	28,309	1,263	13,309	71.97	22.44	405.18	243.60	6.74	38.89	41.22	320
SMITH	Single-family	28,087	1,682	13,949	84.88	24.73	425.36	283.00	9.40	34.62	34.62	297
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	8,913	26	1,700	9.35	2.52	50.36	28.86	0.99	2.52	7.81	0
	Unknown	710	15	130	0.62	0.13	2.40	1.00	0.10	0.44	0.38	22
	Catchment Total	37,710	1,723	15,657	94.85	27.38	478.12	310.06	10.49	37.58	42.82	319
DRYNL1	Single-family	580	26	280	2.70	0.50	0.59	2.70	0.19	0.70	0.70	6
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	47,982	196	9,303	50.92	13.71	274.18	141.59	5.39	13.71	43.09	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0
	Catchment Total	48,561	220	9,582	53.62	14.21	283.77	145.48	5.51	14.41	43.78	6

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
BRYNCL2	Single-family	6,645	301	3,317	38.53	8.75	98.82	42.53	2.18	8.84	8.84	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	31,825	130	6,170	23.77	9.09	381.25	84.17	3.57	9.09	38.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	38,469	431	9,487	62.31	[illegible]	[illegible]	[illegible]	5.76	17.34	26.43	60
LATIG1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	109,672	446	21,263	116.30	31.33	626.70	304.54	12.31	31.33	98.46	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	109,672	446	21,263	116.30	31.33	626.70	304.54	12.31	31.33	98.46	0
LATIG2	Single-family	8,114	476	3,977	23.78	6.99	130.30	51.76	2.66	9.79	9.79	84
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,343	26	1,234	6.75	1.82	36.37	18.83	0.71	1.82	5.72	0
	Unknown	210	15	130	0.62	0.13	2.40	1.00	0.10	0.44	0.37	22
	Catchment Total	14,651	517	5,341	31.16	8.94	169.07	71.59	3.47	12.05	15.89	106
SMB15	Single-family	14,778	866	7,134	43.32	12.74	209.12	94.57	4.84	17.84	17.84	153
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	18	854	4.68	1.26	25.11	13.04	0.49	1.26	3.96	0
	Unknown	770	60	570	3.40	0.52	0.30	4.00	0.40	1.76	1.52	88
	Catchment Total	20,024	944	8,608	50.47	14.53	253.90	111.31	5.24	20.83	23.31	241
SMB11	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,427	14	664	3.64	0.98	19.54	10.14	0.38	0.98	3.08	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,427	14	664	3.64	0.98	19.54	10.14	0.38	0.98	3.08	0
SMB12	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	5,366	22	1,044	5.72	1.54	30.71	15.94	0.60	1.54	4.84	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,366	22	1,044	5.72	1.54	30.71	15.94	0.60	1.54	4.84	0
SOLST1	Single-family	5,795	340	2,798	16.99	5.00	88.93	36.97	1.90	6.99	6.99	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	407,354	1,663	78,977	432.29	116.39	2,327.74	1,205.43	45.72	116.39	365.79	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	413,149	2,003	81,775	449.28	121.38	2,415.67	1,242.41	47.62	123.38	372.78	60

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SOLST2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	38,282	42	1,590	38.91	2.94	84.75	20.43	1.15	2.94	0.33	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	38,282	42	1,590	38.91	2.94	84.75	20.43	1.15	2.94	0.33	0
CORRL1	Single-family	38,835	3,304	8,005	55.35	36.34	379.38	228.15	6.17	32.73	32.73	300
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	207,206	1,699	71,193	389.40	104.92	2,898.32	1,084.63	41.22	104.92	220.74	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	246,041	5,003	80,244	444.59	141.15	3,277.60	1,306.78	47.39	137.63	253.47	300
CORRL2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	20,334	124	3,813	22.21	8.67	173.46	80.23	3.41	8.67	37.26	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	20,334	124	3,813	22.21	8.67	173.46	80.23	3.41	8.67	37.26	0
MARE1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	23,201	1,808	11,401	55.43	23.30	287.79	184.66	9.38	29.80	89.45	2,836
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	38,679	152	7,699	41.05	11.05	221.03	114.46	4.24	11.05	34.73	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	61,880	1,962	19,100	96.47	34.35	478.82	299.13	13.63	40.85	124.19	2,836
MARE2	Single-family	849	51	450	3.83	0.75	22.89	5.55	0.28	1.85	1.85	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,896	20	909	2.20	1.40	37.98	14.49	0.55	1.40	4.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,745	71	1,359	2.34	2.15	60.87	20.03	0.83	3.45	3.45	0
MARE3	Single-family	21,880	696	3,725	34.82	10.34	176.14	75.79	3.50	14.34	14.34	150
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	840	42	370	1.30	0.54	6.80	3.60	0.22	0.57	2.88	66
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,400	6	285	1.56	0.42	3.59	4.26	0.16	0.42	1.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	23,119	744	4,380	37.67	11.30	186.53	83.73	4.37	15.43	17.34	[illegible]
MARE4	Single-family	3,767	321	1,819	11.04	2.25	28.86	24.08	1.30	4.85	4.85	30
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	22,482	1,349	11,241	53.71	22.44	299.20	149.83	8.99	28.10	86.48	2,748
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	26,249	1,669	13,060	64.75	23.73	328.06	173.91	10.23	32.65	91.33	2,767

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TABLE 4-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
[illegible]	Single-family	2,137	187	1,520	9.34	2.75	47.36	20.23	1.04	2.25	2.25	23
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,417	206	1,700	8.16	2.42	37.57	22.78	1.57	4.57	23.13	418
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,875	30	1,130	6.34	1.61	33.57	37.39	0.46	1.68	3.28	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	12,443	477	4,344	23.34	7.44	118.43	86.30	3.07	8.30	23.30	431
PUERC1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	64,139	262	11,433	64.07	18.33	264.31	189.30	7.20	18.33	37.39	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	64,139	262	11,433	64.07	18.33	264.31	189.30	7.20	18.33	37.39	0
PUERC2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	5,344	22	1,044	5.72	1.54	20.78	15.04	0.40	1.54	4.04	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,344	22	1,044	5.72	1.54	20.78	15.04	0.40	1.54	4.04	0
PUERC3	Single-family	8,798	240	2,798	16.99	5.80	65.93	26.97	1.50	4.59	4.59	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	1,430	112	719	3.44	1.44	33.59	9.99	0.54	1.50	2.83	176
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	21,083	86	4,082	22.34	6.02	120.30	62.30	2.36	6.02	20.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	28,287	338	7,599	43.77	13.43	222.22	100.34	4.44	14.11	31.43	236
SMB13	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	5,344	22	1,044	5.72	1.54	20.78	15.04	0.40	1.54	4.04	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,344	22	1,044	5.72	1.54	20.78	15.04	0.40	1.54	4.04	0
SMB14	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	18	854	4.68	1.26	25.11	13.04	0.49	1.26	3.36	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,406	18	854	4.66	1.26	25.11	13.04	0.49	1.26	3.36	0
SMB15	Single-family	580	24	280	2.70	0.50	8.59	3.70	0.19	0.70	0.70	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	5,344	22	1,044	5.72	1.54	20.78	15.04	0.40	1.54	4.04	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,863	26	1,324	2.41	2.04	30.37	19.43	0.79	2.24	5.34	0

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 16	Single-family	3,795	240	2,798	16.99	3.00	85.93	26.97	1.90	6.99	6.99	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	8,875	24	1,139	6.34	1.68	33.57	17.39	0.46	1.66	5.28	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	11,671	264	3,937	23.33	4.67	119.50	44.36	2.36	8.67	12.27	60
SMB 17	Single-family	7,534	442	3,637	22.88	6.49	111.71	40.86	2.47	9.00	9.00	78
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	300	28	100	0.86	0.36	4.80	3.40	0.14	0.43	1.30	44
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	18,095	78	3,702	20.26	5.46	180.11	56.50	2.14	5.46	17.13	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	26,911	548	7,319	43.21	12.31	296.62	100.96	4.76	14.89	27.43	122
SMB 18	Single-family	6,964	488	3,337	20.38	4.80	103.12	44.36	2.28	8.30	8.30	72
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	3,854	230	1,520	7.38	3.06	33.97	28.34	1.03	3.02	11.79	374
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,930	22	570	3.12	0.84	16.79	8.40	0.53	0.64	2.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	13,750	657	5,434	30.81	8.89	153.88	73.44	3.83	13.06	22.83	446
SMB 19	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,917	16	759	4.36	1.12	22.34	11.39	0.44	1.12	2.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,917	16	759	4.36	1.12	22.34	11.39	0.44	1.12	2.32	0
SMB 10	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	15,827	1,201	7,914	57.81	15.83	178.86	105.52	6.33	19.78	61.02	1,934
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,365	26	1,234	6.75	1.82	36.37	18.83	0.71	1.82	3.72	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	22,192	1,227	9,148	64.56	17.65	213.23	124.35	7.05	21.60	64.74	1,934
SMB 11	Single-family	290	17	140	0.51	0.35	4.30	1.85	0.09	0.35	0.35	3
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	5,875	24	1,139	6.34	1.68	33.57	17.30	0.66	1.68	3.28	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,165	41	1,279	6.85	2.03	37.87	19.33	0.75	2.03	3.63	3
SMB 12	Single-family	34,402	949	6,904	42.47	12.49	224.13	92.43	4.35	17.49	17.49	300
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	4,676	264	2,338	11.77	4.64	51.96	31.18	1.57	5.85	19.80	372
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	5,875	24	1,139	6.34	1.68	33.57	17.30	0.66	1.68	3.28	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	26,040	1,237	10,472	30.57	18.84	300.36	140.99	2.28	25.01	40.79	321

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
WNCN1	Single-family	2,767	221	2,519	11.06	2.25	25.86	34.80	1.23	4.55	4.53	39
	Multi-family	629	45	390	1.86	0.30	7.19	2.80	0.30	1.32	1.14	64
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	8,593	609	4,406	21.46	8.99	99.92	30.35	2.60	11.34	34.67	1,099
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	31,825	330	6,370	23.77	9.09	201.85	64.77	2.57	9.09	28.58	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	43,214	1,905	13,575	66.16	21.72	344.83	141.13	6.70	26.30	66.93	1,204
CHEK2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	31,894	2,576	19,744	94.16	30.74	364.51	351.83	15.19	66.83	57.71	3,341
	Open	317,754	1,597	61,606	337.21	60.79	1,815.75	640.30	20.67	60.79	283.35	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	349,650	3,173	81,350	431.37	110.53	2,180.25	1,092.18	36.43	127.61	343.06	3,341
CHEK3	Single-family	82,584	4,841	30,866	362.86	71.19	1,324.53	226.83	27.46	99.67	99.67	884
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	17,806	1,265	6,900	42.54	37.81	107.84	115.70	7.12	22.26	68.45	2,176
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	60,222	366	11,676	43.91	17.21	344.13	378.21	6.76	17.21	54.65	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	160,611	6,472	49,447	449.30	126.20	1,766.49	823.74	40.04	139.13	222.40	3,061
COLDK1	Single-family	80,599	2,990	34,820	149.48	43.96	784.19	305.34	16.71	61.85	61.85	320
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	8,183	800	2,866	24.16	5.07	93.53	28.97	1.90	17.13	14.81	897
	Open	223,347	625	20,711	162.63	43.75	875.70	483.49	17.20	43.75	137.41	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	312,430	4,300	58,397	336.27	92.82	1,753.42	817.80	37.80	122.41	213.57	1,363
COLDK2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	178,707	720	34,647	359.63	31.06	1,821.18	328.53	20.06	31.06	160.47	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	178,707	720	34,647	359.63	31.06	1,821.18	328.53	20.06	31.06	160.47	0
COLDK3	Single-family	67,226	2,941	22,454	297.04	57.85	994.80	428.86	28.02	81.34	81.34	685
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	348,601	1,423	67,586	269.94	99.60	1,992.01	1,031.57	33.13	99.60	212.83	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	415,827	4,364	100,040	566.99	157.45	2,986.81	1,460.43	61.15	180.94	294.16	685
COLDK4	Single-family	6,575	374	2,078	18.40	2.50	94.52	40.87	2.08	7.60	7.60	66
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	50,719	208	9,772	54.04	14.55	290.97	150.46	1.72	14.55	45.73	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	57,294	582	11,850	72.72	20.04	385.49	191.33	3.80	22.34	53.42	66

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
COLDK1	Single-family	62,990	2,669	38,316	282.45	21.96	[illegible]	399.26	22.90	75.54	75.54	617
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	57,284	284	11,306	62.79	36.57	237.34	189.51	6.41	36.57	81.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	119,874	3,003	41,322	344.24	[illegible]	1,251.30	844.79	28.71	81.01	126.98	617
BARCKC1	Single-family	20,342	585	4,896	28.73	8.74	188.30	64.70	2.59	22.34	22.34	385
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	112,899	482	21,977	320.02	32.31	644.35	234.44	22.49	32.31	101.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	133,241	1,064	26,324	349.73	41.06	796.66	299.34	24.02	64.33	113.80	385
ELVR01	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	228,199	920	43,833	340.05	64.43	1,292.57	686.36	28.39	64.43	202.12	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	228,199	920	43,833	340.05	64.43	1,292.57	686.36	28.39	64.43	202.12	0
GATE01	Single-family	32,460	730	6,015	36.52	10.74	184.75	79.49	4.08	15.04	15.04	130
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	74,910	306	14,325	79.30	21.40	428.86	221.67	8.41	21.40	67.27	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	87,370	1,036	20,339	116.02	32.14	612.61	301.16	12.49	36.44	82.30	130
LESER1	Single-family	30,426	1,704	14,688	90.16	26.23	451.14	284.09	9.97	26.72	26.72	313
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	311,391	1,371	68,372	320.46	88.97	1,779.38	821.46	34.99	88.97	279.62	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	341,816	3,063	83,060	410.63	115.20	2,230.51	1,115.56	44.97	115.69	316.34	313
LSTTY2	Single-family	47,347	2,412	30,044	228.60	26.47	610.11	282.49	12.46	40.46	40.46	426
	Multi-family	16,157	1,134	10,802	47.70	10.80	184.45	76.04	7.04	22.25	20.24	1,005
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	28,117	2,806	37,406	53.01	37.41	311.34	233.09	22.90	88.91	80.88	2,046
	Open	254,555	1,047	40,340	272.26	72.30	1,446.63	780.19	28.46	72.30	220.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	341,876	6,622	97,012	552.56	136.18	2,552.13	1,372.51	63.56	215.73	360.13	3,604
LNDR01	Single-family	237,320	23,912	314,548	682.59	204.59	2,518.88	1,512.94	77.94	204.42	204.42	2,480
	Multi-family	36,157	1,134	10,802	47.70	10.80	184.45	76.04	7.04	22.25	20.24	1,005
	Commercial	43,815	3,413	31,842	104.84	43.81	487.61	392.57	37.85	34.06	108.20	8,504
	Public	2,216	406	2,608	12.46	3.22	57.86	34.77	2.09	6.52	28.11	657
	Light Industrial	7,554	848	3,777	18.05	7.51	83.93	86.36	3.07	9.44	28.12	980
	Other Urban	62,759	6,340	64,046	263.05	34.95	1,014.30	422.66	42.57	103.07	108.61	9,599
	Open	512,005	2,314	100,430	849.72	148.80	2,040.03	1,552.87	20.14	148.80	468.35	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	916,396	37,827	304,273	1,880.41	474.19	6,307.43	3,524.11	208.31	725.86	1,150.85	20,571

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
LOBOC1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	226,361	2,372	63,213	234.95	96.10	1,822.06	985.35	37.75	96.10	382.04	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	226,361	2,373	63,213	234.95	96.10	1,822.06	985.33	37.75	96.10	382.04	0
LOBOC2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	37,136	70	3,322	38.19	4.80	97.82	80.71	1.82	4.80	33.39	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	37,136	70	3,322	38.19	4.80	97.82	80.71	1.82	4.80	33.39	0
LOBOC3	Single-family	28,977	1,099	23,999	84.95	24.94	420.44	304.85	9.49	24.97	24.97	200
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	68,854	278	13,184	72.32	30.44	395.89	281.39	7.64	30.44	61.11	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	97,832	1,376	37,183	157.15	60.42	816.34	586.24	17.13	54.42	86.08	200
LVRC02	Single-family	28,697	2,342	28,879	197.12	68.21	784.86	341.88	17.84	64.70	64.70	283
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	6,135	476	3,884	34.61	6.12	67.95	48.77	3.45	7.64	28.84	797
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	33,314	2,388	30,804	98.40	39.80	300.30	173.81	15.30	67.71	30.47	3,988
	Open	142,476	842	27,423	151.20	40.71	814.13	421.61	18.99	40.71	127.84	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	224,512	6,308	76,544	418.34	113.84	2,046.26	984.33	31.39	180.76	274.60	4,467
LVRC03	Single-family	31,011	646	3,316	22.37	0.49	163.37	78.34	3.11	33.39	33.39	114
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	3,237	282	1,639	7.73	2.34	35.97	31.34	1.30	4.80	32.40	284
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	31,480	1,539	13,249	62.19	13.28	244.80	101.52	18.19	44.84	35.73	2,342
	Open	237,104	845	40,153	219.78	39.17	1,183.45	612.86	23.23	39.17	183.57	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	262,734	3,271	60,337	322.98	83.13	1,627.30	806.40	28.34	121.33	280.47	2,222
LVRC04	Single-family	28,531	2,306	37,346	308.32	38.98	332.77	388.22	31.77	43.37	43.37	372
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	8,376	424	2,788	33.32	3.38	61.95	37.37	2.33	6.97	31.90	681
	Public	7,374	874	3,487	17.42	7.37	81.93	48.16	3.85	9.32	38.43	901
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	203,573	14,996	129,117	613.79	128.12	2,383.09	873.20	90.32	437.81	377.42	21,831
	Open	423,511	1,729	83,369	469.44	321.80	2,420.06	1,353.35	47.34	321.80	288.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	680,863	19,340	255,847	1,301.46	204.04	5,460.41	2,342.00	181.81	617.57	831.81	23,303
LVRC05	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	71,972	284	13,854	76.35	20.56	411.27	212.96	8.08	20.56	64.63	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	71,972	284	13,854	76.35	20.56	411.27	212.96	8.08	20.56	64.63	0

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR) TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
LVR01	Single-family	11,301	662	5,454	22.12	9.34	187.57	72.09	2.70	13.64	13.64	117
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	487,831	2,822	96,538	528.42	142.57	2,841.32	1,472.47	28.19	142.37	447.12	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	499,132	3,485	101,993	550.54	151.91	3,012.19	1,541.36	30.39	155.91	460.76	117
MALIBU1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	191,437	781	37,315	203.16	54.70	1,093.92	564.30	20.49	54.70	171.90	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	191,437	781	37,315	203.16	54.70	1,093.92	564.30	21.49	54.70	171.90	0
MALIBU2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	30,885	78	3,702	20.36	5.46	109.11	54.50	2.14	5.46	17.15	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	30,885	78	3,702	20.36	5.46	109.11	54.50	2.14	5.46	17.15	0
MALIBU3	Single-family	4,526	289	2,378	14.44	4.35	73.04	31.42	1.61	5.98	5.98	31
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	192,906	787	37,400	204.72	55.12	1,102.32	570.84	21.65	55.12	173.22	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	197,432	1,076	39,778	219.13	59.36	1,175.36	602.27	23.27	61.06	179.17	31
MALIBU4	Single-family	390	17	149	0.85	0.35	4.30	1.85	0.09	0.35	0.35	3
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	35,467	64	3,028	16.63	4.41	88.53	46.36	1.76	4.41	14.07	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	35,857	81	3,177	17.48	4.73	92.82	48.21	1.85	4.83	14.42	3
MALIBU5	Single-family	78,307	4,637	38,189	231.86	68.30	1,172.96	504.63	25.91	95.47	95.47	833
	Multi-family	2,308	145	1,439	6.81	1.43	26.36	10.59	1.30	4.86	4.38	302
	Commercial	13,660	1,083	6,335	32.65	13.67	151.85	91.13	3.47	37.89	32.70	1,671
	Public	7,374	574	3,457	17.42	7.57	81.89	40.16	2.05	9.52	28.43	901
	Light Industrial	4,834	378	2,432	11.60	4.86	53.96	22.57	1.56	6.07	18.72	384
	Other Urban	3,357	340	2,571	8.91	2.86	36.37	13.59	1.60	7.83	6.81	382
	Open	481,419	1,843	87,520	479.86	128.96	2,578.53	1,335.83	50.67	128.96	405.26	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	542,880	8,999	142,146	781.32	226.34	4,105.01	2,040.12	88.64	284.40	610.94	4,377
MEDEA1	Single-family	22,170	723	3,575	25.67	10.49	188.46	77.64	2.90	34.69	34.69	326
	Multi-family	22,170	880	7,534	25.93	7.53	139.09	57.36	2.80	23.50	22.82	1,575
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	20,669	1,063	6,535	32.65	13.67	151.88	91.13	3.47	37.89	32.70	1,671
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	188,843	799	37,970	207.23	55.96	1,119.10	579.34	22.98	55.96	175.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	253,853	3,443	55,313	312.09	87.65	1,590.53	806.25	32.23	113.33	265.37	3,572

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO3+NO2	Total Cu	Total Pb	Total Zn	Oil&Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
MEDEA2	Single-family	2,967	221	1,819	11.06	2.35	25.24	24.80	1.20	4.33	4.33	30
	Multi-family	20,773	1,664	22,840	61.33	22.46	287.41	88.92	9.69	48.33	37.89	2,176
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	200	25	180	0.86	0.86	4.80	3.40	0.14	0.43	1.30	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44
	Other Urban	6,715	480	4,137	20.82	4.36	96.94	31.97	2.30	14.87	22.15	780
	Open	40,430	202	9,577	82.40	14.13	282.57	146.73	8.55	14.13	44.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	81,063	2,414	28,622	143.33	24.73	694.57	320.66	20.62	96.73	200.06	2,963
MEDEA3	Single-family	388,721	23,573	182,406	1,348.46	363.72	3,913.07	2,543.36	138.62	481.21	481.21	4,125
	Multi-family	6,505	465	4,027	19.30	4.80	74.34	28.96	2.10	13.63	11.77	681
	Commercial	79,764	1,579	9,892	47.28	19.78	219.82	131.19	7.91	24.73	78.28	2,418
	Public	27,871	2,166	13,979	66.60	37.44	309.75	183.83	11.15	34.83	107.40	2,407
	Light Industrial	79,764	1,579	9,892	47.28	19.78	219.82	131.19	7.91	24.73	78.28	2,418
	Other Urban	29,376	2,094	18,183	86.73	18.19	233.72	139.19	12.99	61.33	23.16	2,878
	Open	364,998	673	31,809	773.10	47.14	962.33	488.36	28.33	47.14	148.16	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	667,044	31,833	280,410	2,610.62	460.33	8,014.36	3,632.33	182.30	687.34	904.33	14,127
MEDEA4	Single-family	772,702	30,124	83,373	806.19	140.81	2,560.75	1,301.72	26.37	288.43	288.43	1,707
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	373,201	1,115	82,968	289.93	78.06	1,561.15	808.43	30.87	78.06	245.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	443,903	31,239	136,341	796.12	226.94	4,121.90	1,310.17	87.24	266.49	433.76	1,707
PCMDO1	Single-family	28,700	2,973	24,480	148.63	43.72	781.90	283.49	16.61	61.20	61.20	325
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	383,833	1,567	74,420	487.35	109.57	2,193.66	1,125.39	43.09	109.57	344.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	434,343	4,539	98,901	633.98	153.29	2,943.34	1,418.36	59.70	170.57	405.89	325
POTVY1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	83,093	5,935	51,430	245.32	51.44	909.64	395.44	39.57	174.10	150.26	3,765
	Open	753,507	3,076	146,083	799.64	215.29	4,305.75	2,229.76	84.58	215.29	676.62	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	836,600	9,011	197,527	1,044.96	266.73	5,215.39	2,625.41	124.15	389.39	826.88	3,765
POTVY10	Single-family	30,690	2,327	20,365	116.36	34.32	584.63	283.25	18.00	47.91	47.91	401
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	3,777	294	1,880	9.82	3.78	41.97	28.18	1.51	4.72	14.86	482
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	91,067	372	17,656	96.64	26.02	520.36	269.40	10.22	26.02	81.77	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	124,342	2,993	28,709	222.82	64.82	1,130.96	587.81	24.74	78.43	144.25	872
POTVY11	Single-family	1,720	102	880	2.10	1.90	25.70	11.00	0.57	2.10	2.10	20
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,518	196	1,299	6.82	2.52	27.66	16.79	1.01	3.15	9.71	180
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	160,102	653	31,040	169.90	45.74	914.57	472.77	17.97	45.74	143.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	164,333	951	33,136	181.82	49.76	964.62	501.43	19.33	50.99	155.57	206

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
POTVY12	Single-family	141,077	8,306	68,405	423.32	222.15	2,301.02	903.93	46.42	771.01	771.01	1,466
	Multi-family	430	30	250	1.34	0.36	4.80	2.80	0.20	0.31	0.76	44
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	9,702	40	1,898	30.50	2.30	33.96	25.96	1.10	2.30	2.79	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	151,808	8,376	70,344	426.15	225.21	2,341.77	934.80	47.72	774.60	180.57	1,510
POTVY2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	180,799	616	20,237	100.00	43.09	861.71	444.34	16.93	43.09	135.41	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	180,799	616	20,237	100.00	43.09	861.71	444.34	16.93	43.09	135.41	0
POTVY3	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	132,484	342	25,724	140.81	77.91	784.19	292.44	14.89	77.91	110.34	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	132,484	342	25,724	140.81	77.91	784.19	292.44	14.89	77.91	110.34	0
POTVY4	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	30,109	300	7,904	41.57	11.19	223.82	115.91	4.40	11.19	35.17	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	30,109	300	7,904	41.57	11.19	223.82	115.91	4.40	11.19	35.17	0
POTVY5	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	14,484	60	2,846	13.59	4.30	83.93	43.47	1.65	4.30	13.19	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	14,484	60	2,846	13.59	4.30	83.93	43.47	1.65	4.30	13.19	0
POTVY6	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	24,762	142	6,340	26.59	0.93	208.64	102.57	3.80	0.93	31.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	24,762	142	6,340	26.59	0.93	208.64	102.57	3.80	0.93	31.32	0
POTVY7	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	23,713	138	6,530	25.85	0.65	193.06	90.97	2.79	0.65	30.34	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	23,713	138	6,530	25.85	0.65	193.06	90.97	2.79	0.65	30.34	0

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TABLE 4-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
POTVY3	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	822,341	3,357	159,472	872.90	233.01	4,700.34	2,434.08	80.33	233.01	728.41	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	822,341	3,357	159,472	872.90	233.01	4,700.34	2,434.08	80.33	233.01	728.41	0
POTVY2	Single-family	17,966	1,083	8,673	22.66	15.49	266.39	114.41	3.59	21.60	21.60	106
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	82,254	326	15,947	87.28	23.50	470.02	203.41	9.53	23.50	71.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	100,220	1,349	24,620	139.95	38.99	736.41	333.01	13.12	45.10	93.34	106
BURBL1	Single-family	160,225	9,920	81,095	494.00	145.88	2,509.19	1,879.54	23.44	204.34	209.34	1,731
	Multi-family	3,777	370	2,330	11.15	2.34	43.17	17.99	1.80	7.91	6.83	306
	Commercial	180	16	90	0.43	0.18	2.80	1.30	0.07	0.32	0.60	22
	Public	18,072	783	3,836	34.06	10.07	111.01	67.15	4.85	12.56	20.83	1,201
	Light Industrial	133,433	10,340	64,727	318.00	133.43	1,482.11	879.40	23.34	166.82	314.84	16,311
	Other Urban	37,908	1,993	17,576	82.90	17.28	318.94	132.89	13.59	34.47	38.50	2,504
	Open	182,134	945	35,312	193.79	52.84	1,040.77	538.97	20.44	52.84	163.55	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	536,744	26,104	206,473	1,126.13	361.34	5,308.79	3,727.42	146.43	503.39	970.18	[illegible]
SCHEE1	Single-family	2,318	136	1,110	6.79	3.80	34.37	14.79	0.76	3.80	3.80	34
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	99,880	408	19,344	106.00	28.54	570.74	295.54	11.21	28.54	88.69	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	102,198	544	20,454	112.79	30.34	605.12	310.33	11.97	31.33	92.49	34
SLEEP1	Single-family	25,790	1,512	12,450	75.50	22.23	362.39	164.52	8.45	31.13	31.13	287
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	68,711	248	11,771	64.43	17.35	346.92	179.66	6.81	17.35	54.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	94,501	1,760	24,221	140.43	39.58	729.32	344.17	15.26	48.47	85.64	287
STOKE1	Single-family	7,534	442	3,637	22.08	6.40	111.71	48.06	2.47	0.00	0.00	78
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	557,644	2,276	108,118	591.31	159.33	3,184.68	1,650.23	62.59	159.33	500.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	565,177	2,718	111,756	613.39	163.13	3,296.36	1,698.29	65.06	168.43	500.35	78
TRSUN1	Single-family	6,065	391	3,377	19.53	2.55	98.82	42.52	2.31	5.04	8.04	69
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	204,048	975	41,377	227.58	61.57	1,225.42	634.59	24.07	61.57	192.57	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	211,113	1,366	44,754	247.11	67.02	1,324.24	677.11	26.25	66.31	200.61	69

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

		POLLUTANT LOADINGS (POUNDS PER YEAR)										
CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
TRTUN2	Single-family	268,041	14,540	119,744	737.02	213.83	3,577.84	1,532.33	81.25	399.36	399.36	2,544
	Multi-family	71,572	3,341	44,334	213.40	44.55	332.34	342.73	34.37	130.80	130.34	7,340
	Commercial	80,744	4,863	44,574	214.40	89.75	897.20	590.32	29.90	112.19	344.03	10,500
	Public	34,356	4,267	37,438	131.05	34.36	600.51	361.71	21.94	68.57	211.50	6,788
	Light Industrial	32,573	3,541	34,637	78.49	33.37	264.70	221.82	23.31	41.89	338.30	4,867
	Other Urban	11,121	784	6,844	32.52	6.84	137.10	32.96	8.30	23.30	38.13	3,165
	Open	140,230	612	28,847	234.99	42.81	856.11	443.33	16.72	42.81	134.33	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	634,533	34,723	281,144	1,534.36	461.35	7,460.03	3,467.21	208.79	724.61	1,376.07	33,012
TRTUN3	Single-family	37,324	1,997	23,340	78.84	23.48	483.83	773.76	8.82	32.57	32.57	303
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	6,835	322	3,477	16.32	6.83	73.94	48.34	3.73	3.34	28.33	835
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	170,359	719	24,773	187.85	30.36	1,087.19	321.34	18.71	30.36	151.37	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	210,333	2,544	30,730	283.21	60.44	1,457.01	960.91	31.44	91.78	217.30	1,117
TRTUN4	Single-family	11,011	648	3,316	32.71	0.49	183.37	78.34	3.41	13.39	13.39	114
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	71,483	282	13,859	73.06	20.42	488.47	213.33	8.02	20.42	64.19	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	82,494	937	19,175	105.13	20.92	671.34	291.77	11.43	33.71	77.48	114
TRTUN5	Single-family	8,314	476	3,917	23.76	6.99	220.30	51.76	2.46	9.79	9.79	84
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	105,735	432	20,506	112.25	30.22	604.32	312.95	11.87	30.22	94.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	113,849	907	24,420	136.01	37.21	724.62	364.71	14.33	40.01	104.76	84
TRTUN6	Single-family	90,697	3,317	43,785	263.84	78.19	1,344.82	573.59	30.71	309.46	109.46	[illegible]
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	246,347	1,887	51,630	282.65	76.10	1,521.98	782.17	29.90	76.10	239.17	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	337,044	6,404	95,424	546.49	154.29	2,866.80	1,366.76	60.61	385.56	348.63	[illegible]
TRTUN7	Single-family	6,375	374	2,878	16.49	5.50	94.53	48.67	3.59	7.49	7.49	66
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	485,973	2,024	96,158	526.34	141.71	2,534.13	1,487.87	28.87	141.71	445.36	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	492,348	2,398	99,236	543.02	147.20	2,628.66	1,508.34	57.74	149.40	453.86	66
CRDCH1	Single-family	38,539	2,299	20,605	112.96	28.32	371.44	202.35	12.42	46.51	46.51	399
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	203,187	820	30,393	215.43	88.05	1,361.07	401.27	22.81	88.05	182.45	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	241,726	3,089	57,999	328.39	91.28	1,732.51	647.12	35.43	104.57	228.97	399

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible] 1	Single-family	2,316	[illegible]	2,314	23.20	4.90	77.34	23.37	1.71	6.30	6.30	34
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	63,222	346	11,676	63.91	37.21	344.13	178.21	6.76	37.21	54.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	66,434	333	14,194	75.30	31.70	421.46	211.44	8.47	23.50	60.37	34
SMB 114	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,427	34	664	3.64	0.96	19.31	10.14	0.34	0.96	3.06	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,427	34	664	3.64	0.96	19.31	10.14	0.34	0.96	3.06	0
SMB 115	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	7,344	20	1,424	7.79	2.10	41.57	21.73	0.82	2.10	6.59	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,344	20	1,424	7.79	2.10	41.57	21.73	0.82	2.10	6.59	0
SMB 121	Single-family	2,898	170	1,399	8.49	2.30	42.97	18.49	0.95	2.30	2.30	30
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,469	6	285	1.56	0.42	8.39	4.35	0.16	0.42	1.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,367	176	1,684	10.05	2.72	51.36	22.83	1.11	2.72	4.62	30
SMB 122	Single-family	1,259	68	280	3.40	1.00	17.19	7.30	0.38	1.40	1.40	12
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,853	8	250	2.88	0.56	11.19	5.89	0.22	0.56	1.56	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,111	76	530	6.48	1.56	28.38	13.19	0.60	1.96	2.96	12
SMB 123	Single-family	1,259	68	280	3.40	1.00	17.19	7.30	0.38	1.40	1.40	12
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	480	2	95	0.52	0.34	2.20	1.40	0.08	0.34	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,649	70	654	3.22	1.34	19.96	8.84	0.43	1.34	1.84	12
SMB 124	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,443	10	475	2.40	0.70	13.59	7.24	0.27	0.70	2.20	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,443	10	475	2.40	0.70	13.59	7.24	0.27	0.70	2.20	0

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO3+NO2	Total Cu	Total Pb	Total Zn	Oil & Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
SMB 101	Single-family	6,085	207	2,928	17.84	5.35	90.33	28.82	1.99	7.34	7.34	63
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	26	864	4.68	1.36	25.11	11.04	0.49	1.36	2.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	10,492	373	3,792	22.11	6.30	115.41	51.86	2.49	8.60	11.30	63
SMB 102	Single-family	3,187	187	1,530	9.34	2.75	47.26	20.33	1.04	3.85	3.85	33
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	8,813	36	1,700	9.35	2.52	50.36	26.08	0.99	2.53	7.91	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	12,000	223	3,247	18.70	5.27	97.62	46.41	2.03	6.36	11.76	33
SMB 103	Single-family	5,795	340	2,798	16.99	5.00	83.93	36.97	1.80	6.99	6.99	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,795	340	2,798	16.99	5.00	83.93	36.97	1.80	6.99	6.99	60
SMB 104	Single-family	10,432	612	5,036	30.58	8.99	154.68	66.55	3.42	12.59	12.59	108
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	10,433	612	5,036	30.58	8.99	154.68	66.55	3.42	12.59	12.59	108
SMB 105	Single-family	17,876	1,036	8,533	51.81	15.24	262.09	112.76	5.79	21.33	21.33	183
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,958	8	380	2.08	0.56	11.19	5.80	0.22	0.56	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	19,834	1,044	8,913	53.89	15.80	273.28	118.56	6.01	21.89	23.09	183
SMB 95	Single-family	5,795	340	2,798	16.99	5.00	85.93	36.97	1.80	6.99	6.99	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,938	22	570	3.12	0.84	16.79	8.69	0.33	0.84	2.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,733	362	3,367	20.10	5.84	102.72	45.66	2.13	7.83	9.63	60
SMB 96	Single-family	9,373	546	4,476	27.18	7.99	137.40	59.13	3.04	11.19	11.19	96
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	54,836	224	10,631	58.19	15.67	313.35	162.27	6.16	15.67	49.24	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	64,109	767	15,108	85.37	23.66	450.84	221.42	9.19	26.86	60.43	96

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
SMB 15	Single-family	28,253	2,070	8,813	33.31	15.74	270.44	114.46	5.50	22.03	22.03	189
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,448	10	475	2.80	0.70	13.99	7.24	0.57	0.70	2.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	30,703	2,080	9,288	36.11	16.44	284.47	122.70	6.25	22.73	24.33	189
SMB 16	Single-family	5,506	323	2,458	16.14	4.75	81.63	26.12	1.80	6.64	6.64	57
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	11,751	48	2,378	12.47	3.36	67.15	34.77	1.33	3.36	10.65	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	17,256	371	4,836	28.61	8.10	148.78	60.89	3.13	10.00	17.30	57
LPLCN1	Single-family	35,181	2,309	11,391	67.05	19.06	343.72	167.83	7.90	27.06	27.06	280
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	8,433	671	4,317	20.02	8.63	88.92	57.31	2.43	10.79	23.30	1,088
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	288,146	837	20,773	217.71	58.41	1,172.26	487.86	20.60	58.61	184.21	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	326,960	3,848	35,281	305.57	87.23	1,611.91	812.80	30.07	97.34	243.46	1,368
LPLCN2	Single-family	30,130	3,790	24,201	146.90	40.22	743.30	300.79	16.42	60.50	60.50	319
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	82,744	208	16,042	87.81	20.64	472.82	204.23	9.29	20.64	74.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	132,874	3,376	40,343	234.74	60.86	1,216.13	504.03	25.71	84.14	134.80	319
LTLPL1	Single-family	8,114	476	2,977	23.78	6.99	128.30	51.70	2.46	9.79	9.79	84
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	128,277	324	24,370	136.13	36.45	723.01	379.60	14.60	36.65	115.19	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	136,391	800	28,787	159.91	43.43	851.32	431.33	17.06	46.44	124.98	84
SMB 106	Single-family	37,284	2,019	8,303	30.96	14.59	257.79	110.91	3.70	20.98	20.98	180
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	37,284	2,019	8,303	30.96	14.59	257.79	110.91	3.70	20.98	20.98	180
SMB 107	Single-family	23,619	798	6,575	39.82	11.74	201.94	86.80	4.46	16.44	16.44	161
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	16,647	48	2,327	17.47	4.76	95.12	40.26	1.87	4.76	14.88	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	30,266	846	8,902	57.36	16.50	297.06	126.14	6.33	21.19	31.34	161

TABLE A-3

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
SMB 108	Single-family	7,824	459	3,777	22.55	6.74	116.01	40.91	2.56	9.44	9.44	81
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,854	8	380	2.88	0.56	11.19	2.80	0.32	0.56	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	9,712	467	4,157	25.01	7.30	127.20	43.71	2.78	10.00	11.20	81
SMB 109	Single-family	7,344	425	3,497	21.33	6.35	107.41	46.31	2.37	8.74	8.74	75
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,486	18	854	4.48	1.36	28.18	13.84	0.49	1.36	2.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	11,831	443	4,333	25.81	7.30	133.39	59.23	2.87	10.00	11.70	75
SMB 110	Single-family	4,634	272	2,528	13.90	4.00	61.74	20.54	1.02	3.00	3.00	48
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,854	8	380	2.88	0.56	11.19	2.80	0.32	0.56	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,493	280	3,618	13.67	4.56	79.94	23.37	1.34	6.16	7.33	48
SMB 111	Single-family	16,277	931	7,834	47.34	13.59	240.61	103.32	3.32	19.58	19.58	168
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,926	32	570	2.12	0.84	16.79	8.89	0.33	0.84	2.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	20,343	963	8,403	50.46	14.43	257.39	112.21	3.65	20.42	22.22	168
SMB 112	Single-family	23,040	764	6,576	38.32	11.34	193.33	83.18	4.27	15.74	15.74	135
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	18	854	4.48	1.36	28.18	13.84	0.49	1.36	3.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	27,446	782	7,349	42.80	12.30	211.51	96.22	4.77	17.00	19.60	135
SMB 113	Single-family	8,480	480	4,057	24.83	7.34	204.00	53.61	2.75	10.14	10.14	57
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,440	18	475	2.40	0.70	13.99	7.24	0.57	0.70	2.20	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	10,811	503	4,531	27.23	7.84	218.39	60.85	3.00	10.84	12.34	57
PENA1	Single-family	580	34	280	1.70	0.50	8.50	2.50	0.19	0.70	0.70	6
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	69,524	284	13,479	73.78	19.86	397.30	285.74	7.80	19.86	62.43	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	70,104	318	13,759	75.48	20.36	405.81	288.43	7.99	20.56	63.13	6

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO3+NO2	Total Cu	Total Pb	Total Zn	Oil & Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
SMB 125	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,427	34	664	2.44	0.98	20.54	20.14	0.30	0.98	2.08	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0
	Catchment Total	2,427	34	664	2.44	0.96	20.54	20.14	0.34	0.96	2.08	0
SMB 126	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,854	8	290	2.05	0.54	11.19	2.80	0.22	0.54	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,854	8	290	2.05	0.54	11.19	2.80	0.22	0.54	1.76	0
SMB 127	Single-family	280	34	280	1.70	0.50	8.50	2.70	0.10	0.70	0.70	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,854	8	290	2.05	0.54	11.19	2.80	0.22	0.54	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,134	42	619	3.75	1.06	19.71	5.49	0.41	1.26	2.46	0
SMB 128	Single-family	2,511	136	1,119	0.79	2.00	34.57	16.79	0.76	2.00	2.00	34
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,854	8	290	2.05	0.54	11.19	2.80	0.22	0.54	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,377	144	1,409	8.57	2.54	45.34	20.34	0.96	2.56	4.56	34
TUNA1	Single-family	8,983	527	4,537	26.33	7.74	233.19	37.30	2.34	30.04	30.04	98
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	142,946	584	27,736	151.72	40.85	816.95	423.06	16.65	40.85	128.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	151,944	1,110	32,054	178.05	48.59	1050.14	460.37	18.99	31.60	128.22	98
BROOK1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	24,970	182	4,941	26.50	2.13	142.09	72.89	2.30	2.13	22.42	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	24,970	182	4,941	26.50	2.13	142.60	72.89	2.30	2.13	22.42	0
DEK1	Single-family	31,968	2,941	25,040	152.05	44.71	769.08	328.99	16.99	62.40	62.40	337
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	28,354	224	3,825	32.21	8.67	173.46	99.83	3.41	8.67	27.26	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	82,324	3,144	30,925	184.26	53.39	942.55	420.71	20.40	71.27	89.86	337

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TABLE A-2
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
GARAP1	Single-family	38,545	3,087	8,583	34.36	25.59	254.98	118.31	4.80	22.36	22.36	302
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	229,137	935	44,494	263.17	65.47	1,309.35	671.06	25.72	65.47	200.78	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	267,682	4,022	53,377	297.53	81.43	1,564.33	790.36	31.79	87.83	223.14	302
GEOLP	Single-family	2,367	221	1,819	11.84	3.25	35.84	24.83	1.30	4.85	4.83	30
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	115,947	472	22,402	122.62	33.01	680.27	241.53	32.97	33.01	101.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	119,314	693	24,221	133.46	36.26	716.13	265.96	34.20	37.86	106.30	30
BENDO1	Single-family	7,534	442	3,837	22.08	6.49	112.71	48.86	2.47	9.09	9.00	78
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	91,067	372	17,456	96.64	26.02	520.38	280.41	10.22	26.02	81.77	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	98,601	813	21,293	118.72	32.51	633.09	317.33	12.69	35.11	90.77	78
OTPNO1	Single-family	28,823	3,448	28,397	172.41	58.71	872.20	593.25	18.37	78.90	78.90	650
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	208,291	800	38,444	210.43	54.45	1,133.08	284.78	22.36	54.45	170.06	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	237,114	4,254	66,841	382.84	107.36	2,005.29	882.03	41.53	137.43	249.06	650
OTPNO2	Single-family	12,329	781	6,425	38.07	11.09	197.44	95.83	4.57	16.80	16.80	338
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	165,977	877	32,170	176.14	47.42	946.44	491.26	18.83	47.42	149.84	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	178,306	1,659	38,614	213.21	58.51	1,146.86	576.10	23.80	63.11	166.13	338
OTPNO3	Single-family	28,441	2,899	17,206	104.47	28.73	528.48	287.37	11.08	40.88	40.88	380
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	73,441	380	14,239	77.94	28.98	419.66	217.23	8.24	28.98	65.85	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	100,883	3,289	31,445	182.40	51.71	948.14	504.60	19.32	64.80	108.96	380
RDRCK1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	110,162	450	21,336	116.91	31.47	629.50	325.59	12.37	31.47	98.82	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	110,162	450	21,336	116.91	31.47	629.50	325.59	12.37	31.47	98.82	0

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR) TSS	BOD5	COD	Total P	Soluble P	TKN	NO3+NO2	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 129	Single-family	4,526	209	2,370	14.44	4.25	73.04	31.42	1.61	5.95	5.95	51
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	480	2	95	0.52	0.14	2.30	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,416	211	2,473	14.96	4.39	75.34	32.87	1.67	6.09	6.36	51
SPGOA1	Single-family	200	37	140	0.85	0.35	4.30	1.85	0.00	0.35	0.35	3
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	116,037	474	22,497	122.14	23.15	663.07	243.30	13.02	23.15	104.20	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	116,237	491	22,637	122.99	23.40	667.37	245.22	13.13	23.50	104.33	3
TPNOA1	Single-family	93,016	5,453	44,504	272.43	88.19	1,579.20	593.57	20.47	112.26	112.26	902
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	242,356	999	46,987	257.10	60.24	1,384.89	717.18	37.20	60.24	207.43	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	335,371	6,452	91,891	529.53	149.43	2,964.09	1,310.53	57.67	181.50	320.10	902
TPNOA2	Single-family	28,107	1,648	13,560	82.38	24.23	414.77	179.31	9.31	33.93	33.92	291
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	23,301	96	4,536	24.94	6.71	134.29	69.34	2.44	6.71	21.10	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	51,409	1,744	18,125	107.32	30.95	551.06	248.65	11.85	40.64	55.03	291
TPNOA3	Single-family	227,708	7,491	61,491	374.85	110.36	1,894.76	815.20	41.86	194.20	194.20	1,522
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	300,334	817	38,824	212.51	57.21	1,144.28	582.54	22.48	57.21	179.82	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	528,037	8,308	100,315	587.36	167.58	3,039.07	1,397.77	64.34	251.44	374.04	1,522
TPNOA4	Single-family	48,573	2,701	22,942	135.04	39.72	693.15	293.91	15.09	55.61	55.61	477
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,375	24	1,339	6.24	1.68	23.57	17.39	0.66	1.68	5.28	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	51,948	2,725	23,341	141.28	41.40	716.73	311.30	15.75	57.28	60.88	477
TPNOA5	Single-family	84,612	4,960	40,847	248.00	72.94	1,254.60	539.77	27.72	102.12	102.12	875
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	138,869	564	26,769	146.52	39.45	788.97	401.57	15.50	39.45	123.98	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	223,481	5,524	67,616	394.52	112.39	2,043.56	941.34	43.22	141.57	226.10	875

TABLE A-3

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
TPNGA4	Single-family	21,574	2,040	23,300	80.40	27.40	472.62	303.34	10.44	28.47	28.47	300
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	312,349	1,570	40,751	303.53	80.53	1,790.57	877.36	36.17	80.53	301.57	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	343,224	3,347	[illegible]	425.96	117.01	2,263.19	1,130.39	46.61	126.00	318.84	300
TPNGA7	Single-family	37,384	3,019	2,393	80.96	24.59	207.79	130.91	3.70	20.00	20.00	300
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	27,906	114	3,411	20.42	7.57	209.47	82.54	2.13	7.57	20.06	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	45,794	3,133	13,804	80.34	22.96	417.37	372.30	5.13	28.96	46.84	300
PARKR1	Single-family	33,317	3,320	30,730	154.37	45.94	700.57	348.13	17.47	64.36	64.36	353
	Multi-family	4,616	330	2,834	13.63	2.46	32.76	31.90	2.30	9.57	8.35	404
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	8,633	671	4,317	30.42	8.43	98.92	57.33	3.45	10.79	33.39	1,883
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	30,049	306	2,801	27.34	7.41	345.28	74.79	2.91	7.41	22.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	72,316	4,323	37,343	211.07	64.57	1,087.33	484.43	26.03	82.33	130.39	2,500
QUARY1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	301,536	416	39,344	308.07	30.10	281.93	201.36	11.43	30.10	91.45	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	301,536	416	19,344	308.07	30.10	281.93	201.36	11.43	30.10	91.45	0
SMB 130	Single-family	380	24	290	1.70	0.50	8.50	2.70	0.19	0.70	0.70	6
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,427	24	604	3.64	0.90	20.52	10.14	0.38	0.92	3.05	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,807	48	944	5.34	1.40	28.13	13.84	0.57	1.40	3.76	6
SMB 131	Single-family	16,517	968	7,974	46.41	14.24	244.80	185.37	5.41	20.80	20.80	371
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	400	3	96	0.52	0.14	2.80	1.45	0.00	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	17,806	970	8,080	46.85	14.36	247.70	186.81	5.47	20.87	20.37	371
SMB 132	Single-family	6,054	408	3,357	20.36	6.80	103.12	44.36	2.38	6.30	6.30	52
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,054	408	3,357	20.36	6.80	103.12	44.36	2.36	6.30	6.30	52

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
STNEZ1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	290,190	1,821	48,306	263.31	71.48	1,428.64	960.36	28.88	71.48	284.66	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	290,190	1,821	48,306	263.31	71.48	1,428.64	960.36	28.88	71.48	284.66	0
STNEZ2	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	820	60	820	3.40	0.52	8.90	4.80	0.40	1.76	1.52	88
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	12,730	52	2,465	10.31	3.64	72.74	37.87	1.43	3.64	11.43	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	13,549	112	2,964	13.99	4.16	83.33	41.67	1.83	3.40	12.95	88
STNEZ3	Single-family	145,464	8,577	78,324	426.36	120.40	2,134.17	687.36	47.45	775.34	775.34	1,988
	Multi-family	25,318	1,894	9,482	45.22	9.48	773.86	72.94	7.39	32.09	37.72	1,465
	Commercial	6,395	490	3,147	13.84	6.39	69.94	41.97	2.53	7.57	24.37	709
	Public	18,432	811	3,316	24.92	10.43	115.91	60.54	4.17	13.84	40.32	1,378
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	65,577	4,601	48,457	172.90	40.46	780.60	312.75	31.37	137.41	118.84	6,888
	Open	253,884	1,841	49,433	270.70	72.84	1,457.63	784.85	28.43	72.81	230.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	498,271	16,633	173,182	976.13	263.13	4,726.02	2,160.00	121.54	409.05	611.67	12,004
TRLER1	Single-family	23,900	815	6,715	40.77	11.90	206.23	88.73	4.46	16.79	16.79	144
	Multi-family	4,197	300	2,998	12.30	2.60	47.26	18.98	2.80	8.79	7.50	460
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	820	60	820	3.40	0.52	8.90	4.80	0.40	1.76	1.52	88
	Open	48,263	238	11,396	61.03	16.43	232.93	173.41	4.54	16.43	32.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	77,200	1,413	31,128	117.47	31.35	506.72	285.12	13.40	43.04	58.32	691
PULOA1	Single-family	282,252	12,839	187,394	651.43	301.40	3,280.46	1,477.81	72.11	282.34	282.34	2,399
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,393	688	2,796	24.76	2.30	98.92	30.37	4.80	17.90	18.39	879
	Open	24,795	222	11,811	60.27	16.23	204.84	148.07	6.57	16.23	31.88	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	287,440	13,840	220,401	736.46	313.83	3,715.92	1,625.83	83.18	302.66	304.42	3,176
SMB 133	Single-family	39,670	2,388	18,385	110.41	22.47	588.35	308.31	12.34	46.46	46.46	390
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,799	340	809	4.30	1.80	29.94	11.09	0.72	2.35	6.93	280
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,365	26	1,334	6.75	1.82	26.37	16.83	0.71	1.82	3.72	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	46,833	2,374	20,319	121.46	26.09	644.91	371.13	13.77	48.13	54.11	640
SMB 134	Single-family	11,591	679	5,586	33.57	9.99	171.86	73.94	2.80	13.99	13.99	120
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,936	12	570	2.12	0.84	16.79	8.69	0.33	0.84	2.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	14,522	691	6,145	37.69	10.83	181.65	82.63	4.13	14.83	16.63	120

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TABLE A-3

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 1-25	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,596	20	949	2.30	1.40	27.98	14.49	0.33	1.40	4.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,596	20	949	2.30	1.40	27.98	14.49	0.33	1.40	4.40	0
TEMES1	Single-family	38,323	2,448	28,597	172.41	38.71	872.30	373.35	10.57	78.59	78.59	680
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	1,578	234	989	4.73	1.58	21.58	23.19	0.79	2.47	7.43	302
	Public	11,511	895	8,735	37.30	11.51	157.90	76.74	4.60	14.50	44.38	1,407
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,738	210	1,819	8.67	1.82	20.57	13.99	1.40	6.16	2.52	201
	Open	216,407	883	41,854	228.66	61.83	1,224.61	640.39	24.29	61.83	194.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	281,436	3,591	78,817	441.97	137.43	2,297.26	1,118.33	40.33	133.84	332.64	2,543
MONLV1	Single-family	286,994	22,128	98,280	606.41	778.36	3,067.74	1,319.84	67.71	309.70	309.70	2,140
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,777	270	2,378	11.15	2.34	43.17	17.99	1.80	7.91	6.03	386
	Open	225,381	1,369	63,823	353.92	95.42	1,916.47	992.46	37.64	95.82	301.16	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	546,053	23,767	167,241	973.44	876.32	5,027.37	2,330.26	107.22	413.44	617.40	2,526
RIVAS1	Single-family	34,772	2,838	36,787	201.92	39.90	815.90	281.82	11.50	41.97	41.97	380
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	19,724	1,459	12,310	58.23	12.21	225.42	93.92	9.39	41.20	26.09	2,046
	Open	87,640	258	16,591	63.01	25.04	800.30	299.34	9.84	25.04	78.70	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	142,136	3,805	65,688	323.16	67.23	1,841.81	675.08	30.42	108.33	146.35	2,426
BUSTC1	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	208,379	1,177	33,910	306.03	82.39	1,647.88	853.37	32.37	82.39	298.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	208,379	1,177	33,910	306.03	82.39	1,647.88	853.37	32.37	82.39	294.86	0
BUSTC2	Single-family	68,385	4,889	33,914	288.46	58.95	1,012.99	406.35	20.40	80.53	80.53	397
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	360,841	1,573	69,359	352.93	103.10	2,061.95	1,067.30	40.30	103.10	324.82	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	429,226	3,482	102,973	641.37	162.05	3,073.94	1,304.65	62.90	183.63	405.35	397
BUSTC3	Single-family	111,850	4,537	33,997	227.84	96.42	1,658.47	713.53	26.64	124.99	124.99	1,157
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	3,857	308	1,978	9.45	3.96	43.96	15.38	1.51	4.85	25.26	484
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	115,807	6,845	35,975	237.29	100.34	1,762.44	730.91	28.22	129.94	150.25	1,641

TABLE A-3

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
ELLVN4	Single-family	73,801	4,315	35,532	213.73	63.45	1,091.33	489.52	24.11	88.83	88.83	761
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	297,482	3,315	57,714	315.91	85.85	1,701.04	880.89	33.41	85.08	207.31	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	371,283	8,530	93,243	531.63	144.30	2,792.36	1,370.42	57.52	173.84	296.13	761
SMB 136	Single-family	33,619	780	6,575	58.92	11.94	201.04	86.88	4.46	16.44	16.44	141
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,917	34	789	4.16	1.12	22.38	11.59	0.44	1.12	3.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	37,536	814	7,334	64.07	13.06	224.32	98.47	4.90	17.56	19.95	141
SMB 137	Single-family	1,449	88	480	4.38	1.35	21.40	9.34	0.47	1.78	1.78	15
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	180	14	90	0.43	0.11	2.80	1.30	0.07	0.32	0.60	22
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,896	20	949	3.20	1.40	27.36	14.09	0.55	1.40	4.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,525	119	1,739	8.07	2.83	51.46	24.93	1.10	3.37	6.84	37
SMB 138	Single-family	4,807	238	1,808	11.89	3.50	60.13	25.88	1.35	4.90	4.90	42
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,457	14	604	2.44	0.98	19.34	10.14	0.34	0.98	3.08	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,464	252	2,433	14.33	4.48	79.74	36.02	1.71	5.88	7.97	42
SMB 142	Single-family	73,311	4,398	35,392	204.88	63.20	1,087.65	467.66	24.82	88.40	88.40	780
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	3,255	448	2,578	22.75	5.76	63.85	28.37	2.30	7.19	22.19	780
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	9,303	28	1,804	9.57	2.66	53.16	27.53	1.04	2.66	8.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	86,369	4,783	40,073	236.30	71.61	1,204.14	523.57	27.36	98.33	118.02	1,462
SMMON1	Single-family	207,812	17,411	143,305	878.55	204.05	4,403.97	1,894.73	97.30	283.46	283.46	2,873
	Multi-family	22,940	890	7,704	37.17	7.79	143.82	90.85	4.80	24.38	22.78	1,319
	Commercial	11,891	909	8,845	37.85	11.80	120.90	77.84	4.48	14.61	48.07	1,479
	Public	11,331	881	8,645	32.87	11.32	125.80	73.84	4.53	14.16	43.80	1,505
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	21,843	80	4,377	22.86	6.14	123.10	43.75	2.42	6.36	30.34	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	254,146	20,119	166,846	983.34	273.02	4,926.76	2,171.01	114.82	419.77	483.35	7,205
SMMON2	Single-family	28,846	1,750	14,400	87.48	28.73	462.83	188.40	9.78	34.82	34.82	380
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	3,237	252	1,619	7.73	2.24	25.97	21.84	1.39	4.88	12.48	286
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	180	1.04	0.28	2.40	2.90	0.11	0.28	0.83	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	34,063	2,005	16,217	96.25	28.25	484.11	214.84	11.18	40.35	48.38	704

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CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
[illegible]	Single-family	302,304	20,444	87,990	334.22	87.13	2,702.54	1,342.72	28.71	209.97	209.97	1,835
	Multi-family	29,724	1,409	22,318	34.25	12.21	225.42	91.52	9.39	41.22	26.49	2,066
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,854	0	280	2.00	0.54	11.29	2.80	0.22	0.54	1.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	302,947	22,101	200,579	394.33	100.19	2,979.13	1,363.44	60.33	261.84	237.42	3,852
[illegible]	Single-family	2,187	187	1,579	9.34	2.75	47.26	20.25	1.84	3.85	3.85	30
	Multi-family	89,779	6,570	83,306	263.39	83.21	1,819.11	424.66	42.67	304.25	361.57	8,343
	Commercial	7,914	614	3,957	14.90	7.91	87.50	32.76	3.77	9.89	30.31	987
	Public	37,964	1,799	8,993	42.97	17.89	309.84	119.80	7.19	22.40	60.34	2,198
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,006	380	2,318	14.57	2.12	87.33	23.98	2.40	20.55	9.11	222
	Open	11,721	48	2,378	12.47	2.36	67.15	24.77	1.32	2.36	20.55	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	133,052	8,879	23,090	361.84	90.33	1,476.82	676.41	37.39	226.96	204.74	11,604
[illegible]	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	27,134	2,112	13,579	64.28	27.34	201.76	181.06	10.84	23.95	104.71	2,319
	Public	180	14	90	0.43	0.18	2.00	1.30	0.07	0.22	0.00	22
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	190	1.84	0.26	5.40	2.90	0.11	0.28	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	28,317	2,130	13,839	66.35	27.42	209.33	185.13	11.05	24.43	106.33	2,341
[illegible]	Single-family	220,017	19,329	154,353	961.43	282.77	4,043.71	2,092.52	187.43	305.80	305.80	2,590
	Multi-family	84,341	6,160	81,387	204.62	83.59	983.41	418.67	41.87	180.70	204.06	8,026
	Commercial	5,306	420	2,698	12.89	5.40	59.50	25.97	2.16	6.74	20.00	650
	Public	24,281	1,846	12,140	58.00	24.28	260.78	161.87	9.71	20.26	93.62	2,046
	Light Industrial	2,518	196	1,250	6.02	2.52	27.00	16.70	1.01	2.15	9.71	188
	Other Urban	62,740	4,411	35,139	181.25	26.84	717.80	209.76	20.84	131.45	112.53	4,573
	Open	39,584	80	3,797	20.71	5.40	111.91	57.85	2.20	5.40	17.99	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	438,777	32,434	270,673	1,440.97	412.79	6,033.97	3,074.34	280.47	753.57	807.18	22,936
[illegible]	Single-family	63,160	3,703	30,496	183.15	34.46	804.45	482.96	20.69	74.34	74.34	683
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	63,160	3,703	30,496	183.15	34.46	804.45	482.96	20.69	74.34	74.34	683
[illegible]	Single-family	26,940	1,800	13,010	78.90	20.23	290.84	171.91	8.83	22.52	22.52	279
	Multi-family	4,906	405	4,027	19.20	4.05	74.34	30.96	2.30	13.63	11.77	631
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	3,427	206	1,700	8.16	3.42	37.37	22.79	1.57	4.57	13.30	404
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	34,570	2,310	18,745	106.35	30.44	311.89	225.67	13.39	30.42	37.47	1,376
[illegible]	Single-family	9,573	844	4,676	27.18	7.89	137.49	30.15	2.04	11.39	11.39	96
	Multi-family	157,384	11,256	97,532	463.25	97.35	1,802.96	780.40	75.04	230.18	285.15	16,009
	Commercial	37,770	2,938	18,885	90.23	37.77	419.46	291.20	15.11	47.21	145.42	4,616
	Public	4,854	378	2,428	11.60	4.86	53.96	32.37	1.94	6.07	18.72	594
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,858	0	280	2.88	0.54	11.19	2.30	0.22	0.56	1.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	211,441	15,123	123,721	596.33	148.73	2,423.26	1,099.32	85.35	295.21	462.43	21,315

TABLE A-2
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	[illegible]	[illegible]	[illegible]	31.42	9.34	[illegible]	[illegible]	2.51	22.94	22.94	111
	Multi-family	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	77.88	4,442
	Commercial	1,799	140	[illegible]	4.30	1.30	[illegible]	11.09	0.72	[illegible]	[illegible]	330
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	[illegible]	14	[illegible]	0.43	0.10	2.80	1.30	0.07	0.22	2.00	22
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	[illegible]	1.04	0.38	5.40	0.80	0.11	0.38	0.88	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	[illegible]	[illegible]	[illegible]	37.87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BUNDY1	Single-family	[illegible]	1,807	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.11	[illegible]	[illegible]	281
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,327	[illegible]	1,619	7.73	2.34	30.37	31.34	1.39	4.88	22.48	384
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	[illegible]	773	[illegible]	23.49	3.25	[illegible]	[illegible]	2.30	[illegible]	9.49	[illegible]
	Open	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	414.87	[illegible]	8.11	[illegible]	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	114,844	2,910	[illegible]	199.49	84.41	1,012.00	477.27	20.01	[illegible]	137.96	[illegible]
BUNDY2	Single-family	[illegible]	1,512	[illegible]	[illegible]	[illegible]	[illegible]	104.52	0.45	31.13	31.13	287
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,327	[illegible]	1,619	7.73	2.34	30.37	31.34	1.39	4.88	22.48	384
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	[illegible]	2,733	15.07	4.86	81.14	[illegible]	1.99	4.86	22.73	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	[illegible]	[illegible]	[illegible]	29.33	[illegible]	223.12	11.34	[illegible]	[illegible]	[illegible]
BUNDY3	Single-family	[illegible]	3,907	[illegible]	[illegible]	37.45	[illegible]	425.16	[illegible]	[illegible]	[illegible]	[illegible]
	Multi-family	8,113	[illegible]	[illegible]	26.02	3.46	[illegible]	41.97	4.20	[illegible]	[illegible]	[illegible]
	Commercial	340	[illegible]	370	1.30	0.54	0.00	3.00	0.22	0.67	2.88	64
	Public	[illegible]	[illegible]	[illegible]	22.09	2.40	[illegible]	28.97	2.16	6.74	[illegible]	[illegible]
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	81,395	[illegible]	40,377	233.34	[illegible]	[illegible]	[illegible]	28.40	[illegible]	119.27	[illegible]
KENTR1 (?)	Single-family	[illegible]	[illegible]	110,871	672.11	[illegible]	2,407.77	[illegible]	[illegible]	377.32	377.32	3,377
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	[illegible]	28	[illegible]	0.86	0.26	4.00	2.40	0.14	0.45	1.30	44
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	[illegible]	[illegible]	57.13	[illegible]	287.75	[illegible]	6.85	[illegible]	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	13,714	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81.46	[illegible]	[illegible]	[illegible]
KENTR2 (?)	Single-family	[illegible]	2,577	[illegible]	[illegible]	41.32	777.83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Multi-family	[illegible]	1,739	[illegible]	71.86	[illegible]	371.18	113.91	[illegible]	[illegible]	[illegible]	[illegible]
	Commercial	36,157	[illegible]	[illegible]	[illegible]	16.19	[illegible]	107.91	6.47	[illegible]	[illegible]	[illegible]
	Public	[illegible]	[illegible]	[illegible]	7.30	[illegible]	[illegible]	[illegible]	1.22	3.02	31.79	374
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	22	570	2.12	0.84	16.79	2.00	0.33	0.84	2.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	94,914	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	861.40	[illegible]	[illegible]	[illegible]	[illegible]
KENTR3 (?)	Single-family	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Multi-family	2,977	[illegible]	2,444	11.77	2.47	[illegible]	[illegible]	1.30	[illegible]	7.21	418
	Commercial	2,518	[illegible]	1,299	6.82	2.52	37.86	16.79	1.01	3.13	9.71	[illegible]
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	[illegible]	[illegible]	2,348	[illegible]	4.20	[illegible]	43.47	1.63	4.20	22.19	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	367,316	9,136	77,334	463.13	[illegible]	2,331.33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	119,995	6,911	57,956	349.07	182.67	1,361.59	789.34	39.81	143.73	143.73	
	Multi-family	366,177	11,570	182,578	490.45	182.22	1,590.28	791.37	78.14	262.20	280.73	1,222
	Commercial	185,396	8,197	82,646	251.78	185.40	1,371.86	782.64	42.16	231.74	406.36	17,410
	Public	8,773	713	4,546	21.91	8.17	201.82	61.15	3.67	11.67	28.57	12,152
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,121
	Other Urban	2,838	230	1,819	3.67	1.22	22.57	22.99	1.40	6.16	2.22	0
	Open	47,802	382	8,113	48.28	13.43	266.54	230.80	5.38	13.43	42.21	389
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	448,790	28,144	228,347	1,171.86	313.36	4,340.30	2,467.87	170.43	664.73	853.70	32,853
LA[illegible]	Single-family	92,732	4,264	35,112	213.18	82.70	1,078.44	463.98	28.83	87.70	87.70	
	Multi-family	11,121	794	4,804	32.83	6.86	237.10	32.96	5.30	23.30	28.12	783
	Commercial	4,406	200	2,346	38.74	4.36	40.36	39.98	1.00	5.62	77.34	1,346
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200
	Light Industrial	8,316	486	2,400	22.46	8.22	87.85	84.77	3.00	6.52	28.11	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	677
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	93,543	5,813	44,112	260.21	73.30	1,313.43	581.44	33.01	123.22	143.33	2,105
SMB 139	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,813	26	1,700	9.33	2.12	20.36	20.00	0.59	2.12	7.01	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,813	26	1,700	9.33	2.12	20.36	20.00	0.59	2.12	7.01	0
SMB 140	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,917	36	759	4.16	1.12	22.34	11.59	0.44	1.12	3.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,917	36	759	4.16	1.12	22.34	11.39	0.44	1.12	3.52	0
SMB 141	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	38,282	42	1,993	38.91	2.94	38.75	30.43	1.15	2.04	0.23	0
	Unknown	470	30	260	1.24	0.26	4.80	2.00	0.20	0.81	0.76	44
	Catchment Total	38,701	72	2,253	12.15	3.20	63.55	32.42	1.35	2.82	0.99	44
SMB 143	Single-family	960	51	420	2.55	0.75	12.39	2.83	0.38	1.85	1.85	0
	Multi-family	20,773	1,484	12,800	61.35	12.86	237.41	98.92	0.59	40.53	37.59	2,376
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	240	21	180	0.26	0.26	4.80	2.40	0.14	0.43	1.50	44
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	22,003	1,563	13,430	64.74	13.87	254.30	106.06	10.32	43.82	40.83	2,520
[illegible]	Single-family	279,914	16,409	135,132	628.44	241.31	4,238.48	1,785.87	91.70	237.83	237.83	2,996
	Multi-family	104,877	7,434	64,428	307.37	64.43	1,319.45	485.40	48.86	218.87	288.33	10,900
	Commercial	28,977	2,224	14,399	68.32	28.60	317.75	190.43	11.44	28.75	118.36	3,400
	Public	17,806	1,385	8,903	42.34	17.81	197.84	118.70	7.12	23.36	68.65	2,776
	Light Industrial	22,990	979	6,395	38.08	12.99	239.89	83.83	3.84	15.14	48.34	1,530
	Other Urban	7,554	540	4,676	23.35	4.46	86.33	28.97	3.00	15.83	13.67	701
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	460,539	28,971	233,720	1,250.95	369.40	6,881.73	2,710.33	165.43	543.46	767.30	21,801

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
B11022	Single-family	849	51	420	2.35	0.75	22.09	2.25	0.28	1.05	1.05	0
	Multi-family	46,163	2,397	28,577	226.20	28.34	277.31	219.82	21.94	96.72	83.33	4,626
	Commercial	1,299	88	679	2.01	1.36	13.99	0.30	0.50	1.57	0.63	104
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	2,970	204	1,639	6.57	2.86	31.57	28.18	3.25	2.80	11.30	302
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	51,160	2,670	31,063	244.73	33.46	344.43	251.55	25.97	102.04	96.33	5,031
B11023	Single-family	22,828	2,199	28,800	222.43	48.71	784.37	228.38	77.57	64.80	64.80	849
	Multi-family	169,125	12,010	184,696	499.32	184.70	1,732.85	885.34	88.34	184.36	288.80	77,718
	Commercial	34,712	2,790	17,336	82.92	24.71	303.69	231.41	22.88	43.39	193.83	4,343
	Public	25,310	1,858	12,960	60.13	25.16	278.78	187.87	18.07	31.47	97.88	3,976
	Light Industrial	1,639	112	719	3.44	1.44	13.99	0.59	0.58	1.80	8.35	776
	Other Urban	9,862	784	6,168	28.12	6.11	112.71	46.86	4.70	28.46	97.85	1,833
	Open	2,444	30	473	2.40	0.70	13.99	7.34	0.57	0.70	2.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	265,773	20,473	247,341	832.97	311.53	3,237.38	1,606.71	120.41	314.34	[illegible]	20,796
B2773	Single-family	226,779	19,127	157,514	994.20	281.27	4,427.95	2,801.43	186.81	392.71	393.70	3,378
	Multi-family	111,421	7,959	68,573	222.96	68.97	1,572.38	530.11	30.86	333.43	201.42	11,873
	Commercial	37,770	2,934	18,815	90.25	37.77	419.46	251.80	15.11	47.21	140.43	4,616
	Public	37,518	2,140	13,730	63.76	37.52	205.76	183.43	11.81	34.40	185.10	3,362
	Light Industrial	42,444	3,301	21,220	101.40	42.45	471.43	282.97	36.98	33.86	163.43	8,188
	Other Urban	60,851	4,347	37,579	179.46	37.47	600.44	289.77	28.98	127.30	110.11	6,573
	Open	36,647	60	3,327	77.57	4.76	85.13	40.26	1.57	4.76	14.85	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	622,931	39,879	321,233	1,729.96	500.41	7,791.92	3,460.26	323.84	974.16	1,218.44	38,340
B2801	Single-family	22,738	2,892	25,480	154.58	40.46	781.57	284.43	17.38	63.63	68.68	366
	Multi-family	3,547	253	2,308	16.53	3.21	40.77	36.90	1.70	7.47	6.43	394
	Commercial	8,812	485	4,406	21.85	8.81	97.53	34.75	2.57	11.02	18.58	1,577
	Public	3,957	308	1,978	9.45	2.06	43.06	26.36	1.54	4.86	14.26	484
	Light Industrial	25,827	1,201	7,914	37.81	15.83	173.86	188.52	0.53	10.76	34.02	1,804
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	300	1.84	0.28	3.80	2.30	0.11	0.28	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	65,831	5,575	42,136	234.46	70.53	1,140.60	546.06	20.33	107.15	141.24	4,614
B2808	Single-family	7,824	480	3,777	22.95	6.74	116.01	48.91	2.56	0.44	0.44	81
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,824	480	3,777	22.95	6.74	116.01	48.91	2.56	0.44	0.44	81
B8411	Single-family	90,957	2,334	43,825	266.49	78.44	1,298.12	800.44	20.81	100.21	100.21	961
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	21,883	86	4,982	22.34	6.02	220.30	62.30	2.36	4.02	18.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	112,840	2,420	48,807	289.03	84.43	1,460.42	862.74	23.17	113.83	120.72	961
B04241	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	2,777	304	1,898	9.82	2.78	41.97	25.18	1.51	4.72	14.56	402
	Other Urban	28,229	1,874	16,237	77.44	16.24	299.76	224.90	22.49	34.56	67.46	2,760
	Open	1,469	6	283	1.36	0.42	8.39	4.35	0.16	0.42	1.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	31,475	2,173	18,418	84.62	20.43	350.12	254.43	34.17	60.18	83.34	3,160

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
B1042	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	2,305	365	1,420	6.41	1.43	26.38	30.59	1.30	4.84	4.18	342
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	22,230	881	6,135	28.22	12.23	223.79	81.53	4.89	15.30	47.33	1,498
	Other Urban	22,643	2,619	34,820	66.91	14.85	253.90	107.91	18.70	47.48	41.01	2,374
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
					0.00	0.50	0.00	0.00	0.00	0.00	0.00	
	Catchment Total	37,200	2,735	21,573	162.94	27.60	421.26	200.44	26.78	67.61	43.34	4,111
B1043	Single-family	18,142	598	4,906	28.73	8.74	150.38	64.70	2.22	12.34	12.34	388
	Multi-family	23,721	1,700	14,801	78.42	34.81	273.34	323.01	11.30	30.12	42.30	2,606
	Commercial	1,799	140	899	4.30	1.80	39.06	11.09	0.72	2.25	6.93	330
	Public	27,224	2,126	23,449	63.31	27.34	203.76	102.35	18.84	34.77	100.40	2,341
	Light Industrial	7,734	602	2,447	18.48	7.73	85.93	81.56	2.09	9.67	20.22	643
	Other Urban	22,343	2,409	13,740	64.67	33.77	284.20	188.52	18.59	46.00	48.35	2,320
	Open	2,441	30	475	3.40	0.70	13.99	7.34	0.57	0.70	2.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	98,423	8,770	62,343	256.09	94.89	1,301.62	837.57	60.33	153.73	240.13	9,647
B1435	Single-family	28,439	2,343	22,570	78.14	22.98	295.28	178.06	8.73	32.17	32.17	376
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	8,316	486	2,001	13.46	8.22	57.95	34.77	2.09	6.52	20.11	657
	Public	240	38	180	0.86	0.36	4.80	2.40	0.14	0.45	1.39	44
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	22,022	1,974	23,439	68.06	13.64	211.90	104.72	10.49	46.16	30.57	2,308
	Open	3,427	54	664	2.64	0.98	19.31	10.14	0.36	0.58	3.06	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	57,604	3,364	39,361	160.14	43.18	588.62	332.29	21.84	86.29	86.62	3,383
B1483	Single-family	218,425	22,508	205,476	640.39	183.35	3,529.81	1,373.78	71.57	253.09	253.09	2,380
	Multi-family	17,306	1,229	30,631	30.10	30.43	706.64	81.93	8.19	26.05	31.14	1,808
	Commercial	21,843	1,437	30,522	30.27	21.04	233.81	140.29	8.42	26.30	81.13	2,572
	Public	28,432	2,736	27,316	84.64	25.43	393.44	206.21	14.17	64.79	136.61	4,331
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	282,166	28,429	294,364	826.10	253.48	4,863.73	1,832.22	102.36	370.33	512.57	10,565
B1487	Single-family	123,441	7,326	59,592	361.81	106.41	1,830.33	787.47	48.44	148.98	148.98	1,377
	Multi-family	4,197	300	2,598	12.39	2.60	47.96	19.98	2.00	8.79	7.89	400
	Commercial	23,921	1,041	11,960	57.14	23.92	265.79	159.47	0.57	29.90	92.23	2,024
	Public	3,079	84	840	2.58	1.00	11.09	7.39	0.43	1.35	4.36	122
	Light Industrial	6,115	476	2,050	14.61	6.12	67.35	40.77	2.45	7.64	23.58	787
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	156,753	9,056	77,340	448.53	140.13	2,224.02	1,014.89	54.84	196.67	276.34	3,330
B14811	Single-family	104,458	6,710	55,256	225.40	98.67	1,697.14	720.17	37.49	120.14	120.14	1,784
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	180	84	90	0.43	0.18	2.80	1.20	0.87	0.22	0.00	22
	Public	21,511	885	5,755	37.50	11.51	127.90	76.74	4.80	34.39	44.38	1,607
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	126,149	7,619	61,101	263.41	110.36	1,827.84	808.10	43.17	152.75	163.21	3,413
B14822	Single-family	55,346	3,344	26,719	162.22	47.71	520.44	353.07	18.13	66.80	66.80	373
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	7,554	300	3,777	16.85	7.45	83.83	50.36	3.02	9.44	20.12	920
	Public	719	36	380	1.72	0.72	7.59	4.80	0.29	0.80	2.77	80
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	63,619	3,844	30,855	181.05	55.59	612.57	408.22	21.44	77.34	88.60	1,384

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
[illegible]	Single-family	429,376	26,594	303,537	1,844.72	543.57	8,222.13	4,814.99	206.17	759.39	759.39	6,511
	Multi-family	35,439	1,844	13,977	76.30	25.98	294.96	122.90	12.29	54.88	46.70	2,706
	Commercial	14,544	1,133	7,294	34.80	14.57	161.37	97.13	5.83	18.21	34.77	1,781
	Public	26,520	1,570	12,410	95.39	34.82	573.75	163.47	9.93	31.83	95.70	2,034
	Light Industrial	44,964	2,977	23,442	107.41	44.96	499.40	209.76	17.99	84.31	773.36	2,406
	Other Urban	22,779	849	7,574	35.85	7.53	150.89	57.25	5.80	25.50	32.83	1,575
	Open	7,344	30	1,624	7.79	2.10	41.97	21.73	0.82	2.30	6.59	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	756,033	40,190	376,944	2,366.16	653.33	10,343.40	4,773.32	254.83	946.71	1,340.14	20,799
[illegible]	Single-family	92,736	6,436	46,764	371.76	90.94	1,574.90	691.53	30.38	111.91	111.91	690
	Multi-family	11,341	824	7,344	34.07	7.34	131.59	54.96	2.30	24.11	28.83	1,309
	Commercial	14,384	1,119	7,704	34.57	14.39	150.37	98.82	2.76	17.99	28.46	1,739
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	118,633	7,379	60,103	540.23	101.47	1,856.67	843.41	41.43	154.88	168.27	3,937
[illegible]	Single-family	22,329	781	6,428	30.87	11.49	107.64	65.80	4.37	16.09	16.09	130
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	71,483	282	13,859	73.86	20.42	488.47	211.53	0.82	20.42	64.19	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	94,112	1,073	20,294	104.93	31.91	696.11	296.34	12.39	36.51	80.26	130
[illegible]	Single-family	242,826	14,333	117,226	711.75	209.35	3,600.52	1,349.86	70.55	292.07	292.07	2,312
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	380	14	90	0.43	0.10	2.00	1.30	0.07	0.22	0.80	22
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	70,379	312	14,800	81.06	21.83	404.45	226.82	1.57	21.82	68.39	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	313,344	14,560	132,124	793.21	231.33	4,034.97	1,576.28	86.19	315.11	363.34	2,334
[illegible]	Single-family	512,395	30,309	250,360	1,519.43	446.59	7,464.53	2,307.80	160.82	623.63	623.63	3,303
	Multi-family	149,520	10,701	92,746	442.33	92.75	1,712.33	713.43	71.34	313.91	571.30	15,885
	Commercial	64,748	3,804	32,574	154.88	64.75	719.42	431.65	25.90	80.94	249.64	7,914
	Public	20,324	1,581	30,162	48.55	20.32	223.82	125.49	8.13	25.40	70.36	2,484
	Light Industrial	20,348	3,092	28,574	94.95	20.75	461.83	264.99	18.90	40.89	153.25	4,832
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	46,513	190	9,818	40.36	13.39	283.79	137.64	2.32	13.39	41.77	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	830,548	50,981	414,433	2,300.30	657.23	11,085.43	4,090.20	286.31	1,100.57	1,610.77	34,314
[illegible]	Single-family	48,343	2,378	39,584	118.90	34.97	681.52	284.79	12.39	48.86	48.86	420
	Multi-family	16,367	1,169	10,132	48.32	10.13	187.05	77.94	7.79	34.30	39.42	1,735
	Commercial	100	14	80	0.43	0.11	2.00	1.20	0.07	0.22	0.80	22
	Public	17,884	1,390	8,983	42.97	17.90	200.84	119.30	7.10	22.46	69.34	2,190
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	1,600	105	900	4.34	0.91	16.79	6.99	0.70	3.08	2.66	154
	Open	20,544	84	3,987	21.32	5.83	117.51	60.85	2.31	5.83	18.47	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	97,133	3,149	43,485	236.78	70.05	1,134.70	325.64	31.26	114.01	180.74	4,468
[illegible]	Single-family	28,539	2,259	28,885	132.96	33.32	571.64	245.85	12.62	46.51	46.51	299
	Multi-family	24,598	1,864	8,223	43.98	9.22	170.26	70.94	7.09	31.22	35.86	1,661
	Commercial	1,799	140	800	4.30	1.80	19.96	11.99	0.72	2.25	6.93	220
	Public	1,619	126	800	3.87	1.62	17.99	10.79	0.65	2.02	6.24	198
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	56,554	3,549	38,326	185.11	45.94	779.64	339.34	21.09	82.00	84.63	2,377

TABLE A-3

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	[illegible]	3,573	45,303	275.58	81.55	1,409.37	684.31	31.14	114.71	114.71	933
	Multi-family	28,327	2,023	17,136	83.63	17.34	323.14	134.59	13.49	89.35	81.36	2,044
	Commercial	7,014	646	3,367	16.76	7.01	77.84	46.76	3.31	8.77	37.84	857
	Public	1,579	84	840	2.38	1.88	31.09	7.19	0.43	1.35	4.36	132
	Light Industrial	890	70	450	2.15	0.90	0.59	6.80	0.34	1.13	2.47	110
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	132,364	4,294	67,916	363.60	108.46	1,832.80	801.16	48.33	343.30	300.64	3,660
[illegible]	Single-family	48,571	2,571	28,441	143.34	42.33	726.12	302.40	26.04	88.10	88.10	897
	Multi-family	2,318	100	1,159	3.43	1.36	28.71	31.09	1.30	2.28	4.84	264
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	2,806	188	2,310	12.80	3.84	28.86	20.57	2.01	4.30	20.43	636
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	480	3	95	0.33	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	57,814	3,444	27,313	163.32	48.75	813.63	359.41	39.31	70.81	83.32	1,366
[illegible]	Single-family	90,118	3,383	43,305	284.14	77.49	1,326.35	574.89	29.52	108.76	108.76	932
	Multi-family	20,167	2,063	10,056	84.11	18.06	373.33	138.59	13.59	61.11	22.76	2,066
	Commercial	14,344	1,133	7,284	34.80	14.57	161.57	97.13	3.83	18.21	36.17	1,781
	Public	18,791	839	3,396	25.76	10.79	119.90	71.94	4.32	13.49	41.61	1,319
	Light Industrial	2,138	168	1,079	2.16	2.16	25.90	14.59	0.84	2.70	8.32	264
	Other Urban	420	20	260	1.26	0.26	4.50	2.80	0.20	0.05	0.76	44
	Open	979	4	190	1.04	0.28	3.40	2.90	0.11	0.28	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	146,201	9,340	73,560	418.37	123.80	1,983.71	902.13	54.73	205.43	240.28	7,300
[illegible]	Single-family	90,016	3,453	44,504	272.83	80.19	1,379.30	593.37	30.47	112.36	112.36	932
	Multi-family	91,904	6,365	34,194	371.34	36.59	1,050.36	437.65	43.76	192.57	164.31	9,420
	Commercial	24,101	1,774	13,050	57.57	24.10	287.79	180.67	9.44	28.13	92.92	2,046
	Public	1,439	112	719	2.44	1.44	13.99	9.30	0.54	1.80	3.33	776
	Light Industrial	20,415	1,809	20,340	40.41	20.48	329.83	137.89	3.57	28.83	79.73	2,528
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,443	30	475	2.40	0.70	13.99	7.34	0.37	0.70	2.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	233,313	13,622	125,343	636.99	164.00	2,957.13	1,344.42	93.00	363.30	454.96	14,340
[illegible]	Single-family	1,139	60	580	3.40	1.00	17.19	7.50	0.38	1.40	1.40	12
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	201,259	15,651	100,630	480.79	201.26	2,224.21	1,341.73	80.50	251.57	778.96	24,098
	Public	3,237	202	1,619	7.75	3.24	25.97	21.58	1.29	4.05	12.48	396
	Light Industrial	149,250	11,611	74,640	284.61	149.25	1,454.67	985.20	59.71	184.80	573.36	18,305
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	62,740	4,631	39,379	115.23	30.94	777.07	291.76	29.88	121.45	113.51	6,372
	Catchment Total	417,674	32,063	216,257	1,033.76	383.61	4,463.06	2,444.67	171.77	573.87	1,478.80	49,336
[illegible]	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	11,370	920	8,925	28.36	11.57	131.89	79.14	4.75	14.24	48.57	1,451
	Public	26,971	2,790	17,066	85.93	26.97	299.61	209.31	14.30	44.06	128.09	4,396
	Light Industrial	121,943	9,464	60,971	291.31	121.94	1,284.92	812.95	48.70	152.43	476.16	14,884
	Other Urban	200	15	100	0.42	0.13	3.40	1.80	0.16	0.44	0.28	22
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	160,504	13,220	85,022	406.21	160.91	1,844.89	1,132.89	68.01	212.67	684.09	20,773
[illegible]	Single-family	233,533	22,091	312,750	694.35	201.34	3,463.88	1,498.01	76.51	281.57	281.57	2,416
	Multi-family	351,671	25,120	237,706	1,838.39	377.71	4,819.18	1,574.66	167.47	736.85	684.57	26,843
	Commercial	237,949	18,507	118,975	544.43	237.95	2,643.88	1,586.30	95.18	297.44	917.43	28,803
	Public	183,857	8,864	51,976	343.36	103.96	1,155.08	693.05	41.58	129.95	400.31	12,766
	Light Industrial	84,352	6,541	42,176	201.51	84.35	857.25	562.35	33.74	105.44	325.20	10,310
	Other Urban	40,281	2,578	24,940	118.94	24.94	400.43	391.85	70.18	84.41	72.80	4,521
	Open	7,344	20	1,424	7.79	2.10	41.97	21.73	0.82	2.10	6.90	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,859,132	74,573	869,949	3,367.86	872.34	12,736.82	6,319.57	434.49	1,634.86	2,641.21	85,577

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	362,346	34,201	116,946	716.00	288.82	2,591.82	1,345.36	99.36	282.57	282.57	2,506
	Multi-family	82,570	3,413	31,305	149.30	31.30	577.94	240.31	34.08	103.96	91.31	5,298
	Commercial	35,432	2,756	77,716	84.44	35.43	293.44	224.21	14.17	44.39	136.41	4,331
	Public	3,735	462	2,944	34.15	8.94	65.85	99.57	2.57	7.42	22.88	725
	Light Industrial	23,309	1,825	6,435	31.79	23.31	147.88	88.73	8.32	34.64	81.31	1,627
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	347,412	22,063	225,349	861.35	394.41	4,771.36	2,150.44	135.31	464.67	594.44	14,486
[illegible]	Single-family	36,221	2,325	77,486	386.77	31.20	377.87	201.87	11.87	43.72	43.72	375
	Multi-family	144,794	10,342	89,428	427.46	89.43	1,454.48	689.43	48.94	223.36	261.59	15,146
	Commercial	26,439	2,094	22,219	62.36	20.44	273.76	174.36	18.51	22.85	101.84	3,331
	Public	33,827	1,331	7,914	57.31	13.53	175.86	185.52	4.23	98.79	61.82	1,594
	Light Industrial	2,518	186	1,259	6.82	2.52	27.36	14.79	1.01	3.15	9.71	208
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	180	1.84	0.38	3.40	2.90	0.11	0.38	0.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	226,764	13,853	139,496	641.43	163.52	2,494.94	1,321.87	80.43	403.33	479.33	21,816
[illegible]	Single-family	188,433	22,330	180,719	611.51	179.84	2,091.82	1,330.95	48.33	301.80	301.80	2,158
	Multi-family	48,324	3,237	28,854	133.01	28.86	517.99	215.81	21.34	94.06	82.01	4,348
	Commercial	1,799	140	899	4.30	1.80	19.88	11.59	0.72	2.25	6.93	230
	Public	2,336	182	1,160	3.90	2.34	25.88	23.14	0.84	2.92	9.01	284
	Light Industrial	3,316	406	2,608	12.46	3.33	67.86	34.77	2.90	6.52	28.11	437
	Other Urban	1,679	120	1,070	4.06	1.84	10.18	7.90	0.40	2.52	2.84	776
	Open	4,406	18	884	4.40	1.36	28.18	13.84	0.49	1.36	2.06	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	280,304	16,333	113,347	777.30	210.36	2,750.79	1,630.14	84.96	363.33	376.87	8,328
[illegible]	Single-family	96,493	3,464	46,583	282.82	82.10	1,430.78	615.34	31.61	116.46	116.46	898
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	28,253	144	4,828	37.41	10.07	201.44	104.32	2.86	10.07	31.06	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	131,745	3,800	33,417	320.23	93.26	1,632.19	719.87	28.57	226.53	148.11	898
[illegible]	Single-family	96,493	3,464	46,583	282.82	82.10	1,430.78	615.34	31.61	116.46	116.46	898
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,427	14	684	3.04	0.96	19.58	10.14	0.38	0.98	3.01	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	99,920	3,470	47,267	286.46	84.16	1,450.36	625.70	31.99	117.44	119.53	898
[illegible]	Single-family	112,430	6,591	34,577	228.34	98.92	1,467.87	777.23	26.83	128.09	128.09	1,343
	Multi-family	22,170	689	7,534	28.93	7.33	159.80	87.83	3.80	28.30	22.82	1,373
	Commercial	23,108	1,775	7,534	34.59	23.11	167.87	102.72	6.84	28.88	28.23	1,847
	Public	77,266	1,343	8,433	41.25	17.37	391.25	315.11	6.91	21.98	66.57	2,130
	Light Industrial	40,647	2,361	28,324	97.10	40.43	481.44	278.90	24.26	28.81	186.72	4,944
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	180	1.84	0.38	3.40	2.90	0.11	0.38	0.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	298,401	13,343	98,311	540.15	177.36	2,423.10	1,364.89	71.84	253.75	440.33	11,343
[illegible]	Single-family	225,298	12,421	183,937	631.84	185.40	2,192.34	1,573.45	78.53	299.34	299.34	2,237
	Multi-family	94,315	6,730	34,523	271.36	28.32	1,576.74	442.34	44.86	187.40	170.48	9,578
	Commercial	28,417	2,210	14,209	67.39	28.42	313.75	189.45	11.37	35.82	109.36	3,473
	Public	10,432	811	2,216	24.92	10.43	115.91	60.34	4.77	13.04	40.22	1,378
	Light Industrial	3,227	252	1,619	7.73	3.24	35.97	21.34	1.29	4.05	12.48	396
	Other Urban	8,603	615	5,526	25.40	3.30	91.32	40.97	4.30	10.03	15.57	901
	Open	2,854	8	280	2.88	0.36	11.19	3.80	0.22	0.34	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	362,160	23,246	201,809	1,037.22	281.90	4,844.22	2,349.43	136.34	326.44	609.52	18,142

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	580	24	580	1.70	0.30	0.59	1.70	0.19	0.70	0.70	0
	Multi-family	17,416	1,344	10,731	51.42	10.71	199.84	82.93	0.30	26.49	31.51	1,025
	Commercial	24,528	1,161	7,464	25.46	14.93	243.57	99.32	2.57	18.66	37.36	1,025
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	17,306	1,383	8,903	42.54	17.81	197.84	115.70	7.13	22.26	40.65	2,176
	Other Urban	1,622	125	1,309	2.58	1.17	21.54	8.59	0.80	3.06	3.42	200
	Open	17,426	72	3,417	18.71	2.64	180.72	82.16	1.06	2.64	15.03	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	70,344	4,631	32,614	153.40	50.32	693.64	394.01	14.43	57.10	177.67	4,429
[illegible]	Single-family	93,215	8,304	43,324	372.18	80.84	1,392.80	594.52	30.76	113.31	113.31	971
	Multi-family	91,201	7,014	60,791	279.93	60.79	1,122.30	467.43	46.76	205.76	177.70	10,203
	Commercial	39,348	2,078	19,764	94.52	20.57	409.45	202.79	20.03	40.44	202.84	4,326
	Public	24,101	1,574	13,050	87.57	24.10	257.79	140.67	0.44	20.12	93.92	2,044
	Light Industrial	7,814	616	3,857	18.90	7.91	87.93	52.76	3.17	9.59	20.11	967
	Other Urban	18,492	940	6,498	30.98	6.49	119.90	49.86	2.00	21.08	20.08	1,090
	Open	60,711	246	11,771	64.43	17.25	344.93	179.46	4.51	17.25	84.02	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	334,573	19,843	180,172	831.31	257.13	3,776.34	1,772.36	117.06	467.27	640.50	21,107
[illegible]	Single-family	6,663	391	3,317	19.53	8.75	90.23	43.53	3.18	8.84	8.84	60
	Multi-family	24,330	1,734	15,198	72.46	12.20	290.31	116.91	11.09	51.44	44.42	2,572
	Commercial	11,570	920	5,925	28.36	11.57	131.29	79.14	4.75	14.84	40.77	1,451
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	42,066	3,044	24,311	120.37	32.11	511.30	224.34	14.42	54.32	90.24	4,082
[illegible]	Single-family	113,299	6,642	84,086	322.08	97.47	1,679.16	722.77	37.12	126.74	126.74	1,172
	Multi-family	313,917	15,423	133,643	657.47	122.64	2,467.42	1,028.18	102.02	452.40	399.71	22,420
	Commercial	24,440	1,902	12,230	54.43	24.46	271.78	163.87	9.78	30.34	94.31	2,590
	Public	16,807	1,343	8,804	38.24	16.81	177.84	106.71	6.40	20.01	61.72	1,806
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,367	203	2,301	10.53	2.21	40.77	16.99	1.70	7.47	6.45	204
	Open	1,058	0	200	2.08	0.34	11.19	3.00	0.22	0.34	1.36	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	375,210	25,473	211,181	1,075.34	274.37	4,648.18	2,041.31	156.04	647.36	681.60	20,112
[illegible]	Single-family	26,511	2,140	17,426	107.01	31.47	841.37	232.91	11.96	44.86	44.86	370
	Multi-family	65,321	6,130	33,127	253.38	23.13	980.11	420.67	42.77	170.02	233.30	2,991
	Commercial	19,424	1,511	9,712	46.40	19.42	215.23	129.30	7.77	24.28	74.89	2,574
	Public	5,036	392	2,518	12.03	5.04	55.96	23.57	2.01	6.30	19.42	636
	Light Industrial	20,036	2,336	15,018	71.75	20.04	222.73	180.34	22.01	37.34	155.81	2,671
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	8,813	26	1,700	9.35	2.52	50.36	26.08	0.99	2.52	7.01	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	145,641	12,543	80,710	499.93	141.63	2,175.86	1,030.97	75.42	294.32	412.30	16,020
[illegible]	Single-family	179,636	10,532	86,731	526.58	154.80	2,663.57	1,346.88	58.85	204.83	204.83	1,859
	Multi-family	324,810	23,184	200,949	954.57	200.95	2,700.83	1,543.76	154.38	680.14	587.30	34,007
	Commercial	125,399	9,792	62,950	300.76	125.90	1,398.88	839.23	50.36	157.57	485.41	18,308
	Public	5,036	392	2,518	12.03	5.04	55.96	23.57	2.01	6.30	19.42	636
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	43,086	176	8,353	45.72	12.31	244.20	127.30	4.84	12.31	38.08	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	678,257	44,076	361,501	1,843.46	499.07	6,074.74	3,882.24	270.44	1,072.94	1,347.33	31,800
[illegible]	Single-family	180,128	8,918	72,447	446.80	131.15	2,253.60	970.47	40.24	183.40	183.40	1,576
	Multi-family	800,659	25,761	209,932	1,476.14	309.93	3,721.82	2,304.80	238.41	1,049.80	908.86	52,420
	Commercial	345,863	19,123	122,972	587.34	345.86	3,731.81	1,639.80	98.35	307.33	947.84	30,880
	Public	9,712	735	4,856	23.20	9.71	107.91	64.75	3.88	12.14	37.45	1,357
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	8,813	26	1,700	9.35	2.52	50.36	26.08	0.99	2.52	7.01	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	917,176	64,593	512,840	2,543.52	699.17	10,867.40	5,004.46	391.46	1,554.39	2,083.86	83,261

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1 [illegible]

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

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		POLLUTANT LOADINGS (POUNDS PER YEAR)										
CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
B3576	Single-family	771,832	38,873	82,954	803.63	368.13	2,547.86	1,896.77	86.29	207.38	207.38	1,778
	Multi-family	31,363	2,323	18,333	92.31	19.35	257.31	148.81	14.89	63.51	34.57	2,375
	Commercial	19,063	1,423	9,532	45.34	10.06	221.83	127.10	7.43	22.83	73.51	2,320
	Public	18,252	997	2,136	34.49	10.35	113.01	68.35	4.10	22.11	20.53	1,251
	Light Industrial	890	70	450	2.15	0.50	0.59	4.80	0.36	2.22	2.47	110
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	222,313	34,434	117,416	664.14	187.70	3,346.91	1,666.40	113.36	310.46	300.46	8,346
B3577	Single-family	188,349	11,841	98,927	832.06	162.57	2,792.76	1,301.84	61.70	207.32	207.32	1,848
	Multi-family	76,799	5,486	47,342	226.74	47.84	877.70	263.71	26.57	180.91	130.97	8,846
	Commercial	71,322	5,340	35,411	376.14	71.32	701.37	434.83	28.49	89.83	274.80	8,786
	Public	10,873	703	5,806	34.06	10.87	111.01	67.15	4.80	12.59	20.53	1,201
	Light Industrial	7,734	680	3,867	18.48	7.73	85.73	81.84	3.80	9.67	30.82	945
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	78,474	300	38,510	301.32	37.38	843.34	382.53	38.72	37.38	83.72	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,649,430	23,841	201,494	1,892.80	336.22	4,505.23	2,443.39	144.60	536.79	785.37	20,175
B3578	Single-family	130,683	7,461	63,899	393.04	113.46	1,577.78	822.46	42.81	197.72	197.73	1,382
	Multi-family	180,028	7,339	63,779	304.11	63.78	1,177.46	490.61	49.86	215.37	106.43	10,795
	Commercial	51,259	3,987	28,629	122.45	51.26	809.34	341.73	20.50	64.87	197.43	6,366
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	33,833	2,616	16,517	80.35	33.83	373.70	234.32	13.45	42.04	120.87	4,111
	Other Urban	20,216	2,134	11,768	89.21	18.71	343.32	143.88	14.39	63.51	34.80	2,368
	Open	84,494	386	38,320	180.38	37.80	339.97	379.43	10.61	37.80	84.85	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	443,313	24,167	206,340	1,079.31	387.43	4,843.74	2,311.75	150.82	570.01	610.89	25,666
B3579	Single-family	317,396	18,800	181,177	930.01	273.53	4,704.73	2,024.13	108.94	282.94	282.94	2,382
	Multi-family	61,371	4,376	37,930	180.90	37.93	700.34	291.77	29.18	128.38	110.37	6,419
	Commercial	86,453	4,546	29,227	139.64	34.43	679.40	309.80	22.38	73.87	223.37	7,344
	Public	2,396	420	2,606	12.99	3.40	30.55	25.97	2.14	6.74	20.80	699
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	11,731	48	2,378	12.47	2.36	67.15	34.77	1.22	2.36	10.83	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	454,166	27,991	223,310	1,275.90	371.67	6,181.33	2,376.82	130.98	504.49	730.34	17,305
B3641A	Single-family	30,426	1,784	14,688	80.18	26.23	481.14	194.89	9.97	26.72	26.72	313
	Multi-family	71,533	3,111	44,285	211.35	44.29	817.75	340.73	34.07	149.92	120.40	7,496
	Commercial	9,712	735	4,856	23.30	9.71	107.91	64.73	3.88	12.14	37.43	1,307
	Public	180	14	90	0.43	0.18	2.00	1.20	0.07	0.22	0.69	22
	Light Industrial	2,378	234	1,459	6.97	2.38	31.97	10.18	1.15	3.40	11.30	282
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	114,348	7,844	65,368	320.94	83.30	1,410.77	610.85	48.13	202.40	213.43	9,371
B3640C	Single-family	17,704	1,333	8,512	37.75	16.59	182.77	138.70	6.45	23.70	23.70	384
	Multi-family	1,849	75	649	2.10	0.65	11.50	2.80	0.30	2.38	1.90	110
	Commercial	6,373	643	4,337	10.76	2.37	91.83	23.16	3.31	10.34	31.80	1,011
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	23,849	1,877	6,924	23.88	12.85	163.82	92.33	3.84	17.31	53.40	1,880
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	42,874	2,861	21,222	113.70	30.76	349.86	271.18	15.80	53.43	110.87	2,818
B3677	Single-family	58,120	2,970	24,201	146.90	42.22	743.30	319.70	16.42	68.30	68.30	319
	Multi-family	11,341	826	7,344	34.87	7.34	131.89	54.86	5.80	34.18	28.84	1,380
	Commercial	2,396	420	2,606	12.99	2.40	39.86	25.97	2.16	6.74	20.80	699
	Public	180	14	90	0.43	0.18	2.00	1.20	0.07	0.22	0.69	22
	Light Industrial	7,554	388	3,777	18.88	7.55	83.93	88.36	3.82	9.44	30.12	680
	Other Urban	22,734	2,325	20,364	96.64	28.36	374.10	133.33	15.99	68.99	90.33	3,420
	Open	23,301	96	4,336	24.94	4.71	134.39	68.34	2.44	4.71	21.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	131,823	7,218	62,720	323.85	90.47	1,530.46	687.70	46.30	174.30	213.34	6,562

TABLE A-3

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	57,884	2,346	27,138	367.22	49.21	844.42	264.16	18.70	48.89	48.89	281
	Multi-family	6,785	450	2,877	21.59	3.50	71.84	29.98	3.00	13.10	11.50	659
	Commercial	20,573	2,406	15,448	73.90	28.84	263.72	206.23	22.57	28.67	119.37	2,781
	Public	7,814	546	2,367	28.76	7.81	77.84	46.76	2.11	8.77	27.84	857
	Light Industrial	22,050	857	6,025	28.79	12.88	223.89	68.34	4.82	15.86	46.46	1,673
	Other Urban	1,409	188	959	4.34	0.91	14.79	6.59	0.70	2.88	2.66	284
	Open	2,444	20	475	2.80	0.70	13.59	7.34	0.57	0.70	2.20	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	117,296	7,800	57,130	513.28	104.73	1,504.70	541.31	42.67	144.36	277.82	5,515
[illegible]	Single-family	380,715	22,320	183,313	1,136.01	228.34	5,645.88	2,428.96	124.73	479.37	479.33	2,970
	Multi-family	20,316	2,134	11,705	89.22	11.71	345.32	143.44	14.39	63.31	34.48	3,165
	Commercial	77,578	6,857	38,570	164.04	77.38	863.31	510.18	31.13	97.25	280.36	9,518
	Public	7,914	636	3,857	28.90	7.91	87.93	22.76	2.17	9.59	20.11	957
	Light Industrial	180	14	90	0.40	0.11	3.00	1.20	0.07	0.22	0.60	22
	Other Urban	1,409	75	659	2.10	0.45	11.59	3.00	0.30	2.20	1.80	110
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	487,911	31,340	244,133	1,413.69	433.34	6,951.23	3,130.96	134.01	633.30	847.37	17,722
[illegible]	Single-family	243,405	14,309	117,308	713.40	209.87	3,809.11	1,572.76	79.74	371.76	371.76	2,518
	Multi-family	20,773	1,444	12,340	61.25	12.86	237.41	91.92	0.59	43.53	37.59	2,176
	Commercial	17,436	1,371	8,813	42.11	17.43	180.84	117.31	7.88	22.80	67.36	2,154
	Public	8,094	620	4,047	19.32	8.89	89.93	23.96	2.34	18.12	31.21	959
	Light Industrial	3,513	625	4,406	21.85	8.81	97.82	88.75	3.51	11.82	33.96	1,877
	Other Urban	420	30	260	1.34	0.36	4.30	2.80	0.30	0.81	0.76	44
	Open	979	4	190	1.04	0.38	8.60	2.90	0.11	0.38	0.81	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	300,110	33,472	144,851	851.31	257.76	4,340.60	1,884.79	103.73	281.61	464.13	8,859
[illegible]	Single-family	198,491	11,636	98,523	381.78	171.11	2,943.14	1,264.34	68.82	290.34	290.34	2,883
	Multi-family	2,098	130	1,209	4.20	1.30	23.98	9.99	1.00	4.40	3.00	200
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	21,583	1,879	10,791	81.36	21.36	259.11	143.38	8.43	26.98	83.21	2,428
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	222,172	13,644	107,914	638.34	193.99	3,226.93	1,420.11	74.66	370.83	326.57	4,511
[illegible]	Single-family	18,283	1,570	8,810	83.51	15.74	370.60	116.46	8.88	22.80	22.80	189
	Multi-family	22,590	899	7,784	37.17	7.79	143.38	99.95	6.00	26.30	22.71	1,519
	Commercial	3,397	280	1,780	8.59	3.40	30.77	23.98	1.44	4.50	13.87	440
	Public	7,334	800	3,777	18.86	7.35	83.93	88.36	3.82	9.44	20.12	933
	Light Industrial	8,094	620	4,047	19.32	8.89	89.93	23.96	2.34	18.12	31.21	959
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	38	884	4.48	1.36	28.18	23.84	0.49	1.36	2.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	84,096	3,464	37,083	241.33	44.80	663.38	317.25	20.17	73.73	122.87	3,840
[illegible]	Single-family	15,860	880	7,574	44.16	12.89	282.42	95.12	4.04	18.19	18.19	186
	Multi-family	850	40	350	3.46	0.32	9.59	0.00	0.00	1.76	1.82	88
	Commercial	900	70	480	2.15	0.90	9.59	0.00	0.36	1.12	3.47	110
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,400	6	285	1.36	0.42	8.59	4.35	0.16	0.42	1.88	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	18,373	1,019	8,835	50.35	14.13	251.40	110.46	3.56	21.09	24.40	384
[illegible]	Single-family	17,866	1,053	8,673	32.66	16.49	286.39	114.61	5.59	22.88	22.88	186
	Multi-family	4,406	315	2,728	13.01	2.73	30.36	20.98	2.10	9.20	7.97	482
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	22,372	1,364	11,401	45.67	18.22	316.73	135.59	7.86	30.92	30.44	667

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
BLLNA1	Single-family	[illegible]	1,887	[illegible]	34.36	25.90	274.96	118.31	6.80	32.38	32.38	392
	Multi-family	24,131	1,724	14,578	71.38	34.84	273.75	114.91	11.60	30.54	40.47	3,528
	Commercial	3,977	280	1,790	8.50	3.80	30.37	23.96	1.64	4.50	12.57	440
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	46,573	3,891	[illegible]	124.19	[illegible]	[illegible]	257.19	[illegible]	77.44	79.82	[illegible]
BLLNA10	Single-family	20,574	1,306	9,922	66.30	17.34	305.06	131.34	6.74	24.83	24.83	313
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	20,574	1,306	9,922	66.30	17.34	305.06	131.34	6.74	24.83	24.83	313
BLLNA11	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	3,923	442	2,946	34.18	3.94	63.35	30.37	2.37	7.42	22.44	325
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,923	442	2,946	34.18	3.94	63.35	30.37	2.37	7.42	22.44	325
BLLNA12	Single-family	[illegible]	51	420	2.55	0.75	12.59	3.33	0.30	1.00	1.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	4,317	[illegible]	[illegible]	26.31	4.32	47.96	28.71	1.73	2.40	26.64	[illegible]
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	[illegible]	14	90	0.43	0.11	2.00	1.30	0.07	0.22	0.00	22
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	401	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BLLNA13	Single-family	[illegible]	34	280	2.70	0.50	8.50	2.70	0.10	0.70	0.70	6
	Multi-family	420	30	280	1.34	0.26	4.00	2.00	0.20	0.80	0.76	44
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	[illegible]	3,315	[illegible]	[illegible]	36.91	287.85	112.71	6.76	21.13	[illegible]	[illegible]
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	37,306	3,379	[illegible]	[illegible]	37.67	301.34	116.41	[illegible]	22.71	66.64	[illegible]
BLLNA14	Single-family	2,216	206	2,518	15.30	4.30	77.34	33.37	1.71	6.30	6.30	84
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,216	206	2,518	15.30	4.30	77.34	33.37	1.71	6.30	6.30	84
BLLNA15	Single-family	[illegible]	1,887	16,367	[illegible]	[illegible]	282.70	[illegible]	[illegible]	40.52	40.52	251
	Multi-family	2,511	180	1,550	3.43	1.56	31.76	11.50	1.30	5.30	4.86	[illegible]
	Commercial	[illegible]	[illegible]	[illegible]	3.01	1.26	12.19	8.50	0.80	1.57	4.65	[illegible]
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	[illegible]	[illegible]	109.41	[illegible]	[illegible]	224.46	[illegible]	47.77	[illegible]	[illegible]

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
BLLNA16	Single-family	4,857	328	2,884	11.89	3.80	48.15	28.88	1.23	4.80	4.80	42
	Multi-family	420	30	260	1.34	0.26	4.80	2.80	0.30	0.81	0.74	44
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	4,337	332	2,068	9.88	4.34	45.96	27.34	1.63	5.17	18.85	286
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,613	690	4,337	23.01	7.89	110.91	58.46	3.18	10.85	21.60	372
BLLNA17	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,440	30	473	2.80	0.70	13.99	7.34	0.37	0.70	2.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,441	30	473	2.80	0.70	13.99	7.34	0.37	0.70	2.30	0
BLLNA18	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	10,771	44	2,064	11.43	3.06	61.55	31.57	3.21	3.08	[illegible]	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	0
	Catchment Total	10,771	44	2,064	11.43	3.06	61.55	31.57	3.21	3.08	8.67	0
BLLNA19	Single-family	311,250	6,557	33,997	227.84	96.42	1,658.47	713.53	36.64	234.90	234.90	1,257
	Multi-family	8,403	615	5,326	25.40	3.33	98.32	48.97	4.10	18.80	15.57	901
	Commercial	12,950	1,807	6,475	30.94	12.95	143.88	84.33	5.18	36.19	48.93	1,800
	Public	28,557	2,252	14,478	69.17	28.96	321.74	192.85	11.58	36.30	111.44	3,530
	Light Industrial	17,984	1,399	8,993	42.97	17.99	199.84	119.90	7.19	22.40	68.34	2,198
	Other Urban	118,133	8,438	73,131	344.78	73.13	1,350.12	843.35	36.35	347.32	323.77	22,576
	Open	76,379	312	14,808	81.86	21.82	436.43	226.02	8.57	31.82	68.90	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	574,840	20,380	177,305	826.15	254.59	4,201.83	1,943.34	128.52	497.23	863.83	31,355
BLLNA2	Single-family	22,892	1,342	11,051	67.30	19.73	290.43	146.80	7.80	37.40	37.40	257
	Multi-family	210	15	130	0.42	0.13	2.00	1.00	0.10	0.44	0.38	22
	Commercial	710	56	360	1.72	0.73	7.99	4.80	0.29	0.80	2.77	68
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	23,821	1,413	11,541	69.43	20.58	300.42	151.43	7.89	38.97	38.76	347
BLLNA20	Single-family	800	34	380	1.70	0.80	3.59	3.70	0.10	0.70	0.70	4
	Multi-family	8,693	635	2,326	26.40	3.33	98.33	40.97	4.10	18.80	15.57	901
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	400	3	96	0.52	0.14	2.50	1.45	0.06	0.34	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	9,672	680	3,760	27.42	3.97	100.71	46.11	4.34	18.86	16.71	907
BLLNA3	Single-family	30,420	2,904	24,341	347.78	43.47	747.60	321.84	18.33	48.83	48.83	522
	Multi-family	3,875	420	3,637	17.35	3.64	67.15	27.98	2.00	22.31	10.63	604
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	34,295	3,373	27,978	365.13	47.10	814.75	349.82	20.31	72.16	71.46	1,127

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
BLLNA4	Single-family	38,253	1,870	8,813	83.51	15.74	370.44	136.46	3.98	32.00	32.00	389
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	7,734	402	2,347	18.46	7.73	85.77	81.34	3.09	9.87	38.83	945
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	11,331	881	2,443	37.87	11.33	225.90	73.34	4.33	14.16	43.09	1,383
	Other Urban	22,390	899	7,794	37.17	7.79	343.81	59.85	4.00	28.36	22.78	1,319
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	48,910	3,432	26,130	136.22	43.60	626.43	303.11	20.40	72.34	114.32	3,836
BLLNA6	Single-family	17,676	1,806	8,520	51.81	15.34	262.89	112.76	3.79	21.53	21.53	383
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	8,216	486	2,403	12.46	5.22	57.85	34.77	2.09	6.52	28.11	657
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	14,743	1,347	7,574	35.30	14.75	163.57	98.32	8.00	18.46	34.86	1,803
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	3	95	0.52	0.14	2.00	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	38,129	3,591	18,610	100.02	33.34	484.71	247.30	13.83	46.43	86.74	2,843
BLLNA7	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	9,712	735	4,836	33.30	9.71	187.91	64.75	3.81	13.14	37.43	1,187
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	9,712	735	4,836	33.30	9.71	187.91	64.75	3.84	13.14	37.43	1,187
BLLNA8	Single-family	15,937	984	7,004	46.71	13.74	236.31	201.47	3.32	18.30	18.30	368
	Multi-family	310	16	130	0.62	0.13	3.40	1.80	0.10	0.44	0.38	33
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	13,309	1,826	4,433	31.79	13.31	147.88	88.75	3.32	14.44	51.31	1,637
	Other Urban	91,607	4,316	24,765	270.72	54.76	1,047.94	424.43	43.47	192.13	165.83	9,486
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	121,163	8,314	71,343	349.83	83.94	1,434.53	626.05	54.31	225.44	236.84	11,420
BLLNA9	Single-family	6,463	391	3,317	19.53	5.38	98.82	42.52	2.10	5.04	3.04	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	22,842	1,777	11,421	54.57	22.04	253.80	152.28	9.14	20.33	88.07	2,782
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	29,306	2,167	14,638	74.10	28.39	352.62	194.79	11.33	26.40	91.11	2,841
BLLNA5	Single-family	31,295	1,825	15,308	91.75	26.50	464.85	289.64	18.35	37.77	37.77	394
	Multi-family	3,393	600	2,196	24.78	3.20	95.52	30.37	4.80	17.59	25.19	579
	Commercial	14,829	1,091	7,814	28.51	14.85	153.14	93.53	3.61	17.94	34.09	1,715
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	22,890	937	6,825	26.79	12.86	133.59	88.34	4.52	15.06	46.46	1,673
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	65,767	4,463	33,343	171.81	54.25	849.72	413.47	34.44	87.85	153.51	4,390
BLJONA12	Single-family	19,414	1,138	9,372	36.90	16.74	287.87	223.25	6.34	23.43	23.40	391
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	7,194	540	3,597	37.19	7.19	79.94	47.96	2.81	8.59	27.74	679
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	26,609	1,698	12,970	74.09	23.93	367.81	271.21	9.24	32.42	51.17	1,080

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Ammonia	TKN	NO3+NO2	Total Cu	Total Pb	Total Zn	Oil & Grease
BNDCT1	Single-family	288,343	37,390	841,367	879.51	252.80	4,348.12	1,870.70	98.86	383.92	353.72	3,034
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	288,883	791	37,790	202.76	25.40	1,387.91	573.94	21.76	25.40	774.10	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	87,330	37,982	879,157	1,083.27	208.10	5,636.03	2,444.64	117.63	409.31	328.03	3,034
BNDCT2	Single-family	99,370	3,060	48,341	282.82	86.11	1,482.31	637.34	32.75	120.45	120.45	1,834
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,669	6	285	1.36	0.42	8.39	4.35	0.16	0.42	1.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	101,439	3,066	48,546	284.57	86.60	1,490.71	642.09	33.01	121.07	121.07	1,834
BNDCT3	Single-family	38,343	3,414	28,117	170.71	30.21	863.61	371.83	19.88	70.79	70.79	600
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	360	25	180	0.36	0.36	4.00	2.40	0.14	0.43	1.50	44
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	190	1.04	0.38	5.60	2.90	0.11	0.38	0.88	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	39,342	3,446	28,457	172.61	30.83	873.20	376.43	20.33	71.62	72.36	646
BNDCT4	Single-family	94,181	4,349	35,811	217.43	63.85	1,090.92	473.22	24.30	90.53	90.53	787
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0
	Public	2,878	224	1,430	6.87	2.88	31.87	30.11	1.15	2.60	11.30	282
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	39,376	120	3,666	31.11	8.39	107.87	86.93	3.30	8.39	26.36	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	186,435	4,692	42,946	283.41	75.22	1,250.76	579.34	28.75	101.52	127.00	1,110
BNDCT5	Single-family	60,255	4,860	33,420	282.99	50.70	1,484.08	411.80	28.40	88.88	88.88	716
	Multi-family	86,123	4,152	35,911	171.80	28.86	864.37	374.76	27.46	121.70	108.18	6,899
	Commercial	44,964	3,497	23,482	107.41	44.86	489.60	299.76	77.89	86.31	173.36	3,496
	Public	16,367	1,573	8,183	28.10	16.57	181.85	109.11	6.55	20.46	63.10	3,800
	Light Industrial	16,367	1,573	8,183	28.10	16.57	181.85	109.11	6.55	20.46	63.10	3,800
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	38,949	306	3,831	37.34	7.41	168.28	76.79	2.91	7.41	22.30	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	231,825	14,361	113,294	387.74	180.80	2,702.74	1,313.35	84.36	180.50	511.63	16,302
BNDCT6	Single-family	134,748	6,727	23,396	204.33	98.32	1,701.44	722.01	37.89	120.40	120.40	1,387
	Multi-family	37,704	4,322	25,721	178.36	25.72	689.47	234.70	27.40	128.90	104.42	4,045
	Commercial	28,417	2,310	14,209	67.89	28.42	315.35	197.45	11.57	38.52	108.36	3,473
	Public	3,777	204	1,888	8.82	3.78	41.97	25.18	1.51	4.73	14.56	482
	Light Industrial	4,496	330	2,348	18.74	4.50	49.96	29.91	1.80	3.62	17.34	390
	Other Urban	7,344	325	4,546	21.48	4.55	63.83	34.97	3.30	18.59	12.59	780
	Open	7,344	30	1,424	7.79	2.10	41.97	21.73	0.82	3.10	6.59	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	223,831	14,257	113,433	623.42	177.86	2,894.48	1,308.30	84.07	322.74	484.25	12,406
CCAM	Single-family	188,573	6,353	32,310	317.45	98.43	1,606.91	671.35	38.90	238.80	238.80	1,321
	Multi-family	101,578	7,284	63,129	381.88	63.33	1,345.47	483.61	48.56	212.67	104.83	10,683
	Commercial	23,996	2,574	16,547	79.06	33.09	287.71	220.42	22.24	41.57	127.39	4,845
	Public	8,113	685	4,406	21.85	8.81	97.92	58.75	3.53	11.82	35.96	1,577
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	252,251	16,896	126,401	715.83	195.46	3,234.01	1,434.33	100.33	396.35	476.80	16,826

TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
CNTLA1	Single-family	28,349	2,342	28,465	112.11	32.97	287.15	264.80	12.53	46.16	46.16	386
	Multi-family	6,083	435	2,767	17.97	3.77	68.34	38.98	3.00	12.73	11.01	637
	Commercial	21,763	1,093	20,811	81.09	21.76	201.81	145.08	5.71	27.20	63.91	2,640
	Public	0	0	0	0.00	0.00	0.00	6.20	0.00	0.00	0.00	0
	Light Industrial	18,432	811	5,316	34.92	18.43	113.91	69.34	4.37	13.04	48.32	1,575
	Other Urban	23,639	974	5,643	40.37	8.44	253.88	64.86	6.49	28.58	34.66	1,409
	Open	9,792	40	1,098	18.39	2.80	21.96	28.98	1.30	2.80	2.79	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	99,960	6,186	64,671	257.64	80.18	1,206.23	641.53	28.90	130.53	214.77	6,397
CNTLA2	Single-family	28,925	2,378	24,998	162.92	48.31	828.34	284.76	18.32	67.30	67.30	979
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	719	36	360	1.72	0.72	7.99	4.80	0.39	0.90	2.77	88
	Public	719	36	360	1.72	0.72	7.99	4.80	0.39	0.90	2.77	88
	Light Industrial	37,311	2,140	15,730	68.74	27.32	288.76	183.43	11.01	34.60	108.10	2,363
	Other Urban	28,072	719	6,325	28.74	6.34	115.11	47.86	4.80	21.30	18.32	1,083
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	94,954	6,250	47,313	262.13	83.40	1,246.09	397.77	34.70	124.80	197.37	3,175
COLDW1	Single-family	222,542	13,044	107,424	652.30	201.85	2,399.76	1,419.46	72.90	288.84	288.32	3,302
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	28,376	120	3,695	31.13	8.39	167.87	86.93	3.30	8.39	26.34	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	251,918	13,163	111,129	683.43	210.24	2,567.63	1,506.39	76.20	296.90	294.96	3,302
COLDW2	Single-family	168,355	9,800	81,575	493.45	145.13	2,496.30	1,072.99	55.13	203.19	203.19	1,942
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	5,216	486	2,603	12.46	5.32	57.85	34.77	3.30	6.52	20.11	637
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	2	98	0.52	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	174,061	10,277	83,978	506.43	150.41	2,557.05	1,110.21	58.29	209.85	223.74	2,579
CULVER1	Single-family	65,439	3,720	28,625	186.80	54.71	948.95	484.23	20.79	76.59	76.59	654
	Multi-family	37,426	1,259	10,911	52.06	10.91	201.44	23.93	0.59	24.93	31.09	1,847
	Commercial	3,518	196	1,259	6.82	2.32	37.06	16.79	1.01	4.15	0.71	208
	Public	8,573	643	4,137	19.76	5.37	91.93	25.14	3.31	18.34	31.80	1,011
	Light Industrial	46,343	3,567	22,932	109.36	45.86	509.59	285.76	18.35	57.32	176.83	3,806
	Other Urban	4,197	280	2,998	12.39	2.80	47.86	19.58	2.80	2.79	7.89	440
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	161,926	9,665	72,472	383.77	124.57	1,818.84	854.44	53.84	183.13	324.51	8,067
[illegible]	Single-family	22,592	1,342	11,851	67.10	20.73	280.43	144.83	7.50	27.43	27.43	387
	Multi-family	61,861	4,362	37,300	180.28	37.00	697.84	280.77	20.45	127.86	110.49	6,397
	Commercial	37,590	2,934	18,795	89.80	37.89	477.67	284.80	15.84	46.59	144.83	4,904
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	121,543	8,637	67,446	337.17	95.12	1,454.94	667.40	41.41	202.33	283.06	11,528
[illegible]	Single-family	680,399	25,196	289,348	1,750.79	517.99	6,983.47	2,838.12	196.60	734.42	734.42	6,311
	Multi-family	162,396	7,314	63,369	283.32	63.39	1,770.26	487.61	48.76	204.35	188.39	18,727
	Commercial	72,452	3,637	36,341	172.15	72.44	888.36	473.21	28.99	90.40	279.46	8,839
	Public	8,813	685	4,406	21.05	5.81	97.32	28.75	2.13	11.02	38.94	1,877
	Light Industrial	30,822	1,791	11,511	33.80	20.42	285.50	153.40	9.21	28.76	88.76	2,814
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	13,709	36	2,438	14.33	2.92	78.34	48.57	1.54	3.92	12.31	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	820,823	38,679	408,251	2,325.64	681.21	11,310.14	3,853.75	284.71	1,073.46	1,324.42	38,688

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
DOM113	Single-family	357,934	9,251	76,230	462.88	130.14	2,341.83	1,807.44	31.73	990.60	990.60	1,634
	Multi-family	340,797	30,057	67,140	411.60	67.36	1,609.11	679.46	67.86	355.80	254.70	34,730
	Commercial	86,612	535	2,306	25.25	30.41	177.91	78.74	4.34	13.36	48.91	1,397
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,575	24	2,130	0.24	1.44	22.57	17.39	0.44	1.44	2.20	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	313,200	20,164	130,644	910.13	231.39	4,151.42	1,766.04	123.68	2,003.34	1,301.36	37,761
DOM114	Single-family	496,857	20,132	209,901	1,454.52	438.41	7,344.80	2,770.21	162.79	599.77	599.77	2,341
	Multi-family	237,410	24,101	200,573	996.16	208.57	3,836.11	1,404.71	160.57	704.95	610.35	25,346
	Commercial	237,854	30,720	84,575	309.33	237.80	1,522.77	919.44	28.18	372.44	201.57	16,841
	Public	22,770	997	6,303	30.51	22.77	341.89	83.13	3.11	19.96	40.35	1,341
	Light Industrial	22,642	1,763	31,331	34.14	22.44	251.80	151.80	9.06	28.35	87.57	2,770
	Other Urban	7,344	235	4,346	21.00	4.33	83.73	34.77	3.30	13.59	13.39	760
	Open	4,406	38	854	4.48	1.36	20.15	13.84	0.49	1.36	2.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,019,494	67,280	540,572	2,873.29	816.47	13,200.28	5,390.11	396.81	1,340.10	1,516.05	43,449
DOO	Single-family	375,280	36,177	222,994	898.85	257.31	4,881.73	1,736.60	90.18	322.25	322.25	2,840
	Multi-family	133,905	11,136	96,513	460.39	96.51	1,701.77	741.41	74.34	226.64	282.11	16,333
	Commercial	25,379	2,014	22,950	61.57	25.90	287.77	772.46	18.36	22.57	99.84	3,346
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	42,444	3,301	31,220	301.40	42.45	471.82	282.77	26.98	33.06	143.45	3,186
	Other Urban	36,577	3,184	30,262	48.94	30.26	189.43	70.94	7.59	24.73	28.80	1,737
	Open	490	3	95	0.52	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	314,396	33,775	373,836	1,479.84	412.57	6,513.14	3,604.32	199.71	779.20	906.29	28,371
FRANK1	Single-family	21,805	1,818	14,844	90.88	26.73	499.73	397.79	28.16	37.42	37.42	381
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	126,801	518	34,385	134.57	36.23	724.42	375.25	14.23	36.23	113.87	0
	Unknown	9,273	659	5,715	27.26	5.72	105.52	47.96	4.40	19.34	16.71	907
	Catchment Total	167,046	2,995	43,200	252.71	68.68	1,320.87	617.01	26.79	93.00	168.00	1,288
GRCN1	Single-family	28,397	1,665	13,700	82.25	24.48	421.86	201.15	9.30	34.57	34.57	284
	Multi-family	29,239	2,103	24,391	113.85	24.39	444.44	196.85	10.60	82.21	71.80	4,111
	Commercial	8,093	609	4,696	21.48	2.99	99.92	30.95	2.60	11.34	34.67	1,099
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	7,824	32	1,519	2.31	2.34	46.76	22.18	0.85	2.34	7.88	0
	Unknown	910	35	730	0.02	0.11	2.40	1.80	0.10	0.44	0.31	32
	Catchment Total	84,672	3,314	44,345	220.30	60.13	1,016.30	453.14	23.56	130.41	147.26	5,526
LA1777	Single-family	437,260	25,432	201,091	1,381.82	376.95	4,602.51	2,798.43	143.24	527.73	527.73	4,830
	Multi-family	346,843	30,422	90,408	431.17	90.41	1,640.05	685.44	49.34	306.80	264.37	15,300
	Commercial	82,814	6,379	41,887	186.92	83.01	971.37	546.76	22.81	302.83	316.21	10,824
	Public	21,763	1,073	20,281	51.99	21.76	241.81	141.08	8.71	37.20	63.91	2,640
	Light Industrial	21,403	1,663	20,701	51.13	21.40	257.81	142.60	8.86	26.75	83.53	2,616
	Other Urban	60,222	4,302	57,280	177.80	37.28	681.25	234.77	28.46	126.18	168.97	4,380
	Open	61,201	290	11,066	64.95	17.49	349.72	201.11	4.57	37.49	34.06	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	838,906	50,332	413,224	2,354.34	647.30	10,341.43	4,787.27	288.40	1,133.86	1,626.86	41,432
MDREY1	Single-family	2,306	323	2,658	36.14	4.75	81.82	28.12	1.80	6.64	6.64	57
	Multi-family	25,209	1,844	35,977	76.20	25.98	204.96	222.90	22.39	34.88	40.70	2,704
	Commercial	36,506	1,313	8,453	40.30	36.91	187.25	112.71	6.76	21.13	60.11	2,066
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	231,345	9,368	81,385	287.79	81.39	1,498.80	484.30	62.45	274.70	207.31	12,730
	Open	30,282	42	1,993	30.91	2.94	38.75	30.43	1.15	3.94	9.23	0
	Unknown	44,494	3,192	27,465	171.95	27.57	310.79	212.83	21.78	97.65	80.81	4,882
	Catchment Total	334,342	16,083	157,935	662.78	149.42	2,322.79	1,134.49	105.74	433.22	443.85	23,340

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
MCRAD1	Single-family	97,632	3,734	47,342	264.22	84.18	1,647.94	422.95	31.99	177.36	177.86	1,010
	Multi-family	3,147	325	1,946	9.20	1.95	25.97	14.99	1.30	6.39	2.70	200
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	222,972	392	23,826	130.42	25.11	702.34	363.46	13.79	25.11	118.33	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	323,601	6,451	73,117	423.83	111.24	2,366.13	1,801.40	47.23	209.26	323.90	1,340
MT318	Single-family	154,157	9,027	94,420	451.84	122.89	2,385.77	973.41	30.30	106.85	106.85	1,598
	Multi-family	98,831	7,859	61,181	391.70	61.18	1,128.30	470.63	47.86	207.87	771.84	30,354
	Commercial	30,713	2,406	25,444	73.90	20.94	363.72	206.23	12.57	28.67	119.27	3,781
	Public	8,973	699	4,696	31.40	8.59	90.32	89.95	3.60	31.34	34.67	1,899
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	132,194	9,442	81,324	390.30	81.23	1,310.79	628.30	42.85	374.86	230.21	22,040
	Open	3,364	22	1,844	3.72	1.54	28.71	13.94	0.60	1.54	4.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	430,415	28,444	224,444	1,323.01	317.36	5,400.46	2,363.46	177.09	721.33	943.84	30,677
MT430	Single-family	909	31	420	2.35	0.75	22.99	2.55	0.30	1.05	1.05	0
	Multi-family	40,707	2,900	25,200	120.14	25.20	465.23	203.84	30.36	85.39	73.66	4,303
	Commercial	340	42	370	1.59	0.54	4.80	3.60	0.23	0.67	2.00	66
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,934	32	870	3.12	0.84	26.79	8.60	0.33	0.84	2.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	45,864	3,013	26,430	127.16	27.33	500.90	211.44	28.11	87.43	79.43	4,360
PANPC1	Single-family	725,800	42,300	264,800	3,135.80	625.80	10,749.90	4,625.80	237.90	775.80	775.80	7,800
	Multi-family	257,134	20,310	221,863	1,604.40	221.80	4,881.60	1,700.64	178.66	746.26	644.34	37,614
	Commercial	117,964	9,177	84,973	301.85	117.59	1,314.95	764.57	47.19	147.46	484.80	14,420
	Public	15,527	2,201	7,914	37.81	13.83	375.34	103.32	0.23	30.70	61.80	1,834
	Light Industrial	79,316	6,300	30,434	109.40	79.32	881.20	228.75	21.73	90.16	288.81	6,004
	Other Urban	10,282	734	6,343	20.36	4.36	317.51	40.96	4.30	21.84	18.61	1,077
	Open	198,761	811	28,570	218.95	84.79	1,125.09	488.23	20.31	84.79	178.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,504,336	84,132	722,331	5,528.84	1,132.57	18,411.60	8,343.40	520.02	1,844.83	2,548.85	72,040
BXFRD1	Single-family	164,327	9,750	88,396	487.31	143.30	2,464.35	1,061.85	84.40	280.74	280.74	1,720
	Multi-family	20,426	2,173	11,826	69.85	10.83	247.72	144.88	14.49	63.75	22.86	3,107
	Commercial	79,177	6,135	39,344	189.05	79.14	579.30	227.34	31.65	98.92	288.32	9,672
	Public	3,923	462	2,900	14.18	2.94	66.95	39.57	2.37	7.42	22.80	725
	Light Industrial	25,444	2,300	7,734	28.18	25.47	171.84	103.12	6.19	19.33	28.64	1,899
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	297,292	18,343	148,400	812.52	263.76	3,501.85	1,576.20	140.19	390.16	643.43	17,196
SAWTL1	Single-family	344,534	28,197	164,327	1,809.34	297.81	3,908.61	2,197.89	112.86	433.82	433.82	3,904
	Multi-family	264,391	21,900	163,799	781.19	163.80	3,622.98	1,379.99	126.80	234.40	478.80	37,720
	Commercial	80,733	6,201	40,378	192.92	80.76	977.28	328.37	32.30	108.94	311.36	9,570
	Public	139,528	10,833	69,364	224.27	139.53	1,514.76	922.85	85.97	174.91	339.30	71,302
	Light Industrial	22,842	1,777	11,421	34.57	22.84	253.90	152.38	9.14	28.55	88.57	2,790
	Other Urban	32,734	2,336	20,344	96.64	20.26	394.10	153.82	18.99	68.39	90.23	3,429
	Open	46,823	100	8,823	48.84	13.13	282.99	126.19	3.17	13.15	41.33	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	931,414	60,344	481,875	3,518.27	737.25	11,673.51	5,573.43	357.83	1,334.35	1,834.30	64,677
SEPUL1	Single-family	71,573	4,396	34,522	209.78	61.30	1,061.25	454.38	28.45	84.38	84.38	740
	Multi-family	1,801	135	1,340	5.58	1.17	21.54	5.00	0.50	3.06	3.42	100
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	127,348	9,898	78,347	376.84	78.85	1,453.63	606.51	60.45	264.57	230.40	23,343
	Open	225,180	1,327	63,030	343.80	92.89	1,857.71	962.80	36.49	92.89	291.80	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	325,829	14,733	177,346	936.40	234.60	4,396.14	2,034.12	121.49	450.09	612.20	24,282

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Dissolved P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 148	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	420	20	260	1.34	0.26	4.80	2.80	0.30	0.02	0.76	0
	Open	7,344	20	1,424	7.79	2.10	41.97	21.73	0.82	2.10	6.59	44
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,764	40	1,684	9.13	2.36	46.76	23.73	1.02	2.36	7.35	44
SMB 149	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	420	20	260	1.34	0.26	4.80	2.80	0.30	0.02	0.76	0
	Open	4,896	20	949	5.30	1.40	27.91	14.49	0.53	1.40	4.40	44
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,316	40	1,209	6.63	1.66	32.77	16.49	0.73	2.26	5.16	44
SMB 150	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	420	20	260	1.34	0.26	4.80	2.80	0.30	0.02	0.76	0
	Open	6,855	20	1,329	7.27	1.96	39.17	20.33	0.77	1.96	6.16	44
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,274	36	1,589	8.61	2.22	43.96	23.14	0.97	2.04	6.91	44
SMB 151	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	2,917	16	709	4.16	1.12	22.34	11.59	0.44	1.12	3.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,917	16	709	4.16	1.12	22.34	11.59	0.44	1.12	3.52	0
SMB 152	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	420	20	260	1.34	0.26	4.80	2.80	0.30	0.02	0.76	44
	Open	7,344	20	1,424	7.79	2.10	41.97	21.73	0.82	2.10	6.59	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,764	40	1,684	9.13	2.36	46.76	23.73	1.02	2.36	7.35	44
SMB 153	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	600	45	390	1.86	0.39	7.19	3.00	0.30	1.32	1.34	0
	Open	1,409	6	283	1.56	0.42	8.30	4.35	0.16	0.42	1.32	66
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,094	51	674	3.42	0.81	15.59	7.36	0.46	1.54	2.66	66
SMD402	Single-family	41,727	2,446	28,144	122.30	28.97	656.70	286.19	22.07	90.26	90.26	432
	Multi-family	6,565	446	4,857	19.30	4.85	94.34	28.96	2.10	13.63	31.77	481
	Commercial	31,891	909	8,845	37.93	11.60	279.50	77.94	4.65	36.41	48.07	1,429
	Public	2,578	224	1,630	6.57	2.26	31.57	30.16	1.15	3.80	31.30	282
	Light Industrial	37,230	2,996	30,615	98.94	37.23	413.67	206.20	34.59	46.54	143.54	4,220
	Other Urban	9,023	644	3,346	26.64	3.39	180.12	42.57	4.30	16.90	26.33	945
	Open	20,771	46	2,888	11.43	3.85	61.53	31.57	1.21	3.80	9.67	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	119,324	7,625	57,344	303.32	100.46	1,611.25	717.33	42.99	130.72	387.84	8,389

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
SEPUL1	Single-family	[illegible]	9,644	79,436	482.41	94.89	2,446.65	1,049.96	33.37	[illegible]	[illegible]	1,703
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	4,576	364	2,338	11.77	4.44	81.06	31.11	1.87	5.83	33.83	372
	Public	80,340	3,931	33,370	130.73	30.34	861.33	324.93	30.32	63.17	[illegible]	6,377
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	9,362	784	6,168	35.12	6.11	133.71	46.96	4.70	20.44	37.83	1,833
	Open	23,533	93	4,367	23.90	6.63	123.70	66.63	2.53	6.43	30.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	353,164	14,739	117,336	667.34	209.64	3,253.36	1,533.67	63.33	384.76	649.40	9,444
SEPUL2	Single-family	337,640	8,899	66,447	483.43	118.66	2,860.37	973.83	45.89	364.13	364.13	1,434
	Multi-family	96,338	6,443	53,333	264.39	83.84	1,501.77	429.46	43.97	199.83	363.37	9,432
	Commercial	83,006	4,381	37,518	231.47	83.84	613.31	364.91	33.01	68.79	312.19	6,737
	Public	64,404	3,433	33,313	306.13	44.43	493.60	396.16	37.77	83.53	371.38	3,430
	Light Industrial	71,833	3,476	35,937	96.86	31.83	333.73	313.33	33.73	30.79	133.14	3,891
	Other Urban	33,773	1,634	34,139	67.53	34.34	381.39	338.91	38.89	67.83	61.39	3,396
	Open	1,460	6	383	1.36	0.43	8.39	4.33	0.16	0.43	3.33	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	363,503	36,363	303,393	1,453.33	330.34	4,300.66	2,796.36	331.43	367.43	871.31	38,330
SEPUL3	Single-family	123,731	7,353	59,733	363.46	106.66	1,334.63	709.33	40.33	149.33	149.33	1,380
	Multi-family	37,360	2,443	33,351	110.89	23.35	429.36	373.46	17.89	78.70	67.97	3,935
	Commercial	7,196	560	3,547	17.19	7.19	79.94	47.96	3.83	8.99	37.34	579
	Public	3,597	380	1,799	8.39	3.60	30.97	33.98	1.44	4.50	13.37	440
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,738	198	1,689	8.35	1.60	31.18	13.99	1.30	3.73	4.94	384
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	174,810	10,970	90,044	507.34	143.60	2,414.97	1,053.11	64.03	247.23	283.44	6,330
STONE1	Single-family	137,860	8,835	66,347	401.73	118.16	2,033.37	874.33	46.30	165.63	165.63	1,618
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	33,734	3,546	36,387	79.30	33.73	363.71	311.33	13.80	48.93	338.31	4,801
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	193,395	799	37,498	385.34	85.36	1,303.13	373.39	33.71	83.36	373.66	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	363,189	11,370	130,039	663.16	306.14	3,501.10	1,464.87	79.70	381.39	465.39	3,419
STONE2	Single-family	67,806	3,973	33,734	198.74	56.45	1,006.40	433.55	33.31	81.83	81.83	781
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	3,417	366	1,700	8.16	3.43	37.97	33.76	1.37	4.37	33.10	418
	Public	31,583	1,579	38,791	31.06	31.58	309.31	163.88	8.43	38.98	83.31	3,438
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	38,383	43	1,980	30.91	3.94	36.73	30.43	1.15	3.94	9.33	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	103,087	3,961	47,337	304.37	84.39	1,341.03	639.43	33.37	116.03	187.46	3,737
STONE3	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	33,433	1,004	33,390	66.39	33.90	334.59	306.91	38.60	47.04	40.03	3,333
	Commercial	3,576	434	3,798	13.33	3.34	61.85	37.37	3.33	4.97	33.50	681
	Public	74,381	3,777	37,340	177.45	74.38	835.34	403.30	38.71	93.35	308.39	9,879
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	103,304	7,813	33,837	357.05	93.73	1,343.84	639.39	43.63	146.86	343.33	13,313
WATER	Single-family	4,634	373	3,338	13.59	4.80	68.74	39.53	1.33	3.80	3.80	46
	Multi-family	330	35	130	0.63	0.13	3.40	1.80	0.10	0.44	0.38	33
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	7,914	636	3,857	18.90	7.31	87.93	33.76	3.17	9.89	30.31	987
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	12,760	903	6,335	33.11	12.04	159.07	83.33	4.78	13.93	36.49	1,037

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil&Grease
BB13A	Single-family	38,352	2,973	17,066	103.42	20.40	504.18	225.33	11.51	42.67	42.67	366
	Multi-family	11,841	634	7,344	34.87	7.14	131.89	84.94	5.80	24.18	28.82	1,309
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	3,409	385	699	4.34	0.91	24.79	6.99	0.70	3.08	3.44	264
	Open	4,596	30	909	2.30	1.40	37.80	14.09	0.55	1.40	4.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	23,257	3,622	26,009	147.32	30.33	708.54	301.36	18.33	71.33	78.60	1,729
BB13C	Single-family	187,484	9,311	98,253	480.91	164.38	2,481.41	1,066.44	84.57	282.14	282.14	1,723
	Multi-family	2,934	310	2,119	8.67	1.82	33.57	13.99	1.60	6.16	8.32	308
	Commercial	21,331	881	8,645	37.87	11.53	323.90	73.34	4.53	84.16	43.09	1,363
	Public	35,464	1,303	7,734	26.16	23.47	771.36	102.12	6.19	93.33	39.44	1,590
	Light Industrial	8,433	657	4,227	30.79	0.45	93.92	34.33	3.36	30.57	32.59	1,800
	Other Urban	430,713	30,770	284,576	1,371.84	204.61	4,023.36	2,051.36	205.14	982.60	778.52	45,130
	Open	5,384	22	1,044	2.72	1.54	20.76	15.94	0.60	1.54	4.04	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	641,846	43,342	264,620	1,861.33	449.67	7,842.70	3,344.74	376.11	1,336.49	1,137.72	51,479
BB041	Single-family	323,701	23,314	187,394	633.60	192.83	2,316.94	1,477.86	78.38	289.98	289.98	2,314
	Multi-family	25,390	2,814	15,717	74.96	13.73	280.17	120.90	12.89	53.38	48.94	2,660
	Commercial	33,594	2,574	14,347	79.86	33.89	287.71	220.62	13.34	41.57	127.89	4,065
	Public	37,850	2,812	18,525	88.51	37.86	411.87	397.80	14.82	48.31	143.83	4,528
	Light Industrial	180	14	90	0.40	0.11	2.00	1.20	0.07	0.32	0.09	23
	Other Urban	294,804	31,843	182,574	809.78	182.37	3,344.90	1,402.58	140.29	617.37	323.09	30,843
	Open	80,430	286	9,777	33.52	14.41	284.17	149.23	3.46	14.41	45.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	664,441	41,646	251,624	1,821.93	473.67	6,843.34	3,344.89	250.43	1,043.76	1,165.44	44,433
SMB 144	Single-family	8,983	327	4,537	26.30	7.14	133.19	87.30	2.94	30.84	30.84	90
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	480	3	96	0.52	0.14	2.00	1.42	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	9,472	330	4,631	26.83	7.28	135.19	88.72	3.00	30.98	31.28	90
SMB 145	Single-family	2,998	170	1,399	8.40	2.30	42.97	18.49	0.96	2.30	2.30	30
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,400	6	285	1.86	0.42	8.39	4.35	0.16	0.42	1.32	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,347	176	1,684	10.26	2.82	51.36	22.83	1.11	2.82	4.22	30
SMB 146	Single-family	2,998	170	1,399	8.40	2.30	42.97	18.49	0.96	2.30	2.30	30
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	5,384	22	1,044	2.72	1.54	20.76	15.94	0.60	1.54	4.04	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,383	192	2,443	14.21	4.04	73.74	34.43	1.63	4.04	6.33	30
SMB 147	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	230	15	230	0.42	0.13	2.40	1.80	0.10	0.44	0.36	22
	Open	2,856	12	370	3.12	0.84	16.79	8.09	0.33	0.84	2.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,347	27	609	3.74	0.97	19.18	9.89	0.43	1.28	3.02	22

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Dissolved P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	800	51	430	2.53	0.75	12.59	2.53	0.28	1.85	1.85	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	68,825	4,916	42,606	303.30	42.61	784.57	227.74	32.77	344.30	224.54	3,310
	Open	2,054	8	350	2.00	0.56	11.29	5.30	0.22	0.54	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	71,433	4,975	43,405	307.42	43.91	816.43	236.06	33.28	343.81	227.33	3,310
[illegible]	Single-family	8,693	510	4,397	25.42	7.40	128.90	23.46	2.05	16.49	16.49	90
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	324,820	23,201	201,879	964.90	201.00	3,712.23	1,346.76	154.48	690.34	887.77	34,020
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	333,513	23,711	206,276	984.47	208.57	3,841.13	1,403.22	157.32	691.07	904.26	34,110
[illegible]	Single-family	375,239	22,031	201,428	1,301.57	323.90	3,572.64	2,397.53	122.12	423.50	423.90	3,000
	Multi-family	9,343	780	6,165	30.12	6.11	112.71	46.96	4.70	20.46	77.85	1,050
	Commercial	29,496	2,794	14,740	70.46	29.30	227.74	106.64	11.80	26.57	113.72	3,440
	Public	48,281	3,377	28,144	96.34	40.39	467.64	204.34	16.12	20.36	201.33	4,534
	Light Industrial	180	14	90	0.40	0.10	2.00	1.20	0.07	0.22	0.00	20
	Other Urban	3,567	283	2,200	10.53	2.31	48.77	16.90	1.70	7.47	6.46	294
	Open	7,344	20	1,424	7.70	2.10	41.87	21.73	0.52	2.10	4.59	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	464,344	28,443	254,184	1,516.13	404.37	4,543.46	2,841.44	144.33	571.26	794.23	11,844
[illegible]	Single-family	8,114	476	3,917	22.78	6.90	120.30	51.76	2.66	9.79	9.79	84
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	1,259	98	629	3.01	1.36	13.99	8.39	0.50	1.57	4.85	164
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	9,372	574	4,546	26.79	8.25	134.29	60.15	3.16	11.37	14.63	248
[illegible]	Single-family	78,780	4,140	34,120	207.25	68.58	1,008.26	401.04	23.16	65.33	80.33	781
	Multi-family	34,289	3,019	8,820	42.13	8.83	263.97	67.96	6.79	20.90	28.82	1,455
	Commercial	20,252	797	5,126	24.40	20.25	112.91	68.25	4.10	22.81	30.33	1,250
	Public	6,655	510	3,327	15.90	6.66	73.94	44.36	2.66	8.32	25.66	833
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	301,575	6,479	51,419	281.75	86.40	1,399.28	631.60	36.72	126.36	174.33	4,250
[illegible]	Single-family	4,347	255	2,096	12.74	2.75	64.45	27.73	1.42	2.25	5.25	45
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	1,619	126	809	3.57	1.62	17.99	10.79	0.65	2.02	6.24	198
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,965	381	2,905	16.41	3.37	82.43	38.52	2.07	7.27	11.49	243
[illegible]	Single-family	4,926	289	2,378	14.44	4.25	73.04	31.42	1.61	3.85	3.85	51
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,926	289	2,378	14.44	4.25	73.04	31.42	1.61	3.85	3.85	51

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	4,826	289	2,378	14.44	4.25	73.84	31.42	1.61	3.85	3.85	31
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,826	289	2,378	14.44	4.25	73.84	31.42	1.61	3.85	3.85	31
[illegible]	Single-family	2,318	136	1,110	6.79	2.00	34.37	14.79	0.76	2.00	2.00	24
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,318	136	1,110	6.79	2.00	34.37	14.79	0.76	2.00	2.00	24
BW 13	Single-family	58,323	3,440	28,397	172.41	58.71	872.30	375.35	10.37	70.99	70.99	600
	Multi-family	2,311	180	1,159	7.43	1.86	28.71	11.50	1.30	2.28	4.84	264
	Commercial	1,619	126	800	3.87	1.43	17.59	10.79	0.65	2.02	6.24	100
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	62,960	3,734	30,763	183.71	61.49	918.94	398.03	21.12	78.39	81.79	1,070
SMB 141	Single-family	2,900	170	1,300	8.40	2.30	42.97	18.49	0.95	3.50	3.00	30
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	200	13	130	0.62	0.13	2.40	1.00	0.10	0.44	0.36	3
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,100	183	1,320	9.11	2.43	45.36	19.46	1.05	3.94	3.36	33
SMB 142	Single-family	4,826	289	2,378	14.44	4.25	73.84	31.42	1.61	3.85	3.85	31
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,826	289	2,378	14.44	4.25	73.84	31.42	1.61	3.85	3.85	31
SMB 143	Single-family	4,347	265	2,088	12.74	3.75	64.43	27.73	1.42	3.25	3.25	46
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,347	265	2,088	12.74	3.75	64.43	27.73	1.42	3.25	3.25	46
SMB 144	Single-family	2,798	240	2,798	16.99	5.00	85.93	36.97	1.90	4.99	4.99	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	2,798	240	2,798	16.99	5.00	85.93	36.97	1.90	4.99	4.99	60

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO3+NO2	Total Cu	Total Pb	Total Zn	Oil & Grease
		POLLUTANT LOADINGS (POUNDS PER YEAR)										
SMB 165	Single-family	4,904	408	3,337	20.38	6.00	103.12	44.36	2.38	8.39	8.39	72
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,904	408	3,337	20.38	6.00	103.12	44.36	2.38	8.39	8.39	72
SMB 166	Single-family	4,037	220	1,954	11.90	3.30	60.13	25.86	1.33	4.90	4.90	42
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	200	14	90	0.43	0.14	2.00	1.20	0.07	0.22	0.49	22
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,237	232	2,044	12.33	3.44	62.13	27.06	1.40	5.12	5.39	64
SMB 167	Single-family	4,347	253	2,098	12.74	3.75	64.45	37.73	1.42	3.25	3.25	45
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,347	253	2,098	12.74	3.75	64.45	37.73	1.42	3.25	3.25	45
SMB 168	Single-family	17,096	1,802	8,253	38.11	14.74	253.50	189.86	3.00	20.43	20.43	177
	Multi-family	2,308	363	1,429	6.11	1.43	28.38	38.59	1.30	4.84	4.18	202
	Commercial	3,214	406	2,608	12.46	5.32	57.85	34.77	2.09	6.52	20.11	627
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	24,620	2,573	12,290	60.36	21.34	337.83	254.83	6.79	31.59	44.82	1,006
SMB 169	Single-family	6,375	374	3,078	16.40	3.50	94.53	40.67	2.09	7.40	7.40	46
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,375	374	3,078	16.40	3.50	94.53	40.67	2.09	7.40	7.40	46
SMB 170	Single-family	1,139	48	360	3.40	1.00	17.19	7.39	0.34	1.40	1.40	12
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,139	48	360	3.40	1.00	17.19	7.39	0.34	1.40	1.40	12
SMB 171	Single-family	4,926	289	2,370	14.06	4.25	73.04	31.42	1.61	5.86	5.85	51
	Multi-family	420	30	260	1.38	0.26	4.80	2.00	0.20	0.96	0.76	44
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	5,346	319	2,630	15.44	4.51	77.84	33.42	1.81	6.82	6.70	95

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POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 172	Single-family	7,534	442	3,637	22.88	6.40	111.71	48.86	3.47	9.80	9.80	78
	Multi-family	28,701	764	6,625	31.59	6.42	122.30	80.96	3.10	22.43	30.36	1,121
	Commercial	4,676	264	2,338	11.17	4.44	51.86	31.18	1.57	2.85	16.83	572
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	22,912	1,370	12,600	64.45	17.80	285.57	150.20	9.43	37.26	46.49	1,771
SMB 173	Single-family	2,477	206	1,679	20.19	2.80	51.86	22.18	1.14	4.20	4.20	36
	Multi-family	4,826	343	2,966	14.25	2.59	21.16	22.96	2.30	10.11	8.73	306
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	7,303	549	4,646	34.44	5.39	106.71	45.16	3.44	14.31	12.93	342
B11105	Single-family	325,639	20,113	252,737	1,540.67	451.14	7,792.96	3,321.22	172.19	634.30	634.30	8,638
	Multi-family	80,713	5,770	30,010	234.51	30.01	923.26	304.69	28.47	309.36	346.16	8,443
	Commercial	55,036	4,281	37,518	131.47	15.04	611.51	264.91	22.01	66.79	212.19	6,727
	Public	77,698	6,043	38,849	185.61	77.70	863.31	517.99	31.86	97.12	289.57	9,486
	Light Industrial	4,676	264	2,338	11.17	4.44	51.86	31.18	1.57	2.85	16.83	572
	Other Urban	44,904	3,207	37,796	132.57	37.80	512.19	213.13	21.38	94.80	81.25	4,704
	Open	7,344	30	1,424	2.79	2.10	41.97	21.73	0.82	2.10	6.59	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	596,083	39,509	401,693	2,247.30	670.45	10,799.15	4,681.34	287.83	1,071.60	1,301.22	33,600
B13407	Single-family	32,934	1,936	15,847	96.12	28.40	489.81	210.73	10.82	30.57	30.57	242
	Multi-family	1,888	135	1,300	5.58	1.57	21.58	8.99	0.80	3.06	3.42	98
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	34,822	2,071	17,146	102.40	30.43	511.39	219.72	11.72	43.83	43.39	340
B04150	Single-family	65,867	2,573	31,896	182.84	26.95	979.42	431.46	20.64	70.74	70.74	623
	Multi-family	37,441	1,963	17,816	81.16	17.82	314.13	130.50	13.80	57.50	40.74	2,530
	Commercial	3,237	252	1,619	7.73	3.34	25.97	21.54	1.20	4.85	12.42	306
	Public	23,547	2,324	14,299	68.32	28.40	317.75	180.45	11.44	22.75	130.26	2,408
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	480	2	95	0.32	0.14	2.80	1.45	0.00	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	130,579	8,314	64,823	351.57	108.35	1,640.28	766.04	47.32	177.26	263.66	3,434
SMB 174	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	420	30	300	1.34	0.36	4.80	2.80	0.30	0.00	0.74	44
	Commercial	2,576	404	2,708	22.32	2.54	61.86	37.37	2.25	6.97	21.80	601
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	20,895	1,364	11,820	56.37	11.82	201.25	98.93	0.80	40.01	26.83	2,600
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	23,890	1,828	14,848	78.93	17.46	284.57	130.10	11.83	47.26	34.81	2,726
SMB 175	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	8,393	680	5,306	24.78	3.30	95.52	20.97	4.80	17.59	25.19	979
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,728	135	1,659	3.85	1.69	31.18	12.99	1.30	3.72	4.04	386
	Open	979	4	350	1.04	0.25	5.60	2.90	0.11	0.25	0.25	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	12,100	796	7,674	33.57	7.36	132.69	33.34	5.41	23.34	31.80	1,365

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR)										
		TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
[illegible]	Single-family	184,572	10,577	69,249	341.87	109.57	2,741.21	1,779.36	60.34	222.12	222.12	1,912
	Multi-family	28,577	2,036	17,466	64.25	17.67	326.14	135.59	13.59	39.79	51.64	2,590
	Commercial	7,914	344	2,567	16.76	7.01	77.94	46.76	2.51	8.77	27.04	657
	Public	7,374	374	2,467	17.42	7.37	81.93	49.16	2.05	8.22	28.43	901
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	200	15	120	0.42	0.13	2.40	1.80	0.10	0.44	0.38	22
	Open	3,575	24	1,139	6.34	1.68	23.57	17.39	0.66	1.68	3.38	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	232,443	14,024	113,571	447.33	143.34	3,261.19	2,029.34	80.67	282.02	333.49	6,443
[illegible]	Single-family	222,893	12,861	106,725	648.00	180.80	2,771.28	1,410.42	72.43	284.84	284.84	2,287
	Multi-family	22,770	849	7,534	28.93	7.53	120.89	57.85	5.89	21.56	22.82	1,373
	Commercial	180	14	90	0.43	0.11	2.00	1.20	0.07	0.22	0.49	22
	Public	28,791	829	3,396	25.78	16.79	319.80	71.94	4.32	12.49	61.61	1,319
	Light Industrial	5,316	406	2,408	12.46	3.32	57.85	34.77	1.89	4.53	28.11	437
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	37,418	112	3,314	28.10	7.23	104.57	81.14	3.88	7.83	34.62	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	276,644	15,201	127,678	813.73	222.15	3,333.39	1,617.42	87.77	330.40	373.19	5,441
[illegible]	Single-family	148,071	8,459	71,483	424.80	127.45	2,196.34	944.59	48.51	178.71	178.71	1,532
	Multi-family	34,341	1,779	15,844	71.06	15.87	271.18	113.91	11.59	51.80	44.84	2,130
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	20,432	811	3,314	34.92	10.43	113.91	69.34	4.17	12.84	40.32	1,575
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	100	1.04	0.28	3.40	2.00	0.11	0.28	0.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	183,823	11,054	91,006	531.02	153.43	2,595.22	1,132.94	64.34	243.03	263.83	5,237
[illegible]	Single-family	70,484	4,471	30,400	222.86	68.70	1,181.85	300.34	26.10	96.17	96.17	884
	Multi-family	3,575	420	2,437	17.35	3.44	67.13	37.08	2.80	12.31	10.42	414
	Commercial	23,410	965	6,385	20.45	12.41	127.09	82.73	4.96	15.51	47.83	1,517
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	97,572	6,004	44,311	280.36	84.74	1,304.39	418.48	28.87	124.80	154.43	2,957
[illegible]	Single-family	289,782	22,394	101,579	614.91	180.86	3,110.71	1,338.33	68.72	283.20	283.20	2,170
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	24,836	224	10,431	58.19	15.67	313.35	162.37	6.16	18.67	48.24	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	294,624	22,322	111,910	673.10	196.52	3,424.06	1,500.60	74.88	284.86	283.44	2,170
[illegible]	Single-family	28,307	1,448	12,840	82.38	24.13	406.77	179.31	9.21	28.82	28.82	291
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,090	230	1,340	6.44	2.79	39.36	17.59	1.08	3.57	10.40	230
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,394	22	1,044	5.72	1.54	28.78	15.34	0.80	1.54	4.04	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	36,191	1,579	15,942	94.54	28.47	477.32	213.23	10.19	34.13	48.16	521
[illegible]	Single-family	77,368	4,535	37,330	224.77	64.70	1,147.18	492.83	25.34	92.38	92.38	800
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	11,261	46	2,103	11.95	3.22	64.33	33.32	1.26	3.32	10.11	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	88,629	4,581	39,533	236.72	68.91	1,211.53	526.14	26.61	94.59	103.49	800

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
BW17	Single-family	33,577	3,139	33,819	157.57	46.46	799.16	303.82	37.46	65.85	65.85	333
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	4,576	264	2,338	11.77	4.48	81.86	31.18	1.57	8.85	28.85	372
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	3	95	0.52	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	38,043	3,333	33,432	306.46	51.38	833.82	336.43	38.38	71.03	83.33	[illegible]
MT2911	Single-family	3,506	320	2,438	36.14	4.73	81.63	35.12	1.80	4.44	4.44	37
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,506	320	2,438	36.14	4.73	81.63	35.12	1.80	4.44	4.44	37
MT2912	Single-family	4,857	238	1,834	11.59	2.30	60.15	28.84	1.33	4.80	4.80	42
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	4,857	238	1,834	11.59	2.30	60.15	28.84	1.33	4.80	4.80	42
MT1302	Single-family	8,114	476	3,917	23.78	6.99	120.30	31.76	2.46	9.79	9.79	84
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,114	476	3,917	23.78	6.99	120.30	31.76	2.46	9.79	9.79	84
MT34	Single-family	16,997	985	8,114	48.28	14.49	249.20	107.21	3.31	20.28	20.28	774
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	390	1.04	0.28	2.60	2.90	0.11	0.28	0.81	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	17,766	989	8,503	50.30	14.77	254.80	110.11	3.42	20.56	21.36	774
SMB103	Single-family	7,344	428	3,497	21.58	6.35	107.41	46.71	2.57	8.74	8.74	75
	Multi-family	2,346	375	3,347	25.40	3.35	70.85	34.58	2.30	10.59	9.49	390
	Commercial	7,354	568	3,777	18.85	7.33	83.93	58.34	2.82	0.44	28.12	880
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	20,044	1,367	10,522	54.77	17.85	251.30	121.33	7.19	20.13	47.36	1,346
SMB105	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	23,839	974	8,443	40.57	8.44	153.88	64.85	6.49	28.51	24.68	1,429
	Commercial	240	28	180	0.86	0.36	4.80	2.40	0.14	0.43	1.39	44
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	3	95	0.52	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	24,488	1,804	8,718	41.65	8.94	162.67	68.79	6.60	29.17	26.51	1,473

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil Grease
SMB 187	Single-family	26,301	2,157	27,366	107.34	31.72	543.66	234.76	12.06	44.41	44.41	381
	Multi-family	4,406	315	2,726	13.01	2.73	30.36	20.98	2.10	8.33	7.37	462
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,606	210	1,340	6.44	2.70	29.38	17.50	1.08	2.37	10.40	330
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	400	2	65	0.52	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	44,304	2,684	31,237	127.84	37.30	628.60	273.18	15.29	57.16	63.23	1,173
SMB 191	Single-family	8,863	527	4,337	26.33	7.34	133.19	57.30	2.94	10.84	10.84	93
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,863	527	4,337	26.33	7.34	133.19	57.30	2.94	10.84	10.84	93
SMB 192	Single-family	19,594	1,172	9,432	34.60	17.34	296.46	127.33	6.33	24.13	24.13	207
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	19,594	1,172	9,432	34.60	17.34	296.46	127.33	6.33	24.13	24.13	207
SMB 193	Single-family	15,937	934	7,094	46.71	13.74	236.31	101.67	3.22	19.23	19.23	305
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,406	18	854	4.68	1.26	25.11	13.04	0.49	1.26	3.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	20,344	952	8,548	51.39	15.00	261.49	114.71	3.72	20.49	23.19	3[illegible]
SMB 194	Single-family	6,375	374	2,878	18.49	5.50	94.52	40.87	2.09	7.69	7.69	66
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,427	14	664	3.64	0.98	19.58	10.14	0.38	0.98	3.08	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	9,802	388	3,542	22.32	6.47	114.11	50.41	2.47	8.67	10.77	66
SMB 195	Single-family	13,391	682	5,404	33.12	9.74	167.57	72.00	3.70	13.64	13.64	117
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,864	8	380	2.08	0.56	11.19	5.80	0.22	0.56	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	15,254	670	5,833	35.20	10.30	178.76	77.89	3.92	14.20	15.40	117
SMB 201	Single-family	8,863	527	4,337	26.33	7.34	133.19	57.30	2.94	10.84	10.84	93
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	7,014	546	3,507	16.76	7.01	77.84	45.76	2.81	8.77	27.84	487
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	400	2	65	0.52	0.14	2.80	1.45	0.05	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	16,457	1,074	7,939	43.61	14.90	213.93	105.32	5.80	19.75	38.33	580

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ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 202	Single-family	3,306	222	2,438	36.14	4.75	81.43	31.12	1.80	6.64	6.64	57
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	3,306	222	2,434	36.14	4.75	81.43	31.12	1.80	6.64	6.64	57
SMB 203	Single-family	26,517	988	7,974	48.41	14.34	244.90	105.57	5.41	20.93	20.93	171
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	3,597	280	1,790	8.59	3.46	20.57	23.96	1.44	4.50	13.57	440
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	30,114	1,341	9,772	57.20	17.84	264.87	129.33	6.85	24.43	33.80	611
ALTNR1	Single-family	177,066	6,640	84,515	343.13	108.52	1,738.21	744.80	38.35	141.59	141.59	1,311
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	6,445	814	3,337	16.90	6.45	73.94	46.36	2.46	8.22	25.46	813
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	81,201	280	11,846	64.95	17.49	349.72	181.11	6.57	17.49	64.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	264,723	7,630	[illegible]	423.97	132.46	2,160.47	972.27	47.84	167.09	231.80	2,124
BRKTN1	Single-family	48,494	2,647	21,942	133.34	30.22	694.36	300.33	14.90	34.91	34.91	471
	Multi-family	310	16	120	0.62	0.13	2.40	1.00	0.10	0.44	0.38	22
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	3,897	288	1,976	9.45	2.96	43.06	26.36	1.54	4.88	13.26	484
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	28,334	226	3,502	22.21	0.67	173.46	79.83	3.41	8.67	27.26	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	80,016	3,114	29,254	175.63	31.86	894.34	407.42	19.79	46.96	77.80	976
ELNDK1	Single-family	21,543	1,852	25,348	92.56	27.32	468.33	201.49	10.35	38.12	38.12	327
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	24,199	58	2,253	15.07	4.06	81.34	42.02	1.59	4.06	12.75	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	45,742	1,909	28,601	107.64	31.38	549.66	243.51	11.94	42.18	50.87	327
MT1000	Single-family	6,665	391	2,377	19.53	2.73	98.82	42.82	2.18	8.04	8.04	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,958	8	280	2.08	0.56	11.19	2.80	0.32	0.36	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,623	399	2,657	21.61	6.30	110.01	45.31	2.40	8.40	9.80	60
PD1140	Single-family	9,573	544	4,676	37.18	7.99	237.49	98.25	2.04	11.79	11.79	96
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	4,137	222	2,866	9.88	4.14	45.56	27.51	1.43	3.37	15.85	586
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	18,115	74	3,512	19.22	5.18	183.52	23.61	3.03	3.36	16.57	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	31,825	839	10,057	66.28	17.31	294.97	149.36	6.73	21.84	43.41	682

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
PD131	Single-family	20,044	503	7,374	44.16	12.59	223.42	94.12	4.04	18.19	18.19	164
	Multi-family	2,306	145	1,420	6.11	1.43	26.34	10.59	1.30	4.04	4.18	242
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	1,579	84	540	2.38	1.86	11.59	7.19	0.43	1.28	4.16	122
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,404	38	884	4.05	1.26	25.18	13.84	0.49	1.26	2.96	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	22,042	1,130	10,077	34.23	16.76	284.57	127.33	6.96	23.43	28.44	530
PD1406	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	4,434	300	2,577	16.11	2.38	41.25	25.98	2.60	11.43	9.57	372
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,409	6	285	1.36	0.42	8.39	4.35	0.16	0.42	1.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,934	306	2,862	17.47	2.80	70.34	30.33	2.76	11.85	11.10	372
PD0227	Single-family	35,252	2,072	17,044	105.02	30.40	324.18	225.52	11.34	42.67	42.67	366
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	340	42	370	1.39	0.54	6.00	3.60	0.22	0.67	2.08	64
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,884	8	300	2.08	0.56	11.19	5.80	0.22	0.56	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	37,450	2,122	17,714	108.98	31.57	341.57	234.91	12.02	43.90	46.50	432
PD0343	Single-family	47,812	2,080	22,082	148.14	41.32	708.93	288.01	16.44	57.70	57.70	486
	Multi-family	2,357	340	2,071	8.91	2.88	28.37	15.99	1.60	7.00	6.88	283
	Commercial	2,311	186	1,290	6.42	2.52	37.94	16.79	1.01	3.15	0.71	288
	Public	2,311	186	1,290	6.42	2.53	37.94	16.79	1.01	3.15	0.71	288
	Light Industrial	3,237	282	1,610	7.73	2.34	26.07	21.34	1.39	4.86	22.48	386
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	6,833	22	1,520	7.37	1.06	30.17	20.26	0.77	1.06	6.34	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	64,207	3,114	29,425	177.80	53.33	878.40	396.43	21.34	77.04	101.03	1,834
PD0409	Single-family	25,900	1,887	16,367	98.37	20.23	282.70	204.30	11.11	48.82	48.82	281
	Multi-family	2,987	285	2,468	11.77	2.47	48.14	18.86	1.80	8.25	7.21	418
	Commercial	1,790	140	899	4.30	1.30	19.94	11.09	0.72	2.25	6.03	280
	Public	1,790	140	899	4.30	1.30	19.94	11.09	0.72	2.25	6.03	280
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	14,804	40	2,040	18.59	4.30	23.03	42.47	1.45	4.30	23.19	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	36,175	2,412	22,441	135.32	30.49	672.16	282.71	16.09	57.84	75.19	1,200
PORTU1	Single-family	31,585	1,852	18,048	98.48	27.23	458.33	201.40	10.26	30.13	30.13	227
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	40,148	984	7,784	42.61	11.47	229.42	118.80	4.31	11.47	26.85	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	71,733	3,013	23,832	133.14	38.70	687.74	320.29	14.83	40.59	54.17	227
SMB204	Single-family	38,283	1,970	8,810	31.51	15.74	270.06	116.46	5.99	22.00	22.00	189
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,409	6	285	1.36	0.42	8.39	4.35	0.16	0.42	1.52	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	39,724	1,976	9,095	33.07	16.16	279.06	120.80	6.15	22.43	23.53	189

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

CATCHMENT	LAND USE	POLLUTANT LOADINGS (POUNDS PER YEAR)										
		TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB206	Single-family	2,159	68	300	2.40	1.00	17.19	7.39	0.38	1.00	1.40	12
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,596	20	949	2.30	1.00	27.38	14.49	0.33	1.00	4.40	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,655	88	1,260	4.59	2.40	43.36	21.88	0.83	2.33	2.40	12
SMB211	Single-family	4,877	228	1,888	11.59	2.50	68.15	25.88	1.30	4.50	4.50	42
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	12,990	979	6,588	30.08	12.59	179.79	83.93	2.84	15.74	48.34	1,030
	Public	9,773	713	4,546	21.91	9.17	201.92	61.15	3.17	11.47	25.57	1,121
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	24,400	100	4,346	25.91	6.59	230.79	72.44	2.75	4.59	21.08	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	50,300	2,030	17,366	83.66	32.25	441.83	243.41	13.78	20.09	116.79	2,502
SMB213	Single-family	8,314	476	3,917	23.78	6.59	188.30	51.76	2.66	9.79	9.79	84
	Multi-family	6,305	463	4,827	19.30	4.63	94.34	30.98	3.10	12.63	11.77	481
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	490	3	86	0.52	0.14	2.80	1.45	0.08	0.14	0.44	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	15,108	942	8,830	43.31	11.36	287.44	84.18	5.81	22.56	22.00	565
SMB214	Single-family	1,649	55	499	4.35	1.35	21.40	9.34	0.47	1.58	1.58	15
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	7,034	20	1,819	8.31	2.34	44.76	22.18	0.88	2.34	7.88	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	8,283	117	2,318	13.36	3.69	66.25	32.42	1.33	3.90	8.78	15
SMB216	Single-family	7,824	459	3,777	22.90	6.74	116.01	40.01	2.46	8.44	8.44	81
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,875	24	1,130	6.36	1.68	33.57	27.39	0.66	1.68	2.28	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	11,699	483	4,914	28.17	8.42	149.34	67.20	3.32	11.12	14.72	81
SMB217	Single-family	6,904	400	3,397	20.38	6.00	103.12	44.36	2.38	8.50	8.50	72
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	3,437	14	684	3.64	0.96	19.58	20.14	0.36	0.96	3.08	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	10,342	422	4,022	24.02	6.97	122.70	64.51	2.66	9.37	11.47	72
SMB15	Single-family	28,426	1,704	14,688	89.18	26.25	451.14	184.59	9.57	26.72	26.72	305
	Multi-family	4,406	315	2,728	13.01	2.73	88.36	28.58	2.38	9.25	7.97	402
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	11,251	45	2,375	12.47	3.36	67.15	34.77	1.52	3.36	10.55	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	44,313	2,146	19,686	114.66	32.31	544.64	249.15	13.34	40.31	35.25	776

TABLE A-3

ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
FD10961	Single-family	8,983	327	4,337	28.33	7.34	122.19	57.30	2.94	20.84	20.84	60
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	4,836	378	2,428	11.80	4.86	83.96	22.57	1.94	6.57	12.72	384
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	9,792	40	1,598	10.39	2.30	85.96	28.91	1.10	2.30	2.79	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	23,611	944	8,463	46.32	13.40	243.11	114.46	4.86	29.71	28.36	444
FD10962	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	1,979	84	840	2.58	1.08	11.99	7.19	0.43	1.35	4.36	182
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,484	22	1,044	2.72	1.34	28.78	15.94	0.60	1.54	4.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	6,463	106	1,884	5.30	2.42	42.77	23.13	1.04	2.89	9.00	182
FD122	Single-family	23,034	1,836	18,047	96.82	28.48	479.31	200.73	18.82	39.37	39.37	282
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	1,978	184	889	4.73	1.08	21.96	12.19	0.79	2.67	7.43	282
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	28,564	84	2,887	21.82	5.88	177.51	68.85	2.31	5.88	18.47	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	53,576	2,104	20,823	123.37	36.33	629.30	284.77	22.02	48.22	68.36	564
FD200	Single-family	45,777	3,836	31,283	193.80	54.70	975.22	410.41	21.85	79.30	79.30	680
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	3,006	230	1,349	6.44	2.70	39.86	17.80	1.08	3.57	10.40	280
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,920	230	2,819	8.67	1.83	38.57	13.90	1.40	6.16	5.32	381
	Open	10,184	60	2,797	28.70	5.60	111.91	87.85	2.30	5.60	17.90	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	60,997	4,356	38,119	228.70	64.83	1,150.78	530.34	26.33	94.11	113.00	1,318
SMB210	Single-family	7,534	442	3,637	22.08	6.49	113.71	48.86	2.47	9.09	9.09	78
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,484	22	1,044	2.72	1.34	28.78	15.94	0.60	1.54	4.64	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	12,020	464	4,681	24.80	8.83	142.49	64.80	3.07	10.63	13.73	78
SMB219	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	32,730	52	2,462	13.31	3.64	72.74	37.47	1.43	3.64	11.43	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	32,730	52	2,462	13.31	3.64	72.74	37.47	1.43	3.64	11.43	0
SMB220	Single-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	180	14	90	0.43	0.18	2.00	1.38	0.07	0.32	0.69	22
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	979	4	180	1.04	0.28	3.00	2.90	0.11	0.28	0.88	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	1,159	18	280	1.47	0.46	2.30	4.30	0.18	0.60	1.57	22

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TABLE A-3
ANNUAL POLLUTANT LOADINGS FROM SANTA MONICA BAY CATCHMENTS

POLLUTANT LOADINGS (POUNDS PER YEAR)

CATCHMENT	LAND USE	TSS	BOD5	COD	Total P	Soluble P	TKN	NO2+NO3	Total Cu	Total Pb	Total Zn	Oil & Grease
SMB 221	Single-family	1,609	85	609	4.35	1.35	21.40	9.34	0.47	1.75	1.75	13
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	9,732	40	1,790	30.30	2.80	55.96	25.96	1.10	2.80	2.79	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	11,341	125	2,398	34.64	4.05	77.44	34.32	1.57	4.55	[illegible]	13
SMB 222	Single-family	51,579	3,024	24,900	251.38	44.46	784.79	329.84	16.90	62.25	62.25	334
	Multi-family	3,357	240	2,078	8.91	2.80	38.37	15.99	1.00	7.85	6.80	252
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	300	14	90	0.43	0.11	2.80	1.30	0.07	0.22	0.09	22
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	2,346	375	2,347	25.40	2.35	39.35	24.96	2.30	10.09	0.49	284
	Open	20,774	82	3,790	21.30	2.74	114.71	39.40	2.25	2.74	20.03	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	80,436	3,734	34,208	308.31	53.71	979.52	430.61	22.32	84.34	84.34	1,437
SMB 223	Single-family	28,136	1,767	14,540	88.33	25.98	444.84	182.25	9.37	34.57	34.57	313
	Multi-family	430	45	300	1.86	0.39	7.10	2.80	0.30	1.32	1.14	64
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	2,327	282	1,619	7.73	2.34	38.97	21.34	1.39	4.86	12.41	394
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	1,884	8	384	2.88	0.54	11.19	5.80	0.32	0.54	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	[illegible]	2,071	16,836	100.80	30.17	501.20	212.42	11.40	42.30	51.25	773
SMB 224	Single-family	33,613	1,970	16,327	98.32	29.96	480.40	234.43	11.81	40.57	40.57	300
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	4,496	380	2,346	10.74	4.30	40.06	20.96	1.80	8.62	17.34	800
	Public	1,976	154	989	4.73	1.38	21.38	13.19	0.79	2.47	7.43	342
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Open	4,486	18	884	4.46	1.36	25.10	13.04	0.49	1.36	3.86	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	44,494	2,492	20,310	118.46	36.71	565.52	270.43	14.10	49.52	68.40	1,139
SMB 225	Single-family	36,772	2,030	16,707	101.92	29.96	515.90	231.82	11.39	41.57	41.57	300
	Multi-family	3,777	270	2,320	11.16	2.34	43.17	17.09	1.00	7.91	6.85	396
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	8,434	380	3,377	16.11	2.36	62.35	25.06	2.00	11.43	9.57	552
	Open	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	44,825	2,696	22,363	129.16	35.40	621.30	263.79	15.79	61.31	58.67	1,327
SMB 226	Single-family	7,534	442	3,437	22.88	6.40	121.71	48.86	3.47	9.89	9.89	78
	Multi-family	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Commercial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Public	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Light Industrial	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Other Urban	23,882	1,649	14,389	68.15	14.29	263.79	199.91	10.59	48.36	41.77	2,418
	Open	1,056	8	380	2.88	0.56	11.79	5.30	0.32	0.54	1.76	0
	Unknown	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
	Catchment Total	32,574	2,099	18,305	92.31	21.34	394.69	353.77	13.44	58.01	52.42	2,496

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This appendix describes the data collection of 15 small data sets which were used in building the overall compiled larger data set (Data Set A). A description of the Santa Monica Bay Urban Runoff Database (SMBURD) and summary of the average dry and wet weather contaminants concentrations for 22 selected locations of Santa Monica Bay Watershed are also included.

9.1 DATA COLLECTION

Data were collected or obtained from others for this study for major Los Angeles storm drains during both storm-flow and low-flow discharge. The period of observation for the various data sets ranged from November 20, 1967 and December 4, 1990. Trace metal concentrations and organic chemical concentrations in the discharge (runoff) are reported and analyzed. Table B-1 summarizes 15 data sets characterizing inputs to Santa Monica Bay. Some of the data sets are parts of reports and some are raw data sets. Several data sets have many observations and were useful in building our overall data set describing inputs to the Bay. Data sets which have no value for this project are excluded. Detailed descriptions of these 15 data sets are given in Section 9.2.

There are 42,370 observations in the final data set named "Data Set A" which includes data sets from 9 different sources with 47 sampling locations covering much of the Santa Monica Bay Watershed. Table B-2 gives the location (longitude and latitude) of these 47 sampling locations. A general description of the completed Data Set A is given in Table B-3. A smaller data set named "Data Set B" which includes 22 STORET parameters and is sorted by STORET code was extracted from Data Set A. This data set includes observations of special interest, or for locations which had a sufficient number of observations to warrant statistical analysis.. A description of these 22 STORET parameters is shown in Table B-4. Rainfall data for ten National Weather Service gages which are in or near the Santa Monica Bay Watershed were used to separate samples from Data Set B which were not explicitly know to be "wet" or "dry". . A value of 0.2 inches of rain was used as the difference between a "wet" and "dry" day. Results of "wet" and "dry" data are summarized in Section 9.3.

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9.2 DATA DESCRIPTION

An IBM compatible PC program named SMBURD for IBM compatible PC was written and can be used to extract data from the final data set - Data Set A. Figure B-1 is a flowchart which illustrates the main features of SMBURD Program. The installation procedures of SMBURD ver 1.01 for most IBM compatible PCs and a description of SMBURD's output data format are described below. An output sample format at SMBURB is shown in Table B-5.

Table B-1. Status of Individual Data Sets

Source Number	Agency	Data Set or Report Name	Status Code
1	City of Los Angeles and Engineering Science	Santa Monica Bay Stormwater Pollutant Reduction Study	1
2	Science Applications International Corporation (SAIC)	Santa Monica Bay Coliform Database	2
3	California Regional Water Quality Control Board	Surface Water Quality Survey - Santa Monica Bay Input	1
4	County of Los Angeles, Department of Health Services	Advisory Warning - Discharges from Storm Drains into Santa Monica Bay	1
5	Santa Monica Bay Restoration Project	An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses From Two Santa Monica Storm Drains	1
6	SCCWRP	Stormwater Runoff Program	1
7	NOAA	The National Pollutant Discharge Inventory	2
8	California Regional Water Quality Control Board	NPDES Monitoring Reports	2
9	County Sanitation Districts of LA County	Search for Mutagens and Carcinogens in Pico-Kenter Storm Drain	2
10	City of Santa Monica Department of Engineering	Ozone Pilot Plant Demonstration Project for Kenter Canyon Drain	1
11	Los Angeles County Department of Public Works	Los Angeles County Department of Public Works Surface Water Monitoring Program	1
12	National Park Service	Deposition and Processing of Airborne Nitrogen Pollutants in Mediterranean-Type Ecosystems of Southern California	1
13	State Water Resources Control Board	California State Mussel Watch	2
14	Hyperion Treatment Plant	Hyperion Treatment Plant's Coliform Data Set	2
15	US EPA ERLN Pacific Ecosystem Branch	Los Angeles River Loadings of Trace Metals and Synthetic Organics	1

Status Code Legend:
1 = included in the compiled data set
2 = not included in the compiled data set

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Table B-2. 47 Sampling Locations in Santa Monica Bay Watershed.

Location Code	Latitude	Longitude	Station Name
1	34.06444	118.3547	BALLONA CREEK
2	34.04222	118.2661	FIGUEROA ST. & 12TH ST.
3	34.02694	118.2728	ADAMS & HOPE ST.
4	34.05083	118.3272	WINDSOR BLVD 500FT N. OF 12TH ST.
5	34.02917	118.3147	CIMARRON ST. & 29TH ST.
6	34.03418	118.3313	BRONSON AVE.
7	34.04278	118.6833	MALIBU CREEK @ CROSS CREEK RD
8	34.08472	118.7117	MALIBU CREEK @ SALVATION ARMY CAMP
9	34.04111	118.5800	TOPANGA CANYON CREEK US OF PCH(~1000')
10	34.02833	118.5178	SANTA MONICA CANYON @ PCH
11	33.92500	118.4125	CENTINELA CREEK @ CENTINELA AVE.
12	33.99000	118.4108	BALLONA CREEK @ INGLEWOOD AVE.
13	33.99222	118.4067	BALLONA CREEK @ SEPULVEDA CHANNEL
14	33.99222	118.4072	SEPULVEDA CHANNEL @ BALLONA CREEK
15	34.01528	118.4264	SAWTELLE CHANNEL ABOVE SEPULVEDA CHANNEL
16	34.01556	118.4267	SEPULVEDA CHANNEL ABOVE SAWTELLE CHANNEL
17	34.01611	118.3892	BENEDICT CANYON CHANNEL @ BALLONA CREEK
18	34.02306	118.3675	JEFFERSON BLVD DRAIN @ BALLONA CREEK
19	34.03333	118.3742	LA CIENAGA BLVD DRAIN @ BALLONA CREEK
20	34.03833	118.3678	BALLONA CREEK @ FAIRFAX AVE.
21	34.00556	118.4908	PICO-KENTER OUTFALL
22	33.99667	118.4842	ASHLAND AVE STORM DRAIN OUTFALL
23	33.96083	118.4583	BALLONA CREEK OUTFALL
24	34.00889	118.4956	SANTA MONICA PIER STORM DRAIN OUTFALL
25	33.93056	118.4358	IMPERIAL HWY STORM DRAIN OUTFALL
26			AINSWORTH STORM DRAIN OUTFALL
27	33.83611	118.3894	AVENUE I STORM DRAIN
28	34.02806	118.5189	SANTA MONICA CANYON STORM DRAIN OUTFALL
29	34.03833	118.5414	PULGA CANYON STORM DRAIN OUTFALL
30	33.99667	118.4842	ASHLAND AVE US OF OUTFALL
31	34.00639	118.4911	PICO-KENTER US OF OUTFALL
32			DEER CANYON CREEK
33	34.04592	118.9055	LA CHUSA CANYON CREEK
34	34.03856	118.8425	TRANCAS CANYON CREEK
35	34.02426	118.7865	RAMIREZ CANYON CREEK
36	34.03466	118.7435	SOLSTICE CANYON CREEK
37	34.03553	118.7326	CORRAL CANYON CREEK
38	34.03778	118.6481	CARBON CANYON CREEK
39	34.00556	118.4908	PICO-KENTER DRAIN
40	34.09184	118.5646	UPPER SANTA YNEZ CANYON CREEK
41	33.99667	118.4022	BALLONA CRK @ SAWTELLE BLVD
42	33.91500	118.4119	CENTINELA CRK @ CENTINELA BLVD
43	34.70000	118.7331	CORAL CANYON CRK @ PCH
44	34.00056	118.8056	DUME CRK @ ZUMA BEACH
45	34.02917	118.5158	SANTA MONICA CANYON CHANNEL @ SHORT ST.
46	33.99222	118.4072	SEPULVEDA CHANNEL @ CULVER BLVD
47	33.87245	118.33232	I-405 FREEWAY @ REDONDO BEACH BLVD

Note: Blank Latitude and Longitude means missing data

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Table B-3. General Description of the Completed Data Set A.

LOCATION NAME	LATITUDE	LONGITUDE	Number of Observation	Number Below Detection	Number of Different Parameters	Day of First Observation	Day of Last Observation	Location Code
ADAMS & HOPE ST.	34.02694	118.27278	546	439	73	26-Feb-88	23-Nov-88	3
AINSWORTH STORM DRAIN OUTFALL			27	0	3	21-Jul-86	18-Sep-86	26
ASHLAND AVE STORM DRAIN OUTFALL	33.99667	118.48417	25	0	3	21-Jul-86	18-Sep-86	22
ASHLAND AVE U/S OF OUTFALL	33.99667	118.48417	44	0	3	10-Aug-89	29-Sep-89	30
AVENUE I STORM DRAIN	33.83611	118.38944	27	0	3	21-Jul-86	18-Sep-86	27
BALLONA CREEK	34.06444	118.35472	1278	771	86	28-Nov-70	24-Jul-88	1
BALLONA CREEK @ FAIRFAX AVE.	34.03833	118.36778	8267	1123	130	16-Oct-74	5-Dec-90	20
BALLONA CREEK @ INGLEWOOD AVE.	33.99000	118.41083	1076	417	167	28-Nov-70	6-Feb-90	12
BALLONA CREEK @ SEPULVEDA CHNL	33.99222	118.40667	39	38	39	11-Dec-86	11-Dec-86	13
BALLONA CREEK OUTFALL	33.96083	118.45833	25	0	3	21-Jul-86	18-Sep-86	23
BALLONA CRK @ SAWTELLE BLVD	33.99667	118.40722	14441	1218	125	20-Nov-67	5-Dec-90	41
BENEDICT CYN CHNL @ BALLONA CREEK	34.01611	118.38917	39	39	39	20-Apr-87	20-Apr-87	17
BRONSON AVE.	34.03408	118.33125	643	533	73	27-Feb-88	23-Nov-88	6
CARBON CYN CREEK	34.03778	118.64806	1	0	1	25-Mar-82	25-Mar-82	38
CENTINELA CREEK @ CENTINELA AVE.	33.98500	118.41250	1593	245	86	16-Apr-69	23-Jun-87	11
CENTINELA CRK @ CENTINELA BLVD	33.98500	118.41194	1656	977	59	11-May-88	7-Sep-90	42
CIMARRON ST. & 29TH ST.	34.02917	118.31472	721	609	73	28-Feb-88	23-Nov-88	5
CORAL CYN CRK @ PCH	34.70100	118.73306	133	24	19	10-Jun-90	11-Jul-90	43
CORRAL CYN CREEK	34.03553	118.73253	1	0	1	25-Mar-82	25-Mar-82	37
DEER CYN CREEK			1	0	1	25-Mar-82	25-Mar-82	32
DUME CRK @ ZUMA BEACH	34.00056	118.80566	40	7	20	11-May-88	16-Jun-88	44
FIGUEROA ST. & 12TH ST.	34.04222	118.26611	701	573	73	27-Feb-88	14-Apr-88	2
IMPERIAL HWY STORM DRAIN OUTFALL	33.93056	118.43583	27	0	3	21-Jul-86	18-Sep-86	25
I-405 FREEWAY @ REDONDO BEACH BLVD	33.87245	118.33232	300	24	12	11-Jun-81	19-Mar-81	47
JEFFERSON BLVD DRAIN @ BALLONA CREEK	34.02306	118.36750	39	35	39	11-Jun-87	11-Jun-87	18
LA CHUSA CYN CREEK	34.04592	118.90549	1	0	1	25-Mar-82	25-Mar-82	33
LA CIENAGA BLVD DRAIN @ BALLONA CRKE	34.03333	118.37417	39	39	39	11-Jun-87	11-Jun-87	19
MALIBU CREEK @ CROSS CREEK RD	34.04278	118.68333	1266	722	172	15-Dec-86	5-Jun-90	7
MALIBU CREEK @ SALVATION ARMY CAMP	34.08472	118.71167	80	80	41	23-Dec-86	3-May-88	8
PICO-KENTER DRAIN	34.00556	118.49083	3200	300	8	20-Nov-89	19-Nov-90	39
PICO-KENTER OUTFALL	34.00556	118.49083	45	26	31	11-Apr-71	18-Sep-86	21
PICO-KENTER U/S OF OUTFALL	34.00639	118.49111	1723	954	64	11-May-88	7-Sep-90	31
PULGA CYN STORM DRAIN OUTFALL	34.03813	118.54141	27	0	3	21-Jul-86	18-Sep-86	29
RAMIREZ CYN CREEK	34.02426	118.78648	1	0	1	25-Mar-82	25-Mar-82	35
SANTA MONICA CYN @ PCH	34.02833	118.51778	39	39	39	23-Dec-86	23-Dec-86	10
SANTA MONICA CYN CHNLL @ SHORT ST.	34.02917	118.51583	988	382	36	11-May-88	7-Sep-90	45

Table B-3. General Description of the Completed Data Set A (cont'd).

LOCATION NAME	LATITUTE	LONGTITUDE	Number of Observation	Number Below Detection	Number of Different Parameters	Day of First Observation	Day of Last Observation	Location Code
SANTA MONICA CYN STORM DRAIN	34.02986	118.51889	27	0	3	21-Jul-86	18-Sep-86	28
SANTA MONICA PIER STORM DRAIN	34.00889	118.49556	27	0	3	21-Jul-86	18-Sep-86	24
SAWTELLE CHNL ABOVE SEPULVEDA CHNL	34.01528	118.42639	80	79	41	23-Jun-87	14-Apr-88	15
SEPULVEDA CHNL @ BALLONA CREEK	33.99222	118.40722	284	279	148	11-Dec-85	6-Feb-90	14
SEPULVEDA CHNL @ CULVER BLVD	33.99222	118.40722	1307	617	47	11-May-88	7-Sep-90	46
SEPULVEDA CHNL ABOVE SAWTELLE CHNL	34.01556	118.42667	80	80	41	23-Jun-87	14-Apr-88	16
SOLSTICE CYN CREEK	34.03466	118.74349	1	0	1	25-Mar-82	25-Mar-82	36
TOPANGA CYN CREEK US OF PCH(~1000')	34.04111	118.58080	1034	485	77	23-Dec-86	7-Sep-90	9
TRANCAS CYN CREEK	34.03836	118.84245	1	0	1	25-Mar-82	25-Mar-82	34
UPPER SANTA YNEZ CYN CREEK	34.09184	118.56000	1	0	1	25-Mar-82	25-Mar-82	40
WINDSOR BLVD 300FT N. OF 12TH ST.	34.05083	118.32722	390	310	73	27-Feb-88	27-Sep-88	4

Table B-4. 22 STORET Parameters in Data Set B.

STORET Code	STORET Parameter Description
1027	Cadmium, Total (μg/L as Cd)
1042	Copper, Total (μg/L as Cu)
1051	Lead, Total (μg/L as Pb)
1092	Zinc, Total (μg/L as Zn)
310	BOD, 5 Day, 20°C (μg/L)
340	COD, 0.25 N $K_2Cr_2O_7$ (μg/L)
403	pH, Lab, Standard Unit (SU)
515	Residue, Total Filtrable (Dried at 105°C) (μg/L)
550	Oil and Grease (Soxhlet Extraction) Total, Rec., (μg/L)
608	Nitrogen, Ammonia, Dissolved (μg/L as N)
615	Nitrite Nitrogen, Total (μg/L as N)
620	Nitrate Nitrogen (μg/L as N)
650	Phosphate, Total (μg/L as PO_4)
680	Carbon, Total Organic (μg/L as C)
95	Specific Conductance (μmhos/cm @ 25°C)
31505	Coliform, Tot, MPN, Confirmed Test, 35°C (Tube 31506)
530	Residue, Total Nonfiltrable (μg/L)
31615	Fecal Coliform, MPN, EC Med, 44.5°C (Tube 31614)
610	Nitrogen, Ammonia, Total (μg/L as N)
31616	Fecal Coliform, Mbr Filter, M-FC Broth, 44.5°C
70507	Phosphorus, in Total Orthophosphate (μg/L as P)
31673	Fecal Streptococci, Mbr Filt, KF Agar, 35°C, 48 hours

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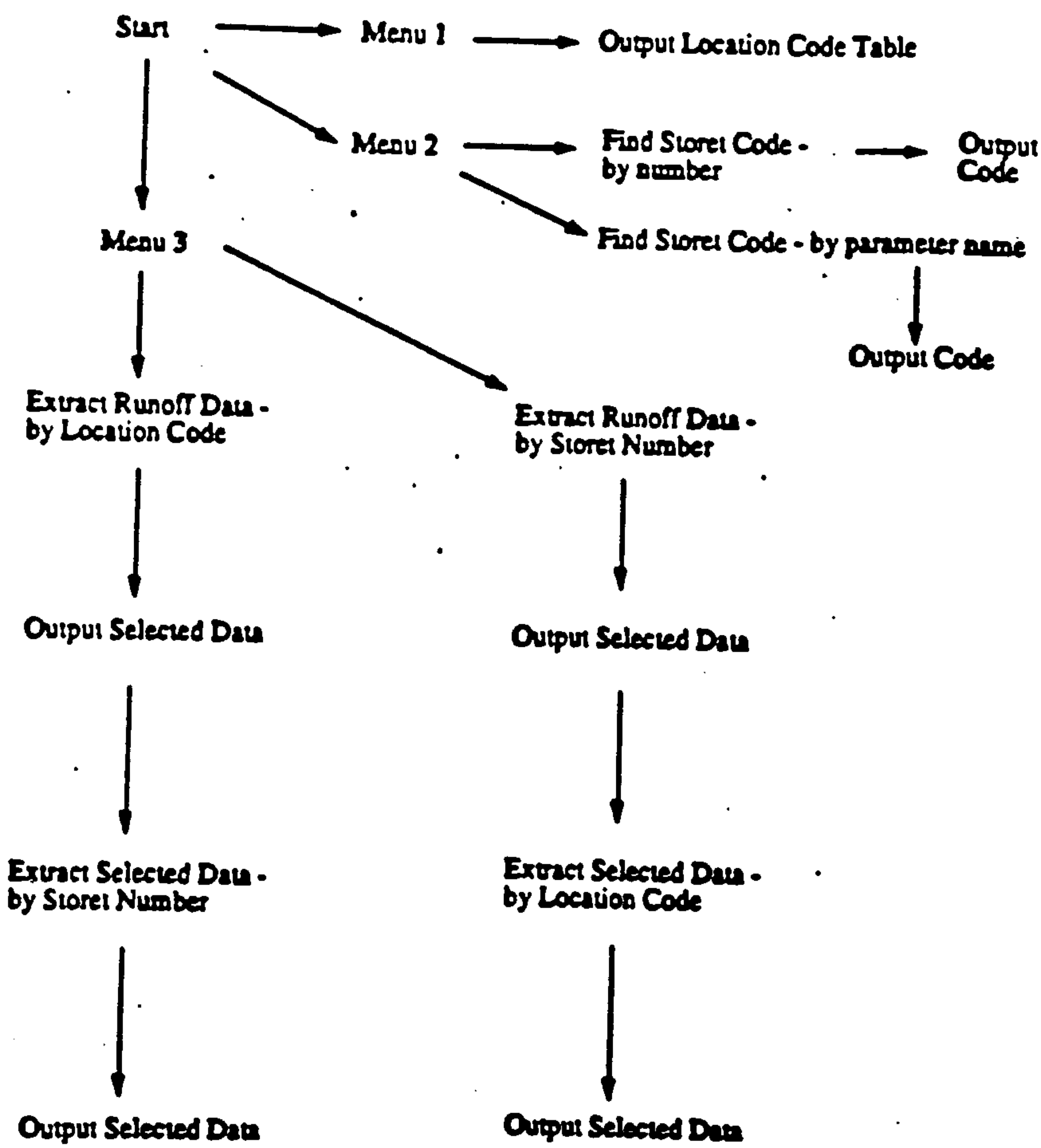

Figure B-1. Overview of SMB Runoff Program.

Table B-5 Output Sample Format of SMBURD ver 1.01

Storet	Concentrat.	Detect.	L.	Date	Time	So.	M.	Q.	St.	Flow	Interval	Mas
1025	20.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
1049	710.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
1090	2200.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
830	166000.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
815	417000.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
340	478000.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
71851	1300.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
612	4600.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
625	1700.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
85313	.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
71886	730.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0
1022	900.000	-2.000	47	11JAN81	-2	3	1	1	1	-2.00	-2.00	-2.0

Note Variable names are not included in the output data files. Some of the above variable names are abbreviated.

9.2.1 Santa Monica Bay Urban Runoff Database (SMBURD) Program Installation

To install SMBURD 1.01 from the disk drive

1. Create a sub-directory on the hard drive.
   For example, at the command prompt C:\, type md smburd and press ENTER.

2. Insert the SMBURD 1.1 disk into a floppy drive, and change to the drive letter of the floppy drive.
   For example, to switch to the A drive, at the command prompt A:\ and press ENTER.

3. At the command prompt A:\, copy all files to the hard disk.
   For example, at the command prompt A:\ , type copy *.* C:\smburd and press ENTER.

4. Uncompress the data file named file.zip using pkunzip.exe.
   For example, at the command prompt C:\smburd, type pkunzip file.zip and press ENTER.

Running the SMBURD Program

1. Type Runoff and press ENTER. A series of menu will be presented.

```
SANTA MONICA BAY URBAN RUNOFF DATABASE PROGRAM
              Version 1.01
  *******    WELCOME TO MAIN MENU    ************
  ***********************************************
  * Menu  1: Location Code Menu                 *
  * Menu  2: Storet Code Menu                   *
  * Menu  3: S.M.B. Runoff database Menu        *
  * Menu  4: Return back to DOS                 *
  ***********************************************
```

Menu 1: To view the Location Name, Location Code, Latitude and Longitude.
Menu 2: To view the Storet Code and its description.
Menu 3: To view the SMB Runoff Databse.

Note: There are 42,370 observations and 13 variables in each observation. Each variable is separated by one or more blank space. Variables are output in the following order: Storet, Concentration, Detection Limit, Location Code, Date, Time, Source, Method, Quality, Storm, Flow rate, Interval, Mass.

2. Format:

   Concentration: Most of the data in this database are in µg/L.
   For bacteria, use MPN or CFU per 100 ml.
   - MPN = Most Probable Number - statistical method. (Most of the data)

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- CFU = Colify Forming Units - actual count of cells. (SMBRP data)

Detection Limit:	in µg/L.
Time:	Hour:min. Example, 1310 = 1:10 pm.
Source:	See attached sheet
Method:	1 = Grab Sample; 2 = Composite Sample over 24 hours.
Quality:	1 = Best available data; 2 = Medium; 3 = Lowest.
Storm:	0 = Dry weather flow conditions; 1 = Wet weather flow conditions; 2 = Not specified.
Flow rate:	Units are in CMS (cubic meters per sec).
Interval:	To be used with flow rate.
Mass:	Units are in grams. Mass = Concentration*Flow rate*Interval.

Note: Variable = -2 or -2.000 means missing data.
Concentration = -1 or -0.000 means not detected.

9.3 RESULTS AND DATA ANALYSIS

9.3.1 Wet annd Dry Data Analysis

Twenty-two STORET parameters have been selected and merged with rainfall data from ten National Weather Service gages in order to extract true "wet" weather data from Data Set A which has unspecified "storm" or "no storm" conditions. A new variable NSTORM (NSTORM = 1) is used to indicate the additional "wet" weather data extracted from Data Set A. As a results, an additional 829 "wet" weather observations are gained to give a total of 1,129 "wet" weather observations for the 22 selected STORET parameters. Statistical analysis is performed on these "wet" weather data and the results are shown in Table B-6.

In addition to the "wet" weather data, "dry" weather data were also extracted from Data Set A and statistical analysis is also performed on these data (Table B-7). Statistical analysis can only be done on limited locations as there is insufficient number of observations on most sampling locations to warrant this analysis.

9.3.2 Sample Histograms

As mentioned in the above sections, Data Set B consists of the extracted data of 22 different STORET parameters in 47 sampling locations of Santa Monica Bay Watershed. Based on the obtained results ("wet" and "dry" weather data), histogram was plottedfor each STORET parameters (Figures B-2 -23).

Table B-6. Statistical Analysis of Wet Weather Data (cont'd).

STORET #	N	MEAN	MAX	MIN	STD DEV	SUM	VAR	USS	CSS	STD MEAN	Percentile 0.25	Percentile 0.50	Percentile 0.75	Percentile 0.90
Location = 41														
1027	38	15	30	1	15	554	1.70E+02	1.44E+04	6.30E+03	2	3	5	30	30
1042	19	41	120	19	28	782	7.94E+02	4.65E+04	1.43E+04	6	20	31	50	88
1051	18	96	500	10	132	1,728	1.74E+04	4.61E+05	2.96E+05	31	48	50	86	410
1092	19	368	1,000	60	269	6,990	7.24E+04	3.87E+06	1.30E+06	62	230	310	570	980
310	62	13,516	45,000	2,000	9,158	838,000	8.39E+07	1.64E+10	5.12E+09	1,163	6,000	12,000	17,000	25,700
31616	28	46,025	430,000	800	89,436	1,288,700	8.00E+09	2.75E+11	2.16E+11	16,902	5,525	13,500	33,250	137,000
340	42	70,762	132,000	15,000	29,439	2,972,000	8.67E+08	2.46E+11	3.55E+10	4,542	52,250	69,000	92,000	111,300
403	70	7	8	6	1	488	2.65E-01	3.42E+03	1.83E+01	0	7	7	7	8
530	34	152,529	476,000	24,000	97,963	5,186,000	9.60E+09	1.11E+12	3.17E+11	16,801	89,500	124,000	191,000	210,000
550	34	17,553	240,000	0	56,502	596,800	3.19E+09	1.16E+11	1.05E+11	9,690	2,000	4,000	4,500	10,000
608	24	533	1,300	10	486	12,790	2.36E+05	1.22E+07	5.43E+06	99	93	445	908	1,300
610	40	344	1,630	0	461	13,770	2.13E+05	1.30E+07	8.30E+06	73	0	119	583	1,070
615	10	342	1,000	60	382	3,420	1.46E+05	2.49E+06	1.31E+06	121	83	90	603	1,000
620	58	1,283	4,290	0	1,210	74,398	1.46E+06	1.79E+08	8.35E+07	159	50	900	1,783	3,200
680	18	24,956	42,000	13,500	9,037	449,200	8.17E+07	1.26E+10	1.39E+09	2,130	19,340	24,000	28,625	42,000
70507	21	299	910	10	236	6,270	5.56E+04	2.98E+06	1.11E+06	51	90	260	425	670
95	80	264	2,100	65	350	21,120	1.22E+05	1.52E+07	9.64E+06	39	99	155	237	636
Location = 47														
340	31	181,806	724,000	23,000	192,502	5,636,000	3.71E+10	2.14E+12	1.11E+12	34,574	53,000	111,000	220,000	535,600
515	32	123,281	461,000	16,000	115,989	3,945,000	1.35E+10	9.03E+11	4.17E+11	20,504	45,250	83,500	158,750	357,100
530	33	1,292,576	15,800,000	18,000	3,611,894	42,655,000	1.31E+13	4.73E+14	4.18E+14	628,750	41,000	102,000	256,500	3,956,000

Note: Refer to Tables B-2 and B-4 for the description of location codes and storet numbers, respectively.

Table B-7. Statistical Analysis of Dry Weather Data.

Storet Number	No. of value	Mean	Standard Dev.	Min. Value	Max. Value	Std Error of Mean	Sum	Variance	C.V
Location = 21									
31505	11	6,531	7,608	80	24,000	2,294	71,840	5,788,589	116
Location = 31									
1027	29	8	25	0	110	5	220	605	324
1042	29	35	53	0	230	10	1,014	2,765	150
1051	29	68	116	0	460	22	1,975	13,458	170
1067	27	6	22	0	110	4	170	493	353
1092	29	71	77	0	370	14	2,070	5,962	108
310	29	8,548	20,414	0	99,000	3,791	247,900	416,716,872	239
31505	29	318,732	633,812	230	3,300,000	117,696	9,243,230	4.02E+11	199
31615	29	16,567	29,561	20	130,000	5,489	480,430	873,874,823	178
31616	15	19,020	24,179	783	75,991	6,243	285,292	584,624,313	127
530	29	2,456,103	3,686,927	406,000	20,024,000	684,645	71,227,000	1.36E+13	150
550	29	2,519	3,231	0	11,900	600	73,040	10,438,069	128
610	29	903	901	0	3,760	167	26,190	811,960	100
615	29	159	515	0	2,600	96	4,600	264,848	324
620	29	1,514	1,113	0	3,820	207	43,890	1,239,074	74
650	29	549	435	60	2,250	81	12,940	189,055	79
680	29	5,171	6,728	0	23,030	1,249	149,970	45,264,720	130
Location = 39									
31505	417	1,519,199	3,492,048	3,300	54,000,000	171,006	633,505,800	1.22E+13	230
31615	417	171,222	688,394	4	79,000,000	33,711	71,399,751	4.74E+13	402
515	412	107,243	508,118	1,100	6,540,000	25,033	44,184,200	2.58E+10	474
530	414	818,887	864,055	231,000	8,909,000	42,466	339,019,000	7.46591E+11	106
680	413	19,695	15,334	2,260	115,000	755	8,134,170	235,127,808	78
Location = 22									
31505	10	12,210	12,436	17	24,000	3,933	122,096	154,660,919	102
31615	10	4,573	7,492	7	24,000	2,369	45,728	56,133,286	164

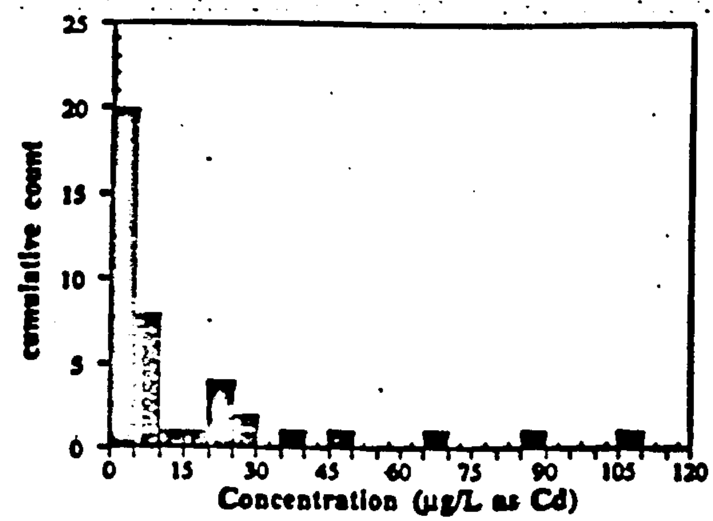

Figure B-2. Histogram Plot for STORET Code = 1027 (Cadmium, Total)

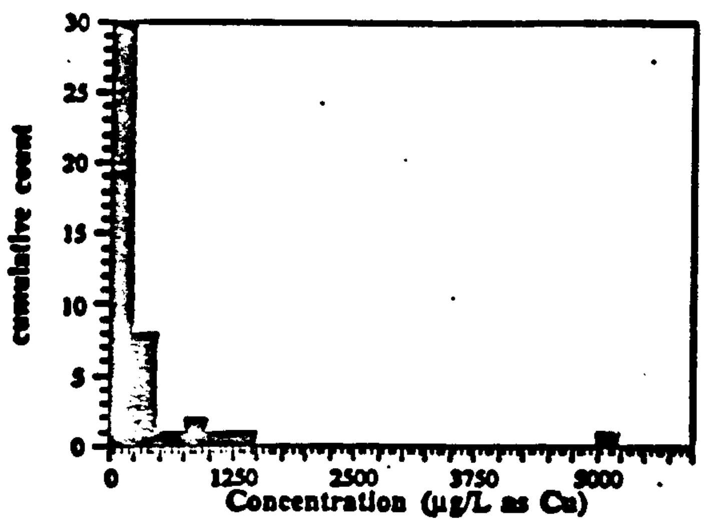

Figure B-3. Histogram Plot for STORET Code = 1042 (Copper, Total).

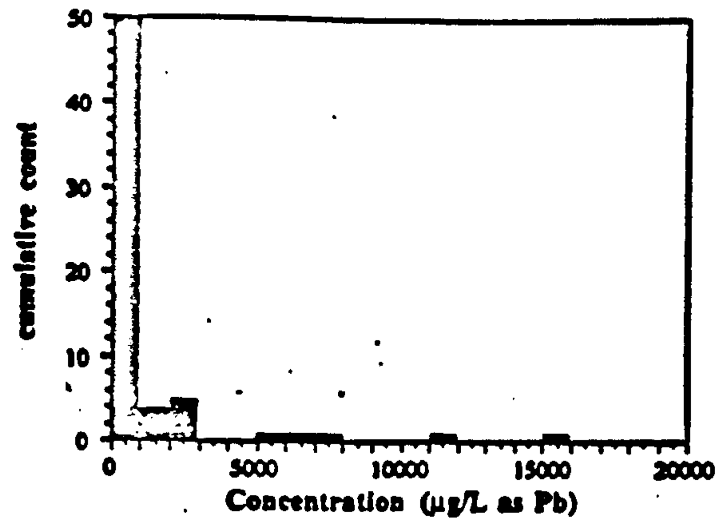

Figure B-4. Histogram Plot for STORET Code = 1051 (Lead, Total).

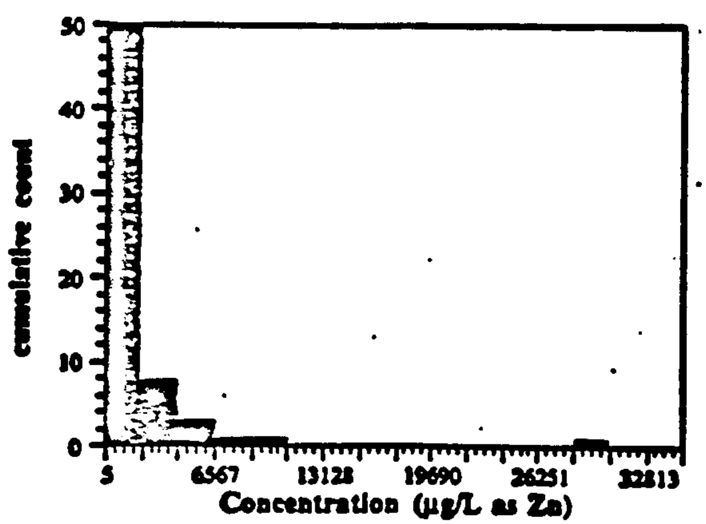

Figure B-5. Histogram Plot for STORET Code = 1092 (Zinc, Total).

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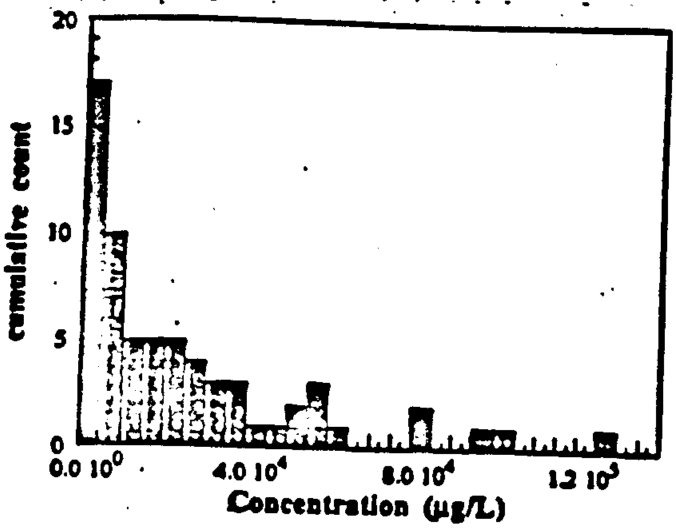

Figure B-6. Histogram Plot for STORET Code = 310 (BOD, 5 Day, 20°C).

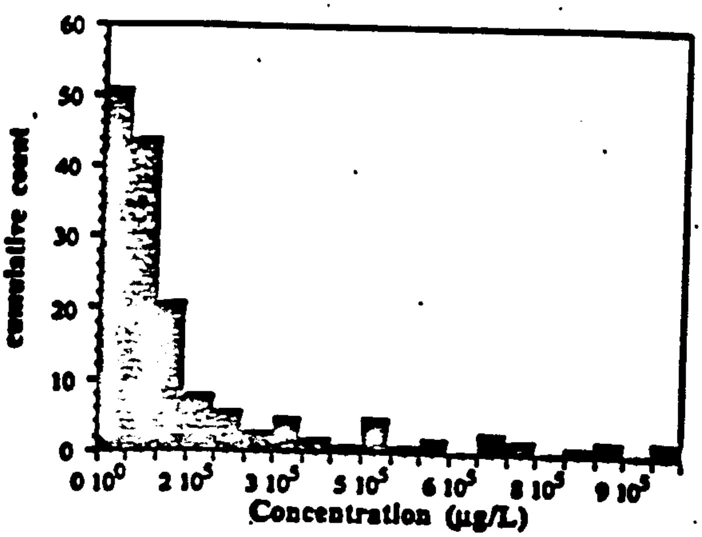

Figure B-7. Histogram Plot for STORET Code = 340 (COD, 0.25 N $K_2Cr_2O_7$).

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R0049609

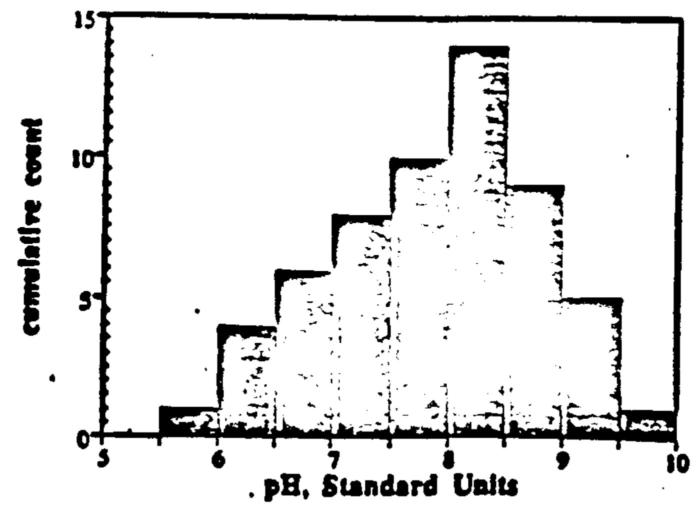

Figure B-8. Histogram Plot for STORET Code = 403 (pH, Lab).

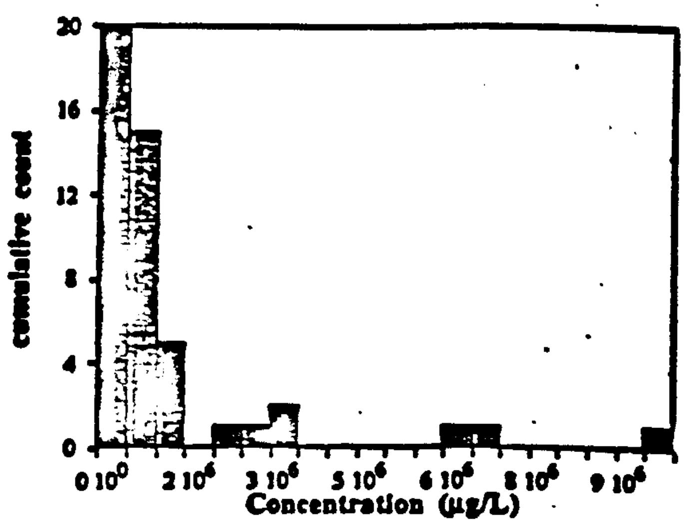

Figure B-9. Histogram Plot for STORET Code = 515 (Residue, Total Filtrable).

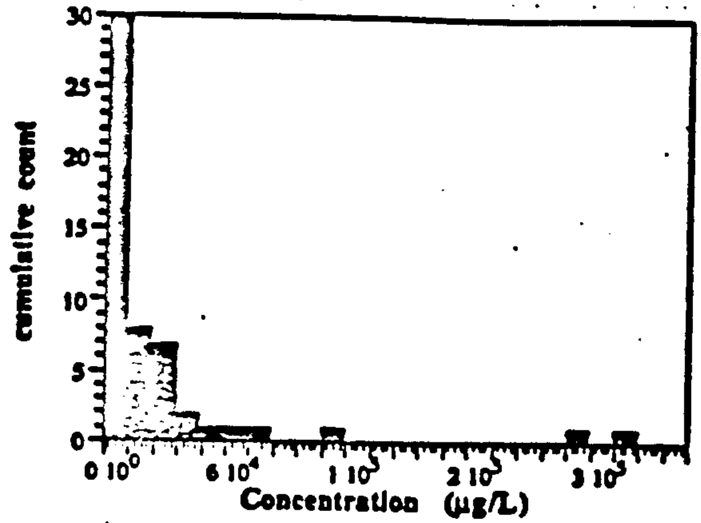

Figure B-10. Histogram Plot for STORET Code = 550 (Oil and Grease, Total).

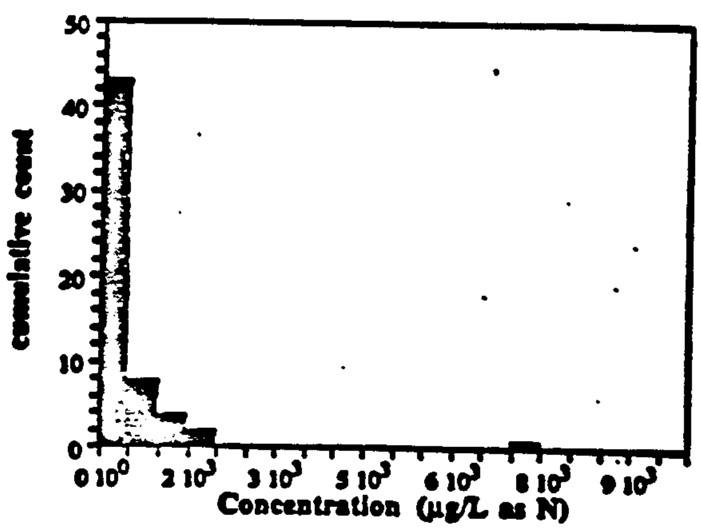

Figure B-11. Histogram Plot for STORET Code = 608 (Nitrogen, Ammonia, Dissolved).

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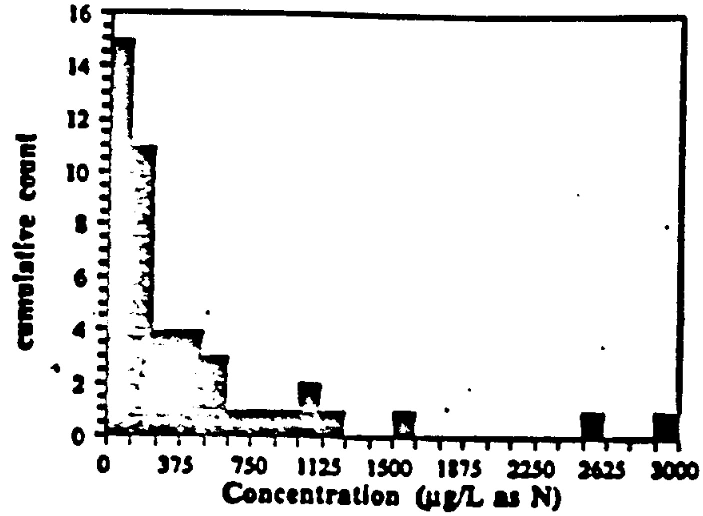

Figure B-12. Histogram Plot for STORET Code = 615 (Nitrite Nitrogen, Total).

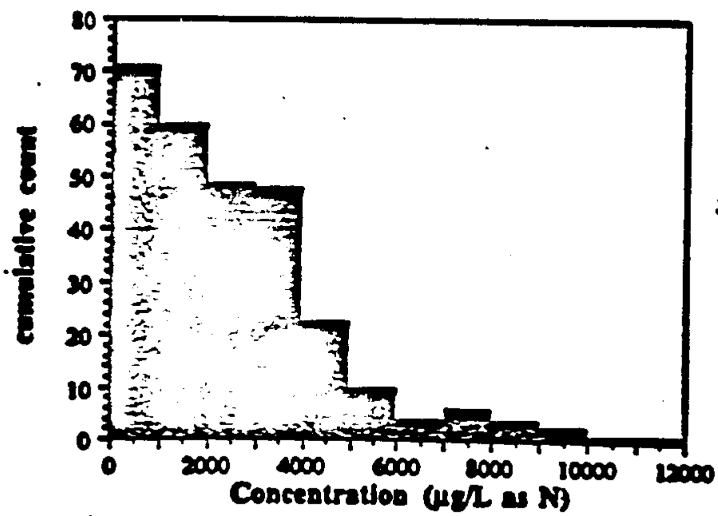

Figure B-13. Histogram Plot for STORET Code = 620 (Nitrate Nitrogen, Total).

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1

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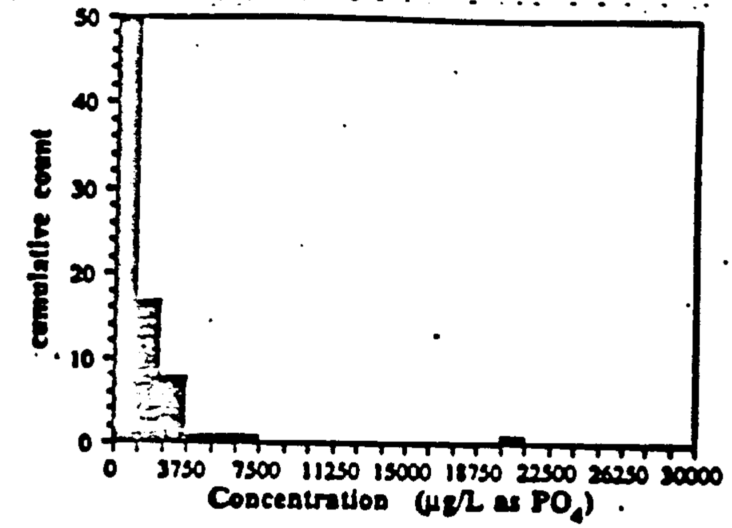

Figure B-14. Histogram Plot for STORET Code = 650 (Phosphate, Total).

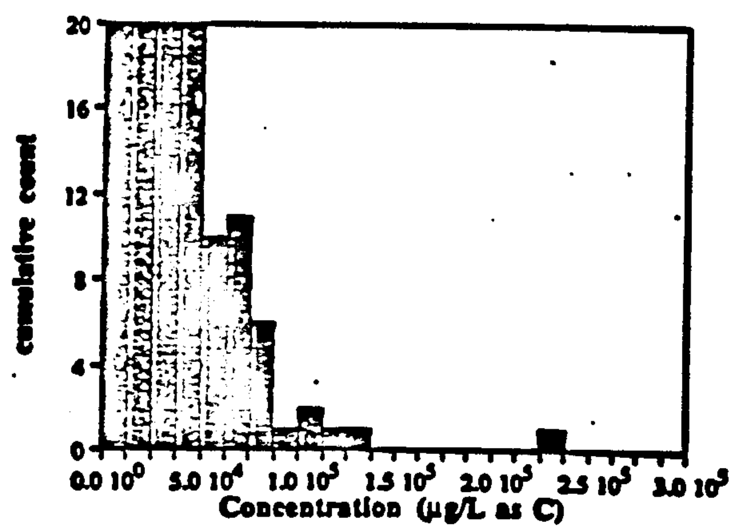

Figure B-15. Histogram Plot for STORET Code = 680 (Carbon, Total Organic).

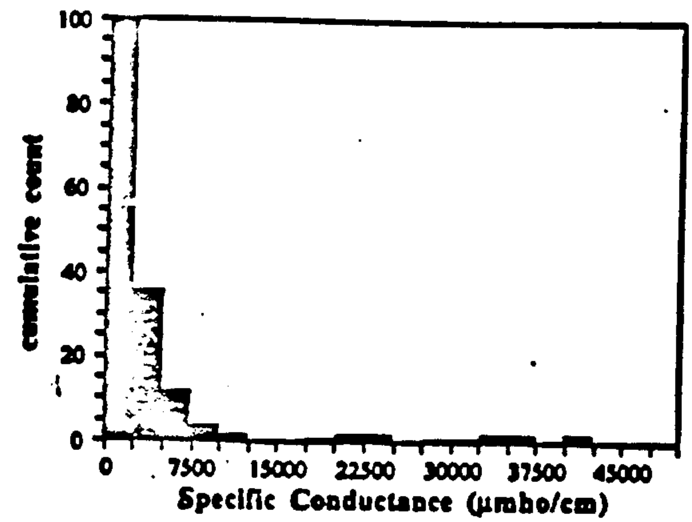

Figure B-16. Histogram Plot for STORET Code = 95
(Specific Conductance, @25°C).

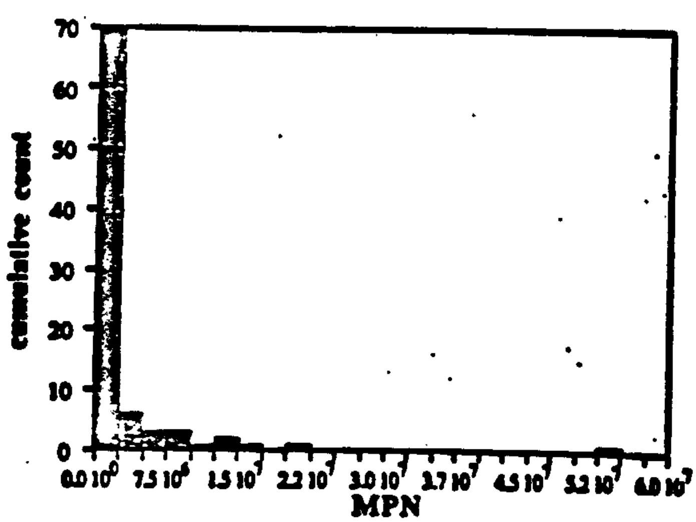

Figure B-17. Histogram Plot for STORET Code = 31505
(Coliform, Total, MPN).

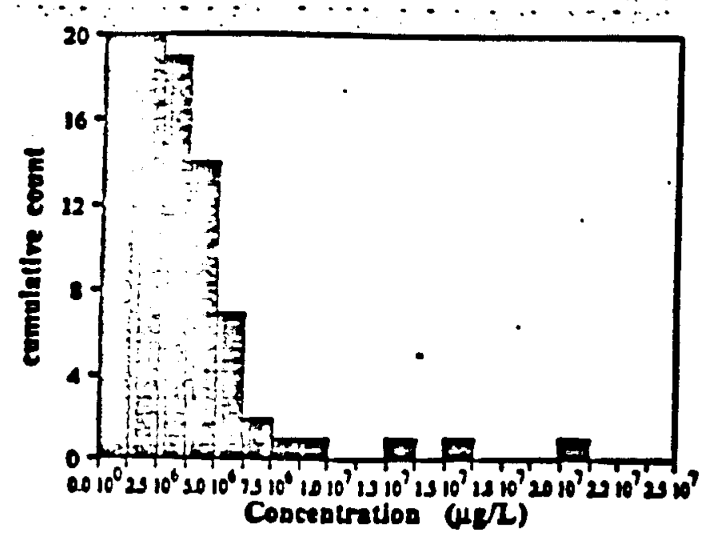

Figure B-18. Histogram Plot for STORET Code = 530 (Residue, Total).

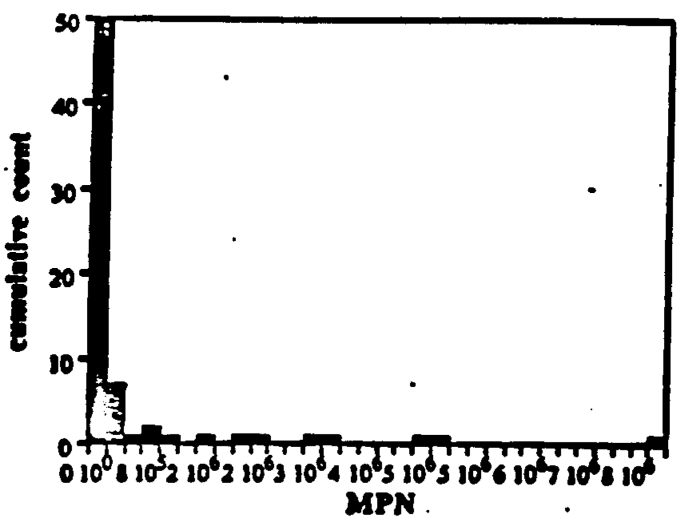

Figure B-19. Histogram Plot for STORET Code = 31615 (Fecal Coliform, MPN).

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1 63-10

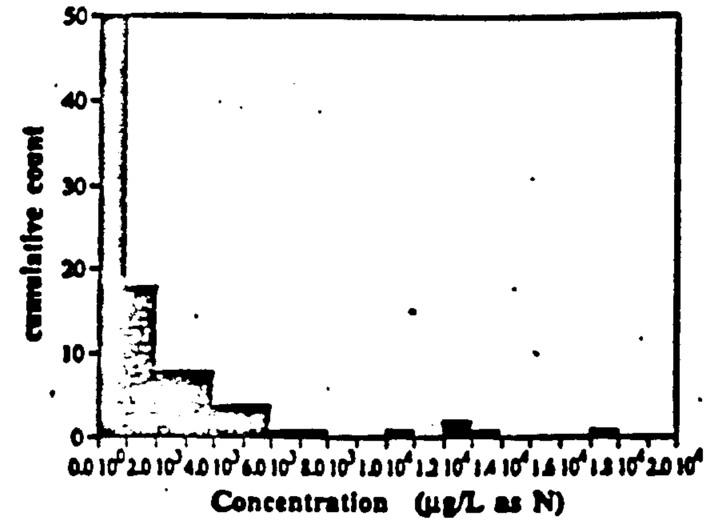

Figure B-20. Histogram Plot for STORET Code = 610 (Nitrogen, Ammonia, Total).

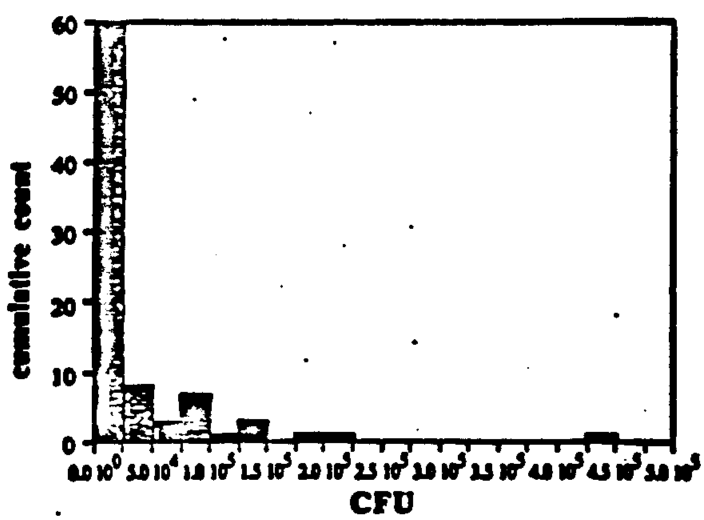

Figure B-21. Histogram Plot for STORET Code = 31616 (Fecal Coliform, Membrane Filter).

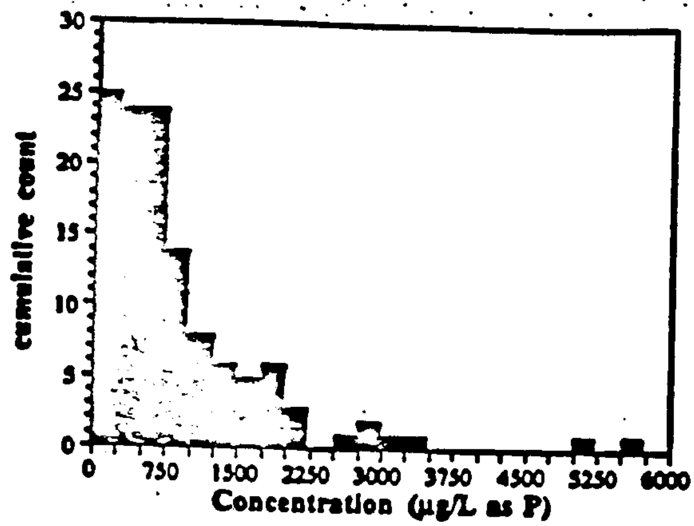

Figure B-22. Histogram Plot for STORET Code = 70507 (Phosphorus, in Total Orthophosphate).

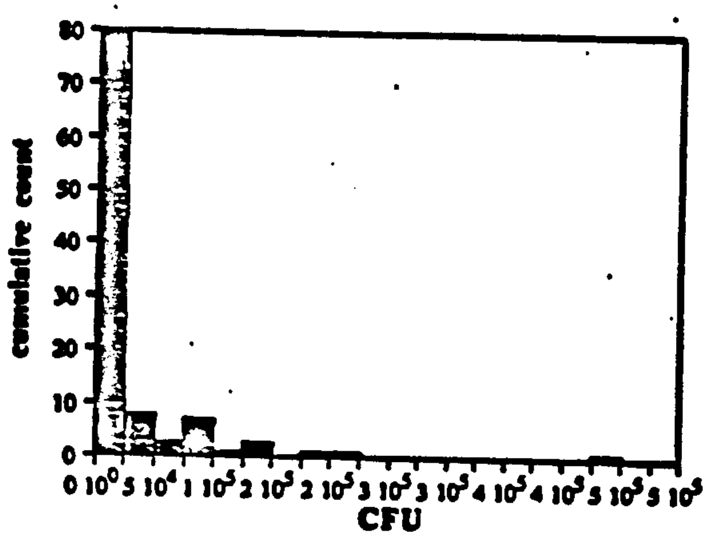

Figure B-23. Histogram Plot for STORET Code = 31673 (Fecal Streptococci, Membrane Filter).

Source Number	1
Title of Data Set or Report	Santa Monica Bay Stormwater Pollutant Reduction Study
Prepared by	Engineering-Science Inc.
Prepared for	City of Los Angeles, Wastewater Program Management Division
Date of Sampling	Throughout 1988
Date Study Released	6/1/89
Sampling Sites	Ballona Creek, Figueroa Street and 12th Street, Adams Blvd and Hope Street, Windsor Blvd (500 feet north of 12th Street), Cimarron Street and 29th Street, Bronson Avenue
Number of Samples	64
Sampling Frequency	Dry Weather Flow: 24 hour composite samples of 24 discrete 1 hour samples Stormwater Samples: grab samples from throughout the storm event
Parameters Tested	TSS, oil and grease, metals, PCBs, herbicides, dioxins, PAHs and enterococcus (includes loading rate calculations)
Applicability For Our Use (high, medium or low)	High
Comments	Data were colected expressly for the purpose of identifying pollutant emissions for various types of land uses, but do not correspond directly to any discharges to the Santa Monica Bay. Detection limits are high, since official EPA analytical techniques were used; consequently many of the observations are less than detection limits.
Reference	David Connally Environmental Science, Incorporated Environmental Science Operations 75 North Fair Oaks Avenue P. O. Box 7107 Pasadena, California 91109 (818) 440-6000 **Job Number: PS 053**

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Source Number 3

Title of Data Set or Report	Santa Monica Bay Coliform Database
Prepared by	Science Applications International Corporation (SAIC)
Prepared for	California Regional Water Quality Control Board
Date of Sampling	9/1/87 through 7/1/90
Date Study Released	August 1990
Sampling Sites	17 shoreline stations from the City of LA treatment plant (Hyperion), 7 shoreline stations from the LA County Sanitation Districts treatment plant and 30 stations from streams and stormdrains from the County of Los Angeles Department of Public Works
Number of Samples	1 sample collected during each sampling
Sampling Frequency	Daily or about twice weekly at each station at each site
Parameters Tested	Total coliform, fecal coliform and enterococcus
Applicability For Our Use (high, medium or low)	High
Comments	Data from shoreline stations do not characterize inputs to the Bay. Data from the Department of Public Works was provided from their STORET database and is included in the data set from Source Number 11.
Reference	

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1 6314

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Source Number	3
Title of Data Set or Report	Surface Water Quality Survey – Santa Monica Bay Inputs
Prepared by	California Regional Water Quality Control Board
Prepared for	Same as above
Date of Sampling	Once or twice annually from 1986 to present
Date Study Released	N/A
Sampling Sites	14 sites throughout Santa Monica Bay drainage basin (concentrated along Ballona Creek)
Number of Samples	20
Sampling Frequency	1 to 2 grab samples per site
Parameters Tested	VOCs, metals, herbicides, pesticides, COD, BNAs, acetone, PCBs, petroleum hydrocarbons and cyanide
Applicability For Our Use (high, medium or low)	High
Comments	Well documented location on topographic maps. Usually no flow data, except rough estimates in some cases. Few observations above detection limits. Not all points are inputs to Santa Monica Bay.
Reference	

1

63115

Source Number 4

Title of Data Set or Report	Advisory Warning – Discharges from Storm Drains into Santa Monica Bay
Prepared by	County of Los Angeles, Department of Health Services
Prepared for	County of Los Angeles, Department of Beaches and Harbors
Date of Sampling	July through September, 1986
Date Study Released	7/28/86
Sampling Sites	Discharges from the following storm drains: Ballona Creek, Imperial Avenue, Pulga Canyon Creek, Ainsworth Avenue, Ashland Avenue, Kenter Canyon at Pico Blvd, Santa Monica Canyon Creek, Santa Monica Pier and Avenue I
Number of Samples	9 samples per site
Sampling Frequency	Weekly from 7/21/86 to 9/3/86 and twice weekly through 9/18/86 for coliforms, twice weekly from 9/3/86 through 9/18/86 for enterococcus
Parameters Tested	Total coliform, fecal coliform and enterococcus
Applicability For Our Use (high, medium or low)	High
Comments	Samples were collected in the surf zone at the mouth of the storm drain and at 10, 25, 50, 80 and 150 yards on each side of the storm drains. Only data from samples collected at the point of discharge are to be incorporated into this database.
Reference	

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1 63/6

Source Number	5
Title of Data Set or Report	An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses From Two Santa Monica Storm Drains
Prepared by	Santa Monica Bay Restoration Project
Prepared for	Santa Monica Bay Restoration Project
Date of Sampling	August and September 1989
Date Study Released	June 1990
Sampling Sites	Outfall from the Kenter Canyon (at Pico Blvd) and the Ashland Avenue storm drains
Number of Samples	15 at each site
Sampling Frequency	Once or twice weekly from 8/10/89 to 9/29/89
Parameters Tested	Total coliform, fecal coliform, enterococcus and enteric viruses
Applicability For Our Use (high, medium or low)	High
Comments	Data collected specifically to determine the existance of human fecal material inputs to the storm drains. Resulus were positive.
Reference	

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1 6 3 1 7

Source Number	6
Title of Data Set or Report	Stormwater Runoff Program
Prepared by	SCCWRP
Prepared for	California Regional Water Quality Control Board
Date of Sampling	11/28/70 to 9/26/73 and 9/23/86 to 9/15/87
Date Study Released	N/A
Sampling Sites	Ballona Creek at Inglewood Avenue
Number of Samples	Varies for each of the 8 storm events
Sampling Frequency	From 2 to 6 grab samples were collected during each storm event
Parameters Tested	Solids, oil and grease, coliform, PCBs, COD, metals, pesticides and PAHs
Applicability For Our Use (high, medium or low)	High
Comments	Samples were collected during low flow periods and for rising, peak and declining flows of each storm event. Includes flow data.
Reference	

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1 6318

Source Number	7
Title of Data Set or Report	The National Pollutant Discharge Inventory
Prepared by	NOAA
Prepared for	Same as above
Date of Sampling	N/A
Date Study Released	7/1/88
Sampling Sites	Estimates for Santa Monica Bay (based on land use data)
Number of Samples	N/A
Sampling Frequency	N/A
Parameters Tested	BOD, TSS, N, P, metals, petroleum hydrocarbons, PCBs and fecal coliform (all values are estimated)
Applicability For Our Use (high, medium or low)	Low
Comments	A model used to generate estimated values from land use characteristics. No data will be included in the final data set.
Reference	

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1

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Source Number	8
Title of Data Set or Report	NPDES Monitoring Reports
Prepared by	California Regional Water Quality Control Board
Prepared for	California Regional Water Quality Control Board
Date of Sampling	Varies with the individual permit
Date Study Released	N/A
Sampling Sites	Throughout Santa Monica Bay drainage basin
Number of Samples	Varies with the individual permit
Sampling Frequency	Varies with the individual permit
Parameters Tested	Typically TSS, oil and grease, BOD, temperature, TOC, flow rate, etc.
Applicability For Our Use (high, medium or low)	High
Comments	Permit compliance data for discharges to storm water drains within the Santa Monica Bay drainage basin. The parameters tested will vary with the individual permit. They could be used to determine upper bounds for legal discharges in Ballona Creek and other storm drains. These data are not included in the final data set.
Reference	

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1

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Source Number 9

Title of Data Set or Report Search for Mutagens and Carcinogens in Pico-Kenter Storm Drain -- Final Report

Prepared by County Sanitation Districts of LA County at their San Jose Creek Water Quality Lab

Prepared for County of Los Angeles, Office of the Chief Administrative Officer

Date of Sampling October 1980

Date Study Released 12/1/80

Sampling Sites Kenter Canyon drain at Pico Blvd

Number of Samples 2

Sampling Frequency Samples taken 16 days apart

Parameters Tested Analysis of HPLC fractionated samples resolved more than 600 compounds

Applicability For Our Use (high, medium or low) Low

Comments This data will not be included in our data set since they do not characterize discharges into the bay. Ames tests were performed and the results suggest that only the whole residue and non-polar fractions were mutagenic. The two samples were quite different in their molecular characterization.

Reference

1 6321

Source Number 10

Title of Data Set or Report	Untitled at this time (tentative title: Ozone Pilot Plant Demonstration Project for the Treatment of Urban Stormdrain Dry Weather Flows)
Prepared by	City of Santa Monica Department of Engineering (Gerry Greene)
Prepared for	The EPA and the Santa Monica Bay Restoration Project
Date of Sampling	11/20/89 to present
Date Study Released	In progress (projected for 1991)
Sampling Sites	Kenter Canyon drain at Pico Blvd
Number of Samples	3 samples collected during each sampling
Sampling Frequency	Daily to weekly
Parameters Tested	Among the numerous parameters tested are: flow rate, total coliform, fecal coliform, TS, TDS, TSS, setteable solids, turbidity and metals
Applicability For Our Use (high, medium or low)	Medium
Comments	This data set has more observations for a single point than any other data set. Unfortunately it does not correspond to a discharge location. Never-the-less, these data should be useful in estimating stormwater variability.
Reference	

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1 6 3 2 2

R0049627

Source Number 11

Title of Data Set or Report	LA County Department of Public Works surface water monitoring program data
Prepared by	LA County Department of Public Works
Prepared for	Same as above
Date of Sampling	1971 to present
Date Study Released	N/A
Sampling Sites	The following storm drains: Ballona Creek at Fairfax Avenue, Ballona Creek at Sawtelle Blvd, Centinela Creek at Centinela Blvd, Corral Canyon Creek at PCH, Dume Creek at Zuma Beach, Kenter Canyon drain at Pico Blvd, Malibue Creek at Cross Creek Road, Santa Monica Canyon at Short Street, Sepulveda Channel at Culver Blvd, Topanga and Canyon Creek at PCH
Number of Samples	Varies with site and year
Sampling Frequency	Typically monthly or anually
Parameters Tested	A wide spectrum of parameters were measured; irregular frequency
Applicability For Our Use (high, medium or low)	High
Comments	A varity of different analytical techniques, different laboratories, and different sampling techniques were used. The data have been placed in a publically readably STORET file. More recent data have been provided by the Department in FOCUS database form. Flow rate data have not been included which makes mass emission rates difficult to estimate.
Reference	

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1 6323

Source Number 12

Title of Data Set or Report	Deposition and Processing of Airborne Nitrogen Pollutants in Mediterranean-Type Ecosystems of Southern California
Prepared by	Pacific Southwest Forest and Range Experiment Station, Forest Service, US Department of Agriculture
Prepared for	Environmental Science and Technology, Volume 19, Number 9
Date of Sampling	March 1982
Date Study Released	September 1985
Sampling Sites	From a stream site in each of the following canyons in the Santa Monica Mountains: Deer, La Chosa, Trancas, Ramirez, Solstice, Corral, Carbon and Upper Santa Ynez
Number of Samples	8 (one from each stream)
Sampling Frequency	Samples were collected once on 3/25/82
Parameters Tested	Stream water nitrate concentrations following a major storm
Applicability For Our Use (high, medium or low)	High
Comments	This paper suggests that atmospheric deposition of nitrate might be as high as 7.0 mg/L in runoff from undeveloped land in the San Gabrial Mountains. Nitrate in runoff from undeveloped land the Santa Monica Mountains was much lower, generally less than 0.2 mg/L. If true, estimates of nitrogen and possibly other pollutants from undeveloped areas will need to be dramatically changed in urban runoff/land use models.
Reference	

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Source Number	13
Title of Data Set or Report	California State Mussel Watch Program
Prepared by	State Water Resources Control Board
Prepared for	State Water Resources Control Board
Date of Sampling	1977 to present
Date Study Released	Annual reports
Sampling Sites	At least 17 stations along the Santa Monica Bay shoreline and within Marina Del Ray
Number of Samples	1 sample collected during each sampling
Sampling Frequency	Approximately once or twice annually
Parameters Tested	Numerous synthetic organic substances and trace elements were detected within collected tissue samples
Applicability For Our Use (high, medium or low)	Low
Comments	Data consists solely of tissue sample analysis. This data will not be included in our data set since they do not characterize discharges into the bay.
Reference	

Source Number - 24

Title of Data Set or Report	Hyperian Treatment Plant's Coliform Data Set
Prepared by	Hyperian Treatment Plant
Prepared for	Hyperian Treatment Plant
Date of Sampling	1986 to present (data exists back to 1976)
Date Study Released	Not compilied into a complete report
Sampling Sites	Pulga Canyon, Santa Monica, Pico, Ashland, Imperial Highway and Avenue I stormdrains and Ballona Creek at Duquesne, Overland, Centin'a and Pacific Avenues; occasional sampling at the Bay Club stormdrain and Rosa, Sunset, Thorton, Whilshire, Grand and Montana Avenues and Redondo and Hermosa Pier stormdrains
Number of Samples	1 to 3 samples collected during each sampling
Sampling Frequency	Varies significantly for each site (daily to monthly)
Parameters Tested	Fecal coliform, total coliform, enterococcus and occasionally rainfall
Applicability For Our Use (high, medium or low)	High
Comments	
Reference	

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Source Number 15

Title of Data Set or Report	Los Angeles River Loadings of Trace Metals and Synthetic Organics
Prepared by	US EPA ERLN Pacific Ecosystems Branch and AScI Corporation
Prepared for	Same as Above
Date of Sampling	1970 to 1985
Date Study Released	April 1991
Sampling Sites	Santa Clara River, Los Angeles River, San Gabriel River, Coyote Creek, Santa Ana River, Calleguas Creek, Dominiques Channel, Arroyo Grande, San Juan Creek, San Luis Rey, Santa Ynez River, Ventura River, Pico Storm Drain, Ballona Creek
Number of Samples	744
Sampling Frequency	One or more samples collected during each sampling
Parameters Tested	TDS, TOC, TSS, Ag, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn
Applicability For Our Use (high, medium or low)	High
Comments	Only data from Ballona Creek and Pico Storm Drain are included in the final data set.
Reference	David R. Young US EPA ERLN Pacific Ecosystems Branch Hatfield Marine Science Center 2111 S.E. Marine Science Drive Newport, Oregon 97365-5260 EPA Report Number 600/X-91/030

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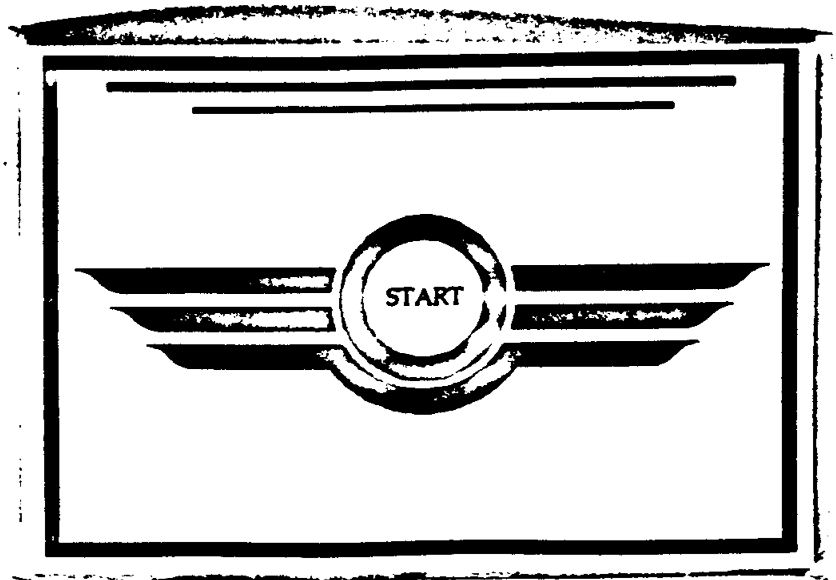
Santa Monica BAY Restoration PROJECT



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ASSESSMENT OF STORM DRAIN SOURCES OF CONTAMINANTS TO SANTA MONICA BAY

VOLUME II
REVIEW OF WATER AND WASTEWATER SAMPLING TECHNIQUES WITH AN EMPHASIS ON STORMWATER MONITORING REQUIREMENTS

by

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May, 1993

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PREFACE AND ACKNOWLEDGEMENTS

This report represents Volume II from a series of four volumes of reports which form the basis of a pollution assessment and monitoring plan for Santa Monica Bay. Volume I describes storm drainage system land use statistics, catchment areas, existing water quality monitoring data, rainfall data, NPDES permit information for existing permits to storm drains, and contaminant mass emission estimates, based upon land use modeling. Volume II reviews sampling techniques, including sampling equipment, and other aspects associated with sampling such as a quality assurance plan. Volume III presents the proposed monitoring plan. Volume IV addresses best management practices as they apply to the Santa Monica Bay area. The first draft of this volume was issued in September 28, 1992.

The contract was performed by UCLA and Woodward-Clyde Consultants (WCC). Professor Michael K. Stenstrom of the Civil and Environmental Engineering Department, UCLA and Eric Strecker from WCC's Portland office were the project managers. There were several key individuals from both UCLA and WCC who assisted with the project; they include Sim-Lin Lau and Kenneth Wong (UCLA) and Lou Armstrong, Gail Boyd, Carol Forrest, and Joan Kersnar (WCC).

The contractors are grateful for the assistance of many individuals. The Santa Monica Bay Project and LA Regional Water Quality Control Board staffs were most helpful. We extend our special thanks to Dr. Guang-yu Wang, Ms. Catherine Tyrrell, Dr. Rainer Hoeinke and Mr. Xavier Swamikannu. Several public agencies were very helpful in providing data and information to us. The Los Angeles County Department of Public Works and the Southern California Association of Governments (SCAG) provided catchment area and land use data, respectively. We are also indebted to the members of the Technical Advisory Committee of the Santa Monica Bay Project and others who reviewed and commented on our draft reports.

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ABSTRACT

This report is a literature review of surface water and wastewater sampling techniques, with an emphasis on applications for storm drain sampling. The report discusses sampling program objectives, statistical approaches, sample types, sampling equipment, flow measuring techniques, special problems in sampling specific biological, chemical, or physical parameters, and quality control/quality assurance plans. A variety of sampling equipment is reviewed, such as bottle samplers, messenger-activated samplers and automatic samplers, among others. Additionally several case studies are presented. The case study review is based upon Woodward-Clyde Consultants' previous experience in monitoring storm drains or developing monitoring programs.

This volume complements Volume III of this four-volume report series. Volume III provides more specific information on the development of a storm drain monitoring program for the Santa Monica Bay watershed.

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1.0
INTRODUCTION

1.1 OBJECTIVES

This review outlines methodologies for sampling storm drains (urban runoff). It is not intended to address any site-specific sampling requirements. A general overview is provided, followed by several case studies of specific programs and their associated procedures and sampling equipment. It was produced as part of a contract to develop a storm drain monitoring program from the Santa Monica Bay Restoration Project to team comprised of the Civil Engineering Department at UCLA and Woodward-Clyde Consultants (WCC).

The following chapters address the sampling program, statistics, sample types, sampling equipment, sample storage and preservation requirements, flow measurement, special techniques required for certain contaminants (e.g., oil and grease), and quality assurance/quality control plans.

1.2 SAMPLING PROGRAM - OVERVIEW

The main objective of any sampling program is to collect a sample which is representative of the state of the media under study. A sample is considered to be representative if the sample possesses the same qualities or properties as the media being sampled at the point and time of collection. A set of representative samples is considered to be valid if it provides a true representation of the temporal and spatial variations of the quantity of the water body for the duration of the measurement program (Wilson, 1982).

No single sampling program can apply to all types of samples (e.g., surface water, ground water, coastal wastes, municipal wastes, etc.). However, each sampling program should consider at least the following criteria (Krajca,1989; Barcelona, 1988; US EPA, 1982) :

- objectives of sampling program
- analytes of interest
- location of sampling points
- frequency and time of sampling
- sample collection, e.g., selection of sampling equipment, sampling methods (grab or composite), etc.
- sample handling, e.g., preservation,
- field determinations, e.g., in situ analysis of unstable constituents, flow measurement, etc.
- sample storage and transport
- quality assurance/quality control (QA/QC)
- health and safety cost

In addition to the above mentioned criteria, the validity of samples in terms of the sampling sites, number of samples, time and frequency of sampling should be considered based on a statistical approach if the objective is to accurately characterize pollutant loadings and/or concentrations.. The above mentioned criteria is not all inclusive. Additional components

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may be added into the sampling plan depending on the objective of the project. The following section discusses the basic required criteria of sampling program.

1.3 SAMPLING PROGRAM OBJECTIVES

The objective(s) of a sampling is the first step in planning of a sampling program. In general, there are four major reasons for sampling and analyses program: planning, research/design, process control, and regulation (including detection, verification and enforcement). A comparison of the sampling program based on these four different objectives are discussed by the US EPA (1982) and is summarized in the Table 1-1. For the purposes of this report, the objective of the sampling program is to provide good monitoring procedures for the evaluation of the pollutant load to Santa Monica Bay from storm drain and runoff flows. A work shop held in conjunction with this project concluded that the proposed monitoring plan should have two objectives: assessing the mass emissions to the Bay, and providing more information on the land-use pollutant runoff characteristics. Thus, the sampling plan , which involves the selection of the types of samples (grab and composite samples), sampling techniques, sampling equipment (manual or automatic), sample preservation, field analysis (e.g., *in situ* analysis, flow measurement), etc., should be based on this objectives.

1.4 ANALYTES OF INTEREST

The selection of constituents of interest to a particular study depends on the objectives of the monitoring program. Examples of the water quality parameters (which include organics, heavy metals, nutrients, etc.) are given in the Appendix A. In cases where insufficient information is available, a staggered program is usually implemented. A full suite of parameters is generally carried out during the initial phase of the monitoring program (or during the first several storms). A reduced suite of analyses can be performed if the results of the preliminary sampling show the absence or low levels (as compare to applied criteria) of specific parameters. In addition to the parameters given in Appendix A, other constituents can also monitored if their presence is expected in the storm water.

Once the analytes of interest are chosen, appropriate analytical methods for specific parameters must be selected. This consideration is not only important for proper sample collection and handling procedures and cost minimization, but also to avoid matrix interferences for certain types of samples. In addition, the minimum sample volumes and types of sample preservation and handling procedures also depend on the detail and specificity of the proposed analytical program (Barcelona, 1988). For example, the sample volume needed for organic analyses differs from those for inorganic analyses.

The selection of methods of analysis generally is left to the experience of the analyst. General guideline for the selection of analysis method were discussed by Mancy and Allen (1982) as follows:

- total number of analyses,
- frequency and geographical scope of analysis,
- required rapidity of analysis,
- sensitivity and detection limit,
- selectivity and interferences,
- constraints on accuracy and precision.

Table 1.1 Sample Program Objectives (EPA, 1982).

Objectives	Planning	Research Design	Process Control	Regulatory
Scope	General	Specific	Specific	Specific
Goals	Establish trends Benchmarks Background levels	New developments Modifications Improvements	Operation quality control	Verification compliance enforcement
Effort	Non-intensive and unlimited	Intensive and limited	Non-intensive and limited	Non-intensive and limited

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The above mentioned requirements give an insight into whether the analysis should be carried out in the laboratory or in the field. In general, in situ analysis is carried out if the conditions of the analyte of interest are unstable and need direct measurement at the sampling sites. These unstable determinads include temperature, pH, dissolved gases (dissolved oxygen).

In addition, the sampling modes, either manually, automatically or through a remote sensing system, can also be determined based on the costs and availability of manpower and equipment. Comprehensive discussion of this topic is given the *Examination of Water for Pollution Control* (1982).

1.5 SAMPLING LOCATIONS

The sampling program objectives usually define the approximate locations for sampling, e.g., the confluence of two stormdrains drains. However, the stated objectives give only a general indication, e.g., when the effect of an effluent on river water quality is of interest.

The quality of water varies from place to place in most water systems. Therefore, locations appropriate to the information needs of a particular program must be selected so that the samples collected from various sampling points can be representative as a whole of the system. No specific guidelines can be given due to the extent and nature of spatial heterogeneity that may vary with time and also differ from one system to another. However, certain general points still have to be considered when the selection of sampling locations is make.

The selected sampling locations must be representative sites. Factors influencing the selection of sampling locations are (US EPA, 1982; Wilson, 1982) :

1. Homogeneity of the water, wastewater or stormwater.
   Homogeneity is generally enhanced by the turbulence and good mixing resulting from a hydraulic jump or flow over a weir.

2. Non-homogeneity or heterogeneity of the water , wastewater or stormwater.
   Generally caused by poor mixing (e.g. vertical, thermal stratification of lakes and reservoirs), and non-homogeneous distribution of the chemicals caused by their different densities (e.g., floating oils or settling suspended solids), and also certain chemical or biological reaction (e.g., pH changes caused by the growth of algae in upper layers of a body of water).

3. Convenience and accessibility of the sampling locations.
   For stormwater such considerations include impact of vandalism, safety to workers, such entering confined spaces (e.g., manholes), and accessibility in all types of weather. Sampling in confined spaces always requires multiple team members and additional safety equipment. Another important consideration for stormwater sampling is the distance among sampling locations. Widely spaced locations may be best from the standpoint of collecting the most representative samples, but may be expensive because of travel time or the need for additional sampling teams.

4. Flow measurement.
   Flow measurement presents a particularly difficult challenge for stormwater monitoring. Often there are no provisions for measuring flow rates.

Conventional flow measuring equipment such as weirs or flumes is usually unsuitable for stormwater because of the increased head loss (resistance to flow) that the weir or flume causes. The increased head loss decreases the maximum capacity of the storm drain that may result in a loss of flood protection.

5. Other considerations
Sampling locations near the boundaries of water systems generally should be avoided except when these regions are of direct interest. Coastal stormdrains are often affected by tidal flows, which makes representative sampling nearly impossible due to the dilution of salt water. Stormdrains are often located in areas which have higher probability of violent crimes and vandalism. Extra precautions are required.

Generally, a preliminary investigation needs to be carried out to assess the degree of non-homogeneity of the proposed stormwater location. If such tests show that quality is homogeneous, one position for sampling may suffice; if heterogeneity is present, two approaches can be used to select the appropriate sampling locations (Wilson, 1982). The first alternative is to sample and test different locations until a suitable homogeneous location is found. For the second alternative, the location originally selected is used, and samples are routinely taken from several positions chosen so that they are properly representative of the quality at the location; the individual results are then weighted and averaged according to a suitable procedure (e.g., volume or flow weighting, etc.). The first alternative is usually preferable due to simplicity.

For the consideration of the spatial distribution of sampling positions, the hydraulic conditions can be characterized approximately as homogeneous, stratified, plug-flow, showing longitudinal mixing, showing lateral and longitudinal mixing, and patchy (e.g., in the distribution of photo plankton). The hydraulic conditions must be considered when selected both the location and number of samples. The number of sampling positions needed to obtain the required information tends to be smallest for homogeneous conditions and greatest for patchy conditions (Wilson, 1982).

1.6 FREQUENCY AND TIME OF SAMPLING

Frequency of sampling will be site specific and no general rules can be provided. However, several important considerations exist for determining sampling frequency: economics, regulatory requirements, and timing. The frequency of sampling is the most significant cost multiplier in a sampling operation. Certain frequencies of sampling are set by regulation and therefore, the required sampling frequency cannot be followed, even though there may be powerful incentives to modify sampling frequency. In general, if the environmental value or quality interest varies with a certain frequency, the sampling frequency must be at least twice the frequency of that variation. In addition, if the process is cyclic in nature, samples should be collected during at least one complete process cycle, or an integer number of process cycles.

For stormwater, monitoring programs often designate a specified number of storms to be sampled and a specified number of flow-weight averaged, composite samples. To obtain the required number of samples, prediction of the number of storms and the length of the storms is required. Such predictions are far from precise and some latitude and variability of sampling is necessary.

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1.7 SAMPLE COLLECTION METHODS

Selection of correct sampling technique for collecting samples is very important in order for the collected samples to be representative. A good sampling collection method generally involves selection of the correct sampling techniques and equipment, trained personnel to perform the sampling procedures and correct handling of samples. This section will only discuss some general criteria involved in the selection of correct sample collection method. Detailed discussion of the types of sampling equipment available for water sampling, sampling methods (either grab or composite) and the correct sample handling (e.g., preservation, transport and storage) are discussed in the later sections of this report.

Samples can be collected either manually or with automatic samplers. Manual sampling involves minimal initial cost, but it is only suitable for collection of a small number of samples. For routine and large sampling programs, manual sampling can be costly and time consuming. Automatic samplers are increasingly being used to monitor water quality due to their cost effectiveness, minimal labor requirement, and ability to sample at greater frequency. Selection of the correct sampling collection mode, either manually or automatically, still depends on the needs of sampling programs (see Chapter 4).

In addition to the correct selection of sampling equipment, types of sample collected can be divided into two categories, i.e., grab (or discrete) and composite samples. A grab sample is defined as an individual discrete sample collected at a particular time and place, whereas a composite sample is defined as a sample formed by mixing discrete samples taken at periodic points in time or a continuous proportion of the flow (US EPA, 1982). Factors involved in the selection of sample types are discussed in the Chapter 3. The types of sample collected are also determined by the regulatory agency. In general, composite samples are required for the NPDES permit. However, grab samples may be allowed when compositing samples is difficult due to reasons such as the absence of flow during dry weather season, or analytical requirements (grab samples for certain analysis such as oil and grease or volatile organic compounds).

Poor sample collection procedures can seriously bias chemical results (Barcelona, 1988). Analyses of blanks and controls should be carried out simultaneously with samples collected from the sampling sites so that any errors, such as contamination, poor handling of sampling equipment, etc., that arise during the sampling and analytical procedures can be monitored. The efficiency with which the operator can control the operation of the sampling equipment, maintain stable, reproducible operation conditions, and recognize a malfunction all play a significant part in minimizing these errors.

Materials selection of sampling equipment can also cause unwanted bias results. Appropriate materials used for the sampling equipment should be based on the most sensitive (i.e., volatile, and reactive) chemical constituents under investigation so that any interaction of material used with the chemical constituent of interest (e.g., leaching, sorption, etc.) can be avoided.

1.8 FIELD PROCEDURES

The sampling program must also specify the various analyses to be performed on the sampling sites. Generally, determinands such as flow rate measurement, and unstable parameters such as dissolved gases, pH, temperature, and conductivity are determined on the field. Greater number of analyses can be performed in the field if a mobile laboratory is available. The mobile laboratory is especially useful when sample degradation is fast, or when immediate analysis is required, such as tracking a spill.

In addition to the collection of representative sample, field procedures must also include proper handling and preservation of samples, good housekeeping and appropriate chain of custody procedures. Factors that are commonly considered to insure good housekeeping of the field operations include (US EPA, 1982):

- written instructions on field sampling procedures should be completed beforehand.
- sampling equipment should also be checked prior to use in order to insure good operating conditions and cleanliness. After the sampling has been completed, the equipment should be cleaned and stored properly.
- all sample bottles should be checked to avoid possible contamination. Prior to collecting the samples, sample bottles usually should be rinsed several times with sample water.
- records of breakdown in the sampling operation, the problems encountered with different equipment and how they were resolved should be maintained.

More detailed procedures are provided by the US EPA (1982).

Conditions at the time of sampling, such as climatic conditions, hydrologic conditions, hydrogeological conditions, should also be noted during the field operations. Sampling from streams and reservoirs can be influenced to a considerable extent by variations in such things as flow rate, sediment and bed loads, temperature regime, and stratification. Sampling problems can also be caused by sudden changes of climatic conditions such as intensity and type of precipitation, air humidity, temperature and pressure, wind and speed direction. For example, intense precipitation can affect the composition of sample through direct contact with the water to be sampled, resulting in dilution or contamination (Krajca, 1989). Therefore, conditions at the time of sampling should be observed.

The safety and hygiene of those collecting the samples also need to be considered. The correct handling of sampling equipment and chemicals used during sampling operation to protect sampling personnel have been discussed by Krajca (1989). Stormwater, while usually not as contaminated with pathogenic organisms as wastewater, should be treated with the same precautions as wastewater. In sampling for many trace compounds, human contact or contact of safety equipment (e.g. rubber gloves) with the sampled water is required not only for personnel safety, but also to prevent sample contamination.

1.9 SAMPLE HANDLING, STORAGE AND TRANSPORT

Correct sample handling should be performed to avoid any unwanted contamination. Most of the Quality Assurance (QA) and Quality Control (QC) guidance manuals provide sound guidance for planning the procedures for sample preservation and handling. Selection of appropriate materials of sample containers, preservation methods, maximum holding times, and sample volume are discussed in the Chapter 5.

In general, the following guidelines for sample handling and preservation should be considered (US EPA, 1982):

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- minimize the number of people handling the sample
- if possible, have the same individual perform all operations when repetitive operations are conducted
- store the sample in a manner which insures that the parameters to be analyzed are not altered, and use appropriate preservation method(s) and holding time,
- make sure the container material does not interfere with the analysis of the specific parameters.

Efforts should also be made to handle and preserved field control samples (i. e., blanks and spikes) in the same manner as the samples collected. This precaution provides more effective identification and control of post-sample collection errors.

2.0
STATISTICAL APPROACH

The number of samples and frequency of sampling need to be considered carefully while planing any monitoring program so that samples collected will be representative. The aim of this Chapter is to give a general review of the statistical approach generally employed in determining an appropriate number of samples and sampling frequency. Detailed explanation on basic statistics is beyond the scope of this study. Information of basic statistics can be found in a numbers of statistics textbooks. References such as Montgomery and Hart (1974), US EPA (1982), and Schaum Series -Statistics are also useful.

2.1 BASIC STATISTICS TERMS

Basic statistics terms that are generally used for the determination of the number of samples and frequency of sampling include the following:

1. arithmetic mean
2. median
3. standard deviation (s)
4. variance (σ or s^2)
5. coefficient of variation (CV)
6. confidence level (α)
7. Normal distribution
8. Chi-square distribution

2.2 DETERMINATION OF NUMBER OF SAMPLES

Two methods have been described by Montgomery and Hart (1974) to determine the number of samples. The first is based on the allowed sample variability while the second is based upon the accuracy of the sample mean. Examples of these two methods also describes by US EPA (1982). Standard deviation and coefficient of variation (CV) of the concentration of the constituents are needed to determine the number of samples. These two parameters are usually obtained from the previously collected data. In the absence of such information, and sometimes in spite of such information, the number and frequency of samples are controlled by cost.

2.3 FREQUENCY OF SAMPLING

As mentioned in Chapter 1, frequency of sampling generally is site specific and no specific rules can be provided. In general, if the environmental value or quality interest varies with a certain frequency, the sampling frequency must be at least twice the frequency of that variation. In addition, if the process is cyclic in nature, samples should be collected during at least one complete process cycle. A detailed description of the procedure for

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determining frequency of sampling is described by US EPA (1982) and Wilson (1982). Various forms of time-series analysis such as harmonic and spectral analysis have also been used to study the nature of variability of water quality. This type of analysis can be found in references such as Thomann (1967), Fuller and Tsokos (1971), Shastry et al (1972) and Edwards and Thornes (1973).

Most of the time the frequency of sampling for the monitoring program is restricted by the availability of costs, regulatory or permit requirements and sampling objectives. Monitoring programs for stormwater sampling are much newer and less information is known. Therefore a tiered sampling approach is often followed, with the objective of the program to develop appropriate sampling frequency. In such programs a certain number of storms is selected for sampling in the first period (e.g. first year or storm season). The initial number of storms must be greater than the expected number of storms to sampled in the final plan. After completion of the initial period a statistical analysis can be performed to determine the impact of reducing sampling frequency. This analysis can be as simple as analyzing a subset of the data and comparing means and variance to the full data set. The increase in variability using a smaller set of data (e.g. less sampling frequency) can be compared to the added costs of more frequent sampling. Formal methods for making such evaluations are also available and are described in several of the previously cited references.

3.0 SAMPLE TYPES

Samples collected for any monitoring program generally can be divided into two types: grab samples - those taken from a single point as individual - and composite samples - which are mixed or poured together. The distinction between these two types of sample are summarized in the following sections. Detailed descriptions and procedures are given by US EPA (1982) and ASTM (1989).

3.1 GRAB SAMPLE

A grab sample is defined as an individual discrete sample collected over a period of time (generally not exceeding 15 minutes). A grab sample represents the conditions existing only at the point and time of sampling. When the source is known to be fairly constant in composition over a considerable period of time or over a substantial distances in all directions, a grab sample may be said to represent a longer time period or a larger volume, or both (Standard Methods, 1989). Generally, the collection of a grab sample is appropriate when it is used to :

- characterize water quality at a particular time,
- provide information about minimum and maximum concentrations,
- allow collection of variable sample volume,
- corroborate composite sample,
- meet a requirement of a discharge permit.

In addition, grab or discrete sampling can also be used when (US EPA, 1982):

- the stream does not flow continuously or a spill is suspected,
- the water or waste characteristics are relatively constant,
- the parameters to be analyzed are subjected to changes with storage (e.g.micro biological parameters, dissolved gases, soluble sulfide, residual chlorine, oil and grease, purgeable organics, and pH),
- information on maximum, minimum or variability is desired,
- the history of water quality is to be established based on its state over relatively short time intervals,
- the spatial parameter variability is to be determined (e.g., the parameter variability throughout the cross section and/or depth of a stream or large body of water).

A grab sample sometimes is also called a discrete sample, spot sample, or catch sample. Sampling is considered discrete if no further sampling is planned. If a number of discrete samples are collected in sequence in time and/or space to produce a set of samples, the sampling is considered to be a repetitive sampling. The variation of determinands in time and/or space can be obtained through a repetitive sampling. Examples of repetitive sampling include zonal sampling and chronological sampling (Krajca, 1989). Zonal sampling is applied to a repetitive collection of samples which are taken from a series of horizons or levels in a source (e.g., reservoir, borehole, swallow hole or lake). When samples are taken from a single source at fixed time intervals so that changes with time can be identified, the sampling process is considered to be chronological sampling. The time interval between successive sampling depends upon the purpose of the analysis, the dynamic character of the determinand, and often the flow regime and flow rate at the sampling point.

Spot samples, another form of grab sample, are usually acquired by filling the sample container or sampler once. They can be used to determine repeatability of non-recurrent, zonal or chronological sampling.

3.2 COMPOSITE SAMPLE

A composite sample is defined as a sample formed by mixing discrete samples taken at periodic points in time or a continuous proportion of the flow. Composite samples are most useful for observing average concentrations that will be used, for example, in calculating mass/unit time loading . Composite samples should not be collected over a period exceeding 24-hours, and care must be taken to prevent the deterioration of the sample during the period of collection by using preservatives, refrigeration, storage in the dark, or other means. Preservatives are normally put into the sample container prior to sampling, so that all sub-samples are preserved at the time of collection. Generally, composite samples should be avoided for the bacteriological/microbiological examination, radiological examination (e.g., short-lived radionuclides), or for constituents/analytical components that are subjected to significant and unavoidable changes on storage (e.g. dissolved gases, purgeable organics, residual chlorine, soluble sulfide, temperature, and pH) (Standard Methods, 1989; ASTM, 1989). Analyses for those constituents that are subjected to changes should be carried out on individual samples as soon as possible after collection and preferably at the sampling points (Standard Methods, 1989; Krajca, 1989).

The number of discrete samples which make up the composite depends upon the variability of pollutant concentration and flow. Generally there are two types of composite samples, i.e. time-interval and flow-proportioned (or flow-weighted) composite samples. A time-interval composite sample is collected in a series of small aliquots in which each aliquot was collected over a fixed interval of time. Sometimes a series of periodic grab samples is collected into an individual containers and then composited to cover a longer time period. This type of sample is called a sequential composite sample. Most of the composite samples are collected using automatic samplers (see Chapter 4). Current automatic samplers can be obtained with a built-in timer, flowmeter and rain gauge. Therefore, time-interval and flow-weighted composite samples can be programmed prior to sampling.

A frequent mistake made with automatic samples is to rely to heavily upon automation. No currently marketed samplers (Stenstrom and Strecker, 1993) can be remotely programmed to collect suitable volumes over suitable intervals for varying size storms and runoff periods. This must still be done manually. Automatic samplers require electric power and may need telemetry (e.g., a phone line connected to a modem). Many stormwater locations are not easily reached with power and phone lines. Rechargeable batteries are one alternative to electricity but can be used only for short storm events.

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There are six methods which can be used to composite samples (Table 3-1). Choice of composite type is dependent on the program and relative advantages and disadvantages of each composite type. For a constant volume/time proportional composite samples, previous flow records can be used to determine an appropriate flow volume increment so that a representative sample is obtained without exceeding the bottle capacity or supply. In addition, composite samples can also be prepared from time constant/variable volume discrete samples in various ways. Examples of these flow-weighted composite samples preparation are given by US EPA (1982).

3.3 BLANKS

The most commonly used analytical tools for assessing and controlling sample contamination are blanks. Blanks may be defined as samples that are expected to have negligible or unmeasurable amounts of the substance of interest. Nomenclature associated with blank samples is far from consistent in the literature, and distinguishing one type of blank from another is sometimes difficult except by context or by a more detailed description (Lewis, 1988). Generally, blanks can classified into two types: field blanks and laboratory blanks. Field blanks, which include equipment blanks and transport blanks are used to provide information about contaminants that may be introduced during sample collection, handling, storage, transport and preparation. Laboratory blanks, which include system/instrument blanks, solvent/calibration blanks, and reagent blanks, are reliable tools for assessing and controlling sample contamination that occurred in the laboratory (Black, 1988; Lewis, 1988).

3.3.1 Field Blanks

Equipment Blanks

An equipment blank is used to estimate incidental or accidental contamination of a sample during the sample collection procedure. It is also can be used to verify the effectiveness of cleaning procedures. Capped and cleaned sample containers are taken to the sample collection site. After a sample is obtained, the sampling equipment is cleaned according to the standard operating procedure prior to taking another sample. At that point, the sampling equipment is rinsed with deionized water, which is collected in a sample container for later analysis. If a preservative is used, then an equal amount is put into the container with the blank. Generally, one equipment blank should be allowed per sampling team per day per sampling equipment.

Transport Blanks

A transport blank is used to estimate sample contamination from the container and preservative during transport and storage of the sample. It is also called trip blank, travel blank or matched-matrix blank. A cleaned sample container is filled with deionized water, preservatives used in the sample are added and then the blank is stored, shipped, and analyzed with its group of samples. This blank is more important when shipping and storage consumes several days or weeks because leaching of the material from the container can become significant. One transport blank should be allowed per day per type of sample.

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Table 3.1 Sample Compositing Methods (EPA, 1982).

Sample Mode	Compositing Principal	Advantages	Disadvantages	Comments
Continuous	Constant pumping rate	Minimal manual effort, requires no flow measurement	Requires large sample capacity; may lack representativeness for highly variable flows	Practical but not widely used
Continuous	Sample pumping rate proportional to stream flow	Most representative especially for high vaiable flow; minimal manual effort	Requires accurate flow measurement equipment, large sample volume, variable pumping capacity, and power	Not widely used
Periodic	Constant sample volume, time interval between samples proportional to stream flow	Minimal manual effort	Requires accurate flow measurement or reading equipment; manual compositing from flow chart	Widely used in automatic as well as manual sampling

Table 3.1 Sample Compositing Methods. (continued)

Sample Mode	Compositing Principal	Advantages	Disadvantages	Comments
Periodic	Constant time interval between samples, sample volume proportional to total stream flow since last sample	Minimal instrumentaion	Manual composition from flow chart in absence of prior information on the ratio of minimum to maximum flow, there is a chnace of collecting either too small or too large individual discrete samples for a given composite volume	Not widely used in automatic samplers but may be done manually
Periodic	Constant time interval between samples, sample volume proportional to total stream flow at time of sampling	Minimal instrumentation	Manual compositing from flow chart. In absence of prior information on the ratio of minimum to maximum flow, there is a chance of collecting either too small or too large individual discrete samples for a given composite volume	Used in automatic samplers and widely used as manual methods

3.3.2 Laboratory Blanks

<u>System Blanks</u>

A system blank is also known as instrument blank. It is not really a blank at all in the sense of simulating a sample. A system blank is a measure of the instrument background, or baseline, response in the absence of a sample. System blanks are often used in gas and liquid chromatographic methods to identify memory effects, or carry-over from high concentration samples, or as a preliminary check for system contamination.

<u>Solvent Blanks</u>

A solvent blank consist only of the solvent used to dilute the sample. It is used to identify or correct for signals produced by the solvent or by impurities in the solvent. Depending on the analytical technique, the solvent blank may be used as a calibration blank. A calibration blank is used directly to set the instrument response to zero, or is used directly as one of a series of calibration standards, where the blank represents an analyte concentration of zero.

<u>Reagent Blanks</u>

In addition to solvent, the reagent blank contains any reagents used in sample preparation and analysis procedure. These reagents may include color development reagents, reagents used in sample digestion steps, reagents used for pH adjustment, preservatives, or other reagents depending upon the analytical method. The reagent blank is carried through the complete analytical procedure in the same manner as an actual sample. This procedure should include all steps involved in sample preparation, such as cleanup, filtration, extraction and concentration. Because it is carried through the complete analytical method, the reagent blank is also sometimes called a method blank. It can also use to determine the lower limit of detection. A reagent blank is analyzed for each 20 samples and analyzed whenever a new batch of reagents is used. The preferred outcome of reagent blanks is a less than detection limit result for all of the analytes of interest.

3.4 CONTROLS

Basically there are two types of control samples : (1) controls used in quality control procedures to determine whether or not the analytical procedure is in control, i.e., calibration control standard, laboratory control standard and matrix control, and (2) controls used to determine whether or not a factor of interest is present in a population (e.g., a group of environmental samples) under study but not in the control, i.e., control sites (local, area, national, background) (Black, 1988).

3.4.1 Calibration Control Standard

A calibration control standard is also known as quality control calibration standard (CCS) or calibration check standard. In most laboratory procedures, this control is a solution containing the analyte of interest at a low but measurable concentration. The precise concentration of this standard need not to be known. The first sample analyzed after an instrument is calibrated is a CCS, and the result should be plotted on a control chart. Another CCS is analyzed after each 20 samples, or after each shift if fewer samples are analyzed per shift. The standard deviation of the CCSs is a measure of the instrument precision unless the CCS is analyzed as if it were a sample, in which case the CCS is a measure of the method precision.

3.4.2 Laboratory Control Standard

The laboratory control standard (LCS) is a certified standard, generally supplied by an outside agency. This standard is used to determined whether or not an analytical procedure is producing results comparable to other analytical laboratories. The National Bureau of Standards (NBS) is a good source of LCSs in which a variety of standard reference materials containing certified concentrations of elements or compounds. The Environmental Monitoring and Support Laboratory of the U.S. Environmental Protection Agency in Cincinnati is another useful source of organic standard in water or organic solvent solutions. An LCS should be analyzed with every batch of samples until 7-10 results are available. If those results are within the control limits specified by the program protocol, the frequency may then be reduced to one per day. However, several LCSs should be analyzed any time the analytical instrument is recalibrated. The mean value of all LCS results is a measure of the method bias.

3.4.3 Matrix Control

Matrix control is commonly known as field spike. A field spike may be required to obtain an estimate of the magnitude of those interferences due to a complex mixture of a sample matrix (e.g., sediments, sludges). The losses from transport, storage, treatment, and analysis can be assessed by adding a known amount of the analyte of interest to the sample during collection in the sampling site.

3.4.4 Control Sites

In addition to the controls that are used to measure the precision and bias of sampling and analysis, a control site or a control population is also very important so that the results of a study of a given area can be judged as high, low, or insignificant. For example, if the contribution of pollutants from an urban area to environmental pollution is to be assessed, then the contribution of pollutants from sources other than the urban area must be known. However, if the environmental impact of a given facility, such as a waste disposal site, is to be assessed, then the environmental levels in the absence of that facility must be known. The sites or populations that can supply control samples can be classified as local, area, or national, depending on the location selected (Black, 1988).

<u>Local Control Site</u>

A local control site is a control near in time and space to the sample of interest. Factors to be considered in the selection of local control sites include the following:

- local control sites should be upwind of the facility most of the time,
- local control sites should be upgradient from the facility with relation to surface and groundwater flow,
- the potable water source should not be affected by site effluents,

- travel between the control site and the facility should be minimal because of problems associated with transport.

<u>Area Control Site</u>

This control site is in the same area (e.g. city or county) as the pollutant source but not adjacent to it. The factors to be considered in site selection are similar to those for local control sites. All possible effort should be made the sites identical except for the presence of the pollutant at the site under investigation.

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Sampling equipment used for various types of natural waters (lake, reservoir, municipal wastes, surface waters, groundwater, stormwater, etc.) usually have common features. The sampling equipment can be divided into two major groups: surface and sub-surface sampling. Surface sampling equipment include (Krajca, 1989) :

- samplers and sampling containers (including pressure vessels) for samples collection and transportation,
- sampling accessories such as scoops on long poles, grips, and forceps and for handling samplers,
- equipment for closed pipe sampling,
- suction probes for pore water sampling,
- precipitation samplers,
- automatic sampling equipment with basic components such as automatic control blocks water distribution systems and sets of samplers or collecting vessels).

For the sub-surface sampling, the sampling equipment includes depth samplers and other equipment which parts designed to operate under water, in places that are inaccessible to the operator.

For the selection of appropriate sampling equipment, factors such as appropriate materials for sampling equipment and sample containers, type of sampling equipment (manual or automatic), cleaning of sampling equipment (Krajca, 1989). The following section discusses these criteria and the description of the commonly used water sampling equipment also included.

4.1 MATERIAL USED FOR SAMPLING EQUIPMENT AND CONTAINERS

Selection of the material for sampling equipment and sample containers should consider (Krajca, 1989):

- the material must be inert to the sample or more particularly those of its constituents which are to be analyzed,
- no biological activity occurs,
- able to withstand any sterilization, cleansing or preservation procedures.

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Materials commonly used for sample containers include glass and plastics (e.g., polyethylene). Selection of the type of sample containers will be discussed in Chapter 5. In addition to glass and plastics, metals are also commonly used, especially for the sampling equipment. Stainless steel sampling equipment is usually made of chrome-nickel steel with alloying additions of tungsten and molybdenum (both non-magnetic). These alloys are corrosion resistant and able to withstand strong acidic or alkaline samples for a long period of time. Compatibility of metals with various types of water samples was discussed by Krajca (1989) (see Appendix B). However, non-metallic material (e.g. plastic) should be used for metal analysis in order to avoid leaching problems. Blank tests should always be carried out to confirm that the sample is not affected by the material of the sampling equipment or sample containers (e.g., equipment blank).

4.2 WATER SAMPLING EQUIPMENT - MANUAL

As mentioned above, there are two types of water sampling equipment: surface and subsurface sampling. Surface water samples are usually taken directly into the sample container, which is also used for transport. If it is not possible to collect the sample by submerging the container by hand, laboratory forceps or a holder with a sliding sleeve can be used. If the sample is to be taken from the mainstream by reaching out from the bank then it may be best to attach the container to a segmented rod made up to appropriate length (e.g. dip sampler). Such sampling device is usually made of stainless steel.

Subsurface sampling is generally for depth sampling. Samplers can be categorized into three general types: free-flushing samplers, non-flushing samplers and combined samplers. Free-flushing samplers consist of a tubular body which is open at both ends. This allows the sampling chamber to pass through the water on its way down to the sampling point with only a minimum disturbance or mixing. Simple flushed samplers usually can be used in the horizontal mode, e.g. for sampling open streams, provided that suspension and controls have been suitably adapted. Flushing occurs with the sampler at rest. The degree of flushing depends upon the water velocity at the sampling point. Flushed samplers are primarily suitable for homogeneous, single phase liquid samples. Their main advantage is simple design and reliable operation, even at high pressures and temperature. When sampling heterogeneous liquids, attempts to flush the sampler by repeatedly raising and lowering, can result in partial separation of the mixture because the hydraulic resistance inside the sampler may cause more the mobile phase to flow around the sampler.

Unlike free-flushing samplers, non-flushed samplers make use of reduced pressure to effect sampling in which flushing of water samples through the sampling chamber is avoided. This is achieved through a difference in pressure between the inside of the sample chamber and the water at the sampling level. Examples of non-flushed samplers include bottle samplers, bag samplers, telescopic samplers and piston samplers. The third kind subsurface samplers is the combined sampler that combines the features of two or more basic types of sampler.

4.2.1 Kemmerer Bottles (Figure 4-1)

Kemmerer bottles may be used in most situations where access to the sampling sites is from a boat or structure such as bridge or pier, and where samples at depth are required. Kemmerer bottles are a messenger-activated water sampling devices. Water flows easily through the bottle in the open position. Once it is lowered to the desired depth, a messenger is dropped down to the sample line, tripping the release mechanism which

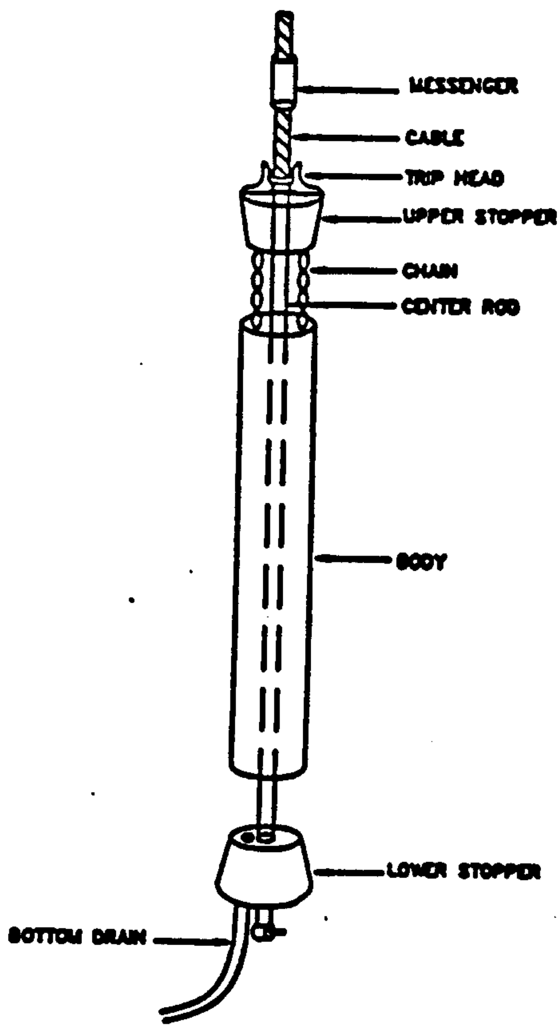

Figure 4-1 Kemmerer Bottles (US EPA, 1991)

causes the bottle to close. Both top and bottom are sealed to prevent further contact with the water column. Commercially available Kemmerer bottles are made of different types of material such as brass, plastic, stainless steel or acrylic. They can collect sample at specific depths between 3 - 600 feet.

4.2.2 Dip Samplers (Figure 4-2)

When the direct access to a sampling site is limited, such as an outfall or lagoon bank, a dip sampler is very useful for such sampling situations. The long handle on the dip sampler allows access from a discrete location. Dip sampler can be constructed of inert material such as stainless steel or Teflon.

4.2.3 Pond Samplers (Figure 4-3)

A pond sampler consists of an adjustable clamp attached to the end of a two- or three-pieces telescoping aluminum tube that serves as the handle. The clamp is used to secure a sampling beaker/container. A pond sampler is easily and inexpensively fabricated and usually not available commercially. It is commonly used to collect water samples from disposal ponds, pits, lagoons, and similar reservoirs. Grab samples can be obtained at distances as far as 3.5 m from the edge of the ponds.

4.2.4 Van Dorn Samplers

Van Dorn samplers, also known as alpha water samplers by others, are made of inert plastic tubing (generally PVC) closed with hemispherical rubber (urethane) end caps connected by a length of rubber passing through the sample chamber (available in 2,3, or 6 L capacities). When the sampler is being lowered the end caps are held open by a pair of chains attached to a 'lock' on the outside of the chamber. A messenger weight is released when the sampler is at the desired sampling depth. This will cause the end caps to snap sharply over the ends of the chamber to close it. There are two types of Van Dorn water samplers, i.e. Van Dorn-Vertical (Figure 4-4) and Van Dorn-Horizontal (Figure 4-5). The Van Dorn-Vertical is good for general water sampling. The Van Dorn-Horizontal is useful for collecting water at the sediment-water interface or sampling a thin layer of the water column. Van Dorn samplers generally are not recommended for sampling trace organics as they rely on an organic elastic closing mechanisms that can contaminate the samples.

Similar sampling mechanism as Van Dorn Samplers include Ruttner and Theiler-Friedinger water samplers. These two samplers are commonly used in Europe (Krajca, 1989). Ruttner's water samplers (Figure 4-6) are generally constructed of Perpex (plexiglass) and its open lids are in the horizontal position. Theiler-Friedinger's samplers, on the other hand, have the open lids in the vertical position and are constructed of light-metal or PVC (Figure 4-7). Both Ruttner and Theiler-Friedinger samplers have 1 - 3 L volume capacities.

4.2.5 Peristaltic Pumps

Peristaltic pumps can be used to draw in water sample through a Teflon tubing and pumped directly into the sampling containers (Figure 4-8). A medical grade silicone or C-Flex tubing is generally used as the pumping tubing. This system is highly versatile and portable. A timer can be used to provide constant sampling intervals and can also provide

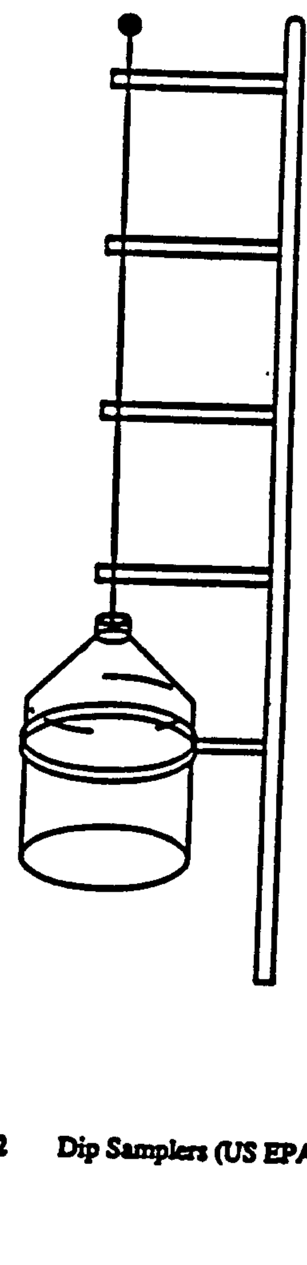

Figure 4-2 Dip Samplers (US EPA, 1991)

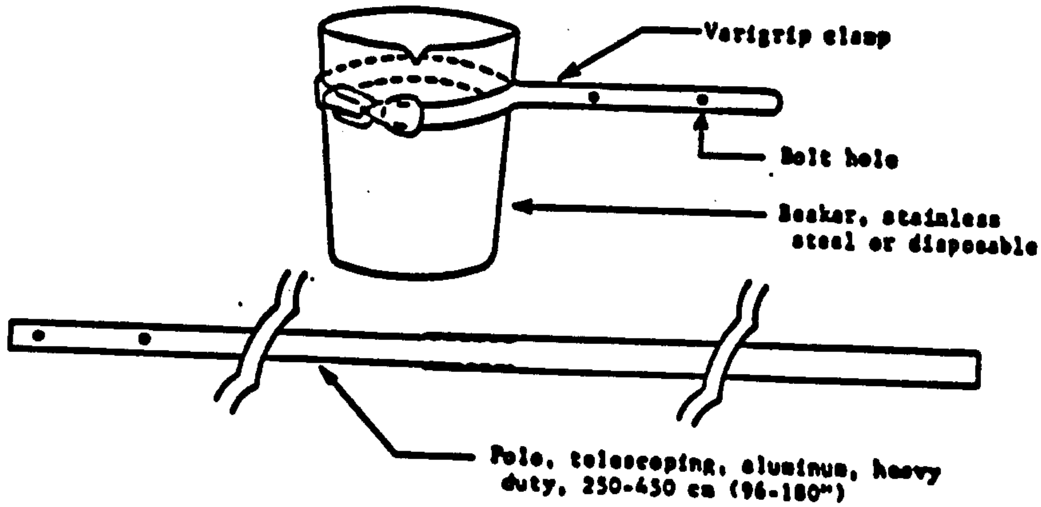

Figure 4-3 Pond Samplers (US EPA, 1984)

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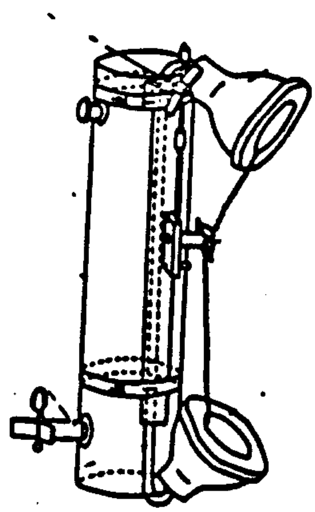

Figure 4-4 Van Dorn Vertical Sampler (Krajca, 1989)

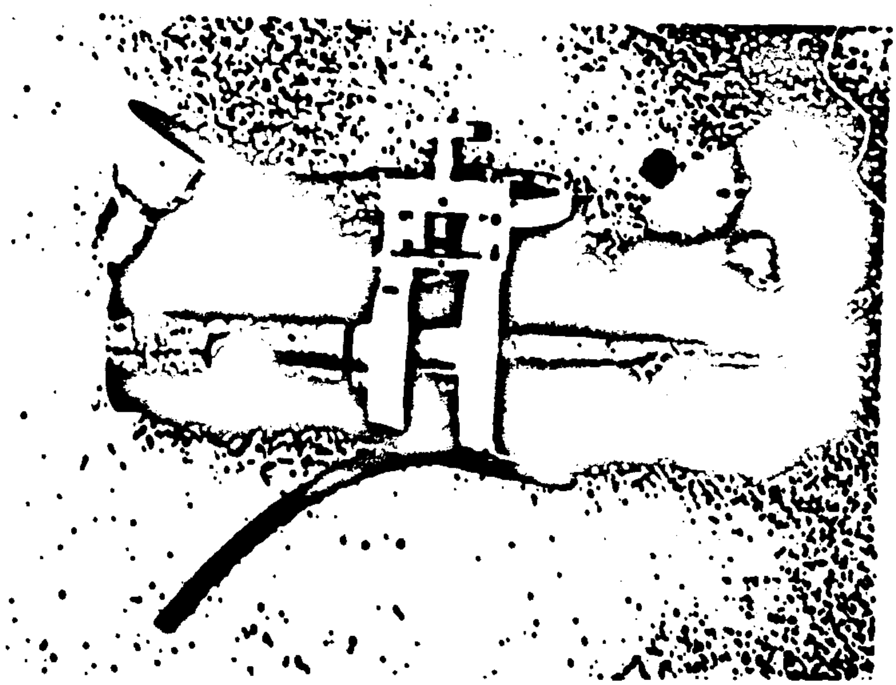

Figure 4-5 Van Dorn Horizontal Sampler (US EPA, 1982)

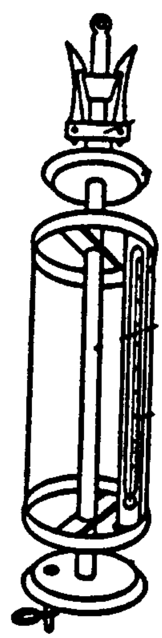

Figure 4-6 Ruttner's Sampler (Krajca, 1989)

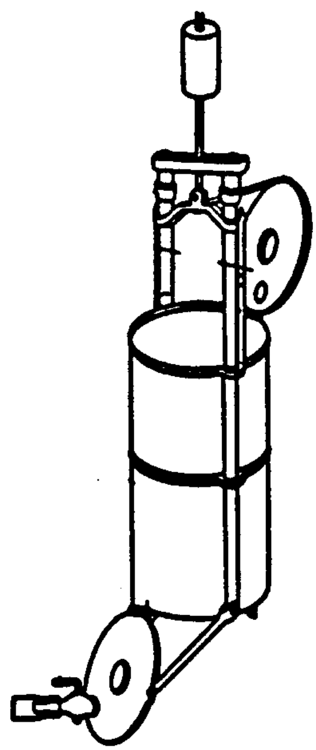

Figure 4-7 Theiler-Friedinger Sampler (Krajca, 1989)

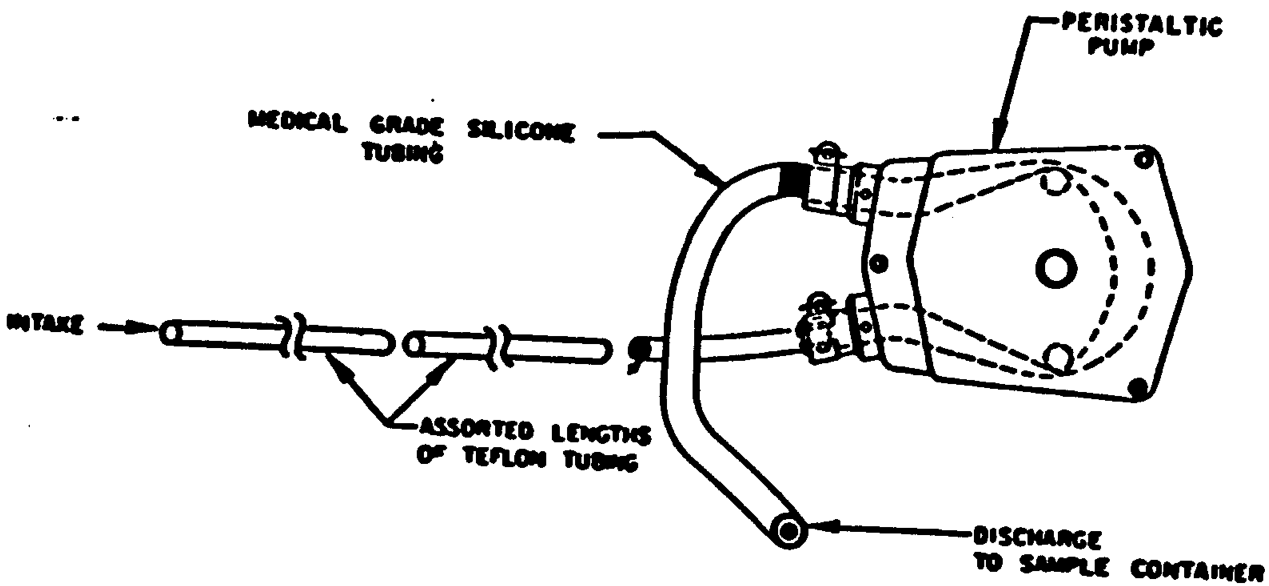

Figure 4-8 Peristaltic Pump Sampler (US EPA, 1984)

composite samples. This system allows sample collection at depths to 30 feet. The water sample contacts only tubing and stainless steel fittings. This method is not recommended for sampling volatile organics due to reduced pressure in the suction tubing, or for oil and grease due to coating of the tubing.

The system as shown in Figure 4-8 can also be altered so that the water sample is collected in a vacuum flask and does not enter the pump (Figure 4-9). The integrity of the collection system can be maintained with only the most non-reactive material (Teflon) contacting with the sample.

The main disadvantage of this method is the limited lift capacity of the pump, i.e. at ~30 feet. This lift capacity decreases with higher density fluids and with increase wear on the silicone pump tubing. Increased altitude decreases the pump's ability to lift. When sampling a liquid stream with a considerable flow rate, it may be necessary to weight the bottom of the suction line.

4.2.6 Knudsen Bottles

A Knudsen bottle is generally used for collection of water samples and water temperature data using up to three reversing thermometers. The sampler is constructed of nickel-plated metal with an average length and capacity of 0.5 m and 1.2 L, respectively.

4.2.7 Nansen Bottles

A Nansen bottle is similar to the Knudsen bottle, but it is designed to sample depths of ~3000 feet or more. The end valves is made of bronze, and the cylinder is made of brass. It is also available with either a tin-plated or Teflon-lined cylinder. A Nansen bottle has a capacity of 1.3 L and an overall length of ~2 feet. Several Nansen bottles can also be used in series for water sampling.

4.2.8 Simple Bottle Samplers

A simple bottle sampler is essentially a glass or polyethylene bottle and is generally used for surface sampling. The sample container is filled by displacement when the open bottle is put beneath the surface. Its advantage of this bottle sampler is its simplicity of operation mode, inexpensive, small size and weight in relation to the sample volume. However, there is no depth control using simple bottle sampler. In addition, the water sample is partially aerated which may be unsuitable for sampling dissolved oxygen (DO), carbon dioxide or other gases.

4.2.9 Niskin's Bag Samplers (Figure 4-10)

A Niskin's sampler is made of two ribbed aluminum plates connected by spring loaded hinges. It is kept in the closed position by a messenger operated mechanism. The sampling bag is fitted with pockets on each side to hold the plates, and is filled through a tube protected by a plastic casing. When the sampler is at the sampling depth, the messenger is released and activates a guillotine to cut off the cover of the inlet tube, which hangs away from the sampler body. At the same time, the two plates spring apart and the sample is sucked into the bag through the inlet. After the bag is filled, the end of the tube is automatically closed with a clamp, and the sampler can be pulled up to the surface. The

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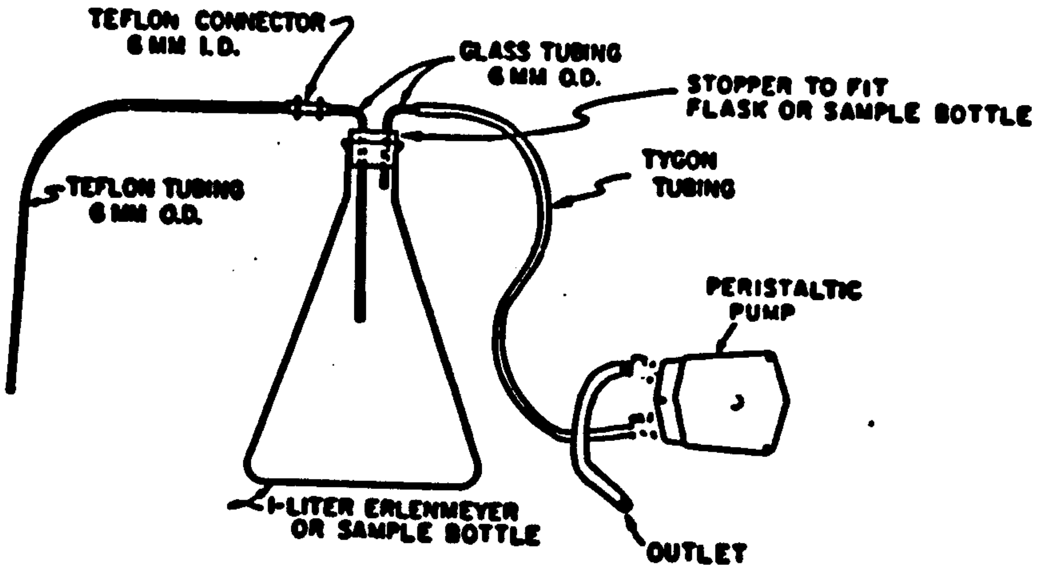

Figure 4-9 Peristaltic Pump (US EPA, 1984)

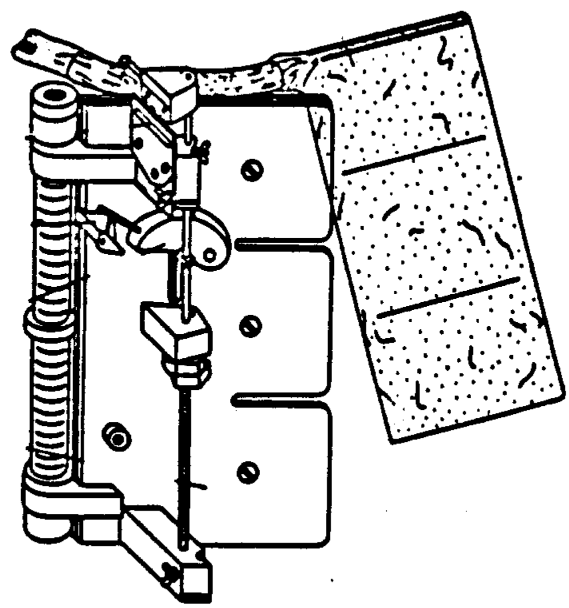

Figure 4-10 Niskin's Bag Sampler (Krajca, 1989)

bag can be used for transportation and storage, or emptied into another container. Sample contamination by this sampler is virtually eliminated, and groups of bags can be submerged as a series, on a single suspension cable either one above the other or side by side. Niskin's bag samplers are available in PVC and Teflon-lined for organics sampling. The sample volume capacity is 1.2 - 30 L.

4.3 AUTOMATIC SAMPLERS

Automatic samplers are being used increasingly in most of the monitoring programs to meet the requirements of NPDES permits. The advantages of automatic samplers include their consistency in samples collection, capability of collecting multiple bottle samples, minimal labor requirements, unattended operation, and the decrease in variability of samples caused by sample handling. However, no single automatic sampler is ideally suited for all situations. General criteria needed to be considered in selection of an automatic sampler include:

- ease of operation and repair,
- simple design with minimum operating parts and maximum long-term reliability,
- minimum number of parts in contact with water,
- resistance to corrosion, dust and sand, and low susceptibility to clogging,
- ability to use battery or main power,
- ability to tolerate varying climatic conditions,
- ability to operate a sampling schedule based on time or flow volume through the sampling chamber,
- ability to preserve samples at specified temperature for at least 24 hours.

Detailed information on the theoretical design considerations and actual field performance data for automatic samplers can be found in references such as Lauch (1976) and Shelley and Kirkpatrick (1975). The basic components of automatic samplers are a pump and a system for transporting the water sample to the collecting center (a tank or sample containers). Medical-grade silicone tubing must be used in peristaltic pumps to avoid contamination of the sample by organic peroxides used in the manufacturing of conventional grades of silicone tubing. Additionally, when sampling for toxic pollutants, the suction line must be made of Teflon (Newburn, 1988). The sample collection chamber sometimes is also connected to an autoanalyzer (e.g. flowmeter, pH and DO meter). Examples of automatic samplers used previously for stormwater sampling include ISCO models 3700 and 2900, Sigma Model 800SL, NB Model WS-1000, TN Technologies Priority Contaminant Samplers (PCS), etc. A full detailed list of automatic samplers is also given in *Addendum to Handbook for Sampling and Sample Preservation* (US EPA, 1983).

Automatic samplers are constantly being developed and improved. Recent innovations include flow and rainfall measuring equipment, and remote telemetry capability. In order to obtain the most current and correct information, manufacturers must be contacted to obtain specifications.

Automatic samplers are capable of collecting either grab or composite samples. Current automatic samplers mostly contain at least 24 sample bottles for grab sampling in which each individual sample is collected into separate sample bottle. For composite samples, small aliquots are taken at frequent intervals, usually over a 24-hours period, and collected in a single container. Most automatic samplers are also capable of gathering either timed-interval samples or samples collected proportional to flow. Timed-interval samplers have a fixed interval of time between each aliquot or sample. Flow-proportioned or flow-weighted samples are based generally on equal increments of flow as measured by the built-in flowmeter. A flow-weighted composite sample can be obtained by collecting small aliquots in a single container over small increments of flow (Newburn, 1988). However, dry weather conditions can create problems in collecting flow-weighted composite samples due to the absence of flow in the stormdrains. In such situation, only time-interval grab or composite samples can be collected.

Although automatic samplers are considered versatile and reliable in collecting samples, considerable maintenance is required for proper operation. Other disadvantages of automatic samplers include susceptibility to fouling by solids, inflexibility (fixed maximum sample volume), and possible sample contamination. Furthermore, automatically samplers cannot properly sample certain contaminants, such as oil and grease. Oil and grease can be stratified in the sample stream which makes collecting a representative sample from a single point impossible. The tubing required in the sampler's pumping system may contaminate samples (carry over from one sample to another) or may alter the sample concentration (adsorption of the contaminants to the tubing walls). Another major disadvantage of automatic samplers is their cost and susceptibility to vandalism. The sampler itself may cost as little as $1,000, but the infrastructure associated with the sampler, including telemetry, construction and flow measuring equipment may cost as much as $30,000 or more per station.

Most of the new stormwater monitoring programs are based upon automatic samplers. The cost and difficulty of manually collecting flow-weighted composite samples are prohibitive. Chapter 9 of this report includes several case studies, all of which used automatic samplers. It should be consulted for further information.

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Some properties of the samples can change, either quantitatively or qualitatively, during the interval between their collection and analyses. These changes may be spontaneous or due to the sampling handling procedures. If possible, field analysis, or *in situ* analysis, is recommended in order to avoid any possible changes. When *in situ* analysis can not be carried out, the samples should be appropriately stored and preserved to maintain parameter stability during the delays in transport and storage. The following sections will discuss the samples storage, sample preservation, recommended holding time and sample volume prior to any analysis in the laboratory.

5.1 FIELD ANALYSIS

Field analysis, or *In situ* analysis, refers to all measurements made at the sampling site. Field analysis is generally used when the parameters are known to change with time and cannot be preserved. In addition, field analysis can also be used to check the reliability and reproducibility of the sample. The parameters measured in the sampling site include temperature, pH, conductivity, buffering capacity, ferrous iron, E° (effectively oxidation and reduction potential), some organoleptic properties (e.g., taste, odor, color and turbidity), concentrations of carbon dioxide, hydrogen sulfide and other soluble gases. Some of these parameters, such as conductivity, pH, and ferrous iron, should be determined first in the field and then in the laboratory using preserved samples. In this way, the degree of change that occurred during transport and storage can be determined (Krajca, 1989).

5.2 SAMPLE STORAGE

It is important to take proper precautions for samples storage during sample transportation from the sampling site to the laboratory. Sample containers used in storing the sample prior to analysis are very important. Selection of sample container depends on factors such as resistance to breakage, size, weight, interference with constituents, cost and availability (US EPA, 1982). The following sections discuss factors that need to be considered prior to sample storage.

5.2.1 Container Material

There are two major types of material used for sample container, i.e., plastic and glass (Hellwig, 1964):

1. Glass
   - Kimax or Pyrex brand - borosilicate
   - Vycor - generally lab ware
   - Ray-Sorbor Low - Actinic - generally lab ware
   - Corex - generally lab ware

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2. Plastic:
   - Conventional polyethylene
   - Linear polyethylene
   - Polypropylene
   - Polycarbonate
   - Rigid polyvinyl chloride
   - Teflon

The above glass and plastic materials have their advantages and disadvantages (Table 5-1). For example, borosilicate glass bottles have the advantages that their internal surface is readily apparent and that they can be more vigorously cleaned. In addition, they are inert to most materials. However, glass bottles are more liable to breakage.

In general, three main considerations involve in choosing container materials (Suess, 1982):

1. the material of the containers may cause contamination of samples (e.g., sodium and silica can leached from glass, organic substances can be leached from plastics),

2. determinands may be sorbed on the walls of containers (e.g., trace metals by ion-exchange processes on glass surfaces, adsorption of benzene by plastics),

3. constituents of the sample may react with the containers (e.g., fluoride may react with glass).

The above mentioned processes generally become more important as the concentrations of determinands become smaller (e.g., less than 1 mg/L). Thus type of container used for storing samples can be critical. However, if large concentrations of constituents such as chloride, sulfate, hardness, nitrate, etc., the type of container is usually unimportant.

As a general rule, glass bottles should be used when organic compounds (e.g., pesticides, oil and grease) are to be determined. Plastic or polyethylene bottles should be used for determinands that are major constituents of glass, e.g., sodium, potassium, boron, silica (Suess, 1982; US EPA, 1982). For most bacteriological samples, bottles that can withstand sterilization temperatures should be used (ASTM, 1989).

5.2.2 Container Caps

The types of container caps used with the sample containers is also important. There are two major types of plastic used in container caps: polyethylene and bakelit with liners. Polyethylene caps are recommended for ease of cleaning unless oil and grease are to be analyzed. There are three types of liners available and their advantages and disadvantages are listed in Table 5-2. Generally caps with Teflon liners should be used for pesticides and oil and grease samples. Silicone rubber material should be avoided for trace metals due to possible zinc contamination (Gibbs, 1975; ASTM, 1989).

5.2.3 Container Structure

Wide mouth containers are mostly used. This structure permits easy filling and sample removal. It is also easily cleaned, quickly dried, and can be stored inverted. A narrow

Table 5.1 Glass and Plastic Advantages and Disadvantages (EPA, 1982).

	Borosilicate Glass	Conventional Polyethylene
Interference with sample	Inert to all constituents except strong alkali	Good for most constituents except organics and oil and grease
Weight	Heavy	Light
Resistance to breakage	Very fragile	Durable
Cleaning	Easy to clean	Some difficulty in removing adsorbed components
Sterilizable	Yes	In some instances
Space	Takes up considerable space	Cubitainers - substantial space savings during extended field studies

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Table 5.2 Bottle Cap Liner Advantages and Disadvantages (EPA, 1982).

Liner Type	Advantages	Disadvantages
Wax coated paper	Generally applicable to most samples, inexpensive	Must be inspected prior to each because of deterioration. Cannot use with organics
Neoprene	Same as wax coated paper	Same as wax coated paper
Teflon	Applicable for all analyses Minimizes container/sample interaction	High cost

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neck bottle is recommended when the interaction with the cap liner or outside environment is to be minimized. For pesticide sample collection, a solvent cleaned glass container should be used (Hellwig, 1976).

5.2.4 Disposable Containers

When the cost of cleaning is high, disposable containers generally are recommended. These containers should be precleaned and sterile. The most commonly used disposable container is the molded polyethylene container which is shipped nested and sterile to the buyer (US EPA, 1982).

5.2.5 Container Cleaning

Cleaning of sample containers prior to sampling is another important step in order to avoid any unnecessary contamination. Chromic acid is often suitable for glass, and hydrochloric acid (approximately 1 mole/L) can be used to clean polyethylene. The use of concentrated nitric acid should be avoided for cleaning plastic bottles as it may cause the formation in the plastic of chemical groups with ion-exchange properties (Suess, 1982). Non-phosphate or biodegradable detergent can also be used. Glass bottles that have contained samples with chromate or heavy metals should be rinsed with dilute nitric acid before final thorough rinsing with water. After the final rinse the pH should be checked to assure that toxic acids or chromate are not present (ASTM, 1989).

5.2.6 Container Preparation

In addition to the above mentioned cleaning procedure, special precaution should be taken to avoid adsorption and contamination due to interaction with container walls. Special procedures to prepare the sample containers for metals, organics and microbiological samples are outlined below (US EPA, 1982) :

1. <u>Metals</u> : A solution of one part nitric acid to four parts water should be used to rinse the container, and then followed with a rinse using distilled water. If phosphorous is to be analyzed, a solution of one part hydrochloric acid to one part water is used instead. The container caps are treated in similar way.

2. <u>Organics</u> : When oil and grease or pesticides are to be analyzed, methylene chloride should be used to rinse the containers, followed by acetone. For pesticide analysis, pesticide grade acetone or hexane should be used. The containers should have been previously treated with chromic acid solution. The caps are also treated similarly.

3. <u>Microbiological</u> : For microbiological analyses, the containers and its cap/stoppers should be sterilized by autoclaving at 121°C for 15 minutes or by dry heat at 180°C for 2 hours. The bottles should also be wrapped in Kraft paper or covered with aluminum foil before sterilization so contamination can be avoided.

5.3 HOLDING TIME

Holding time is defined as the time interval between collection and analysis. More reliable analytical results will be obtained with shorter holding time. It is, however, difficult to determine the maximum time that is allowed to elapsed between sample collection and analysis before any deterioration of sample occurs. The characteristics of the samples, analysis that are to be performed, and the conditions of the storage are among the factors that need to be considered in determining the holding time. There is some variability among various authors on the maximum allowable holding times for various analytes. Recommended maximum holding times for various analytical parameters, which have been compiled by the US EPA (1974), are listed in Appendix C.

5.4 SAMPLE VOLUME

The volume of sample collected generally is not important as long as it is sufficient for all the required analyses and there is enough leftover in case some analyses need to be repeated. In general, approximately 8 liters (about 2 gallons) are required for a fairly complete analysis. The volume of sample required for specific types of pollutants analyses, which has also been compiled by the US EPA (1974), are shown in the Appendix C.

However, certain points need to be considered while collecting the samples (Suess, 1982):

- the sample containers should be completely filled for determining dissolved gases, purgeable/volatile organics, pH and conductivity in weakly buffered waters,
- the sample containers should not be completely filled when samples require vigorous shaking before portions for analysis (e.g., for bacteria or undissolved materials),
- when small concentrations of determinands are present as discrete particles (e.g., dissolved materials, algae, bacteria), a minimum volume of sample may be needed to control errors arising from the statistical variations in the number of particles in a given volume of sample. The required sample volume usually will be given in the analytical method.

5.5 SAMPLE PRESERVATION

Changes of the physical (e.g., volatilization, adsorption, diffusion, and precipitation) and chemical (e.g., photochemical and microbiological degradation) conditions of the samples may occur during the time interval between sample collection and analyses. These changes can be minimize by using proper preservation techniques.

Preservation techniques are selected on the basis of their ability to minimize changes in order to preserve the integrity of the sample after collection. Preservation guidelines for certain types of sample and analyses have been compiled by the US EPA (1974). The recommended preservation methods are listed in the Appendix C. Preservation of samples has also been discussed in a number of literature such as US EPA (1982), Keith (1988), Suess (1982) and ASTM (1989). Preservation methods are generally limited to addition of preserving reagent, pH control, refrigeration and freezing. Combination of these methods are often used for the preservation of sample. The following section discusses some of the preservative methods commonly used.

5.5.1 Addition of Preserving Reagent

Stability of sample conditions can be achieved by adding a chemical reagent (or a preservative) to an empty sample container before collection. When the sample is added, the preservative disperses immediately, stabilizing the parameter(s) of concern for a certain period of time. However, when the added preservative interferes with other parameters being measured, additional samples for those parameters must be collected. For example, concentrated nitric acid added for preserving the metals would interfere with BOD, so an additional sample must be collected for BOD.

As a general guideline, acidification (usually with nitric or hydrochloric acid) of samples is carried out for trace metals analyses. Different acids and acidities can be use for different metals. The minimum acidity required for stability depends on the metal. In general, sufficient amount of nitric or hydrochloric acids should be added to give a final concentrations in the range of 0.05 - 0.1 mole/L in the sample after collection (Suess, 1982).

When the samples are subject to biological changes, addition of mercuric chloride or acidification are more frequently used. In general, mercuric chloride (20 - 40 mg/L) can be used for preserving nitrogen compounds, while sulfuric acid (1 - 2 ml/L) is used for determinands such as COD, fats, and greases (Suess, 1982).

5.5.2 pH Control

This type of preservation method usually involves acidification (or chemical addition) of the sample. For example, concentrated nitric acid is added to lower the pH to less than 2 in order to keep metal ions in a dissolved state.

5.5.3 Refrigeration

Refrigeration of samples is another common preservation method. It is commonly used for biological examination in which the samples is refrigerated immediately after collection and held at a temperature less than 4°C.

5.5.4 Special Sample Containers

Samples with photosensitive constituents (e.g., polynuclear aromatic hydrocarbons and bromo- or iodo-compounds) should be collected and stored in amber glass containers to protect them from light (Parr et al., 1988) and stored in dark areas prior to analysis. It is also possible to use collapsible containers which facilitate collecting samples with no gas space in the container.

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6.0
FLOW MEASUREMENT

Flow measurement is one of the most important monitoring parameters in any sampling program. Care must be taken in selecting a site suitable for flow measurement as well as the flow measurement method. The ideal site allows flow measurements to meet program objectives, provides ease of operation and accessibility, personnel and equipment safety, and freedom from vandalism. Flow measurement is so important that site selection may be dominated by the ability to measure flow rate.

There are many flow measurement methods. The objective of this section is to present a brief overview of the current flow measurement methods and equipment appropriate for the storm drain monitoring programs and to list advantages/disadvantages. Detailed information of methods of flow measurements can be found in references such as *Flow Measurement Engineering Handbook* (Miller, 1983), *Water Measurement Manual* (USDI, 1974) and *Fluid Meters* (ASME, 1971).

The measured flow rate is generally used to determined the mass emission of contaminants (mass emission = flow rate x concentration). If the concentration of contaminants and flow rate vary with time, a flow weighted average must be determined to quantify mass emission. In addition, the number of discrete samples that make up the composite sample depends upon the variability of contaminant concentration and flow. Examples of manual compositing samples based on flow rate are given by the US EPA (1982). Inaccurate flow measurements will lead to inaccurate flow proportional composite samples.

Most of the flow measuring devices, however, have disadvantages such as:

- devices (e.g. weir) can reduce flow in the storm drain
- increase the risk of flooding,
- debris and trash can hang up on the device.

General criteria for an ideal flow measuring device include:

- no or insignificant restriction of storm drain flow,
- ability to use the device over a wide range of flows,
- no tendency to be fouled by debris.

6.1 OVERVIEW OF TRADITIONAL FLOW MEASURING DEVICES

The traditional flow measuring devices commonly used include weirs, flumes, venturis, orifices, positive displacement meters, flow nozzles, etc. These devices are generally not suited for stormwater flow measurements primarily because they restrict flow too much and require too much pressure drop for accurate measurement. In addition, they are also susceptible to clogging or fouling by the debris or suspended solids. More detailed information of these flow measuring devices can be found in the literature, but a brief overview is provided here.

6.1.1. Weirs

A weir is an overflow structure built across an open channel to measure the rate of flow. Weirs may be termed rectangular, triangular or trapezoidal, depending on the shape of the opening. The relationship between head and discharge are different for different weirs. More detailed information can be found in references such as *Water Measurement Manual* (USDI, 1974) and *Fluid Meters* (ASME, 1971). One of the parameters that affects weir flow measurements is the weir coefficient (C_w), i.e. a coefficient characteristic of flow conditions over the weir. The coefficient differs from one type of weir to another. Corrosion of the weir crest or damage caused by floating debris may alter the C_w value. Weirs also have the tendency to settle suspended particles or debris near their upstream side. This build-up will further restrict the flow in the sewer, increase the risk of flooding and bias water quality samples. In addition, the use of a weir usually results in a relatively large head loss. Therefore, permanently installed weirs are generally not suited for flow measurements in storm drains, unless they have been previously installed for other purposes and their head loss has already been accounted for in providing for flood protection. Temporary weirs are sometimes useful. The downstream side of a weir can be used a place to obtain representative samples from stratified streams, since the entire flow is mixed as it passed over the weir. In areas like Southern California, with seasonal rainfall, and dry weather runoff, low flow channels may be equipped with weirs without loss of flood protection.

6.1.2 Flumes

Flumes consist of three sections: a converging upstream section, a throat or contracted section, and diverging downstream section. The flume size is given by the width of the throat section. Flumes are considered better than weirs as most flumes have a self-cleansing feature in which build-up of particulate matters onto their upstream side can be avoided. In addition, the head loss resulted from flumes is relatively less than weirs. Commonly used flumes as flow measurement devices include Parshall flumes, Palmer Bowlus flumes and cut-throat flumes. Flumes create head loss and reduce maximum flow rate. Additionally they are expensive to construct, especially if they need to be retrofitted into existing facilities.

6.1.3 Positive-Displacement Meters

Positive-displacement (PD) meters separate the flow into discrete volumes and then sum to total volume by counting unit volume that passes through the meter. As fluid enters a chamber, an impeller, a piston, a diaphragm, or a disk rotates or moves to accommodate the entering fluid, and a known volume is discharged. Seals are required to separate the volumes, and the pressure loss across the meter provides the energy to drive the moving parts. The fluid temperature and viscosity affect the range and accuracy. Manufacturers should be consulted on temperature, pressure and viscosity limitations. Positive-displacement meters have no time basis. Therefore, they are seldom used to indicate instantaneous flow rate. They are unsuitable for storm drain monitoring because of their head loss and tendency to foul.

6.1.4 Differential Head Meters

Examples of differential head meters include venturi meters, flow nozzles, orifice plates, elbow flowmeter and pitot tubes. The measured the flow rate is proportional to the differential pressure between the undisturbed flow and the constriction section of the pipe caused by the meters. The difference of pressure may be measured with a differential manometer or pressure gauge. A straight length of pipe at least 10 diameters long is usually installed upstream of the meter. The main disadvantage of these differential head meters is the large permanent pressure loss that occurs across the section. Among these differential head metes, venturi meters have the lowest pressure loss whereas orifice meters cause the largest permanent pressure loss. Another disadvantage of these differential head meters is their susceptibility to clogging in waters with high suspended solids concentration. The head differences are also difficult to measure at low flow conditions.

6.2 ALTERNATIVE FLOW MEASURING DEVICE

Most of the traditional flow measuring devices mentioned above are considered poor in obtaining accurate results because they restrict flow too much. Alternative flow measuring devices include magnetic flowmeters, ultrasonic flowmeters and flow gauges (in which the flow is estimated using equations such as Manning, Chezy and Hazen-William's equations). These alternative devices are superior to those mentioned above due their low or negligible pressure loss.

6.2.1 Magnetic Flowmeter

The operation of magnetic flowmeter is based on Faraday's Law of Induction which essentially averages velocity over the pipe area. The voltage induced by a conductor (which is the liquid stream to be measured) moving perpendicular to flow direction and magnetic field (which is produced by a set of electromagnetic coils). The induced voltage is then detected by two flushed-mounted electrodes on a diameter of a non-conducting pipe wall. The low level millivolt signal is proportional to the average pipeline velocity. Thus magnetic flowmeters are considered ideal for all conductive fluids that operate in both laminar and turbulent flow regimes. Fluids to be measured must be a conductivity of at least 2 μmho/cm to be measurable (Miller, 1983).

Magnetic flowmeters generally are used in pipes flowing full. In addition to their ability to operate in a wide flow measurement range (laminar and turbulent flow regimes), their advantages also include accuracy of ± 0.5 - 1 %, negligible pressure loss, no moving parts, and rapid response time. However, the cost of magnetic flowmeters is high. Build-up of grease deposits or pitting by abrasive wastewaters can also foul the electrodes. Installation of magnetic flowmeters also require straight sections along the pipes with minimum length. Thus, regular inspection and cleaning of the electrodes are necessary. Built-in ultrasonic cleaning devices are the most commonly used (Hayward, 1979).

6.2.2 Ultrasonic Flowmeters

There are two types of ultrasonic flowmeters: time-of-flight and Doppler effect (Miller ,1983).

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- Time-of-flight meter: In time-of-flight ultrasonic flowmeters, a high-frequency (~ 1 MHz) pressure wave is beamed at an acute angle across the pipe. The time required for the wave to reach the opposite wall depends on liquid velocity, whether it is moving with or against the flow and on the speed of sound through the liquid. Flow rate information is obtained from the measured time of travel. There are many varieties of time-of-flight meters. The main differences are usually in the number of beam paths across the pipe. A single beam instrument averages along the beam and not across the pipe area. This make the single-path measurement dependent on velocity profile. Multipath meters average along several paths, reducing profile dependency. Both single-path and multipath ultrasonic flowmeters are sensitive to swirl. They are generally used in clean fluid applications, where the ultrasonic beam is not continuously interrupted by fluid particles. Their accuracy is between ± 1 to 4 %, depending on design and applications.

- Doppler flowmeters: In Doppler flowmeters, the sound pressure front does not pass through the pipe. It is reflected back to a detector by particulate matter moving with the flow. The difference between reflected frequency and fixed transmitted frequency is used to calculate the flow rate (Miller, 1983). Doppler flowmeters depend on small particles or impurities in the flow. Therefore, its accuracy depends on particles concentration and distribution. Accuracy is also influenced by the relative velocity between fluid and particles.

The advantages of ultrasonic flowmeters are low maintenance (including cleaning), wide flow range, low headloss and relative high accuracy of measurement. However, their disadvantages include high initial cost and errors from heavy turbulence and foam (US EPA, 1982). New types of ultrasonic flowmeters can be inserted into pipes using a metal bar which holds the meter against the pipe wall. This type of installation produces the least pressure drop and tendency to catch fouling materials.

6.3 ESTIMATED FLOW MEASUREMENT METHODS

In the absence of a flow measuring device, channel or sewer bottom slope, depth of flow and flow velocity measurements can also be used to estimate the flow. Among the commonly used estimation methods are the Manning, Chezy and Hanzen-William's equations.

6.3.1 Manning Equation

$$V = \frac{1}{n}(R)^{\frac{2}{3}}(S)^{\frac{1}{2}} \qquad (1)$$

where

V = average velocity of flow (ms^{-1})
R = hydraulic radius (cross-sectional area divided by wetted perimeter, m)
S = slope of the energy grade line
n = roughness coefficient

The Manning equation can be used to estimate flow in channels or pipes.

6.3.2 Chezy Equation

$$V = C(RS)^{\frac{1}{2}} \qquad (2)$$

where

C = Chezy coefficient

Chezy coefficient is most frequently expressed as

$$C = \frac{1}{n}(R)^{\frac{1}{6}}$$

The Chezy equation generally applies to open channel only.

6.3.3 Hanzen-William's Equation

$$V = 0.85\ C_H R^{0.63} S^{0.54} \qquad (3)$$

where

C_H = Hanzen-William's coefficient

The Hazen-William's equation is generally used for pipes flowing full.

The usefulness of the above equations for flow measurement is limited due to the difficulties of assigning an appropriate value to the roughness coefficient which varies with the channel or sewer material (concrete or brick), and the surface of the channel or sewer. For sewers, it varies also with the ratio of depth of flow to the depth when flowing full. In addition, the slope of energy grade line (which is taken as the slope of the channel or sewer) may also cause the inaccuracy in flow measurement. For example, the Manning equation is only applicable when the channel slope is less than about 0.10. Various tables, nomographs, slide rules, and charts have been prepared to simplify calculation and facilitate solution of these problems (Linsley and Franzini, 1979).

6.4 FLOW MEASUREMENT CONCLUSIONS

There is no ideal flow measuring device that is suited for all sampling locations. The flow measuring devices should provide "real-time" indication of flow rate in order for automatic samplers to obtain flow weighted composites. Total flow, provided by integrators or totalizers is also very important, especially to determine the accuracy of rainfall/runoff models, which were used extensively in the design of the Santa Monica Bay monitoring plan developed as a part of this study. The flow measurement cost per sampling points may be as high as $25,000 - 30,000 (in 1991 dollars). Site-specific information on previously used monitoring equipment is presented in Chapter 9.

Implementation of correct sampling procedures is very important so that accurate results can be obtained. However, problems still occur in sampling, even in the hand of an experience sampling personnel. The most commonly encountered sampling problems include sample contamination (caused by sampling devices or sample containers), interaction between samples and sampler material (e.g. sorption), and problems due to stratified contaminants such as suspended solids and oil and grease.

7.1 SAMPLE CONTAMINATION

Water sample contamination is the most common sampling problem. The usual sources of contamination are the sampling devices and sample containers. Carryover between samples from the sampling devices will occur if the device is not cleaned thoroughly prior to sampling. Sampling devices are generally cleaned with detergent (non-phosphate) and hot water. Sometimes manufacturers also provide guidelines for cleaning the sampling devices and these guidelines should always be followed. The devices also should be rinsed at least three times with water to be sampled; this procedure flushes out any remaining cleaning solutions that may dilute the sample. Special cleaning procedures are often required for specific contaminants. Consult the analytical protocol for further information.

In addition to sampling devices, sample containers must also be cleaned according to appropriate cleaning procedure (e.g. the Standard Operating Procedure (SOP), and ASTM's cleaning procedures). Solvents used for cleaning sample containers include 10% nitric acid (for trace metals analyses), pesticide grade hexane or acetone (for organics analyses) and methanol. Concentrated chromate acid (typically 20 g potassium dichromate in a liter of concentrated sulfuric acid) is also commonly use to clean glass sample containers. Detailed information on the cleaning procedures of sample containers can be found in references such as ASTM and Standard Methods.

Blanks are used to assess contamination. Blank samples usually include an equipment blank and transport blank (see Chapter 3). Selections of blanks should be made by considering all likely sources of contamination for the specific situation.

7.2 SORPTION

Analyte sorption is another common sampling problem. Materials used for sampling devices or sample containers should be inert to the collected water samples (see Chapter 5). For example, PVC and plastics other than Teflon tend to sorb organics and leach plasticizers and other chemicals used in their manufacture. In addition, some pesticides and halogenated compounds strongly sorb to glass (Keith, 1991).

Tubing material used in the automatic samplers is very important. Thermoplastic materials, such as polypropylene, have the tendency of sorbing many organics. Therefore they should be avoided. Teflon tubing is recommended as the suction tubing in the automatic samplers as Teflon materials are inert to almost all constituents. Selection of an appropriate tubing material should be made based on the manufacturer's guidelines, in which compatibility of the tubing materials with certain analytes is provided.

7.3 OTHER SAMPLING PROBLEMS

Oil and grease and suspended solids usually require special techniques to avoid problems. Sampling problems caused by oil and grease include the following:

a. Adsorption of oil and grease onto the tubing wall
   - common problem in automatic samplers.
   - suitable tubing material has to be chosen in which adsorption onto the tubing wall can be avoided.
   - tubing suitable for sample may not be compatible with peristaltic pumps.

b. Sample stratification
   - free oil and grease tends to float on water surface whereas the fraction that attached to the particulates tends to deposit on the bottom.
   - at the chosen sampling location (or sampling depth) one should be able to collect samples which include the free-floating and heavy fractions of oil and grease in the water. Automatic samplers are not capable of doing that as the samples is generally collected from a specific sampling depth.
   - manual water samplers (such as Kemmerer bottles, Von Dorn Vertical bottles) are suitable to collect a sample from the water column.

Suspended solids in water may cause the following sampling problems:

a. Clogging/fouling problems in the automatic samplers
   - constant cleaning/flushing of the automatic sampler intake position is needed.

b. Fouling of flow measuring devices
   - especially in weirs in where the suspended solids are deposited onto their upstream section and restrict flow.

c. Sample stratification
   - the effects similar to those of oil and grease.
   - It is difficult to collect representation samples using automatic equipment, for the same reasons as for oil and grease. Manual water samplers such as Van Dorn and Kemmerer bottles are recommended to collect water samples with high concentration of suspended solids.

8.0
QUALITY ASSURANCE IN SAMPLING

All sampling programs should have a Quality Assurance (QA) plan. The objectives of QA plan are to make sure the generated data are precise, accurate, representative, comparable and complete. Data falling outside the acceptable levels for these criteria will results in the potential sources of error being investigated, corrected, and recorded with a repeated analysis of questionable samples. Examples of quality assurance elements include the collection of sample blanks, duplicates and spike samples (US EPA, 1984). A QA Coordinator within the organization should be assigned so that he/she can undertake activities such as quality planning, auditing and other programs to insure reliability and complete integration of the QA plan.

A quality assurance plan for a sampling program generally include the following steps:

1. The sampling program should describe details on sampling locations, sample type, sample frequency, number of samples, duration of sampling, sample volume, sample collection methods and holding times, equipment to be used for the sample collection, sample containers, pretreatment of containers, type and amount of preservative to be used, blanks, duplicates/triplicates, spiked samples, replicates, and chain of custody procedures.

2. Procedures for routine testing, maintenance and calibration of sampling equipment should be developed. Manufacturers' instructions are appropriate guides for these procedures. Information on quality assurance guidelines for field analysis, equipment calibration and documentation is given by US EPA (1977).

3. Random control checks should be performed to make sure that appropriate sampling guidelines on sample collection, handling and chain of custody are followed by the field personnel. If deviation occurs, appropriate corrective action should be taken. In addition, analytical quality control as an aid to quality assurance must be performed through duplicate, split, and spike samples. Sample preservative blanks, and known standard solutions, and accuracy may be evaluated using control chart.

The above mentioned steps are just a general descriptions of a QA plan for a sampling program. More detailed information on implementation of QA plan is given by US EPA (1980). In general, a QA project plan should address the following:

1. Title page, with provision for approval signatures
2. Table of contents
3. Project descriptions
4. Project organization(s) and responsibilities
5. QA objectives for measurement data (precision, accuracy, completeness, representativeness, and comparability)
6. Sampling procedures
7. Sample custody
8. Calibration procedures, references and frequency

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9. Analytical procedures
10. Data reduction, validation, and reporting
11. Internal QC checks and frequency
12. QA performance audits, system audits, and frequency
13. QA reports to management
14. Preventive maintenance procedures and schedule
15. Specific procedures to be used to routinely assess data precision, representativeness, comparability, accuracy and completeness of the specific measurement parameters involved.
16. Corrective action

Successful implementation of a QA plan depends on the competence of the monitoring personnel. All personnel involved in any function that may affect data quality (e.g. sample collection, analysis, data reduction and quality assurance) should have sufficient training in their appointed jobs to contribute to the reporting of complete and high quality data.

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9.0

REVIEW OF EXISTING MONITORING PROGRAMS

In order to facilitate the development of a comprehensive monitoring program for the Santa Monica Bay Project, existing nonpoint source storm water projects that are similar to the Santa Monica Bay Project were reviewed to provide important information on the following monitoring elements for both dry and wet weather periods:

- number of monitoring stations
- types of constituents monitored
- frequency of sampling

The following nonpoint source projects were reviewed:

1) Santa Clara Nonpoint Source Control Program
2) Alameda County Urban Runoff Clean Water Program
3) Orange County NPDES Stormwater Permit Program
4) Bellevue Urban Runoff Program

The following discussion will provide a review of each project. For each project reviewed, a brief background of the project is discussed. Next, the discussion is organized according to 1) number of monitoring stations, 2) types of constituents monitored, and 3) frequency of sampling. Lastly, a brief summary is provided. The description include the rationale for some aspects of the plan which may be repetitive with other parts of this report, but is included for emphasis.

9.1 SANTA CLARA NONPOINT SOURCE CONTROL PROGRAM

9.1.1 Background: Initial Characterization Phase

The Santa Clara Nonpoint Source Control Program (Program) was initiated in 1987 to address concerns on nonpoint source discharges from storm water into the South San Francisco Bay Region or commonly known as the Lower South Bay. The Lower South Bay is classified by US EPA and the California State Water Quality Control Board as a water quality limited segment under section 304(L) of the Clean Water Act. Because of the water quality concerns of the Lower South Bay, the San Francisco Bay Regional Water Quality Control Board (Regional Board) has pursued an active regulatory role in controlling point and nonpoint discharges into the Lower South Bay. In the 1986 Basin Plan, the Regional Board directed Santa Clara County to develop and implement an Action Plan to conduct dry and wet weather water quality monitoring "for the evaluation of both concentrations of pollutants as well as total pollutant loadings and comparison with waste loads from point source discharges".

An action plan was developed in the summer of 1987 (CH2M-Hill and EOA, Inc. 1987) and implemented by WCC in the fall of 1987, and completed by WCC in the summer of 1989. The results of the hydrologic and water quality monitoring program, and the loads estimates were presented in Volume I of the Loads Assessment report (WCC, 1991a). This report constitutes the initial characterization phase of the Program. It should be

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emphasized that the major objective of this phase was to evaluate dry and wet weather pollutant concentrations and loads to the Lower South Bay.

9.1.1.1 Monitoring Stations

The Study Area is approximately 690 square miles and is divided into 11 watersheds. Given the size of the Study Area, and the need to project loads from the entire area, it was not feasible to monitor the entire Study Area and thereby estimate loads based on monitoring data alone. Instead, the study was designed to develop sufficient monitoring data to calibrate and verify a watershed load prediction model, which then could be applied to estimate loads from both gauged and ungauged watersheds.

There were a total of 16 stations representing three types of stations. Figure 9-1 shows the locations of these stations, and the 11 watersheds of the Santa Clara County.

9.1.1.1.1 Land use Stations

A total of seven stations representing small, relatively homogeneous land use catchments found in the area. Two stations (L1 and L2) represented industrial land use, and three stations represented low-density single-family residential (L4 and L5), and multi-family residential (L6) land uses. One station each is represented for commercial (L3) and open (L7) land uses. Table 9-1 provides a brief description of each station. Most of these stations are manhole or open channel stations except for the open land use station (L7), which is a natural creek. Data generated from these land use stations were used to characterize water quality from specific land uses, and also used as input to the loading model.

9.1.1.1.2 Stream Stations

Four stream stations were located in the lower portions of the watersheds and had relatively large, multiple land use catchments. These stations are located near the Bay, but above the zone of tidal influence in order to eliminate the effect of backwater on flow monitoring. Two stations (S3 and S4) drain the largest watersheds located in the eastern and central regions representing about 50 % of the total area. These two stations representing two of the largest watersheds also receive substantially more rainfall than the other smaller western watersheds. The other two stations (S1 and S2) represents smaller watersheds occupying the western region of the study area. WCC evaluated the adequacy of these four stream stations in representing the 11 watersheds (WCC 1991b). WCC found that the land use distribution of all four stations not only represented their respective watersheds that they reside, but also adequately represents the overall land use composition of the Study Area.

The important distinction between the stream and the land use stations is that the stream stations support aquatic habitat and therefore water quality must meet aquatic life criteria. Both dry (from base flow) and wet weather sampling were conducted at the stream stations.

9.1.1.1.3 Reservoir Stations

Six reservoir stations were located below the upland reservoirs and were used to estimate loads associated with reservoir (spillway) releases during wet years.

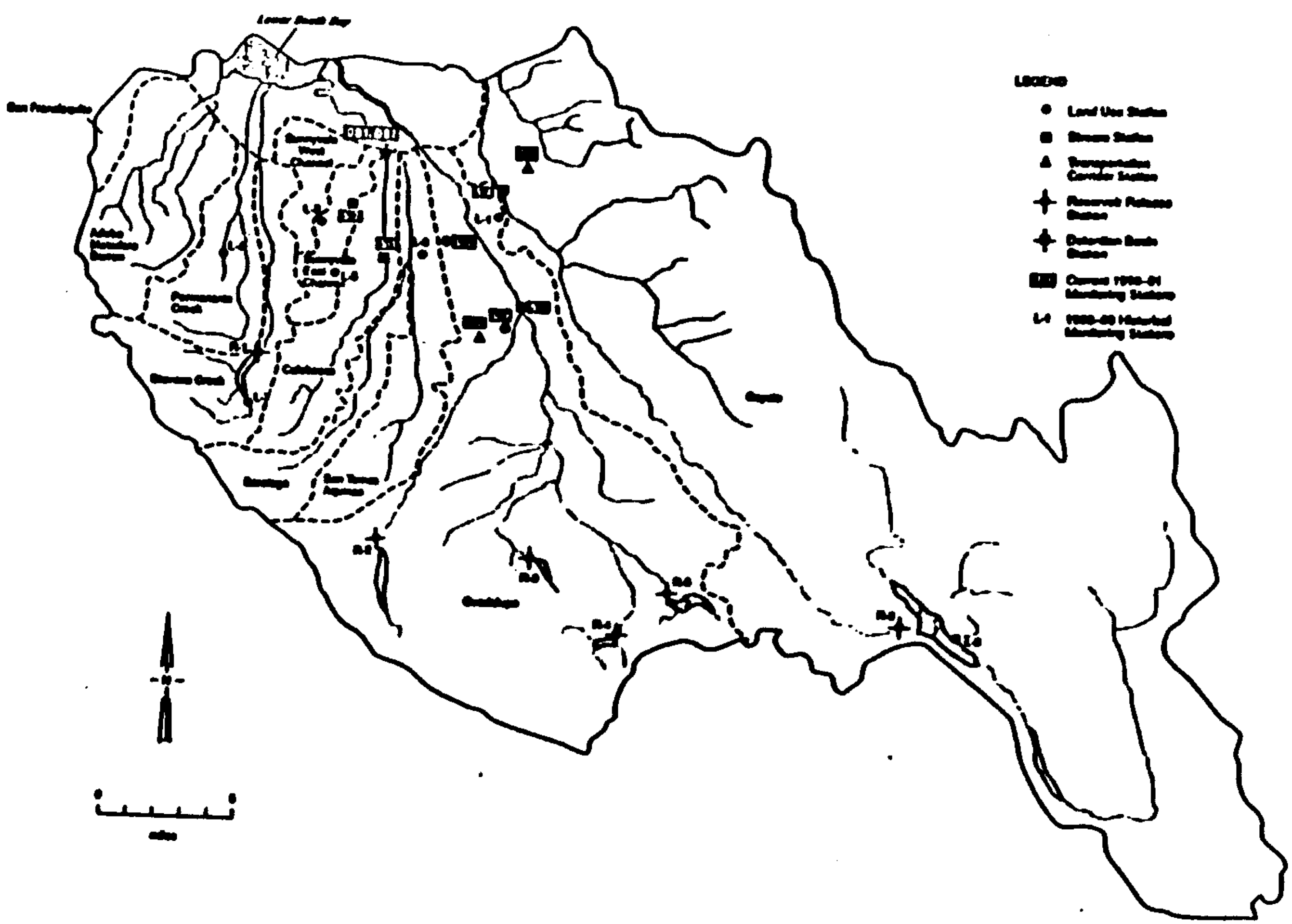

Figure 9-1 Sampling Stations and Watersheds in Santa Clara County.

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Table 9.1. Description of Stations for Characterization Phase of the Santa Clara Valley Nonpoint Source Program

Station ID.	Principal Land Use	Drainage Area (acres)
A. Landuse Stations		
L1	Industrial Park	22
L2	Heavy Industry	28
L3	Commercial	265
L4	Low Density Single Family Residential	1600
L5	Single-Family Residential	2080
L6	Multi-Family Residential	85
L7	Open	8410
B. Stream Stations		
S1	Mixed (21% O, 0% I, 7% C, 71% R)	9200
S2	Mixed (0% O, 0% I, 32% C, 68%R)	3400
S3	Mixed (30% O, 4% I, 5% C, 61% R)	15900
S4	Mixed (64% O, 5% I, 1% C, 30% R)	79600
C. Reservoir Stations		
R1	Open	11000
R2	Open	24000
R3	Open	3800
R4	Open	7670
R5	Open	4600
R6	Open	125000

In comparisons with the requirements of Part II of the Federal NPDES storm water regulations, the regulations require monitoring of five to ten stations.

9.1.1.2 Constituents Monitored

The suite of constituents that were selected for chemical analyses on water and sediment samples were focused on potentially toxic contaminants, including heavy metals, organics (volatiles, semi-volatiles, pesticides and herbicides), nutrients, bacteria, and some conventional pollutants. This list of constituents were developed based on results of a Nationwide Urban Runoff Program, NURP (US EPA 1983), and also water quality excedances of specific pollutants in the South Bay. Table 9-2 summarizes the full list of constituents analyzed. This is a relatively comprehensive list when compared with the requirements specified in the Federal NPDES Part II regulations.

Metals analysis are commonly measured based on the total extractable fraction, i.e., metals that in solution as well as those associated with the suspended solids. The total fraction is used in estimating the total loads and comparisons with water quality criteria. However, the dissolved fraction, i.e., sample that is filtered through a 0.45μm filter, is the fraction that is directly available for organism uptake and therefore is more relevant for use in comparisons with water quality criteria. For two storm events, the dissolved fraction for metals was also analyzed.

This full suite of constituents was only conducted during the first storm, and sometimes in a few stations for the second storm only. Based on the results of the initial sampling a more limited suite (reduced) of analyses were performed for subsequent sampling rounds. The reduced suite of analyses is also presented in Table 9-2. The constituents that were dropped included volatile and semi-volatile organics, chlorinated herbicides, organophosphorus pesticides, and hexavalent chromium. These constituents that were dropped were mostly not detected in the storm water.

Constituents such as volatile organics have high potential to volatilize in turbulent storm waters. Unless the monitoring station is very close to the source (such as adjacent to an industrial facility that is illegally discharging volatiles), the presence of volatile organics in storm water is rarely found. For semi-volatiles, only the polynuclear aromatic hydrocarbons (PAHs) were retained for subsequent sampling analyses because PAHs are relatively toxic and some are known carcinogens. Additionally, PAHs are commonly found in petroleum by-products, and in combustion of wood and petroleum fuels. Rather than analyzing for 80 compounds in the semi-volatiles analysis, a specific PAH method using EPA 610 was used in subsequent sampling. In the EPA 610 method, a total of 16 specific PAH compounds are analyzed.

Another important secondary objective of the characterization phase was to evaluate the effects of storm water on toxicity in streams in Santa Clara County. While chemical monitoring has traditionally played an important role in evaluating water quality, toxicity monitoring using surrogate organisms is increasingly becoming a vital tool to evaluate potential impairment of receiving water bodies. Short-term chronic bioassay tests using three freshwater organisms were used to evaluate potential toxicity effects of both dry and wet weather samples. These tests are developed by US EPA (1986) and are routinely used in compliance monitoring of potential toxic effluent from industrial-treated as well as publicly-owned treatment works (POTW) wastewaters. The three surrogate organisms used in these tests are *Ceriodaphnia dubia* (an aquatic invertebrate), *Selenastrum capricornutum* (a freshwater alga), and *Pimephales promelas* (a fathead minnow fish).

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Table 9-2 Full and Reduced Suites of Chemical Analysis for Water Samples.

Class	Full Suite	Reduced Suite
Organics	Total Organic Halogens	Total Organic Halogens
	Total Organic Carbon (TOC)	TOC
	Volatiles	
	Semi-volatiles	Polynuclear Aromatic Hydrocarbons (PAH)
	Organochlorine pesticides	Organochlorine pesticides
	Chlorinated herbicides	
	Organophosphorus pesticides	
Metals, Total	Arsenic	Arsenic
	Cadmium	Cadmium
	Chromium (total)	Chromium (total)
	Chromium (hexavalent)	Chromium (hexavalent)
	Copper	Copper
	Lead	Lead
	Mercury	Mercury
	Nickel	Nickel
	Selenium	Selenium
	Silver	Silver
	Zinc	Zinc
Nutrients	Total Kjeldahl Nitrogen (TKN)	TKN
	NH3-N	
	NO2 and NO3	
	Total Phosphate	
Bacteria	Total and fecal coliform	Total and fecal coliform
Other	BOD5	BOD5
	Temperature	Temperature
	pH	pH
	Total Suspended Solids	Total Suspended Solids
	Total Hardness	Total Hardness
	Turbidity	Turbidity

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These tests evaluate the effects of storm water on three key organism indicators: mortality, reproduction, and growth.

9.1.1.3 Frequency of Sampling

9.1.1.3.1 Wet Weather

Figure 9-2 summarizes the types and frequency of sampling during both dry and wet weather periods. The goal of the study was to conduct sampling over two wet weather seasons (1987-1988 and 1988-1989). However, because of the extensive time required to select stations, install and test automated sampling equipment, only one storm was captured for the first wet weather season (1987-1988). A total of six storms were captured for the second wet weather season (1988-1989). Samples were collected as flow-weighted composites by automatic samplers. These samples represent average pollutant concentrations that were used to estimate total pollutant loads. Additionally, grab samples were taken during the early part of the storm for selected pollutants (such as oil and grease, volatile organics, bacteria) because of short holding times, special container requirements, or volatility. The following paragraphs discuss the rational for selecting the sampling frequency.

The wet weather season for California is about six months, starting in October and ending in April. Based on the national weather service rainfall gage at San Jose, the average storm volume for the 1948-1989 period is 0.7 inches, with most of the rain occurring during the months of November through March.

To adequately characterize storms during the wet weather season, a total of six storms collected about once every month were considered sufficient to cover the range of hydrological conditions. Of the six storms, the first storm of the wet weather season must be collected. This is because the first storm of the wet weather season is thought to have the largest pollutant concentrations. The high concentrations are attributable to the opportunity for dry deposition of pollutants on ground surfaces during the extended dry summer period, which are scoured by the first rainfall.

It is important to note that continued monitoring of the stream stations and specific industrial stations have to date generated about 15 to 20 data points per station. These data will be used as initial baseline conditions to be compared with additional monitoring (in future monitoring years) to evaluate potential improvements in water quality due to implementation of storm water pollution control measures across the County.

To provide a comparison with the requirements for Part II of the Federal storm water regulations, a minimum of three storm events separated by at least one month are required.

9.1.1.3.2 Dry Weather

Dry weather sampling was conducted during the summer of 1988, as well as dry weather flows during the wet weather season (i.e., in between storms). Both water and sediment samples were collected. The main objective of dry weather water sampling is to evaluate pollutant concentrations and loads during base flow from stream stations. A total of seven samples were collected; two during the summer, and five in between storms. Sediment sampling was conducted four times to evaluate sediment concentrations which serve as both sources and sinks for pollutants. All dry weather samples were collected as manual grabs.

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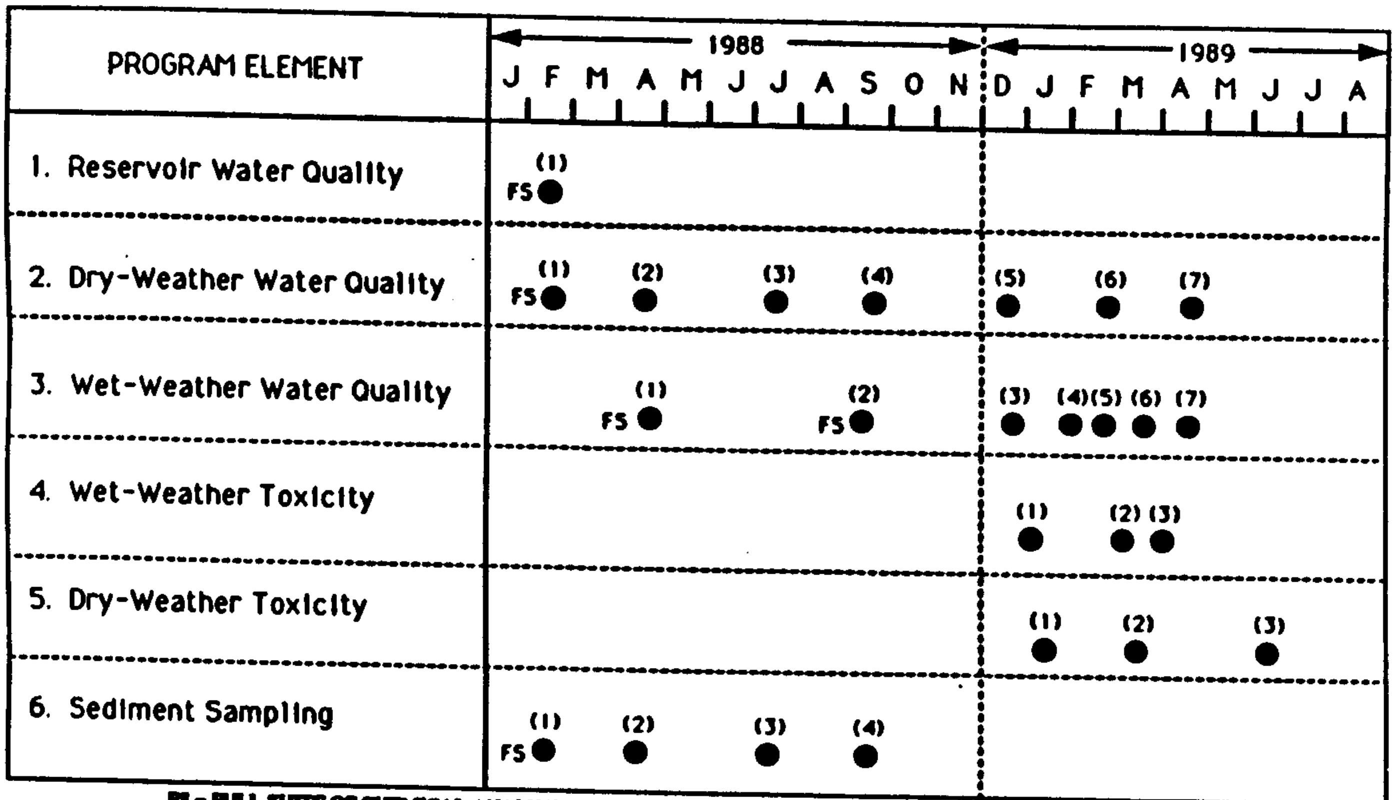
Figure 9.2. Type and Frequency of Monitoring for Santa Clara Valley.



FS = FULL SUITE OF CHEMICAL ANALYSIS. REDUCED SUITE WAS PERFORMED AT OTHER STATIONS

9.1.2 Background: NPDES Permit Phase

Following the characterization phase, the Program applied for and obtained an NPDES storm water permit in June of 1990. From 1990 to date, WCC has continued to conduct monitoring for the Program. However, the monitoring objectives in this Permit period have expanded to include additional objectives. It must be emphasized here that the objectives of a monitoring program clearly drives the requirements for the type and frequency of monitoring.

The objectives of the monitoring program for the Permit Phase include the following:

- evaluate long-term trends in water quality
- identification of storm water pollutant sources
- comply with water quality objectives
- water quality improvements
- evaluate control measure effectiveness monitoring

Additional monitoring elements of this phase that are relevant to this discussion are summarized in section 9.1.2.1

9.1.2.1 Monitoring Stations

Table 9-3 shows the types of stations in the Permit phase. The total number of stations is ten. Five stations were retained from the characterization phase. These include four stream stations (S1 through S4), and one industrial station (L2). It was important to continue to monitor these stations because the stream stations can be considered as receiving water bodies supporting aquatic habitat, and as such can represent long-term monitoring stations. The industrial station was kept because of high concentrations of pollutants (especially chromium, cadmium, copper, lead and zinc) detected in the storm water. Continued monitoring of this industrial station will help in monitoring effectiveness of various source control measures that will be implemented in this industrial sub-catchment.

Five new stations were added. These include two stations for monitoring the effectiveness of pollutant removal of a detention basin, and another two for monitoring two major highways. The fifth station was selected to represent another industrial land use area.

9.1.2.2 Constituents Monitored

A set of constituents similar to the reduced suite was used in the permit phase, with the exception of PAHs. This reduced suite of analyses is shown in Table 9-4. Results of PAH analyses using EPA method 610 showed that most of the concentrations were less than the detection limit. Frequently, detection limits were elevated to 5 to 10 times the acceptable detection limits. A combination of high matrix interferences from salts and other natural humic organics found in the storm water, and low detection resolution by the High Performance Liquid Chromatography (HPLC) method, are likely responsible for the poor results.

A more superior method developed by Texas A&M's Geochemical and Environmental Research Group (GERG) was used for subsequent analysis of PAHs. The GERG method eliminates the matrix interference by various cleanup techniques, and uses Gas Chromatography / Mass Spectrometry (GC/MS) - Selected Ion Monitoring Mode (SIM) instrumentation to optimize detection of the specific PAHs. The number of PAHs include

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Table 9.3 Description of Stations for Permit Phase of the Santa Clara Valley Nonpoint Source Program.

Station ID	Principal Land Use	Drainage Area (acres)
A. Stream Stations		
S1	Mixed	9220
S2	Mixed	3440
S3	Mixed	15900
S4	Mixed	79600
B. Transportation Stations		
T1	Paved Roadway	12
T2	Highway	35
C. Detention Basin Stations		
DB1 (inlet)	Mixed	250
DB2 (outlet)	-	-
D. Industrial Stations		
L2 *	Heavy Industry	28
L9	Light Industry	40

* The station was part of the initial characterization phase.

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Table 9.4. Suite of Chemical Analysis for Permit Phase of Santa Clara Valley Nonpoint Source Program

Parameter	Units	Methodology	EPA Method (a)	Maximum Holding Time	Preservation	Target Detection Limit
INORGANICS						
pH	pH	pH electrode	150.1	Analyze Immediately	None	-
Hardness	mg/L	Titrimetric EDTA	130.2	6 months	HNO3 pH<2	1
Turbidity	NTU	Nephelometric	180.1	Analyze Immediately	Cool 4°C	1
TSS	mg/L	Gravimetric	160.2	7 days	Cool 4°C	10
METALS -TOTAL						
Arsenic	µg/L	Furnace-AA	206.2	6 months	pH <2 HNO3	1
Cadmium	µg/L	Furnace-AA	213.2	6 months	pH <2 HNO3	0.2
Chromium (Total)	µg/L	Furnace-AA	218.2	6 months	pH <2 HNO3	1
Copper	µg/L	Furnace-AA	220.2	6 months	pH <2 HNO3	1
Lead	µg/L	Furnace-AA	239.2	6 months	pH <2 HNO3	1
Mercury	µg/L	Cold Vapor - AA	245.1	28 days	pH <2 HNO3	0.2
Nickel	µg/L	Furnace-AA	249.2	6 months	pH <2 HNO3	2
Selenium	µg/L	Hydride - AA	270.3	6 months	pH <2 HNO3	0.2
Silver	µg/L	Furnace-AA	272.2	6 months	pH <2 HNO3	0.2
Zinc	µg/L	Furnace-AA	289.2	6 months	pH <2 HNO3	1
METALS - DISSOLVED						
Cadmium	µg/L	Furnace-AA	213.2	6 months	pH <2 HNO3	0.2
Copper	µg/L	Furnace-AA	220.2	6 months	pH <2 HNO3	1
Lead	µg/L	Furnace-AA	239.2	6 months	pH <2 HNO3	1
Silver	µg/L	Furnace-AA	272.2	6 months	pH <2 HNO3	0.2
Zinc	µg/L	Furnace-AA	289.2	6 months	pH <2 HNO3	1
Organics						
PAH *	µg/L	GC-MS	Texas A&M	7 day (extraction) 40 day (analysis)	Cool 4°C	0.003-0.100
TOC	mg/L	Combustion	9060	28 days	Cool 4°C pH < 2 H2SO4	1
Total Oil and Grease	mg/L	IR	413.2	7 day (extraction) 40 day (analysis)	Cool 4°C pH < 2 H2SO4	0.2

(a) Methods for Chemical Analysis of Water and Wastes (1983) EPA-600/ 4-79-020 the 16 EPA method 610 methods, and 14 additional methylated PAHs. Detection limits range from 0.003 to 0.100 µg/L, which is about more than 100 times lower than the detection limits for EPA method 610.

More sophisticated techniques to evaluate the groups of pollutants responsible for toxicity were used for toxicity testing. The 7-day short-term chronic bioassays used in the characterization phase showed that storm water from urbanized land uses were mostly toxic, especially to Ceriodaphnia. The tests, however, do not show what pollutants are responsible for toxicity.

Phase I Toxicity Identification Evaluation (TIE) tests (Mount and Carnahan, 1988, 1989a, 1989b) were used on storm water samples in the Permit Phase. If samples show toxicity (i.e., mortality), these Phase I TIE tests, using a combination of chemical and physical manipulations, are able to distinguish what broad groups of pollutants are responsible for causing toxicity. These groups tested include metals, non-polar organics, volatiles, ammonia, and strongly oxidizing agents.

9.1.2.3 Frequency of Sampling

All stations sampled for five storms for the wet weather season. Samples were collected as flow-weighted composites by automatic samplers. No dry weather water or sediment samples were conducted because of the fact that dry weather concentrations and loads were believed to be small and insignificant when compared with wet weather loads.

9.2 ALAMEDA COUNTY URBAN RUNOFF CLEAN WATER PROGRAM

9.2.1 Background: Initial Characterization Phase

In the San Francisco Bay Region, the Alameda County Urban Runoff Clean Water Program also addresses the impact of nonpoint source pollution from storm water runoff on the South Bay . The objectives of this Program is similar to the Santa Clara Valley Nonpoint Source Control Program. The Alameda Program was initiated in September 1988, and monitoring was conducted for two wet weather periods and one dry weather period between October 1989 and April 1991 (WCC 1991c).

9.2.1.1 Monitoring Stations

The Study Area is 345 square miles and 15 watersheds drain the area. There were a total of 16 stations. Figure 9-3 shows the locations of these stations. Out of these 16 stations, 10 were land use stations (L1 through L10) draining homogeneous land uses such as commercial, industrial, and residential. Another six stations were major stream or creek stations draining large mixed land uses. Table 9-5 summarizes the land uses types and drainage areas for each of the station.

9.2.1.2 Constituents Monitored

The suite of chemical analyses are similar to the Santa Clara Valley Nonpoint Source Control Program. A full suite of analyses were conducted for the first storm and a reduced suite was conducted for subsequent storms. A similar procedure was also followed for dry

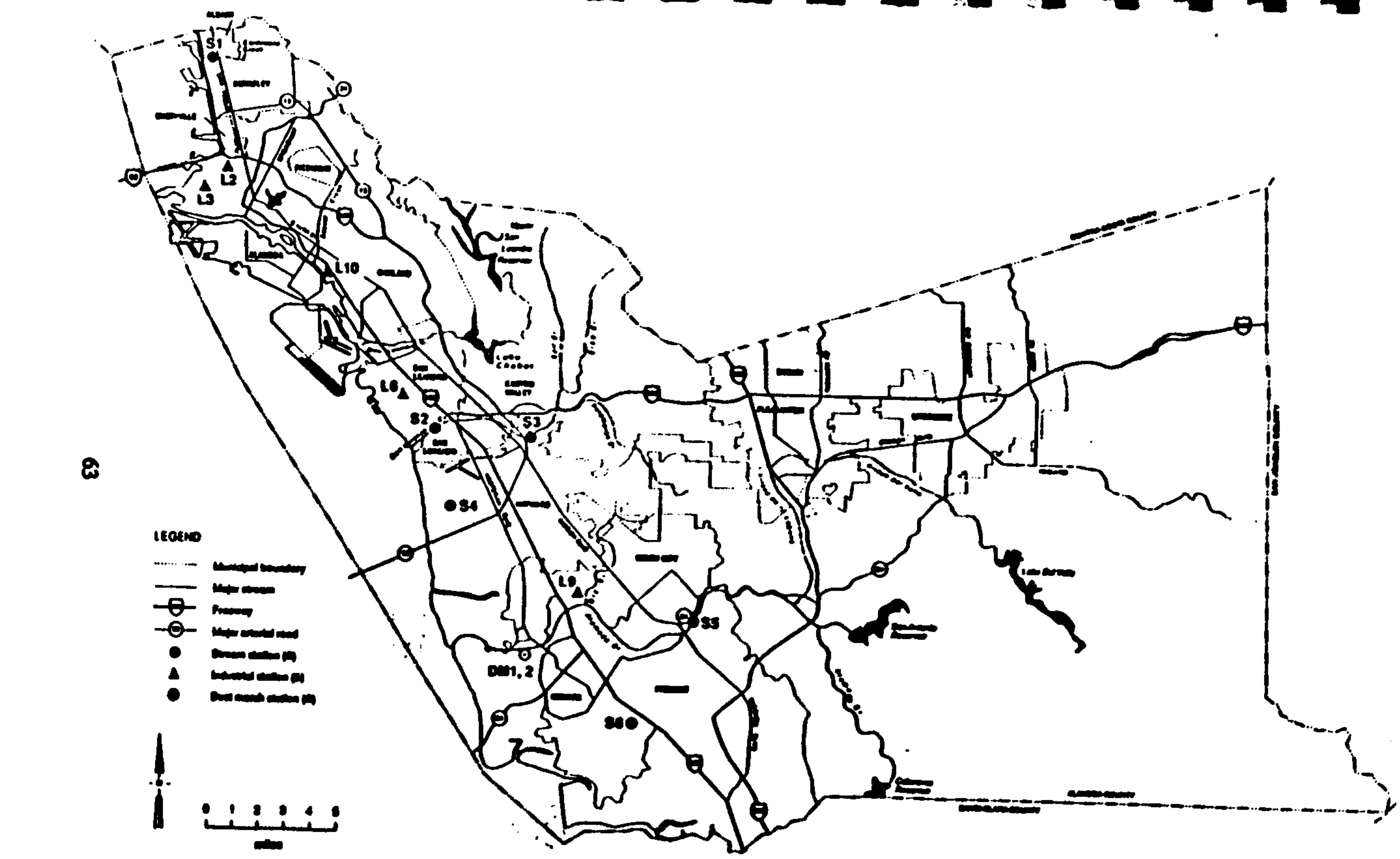

Figure 9-3 Sampling Stations and Study Area Detail in Alameda County.

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Table 9-5 Description of Stations for the Characterization Phase of the Alameda County Urban Runoff Clean Water Program.

Station ID	Principal Land Use	Drainage Area (acres)
A. Landuse Stations		
L1	Open	176
L2	Mixed	950
L3	Industrial	168
L4	Residential/Commerial (59% R, 20% C)	20
L5	Residential/Commerial (83% R, 9% C)	355
L6	Industrial Park	690
L7	Residential/Commercial (33% R, 67% C)	78
L8	Open	6040
L9	Industrial Park	260
L10	Mixed (27% R, 27% C, 39% I)	140
B. Stream Stations		
S1	Mixed (88% R, 8% C)	180
S2	Mixed (12% R, 81% O)	28800
S3	Mixed (73% R, 7% C, 17% O)	3260
S4	Mixed (42% R, 21% C, 27% I)	1020
S5	Mixed	405000
S6	Mixed (68% R, 21% C)	1730

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weather samples. For metals, both the total and dissolved fractions were analyzed on all samples.

9.2.1.3 Frequency of Sampling

Figure 9-4 summarizes the types and frequency of monitoring. A total of 11 storm events were conducted for the two wet weather periods. For each station, anywhere from five to nine storms were sampled.

Eight sampling events were conducted for the dry weather period at the six stream stations that had base flow. Two events were conducted during the summer (April to August 1990), and six events in between storms; three during the first wet weather, and another three during the second wet weather.

Four sediment sampling events were conducted at the six stream stations.

9.2.2 Background: NPDES Permit Phase

Subsequent to the initial characterization phase, the Program obtained a NPDES storm water permit in July 1990. The results of the characterization phase were used to direct the monitoring program for the permit phase.

9.2.2.1 Monitoring Stations

The number of stations were reduced from 16 to seven. Out of these seven stations, five of them were from the initial phase. These five stations are four stream stations (S1, S2, S3, and S5), and one industrial station (L3). The four stream stations drain the most important watersheds of the Alameda County, and also support aquatic habitat and riparian vegetation. The industrial station was retained because of the presence of elevated concentrations of metals and acute toxicity to biological organisms. Two new stations were initiated in a marsh environment to evaluate storm water pollutant removal effectiveness of the marsh.

9.2.2.2 Constituents Monitored

A reduced suite of analyses was conducted as shown in Table 9-4. Additionally, to aid in better understanding the issue of how much of the sorbed metals (attached to suspended solids) is bioavailable for organism uptake, a weak-acid extraction method, to supplement the traditional total and dissolved methods, was included. This weak-acid extraction was conducted on storm samples from one stream station for selected metals (cadmium, chromium, copper, lead, and zinc).

9.2.2.3 Frequency of Sampling

For each wet weather season, five storm events per station were conducted. Storm samples were collected as flow-weighted composites by automatic samplers.

Figure 9.4. Type and Frequency of Monitoring for Alameda County Urban Runoff Clean Water Program

MONITORING TYPE	1989 O	N	D	1990 J	F	M	A	M	J	J	A	S	O	N	D	1991 J	F	M	A	M
1. Wet Weather Sampling		X		X	X	X									X	X	X	XXXX		
2. Dry Weather Sampling			X		X		X		X		X					X	X		X	
3. Sediment Sampling			X		X		X									X				
4. Toxicity Testing							X		X						XX			XXXX		

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9.3 ORANGE COUNTY NPDES STORMWATER PERMIT PROGRAM

In July 1990, the San Diego and Santa Ana Regional Water Quality Control Boards issued NPDES Storm Water and Urban Runoff permits to the Orange County Storm Water Permit Program. The Program is comprised of the Orange County Flood Control District, the County of Orange, and its 29 incorporated cities. The objectives of the monitoring program are the following:

- to define the type, magnitude and sources of pollutants in the storm water system discharges within each permittees respective jurisdiction so that appropriate pollution prevention and correction measures can be identified;
- to evaluate the effectiveness of pollution prevention and correction measures; and
- to evaluate the compliance with water quality objectives established for the storm water system or its components.

The monitoring program to meet these objectives include extensive dry and wet weather sampling in four major watersheds of the County. Monitoring was initiated in January 1991. The following sections summarizes the scope of the monitoring program.

9.3.1 Monitoring Stations

There are a total of 54 stations spread over four major watersheds. These four watersheds are:

- Huntington Harbor / Anaheim, Sunset, Bolsa Bay
- Upper Newport Bay
- South County
- Santa Ana River

The types of stations are basically divided into storm channels (upstream of tidally-influenced areas) and receiving waters in the Bay. There are 34 storm channel stations and 20 Bay monitoring stations. Table 9-6 shows the list of storm channel and Bay monitoring stations in their respective watersheds. About half of these stations are located in the Newport Bay watershed. Most of these stations have been previously monitored by the Orange County Flood Control District. The bulk of the monitoring prior to the permit period was conducted during non-storm periods. Only limited data were collected during storm periods.

Out of the 34 storm channel stations, 23 are considered to be "waters of the State" and are therefore receiving waters. The other storm channel stations drains into stream tributaries that are receiving waters. Water from all these 34 storm channels ultimately drain into the Bay. Monitoring in the Bay include 20 stations.

9.3.2 Constituents Monitored

The selection of monitoring constituents was based on the analyses of past data conducted by the Orange County Environmental Management Agency, the RWQCB Toxic Substances Monitoring Program for Huntington Beach Channels and the State Mussel Watch Program. The list of constituents including nutrients, metals and organics are shown in Table 9-6.

Table 9-6 Frequency of Monitoring at Storm Channel and Bay Stations.

Station	Nutrients	Metals (W)	Metals (S) PHP/PAH (S)
A. Channel Monitoring Stations			
A.1 HUNTINGTON HARBOR/ANAHEIM, SUNSET, BOLSA BAY WATERSHED			
Bolsa Chica Channel	M ST	ST	
Anaheim Barber City Channel	ST	ST	
Westminster Channel	ST	ST	
E. Garden Grove-Wintersburg Channel	M ST	ST	
Sunset Channel	ST	ST	
A.2 UPPER NEWPORT BAY WATERSHED			
Santa Ana-Delhi Channel	ST	ST	
Bonita Canyon Channel	ST	ST PS	SEMI
San Diego Creek (Culver Drive)	M ST PS	ST PS	SEMI
San Diego Creek (Campus Drive)	M ST PS	ST PS	SEMI
Peters Canyon Wash	M ST PS	ST PS	SEMI
Lane Channel	ST	M ST	SEMI
Barrance Channel	ST	M ST	SEMI
San Canyon Channel	M ST	ST PS	SEMI
Bee Canyon Channel	M ST PS	ST PS	SEMI
Aqua Chinon Wash	M ST PS	ST PS	SEMI
Serrano Creek	M ST PS	ST PS	SEMI
Rattlesnale Canyon Wash	M ST PS	ST PS	SEMI
Hicks Canyon Wash	M ST PS	ST PS	SEMI
Costa Mesa Channel	ST	ST	
Santa Isabella Channel	ST	ST	
Big Canyon Wash	ST	ST	
A.3 SOUTH COUNTY WATERSHED			
Laguna Canyon Channel	ST	ST PS	
Aliso Creek Channel	M ST PS	ST PS	SEMI
Sulphur Creek Channel	ST	ST PS	SEMI
San Juan Creek (La Novia Avenue)	M ST	ST PS	SEMI
San Juan Creek (Hot Springs Canyon)	ST	ST PS	SEMI
Trabuco Creek	ST	ST PS	SEMI
Oso Creek	M ST	ST PS	SEMI
Prima Deschecha Channel	M ST	ST PS	
Segunda Deschecha Channel	M ST	ST	SEMI
A.4 SANTA ANA RIVER WATERSHED			
Santa Ana River (Imperial Highway)	ST	ST PS	SEMI
Santa Ana River (Fifth Street)	ST	ST PS	SEMI
Santiago Creek	ST	ST PS	SEMI
Silverado Creek	M ST	ST	SEMI

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Table 9-6 Frequency of Monitoring at Storm Channel and Bay Stations. (concluded)

Station	Nutrients	Metals (W)	Metals (S) PHP/PAH (S)
B. Harbor/Bay Monitoring Stations			
B.1 HUNTINGTON HARBOR/ANAHEIM, SUNSET, BOLSA BAY			
Sunset Aquatic Park	SEMI ST PS	ST PS	
Huntington Harbor (Chica Balsa Channel)	SEMI ST PS	ST PS	SEMI
Huntington Harbor (Warner Avenue)	SEMI ST PS	ST PS	SEMI
Christiana Bay	SEMI ST PS	ST PS	SEMI
Anaheim Bay	ST	ST	
Bolsa Bay	SEMI ST PS	ST PS	SEMI
B.2 NEWPORT BAY			
Upper Newport Bay (San Diego Creek)	M ST PS	ST PS	SEMI
Upper Newport Bay (Big Canyon Wash)	M ST PS	ST PS	SEMI
Upper Newport Bay (Shellmaker Island, N. Star Beach)	M ST PS	ST PS	
Upper Newport Bay (Newport Dunes)	M ST PS	ST	SEMI
Upper Newport Bay (PCH)	ST	ST	
Lower Newport Beach (Harbor Island Reach)	SEMI ST PS	ST PS	SEMI
Lower Newport Bay (Turning Basin)	ST	ST	
Lower Newport Bay (Rhine Channel)	ST	ST	SEMI
Lower Newport Bay (Harbor entrance)	ST	ST	
B.3 DANA PONT HARBOR			
East Basin	SEMI ST PS	ST PS	SEMI
West Basin	SEMI ST PS	ST PS	SEMI
Launch Ramp	SEMI ST PS	ST PS	SEMI
Boatyard	ST PS	ST PS	SEMI
Harbor Entrance	ST	ST	

M = Monthly Dry Weather Water Samples
ST = Storm Samples (4 for Storm Channels and 2 for Bay Stations)
PS = Post Storm Samples
SEMI = Semi-Annual Dry Weather Water and Sediment Samples
NUTRIENTS = Nitrate + Nitrite, Ammonia, Total Kjeldahl Nitrogen (TKN), Total Phosphate, Total Suspended Solids, Volatile Suspended Solids, pH, Dissolved Oxygen, Specific Conductance, Turbidity.
PAHs = Polynuclear Aromatic Hydrocarbons
PHP = Organochlorine Pesticides and Polychlorinated biphenyls, Chlorinated Herbicides and Selected Organophosphorus Pesticides
METALS = Copper, Chromium, Lead, Cadmium, Silver, Nickel, Zinc
S = Sediment
W= Water

The constituents that will be routinely analyzed for both dry and wet weather include the nutrients and metals. Nutrients, metals and organic constituents will only be analyzed on sediment samples collected during the dry weather periods. The decision to monitor only organic constituents during the dry weather is likely due to non-detectable concentrations of these organics during the wet weather.

9.3.3 Frequency of Sampling

Table 9-6 shows the frequency of monitoring for both storm channel and Bay stations. For the storm channel stations, two storms per station are proposed to be monitored for the first wet weather season for all stations. In subsequent years, three to five storms will be sampled. Two post-storm samples will be conducted to evaluate potential chronic effects of storm water for selected stations. During dry weather, water samples will be collected monthly for analysis. Sediment samples will also be collected two times during the dry weather period for selected stations.

Sampling storm water in the Bay is difficult because of tidal influence, and significant amounts of rainfall to produce a freshwater lens. An estimated rainfall of more than 0.5 inch is required for the receiving waters to exhibit a freshwater influence. The number of storms sampled per station will vary depending the weather and the amount of manpower and equipment available. Two post-storm samples (48 and 96 hours after the storm event) will be conducted for selected stations. Monthly water samples, and semi-annual sediment samples will be collected during the dry weather period for selected stations.

Water samples will be collected as discrete hourly samples for a 24 hour period by automatic samplers during storms and flow composited in the laboratory. The post storm sampling will be conducted 12 hours after the initial 24 hour sampling period. Samples will be taken once every three hours for a 72 hour period. Dry weather samples will be collected by a combination of grabs and automatic samplers, depending on the availability of the automatic samplers. Post-storm sampling and sediment samples will be collected by manual grab methods.

9.4 BELLEVU URBAN RUNOFF PROGRAM

Many aspects of urban runoff have been studied in Bellevue, Washington by the Environmental Protection Agency under the NURP study, with cooperation from the University of Washington, the US Geological Survey (USGS), the Municipality of Metropolitan Seattle (METRO), and the City of Bellevue Storm and Surface Water Utility. This section will describe briefly some of those studies and will focus on the sampling performed by the USGS.

9.4.1 University of Washington Projects

The University of Washington's Civil Engineering Department and Fisheries Research Institute performed studies of two receiving water bodies, one which had contributions from urban runoff and one that did not, to identify the impacts associated with urban development on receiving waters. Biological, chemical and physical parameters were analyzed. The main objectives of the project were:

- Document the variations (spatial and temporal) in distribution and abundance of aquatic organisms in urban streams
- Compare the condition of an urban and rural stream in the same general area
- Evaluate the biological, chemical and physical effects of urbanization on streams

9.4.2 Seattle METRO Project

The purpose of this project was to identify priority pollutants and other toxic pollutants in storm water as part of METRO's "Toxic Pollutant Inventory." The projects in Bellevue supplied samples to the Metro program for analysis. The results of this study were used to assess potential problems and evaluate best management practices. Besides identifying the toxic substances, the project also focused on identifying their sources through sampling and a literature review.

9.4.3 US Geological Survey Project

The USGS performed monitoring from 1979 to 1982 as part of the NURP study. The USGS reported the four main objective of the study were:

- Establish a consistent and accessible data base for typical watersheds
- Determine the magnitude and frequency of storm runoff loads of water quality constituents from three catchments in the city
- Develop methods for estimating storm and annual loads of water quality constituents from unsampled catchments in the study area
- Test the effectiveness of storm water quality management alternatives for the attenuation of constituent loads carried in storm water.

9.4.4 Monitoring Stations

There were a total of 8 stations within three catchments. These catchments were:

- Surrey Downs
- Lake Hills
- 148th Avenue S.E.

Five of these stations were used to monitor storm water quality and three of them were used to monitor wet and dry atmospheric deposition quality, only the storm water quality stations will be considered in this report. Table 9-7 shows the list of monitoring stations, their respective catchment, and land use breakdown. The Surrey Downs and Lake Hills catchments were predominately single family residential areas and are both approximately 100 acres. These two catchments were used to evaluate the effectiveness of street sweeping.

The 148th Avenue S.E. catchment has three main land uses: open park land, high density residential (9 dwellings per acre), and commercial. The total size of the catchment is 24 acres, however, one fourth of the catchment is occupied by 148th Avenue S.E. This catchment was used to investigate the effects of detention basins on storm water quality.

Table 9.7 Description of Stations for the USGS Monitoring in Bellevue, Washington.

Catchment	Station ID	Land Use of Catchment	Drainage Area (acres)
Surrey Downs	Catchment Outfall	91% R, 6% C, 3% O	95
Lake Hills	Catchment Outfall	90% R, 7% C, 3% O	102
148th Ave S.E.	Storm sewer below Lake Hills Boulevard	16% R, 24% C, 60% O	24
	Outlet from Detention Basin No. 3		
	Outlet from Detention Basin No. 5		

Three stations were located in this catchment. One captured storm water at the outlet of the catchment, one captured storm water at the outlet of control structure No. 3, and one at the outlet of detention basin No. 5. The samples from the outlet of control structure No. 3 were considered to be representative of the inflow into detention basin No. 5.

Water from all the catchments eventually drained into Lake Washington. The Surrey Downs catchment drains into an artificial pond, then into Mercer Slough and into Lake Washington. Lake Hills drains into Kelsey Creek, then into Mercer Slough and into Lake Washington. The 148th Avenue S.E. catchment drains into Larson Lake, then into Kelsey Creek and Lake Washington.

9.4.5 Constituents Monitored

The selection of monitoring constituents was specified by the Advisory Technical Planning Committee for the USGS and the US EPA. The list of constituents including nutrients, metals and organics is shown in Table 9-8. Also some samples were analyzed for major anions and cations, trace elements, ultimate carbonaceous biochemical oxygen demand, insecticides, herbicides, oil and grease, and total volatile residue.

9.4.6 Frequency of Sampling

Figure 9-5 shows the frequency of water quality monitoring in the three catchments. A total of 31 storm events were monitored at the Surrey Downs station and 37 storm events at the Lake Hills station. The 148th Avenue S.E. catchment was monitored for 23 storm events at the sampling station below Lake Hills Boulevard and 7 storm events at the other two stations.

Most catchment outlet water samples were collected by automatic samplers preset at 5 to 50 minute sampling intervals during storms. Each sampler filled 24 two-liter bottles in approximately 10 seconds. Samples collected at control structure No. 3 and detention basin No. 5 were collected manually using a depth integrated sampler. Depth integrated samplers were used at the outlets to collect samples for insecticide, herbicide, oil and grease, and sediment particle size analysis.

9.5 EQUIPMENT SUMMARY

Table 9-9 shows equipment used in two of the reviewed monitoring programs and three other programs known to the authors. It is included to show the types of equipment being used and specified. The inclusion is in no way an endorsement of the indicated products (some of the products are no longer available). The table indicates that automatic samplers are being used in all monitoring programs.

Table 9-8. Core Characteristics and Constituents Analyzed by the USGS in Belluvue, Washington.

Field determinations	Specific Conductance
	pH
Major Nutrients	Dissolved nitrite-plus-nitrate (as N)
	Dissolved ammonia (as N)
	Total ammonia plus organic nitrogen (as N)
	Total Phosphorus (as P)
	Dissolved phosphorus (as P)
Trace Elements	Total recoverable lead
Organic and Biological Constituents	Chemical oxygen demand
	Carbonaceous biochemical oxygen demand, 5-day
	Dissolved organic carbon
	Suspended organic carbon
	Fecal coliform bacteria
Other	Suspended solids
	Dissolved solids

Table 9-8. Core Characteristics and Constituents Analyzed by the USGS in Belluvue, Washington.

Field determinations	Specific Conductance pH
Major Nutrients	Dissolved nitrate-plu-nitrate (as N) Dissolved ammonia (as N) Total ammonia plus organic nitrogen (as N) Total Phosphorus (as P) Dissolved phosphorus (as P)
Trace Elements	Total recoverable lead
Organic and Biological Constituents	Chemical oxygen demand Carbonaceous biochemical oxygen demand, 5-day Dissolved organic carbon Suspended organic carbon Fecal coliform bacteria
Other	Suspended solids Dissolved solids

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Figure 9-5. Frequency of Monitoring for Stations Monitored by the USGS Bellevue, Washington

MONITORING TYPE	1979			1980												1981												1982	
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
1. Surrey Downs	X		X		XX	XX	XX	X		X	X		X	X	X	X	XXXX	X		X	XX		X	X	X		XXX	XX	
2. Lake Hills	X		X		XX	XX	XX	X		X	X		XX	X	XX	X	XXXXXX			X	XX		XX	X	X		XXX	XXXX	
3. 148th Ave. below Lake Hills Boulevard			X	X		X	X		X					X		XX	XXX			X	XX			X	XXXX	X	X	X	
4. Outlet from Detention Basins No. 3 and 5																					X			X	XX	X	X	X	

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Table 9.9 Summary of Equipment Used in Previous Monitoring Programs

	Santa Clara Valley CA	Alameda County CA	Eugene OR	Portland OR	Pheonix AZ
Flow Monitoring Hardware					
ADS Quadredundant Depth Sounder			X	X	X
ADS Ultrasonic Velocity Sensor			X	X	X
Detechtronics IS Surveylogger Depth/Velocity Meter		X			
Drucks Pressure Transducer	X				
Monterdoro-Whitney Doppler Depth/Velocity Meter	X				
Sampling Hardware					
Isco 2700 Sampler	X				
Isco 3700 Sampler	X	X	X		X
American Sigma 800SL Sampler				X	

10.0 CONCLUSIONS

This report has reviewed sampling methods for water and wastewater with particular regard for stormwater. Chapters 2 through 5 discussed statistical methods, sample types, sampling equipment and sample storage and preparation. Chapter 6 reviewed flow measuring techniques. Chapter 7 discussed specific sampling problems while Chapter 8 reviewed quality assurance plans. Chapter 9 reviewed four case studies to illustrate the application of the materials presented in the earlier chapters. From this information, several conclusions are made:

1. Stormwater sampling programs may have many common procedures but many if not most of the elements are based upon site-specific considerations.

2. Stormwater monitoring programs are new and have been implemented in a development at fashion within tiered programs. The first parts of such programs usually sample a large number of stations, storm events and water quality parameters with the objective of determining the best monitoring strategy. Such programs anticipate a reduced suite of analysis and storm samples in subsequent years of the sampling program.

3. The most popular way to monitor is through automatic samplers which are set-up and programmed to sample specific storm events. Flow measuring equipment is usually provided with the automatic samplers and is usually comprised of Doppler-type flowmeters which can be installed without reducing the storm drain capacity. Traditional flow measuring equipment has little applications for stormwater monitoring.

4. Monitoring programs are created to both estimate pollutant loads as well as to better define aspects of the monitored watershed, such as land-use/pollutant concentration characteristics.

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11.0 REFERENCES

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1 Organic toxic pollutants

a. **Volatiles**

Acrolein
Acrylonitrile
Benzene
Bromoform
Carbon tetrachloride
Chlorobenzene
Chlorodibromoethane
Chloroethane
2-Chloroethylvinyl ether
Chloroform
Dichlorobromomethane
1,1-Dichoroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-Dichloropropane
1,3-Dichloropropylene
Ethylbenzene
Methyl bromide
Methyl chloride
Methylene chloride
1,1,2,2-tetrachloroethane
Tetrachloroethylene
Toluene
1,2-trans-dichloroethylene
1,1,1-trichloroethane
1,1,2-trichloroethane
Trichloroethylene
Vinyl chloride

b. **Acid Compounds**

2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
4,6-Dinitro-o-cresol
2,4-Dinitophenol
2-Nitrophenol
p-Chloro-m-cresol
Pentachlorophenol
Phenol
2,4,6-trichlorophenol

c. Base/Neutral

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzidine
- Benzo(a)anthracene
- Benzo(a)pyrene
- 3,4-benzofluoranthene
- Benzo(ghi)perylene
- Benzo(k)fluoranthene
- Bis(2-chloroethoxy)methane
- Bis(2-chloroethyl)ether
- Bis(2-chloroisopropyl)ether
- Bis(2-ethylhexyl)phthalate
- 4-Bromophenyl phenyl ether
- Butylbenzyl phthalate
- 2-Chloronaphthalene
- 4-Chlorophenyl phenyl ether
- Chrysene
- Dibenzo(a,h)anthracene
- 1,2-Dichlorobenzene
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- 3,3'-Dichlorobenzidine
- Diethyl phthalate
- Dimethyl phthalate
- Di-n-butyl phthalate
- 1,2-Dinitrotoluene
- 2,6-Dinitrotoluene
- Di-n-octyl phthalate
- 1,2-diphenylhydrazine (as azobenzene)
- Fluroranthene
- Fluorene
- Hexachlorobenzene
- Hexachlorobutadiene
- Hexachlorocyclopentadiene
- Hexachloroethane
- Indeno(1,2,3-cd)pyrene
- Isophorene
- Napthalene
- Nitrobenzene
- N-nitrosodimethylamine
- N-nitrosodi-n-propylamine
- Phenanthrene
- Pyrene
- 1,2,4-trichlorobenzene

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d. Pesticides

Aldrin
alpha-BHC
beta-BHC
gamma-BHC
delta-BHC
Chlordane
4,4'-DDT
4,4'-DDE
4,4'-DDD
Dieldrin
alpha-endosulfan
beta-endosulfan
endosulfan sulfate
endrin
endrin aldehyde
Heptachlor
Heptachlor epoxide
PCB-1242
PCB-1254
PCB-1221
PCB-1232
PCB-1248
PCB-1260
PCB-1016
Toxaphene

2. Other toxic pollutants (metal and Cyanide) and Total Phenols

Antimony, Total
Arsenic, Total
Beryllium, Total
Cadmium, Total
Chromium, Total
Copper, Total
Lead, Total
Mercury, Total
Nickel, Total
Selenium, Total
Silver, Total
Thallium, Total
Zinc, Total
Cyanide, Total
Phenol, Total

3. Others parameters

Total suspended solids (TSS)
Total dissolved solids (TDS)
COD
BOD_5
Oil and grease
Fecal Coliform
Fecal streptococcus
pH
Total Kjeldahl nitrogen
Nitrate-Nitrite
Dissolved phophorus
Total phosphorus

Non-Ferrous Metals

Ability to withstand	Non-soldered copper	Brass	Bronze
Max. dry heat			
short-term	Above achievable water/steam sample temperatures		
long-term	Above achievable water/steam sample temperatures		
Hot neutral salt solution	Good, but unsuitable for determining metal and sulfuric acid content		
Weak acid	Varies with acid	Varies with acid	Varies with acid
Strong acid	Surface attacked	Surface attacked	Surface attacked
Weak alkali	Varies with alkali	Varies with alkali	Varies with alkali
Strong alkali	Metal surface attacked by the alkali		
Liquid organic solvents	Resistant to all known solvents		
Hydrocarbon diffusion	Resistant to diffusion at achievable water/steam sample temperatures		
Natural gas diffusion	Resistant to diffusion at achievable water/steam sample temperatures		

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Ferrous Metals

Ability to withstand	Mild steel	Non-soldered corrosion resistant martensitic steel	Non-soldered corrosions resistant austhenitic/non-magnectic steel
Max. dry heat			
short-term	Above achievable water/steam sample temperatures		
long-term	Above achievable water/steam sample temperatures		
Hot neutral salt solutions	Good, but unsuitable for determining metal content		
Weak acid	Poor	Good	Very good
Strong acid	Surface attacked	Surface attacked	Very good
Weak alkali	Good	Very good	Very good
Strong alkali	Poor	Good	Very good
Liquid organic solvents	Resistant to all knowm solvents		
Hydrocarbon diffusion	Resistant to diffusion at achievable water/steam sample temperatures		
Natural gas diffusion	Resistant to diffusion at achievable water/steam sample temperatures		

Reference: Krajca (1989)

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RECOMMENDED SAMPLE VOLUME AND PRESERVATION TECHNIQUE

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (ml)
Acidity	Grab or composite	P, G	Cool, 4°C	14 days	100
Alkalinity	Grab or composite	P, G	Cool, 4°C	14 days	100
Asbestos	Grab or composite	P	Cool, 4°C	48 hours	1000
Bacteria	Grab only	Pro, G	Cool, 4°C, 10% $Na_2S_2O_3$, EDTA	6 hours	200
Bicarbonate	Grab only	P, G	Determine on site	No holding	100
BOD	Grab only	P, G	Cool, 4°C	48 hours	1000
Bromide	Grab or composite	P, G	None required	28 days	100
Carbonate	Grab only	P, G	Determine on site	No holding	100
Chloride	Grab or composite	P, G	None required	28 days	50
Chloride demand	Grab only	P, G	Determine on site	No holding	200
Chromium VI	Grab or composite	P, G	Cool, 4°C	24 hours	100
COD	Grab only	P, G	H_2SO_4 to pH < 2; Cool, 4°C	28 days	50
Color	Grab or composite	P, G	Cool, 4°C	48 hours	50
Conductance	Grab or composite	P, G	Cool, 4°C	28 days	100

Appendix C (cont'd)

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (ml)
Cyanide	Grab or composite	P, G	NaOH to pH > 12, 0.6g Ascorbic acid[d]	14 days	500
Fluoride	Grab or composite	P	None required	28 days	300
Hardness	Grab or composite	P, G	HNO_3 to pH < 2	6 months	100
Hydrazine	Grab or composite	P, G	Do not analyzed immediately, collect under acid. Add 90 ml to sample to 10ml (1+9) HCl.	7 days	100
Iodine	Grab or composite	P, G	Cool, 4°C	24 hours	100
Iodine	Grab only	P, G	Determine on site	No holding	500
<u>Metals</u> (Except Cr VI)					
Dissolved	Grab or composite	P, G	Filter on site, HNO_3 to pH < 2	6 months, except Mg- 28 days	200
Suspended	Grab or composite	P, G	Filter on site	6 months, except Mg- 28 days	200
Total	Grab or composite	P, G	HNO_3 to pH < 2	6 months, except Mg- 28 days	100

Appendix C (cont'd)

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (ml)
<u>Nitrogen</u> Ammonia	Grab or composite	P, G	Cool, 4°C, H_2SO_4 to pH < 2	28 days	400
Kjeldahl (total)	Grab or composite	P, G	Cool, 4°C, H_2SO_4 to pH < 2	28 days	500
Nitrate plus Nitrite	Grab or composite	P, G	Cool, 4°C, H_2SO_4 to pH < 2	28 days	100
Nitrate	Grab or composite	P, G	Cool, 4°C, H_2SO_4 to pH < 2	48 hours	100
Nitrite	Grab or composite	G	Cool, 4°C, H_2SO_4 to pH < 2	48 hours	50
Oil and Grease	Grab only	G	Cool, 4°C, H_2SO_4 to pH < 2	28 days	1000
<u>Organics</u> Extractable (base/neurals and acids)	Grab or composite	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 30 days after extraction	1000
Purgeable (halocarbons-aromatics)	Grab only	G, Teflon-lined cap	Cool, 4°C	14 days	40

Appendix C (cont'd)

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (ml)
TOX	Grab or composite	G, amber, Teflon-lined cap	Cool, 4°C, add 1 ml 0.1 M sodium sulfite	7 days	100
Turbidity	Grab or composite	P, G	Cool, 4°C	48 hours	100

Note:
[a]P = Polyethylene G = Glass Pro = Polypropylene

[b]The holding time are those listed in *Technical Additions to Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-82-055 and *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA-600/4-82-057.

Reference: US EPA (1984)

Appendix C (cont'd)

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (ml)
Oragnic(cont'd) Purgeable (acroleina nd acrylonitrile)	Grab only	G, Teflon-lined cap	Cool, 4°C	14 days	40
Pesticides and PCBs	Grab or composite	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 30 days after extraction	250
pH	Grab only	P, G	Cool, 4°C	2 hours	25
Phenol	Grab or composite	G	Cool, 4°C, H_2SO_4 to pH < 2	24 hours	500
Phosphorus Ortho-phosphate	Grab or composite	P, G	Filter on site, cool, 4°C	48 hours	50
Phosphorus, total	Grab or composite	P, G	Cool, 4°C, H_2SO_4 to pH < 2	28 days	50
Radioactivity	Grab or composite	P, G	HNO_3 to pH < 2	6 months	1 gal
Silica Dissolved	Grab or composite	P	Cool, 4°C	28 days	50
Total	Grab or composite	P	Cool, 4°C,	28 days	50

Appendix C (cont'd)

Parameter	Collection technique	Container[a]	Preservation	Holding time[b]	Minimum required volume (ml)
Solids					
Dissolved	Grab or composite	P, G	Cool, 4°C	7 days	100
Volatile Dissolved	Grab or composite	P, G	Cool, 4°C	7 days	100
Suspended	Grab or composite	P, G	Cool, 4°C	7 days	100
Volatile suspended	Grab or composite	P, G	Cool, 4°C	7 days	100
Total	Grab or composite	P, G	Cool, 4°C	7 days	100
Volatile Total	Grab or composite	P, G	Cool, 4°C	7 days	100
Settleable	Grab or composite	P, G	Cool, 4°C	48 hours	100
Sulfate	Grab or composite	P, G	Cool, 4°C	28 days	50
Sulfide	Grab or composite	P, G	Cool, 4°C, 2 ml zinc acetate plus NaOH to pH > 9	7 days	500
Sulfite	Grab or composite	P, G	Determine on site	No holding	50
Surfactants	Grab or composite	P, G	Cool, 4°C	48 hours	250
TOC	Grab or composite	G, Teflon lined-cap	Cool, 4°C, HCl to pH < 2	28 days	25

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Santa Monica
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ASSESSMENT OF STORM DRAIN SOURCES OF CONTAMINANTS TO SANTA MONICA BAY

VOLUME III
SURFACE DRAINAGE WATER QUALITY MONITORING PROGRAM PLAN

by

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May 1993

PREFACE AND ACKNOWLEDGEMENTS

This report represents Volume III from a series of four volumes of reports which form the basis of a pollution assessment and monitoring plan for Santa Monica Bay. Volume I describes storm drainage system land use statistics, catchment areas, existing water quality monitoring data, rainfall data, NPDES permit information for existing permits to storm drains, and contaminant mass emission estimates, based upon land use modeling. Volume II reviews sampling techniques, including sampling equipment, and other aspects associated with sampling such as a quality assurance plan. Volume III presents the proposed monitoring plan. Volume IV addresses best management practices as they apply to the Santa Monica Bay area. The first draft of this volume was issued in October, 1992.

The contract was performed by UCLA and Woodward-Clyde Consultants (WCC). Professor Michael K. Stenstrom of the Civil and Environmental Engineering Department, UCLA and Eric Strecker from WCC's Portland office were the project managers. There were several key individuals from both UCLA and WCC who assisted with the project; they include Sim-Lin Lau and Kenneth Wong (UCLA) and Lou Armstrong, Gail Boyd, Carol Forrest, and Joan Kersnar (WCC).

The contractors are grateful for the assistance of many individuals. The Santa Monica Bay Project and LA Regional Water Quality Control Board staffs were most helpful. We extend our special thanks to Dr. Guang-yu Wang, Ms. Catherine Tyrrell, Dr. Rainer Hoeinke and Mr. Xavier Swamikannu. Several public agencies were very helpful in providing data and information to us. The Los Angeles County Department of Public Works and the Southern California Association of Governments (SCAG) provided catchment area and land use data, respectively. We are also indebted to the members of the Technical Advisory Committee of the Santa Monica Bay Project and others who reviewed and commented on our draft reports.

The monitoring plan includes two primary goals: 1) assessing mass emissions of contaminants to Santa Monica Bay, and 2) developing more data in order to provide a better understanding of the relationship between land use and pollutant runoff. These two goals were developed in a workshop conducted in June, 1992 which was attended by representatives from the agencies responsible for implementing the monitoring plan, citizens groups and regulatory agencies. The plan addresses these goals by proposing 16 sampling stations

To determine the mass emissions 4 candidate sampling stations, located on Ballona Creek, Malibu Creek, Pico-Kenter and Topanga Creek, are proposed. These stations would sample runoff from about 75 percent of the Bay's watershed. To better understand the relationship between land-use and pollutant runoff characteristics, 12 additional candidate stations are proposed to monitor 6 different types of land uses, including single-family residential, multi-family residential, commercial, industrial, open, and highway.

Final sampling station locations are not proposed because the exact location will depend upon many site specific concerns, which are beyond the scope of this project. It is felt that the exact monitoring locations should be determined by the monitoring agency, who will be able to address such issues as proximity to electric power, freedom from vandalism, site hydraulics, and safety.

In addition to the candidate locations of the monitoring stations, additional information is provided on sampling techniques, analytical procedures, quality assurance procedures, data reporting, field crew training and methods for estimating pollutant loads. This information complements the sampling review presented in Volume II.

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1.0 INTRODUCTION

This monitoring plan describes the objectives and approach for collecting data on the quality of storm drain discharges to Santa Monica Bay. The plan presents the methods used for selecting monitoring sites, specifies types of equipment required, discusses storm selection and runoff estimation procedures, and presents sampling event management and field sampling methods. Quality assurance and control, data reporting, monitoring schedule and training requirements are also presented. A more detailed review of sampling procedures and techniques is presented in Volume II of these reports (Stenstrom, et al., 1993) and should be consulted for more information on sampling. Included in the plan is a discussion of methods for pollutant load estimation.

1.1 MONITORING PLAN OBJECTIVES

The objective of this monitoring program is to provide accurate data for assessing the extent of pollutant loadings to Santa Monica Bay from storm drains and streams, from both dry and wet weather flows. The data should provide information that allows the determination of the need for and the prioritization of best management practices (BMPs). It should identify areas with potential water quality problems and provide for accurate and defensible detection of constituents. It should also provide information for assessing long-term trends in the quality of storm drain discharges to Santa Monica Bay. The monitoring program provides for an assessment of pollutant mass emissions to the Bay in an economical fashion. The plan includes installation of continuous flow monitoring stations, which will allow for collection of hydrologic data from all events, and in addition could be used to identify illicit dumping or illegal connections.

It is recommended that this program be integrated with other monitoring programs including those that are not part of the early NPDES permit, such as the comprehensive Bay monitoring Bay plan. If possible, collecting information on receiving waters (e.g., surf zone, coastal lagoons, and Malibu Estuary) during monitored storm events would also be appropriate, at least initially. Receiving water quality information can be used to determine the impact of storm water discharges on the health of the Bay, during and just after runoff events.

Finally, the proposed plan has been designed to assist the co-permittees in meeting the intent of both the Federal regulatory program for municipalities as well as Los Angeles County's "early permit" requirements specific to Santa Monica Bay.

1.2 MONITORING APPROACH

To meet the monitoring plan objectives noted above, a combination of two sampling approaches have been formulated. One approach is to collect samples at locations that monitor runoff from the largest possible areas of the watershed. Mass emissions can be estimated directly from these data. The second approach is to monitor runoff from locations having a single predominant land use. Data from these monitoring stations can be used with a pollutant loadings model to determine loadings to the Bay from unmonitored areas. These data can also be used to prioritize drains and to facilitate the process of selecting appropriate and effective BMPs.

The combination of these two approaches provides some redundancy in how loadings can be estimated as well as improve our information and understanding of pollutant/land use relationships for the Santa Monica Bay watershed. Having both types of stations allows the use of the data from the mass emission stations with the data from a variety of land use stations to calibrate and validate with existing and future land-use-based pollutant loadings models.

The mass emission stations will likely be permanent and used for quite sometime. Data from these stations will also establish a baseline for future comparisons. The permanence of these stations helps justify their costs, including the cost for data telemetry. The permanency of the land use stations will depend upon future efforts to model the Santa Monica Bay watershed. Data from these stations, and the ability to exactly repeat the sampling protocol, will be vitally important for future modeling efforts.

The plan includes a detailed Quality Assurance/Quality Control element to help assess the accuracy of the field and analytical program. Station equipment was recommended to provide accuracy of measured flows, and ease and accuracy in sample collection. The plan also includes a description of the storm selection process, sampling methods, and data reporting.

Water quality data should be obtained during dry weather as well as wet weather. Flow measurements should be made continuously at all stations, and samples will be collected for laboratory analyses in both wet and dry weather. Dry weather monitoring should provide information on the quantity and quality of base flows and may indicate the presence of illicit discharges or illegal dumpings. However, it is highly recommended that a separate illicit connection detection program be developed and implemented to find and eliminate these sources of pollutants. Monitoring of storm events would provide information on rainfall-runoff relationships and pollutant loadings from specific catchments and land uses.

1.3 MONITORING PLAN SUMMARY

In designing the monitoring plan, the climate and rainfall patterns of the Los Angeles area were considered. The number of storms that can be sampled during a given year may be quite limited; a total of eight storms will be targeted over the two-year monitoring period. Monitoring during dry weather is also proposed. The monitoring program proposed in this plan is summarized as follows:

- Monitoring of drainage areas with single land uses (i.e., residential, commercial, and light industrial), as well as drainage areas with mixed land uses (i.e., mass emissions stations).
- Continuous flow and rainfall measurement for all stations.
- Collection of grab samples and flow-composited samples for eight storm events over a period of 2 years.
- Collection of grab samples and 24-hour flow-composited samples during dry weather 4 to 6 times per year over a period of 2 years at the mass emissions stations; collection of grab samples during dry weather at the single land use sites if flow measurements indicate a possible problem (if a

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permitted discharge to the selected stormdrain is found, it must be accounted for it the plan, or a different single land use site must be selected.

- Analysis of the samples for:
  - conventional pollutants
  - nutrients
  - bacteria
  - total and dissolved metals
  - volatile and semi-volatile organic compounds
  - pesticides/herbicides

In addition to the full suite of parameters listed above, a reduced suite of parameters has been recommended. Final locations of the monitoring stations have not been provided at this time, since this will require consideration of detailed site-specific information such as hydraulic conditions, general site access, and health and safety of the sampling crew.

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This section of the monitoring plan describes the criteria that were used to select candidate sites for flow and water quality monitoring in Santa Monica Bay.

2.1 SITE SELECTION CRITERIA

To accurately determine storm water characteristics in a large, diverse study area, a strategic monitoring program can use some stations that sample runoff from relatively small and homogenous land use catchments (so called "single land use" or "upland" stations) and some stations that sample runoff from relatively large catchments representing a composite of land uses (so called "mass emissions" stations). The mass emissions stations are sometimes located in streams toward the lower ends of watersheds and are sometimes referred to as "stream" stations.

The study design requires a station mix that is representative of the land use distribution in the Santa Monica Bay Watershed. Table 2-1 shows the land use distribution within Santa Monica Bay Watershed. The table shows that the principal land uses within the watershed are single-family residential (26 percent) and undeveloped or open lands (57 percent). Other land uses include multiple-family residential (7 percent), commercial (3 percent), light industrial (2 percent), and public (2 percent) areas. Other urban areas constitute the remaining 3 percent of the total area.

Single-family residential areas and open spaces should be targeted in the monitoring program because these land use categories overwhelmingly form the largest types of land uses. Commercial and industrial areas are candidates for direct sampling, because previous studies have shown that these land use types contribute a significant percentage of pollutants to urban storm water runoff despite their relatively small contributing area (EPA, 1983). These previous studies also indicated that the quality of runoff from these types of land uses are widely variable from site to site, so that large parcels with various properties and uses are desirable to characterize the overall pollutant loadings from these types of land uses. Although not included in the land use breakdown, traffic corridors can also be significant contributors of runoff pollutants (Driscoll, et al., 1989). One traffic corridor site previously monitored by Cal Trans should be included with the single land use sites.

Other urban and public land uses not targeted by the single land use sites should be sampled at the designated mass emissions stations. The single land use stations should also monitor other land use types in those instances where the other land uses form a small percentage of the catchment to the monitoring station.

The following criteria were used as guidelines in selecting the single land use sites:

- The total catchment area is large enough (greater than about 50 acres) to generate significant runoff and not be affected by possible localized irregularities.
- The catchment consists primarily of one of the targeted land use types.

TABLE 2-1

LAND USE IN SANTA MONICA BAY WATERSHED

LAND USE	ACREAGE	PERCENT OF TOTAL
Single-Family Residential	70,200	26
Multi-Family Residential	18,500	7
Commercial	8,500	3
Light Industrial	4,000	2
Public	5,200	2
Other Urban	8,200	3
Open	150,200	57
Unknown	400	<1
TOTAL	265,200	100

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- A single outfall or discharge point for the catchment has been identified or is likely to exist.

In determining the single land use stations, the land use data generated by the WCC geographical information system (GIS) was heavily relied upon. The subbasins having more than 50 acres were ranked by the percentage of each land use type. Maps of the subbasin drainage systems were then reviewed to select potential candidates from the subbasins with the highest percentage of each land use type. Drainage system maps for subbasins in the Hollywood Quadrangle were not available for review. Further evaluation of the potential sites is required before final selection.

Monitoring sites on basins that discharge directly to the sea (via outfalls) would need to be located upstream to avoid tidal influences and/or backwater effects that could affect sampling results.

Preliminary storm water monitoring stations were selected from examination of County of Los Angeles Department of Public Works drainage maps, based on the above criteria and are presented in the next section. Additional information from field reconnaissance would be required for each site to confirm the preliminary monitoring site selections reported herein. The following technical and operational requirements should be used during the final site selection and verification process:

Catchment Area Characteristics

- The drainage system and boundaries are known
- Land uses are known
- Contamination from or interaction with the sanitary system is unlikely to occur (this may be challenging for some catchments, such as Ballona Creek, where spills from sanitary sewers are frequent)

Hydraulic Suitability

- Uniform flow conditions exist
  - upstream sections are straight and uniform for (at least approximately six channel widths or 12 pipe diameters)
  - backwater conditions do not exist (i.e., receiving waters do not back up to the monitoring site)
  - pressure flow or pipe surcharging does not occur within normal precipitation ranges for sampling and never occurs at levels that could endanger equipment
  - tidal flows do not affect the sampling location
- A rating curve can be reliably determined or other flow measuring technique developed (channel bottom must be stable and not subject to cutting and filling during periods of high and low flows).
- The channel or storm drain is soundly constructed and stable
- Well mixed conditions exist (i.e., the sampling site is located sufficiently downstream from any major upstream storm water inflows)
- The access point (e.g., manhole, bridge) is not excessively deep

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- The sampling equipment should not impede flow and reduce flood protection

Crew Safety

- The site has good access during all weather conditions
- The crew should be easily visible
- Minimal traffic or other hazards exist
- The station is relatively secure from vandalism
- Confined space entry can be performed safely and in compliance with regulations during wet and dry weather conditions

Use of the above criteria would help ensure that the storm water samples are representative, as well as meeting safety requirements.

2.2 PRELIMINARY SINGLE LAND USE STATION SITES

Preliminary monitoring sites were selected to represent the following land use types: single-family residential, multi-family residential, commercial, light industrial, and traffic corridor. For each of these sites, the basin number, subbasin name, and component land use type areas, by acreage or percentage, is presented in Table 2-2a and 2-2b. Following the subbasin name, a paragraph is included which describes the catchment composition. The site identification codes, or subbasin names, are based upon the County of Los Angeles Public Works maps. Each code represents the name of a subbasin from the map and the name of the outfall draining the subbasin.

2.2.1 Single-Family Residential

The screening process identified six preliminary station sites (outfalls or manholes draining a particular subbasin) for single-family residential land use. Two of these sites would be selected for monitoring.

BI9815 is in basin #24 of the Venice Quadrangle located near Hermosa Beach in the City of Manhattan Beach. BI9815 is approximately 225 acres with land use breakdowns of 93 percent single-family residential, 4 percent multi-family residential, 2 percent commercial, and 1 percent open. BI9815 is a piped system draining to Santa Monica Bay. The outfall is located near Hermosa Beach in Manhattan Beach.

BI5238 is in basin #21 of the Inglewood Quadrangle located north of UCLA in Bel Air. The 248-acre basin drains a steep canyon with land uses of 95 percent single-family residential, 4 percent public, and 1 percent open space. BI5238 has only one pipe outlet.

SMB62 is in basin #8 of the Point Dume Quadrangle on Point Dume. SMB62 contains 181 acres of 95 percent single-family residential, 4 percent public, and 1 percent open land use. The open channel system drains into Santa Monica Bay possibly requiring the sampling station to be moved upstream from the outfall to avoid tidal influences.

TABLE 2-2a
PRELIMINARY LAND USE STATION SITES

LAND USE (Acres)

BASIN #	SUBBASIN NAME	Single-Family Residential	Multi-Family Residential	Commercial	Light Industrial	Public	Other Urban	Open	Unknown	Subbasin Total Acreage
Single-Family Residential (2 stations to be selected)										
8	SMB62	171.3	0.0	0.0	0.0	7.5	0.0	2.0	0.0	180.8
21	B15238	230.4	0.0	0.0	0.0	0.0	0.0	17.8	0.0	248.2
24	B19815	210.6	8.3	5.0	0.0	0.0	0.0	1.5	0.0	225.3
21	B181	711.9	7.1	0.1	65.7	0.0	0.1	0.0	0.0	784.9
26	B19817	193.7	0.0	0.0	0.0	16.2	0.0	3.1	0.0	213.0
21	B14881	410.1	0.0	0.6	0.0	39.6	0.0	0.0	0.0	450.2
Multi-Family Residential (2 stations to be selected)										
20	B1249C	10.9	296.9	24.0	0.0	61.6	14.7	97.6	0.0	505.5
21	B15212	108.5	401.5	67.3	6.6	44.9	0.0	5.6	0.0	634.3
Combined Residential										
21	B1504	340.5	94.1	21.6	2.7	3.8	0.1	0.0	0.0	462.8
21	B1503	138.5	49.8	5.4	0.0	5.2	0.0	0.0	0.0	198.8
20	B1736	38.9	142.0	5.7	0.6	0.1	0.0	8.5	0.0	195.8
21	B15213	623.1	125.9	4.6	13.3	6.7	4.0	31.8	0.0	809.4
21	B1648A	91.0	198.5	24.5	7.3	0.7	0.0	0.0	0.0	322.1
21	B111021	836.0	288.7	72.5	32.0	50.6	18.7	0.3	0.0	1298.8
21	B1572	338.6	599.0	61.9	0.0	45.4	8.9	14.3	0.0	1068.1

TABLE 2-2a (continued)
PRELIMINARY LAND USE STATION SITES

BASIN #	SUBBASIN NAME	Single-Family Residential	Multi-Family Residential	Commercial	Light Industrial	Public	Other Urban	Open	Unknown	Subbasin Total Acreage
Commercial (2 sites to be selected)										
20	BI249D	0.0	0.0	68.8	0.0	0.3	0.0	6.5	0.0	75.6
21	RXFRD1	458.4	77.8	185.3	36.1	15.7	0.0	0.0	0.0	773.2
Light Industrial (2 sites to be selected)										
21	BLLNA9	19.7	0.0	0.0	58.2	0.0	0.0	0.0	0.0	77.8
21	BLLNA6	52.7	0.0	13.1	37.5	0.0	0.0	4.6	0.0	107.9
21	CULVER1	189.8	49.0	6.2	116.5	23.6	10.4	0.0	0.0	395.6
21	BI81	711.9	7.1	0.1	65.7	0.0	0.1	0.0	0.0	784.9
Commercial/Light Industrial										
23	BI3402	149.1	21.5	35.6	113.4	9.5	26.3	87.4	0.0	442.7
21	BI5243	402.5	40.8	46.1	123.7	58.8	0.2	9.2	0.0	681.2
21	BI52041	3.4	0.0	510.5	378.5	9.2	0.0	0.0	180.2	1081.7
21	BI52042	0.0	0.2	30.0	309.5	102.2	0.5	0.0	0.0	442.3
21	BI52043	697.3	975.3	603.7	213.9	295.6	98.4	50.4	0.0	2934.5

TABLE 2-2a (continued)
PRELIMINARY LAND USE STATION SITES

BASIN #	SUBBASIN NAME	*LAND USE (Acres)* Single-Family Residential	Multi-Family Residential	Commercial	Light Industrial	Public	Other Urban	Open	Unknown	Subbasin Total Acreage
Open (2 sites to be selected)										
1	ARSEQ2	0.0	0.0	0.0	0.0	0.0	0.0	2912.7	0.0	2912.7
1	ARSEQ1	0.0	0.0	0.0	0.0	0.0	0.0	2169.1	0.0	2169.1
1	ARSEQ3	0.0	0.0	0.0	0.0	0.0	0.0	1906.3	0.1	1906.3
4	LACHU1	0.0	0.0	0.0	0.0	0.0	0.0	826.1	0.0	826.1
10	LATIG1	0.0	0.0	0.0	0.0	0.0	0.0	696.6	0.0	696.6
15	PENA1	1.7	0.0	0.0	0.0	0.0	0.0	481.1	0.0	482.8
8	RAMRZ1	11.7	0.0	0.0	0.0	0.0	0.0	1664.0	0.0	1675.6
3	LALIS1	11.2	0.0	0.0	0.0	0.0	0.0	932.7	0.0	943.9
6	TRANC3	2.5	0.0	0.0	0.0	0.0	0.0	351.6	0.0	354.1
6	TRANC1	40.8	0.0	0.0	0.0	43.3	0.0	4702.4	0.0	4786.5
2	SNICH	12.7	0.0	0.0	0.0	0.0	3.0	831.5	0.0	847.1
15	TUNA1	24.6	0.0	0.0	0.0	0.0	0.0	909.9	0.0	934.5
6	TRANC2	7.2	0.0	0.0	0.0	0.0	0.0	69.0	0.0	76.2

Transportation (2 sites to be selected)

I-405		3.2
Hollywood Freeway	Approximately	15.0

TABLE 2-2b
PRELIMINARY LAND USE STATION SITES

BASIN #	SUBBASIN NAME	*LAND USE (Percent of Total)* Single-Family Residential	Multi-Family Residential	Commercial	Light Industrial	Public	Other Urban	Open	Unknown	Total
Single-Family Residential (2 stations to be selected)										
8	SMB62	95%	0%	0%	0%	4%	0%	1%	0%	100%
21	B15238	93%	0%	0%	0%	0%	0%	7%	0%	100%
24	B19815	93%	4%	2%	0%	0%	0%	1%	0%	100%
21	B181	91%	1%	0%	8%	0%	0%	0%	0%	100%
26	B19817	91%	0%	0%	0%	8%	0%	1%	0%	100%
21	B14881	91%	0%	0%	0%	9%	0%	0%	0%	100%
Multi-Family Residential (2 stations to be selected)										
20	B1249C	2%	59%	5%	0%	12%	3%	19%	0%	100%
21	B15212	17%	63%	11%	1%	7%	0%	1%	0%	100%
Combined Residential										
21	B1504	74%	20%	5%	1%	1%	0%	0%	0%	100%
21	B1503	70%	25%	3%	0%	3%	0%	0%	0%	100%
20	B1736	20%	73%	3%	0%	0%	0%	4%	0%	100%
21	B15213	77%	16%	1%	2%	1%	0%	4%	0%	100%
21	B1648A	28%	62%	8%	2%	0%	0%	4%	0%	100%
21	B111021	64%	22%	6%	2%	4%	1%	0%	0%	100%
21	B1572	32%	56%	6%	0%	4%	1%	1%	0%	100%

TABLE 2-2b (continued)
PRELIMINARY LAND USE STATION SITES

		LAND USE (Percent of Total)								
BASIN #	SUBBASIN NAME	Single-Family Residential	Multi-Family Residential	Commercial	Light Industrial	Public	Other Urban	Open	Unknown	Total
Commercial (2 sites to be selected)										
20	BI249D	0%	0%	91%	0%	0%	0%	9%	0%	100%
21	RXFRD1	59%	10%	24%	5%	2%	0%	0%	0%	100%
Light Industrial (2 sites to be selected)										
21	BLLNA9	25%	0%	0%	75%	0%	0%	0%	0%	100%
21	BLLNA6	49%	0%	12%	35%	0%	0%	4%	0%	100%
21	CULVER1	48%	12%	2%	29%	6%	3%	0%	0%	100%
21	BI81	91%	1%	0%	8%	0%	0%	0%	0%	100%
Commercial/Light Industrial										
23	BI3402	34%	5%	8%	26%	2%	6%	20%	0%	100%
21	BI5243	59%	6%	7%	18%	9%	0%	1%	0%	100%
21	BI52041	0%	0%	47%	35%	1%	0%	0%	17%	100%
21	BI52042	0%	0%	7%	70%	23%	0%	0%	0%	100%
21	BI52043	24%	33%	21%	7%	10%	3%	2%	0%	100%

TABLE 2-2b (continued)
PRELIMINARY LAND USE STATION SITES

BASIN #	SUBBASIN NAME	*LAND USE (Percent of Total)* Single-Family Residential	Multi-Family Residential	Commercial	Light Industrial	Public	Other Urban	Open	Unknown	Total
Open (2 sites to be selected)										
1	ARSEQ2	0%	0%	0%	0%	0%	0%	100%	0%	100%
1	ARSEQ1	0%	0%	0%	0%	0%	0%	100%	0%	100%
1	ARSEQ3	0%	0%	0%	0%	0%	0%	100%	0%	100%
4	LACHU1	0%	0%	0%	0%	0%	0%	100%	0%	100%
10	LATIGI	0%	0%	0%	0%	0%	0%	100%	0%	100%
15	PENA1	0%	0%	0%	0%	0%	0%	100%	0%	100%
8	RAMRZ1	1%	0%	0%	0%	0%	0%	99%	0%	100%
3	LALIS1	1%	0%	0%	0%	0%	0%	99%	0%	100%
6	TRANC3	1%	0%	0%	0%	0%	0%	99%	0%	100%
6	TRANC1	1%	0%	0%	0%	1%	0%	98%	0%	100%
2	SNICH	1%	0%	0%	0%	0%	0%	98%	0%	100%
15	TUNA1	3%	0%	0%	0%	0%	0%	97%	0%	100%
6	TRANC2	9%	0%	0%	0%	0%	0%	91%	0%	100%
Transportation (2 sites to be selected)										
	I-405						100%	Transportation		100%
	Hollywood Freeway						100%	Transportation		100%

BI9817 is in basin #26 of the Redondo Beach Quadrangle near Palos Verdes Point. The 231 acre subbasin is 91 percent single-family residential, 6 percent multi-family residential, and 3 percent commercial land use. The system is piped with a direct outfall into Lunada Bay.

BI81 is in basin #21 of the Venice Beach/Inglewood Quadrangles east of Hughes Airport and north of Los Angeles Airport. The 785-acre piped system runs from Manchester Avenue to 83rd Avenue and is 91 percent single-family residential, 1 percent multi-family residential, and 8 percent light commercial land uses.

BI4881 is in basin #21 of the northern Inglewood Quadrangle located near Pepperdine University. The 450-acre piped system drains an area from the 66th Street to Manchester Avenue into a larger subbasin, BI4883. The land uses include 91 percent single-family residential and 9 percent public. Because of BI4881's proximity to BI81, only one of these two stations should be selected.

2.2.2 Multi-Family Residential

The screening process identified one preliminary station site and 10 potential sites that require further review of drainage system maps for multi-family residential land use. Two sites are suggested for monitoring.

BI249C is in basin #20 of the southwest Beverly Hills Quadrangle. The basin contains 505 acres with 59 percent multi-family residential, 19 percent open, 12 percent public, 5 percent commercial, 3 percent other urban, and 2 percent single-family residential land use. The basin is located in Santa Monica along Pico Boulevard. The piped system drains into the Kenter Canyon Storm Drain System. A station could be put on the upper reach of the basin near 14th Street to increase the multi-family land use percentage.

BI5212 is in basin #21 of the east Hollywood Quadrangle and is located in Los Angeles north of Wilshire Boulevard and south of Sunset Boulevard. The 634 acre channel and piped system contains 63 percent multi-family residential, 17 percent single-family residential, 11 percent commercial, 7 percent public, 1 percent light industrial, and 1 percent open land uses. BI5212 eventually forms a piped system which drains to the Grant Boundary Piped System.

2.2.3 Combined Residential

The screening process identified three preliminary station sites and nine potential sites that require further review of drainage system maps for combined residential land use. These sites could be substituted for one or more of the single or multi-family sites mentioned above.

BI504 is in basin #21 of the central Beverly Hills/Venice Beach Quadrangles and is located in Ballona. The land uses are 74 percent single-family residential, 25 percent multi-family residential, 3 percent commercial, and 3 percent public. BI504 drains an area of 462 acres from Charnoch Road to Ballona Creek between Bentivela Avenue and Alla Road. BI504 is most likely a piped system.

BI503 is in basin #21 of the central Beverly Hills/Venice Beach Quadrangle located east of BI504. The land uses are 70 percent single and 25 percent multi-family. It drains an 198 acre area from Venice Avenue and Sepulveda Channel into Ballona Creek. Sample station #12 is located at the outfall of the piped system to Ballona Creek.

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BI736 is in basin #20 of the southwest Beverly Hills Quadrangle located in Santa Monica, south of Pico Boulevard and north of Rose Avenue. BI736 drains 195 acres of 73 percent multi-family residential, 20 percent single-family residential, 4 percent open, and 3 percent commercial land uses. BI736 drains directly into Santa Monica Bay through a piped system. Two sample stations are located at the outfall, #30 and #22.

BI5213 is basin #21 of the east Hollywood Quadrangle and is located in Los Angeles north of the Hollywood Freeway and south of Silver Lake Reservoir. The 809 acre piped system contains 77 percent single-family residential, 16 percent multi-family residential, 4 percent open, 2 percent light industrial, 1 percent commercial, and 1 percent public land uses. BI5213 drains into the Grant Boundary Piped System.

BI648A is in basin #21 of the central Hollywood Quadrangle and is located in Las Cienegas between Venice Boulevard and Washington Boulevard. The 322 acre piped system drains to the upper reach of Ballona Creek. the land uses include 62 percent multi-family residential, 28 percent single-family residential, 8 percent commercial, and 2 percent open. BI648A also is a possible multi-family residential land use site candidate.

BI11021 is in basin #21 of the northeast Hollywood Quadrangle. The basin contains 1,299 acres with 64 percent single-family residential, 22 percent multi-family residential, 6 percent commercial, 4 percent public, 2 percent light industrial, and 1 percent other urban land uses. The basin is located in east Hollywood between Olive Hill and the Silver Lake Reservoir, north of the Hollywood Freeway and south of Los Feliz Boulevard. The piped system drains to the Grant Boundary piped system. The BI11021 monitoring site would need to be moved upstream near the intersection of Hillhurst Avenue and Romaine Street to avoid possible dual outlets.

BI572 is in basin #21 of the east Hollywood Quadrangle and is located in Hollywood between 4th Street and the Santa Monica Mountains. The 1,068 acre piped system eventually drains to Ballona Creek. Land uses include 56 percent multi-family residential, 32 percent single-family residential, 6 percent commercial, 4 percent public, 1 percent open, and 1 percent other urban.

2.2.4 Commercial

The screening process identified two preliminary station sites and two potential sites that require further review of drainage system maps for commercial land use. Two commercial sites would be recommended.

BI249D is in basin #20 of the southwest Beverly Hills Quadrangle located between w Boulevard and Colorado Avenue in Santa Monica. The basin is 76 acres with 91 percent commercial and 9 percent open land use. The piped system discharges into Santa Monica Bay. It appears to have two possible outlets and actual drainage must be further investigated.

RXFRD1 is in basin #21 of the central Beverly Hills Quadrangle located between Santa Monica Boulevard and Wilshire Boulevard in Beverly Hills. The upper reach of storm drain #412 can be isolated for approximately 80 acres of commercial property. RXFRD1 is 59 percent single-family residential, 24 percent commercial, 10 percent multi-family residential, 5 percent light industrial, and 2 percent public land uses.

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2.2.5 Light Industrial

The screening process identified four preliminary station sites and two potential sites that require further review of drainage system maps for light industrial land use. Two stations would be recommended for sampling.

BLLNA9 is in basin #21 of the Beverly Hills Quadrangle located northwest of Santa Monica High School on Wilshire Boulevard. The 78-acre piped system appears to drain to two possible outlets but remains a good candidate due to its high concentration of light industrial land use. The land uses are 75 percent light industrial and 25 percent single-family residential.

BLLNA6 is in basin #21 in the southeastern Beverly Hills Quadrangle located in Culver City near the Santa Monica Freeway. BLLNA6 is a 108-acre piped system draining to Ballona Creek with two pipe/channel storm drains, #424 and MTD 613. Storm drain #424 is predominantly light industrial and appears to be easily isolated, thus increasing the light industrial land use percentage.

CULVER1 is in basin #21 of the southeastern Beverly Hills Quadrangle located just northwest of DESILU Studios in Culver City. The piped section along Washington Boulevard could be isolated, as it appears to drain a light industrial area of approximately 60 acres. The land use percentages are 48 percent single-family residential, 29 percent light industrial, 12 percent multi-family residential, 6 percent public, 3 percent other urban, and 2 percent commercial.

2.2.6 Commercial and Light Industrial

The screening process identified two preliminary station sites and four potential sites that require further review of drainage system maps for combined commercial and light industrial land use. These sites could be substituted for one or more of the commercial and/or light industrial sites.

BI5242 is in basin #21 of the Venice Quadrangle located in Ballona north of Marina Del Ray. The 681-acre piped system drains 170 acres of commercial and light industrial land (25 percent of the total). Approximately 80 acres of light industrial and commercial land could be isolated on storm drain 3872 at the intersection of Thatcher and Oxford Avenues. The reach drains from Redwood Avenue to Thatcher Avenue. Additional confirmation of actual area drainage patterns will be needed.

BI3402 is in basin #23 of the Venice Quadrangle located in El Segundo just south of the Los Angeles International Airport (LAX). The 443-acre basin drains 149 acres of commercial and light industrial land (34 percent of the total). BI3402 drains from Mariposa Avenue to El Segundo Boulevard. Reach 3401 on the eastern portion could be isolated at Penn Street and El Segundo Boulevard, providing approximately 100 acres of light industrial and commercial land use.

BI52041 is in basin #21 of the southeast Hollywood Quadrangle and is located in Los Angeles between 12th Street and Jefferson Boulevard. The 1,082 acre piped system drains into storm line #5204. The land use percentages include 47 percent commercial, 35 percent light industrial, 17 percent unknown, and 1 percent public.

BI52042 is in basin #21 of the southeast Hollywood Quadrangle adjacent to BI52041. BI52042 is located in Los Angeles between 12th Street and the University of Southern California. The 442 acre piped system drains to storm line #5204. The land use percentages include 70 percent light industrial, 23 percent public, and 7 percent commercial. Sample station #3 is located in BI52042.

BI52043 is in basin #21 of the southeast Hollywood Quadrangle and is located in Los Angeles adjacent to BI52041 and BI52042. The 2,934 acre system drains to storm line #5402. The land use percentages include 33 percent multi-family residential, 24 percent single-family residential, 21 percent commercial, 10 percent public, 7 percent light industrial, 3 percent other urban, and 2 percent open. BI52043 should be isolated on the upper reach to produce a much higher commercial and light residential land use percentage.

2.2.7 Open Space

The screening process identified ten preliminary station sites for open space land use. Two stations would be recommended.

ARSEQ1, ARSEQ2 and ARSEQ3 are in basin #1 of the Trifuno Pass Quadrangle. The 8000 acres of combined area drain portions of the Santa Monica Mountains into the Arroyo Sequint and discharges into the Pacific Ocean near Sequint Point and Leo Carrillow State Beach, east of Solromar. The Roosevelt Highway appears to provide good access to the channel. The drainage system is well defined with approximately 99 percent open land use.

LATIG1 is in basin #10 of the Point Dume Quadrangle located east of Malibu Riviera and Point Dume. LATIG1 drains 697 acres of 100 percent open space in Latigo Canyon to Santa Monica Bay.

LACHU1 is in basin #4 of the Trifuno Pass Quadrangle located east of Sequint Point and north of the Roosevelt Highway, allowing good access. The basin drains 826 acres of open space in Lachusa Canyon to the Pacific Ocean. Rain gage #4867 is located in the northern end of LACHU1 allowing access to local rainfall information.

PENA1 is in basin #15 of the Topanga Quadrangle located west of Topanga Beach in Pena Canyon. The 483 acres of 100 percent open space drains directly to Santa Monica Bay via a channel system.

TUNA1 is in basin #15 of the Topanga Quadrangle located in Tuna Canyon west of Topanga Beach and Pacific Palisades and directly east of PENA1. The 935 acres drains the 97 percent open and 3 percent single-family residential land uses through a channelized system.

RAMRZ1 is located in basin #8 of the Point Dume Quadrangle east of Malibu. The 1675-acre basin contains 99 percent open space and 1 percent single-family residential land uses. The basin drains most of the steep terrain of Ramiriz Canyon.

LALIS1 is in basin #3 of the Trifuno Pass Quadrangle located east of Sequint Point and north of the Roosevelt Highway, allowing good access. The basin drains 943 acres of open space in Los Alisos Canyon to the Pacific Ocean. LALIS1 is located west of LACHU1.

TEMES1 is in basin #18 of the central Topanga Quadrangle located north of Pacific Palisades. The 1548-acre area drains Temescal Canyon which is 87 percent open space and 13 percent single-family residential land use. The 1300 acres of the upper basin could be isolated, providing a possible monitoring site.

TRANC1, TRANC2, and TRANC3 are adjacent to one another in basin #6 of the Point Dume Quadrangle located in Trancas Canyon west of Point Dume. The three basins drain 5217 acres in the Santa Monica Mountains National Recreation Area and discharge to the Pacific Ocean through an open channel near Trancas. The land uses are 98 percent open, 1 percent single-family residential, and 1 percent public land uses. Sampling Station #34 is also located just south in TRANC4 providing additional monitoring information.

SNICH is in basin #6 of the Trifuno Pass Quadrangle located east of Sequint Point and north of the Roosevelt Highway, allowing good access. The basin drains 847 acres of open space to the Pacific Ocean. SNICH is located directly west of LACHU1 and LALIS1.

2.2.8 Transportation

The land use breakdowns that were obtained from Southern California Association of Governments (SCAG) and incorporated into the Project GIS system did not include a category for highways or other major transportation corridors. However, one site in the watershed was previously monitored by Cal Trans (Racin et al., 1982) and is proposed as a transportation land use station site for this monitoring program. The station site is located in Los Angeles on Interstate 405 at a 36-inch reinforced concrete pipe culvert. The station receives runoff from 3.2 acres of paved highway. At this location, Interstate 405 has 4 lanes in each direction and had an average daily traffic load of 200,000 vehicles in 1980.

The second candidate transportation site is in basin #21 of the east Hollywood Quadrangle and is located in Los Angeles. Over 6,500 linear feet of the Hollywood Freeway Corridor drain to the B15213 system including 4,000 feet from basin B15212. This represents a preliminary site selection and will require further review of specific highway drainage maps, which is beyond the scope of this plan.

2.3 PRELIMINARY MASS EMISSIONS STATION SITES

Stations were selected for mass emissions station sites which comprise large percentages of Santa Monica Bay Watershed land use mix or have been estimated to contribute significant portions of storm water runoff pollutants. The land use composition of the catchments of each of the mass emission monitoring sites is summarized in Table 2-3. Descriptions of the mass emissions station sites are presented below. The stations listed below are preliminary. The actual location of the station would depend on field reconnaissance of the storm drainage system. Together, these stations would measure runoff from a 4-basin total of 169,376 acres or approximately 75 percent of the 225,474 acre Santa Monica Bay Watershed.

2.3.1 Ballona Channel

Ballona Channel drains 82,287 acres of basin #21 and a total of 36.5 percent of the Santa Monica Bay Watershed. Land use in the basin includes 46 percent single-family residential, 18 percent multi-family residential, 8 percent commercial, 4 percent light industrial, 4 percent public, 3 percent other urban, 17 percent open space, and less than 1 percent unknown.

TABLE 2-3a
PRELIMINARY MASS EMISSIONS SAMPLING STATION SITES

LAND USE (Acres)

SUBBASIN NAME	BASIN #	Single-Family Residential	Multi-Family Residential	Commercial	Light Industrial	Public	Other Urban	Open	Unknown	Subbasin Total Acreage
Ballona Channel	21	38,049	14,996	6,664	3,371	3,048	2,929	13,874	356	83,287
Malibu Creek	12	5,694	353	430	414	346	1,184	61,874	0	70,292
Pico-Kenter Storm Drain	20	1,554	398	72	0	100	25	1,043	0	3,191
Topanga Creek	16	1,457	0	0	0	0	0	11,149	0	12,606
	TOTALS	46,754	15,747	7,166	3,785	3,494	4,138	87,940	356	169,376

TABLE 2-3b
PRELIMINARY MASS EMISSIONS SAMPLING STATION SITES

LAND USE (Percent of Total)

SUBBASIN NAME	BASIN #	Single-Family Residential	Multi-Family Residential	Commercial	Light Industrial	Public	Other Urban	Open	Unknown	Total
Ballona Channel	21	46%	18%	8%	4%	4%	3%	17%	<1%	100%
Malibu Creek	12	8%	1%	1%	1%	<1%	2%	87%	0%	100%
Pico-Kenter Storm Drain	20	49%	12%	2%	0%	3%	1%	33%	0%	100%
Topanga Creek	16	12%	0%	0%	0%	0%	0%	88%	0%	100%
	TOTALS	28%	9%	4%	2%	2%	2%	52%	<1%	100%

2.3.2 Malibu Creek

Malibu Creek drains 70,292 acres of basin #12 and a total of 31.2 percent of the Santa Monica Bay Watershed. Land use in the basin includes 8 percent single-family residential, 1 percent multi-family residential, 1 percent commercial, 1 percent light industrial, less than 1 percent public, 2 percent other urban, and 87 percent open space.

2.3.3 Pico-Kenter Storm Drain

Pico-Kenter Storm Drain drains 3,191 acres in basin #20 and a total of 1.4% of the Santa Monica Bay Watershed. Land use in the basin includes 49 percent single-family residential, 12 percent multi-family residential, 2 percent commercial, 3 percent public, 1 percent other urban, and 33 percent open space.

2.3.4 Topanga Creek

Topanga Creek drains 12,606 acres of basin #16 and a total of 5.6 percent of the Santa Monica Bay Watershed. Land use in the basin includes 12 percent single-family residential, 18 percent multi-family residential and 88 percent open space. Topanga Creek was selected because flows were previously measured at this creek, and records of stream flow are available from USGS and the Los Angeles County Department of Public Works. Since selecting this site we have learned that the flow monitoring station was removed; restoration of this station will be necessary for this creek to be used.

This section describes the types of equipment needed to implement the monitoring plan. Overviews of equipment installation, calibration, verification, and operation are also presented.

3.1 EQUIPMENT SELECTION

Equipment should be selected to perform flow monitoring and water quality sampling to meet the monitoring plan objectives. Various types and models of rain gages, water quality samplers, and flow monitoring systems are available. Minimum technical specifications should be developed for requesting bids from vendors. In general, the specifications should include that the stations be: automated with various programming and sampling options; capable of being linked by telemetry for remote operation and data transfer (recommended for long-term monitoring because it will reduce staff maintenance time and allows for continuous monitoring of the stations); installed as permanent but easily moveable stations; and supported by a sophisticated station and flow data management program.

3.1.1 Rain Gages

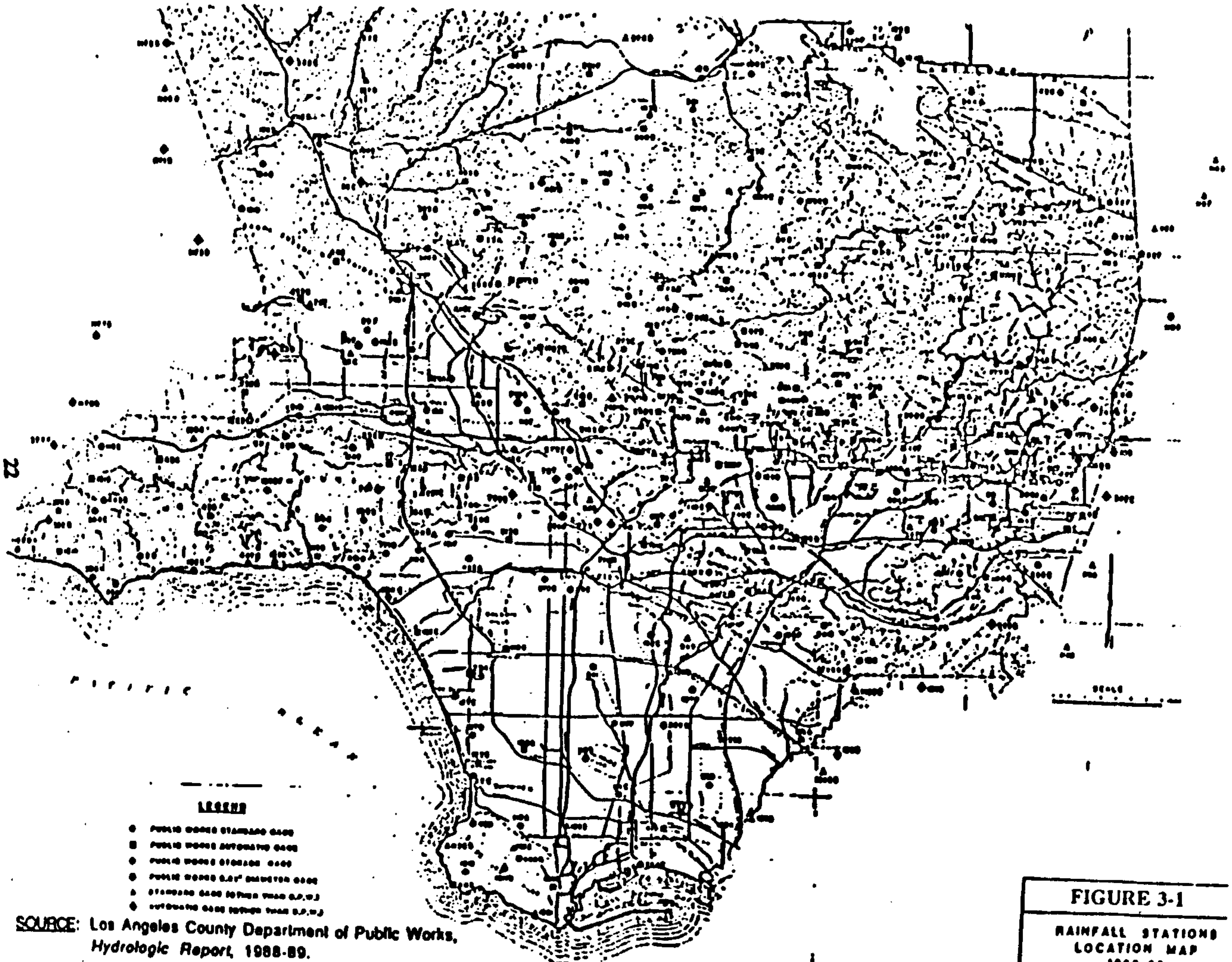
Rain gages are located throughout the watershed as shown in Figure 3-1. These gages are operated by the Los Angeles County Department of Public Works who should consider making them available for use in the monitoring program. The system should be set up so that at least some of the data (based upon final monitoring station selection) collected by these gages can be immediately available for inspection via a telemetry system and can be downloaded to a computer for graphical or tabular display.

3.1.2 Flow Monitoring Hardware/Software and Equipment Control

It is recommended that when possible monitoring stations (closed conduit stations), both water depth and velocity, be independently monitored because a variety of parameters (slope, roughness...) are necessary to ensure the accuracy of Manning's equation. The cross-sectional area of water can be obtained from the measured water depth and the shape of the given pipe. The flow can then be computed as the cross-sectional area multiplied by the average velocity.

Flow estimates for open channel stations should be obtained using rating curves established for each station. Rating curves correlate flow with depth using a limited set of velocity and flow depth measurements. This would require measurement of velocities over a variety of flow depths during several storm events.

Alternative methods for estimating flow without velocity measurements exist and may be utilized prior to establishing a rating curve to estimate flow rates. Depth measurements can be used in conjunction with channel characteristics and empirical flow equations to calculate flows (Manning's equation).



SOURCE: Los Angeles County Department of Public Works, *Hydrologic Report*, 1988-89.

FIGURE 3-1

RAINFALL STATIONS LOCATION MAP 1988-89

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Other equipment that should be installed at the monitoring stations include a system microprocessor; water quality sampler control unit; equipment housing (open channel stations only); computer site-specific software for hardware control; telemetry equipment; and power source (batteries or other electrical power). Decisions regarding specific equipment types or makes should be made by the implementing agency.

A typical station configuration is presented in Figure 3-2, which shows the major components of a monitoring station located in a manhole. A monitoring station located in an open channel would have a separate enclosure for the flow monitor and sampler. Open channel stations would use an overhead structure (a bridge) to mount the non-intrusive ultrasonic depth sensors or stream bottom-mounted pressure transducer. A rain gage is not shown in the figure. Finally a separate structure can be located adjacent to the sampling location and the equipment can be located inside, with appropriate connection to the liquid surface.

The exact type of installation will depend upon site-specific conditions; in some cases several alternative installations can provide adequate sampling. In such cases the preference of the agency performing the sampling will determine the sampling station design.

Station operation is depicted in Figure 3-3. Software on a personal computer would enable communication with the rain gage and flow monitor over a phone line. The flow estimated from the depth and velocity data would be used to update the cumulative volume. When a pre-defined cumulative volume is exceeded, the flow monitor would send a signal to activate the water quality sampler. The sampler collects a sample through the intake line. Signals from the rain gage can also be used to activate the water quality sampler for individual samples, but this method is not recommended in this plan.

3.1.3 Water Quality Samplers

Each station should be equipped with an automatic water quality sampler that can be configured for either discrete or composite sampling. For storm water monitoring, the samplers can be configured to fill sample bottles for composite sampling by collecting samples per calculated flow volumes. For parameters that need to be tested on-site or in discrete samples, grab samples can be collected manually. For some parameters, such as oil and grease, in some cases it is necessary to use a hand sampler to collect a representative sample (see Volume II of these reports). Water quality samplers are available in refrigerated units which require a source of electrical power. If no power source is readily available, samples can be kept cool using ice, and the equipment can be powered using batteries. This decision should be made by the implementing agency.

3.2 EQUIPMENT INSTALLATION

The monitoring stations would be located in manholes, closed conduits, or in open channels. The following text provides a generalized overview of equipment installation procedures at these stations.

3.2.1 Closed Conduit and Manhole Stations

At manhole stations, sensor equipment should be installed in locations which provide the most stable hydraulic conditions. Typically these conditions occur just upstream from the location of the manhole, because construction of the manhole may have altered the original

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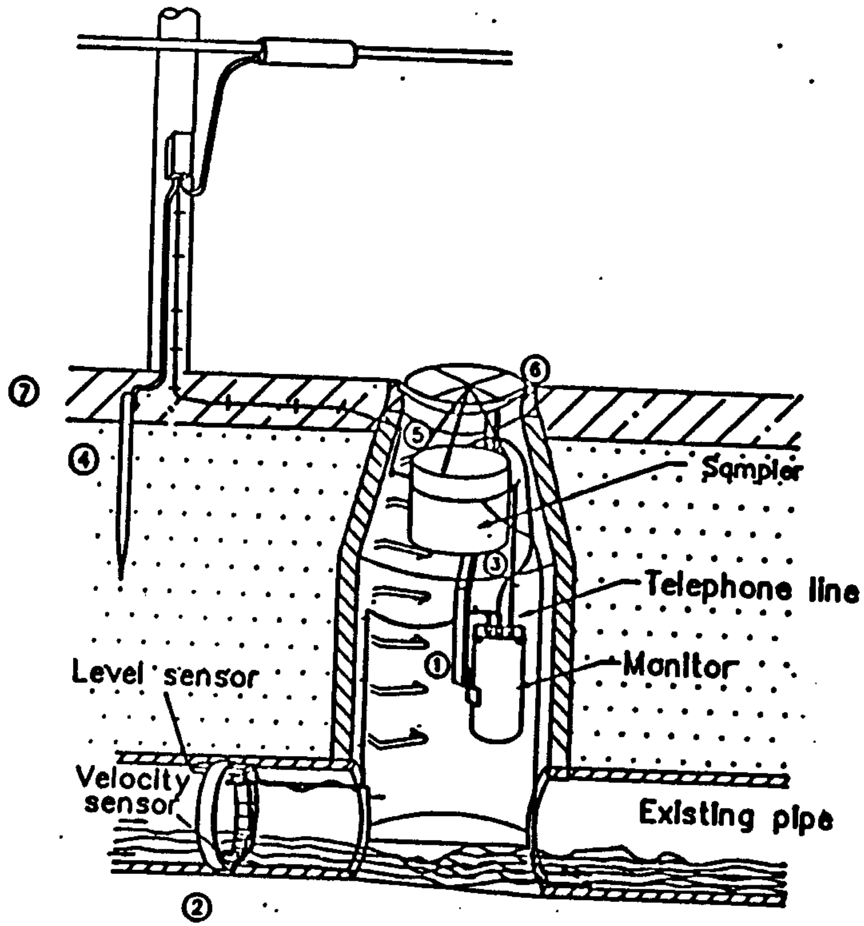

Mounting Details

1. Mounting flange consists of marine grade aluminum bar stock. Width is 3" — length is determinate upon the individual site condition.
2. Sensor mounting plates consist of marine grade aluminum bar stock that are attached with 1/4" anchor bolts (316SS). Embedment depth approx. 1".
3. Cables are anchored with 1/4" anchor bolts (316SS). Approximate embedment depth is 1".
4. Grounding rod is provided by phone company and is installed by them as per their specifications.
5. Cable penetration through corbel is made with rotary hammer drill and is then sealed with a urethane or epoxy compound.
6. Manhole rim is drilled and tapped. Aluminum mounting flange is attached with 3/8" threaded stud (316SS).
7. Roadcut depth varies between 6" and 12" depending on local regulations. Cut is then sealed with PRECO road sealant.

FIGURE 3-2 MONITOR AND SAMPLER INSTALLATION SPECIFICATIONS

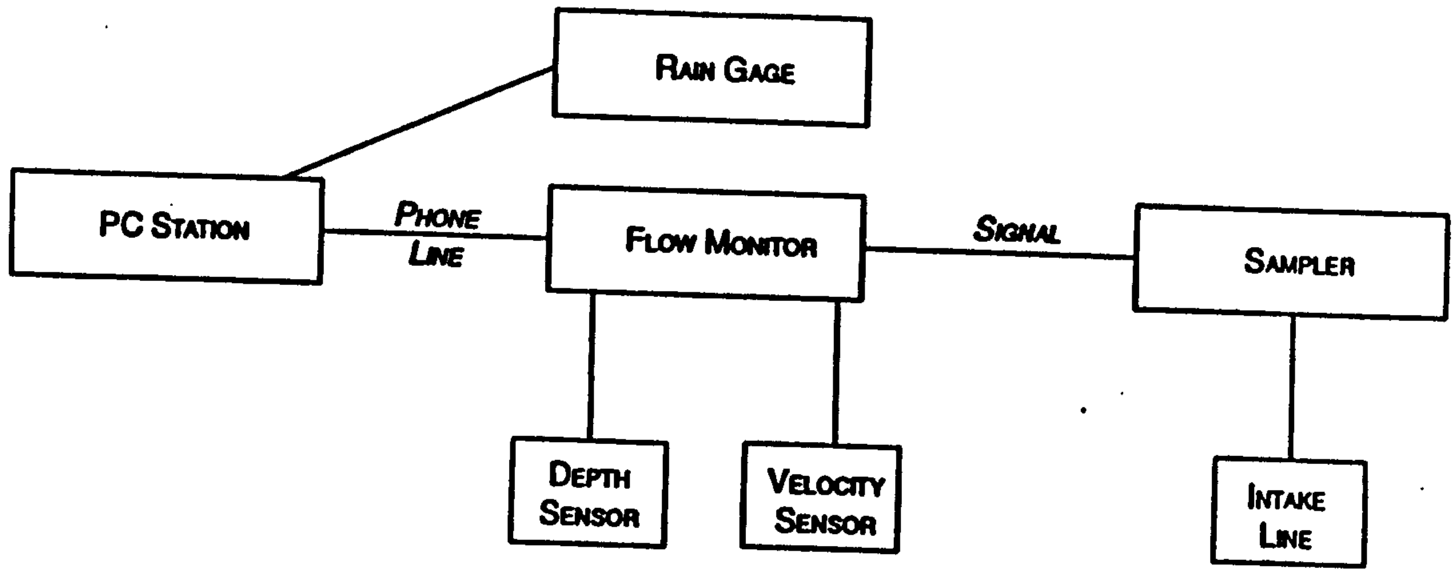

FIGURE 3-3 STATION COMMUNICATION

shape of the pipe at this point, thus changing the hydraulic characteristics of the channel. Actual sensor installation consists of mounting the depth and velocity sensors to expansion rings sized for an individual pipe and then expanding the ring for a tight fit. The expansion rings facilitate easy removal of the sensors for maintenance or replacement or movement to another site. The water sampler intake tubing and strainer are to be mounted at the invert of the pipe just downstream of the sensing equipment ring.

The sampling equipment can be mounted in the manhole so that it does not interfere with activities on the surface. Alternatively, it may be more desirable to mount the equipment in a protective enclosure at the surface. The choice will depend upon site-specific conditions.

3.2.2 Open Channel Stations

For an open channel station at a bridge or culvert, non-intrusive ultrasonic depth sensors can be mounted to the underside of these structures at or near mid-channel. Velocity sensors and pressure transducers should be mounted on the bottom at the center of these channels. The water quality sampler intake tubing and strainer are to be located just downstream at mid-channel. The intake is to be located so that water samples would be collected at the same width cross section location where depth measurements are made. The flow monitor microprocessor and water quality sampler units should be mounted in weather proof enclosures. For channels with low flow sections, the pressure transducer and intake screen will need to be located to sense the lowest point of the invert. If both wet and dry weather flows are to be measured, two sensors with different ranges may be required.

3.3 EQUIPMENT CALIBRATION

Calculation of flow in the closed conduits can be based either on the depth of flow, or the depth and the velocity of flow. Both depth and velocity of flow should be measured upon installation by means independent of the flow sensor to verify sensor readings. Depth measurements can be verified with a scaled wading rod or similar device. In order to verify and adjust the velocity sensors, concurrent measurements should be taken with hand-held electromagnetic velocity meters.

In cases were pressure flows exists alternative procedures may be required.

3.4 VERIFICATION AND OPERATION OF STATION EQUIPMENT

Station equipment and telemetry should be verified prior to storm sampling events. Equipment diagnostics should be performed to check the equipment. In addition, operation of each of the water quality samplers should be verified through operation of the samplers. Station preparation, event initiation, event operation, event shut down, and data transfer procedures will be fully described in the Standard Operations Procedures (SOPs). These are outlined in Chapter 7.

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4.0 STORM SELECTION AND RUNOFF ESTIMATION PROCEDURES

This section describes procedures used to estimate and measure rainfall and storm water runoff volumes. Also included are the criteria used for the selection of storms to be sampled.

4.1 BACKGROUND

One objective of the storm water sampling program is to estimate the relationship between rainfall amounts and runoff volumes for use in pollutant load estimation models. The runoff coefficient is defined as the fraction of the total rainfall volume (i.e., the amount of rainfall over the watershed area) that becomes storm water runoff. Runoff volume estimates (calculated by multiplying the runoff coefficient and the predicted rainfall volume) are used to program the sampling equipment to collect representative flow-weighted composite samples. Runoff volumes are also used in conjunction with calculated site median concentrations (SMC) of pollutants as input to storm water runoff models that generate (basin wide) pollutant loads.

Eight storm events are to be sampled over the course of two years (an average of 4 sampling events per year). These events should be selected to represent the various typical seasonal storms for the Santa Monica Bay area with the realization that storms available for sampling may be few. Storm selection criteria are designed to determine which storms will be sampled. These criteria will be used to ensure that sampled storms represent the storm characteristics (e.g., volume, intensity, antecedent dry period) that are typical for Santa Monica Bay and meet Federal regulatory requirements.

4.2 STORM SELECTION CRITERIA

Storm characteristics were determined for selected rain gages operated by the Los Angeles County Department of Public Works (LACDPW) with records available through the National Weather Service. Details are presented in Stenstrom and Strecker (1993). The rain gage records were analyzed for storms that were defined as having more than 0.10 inches of precipitation with a six-hour inter-event time. Characteristics of storms occurring during the wet season (i.e., November through April) were computed separate from the dry season. The results of the analyses are compiled by station and for the entire watershed in Table 4-1. Santa Monica Bay has an average of approximately 16 storm events per wet season.

The NPDES permit application requires storm water data from three storm events occurring at least one month apart, with an "event" defined as a minimum of 0.1 inches of rain occurring at least 72 hours from the previously measurable (greater than 0.1 inch of rainfall) storm event. At least three storms should be sampled where the duration and total volume are within about 50 percent of the average storm to meet the NPDES permit application requirements. Based upon analysis of data from the LACDPW rain gages, these storms should be between 6 to 25 hours in duration and about 0.4 to 1.7 inches in volume. These criteria can be relaxed if needed to make sure that enough storms are available for sampling.

TABLE 4-1
WET SEASON STORM STATISTICS (a)

STATION	PERIOD OF ANALYSIS (water years)	STORM VOLUME (inches/storm)		STORM INTENSITY (inches/hour)		STORM DURATION (hours/storm)		TIME BETWEEN STORMS (hours)	
		Average	Coef of Var	Average	Coef of Var	Average	Coef of Var	Average	Coef of Var
0619	1948-1980	1.06	1.22	0.084	0.66	12.5	0.85	209	1.32
0818	1948-1976	0.98	1.22	0.068	0.74	14.2	0.92	258	1.25
1194	1948-1989	0.88	1.31	0.067	0.69	13.0	0.89	231	1.20
1682	1948-1989	0.88	1.27	0.063	0.69	14.0	0.91	230	1.22
4867	1948-1989	1.09	1.17	0.101	0.73	11.3	0.87	198	1.35
5085	1977-1989	0.67	1.05	0.061	0.79	11.3	0.71	221	1.10
5114	1948-1989	0.68	1.16	0.062	0.72	12.0	0.83	221	1.23
5115	1948-1989	0.81	1.18	0.067	0.69	12.8	0.87	221	1.21
8092	1948-1989	0.96	1.26	0.069	0.74	13.5	0.89	238	1.23
8230	1948-1989	0.69	1.07	0.074	0.73	10.5	0.88	219	1.36
Minimum		0.67		0.061		10.5		198	
Maximum		1.09		0.101		14.2		258	
Average		0.87		0.072		12.5		225	

(a) For storms having more than 0.10 inches of precipitation with a 6-hour inter-event time during November through April.

Storms can be sampled during both the wet and dry seasons. As defined in Table 4-1, the wet season is defined as lasting from the beginning of November through the end of April. This wet season is associated with more frequent storms and shorter dry weather intervals between storms. Conversely, the dry season is associated with less frequent storms of greater intensity and longer dry weather intervals between storms. It is likely that almost all of the representative storm events will occur during the wet season.

4.3 RUNOFF ESTIMATION PROCEDURES

The predicted rainfall amounts, watershed area, and runoff coefficients (the product of all three parameters) can used to estimate runoff volumes for each of the selected catchments. Runoff coefficients by land use were developed for the loadings model based upon information from Los Angeles County.

Water depth and resulting flow data should be continually collected from each sampling station at a uniform time interval (5 minutes is typical during a storm event). The data would be retrieved using a portable computer (directly or by modem through telemetry equipment) and would ultimately be downloaded to a database. Runoff coefficients specific to each sampled catchment should be based upon an estimate of the impervious area percent in previous estimates for each of the land uses in the catchment.

Each storm event monitored by the flow and rainfall monitors provides additional information for calculating runoff coefficients. These coefficients can be calculated by dividing the total measured runoff for the event by the total rainfall volume over the contributing catchment. As those data are developed, the expected result coefficient for each watershed can be refined. It will also be a function of total rainfall and as well as condition of the watershed (e.g., the presence of residual moisture from a previous rainfall). Finally, flows from permitted discharges (if any) must be subtracted from the measured flow rates.

Once the total runoff volume is estimated, the water quality samplers should be programmed to collect a sample each time after approximately five percent of the runoff volume has flowed past the sensors. Therefore, the water quality sampler is programmed to collect about 20 samples over the entire storm. Each time the sampler is triggered to collect a sample a pre-specified volume of storm water would be deposited into one of the bottles. The total volume of storm water collected should be greater than or equal to the volume of sample needed by the laboratory to conduct all of the specified analyses. If a storm happens to be larger than expected, the sampler's bottles may be filled prior to the end of the storm. In this case it will be necessary to replace the full bottles with empty bottles.

For dry weather sampling, the water quality samplers should be programmed to collect a sample once each hour for 24 hours. The samples collected would be flow-weighted for laboratory analysis. Grab samples can be collected at the beginning of the sampling period and/or at the end of the sampling period. Dry weather sampling at the mass emission stations is proposed for 4 to 6 times per year during the 2-year sampling period. Unlike the mass emission stations, the single land use sites may not have base flows. Any flows that do occur during dry weather at the single land use stations may be due to illicit connections. It is proposed that one grab sample would be collected at the single land use stations if the continuous flow measurements indicate a potential problem (i.e., unaccounted for flow).

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5.0 SAMPLING EVENT MANAGEMENT AND WATER QUALITY FIELD SAMPLING METHODS

The objective of this section is to describe the field sampling methods for obtaining water samples. Automatic flow-weighted composite samples and manual grab samples should be collected. Automatic samplers would be used to collect flow-weighted composite water samples throughout the duration of a storm event or the duration of the dry-weather monitoring period, whereas grab samples would represent instantaneous samples.

Storm sampling would primarily be performed by automatic samplers because of their ability to automatically trigger sampling when a storm starts and their ability to composite storm water samples, based on flow volumes. Automatic samplers would also be used to collect the 24-hour flow composited sample during dry weather at the mass emission stations (by reprogramming the samplers). Grab samples would be collected for instantaneous field measurements at each initial station visit during a storm event and at the beginning and/or end of the dry-weather monitoring period. At the time of grab sample collection, chemical/bacteriological constituents that have short holding times (such as fecal streptococci) and those that are highly volatile in nature (such as volatile organic compounds) would be collected.

Figure 5-1 provides an overview of the storm event decision/action tree. The main elements of the tree are discussed below. Dry-weather monitoring would occur as described in Section 4.3.

5.1 PRE-STORM PREPARATION STRATEGY

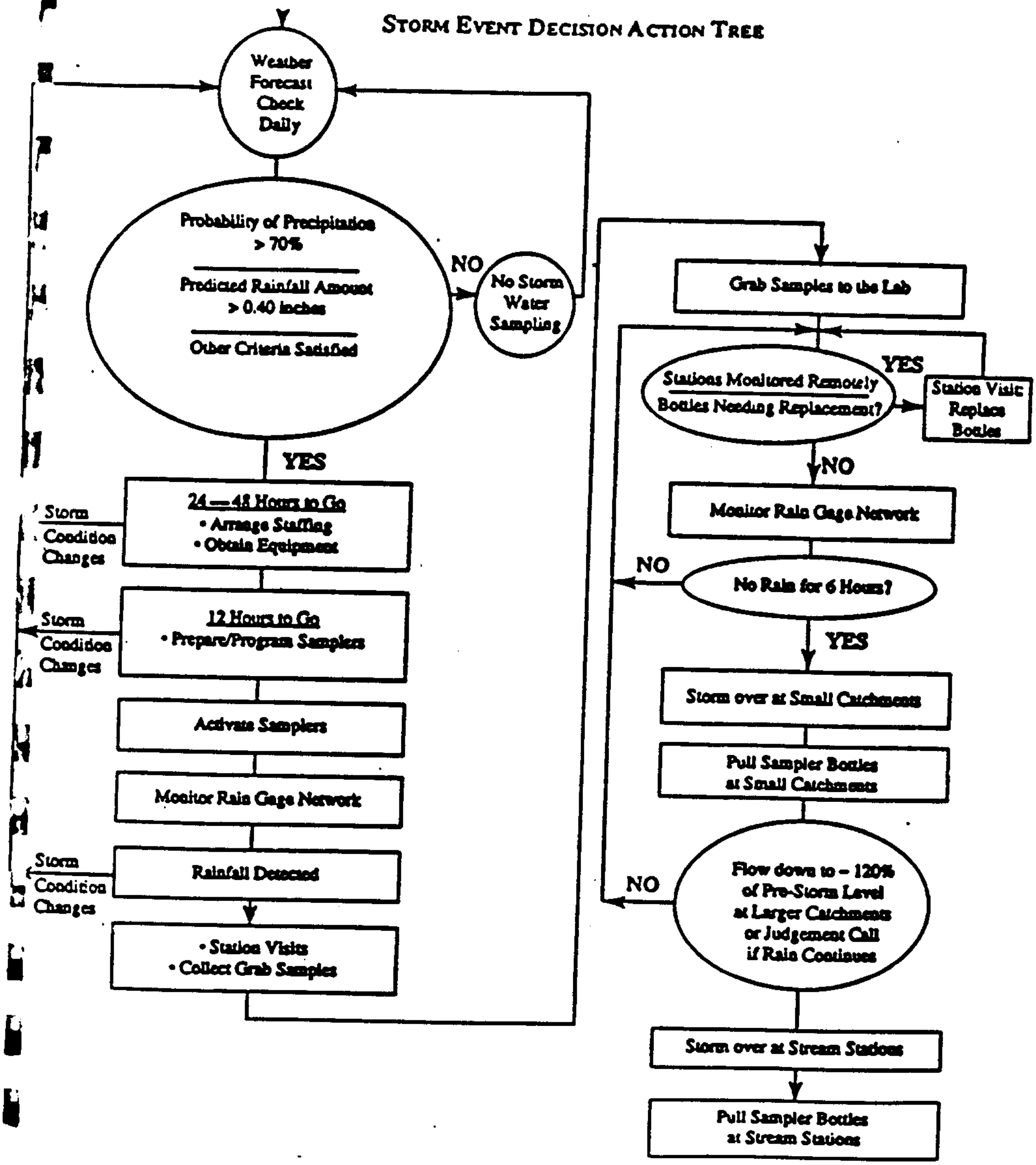
For wet-weather monitoring, preparation for storm water sampling would include weather forecasting, storm selection, mobilization strategies, and determination of appropriate automatic sampler settings. Proper coordination and management of these tasks would set the stage for effective storm sampling.

Weather forecasting will be an important aspect of storm water collection. It will be necessary to obtain the most reliable and up-to-date information on each storm's physical characteristics. The Sampling Event Coordinator (for discussion of sampling event staffing and roles, see Section 9), in consultation with the Program Manager would decide to mobilize and prepare for a given sampling event based on the probability of rainfall and, the expected rainfall amount, coverage, duration, and intensity.

The Sampling Event Coordinator would discuss upcoming storms with the Program Manager to ensure consistency with the storm selection criteria previously outlined. Preparation for a storm sampling event would be initiated when the probability of precipitation is about 70 percent or greater and the predicted rainfall amount is approximately 0.40 inches or greater, provided that the required conditions for the antecedent dry period are met (i.e., at least 72 hours with less than 0.1 inches of rain) and the target number of storms to be sampled in the season has not been reached. Additional criteria may be applied, including longer antecedent dry periods. Criteria could also be relaxed to make sure that enough storms are sampled.

Figure 5-1

Storm Event Decision Action Tree



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Weather forecasts are available each day from the National Weather Service and from private consultants. These forecasts include probability of precipitation, precipitation start and end times, and precipitation amount. If the forecast suggests that the storm satisfies the selection criteria, mobilization activities should begin 48 hours before the storm. Specific crew personnel would be identified, sampler batteries would be recharged, and sample bottles would be checked and made available. Within 12 hours of a given storm's arrival, if the updated forecast shows that the storm still satisfies the selection criteria, field crews would prepare the samplers (e.g., load and ice bottles, load the batteries, check the sampler program, and start the samplers).

5.2 SAMPLING EVENT MANAGEMENT

At least two to three field teams of two people each would be used during the initial stages of monitoring to visit each site, collect grab samples, and check the performance of the automatic samplers. As the sampling event progresses and grab sampling is completed only one to two field teams would be needed to check the samplers, change bottles, and deliver samples to the analytical laboratory.

All in-field water sampling activities would be coordinated from a centralized location. The Sampling Event Coordinator would coordinate all field crews during the sampling event. Communication is best maintained with each crew in the field via cellular phones or radios.

If any problems with the sampling equipment occur during the sampling event, it is the Sampling Event Coordinator who would decide the solution. For wet weather monitoring, the Coordinator would also decide when the storm is "over" based on previously-specified criteria. These criteria may be based on the number of hours since the last recorded rainfall or the number of hours since the start of the storm and/or a return to or near to pre-storm base flow conditions.

5.3 FLOW COMPOSITE SAMPLES

Once the decision is made to sample, estimates of the runoff volume expected at each station would be made, based on the predicted rainfall amount and the runoff coefficients corresponding to land use and soil type for the catchment of each sampling station. Monitoring stations are required that have flow measuring equipment as well as one or more automatic samplers that can communicate with the flow measuring equipment (some manufacturers make combine units). Once a runoff volume is projected, the data logger/controller for each station would be programmed to trigger the water quality sampler to collect a sample after each 1/20 of the total projected storm event volume has flowed past the flow monitor.

Borosilicate glass bottles would be placed in each automatic sampler. The bottles would be solvent-rinsed to remove trace organic contaminants and acid-cleaned to remove trace metal contaminants. If the water quality sampling units are not refrigerated, a sufficient amount of ice or "blue ice" would also be placed around the bottles in order to keep the storm water samples cool. Once activated, the automatic samplers would collect equal volumes of runoff water at flow-paced intervals for wet-weather monitoring and unequal volumes of runoff water at equal time intervals for dry-weather monitoring. All samples would be combined in the laboratory to create a single flow-weighted composite sample for analysis.

The goal is for the automatic sampler to collect the volume of sample that is adequate for the specified suite of chemical analyses. The required sample volumes are shown in Table 5-1. If insufficient volumes are collected, the runoff samples would be analyzed for fewer chemical constituents, as prioritized in Table 5-1. An excess amount of sample collected would require additional time and effort for sample bottle handling in the field, and compositing of samples in the laboratory, and could result in incomplete sampling event due to full bottles. When the forecasted runoff is different from the actual runoff volume, the sampling volume can be adjusted during the event. This may be important to assure complete sample capture, as the automatic units will not continue to collect samples when the sample bottles are full. If the programmed sampling volume is altered during the event, the sample bottles would be changed and the laboratory would recomposite the bottles proportionate to the sampling volume setting for each bottle.

During wet-weather monitoring, the criteria for when to stop sampling at a given station would depend on the amount of flow occurring at that station, rather than the amount of rainfall. The automatic samplers are triggered by flow, so if the flow monitoring equipment detects no flow, the sampler would not try to collect a sample. For the stations which have base flow, the criterion for halting sampling can be based on the return of flow to about 120 percent above the pre-storm base flow. This criterion is a compromise between the time needed to capture the falling limb of the stream hydrograph and the deadlines imposed by constituents with short holding times. As the overall monitoring program progresses, more specific criteria for halting the samplers at each station can be developed as more hydrographs are obtained.

If another storm front arrives unexpectedly within a six-hour period from when rainfall and sampling was halted, the two fronts could be considered one storm event, sampling could resume, and the sample bottles from both fronts could be composited in the lab. Weather forecasting should be utilized to minimize the likelihood of halting sampling prematurely.

For the dry-weather sampling, a procedure similar to that described above should be used to collect the composite samples. The primary difference between the dry-weather and wet-weather procedures is that in dry-weather sampling, initiation and completion of sampling would be set to correspond to convenient working hours rather than flow conditions.

Once sampling is terminated, the sample bottles will be removed and transferred directly to the laboratory under strict chain-of-custody procedures. If an excess amount of water is collected, these samples will be manually composited in the laboratory. In this case, the sample water must be thoroughly mixed by using a pump to transfer the water back and forth between a bottle from each set. Mixing will be considered adequate when the turbidity (as determined by EPA Method 180.1) of the samples in the bottles is the same.

5.4 GRAB SAMPLES

Grab samples would be collected for bacteria (due to the short 24-hour holding time required), volatile organic compounds, TPH, oil and grease, total phenols, cyanide, acrolein, acrylonitrite, and field measurements including pH, temperature, conductivity and turbidity. For manhole stations that are deeper than 10 feet below ground surface elevation, grab samples could be collected using the automatic samplers. The program on the automatic sampler could be halted temporarily. The pump tube would then be disconnected from the sampler in order to fill the grab sample bottles using the manual pump actuating feature of the automatic sampler. Grab samples from depths of less than 10 feet can usually be taken using manual grab sampling equipment. Alternatively, other types of pumps can be provided for deep locations.

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TABLE 5-1
PRIORITIZED COMPOSITE ANALYSIS LIST AND VOLUME REQUIREMENTS WATER QUALITY SAMPLES

Composite Sample Priority Level	Priority Analyte	Volume Required	Volume Required	Volume Required	Volume Required	Volume Required
1	TOTAL METALS Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, Zinc	250 mL	250 mL	250 mL	250 mL	250 mL
2	DISSOLVED METALS Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, Zinc	250 mL	250 mL	250 mL	250 mL	250 mL
3	TSS/TDS/ HARDNESS/BOD5/ COD	1L	1L	1L	1L	1L
4	NH3/TKN/TOTAL P/ NO3/ORTHO-P	1L	1L	1L	1L	1L
5	SEMI-VOLATILE ORGANICS	1L	1L	1L	1L	
6	POLYNUCLEAR AROMATIC HYDROCARBONS (PAH)	2L	2L	2L		
7	ORGANOPHOSPHORUS PESTICIDES/ ORGANOCHLORINE PESTICIDES	2L	2L			
8	CHLORINATED HERBICIDES	1L				
	TOTAL VOLUME REQUIRED	8.5 L	7.5 L	5.5 L	3.5 L	2.5 L

Grab Samples:

1. Bacteria - a) Fecal Coliform (1 - 125 ml container)
   b) Fecal Streptococci (1 - 125 ml container)
   c) Enterococci (1 - 125 ml container)
2. Total Oil and Grease/TPH (1 - 1L Glass Bottle)
3. Volatile Organics (2 - 40 ml VOA vials)
4. Acrylonitrile and Acrolein (2 - 40 ml VOA vials)
5. Total Phenols (1 - 1L Glass Bottle)
6. Cyanide (1 - 1L Glass Bottle)

For wet-weather monitoring, grab samples should be collected during the beginning of the storm on the rising limb of the hydrograph. This may provide concentrations reflecting the higher levels of pollutants which are sometimes observed in the first part of an event, as compared with those observed during the remainder of the event. If the total mass emissons are to be estimated, a representative number of samples must be collected from both legs of the hydrograph.

5.5 SAMPLE TRANSFER AND CHAIN-OF-CUSTODY

The transfer of samples from the field to the laboratory should proceed through the proper chain of custody. Once grab samples are collected in the field, they should be taken to a centralized location for transfer to the laboratory. The centralized location should be accessible to all field personnel and laboratory couriers. Samples should be iced, labeled, and readied for pick-up or delivered to the laboratory. Chain-of-custody forms similar to the example shown in Figure 5-2 will be completed. The field sampling team leader would coordinate sample transferrals and courier pick-ups, as appropriate. A similar procedure should be used when composite samples have been collected.

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Woodward-Clyde
111 S.W. Columbia, Suite 990
Portland, OR 97201 (503) 222-7200

Chain of Custody Record

PROJECT NO.

SAMPLERS (Signature)

DATE	TIME	SAMPLE NUMBER	General Mineral	Priority Pollutant Metals	EPA Method 624	EPA Method 625	EPA Method 608							NUMBER OF CONTAINERS	REMARKS (Sample preservation, handling procedures, etc.)

(ANALYSES)

TOTAL NUMBER OF CONTAINERS

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)

METHOD OF SHIPMENT	SHIPPED BY: (Signature)	COURIER: (Signature)	RECEIVED FOR LAB BY: (Signature)	DATE/TIME

Figure 5-2 CHAIN-OF-CUSTODY RECORD FORM

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This section of the monitoring plan describes the selection of sample analysis methods and the analysis suites.

6.1 BACKGROUND

The main purpose of the monitoring plan is to improve the quantification of pollutant loadings to Santa Monica Bay from separate storm sewer systems and to facilitate efforts to identify "problem" land use areas for prioritizing the implementation of a storm water management program. The sample analysis methods are EPA-approved methods which have low detection limits in order to generate reliable data at the typically low analyte concentrations present in storm water samples. The general strategy for selection of constituents for analysis is to begin with a broad analysis list (i.e., full analytical suite) (Table 6-1) and, based on the results from the first three storm events, focus the program on those constituents which are present in storm drains to Santa Monica Bay at concentrations which may be of concern (i.e., the proposed reduced analytical suite). The analysis suite required for the Federal NPDES Permit Part 2 discharge characterization application for separate storm sewer systems is shown for the readers' information.

6.2 CONSTITUENTS AND ANALYSIS METHODS

For the Santa Monica Bay Storm Water Monitoring Program, the suggested list of chemical constituents that should be analyzed in storm water runoff contains all of the parameters required for the Part 2 NPDES permit application plus several additional constituents which are of local interest. The analyses should be performed by a certified laboratory.

6.2.1 Federal Permit Requirement Sampling Suite

The Federal requirements do not include analyses for some chemical parameters which may be important components of storm water discharge (e.g., pesticides, herbicides, total petroleum hydrocarbons). Therefore, storm water analysis for Santa Monica Bay should include these parameters during the first three storm events (Table 6-1). Selection of these additional constituents was based on two major considerations: 1) analytes expected to be present in separate storm sewer systems based on results of the Nationwide Urban Runoff Program (NURP); and 2) parameters which are necessary to interpret data for other pollutant chemicals. For example, total hardness is necessary to determine the aquatic toxicity of some metals and, total petroleum hydrocarbons have been shown to be present at significant concentrations in other urban storm water studies. The reduced analysis list may be used for subsequent sampling events, based on results from the first three events.

6.2.2 Reduced Analysis Suite

The reduced analysis suite should be finalized after the results from several full analysis storms are available. Due to the anticipated turn-around-time for laboratory analysis, an

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additional storm event may be sampled before all of the data have been obtained from the previous storm. An anticipated reduced suite that is based on the results of NURP and storm water monitoring in other municipalities has been developed for interim storm water analysis (Table 6-1).

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TABLE 6-1
ANALYSIS SUITES

PARAMETER	EPA METHOD	FULL SUITE	REDUCED SUITE	REQUIRED SUITE*
CONVENTIONAL				
TSS	160.2	X	X	X
TDS	160.1	X	X	X
BOD5	405.1	X	X	X
COD	410.1	X	X	X
Hardness	130.2	X	X	
NUTRIENTS				
Total Phosphorous	365.2	X	X	X
Ortho-Phosphate	365.2	X	X	X
TKN	351.2	X	X	X
Nitrate	352.1 or 300.0	X	X	X
Ammonia	350.2	X	X	X
BACTERIA				
Fecal Coliform	SM 9222D	X	X	X
Fecal Streptococci	SM 9230C	X	X	X
Enterococcus	SM 9230C	X		
METALS- TOTAL AND DISSOLVED				
Antimony	204.2	X		X
Arsenic	206.2	X	X	X
Beryllium	210.2	X		X
Cadmium	213.2	X	X	X
Chromium (total)	218.2	X	X	X
Copper	220.2	X	X	X
Lead	239.2	X	X	X
Mercury	245.1	X	X	X
Nickel	249.2	X	X	X
Selenium	270.3	X	X	X
Silver	272.2	X	X	X
Thallium	279.2	X		X
Zinc	289.2	X	X	X
Cyanide	335.2	X		X
ORGANICS				
PAH	Modified 625	X	X	X
Total Oil and Grease	413.2	X	X	X
Volatile Organics	624	X		X
Semi-Volatile Organics	625	X	X	X
Total Phenols	420.1	X		X
Acrolein and Acrylonitrile	624 (modified)	X		X
Total Petroleum Hydrocarbons	418.1/SaO_2	X	X	
PESTICIDES/HERBICIDES				
Organochlorine Pesticides	608	X	X	X
Organophosphate Pesticides	614	X	X	
Chlorinated Herbicides	615	X	X	

* Required for Part 2 of the Federal NPDES storm water permit application.

7.0 QUALITY ASSURANCE AND CONTROL PLAN

This section presents the Quality Assurance and Quality Control Plan for the monitoring program.

7.1 BACKGROUND

The measurement of chemical constituents at the trace level is often difficult due to inherent properties of environmental samples, field sampling techniques, and analysis techniques. In order to assess and maximize data quality, a strict Quality Assurance and Quality Control (QA/QC) Plan should be implemented as an integral part of the monitoring program.

The objective of a QA/QC Plan is to provide a mechanism for on-going control and evaluation of the sampling and analysis procedures throughout the course of the project, and to quantify data precision and accuracy for use in future data interpretation processes.

A strict system of quality assurance and quality control should be followed in all phases of the monitoring program, including sampling, laboratory analysis, and data reporting/validation. This plan includes elements to address both sampling and analysis concerns, including sample contamination, variability, and analytical accuracy and precision.

7.2 STANDARD OPERATING PROCEDURES

A field manual of Standard Operating Procedures (SOPs) should be prepared for crews. This section contains information that should be incorporated into the SOPs.

7.2.1 General Field Procedures

Field crews would be responsible for setting up the stations, collecting grab samples, ensuring that composite sampling is occurring properly, replacing bottles, recording information from the samplers, and documenting activities taking place, transferring and labeling bottles properly. The following Standard Operating Procedures should be followed by field crews to ensure acquisition of reliable and accurate data.

7.2.2 Pre-Sampling Mobilization

Station Assignments

Field personnel should be divided into a number of two-person crews (Field Teams) depending on the duration of the sampling event, and local safety rules. One member of each Field Team would be designated as the Team Leader. Multiple Field Teams would be used to ensure the timely collection of grab samples during the beginning of a sampling event, especially in short storms, which require very rapid collection of grab samples. The Field Manager should assign each Field Team to a set of monitoring stations, based on the geographical location of the monitoring stations. A single Field Team should assist during the later stages of a sampling event.

Sample Bottle Check

Pre-Storm Bottle Delivery - The Field Manager would make arrangements for clean bottles, ice chests, and blue-ice packs with laboratory personnel for all deliveries and pickups.

Bottle Inventory - Each Field Team would perform a bottle inventory check before leaving for the field. Individual inventories would depend on the number of sampling stations a Field Team has been assigned. Tables 7-1 and 7-2 contains the number, size, and types of bottles required for a single station.

Equipment Check

Each Team Leader should perform an equipment check-out on all field equipment. The check should confirm that all equipment is available and in proper working order. Check lists for vehicles, water quality, safety, personnel, and miscellaneous equipment would be provided.

Water Quality Sampler Preparation

All automatic water quality samplers should be inspected and made operational before each sampling event. This process would consist of the following procedures:

- Inspection of the sampler, hoses, and electrical connections
- Checking of the sampler program
- Installation of charged batteries (if applicable)
- Inspection of pump tube and replacement as needed
- Loading of cleaned sample bottles
- Icing of cleaned sample bottles (if temperatures are above 40°F)
- Setting of sampler to "run" mode

7.2.3 Sample Collection

Sampler Access Procedures

Sampler Access (Manhole Sites) - Water quality samplers at manhole sites could besuspended below the manhole covers using three suspension cables and clips, or located at the surface in a structure, as indicated previously. Removal of the manhole cover would be preceded by setting up the traffic control system and checking the manhole with a four-gas meter (used to test for indications of oxygen, methane, carbon monoxide, and hydrogen sulfide). If the meter indicates a problem, the manhole cover would not be opened, and the station would not be sampled until the meter indicates there is no problem.

Sampler Access (Stream Stations) - Stream stations would have samplers contained in locked enclosures. Access would be gained by unlocking a padlock and lifting the top of the enclosure. The lid would be supported by a brace located inside the enclosure. The

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TABLE 7-1

SAMPLE BOTTLE INVENTORY

Sampling Device	Type of Sample	Is Sample Preserved?	Type of Bottle	No. of Bottles	Size of Bottles
Automatic Sampler	Composites	No	Glass	4	3.78 L
Grab	Volatile Organics	No	Glass	2	40 ml
	Acrolein & Acrylonitrile	Yes	Glass	2	40 ml
	Bacteria	No	Plastic	3	125 ml
	Oil & Grease	Yes	Glass	1	1000 ml
	Total Phenols	Yes	Glass	1	1000 ml
	Cyanide	Yes	Plastic	1	1000 ml
Beaker(s)	Field Analysis	N/A	Glass	2	500 ml

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TABLE 7-2

GRAB SAMPLING REQUIREMENTS

Constituent	Is Sample Preserved?	Type of Bottle	No. of Bottles	Bottle Size	Special Instructions
VOC	No	Glass	1	40 ml	Fill to top/no trapped air
Acrolein & Acrylonitrile	Yes	Glass	1	40 ml	Fill to top/no trapped air
Bacteria	No	Plastic	3	125 ml	
Oil & Grease	Yes	Glass	1	1000 ml	
Total Phenols	Yes	Glass	1	1000 ml	
Cyanide	Yes	Plastic	1	1000 ml	

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sampler should not need to be removed from the enclosure for any of the sampling activities.

Grab Sampling Procedures

Type of samples to be collected at each station - Grab samples would be collected for six analyses. Each analysis has specific volume and bottle material requirements which must be met. In addition, some constituents require preservatives or other special attention. Table 7-2 summarizes specific grab sampling requirements. Note that grab sample QA/QC would require the collection of additional volumes for each of the parameters at a location designated by the Field Manager. The sample bottles for the volatile organic compounds and acrolein and acrylonitrile must be completely filled with no trapped air.

Getting sample into bottles - At stations deeper than 10 feet, grab samples should be obtained by pumping samples with the water quality sampler. The flow composite program would be interrupted, and the sample would be pumped using the sampler's manual mode. In order to avoid interfering with the normal flow compositing process, Field Teams would need to consult with the Sampling Event Coordinator before interrupting and restarting any sampler program. At stations less than 10 feet deep, manual sampling equipment would be utilized.

Field QA/QC Procedures

Water Sampling QA/QC - Several tests would be conducted to help identify potential sources of introduced error in the water sampling process. These tests include: travel, grab sample, and equipment blanks; grab and composite duplicates; and matrix spike and matrix spike duplicates. Potential laboratory and/or field contamination would be assessed through analysis of blind equipment blanks and sample duplicates at a frequency of one duplicate and one equipment blank per sampling event. The degree to which collected samples reflect actual field samples would be assessed through the analysis of duplicate field samples at a frequency of one field duplicate per sampling event. The Field Manager would assign QA/QC responsibilities during sampling mobilization. The specific field procedures for conducting these tests are presented below.

Travel Blanks - The travel blanks should be supplied by the contract laboratory. Travel blanks would be placed in one of the fields outgoing ice chests and transported through the entire sampling event. These blanks would then be returned to the lab for analysis. Travel blanks would not be opened by any person(s) other than laboratory personnel.

Grab Sample Blanks - Grab sample blanks would be obtained by completing the normal grab sampling process, but instead of pumping sample water, clean deionized water should be used. One set of blanks will be collected for each sampling event.

Equipment Blanks - Equipment blanks would be obtained by letting the sampler fill a complete set of bottles with clean deionized water. One set of blanks would be collected from a single station for each sampling event. Equipment blanks should be collected at the end of a sampling event to minimize program interruptions.

Flow Composite Matrix Spike and Matrix Spike Duplicates - One automatic water quality sampler should be set to collect twice the normal sample volume per sampling event in order to provide for the matrix spike and matrix spike duplicate analysis. Water quality samplers would be instructed to take twice the normal sample volume by doubling the number of triggers generated by the flow monitor. The process would be controlled by the

Sampling Event Coordinator. This would require collection of two sets of sample bottles and compositing in the laboratory.

Sample Labeling and Chain of Custody Procedures

Team Leaders would bear responsibility for the care and proper transfer of samples. Care of the samples would be the responsibility of the Team Leaders until official transfer (using proper chain-of-custody records) of the samples to the assigned Sample Custodian. As part of this responsibility, the Team Leader must be sure samples are labeled correctly and meet critical holding times. Samples with short holding times must be transferred in a timely manner.

Sample Labeling - Sample labels must be filled out completely. At a minimum, the following information should be entered on every label:

1. Date and time (24-hour clock). Storm composites should include the time when sampling was initiated.
2. Site code (station identification)
3. Type of analysis required
4. Total number of containers for each analysis and the number of each contained (e.g., 1 of 3, 2 of 3, and 3 of 3)
5. Signature or initials of Team Leader

Chain-of-Custody - The following organizational scheme has been developed to minimize confusion during the sample chain-of-custody process:

1. Each Team Leader should check bottle labeling, assemble all samples in an orderly manner, and fill out chain-of-custody forms.
2. Each Team Leader should surrender samples to the Sample Custodian (designated by the Sampling Event Coordinator) using chain-of-custody forms.
3. The Sample Custodian should then transfer the samples to laboratory personnel. The Sample Custodian would be fully responsible for the care of the sample and meeting critical holding time limitations until the samples are officially transferred to the contract laboratory.

7.2.4 Post-Sampling Procedures

When the Sampling Event Coordinator makes the final determination that the sampling is complete, crew(s) will:

1. Remove and label the remaining sample bottles.
2. Record the number and timing of samples taken by the sampler. This will be accomplished by halting the Water Quality Sampler Program and reviewing the sampler history log.
3. Turn off the samplers.

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4. Remove the batteries.

After sampling is complete and the sampling event is officially over (as determined by the Sampling Event Coordinator), field crews would unload equipment. Crews should check in with the Sampling Event Coordinator to make sure all staff are safely accounted for.

7.3 LABORATORY PROCEDURE QA/QC

A list of laboratory analysis methods are described in Section 7.0. A certified contract laboratory would be contracted to perform all chemical analyses (unless a certified public agency laboratory is utilized). The suite of chemical analysis for all water samples is shown in Table 6-1. In addition to performing the analysis, the laboratory must make every effort to meet target detection limits for each analytical method. Other QA/QC objectives that the laboratories must meet include holding times and sample preservation techniques, as shown in Table 7-3.

7.3.1 Precision

Laboratory precision should be assessed through the analysis of laboratory duplicates and matrix spike duplicates at the frequency of 10 percent of the total samples for the lab duplicates and five percent for the matrix spike duplicates. Combined field and laboratory precision should be evaluated through the analysis of field duplicate samples at the frequency of one duplicate sample per sampling event, as described above. Specific field duplicate precision objectives are presented in Table 7-3. Due to the inherent variation in environmental samples, these objectives may be viewed as goals and not requirements.

7.3.2 Accuracy

Laboratory accuracy should be assessed through the analysis of "blind" standard reference samples and through the analysis of laboratory-prepared matrix spike samples. A goal of five percent of the samples would be analyzed as matrix spikes by spiking the sample with standard and measuring the analytical recovery. Blind reference samples would be analyzed once every quarter in which samples are analyzed.

7.3.3 Laboratory Blank

Sample contamination resulting from laboratory analysis procedures or sample storage methods should be assessed through the analysis of laboratory blanks and equipment blanks. Laboratory blanks (reagent and/or method) should be reported for each day samples are analyzed.

7.3.4 Completeness

All reported analyses should be evaluated against the requested analyses to evaluate the completeness of the analytical characterization of the water samples. Any missing data will be accounted for by the laboratory or field programs with an overall goal of 95 percent completeness.

TABLE 7-3
QUALITY CONTROL LIMITS FOR WATER QUALITY SAMPLES

Parameter	Units	Methodology	EPA Method (a), (b)	Maximum Holding Time	Target Detection Limit	MS/MSD Precision %RPD	Sample Dup Precision % RPD
CONVENTIONAL							
Hardness	mg/L	Semi-automated	130.2	6 months	1	NA	<15
TSS	mg/L	Gravimetric	160.2	7 days	4	NA	<15
TDS	mg/L	Gravimetric	160.1	7 days	10	NA	<15
BOD5	mg/L	Bio-assay	405.1	48 hours	1	NA	<15
COD	mg/L	Spectrophotometric	410.1	28 days	1	NA	<15
NUTRIENTS							
Total Phosphorus	mg/L	Spectrometric	365.2	28 days	0.05	<20	<30
Ortho-Phosphate	mg/L	Spectrometric	365.2	48 hours	0.05	<20	<30
TKN	mg/L	Titrimetric	351.2	28 days	0.1	<20	<30
Nitrate	mg/L	IC	300	48 hours	0.05	<20	<30
Ammonia	mg/L	Titrimetric	350.2	28 days	0.1	<20	<30
BACTERIA							
Fecal Coliform	MPN/100ml	Assay	SM9222D	6 hours	2	NA	<25
Fecal Streptococci	MPN/100ml	Assay	SM9230C	6 hours	2	NA	<25
Enterococcus	MPN/100ml	Assay	SM9230C	6 hours	2	NA	<25
METALS - TOTAL AND DISSOLVED							
Antimony	ug/L	HGA-Furnace	204.2	6 months	1	<25	<35
Arsenic	ug/L	HGA-Furnace	206.2	6 months	5	<25	<35
Beryllium	ug/L	HGA-Furnace	210.2	6 months	1	<25	<35
Cadmium	ug/L	HGA-Furnace	213.2	6 months	0.2	<25	<35
Chromium (Total)	ug/L	HGA-Furnace	218.2	6 months	1	<25	<35
Copper	ug/L	HGA-Furnace	220.2	6 months	1	<25	<35
Lead	ug/L	HGA-Furnace	239.2	6 months	5	<25	<35
Mercury	ug/L	Cold Vapor	245.1	28 days	0.5	<25	<35

TABLE 7-3
QUALITY CONTROL LIMITS FOR WATER QUALITY SAMPLES (concluded)

Parameter	Units	Methodology	EPA Method (a), (b)	Maximum Holding Time	Target Detection Limit	MS/MSD Precision %RPD	Sample Dup Precision % RPD
Nickel	ug/L	Cold Vapor	249.2	6 months	5	<25	<35
Selenium	ug/L	HGA-Furnace	270.3	6 months	0.5	<25	<35
Silver	ug/L	HGA-Furnace	272.2	6 months	0.2	<25	<35
Thallium	ug/L	HGA-Furnace	279.2	6 months	1	<25	<35
Zinc	ug/L	HGA-Furnace	289.2	6 months	5	<25	<35
Cyanide	ug/L	Spectrophotometric	335.2	14 days	20	<25	<35
ORGANICS							
PAH	ug/L	HPLC	mod 625	7 days	5	<30	<30
Total Petroleum Hydrocarbons	mg/L	IR	418.1	7 days	0.5	<30	<50
Total Oil and Grease	mg/L	IR	413.1	28 days	0.5	<30	<50
Volatile Organics	µg/L	GC/MS	8240	14 days	5 - 20	<30	<40
Semi-Volatile Organics	µg/L	GC/MS	8270	7 days	10 - 50	<30	NA
Total Phenols	mg/L	Spectrometric	420.1	7 days	5	<30	<30
PESTICIDES/HERBICIDES							
Organochlorine Pest.	µg/L	GC/ECD	608	7 days	.005-0	<30	<30
Organophosphate Pest.	µg/L	GC/NPD	614	7 days	1 - 20	<30	<30
Chlorinated Herbicides	µg/L	GC/ECD	615	7 days	0.5 - 5	<30	<30

(a) Methods for Chemical Analysis of Water and Wastes (1983) EPA-600/ 4-79-020
(b) Standard Methods for the Examination of Water and Wastewater, 16th Ed., APHA-WPCF, 1985

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7.4 LABORATORY COMPOSITING

Compositing of the samples would be performed at contract laboratory. Unless the trigger volumes have been changed with the second set, the mixing is done directly. A 19 liter glass bottle should be cleaned using non-phosphate liquid detergent and triple-rinsed with deionized water. The bottle should be placed on a stir plate with a magnetic stir bar. The minimum volume in the bottles should be determined, and this quantity should be taken from each sample bottle and added to the 19 liter glass bottle. The final mixed sample should be distributed into the appropriate glass, amber, or plastic bottles prior to the analytical testing. If the volume for triggering a particular sample was changed during the course of a sampling event, the Sample Custodian would work with the contract laboratory to composite properly the sample.

7.5 DATA REDUCTION, VALIDATION, AND REPORTING

Overall data quality would be assessed based on sampling and analytical conditions, adherence to internal QC procedures, and results of accuracy and precision checks.

Actual detection limits would be reported in the final report summary along with the results of the external QA samples, field replicates, laboratory duplicates, matrix spike, matrix spike duplicates, and equipment and reagent blanks.

7.6 CORRECTIVE ACTION

In the event the data quality objectives are not met, the contract laboratory should notify the Quality Assurance Task Leader who would evaluate the severity of the problem and recommend a solution to the monitoring task leader.

7.7 QA/QC REPORT

Summary results of the QA/QC program would be provided as brief memorandums detailing any analysis or sampling problems and the potential effects on the analysis results for each event.

8.0
DATA REPORTING

Data collected as part of this monitoring program should be stored in electronic format to enable easy retrieval, data interpretation, and graphing.

Data collected would fall under the following categories:

- Rainfall
- Runoff
- Field Chemical Data
- Laboratory Chemical Data
- Quality Assurance/Quality Control Data

Hydrological data (rainfall and runoff) collected at the monitoring stations should be transferred to a centralized file. These data should be checked for errors and arranged to show rainfall and runoff volumes and hydrographs during each sampled storm event. Following each event, a storm report should be prepared which summarizes the results of sampling, except laboratory results.

Chemical data generated by the contract laboratory would be input into a database by the laboratory. In addition to the laboratory electronic data, raw laboratory data reports would also be received from the laboratory. Once the data are received by the Project Manager, errors in transcription and reporting and compliance to QA/QC contract objectives would be checked and resolved. The final chemical data would be reported in a manner that is easy to read and understand. After laboratory results are received from the laboratory, a brief memorandum would be prepared which summarizes the chemistry results for each event.

At the end of the program, a monitoring data report would be prepared which summarizes results of the program. The report would be based upon the storm reports and a laboratory results memorandum.

9.0 MONITORING PLAN MANAGEMENT, ADMINISTRATION AND COORDINATION

An example organizational chart for the Monitoring Program is provided in Figure 9-1. Implementation and overall coordination of the Monitoring Program is the responsibility of the Program Manager. The Program Manager would be assisted by the Sampling Event Coordinator and the Quality Assurance Task Leader.

The Sampling Event Coordinator would be responsible for evaluating the weather forecasts as provided by the storm forecasting service and, in consultation with the Program Manager, deciding on which storms warrant mobilization for the sampling efforts. The Sampling Event Coordinator would also be responsible for the Field Manager.

The Field Manager would be in charge of the field sampling program, which includes; 1) assignment and supervision of Field Teams and Team Leaders, 2) field equipment maintenance and operation, 3) proper sampling collection and handling, and 4) field QA/QC and laboratory analysis.

The Quality Assurance Task Leader would be responsible for on-going review, auditing, and evaluation of the overall QA program related to sampling and laboratory procedures.

The Project Manager would also be responsible for the contract laboratory. Prior to selection, the contract laboratory should be audited to 1) evaluate the laboratory's ability to perform the work, 2) ensure proper QA/QC programs are in place, and 3) initiate education of specific personnel at the laboratory on protocols involved in the analysis of water samples.

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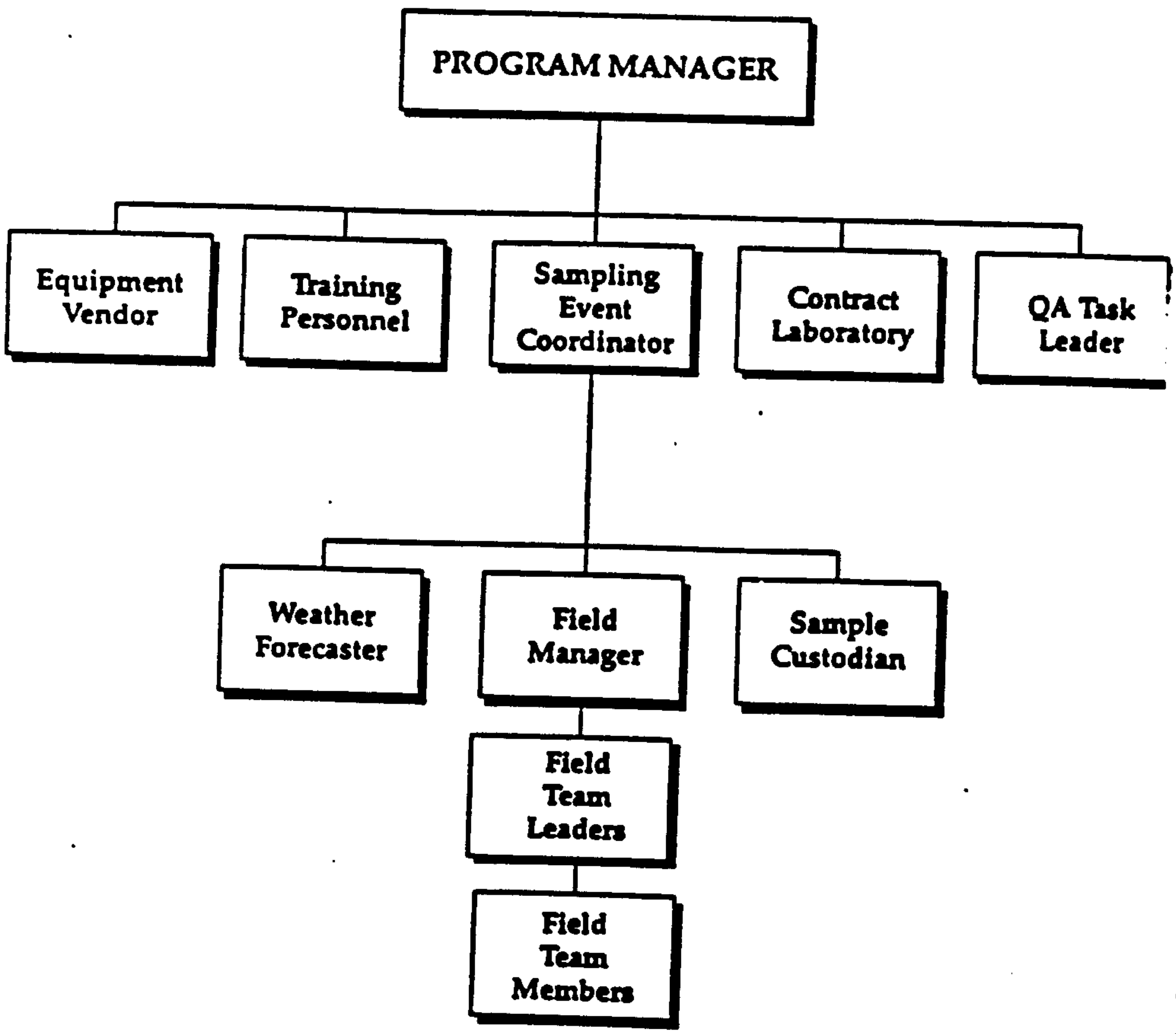
FIGURE 9-1 MONITORING PROGRAM ORGANIZATION AND COORDINATION



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10.0
MONITORING PLAN SCHEDULE

The schedule for implementation of a plan like this should be developed based upon the implementing agencies time and budgetary constraints and desired timing of data needs for water quality management planning.

Sufficient time must be allowed for:

1. Final station selection, 1-2 months
2. Equipment selection, ordering, and receiving, 1-2 months
3. Equipment installation, 1 month
4. Equipment testing, weather dependent

Personnel to be involved with the field operations of the Monitoring Program would be trained in the water sampling and flow monitoring protocols set forth in this plan. The training sessions would include instruction in the set-up and operation of monitoring equipment and software used to operate the sampling equipment. Operating procedures and sampling criteria would be developed for field personnel as part of the training task. Descriptions of the training sessions are presented in this section.

11.1 MONITORING EQUIPMENT OPERATION AND MAINTENANCE

Two training sessions would be conducted on monitoring equipment operation and maintenance. The first training session would be a "dry" session to teach personnel the standard procedures necessary for successful monitoring. The second session would be a "wet" session conducted in the field during a "practice" sampling event. Field crews would be trained as they assist training personnel in all of the field procedures during an actual sampling event.

During the two training sessions, the training personnel would provide standard operating procedure summaries (SOPs) and familiarize field crews in the operation and maintenance of sampling equipment and software. The equipment for each station would consist of an automatic type composite sampler, a compatible data logger and modem, a control module, depth monitoring equipment, and possibly velocity-flow monitoring equipment.

11.2 SAMPLE COLLECTION TRAINING

Field personnel should be trained for in-field water quality sampling and measurements and data recording procedures. This training would include procedures for grab sampling to obtain certain field measurements such as temperature, pH, and dissolved oxygen content. Also, field personnel would learn techniques for field sampling consisting of composite sampler operation and grab sampling for constituents which cannot be reliably measured in composite samples. Personnel would learn the procedures for getting samples from the monitoring site to the laboratory. This would include proper sample handling, storage, and chain-of-custody procedures for both grab samples and samples taken with the automatic composite sampling equipment.

11.3 HEALTH AND SAFETY

A health and safety manual should be developed for the sampling program. All personnel should review the manual and should receive a health and safety briefing during training.

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12.0 METHODS FOR ESTIMATING POLLUTANT LOADS

As noted in the introductory section, one objective of the monitoring program is to assess pollutant mass emissions to Santa Monica Bay. This section presents methods for estimating pollutant mass loads using the data to be collected in the monitoring program.

12.1 OVERVIEW OF STORM WATER POLLUTANT LOADING MODELS

The median land use concentrations by land use computed by Nationwide Urban Runoff Program (NURP) have been used in subsequent studies to estimate pollutant load from urban areas. This is commonly used for preliminary planning studies where little or no local sampling was conducted. Eugene, Oregon, for example, used NURP's mean estimate total pollutant load (WCC, 1991) as did the Piper's Creek Nonpoint Source Action Plan Study in Seattle, Washington. For both studies, runoff volumes were computed from the long-term average rainfall times the area times the runoff coefficient of each land use. Runoff coefficients were computed based on the percent impervious area typical of each land use, using a relationship developed by the Federal Highway Administration (FHWA 1990; Driscoll, et al., 1990). The relationship is expressed as follows:

$$R_V = 0.007*IMP+0.10$$

Where:

R_V = runoff coefficient
IMP = impervious fraction of the drainage area (as a percentage)

This method of computing pollutant load is the simplest of all those reviewed. It is probably sufficient for a preliminary planning study and has the advantage of minimal data requirements. However, this method assumes that the water quality of the area being modeled can be sufficiently represented by the NURP data.

Several other studies have used land-use-specific EMCs, using either NURP data or locally collected data, to compute pollutant load from a region. Woodward-Clyde Consultants estimated pollutant loads from Santa Clara Valley, California, using data from local sampling stations (WCC, 1991). Sampling stations were selected to represent uniform land use. A representative concentration for each respective land use category was computed by averaging the site mean concentrations from stations with similar land use. Runoff volumes were computed using the runoff block of the EPA's Storm Water Management Model (SWMM). Volumes of runoff from each land use type were multiplied by the representative concentration to compute loads. Mixed land use stations were used to verify the load estimates. A bias correction factor was calculated as the ratio of the predicted loads and the measured loads for the mixed land use stations. This factor was used to correct the estimate of loads from each land use. The main difference between this method and the NURP method is that SWMM is used to estimate runoff and the water quality data was collected exclusively in the study area. The advantage of this method is that by using the SWMM model the benefits of large control structures or other storm water retention best management practices can be investigated. However, a disadvantage of this method is that large amounts of data are required by SWMM for simulation. Another

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disadvantage is the error associated with using data from a small set of homogeneous land use stations to represent all the land use areas in the study area.

The Aquatic Habitat Institute (AHI) used data from WCC's Santa Clara Valley study and several other studies to compute pollutant loads to the entire San Francisco Bay (Gunther, 1991). AHI used runoff coefficients to compute runoff volume, in a manner similar to the Eugene study. Constituent concentrations were computed similarly to the Santa Clara study, but with a data set which included stations throughout the Bay area. This method is similar to the NURP method but uses water quality data from a specific region instead of the whole country.

Silverman, et al. (1988) developed an approach to concentration and load computation using regression analysis. They computed the load of oil and grease to San Francisco Bay using data collected at 15 stations within the region. They used runoff coefficients to compute flow volumes, which were computed from the measured flow volume at five of the sampling stations. Land uses extracted from census tract data were used to determine the percent of land tributary to each station identified as residential, commercial/industrial or undeveloped. A total of 34 samples were taken at these stations. Using land use as the independent variables and the oil and grease concentration as the dependent variable, a regression model relating land use to oil and grease loading was derived using 34 equations and three variables or unknowns. Using the coefficients from the regression model, the pollutant concentrations in storm water were calculated from all watersheds tributary to San Francisco Bay from the known areas of each land use.

Woodward-Clyde Consultants developed a regression model for computing pollutant loads in Alameda County, California, using the proportion of runoff from each land use tributary to sampling stations (WCC, 1991). This method used the assumption that the measured concentration at a sampling station is the flow weighted average of the concentration in runoff from each tributary land use. Samples were taken at 15 stations during a total of 11 storms. The land uses were divided into four categories (open, residential, commercial, and industrial). Runoff volumes, by land use, were computed using the runoff block of SWMM. Using runoff volume by land use as the independent variables and concentration at each station as the dependent variables, a multiple linear regression was performed to determine the best estimate of the concentration by land use. These concentrations by land use were then multiplied by the runoff volume by land use for the entire study area to determine the total load. The advantage of using this method is that it allows data from nonhomogeneous land use stations to be included when computing the water quality associated with each land use.

The USGS published a report (Driver and Tasker, 1990) which describes methods developed for estimating storm runoff loads and concentrations. These methods were developed by applying step-wise linear regression to the data collected from the National Urban Runoff Program (EPA, 1983). The nation was divided into three general climatic regions. For each region, a regression model was developed relating storm-runoff volumes and storm-runoff loads for 11 constituents to physical, land-use, and climatic characteristics.

The USGS selected a group of response variables according to the frequency of the variable in the database and according to the importance of the variable in urban planning. Specific response variables for each regression model were then selected using the step-wise regression procedure. This procedure sequentially selects response variables for inclusion to the model by testing the contribution the variable makes to improving the model. The variables most often selected were:

Total contributing drainage area

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Total storm rainfall
Percent impervious area
Percent industrial land use

The variables included in each regression model varied by region and constituent. However, there is some question of the validity of using rainfall as a variable in the regression analysis since it is directly related to runoff quantity.

These regression models provide a convenient, planning-level tool for estimating storm runoff loads. Mean annual loads can be estimated by multiplying the estimated storm load by the average number of storms per year. The chief advantage of the USGS's methodology is that it can be performed using data commonly available to planners, before any sampling is conducted. The primary disadvantage is that it does not provide any means of identifying any unusual conditions within the region of interest.

The methods previously used to model pollutant loads from storm water runoff represent a range of approaches, from fairly simple to rather complex. All of the methods, with the exception of the USGS regression analysis provide a methodology for computing the runoff and a methodology for estimating water quality; each exclusive of the other. As with any modeling effort, the method chosen for a particular study depends on the resources available, the availability of data, and the purpose of the study.

12.2 RECOMMENDATIONS

The NURP method was used as an initial estimate of storm water pollutant loads to Santa Monica Bay (Stenstrom and Strecker, 1993). However, the NURP 90th percentile values of the EMCs were used in place of the median (50th percentile) values of the EMCs because existing water quality data indicated that pollutant concentrations in the watershed are higher than the NURP median values.

Water quality data collected during the monitoring program should be used to calibrate and validate the NURP model for Santa Monica Bay. Regression techniques used in other studies could be applied to the data to determine the best estimate of pollutant concentrations for each land use type. The results of the model will provide a quick estimate of mass emissions to the Bay by subbasins and land use for use in water quality management and planning.

More detailed assessment of pollutant loadings could be developed using more complex physically-based computer models such as SWMM. Physical models have several advantages over the lump parameter models such as those using the NURP data. Storm water variations that occur between and during storms and in wet and dry seasons could be captured by physical models. Also, the effectiveness of storm water management controls could be better evaluated with physical models. The drawbacks to physical models are that more data are required and greater analytical resources including modeling expertise, computing power, and time are needed.

The data to be collected in the monitoring program will provide the data required for physical modeling. Rainfall and runoff quantities will be measured throughout the two-year monitoring period. Water quality data collected during both wet weather and dry weather will also be available. The extent to which these data can be used in a physical model will depend on the amount of data collected and the quality of the data. In addition to the data, the success of the modeling effort will depend on the expertise of the modeler and the resources allocated to the task.

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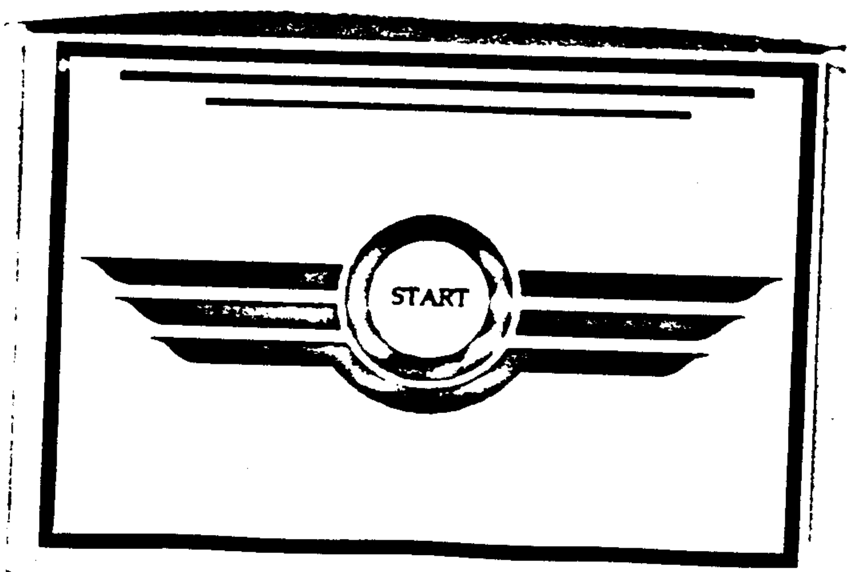

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ASSESSMENT OF STORM DRAIN SOURCES
OF CONTAMINANTS TO SANTA MONICA BAY

VOLUME IV
SELECTION OF BEST MANAGEMENT PRACTICES
FOR CONTROL OF STORM WATER POLLUTION TO
SANTA MONICA BAY

by

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PREFACE AND ACKNOWLEDGEMENTS

This report represents Volume IV from a series of four volumes of reports which form the basis of a pollution assessment and monitoring plan for Santa Monica Bay. Volume I describes land use statistics, catchment areas, existing water quality monitoring data, rainfall data, NPDES permit information for existing permits to storm drains, and contaminant mass emission estimates, based upon land use modeling. Volume II reviews sampling techniques, including sampling equipment, and other aspects associated with sampling such as a quality assurance plan. Volume III presents the proposed monitoring plan. Volume IV addresses best management practices as they apply to the Santa Monica Bay area. The first draft of Volume IV was issued on November 9, 1992.

The contract was performed by UCLA and Woodward-Clyde Consultants (WCC). Professor Michael K. Stenstrom of the Civil and Environmental Engineering Department, UCLA and Eric Strecker from WCC's Portland office were the project managers. There were several key individuals from both UCLA and WCC who assisted with the project; they include Sim-Lin Lau and Kenneth Wong (UCLA) and Lou Armstrong, Gail Boyd, Carol Forrest, and Joan Kersnar (WCC).

The contractors are grateful for the assistance of many individuals. The Santa Monica Bay Project and LA Regional Water Quality Control Board staffs were most helpful. We extend our special thanks to Dr. Guang-yu Wang, Ms. Catherine Tyrrell, Dr. Rainer Hoeinke and Mr. Xavier Swamikannu. Several public agencies were very helpful in providing data and information to us. The Los Angeles County Department of Public Works and the Southern California Association of Governments (SCAG) provided catchment area and land use data, respectively. We are also indebted to the members of the Technical Advisory Committee of the Santa Monica Bay Project and others who reviewed and commented on our draft reports.

ABSTRACT

This report presents a procedure for developing a suite of best management practices (BMPs) to control or reduce pollutants from nonpoint sourcs to Santa Monica Bay. Provisions are made for stormwater as well as dry weather flow. The procedure provide a methodology for operators of municipal storm water drainage system in Santa Monica Bay to select appropriate BMPs based upon available knowledge and resources. The procedure includes a "menu" concept where three menus of BMPs are provided. The first menu (Menu A) represents very important BMPs which might be considered mandatory. Menus B and C list BMPs that are complementry to Menu A but are more difficult to implement or produce less certain benefits. These BMPs are optinal and a technique is presented for screening the various BMPs in order to identify those most applicable to the Santa Monica Bay watershed.

During the course of this project a variety of BMPs were discussed or researched at various times by contract personnel or by others participating or reviewing the project. In order to perserve this information, the various BMPs are listed in an Appendix. Most of these BMPs are similar to one or more items covered in a menu but are more specific to the Santa Monica Bay watershed. The Appendix provides additional information which should be helpful in deciding to implement or implementing the BMP.

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1.0
INTRODUCTION

The purpose of this report is to provide operators of municipal storm water systems with the information needed to evaluate a series of candidate Best Management Practices (BMPs), formally select BMPs that would be most effective in dealing with local conditions, and begin the process of developing effective implementation plans. It is difficult to develop an entirely successful plan, and more than one iteration may be required. The BMPs presented here as candidates have been "pre-screened" and "pre-qualified" by the consulting team--i.e., they are known to be worthy of consideration for addressing the problems and conditions that exist in the watersheds that contribute storm water runoff to Santa Monica Bay. In this report, we have recommended a set of BMPs that we feel should be implemented, along with those that we feel should be carefully considered for inclusion in a Santa Monica Bay Watershed Management Plan.

The formal selection process described herein is recommended because local opportunities, constraints, priorities, and other factors need to be taken into account by local decision makers before specific BMPs are selected and implemented. Furthermore, use of a formal, well-documented evaluation and selection process is prudent in circumstances where program decisions and resource commitments may come under scrutiny or challenge.

This report covers information that was presented in abbreviated form during a workshop that was held in Santa Monica on June 14, 1992. The workshop and this report were developed and presented to the municipal storm water co-permittees by personnel from Woodward-Clyde Consultants (WCC) and University of California at Los Angeles (UCLA) on behalf of the Santa Monica Bay Restoration Project.

1.1 BACKGROUND

After many years of conducting technical studies to assess the importance of urban storm water discharges as a source of water pollution, the US. Environmental Protection Agency (EPA) issued a set of draft regulations in December 1988. These draft regulations were intended to initiate and guide municipal programs for identifying and controlling pollutants that are carried through and discharged from municipal separate storm sewer systems. The regulations were issued in draft form to provide interested parties (e.g., municipal storm water dischargers, commercial and industrial interests, state and regional water quality control agencies, public interest groups, and the general public) the opportunity to review the requirements and provide comments that would guide the final rule-making process. The final rule, which is a part of EPA's National Pollutant Discharge Elimination System (NPDES), was issued by EPA in November 1990 and requires most sizable cities (based on population) in urbanized areas nationwide (as well as some industries) to conduct technical studies, identify and assess sources of storm-water-borne pollutants, and implement practical pollution controls in the form of BMPs.

During the period when EPA's draft regulations were being subjected to public review and comment (i.e., December 1988 to November 1990), several California cities, counties, flood control districts, the US EPA, the State and regional water quality control boards, and other public entities joined together in various regional consortia and developed strategies that would allow them more flexibility than the emerging federal regulations were thought to provide. These so-called "early permitting" strategies were worked out by eight groups of co-applicants in Northern, Central, and Southern California and were approved by EPA Region 9 and the respective Regional Water Quality Control Boards (RWQCBs). The resultant early permits were issued under then-existing NPDES permit structures (i.e., before the storm-water-specific regulations came into effect in November 1990). In most respects, the early permits issued for Southern California municipal storm water dischargers have similar requirements to the programs being pursued elsewhere in the United States,, but there are two important differences:

- For one, the co-permittees were given a longer time period to conduct most of the studies and planning efforts. Most sizable US. cities are required to complete their studies and planning before applying for permits in November 1992 or May 1993 (depending primarily on the size of the respective municipal separate storm sewer systems), whereas the Southern California early co-permittees are allowed to conduct the studies and planning efforts during the 5-year term of their NPDES permits.

- Second, the Southern California co-permittees were required to select and implement certain "early action best management practices" from the outset and then conduct studies and more definitive planning efforts to select and implement additional BMPs in accordance with schedules worked out with their respective RWQCBs.

During the past few years, representatives of many cities, county agencies, environmental organizations, other public interest groups, and many interested citizens and regulatory agency personnel have worked cooperatively and proactively to protect and restore water quality and beneficial uses in Santa Monica Bay. The efforts and accomplishments of the Santa Monica Bay Restoration Project, Heal the Bay, the LA-RWQCB, and others that have worked to address challenging water quality management issues, have been considerable. Their actions should not be seen as being driven by the NPDES storm water permitting process, because they have had other specific water quality improvement goals as their primary motivation. Nonetheless, there are numerous ways in which the programs have come together. This report and the June 15, 1992 workshop that preceded it are examples of how the Restoration Project and the so-called "early co-permittees" have worked together to plan appropriate BMPs.

1.2 REPORT ORGANIZATION

This document is organized into four sections. Section 1.0 (this section) provides the background needed to understand why this report was written and provides an overview of the regulatory framework. Section 2.0 provides insight on the ideas and concepts usually associated with BMPs and acts as a back drop for the rest of the report. Section 3.0 discusses the various BMPs, recommends BMPs that should be implemented now, and provides a mechanism for selecting future BMPs. Section 4.0 discusses what should be done in the future.

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2.0 PRINCIPLES FOR DEVELOPING STORM WATER MANAGEMENT PROGRAMS

As described in Section 1.1, over 80 cities and the County of Los Angeles are parties to an "early" NPDES permit that is intended to reduce the amounts of pollutants that enter storm water conveyance systems and receiving waters. The co-permittees that manage storm waters that discharge into Santa Monica Bay have identified existing Best Management Practices (BMPs) and instituted easily implementable BMPs. For the most part, these were practices that were either already in place (i.e., before the permit requirements came into effect) or are some variations of the pre-existing public works operations and maintenance programs (e.g., storm inlet inspection and cleaning, street cleaning, litter control). In 1991, the co-permittees developed and submitted reports (to the Los Angeles-Regional Water Quality Control Board), documented their existing programs, looked for ways to modify, refine, or intensify their practices to obtain greater storm water quality benefits, and planned early action storm water BMPs. The purpose of this early action phase was to assure that significant controls would be implemented as quickly as possible, but the co-permittees were aware that additional controls could also be needed. This section describes some principles that should be considered as co-permittees continue their efforts to evaluate local conditions and select among candidate supplementary controls.

Section 3.0 presents a structured process that is recommended for co-permittees' use for evaluating and selecting among candidate BMPs. Specifically, section 3.3 presents a sizable, pre-screened list of BMPs to consider as candidates and describes several factors that co-permittees should take into account in their selection process. The pre-screening was performed by Woodward Clyde Consultants with the assistance of the Santa Monica Bay Project staff and Technical Advisory Committee members. These concepts of pre-screening, evaluation factors, and the use of a formal structural process warrant some introduction, and that are the subject of Sections 2.2, 2.3, and 2.4.

2.1 PRE-SCREENING

The importance of urban storm water as a cause of water pollution has become apparent in some parts of the country earlier than others. This is largely because of the broad variety of hydrologic conditions and pronounced differences in receiving water conditions from area to area within the US. As a result, water quality programs in some areas have been working with storm water BMPs for many years. Fortunately, many of these BMPs have been studied to assess their performance, practicality, and costs; and this information is available for consideration by local decision-makers.

The BMPs presented herein have been selected (by Woodward-Clyde and UCLA) from a long list of storm water controls that have been used (or considered for use) in other urban locations nationwide. The pre-screening that led to the list of BMPs presented for consideration in the Santa Monica Bay area was performed in two steps, as follows:

- The first step involved eliminating BMPs that would have little or no application, given local climatic and land-use conditions. This step eliminated BMPs related to de-icing, snow removal, and control of agricultural practices (e.g., large-scale use of pesticides, herbicides, fungicides, erosion controls, poultry and livestock management, and agricultural waste management). BMPs targeted toward these types of practices are common in significant parts of many urban areas, but are not seen as being relevant in the Santa Monica Bay area.

- The second step involved establishing a philosophical bias in favor of pollution prevention (i.e., source control) and in favor of building upon a manageable number of existing programs. The concept of "pollution prevention" or "source control" implies that one should emphasize BMPs that keep pollutants out of storm water, rather than trying to remove pollutants that have already entered storm water or the receiving waters. Some source controls are structural (e.g., providing roofs to keep precipitation off of exposed storage piles, providing berms to keep site runoff away from storage piles), but most source controls are non-structural. They typically include the use of educational programs aimed toward changing people's awareness and behavior (especially regarding the proper use and disposal of household and automotive products), the use of local ordinances and inspection programs focused on identifying and converting illicit connections and illegal dumping, and the use of public works programs focused on improved "housekeeping" of public infrastructure (e.g., street sweeping, litter control, storm inlet and storm drain cleaning, channel maintenance, fleet maintenance).

2.2 EVALUATION FACTORS

The BMP evaluation and selection process described in Section 3.0 involves considering several "factors" which are intended to provide a means for incorporating the decision-makers' preferences, priorities and constraints. It is recognized that the co-permittees in the Santa Monica Bay area are all public agencies that must function within a context of: limited resources; multiple (often conflicting) demands; pre-existing obligations, commitments, and constraints; and political tensions. The requirement for intensified storm water control at the municipal level is only one of many requirements each co-permittee must deal with. Therefore, each co-permittee agency needs to carefully consider a variety of factors that reflect local social, political, environmental, and fiscal realities--because these combine to define what is "practicable" in their real-world setting. Section 3.3 describes 13 factors which are intended to help decision makers consider the following: environmental implications, effectiveness regarding pollutants of concern, implementing agency/department acceptability, regulatory requirements, public acceptance, risk/liability, fairness, reliability, sustainability, universality, implementation cost, flexibility for phased implementation, and ability to demonstrate compliance.

2.3 FORMAL EVALUATION AND SELECTION PROCESS

Section 3.0 presents a formal method for evaluating and selecting appropriate BMPs for several reasons, all of which are related to the concept that the decision makers within any given co-permittee agency may be pressed to explain (or even defend) the basis for their evaluations and selections. The need to explain their decision process may come from any of several sources, including:

- The selected BMPs will have some degree of impact on municipal services that public agencies can provide. Members of the public, interest groups, elected or appointed officials, and/or department heads may challenge (or at least inquire about) the rationale for committing public resources toward specific aspects of storm water quality control.

- Some of the BMPs will require certain parties (e.g., residents, commercial/industrial establishments, institutions, public agencies) to do things they do not want to do (or to stop doing things they want to do). Therefore, some people will not be pleased with the selected BMPs and may challenge the basis for their selection.

- On the other hand, there are those who would like to see additional (or at least more intensive) BMPs and may challenge the basis for limiting the co-permittees' obligations to only the selected BMPs.

It should be clear that the best defense against even an informal challenge would be to avoid as much as possible the allegation of having been arbitrary and capricious by employing the following strategies from the outset:

- involve the right people at the appropriate times in the process of evaluating and selecting BMPs.

- Employ relevant and appropriate information so the decision makers do not have to operate in a vacuum regarding key issues.

- Establish and follow a rational, formal decision process that is well-documented throughout. Section 3.3 describes a process that meets these objectives.

2.4 LAND-USE AND WATER QUALITY CONCERNS

It is important that decision makers have an understanding of the land-use and water quality considerations from which to base the evaluation of the BMPs on. This section presents a brief discussion of land-use considerations with regard to pollutant loadings to the Bay and a discussion of water quality parameters of concern.

2.4.1 Land-use Considerations for Selection and Targeting of BMPs

In development of the loadings model for Santa Monica Bay, the land-use data available from the Southern California Association of Governments was utilized. These land-uses included:

- Single Family Residential,
- Multi-family Residential,
- Commercial,
- Public (schools, government offices),
- Light industrial,
- Other urban (not included above), (parks, undeveloped land), and
- Unknown.

The NURP program developed estimates of typical runoff concentrations in urban areas for commercial, residential and open land uses. Other programs have been developing data for industrial runoff, although industrial runoff would be expected to vary considerably with the type of industry present.

The Santa Monica Bay Storm Drainage Pollutant Model was used to develop initial loading estimates based upon NURP data for runoff concentrations, which was adjusted based local data summarized in the loadings model report (Stenstrom and Strecker, 1993). Localized data for rainfall, land-use type, and percent impervious (estimated based upon land-use) was utilized to develop loading estimates.

Because of the large area of residential land-use in the watershed (33 percent), this land-use was found to be the highest contributor of pollutants to the Bay. Commercial areas constitute 3 percent and light industrial 2 percent of the total Bay watershed, as a comparison. However, because of their usually higher percent impervious areas and higher concentrations, commercial and industrial areas have a much higher unit area loading rate. Therefore, targeting of structural control measures in these areas would result in the highest pollutant removals per unit cost. Watershed-wide source control measures are warranted in existing residential land-uses.

Highway runoff is another likely large source of pollutants to the Bay. Because the data was not available, highways were not individually modeled. The FHWA studies (FHWA, 1990) found that in general, pollutant concentrations for heavy metals were 2 to 4 times higher in highway runoff than general urban runoff. Combined with their higher percent imperviousness, focusing on controlling pollutants from freeways and highways would also be warranted. In addition, automotive repair shops have been targeted by many other programs (Santa Clara, Bellevue) due to their expected higher contribution of pollutants.

New construction is a target that is specifically called out for action in the NPDES regulations. Both in terms of controlling erosion of soils, but also for designing and building best management practices to control pollutants from these areas. For example, in new construction the use of grass swales rather than piped drainage would improve water quality and lead to lower piping costs. Open land comprises a great fraction of certain watersheds, such as in the Malibu and Las Virgines areas. BMPs to mitigate the impacts of construction could be especially important in these areas.

2.4.2 Water Quality Parameters

Key water quality parameters that are of concern to urban nonpoint source runoff have been analyzed in many studies of urban runoff. Some pollutants have been identified as causing problems in receiving waters while other parameters have not routinely been detected or have been detected in concentrations which have not indicated that problems exist. The water quality parameters analyzed in many studies, including the Nationwide Urban Runoff Program (US EPA 1983), Santa Clara and Alameda Runoff Studies and the City of Portland Study include solids, nutrients, heavy metals, hydrocarbons, oil and greases, pesticides, herbicides, volatile organics, and oxygen demand.

The following briefly describes the groups of pollutants which typically have been found to be of concern and warrant attention in the development of plans to reduce pollutant loadings to receiving waters. These pollutants are based on the results of past sampling in the local area (Stenstrom and Strecker, 1993) and on the results of several major runoff water quality studies. These studies were conducted by Woodward-Clyde Consultants (WCC) for the Environmental Protection Agency (US EPA, 1983), Federal Highway Administration (FHWA, 1990), Santa Clara and Alameda Counties, and the Cities of Portland and Eugene.

Total Suspended Solids (TSS) The term "suspended solids" is descriptive of the organic and inorganic particulate matter which is of a size and type that allows the particles to stay suspended in water. The sediment load in a water body is influenced by a number of factors including but not limited to: particle size, stream flow, climate, geology, and vegetation of each drainage system. The conditions under which suspended sediments are considered a pollutant is a matter of definition. In general, suspended solids are considered a pollutant when they significantly exceed natural concentrations and have a detrimental effect on water quality and/or beneficial uses of the water body. Suspended sediments are often used as a indicator for other contaminants which bind easily with fine particulate matter, including heavy metals and phosphorus.

Sediment loads have been considered a problem in most all urban runoff studies, both due to their direct problems (siltation, aquatic life respiration inhibition, etc.) and their transport of other pollutants. On the other hand, sediments from natural areas provide sands for beaches, providing critical habitat. Therefore, in Santa Monica Bay, sediments from urban surfaces and from construction should be targeted, rather than natural unaccelerated erosion from undisturbed areas.

Nutrients. Nutrients are necessary for the growth and support of biota in natural water systems. Excessive quantities can over-stimulate biological growth and create objectionable water quality conditions. Runoff from fertilized areas and discharges of sewage or industrial wastes are frequently sources of significant quantities of nutrients. Other sources include urban storm water runoff and direct atmospheric deposition to water body surfaces. In general, the most important nutrient factors causing an acceleration in algae production are nitrogen compounds and phosphorus.

Nutrients have not been identified as a general problem in Santa Monica Bay. In fact the Bay is considered nutrient poor. However, urban runoff is a significant source of nutrients to receiving waters. Therefore, nutrient controls should be considered to control "localized" problems for identified receiving waters. These could include Malibu Lagoon and Marina del Rey.

Heavy Metals. Heavy metals such as copper, lead, and zinc are naturally released in very small quantities by the weathering of exposed soils and mineral deposits, corroding metal surfaces, decomposing paints, and certain corrosion-control compounds. Vehicles are sources of heavy metals. Lead from leaded fuels is a very important source. Tires can contain significant quantities of zinc. Catalytic converters are also potential sources. Heavy metals tend to have comparatively low solubility and are often mobilized by forming soluble complexes with humic materials or by becoming attached to suspended solids.

These metals are present in the biosphere as trace elements and are micronutrients necessary for plant and animal growth. Heavy metals are of concern because elevated concentration levels of soluble forms in natural water bodies can produce toxic effects in biota. Sources include regulated domestic and industrial point-source discharges, urban storm water runoff, and direct atmospheric deposition.

The most frequently detected pollutants in the NURP study were lead (94 percent), zinc (94 percent), and copper (91 percent). Chromium and arsenic were detected in 58 and 52 percent of the samples, respectively. Of the inorganic pollutants, lead, zinc, and copper exceeded criteria most often. In Portland, cadmium, nickel, and silver have also been identified as heavy metals of concern. However, in looking at treatment based controls the conclusions drawn from the analysis of lead, zinc and copper can be used to indicate the behavior of other heavy metals. For source controls, specific parameters may require individual analysis and planning. For instance, a likely source of silver in storm drains could be discharges from photographic laboratories. The State of the Bay report has indicated that there are elevated heavy metals in the sediments of the Bay, including elevated lead levels in sediments of Marina del Rey. In addition, the data developed and analyzed for this study of Santa Monica Bay (Stenstrom and Strecker, 1993) indicated that observed metals levels during storm events were significantly higher than NURP concentrations for lead and zinc. There was not enough data on other metals to make such comparisons, but they are likely high as well. Heavy metals are considered a potentially significant problem. The proposed monitoring program for storm water drainage in Santa Monica Bay should further identify the significance of heavy metals being discharged to Santa Monica Bay.

Oxygen Demand. Oxygen demand refers to the amount of oxygen that will be consumed by biological or chemical reactions involving organic and inorganic compounds. In general, moderately high dissolved oxygen content is necessary for the maintenance of healthy aquatic ecosystems. The relationship of oxygen-consuming discharges to the amount of dissolved oxygen in a receiving water body, therefore, is fundamental to the maintenance of environmental quality in natural water bodies.

Oxygen demand is measured in terms of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The BOD test provides an indirect measure of the quantity of biologically degradable organic matter in water in terms of the amount of oxygen required by microorganisms to oxidize it to carbon dioxide and water. The COD test measures the consumption of oxygen from a strongly oxidizing chemical agent.

In urban storm water COD levels are typically found to be about 8 times greater than BOD levels, indicating that much of the demand does not come from easily biodegradable materials. Stormwaters are often close to saturation DO concentration, and in some cases during low flow can be supersaturated due to photosynthesis. BOD and COD generally take several days to have impacts on receiving waters. It is likely that the Santa Monica Bay does not have significant oxygen deficits due to BOD and COD, but that localized problems could occur in smaller receiving waters such as Malibu Lagoon and possibly Marina del Rey.

Aesthetics. This category of pollution refers to litter, floatables, odor, scum, algae, bubbles, color(s), marine debris, and riparian vegetation impacts. Some of these inhibit habitat values, while others detract from human enjoyment or cause possibly safety problems. These pollutants have been identified as a problem in Santa Monica Bay.

Organic Pollutants. In the NURP program it was found that 63 of a possible 106 organics analyzed were detected in urban runoff. However, in general, organic pollutants exceeded applicable EPA water quality criteria much less frequently than inorganic pollutants. Of the pesticides analyzed, only 4 had a frequency of detection greater than 10 percent. These ranged in frequency of detection from 15 to 20 percent, and exceeded criteria from 8 to 17 percent of the time. Four polycyclic aromatic hydrocarbons (PAHs) were detected in urban runoff, but did not exceed EPA's freshwater life criteria. Only one form of PCB was detected (PCB-1260) and that was only a single detection. DDT was found in less than one percent of samples analyzed. The Portland study has found that organics are not generally a problem in storm water. There are however instances of pesticide concentrations in sediments. PAHs have also been detected in concentrations which exceeded the new Washington State standards.

Given that these constituents have not been found in quantities to warrant significant attention, they probably should receive less attention at this time. However, it is recommended that the Santa Monica Bay Monitoring Plan be implemented so that these parameters can be evaluated locally at an appropriate frequency until their presence or absence is determined. These parameters still warrant attention in the form of education and minimization of use; however, banning the use of pesticides and herbicides is not warranted.

Oil and Grease. Oil and grease is a prevalent constituent in urban runoff. In a study of oil and grease concentrations in urban runoff in Richmond, California, Stenstrom et al. (1984) found that oil and grease concentrations in runoff from commercial properties and parking lots are about three times higher than from residential and open areas. The NURP program did not address oil and grease. Accurately measuring oil and grease is very difficult, especially due to its affinity for coating sampling bottles and tubing. Furthermore, separating oil and grease from anthropogenic (man made) and biogenic (naturally occurring) sources is not easy to do, but has a major impact on its potential impact. Eganhouse and Kaplan (1981) measured oil and grease concentrations in the Los Angeles River and found that concentrations were generally lower during storm events than during dry flows. The State of the Bay report (MBC, 1988) estimated that urban runoff accounted for about 3 percent of the total input of oil and grease to the Bay. Recent data in Portland has found relatively low levels of oil and grease contamination. However, it is considered a problem by the public, and is sometimes visually apparent in Santa Monica Bay drainage channels, such as Ballona Creek. Therefore, it warrants a modest amount of attention in implementation of BMPs, including programs to avoid or prevent illegal dumping.

Pathogens. The State of the Bay report (MBC, 1988) indicates that during storm events, indicators of pathogens increase (fecal coliform, enterococcus), but it is uncertain whether these are primarily from animal or human wastes. Studies in Portland, Santa Clara, Alameda, Eugene, and Seattle have shown that these bacterial measures increase during storm events. In addition, on-going local studies sponsored by the Santa Monica Bay Restoration Project have shown storm drains to be a source of these indicator parameters as well as human viruses. Therefore, in Santa Monica Bay the concern for human health due to pathogens has become a concern. It is important to note that there have been many incidents of the direct release of sewage into Ballona Channel and other drainage facilities during failures of the sewer system and these direct releases more than nonpoint source runoff may be a contributor to pathogen problems. A program to locate sanitary sewer and stormdrain cross connections, including an aggressive field screening program to locate problem outfalls, is warranted.

Numerous storm water Best Management Practices (BMPs) have been developed, implemented, and evaluated over the last 20 years. Some of these BMPs specifically meet the requirements prescribed in EPA's NPDES regulations, and others are simply considered beneficial for controlling storm water. These BMPs have been pre-screened because not all of them are appropriate for use in the Santa Monica Bay area.

The following sections describe certain BMPs that should be implemented and provides the tools to select other BMPs that will be useful in controlling storm water pollution.

3.1 THE MENU CONCEPT

In the Santa Monica Bay area, municipal co-permittees are required to implement various BMPs to help control pollutants that would otherwise be discharged via their storm sewer systems. The program being guided by the Los Angeles Regional Water Quality Control Board is intended both to provide the co-permittees with the freedom to select BMPs that are appropriate to local conditions, and to assure that all co-permittees implement enough controls to achieve a meaningful level of pollution prevention.

The three-element "menu" system described herein provides a basis for balancing flexibility and assurance of meaningful control. The following discussion explains the menu system--first in direct terms, then by analogy, and then through a simple example.

Co-permittees are being provided with three lists of candidate BMPs for possible implementation in their respective jurisdictions. These lists (referred to herein as "menus") differ from one another in terms of the degree of obligation associated with each. As explained in detail below, the BMPs on Menu A are "mandatory," the BMPs on Menu B are "recommended," and those on Menu C are entirely "optional." During the process of developing local (i.e., city-specific) storm water management plans, the co-permittees will consider all three menus, but will only have to select BMPs from Menu A and Menu B. More specifically, they must select all BMPs on Menu A, but they need to select only the most appropriate BMPs from Menu B. Some co-permittees may decide to include additional BMPs from Menu C, but others may decide not to include any from Menu C. The hierarchy of obligation can be summarized as follows:

> Menu A - Mandatory - All co-permittees are required to select and implement all of the BMPs listed on Menu A, because there is sufficient evidence that these BMPs would be effective in controlling water pollution problems in the Santa Monica Bay watershed area.
>
> Menu B - Recommended - All co-permittees are required to consider all of the BMPs listed on Menu B, because they have a high likelihood of being effective if properly implemented. However, the co-permittees do not have to select or implement all Menu B BMPs, if the rejected BMPs would not be practicable or warranted (given local circumstances, conditions, and constraints) and that the selected BMPs are believed to be sufficient to control storm water pollution. That is, the burden of proof for not selecting a BMP from Menu B lies with the co-permittee.

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Menu C - Optional - Co-permittees will be provided with an inventory of ideas to consider but are under no obligation to select or implement any of the BMPs from Menu C. The concepts listed on Menu C have been explored and/or implemented in other storm water pollution control programs, but they are provided here only as a resource to facilitate the planning process. It is likely that some co-permittees may decide to pursue one or more of the Menu C BMPs (perhaps because they may represent an opportunity to solve a local problem or because they may make good use of local resources or they would be more likely to be successful than a measure in Menu B for a given problem), but the co-permittees do not have any burden of proof for demonstrating why they did not select Menu C BMPs.

The concept of using a hierarchy of lists to structure a decision-making process has broad application. The most obvious application is the source of the term "menu." Patrons in a restaurant are presented with options in a way that facilitates matters for both the customers and the restaurant staff. Some would consider Menu A and Menu B to consist of items that are the "main course" on a menu, whereas Menu C contains "appetizers" or "dessert" items. Perhaps a more apt analogy would be the lists of courses in a college catalog. Menu A corresponds to the "core courses" that are mandatory curriculum requirements for graduation. Menu B corresponds to the courses that pertain to a particular major or are part of the standard curriculum for a degree from a particular department. Menu C corresponds to "elective" courses that a given student might take to round out their education or to build upon some particular talent. Continuing this analogy, credit would be given for every course the student takes (i.e., every BMP that is implemented), but only certain courses are obligatory.

The above-described menu system will be used in the Santa Monica Bay area to structure the process by which co-permittees evaluate, select, and implement BMPs. The BMPs that have been considered appropriate to designate as "mandatory" are listed on Tables 3-1, 3-2, 3-3, and 3-4. Again, these Menu A BMPs are well understood, by virtue of having been used with notable success in many areas. They are also believed to be cost-effective for dealing with the kinds of pollutants and conditions that exist in the Santa Monica Bay area. Furthermore, it is relatively easy for them to be implemented in compliance with the regulatory requirements of a Municipal Storm Water Management Program, as defined by the Environmental Protection Agency's (EPA's) current regulations.

3.2 MENU A BMPs

Several BMPs have been designated as being of high priority for implementation. These BMPs are to be considered mandatory by all participants in the Santa Monica Bay watershed. The Menu A BMPs focus mainly on education construction, industry, and illicit connections/illegal dumping controls.

Public Education

The central goal of public education is to reduce the amount of pollutants entering Santa Monica Bay through the storm drain system by informing the public about the causes of storm water pollution (i.e., pollutant sources and pathways) and by encouraging public involvement in reducing the storm water pollution. Public education can also teach the proper use and management of potential pollutants so they do not end up in the storm water conveyance systems.

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Table 3-1. Best Management Practices For Public Education.

Best Management Practices	Description	Suggested Steps for Implementation	Suggested Methods to Assess Effectiveness	Land Use
Label storm drain inlets and maintain labels on.	Coordinate volunteer efforts to label storm drain inlets with slogans like "No Dumpling, Flows into Bay" and Provide signs along the banks of drainage channels and creeks explaining the environmental impacts of dumping wastes.	1) Develop slogan to be used for labeling. 2) Develop a symbol that will be associated with the SMB Project. 3) Procedure stencils/signs. 4) Coordinate with community organizations to help paint the storm drains and install signs.	Record the number of catchbasins labeled and the number of signs placed along the channels and creeks.	All
Develop a general purpose brochure on Water Quality Protection and NPDES Program.	A "user friendly" brochure can be used to handout to people at community events and festivals. The brochure could also be mailed to people. The brochure would explain why storm water pollution is a problem and what people can do to help prevent it.	1) Develop graphic layout and text. 2) Develop distribution strategy, including number of brochures need. 3) Print brochures.	Count number of brochures distributed.	Residential and Comeercial

Table 3-2. Best Management Practices for Industrial Facilities.

Best Management Practices	Description	Suggested Steps for Implementation	Suggested Methods to Assess Effectiveness	Land Use
Assist industries to comply with general Permits.	Some industries may be unfamiliar with laws which requires SWPPP preparation at individual facilities. The appropriate agency should advise such industries of the State and Federal requirements.	1) Examine SWPPPs for completeness. 2) If SWPPPs are unavailable, advice the facility of State requirement and document advice with Regional Water Quality Board. 3) Assist facilities to prepare SWPPPs. 4) Provide facilities with sample SWPPPs.	Record number of industries that violate Storm Water Regulations and/or require assistance to prepare SWPPPs.	Industrial

Table 3-3. Best Management Practices for Illicit Discharge Elimination.

Best Management Practices	Description	Suggested Steps for Implementation	Suggested Methods to Assess Effectiveness	Land Use
Develop Enforcement Procedures	To clarify roles and responsibilities of inspectors, develop a set of follow-up enforcement procedures; these should be based on existing laws and regulations. The procedures should outline action to be taken for different degrees of violation severity. *This task should also be coordinated with the Industrial component.*	1) Collect data on pertinent existing laws and regulations (city, county, state and federal). 2) Develop new ordinance, if needed. 3) Empower inspectors to issue citations. 4) Develop a uniform and consistent procedures to keep records of all contact (personal, telephone, etc.) made with illicit dischargers. 5) Develop forms and/or a computer database to maintain consistency. 6) Review and adopt the procedure. 7) Train inspectors.	Effectiveness should be subjectively evaluated by the inspectors who implement the procedures. Inspectors should determine if procedures are too laborious, time-consuming, or ineffective.	N/A

Table 3-3. Best Management Practices for Illicit Discharges Elimination.

Best Management Practices	Description	Suggested Steps for Implementation	Suggested Methods to Assess Effectiveness	Land Use
Conduct "Below-ground" Inspections.	Look for illicit connections and evidence of illegal dumping by making observations from the storm drain system and tracing results upstream to the source.	1) Develop an implementation plan (including staffing and schedules). Identify high-priority areas based on land use and historical data. 2) Inspect the storm drain system - methodologies include: • walk the lines and use storm drain maps to trace dry-weather flows upstream to the sources, or • utilize dye studies or smoke tests as part of the industrial inspections, or • use video cameras in the storm drain lines to find illicit connections. 3) Make observations, and when deemed necessary, use test kits or take lab samples to find chemical constituents or bacteria. 4) Trace flows upstream to source: when source is identified either, • conduct "above-ground" inspections, or • implement enforcement procedures.	Catalog the number and nature of both confirmed and suspected illicit discharges. Also, determine the percentage of illicit discharges that could be tracked to the source. If tracked to source, estimate what percent would have been found if only "above-ground" inspections had been conducted.	Industrial, Commercial and Residential.

Table 3-3. Best Management Practices for Illicit Discharge Elimination.

Best Management Practices	Description	Suggested Steps for Implementation	Suggested Methods to Assess Effectiveness	Land Use
Conduct "above-ground" Inspections.	Investigate businesses that have a high potential for being illicit dischargers, and stop pollutants at the source. *Involves coordination with the industrial component.*	1) Develop procedures and an implementation plan (staffing and schedule). 2) Contact owners and/or operators of high priority facilities, and determine whether illicit discharges originate from site (or provide them with a questionnaire). 3) Provide information (e.g., BMPs for auto facilities or restaurants). Keep accurate records of observations made on site visits. 4) Implement follow-up procedures.	Catalog the number of illicit discharges identified and ceased. Estimate quantity of pollutants intercepted and determine the average number of person-hours required to cease each illicit discharge incidence and remove each unit (volume or weight) of pollutant.	Industrial and Commercial
Coordinate with building inspectors.	Required building inspectors to also check for illicit connections during physical inspections. *This should be coordinated with the industrial component.*	1) Educate building inspectors about urban runoff and familiarize them with the urban runoff program. 2) Develop/modify forms to facilitate inspections. 3) Implement and integrate with current ongoing inspections.	Record (1) number of illicit connections identified, and (2) number of facilities that will not require further independent inspection. Quantify savings.	Industrial and Commercial

Table 3-3. Best Management Practices for Illicit Discharge Elimination.

Best Management Practices	Description	Suggested Steps for Implementation	Suggested Methods to Assess Effectiveness	Land Use
Oil recycling	Provide a recycling alternative for people who need to dispose of used motor oil.	1) Develop an implementation plan and set up communication lines with recyclers. 2) Encourage service stations, part stores, and other related facilities to collect oil for recycle. 3) Provide facilities for citizens to deposit used oil.	Estimate unit cost to recycle each quart of oil. Compare these costs to other expenditures within the program.	All
Disposal of Hazardous Material	Provide an easy way to dispose of hazardous materials (e.g., paints).	1) Develop an implementation plan and set up communication lines with disposers. 2) Set-up a contract to provide for disposal of hazardous materials. 3) Provide a hazardous waste facility to accept small quantities of wastes from all users.	Estimate unit cost to dispose of each unit of hazardous material. Compare these costs to other expenditures within the program.	All
Illicit Discharge Hotline	Develop a hotline where citizens or inspectors cab report occurrences of illicit discharges.	1) Explore telephone alternatives and address staffing needs (may involve contracting an answering service). 2) Create a toll free that is on-line 24 hours/day.	Compare the cost of establishing the toll-free number to the amount of useful information gathered.	All

Table 3-4 Best Management Practices for Construction and New Development

Best Management Practices	Description	Suggested Steps for Implementation	Suggested Methods to Assess Effectiveness	Land Use
Insure that Construction SWPPP are complete	Provide an inspection program to insure that SWPPPs are complete.	1) Training Building Department on how to check Construction SWPPP. 2) Require submittal of a copy of SWPPP with application for Building Permit.	Record the number of SWPPPs checked.	All
Publicize the existence and encourage the use of a Guidance Manual for construction industry	Currently, in California, construction activity disturbing acres or more need to develop a SWPPP. A guidance document describing the process of developing a SWPPP and recommending BMPs should be developed.	1) Publicize a Guidance Manual. Conduct workshops to encourage users.	Record the number of construction industry representatives attending workshop or requesting manual.	All
Develop Guidance Manual for New Development	To prevent increased storm water pollution associated with new development, a Guidance Manual describing BMPs should be developed.	1) Collect and develop New Development BMPs. 2) Compile a Guidance Manual. Present manual at a workshop.	Record the number of developers attending workshop or requesting manual.	All

There are several educational BMPs that can be implemented to help reduce storm water pollution. Although their goals are related, they are diverse in terms of the audiences and pollutant types they address. Since Menu A BMPs are considered mandatory, only a few BMPs which would be beneficial to the whole watershed have been designated. Other educational BMPs should be considered from Menu B.

Table 3-1 lists public education BMPs.

Industry

Since most field studies have shown that industrial areas tend to be associated with high concentrations of pollutants in urban runoff, an effort should be made to help reduce the concentration of pollutants from industrial areas. However, in order to comply with federal and state regulations, certain industrial facilities are required to prepare their own site-specific Storm Water Pollution Prevention Plans (SWPPPs). These plans identify potential sources of storm water pollution at the facility and prescribe a series of control measures. It is likely that the Regional Water Quality Control Board will not soon be able to review all the industrial SWPPPs. As a result, the cities should implement a local program to periodically check SWPPP implementation at industrial facilities in their respective jurisdictions, as described in Table 3-2. By doing so, the cities would become familiar with industrial facility operations and may be able to avoid implementing redundant BMPs on an area-wide basis, and help ensure that the cities' storm water permit provisions are not violated because of improper discharges from industrial sites. These BMPs do not require official facility audits", only to assure that SWPPPs have been developed and updated. Facility audits can be considered under Menu B.

Illicit Discharges and Illegal Dumping

Elimination of illicit discharges and illegal dumping are important elements of storm water pollution control. Illicit discharges are physical connections that inappropriately convey and direct non-storm water flows (that should go to the sanitary sewer) to the storm drain system. Illicit discharges can originate from virtually anywhere. In industrial and commercial areas, illicit connections are a major concern, and industries are required by Federal and State storm water regulations to eliminate them. Older sewered areas, which originally had on-site treatment systems (e.g., septic tanks) may have illicit connections to the stormdrains.

Illegal dumping is the disposal of liquids or other debris into the streets, gutters, storm drain inlets, or other locations where they can wash into the storm drain system. Pollutants resulting from poor housekeeping practices, however, can also be a significant source of illegal dumping in industrial, commercial, and residential areas.

Table 3-3 identifies BMPs which address inspections, recycling programs, public education, and field screening. Recycling/disposal programs should be concentrated in residential and commercial areas. These areas may currently have the fewest programs for recycling hazardous materials. The inspection BMPs focus efforts in industrial and commercial areas.

The BMPs on Menu A should be the elements of a comprehensive illicit discharge detection and elimination program. Failure to include "below-ground" inspections or "above-ground" inspections would likely result in failure to meet regulatory requirements. Thus, at a minimum, it is mandatory that either the "below-ground" and/or the "above ground" inspections be implemented.

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Construction and New Development

To comply with federal and state regulations, construction sites larger a specific size (generally greater than 5 acres) are required to prepare a Storm Water Pollution Prevention Plan (SWPPP). This plan identifies potential sources of storm water pollution at the site and prescribes a series of BMPs to control that pollution. When identifying sources the SWPPP should contain a detailed list of materials and wastes with storage/access areas, loading and unloading plans and a site map showing proposed storm water discharge locations. The Program should develop a standardized guidance manual for the construction industry and develop guidelines for checking SWPPP for the building permit plan checkers. Similar guidance for new development control measures should be developed for plan checkers. Table 3-4 identifies the BMP that address construction and new development.

3.3 Menu B BMPs

Several excellent BMPs were not chosen as part of Menu A despite their merits. Although these BMPs were not chosen as Menu A BMPs (because their local applicability is yet to be confirmed), they may be very effective at reducing pollutants entering Santa Monica Bay. In fact, many of the Menu B BMPs, listed in table 3-5, should be part of a comprehensive plan to reduce pollutants due to storm water discharges. In some cases, BMPs were left in Menu B because a number of them could be used to address a certain pollutants or a specific problem, however only one or two might be needed. Therefore, the Menu B BMPs are recommended but should first be screened to determine their appropriateness. The recommended BMPs are listed in Table 3-5.

In order to help the various cities decide which of the Menu B BMPs should be implemented, a formal decision-making process has been developed. The process involves using a matrix to allow the cities to apply a series of evaluation factors to the candidate BMPs to assess their usefulness. The factors and scoring methodology are described below. The factors should be used to determine if a BMP is appropriate for implementation in a particular city. The BMPs are to be rated using a simple plus or minus scoring system. After rating each candidate BMP relative to all of the factors, the sum total of all the pluses can be used to assign an overall score to each BMP.

3.3.1 Possible Factors for Selecting Appropriate BMPs

Environmental Implications

This factor pertains to the potential environmental impacts or benefits which might be derived from the use of a candidate BMP. Although most BMPs have largely positive environmental implications, the development and operation of some of the larger-scale treatment-based controls and some maintenance-type controls could have adverse environmental consequences which warrant consideration.

Scoring:

\+ Implementation of the BMP will have more positive environmental impacts (i.e., enhances natural resources, wildlife and/or water quality) than negative impacts.

\- Implementation of the BMP could have more negative than positive environmental impacts. For example, installation of a BMP which

Table 3-5: Menu B CANDIDATE BMPS
(organized by function)

	Land-Use	Pollutants Addressed
CANDIDATE "SOURCE CONTROLS"		
1. Control the Use and Disposal of Fertilizers, Pesticides, and Herbicides		
a. Review current certification procedures/requirements for high volume users (e.g. commercial applicators, public agency personnel) and make recommendations for expanding the requirements to better address storm water quality impacts, as necessary.	C,R,T,I	nutrients, organic compounds
b. Restrict use of fertilizers, pesticides, and herbicides (e.g., regulate the sale of household pesticide/fertilizer products)	R	nutrients, organic compounds
c. Encourage the manufacturers & distributors of pesticides, herbicides, and fertilizers to educate the public about the proper use and management of the products.	R,C	nutrients, organic compounds
d. In cooperation with State Dept. of Agriculture and SCS, develop maps of appropriate fertilizer types and appropriate rates and combine with educational program.	ALL	nutrients, organic compounds
e. Establish planting/landscape requirements for various districts and for land uses which encourage use of vegetation, either indigenous or imported that are self sustainable without the need for human applications of fertilizers, pesticides or herbicides.	ALL	nutrients, organic compounds
f. Develop a program to educate architects, landscape architects and engineers about storm water friendly design practices to reduce the need for fertilizers, herbicides and pesticides.	NA	nutrients, organic compounds
g. Collect additional samples for pesticide/herbicide analyses and try to define problem better	NA	nutrients, organic compounds
h. Review current educ. programs related to how vol. use of pesticides/herbicides/fertilizers (e.g., household uses) & make recommendations for supplementing the pgms. with education re. storm water quality impacts & use of non-polluting alternate products.	R	nutrients, organic compounds
i. Evaluate existing O&M (and/or landscape mgmt.) programs for public right-of-ways and public drainage channels and ensure that these programs limit the discharge of pollutants from pesticides/herbicides/fertilizers to runoff	T	nutrients, organic compounds
2. Control Littering and Improper Waste Disposal Practices		
a. Continue to educate the public re: the storm water pollution impacts that result from littering practices.	ALL	BOD, Metals
b. Strengthen enforcement of existing regulations which provide legal authority to control littering	ALL	BOD, Metals
c. Work with citizen action programs to facilitate efforts to reduce littering (e.g. provide litter bags for use in cars).	R,C	BOD
d. Develop a comprehensive solid waste management program to reduce, recycle and control trash and yard debris.	ALL	BOD
e. Continue to provide, collect, and maintain more litter receptacles in strategic public areas, and during major public events. Expand programs as appropriate.	R,C	BOD
f. Educate owners and operators of trucks about the impacts of leaks, spills, and other releases from bulk materials during transportation (pollution effects of materials that are spilled onto roadways or other open space being washed into storm drains or waterways.	C,I	nutrients, oil & grease

Table 3-5: Menu B CANDIDATE BMPS
(organized by function)

	Land-Use	Pollutants Addressed
g. Promote public involvement in "Keep Watershed Clean" campaigns to "adopt-a-creek" programs for specific waterways.	ALL	All
h. Support public involvement on such issues as transportation, planning, recycling, packaging control, etc.	ALL	All
i. Strengthen enforcement of existing regulations and programs regarding spill prevention and response. The objective is to eliminate spills of contaminants onto roadways or open spaces, where they may be washed into storm drains or waterways.	T	nutrients, oil & grease, hydrocarbons
j. Develop and implement a program to ensure that municipal trucks hauling bulk materials do not leak, spill, or otherwise release contaminants onto roadways or open spaces, where they may be washed into storm drains or waterways. Consider educational activities as appropriate.	T	nutrients, oil & grease, hydrocarbons
k. Develop a program to encourage businesses (such as auto supply outlets and service stations) to provide collection services for used automobile fluids. Regulate to ensure appropriate disposal.	C,R	nutrients, oil & grease, hydrocarbons, metals
3. Prevent the Dumping of Pollutants into Storm Sewers and Drainage Channels		
a. Expand programs which provide convenient means for people to properly dispose of oil, antifreeze, pesticides, herbicides, paints, solvents, and other potentially harmful chemicals, and waste materials (recycle if possible).	R,C	BOD, oil & grease, hydrocarbons, nutrients, metals
b. Coordinate with EPA/DEQ to be sure that all potential water quality impacts are adequately considered in the new NPDES permits are issued for any discharges to storm sewers or drainage channels. Include monitoring of all pertinent constituents as a permit stipulation.	ALL	All
4. Control Oil and Grease		
a. Educate commercial/industrial sector re: the effective use of "housekeeping" practices, and oil/grease traps. Include the use of absorbents, cleaning compounds, oil/grease traps, and other techniques for controlling oil and grease in gas stations, automotive repair shops, parking areas, commercial/industrial facilities, and food service facilities.	C	oil & grease, hydrocarbons, metals
b. Educate the public to detect and repair vehicle fluid leaks.	C,R,T,I	oil & grease, hydrocarbons, metals
c. Research, strengthen (if necessary), and enforce regulations which give local jurisdictions the authority to require oil and grease controls in areas which are significant sources (e.g., gas stations, automotive shops, commercial/industrial facilities, parking areas, food service establishments).	C,I	oil & grease, hydrocarbons, metals
d. Develop technical guidance which will facilitate compliance with regulations requiring oil and grease controls (e.g., oil/grease traps, plate separators, synthetic absorbent media, grassy swales) for indus./commercial facilities.	C,I	oil & grease, hydrocarbons, metals
e. Develop and implement maintenance programs for oil/water separators where they do not exist. Ensure maintenance of existing separators.	C,I	oil & grease, hydrocarbons, metals

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Table 3-5: Menu B CANDIDATE BMPS
(organized by function)

	Land-Use	Pollutants Addressed
5 Control Erosion at Construction Sites		
a. Implement a comprehensive erosion control program which includes expanding erosion control requirements/policy city-wide, to incorporating new techniques/practices, increasing inspection and enforcement activities, and educating all affected groups (architects, engineers, contractors, public agency personnel)	O	TSS, nutrients
b. Take a more active role in the NEPA process to better address the topics of erosion potential, proposed erosion and sediment control plans, proposed inspection programs, related environmental impacts, and enforceable mitigation measures minimizing environmental impacts.	NA	TSS, nutrients
c. Establish incentives and/or requirements for contractors/developers to ensure that potential damages from erosion and/or sediment deposition are addressed and paid for	NA	TSS, nutrients
6 Control Erosion of Undeveloped Land, Park Land, and Agricultural Land		
a. Educate farmers, ranchers, and other managers of agricultural and/or open space lands re: the need for and practical methods for erosion control and sediment control	O	TSS, nutrients
b. Develop and implement programs to actively search for, identify, evaluate, and prioritize erosion problems on undeveloped land, park land, and agricultural land	O	TSS, nutrients
c. Develop and implement programs to work with landowners, tenants, and/or public agencies to apply practical erosion control and sediment control practices.	ALL	TSS, nutrients
d. Educate managers and users of park lands and open-space lands re: the need to restrict off-trail activities. Establish and enforce practical, site-specific regulations to control off-trail activities	O	TSS, nutrients, bacteria
e. Develop and implement practical programs for revegetating and otherwise restoring eroding areas (e.g., areas damaged by fires, overgrazing, landslides, improper tillage, and off-road vehicle use).	O	TSS, nutrients
f. Research, strengthen (if necessary), and enforce regulations to require erosion control and/or hydraulic runoff controls on privately-owned vacant or neglected land	O	TSS, nutrients
g. Coordinate with the Soil Conservation Service and local resource conservation programs to support their activities to control erosion and sedimentation problems.	O	TSS, nutrients
h. Restrict livestock from entering stream channels or damaging vulnerable stream bank areas.	O	TSS, bacteria
7 Control Airborne Particles		
a. Educate re: the relationship between air pollution and storm water quality problems. Coordinate with and obtain information from air quality agencies.	ALL	metals, hydrocarbons
b. Cooperate with programs (by others) which seek to reduce particulate atmospheric emissions of pollutants from individual, public, commercial, and industrial sources.	ALL	metals, hydrocarbons
c. Cooperate with programs (by others) which seek to reduce automobile use by various means (e.g., ride sharing, carpooling, public transportation, human-powered transportation).	ALL	metals, hydrocarbons
d. Suggest and encourage inspection and maintenance efforts to reduce automobile atmospheric emissions.	ALL	metals, hydrocarbons

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Table 3-5: Menu B CANDIDATE BMPS
(organized by function)

	Land-Use	Pollutants Addressed
e. Cooperate with public transportation agencies, public agency motorpools, and/or public works departments to provide effective air pollution controls on publicly-owned vehicles and motorized equipment, and/or to use alternative clean-burning fuels where possible	C,R,I,T	metals, hydrocarbons
f. Coordinate with the State's program to control and minimize atmospheric emissions associated with fireplaces and wood-burning stoves, and to educate the public about the regulations	R	metals, hydrocarbons
8 Intensify the Maintenance/Repair of Storm Water Drainage Systems		
a. Develop O&M plan (or review & revise as appropriate, existing O&M plan) for all public storm water facilities (new & existing). Incorporate evaluation of effectiveness into the O&M plan. Provide a means of recording the observations of field inspection & maintenance personnel, and transferring that information to the appropriate dept./agency, so the information can be used to locate and eliminate the source(s) of pollutants	NA	All
b. Require O&M plans for storm water facilities related to new private development	C,R,I	All
c. Develop and implement an aggressive field program to search for, test, remove, and properly dispose of sediment deposits (in drainage channels, streams and storm water storage/retention basins) containing relatively high concentrations of pollutants	NA	All
d. Det. effectiveness of increasing freq of cleaning out inlets, catchbasins, storm sewers, pump stations, channels, & sw retention basins in areas where sediment &/or debris tend to accumulate. Implement improved pgms where approp. (private facilities)	NA	All
e. Research methods of economically and safely detoxifying high concentrations of pollutants at locations where they accumulate, i.e. detention basins, drainage channels, sedimentation trapping facilities, etc. Current information on bio-remediation and solar detoxification may offer some solutions to the disposal of wastes issue.	NA	All
f. Keep up to date inventories and maps of the storm sewer system	NA	All
9 Improve the Maintenance of Major Paved Areas		
a. Develop and implement intensified street sweeping programs in strategic locations (e.g., central business districts, shopping malls, major parking lots, industrial areas) and/or at strategic times (e.g., following extended periods of dry weather)	C,I	All
b. Determine the effectiveness of using street flushers to reduce pollutants in runoff	NA	All
c. Improve street sweeping on a watershed-wide basis (e.g., sweep more areas, more frequently)	ALL	All
d. Provide incentives to property owners to optimize street sweeping of private parking lot and other paved private areas (intensify as appropriate for selected locations).	C,I	All
e. Continue and expand pavement repair and maintenance on streets and parking areas (e.g., fill potholes, seal cracks, apply surface treatments) through a computerized pavement management system to reduce pollutants discharged to the storm drain system.	NA	All
f. Evaluate ways that transportation authorities can reduce pollutant discharges associated with their maintenance and road rehabilitation operations.	NA	All

Table 3-5: Menu B CANDIDATE BMPS
(organized by function)

	Land-Use	Pollutants Addressed
10 Prevent Rainfall and Runoff from Contacting Potential Contaminants		
a. Educate re: the need to keep rainfall and runoff from contacting potential contaminants. Describe typical examples of the problem and practical solutions	ALL	All
b. Develop and implement regulations which require landowners and/or tenants to provide covers (e.g., roofs, tarps) to keep run off of areas which contain contaminants (e.g., chemical storage areas, waste storage areas, contaminated industrial areas), and keep runoff from draining through areas which contain contaminants	I,C	All
c. Develop and implement an aggressive field program to search for, detect, and correct situations where rainfall and/or runoff presently contact potential contaminants	I,C	All
11 Other Source Controls for Industries/Commercial Facilities		
a. Develop and enforce requirements (e.g., structural controls, BMPs, connection requirements, development and redevelopment practices) for existing and developing industries and commercial establishments	I,C	All
CANDIDATE "HYDRAULIC CONTROLS"		
1. Reduce the Volume of Roof Runoff which Enters Storm Sewers		
a. Educate re: the need to minimize the total roof drain runoff volume contributing directly to both storm sewers and drainage channels. Describe basic principles and suggest practical alternatives to minimize their peak rate of discharge	C,I	All
b. Research, strengthen, implement, and enforce regs providing legal authority to prohibit new direct connections (roof drains to storm system) & which require retrofitting existing bldgs, where practical	C,I,R	All
c. Provide education and guidance encouraging architects, engineers, and building departments to implement systems which temporarily retain rainfall peaks on rooftops and/or in retention facilities, minimizing the peak rate of discharge to the storm sewer system or drainage channels.	C,I,R	All
d. Create incentives and make institutional changes to encourage that roof drains not be connected directly to the storm drainage system.	C,I	All
2. Enhance Surface Retention and Infiltration		
a. Educate re: the need to minimize the total volume of runoff and the peak rate of runoff from a given area. Describe basic principles and suggest practical alternative means to enhance surface retention and infiltration.	C,I,R	All
b. Research, strengthen (if necessary), implement, and enforce regulations which give jurisdictions the legal authority to require the drainage designs and systems which minimize the total volume of runoff and the peak rate of runoff from new construction, where local conditions permit.	C,I,R	All
c. Require new commercial, industrial, institutional, and major multi-family residential building complexes to have drainage facilities that incorporate on-site retention and/or infiltration, to assure that neither the total volume of runoff nor the peak rate of discharge to the storm sewer system or drainage channels are increased.	C,I,R,T	All

Table 3-5: Menu B CANDIDATE BMPS
(organized by function)

	Land-Use	Pollutants Addressed
d. Require new public- and private-sector developments to make significant use of design techniques for new buildings, landscaping, recreation areas, walkways, and parking areas to maximize infiltration (e.g., vegetation, groundcover, brick, cobblestones, paving blocks, "grasscrete", porous pavement). Use planted areas and/or grassy swales, where appropriate, to maximize retention and infiltration.	C,I,R,T	All
e. Remove (or perforate) paved bottoms of drainage channels, where practical, to maximize infiltration and reduce peak rates.	NA	All
f. Provide financial incentives to encourage reduction of peak rate and total volume (e.g., impervious area charge rebates)	C,I,R	All
3. <u>Evaluate Hydraulic Design Standards</u>		
a. Review and modify existing design standards (for flood control & water quality facilities) to improve water quality. Research methods being used in other areas and develop applicable regional criteria.	NA	All
b. Develop a program to educate engineers and others of new structural techniques that reduce negative water quality impacts to streams and the storm system.	NA	All
CANDIDATE "TREATMENT BASED CONTROLS"		
1. <u>Provide Sedimentation Facilities to Remove Pollutants</u>		
a. Determine the effectiveness of retrofitting selected storm sewers, sanitary sewers, and portions of the existing POTWs allowing the plants to receive and treat runoff from small storms and strategic portions of large storms.	NA	All
b. Develop a program to encourage owners of selected private areas (parking areas, vacant land, etc.) to route runoff through appropriate control structures: sedimentation basins, grassy swales; oil traps/separators (with periodic cleaning), or others. Provide special incentives (such as tax incentives) and technical assistance.	C,I,O,R	All
c. Provide financial incentives to encourage use of treatment based controls such as detention and retention facilities.	C,I,R	All
d. Develop a program encouraging public/private agencies to research new, more economical methods of improving storm water quality, i.e. compost filters and other existing experimental techniques.	ALL	All
e. Develop a program (possibly financial rewards/public recognition) to encourage individuals/inventors to create efficient, cost effective treatment techniques to replace some of the expensive devices and O&M practices now being employed i.e. oil/water separators, sedimentation man-holes, etc.	ALL	All
2. <u>Employ Vegetation to Remove Pollutants from Storm Runoff</u>		
a. Develop a program to provide financial incentives to property owner's who protect natural areas on their property considered to have valuable water quality characteristics.	ALL	All
3. <u>Provide Infiltration Basins to Remove Pollutants</u>		
a. Determine the effectiveness and potential negative environmental impacts of installing facilities on public property to encourage infiltration of runoff from neighborhood streets (e.g., use street circles, cul-de-sacs, and other curbside areas as infiltration basins or dry wells). Consider potential conflicts with existing policies and regulations. If feasible, install and maintain the facilities.	R	All

Table 3-5: Menu B CANDIDATE BMPS
(organized by function)

	Land-Use	Pollutants Addressed
4. Comprehensive Treatment Based Controls		
a. Determine the feasibility of retrofitting existing drainage and flood control facilities (e.g., storm drain inlets, retention basins, drainage channels) to function as water quality facilities. Retrofits could include installation of in-line sediment trap devices, detention/infiltration facilities or wetlands/riparian vegetation, or modification of retention facilities to detention facilities. If feasible, develop plan and implement.	NA	All
b. Determine the feasibility of building, establishing and maintaining water quality facilities (e.g., detention/retention/infiltration basins, man-made/natural wetlands, etc.). If feasible, develop a plan for conducting the work and implement the plan. Include evaluation methods to assess the performance of the facility.	ALL	All
c. Develop a pilot program for a selected small well-defined sub-basin (which is representative of a typical urbanized watershed) to implement every applicable aspect of the SWMP and conduct monitoring to assess effectiveness of the overall pilot program.	ALL	All

improves water quality could contribute to flooding problems (and impairment of natural resources) if not maintained properly

Effectiveness Regarding Pollutants of Concern

This factor refers to the candidate BMPs ability to afford a reasonable increment of control for the targeted pollutants (i.e., those pollutants that have been designated as being the focus of this storm water quality program - see discussion of pollutants in Section 2.5). It is recognized that each storm water BMP, taken independently, might not have much effect on the overall storm water pollutant loading problem. However, it is intended that each selected BMP should contribute enough toward the overall program to warrant its inclusion.

Scoring:

+ The BMP is expected to control the pollutants of concern identified for Santa Monica Bay.
- The BMP is not expected to control any of the pollutants of concern to a significant extent.

Implementing Agency/Department Acceptability

This factor pertains to how readily various public agencies and/or city departments (i.e., the storm water dischargers, not the regulatory agencies) would accept the measure and implement it properly. In many cases, implementing agencies/departments are more likely to accept a candidate BMP if its implementation would help them meet some other objective and/or if the BMP is an extension of some other program that is already in place or is expected to be implemented.

Scoring:

+ The various implementing agencies and departments would readily accept the BMP and could incorporate it into their existing programs and tasks to accomplish multiple objectives.

- The BMP would not be readily accepted and implemented by the various agencies and departments.

Regulatory Requirements

This factor refers to the candidate BMPs consistency with present and anticipated regulatory requirements. For example, the EPA is presently developing programs and policies which will require the implementation of certain storm water control measures. Candidate control measures that are likely to be required by these or other federal, state, and/or regional regulatory actions should probably be given higher priority (if they appear to be generally cost-effective) in both the screening and the selection process.

Scoring:

+ The BMP meets the intent of the NPDES storm water requirements for Storm Water Management Programs.

- The BMP does not meet the intent of the NPDES storm water requirements for Storm Water Management Programs.

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Public Acceptance

This factor refers to how readily the public would likely accept the BMP. Such evaluations are clearly subjective and depend heavily upon the segment of the "public" that is likely to be most affected, and that public's knowledge, understanding, and attitudes regarding the candidate BMP and its purpose. This latter factor can often be influenced by focused education and public information programs.

Scoring: + The public would readily understand and accept the BMP and participate (to the extent necessary/possible) in ensuring successful implementation.

\- The BMP would not be readily understood and accepted by the public.

Risk/Liability

This factor pertains the risks or liabilities which might accompany implementation of a candidate BMP. In some cases, the problems (e.g., legal, political, institutional, insurance) associated with risk and/or liability might well be more important than their cost or their effectiveness in controlling storm water pollution problems.

Scoring: + Implementation of the BMP includes a minimal amount of risk and liability.

\- Implementation of the BMP could generate a high level of liability for the implementing agency/individual (e.g., an unfenced detention facility in a residential area could be a hazard to small neighborhood children).

Equitability

This factor pertains to the degree to which the candidate BMPs associated costs and resultant benefits would be considered generally equitable. The issue here is one of fairness. In some cases, it may be necessary (or at least expedient) to implement a BMP which is considered to be inequitable (i.e., the party who will pay for the control is not the party who caused the problem and/or will not receive the benefit of the control). Such cases can be avoided by evaluating candidate BMPs relative to this factor.

Scoring: + The BMP is equitable in terms of costs and benefits--costs are borne by those who are responsible for the pollution problem and/or those who benefit from the BMP.

\- Those who pay for implementation of the BMP are not responsible for the problem and/or receive little or no benefit.

Reliability

This factor refers to the candidate BMPs ability to function, if properly implemented, in a predictable manner to effectively control pollutants. This is an important consideration as some controls are not very effective during sizable storm runoff events and/or are unpredictable in terms of their performance.

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Scoring: + It is highly likely that the BMP will control pollutants as it was designed to, or is expected to (as long as it is implemented and maintained properly).

- It is difficult to accurately predict how effective the BMP will be at controlling pollutants.

Sustainability

This factor refers to the candidate BMPs likelihood of being properly implemented over a long period of time after its initial introduction, and the likelihood that the BMP will continue to be effective over a long period of time. This is an important consideration for those BMPs whose effective performance depends on education, volunteer efforts, and/or the consciousness and cooperation of the public.

Scoring: + It is highly likely that the BMP will be effective at controlling pollutants over a long period of time.
- It is less likely that the BMP could be effective over a long period of time.

Universality

This factor refers to the degree to which implementation of the candidate BMP would be practical only if achieved on a very large geographic scale. For example, the lead content of urban runoff has diminished significantly, probably in response to a decade of concerted regulatory requirements and technical actions to reduce the lead content of gasoline, paint, and other products on a nationwide scale. Similar large-scale actions may be capable of reducing other storm water pollutants. Candidate BMPs need to be evaluated in this instance in terms of how universally they would have to be applied to achieve significant benefits. This can be an important consideration, because it can have significant cost, schedule, and legal/political/ institutional implications.

Scoring: + This BMP would be effective at controlling pollutants regardless of how extensively it is implemented in the Santa Monica Bay area.
- In order to be effective, it will be necessary to implement this BMP in every basin of the Santa Monica Bay Metro area.

Implementation Costs

This factor refers to the approximate magnitude of the various costs involved in the initial implementation of a candidate BMP. The cost elements to consider may vary significantly for each BMP. Implementation costs considered here include such one-time cost items as planning, design, land acquisition, construction, and equipment acquisition.

Scoring: + It would be relatively inexpensive to initiate implementation of the BMP.

- The initial cost of implementing the BMP is expected to be fairly expensive.

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<u>Operational Costs</u>

This factor refers to the approximate magnitude of the various costs associated with operations, maintenance, repair, support services, and periodic equipment replacement (where applicable). For some BMPs, this would include labor, electric power, fuel, replacement parts, monitoring programs, laboratory services, consulting services, legal services, and other continuing costs.

Scoring:
- \+ The continued cost of implementing/maintaining the BMP over time is expected to be inexpensive.
- \- The continued cost of implementing/maintaining the BMP over time is expected to be fairly expensive.

<u>Flexibility for Phased Implementation</u>

This factor refers to whether or not the BMP can easily be phased for implementation over the 5-year term of the NPDES permit.

Scoring:
- \+ It would be easy and possible to phase this BMP for gradual implementation over the life of the permit. For example, the BMP could be implemented in a pilot or demonstration study first, followed by full-scale implementation if the pilot test is successful.
- \- In order to be effective, the BMP would have to be implemented initially and continuously at a full-scale rate.

<u>Ability to Demonstrate Compliance</u>

It will be necessary to demonstrate the program's success and compliance with the NPDES permit by documenting tasks which have been accomplished and by evaluating the effectiveness of the BMPs when possible. In selecting BMPs, it is important to consider the ease of demonstrating compliance, either qualitatively or quantitatively.

Scoring:
- \+ It would be easy to demonstrate to the RWQCB and other regulatory agencies that the BMP is effective at meeting the goals and objectives of the NPDES requirements (i.e., improving storm water quality).
- \- It would be time consuming or expensive to demonstrate compliance and assess the effectiveness of the BMP either quantitatively or qualitatively.

3.4 MENU C BMPs

Menu C BMPs are BMPs that may help reduce storm water pollution in an indirect way or for a specific circumstance. Table 3- 6 lists the Menu C BMPs. These BMPs can be implemented if the circumstances for implementation are correct. For example, Menu C BMPs 3a, b are directed at controlling leaks from storage tanks. There are already regulatory requirements regarding tank leaks. Therefore, this BMP is only important if there is concern that the other regulations are not sufficient. Another example is Menu C

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TABLE 3-6: MENU C CANDIDATE BMPS (organized by function)	Land-Use	Pollutants Addressed
1 Control Littering and Improper Waste Disposal Practices		
a. Educate community residents about the advantages of composting and about proper composting techniques.	R	Bacteria, nutrients
b. Provide neighborhood compost sites, city operated or citizen operated. Post instruction signs, or organize local volunteer organizations to instruct residents and to maintain the site.	R	All
2 Control Leaks from Gasoline, Fuel Oil, and Chemical Storage Tanks		
a. Educate re: environmental impacts resulting from leaks and spills from gasoline, fuel oil, and chemical tanks (above and below ground).	I,C	oil & grease, hydrocarbons, metals
b. Coordinate with efforts (by others) to intensify the implementation of existing regulations calling for improved new tanks designs (e.g., double walls, monitoring locations), an aggressive self-monitoring program to be conducted by landowners and tenants, and implement a strategically focused spot-check program to search for, identify, test, and control leaking storage tanks.	I,C	oil & grease, hydrocarbons, metals
3 Control Human and Animal Wastes		
a. Educate the public through brochures re: the need to clean up and properly dispose of pet wastes.	R	bacteria
b. Implement and enforce leash laws and pet waste cleanup ordinances in selected public-use areas.	R	bacteria
c. Provide informational signs and dispense doggie litter bags in parks and other selected areas.	R	bacteria
d. Educate re: the need for proper management of wastes from suburban livestock (e.g., horses, chickens) and agricultural operations in the watershed.	I	bacteria
e. Implement a program to monitor septic tanks and cesspools, to identify failing systems, and to require repair or replacement of failing systems.	R,C,I	bacteria
f. Coordinate with Department of Agriculture to control discharge of wastes into the storm sewer system from confined animal feeding (CAF) operations.	I	bacteria

C - Commercial, R - Residential, T - Transportation, I - Industrial, O - Open, NA - Not Applicable

BMPs 4 a-f. These BMPs only need to be implemented if high levels of bacteria and fecal coliforms are found in storm water.

3.5 THE SCREENING PROCESS AND DEVELOPMENT OF THE BMP PLAN

The above sections present the tools necessary to conduct a BMP selection process utilizing a methodical approach. This approach takes into account factors that should be utilized to select a defensible set of BMPs for implementation. Section 2.5 presented a brief discussion of water quality parameters of concern and land-use considerations that should be consulted when evaluating the factor "Effectiveness regarding pollutants of concern." When evaluating the BMPs most agencies that we have worked with in the past have chosen to convene a number of individuals from the affected departments within the agencies and have each of them participate in workshops to set-up and define the water quality problems and define the BMP selection process.

There are a number of ways that co-permittees could proceed with an evaluation and selection of appropriate BMPs. Each co-permittee could evaluate the BMPs separately, with their own decision makers, and then come together to discuss and decide which BMPs should be implemented watershed wide. Or alternatively, the co-permittees could conduct the screening process as a group and then evaluate which BMPs they should consider for their areas. For many of the BMPs, it would probably make the most sense to implement them basin-wide by an overall program manager (i.e., Los Angeles County), while others may need to be implemented basin-wide but by each co-permittee, and still others will be implemented individually and not basin-wide.

In screening evaluations conducted in Eugene and Portland, another approach was to screen the selection factors first. The decision makers sometimes chose to combine factors (e.g. Implementation Costs and Operational Costs into just Costs) or to select the top 5 or 6 factors which they felt were the most important to selecting the BMPs. After this was completed, some also chose to weight the scores for 2 or 3 of the 5 or 6 factors which received the most votes as important selection factors. Those that were weighted higher received higher scores for each positive vote. Finally, in some of the evaluations, the factors were not just evaluated as either positive (+) or negative (-), but a neutral rating was also established. When this was done, summed negative ratings were subtracted from summed positive ratings to achieve a factor score from the group scoring the BMP. Then the weighting was applied to the factor score, before the total score was recorded and combined with other factor scores.

Once the rating and scoring procedures are decided upon and completed, co-permittees will then have a list of BMPs with overall scores. The next step is to then decide at what score should BMPs be implemented. It is our opinion and experience that co-permittees should not try to implement too many BMPs at one time. Our approach in Portland was to develop a histogram plot of the scores and to look for a break point in the histogram. This occurred at about 35 control measures. We felt that this was reasonable number of BMPs to consider implementing over a 5-year period; especially when one considers that many of the BMPs can be combined into more comprehensive BMPs, such as having one public education program which targets the individual education BMPs selected for implementation. The scores of the BMPs selected for implementation can also be used to guide the priority for implementation.

Once the BMPs are selected, detailed descriptions of the BMPs should be prepared. The descriptions should include a more detailed description of the BMP, identification of the staff that will be responsible for implementing the BMP (including getting it started and maintaining it), the funding requirements, schedule for implementation and ongoing activities (i.e., catch basin cleaning frequency), and how the implementation of the BMP will be documented and evaluated. These descriptions should be either prepared by the implementing departments within the perimeter's agency or at least circulated within that department for comments and input. Once the BMP descriptions are prepared and compiled, the co-permittee agency should seek and document approvals and commitments by the managers of the co-permittee agency to implement and/or support the implementation by others (i.e., Los Angles County for watershed-wide measures) of BMPs.

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This document has recommended a list of BMPs that should be implemented now, and a list of BMPs that should be carefully considered for implementation either now or during the next several years. The BMPs recommended in Section 3 are ones that are considered to be a base set of BMPs that should be completed as a part of an overall storm drainage quality management plan and be implemented basin-wide.

In this document, we have also described a method for carefully evaluating and selecting BMPs from a second list (Menu B). It is expected that a number of these measures should be implemented as a part of an overall storm drainage pollution management plan. However, each agency and City should carefully consider each of these measures in relation to their own identified problems and constraints. It is likely that some of these measures would be implemented by only some of the agencies or Cities in the watershed, while others may be implemented watershed-wide. We believe that agencies and Cities should evaluate this list and make selection of BMPs from the list (or any added BMPs) within 6 months. Implementation of the measures should be based upon prioritizing the BMPs for implementation during the screening process.

Participating agencies and Cities should carefully monitor the implementation of BMPs and monitor their effectiveness. Monitoring for effectiveness does not imply that water quality testing needs to be completed, but does imply that some measure be developed for each BMP to gage its effectiveness (i.e., public surveys for education campaign effectiveness, or keeping records on pounds of materials removed during street sweeping and catchbasin cleaning programs), and document that the BMP has been implemented. This "evidence" should be compiled in an annual report prepared by the County with regards to the County's NPDES permit with the Regional Board.

Finally, it is imperative that a carefully designed and implemented monitoring program be implemented. A suggested program was prepared as a part of this effort (Strecker and Stenstrom, 1993). The purpose of the program would be to better define the water quality characteristics of storm drainage discharges to Santa Monica Bay from various land-uses and overall loadings from large mixed drainages. This will enable Agencies and Cities to prioritize water quality problems and BMPs to address those problems in future management plans to be developed under the NPDES permit program. It will also begin to develop a base to which future water quality can be compared to.

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6.0 APPENDIX BEST MANAGEMENT PRACTICES SPECIFIC FOR SANTA MONICA BAY

The first parts of this report have described a consensus building procedure for selecting best management practices (BMPs) for Santa Monica Bay. It is an adaptation of a general procedure that is applicable to almost any watershed and should be used to develop the final set of BMPs for the Bay. In spite of our recommendation to follow this procedure, there are several BMPs that have been studied or discussed during the course of this project, which have high applicability to the Santa Monica Bay Watershed. The authors would like to present these BMPs for further consideration and to provide a reference to existing or previous activity associated with the BMP. Pervious experience with the BMPs within the Bay watershed should be helpful in the consensus building. Several other BMPs are also presented which may not be specific to the Bay, but have been discussed over the course of this project and deserve further consideration. It is hoped that this appendix will preserve the work done in developing and studying them, and that this information will be used in the previously described consensus building procedure.

The following BMPs are recommended. They are divided into two categories; the first category is for BMPs which can most likely be implemented with existing knowledge and do not require pilot studies or demonstration projects prior to implementation. The second category includes BMPs that probably require a demonstration project before wide scale implementation.

6.1 BMPs SUITABLE FOR IMMEDIATE IMPLEMENTATION

The following BMPs are recommended for further consideration and implementation in the Santa Monica Bay watershed. The authors believe that they can be implemented based on existing information, which includes experience from other areas as well as knowledge within the technical staff of the Santa Monica Bay Restoration Project, its contractors and technical advisory committee.

<u>Public Education and Outreach Programs</u> Public education is the key to managing many problems associated with urban runoff pollution. Public education programs are preventive in nature and therefore tend to be less expensive. It is always less expensive to prevent an urban runoff pollution problem than to treat it after it has occurred. Active public participation is required to mitigate many problems such as illegal dumping, littering and other undesirable practices. Therefore, education programs should have very high priority. Several programs are underway already within the watershed. This list is not inclusive and is meant to complement and/or note the public education programs currently being developed and implemented by the City and County of Los Angeles, as well as other cities within the Santa Monica Bay Watershed.

- A watershed-wide brochure on water quality protection and NPDES permit information could be developed and distributed to residents (see menu A in the text of the report). An alternative is to develop a brochure that contains the basic education principles while leaving room for various cities and agencies to customize the brochure by including information about their specific programs or concerns. Masters of this alternative brochure could be distributed to cities and agencies for customization and publication.

- Construction is a large source of suspended solids that eventually become entrained in urban runoff. There are many construction techniques that can minimize suspended solids pollution. Education and training programs need to be developed to educate contractors and inspectors to insure that the appropriate building techniques are used. There are many Universities and Colleges in the Santa Monica Bay Watershed area that have extension programs and other education mechanisms that can be employed to provide this training. A local contractors organization (i.e. Association of General Contractors) could be utilized to help develop a manual or other educational materials describing proper erosion and pollution control practices at construction sites

- Automotive businesses are large potential sources of urban runoff pollution, especially for hydrocarbons and metals. Education programs including workshops, extension classes, and inclusions of new materials in existing automotive repair school curricula, are mechanism to educate businesses about practices to minimize urban runoff pollution.

- A "hot line" can be set up to allow citizen reports of urban pollution events. Its success would be directly related to the follow-up action (e.g., enforcement, clean-up) by appropriate agencies.

Public Participation Programs Programs to take advantage of volunteerism can be developed. Such programs could be used to clean up problem areas, stencil storm drains, post signs and foster other activities that reduce urban runoff pollution. Several Issues must be addressed prior to implementation, such as safety of the volunteers and liability.

Storm Channel Cleaning Late in the dry season, Ballona Creek and other stormwater channels with dry weather flow are heavily covered with debris and algae rafts. These algae rafts are dense and anaerobic. A proposed BMP is to clean the Creek and other channels by removing the debris and rafts. The debris and algae can either be removed or reduced in magnitude. In this way "shock" loading to the Bay during the first heavy rainfall will be reduced.

If the proposed Ballona Creek treatment plant is constructed, it might be used in conjunction with the proposed cleaning program. In this case algae mats and sediment could be mobilized and pushed toward the plant. The plant, probably composed of physical processes such as screening and sedimentation and located at the old stormwater diversion facility on Ballona Creek, could be designed to remove grit (silt) and debris. Through such treatment the mass emissions of potential toxics adsorbed to the surface of particulate are reduced, and that trash collection on the beaches is minimized. Reduced debris has beneficial impact on marine life (e.g., avoidance of mammals swallowing clear plastic bags, etc.).

Erosion Control The Malibu Creek watershed, due to its size and steep slopes, contributes a large fraction of the particulates entering the Bay, and is largely open or undeveloped. To control particulates, construction codes that minimize erosion need to be implemented. Such codes and practices should be enforced through an active inspection program, which is particularly important during the rainy season.

NPDES Enforcement After NPDES permits are required it will be difficult for the Water Quality Control Board to insure that all businesses required to obtain permits actually obtain them. To assist the Board, a database can be created from the tax assessor's databases, business code databases and SIC codes. This database can be compared to the Board's permit database and businesses not having permits can be reminded to obtain them. If they do not cooperate their non-compliance can be reported to the board for action.

Oil Recycling Oil recycling programs are still inadequate and more facilities that will accept used oil are needed. An ordinance requiring businesses selling more than a certain minimum amount of oil to accept used oil is one way of creating more recycling facilities. Also an ordinance restricting sales of oil at very small facilities (convenience stores) would force sales from to stores with recycling facilities.

Storm Drain Inlet Identification Stenciling storm drains to identify them and protect them from accidental contamination can be done County-wide. The experience in Santa Monica can be used as a model for the county-wide program. It should be possible to use volunteers or to use this as a public service activity.

Storm Drain Effluent Dispersion Many storm drains (e.g., Pico-Kenter) terminate upstream, far from the beach water line. These drains actually encourage human contact and should be extended to meet the surf line, or extended beyond the surf line if dilution is desired. In this way there will be less risk to beach goers. Pico-Kenter storm drain has been extended to provide this dilution and this experience can be used in the further evaluation and development of this BMP.

Street Sweeping and Disposal Practices A county-wide approach to disposal practices of could be employed to insure street sweeping and certain basin materials are disposed properly and to minimize losses of debris during transportation. Street sweeping practices can be reviewed to ensure that maximum benefits are obtained.

Improved Highway Runoff Control Runoff from highways is usually 2 to 4 times greater in contaminant concentration than runoff from other land uses. Controlling pollution from this land use is potentially much more cost effective than controlling pollutants from other land uses such as single-family residential. Programs could be developed with Cal Trans and others responsible for street and highway maintenance to insure that new construction and retrofit projects use the best techniques for minimizing urban runoff pollution.

BMP Construction Manual A BMP construction manual could be developed with a general contractors' organization to further BMP construction technology. Several similar manuals have been developed for other areas or disciplines and may be adaptable for this use.

Illegal Dumping and Illicit Stormdrain Connection Existing techniques for regulating and monitoring dumping and sewer/stormdrain connections can be reviewed to insure that maximum benefits are obtained. A model inspection/investigation manual could be developed for county-wide use by appropriate agencies. The manual could provide specific details on procedures, health and safety requirements and inspection practices. The manual would serve to facilitate the early implementation of this important BMP.

6.2 BMPs REQUIRING DEMOSTRATION PROJECTS BEFORE IMPLEMENTATION

Porous Pavements Porous pavement parking lots need to be demonstrated to public agencies and consulting firms in order to evaluate and prove their effectiveness. Currently, many agencies believe that porous pavement parking lots are unmanageable, and this perception needs to be changed, or new techniques need to be developed. There are other practices potentially useful for parking lots that can be implemented. Parking areas have very high emission rates per unit area and their management is probably one of the more cost effective techniques for minimizing urban runoff pollution. Additionally, parking lots generate income that can recover the cost of the management.

Infiltration Areas Grassy swales (green belts) have been used with success in many areas but are not considered a proven technology in Los Angeles. One or more demonstration projects quantifying pollutant removals are recommended.

Vehicle Inspection Programs Smog inspection programs are largely ineffective for certain problem vehicles, which have high mass emissions and whose owners avoid the intent of the inspection by finding dishonest inspectors or defeating controls after an inspection. The gaseous emissions from vehicles contribute to urban runoff pollution as they settle on land or are rained out. It is estimated that the majority of pollutants from automobiles in Los Angeles are produced by older vehicles and it is very likely that automobiles are one of the greatest contributors to urban runoff pollution. Smog inspection programs have no requirements at present to control dripping or leaking vehicles.

It may be economically impractical to require leaks to be fixed, especially for older cars. Never the less, smog inspection programs can be improved; for example, there is a proposal to change the existing program of static inspections to moving vehicle inspections, or requiring independent inspectors who do not also perform repairs. Recent programs to remove old vehicles by allowing industries to purchase them to obtain air pollution credits should be encouraged since reduced hydrocarbon emissions in urban runoff will undoubtedly occur.

Stormdrain Water Disinfection Two recent studies (Green, 1992; Gold et al., 1993) have shown the presence of fecal contamination in stormdrains. An inspection program that can target illegal connections and leaks will help eliminate this problem. Indicator water quality parameters are required.

Detention Basins Detention basins are now a well-developed technology for stormwater pollution control. One or more demonstration projects are required to convince agencies and the public of their value in Los Angeles.

Stormwater Infiltration Dry weather flow constitutes the vast majority of urban runoff pollution during the April to September periods. Dry weather flow can be reduced by using infiltration zones in regions near stormdrains. For example, Ballona Creek could be equipped with a porous low flow channel to allow infiltration. Further study to determine the feasibility, amount and impacts of the infiltration are required.

<u>Diversion of Dry Weather Flow to Sanitary Sewers</u> Dry weather flow in particularly sensitive areas or areas without proper stormdrain termination (e.g., Pico-Kenter) could be diverted to sanitary sewers. This option has several advantages. Sanitary facilities usually have lower flow rates in the summer than in the winter, when sanitary sewer infiltration occurs. The reduced summer sanitary flow may provide capacity to allow several stormdrains to be diverted. In wet weather the diversion can be terminated by automatic monitoring equipment. The demonstration project at Pico-Kenter is a good example of this practice and should be further investigated and developed to allow its more widespread use. Spill detection technology, to prevent the introduction into the sanitary sewer of a spill, such as gasoline, may be required.

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Santa Monica
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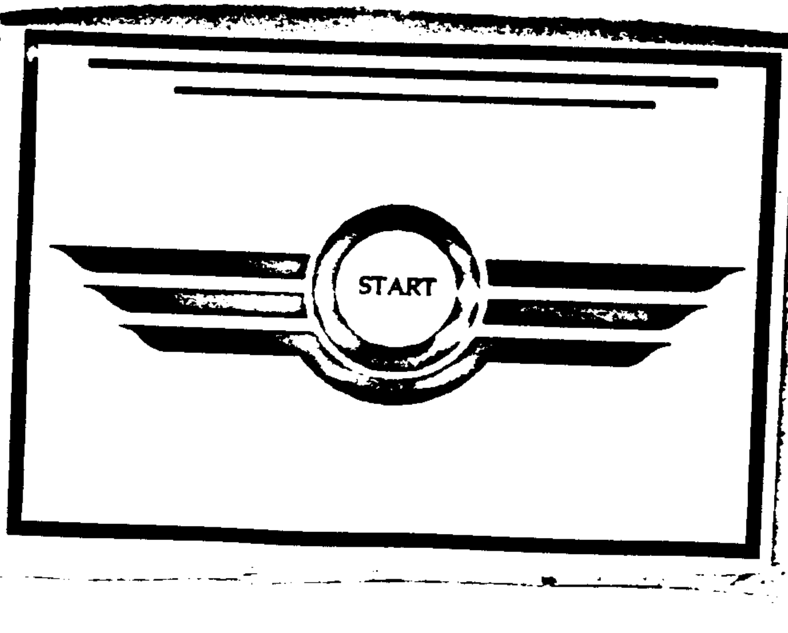
PROJECT



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ASSESSMENT OF STORM DRAIN SOURCES OF CONTAMINANTS TO SANTA MONICA BAY

VOLUME V
TOXICITY OF DRY WEATHER URBAN RUNOFF

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This report represents Volume V from a series of reports which form the basis of a pollution assessment and monitoring plan for Santa Monica Bay. Volume I describes land use statistics, catchment areas, existing water quality monitoring data, rainfall data, NPDES permit information for existing permits to storm drains, and contaminant mass emission estimates, based upon land use modeling. Volume II reviews sampling techniques, including sampling equipment, and other aspects associated with sampling such as a quality assurance plan. Volume III presents the proposed monitoring plan. Volume IV addresses best management practices as they apply to the Santa Monica Bay area. This volume describes dry weather flow water quality and chronic toxicity.

The contract was performed by UCLA under the direction of Professor Michael K. Stenstrom of the Civil and Environmental Engineering Department, and Professor I.H.(Mel) Suffet of the Environmental Health Sciences Department. There were several key individuals from both UCLA departments who assisted with the project; they include Kenneth Wong, Linda Schweitzer, Mario Capangpangan and Ed Ruth.

The project was conducted in parallel with a project sponsored by the American Oceans Campaign. Samples were collected, analyzed and toxicity testing was performed by the funding provided through this project. Special organic analysis were funded by the American Ocean Campaign.

The contractors are grateful for the assistance of many individuals. The Santa Monica Bay Project and LA Regional Water Quality Control Board staffs were most helpful. We extend our special thanks to Dr. Guang-yu Wang, Ms. Catherine Tyrrell, Dr. Rainer Hoeinke and Mr. Xavier Swamikannu. The Los Angeles County Department of Public Works and the City of Santa Monica were helpful in permitting the sampling. We are also indebted to the members of the Technical Advisory Committee of the Santa Monica Bay Project and others who reviewed and commented on our draft reports.

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ABSTRACT

Five storm drains representing different types of land use and hydraulics were sampled over an extended dry weather season. Samples were taken for routine water quality analysis as well as short-term, chronic toxicity analysis. The five drains had water quality approximating secondary treated wastewater effluents for many parameters, and were somewhat higher for other parameters, such as COD, TSS and turbidity.

Four drains were tested with three marine species for toxicity and varying amounts were found in all four drains. The most toxic drain had the least flow rate, and it is suspected that the higher toxicities are associated with stagnant drain water and lack of dilution from flushing which occurred with the other drains.

One storm drain was analyzed in depth to ascertain the source of the toxicity. Inconclusive results were obtained in that different most likely causes were found from three different samplings. In one case the cause was consistent with the presence of organic chemicals. On another occasion the cause was consistent with the presence of toxic metals. On another occasion the toxicity disappeared after 24 hours, which is consistent with the presence of an oxidizing agent, such as residual chlorine from disinfection.

The toxicity was generally present in samples that contained more than 10% and less than 50% storm drain effluent. This suggests that a 10 fold dilution would reduce the toxicity below the detection limits used in this analysis. A brief review of the literature to determine ways of estimating the initial dilution of a storm drain found no reliable, proven methods for low flow conditions. For high flow conditions, jet nozzle methods might be applicable, but must be verified.

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1.0 INTRODUCTION

This report presents the results of a one-year investigation of the toxicity of dry weather urban runoff to Santa Monica Bay. It is one of many projects sponsored by the Santa Monica Bay Restoration Project to ascertain the status of contaminant inputs to the Bay, with the eventual goal of developing a comprehensive action plan to restore and maintain the quality of Santa Monica Bay.

Dry weather runoff is a potential problem to Santa Monica Bay. Dry weather runoff is a somewhat confusing term, since "dry weather" suggests no rainfall and therefore no stormwater runoff. Storm drains in Los Angeles, with perhaps very minor exceptions, are separated from sanitary drains. The sanitary flow is conveyed to the various treatment plants through separate drains and sewers. One wonders why storm drains have flow when there is no rain and no wastewater discharge.

The answer is that certain wastewaters are discharged to the storm drains. There are also other inputs such as runoff from landscape irrigation, natural seeps and springs, uncontrolled and/or unregulated discharges, including illegal discharges, and treated secondary effluents. The discharges are sometimes referred to as "nuisance waters," although the magnitude of the discharges to the various storm drains in the Los Angeles Basin are much greater in magnitude than the traditional concept of nuisance waters.

Discharges entering storm drains include legal, NPDES permitted discharges. These might be cooling tower blow down, such as occurs with air conditioning systems, land dewatering, which is sometimes necessary when constructing new buildings, and discharges from facilities that use water without contaminating it, such as cooling towers. Cooling tower discharges should be free of most contaminants. They may be elevated in salt concentrations but should have a total organic carbon (TOC) concentration of 5 mg/L or less, and have no residual chlorine or corrosive inhibitors.

These permitted, normally harmless waters and wastewaters comprise the dry weather flow into Santa Monica Bay. Potential problems exist with these discharges. One potential problem is that the dry weather flow may hide or disguise an unpermitted, illegal, discharge. Several examples of sanitary sewer breaks have been documented in the course of the projects sponsored by Santa Monica Bay. Another problem is that the dry weather flow may scour pollutants from surfaces as they flow to the Bay. Emissions from vehicles maybe scoured and transported to the Bay through this mechanism. Also trash and other debris maybe washed into the Bay by dry weather flow.

The purpose of this investigation was to ascertain the potential aquatic toxicity and water quality of the dry weather flows just prior to their entering the Bay. Five storm drains were monitored for many water quality parameters, including conventional contaminants and analysis for a broad range of organics using gas chromatography/mass spectrometry (GC/MS). The drains were Pico-Kenter, Ashland Avenue, Ballona Creek (at the Inglewood overpass), Centinela Creek (at the Inglewood over pass), and the Sepulveda Channel as it enters Ballona Creek, just east of the Inglewood over pass.

Marine aquatic toxicity was assessed for four storm drains using three species (the Centinela Drain was not tested for toxicity). A screening assay was first performed to determine which drains had the highest toxicity. An in-depth analysis was later performed to attempt to determine the type of contaminants causing the toxicity in the runoff.

The toxicity analysis were performed at the Southern California Coastal Water Research Project (SCCWRP) in their Long Beach laboratory. The other analysis were performed at UCLA, principally in the Department of Civil and Environmental Engineering and the Department of Environmental Health Sciences.

The bulk of the results are contained in appendices. Appendix B contains all the water quality data. Appendix D contains the toxicity data and the interpretation of the results. Appendix E contains the GC/MS data.

A parallel study was performed under partial sponsorship of the American Oceans Campaign (Suffet *et al*, 1993). This parallel study provided funding to perform the GC/MS analysis.

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2.1 Sampling Location

The selection of storm drains as sampling locations of this project were based on the types of land-use, location and ease of sampling. Five storm drains in the Santa Monica Watershed were selected for sampling: Pico-Kenter; Ashland Avenue; Ballona Creek at Inglewood; Sepulveda Channel at Ballona Creek, and Centinela Creek at Inglewood (the first two storm drains were named with reference to their neighboring streets). Figure 1 shows the location of these five storm drains.

Originally only three storm drains were required in the request for proposals. A fourth storm drain was added in order to make a more complete evaluation of different land uses. Later, a cooperative sampling program was started with a project funded by the American Oceans Campaign (Suffet *et al.*, 1993), which required the addition of a fifth storm drain. Centinela Creek was selected as the fifth storm drain. Toxicity testing was never performed at this drain.

2.2 Sampling Procedures

Samples were bailed from the storm drains using a stainless steel bucket. Morning and afternoon grab samples were collected into a 2- or 4-L glass bottles, composited, and stored in ice chests with blue-ice packs while being transported to the laboratory. Samples were collected from the middle of the open channel from Ballona Creek, Centinela Creek (low flow channel) and the Sepulveda Channel. At Pico-Kenter, they were collected from the wet well installed to divert low flow to the sanitary sewer. At Ashland Avenue samples were withdrawn from an open access hole on Neilson Avenue in Santa Monica. All samples were stored in a refrigerator at 4°C until the time of analysis. The time between sample collection and analysis was within the holding times recommended by the US EPA (1983).

2.3 Materials

Chemicals. Analytical or better grade chemicals and HPLC grade solvents (e.g., methanol and methylene chloride) were used for the chemical analyses and solid phase extraction. All these materials were obtained from Fisher Scientific (Tustin, CA).
SPE columns. The 1000 mg C18 columns used were obtained from Burdick and Jackson (Muskegon, MI).

2.4 Conventional Chemical Analysis

Conventional water quality analyses were performed on the collected storm drains samples. The analyzed water quality parameters are listed in Table 1. All the parameters, except for UV absorbance, were analyzed according to the *Standard Methods* (1989) procedures. The

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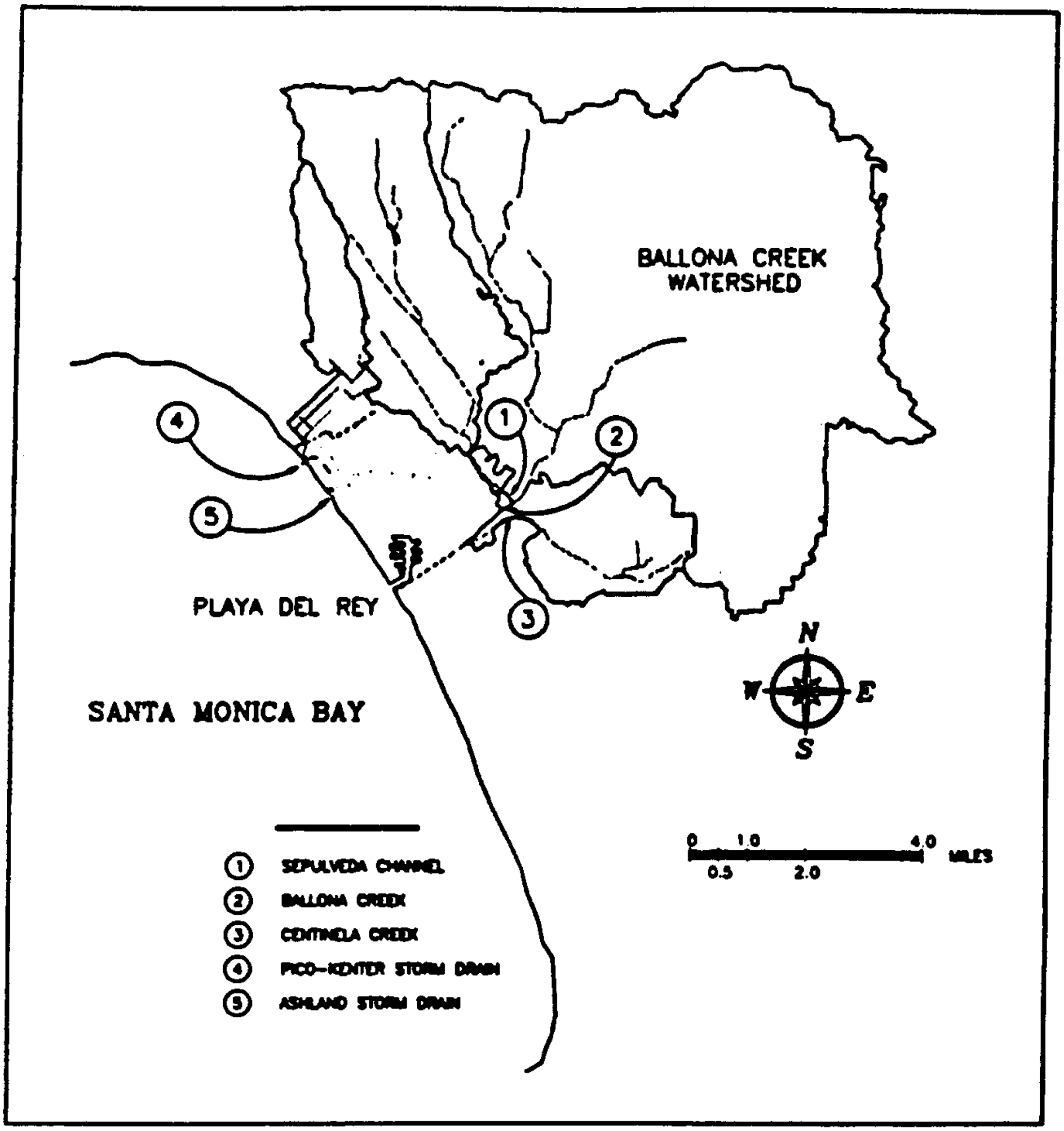

Figure 1. Sampling location of the five selected storm drains.

UV-absorbance of the collected storm drain samples (filtered) was measured at a wavelength of 254 nm, using Hewlett-Packard HP 8452A Diode Array Spectrophotometer. The measured UV-absorbance is a qualitative measure of the amount of organic carbon in the samples.

Table 1. Conventional Water Quality Parameters.

Water Quality Parameter (1)	Unit (2)	Method (3)
Laboratory Analysis		
Alkalinity	mg/L as $CaCO_3$	Standard Method 2320.B
Hardness	mg/L as $CaCO_3$	Standard Method 2340.C
Ammonia	mg/L as NH_3-N	Standard Method 4500-NH_3.F
Nitrite	mg/L as NO_2-N	Standard Method 4500-NO_2.B
Total Dissolved Solids (TDS) Dried at 180°C	mg/L	Standard Method 2540.C
Total Suspended Solids (TSS) Dried at 105°C	mg/L	Standard Method 2540.D
Volatile Suspended Solids (VSS)	mg/L	Standard Method 2540.E
Chemical Oxygen Demand (COD)	mg O_2/L	Standard Method 5220.B
Dissolved Organic Carbon (DOC)	mg C/L	Standard Method
UV absorbance (at λ = 254nm)		Hewlett-Packard HP8452A Diode Array Spectrophotometer
Conductivity	µmho/cm	Standard Method 2130.B
pH		
Turbidity	NTU	Standard Method 2130.B
Field Analysis		
Dissolved Oxygen - Probe (DO)	mg/L	Standard Method 4500-OG
Temperature	°C	Standard Method
% Salinity	%	

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2.5 Velocity Measurement

The velocities of the flow across Ballona Creek, Sepulveda Channel and Centinela Creek were measured during each sampling period. The velocity at Ballona Creek and Sepulveda Channel were measured using a Marsh McBurney velocity meter at approximately five foot intervals across the channel. The water depth was also recorded at the same time and location. The velocity at the Centinela Creek was determined differently. Several small floating objects (bits of Styrofoam cup, etc.) were timed and the results were averaged. The depth of flow, which was too shallow to permit the use of the velocity meter, was also measured. The obtained data were used to calculate the average flow rate through the channel.

2.6 Solid Phase Extraction

The C18 SPE method described by Mount and Carnahan (1989) was the basis of our fractionation procedures to isolate non polar organic compounds from the collected storm drain samples. However, instead of using the proposed elution solvent system of methanol-water mixtures, a modified elution solvent system which involved mixtures of methanol-water and methanol-methylene chloride was used. A detailed description of the development of this modified elution system is given in the Appendix A and also described by Lau and Stenstrom (1993). The modified procedure was required because of the poor recoveries observed by the Mount and Carnahan procedure. The following procedures were used to fractionate non- polar organic compounds from the collected samples.

Filter blank. A 1 µm glass fiber filter (Whatman GF/B) was prepared by first acid washing with 10% HNO_3 and then rinsing thoroughly with deionized water. Next, approximately 200 ml of deionized water was passed through the filter, and the last 30-50 mls of filtrate were collected for the filter toxicity blank. The storm drain sample was then filtered.

Column blank. The 1000 mg C18 SPE columns were conditioned by pumping through 25 mls of HPLC grade methanol through the column at a flow rate of 5 mls/min. Before the sorbent dried, approximately 50 mls of deionized water were pumped through the column. The last 25-30 mls deionized water were collected for a column blank toxicity test. Pumping continued until no water emerged from the column.

Elution blank. Three elution blanks were collected from the prepared column by pumping 2 x 1.0 ml of each of the following solvents: 50% (v/v) methanol in water, 100% methanol, and 50% (v/v) methylene chloride in methanol, through the column and the eluates were collected in a clean glass vial as the SPE elution blanks. The column was allowed to dry between each elution.

SPE fractionation. The same C18 SPE column was again conditioned with 25 mls of methanol and 25 mls of deionized water. Before the sorbent dried, 1000 mls of filtered storm drain sample were pumped through the column at a rate of 5 mls/min. A 30 ml sample of the post C18 column effluent was collected after 500 mls of the sample passed through the column. The sorbent was dried by continuing the pumping after the entire 1000 mls sample passed through the column. Then 2 x 1.0 ml of 50% (v/v) methanol in water, 100% methanol, and 50% (v/v) methylene chloride in methanol were added sequentially into the column. Each fraction was collected into clean glass vials. The column was allowed to dry prior addition of each elution solvent mixture.

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Toxicity testing was performed on the filtered sample, post C18 sample, the SPE eluates and all blanks (e.g., filter blank, column blank and elution blank).

2.7 Toxicity Procedures

Three marine test methods described in the California Ocean Plan (SWRCB, 1990) were used in this study: the echinoderm fertilization test, red abalone embryo development test, and giant kelp germination/germ tube growth test. Storm drain samples were stored under refrigeration in sealed 4-L glass bottles until the day of testing. Samples were thoroughly mixed before a 2.5-L subsample was removed and filtered through 1 µm glass fiber filter (Whatman GF/B).

The toxicity tests were conducted in two phases: Phase I - Relative Toxicity of Storm Drains and Phase II - Examination of Toxic Components. Toxicity testing was performed at the Southern California Coastal Water Research Project's (SCCWRP) laboratory in Long Beach. Seawater dilutions of each sample were prepared by adding appropriate amounts of seawater and brine solutions to create the desired dilutions and maintain a salinity of 32 - 35 mg/g. The dilution of the collected storm drain sample produced the required concentrations of storm drain sample for the toxicity tests, and test organisms were added to each sample within three hours of dilution. The concentrations of storm drain sample used in the toxicity testing were expressed in percentage of storm drain sample water used in the dilutions. For example, a concentration of 56% corresponds to a diluted sample consisting of 56% storm drain sample and 44% dilution water. The number of concentrations (expressed in % of storm drain sample (v/v)) and replicates of the samples used in the toxicity tests are shown in Table 2.

Table 2. Number of dilutions and replicates of each toxicity test.

Phase (1)	No. locations (2)	No. dilutions (3)	Concentration (% v/v) (4)	No. replicates (5)
I	4	5	5.6, 10, 18, 32, 56	3
	3	4	5.6, 12, 25, 56	3
II	1	3 for blanks	12, 25, 56	2
		2 for SPE eluates	0.1, 0.2	2

Echinoderm fertilization test. The echinoderm fertilization test was conducted according to methods described by Dinnel *et al.* (1987). Purple sea urchins *Strongylocentrotus purpuratus* were collected from the intertidal in northern Santa Monica Bay and held at SCCWRP until used in the tests. Ten mls of each sample dilution were added to replicate glass test tubes and equilibrated to 15°C in a water bath. Sea urchins were then induced to spawn through injection of potassium chloride. The gametes were collected and diluted with seawater to produce stock solutions of the density recommended by the protocol. The test was conducted by adding sperm to each test tube. After 60 minutes of sperm

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exposure, eggs were added to each tube for a 20 minute fertilization period. The sample was then preserved for microscopic examination. Toxic effects were indicated by a reduction in the percentage of fertilized eggs from that observed in a control sample (seawater).

Abalone development test. The abalone development test, using embryos of the red abalone *Haliotus rufescens*, was conducted according to methods described by Anderson *et al.* (1990). Sexually mature abalone were obtained from a commercial aquaculture facility and held at SCCWRP until used in the tests. Two hundred mls of each sample dilution were added to replicate 250 ml glass beakers and placed in a 15°C water bath. Abalone were induced to spawn by exposure to a hydrogen peroxide solution. The eggs were then fertilized, adjusted in density, and added to the exposure beakers. The developing embryos were exposed for 48 hours and preserved for microscopic examination. Toxic effects were indicated by an increased incidence of larvae with abnormally developed shells.

Giant kelp test. Tests with giant kelp were also conducted according to the procedures described by Anderson *et al.* (1990). Kelp blades containing reproductive spores (sporophyll) were obtained from offshore, uncontaminated kelp beds located near Santa Barbara and used within 24 hours. The toxicity test was conducted in 250 ml beakers containing 200 ml of the sample dilution. A glass microscope slide was placed on the bottom of each beaker to provide a surface for settlement of the kelp spores. Zoospore release from the sporophyll blades was induced by desiccation followed by immersion in seawater. The density of the released spores was adjusted and the appropriate number of spores was added to each beaker. The spores were exposed to the sample dilutions for 48 hours at 15°C and a controlled light level ($50 \mu Em^{-2} sec^{-1}$). During this period of 48 hours, the spores germinated and formed gamethphyte plants. The slides were then removed from each beaker and preserved for microscopic examination. Two endpoints were assessed: percentage spore germination and gametophyte length. Toxic effects were indicated by reductions in germination and gametophyte length, relative to a control group.

2.8 EDTA and Sodium Thiosulfate Addition Tests

EDTA and sodium thiosulfate addition tests described by Norberg-King *et al.* (1992) were conducted during the second phase of the toxicity test. The unfiltered storm drain samples with EDTA or sodium thiosulfate were analyzed for toxicity using the echinoderm fertilization test.

EDTA addition test. A stock solution of EDTA was prepared and added into 30 ml unfiltered storm drain samples. The final concentrations of EDTA in the samples were 3, 8, and 30 mg/L. Three different concentrations, 12%, 25% and 56% (v/v) of storm drain sample, were prepared from these EDTA-added samples and used for the toxicity test.

Sodium thiosulfate addition test. A stock solution of sodium thiosulfate was prepared and added into 30 mls of unfiltered storm drain samples. The final concentrations of sodium thiosulfate in the samples were 10 and 25 mg/L. Similar to the EDTA addition test, three concentrations, 12%, 25% and 56% (v/v) of storm drain sample, were prepared and used for the toxicity test.

2.9 GC and GC-MS

GC. The three SPE fractions were first analyzed using a Varian Vista 6000 gas chromatograph equipped with a splitless injector and flame ionization detector (FID). A 30 m x 0.25 mm i.d. DB5.625 capillary column (J & W Scientific) was used to analyzed the non polar organic compounds (e.g., polyaromatic hydrocarbons) in the fractions. The GC temperature program was 40°C for 2 min., 40° - 140°C at 25°C/min., 140° - 290°C at 10°C/min., and 290°C for 20 min. The splitless injector and FID temperatures were 275°C and 300°C, respectively.

GC-MS. The SPE fraction(s) which show toxicity were analyzed by GC-MS to identify possible organic compounds present in that fraction. The GC-MS system used was a Finnigan 4000 Quadrapole mass-spectrometer with a Finnigan 9610 gas chromatograph. A Grob type splitless injector (at 290°C) was used for sample injection onto a 30 m x 0.25 mm i.d. DB-5MS capillary column (J & W Scientific). The GC temperature program was 30°C for 4 min., 40° - 300°C at 6°C/min. and 300°C for 30 min. Mass spectral data were collected by using a scan range of 35 - 500 amu and a scan rate of 1 scan/s.

3.1 Summary of Water Quality Data

Samplings were conducted from April 1992 to January 1993. The number of samples collected from each storm drain during this period are given in Table 3. The number of samples collected varied from location to location due to several factors. For example, no sample was collected from the storm drain at Ashland Avenue on several occasions due to seawater intrusion into the storm drain. More samples were taken from the Ballona Creek since it was the selected storm drain for the second phase of the toxicity testing.

As mentioned in the previous experimental sections, conventional water quality parameters (Table 1) of the collected samples were analyzed according to the *Standard Methods*. All the data collected between April 1992 and January 1993 for these five storm drains are tabulated in Appendix B. The mean and standard deviation of each analyzed water quality parameter are given in Table 3. From Table 3, it is observed that the water quality of the storm drain at Ashland Avenue is usually worse than the other four storm drains. Most of the analyzed water quality parameter concentrations from the Ashland Avenue storm drain are greater than the other storm drains. This poor water quality may be due to the storm drain condition. The Ashland Avenue storm drain is stagnant during low flow periods, due perhaps because of sand plugging its mouth (The Ashland Avenue drain, unlike the Pico-Kenter Drain, terminates at the surf line). During high tides, sea water may enter the drain, which was detected by high conductivity and total dissolved solids (TDS) concentration. Ashland Avenue is the only drain that has a tidal interaction (the sampling station on Ballona Creek is above the point of tidal interaction).

Table 3 also shows that samples from the Sepulveda Channel have high total dissolved solids (TDS) and hardness. The high TDS concentration results from ion exchange regeneration waters released by NPDES permit to this storm drain. The dissolved oxygen (DO) concentrations in Ballona Creek, Sepulveda Channel and Centinela Creek were often greater than the saturation concentration because of photosynthesis; both drains are open channels and had abundant algae during the sampling.

At various sampling times, the water quality of some of the storm drains was comparable or worse than typical secondary effluents. Table 4 shows the selected water quality comparison between the storm drain samples and typical secondary effluent. The secondary effluent parameters are typical of those plants which discharge into the storm drains in Los Angeles County. These discharges are regulated more strictly than other plants, due to the possibility of human contact in the open drain channels and infiltration into ground water basins. The results show that the chemical oxygen demand (COD) of water samples from Ashland Avenue is much greater than the value of typical secondary effluents prior discharge to the receiving waters. A similar observation was made on the total suspended solids (TSS) of the analyzed storm drain samples.

3.2 Hardness Interference

According to the *Standard Methods* (1989), the presence of certain metallic ions such as aluminum, cadmium, copper and lead may interfere the hardness test. Indistinct end-point

Table 3. Summary of water quality data (average and standard deviation) for the selected storm drains.

Parameters (1)	Pico-Kenter (2)	Ashland Avenue (3)	Ballona Creek (4)	Sepulveda Channel (5)	Centinela Creek (6)
No. of sampling	10	7	10	9	6
Alk (mg/L as $CaCO_3$)*	266 ± 36	316 ± 64	233 ± 40	176 ± 49	152 ± 19
Hardness (mg/L as $CaCO_3$)	287 ± 90	1290 ± 1122	675 ± 349	1513 ± 792	270 ± 44
Conductivity (μmho/cm)	1795 ± 927	7560 ± 6702	2052 ± 919	4852 ± 1411	1090 ± 252
TDS (mg/L)	1050 ± 510	4618 ± 4323	1445 ± 795	3346 ± 3346	684 ± 167
TSS (mg/L)	49 ± 55	365 ± 475	47 ± 65	24 ± 32	5 ± 3
VSS (mg/L)	21 ± 25	86 ± 101	9 ± 9	9 ± 6	4 ± 2
COD (mg/L)	66 ± 35	249 ± 61	41 ± 18	70 ± 16	54 ± 19
DOC (mg/L)	31 ± 32	46 ± 18	28 ± 33	29 ± 27	20 ± 11
Turbidity (NTU)	15.5 ± 13	145.4 ± 208.2	23.3 ± 43.9	7.3 ± 12.2	3.8 ± 0.9
DO (mg/L)**	7 ± 1.3	3.3 ± 2.6	13.7 ± 1.1	14.5 ± 0.5	13.0 ± 1.5
pH	8 ± 0	7.6 ± 0	8.6 ± 0.5	8.7 ± 0.3	9.2 ± 0.3
uv absorbance (at 254 nm)	0.407 ± 0.102	0.870 ± 0.339	0.172 ± 0.051	0.173 ± 0.053	0.296 ± 0.137
Ammonia (mg/L as NH_3-N)	0.18 ± 0.22	0.84 ± 0.96	0.28 ± 0.33	0.22 ± 0.49	0.05 ± 0.03
Nitrite (mg/L as NO_2-N)	0.10 ± 0.05	0.12 ± 0.18	0.10 ± 0.08	0.16 ± 0.15	0.02 ± 0.01

Note: * See section 3.2 for the interferences in the alkalinity test for some of the samples.
** Parameter measured in the field.

Table 4. Comparison of water quality of storm drain samples and secondary effluent.

Parameter (1)	Location					Secondary Effluent (7)
	Pico-Kenter (2)	Ashland (3)	Ballona Crk (4)	Sepulveda Ch. (5)	Centinela Crk (6)	
COD (mg/L)	72	249	41	70	54	~50-100
TSS (mg/L)	49	365	47	24	5	< 30
Turbidity (NTU)	15.5	145.5	23.3	7.3	3.8	< 2.2
DO (mg/L)	7	3.3	13.7	14.5	13.0	> 2
pH	8	7.6	8.6	8.7	9.2	~ 6-9
Ammonia (mg/L as NH_3-N)	0.18	0.84	0.28	0.22	0.05	< 2

or stochiometric consumption of EDTA may occur. False, high indications of total hardness may be obtained. This type of interference can be eliminated by adding certain inhibitors (i.e., sodium sulfide nonahydrate or sodium cyanide) as suggested by *Standard Methods*. It was observed that the total hardness of some samples from the Ashland Avenue, Ballona Creek and Sepulveda Channel were lower after addition of sodium sulfide nonahydrate. For example, the afternoon grab sample from Ballona Creek which was collected on December 14, 1992 had a total hardness of 1750 mg/L as $CaCO_3$ without addition of sodium sulfite nonahydrate. The total hardness of the same sample decreased to 1180 mg/L as $CaCO_3$ (~ 33% decrease) after adding the inhibitor. This indicates the presence of interfering ions such as aluminum, cadmium, copper or lead in those samples. Appendix C describes the effect of these interfering ions on the total hardness of some samples.

3.3 Mass Emissions

The velocity and depth of water in the Ballona Creek, Sepulveda Channel and Centinela Creek were measured during sampling. Figure 2 shows the cross-section of the Ballona Creek, Sepulveda Channel and Centinela Creek. The velocity and water depth measurements were used to calculate the flow rate of the water passed through the storm drain, using the following equation (1):

$$\textit{Flow rate}\ (\frac{ft^3}{s}) = \text{Area}\ (ft^2)\ \times\ \text{Velocity}\ (\frac{ft}{s}) \qquad (1)$$

The area of Sepulveda Channel and Ballona Creek (except the first and last 5 ft of Ballona Creek) was determined as follows:

$$\textit{Area}\ (ft^2) = \text{width}\ (ft)\ \times\ \text{depth}\ (ft) \qquad (2)$$

For the Ballona Creek, the areas of the first and last 5 ft sections were determined as follows:

$$\textit{Area}\ (ft^2) = \frac{1}{2}\ \times\ \text{width}\ (ft)\ \times\ \text{depth}\ (ft) \qquad (3)$$

The flow rate at the Centinela Creek was measured differently than the above two storm drains. Unlike Ballona Creek and the Sepulveda Channel which were divided into several small areas, there was only one area determined in the Centinela Creek in which Eq. (2) was used. The width across the low-flow channel in Centinela Creek at the point of measurement is 85 in.

Table 5 shows the flow rate of the Ballona Creek, Sepulveda Channel and Centinela Creek. It is observed that Ballona Creek has greater flow rate than Sepulveda Channel and Centinela Creek. The average flow rate during the sampling of Ballona Creek, Sepulveda

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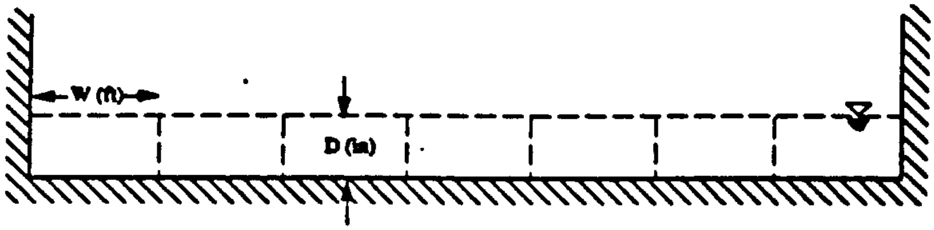
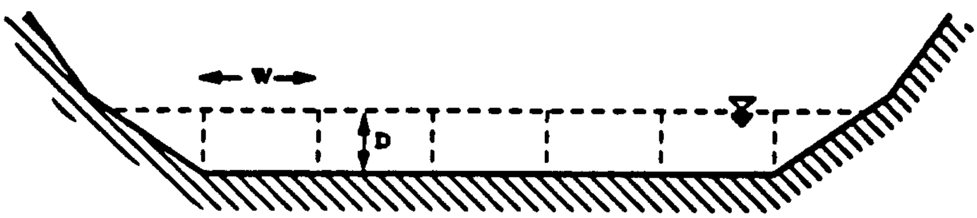


Cross-section of Sepulveda Channel



Cross-section of Ballona Creek

Cross-section of Centinela Creek

Figure 2. Cross-section of Ballona Creek, Sepulveda Channel and Centinela Creek.

Table 5. Flow rate measured at various sampling periods for Ballona Creek, Sepulveda Channel and Centinela Creek.

Sampling date (1)	Flow rate (ft^3/s) Ballona Creek (2)	Sepulveda Channel (3)	Centinela Creek (4)
7/7/92 pm	2.80	0.92	1.00
7/27/92 am	3.04	2.14	0.71
7/27/92 pm	3.07	1.83	0.46
8/24/92 am	1.90	0.60	-
8/24/92 pm	2.52	0.58	-
9/8/92 am	3.29	0.61	1.21
9/8/92 pm	2.98	0.63	0.33
9/29/92 am	3.66	0.61	-
9/29/92 pm	2.50	0.84	-
10/12/92 am	2.55	0.81	-
10/12/92 pm	2.53	0.90	-
11/2/92 am	2.48	0.56	1.09
11/2/92 pm	2.83	0.65	5.21
11/23/92 am	2.66	-	-
11/23/92 pm	2.18	-	-
12/10/92 am	2.85	0.96	0.29
12/10/92 pm	3.35	0.59	0.34
12/14/92 am	2.86	-	-
12/14/92 pm	3.05	-	-
1/19/92 pm	14.33	-	-
Average	3.37	0.85	1.18

Note: - not measured/no samples were taken

Channel and Centinela Creek are 3.37 ft^3/s, 0.85 ft^3/s and 1.18 ft^3/s, respectively (see Table 5). The calculated flow rate at Ballona Creek, Sepulveda Channel and Centinela Creek were then used to determine the annual mass emission of pollutants from dry weather flow into the Santa Monica Bay using the following equation:

$$\textit{Mass emission}\ (\frac{kg}{yr}) = \text{Concentration}\ (\frac{kg}{m^3}) \times \text{Flow rate}\ (\frac{m^3}{yr}) \qquad (4)$$

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The calculated average dry weather mass emission of pollutants (i.e., TDS, TSS, COD, NH_3-N and NO_2-N) from Ballona Creek, Sepulveda Channel and Centinela Creek are given in Table 6. The obtained results show that the mass emission of those selected pollutants from Ballona Creek are greater than those from Sepulveda Channel and Centinela Creek. No estimates are given for Pico-Kenter and Ashland Avenue storm drains as the flow rates were not determined in these two drains. The flow at Ashland Avenue was mostly stagnant during the dry season, suggesting that few pollutants from this storm drain were discharged into the Bay on a routine basis. It is assumed that the stagnant water was "blown out" from the drain from time to time due to release of the sand plug at the surf line; however no blow outs were observed during testing. The dry weather flow from the Pico-Kenter storm drain during the period of the study was discharged to the Hyperion treatment plant.

The flow rates reported in Table 6 vary from those indicated by the gauging stations on Ballona Creek. A review of the procedure and the gauging station data found no error in reporting or calculating flow rates. One possible source of error is a difference in calibration - the gauging station might be calibrated for wet weather flow.

The appearance of the drain water varied from drain-to-drain. The open channel drains (Ballona, Sepulveda, and Centinela) were usually clear in appearance except for algae. Strings and rafts of algae were routinely observed in these drains. The color was usually green but occasionally they were "sandy" colored. Pico-Kenter frequently appeared highly colored from high turbidity. The color was often light orange or tan, which suggest the presence of clays in the suspended solids. Ashland Avenue always appeared black or dark gray and frequently had an odor.

3.4 Toxicity

The following section summarizes the toxicity results of four storm drains, i.e., Pico-Kenter, Ashland Avenue, Ballona Creek and Sepulveda Channel. The detailed reports and raw data of the toxicity tests are included in Appendix D.

3.4.1 Phase I - Relative Toxicity of Storm Drains

The objective of this phase of toxicity testing was to determine the most toxic storm drain among these four storm drains (Centinela Creek was excluded from toxicity analysis), and also to determine the most sensitive test organism among the three test species. Four sampling periods were performed in this phase, i.e., August 24, September 8, September 29 and October 12, 1992. Sampling was performed on two locations on the August 24 (i.e., Pico-Kenter and Ashland Avenue) and September 8, 1992 (i.e., Ballona Creek and Sepulveda Channel). It was necessary to sample drains in pairs because only two sets of storm drains could be analyzed by SCCWRP at a time. The storm drain with the least toxicity from this first sampling was excluded from the next following toxicity tests.

Samples collected from the selected storm drains were tested for toxicity according to the previously described procedures. For each toxicity test, except the kelp germ tube test, the percentage response of the organisms at each tested dilution/concentration of the collected storm drain samples was calculated; for the kelp germ tube test, the mean length of the kelp germ tube was measured instead. These dose-response results were then plotted versus the various concentration of the samples {expressed in % of storm drain sample (v/v)} used in the toxicity tests. Figures 3 - 6 show examples of dose-response plots for abalone, sea

Table 6. Average emission of selected pollutants from Ballona Creek, Sepulveda Channel and Centinela Creek.

Location (1)	Average flow rate (m^3/hr) (2)	Mass emission (kg/yr) TDS (3)	TSS (4)	COD (5)	NH_3-N (6)	NO_2-N (7)
Ballona Creek	391.52	4.44×10^6	18.5×10^4	13.4×10^4	724	275
Sepulveda Channel	90.01	2.41×10^6	1.97×10^4	5.55×10^4	158	104
Centinela Creek	118.66	0.583×10^6	0.931×10^4	3.98×10^4	49	17

Table 7. NOEC and EC50 values for storm drains samples (Phase I).

Location	Sampling Date	NOEC				EC50			
		Abalone Development	Kelp Germ.	Kelp Length	Urchin Fertilization	Abalone Development	Kelp Germ.	Kelp Length	Urchin Fertilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Pico-Kenter	Aug. 24 '92	18	>56	>56	>56	42	> 56	> 56	> 56
	Sept. 29 '92	nd	nd	nd	≥56	nd	nd	nd	> 56
	Oct. 12 '92	12	≥56	25	25	21	> 56	> 56	41
Ashland Avenue	Aug. 24 '92	<5.6	18	18	10	6.8	32	> 56	17
	Sept. 29 '92	nd	nd	nd	5.6	nd	nd	nd	14
	Oct. 12 '92	5.6	5.6	5.6	<5.6	10	22	50	< 5.6
Ballona Creek	Sept. 8 '92	>56	>56	>56	<5.6	> 56	> 56	> 56	14
	Sept. 29 '92	nd	nd	nd	12*	nd	nd	nd	> 56
	Oct. 12 '92	≥56	≥56	≥56	≥56	> 56	> 56	> 56	> 56
Sepulveda Channel	Sept. 8 '92	>56	>56	>56	10	> 56	> 56	> 56	nt

Note: All values are in % (v/v) of the storm drain samples. NOEC = the highest concentration not statistically different from controls; EC = effective concentration to cause 50% toxic effect; nd = not determined as technical difficulties prevented measurement of toxicity; nt = toxicity found but data not amenable to testing for EC50 (see Figure 2a); * = NOEC can also be stated as ≥56 since 56% concentration was not significantly different from respective brine control. A NOEC of 12 is felt to be more appropriate since 25% concentration was significantly toxic and 56% brine control was toxic, making accuracy Of 56% effluent results questionable.

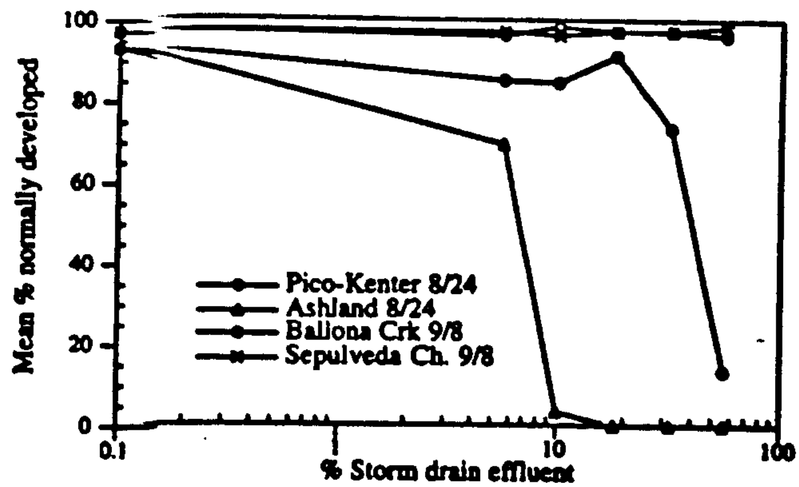

Figure 3. Example of dose response plot for abalone development test (for samples collected on August 24, 1992 for Pico-Kenter and Ashland, and September 8, 1992 for Ballona Creek and Sepulveda Channel). Control values are those plotted at a concentration of 0.1%.

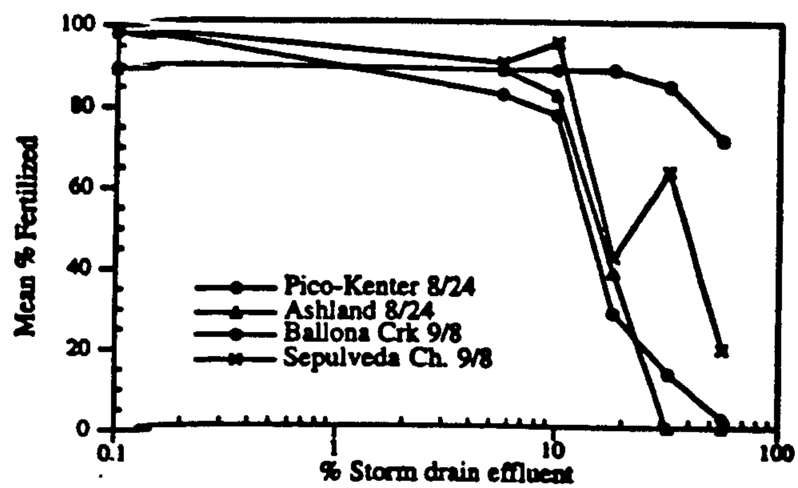

Figure 4. Example of dose-response plot for sea urchin fertilization test (for samples collected on August 24, 1992 for Pico-Kenter and Ashland, and September 8, 1992 for Ballona Creek and Sepulveda Channel). Control values are those plotted at a concentration of 0.1%.

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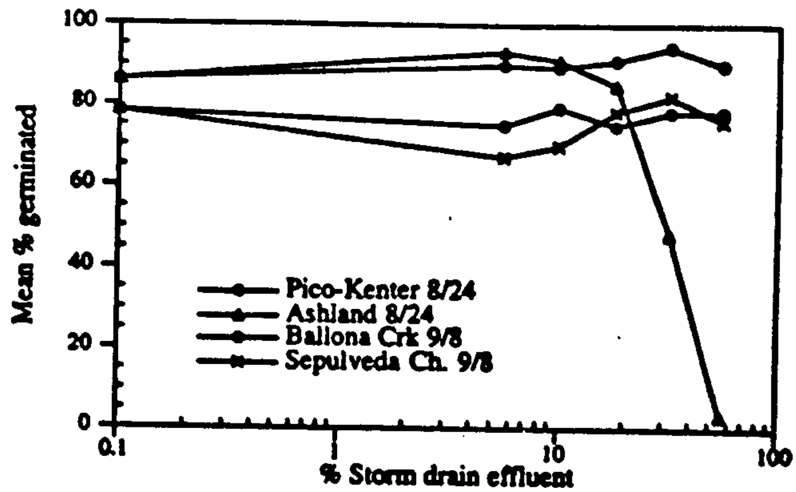

Figure 5. Example of dose-response plot for giant kelp germination test (for samples collected on August 24, 1992 for Pico-Kenter and Ashland, and September 8, 1992 for Ballona Creek and Sepulveda Channel). Control values are those plotted at a concentration of 0.1%.

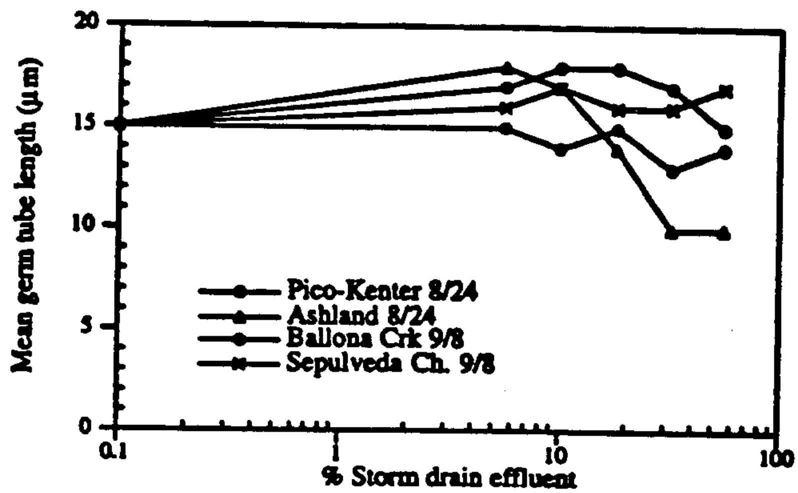

Figure 6. Example of dose-response plot for germ tube length test (for samples collected on August 24, 1992 for Pico-Kenter and Ashland, and September 8, 1992 for Ballona Creek and Sepulveda Channel). Control values are those plotted at a concentration of 0.1%.

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urchin, giant kelp germination and germ tube length tests (for samples collected on August 24, 1992).

From the dose-response data, EC50 values, i.e., the effective concentrations that caused 50% toxic effect on the test organisms, were calculated. The obtained EC50 values are used as the indicator of relative toxicity; lower EC50 values indicate greater toxicity. Table 7 shows the EC50 values obtained from the first toxicity testing for the collected samples of the four selected storm drains. The Ashland sample showed significant toxicity in three toxicity tests, except the kelp germ tube test. Both Pico-Kenter and Ballona Creek samples showed toxicity in one toxicity tests, i.e., abalone and urchin tests, respectively. The EC50 value of both abalone and germ growth tests for Ashland sample were lower than Pico-Kenter and Ballona Creek samples (EC50 values of greater than 56% indicate that no or very little toxicity present for the conditions tested).

In addition to EC50, another parameter was also obtained from the toxicity data, i.e., NOEC - the highest concentration not statistically different from controls. When both NOEC and EC50 values of a sample are 56%, they indicate that no toxicity is present in the sample. Little toxicity is said to be present in the sample when its NOEC value is <56%, and the EC50 of the sample is >56%. Table 7 shows an example of such observation. For the Ashland sample collected at August 24, the EC50 value of kelp germ tube test is >56%; however, the NOEC value of the same test is 18%. This result indicates that toxicity was present in the Ashland sample even though the EC50 value could not be determined.

The Sepulveda Channel sample collected on the September 8 has very little toxicity. The EC50 values were greater than 56% (see Table 7) and NOEC values for all toxicity tests, except urchin test, were greater than 56%. An inconsistent pattern of toxicity was found in the urchin test and thus the EC50 value was not able to be determined (see Figure 2a). Based upon these data, Sepulveda Channel was, therefore, excluded from subsequent toxicity tests.

As mentioned above, the second and third samplings of the Phase I toxicity tests were performed on the September 29 and October 12, 1992. Similar to the first toxicity tests, the percentage response of the organisms at each tested concentration (% in v/v) of the collected storm drain samples was calculated. However, only four instead of five concentrations (% in v/v) of the storm drain samples were used, i.e., 5.6%, 12%, 25% and 56%. Three replicates of each sample were conducted for each toxicity test. The EC50 values calculated from the dose-response data of the toxicity tests are shown in Table 7.

For samples collected on September 29, the EC50 of the abalone and kelp tests was not determined due to technical difficulties which prevented the measurement of toxicity. The EC50 could only be determined on the urchin test. Table 7 shows that Ashland Avenue sample had the lowest EC50 value, e.g., 14%, among the three storm drains tested. Very little toxicity was present in the samples collected from Pico-Kenter and Ballona Creek on Sept. 29, as shown by the EC50 of >56%. However, the NOEC of Ballona Creek sample was found to be 12% in the urchin test whereas NOEC of Pico-Kenter sample was ≥ 56%. Therefore, the Ballona Creek sample collected on Sept. 29 was more toxic than Pico-Kenter sample in the urchin test.

For samples collected on October 12, toxicity was detected in all four toxicity tests for Ashland Avenue sample. The Pico-Kenter storm drain tested toxic with all toxicity tests, except the kelp germination test (where both EC50 and NOEC were >56%). There was very little toxicity detected in all the toxicity tests for Ballona Creek samples. The NOEC and EC50 values obtained from the toxicity tests for samples collected on October 12 are also shown in Table 7.

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3.4.2 Relative Toxicity

By using the obtained EC50 values from toxicity tests, the relative toxicity of Pico-Kenter, Ashland Avenue and Ballona Creek storm drains were assigned 3 for the most toxic to 1 for the least toxic storm drain for each toxicity test. For example, for samples collected on October 12, Ashland Avenue was the most toxic to the abalone test, followed by Pico-Kenter and Ballona Creek. Therefore, 3 was assigned to Ashland, 2 to Pico-Kenter and 1 to Ballona Creek. By using the same procedures, similar numbers were also assigned to all samples for all four toxicity tests and the results are shown in Tables 8 and 9. Table 8 shows the relative site toxicity ranks by species whereas Table 9 shows the relative rank test sensitivity to storm drain samples.

The Ashland Avenue storm drain was usually the most toxic to each test organism and consistently produced the greatest toxicity in all tests conducted. No clear distinction between the relative toxicity of the Ballona Creek and Pico-Kenter storm drains was observed. The abalone test was more sensitive to Pico-Kenter samples, with kelp test being the least sensitive. Ballona Creek samples produced the greatest toxic effects on sea urchin sperm while the abalone and kelp tests were unaffected by samples from this storm drain.

3.4.3 Phase II - Examination of Toxic Components

The objective of this phase of toxicity testing was to determine the type of compounds (e.g., organics or metals) that caused the toxicity in the selected storm drain. Based on the toxicity results from Phase I, the Ballona Creek storm drain and the sea urchin test were selected for this phase. Even though the relative toxicity of this location is not as great as Ashland Avenue, the annual input of runoff from Ballona Creek to Santa Monica Bay is much greater than the other storm drains, which means the mass emission from Ballona Creek will be much larger.

Three samplings were performed during this phase, i.e., on the November 23 and December 14, 1992, and January 19, 1993. The sampling procedures were slightly different than previous samplings. Grab samples from morning and afternoon were collected separately. Preliminary toxicity tests were performed on these two grab samples in order to determine which grab sample had a higher level of toxicity. Solid phase extraction (SPE) was then performed on the grab sample which exhibited greater toxicity. Samples collected from the extraction (e.g., SPE eluates, post C18, column blanks, etc.) were tested for toxicity. These tests were performed after the first rainfall of the 1992-93 water year, which occurred in late October. In order to insure that only dry weather flow was collected during sampling, the storm drain flow was monitored to insure that it returned to dry weather flow rates prior to sampling.

3.4.3.1 SPE Eluates

Currently, most of the methods used for toxicity-based (bioassay-directed) fractionations required the extraction of the sample with an organic solvent after some preliminary clean-up, and subsequent fractionation of the extract using normal-phase chromatography. The solvent systems used are extremely toxic to aquatic organisms (Burkhard *et al.*, 1991) and when these methods are used, solvent exchange and/or evaporation procedures are required before toxicity testing can be done. Losses of volatile toxicants can occur during these steps which may bias results

1
6
5
7
3

Table 8. Relative site toxicity ranks by species. Sample numbers refer to the three time periods studied (Sample 1 = 8/14 or 9/8/92). 3 = most toxic, 1 = least toxic.

Location (1)	Relative toxicity Sample 1 (2)	Sample 2 (3)	Sample 3 (4)	Sum of ranks (5)
Abalone development				
Ashland	3	3	3	9
Ballona	1	1	1	3
Pico-Kenter	2	2	2	6
Kelp germination/growth				
Ashland	3	3	3	9
Ballona	1.5	1.5	1	4
Pico-Kenter	1.5	1.5	2	5
Sea urchin fertilization				
Ashland	2.5	3	3	8.5
Ballona	2.5	2	1	5.5
Pico-Kenter	1	1	2	4

Table 9. Relative rank test sensitivity to storm drain effluents. Rank assignments made on the basis of EC50 values (3 = most sensitive test).

Species (1)	Relative sensitivity Sample 1 (2)	Sample 3 (3)	Sum of ranks (4)
Ashland			
Abalone	3	2	5
Kelp	1	1	2
Sea urchin	2	3	5
Pico-Kenter			
Abalone	3	3	6
Kelp	1.5	1	2.5
Sea urchin	1.5	2	3.5
Ballona Creek			
Abalone	1.5	2	3.5
Kelp	1.5	2	3.5
Sea urchin	3	2	5

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The octadecyl (C18) solid phase extraction procedure used in this project was based on the method developed by Mount and Anderson-Carnahan (1989). This toxicity-based method has been successfully used to extract and fractionate non polar toxicants from the effluents for toxicity tests using cladocerans (water fleas) and fishes. In addition, low artifactual toxicity and excellent detection limits for gas chromatography/mass spectrometry (GC/MS) for toxicants identification can be obtained from this method. However, a preliminary recovery study showed that highly hydrophobic compounds such as chrysene and benzo(a)pyrene could not be eluted from the C18 sorbent by the elution solvents used by Mount and Anderson-Carnahan. Therefore a modified elution solvent system which consists of three fractions was developed for use on Phase II samples.

The first sampling of this phase was conducted on November 23, 1992. Preliminary toxicity results on the morning and afternoon grab samples showed that the afternoon sample produced toxic effects at concentrations ≥ 25%. Therefore, solid phase extraction procedures were used to concentrate the afternoon grab sample of Ballona Creek. In addition to the overall extraction procedures which were described in the experimental section, an additional sample manipulation was conducted. The pH of the sample was adjusted to pH 3 and pH 11 using 1N HCl acid and NaOH, respectively. Then samples with initial pH (pH_o), pH 3 and pH 11 were extracted using the C18 columns. The pH of deionized water used to prepare the filter and column blanks for the pH 3 and pH 11 samples was also adjusted prior to the extraction. During the solid phase extraction, two 30 ml samples of post C18 column effluents (i.e., after 25 mls and 950 mls of the sample passed through the column) were collected from each column. After the whole sample passed through the column and the column dried, 2 x 1.0 ml volume of six solvent mixtures were used to elute the sorbed organic from the C18 column. The solvent mixtures used for the elution of sorbed organics was 50%, 80%, 90% (v/v) of methanol in water, 100% of methanol, 10%, 20% and 50% (v/v) of methylene chloride in methanol.

Initially toxicity tests using the sea urchin were conducted on the filter blanks, column blanks and post C18 column effluents. Three concentrations were used, i.e., 12%, 25% and 56% (v/v) of storm drain sample. The results show that the pH_o filter and column blanks were highly toxic. Filter blank toxicity was also found at pH 3 and less at pH 11. Post C18 column effluent at pH_o was not toxic. In addition, a repeat of the baseline toxicity test with the Ballona Creek afternoon sample stored at SCCWRP showed a reduction of toxicity. Due to these bad results, it was suspected that toxicity may be introduced into the samples during the sample manipulations and extraction process. Therefore, it was decided that no further toxicity should be performed on the other samples, such as the SPE eluates, in order to save costs.

Two additional samples from Ballona Creek were collected on December 14, 1992 and January 12, 1993. The afternoon grab sample of December 14 and morning grab sample of January 12 were selected for the toxicity evaluation. Unlike the first sampling, the pH of the samples was not adjusted to either pH 3 or pH 11. Based on the earlier experience with the acute TIEs, it was found that major pH adjustment tests were not needed to characterize the toxicity of the sample (Norberg-King *et al*, 1992).

The solid phase extraction procedures used were as described in the experimental section. The three SPE eluates were then tested for toxicity using the urchin fertilization test. Two concentrations were used for the test, i.e., 0.1% and 0.2%, which corresponds to 50% and 100% (v/v) of storm drain sample, including the 500 fold increase obtained through the SPE procedures (the concentration factor of 500 times was obtained based on a sample volume of 1000 ml and elution volume of 2 ml). Table 10 shows the percentage fertilization of the SPE eluates (which has been normalized for blank response), post C18 effluents and the filtrates (pre-C18) of the Ballona Creek samples collected during this

Table 10. Toxicity results of C18 solid phase extraction (SPE) samples.

Sampling date and grab sample analyzed	Filtrate (pre-C18)			SPE Eluates						Post C18		
				50% MeOH		100% MeOH		50% $MeCl_2$				
	12%	25%	56%	0.1%	0.2%	0.1%	0.2%	0.1%	0.2%	12%	25%	56%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Dec. 14 '92 PM	86	66	15	100	100	94	7	100	63	-	92	76
Jan. 19 '93 AM	50	30	16	88	100	52	56	93	100	72	43	20

Note: All values are the mean % fertilization of sea urchin of two replicates.

phase. The results show that the 100% methanol fraction was the most toxic among the three eluates for both sampling periods. Little or no toxicity was present in the first and third eluate. The results suggest that most of the toxicants were present in the 100% methanol fraction for both sampling periods.

Table 10 also shows the toxicity results of pre- and post C18 samples at the concentrations tested. For the December 14 afternoon sample, a decrease in toxicity was observed after the passing the sample through the C18 column. At the concentration of 56%, the post C18 sample showed greater percentage fertilization (76%) than the untreated (pre-C18) sample (which only has 15% fertilization). This observation suggests that the C18 column removed toxicity and organic toxicants were most likely present in the sample. For the January 19 morning sample, no reduction of toxicity was observed in the post C18 sample and only moderate toxicity was observed in the 100% methanol fraction. Normally this result would suggest the presence of non-organics (e.g., metals), which are not removed by the C18 column; however, in this case it is not conclusive due to poor fertilization in the column blank. The presence of metals and other toxicants such as oxidative compounds in the samples can be confirmed by the EDTA and sodium thiosulfate addition tests.

3.4.3.2 EDTA and Sodium Thiosulfate Addition Tests

The objective of EDTA addition test is to detect toxicity caused by certain cationic metals. Non-toxic complexes will be formed after EDTA addition to the collected storm drain samples. Loss of toxicity with EDTA addition suggests that cationic metals are causing toxicity. The sodium thiosulfate addition test can detect toxicity caused by oxidative compounds (such as chlorine) and other compounds (such as copper and manganese). Toxicity from bromine, iodine, ozone, and chlorine dioxide is also reduced by the addition of sodium thiosulfate (Norberg-King *et al.*, 1992). The toxicity results of EDTA and sodium thiosulfate addition tests are shown in Table 11. For the sample collected on December 14, sodium thiosulfate reduced toxicity while EDTA only partially reduced the toxicity. This indicates that oxidative compounds may have caused toxicity in the December 14 sample. Reverse results were obtained for the sample collected on January 19, 1993. High percentage fertilization (Table 11) was observed in the samples with added EDTA while low percentage fertilization was observed in the thiosulfate addition test. These results show that EDTA completely removed the toxicity of the January 19 sample while thiosulfate had no effect on the sample toxicity. Therefore, cationic metals may be present in the January 19 sample and thus causing the toxicity.

Table 11. Toxicity results of the EDTA and sodium thiosulfate addition tests.

Sampling Date	EDTA Addition			Thiosulfate Addition	
	3 mg/L	8 mg/L	30 mg/L	10 mg/L	25 mg/L
(1)	(2)	(3)	(4)	(5)	(6)
Dec. 14 '92	44	12	-	99	98
Jan. 19 '93	92	96	92	10	12

Note: All values are the mean value of % fertilization of sea urchin at a concentration of 56% (v/v) storm drain sample.

The toxicity results obtained from this phase were variable and not conclusive due to the small number of samples tested. For example, for December 14 sample, toxicity was found in the raw sample (pre-C18 sample), the 100% methanol eluate and EDTA addition test, whereas no toxicity was found in the thiosulfate addition test and post C18 sample. It is not clear what might cause this type of toxicity, but an organic oxidant is possible; it would be reduced by the thiosulfate and through adsorption onto the C18 column. Other possibilities also exist. More toxicity tests should be performed in order to determine these variabilities.

3.5 GC/MS Results

Tables 12 and 13 show the GC/MS results averaged over the period of the study. The results show many compounds that are potentially toxic to the marine organisms tested. Appendix E contains the GC/MS data for the separate samplings based on the parellel study performed by Suffet *et al* (1993). The absence of compounds does not assume that they were not present, but only that they were below detection limits.

No correlations were observed between the measured compounds and the observed toxicity.

Table 12. GC/MS results for volatile organic analysis (6/12 - 12/10/92).

CHEMICAL [1]	Ashland Avg Conc. ng/L [2]	Pico-Kenter Avg Conc. ng/L [3]	Sepulveda Avg Conc. ng/L [4]	Ballona Avg Conc. ng/L [5]	Cent. Avg Conc. ng/L [6]	Grand Avg Conc. ng/L [7]	Grand Std Dev ng/L [8]	Number of Sample >MDL [9]
Benzene	90	91	109	77	91	90	61	59
Bromochloromethane	454		309	519	164	401	310	7
Bromodichloromethane	1,683	160	772	293	420	554	1,307	32
Bromoform	10,535	390	401	179	337	1,351	7,179	49
2-Butanone = MEK	1,191	423	477	602	423	673	656	48
n-Butyl Benzene	60					60	0	1
Carbon Disulfide	1,102	299	227	299	213	442	775	58
Chloroform	4,066	366	568	636	779	1,152	2,647	67
Chloromethane	418	421	578	421	324	526	589	65
2-Chlorotoluene	89					89	0	1
4-Chlorotoluene	148					148	0	1
Dibromochloromethane	4,877	205	1,179	281	883	1,089	3,348	30
Dibromomethane	740	50	74	50		298	465	26
1,2-Dichlorobenzene	74					74	0	1
Dichlorodifluoromethane	267	210	200	210	221	221	39	12
1,1-Dichloroethane	187					187	0	1
1,2-Dichloroethane	53					53	0	1
Dichloromethane	6,298	2,177	525	2,163	1,905	2,325	8,422	63
1,1-Dichloropropene				102		102	0	1
Ethyl Benzene	57			50		54	5	2
2-Hexanone	225	213	127	213	135	193	84	14
p-Isopropyltoluene	687	72		72		482	834	9
4-Methyl-2-Pentanone	573	295	232	295	9,478	1,422	6,935	43
Naphthalene	401		287	256	464	352	76	4
Styrene	54	46	47	46	47	49	9	19
Tetrachloroethene = PCE				242		242	90	16
Toluene	747	158	107	149	104	126	78	54
Trans 1,2-Dichloroethene			191	130		161	43	2
1,1,1-Trichloroethane			94	564		558	292	15
Trichloroethene = TCE	69			53		56	12	15
1,2,4-Trimethylbenzene	77	52		52		68	42	11
1,3,5-Trimethylbenzene	672					672	852	2
o-xylene	71		59			67	21	3

Dichloromethane = methylene chloride TCE = Trichloroethylene PCE = Perchloroethylene
Note: Only compounds that were found >MDL were averaged
Grand Average = Concentrations of compounds that are found >MDL/number of samples.

Table 13. GC/MS results for base neutral analysis (6/12 - 12/10/92).

CHEMICAL [1]	Ashland Avg Conc. ng/L [2]	Pico-Kenter Avg Conc. ng/L [3]	Sepulveda Avg Conc. ng/L [4]	Ballona Avg Conc. ng/L [5]	Centenila Avg Conc. ng/L [6]	Grand Avg Conc. ng/L [7]	Grand Std Dev. ng/L [8]	Number of Sample >MDL [9]
Acenaphthene*	6	4	30	3	5	10	16	9
Anthracene*	38	22	1,046	23	107	257	954	19
Azobenzene	34	25	21	17	14	21	14	23
Benz(a)anthracene*	32	32	14	22	22	27	19	15
Benzo(b)fluoranthene*	24	37	20	4	2	20	21	11
Benzo(k)fluoranthene*	25	14	39	5	2	18	18	7
Benzoic acid	472	920	501	543	584	523	393	21
Benzo(g,h,i)perylene*	71		58			66	55	3
Benzo(a)pyrene*	162	41	1,803	47	145	400	1,297	17
Benzyl alcohol	896			459		730	441	3
Bis(2-ethylhexyl)phthalate	14,765	6,800	4,349	4,518	6,240	6,627	7,013	42
Butyl benzyl phthalate	1,486	962	1,148	1,248	708	1,088	730	44
4-Chloro-3-methylphenol	9					9	0	1
2-Chloronaphthalene			1			1	0	1
4-Chlorophenyl phenyl ether	34	37	22	28	24	30	16	34
Chrysene*	126	60	2,016	61	181	513	1,828	19
Dibenzo(a,h) anthracene*	39		99			44	43	4
Dibenzofuran*	11	5	7	7	8	8	4	19
Di-n-butyl phthalate	3,050	1,046	1,223	1,337	816	1,421	1,967	44
1,4-Dichlorobenzene	68	66	58	75	44	63	31	40
Diethyl phthalate	463	187	201	214	216	247	209	43
2,4-Dimethylphenol	365					365	180	2
Dimethyl phthalate	31	14	26	27	20	22	28	16
Di-n-octyl phthalate	3,054	4,249	391	1,442	59	1,888	6,504	41
Fluoranthene*	49	99	19	9	9	31	58	34
Fluorene*	13	4	43	5	13	22	49	27
Indeno(1,2,3,4-c,d)pyrene*	40	7	71			39	41	5
Isophorone	42	1	17	33	52	35	26	9
2-Methylnaphthalene*	43	57	58	53	53	54	21	41
2-Methylphenol		8				8	0	1
4-Methylphenol	1,042	2,649		25		1,905	3,317	10
Naphthalene*	85	98	102	99	90	98	38	34
2-Nitroaniline	463					463	0	1
Nitrobenzene	230			24	29	51	70	7
2-Nitrophenol	38	455	27	42	30	147	624	30
4-Nitrophenol		3,903				3,903	0	1
N-Nitrosodiphenylamine		161				161	0	1
N-Nitrosodi-n-propylamine				3		3	0	1
Phenanthrene*	62	46	26	17	23	29	31	30
Phenol	162	1,204	100	166	83	465	1,145	22
Pyrene*	87	69	956	21	145	263	1,239	37

Grand Average = Concentrations of compounds that are found >MDL/number of samples.

Note: Only compounds that were found >MDL were averaged

* = Polyaromatic Hydrocarbon (PAH)

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4.0 DILUTION

The toxicity analyses presented earlier in this report show that dilution of the dry weather urban runoff with uncontaminated seawater can reduce toxicity to below detection limits. It was also observed that in some cases the toxicity in the storm drain sample disappeared after 2 or 3 days. This disappearance could be due to a chemical or biochemical detoxification reaction. For example, if free or combined chlorine were present in the urban runoff, it would decompose after a finite period of time, perhaps hours to one or two days, depending upon the concentration and type of chlorine residual. It is therefore reasonable to consider mixing and dilution as a best management practice. The initial dilution would protect aquatic species near the mouth of the storm drain and allow the toxicity-producing contaminants to decompose. For long lasting toxicity-producing contaminants, or for contaminants that might bioaccumulate, dilution might mitigate the immediate impact but would probably not prevent longer term impacts. For biodegradable contaminants, dilution could have a large beneficial effect.

A literature review was conduced to determine if previous research had been performed to determine dilution and initial mixing of a low flow rate, buoyant plume of fresh water entering sea water at surface level. No previous experimentally based research was found. Previous researchers (Stenstrom *et al.*, 1982), have suggested dilution as a best management practice, and a low flow diffuser has been installed at Pico-Kenter storm drain; however no quantitative experimental validation of the amount of dilution or anticipated benefits has been made.

A large body of research exists on deeper water diffuser systems, such as those used for the City of Los Angeles Hyperion treatment plant in El Segundo, the Los Angeles County Joint Water Pollution Control Plant in Carson and the Orange County Treatment Plant. These studies however are not directly applicable to storm drains discharging across beaches or small creeks flowing into coastal waters. One of the authors of this report has submitted a proposal to the USC Sea Grant program in order to study the initial dilution that occurs at the mount of a storm drain during wet and dry weather conditions. The results of this study, if funded, should provide experimental evidence of initial dilution of storm drains.

Woodward Clyde Consultants performed a "scoping" estimate of initial dilution of Ballona Creek as part of the Playa Vista Project. No experimental verification was performed, and they qualified their estimate for planning purposes only; however, their results and methodology provide the best estimate for dilution available at this time. They calculated a dilution based upon a dimensional analysis of the "near field" mixing and solved the diffusion equation to estimate "far field" dilution.

The near field effect is caused by the energy of the discharge (a jet or plume of fresh water entering saline water). They used a non-dimensional analysis using the Froude number, subject to the following assumptions:

- Steady-state conditions exist for the Bay as well as for the storm drain;
- The water depth of the Bay at the point of discharge is much deeper than the thickness of the plume of storm drain water;

- The shoreline is straight and storm drain and plume are perpendicular to the shoreline;
- The maximum concentration (minimum concentration) occurs along the shoreline;
- Mixing processes can be adequately characterized by a bulk dilution factor.

These assumptions are stringent and not fully applicable to the various storm drains that enter the Bay. For example, the Bay and the drains are in a constant state of flux. Tides and wind-induced currents are time-varying. The straight shoreline is not applicable to a situation where pockets or local stagnant zones are created by coastal structures or geometry of the shoreline.

WCC estimated the initial dilution factor from as follows:

$$S_s = F_o (b/h)^{0.25}$$

where,

S_s	=	Bulk dilution defined as the ratio of the local flow rate to the initial flow rate,
F_o	=	Froude number,
b	=	discharge half-width,
h	=	discharge depth.

Using this equation for Ballona Creek at a flow rate of 5,000 ft^3/sec, which is significantly more than its flow rate during dry weather conditions, they estimated a initial near field dilution of 1.2 to 1.9, and concluded that 1.5 was a reasonable estimate.

The far field dilution was estimated by assuming steady state conditions and modeling the flows and currents as a two-dimensional diffusion problem. In this approach, tides and wind-induced waves are treated as diffusion or dispersion, which are random in direction. They solved the two dimensional equations and performed a sensitivity study over a range of dispersion coefficients (D) from 0.01 to 0.00001 ft/sec. Over this range the far field dilution was estimated as 1 at D=0.00001 to 3 with D=0.01 at a distance of 5,000 feet from the Creek mouth. At 25,000 feet with D=0.01 the dilution increased to 9, but remained between 1 and 2 with D=0.00001.

The total dilution for a Ballona Creek, over the range of assumptions provided, ranges from 1 to perhaps as much as 20. These dilutions are far less than normally considered by the California Ocean Plan (e.g., 100 to 200), and far less than can be obtained with ocean outfall diffusers, such as those used at the large coastal wastewater treatment plants.

The dilution of dry weather flow, which is much less than the 5,000 ft^3/sec. flow rate used in the above analysis, should be significantly less for the near field, since there is very little energy contained in discharge (the discharge is not like a "jet" entering the shoreline), but perhaps greater for the far field, since there is much less volume entering the Bay.

It is concluded that no reliable quantitative estimates of low flow dilution of storm drain discharges can be made. Best available information suggests that 1 to 10 is the probable dilution. Undoubtedly dilution of storm drains like Pico-Kenter can be enhanced by devices such as a low-flow diversion that conveys dry weather flow across the beach and well into the surf. Further research is needed to adequately characterized initial dilution and its potential benefits.

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5.0 CONCLUSIONS

Water quality of five storm drains and relative toxicity of four storm drains in Santa Monica Bay Watershed were analyzed during low flow (dry weather) conditions. The water quality of the selected storm drains varied during the sampling periods, and was often comparable or worse than typical secondary effluents. This indicates that it is just as important to control dry weather urban runoff as it is to control secondary effluents.

Short-term chronic toxicity tests also show that significant toxicity was present in the selected storm drains. Probable sources of the toxicity ranged from non-organic (e.g., metals and oxidizing compounds) to organic contaminants. More samplings are needed to determine the variability of the toxicity. Toxicity testing should also be included in monitoring programs of urban runoff. Further work to identify the toxic components through quantitative chemical analysis (such as gas chromatography/mass spectrometry for organics) are also needed. Dilution of 10 fold or more was usually sufficient to reduce toxicity to below detection limits. A survey of the literature to determine dilution of storm drains that enter coastal waters found very little information. For Ballona Creek, during wet weather flow, the dilution might be as much as 10 fold. Further research is needed to determine the likely dilution at the mouth of storm drains.

A large amount of dry weather water quality data was collected. This data set is larger and more complete than any available previously for a single Santa Monica Bay storm drain at a single location. The new data have been added to the combined data set assembled from agency monitoring data in an earlier report (Stenstrom and Strecker, 1993).

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INTRODUCTION

Currently, most of the methods used for toxicity-based (bioassay-directed) fractionations require the sample extraction with an organic solvent after some preliminary clean-up, and subsequent fractionation of the extract using normal-phase chromatography. The solvent systems used are extremely toxic to aquatic organisms (Burkhard *et al.*, 1991) and solvent exchange and/or evaporation procedures are required before toxicity testing can be done. Losses of volatile toxicants can occur during these steps which may bias results.

After completing the development of the improved procedures, US EPA (Durhan *et al.*, 1993a, b) published an improved procedures which were nearly identical to the procedures we developed.

C18 SOLID PHASE EXTRACTION

The toxicity-directed method for fractionating non-polar organic toxicants using solid-phase extraction (SPE) described in phase II of EPA's "Methods for Aquatic Toxicity Identification Evaluations" (TIE) were used in this project. The proposed SPE method used octadecylsiloxane (C18) columns and an elution scheme with decreasing polarity. Prior to the extraction of actual storm drain samples, recovery studies using standard solutions of a combination of eight common polyaromatic hydrocarbons (PAHs) were performed. Modifications of the SPE procedures have been made based on the results of the recovery study in order to obtain good percentage recovery of PAHs from the C18 SPE columns. The following section described the rationale of the SPE procedures development which will be used for the actual storm drain samples.

EXPERIMENTAL PROCEDURES

Materials

SPE column. The 500 mg and 1000 mg octadecyl C18 columns used were obtained from Burdick and Jackson (Muskegon, MI)

Chemicals. Polyaromatic hydrocarbons (PAHs) mixed in the standard solutions, i.e., napthalene, 2-methylnapthalene, acenpathene, fluorene, anthracene, pyrene, chrysene and benzo(a)pyrene were obtained from Aldrich (Milwaukee, WI). The PAHs mixture in methanol was spiked into one liter deionized water.

Solvents. HPLC grade methanol, methylene chloride, hexane, carbon tetrachloride and isopropanol from Fisher Scientific (Tustin, CA) were used for SPE.

SPE procedures

The 1000 nmg C18 SPE column was conditioned with 25 ml of methanol and 25 ml of deionized water. Before the sorbent dried, 1000 ml standard water solution containing PAHs was then pumped through the column at a rate of 5 ml/min. The sorbent was dried by continuing the pumping for ~ 15 minutes after the whole 1000 ml sample passed through. Then 2 successive 1.0 ml volume of methanol/water, methanol and

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methylene chloride/methanol were added sequentially into the column. Each fraction was collected separately into clean glass vials. The column was allowed to dry prior addition of each elution solvent mixture. The concentration of PAHs in each eluates were then analyzed using GC/FID. With the known initial concentration of each PAHs in the standard solution, the percentage recovery of each PAH was determined as follows:

$$\% \text{ Recovery} = \frac{\text{Concentration of PAH in eluate (GC determined)}}{\text{Expected concentration}} \times 100$$

Gas Chromatography Analysis

The SPE fractions were analyzed using a Varian Vista 6000 gas chromatograph equipped with a splitless injector and flame ionization detector (FID). A 30 m x 0.25 mm i.d. DB5.625 capillary column (J & W Scientific) was used to analyzed the PAHs in the fractions. The GC temperature program was 40°C for 2 min, 40° - 140°C at 25°C/min, 140° - 290°C at 10°C/min, and 290°C for 20 min. The splitless injector and FID temperatures were 275°C and 300°C, respectively.

The above procedure is a general description of C18 SPE procedures used in our recovery study. Changes on the elution volume and elution solvents were made when the effect of these parameter on the percentage recovery of PAHs were studied.

RESULTS AND DISCUSSION

Methanol as the Elution Solvent

Our first recovery studies used only one fraction of 2 x 1.5 ml of methanol to elute the sorbed PAHs from the 500 mg C18 column. The final concentrations of PAHs in the eluates collected from the 100 mg size columns were used to determine the recovery of the each PAHs. Low recoveries were obtained for most of the PAHs (Table A-1). Anthracene, acenapthene, fluorene and 2-methylnpathalene were recovered the most, greater than 40%. Both napthalene and benzo(a)pyrene have low recovery, less than 10%. It is suspected that the low recoveries might be caused by insufficient elution volume. Therefore, additional three successive 1.5 ml of methanol was used to elute the sorbed PAHs from the 500 mg and 1000 mg C18 columns. The obtained results only show slight improvement of the recoveries of PAHs (Table A-1). Therefore, it was suspected that maybe methanol might be too polar to be able to elute the strongly hydrophobic PAHs. Low recovery of napthalene may also due to it's loss through volatilization as napthalene is considered semi-volatile ($H_c = 0.018$).

To determine the suitability of methanol as the elution solvent for PAHs, an addition of 200 µL of methylene chloride was used to elute the sorbed PAHs from the 100 mg C18 columns after the first 300 µL methanol. The results show that PAHs were only partially desorbed from the C18 sorbent by 100% methanol. Subsequent addition of methylene chloride helped to further elute some of the PAHs. The overall recovery (combination of methanol and methylene chloride eluates) of PAHs improved for most of the PAHs. However, the percentage recovery of chrysene and benzo(a)pyrene was still not good (Table A-1).

The improvement of the percentage recovery of most of PAHs helps to reconfirm our suspicions of the weakness of methanol as the elution solvent for PAHs. Therefore, the effect of other solvents, i.e., hexane, carbon tetrachloride, methylene chloride and 2-propanol, as the elution solvent for PAHs was studied. However, only 1000 mg size columns were used as hexane, methylene chloride and carbon tetrachloride were not miscible in water. The percentage recovery of most of the PAHs approached 100% in the hexane, carbon tetrachloride and methylene chloride cases (Table A-2). The percentage recovery of benzo(a)pyrene has improved from about 20% to almost 50%. No improvement of the recovery was obtained by using 2-propanol as the elution solvent.

Even though strong non-polar solvents such as hexane, carbon tetrachloride and methylene chloride improved the recovery of the PAHs, these solvents are not desirable as the elution solvent as (1) they are not miscible in water, and (2) they are toxic to the marine organisms used in the toxicity tests. A solvent exchange procedure is usually required before they can be used in toxicity assays. An alternative elution solvent system which meet these two criteria is needed as preliminary results had shown that the proposed elution solvent system by Mount and Carnahan cannot elute PAHs from the C18 sorbent efficiently. The modified elution solvent include methanol-methylene chloride mixtures so that those strongly sorbed PAHs such as chrysene and benzo(a)pyrene can be eluted from the C18 sorbent.

Composition Methanol-Water and Methanol-Methylene Chloride

Preliminary tolerance tests for marine organisms showed that methanol-water, methanol, and methanol-methylene chloride were acceptable elution mixtures. However, it was very desirable to limit the quantity of methylene chloride to less than 0.1% in the toxicity assay. Therefore, different composition of methanol-water and methanol-methylene chloride as elution solvents were studied.

A total of six fractions were used to fractionate the PAHs from the C18 columns. Two different compositions of methanol-water and methanol-methylene chloride were studied, i.e., a 10% and 25% gap between each fraction. The 10% gap in the first proposed elution solvent system consisted of 80% and 90% of methanol (v/v) in water, 100% methanol, 10%, 20% and 50% methylene chloride (v/v) in methanol. The second proposed solvent system, which has a 25% gap between each fraction, consisted of 50% and 75% of methanol (v/v) in water, 100% methanol, 25%, 50% and 75% of methylene chloride (v/v) in methanol. The percentage recovery of the eight PAHs were determined in each fractions and compared. The results of the first and second proposed elution solvent systems are shown in Tables A-3 and A-4.

Table A-3 shows that more fractionation occurs in the 10% gap solvent system than the 25% gap system. It is observed that at least 3 distinct fractions could be collected in the 10% gap system (Table A-3). For example, both napthalene and 2-methylnapthalene were fractionated into the 2nd fractions (i.e., 90% methanol), while most of the acenapthene, fluorene, anthracene and pyrene were found in the 3rd fraction (i.e., 100% methanol). Both chrysene and benzo(a)pyrene were fractionated into the 4th fraction (i.e., 10% methylene chloride).

For the 25% gap elution solvent system, less fractionation of PAHs was observed (Table A-4). There were only two distinct fractions collected in this system. Most of napthalene, 2-methynapthalene, acenpathene, fluorene and anthracene were fractionated in the 3rd fraction (i.e., 100% methanol). Pyrene, chrysene and benzo(a)pyrene were found in the

4th fraction (i.e., 25% methylene chloride). There was no or insignificant PAHs found in the first and last two fractions.

Tables A-3 and A-4 also show that the overall percentage recovery of PAHs were greater in the 25% gap solvent system. However, as better fractionation of PAHs was obtained in the 10% gap system, it was decided that the composition of methanol-water and methylene chloride-methanol in the 2nd proposed elution solvent system will be used instead.

Elution Volume

The fractionation of PAHs caused by the volume of the elution solvent used was also studied. Two different elution volumes were compared, i.e., 2 x 1.0 ml and 2 x 1.5 ml of 80% and 90% of methanol (v/v) in water, 100% methanol, 10%, 20% and 50% of methylene chloride (v/v) in methanol. The results of the percentage recovery of PAHs using 2 x 1.0 ml and 2 x 1.5 ml of elution volume are shown in Tables A-3 and A-5. The total percentage of both volumes each PAH are quite similar, except for 2-methylnapthalene in which a total of 76% was recovered when 2 x 1.5 ml elution volume was used and only 46% was recovered when 2 x 1.0 ml of elution volume was used.

Tables A-3 shows that for the 2 x 1.0 ml elution volume, greater recovery was observed with 100% methanol fraction than 90% methanol. For the 2 x 1.5 ml elution volume (Table A-5), the opposite was observed. Few PAHs were recovered in the 80% methanol and 50% methylene chloride fractions (for both 2 x 1.0 ml and 2 x 1.5 ml cases). No conclusion can be made here regarding which volume is better, except the volume of solvent and solvent make up can interact to effect recovery.

Based on the results of the above mentioned recoveries, it was decided to use the following elution scheme for the fractionation of PAHs from the C18 columns: 2 x 1.0 ml of 80% and 90% of methanol (v/v) in water, 100% methanol, 10%, 20% and 50% of methylene chloride (v/v) in methanol. The following section discussed the repeatability of this modified system based on a total of eight similar extractions.

Repeatability of the Modified Elution Solvent System

As mentioned in the above sections, the modified elution solvent system consists a total of 6 fractions, i.e., 2 x 1.0 ml volume of the following solvents: 80% and 90% methanol (v/v) in water, 100% methanol, 10%, 20% and 50% methylene chloride (v/v) in methanol. A total of 8 extractions were conducted to determine the variability SPE procedures using the modified elution solvent system. The extraction procedures of these extractions were identical except for the concentration of PAHs. For each extraction, the concentration of all PAHs, except benzo(a)pyrene were equal; the range of concentrations of each PAH (in the water solution) was varied from 10 µg/L to 40 µg/L. The concentration of benzo(a)pyrene ranged from 20 µg/L to 80 µg/L. The average percentage and standard deviation of each PAH recovery in each SPE fraction obtained from 8 extractions are shown in Table A-6. Repeatability of the extraction procedures, as measured by the standard deviation of the recovery, was generally within 5% for fluorene as the most repeatable, and 21% for 2-methylnapthalene as the least repeatable.

From Table A-6 it is observed that the 80% methanol-water fraction (1st fraction) eluted no PAHs. Most of the napthalene was recovered in the 90% methanol fraction (2nd fraction). Anthracene, fluorene and acenapthene were eluted almost entirely in the 100% methanol fraction (3rd). 2-methynapthalene, pyrene, chrysene and benzo(a)pyrene were not well separated. Table A-6 also shows that elution with methylene chloride (4th and 5th fractions) is required to recover those PAHs with high log K_{ow} value (such as chrysene and benzo(a)pyrene). Most were recovered with a maximum of 20% methylene chloride. The sequence of PAHs elution from the C18 column is also shown in Figure 1.

CONCLUSIONS

Based on the results of the recovery studies using eight commonly detected PAHs, a modified elution solvent system consists of six fractions of methanol-water, methanol and methylene chloride mixtures was developed, i.e., 2 x 1.0 ml of 80% and 90% of methanol (v/v) in water, 100% methanol, 10%, 20% and 50% of methylene chloride (v/v) in methanol. Three distinct groups of PAHs were obtained from the C18 column when this elution solvent system was used: napthalene in the 90% methanol fraction; acenapthene, fluorene and anthracene in the 100% methanol fraction, and chrysene and benzo(a)pyrene in either 10% or 20% methylene chloride fraction. The repeatability of the extraction was within the range of 5-21%.

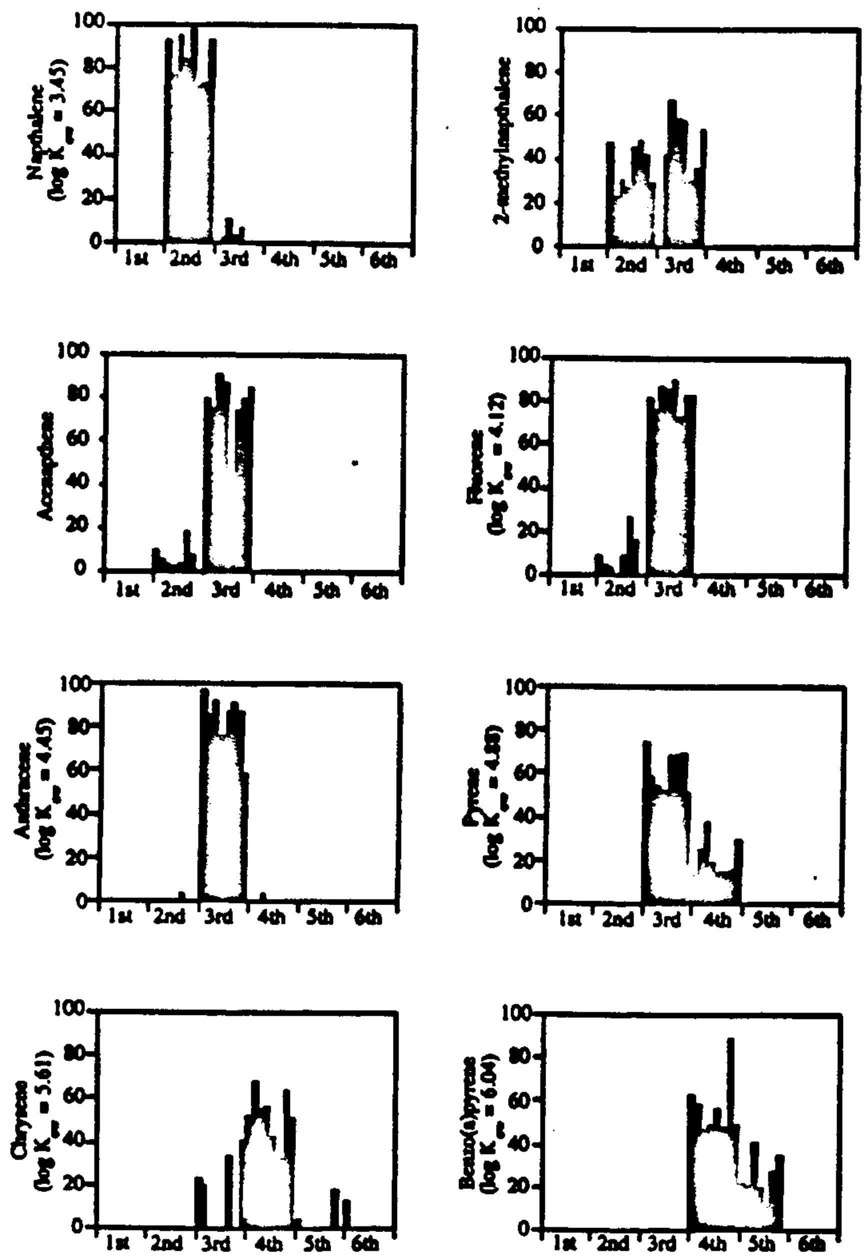

Figure A-1. C18 SPE modified elution scheme. The vertical axis represents the percent recovery of each PAH in each fraction. 1st: 80% methanol in water; 2nd: 90% methanol in water; 3rd: 100% methanol; 4th: 10% methylene chloride in methanol; 5th: 20% methylene chloride in methanol; 6th: 50% methylene chloride in methanol.

Table A-1. Total percentage recovery of PAHs from initial SPE recovery studies.

PAHs compounds (1)	1st Recovery 500 mg C18 (2)	2nd Recovery 500 mg C18 (3)	2nd Recovery 1000 mg C18 (4)	3rd Recovery* 1000 mg C18 (5)
Anthracene	58	67	70	103
Acenapthene	40	66	57	90
Fluorene	49	89	65	99
2-methylnapthalene	44	62	53	70
Pyrene	18	38	34	112
Chrysene	13	19	27	12
Benzo(a)pyrene	9	6	0	0
Napthalene	8	13	16	27

Note: * Combination of methanol and methylene chloride eluates.

Table A-2. Percentage recovery of PAHs using different solvents.

PAH Compound (1)	Total % Recovery: n-Hexane (2)	Carbon Tetrachloride (3)	Methylene chloride (4)	2-Propanol (5)
Napthalene	134	165	142	46
2-methylnapthalene	128	156	134	47
Acenapthene	146	161	139	56
Fluorene	149	165	142	68
Anthracene	123	150	134	53
Pyrene	138	160	129	98
Chrysene	116	85	55	47
Benzo(a)pyrene	49	58	42	19

Note: The excessive recovery (i.e., > 100%) of several PAHs was due to negligence in volume measurements.

Table A-3. Percentage recovery of PAHs using the 10% gap elution solvent system.

PAH compounds (1)	Percentage recovery						Total Recovery (8)
	80% MeOH (2)	90% MeOH (3)	100% MeOH (4)	10% $MeCl_2$ (5)	20% $MeCl_2$ (6)	50% $MeCl_2$ (7)	
Napthalene	5	93	0	0	0	0	98
2-methylnapthalene	0	47	0	0	0	0	47
Acenapthene	0	10	79	0	0	0	89
Fluorene	0	9	81	0	0	0	90
Anthracene	0	0	97	0	0	0	97
Pyrene	0	0	74	14	0	0	88
Chrysene	0	0	24	53	5	13	95
Benzo(a)pyrene	0	0	0	63	23	0	86

Note: MeOH = methanol; $MeCl_2$ = methylene chloride. The elution solvent volume used was 2 x 1.0 ml.

Table A-4. Percentage recovery of PAHs using the 25% gap elution solvent system.

PAH Compounds (1)	Percentage recovery 50% MeOH (2)	75% MeOH (3)	100% MeOH (4)	25% $MeCl_2$ (5)	50% $MeCl_2$ (6)	75% $MeCl_2$ (7)	Total Recovery (8)
Napthalene	0	0	84	33	0	0	117
2-methylnapthalene	0	0	84	5	0	0	89
Acenapthene	0	0	73	19	0	0	92
Fluorene	0	9	76	16	0	0	101
Anthracene	0	0	53	35	0	0	88
Pyrene	0	0	13	74	0	0	87
Chrysene	0	0	0	124	0	0	124
Benzo(a)pyrene	0	0	0	98	18	0	116

Note: The elution solvent volume used was 2 x 1.0 mL.

Table A-5. Percentage recovery of PAHs using the elution volume of 2 x 1.5 ml.

PAH compounds (1)	Percentage recovery						Total Recovery (8)
	80% MeOH (2)	90% MeOH (3)	100% MeOH (4)	10% $MeCl_2$ (5)	20% $MeCl_2$ (6)	50% $MeCl_2$ (7)	
Napthalene	5	83	0	0	0	0	88
2-methylnapthalene	0	76	0	0	0	0	76
Acenapthene	0	61	19	0	0	0	80
Fluorene	0	63	17	0	0	0	80
Anthracene	0	33	55	0	0	0	88
Pyrene	0	0	104	0	0	0	104
Chrysene	0	0	85	11	0	3	99
Benzo(a)pyrene	0	0	16	78	0	0	94

Table A-6. Average percent recovery and standard deviation of each PAH from 8 different extractions using the modified elution scheme.

PAH compounds (1)	Log K_{ow} (2)	Average percentage recovery ± standard deviation					
		80% MeOH (3)	90% MeOH (4)	100% MeOH (5)	10% $MeCl_2$ (6)	20% $MeCl_2$ (7)	50% $MeCl_2$ (8)
Napthalene	3.54	0	86 ± 11	3 ± 4	0	0	0
2-methylnapthalene	0	0	37 ± 10	43 ± 21	0	0	0
Acenapthene	0	0	7 ± 6	77± 14	0	0	0
Fluorene	4.12	0	9 ± 9	82 ± 6	0	0	0
Anthracene	4.45	0	0.5 ± 1	84 ± 12	0.5 ± 1	0	0
Pyrene	4.88	0	0	62 ± 9	22 ± 9	0	0
Chrysene	5.61	0	0	15 ± 17	53 ± 11	3 ± 7	2 ± 5
Benzo(a)pyrene	6.04	0	0	0	57 ± 14	23 ± 13	0

Appendix B includes the results of water quality analyses of the samples from the five selected storm drains which were collected from April 1992 to January 1993.

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Table B-1. Water quality data of Pico-Kenter storm drain (April '92 - December' 92).

Parameter (1)	4/17/92 (2)	6/12/92 (3)	7/7/02 (4)	7/27/92 (5)	8/24/92 (6)	9/8/92 (7)	9/29/92 (8)	10/12/92 (9)	11/2/92 (10)	12/10/92 (11)
Sample Type	Grab	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
Alk (mg/L as $CaCO_3$)	304	250	325	275	244	230	260	275	295	205
Hardness (mg/L as $CaCO_3$)	298	234	256	242	536	234	284	239	272	270
pH*	8.5	8.4	8.4	7.9	7.6	7.6	7.7	7.65	7.9	8.4
Conductivity (µmho/cm)*	1477	1460	1902	1743	4350	1380	1620	1450	1540	1025
Ammonia (mg/L as NH_3-N)	-	-	0.28	0.0522	0.2154	0.6813	0.0801	0.0287	0.0377	0.0906
Nitrite (mg/L NO_2-N)	0.114	0.056	0.0686	0.1607	0.2021	0.099	0.0496	0.0695	0.1024	0.0419
TDS (mg/L)	886#	791	1055	751	2456	876	1123	900	943	723
TSS (mg/L)	-	9	13	29	149	40	138	21	4	39
VSS (mg/L)	-	-	6	12	65	15	56	4	4	8
COD (as mg/L)	-	-	93	66	132	43	69	63	41	19
DOC (ppm)	-	-	18	15	14	7	16	15	89	74
Detergent (ppm as LAS)	-	-	-	-	0.75	0.5	0.5	1	-	9.7
uv absorbance (at λ = 254nm)	-	0.36	0.40	0.38	0.46	0.47	0.57	0.43	0.4	0.19
Turbidity (NTU)	2.05	7.3	3.67	22	45	17.4	16.9	24.8	4.8	11.3
% Salinity**	-	-	-	0.75	1.5	0.25	0.9	0.3	0.0375	0.625
DO (ppm)**	-	-	7.9	6.5	5.7	5.8	7.2	6.85	5.95	9.7

Note: # TDS = 0.6 x conductivity; * = measured in the lab; ** = measured in the field; - = no sample taken/no anaysis done.

Table B-2. Water quality data of Ashland Avenue storm drain (April '92 - December '92).

Parameter (1)	4/17/92 (2)	6/12/92 (3)	7/7/92 (4)	7/27/92 (5)	8/24/92 (6)	9/8/92 (7)	9/29/92 (8)	10/12/92 (9)	11/2/92 (10)	12/10/92 (11)
Sample Type	Grab	-	Composite	Composite	Composite	-	Composite	Composite	Composite	-
Alk (mg/L as $CaCO_3$)	198	-	310	370	355	-	370	345	265	-
Hardness (mg/L as $CaCO_3$)	3310	-	224	388	274	-	1286	1680	1868	-
pH*	7.6	-	7	8	7.75	-	7.75	7.4	7.7	-
Conductivity (μmho/cm)*	1000	-	1753	3640	2680	-	13170	14620	16060	-
Ammonia (mg/L as NH_3-N)	-	-	0.052	2.578	1.2916	-	0.4711	0.5109	0.1215	-
Nitrite (mg/L NO_2-N)	0.079	-	0.0438	0.0371	0.5176	-	0.0308	0.0266	0.1195	-
TDS (mg/L)	587#	-	910	2008	1615	-	7032	9527	10650	-
TSS (mg/L)	36	-	446	1169	849	-	28.55	19	10	-
VSS (mg/L)	21	-	80	237	221	-	23	13	8	-
COD (mg/L)	-	-	163	274	202	-	231	324	297	-
DOC (ppm)	-	-	46	50	27	-	51	25	75	55
Detergent (ppm as LAS)	-	-	-	-	3	-	4	3	-	-
uv absorbance (at λ = 254 nm)	-	-	0.71	1.19	1.23	-	0.73	1.02	0.34	-
Turbidity (NTU)	2.6	-	88	505	380	-	11.8	23.9	6.3	-
% Salinity**	-	-	-	1.50	1.10	-	2.25	3.25	3.25	-
DO (ppm)**	-	-	8.1	2.45	1.80	-	1.20	1.70	4.70	-

Note: # TDS = 0.587 x conductivity; * = measured in the lab; ** = measured in the field; - = no sample taken/no anaysis done.

Table B-3. Water quality data of Ballona Creek @ Inglewood storm drain (June'92 - January'93).

Parameter (1)	6/12/92 (2)	7/7/92 (3)	7/27/92 (4)	8/24/92 (5)	9/8/92 (6)	9/29/92 (7)	10/12/92 (8)	11/2/92 (9)	11/23/92 pm (10)	12/10/92 (11)
Sample Type	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Grab	Composite
Alk (mg/L as $CaCO_3$)	220	250	165	185	205	215	215	275	175	275
Hardness (mg/L as $CaCO_3$)	480	494	356	628	594	1082	492	720	388	808
pH*	8.9	8.7	9.5	9.15	8.6	8.8	9	8.5	9.6	8.2
Conductivity (µmho/cm)*	1900	1855	1439	2230	1975	3140	1630	2390	1126	2540
Ammonia (mg/L as NH_3-N)	-	0.11	0.0629	0.0821	0.1	0.0136	0.0287	0.0255	0.1	0.6486
Nitrite (mg/L NO_2-N)	0.072	0.0493	0.0153	0.0588	0.0371	0.0929	0.0509	0.1479	0.0296	0.1347
TDS (mg/L)	980	886	856	1362	1414	2328	1134	1526	837	1901
TSS (mg/L)	173	22	14	8	8	13	3	5	3	16
VSS (mg/L)	-	12	10	6	4	9	2	4	2.6	6
COD (mg/L)	-	35	33	48	17	65	70	34	13	45
DOC (ppm)	-	14	8	7	8	12	7	71	31	96
Detergent (ppm as LAS)	-	-	-	0.75	1.5	0.5	0.25	-	-	-
uv absorbance (at λ =254nm)	0.17	0.20	0.13	0.18	0.15	0.16	0.22	0.15	0.10	0.13
Turbidity (NTU)	9.5	1.78	3.8	2.6	3.4	3.08	2.4	1.8	2.3	2.8
% Salinity **	-	-	1.33	1.78	1.22	1.22	1.07	1.23	0.85	1.51
DO (ppm) **	-	13.6	> 15	> 15	> 15	14.7	> 15	> 15	> 15	14.2

Note: * = measured in the lab; ** = measured in the field; - = no sample taken/no anaysis done.

Table B-3. Water quality data of Ballona Creek @ Inglewood storm drain (cont'd).

Parameter (1)	12/14/92 am (12)	12/14/92 pm (13)	1/12/93 am (14)	1/19/93 am (15)	1/19/93 pm (16)
Sample Type	Grab	Grab	Grab	Grab	Grab
Alk (mg/L as $CaCO_3$)	285	285	235	254	255
Hardness (mg/L as $CaCO_3$)	854	1725	500	530	480
pH*	8.4	8.15	8	8.1	8.1
Conductivity (μmho/cm)*	2180	4620	1644	1053	1054
Ammonia (mg/L as NH_3-N)	1.0636	0.705	0.5179	0.2795	0.1228
Nitrite (mg/L NO_2-N)	0.2593	0.1737	0.2453	0.0624	0.0795
TDS (mg/L)	1770	3810	1202	829	839
TSS (mg/L)	6	174	19	97	148
VSS (mg/L)	4	37	4	12	16
COD (mg/L)	28	70	37	37	46
DOC (ppm)	-	-	-	-	-
Detergent (ppm as LAS)	-	-	-	-	-
uv absorbance (at λ = 254nm)	0.12	0.27	0.11	0.25	0.23
Turbidity (NTU)	2.8	146	9.4	55.5	102
% Salinity **	0.92	-	-	-	-
DO (ppm)**	12.3	-	-	-	-

Note: * = measured in the lab; ** = measured in the field; - = no sample taken/no anaysis done.

Table B-4. Water quality data of Sepulveda Channel @ Ballona Creek storm drain (June '92 - December '92).

Parameter (1)	6/12/92 (2)	7/7/92 (3)	7/27/92 (4)	8/24/92 (5)	9/8/92 (6)	9/29/92 (7)	10/12/92 (8)	11/2/92 (9)	12/10/92 (10)
Sample Type	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
Alk (mg/L as $CaCO_3$)	85	212	160	145	145	170	215	205	245
Hardness (mg/L as $CaCO_3$)	1364	1570	250	2100	1434	818	1524	3113	1444
pH*	9	8.5	9	8.8	8.7	9.1	8.6	8.5	8.1
Conductivity (µmho/cm) *	4000	5650	2870	7150	4720	3270	5530	6260	4220
Ammonia (mg/L as NH_3-N)	-	0.063	0.0629	0.0675	0.0681	0.0136	0.0162	0.0377	1.4251
Nitrite (mg/L NO_2-N)	0.095	0.0989	0.0248	0.2129	0.0605	0.0525	0.1296	0.5093	0.2185
TDS (mg/L)	3246	3548	1846	4657	4071	1931	3721	3827	3267
TSS (mg/L)	15	41	15	12	13	11	5	2	104
VSS (mg/L)	-	19	8	7	7	7	3	2	17
COD (mg/L)	-	62	73	88	73	40	90	63	71
DOC (ppm)	-	16	14	11	16	-	10	69	67
Detergent (ppm as LAS)	-	-	-	1	0.5	0.5	0.75	-	-
uv absorbance (at λ = 254nm)	0.10	0.24	0.10	0.20	0.18	0.18	0.16	0.14	0.25
Turbidity (NTU)	2.3	3.4	5.6	3.1	4.22	2.64	3.35	1.34	39.7
% Salinity **	-	-	1.18	3.17	2.12	2.02	1.85	2.12	1.57
DO (ppm) **	-	13.6	14.8	> 15	> 15	14.9	14.9	> 15	14.5

Note: * = measured in the lab; ** = measured in the field; - = no sample taken/no analysis done.

Table B-5. Water quality data of Centinela Creek @ Inglewood storm drain (July'92 - December'92).

Parameter (1)	7/7/92 (2)	7/27/92 (3)	8/24/92 (4)	9/8/92 (5)	9/29/92 (6)	10/12/92 (7)	11/2/92 (8)	12/10/92 (9)
Sample Type	Composite	Composite	Composite	Composite	-	-	Composite	Composite
Alk (mg/L as $CaCO_3$)	184	145	155	155	-	-	145	125
Hardness (mg/L as $CaCO_3$)	268	244	276	312	-	-	200	320
pH*	9.2	9.6	9.4	9.1	-	-	9	8.8
Conductivity (µmho/cm)*	1214	1090	1300	1338	-	-	683	915
Ammonia (mg/L as NH_3-N)	0.11	0.0434	0.0455	0.0562	-	-	0.0255	0.0412
Nitrite (mg/L NO_2-N)	0.0273	0.0221	0.0129	0.0454	-	-	0.0057	0.0149
TDS (mg/L)	743	660	728	900	-	-	390	680
TSS (mg/L)	7	2	7	8	-	-	2	4
VSS (mg/L)	4	-	5	5	-	-	2	2
COD (mg/L)	58	75	66	60	-	-	19	48
DOC (ppm)	17	19	15	12	-	-	-	39
Detergent (ppm as LAS)	-	-	1	1	-	-	-	-
uv absorbance (at λ = 254nm)	0.42	0.33	0.43	0.30	-	-	0.06	0.24
Turbidity (NTU)	4.07	3.9	4.2	4.27	-	-	1.96	4.6
% Salinity **	-	0.70	0.50	0.75	-	-	0.20	0.25
DO (ppm)**	13.6	14.7	> 15	> 15	-	-	12.5	11.3

Note: * = measured in the lab; ** = measured in the field; - = no sample taken/no analysis done.

INTRODUCTION

According to *Standard Methods*, the presence of some metal ions such as Al, Cd, Cu, and Pb can cause interference in the hardness analysis. Indistinct end-point or stochiometric consumption of EDTA may happen. These interferences may be reduced by adding certain inhibitors. There are three types of Inhibitors suggested by *Standard Methods*, i.e.,

1. Inhibitor I: Sodium cyanide
2. Inhibitor II: Sodium sulfide nonahydrate ($Na_2S.9H_2O$) or $Na_2S.5H_2O$
3. Magnesium salt of 1,2-cyclohexanediaminetetraacetic acid (MgCDTA)

Due to the unavailability of MgCDTA, it was decided to test the effect of Inhibitors I and II on the hardness test.

EXPERIMENT I

Sample: Ballona Creek @ Inglewood (sampled on 12/14/92)

Inhibitor: Inhibitors I and II

Hardness Results:

Table C-1. Total hardness results from Experiment 1.

Sample (1)	Without Inhibitors (2)	Inhibitor I (3)	Inhibitor II (4)
Morning	860	832	619
Afternoon	1750	1700	1180

Note: All values are in mg/L as $CaCO_3$

Discussion

From Table C-1, total hardness of Ballona Creek samples collected in the morning and afternoon, without addition of either inhibitor, was 860 and 1750 mg/L as $CaCO_3$, respectively. When Inhibitor I (250 mg/ 50 ml diluted sample) was added into these samples, a slight decrease of the total hardness was observed (~ 3%). With Inhibitor I, the total hardness of the morning sample was 832 mg/L as $CaCO_3$ whereas the afternoon sample has total hardness of 1700 mg/L as $CaCO_3$. Different observations were made in the samples with the addition of Inhibitor II. When 1 ml of Inhibitor II solution was added into 50 ml of the diluted samples, a decrease of total hardness to 619 and 1180 mg/L as $CaCO_3$ was observed for morning and afternoon samples, respectively (~ 28 - 33% decrease). Therefore, it is concluded that significant interfering metal ions (such as Al, Pb, Cu, Cd and Zn) were presence in the Ballona Creek samples, causing false high value of total hardness.

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EXPERIMENT 2

Sample: Standard solution of Ca and Mg (mixture) (Concentration: 108 mg Ca/L and 82 mg Mg/L with a theoretical hardness of 606 mg/L as $CaCO_3$; 1000 ppm Ca and Mg reference solutions were used to prepare this standard solution)

Inhibitor: None

Hardness results:

Table C-2. Total hardness results from Experiments 2 and 3.

	Ca and Mg standard solution		
	Without interfering ions (1)	With interfering ions (2)	With interfering ions + Inhibitor II (3)
Total hardness (mg/L as $CaCO_3$)	625	895	650

EXPERIMENT 3

Sample: Same concentrations of Ca and Mg except with addition of the following ions:

Al ~10 mg/L
Cd ~13 mg/L
Cu ~10 mg/L
Pb ~13 mg/L
Zn ~111 mg/L

Inhibitor: Inhibitor II

Hardness results: See Table C-2

Discussion

Table C-2 shows that total hardness of the standard solution with added interfering ions, without adding Inhibitor II, was 895 mg/L as $CaCO_3$. By comparing these total hardness results with those obtained from Experiment 2, we can conclude that the presence of these ions increased the consumption of EDTA and gave false high results of total hardness measurement. Another observation was noted during the titration. The sharp end-point of the indicator was absent. The presence of these interfering ions may also cause an indistinct end-point. By adding Inhibitor II before titration these interferences were reduced. Table C-2 shows that total hardness of the standard solution after addition of Inhibitor II decreased from 895 mg/L to 650 mg/L as $CaCO_3$. Thus it can be concluded that Inhibitor II reduces the interferences caused by the above mentioned metal ions.

Due to the above observation, analysis of total hardness of previous samples from Sepulveda Channel, Ballona Creek and Ashland (with suspected high content of total hardness) were repeated. The total hardness results without the addition of Inhibitor II were compared with total hardness of those samples analyzed with Inhibitor II. The purpose of this comparison was to determine the presence of the any interfering metal ions (such as Al, Cu, Cd, Zn, Pb, etc.). It is important to note that some of these samples may deteriorated due to the long storage period (~ 1-2 months).

EXPERIMENT 4

Sample: Ca and Mg standard solution (no interfering ions)

Inhibitor: Inhibitor II

Results:

Table C-3. Comparison of total Hardness of Ca and Mg standard solution with and without using Inhibitor II.

	Ca and Mg standard solution	
	Without Inhibitor II (1)	With Inhibitor II (2)
Total hardness (mg/L as $CaCO_3$)	620	620

Discussion

Table C-3 shows that Inhibitor II does not affect the total hardness results if none of the interfering ions are present in the sample. The total hardness of Ca and Mg standard solution without addition of Inhibitor II is the same as the total hardness of standard solution which has added Inhibitor II.

EXPERIMENT 5

Sample: Previous samples from Sepulveda Channel @ Ballona Creek, Ballona Creek @ Inglewood and Ashland
Note: Almost all of the Sepulveda Channel samples were re-analyzed, except sample taken on 11/2/92 which was unavailable. Only a subset of the Ballona Creek samples (which had total hardness of > 500 mg/L as $CaCO_3$) were analyzed. Previous results show that three Ashland samples have a total hardness of > 1000 mg/L as $CaCO_3$. However, only two Ashland samples were analyzed as the sample from 11/2/92 was not stored.

Inhibitor: Inhibitor II

Results: See Tables C-4 (Sepulveda Channel), C-5 (Ballona Creek) and C-6 (Ashland)

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Discussion

Tables C-4, C-5 and C-6 show that the total hardness of the stored samples (which were stored for more than 1-2 months) of Ballona Creek and Sepulveda Channel, without addition of the Inhibitor II, are quite similar to those results obtained previously. After addition of Inhibitor II, the total hardness of some samples was reduced, which indicates that some interfering metal ions were present. Almost all the Sepulveda Channel samples (except sample which was taken on 6/12/92) have reduced total hardness (about 20-30% reduction) (Table C-4). For Ballona Creek samples, only half of the samples analyzed were found to have reduced total hardness results with the addition of Inhibitor II (Table C-5). The percentage reduction of these samples is less than those in the Sepulveda Channel samples, i.e., about 10-15% only. This shows that the amount of interfering ions present in the Ballona Creek samples is less than those in the Sepulveda Channel samples.

Unlike Ballona Creek and Sepulveda Channel samples, the total hardness results for stored Ashland samples, without the addition of Inhibitor II, were quite different from those obtained previously. For example, the total hardness of Ashland sample dated 9/29/92 increased from 1286 mg/L to 1670 mg/L as $CaCO_3$ after the sample was stored for nearly 3 months. This dissimilarity may be due to deterioration of Ashland samples. However, the purpose of this experiment was to determine the presence of interfering ions in the sample that may cause the false results of total hardness test. The results show that interfering ions are present in two Ashland samples as the total hardness was reduced after addition of Inhibitor II (Table C-6).

Table C-4. Total hardness of Sepulveda Channel @ Ballona Creek samples.

Sampling date (1)	Previous analysis (2)	Total hardness ($CaCO_3$) Repeated analysis: Without Inhibitor II (3)	Total hardness ($CaCO_3$) Repeated analysis: With Inhibitor II (4)
6/12/92	1364	1370	1350
7/7/92	1570	1440	1090
7/27/92	750	780	690
8/24/92	2100	2080	1390
9/8/92	1434	1340	1015
9/29/92	818	870	795
10/12/92	1524	1490	1150
11/2/92	3113	-	-
12/10/92	1444	1330	1085

Table C-5. Total hardness of Ballona Creek @ Inglewood samples.

Sampling date (1)	Previous analysis (2)	Total hardness (mg/L as $CaCO_3$) Repeated analysis: Without Inhibitor II (3)	Total hardness (mg/L as $CaCO_3$) Repeated analysis: With Inhibitor II (4)
8/24/92	628	600	600
9/8/92	594	650	580
9/29/92	1082	1000	870
11/2/92	720	560	560
12/10/92	808	920	800

Table C-6. Total hardness of Ashland Avenue samples.

Sampling date (1)	Previous analysis (2)	Total hardness (mg/L as $CaCO_3$) Repeated analysis: Without Inhibitor II (3)	Total hardness (mg/L as $CaCO_3$) Repeated analysis: With Inhibitor II (4)
9/29/92	1286	1670	1280
12/10/92	1680	1810	1215

CONCLUSION

It is suspected that interfering ions such as aluminum, cadmium, copper and lead were present in some of the samples collected from Ashland, Ballona Creek and Sepulveda Channel. The total hardness results obtained from samples in the absence of inhibitor sodium sulfide nonahydrate was found to be higher than those samples that had added the inhibitor.

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APPENDIX D1
TOXICITY ANALYSIS OF
STORM DRAIN DRY WEATHER FLOW
SAMPLES COLLECTED 8/24 AND 9/28/92

INTRODUCTION

This report summarizes the results of marine toxicity tests conducted on samples of dry weather flow collected from four storm drains in Los Angeles (Ashland, Ballona Creek, Pico-Kenter, and Sepulveda). The intent of these experiments was to determine the concentration of effluent (diluted with seawater) that caused a 50% response in the test organisms (EC50) and also the highest concentration that did not cause a statistically significant level of toxicity (NOEC).

METHODS

Three species were used for toxicity testing. These were giant kelp (*Macrocystis pyrifera*), red abalone (*Haliotis rufescens*), and purple sea urchins (*Strongylocentrotus purpuratus*). Toxicity tests were conducted in accordance with the methods described in the State of California's Ocean Plan wherever possible. The prinicpal deviation from these methods was the degree of replication used. Three instead of the recommended five replicates were tested for each effluent concentration. Replication was reduced in response to the EPA's (Region IX) request to increase the number of concentrations tested.

Storm drain samples were stored under refrigeration in sealed 4 L glass bottles until the day of testing. Tests were initiated within 48 hours of sample collection. Samples were thoroughly mixed before a 2.5 L subsample was removed and filtered through Whatman GF/B glass fiber filters. Samples from two locations (Ashland and Pico-Kenter) were centrifuged (3,200 x g for 10 min) prior to filtration to remove large particulates.

Seawater dilutions of each sample were prepared by adding appropriate amounts of seawater and brine solutions to create the desired concentrations and maintain a salinity of 32-35 mg/g. Concentrations containing 5.6, 10, 18, 32, and 56% storm drain effluent were prepared for each location. Toxicity test organisms were added to each sample within three hours of dilution. The pH of some dilutions of the Ballona and Sepulveda effluents was adjusted by addition of 0.2 N HCl in order to maintain a pH range of 7.9-8.3.

Several dilutions of unfiltered samples were also prepared to examine potential changes in toxicity related to filtration. Only one replicate was prepared for each of these samples. Brine controls (containing the same volumes of brine added to the three highest concentrations of storm drain effluent) were prepared to identify test effects related to the salinity adjustment method.

The dissolved oxygen, pH, and total ammonia content of a subsample of each effluent dilution was measured at the start of the toxicity tests. Measurements were made using electrodes that were calibrated daily. Oxygen and pH measurements were also made at the termination of each 48 hour test. Separate measurements were made on solutions obtained from kelp and abalone test beakers. Temperature within selected test chambers was measured daily with a mercury thermometer during the 48 hour tests. Water temperature

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during the sea urchin fertilization test was measured in a test tube placed alongside the rack containing the test samples.

A concurrent reference toxicant test was run for each of the different toxicity tests. Seawater dilutions of copper chloride were used in the sea urchin and kelp reference toxicant tests. Zinc sulfate was the reference toxicant for the abalone test.

RESULTS AND DISCUSSION

Water Quality

Initial water quality measurements indicated that the undiluted samples were of low salinity (Table D1-1). Seawater brine was added during dilution preparation so that most of the diluted samples had a salinity of 34 mg/g (Appendix Tables D1.a-1 and a-4). Insufficient brine was available to fully adjust the Ashland 56% dilution to normal seawater salinity. The final salinity of this sample was 32 mg/l, a level still within the tolerance range of the test organisms.

Initial pH was elevated in the Ballona Creek and Sepulveda samples (Table D1-1). The 32 and 56% dilutions of these samples had unacceptably high pH values as a result. A small amount of HCl was added to these dilutions to reduce the pH and thus minimize toxicity artifacts during the tests.

Dissolved oxygen and ammonia concentrations were also measured on the sample dilutions (Tables D1.a-1 - a-6). Oxygen was within an acceptable range for all dilutions. Ammonia was elevated in dilutions of Ashland effluent only. These ammonia concentrations may have contributed to the toxicity of Ashland effluent to abalone. The measured concentrations of ammonia are not likely to have produced toxic effects on sea urchin sperm or kelp spores.

Kelp and abalone test chamber temperatures were generally within the desired range of 14-16°C (Tables D1.a-2, a-3, a-5, and a-6). Excessive temperatures were measured during the first day of the August 26-28 kelp test. Heat generated from the increased illumination required for this test was responsible for this situation. Temperatures were successfully reduced and stabilized after this situation was discovered. The control and reference toxicant results for this test are within the expected ranges, indicating that the temperature deviation did not seriously affect the test. Temperatures during the August and September sea urchin tests were 15.5 and 14.6°C, respectively.

Sea Urchin Toxicity

Results of sea urchin fertilization toxicity tests are summarized in Tables D1-2 and D1-3. Control fertilization was 89-98%, well within the desired range of 50-100%. Effluent from Ashland, Ballona, and Sepulveda storm drains were toxic to sea urchin sperm. Examination of the NOEC and EC50 statistics (Table D1-4) indicates the relative toxicity of each site. Fertilization was inhibited at concentrations ≥ 5.6% for Ballona and > 10% for Ashland and Sepulveda.

The EC50 (when available) is the best indicator of relative toxicity; lower EC50 values indicate greater toxicity. Ballona was the most toxic station, with an EC50 of 14%.

Ashland was slightly less toxic and Sepulveda had the lowest toxicity of the three stations producing an effect on sea urchin fertilization. An unusual dose-response pattern was found for the Sepulveda sample (Figure D1-1), an increase in fertilization relative to the value at 18% (instead of a decrease) was measured for the 32% concentration. Consequently, an EC50 could not be calculated for Sepulveda.

Additional treatments (brine controls, unfiltered samples, and egg controls) were tested to determine the impact of various aspects of the testing procedure. Brine controls at the 56% water concentration were toxic to sea urchin sperm.. This result was not unexpected, as the sea urchin fertilization tests is very sensitive to most salinity adjustment procedures. Brine toxicity did not influence the results of the tests, however, since storm drain effluent toxicity was found at concentrations much lower than those containing toxic concentrations of brine.

Several dilutions of unfiltered effluent were tested to determined if the filtration step had a substantial effect on toxicity. The Ashland sample caused greater effects on fertilization in the unfiltered state. Results for the filtered and unfiltered samples from the other locations were similar.

Egg controls (no sperm added during test) were incorporated at EPA's request. Results for the egg controls indicate that there was no false fertilization caused by the storm drain samples or the handling of the egg solution.

<u>Abalone Toxicity</u>

Toxicity to red abalone embryos was caused by exposure to effluent from the Ashland and Pico-Kenter locations (Table D1-5). Effluent from Ballona Creek and the Sepulveda Channel did not produce toxicity at the concentrations tested (Table D1-6). Ashland effluent was more toxic than Pico-Kenter effluent, as can be seen from examination of the dose-response plots (Figure D1-1) and NOEC and EC50 statistics (Table D1-4). The lowest concentration of Ashland effluent tested (5.6%) caused significant toxicity to the abalone.

There was no toxicity associated with the use of brine in the abalone toxicity tests. Unfiltered effluent from Pico-Kenter appeared to produce greater toxicity than did similar concentrations of filtrate (Table D1-5). Toxicity results for unfiltered samples from the other locations were similar to those obtained for filtrates.

<u>Kelp Toxicity</u>

Two endpoints were assessed during the kelp spore toxicity tests. Both spore germination percentage and length of the germ tube were significantly reduced by exposure to Ashland effluent (Tables D1-7 and D1-8). The kelp test was the least sensitive of the three toxicity tests, as shown by the relatively high Ashland NOEC and EC50 values.

Exposure of kelp spores to effluent from Pico-Kenter, Ballona, and Sepulveda did not produce any toxicity at the dilutions tested Tables D1-7 -10). Many of the test concentrations produced germ tube lengths greater than the corresponding reference groups (Figure D1-2). This situation is occasionally encountered in tests where growth is measured. Increased growth in a toxicity test is usually regarded as an overcompensation to a small stress. Another possibility is that germ tube growth was influenced by nutrients present in the storm drain effluents.

The brine control results indicated an inhibitory effect on germination at the 18% concentration during the September 9, 1992 experiment (Table D1-9). Higher concentrations of brine did not produce similar effects, indicating toxicity was caused by something other than the brine. The brine results did not affect the interpretation of the data since the effluent samples did not cause toxicity. Brine effects were not indicated for the other test time or endpoint.

The effect of filtration on Ashland toxicity to kelp spores could not be assessed. The high concentration of particulates in the dilutions tested prevented settlement of the spores on the glass slides used for measurement of germination and germ tube length.

Table D1-1. Summary of initial water quality data for undiluted storm drain effluent samples. Measurements were made on the day of toxicity test initiation. Values are expressed in percent effluent. Salinity is expressed as mg/g.

Location (1)	Collection Date (2)	pH (3)	Salinity (4)
Ashland	8-24-92	8.40	1
Ballona	9-8-92	9.45	2
Pico-Kenter	8-24-92	8.12	2
Sepulveda	9-8-92	9.54	4

Table D1-2. Summary of Purple sea urchin fertilization test 184; conducted August 26, 1992. Abbreviation: % Ref = mean response expressed as a percentage of the appropriate reference group(s); NS = not significantly difference relative to reference; S = statistically significant difference; NT = not tested (no need or data not sufficient).

Group (1)	Description (2)	Reference group (3)	Percent Fertilized Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		89	(8)			98, 83, 87
2	Brine control 18%	1	86	(4)	NS	97	85, 80, 89,90
3	Brine control 32%	1	81	(5)	NS	90	75, 78, 86, 84
4	Brine control 56%	1	42	(5)	S	47	42, 45, 35, 47
5	Pico-Kenter filtrate 5.6%	1-3	88	(3)	NS	104	91, 88, 86
6	Pico-Kenter filtrate 10%	1-3	88	(6)	NS	104	82, 90, 93
7	Pico-Kenter filtrate 18%	1-3	88	(5)	NS	104	88, 92, 83
8	Pico-Kenter filtrate 32%	1-3	84	(2)	NS	99	84, 82, 86
9	Pico-Kenter filtrate 56%	4	71	(1)	NT	170	71, 71, 72
10	Pico-Kenter 10% (unfilt.)	1-3	92		NT	108	92
11	Pico-Kenter 18% (unfilt.)	1-3	79		NT	93	79
12	Pico-Kenter 32% (unfilt.)	1-3	82		NT	97	82
13	Ashland filtrate 5.6%	1-3	88	(6)	NS	104	95, 83, 87
14	Ashland filtrate 10%	1-3	82	(4)	NS	97	80, 80, 87
15	Ashland filtrate 18%	1-3	38	(11)	S	45	28, 37, 50
16	Ashland filtrate 32%	1-3	0	(0)	S	0	0, 0, 0
17	Ashland filtrate 56%	4	0	(0)	NT	0	0, 0, 1
18	Ashland 10% (unfilt.)	1-3	1		NT	1	1
19	Ashland 18% (unfilt.)	1-3	0		NT	0	0
20	Egg control (Seawater)	1-3	0		NT	0	0
21	Egg control (brine 32%)	1-3	0		NT	0	0
22	Egg control (Pico 5.6%)	1-3	0		NT	0	0
23	Egg control (Pico 18%)	1-3	0		NT	0	0
24	Egg control (Pico 56%)	4	0		NT	0	0
25	Egg control (Ashland 5.6%)	1-3	0		NT	0	0
26	Egg control (Ashland 18%)	1-3	0		NT	0	0
27	Egg control (Ashland 56%)	4	0		NT	0	0

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Table D1-3. Summary of Purple Sea Urchin fertilization test 186; Conducted September 9, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent Fertilized Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		98	(1)			99, 98, 97
2	Brine control 18%	1	96	(2)	NS	98	94, 94, 96, 99
3	Brine control 32%	1	93	(6)	NS	95	96, 94, 86, 98
4	Brine control 56%	1	73	(6)	S	75	70, 72, 70, 82
5	Ballona filtrate 5.6%	1-3	82	(6)	S	86	83, 88, 76
6	Ballona filtrate 10%	1-3	77	(0)	S	80	76, 77, 76
7	Ballona filtrate 18%	1-3	28	(5)	S	29	25, 33, 25
8	Ballona filtrate 32%	1-3	13	(10)	S	14	6, 9, 24
9	Ballona filtrate 56%	4	2	(2)	NT	2	1, 0, 4
10	Ballona 10% (unfilt.)	1-3	96		NT	101	96
11	Ballona 18% (unfilt.)	1-3	38		NT	40	38
12	Ballona 32% (unfilt.)	1-3	58		NT	61	58
13	Sepulveda filtrate 5.6%	1-3	90	(4)	NS	94	94, 86, 87
14	Sepulveda filtrate 10%	1-3	95	(3)	NS	100	92, 97, 96
15	Sepulveda filtrate 18%	1-3	42	(15)	S	43	59, 32, 34
16	Sepulveda filtrate 32%	1-3	63	(7)	S	66	59, 72, 58
17	Sepulveda filtrate 56%	1-3	19	(8)	NT	26	10, 26, 21
18	Sepulveda 10% (unfilt.)	1-3	64		NT	65	64
19	Sepulveda 18% (unfilt.)	1-3	40		NT	41	40
20	Sepulveda 32% (unfilt.)	1-3	85		NT	87	85
21	Egg control (seawater)	1-3	0		NT	0	0
22	Egg control (brine 18%)	1-3	0		NT	0	0
23	Egg control (Ballona 18%)	1-3	0		NT	0	0
24	Egg control (Ballona 56%)	4	0		NT	0	0
25	Egg control (Sepulveda 5.6%)	1-3	0		NT	0	0
26	Egg control (Sepulveda 18%)	4	0		NT	0	0

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Table D1-4. Summary of storm drain effluent NOEC and EC50 values for marine test species. Values are expressed in percent effluent.

Location (1)	Sampling Date (2)	NOEC Abalone Develop. (3)	NOEC Kelp Germ. (4)	NOEC Kelp Length (5)	NOEC Urchin Fert. (6)	EC50 Abalone Develop (7)	EC50 Kelp Germ. (8)	EC50 Kelp Length (9)	EC50 Urchin Fert. (10)
Ashland	8-24-92	<5.6	18	18	10	6.8	32	> 56	17
Ballona	9-8-92	>56	>56	>56	<5.6	> 56	> 56	> 56	14
Pico-Kenter	8-24-92	18	>56	>56	>56	42	> 56	> 56	> 56
Sepulveda	9-8-92	>56	>56	>56	10	> 56	> 56	> 56	nt[a]

[a]Data not amenable to testing for EC50.

Table D1-5. Summary of 48 hour red abalone larval development test H-2; Conducted August 26, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent normal development Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw Data (8)
1	Seawater control	1	93	(6)			97, 89, 10[a]
2	Brine control 18%	1	83	(6)	NS	98	91, 82, 79
3	Brine control 32%	1	84	(6)	NS	99	86, 89, 76
4	Brine control 56%	1	85	(8)	NS	99	75, 89, 90
5	Pico-Kenter filtrate 5.6%	1-4	85	(9)	NS	99	93, 75, 86
6	Pico-Kenter filtrate 10%	1-4	84	(5)	NS	98	79, 83, 86
7	Pico-Kenter filtrate 18%	1-4	91	(5)	NS	106	92, 94, 85
8	Pico-Kenter filtrate 32%	1-4	73	(9)	S	86	72, 65, 82
9	Pico-Kenter filtrate 56%	1-4	13	(8)	S	15	13, 5, 21
10	Pico-Kenter 10% (unfilt.)	1-4	79		NT	93	79
11	Pico-Kenter 18% (unfilt.)	1-4	77		NT	90	77
12	Pico-Kenter 32% (unfilt.)	1-4	29		NT	34	29
13	Ashland filtrate 5.6%	1-4	69	(2)	S	81	71, 68, 68
14	Ashland filtrate 10%	1-4	3	(2)	S	4	2, 6, 2
15	Ashland filtrate 18%	1-4	0	(0)	NT	0	0, 0, 0
16	Ashland filtrate 32%	1-4	0	(0)	NT	0	0, 0, 0
17	Ashland filtrate 56%	1-4	0	(0)	NT	0	0, 1, 0
18	Ashland 10% (unfilt.)	1-4	0		NT	0	0
19	Ashland 18% (unfilt.)	1-4	0		NT	0	0
20	Ashland 32% (unfilt.)	1-4	0		NT	0	0

[a] Outlier value was not included in statistical calculations.

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Table D1-6. Summary of 48 hour red abalone larval development test H-4; Conducted September 9, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent normal development Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		97	(1)			97, 96, 98
2	Brine control 18%	1	98	(1)	NS	101	98, 99, 97, 98
3	Brine control 32%	1	96	(0)	NS	99	96, 96, 95, 96
4	Brine control 56%	1	97	(2)	NS	100	97, 96, 95, 100
5	Ballona filtrate 5.6%	1-4	96	(4)	NT	99	99, 96, 92
6	Ballona filtrate 10%	1-4	98	(1)	NT	101	98, 97, 98
7	Ballona filtrate 18%	1-4	97	(1)	NT	100	98, 97, 97
8	Ballona filtrate 32%	1-4	97	(1)	NT	100	96, 98, 97
9	Ballona filtrate 56%	1-4	96	(2)	NT	99	97, 94, 97
10	Ballona 10% (unfilt.)	1-4	96		NT	99	96
11	Ballona 18% (unfilt.)	1-4	99		NT	102	99
12	Ballona 32% (unfilt.)	1-4	98		NT	101	98
13	Sepulveda filtrate 5.6%	1-4	97	(1)	NT	100	96, 97, 97
14	Sepulveda filtrate 10%	1-4	96	(1)	NT	99	95, 96, 98
15	Sepulveda filtrate 18%	1-4	97	(2)	NT	100	95, 98, 97
16	Sepulveda filtrate 32%	1-4	97	(2)	NT	100	97, 95, 98
17	Sepulveda filtrate 56%	1-4	98	(1)	NT	101	98, 99, 98
18	Sepulveda 10% (unfilt.)	1-4	99		NT	102	99
19	Sepulveda 18% (unfilt.)	1-4	94		NT	97	94
20	Sepulveda 32% (unfilt.)	1-4	96		NT	99	96

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Table D1-7. Summary of kelp spore germination endpoint for test M-3; Conducted August 26, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent germinated Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		86	(1)			88, 85, 86
2	Brine control 18%	1	86	(4)	NT	100	86, 90, 88, 81
3	Brine control 32%	1	92	(4)	NT	106	94, 94, 93, 86
4	Brine control 56%	1	93	(2)	NT	108	92, 95, 93
5	Pico-Kenter filtrate 5.6%	1-4	90	(5)	NT	101	85, 95, 90
6	Pico-Kenter filtrate 10%	1-4	89	(4)	NT	100	87, 87, 93
7	Pico-Kenter filtrate 18%	1-4	91	(2)	NT	101	92, 91, 89
8	Pico-Kenter filtrate 32%	1-4	94	(4)	NT	105	94, 89, 97
9	Pico-Kenter filtrate 56%	1-4	90	(6)	NT	101	94, 84, 93
10	Pico-Kenter 10% (unfilt.)	1-4	91		NT	102	91
11	Pico-Kenter 18% (unfilt.)	1-4	85		NT	95	85
12	Pico-Kenter 32% (unfilt.)	1-4	76		NT	85	76
13	Ashland filtrate 5.6%	1-4	93	(2)	NS	104	91, 94, 93
14	Ashland filtrate 10%	1-4	91	(4)	NS	102	95, 89, 89
15	Ashland filtrate 18%	1-4	85	(1)	NS	95	85, 84, 86
16	Ashland filtrate 32%	1-4	48	(6)	S	53	49, 41, 52
17	Ashland filtrate 56%	1-4	3	(2)	S	3	4, 4, 0
18	Ashland 10% (unfilt.)	1-4	ND[a]				
19	Ashland 18% (unfilt.)	1-4	ND[a]				

[a] Slide was unreadable due to particulates in sample.

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Table D1-8. Summary of Kelp spore germ tube length endpoint for test M-3; Conducted August 26, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent germinated Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		15	(2)			13, 17, 16
2	Brine control 18%	1	12	(0)	S	80	12, 12, 13, 12
3	Brine control 32%	1	13	(1)	NS	87	12, 14, 14, 12
4	Brine control 56%	1	14	(2)	NS	93	13, 12, 16
5	Pico-Kenter filtrate 5.6%	1,3,4	15	(1)	NT	107	14, 16, 14
6	Pico-Kenter filtrate 10%	1,3,4	14	(1)	NT	100	15, 13, 14
7	Pico-Kenter filtrate 18%	2	15	(3)	NT	125	17, 12, 15
8	Pico-Kenter filtrate 32%	1,3,4	13	(2)	NT	93	15, 13, 11
9	Pico-Kenter filtrate 56%	1,3,4	14	(2)	NT	100	13, 16, 14
10	Pico-Kenter 10% (unfilt.)	1,3,4	12		NT	86	12
11	Pico-Kenter 18% (unfilt.)	2	16		NT	133	16
12	Pico-Kenter 32% (unfilt.)	1,3,4	16		NT	114	16
13	Ashland filtrate 5.6%	1,3,4	18	(1)	NS	129	18, 17, 19
14	Ashland filtrate 10%	1,3,4	17	(1)	NS	121	17, 18, 16
15	Ashland filtrate 18%	2	14	(1)	NT	117	13, 16, 13
16	Ashland filtrate 32%	1,3,4	10	(2)	S	71	8, 11, 12
17	Ashland filtrate 56%	1,3,4	10	(1)	S	71	11, 8, 10
18	Ashland 10% (unfilt.)	1,3,4	ND[a]				
19	Ashland 18% (unfilt.)	2	ND[a]				

[a] Slide was unreadable due to particulates in sample.

Table D1-9. Summary of Kelp spore germination endpoint for test M-5; Conducted September 9, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent germinated				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		78	(5)			79, 82, 73
2	Brine control 18%	1	67	(9)	S	86	73, 58, 63, 75
3	Brine control 32%	1	75	(4)	NS	96	81, 74, 71, 76
4	Brine control 56%	1	78	(4)	NS	100	82, 77, 79, 73
5	Ballona filtrate 5.6%	1,3,4	75	(12)	NT	98	61, 85, 80
6	Ballona filtrate 10%	1,3,4	79	(7)	NT	103	85, 71, 81
7	Ballona filtrate 18%	2	75	(7)	NT	112	82, 76, 68
8	Ballona filtrate 32%	1,3,4	78	(1)	NT	101	78, 77, 80
9	Ballona filtrate 56%	1,3,4	78	(1)	NT	101	79, 77, 77
10	Ballona 10% (unfilt.)	1,3,4	78		NT	101	78
11	Ballona 18% (unfilt.)	2	79		NT	118	79
12	Ballona 32% (unfilt.)	1,3,4	74		NT	96	74
13	Sepulveda filtrate 5.6%	1,3,4	67	(7)	NT	86	66, 73, 60
14	Sepulveda filtrate 10%	1,3,4	70	(3)	NT	91	68, 73, 69
15	Sepulveda filtrate 18%	2	78	(8)	NT	116	78, 71, 86
16	Sepulveda filtrate 32%	1,3,4	82	(11)	NT	106	86, 91, 69
17	Sepulveda filtrate 56%	1,3,4	76	(5)	NT	99	72, 75, 83
18	Sepulveda 10% (unfilt.)	1,3,4	69		NT	90	69
19	Sepulveda 18% (unfilt.)	2	70		NT	91	70
20	Sepulveda 32% (unfilt.)	1,3,4	69		NT	90	69

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Table D1-10. Summary of Kelp spore germ tube length endpoint for test M-5; Conducted September 9, 1992. Abbreviations as for Table D1-2.

Group (1)	Description (2)	Reference group (3)	Percent germinated				
			Mean (4)	SD (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		15	2			15, 17, 14
2	Brine control 18%	1	15	0	NT	100	15, 15, 14, 15
3	Brine control 32%	1	15	0	NT	100	15, 15, 14, 15
4	Brine control 56%	1	16	3	NT	107	19, 12, 15,16
5	Ballona filtrate 5.6%	1,3,4	17	2	NT	113	16, 16, 19
6	Ballona filtrate 10%	1,3,4	18	1	NT	120	19, 17, 19
7	Ballona filtrate 18%	2	18	1	NT	120	18, 18, 19
8	Ballona filtrate 32%	1,3,4	17	1	NT	113	17, 17, 18
9	Ballona filtrate 56%	1,3,4	15	1	NT	100	14, 14, 16
10	Ballona 10% (unfilt.)	1,3,4	18		NT	120	18
11	Ballona 18% (unfilt.)	2	16		NT	107	16
12	Ballona 32% (unfilt.)	1,3,4	18		NT	120	18
13	Sepulveda filtrate 5.6%	1,3,4	16	1	NT	107	16, 17, 15
14	Sepulveda filtrate 10%	1,3,4	17	1	NT	113	16, 18, 16
15	Sepulveda filtrate 18%	2	16	2	NT	107	15, 15, 19
16	Sepulveda filtrate 32%	1,3,4	16	2	NT	107	19, 15, 15
17	Sepulveda filtrate 56%	1,3,4	17	2	NT	113	18, 18, 15
18	Sepulveda 10% (unfilt.)	1,3,4	17		NT	113	17
19	Sepulveda 18% (unfilt.)	2	15		NT	100	15
20	Sepulveda 32% (unfilt.)	1,3,4	17		NT	113	17

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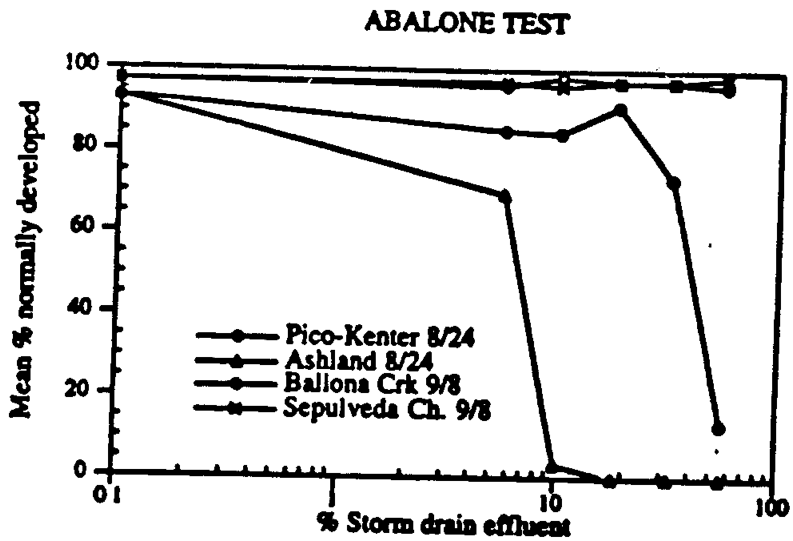

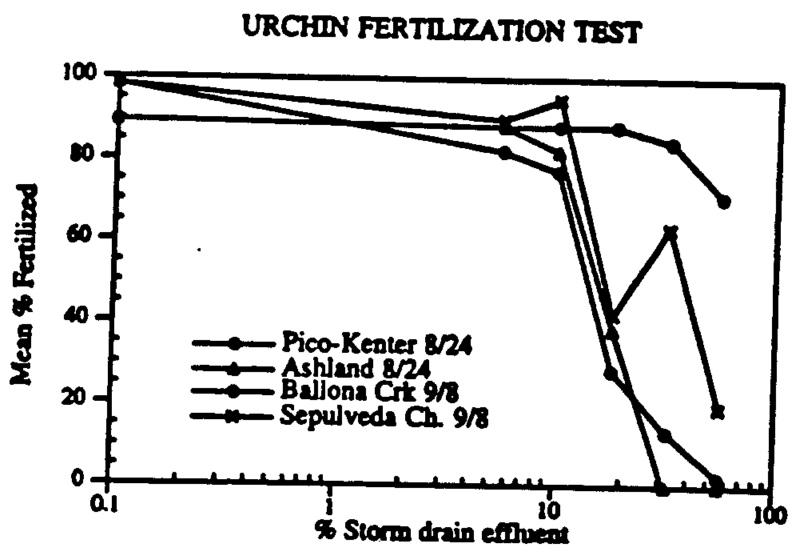

Figure D1-1. Dose-response plots for abalone embryo development and sea urchin fertilization tests. Control values are those plotted at a concentration of 0.1%.

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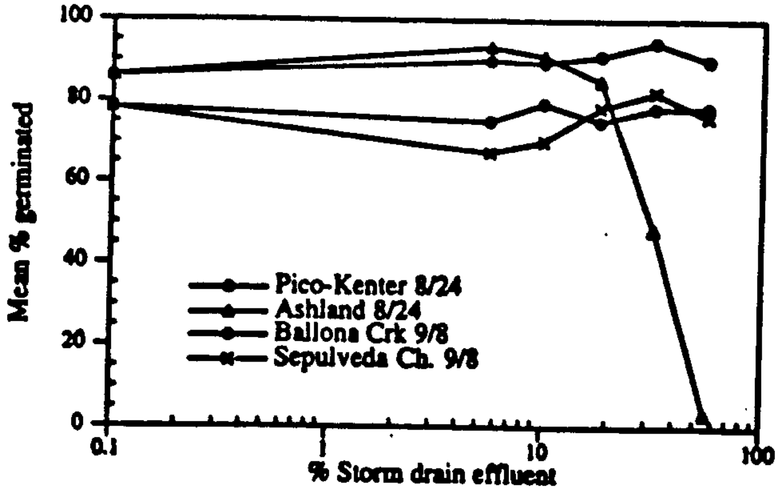
GIANT KELP GERMINATION TEST



GERM TUBE LENGTH TEST

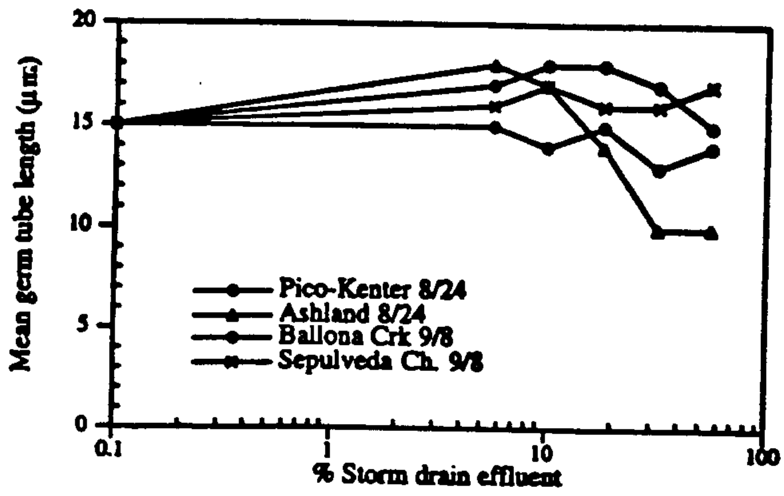


Figure D1-2. Dose-response plots for giant kelp germination and germ tube length tests. Control values are those plotted at a concentration of 0.1%.

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Table D1.a-1. Summary of initial water quality data for toxicity tests conducted August 26-28, 1992 (tests S184, H2, M3). DO = dissolved oxygen.

Description (1)	DO mg/L (2)	Ammonia mg/L (3)	pH (4)	Salinity mg/g (5)
Seawater control	7.8	0.04	7.90	34
Brine control 18%			8.26	34
Brine control 32%			8.26	34
Brine control 56%			8.22	34
Pico-Kenter filtrate 5.6%	8.4	0.03	8.23	34
Pico-Kenter filtrate 10%	8.4	0.03	8.22	34
Pico-Kenter filtrate 18%	8.4	0.03	8.18	34
Pico-Kenter filtrate 32%	8.4	0.04	8.14	34
Pico-Kenter filtrate 56%	8.0	0.05	8.11	35
Ashland filtrate 5.6%	7.8	0.10	8.23	34
Ashland filtrate 10%	7.6	0.13	8.21	34
Ashland filtrate 18%	7.8	0.25	8.17	34
Ashland filtrate 32%	7.8	0.46	8.11	34
Ashland filtrate 56%	7.9	0.91	8.06	32

R0049929

Table D1.a-2. Summary of final water quality and temperature data for abalone toxicity test H2, conducted August 26-28, 1992. DO = dissolved oxygen.

Description	DO mg/L	pH	Salinity mg/g	Temperature Day 0	Day 1	Day 2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Seawater control	7.2	7.87	35	16.2	15.9	15.5
Brine control 18%	7.3	7.90	34	16.3	16.1	15.5
Brine control 32%	7.2	7.87	34	16.3	16.1	15.4
Brine control 56%	7.2	7.86	34	15.9	16.1	15.5
Pico-Kenter filtrate 5.6%	7.6	7.92	34	16.0	16.0	15.7
Pico-Kenter filtrate 10%	7.5	7.94	35	15.9	16.0	15.8
Pico-Kenter filtrate 18%	7.5	7.96	35	16.0	16.0	15.4
Pico-Kenter filtrate 32%	7.4	8.00	35	16.0	16.0	15.5
Pico-Kenter filtrate 56%	7.3	8.03	35	16.1	16.1	15.5
Ashland filtrate 5.6%	7.6	7.95	34	16.2	16.1	15.5
Ashland filtrate 10%	7.5	8.00	34	15.9	15.9	15.3
Ashland filtrate 18%	7.2	8.00	34	16.1	16.0	15.4
Ashland filtrate 32%	7.0	8.03	35	15.9	16.1	15.7
Ashland filtrate 56%	6.9	8.08	32	16.1	16.2	15.5

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R0049930

Table D1.a-3. Summary of final water quality and temperature data for kelp toxicity test M3, conducted August 26-28, 1992. DO = dissolved oxygen.

Description (1)	DO mg/L (2)	pH (3)	Salinity mg/g (4)	Temperature Day 0 (5)	Temperature Day 1 (6)	Temperature Day 2 (7)
Seawater control	7.6	8.00	34	15.9	16.2	15.9
Brine control 18%	7.8	8.03	34	14.9	16.5	16.0
Brine control 32%	7.5	7.99	34	15.3	16.6	15.9
Brine control 56%	7.8	8.00	34	15.3	16.6	15.8
Pico-Kenter filtrate 5.6%	7.6	8.03	34	15.4	16.6	15.9
Pico-Kenter filtrate 10%	7.6	8.03	34	15.2	16.4	15.9
Pico-Kenter filtrate 18%	7.5	8.03	35	15.7	17.0	15.9
Pico-Kenter filtrate 32%	7.5	8.05	34	15.8	17.0	15.9
Pico-Kenter filtrate 56%	7.6	8.08	34	15.4	16.6	15.9
Ashland filtrate 5.6%	7.7	8.04	35	14.9	16.7	15.9
Ashland filtrate 10%	7.6	8.05	34	15.2	17.1	16.0
Ashland filtrate 18%	7.5	8.06	34	14.9	16.4	16.0
Ashland filtrate 32%	7.4	8.09	34	15.5	16.3	15.9
Ashland filtrate 56%	7.1	8.12	31	14.8	16.4	16.0

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Table D1.a-4. Summary of initial water quality data for toxicity tests conducted September 9-11, 1992 (tests S186, H4, M5).

Description (1)	DO mg/L (2)	Ammonia mg/L (3)	pH (4)	Salinity mg/g (5)
Seawater control	7.4	0.03	8.06	34
Brine control 18%	7.4		8.17	33
Brine control 32%	7.5		8.19	34
Brine control 56%	7.3		8.20	32
Ballona filtrate 5.6%	7.6	0.02	8.21	34
Ballona filtrate 10%	7.6	0.02	8.25	34
Ballona filtrate 18%	7.6	0.02	8.31	34
Ballona filtrate 32%	7.8	0.02	8.24[a]	34
Ballona filtrate 56%	7.7	0.02	8.23[a]	34
Sepulveda filtrate 5.6%	7.9	0.02	8.19	34
Sepulveda filtrate 10%	7.9	0.02	8.25	34
Sepulveda filtrate 18%	7.9	0.02	8.31	34
Sepulveda filtrate 32%	7.7	0.02	8.23[a]	34
Sepulveda filtrate 56%	7.7	0.02	8.23[a]	34

[a] Value after pH adjustment.

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Table D1.a-5. Summary of final water quality and temperature data for abalone toxicity test H4, conducted September 9-11, 1992. DO = dissolved oxygen.

Description	DO mg/L	pH	Salinity mg/g	Temperature		
				Day 0	Day 1	Day 2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Seawater control	6.8	8.07	34	14.9	14.8	14.7
Brine control 18%	6.8	8.06	34	14.8	14.9	14.6
Brine control 32%	6.8	8.06	34	14.8	14.9	14.5
Brine control 56%	6.8	8.08	33	14.8	14.9	14.5
Ballona filtrate 5.6%	6.8	8.11	34	15.0	15.0	14.5
Ballona filtrate 10%	6.8	8.14	34	14.7	14.8	14.7
Ballona filtrate 18%	6.6	8.19	34	14.8	14.9	14.5
Ballona filtrate 32%	6.6	8.20	34	14.9	14.9	14.7
Ballona filtrate 56%	6.5	8.24	34	14.8	14.8	14.5
Sepulveda filtrate 5.6%	6.8	8.09	34	14.8	14.9	14.6
Sepulveda filtrate 10%	6.9	8.12	34	14.8	15.0	14.8
Sepulveda filtrate 18%	6.7	8.16	34	14.9	14.8	14.5
Sepulveda filtrate 32%	6.8	8.15	34	14.7	15.0	14.0
Sepulveda filtrate 56%	6.6	8.19	34	14.8	14.9	14.6

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Table D1.a-6. Summary of final water quality and temperature data for kelp toxicity test M5, conducted September 9-11, 1992. DO = dissolved oxygen.

Description (1)	DO mg/L (2)	pH (3)	Salinity mg/g (4)	Temperature Day 0 (5)	Temperature Day 1 (6)	Temperature Day 2 (7)
Seawater control	7.2	8.15	34	16.0	16.0	15.6
Brine control 18%	7.3	8.13	34	16.3	15.9	15.5
Brine control 32%	7.4	8.14	34	16.1	16.1	15.7
Brine control 56%	7.3	8.14	33	15.9	16.0	15.4
Ballona filtrate 5.6%	7.2	8.18	35	16.0	16.0	15.6
Ballona filtrate 10%	7.3	8.20	34	16.1	16.0	15.5
Ballona filtrate 18%	7.2	8.25	34	16.0	16.0	15.5
Ballona filtrate 32%	7.2	8.26	34	16.1	16.0	15.5
Ballona filtrate 56%	7.2	8.30	34	16.2	16.0	15.5
Sepulveda filtrate 5.6%	7.2	8.16	34	15.9	15.9	15.6
Sepulveda filtrate 10%	7.2	8.20	34	15.9	16.0	15.5
Sepulveda filtrate 18%	7.4	8.23	35	15.8	16.0	15.5
Sepulveda filtrate 32%	7.3	8.22	34	16.3	15.9	15.5
Sepulveda filtrate 56%	7.1	8.24	34	16.1	16.1	15.5

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APPENDIX D2
TOXICITY ANALYSIS OF
STORM DRAIN DRY WEATHER FLOW
SAMPLES COLLECTED 9/29 AND 10/12/92

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INTRODUCTION

This report summarizes the results of marine toxicity tests conducted on two samples of dry weather flow collected from three storm drains in Los Angeles (Ashland, Ballona Creek, and Pico-Kenter). These tests were a continuation of work initiated in August, 1992. The objective of the tests described in this report was to collect additional toxicity data for use in determining the most toxic location and relative sensitivity of the test species used. Reference toxicant results for all tests conducted to date are also summarized in this report.

METHODS

Storm drain dry weather flow samples were collected on September 29 and October 12, 1992. Basic test methods were essentially the same as described in the previous report dated September 29, 1992. The number of dilutions tested was reduced to four (instead of five) and the concentrations used previously (5.6, 10, 18, 32, and 56%) were changed. Concentrations containing 5.6, 12, 25, and 56% storm drain effluent were prepared for each location.

Toxicity tests of samples collected September 29, 1992 were initiated on two successive days. Filtrate prepared on the first day (abalone and kelp tests) was stored at 5°C and used to prepare fresh effluent dilutions for the second day's work (sea urchin test). All three toxicity tests of the October 12, 1992 samples were initiated on the same day. Toxicity tests were initiated within 48 hours of sample collection in all cases.

Abalone and kelp toxicity tests of the September 29 sample were judged unacceptable because of poor control performance. Consequently, only limited water quality and microscopic analyses of these tests were performed. NOEC and EC50 values were not calculated for these data. An additional set of kelp and abalone toxicity tests was conducted on the October 12 sample in order to complete the initial phase of the project.

RESULTS AND DISCUSSION

Water Quality

The initial pH of undiluted Ballona Creek effluent was high (Table D2-1) and similar in value to the first sample tested. The pH values for the 56% Ballona test concentrations were unacceptably high (> 8.3) and were adjusted with dilute HCl before use (Appendix Tables D2.a-1 and a-2). The pH of samples from Ashland and Pico-Kenter were lower (Table 1) and did not produce unacceptable values once diluted with seawater.

Salinity of Ballona and Pico-Kenter effluents were low (Table D2-1) and similar to the values measured previously. The salinity of Ashland effluent was elevated on both sampling occasions, probably because of tidal seawater intrusion. Adjustments made during the preparation of effluent dilutions eliminated salinity variations in the test solutions Tables D2.a-1 and a-2).

All experiments except the October 1 sea urchin fertilization test were conducted at temperatures of 14-15°C. The exposure temperature for the October 1 sea urchin test was 11.8°C. Temperature during the October 13 sea urchin experiment was 14.5°C. Fluctuations in temperature were well within the tolerance range of the test species and were not likely to cause undesirable levels of stress. Concurrent reference toxicant test data indicate that the test sensitivity did not vary greatly as a result of this temperature difference. Other water quality measurements of test solutions at the beginning and end of the toxicity tests indicated that acceptable conditions were present during all of the tests (Tables D2.a-1 - a-4).

Relative Toxicity

Effluent from the Ashland storm drain had the greatest relative toxicity on both sampling occasions (Table D2-2). EC50s for this location ranged from 10% (abalone) to 22% (kelp). Ballona Creek effluent was least toxic of the three sites. No toxicity was found in the October sample and relatively minor toxicity was measured in the September 29 Ballona Creek sample. Pico-Kenter effluent from September 29 was not toxic to sea urchins (only test completed). The October sample produced intermediate toxic responses in all three test species, with EC50s ranging from 21% (abalone) to >56% (kelp).

Sea urchin toxicity

The sea urchin test was the only test conducted on the 9/29 sample that had acceptable control performance. A small reduction in fertilization was measured in one of the brine controls (56%, Table D2-3). Effluent from the Ashland drain was most toxic, producing reduced fertilization at concentrations of 12% and above. No toxicity was produced by exposure to Pico-Kenter effluent. An unusual dose-response pattern was obtained for the Ballona Creek sample. Significant toxicity was measured at a concentration of 25%, but not at 56%. The reason for this occurrence is not known, although it may be the result of an interaction between the effluent and the brine solution used to adjust salinity.

Fertilization test results for the 10/12 samples indicated toxicity for Ashland and Pico-Kenter only (Figure D2-1). Seawater and brine control results were within the desired range (Table D2-4). No fertilization was observed in any of the test samples exposed to Ashland effluent. Consequently, there was no need to conduct statistical tests on these data.

Abalone toxicity

Poor quality gametes were used in the abalone toxicity test of the 9/29 samples, resulting in poor control embryo development (Table D2-5). A few samples from this experiment were examined in order to estimate the relative toxicity of the samples. These data indicated that Ashland was toxic at 12%, some toxicity was present at Pico-Kenter, and no toxicity was evident at Ballona Creek (Figure D2-1). These accuracy of these results is uncertain because of the poor control results and limited number of samples examined.

Much better control results were obtained in the toxicity test of the 10/12 samples (Table D2-6). Control survival (68%) was still below the acceptable limit of 85% used for compliance monitoring purposes. Poor embryo development was also observed in the brine control for the 56% concentration. It was not felt that the low control survival would eliminate the usefulness of this test and all samples were therefore examined. This decision was supported by the reference toxicant test results, which indicated that the sensitivity of this test was within acceptable limits. Abalone embryo toxicity was produced by the Ashland and Pico-Kenter samples, but not Ballona Creek. This is similar to the pattern suggested by the aborted test of the 9/29 samples. Ashland was most toxic, with significant embryo deformities caused by exposure to 12% effluent.

Kelp toxicity

Spore germination in controls for the toxicity test of the 9/29 samples was very low and indicated that the test results could be unreliable. Control germ tube length measurements were within normal limits, however, and a limited number of samples were measured to estimate the relative toxicity of each site (Table D2-7). No indication of substantial toxic effects on germ tube length was found for any of the storm drain sites. Even Ashland, typically the most toxic site, produced only a slight reduction in length (Figure D2-2).

Control germination and tube length during the test of the 10/12 samples were higher and within acceptable limits. Germination was only reduced by Ashland effluent concentrations of 12% and above (Table D2-8). Reductions in germ tube length were produced by the brine, 12% and greater concentrations of Ashland effluent, and 56% Pico-Kenter effluent (Table D2-9). The dose response plots for these samples were typical in appearance (Figure D2-3).

Reference toxicant results

An important part of the QA/QC effort for this project was the testing of a concurrent reference toxicant dilution series for each species and sample investigated. The reference toxicant results are intended to document the relative sensitivity of the test species between experiments. Results for all of the reference toxicant tests are summarized in this report (raw data is available upon request). Corresponding storm drain effluent toxicity test data for the first sampling period (8/24 & 9/8) are described in the previous report dated 9/29/92.

Zinc was the reference toxicant used for the abalone toxicity tests. Reference toxicant results (NOEC) for experiments conducted on 8/26, 9/9, and 10/13 were all within limits stated in the test procedure.

Copper was used as the reference toxicant in the kelp toxicity tests. Experiments conducted on 9/9 and 10/13 were within the desired range, but the NOEC for the 8/26 test was above the acceptable limit. These results indicate that the 8/26 kelp test of Ashland and Pico-Kenter samples may have been less sensitive than subsequent experiments. It should be emphasized that there is no guarantee that the reference toxicant results bear any relation to variations in the actual sensitivity of kelp spores to storm drain effluents. The measured toxicity to kelp of Ashland and Pico-Kenter samples tested on 8/26 and 10/13 was very similar, suggesting that the 8/26 data are of acceptable accuracy.

Sea urchin fertilization reference toxicant tests also used copper. Results for this group of tests are presented as the EC50 and compared to SCCWRP data for the previous two years.

An acceptable range of response for the sea urchin test has not yet been developed. As a substitute, the data are plotted as quality control charts using ± 2 standard deviations of the cumulative mean as control limits. This approach is recommended by the EPA for toxicity data. All of the storm drain reference test data fell within control limits and were similar to prior results obtained at SCCWRP. The conclusion is that the sea urchin fertilization tests conducted during this project were of typical sensitivity.

CONCLUSIONS

The phase 1 toxicity test objectives for this project have been successfully completed. Tests with three marine species were conducted and have provided data that can be used to rank the relative toxicity of the sites and describe variability in toxicity.

The Ashland site was found to be most toxic to each of the three species of test organisms (Table D2-10). This location consistently produced the greatest toxicity in all tests conducted. No clear distinction between the relative toxicity of the Ballona Creek and Pico-Kenter sites can be made. Comparison of the EC50 values for the different samples shows that the test species responded differently to these sites, as shown in Table D2-11. The abalone test was more sensitive to Pico-Kenter effluent, with the kelp test being least sensitive. Ballona Creek effluent produced the greatest toxic effects on sea urchin sperm, however, while the abalone and kelp tests were unaffected by effluent from this site.

The differential sensitivity to each site shown by the tests also makes it difficult to generalize about which species is the most sensitive. The kelp test was always the least sensitive to each of the effluent types, however.

A moderate degree of temporal variability in effluent toxicity was found in this study. The magnitude of toxic effects produced by Ashland effluent was similar between sampling times. Pico-Kenter effluent was consistently toxic to abalone embryos, but produced toxic effects on sea urchin sperm in only one of three tests. Ballona Creek effluent produced a different level of toxicity to sea urchin sperm in each of the three tests conducted; toxic effects ranged from strong (EC50 = 14%) in the first sample to nontoxic in the last sample tested.

The temporal variability found in this study is not surprising, considering that each effluent represents a mixture of many separate inputs. It is interesting to note that the Ballona and Pico-Kenter samples having the greatest initial pH usually produced the greatest toxic effects. While pH itself was controlled during the test and not likely to produce toxicity directly, these pH changes may be related to variations in other effluent characteristics having an impact on relative toxicity.

Table D2-1. Summary of initial water quality data for undiluted storm drain effluent samples. Measurements were made on the day of toxicity test initiation. Salinity units are mg/g.

Location (1)	Collection Date (2)	pH (3)	Salinity (4)
Ashland	9-29-92	8.13	8
	10-12-92	8.03	9
Ballona	9-29-92	9.40	2
	10-12-92	9.16	3
Pico-Kenter	9-29-92	8.32	2
	10-12-92	8.58	2

Table D2-2. Storm drain effluent NOEC and EC50 values for storm drain samples collected September 29 and October 12, 1992. Values are expressed in percent effluent.

Location (1)	Sampling Date (2)	NOEC: Abalone Develop. (3)	NOEC: Kelp Germ. (4)	NOEC: Kelp Length (5)	NOEC: Urchin Fert. (6)	EC50: Abalone Develop (7)	EC50: Kelp Germ. (8)	EC50: Kelp Length (9)	EC50: Urchin Fert. (10)
Ashland	9-29-92	nt[a]	nt	nt	5.6	nt	nt	nt	14
	10-12-92	5.6	5.6	5.6	<5.6	10	22	50	< 5.6
Ballona	9-29-92	nt	nt	nt	12[b]	nt	nt	nt	> 56
	10-12-92	≥56	≥56	≥56	≥56	> 56	> 56	> 56	> 56
Pico-Kenter	9-29-92	nt	nt	nt	≥56	nt	nt	nt	> 56
	10-12-92	12	≥56	25	25	21	> 56	> 56	41

[a]Insufficient data to calculate value.

[b]NOEC could also be stated as ≥56% since 56% concentration was not significantly different from respective brine control. A NOEC of 12 is felt to be more appropriate since 25% concentration was significantly toxic and 56% brine control was toxic, making accuracy of 56% effluent results questionable.

Table D2-3. Summary of Purple sea urchin fertilization test; conducted October 1, 1992. Abbreviation: % Ref = mean response expressed as a percentage of the appropriate reference group(s); NS = not significantly difference relative to reference; S = statistically significant difference; NT = not tested (no need or data not sufficient).

Group (1)	Description (2)	Reference group (3)	Percent Fertilized Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		81	(2)			79, 81, 82
2	Brine control 25%	1	87	(3)	NS	107	87, 90, 84
3	Brine control 56%	1	75	(1)	S	93	75, 76, 74
4	Ballona filtrate 5.6%	1-2	86	(2)	NS	103	84, 88, 85
5	Ballona filtrate 12%	1-2	83	(6)	NS	99	76, 88, 85
6	Ballona filtrate 25%	1-2	64	(3)	S	76	61, 63, 68
7	Ballona filtrate 56%	3	69	(8)	NS	92	67, 77, 61
8	Ashland filtrate 5.6%	1-2	87	(5)	NS	104	87, 92, 82
9	Ashland filtrate 12%	1-2	62	(12)	S	74	49, 63, 73
10	Ashland filtrate 25%	1-2	0	(0)	S	0	1, 0, 0
11	Ashland filtrate 56%	3	0	(0)	NT	0	0, 0, 0
12	Pico-Kenter filtrate 5.6%	1-2	83	(6)	NS	99	90, 80, 78
13	Pico-Kenter filtrate 12%	1-2	77	(3)	NS	92	74, 79, 77
14	Pico-Kenter filtrate 25%	1-2	82	(3)	NS	98	82, 85, 78
15	Pico-Kenter filtrate 56%	3	77	(4)	NS	103	75, 82, 75
16	Egg control (Seawater)	1-2	0		NT	0	0
17	Egg control (Ballona 25%)	1-2	0		NT	0	0
18	Egg control (Ashland 25%)	1-2	0		NT	0	0
19	Egg control (Pico-Kenter 25%)	1-2	0		NT	0	0

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Table D2-4. Summary of Purple Sea Urchin fertilization test 190; Conducted October 13, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Percent Fertilized Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		84	(10)			87, 91, 72
2	Brine control 25%	1	92	(2)	NS	110	90, 91, 94
3	Brine control 56%	1	78	(10)	NS	94	70, 90, 75
4	Ballona filtrate 5.6%	1-3	96	(2)	NT	114	93, 96, 98
5	Ballona filtrate 12%	1-3	97	(2)	NT	115	99, 96, 96
6	Ballona filtrate 25%	1-3	86	(7)	NT	102	80, 94, 83
7	Ballona filtrate 56%	1-3	88	(5)	NT	104	92, 91, 82
8	Ashland filtrate 5.6%	1-3	0	(1)	NT	0	0, 1, 0
9	Ashland filtrate 12%	1-3	0	(0)	NT	0	0, 0, 0
10	Ashland filtrate 25%	1-3	0	(1)	NT	0	0, 0, 1
11	Ashland filtrate 56%	1-3	0	(0)	NT	0	0, 0, 0
12	Pico-Kenter filtrate 5.6%	1-3	97	(2)	NS	115	95, 99, 97
13	Pico-Kenter filtrate 12%	1-3	94	(6)	NS	111	86, 98, 96
14	Pico-Kenter filtrate 25%	1-3	90	(2)	NS	107	88, 90, 92
15	Pico-Kenter filtrate 56%	1-3	9	(3)	S	11	10, 12, 6
16	Egg control (Seawater)	1-3	0		NT	0	0
17	Egg control (Ballona 25%)	1-3	0		NT	0	0
18	Egg control (Ashland 25%)	1-3	0		NT	0	0
19	Egg control (Pico-Kenter 25%)	1-3	0		NT	0	0

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Table D2-5. Summary of 48 hour red abalone larval development test H-6; Conducted September 30, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Percent normal development Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw Data (8)
1	Seawater control	1	7				7
2	Brine control 25%	1	7	(1)	NT	100	8, 6, 6
3	Brine control 56%	1	6	(1)	NT	86	7, 6, 6
4	Ballona filtrate 56%	1-3	9	(1)	NT	128	9, 10, 9
5	Pico-Kenter filtrate 56%	1-3	2	(2)	NT	29	1, 4, 1
6	Ashland filtrate 5.6%	1-3	5	(2)	NT	71	4, 4, 7
7	Ashland filtrate 12%	1-3	1	(1)	NT	14	0, 1
8	Ashland filtrate 25%	1-3	0	(0)	NT	0	0, 0
9	Ashland filtrate 56%	1-3	0		NT	0	0

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Table D2-6. Summary of 48 hour red abalone larval development test H-8; Conducted October 13, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Percent normal development				
			Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control	1	68	(12)			59, 82, 63
2	Brine control 25%	1	67	(1)	NS	99	66, 67
3	Brine control 56%	1	17	(2)	NT	25	18, 17, 15
4	Ballona filtrate 5.6%	1-2	70	(3)	NS	103	73, 68, 68
5	Ballona filtrate 12%	1-2	67	(8)	NS	100	66, 60, 76
6	Ballona filtrate 25%	1-2	66	(8)	NS	98	69, 57, 71
7	Ballona filtrate 56%	3	60	(4)	NT	89	58, 57, 71
8	Pico-Kenter filtrate 5.6%	1-2	61	(4)	NS	91	57, 63, 64
9	Pico-Kenter filtrate 12%	1-2	62	(8)	NS	92	71, 57, 59
10	Pico-Kenter filtrate 25%	1-2	24	(4)	S	35	28, 24, 20
11	Pico-Kenter filtrate 56%	3	0		NT	0	0
12	Ashland filtrate 5.6%	1-2	61	(2)	NS	90	62, 62, 58
13	Ashland filtrate 12%	1-2	25	(8)	S	37	23, 35, 18
14	Ashland filtrate 25%	1-2	0	(0)	NT	0	0, 0, 0
15	Ashland filtrate 56%	3	0		NT	0	0

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Table D2-7. Summary of Kelp spore germ tube length endpoint for test M-7; Conducted September 30, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Germ Tube Length (mm) Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		15	(2)			17, 15, 14
2	Brine control 25%	1	13	(1)	NT	87	14, 12, 14
3	Brine control 56%	1	15	(2)	NT	100	15, 13, 16
4	Ballona filtrate 56%	1-3	16	(1)	NT	107	17, 17, 15
5	Ashland filtrate 5.6%	1-3	14	(1)	NT	93	14, 15, 14
6	Ashland filtrate 12%	1-3	14	(2)	NT	93	14, 16, 13
7	Ashland filtrate 25%	1-3	13	(1)	NT	87	14, 13, 12
8	Ashland filtrate 56%	1-3	13	(1)	NT	87	14, 14, 12
9	Pico-Kenter filtrate 25%	1-3	13	(1)	NT	87	13, 14, 13
10	Pico-Kenter filtrate 56%	1-3	16	(2)	NT	107	15, 18, 16

Table D2-8. Summary of Kelp spore germination endpoint for test M-9; Conducted October 13, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Percent germinated Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		87	(5)			91, 88, 81
2	Brine control 25%	1	95	(1)	NS	109	95, 95, 94
3	Brine control 56%	1	92	(2)	NS	106	90, 92, 94
4	Ballona filtrate 5.6%	1-3	88	(3)	NT	96	87, 91, 85
5	Ballona filtrate 12%	1-3	87	(4)	NT	95	90, 88, 83
6	Ballona filtrate 25%	1-3	93	(2)	NT	102	95, 91, 92
7	Ballona filtrate 56%	1-3	94	(1)	NT	103	93, 93, 95
8	Ashland filtrate 5.6%	1-3	94	(4)	NS	103	96, 95, 89
9	Ashland filtrate 12%	1-3	79	(8)	S	87	87, 71, 79
10	Ashland filtrate 25%	1-3	38	(27)	S	42	66, 13, 37
11	Ashland filtrate 56%	1-3	2	(2)	S	2	1, 0, 4
12	Pico-Kenter filtrate 5.6%	1-3	93	(2)	NT	102	92, 93, 95
13	Pico-Kenter filtrate 12%	1-3	91	(4)	NT	100	96, 89, 88
14	Pico-Kenter filtrate 25%	1-3	90	(3)	NT	99	87, 94, 91
15	Pico-Kenter filtrate 56%	1-3	89	(4)	NT	98	92, 92, 84

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Table D2-9. Summary of Kelp spore germ tube length endpoint for test M-9; Conducted October 13, 1992. Abbreviations as for Table D2-3.

Group (1)	Description (2)	Reference group (3)	Germ Tube Length (mm) Mean (4)	(SD) (5)	Sig. (6)	% Ref. (7)	Raw data (8)
1	Seawater control		17	(1)			17, 18, 17
2	Brine control 25%	1	14	(1)	S	82	15, 13, 14
3	Brine control 56%	1	14	(2)	S	82	15, 14, 12
4	Ballona filtrate 5.6%	2,3	19	(1)	NS	136	18, 19, 19
5	Ballona filtrate 12%	2,3	19	(1)	NS	136	19, 19, 18
6	Ballona filtrate 25%	2,3	18	(1)	NS	129	19, 17, 17
7	Ballona filtrate 56%	2,3	17	(1)	NS	121	18, 16, 18
8	Ashland filtrate 5.6%	2,3	14	(2)	NS	100	12, 17, 14
9	Ashland filtrate 12%	2,3	12	(1)	S	86	13, 11, 11
10	Ashland filtrate 25%	2,3	9	(1)	S	64	10, 9, 8
11	Ashland filtrate 56%	2,3	6	(1)	S	43	7, 6
12	Pico-Kenter filtrate 5.6%	2,3	18	(1)	NS	129	17, 18, 18
13	Pico-Kenter filtrate 12%	2,3	17	(1)	NS	121	17, 16, 17
14	Pico-Kenter filtrate 25%	2,3	15	(1)	NS	107	14, 15, 16
15	Pico-Kenter filtrate 56%	2,3	12	(1)	S	86	12, 12, 11

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Table D2-10. Relative site toxicity ranks by species. Sample numbers refers to the three time periods studied (Sample 1 = 8/24 or 9/8/92). 3 = most toxic, 1 = least toxic.

Location (1)	Relative toxicity Sample 1 (2)	Sample 2 (3)	Sample 3 (4)	Sum of ranks (5)
Abalone development				
Ashland	3	3	3	9
Ballona	1	1	1	3
Pico-Kenter	2	2	2	6
Kelp germination/growth				
Ashland	3	3	3	9
Ballona	1.5	1.5	1	4
Pico-Kenter	1.5	1.5	2	5
Sea urchin fertilization				
Ashland	2.5	3	3	8.5
Ballona	2.5	2	1	5.5
Pico-Kenter	1	1	2	4

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Table D2-11. Relative rank test sensitivity to storm drain effluents. Rank assignments made on the basis of EC50 values (3 = most sensitive test).

Species (1)	Relative toxicity Sample 1 (2)	Sample 3 (3)	Sum of ranks (4)
Ashland			
Abalone	3	2	5
Kelp	1	1	2
Sea urchin	2	3	5
Pico-Kenter			
Abalone	3	3	6
Kelp	1.5	1	2.5
Sea urchin	1.5	2	3.5
Ballona Creek			
Abalone	1.5	2	3.5
Kelp	1.5	2	3.5
Sea urchin	3	2	5

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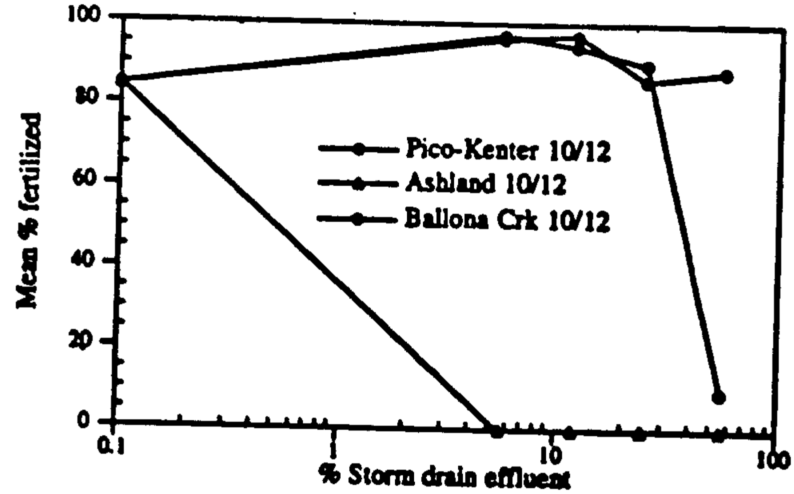
URCHIN FERTILIZATION TEST



ABALONE TEST

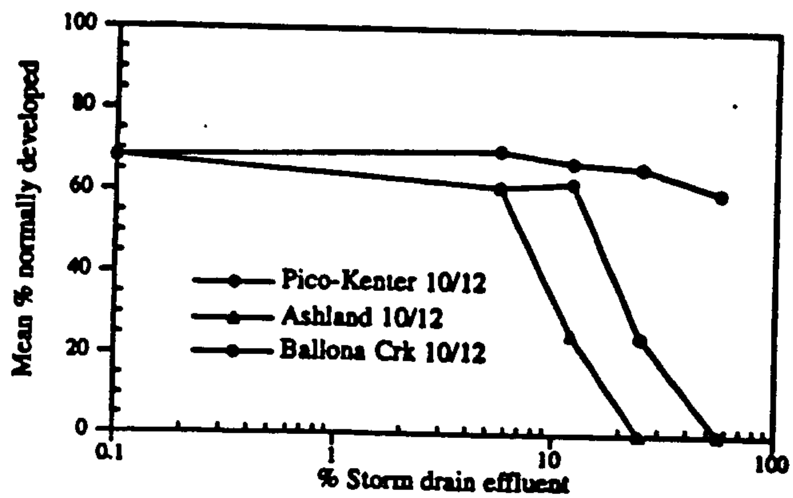


Figure D2-1. Dose-response plots for sea urchin fertilization and abalone embryo development tests of storm drain samples collected on October 12, 1992. Control values are those plotted at a concentration of 0.1%.

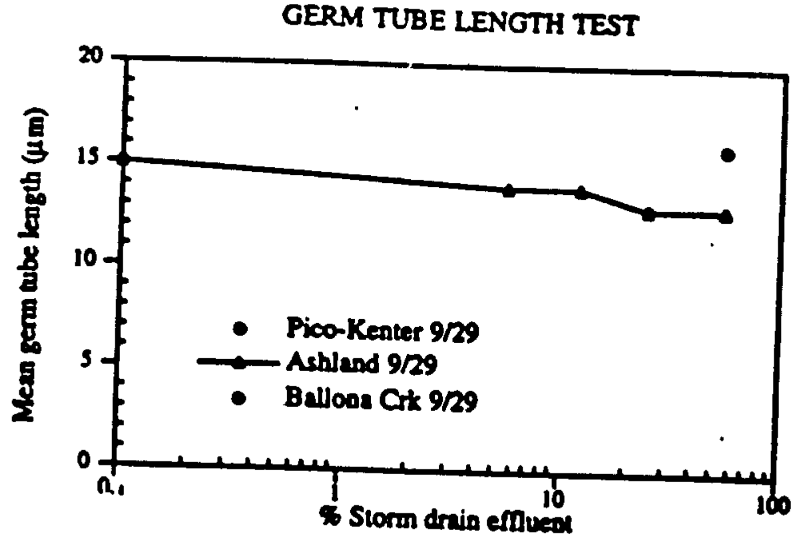


Figure D2-2. Dose-response plots for giant kelp germ tube length test of storm drain samples collected on September 29, 1992. Percent germination was not assessed because of poor control performance. Control values are those plotted at a concentration of 0.1%.

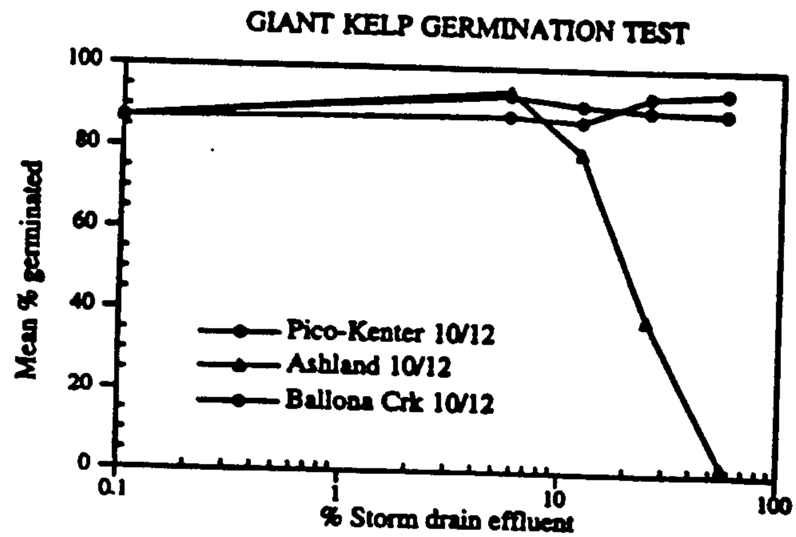


Figure D2-3. Dose-response plots for giant kelp germination of storm drain samples collected on October 12, 1992. Control values are those plotted at a concentration of 0.1%.

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Table D2.a-1. Summary of initial water quality data for toxicity test conducted October 1, 1992 (test S188).

Description (1)	pH (2)	Salinity mg/g (3)
Seawater control	8.04	34
Brine control 25%	8.06	34
Brine control 56%	8.10	32
Ballona filtrate 5.6%	8.15	34
Ballona filtrate 12%	8.17	34
Ballona filtrate 25%	8.21	34
Ballona filtrate 56%	8.19	32
Ashland filtrate 5.6%	8.12	34
Ashland filtrate 12%	8.10	34
Ashland filtrate 25%	8.06	34
Ashland filtrate 56%	7.99	34
Pico-Kenter filtrate 5.6%	8.11	34
Pico-Kenter filtrate 12%	8.08	34
Pico-Kenter filtrate 25%	8.03	34
Pico-Kenter filtrate 56%	7.96	32
Ballona raw filtrate	9.30	

Table D2.a-2. Summary of initial water quality data for toxicity tests conducted October 13-15, 1992 (tests S190, M9, H8). DO = dissolved oxygen.

Description (1)	DO mg/L (2)	Ammonia mg/L (3)	pH (4)	Salinity mg/g (5)
Seawater control	7.8	0.02	8.18	34
Brine control 25%	8.4		8.16	34
Brine control 56%	8.2		8.18	34
Ballona filtrate 5.6%	8.6	0.01	8.19	34
Ballona filtrate 12%	8.4	0.01	8.25	33
Ballona filtrate 25%	8.5	0.02	8.30	34
Ballona filtrate 56%	8.7	0.02	8.26	34
Ashland filtrate 5.6%	8.3	0.01	8.13	34
Ashland filtrate 12%	8.6	0.21	8.09	33
Ashland filtrate 25%	8.3	0.44	8.03	34
Ashland filtrate 56%	7.5	1.06	7.94	33
Pico-Kenter filtrate 5.6%	8.6	0.03	8.15	34
Pico-Kenter filtrate 12%	8.6	0.02	8.13	34
Pico-Kenter filtrate 25%	8.6	0.03	8.09	34
Pico-Kenter filtrate 56%	8.5	0.07	8.01	34

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Table D2.a-3. Summary of final water quality and temperature data for abalone toxicity test H8, conducted October 13-15, 1992. DO, dissolved oxygen.

Description (1)	DO mg/L (2)	pH (3)	Salinity mg/g (4)	Temperature Day 0 (5)	Temperature Day 1 (6)	Temperature Day 2 (7)
Seawater control	7.8	8.09	34	14.3	14.5	14.1
Brine control 25%	7.8	8.10	34	14.3	14.5	14.1
Brine control 56%	7.9	8.11	34	14.3	14.5	14.2
Ballona filtrate 5.6%	7.9	8.13	34	14.2	14.6	14.1
Ballona filtrate 12%	7.7	8.17	34	14.2	14.5	14.2
Ballona filtrate 25%	7.8	8.24	34	14.2	14.6	14.2
Ballona filtrate 56%	7.7	8.29	34	14.2	14.5	14.1
Ashland filtrate 5.6%	7.8	8.10	34	14.1	14.5	14.1
Ashland filtrate 12%	7.7	8.12	33	14.2	14.5	14.1
Ashland filtrate 25%	7.3	8.13	33	14.1	14.5	14.1
Ashland filtrate 56%	6.8	8.15	33	14.1	14.5	14.2
Pico-Kenter filtrate 5.6%	7.8	8.11	34	14.0	14.5	14.1
Pico-Kenter filtrate 12%	7.8	8.13	33	14.2	14.6	14.1
Pico-Kenter filtrate 25%	7.8	8.16	33	14.1	14.6	14.1
Pico-Kenter filtrate 56%	7.8	8.20	33	14.1	14.5	14.1

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Table D2.a-4. Summary of final water quality and temperature data for kelp toxicity test M9, conducted October 13-15, 1992. DO, dissolved oxygen.

Description (1)	DO mg/L (2)	pH (3)	Salinity mg/g (4)	Temperature Day 0 (5)	Temperature Day 1 (6)	Temperature Day 2 (7)
Seawater control	8.2	8.08	34	14.9	14.9	14.8
Brine control 25%	8.1	8.10	34	15.1	15.0	15.0
Brine control 56%	8.0	8.11	34	14.8	14.9	15.0
Ballona filtrate 5.6%	8.1	8.11	34	14.9	14.9	14.8
Ballona filtrate 12%	8.1	8.18	33	14.9	15.0	14.9
Ballona filtrate 25%	8.1	8.24	34	14.9	15.0	14.9
Ballona filtrate 56%	8.1	8.28	33	14.9	15.0	15.0
Ashland filtrate 5.6%	8.0	8.11	34	14.9	15.0	14.8
Ashland filtrate 12%	7.7	8.10	33	15.0	15.0	14.9
Ashland filtrate 25%	7.7	8.14	33	14.9	15.1	14.8
Ashland filtrate 56%	7.4	8.16	34	14.9	15.1	14.8
Pico-Kenter filtrate 5.6%	8.1	8.12	34	14.9	15.0	14.9
Pico-Kenter filtrate 12%	8.1	8.13	33	15.0	15.0	14.9
Pico-Kenter filtrate 25%	8.1	8.14	34	14.9	14.9	14.8
Pico-Kenter filtrate 56%	7.9	8.16	34	15.1	15.0	14.9

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APPENDIX D3
TOXICITY RESULTS OF BALLONA CREEK SAMPLE COLLECTED 12/10/92

The following are data reports for the two toxicity tests conducted on samples of Ballona Creek dry weather flow collected December 14, 1992.

Experiment 194

The first experiment was conducted on December 14, immediately after sample collection to characterize the initial toxicity of the samples. Samples were tested at concentrations of 12, 25, and 56%. Control fertilization was 68% which is within the range considered acceptable for this test. Samples containing 56% runoff were not examined for fertilization because the 56% brine control was strongly toxic (Table D3-1). Results for the 12 and 25% concentrations indicated that the afternoon sample was about twice as toxic as the sample collected in the morning.

The pH of the runoff samples ranged from 8.45 (a.m.) to 8.26 (p.m.) which is considerably lower than the pH of samples collected previously.

Samples of deionized water from UCLA and filter blanks prepared with either UCLA or SCCWRP water were also tested for toxicity in the first experiment. No toxicity was detected in a sample of 25% UCLA water. Egg fertilization in the filter blank prepared from UCLA water was 79% of the unfiltered sample, indicating that some toxicity was introduced by the filtration process. The filter blank using SCCWRP water was more toxic; fertilization in these samples was only 38% of the unfiltered water (25% brine control).

Experiment 195

The second experiment was conducted on December 16, following laboratory manipulation of the Ballona p.m. sample to characterize toxicity. Control fertilization and brine control results were satisfactory for this test (Table D3-2). A baseline toxicity test was conducted on a sample of effluent that had been stored at SCCWRP (unfiltered, 5°C). Baseline toxicity was substantially less than measured on December 14, but still sufficient to permit evaluation of the TIE samples.

Strong toxicity was found in the 56% filter blank solution. Filter blank results (corrected for control response) at 25% were similar for the 12/14 and 12/16 experiments, indicating the same level of toxicity was probably present in both blanks. Toxicity was also found in the column blank samples, reflecting the toxicity of the filter blank solution passed through the column.

Toxicity was reduced by the C18, EDTA, and thiosulfate treatments. Examination of the results for the 56% samples indicate that toxicity was partially removed by the C18 column and completely removed by thiosulfate treatment. Toxicity was found in the thiosulfate blank, as was the case in the previous TIE experiment.

The EDTA treatment results had an unusual pattern. Fertilization at 25% sample concentration was high (no toxicity) for both the 3 and 8 mg/l EDTA solutions. Reduced fertilization was measured at the 56% sample concentrations, with the lowest fertilization occurring in the 8 mg/l solution. There are two interpretations of this pattern. First it could be an indication of partial toxicity removal, as was found for C18 column treatment. An alternate explanation would be toxicity produced by the EDTA treatment. Toxicity due to the EDTA compound is unlikely since the results of previous experiments indicate that solutions of 250 mg/l EDTA were nontoxic. One possibility is that the 56% EDTA solutions may have had an altered pH which adversely affected fertilization rate (pH of the EDTA solutions was not checked or adjusted in this experiment, but was adjusted in the previous TIE experiment). We are investigating this situation and should have more information in a few days.

Analysis of the column elutriate blanks indicated no toxicity for methanol solutions and slight toxicity for the 50% methylene chloride/50% methanol blank. Elution of the C18 column with 100% methanol was successful in recovering a portion of the toxicity in the aqueous sample.

Solvent extracts of two different Ballona Creek samples (11/23 and 12/14 collections) were also tested for toxicity. Strong toxicity was found in solutions containing 0.1% of the extract while 0.01% solutions were nontoxic. It is questionable whether the extract toxicity corresponds to the whole effluent toxicity since the toxic reconstituted solutions were much more concentrated than the original aqueous sample. Even the nontoxic 0.01% extract solutions were more concentrated (equivalent to 80% undiluted effluent) than the highest concentration of aqueous sample tested (56%).

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Table D3-1. Summary of Experiment 194 (Conducted Dec. 14, 1992).

Sample (1)	% Fertilized (2)	Mean (3)
Seawater control	67, 68	68
Brine control 25% DIW	73	
Brine control 56% DIW	3, 1	2
Ballona A.M. filtrate 12%	63, 58	60
Ballona A.M. filtrate 25%	44, 45	44
Ballona A.M. filtrate 56%		
Ballona P.M. filtrate 12%	49, 33	41
Ballona P.M. filtrate 25%	16, 19	18
Ballona P.M. filtrate 56%		
UCLA DIW 25%	72, 72	72
UCLA DIW 56%		
Filter Blank #1 (UCLA water) 12%		
Filter Blank #1 (UCLA water) 25%	56, 58	57
Filter Blank #1 (UCLA water) 56%		
Filter Blank #2 (SCCWRP water) 12%		
Filter Blank #2 (SCCWRP water) 25%	24, 31	28
Filter Blank #2 (SCCWRP water) 56%		

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Table D3-2. Summary of Experiment 195 (Conducted Dec. 16, 1992).

Sample (1)	% Fertilized (2)	Mean (3)
Seawater control	96, 98	97
Brine control 25% DIW	100, 98	99
Brine control 56% DIW	69, 78	74
Ballona P.M. filtrate 12%	82, 91	86
Ballona P.M. filtrate 25%	67, 65	66
Ballona P.M. filtrate 56%	18, 12	15
Filter Blank 12%	94, 97	96
Filter Blank 25%	82, 75	78
Filter Blank 56%	5, 5	5
Column Blank 12 %		
Column Blank 25%	52, 51	52
Column Blank 56%	21, 23	22
Post Column filtrate 12%		
Post Column filtrate 25%	89, 94	92
Post Column filtrate 56%	69, 82	76
EDTA 3 mg/l 12%		
EDTA 3 mg/l 25%	90, 90	90
EDTA 3 mg/l 56%	39, 50	44
EDTA 8 mg/l 12%		
EDTA 8 mg/l 25%	91, 98	94
EDTA 8 mg/l 56%	11, 13	12
Thiosulfate blank 12%		
Thiosulfate blank 25%	13, 35	24
Thiosulfate blank 56%	2, 0	1
Thiosulfate 10 mg/l 12%		
Thiosulfate 10 mg/l 25%	86, 91	88
Thiosulfate 10 mg/l 56%	99, 99	99
Thiosulfate 25 mg/l 12%		
Thiosulfate 25 mg/l 25%	98, 100	99
Thiosulfate 25 mg/l 56%	96, 99	98
50% Methanol elutriate blank 0.1%		
50% Methanol elutriate blank 0.2%	99, 100	100
100% Methanol blank 0.1%		
100% Methanol blank 0.2%	97, 96	96
50% $MeCl_2$ Blank 0.1%	98, 98	98
50% $MeCl_2$ Blank 0.2%	73, 78	76

Table D3-2 (continued).

Sample (1)	%Fertilized (2)	Mean (3)
50% Methanol eluate 0.1%	100, 99	100
50% Methanol eluate 0.2%	100, 99	100
100% Methanol eluate 0.1%	92, 88	90
100% Methanol eluate 0.2%	8, 6	7
50% $MeCl_2$ eluate 0.1%	97, 99	98
50% $MeCl_2$ eluate 0.2%	50, 47	48
$MeCl_2$ extract 11/23 0.01%	97, 96	96
$MeCl_2$ extract 11/23 0.1%	0	
$MeCl_2$ extract 12/14 0.01%	80, 86	83
$MeCl_2$ extract 12/14 0.1%	0	
$MeCl_2$ extract blank 0.01%	99, 97	98
$MeCl_2$ extract blank 0.1%	77, 75	76

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The following are data reports for the two toxicity tests conducted on samples of Ballona Creek effluent collected January 19, 1993.

Experiment 196

The first experiment was conducted on January 19, immediately after sample collection to characterize the initial toxicity of the samples. Samples were tested at concentrations of 12, 25, and 56%. The initial pH values of the two effluent samples were 8.26 and 8.33, similar to the pH of the December 14 samples.

Control fertilization was 100% (Table D4-1), indicating the test organisms were of acceptable health. No toxicity was present in the brine controls. Both the morning and afternoon samples were toxic, with less than 10% fertilization at a concentration of 56% effluent. The results for the 25% concentration indicated that the morning (a.m.) sample was slightly more toxic; this sample was selected for the TIE procedure.

Experiment 197

The second experiment was conducted on January 21, following laboratory manipulation of the Ballona a.m. sample to characterize toxicity. The pH of the effluent sample declined slightly to 7.87 after two days of storage. The pH of the EDTA- and Thiosulfate-treated effluent samples was 7.40-7.93 after dilution with laboratory seawater which had a pH of 7.99. A small amount of HCl was added to samples having a pH less than 7.9 to adjust them to pH 7.93-8.09.

Control fertilization and brine control results were satisfactory for this test (Table D4-2). A baseline toxicity test was conducted on a sample of effluent that had been stored at SCCWRP (unfiltered, 5°C). Baseline toxicity was similar to that measured two days earlier. Slightly greater toxicity was measured at 12 and 25%, which is a pattern not seen in previous tests of stored Ballona Creek samples.

Some toxicity was found in the filter blank samples, although it was much less than measured in previous experiments. This result may indicate a beneficial effect of using distilled water from SCCWRP. Increased toxicity (relative to the filter blank) was measured in the column blank samples. This is an indication of toxic materials being leached from the column. Evidence of column toxicity could not be detected in previous experiments because of the high toxicity of the filter blanks.

Only a slight reduction in toxicity was measured following treatment of the Ballona Creek sample with the C18 column.

Toxicity was completely removed by a 3 mg/L EDTA addition. The additional EDTA treatments were also nontoxic, indicating that no adverse effects were produced by this chemical.

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Toxicity was absent in the thiosulfate blank. This result was somewhat unexpected, as strong blank toxicity was measured in both previous TIE experiments. Thiosulfate treatment had no effect on Ballona Creek effluent toxicity.

The solvent elution fractions of the C18 column were tested for toxicity even though column treatment was relatively ineffective. The solvent blank results were generally acceptable; only the 50% $MeCl_2$ blank showed moderate toxicity at a concentration of 0.2%. A small amount of toxicity was recovered from the column by elution with 100% methanol. The amount of toxicity recovered was too small to significantly contribute to the baseline toxicity of the effluent sample. Elutions with 50% methanol or methylene chloride were ineffective.

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Table D4-1. Summary of Experiment 196 (Conducted Jan. 19, 1993).

Sample (1)	% Fertilized (2)	Mean (3)
Seawater control	100, 100	100
Brine control 25% DIW	100, 99	100
Brine control 56% DIW	100, 98	99
Ballona A.M. filtrate 12%	98, 94	96
Ballona A.M. filtrate 25%	56, 44	50
Ballona A.M. filtrate 56%	7, 5	6
Ballona P.M. filtrate 12%	96, 98	97
Ballona P.M. filtrate 25%	68, 64	66
Ballona P.M. filtrate 56%	1, 2	2

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Table D4-2. Summary of Experiment 197 (Conducted Jan. 21, 1993).

Sample (1)	% Fertilized (2)	Mean (3)
Seawater control	87, 94	90
Brine control 25% DIW	80, 71	76
Brine control 56% DIW	89, 81	85
Ballona A.M. filtrate 12%	57, 43	50
Ballona A.M. filtrate 25%	31, 28	30
Ballona A.M. filtrate 56%	14, 17	16
Filter blank 12%	68, 69	68
Filter blank 25%	63, 70	66
Filter blank 56%	58, 66	62
Column blank 12 %	76, 71	74
Column blank 25%	23, 19	21
Column blank 56%	7, 15	11
Post column effluent 12%	75, 69	72
Post column effluent 25%	44, 42	43
Post column effluent 56%	20, 19	20
EDTA 3 mg/l 12%	90, 87	88
EDTA 3 mg/l 25%	92, 94	93
EDTA 3 mg/l 56%	95, 90	92
EDTA 8 mg/l 12%	91, 95	93
EDTA 8 mg/l 25%	93, 95	94
EDTA 8 mg/l 56%	96, 95	96
EDTA 30 mg/l 12%	95, 97	96
EDTA 30 mg/1 25%	95, 97	96
EDTA 30 mg/l 56%	95, 90	92
Thiosulfate blank 12%	89, 88	88
Thiosulfate blank 25%	100, 89	94
Thiosulfate blank 56%	97, 96	96
Thiosulfate 10 mg/l 12%	25, 30	28
Thiosulfate 10 mg/l 25%	4, 5	4
Thiosulfate 10 mg/l 56%	9, 12	10
Thiosulfate 25 mg/l 12%	27, 28	28
Thiosulfate 25 mg/l 25%	23, 14	18
Thiosulfate 25 mg/l 56%	10, 14	12
50% Methanol elut. blank 0.1%	77, 85	81
50% Methanol elut. blank 0.2%	82, 81	82
100% Methanol elut. blank 0.1%	79, 86	82

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Table D4-2 (cont'd).

Sample (1)	% Fertilized (2)	Mean (3)
100% Methanol elut. blank 0.2%	69, 78	74
50% $MeCl_2$ elut. blank 0.1%	83, 82	82
50% $MeCl_2$ elut. blank 0.2%	61, 55	58
50% Methanol eluate 0.1%	80, 65	72
50% Methanol eluate 0.2%	89, 85	87
100% Methanol eluate 0.1%	46, 40	43
100% Methanol eluate 0.2%	46, 39	42
50% $MeCl_2$ eluate 0.1%	86, 67	76
50% $MeCl_2$ eluate 0.2%	77, 77	77

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APPENDIX E
GC/MS RESULTS

Tables E-1 to E-10 show the GC/MS results of the volatile organic and base neutral analyses of samples collected from Pico-Kenter, Ashland Avenue, Ballona Creek, Sepulveda Channel and Centinela Creek storm drains. These GC/MS results were obtained from the parallel study performed under the partial sponsorship of the American Ocean Campaign (Suffet *et al*, 1993).

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Table E-1. GC/MS results of volatile orgnaic analysis for Pico-Kenter samples (6/12 - 12/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BL'K [4]	AVERAGE ug/l [5]	RANGE ug/l - ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15 - 0.20	4	0.22	0.20 - 0.25	
Chloromethane	0.14	0.14 - 0.17	13	0.42	0.29 - 0.94	
Carbon Disulfide	0.11	0.11 - 0.14	11	0.30	0.15 - 0.71	
Methylene Chloride(1)	0.07	0.11 - 0.14	14	2.18	0.18 - 12.82	5*
2-Butanone	?	0.24 - 0.33	8	0.61	0.33 - 1.24	
Chloroform	0.11		15	0.35	0.11 - 0.98	100 THMs
Benzene	0.04		12	0.09	0.04 - 0.25	5
Dibromomethane	0.03		5	0.05	0.03 - 0.07	
Bromodichloromethane	0.06		2	0.16	0.11 - 0.22	100 THMs
4-Methyl-2-Pentanone	0.12		11	0.30	0.13 - 1.30	
Toluene	0.05		12	0.16	0.06 - 0.35	1000
2-Hexanone	0.09		4	0.21	0.12 - 0.30	
Dibromochloromethane	0.09		2	0.21	0.19 - 0.23	100 THMs
Styrene	0.04		5	0.05	0.04 - 0.05	100
Bromoform	0.06		6	0.39	0.07 - 1.49	100 THMs
1,2,4-Trimethylbenzene	0.04		1	0.05	-	
p-Isopropyltoluene	0.06		3	0.07	0.06 - 0.08	

15 Samples - 6/12 to 12/10/9 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed MDL only

MDL - Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs - Trihalomethanes

(1) Note- Methylene chloride in the 6/12 sample (33.448 ug/l) is considered an artifact and is not included in the data. Fourteen samples were completed for methylene chloride.

Table E-2. GC/MS results of volatile organic analysis for Ashland samples (6/12 - 12/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BLK [4]	AVERAGE ug/l [5]	RANGE ug/l - ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15-0.20	2	0.27	0.20 - 0.33	
Chloromethane	0.14	0.14-0.17	14	0.42	0.22 - 0.91	
1,1-Dichloroethane	0.17		1	0.19	-	
Carbon Disulfide	0.11	0.11-0.14	14	1.10	0.16 - 5.80	
Methylene Chloride (1)	0.07	0.11-0.14	13	6.30	0.24 - 65.74	5*
2-Butanone	?	0.24-0.33	9	1.09	0.29 - 3.73	
Bromochloromethane	0.16		4	0.45	0.17 - 1.05	
Chloroform	0.11		11	4.07	0.13 - 19.11	100 THMs
Benzene	0.04		13	0.09	0.05 - 0.22	5
1,2-Dichloroethane	0.04		1	0.05	-	5
Trichloroethene	0.04		3	0.07	0.06 - 0.08	5
Dibromomethane	0.03		9	0.74	0.11 - 2.00	
Bromodichloromethane	0.06		5	1.68	0.10 - 7.42	100 THMs
4-Methyl-2-Pentanone	0.12		11	0.57	0.16 - 1.40	
Toluene	0.05		11	0.75	0.09 - 6.63	1000
2-Hexanone	0.09		5	0.23	0.15 - 0.41	
Dibromochloromethane	0.09		4	4.88	0.11 - 18.54	100 THMs
Ethyl Benzene	0.05		1	0.06	-	700
o-Xylene	0.04		2	0.15	0.05 - 0.09	10000 (Total)
Styrene	0.04		5	0.05	0.04 - 0.08	1000
Bromoform	0.06		5	10.56	0.04 - 50.52	100 THMs
1,3,5-Trimethylbenzene	0.05		2	0.67	0.07 - 1.27	
1,2,4-Trimethylbenzene	0.04		8	0.08	0.04 - 0.17	
p-Isopropyltoluene	0.06		6	0.69	0.06 - 2.51	
n-Butylbenzene	0.06		1	0.06	-	
Naphthalene	0.25		1	0.40	-	
1,2-Dichlorobenzene	0.04		1	0.07	-	600

14 Samples - 6/12 to 12/10/9 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed MDL only

MDL - Minimum Detectable Limit
Average = Values above MDL and Blank/No. Found
THMs - Trihalomethanes

(1) Note- Methylene chloride in the 9/8 AM sample (11.862 ug/l) is considered an artifact and is not included in the data. Thirteen samples were completed for methylene chloride.

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Table E-3. GC/MS results of volatile organic analysis for Ballona Creek samples (6/12 - 12/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BL'K [4]	AVERAGE ug/l [5]	RANGE ug/l - ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15-0.20	1	-	0.21	
Chloromethane	0.14	0.14-0.17	12	0.51	0.26 - 2.17	
Carbon Disulfide	0.11	0.11-0.14	15	0.20	0.14 - 0.29	
Methylene Chloride (1)	0.07	0.11-0.14	13	?	0.19 - 2.12	5*
Trans-1,2-Dichloroethene	0.12		1	-	0.13	100
2-Butanone	?	0.24-0.33	11	0.60	0.34 - 1.58	
Bromochloromethane	0.16		1	-	0.52	
Chloroform	0.11		17	0.63	0.21 - 2.16	100 THMs
1,1,1-Trichloroethane	0.06		15	0.55	0.11 - 0.96	200
Benzene	0.04		13	0.08	0.04 - 0.22	5
Trichloroethene	0.04		11	0.05	0.05 - 0.08	5
Dibromomethane	0.3		3	0.06	0.04 - 0.26	
Bromodichloromethane	0.06		16	0.23	0.11 - 0.57	100 THMs
4-Methyl-2-Pentanone	0.12		10	0.27	0.15 - 0.59	
Toluene	0.05		13	0.10	0.05 - 0.17	1000
Tetrachloroethene	0.05		16	0.24	0.07 - 0.41	5
2-Hexanone	0.09		2	0.14	0.07 - 0.20	
Dibromochloromethane	0.09		16	0.28	0.11 - 0.82	100 THMs
Styrene	0.04		3	0.05	0.04 - 0.07	1000
Bromoform	0.06		18	0.18	0.07 - 0.42	100 THMs
1,2,4-Trimethylbenzene	0.04		2	0.04	0.04	
Napthalene	0.25		1	-	0.26	
1,1-Dichloropropene	0.06		1	-	0.10	

17 Samples - 6/12 to 12/10/92 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed only

MDL - Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs - Trihalomethanes

(1) Note- Methylene chloride in the 6/12 and 9/8 AM samples of 129.41 and 154.22 ug/l, respectively are considered artifacts and are not included in the data. Fifteen samples were completed for methylene chloride.

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Table E-4. GC/MS results of volatile organic analysis for Sepulveda Channel samples (6/12 -2/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BLK [4]	AVERAGE ug/l [5]	RANGE ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15 - 0.20	1	0.20	0.20	
Chloromethane	0.14	0.14 - 0.17	14	0.58	0.20 - 2.90	
Carbon Disulfide	0.11	0.11 - 0.14	8	0.23	0.14 - 0.34	
Methylene Chloride (1)	0.07	0.11 - 0.14	12	0.52	0.14 - 1.75	5*
Trans-1,2-Dichloroethene	0.12		1	0.19	0.19	100
2-Butanone	?	0.24 - 0.33	9	0.77	0.36 - 3.15	
Bromochloromethane	0.16		1	0.31	0.31	
Chloroform	0.11		14	0.57	0.14 - 2.13	100 THMs
1,1,1-Trichloroethane	0.06		1	0.09	0.09	200
Benzene	0.04		13	0.10	0.04 - 0.25	5
Dibromomethane	0.03		9	0.07	0.03 - 1.29	
Bromodichloromethane	0.06		4	0.82	0.06 - 1.54	100 THMs
4-Methyl-2-Pentanone	0.12		5	0.25	0.15 - 0.62	
Toluene	0.05		11	0.10	0.06 - 0.37	1000
2-Hexanone	0.09		2	0.13	0.11 - 0.14	
Dibromochloromethane	0.09		4	1.18	0.18 - 2.14	100 THMs
(m+p)-Xylene	0.1		1	0.15	0.15	100,000 /
o-Xylene	0.04		1	0.06	0.06	TOTAL
Styrene	0.04		3	0.05	0.05	1000
Bromoform	0.06		15	0.40	0.13 - 1.09	100 THMs
Naphthalene	0.25		1	0.29	0.29	

15 Samples - 6/12 to 12/10/92 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed only

MDL - Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs - Trihalomethanes

(1) Note- Methylene chloride in the 6/12 and 9/8 AM samples of 75.115 and 4.696 ug/l, respectively are considered artifacts and are not included in the data. Twelve samples were completed for methylene chloride

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Table E-5. GC/MS results of volatile organic analysis for Centinela Creek samples (7/12 - 12/10/92).

CHEMICAL NAME [1]	MDL ug/l [2]	FIELD & LAB BLANK ug/l [3]	NUMBER FOUND ABOVE MDL & BLK [4]	AVERAGE ug/l [5]	RANGE ug/l - ug/l [6]	DRINKING WATER MCLs ug/l [7]
Dichlorodifluoromethane	0.18	0.15 - 0.20	2	0.22	0.21 - 0.23	
Chloromethane	0.14	0.14 - 0.17	11	0.32	0.19 - 0.47	
Carbon Disulfide	0.11	0.11 - 0.14	10	0.21	0.16 - 0.29	
Methylene Chloride	0.07	0.11 - 0.14	11	1.90	0.20 - 8.19	5*
2-Butanone	?	0.24 - 0.33	4	0.57	0.34 - 1.28	
Bromochloromethane	0.16		1	0.16	-	
Chloroform	0.11		11	0.78	0.23 - 2.01	100 THMs
Benzene	0.04		8	0.09	0.04 - 0.19	5
Bromodichloromethane	0.06		5	0.42	0.07 - 1.24	100 THMs
4-Methyl-2-Pentanone	0.12		5	9.48	0.16 - 45.79	
Toluene	0.05		8	0.10	0.06 - 0.17	1000
2-Hexanone	0.09		8	0.03	0.09 - 0.18	
Dibromochloromethane	0.09		4	0.88	0.11 - 2.24	100 THMs
Styrene	0.04		3	0.05	0.04 - 0.05	1000
Bromoform	0.06		5	0.34	1.12	100 THMs
Napthalene	0.25		1	0.46		

11 Samples - 7/12 to 12/10/92 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed only

MDL -Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs- Trihalomethanes

Table E-6. GC/MS results of base neutral analysis for Pico-Kenter Samples (7/7 - 12/10/92).

CHEMICAL NAME [1]	Number Found Above MDL & Blank (11 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Phenol	7	1,204	30 - 4,073		
2-Methylphenol	1	8	-		
4-Methylphenol	6	2,649	38 - 9,749		
2-Nitrophenol	8	455	9 - 3451		
Benzoic Acid	6	920	196 - 1,707		
4-Chloro-3-methylphenol	0	<MDL	-		
4-Nitrophenol	1	3,903	-		
1,4-Dichlorobenzene(*)	10	66	33 - 127	75,000	18,000 (c)
N-Nitrosodi-n-propylamine	0	<MDL	-		
Nitrobenzene	2	30	15 - 46		4,900 (d)
Isophorone	1	1	-		150,000,000 (d)
Naphthalene(*)	10	98	37 - 160		
2-Methylnaphthalene	10	57	23 - 105		
Acenaphthylene	0	<MDL	-		8.8 (c,f)
Dimethyl phthalate	3	14	2 - 28		820,000,000 (d)
Acenaphthene	1	4	-		
Dibenzofuran	4	5	4 - 7		
Fluorene	7	4	2 - 8		8.8 (c,f)
Diethyl phthalate(*)	10	187	76 - 236		33,000,000 (d)
4-Chlorophenyl phenyl ether	8	37	14 - 82		
N-Nitrosodiphenylamine	1	161	-		2,500 (c)
Azobenzene	*9	25	12 - 47		
Phenanthrene	9	46	6 - 165		8.8 (c,f)
Anthracene	5	22	1 - 33		8.8 (c,f)

Table E-6 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (11 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Di-n-butyl phthalate(*)	10	1,046	445 - 1,905		
Fluoranthene	8	59	5 - 327		
Pyrene	8	69	6 - 211		8.8 (c,f)
Butyl benzyl phthalate(*)	11	962	265 - 1,006		
Benz(a)anthracene	4	32	10 - 75		
Chrysene(*)	4	69	1 - 185		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	11	6,800	1,241 - 28,173	6,000	3,500 (c)
Di-n-octyl phthalate(*)	10	4,249	11 - 39,206		
Benzo(b)fluoranthene	2	37	10 - 64		
Benzo(k)fluoranthene	3	14	2 - 30		8.8 (c,f)
Benzo(a)pyrene	4	41	4 - 128	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	1	7	-		8.8 (c,f)
Dibenzo(a,h)anthracene	0	<MDL	-		8.8 (c,f)
Benzo(g,h,i)perylene	0	<MDL	-		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c)California Ocean Plan, Carcinogen

(d)California Ocean Plan, Non-Carcinogen

(e)Sum of 1,2 and 1,3-dichlorobenzenes

(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*)Values are compared versus blank instead of the MDL.

Table E-7. GC/MS results of base neutral analysis of Ashland samples (7/7 - 12/10/92).

CHEMICAL NAME [1]	Number Found Above MDL & Blank (8 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Phenol	5	162	65 - 375		
2-Methylphenol	0	<MDL	-		
4-Methylphenol	3	1,042	20 - 2,764		
2-Nitrophenol	5	38	21 - 74		
2,4-Dimethylphenol	2	365	238 - 492		
Benzoic Acid	6	472	60 - 1,518		
4-Chloro-3-methylphenol	1	9	-		
2,4,6-Trichlorophenol	0	<MDL	-		290 (c)
2,4,5-Trichlorophenol	0	<MDL	-		
1,4-Dichlorobenzene(*)	6	68	32 - 107	75,000	18,000 (c)
1,2-Dichlorobenzene	0	<MDL	-	600,000	5,100,000 (e)
Benzyl alcohol	2	896	533 - 1,258		
Nitrobenzene	2	230	204 - 257		4,900 (d)
Isophorone	3	42	10 - 75		150,000,000 (d)
Naphthalene(*)	7	85	48 - 126		
2-Methylnaphthalene	7	43	30 - 57		
2-Nitroaniline	1	463	-		
Dimethyl phthalate	4	31	2 - 102		820,000,000 (d)
Acenaphthene	2	6	5 - 6		
Dibenzofuran	4	11	5 - 16		
Fluorene	3	13	6 - 18		8.8 (c,f)
Diethyl phthalate(*)	7	463	124 - 1,110		33,000,000 (d)
4-Chlorophenyl phenyl ether	7	34	19 - 44		
Azobenzene	6	34	11 - 63		
Phenanthrene	7	62	20 - 152		8.8 (c,f)

Table E-7 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (8 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Anthracene	4	38	4 - 125		8.8 (c,f)
Di-n-butyl phthalate(*)	7	3,050	637 - 13,667		3,500,000 (d)
Fluoranthene	7	49	10 - 94		15,000 (d)
Pyrene(*)	7	87	14 - 295		8.8 (c,f)
Butyl benzyl phthalate(*)	7	1,486	631 - 2,500		
Benz(a)anthracene	3	32	21 - 51		
3,3'-Dichlorobenzidine	0	<MDL	-		
Chrysene(*)	4	126	11 - 391		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	5	14,765	8,445 - 24,668	6,000	3,500 (c)
Di-n-octyl phthalate(*)	6	3,054	406 - 15,488		
Benzo(b)fluoranthene	4	24	8 - 49		
Benzo(k)fluoranthene	3	25	10 - 46		8.8 (c,f)
Benzo(a)pyrene	3	162	19 - 393	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	3	40	5 - 95		8.8 (c,f)
Dibenzo(a,h)anthracene	3	39	8 - 97		8.8 (c,f)
Benzo(g,h,i)perylene	2	71	16 - 125		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c)California Ocean Plan, Carcinogen

(d)California Ocean Plan, Non-Carcinogen

(e)Sum of 1,2 and 1,3-dichlorobenzenes

(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*) Values are compared versus blank instead of the MDL.

Table E-8. GC/MS results of base neutral analysis of Ballona Creek samples (7/7 - 12/10/92)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (10 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Phenol	7	166	29 - 749		
2-Methylphenol	0	<MDL	-		
4-Methylphenol	0	25	-		
2-Nitrophenol	7	42	27 - 72		
Benzoic Acid	5	543	111 - 961		
1,4-Dichlorobenzene(*)	9	75	38 - 146	75,000	18,000 (c)
Benzyl alcohol	1	459	-		
N-Nitrosodi-n-propylamine	1	3	-		
Nitrobenzene	2	24	7 - 40		4,900 (d)
Isophorone	2	33	19 - 47		150,000,000 (d)
Naphthalene(*)	9	99	61 - 138		
2-Methylnaphthalene	9	53	33 - 60		
Acenaphthylene	0	<MDL	-		8.8(c,f)
Dimethyl phthalate	4	27	4 - 70		820,000,000(d)
Acenaphthene	1	3	-		
Dibenzofuran	3	7	6 - 10		
Fluorene	4	5	3 - 6		8.8 (c,f)
Diethyl phthalate(*)	10	214	99 - 378		33,000,000 (d)
4-Chlorophenyl phenyl ether	7	28	7 - 53		
Azobenzene	7	17	5 - 26		
Phenanthrene	9	17	5 - 39		8.8 (c,f)
Anthracene	2	23	6 - 39		8.8 (c,f)
Di-n-butyl phthalate(*)	10	1,337	679 - 1,947		3,500,000 (d)
Fluoranthene	8	9	3 - 21		15,000 (d)

Table E-8 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (10 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Pyrene(*)	9	21	2 - 126		8.8 (c,f)
Butyl benzyl phthalate(*)	10	1,248	217 - 2,245		
Benz(a)anthracene	5	22	9 - 46		
Chrysene(*)	3	61	13 - 145		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	9	4,518	2,248 - 7,120	6,000	3,500
Di-n-octyl phthalate(*)	9	1,442	17 - 3,655		
Benzo(b)fluoranthene	1	4	-		
Benzo(k)fluoranthene	1	5	-		8.8 (c,f)
Benzo(a)pyrene	4	47	18 - 106	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	0	<MDL	-		8.8 (c,f)
Dibenzo(a,h)anthracene	0	<MDL	-		8.8 (c,f)
Benzo(g,h,i)perylene	0	<MDL	-		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.
(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.
(c)California Ocean Plan, Carcinogen
(d)California Ocean Plan, Non-Carcinogen
(e)Sum of 1,2 and 1,3-dichlorobenzenes
(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L
(*) Values are compared versus blank instead of the MDL.

Table E-9. GC/MS results of base neutral analysis of Sepulveda Channel samples (7/7 - 12/10/92).

CHEMICAL NAME [1]	Number Found Above MDL & Blank (9 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Phenol	5	100	33 - 290		
2-Nitrophenol	5	27	13 - 49		
Benzoic Acid	5	501	226 - 810		
1,4-Dichlorobenzene(*)	8	58	34 - 117	75,000	18,000 (c)
Isophorone	1	17	-		150,000,000 (d)
Naphthalene(*)	8	102	38 - 153		
2-Methylnaphthalene	8	58	26 - 100		
2-Chloronaphthalene	1	1	-		
2-Nitroaniline	0	<MDL	-		
Dimethyl phthalate	2	26	23 - 30		820,000,000 (d)
Acenaphthene	2	30	8 - 53		
Dibenzofuran	4	7	2 - 12		
Fluorene	5	43	2 - 190		8.8 (c,f)
Diethyl phthalate(*)	8	201	88 - 420		33,000,000 (d)
4-Chlorophenyl phenyl ether	7	22	15 - 34		
Azobenzene	4	21	9 - 29		
Phenanthrene	7	26	8 - 43		8.8 (c,f)
Anthracene	4	1,046	2 - 4,177		8.8 (c,f)
Di-n-butyl phthalate(*)	8	1,223	570 - 2,782		
Fluoranthene	6	19	5 - 33		15,000 (d)
Pyrene(*)	8	956	4 - 7,560		8.8 (c,f)
Butyl benzyl phthalate(*)	9	1,148	408 - 3,271		
Benz(a)anthracene	4	14	9 - 17		

Table E-9 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (9 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Chrysene(*)	4	2,016	3 - 8,032		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	9	4,349	2,783 - 5,400	6,000	3500 (c)
Di-n-octyl phthalate(*)	8	391	2 - 1,902		
Benzo(b)fluoranthene	2	20	1 - 38		
Benzo(k)fluoranthene	1	39	-		8.8 (c,f)
Benzo(a)pyrene	3	1,803	3 - 5,398	200	8.8 (c,f)
Indeno(1,2,3,4-c,d)pyrene	1	71	-		8.8 (c,f)
Dibenzo(a,h)anthracene	1	59	-		8.8 (c,f)
Benzo(g,h,i)perylene	1	58	-		

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.
(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.
(c)California Ocean Plan, Carcinogen
(d)California Ocean Plan, Non-Carcinogen
(e)Sum of 1,2 and 1,3-dichlorobenzenes
(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L.
(*)Values are compared versus blank instead of the MDL.

Table E-10. GC/MS results of base neutral analysis of Centinela Creek samples (7/7 - 12/10/92).

CHEMICAL NAME [1]	Number Found Above MDL & Blank (8 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Phenol	3	83	6 - 125		
2-Nitrophenol	5	30	7 - 49		
Benzoic Acid	5	584	38 - 1,194		
4-Chloro-3-methylphenol	0	<MDL	-		
1,4-Dichlorobenzene(*)	7	44	2 - 77	75,000	18,000 (c)
Nitrobenzene	1	29	-		
Isophorone	2	52	37 - 68		
Bis(2-chloroethoxy)methane	0	<MDL	-		4,400 (d)
Naphthalene(*)	7	90	6 - 130		
2-Methylnaphthalene	7	53	3 - 73		
2-Chloronaphthalene	0	<MDL	-		
Dimethyl phthalate	3	20	3 - 31		820,000,000 (d)
Acenaphthene	3	5	3 - 7		
Dibenzofuran	4	8	2 - 16		
Fluorene	3	13	4 - 24		8.8 (c,f)
Diethyl phthalate(*)	8	216	6 - 730		33,000,000 (d)
4-Chlorophenyl phenyl ether	6	24	1 - 37		
Azobenzene	6	14	1 - 20		
Phenanthrene	5	23	1 - 65		8.8 (c,f)
Anthracene	4	107	1 - 406		8.8 (c,f)
Di-n-butyl phthalate(*)	8	816	70 - 1,931		3,5000,000 (d)
Fluoranthene	5	9	1 - 17		15,000 (d)
Pyrene(*)	5	145	1 - 665		8.8 (c,f)

Table E-10 (cont'd)

CHEMICAL NAME [1]	Number Found Above MDL & Blank (8 Samples) [2]	Average (ng/L) [3]	Range (ng/L) [4]	Drinking Water Standards (a) (ng/L) [5]	Ocean Standards (b) (ng/L) [6]
Butyl benzyl phthalate(*)	8	708	62 - 1,606		
Benz(a)anthracene	3	22	10 - 38		
Chrysene(*)	4	181	11 - 654		8.8 (c,f)
Bis(2-ethylhexyl) phthalate(*)	8	6,240	807 - 32,055	6,000	3,500 (c)
Di-n-octyl phthalate(*)	8	59	4 - 147		
Benzo(b)fluoranthene	2	2	2 - 3		
Benzo(k)fluoranthene	2	2	1 - 3		8.8 (c,f)
Benzo(a)pyrene	4	145	4 - 546	200	8.8 (c,f)

(a)USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.
(b)California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.
(c)California Ocean Plan, Carcinogen
(d)California Ocean Plan, Non-Carcinogen
(e)Sum of 1,2 and 1,3-dichlorobenzenes
(f)Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L
(*)Values arecompared versus blank instead of the MDL.

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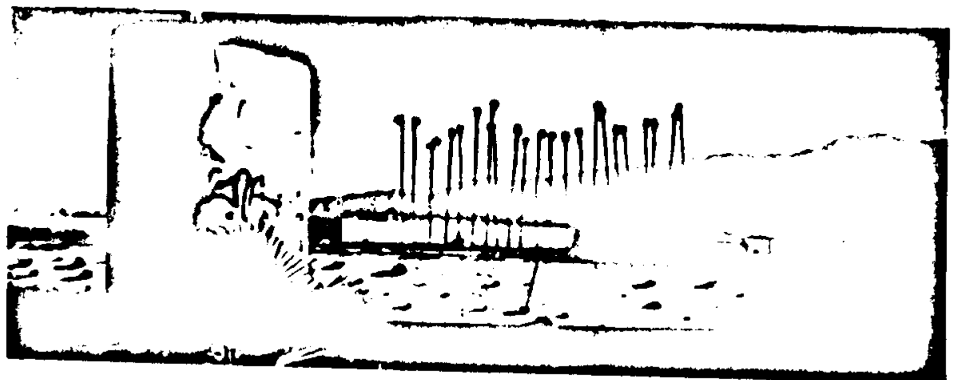
LOS ANGELES RIVER



PARK AND RECREATION AREA STUDY

State Coastal Conservancy
December 1993

VOL 12

State of California
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Douglas Wheeler, *Secretary of Resources*

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LOS ANGELES RIVER

PARK AND RECREATION AREA STUDY

State Coastal Conservancy

December 1993

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STATE OF CALIFORNIA—THE RESOURCES AGENCY

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December 1993

Dear Reader:

The State Coastal Conservancy is pleased to present its Los Angeles River Park and Recreation Area Study. This study was prepared in response to a request from the State Legislature to help explore beneficial uses of the river, including an assessment of the river's potential for public access, recreation and wildlife enhancement. Its specific purpose is to provide, for the first time, a comprehensive set of information on potential improvement projects that could contribute to overall river corridor planning, and to cooperative efforts of communities along the river to improve their river frontage.

Sincerely,

Peter Grenell
Executive Officer

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I. INTRODUCTION

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I. INTRODUCTION

In recent years, interest in the Los Angeles River has been growing among state and local legislators, local governments, and a host of environmental groups and community organizations. Long managed primarily as a flood control channel and considered by many to be nothing more than a blight on the urban landscape, there is an increasing awareness of the tremendous potential of the Los Angeles River to become a recreational and environmental amenity for the greater Los Angeles area. Despite substantial community interest in the "greening" of the Los Angeles River, until recently no public agency has planned comprehensively for such a multiple-benefits vision. Local jurisdiction for the river corridor is fragmented among 12 cities, Los Angeles County, and the U.S. Army Corps of Engineers, making comprehensive planning for the entire watershed a difficult and complicated undertaking.

Then, in the spring of 1990, Los Angeles Mayor Tom Bradley established a Los Angeles River Task Force. Composed of representatives of the city council, commissioners, and city staff, the mission of the task force was to "articulate a vision for the future of the river." The task force established a broad set of goals for the river and proposed three demonstration projects that would express these goals.

Not long after the formation of the Los Angeles River Task Force, the Los Angeles County Board of Supervisors initiated the Los Angeles River Master Plan. The master plan is being prepared by the Los Angeles County Department of Public Works with input from 13 cities, as well as citizens' groups and representatives from state and federal agencies. The purpose of the master plan is to explore the potential of the river to become a recreational amenity while maintaining its function of flood protection.

It is in this context that the State Coastal Conservancy has conducted its study. The Conservancy was requested by the State Legislature in 1990 to assist in the mounting efforts to examine the potential beneficial uses of the Los Angeles River. Senate Bill 1920 authorized the Coastal Conservancy to prepare a plan for this area that included an assessment of the river's potential for enhancement for public recreation and wildlife habitat uses.

The Conservancy's response was to initiate two complimentary studies. The first, to be carried out through the American Institute of Architects, is to be an analysis of the major issues, opportunities, and constraints involved in a large-scale restoration of the river corridor. This study is still in progress. The second study, carried out directly by Conservancy staff, is an identification of improvement projects that could be carried out in the near-term along the river corridor. This document represents the results of this second study.

This study was carried out in consultation with the Los Angeles County Department of Public Works, with other local agencies having jurisdiction over various portions of the study area, and other interested groups. This study built in particular upon the ongoing work of the Department of Public Works and the Army Corps of Engineers and upon the work of the city of Los Angeles' Los Angeles River Task Force. The Department of Public Works, in conjunction with other county departments and the National Park Service, has begun to develop a multi-purpose master plan for the Los Angeles River and Tujunga Wash.

The study area was the approximately 50 miles of river corridor from the confluence of Bell Creek and Arroyo Calabasas in Canoga Park to Long Beach Harbor. It includes 12 cities as well as portions of unincorporated Los Angeles County. Contacts were initiated with all of the local jurisdictions contained in the study area, including the city and county of Los Angeles, Burbank, Glendale, Vernon, Bell, Maywood, South Gate, Cudahy, Lynwood, Paramount, Compton, and Long Beach. Efforts were made to identify the recreation and enhancement priorities of these jurisdictions. Projects identified range from those that require no changes in existing river conditions or management practices, to those that would demand dramatic changes in current land uses and priorities. Recommendations are also made regarding areas and issues requiring future study.

Los Angeles County covers an area of over 4,000 square miles and has a population that is rapidly approaching 9 million people. According to a 1989 *Los Angeles Times* survey, the quality of the human environment is generally perceived by residents to have declined in recent years. The entire region is heavily urbanized and is plagued with many of the environmental quality problems associated with such an area: significant air pollution, water quality problems, crowding, urban blight, noise, toxic waste disposal problems, including groundwater contamination, and very heavy traffic. Air pollution in the basin exceeds federal clean air standards 30-50% of the year. Recent plans by environmental regulatory agencies in the basin suggest that improving environmental quality would require significant government action; plans provide for significant restrictions on development, transportation, land use, and energy use.

Along with the population, the density of development in Los Angeles is increasing, and as a result, noise and traffic are increasing. Recent studies of the major transportation corridors indicate that on some freeways "rush hour" conditions exist for extended periods (as long as six hours in the morning and five hours in the afternoon). Adjacent surface streets are also crowded with traffic. These conditions adversely affect commercial activity as well as the general social environment.

The Los Angeles metropolitan area has less per capita park acreage than any other large metropolitan area in the United States. In most communities, parks and open space are in short supply and high demand. Clearly, there is an urgent need for more open space and additional recreational facilities in the Los Angeles area, as well as a need to ameliorate the problems of air pollution and traffic congestion. The enhancement of the Los Angeles River as a recreational and environmental resource could serve in large part to meet these needs.

II. BACKGROUND

Figure 1
Location Map

II. BACKGROUND

The Los Angeles River flows for more than 50 miles from the Santa Monica Mountains at the western end of the San Fernando Valley to the Pacific Ocean at Long Beach. From its start at the junction of Calabasas and Bell creeks in the Santa Monica Mountains, the river flows eastward through the San Fernando Valley. It bends around the Hollywood Hills and flows south onto the broad coastal plain of the Los Angeles Basin, eventually discharging into San Pedro Bay at Long Beach Harbor. The river is joined by several tributaries, notably the Tujunga Wash, Arroyo Seco, Rio Hondo, and Compton Creek, and drains an area of 824 square miles.

The river has been channelized for its entire length. The river bottom and banks are lined with either concrete or grouted rock except for two areas, one in the vicinity of Glendale, and the other a stretch of river from Willow Street to the Pacific Ocean in Long Beach. The river channel in both areas is soft-bottomed with riprap or concrete along the banks.

Since the flood control system was completed, development has been permitted to directly abut the channel right of way. The river is bordered by a dense mixture of residential, commercial, and industrial development for much of its length. Through the San Fernando Valley, the river flows past heavily developed residential and commercial areas. From the Arroyo Seco, north of downtown Los Angeles to the confluence with the Rio Hondo, the river passes through industrial and commercial areas and is bordered by rail yards, freeways, and major commercial and government buildings. From the Rio Hondo to the Pacific Ocean, the river flows through industrial, residential, and commercial areas, including major refineries and petroleum products storage facilities, several major freeways, rail lines and rail yards serving the ports of Los Angeles and Long Beach, large industrial complexes, and extensive residential and commercial developments.

Los Angeles River
Park and Recreation Area Study

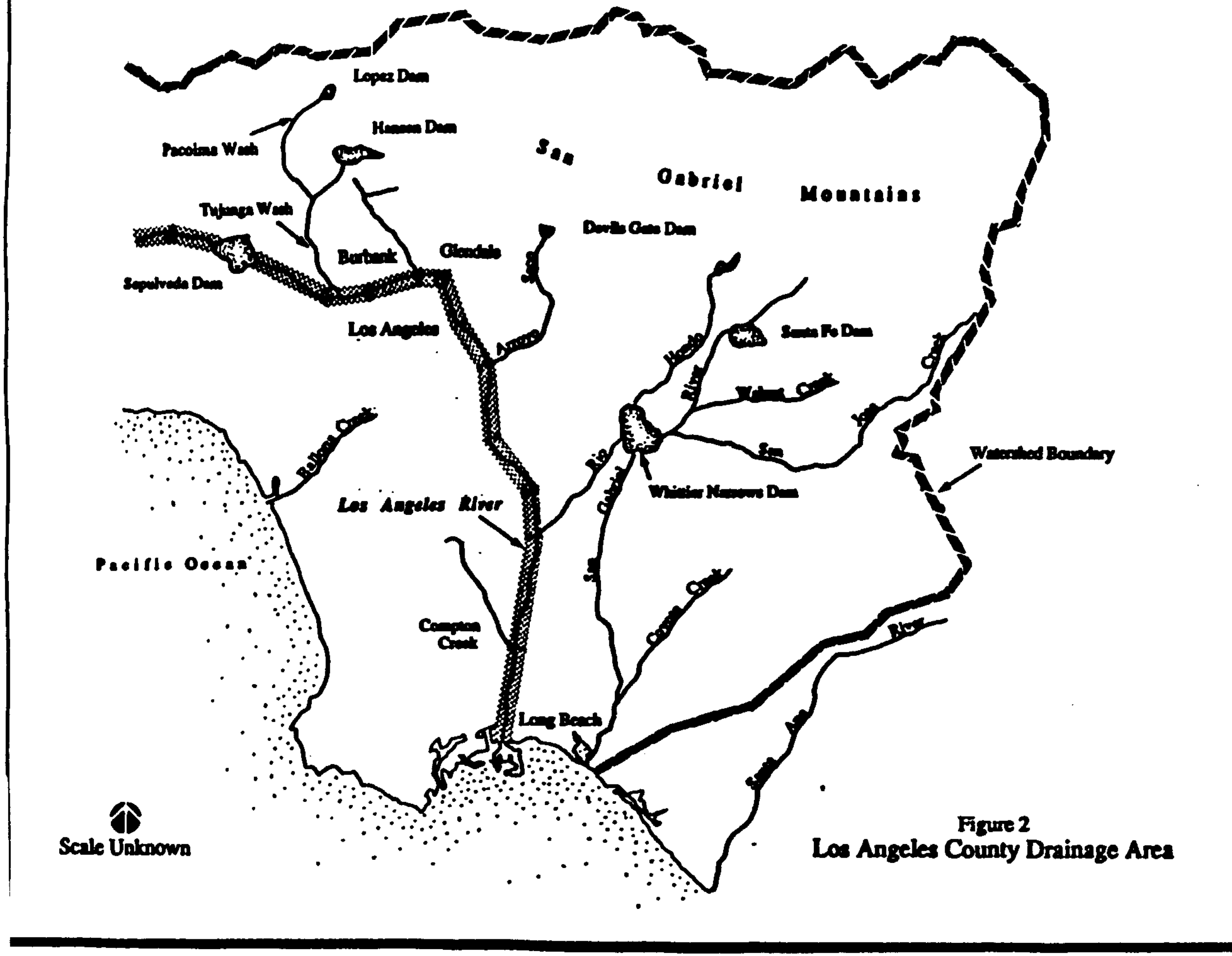

Figure 2
Los Angeles County Drainage Area

HYDROLOGY

The Los Angeles River and the San Gabriel River are the two principal streams that drain the entire Los Angeles Basin south of the San Gabriel Mountains. This area comprises the Los Angeles County Drainage Area (LACDA). The Los Angeles River is fed by several tributaries that start in the mountain ranges that rim the Los Angeles Basin.

The Los Angeles River channel was constructed between the late 1930s and the 1950s. The river channel consists of a concrete paved invert and sides from Willow Street to Interstate 5, near the Pasadena Freeway, and from the Riverside Drive bridge to Tujunga Wash. The area between Interstate 5 and Riverside Drive is a stone or earth and stone channel bottom with concrete-paved or stone sides. The river south of Willow Street to the mouth consists of a natural earth invert with concrete-paved or stone side slopes. The reach of the river above the confluence of the Tujunga Wash consists of concrete channel sections, except for an earthen channel and berm stretch within the Sepulveda Basin.

Most of the Los Angeles River has a trapezoidal channel section with some reaches consisting of a rectangular channel section. The bottom width of the trapezoidal channel ranges from 160 feet to 510 feet. Rectangular sections of the river range from 50 feet to 220 feet in width. The channel depths vary; deeper sections are generally located in the downstream reaches. The Los Angeles River channel has depths varying from 13 to 34 feet, measured from the top of the berm (or top of channel if there is no berm) to the invert.

Earthen levees with concrete facing typically parallel each side of the river channel. The levees act as access roadways, and many areas have been paved. Equestrian and bicycle trails are also located on or next to the levees south of the Rio Hondo. Chain-link fencing has typically been used to separate the river channel from the berms in order to keep maintenance workers and others using the levees from falling into the river channel.

Beyond the berms on one or both sides of the river are parallel overhead electric transmission lines. These lines parallel portions of the river.

Low-flow water in the river channel is from residential runoff through storm drains and from two city of Los Angeles wastewater treatment plants — Tillman and Glendale. The water from the treatment plants makes up nearly all the low-flow in the channel during the dry months.

The Los Angeles River channel is operated and maintained by two agencies — the U.S. Army Corps of Engineers (the Corps) and the Los Angeles County Department of Public Works (LACDPW). The Corps operates the reach of the river between the Rio Hondo and the Tujunga Wash. The remaining portions of the river are operated and maintained by the LACDPW.

The Corps has determined that the LACDA system does not at present provide the desired urban area base standard of 100-year flood protection for all parts of the drainage area. In the lower portion of the river, the current system has the capacity to withstand only a 25- to 40-year storm event. The Corps has proposed increasing the flood control capacity of the existing system by building parapet walls on top of existing levees along the Rio Hondo channel and along the Los Angeles River channel south of the confluence with the Rio Hondo. The project will require modifications to existing bridges on both rivers, modifications to existing channels at the confluence, and reinforcement of the levees.

ECONOMICS AND DEMOGRAPHICS

The Los Angeles metropolitan area is the center of the manufacturing, trade, financial, and service industries in the western United States, with a gross product exceeding $100 billion annually. The economy, although dominated by manufacturing and trade, is quite diversified and has sustained long-term growth for almost 70 years. The Los Angeles/Long Beach harbors form the largest harbor complex on the west coast of the United States, handling almost as much cargo as the three other major port complexes combined (San Francisco-Oakland, Seattle-Tacoma, and Portland). The region is a major transshipment point for Pacific Rim trade.

Throughout the 1980s the economy of the Los Angeles area remained strong relative to other parts of the state and the nation, and although unemployment has increased over the last two years, 15 of California's 27 largest employers are located in the Los Angeles area. The principal employment sectors in the region are trade, manufacturing, services, and government. Per capita income in Los Angeles county in 1990 was $15,368. As of 1990, the average price of a house in Los Angeles County was $226,400, and average rent for a two-bedroom apartment was $570. Housing units are almost evenly divided between owner-occupied and rented.

With a population approaching 9 million people over an area of over 4,000 square miles, Los Angeles County has the largest population of any county in the United States. From 1980 to 1990 the population of Los Angeles County increased by more than 18% (from 7,477,400 to 8,863,164), the largest population increase of any county in the nation. The population density in Los Angeles County is extremely high, with 2,183 people per square mile. The Southern California Association of Governments (SCAG) predicts a county population of over 10 million by the year 2010. The population is evenly divided between male and female.

The Los Angeles area has always been multi-ethnic and multi-cultural. In recent years, the area has experienced a large immigration of peoples from Mexico and Central America and Asia, as well as from other areas of the United States. According to U.S. Census data, the years between 1980 and 1990 saw dramatic shifts in ethnic demographics. Although still the single largest racial group in Los Angeles County, the population of non-Hispanic whites decreased from 52.9% of the total population to 40.8%. Hispanics represent the second-largest ethnic group (after non-Hispanic whites) in Los Angeles County. People of Hispanic origin increased as a percentage of population from 27.6% to 37.8% between 1980 and 1990, with Mexican-Americans constituting the largest segment of this group. It is predicted that Hispanics will become the majority ethnic group in Los Angeles County in the very near future. The percentage of African-Americans in the population decreased from 12.6% to 11.2% (although total numbers increased slightly). The most dramatic change was the increase in the Asian population in Los Angeles County. The percentage of Asian-Americans in the total population almost doubled between 1980 and 1990, increasing from 6.1% to 10.8%, with Chinese- and Filipino-Americans representing the largest segments of this group.

The ethnic distribution within the county has also shifted over the last ten years, with non-Hispanic whites and African-Americans moving out of the central and southern portions of the city of Los Angeles and the small cities south of Los Angeles and Hispanics moving in. Downtown and

East Los Angeles, as well as many "eastside" cities, are now predominantly Hispanic. Asians are settling primarily in the San Gabriel and San Fernando valleys and the northern-central portions of the city of Los Angeles.

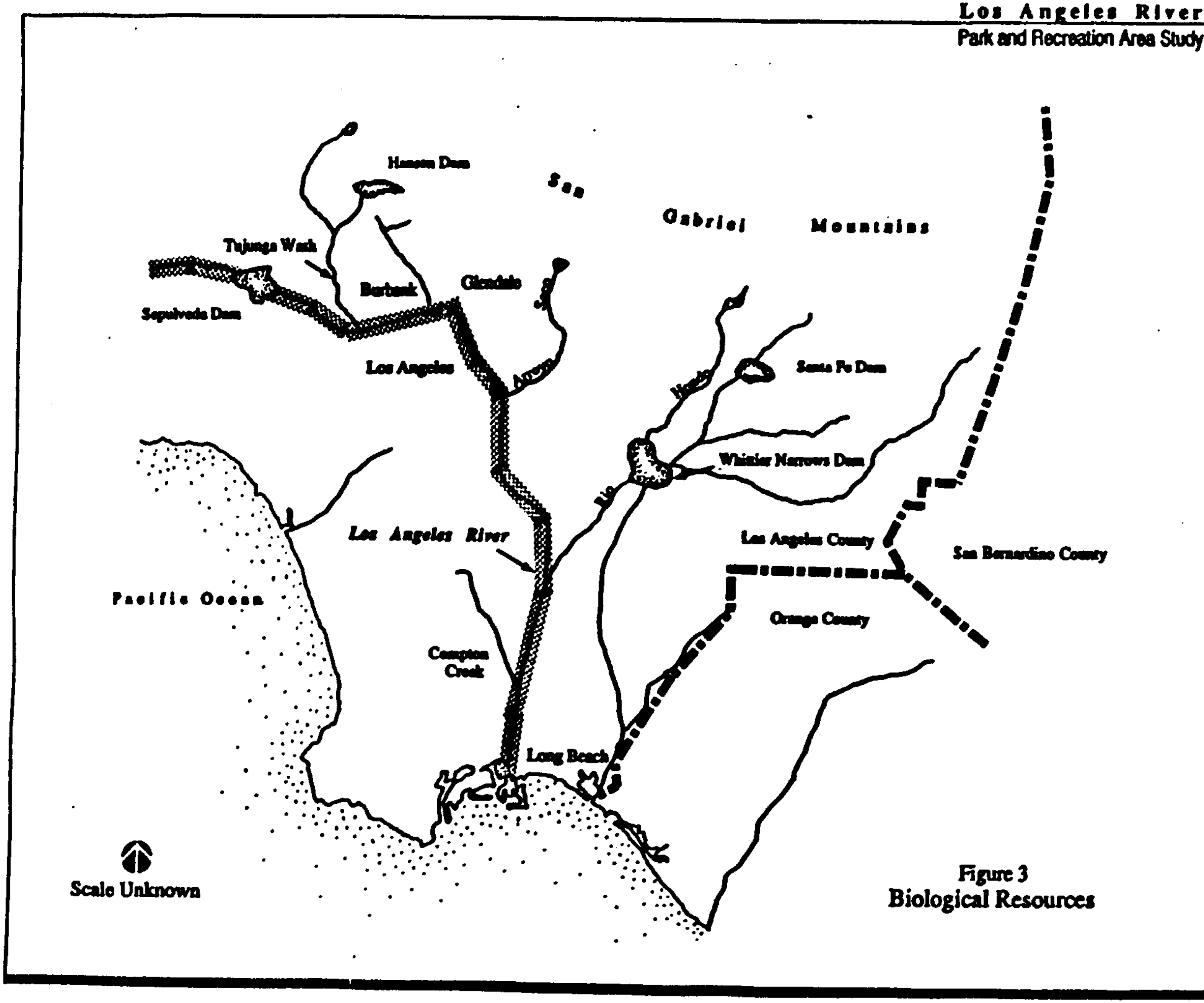

Figure 3
Biological Resources

BIOLOGICAL RESOURCES

The Los Angeles River has been modified from its natural condition to such an extent that little remains of the formerly rich riparian and related habitats that made up the river system. Most of the river below the Sepulveda Basin is contained within a concrete-lined channel surrounded by urbanized areas. A recently completed study of the biota of the river by the Los Angeles County Museum of Natural History concluded, however, that:

> Despite the severe fragmentation of natural habitat associations, the loss of numerous native taxa, and the establishment of many exotic plant and animal species, the Los Angeles River and its tributaries continue to harbor a rich biota in certain soft-bottomed channel areas, flood control basins, and unchannelized foothill and montane reaches. The potential for restoration of wetland and riparian habitats and other heavily impacted upland habitats bears investigation. (NHMLACF, March 1993, pp i-ii)

Vegetation

Three areas of the Los Angeles River that were not paved when the river was channelized are the area upstream of Sepulveda Dam within the Sepulveda Basin, the Glendale Narrows, a 6-mile stretch of the river near Glendale between the Burbank Western Channel and the Arroyo Seco, and a 2.6-mile section in Long Beach.

The Glendale Narrows has a cobblestone bottom and a large, stabilized gravel bank with dense vegetation consisting mainly of willows (*Salix* spp.), giant reeds (*Arundo donax*), Bermuda grass (*Cynodon dactylon*), fennel (*Foeniculum vulgare*), and castor bean (*Ricinus communis*). Scattered sycamore (*Platanus racemosa*), ash (*Fraxinus uhdei*), mulberry (*Morus alba*), and pepper trees (*Schinus molle*) are also found on the bank. Bulrush (*Scirpus americana*), ludwigia (*Ludwigia peploides*), speedwell (*Veronica anagalis-aquatica*), and knotweed (*Polygonum* spp.) occur along the edges of the bank.

In Long Beach, the section of the river below Willow Street is soft-bottomed. The buildup of silt on both sides of the river in this area has allowed for the growth of a 10- to 15-foot-wide riparian corridor, containing rushes (*Scirpus* spp.), cattails (*Typha* spp.), willows (*Salix* spp.), mulefat (*Baccharis glutinosa*), and several ruderal species. This area is influenced by tidal waters from the mouth of the river and, at high tides, sea water extends almost up to Willow Street.

Other areas within the watershed that contain habitat areas include Hansen Dam, Sepulveda Dam, Santa Fe Dam, Whittier Narrows Dam, and Compton Creek. Hansen Dam and Whittier Narrows Dam, in particular, have good riparian habitat and support a variety of animal species. The Santa Fe Dam basin has a small riparian area and a unique assemblage of alluvial scrub. Compton Creek is a tributary of the lower Los Angeles River and has a soft-bottomed section upstream of its confluence with the river. This section of the creek is characterized by riparian habitat dominated by such species as bulrush (*Scirpus americana*) and arroyo willow (*Salix lasiolepis*).

Small patches of freshwater marsh still exist in some areas of the river, notably the soft-bottomed area near Glendale and in the Sepulveda Basin.

Flood plain (willow/cottonwood) forest remnants occur in the Sepulveda and Hansen basins. Big Tujunga Wash has areas of unaltered streambed with riparian woodlands consisting of willow (*Salix bonplandiana*), white alder

(*Alnus rhombifolia*), and western cottonwood (*Populus fremontii*).

Other habitats associated with the Los Angeles River and its watershed, such as valley oak savanna, live oak woodland, chaparral, alluvial scrub, douglas fir/canyon oak woodland, and mixed coniferous forest, continue to exist, generally in the outlying areas of the watershed. The Los Angeles County Natural History Museum noted in its study of the biota of the river that:

> It is important to recognize the value of the vegetation of the Los Angeles River as habitat for other biotic resources. It may represent a highly altered state from native vegetation but studies might show it to function similarly on some levels. (NHMLACF, 1993: B-9)

Wildlife

Populations of mollusks, fish, reptiles, amphibians, and mammals also live in and around the river:

Mollusks: The number of mollusks found in the river has declined precipitously since the river was channelized (NHMLACF, 1993: C-1- C-8) but a few snail species and other mollusks still occur in the river system. Decline of mollusk populations is attributed to loss of habitat due to channelization and water pollution.

Fish: Of the seven endemic species of fish once found in the river only three are still found in the river system. Of these three (arroyo chub, Santa Ana sucker, Santa Ana speckled dace) only one species, the arroyo chub, still exists in large numbers in the river. Four introduced species (fathead minnow, goldfish, mosquito fish, and tilapia) are also present in the river. Poor water quality and the lack of refuge areas during high flows (a result of channelization) are the major reasons for the decline of the native fish species.

Amphibians & Reptiles: Of the 33 species of amphibians and reptiles known to have inhabited the Los Angeles River drainage historically, 19 species are thought to still occur in or along the river channel. These include four species of salamanders, three species of frogs, six species of lizards and six species of snakes. The western toad (*Bufo boreas*), Pacific treefrog (*Hyla regilla*), bullfrog (*Rana catesbeiana*), and two-striped garter snake (*Thamnophis hammondii*) are found in the river channel. The other species occur in the riparian zone or in the foothills of the Santa Monica Mountains near the river channel.

Birds: The Los Angeles River drainage supports a great diversity of bird species in spite of the channelization of much of the river. The river channel in Long Beach has both concrete and soft-bottom stretches. In summer and fall, algal growth on areas of the concrete-lined channel attract large numbers of shorebirds and other birds that feed on invertebrates in the algae.

The soft-bottomed channel in Long Beach supports areas of willows and other vegetation that may provide habitat for some bird species. This vegetation is removed occasionally by the Los Angeles County Department of Public Works (with the approval of the California Department of Fish and Game). Large numbers of migrating shorebirds feed in this area of the river from July through October. Species found in the area include western sandpiper, American avocet, black-necked stilt, long-billed dowitcher, and least sandpiper. Black-necked stilts and American avocets nest on small islands in the river south of Willow Street.

The vegetated, soft-bottomed portion of Compton Creek, the spreading basins along the Rio Hondo channel, and the soft-bottomed Glendale Narrows section provide habitat for a number of different species. Great egrets, snowy egrets, black-crowned night-herons, and loggerhead shrikes occur along Compton Creek. Northern shovelers, American wigeons, American coots, and several species of shorebirds use the Rio Hondo spreading basins as overwintering grounds. Pied-billed grebe, cinnamon teal, killdeer, black phoebe, and red-winged blackbirds nest in the Glendale Narrows section of the river.

Sepulveda Basin, Hansen Dam, and Big Tujunga Wash also support significant numbers of birds. Canada geese overwinter at the Sepulveda Basin. Waterfowl and shorebirds are commonly seen in the basin. Hansen Dam Basin supports a large number of waterbirds and shorebirds, including five species of grebes and nine species of herons. Riparian species nesting in the basin include green heron, belted kingfisher, and blue grosbeak. Alluvial wash and scrub areas of Big Tujunga Wash provide habitat for greater roadrunner, lesser nighthawk, cactus wren, rock wren, and Costa's hummingbird

Mammals: Rats (*Rattus*), house mice (*Mus*), and feral cats and dogs constitute the majority of the mammal population of the channelized portions of the river. The channelized river section has little remaining habitat suitable for native species. Raccoon, coyote, striped skunk, and opossum, which can adapt to urban environments, are generally found throughout the watershed. Open fields adjacent to the river often provide habitat for such species as rabbits, gophers, voles, moles, and shrews. Much of the upper watershed, however, still supports many, if not all, of the historic number of mammal species native to the area. The Tujunga Wash area supports a number of different species, including native mice, kangaroo rats, bats, and jack rabbits.

Los Angeles River
Park and Recreation Area Study

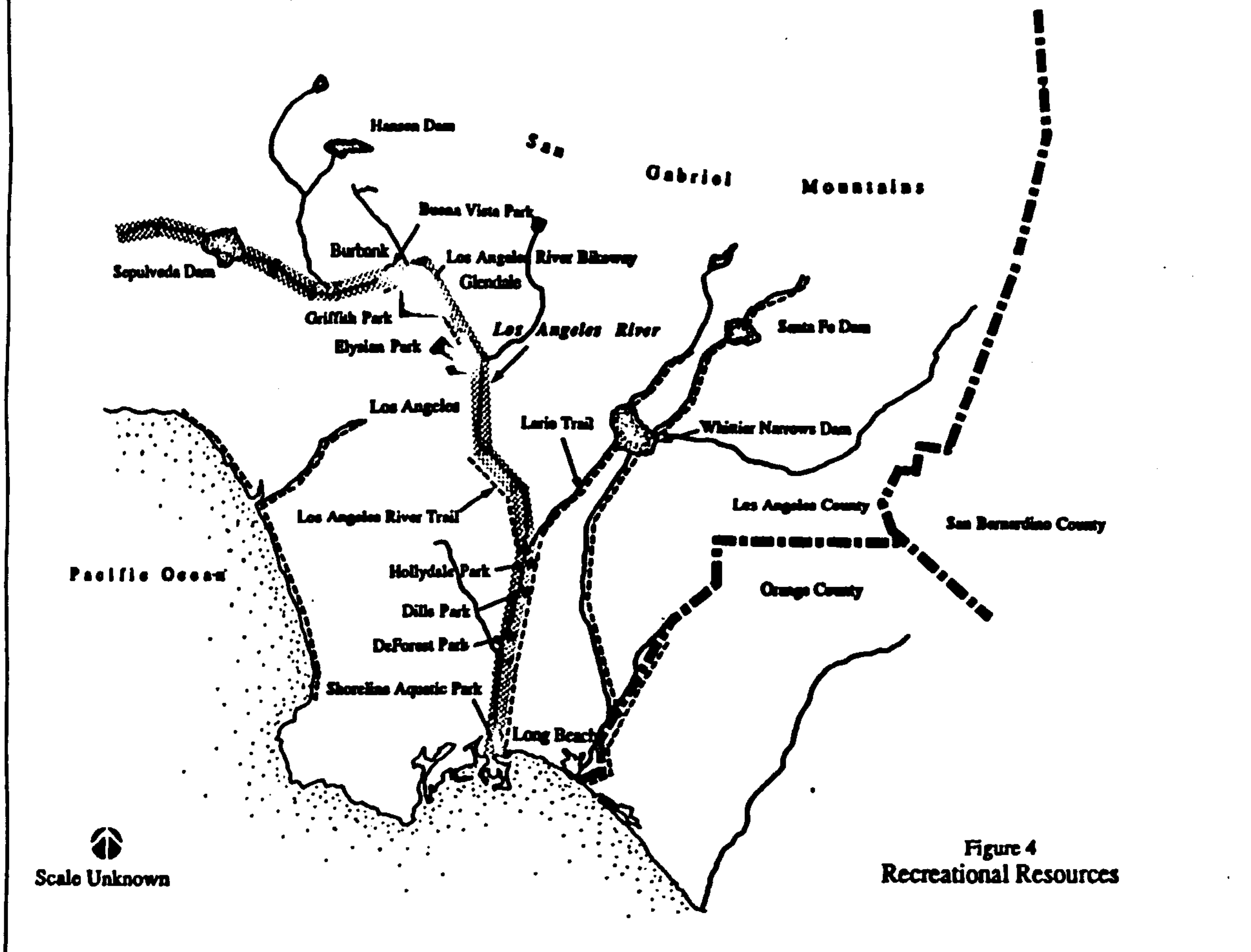

Figure 4
Recreational Resources

RECREATIONAL RESOURCES

The Los Angeles River and the flood control system of which it is a part currently provide several different types of recreational facilities. These facilities, which are concentrated at the four flood control basins (Sepulveda Basin, Hansen Dam, Whittier Narrows, Santa Fe Dam), include recreation lakes, picnic grounds, hiking and riding trails, and playing fields. All four basins have been designated as recreation areas by Los Angeles County.

Recreation facilities associated with the river channel itself are limited to the Lario (Los Angeles River-Rio Hondo Channel) Trail, the Los Angeles River Trail, and associated equestrian trails. The channel provides several miles of hiking and bicycle trails. The trail along the Los Angeles River begins at the Pacific Ocean and connects with the Rio Hondo and San Gabriel trail systems, which provide access into the San Gabriel Mountains. The bike path uses the service roads on top of the channel levees. Equestrian trails are often separate from the bike path and are either a fenced paved trail or an unpaved strip next to the bike path. The trails along the river are not landscaped and do not include rest stops or other facilities that would make them more attractive to trail users.

Access to the bike trails is often from major streets, and access to equestrian trails is from parks adjacent to the river. A gate in the fencing at these river crossings provides access to the trails. These access points are generally between one and two miles apart.

The city of Los Angeles is currently in the process of constructing Phase I of the new Los Angeles River Bikeway. Phase I will consist of a seven-mile trail beginning at the confluence of the Arroyo Seco and the Los Angeles River at Figueroa Street (adjacent to Elysian Park) and extending along the west bank of the river to the intersection of Riverside and Zoo drives in Griffith Park. Phase I is expected to be completed by 1995. The city intends to begin planning next year for the Phase II extension of the trail, from Griffith Park along the Los Angeles River and the Tujunga Wash to Strathern Park in the San Fernando Valley.

The Los Angeles River channel adjoins several community parks, including Griffith Park and Elysian Park in Los Angeles, Buena Vista Park in Burbank, Hollydale Park in South Gate, Dills Park in Paramount, and DeForest Park and Shoreline Aquatic Park in Long Beach.

The Juan Bautista de Anza National Historic Trail, which is presently in the planning stage, will follow the Los Angeles River from Glendale to the San Fernando Valley. The trail follows the route of the de Anza Expedition of 1775-76 from Mexico to San Francisco. The National Park Service has begun preparation of a comprehensive plan for the trail route. National historic trails combine recreation and historic interpretation.

III. PREVIOUS STUDIES

III. PREVIOUS STUDIES

Numerous studies of the Los Angeles River have been conducted over the past several years by public agencies, nonprofit organizations, and community groups. These studies vary widely, from conceptual sketches to detailed plans for specific areas. Content ranges from bird inventories to proposals for freeway development. Since the emphasis of this study is parks and recreation development, those studies that focus on these uses of the river are briefly summarized below. These studies include two conducted by the city of Los Angeles and two completed by the U.S. Army Corps of Engineers.

The LACDA System Recreation Study: Los Angeles County Drainage Area (U.S. Army Corps of Engineers, Los Angeles District, March 1980)

This report presents the results of a study conducted by the Los Angeles District of the Army Corps of Engineers that analyzed the recreational potential of the land within the Los Angeles County Drainage Area (LACDA). The LACDA includes all of Los Angeles County south of the San Gabriel Mountains. This drainage area has been developed over the past 50 years by the Corps and the Los Angeles County Flood Control District into a complex system of rivers, channels, and flood control basins that collect the urban runoff from the entire greater Los Angeles area, as well as runoff from the mountain ranges that surround the area, and carry it to the ocean or to spreading basins. The primary purpose of the system was to prevent flooding in developed areas within the flood plain.

This study was the first comprehensive effort on the part of the Corps to assess the recreational potential of the land within the LACDA system. The methodology consisted of data gathering from literature searches, meetings with local agencies and community groups, and physical inspection of the entire system. The data were analyzed to determine those recreation uses that were possible in the system and to assess the recreational needs of the Los Angeles area. This analysis included an assessment of existing trail systems and recreational facilities and a determination of where new trails and recreational facilities were most needed. The study includes in the appendices a set of detailed, annotated maps of each section of the LACDA system showing existing conditions and facilities and proposed projects.

The primary emphasis of the study is a proposal for the development of a regional trail network along the channel system. The study includes a detailed survey of existing conditions throughout the channel system, an analysis of the suitability of different channel segments for trail development, and a system for prioritizing the development of new trails. The study does not include an analysis of the recreational uses of the many flood control basins and reservoirs in the system. All other parts of the system are included in the study with the exception of Ballona Creek, the San Gabriel River, the Rio Hondo River, and the Los Angeles River south of the Rio Hondo confluence. These areas were excluded from the study because trail systems were already in place or under construction (the Lario and San Gabriel river trails).

The Regional Trail System: The LACDA report proposes the creation of a network of trails linking the major parts of the Los Angeles region through the use of the LACDA flood control channels. The backbone of the system would be formed by the Lario and San Gabriel trails, together with extensions from both these trail systems west through the San Fernando Valley and east through the San Gabriel Valley. Secondary connector trails would provide access to the backbone trail from nearby residential areas.

Non-Trail Projects: Although the main emphasis of the LACDA Recreation Study is on the development of a trail system, the report also discusses the potential for the development of other, non-trail recreational facilities within the LACDA system. The discussion does not attempt to identify all of the possible locations for such facilities but rather to identify the types of non-trail uses that would be desirable and to suggest some of the most feasible potential locations for these types of projects.

The study proposes the following kinds of non-trail projects:

- Linear parks and green spaces for urban neighborhoods
- Non-linear parks
- Transportation projects
- Nature study and wildlife conservation areas.

Los Angeles County Drainage Area (LACDA) Review; Final Feasibility Report (U.S. Army Corps of Engineers, Los Angeles District, December 1991)

The Corps' December 1991 LACDA Review summarizes the findings of a feasibility study that examined the potential problems and inadequacies of the existing LACDA mainstem flood control system. Extensive new development in the Los Angeles Basin over the past 50 years has resulted in increased runoff, particularly in the lower portion of the basin. The report concluded that the current system has the capacity to withstand only a 25- to 40-year storm event and outlines several measures that could be taken to prepare the system for a 100-year storm.
The Corps proposes to increase the flood control capacity of the existing system by building parapet walls ranging from one to eight feet in height on top of existing levees along the entire Rio Hondo channel south of Whittier Narrows Dam and along the Los Angeles River channel south of the confluence of the Rio Hondo, a total distance of 21 miles. Construction of the parapet walls would require raising or modifying several street, railroad and utility bridges to accommodate the added height and would cost an estimated $280 million.

The Corps concluded that increasing the channel height in the lower reach of the system was the "optimum" means of increasing flood control capacity in the system based on its National Economic Development (NED) criteria. These criteria attempt to balance the cost of any proposed system improvements against the benefits that would be derived from their implementation. According to the Corps' analysis, other alternative methods for increasing the system's capacity would not be cost-effective.

Other alternatives examined included measures taken in the upper watershed that might reduce the inflow of flood waters to the existing system, alterations to existing flood control reservoirs, and modifications to the mainstem channel areas other than the construction of parapet walls. It was determined by the Corps that none of the alternative approaches analyzed was cost-effective according to NED criteria. This finding led the Corps to conclude that raising the channel walls was the only method feasible for increasing the system's flood control capacity.

The raising of parapet walls along the Rio Hondo and the lower reach of the Los Angeles River channel would have serious impacts on both public use of the river and the aesthetics of the river generally. Walls along the riverside of the public access trails could obstruct or eliminate visual contact with the river, thereby diminishing the attraction of the trail. The Corps and the County Department of Public Works have decided to address this concern by raising the height of the access road adjacent to the parapet walls. The road will be raised depending on the height of the walls such that the wall height is never more than four feet above the grade of the access road.

Los Angeles River Greenbelt Corridor Feasibility Study (City of Los Angeles Planning Department - Recreation & Parks Department, December 1990)

This report outlines several recommendations that the city of Los Angeles should follow toward the goal of creating a Los Angeles River Greenbelt Corridor.

Recommendations include: development of a specific plan around a linear park concept; construction of a bikeway along the river; initiation of landscaping of the river corridor; provision of incentives to owners of land adjacent to the river to provide open space when developing their property; work with the U.S. Army Corps to improve its properties; development of a demonstration project for adaptive reuse of flood control right-of-way for recreational and aesthetic purposes.

The report also includes the following points:

- Most of the right-of-way of the river within the city of Los Angeles is already designated as open space in various plans.
- Opportunities for multiple use of public lands, including flood control, recreation, open space, transportation, and public utilities, should be considered in all planning efforts.
- Creation of a continuous uninterrupted bikeway system along the entire length of the river will be difficult because of the narrowness of the right-of-way and/or obstructions in many areas.
- The greenbelt corridor could serve to connect parks and open spaces throughout the region and in this way act as a wildlife corridor.
- A prototype greenbelt corridor has been established in Long Beach at DeForest Park.
- Planning for the greenbelt corridor should be coordinated among all the affected cities and agencies along the river.

Report of the City of Los Angeles - Los Angeles River Task Force (Office of the Mayor, City of Los Angeles and National Park Service Rivers, Trails and Conservation Assistance Program, January 1992)

This report summarizes the activities of the Los Angeles River Task Force, outlines broad goals for the river and identifies three demonstration projects.

The goals developed by the task force are the following:

- Meet flood control needs within the context of multiple use of the Los Angeles River.
- Restore the river's natural ecosystem wherever possible.
- Improve quality and maximize use of river water.
- Enhance the inherent beauty of the river and its environs.

- Maximize appropriate public uses and recreation opportunities of the river.
- Develop alternative transportation uses.
- Encourage land uses that enhance the environment of the river.
- Enhance public awareness and build support for the Los Angeles River.
- Develop coordinated governance of the river corridor.
- Produce and adopt a master plan for the river.
- Develop strategies for implementation of the plan.

The task force recommended the following demonstration projects:

- *River/Recreation Link in Sepulveda Basin* (San Fernando Valley)
  This project would incorporate the river into the adjacent Balboa Park environment by creating visual and physical linkages between the two. Project components include: river cleanup, vegetation rehabilitation, development of a nature trail, nature study program, river and boating safety program, and water quality monitoring.

- *Los Angeles River Greenway* (Griffith Park)
  This project consists of the development of the first segment of a greenway along the route of the proposed Los Angeles River bike path. Project components include: landscape planting, signage, and a bicycle safety program.

- *Downtown Historic Site and Bridge Event* (Downtown)
  Development of an historical site and a native plant demonstration garden at the Broadway Bridge near Elysian Park. The garden will replicate as closely as possible the landscape encountered by Spanish explorers de Portola and de Anza in 1769 as they prepared to ford the Los Angeles River. Other project components include a cultural festival, an annual bridge celebration, an arts festival, a native plant garden dedication, and a river regatta.

The Los Angeles River Watercourse Improvement Draft Reconnaissance Report; Environmental Restoration/Recreation
(U.S. Army Corps of Engineers, November 1992)

This reconnaissance study was initiated at the behest of the city of Los Angeles to determine what opportunities exist in or near the river corridor for environmental restoration, public recreation, non-motorized (bicycle, equestrian, and pedestrian) transportation, and water conservation. The study was limited to the approximately 19 miles of river corridor that run between Sepulveda Reservoir and the Arroyo Seco confluence (the San Fernando Valley to Downtown Los Angeles). It is a preliminary investigation only and will be used by the Corps to determine whether to actually develop a project plan. The Corps conducted a series of workshops in the project area to solicit public input. The draft Reconnaissance Report recommends that a feasibility analysis be conducted for the following four projects:

- A detention basin at the Taylor Yard, an old railroad switch yard owned by Southern-Pacific
- A riparian habitat area on a 12-acre parcel of undeveloped land at Crystal Springs in Glendale
- A spreading grounds on a 48-acre site on the south bank of the river in Griffith Park
- A 19.2-mile recreation and commuter bikeway along the west and south bank of the river channel from the confluence of the Arroyo Seco to the San Diego

Freeway (The bikeway has not been approved for further study and will not be included in the final report).

The draft report was released in November 1992 and it is anticipated that the final report will be completed by July 1993. If a local sponsor, such as the city of Los Angeles, is identified, the Corps will proceed to a feasibility study.

The Biota of the Los Angeles River: An Overview of the Historical and Present Plant and Animal Life of the Los Angeles River (State Department of Fish and Game and the Los Angeles County Museum of Natural History, March 1993)

This 300-page report was prepared by the Natural History Museum of Los Angeles County with a grant from the California Department of Fish and Game. The report consists primarily of a series of comprehensive inventories of the plant and animal species currently found in or around the Los Angeles River. These inventories were conducted for algae, vascular plants, freshwater mollusks, fish, amphibians and reptiles, birds, and mammals. The report also documents historical changes in composition of the plant and animal communities of the Los Angeles River. The boundaries of the study areas used for the species inventories varied with the type of organisms being sampled. Birds, for example, were surveyed on a drainage-wide basis, whereas algae and fish were sampled only in major channels.

Report on the Taylor Yard Planning and Urban Design Workshop (American Institute of Architects, American Planning Association, American Society of Landscape Architects, Urban Design Advisory Coalition, Los Angeles Forum for Architecture and Urban Design, and the Architectural Foundation of Los Angeles, December 1992)

The workshop was initiated at the request of Los Angeles City Councilman Mike Hernandez and the Friends of the Los Angeles River (FOLAR) in order to study alternative uses for the Taylor Yard, a 241-acre railroad maintenance facility that is currently being offered for sale by the owner, Southern Pacific Railroad. Taylor Yard represents the largest undeveloped parcel near downtown Los Angeles. The site's proximity to downtown, Elysian Park, several significant neighborhoods, and the junction of the Glendale, Pasadena, and Golden State freeways, as well as its frontage on the Los Angeles River, makes it of particular interest to planners, developers, and elected officials.

This report represents the results of a planning workshop, conducted in two, two-and-one-half day sessions, that was intended to gather information, generate involvement from the members of the surrounding communities, and develop a set of recommendations for future uses of the Taylor Yard site. The articulated goals of the workshop were: to generate viable concepts for mixed-use development of the Taylor Yard and its surrounding area; identify and involve the stakeholders in the area; address the major constraints, issues and opportunities of the Taylor Yard site; present recommendations for the refinement and implementation of the alternative use concepts generated.

The report presents a set of basic development principles for the area, as well as some alternative scenarios for land use, urban design, and transportation.

The basic development principles for the Taylor Yard site presented in this report were the following:

- Require that development contributes job opportunities to the community

- Preserve and reinforce local-serving commercial uses
- Facilitate local business development and ownership
- Facilitate the development of housing that provides for the needs of the community
- Use development of Taylor Yard to stimulate capital formation that benefits the community.

The report outlines two general scenarios for land use and development. The first of these scenarios emphasizes the development of a mixed-use community-serving area or "town center," which would extend from Division Street into the Taylor Yard. This town center would be flanked by light-industrial and community-serving recreation areas. The other scenario emphasizes job creation and revenue generation through the development of "big box" discount retail commercial and large-scale industrial uses.

The report recommends the development of the Los Angeles River frontage as an intensive recreation-oriented corridor, containing bike, pedestrian, and/or equestrian paths, nature-study areas, and other amenities, as well as extensive landscaping.

IV. ONGOING STUDIES

IV. ONGOING STUDIES

Concurrent with the Coastal Conservancy's efforts, a number of other studies of the Los Angeles River have been undertaken by other organizations. These studies are still in progress but when completed should add substantially to the general knowledge about the Los Angeles River and contribute to ongoing planning efforts.

The Los Angeles River Master Plan **(Los Angeles County Department of Public Works)**

In July 1991, the Los Angeles County Board of Supervisors directed the Department of Public Works (the Department), which along with the U.S. Army Corps of Engineers oversees the LACDA Flood Control System, to undertake a comprehensive study of possible public uses of the Los Angeles River and Tujunga Wash corridors.

This effort is being managed by the Department of Public Works in coordination with the Los Angeles County Department of Parks and Recreation, the Los Angeles County Department of Regional Planning, and the National Park Service Rivers, Trails, and Conservation Assistance Program. The primary focus of the master plan will be the river's potential for open space, environmental enhancement, recreation, and education. Other ancillary uses will be explored as well, including housing, commercial development, and transit. The study will look at the entire length of the Los Angeles River from its origin in the San Fernando Valley to its mouth in Long Beach and the length of Tujunga Wash from its confluence with the Los Angeles River to Hansen Dam.

Its purpose is to identify optimal uses of the channel system compatible with the overriding purpose of flood control. This study will not be looking at any proposals that could interfere with the flood control function of the system.

A major component is public outreach and community participation. The Department will be initiating a series of public workshops intended to solicit input from the residents of all of the cities in the river corridor. Regular advisory committee meetings began in September 1992. The advisory committee consists of representatives of cities along the river and other interested agencies. The Department is projecting a two- to three-year time frame for the entire effort.

Taylor Yard Flood-Detention Study **(California Department of Water Resources, Los Angeles County Department of Public Works and the Friends of the Los Angeles River)**

This study is being conducted with a $77,000 grant from the Urban Streams Restoration Program of the California Department of Water Resources. It will take a multi-objective approach to flood control on the Los Angeles River by exploring the feasibility of developing a flood water detention basin in the Taylor Yard just north of downtown Los Angeles. This use of the Taylor Yard could potentially provide flood protection for downtown Los Angeles, as well as providing parkland and riparian habitat. It is anticipated that a plan will be completed by September 1993.

V. TRANSIT STUDIES

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V. TRANSIT STUDIES

Over the years, various proposals have been made regarding the possible use of the Los Angeles River as a transportation corridor. The Los Angeles area suffers from chronic and severe traffic congestion and solutions to this problem are continually being sought. The construction of new transportation corridors in the Los Angeles area, where most of the likely sites are already fully developed, would be very costly and disruptive. This has led to the consideration of the river course as a possible location of a new transportation corridor. The two most recent studies to examine this potential use of the river corridor are briefly described below.

Los Angeles River and Tujunga Wash Channels Conceptual Engineering Analysis of Potential Transportation Uses **(Los Angeles County Transportation Commission, February 1991)**

This study examines the possibility of using the channel bottoms themselves for vehicular traffic. Specifically, the study examined using the Tujunga Wash channel as a two-lane reversible High Occupancy Vehicle facility. The Los Angeles River channel was proposed for use by truck and other commercial traffic. Such a use may relieve traffic congestion, at least temporarily, but would have some very serious drawbacks. Most importantly, the channel could not be used to carry traffic at all during periods of flood runoff, or when flooding is expected. Also, the year-round low flows in the channel are expected to increase in the next few years, due to increased urban runoff, and these increased flows could interfere with use of the channel by vehicles at all times of the year. Finally, the use of the channel bottoms by traffic would seriously interfere with the use of the bicycle and equestrian paths on the channel banks. The proposal was strongly rejected by several public agencies and by local citizens and is no longer being actively promoted.

Advanced Implementation Proposal **(Los Angeles River Transit Committee, March 1992)**

The Los Angeles River Transit Committee proposal calls for the development of a Los Angeles River rapid transit system. The proposal envisions a system of electric-powered elevated trains along the entire length of the river as well as the development of "River Center Plazas" that would consist of retail stores, restaurants, community centers, and other facilities. The proposal also suggests that a series of parks, recreation areas, and wildlife areas be created along the river banks as part of the project. The project would also include redevelopment programs for surrounding communities.

Los Angeles River
Park and Recreation Area Study

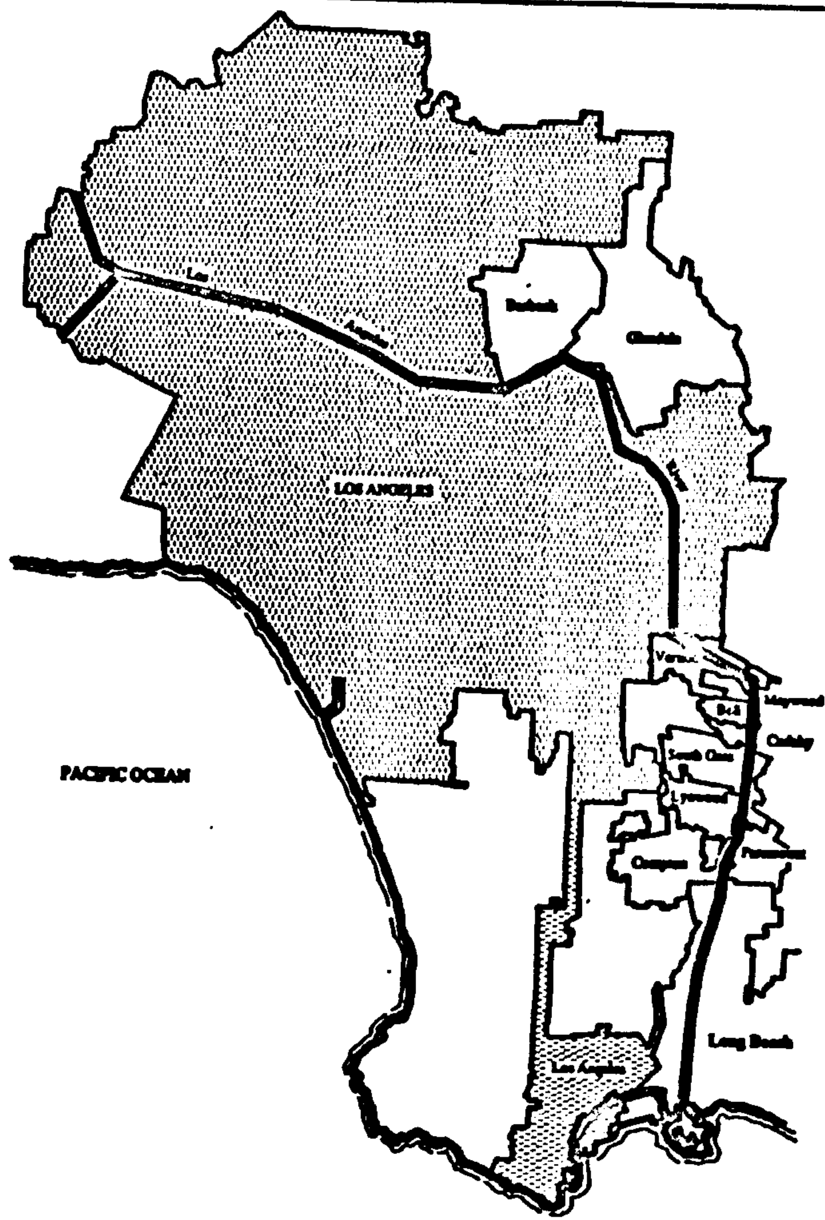

Figure 5
Los Angeles River Cities

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VI. COMMUNITY PROJECT INVENTORY

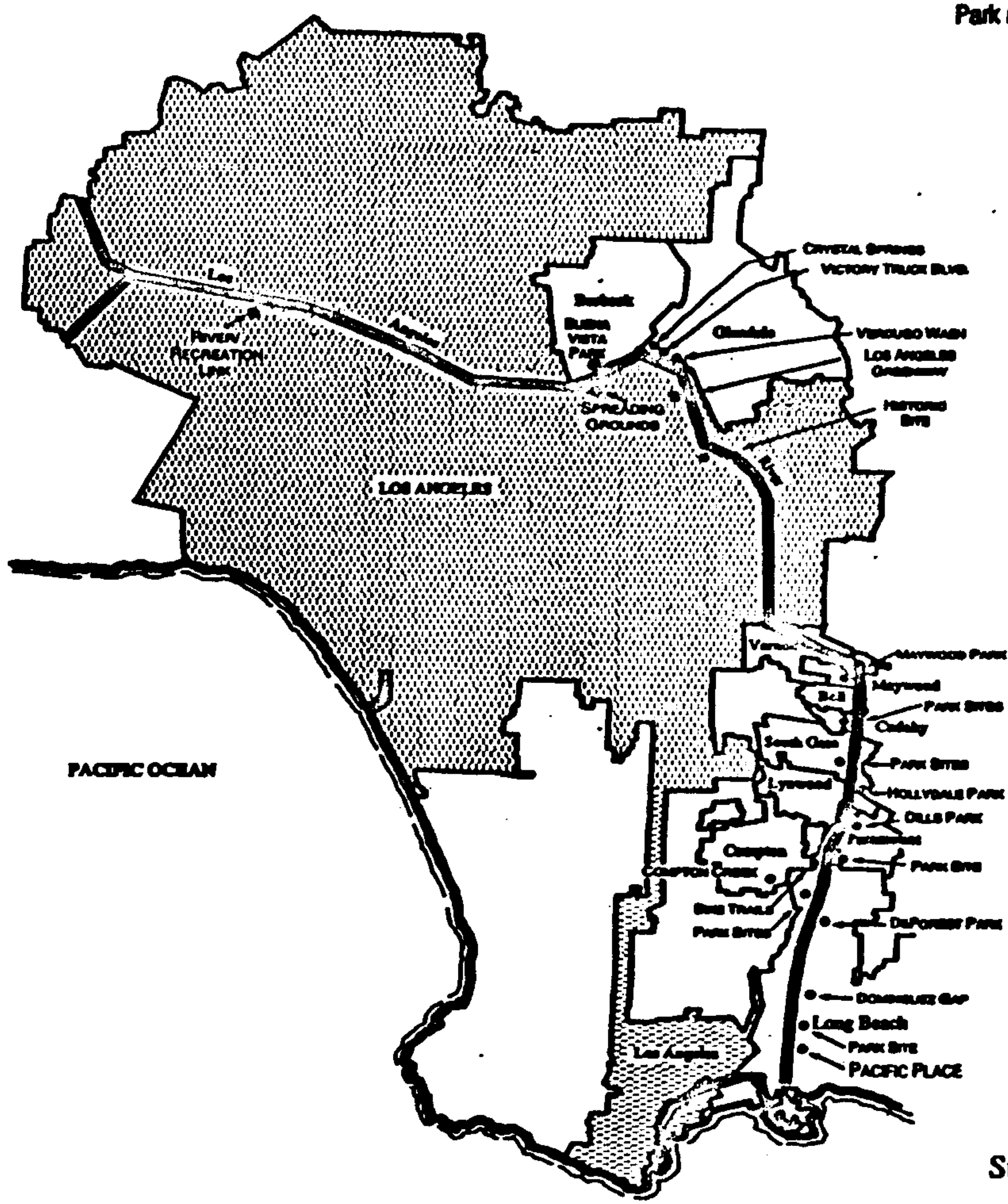

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Figure 6
Summary of Projects

VI. COMMUNITY PROJECT INVENTORY

Coastal Conservancy staff made site visits to most of the communities along the Los Angeles River, meeting with city and county officials in order to directly observe the state of existing park and recreation facilities and assess the potential for enhancement. These site visits were carried out in cooperation with staff from the Los Angeles County Department of Public Works.

The results of the Conservancy's observations are summarized below. An effort has been made to include examples of effective uses of the river corridor as well as to point out areas in need of improvement.

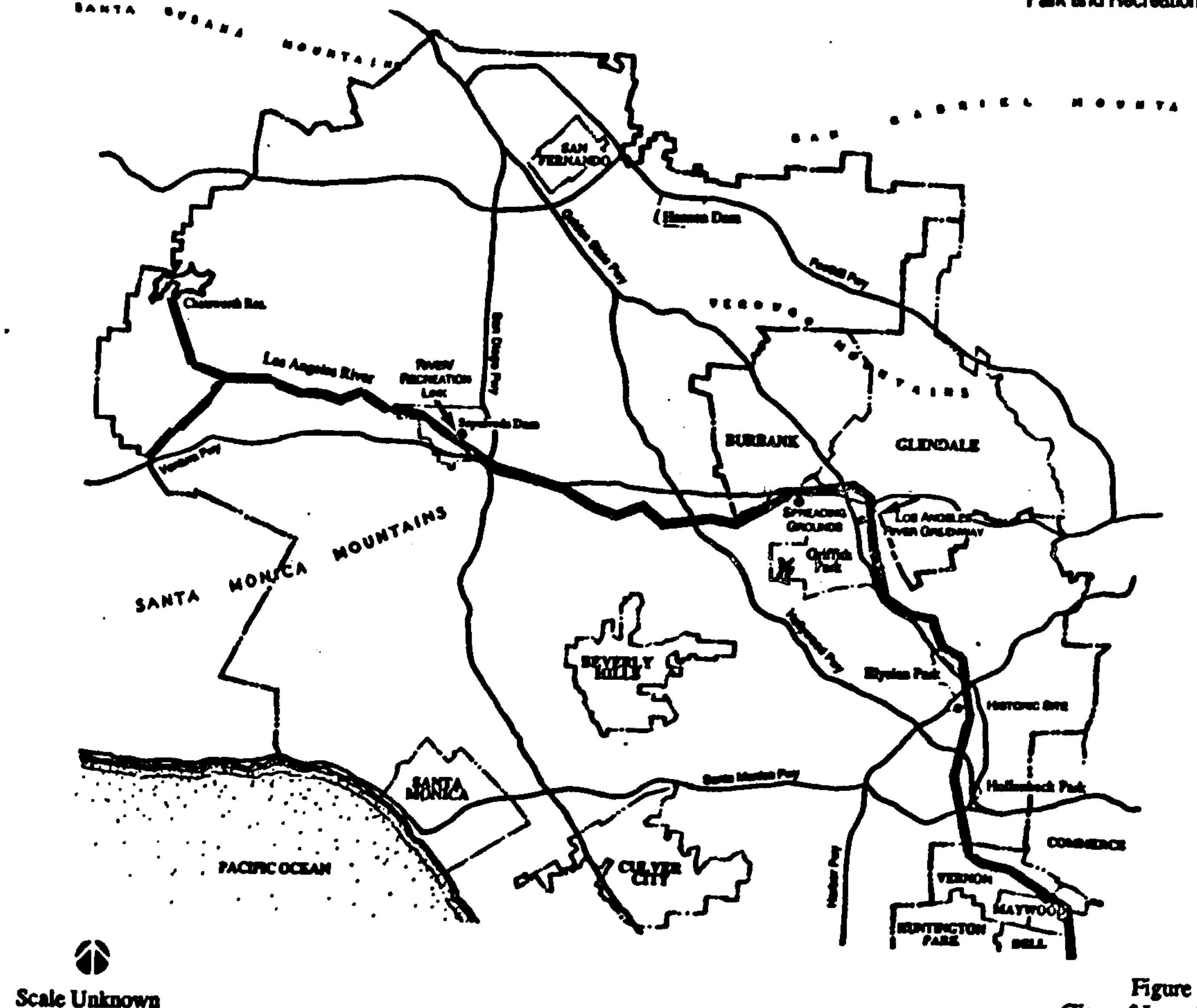

Figure 7
City of Los Angeles

LOS ANGELES

Community Profile
Area: 468.7 square miles *Population: 3,422,600*
Los Angeles is the largest city on the West Coast and the second largest city in the nation. It is the home of numerous cultural institutions, including two major universities, several art museums, and an internationally acclaimed symphony.

Los Angeles is perhaps best known as the capital of the country's multi-billion dollar motion picture industry, but the economy is in fact quite diversified, providing over 1 million jobs in 1990, primarily in the manufacturing and service industries. Both per capita income and household income in Los Angeles are slightly higher than statewide averages.

The strong economy of the Los Angeles region has attracted newcomers from all over the world, and the city of Los Angeles hosts a population of remarkable ethnic diversity. This diversity contributes greatly to the richness of Los Angeles' cultural mix.

The ethnic composition has changed somewhat in recent years, with Hispanic and Asian-American populations increasing most rapidly. African-Americans, who are leaving central and south-central Los Angeles, are gradually being replaced by a recent wave of immigrants from southeast Asia, Mexico, and Central America

Los Angeles has not escaped the problems typical of all large cities, however. As of 1989, nearly 19% of Los Angeles residents, primarily people of color, live below the poverty line. The city of Los Angeles, as well as most of the smaller surrounding cities, is plagued with gang activity, drug trade, and violent crime. Like most cities, Los Angeles has too few resources to devote to the social problems that result from poverty.

Los Angeles has 8,593 total acres of park space, more per capita acreage than many other cities along the river. The major open space areas within the city are Griffith and Elysian parks, and the Sepulveda Basin and Hansen Dam recreation areas. These parks are heavily used, attracting over 30 million visitors per year from throughout the region.

River Profile
With the exception of the stretches through Griffith Park and Sepulveda Basin, the banks of the Los Angeles River as it flows through the city of Los Angeles are entirely developed. This development is composed of a variety of land uses, ranging from dense, low-income housing, to industrial, municipal, and commercial. Much of the river is inaccessible to the public in Los Angeles. The main public open spaces within the city limits are the Sepulveda Basin and Hansen Dam recreational areas, Griffith Park, and Elysian Park, with a combined area of 8,292 acres.

<u>Sepulveda Basin Recreation Area</u>
Sepulveda Basin is a 2,150-acre flood control reservoir located in the San Fernando Valley. It serves as a good example of how flood control uses can be combined with recreation. Designed primarily as a basin to collect and hold

storm water runoff, the basin is dry outside of flood conditions and contains land in natural or semi-natural conditions suitable for wildlife habitat and low-intensity recreational uses. The entire basin is owned by the Corps of Engineers and the majority of the developable land is leased to the city of Los Angeles Department of Recreation and Parks. The city has developed the basin into a multi-use recreational area that includes three public golf courses, various baseball fields, a sports center, a landscaped park, cricket fields, picnic areas, a recreational lake, a bike path and several hiking and jogging trails. The river is used by park visitors in the Sepulveda Basin, and the city of Los Angeles has recently attempted to obtain permits from the county and the Corps to operate a recreational canoeing program on the river.

Griffith Park

Griffith Park is a 4,217-acre park located at the border of Los Angeles and Burbank. It is the largest park in the city of Los Angeles. Griffith Park is one of the three locations where the Los Angeles River seems most like a natural river. The high water table made it impossible to pave the channel bottom in this area and so the river through Griffith Park remains soft-bottomed and supports a riparian ecosystem. The river is flanked by stands of willows, sycamores, and cottonwoods, and bird and animal life abounds in and around it. The river is spring-fed in this area and so contains water year-round. The trails and paths along the river in this area, both formal and informal, are heavily used by the public for hiking, horseback riding, and bird watching. The Juan Bautista de Anza National Historic Trail, which is currently in the planning stage, will cross the river in Griffith Park. (It is thought that de Anza's 1775-76 expedition camped along the river in what is now Griffith Park.) The river corridor through Griffith Park provides city residents with a tremendous recreational amenity, while continuing to function as a flood control channel during winter storms.

Griffith Park can serve as an example of the benefit of incorporating green areas into the urban landscape. The water and plant life serves to lower temperatures and improve air quality considerably. In addition, although it is surrounded by dense development, Griffith Park provides an atmosphere of natural serenity that can provide a much-needed antidote to the rigors of urban life. In a city as densely populated as Los Angeles, more of these oases are sorely needed.

Potential Projects

Much of the industrial corridor along the river in Los Angeles is in economic transition. The largest landowners on the river, the three large transcontinental railroad companies, are selling off rights-of-way and old terminal and equipment yard facilities. Many of these facilities are being acquired by the Metropolitan Transit Authority, or MTA, (formerly the Los Angeles County Transportation Commission, or LACTC) for incorporation into the new county-wide public transit system. In addition to railroad land, many of the large industrial tracts near downtown are obsolete and are in demand for conversion to commercial and residential uses. The coming years may represent a unique historic opportunity to incorporate the river as an environmental and recreational resource into a changing downtown. Careful, proactive planning on the part of city and regional decision makers will be required. The river could be enhanced to provide the recreation facilities and green space so desperately needed within the city.

A good start has been made toward a comprehensive planning effort for the river corridor by Mayor Tom Bradley's Los Angeles River Task Force. In January 1992, this group of planners, city and county officials, administrators, and design professionals released a report that developed a set of goals for enhancing the river corridor and proposed three demonstration projects that would incorporate the stated goals. The demonstration projects are: the development of a river/recreation link in the Sepulveda Basin; the creation of a greenbelt along a segment of proposed bike path near Griffith Park; and the development of an historical site interpretive center and native plant garden in the downtown area. The mayor's staff is currently pursuing funding to implement the model projects.

The city of Los Angeles is also currently developing Phase I of the new Los Angeles River Bikeway, a Class I bikeway that will run along the west bank of the river from Elysian Park to Strathern Park in the San Fernando Valley. Phase I of the project consists of the first 7.3 miles, beginning at the confluence of the Arroyo Seco and the Los Angeles River and ending at the intersection of Riverside and Zoo drives in Griffith Park. This section of the bikeway is expected to be completed in 1995.

The development of a bikeway along the Los Angeles River is also proposed in the Army Corps of Engineers' Environmental Restoration/Recreation Reconnaissance Study. The Corps' bike path proposal includes plans for a 19.2-mile Class I bicycle path running from the confluence of the Los Angeles River and the Arroyo Seco near downtown, to the Sepulveda Dam Recreation Area. The trail would run along the west bank of the river (becoming the south bank where the river bends to run east-west) from the Arroyo Seco, crossing over the river at Hazeltine Avenue at the Ventura Freeway, and from there would continue on the north bank of the river to the Sepulveda Dam Recreation Area. The Corps proposes the development of a parallel bike trail on the north bank of the river between Fulton Avenue and Colfax Avenue in the San Fernando Valley. The Corps' proposal also includes plans for open space amenities such as small parks along the bike path and a golf course on the north bank in the San Fernando Valley. The bikeway proposal, though approved, has not been recommended for further study. Implementation of the project is, therefore, uncertain.

Another proposal included in the Army Corps of Engineers' Environmental Restoration/Recreation Reconnaissance Study is the construction of a spreading grounds for groundwater recharge on a 48-acre parcel (owned by the Los Angeles City Department of Water and Power) on the south bank of the river in Griffith Park. This proposal includes plans for the construction of an artificial streambed that would run along the perimeter of the spreading grounds and would be flanked on both sides by riparian vegetation. The center of the spreading grounds would remain bare or would be paved with a permeable material that would allow water percolation but prevent the growth of volunteer plants. The existing equestrian staging area adjacent to the 48-acre site could also be used as a spreading grounds with the existing equestrian trail running along the perimeter. Lawns and rest areas could be placed adjacent to the spreading grounds along the existing trails.

Some additional proposals for the river area downtown may grow out of the Downtown Strategic Plan, currently under development by the Los Angeles Community Redevelopment Agency. The draft Downtown Strategic Plan contains a major open space element that recognizes the opportunity to create additional park space on the east side the river.

One very ambitious scenario proposes that the entire area from the river east to Hollenbeck Park, between the 1st Street Bridge and the Olympic Boulevard Bridge, be developed into one large park. Smaller-scale scenarios include proposals for a 100-foot-wide river-front esplanade linking a series of smaller parks. All of the proposals include the assumption that a river-front park should also function as a flood detention basin during the rainy season. The river area is not currently included in the downtown redevelopment district, however, and so such plans are still only conceptual.

A new redevelopment district may soon be forming to include much of the area east of the Los Angeles River. Steps should be taken to include the river in either this new redevelopment district or in the downtown redevelopment district for the express purpose of formulating a comprehensive open space plan for the area near the river.

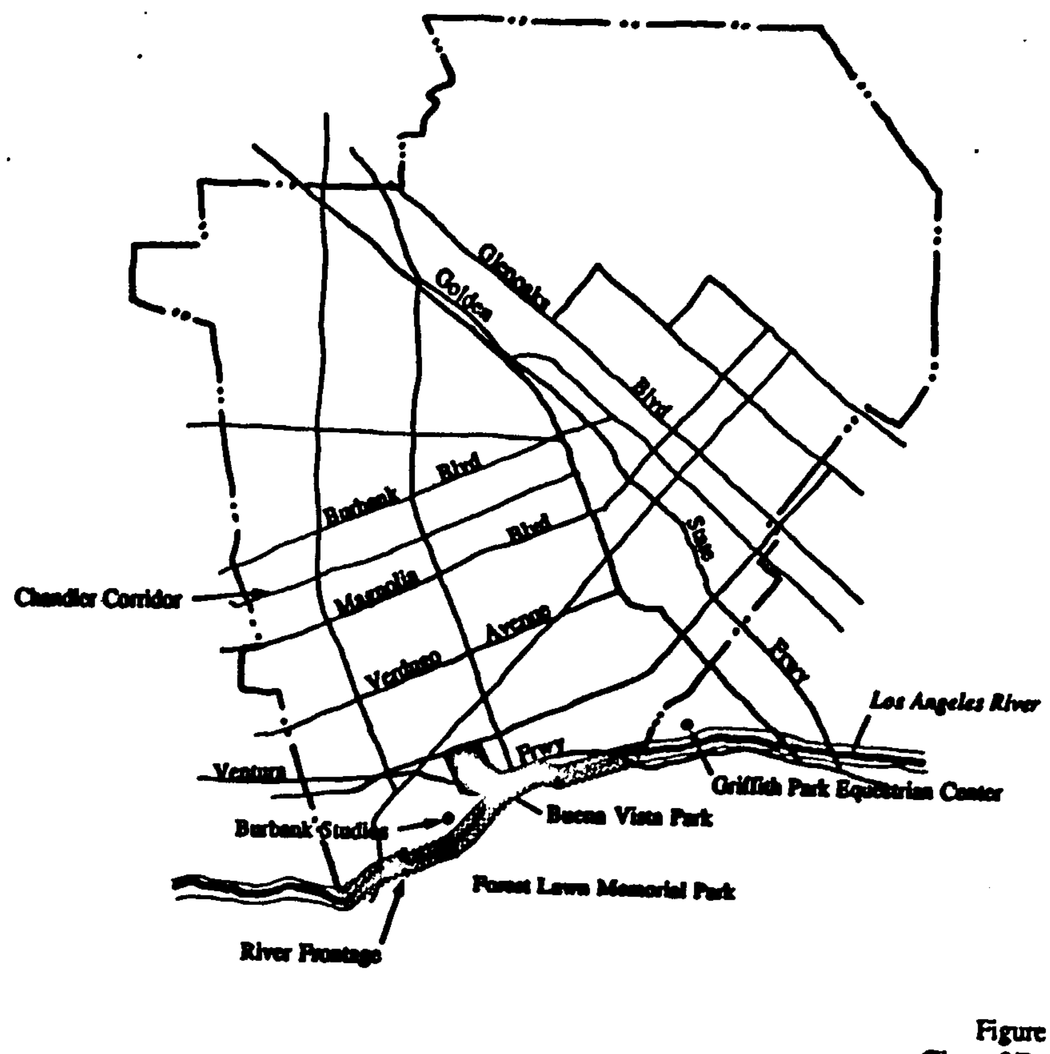

Figure 8
City of Burbank

BURBANK

Community Profile

Area: 17 square miles *Population: 93,643*

Burbank is the fourth-largest city in the study area. Its population is primarily non-Hispanic white, with Hispanics comprising the second-largest ethnic group.

Burbank was incorporated in 1917 and by the mid-1920s had become a center for the burgeoning motion picture and aviation industries; a trend that exists to this day. Warner Brothers and Walt Disney studios and the Lockheed Corporation are still among the city's ten largest employers. Burbank is economically healthier than many other cities in the Los Angeles area. As of 1992, Burbank's unemployment rate was 5.9%, substantially lower than state and county-wide averages. With an almost 1:1 ratio of employment to population, Burbank has been classified by the federal government as a job-rich "Central City."

The city is actively undertaking the revitalization of its downtown business district through the planned development of several projects, including a sports arena, a new retail center, a new branch of the Los Angeles County Natural History Museum, and a transit center to accommodate the county public transit system that is currently under construction. City officials are interested in encouraging non-motorized transportation as a part of redevelopment plans through the development of bicycle trails that would connect with transportation nodes. The river corridor in Burbank could undoubtedly play a role in the development of such facilities.

The city of Burbank contains 830.7 acres of parks and open space, including the 113-acre DeBell Golf Course. The largest parks in Burbank are Stough Park, Wildwood Canyon Park, and Brace Canyon Park. Stough Park and Wildwood Canyon Park are largely undeveloped open space.

River Profile

Burbank contains approximately two miles of river frontage. Through Burbank, the Los Angeles River is contained in a below-grade concrete channel. The river approximately delineates the boundary between the city of Burbank (on the north) and the city of Los Angeles (on the south). Through Burbank, land use on the north bank of the river is residential (upper middle class homes on 1/3- to 1/2- acre lots), with fenced and landscaped back yards facing the river. Many of these homes are zoned to allow horse ownership, and a dirt equestrian trail, beginning at the Griffith Park Equestrian Center, continues through Burbank past these homes, ending at the Burbank Studios. Across the river from Burbank lies Forest Lawn Memorial Park, and an undeveloped portion of the Hollywood Hills. Because of the open space on the south bank and the landscaped back yards facing onto the north bank, this portion of the river is lined on both sides with trees that produce a pleasant and inviting atmosphere for the equestrian trail. It is a good example of the dramatic improvement that can be made simply by landscaping the river banks. Trees growing alongside the channel can make a great deal of difference in the appearance and overall feeling without altering the actual channel at all.

Buena Vista Park is the primary public open space near the river in Burbank. The park is centered around a tributary flood channel that flows into the Los Angeles River. The flood channel was formerly a typical concrete-lined culvert that was replaced with an artificial streambed that carries the creek's normal flows. The artificial stream has a winding, rocky bed similar in appearance to a natural streambed. The main channel meanders and has been embellished with rocks and plants. It is flanked by grassy terraces about four feet high on either side that have been landscaped and contain concrete benches and picnic tables. These terraces are about three feet lower than the rest of the park and carry high waters when the main channel overflows. The terraces are bounded by artificial rock ledges, which act as the walls of the high-flow channel. The artificial streambed is a vast improvement aesthetically over the old concrete culvert and is a major attraction of Buena Vista Park. The project won a design award from the American Society of Landscape Architects for park and recreational planning. The park is very well used; it is adjacent to three major television studios and a large medical center, and close to a residential area.

Potential Projects

Buena Vista Park continues across Riverside Drive down to the river where it connects with the equestrian trail that runs along the top of the Los Angeles River channel. This equestrian trail is at present the only recreational facility actually located on the river in Burbank. City officials have expressed interest in expanding uses of its river frontage for bicyclists and pedestrians, and in expanding Buena Vista Park to the east to connect with Griffith Park. This expansion is proposed for some land adjacent to the river that is owned by the city of Los Angeles but is physically accessible only from Burbank. Such an expansion would create a continuous greenbelt from Griffith Park to Buena Vista Park that could be incorporated into the existing river trail system.

Burbank contains two flood hazard areas and control of flood waters is a high priority for the city, but the development of bikeways and pedestrian paths is also a high priority. Burbank will soon begin developing a comprehensive bikeway plan for the entire city that will include plans for a river bikeway. An off-street bikeway along Interstate 5 has already been developed and the mayor is expected to appoint a task force to develop the bikeway plan. One of the main objectives is to create a link with bike trails from other cities and to actually make it feasible to commute by bicycle.

One area under discussion is the Chandler Corridor, an old Southern Pacific railroad line that is now owned jointly by the Metropolitan Transit Authority (MTA) and the city of Burbank. Plans for this corridor include a light rail mass transit line and a bicycle trail that will connect with the Multi-Modal Transit Center (for the Red Line) planned for downtown Burbank. The city has already purchased land for the transit center from Southern Pacific Railroad.

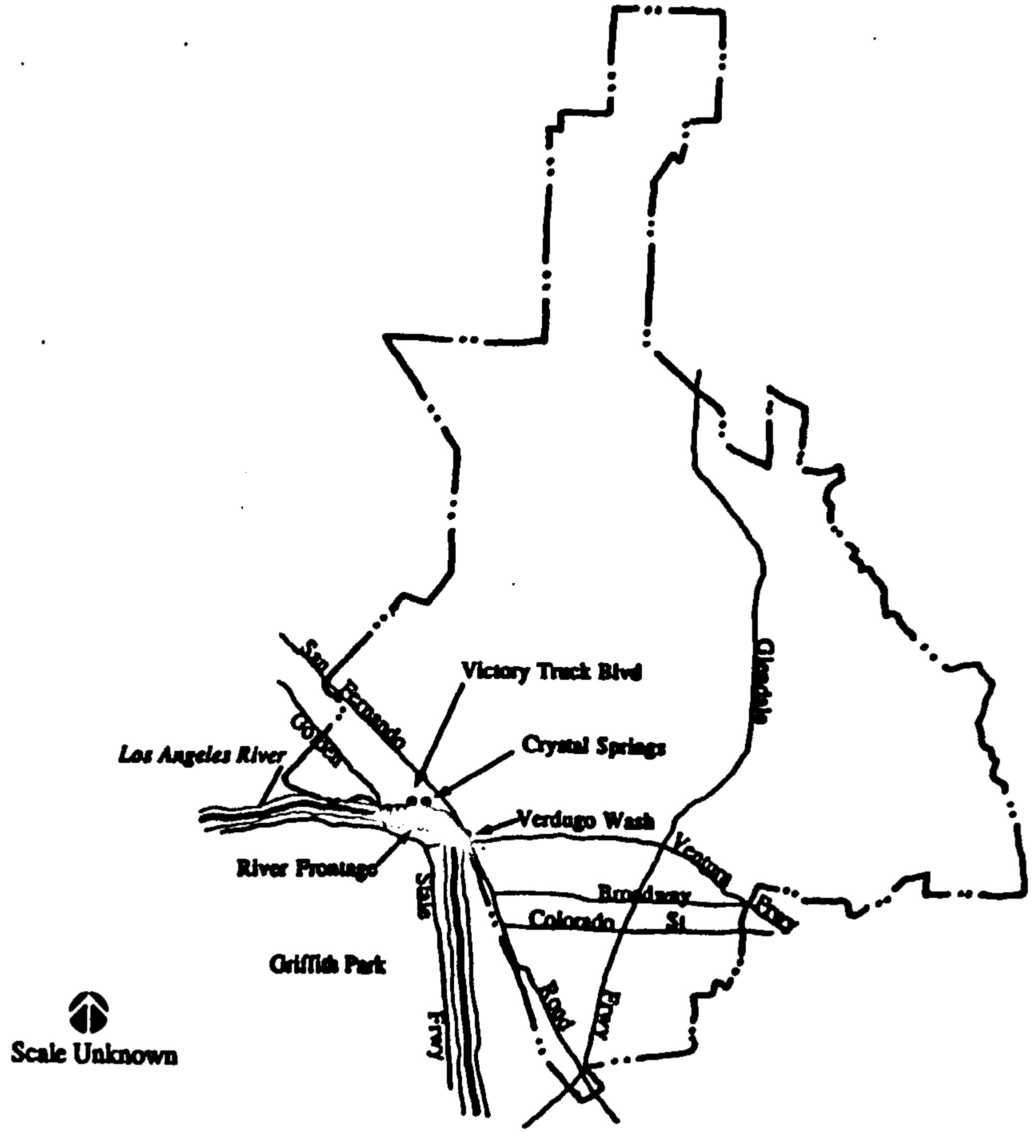

Figure 9
City of Glendale

GLENDALE

Community Profile

Area: 30.48 square miles *Population: 185,000*

Glendale is the third-largest city in Los Angeles County after Los Angeles and Long Beach. The city has experienced significant population growth in the last ten years. The 1990 Census found that the population of Glendale increased by 29.5% between 1980 and 1990. Glendale's annual growth rate had been declining since the 1960s to a low of 0.5% between 1970 and 1980. A building boom in the 1980s, however, reversed the trend and resulted in a growth rate of 2.6%, which was higher even than the 2.2% rate between 1950 and 1960.

Glendale's population is predominantly non-Hispanic white (64%) and 68% of the population is older than 25. The city has the highest average household income ($44,936) of any of the Los Angeles River cities. Retail trade, finance, insurance, and real estate are the city's major employers.

Along with population growth has come a large demand for recreational and open space facilities. Existing parks and athletic fields are always in use. There is an especially great need for parks on the west side of the city.

The city has formed a redevelopment agency for the San Fernando Road corridor adjacent to the river. The redevelopment agency is interested in public improvements along the river and has proposed that $1.5 million be allocated for planning such improvements.

The Juan Bautista de Anza National Historic Trail, presently in the planning stage, will cross Glendale in the vicinity of the Los Angeles River.

River Profile

The portion of the Los Angeles River within the city of Glendale is approximately one mile long and includes the area where the river curves south heading toward the sea. The river area is a mix of residential, office park, and industrial uses. There is some vacant land immediately adjacent to the river, eight acres owned by the city of Los Angeles, identified as Crystal Springs, and four acres of land owned by the city of Glendale along Victory Truck Boulevard. Griffith Park is located across the river from Glendale.

The river channel in Glendale is part of one of the three unpaved sections of the Los Angeles River. The river channel has near vertical concrete walls and a cobblestone bottom. A significant amount of mixed native riparian and exotic vegetation has grown in the channel on the Griffith Park side of the river. The Glendale Narrows area provides habitat for a number of different bird species, including pied-billed grebe, cinnamon teal, black phoebe, and red-winged blackbirds.

The mouth of the Verdugo Wash, near where the 134 Freeway crosses the river, has a soft-bottomed channel. The wash supports a dense growth of mixed native riparian and exotic vegetation, including willows. The area may now be functioning as riparian habitat for several plant and animal species.

Potential Projects

Crystal Springs: This is an eight-acre site along the river owned by the city of Los Angeles and managed by the Department of Water and Power. It is currently vacant and used for monitoring well sites and storage of materials.

The city of Glendale is interested in developing the site (in conjunction with a parcel of land owned by Glendale along Victory Truck Boulevard) with athletic fields. The park could have a bike trail and bridge across the river to Griffith Park.

The city has also considered establishing an environmental education program, possibly including an interpretive center, at this site as part of the proposed park. Interpretation of the river at this site would make sense as the Glendale Narrows section is one of the three remaining soft-bottomed sections of the river, contains a significant amount of vegetation in the channel, and supports high bird use.

The U.S. Army Corps of Engineers has prepared a draft environmental restoration/recreation reconnaissance study for the Los Angeles River (November 1992). The study identifies this site for potential restoration. The proposal calls for the creation of a two-acre seasonal wetland, plantings of riparian and wetland vegetation, and construction of a trail on one side of the wetland.

Victory Truck Boulevard: This four-acre parcel is owned by the city of Glendale. The property could be connected with Crystal Springs to be developed as a large active recreation park, including athletic fields and a bike trail, or it could be included in the Army Corps' proposed wetland restoration project.

Environmental education: The city is interested in the idea of developing an environmental education program for the Los Angeles River similar to one now being developed at the Governor Deukmejian Wilderness Park in the San Gabriel Mountains. An interpretive center could be established as part of the development of a river park at the Crystal Springs site. An environmental education program would likely focus on: the plant and animal habitats of the Glendale Narrows section of the river; Native American history of the area; the Juan Bautista de Anza expedition, etc.

Verdugo Wash: The habitat value of this channel should be assessed and recommendations made for its improvement for plants and animals.

Los Angeles River
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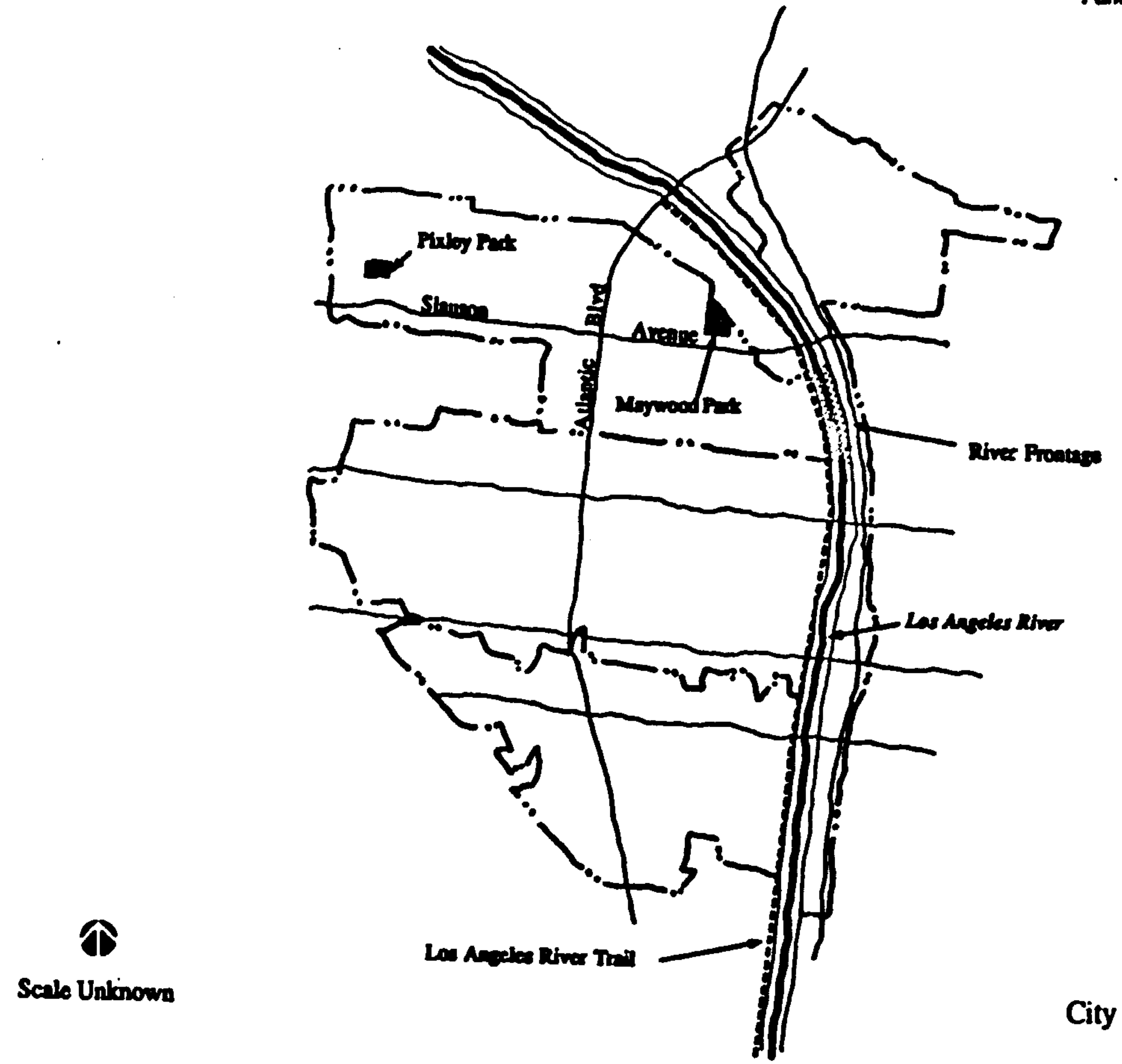

Figure 10
City of Maywood

MAYWOOD

Community Profile

Area: 1.41 square miles *Population: 28,552*

Maywood is a small residential community located southeast of Los Angeles. The city is primarily residential with two main commercial streets, Atlantic Boulevard and Slauson Avenue, and some light industry on the city's periphery. Maywood's population is predominantly Hispanic (93%) and the city's population density (23,900 persons/square mile) is the highest of any of the cities along the Los Angeles River. Manufacturing and retail trade are the largest employers in the city.

Maywood has two parks, Maywood Park (five acres) and Pixley Park (half acre). Existing recreation facilities are in heavy demand and the city needs to develop more, especially soccer fields and baseball fields.

River Profile

Maywood's river frontage extends for approximately one-half mile between Slauson Avenue and Randolph Street on the west bank of the river. The river in Maywood is characterized by steep rock-gunite banks and a concrete bottom. The Los Angeles River Trail runs along the top of the levee. Access to the trail is possible from Randolph Street and Slauson Avenue.

The land uses along the river consist of several light industrial activities in the first block immediately adjacent to the river channel and residential development behind the industrial area.

Potential Projects

There are no park, recreation or habitat improvements possible along the river channel in Maywood at this time. The river bank and levee are completely paved. The area adjacent to the river is zoned industrial and consists of a paved street and a developed industrial strip.

The city would like to make some improvements to Maywood Park, located three blocks from the river channel. This heavily used park is in need of new landscaping and walkways.

The city would also like to develop some new soccer fields to address the increasing demand on the limited existing facilities. These new facilities would likely not be constructed near the river.

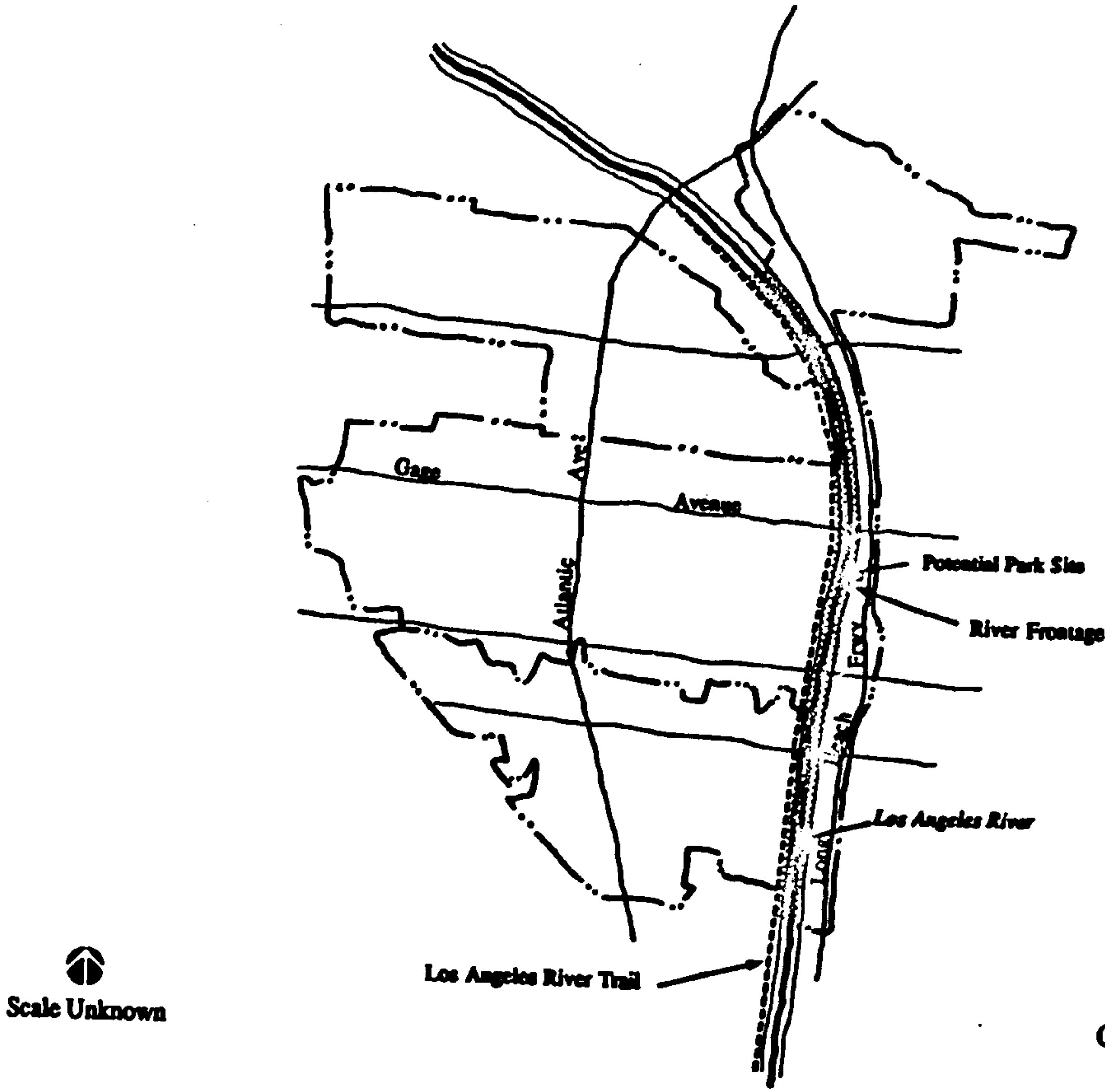

Figure 11
City of Bell

BELL

Community Profile

Area: 2.81 square miles *Population: 34,365*

The population of Bell is predominantly Hispanic (86%) with an average household size of 3.8 and an average household income of $31,569. Bell is a densely developed city but has very little park space. There are only five parks within the city limits, all less than three acres in size. With less than 12 acres of total park space and more than one-third of its population below the age of 18, the demand for parks and recreation facilities in Bell clearly exceeds demand.

River Description

The city of Bell straddles the river over a distance of approximately three miles. As it runs through Bell, the river is contained within levees that stand approximately ten feet above street level. The city's entire residential area and most of its commercial development is west of the river. This portion of Bell is entirely developed with no vacant land whatsoever. Residential development extends all the way to the county right-of-way at the edge of the levee. The area adjacent to the river contains some of Bell's lowest-cost housing. The Los Angeles River Trail runs along the top of the west levee through Bell.

The portion of the city lying east of the river is also very densely developed, almost entirely with industrial uses, but does contain the few undeveloped parcels remaining in Bell. Ownership of the vacant parcels is not certain, as this land lies between the Long Beach Freeway and the river's edge.

Potential Projects

Parks and recreational facilities are sorely lacking in Bell and the development of additional recreational facilities is a high priority for the city. Unfortunately, Bell has very little money available for the acquisition and development of additional park space. City Parks and Recreation staff are currently pursuing funding options for parks development.

Bell's redevelopment district includes some river frontage on the east side of the river, and the creation of additional park space on any vacant land near the river could be included in any redevelopment proposals. In addition, some of the large industrial tracts immediately adjacent to the river, west of the Long Beach Freeway, could potentially be converted to park use. Such a park should be made accessible to users of the Los Angeles River Trail by providing crossover points at Florence or Gage Street. It should include landscaping with native and/or drought-tolerant species, restrooms, drinking fountains, benches, and shaded areas. The adjacent city of Bell Gardens is currently preparing a parks master plan. It may be advantageous for both cities to establish a park on river-front property in Bell and adjacent to Bell Gardens to be administered jointly by the two cities.

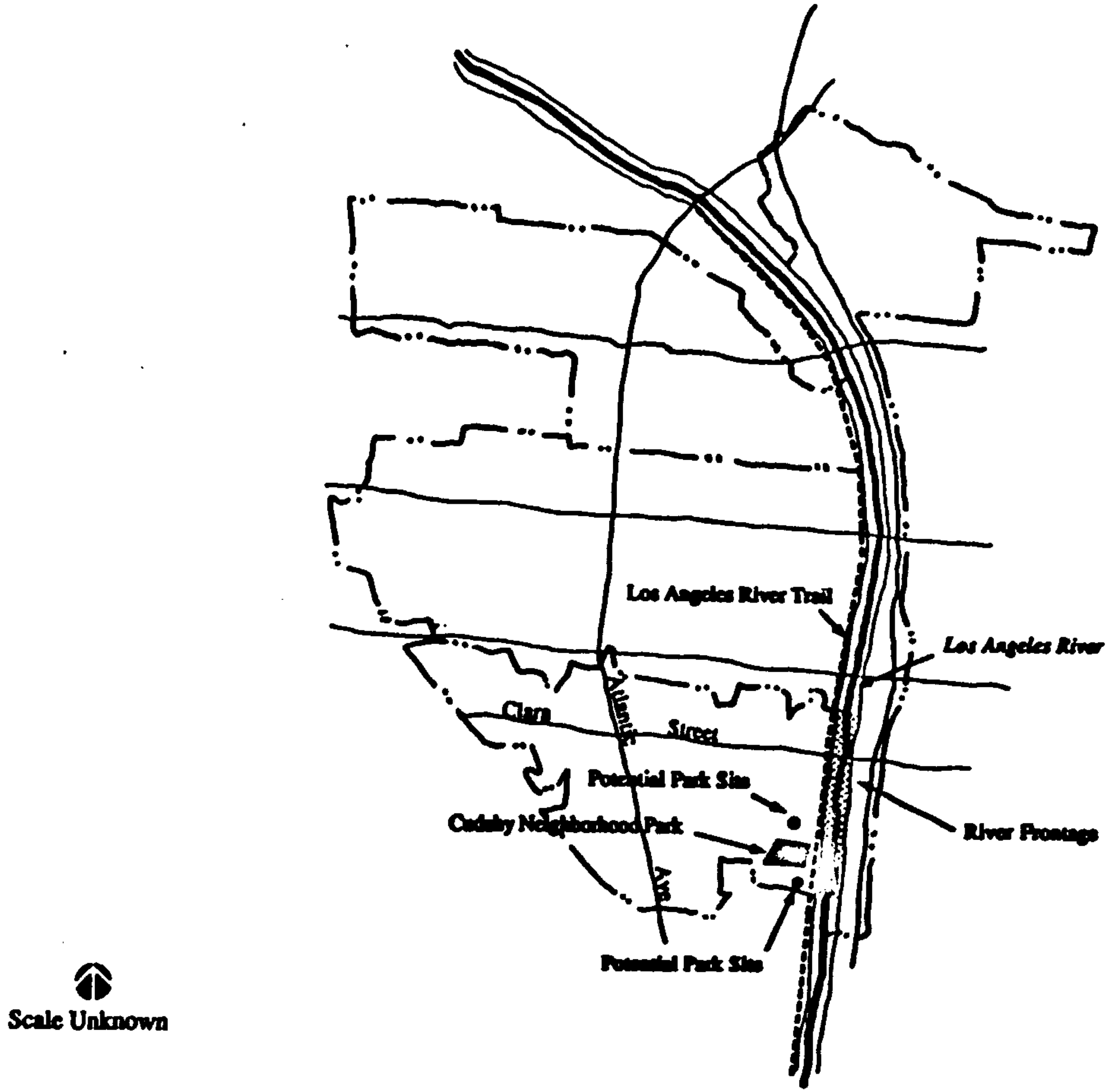

Figure 12
City of Cudahy

CUDAHY

Community Profile

Area: 1.07 square miles *Population: 20,400*

Cudahy is a small city with one of the lowest per capita incomes in the state. Its population is predominantly Hispanic (88%) and extremely young: over 38% of the population is under the age of 18. Average household size is 4.3 persons and the average household income is $30,336. Cudahy has one of the highest population densities in Los Angeles County. The city has approximately 5,416 housing units, and another 200 are expected to be constructed by 1995. Once these units are built, the city will be very near its projected maximum housing build-out level. The current population density and the expected near-term growth point to the need for additional park space and supervised recreation programs.

Besides the Cudahy Neighborhood Park, there are only two other, much smaller, parks in Cudahy for a total of 19 acres of park area. The city's particularly low median age imposes a great demand on municipal recreation programs; participation in youth recreation programs has more than doubled in the last three years. Currently, more than 1,000 youngsters are enrolled in the city's recreation programs. The need for playing fields and ballparks is particularly great, but more space is also needed to provide passive recreation opportunities for senior citizens, and picnic facilities and play areas for young families.

River Profile

The Los Angeles River is contained behind levees approximately 15 feet above grade as it runs through Cudahy for approximately one mile. The land adjacent to the river in Cudahy is a high-density, low-income residential area developed in the 1950s. The 13-acre Cudahy Neighborhood Park and Civic Center, as well as the public elementary school, are located next to the river. Development extends all the way up to the county right-of-way at the foot of the levee. The area below the levees is extremely low ground that floods routinely during even minor storms. The Los Angeles River Trail runs along the west levee.

Potential Projects

The demand for recreational facilities in Cudahy is very high and the existing facilities are inadequate to meet this demand. City staff have identified two vacant parcels near the river as suitable for these uses: a small one-acre parcel at Park and Elizabeth streets, and a large 40-acre parcel at Fostoria Street and River Road. Both of these sites are in close proximity to the river and to Cudahy Neighborhood Park. The overriding recreational need in Cudahy is for playing fields of all kinds, baseball and/or softball parks in particular. Were these parcels to be acquired by the city, their primary use would undoubtedly be as playing fields given the high demand, but these parcels could also serve as staging areas for the Los Angeles River Trail. Restrooms, drinking fountains, benches, and bike racks should be provided, as well as a striped and signed bicycle route over city streets connecting both of these areas with Cudahy Neighborhood Park and with the Los Angeles River Trail. The city of Cudahy lacks the funds to acquire or develop additional park space, but city staff are working with state and local agencies to identify funding sources for the acquisition of these parcels.

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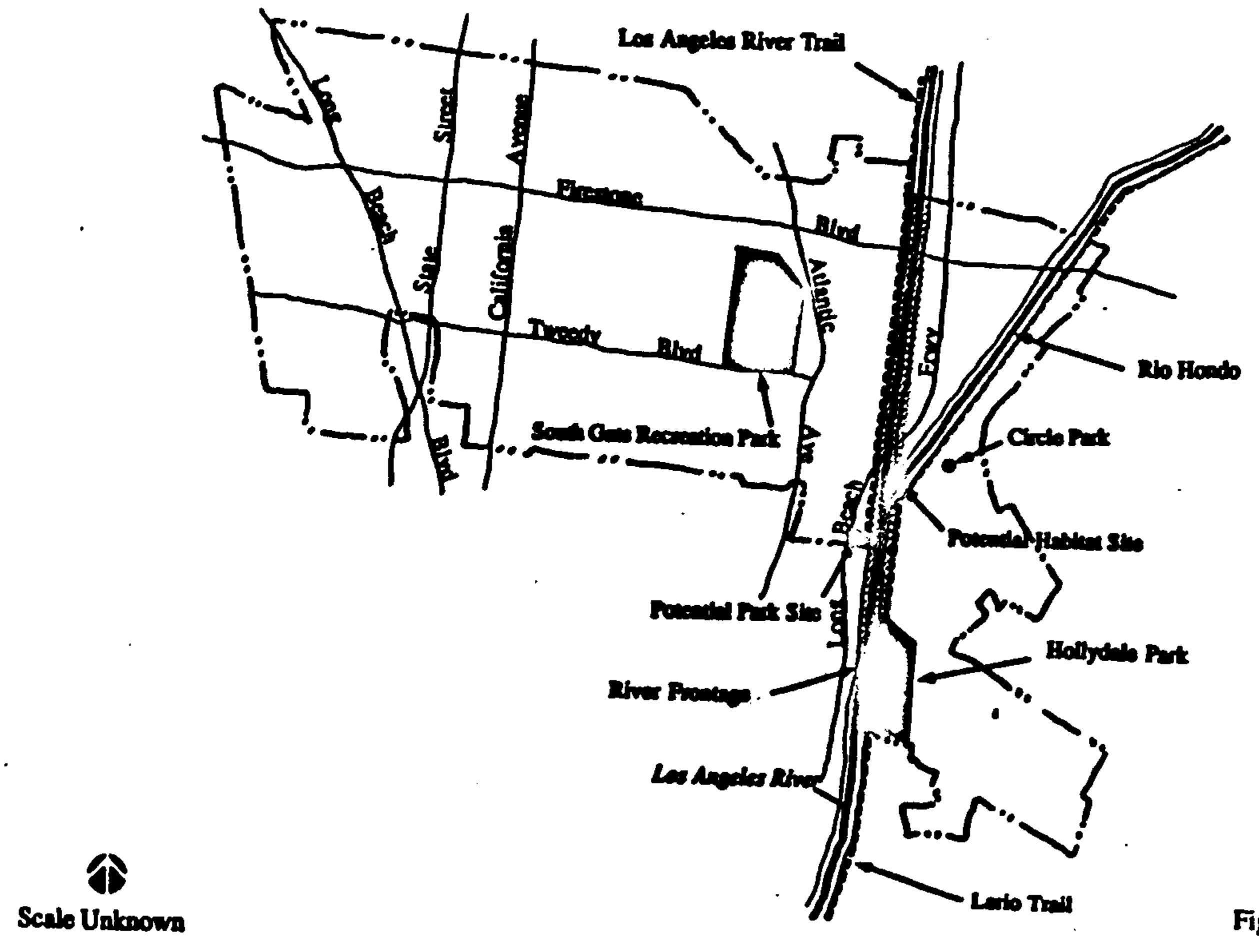

Figure 13
City of South Gate

SOUTH GATE

Community Profile

Area: 7.32 square miles *Population: 86,284*

South Gate is a small industrial city located ten miles south of downtown Los Angeles. The city has a young (68% under age 35) and predominantly Hispanic population (83%).

Manufacturing and retail trade are the largest employment sectors in the city. In recent years, however, several of the large industrial employers have closed their plants in South Gate. Many of these plant closings have occurred in the industrial area along the Los Angeles River. The city has created a redevelopment agency to address redevelopment of much of the area adjacent to the river.

The city has eight park facilities, ranging from 97-acre South Gate Recreation Park and 56-acre Hollydale Park on the east side of the city to three small playgrounds on the west side. Hollydale Park is the only park located adjacent to the Los Angeles River.

The city's major need is for park/open space on its west side. Its major park and recreation facilities are all located on the east side of the city. Hollydale Park, the city's second-largest park, is isolated from most of the city by virtue of its location on the east side of the Los Angeles River. Residents of the west side of the city are poorly served by the existing facilities.

River Profile

South Gate has an approximately 2.5-mile stretch of the Los Angeles River within its city limits and occupies both banks of the river for much of that stretch. The Rio Hondo meets the Los Angeles River in South Gate. The river in South Gate is characterized by steep rock-gunite banks and a concrete bottom. The Lario Trail follows the east bank of the river until it reaches the mouth of the Rio Hondo, from which point it travels along the Rio Hondo. The paved trail is paralleled by an equestrian trail. The Los Angeles River Trail runs along the levee on the west bank of the river north from Imperial Highway.

The river is lined by a mixture of industrial and residential land uses. Much of the industrial area is now derelict. The city has one large park located adjacent to the river, Hollydale Park. The city's major park, 97-acre South Gate Recreation Park is located approximately one-half mile west of the river. Circle Park, a four-acre neighborhood park, adjoins the Rio Hondo north of the confluence of the Rio Hondo and Los Angeles River.

Hollydale Park has a playground, basketball, volleyball, handball and tennis courts, several athletic fields, and an equestrian center. The park is located on the east bank of the river in the Hollydale neighborhood, which is isolated by its location on the opposite bank of the river, south of the rest of the city.

A narrow strip of undeveloped county right-of-way lies along the residential areas adjoining the river. A large undeveloped property lies along the west bank of the river immediately north of Imperial Highway. A triangular parcel at the confluence of the Los Angeles River and the Rio Hondo is also undeveloped.

Potential Projects

South Gate is in great need of active and passive parks and open space. The city needs new athletic fields, playgrounds, community recreation rooms, and picnic areas. Although the need for new facilities is on the west side of the city, vacant land along the Los Angeles River developed as a park or recreational facility would still benefit the community.

The possibility of developing the vacant rights-of-way and easements described above should be pursued. Narrow, vacant stretches of right-of-way on both sides of the river should be landscaped, preferably with native and/or drought tolerant species.

The triangular parcel at the confluence of the Los Angeles River and the Rio Hondo is not easily accessible as it is surrounded by water on two sides and the Long Beach (710) Freeway and the Union Pacific Railroad tracks block access from the north. The isolation of this parcel, though not conducive to a park site, would be beneficial for habitat. The introduction of shallow ponds and riparian vegetation may attract birds to this relatively isolated and, therefore, relatively "safe" site.

The large vacant parcel on the west bank of the river north of Imperial Highway between the Long Beach Freeway and the river is a continuation of a vacant parcel south of Imperial Highway in Lynwood. The parcel is accessible from the Imperial Highway; the Los Angeles River Bike Trail begins adjacent to the parcel at Imperial Highway. Use of the site could be addressed in a number of ways: landscaping with native and/or drought tolerant trees and shrubs, development of a passive park or staging area for the Los Angeles River Trail, or development of a small-scale recreational facility.

The park or staging area should be landscaped and provide some or all of the following: parking, bike racks/lockers, restrooms, water fountains, benches, and trash receptacles. The staging area could serve both the Los Angeles River Trail and the Lario Trail on the east bank of the river.

Development of a recreational facility, i.e., playground or athletic field, could be problematic at this site due to the small size of the parcel in relation to the amount of space needed for a soccer field, parking lot, restrooms, etc. In addition, access to and from the site from Imperial Highway would be more of an issue for a facility such as a soccer field, which would likely attract more car traffic than would a small passive park or staging area.

The city would like to make several improvements to Hollydale Park, including new tennis courts, new fencing for the equestrian center, and upgrading of the existing playground.

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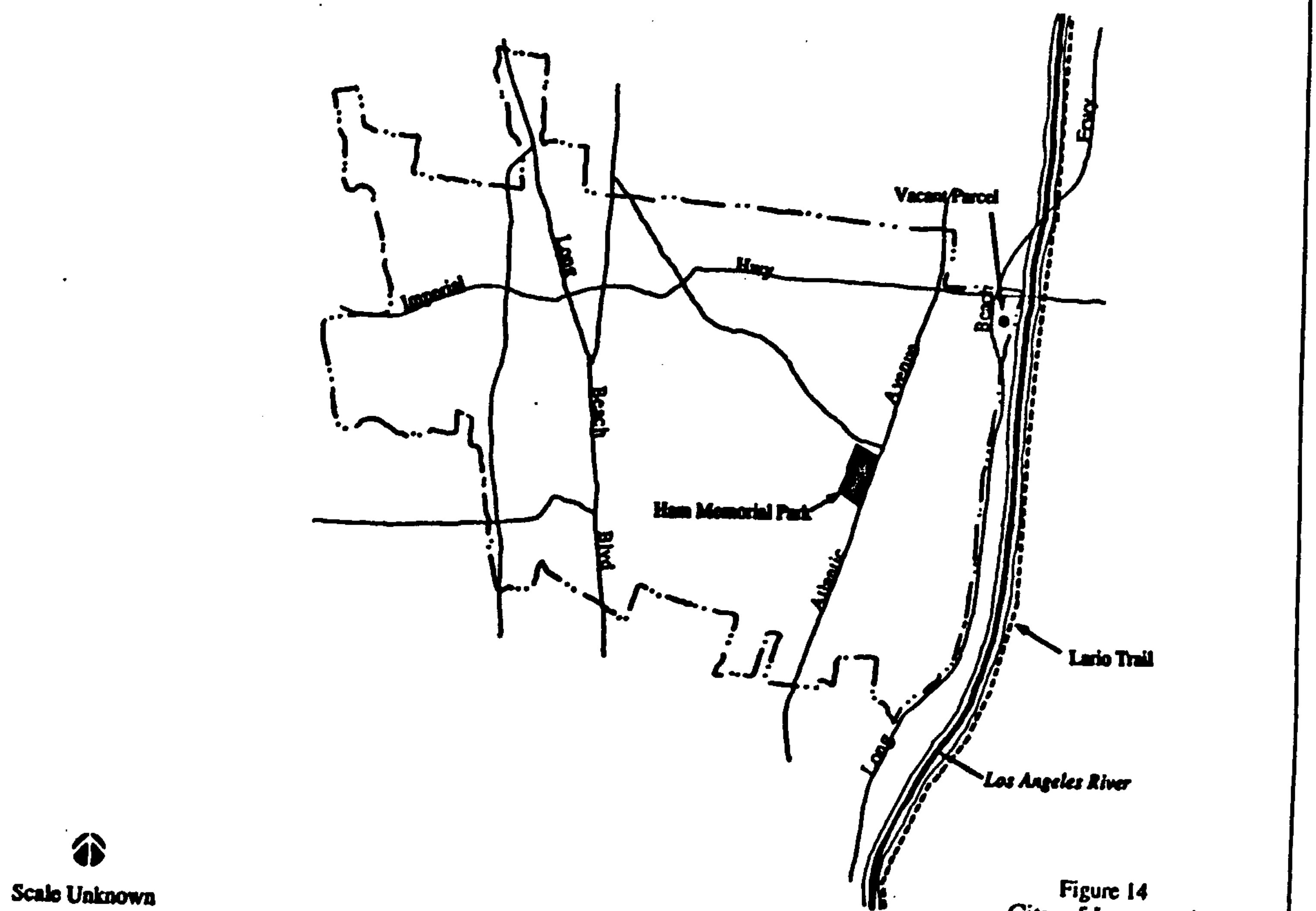

Figure 14
City of Lynwood

LYNWOOD

Community Profile

Area: 5 square miles *Population: 54,400*

Lynwood is extremely densely developed with very little vacant land. Affordable housing is in very short supply and the construction of additional housing is a high priority for the city. Only three parks serve Lynwood: Mervyn Dymally Park, Ham Memorial Park, and Los Amigos Park. Dymally Park is the largest at 32 acres. Ham and Los Amigos parks are substantially smaller, 11 acres and three acres, respectively. With 46 acres of park space for over 66,000 people, the existing park facilities in Lynwood are inadequate to serve the recreational needs of the community.

River Profile

The land adjacent to the river in Lynwood is almost entirely developed, and the Long Beach Freeway obstructs any direct access to the river from Lynwood. The only undeveloped areas of river frontage are small patches of vacant land between freeway on-ramps. The Lario Trail runs along the east levee of the river in this location, across the river from Lynwood, and there is no access to the trail from Lynwood.

The largest tracts of land in single ownership directly adjacent to the river are industrial tracts that are currently in use.

Potential Projects

Lynwood would appear to have very little potential for parks development. City staff have stated that the construction of additional housing on the remaining vacant land is a higher priority than parks development. Lynwood has few resources to devote to parks and recreation, and even were it to receive money from outside sources, very few sites are suitable for new parks development. The only possibilities for additional recreational facilities in Lynwood would appear to be through the conversion of existing uses.

However, residents of Lynwood could gain better access to the parks on the east side of the river in South Gate and Paramount if connections were provided from Lynwood across the freeway and the river to the Lario Trail. It may be possible to provide such a connection from Imperial Highway. A striped bike and pedestrian lane would be one way to provide this connection, but it may be safer and more feasible to shuttle bicyclists and pedestrians from Lynwood to the east side of the river via the existing shoppers' shuttle bus service. Buses could be equipped with bike racks and expand their current route to include a destination on the east side of the river at or near an access point to the Lario Trail.

Some small vacant parcels between the freeway on-ramps and the river could possibly be improved with landscaping or enhanced for wildlife habitat. In particular, the vacant parcel between the river and the Long Beach Freeway that connects with a vacant parcel in South Gate could potentially be landscaped or enhanced in such a way. In South Gate, this parcel connects to the Los Angeles River Trail, but no such connection exists in Lynwood. This area is not safely accessible to the public for recreational use.

Figure 15
City of Paramount

PARAMOUNT

Community Profile

Area: 4.8 square miles *Population: 45,700*

Paramount is a small industrial city located north of Long Beach. Hispanics are the largest segment of the population (60%), with non-Hispanic whites and African-Americans representing the next largest ethnic groups, 20% and 10%, respectively. Average household size is 3.8 and average household income is $32,466. The manufacturing and wholesale trade industries are the largest employers.

Paramount has approximately 40 acres of total park space. The largest park in Paramount is Senator Ralph C. Dills Park, better known as Banana Park, a ten-acre park next to the east levee of the Los Angeles River.

River Profile

Paramount has slightly more than two miles of river frontage. The river frontage north of Rosecrans Avenue is entirely developed with residential and industrial uses. Dills Park, the largest of Paramount's ten parks, runs next to the river right-of-way for approximately one-half mile between Rosecrans Avenue and Somerset Boulevard. Dills Park is a long narrow strip-park immediately adjacent to the county right-of-way below the east levee. It is bordered by the Compton Golf Course on the south. The park has a bike trail, picnic facilities, handball courts, and some play equipment and is heavily used by Paramount residents. There is a connection to the Lario Trail in Dills Park but the park is below the levee, and has no visual or physical connection to the river.

Immediately south of Dills Park are the Compton Golf Course and Dominguez High School, both lying within a small pocket of Compton on the east side of the river. The Lario Trail runs along the top of the levee embankment through Paramount. Except for the portion running past Dills Park and the Compton Golf Course, this stretch of the river is entirely devoid of landscaping. Trail users overlook the high cinder block walls and chain-link fences that separate the back yards of homes, industrial sites, and municipal and county equipment yards from the river right-of-way. Some vacant land adjacent to the river right-of-way is located south of the Compton Golf Course.

Potential Projects

Additional recreational facilities are needed in Paramount. The city staff are interested in acquiring more lands for parks and linking these with the Lario Trail. The area near the river is densely developed, however, and the only property adjacent to the river with any potential for park development is an eight-acre parcel between Atlantic Place and Hunsaker Avenue south of Alondra Boulevard. This parcel is currently in use as a truck yard but has been included in Paramount's redevelopment district. The redevelopment plan for the site proposes retail uses. Due to its proximity to the river and Dills Park, it would be highly desirable for at least part of the site to be devoted to park space. This property is large enough to accommodate at least modest recreation and park facilities in addition to the proposed retail uses. The strip along Alondra and along the river could be landscaped and developed with benches, restrooms, drinking fountains, small playgrounds, and possibly handball and/or basketball courts. Such facilities would undoubtedly be heavily used since Paramount currently has only 40 acres of park space to serve its more than 45,000 residents. Development of this strip as a park would also further extend the greenbelt created by Dills Park and the Compton Golf Course and could provide another connection with the Lario Trail.

City staff are also interested in improving the appearance of the space between Dills Park and the levee embankment with landscaping. This levee wall is currently bare and unattractive and screening it with vegetation would greatly enhance the appearance of the park. This area could be planted with small trees and shrubs, preferably drought-tolerant natives. Because of the densely populated area immediately adjacent to the river, any landscaping done here must not interfere with the integrity of levee. The levee wall itself is maintained by the Los Angeles County Department of Public Works (LACDPW) and is fenced off.

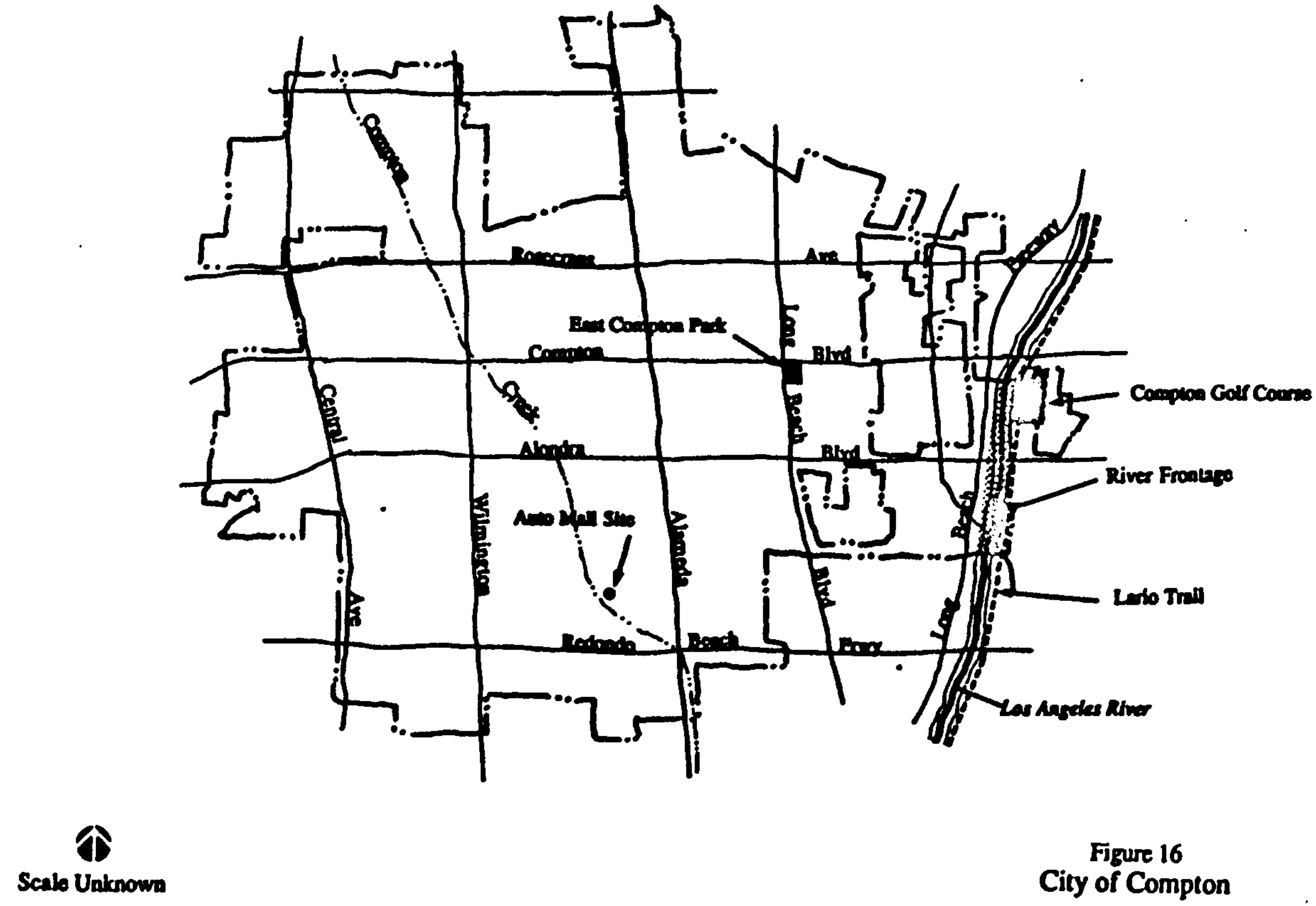

Figure 16
City of Compton

COMPTON

Community Profile

Area: 10.1 square miles *Population: 90,454*

The population of Compton is approximately 55% African-American and 43% Hispanic. Average household income is $37,066 and average household size is 4.0 persons. The median home value is $108,000 and the median rent is $477 per month. The primary industries are manufacturing and wholesale trade.

There are 13 parks in the city of Compton, plus the Compton Golf Course, a par three golf course heavily used by Compton residents. Total park area in Compton, not including the golf course, is 58 acres. The largest park in Compton is Gonzales Park, which is 14 acres in size. All the other parks in the city are less than six acres in size.

River Profile

The Los Angeles River is contained in levees as it flows through Compton. Land uses near the river include low-income residential, industrial, and municipal. Many of the industrial sites near the river in Compton are becoming obsolete and may be converted into other uses in the future. The largest open space area near the river in Compton is the Compton Golf Course, which is located next to the river on the east side. Immediately adjacent to the golf course is Dominguez High School, one of Compton's public high schools. The Lario Trail runs along the east levee in Compton, but the trail is in a severe state of disrepair and is impassable in many locations.

Compton Creek is a major tributary of the Los Angeles River. Although culverted over approximately half of its length, it runs above ground through Compton. Compton Creek, although channelized, supports surprisingly dense riparian vegetation in this area. Directly adjacent to Compton Creek is the site of a 33-acre auto mall, now deserted. New uses for the site are currently under development, and city planners envision using the site for another commercial use that would generate revenue for the city.

Potential Projects

Like all other cities in the south watershed, Compton has too little park space and too few recreational facilities to serve its citizens. Recreational facilities for young people are particularly needed. Because most of the city of Compton lies on the west side of the river, City Parks and Recreation staff are interested in developing a bike path on the west levee to make it more accessible to Compton residents. Were a path to be developed on the west levee, it would be necessary to provide a crossing of some kind near the Compton Golf Course so the path could rejoin the Lario Trail on the east levee in Paramount. City staff have also expressed interest in developing a bike route that would connect East Compton Park, a county regional park that lies 0.3 miles from the river, with the Lario Trail. This could be established either through the construction of a separate bike path, or more simply by creating a striped bicycle lane over city streets. In any case, a way should be found to connect the Lario Trail on the east side of the river with the rest of Compton on the west side. The Lario Trail through Compton is badly in need of rehabilitation and repair. Such repair work should also include landscaping with native shrubs and the addition of benches and rest areas for trail users.

Another potential site for the development of recreational facilities is the old auto mall site on Compton Creek. The vacant land directly alongside the creek here has the potential to be developed into a creekside park for passive recreation. The creek is readily accessible from here and would be a good candidate for an urban creek restoration project that could combine wildlife habitat enhancement with environmental education opportunities. It may also be possible to develop a pedestrian/bike path along one of the banks of Compton Creek. Any development plans for the auto mall site should incorporate Compton Creek into the design and include provisions for park development along the creek. Such a park could prove to be a tremendous amenity to Compton residents. The 1991 LACDA Review proposes the construction of three-foot high parapet walls and armoring the outside of the levees along one mile of Compton Creek, including the reach through the auto mall site. The construction of these walls would in all likelihood preclude the enhancement of Compton Creek in this location, but may possibly still accommodate the development of recreational features.

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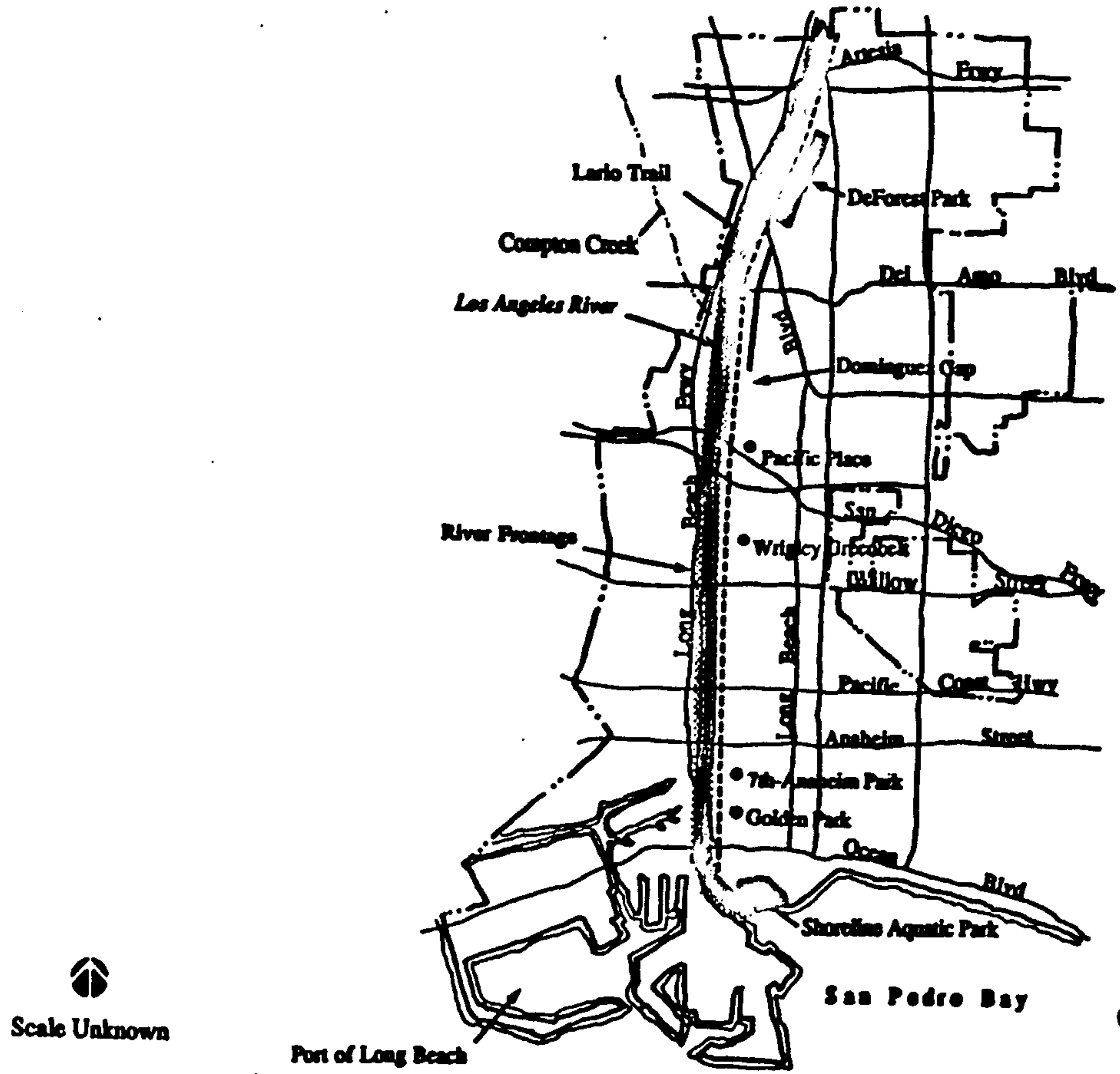

Figure 17
City of Long Beach

LONG BEACH

Community Profile

Area: 49.71 square miles *Population: 439,300*

Long Beach is the second-largest city in Los Angeles County and the fifth-largest city in California. The city is located 22 miles south of downtown Los Angeles. The Port of Long Beach handles the most cargo tonnage of any West Coast port.

The 1990 Census indicated that the population of Long Beach is getting younger and more ethnically diverse. The median age of the population declined from 31.1 in 1980 to 30.0 in 1990. The Hispanic and Asian/Pacific Islander populations of the city have increased significantly since 1980: the Hispanic population was 100% larger in 1990 than it was in 1980; the Asian/Pacific Islander population was 197% larger in 1990 than it was in 1980.

Long Beach has a number of park and recreation facilities. These range from the 726-acre El Dorado Park and 239-acre Recreation Park to many small neighborhood parks. As the population of the city has grown younger in the last ten years, the demand for more active recreation facilities has also increased. Much of the population increase is occurring on the city's west side in districts adjoining the river. The city is presently attempting to address the increased demand for both active and passive parks by developing such parks on vacant lands along the river (see discussion of specific projects below).

River Profile

Long Beach has approximately nine miles of river frontage, from the Artesia Freeway (91) to the mouth of the river at San Pedro Bay. The Long Beach Freeway (710) and an almost continuous band of undeveloped city and county rights-of-way and utility easements take up much of the west bank of the river for most of its course through Long Beach. Surrounding land uses are predominantly residential for most of the river's extent in Long Beach. The city has two parks on the east bank of the river, DeForest Park, between 59th and 63rd streets, and Shoreline Aquatic Park, located at the river mouth. The Lario Trail and an adjoining equestrian trail run along the east bank of the river

A stretch of the river from Willow Street south to the ocean is one of three areas along the river with soft bottoms. The buildup of silt on both sides of the river has allowed for the growth of a 10- to 15-foot-wide riparian corridor, containing rushes, cattails, willows, mulefat, and several exotic species. This vegetation likely provides habitat for some animal species, including mollusks, amphibians, reptiles, birds, and small mammals. The area is cleared of vegetation periodically by the Los Angeles County Department of Public Works.

This lower stretch of the river provides feeding grounds for a variety of sea birds, including the brown pelican and the California least tern, nesting habitat for such species as red-winged blackbirds, and roosting areas for several types of shorebirds. Large numbers of migrating shorebirds feed here from July through October.

Compton Creek, a tributary of the Los Angeles River, has a soft-bottomed section upstream of its confluence with the Los Angeles River south of Del Amo Boulevard. The native riparian and exotic vegetation of the soft-bottomed creek area attracts egrets, black-crowned night herons, and loggerhead shrikes.

The Dominguez Gap spreading grounds and channel extend north for approximately two miles from Del Mar Avenue to DeForest Park immediately adjacent to the river levee on the east bank of the river. The spreading grounds and channel contain water at times during the winter and spring and attract some bird use. Riparian vegetation occurs in some areas of the spreading grounds/channel.

Water quality, siltation, and debris from upstream are issues of concern to the city. Debris originating upstream of Long Beach travels downstream, is trapped by the breakwaters in Long Beach Harbor, and ends up on the city beaches. Poor water quality in the river is a problem, especially when it rains and the rising coliform levels result in the closure of the city's beaches.

The city is presently in the process of developing three park projects along the river. Long Beach has secured a permit from the Los Angeles County Department of Public Works to develop a passive neighborhood park on a county-owned strip of land between Willow and 34th Street. The park, the Wrigley Greenbelt, will include a meandering path and landscaping. It will be developed by the city and the neighborhood and maintained with the help of the neighborhood. The neighborhood to the south of the proposed park has expressed an interest in extending the park to their area.

The city is developing an active recreation park, Golden Park, to the east of the river channel at Golden Avenue between 6th Street and Broadway. The seven-acre park will contain baseball fields, soccer fields, basketball and tennis courts, and picnic areas. It is intended to serve residents of the downtown area. The city would like to add an additional seven acres to the park by moving an existing highway off-ramp west of its present location. It has applied for grant funds to relocate the off-ramp.

The third park development is proposed as part of the city's plan for redesign of the Queensway Bay area at the mouth of the river. The plan calls for the creation of a landscaped park strip, including a "shallow water habitat" on the south side of the river. The park strip would include a new amphitheater and the existing Spruce Goose Dome.

Potential Projects

The major potential projects for the Long Beach stretch of the river involve developing the large county flood control rights-of-way, vacant city-owned parcels, and utility easements that line the river into passive and active parks and, where feasible, habitat areas. The large utility easements on the west side of the river and the smaller city- and Los Angeles County Department of Public Works-owned parcels on the east side are very significant resources for the city of Long Beach. Multiple use of these parcels (e.g. passive park and flood control) on both sides of the river should be investigated.

A less intensive use of these areas would be large-scale tree planting that would reduce both urban heat island effect and poor air quality, aesthetically improve the river corridor and possibly provide habitat for bird species if appropriate native riparian species (willows, cottonwoods) are used. Small depressions could be filled with water and planted with cattails and bulrushes to provide freshwater marsh habitat. Another potential use is as community gardens. Some areas have already been leased to commercial nurseries.

Neighborhood Parks: Development of a string of neighborhood parks, such as DeForest Park and the Wrigley Greenbelt would "green" the river through Long Beach, providing an amenity for the adjoining neighborhoods and potentially, if consideration is given to plant selection and potential habitat creation, for birds and other wildlife.

Dominguez Gap: Use of the Dominguez Gap spreading basin as a multi-function facility should be investigated. Can the facility's function as a spreading ground be compatible with creation of wetland/riparian habitat of some kind? Any study should examine whether creation of both open water areas and riparian zones, by maintaining some water in the basin throughout the year and planting native riparian vegetation (willows, cottonwoods, etc.) in some parts of the basin/channel, would interfere with the function of the spreading basin. Willow and cottonwood trees could be planted around the immediate perimeter of the basin but not in the basin bottom itself in order to maintain percolation rates.

Other Projects: The city has long-range plans for two future park sites along the east bank of the river. Neither project has developed very far

- *Pacific Place site* — This 21-acre site located between the San Diego (405) Freeway and Del Mar Avenue is a high-priority park acquisition site for the city. The site is an abandoned oil field/water separation facility. The city would like to expand an existing neighborhood park, Los Cerritos Park, which adjoins the site, into a community park with active recreation facilities, such as baseball and soccer fields.

- *7th Street to Anaheim Street Park* — The city would also like to develop a park along the river between 7th Street and Anaheim Street in a narrow band of land west of DeForest Avenue. The park has not been planned at this time but would likely consist of a landscaped strip with a jogging/walking trail paralleling the river.

The city would like funding assistance for two other park projects:

- *A redesign of DeForest Park* to regrade the site, remove vegetation, and mosquito abatement.

- *Development of an irrigation system* for the Wrigley Greenbelt.

- *Access connections* from the neighborhoods to the Lario Trail need to be improved. More frequent access points and/or better directional signage are necessary. The trail is heavily used but access to it is not convenient or easy from most neighborhoods.

Environmental education: An environmental education program, potentially including an interpretive center, would focus on the rich bird life of the Long Beach section of the river and the hydrologic function and habitat value of the river mouth.

VII. CONSTRAINTS TO ALTERNATIVE USES OF THE LOS ANGELES RIVER

VII. CONSTRAINTS TO ALTERNATIVE USES OF THE LOS ANGELES RIVER

Introduction

The LACDA study prepared by the U.S. Army Corps of Engineers, discussed above, outlined several areas of potential conflict with plans for non-flood control uses of the flood control system. Any or all of these issues could be significant constraints to proposals for the development of parks, recreation facilities, etc., within the boundaries of the flood control system. Every change of use proposed for the Los Angeles River channel must address these issues.

The LACDA study identified seven issues that could potentially block proposed new uses within the flood control system:

Regulatory Constraints

Secondary uses of the flood control system must not interfere with the flood control function of the system. No changes can occur that would alter the channel's ability to hold or carry water. Any obstructions such as dams, landscaping, etc., must be removable or must not impede the movement of flood waters. Both the Army Corps of Engineers and the Los Angeles County Department of Public Works (LACDPW) must review and approve proposed secondary uses.

Physical Constraints

The flood control channels are crossed by numerous bridges for streets and railroads that are physical obstacles to public access.

Ownership

Not all land within flood channel corridors is owned by the Corps of Engineers or by the LACDPW. Many areas are easements with provisions that only allow use for flood control purposes. Secondary uses are generally not allowed under the terms of the leases. Purchase or acquisition through condemnation may be required to gain the legal rights to use land for non-flood control purposes.

Jurisdictional Coordination

It is extremely difficult to coordinate the multitude of local governments and state and federal agencies that have jurisdiction over the Los Angeles River corridor to carry out projects of a regional nature.

Safety

Safety is a major concern when considering increasing public access to the flood control channels. Safety hazards can result from user conflicts, such as encounters between bicyclists and equestrians, or bicyclists and pedestrians. In some areas, recreational users are in danger of falling into the channel, or being assaulted or robbed.

Conflicts with Channel Neighbors

Some owners of property adjacent to flood control channels object to increased public access along the channels because of concerns of loss of privacy, vandalism, and use of the public trails by criminals to gain access to homes and businesses.

Funding

Funding to carry out any park and recreation projects is quite limited. Many of the cities along the river corridor do not have local revenues available to fund such improvements.

In spite of these constraints, improvements to the river corridor are possible, both in the near term and over a longer period of the next ten to 50 years. What is needed is careful planning, close coordination among the participating jurisdictions, and an overriding commitment to opening up the river for the use and enjoyment of future generations of Los Angeles County residents.

VIII. RECOMMENDATIONS

VIII. RECOMMENDATIONS

GENERAL RECOMMENDATIONS

As the population density in the Los Angeles area increases, it is becoming apparent that the need for additional park and open space has reached a critical state. The greater Los Angeles area has the lowest amount of per capita park acreage of any major metropolitan area in the nation. The "discovery" of the Los Angeles River as a possible source of new park space and recreational facilities creates a unique opportunity to look at the river in a new way. The Los Angeles River has the potential to become one of the region's greatest recreational resources, forming a 50-mile open space/recreational "green corridor" through the center of the region.

Attention has also been focused on the river corridor as a potential site for redevelopment and economic revitalization. Several scenarios have been proposed for commercial, light industrial, and public transit facilities development on parcels adjoining the river. More proposals of this kind can be expected in the future as efforts are made by local governments to generate public and private sector interest in revitalizing the river corridor.

In general, the State Coastal Conservancy recommends that parks and recreation become a high-priority land use for the entire river corridor. Development of this use should be linked to improved flood control, economic, and transportation development along the corridor. Other uses in the river corridor that should be part of a multi-objective river management strategy include non-motorized transportation, local economic development, expanded native riparian habitat, detention basins, and spreading grounds.

Specifically, policies should be adopted by local governments and state and federal agencies with jurisdiction over the river that have as an ultimate goal the creation of a continuous system of parks and recreational trails along the river's banks from the Sepulveda Basin to Long Beach, consistent with flood control and economic development needs.

- Undeveloped utility, flood control, and other easements and rights-of-way along the river channel should be developed into parks, trail corridors, and/or plant and animal habitat wherever feasible and without sacrificing flood control needs. River-fronting parks and trails should be incorporated into commercial, residential, and industrial development along the river. Those easements or lots adjacent to the river that are not large enough or otherwise cannot accommodate park development should be landscaped along the river to provide air quality benefits, animal habitat and aesthetic improvement of the river corridor.

- New land uses should not obstruct public access to the river corridor, or prevent the extension and improvement of the regional trail system. New land uses should accommodate the placement of landscaping materials on lands directly adjacent to the river.

- Alternative methods for flood control should be explored, with a goal of providing protection against a 100-year flood, removing the Federal Emergency Management Agency (FEMA) floodplain designation from surrounding areas, creating a wider and more permeable channel, increasing flood water retention, reducing peak flood flows, restoring the upper watershed, increasing groundwater recharge capacity, and restoring riparian and tidal wetlands. Flood control needs of downstream communities must be considered of primary importance in the development of any alternative methods.
- Any proposals for public transit along the river corridor should include environmental enhancement and public access as integral parts of their schemes.
- Coordination of planning activities, funding for river corridor improvements, and formulation of strategies for assuring equity of benefits and costs among river corridor communities should be carried out on a regional basis by representatives of local governments and community groups with assistance from state and federal agencies.

ALTERNATIVE FLOOD CONTROL

There is a growing recognition that the benefits of channelization have been overestimated on many flood control projects in the United States and elsewhere in the world. The problems of channelization include: underestimation of the costs of channel maintenance, unrealistic expectations of the smoothness of concrete channels, underestimation of the effects of sediment and debris in major floods, problems with maintaining supercritical flows, loss or significant reduction in groundwater recharge, worsened water quality, disruption of wildlife corridors, loss of plant and animal habitat, and replacement of a natural river corridor by a concrete channel. Recognition of these problems has resulted in a major reexamination of the way rivers are managed.

Protection of lives and property must be the first priority of any river management plan, but as existing flood control systems need to be redesigned to address ever increasing runoff and water flows, alternative flood control methods should be considered as part of a multi-objective approach to river management.

Examples of such techniques include soft-bottomed channels that allow for scour, a series of flood water detention basins, enlarged spreading basins, alternative channel bank stabilization, increased percolation in the watershed (e.g., porous parking lots and driveways), diversion of peak flood flows, onsite storage of runoff, restoration of the upper watershed (e.g., revegetation of the slopes, upstream reservoirs), and creation of a "riverway." [1]

(Note: The U.S. Army Corps of Engineers in the 1991 Los Angeles County Drainage Area (LACDA) Review studied several alternative flood control methods, including diversion alternatives, non-structural measures, new reservoirs and upper basin modifications, and concluded that these methods were either too expensive or ineffective in reducing peak flows in the lower basin.)

A benefit of such alternative methods could be the restoration of such natural river features as wetlands, which would act

[1] A "riverway" is the river corridor between the flood protection levees or walls and may include the main river channel, adjacent flood plain, seasonal and permanent wetlands, and detention or retention ponds.

as water retention basins. Restoration of former wetland areas along channelized rivers would provide flood control, groundwater recharge, habitat, and aesthetic benefits.

The function of the Los Angeles River is first and foremost as a flood control channel serving much of the Los Angeles Basin. Any proposed alteration of the existing channel must clearly be found not to interfere with or lessen the flood control function of the river. The intent of this section is to present alternative flood control methods that could be incorporated into the management of the Los Angeles River.

These alternative flood control methods offer several advantages over traditional channelization in terms of plant and animal habitat creation, groundwater recharge, and other natural river functions that concrete-lined channels do not provide while also addressing the flood control needs of the region. We recommend that the use of such methods be incorporated into a multi-objective approach to river management.

USE-SPECIFIC RECOMMENDATIONS

Recreation/Public Access

- Extend the regional trail system along the river through downtown and into the San Fernando Valley, thus creating a trail system for the entire length of the Los Angeles River from the western San Fernando Valley to the ocean at Long Beach. The Lario Trail follows the Los Angeles River up to its confluence with the Rio Hondo, from which point it follows the Rio Hondo into the San Gabriel Valley. The existing Los Angeles River Trail runs along the levee on the west bank of the river for approximately four miles from Maywood to South Gate, connecting with the Lario Trail in South Gate. This trail should be extended north into downtown Los Angeles where it could connect with the new Los Angeles River Bikeway that begins at Elysian Park.

- Many of the project proposals described in the U.S. Army Corps of Engineers' 1980 LACDA System Recreation Study would be valuable additions to the regional trail system. The 1980 LACDA Study should be reexamined, updated where necessary, and a concerted effort made to begin implementation of the regional trail concept proposed in the study.

- Improve access connections to the existing trail network. These should include improvements to existing access points, development of new access points, and better directional signage.

- Implement the "Los Angeles River Greenway" demonstration project proposed by the Los Angeles River Task Force. This project proposes the incorporation of landscaping into the various bicycle paths that are being planned along the Los Angeles River north of downtown. The purpose would be not only to improve the bike paths aesthetically, but to enhance air quality and reduce the urban heat island effect, providing a more enjoyable and healthier environment for bicyclists and pedestrians. Reclaimed water from the river channel itself would be used for irrigation as it is already being used at an adjacent city recreation facility. Landscaping should incorporate appropriate native plants.

- Linear parks, like those proposed in the 1980 LACDA Recreation Study, should be developed on vacant lands adjacent to the river. These parks need not be large, and could be nothing more than small landscaped areas with trees, benches, and drinking fountains. The emphasis should be on interspersing segments of the regional trail with green areas that can be used for rest and quiet enjoyment.

- Development and implementation of the following specific projects: Burbank (Buena Vista Park expansion); Glendale (Crystal Springs Park); Cudahy (land acquisition); South Gate (development of flood control rights of way); Paramount (land acquisition); Long Beach (development of flood control rights-of-way/utility easements).

Habitat Enhancement

- Preserve and enhance those few areas that still contain riparian plant communities to improve the quality of these areas for wildlife habitat. Where possible, additional habitat areas should be created.

- Redesign of the river channel where feasible to create a wide, permeable channel and flood plain system that would better integrate flood control with groundwater recharge, habitat, and open space uses. Further feasibility studies are needed to determine locations where the removal of concrete channel bottoms and banks and the creation of a wider, permeable channel might be possible. The new design should not result in induced flooding upstream or downstream or increase the potential for channel erosion or structural failure.

- Landscape flood control rights-of-way and public and utility easements with appropriate native vegetation to provide plant and animal habitat.

- Implement the "Sepulveda Basin River Recreation Link" demonstration project proposed by the Los Angeles River Task Force to improve the visual and physical linkages between the Los Angeles River and adjacent Balboa Park. Project components include the ongoing cleanup of trash and debris from the river channel, and the restoration and enhancement of native riparian vegetation in and along the channel. The project also proposes the development of a nature trail and interpretive signage.

- Develop and implement the following projects: Los Angeles (DWP Spreading Basin); Glendale (DWP Site - Crystal Springs); Long Beach (Dominguez Gap).

Environmental Education

- Those parts of the river corridor that contain natural or semi-natural riparian habitat can be used for environmental education of adults as well as schoolchildren. In highly urbanized settings, even very small reaches of semi-natural habitat areas can provide important educational opportunities. Efforts should be made to enhance these degraded areas for the enjoyment and education of local residents.

- Develop specific regional and local environmental education programs focused on the Los Angeles River as a functioning natural habitat in a developed urban area — curriculum programs for local schools and a series of interpretive centers/museums along the river.

- The Sepulveda Basin River/Recreation Link demonstration project cited above includes a proposed nature trail and interpretive signs for the river where it connects with

Balboa Park. The development of these facilities would be a valuable educational asset.

- Develop and implement the following project: Glendale (environmental education program and/or interpretive center for the Los Angeles River).

Aesthetic Improvements

- Over the entire course of the river, recreational facilities (parks and trails) should be enhanced with native and/or drought tolerant landscaping, attractive signs, inviting rest and entry areas, and murals. A unified design scheme, including directional and interpretive signage for such features, should be used to give a sense of connection to these facilities throughout the various communities along the river.

- Flood control rights-of-way and public and utility easements along the river corridor should be landscaped with native and/or drought tolerant vegetation. Use of native species should be emphasized.

- Implement the first phase of the Los Angeles River Task Force "Los Angeles River Greenway" project. This project proposes the development of coordinated landscaping, including trees, shrubs, and ground cover, along the bike paths that line the river. The location for the first phase of this project is the unpaved land adjacent to the flood control maintenance road near the Zoo Drive overpass of I-5 in the city of Los Angeles.

Alternative Flood Control Methods

- Hydrological studies should be conducted that explore the potential for alternative methods of flood control for the Los Angeles River that do not sacrifice or undermine 100-year or other flood protection standards and needs. These studies will utilize computer models and relevant experiences elsewhere in the United States to determine whether a multi-objective restoration plan is feasible. These studies should include the following elements:

1. Establishment of clear objectives for the Los Angeles River.
2. Compilation of all hydrologic data relating to the Los Angeles River that may affect flood control, groundwater recharge, etc.
3. Identification of opportunities and constraints, including flood protection, groundwater recharge, surface water levels, recreation, biological resources, and economic impacts.
4. Establishment of a technical working group comprising agencies, public interest groups, and all local governments/cities adjacent to the Los Angeles River (The Los Angeles County Department of Public Works has done this as part of its master plan effort).
5. Development of a computer model of the entire Los Angeles River system to investigate the possibilities of alternative flood control measures and ascertain the upstream and downstream impacts of implementing these alternative flood control measures in a staged fashion. This is important to ensure that a restoration plan for one area does not create induced flooding upstream or downstream.

The model could be used as a design and management tool for the watershed. The computer model would complement the results obtained from the U.S. Army Corps of Engineers physical model of the river. The physical model simulates the flows in the Rio Hondo and lower reaches of the Los Angeles River.

6. Conceptual designs for specific reaches of the Los Angeles River.

Recent developments in flood plain management and flood alleviation methods that should be considered (and their economic impacts analyzed) include:

- Soft-bottomed channels
- Series of flood water detention basins
- Enlarged spreading basins
- Increased percolation in the watershed
- Restoration of the upper watershed
- Diversion of peak flows
- Onsite storage of runoff
- Creation of a "riverway"

Any recommendations resulting from these studies should provide protection against floods up to the 100-year event and should be designed to remove the FEMA 100-year flood plain designation from surrounding areas.

(Note: The U.S. Army Corps of Engineers in the 1991 Los Angeles County Drainage Area (LACDA) Review studied several alternative flood control methods, including diversion alternatives, non-structural measures, new reservoirs and upper basin modifications, and concluded that these methods were either too expensive or ineffective in reducing peak flows in the lower basin.)

Air Quality

- Landscaping along the river corridor, most importantly the planting of double rows of trees should be undertaken wherever feasible. Such planting will improve the air quality of the area around the river and will help to counteract the pollution created by millions of cars that travel daily along the streets and freeways adjacent to the river. Tree planting can also counteract the heat island effect by helping to lower temperatures near the river. The landscaping should consist of appropriate native species.

Institutional

- Create a mechanism for coordination among the many agencies and governments that have jurisdiction along the river.

- Establish an intergovernmental association or agreement to coordinate planning activities and channel funds for river improvement projects. The association should be made up of representatives of local governments, local, state and federal agencies, and community groups.

- Prepare a master plan for the river that promotes the concept of the Los Angeles River as a regional resource. (The Los Angeles County Department of Public Works began such a planning effort in 1991.)

IX. ACKNOWLEDGEMENTS

IX. ACKNOWLEDGEMENTS

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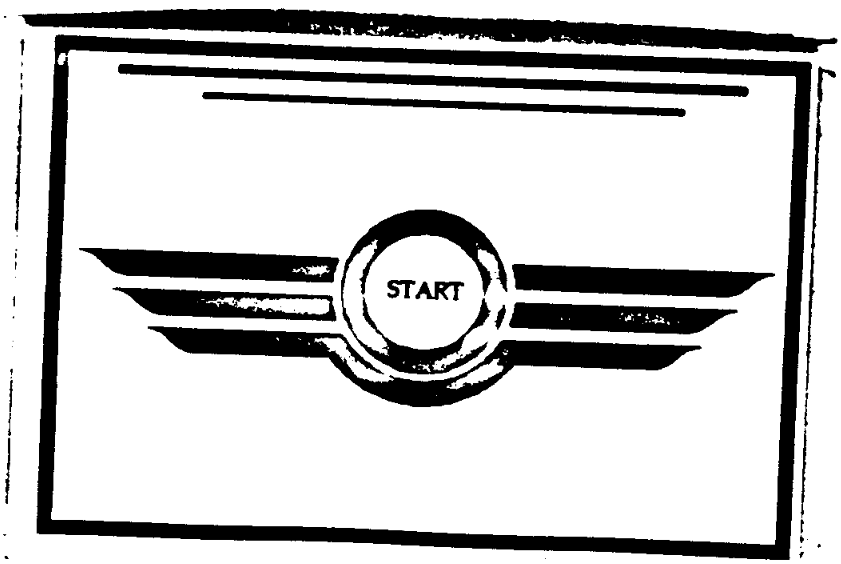
PORT OF LONG BEACH

NON POINT SOURCE STORM WATER PROGRAM

PRESENTATION

TO THE

L.A. REGIONAL WATER QUALITY CONTROL BOARD



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PORT OF LONG BEACH

NON POINT SOURCE STORM WATER PROGRAM

PRESENTATION

TO THE

L.A. REGIONAL WATER QUALITY CONTROL BOARD

JULY 19, 1994

VOL 12

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VOL 12

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DATE: July 31, 1991

TO: Tenants

FROM: Geraldine Knatz, Director of Planning

SUBJECT: Non-Point Source Permits for Stormwater Discharges

In November, 1990, the U.S. Environmental Protection Agency published its final rule on non-point source stormwater discharges. These rules require operators of industrial facilities (which includes most of the Port's tenants) to apply for National Pollutant Discharge Elimination Systems (NPDES) permits for their stormwater discharges by November, 1991.

There are two ways by which we can comply with these new regulations. The first is for each tenant to apply for an individual permit, independently gathering the information and filling out the forms. The second is for the Port to apply for a "master" permit on behalf of our tenants. Clearly, the second option will be more efficient and will considerably lessen the burden on each of you, since the effort and expense of gathering, organizing, and presenting the necessary information will be substantial.

The Port intends to submit a joint application on behalf of our tenants. To be included in the joint application, each of you must give us your help and cooperation. We cannot include you in the application if you do not do your part. The application requires us to provide information on the storm drain system and on each facility's operational characteristics and current permit status. Enclosed is a questionnaire that requests the necessary information. It is essential that each of you assign someone from your organization to fill out this questionnaire and to act as a point of contact for the Port on this matter.

We ask that you immediately fill out the questionnaire completely and with accurate information. A Port representative will be contacting you after August 15, 1991 to collect the questionnaire and, if necessary, to help complete it. We will, of course, arrange in advance a mutually convenient time for that visit. In the meantime, if you have any questions, please contact Dr. Robert Kanter, Manager of Environmental Planning at (213) 590-4156.

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Planning

SH:TDJ:S

Attachment

R0050078

THE PORT OF LONG BEACH

Tenant ID # ______________

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STORM RUNOFF FACILITY QUESTIONNAIRE

Part I. GENERAL INFORMATION

1. Facility Name: ______________
2. Address: ______________ Zip: ______
3. Harbor District - Check one as appropriate: (See Attached Map)

   [ ] North Harbor [ ] Middle Harbor [ ] Southeast Harbor

   [ ] Northwest Harbor [ ] Queensway Bay [ ] Southwest Harbor

   [ ] Northeast Harbor [ ] West Harbor

4. Nearest cross street: ______________
5. Mailing address (if different):

   Street: ______________

   City: ______________ State: ____ Zip: ______

6. Contact Person: ______________

   Title: ______________ Phone: ______________

7. Backup Person: ______________

   Title: ______________ Phone: ______________

8. Facility Operator: ______________
9. Facility Description:

   [ ] Manufacturing [ ] Import/Export

   [ ] Distributing [ ] Warehousing [ ] Service [ ] Retailing

   [ ] Other: ______________

1 6774

R0050079

10. Standard Industrial Classification (SIC) codes (A partial list of SIC codes is attached in Table 1 and Table 2. A full listing is available at public libraries).

a. [ ] b. [ ] c. [ ] d. [ ] e. [ ]

f. [ ] g. [ ] h. [ ] i. [ ] j. [ ]

11. Approximate total area of property: square feet _______ or acres _________.

12. Does this business currently hold a National Pollutant Discharge Elimination System (NPDES) permit for any process wastewater and/or surface runoff? Yes______ No______

If Yes, what is the number of the permit? Permit No.____________

If Yes, list the constituents regulated:

a. ____
b. ____
c. ____
d. ____
e. ____
f. ____

If Yes, does the permit cover discharges to the storm drainage system?

13. Are you required by the new federal regulations to apply for a NPDES Permit for the discharge of your storm water runoff? Yes______ No______

Part II. ADDITIONAL INFORMATION

A. Storm Runoff Quality

14. Has storm runoff from this property been sampled at any time for:

[ ] Oil and grease
[ ] pH
[ ] Chemical oxygen demand
[ ] Biological oxygen demand
[ ] Total suspended solids
[ ] Total phosphorous
[ ] Total Kjeldahl nitrogen
[ ] Nitrate plus nitrite nitrogen

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15. To the best of your knowledge, are any of the chemicals listed on Attachment 1 or 2 present on this property? Yes_____ No_____

If Yes, list chemicals:

Present in storm runoff from this property? Yes_____ No_____

If Yes, list chemicals:

B. <u>Existing Effluent Limitations</u>

16. Is this facility subject to pre-treatment standards for disposal to the sanitary sewer? Yes_____ No_____

If Yes, list the constituents subject to pre-treatment standards.

C. <u>Materials Management</u>

Do any of the following activities occur on your facility?

17. Vehicle or equipment washing? Yes_____ No_____

18. Vehicle maintenance? Yes_____ No_____

19. Loading/Unloading of liquid materials? Yes_____ No_____

If Yes, list materials:

19b. Loading/Unloading of dry bulk materials? Yes_____ No_____

If Yes, list materials:

20. Manufacturing processes? Yes______ No______

If Yes, list processes:

21. Indicate if any of the following materials are principal raw materials products, byproducts, or wastes of your facility AND the quantities that are used and/or stored on the premises?

PRODUCTS	UNITS[1]	a. INDOORS	b. OUTDOORS, COVERED, CONTAINERIZED	c. OUTDOORS, UNCOVERED
a. Flammable or Explosive Materials				
b. Acid, Alkaline, or Corrosive Materials (including batteries)				
c. Pesticides or Toxic Materials				
d. Oil, Solvents, or Thinner				
e. Soap or Detergent				
f. Paint or Dyes				
g. Radioactive Materials				
h. Gravel				
i. Sand				
j. Topsoil				
k. Compost				
l. Sawdust				
m. Woodchips				
n. Lumber				
o. Building Materials				
p. Cement or Concrete				
q. Metal Products (including Scrap Metal)				
r. Feedstock				
s. Petroleum or other Fuels				
t. Petroleum/Coke/Coal				
u. Salt				
v. Other (Please list below)				

1. Units: gallons, barrels, pounds, cubic feet, etc.

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16777

R0050082

22. Are any control measures, such as a berm, used to prevent drainage from entering the storm drains from the location(s) of any outside activities, identified by questions 17 through 21?
Yes_______ No_______

If Yes, describe:

23. Does this facility discharge any process wastewater, such as cooling tower or wash water, or any other materials to the storm drains?
Yes_______ No_______

If Yes, describe:

23b. To the municipal sewer system? Yes_______ No_______

If Yes, describe discharge:

D. <u>Other Discharges</u>

24. Is the Site Map attached: Yes_______ No_______

25. Do you have any knowledge of the discharge or dumping of used oil, toxic chemicals, or/any other materials into the storm drains at this business?
Yes_______ No_______

If Yes, describe:

26. Do you have an emergency spill cleanup plan? Yes_______ No_______

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27. Do you have any knowledge of previous leaks or spills of any materials listed on Attachment 1 or Attachment 2? Yes______ No______

If Yes, include the approximate date, amount and type of material released.

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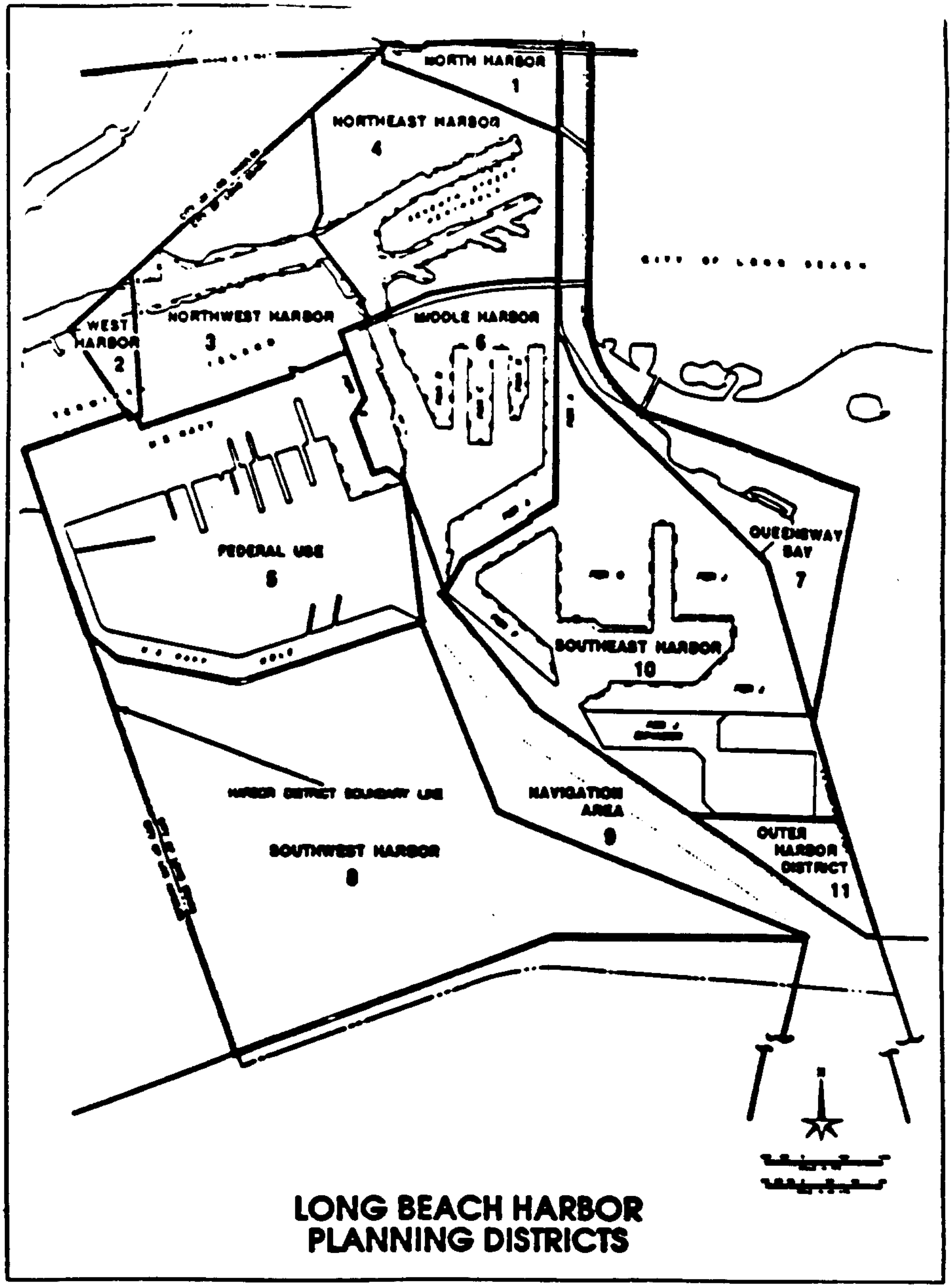
1 6779



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R0050085

Table 1 Industries Affected By Stormwater Regulation

Mandatory Industries
(Require a permit in any case)

Lumber & Wood Products, Except Furniture
2411 Logging Camps & Logging Contractors
2421 Sawmills & Planing Mills, General
2426 Hardwood Dimension & Flooring
2429 Sawmills, Special Product, N.E.C.
2431 Millwork
2435 Hardwood Veneer & Plywood
2436 Softwood Veneer & Plywood
2439 Structural Wood Members, N.E.C.
2441 Boxes, Nailed Wood & Shook
2448 Pallets & Skids, Wood
2449 Containers, Wood, N.E.C.
2451 Mobile Homes, Wood
2452 Buildings, Prefabricated Wood
2491 Wood Preserving
2493 Reconstituted Wood Products
2499 Wood Products, N.E.C.

Paper & Allied Products
2611 Pulp Mills
2621 Paper Mills
2631 Paperboard Mills

Chemicals & Allied Products
2812 Alkalies & Chlorine
2813 Gases, Industrial
2816 Pigments, Inorganic
2819 Chemicals, Industrial Inorganic, N.E.C.
2821 Plastics Materials & Resins
2822 Rubber, Synthetic
2823 Cellulosic Man-Made Fibers
2824 Organic Fibers, Noncellulosic
2841 Soap & Other Detergents
2842 Polishes & Sanitation Goods
2843 Surface Active Agents
2844 Toilet Preparations
2861 Gum & Wood Chemicals
2865 Cyclic Crudes & Intermediates
2869 Chemicals, Industrial Organic, N.E.C.
2873 Fertilizers, Nitrogenous
2874 Phosphatic Fertilizers
2875 Fertilizers, Mixing Only
2879 Chemicals, Agricultural, N.E.C.
2891 Adhesives & Sealants
2892 Explosives
2893 Printing Ink
2895 Carbon Black
2899 Chemical Preparations, N.E.C.

Petroleum Refining & Related Industries
2911 Petroleum Refining
2951 Paving Mixtures & Blocks
2952 Asphalt Felts & Coatings
2992 Lubricating Oils & Greases

Petroleum Refining & Related Industries (cont'd)
2999 Petroleum & Coal Products, N.E.C.

Leather & Leather Products
3111 Leather Tanning & Finishing

Stone, Clay, Glass, & Concrete Products
3211 Glass, Flat
3221 Glass Containers
3229 Glass, Pressed & Blown, N.E.C.
3241 Cement, Hydraulic
3251 Brick & Structural Clay Tile
3253 Tile, Ceramic Wall & Floor
3255 Clay Refractories
3259 Clay Products, Structural, N.E.C.
3261 Plumbing Fixtures, Vitreous
3262 Food Utensils, Vitreous China
3263 Food Utensils, Fine Earthenware
3264 Electrical & Electronic Supplies, Porcelain
3269 Pottery Products, N.E.C.
3271 Concrete Block & Brick
3272 Concrete Products, N.E.C.
3272 Concrete, Ready-Mixed
3274 Lime
3275 Gypsum Products
3281 Stone & Stone Products, Cut
3291 Abrasive Products, Nonmetallic
3292 Asbestos Products
3295 Minerals, Ground Or Treated
3296 Mineral Wool
3297 Refractories, Nonclay
3299 Mineral Products - Nonmetallic, N.E.C.

Primary Metal Industries
3312 Blast Furnaces & Steel Mills
3313 Electrometallurgical Products
3315 Wire, Steel & Related Products
3316 Steel Shapes, Cold Finishing
3317 Pipe & Tubes, Steel
3321 Foundries, Gray Iron
3322 Foundries, Malleable Iron
3324 Foundries, Steel Investment
3325 Foundries, Steel, N.E.C.
3331 Copper, Primary
3334 Aluminum, Primary
3339 Nonferrous Metals, Primary, N.E.C.
3341 Nonferrous Metals, Secondary
3351 Copper Rolling & Drawing
3353 Aluminum Sheet, Plate, & Foil
3354 Aluminum Extruded Products
3355 Aluminum Rolling & Drawing, N.E.C.
3356 Nonferrous Metals, Rolling & Drawing, N.E.C.
3357 Wire Drawing & Insulating, Nonferrous
3363 Aluminum Die Castings

VOL 12

Table 1 Industries Affected By Stormwater Regulation

Mandatory Industries
(Require a permit in any case)

Primary Metal Industries (cont'd)
3364 Nonferrous Die Castings, Except Aluminum
3365 Aluminum Foundries
3366 Copper Foundries
3369 Foundries, Nonferrous, N.E.C.
3398 Heat Treating, Metal
3399 Metal Products, Primary, N.E.C.

Fabricated Metal Products, Except Machinery, & Transportation Equipment
3441 Structural Metal, Fabricated

Electronic & Other Electrical Equipment & Components, Except Computer Equipment
3648 Lighting Equipment, N.E.C.
3652 Phonograph Records & Prerecorded Audio Tapes & Disks
3679 Electronic Components, N.E.C.

Transportation Equipment
3731 Ship Building & Repairing
3732 Boat Building & Repairing

Railroad Transportation
4011 Railroads, Line-Haul Operating
4013 Railroad Switching & Terminal Companies

Local & Suburban Transit & Interurban Highway Passenger Transportation
4111 Local & Suburban Transit
4119 Local Passenger Transportation, N.E.C.
4121 Taxicabs
4131 Intercity Highway Transportation
4141 Bus Charter Service, Local
4142 Bus Charter Service, Except Local
4151 School Buses
4173 Bus Terminal & Service Facilities

Motor Freight Transportation & Warehousing
4212 Trucking, Local, Without Storage
4213 Trucking, Except Local
4214 Local Trucking & Storage
4215 Courier Services, Except By Air
4226 Special Warehousing & Storage, N.E.C.
4231 Trucking Terminal Facilities

United States Postal Service
4311 United States Postal Service

Water Transportation
4412 Deep Sea Foreign Transportation of Freight
4424 Deep Sea Domestic Transportation of Freight
4432 Freight Transportation on the Great Lakes - St. Lawrence Seaway

Water Transportation (cont'd)
4449 Water Transportation of Freight, N.E.C.
4481 Deep Sea Transportation of Passengers, Except By Ferry
4482 Ferries
4489 Water Transportation of Passengers, N.E.C.
4491 Marine Cargo Handling
4492 Towing & Tugboat Services
4493 Marinas
4499 Water Transportation Services, N.E.C.

Transportation By Air
4512 Air Transportation, Scheduled
4513 Air Courier Services
4522 Air Transportation, Nonscheduled
4581 Services Related to Air Transportation

Wholesale Trade - Durable Goods
5015 Motor Vehicle Parts, Used
5093 Scrap & Waste Materials

Wholesale Trade - Nondurable Goods
5171 Petroleum Bulk Stations & Terminals

1 6782

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Table 1 Industries Affected By Stormwater Regulation

Conditional Industries

(Require a permit only if materials, machinery, or products are exposed to stormwater)

Textile Mill Products (cont'd)

2259 Knitting Mills, N.E.C.
2261 Cotton, Finishing Plants
2262 Synthetics, Finishing Plants
2269 Finishing Plants, N.E.C.
2273 Carpets & Rugs
2281 Yarn Spinning Mills
2282 Yarn Texturizing, Throwing, Twisting, & Winding Mills
2284 Thread Mills
2295 Coated Fabrics, Not Rubberized
2296 Tire Cord & Fabrics
2297 Nonwoven Fabrics
2298 Cordage & Twine
2299 Textile Goods, N.E.C.

Apparel & Other Finished Products Made From Fabrics & Similar Materials

2311 Suits & Coats, Men's & Boy's
2321 Shirts, Men's & Boy's
2322 Underwear & Nightwear, Men's & Boy's
2323 Neckwear, Men's & Boy's
2325 Separate Trousers & Casual Slacks, Men's & Boy's
2326 Work Clothing, Men's & Boy's
2329 Clothing, Men's & Boy's, N.E.C.
2331 Blouses & Waists, Women's & Misses'
2335 Dresses, Women's & Misses'
2337 Suits & Coats, Women's & Misses'
2339 Outerwear, Women's & Misses', N.E.C.
2341 Underwear, Women's & Children's
2342 Brassieres & Allied Garments
2353 Hats, Caps, & Millinery
2361 Girls', Children's & Infants' Dresses, Blouses, Waists, & Shirts
2369 Outerwear, Children's, N.E.C.
2371 Fur Goods
2381 Gloves, Fabric Dress & Work
2384 Robes & Dressing Gowns
2385 Waterproof Outerwear
2386 Leather & Sheep Lined Clothing
2387 Belts, Apparel
2389 Apparel & Accessories, N.E.C.
2391 Curtains & Draperies
2392 Housefurnishings, N.E.C.
2393 Bags, Textile
2394 Canvas & Related Products
2395 Pleating & Stitching
2396 Automotive & Apparel Trimmings
2397 Schiffli Machine Embroideries
2399 Textile Products, Fabricated, N.E.C.

Lumber & Wood Products, Except Furniture

2434 Cabinets, Wood Kitchen

Furniture & Fixtures

2511 Furniture, Wood Household
2512 Furniture, Upholstered Household
2514 Furniture, Metal Household
2515 Mattresses & Bedsprings
2517 Wood Television, Radio, Phonographic, & Sewing Machine Cabinets
2519 Furniture, Household, N.E.C.
2521 Furniture, Wood Office
2522 Furniture, Office, Except Wood
2531 Furniture, Public Building
2541 Partitions & Fixtures, Wood
2542 Partitions & Fixtures, Except Wood
2591 Drapery Hardware & Blinds & Shades
2599 Furniture & Fixtures, N.E.C.

Paper & Allied Products

2652 Boxes, Setup Paperboard
2653 Boxes, Corrugated & Solid Fiber
2655 Cans, Drums & Similar Products, Fiber
2656 Sanitary Food Containers
2657 Boxes, Folding Paperboard
2671 Paper Coating & Laminating For Packaging
2672 Paper Coating & Laminating, Except For Packaging
2673 Bags, Plastics, Laminated & Coated
2674 Bags, Uncoated Paper & Multiwall
2675 Paper & Board, Die-Cut
2676 Sanitary Paper Products
2677 Envelopes
2678 Stationery Products
2679 Pulp Goods, Pressed & Molded

Printing, Publishing, & Allied Industries

2711 Newspapers
2721 Periodicals
2731 Book Publishing
2732 Book Printing
2741 Publishing, Directories & Catalogs, Misc
2752 Printing, Lithographic
2754 Printing, Gravure
2759 Printing, Commercial, N.E.C.
2761 Business Forms, Manifold
2771 Publishing, Greeting Card
2782 Binders, Blankbooks & Looseleaf
2789 Bookbinding & Related Work
2791 Typesetting
2796 Platemaking

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Table 1 Industries Affected By Stormwater Regulation

Conditional Industries

(Require a permit only if materials, machinery, or products are exposed to stormwater)

Industrial & Commercial Machinery & Computer Equipment (cont'd)

3554 Machinery, Paper Industries
3555 Machinery, Printing Trades
3556 Machinery, Food Products
3559 Machinery, Special Industry, N.E.C.
3561 Pumps & Pumping Equipment
3562 Bearings, Ball & Roller
3563 Compressors, Air & Gas
3564 Blowers & Fans
3565 Packaging Machinery
3566 Speed Changers, Drives & Gears
3567 Furnaces & Ovens, Industrial
3568 Power Transmission Equipment, N.E.C.
3569 Machinery, General Industrial, N.E.C.
3571 Computers
3572 Computer Storage Devices
3575 Computer Terminals
3577 Computer Peripheral Equipment, N.E.C.
3578 Calculating & Accounting Machines
3579 Office Machines, N.E.C.
3581 Merchandising Machines-Automatic
3582 Laundry Equipment, Commercial
3585 Refrigeration & Heating Equipment
3586 Pumps, Measuring & Dispensing
3589 Machinery, Service Industry, N.E.C.
3592 Carburetors, Pistons, Rings, Valves
3593 Fluid Power Cylinders & Actuators
3594 Fluid Power Pumps & Motors
3596 Scales & Balances, Except Laboratory
3599 Machinery, Except Electrical, N.E.C. & Machine Shop Job Work

Electronic & Other Electrical Equipment & Components, Except Computer Equipment

3612 Transformers, N.E.C.
3613 Switchgear & Switchboard Apparatus
3621 Motors & Generators
3624 Carbon & Graphite Products
3625 Relays & Industrial Controls
3629 Electrical Industrial Apparatus, N.E.C.
3631 Cooking Equipment & Household
3632 Refrigerators & Freezers, Household
3633 Laundry Equipment, Household
3634 Housewares & Fans, Electric
3635 Vacuum Cleaners, Household
3639 Appliances, Household, N.E.C.
3641 Lamps, Electric
3643 Wiring Devices, Current-Carrying
3644 Wiring Devices, Noncurrent-Carrying
3645 Lighting Fixtures, Residential

Electronic & Other Electrical Equipment & Components, Except Computer Equipment (cont'd)

3646 Lighting Fixtures, Commercial & Industrial
3647 Lighting Equipment, Vehicular
3651 Audio & Video Equipment, Household
3661 Telephone & Telegraph Apparatus
3663 Radio & TV Broadcasting & Communications Equipment
3669 Communications Equipment, N.E.C.
3671 Electron Tubes
3672 Printed Circuit Boards
3674 Semiconductors & Related Devices
3675 Capacitors, Electronic
3676 Resistors, Electronic & Electric
3677 Coils & Transformers, Electronic
3678 Connectors, Electronic
3691 Batteries, Storage
3692 Batteries, Primary, Dry & Wet
3694 Engine Electrical Equipment
3695 Recording Media, Magnetic & Optical
3699 Electrical Equipment & Supplies, N.E.C.

Transportation Equipment

3711 Motor Vehicles & Car Bodies
3713 Truck & Bus Bodies
3714 Motor Vehicle Parts & Accessories
3715 Truck Trailers
3716 Motor-Homes
3721 Aircraft
3724 Aircraft Engines & Engine Parts
3728 Aircraft Equipment, N.S.C. Ground Support
3743 Railroad Equipment
3751 Motorcycles, Bicycles, & Parts
3761 Guided Missiles & Space Vehicles
3764 Space Propulsion Units & Parts
3769 Space Vehicle Equipment, N.E.C.
3792 Travel Trailers & Campers
3795 Tanks & Tank Components
3799 Transportation Equipment, N.E.C.

Measuring, Analyzing & Controlling Instruments; Photographic, Medical & Optical Goods; Watches & Clocks

3812 Search, Detection, Navigation, & Guidance Systems & Instruments
3821 Laboratory Apparatus & Furniture
3822 Environmental Controls
3823 Instruments, Measurement & Display Process Control
3824 Fluid Meters & Counting Devices
3825 Instruments To Measure Electricity

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PRIORITY POLLUTANTS

Metals

antimony
arsenic
beryllium
cadmium
chromium
copper
lead
mercury
nickel
selenium
silver
thallium
zinc

Volatile organic compounds

acrolein
acrylonitrile
benzene
carbontetrachloride
chlorobenzene
1.1-dichloroethane
1.2-dichloroethane
1.1.1-trichloroethane
1.1.2-trichloroethane
1.1.2-2-tetrachloroethane
chloroethane
2-chloroethylvinyl ether
chloroform
1.1-dichloroethylene
1.2-trans-dichloroethylene
1.2-dichloropropane
1.3-dichloropropylene
ethylbenzene
methylene chloride
methyl chloride
methyl bromide
bromoform
dichlorodifluoromethane
trichlorofluoromethane
dichlorobromomethane
chlorodibromomethane
tetrachloroethylene
toluene
trichloroethylene
vinyl chloride
bis (chloromethyl) ether

Base-neutral extractable organic compounds

acenaphthene
benzidine
1.2.4-trichlorobenzene
hexachlorobenzene
hexachloroethane
bis (2-chloroethyl) ether
2-chloronaphthalene
1.2-dichlorobenzene
1.3-dichlorobenzene
1.4-dichlorobenzene
3.3'-dichlorobenzidine
2.4-dinitrotoluene
2.6-dinitrotoluene
1.2-diphenylhydrazine
fluoranthene
4-chlorophenyl phenyl ether
4-bromophenyl phenyl ether
bis (2-chloroisopropyl) ether
bis (2-chloroethoxy) methane
hexachlorobutadiene
hexachlorocyclopentadiene
isophorone
naphthalene
nitrobenzene
N-nitrosodimethylamine
N-nitrosodiphenylamine
N-nitrosodi-n-propylamine
butyl benzyl phthalate
di-n-butyl phthalate
di-n-octyl phthalate
diethyl phthalate
dimethyl phthalate
benzo(a)anthracene
benzo(a)pyrene
3.4-benzofluoranthene
benzo(k)fluoranthene
chrysene
acenaphthylene
anthracene
benzo(ghi)perylene
fluorene
phenanthrene
dibenzo(a.h)anthracene
ideno(1.2.3-cd)pyrene
pyrene
bis (2-ethylhexyl) phthalate

1 6785

Attachment No 2

MISCELLANEOUS POLLUTANTS

Algicides
Aluminum
Ammonia
Banum
Boron
Bromide
Calcium
Cobalt
Cyanide
Fluonde
Formaldehyde
Hydrocarbons
Iodide
Iron
Magnesium
Manganese
Molybdenum
Phosphorus
Potassium
Radioactivity
Sodium
Solvents
Sulfate
Sulfide
Sulfite
Surfactants (MBAS)
Titanium
Tin
Vanadium

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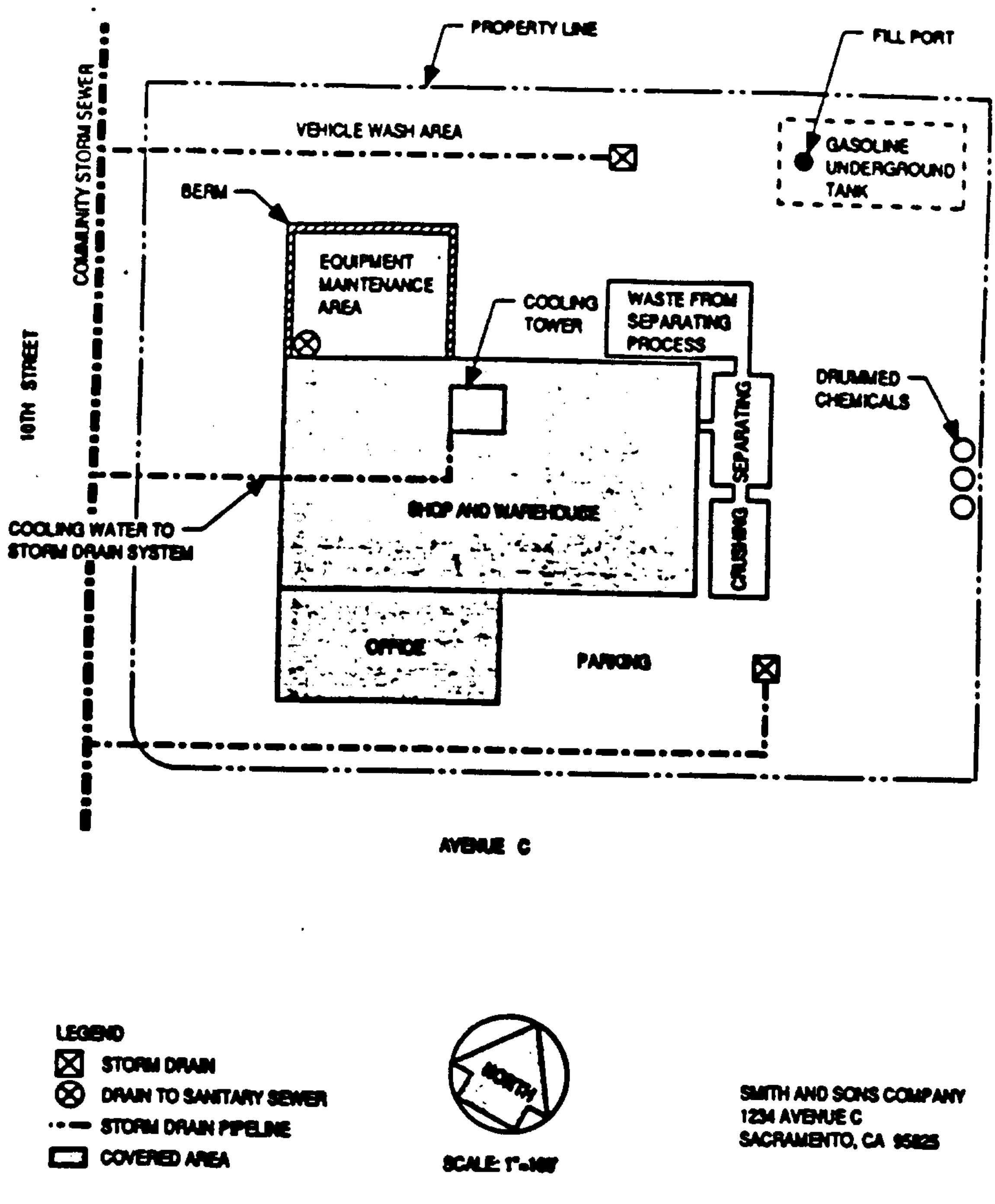
R0050091



SAMPLE SITE MAP

VOL 12

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R0050092

VOL 12

16788

Date: December 4, 1991

To: Tenants and Non-Tenants of the Long Beach Harbor District Included Under the Port's Stormwater Runoff Permit

From: Geraldine Knatz, Director of Planning

Subject: Guidelines for Preparation of a Stormwater Pollution Prevention Plan

As you are aware, the Port is preparing an application for a Stormwater Runoff Permit required by Federal and State Law. Inclusion is free to Port tenants and at a nominal charge to non-tenants. Our previous letter described in some detail the complex requirements of this new permit and the unique requirements within the Harbor District.

Because the permit requirements are new we are finding the enforcement agency, the Regional Water Quality Control Board (RWQCB), cannot answer all of our questions regarding implementation of the law. Nevertheless certain requirements are clear and the Port is moving ahead with its application.

The Port is currently providing the following services to you during this initial phase of permit application:

1. Meeting with the RWQCB to clarify issues related to individual industrial facilities in the Harbor District and how these facilities should be addressed in the National Pollution Discharge Elimination System (NPDES) permit.

2. Conducting a complete engineering/hydrology study in the Harbor District to define stormwater infrastructure and drainage patterns.

3. Obtaining physical and operational data on each facility and entering that data into a computer database.

4. Designing a monitoring plan for the Harbor District to meet the program's requirements.

5. Conducting "Year One" of the water quality monitoring and reporting program required under this permit.

These elements comprise approximately 90% of the permit requirements. The final permit element is a "Stormwater Pollution Prevention Plan" (plan) for each facility. This is a requirement that only the facility operator/owner can prepare. We are providing you with guidelines for the preparation of a plan for your facility (Enclosure). The State Water Quality Control Board has issued these guidelines which attempt to cover all types of industrial facilities. We have reviewed these guidelines and feel that some items may not be relevant to all facilities. We recommend that you develop a plan that addresses as many of the categories as possible. The Port will be happy to answer as many of your questions as we can. As we have indicated on the guidelines we can supply, at your request, a copy of the drainage pattern maps surrounding your facility.

A copy of your final "Stormwater Pollution Prevention Plan" must be submitted to ths Port no later than May 1, 1992. You will also be required to keep a copy on site so RWQCB representatives can review it upon request. If you have any questions at all please contact Dr. Robert Kanter at (213) 590-4156.

Cordially,

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Planning

RK:dp

VOL 12

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GUIDELINES FOR PREPARING A STORMWATER POLLUTION PREVENTION PLAN

A Stormwater Pollution Prevention Plan *(plan)* must be prepared by each facility covered by the Port's Non-Point Source (NPS) National Pollution Discharge Elimination System (NPDES) permit. The *plan* is required to include the Best Available Technology/Best Control Technology (BAT/BCT) to prevent contaminants from entering State waters.

The *plan* must be submitted to the Port and a copy must be retained on site. Plans kept on site may be inspected by representatives of the Regional Water Quality Control Board (RWQCB) and/or local agencies with jurisdiction over storm drains or water courses which receive stormwater discharge from the facility.

This *plan* may reflect requirements for Spill Prevention Control and Countermeasure of the Clean Water Act or Best Management Practices Programs and may incorporate any part of such plans into the Stormwater Pollution Prevention Plan. The RWQCB and/or local agencies may notify the facility operator if the minimum requirements for the *plan* are not met. After making the required changes the operator shall send *plan* modifications to RWQCB.

The facility operator must also amend the *plan* whenever there is a change in design, construction, operation, or maintenance which has a significant effect on the potential for the discharge of pollutants to surface waters or the local agency's storm drain system. The *plan* may also have to be amended if the facility has not attained compliance with current water quality control standards.

The *plan* shall include, at a minimum, the following items:

** a. A topographic map (or other map if a topographic map is unavailable), extending one-quarter mile beyond the property boundaries of the facility, showing the facility, springs, other surface water bodies, and drinking water wells listed in public records or otherwise known to the discharger.

b. A site map showing:

** (1) All drainage and discharge structures;

** (2) An outline of the tributary drainage areas for each discharge point;

(3) Paved areas and buildings;

(4) Past and present areas of potential pollutant contact;

(5) Existing pollutant controls;

(6) Surface water locations;

(7) Areas of existing or potential soil erosion.

c. Description of significant potential sources of pollutants in stormwater discharges and identification of any dry-weather pollutant discharge locations including:

(1) Loading/unloading liquids or dry bulk materials;

(2) Any outdoor storage of raw materials, intermediate products, or finished products;

(3) Outdoor process activities, and any activities which generate dust or particulates;

(4) Illicit connections or management practices; and

(5) Waste disposal practices.

d. A listing of all chemicals which may contact stormwater and estimates of concentrations in the stormwater runoff;

e. An estimate of the area of impervious surfaces (including paved area and building roofs) within each drainage area;

f. Source controls, such as covering of pollutant areas, sweeping of paved areas, containment of potential pollutants, etc.;

g. Isolation/separation of industrial from non-industrial pollutant sources so that runoff from these areas do not mix;

h. Treatment/conveyance structures such as drop inlets, channels, retention/detention basins, treatment vaults, infiltration galleries, filters, oil/water separators, etc., and the effect of any of these on groundwater quality;

i. Design criteria for the structures/conveyances;

j. Maintenance schedules including inspection and testing for failure;

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k. Spill prevention and response procedures, staff training and responsibilities;

l. Ercsion control measures such as riprap, revegetation, slope stabilization, etc.;

m. An estimate of pollutant reduction levels expected from implementing the controls and how the discharge will meet effluent limits (if any) and water quality objectives;

n. Creation of a Stormwater Pollution Prevention Committee. Name the specific individuals within the organization who are responsible for developing the *Plan* and assisting the Plan Manager in its implementation, maintenance and revision;

o. Creation of employee training programs to inform personnel at all levels of responsibility of the components and goals of the *Plan*. Training should address topics such as spill response, good housekeeping and material management practices. The *Plan* shall identify periodic dates for such training.

p. Identification and training of qualified plant personnel to inspect equipment and plant areas, including any stormwater control facilities. Material handling areas shall be inspected for evidence of or the potential for pollutants entering the waters of the State. A tracking and follow-up procedure shall be described to ensure that adequate response and corrective actions have been taken in response to the inspection. Records of inspections shall be maintained.

q. Establishment of internal record keeping and internal reporting procedures;

r. Provision for inspections of sufficient frequency to ensure continued compliance with this Order.

** Items the Port can supply to you upon request.

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16792

The Port of Long Beach

VOL 12

DATE: April 29, 1992

TO: Tenants and Non-Tenants Preparing Storm Water Pollution Prevention Plans

FROM: Geraldine Knatz, Director of Planning

SUBJECT: Drainage Maps

Enclosed please find copies of your facility's Storm Water Pollution Prevention Plan drainage maps. They fulfill the drainage and area boundary requirements (part a. and parts b. 1 & 2) listed in the guidelines that we sent to help you prepare your plan. We have done our best to select maps for your site that meet guideline requirements that the area covered should extend, where possible, one-quarter mile from your facility's boundaries. If you see from the legend that other maps are available that would improve your plan, please contact our office to request them.

The Port of Long Beach submitted its Notice of Intent (NOI) to the Regional Water Quality Control Board (RWQCB) on March 30, 1992. Board staff is now in the process of reviewing that information. Unless we receive further instructions from the RWQCB, the only remaining obligations of the Port's tenants and non-tenants included in the NOI are to complete a comprehensive Storm Water Pollution Prevention Plan (SWPPP) and follow that plan in daily facility operations.

At the end of the program's first year we will send you a reminder to update your SWPPP, including any changes in chemicals used, storage facilities, facility layout, or staff training procedures. The Port will be investigating, and passing on to you, Best Management Practices (BMP) for preventing storm water pollution. If you develop any interesting pollution reduction ideas we would like to hear about them. By sharing innovations we can promote cleaner, safer coastal waters.

If you would like to suggest control techniques, need to request additional maps, or have any questions regarding your plan, please contact Darcelle Pruitt at (310) 590-4160.

Sincerely,

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Planning

DP:a

Enclosures

1
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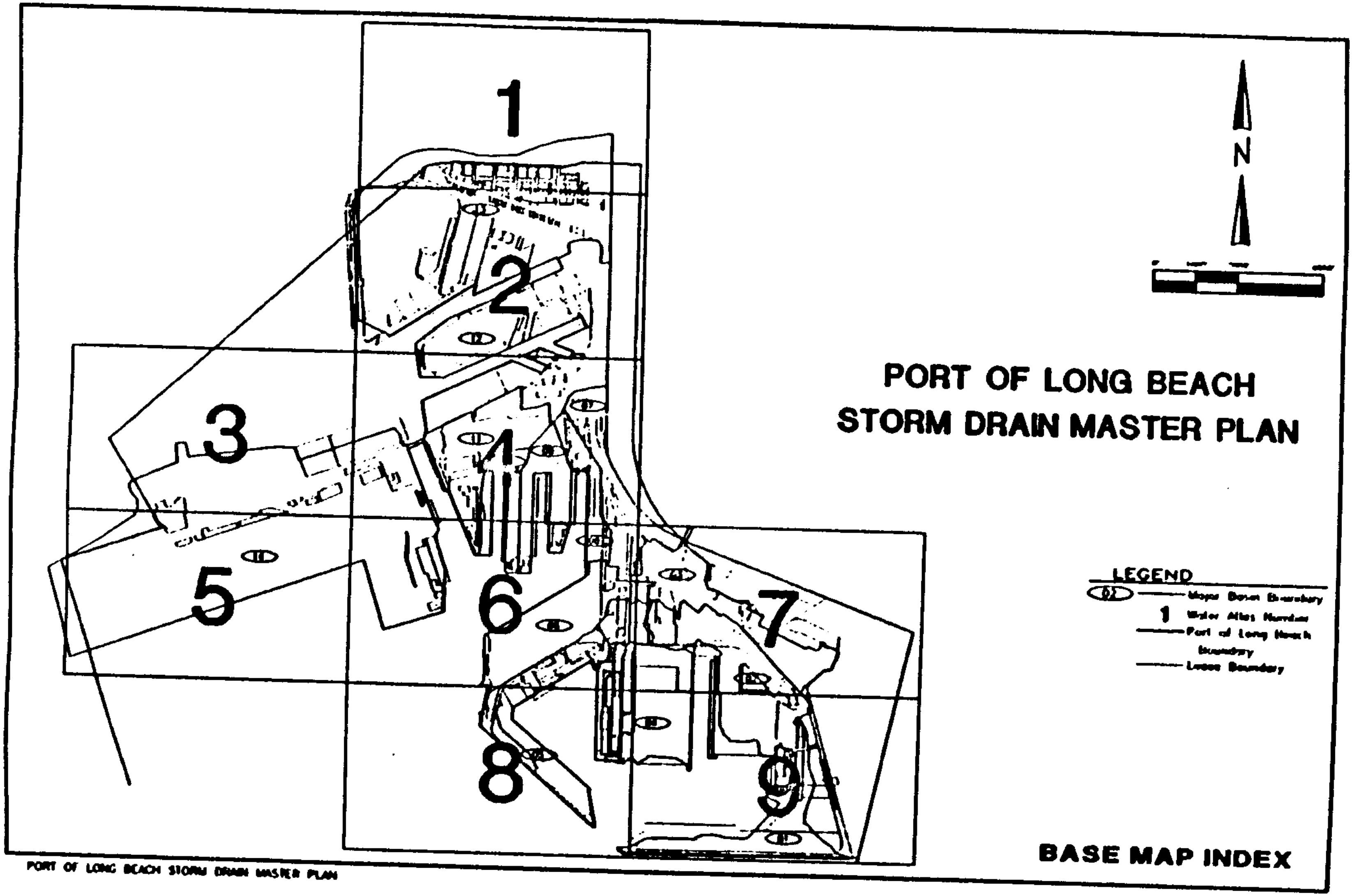
PORT OF LONG BEACH
STORM DRAIN MASTER PLAN
BASE MAP INDEX
N
LEGEND
1
2
3
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5
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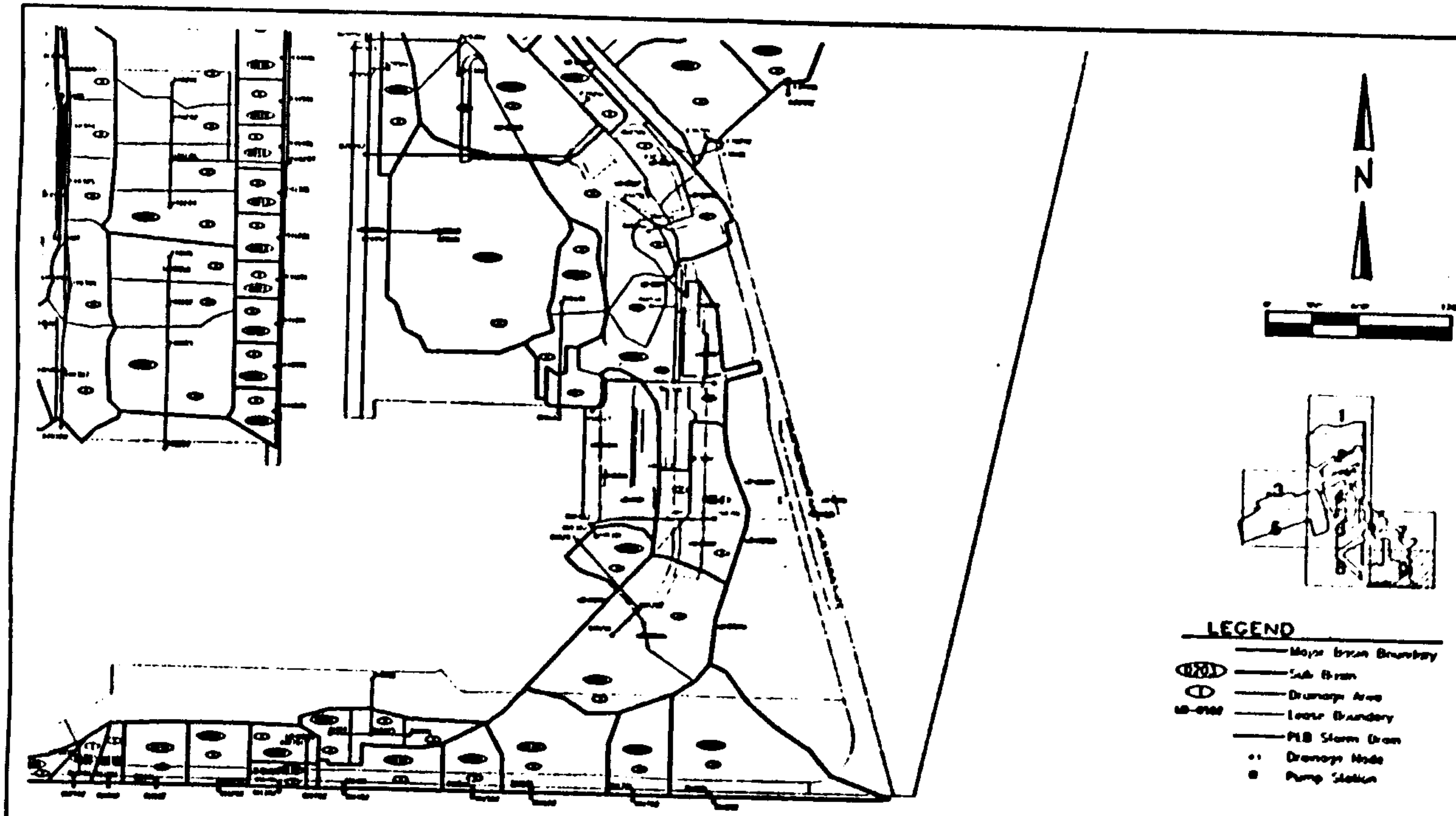
7
8
9



INDUSTRIAL FACILITY / DRAINAGE MAP
Sheet 8

The Port of Long Beach
"America's most Modern Port"
P O BOX 570 · LONG BEACH, CA 90801-0570 · TELEPHONES (310) 437-0041 · FAX (310) 437-3231 · TELEX 65-6452 PORTOBEACH LGB

VOL 12

Date: May 20, 1992

To: Storm Water Program Participants

From: Geraldine Knatz, Director of Port Planning

Subject: Storm Water Pollution Prevention Plan

The Port's May 1st target date for the completion of your facility's Storm Water Pollution Prevention Plan has come and gone, but we have not received any documentation from you that fulfills the State of California's Storm Water Pollution Prevention Plan (SWPPP) requirements.

The Port has already accepted much of the responsibility necessary for successfully completing the State's mandated program. However, the things we have asked you to prepare require site-specific information about operations of your facility, that only you can provide. Accordingly, you need to proceed with the preparation of the SWPPP. The Port has provided the Regional Water Quality Control Board (RWQCB) with a list of facilities included under our storm water permit. We will also provide them with a list of Pollution Prevention Plans on file with us which correspond to the named facilities. Those facilities which have not provided the Port with an SWPPP will be listed separately. The Port, because of its size, fully expects an audit by the RWQCB. We want all facilities in compliance before such an audit occurs.

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Since enforcement is likely to include fines for non-compliance, we wish to emphasize that you must complete a Storm Water Pollution Prevention Plan as soon as possible, and submit it to the Port no later than June 15, 1992. If you need additional help in completing your plan, please call Darcelle Pruitt at (310) 590-4160.

Sincerely,

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Port Planning

RK:dp

R0050101

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VOL 12

Date: August 27, 1992

To: Storm Water Program Participants

From: Geraldine Knatz, Director of Planning

Subject: Storm Water Pollution Prevention Plan

Thank you for your interest in the Port's Storm Water Pollution Prevention Program. We are approaching the State's October 1, 1992 Storm Water Pollution Prevention Plan (SWPPP) implementation date. After that date, facilities without a SWPPP in place can be inspected and fined by the State Water Resources Control Board (SWRCB) or the Regional Water Quality Control Board (RWQCB).

As you know, the Port has been offering assistance to program participants to help them comply with the State's storm water requirements. Thus far, response to the Port's program has been very good, but we are still concerned that not all participants have an adequate SWPPP at the facility and on file with the Port. Our records show that your facility:

0 needs to submit SWPPP

0 needs to make substantial revisions to its SWPPP (please revise per attached guidelines)

0 needs to make suggested revisions to its SWPPP

0 needs to submit final SWPPP for Port files

Please submit the necessary material by September 5, 1992. The Port will then integrate your SWPPP into our files for the SWRCB and RWQCB should they decide to visit the Port after October 1, 1992.

At the end of the program's first year the Port will be providing you with an update of recent developments in Best Management Practices (BMP) for preventing storm water pollution and we will conduct a site visit to review adherence to your SWPPP. We will also discuss updates to your SWPPP, including any changes in personnel responsibilities, chemicals used, storage facilities, facility layout, or staff training procedures. If you develop any interesting pollution reduction ideas we would like to hear about them so we can share them with others.

If you have any questions, please contact Darcelle Pruitt at (310) 590-4160.

Sincerely,

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Planning

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VOL 12

Date: August 28, 1992

To: Storm Water Program Participants

From: Geraldine Knatz

Subject: Storm Water Pollution Prevention Plan

Thank you for submitting your facility's Storm Water Pollution Prevention Plan (SWPPP). We have reviewed your document and believe it meets the Regional Water Quality Control Board's SWPPP requirements. We are very pleased with the results of your efforts. Now that you have a complete document you should begin implementing your best management practices for controlling storm water pollution.

At the end of the program's first year the Port will be providing you with an update of recent developments in Best Management Practices (BMP) for preventing storm water pollution and we will conduct a site visit to review adherence to your SWPPP. We will also discuss updates to your SWPPP, including any changes in personnel responsibilities, chemicals used, storage facilities, facility layout, or staff training procedures. If you develop any interesting pollution reduction ideas we would like to hear about them so we can share them with others.

If you have any questions, please contact Darcelle Pruitt at (310) 590-4160.

Sincerely,

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Planning

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VOL 12

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DATE: November 25, 1992

TO: Interested Parties

FROM: Geraldine Knatz, Director of Planning

SUBJECT: Request for Proposal to Conduct Non Point Source Run-off Water Quality Monitoring

INTRODUCTION

The Port of Long Beach in compliance with the California National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Industrial Activities will be conducting water quality monitoring for non point source discharges throughout the Harbor District.

A. SCOPE OF SERVICES

Qualified firms are invited to submit proposals to provide water quality monitoring services.

The monitoring program will include two years of field observations, field sampling, laboratory analyses, and reporting. The analytical techniques utilized will be identical at each station (Figure 1). However, the variables analyzed at each station differ, because the industrial activities which may contribute to the input differ from one area of the Harbor to another.

1. Establish Station Coordinates

On or prior to the first storm water monitoring event establish station locations with suitable navigation equipment so that the visits will be repeatable and accurate to within 5 meters (~15 feet). Pre and Post calibration logs for all field equipment shall be maintained during the contract period by the contractor. These logs shall be made available upon request to the Port or their designated representative for review.

2. Sampling Frequency

Wet Season Sampling - Collection and analysis of grab water samples of storm water discharges within 30 minutes of one significant storm event for the first year and two significant (continuous discharge of storm water for approximately one hour or more) storm events for the second year that are preceded by at least three working days of dry weather. If collection of the sample during the first 30 minutes is impracticable, the sample will be taken as soon as practicable thereafter, and documentation must be provided explaining why the sample could not be taken in the first 30 minutes.

Dry Season Sampling - Collection and analysis of water samples will take place once during the dry season. All stations and variables monitored during the wet season will be repeated during the dry season. Results will be compared with those obtained during the wet season.

3. <u>Field Sampling and Observations</u>

a. During each sampling event and at each station the following observations will be recorded:

- Measure or estimate of storm water discharged from surface runoff and storm drains;
- Observed flows or discharges from storm drains or paved surfaces;
- Presence or discharge of floating material;
- Presence or discharge of oil and grease on water surface; and
- Presence of any odors adjacent to the sampling station.

b. Two water samples will be collected at each station, resulting in a total of 40 samples (plus 10% QA/QC) for the entire sampling area during each sampling episode. Each sample will consist of a "Grab Sample" collected within one meter of the surface. All sampling and sample preservation will be in accordance with the current edition of "Standard Methods for the Examination of Water and Wastewater" (American Public Health Association), including the use of appropriate non-contaminating sampling apparatus and sample holding glassware which is compatible with the subsequent chemical analyses to be performed. Table 1 shows specific analyses required at each station. All analyses will be conducted in a laboratory certified for such analyses by the State Department of Health Services. Analytical techniques will follow those listed in 40 CFR Part 136. Analytical results will be reported in appropriate units along with detection limits as appropriate.

4. <u>Laboratory Analyses and Quality Assurance</u>

a. A minimum of 10% of all samples will be re-analyzed and compared with the original analytical results for Quality Control. In addition, a minimum of two "blind spiked" synthetic seawater samples with known contaminant levels will be analyzed to ensure instrument accuracy.

5. <u>Accessory Data</u>

Collect historic and current data from facilities that have NPDES permits with or without storm water requirements. Compare historic data with data collected during this program. These facilities include Dow Chemical U.S.A., Atlantic Richfield Corporation, County of Los Angeles Department of Public Works, the Southern California Edison Company, and others (names to be provided by the Port).

6. <u>Reporting</u>

Storm water monitoring reports will be submitted to the Planning Division in draft form by tha prime contractor within 21 days following the sampling period. The following information will be reported for each sampling period:

a. The date, exact location, and time of sampling, observations, and/or measurements;

b. The individual(s) who performed the sampling, observations, and/or measurements;

c. Flow measurements or estimates based on calculations tied to the storm event;

d. The date(s) and times the laboratory analyses were performed;

e. The individual(s) who performed the analyses;

f. The analytical techniques or methods used and the results of such analyses;

g. Quality assurance/quality control results;

h. Non-storm water discharge records; and

i. All calibration and maintenance records of instruments used.

j. Brief narrative comparing point source data from No. 5 above with data from comparable water areas in the Port.

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B. GENERAL PROPOSAL INFORMATION AND CONTENT

1. Proposal Content

- A summary of the firm's and any subcontractor's experience in conducting water quality monitoring surveys.
- A description of the technical approach to conducting the monitoring surveys including a project schedule.
- Resumes and qualifications of all technical personnel who would be assigned to the conduct the surveys, perform laboratory analyses, and evaluate the results.
- A summary of the firm's project management system. The proposed Project Manager and Project Principal should be clearly designated, and the organization of a typical project team, including lines of communication and responsibility, should be described.
- A detailed cost breakdown for each task including staff costs by labor category, equipment and other direct costs, and a schedule of overhead, indirect, general and administrative costs and fees.

2. Insurance Requirements

Firms are advised that the selected consultant will be required to provide and maintain insurance coverage with limits no less than:

a. General Liability: $1,000,000 per occurrence for bodily injury, personal injury, and property damage. If Commercial General Liability Insurance or other form with a general aggregate limit is used, either the general aggregate limit shall apply separately to this project/location or the general aggregate limit shall be twice the required occurrence limit.

b. Automobile Liability: $1,000,000 per accident for bodily injury and property damage.

c. Ocean Marine Liability with Protection and Indemnity: $1,000,000 per accident for bodily injury and property damage.

d. Employer's Liability: $1,000,000 per accident for bodily injury.

e. Professional Liability: $1,000,000 per claim.

Proof of insurance coverage must be provided by insurance endorsement forms or a certified copy of policy which names the Port of Long Beach as coinsured.

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C. EVALUATION FACTORS

Proposals shall be a maximum of 15 pages in length and will be evaluated on a 100-point basis as follows:

1. <u>Criteria</u>

Criteria	Points
Corporate Experience (including subcontractors)	20
Staff Qualifications (including subcontractors)	30
Technical Approach/Understanding of the Program	30
Management Approach/System	10
Cost	10

To be eligible for consideration, cost proposal must be clear, accurate, and complete as regards to the requirements set forth above. Proposal will be evaluated to determine the bidder's understanding of the program and ability to respond realistically to this request.

D. SUBMISSION OF PROPOSALS

Five copies of the proposal are due no later than 4:30 p.m. on December 15, 1992. Proposals may be mailed or hand delivered to:

Planning Division
Port of Long Beach
925 Harbor Plaza
Long Beach, CA 90802

Hand-carried proposals must be delivered to the offices of the Planning Division on the 4th floor.

If you have any questions concerning this solicitation, please contact Ms. Stacey Crouch, at (310) 590-4160.

Sincerely,

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Planning

SEC:s

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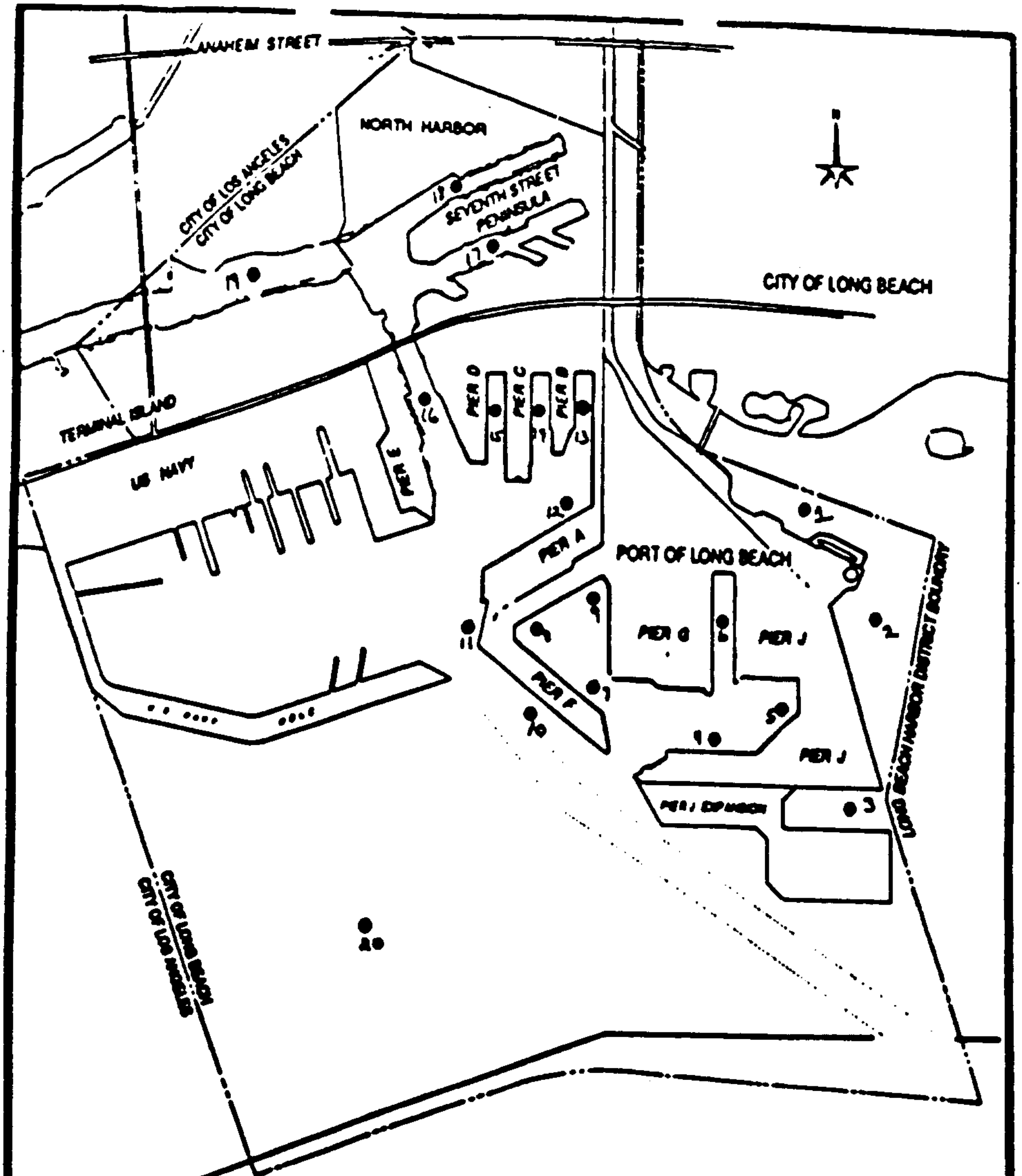

MONITORING STATIONS

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FIGURE 1

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TABLE 1

NON POINT SOURCE MONITORING PLAN
PARAMETERS TABLE

STATION	PARAMETERS
1	pH[1], TSS[1], SC[1], TOC[1], TRPH[2], BTXE[3], ICAP[4] Scan, MBAS[5]
2	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan, MBAS
3	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan
4	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan, MBAS
5	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan, MBAS
6	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan, MBAS
7	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan
8	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan
9	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan, Sulfides
10	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan
11	pH, TSS, SC, TOC, TRPH
12	pH, TSS, SC, TOC, TRPH
13	pH, TSS, SC, TOC, TRPH, BTXE, MBAS
14	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan
15	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan
16	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan
17	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan, F001 - F005 Series[6]
18	pH, TSS, SC, TOC, TRPH, BTXE, ICAP Scan, F001 - F005 Series
19	pH, TSS, SC, TOC, TRPH
20	pH, TSS, SC, TOC, TRPH

1. State Required Parameters
2. Total Recoverable Petroleum Hydrocarbons (EPA 418.1)
3. Benzene, Toluene, Xylenes, Ethylbenzene (mod 602)
4. Inductively Coupled Argon Plasma (6010) - Metals
5. Methyl Blue Active Substance - Surfactants
6. Solvents

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DATE: April 5, 1993

TO: Interested Persons

FROM: Geraldine Knatz, Director of Planning

SUBJECT: Annual Site Inspection/Best Management Practice Guidelines

Last year the Port, with your help, embarked on a very progressive program to comply with the Environmental Protection Agency's Storm Water Pollution Control requirement, which is part of the nation's Clean Water Act. When my staff met with you during the preparation of your Storm Water Pollution Prevention Plan (SWPPP), we indicated that yearly updates and compliance checks would be necessary. The law requires us, as the permit holder, to self monitor and to report our findings yearly. In addition, the law requires everyone in the program to adopt Best Management Practices (BMPs) to control storm water pollution.

This spring, in accordance with those permit requirements, we will conduct the first annual site inspection of our Storm Water Program participant's facilities. The purpose of the inspection is to verify that your facility is following its SWPPP and to suggest modifications to the SWPPP if necessary. We plan to conduct the inspections in April and May. A Port staff member will contact you soon to schedule the site visit.

In addition, as a service to facility participants, the Port is currently preparing a compendium of storm water BMPs. A copy of those BMPs will be distributed to you when it becomes available. The guidelines will provide you with an array of source controls and treatment technologies that may help your facility meet the Storm Water Pollution Control objectives. These guidelines should also be used to evaluate the effectiveness of the BMPs that you have already identified in your SWPPP.

If you have any questions, please contact Stacey Crouch, Project Manager, at (310) 590-4160.

Sincerely,

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Planning

SECs

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COMPENDIUM OF
STORM WATER
BEST MANAGEMENT PRACTICES (BMPs)

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BEST MANAGEMENT PRACTICES GUIDELINES

The techniques described below provide guidance in developing and implementing best management practices (BMPs) for storm water pollution control at industrial sites and commercial facilities. The techniques in these guidelines will provide you with several alternatives for addressing the requirements of the Clean Water Act and helping you comply with state water quality requirements.

WHAT ARE BMPs?

Federal law requires that industrial storm water discharges meet all provisions of Sections 301 and 402 of the Clean Water Act (CWA) in order to control pollutant discharges. These provisions require the use of best available technology (BAT) economically available and best conventional pollution control technology (BCT) to reduce pollutants to meet water quality standards.

The State of California has interpreted Federal regulations to include both the use of BMPs (to control or eliminate sources of pollutants in storm water) and limitations on the discharge of polluted non-storm water. The State defines BMPs as schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States.

SELECTING BMPs

From a water quality standpoint there are generally two reasons to implement Best Management Practices. The first is to protect existing water quality from future degradation, the second is to correct existing water quality problems.

Source control BMPs are the best solution for protecting existing water quality. Source control BMPs are operational practices that prevent pollution by reducing potential pollutants at the source. Treatment control BMPs, on the other hand, are methods of treatment to remove pollutants from storm water. In general, treatment control BMPs do not need to be introduced unless source control BMPs fail to reduce or eliminate pollutants. On the other hand, if an owner/operator is considering improvements to a facility, all appropriate and feasible alternatives should be incorporated into the facility's design and operation.

Your choice of BMPs for your facility will be most effective if you employ a step-wise decision-making process:

Step 1: Identify Activities and Existing BMP Controls

You should first identify the activities at your facility that could cause water pollution, and note their locations. You probably already use BMPs, but some may need "tightening up" to achieve their full effectiveness.

Step 2: Identify Potential Remedies for Non-Storm Discharges

Resolving non-storm water discharges has first priority. Non-storm water discharges to storm water collection systems must be either eliminated or permitted under a separate NPDES permit.

Step 3: Identify Readily Applicable Source Control BMPs

Low and modest cost BMPs, many of which are probably already in place at your facility, will usually satisfy permit requirements. For example, proper housekeeping practices are often all that is needed to provide effective source control.

Step 4: If Necessary, Consider More Substantial Control BMPs

If the BMPs identified in Step 3 still leave areas of significant pollution, or if you are required to meet numeric effluent limits, then you should consider more substantial source control BMPs. For example, you might cover a large exposed activity area to eliminate runoff.

You should also consider whether treatment control BMPs may be less expensive than elaborate source control BMPs.

Step 5: Prepare BMP List and Set Priorities

List the BMPs you have identified as necessary to achieve compliance. Make sure the BMP list meets the minimum requirements specified in the general permit. Then, decide which BMPs to implement first, and include them in your SWPPP.

SOURCE CONTROL OR TREATMENT TECHNOLOGIES?

Source control BMPs are preferred because (1) they are generally 100% effective if implemented properly; and (2) they are generally less expensive than treatment control BMPs. Treatment technology BMPs, on the other hand, are rarely 100% effective, even if maintained and operated properly.

The following two sections present analyses, compiled for the Storm Water Quality Task Force, of source control measures and treatment technologies. This material may help you to formulate appropriate measures for your facility. For source control, each BMP is keyed

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to a specific industrial activity, and describes recommended management practices to control waste from that activity. The second section presents several treatment technologies appropriate for reducing pollutants in storm water.

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SOURCE CONTROL BMPs

Excerpts from
California Storm Water Best Management Handbook
March 1993

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INTRODUCTION

This chapter describes specific source control Best Management Practices (BMPs) for common industrial activities that may pollute storm water. Chapter 2 led you through the steps of identifying activities at your facility that can pollute storm water while Chapter 3 provided guidance on selection of BMPs. This chapter provides you with the BMPs that best fill your facility's need. Best management practices for each of the activities shown below are provided in the following fact sheets.

Each fact sheet contains a cover sheet with:

- A description of the BMP
- Approach
- Requirements
  - Cost, including capital costs, and Operation and Maintenance (O&M)
  - Maintenance (including administrative and staffing)
- Limitations

The side bar presents information on where this BMP applies, targeted constituents, and an indication of the level of effort and cost to implement.

Further information is also provided in additional sheets. This information includes a more detailed description of the BMP, requirements to implement, examples of effective programs, and references.

BMPs are provided for each of the following industrial activities consistent with Worksheet 4 in Chapter 2.

Industrial Activities Requiring BMPs

- **SC1** Non-Storm Water Discharges to Drains
- **SC2** Vehicle and Equipment Fueling
- **SC3** Vehicle and Equipment Washing and Steam Cleaning
- **SC4** Vehicle and Equipment Maintenance and Repair
- **SC5** Outdoor Loading/Unloading of Materials
- **SC6** Outdoor Container Storage of Liquids
- **SC7** Outdoor Process Equipment Operations and Maintenance
- **SC8** Outdoor Storage of Raw Materials, Products, and By-Products
- **SC9** Waste Handling and Disposal
- **SC10** Contaminated or Erodible Surface Areas
- **SC11** Building and Grounds Maintenance
- **SC12** Building Repair, Remodeling, and Construction
- **SC13** Over-Water Activities
- **SC14** Employee Training

Fact sheet SC14, Employee Training, is a compilation of the training aspects of the individual source control fact sheets. Its purpose is to facilitate the integration and development of a comprehensive training program for all industrial activities at a facility.

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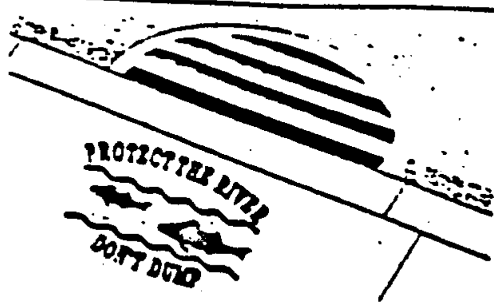
ACTIVITY: NON-STORM WATER DISCHARGES TO DRAINS



Applications

- Manufacturing
- Material Handling
- Vehicle Maintenance
- Construction
- Commercial Activities
- Roadways
- Waste Containment
- Housekeeping Practices

DESCRIPTION

Eliminate non-storm water discharges to the storm water collection system. Non-storm water discharges may include: process wastewaters, cooling waters, wash waters, and sanitary wastewater.

APPROACH

The following approaches may be used to identify non-storm water discharges:

- Visual Inspection
  - The easiest method is to inspect each discharge point during dry weather.
  - Keep in mind that drainage from a storm event can continue for three days or more and groundwater may infiltrate the underground storm water collection system.
- Piping Schematic Review
  - The piping schematic is a map of pipes and drainage systems used to carry wastewater, cooling water, sanitary wastes, etc.
  - A review of the "as-built" piping schematic is a way to determine if there are any connections to the storm water collection system.
  - Inspect the path of floor drains in older buildings.
- Smoke Testing
  - Smoke testing of wastewater and storm water collection systems is used to detect connections between the two systems.
  - During dry weather the storm water collection system is filled with smoke and then traced to sources. The appearance of smoke at the base of a toilet indicates that there may be a connection between the sanitary and the storm water system.
- Dye Testing
  - A dye test can be performed by simply releasing a dye into either your sanitary or process wastewater system and examining the discharge points from the storm water collection system for discoloration.

REQUIREMENTS

Costs (Capital, O&M)

- Can be difficult to locate illicit connections especially if there is groundwater infiltration.

LIMITATIONS

- Many facilities do not have accurate, up-to-date schematic drawings.
- TV and visual inspections can identify illicit connections to the storm sewer, but further testing is sometimes required (e.g. dye, smoke) to identify sources.

Targeted Constituents

- ○ Sediment
- ● Nutrients
- ● Heavy Metals
- ● Toxic Materials
- ◐ Floatable Materials
- ● Oxygen Demanding Substances
- ● Oil & Grease
- ● Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ◐ Capital Costs
- ○ O&M Costs
- ○ Maintenance
- ◐ Training

● High ○ Low

SC1

Best Management Practices

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Additional Information — Non-Storm Water Discharges to Drains

Facilities subject to storm water permit requirements must include a certification that the storm water collection system has been tested or evaluated for the presence of non-storm water discharges. The State's General Industrial Storm Water Permit requires that non-storm water discharges be eliminated prior to implementation of the facility's SWPPP.

Non-storm water discharges to the storm water collection system may include any water used directly in the manufacturing process (process wastewater), air conditioning condensate and coolant, non-contact cooling water, cooling equipment condensate, outdoor secondary containment water, vehicle and equipment wash water, sink and drinking fountain wastewater, sanitary wastes, or other wastewaters. Table 4.1 presents disposal option information for specific types of wastewaters.

To ensure that the storm water system discharge contains only storm water, industry should:

- Locate discharges to the municipal storm sewer system or waters of the United States from the industrial storm sewer system from:
  - "as-built" pipeline schematics, and
  - visual observation (walk boundary of plant site).
- Locate and evaluate all discharges to the industrial storm sewer system (including wet weather flows) from:
  - "as-built" pipeline schematics,
  - visual observation,
  - dye tests,
  - TV camera,
  - chemical field test kits, and
  - smoke tests.
- Develop plan to eliminate illicit connections:
  - replumb sewer lines,
  - isolate problem areas, and
  - plug illicit discharge points.
- Develop disposal options.
- Document that non-storm water discharges have been eliminated by recording tests performed, methods used, dates of testing, and any on-site drainage points observed.

REFERENCES

General Industrial Storm Water Permit, SWRCB, 1992.

NPDES General Permit for Discharges of Storm Water Associated with Industrial Activity in Santa Clara County to South San Francisco Bay or its Tributaries, SFBRWQCB, 1992.

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 832-R-92-006, USEPA, 1992.

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SC1

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TABLE 4.1 QUICK REFERENCE - DISPOSAL ALTERNATIVES

(Adopted from Santa Clara County Nonpoint Source Pollution Control Program - December 1992)

All of the waste products on this chart are prohibited from discharge to the storm drain system. Use this matrix to decide which alternative disposal strategies to use. **ALTERNATIVES ARE LISTED IN PRIORITY ORDER.**

Key:
- HHW — Household hazardous waste (Government-sponsored drop-off events)
- POTW — Publically Owned Treatment Plant
- Reg.Bd. — Regional Water Quality Control Board (Oakland)

"Dispose to sanitary sewer" means dispose into sink, toilet, or sanitary sewer clean-out connection.
"Dispose as trash" means dispose in dumpsters or trash containers for pickup and/or eventual disposal in landfill.
"Dispose as hazardous waste" for business/commercial means contract with a hazardous waste hauler to remove and dispose.

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	BUSINESS/COMMERCIAL Approval	RESIDENTIAL Disposal Priorities
General Construction and Painting; Street and Utility Maintenance			
Excess paint (oil-based)	1. Recycle/reuse. 2. Dispose as hazardous waste.		1. Recycle/reuse. 2. Take to HHW drop off
Excess paint (water-based)	1. Recycle/reuse. 2. Dry residue in cans, dispose as trash. 3. If volume is too much to dry, dispose as hazardous waste.		1. Recycle/reuse. 2. Dry residue in cans, dispose as trash 3. If volume is too much to dry, take to HHW drop off
Paint cleanup (oil-based)	Wipe paint out of brushes, then: 1. Filter & reuse thinners, solvents. 2. Dispose as hazardous waste.		Wipe paint out of brushes, then: 1. Filter & reuse thinners, solvents 2. Take to HHW drop off
Paint cleanup (water-based)	Wipe paint out of brushes, then: 1. Rinse to sanitary sewer.		Wipe paint out of brushes, then: 1. Rinse to sanitary sewer.
Empty paint cans (dry)	1. Remove lids, dispose as trash.		1. Remove lids, dispose as trash
Paint stripping (with solvent)	1. Dispose as hazardous waste.		1. Take to HHW drop off.
Building exterior cleaning (high-pressure water)	1. Prevent entry into storm drain and remove offsite 2. Wash onto dirt area, spade in 3. Collect (e.g. mop up) and discharge to sanitary sewer	POTW	
Cleaning of building exteriors which have **HAZARDOUS MATERIALS** (e.g. mercury, lead) in paints	1. Use dry cleaning methods *** 2. Contain and dispose washwater as hazardous waste (Suggestion: dry material first to reduce volume)		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
General Construction and Painting; Street and Utility Maintenance (cont'd)			
Non-hazardous paint scraping/ sand blasting	1. Dry sweep, dispose as trash		1. Dry sweep, dispose as trash
HAZARDOUS paint scraping/sand blasting (e.g. marine paints or paints containing lead or tributyl tin)	1. Dry sweep, dispose as hazardous waste		1. Dry sweep, take to HHW drop-off
Soil from excavations during periods when storms are forecast	1. Should not be placed in street or on paved areas 2. Remove from site or backfill by end of day 3. Cover with tarpaulin or surround with hay bales, or use other runoff controls 4. Place filter mat over storm drain Note: Thoroughly sweep following removal of dirt in all four alternatives.		
Soil from excavations placed on paved surfaces during periods when storms are not forecast	1. Keep material out of storm conveyance systems and thoroughly remove via sweeping following removal of dirt		
Cleaning streets in construction areas	1. Dry sweep and minimize tracking of mud 2. Use silt ponds and/or similar pollutant reduction techniques when flushing pavement		
Soil erosion, sediments	1. Cover disturbed soils, use erosion controls, block entry to storm drain. 2. Seed or plant immediately.		
Fresh cement, grout, mortar	1. Use/reuse excess 2. Dispose to trash		1. Use/reuse excess 2. Dispose as trash
Washwater from concrete/mortar (etc.) cleanup	1. Wash onto dirt area, spade in 2. Pump and remove to appropriate disposal facility 3. Settle, pump water to sanitary sewer	POTW	1. Wash onto dirt area, spade in 2. Pump and remove to appropriate disposal facility 3. Settle, pump water to sanitary sewer
Aggregate wash from driveway/patio construction	1. Wash onto dirt area, spade in 2. Pump and remove to appropriate disposal facility 3. Settle, pump water to sanitary sewer	POTW	1. Wash onto dirt area, spade in 2. Pump and remove to appropriate disposal facility 3. Settle, pump water to sanitary sewer

Table 4-1 (Continued)
Page 3

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
General Construction and Painting; Street and Utility Maintenance (cont'd)			
Rinsewater from concrete mixing trucks	1. Return truck to yard for rinsing into pond or dirt area 2. At construction site, wash into pond or dirt area		
Non-hazardous construction and demolition debris	1. Recycle/reuse (concrete, wood, etc.) 2. Dispose as trash		1. Recycle/reuse (concrete, wood, etc. 2. Dispose as trash
Hazardous demolition and construction debris (e.g. asbestos)	1. Dispose as hazardous waste		1. Do not attempt to remove yourself. Contact asbestos removal service for safe removal and disposal 2. Very small amounts (less than 5 lbs) may be double wrapped in plastic and taken to HHW drop off
Saw cut slurry	1. Use dry cutting technique and sweep up residue 2. Vacuum slurry and dispose off-site. 3. Block storm drain or berm with low weir as necessary to allow most solids to settle. Shovel out gutters; dispose residue to dirt area, construction yard or landfill		
Construction dewatering (Nonturbid, uncontaminated groundwater)	1. Recycle/Reuse 2. Discharge to storm drain		
Construction dewatering (Other than nonturbid, uncontaminated groundwater)	1. Recycle/reuse 2. Discharge to sanitary sewer 3. As appropriate, treat prior to discharge to storm drain	POTW Reg. Bd.	
Portable toilet waste	1. Leasing company shall dispose to sanitary sewer at POTW	POTW	
Leaks from garbage dumpsters	1. Collect, contain leaking material. Eliminate leak, keep covered, return to leasing company for immediate repair 2. If dumpster is used for liquid waste, use plastic liner		

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DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
General Construction and Painting; Street and Utility Maintenance (cont'd)			
Leaks from construction debris bins	1. Insure that bins are used for dry nonhazardous materials only (Suggestion: Fencing, covering help prevent misuse)		
Dumpster cleaning water	1. Clean at dumpster owner's facility and discharge waste through grease interceptor to sanitary sewer 2. Clean on site and discharge through grease interceptor to sanitary sewer	POTW POTW	
Cleaning driveways, paved areas * (Special Focus = Restaurant alleys Grocery dumpster areas) * Note: Local drought ordinances may contain additional restrictions	1. Sweep and dispose as trash (Dry cleaning only). 2. For vehicle leaks, restaurant/grocery alleys, follow this 3-step process: a. Clean up leaks with rags or absorbents. b. Sweep, using granular absorbent material (cat litter). c. Mop and dispose of mopwater to sanitary sewer (or collect rinsewater and pump to the sanitary sewer). 3. Same as 2 above, but with rinsewater (2c)(no soap) discharged to storm drain.		1. Sweep and dispose as trash (Dry cleaning only) 2. For vehicle leaks, follow this 3-step process: a. Clean up leaks with rags or absorbents; dispose as hazardous waste. b. Sweep, using granular absorbent material (cat litter) c. Mop and dispose of mopwater to sanitary sewer.
Steam cleaning of sidewalks, plazas * * Note: Local drought ordinances may contain additional restrictions	1. Collect all water and pump to sanitary sewer. 2. Follow this 3-step process: a. Clean oil leaks with rags or adsorbents b. Sweep (Use dry absorbent as needed) c. Use no soap, discharge to storm drain		
Potable water/line flushing Hydrant testing	1. Deactivate chlorine by maximizing time water will travel before reaching creeks		
Super chlorinated (above 1 ppm) water from line flushing	1. Discharge to sanitary sewer 2. Complete dechlorination required before discharge to storm drain		

Table 4.1 (Continued)
Page 5

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Landscape/Garden Maintenance			
Pesticides	1. Use up. Rinse containers use rinsewater as product. Dispose rinsed containers as trash 2. Dispose unused pesticide as hazardous waste		1. Use up. Rinse containers, use rinsewater as pesticide. Dispose rinsed container as trash 2. Take unused pesticide to HHW drop-off
Garden clippings	1. Compost 2. Take to Landfill		1. Compost 2. Dispose as trash
Tree trimming	1. Chip if necessary, before composting or recycling		1. Chip if necessary, before composting or recycling
Swimming pool, spa, fountain water (emptying)	1. Do not use metal-based algicides (i.e. Copper Sulfate) 2. Recycle/reuse (e.g. irrigation) 3. Determine chlorine residual = 0, wait 24 hours and then discharge to storm drain.	POTW	1. Do not use metal-based algicides (i.e. Copper Sulfate) 2. Recycle/reuse (e.g. irrigation) 3. Determine chlorine residual = 0, wait 24 hours and then discharge to storm drain
Acid or other pool/spa/fountain cleaning	1. Neutralize and discharge to sanitary sewer	POTW	
Swimming pool, spa filter backwash	1. Reuse for irrigation 2. Dispose on dirt area 3. Settle, dispose to sanitary sewer		1. Use for landscape irrigation 2. Dispose on dirt area 3. Settle, dispose to sanitary sewer
Vehicle Wastes			
Used motor oil	1. Use secondary containment while storing, send to recycler.		1. Put out for curbside recycling pickup where available 2. Take to Recycling Facility or auto service facility with recycling program 3. Take to HHW events accepting motor oil
Antifreeze	1. Use secondary containment while storing, send to recycler.		1. Take to Recycling Facility
Other vehicle fluids and solvents	1. Dispose as hazardous waste		1. Take to HHW event
Automobile batteries	1. Send to auto battery recycler 2. Take to Recycling Center		1. Exchange at retail outlet 2. Take to Recycling Facility or HHW event where batteries are accepted
[illegible]	1. Use holding tank. Dispose to [illegible]		1. Use holding tank, dispose to sanitary

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Table 4.1 (Continued)
Page 6

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Vehicle Wastes (cont'd)			
Vehicle Washing	1. Recycle 2. Discharge to sanitary sewer, never to storm drain	POTW	1. Take to Commercial Car Wash. 2. Wash over lawn or dirt area 3. If soap is used, use a bucket for soapy water and discharge remaining soapy water to sanitary sewer.
Mobile Vehicle Washing	1. Collect washwater and discharge to sanitary sewer.	POTW	
Rinsewater from dust removal at new car fleets	1. Discharge to sanitary sewer 2. If rinsing dust from exterior surfaces from appearance purposes, use no soap (water only); discharge to storm drain.	POTW	
Vehicle leaks at Vehicle Repair Facilities	Follow this 3-step process: 1 Clean up leaks with rags or absorbents 2 Sweep, using granular absorbent material (cat litter) 3 Mop and dispose of mopwater to sanitary sewer.		
Other Wastes			
Carpet cleaning solutions & other mobile washing services	1. Dispose to sanitary sewer	POTW	1. Dispose to sanitary sewer
Roof drains	1. If roof is contaminated with industrial waste products, discharge to sanitary sewer 2. If no contamination is present, discharge to storm drain		
Cooling water Air conditioning condensate	1. Recycle/reuse 2. Discharge to sanitary sewer	POTW	
Pumped groundwater, infiltration/ foundation drainage (contaminated)	1. Recycle/reuse (landscaping, etc.) 2. Treat if necessary; discharge to sanitary sewer 3. Treat and discharge to storm drain	Reg. Bd. POTW Reg. Bd.	
Fire fighting flows	If contamination is present, Fire Dept. will attempt to prevent flow to stream or storm drain		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Other Wastes (cont'd)			
Kitchen Grease	1. Provide secondary containment, collect, send to recyler. 2. Provide secondary containment, collect, send to POTW via hauler.	POTW	1. Collect, solidify, dispose as trash
Restaurant cleaning of floor mats, exhaust filters, etc.	1. Clean inside building with discharge through grease trap to sanitary sewer. 2. Clean outside in container or bermed area with discharge to sanitary sewer.		
Clean-up wastewater from sewer back-up	1. Follow this procedure: a. Block storm drain, contain, collect, and return spilled material to the sanitary sewer. b. Block storm drain, rinse remaining material to collection point and pump to sanitary sewer. (no rinse-water may flow to storm drain)		

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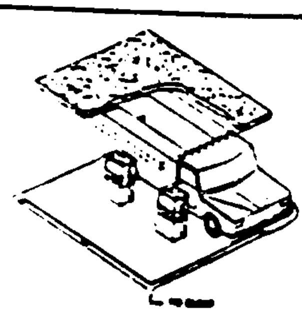
ACTIVITY: VEHICLE AND EQUIPMENT FUELING



Applications
Manufacturing
Material Handling
Vehicle Maintenance
Construction
Commercial Activities
Roadways
Waste Containment
Housekeeping Practices

Targeted Constituents

- ○ Sediment
- ○ Nutrients
- ● Heavy Metals
- ● Toxic Materials
- ○ Floatable Materials
- ○ Oxygen Demanding Substances
- ● Oil & Grease
- ○ Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ◒ Capital Costs
- ○ O&M Costs
- ◒ Maintenance
- ◒ Training

● High ○ Low

SC2

Best Management Practices

DESCRIPTION

Prevent fuel spills and leaks, and reduce their impacts to storm water.

APPROACH

- Design the fueling area to prevent the runon of storm water and the runoff of spills:
  - Cover fueling area if possible.
  - Use a perimeter drain or slope pavement inward with drainage to sump.
  - Pave fueling area with concrete rather than asphalt.
- Where covering is infeasible and the fuel island is surrounded by pavement, apply a suitable sealant that protects the asphalt from spilled fuels.
- If dead-end sump is not used to collect spills, install an oil/water separator.
- Install vapor recovery nozzles to help control drips as well as air pollution.
- Discourage "topping-off" of fuel tanks.
- Use secondary containment when transferring fuel from the tank truck to the fuel tank.
- Use adsorbent materials on small spills and general cleaning rather than hosing down the area. Remove the adsorbent materials promptly.
- Carry out all Federal and State requirements regarding underground storage tanks, or install above ground tanks.
- Do not use mobile fueling of mobile industrial equipment around the facility; rather, transport the equipment to designated fueling areas.
- Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date.
- Train employees in proper fueling and cleanup procedures.
- For a quick reference on disposal alternatives for specific wastes see Table 4.1, SC1.

REQUIREMENTS

- Costs (Capital, O&M)
  - The retrofitting of existing fueling areas to minimize storm water exposure or spill runoff can be expensive. Good design must occur during the initial installation. Extruded curb along the "upstream" side of the fueling area to prevent storm water runon is of modest cost.
- Maintenance
  - Clean oil/water separators at the appropriate intervals.
  - Keep ample supplies of spill cleanup materials on-site.
  - Inspect fueling areas and storage tanks on a regular schedule.

LIMITATIONS

- Oil/water separators are only as effective as their maintenance program.

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Additional Information — Vehicle and Equipment Fueling

Spills from fueling or from the transfer of fuels to the storage tank can be a significant source of pollution. Fuels carry contaminants of particular concern to humans and wildlife, such as heavy metals, toxic materials, and oil and grease, which are not easily removed by storm water treatment devices. Consequently, control at the source is particularly important. Adequate control can be achieved with careful design of the initial installation, retrofitting of existing installations, and proper spill control and cleanup procedures, as described below.

Design

With new installations, design the fueling area to prevent the runon of storm water and the runoff of spills. This can be achieved by contouring the site in the appropriate fashion. Covering the site is the best approach but may not be feasible if very large mobile equipment is being fueled. Storm water runon can be diverted around the fueling area by an extruded curb or with a "speed bump", if vehicle access is needed from this direction. Spills can be contained within the fueling area either by using a perimeter drain or by sloping the pavement inward with drainage to a sump. In both cases the drain can be connected to the storm drain with a valve that is only closed during fueling operations and left open at all other times. Pave the fueling area with Portland cement concrete rather than asphalt, since the latter will gradually disintegrate and be washed from the site.

Spill Control

The following spill control measures will reduce spilling or reduce the loss of spilled fuels from the site:

- Install vapor recovery nozzles.
- Do not "top off" tanks.
- Place secondary containment around the fuel truck when it is transferring fuel to the storage tank. The truck operator should remain with the truck while the transfer is in progress.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Use dry methods to clean the fueling area whenever possible. If you periodically clean by pressure washing, place a temporary plug in the downstream drain and pump out the accumulated water. Properly dispose the water.
- Train employees on proper fueling and cleanup procedures.

Designated Area

If your facility has large numbers of mobile equipment working throughout the site and you currently fuel them with a mobile fuel truck, consider establishing a designated area for fueling. With the exception of tracked equipment such as bulldozers and perhaps small forklifts, most vehicles should be able to travel to a designated area with little lost time. Place temporary "caps" over nearby catch basins or manhole covers so that if a spill occurs it is prevented from entering the storm drain.

Examples of Effective Programs

- The Spill Prevention Control and Countermeasure (SPCC) Plan, which is required by law for some facilities, is an effective program to reduce the number of accidental spills.
- The City of Palo Alto has an effective program for commercial vehicle service facilities. Many of the program's elements, including specific BMP guidance and lists of equipment suppliers, are also applicable to industrial facilities.

REFERENCES

Best Management Practices for Automotive-Related Industries. Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Best Management Practices for Industrial Storm Water Pollution Control. Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices. EPA 832-R-92-006. USEPA, 1992.

Water Quality Best Management Practices Manual. City of Seattle, 1989.

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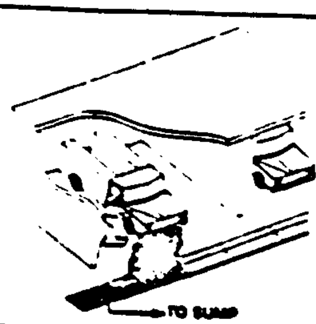
ACTIVITY: VEHICLE AND EQUIPMENT WASHING & STEAM CLEANING



DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from vehicle and equipment washing and steam cleaning.

APPROACH

- Consider off-site commercial washing and steam cleaning businesses.
- Use designated wash areas, preferably covered to prevent contact with storm water and bermed to contain wash water.
- Discharge wash water to sanitary sewer, after contacting local sewer authority to find out if pretreatment is required.
- Educate employees on pollution prevention measures.
- Consider filtering and recycling wash water.
- Do not permit steam cleaning wash water to enter the storm drain.
- For a quick reference on disposal alternatives for specific wastes see Table 4.1, SC1.

REQUIREMENTS

- Capital costs vary depending on measures implemented.
  - Low cost ($500-1,000) for berm construction.
  - Medium cost ($5,000-20,000) for plumbing modifications (including re-routing discharge to sanitary sewer and installing simple sump).
  - High cost ($30,000-150,000) for on-site treatment and recycling.
- O&M costs increase with increasing capital investment.
- Maintenance
  - Berm repair and patching.
  - Inspection and maintenance of sumps, oil/water separators, and on-site treatment/recycling units.

LIMITATIONS

- Some municipalities may require pretreatment and monitoring of wash water discharges to the sanitary sewer.
- Steam cleaning can generate significant pollutant concentrations requiring permitting, monitoring, pretreatment, and inspections. The measures outlined in this fact sheet are insufficient to address all the environmental impacts and compliance issues related to steam cleaning.

Applications

- *Manufacturing*
- *Material Handling*
- *Vehicle Maintenance* (circled)
- *Construction* (circled)
- *Commercial Activities* (circled)
- *Roadways*
- *Waste Containment*
- *Housekeeping Practices* (circled)

Targeted Constituents

- ● *Sediment*
- ● *Nutrients*
- ● *Heavy Metals*
- ● *Toxic Materials*
- ○ *Floatable Materials*
- ● *Oxygen Demanding Substances*
- ● *Oil & Grease*
- ○ *Bacteria & Viruses*

● *Likely to Have Significant Impact*
○ *Probable Low or Unknown Impact*

Implementation Requirements

- ◐ *Capital Costs*
- ○ *O&M Costs*
- ○ *Maintenance*
- ◐ *Training*

● *High* ○ *Low*

SC3

Best Management Practices

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Additional Information — Vehicle and Equipment Washing and Steam Cleaning

Washing vehicles and equipment outdoors or in areas where wash water flows onto the ground can pollute storm water. If your facility washes or steam cleans a large number of vehicles or pieces of equipment, consider contracting out this work to a commercial business. These businesses are better equipped to handle and dispose of the wash waters properly. Contracting out this work can also be economical by eliminating the need for a separate washing/cleaning operation at your facility.

If washing/cleaning must occur on-site, consider washing vehicles inside the building to control the targeted constituents by directing them to the sanitary sewer where they can be pretreated or sent directly to the sanitary treatment facility. Washing operations outside should be conducted in a designated wash area having the following characteristics:

- Paved with Portland cement concrete,
- Covered or bermed to prevent contact with storm water,
- Sloped for wash water collection,
- Discharges wash water to the sanitary or process waste sewer, or to a dead-end sump. Discharge pipe should have a positive control valve that allows switching between the storm drain and sanitary or process sewer,
- Clearly designated, and
- Equipped with an oil/water separator (see Chapter 5, TC7, Oil/Water Separators and Water Quality Inlets).

Examples of Effective Programs

The City of Palo Alto has an effective program for commercial vehicle service facilities. Many of the program's elements, including specific BMP guidance and lists of equipment suppliers, are applicable to industrial vehicle service facilities.

The U.S. Postal Service in West Sacramento has a new vehicle wash system that collects, filters, and recycles the wash water.

REFERENCES

Best Management Practices for Automotive-Related Industries, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 8320R-92-006, USEPA, 1992.

Water Quality Best Management Practices Manual, City of Seattle, 1989.

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SC3

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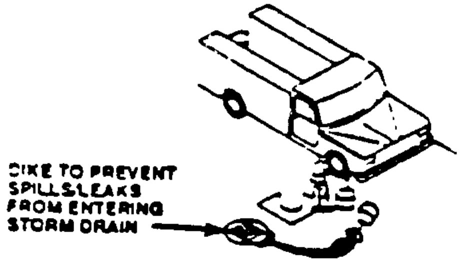
ACTIVITY: VEHICLE AND EQUIPMENT MAINTENANCE AND REPAIR



Applications

Manufacturing
Material Handling
Vehicle Maintenance
Construction
Commercial Activities
Roadways
Waste Containment
Housekeeping Practices

DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from vehicle and equipment maintenance and repair by running a dry shop.

APPROACH

- Keep equipment clean, don't allow excessive build-up of oil and grease.
- Keep drip pans or containers under the areas that might drip.
- Do not change motor oil or perform equipment maintenance in non-appropriate areas. Use a vehicle maintenance area designed to prevent storm water pollution.
- Inspect equipment for leaks on a regular basis.
- Segregate wastes.
- Make sure oil filters are completely drained and crushed before recycling or disposal.
- Make sure incoming vehicles are checked for leaking oil and fluids.
- Clean yard storm drain inlets(s) regularly and especially after large storms.
- Do not pour materials down drains or hose down work areas; use dry sweeping.
- Store idle equipment under cover.
- Drain all fluids from wrecked vehicles.
- Recycle greases, used oil or oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic, and transmission fluids.
- Switch to non-toxic chemicals for maintenance when possible.
- Clean small spills with rags, general clean-up with damp mops and larger spills with absorbent material.
- Paint signs on storm drain inlets to indicate that they are not to receive liquid or solid wastes.
- Train employees.
- Minimize use of solvents.
- For a quick reference on disposal alternatives for specific wastes see Table 4.1, SC1.

REQUIREMENTS

- Costs (Capital, O&M) - Should be low, but will vary depending on the size of the facility.
- Maintenance - Should be low if procedures for the approach are followed.

LIMITATIONS

- Space and time limitations may preclude all work being conducted indoors.
- It may not be possible to contain and clean up spills from vehicles/equipment brought on-site after working hours.
- Drain pans (usually 1 ft. x 1 ft.) are generally too small to contain antifreeze, which may gush from some vehicles, so drip pans (3 ft. x 3 ft.) may have to be purchased or fabricated.
- Dry floor cleaning methods may not be sufficient for some spills. Use three-step method instead.
- Identification of engine leaks may require some use of solvents.

Targeted Constituents

- ○ Sediment
- ○ Nutrients
- ● Heavy Metals
- ● Toxic Materials
- ○ Floatable Materials
- ○ Oxygen Demanding Substances
- ● Oil & Grease
- ○ Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ○ Capital Costs
- ◐ O&M Costs
- ◐ Maintenance
- ◐ Training

● High ○ Low

SC4

Best Management Practices

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Additional Information — Vehicle and Equipment Maintenance and Repair

Vehicle or equipment maintenance is a potentially significant source of storm water pollution. Activities that can contaminate storm water include engine repair and service (parts cleaning, spilled fuel, oil, etc.), replacement of fluids, and outdoor equipment storage and parking (dripping engines). For further information on vehicle or equipment servicing, see SC2, Vehicle and Equipment Fueling, and SC3, Vehicle and Equipment Washing and Steam Cleaning.

Waste Reduction

Parts are often cleaned using solvents such as trichloroethylene, 1,1,1-trichloroethane or methylene chloride. Many of these cleaners are harmful and must be disposed of as a hazardous waste. Cleaning without using liquid cleaners (e.g. wire brush) whenever possible reduces waste. Prevent spills and drips of solvents and cleansers to the shop floor. Do all liquid cleaning at a centralized station so the solvents and residues stay in one area. Locate drip pans, drain boards, and drying racks to direct drips back into a solvent sink or fluid holding tank for re-use.

Safer Alternatives

If possible, eliminate or reduce the amount of hazardous materials and waste by substituting non-hazardous or less hazardous materials. For example:

- Use non-caustic detergents instead of caustic cleaning agents for parts cleaning (ask your supplier about alternative cleaning agents).
- Use detergent-based or water-based cleaning systems in place of organic solvent degreasers. Wash water may require treatment before it can be discharged to the sewer. Contact your local sewer authority for more information.
- Replace chlorinated organic solvents (1,1,1-trichloroethane, methylene chloride, etc.) with non-chlorinated solvents. Non-chlorinated solvents like kerosene or mineral spirits are less toxic and less expensive to dispose of properly. Check list of active ingredients to see whether it contains chlorinated solvents. The "chlor" term indicates that the solvent is chlorinated.
- Choose cleaning agents that can be recycled.
- Contact your supplier or refer to trade journals for more waste minimization ideas.

Reducing the number of solvents makes recycling easier and reduces hazardous waste management costs. Often, one solvent can perform a job as well as two different solvents.

Recycling

Separating wastes allows for easier recycling and may reduce treatment costs. Keep hazardous and non-hazardous wastes separate, do not mix used oil and solvents, and keep chlorinated solvents (like 1,1,1-trichloroethane) separate from non-chlorinated solvents (like kerosene and mineral spirits).

Many products made of recycled (i.e., refined or purified) materials are available. Engine oil, transmission fluid, antifreeze, and hydraulic fluid are available in recycled form. Buying recycled products supports the market for recycled materials.

Spill Leak Clean Up

Clean leaks, drips, and other spills with as little water as possible. Use rags for small spills, a damp mop for general cleanup, and dry absorbent material for larger spills. Use the following three-step method for cleaning floors:

1. Clean spills with rags or other absorbent materials.
2. Sweep floor using dry absorbent material.
3. Mop floor. Mop water may be discharged to the sanitary sewer via a toilet or sink.

SC4

Best Management Practices

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Additional Information — Vehicle and Equipment Maintenance and Repair

Good Housekeeping

Also consider the following measures:

- Avoid hosing down your work areas. If work areas are washed, direct wash water to sanitary sewer.
- Collect leaking or dripping fluids in drip pans or containers. Fluids are easier to recycle if kept separate.
- Keep a drip pan under the vehicle while you unclip hoses, unscrew filters, or remove other parts. Use a drip pan under any vehicle that might leak while you work on it to keep splatters or drips off the shop floor.
- Promptly transfer used fluids to the proper waste or recycling drums. Don't leave full drip pans or other open containers lying around.

Do not pour liquid waste to floor drains, sinks, outdoor storm drain inlets, or other storm drains or sewer connections. Used or leftover cleaning solutions, solvents, and automotive fluids and oil are toxic and should not be put in the sanitary sewer. Post signs at sinks to remind employees, and paint stencils at outdoor drains to tell customer and others not to pour wastes down drains.

Oil filters disposed of in trash cans or dumpsters can leak oil and contaminate storm water. Most municipalities prohibit or discourage disposal of these items in solid waste facilities. Place the oil filter in a funnel over the waste oil recycling or disposal collection tank to drain excess oil before disposal. Oil filters can be crushed and recycled. Ask your oil supplier or recycler about recycling oil filters.

Put pans under leaks to collect fluids for proper recycling or disposal. Keeping leaks off the ground reduces the potential for storm water contamination and reduces cleanup time and costs. If the vehicle or equipment is to be stored outdoors, oil and other fluids should be drained first.

Designate a special area to drain and replace motor oil, coolant, and other fluids, where there are no connections to the storm drain or the sanitary sewer and drips and spills can be easily cleaned up.

Be especially careful with wrecked vehicles, whether you keep them indoors or out, as well as vehicles kept on-site for scrap or salvage. Wrecked or damaged vehicles often drip oil and other fluids for several days.

- As the vehicles arrive, place drip pans under them immediately, even if you believe that the fluids have leaked out before the car reaches your shop.
- Build a shed or temporary roof over areas where you park cars awaiting repair or salvage, especially if you handle wrecked vehicles. Build a roof over vehicles you keep for parts.
- Drain all fluids, including air conditioner coolant, from wrecked vehicles and "part" cars. Also drain engines, transmission, and other used parts.
- Store cracked batteries in a non-leaking secondary container. Do this with all cracked batteries, even if you think all the acid has drained out. If you drop a battery, treat it as if it is cracked. Put it into the containment area until you are sure it is not leaking.

Examples of Effective Programs

The City of Palo Alto has an effective program for commercial vehicle service facilities. Many of the program's elements, including specific BMP guidance and lists of equipment suppliers, are also applicable to industrial vehicle service facilities.

Pick N Pull Auto Dismantlers in Rancho Cordova drains all fluids from automobiles before they enter the yard.

Ecology Auto Wrecking in Rialto is surrounded by a steel plate/concrete fence and has a completely paved lot that is graded to a central low point. Collected storm water is channeled through an underground drainage system of clarifiers

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and then stored in a 60,000 gallon UST before being processed through a filter system. In addition, the work area is covered, ventilated and has an additional sump. Vehicle fluids are drained in this area and segregated for recycling.

All Auto Parts, Fontana, has a complete water recycling system in a 10,000 square foot concrete slab surrounded by a curb that contains all the runoff and sends it to the recycling system. All receiving, dismantling, and shipping occurs on the slab.

REFERENCES

Best Management Practices for Automotive-Related Industries, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

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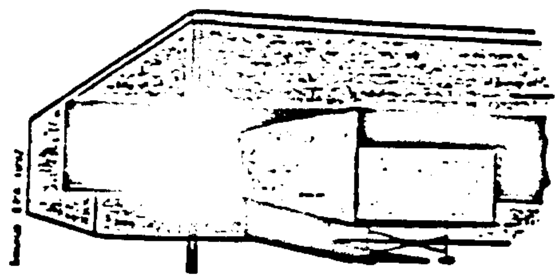
ACTIVITY: OUTDOOR LOADING/UNLOADING OF MATERIALS



Applications

Manufacturing

Material Handling

Vehicle Maintenance

Construction

Commercial Activities

Roadways

Waste Containment

Housekeeping Practices

DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from outdoor loading/unloading of materials.

APPROACH

- Park tank trucks or delivery vehicles so that spills or leaks can be contained.
- Cover the loading/unloading docks to reduce exposure of materials to rain.
- Seal or door skirt between trailer and building can also prevent exposure to rain.
- Design loading/unloading area to prevent storm water runon:
  - grading or berming, and
  - position roof downspouts to direct storm water away from loading/unloading areas.
- Contain leaks during transfer.
- Use drip pans under hoses.
- Make sure fork lift operators are properly trained.
- Employee training for spill containment and cleanup.

REQUIREMENTS

- Costs (Capital, O&M) - Should be low except when covering a large loading/unloading area.
- Maintenance
  - Conduct regular inspections and make repairs as necessary. The frequency of repairs will depend on the age of the facility.
  - Check loading and unloading equipment regularly for leaks:
    - valves,
    - pumps,
    - flanges, and
    - connections.

LIMITATIONS

- Space and time limitations may preclude all transfers from being performed indoors or under cover.
- It may not be possible to conduct transfers only during dry weather.

Targeted Constituents

- ○ Sediment
- ● Nutrients
- ● Heavy Metals
- ● Toxic Materials
- ● Floatable Materials
- ● Oxygen Demanding Substances
- ● Oil & Grease
- ○ Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ◐ Capital Costs
- ○ O&M Costs
- ○ Maintenance
- ◐ Training

● High ○ Low

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Additional Information — Outdoor Loading/Unloading of Materials

The loading/unloading of materials usually takes place outside. Loading or unloading of materials occurs in two ways: materials in containers or direct liquid transfer. Materials spilled, leaked or lost during loading/unloading may collect in the soil or on other surfaces and be carried away by runoff or when the area is cleaned. Rainfall may wash pollutants from machinery used to unload or move materials. The loading or unloading may involve rail or truck transfer.

The most important factors in preventing these constituents from entering storm water is:
- Limit exposure of material to rainfall.
- Prevent storm water runon.
- Check equipment regularly for leaks.
- Contain spills during transfer operations.

Loading or unloading of liquids should occur in the manufacturing building so that any spills that are not completely retained can be discharged to the sanitary sewer, treatment plant, or treated in a manner consistent with local sewer authorities and permit requirements. Best management practices include:
- Use overhangs or door skirts that enclose the trailer.
- Park tank trucks during delivery so that spills or leaks can be contained.
- Design loading/unloading area to prevent storm water runon which would include grading or berming the area, and positioning roof downspouts so they direct storm water away from the loading/unloading areas.
- Check loading and unloading equipment regularly for leaks, including valves, pumps, flanges and connections.
- Look for dust or fumes during loading or unloading operations.
- Use a written operations plan that describes procedures for loading and/or unloading.
- Have an emergency spill cleanup plan readily available.
- Employees trained in spill containment and cleanup should be present during the loading/unloading.
- Establish depots of cleanup materials next to or near each loading/unloading area, and train employees in their use.
- For loading and unloading tank trucks to above and below ground storage tanks, the following procedures should be used.
  - The area where the transfer takes place should be paved. If the liquid is reactive with the asphalt, Portland cement should be used to pave the area.
  - Transfer area should be designed to prevent runon of storm water from adjacent areas. Sloping the pad and using a curb, like a speed bump, around the uphill side of the transfer area should reduce runon.
  - Transfer area should be designed to prevent runoff of spilled liquids from the area. Sloping the area to a drain should prevent runoff. The drain should be connected to a dead-end sump or to the sanitary sewer. A positive control valve should be installed on the drain.
- For transfer from rail cars to storage tanks that must occur outside, use the following procedures:
  - Drip pans should be placed at locations where spillage may occur, such as hose connections, hose reels, and filler nozzles. Use drip pans when making and breaking connections.
  - Drip pan systems should be installed between the rails to collect spillage from tank cars.

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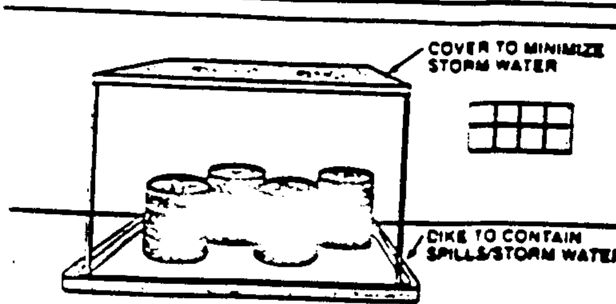
ACTIVITY: OUTDOOR CONTAINER STORAGE OF LIQUIDS



Applications

- *Manufacturing*
- *Material Handling* (circled)
- *Vehicle Maintenance*
- *Construction* (circled)
- *Commercial Activities* (circled)
- *Roadways*
- *Waste Containment*
- *Housekeeping Practices* (circled)

DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from outdoor container storage areas by installing safeguards against accidental releases, installing secondary containment, conducting regular inspections, and training employees in standard operating procedures and spill cleanup techniques.

APPROACH

- Protect materials from rainfall, runon, runoff, and wind dispersal:
  - Store materials indoors.
  - Cover the storage area with a roof.
  - Minize storm water runon by enclosing the area or building a berm around it.
  - Use "doghouse" for storage of liquid containers.
  - Use covered dumpsters for waste product containers.
- Storage of oil and hazardous materials must meet specific Federal and State standards including:
  - Spill Prevention Control and Countermeasure Plan (SPCC) Plan,
  - secondary containment,
  - integrity and leak detection monitoring, and
  - emergency preparedness plans.
- Train operator on proper storage.
- Safeguards against accidental releases:
  - overflow protection devices to warn operator or automatic shut down transfer pumps,
  - protection guards (bollards) around tanks and piping to prevent vehicle or forklift damage, and
  - clear tagging or labeling, and restricting access to valves to reduce human error.
- Berm or surround tank or container with secondary containment system:
  - dikes, liners, vaults, or double walled tanks.
- Some municipalities require that secondary containment areas be connected to the sanitary sewer, prohibiting any hard connections to the storm drain.
- Facilities with "spill ponds" designed to intercept, treat, and/or divert spills should contact the appropriate regulatory agency regarding environmental compliance.

REQUIREMENTS

- Cost (Capital, O&M)
  - Will vary depending on the size of the facility and the necessary controls.
- Maintenance: Conduct routine weekly inspections.

LIMITATIONS

- Storage sheds often must meet building and fire code requirements.

Targeted Constituents

- ○ *Sediment*
- ○ *Nutrients*
- ● *Heavy Metals*
- ● *Toxic Materials*
- ○ *Floatable Materials*
- ● *Oxygen Demanding Substances*
- ○ *Oil & Grease*
- ○ *Bacteria & Viruses*

● *Likely to Have Significant Impact*
○ *Probable Low or Unknown Impact*

Implementation Requirements

- ◒ *Capital Costs*
- ◒ *O&M Costs*
- ◒ *Maintenance*
- ◒ *Training*

● *High* ○ *Low*

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Additional Information — Outdoor Container Storage of Liquids

Accidental releases of materials from aboveground liquid storage tanks, drums, and dumpsters present the potential for contaminating storm waters with many different pollutants. Materials spilled, leaked or lost from storage containers and dumpsters may accumulate in soils or on the surfaces and be carried away by storm water runoff. These source controls apply to containers located outside of a building used to temporarily store liquid materials. It should be noted that the storage of reactive, ignitable, or flammable liquids must comply with fire codes.

Container Management

To limit the possibility of storm water pollution, containers used to store dangerous waste or other liquids should be kept inside the building unless this is impractical due to site constraints. If the containers are placed outside, the following procedures should be employed:

- Dumpsters used to store items awaiting transfer to a landfill should be placed in a lean-to structure or otherwise covered, dumpsters shall be kept in good condition without corrosion or leaky seams.
- Garbage dumpsters shall be replaced if they are deteriorating to the point where leakage is occurring. It should be kept undercover to prevent the entry of storm water. Employees should be made aware of the importance of keeping the dumpsters covered and free from leaks.
- A fillet should be placed on both sides of the curb to facilitate moving the dumpster.
- Waste container drums should be kept in an area such as a service bay. If drums are kept outside, they must be stored in a lean-to type structure, shed or walk-in container to keep rainfall from reaching the drums.

Storage of reactive, ignitable, or flammable liquids must comply with the fire codes of your area. Practices listed below should be employed to enhance the fire code requirements.

- Containers should be placed in a designated area.
- Designated areas should be paved, free of cracks and gaps, and impervious in order to contain leaks and spills.
- Liquid waste should be surrounded by a curb or dike to provide the volume to contain 10 percent of the volume of all of the containers or 110 percent of the volume of the largest container, whichever is greater.
- The area inside the curb should slope to a drain.
    - For used oil or dangerous waste, a dead-end sump should be installed in the drain.
    - All other liquids should be drained to the sanitary sewer if available. The drain must have a positive control such as a lock, valve, or plug to prevent release of contaminated liquids.
- The designated storage area should be covered.
- Containers used for liquid removal by an employees must be placed in a containment area.
    - A drip pan should be used at all times.
- Drums stored in an area where unauthorized persons may gain access must be secured to prevent accidental spillage, pilferage, or any unauthorized use.
- Employees trained in emergency spill cleanup procedures should be present when dangerous waste, liquid chemicals, or other wastes are loaded or unloaded.

The most common causes of unintentional releases:

- External corrosion and structural failure,
- Installation problems,
- Spills and overfills due to operator error,
- Failure of piping systems (pipes, pumps, flanges, couplings, hoses, and valves), and
- Leaks during pumping of liquids or gases from truck or railcar to a storage facility or vice versa.

Operator Training/Safeguards

Well-trained employees can reduce human errors that lead to accidental releases or spills. Employees should be familiar with the Spill Prevention Control and Countermeasure Plan. The employee should have the tools and knowledge to

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immediately begin cleaning up a spill if one should occur. Operator errors can be prevented by using engineering safe guards and thus reducing accidental releases of pollutant. Safeguards include:

- Overflow protection devices on tank systems to warn the operator to automatically shutdown transfer pumps when the tank reaches full capacity,
- Protective guards (bollards) around tanks and piping to prevent vehicle or forklift damage, and
- Clearly tagging or labeling all valves to reduce human error.

Tank systems should be inspected and tank integrity tested regularly. Problem areas can often be detected by visually inspecting the tanks frequently. Problems or potential problems should be corrected as soon as possible. Registered and specifically trained professional engineers can identify and correct potential problems such as loose fittings, poor welding, and improper or poorly fitted gaskets for newly installed tank systems. The tank foundations, connections, coatings, and tank walls and piping systems also should be inspected. Inspection for corrosion, leaks, cracks, scratches in protective coatings, or other physical damage that may weaken the tank system should be a part of regular integrity testing.

<u>Secondary Containment</u>

Tanks should be bermed or surrounded by a secondary containment system. Leaks can be detected more easily and spills can be contained when a secondary containment systems are installed. Berms, dikes, liners, vaults, and double-wall tanks are examples of secondary containment systems.

One of the best protective measures against contamination of storm water is diking. Containment dikes are berms or retaining walls that are designed to hold spills. Diking is an effective pollution prevention measure for above ground storage tanks and railcar or tank truck loading and unloading areas. The dike surrounds the area of concern and holds the spill, keeping spill materials separated from the storm water side of the dike area. Diking can be used in any industrial facility, but it is most commonly used for controlling large spills or releases from liquid storage areas and liquid transfer areas.

For single-wall tanks, containment dikes should be large enough to hold the contents of the storage tank for the facility plus rain water. For trucks, diked areas should be capable of holding an amount equal to the volume of the tank truck compartment. Diked construction material should be strong enough to safely hold spilled materials. Dike materials can consist of earth, concrete, synthetic materials, metal, or other impervious materials. Strong acids or bases may react with metal containers, concrete, and some plastics. Where strong acids or bases or stored, alternative dike materials should be considered. More active organic chemicals may need certain special liners for dikes. Dikes may also be designed with impermeable materials to increase containment capabilities. Dikes should be inspected during or after significant storms or spills to check for washouts or overflows. Regular checks of containment dikes to insure the dikes are capable of holding spills should be conducted. Inability of a structure to retain storm water, dike erosion, soggy areas, or changes in vegetation indicate problems with dike structures. Damaged areas should be patched and stabilized immediately. Earthen dikes may require special maintenance of vegetation such as mulching and irrigation.

Curbing is a barrier that surrounds an area of concern. Curbing is similar to containment diking in the way that it prevents spills and leaks from being released into the environment. The curbing is usually small scaled and does not contain large spills like diking. Curbing is common at many facilities in small areas where handling and transfer liquid materials occur. Curbing can redirect contaminated storm water away from the storage area. It is useful in areas where liquid materials are transferred from one container to another. Asphalt is a common material used for curbing; however, curbing materials include earth, concrete, synthetic materials, metal, or other impenetrable materials. Spilled materials should be removed immediately from curbed areas to allow space for future spills. Curbs should have manually-controlled pump systems rather than common drainage systems for collection of spilled materials. The curbed area should be inspected regularly to clear clogging debris. Maintenance should also be conducted frequently to prevent overflow of any spilled materials as curbed areas are designed only for smaller spills. Curbing has the following advantages:

- Excellent runon control,
- Inexpensive,
- Ease of installment,
- Provides option to recycle materials spilled in curb areas, and
- Common industry practice.

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Additional Information — Outdoor Container Storage of Liquids

Maintenance

- Weekly inspection should be considered and include:
  - Check for external corrosion and structural failure.
  - Check for spills and overfills due to operator error.
  - Check for failure of piping system (pipes, pumps, flanges, coupling, hoses, and valves).
  - Check for leaks or spills during pumping of liquids or gases from truck or rail car to a storage facility or vice versa.
  - Visually inspect new tank or container installation loose fittings, poor welding, and improper or poorly fitted gaskets, and
  - Inspect tank foundations, connections, coatings, and tank walls and piping system. Look for corrosion, leaks, cracks, scratches, and other physical damage that may weaken the tank or container system.

Examples of Effective Programs

The "doghouse" design has been used to store small liquid containers. The roof and flooring design prevent contact with direct rain or runoff. The doghouse has two solid structural walls and two canvas covered walls. The flooring is wire mesh about secondary containment. The unit has been used successfully at Lockheed Missile and Space Company in Sunnyvale.

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Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

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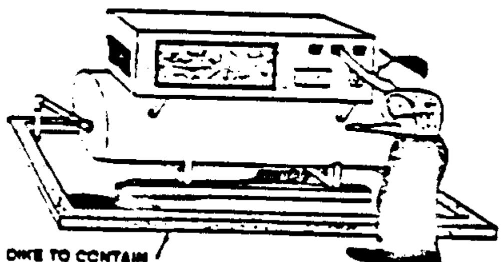
ACTIVITY: OUTDOOR PROCESS EQUIPMENT OPERATIONS AND MAINTENANCE



Applications

- Manufacturing (circled)
- Material Handling
- Vehicle Maintenance
- Construction (circled)
- Commercial Activities (circled)
- Roadways
- Waste Containment
- Housekeeping Practices (circled)

DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from outdoor process equipment operations and maintenance by reducing the amount of waste created, enclosing or covering all or some of the equipment, installing secondary containment, and training employees.

APPROACH

- Alter the activity to prevent exposure of pollutants to storm water.
- Move activity indoors.
- Cover the area with a permanent roof.
- Minimize contact of storm water with outside manufacturing operations through berming and drainage routing (run on prevention).
- Connect process equipment area to pubic sewer or facility wastewater treatment system.
- Clean regularly the storm drainage system.
- Use catch basin filtration inserts (Chapter 5, TC6, Media Filtration) as a means to capture particulate pollutants.
- Some municipalities require that secondary containment areas (regardless of size) be connected to the sanitary sewer, prohibiting any hard connections to the storm drain.

REQUIREMENTS

- Costs (Capital, O&M)
  - Variable depending on the complexity of the operation and the amount of control necessary for storm water pollution control.
- Maintenance
  - Routine preventive maintenance, including checking process equipment for leaks.

LIMITATIONS

- Providing cover may be expensive.
- Space limitations may preclude enclosing some equipment.
- Storage sheds often must meet building and fire code requirements.

Targeted Constituents

●	Sediment
○	Nutrients
●	Heavy Metals
●	Toxic Materials
○	Floatable Materials
○	Oxygen Demanding Substances
●	Oil & Grease
○	Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

●	Capital Costs
◐	O&M Costs
◐	Maintenance
◐	Training

● High ○ Low

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Additional Information — Outdoor Process Equipment Operations and Maintenance

Outside process equipment operations can contaminate storm water runoff. Activities, such as rock grinding or crushing, painting or coating, grinding or sanding, degreasing or parts cleaning, landfills, waste piles, wastewater and solid waste treatment and disposal, and land application are process operations that use hazardous materials and that can lead to contamination of storm water runoff. Pollutants from the wastewater and solid waste treatment and disposal areas result from waste pumping, additions of treatment chemicals, mixing, aeration, clarification, and solids dewatering.

Possible storm water contaminants include heavy metals, toxic materials, and oil and grease. Waste spilled, leaked, or lost from outdoor process equipment operations may build up in soils or on other surfaces and be carried away by storm water runoff. There is also a potential for liquid waste from lagoons or surface impoundments, associated with outdoor equipment operations, to overflow to surface waters or soak the soil, which can be picked up by storm water runoff.

The preferred (and possibly the most economical) action to reduce storm water pollution is to alter the nature of activity such that pollutants are not exposed to storm water. This may mean performing the activity during dry periods only or substituting benign materials for more toxic ones. Actions other than altering the activity include enclosing the activity in a building and connecting the floor drains to the sanitary sewer. The area used by the activity may be so great as to make enclosure prohibitively expensive. Building cost can be reduced by not covering the sides, and thus eliminating the need for ventilating and lighting systems. When certain parts of the activity are the worst source of pollutants, those parts can be segregated and enclosed or covered.

Curbs can be placed around the immediate boundaries of the process equipment. The storm drains from these interior areas can be connected to the facility's process wastewater system.

Reducing the amount of waste that is created and consequently the amount that must be stored or treated is another way to reduce the potential for storm water contamination from outside manufacturing activities. Waste reduction BMPs are available for a wide range of industries and are designed to provide ideas and ways to reduce waste (see References).

Hydraulic/Treatment Modifications

If storm water becomes polluted, it should be captured and treated. If you do not have your own process wastewater treatment system, consider discharging to the public sewer system. Use of the public sewer might be allowed under the following conditions:

- If the activity area is very small (less than a few hundred square feet), the local sewer authority may be willing to allow the area to remain uncovered with the drain connected to the public sewer.
- It may be possible under unusual circumstances to connect a much larger area to the public sewer, as long as the rate of storm water discharges do not exceed the capacity of the wastewater treatment plant. The storm water could be stored during the storm and then transferred to the public sewer when the normal flow is low, such as at night.

The majority of the pollutants in storm water are discharged over time by the small, high frequency storms. Less polluted runoff from the infrequent large storms can be bypassed to the storm drain. To implement this BMP, a hydraulic evaluation of the downstream sewer system should occur in consultation with the local sewer authority.

Industries that generate large volumes of process wastewater typically have their own treatment system that discharges directly to the nearest receiving water. These industries have the discretion to use their wastewater treatment system to treat storm water within the constraints of their permit requirements for process treatment. It may also be possible for the industry to discharge the storm water directly to its effluent outfall without treatment as long as the total loading of the discharged process water and storm water does not exceed the loading had a storm water treatment device been used. This could be achieved by reducing the loading from the process wastewater treatment system. Check with your Regional Water Quality Control Board, as this option would be subject to permit constraints and potentially regular monitoring.

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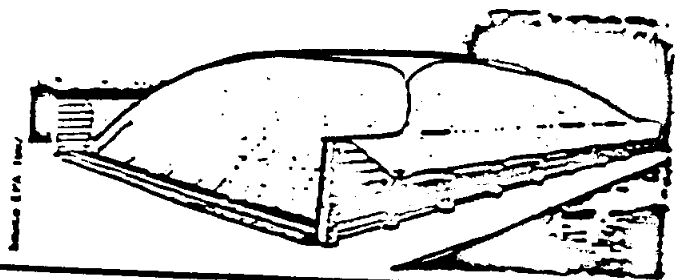
ACTIVITY: OUTDOOR STORAGE OF RAW MATERIALS, PRODUCTS, AND BY-PRODUCTS



Applications

- *Manufacturing*
- *Material Handling* (circled)
- *Vehicle Maintenance*
- *Construction* (circled)
- *Commercial Activities* (circled)
- *Roadways*
- *Waste Containment*
- *Housekeeping Practices* (circled)

Targeted Constituents

- ● *Sediment*
- ○ *Nutrients*
- ● *Heavy Metals*
- ● *Toxic Materials*
- ● *Floatable Materials*
- ○ *Oxygen Demanding Substances*
- ● *Oil & Grease*
- ○ *Bacteria & Viruses*

● *Likely to Have Significant Impact*
○ *Probable Low or Unknown Impact*

Implementation Requirements

- ◒ *Capital Costs*
- ○ *O&M Costs*
- ○ *Maintenance*
- ◒ *Training*

● *High* ○ *Low*

SC8

Best Management Practices

DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from outdoor material and product storage areas by enclosing or covering materials, installing secondary containment, and preventing storm water runon.

APPROACH

- Protect materials from rainfall, runon, runoff and wind dispersal:
  - Store material indoors.
  - Cover the storage area with a roof.
  - Cover the material with a temporary covering made of polyethylene, polypropylene, or hypalon.
  - Minimize storm water runon by enclosing the area or building a berm around the area.
  - Use "doghouse" for storage of liquid containers.
- Parking lots or other surfaces near bulk materials storage areas should be swept periodically to remove debris blown or washed from storage area.
- Install pellet traps at storm water discharge points where plastic pellets are loaded and unloaded.
- Keep liquids in a designated area on a paved impervious surface within a secondary containment.
- Keep outdoor storage containers in good condition.
- Use berms and curbing.
- Use catch basin filtration inserts (Chapter 5, TC6, Media Filtration)

REQUIREMENTS

- Costs (Capital, O&M)
  - Costs should be low except where large areas may have to be covered.
- Maintenance
  - Berm and curbing repair and patching.

LIMITATIONS

- Space limitations may preclude storing some materials indoors.
- Some municipalities require that secondary containment areas (regardless of size) be connected to the sanitary sewer, prohibiting any hard connections to the storm drain.
- Storage sheds often must meet building and fire code requirements.

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Additional Information — Outdoor Storage of Raw Materials, Products, and By-Products

Raw materials, by-products, finished products, containers, and material storage areas exposed to rain and/or runoff can pollute storm water. Storm water can become contaminated by a wide range of contaminants when materials wash off or dissolve into water or are added to runoff by spills and leaks.

Paved areas should be sloped in a manner that minimize the pooling of water on the site, particularly with materials that may leach pollutants into storm water and/or groundwater, such as compost, logs, and wood chips. A minimum slope of 1.5 percent is recommended.

Curbing should be placed along the perimeter of the area to prevent the runon of uncontaminated storm water from adjacent areas as well as runoff of storm water from the stockpile areas. The storm drainage system should be designed to minimize the use of catch basins in the interior of the area as they tend to rapidly fill with manufacturing material. In these cases, consider the use of the catch basin insert filter described in Chapter 5, TC6 (Media Filtration). The area should be sloped to drain storm water to the perimeter where it can be collected or to internal drainage alleyways where material is not stockpiled. If the raw material, by-product, or product is a liquid, more information for outside storage of liquids can be found under SC6, Outdoor Container Storage of Liquids.

Examples

The "doghouse" design has been used to store small liquid containers. The roof and flooring design prevent contact with direct rain or runoff. The doghouse has two solid structural walls and two canvas covered walls. The flooring is wire mesh about secondary containment. The unit has been used successively at Lockheed Missile and Space Company in Sunnyvale.

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Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

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Water Quality Best Management Practices Manual, City of Seattle, 1989.

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ACTIVITY: WASTE HANDLING AND DISPOSAL

DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from waste handling and disposal by tracking waste generation, storage, and disposal; reducing waste generation and disposal through source reduction, re-use, and recycling; and preventing runon and runoff from waste management areas.

APPROACH

- Maintain usage inventory to limit waste generation.
- Raw material substitution or elimination.
- Process or equipment modification.
- Production planning and sequencing.
- SARA Title III, Section 313 requires reporting for over 300 listed chemicals and chemical compounds. This requirement should be used to track these chemicals although this is not as accurate a means of tracking as other approaches.
- Track waste generated.
  - Characterize waste stream.
  - Evaluate the process generating the waste.
  - Prioritize waste streams using: manifests, biennial reports, permits, environmental audits, SARA Title III reports, emission reports, NPDES monitoring reports.
  - Inventory reports.
  - Data on chemical spills.
  - Emissions.
  - Shelf life expiration.
- Use design data and review: process flow diagram, materials and applications diagram, piping and instructions, equipment list, plot plan.
- Use raw material and production data and review: composition sheets, materials safety data sheets (MSDS), batch sheets, product or raw material inventory records, production schedule, operator data log.
- Use economic data and review:
  - Waste treatment and disposal cost.
  - Product utility and economic cost.
  - Operation and maintenance labor cost.
- Recycle materials whenever possible.
- Maintain list of and the amounts of materials disposed.
- Waste segregation and separation.
- Check industrial waste management areas for spills and leaks.
- Cover, enclose, or berm industrial wastewater management areas whenever possible to prevent contact with runon or runoff.
- Equip waste transport vehicles with anti-spill equipment.

Applications

- Manufacturing
- Material Handling
- Vehicle Maintenance
- Construction (circled)
- Commercial Activities (circled)
- Roadways
- Waste Containment (circled)
- Housekeeping Practices (circled)

Targeted Constituents

- ○ Sediment
- ○ Nutrients
- ● Heavy Metals
- ● Toxic Materials
- ○ Floatable Materials
- ○ Oxygen Demanding Substances
- ● Oil & Grease
- ○ Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ○ Capital Costs
- ◐ O&M Costs
- ○ Maintenance
- ◐ Training

● High ○ Low

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ACTIVITY: WASTE HANDLING AND DISPOSAL (Continue)

- Minimize spills and fugitive losses such as dust or mist from loading systems.
- Ensure that sediments or wastes are prevented from being tracked off-site.
- Training and supervision.
- Stencil storm drains on the facility's property with prohibitive message regarding waste disposal.
- For a quick reference on disposal alternatives for specific wastes see Table 4.1, SC1.
- Consider ordering industry-specific or waste stream-specific guidance from PPIC (see Appendix G).

REQUIREMENTS

- Costs (Capital, O&M)
  - Capital and O&M costs for these programs will vary substantially depending on the size of the facility and the types of waste handled. Costs should be low if there is an inventory program in place.
- Maintenance
  - None except for maintaining equipment for material tracking program.

LIMITATIONS

- Hazardous waste that cannot be re-used or recycled must be disposed of by a licensed hazardous waste hauler.

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Additional Information — Waste Handling and Disposal

Industrial waste management activities occur in areas that can contaminate storm water and include landfills, waste piles, wastewater and solid waste treatment and disposal, and land application. Typical operations which affect storm water pollution may include waste pumping, treatment chemicals storage, mixing, aeration, clarification, and solids dewatering.

Waste Reduction

Waste spilled, leaked, or lost from waste management areas or outside manufacturing activities may build up in soils or on other surfaces and be carried away by storm water runoff. There is also a potential for liquid waste from lagoons or surface impoundments to overflow to surface waters or soak the soil where pollutants may be picked up by storm water runoff.

Waste reduction for manufacturing activities is the best way to reduce the potential of storm water contamination from waste management areas. Reduction in the amount of industrial waste generated can be accomplished using many different types of source controls such as:

- Production planning and sequencing.
- Process or equipment modification.
- Raw material substitution or elimination.
- Loss prevention and housekeeping.
- Waste segregation and separation.
- Close loop recycling.

An approach to reduce storm water pollution from waste handling and disposal is to assess process activities at the facility and reduce waste generation. The assessment is designed to find situations where waste can be eliminated or reduced and emissions and environmental damage can be minimized. The assessment involves collecting process specific information, setting pollution prevention targets, and developing, screening and selecting waste reduction options for further study. Starting a waste reduction program is economically beneficial because of reduced raw material purchases and lower waste disposal fees. In addition, material tracking systems to increase awareness about material usage can reduce spills and minimize contamination, thus reducing the amount of waste produced.

Spill/Leak Control

Waste can be prevented from contaminating storm water by checking waste management areas for leaking containers or spills. Corroded or damaged containers can begin to leak at any time. Transfer waste from these damaged containers into safe containers. Dumpsters should be covered to prevent rain from washing waste out of holes or cracks in the bottom of the dumpster. Leaking equipment including valves, lines, seals, or pumps should be repaired promptly.

Vehicles transporting waste should have spill prevention equipment that can prevent spills during transport. The spill prevention equipment includes:

- Vehicles equipped with baffles for liquid waste.
- Trucks with sealed gates and spill guards for solid waste.

Loading or unloading wastes can contaminate storm water when the wastes are lost from the transfer. Loading systems can also be used to minimize spills and fugitive emission losses such as dust or mist. Vacuum transfer systems can minimize waste loss.

Runon/Runoff Prevention

Storm water runon should be prevented from entering the waste management area. Storm water pollution from runon can be prevented by enclosing the area or building a berm around the area. Other alternatives for reducing storm water pollution include:

- Preventing the waste materials from directly contacting rain.

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Additional Information — Waste Handling and Disposal

- Moving the activity indoor after ensuring that all safety concerns such as fire hazard and ventilation are addressed.
- Covering the area with a permanent roof.
- Covering waste piles with temporary covering material such as reinforced tarpaulin, polyethylene, polyurethane, polypropylene or hypalon.

To avoid tracking materials off-site, the waste management area should be kept clean at all times by sweeping and cleaning up spills immediately. Vehicles should never drive through spills. If necessary, wash vehicles in designated areas before they leave the site, and control the wash water.

Minimizing the runoff of polluted storm water from land application of industrial waste on-site can be accomplished by:

- Choosing a site where:
  - slopes are under 6 percent
  - the soil is permeable
  - there is a low water table
  - it is located away from wetlands or marshes
  - there is a closed drainage system
- Avoiding applying waste to the site:
  - when it is raining
  - when the ground is frozen
  - when the ground is saturated with water
- Growing vegetation on land disposal areas to stabilize soils and reduce the volume of surface water runoff from the site.
- Maintaining adequate barriers between the land application site and the receiving waters. Planted strips are particularly good.
- Using erosion control techniques
  - mulching and matting,
  - filter fences,
  - straw bales,
  - diversion terracing,
  - sediment basins.
- Performing routine maintenance to ensure the erosion control or site stabilization measures are working.

Examples of Effective Programs

The port of Long Beach has a state-of-the-art database for identifying potential pollutant sources, documenting facility management practices, and tracking pollutants.

REFERENCES

Best Management Practices for Industrial Storm Water Pollution Control. Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Publications Than Can Work For You!: California Department of Toxic Substances Control, Sacramento, CA, 1991 (A list and order form for waste minimization publications from the State).

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices. EPA 832-R-92-006, USEPA, 1992.

Distribute List, Pollution Prevention Information Clearinghouse, USEPA 1992.

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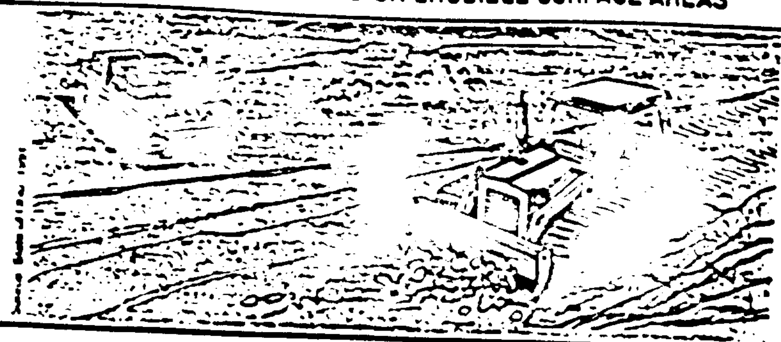
ACTIVITY: CONTAMINATED OR ERODIBLE SURFACE AREAS



Applications

Manufacturing
Material Handling
Vehicle Maintenance
Construction
Commercial Activities
Roadways
Waste Containment
Housekeeping Practices

DESCRIPTION
Prevent or reduce the discharge of pollutants to storm water from contaminated or erodible surface areas by leaving as much vegetation on-site as possible, minimizing soil exposure time, stabilizing exposed soils, and preventing storm water runon and runoff.

APPROACH
This BMP addresses soils which are not so contaminated as to exceed criteria (see Title 22 California Code of Regulations for Hazardous Waste Criteria), but the soil is eroding and carrying pollutants off in the storm water.

Contaminated or erodible surface areas can be controlled by:
- Preservation of natural vegetation,
- Re-vegetation,
- Chemical stabilization,
- Removal of contaminated soils, or
- Geosynthetics.
- For a quick reference on disposal alternatives for specific wastes see Table 4.1, SC1.

REQUIREMENTS
- Cost (Capital, O&M)
  - Except for preservation of natural vegetation, each of the above solutions can be quite expensive depending upon the size of the area.
- Maintenance
  - Maintenance should be minimal, except possibly if irrigation of vegetation is necessary.

LIMITATIONS
Disadvantages of preserving natural vegetation or re-vegetating include:
- Requires substantial planning to preserve and maintain the existing vegetation.
- May not be cost-effective with high land costs.
- Lack of rainfall and/or poor soils may limit the success of re-vegetated areas.

Disadvantages of chemical stabilization include:
- Creation of impervious surfaces.
- May cause harmful effects on water quality.
- Is usually more expensive than vegetative cover.

Targeted Constituents

- ● *Sediment*
- ● *Nutrients*
- ● *Heavy Metals*
- ● *Toxic Materials*
- ● *Floatable Materials*
- ● *Oxygen Demanding Substances*
- ● *Oil & Grease*
- ○ *Bacteria & Viruses*

● *Likely to Have Significant Impact*
○ *Probable Low or Unknown Impact*

Implementation Requirements

- ◒ *Capital Costs*
- ◒ *O&M Costs*
- ○ *Maintenance*
- ○ *Training*

● *High* ○ *Low*

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Additional Information — Contaminated or Erodible Surface Areas

Of interest here are areas within the industrial site that are bare of vegetation and therefore subject to erosion. They may or may not be contaminated from past or current activities. Activity may or may not be occurring in the area of interest. According to the State's General Industrial Activity Storm Water Permit, the SWPPP must include BMPs that deal with these situations. If the area is temporarily bare because of construction, see SC12, Building Repair, Remodeling, and Construction.

Contaminated or erodible surfaces can result from the human activities such as vegetation removal, compacting or disturbing soil, and changing natural drainage patterns. Industries must identify the areas of contaminated or erodible surfaces. The areas may include:

- Heavy activity where plants cannot grow.
- Soil stockpiles.
- Steep slopes.
- Construction areas.
- Demolition areas.
- Any area where soil is disturbed.

The most effective way to control erosion is to preserve existing vegetation. Preservation of natural vegetation provides a natural buffer zone and an opportunity for infiltration of storm water and capture of pollutants in the soil matrix. By preserving stabilized areas, it minimizes erosion potential, protects water quality, and provides aesthetic benefits. This practice is used as a permanent control measure. Vegetation preservation on-site should be planned before disturbing the site. Preservation requires good site management to minimize the impact of construction when construction is underway. Proper maintenance is important to ensure healthy vegetation that can control erosion. Different species, soil types, and climatic conditions will require different maintenance activities such as mulching, fertilizing, liming, irrigation, pruning and weed and pest control. Maintenance should be performed regularly especially during construction phases.

Advantages of preservation of natural vegetation are:

- Can handle higher quantities of storm water runoff than newly seeded areas.
- Increases the filtering capacity because vegetation and root systems are usually dense in preserved natural vegetation.
- Enhances aesthetics.
- Provides areas for infiltration, thus reducing the quantity and velocity of storm water runoff.
- Allows areas where wildlife can remain undisturbed.
- Provides noise buffers and screens for on-site operation.
- Usually requires less maintenance than planting new vegetation.

The measure of choice is to leave as much native vegetation on-site as possible, thereby reducing or eliminating the problem. However, assuming the site already has contaminated or erodible surface areas, there are three possible courses of action:

1. Re-vegetate the area if it is not in use and therefore not subject to damage from site activities. In as much as the area is already devoid of vegetation, special measures are likely necessary. Lack of vegetation may be due to the lack of water and/or poor soils. The later can perhaps be solved with fertilization. Or the ground may simply be too compacted from prior use. Improving soil conditions may be sufficient to support vegetation. If available process wastewater can be used for irrigation, see Construction Best Management Practice Handbook for procedures to establish vegetation.

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2. Chemical stabilization (for example ligno sulfate) can be used as an alternate in areas where temporary seeding practices cannot be used because of season or climate. It can provide immediate, effective, and inexpensive erosion control. Application rates and procedures recommended by the manufacturer should be followed as closely as possible to prevent the product from forming ponds and creating large areas where moisture cannot penetrate the soil. The advantages of chemical stabilization include:
   - Easily applied to the surface.
   - Effective in stabilizing areas.
   - Provides immediate protection to soils that are in danger of erosion.

3. Removal of contaminated soils is a last resort and quite expensive. The level and extent of the contamination must be determined. This determination and removal must comply with State and Federal regulations. permits must be acquired, and fees paid.

4. Geosynthetics include those materials that are designed as an impermeable barrier to contain or control large amounts of liquid or solid matter. Geosynthetics have been developed primarily for use in landfills and surface impoundments, and the technology is well established. There are two general types of geosynthetics: geomembranes(impermeable) and geotextiles(permeable).
   - Geomembranes are composed of one of three types of impermeable materials: elastomers(rubbers), thermoplastics(plastics), or a combination of these two types of materials. The advantages of these materials include: 1) the variety of compounds available, 2) sheeting is produced in a factory environment, 3) polymeric membranes are flexible, and 4) simple installation. The disadvantages include: 1) chemical resistance must be determined for each application, 2) seaming systems may be a weak link in the system, and 3) many materials are subject to attack from biotic, mechanical, or environmental sources.
   - Geotextiles are uncoated synthetic textile products that are not water tight. They are composed of a variety of materials, most commonly polypropylene and polyester. Geotextiles serve five basic functions: 1) filtration, 2) drainage, 3) separation, 4) reinforcement, and 5) armoring.

For more information on geosynthetics, see the reference below.

REFERENCES

Covers for Uncontrolled Hazardous Waste Sites, USEPA, EPA/540/2-85/002, PB87-119483, 1985.

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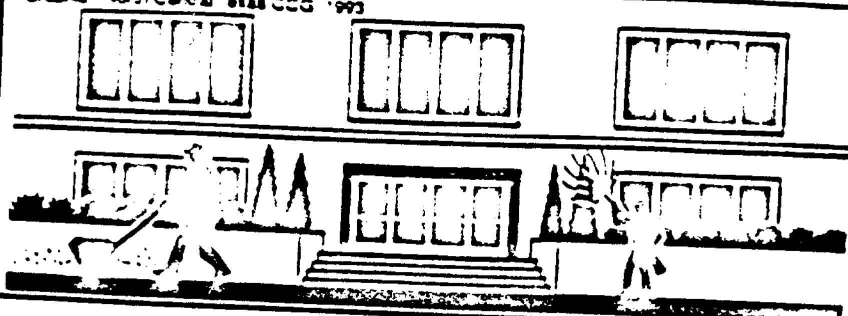
ACTIVITY: BUILDING AND GROUNDS MAINTENANCE

Graphic: North Central Texas CCG 1993



Applications

Manufacturing
Material Handling
Vehicle Maintenance
Construction
Commercial Activities
Roadways
Waste Containment
Housekeeping Practices

Targeted Constituents

- ● *Sediment*
- ● *Nutrients*
- ● *Heavy Metals*
- ● *Toxic Materials*
- ● *Floatable Materials*
- ● *Oxygen Demanding Substances*
- ● *Oil & Grease*
- ○ *Bacteria & Viruses*

● *Likely to Have Significant Impact*
○ *Probable Low or Unknown Impact*

Implementation Requirements

- ○ *Capital Costs*
- ◒ *O&M Costs*
- ◒ *Maintenance*
- ◒ *Training*

● *High* ○ *Low*

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Best Management Practices

DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from buildings and grounds maintenance by washing and cleaning up with as little water as possible, preventing and cleaning up spills immediately, keeping debris from entering the storm drains, and maintaining the storm water collection system.

APPROACH

- Leaving or planting native vegetation to reduce water, fertilizer, and pesticide needs.
- Careful use of pesticides and fertilizers in landscaping.
- Integrated pest management where appropriate.
- Sweeping of paved surfaces.
- Cleaning of the storm drainage system at appropriate intervals.
- Proper disposal of wash water, sweepings, and sediments.
- For a quick reference on disposal alternatives for specific wastes see Table 4.1, SC1.

REQUIRMENTS

- Costs (Capital, O&M)
  - Cost will vary depending on the type and size of facility.
  - Overall costs should be low in comparison to other BMPs.
- Maintenance
  - The BMPs themselves relate to maintenance and do not require maintenance as they do not involve structures.

LIMITATIONS

- Alternative pest/weed controls may not be available, suitable, or effective in every case.

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Additional Information — Building and Grounds Maintenance

Buildings and grounds maintenance includes taking care of landscaped areas around the facility, cleaning of parking lots and pavement other than in the area of industrial activity, and the cleaning of the storm drainage system. Painting and other minor or major repairs of buildings is covered in SC12 (Building Repair, Remodeling, and Construction). Certain normal maintenance activities can generate materials that must be properly disposed. Other maintenance activities can enhance water quality if they are carried out more frequently and/or in a more deliberate fashion.

<u>Pesticide/Fertilizer Management</u>

Landscape maintenance involves the use of pesticides and fertilizers. Proper use of these materials will reduce the risk of loss to storm water. In particular, do not apply these materials during the wet season as they may be carried from the site by the next storm. When irrigating the landscaped areas, avoid over-watering not only to conserve water but to avoid the discharge of water which may have become contaminated with nutrients and pesticides.

It is important to properly store pesticides and application equipment, and to dispose the used containers in a responsible manner, consistent with state regulations. Personnel who use pesticides should be trained in their use. The California Department of Pesticide Regulation and county agricultural commissioners license pesticide dealers, certify pesticide applicators, and conduct on-site inspections.

Written procedures for the use of pesticides and fertilizers relevant to your facility would help maintenance staff understand the "do's" and "don'ts". If you have large vegetated areas, consider the use of integrated pest management (IPM) techniques to reduce the use of pesticides.

<u>Parking/Storm Sewer Maintenance</u>

A parking area that drains to the same storm drainage system as the industrial activity that is to be permitted must also be evaluated for suitable BMPs. Storm water from parking lots may contain undesirable concentrations of oil, grease, suspended particulates, and metals such as copper, lead, cadmium, and zinc, as well as the petroleum byproducts of engine combustion. Deposition of air particulates, generated by the facility or by adjacent industries, may contribute significant amounts of pollutants.

The two most appropriate maintenance BMPs are periodic sweeping and cleaning catch basins if they are part of the drainage system. A vacuum sweeper is the best method of sweeping, rather than mechanical brush sweeping which is not as effective at removing the fine particulates.

Catch basins in parking lots generally need to be cleaned every 6 to 12 months, or whenever the sump is half full. A sump that is more than half full is not effective at removing additional particulate pollutants from the storm water. If the storm drain lines have a low gradient, less than about 0.5 feet in elevation drop per 100 feet of line, it is likely that material is settling in the lines during the small, frequent storms. If you have not cleaned the storm drain system for some time, check the lines as well. If they are not cleaned, the catch basins will likely be filled during the next significant storm by material that is washed from the lines. Also, install "turn-down" elbows or similar devices on the outlets of the catch basins; they serve to retain floatables, oil and grease.

Clearly mark the storm drain inlets, either with a color code (to distinguish from process water inlets if you have them) or with the painted stencil of "DO NOT DUMP WASTE". This will minimize inadvertent dumping of liquid wastes.

Sweepings and sediments from these maintenance activities are generally low in metals and other pollutants and therefore can be disposed on-site or to a construction debris landfill. Test the material if there is a reasonable doubt whether metals or other pollutants are present. If concentrations of contaminants are high, it indicates that other BMPs may be needed to eliminate or reduce emissions from the source. If a vactor truck is used to clean the storm drainage system,

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dirty water will be generated. This water should not be discharged to the storm drainage system as it is silt laden and contains much of the pollutants that were removed by the catch basins. The water should be disposed to the process wastewater system, if you have one, or to the public sewer if permission is granted by the local sewer authority. Alternatively, the water can be placed somewhere on the site where it can evaporate.

The cleaning of the paved surfaces and catch basins in the areas of industrial activity has been discussed previously in SC5 (Loading and Unloading of Materials), SC7 (Outdoor Process Equipment Operations and Maintenance), and SC8 (Outdoor Storage of Raw Materials, Products, and Byproducts).

If some employees have cars that are leaking abnormal amounts of engine fluids, encourage them to have the problem corrected.

<u>Examples of Effective Programs</u>

Information on integrated pest management may be obtained from the Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA 94707, 510-524-2467.

REFERENCES

Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

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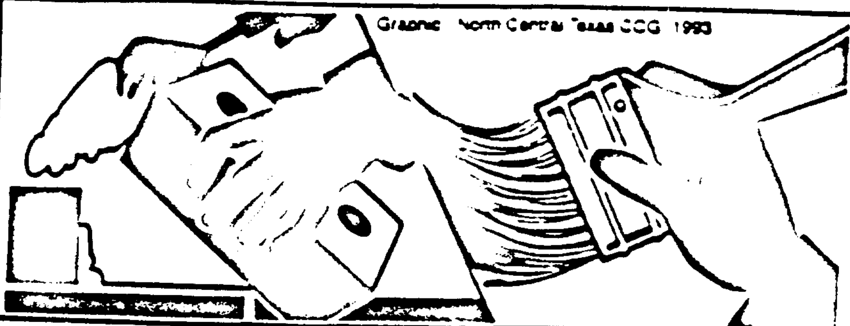
ACTIVITY: BUILDING REPAIR, REMODELING AND CONSTRUCTION



DESCRIPTION

Prevent or reduce the discharge of pollutants to storm water from building repair, remodeling, and construction by using soil erosion controls, enclosing or covering building material storage areas, using good housekeeping practices, using safer alternative products, and training employees.

APPROACH

- Use soil erosion control techniques if bare ground is temporarily exposed. See the Construction Activity Best Management Practice Handbook.
- Use permanent soil erosion control techniques if the remodeling clears buildings from an area that are not to be replaced. See SC10 (Contaminated or Erodible Surface Areas).
- Enclose painting operations, consistent with local air quality regulations and OSHA.
- Properly store materials that are normally used in repair and remodeling such as paints and solvents.
- Properly store and dispose waste materials generated from the activity. See CA20, Solid Waste Management, Construction Handbook.
- Maintain good housekeeping practices while work is underway.

REQUIREMENTS

- Costs (Capital, O&M)
  - These BMPs are generally of low to modest in cost.

LIMITATIONS

- This BMP is for minor construction only. The State's General Construction Activity Storm Water Permit has more requirements for larger projects. The companion "Construction Activity Best Management Practice Handbook" contains specific guidance and best management practices for larger-scale projects.
- Hazardous waste that cannot be re-used or recycled must be disposed of by a licensed hazardous waste hauler.
- Safer alternative products may not be available, suitable, or effective in every case.
- Be certain that actions to help storm water quality are consistent with Cal- and Fed-OSHA and air quality regulations.

Modifications are a common occurrence particularly at large industrial sites. The activity

Applications

- Manufacturing
- Material Handling
- Vehicle Maintenance
- (Construction)
- (Commercial Activities)
- Roadways
- Waste Containment
- (Housekeeping Practices)

Targeted Constituents

- ● Sediment
- ○ Nutrients
- ● Heavy Metals
- ● Toxic Materials
- ● Floatable Materials
- ○ Oxygen Demanding Substances
- ● Oil & Grease
- ○ Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ○ Capital Costs
- ◐ O&M Costs
- ◐ Maintenance
- ◐ Training

● High ○ Low

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Additional Information — Building Repair, Remodeling, and Construction

may vary from minor and normal building repair to major remodeling, or the installation of new facilities on currently open space. These activities can generate pollutants that can reach storm water if proper care is not taken. The sources of these contaminants may be solvents, paints, paint and varnish removers, finishing residues, spent thinners, soap cleaners, kerosene, asphalt and concrete materials, adhesive residues, and old asbestos installation.

Good Housekeeping

Proper care involves a variety of mostly common sense, housekeeping actions such as:

- Keep the work site clean and orderly. Removing debris in a timely fashion. Sweep the area.
- Cover materials of particular concern that must be left out, particularly during the rainy season.
- Educate employees who are doing the work.
- Inform on-site contractors of company policy on these matters and include appropriate provisions in their contract to make certain proper housekeeping and disposal practices are implemented.
- Make sure that nearby storm drains are well marked to minimize the chance of inadvertent disposal of residual paints and other liquids.
- Do not dump waste liquids down the storm drain.
- Advise concrete truck drivers to not wash their truck over the storm drain. Have a designated area that does not drain to the storm drain.
- Clean the storm drain system in the immediate vicinity of the construction activity after it is completed.

Proper education of off-site contractors is often overlooked. The conscientious efforts of well trained employees can be lost by unknowing off-site contractors, so make sure they are well informed about what they are expected to do.

Painting operations should be properly enclosed or covered to avoid drift. Use temporary scaffolding to hang drop cloths or draperies to prevent drift. Application equipment that minimizes overspray also helps. Local air pollution regulations may, in many areas of the state, specify painting procedures which if properly carried out are usually sufficient to protect water quality. If painting requires scraping or sand blasting of the existing surface, use a ground cloth to collect the chips. Dispose the residue properly. If the paint contains lead or tributyl tin, it is considered a hazardous waste.

Mix paint indoors before using so that any spill will not be exposed to rain. Do so even during dry weather because cleanup of a spill will never be 100% effective. Dried paint will erode from a surface and be washed away by storms. If using water based paints, clean the application equipment in a sink that is connected to the sanitary sewer. Properly store leftover paints if they are to be kept for the next job, or dispose properly.

When using sealants on wood, pavement, roofs, etc. quickly clean up spills. Remove excess liquid with absorbent material or rags. If when repairing roofs, small particles have accumulated in the gutter, either sweep out the gutter or wash the gutter and trap the particles at the outlet of the downspout. A sock or geofabric placed over the outlet may effectively trap the materials. If the downspout is tight lined, place a temporary plug at the first convenient point in the storm drain and pump out the water with a vactor truck, and clean the catch basin sump where you placed the plug.

Soil/Erosion Control

If the work involves exposing large areas of soil employ the appropriate soil erosion and control techniques. See the Construction Best Management Practice Handbook. If old buildings are being torn down and not replaced in the near future, stabilize the site using measures described in SC10, Contaminated or Erodible Surface Areas.

If a building is to be placed over an open area with a storm drainage system, make sure the storm inlets within the

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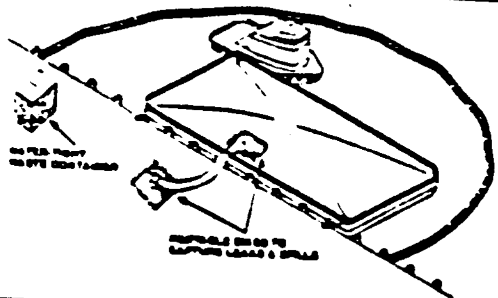
building are covered or removed, or the storm line is connected to the sanitary sewer. If because of the remodeling a new drainage system is to be installed or the existing system is to be modified, consider installing catch basins as they serve as effective "in-line" treatment devices. See TC2 (Wet Ponds) in Chapter 5 regarding design criteria. Include in the catch basin a "turn-down" elbow or similar device to trap floatables.

Recycle residual paints, solvents, lumber, and other materials to the maximum extent practical. Buy recycled products to the maximum extent practical.

REFERENCES

Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

ACTIVITY: OVER-WATER ACTIVITIES



DESCRIPTION
Prevent or reduce the discharge of pollutants to storm water and receiving waters from over-water activities by minimizing over-water maintenance, keeping wastes out of the water, cleaning up spills and wastes immediately, and educating tenants and employees.

APPROACH
- Properly dispose of domestic wastewater and ballast water.
- Limit over-water hull surface maintenance to sanding and minor painting.
- Use phosphate-free and biodegradable detergents for hull washing.
- Use secondary containment on paint cans.
- Have available spill containment and cleanup materials.
- Use ground cloths when painting boats on land.
- Use tarps, plastic sheeting, etc. to contain spray paint and blasting sand.
- Properly dispose of surface chips, used blasting sand, residual paints, and other materials. Use temporary storage containment that is not exposed to rain.
- Immediately clean up spills on docks or boats.
- Sweep drydocks before flooding.
- Clean catch basins and the storm drains at regular intervals.
- Post signs to indicate proper use and disposal of residual paints, rags, used oil, and other engine fluids.
- Educate tenants and employees on spill prevention and cleanup.
- Include appropriate language in tenant contracts indicating their responsibilities.
- Marinas should provide wastewater disposal facilities.

REQUIREMENTS
- Cost (Capital, O&M)
  - Most of the BMPs are of low and modest cost. Exceptions are stations for temporary storage of residual paints and engine fluids, and wastewater pumpout facilities.
- Maintenance
  - Keep ample supply of spill cleanup materials.

LIMITATIONS
Private tenants at marinas may resist restrictions on shipboard painting and maintenance. Existing contracts with tenants may not allow the owner to require that tenants abide by new rules that benefit water quality. Even biodegradable cleaning agents have been found to be toxic to fish.

Applications

- Manufacturing
- Material Handling (circled)
- Vehicle Maintenance
- Construction
- Commercial Activities (circled)
- Roadways
- Waste Containment (circled)
- Housekeeping Practices (circled)

Targeted Constituents

- ○ Sediment
- ○ Nutrients
- ● Heavy Metals
- ● Toxic Materials
- ● Floatable Materials
- ● Oxygen Demanding Substances
- ● Oil & Grease
- ● Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ○ Capital Costs
- ◒ O&M Costs
- ◒ Maintenance
- ◒ Training

● High ○ Low

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Additional Information — Over-Water Activities

Over-water activities occur at boat and ship repair yards, marinas, and yacht clubs, although the later are not required to obtain a permit. Activities of concern include chipping and painting of hulls, on board maintenance of engines, and the disposal of domestic wastewater and ballast water. With few exceptions, BMPs to protect water quality are common sense, low cost changes to normal day-to-day procedures.

Over-water Activity Minimization
Work on boats in the water should be kept to a minimum. Major hull resurfacing should occur on land. Surface preparation over water should be limited to sanding. Painting should be limited to spot work. In marinas, tenant maintenance over water should be such as to not require opening more than a pint size paint can. Paint mixing should not occur on the dock.

Good Housekeeping
When conducting on board maintenance, used antifreeze should be stored in a separate, labeled drum and recycled. Fuel tank vents should have valves to prevent fuel overflows or spills. Boats with inboard engines should have oil absorption pads in bilge areas and they should be changed when no longer useful or at least once a year.

Marina owners should provide temporary storage stations for used engine fluids, paint cans, and other maintenance materials. Signs should be posted at the head of each dock indicating maintenance rules. Marina owners should install a wastewater disposal system, either dockside lines or a pumpout station. Tenant contracts should include language indicating their responsibilities.

When painting on shore, place paint cans in a tray or comparable device that collects spills and drips. Use groundcloths when painting. Use spray guns that minimize overspray; also enclose the area with plastic tarps. Identify a designated area for washing boats. Vacuum sweep work areas frequently. When doing repairs or painting on a tidal grid or similar open "dry dock", use ground cloths to retain chips and spilled paint. The repair yard owner should install signs so that boat owners who are doing their own work know their responsibilities.

Large boat repair yards can implement the above BMPs. There are several additional measures. With regard to dry dock operations: sweep the accessible areas of the dry dock before flooding; and pick up other debris that appears after the ship is floated. Remove floatable debris such as wood. Shipboard cooling and process water discharges should be directed to minimize contact with spent abrasives, paints, and other debris. Look for and repair leaking valves, pipes, hoses, or soil chutes carrying either water or wastewater. Plastic sheeting or other suitable materials should be installed when sandblasting and spray painting.

Use drip pans or comparable devices when transferring oils, solvents, and paints. Regularly clean the shoreside work areas of debris, sandblasting material, etc. Clean catch basins or other parts of the storm drainage system that might accumulate these materials.

Fish Waste
Fish wastes must also be managed properly. Recycling fish wastes back to the water is encouraged when disposal will not result in water quality or public nuisance problems, such as wastes washing up onshore or causing odors or bacteria problems. Fish wastes should not be recycled in any dead end lagoons or other poorly flushed areas. Marina owners should provide fish cleaning stations where waste recycling can occur without adversely affecting water quality.
Note: San Francisco Bay Area boat repair and maintenance facilities. The San Francisco Bay Regional Water Quality Control Board has issued a General Storm Water NPDES Permit to boat yards which work primarily on pleasure vessels less than 65 feet in length. The General Permit requires maintenance of pressure wash containment and recycle or pretreatment system implementation of a Storm Water Pollution Control Plan (SPCP) and a Monitoring Program.

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Additional Information — Over-Water Activities

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REFERENCES

Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. USEPA. 1992.

General NPDES Permit for Discharges of Storm Water from Boat Repair Facilities. SFBRWQCB. 1992.

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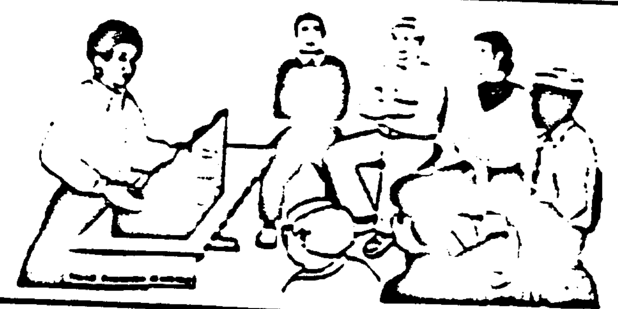
ACTIVITY: EMPLOYEE TRAINING



Applications

- Manufacturing
- Material Handling
- Vehicle Maintenance
- Construction
- Commercial Activities
- Roadways
- Waste Containment
- Housekeeping Practices

DESCRIPTION

Employee training, like equipment maintenance, is not so much a best management practice as it is a method by which to implement BMPs. This fact sheet highlights the importance of training and of integrating the elements of employee training from the individual source controls into a comprehensive training program as part of a facility's Storm Water Pollution Prevention Plan (SWPPP).

The specific employee training aspects of each of the source controls are highlighted in the individual fact sheets. The focus of this fact sheet is more general, and includes the overall objectives and approach for assuring employee training in storm water pollution prevention. Accordingly, the organization of this fact sheet differs somewhat from the other fact sheets in this chapter.

OBJECTIVES

Employee training should be based on four objectives:

- Promote a clear identification and understanding of the problem, including activities with the potential to pollute storm water;
- Identify solutions (BMPs);
- Promote employee ownership of the problems and the solutions; and
- Integrate employee feedback into training and BMP implementation.

APPROACH

- Integrate training regarding storm water quality management with existing training programs that may be required for your business by other regulations such as: the Illness and Injury Prevention Program (IIPP) (SB 198) (California Code of Regulations Title 8, Section 3203), the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard (29 CFR 1910.120), the Spill Prevention Control and Countermeasure (SPCC) Plan (40 CFR 112), and the Hazardous Materials Management Plan (Business Plan) (California Health and Safety Code, Section 6.95).
- Businesses, particularly smaller ones that are not regulated by Federal, State, or local regulations, may use the information in this Handbook to develop a training program to reduce their potential to pollute storm water.

LISTING OF INDUSTRIAL ACTIVITIES

Employee training is a vital component of many of the individual source control BMPs included in this chapter. Following is a compilation of the training aspects of the source control fact sheets.

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ACTIVITY — EMPLOYEE TRAINING (Continue)

SC1 Non-Storm Water Discharges to Drains
- Use the quick reference on disposal alternatives (Table 4.1) to train employees in proper and consistent methods for disposal.
- Consider posting the quick reference table near storm drains to reinforce training.

SC2 Vehicle and Equipment Fueling
- Train employees in proper fueling and cleanup procedures.
- The SPCC Plan may be an effective program to reduce the number of accidental spills from fueling.

SC3 Vehicle and Equipment Washing and Steam Cleaning
- Train employees in standard operating procedures and spill cleanup techniques described in the fact sheet.

SC4 Vehicle and Equipment Maintenance and Repair
- Train employees in standard operating procedures and spill cleanup techniques described in the fact sheet.
- Paint stencils to remind employees not to pour waste down storm drains.

SC5 Outdoor Loading/Unloading of Materials
- Use a written operations plan that describes procedures for loading and/or unloading.
- Have an emergency spill cleanup plan readily available.
- Employees trained in spill containment and cleanup should be present during loading/unloading.
- Make sure fork lift operators are also properly trained.

SC6 Outdoor Container Storage of Liquids
- Registered and specifically trained professional engineers can identify and correct potential problems such as loose fittings, poor welding, and improper or poorly fitted gaskets for newly installed tank systems.
- Employees trained in emergency spill cleanup procedures should be present when dangerous waste, liquid chemicals, or other wastes are handled.

SC7 Outdoor Process Equipment Operations and Maintenance
- The preferred and possibly most economical action to reduce storm water pollution is to alter the activity. This may mean training employees to perform the activity during dry periods only or substituting benign materials for more toxic ones.

SC8 Outdoor Storage of Raw Materials, Products, and By-Products
- Train employees in standard operating procedures and spill cleanup techniques described in the fact sheet.

SC9 Waste Handling and Disposal
- Train employees in standard operating procedures and spill cleanup techniques described in the fact sheet.
- Paint stencils to remind employees not to pour waste down storm drains.

SC10 Contaminated or Erodible Surface Areas
- Training is not a significant element of this best management practice.

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ACTIVITY — EMPLOYEE TRAINING (Continue)

SC11 Building and Grounds Maintenance

- Personnel who use pesticides should be trained in their use. The California Department of Pesticide Regulation and county agricultural commissioners license pesticide dealers, certify pesticide applicators, and conduct on-site inspections.
- Written procedures for the use of pesticides and fertilizers relevant to your facility would help maintenance staff understand the "do's" and "don'ts". If you have large vegetated areas, consider the use of integrated pest management (IPM) techniques to reduce the use of pesticides.

SC12 Building Repair, Remodeling, and Construction

- Proper education of off-site contractors is often overlooked. The conscientious efforts of well trained employees can be lost by unknowing off-site contractors, so make sure they are well informed about what they are expected to do.

SC13 Over-Water Activities

- Post signs to indicate proper use and disposal of residual paints, rags, used oil, and other engine fluids.
- Educate tenants and employees on spill prevention and cleanup.
- Include appropriate language in tenant contracts indicating their responsibilities.

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TREATMENT CONTROL BMPs

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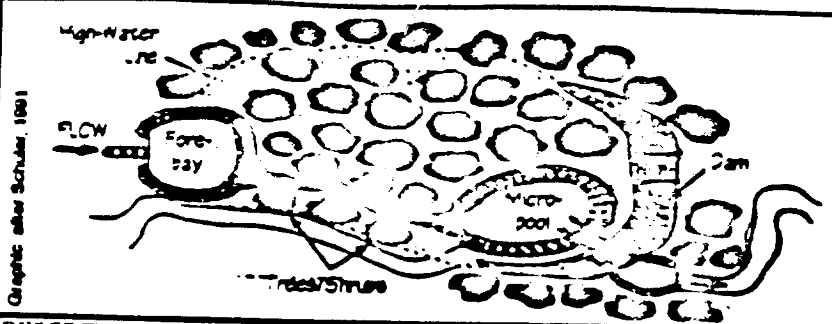
BMP: EXTENDED DETENTION BASINS



DESCRIPTION

Extended detention basins are dry between storms. During a storm the basin fills. A bottom outlet releases the storm water slowly to provide time for sediments to settle.

EXPERIENCE IN CALIFORNIA

There are no known basins in California. Hydraulic detention basins may function like extended detention basins if the former has been sized to control the pre-development 2-year event. More liberal standards do not provide sufficient detention time.

SELECTION CRITERIA

- Objective is to remove only particulate pollutants.
- Use where lack of water prevents the use of wet ponds, wetlands or biofilters.
- Use where wet ponds or wetlands would cause unacceptable mosquito conditions.

LIMITATIONS

- May be less reliable than other treatment control BMPs.
- Inability to vegetate banks and bottom may result in erosion and resuspension.
- Limitation of the orifice diameter may preclude use in small watersheds.
- Requires differential elevation between inlet and outlet.
- Pending their volume and depth basin designs may require approval from State Division of Safety of Dams.

DESIGN AND SIZING CONSIDERATIONS

- Basin volume is sized to capture a particular fraction of the runoff.
- Drawdown time of 24 to 40 hours.
- Shallow basin with large surface area performs better than deep basin with same volume.
- Place energy dissipators at the entrance to minimize bottom erosion and resuspension.
- Vegetate side slopes and bottom to the maximum extent practical.
- If side erosion is particularly severe, consider paving or soil stabilization.
- If floatables are a problem, protect outlet with trash rack or other device.
- Provide bypass or pass through capabilities for 100 year storm.

CONSTRUCTION/INSPECTION CONSIDERATIONS

- Make sure the outlet is installed as designed.

Considerations

- Soils
- Area Required (circled)
- Slope
- Water Availability
- Aesthetics
- Hydraulic Head (circled)
- Environmental Side Effects

Targeted Constituents

- ● Sediment
- ◐ Nutrients
- ◐ Heavy Metals
- ◐ Toxic Materials
- ◐ Floatable Materials
- ◐ Oxygen Demanding Substances
- ◐ Oil & Grease
- ○ Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ● Capital Costs
- ◐ O&M Costs
- ◐ Maintenance
- ○ Training

● High ○ Low

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Best Management Practices

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BMP: EXTENDED DETENTION BASINS (Continue)

MAINTENANCE REQUIREMENTS

- Check outlet regularly for clogging.
- Check banks and bottom of surface basin for erosion and correct as necessary.
- Remove sediment when accumulation reaches 6-inches, or if resuspension is observed.

COST CONSIDERATIONS

- Generally less expensive than wet ponds and wetlands, but more expensive than biofilters.

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Additional Information — Extended Detention Basins

General

Extended detention ponds and vaults may be particularly appropriate to California where dry weather base flow cannot be used to maintain water levels, as is required for wet ponds and constructed wetlands. These systems are suitable for essentially any size tributary area from an individual commercial development to a large residential area. Surface ponds are less expensive to construct, but underground vaults may be appropriate in commercial developments. Use of concrete retaining walls will reduce the space required by a pond. The basic elements of an extended detention basin are illustrated in Figure 5A. The configuration shown in Figure 5A is most appropriate for large sites.

Extended detention provides a lower removal efficiency than wet ponds and constructed wetlands: the facilities are smaller thereby reducing their effectiveness with particulate pollutants, and they do not have the ability to remove dissolved contaminants. Also, extended detention facilities may be less reliable than constructed wetlands or wet ponds because of the lack of a permanent water pool (See Figure 5A). But if desired, a shallow pool of 1 to 3 feet could be included in the design but this is more of an aesthetic consideration. If irrigation water is available, a thick grass turf on the bottom of the facility may provide some removal of dissolved contaminants, like a vegetated biofilter. See TC4 Biofilters for recommendations on turf grass and groundcover species.

Where irrigation water is not available, there may be concerns about erosion and resuspension of particulate pollutants in surface ponds. This, however, has not been a significant problem in Austin, Texas where sand filters are preceded by dry settling ponds (Hartigan, pers. comm.). However, the design must incorporate several features to minimize the potential for this problem. Drought tolerant vegetation may work but has not been evaluated. Nonvegetative materials may help such as concrete or plastic grids, small riprap, erosion matting, or paving. A paved forebay may facilitate maintenance thereby reducing the material available for resuspension.

The recommended drawdown time of 24 to 40 hours for a full pond is based on very limited laboratory data. A few extended detention ponds have been monitored and generally provide a removal efficiency of 60 to 80% with a drawdown time of about 24 hours. Forty hours is recommended in order to settle out the finer clay particles in California sediment that typically adsorb toxic pollutants.

Design

Determine the volume of the basin using the appropriate figure from Appendix D. The procedure is as follows: (1) select the appropriate figure for your area; (2) determine for the catchment the percentage of impervious area directly connected to the storm drain system; (3) choose a capture goal, and read the required unit volume required for the basin; and (4) multiply this unit volume times the total acreage of the catchment and convert to cubic feet. This volume is also referred to as water quality capture volume shown in Figure 5A. Total impervious acres may be used in lieu of directly connected impervious acres if it is easier to determine the former, although this will result in a larger facility. Although these variations are not equivalent, they are reasonable given the uncertainty of the methodology and expected basin performance.

What should be the capture goal? To achieve an equivalent pollutant capture percentage as a wet pond, 85 to 95 percent of the runoff must be captured and detained. But capture volumes over 85 percent are not cost effective as the capture cases in Appendix D show. Therefore it is recommended that a capture volume of 85 percent be used for determining the detention basin size required. Because of the possibility of resuspension of materials during extreme storms consideration should be given to placing the basin off line, that is, it should have a bypass for the extreme events. Bypassing larger events will also allow the bedload carried by the storm and is necessary for beach replenishment to move downstream.

A drawdown time of 40 hours is recommended in order to settle out the finer clay particles as stated above; however, 24 hours can be used if it can be demonstrated that this rate will remove 80% of the solids. The analysis of runoff using

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the hydrologic model STORM and California precipitation data found that increasing the drawdown time from 24 to 40 hours increased the size of the basin by only about 10% to 20% depending on the location (see Appendix D).

Proper hydraulic design of the outlet is critical to achieving good performance of the detention basin. The two most common outlet problems that occur are: 1) the capacity of the outlet is too great resulting in partial filling of the basin and less than designed for drawdown time and 2) the outlet clogs because it is not adequately protected against trash and debris. To avoid these problems, two alternative outlet types are recommended for use: 1) V-notch weir, and 2) perforated riser. The V-notch weir will not clog, but it is also difficult to maintain small release rates at low heads. The perforated riser if properly designed and gravel packed gives much better control and is recommended over the V-notch weir.

Two different approaches can be used to control the outflow. One is to use a single orifice outlet with or without the protection of a riser pipe. The other is to use the perforated riser itself for discharge control. Both approaches are presented below.

<u>Flow Control Using a Single Orifice</u>
The outlet control orifice should be sized using the following equation (GKY, 1989).

$$a = \frac{2A(H-H_o)^{0.5}}{3600CT(2g)^{0.5}} = \frac{(7x10^{-5})A(H-H_o)^{0.5}}{CT} \qquad (1)$$

where:
- a = area of orifice (ft^2)
- A = average surface area of the pond (ft^2)
- c = orifice coefficient
- T = drawdown time of full pond (hrs.)
- g = gravity (32.2 $ft./sec^2$)
- H = elevation when the pond is full (ft)
- H_o = final elevation when pond is empty (ft)

With a drawdown time of 40 hours the equation becomes:

$$a = \frac{(1.75X10^{-6})A(H-H_o)^{0.5}}{C} \qquad (2)$$

Assuming an average release rate at one half the pond depth, a common approach in several design manuals, leads to considerable error. If the pond has a significant variation of surface area with depth, do not use Equation (2); consult GKY (1989).

Care must be taken in the selection of "c": 0.60 is most often recommended and used. However, based on actual tests GKY (1989) recommends the following:

c = 0.66 for thin materials, that is, the thickness is equal to or less than orifice diameter

c = 0.80 when the material is thicker than the orifice diameter

Drilling the orifice into an outlet structure that is made of concrete can result in considerable impact on the coefficient, as does the beveling of the edge. The experiments by GKY (1989) were with sharp edged orifices.

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Additional Information — Extended Detention Basins

Equation (1) defines the orifice area where a single orifice outlet is used to regulate the detention basin outflow. However, a recent survey of extended detention facilities (Galli, pers. comm.) found the drawdown time of small storms that do not fill the facility to be too short to provide effective treatment. The facilities surveyed were designed for a drawdown time of 24 hours. A 40 hour drawdown may provide sufficient time for the smaller storms. But it may be prudent to take additional steps to be certain that the small storms, which represent the majority of pollution, are effectively treated. One approach would be to check the design analysis to determine if the facility takes at least 24 hours to drain when half full. If not, either modify the design to achieve this objective, or install a two orifice outlet. The lower outlet is sized to drain a half-full facility in 24 hours. The second orifice is placed at the mid-water elevation and is sized in combination with the lower orifice to drain the entire facility in 40 hours. Another approach is to install the outlet about one foot above the bottom of the pond (essentially enlarging the micropool area). This lower area will dry up between storms and will capture much of the volume of small storms and improving pollutant removal.

Three alternative outlet structures are suggested (Figure 5B). The concrete block structure is appropriate for large ponds. The riser pipe is suggested for small to large ponds. Placing the outlet control in the berm or in a manhole located downstream of the facility is most suitable for small ponds.

Recommendations regarding the design of a riser pipe are shown in Table 5A for Austin (1988). Table 5A provides guidance on the location of holes. To prevent clogging of this orifice and the bottom orifices of the riser pipe, wrap the bottom three rows of orifices with geotextile fabric and a cone of one to three inch rock. The holes in the riser pipe should not be modified to achieve a 40 hour drawdown time. Rather, <u>the control orifice should be placed downstream.</u> For small facilities, place the control orifice in a manhole between the pond and the filter as shown in Figure 5B. Use a "T-pipe" (Figure 5B) to submerge the orifice.

TABLE 5A PERFORATED OUTLET RISER PIPE ORIFICES (Austin, 1988)

RISER PIPE DIAMETER	VERTICAL SPACING BETWEEN ROWS (center to center)	NUMBER OF PERFORMATIONS	PERFORATION DIAMETER
6 in.	2.5 in.	9 per row	1 in.
8 in.	2.5 in.	12	1 in.
10 in.	2.5 in.	16	1 in.

Clogging of the bottom holes has been observed in riser pipes in the mid-Atlantic states (MWCOG, 1992) suggesting that the diameter of the riser holes should not be less than 3/4 to 1" (MWCOG, 1992) although a minimum diameter of 2" is now being considered (Galli, pers comm.). However, most of the facilities surveyed had risers <u>without</u> the gravel cone and the outlet holes were modified to provide drawdown control. Modifying the holes in the riser to control the outlet rate reduces the diameter of the holes and increases the risk of clogging. However, gravel packing the riser pipe as shown in Figure 5B.2 and 5C.1 will minimize this risk. Submerging the control orifice as shown in Figure 5B.3 will allow the use of a smaller orifice diameter. One orifice with a diameter of 1/2 inch, or 1 inch to be conservative, allows the use of extended detention for very small catchments. Detention facilities in western Washington use this concept and have not experienced clogging problems.

<u>Flow Control Using the Perforated Riser</u>

For outlet control using the perforated riser as the outflow control, it is recommended that the procedure developed by the Denver Urban Drainage and Flood Control District be used (UDFCD, 1992) as illustrated in Figures 5C and 5D. Figure 5D uses a valve for C_e of 0.65. This design incorporates flow control for the small storms in the perforated riser but also provides an overflow outlet for large storms. If properly designed, the facility can be used for both water quality and

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Additional Information — Extended Detention Basins

drainage control by: 1) sizing the perforated riser as indicated for water quality control; 2) sizing the outlet pipe to control peak outflow rate from the 2 year storm; and 3) using a spillway in the pond berm to control the discharge from larger storms up to the 100 year storm.

Other Design Considerations

- Do not locate on fill sites or on or near steep slopes if it is expected that much of the water will exit through the bottom, or modify the bottom to prevent excessive infiltration.
- Energy dissipation at the inlet to minimize erosion
- Vegetate the slopes and bottom for the same reason
- Freeboard of 1 foot
- Side slopes of at least 2:1 unless vertical retaining walls are used
- Incorporate bypass or overflow for large events
- Provide dedicated access to the basin bottom (minimum 4:1) for maintenance vehicles
- With a riser structure, include an anti-vortex device and a debris barrier.

Maintenance

Conduct inspections semiannually and after each significant storm. Remove floatables and correct erosion problems in the pond slopes and bottom. Pay particular attention to the outlet control orifice(s) for signs of clogging. If the orifice is located in a Type 2 catch basin, remove sediments if they are within 18 in. of the orifice plate. Often extended detention basins serve multiple uses, e.g. baseball field, resulting in higher maintenance costs.

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Whipple, W. and J. Hunter, 1981, "Settleability of Urban Runoff Pollution", J. Water Pollution Control Federation, 53 (12): 1726-1731.

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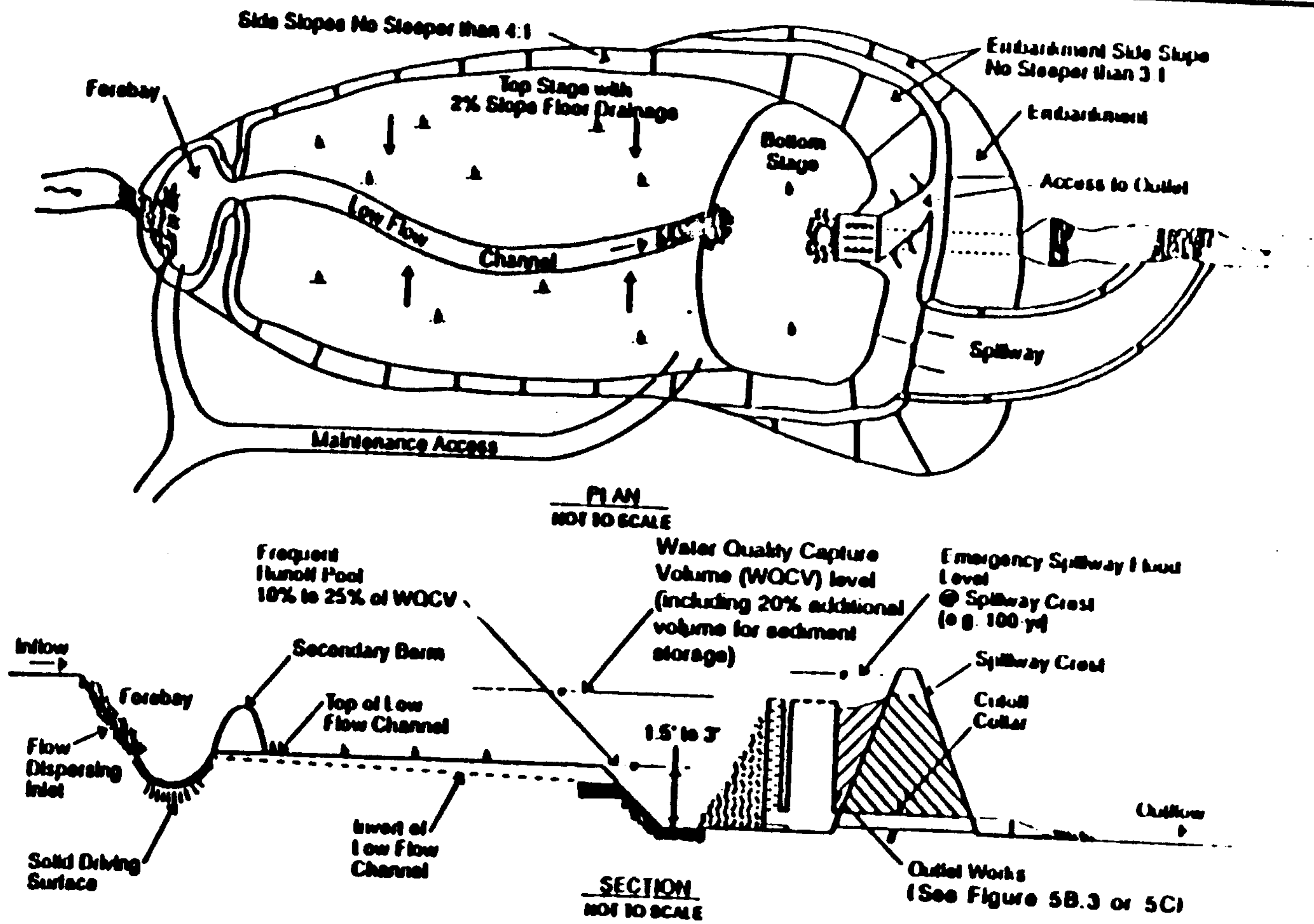

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FIGURE 5A. PLAN AND SECTION OF AN EXTENDED DETENTION BASIN

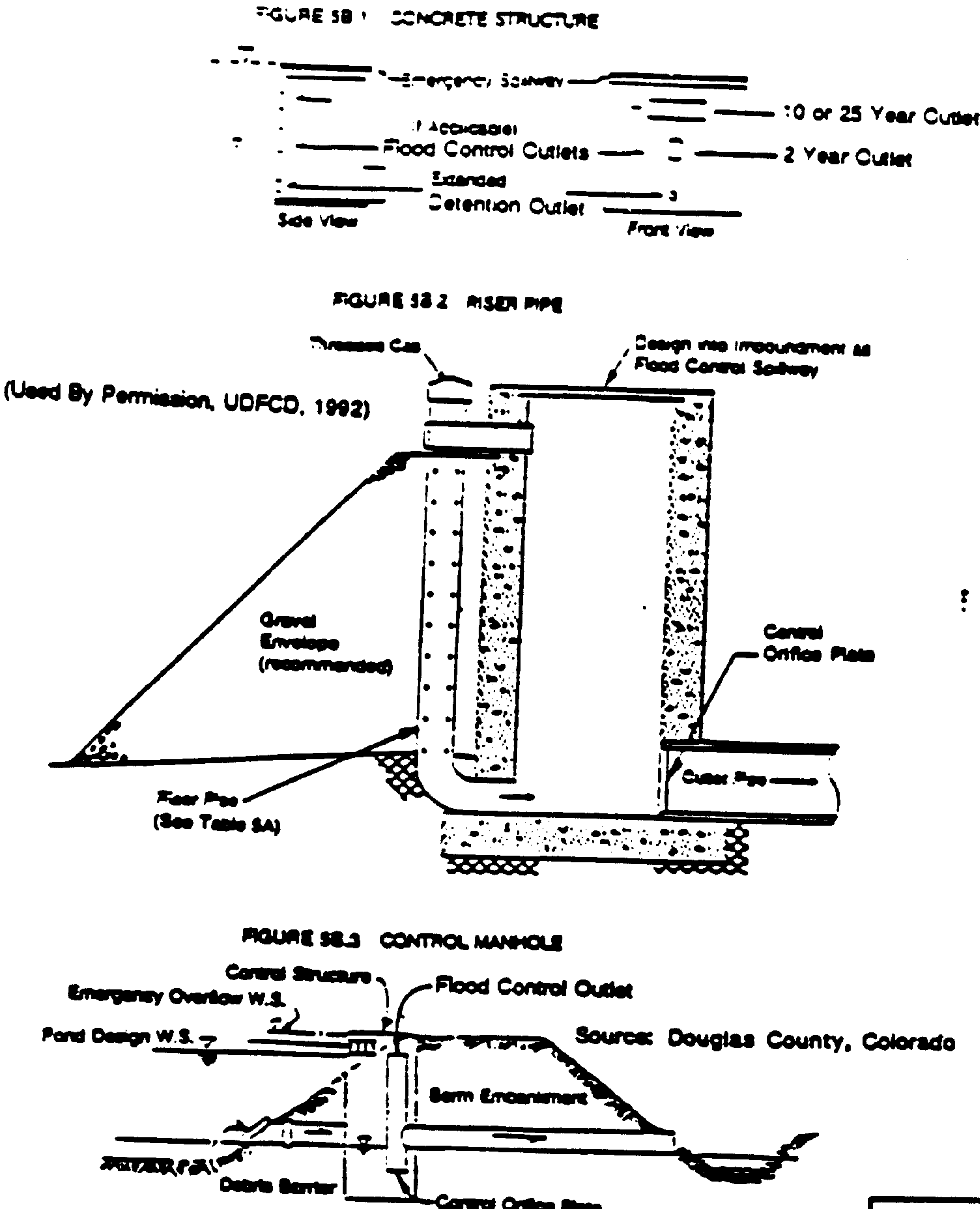

FIGURE 5B. OUTLET CONFIGURATIONS USING SINGLE ORIFICE FOR FLOW CONTROL

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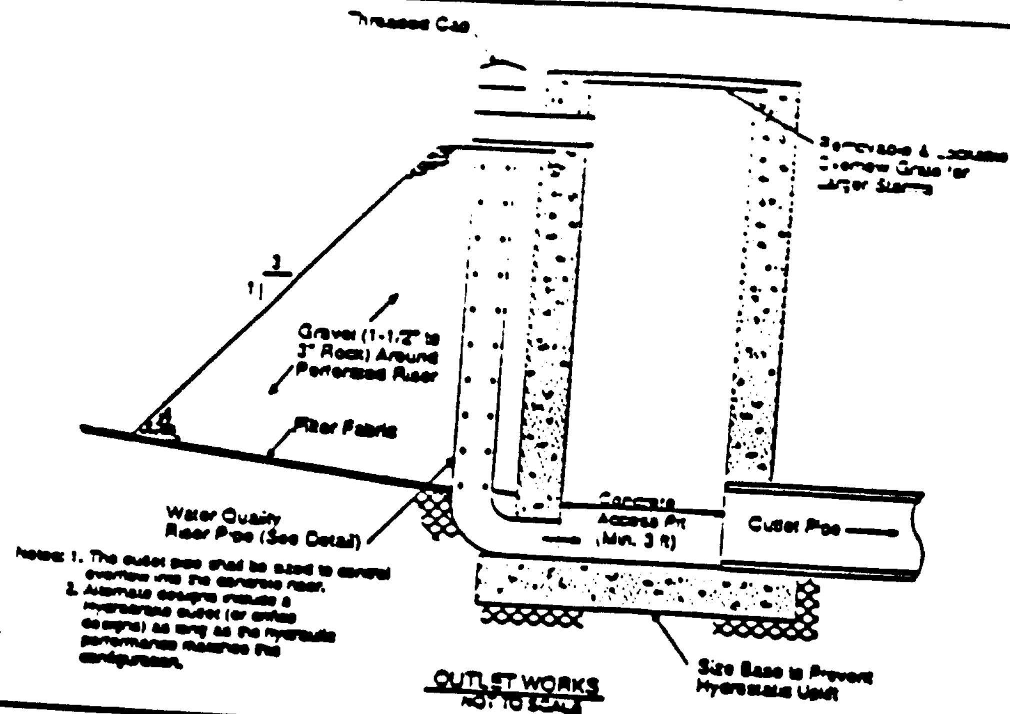
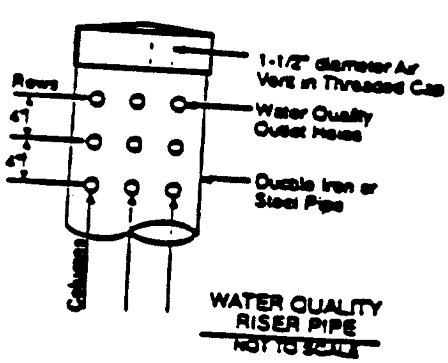


Notes: 1. Minimum number of holes = 8
2. Minimum hole diameter = 1/8" dia.



Maximum Number of Perforated Columns				
Riser Diameter (in.)	Hole Diameter, in.			
	1/4"	1/2"	3/4"	1"
4	8	8	-	-
6	12	12	9	-
8	16	16	12	8
10	20	20	14	10
12	24	24	18	12

Hole Diameter (in.)	Area of Hole (in.²)
1/8	0.013
1/4	0.049
3/8	0.110
1/2	0.196
5/8	0.307
3/4	0.442
7/8	0.601
1	0.785

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FIGURE 5C. OUTLET CONFIGURATION USING PERFORATED RISER FOR FLOW CONTROL

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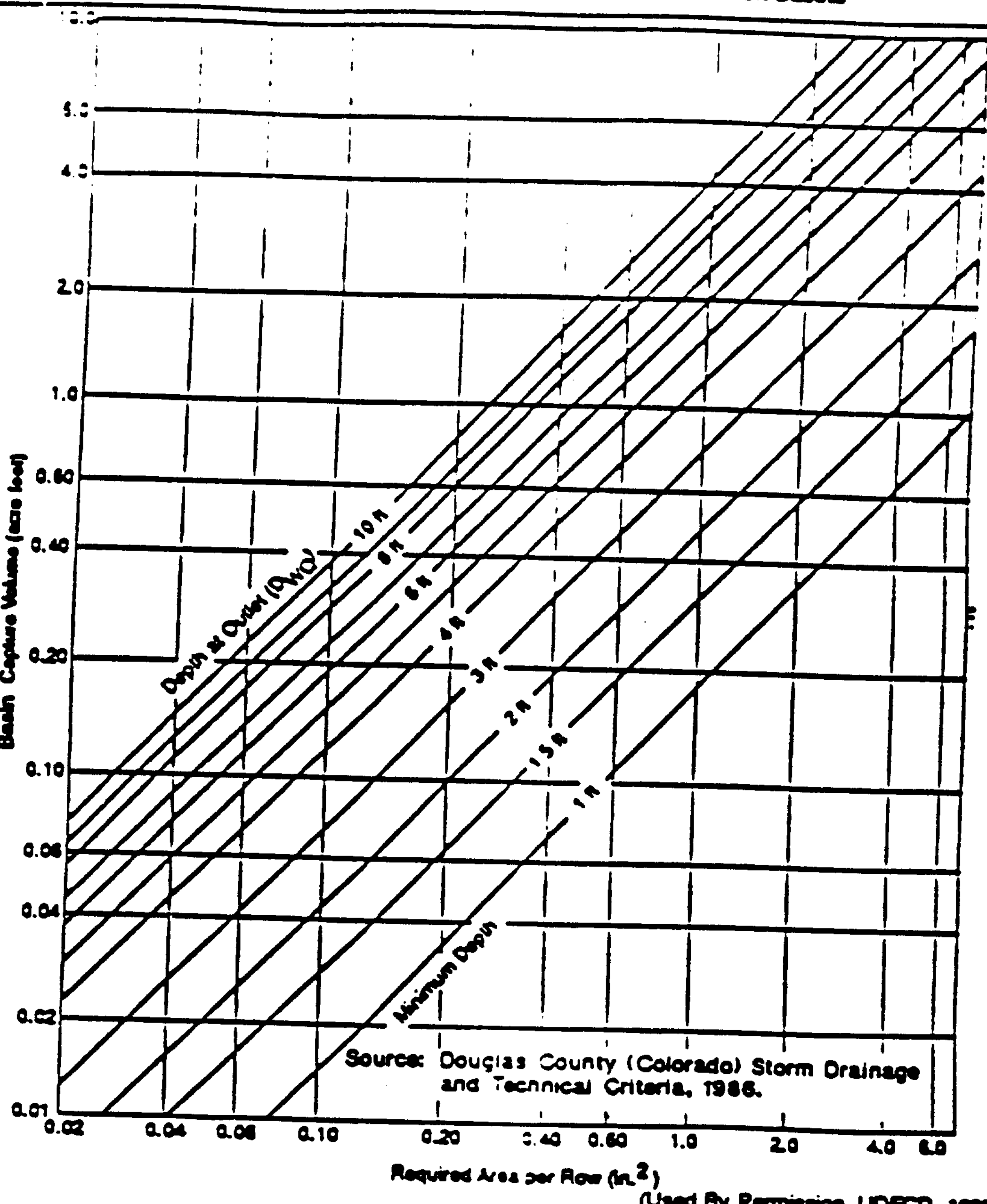

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FIGURE 5D. WATER QUALITY OUTLET SIZING: EXTENDED DETENTION BASIN WITH A 40-HOUR DRAIN TIME OF THE CAPTURE VOLUME

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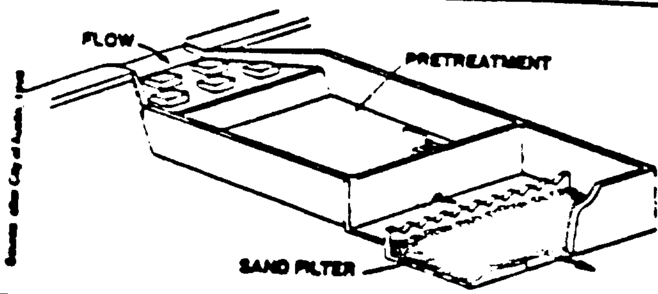
BMP: MEDIA FILTRATION



Considerations

- Soils
- Area Required
- Slope
- Water Availability
- Aesthetics
- Hydraulic Head
- Environmental Side Effects

DESCRIPTION

Consists of a settling basin followed by a filter. The most common filter media is sand; some use peat/sand mixture.

EXPERIENCE IN CALIFORNIA

- A tenant at the Port of Long Beach recently installed a sand filter. The City of Los Angeles will soon install several experimental filters.

SELECTION CRITERIA

- Objective is to remove only sediment (particulate pollutants).
- Use where unavailability of water prevents the use of wet ponds, wetlands, or biofilters.
- Can be placed underground.
- Suitable for individual developments and small tributary areas up to about 100 acres.
- May require less space than other treatment control BMPs.

LIMITATIONS

- Filter may require more frequent maintenance than most of the other BMPs.
- Head loss.
- Dissolved pollutants are not captured by sand.
- Severe clogging potential if exposed soil surfaces exist upstream.

DESIGN AND SIZING CONSIDERATIONS

- Settling basin smaller than wet or extended detention basin.
- Spread flow across filter.
- Place filter offline to protect from extreme events.
- Minimize erosion in settling basin.

CONSTRUCTION/INSPECTION CONSIDERATIONS

- Be certain filter sand is clean and the outlet device from the basin to the filter is level.

MAINTENANCE REQUIREMENTS

- Clean filter surface about twice annually; or more often if watershed is excessively erosive.

COST CONSIDERATIONS

- Filtration system may use less space than other systems.
- Smaller media improves performance but increases maintenance costs.

Targeted Constituents

- ● Sediment
- ◒ Nutrients
- ◒ Heavy Metals
- ○ Toxic Materials
- ● Floatable Materials
- ◒ Oxygen Demanding Substances
- ◒ Oil & Grease
- ◒ Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ● Capital Costs
- ◒ O&M Costs
- ◒ Maintenance
- ○ Training

● High ○ Low

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Additional Information — Media Filtration

Sand filters may be particularly suitable for industrial sites because the settling basin can be located underground. A sand filter consists of two units: settling basin and the filter. Pretreatment is essential to avoid rapid clogging of the filter. Peat/sand mixture has been used: peat having the ability to remove dissolved contaminants. However, there have been clogging problems (Tomasak, et al., 1987) but this may be due to using the wrong type of peat (Galli, 1990). Limited research indicates that compost made from leaves is very effective at removing dissolved phosphorus and metals, and oil and grease (Stewart, 1989). A new concept is placement of a filter device in a catch basin insert (McPherson, 1992) which may be very well suited for industrial sites.

Field research in the City of Austin, Texas (Austin, 1990) indicates the sand filter has a removal efficiency of suspended solids that is similar to wet ponds and extended detention: 70 to 90%. The observed removal of metals was 20 to 80%, depending on the metal, 20 to 30% for nitrogen, and 50 to 60% for phosphorus. These rates are also similar to wet ponds, which is not expected as a filter does not remove dissolved contaminants. Sand with a diameter smaller than used in Austin would likely improve performance but has not been tried.

The sand filter should be an ideal system for the Central Valley and Southern California. It does not rely on vegetation, and has proven itself in the City of Austin. The sand filter is suitable for tributary areas of a less than an acre to about 50 acres.

Make certain that any soil erosion problems in the site have been corrected (Chapter 4). Experience in Austin indicates that exposed soils during construction "upstream" from the filter can result in penetration of fines into the filter media, resulting in a need to replace the entire filter bed. The system should have a bypass for extreme events.

Alternative configurations

The most experience to date is with surface facilities shown conceptually in Figure 6A. It can be used on catchments up to perhaps 50 acres. Its origin is Austin, Texas where there are now several hundred facilities. The "Austin" filter uses an extended detention basin with a drawdown time of 24 hours. Two other systems are most suitable for small catchments of a few acres. An underground "linear" filter (Figure 6B) is used in Delaware (Shaver, 1991). The filter accepts sheet flow from adjacent pavement. It, therefore, may be ideal for industrial applications. Another underground design (Figure 6C) developed in Washington D.C. (Truong, 1989) is also ideal for developments. It accepts concentrated flow. Both of these underground systems use a wet vault (or water quality inlet, see TC7) as the pretreatment device. The fourth concept is (Figure 6D) is an insert placed in existing catch basins. It should only be used where maintenance staff are available to check the filter frequently and where local flooding will not occur if the filter clogs.

Determining the volume of the pretreatment unit

To size the pretreatment basin refer to the sizing methods for extended detention (TC5). With the sand filter the pretreatment basin need not be as efficient as a full size system. The pretreatment system, however, should be large enough to provide a removal efficiency that avoids rapid clogging of the filter. As yet, there is no clear answer on this question. For now it is suggested that the volume of a wet vault be such as to achieve a removal efficiency of 50 to 60%.

The volume of an pretreatment unit can be decreased by reducing the drawdown time, which results in a lower but acceptable removal efficiency. The facility volume can be determined from TC5 Extended Detention using a drawdown time of 24 hours.

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<u>Determining the surface area of the filter</u>

The following equation is derived from Austin (1988) for a maximum (full pretreatment basin) filtration time of 24 hours:

$$\text{Filter area (ft}^2\text{)} = 3630 S_u AH/K(D+H) \quad (1)$$

where:
- S_u = unit storage (inches-acre) from Appendix D
- A = area in acres draining to facility
- H = depth (ft) of the sand filter
- D = average water depth (ft) over the filter taken to be one-half the difference between the top of the filter and the maximum water surface elevation
- K = filter coefficient recommended as 3.5 (Austin)

Equation (1) is appropriate for the filter media size recommended by the City of Austin, diameter of 0.02 to 0.04 inches. The filter area must be increased if a smaller media is used (see Austin, Texas (1988)).

Configuring a surface sand filter (City of Austin concept)

Additional design criteria for the settling basin (Austin, 1988):

- For the outlet use a perforated riser pipe, as described in TC5, Extended Detention
- Size the outlet orifice for a 24 hour drawdown
- Energy dissipator at the inlet to the settling basin
- Trash rack at outlets to the filter
- Vegetate slopes to the extent possible (see Vegetated Biofilters)
- Access ramp (4:1 or less) for maintenance vehicles
- One foot of freeboard
- Length to width ratio of at least 3:1 and preferably 5:1
- Sediment trap at inlet to reduce resuspension. One concept is shown in Figure 6E.

Additional design criteria for the filter:

- Use a flow spreader (Figure 6A).
- Use either of two alternative sand bed designs (Figure 6F).
- Use clean sand 0.02 to 0.04 inch diameter.
- Some have placed geofabric on sand surface to facilitate maintenance.
- Underdrains (Figure 6A).
  - Schedule 40 PVC.
  - 4 inch diameter.
  - 3/8 inch perforations placed around the pipe, with 6 inch space between each perforation cluster.
  - maximum 10 foot spacing between laterals.
  - minimum grade of 1/8" per foot.

<u>Configuring the linear filter</u>

Take the volume for the pretreatment unit and the filter area identified above and configure into a structure similar to that shown in Figure 6B. The structural design in Figure 6B assumes traffic loads over the filter. The structure can be less robust if it is located along the edge of the pavement, away from traffic. Other recommendations (Shaver, 1991):

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- Depth of sand 18"
- Diameter of the outlet pipe should be 6" or less: use multiple outlets if necessary

The filter must be positioned relative to the pavement in a manner that evenly distributes the flow as it enters the sedimentation chamber. Pavement design and construction is therefore critical.

Configuring the wet vault filter
Similarly the volume of the wet vault and filter area are configured into a rectangular unit similar to that shown in Figure 6C. Other considerations for the wet vault include:

- A length to width ratio of at least 3:1 to minimize short-circuiting
- Baffles to reduce entrance velocities and to retain floatables
- Access ports to facilitate maintenance
- Depth of the wet pool of at least 3 feet but not more than 10 feet

Catch basin insert
The catch basin insert filter may be ideal for industrial sites as it can be placed in existing catch basins, and therefore may avoid the need for an "end-of-pipe" facility. The system is illustrated in Figure 6D. It consists of a series of trays. The top tray is a sediment trap. Filter material is placed in the lower trays. Of several materials examined, the most suitable appears to be household fiberglass insulation. Limited tests indicate over 90% removal of metals and oil (McPherson, 1992). As the insert requires frequent attention it should only be used where a maintenance person is located on-site. The insert has a bypass along one side should the filter material clog and is hydraulically designed so as to not compromise the primary purpose of a catch basin, to get storm water into the drain system. The concept shown in Figure 6D is proprietary (Enviro-drain, 1992).

Maintenance
Inspect semiannually, and after major storms. Sediment should be removed from the settling basin when 4 inches accumulates and from the filter when 1/2 inch accumulates, or when there is still water in the basin or over the filter 40 hours after the storm. Remove floatables. Experience in Austin indicates the filter surface must be cleaned about twice each year by raking off the dried sediment. Failure to clean the filter regularly may result in the need to replace the entire media because of penetration of fines into the filter. It is more cost effective over the long term to clean the filter regularly as recommended. If there are open space areas in the tributary that are erosive or if construction is occurring, more frequent cleaning will be necessary. It may be necessary to replace the filter media after construction activity has ceased and the soils are stabilized.

Consult Austin (1988), Truong (1989), and Shaver (1991) for additional design and maintenance criteria.

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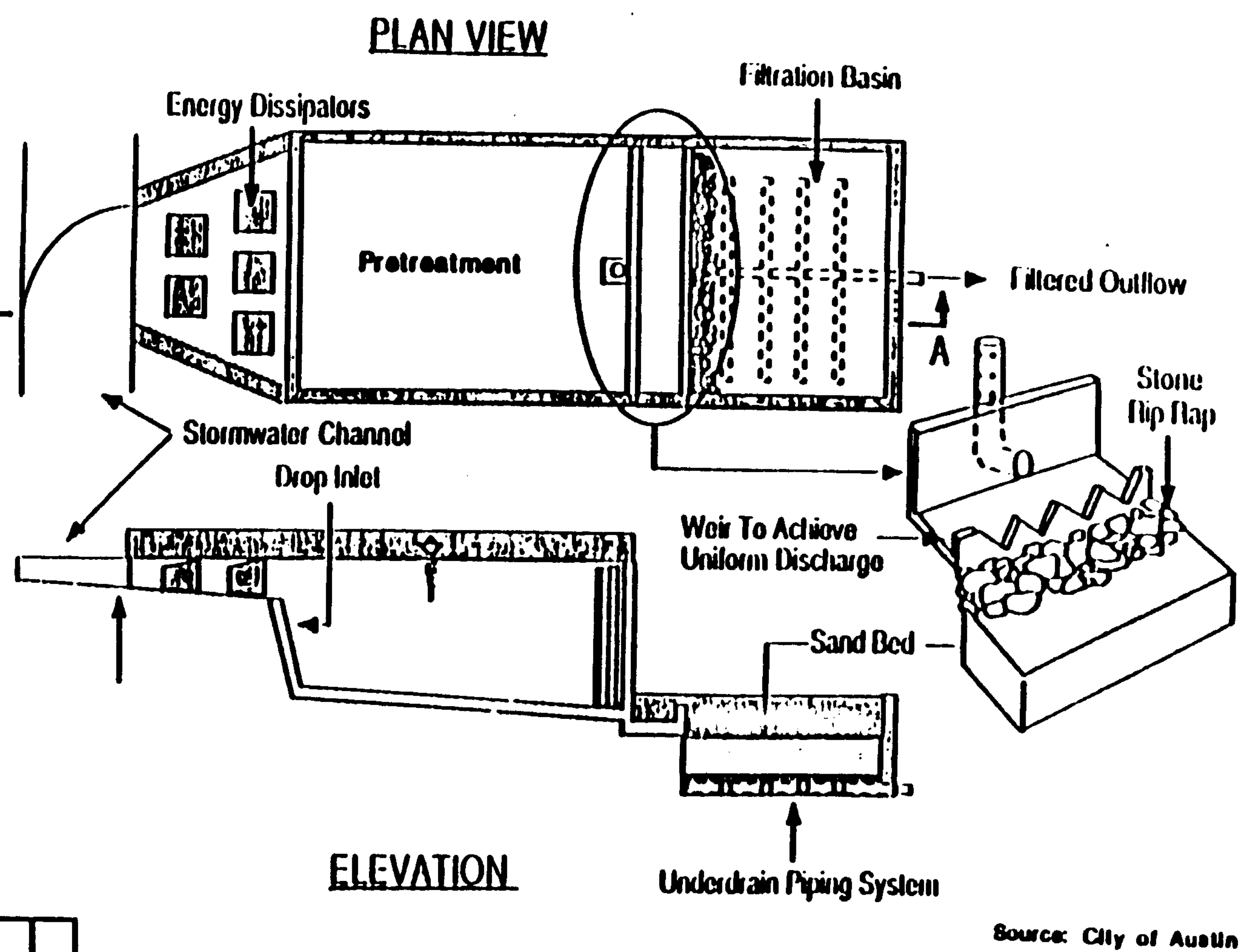

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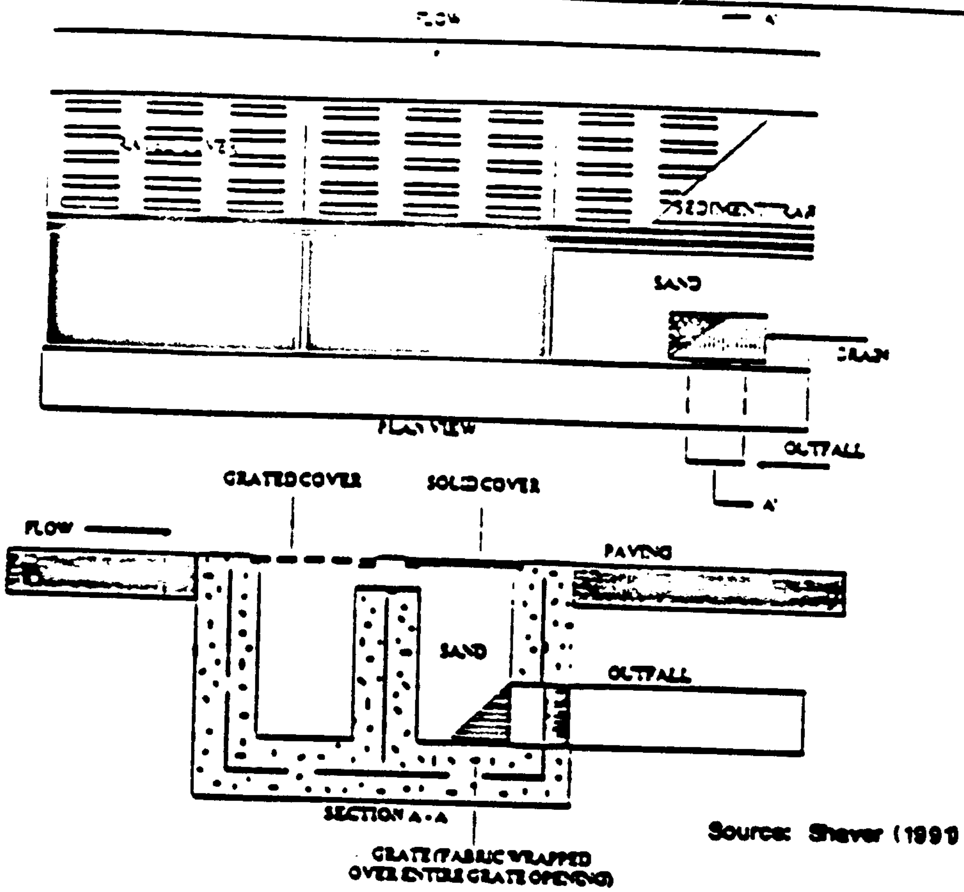
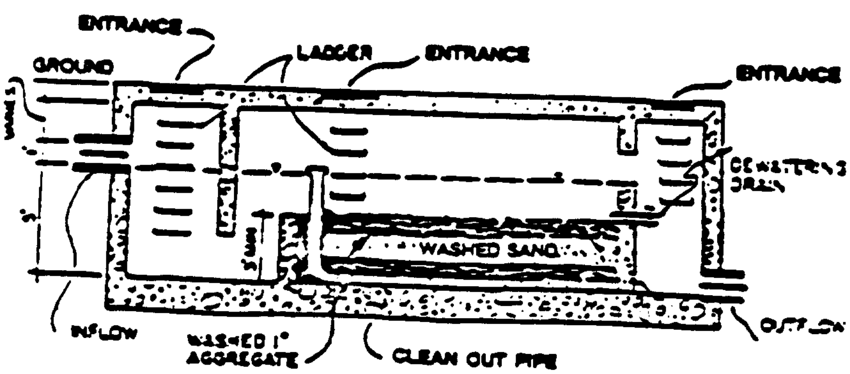
FIGURE 6A. CITY OF AUSTIN SAND FILTER



Source: Shaver (1991)

FIGURE 6B. LINEAL SAND FILTER



Source: District of Columbia

FIGURE 6C. VAULT SAND FILTER

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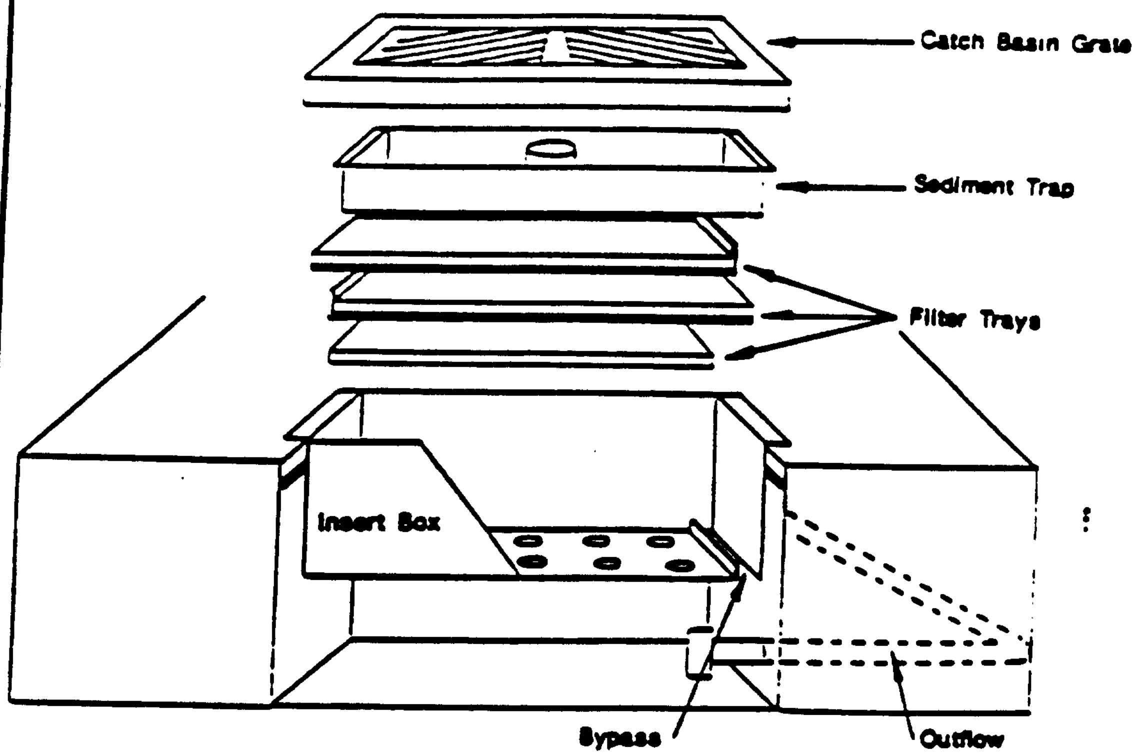
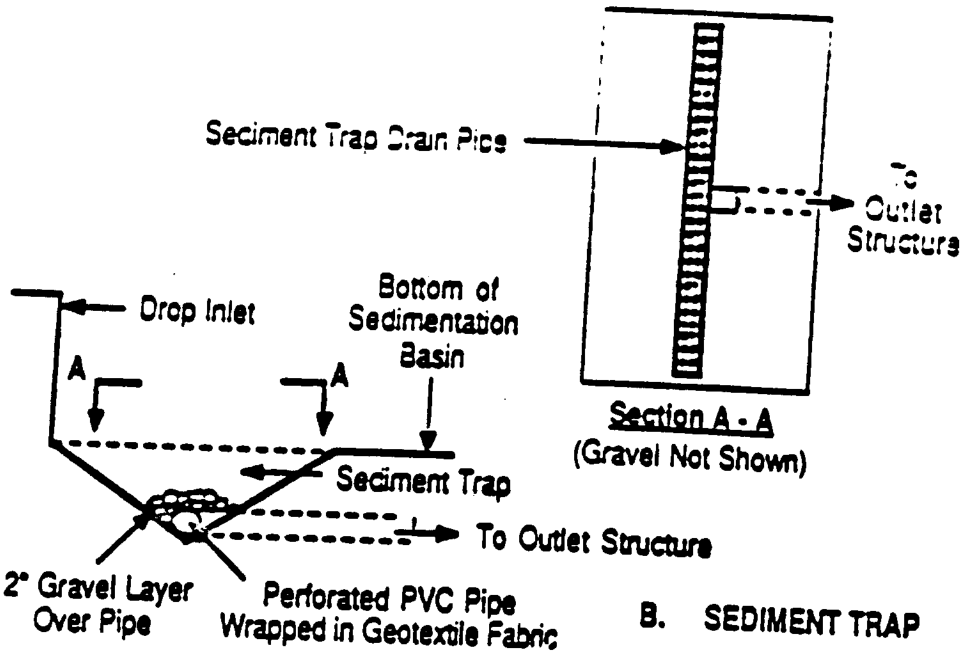


Source: McPherson (1992)

FIGURE 6D. CATCH BASIN FILTER



B. SEDIMENT TRAP

Source: City of Austin

FIGURE 6E. EXAMPLE RISER PIPE AND SEDIMENT TRAP DETAILS

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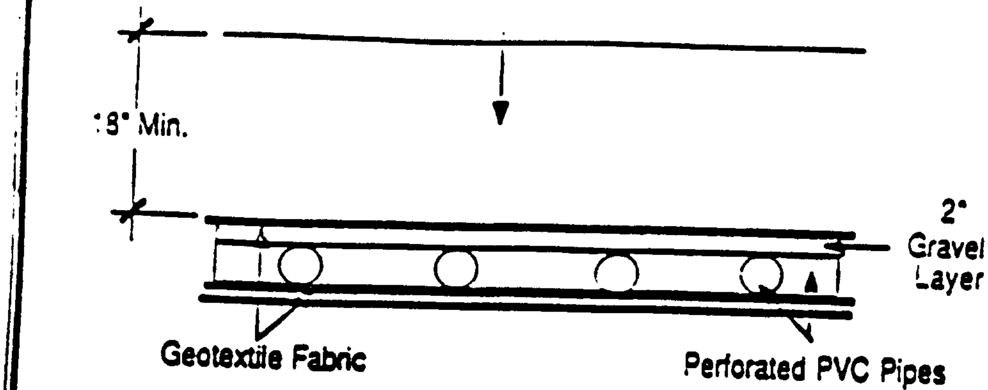
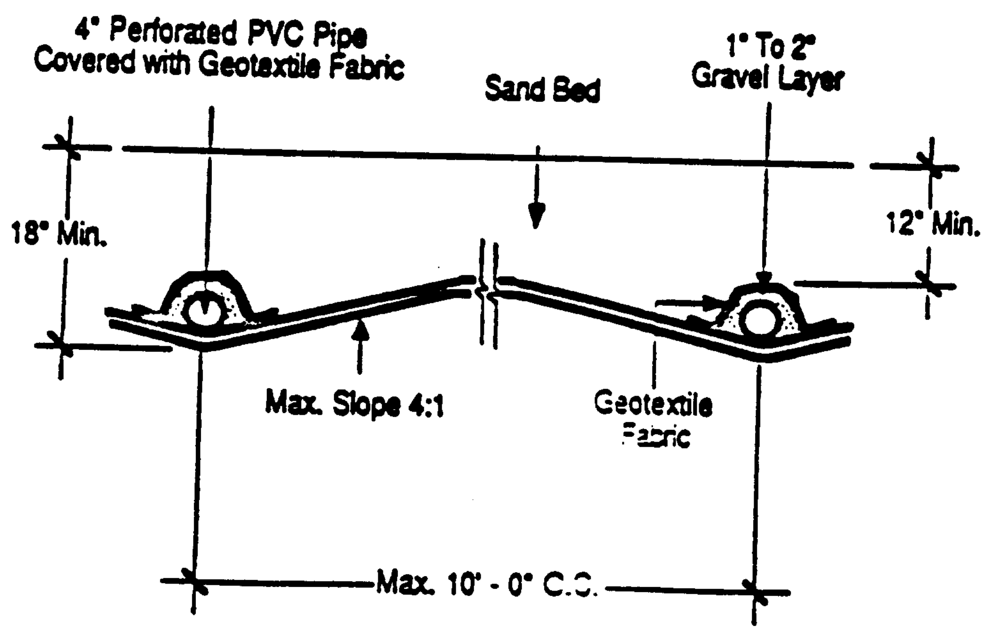


A. SAND BED PROFILE (WITH GRAVEL LAYER)



B. SAND BED PROFILE (TRENCH DESIGN)

Adapted from City of Austin (1988)

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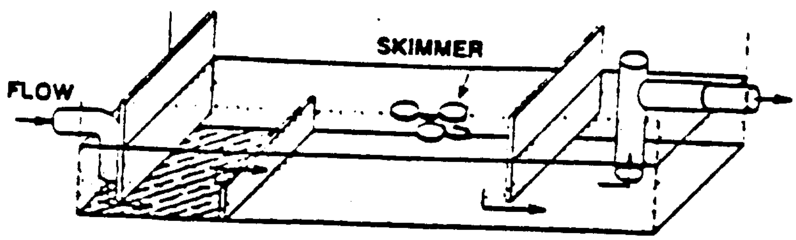
FIGURE 6F. SAND BED FILTRATION CONFIGURATIONS

BMP: OIL/WATER SEPARATORS AND WATER QUALITY INLETS



DESCRIPTION

Oil/water separators are designed to remove one specific group of contaminants: petroleum compounds and grease. However, separators will also remove floatable debris and settleable solids. Two general types of oil/water separators are used: conventional gravity separator and the coalescing plate interceptor (CPI).

EXPERIENCE IN CALIFORNIA

Oil/water separators are in use throughout California at industrial sites. Oil/water separators are used at all bulk petroleum storage and refinery facilities. A few jurisdictions require new commercial developments to install separators under certain situations that are environmentally sensitive.

SELECTION CRITERIA

Applicable to situations where the concentration of oil and grease related compounds will be abnormally high and source control cannot provide effective control. The general types of businesses where this situation is likely are truck, car, and equipment maintenance and washing businesses, as well as a business that performs maintenance on its own equipment and vehicles. Public facilities where separators may be required include marine ports, airfields, fleet vehicle maintenance and washing, facilities, and mass transit park-and-ride lots. Conventional separators are capable of removing oil droplets with diameters equal to or greater than 150 microns. A CPI separator should be used if smaller droplets must be removed.

LIMITATIONS

- Little data on oil characteristics in storm water leads to considerable uncertainty about performance.
- Air quality permit (conditional authorization) permit-by-rule from DTSC may be required.

DESIGN AND SIZING CONSIDERATIONS

- Sizing related to anticipated influent oil concentration, water temperature and velocity, and the effluent goal. To maintain reasonable separator size, it should be designed to bypass flows in excess of first flush.

CONSTRUCTION/INSPECTION CONSIDERATIONS

- None identified.

MAINTENANCE REQUIREMENTS

- Clean frequently of accumulated oil, grease, and floating debris.

COST CONSIDERATIONS

- Coalescing plate material is costly but requires less space than the conventional separator.

Considerations

- Soils
- Area Required (circled)
- Slope
- Water Availability
- Aesthetics
- Hydraulic Head
- Environmental Side Effects

Targeted Constituents

- ◐ Sediment
- ◐ Nutrients
- ◐ Heavy Metals
- ◐ Toxic Materials
- ● Floatable Materials
- ◐ Oxygen Demanding Substances
- ● Oil & Grease
- ○ Bacteria & Viruses

● Likely to Have Significant Impact
○ Probable Low or Unknown Impact

Implementation Requirements

- ◐ Capital Costs
- ◐ O&M Costs
- ◐ Maintenance
- ○ Training

● High ○ Low

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Additional Information — Oil/Water Separators and Water Quality Inlets

General Information

Oil/water separators will be needed for a few types of industrial sites where activities result in abnormal amounts of petroleum products lost to exposed pavement, either by accidental small spills or normal dripping from the vehicle undercarriage. This will most likely be related to vehicle and mobile equipment maintenance activities. Separators may also be advisable where an area is heavily used by mobile equipment such as loading wharfs at marine ports. Limited data indicates oil/water separators can reduce the oil/grease concentration below 10 mg/l (Lettenmaier, et al. 1985).

Wet ponds, constructed wetlands, and biofilters will remove petroleum products but their reliability is uncertain where high concentrations of petroleum products may occur frequently. Also, BMPs that rely on vegetation may be damaged or become unsightly if high concentrations of oil and grease occur frequently.

The sizing of separators is based upon the rise rate velocity of oil droplet and rate of runoff. However, with the exception of storm water from oil refineries there are no data describing the characteristics of petroleum products in urban storm water that are relevant to design: either oil density and droplet size to calculate rise rate or direct measurement of rise rates. Further, it is known (Silverman, 1982) that a significant percentage of the petroleum products are attached to the fine suspended solids and therefore are removed by settling not flotation. Consequently, the performance of oil/water separators is uncertain.

The basic configurations of the two types of separators are illustrated in Figure 7A. With small installations, a conventional gravity separator has the general appearance of a septic tank, but is much longer in relationship to its width. Larger facilities have the appearance of a municipal wastewater primary sedimentation tank. The CPI separator contains closely spaced plates which enhances the removal efficiency. In effect, to obtain the same effluent quality a CPI separator requires considerably less space than a conventional separator. The angle of the plates to the horizontal ranges from 0° (horizontal) to 60°, although 45° to 60° is the most common. The perpendicular distance between the plates typically ranges from 0.75 to 1 inch. The storm water will either flow across or down through the plates, depending on the plate configuration.

A related system is the water quality inlet illustrated in Figure 7B. It is essentially a conventional gravity separator but without the appropriate geometric configuration (see Design discussion below). Another name for this systems is a wet vault. Water quality inlets have been found to be generally ineffective (Shepp, et al., 1992) because the recommended size (200 to 400 ft^3/acre of tributary) is too small. To be effective, a water quality inlet must have the surface area and volume that is similar to that of conventional separators. They may exhibit odor problems during the summer because of the lack of bacterial degradation of accumulated organic matter and the lack of reaeration of the wet pool. Facilities in Washington D.C. have been observed to have odor but, it has been noticeable only when the system is opened for inspection.

Design of Conventional Separators

The sizing of a separator is based upon the calculation of the rise rate of the oil droplets using the following equation (modified from API, 1990):

$$V_p = 1.79\,(d_p - d_c)\,d^2 \times 10^{-8}/a \qquad (1)$$

where:
- V_p = rise rate (ft/second)
- a = absolute viscosity of the water (poises)
- d_p = density of the oil (gm/cc)
- d_c = density of the water (gm/cc)
- d = diameter of the droplet to be removed (microns)

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A water temperature must be assumed to select the appropriate values for water density and viscosity from Table 7A. The engineer should use the expected temperature of the storm water during the December-January period. There are no data on the density of petroleum products in urban storm water but it can be expected to be between 0.85 and 0.95. To select the droplet diameter the engineer must identify an efficiency goal based on an understanding of the distribution of droplet sizes in storm water. However, there is no information on the size distribution of oil droplets in urban storm water. Figure 7C is a size and volume distribution for storm water from a petroleum products storage facility (Brown et al., undated). The engineer must also select a design influent concentration, which carries considerable uncertainty because it will vary widely within and between storms.

To illustrate Equation 1: if the effluent goal is 10 mg/l and the design influent concentration is 50 mg/l, a removal efficiency of 80% is required. From Figure 7C: this efficiency can be achieved by removing all droplets with diameters 90 microns or larger. Using a water temperature of 10°C gives a water density of 0.998. Using an oil density of 0.898, the rise rate for a 90 micron droplet is 0.0011 feet per second.

It is generally believed that conventional separators are not effective at removing droplets smaller than of 150 microns (API, 1990). Theoretically, a conventional separator can be sized to remove a smaller droplet but the facility may be so large as to make the CPI separator more cost-effective.

Sizing conventional separator (modified from API, 1990).

$$D = (Q/2V)^{1/2} \qquad (2)$$

where: D = depth, which should be between 3 and 8 feet
Q = design flow rate (cfs)
V = allowable horizontal velocity which is equal to 15 times the design oil rise rate but not greater than 0.05 feet per second

If the depth exceeds 8 feet, design parallel units dividing the design flow rate by the number of units needed to reach the maximum recommended depth of 8 feet. Equation (2) is simplified from equations in API (1990) based on a recommended width to depth ratio of 2. The constant in Equation (2) can be changed accordingly if a different ratio is assumed. Some engineers may wish to increase the facility size to account for flow turbulence. See API (1990) for the design procedure.

Then:

- Calculate length, $L = VD/V_p$
- Compute width, $W = Q/(VD)$. This should be 2 to 3 times the depth, but not to exceed 20 feet
- Baffle height to depth ratio of 0.85 for top baffles and 0.15 for bottom baffles
- Locate the distribution baffle at 0.10L from the entrance
- Add one foot for freeboard
- Install a bypass for flows in excess of the design flow

Determining the design flow, Q, requires identification of the design storm. The separator is expected to operate effectively at all flow rates equal to or less than the peak runoff rate of the design storm. The design storm need not be an extreme event, as is typically used in the sizing of flood control facilities. If sized to handle a storm frequency between the 3-month to 1-year event, the facility will effectively treat the vast majority of storm water that occurs over time. All events equal to or less than the 6-month event represents about 90% of the precipitation over time; designing for a 2-year

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event only increases the amount of runoff treated by about 5% (increase from 90% to 95% of rainfall treated). For the design storm selected, calculate the peak runoff rate using the rational method.

Application of the Conventional Oil/Water Separator
Assume that a conventional oil/water separator is to be used to treat runoff from a 1/2 acre parking lot. Assume further it is to be sized to treat runoff from a rainfall rate of 0.50 inches/hr (which translates to a runoff rate of 0.50 cfs/acre when the area is 100 percent impervious.

Using the example above, the computed Vp is 0.0011 ft/sec. Using Equation 2, V =15 x 0.0011= 0.0165 ft/sec which is less than 0.05 ft/sec; thus,

D = (Q/2V)0.05 = (1/2 x 0.05/(2 x 0.0165)) x 0.05
D = 3.8 ft.

L = VD/Vp = 0.0165 x 3.8/0.0011
L = 57 ft.

W = Q/(VD) = 0.25/(0.0165 x 3.8)
W = 4.0 ft, since W is less than 2 x D, increase width to W = 3.8 x 2 = 7.6 ft.

Thus, a conventional oil/water separator sized to capture runoff from a 0.5 in/hr rainfall on a 1/2 acre parking lot would be:

D = 3.8 ft
W = 7.6 ft
L = 57 ft

Sizing CPI separator
Manufacturers can provide packaged separator units for flows up to several cubic feet per second. For larger flows, the engineer must size the plate pack and design the vault. Given the great variability of separator technology among manufacturers with respect to plate size, spacing, and inclination, it is recommended that the design engineer consult vendors for a plate package that will meet the engineer's criteria. Manufacturer's typically identify the capacity of various standard units. However, the engineer's design criteria must be comparable to that used by the manufacturer in rating its units.

The engineer can size the facility using the following procedure. First identify the expected plate angle, H (as degrees), and calculate the total plate area required, A(ft^2).

$$A = Q/V_p \text{Cosine} H \qquad (3)$$

CPI separators are not 100% hydraulically efficient, ranging from 0.35 to 0.95 depending on the plate design (Aquatreod, undated). If the engineer wishes to incorporate this factor, divide the result from Equation 3 by the selected efficiency.

- Select spacing, S, between the plates, usually 0.75 to 1.5 inch.
- Identify reasonable plate width, W, and length, L.
- Number of plates, N = A/WL.
- Calculate plate volume, P_v(ft^3).

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P_V = (SS/12 + LCosineH)(WLSineH)   (4)

- Add a foot beneath the plates for sediment storage.
- Add 6" to 12" above the plates for water clearance so that the oil accumulates above the plates.
- Add one foot for freeboard.
- Add a forebay for floatables and distribution of flow if more than one plate unit is needed.
- Add after bay for collection of the effluent from the plate pack area.
- For larger units include device to remove and store oil from the water surface.

Horizontal plates require the least plate volume to achieve a particular removal efficiency. However, settleable solids will accumulate on the plates complicating maintenance procedures. The plates may be damaged by the weight when removed for cleaning. The plates should be placed at an angle of 45° to 60° so that settleable solids slide to the facility bottom. Experience shows that even with slanted plates some solids will "stick" to the plates because of the oil and grease. Placing the plates closer together reduces the plate volume. However, if debris is expected such as twigs, plastics, and paper, select a larger plate separation distance. Or install ahead of the plates a trash rack and/or screens with a diameter somewhat smaller than the plate spacing.

Recognizing that an oil/water separator also removes settleable solids, it can also be considered a wet vault (TC2). The engineer can use Figure 2B (See TC2) to estimate the efficiency of both the conventional and CPI separators. As Figure 2B does not include the effect of plate technology, a CPI separator should perform considerably better than indicated in Figure 2B for the same V_b/V_r ratio.

See API (1990) for further design concepts for both the conventional and CPI separators.

<u>Maintenance</u>

Check monthly during the wet season and clean several times a year. Always clean in October before the start of the wet season. Properly dispose the oil.

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TABLE 7A. WATER VISCOSITIES & DENSITIES

Temperature °C	Temperature °F	Absolute Viscosity (Poises)	Absolute Viscosity (slugs/ft.sec.)	Density (gm/cc)	Density of pure water in air (lbs/ft^3)
0	32.0	0.017921	0.00120424	0.999	62.351
1	33.8	0.017343	0.00116338	0.999	62.355
2	35.6	0.016728	0.00112407	0.999	62.358
3	37.4	0.016191	0.00108799	0.999	62.360
4	39.2	0.015674	0.00105324	1.000	62.360
5	41.0	0.015188	0.00102059	0.999	62.360
6	42.8	0.014728	0.00098968	0.999	62.359
7	44.6	0.014284	0.00095984	0.999	62.357
8	46.4	0.013860	0.00093135	0.999	62.354
9	48.2	0.013462	0.00090460	0.999	62.350
10	50.0	0.013077	0.00087873	0.999	62.345
11	51.8	0.012713	0.00085427	0.999	62.339
12	53.6	0.012363	0.00084870	0.999	62.333
13	55.4	0.012028	0.00080824	0.999	62.326
14	57.2	0.011709	0.00078681	0.999	62.317
15	59.0	0.011404	0.00076631	0.999	62.309
16	60.8	0.011111	0.00074662	0.999	62.299
17	62.6	0.010828	0.00072761	0.999	62.289
18	64.4	0.010559	0.00070953	0.999	62.278
19	66.2	0.010299	0.00069206	0.999	62.266
20	68.0	0.010050	0.00067533	0.998	62.254

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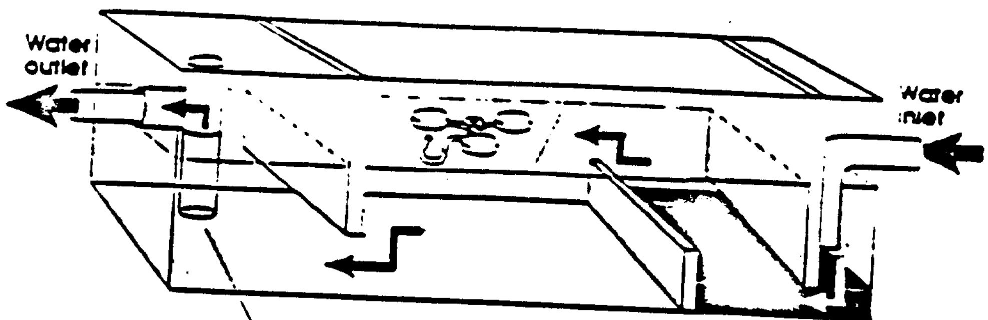
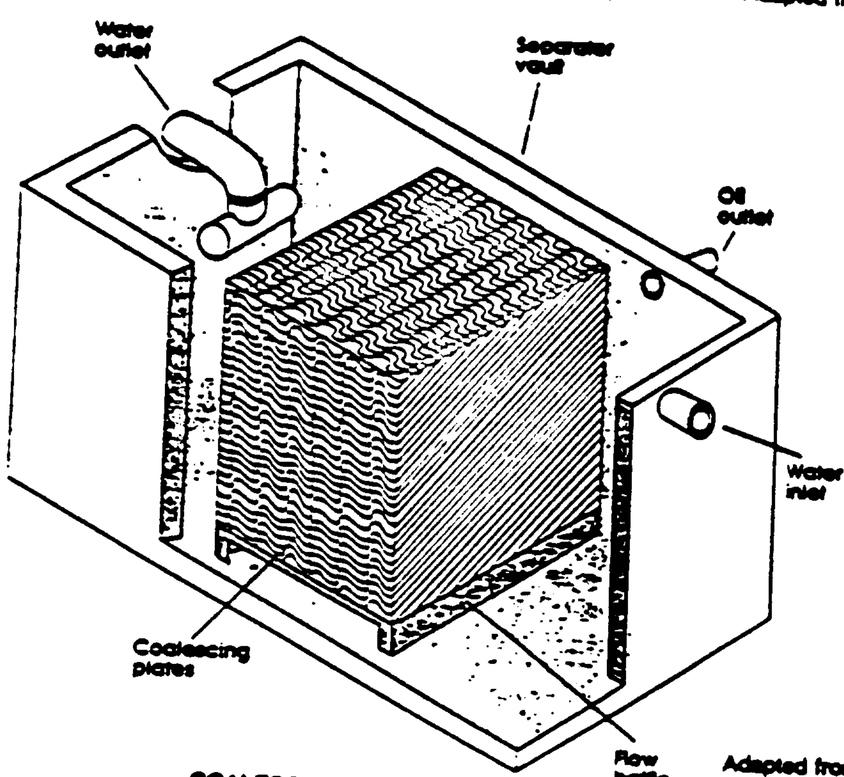


CONVENTIONAL SEPARATOR

Adapted from Romano, 1990

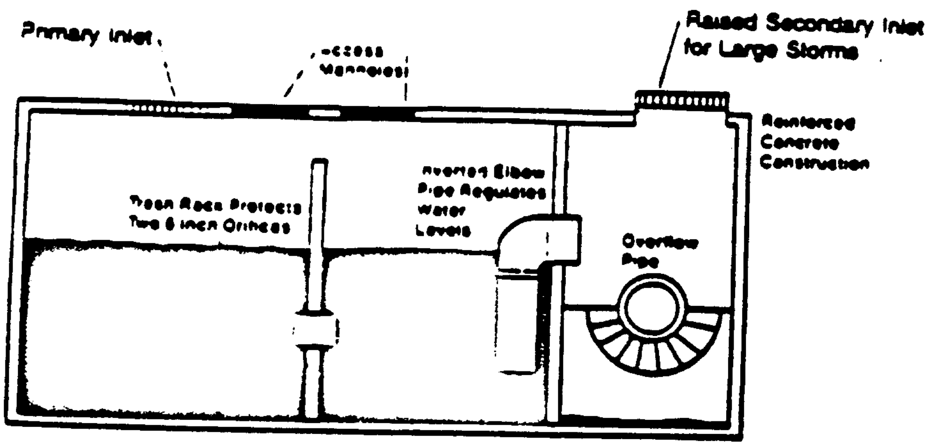


COALESCING PLATE SEPARATOR

Adapted from Romano, 1990

TC7

FIGURE 7A. CONVENTIONAL AND COALESCING PLATE SEPARATORS

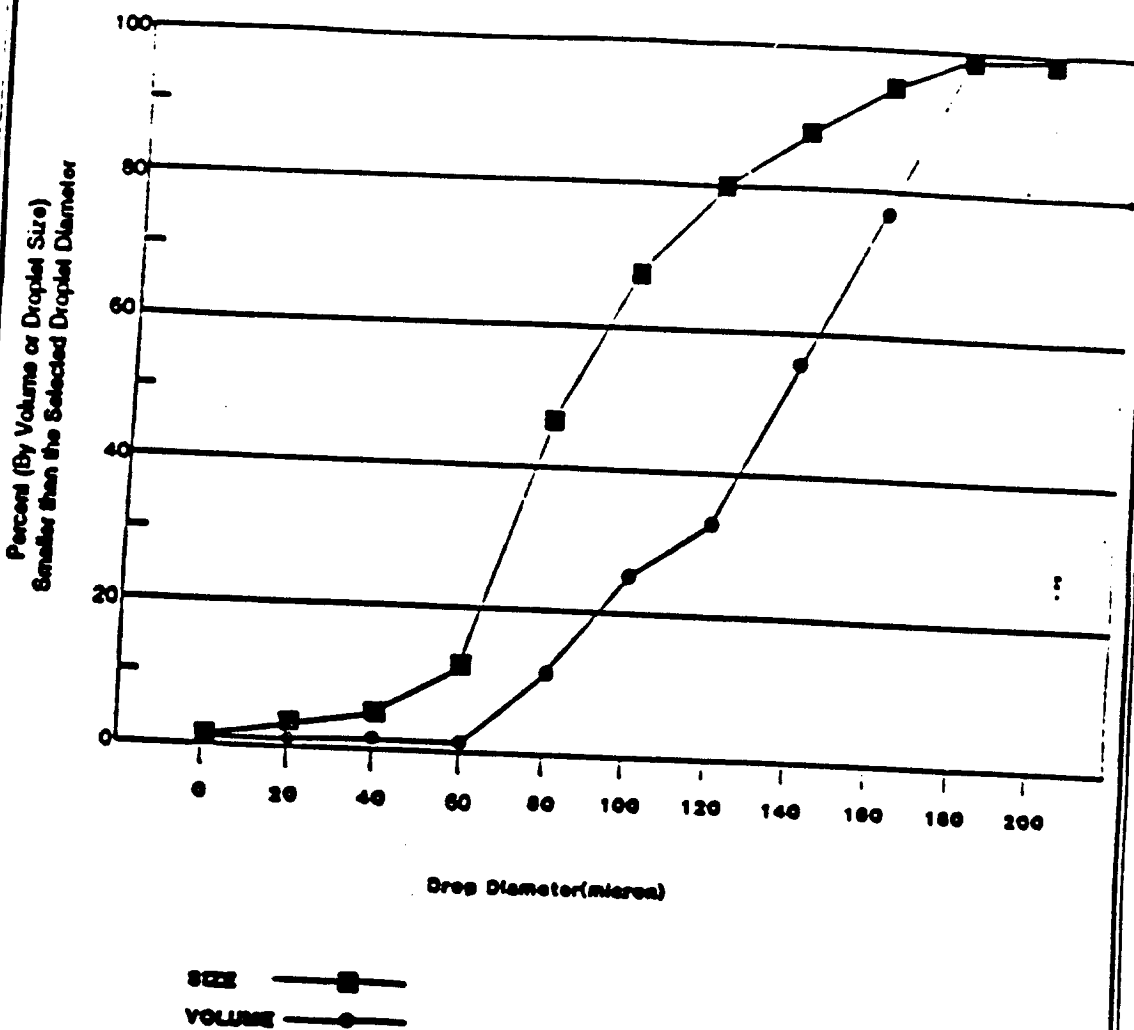


Adapted from Schueler, 1987

NOTE:
1. Size as conventional separator.
2. Design outlet orifice in elbow to limit outflow to the design rate for the unit.

FIGURE 7B. WATER QUALITY INLET

TC7



Source: Branion (undated)

FIGURE 7C. SIZE AND VOLUME DISTRIBUTION

TC7

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R0050194

Non Point Source Permits	Questionnaires		Pollution Prevention Plan	
Tenant Participants	Meeting	Received	Meeting	Received
Joseph Lombardi - (310) 436-5234 Applied Industrial Materials Corporation 1270 Pier G Avenue Long Beach, CA 90802 ID# 016378-ND4-89		9/12/91	2/24/92	
Leroy Maples - (310) 886-9050 A.S.I. 855 W. Walnut Compton, CA Location: 1326 W. 12th Street ID# 015230-ND4859	1/31/92	1/31/92		
Thomas W. Vaughan - (213) 268-2801 Baker Commodities, Inc. 4020 Bandini Blvd. Los Angeles, CA 90023 Location: 530 Pier D Avenue ID# 016352-ND3227		9/3/91		
Gus Paul - (408) 432-8870 or (310) 435-8950 Boliden Bulen, Inc. Fleur Building 10 Twin Dolphin Drive, Suite 503 Redwood City, CA 94065 Location: Pier 8, Berth 214 ID# 016410-ND2-628		9/12/91		
Charles Wyant - (310) 435-8235 California United Terminals 300 Pier B Avenue Long Beach, CA 90802 ID# 016162-ND6-175		9/6/91		
Ken Johnson - (415) 894-6560 Chevron U.S.A., Inc. 575 Market Street, Room 2652 San Francisco, CA 94120-7006 Location: 1140 Pier G Avenue ID# 016162-ND3406/1		11/25/91		

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Sue Mitas Goldenwest Distribution Services P.O. Box 2128 Santa Fe Springs, CA 90670 Location: 1200 W. Panorama Drive ID# 016196-ND4-31/1		9/26/91		
Victor Hovsepian - (310) 432-8067 City Paper and Metal Company, Inc. 1452 W. 11th Street Long Beach, CA 90813 Location: 1430 & 1452 W. 11th Street ID# 015198-ND4742	12/16/91	12/16/91	2/26/92	
Chris Gregory - (310) 432-1415 Clean Coastal Waters 1185 W. Seaside Blvd. Long Beach, CA 90802-1097 ID# 014779-ND2-556		9/5/91	2/19/92	
Dennis Werner - (213) 955-3444 Coast Citrus Distributors, Inc. .O. Box 21831 Los Angeles, CA 90021 Location: 1420 Panorama Drive ID# 013177-ND3207		2/7/92		
Mary Palleros - (310) 436-6876 Creative Unicellular Products 1556 W. 9th Street Long Beach, CA 90802 ID# 015008-ND4834		2/5/92	2/26/92	
Ed Viner - (310) 436-2259 Cooper T./Smith Stevedoring Co., Inc. P.O. Box 229 Long Beach, CA 90801 Location: Pier F, Berths 203-204 (Transit Shed) ID# 016527-ND4-83		8/5/91	2/24/92	
Ed Viner - (310) 436-2259 Cooper T./Smith Stevedoring Co., Inc. P.O. Box 229 Long Beach, CA 90801 Location: Pier F, Berths 205 (Niuka America) ID# 016527-ND4-83		8/5/91	2/24/92	
Wisniewski - (310) 432-6477		9/6/91	2/19/92	

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Crescent Terminals, Inc. Pier F, Berths 206 Long Beach, CA 90802 ID# 016220-ND3389				
Ralph J. Wagoner - (310) 491-4744 Crowley Transportation and Towing Pier 1, Berths 47-49 Long Beach, CA 90802 ID# 014217-ND4-69		9/12/91		
Roland Johnson - (310) 436-4611 Domtar Gypsum, Inc. 1401 Water Street Long Beach, CA 90802 ID# 014761-ND3-71		8/30/91		
Jack Slum - (310) 432-5401 Forest Terminals, Inc. Pier 1, Berth 50 Long Beach, CA 90802 ID# 016337-ND6234		9/6/91		
Lex Delgado - (310) 435-4839 Fremont Forest Products 800 Pier E Avenue Long Beach, CA 90802 ID# 016287				
Sue Gonzales - (310) 499-3218 Arco CQC Kiln (Great Lakes Coke Storage) P.O. Box 1028 Wilmington, CA 90748 Location: Pier G				
Larry E. Vining - (310) 432-6475 Hampton Tedder Electric Company, Inc. 1120 W. Seaside Blvd. Long Beach, CA 90802 ID# 014613-ND2-598		8/2/91	2/19/92	
Mike Jones - (310) 499-4697 Hanjin Shipping 1321 W. 7th Street Long Beach, CA 90813 ID# 016543-ND4-85		9/12/91		
Arnold Pantus - (310) 435-7323 bor Terminal Services (Davies Transportation)		9/5/91	2/26/92	

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R0050197

Contact				
P.O. Box 1140 Long Beach, CA 90801 Location: 1362 W. 12th Street ID# 015225-ND4831				
Richard Jones - (310) 437-0921 Hartley Nixon Rentals P.O. Box 9216 Long Beach, CA 90810 Location: 1900 W. Anaheim Street ID# 014522-7		9/5/91	1/29/92	
Michael Fogerty - (310) 435-7781 International Transportation Service, Inc. 1281 Pier J Avenue Long Beach, CA 90802 ID# 016105-ND6-104		9/4/91		
John Moore - (310) 491-5550 Island Express Helicopters 900 Queensway Drive Long Beach, CA 90802 ID# 013128-ND2-694		9/16/91		
Scott Lebbin - (310) 436-4680 Koch Carbon, Inc. 1202 W. Panorama Drive Long Beach, CA 90802 ID# 016501-ND3-225/11		8/30/91	3/4/92	
Sam Van Os - (310) 436-9918 Lomita Gasoline Company P.O. Box 1330 Long Beach, CA 90801-1330 Location: 1332 & 1334 W. 9th Street ID# 015115-ND3464		2/6/92		
Art Merrick - (310) 435-8585 Long Beach Container Terminal 1493 Panorama Drive Long Beach, CA 90802 ID# 016469-ND6-244		9/12/92		
Robert Brady - (310) 432-5451 Long Beach Iron Works, Inc. 2100 W. Anaheim Street Long Beach, CA 90813 ID# 015248-3		1/30/92		

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John Spilis - (818) 246-5837 Lucky Cement Corporation, U.S.A. 517 E. Wilson Avenue, Suite 101 Glendale, CA 91260 Location: 1452 Panorama Drive ID# 016519-ND2728		8/23/91		
Pete Aspaturian - (310) 436-1274 Maersk Pacific Ltd. 1521 Harbor Scenic Drive Long Beach, CA 90802 ID# 016477-ND6-248		10/7/91		
Rich Colarusso - (310) 432-8721 Metropolitan Stevedore Pier 8, Berth 212 Long Beach, CA 90802 ID# 016014-ND4-62		9/12/91	2/24/92	
Keith Morgan - (310) 437-0071 Morton International, Inc. .O. Box 2289 Long Beach, CA 90801-2289 Location: 1250 Panorama Drive ID# 016188-ND3158		9/6/91	3/2/92	
Rick Gales - (310) 435-4465 x257 National Gypsum Company (Gold Bond Building Products) 1850 W. 8th Street Long Beach, CA 90813 ID# 016436-ND3210	1/31/92	2/7/92	3/4/92	
C.H. Perbix - (310) 435-7151 Pacific Coast Cement Corporation 1605 Water Street Long Beach, CA 90802 Location: 601 Pier D Avenue ID# 016261-ND419		3/2/92		
Bruce Wargo - (310) 495-8520 Pacific Container Terminal P.O. Box 1960 Long Beach, CA 90801 Location: 871 Harbor Scenic Way ID# 016097-ND4-60/I		9/5/91		
n Noble - (310) 639-7190 cific Rim Transport, Inc. (P.R.T.I.)		10/17/91		

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2960 E Victoria Street Compton, CA. 90221 Location: 1187 El Embarcadero ID# 016097-ND4-60				
Sean Torkelson - (310) 435-0171 Pacific Towboat & Salvage Company (Foss Maritime) Pier D, Berth 35 Long Beach, CA 90802 ID# 013557-ND444		9/14/91		
Wayne Hall - (714) 553-0112 Petro Diamond Terminal Company 1920 Lugger Way Long Beach, CA 90813 ID# 016444-ND3370/1		8/27/91		
Matt Winefield - (310) 944-6111 Powerine Oil Company 12354 Lakeland Road Santa Fe Springs, CA 90813 Location: 1605 W. 7th Street ID# 015214-ND3244		10/1/91		
Bob Shepard - (213) 685-5630 x483 Power Systems Associates P.O. Box 7044 Los Angeles, CA 90022 ID# 016845-ND2-490		8/30/91	3/10/92	
Paul Edgington - (310) 590-2128 Sea-Land Service, Inc. 669 Panorama Drive Long Beach, CA 90802 ID# 016139-ND3-21 (Container Freight Station) ID# 016113-ND2-483 (Pier G)		9/16/91	2/26/92	
Veronica Wegener - (310) 495-6250 Seal Beach Sportfishing P.O. Box 26 Seal Beach, CA 90740 Location: Berth 11 ID# 013102-ND2411		9/6/91		
Jonathan Grossman - (310) 431-8486 Security Environmental Systems 7245 J Garden Grove Blvd. Garden Grove, CA 92641		8/14/91		

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Contact				
Location: 2701 W. Seaside Blvd. ID# 015370-HD2-483				
Larry Alexander - (714) 520-3374 Shell Pipe Line Corp. P.O. Box 4848 Anaheim, CA 92803 ID# 014837-HD2-428		2/7/92		
Rex Osborne - (310) 495-3617 S.R.M Corporation 555 No. Pico Avenue Long Beach, CA 90802 ID# 014316-HD3-241		9/6/91		
Tommy Thompson - (310) 522-6204 Texaco Refining and Marketing, Inc. P.O. Box 817 Wilmington, CA 90748 2050 Edison Way ID# 016071-HD3230		9/12/91		
Kathye Lehman - (310) 983-6456 THUMS Long Beach Company P.O. Box 2900 Long Beach, CA 90801-2900 Location: Throughout Harbor District ID#				
Mark Shemaria - (310) 436-9918 Tidelands Oil Production Company (TOPKO) 301 E. Ocean Blvd., Suite 300 Long Beach, CA 90801 Location: Throughout Harbor District ID#		1/8/92		
Cecil Ransom - (310) 618-4793 Toyota Motor Sales, U.S.A, Inc. 785 Edison Avenue Long Beach, CA 90813 ID# 016295-HD8-218		9/25/91		
James Lacy - (310) 435-5623 Westway Trading Corporation 228 St. Charles Avenue, Suite 700 New Orleans, LA 70115 1395 Pier J Avenue ID# 016089-HD3365		10/16/91		

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Non Point Source Permits / Non Tenant Participants	Questionnaires: Meeting	Questionnaires: Received	Pollution Prevention Plan: Meeting	Pollution Prevention Plan: Received
Martyn Temple - (310) 432-3373 Weyerhaeuser Company P.O. Box 830 Long Beach, CA 90802 Location: 280 Pier E Avenue ID# 016279-H08-256		9/11/91		
Greg Owen - (310) 518-8983 Aid Forwarding Company/City Distribution Services, Inc. 505 So Anaheim Blvd. Anaheim, CA 92815 Location: 1141 Campion Avenue ID# 000001-44	12/13/91	12/13/91		
David Hensch - (310) 437-1247 Coast Oil Salvage 1400 W. Anaheim Street Long Beach, CA 90813 ID# 000001-21	12/11/91	12/11/91		
Rick Everist - (310) 436-3281 L.S. Everist, Inc. 1605 Water Street Long Beach, CA 90802 Location: 1601, 1605, and 1925 Water Street ID# 000001-8613-7/1				
Violet Miller - (310) 437-6966 R&I Enterprises dba A&A Oil Tools and Service Company 1426 W. 12th Street Long Beach, CA 90813 ID# 000001-47				
John S. Hanson - (310) 436-1040 Spun Products, Inc. 1800 W. 9th Street Long Beach, CA 90813 ID# 000001-15	12/13/91	12/13/91		
Mark Steckler - (310) 495-3808 Superior Electrical Advertising, Inc. 1700 W. Anaheim Street Long Beach, CA 90813 ID# 000001-16				

1 6897

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VOL 12

February 23, 1994

Mr. Xavier Swamikannu
California Regional Water
 Quality Control Board
Los Angeles Region
101 Centre Plaza Drive
Monterey Park, CA 91754

Subject: Deletion of Coast GM Salvage from the Port of Long Beach Non-Point Source Program

Reference: NOI #4B10S003628

Dear Mr. Swamikannu:

As you know, the Port of Long Beach elected to hold the Storm Water NPDES Permit to cover its tenants under the NPDES Program. In order to be covered under the program, tenants must cooperate with Port requirements, most importantly by preparing, submitting, and updating a Storm Water Pollution Prevention Plan. Tenant cooperation is essential to ensure that the Port's program complies with the EPA's NPDES requirements for participating in the NPDES Program.

Coast GM Salvage, however, has not complied with the Port's requirements. Accordingly, please update your files to reflect that Coast GM Salvage has not elected to be included under the Port of Long Beach Storm Water NPDES Permit Program.

If you have any further questions regarding this matter, please contact Stacey Crouch at (310) 590-4160.

Sincerely,

Geraldine Knatz, Ph.D.
Director of Planning

MJ:s

1 6898

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VOL 12

DATE: January 13, 1994

TO: Interested Persons

FROM: Geraldine Knatz, Director of Planning

SUBJECT: Annual Site Inspections

Thank you for participating in the Non-Point Source Pollution Control Program and doing your part to comply with the Federal and State's Clean Water Act. As in the past year, the Port of Long Beach will continue to coordinate facility compliance with EPA Non-Point Source Storm Water Pollution Prevention Plan (SWPPP) requirements. Your continued cooperation is essential to the success of this very important program.

This spring, Planning Division staff will conduct its 1994 Storm Water Pollution Prevention Plan site inspections of the participating facilities. As in the past year, Planning staff encourages continued adherence to your approved facility SWPPP and the use of Best Management Practices (BMP's). In addition, we urge you to review and implement additional BMP's as appropriate. If there are modifications to your facility, please incorporate those changes into your facility's SWPPP and submit the revised SWPPP to the Planning Division for approval.

Planning staff will be in contact with your facility to arrange a date to conduct its 1994 site inspection. If you have any further questions, please contact Stacey Crouch at (310) 590-4160. Thank you for your continued participation in the SWPPP program.

Sincerely,

Geraldine Knatz

Geraldine Knatz, Ph.D.
Director of Planning

GKJ:s

1
5899

R0050204

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VOL 12

DATE: May 23, 1994

TO: Interested Persons

FROM: Geraldine Knatz, Director of Planning

SUBJECT: Annual Site Inspections

As a participant in the EPA's Non-Point Source Program, it is a vital concern of the Port of Long Beach to be continually striving to improve pollution control measures within the Harbor District. The recent lawsuits over alleged violations of the Non-Point Source Program's regulations make it more important than ever that the Port of Long Beach enforce both strict adherence by its tenants to their approved SWPPPs and the use of Best Management Practices.

Starting in June, 1994, Planning Division staff will begin to conduct the 1994 site inspections required by our Storm Water Pollution Prevention Plan. Accordingly, in the next few weeks Planning staff will contact you to arrange a date for the 1994 site inspection.

If you have any further questions, please contact Stacey Crouch at (310) 590-4160. Thank you for your continued participation in the SWPPP program.

Sincerely,

Robert Kanter

for Geraldine Knatz, Ph.D.
Director of Planning

MJ:s

1
6900

NON POINT SOURCE PERMIT MONITORING
1993-1994

Tenant:

Contact:

Phone:

Address:

ID #:

SWPPP

Received: ______

Complete: ______ Incomplete: ______ Revision Requested: ______

Reviewed: ______

Approved: ______

Implemented: ______

Updated: ______

Tenant Follow Up ______

Annual Inspection

Date Conducted (Initials): ______ __

Compliance with SWPPP (Y/N) __

Port Follow Up date: ______

Comments:

Additional Comments:

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R0050206

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VOL 12

July 5, 1994

Mr. Charles Wyant
California United Terminals
1200 Pier E Street
Long Beach, CA 90802

Subject: Annual Storm Water Pollution Prevention Plan (SWPPP) Site Inspection

Dear Mr. Wyant:

On June 30, 1994, the Planning Division of the Port of Long Beach conducted its annual site inspection of your facility. Since there have not been any significant changes to your facility, the current SWPPP is still in effect.

Please be advised that if there are changes to your facility in the future, a revised SWPPP must be submitted to the Planning Division of the Port of Long Beach for approval. In the meantime, please remember that facility cleaning and good housekeeping practices are effective tools in keeping contaminants from reaching the storm drain system.

If you have any further comments or questions, please contact Stacey Crouch at (310) 590-4160.

Sincerely,

Geraldine Knatz, Ph.D.
Director of Planning

MJ:s

1 6902

VOL 12

NON POINT SOURCE PERMIT MONITORING
1993-1994

Tenant: C. U. T.

Contact: Charlie Wyant

Phone: (310) 435-8235

Address: 1200 Pier E St. Long Beach

ID #:

SWPPP

Received: X

Complete: X **Incomplete:** ______ **Revision Requested:** ______

Reviewed: X

Approved: X

Implemented: X

Updated: X

Tenant Follow Up Y

Annual Inspection

Date Conducted (Initials): 6/20/94 MJ

Compliance with SWPPP (Y/N) Y

Port Follow Up date: ______

Comments: Facility looks good, maintenance area is clean. BMPs are being used. Not a worry.

Additional Comments:

1 6 9 0 0 3

R0050208

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VOL 12

July 12, 1994

Mr. John Mora
Applied Industrial Materials Corporation
1270 Pier G Avenue
Long Beach, CA 90802

Subject: Annual Storm Water Pollution Prevention Plan (SWPPP) Site Inspection

Dear Mr. Mora:

On July 11, 1994, the Planning Division of the Port of Long Beach conducted its annual site inspection of your facility. Since there have not been any significant changes to your facility, the current SWPPP is still in effect. However, our inspection indicated that the following change is needed to employ Best Management Practices for the SWPPP for your facility:

- The placement of all drums containing liquids in a bermed and/or covered area.

Please be advised that if there are changes to your facility in the future, a revised SWPPP must be submitted to the Planning Division of the Port of Long Beach for approval. In the meantime, please remember that facility cleaning and good housekeeping practices are effective tools in keeping contaminants from reaching the storm drain system.

If you have any further comments or questions, please contact Stacey Crouch at (310) 590-4160.

Sincerely,

Robert Kanter

Geraldine Knatz, Ph.D.
for Director of Planning

MJ:s

1 6904

VOL 12

NON POINT SOURCE PERMIT MONITORING
1993-1994

Tenant: AIMCOR

Contact: John Mora

Phone: (310) 436-5234

Address: 1270 Pier G Street, Long Bch

ID #:

SWPPP

Received: ✓

Complete: X Incomplete: ______ Revision Requested: ______

Reviewed: X

Approved: X

Implemented: X

Updated: X

Tenant Follow Up ______

Annual Inspection

Date Conducted (Initials): 7/11/94 [illegible] + SEC

Compliance with SWPPP (Y/N) Y

Port Follow Up date: ______

Comments: Facility looked good, but needs to make sure drums are behind their berms

Additional Comments:

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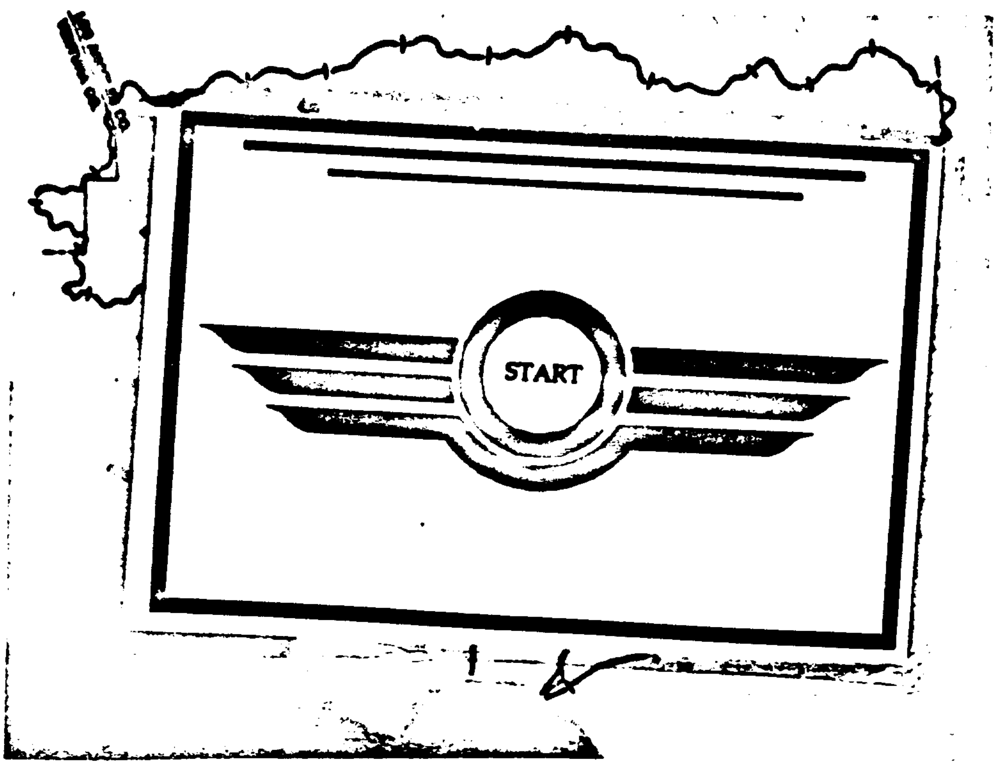
US Army Corps
of Engineers
Los Angeles District

SE' 79

LOS ANGELES COUNTY DRAINAGE AREA REVIEW



DRAFT FEASIBILITY REPORT

VOL 12

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US Army Corps
of Engineers
Los Angeles District

SEPTEMBER 1991

VOL 12

LOS ANGELES COUNTY DRAINAGE AREA REVIEW

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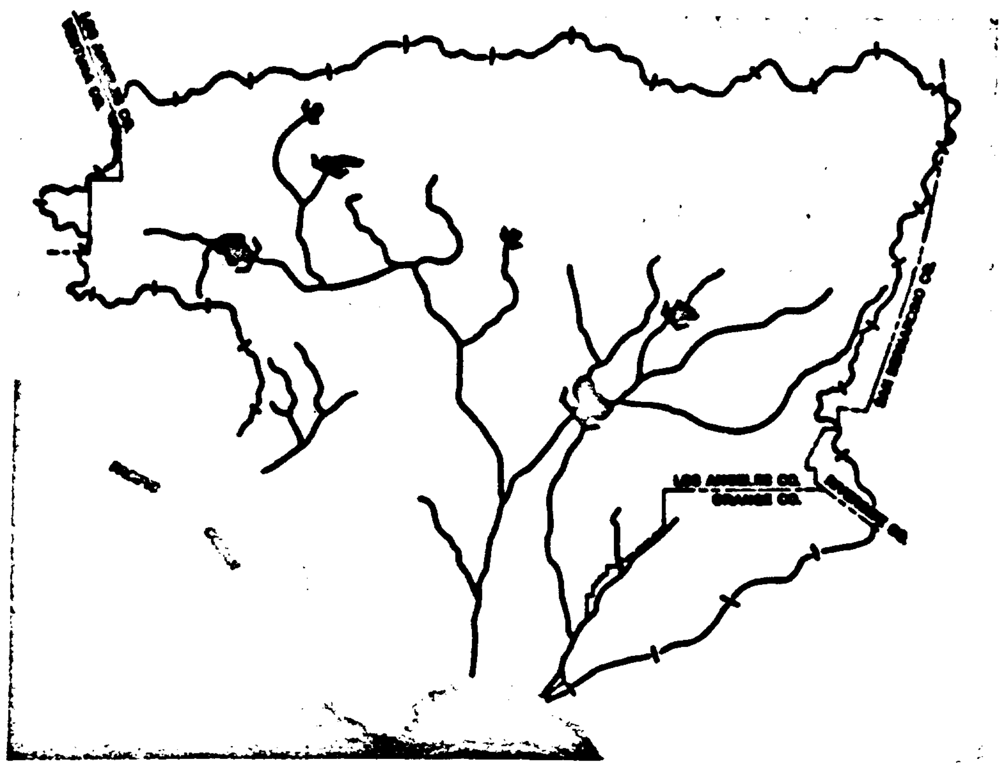
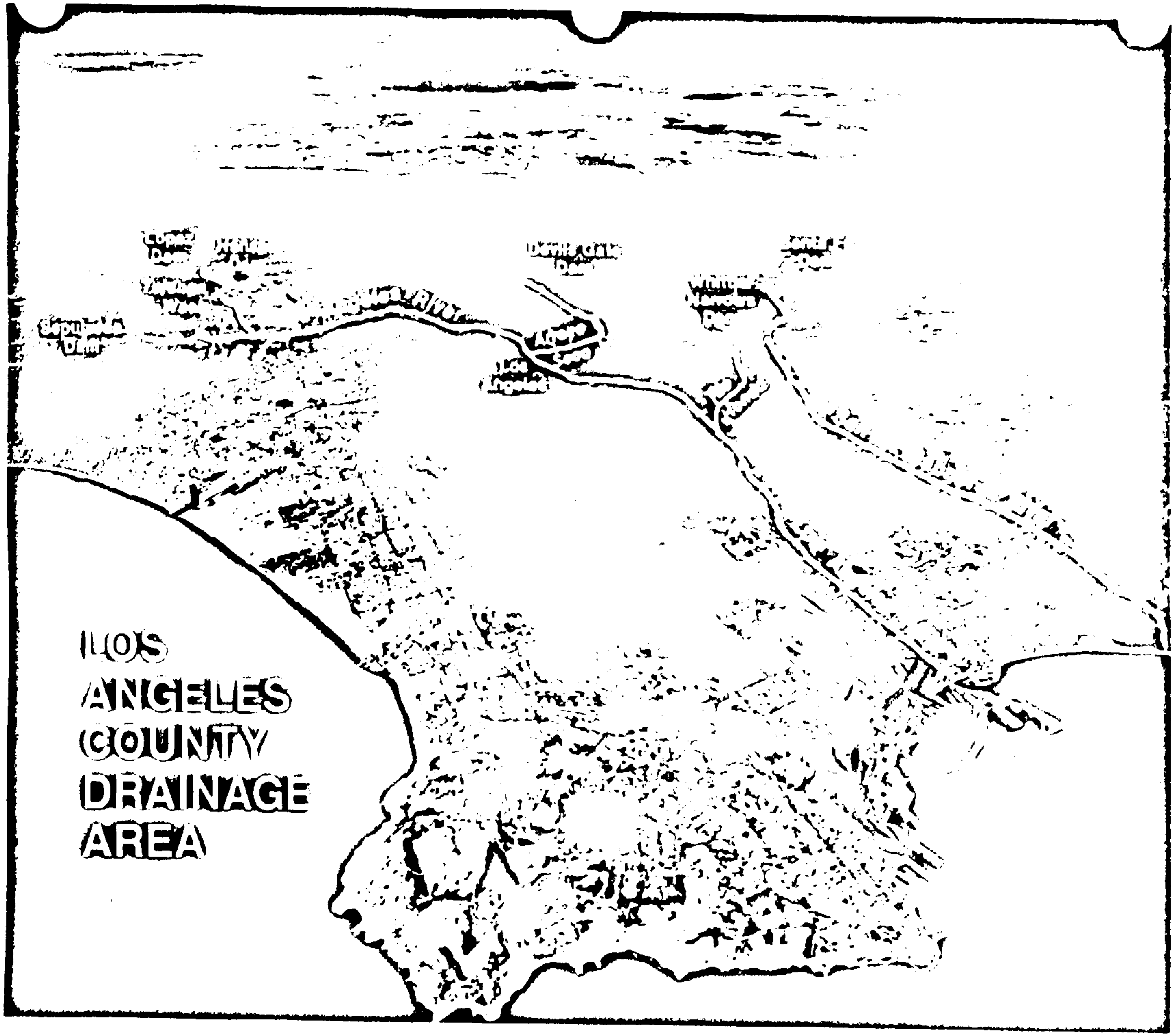


DRAFT FEASIBILITY REPORT


Sepulveda Dam
LOS ANGELES COUNTY DRAINAGE AREA

LOS ANGELES COUNTY DRAINAGE AREA REVIEW

FEASIBILITY STUDY

DRAFT INTERIM REPORT

AND

ENVIRONMENTAL IMPACT STATEMENT

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT
PLANNING DIVISION
WATER RESOURCES BRANCH
P.O. BOX 2711
LOS ANGELES, CA 90053

September 1991

LOS ANGELES COUNTY DRAINAGE AREA
REVIEW FEASIBILITY STUDY

SECTION ONE: EXECUTIVE SUMMARY

This is an interim report for the Los Angeles County Drainage Area (LACDA) Review studies conducted under authorization provided in the House Resolution dated 11 June 1969. It summarizes the findings of an extensive feasibility investigation of problems and opportunities related to flood control, water conservation, recreation, transportation, and environmental enhancement in the LACDA Mainstem System (the Los Angeles and San Gabriel Rivers, the Rio Hondo, and the Tujunga Wash) as depicted in Figure 1. The major findings of this investigation are:

1) While the LACDA Mainstem System of flood control reservoirs and channel improvements has provided effective protection to the urban communities of the basin for over 40 years, there are inadequacies in the system. Some reaches of the mainstem system provide only 25- to 50-year protection. In the lower Rio Hondo and Los Angeles River reaches protected by levees, there is a threat that floods exceeding the 25- to 40-year event could overtop the existing levees and cause these levees to fail with catastrophic results. The 500-year flood plain covers approximately 200 square miles (320,000 structures), mostly in the lower reaches of the basin; damages in this flood plain would total approximately $5.4 billion. The 100-year flood plain covers approximately 82 square miles; damages from the 100-year flood would be $2.3 billion.

2) The system inadequacies are the result of different factors. The various design storms formulated for the individual sections of the system over 50 years ago were based on a short period of record; based on a longer period of record, it now appears that the overall system was only designed to control a flood resulting from a storm with a 50-year recurrence interval.

Also, extensive urban development in the basin, combined with a comprehensive system of storm drains to carry local runoff into the mainstem system, has greatly accelerated runoff, particularly in the lower river basin areas. Thus peak flows have increased dramatically compared to those originally predicted for these reaches of the system.

3) Based on a thorough analysis of measures to correct the system inadequacies, it was concluded that only improvements to the lower basin channels themselves would be cost-beneficial solutions to the flooding problems identified. Other alternatives were found to be either excessive in cost (new channels, diversion alternatives, new reservoirs, modifying existing reservoirs) or ineffective in reducing peak flows through the critical project reaches in the lower basin (new reservoirs, non-structural measures, modifying existing reservoirs, modifying channel bridges, re-regulation of reservoirs). Modifications in upper basin reaches were found to have very low benefit-to-cost ratios, in part because the channels in most reaches of the upper basin provide nearly 100-year levels of protection; in areas with lower levels of protection, the overflow areas are limited and damages are not extensive. No economically justified alternatives were identified for increasing the level of protection in upper basin reaches.

   Transfer of Whittier Narrows Dam releases from the Rio Hondo to the San Gabriel River was determined to be unjustified because this would require modifications to the San Gabriel River channel greater in cost than those contemplated for the Los Angeles River and Rio Hondo channels while having larger environmental impacts and still requiring improvements to the Los Angeles River. Modifying flood control releases to involve two distinct channels was not economically justified.

4) Given the nature and extent of the flooding problem identified in this study, it was determined that the focus of study should be on flood control improvements. Water conservation, recreation, transportation, and/or environmental enhancement opportunities would be studied within the

framework of the flood control improvements being investigated. This decision was made following an initial review of potential opportunities to pursue these objectives; this review indicated that opportunities were limited or constrained by the flood control solution and were therefore dependent on the nature of the flood control solution identified.

5) The plan selected to improve available flood protection in the lower Los Angeles Basin requires modification of the Rio Hondo from Whittier Narrows Dam to the Los Angeles River and continuing down the Los Angeles River to the Pacific Ocean. The modifications are as follows: (a) Raising the effective channel height by building parapet walls on 21 miles of existing levees; (b) raising or modifying 27 bridges to accommodate the parapet walls; (c) widening and converting to rectangular cross-section 1.5 miles of channel below the confluence with the Rio Hondo; (d) armoring the land side of the levees in four locations and (e) applying a concrete overlay in reaches with an existing rough grouted stone channel surface.

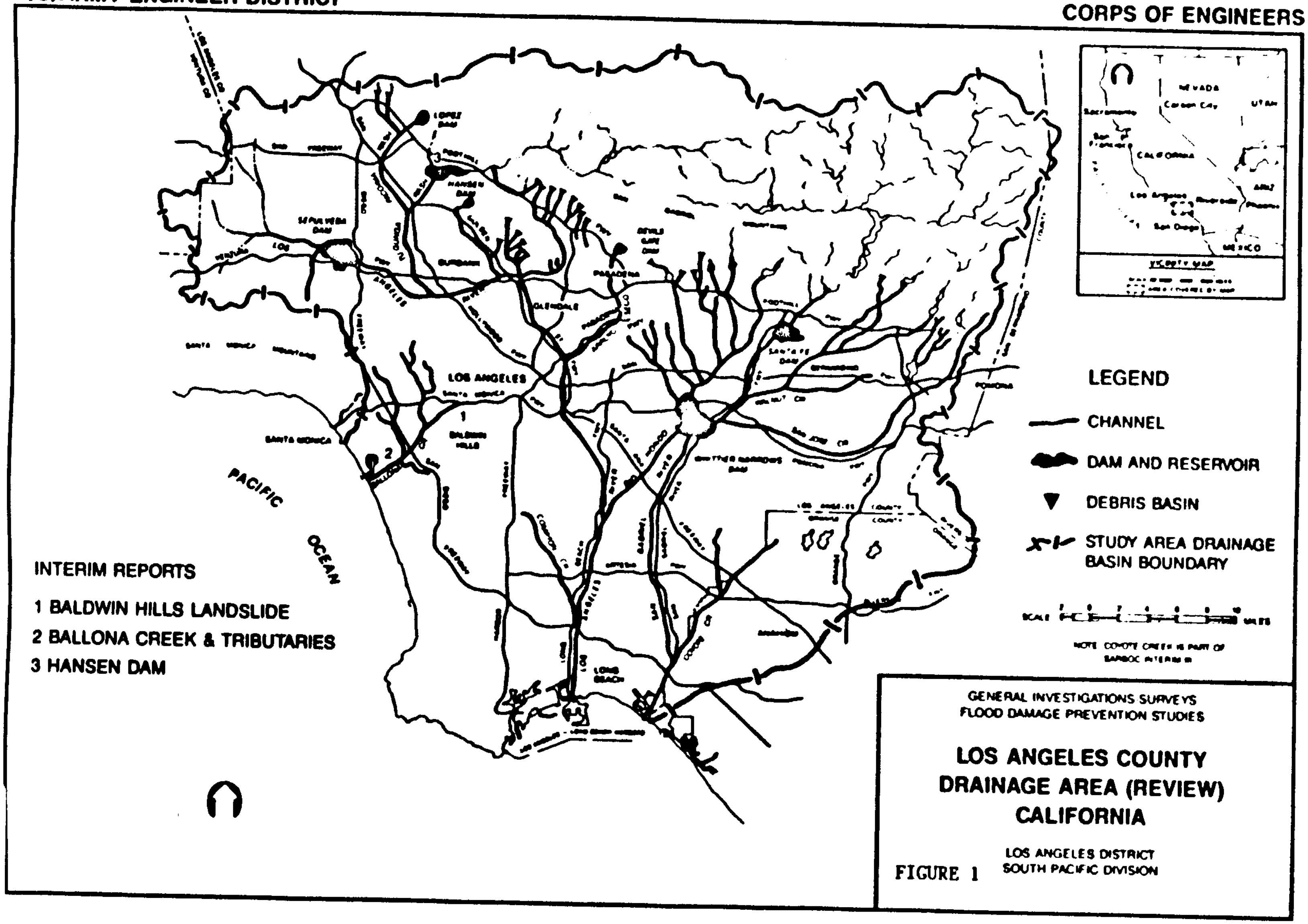
6) The optimum level of protection for the proposed plan was established based on National Economic Development (NED) criteria. The need to avoid raising the Artesia/Long Beach Freeway overcrossing was also considered in defining the NED level of protection. Modifications of channel walls may be made to convey the 133-year design flows for the lower reach of the Los Angeles River without requiring this overcrossing to be altered, thereby avoiding the expense and social impacts of freeway bridge modification. The ability of flood flow breakouts to spread over large areas makes the minimum level of protection provided in the proposed plan also the overall level of protection. The NED Plan provides between 100 and 133-year level of protection for the lower LACDA basin.

7) Cost and benefit estimates indicate the NED Plan would provide $60.2 million in annual flood damage reduction benefits at an annualized cost of $46.5 million. Net annual NED benefits from the plan are $13.7 million, and the project benefit-to-cost ratio is 1.3 to 1. The Federal share of the $337.4 million first costs would be $168.7 million (50 percent of total first costs); the local sponsor, the Los Angeles County Flood Control District, would bear the remaining cost of $168.7 million (50 percent of total first costs).

Based on these findings, the District Engineer recommends that improvements to the Los Angeles River and Rio Hondo channels in the lower reaches of the LACDA basin be constructed substantially in accordance with the plan outlined in this report.

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



GENERAL INVESTIGATIONS SURVEYS
FLOOD DAMAGE PREVENTION STUDIES

LOS ANGELES COUNTY
DRAINAGE AREA (REVIEW)
CALIFORNIA

FIGURE 1

LOS ANGELES DISTRICT
SOUTH PACIFIC DIVISION

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LOS ANGELES COUNTY DRAINAGE AREA REVIEW

FEASIBILITY STUDY

DRAFT INTERIM REPORT

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LOS ANGELES COUNTY DRAINAGE AREA
REVIEW FEASIBILITY STUDY

SECTION TWO: THE STUDY AND FEASIBILITY REPORT

A. STUDY AUTHORITY

This study was conducted in response to local concerns regarding the completeness and adequacy of flood control within the Los Angeles County Drainage Area (LACDA) and in response to local interest in the potential to increase water conservation, transportation, and recreation resources within LACDA. These interests led to the following congressional resolution:

House of Representatives Resolution, approved 11 June 1969, reading in part:

"Resolved by the Committee on Public Works of the House of Representatives, United States, that in accordance with Public Law 639, Eighty-seventh Congress, the Secretary of the Army and the Secretary of Agriculture are directed to make a joint investigation and survey in accordance with their existing authorities of the San Gabriel River Basin, California, and to prepare a joint report on such investigation and survey setting forth their recommendations for the installation of the works of improvement needed for utilization, and disposal of water, and for flood control and allied purposes."

B. PURPOSE AND SCOPE OF STUDY

This combined Feasibility Report and Environmental Impact Statement presents the study findings associated with the Los Angeles County Drainage Area (LACDA) Review Study, Los Angeles County, California. Its intent is to review the adequacy of flood control along the mainstem systems of the Los Angeles and San Gabriel rivers, the Rio Hondo, and Tujunga Wash.

The focus of this study was originally quite broad, including investigations throughout the LACDA basin for flood control, water conservation, recreation, transportation, and environmental problems and opportunities. During the feasibility study phase, the magnitude of the flooding problem was recognized, and a greater effort was devoted to developing a solution to this problem. The other study purposes had shown only limited opportunities, and their implementation may have conflicted with potential flood control solutions. In order to accomplish this study, it was decided that other study purposes would be incorporated within the framework of the flood control solution if at all possible. The flood control solution ultimately focused on the three mainstem river systems for the following reasons:

1. **Previous Interim Reports addressed major issues.** Two previous interim reports have addressed problems and opportunities considered critical in areas outside of the mainstem system (Baldwin Hills and Ballona Creek). An additional study of Hansen Dam was also completed. Thus, the primary focus of this interim is appropriately on the mainstem. The previously completed interims are as follows.

   Interim 1: Ballona Creek and Tributaries. This study investigated possible inadequacies in flood protection on Ballona Creek and tributaries due to increases in runoff brought about by urbanization and storm drain installation. No economically justified plan for Federal implementation could be found. However, two bridges were identified on Ballona Creek that constricted flow and caused flooding.

   Interim 2: Baldwin Hills Landslide Study. This study addressed landslide, mudslide and related problems caused by the storms of 1978 and 1980 in the Baldwin Hills area of Los Angeles. No economically justified plan of improvement could be found.

Interim 3: Hansen Dam. This study investigated sedimentation problems and incidental water conservation and recreation opportunities. The study found that the ongoing excavation of reservoir material by sand and gravel contractors continues to maintain project capacity and provides an ongoing solution to sedimentation problems at this facility. Additional recreation was not found to be economically justified at this site. Because Hansen Dam is an integral part of the LACDA system, the report deferred analysis of flood control and water conservation to this mainstem report.

2. **Levels of protection on many tributaries were adequate.** A general analysis of numerous tributaries to the mainstem system concluded that levels of protection on these tributaries were adequate (100-year or higher). This conclusion was based on detailed analysis of data from stream gauges in the watershed. Compton Creek was found to provide slightly less than 100-year protection. While no analysis for Compton Creek was proposed, any relief the mainstem study could provide would be evaluated, and certainly, any impacts involved in a mainstem solution would be mitigated as part of the overall solution. Further study of Compton Creek may be undertaken at a later date. The effect of this analysis of tributaries was to reduce the scope of this study interim.

   In 1985, the Sierra Madre channel in eastern Los Angeles County was evaluated, but no improvements were recommended because the city council and local residents were generally opposed to alterations which would affect structures built up to the existing channel wall system. Los Angeles County subsequently requested that further analysis of the channel be suspended.

3. **Work on smaller, non-tributary drainages was not justified.** A post-1969 flood review of many small streams draining directly into the Pacific indicated that flood control improvements would be inappropriate for one or more of the following reasons: (a) the level of development within the flood plain was too sparse to justify a project; (b) local residents were opposed to alteration of the channel; (c) development was planned for the future, but existing levels were inadequate to support a project; (d) justification of a project would depend on

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land enhancement benefits; (e) the overflow was contained within a well-entrenched channel; and/or (f) the scope of the problem was limited and its solution was appropriate for local action. Of 39 local streams surveyed, including some in the upper watershed areas for the LACDA mainstem system, only two were identified for which further study would be necessary to determine whether there was potential for a justifiable project: Topanga Canyon and Trifuno Creek.

In the absence of significant new development of the 100-year flood plain in many of these small watersheds, no project appeared to be feasible in 1969; the advent of flood plain management regulations several years later placed restrictions on flood plain development, which limited flood-prone development in many of these small streams. Increased public opposition to flood control measures such as channel improvements and dams also contributed to the conclusion that these smaller streams would not be appropriate for Federal action. Topanga Canyon and Trifuno Creek were eliminated from this study on the basis of these considerations.

4. **Problems identified by the local sponsor were studied and issues resolved.** In 1975, the Los Angeles County Flood Control District (LACFCD) identified six county priorities in addition to mainstem rivers and related facilities. Ballona Creek was one of these six potential projects. The other five (Arroyo Seco near Pasadena, Stone Canyon in West Los Angeles, Laguna Dominguez Channel near Dominguez Hills, Los Cerritos Channel near Long Beach, and Bee Canyon in the Santa Susana Mountains above the San Fernando Valley) were evaluated for flooding problems. Arroyo Seco was found to provide protection above the 100-year level. Devil's Gate Dam on this arroyo was found to be unsuitable for modification for system-wide flood control purposes. The Stone Canyon channel was found to provide 100-year protection. Laguna Dominguez Channel was subsequently studied by the Los Angeles County Department of Public Works and found to be adequate in all but the uppermost reach. The uppermost reach has been improved as a result of the Century Freeway construction project. Los Cerritos channel was found to provide near 100-year protection and thus became

a low priority. Outflow from the Bee Canyon watershed flows past the upper Van Norman Reservoir. Although there was concern that flood flows could contaminate the water supply system, this watershed was found to have an insignificant local flooding impact or impact within the overall system and, therefore, is a low study priority.

5. **The flood threat is greatest on the mainstem system.** Finally, the study was focused on the mainstem because subsequent to the floods of 1969, it was believed that the existing mainstem system might have insufficient capacity in some reaches. The February 16, 1980 flood, about a 40-year event, caused near-capacity channel flows in the lower Los Angeles River that deposited debris on the top of levees (see Figure 2) which had previously been thought to have 100+ year protection. The mainstem system carries substantially greater flows than the tributary system and crosses the areas of greatest urban density. Review of the mainstem system thus became a high priority for the entire basin.

The review of mainstem problems and opportunities included an analysis of the entire mainstem system from the upstream flood control reservoirs of the mainstem rivers to the mouth of the two river systems (Los Angeles-Rio Hondo and San Gabriel). Therefore, this report considers the following watercourses (Figure 1):

a) The Los Angeles River, from Sepulveda Dam to the Pacific Ocean;
b) The San Gabriel River, from Santa Fe Dam to the Pacific Ocean;
c) Tujunga Wash, from Hansen Dam to the Los Angeles River; and
d) Rio Hondo, from Whittier Narrows Dam to the Los Angeles River.

The report considers alternative solutions to the water and related land use problems on these watercourses and recommends a feasible solution to the problems for implementation. Consideration was given to economic, environmental, and social needs of the area.

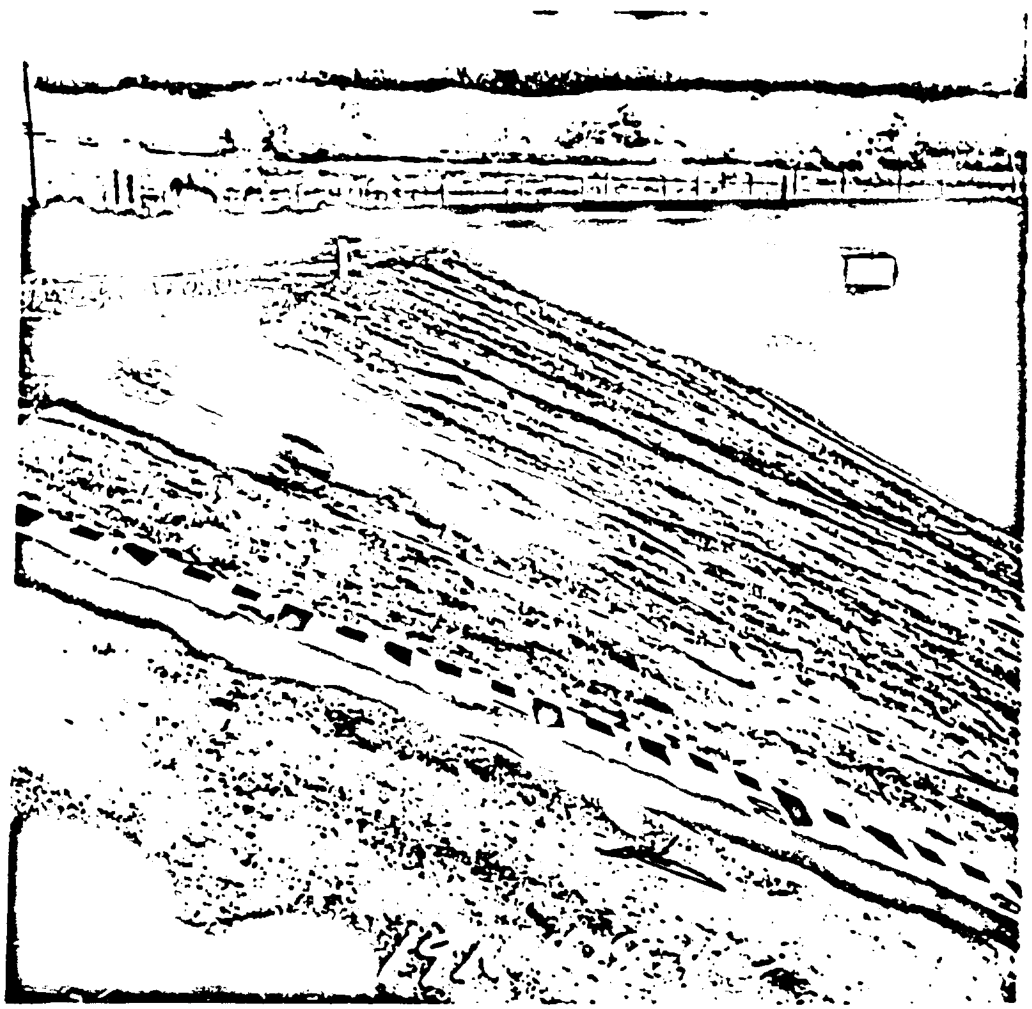

FIGURE 2 Los Angeles River below Wardlow. High water marks from storm of February 16, 1980.

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C. STUDY PARTICIPATION AND COORDINATION

The Corps of Engineers, Los Angeles District - which will be referred to in this document as the Corps - has been responsible for managing the LACDA Review Study; for plan formulation and evaluation; for coordinating the flood control planning process with other local, state, and Federal agencies and the public; and for report preparation.

The Los Angeles County Flood Control District (LACFCD), an element of the Los Angeles County Department of Public Works (LACDPW), is the local sponsor of the study. The County Department of Public Works consists of the former County Flood Control District, the former County Engineer, and the former County Department of Roads. The unification of these functions occurred in 1985. For purposes of this report, the local sponsor will be referred to as Los Angeles County, or simply the County. Throughout the study, and especially during problem analysis and plan formulation, Los Angeles County assisted the Corps in identifying areas which should receive priority in the study during plan formulation and in evaluating the acceptability of flood control measures.

There has been ongoing coordination with the U.S. Fish and Wildlife Service, who also cooperated in the investigation. They provided the Corps with a Planning Aid Letter and prepared the Coordination Act Report. Because no reservoir re-regulation was proposed, there was no need for a Habitat-Based Evaluation of the proposed improvements. Nearly all of the viable habitat in the flood control system is in the reservoir area behind the dams, since a majority of the channels in the LA River system are concrete lined from dam outlet to the ocean. No improvements are proposed for areas in which significant habitat for wildlife exists.

The general public has also been kept informed of the study, and public participation has been an important goal throughout this study. Public dissemination of information has been achieved through press releases, direct-mail brochures and newsletters, and public workshops and meetings. At these meetings, the public has had an opportunity to participate in study scoping, problem identification, plan formulation, and alternative evaluation phases of the study.

A complete list of agencies and representatives with which coordination has taken place may be found in Section 8 of the Environmental Impact Statement (EIS).

D. PRIOR REPORTS BY THE CORPS OF ENGINEERS AND OTHER AGENCIES

CORPS OF ENGINEERS

1. Flood Control in the Los Angeles County Drainage Area. LA District, Corps of Engineers, 1939.
2. Hydrology in the Los Angeles County Drainage Area. LA District, Corps of Engineers, 1939.
3. Hydrology, San Gabriel River and the Rio Hondo Above Whittier Narrows Flood Control Basin. LA District, Corps of Engineers, 1944.
4. DPR-Whittier Narrows Flood Control Basin. LA District, Corps of Engineers, 1945.
5. Operations and Maintenance Manual, Los Angeles County Drainage Area. LA District, Corps of Engineers, 1975.
6. Plan of Study, Review Report for Flood Control and Allied Purposes, Los Angeles County Drainage Area. LA District, Corps of Engineers, 1976.
7. Interim Report on Hydrology and Hydraulic Review of Design Features of Existing Dams for LACDA Dams. LA District, Corps of Engineers, 1978.
8. Report on Floods of February and March 1978 in Southern California. LA District, Corps of Engineers, 1978.
9. Reconnaissance Report on Landslide Study, Baldwin Hills Area, LA County, CA. LA District, Corps of Engineers, 1981.
10. Baldwin Hills, Los Angeles, CA: A Geotechnical Supplement to the Landslide Study. Portland District, Corps of Engineers, 1981.

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11. Interim Feasibility Report for Landslide Study: Baldwin Hills, CA. LA District, Corps of Engineers, 1982.

12. Interim Feasibility Report for Ballona Creek and Tributaries. LA District, Corps of Engineers, 1982.

13. Hansen Dam Sediment Modeling Study. LA District, Corps of Engineers, 1983.

14. Hansen Dam Preliminary Formulation Report. LA District, Corps of Engineers, 1984.

15. Final Report, Review of Water Resources within the Los Angeles County Drainage Area. LA District, Corps of Engineers, 1985.

OTHERS

1. Reports of the Board of Engineers, Flood Control to the Board of Supervisors: LA County, CA. Los Angeles County, 1915.

2. Review Report and Environmental Assessment with Technical Appendices for the Los Angeles River Flood Prevention Program. US Department of Agriculture, Forest Service, Angeles National Forest, 1980.

3. Review Report for the Los Angeles River Flood Prevention Program. US Department of Agriculture, Forest Service, Angeles National Forest, 1982.

E. THE STUDY PROCESS AND THE CONTENT OF THIS REPORT

The Study Process

This feasibility study has been conducted in accordance with Corps Planning Regulations and Guidance (summarized in the Planning Guidance Notebook). It has been an iterative process; that is, there have been several phases of problem analysis/plan formulation and plan evaluation. The purpose of this iterative process has been to ensure that all problems have been given full consideration and all alternatives have been identified and evaluated.

The general flow of a feasibility study is to begin with the broadest possible scope within the constraints imposed by the authorization and Corps regulations and slowly narrow the scope by eliminating alternatives, using data developed during the study. Thus, an initial step is to formulate a very broad range of alternative measures which can be considered for solving problems. The general feasibility of these measures is evaluated, and those measures that are clearly infeasible or ineffective are eliminated after an initial review. A smaller number of measures are then evaluated in more detail. After the remaining measures have been evaluated, the scope of study shifts to evaluation of combinations of these measures (alternatives). Alternatives are evaluated in detail in terms of their completeness, acceptability, efficiency (cost-effectiveness), and environmental and socio-economic impacts. As the number of alternatives is narrowed, the level of detail of study increases. This iterative process is reflected in the plan formulation section of this report.

Feasibility Report Contents

This report can be viewed as containing two parts. Part I is the main report and the environmental impact statement (EIS). Part II consists of the technical documentation reports, as listed below. Note that only Part I is being circulated for public comment. The technical reports are too voluminous and generally too technical to justify their general circulation. They are available for review at the Los Angeles District Office of the Corps of Engineers, 300 N. Los Angeles Street, Los Angeles, California, 90053. The appropriate telephone number is (213) 894-5461. For reference, the technical reports are:

A) **Hydrology**: This is a detailed discussion of storm history, predicted storm frequency and intensity, rainfall-runoff analysis combined with reservoir operations, and downstream floodrouting to define the resulting flood flow frequencies in the LACDA basin.

B) **Hydraulics**: This technical report provides an analysis of the projected overflows resulting from various-sized floods. It also provides an analysis of the existing channel capacities and the design analysis of the various alternatives.

C) **Design**: This technical report describes the various elements of the recommended design, and provides detailed materials and construction costs.

D) **Recreation**: This technical report identifies all existing recreation on the mainstem.

E) **Geotechnical**: This technical report describes the general site conditions and provides design and construction material considerations.

F) **Real Estate**: This technical report identifies real estate requirements and associated costs.

G) **Economics**: This technical report analyzes damages associated with the existing (baseline) condition and compares the costs and benefits of the alternatives. Support for the selection of the NED Plan is documented.

The main report summarizes the results of the feasibility study in a nontechnical manner, and presents the material on the NED Plan somewhat more technically. Following the Commander's recommendations at the end of the main report, the environmental impact statement describes the nature and scope of the environmental impacts of the NED Plan and evaluates the other alternative given consideration during the study process.

F. STUDY AREA DESCRIPTION

Location and Extent of Study Area

Los Angeles County, located in the South Coastal Basin of the Pacific slope, has varied terrain consisting of precipitous mountains, low-lying foothills, valleys, and coastal plains. A vast majority of urban development is found on flat alluvial plains and uplifted terraces which are surrounded by various mountain ranges. The area bounded by the Santa Susana and San Gabriel Mountains on the north, and on the east and southeast by the Chino, San Jose, and Puente Hills, is the area under study that is usually referred to as the Los Angeles County Drainage Area (LACDA) basin. See Figure 1 for a map of the LACDA basin.

Drainage Basin Description

The LACDA basin feeding the mainstem system covers 1,459 square miles, a large percentage of which is urbanized flatlands and valleys crossed by three major rivers: the Los Angeles, Rio Hondo, and San Gabriel. The remaining watersheds of the LACDA basin cover approximately 300 square miles.

The Los Angeles River is formed by the junction of the Calabasas and Bell Creeks in the Santa Monica Mountains. From the junction of these two creeks, the river flows into the Sepulveda Reservoir, a Corps flood control facility with a design capacity of 22,493 acre-feet. Tujunga Wash (flowing out of Hansen Dam, capacity 25,446 acre-feet), Pacoima Wash (flowing out of Lopez Dam, capacity 441 acre-feet), Burbank-Western, and smaller creeks draining the western San Gabriel Mountains join the river as it flows easterly along the San Fernando Valley. The river bends south around the Hollywood Hills, is joined by Verdugo Wash, and then flows south through the Los Angeles Narrows and onto the broad coastal plain. The river is joined by a number of tributaries, including Sycamore Canyon, Arroyo Seco, and the Rio Hondo. The Rio Hondo carries runoff from its own watershed and also runoff from the San Gabriel Basin, as transferred through Whittier Narrows Reservoir (capacity 34,947 acre-feet). From the Rio Hondo confluence, the Los Angeles River continues south another 12 miles and discharges into San Pedro Bay at the Long Beach Harbor. The Los Angeles River drains an area of 824 square miles, which includes 132 square miles of the Rio Hondo basin.

The San Gabriel River drains the eastern San Gabriel Mountains and portions of the Chino, San Jose, and Puente Hills. The river's upstream tributaries merge above Santa Fe Dam (capacity 32,109 acre-feet). Two major tributaries, Walnut and San Jose creeks, join the river before it reaches Whittier Narrows Reservoir. The San Gabriel and Rio Hondo combine flows at this reservoir. Flood control releases from Whittier Narrows Dam are made to the Rio Hondo (also referred to as the Rio Hondo Diversion Channel), which travels southwest and connects with the Los Angeles River. On the east side of Whittier Narrows Dam, the San Gabriel River exits in a southerly direction, is joined by Coyote Creek downstream, and finally discharges into Alamitos Bay, six miles east of the mouth of the Los Angeles River. The San Gabriel River drains an area of 635 square miles.

Whittier Narrows Reservoir receives flows from both the Rio Hondo and the San Gabriel River. Under normal operating conditions, primary flood control releases are made to the Rio Hondo, which has a capacity of 36,500 ft^3/s, and only 5,000 ft^3/s is released into the San Gabriel River. The San Gabriel River is intended to receive spillway overflow from Whittier Narrows in large flood events. There are no uncontrolled spillway flows to the San Gabriel River for flood events of less than 100-year magnitude.

Study Reaches

Table 1 indicates the channel reach designations used throughout this study (see Figure 3). The reach designations are generally based on clearly definable geographic boundaries. Reaches generally begin at a reservoir or at the confluence of a major tributary; thus, a new reach may have significantly different hydraulic characteristics from the reach immediately upstream. For example, the upper Los Angeles River reach from Sepulveda Dam to Arroyo Seco confluence is an entrenched channel with an initial channel capacity of 16,900 ft^3/s. This capacity increases to 83,000 ft^3/s as tributaries join the river. At Arroyo Seco, the capacity increases to 104,000 ft^3/s to accommodate inflows from this major tributary. On the San Gabriel River, study Reach 7 begins at Imperial Highway, a major bridge crossing and a general transition point in topography for the watershed.

STUDY REACH DESIGNATIONS

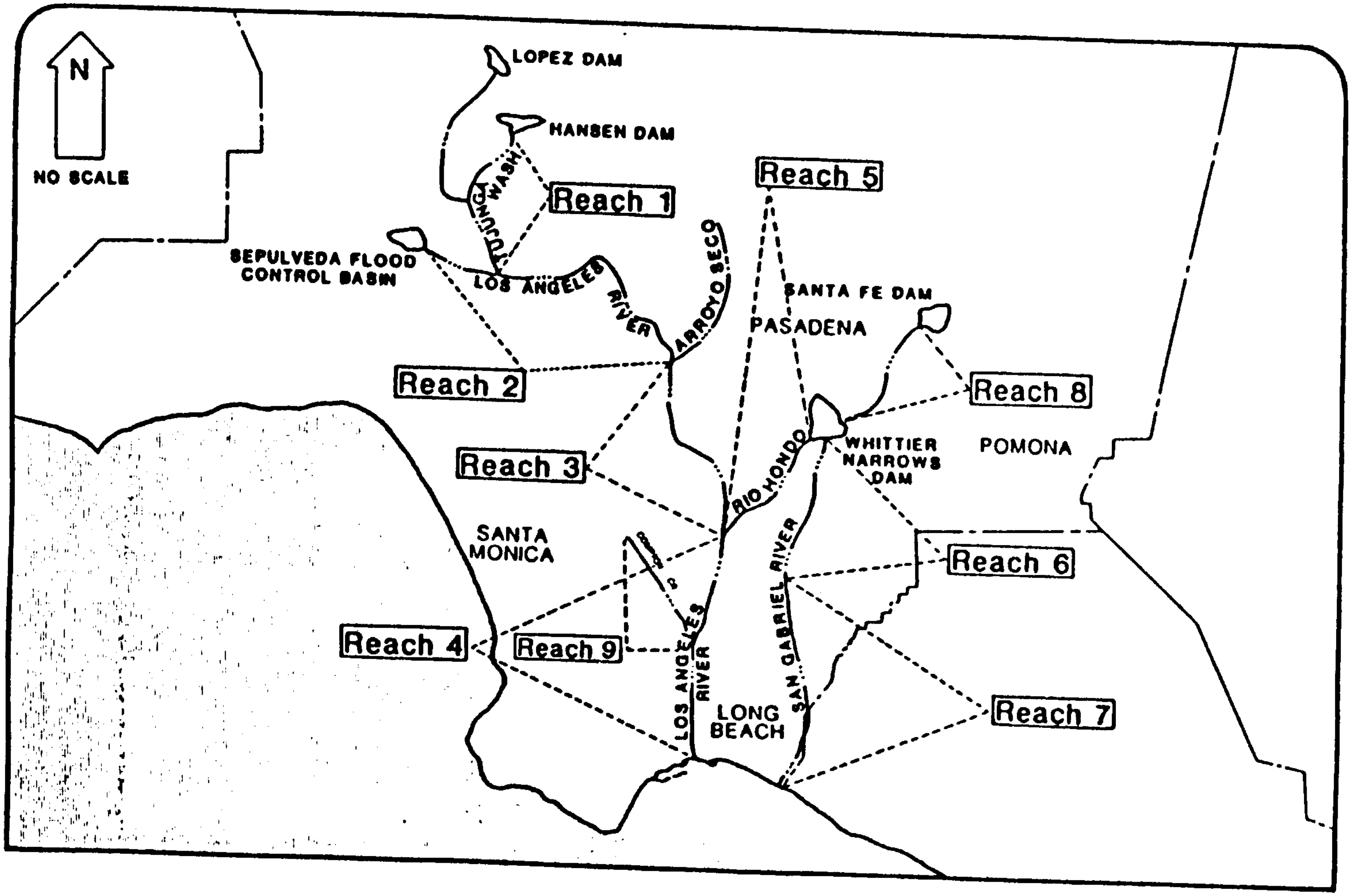

FIGURE 3

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Table 1. Study Reaches, LACDA Mainstem.

Reach Number	Location	Channel Length (mi)
1	Tujunga Wash Channel from Hansen Dam to the Los Angeles River	9.3
2	Upper Los Angeles River from Sepulveda Dam to Arroyo Seco Confluence	19.2
3	Los Angeles River from Arroyo Seco to the Rio Hondo Confluence	23.9
4	Lower Los Angeles River from Rio Hondo Confluence to the Pacific Ocean	11.7
5	Rio Hondo Diversion Channel from Whittier Narrows Dam to Los Angeles River	11.9
6	San Gabriel River from Whittier Narrows Dam to Imperial Highway	9.2
7	San Gabriel River from Imperial Highway to the Pacific Ocean	13.2
8	San Gabriel River from Santa Fe Dam to Whittier Narrows Dam	7.0
9	Compton Creek Channel from Main Street to the Los Angeles River	7.9

Climate, Precipitation, Topography, Land Use, and Runoff

It is critical to understand the climate in Southern California in order to gain an appreciation of the nature of the flood threat facing Los Angeles. Flooding is caused by the interaction of climate, topography, and development.

In general, the Los Angeles area has a mild climate characterized by warm, dry summers and cool, wet winters. Both temperature and precipitation vary considerably with elevation, topography, and distance from the Pacific Ocean: a storm producing moderate rainfall on the coast (1" during a 24-hour period) may produce very heavy rainfall in the mountains (up to 10-20" during the same 24-hour period). Precipitation characteristically occurs in the form of localized cloudbursts and general heavy rains, although snow occurs in the higher elevations. In general, the quantity of precipitation increases with elevation. Flood flows, which normally occur during the period of November through March, are characterized by high peak flows and short durations.

The physical characteristics of the drainage area serve to intensify precipitation. As storm clouds cross the basin and are forced over the mountains to the east, they lose a vast majority of their moisture content in the mountain areas. High rainfall rates, combined with the steep slopes in the upper reaches, can cause violent, debris-laden flows from local canyons. Once mountain soils are saturated, runoff is very rapid from the steep mountain slopes, creating a very fast rise in the level of rivers and streams. As these peak flows reach the flat developed plain, their velocity is reduced and sediment begins to settle out into the river bed. This can reduce channel capacity, and therefore a number of upper watershed debris basins have been constructed as a part of the LACDA system to control debris.

Rapid runoff and erosion of upper basin watershed areas is unimpeded by the sparse vegetative cover found in these areas of coarse, porous, and rocky soils. At very high altitude, well-developed forests of evergreens and oaks provide some stability to soils, and there are riparian bands along many stream courses. The remainder of the upper watershed is in chaparral and coastal sage vegetation which is susceptible to burning, particularly during dry periods in the late summer and early fall. In burned out areas, which may not have an opportunity to regrow before storms begin in late fall, high intensity rainfall runs off rapidly and causes massive erosion of the watershed, carrying mud and debris into the basin below.

Local rainfall in developed areas also runs off quickly; the greater the development, the less opportunity there is for rainfall to soak into the ground. Runoff from roofs, parking lots, and streets builds rapidly, contributing to peak flows as it runs through local drainage systems to the main streams and rivers. Combined peak flows from the mountains and from local runoff may exceed channel capacity for a period of only six hours, but in this time they can cover a substantial area with debris-laden flow.

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Flood History

The Los Angeles River has altered its point of discharge to the ocean numerous times in the distant past. This is consistent with the alluvial nature of the L.A. basin. The most recent relocation occurred in the mammoth flood of 1862 when the mouth of the LA River moved from Ballona Creek to its present location in Long Beach Harbor. Since 1900, significantly damaging flood flows occurred in 1914, 1934, 1938, 1952, 1969, 1980 and 1983. It can clearly be seen that large floods occur only infrequently in Los Angeles, but the magnitude of their destruction is enormous. Although a flood with a 100-year or greater frequency has not occurred in the 20th century, floods of near this magnitude have occurred in the past and caused extensive damages throughout the basin.

1

The February 1938 flood is the most damaging flood of record. It caused an estimated $40 million in damages ($795 million in 1990 dollars) throughout Los Angeles County and the loss of 49 lives. A large volume of floodwater, predominately originating in the San Gabriel Mountains, caused significant flooding in the cities of Glendale and Burbank. Extreme flood flows eroded the banks of the Tujunga Wash, damaging residential and commercial structures and washing out bridges and roads.

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With the construction of the LACDA system, especially reservoirs and channel modifications, the magnitude and frequency of flooding in the area has been reduced. The floods of January and February 1969 were the most devastating to occur since 1938; and in some areas of the County, rainfall actually surpassed that experienced during the 1938 storm. Most notable was the channel flow on the lower half of the Los Angeles River which represented over 80% of the design capacity. However, the LACDA flood control system, which was 99% complete, protected the Los Angeles metropolitan area from what otherwise would have been unprecedented damage. Most of the damages which did occur were caused by mudflows in the foothill areas or by local storm drain inadequacies. In the entire Los Angeles County, seventy-three lives were lost, and damages amounted to $31 million; $12 million in damages were sustained in the LACDA basin ($45 million in 1990 dollars).

The LACDA system was severely tested during the flood of 1980. Channel capacities were exceeded in the upper reaches of the Los Angeles River and the levee near the City of Long Beach was very nearly overtopped. If the levee had been overtopped and actually failed due to erosion of the back side of the levee, the resultant flooding could have caused a catastrophic loss of life in addition to the economic damages to the residential, commercial, and industrial properties in the City of Long Beach.

While the existing system has prevented a total of nearly $3.6 billion in flood damages since construction, there have, nevertheless, been flood damages experienced in recent years. Estimates of damages throughout the LACDA basin from floods of January-February 1969 totaled over $12 million ($45 million in 1990 dollars). Flooding in recent years has generated damages in localized areas, and the mainstem system has been seriously tested, but it has not failed catastrophically.

History of Flood Control Improvements in Los Angeles County

Prior to 1914, little attention had been directed to the problem of flood control within the basin. The principal land use was for agriculture, and farmers more or less accepted the occasional floods. The 1914 flood caused over $10 million worth of structural damages (approximately $470 million in 1990 dollars) and captured the attention of area residents. Flood control improvements were then recognized as necessary to protect the widespread developments in the foothills and flood plain. On June 12, 1915, the Los Angeles County Flood Control District was created by an Act of the California Legislature and was given the responsibility for flood control and water conservation in the Los Angeles County area. The original flood control plan called for the construction of reservoirs within the surrounding mountains. Between 1917 and

1939, the Flood Control District constructed 14 dams in the San Gabriel Mountains, numerous debris basins at canyon mouths, and some unrelated channel improvements.

By 1930 it became apparent that the construction program was barely keeping pace with the increase of storm water runoff resulting from the rapid urbanization of Los Angeles County. The Flood Control District began to prepare a comprehensive flood control plan which would protect the urban areas. However, extensive damages and loss of life caused by the 1934 flood mandated immediate construction of additional flood control improvements. In order to meet this urgent need, Congress appropriated nearly $14 million under the Emergency Relief Act of 1935 for construction of storm drains, permanent channel improvements, and debris basins.

The Flood Control Act of June 22, 1936, redefined the mission of the Army Corps of Engineers from that of providing emergency relief to the permanent supervision of future flood control plans. This Act authorized the construction of flood control facilities on the Los Angeles and San Gabriel Rivers at a Federal cost not to exceed $70 million. Under this authorization, the Corps of Engineers submitted a project plan for control of the Los Angeles River in 1936 and a general plan for the Rio Hondo and San Gabriel River in 1938. The Corps plan outlined the construction of debris basins at the base of the foothills, permanent channel improvements, and the construction of three additional flood control basins. These reservoirs were to be placed at strategic locations where the various streams merged and their flows could be controlled and regulated. Sepulveda and Hansen Dams were planned for the San Fernando Valley, and Santa Fe Dam for the San Gabriel River.

The 1938 flood demonstrated the need for additional flood control measures. It left 49 dead and $40 million in damaged property (1938 dollars, which is equivalent to approximately $795 million 1990 dollars). The previously constructed flood control works proved beneficial by preventing the tragedy from being worse. At the same time it was recognized that the tributaries of the Los Angeles and San Gabriel Rivers would have to be included in the overall plan. Under the Flood Control Act of June 28, 1938, the Corps of Engineers prepared a revised plan calling for over $230 million of construction for the entire Los Angeles County Drainage Area. Additional works

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included construction of Lopez Dam on Pacoima Wash and Whittier Narrows Dam on the San Gabriel River.

The plan was approved by Congress in the Flood Control Act of August 8, 1941. It authorized construction of a comprehensive system consisting of the five major flood control basins previously mentioned; debris basins at the mouth of 31 tributary canyons; improvement of 93 miles of main channel and 147 miles of tributary channels; and reconstruction of 316 bridges on the Rio Hondo, Los Angeles, and San Gabriel Rivers.

Work on Hansen and Sepulveda basins, which began under the authorization of the three previous Flood Control Acts, was completed in 1941. Lopez Dam was completed in 1954 and regulates debris and streamflow from Pacoima Wash, a tributary of Tujunga Wash.

World War II temporarily brought a halt to the work on Santa Fe Dam, and it was finally completed in 1949. Whittier Narrows, the last of the five basins to be constructed, was completed in 1957. Construction of debris basins and permanent channel modifications, which had been progressing since 1935, was finally completed in 1970.

Existing Improvements

The LACDA project is one of the most extensive flood control systems ever built to protect a metropolitan area. It includes facilities on the Los Angeles and San Gabriel Rivers, Rio Hondo, Ballona Creek, and related tributaries (Figure 1). The system was built as a cooperative effort between the Los Angeles County Flood Control District and the Corps of Engineers. Flood control improvements to the LACDA system fall into four general categories, as follows:

1. Flood control reservoirs are designed to control and reduce streamflow so that downstream main channel capacities are not exceeded. The Corps operates four major reservoirs with a total combined capacity of over 110,000 acre-feet, and Lopez Dam with a capacity of 441 acre-feet. In

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addition, there are two Corps dams on small tributaries of the San Gabriel River system, Brea Dam (capacity 4,020 acre-feet) and Fullerton Dam (764 acre-feet). These facilities ultimately drain into the San Gabriel River system but are located in Orange County and are covered by the Santa Ana River Basin and Orange County authority. They have no impact on the LACDA system problems and no impact on plan formulation for LACDA system improvements. Therefore they have not been discussed in this report. Locally operated facilities include 15 flood control and water supply reservoirs in the upper watershed areas of the LACDA basin. Combined, these local reservoirs have a maximum combined capacity of about 102,000 acre-feet, of which over half is reserved for flood control.

2. Debris basins, found at the mouth of canyons, are designed to trap debris carried by floodwaters, leaving relatively clean water to flow unimpeded in downstream channels. There are currently 129 debris basins in the watershed of the Los Angeles and San Gabriel river systems. Their purpose is to reduce the amount of debris (mud, rock, sand) which reaches the lower basin reservoirs and channels.

3. Tributary channels, such as the Arroyo Seco and Compton Creek, are designed to pass local runoff and floodwaters efficiently into the main channels. There are improved channels on 37 major tributaries of the two river systems in the LACDA basin. One effect of these channels is to speed passage of flood flows through the local communities and into the mainstem river system, either draining into a flood control reservoir or directly into one of the two mainstem rivers.

4. Main channel improvements pass the controlled or partially controlled flows to the ocean. The two main river systems have over 100 miles of mainstem channel, the characteristics of which are identified, by reach, in Table 2. The mainstem channels cross the generally flat, heavily developed flood plain; to effectively contain peak floodflows, they must be hydraulically efficient to overcome the natural tendency for water to slow

down as it crosses a flat plain. In the lower reaches of the basin, mainstem channels are at or near sea level and flow across very flat ground. To contain flows under such conditions, the natural channels are augmented by levee systems, which raise the maximum level of the river as much as 15 feet above the surrounding flood plain.

Each of these measures are combined in a unique manner to regulate flows on the Rio Hondo, Los Angeles, and San Gabriel Rivers. The major tributaries of the Los Angeles River are, in sequence proceeding downstream, Tujunga Wash, Burbank Western, Burbank Eastern, Verdugo Wash, Arroyo Seco, Rio Hondo, and Compton Creek. The tributaries are, for the most part, concrete-lined channels.

Flows to the main channel of the Los Angeles River are regulated by Sepulveda and Hansen Dams which are operated and maintained by the Corps of Engineers. The river is improved for its entire reach below Sepulveda Dam, and the channel has a shape that fluctuates between trapezoidal and rectangular. The sides and invert are lined with either concrete or grouted rock, except for an ungrouted stone invert reach in the vicinity of Glendale and the reach from Willow Street to the Pacific Ocean where the channel is soft bottomed and the walls have rip-rap protection. The Los Angeles River is entrenched down to Atlantic Boulevard, and it becomes leveed from that point to the ocean.

The San Gabriel River originates in the San Gabriel Mountains where the East and West forks merge. The upstream watershed is controlled by three Los Angeles County dams: Cogswell, San Gabriel, and Morris. As it leaves the mountains, the river is regulated by Santa Fe Dam, which is operated by the Corps of Engineers. The river continues to flow in a southerly direction and is joined by Walnut Creek and San Jose Creek. The County operates six water control reservoirs on these tributaries, the largest of which is Puddingstone Dam. The San Gabriel River flows through Whittier Narrows, is joined downstream by Coyote Creek, and finally discharges into the ocean. The San Gabriel River primarily has rip-rapped channel sides with a soft-bottom invert to permit groundwater recharge. Seven miles downstream of Whittier Narrows Dam the river becomes a trapezoidal concrete-lined channel and remains so until it reaches the tidal influences of the ocean.

The third major watercourse of the system is the Rio Hondo. It originates in the San Gabriel Mountains and has a number of tributaries, including Eaton, Santa Anita, and Sawpit washes. The County operates four small water conservation dams in this region. The Rio Hondo flows through Whittier Narrows Reservoir, continues in a southwesterly direction, and then joins the Los Angeles River.

In addition, Los Angeles County has constructed a comprehensive underground storm drain system totaling approximately 2,000 miles. This system is very effective in delivering local runoff to the major flood control channels. The County also operates twenty-nine groundwater recharge basins totaling approximately 2,000 acres.

In total, the LACDA system has over 100 miles of mainstem channel, over 370 miles of tributary channels, 129 debris basins, 15 flood control and water conservation dams, and 5 flood control dams. In spite of the current projected flood threat, it is important to note that the existing system has prevented over $3.6 billion in damages since construction.

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Table 2.
Channel characteristics of the Los Angeles and San Gabriel River Mainstem systems, existing conditions.

Reach	Level of Protection*	Lining	Leveed/Entrenched
1	70-150 year	Concrete	Entrenched
2	10-100+ year	Concrete	Entrenched
3	75-250 year	Concrete	Entrenched above Atlantic Blvd.
4	25-250 year	Concrete	Leveed and Rip-Rap
5	25 year	Concrete	Leveed
6	100+ year	Rip-rap and Concrete	Leveed
7	100+ year	Rip-rap and Concrete	Leveed and Entrenched
8	100+ year	Concrete	Entrenched
9	<100 year	Rip-Rap and Concrete	Leveed

* Levels of protection are approximate and vary, depending on the particular stretch of channel in the reach. Thus there are different potential breakout points for floods of varying magnitude.

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Economic and Demographic Development

The Los Angeles area is one of the largest manufacturing, trade, financial, and service economies in the nation, with a gross product exceeding $100 billion annually. The economy is diversified and has sustained long-term growth for almost 70 years. The Los Angeles/Long Beach harbors form the largest harbor complex on the west coast of the United States, handling almost as much cargo as the three other major port complexes combined (San Francisco-Oakland, Seattle-Tacoma, and Portland). The region is a major trans-shipment point for Pacific Rim trade.

The economy is generally considered recession-proof due to the steady net migration of residents and industry from other areas of the state and the nation: from 1980 to 1988, the population of the county increased from 7,477,400 to 8,407,400. The Southern California Association of Governments predicts a county population of 10,231,000 by the year 2010. An equal or greater percentage of growth in surrounding Ventura, San Bernardino, Riverside, and Orange counties is anticipated as well, and total southern California population (including San Diego) is projected to climb to over 23,000,000 by the year 2030. At the same time population has grown, unemployment has remained relatively low compared to urban areas in the east and midwest.

Demographically speaking, the area has always been multi-ethnic and multi-cultural. In recent years, the area has experienced a large immigration of peoples from central America and southeast Asia, as well as from other areas of the United States. Los Angeles is considered a stable, desirable location and is becoming an international city with numerous Pacific Rim corporations establishing major corporate headquarters in the area. This trend strengthens the economy of the region.

As a result of favorable economic conditions and this projected population increase, land use in the basin is intensive and property values are high and increasing rapidly. Within the 82 square-mile 100-year flood plain, there are 142,000 structures (123,000 residences) with a structure-contents value of $16.7 billion dollars. Within the 198-square-mile 500-year flood plain, there are 322,000 structures (278,000 residences) valued at $41 billion. About 500,000 people reside in the 100-year flood plain with 1,200,000 people residing in the 500-year flood plain.

Development adjacent to mainstem channels ranges from heavy industry (power stations, manufacturing, railroad facilities, refineries) to residential. Since the channel system was completed, development has been permitted to abut the right of way for the channels.

Recent development within the area is dominated by conversion of existing low density areas to high density residential and commercial zones. Moderately priced detached homes are, for example, replaced with high density condominiums (usually with garage facilities on the lower floor) which increase population density and the number of vehicles in the flood plain. Low value shopping areas are, likewise, converted to multi-story office and commercial complexes. The value of the property within the LACDA overflow area is thus projected to increase. Assuming that preliminary FEMA maps are used as the basis for flood plain designations in the 1990's, new construction should be designed to reduce flood damage, and the losses expected from a flood event are not expected to increase in real dollar terms as a result of development.

Total employment in the Los Angeles-Long Beach Partial Metropolitan Statistical Area (PMSA), which covers approximately the same area as Los Angeles County, was 4,000,000 as of 1983. The largest employment category is the service sector with 2,850,000 jobs, followed by manufacturing with nearly 900,000 employed.

Urban Growth and Runoff Characteristics

Development affects runoff because impervious areas such as roads, buildings, parking lots, and similar structures have a rapid runoff response, filling local storm drains with flows which, prior to development, would have been absorbed into the soil. Urban growth was anticipated and indeed had already occurred in portions of the LACDA basin during the initial project design phases in the 1930's and 1940's. However, the effects of urbanization on runoff exceeded the expectations of design engineers and city planners. Between 1940 and 1980, the population of Los Angeles County increased almost 270% to 7.5 million people.

Not only did this cause a greater amount of runoff from all of the impervious surfaces that now cover the basin, but it also necessitated the construction of an underground storm drain system to keep local runoff from building up in roads and low-lying areas of neighborhoods. This storm drain system concentrates and speeds flows directly into the main LACDA channels. The result of rapid runoff and a storm drain system which concentrates flows is a higher peak flow in the system. Thus, precipitation which would at one time have caused local flooding is now quickly carried to the mainstem channel where it contributes to an accumulation of flow that may break out and cause significant flooding in a more developed area downstream.

Current analysis of the LACDA system indicates that drainage from urban areas now results in larger contributions to the peak flow than predicted in original analyses. Especially evident are shortcomings in the Rio Hondo Diversion Channel and the lower Los Angeles River sizing for local stormwater inflow. The predicted and actual contributions of urban drainage to the mainstem flow of various reaches are compared in Table 3. As this table indicates, local drainage accounts for a substantial percentage of the increase in peak flows in the channels.

Table 3.
Increased flow on the Los Angeles River and Rio Hondo due to urbanization effects.

Location	Flow (ft^3/s)		
	Upstream	Downstream	Difference
Rio Hondo Diversion Channel			
Design Discharge	40,500	42,000	+1,500
50-year Computed	40,000	46,000	+6,000
1969 Flood*	38,800	46,900	+8,100
Lower Los Angeles River			
Design Discharge	110,000	146,000	+36,000
50-year Computed	100,000	148,000	+48,000
1969 Flood*	74,000	129,000	+55,000

* Observed by the Los Angeles County Department of Public Works.

To a lesser degree, urban growth in the drainage area above the flood control dams has also increased runoff, and peak runoff in particular. The increasingly impervious upstream drainage areas result in higher flow rates and quicker reactions to rainfall. These factors tend to reduce the size of the flood which can be controlled by the impoundment structure.

The impact of this urbanization is smaller in percentage terms than that in downstream reaches because the urbanized drainage area above the reservoirs is smaller in size than the urbanized drainage area in downstream areas. The reservoirs still provide significant peak flow reduction, but because the peak flow and the total inflow may have increased due to urbanization of the upper watershed, the level of protection afforded to downstream communities has been reduced. Two primary examples are Sepulveda Dam in the San Fernando Valley, which now provides just slightly less than 100-year protection, and Whittier Narrows Dam, which provides slightly greater than 100-year protection on the San Gabriel River. These facilities were originally designed for a significantly greater level of protection than they currently afford.

Environmental Resources

General

The Los Angeles area is heavily urbanized with many of the environmental quality problems associated with such an area: significant air pollution, water quality problems, crowding, urban blight, noise, toxic waste disposal problems including groundwater contamination, and very heavy traffic. Air pollution in the basin exceeds Federal clean air standards approximately 30-50 percent of the year. Water quality for human consumption is generally quite high because much of the water used is imported from the State Water Project, Owens Valley, or the Colorado River. Local water supplies from groundwater basins, which account for about 35% of all water used in the basin, are threatened by seawater intrusion and toxic waste spills. Recent plans by environmental regulatory agencies in the basin suggest that raising environmental quality would require significant government action; plans provide for significant restrictions on development, transportation, land use, and energy use.

Both water quality and water supply are issues of major concern to local agencies. Long-term projections of water supply and demand show a net deficiency in water supply for the entire southern California region by the period 2000-2010. Additional supplies are difficult to develop, and therefore conservation programs have a high priority in this region's long-range planning. There are also concerns that existing supplies may be lost due to contamination by toxic wastes.

The density of development in Los Angeles is increasing, and as a result, noise and traffic are increasing. Recent studies of the major transportation corridors indicate that there are some freeways where "rush hour" conditions exist for extended periods (as long as six hours in the morning and five hours in the afternoon). Adjacent surface streets are also crowded with traffic. These conditions affect commercial traffic and development as well as the general social environment. The quality of the human environment is generally perceived by residents to have declined in recent years, according to a 1989 Los Angeles Times survey.

Biological Resources

Below the major Corps flood control reservoirs, a majority of the mainstem channels have been modified to the extent that there are few environmental resources of significance in these reaches. In the upper reaches of the Los Angeles River, the channels are concrete lined with the exception of a six-mile reach of cobble-bottomed channel in the vicinity of Glendale, and at the downstream end of the river there is a 2.6-mile section of rip-rap lined channel with a natural invert. This channel section supports some aquatic vegetation and some fisheries resources which utilize its soft-bottomed reach. It provides feeding grounds for a variety of sea birds, including the brown pelican and the California least tern. This area is influenced by tidal forces, and vegetation and other resources are routinely scoured from the channel.

The San Gabriel River generally has a natural invert and concrete-lined channel walls for a stretch of seven miles downstream of Whittier Narrows Dam. This design was specified to allow incidental water conservation during late-season releases from the reservoir. Previously, during periods of low flow in the river, Los Angeles County contoured the channel invert into a series of terraced ponds to augment groundwater recharge. This activity used heavy machinery which effectively removed much of the vegetation which might otherwise grow in the unlined invert. Recently, seven rubber dams were installed in the channel, achieving the same water conservation goal without the impact to vegetation.

Development along the right-of-way of the channels is generally heavy on the Los Angeles River from Sepulveda Dam to the river mouth. On the San Gabriel system, however, there are several large linear park systems abutting the channel levees, including a park near the San Diego Freeway crossing. This park system, along with the undeveloped area on the back side of the mainstem levees, may provide a limited corridor for some wildlife in the region, particularly coyotes and other animals which adapt well to urban environments.

Environmental resources in the reservoirs themselves and in the watershed above are significantly greater than in the mainstem channels. The reservoirs have been designed

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to provide wildlife refuge areas as well as a wide range of recreation activities. As urbanization has surrounded these reservoir areas, they have become in some instances the largest areas of undeveloped land within the lower basins. The biological resources of the five main Corps reservoirs and upper watershed areas in the LACDA system are summarized below (see environmental documentation at the end of this report for more information):

1. Lopez Reservoir. This site has little biological value except as open space for wildlife habitat.

2. Hansen Dam. The reservoir provides diverse habitat for a wide variety of wildlife, potentially including an endangered bird species and an endangered plant species.

3. Sepulveda Dam. Outside of recreation areas, this reservoir contains some natural habitat areas. The reservoir area supports substantial numbers of wildlife year-round and migratory birds.

4. Santa Fe Dam. This reservoir has unique alluvial scrub areas with some areas of potential habitat for endangered species.

5. Whittier Narrows Dam. This large area has extensive riparian habitat in wildlife sanctuary areas with a wide variety of wildlife, including several endangered species.

6. Los Angeles River Channel. There is very little biological value as most of the channel is completely concrete lined, except in the area of Glendale and near the mouth of the river. The lower reach is where foraging habitat of value to two endangered species is found.

7. Rio Hondo Channel. Very little biological value due to the channel being completely lined with concrete.

8. San Gabriel River Channel. Below Whittier Narrows Dam there is a seven-mile stretch with extensive riparian habitat supporting a wide variety of wildlife. In the lower river, there is some emergent vegetation providing foraging area for native wildlife, including two endangered species of birds (brown pelican and the California least tern).

9. Compton Creek Channel. This reach has little habitat of value as it, like the mainstem LA River channel, flows through heavily developed urban area. There is soft-bottomed channel through this reach with minimal environmental value, although it is littered with refuse and is likely to be scoured on a regular basis during the rainy season.

The upper watershed areas of the LACDA system are rugged and relatively undeveloped in many areas, particularly in the San Gabriel mountain areas, which feed the Los Angeles and the San Gabriel rivers. In these areas, tributary streams provide a band of riparian vegetation leading into the mountains; local flood control and water conservation dams also provide water resources for wildlife. The tributary streams to the LACDA system, particularly unimproved reaches in the upper watershed, are a critically important environmental resource, being among the few remaining major areas of riparian habitat in the southern California area. A complete listing of plant and animal species in the reservoirs and upstream drainage areas is found in the EIS which follows this main report.

Cultural Resources

Within the immediate project location, the area of improved channels and existing reservoir facilities, cultural resources are limited to historic resources such as the many historic bridges across the Los Angeles River. There are a number of historic buildings near the channel rights-of-way for both rivers (most are in the LA River reaches).

Recreational Resources

The LACDA flood control system itself is a major recreational resource for the Los Angeles area. There are recreational areas at four of the five flood control reservoirs, with a total use of these facilities in 1988 estimated at over 5,000,000 visits. Recreation facilities include a velodrome (Sepulveda), recreation lakes, picnic grounds, hiking and riding trails, and playing fields of many types. These facilities are available for a majority of the year when the reservoirs are not in use for water storage.

The mainstem channels provide 49 total miles of hiking and bicycle trails. The trail on the Los Angeles River begins at the Pacific Ocean and connects with the Rio Hondo trail system, allowing passage through Whittier Narrows Reservoir into the San Gabriel Mountains. On the San Gabriel River trails, it is possible to travel by foot or bicycle from the mouth of the river, through Whittier Narrows and Santa Fe reservoirs, and into the San Gabriel Mountains. These trails are an important resource in an urban area where cycling on surface streets is dangerous and where few other cycling paths are available.

G. NATIONAL OBJECTIVES

The objective of Federal and federally assisted water and related land resources planning is to attempt to maximize national economic development. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units, or increases in economic efficiency. Plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to the national economic development. By definition, the "NED Plan" is the one which maximizes the net national economic development benefits, consistent with the Federal objective.

The policy of the Corps of Engineers in identifying the NED plan is specified in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. This document states:

"The Federal objective of water and related land resources planning is to contribute to the national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements."

"Protection of the Nation's environment is to be provided by mitigation (as defined in 40 CFR 1508.20) of the adverse effects (as defined in 40 CFR 1508.8) of each alternative plan. Accordingly, each alternative should include mitigation determined to be appropriate by the Agency decision-maker."

For this type of multi-purpose study, the primary category of NED benefits evaluated is generally flood damage reduction benefits. Other benefits which may be considered include benefits from water conservation, benefits from increasing the value of project area lands, benefits from providing recreation, and benefits from enhancing the socio-@ economic conditions of the project area. Flood damage reduction benefits are the principal source of NED benefits evaluated in this study.

H. STUDY PROCEDURE

Within the context of these national objectives, the intent of this study was to review the adequacy of the existing LACDA mainstem system to protect the heavily urban areas of Los Angeles. A secondary purpose was to determine if there were water conservation, recreation, environmental enhancement, and transportation needs which could be addressed in conjunction with any flood control needs. Specific study objectives were:

1. Re-evaluate the estimates of potential rainfall and runoff for the LACDA basin (meteorology and hydrology review) in light of (a) the experience of the last 40 years and (b) scientific advances which make possible more accurate projections of rainfall and runoff.

2. Given revised rainfall and runoff projections, re-evaluate the capacity of the existing system to safely contain and convey flood flows from headwaters to the Pacific Ocean, using modern computer modeling techniques to determine the actual capacity of existing system elements, primarily channels.

3. Define the nature and extent of any flooding problem, and identify any related problems which could be addressed in conjunction with a solution to flood control problems.

4. Formulate and evaluate alternative measures for addressing problems and opportunities.

5. Identify the National Economic Development plan for solving identified flood control problems.

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SECTION THREE: PLAN FORMULATION

A. FLOOD CONTROL PROBLEMS AND OPPORTUNITIES IN THE MAINSTEM LACDA SYSTEM

Causes of the Flooding Problem

The design of flood control channels and reservoirs is based on estimates of precipitation, runoff, and resulting flow in stream and river channels from storms of varying magnitude. It is the goal of the Corps to provide flood protection in the most cost effective manner possible. In urban areas where system failure could result in catastrophic damages and loss of life, it is often considered desirable to provide at least 100-year flood protection. A 100-year flood is an event that is likely to occur on average once in 100 years or, otherwise stated, has a 1 percent probability of occurring in any given year. The accuracy of precipitation, runoff, and channel flow frequency estimates is thus critical to the design of an effective system.

Since 1939, when the LACDA system was designed, there have been significant improvements in methods used for estimating the frequency and magnitude of potential floods. This is due in part to a longer period of record and in part to better analysis techniques. Applying more advanced analytical methods, and taking into account the significant changes in the development level within the LACDA basin, the estimated flow in most reaches of the Los Angeles, Rio Hondo, and San Gabriel rivers was determined for storms of various intensities. The conclusions of this review were that the existing mainstem system provided lower levels of protection than are appropriate for an urban area. This conclusion was based on the following findings:

1. The storms used as the basis for designing LACDA features in early (1930's) hydrologic studies, the so-called "design-storms," were found to occur more often than once in 100-years. This conclusion was based on current analysis that includes an additional 50 years of storm records since the beginning of the LACDA system construction. Using the updated rainfall frequency statistics and more modern techniques of analysis, Corps hydrologic engineers have

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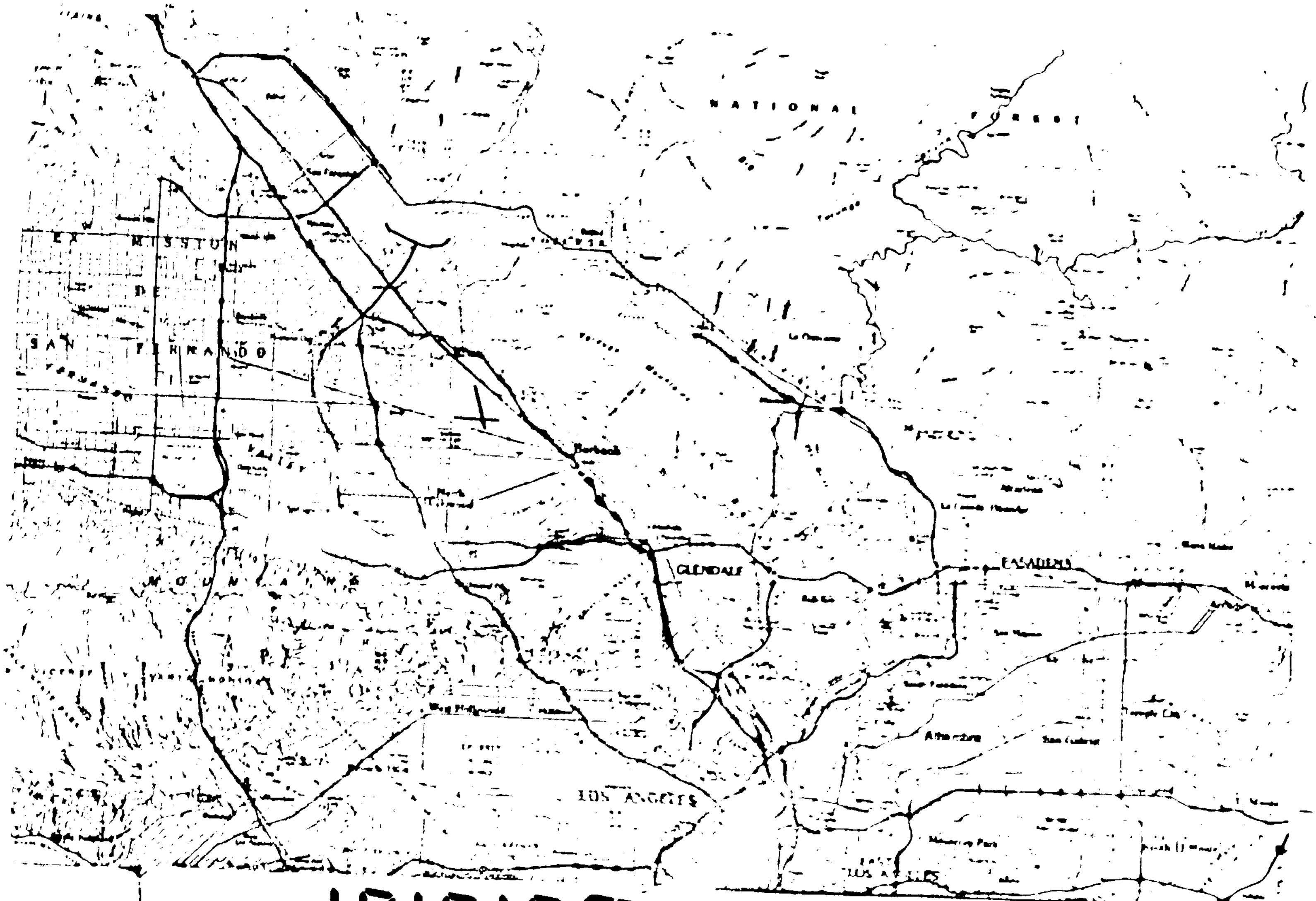
determined that the basis of design for much of the LACDA system was a storm with a 50-year recurrence interval. A 100-year storm is estimated to produce significantly more precipitation, runoff, and flow in streams and river channels. Thus, the LACDA system does not provide 100-year protection in all reaches.

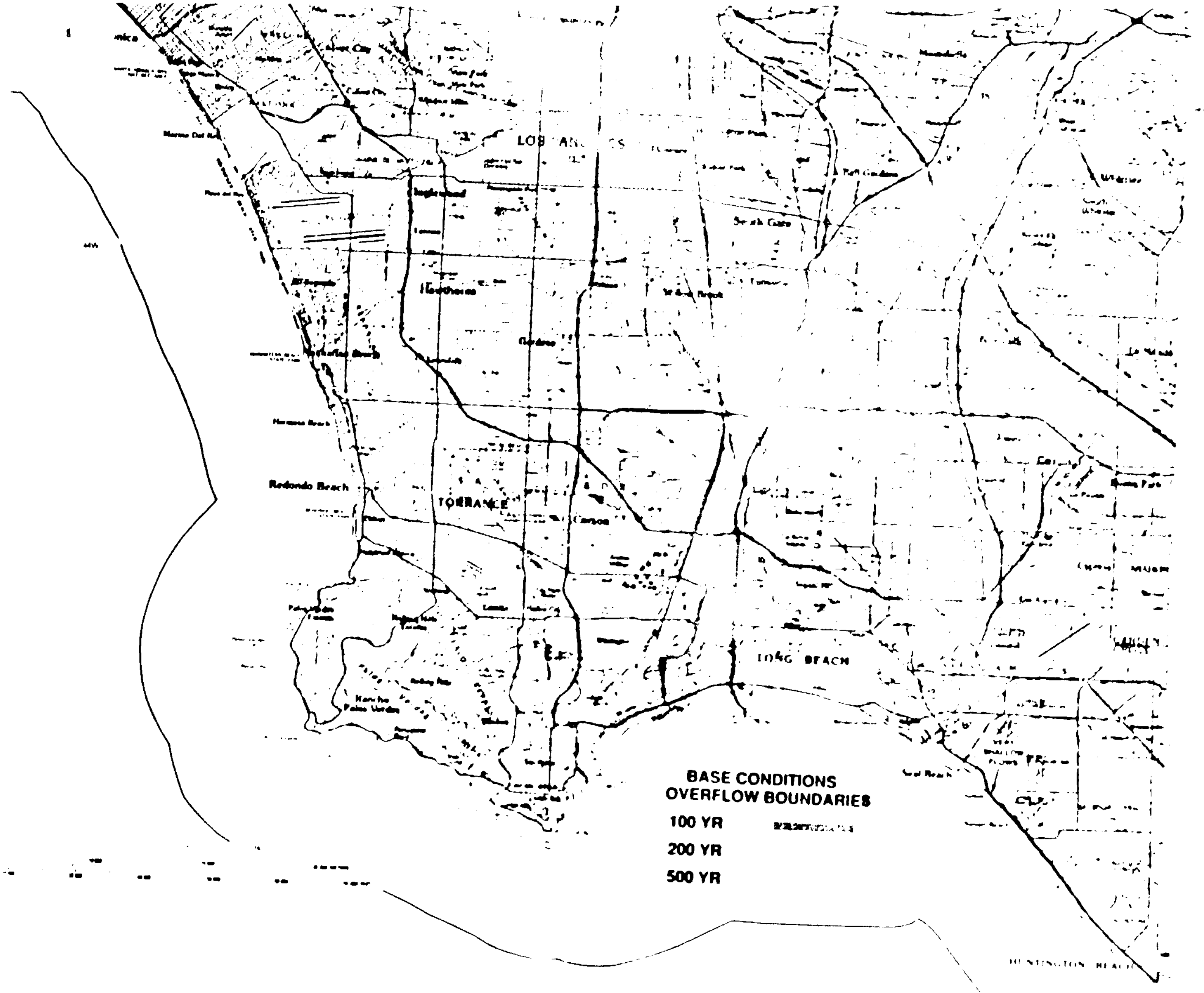
2. Increasing urban development has resulted in increased runoff because rapidly draining, impervious cover replaces runoff-retarding soils that support vegetation. The studies which led to the design of the LACDA system addressed future urban growth in the southern California area, however, the designers were unable to predict the impact of urbanization and the effectiveness of the local storm drain system at carrying this increased runoff into the main flood control channels.

Since 1939, local officials have constructed a comprehensive system of storm drains to prevent local flooding. These drains collect runoff and carry it to the mainstem river channels rapidly. They thus have the effect of concentrating local runoff; the effect on the flow in the mainstem channels is: (1) very rapid build up to peak flow and (2) peak flows higher than previously calculated. The system of flood control reservoirs designed to collect flood flows from the upper watershed areas does not, for the most part, control the runoff from urban areas, which are in the lower basin.

From Figure 4 it can be seen that some flooding occurs immediately below Corps flood control dams during the 100-year event. This excess channel flow is the result of local storm drain contributions to the mainstem channel. On the 23 mile length of channel from Whittier Narrows Dam to the Pacific Ocean (Reaches 4 and 5) there are at least 64 storm drains connecting to the mainstem channel and 12 pumping plants discharging to the river (see Figure 5). The pumping plants collect local surface runoff and pump it up over the levees into the river. On average there is local runoff added to the channel every third of a mile through its entire length.

The majority of the heavily urbanized watershed lies downstream of any flood control structure. The rainfall meets impervious surfaces such as buildings, parking lots


NATIONAL
FOREST
SAN FERNANDO
Burbank
GLENDALE
PASADENA
Alhambra
San Gabriel
LOS ANGELES


LOS ANGELES
Inglewood
Hawthorne
Gardena
South Gate
Redondo Beach
Hermosa Beach
Manhattan Beach
TORRANCE
Carson
LONG BEACH
Rancho Palos Verdes
Seal Beach
Whittier
HUNTINGTON BEACH
BASE CONDITIONS
OVERFLOW BOUNDARIES
100 YR
200 YR
500 YR

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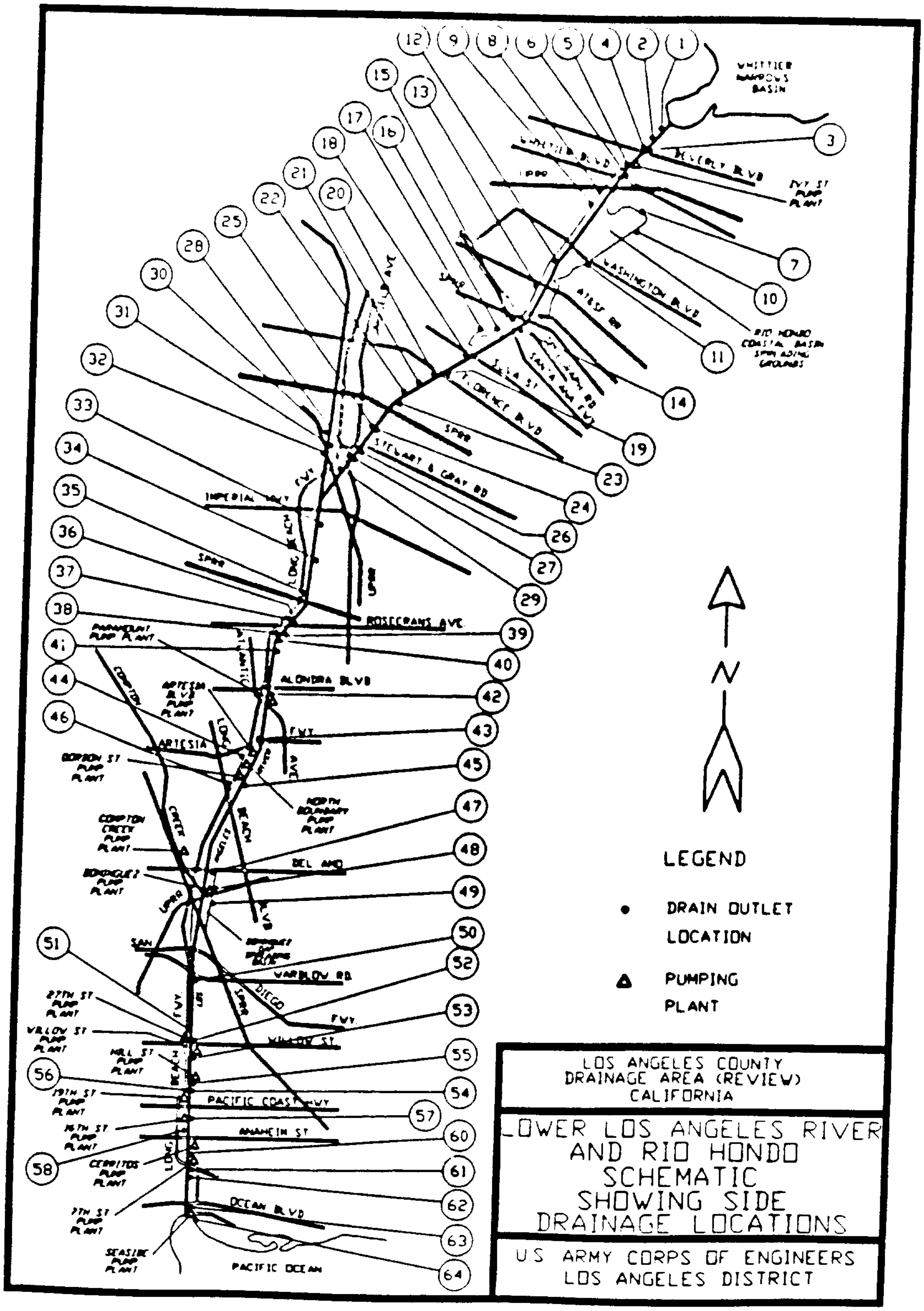

FIGURE 5

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and streets, and runs off into the local storm drain network. There are approximately 2000 miles of underground storm drains in Los Angeles County. These drains collect flows and efficiently convey it to the closest point of discharge, the mainstem flood control channels. This conveyance process responds very rapidly and provides little infiltration, storage or route down. The effectiveness of this system precludes any need to improve the storm drains on a wide scale basis.

Utilization of computer modelling techniques has allowed for a more detailed simulation and evaluation of the basin's drainage system performance than was previously possible. The numeric model used in the analysis is a complex single event simulation tool that provides insight on the magnitude and location of excess channel flow and as a result provides the basis for quantifying the overflow in the flood plain.

When the high velocity flood control channels were built in the 1930's there was little operational experience with this type of facility. Since that time the freeboard requirements for this type of channel have increased slightly due to the potential height of standing waves in the full flowing channel. This is only a minor consideration in determining how much flow will escape from the channel in a greater than design event.

Preliminary to modeling the mainstem channels in the LACDA study, the major tributaries of the system were evaluated using a generalized peak-area relationship. The levels of protection were found to be generally adequate or the extent of development in areas which might be flooded did not appear to be sufficient to justify further investigation.

The Without-Project Condition and the Flood Threat

For purposes of evaluating the need for increased flood protection, it is necessary to determine how often flooding would occur if no additional protection is provided, how widespread the flooding would be, and how much damage would be caused by the flooding. This is called the without-project condition. The without-project condition is generally projected over the entire economic life of the proposed project (100 years for a

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major reservoir or channel project); that is, an effort is made to predict the changes which would occur in development in the project area over this period of time. This projection is made so that the costs and benefits of the project can be analyzed over the life of the project, and to accommodate the probability that development levels in a project area will increase. In the Los Angeles basin, however, there is extensive existing development. The effect of potential future development in areas of the basin tributary to the mainstem system was calculated and was determined to have little impact on peak flows in the lower basin. As a result, the without-project condition does not change markedly throughout the life of the project.

Based on the review of precipitation and runoff and on re-evaluation of system capacity, it was determined that the LACDA system does not adequately protect many areas; the potential for the system to fail is particularly serious in the lower river reaches. Figure 4 shows the without-project overflow areas evaluated during this study. The Los Angeles River lacks 100-year protection through about half of its length. In the most critical reaches, such as the leveed sections along the Rio Hondo and the lower end of the Los Angeles River, the level of protection is less than the 50-year level.

The estimated 500-year overflow area is approximately 200 square miles, of which nearly all may be considered a fully developed, urban landscape. The population residing within this 500-year overflow area is estimated to be about 1,200,000. Similarly, the 100-year overflow area covers approximately 82 square miles, with a population estimated to be about 500,000.

Table 4 gives the total number of structures and expected damages within the 100-year and 500-year overflow area. The total value of structures and contents in the 500-year flood plain is $40.7 billion. Should such a flood occur, expected damages would total $5.4 billion (13 percent). Of the 322,000 structures in the 500-year flood plain, approximately 278,000 (86%) are single-family residences. Similarly, the total value of structures and contents in the 100-year flood plain is $17.5 billion, of which expected damages would total $2.3 billion (13 percent). Of the 142,000 structures in the 100-year flood plain, approximately 123,000 (87%) are single-family residences.

Measurement of structure elevation for damage estimation was test sampled. To ensure that any measurement error was minimized, an analysis of the combined effects of hydrology and topography were applied. For this analysis a random sample of 1% of the data caells was selected. Hydrologic cross-sections were site visited with stucture elevations measured and corrected with street topography maps. Flood inundation damages under this analysis were compared to those generated by the study's partitioned cell method. The result of this comparison indicates differences between the two methods were not statistically significant. Since neither the economic justification nor the NED plan is affected, no changes were made in the estimates of damages avoided.

For the existing without-project condition, the potential for flooding and damage along the mainstem system of LACDA can be summarized as follows:

1) **Reach 1.** From Hansen Dam to the Los Angeles River, the Tujunga Wash flows through suburban and commercial districts of the San Fernando Valley. The channel itself is within a greenbelt area which contains several major water recharge spreading grounds and numerous recreational areas. A flood in this reach would thus inundate some development, but the most significant overflows would be confined to a largely undeveloped area. A majority of anticipated damages would be to residential structures and their contents.

2) **Reach 2.** From Sepulveda Dam to the Arroyo Seco confluence, the Los Angeles River flows in an entrenched channel through highly developed commercial and residential property. A significant flood could break out of the channel at a number of points, but the extent of a breakout would be limited by the slope of the land towards the channel. Very high value property such as several movie and television studios would be flooded, but flood depths would not be great. A similar flooding scenario would occur as the river flows out of the San Fernando Valley into the central Los Angeles Basin. Rail yards and some heavy industrial areas would be flooded, but impacts would be limited and of short duration.

3) **Reach 3.** From Arroyo Seco to the Rio Hondo confluence, the Los Angeles River passes through very heavily developed industrial and commercial areas. A 100-year flood would break out in an area between the Pasadena Freeway and the Santa Monica Freeway, inundating rail yards, blocking major roads and freeways, and flooding major shopping, commercial, and government buildings. A vast majority of damages would be to commercial and industrial structures and their contents. A 500-year flood would break out in the same general vicinity but would spread over a much larger area, flowing across much of central Los Angeles before returning to the mainstem channel downstream. Flow depths would be moderate over a majority of this area.

4) **Reach 4.** The most serious flood threat is to this Los Angeles River reach, from the Rio Hondo to the Pacific Ocean. Flows overtopping the levees (generally upstream from bridges) would rapidly erode the unprotected levee walls and inundate the relatively flat and very heavily developed areas in this lower basin. Structures in the immediate vicinity of the breakout would suffer heavy damage from very deep and fast moving flows. Damages would also be high in several large low-lying areas where flood waters would tend to accumulate. Development in this reach includes several major freeways, rail lines and rail yards serving the Ports of Los Angeles and Long Beach, major refineries and petroleum products storage facilities, large industrial complexes, and extensive residential and commercial developments.

5) **Reach 5.** The Rio Hondo reach, from Whittier Narrows Dam to the Los Angeles River confluence is also heavily developed. Breakouts from the Rio Hondo would also involve levee failure, and flows from a flood originating in this reach would eventually co-mingle with those from the Los Angeles River, exacerbating the flooding in the lower river basin.

6) **Reaches 6 and 7.** The San Gabriel River from Whittier Narrows Dam to the Pacific Ocean flows through predominantly residential and commercial areas, although there is some industrial development near the river. This section currently provides a minimum of 100-year protection, but levee failures on the

Rio Hondo during more frequent events can result in floodwaters along the western bank of the San Gabriel River.

7) **Reach 8.** From Santa Fe Dam to Whittier Narrows Dam the San Gabriel River flows through residential and commercial areas, but no significant overflows along this reach are anticipated. The channel provides 500-year protection levels because of the controlling presence of Santa Fe Dam. Inflows to the dam greater than the 200-year event would spill into nearby gravel pits which have relatively massive capacities (on the order of 100,000 acre-feet). There would be significant damages to gravel mining operations, but adequate flood warning should permit all personnel to be removed prior to a flood. Damages in this infrequent event could be severe to the gravel pits.

8) **Reach 9.** Compton Creek is included as a reach so that the effects of a mainstem solution could be mitigated. The creek itself does not provide 100-year protection and is more appropriately studied under a separate authority. Any future improvements to Compton Creek do not affect plan formulation on the mainstem Los Angeles River.

Channel inadequacies are most serious in the lower Rio Hondo and Los Angeles River reaches for several reasons. First, in these reaches the river is contained by levees which may be 10-15 feet above the surrounding ground. Flow over the top of these levees for a period of an hour or more would very likely erode the unprotected back face and cause the levee to fail. The result would be high velocity breakout from the channel which would do significant damage in the immediate vicinity of the breakout and would then spread out over a wide area. Second, in the lower basin, there are also low lying areas where flows would accumulate to depths of 10 feet or more, causing serious damage to structures in these areas. Third, the lower mainstem is carrying the collected flow from the hundreds of square miles of drainage area. This massive accumulated flow represents a greater flood threat in the event of a system failure than exists in the upper reaches.

Table 4.
Number of structures and estimated damages, by reach,
100-year and 500-year flood plains, Los Angeles River and Rio Hondo.

Reach	500-year Flood plain No. of Structures	500-year Flood plain Damages in $mill	100-year Flood plain No. of Structures	100-year Flood plain Damages in $mill
1 Tujunga Wash	17,948	252.8	3,605	101.9
2 LAR above Arroyo Seco	9,425	310.6	1,272	19.7
3 LAR above Rio Hondo	81,703	618.7	700	67.1
4 LAR above Pacific Ocean	71,093	2,143.0	58,248	1,685.4
5 Rio Hondo	)*44,900	246.4	)*24,108	447.7
6 San Gabriel below Whittier Narrows		739.2		0
7 San Gabriel above Pacific Ocean	96,711	1,127.8	**53,575	0
Total Project	***321,780	5,438.5	141,508	2,321.8

NOTES * Combined total for Reaches 5 and 6 (overflows originating in these reaches commingle)

** Some structures in this reach may experience flooding but the source of the overflow is not Reach 7, thus the damage is not attributed to Reach 7.

*** Damages in the upper San Gabriel River reach (Reach 8) were not estimated because this portion of the LACDA system was found to provide 500-year protection, with the exception of the gravel pits that receive spillway flow from Santa Fe Dam.

Damages from overflows along Compton Creek were not calculated. Compton Creek was included as a project reach only because of the potential for channel modifications on mainstem reaches to impact levels of protection at Compton Creek.

B. RELATED PROBLEMS AND OPPORTUNITIES

While exploring flood control problems and appropriate methods for solving them, it is also appropriate to identify related problems and opportunities which may be addressed as a part of a solution to the primary flood control problem. For example, in designing a channel to solve a flood problem, it may be possible to provide a recreation area adjacent to the channel at little additional cost. The problems and related planning opportunities identified in this study are discussed below.

Sediment Management

There are 129 debris basins, generally located at the mouth of the canyons in the San Gabriel Mountains. These facilities are nearly all owned and maintained by the County. Their purpose is to retain sediment and debris while passing the clearer runoff into the flatter gradient channels of the Los Angeles basin. Channels flowing with clear water are far more effective conveyors of runoff than when they are filled with sediment laden flows. The County also owns and maintains 15 multi-purpose dams in the LACDA basin, generally upstream from the Corps' facilities. At present, more than half of the space behind these dams is reserved for flood control and the remainder is reserved for water conservation purposes. These dams intercept most of the sediment from the watershed above them, effectively limiting the sediment load reaching the major Corps flood control facilities. The County is thus faced with a significant maintenance problem, as high sediment loads tend to reduce the capacity of these facilities for water conservation as well as flood control purposes. In the past the County has occasionally sluiced this sediment downstream as a part of an operation and maintenance activity. If the sediment reached a Corps facility and settled out, it was subsequently removed by the County. There are environmental impacts associated with sedimentation of downstream streambeds, and there are also associated short-term reductions in flood storage capacity when this material settles out in a flood control facility. Addressing future management of sedimentation may require greater expense and the development of alternative methods of collection and disposal.

At present, sedimentation is not a significant problem at any of the Corps flood control facilities because the upstream County dams and the system of debris basins in tributary watersheds effectively limit sediment inflow to the facilities. The exception of high sediment inflow at Hansen Dam has been effectively addressed through a commercial sand and gravel mining lease arrangement. As a result of these efforts, no sediment allowance at any LACDA mainstem reservoir is currently filled.

While sediment is not currently considered a major problem from a flood control perspective, sediment management was considered worthy of study. This feasibility study looked at upper watershed sediment control through erosion control and check dam construction.

Water Conservation

Given the outlook for population growth (and therefore for increased water demand) and the limited supply of water available in the semi-arid southwestern United States, major flood control reservoirs represent a potential water conservation resource of some importance. At such reservoirs, conservation programs involve capturing late storm season inflows (when the danger of a major storm and flood event is low) and releasing them slowly to downstream groundwater recharge basins. This action is always limited by the need to ensure against flood damages.

It may be possible to increase the amount of water conserved in this manner. Any increase would depend on a re-evaluation of the amount and timing of inflows and of the flood control capacity of downstream reaches of the mainstem system. If it were possible to safely begin to store water for conservation purposes earlier in the spring, then water now lost to the sea could be captured.

The key to such action is the capability of the downstream mainstem channel system to contain releases from the reservoirs. The greater the capacity of downstream channels (to an extent), the less risk there is in holding supplies behind the mainstem dams for water conservation. Thus, before water conservation could be studied in detail, it was essential to evaluate the flooding problems on the mainstem system and develop solutions which would reduce the probability of significant flood damages.

This feasibility study explored the potential to increase water conservation by increasing delivery to spreading grounds, creating off-stream detention/conservation basins and trading developable flood control space for existing water conservation storage. None of these measures were supportable on a flood control basis, and, as such, this report does not specifically address alternatives for water conservation. Once the flood control capability of the mainstem system is upgraded to appropriate levels, it will be possible to formulate and evaluate these and other water conservation measures. This analysis may be undertaken as a separate study on a system-wide basis or under the general operational review authority granted to each District Commander. The District Commander is authorized to revise the storage allocations and operating schedules for Corps reservoirs within specific limits, provided that the public has an opportunity for review and comment. The Corps currently cooperates closely with the County to conserve as much runoff as possible.

Transportation

The need for transportation improvements in southern California is documented in numerous local, state, and federal reports. Basin freeways currently experience long periods of congestion, as do many city arterials.

Numerous studies by other agencies have suggested that the flood control channel rights-of-way, and indeed the channels themselves, could be used as transportation corridors. The Los Angeles River channel, for example, runs parallel to the Long Beach Freeway for much of its length and passes from Long Beach to downtown Los Angeles through major industrial areas. From downtown it then proceeds northwest into the major industrial and commercial areas of the San Fernando Valley. The San Gabriel River channel parallels the San Gabriel River Freeway (I-605), passing from south Long Beach through commercial and residential districts into the San Gabriel Valley. In all cases, these are heavily traveled routes. If the river channels could be adapted for transportation purposes, then a significant transportation benefit might be achieved.

In the late 1970's and early 1980's, the transportation problem was addressed to determine whether it should be carried forward for detailed study as a part of this report. Two studies were undertaken. First, the feasibility of using the existing Los Angeles River channel (concrete lined) as a busway was evaluated in a cooperative Corps-Southern California Rapid Transit District (SCRTD) test. The channel, without alterations, would not provide for short-haul service as there are no terminal facilities, and access to the channel is limited. However, SCRTD developed a test of the channel as a commute (express) busway. In this test, buses traveled the route from Long Beach to downtown Los Angeles both within the unobstructed channel (cleared of water and debris) and along local freeways.

The result of this SCRTD test was that local freeway routes were as efficient as use of the river channel. Although there was no traffic in the channel invert, the driving time between destination points via the channel right-of-way was equal to or greater than the driving time via existing roads.

Following this test, a conceptual study of potential roadways along the river channels was conducted. A number of busway and railway alternatives were evaluated. While several designs were found to be promising and technically feasible, two problems were identified which have a significant impact on project feasibility. First, designs involving single structures raised above channel level on piers placed in the center of the channel would raise the water level in the channel and would create significant turbulence and backwater, thereby increasing the risk of flooding. Second, all designs, including designs which provided for single-lane and double-lane corridors along each side of the channel, required numerous costly overpasses at bridge crossings along the river. The Los Angeles County Transportation Commission independently abandoned the Los Angeles River alignment of the San Fernando Valley light rail system in 1988.

The general conclusion of these studies was that effective use of the channel rights-of-way for transportation would have prohibitive costs. Furthermore, implementing transportation within the existing channel right-of-way would constrain numerous flood control solutions being studied. Because of the magnitude of the flood damage potential, this was not considered an appropriate constraint.

For these reasons, transportation problems have not been included in the detailed analysis of flood control problems and alternatives for their solution on the mainstem system. However, recent proposals for transportation use of the channel invert from Long Beach to downtown Los Angeles have some potential for implementation. Use of the channel by trucks would, according to state officials, greatly reduce traffic on the Harbor and Long Beach Freeways, which are major commercial arteries from the harbor area to industrial and commercial centers in the basin. Transportation proposals may be evaluated separately by the Corps at a later date; nothing in the planned upgrade of the LACDA system appears at this time to preclude adaptation of the channel for such uses. The expectation of utilizing this facility as a transportation corridor must be tempered with the constraint that flood control operations cannot be hindered or diminished and that public safety is paramount in operating the flood control system. The channel will continue to be used as a bus driver training ground/motorcycle policeman practice location and a favorite set for the movie industry.

Recreation

Because the study area is a densely populated urban environment, recreation opportunities are limited and opportunities to improve recreation are important. Throughout this study, it was clear that an effort should be made to identify and pursue new recreation opportunities to complement the existing recreation network. Recreation opportunities explored during this study included the potential for recreation associated with any new reservoirs or channels. In considering channel alterations, the potential to create new linear urban parks was given consideration. Where an alternative would involve changes to an existing channel or reservoir, alterations to improve the existing recreation system could also be addressed.

Aesthetic Improvement

Within the mainstem channel system, there are numerous opportunities to enhance the environment; many alterations to the channel environment have been proposed by local, state, and federal agencies, including restoring the channel invert to a natural condition, removing asphalt from the channel levee crest and creating a greenbelt. A number of suggestions were evaluated for altering the channel configuration to provide off-channel basins for recreation and to improve channel aesthetics.

The general conclusions of early study of these proposals has been that (1) they would be difficult to implement within the highly constrained rights-of-way for the existing mainstem system and (2) the cost of expanding the rights-of-way to permit such alterations to the system would be prohibitive. For example, doubling the width of the right-of-way for the Los Angeles River to permit a greenbelt area to be developed would involve removal of a major railway line and switching/cargo transfer yard, removal of numerous major manufacturing and distribution facilities, and removal of hundreds of residences and small businesses. The cost of this action for the reach from Long Beach to downtown Los Angeles would be excessive.

Early in the study process, then, it was determined that only limited aesthetic improvement enhancement would be economically feasible within the LACDA mainstem system existing rights-of-way. The problems which could be addressed were (1) the potential to add greenbelt corridors in reaches where rights-of-way were not seriously constrained, and (2) in locations where no additional rights-of-way are available, improving the existing aesthetics with vegetation.

C. PLANNING CONSTRAINTS

Planning constraints are overriding concerns that must be considered in the development of plans. The following are planning constraints identified in this study.

Environmental Values

Although the County of Los Angeles and all of its attendant cities recognize the seriousness of the flood problem within the LACDA basin, it is very important that environmental and esthetic values be respected. Any proposed program for flood control must take these values into account.

Cultural Resources

The Corps of Engineers, pursuant to regulations of the Advisory Council on Historic Preservation implementing Section 106 of the National Historic Preservation Act (36 CFR Part 800), is responsible for identifying cultural resources that may be affected by the proposed project. The Corps must also evaluate the eligibility of such resources for listing in the National Register of Historic Places. An assessment is made in consultation with the California Historic Preservation Officer of the project effects on cultural resources that are determined to be eligible for inclusion in the National Register.

Rights-of-Way Requirements

Dense residential and commercial development currently borders the rights-of-way of existing channels. In general, while limited increases in rights-of-way may be acquired for flood control purposes at a cost consistent with economic feasibility, acquisition of large blocks of land would have very significant social and economic impacts. If other cost-effective methods for providing flood protection are available, it is imprudent to consider acquiring significant new rights-of-way. Such an approach has the effect of disrupting the communities and businesses which the flood control project is intended to protect.

While it must be recognized that many alternatives involve buying rights-of-way within the community, a widening plan that displaces miles and miles of people and

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businesses is therefore unacceptable if an alternative can be formulated that would stay within the existing channel rights-of-way and provide similar benefits.

Displacement of People and Businesses

The Uniform Relocation Assistance and Real Property Law (Public Law 91-646, as amended) requires that any local sponsor acquiring land for a project involving the federal government must comply with provisions of this law. Specifically, this entitles people or businesses that are displaced or otherwise impacted by the project to proper compensation for their inconvenience, and to assistance in relocation if necessary. This assistance is in addition to any funds expended for actual purchase of property and improvements.

Groundwater Recharge

Recharge of the groundwater basins is extensive throughout the Los Angeles Basin, and is conducted by several Water Replenishment Districts. An overriding concern of both the local sponsor and the members of the Water Replenishment Districts is not to decrease the existing groundwater recharge. An example of an area that might be impacted is the stretch of the San Gabriel River that is currently soft bottom, in which water is frequently recharged. Accordingly, any flood control improvement along this reach of channel should not have an impervious bottom, or should make provision for the mitigation of loss of recharge area.

Bridges and Traffic

Automobile traffic in southern California currently strains the existing system of freeways, which have extended rush-hour periods. The freeways cross the Los Angeles, Rio Hondo, and San Gabriel rivers at numerous locations. Efforts to avoid impacts to these freeway overcrossings, and thus to traffic within the basin, were a significant

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planning constraint. Plans which would involve disrupting a major freeway interchange were considered to have severe socio-economic impacts.

D. PLANNING OBJECTIVES

General

The water and related land resources problems and opportunities identified in this study are stated as specific planning objectives to provide a focus for the formulation of alternatives. These planning objectives are as follows.

To reduce the potential for human suffering and possible loss of life due to catastrophic failure of the flood control system, wherever feasible.

To reduce flood damages from the study reaches, wherever feasible.

To provide, where feasible, project-related water conservation, recreation development, sediment management, transportation, and environmental enhancement opportunities.

Selection of the National Economic Development (NED) Plan

A project for flood control involving federal funds must satisfy general economic criteria that have been developed to protect the Nation's investments. The following three items are used when evaluating alternatives.

a) A positive benefit-to-cost ratio must exist. That is, the annual dollar value of tangible benefits must exceed the project's annualized cost. The benefit/cost ratio must be at or above 1.0 for an alternative to be considered economically feasible.

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b) The scale of the improvements should consider maximization of net benefits (benefits minus costs).

c) The stated result of the improvements must be accomplished with the most economic means available.

Principles and Guidelines for Federal water resources planning require that a plan be identified that produces the greatest contribution to the national economic development (NED). This plan, termed the NED plan, is defined as the plan providing the greatest net benefits as determined by subtracting annual charges from annual benefits. Further, the NED plan is to be selected as the recommended plan unless the Secretary of the Army grants an exception when there is some overriding reason for selecting another plan based on federal, state, local, or international concerns.

E. FORMULATION OF PRELIMINARY PLANS

Plans for rehabilitation and upgrade of the LACDA flood control system were formulated in accordance with the National Environmental Policy Act and the 1983 Water Resources Council Principles and Guidelines. Economic, environmental, and social impacts were considered throughout plan formulation.

Alternative Identification

Alternative solutions were identified in close cooperation with representatives of the Los Angeles County Department of Public Works and the U.S. Forest Service. County and Forest Service reports and plans were reviewed to avoid duplication of effort during the initial stages of plan formulation. Members of these agencies, as well as Corps representatives of the LACDA study team, held weekly plan formulation meetings over several months to address all possible alternatives.

The alternative analysis was a logical outgrowth of the problem identification phase of the study. It was initially obvious that a system-wide review was appropriate, as opposed to a limited review which would only address problems in specified reaches of the LACDA system. With this initial direction established, it was possible to approach plan formulation from a broad point of view, examining measures which could be taken to improve system performance throughout the basin, including the areas upstream of major reservoirs, the channel system in place throughout the urbanized basin, and the features of the local drainage system.

<u>Initial Stage of Plan Formulation: Review of Measures for Addressing Flooding and other Problems</u>

The initial stage of plan formulation was a broad, strategic review of all potential measures which could reasonably be used to address flooding problems. The procedure for identifying these measures was, first, to generate a checklist of all possible strategies for flood damage reduction; and second, to use the checklist geographically by formulating possible solutions on each segment of the LACDA system. The analysis began with the upper watershed areas and worked downstream through the system. In this way, any downstream measures would be formulated with full understanding of the potential effects that upstream modifications might have on channel flow characteristics.

The flood damage reduction measures fit into four main categories:

1) Reduce inflow to the system (detain water),
2) Convey more water in the system (increase channel capacity),
3) Damage management (floodfighting, floodproofing, etc.), and
4) Alter the reservoir's current operating regulations.

Item 4, re-regulating reservoirs on a system-wide basis to coordinate releases and thereby reduce flows within the channels, was proposed and given an initial evaluation. Studies were conducted to optimize the current mode of reservoir operations.

It was concluded that reoperating reservoirs cannot eliminate the potential flooding problems in the Los Angeles Basin. It is possible to improve the level of protection on some channel reaches but this benefit is often offset by a decrease in the level of protection elsewhere in the system. The Reservoir Regulation Section of the Los Angeles District is constantly striving to improve the methods of reservoir operation. While some improvement can be expected over time, it cannot be guaranteed or quantified at present. Thus, the existing approved operation schedules are used as the basis for comparing alternatives.

The use of a "real-time" reservoir response procedure has also been evaluated. Real-time operation involves nearly instantaneous transmission of extensive field data to the District's operational center. This information is usually processed by computer model to aid in deciding on the most efficient reservoir operation plan. The LACDA system was evaluated to determine the applicablity of this process.

A real-time network of gages currently exists in the basin. The accompanying computer model was modified in order to minimize its run time but the shortest run time acheived was approximately one hour. Decisions must be made in a shorter time frame than this so the model was eliminated as a feasible tool. As an alternative, it can be assumed that the information can be received, evaluated and acted upon within 30 minutes. The time it then takes for a dam tender to complete a gate change can be 15 minutes or longer per gate. If, for example, the system location under stress was the confluence of the Los Angeles River and the Rio Hondo, the controlling dam would be Whittier Narrows Dam. The travel time for flows from Whittier Narrows Dam to the confluence is 30 minutes. Thus, an optimal real-time operation could have an influence on flows at the confluence 1-1/4 hours after knowledge of the threatening situation was received. This assumes that all gages and system elements are fully functional.

The basin's response time is usually an hour or less, especially in the urbanized portions of the lower Los Angeles River. As a result, it appears that an optimal real-time response cannot avoid adverse impacts should the floodwaters threaten to exceed channel capacity. While future refinements to the current operating plans may be expected, they are not adequate or reliable enough to preclude the need for structural solutions to the flooding problem. These considerations led to the decision not to rely on re-regulation of the reservoirs as a solution to the downstream flooding problem. Having eliminated reservoir re-regulation as a measure under consideration, the remaining three categories of measures (Table 5) were examined for general appropriateness for each reach of the LACDA mainstem system.

Regional Applicability of Alternatives

Upper Watershed Areas

The first geographical areas to be explored were the watersheds above existing flood control reservoirs. Using previous Corps, County, and Forest Service studies, these watersheds were examined to determine which measures might reduce the inflow of floodwater to the existing LACDA system.
Measures considered included:

1) New dam construction in the upper canyons,
2) Vegetation and debris management measures, and
3) Modifications to the existing operating procedures of the County's upstream reservoirs (increase the storage space allocated for flood control).

Alterations to Existing Flood Control Reservoirs

Excavation of a reservoir to increase its flood storage potential and the capability of raising, re-gating, or otherwise altering the spillway elevation for the four major flood control reservoirs in the LACDA system was evaluated. Modifications that would increase the amount of flood control storage at existing dams by impounding water at a higher elevation are generally only possible where development around the reservoir's existing maximum storage boundary is sparse. The surrounding lands may then be available for purchase at an economically feasible price.

Mainstem Channel Areas Downstream from Major Reservoirs

During the analysis of the channels downstream from the major reservoirs, the focus of the plan formulation process shifted from retention of floodwater to quicker conveyance or short-term detention of channel flow. A wide variety of measures was considered in this evaluation, to include:

1) Deepen existing channels
2) Widen existing channels
3) Raise existing channel walls
4) Remove and replace or modify bridges constricting channel flow
5) Divert flows into tunnels for delivery to the ocean
6) Divert excess flows into new detention or groundwater recharge facilities
7) Alter the channel shape from trapezoidal to rectangular
8) Change the channel substrate and side wall material (from rock to concrete, for example)
9) Armor the back sides of earthen levees with non-eroding material to prevent catastrophic levee failure
10) Alter inlet structures and bridge piers to reduce turbulence in the channel
11) Floodproof and/or construct temporary walls on major roadways which would permit the diversion of floodwater for brief periods into these temporary channels

At the same time these measures were being considered, each reach of channel was evaluated to determine if damage management measures such as local flood walls, other flood proofing measures, or flood plain management might reduce the extent of damages. In addition, flood warning and evacuation plans were considered.

The result of this initial planning was a list of measures (Table 5) which might be appropriate for each distinct reach of the LACDA flood control system. These measures were screened to determine which measures would be carried forward for detailed feasibility analysis.

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Table 5. Measures considered for flood damage reduction.

STRATEGY	SPECIFIC MEASURES CONSIDERED
1. Reduce Inflow to Mainstem System	
A. Integrate Flow Retarding Facilities into the System	
	Floodways
	Underground Aquifers
	Wetlands
	Vegetation/Debris Management
	New Dams
	Detention Basins
	Gravel Pits
B. Modify Existing Facilities	
	Modify Existing Dams
	Increase Height
	Excavate Material
	Change Gates/Outlets
2. Convey More Water in the Mainstem System	
A. Create New Conveyance Facilities	
	Pipelines/Diversions
	Tunnels
	New Channels/Aqueducts
B. Increase Existing Channel Efficiency	
	Alter Existing Channels
	Raise Channel Walls
	Widen
	Convert to Rectangular
	Deepen
	Increase Slope
	Armor Back Side of Levees
	Reduce Channel Roughness
	Reduce Bridge Obstructions
	Clear Span Bridges
	Modify Piers and Decks
3. Damage Management	
	Relocation
	Floodproofing
	Floodfighting
	Flood Plain Management/Insurance

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Public Involvement

A complete initial planning effort involving local and other Federal governmental agencies was critical to ensure that the public was presented a thorough list of possible solutions. No measure which could reasonably be expected to contribute to the solution of the identified problem was eliminated during the initial phase of plan formulation. Thus, when the public presentations were formulated, no measures which were viable from an engineering standpoint and which could contribute to the solution of flood control problems had been eliminated. The public was presented with a broad spectrum of measures to consider and discuss.

The effort to formulate a public involvement program was complicated by the size and population of the affected area. There are over 750,000 households and businesses in the area directly affected by projected overflows from the existing LACDA system, and the population which would be affected by any project is well over 4 million. These people must be afforded the opportunity to comment on formulated solutions and to recommend measures, in addition to those addressed during the initial plan formulation process. To make this possible in such a densely populated region, multiple approaches were used for public involvement.

Personnel from the County Department of Public Works were involved in the planning from the beginning. Local officials were relied on to help guide the initial planning, pointing out where some measures might not be locally acceptable and explaining local perspectives on the problem. To inform other local officials at the city level, open-forum workshops were held to discuss issues, concerns, and other solutions. Also, the Los Angeles County Board of Supervisors, the governing body of the local sponsor, was kept informed of study progress.

Information about the general potential flooding problem for the drainage basin was made available to people through the local media, in particular through press releases and interviews in the major newspapers in the region. An initial problem analysis was made available in mid-1985, prior to plan formulation, giving the general public an overview and an opportunity to communicate with Corps planners. There was an intensive publicity campaign that included a public mailing of informational brocures in 1987, and follow-up publicity about the project in spring of 1989.

Public presentations were made in October 1987 and again in March 1989. They were focused on the identified problem, including both overflow analysis and the economic assessment of damages and the array of formulated, corrective measures being considered. At least one such presentation was made in each affected area of the LACDA watershed. Presentations consisted of a general introduction and a detailed slide/video briefing, followed by an open question-and-answer period. An information bulletin was provided to all attendees. At the end of each briefing, response cards were handed out and a mailing list circulated to ensure that all interested in the study received future informational bulletins.

This open and active public involvement effort will be continued, to include review of this Feasibility Report and review of future design efforts.

F. EVALUATION OF PRELIMINARY ALTERNATIVES

The large number of preliminary alternatives considered were evaluated at several levels of detail. First, all alternatives were evaluated to determine if they showed promise of meeting project objectives. Numerous alternatives were eliminated on the basis of this initial analysis. Second, alternatives which showed some promise of meeting project objectives were subjected to a preliminary benefit-cost analysis. The screened alternatives are described in this section in the order they were presented in Table 5.

Strategy One: Reduce Inflow to Mainstem System

A. Integrate Flow Retarding Facilities into the System

Detention of water within the system of dams and channels is a primary strategy for reducing inflow to the mainstem system and improving flood control in urban areas. Detention can be achieved by capturing flows behind dams or by diverting flows into undeveloped areas such as gravel pits, groundwater spreading basins, floodways, wetlands, and other low-lying areas. In addition, a number of secondary options for reducing flows in the mainstem channels by increasing groundwater storage were considered, among them, injection wells and channels with holes in the invert and side slopes (perforated channels). Several detention strategies were eliminated after a cursory review. First, floodways were eliminated because there is simply no adequate undeveloped land for such floodways, and the massive amounts of water which would need to be diverted into the floodway would move with such force as to threaten to cause significant damage to any natural landform. A floodway susceptible to failure would thus merely transfer damages from one reach of the river to another, an unacceptable solution to the problem.

Second, storage in underground reservoirs, aquifers, or wetlands was eliminated because there are no undeveloped sites in the LACDA basin appropriate for these alternatives. Underground reservoirs would have to be capable of 10,000-20,000 acre-feet of storage and would cost perhaps hundreds of millions of dollars to construct. Injection of excess flow into aquifers would be too slow to affect peak flow significantly. And there are no wetland sites in the LACDA basin which could be used to store water; all wetlands remaining in the basin are near the coast. None of these options was found to have any appreciable impact on peak flows in the channels. Given only limited water conservation benefits from these options, and the potential for high costs and some impacts to flow rate in the channels (greater flow resistance and turbulence from perforated channels), they were eliminated from consideration early in planning.

Another option involves land management to reduce runoff and debris production in the upper watershed, thereby reducing peak flows. Management of vegetation is one approach, but it is generally effective only where the slope of hillsides is moderate and substantial vegetation can be established. This is not feasible in the semi-arid mountains surrounding the Los Angeles Basin. The steep slopes and long hot, dry seasons mean that vegetative communities at most elevations are limited to coastal sage scrub, grasses, and chaparral. These communities burn off in the fire season with some regularity, and there is often little chance for significant growth prior to the start of the rainy season.

A second approach is construction of debris basins and check dams. There are already 129 major debris basins in the upper watershed areas, and effective sites for additional basins or check dams have generally been utilized. In addition, these structures are generally too small to significantly reduce peak flows to downstream areas; they fill quickly in early flood stages and have no capacity remaining when peak flows occur.

Erosion control and alteration of the watershed to improve retention of rainfall are both extremely difficult to accomplish. If they could be achieved, it is doubtful that they would have a significant impact on peak flooding because peak flows occur when thin soils have been saturated and there is no additional capacity in the soil. This approach is worth pursuing in the long term for the benefit of improved land management, but cannot presently be relied on to provide significant reductions in peak flows.

Upper watershed erosion control also does not address the problem of increases in lower basin local runoff, which cause the majority of the flooding problems in the basin. Therefore, there would be only minor benefits from programs that reduced upper watershed runoff and erosion. They were not pursued as primary solutions to the flooding problem.

New Dams

New dams in the canyons above existing Corps facilities were considered at the following locations:

1) The Los Angeles River basin above Sepulveda Dam,
2) Tujunga Wash above Hansen Dam,
3) Arroyo Seco watershed above Devil's Gate Dam, a local dam owned by the city of Pasadena, and
4) The watershed above the Santa Fe Flood Control Basin.

These locations were determined to have the largest potential capacity of all those surveyed.

Small dams have little effect on peak flood flows because they fill up very early in a flood and therefore have no capacity when peak flows arrive; the runoff they do capture arrives prior to peak flows and would therefore generally pass harmlessly within the main river channel to the ocean. Since they are spilling when peak flows occur, they do not reduce the flooding problem. To be effective, an upstream dam would require at least 10,000 acre-feet of storage.

Factors that needed consideration in an analysis of new dam sites include the following:

1) The environmental impacts associated with the construction of a new dam would require substantial mitigation.

2) The Forest Service would not favor dams unless they have public access and recreation areas.

3) Small dams would require costly debris removal while providing minimal benefits.

4) Many of the dam sites considered in the initial plan formulation stage were in relatively developed areas, and construction would require relocation of recreation facilities, roads and some homes.

5) If new flood control capacity were proposed, a reoperation analysis would need to address how the existing space would be incorporated into the existing system and what potential existed for increasing available water conservation space.

In the western upper watershed, the three sites were identified - north of Pipe Canyon, near Bill Lake Camp, and on the Little Tujunga - and evaluated to determine whether they would have a significant impact on flooding; that is, whether their maximum potential capacity would be adequate to affect peak flows. An analysis indicated that these reservoirs would be at or near capacity when peak inflows were experienced and, therefore, that they would have virtually no impact on peak flow into the major downstream reservoirs (Sepulveda and Hansen Reservoirs). In addition, their estimated costs were high, and there was potential for significant environmental and recreational impacts.

None of the new dam alternatives would have allowed outflows from Hansen or Sepulveda reservoirs to be reduced enough to have an effect on downstream flooding problems. For example, even a reduction in releases from Sepulveda Dam of 20% (3300 ft^3/s) would have only minor impacts on downstream flows because local runoff increases flow in the mainstem by as much as 40,000 ft^3/s.

A new reservoir was considered in the watershed above Devil's Gate Dam on Arroyo Seco. Such a reservoir would reduce flooding to some extent in the downtown Los Angeles area, but would not have a major impact on the lower Los Angeles River where the flooding problem is greatest. Thus there would be relatively high costs and environmental impacts without offsetting flood control benefits.

In the upper San Gabriel River watershed, several sites were evaluated. In this watershed, the major dam sites have already been used, and the remaining sites would have little storage and thus little impact on downstream flooding.

In short, new dams in the upstream canyons were found to have too little storage to provide significant flood control benefits. At the same time, they would have had high costs and potentially high environmental impacts.

New dams were also briefly considered below the existing major reservoirs, for example, on Tujunga Wash below Hansen Dam and on uncontrolled tributaries such as Compton Creek. A brief survey of the potential sites, none of which held much promise as dam locations, indicated that a facility large enough to have an effect on flows downstream would require acquisition and clearing of heavily urbanized areas. The cost of this would be prohibitive given the high value of commercial property in the potential storage areas. Therefore, new dams were eliminated from further study.

Detention Basins

Where adequate land is available, peak flows may be directed over a weir or through an inlet structure to detention basins. This effectively reduces the flow moving through downstream channel reaches and thus prevents channel capacity from being exceeded.

Several detention basin sites were identified in the upper reaches of the Los Angeles River system, and these were evaluated to determine the feasibility of diverting peak flows to them (Table 6).

Table 6. Detention basin sites/gravel pits considered.

Project Reach	Detention Basin	Potential Size Acres	Potential Size Storage	Conclusions
1	Pacoima Spreading Grounds	153	2,200 af	Not cost effective
1	Tujunga Wash Spreading Grounds	188	2,000 af	Not cost effective
2	Taylor Yard	200	5,200 af	Not cost effective
8	Livingston Gravel Pits	415	29,000 af	Not cost effective
8	Conrock Gravel Pits	365	30,000 af	Not cost effective

Pacoima Spreading Grounds. The Pacoima Spreading Grounds are a 153-acre site located off the Pacoima Wash in Reach 1 of the LACDA System (see Figure 6). During initial plan formulation, a weir to direct flow to the spreading basin was investigated which would require excavation of the existing grounds to a depth of 15 feet and would entail removal of approximately 4,600,000 yds^3 and provide storage of 2,200 acre-feet at a cost of almost $24,000,000 ($5/yd^3). Greater excavation depths are not feasible or consistent with water conservation operation of these areas. Initial evaluation of this alternative indicated a benefit-to-cost ratio of greater than one-to-one, but later evaluation determined that costs would greatly exceed benefits.

The more detailed review of this alternative determined that, to accommodate the peak flow and volume necessary to significantly reduce flooding downstream, a 2-mile weir would be required. Due to the fact that the site cannot accommodate a 2-mile weir, an inlet structure would need to be designed instead to intercept floodflows on the wash and deliver them to the basin at a rate of 9600 ft^3/s. This inlet structure raised estimated project costs significantly.

A second problem was the need to drain the detention basin rapidly after each flood event. The general winter storm pattern in southern California is often characterized by a series of storms sweeping out of the north or central Pacific at one- to five-day intervals. This occurs when the Pacific High locates to the south and east of the area, permitting a regular sequence of storms to penetrate to the south. Under such conditions, it is possible for one flood event to be followed relatively rapidly by another significant storm. To retain flood control capacity in dams and detention basins, it must be possible to draw them down within several days. Thus the detention basins would have to be connected to the local storm drainage system, which would require significant upgrading of the system. This requirement also added to the preliminary costs. Impacts, both positive and negative, to the existing water spreading activities were not evaluated in detail.

Finally, a detention basin in this reach would have only very limited benefits for the downstream Los Angeles River reaches where a majority of damages occur. Detention would have to be justified on the basis of Tujunga Wash flood control benefits alone.

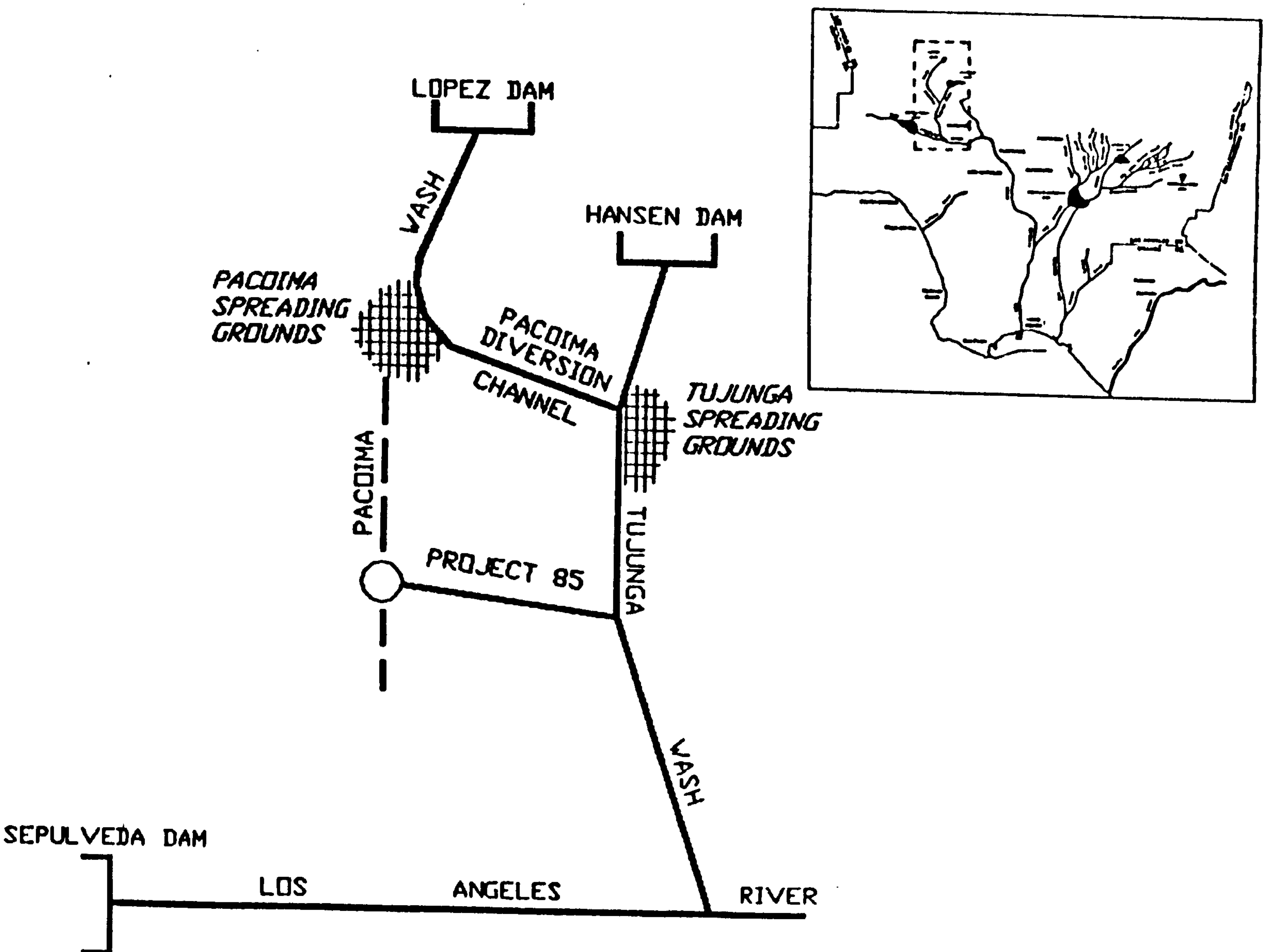

FIGURE 6 LOCATION OF POTENTIAL DETENTION BASINS AFFECTING TUJUNGA WASH

Tujunga Wash Spreading Grounds. This 188-acre spreading ground is located south of the Highway 101 and Interstate 5 interchange several miles south of Hansen Dam (see Figure 5). The existing inlet works have a capacity of 400 ft^3/s, and the spreading grounds have a capacity of 390 acre-feet. Deepening this area by 11 feet by removing 2.5 million cubic yards of earth would increase this capacity to 2,000 acre-feet.

This alternative shared the disadvantages of the Pacoima Spreading Ground alternative: It was costly and would have a limited impact on peak flows. As a stand-alone alternative, it was eliminated from further consideration.

Pacoima/Tujunga Basins Combined. Although each spreading ground would, by itself, have little impact on flood flows, a combination could reduce peak flows (at least for a period of time) by at least 9,600 ft^3/s and provide off channel storage of over 4,000 acre-feet.

This combination was evaluated, with the following conclusions:

1) Partly because of the cost of inlet and drainage structures, the cost of the combined alternative would be quite high, even without considering complex drainage structures;

2) The reach of Tujunga Wash where benefits would be realized currently has 70-year protection;

3) Therefore, annual NED benefits from the project would be exceeded by annual costs, and the benefit to cost ratio of the alternative would be substantially less than one-to-one.

Taylor Yard Detention Facility. The Los Angeles River flows out of the San Fernando Valley through a low-lying area bounded on the west by the Golden State Freeway and on the east by San Fernando Road. In this area, there is a railroad yard and a number of aging commercial structures. If cleared, excavated, and used for off-channel

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detention, this low-lying area could accommodate approximately 5200 acre-feet of storage. This would reduce peak flows into the downtown Los Angeles area.

Detention at this site would have only a minor impact on overall downstream flooding and minimal impact on damages because predicted depths in the downtown area which would be protected are not great and damage is estimated to be minor. It would not significantly reduce peak flows breaking out of the channel in the lower Los Angeles River; it would thus raise levels of protection only marginally. For this benefit to be achieved, a commercially valuable industrial and commercial area would have to be taken at significant cost. Weighed against the high social impact and the $60,000,000 cost of acquiring and excavating the basin (initial cost estimate), it would thus not be a justified project element.

Gravel Pits

Livingston-Graham and Conrock Sites. Gravel mining near Santa Fe Dam has created extensive gravel pits in the vicinity of the San Gabriel River. Two large, well situated pits have a combined capacity of over 59,000 acre-feet of storage. Mining operations at these pits are scheduled to be terminated after the turn of the century, and therefore they will be available for other uses. This is a significant potential off-channel storage area, given that the total capacity of the Corps flood control dams is about 120,000 acre-feet.

The gravel pits would have to be modified to be used for flood control. The existing quarries have nearly vertical walls which would have to be altered to a 2:1 (about a 33° angle) slope for stability. The poorly consolidated alluvium would be subject to slumping if the porous material surrounding the pits were saturated due to high groundwater or short-term flood water impoundment. The current walls are close to the San Gabriel River, the San Gabriel Freeway and local surface streets, any of which could be jeopardized by a significant wall failure.

Inlet weirs or pipelines would be constructed to divert flows into the gravel pits from the mainstem San Gabriel River. For these to be effective, they would have to be sized to accommodate flows of about 20,000 ft^3/s.

Additional modifications would have to be made to permit the gravel pits to drain rapidly following a major storm. This is necessary to restore storage capacity in anticipation of a subsequent storm event. Other major flood control facilities in the Los Angeles basin are designed to be drained in as little as two days; this is important because precipitation in southern California is often characterized in the winter by a series of storms, with storms arriving at intervals of one to five days. Modifying the gravel pits for drainage would require a tunnel to be constructed to a downstream point along the river below the grade of the gravel pit bottom; a long and costly tunnel would thus be a feature of this alternative. Other modifications might be needed, but these major features were considered in preliminary cost estimates.

Initial study indicated that the gravel pits would have a significant impact on volume inflow into Whittier Narrows Reservoir and could therefore reduce the scheduled releases from that facility to the Rio Hondo channel. The projected reduction in release to the Rio Hondo was up to 8,000 ft^3/s. This would eliminate the current inadequacy in channel capacity on the Rio Hondo but would not fully alleviate the flooding problem on the Los Angeles River. An initial decision was made to pursue this alternative further because of the high potential for both flood control and water conservation benefit. The cost of the storage was undefined at the time this decision was made. This alternative was not carried forward for detailed design and analysis, however, due to several factors:

1) There would be a significant cost in acquiring the rights to the gravel pits because current operators would have to be compensated for loss of potential income. The period of time projected for profitable operation is uncertain, but may extend well into the proposed flood control project's period of operation.

2) The City of Irwindale has developed plans for use of these gravel pits for other purposes, including filling the pits and developing them for commercial ventures. An area of existing groundwater would also be used for recreational purposes.

Use for flood control would complicate these plans and benefits from flood control use would have to be compared to the opportunity costs of more intensive development of the sites.

3) While reduction of inflows to Whittier Narrows Dam would possibly reduce the need to improve the Rio Hondo channel, it would have a less significant impact on the lower Los Angeles River because that problem is primarily a result of accumulated, uncontrolled drainage. Flood control benefits would thus be mainly limited to the Rio Hondo channel. The gravel pits are also located sufficiently upstream from the primary flood damage areas such that they do not provide an operationally flexible solution to downstream flooding compared to improvements closer to the inundated areas.

4) Grading to stabilize the gravel pits' side slopes would involve moving large quantities of material. Grading operations might require hauling material to other disposal sites or placement of any excess spoil in the pits themselves, thereby reducing the projected effective capacity of the pits. Movement of large quantities of material is generally very expensive.

5) Drainage of the pits within a short period of time would require a costly outlet works to be constructed. Pumps were initially considered but rejected because they cannot be relied on, especially given that they would remain idle for periods of 20-30 years. Tunneling was the preferred alternative, but the proposed tunnel would have to extend six miles to Whittier Narrows. An initial cost estimate of $100 million (excluding rights-of-way) raised total project costs significantly.

Based on an initial analysis, use of the gravel pits near Santa Fe Dam was not considered economically feasible.

<u>Strategy One (A) Summary: Integrate Flow-Retarding Facilities Into the System</u>

In part because of the nature of the flooding problem in the LACDA system and in part because of the lack of effective and cost-efficient sites for detention basins, no alternative involving new flow detaining facilities was carried forward for detailed analysis.

Strategy One: Reduce Inflow to Mainstem System

B. <u>Modify Existing Facilities</u>

Modify Existing Dams

Corps Facilities. There are a number of modifications possible at existing Corps flood control reservoirs: (1) increasing dam height and, as a result, reservoir capacity; (2) excavation of the basin to increase capacity; and (3) alteration of gates and spillways.

At Sepulveda and Whittier Narrows, raising the dam height was considered. Small increases in dam height at these sites would produce significant increases in storage because of the flat slope of the reservoir basin. This option was less attractive at Hansen and Santa Fe dams because those dams provide a satisfactory level of protection, and raising the dam would have only marginal impacts on total flood control storage. At the two potential sites, however, the cost of raising main embankments would be quite high because of the length of the embankments. In addition, development has occurred at the margins of the existing reservoirs, and raising the dams would mean that this urban development would be inundated during a significant flood. Acquisition of this property would be required, and this would not only be costly but disrupt existing communities. This option would be prohibitively costly and unacceptable, and it was therefore eliminated from further study.

Excavation in the reservoir to deepen it and thereby increase capacity was not considered at Sepulveda and Whittier Narrows reservoirs because of the extensive environmental and recreation development in these reservoir basins. It was considered at Santa Fe and Hansen Reservoirs where planned or existing excavation activities have already impacted some of these resources and where there are large areas which would be excavated.

Excavation is an extremely costly approach to increasing reservoir storage. Costs may be as high as several dollars per cubic yard excavated, and there are additional costs for hauling to a disposal site. Removal of a significant amount of sediment, enough to have an impact on downstream flooding, would involve increasing storage by more than 10,000 acre-feet. This is equivalent to approximately 50 million cubic yards, making costs for such a project exceed several hundred million dollars. This additional storage could not be below the existing grade of the outlet gates as it would not be drainable and would thus not be available for flood control. Providing new gates to solve this problem would be difficult and cost prohibitive. First, new gates constructed below the existing gate elevation could involve changes to the reservoir foundation. Second, new gate construction would be very costly, adding to the already high cost of sediment removal. Thus, excavation would have to occur in the upper elevations of the basin, away from gates and existing maintenance sediment removal operations.

Disposal of approximately 50 million cubic yards of spoil from this alternative would also have very significant costs. Available landfill sites are reaching capacity in Los Angeles, and the cost of hauling to sites outside of the basin would be prohibitive. It is unlikely that a suitable existing landfill site could be identified within an economical haul range. Creation of a site would have significant environmental consequences.

Sediment buildup behind the two dams in question is also an ongoing process. There are a number of factors which could cause massive sediment movement into the reservoirs prior to a significant flood event, which would therefore eliminate the excavated storage prior to peak flows. As such, this solution to flooding problems is not wholly reliable. Additionally, increasing storage in the upstream dams will not significantly affect the overall flooding condition. A reduction in reservoir releases of 4,000 ft^3/s during the 100-year event at Hansen Dam would require extensive excavation and yet would not compensate for the massive inflows to the system occurring from local drainage in downstream reaches.

Finally, Hansen Dam already provides control of the 200-year flood. Increasing its capacity would have very little effect on flooding on Tujunga Wash or reaches below because the flooding is a result of increased local drainage. Thus, excavation to increase reservoir capacity is cost prohibitive, ineffective, and potentially environmentally damaging at both the reservoir site and any disposal site. No excavation alternative was carried forward for final analysis.

Altering outlet structures may reduce net outflows from the reservoirs under some conditions and thereby somewhat reduce peak flows throughout the river system. This was initially considered at Sepulveda because its spillway design limits the ability to hold back flows from the reservoir. At this site, the gates and spillway could be modified to permit some reduction in outflow. However, significant reductions in outflow from the gates would not be possible because retaining additional water behind the dam to reduce peak flows early in a flood would increase the possibility of greater flooding later if inflow continued to exceed outflow.

In addition, gate/spillway alterations affect releases from the reservoirs only, and do nothing to solve the problem of increased local drainage flows in the lower river basins. Only a minor reduction in outflow is possible through gate/spillway modifications, and therefore there is only a very small benefit to be achieved. The cost of gate modifications is high as well.

Devil's Gate Dam. Devil's Gate dam on Arroyo Seco in Pasadena controls a watershed of approximately 32 mi^2. Reducing inflows to the Los Angeles River from this source would provide some additional protection to downtown Los Angeles. Reducing inflows from Arroyo Seco would mean that the reach of the Los Angeles River near downtown would be able to accommodate more of the local drainage. However, modification to Devil's Gate Dam would not reduce flows on the lower Los Angeles River enough to compensate for the massive local drainage inflows in that reach, and would therefore have only a minor impact in the area of greatest potential flood damages.

Devil's Gate Dam is currently operated under restrictions imposed by the State of California. It is unlikely that the renovations necessary in order to incorporate this facility as a flood control element would be an appropriate option. Removal and reconstruction might be considered, but given the existing need for operational restrictions, it might not be acceptable to reconstruct a facility on this site. The dam also has lost much of its capacity due to sediment buildup. Devil's Gate Dam is controlled by Los Angeles County, which has studied plans for both rehabilitation and replacement, and they have concluded that maintenance of the existing facility is the appropriate action at the present time. Therefore, modification/replacement of this facility was eliminated from further consideration.

Strategy One (B) Summary: Modify Existing Facilities

The impact of increasing upstream flood control storage does not result in significantly reduced flood flows downstream, due to inflow from uncontrolled, local drainage. As a result, no modification of existing reservoirs was found to make a significant contribution to a complete, cost-effective, acceptable plan for solving the flooding problem in the LACDA system.

Strategy Two: Convey More Water in the Mainstem System

A. Create New Conveyance Facilities

Pipelines

There are a number of ways of diverting flows from the LACDA system to reduce peak flows in the channels where capacity is too low to provide adequate protection. Transfer of water from one watershed to another via pumping stations/pipelines was initially given brief consideration, a possible alignment being from the LACDA basin to the Antelope Valley. This alternative, along with a diversion to Ballona Creek, was eliminated from consideration as a result of very high costs involved in moving the significant volumes of water needed to affect peak flooding. In addition, system maintenance costs would be extremely high because pumping facilities deteriorate when not in use.

Diversions of Rio Hondo releases to San Gabriel River

Transfer of flows at Whittier Narrows Dam from the Rio Hondo to the San Gabriel River was studied in somewhat greater detail. At present, the Rio Hondo is designed to receive all primary flood control releases from Whittier Narrows Dam. The original design of the Rio Hondo allowed for Whittier Narrows Dam flood control releases of 40,000 cfs. Due to increases in local inflow to the channel, the current maximum release rate into Rio Hondo is 36,500 cfs. The San Gabriel River below Whittier Narrows is essentially a spillway flow channel for Whittier Narrows Dam. Scheduled releases of 5,000 cfs are routinely made from Whittier Narrows Dam when the water surface elevation is between 200 ft and 228.5 ft NGVD (National Geodetic Vertical Datum). The gate invert on the Rio Hondo side is at elevation 184 ft and a pool 16 feet deep must be impounded before the San Gabriel outlet sill of 200 ft is reached. Above elevation 228.5 ft, the automatic spillway gates on the San Gabriel River outlet go into effect, and release rates escalate rapidly.

Initially, it appears that greater routine releases could be made to the San Gabriel River because the scheduled release of 5,000 cfs is lower than the receiving channel capacity of 13,500 cfs. This margin of 8,500 cfs is diminished in downstream locations by increasing local inflow. Above the confluence with Coyote Creek, the 100-year computed flow on the San Gabriel River is 17,200 cfs and the channel capacity is 20,000 cfs, leaving a margin of only 2,800 cfs. In order to convey substantially greater flood control releases, a significantly lower level of protection would be provided by the river channel, or it would require a structural upgrade to increase its capacity.

Expanding primary flood control releases to both the Rio Hondo and the San Gabriel River could shift flooding from one area to another, which would require extensive improvements to the San Gabriel system. It was not considered appropriate to solve a flooding problem by transferring the problem, and the associated damages, to another system. Therefore, in order to redirect some of the Rio Hondo flows, the San Gabriel River would most likely be converted from a soft-bottomed channel to a concrete invert channel and the channel capacity would have to be otherwise increased.

Immediately downstream from Whittier Narrows Dam the San Gabriel River is soft-bottomed channel for 7 miles. The remaining concrete channel is trapezoidal and extends 13.2 miles to the ocean. Converting the upstream reach to concrete channel would increase capacity from 13,500 ft^3/s to approximately 31,000 ft^3/s. This increase in capacity would have to be implemented through the remaining channel. Using parapet walls was determined to be the most cost-effective method of accomplishing this; this would require raising 22 bridges from 1.2 feet to 6.9 feet.

Increased San Gabriel River capacity would allow operation of Whittier Narrows Dam to be modified; the optimal theoretical use of the additional capacity in the San Gabriel River would mean filling the reservoir to 99% capacity during the 100-year event and limiting releases to the Rio Hondo channel to as little as 15,000 ft^3/s. This would eliminate the need to modify the Rio Hondo channel. There would still be significant flooding on the lower Los Angeles River, and protection would remain below the 100-year level. Furthermore, balancing releases to the two channels would require excellent field information and precise operational control, both of which are difficult to achieve during emergency operations.

The cost of improving the San Gabriel River would not be equally offset by reductions in costs on the Rio Hondo and Los Angeles River. In addition, the soft-bottomed reach of the San Gabriel River is a major environmental and groundwater recharge resource. Compensation for loss of groundwater recharge potential may require a 200+ acre parcel of land or provision of other, less expensive water supplies. Loss of any environmental resources would also require mitigation.

Finally, simultaneous work on the San Gabriel and lower Los Angeles Rivers would mean traffic impacts on two sets of bridges and general neighboorhood disruption in two areas rather than one. Given that the Rio Hondo-lower Los Angeles River channels are generally in a more disturbed urban (commercial and industrial) environment, the social impacts of construction in these areas would be lower than for the more residential San Gabriel River area.

There would thus be no cost advantage to diverting releases to the San Gabriel River, and the channel modification impacts would be greater than those experienced on the Rio Hondo-lower Los Angeles River. For these reasons, diversion of flows to the San Gabriel River, with attendant channel alterations of any sort, were considered to be unjustifiable.

Tunnels

A tunnel could be constructed along three possible alignments to divert water from either reservoirs or the mainstem channel system (Figure 6). A tunnel from Sepulveda Dam could divert water through the hills separating the San Fernando Valley and the Los Angeles basin and from there into the Pacific Ocean. Alternately, flow could be diverted from Arroyo Seco across the basin to the ocean. These alignments could reduce inflows to the mainstem Los Angeles River by up to 20,000 ft^3/s. A third alignment would involve diversion of flows from the Rio Hondo to Long Beach, virtually paralleling the river alignment.

An initial benefits analysis indicated that there would be only marginal benefits (annual benefits of only $1,620,000 for a 20,000 ft^3/s tunnel) from a diversion of water from Sepulveda Dam, and this option was dropped from consideration as costs would clearly exceed benefits. Potential benefits resulting from a tunnel of this capacity from the Arroyo Seco or the Rio Hondo were much more significant and a preliminary cost estimate was made to determine if tunnels were worthy of detailed consideration. The screening analysis was conducted for tunnels of 5,000, 10,000, and 20,000 ft^3/s capacity. For purposes of simplifying the analysis, the tunnel with the shortest route (which would have the least cost) from the Rio Hondo was evaluated (Table 7).

A large tunnel from either diversion site would have a significant impact on flooding. However, construction costs would be extremely high. Costs for the estimates shown on Table 7 were developed using current construction cost data from the Los Angeles Metrorail project and thus represent costs associated with tunneling under existing development in the Los Angeles basin.

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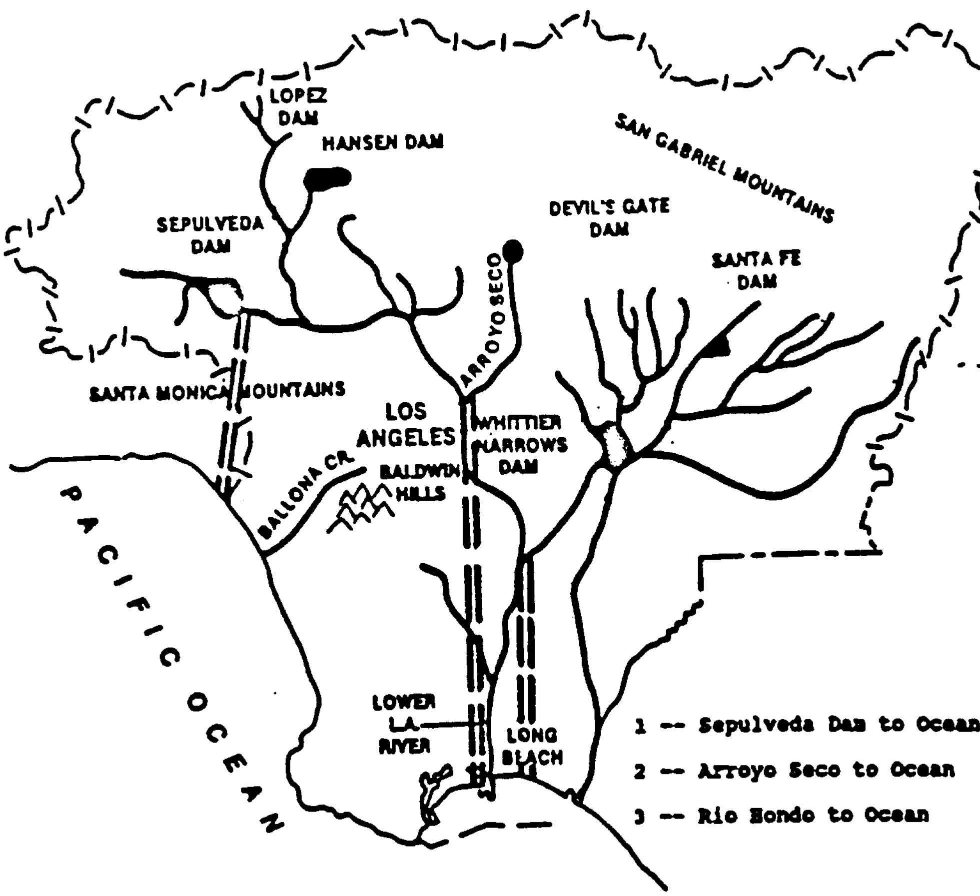

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FIGURE 7 TUNNEL ALIGNMENTS

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Table 7.

Tunneling alternatives, benefits and costs (1988 $1,000)

Alignment and Capacity	Average Annual Benefits and Costs: Benefits	Costs	Net Benefit	B/C Ratio
Rio Hondo[a]				
5,000 ft^3/s	$13,480	$34,015	<$20,535>	0.40
10,000 ft^3/s	$19,730	$41,689	<$21,959>	0.47
20,000 ft^3/s	$25,980	$65,458	<$39,478>	0.40

a. Tunnel diversions from two other locations were also considered: a tunnel from Sepulveda Dam to the ocean and from Arroyo Seco to the ocean. These tunnels would have been longer and more costly than a tunnel from the Rio Hondo; they would also likely have either comparable or lower benefits. The Rio Hondo tunnel alternative was thus considerd to have the greatest potential for net NED benefits. Given that this preliminary analysis indicated a very low benefit-to-cost ratio for this alternative, the other tunnel alignments were also eliminated from further consideration.

Based on this preliminary design/cost analysis, it was apparent that even the shortest, least-costly tunnel alternative could not be justified when considering first costs alone. Operation and maintenance costs would further reduce the benefit-to-cost ratio for such a project. The heavily developed nature of the flood plain which raises construction costs due to the difficulties of tunneling in a developed area, thus makes tunneling an impractical alternative. Finally, it was also clear that a tunnel would not fully address the need for flood control in the lower Los Angeles River; additional structural works would also be required. Tunnels were therefore not carried forward for more detailed analysis.

New Channels and Aqueducts

New channels and aqueducts were considered, but a review of the LACDA system indicated that there are few alignments which would not pass through heavily developed areas. The most effective alignment for additional conveyance capacity is on the lower Los Angeles River, where the most efficient river course is the existing alignment. The costs of rights-of-way for new channels along other alignments when combined with the construction costs for new channels make this alternative too costly. In addition, new channels would severely disrupt existing neighborhoods. New channels were therefore eliminated from consideration.

There were similar constraints on potential aqueduct alignments within the LACDA system. One alignment considered would divert water from Lopez Reservoir to an aqueduct along a utility right-of-way and empty into Hansen Dam. This would reduce releases from Lopez Dam down Pacoima Wash. The additional flow into Hansen would not critically affect its storage capacity, but further analysis revealed that diverting releases from Lopez would not significantly reduce flooding on Tujunga Wash.

Aqueducts which are constructed over uneven ground require grade adjustment and significant new rights-of-way. Construction costs are quite high for this type of structure. After a cursory review of possible aqueducts, they were rejected as infeasible.

<u>Strategy Two (A) Summary: Create New Conveyance Facilities</u>

Diversions, including greater use of the San Gabriel River for primary flood releases from Whittier Narrows Dam, were not considered viable alternatives. New channels are prohibitively expensive. No alternatives were carried forward from this strategy.

Strategy Two: Convey More Water in the Mainstem System

B. Increase Existing Channel Efficiency

Alter Existing Channels

Channels may be altered in a number of ways to meet various project objectives. In the initial stages of planning, alteration of the channels solely for water conservation and environmental enhancement purposes was considered briefly. Alternatives included removing concrete channel inverts and perforating the inverts to permit groundwater recharge through the channel bottom. This type of alternative would have net adverse impacts to flood protection, however, because it would reduce the rate of flow in the already inadequate channel. Small sections might be feasible, but costs would be high with only minimum water conservation benefits; such approaches would need to be a part of a flood control alternative and not a stand-alone alternative.

There are a number of specific ways to increase the net capacity of the channel: raising channel walls, widening the channel, converting the channel from trapezoidal to rectangular, deepening the channel, changing the channel slope, and removing obstructions from the channel area. All of these techniques share the basic purpose of increasing flow in the channel by changing cross-section and/or slope. This group of alternatives was carefully explored during initial screening to determine which approaches would be best to pursue in detailed studies.

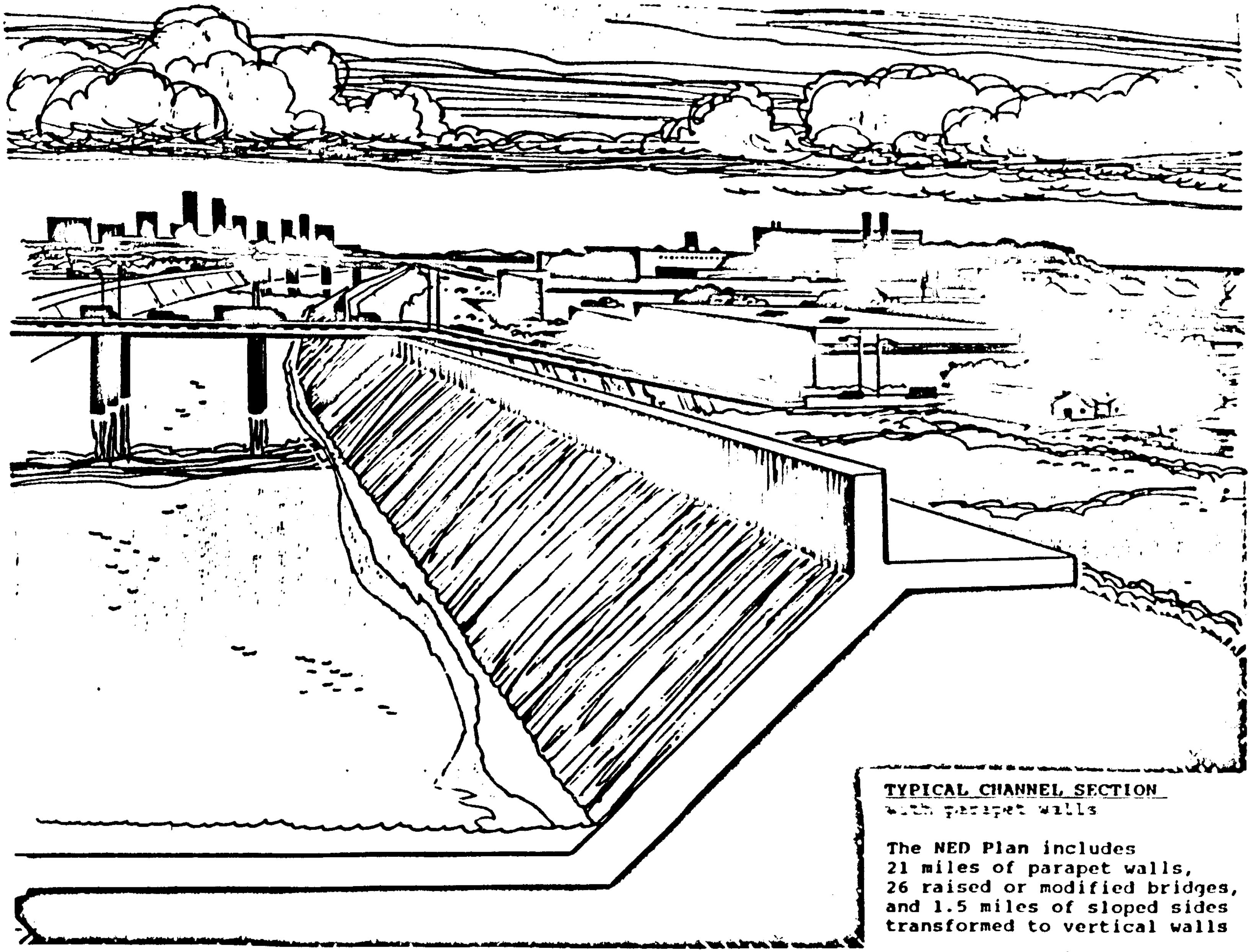
Raise Channel Walls. There are several ways to raise channel walls. First, the entire levee embankment can be raised. To accomplish this, the paved crest of the levee is removed and additional fill is placed on the crest and the levee back slope to raise the embankment to the desired height and widen the levee for stability. The crest pavement is then replaced. In many locations, raising the levee requires bridges to be raised because the low point of the bridge structure is the top of the existing levee. The disadvantages of raising levee walls are cost, encroachment onto limited rights-of-way, and the need to extend bridge span lengths and change abutment and pier structures because the levee crest is shifted away from the center of the channel.

A second approach is to construct parapet walls along the inner (channel side) edge of the existing levee crest. To accomplish this, the paving at the edge of the channel is removed, and a reinforced concrete foundation and wall is poured (Figure 7). This option also requires many bridges to be raised but, for the most part, does not require as many alterations in bridge abutment and pier alignments. Therefore, parapet walls are a less costly approach to raising channel walls.

Raising channel walls was evaluated for Reaches 1-5 (Los Angeles River-Rio Hondo system). In initial planning two levels of protection were evaluated to give a preliminary indication of the feasibility of this alternative: 100-year and 200-year protection. In all reaches where the river is an entrenched channel and overflows are confined to relatively narrow corridors adjacent to the existing channel right-of-way (Reaches 1-3), raising channel walls was found to have costs far exceeding benefits. For these reaches, the best preliminary benefit-to-cost ratio estimated was 0.6 for 200-year protection for Reach 1, Tujunga Wash from Hansen Dam to the Los Angeles River. For other reaches, benefit-to-cost ratios ranged from 0.1 to 0.5.

In the lower reaches of the river where levee armoring for protection of the exposed back side of the levee was an added design element, the initial economic analysis indicated that raising channel walls would have significant net NED benefits. Preliminary benefit-to-cost ratios for Reaches 4, 5, and 9 ranged from 3.1 for 100-year protection up to 4.1 for 200-year protection. For these lower project reaches, then, raising channel walls appeared to be a promising alternative; this alternative was carried forward for further consideration.

Widen Channel. Another possible approach to modifying the channel cross-section is to widen the channel while retaining the trapezoidal cross section of the channel. Channels may be widened in a number of ways. The most direct method is to remove existing walls, excavate, and reconstruct the channel. Another method is to construct a high flow system of side channels which run parallel to the mainstem channel and take flow only



TYPICAL CHANNEL SECTION
with parapet walls

The NED Plan includes
21 miles of parapet walls,
26 raised or modified bridges,
and 1.5 miles of sloped sides
transformed to vertical walls

FIGURE 8

when the capacity of the main channel is exceeded. A significant constraint on channel widening is the potential impact to existing bridges that would need to be reconstructed.

Side channels have the advantage of not requiring removal of the existing channel wall system, but the disadvantage of requiring additional rights-of-way and necessitating extensive bridge modifications. Because rights-of-way in most reaches of the Los Angeles River are severely constrained and their acquisition along with bridge modification would have very high costs, side channels were eliminated from further consideration.

A preliminary analysis of channel widening which would produce either 100-year or 200-year protection indicated that costs greatly exceed benefits in the upper reaches where the channel is entrenched and overflows are contained in a relatively small area. For example, widening of the reach from Sepulveda Dam to Arroyo Seco to provide 100-year protection would have annual flood damage reduction benefits of only $220,000 with annualized costs of over $15,312,000 for a benefit-to-cost ratio of less than 0.02. The net NED benefits of widening, again with the design feature of armoring the levee back slopes, exceed costs only in the lower reaches of the Los Angeles system, where the preliminary benefit-to-cost ratio was between 1.7 and 2.3. Channel widening was thus considered a potentially viable alternative in the lower reaches of the LACDA system.

Convert Trapezoidal Channel to Rectangular Channel. Modifying the channel cross-section can provide an additional conveyance capacity. Compared to a trapezoidal channel, a rectangular channel provides a larger area (channel cross section) for a given channel top width (and therefore right of way). Conversion would involve removal of channel walls, excavation, and reconstruction of the channel invert and walls with reinforced concrete. This is not an option on Tujunga Wash, where the channel is already rectangular, but it was evaluated for Reaches 2-5 on the Los Angeles River at 100-year and 200-year levels of protection. In some areas, these levels of protection could be achieved with a channel of composite geometry involving a partly rectangular and partly trapezoidal cross-section.

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Conversion of trapezoidal channel to rectangular channel may, in some areas, permit channel capacity to be increased without affecting the bridges which span the river. This can be accomplished only if the conversion does not interfere with existing bridge piers and the abutment is set back from the edge of the channel. Some bridge abutments may be impacted by this alternative requiring reconstruction of the abutment.

An initial design and economic analysis indicated that the cost of constructing a rectangular channel would greatly exceed benefits except in the lower reaches of the Los Angeles River and along the Rio Hondo, where the project would include armoring of levee back slopes. In Reaches 4, 5, and 9 this conversion would be marginally justified with preliminary benefit-to-cost ratios of from 1.0 to 1.1. These benefit-to-cost ratios were substantially lower than those for lower-cost alternatives such as raising channel walls. This alternative would involve disposal of large amounts of concrete and excavated material taken from the old channel. Handling this material would be costly, and, given the limited availability of landfill sites in the Los Angeles basin, disposal might add significant cost if permits could not be obtained to use the nearest landfill sites. Nevertheless, the marginal justification of this approach in the lower reaches of the LACDA system resulted in a decision to carry channel conversion with armoring forward for further study.

Deepen Channels. In areas with adequate slope, it is often possible to deepen channels to increase the cross-section of the channel and therefore the channel capacity. Deepening, however, often has very high costs for several reasons. First, the existing channel slope must not vary too much or in such a way as to make this alternative impractical. Second, many existing utility lines run immediately beneath the channel invert and deepening thus requires extensive utility replacement. Third, deepening may require reconstruction of bridge piers and foundation works. Fourth, excavation and disposal of significant quantities of material is costly. For these reasons, deepening in most reaches of the LACDA system was not feasible. Deepening remained a consideration in Reach 4, the lower Los Angeles River.

In Reach 4, deepening of the downstream portion of the channel (Station 153+00 to the Pacific Ocean) would not involve the high cost of removing concrete invert as the channel is soft bottomed in this reach and protected by rip-rap. In addition, only seven bridges cross the channel in this reach. Thus construction costs were estimated to be in the $25,000,000 range for deepening this reach. Deepening this section would have uncertain impact on peak flows because the lower reaches of the channel have very little slope and seawater would move into the excavated channel area. Although the interaction of seawater with flood flows is not well understood hydraulically, additional net channel capacity would be expected from channel deepening. This alternative thus remained a viable option for further study, primarily in combination with other solution techniques.

Increase Channel Slope. Increasing flow velocity in the channel by increasing the channel slope has the effect of increasing total channel capacity. To effectively accomplish this, it must be possible to increase flow velocity throughout the entire reach from the initial point of channel slope modification to the ocean. If this cannot be done, it will be necessary to increase velocity through a developed reach where overflows would cause damages, and then make a compensating decrease in flow velocity in areas with greater channel capacity or increase the channel capacity to accommodate the higher water surface elevation. The uniform channel slope in the lower river (where most damages occur), makes this alternative infeasible. Increasing slope in an upper reach would merely increase problems in a lower reach. As a result, changing the slope of the channel was not given detailed consideration.

Armor Back Side of Levees. Under existing conditions, when flood waters in the leveed channel sections exceed the available channel capacity, water flows over the top of the levee and quickly erodes the unprotected, earthen levee back side. Levee failure leaves only the entrenched capacity of the channel to carry runoff to the ocean. The entrenched channel capacity is as much as 100,000 cfs less than the leveed channel capacity, causing the excess flow to pour into the flood plain. Armoring the back side of the existing levees was analyzed as an alternative that would protect against this catastrophic scenario.

Overflow areas were determined under the assumption that no levee failures occurred during events greater than channel capacity. Because armoring alone does not

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increase the level of protection offered by leveed channel sections, reaches with inadequate channel capacity still experienced levee overtopping for significant periods of time during the 100-year event. The overtopping problem is exacerbated by the fact that many bridges go to pressure flow which severely curtails their hydraulic capacity and creats an elevated backwater that pushes high volumes of flood waters out onto the flood plain. As a result, the areal extent of flood plain inundation due to overtopping was similar to the overflow area occurring with levee failure, although inundation depths were reduced.

The benefit resulting from a reduced flood depth was analysed as a stand alone alternative. The preliminary cost of armoring just the lower Los Angeles River was $24 million and resulted in a significant net benefit. Unfortunately, the Rio Hondo's level of protection is unimproved and the 25-year event still generates damages throughout the basin.

Armoring the Rio Hondo below Whittier Narrows Dam and the lower Los Angeles River would cost approximately $40 million and result in a benefit-cost ratio of greater than 6-to-1, although the net benefits are only moderate when compared to other alternatives. The greatest drawback to this approach, aside from it's failure to improve the existing flood frequency protection, is the fact that damages are significantly worse in the 50-year event. This results from the conveyance of all the flows that would have broken out of the Rio Hondo into the lower Los Angeles River. There the flows overtop the levees in numerous places, rather than only one location under the lower Los Angeles River armoring alternative. The flood plain damage locations shift downstream and are more severe than the lower Los Angeles River levee armoring alternative where breakouts and flooding are more evenly distributed on the system and less catastrophic in nature.

Levee armoring as a stand alone solution was not pursued as a comprehensive alternative because a) it shifted damages within the flood plain, b) it did not increase protection levels, c) it did not provide the greatest net benefits among the array of alternatives, and d) there were significant residual damages remaining in the basin.

Instead, levee armoring was analysed as a design element in all channel modification alternative

Reduce Channel Roughness. Some sections of the mainstem system have soft-bottom or cobblestone inverts and/or grouted stone channel walls. Use of these construction materials results in a high channel roughness coefficient and in turn reduces the channel's conveyance capacity. Providing a smoother overlay in these locations was investigated.

Constructing a concrete channel to replace the soft-bottom section of the San Gabriel River below Whittier Narrows Dam was disscussed previously, under Pipelines/Diversions. In the cobblestone Glendale section of the Los Angeles River, the existing vegetation is expected to either lay down as a smooth mat or be removed through scour during high flows. In either case, the channel capacity is not significantly reduced. Utilizing a concrete channel would be difficult due to the local high groundwater and the resulting environmental impacts. Trapezoidal, grouted stone channel reaches along the Rio Hondo and lower Los Angeles River could receive a concrete overlay to reduce the channel roughness. While this did not provide large increases in channel capacity, it was considered an effective element when used in combination with other channel modification techniques.

Modify Bridges

Bridges have an adverse impact on channel flows due to the backwater effect of piers and are a significant flood control problem when their abutments and/or piers constrict flow in the channel, when the lower deck of the bridge encroaches on the channel, or when piers catch debris and create a channel blockage. As a result, flood breakouts frequently occur in areas just upstream from bridge constriction points.

Eliminating all obstructions by completely reconstructing bridges so that there is a clear, high span with no piers extending from the channel is the best way to remove flow

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restrictions caused by bridges. This extremely costly alternative was not able to achieve an adequate level of protection in the mainstem channels. Upgrading of all bridges to clear span design as an overall flood control solution was eliminated from further consideration.

Less costly bridge modifications, such as raising spans and modifying bridge piers, were determined to be effective primarily in combination with other structural alternatives and were therefore carried forward as elements of other alternatives rather than as stand-alone approaches to flood damage reduction.

Strategy Two (B) Summary: Increase Existing Channel Efficiency

The cost and limited benefits of structural alterations to channels in the upper Los Angeles River system eliminated alternatives for these reaches. The existing adequate level of protection for the San Gabriel River and the very high cost and impacts associated with raising that level of protection eliminated structural alterations to the channel on this river system. Channel modifications, in particular raising channel walls and modifying the channel cross-section by either widening the channel or converting it to rectangular cross-section were found to have potentially large net benefits, either alone or in combination. Damage reduction measures that are limited in scope, but viable when combined with more comprehensive solutions include, deepening the Los Angeles River near its mouth, modifying bridges to improve conveyance, armoring levees to avoid catastrophic failure and providing grouted stone channel reaches with a concrete overlay.

Strategy Three: Damage Management

Non-structural or less centralized construction approaches are not generally effective in heavily developed urban areas with a large flood damage potential. They were given an evaluation, however, to determine if they could be useful components in an overall plan. The conclusions of this evaluation are listed below.

Relocation

Relocating structures threatened by flooding was considered in Reaches 1, 2, and 3 where the area flooded would be limited and relocations would be minimal. No relocation plan, however, had a benefit-to-cost ratio of greater than 0.04 (Tujunga Wash). This is due to the high cost of relocation, the value of the property in these areas, and the limited damages incurred. In downstream areas, relocation would be even less cost effective due to the very large area flooded.

Floodproofing

Floodproofing measures, such as raising structures above the flood plain, ring levees, and floodwalls, are too costly when applied to thousands of structures ranging from residences to major industrial plants to refineries. In addition, floodproofing is ineffective in areas such as the lower Los Angeles River basin where flood depths could exceed 10 feet and where flood flows from a failed levee would be extremely destructive in the vicinity of the levee break.

Floodfighting

To be effective, floodfighting efforts must be directed at preventing damage. Damage prevention requires adequate flood warning to permit evacuation and action to prevent major failure of the system. Given the short period of time - on the order of six hours - needed to reach peak flow and the many potential breakout points along the lower reaches of the LACDA system, it is not likely that breakout could be forecast precisely or that mobilization could occur rapidly enough to prevent overtopping of the levee system. In addition, flow over the levees in some locations could be several feet deep over a relatively long reach; a massive emergency response would be needed to respond to this magnitude of problem. Finally, there would be no assurance that floodfighting efforts would succeed.

Flood Plain Management/Insurance

There is significant damage potential within the existing flood plain. Continued efforts to avoid placing additional people and structures at risk will only marginally affect the current threat. The lower basin communities in the 100-year overflow area (except Downey and Bell Gardens) participate in a flood plain management program as part of the National Flood Insurance Program. While insurance coverage and risk assessment are appropriate endeavors in the flood plain, the magnitude of the flooding problem in the lower basin makes it imprudent to accept the potential flood threat. Prevention of damages is needed to ensure that major industrial areas are not severely damaged; the overall impact of flooding in the lower basin is too great for the entire region. Compensation for flood damages would also probably exceed several billion dollars following a major flood. This level of relief for damage which could be prevented at a much lower cost is unjustified.

Conclusions of Preliminary Screening

The primary conclusion of preliminary screening was that economically justified, effective flood damage reduction is limited to the Rio Hondo below Whittier Narrows Dam and the lower reaches of Los Angeles River. Measures in the upper basin either have an insignificant impact on the flooding problem downstream (caused by local runoff) or do not have adequate benefits within the upstream reaches to justify implementation. This is due to the nature of the problem on the LACDA system: rapid and massive local runoff swells the river at the point where it becomes a leveed system which can fail when overtopped. Also, it is not possible to constrain most structural approaches to a limited segment of the river channel where protection levels are low. Widening, deepening, and converting the channel from trapezoidal to rectangular all require increased conveyance capacity through the remaining downstream reaches. This raises the costs of an upstream alternative significantly. Because levee failure would inundate large areas to depths that could exceed 10 feet, damages are severe in the lower basin, and therefore justify structural measures.

Problems are not as serious on other reaches such as the Los Angeles River above the downtown area, where levels of protection range from 70-year to over 100-year. In these areas, damages would occur less frequently and would result in relatively minor residual damages such that extensive structural work is not justified. Nor is it justified to transfer damages from the Rio Hondo-Los Angeles River system to the San Gabriel River system, both from a policy view and from an economic view.

Innovative measures such as diversion tunnels, off-channel storage, and pumping to another watershed (Antelope Valley) or channel (Ballona Creek) would have the desired effect of reducing flows in the critical reaches of the channel, but costs would be prohibitive and would far outweigh projected flood damage reduction benefits. Other innovative approaches such as non-structural measures and watershed management were found to have negligible benefits at relatively high costs.

The result of initial screening was to focus the detailed alternative analysis on Reaches 4 and 5, and on three methods of modifying the mainstem channel: widening, converting trapezoidal channel to rectangular channel, and raising levee walls with parapet walls. Selective levee back slope armoring was included as a design element of each of these alternatives along with bridge modifications and concrete overlays for grouted stone sections. Deepening the channel bottom on the Los Angeles River near the ocean might also have a role in a comprehensive solution.

G. ALTERNATIVES CONSIDERED FURTHER

On the basis of preliminary screening and economic evaluation, improvements were found to be justified only for Reaches 4 and 5. The improvements given detailed study took the form of three different alternatives. All involved altering the flow characteristics of the lower Los Angeles River, which would in turn affect the water surface elevation along Compton Creek. Reach 9 was thus included in the detailed analysis of alternatives, with improvements in this reach generally limited to those that would be needed to compensate for impacts from the improvements on the mainstem system. All three alternatives carried forward for detailed consideration had two common elements:

1) Selected levee armoring in reaches where flows in excess of channel capacity were likely to break out of the channel.

2) Improvements to Compton Creek to compensate for potential impacts to this reach.

Each alternative was initially formulated at defined levels of protection, rather than optimized on a plan-by-plan basis to permit comparison on an equal basis. Given equal and already-defined levels of protection, it would be possible to evaluate plans almost entirely on the basis of cost. Environmental considerations would have a minimum impact on the cost or benefits from any project because all alternatives were confined to the existing channel rights-of-way or a thin strip of land immediately adjacent to the channel. Most of this land is already highly disturbed.

In addition, all alternatives would involve disruption of traffic and some utility relocations and service interruptions. Problems associated with issues such as disposal of materials excavated from the channel would be reflected in estimated project cost as well. None of the alternatives was thought to have a significant acceptability advantage compared to the other plans.

Given this approach, the least-cost alternative for a given level of protection would generally be the preferred alternative. This alternative could then be optimized to find the level of protection offering the greatest net NED benefits.

The alternatives evaluated (Figure 8A) in this final stage of plan development were:

1) Raising channel walls to provide 100/200-year protection.

2) Widening Reaches 4 and 5 to provide 100/200-year protection.
3) Converting trapezoidal channel to rectangular channel in Reaches 4 and 5 to provide 100/200-year protection.

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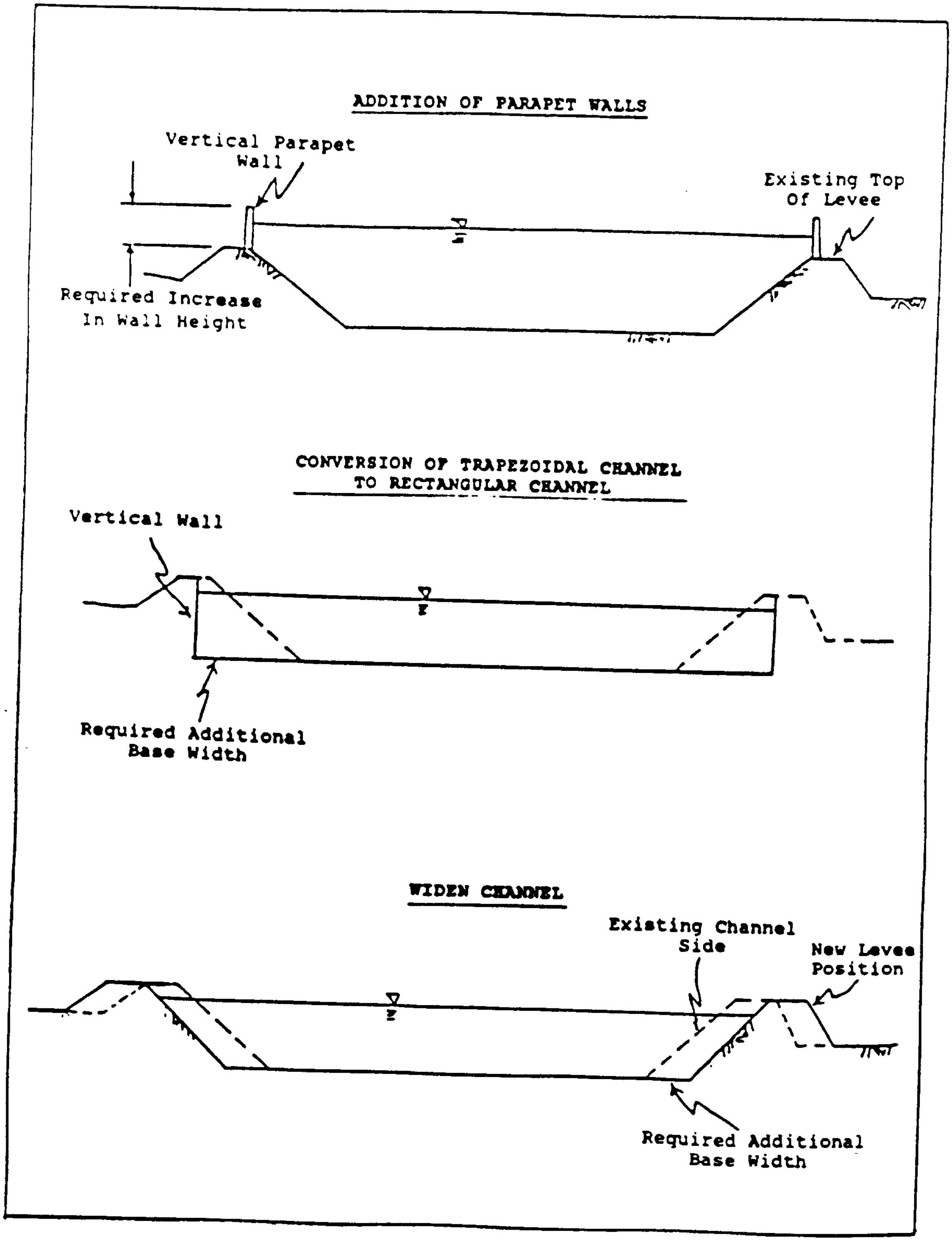

FIGURE 8 A INCREASED CHANNEL CAPACITY ALTERNATIVES EVALUATED

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H. EVALUATION OF ALTERNATIVES CONSIDERED IN DETAIL

ALTERNATIVE ONE: Raising Channel Walls in Reaches 4 and 5 100-year and 200-year Levels of Protection.

Placement of parapet walls along the crest of the existing channels (Figure 7) would effectively create a composite channel cross-section without requiring extensive demolition, excavation, and channel replacement. In most areas, walls would be raised only two to five feet to provide the desired level of protection. Raising the walls, however, means that all bridges currently built from the top of the existing levee or not providing adequate space to raise the channel height would need to be raised or otherwise modified. The considerable bridge-raising effort required for these alternatives is displayed in Tables 8 and 9 for the lower Los Angeles River and Rio Hondo, respectively. The economic question to be addressed, then, is whether cost savings for channel modification outweigh potential higher costs for bridge modifications.

As a part of this alternative, channel back slopes would be armored upstream of bridges and at the same potential breakout points in the Rio Hondo and lower Los Angeles River reach as provided for under other alternatives.

For these alternatives, an initial assumption was made that all bridges could be raised to any required level, including the freeway bridges (Santa Ana, Artesia, and San Diego Freeways). This assumption made it possible to evaluate levels of protection on the basis of cost alone.

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Table 8. Preliminary estimates of affected bridges resulting from increased wall heights

Reach 4, Lower Los Angeles River

NO.	BRIDGE	100-YR ADD'L WALL HT	100-YR RAISE BRIDGE	200-YR ADD'L WALL HT	200-YR RAISE BRIDGE
1	IMPERIAL HWY	0.0	0.0	0.0	0.0
2	SPRR	4.2	5.8	6.0	7.6
3	STANDARD OIL UTIL	1.9	1.0	3.6	2.7
4	ROSECRANS	2.1	2.1	3.9	3.9
5	COMPTON	2.4	2.4	4.7	4.7
6	ALONDRA	2.3	0.3	4.0	2.0
7	ATLANTIC	2.4	2.4	4.6	4.6
8	ARTESIA FWY RAMP 1	4.2	0.0	6.0	0.0
9	ARTESIA FWY RAMP 2	4.0	2.0	5.8	3.8
10	ARTESIA FWY RAMP 3	4.0	0.0	5.8	0.0
11	ARTESIA FWY	3.5	0.0	5.3	0.0
12	ARTESIA FWY RAMP 4	3.4	0.0	5.2	1.4
13	ARTESIA FWY RAMP 5	3.2	1.2	5.0	3.0
14	ARTESIA BLVD	3.8	0.0	6.0	1.5
15	LONG BEACH	4.0	4.0	6.2	6.2
16	DEL AMO	3.3	2.3	5.6	4.6
17	UPRR	0.9	0.9	2.8	2.8
18	LA-LB LIGHT RAIL	2.7	1.7	4.9	3.9
19	SAN DIEGO FWY RAMP	1.8	0.0	3.7	0.0
20	SAN DIEGO FWY	2.1	0.0	4.0	0.7
21	SAN DIEGO FWY RAMP	2.1	0.0	4.0	0.0
22	UNION OIL UTIL	2.7	0.0	5.1	2.1
23	WARDLOW	3.2	0.0	5.5	0.0
24	TEXAS OIL UTIL	2.9	1.9	5.2	4.2
25	WILLOW	2.5	2.5	4.8	4.8
26	RICHFIELD OIL UTIL	2.7	2.7	4.5	4.5
27	PCH	2.8	1.3	5.2	3.7
28	ANAHEIM	3.0	0.0	5.4	1.4
29	7TH STREET	2.9	0.0	5.2	0.0
30	EDISON UTIL	2.9	1.2	5.2	3.5
31	PERR	2.8	2.3	5.1	4.6
32	OCEAN BLVD	1.1	0.0	2.7	0.0
	TOTAL NUMBER OF BRIDGES TO BE RAISED:		17 *		23

* ASSUMES ALONDRA IS NOT RAISED 0.3 FT.

Table 9. Preliminary estimates of affected bridges resulting from increased wall heights

Reach 5, Rio Hondo

		100-YR		200-YR	
NO.	BRIDGE	ADD'L WALL HT	RAISE BRIDGE	ADD'L WALL HT	RAISE BRIDGE
1	BEVERLY	1.9	0.0	1.9	0.0
2	WHITTIER	0.0	0.0	0.0	0.0
3	U.P.R.R.	1.1	8.1	1.1	8.1
4	WASHINGTON	0.0	0.0	0.0	0.0
5	A.T. & S.F. RY	0.0	0.0	0.0	0.0
6	SLAUSON	1.5	1.5	1.7	1.7
7	P.E. RY	0.6	0.6	0.8	0.8
8	TELEGRAPH	1.4	0.0	1.6	0.0
9	SANTA ANA FWY	2.1	0.0	2.3	0.0
10	SUVA	1.4	1.4	1.5	1.5
11	FLORENCE	1.2	0.2	1.3	0.3
12	S.P.R.R.	2.5	2.5	2.8	2.8
13	FIRESTONE	3.2	3.2	3.5	3.5
14	STEWART & GRAY	3.7	0.3	4.0	0.6
15	GARFIELD	0.7	0.0	1.0	0.0
16	U.P.R.R.	1.6	4.0	2.0	4.4
TOTAL NUMBER OF BRIDGES TO BE RAISED:			7 *		8 *

* ASSUMES THE FOLLOWING:
- FLORENCE IS NOT RAISED 0.2 OR 0.3 FT
- STEWART & GRAY IS NOT RAISED 0.3 FT

A total of 23.6 miles of channel would be included in this alternative; not all reaches would require increased wall height, and walls would taper to the existing levee surface in some reaches. The initial estimates of wall height to provide 100-year and 200-year levels of protection indicated that 200-year protection on the Rio Hondo would require walls less than 0.5 foot higher than for the 100-year level of protection. This is because releases from Whittier Narrows Dam are at the maximum during the 100-year event and do not increase for the 200-year event. On the lower Los Angeles River, the higher level of protection would require parapet walls from 2 to 4 feet higher than for the 100-year level of protection. Average wall heights for the reach would be from 2 to 5 feet, with the maximum height being approximately 8 feet. Parapet walls would have to be extended 900 feet up Compton Creek from its confluence with the Los Angeles River to accommodate the increased water surface elevation in the Los Angeles River.

The parapet walls would be one-foot-thick reinforced concrete. They would be placed at the inner margin of the existing access road/bicycle trail and joined to the edge of the existing channel side slope to form a continuous channel wall. The footing of the parapet wall would extend across the top of the levee and would be keyed into the top of the levee to resist sliding forces. The top surface of this footing would also serve as bike trail and maintenance access road.

Environmental Considerations

The actual parapet wall construction would have fewer construction impacts to the local area compared to the other alternatives, and there would be no significant disposal of materials from demolition and/or excavation. Traffic impacts would be approximately equal to or slightly greater than those of other alternatives. The parapet walls would not alter the existing soft-bottomed reaches of the lower river, and therefore would have minimal adverse impact in these areas. There would be a temporary increase in noise and dust during construction.

It is probable that there would be some recreation and aesthetic impacts. The walls would raise levee heights by up to 8 feet; for those residing along the river channel, this

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would further block views. In some areas, the walls would add to an existing 15-foot high obstruction. Where local residents have constructed fences or planted shrubs and trees to obscure the view of the channel, the parapet wall would constitute a new intrusion. Aesthetic treatments to mitigate for this impact are limited. Additional plantings on the levee are hard to implement because they leave the levee susceptible to root damage and make detection of levee seepage difficult. Aesthetic treatment of the wall itself would be limited to texturing and painting. It is likely that in many places the wall would become a target for graffiti. The walls could also lower the aesthetics of the channel for recreation purposes. In areas where the walls are high, there would be no view across the channel. Aesthetic impacts would be greatest for the 200-year level of protection. These aesthetic impacts are unavoidable consequences of this approach to increasing channel capacity. Aesthetic treatment plans would have to be developed in coordination with local communities.

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Net Benefits

Based on preliminary designs, raising walls (plus armoring at selected sites) was found to be justified for the lower basin reaches, with benefit-to-cost ratios of from 3.1 (200-year) to 4.1 (100-year). On Reach 4 alone the benefit-to-cost ratios are 2.7 (200-year) to 4.0 (100-year). The greatest preliminary net annual benefits were for the sum of reaches 4, 5, and 9 with 100-year protection levels ($39,132,000). Estimated annual net benefits for this alternative were:

Reach 4:	100-year = $24,810,000;
	200-year = $23,250,000
Reaches 4, 5, and 9:	100-year = $39,132,000;
	200-year = $37,532,000

ALTERNATIVE TWO: Widening the Channel in Reaches 4 and 5
100-year and 200-year Levels of Protection.

This alternative is evaluated at two levels of protection, but there are relatively minor differences, so they may be described and evaluated together. The general technique involves removal of the existing leveed channel, setback of the existing levee, and reconstruction of the concrete trapezoidal channel. This also requires lengthening or raising numerous bridges and modification and realignment of bridge abutments and approach grades.

On the Rio Hondo, the 100-year channel design required up to an additional 56 feet in width; the 200-year, an additional 60 feet. The lower Los Angeles River 100-year channel design necessitates an additional 177 feet in the vicinity of the Century Freeway, the location needing the most widening. For the 200-year channel, an additional 237 feet in width is needed, and a longer stretch of channel is impacted. The wider 200-year-capacity channel also requires wider bridge spans and abutment modifications resulting in an increase in costs.

Two widening options were initially considered: widening along both sides of the channel and widening on one side only. Widening on one side was selected for detailed analysis because of the obvious cost advantages involved in having to remove only one channel wall. First, demolition costs would be reduced by one half. Second, the cost of channel wall replacement would be reduced by approximately 40 percent in most reaches due to a reduction in both quantities of materials and on-site preparation. In addition, the levee road on one side of the channel would remain intact and would thus not require replacement. Widening could affect bridge span length and approach slope and reconstruction of abutments would be necessary in some locations. Finally, many utility lines run parallel to the channel alignment and one-sided widening would reduce the number of utility line relocations, resulting in significant cost savings.

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As a part of this alternative, channel back slopes would be armored upstream of bridges and at other potential breakout points in the Rio Hondo and lower Los Angeles River reach. Also, reaches that currently have grouted stone sidewalls would be overlaid with concrete to improve the hydraulic efficiency.

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Environmental Considerations

There would be no significant long-term environmental, socio-economic, or cultural resource impacts as a result of the channel widening above station 157+83 (Willow Street). All channel reaches involved are currently concrete or lined with grouted stone except for the lower reaches of the Los Angeles River. In the lower river area, the channel would be widened, but the soft-bottomed, rip-rap channel would not otherwise be altered. There would be a temporary impact to the environment in this reach. There would be some short-term loss of soft-bottomed habitat in the lower channel during construction, but the biological communities of this reach could be expected to be restored in a relatively short time following construction. This alternative would not affect significant cultural resources, nor would there be long-term socio-economic impacts of an adverse nature. There would be temporary increases in noise and dust, and significant traffic delays, during construction. Recreational use of the bike trail would be disrupted for short periods.

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Net Benefits

Based on preliminary designs, channel widening was found to be justified on Reach 4 alone and on Reaches 4, 5 and 9 in combination. The benefit-to-cost ratio on Reach 4 ranges from 2.2 (100-year) to 1.7 (200-year). The more comprehensive solution has benefit-to-cost ratios of 2.3 (100-year) and 2.0 (200-year).

Estimated annual net benefits for this alternative were:

Reach 4:	100-year = $18,299,000;
	200-year = $15,442,000
Reaches 4, 5 & 9:	100-year = $29,319,000;
	200-year = $28,010,000

ALTERNATIVE THREE: Conversion of Trapezoidal Channel to Rectangular Channel for Reaches 4 and 5 100-year and 200-year Levels of Protection.

The conversion alternative involves removal of the existing channel wall lining, excavation, and reconstruction of trapezoidal channel as concrete rectangular channel. This design has a greater cross-sectional area for a given top width than the trapezoidal channel. The design of the channel is similar for both levels of protection evaluated.

In some reaches, it was not necessary to convert the channel to a full rectangular cross-section to achieve the desired flood control; this was particularly true for the 100-year protection option. In these cases, a composite channel geometry was developed. A composite channel involves removal of the lower portion of the trapezoidal side slope and replacement of that section with a vertical wall section. The upper portion of the channel wall would remain trapezoidal, angling out from the top of the vertical section. Proposed channel characteristics for the 100-year and 200-year protection levels vary widely. On the Rio Hondo, the invert width of the trapezoidal channel is increased from the existing 100 feet to as much as 200 feet (fully rectangular cross-section) for both levels of protection. The lower Los Angeles River requires a rectangular cross-section as much as 200 feet wider for the 200-year design than the existing top width of the channel. The need for widening is greater on Reach 4, and in the 200-year as opposed to the 100-year design, but channel widening is necessary in numerous sections for both levels of protection.

As a result, this plan is essentially a channel widening alternative using a slightly different technique in construction. The additional channel widths needed in this alternative are not so great as those needed with the channel widening alternative, but significantly more earth would need to be excavated and removed. Also, in areas where a composite geometry is possible, breaking the concrete channel to construct the rectangular section would generally damage the remaining channel lining, and it would need to be completely replaced. Impacts to bridges are site specific, but an overall widening will necessitate bridge modifications and utility relocations.

As a part of this alternative, channel back slopes would be armored upstream of bridges and at other potential breakout points in the Rio Hondo and lower Los Angeles River reach.

Environmental Considerations

The conversion plans and channel widening plans have roughly equivalent impacts, except that there would be slightly less right-of-way required and thus a reduced need to impact additional lands along the channel alignment. Although there would be construction period noise, dust, air quality, and traffic impacts, there would be no long-term impacts from construction activities.

Net Benefits

Based on preliminary designs, conversion was found to be marginally justified with benefit-to-cost ratios ranging from 1.0 to 1.1. A detailed analysis of bridge and additional right-of-way costs is not included in these estimates; so more detailed net benefits may be expected to decreased somewhat.

Reach 4: 100-year = $1,469,000;
200-year = $ 455,000

Reach 5: 100-year = $4,895,000;
200-year = $3,467,000

ALTERNATIVE FOUR: NED PLAN

DETAILS OF THE PLAN IN SECTION 4, PAGE 122

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I. COMPARISON OF DETAILED PLANS

Evaluation Criteria

The comparison between adding parapet walls, channel widening, and conversion to rectangular cross-section was focused on economic considerations because of the very limited environmental, socio-economic, cultural resource, and aesthetic/recreational resource considerations.

Environmental, Social, Cultural Resource, Recreation, and Aesthetic Impacts

The primary differences in the plans from these perspectives are summarized below:

1) Environmental. The marine-estuarine resources of the lower Los Angeles River would be impacted by Alternatives 2 and 3 which involve construction activities in the soft-bottomed channel. Raising channel walls and armoring the levee back slopes would not have these impacts. These differences are considered relatively minor because of the degraded nature of the habitat in the channel and the relatively short reach of vegetative growth along the margin of the channel.

2) Socio-economic. There are virtually no differences in the socio-economic impacts of the alternatives as all are effectively confined to the existing rights-of-way for the channel (with only minor increases in rights-of-way required at some locations). All alternatives will affect traffic during construction to some degree.

3) Cultural resources. There are virtually no cultural resources affected by any alternative except for some impacts due to a few bridge modifications. In Reach 5, it would be necessary to move the historical marker for the Battle of San Gabriel near Washington Blvd, an action with minor and only temporary effects.

4) Recreation/aesthetics. There are some differences among alternatives in terms of their impact on recreation use of the channel rights-of-way. Significant channel widening would reduce the rights-of-way available for recreational trails and open space. Conversion of the channel to rectangular concrete channel might pose a safety hazard, and additional fencing could be necessary. Parapet walls would, in some reaches, completely block the view of the channel; in other areas they would have only limited aesthetic impacts for those using the channel trails.

None of these differences was considered significant enough to affect plan formulation, although potential mitigation for environmental impacts in lower Reach 4 would add somewhat to the costs of the widening and conversion alternatives.

Comparison of Alternatives: Economics

Based on analysis of the net benefits from 100-year and 200-year levels of protection, the alternative of raising channel walls has the highest net benefits and the lowest cost of the alternatives evaluated. It is clearly the most efficient method of correcting the flooding problem, as seen on Table 10. These preliminary costs did not involve detailed analysis of bridge costs or right-of-way, but compared to the other alternatives carried forward, raising walls stands out as the alternative of choice.

Table 10

Net benefits comparison,

first iteration, for Reaches 4, 5, and 9. ($1000)

Alternative	Average Annual Benefits	Annual Cost	Net Benefits	B/C Ratio
Parapet Walls				
100-year	51,800	12,668	39,132	4.09
200-year	55,600	18,068	37,532	3.08
Widening				
100-year	51,800	22,481	29,319	2.30
200-year	55,600	27,590	28,010	2.02
Conversion				
100-year	51,800	46,905	4,895	1.10
200-year	55,600	52,133	3,467	1.07

Analysis of Alternative Combinations

Although parapet walls appeared to be the obvious choice as an overall solution, an effort was made to examine logical combinations of parapet walls with channel widening and conversion in certain reach segments to determine if an optimum combination could be identified. This was done because each of the many bridges in the project reach presents a unique set of design constraints, and in some locations bridge reconstruction costs might exceed the cost of channel widening, for instance, within the existing bridge. Furthermore, practical design considerations may not allow every bridge to be raised as high as initially formulated.

To develop optimizations, the following factors must be considered:

1) The availability and affordability of needed rights-of-way;
2) The available room between the levee top and bridge soffet, as well as additional room between bridge abutments;
3) The transportation impacts of raising or reconstructing bridges;
4) The cost and extent of channel improvements needed to avoid bridge modifications.

An alternative that optimized these considerations was developed. Reconstruction of bridges that required very expensive modifications was avoided by widening the channel instead. Because long transitions are necessary to effect a change in channel width, other bridges nearby were also spared extensive modifications.

At the time this plan was being designed, detailed cost estimates for specific bridge modifications were only partially defined, and total costs contained approximately 50 percent contingencies. As a result, it was not possible to confidently select channel widening in specific reaches as less expensive than bridge raising and parapet walls. Because raising channel heights with parapet walls incurs significantly less expense than any other construction technique on the channel itself, it made sense as the greatest net benefit alternative. A widely varying combination plan (channel widening in some locations and raised channel walls in others) could not be confidently supported as having a greater economic efficiency. Therefore, the parapet wall/bridge modification alternative for the Rio Hondo and lower Los Angeles River would remain as the framework for the recommended plan. Value engineering in the Preconstruction Engineering and Design Phase may indicate where minor improvements can be made in the plan.

Designation of the NED Plan

Because it provides the maximum net benefits, raising the channel height using parapet walls and modifying the necessary bridges is the NED alternative. An additional element of this alternative is levee armoring that prevents catastrophic levee failure during larger than design events to be implemented in selected locations. This

Los Angeles River from the Rio Hondo confluence down to the ocean, and a portion of Compton Creek. In specific locations, should this solution be difficult to implement, alternatives will be evaluated during the Preconstruction Engineering and Design Phase.

This plan does not have major right-of-way requirements or environmental mitigation problems. It avoids significant construction modification of the existing channel while providing increased protection from flooding.

There are few aspects of this plan that lend themselves to other project purposes. No additional facilities are directly available for water conservation or increased recreation. Any impacts to existing recreation will be reversed so that all existing recreation elements remain intact. No opportunities for transportation or sediment management improvements are incorporated in this NED plan.

Optimization of the NED Plan

Having selected the format of the NED plan, it then became necessary to optimize the level of flood control protection the plan would provide in order to maximize net NED benefits. The 100-year net benefits were initially only 4 percent greater than the 200-year net benefits. Because there was no knowledge of the characteristics of the net benefits curve between these two levels of protection, additional levels were analyzed.

This optimization analysis was performed only for Reach 4. The level of protection provided by Reach 5, the Rio Hondo, was not optimized independently. There were no anticipated breakpoints in the Rio Hondo net benefits curve. Because the outflow from Whittier Narrows Dam is a fixed maximum, increasing the level of protection on the Rio Hondo is possible with very small increases in construction costs. Because Reach 5 discharges into Reach 4, a significant portion of its total flow and Reach 4 must be able to accomodate any increase in design flows, Reach 5 is not considered a separable element. This simplified the analysis and resulted in compatible project elements. The level of protection provided by the Rio Hondo was matched to the optimized level of protection provided by the lower Los Angeles River.

To optimize protection on Reach 4, additional hydrology, hydraulics, and design costs were developed for the 150-year, 250-year, and 300-year events. More refined cost estimates were developed for both the existing and new levels of protection. Damages avoided (i.e. benefits) for the varying levels of protection were developed by truncating the damage-probability curve at the assigned protection frequency. A new net benefit matrix was developed (Table 11), that included interest and amortization, and this information is displayed as a net benefits curve in Figure 9.

Table 11.
Incremental justification of raised parapet wall heights, Reach 4, lower Los Angeles River ($1000).

Level of Protection	NED Net Benefits (For optimization only)	B/C Ratio
100-year	$30,271	4.5
150-year	30,523	4.1
200-year	29,541	3.5
250-year	28,914	3.3
300-year	28,479	3.1

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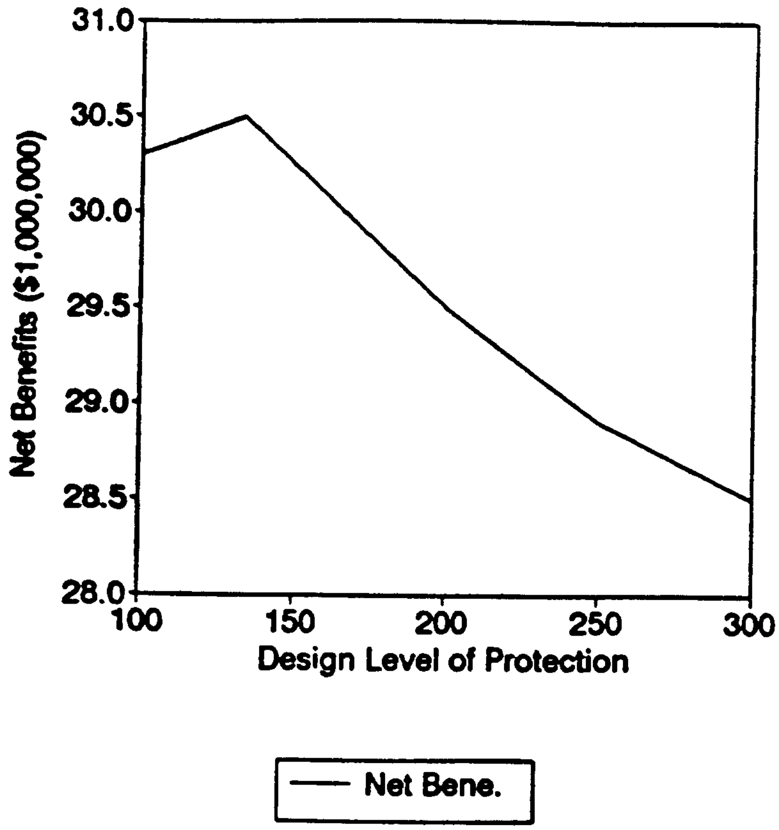

Figure 9. Net benefits curve for recommended alternative at various levels of protection.

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As seen in Table 11, the 150-year levee provides the maximum net benefits. Because of the dense urban development, additional increments of protection generate significant benefits to offset increased construction costs. The net benefits maximize at a level of protection below the 200-year because otherwise the Artesia Freeway (91) requires considerable construction modifications. The cost of raising freeway access ramps is substantial enough to reduce the overall net benefits. The associated transportation and social impacts must be avoided in order for the plan to remain acceptable.

It is conceded that the increase in net benefits between the 100-year and 150-year plans is small, on the order of 1 percent. Nevertheless, the analysis was performed with consistent levels of detail, and the indication that the net benefits curve increases above the 100-year level of protection is justification for selecting the 150-year level in this optimization procedure.

Following this initial determination that the optimum level of protection would be the 150-year level, a more precise hydraulic analysis was performed for the Artesia Freeway overcrossing segment of the river to determine the exact flow which would pass under the existing bridge. This analysis indicated that the capacity would be 164,000 ft^3/s with raised parapet walls, and more precise analysis of magnitude/frequency relationships indicated that this would be a 133-year flood event. Since the added cost of raising the Artesia Freeway overcrossing had been determined to be a controlling factor in the net benefits analysis, the optimum level of protection for this reach was then re-defined to be the 133-year flood.

Redesignation of the level of protection (from the nominal 150-year level to the 133-year level) hardly altered the shape of the net benefits curve (Figure 9). It shifted the crown of the curve to the left slightly; thus slightly fewer net benefits accrued to greater levels of protection, but the peak in net benefits remained at the level established by the upper limit of flow capacity under the Artesia Freeway.

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NED Plan Design Refinements

Having selected a recommended level of protection, the Rio Hondo component was added, and the following design refinements were incorporated into the NED plan.

1) From just above the confluence of the Rio Hondo and the Los Angeles River to just downstream from Century Boulevard (where the Century Freeway will cross the river), the Los Angeles River channel would be converted from trapezoidal to concrete rectangular channel and slightly widened. This change was made because detailed design analysis indicated that the Union Pacific Railroad bridge would need to be raised approximately four feet at its intersection with the Rio Hondo and then quickly returned to its original elevation in order to pass under the Long Beach Freeway. This design violated grade requirements for railways and, as such, warranted an alternative solution. By widening the channel downstream, the water surface elevation was lowered sufficiently to avoid modifications to the railroad bridge.

   This change would also improve hydraulic characteristics of the channel at a point where significant turbulence is expected due to the confluence of two flows. By converting to rectangular channel, the water surface is lowered downstream of the confluence as well. This action will require that levees be reconstructed, and the east abutment of Imperial Highway be rebuilt.

2) Back slopes of the levees would be armored in four locations where a potential for overtopping exists (see Figure 10). Two of the locations are where freeway overcrossings will not be altered by the project (the Artesia and the Century Freeways). Thus, the lower decks of these overcrossings will begin to block flows which exceed the 133-year level. Armoring along about two thirds of a mile of channel would protect the area downstream of the concrete rectangular section of channel and the area near the Artesia Freeway-Long Beach Freeway interchange. Levee armoring would also be required for the reach upstream from the Union Pacific Railroad bridge on the Rio Hondo, as this bridge also

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would impede flows during events greater than the 133-year flood, creating a backwater. Compton Creek would be armored for approximately one mile upstream from its confluence with the Los Angeles River. These armored areas are the breakout points for flood levels greater than the design flood. Protection of the back slopes of the levee in these areas thus has the effect of eliminating the potential for levee failure throughout the project area. Levee armoring would be adequate to prevent levee failure during any event greater than the design event.

Adding the cost of these design refinements and including the Rio Hondo component provided a more comprehensive total project cost. The resulting benefit-to-cost ratios and net benefits for the project are different from those used to optimize the NED Plan level of protection. Updated costs and benefits are found in the description of the NED Plan.

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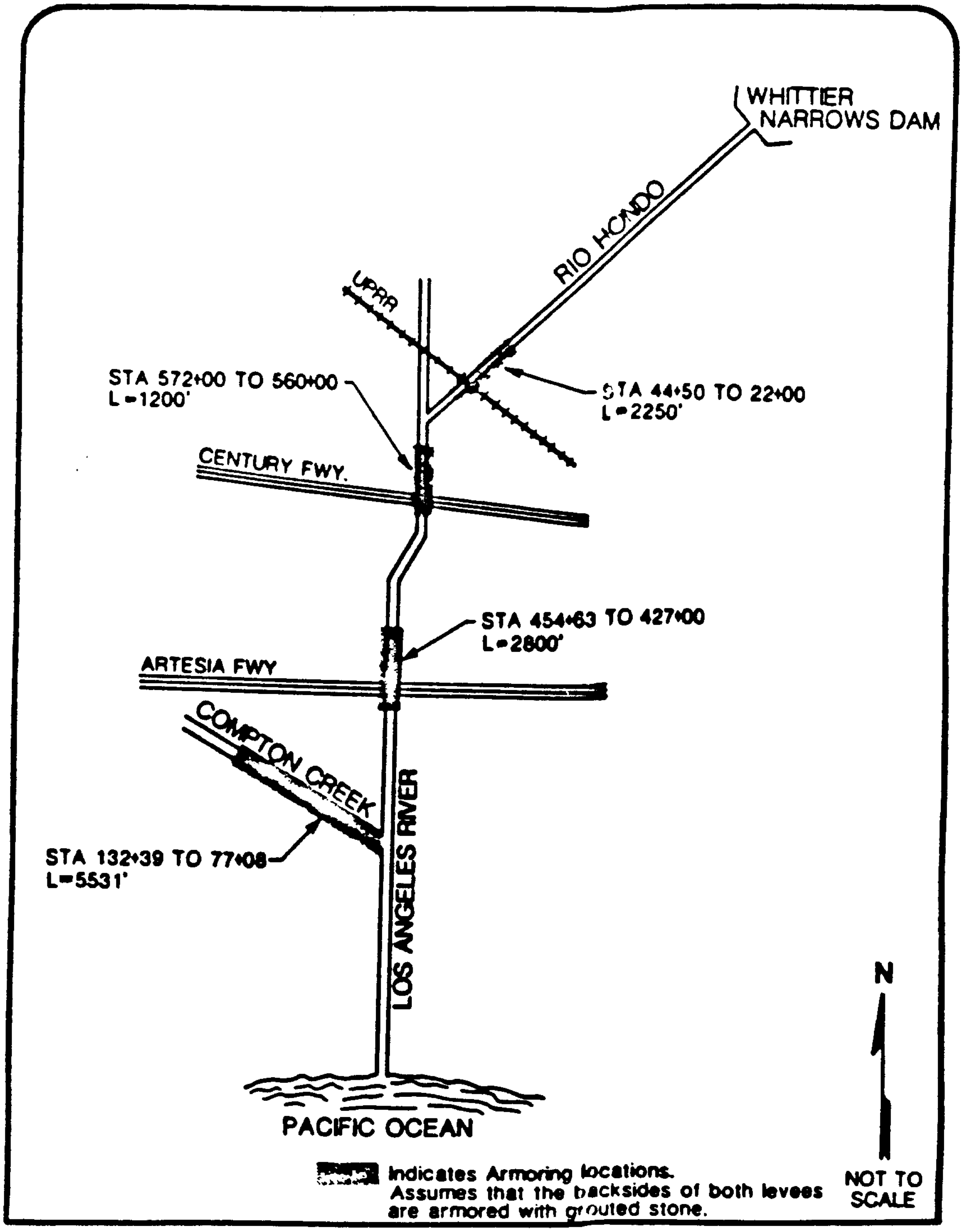

FIGURE 10. SELECTED LEVEE ARMORING LOCATIONS

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SECTION FOUR: THE NATIONAL ECONOMIC DEVELOPMENT PLAN

A. THE NED PLAN

Plan Overview

The NED Plan addresses the area of most critical need in the LACDA System: the downstream reaches of the Los Angeles-Rio Hondo system. Improvements on reach 5 begin at Whittier Narrows Dam and extend downstream on the Rio Hondo to the confluence with the Los Angeles River. Improvements on the Los Angeles River (Reach 4) continue from the confluence with the Rio Hondo and extend downstream to the mouth of the river in Long Beach Harbor. A total of about 23 miles of channel is to be improved.

The objective of the improvements is to reduce the potential for damaging flood flows by providing increased levels of protection to the urbanized reaches of the Rio Hondo and lower Los Angeles River. The 133-year design level of protection was selected because of its maximum net benefits and the constraints on plan design imposed by the Artesia Freeway overcrossing. This level of protection was used as the basis for designing all plan elements for the NED Plan, with the exception of Compton Creek.

The following measures are employed individually and in combination to achieve this objective:

1) Vertical, reinforced concrete parapet walls of from two feet to eight feet in height would be constructed along the crest of the existing channel levees.

2) Conversion of 6950 feet of concrete trapezoidal to concrete rectangular channel would occur in the confluence area where parapet walls cannot be raised to the necessary height to provide adequate protection (at and just below the confluence of the Rio Hondo and the Los Angeles River).

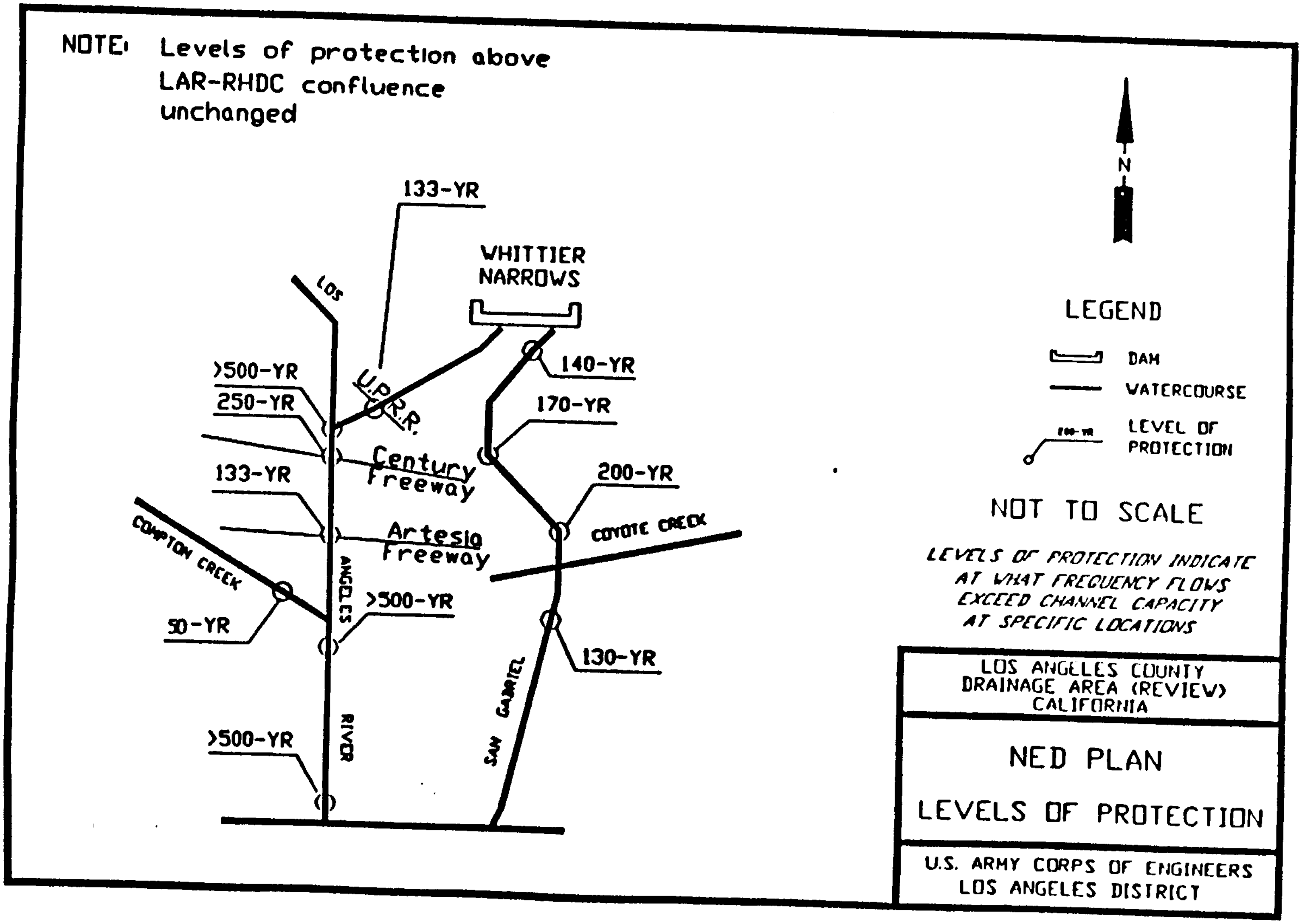
3) Raise and/or modify bridges which currently are too low to permit 133-year flows to pass underneath them or which have other impacts on the hydraulic characteristics of the channel that make alteration of their design necessary. Twenty-seven of forty-three bridges in the project reach will be modified.

4) Armor the landward levee slope on both sides of the channel in selected locations (a total of about 2.2 channel miles in four separate areas) to prevent greater than design event overflows from eroding the earthen slope and subsequently causing the levee to fail.

5) Apply a concrete overlay to the grouted stone channel walls in the vicinity of the Rio Hondo-Los Angeles River confluence.

Figure 11 indicates the estimated NED Plan levels of protection for various specific channel locations in reaches 4 and 5. While higher levels of protection are shown in some locations, it must be understood that breakout at any point will inundate a wide area, depending on the side of the channel which is overtopped. Therefore, while variations in level of protection exist throughout each reach, the flood protection provided by the NED Plan is defined by the lowest level of protection in that reach.

While no improvements are proposed for upsteam reaches of the Los Angeles River, breakouts occur just south of downtown Los Angeles for events greater than the 100-year flood. This water moves into the flood plain and spreads south along the western edge of the Los Angeles River. In the 133-year event, these inundations are expected to be very shallow, but their existence prevents the NED Plan from fully providing 133-year protection throughout the plan's area of influence. For this reason, the average level of protection provided by the NED Plan is considered to be between the 100 and 133-year level; residual damages are assumed in most locations contiguous to reaches 4 and 5 for floods which exceed the 133-year event, and in some areas west of reach 4, for events greater than the 100-year flood.



NOTE: Levels of protection above LAR-RHDC confluence unchanged
133-YR
WHITTIER NARROWS
LOS
U.P.R.R.
>500-YR
250-YR
140-YR
170-YR
Century Freeway
133-YR
200-YR
Artesia Freeway
COYOTE CREEK
COMPTON CREEK
ANGELES
>500-YR
50-YR
130-YR
SAN GABRIEL
RIVER
>500-YR
N
LEGEND
DAM
WATERCOURSE
LEVEL OF PROTECTION
NOT TO SCALE
LEVELS OF PROTECTION INDICATE AT WHAT FREQUENCY FLOWS EXCEED CHANNEL CAPACITY AT SPECIFIC LOCATIONS
LOS ANGELES COUNTY DRAINAGE AREA (REVIEW) CALIFORNIA
NED PLAN
LEVELS OF PROTECTION
U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT

FIGURE 11

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Plan Components

Parapet Walls

Parapet walls will be constructed of reinforced concrete one foot thick. Their height will vary from section to section to reflect the changing water surface requirements at the particular location. The minimum wall height will be two feet and the maximum will reach eight feet. Transitions from one parapet wall height to another will be accomplished with an instantaneous change in height. The walls will thus not have the appearance of a monolith, but will be perceived as distinct sections of varying heights, thereby reducing the visual impact of the parapet wall system. As Tables 12 and 13 indicate, wall heights will vary significantly and irregularly. In one 300-foot reach of the Rio Hondo system, for example, an 8-foot high section will be sandwiched between a 4-foot high section upstream and a 5-foot high section downstream. Only 300 feet further downstream, the wall height will be only 2 feet. In some reaches, where hydraulic analysis indicates wall heights would be less than 0.5 feet, no parapet walls will be required. The parapet walls will be constructed on the channel side of the existing access road/bicycle trail system to permit their continued use along this reach of the river.

The parapet wall design will vary, depending on wall height and whether the levee is being armored on the landward side. Details of the different wall configuration/levee armoring combinations are shown in Figure 12.

At most bridges, the existing access road/bicycle trail located on the top of the levee either veers channel-ward and dips under the bridge or it descends the outside of the levee and passes through a tunnel in the bridge approach before rejoining the levee top. In the case of the tunnel, the parapet walls will simply join the bridge abutment and continue on the other side of the abutment. Where the road goes under the bridge, as you approach the bridge, the road will gradually rise to meet the top of the parapet wall and then descend with the parapet wall to the land side of the road. The descending road will connect with the existing road as it passes under the bridge, while the

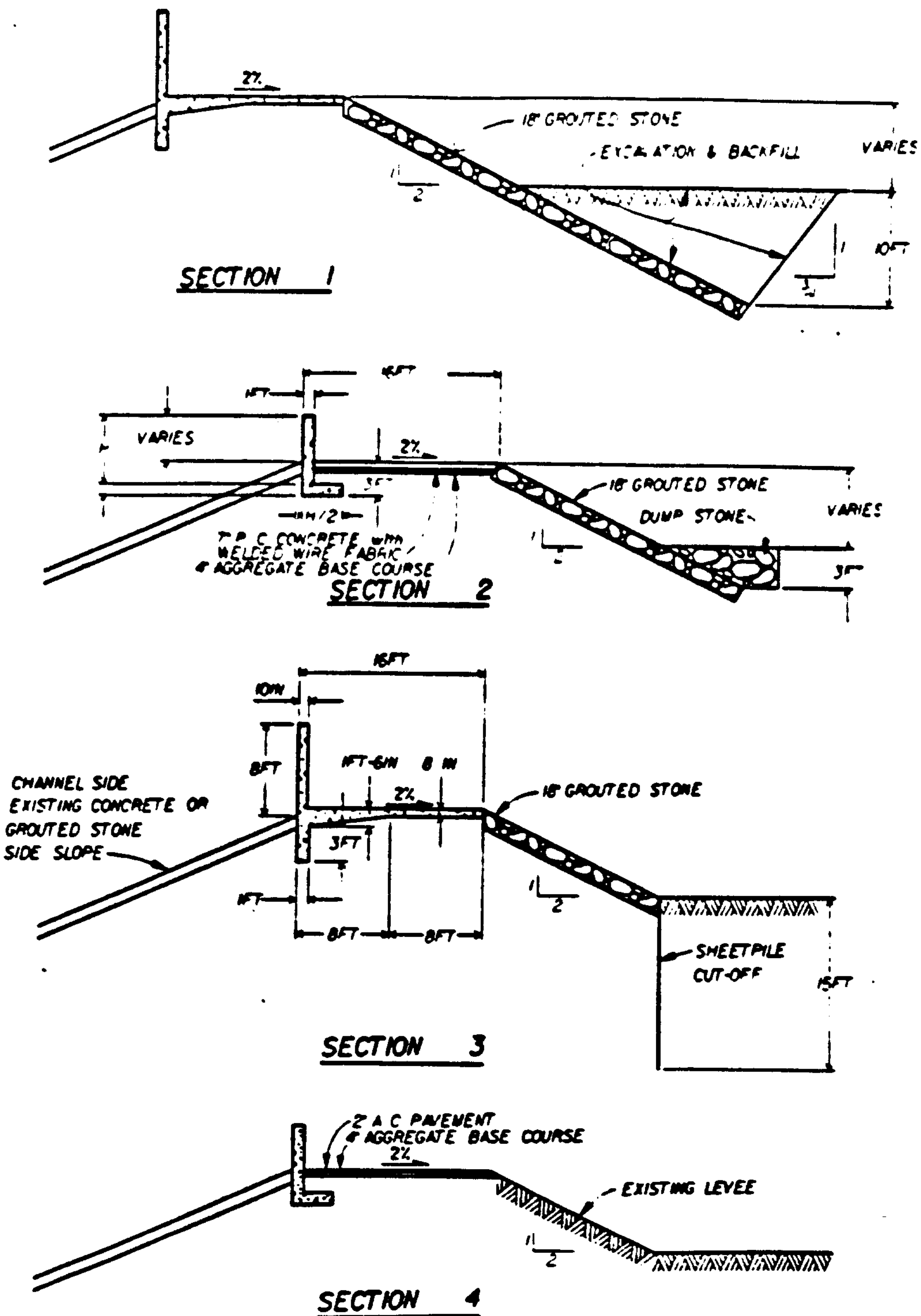

FIGURE 12

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landward-side parapet wall joins the bridge abutment and continues again on the other side of the bridge.

The walls will alter the aesthetics of the system significantly when they exceed three to four feet in height, blocking some of the view across the river. For those living adjacent to the levee, the raised walls will further impinge on the visual landscape. To offset these impacts, the walls themselves may be treated with murals; a mural created and maintained by local community groups, such as the one in the Tujunga Wash channel, may be one option for improving the aesthetics of the parapet walls. Another possibility may involve the use of ivy to cover the walls.

Table 12.

Parapet Wall Height Ranges
Rio Hondo from Whittier Narrows to LA River Channel
133-year design

Miles from LA River Channel	Station	Bridge	Height To Raise Bridge (feet)	Parapet Wall Height Range (feet)	Length (feet)
8.3	437 + 23.71			0 - 2	2823.71
7.7	409 + 00.00			1 - 4	1200.00
7.5	397 + 00.00			5 - 8	300.00
7.5	394 + 00.00			1 - 6	1549.01
7.2	378 + 50.99	Whittier	5.0	0 - 1	3950.99
6.4	339 + 00.00			0 - 6	3060.00
5.8	308 + 40.00	Washington	4.8	5 - 8	4006.26
5.1	268 + 33.74	A.T.S.F. Railway	2.5	2 - 5	2442.49
4.6	243 + 91.25	Slauson	2.2	1	839.35
4.5	235 + 51.90	P.E. Railway	1.4	1 - 5	1706.90
4.1	218 + 45.00	Ped Xing	3.6	4 - 5	3844.56
3.4	180 + 00.44	Sova	5.2	1 - 6	2970.87
2.8	150 + 29.57	Florence	3.5	1 - 6	2579.57
2.4	124 + 50.00	Ped Xing	5.3	4 - 5	3844.56
1.8	94 + 95.56	S.P.R.R.	3.2	2 - 4	1340.64
1.5	81 + 54.92	Firestone	1.6	0 - 6	1926.49
1.2	62 + 28.43			1 - 4	2028.43
0.8	42 + 00.00			0	2028.43
0.2	9 + 13.99				

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Table 13.

Parapet Wall Height Ranges
Lower Los Angeles River 133-year design

River Miles From Mouth	Station	Bridge	Height To Raise Bridge (feet)	Parapet Wall Height Range (feet)	Length (feet)
12.3	650 + 00.00				
				0 - 6	4000.00
11.5	610 + 00.00				
				6 - 8	3800.00
10.8	572 + 00.00				
				3 - 8	725.00
10.7	564 + 75.00				
				4 - 8	775.00
10.5	557 + 00.00				
				4	400.00
10.5	553 + 00.00				
				3 - 5	1562.00
10.2	537 + 38.00	Standard Oil Util.	3.4		
				3 - 4	464.47
10.1	532 + 73.53	Rosecrans	3.9		
				0 - 3	3070.14
9.5	502 + 03.39	Compton	2.7		
				0 - 4	4740.03
8.6	434 + 62.56	Atlantic	6.3		
				1	962.56
8.4	443 + 0.00				
				7	1040.00
8.2	434 + 60.00				
				3 - 4	1298.82
8.0	421 + 61.18				
				0 - 3	3811.22
6.9	383 + 49.96	Long Beach Blvd.	4.0		
				0 - 3	2649.96
6.4	337 + 00.00				
				0 - 3	2517.82
5.9	311 + 82.18	Del Amo	2.5		
				1 - 3	2421.63
5.4	287 + 60.55	U.P.R.R.	**		
				1 - 7	1160.55
5.2	276 + 00.00				
				4	1434.18
5.0	261 + 65.82	LA-LB Light Rail	2.3		
				5 - 7	865.82
4.8	253 + 00.00				
				5	1310.00
4.5	239 + 90.00				
				2 - 4	2245.01
4.1	217 + 44.00				
				3 - 7	844.99
4.0	209 + 00.00				
				6	1900.00
3.6	100 + 00.00				
				3 - 5	1913.17
3.2	170 + 84.83	Texas Oil Util.	2.8		
				0 - 5	1301.82
3.0	157 + 83.01	Willow	4.2		
				3 - 5	1320.93
2.7	144 + 62.00	Richfield Oil Util.	3.9		
				4 - 6	3965.82
2.0	104 + 96.26	Pacific Coast Hwy.	3.1		
				4 - 6	2621.96
1.5	78 + 74.30				
				4 - 5	2899.30
0.9	49 + 75.00	Edison Util.	1.6		
				3 - 4	2784.47
0.4	22 + 70.53				

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Conversion of the Channel to Rectangular Concrete-lined Channel

At the confluence of the Rio Hondo and the Los Angeles River, construction of both parapet walls and conversion of the channel to concrete-lined rectangular is required to accommodate flood flows. In this approximately 7000-foot reach, the anticipated flow of 158,000 ft^3/s is accommodated by converting the existing trapezoidal channel, with top width of approximately 390 feet, into a rectangular cross-section with a width of 420 feet. In addition to widening the channel approximately 30 feet, parapet walls as high as seven feet will be added to the sides of the Los Angeles River. The reduction in water surface elevation in the Rio Hondo is sufficient to avoid otherwise necessary modifcations to the Union Pacific Railroad bridge.

The channel modifications would require removal of the existing concrete in the channel and excavation of 560,000 yd^3 of earth. The vertical reinforced concrete walls will extend above the existing levee surface and will be cast in place. Because of the wider channel, the right (west) abutment of the Imperial Highway bridge will also need to be rebuilt.

Bridge Modifications

The bridge crossings in Reaches 4 and 5 are displayed in Figure 13. Twenty-seven of the forty-three total bridges would be affected: eighteen would be raised, one raised and modified, six modified only, one moved, and one removed to permit the design flow to pass underneath the bridge (Tables 14 and 15).

Raising of bridges will generally be accomplished by removal of the existing bridge and construction of a new bridge in its place. It had originally been thought that some bridges could be raised by elevating the bridge deck and adding height to the existing piers, but current seismic building codes make it necessary to replace the old piers.

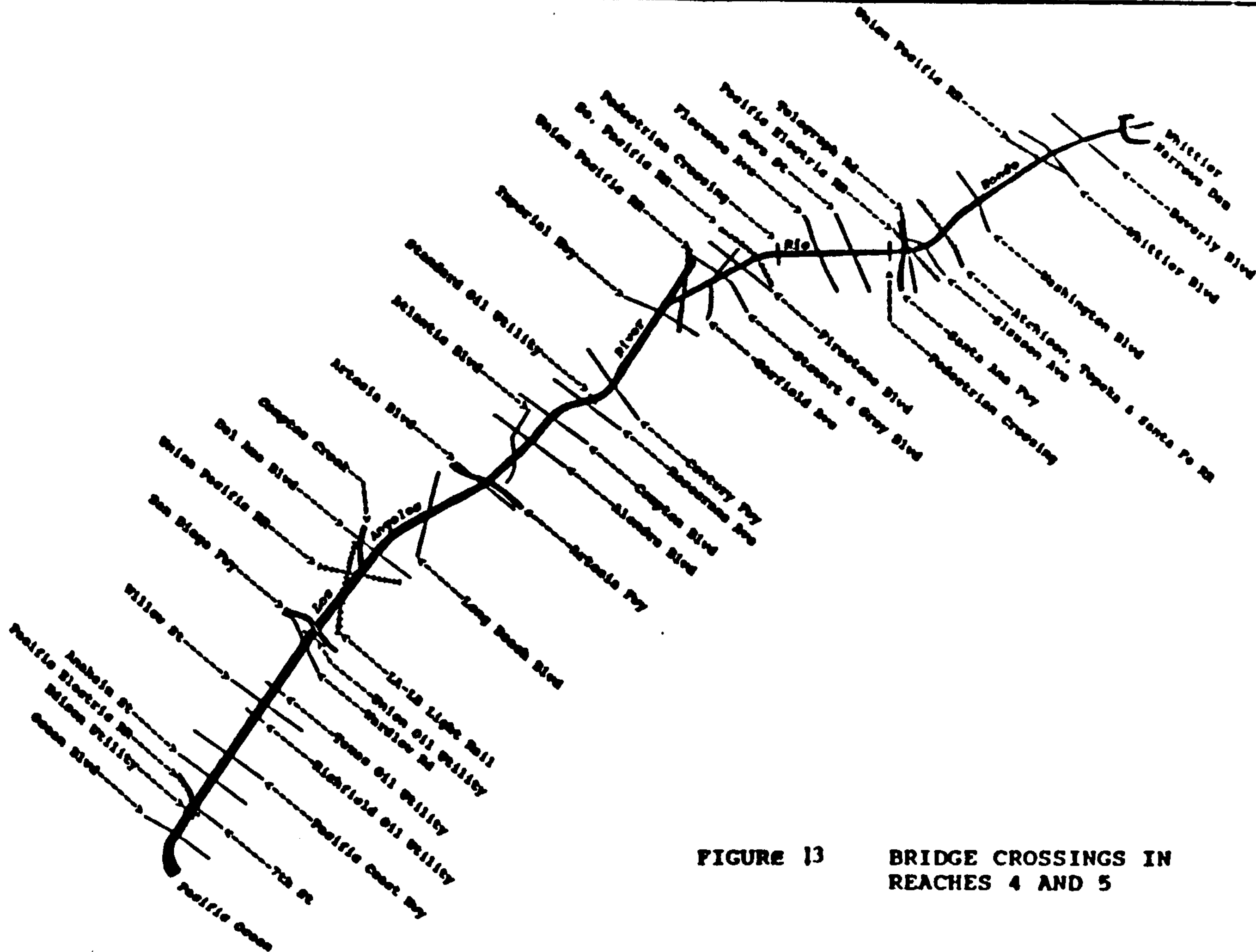

FIGURE 13 BRIDGE CROSSINGS IN REACHES 4 AND 5

Table 14. Los Angeles River Bridge Modifications

Bridge	Type	NED Plan Proposal
Lower Los Angeles River, moving downstream from Rio Hondo confluence		
Imperial Highway	Traffic	Reconstruct right abutment in conjunction with channel widening (trap. to rectangular channel) Traffic detour (requires lease of 1.7 acres)
Standard Oil	Utility	Raise 3.4 feet
Rosecrans Avenue	Traffic	Remove and reconstruct 3.9 feet higher Traffic detour required
Compton Boulevard	Traffic	Remove and reconstruct 2.7 feet higher Traffic detour (requires lease of 1.4 acres)
Atlantic Avenue	Traffic	Remove and reconstruct 6.3 feet higher Traffic detour (requires lease of 1.1 acres)
Long Beach Boulevard	Traffic	Remove and reconstruct 4 feet higher Traffic detour (requires lease of 1.0 acres)
Del Amo Boulevard	Traffic	Remove and reconstruct 5 feet higher Traffic detour (requires lease of 1.3 acres)
Union Pacific	Railroad	Remove and replace with two-pier, through-truss design Track detour (requires lease of 2.6 acres)
LA-Long Beach	Light Rail	Remove and reconstruct 3.3 feet higher Track detour (requires lease of 2.0 acres)
Texas Oil	Utility	Raise 2.8 feet
Willow Street	Traffic	Remove and reconstruct 4.2 feet higher Traffic detour (requires lease of 1.2 acres)
ARCO Oil	Utility	Remove and reconstruct 3.9 feet higher
Pacific Coast Highway	Traffic	Remove and reconstruct 3.1 feet higher Traffic detour (requires lease of 0.1 acre)
6th Street	Utility	Raise 1.6 feet
SPRR	Railroad	Remove and reconstruct 115 feet downstream

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Table 15. Rio Hondo Bridge Modifications

Bridge	Type	NED Plan Proposal
Rio Hondo, moving downstream from Whittier Narrows Dam to Los Angeles River		
Whittier Boulevard	Traffic	Remove and reconstruct 5 feet higher Traffic detour (requires lease of 1.4 acres)
Union Pacific	Railroad	Replace deck girder with through girder bridge, rebuild piers and abutments Rail elevation remains unchanged Track detour (requires lease of 1.9 acres)
Washington Boulevard	Traffic	Remove and reconstruct 4.8 feet higher Traffic detour (requires lease of 2.2 acres)
AT&SF	Railroad	Preserve superstructure Construct new piers 2.5 feet higher and rebuild abutments Track detour (no leased land needed)
Slauson Avenue	Traffic	Remove and reconstruct 2.2 feet higher Traffic detour (requires lease of 2.2 acres)
SPRR	Railroad	Remove and reconstruct 1.4 feet higher Track detour (requires lease of 1.3 acres)
Steel Bridge Sta. 218+45)	Pedestrian	Owned by LA Co. Parks and Rec. Out of service. Remove. Additional 3.6 feet elevation needed
Suva Street	Traffic	Remove and reconstruct 5.2 feet higher Traffic detour required
Florence Avenue	Traffic	Remove and reconstruct 3.5 feet higher Track detour (requires lease of 0.7 acres)
Timber Bridge (Sta. 129+50)	Pedestrian	Raise 5.3 feet
SPRR	Railroad	Remove and reconstruct 3.2 feet higher Track detour (requires lease of 1.5 acres)
Firestone Boulevard	Traffic	Remove and reconstruct 1.6 feet higher Traffic detour (requires lease of 1.8 acres)

For a typical bridge site, the following schedule will prevail:

A. Set up and staging at site	1 month
B. Build detour bridge	5 months
C. Demolish existing bridge	3 months
D. Build new bridge	12 months
E. Demolish detour bridge	3 months
F. Site restoration	1 month
Total	25 months

The detour bridge will require concrete pier construction and will utilize leased bridge decking of a steel through-truss design.

Traffic over the bridges in question is generally in the range of 20,000 to 50,000 cars a day; it will therefore be necessary to construct a detour for both directions of traffic before bridge raising may be accomplished. Given the volume of traffic, it will probably be necessary to provide a minimum of three lanes and preferably four lanes with two in each direction to accommodate traffic flow; most of the roads crossing the Los Angeles River are essential, major traffic corridors. Speed reductions would be necessary at these bridge crossings. Detours would require some construction right-of-way (approximately twenty-six acres total for twenty bridge sites); in some areas detours might impact existing structures.

An initial investigation for an impact analysis on traffic delays was governed by the goal to utilize existing transportation models and adapt them to reflect the impacts in the study area. The city of Long Beach utilizes a traffic simulation model to evaluate impacts on traffic flows of proposed roadwork. It is a trip based model of the Los Angeles Basin and upon input of a constraint it redistributes traffic to minimize the impact on the total system traffic time. The modified bridges that were input into the model are considered representative of the bridges that are affected along the entire LACDA project area. A base case was established and constraints were placed on Long Beach Boulevard, Pacific Coast Highway and Willow Street. Willow Street exhibited the most impact so it was used as a proxy for the estimation of delay times for the remaining bridges by applying a proportionate ratio based on traffic counts. The detour delay time was assumed to be the difference between the time to travel the detour route under constrained conditions and the time to travel the original route under base conditions. The approximate delay time is estimated to be less than five minutes per vehicle during peak hours. The value associated with these traffic delays are considered to be NED costs and will be included in the cost/benefit analysis in the Final Report.

Railway bridges and utility bridges will require less complex construction methods. The superstructures of railway bridges may be unfastened from piers and then removed as a unit by a crane while pier extensions are constructed. Detours may also need to be maintained for railroad traffic during construction. Utility bridges will be raised in a manner similar to raising rigidly framed bridges. Utility connections on either side of the bridge will be closed for a brief period of time while flexible connections are installed, then the bridge and the existing utility features will be raised simultaneously. The flexible connections will then be installed on a schedule to be coordinated with the various utilities involved.

Levee Armoring

As shown in Figure 10, there are four reaches totaling approximately 11,800 feet of channel that will receive protective armoring on the outer (landward) face of the levee on both sides of the channel. The objective of the armoring is to avoid erosion of the outer face of the earthen levee should an event greater than the design event occur. The armoring consists of an 18-inch-thick blanket of stones ranging from 4 to 18 inches in diameter. This blanket covers the earthen levee face and is grouted in place. The toe, or bottom edge, of the armoring needs to be protected because, otherwise, the force of the overtopping waters can erode under the armoring and still cause levee failure. To accomplish this, in areas of unconstrained right-of-way, the armoring will continue 10 feet below the ground surface as shown in Figure 14. Where adequate right-of-way is unavailable, dump stone or steel sheet piles would protect the toe of the armored levee.

Concrete Channel Overlay

Where the channel is currently grouted stone, predominantly in the vicinity of the Rio Hondo-Los Angeles River confluence, the channel roughness is not conducive to efficient conveyance of floodflows. These rougher areas will receive a smooth overlay consisting of a three-inch thick minimum concrete cover. The channel will be prepared by sandblasting, and then the concrete will be sprayed on the surface and smoothed.

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Compton Creek

Improvements on the Los Angeles River will lower water surface elevations on Compton Creek and provide a slightly greater than 50 year level of protection. However, a backwater situation remains that would induce the creek to overflow its existing walls during the 100-year event. To mitigate this, levees may be raised slightly and parapet walls three feet in height would be added along 900 feet of channel. A modified "L" wall will be used for stability, and a concrete apron would be extended to the existing channel armoring. The back side of the levees would also be armored along 5530 feet of channel, 4630 feet of which would be upstream from the section protected by parapet walls. In a 133-year design flood, this armored section would act as a weir, allowing sheet flow to pass over the levee without resulting in levee failure.

Operation and Maintenance

The Corps' primary operation and maintenance responsibility in the LACDA mainstem system involves the five Corps reservoirs and the Los Angeles River from below Tujunga Wash to just upstream of the Rio Hondo confluence. Except for various minor features, Los Angeles County operates and maintains the rest of the LACDA system. The reaches affected by the NED Plan are all currently maintained by the County. Increased operation and maintenance costs of the proposed project will be minor. Additional channel cleanout and routine repair will cost approximately $20,000 annually, with new bridge maintenance costing about $50,000 annually. Should extreme effort be required to remove graffiti from the parapet walls, some of these monies will need to be redirected.

Recreation Features

The NED Plan does not significantly alter the cycling and hiking trail system along the Los Angeles River and the Rio Hondo, although the aesthetics of this area are affected by the addition of parapet walls in some reaches. However, for much of the affected reach, the aesthetic quality of the trails is minimal, as the river passes through commercial and industrial areas and along the Long Beach Freeway The NED Plan will retain all existing recreation features that would be impacted by the project. Cycling and equestrian trails will be temporarily impacted by construction activities but will be returned to use in all of the reaches impacted by the plan. Unfortunately, there are no additional recreation features proposed at present. The cost of additional recreation facilitites would be borne by the local sponsor or another local entity. It is hoped that some additional recreation facilities can be incorporated during the planning and design phase after coordination with potential local sources of funding.

B. PLAN ACCOMPLISHMENTS

The NED Plan will provide between 100- and 133-year protection to approximately 75 square miles of intensively developed urban area, providing average annual flood damage reduction benefits estimated as $60.2 million, and reducing the 100-year flood plain from 82 square miles to 7 square miles (Figure 13). In addition, the plan will improve the safety of numerous bridges, many of which were designed prior to imposition of new seismic safety guidelines. Benefits from advanced replacement of bridges total $129,000 annually. The estimated annual benefits are shown in Table 16 below in October 1990 price levels. Details of the Economic Benefit Analysis are provided in Appendix G, the Economic Appendix.

TABLE 16
SUMMARY OF ANNUAL BENEFITS
LACDA NED PLAN

Damages avoided to structure and contents	$52,158,160
Vehicle damages avoided	6,249,000
Emergency Costs Avoided	1,109,000
Advanced Replacement of Bridges	129,000
Flood Insurance Overhead Costs Avoided	489,000
Freeboard	71,000
Total	$60,205,160

Although no improvements are recommended for the upper reaches of the Los Angeles River or the San Gabriel River system, the LACDA system as a whole will provide post-project protection from floods ranging from the 10 to 140-year event (Table 17). In areas with less than 100-year protection such as those in the upper reaches below Sepulveda and Hansen Dams, outbreaks from the entrenched channel are not extensive enough to justify a federally supported remedy.

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Table 17. Minimum levels of protection under the NED Plan
All reaches of the LACDA System
(Return period in years)

System Reach	Level of Protection Existing	Level of Protection Proposed
1. Tujunga Wash Hansen Dam to Los Angeles River	71	71
2. Los Angeles River Sepulveda Dam to Arroyo Seco	10	10
3. Los Angeles River Arroyo Seco to Rio Hondo	77	77
4. Los Angeles River Rio Hondo to Pacific Ocean	25	100
5. Rio Hondo Whittier Narrows to Los Angeles River	25	133
6. San Gabriel River Whittier Narrows to Imperial Hwy	100	140
7. San Gabriel River Imperial Highway to Pacific Ocean	111	130
8. San Gabriel River Santa Fe Dam to Whittier Narrows Dam	500	500
9. Compton Creek Main Street to Los Angeles River	25	50

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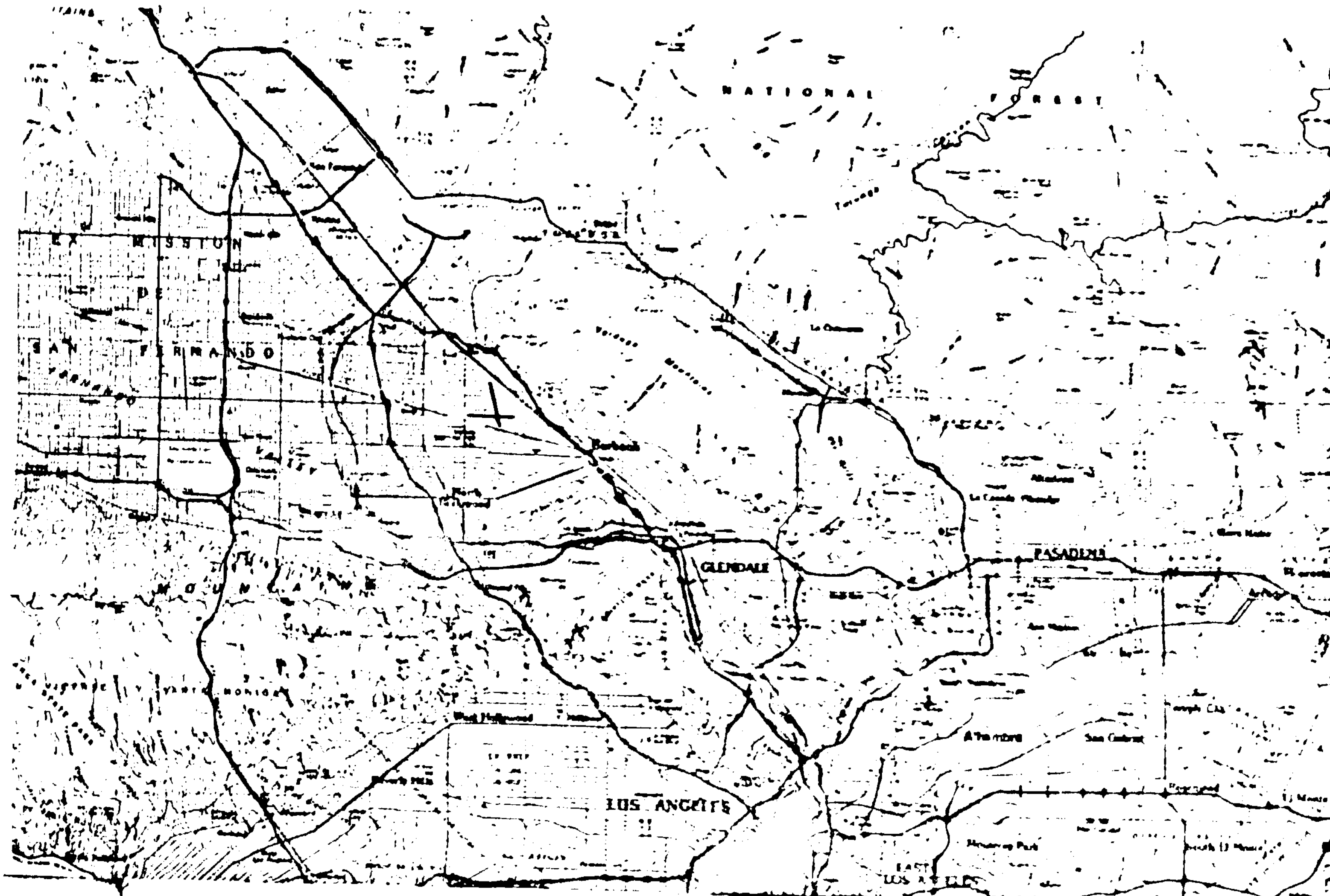
NATIONAL FOREST
SAN FERNANDO
MISSION
VALLEY
MOUNTAINS
Burbank
GLENDALE
PASADENA
Alhambra
San Gabriel
West Hollywood
LOS ANGELES
EAST LOS ANGELES
Monterey Park

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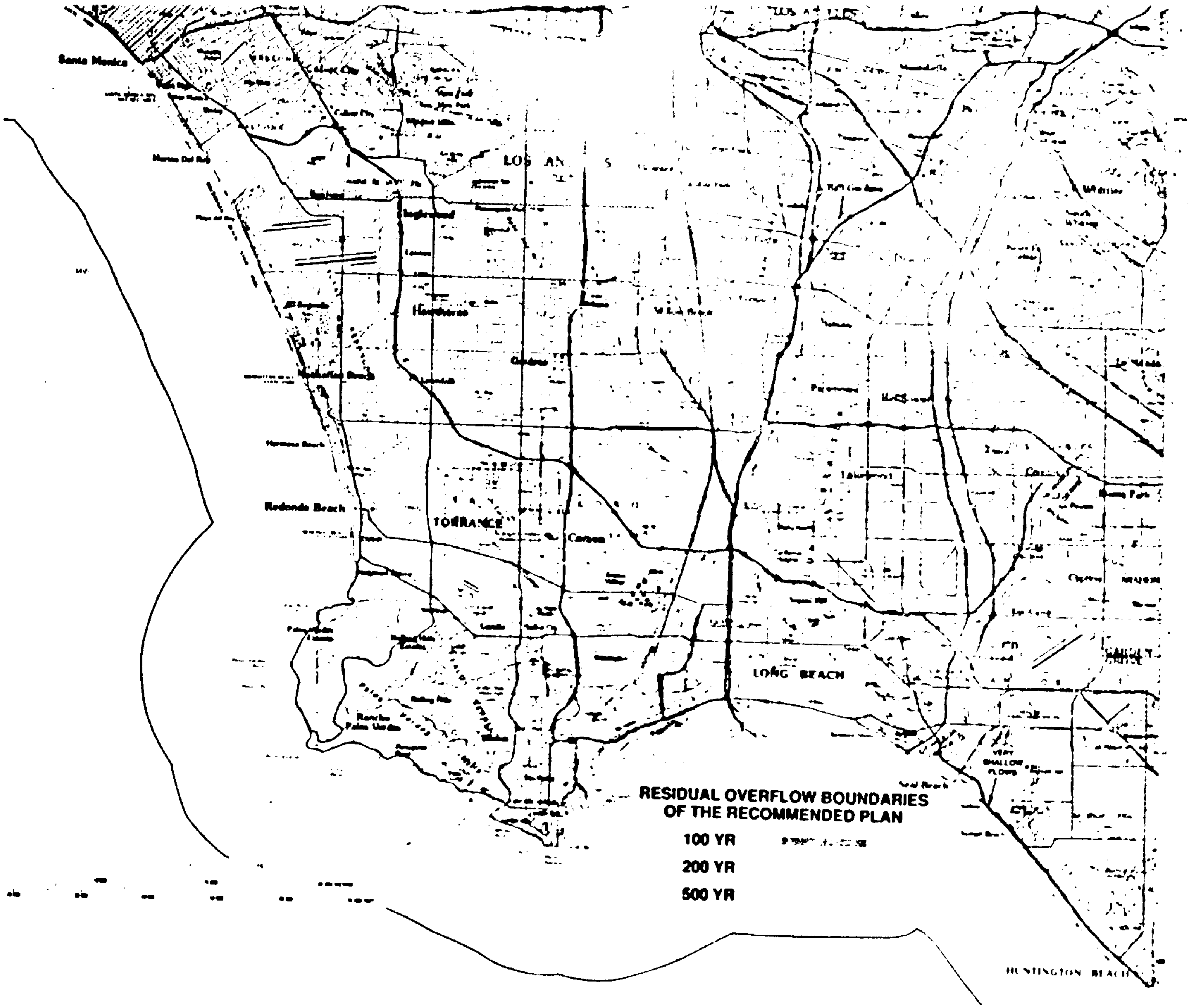

Santa Monica
Inglewood
Hawthorne
Gardena
Manhattan Beach
Hermosa Beach
Redondo Beach
TORRANCE
Carson
LONG BEACH
Rancho Palos Verdes
Whittier
VERY SHALLOW FLOWS
HUNTINGTON BEACH
RESIDUAL OVERFLOW BOUNDARIES
OF THE RECOMMENDED PLAN
100 YR
200 YR
500 YR

C. RESIDUAL FLOODING

The NED Plan does not affect upper basin reaches, and residual flooding in these areas will be the same as for the without-project condition. In the lower LACDA basin, the NED Plan may have a minor impact on local flooding because of the increased difficulty locally generated runoff will have entering the channel during short periods of higher water surface elevations in the channel.

The primary impact is expected to be felt at the 13 pump plants on the Los Angeles River and the one pump plant on the Rio Hondo, which are operated by either Los Angeles County or the City of Long Beach. The flow peak has a duration of approximately six hours during which time the pump plants may be less efficient in delivering water to the mainstem system. This reduction in storm water handling capacity may require compensation by an increase in available short-term detention storage along the channel or additional pumping capacity. Local ponding would not be increased except for very rare flood events; much of the ponding anticipated would have occurred under the without-project condition because the levee walls are currently up to 15 feet above the surrounding ground in some areas.

An evaluation of interior drainage indicated that the existing interior flood condition is primarily nuisance street flooding, and damages were insignicant compared to flooding from mainstem overflows. The existing system's ability to deliver storm runoff to the mainstem channels will be evaluated along with the marginal impact the NED Plan may have on this capability during the Preconstruction, Engineering and Design phase of this project.

The NED Plan provides for between 100 and 133-year protection in the lower basin. For events of greater magnitude, flows would overtop the parapet walls and cascade down the levee back slopes in shallow sheet flow. The resulting flooding would be less destructive than under the without-project condition because (1) the drop from the vertical parapet wall to the pavement of the cycling trail-access road would act somewhat as a drop structure, reducing flow velocity, and (2) the levees in the protected sections would not fail during flood events greater than the 133-year flood. The post-project flood plain is shown for various storm recurrence intervals on Figure 13.

D. ADDITIONAL BENEFITS OF THE NED PLAN

The 133-year level of protection recommended in the improved reaches is the optimum level from an economic point of view, but there are other considerations which reinforce this recommendation. First, any greater level of protection would involve very significant traffic impacts on the Artesia Freeway-Long Beach Freeway interchange. It is likely that these impacts would be so significant as to raise project costs or to be a significant project disbenefit during the construction period. They would probably be socially unacceptable and could threaten local support for the project.

Second, the proposed level provides a margin of safety which may be needed if future improvements are made by local agencies in upstream system reaches. The final analysis of levels of protection for the lower Los Angeles River assumed that there would be some flooding in upper reaches of the river system, including downtown. This upstream breakout of flood flows has the effect of reducing the peak flow in the lower river for the short period when peak flows are anticipated in the LACDA system. The 133-year conveyance capacity assumes that there is no increase in the level of protection in the upstream reaches and that some of the peak flow which would otherwise reach the lower river is effectively "spread out" when the downtown area is flooded, albeit to a low depth and with only limited damages. If improvements are made in the future, then the level of protection provided by the NED Plan would be reduced by a small increment but not below the 100 year level of protection.

E. FIRST COSTS

The cost estimates for the NED Plan have been prepared in accordance with guidance provided in the following documents: EC 1110-2-263, Civil Works Construction Cost Estimating; EC 1110-2-538, Civil Works Cost Estimating, Code of Accounts; and EC 1110-2-1302, Cost Estimates, Planning and Design Stages. The work to be completed for this project was broken down into line items according to the code of accounts. The estimate was developed using quantities, drawings, and other data obtained from the design team. Unit prices were developed using labor rates and site specific conditions. Overhead, bond, and profit were separately computed and distributed to the unit prices. Contingencies were determined based on current uncertainties with the design, quantities, and/or unit prices. Cost summary spreadsheets were prepared based on the output from the M-CACES program in October 1990 price levels. The cost estimate by code of accounts for all the components of the NED Plan is presented in Table 18.

The estimated first cost of the NED Plan is $337,400,000, of which approximately $96.5 million is for improvements to the Rio Hondo channel and $209 million is for improvements of the Los Angeles River channel. Modifications to the confluence are estimated as $31.5 million. Of the total, approximately 53 percent is for bridge modifications and utility relocations. A summary of cost apportionment is displayed in Table 18 and reflects cost sharing requirements and procedures as stated in the Water Resources Development Act of 1986. The non-Federal share of the estimated cost of the NED plan is $168,700,000 (50%) and the Federal share is $168,700,000 (50%).

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TABLE 18

CODE OF ACCTS	DESCRIPTION	COST WITHOUT CONTINGENCY	CONTINGENCY	COST WITH CONTINGENCY	CONTINGENCY PERCENT	MID PT CONST ESCALTN FACTR	ESCALATED TO W/OUT CONTING	ESCALATED TO W/CONTINGENCY	FOOT NOTE
	FEASIBILITY COST ESTIMATE OCTOBER 1990 PRICE LEVEL — LOS ANGELES COUNTY DRAINAGE AREA								
	HIGHWAY BRIDGES								
	RIO HONDO CHANNEL								
	FIRESTONE BLVD 81+55								
01----	LANDS & DAMAGES	359,609	100,691	460,300	28%				
02----	RELOCATIONS	38,462	11,538	50,000	30%				
021---	TOTAL CONSTRUCTION COST	4,138,091	1,076,164	5,214,998	26%				
30---	PLANNING, ENG. & DESIGN	675,289	94,541	769,830	14%				
31---	CONSTRUCTION MANAGEMENT	546,870	82,030	628,900	15%				
	TOTAL COSTS 81+55	5,760,000	1,360,000	7,120,000	24%				
	FLORENCE AVE 150+30								
01----	LANDS & DAMAGES	206,923	62,077	269,000	30%				
02----	RELOCATIONS	0	0	0	0%				
021---	TOTAL CONSTRUCTION COST	3,198,189	831,009	4,036,193	26%				
30---	PLANNING, ENG. & DESIGN	520,800	78,120	598,920	15%				
31---	CONSTRUCTION MANAGEMENT	419,746	58,764	478,510	14%				
	TOTAL COSTS 150+30	4,340,000	1,030,000	5,380,000	24%				
	SUVA STREET 180+00								
01----	LANDS & DAMAGES	0	0	0	0%				
02----	RELOCATIONS	0	0	0	0%				
021---	TOTAL CONSTRUCTION COST	1,348,543	431,534	1,779,947	32%				
30---	PLANNING, ENG. & DESIGN	220,202	30,828	251,030	14%				
31---	CONSTRUCTION MANAGEMENT	178,619	23,221	201,840	13%				
	TOTAL COSTS 180+00	1,750,000	490,000	2,230,000	28%				
021-	SLAUSON AVE 243+91								
01----	LANDS & DAMAGES	514,409	138,891	653,300	27%				
02----	RELOCATIONS	461,538	138,462	600,000	30%				
021---	TOTAL CONSTRUCTION COST	4,220,872	1,087,427	5,310,644	26%				
30---	PLANNING, ENG. & DESIGN	679,931	108,789	788,720	16%				
31---	CONSTRUCTION MANAGEMENT	547,609	82,141	629,750	15%				
	TOTAL COSTS 243+91	6,420,000	1,570,000	7,990,000	24%				
021-	WASHINGTON BLVD 308+44								
01----	LANDS & DAMAGES	452,188	126,613	578,800	28%				
02----	RELOCATIONS	384,615	115,385	500,000	30%				
021---	TOTAL CONSTRUCTION COST	5,645,810	1,473,372	7,119,160	26%				
30---	PLANNING, ENG. & DESIGN	923,115	120,005	1,043,120	13%				
31---	CONSTRUCTION MANAGEMENT	177,053	24,787	201,840	14%				
	TOTAL COSTS 308+44	7,000,000	1,860,000	8,440,000	24%				

TABLE 16

CODE OF ACCTS	FEASIBILITY COST ESTIMATE OCTOBER 1990 PRICE LEVEL — DESCRIPTION	COST WITHOUT CONTINGENCY	CONTINGENCY	COST WITH CONTINGENCY	CONTINGENCY PERCENT	MID PT CONST ESCAL'N FACTR	ESCALATED TO W/OUT CONTING	ESCALATED TO W/CONTINGENCY	FOOT NOTE
	LOS ANGELES COUNTY DRAINAGE AREA								
	WHITTIER BLVD 378+51								
01----	LANDS & DAMAGES	551,181	148,819	700,000	27%				
02----	RELOCATIONS	384,615	115,385	500,000	30%				
021---	TOTAL CONSTRUCTION COST	4,639,858	1,208,383	5,845,145	26%				
30---	PLANNING, ENG. & DESIGN	679,931	108,789	788,720	16%				
31---	CONSTRUCTION MANAGEMENT	615,164	98,426	713,590	16%				
	TOTAL COSTS 378+51	6,870,000	1,680,000	8,550,000	24%				
	LOS ANGELES RIVER CHANNEL								
	PACIFIC COAST HWY 104+98								
01----	LANDS & DAMAGES	745,664	208,786	954,450	28%				
02----	RELOCATIONS	230,769	69,231	300,000	30%				
021---	TOTAL CONSTRUCTION COST	7,528,127	1,881,532	9,422,935	25%				
30---	PLANNING, ENG. & DESIGN	1,224,112	195,858	1,419,970	16%				
31---	CONSTRUCTION MANAGEMENT	989,500	197,900	1,187,400	20%				
	TOTAL COSTS 104+98	10,720,000	2,550,000	13,280,000	24%				
	WILLOW ST 157+83								
01----	LANDS & DAMAGES	398,281	111,519	509,800	28%				
02----	RELOCATIONS	0	0	0	0%				
021---	TOTAL CONSTRUCTION COST	8,302,065	2,075,516	10,408,510	25%				
30---	PLANNING, ENG. & DESIGN	1,349,574	202,436	1,552,010	15%				
31---	CONSTRUCTION MANAGEMENT	1,084,595	227,765	1,312,360	21%				
	TOTAL COSTS 157+83	11,130,000	2,620,000	13,780,000	24%				
	DEL AMO BLVD 311+82								
01----	LANDS & DAMAGES	156,094	43,706	199,800	28%				
02----	RELOCATIONS	57,692	17,308	75,000	30%				
021---	TOTAL CONSTRUCTION COST	5,679,704	1,478,723	7,164,808	26%				
30---	PLANNING, ENG. & DESIGN	921,543	147,447	1,068,990	16%				
31---	CONSTRUCTION MANAGEMENT	742,744	155,976	898,720	21%				
	TOTAL COSTS 311+82	7,560,000	1,840,000	9,410,000	24%				
	LONG BEACH BLVD 363+50								
01----	LANDS & DAMAGES	158,125	44,275	202,400	28%				
02----	RELOCATIONS	76,923	23,077	100,000	30%				
021---	TOTAL CONSTRUCTION COST	13,843,360	3,460,838	17,276,891	25%				
30---	PLANNING, ENG. & DESIGN	2,259,530	338,930	2,598,460	15%				
31---	CONSTRUCTION MANAGEMENT	1,820,385	345,875	2,168,270	19%				
	TOTAL COSTS 363+50	18,160,000	4,210,000	22,340,000	23%				

TABLE 18

CODE OF ACCTS	DESCRIPTION	COST WITHOUT CONTINGENCY	CONTINGENCY	COST WITH CONTINGENCY	CONTINGENCY PERCENT	MID PT CONST ESCALTN FACTR	ESCALATED TO W/OUT CONTING	ESCALATED TO W/CONTINGENCY	FOOT NOTE
FEASIBILITY COST ESTIMATE		OCTOBER 1990 PRICE LEVEL			LOS ANGELES COUNTY DRAINAGE AREA				
	ATLANTIC AVE 454+63								
01----	LANDS & DAMAGES	203,556	56,995	260,550	28%				
02----	RELOCATIONS	69,231	20,769	90,000	30%				
021---	TOTAL CONSTRUCTION COST	9,110,495	2,368,729	11,466,987	26%				
30---	PLANNING, ENG, & DESIGN	1,481,388	237,022	1,718,410	16%				
31---	CONSTRUCTION MANAGEMENT	1,190,398	214,272	1,404,670	18%				
	TOTAL COSTS 454+63	12,060,000	2,900,000	14,940,000	24%				
	COMPTON BLVD 502+03								
01----	LANDS & DAMAGES	370,000	103,600	473,600	28%				
02----	RELOCATIONS	38,462	11,538	50,000	30%				
021---	TOTAL CONSTRUCTION COST	3,903,489	1,053,942	4,969,892	27%				
30---	PLANNING, ENG, & DESIGN	742,235	111,335	853,570	15%				
31---	CONSTRUCTION MANAGEMENT	597,939	89,691	687,630	15%				
	TOTAL COSTS 502+03	5,650,000	1,370,000	7,030,000	24%				
	ROSECRANS AVE 532+74								
01---	LANDS & DAMAGES	0	0	0	30%				
02---	RELOCATIONS	0	0	0	30%				
021---	TOTAL CONSTRUCTION COST	9,016,204	2,434,375	11,410,555	27%				
30---	PLANNING, ENG, & DESIGN	1,457,316	247,744	1,705,080	17%				
31---	CONSTRUCTION MANAGEMENT	1,177,563	223,737	1,401,300	19%				
	TOTAL COSTS 532+74	11,650,000	2,910,000	14,520,000	25%				
	IMPERIAL HWY 634+04								
01----	LANDS & DAMAGES	272,969	76,431	349,400	28%				
02----	RELOCATIONS	0	0	0	30%				
021---	TOTAL CONSTRUCTION COST	6,938,056	2,012,037	8,937,753	29%				
30---	PLANNING, ENG, & DESIGN	1,119,483	179,117	1,298,600	16%				
31---	CONSTRUCTION MANAGEMENT	899,137	152,853	1,051,990	17%				
	TOTAL COSTS 634+04	9,230,000	2,420,000	11,640,000	26%				
	RAILROAD BRIDGES								
	RIO HONDO RIVER								
	SOUTHERN PACIFIC 94+96								
01---	LANDS & DAMAGES	168,219	47,231	215,450	28%				
02---	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	1,979,082	554,344	2,533,408	28%				
30---	PLANNING, ENG, & DESIGN	319,930	49,710	369,640	16%				
31---	CONSTRUCTION MANAGEMENT	257,780	42,000	299,780	16%				
	TOTAL COSTS 94+96	2,720,000	690,000	3,420,080	25%				

TABLE 18

CODE OF ACCTS	DESCRIPTION	COST WITHOUT CONTINGENCY	CONTINGENCY	COST WITH CONTINGENCY	CONTINGENCY PERCENT	MID PT CONST ESCAL'N FACTR	ESCALATED TO W/OUT CONTING	ESCALATED TO W/CONTINGENCY	FOOT NOTE
FEASIBILITY COST ESTIMATE	OCTOBER 1990 LEVEL			LOS ANGELES COUNTY DRAINAGE AREA					
	SOUTHERN PACIFIC 235+52								
01----	LANDS & DAMAGES	174,800	47,700	222,500	27%				
02----	RELOCATIONS	38,462	11,539	50,001	30%				
022---	TOTAL CONSTRUCTION COST	2,195,762	602,625	2,798,387	27%				
30---	PLANNING, ENG. & DESIGN	351,460	49,470	400,930	14%				
31---	CONSTRUCTION MANAGEMENT	283,200	44,000	327,200	16%				
	TOTAL COSTS 235+52	3,040,000	760,000	3,800,000	25%				
	A.T. & SANTA FE 268+34								
01----	LANDS & DAMAGES	0	0	0	0%				
02----	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	3,662,398	1,024,400	4,686,798	28%				
30---	PLANNING, ENG. & DESIGN	585,970	89,130	675,100	15%				
31---	CONSTRUCTION MANAGEMENT	472,150	70,000	542,150	15%				
	TOTAL COSTS 268+34	4,720,000	1,180,000	5,900,000	25%				
	UNION PACIFIC 369+04								
01----	LANDS & DAMAGES	49,950	9,400	59,350	19%				
02----	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	5,962,197	1,855,198	7,817,395	31%				
30---	PLANNING, ENG. & DESIGN	951,050	143,930	1,094,980	15%				
31---	CONSTRUCTION MANAGEMENT	766,320	121,000	887,320	16%				
	TOTAL COSTS 369+04	7,730,000	2,130,000	9,860,000	28%				
	LOS ANGELES RIVER CHANNEL								
	SOUTHERN PACIFIC 37+04								
01----	LANDS & DAMAGES	487,692	127,308	615,000	26%				
02----	RELOCATIONS	615,385	184,616	800,001	30%				
022---	TOTAL CONSTRUCTION COST	6,219,223	1,797,153	8,016,376	29%				
30---	PLANNING, ENG. & DESIGN	1,009,700	149,340	1,159,040	15%				
31---	CONSTRUCTION MANAGEMENT	813,570	130,000	943,570	16%				
	TOTAL COSTS 37+04	9,150,000	2,380,000	11,530,000	26%				
	LA-LB LIGHT RAIL 262+46								
01----	LANDS & DAMAGES	27,450	6,000	33,450	22%				
02----	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	6,672,576	1,796,948	8,469,524	27%				
30---	PLANNING, ENG. & DESIGN	1,085,650	161,180	1,246,830	15%				
31---	CONSTRUCTION MANAGEMENT	874,770	150,000	1,024,770	17%				
	TOTAL COSTS 262+46	8,680,000	2,110,000	10,770,000	24%				

TABLE 18

CODE OF ACCTS	DESCRIPTION	COST WITHOUT CONTINGENCY	CONTINGENCY	COST WITH CONTINGENCY	CONTINGENCY PERCENT	MID PT CONST ESCAL'N FACT'R	ESCALATED TO W/OUT CONTING	ESCALATED TO W/CONTINGENCY	FOOT NOTE
	FEASIBILITY COST ESTIMATE OCTOBER 1990 PRICE LEVEL — LOS ANGELES COUNTY DRAINAGE AREA								
	UNION PACIFC 287+61								
01---	LANDS & DAMAGES	112,146	32,154	144,300	29%				
02---	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	5,461,400	1,600,160	7,061,560	29%				
30---	PLANNING, ENG, & DESIGN	879,380	131,200	1,010,580	15%				
31---	CONSTRUCTION MANAGEMENT	708,550	120,000	828,550	17%				
	TOTAL COSTS 287+61	7,160,000	1,880,000	9,040,000	26%				
	UTILITY BRIDGES								
	LOS ANGELES RIVER CHANNEL								
	SIXTH ST 47+65								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	1,564,786	615,724	2,180,510	39%				
30---	PLANNING, ENG, & DESIGN	270,390	36,477	306,867	13%				
31---	CONSTRUCTION MANAGEMENT	217,870	32,026	249,896	15%				
	TOTAL COSTS 47+65	2,060,000	680,000	2,740,000	33%				
	ATLANTIC RICHFLD 145+11								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	1,595,235	509,576	2,104,811	32%				
30---	PLANNING, ENG, & DESIGN	267,540	36,491	304,031	14%				
31---	CONSTRUCTION MANAGEMENT	215,570	31,904	247,474	15%				
	TOTAL COSTS 145+11	2,080,000	560,000	2,640,000	28%				
	TEXAS OIL 171+68								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	1,388,100	511,163	1,899,263	38%				
30---	PLANNING, ENG, & DESIGN	224,220	30,510	254,730	13%				
31---	CONSTRUCTION MANAGEMENT	182,280	24,972	207,252	14%				
	TOTAL COSTS 171+68	1,760,000	570,000	2,330,000	32%				
	STANDARD OIL 637+30								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
022---	TOTAL CONSTRUCTION COST	831,015	289,554	1,120,569	35%				
30---	PLANNING, ENG, & DESIGN	141,330	18,382	159,712	14%				
31---	CONSTRUCTION MANAGEMENT	113,880	15,032	128,912	13%				
	TOTAL COSTS 637+30	1,090,000	320,000	1,410,000	29%				

TABLE 18

CODE OF ACCTS	DESCRIPTION	COST WITHOUT CONTINGENCY	CONTINGENCY	COST WITH CONTINGENCY	CONTINGENCY PERCENT	MID PT CONST (ESCAL'TN FACTR)	ESCALATED TO W/OUT CONT'NG	ESCALATED TO W/CONTINGENCY	FED'T NET
	FEASIBILITY COST ESTIMATE — OCTOBER 1990 PRICE LEVEL — LOS ANGELES COUNTY DRAINAGE AREA								
	PEDESTRIAN BRIDGES								
	RIO HONDO CHANNEL								
	PED CROSSING 129+50								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
023---	TOTAL CONSTRUCTION COST	144,322	48,839	193,161	34%				
30---	PLANNING, ENG. & DESIGN	25,580	3,130	28,710	12%				
31---	CONSTRUCTION MANAGEMENT	20,820	1,440	22,260	7%				
	TOTAL COSTS 129+50	190,000	50,000	240,000	26%				
	PED CROSSING 218+45								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
023---	TOTAL CONSTRUCTION COST	218,369	104,967	323,336	48%				
30---	PLANNING, ENG. & DESIGN	29,300	3,210	32,510	11%				
31---	CONSTRUCTION MANAGEMENT	23,600	3,000	26,600	13%				
	TOTAL COSTS 218+45	270,000	110,000	380,000	41%				
	CHANNEL MODIFICATIONS								
	COMPTON CREEK								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
09---	TOTAL CONSTRUCTION COST	4,809,353	994,933	5,804,286	21%				
30---	PLANNING, ENG. & DESIGN	773,930	109,873	883,803	14%				
31---	CONSTRUCTION MANAGEMENT	625,220	101,285	726,505	16%				
	TOTAL COSTS	6,210,000	1,210,000	7,420,000	19%				
	LOS ANGELES RIVER CHANNEL								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
09---	TOTAL CONSTRUCTION COST	29,467,144	5,926,491	35,393,635	20%				
30---	PLANNING, ENG. & DESIGN	5,292,570	883,279	6,175,849	17%				
31---	CONSTRUCTION MANAGEMENT	4,264,540	788,939	5,053,479	18%				
	TOTAL COSTS	39,020,000	7,600,000	46,620,000	19%				
	RIO HONDO RIVER CHANNEL								
01---	LANDS & DAMAGES	0	0	0	0%				
02---	RELOCATIONS	0	0	0	0%				
09---	TOTAL CONSTRUCTION COST	20,782,027	4,189,468	24,971,495	20%				
30---	PLANNING, ENG. & DESIGN	3,442,170	559,103	4,001,273	16%				
31---	CONSTRUCTION MANAGEMENT	2,773,560	502,014	3,275,574	18%				
	TOTAL COSTS	27,000,000	5,250,000	32,250,000	19%				

TABLE 18

CODE OF ACCTS	DESCRIPTION	COST WITHOUT CONTINGENCY	CONTINGENCY	COST WITH CONTINGENCY	CONTINGENCY PERCENT	MID-PT CONST ESCAL'N FACTR	ESCALATED TO W/OUT CONTING	ESCALATED TO W/CONTINGENCY	FOOT NOTE
FEASIBILITY COST ESTIMATE		OCTOBER 1990 PRICE LEVEL			LOS ANGELES COUNTY DRAINAGE AREA				
	CONFLUENCE MODIFICATION								
01----	LANDS & DAMAGES	0	0	0	0%				
02----	RELOCATIONS	0	0	0	0%				
09---	TOTAL CONSTRUCTION COST	19,748,579	4,947,771	24,696,350	25%				
30---	PLANNING, ENG. & DESIGN	3,186,210	536,487	3,722,697	17%				
31---	CONSTRUCTION MANAGEMENT	2,567,320	469,819	3,037,139	18%				
	TOTAL COSTS	25,500,000	5,950,000	31,460,000	23%				
	LA RIVER CHANNEL DEWATER								
01----	LANDS & DAMAGES	0	0	0	0%				
02----	RELOCATIONS	0	0	0	0%				
09---	TOTAL CONSTRUCTION COST	4,528,691	2,264,346	6,793,037	50%				
30---	PLANNING, ENG. & DESIGN	543,443	135,861	679,304	25%				
31---	CONSTRUCTION MANAGEMENT	380,410	95,103	475,513	25%				
	TOTAL COSTS	5,450,000	2,500,000	7,950,000	46%				
	TOTAL PROJECT COST	272,700,000	64,770,000	337,400,000	24%				

NOTES:
SEE M-CACES PRINTOUT FOR A DETAILED BREAKDOWN.

TABLE 19 COST APPORTIONMENT

ITEM	FEDERAL	NON-FEDERAL
HIGHWAY BRIDGES-LOS ANGELES		$106,940,000
RAILROAD BRIDGES	$ 31,340,000	
UTILITY BRIDGES		9,140,000
CHANNEL MODIFICATIONS		
COMPTON CREEK	7,420,000	
LOS ANGELES RIVER	46,620,000	
DEWATER LA RIVER	7,950,000	
TOTAL LOS ANGELES RIVER WITH COMPTON CREEK FEATURES	$ 93,330,000	$116,100,000
HIGHWAY BRIDGES-RIO HONDO		$ 40,700,000
RAILROAD BRIDGES	$ 22,980,000	
PEDESTRIAN BRIDGES		620,000
CHANNEL MODIFICATIONS	$ 32,250,000	
TOTAL RIO HONDO PORTION	$ 55,230,000	$ 41,320,000
CONFLUENCE MODIFICATION	$ 31,460,000	
SUBTOTAL BOTH PORTIONS	$180,000,000	$ 157,400,000
INITIAL 5% CASH CONTRIBUTION	- 16,870,000	$ 16,870,000
TOTAL	$163,130,000	$ 174,270,000
COST APPORTIONMENT	$168,700,000	$ 168,700,000

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F. DESIGN AND CONSTRUCTION SCHEDULE

The present schedule consists of a 3 year Preconstruction, Engineering and Design phase (PED) lasting from September 1991 until August 1994. The General Construction period would last about eight years, from September 1994 until December 2002.

(1.) Immediately commencing with the initiation of PED, these work items will be scheduled for completion; LCA negotiations, mapping and surveying, geotechnical investigations, materials investigations, environmental mitigation analyses, economic validations, real estate and other acquisition plans, and hydrology and hydraulic studies. reek.

(2.) The second phase of the construction package consists of parapet walls and levee armoring along Compton Creek and the first set of final plans and specifications that mark the end of the PED phase and the beginning of the construction phase of the project. The work along Compton Creek will be based on a Basis of Design document that will address only the technical data pertinent to Compton Creek. Construction of the improvements to Compton Creek is expected to last about 18 months.

(3.) The third phase of the construction schedule is the Physical Model at the Waterways Experiment Station (WES). Due to several unstable flow regimes along the project length, considerable factors of safety in the form of increased height were added to some of the bridges spanning the Los Angeles River and Rio Hondo Channel. The mathematical models used to predict the project flowlines are particularly ill-suited for these hyraulic discontinuities. The WES model will be used to determine if any of the factors of safety employed may be reduced or perhaps preclude the modification of one or more of the bridges along the project length. The model construction will begin prior to initiation of PED.

(4.) The fourth phase of construction includes modification to utility and pedestrian bridges. These modification may be accomplished with no additional rights-of-way, no traffic impacts, and at a low cost. Construction of these modifications is expected to take approximately 15 months.

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(5.) The fifth phase of work includes the first group of highway bridge modifications for the Los Angeles River and the Rio Hondo Channel. These would be the bridges mentioned in the WES work phase that would have a relatively high likelihood of not requiring extensive modification. Construction of all highway bridges would be phased so that no more than two bridges on either river would be modified at the same time. At no time will two adjacent bridges be modified at the same time. Due to this constraint, the construction period may be as long as 7 years.

(6.) The second set of highway bridge modifications may have a construction period of approximately 6 years due to the same constraints as the first group of bridges

(7.) The channel work construction for the Rio Hondo, Los Angeles River and their confluence will proceed by seperate contract and construction will last approximately 3 years.

(8.) The final phase consists of the Federal responsibility of modification of seven railroad bridges. The construction period for all seven bridges would span approximately 5 years.

Table 20. Summary of Design and Construction Schedule

Phase	Start	Finish	Years
Design	1991	1994	3
Construction			
1. Channel Modifications Compton Creek	1994	2001	6
2. Utility and Pedestrian Bridges	1994	1995	1
3. Highway Bridges	1995	2000	6
4. Highway Bridges	1997	2002	5-1/2
4. Railroad Bridges	1997	2002	6
5. Channel Modifications	1996	1999	2-1/2

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G. PLAN IMPLEMENTATION

Institutional Requirements

Under the Water Resources Development Act of 1986, the local sponsor for a project is responsible for:

1) Paying 5 percent of the cost of the project assigned to flood control during construction of the project,

2) Providing all lands, easements, rights of way, and dredged material disposal areas required only for flood control,

3) Performing all necessary relocations related to flood control, and

4) Providing that portion of the joint costs of lands, easement, rights-of-way, dredged materials disposal areas, and relocations which is assigned to flood control.

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The local sponsor is required to pay a minimum of 25 percent of total project costs assigned to flood control during construction if its contributions under the conditions listed above do not equal 25 percent of total cost attributable to flood control. All project costs for the NED Plan are attributable to flood control. Los Angeles County, as local sponsor, is required to provide all lands easements, rights-of-way and relocations (LERR) in support of the project. Because bridge modifications are part of LERR, Los Angeles County would normally be responsible for these costs. Bridge costs constitute 64 percent of the total project costs, and the ceiling on local sponsor fiscal participation is 50 percent. As a result, all project costs are divided evenly between Los Angeles County and the Federal government.

The local sponsor may be expected to waive application of the ability-to-pay test.

H. NON-FEDERAL SPONSOR RESPONSIBILITIES

The presently estimated non-Federal share of the total first cost is $168,700,000.

In addition, maintenance and operation of the project would cost local interests approximately $70,000 annually.

The local sponsor for the project is the Los Angeles County Flood Control District.

Requirements of local cooperation are specified below:

(1) Pay five percent of the cost of the project assigned to flood control during construction of the project, presently estimated at $16,870,000.

(2) Provide all lands, easements and rights-of-way, including suitable borrow and spoil disposal areas, necessary for construction and maintenance of the project, including associated mitigation measures, at a cost presently estimated at $5,611,400.

(3) Accomplish all relocations and alterations of buildings, roads, highways, bridges, storm drains, sewers, and utilities, at a cost presently estimated at $151,788,600.

(4) If, the value of the contributions required by the non-Federal interest is less than 25 percent of the project cost, the non-Federal interest shall pay during construction such additional amounts necessary so that the total contribution of the non-Federal interest is equal to 25 percent of the cost of the project assigned to flood control.

(5) Maintain and operate project facilities after completion in accordance with regulations to be prescribed by the Secretary of the Army at an average annual cost presently estimated at $70,000.

(6) Hold, and save the United States free from damages due to construction, operation, and maintenance of the project, excluding damages due to the fault or

negligence of the United States or its contractors, and free from water rights claims caused by construction and operation of the project.

(7) Prescribe and enforce regulations to prevent obstruction or encroachment on flood control works that would reduce their flood-carrying capacity or hinder maintenance and operation.

(8) Comply with the applicable requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

(9) Comply with Section 221 of the Flood control Act of 1970.

(10) Publicize flood plain information in the areas where structural measures were not found justified and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise development in the flood plain.

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SECTION FIVE: PUBLIC COORDINATION

Public coordination for this feasibility phase of the LACDA study included a series of public workshops in October 1987 at five locations in the LACDA basin. At these workshops, study staff, staff from LACDPW, and staff from the Federal Emergency Management Agency (FEMA) briefed over 150 workshop participants, including community leaders and members of the press. In addition, there have been regular comprehensive newspaper articles to ensure that the purpose and scope of the study has been adequately known to LACDA basin residents. Public review and comment of the proposed project was considered in formulation of the array of alternatives screened, as well as in evaluating alternatives.

The public was presented with a full array of alternatives to be considered, and their comments on these alternatives were given full consideration during all phases of the planning process.

Public meetings were able to reach only a small fraction of the basin's over 4 million residents; a public involvement program for an area so densely populated thus involved a number of other approaches.

First, personnel from the Los Angeles County Department of Public Works were involved in the planning effort from the beginning. Local officials, likely to be aware of local concerns and attitudes, were able to help guide the planning process toward measures which would be acceptable to the local communities.

Second, information about the project was made available to the public through the media. An initial problem analysis was made available in 1985, prior to plan formulation. A number of other press releases concerning the potential flooding problem and potential alternative solutions were made over a period of about four years.

Third, the recommendations of this planning effort will be presented to the Los Angeles County Board of Supervisors for critical review.

Fourth, public presentations of the data in this report will be made in various geographical areas of the LACDA basin. This will provide those with an intense interest in the project with an opportunity to comment in detail. Because these meetings will be attended by representatives of the local press, the discussions in these meetings may be locally reported. Thus the meetings will have the effect of informing a broad cross-section of the community about the various points of view related to the project. Presentations will consist of general introductions to the problem and the planning process, a detailed slide/video presentation, and an open question-and-answer period. An informational brochure will be available to all who attend the meetings and/or are currently on the project mailing list.

Finally, briefings and workshops may be held for public officials in the LACDA basin on a by-request basis at which an open forum discussion of issues may take place.

A record of public involvement efforts and the views of the public are on file in the Los Angeles District Office. For summary purposes, major issues raised during public involvement to date are listed and briefly described below:

1) The Need for Upgrading the LACDA System. Those present at public workshops did not initially understand the need for the upgrade of the system. There are several reasons for this. First, the LACDA system components have performed quite well over the past 40-50 years; during this time there has not been a flood exceeding current capacity. Thus the public perceives the system as highly reliable. Second, the concept of flood magnitude-frequency relationships is often difficult to grasp. Third, recent drought periods have focused public attention on problems caused by periods of low precipitation, rather than on infrequent flood periods. These issues have been successfully addressed in both public meetings and newspaper articles.

2) Factors influencing flooding. There were many questions regarding the interaction of factors which affect protection levels. Factors of apparent greatest concern were debris, releases from major reservoirs, and problems with trash and debris in the channels.

3) Project costs. There were numerous questions regarding the costs of the proposed project and community responsibility to cost share.
4) Alternatives. The primary concern regarding alternatives appeared to be their relative cost.
5) Local financing. There was concern over full participation of all affected communities in the project area.
6) Safety of the LACDA system. Concern over system safety focused on the potential for dam failure, which was explained as being very small, on precise identification of areas likely to be subject to levee failure, and on adequate flood fighting and evacuation programs.
7) Project delay. There was concern that a project might not be in place due to delays in project study and construction.
8) Specific project areas. There were a number of individual concerns related to resources and problems of specific features of the LACDA system. In particular, there was concern that upper basin environmental resources should not be impacted by a project. Specific safety issues were also raised.
9) Flood insurance. There were many questions regarding the cost and availability of flood insurance.
10) Local flooding problems. There were a number of questions regarding local street flooding and the potential for a project to solve these problems.

It is important to note that to date there has been no significant opposition to the proposed channel improvements in the areas under consideration. There are interests which oppose the continued use of concrete channels, preferring to return the existing channels to their natural state. Some opposition to the project is anticipated for these reasons, and traffic problems associated with raising and modifying bridges are anticipated to generate some opposition as well.

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SECTION SIX: CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The District Engineer finds that the existing LACDA system lacks adequate capacity to prevent catastrophic flooding in the lower reaches of the Rio Hondo from Whittier Narrows Dam to the confluence with the Los Angeles River, and the Los Angeles River from this confluence downstream to the Pacific Ocean. Upgrade of the system capacity has been identified as a vital concern to communities in the lower LACDA basin. In addition, the District Engineer finds:

1) The primary cause of the existing system inadequacies is a substantial increase in local runoff from developed areas into an improved storm drain system.

2) Improved analysis methods and 50 years of additional hydrologic records also indicate that the design storms for portions of the LACDA system have a recurrence interval of only about 50 years (2% chance each year), and that therefore the system is not able to provide the desired level of performance expected from flood control facilities in highly developed urban areas.

3) The LACDA system has provided protection from major flooding in the basin for a period of almost 50 years but has an inadequate capability to protect the LACDA basin communities in the future.

4) The San Gabriel River element of the LACDA system provides 100-year or greater levels of protection and thus does not require upgrade.

5) There are no feasible sites for new reservoirs in the system watershed which could be utilized to reduce flooding in the LACDA system in a cost-beneficial manner. This is because the flooding is the result of local runoff in the downstream basin areas.

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6) Modification of existing Corps and local dams in the upper basin is not feasible due to high costs and lack of effectively controlling flooding.

7) There are no cost-effective diversion, off-channel storage, or non-structural measures which could be implemented to solve all or a portion of the flooding problem.

8) Transfer of flows from the Rio Hondo-Los Angeles River system to the San Gabriel system by diversion at Whittier Narrows Reservoir is not a cost-effective approach to the identified problems because it would require equally costly improvements to the San Gabriel River system channel in conjunction with needed improvements on the lower Los Angeles River.

9) Channel modifications in the upper LACDA basin areas are not justified economically because there is already a relatively high level of protection in these reaches of the LACDA system and because overflows in these reaches do not cause damages justifying the available costly solutions.

10) The most cost-efficient approach to modifying the existing channels in the lower LACDA basin is to raise the height of leveed sections of the river from two to eight feet using reinforced concrete parapet walls. This requires modification of twenty-seven bridges, primarily to accomodate the height of the parapet walls.

11) A 133-year conveyance capacity is optimum in the Rio Hondo and lower Los Angeles River reaches because higher levels of protection would require raising of major freeway overcrossings, including the interchange of the Long Beach and Artesia-Riverside Freeways, and a railroad overcrossing which passes beneath an existing freeway overcrossing. These actions would significantly raise costs for a project and would create massive socio-economic dislocations due to traffic interruptions.

B. RECOMMENDATIONS

I recommend that the plan described herein for flood control be authorized for implementation as a Federal project, with such modifications as in the discretion of the Chief of Engineers may be advisable, and subject to cost sharing, financing and other applicable requirements of Public Law 99-662 for this kind of project and as otherwise provided by law. The total first cost of the flood protection project at October 1990 price levels is $337,400,000. The Federal share is currently estimated at $168,700,000. This recommendation is made with the provision that the non-Federal interest will, prior to implementation, agree to the following:

1. Pay 5 percent of the costs of the project assigned to flood control during construction of the project.

2. Provide all lands, easements, rights-of-way, and dredged material disposal areas required only for flood control and perform all related necessary relocations.

3. Payment of additional funds during construction of the project in order to pay a minimum of 25 percent of the total project cost. In accordance with the Water Resources Development Act of 1986 (PL 99-662), the non-Federal share of the project cost shall not exceed 50 percent of the project cost assigned to structural flood control.

4. Maintain and operate without cost to the United States, all project facilities after completion in accordance with regulations prescribed by the Secretary of the Army.

5. Hold and save the United States free from damages due to construction, operation, and maintenance of the project, excluding damages due to the fault or negligence of the United States or its contractors, and free from water rights claims caused by construction and operation of the project.

6. Prior to installation or construction, prescribe and enforce regulations to prevent obstruction or encroachment on flood control works that would reduce their flood-carrying capacity or hinder maintenance and operation.

7. Comply with the applicable requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646).

8. Comply with Section 221 of the Flood Control Act of 1970.

9. Publicize flood plain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership on preventing unwise development in the flood plain.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding.

Charles S. Thomas
Colonel, Corps of Engineers
District Engineer

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LOS ANGELES COUNTY DRAINAGE AREA REVIEW STUDY

DRAFT INTERIM FEASIBILITY REPORT

DRAFT ENVIRONMENTAL IMPACT STATEMENT

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U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

September 1991

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LOS ANGELES COUNTY DRAINAGE AREA (LACDA) REVIEW STUDY
DRAFT ENVIRONMENTAL IMPACT STATEMENT

Lead Agency: U.S. Army Corps of Engineers, Los Angeles District.

Cooperating Agency: County of Los Angeles, Department of Public Works.

<u>ABSTRACT</u>:

The LACDA Review Study is a system-wide approach to identifying means for improving the Los Angeles County Drainage Area flood control system. During the 40 years since its construction, its ability to provide a high level of protection has diminished. This is the result of an increase in surface runoff and an associated increase in flow from additional storm drains.

The proposed plan provides for the construction of concrete parapet walls along the existing channels of the lower Rio Hondo, Los Angeles River and Compton Creek. Selected areas of levee armoring are also part of the proposed action. Additionally, implementation of this project would necessitate the raising of numerous bridges crossing the channel.

Other alternatives were considered and found to be not feasible from an engineering, economic and/or environmental perspective.

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Comments on this Draft EIS should be sent to:

THE OFFICIAL CLOSING DATE FOR THE RECEIPT OF COMMENTS IS 45 DAYS FROM THE DATE ON WHICH THE NOTICE OF AVAILABILITY OF THIS DRAFT EIS APPEARS IN THE <u>FEDERAL REGISTER</u>.

U.S. Army Corps of Engineers
Los Angeles District
P.O. Box 2711
Los Angeles, California
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Attention - Mr. Ron Ganzfried
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Note: Information, displays, maps, etc. discussed in the LACDA Feasibility Study are incorporated by reference in this EIS.

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SUMMARY

S.1 MAJOR FINDINGS AND CONCLUSIONS

Several alternative and plans were considered for improvement of the Los Angeles County Drainage Area (LACDA) to reduce the current flood potential in some portions of the system. Preliminary engineering and environmental analysis resulted in the screening out of all but two, plus the No Action alternative.

Continued flooding potential in portions of the LACDA system, particularly in the lower Rio Hondo and the lower Los Angeles rivers would be the consequense of implementation of the No Action alternative although there would be no environmental consequenses.

The proposed plan, consists of construction of parapet walls ranging in height from 2 to 8 feet along the top of the existing levee. This plan would necessitate the raising of numerous bridges along the Rio Hondo and Los Angeles rivers. Environmental impacts associated with the implementation of this alternative center around construction-related impacts, including noise and dust generation, traffic impacts and temporary disruption of bicycle and equestrian trails. Aesthetic impacts are also anticipated in conjunction with construction of the walls. It should be noted that the plan would reduce the flooding potential on the lower Los Angeles and Rio Hondo rivers, but would not correct the less severe upstream flooding potential.

The Modified Cross-section Alternative is a composite of Alternatives Two and Three in the Main Report, and consists of either converting existing trapezoidal channels into rectangular channels through construction of vertical retaining walls along the lower Rio Hondo and Los Angeles rivers, widening the existing trapezoidal channel, or a combination of both actions. This alternative would also include dredging the lower 2.5 miles of the Los Angeles River channel to a maximum of an additional 5 feet. Minimal bridge reconstruction would be involved with this alternative. Impacts associated with this alternative include the potential loss of approximately 6 acres of wetland, sedimentation impacts associated with construction and dredging, as well as noise and traffic related impacts. There would be additional public safety impacts associated with bike and equestrian trails along the river. Similar to the proposed plan, this alternative would increase flood protection in the lower Rio Hondo and Los Angeles Rivers, but afford no improvements in the upper Los Angeles River.

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S.2 AREAS OF CONTROVERSY

Based upon public input at the March 1989 public scoping meetings, two areas of potential controversy are presented below. Other issues discussed at the scoping meetings are identified in Section 5.1 of this EIS.

S.2.1 Areawide Planning and Growth Management

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Many communities in the flood plain, including the City of Los Angeles, are attempting to implement growth control strategies, and concern has been expressed that the magnitude of the proposed project may not be in line with other basin planning activities.

More specifically, the flow simulation model used by the Corps in designing the required improvement contains certain assumptions regarding development of currently undeveloped lands within the basin. It has been suggested that the proposed Corps project may be growth inducing as a result of these design assumptions and the "capacity" which is built in to handle flows from future areas of potential development.

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Two aspects are important to note concerning this issue. The first has to do with what is growth inducing. The Corps model does assume a developed condition for certain currently undeveloped lands in the drainage area. The percentage of flow increase attributed to this development is about 2 percent of the total flow handled by the system, which and makes little difference in the magnitude of improvements proposed. The basin is considered already fully developed. Further, flood control structures, or lack thereof, do not limit growth in the manner that lack of water or sewer service limit growth. Lack of flood control facilities has not been an important factor historically in stopping development activity.

The second aspect of this growth-inducement issue is the fact that the primary areas of potential development exist in the drainage area headwaters, and the proposed system improvements are focused on the lower, downstream area of the drainage system. The present flood control inadequacies in the lower Los Angeles River and Rio Hondo need to be addressed. No upstream projects can alleviate the need to provide downstream solutions. An incrementally larger downstream solution can provide improved protection in a cost-effective manner. Additional improvements upstream are not effective from a flood control, economic, or environmental point of view.

S.2.2 <u>Project Economics</u>

The economic impact of the project on the cities within the 100-year flood plain was an issue of concern on the part of several participant representatives of local communities. The main issue was whether they would have to pay any costs of the project.

The cost of the project will be shared among the principal local, state, and Federal entities. The Federal government, through the Army Corps of Engineers, is responsible for between 50 and 75 percent of the total project costs. Non-federal interests are, therefore, responsible for between 25 and 50 percent of the total project costs. The local sponsor, the Los Angeles County Department of Public Works, will be responsible for paying this portion. It is possible that the State of California will reimburse up to 70 percent of the local outlay through its subvention program. The local sponsor's funds would come from the flood control budget and would be sufficient to cover project costs. Cities and communities within the lower river flood plain will benefit from the improvements, but will not be required to pay for any construction or maintenance.

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S.3 UNRESOLVED ENVIRONMENTAL ISSUES

There are no unresolved environmental issues with the proposed plan.

S.4 RELATIONSHIP TO ENVIRONMENTAL QUALITY STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS

During the initial project planning and engineering process for the proposed action, consideration was given to the applicable environmental regulations and statutes affecting the environment. Table S.1-1 lists the statutes and indicates the degree of compliance achieved for each alternative. The applicable statutes are also briefly discussed below.

National Environmental Policy Act. This Environmental Impact Statement (EIS) has been prepared in accordance with the National Environmental Policy Act (NEPA) and the Army Corps of Engineers' Procedures For Implementing NEPA, dated March 1988. This EIS contains all sections of content required by NEPA, including a description of the alternatives under consideration as well as a description of environmental resources affected by the proposed alternatives. A description of the public involvement process is also included.

Fish and Wildlife Coordination Act. In compliance with this act, the Corps of Engineers initiated early coordination with the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (Appendix G). Through these consultations and associated field studies, it was determined that the proposed action would not require the use of a Habitat Evaluation Procedure (HEP). The channels of the Los Angeles and Rio Hondo drainages support little wildlife, except at the ocean interface. Also, the alternatives evaluation process determined that alternatives which would affect the biotic resources within flood control basins were infeasible. Consultation with these agencies will remain ongoing throughout the EIS process.

Endangered Species Act of 1973, as amended. The Endangered Species Office of the USFWS identified four species that are endangered or threatened in the area of the proposed action. The mouth of the Los Angeles River supports resident California least tern populations, and the area is also known foraging habitat for the California brown pelican. The other two listed species are the Nevins barberry and San Fernando Valley spine-flower. After assessing proposed impacts, the Corps and USFWS have determined, through the Biological Assessment (see Appendix C), that there will be no significant effect on the endangered species. As such, formal consultation pursuant to the Endangered Species Act is not required.

Executive Order 11988, Flood Plain Management. The proposed action is designed to maintain the integrity of the flood plain and to improve the capacity of the existing flood conveyance system. The proposed project complies with this Executive Order.

Executive Order 11990, Protection of Wetlands. Wetlands protection has been considered. No wetlands are affected by the construction activities.

National Historic Preservation Act of 1966, as amended. The Corps is in partial compliance with this act. Determinations of eligibility to the National Register of Historic Places (NRHP) for all of the bridges which will be modified have yet to be made. The State Historic Preservation Officer has been consulted in regard to the need for additional studies (36 CFR 800.4). These studies will be completed during the Preconstruction Engineering and Design phase and coordinated to bring the project into full compliance prior to any construction.

Clean Air Act of 1972, as amended. The South Coast Air Quality Management District (SCAQMD) is the agency with jurisdiction to enforce the Clean Air Act regulations and other relevant local air quality regulations. The project construction emissions have been compared to the threshold limits which trigger New Source Review Rules as defined by the Clean Air Act. The project does not exceed these threshold limits and therefore can be considered in compliance with the act. However, dust abatement measures have been proposed so that project construction operations will comply with SCAQMD Local Rule 403.

Clean Water Act of 1977, as amended. In compliance with the guidelines at the 40 CFR 230.10(c) (promulgated by the EPA under Section 404(b) of the Clean Water Act), no discharge of dredged or fill material due to this project shall be permitted which will cause or contribute to significant degradation of the waters of the United States. The Section 404(b)(1) Evaluation required by the Act appears as Appendix D. It concludes that the proposed discharge sites for the discharge of dredged or fill materials are specified as complying with the requirements of the guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem. Compliance with Clean Water Act requirements exempting the project from State water quality certification will be effected by submission of this report to Congress and receiving project authorization.

Coastal Zone Management Act of 1972, as amended. Federal consistency review is required when Federal actions may have a direct effect on the coastal zone as defined by the subject act, the California Coastal Act and, specifically, the California Coastal Management Plan. The Corps of Engineers has had informal contact with California Coastal Commission staff relative to the requirements for consistency review. It has tentatively been decided that consistency review will be required because of the potential temporary disruption of recreational activities involving bike and hiking trails along the river and the potential for temporary restricted access to the coast. A coastal consistency determination is provided in EIS Appendix E.

Estuary Protection Act. In planning for use or development of water and land resources, all Federal agencies shall give consideration to estuaries and their natural resources and their importance for commercial and industrial developments. (16 U.S.C. 1224).

All project plans and reports affecting estuaries and their natural resources that are submitted to Congress shall contain a discussion by the Secretary of the Interior concerning the estuaries and their resources and effects of the project on them and his recommendation thereon. Ninety days are allowed after receipt of plans and reports for recommendations to be made. (16 U.S.C. 1224).

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The proposed action and alternatives do not affect an estuary.

Land and Water Conservation Fund Act of 1965, as amended. No financial assistance may be given under any other Federal program for any project with respect to which such assistance to a State has been given or promised under this statute. (16 U.S.C. 4601-8(f)(1)).

No property acquired or developed with assistance from the Land and Water Conservation Funds shall, without the approval of the Secretary of the Interior, be converted to other than outdoor recreation uses. (16 U.S.C. 4601-8(f)(1)).

In order to assure consistency of policies and actions under this Act with other related Federal programs and activities and to assure coordination of planning, acquisition and development assistance to states under the Act with other related Federal programs and activities, the President may issue regulations. (16 U.S.C. 4601-8(g)). There are no lands associated with the proposed project or alternatives that would be purchased with Land and Water Conservation Funds.

Federal Water Project Recreation Act, as amended. It is policy of the Congress and the intent of the Act that:

1. In planning any Federal navigation, flood control, hydroelectric, or multiple-purpose project, full consideration shall be given to the opportunities afforded by the project for outdoor recreation and fish and wildlife enhancement;

2. Planning for development of the recreational potential of Federal projects shall be based on coordination of use with existing and planned Federal, state, and local public recreation developments; and,

3. Construction agencies shall encourage non-Federal administration of project lands and water areas for recreation and fish and wildlife enhancement except where areas or facilities are proposed for certain situations including national recreation areas, national forests, and wildlife conservation areas. (16 U.S.C. 4601-12).

Some facilities within flood control basins and channels have been developed with Federal Water Project Recreation Act funds. None of these uses will be significantly altered or affected by the proposed project. The Secretary of the Interior will be consulted regarding the effect of the development.

Marine Protection, Research and Sanctuaries Act of 1972, (Ocean Dumping). This act regulates the dumping of material into ocean water and strictly limits dumping of material which would adversely affect human health, welfare or amenities, or the marine environment, ecological systems or economic potentialities.

Disposal of dredged material associated with the modified channel cross-section alternative (Main Report Alternatives Two and Three) has not been fully addressed in terms of quantifying toxicity of the material to be disposed. This would be required prior to disposal of this material to an ocean disposal site. This is not the recommended alternative for construction. The NED plan does not require ocean disposal.

Wild and Scenic Rivers Act, as amended. This drainage basin has been highly altered over most of it's area for many years. None of the streams in the area of study are suitable for designation under this act.

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Table S.1-1

RELATIONSHIP OF PLANS TO ENVIRONMENTAL PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS

Federal Statutes	No Action Alternative	Corps NED Plan Alternative	Modified Channel X-section Alternative
FEDERAL STATUTES			
Clean Air Act	N/A	Full	Full
Clean Water Act	N/A	Partial	Partial
Endangered Species Act	N/A	Full	Full
Fish and Wildlife Coordination Act	N/A	Full	Full
National Historic Preservation Act	N/A	Full	Full
National Environmental Policy Act	N/A	Partial	Partial
Coastal Zone Management Act	N/A	Full	Full
Estuary Protection Act	N/A	N/A	N/A
Federal Water Project Restoration Act	N/A	Full	Full
Land and Water Conservation Fund Act	N/A	Full	Full
Marine Protection, Research and Sanctuaries Act	N/A	N/A	Partial
EXECUTIVE ORDERS			
Floodplain Management (E.O. 11988)	N/A	Full	Full
Protection of Wetlands (E.O. 11990)	N/A	Full	Partial
STATE AND LOCAL POLICIES			
Section 1601 California Fish and Game Code	N/A	Partial	Partial
California Coastal Act of 1976	N/A	Full	Full

Notes:

Full - Full Compliance. Having met all requirements of the statute, E.O. or other environmental requirements for the current stage of planning (either pre- or post-authorization).

Partial - Partial Compliance. Not having met some of the requirements that normally are met in the current stage of planning. Partial compliance entries should be explained in appropriate places in the report and/or EIS and referenced in the table.

NC - Non-Compliance. Violation of a requirement of the Statute, E.O., or other environmental requirement. Non-compliance entries should be explained in appropriate places in the report and/or EIS or referenced in the table.

N/A - Not applicable. No requirements for the statute, E.O., or other environmental requirement for the current stage of planning.

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S.5 PREVIOUSLY PREPARED DOCUMENTS

A substantial number of reports have been prepared specifically relating to the LACDA system. These reports are referenced in Section 8. NEPA documents have been prepared for various aspects of specific portions of the LACDA system and are listed below.

Army Corps of Engineers, Los Angeles District

1981 Sepulveda Basin Master Plan and Final Environmental Impact Report/Statement.

n.d. Draft Environmental Assessment, Routine Operations and Maintenance within the Los Angeles County Drainage Area (LACDA). In preparation.

n.d. Hansen Dam Sediment Removal, Supplemental Environmental Assessment. In preparation.

n.d. Hansen Dam Recreation Master Plan, Environmental Impact Statement. In preparation.

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SECTION 1 - NEED FOR AND OBJECTIVES OF THE ACTION

1.1 STUDY AUTHORITY

Under congressional authority, the Los Angeles District of the U.S. Army Corps of Engineers is conducting a flood control study of the Los Angeles County Drainage Area (LACDA) project. The existing flood control system was constructed by the Corps of Engineers and the Los Angeles County Flood Control District (now part of the Department of Public Works) from the 1930s through the 1960s to protect the City of Los Angeles and other metropolitan areas in coastal Los Angeles County from flood damage. Increased urbanization resulting in increased runoff as well as changes in design criteria have resulted in an inadequate level of flood protection afforded by the LACDA system. The purpose of the study is to determine potential methods of increasing the level of flood control protection as well as assessing the environmental effects of modifying facilities. Figure 1.1-1 identifies the general project area.

Prior to 1914, little attention had been directed to the problem of flood control within the LACDA area. The Los Angeles County Flood Control District maintained exclusive authority for flood control from 1916 to 1935. A major flood in 1934 prompted Congress to pass the Emergency Relief Act of 1935 for construction of storm drains, permanent channel improvements and debris basins. The Flood Control Act of June 22, 1936 refined the mission of the Corps of Engineers from that of providing emergency relief to the permanent supervision of future flood control plans which permitted construction of flood control facilities on the Los Angeles and San Gabriel rivers. The Flood Control Act of June 28, 1938, and subsequent Flood Control Acts in 1941, 1944, 1946, 1950, 1954, and 1958 allowed for the completion of the LACDA system.

1.2 PUBLIC CONCERNS

Based on the public scoping meetings held on March 9, 1989, as well as prior meetings, the following are considered major public concerns:

- o Potential impact to wildlife, including areas behind the various dams; the aquatic vegetation in a small portion of the lower Los Angeles River; and potential impact to the California least tern.
- o Potential aesthetic impacts both from the parapet walls as well as from graffiti that the walls may invite.
- o Cumulative impacts associated with development within the LACDA area.
- o Potential impacts to recreation, including bicycle and equestrian trails.
- o Safety concerns associated with the LACDA system.
- o Economic concerns relative to the cost and funding share for LACDA improvements.
- o Concern over the NED plan and the feasibility of other alternatives.

1.3 PLANNING OBJECTIVES

The planning objectives of the LACDA Feasibility Study are as follows:

- o To reduce the potential for human suffering and possible loss of life due to catastrophic failure of the flood control system, wherever feasible;
- o To reduce flood damages originating from the study reaches by increasing the level of flood protection, wherever feasible;

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- To provide, where feasible, project-related water conservation, recreation development, sediment management, transportation, and environmental enhancement opportunities.

A number of factors have gradually increased the flood threat to Los Angeles County. Analyses indicate that flood events as frequent as 25 years may exceed the capacity of the flood control channels and inundate certain urban areas, especially in the lower Los Angeles River (Reach 4). The low level of protection is attributable to the following factors.

- The original design storm for portions of the LACDA system is based on hydrology that now translates to an approximately 50-year flood;

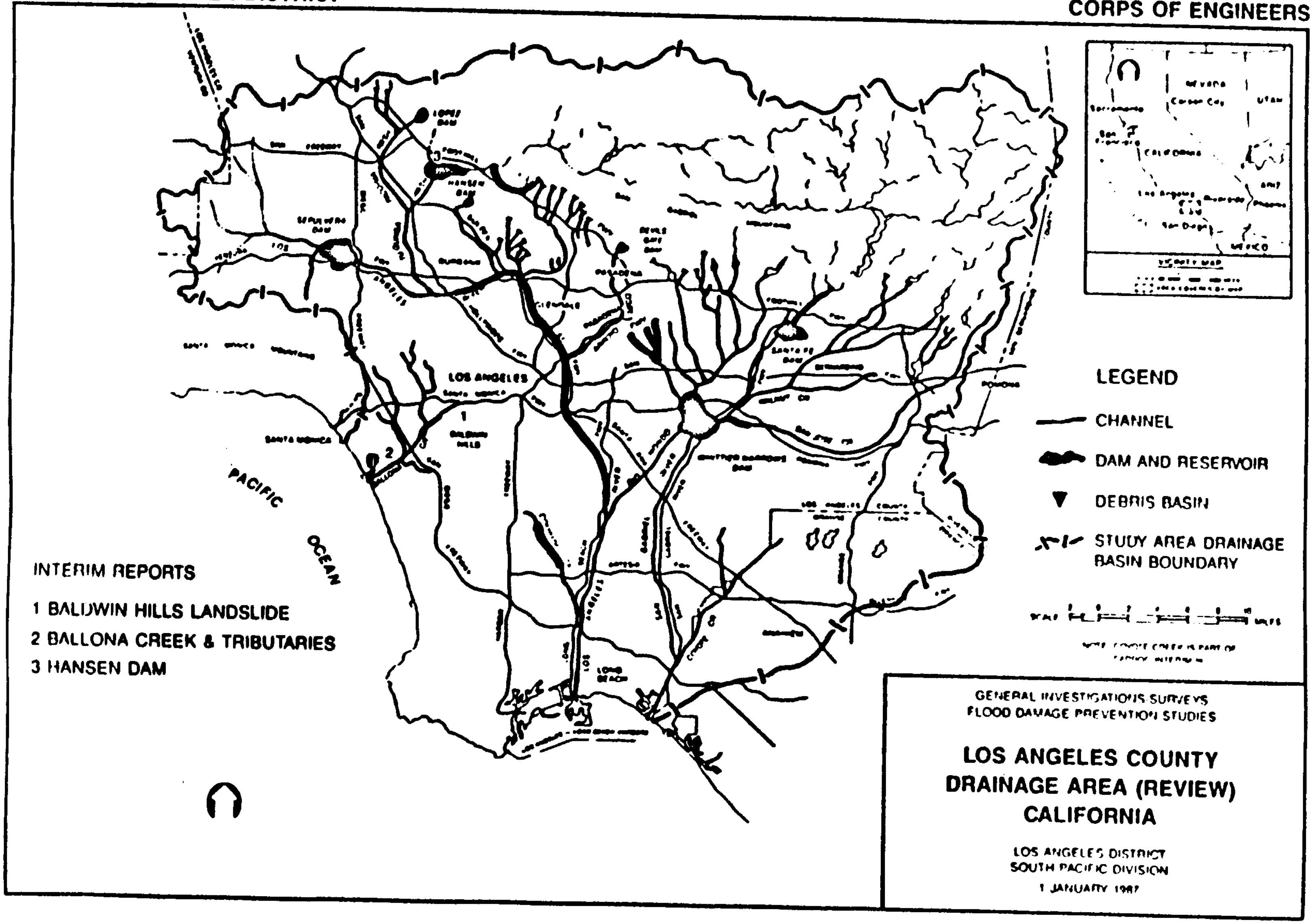
- Intensive urbanization in the last fifty years has significantly increased the runoff response of the watershed, thereby increasing the maximum peak flow of water the system must handle during a major storm event;

- Greater understanding of freeboard requirements in leveed channel sections has lowered the calculated safe conveyance capacity of some portions of the LACDA channels below original design capacities;

This environmental impact statement describes and assesses the environmental impacts of the alternatives associated with various levels of flood protection within the LACDA system.

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



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SECTION 2 - ALTERNATIVES

2.1 PLANS ELIMINATED FROM FURTHER CONSIDERATION

A range of solutions to reduce the flood threat along the Los Angeles River and the Rio Hondo has been considered by the Corps of Engineers during the initial plan formulation phase of the study. Two stages of analysis were conducted to determine the most feasible alternatives. The first step entailed a general screening and preliminary analysis of many varied alternatives which were listed under the heading of heading of "Strategies" in the main report (Table 5). Several plans were considered and initially rejected. Those passing the primary screening process were analyzed in a more intensive manner. Those passing the second screening were analyzed in further detail. Table 2.1-1 summarizes the various factors used to reject these alternatives from further consideration.

2.1.1 Plans Considered and Initially Rejected

2.1.1.1 Integrate Flow Retarding Facilities into the System

Providing flow retarding facilities other than new flood control dams was eliminated from consideration. This alternative would involve providing additional flood detention facilities in the form of underground reservoirs or aquifers, designation and maintenance of floodways, or discharge of flood flows to wetlands. All of these possibilities have major drawbacks. Underground reservoirs are very expensive and could not be built large enough to be effective. Use of aquifers requires that surface recharge areas be provided. Significant new recharge areas are scarce in the Los Angeles area. Also, recharge does not occur rapidly and is not responsive to rapid runoff events. Designation of floodways is not feasible in urban Los Angeles since development occurs directly adjacent to channels and rivers. Discharge to wetlands is not feasible since an insignificant amount of wetlands exists in the locations where discharging would be most effective.

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Table 2.1-1

SUMMARY OF ALTERNATIVES CONSIDERED

Plans Initially Rejected	Ability to Meet Objective	Feasibility	Environmental Factors	Cost/Benefit Ratio	Reason for Rejecting
PLANS INITIALLY REJECTED					
Flow Retarding Facilities	Will not meet objective	Not feasible	Positive	Not computed, but very low	Not effective or implementable
Construct New Dams	May meet objective	No feasible sites found	Major environmental impacts	Not computed but very low	Not feasible plus major environmental impact
Detention Basins	Would not accomplish objective	May be feasible	Soil disposal impacts	Low benefit-to-cost ratio	Not cost effective
Gravel Pits	May meet objective	Questionable feasibility; will require tunnel or pumps	Some impacts anticipated	Low benefit-to-cost ratio	High cost/availability of sites
Increase Height of Existing Dams	May partially accomplish objective	Feasibility questionable	Possible substantial biological impact; land acquisition impact	Not computed	Environmental impact and may not be feasible
Increase Volume of Existing Dams	May partially accomplish objective	Is not feasible	Significant biological impacts	Not computed	Feasibility and environmental impacts
Modify Gates and Outlet Design in Existing Dams	Will not accomplish objective by itself	Feasible, but will not achieve objective	May create significant impact	Not computed	Will not accomplish objective
Renovate Devils Gate Dam	Would not accomplish objective	May not be feasible	May create significant impact; historic implications	Not computed, but very low	Will not accomplish objective, not feasible
Reoperate Existing Dams	Will not accomplish objective	May be feasible	Potential significant biological impact	Not computed	Environmental and feasibility considerations
New Flood Conveyance Facilities	May meet objectives	Probably not feasible	May have substantial impacts	Not computed but very low	Feasibility/cost and impacts
Expand Capacity of San Gabriel	May partially accomplish objective	Feasibility questionable	Will eliminate soft bottom	Low compared to NED project	Feasibility/greater construction impacts/potential

Table 2.1-1 (Continued)

SUMMARY OF ALTERNATIVES CONSIDERED

Plans Initially Rejected	Ability to Meet Objective	Feasibility	Environmental Factors	Cost/Benefit Ratio	Reason for Rejecting
Deeping Existing Channels	May partially meet objectives	Feasibility questionable	May create substantial impacts/soil disposal, utility disruptions	Low compared to NED project	High cost/soil disposal/utility problems
Damage Management	Will not accomplish objective	Not feasible	No additional impacts from present	Not computed	Will not accomplish objectives
PLANS CONSIDERED FURTHER					
Raise Channel Walls and Modify Bridges	Will accomplish objective	Feasible	Construction impacts significant, especially bridges	B/C = 1.7	Studied in detail
Modification of Channel Cross-Section	May accomplish objective	Feasible	Construction impacts significant	Not computed Greater than unity	Studied in detail

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2.1.1.2 New Dams

In order to reduce peak flood flows on the Rio Hondo and Los Angeles rivers, it may be possible to construct an additional flood control dam(s). This would have the effect of providing an additional major flood flow detention facility which could reduce peak flows in channels downstream. From an economic standpoint, land acquisition and construction of a new major flood control dam would be very expensive. No feasible site has been identified in a location which would provide effective flow detention for the Rio Hondo and Los Angeles River. Also, the inevitable conversion of existing uses to that of flood control would not have a high level of public acceptance even though some recreational benefits are possible. Alternatives involving construction of new dams were not considered feasible and were eliminated from further consideration.

2.1.1.3 Detention Basins

Pacoima Spreading Grounds. Adaptation of the existing Pacoima spreading grounds at the confluence of the Pacoima Diversion Wash and Pacoima Wash was considered to accommodate occasional flood flows. The existing spreading grounds, which contain approximately 153 acres (62 ha), would be excavated to a uniform 15-foot (4.6 m) depth creating a volume of 2,200 acre-feet (2.7 million m^3). Control works for the Pacoima Wash would inlet water directly to the detention facility. The outlet works would include a gated outlet delivering flow to Pacoima Wash.

This alternative would only influence portions of Tujunga Wash. Due to the limited flood damage reduction, this is not a cost-effective flood control solution. It was therefore dropped from further consideration.

Tujunga Wash Spreading Grounds. This is a similar facility to the Pacoima Spreading Grounds. It is located at the confluence of the Pacoima Diversion Channel and Tujunga Wash. It is not a cost-effective solution to local flood control and is not considered further.

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Taylor Yard Detention Facility The existing Taylor Railroad Yard contains approximately 200 acres (81 ha) and is located in the Los Angeles Narrows area generally south of the Glendale Freeway between the Los Angeles River and San Fernando Road. The site was considered for use as a temporary flood flow detention facility. All existing facilities would be removed and the site would be excavated to a uniform 29 feet (9 m) in depth providing approximately 4,500 acre-feet (5.5 million m^3) of detention storage capacity. The site might double as a spreading ground during non-detention periods. New inlet/outlet works would be provided.

This alternative was rejected primarily on a cost-benefit basis as the upstream modifications would be very costly while only creating moderate benefits, and since projected flooding in the downtown Los Angeles area would only create relatively low levels of property damage. There would also be substantial impacts associated with extensive excavations and the disposal of large quantities of earth. Furthermore, the availability of the Taylor Yard is questionable since a development proposal has recently been submitted to local planning authorities.

2.1.1.4 Gravel Pits

Two possible gravel pit sites that could be used as off-channel flood storage were identified in the Irwindale area. The Livingston-Graham-El Monte pit has an approximate potential volume of 40,000 acre-feet (49.4 million m^3) with a surface area of approximately 415 acres (168 ha). The Conrock-Durbin pit has an approximate volume of 41,000 acre-feet (50.6 million m^3) with a total surface area of 365 acres (148 ha).

An inlet to the detention pits would be taken directly from the San Gabriel River channel either as a side flow weir or as a valved, operable reinforced concrete inlet. The amount of water that would be diverted would depend on the frequency of event for which this element is used.

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The existing vertical walls of the quarries would need to be worked to create more gradual side slopes (2:1) and/or stabilized to preclude slippage. Water conservation is a side benefit of this element, either as direct infiltration or by recharge when subsequently returned to the river.

This alternative was rejected from further consideration due to the high cost involved with acquiring the gravel pits, as well as the costs involved with construction of a tunnel or a series of high volume pumps for evacuation. Since the sites are still used for gravel extraction, the Corps would be required to pay for the cost of the unused sand and gravel resources as well as for the costs of the pits themselves. These sites are also proposed for redevelopment by the City of Irwindale, and their acquisition for flood control would impair these plans.

2.1.1.5 Modify Height of Existing Dams

Increasing the capacity of existing flood regulating reservoirs by adding height to the structure was considered. By increasing capacity at major basins, peak flows in channels can be reduced, but not to a wholly satisfactory level. Increasing the height of the dams means that the flood pool elevation and surface coverage would also increase. The additional acreage covered would have to be acquired and managed by the Corps. Land acquisition costs would be significant. Also, the two dams that have the greatest potential benefits from increased capacity, Sepulveda and Whittier Narrows, are most problematical from the standpoint of acquisition of additional land. Increasing the height of existing dams would require expensive structural upgrades, including possible modification of gates and outlet structures. The alternative of increasing the height of existing dams is not considered feasible and is eliminated from further consideration.

2.1.1.6 Modify Volume of Existing Dams

This alternative increases the capacity of existing flood regulating reservoirs by excavation and deepening. Preliminary engineering has determined that the excavation of a significant flood-reducing volume at existing dams has questionable cost effectiveness and feasibility. The excavations currently underway at Hansen Dam and planned for Santa Fe Dam will remove millions of cubic yards of silt and gravel. These maintenance excavations do not increase the capacity of the flood control system, but retain space in the debris pool for future incoming sediment. Disposal of the material may be problematical, and future sediment inflow could render this alternative ineffective. In addition, most of the basins now contain significant biological resources which would be impacted by any major excavation project. Thus it appears that only maintenance-oriented silt removal is feasible at flood control dams and that excavation within flood control dams is not a viable method of increasing system capacity. This alternative will not be considered further in this study.

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2.1.1.7 Modify Gates and Outlet Design in Existing Dams

This alternative attempts to reduce peak flood flows through modification of the gate and outlet works at flood control basins. Of the five major flood control dams, Sepulveda has been identified as the most likely candidate for such modifications because of its unique spillway design. The main disadvantage of this alternative is that gate modifications alone cannot effect significant reduction in peak flow volumes. The channels downstream of dams were designed in conjunction with the existing outlets, and discharge flows from the dams can be modified only to a certain degree without making changes to the channels as well. In addition, structural improvements modifying gate and outlet works would be expensive relative to the benefit received. For these reasons, modification of gates and outlet design at existing dams will not be considered further in this study.

2.1.1.8 Renovate Devil's Gate Dam

This alternative calls for the renovation of the existing Devil's Gate Dam on Arroyo Seco. Although this alternative would have no appreciable flood control benefit for the lower Los Angeles River, it may provide an increment of protection for downtown Los

Angeles. However, structural renovation was considered to be too expensive. The dam is also considered to have historical significance which must be considered in any renovation project. This alternative has been eliminated from further consideration since it does not alleviate any flood threat in target areas of the lower Los Angeles River, and its feasibility and cost effectiveness is questionable.

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2.1.1.9 Re-operation of Existing Dams

Re-operation (or re-regulation) of existing dams involves changing the basic operating criteria of the dams during the rainy season in an effort to change the peak runoff volumes discharged to the channels. This alternative cannot eliminate flooding inadequacies in the LACDA basin. Implementation may reduce the flood threat in some locations but has the potential to increase the flood threat elsewhere as a result. Furthermore, the rapid response time of flood events in the LACDA system would require accurate and prompt transmission of field data and immediate operational response to the information. These constraints jeopardize the viability and reliability of the alternative. As a result, this alternative will not be considered further in this study.

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2.1.1.10 Construct New Conveyance Facilities

Options to convey additional flood flows include construction of new aqueducts, pipelines, tunnels and/or channels. Overland options such as channels and aqueducts have the major problem of the high cost of obtaining new rights-of-way. The construction of underground options would also be very costly and construction limitations would probably not allow the building of structures large enough to handle a sufficient capacity. The costliness of these options makes them infeasible, and therefore the construction of new conveyance facilities will not be considered further.

2.1.1.11 Expand Capacity of San Gabriel River

As an option to constructing improvements to the Los Angeles River channel, flood conveyance capacity of the San Gabriel River channel could be expanded instead, and flows could be diverted from Los Angeles River to San Gabriel River through re-regulation of Whittier Narrows Dam. This option has low feasibility from both policy and technical perspectives. Improvements would have to be constructed along San Gabriel River similar to those proposed for the Los Angeles River. Modification of the San Gabriel River channel would not be easier or less costly than modifications of the Los Angeles River. Additional improvements would call for eliminating extensive areas of soft bottom along the San Gabriel, involving attendant water rights implications. Significant environmental mitigation would also be required. Thus, benefit-to-cost considerations actually would be less favorable compared to improving the lower Los Angeles River.

Currently, the San Gabriel River provides more than 100-year protection to the flood plain, which is significantly better than the lower Los Angeles River provides. Improving the San Gabriel River channel and burdening it with additional flows is not considered desirable or feasible and will not be considered further.

2.1.1.12 Alter Existing Channels

As an option to increasing the existing channel efficiency, it is possible to excavate and deepen channels to increase flood conveyance capacity. This alternative would have very high costs, perhaps comparable to construction of new channels. Existing concrete channel inverts would be removed, the channels deepened, and new concrete inverts placed. Those sewer pipelines and other utilities which presently run beneath the channel invert would have to be relocated at great expense, and extension and possibly reconstruction of bridge piers would be necessary. Earth moving/hauling would be an extensive undertaking which could only be accomplished during non-rainy months. This option has a low benefit-to-cost relationship and has been eliminated from further consideration.

2.1.1.13 Damage Management Alternative

This alternative would focus on measures to reduce the extent of property damage rather than improving the flood control system. These measures would focus upon four basic features including relocation, flood-proofing, flood-fighting and flood plain management/insurance.

Relocation is impractical in the lower reaches of the LACDA basin due to the extensive area impacted. On upper reaches such as Tujunga Wash, this alternative has a poor benefit-to-cost ratio due to the high value of real estate and relatively low flood damage potential.

Flood-proofing would involve the use of dikes and other structures to reduce the extent of damage to structures. Other measures would involve the raising of structures above flood plain levels and the use of materials to minimize damage on ground floors of buildings.

Flood-fighting would involve the use of sandbagging and other emergency measures to reduce the extent of flooding during a major event storm. This could reduce the magnitude of an event but relies on having sufficient warning time in order to respond effectively.

Flood plain management and insurance are currently in place in the majority of the LACDA basin. This does not diminish the existing flood threat but provides for future regulation of flood plain development and an opportunity for financial recovery in the event of flood damage. In a significant flood event, the insurance payout could be in the billions of dollars.

These alternatives were not considered feasible nor did they achieve the study objective. They were no longer considered in this study.

2.2 NO-ACTION ALTERNATIVE

Under the No Action Alternative, no modifications to the LACDA system other than that associated with general operation or maintenance will be provided. There will continue to be a flood threat on portions of the LACDA system, most notably in the lower Los Angeles River near the City of Long Beach where flood protection of only a 40-year level is provided in some areas.

This alternative would involve no new construction and therefore cause no construction-related environmental impacts. In the event of flood flows exceeding the capacity of the system, the levees would be overtopped and could fail due to erosion on the back side of the levee. This would cause general flooding within the City of Long Beach and adjacent areas which would have the potential for loss of life and severe property damage to residential, industrial and commercial properties as well as public facilities. It is estimated that property damage could exceed $2 billion for a 100-year flood.

There would be severe disruption of transportation systems and the potential for toxic material spills and other water quality impacts. There would also be considerable expenditure of energy and other non-renewable resources associated with the rebuilding of flood damaged areas.

2.3 ALTERNATIVES CONSIDERED IN DETAIL

This section provides a description of the alternatives that can accomplish the project objectives and that will be analyzed in detail in this EIS. The action which is contemplated by the Corps has multiple objectives which include:

- Reducing peak flood flows in target areas of the LACDA system,
- Increasing system flow capacity and/or reducing flood-related damage in areas subject to flooding.

The physical and operational aspects of the alternatives which meet these objectives are described below.

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2.3.1 NED Plan of Improvements (Main Report Section 4)

The National Economic Development (NED) Plan alternative would provide between 100- and 133-year protection for the Rio Hondo and lower Los Angeles Rivers through the implementation of various physical and structural improvements. The proposed improvements fall into the following categories of modification: (1) construction of parapet walls of various heights along the tops of channel levees; (2) raising or modifying traffic, railroad, utility and pedestrian bridges to accommodate higher channel walls; (3) miscellaneous armoring of the levees with stone to prevent wash out;
(4) channel widening at the confluence of the Rio Hondo and Los Angeles rivers; and
(5) overlaying some existing grouted stone channel sides with concrete. It is anticipated that the overall project will require approximately nine years to construct.

2.3.1.1 Parapet Walls (NED Plan)

Parapet walls would be provided on the tops of existing levees on the Rio Hondo Channel and lower Los Angeles River for nearly the entire length of the reaches from Whittier Narrows to the Pacific Ocean. Wall heights would range in height from two to eight feet (0.7 to 2.4 m). Figure 2.3-1 illustrates a typical section detail for a parapet wall. Tables 2.3-1 and 2.3-2 provide information on the location and extent of proposed parapet walls for the lower Los Angeles River and Rio Hondo, respectively. Figures 2.3-2 and 2.3-3 provides a schematic of the maximum parapet wall height by area for each major segment. Concrete would be supplied by batch plants in the area with aggregate coming from the Irwindale area.

2.3.1.2 Raising of Existing Bridges (Main Report NED Plan)

In order to provide parapet walls continuously along the channels, many of the vehicle, railroad and utility bridges which cross the channels must be raised in height. The required height adjustments range from 1.6 to 6.3 feet (0.5 to 1.9 m) for the lower Los Angeles River, and 1.4 to 5.3 feet (0.4 to 1.6 m) along the Rio Hondo.

Of the 25 bridges which cross the lower Los Angeles River, 15 need to be significantly modified. Twelve of the 18 bridges over the Rio Hondo are proposed to be significantly modified. Table 2.3-3 lists the bridges that must be raised and the required height increase for the lower Los Angeles and Rio Hondo. Figures 2.3-5 and 2.3-6 delineate the approximate location of each of these bridges. Raising of these bridges would entail closure for up to an 18-month period. Detours will be provided at most bridges in order to lessen the impact to traffic during the construction period. The proposed detours are summarized in Table 2.3-3. In general, temporary roadway bridges of at least four lanes will be constructed immediately upstream or downstream of the existing bridge. Construction of these bridges may require use of right-of-way in the vicinity of the bridge, as shown in Table 2.3-4. Temporary railroad bridges will also be constructed in a similar manner. Pipeline bridges are not anticipated to require temporary replacement since the construction period to raise these bridges will be much shorter than for railroad and roadway bridges. The bridges are proposed to be constructed in five phases to reduce the intensity of cumulative and adjacent bridge closures.

2.3.1.3 Levee Armoring (NED Plan)

Existing levees would be strengthened by armoring the back slope at selected locations with grouted stone. The specific reaches to receive armoring are shown in Figure 2.3-4. In each location shown on Figure 2.3-4, it is assumed that back sides of both levees will be armored to prevent erosion of the back of the earthen levee in case they are overtopped. Approximately 21,000 cubic yards (15,960 m^3) of grouted stone will be required for the armoring operation. Stone armoring would be delivered from the San Gabriel Rock Quarry or from locations at Santa Catalina Island, San Juan Capistrano, Corona, Colton or Riverside. Stone would be hauled to the site via truck.

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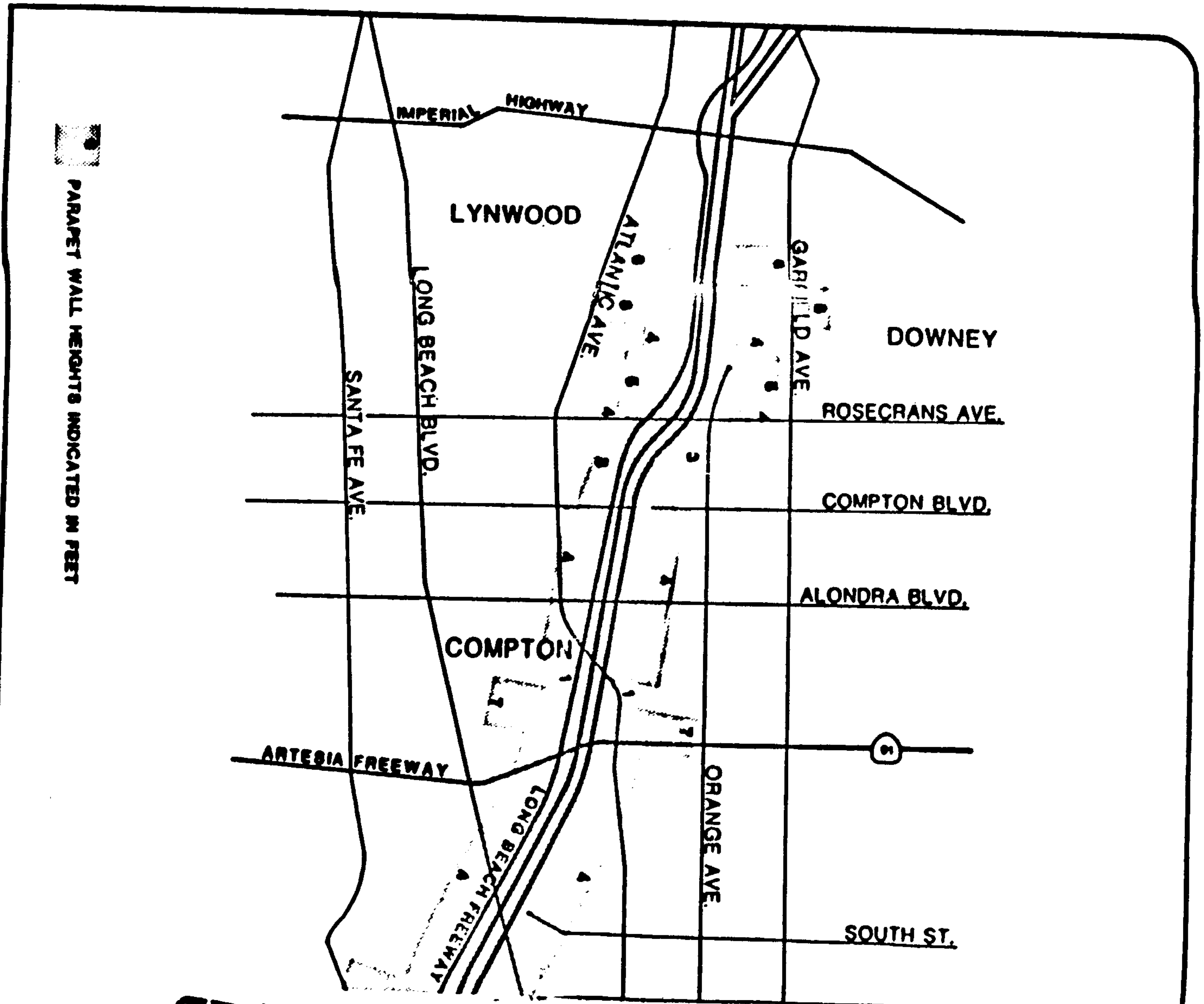
MAXIMUM PARAPET WALL HEIGHTS PROPOSED FOR LOWER LOS



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.NGELES RIVER

FIGURE 2.3-2

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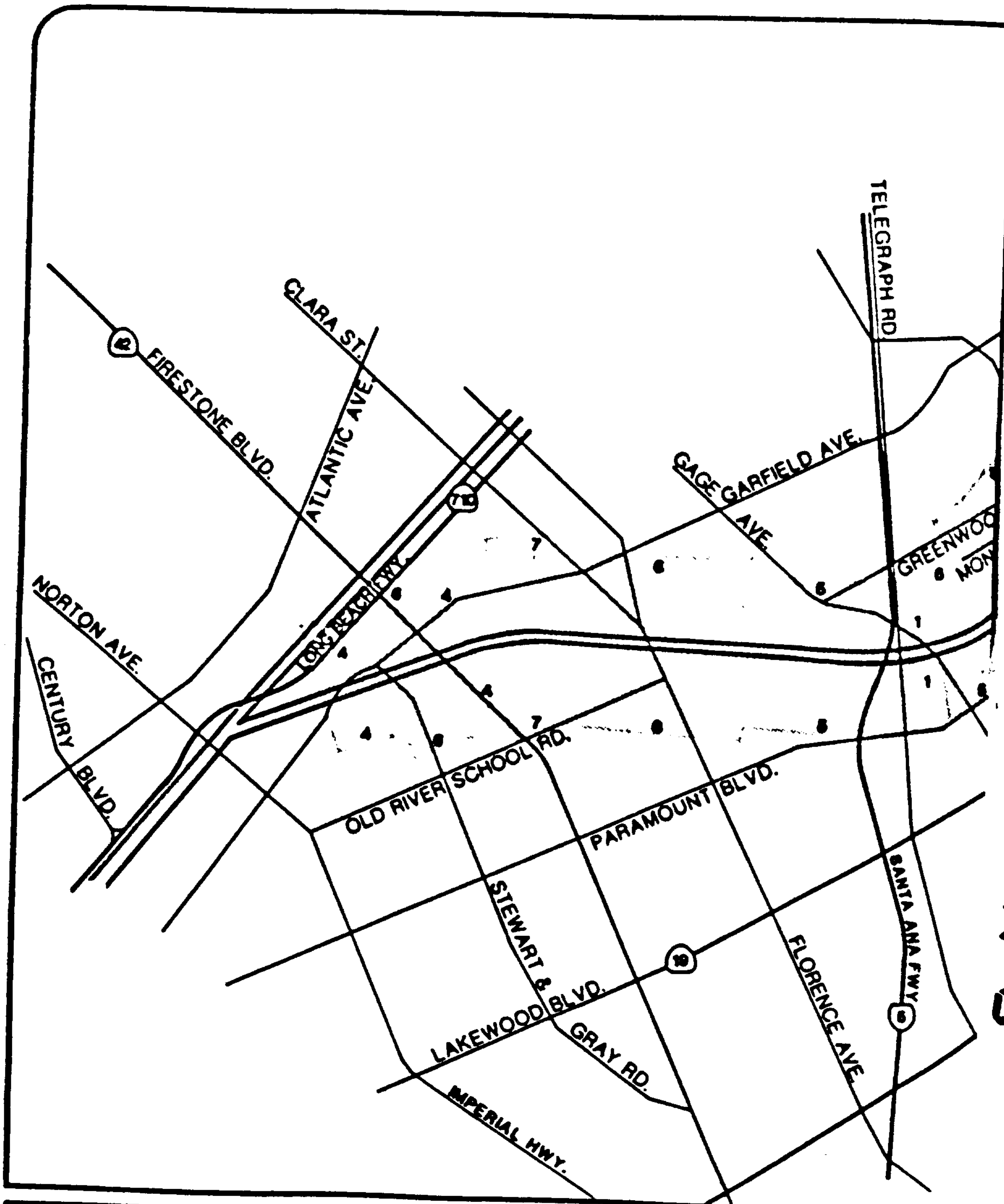

MAXIMUM PARAPET WALL HEIGHTS PROPOSED FOR RIO HONDO C

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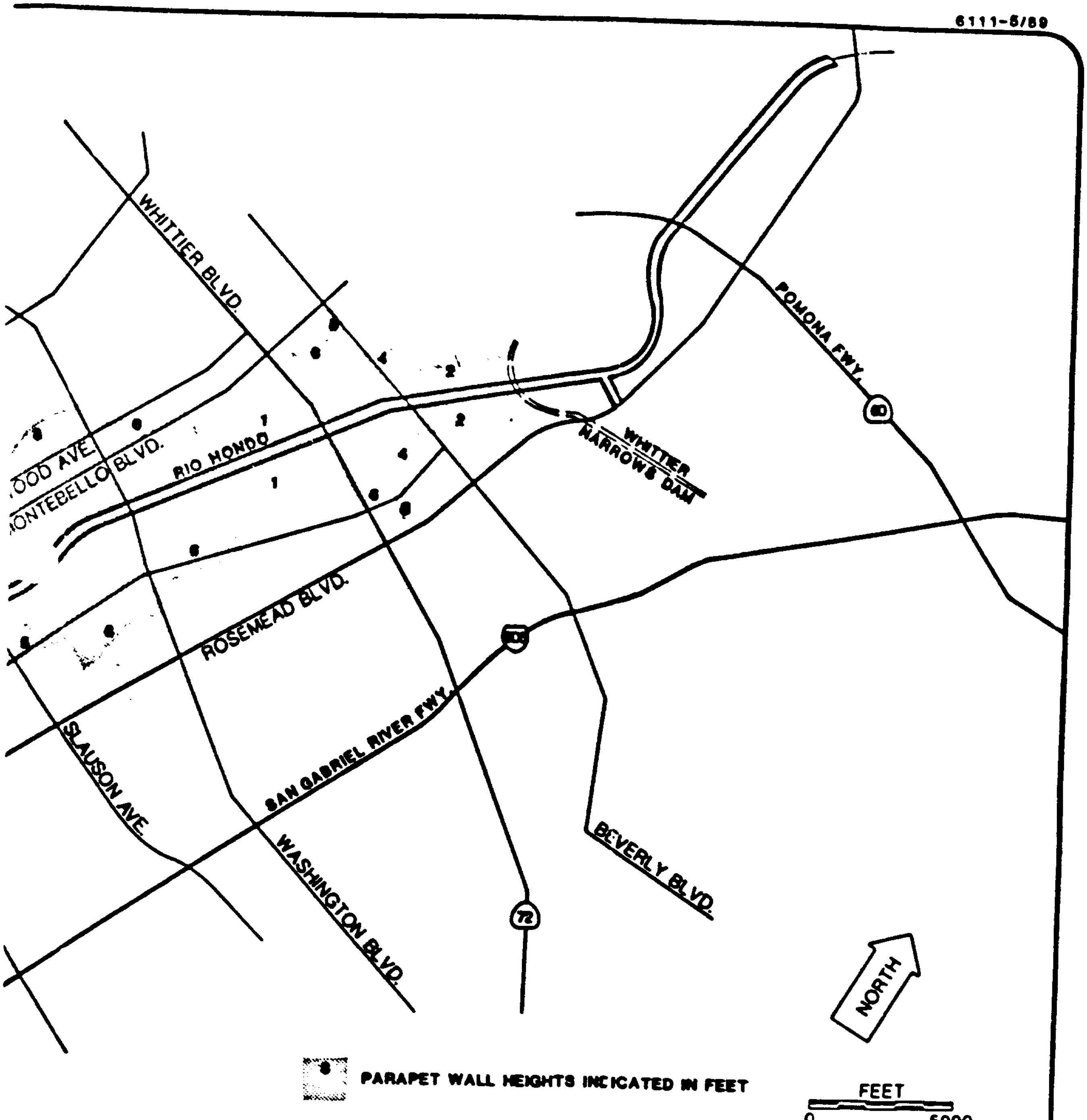

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FIGURE
2.3-3

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Table 2.3-3

RAISE BRIDGE ANALYSIS
LOWER LOS ANGELES RIVER 133-YEAR DESIGN

No.	Bridge	Station	Height To Raise Bridge	Detours
1	Imperial Hwy	634 + 04	0.0[1]	Not required
2	Standard Oil Util	537 + 38	3.4	Not required
3	Rosecrans	532 + 74	3.9	4-lane bridge
4	Compton	502 + 03	2.7	4-lane bridge
5	Atlantic	454 + 63	6.3	4-lane bridge
6	Long Beach	363 + 50	4.0	4-lane bridge
7	Del Amo	311 + 82	5.0	4-lane bridge
8	UPRR	287 + 61	0.0	Temporary bridge
9	LA-LB Light Rail	262 + 48	3.3	Two-track bridge
10	Texas Oil Util	170 + 85	2.8	Not required
11	Willow	157 + 83	4.2	4-land bridge
12	Richfield Oil Util	144 + 62	3.9	Not required
13	Pacific Coast Hwy	104 + 96	3.1	6-lane bridge
14	Edison Util	49 + 75	1.6	Not required
15	PERR	37 + 04	0.0[2]	Not required

[1] Rebuild right abutment
[2] Move bridge 115 feet downstream.

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Table 2.3-4

RAISE BRIDGE ANALYSIS
RIO HONDO CHANNEL 133-YEAR DESIGN

No.	Bridge	Station	Height To Raise Bridge	Detours
1	Whittier	378 + 50.99	5.0	4-lane bridge
2	U.P.R.R.	369 + 03.79	0.0'	Temporary bridge
3	Washington	308 + 43.86	4.8	4-lane bridge
4	A.T. & S.F. Railway	268 + 33.74	2.5	Temporary bridge
5	Slauson	243 + 91.25	2.2	4-lane bridge
6	P.E. Railway	235 + 51.90	1.4	Temporary bridge
7	Pedestrian Xing	218 + 45.00	3.6	Not proposed
8	Suva	180 + 00.44	5.2	Not proposed
9	Florence	150 + 29.57	3.5	4-lane bridge
10	Pedestrian Xing	124 + 50.00	5.3	Not proposed
11	S.P.R.R.	94 + 95.56	3.2	Temporary bridge
12	Firestone	81 + 54.92	1.6	4-lane bridge

' Modify bridge design from plate support to truss type

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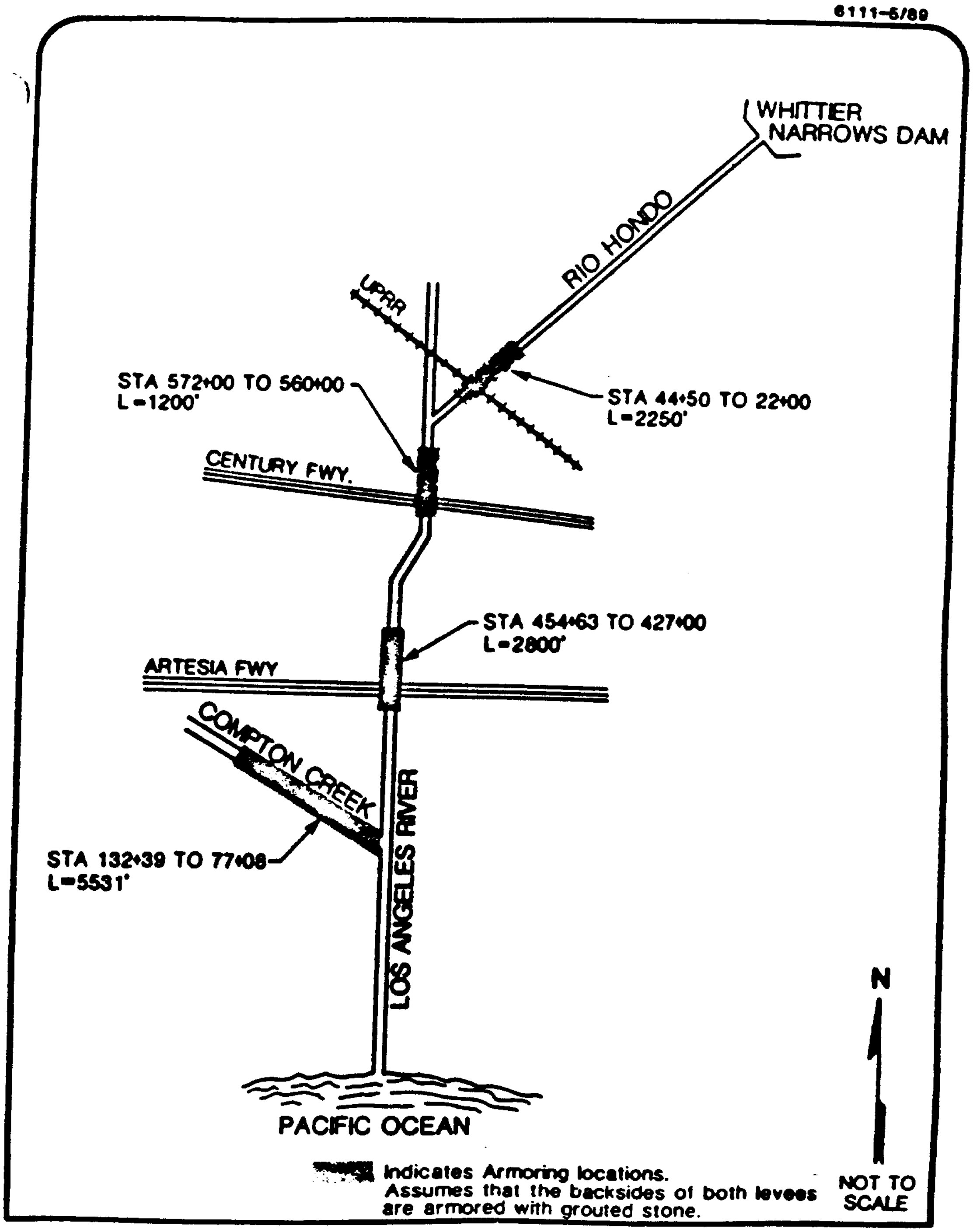

LEVEE ARMORING LOCATIONS

FIGURE 2.3-4

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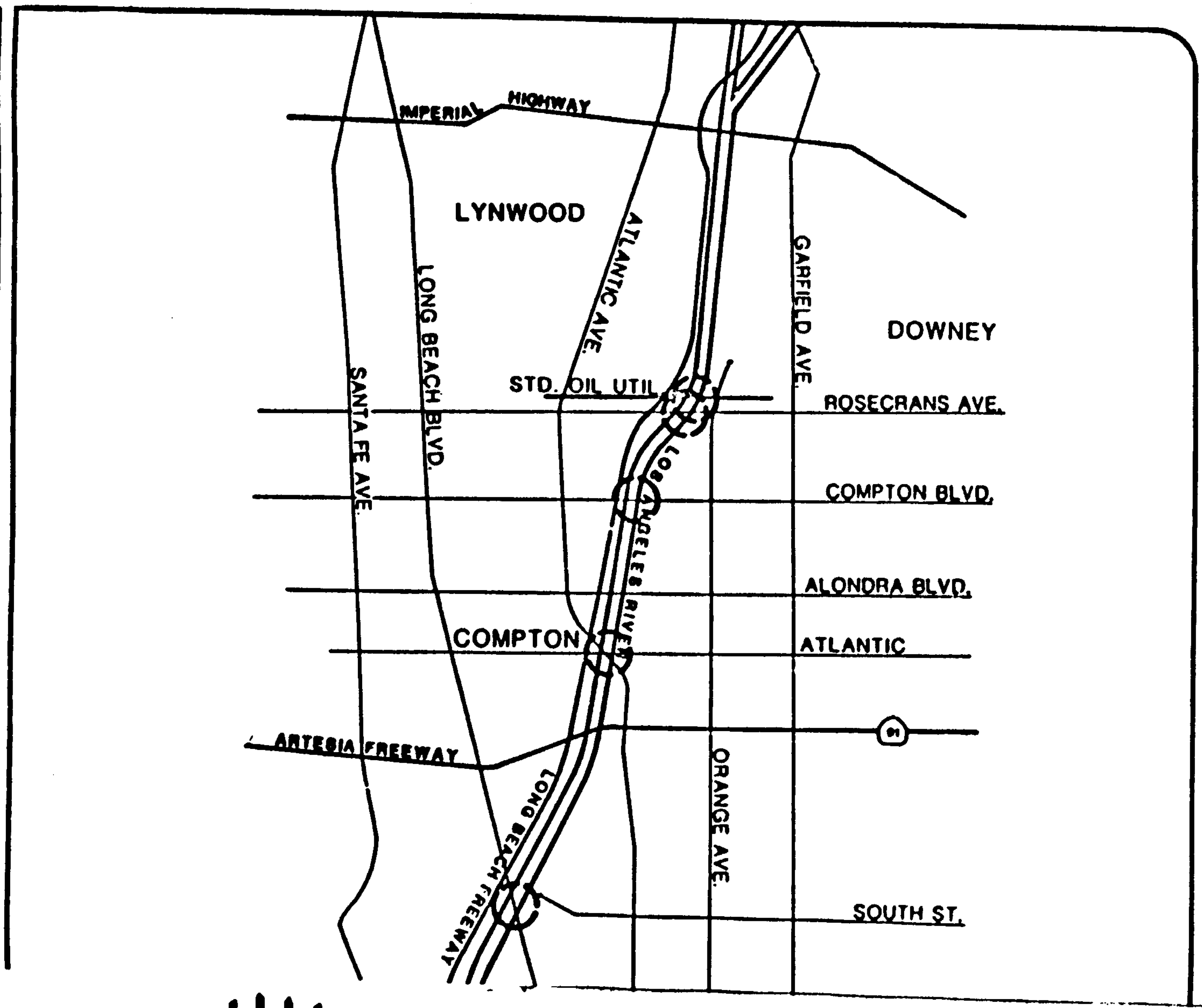
BRIDGES TO BE RAISED ALONG LOWER LOS ANGELES RIVER



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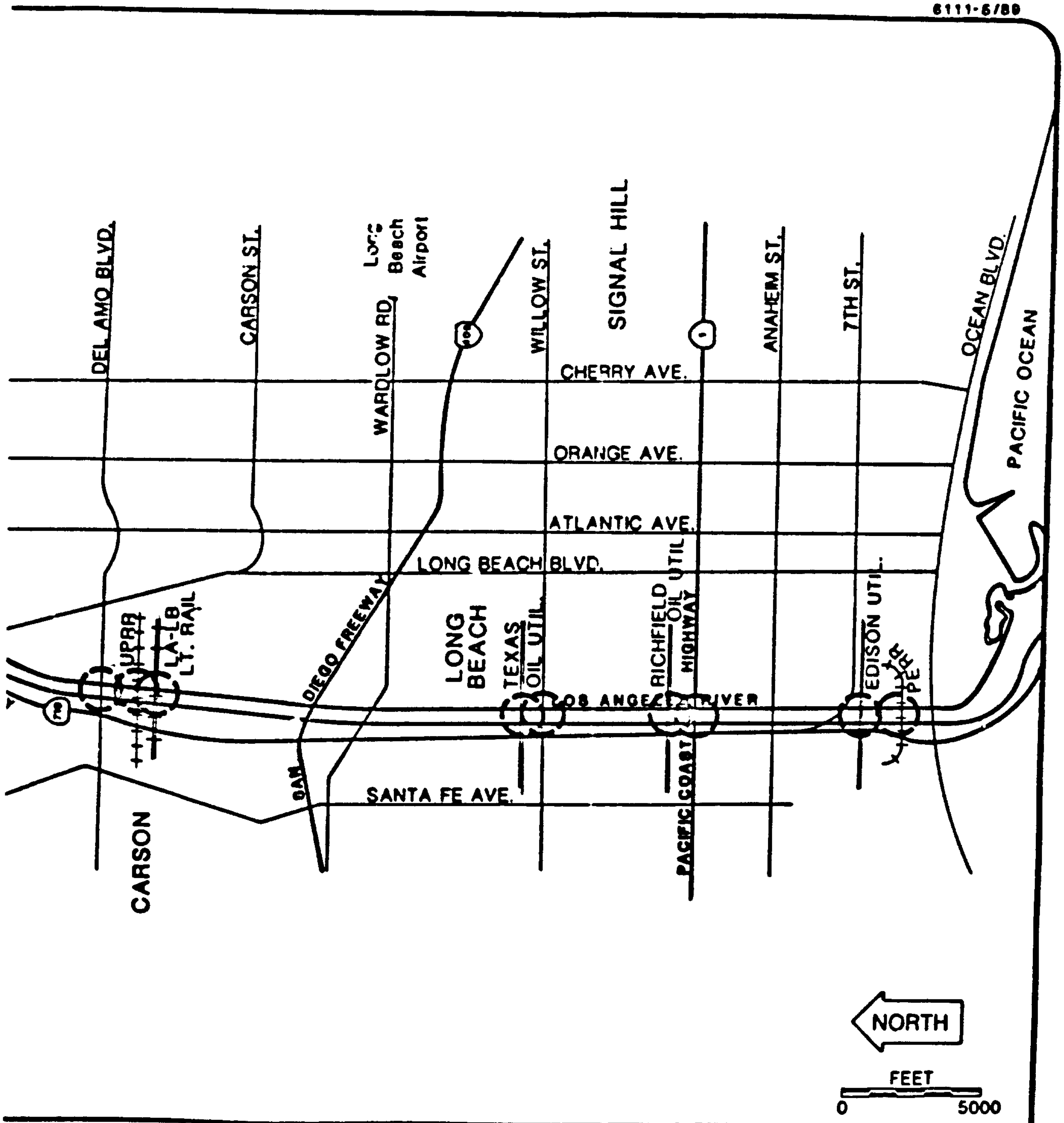
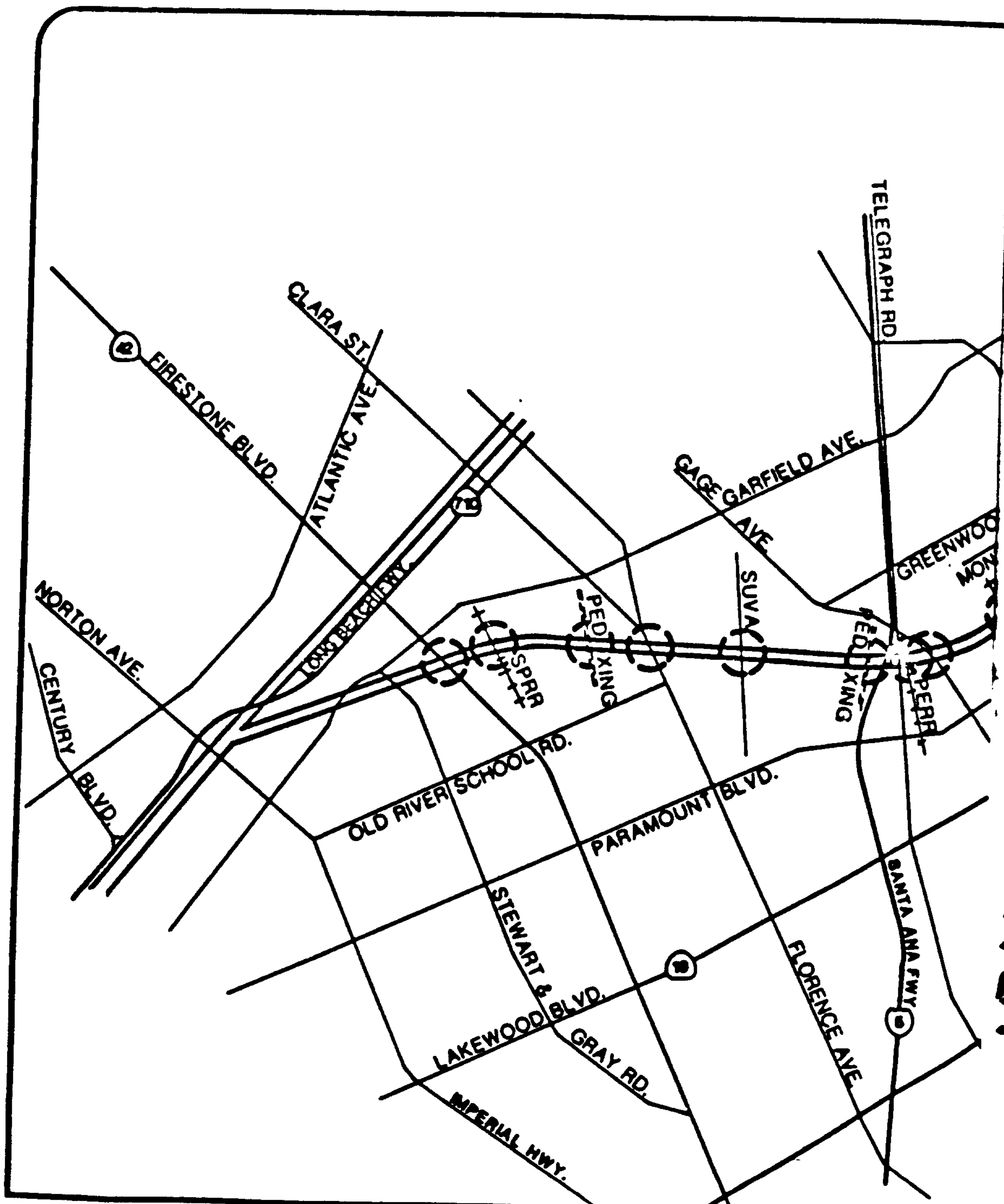


FIGURE 2.3-5



BRIDGES TO BE RAISED ALONG RIO HONDO CHANNEL

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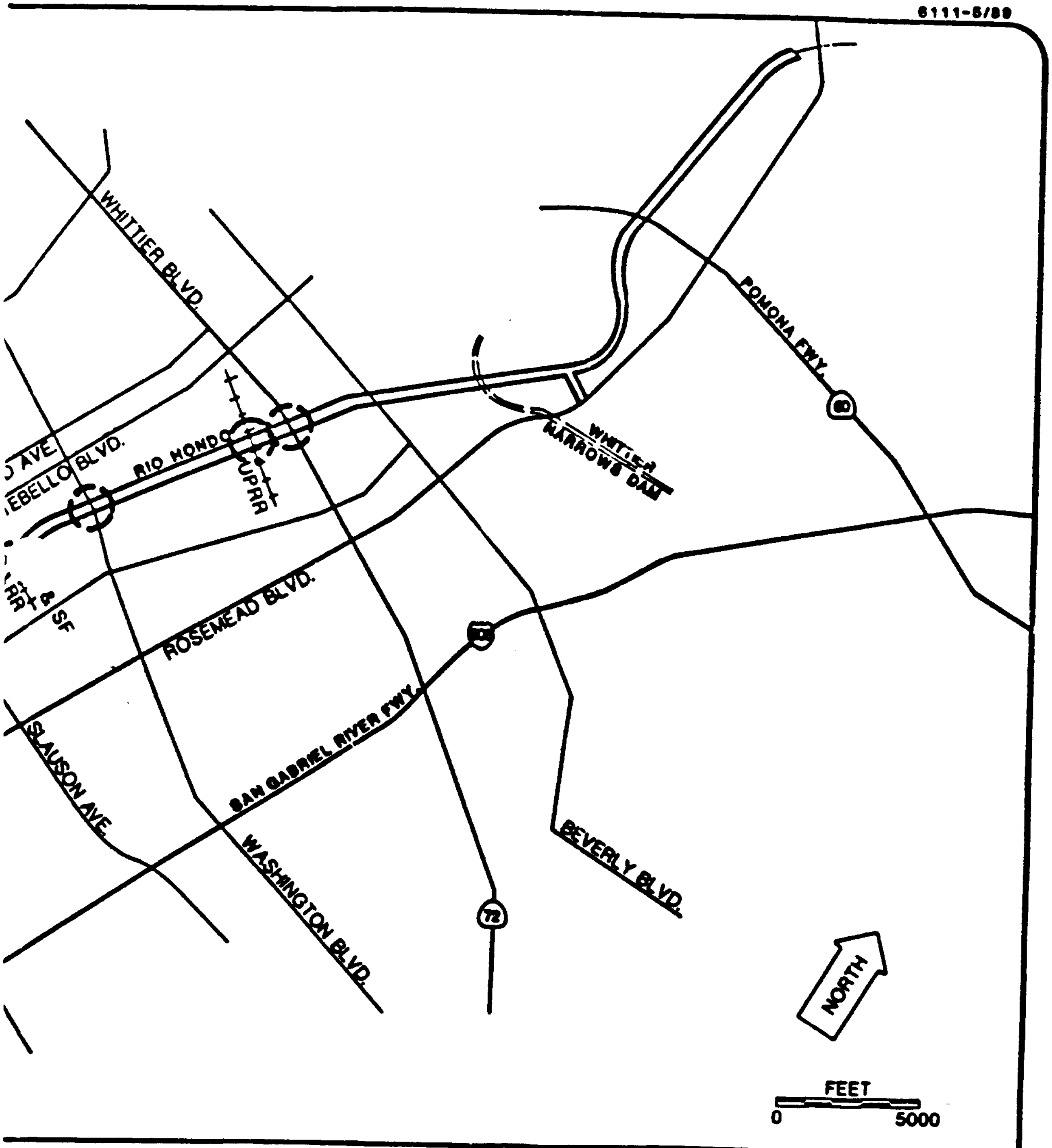

FIGURE
2.3-6

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Table 2.3-5

ESTIMATED PERSONNEL FOR NED ALTERNATIVE

Category	Number
Wall Construction	
Supervisors	2
Surveyors	3
Equipment Operators	12
Laborers	10
Truck Drivers	5
Armoring	
Supervisors	2
Surveyors	2
Equipment Operators	8
Truck Drivers	5
Laborers	6
Bridge Construction	
Supervisors	3
Surveyors	4
Heavy Equipment Operators	14
Laborers	20
Truck Drivers	15
Traffic Control	8

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Table 2.3-6

ESTIMATED EQUIPMENT FOR NED ALTERNATIVE

Category	Number
Wall Construction	
Backhoe	2
Survey trucks	3
Drilling rigs	2
Compressors	4
Concrete trucks	4
Flatbed trucks	1
Soil compactors	2
Motorized Grader	2
Bulldozer	1
Light duty trucks	4
Medium duty trucks	3
Heavy duty trucks	3
Armoring	
Backhoe	2
Bulldozer	2
Compactor	2
Water truck	1
Grout pump and truck	1
Light duty trucks	3
AC Paver	1
Heavy duty truck	4
Bridge Construction	
Backhoe	5
Bulldozer	3
Compactors	5
Light duty trucks	6
Medium duty trucks	7
Heavy duty trucks	8
Generators	4
Compressors	3
Concrete trucks	5
AC paver	1
Motorized grader	3
Drill	4
Crane	3

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Table 2.3-7

TEMPORARY RIGHT-OF-WAY NEEDED FOR BRIDGE CONSTRUCTION

Location of Bridge	Location and Type of Property *Right Bank	*Left Bank
Rio Hondo		
Whittier Blvd.	East end of warehouse, paved parking area	Auto salvage yard
UPRR Bridge, so. of Whittier Blvd.	Horse stables, farms, movable bldg.	Industrial land, no buildings
Washington Blvd.	Office and mgr's qtrs and parking area of 32-unit motel	No impact
Slauson Ave.	Paved and fenced industrial parking	Partial take on Weiner Steel Works, not inclg main bldg.
RR Bridge No. of Telegraph Rd.	Industrial yard with ass'td stored materials	North end of Weiner Steel, fencing
Florence Ave	Partial take of fenced, paved industrial area w/ misc stored items	Affects single-lane dirt access road
RR Bridge No. of Firestone Blvd.	Vacant land at nursery	Vacant land
Firestone Blvd.	Paved and fenced yard area for storage and sale of new autos	Nursery operations and lightly built improvements under power lines
Los Angeles River		
Imperial Highway	County Park, paved roads, landscaping, no structures	Nursery storage, fencing

* Looking downstream.

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Table (continued)

TEMPORARY RIGHT-OF-WAY NEEDED FOR BRIDGE CONSTRUCTION

	Location and Type of Property	
Location of Bridge	*Right Bank	*Left Bank
Los Angeles River		
Compton Blvd.	Paved truck and trailer parking lot, no buildings	Partial take on 3-par golf course incl. fence, grass, access roadAtlantic Ave.
Industrial land,	Horse stables, 3 buildings and paved area	fencing, open paddock area
Long Beach Blvd.	No impact	Trailer park, incl. 7 trailer spaces and improvements
Del Amo Blvd.	No impact	Portion of Sutter school yard, no buildings
Willow Street	No impact	Small area of Long Beach City Park incl. grass and some trees
Pacific Coast Hwy.	No impact	Corner lot with 3-unit building under construction

* Looking downstream.

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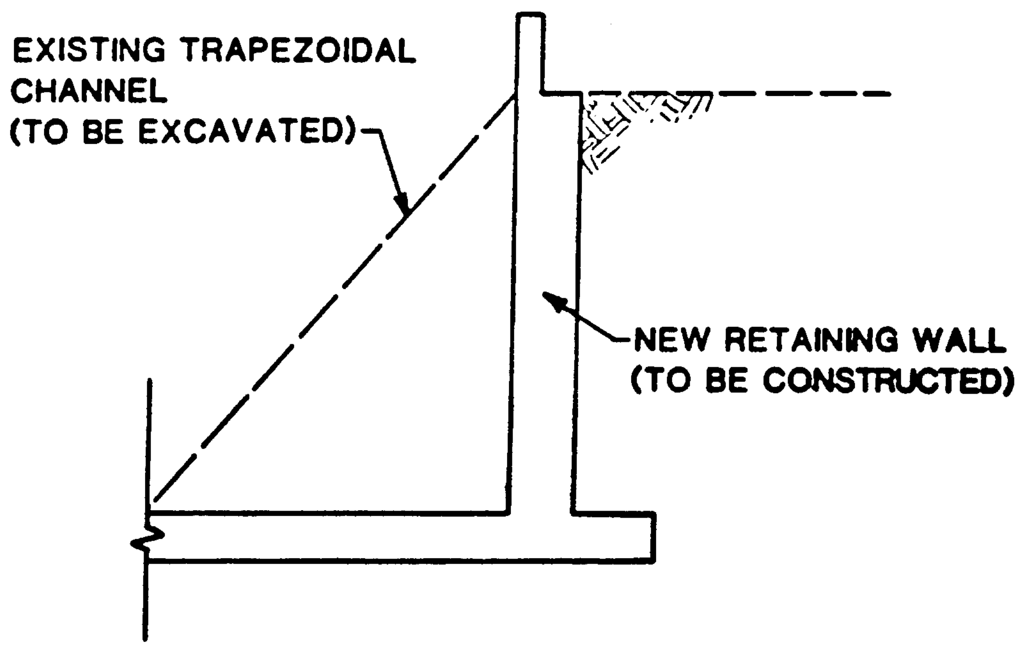

CONCEPTUAL DESIGN OF CHANNEL WIDENING ALTERNATIVE

FIGURE 2.3-7

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2.3.1.4 Widening Channel at Confluence (NED Plan)

At and just downstream of the Rio Hondo-Los Angeles River confluence, a 7000 foot section of the Los Angeles River would be converted from trapezoidal to rectangular cross-section and widened 30 feet. Parapet walls would be constructed on the rebuilt channel walls. Approximately 453,000 cubic yards of excavated material would need to be transferred to a landfill disposal site.

2.3.1.5 Application of Concrete Overlay (NED Plan)

The existing grouted stone channel walls in the vicinity of the Rio Hondo-Los Angeles River confluence will be overlaid with concrete to reduce hydraulic friction and improve channel flow characteristics.

2.3.1.6 Construction (NED Plan)

Overall, construction of the NED alternative will require approximately nine years. Bridge modifications will be accomplished prior to parapet wall construction so that the wall construction can proceed smoothly. Each bridge modification could take from eighteen to thirty months to complete. Tables 2.3-5 and 2.3-6 summarize the personnel and equipment required for construction of this alternative. It should be noted that these are estimates only. An individual contractor may modify the equipment and personnel use.

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2.3.1.7 Additional Flood Protection (NED Plan)

An additional level of flood protection (up to 250-year protection) could be provided to the flood plain on the lower Los Angeles and Rio Hondo rivers by adding height to the proposed parapet walls and raising additional bridges. In most cases, parapet walls could be increased in height by less than two feet (compared to the NED protection levels) to accomplish the additional protection.

A major drawback of this alternative would be the necessity of closing bridge ramps over the Los Angeles River on the Artesia Freeway (Freeway 91). The NED plan (100- to 133-year level of protection) represents the greatest level of flood protection without necessitating the raising of the Artesia Freeway bridges.

2.3.2 Modified Channel Cross-section Plan of Improvement (Main Rpt. Alts. 2 and 3)

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This alternative would entail the widening and/or converting from trapezoidal to rectangular cross-section of the Los Angeles and Rio Hondo channels in the same reaches as the NED project rather than the construction of the parapet walls. The alternative would involve reconstruction of the trapezoidal channel to a rectangular channel along most of the reaches. The last approximately 2.5 miles (4 km) of the Los Angeles River (from Willow Street to the river mouth) would be dredged out to a maximum of five feet below the current channel bottom (invert). The general characteristics of this alternative are described below. The entire project construction would last an estimated six years.

2.3.2.1 Reconstruction of Channel Walls (Main Report Alternatives 2 and 3)

Under this alternative, the existing concrete trapezoidal channel walls would be removed on one side or possibly both sides of the channel. The concrete, as well as a portion of the existing levee, would be removed. A vertical concrete retaining wall would be poured in place. Additionally, a parapet wall of a maximum of 3 feet (0.9 m) would be placed on top of the wall in some locations. Bicycle and other trail systems would remain in approximately the same location as present. Figure 2.3-7 provides a conceptual drawing of the anticipated design.

Equipment required for this aspect of construction would include cranes, excavators and jackhammers for concrete removal. Bulldozers and wheeled loaders would be required to fill up to 100 trucks per day of concrete and other material. These would be hauled away from the site for disposal. Depending upon the location, some of this material could be placed behind the existing levee, but most would be hauled to a landfill or Pier J in Long Beach Harbor. It is anticipated that up to 100 ready-mix concrete trucks would be required on a daily basis for construction of the new vertical retaining wall. Construction activities at any one location would last up to one year.

Although some modifications of bridge supports may be required, it is not anticipated that many bridges would have to be raised. Therefore, most existing bridges would not require reconstruction and would remain in operation throughout the proposed project. It is also anticipated that only a few additional feet behind the existing footprint of the levee would be required for channel modifications.

Approximately the same amount of armoring as described for the NED project would be required. The locations for channel armoring may vary from the NED project. Exact locations for armoring would be determined during final engineering design.

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Table 2.4-1

COMPARISON OF ALTERNATIVES

Impacts	No Action	Alternative NED Plan	 Mod. Chan. X-sec
Ability to Meet Objectives	No	Yes	Yes
Land Use	No impact	Possible significant temp. impact various locations (Table 2.3-7)	Indirect impact to other resources
Air Quality	No impact	Adverse during constr, but not significant	Adverse during constr, but not significant
Water Quality	No impact flood potential remains	Sedimentation impacts not significant flood potential reduced in lower river	Significant impacts associated with dredging. Flood potential reduced in lower river.
Noise	No impact	Significant impact in localized areas during constr	Significant impact in localized areas during constr
Vegetation	No impact	No signficant impact	Temporary loss of approx. 6 acres of wetland habitat.
Wildlife/Aquatic Resources	No impact	No significant impact	Temp. impact to aquatic resources. Impact to species in wetland.

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Table 2.4-1 (continued)

COMPARISON OF ALTERNATIVES

Impacts	No Action	NED Plan	Mod. Chan. X-sec
	Alternative		
Threatened/Endangered Species	No impact	No adverse effect on the existence of least tern/ brown pelican	No adverse effect on the existence of least tern/ brown pelican
Cultural Resources	No impact	Potential impact if NRHP properties are present	No impact
Traffic	No impact	Significant impacts during construction	Potential impacts during construction
Recreation/Aesthetics	No impact	Temp. signif. recreational impact. Sig loss of aesthetics at wetlands area. Impacts from graffiti. LCP impacts.	Temp. signif. recreational impacts. Sig loss of aesthetics at wetlands area. Impacts from graffiti. LCP impacts.
Public Safety	Potential impacts from channel embankment failure	Impacts to trail users during construction. Traffic safety impacts.	Impacts to trail users and general traffic during construction. Impacts from vertical channel walls.
Utilities	No impact	Potentially significant temp. impacts	Potentially significant temp. impacts

2.3.2.2 Dredging Operations (Main Report Alternatives 2 and 3)

The 2.5 mile (4 km) segment of the Los Angeles River from the river mouth to Willow Street would be dredged rather than widened. Although precise dredging requirements are not now known, the maximum depth of dredging would be 5 feet (1.5 m). A diesel-powered dredge would be used in the channel. Removed material would be either loaded on barges and disposed of at a deep water disposal area (probably LA-2 or LA-3) or loaded onto trucks and transported to approved onshore disposal areas such as Pier J in Long Beach. Assuming that removal of the 5 feet (1.5 m) of material were required for all portions of the reach, up to 560,000 cubic yards (425,600 m^3) of material would be dredged and require disposal.

2.4 COMPARATIVE IMPACTS OF ALTERNATIVES

Project impacts are presented in table format in Table 2.4-1 to provide a comparison of the project alternatives.

2.5 ENVIRONMENTAL COMMITMENTS (MITIGATION COMMITMENTS)

Mitigation measures proposed for the project alternatives are as follows:

2.5.1 Land Use

2.5.1.1 No Action Alternative

No Impacts.

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2.5.1.2 NED Plan Alternative (Main Report)

Mitigation for use of the various properties identified in Table 2.3-4 would include financial compensation and full replacement of the site after construction activity has ceased.

2.5.1.3 Modified Channel Cross-section Alternative (Main Report Alts. 2 and 3)

Mitigation measures for activities which encroach upon adjacent uses are presented under other resource sections within this document, including noise, air quality and traffic.

2.5.2 Air Quality

2.5.2.1 No Action Alternative

No Impacts.

2.5.2.2 NED Plan Alternative (Main Report)

o Frequent watering of the construction area to limit dust emissions from on-site equipment and off-site trucks accessing the project,

o Provisions for terminating operations during strong Santa Ana wind conditions,

o Good maintenance, involving proper tuning of off-road heavy equipment to reduce combustion source air emissions (especially NOx),

o Control of diesel fuel quality (low sulfur content),

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o Site activity control/termination during Stage II smog episodes,

o Contractor participation in the AQMD mandatory rideshare program (Regulation XV).

2.5.2.3 Modified Channel Cross-section Alternative (Main Report Alts. 2 and 3)

Mitigation measures are the same as listed above in Section 2.5.2.2.

2.5.3 <u>Water Quality</u>

2.5.3.1 No Action Alternative

No Impacts.

2.5.3.2 NED Plan Alternative (Main Report)

Whenever possible, work within the channel will be confined to low flow periods. Downstream sediment basins will be constructed in order to trap sediments from construction operations. Refueling of equipment near the channel will be limited and closely monitored.

2.5.3.3 Modified Channel Cross-section Alternative (Main Report Alts. 2 and 3)

Sedimentation basins will be constructed downstream of construction activities. A hydraulic cutterhead dredge will be used to minimize turbidity in the channel. Use of these methods should reduce impacts to insignificant levels.

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2.5.4 Noise

2.5.4.1 No Action Alternative

No Impacts.

2.5.4.2 NED Plan Alternative (Main Report)

- o A line-of-sight break between noise sources and the nearest sensitive receptors is a the critical factor in maintaining project activity noise impacts at unobtrusive levels. This would be accomplished by placement of a temporary berm to shield residences and other receptors from construction activity. In areas where land is accessible and available, a large berm would reduce noise levels by as much as 20 dB.

- o In areas of extreme noise conditions where berms are not feasible, either construction of temporary walls to serve as noise barriers or additional limits on work hours will be warranted to protect these sensitive receptors.

- o Smaller, and therefore less noisy, construction equipment will be evaluated for use in the preconstruction engineering design phase in some sensitive construction areas such as parapet walls near sensitive noise receptors.

- o Because of the increased noise sensitivity during quiet hours, time limits on allowable on-site equipment operations are normally made a condition on construction permits. No on-site activities would be permitted before 7:00 AM weekdays and not before 8:00 AM on Saturdays, and not at all on Sundays or holidays because the noise background is lower on those days and project impacts will become more distinct when they are not blended into the background noise environment. No construction activities would occur after 7:00 PM.

- o No effective mitigation is available for the use of pile drivers.

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2.5.4.3 Modified Channel Cross-section Alternatives (Main Rpt. Alts. 2 and 3)

Noise mitigation measures are identical to those described in Section 2.5.4.2 for the NED Alternative except that pile drivers are eliminated and as such, there are no concerns of mitigation for that equipment.

2.5.5 Biological Resources

2.5.5.1 No Action Alternative

No Impacts.

2.5.5.2 NED Plan Alternative (Main Report)

- o The wetland areas in the lower most portion of the Los Angeles river will not be destroyed by construction activities. This area will be monitored to assure that no activities or materials are discharged in this area.

- o In order to prevent impacts to nesting birds in the wetland as well as not to disturb foraging activities of the least tern and brown pelican, activities will not be conducted from April through September in the last one-mile reach of the river near the river mouth. This would result in no adverse effects on the species.

2.5.5.3 Modified Channel Cross-section Alternative (Main Report Alts. 2 and 3)

- o Disturbance to the wetland area can be mitigated through replacement of habitat near the channel area. Mitigations as described under the NED Plan would result in no adverse effect on the species.

- o A hydraulic cutterhead dredge will be used to reduce the degree of turbidity. If chemical testing indicates that dredge specimens are highly contaminated, dredging operations would be restricted to periods of slack tide and low or no river flow. Contaminated sediments would be disposed of at an approved facility and/or site.

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2.5.6 Cultural Resources

2.5.6.1 No Action Alternative

No Impacts.

2.5.6.2 NED Plan Alternative (Main Report)

o The Corps shall complete compliance with Section 106 of the National Historic Preservation Act prior to the initiation of construction. 1

o Prior to implementation of the project, an evaluation and determination of National Register of Historic Places eligibility for all bridges which will be modified must be made. This step has been partially completed. There are still four bridges on the Rio Hondo that must be evaluated by a qualified historian and results coordinated with the State Historic Preservation Officer and the Advisory Council on Historic Preservation.

o If any bridges are determined to be NRHP eligible which would be modified, mitigation would be required. It is assumed that mitigation would consist of HABS/HAER recordation. These mitigation measures would have to be agreed to in a Memorandum of Agreement between the Corps, the California State Historic Preservation Officer and the Advisory Council on Historic Preservation. Execution and implementation of the MOA would constitute compliance with Section 106 of the National Historic Preservation Act.

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2.5.6.3 Modified Channel Cross-section Alternative (Main Report Alts. 2 and 3)

No Impacts.

2.5.7 Transportation

2.5.7.1 No Action Alternative

There is no change; therefore, mitigation is not an issue.

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2.5.7.2 NED Plan Alternative (Main Report)

- o Schedule construction traffic to off-peak hours;
- o Utilize the river channel for construction vehicle traffic and vehicle staging whenever possible;
- o Avoid reducing traffic capacity on two adjacent bridges simultaneously, if possible;
- o Utilize signing and flagmen where construction equipment interface with public traffic;
- o Institute public information programs to enable motorists to avoid congested areas:
    - Place large signs far enough in advance of potentially impacted roadway segments to allow motorists opportunity to alter their routes,
    - Place public notices in local newspapers and cable TV bulletin boards,
    - Distribute mailers in the project area.

2.5.7.3 Modified Channel Cross-section Alternative (Main Report Alts. 2 and 3)

- o Schedule construction traffic to off-peak hours;
- o Utilize the river channel for construction vehicle traffic and vehicle staging whenever possible;
- o Establish an on-site batch plant to mix concrete.
- o Utilize an ocean dredged material disposal site, if possible;

- Utilize signing and flagmen where construction equipment interface with public traffic.

2.5.8 <u>Recreation and Aesthetics</u>

2.5.8.1 No Action Alternative

No Impacts.

2.5.8.2 NED Plan Alternative (Main Report)

- No equally satisfactory alternative exists for mitigation of the rerouting of recreational trails during construction. While construction occurs on the bike path, the possibility exists of using the west side of the levee and surface streets for bicyclists, although this is less appealing due to the presence of automobiles. No mitigation exists for equestrian users. This impact is temporary for the duration of construction (approximately one year) between recreational trail access points.

- Mitigation for the loss of aesthetic views includes the design of trails on the levee top such that views are provided of the land areas to the outside of the channels. This could also include the planting of shubbery in accessible areas and the possible development of additional strip park areas. The development of additional park areas could serve to provide additional recreational resources within communities adjacent to the channel and could be developed under a joint agreement with those communities. As an alternative, mitigation could be provided by the strategic setting of areas of large potted plants or built-in planters and designed seating areas/rest stops at areas along the trails. These measures would result in aesthetic conditions which are improved over existing conditions. These options will be evaluated during the Preconstruction Engineering and

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Design phase when the final project designs and the availability of local fiscal support are known.

- Mitigation measures for the problem of graffiti on the parapet walls include coating the walls with a material such that clean up is easier and incorporating graffiti removal into maintenance activities. There is also a potential that murals could be painted in some areas by the local sponsor(s).

- Mitigation measures include determining whether a temporary bike path can be routed so that access to the coast is still available to recreation users.

2.5.8.3 Modified Channel Cross-section Alternative (Main Report Alts. 2 and 3)

- As described in Section 2.5.8.2, no safe, feasible mitigation exists for the rerouting of recreational trails during construction. The possibility exists of using surface streets for bicyclists, although safety hazards exist for accidents with automobiles. No mitigation exists for equestrian users. This impact is temporary for the duration of construction between recreational trail access points.

- No loss of aesthetic views will occur except for the potential loss of wetlands areas. General mitigation measures include the design of trails on the levee top such that views are provided of the land areas to the outside of the channels. This could also include the planting of shubbery in accessible areas and the possible development of additional strip park areas. The development of additional park areas could serve to provide additional recreational resources within communities adjacent to the channel and could be developed under a joint agreement with those communities. As an alternative, mitigation could be provided by the strategic setting of areas of large potted plants or built-in planters and designed seating areas/rest stops at areas along the trails. These measures would improve aesthetic conditions over existing conditions. These options may be evaluated during the Preconstruction Engineering and Design phase when the final project designs and the availability of local fiscal support are known.

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o Mitigation measures for the problem of graffiti on the parapet walls includes coating the walls with a material such that clean up is easier and incorporating a routine graffiti removal program into maintenance activities. There is also a possiblity that murals could be painted on the walls.

2.5.9 Public Safety

2.5.9.1 No Action Alternative

No changes are being made; therefore, mitigation is not an issue.

2.5.9.2 NED Plan Alternative (Main Report)

o Mitigation for safety impacts along trails at channel levees requires that the trails be closed between trail access points for the duration of construction along that segment. No equally satisfactory alternative exists for the rerouting of recreational trails during construction. Surface streets provide a less appealing alternative for bicyclists. No mitigation exists for equestrian users. This impact is temporary for the duration of construction between recreational trail access points.

o Mitigation includes that fencing and barriers be placed around areas of construction and that construction equipment be placed in areas at night that are secured from the gene.al public. Also, warning signs will be placed in appropriate locations to warn pedestrians and motorists of potential safety hazards.

o Mitigation for trucks delivering materials to and taking materials from construction sites includes the limitation of activity during peak traffic hours and during hours when children are traveling to and from school. Additionally, signs and flagmen will be used in areas to direct traffic where necessary.

o The potential for release of toxic material is also reduced if flood potential is reduced.

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2.5.9.3 Modified Channel Cross-section Alternative (Main Report Alts. 2 and 3)

- Mitigation for safety impacts along trails at channel levees requires that the trails be closed between trail access points for the duration of construction along that segment. No equally satisfactory alternative exists for the rerouting of recreational trails during construction. Surface streets provide a less appealing alternative for bicyclists. No mitigation exists for equestrian users. This impact is temporary for the duration of construction between recreational trail access points.

- Mitigation for the vertical drop of the channel walls includes placing a chain-link or other fencing on top of parapet walls to a minimum combined height of seven feet (2.1 m). This will provide for safe use of the trail system. An alternative would be to build the parapet walls to a height of seven feet (2.1 m), although this results in a "closed-in" feeling, reduces aesthetics and provides more opportunity for graffiti on solid walls.

- Mitigation for trucks delivering materials to and taking materials from construction sites includes the limitation of activity during peak traffic hours and during hours when children are traveling to and from school. Additionally, signs and flagmen will be used in areas to direct traffic where necessary.

2.5.10 Utilities

2.5.10.1 No Action Alternative

No Impacts.

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2.5.10.2 NED Plan Alternative (Main Report)

Close coordination with the pertinent utilities will help mitigate any impacts. Disruption to service will be minimized.

2.5.10.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. 2 and 3)

Mitigation includes that affected utility lines be moved or replaced in conjunction with construction activities. Disruption to service will be minimized.

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SECTION 3 - AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This section describes existing environmental conditions relative to areas affected by the proposed action of the NED Plan and modified channel cross-section alternative. The project study area is composed of two distinct sub-areas, and affected environment descriptions have been provided for these two areas, as appropriate. One study subarea is the existing flood overflow area. This includes both the 500-year and 100-year flood plains (or overflow areas). The 100-year flood plain is important since this subarea will be almost entirely eliminated by the alternatives to the proposed action. The existing conditions in the flood plains are covered to a general level of detail. The lower Los Angeles and Rio Hondo Rivers were analyzed more intensively since any impacts would occur in these areas.

3.2 STUDY AREA OVERVIEW AND FLOOD OVERFLOW AREA DEFINITION

The area of primary interest for the LACDA Review Study includes the major interconnected channels within the LACDA flood control system. Specifically, this general area includes all of the Los Angeles River below Sepulveda Dam, its Tujunga Wash tributary below Hansen Dam, the Rio Hondo between Whittier Narrows Dam and the confluence with Los Angeles River, the San Gabriel River below Santa Fe Dam, and Compton Creek. The reach designations for LACDA channels of interest to this study are shown on Figure 3.2-1 and listed in Table 3.2-1.

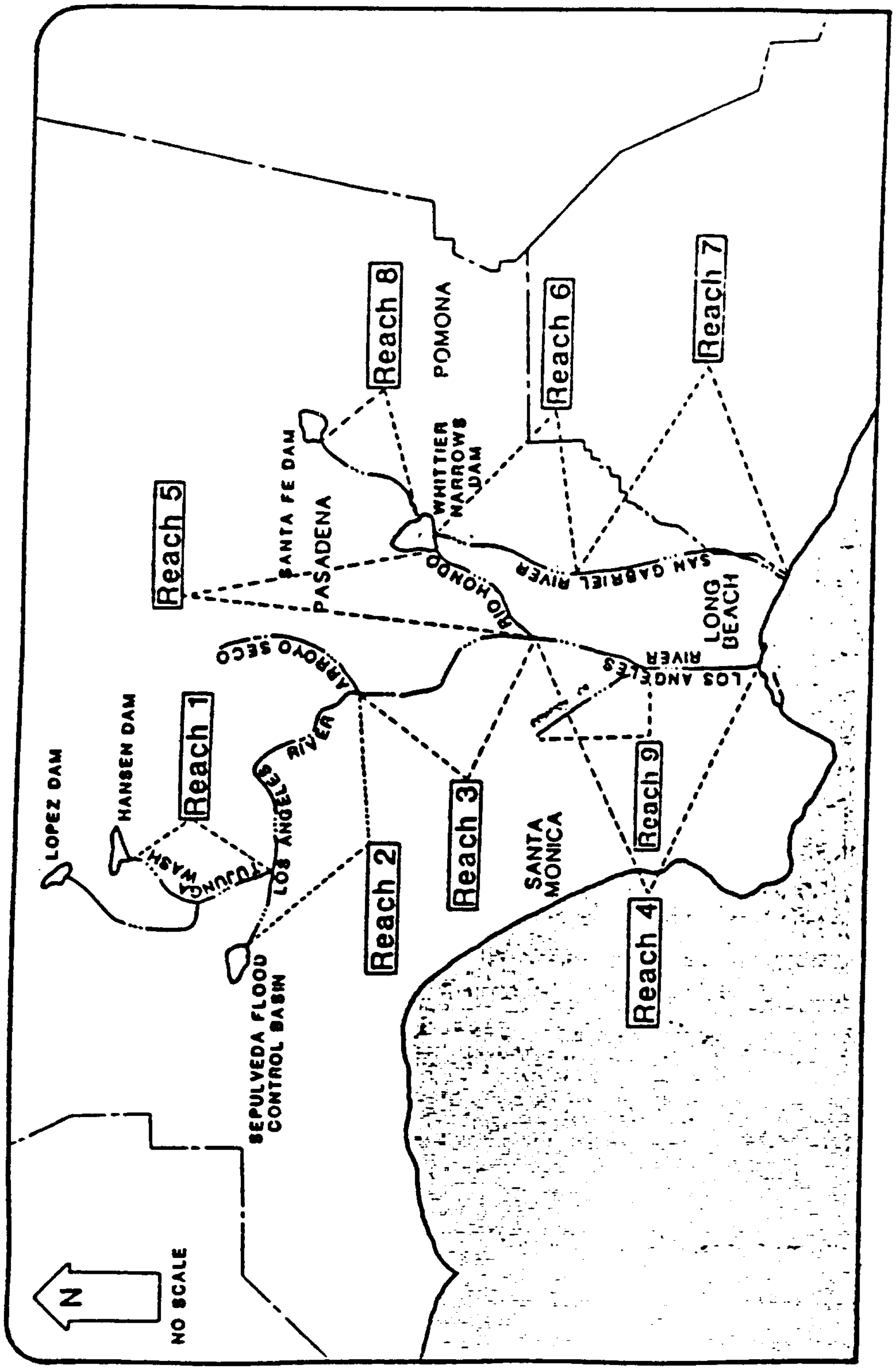

FIGURE 3.1-1 STUDY REACH DESIGNATIONS

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Table 3.2-1

REACH DESIGNATIONS FOR LACDA SYSTEM MAIN CHANNELS

Reach	Location
1	Tujunga Wash Channel - Hansen Dam (499+88.27) to the Los Angeles River (7+00)
2	Upper Los Angeles River - Sepulveda Dam (969+88.83) to Arroyo Seco Confluence (1273.10)
3	Los Angeles River - Arroyo Seco Confluence (1273+10) to Rio Hondo Confluence (614+52.50)
4	Lower Los Angeles River - Rio Hondo Confluence (641+52.50) to Pacific Ocean (16+00)
5	Rio Hondo Channel - Whittier Narrows Dam (442+23.71) to Los Angeles River (7+00)
6	San Gabriel River - Whittier Narrows Dam to Imperial Highway
7	San Gabriel River - Imperial Highway to Pacific Ocean
8	San Gabriel River - Santa Fe Dam to Whittier Narrows Dam
9	Compton Creek

Flood size predictions are made by the Corps of Engineers based on potential rainfall and runoff rates. Floods are also categorized in terms of their statistically projected frequency. A 10-year flood has a 10 percent chance of happening every year, while a 100-year flood has a one percent chance of occurrence every year, and a 500-year flood has a 0.2 percent chance of occurrence every year. However, flood risk increases over long periods of time. A 50-year flood has an 85 percent chance of occurring one or more times over a 100-year period. A 100-year storm has a 65 percent chance of occurring once in 100 years.

Presently, portions of the LACDA system do not have the capacity to prevent flooding from the 100-year flood. The majority of the flood control system was built in the 1930s and 1940s. Since that time, there has been substantial urbanization within the study area with accompanying increases in storm water runoff to channels. This is a result of an increase in impervious surfaces and the increased effectiveness of the storm drain system. Several key portions of the flood control system within the study area could overflow during a 50-year flood.

The 100-year flood overflow area is delineated on Figure 3.2-2. The overflow from a 100-year flood would cover approximately 82 square miles (212 km^{fect} developed areas in the San Fernando Valley near the Los Angeles River and Tujunga Wash, downtown Los Angeles near the Los Angeles River, and a large area bordering the Los Angeles River and the Rio Hondo that encompasses parts of Bellflower, Burbank, Carson, Cerritos, Compton, Downey, Glendale, Lakewood, Long Beach, Lynwood, Montebello, Paramount, Pico Rivera, and South Gate, in addition to some Los Angeles County territory. In some localized areas, flood waters could be as deep as eight to ten feet (2.4 to 3.1 m). Most areas, however, could experience flooding of one to four feet (0.3 to 1.2 m).

The 500-year overflow area also is delineated on Figure 3.2-2. The overflow from a 500-year flood would cover nearly 200 square miles (518 km^2), virtually all of which is urban development. A 500-year flood would cover all of the areas affected by the 100-year flood and, in addition, would cover a large area of central Los Angeles, additional areas in the San Fernando Valley and large portions of the cities of Artesia, Bell, Cudahy, Hawaiian Gardens, Huntington Park, Maywood, Norwalk, Santa Fe Springs, Seal Beach, Vernon and Whittier. There are 26 cities, some Los Angeles County territory, and some Orange County territory within the 500-year overflow area.

Table 3.2-2 provides an estimate of the area covered by flood flows in each major channel reach within the study area for both the 100-year and 500-year floods.

3.3 LAND USE AND SOCIAL CONCERNS

3.3.1 Flood Overflow Areas

The 100- and 500-year flood overflow areas overlay a highly diverse urban environment. The total population within Los Angeles County in 1989 was approximately 8,700,000 persons. The Corps of Engineers estimates that 1,200,000 people reside in the 500-year overflow area, or about 15 percent of the County population. Total employment in the Los Angeles-Long Beach Partial Metropolitan Statistical Area (PMSA), which covers approximately the same area as Los Angeles County, as of 1983 was 4,000,000. The highest employment category is the service sector, with 1,090,000 jobs, followed by manufacturing, with nearly 900,000 employed. Los Angeles County is projected to continue growing through the year 2000. Population and employment trends for the 500-year flood overflow area will be similar to those of the PMSA as a whole; thus population within the 500-year overflow area could reach 1,800,000 by the year 2000.

Land use within the 500-year overflow area is highly diverse with residential, commercial, industrial and public uses spread throughout the area. However, there are high concentrations of particular property categories. Downtown Los Angeles is highly commercial, while there is a concentration of industrial facilities in the area of the lower Los Angeles River below the Compton Creek confluence. The San Fernando Valley is predominantly residential with corridors and pockets of commercial and industrial activity. The area of the San Gabriel River below Imperial Highway is largely residential.

Overall, the total value of improvements within the 500-year flood plain is approximately $40 billion, of which about 50 percent is attributable to single-family residences.

Table 3.2-2

SUMMARY OF AREA FLOODED
(in square miles)

Reach	500-Year Flood	100-Year Flood
Reach 1	11.1	2.0
Reach 2	7.2	1.8
Reach 3	52.6	1.7
Reach 4	46.2	38.5
Reach 5	12.3	12.3
Reach 6	18.2	0.0
Reach 7	50.4	25.7
TOTAL	198.0	82.0

NOTES: Reach definitions are indicated in Figure 3.2-1 and described in Section 2.

Reach 7, 500-year flood includes 4.8 square miles of shallow flows over Seal Beach U.S. Naval Weapons Station and Seal Beach National Wildlife Refuge.

There is not a significant amount of open space in the flood overflow area since the bulk of the area is highly developed. Most open space is associated with recreational facilities such as parks, golf courses and sport fields. Other substantial open space which occurs in the flood plain includes the major water spreading grounds, i.e., the coastal grounds along Rio Hondo and the San Gabriel grounds along the San Gabriel River, and includes the wetlands areas in Seal Beach under control of the U.S. Navy.

The Corps of Engineers has conducted land use surveys in the 500-year overflow area and has tallied the number of damageable structures in each land use category. The inventoried flood plain land use improvement categories included residential use (single-family, multi-family and mobile homes); commercial uses (including retail outlets, hotels and privately-owned offices); industrial uses (including manufacturing plants, research and engineering facilities, warehouses, business parks and construction yards); and public use (including schools, hospitals, churches, public organizations and offices, and police and fire stations). Tables 3.3-1 and 3.3-2 provide data on the number of damageable units by channel reach for the 500-year and 100-year overflow areas respectively.

3.3.2 Land Use Adjacent to Channel Reach Construction Reaches

3.3.2.1 Lower Los Angeles River

The generalized land uses adjacent to this reach are shown in Figure 3.3-1. The predominant use within 2,000 feet (610 m) on either side of the channel is residential. Industrial uses are also prevalent along this reach. Public parks, golf courses and public structures occur throughout the channel study zone; however, many of these features are linear and border the channel. There are six schools whose property is either wholly or partially within 2,000 feet (610 m) of the channel. No churches or hospitals are located within this zone.

3.3.2.2 Rio Hondo Channel

The generalized land uses along the Rio Hondo, Reach 5, are shown in Figure 3.3-2. As with most areas of the LACDA, the uses are mixed, with residential and industrial being the predominant types. There is a substantial amount of public-controlled land in this reach, primarily due to the large spreadings grounds at mid-reach. Three schools are located within 2,000 feet (610 m) of the channel, and no churches or hospitals were identified in this area near construction zones.

Table 3.3-1

NUMBER OF DAMAGEABLE UNITS BY PROPERTY TYPE
(500-YEAR OVERFLOW AREA)

Property Type	Reach 1	Reach 2	Reach 3	Reach 4	Reaches 5 and 6	Reach 7	Total Project
Residential							
Single-Family	13,803	7,622	67,984	60,941	40,167	87,502	278,019
Mobile Homes	269	12	605	4,349	796	2,971	9,002
Multi-Family	2,533	1,168	4,867	1,798	1,166	3,400	14,932
Commercial	886	454	4,519	1,828	504	1,444	9635
Industrial	335	106	2,411	1,417	679	359	5,307
Public	122	63	1,317	750	1,588	1,035	4,885
TOTAL	17,948	9,425	81,703	71,093	44,900	96,711	321,780

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Table 3.3-2

NUMBER OF DAMAGEABLE UNITS BY PROPERTY TYPE
(100-YEAR OVERFLOW AREA)

Property Type	Reach 1	Reach 2	Reach 3	Reach 4	Reaches[1] 5 and 6	Reach[2] 7	Total Project
Residential							
Single-Family	2,616	1,020	74	48,568	21,639	48,680	122,615
Mobile Homes	100	0	0	4,336	234	1,637	6,307
Multi-Family	664	144	56	1,618	809	1,649	4,940
Commercial	66	37	335	1,710	264	776	3,188
Industrial	135	64	138	1,380	286	212	2,215
Public	24	7	97	618	876	621	2,243
TOTAL	3,605	1,272	700	58,248	24,108	53,575	141,508

NOTES: [1]All units are within Reach 5.

[2]Units are located in Reach 7, but damaging flows originate from breakouts on Reach 5.

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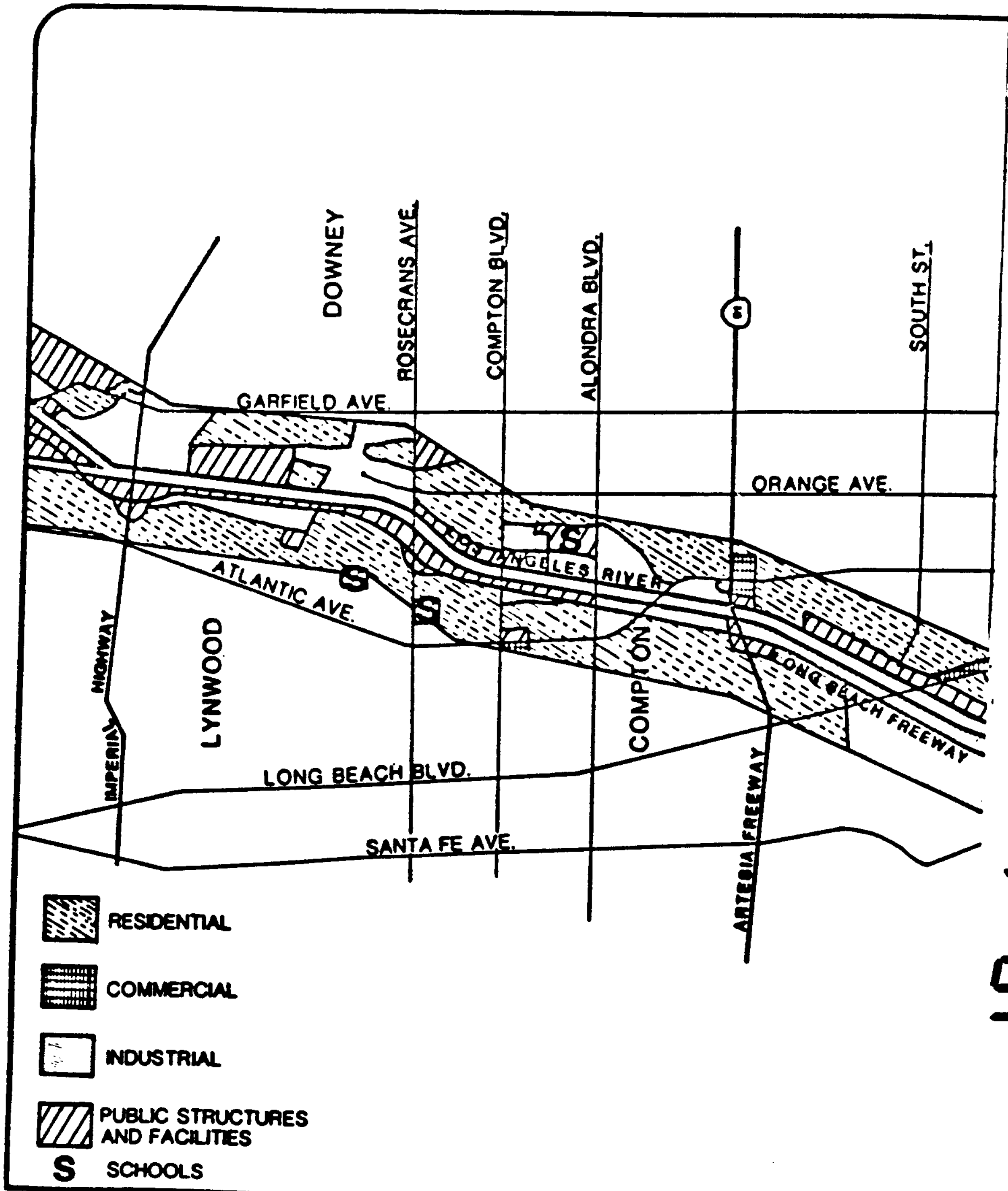

LOWER LOS ANGELES RIVER – REACH 4 GENERALIZED ADJACENT

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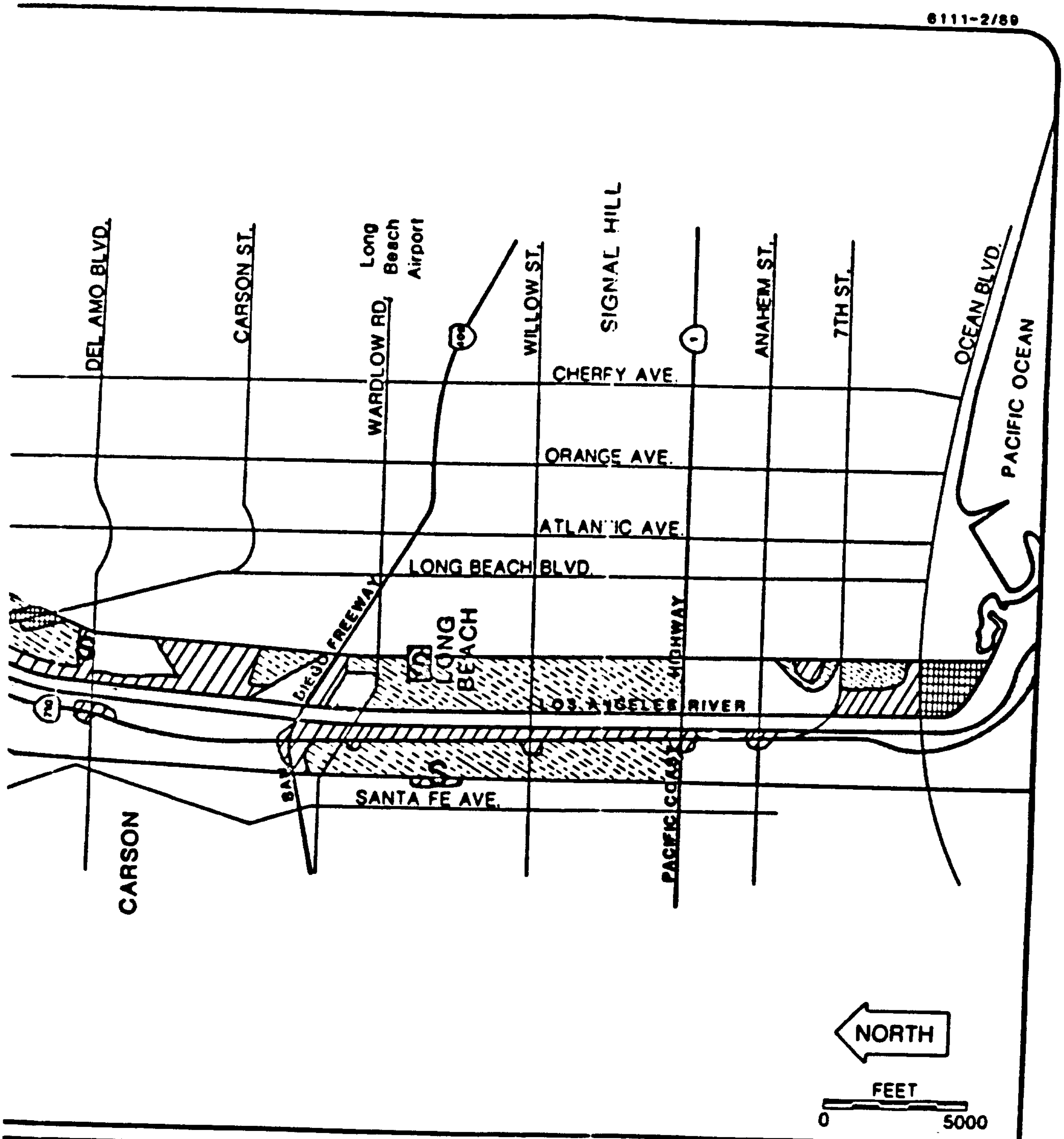
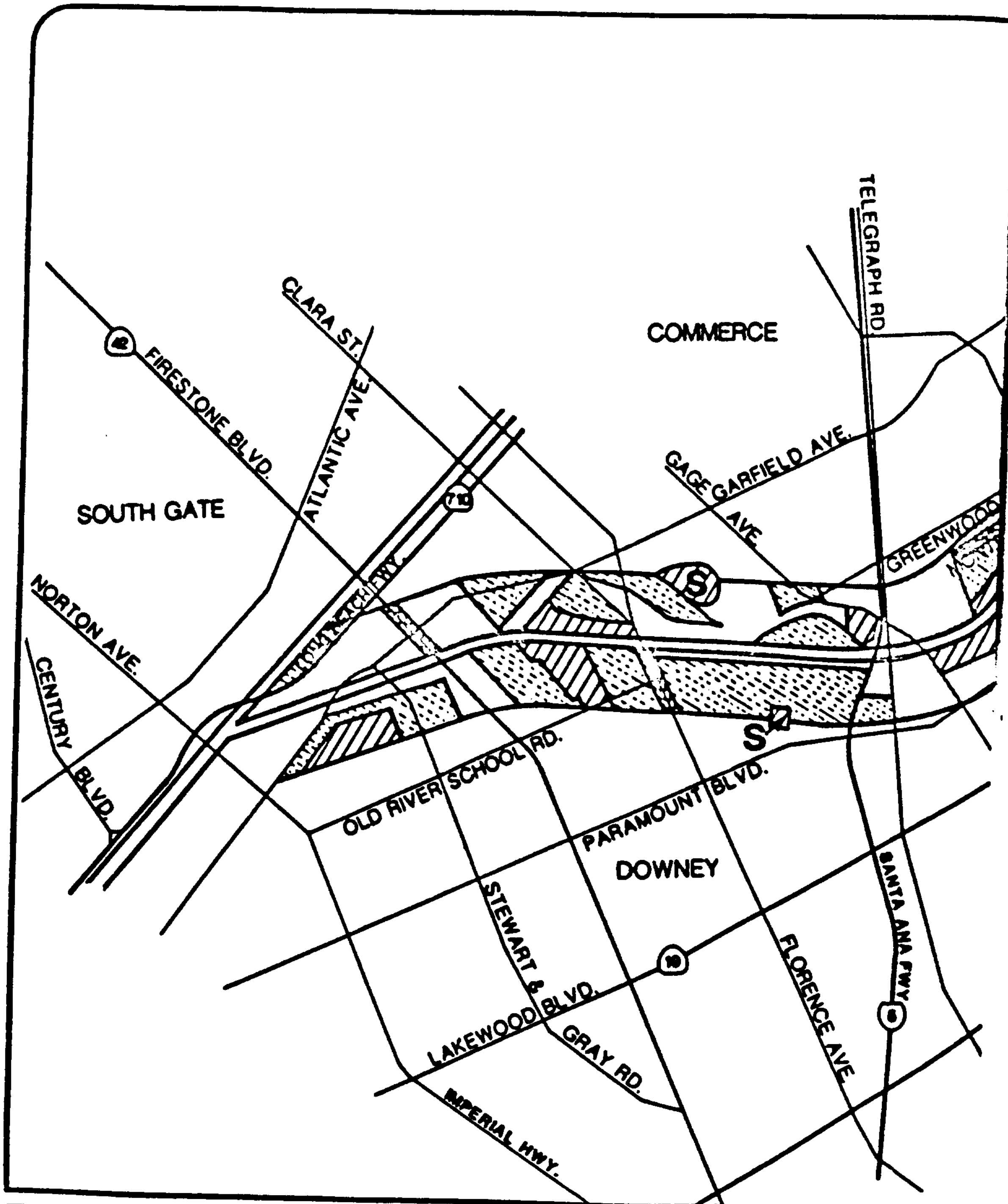


LAND USE

FIGURE 3.3-1



RIO HONDO CHANNEL – REACH 5 GENERALIZED ADJACENT LAND

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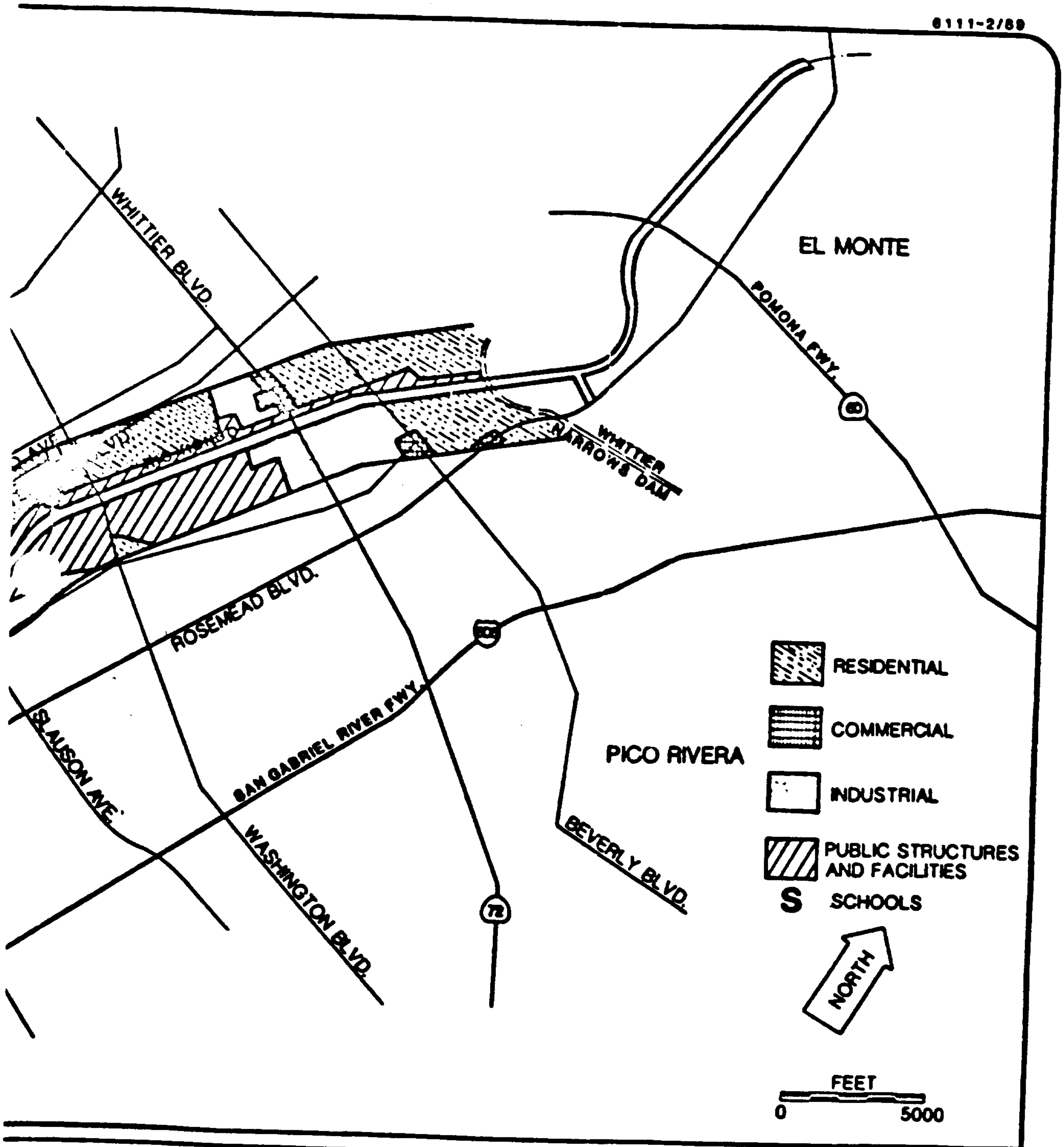

USE

FIGURE
3.3-2

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3.4 AIR QUALITY

3.4.1 Climatic and Ambient Air Quality Factors

The project is located within the South Coast Air Basin, which is monitored by the South Coast Air Quality Management District (SCAQMD). The distinctive climate of the basin is determined by its terrain and geographical location. The basin is a coastal plain with connecting broad valleys and low hills, bounded by the Pacific Ocean in the southwest quadrant, and with high mountains forming the remainder of the perimeter. The general region lies in the semi-permanent high pressure zone of the eastern Pacific. As a result, the climate is mild, tempered by cool sea breezes. This usually mild climatological pattern is interrupted infrequently by periods of extremely hot weather, winter storms, and Santa Ana winds.

The SCAQMD and the California Air Resources Board (CARB) maintain a network of air quality monitoring stations within the basin. The stations monitor the surrounding air for the presence of ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulate matter (PM_{10}), lead (Pb), sulfate (SO_4), and nitrate (NO_3). Excepting nitrate, these are pollutants for which the State and Federal governments have established air quality standards and, in some cases, episode criteria. Table 3.4-1 contains current Federal and State air quality standards.

Existing levels of air quality near the project channel and in 100-year and 500-year flood overflow areas can be inferred from ambient air quality measurements from seven air quality monitoring stations located in reasonable proximity. These stations include Los Angeles, West Los Angeles, Long Beach, Reseda, Burbank, Azusa and Lynwood. Data is summarized in Table 3.4-2.

The South Coast Air Basin remains a non-attainment area for all State and Federal ambient air standards except lead and sulfur dioxide. Ozone and particulate standards are exceeded throughout the Basin, carbon monoxide standards in about one-fourth of the Basin, and nitrogen dioxide and sulfate standards only in specific portions of Los Angeles.

Table 3.4-1

STATE AND FEDERAL AMBIENT AIR QUALITY STANDARDS AND EPISODE CRITERIA

AMBIENT AIR QUALITY STANDARDS, 1987

Air Pollutant	California: Concentration	California: District Method	Federal: Primary	Federal: Secondary	Federal: Method[a]
Ozone	0.10 ppm, 1-hr. avg. *	U.V. photometry	0.12 ppm, 1-hr avg	0.12 ppm, 1-hr avg	Chemiluminescence
Carbon Monoxide	9.0 ppm, 8-hr avg. [b] 20 ppm, 1-hr avg. *	Non-dispersive Infrared Spectrophotometry	9 ppm, 8-hr avg [b] 35 ppm, 1-hr avg.	9 ppm, 8-hr avg 35 ppm, 1-hr avg.	Non-dispersive Infrared Spectrophotometry
Nitrogen Dioxide	0.25 ppm, 1-hr avg. * [c]	Gas Phase Chemiluminescence	0.053 ppm, ann avg [f]	0.053 ppm, ann avg [f]	Gas Phase Chemiluminescence
Sulfur Dioxide	0.05 ppm, 24-hr avg ** with ozone => 0.10 ppm 1-hr avg or TSP => 100 ug/m³, 24-hr avg. 0.25 ppm, 1-hr. avg. * [g]	Ultraviolet Fluorescence	0.03 ppm, ann. avg. 0.14 ppm, 24-hr avg.	0.50 ppm, 3-hr avg.	Pararosaniline
Suspended Particulate Matter (PM10)	30 ug/m³, ann. geometric mean > 50 ug/m³, 24-hr average > [e] **	Size Segregated Inlet High Volume Sampling	50 ug/m³ annual [h] arithmetic mean 150 ug/m³, 24-hr avg	50 ug/m³ annual [h] arithmetic mean 150 ug/m³, 24-hr avg	
Sulfates	25 ug/m³, 24-hr avg. **	High Vol. Sampling Methylthymol Blue			
Lead	1.5 ug/m³, 30-day avg. **	High Vol. Sampling Atomic Absorption	1.5 ug/m³, calendar Quarter	1.5 ug/m³, calendar Quarter	High Volume Sampling Atomic Absorption
Hydrogen Sulfide	0.03 ppm, 1-hr avg. **	Cadmium Hydroxide Stractan			
Vinyl Chloride	0.010 ppm, 24-hr avg. **	Gas Chromatography			
Visibility Reducing Particles	In sufficient amount to reduce the prevailing visibility to less than 10 miles at relative humidity less than 70%, 1 obs.	*			

a) Reference method as described by the federal government. An equivalent method of measurement may be used as approved by the federal government.
b) Effective December 15, 1982. The standards were previously 10 ppm, 12-hour average and 40 ppm, 1-hour average.
c) Effective October 5, 1984. The standard was previously .5 ppm, 1-hour average.
d) Effective August 19, 1983. The standards were previously 60 ug/m³ TSP, annual geometric mean, and 100 ug/m³ TSP, 24-hour average.
e) Effective September 12, 1983. standard changed from > 10 ug/m³ (=> 0.1 ppm) to > 9 ppm(=> 0.5 ppm).
f) Effective July 1, 1985, standard changed from > 100 ug/m³ (> .0532 ppm) to > .053 ppm (> .0534 ppm).
g) Effective March 5, 1987, standard changed from => .25 ppm to > .25 ppm.
h) Effective July 1, 1987. The standards were previously:
Primary - Annual geometric mean TSP > 75 ug/m³, and 24-hour average TSP > 260 ug/m³.
Secondary - Annual geometric mean TSP > 60 ug/m³, and 24-hour average TSP > 150 ug/m³.

* ppm = parts per million by volume.
** ug/m³ = micrograms per cubic meter.

EPISODE CRITERIA

Air Pollutant	South Coast and California: [illegible]	[illegible]	[illegible]	Federal: [illegible]	[illegible]	[illegible]
Ozone	0.20 ppm, 1-hr. avg.	0.35 ppm, 1-hr. avg.	0.50 ppm, 1-hr. avg.	-	-	0.?? ppm, 1-hr. avg.
Carbon Monoxide	40 ppm, 1-hr. avg. 20 ppm, 12-hr. avg.	75 ppm, 1-hr. avg. 35 ppm, 12-hr. avg.	100 ppm, 1-hr. avg. 50 ppm, 12-hr. avg.	15 ppm, 8-hr. avg.	30 ppm, 8-hr. avg.	40 ppm, 8-hr. avg.
Nitrogen Dioxide	-	-	-	0.60 ppm, 1-hr. avg. 0.15 ppm, 24-hr. avg.	1.20 ppm, 1-hr. avg. 0.30 ppm, 24-hr. avg.	1.60 ppm, 1-hr. avg. 0.40 ppm, 24-hr. avg.
Sulfur Dioxide	0.50 ppm, 1-hr. avg. 0.20 ppm, 24-hr. avg.	1.00 ppm, 1-hr. avg. 0.70 ppm, 24-hr. avg.	2.00 ppm, 1-hr. avg. 0.90 ppm, 24-hr. avg.	-	-	-
Sulfur Dioxide/ Particulate Matter Combined	-	-	-	65,000*, 24-hr. avg.	261,000*, 24-hr. avg.	393,000*, 24-hr. avg.
Particulate Matter	-	-	-	375 ug/m³, 24-hr. avg.	625 ug/m³, 24-hr. avg.	875 ug/m³, 24-hr. avg.
Sulfates**	25 ug/m³, 24-hr. avg. combined with ozone > 0.20 ppm, 1-hr. avg.			-	-	-
Actions to be Taken	Health advisory to a) Persons with respiratory and coronary disease. b) School officials in order to curtail students' participation in strenuous activities. First steps in abatement plans.	Intermediate Stage. Abatement actions taken to reduce concentration of pollutant at issue.	Mandatory abatement measures. Extensive actions taken to prevent exposure at indicated levels. State can take action if local efforts failed.	Open burning prohibited. Reduction in vehicle operation requested. Industrial curtailment.	Incinerator use prohibited. Reduction in vehicle operation required. Further industrial curtailment.	Vehicle use prohibited. Industry shut down or curtailment. Public activities ceased.

*Product of sulfur dioxide (ppm), particulate matter (ug/m³) and a factor (2620).
**Episodes based upon these criteria are not classified according to stages.

Source: South Coast Air Quality Management District, April 1987.

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Table 3.4-1

STATE AND FEDERAL AMBIENT AIR QUALITY STANDARDS AND EPISODE CRITERIA

AMBIENT AIR QUALITY STANDARDS, 1987

	CALIFORNIA		FEDERAL		
AIR POLLUTANT	CONCENTRATION	DISTRICT METHOD	PRIMARY (>)	SECONDARY (>)	METHOD[a]
Ozone	0.10 ppm, 1-hr. avg. >= *	U.V. photometry	0.12 ppm, 1-hr avg.	0.12 ppm, 1-hr avg.	Chemiluminescence
Carbon Monoxide	9.0 ppm, 8-hr avg. >[b] 20 ppm, 1-hr avg. >	Non-dispersive Infrared Spectrophotometry	9 ppm, 8-hr avg[b] 35 ppm, 1-hr avg.	9 ppm, 8-hr avg. 35 ppm, 1-hr avg.	Non-dispersive Infra-red Spectrophotometry
Nitrogen Dioxide	0.25 ppm, 1-hr avg. >[g]	Gas Phase Chemiluminescence	0.053 ppm, ann avg[f]	0.053 ppm, ann avg[f]	Gas Phase Chemiluminescence
Sulfur Dioxide	0.05 ppm, 24-hr avg >= with ozone >= 0.10 ppm, 1-hr avg or TSP >= 100 ug/m³, 24-hr avg. 0.25 ppm, 1-hr, avg. >[c]	Ultraviolet Fluorescence	0.03 ppm, ann. avg. 0.14 ppm, 24-hr avg.	0.50 ppm, 3-hr avg.	Pararosaniline
Suspended Particulate Matter (PM10)	30 ug/m³, ann. geometric mean > 50 ug/m³, 24-hr average >[d] **	Size Segregated Inlet High Volume Sampling	50 ug/m³, annual[h] arithmetic mean 150 ug/m³, 24-hr avg.	50 ug/m³, annual[h] arithmetic mean 150 ug/m³, 24-hr avg	
Sulfates	25 ug/m³, 24-hr avg. >=	High Vol. Sampling Methylthymol Blue			
Lead	1.5 ug/m³, 30-day avg. >=	High Vol. Sampling Atomic Absorption	1.5 ug/m³, calendar quarter	1.5 ug/m³, calendar quarter	High Volume Sampling Atomic Absorption
Hydrogen Sulfide	0.03 ppm, 1-hr avg. >=	Cadmium Hydroxide Stractan			
Vinyl Chloride	0.010 ppm, 24-hr avg. >=	Gas Chromatography			
Visibility Reducing Particles	In sufficient amount to reduce the prevailing visibility to less than 10 miles at relative humidity less than 70%, 1 obs.				

a) Reference method as described by the federal government. An equivalent method of measurement may be used as approved by the federal government.
b) Effective December 15, 1982. The standards were previously 10 ppm, 12-hour average and 40 ppm, 1-hour average.
c) Effective October 5, 1984. The standard was previously .5 ppm, 1-hour average.
d) Effective August 19, 1983. The standards were previously 60 ug/m³ TSP, annual geometric mean, and 100 ug/m³ TSP, 24-hour average.
e) Effective September 13, 1985, standard changed from > 10 mg/m³ (>= 9.3 ppm) to > 9 ppm (>= 9.5 ppm).
f) Effective July 1, 1985, standard changed from > 100 ug/m³ (> .0532 ppm) to > .053 ppm (> .0534 ppm).
g) Effective March 8, 1987, standard changed from >= .25 ppm to > .25 ppm.
h) Effective July 1, 1987. The standards were previously:
Primary - Annual geometric mean TSP > 75 ug/m³, and 24-hour average TSP > 260 ug/m³.
Secondary - Annual geometric mean TSP > 60 ug/m³, and 24-hour average TSP > 150 ug/m³.

* ppm = parts per million by volume.
** ug/m³ = micrograms per cubic meter.

EPISODE CRITERIA

	SCAQMD AND CALIFORNIA			FEDERAL		
AIR POLLUTANT	STAGE 1	STAGE 2	STAGE 3	STAGE 1	STAGE 2	STAGE 3
Ozone	0.20 ppm, 1-hr. avg.	0.35 ppm, 1-hr. avg.	0.50 ppm, 1-hr. avg.	-	-	0.50 ppm, 1-hr. avg.
Carbon Monoxide	40 ppm, 1-hr. avg. 20 ppm, 12-hr. avg.	75 ppm, 1-hr. avg. 35 ppm, 12-hr. avg.	100 ppm, 1-hr. avg. 50 ppm, 12-hr. avg.	15 ppm, 8-hr. avg.	30 ppm, 8-hr. avg.	40 ppm, 8-hr. avg.
Nitrogen Dioxide	-	-	-	0.60 ppm, 1-hr. avg. 0.15 ppm, 24-hr. avg.	1.20 ppm, 1-hr. avg. 0.30 ppm, 24-hr. avg.	1.60 ppm, 1-hr. avg. 0.40 ppm, 24-hr. avg.
Sulfur Dioxide	0.50 ppm, 1-hr. avg. 0.20 ppm, 24-hr. avg.	1.00 ppm, 1-hr. avg. 0.70 ppm, 24-hr. avg.	2.00 ppm, 1-hr. avg. 0.90 ppm, 24-hr. avg.	-	-	-
Sulfur Dioxide/ Particulate Matter Combined	-	-	-	65,000*, 24-hr. avg.	261,000*, 24-hr. avg.	393,000*, 24-hr. avg.
Particulate Matter	-	-	-	375 ug/m³, 24-hr. avg.	625 ug/m³, 24-hr. avg.	875 ug/m³, 24-hr. avg.
Sulfates**	25 ug/m³, 24-hr. avg. combined with ozone > 0.20 ppm, 1-hr. avg.			-	-	-
Actions to be Taken	Health advisory to a) Persons with respiratory and coronary disease. b) School officials in order to curtail students' participation in strenuous activities. First steps in abatement plans.	Intermediate Stage. Abatement actions taken to reduce concentration of pollutant at issue.	Mandatory abatement measures. Extensive actions taken to prevent exposure at indicated levels. State can take action if local efforts failed.	Open burning prohibited. Reduction in vehicle operation requested. Industrial curtailment.	Incinerator use prohibited. Reduction in vehicle operation required. Further industrial curtailment.	Vehicle use prohibited. Industry shut down or curtailment. Public activities ceased.

*Product of sulfur dioxide (ppm), particulate matter (ug/m³) and a factor (2620).
**Episodes based upon these criteria are not classified according to stages.

Source: South Coast Air Quality Management District, April 1987.

Table 3.4-2

AIR QUALITY MONITORING DATA FOR CHANNEL AREAS

Monitoring Stations	Suspended Particulates PM10: No. of Samples Exceeded – Federal	No. of Samples Exceeded – State	Standard % Exceeded – (AAM) Federal	Standard % Exceeded – (AGM) State	Sulfate No. Samples Exceeded State	Carbon Monoxide* Number Days Exceeded – Federal	Carbon Monoxide* Number Days Exceeded – State	Ozone Number Days Exceeded – Federal	Ozone Number Days Exceeded – State	Nitrogen Dioxide No. Days Exceeded State
Los Angeles	1	36	13.2	68.7	0	1	1	36	91	4
West Los Angeles	NM	NM	NM	NM	0	0	0	16	58	1
Long Beach	0	18	1.0	52.7	0	0	1	4	11	1
Reseda	NM	NM	NM	NM	NM	1	2	60	121	0
Burbank	0	36	20.4	78.9	0	9	11	76	130	1
Azusa	2	38	36.4	95.7	0	0	0	111	143	0
Lynwood	NM	NM	NM	NM	0	40	47	11	24	1

*For 8-hour standard.
NM = Not measured
SOURCE: SCAQMD, 1987

All monitoring stations in the study area recorded frequent exceedances of the ozone standard. Only the west Los Angeles, Long Beach and Azusa stations did not exceed the Federal carbon monoxide standard. Suspended particulate concentrations were particularly severe at the Los Angeles, Burbank and Azusa stations (Reaches 3, 2 and 6, respectively).

Although the study area has notoriously unhealthful air quality, there is an encouraging improvement trend. The number of second stage alerts for ozone (1 hour >0.35 ppm) has decreased dramatically from a recent high of 23 in 1978 to only one episode in 1988.

3.4.2 Air Quality in Channel Reach Construction Zones

3.4.2.1 Lower Los Angeles River

A major source of localized air pollution along this reach is the Long Beach Freeway. The freeway parallels the river for the entire length of Reach 4 (from the ocean to the confluence with Rio Hondo). Other important air pollutant generators include miscellaneous industrial uses, agricultural operations and the numerous unpaved lots that are used for equipment storage and other unauthorized uses.

3.4.2.2 Rio Hondo Channel

Vehicular sources contribute to localized air quality degradation along this reach, however, not to the extent that occurs along Reach 4. In addition to industrial uses, the unpaved and unvegetated spreading grounds are a major source of suspended particulates.

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3.5 WATER QUALITY

3.5.1 Flood Plain Area

3.5.1.1 Surface Water

The flood plain area is located within the urban environment with the LACDA system serving as the principal drainage for the area. Water quality in the region is generally poor due to mixing of the runoff with contaminants on roadways and other areas. Grease, heavy metals and other particulates are of substantial concern.

3.5.1.2 Groundwater

Total dissolved solids (TDS) are high in portions of the Coastal Plain as a result of seawater intrusion. The West Coast Basin has the highest average TDS; in 1982, it averaged 1441 mg/l. TDS in the Santa Monica-Hollywood and Central Basins averaged 924 and 407 mg/l, respectively (LACFCD, 1982). Because these figures are averages over entire basins, they may not be representative of the water actually used. For example, the high TDS for the West Coast Basin is probably partly due to seawater intrusion in some wells.

Iron and manganese occasionally exceed standards in some wells. This sporadic problem is not a health hazard. High iron and manganese tend to precipitate as hydroxides and stain laundry and porcelain fixtures and can cause the taste and color of water to be objectionable.

In addition to the general contaminants, the groundwater is subjected to many contaminants associated with hazardous waste from underground storage tanks and other sources.

3.5.2 Los Angeles, Rio Hondo and Compton Creek Channels

3.5.2.1 Surface Water

The Los Angeles River receives substantial contribution from urban sources during rainy periods. The main channel through the coastal plain is primarily impervious, which reduces groundwater recharge.

Recent water quality data for the Los Angeles River collected during dry weather flow conditions is shown in Table 3.5-1. It shows average water quality data for Firestone Boulevard and Wardlow Street in Long Beach. Of the constituents measured, coliforms and heavy metals tended to vary the most from one sample to the next. Since the Los Angeles River system drains the heavily urbanized portion of the basin, runoff to channels will sometimes contain significant levels of oil, grease and other hazardous residues. Field visits to LACDA facilities have confirmed that surface flows have contained an oil sheen, and some silts and debris removed from channels have had a black tar-like color even after being dewatered. This problem is especially prevalent in the Los Angeles River channel and in the Compton Creek channel.

Phosphorus concentrations are not significantly elevated at the downstream locations being measured but can be presumed to be higher to those upstream portions of the Los Angeles River receiving treatment plant effluent. Some of the phosphorus and nitrogen content is expected to be assimilated by the existing vegetation in the cobbled section of the river near Glendale/Atwater.

The Compton Creek channel experiences additional water quality problems due to dumping of oils and other toxics into the channel by illegal dischargers. Maintenance personnel have noted considerable oil and other contaminants within this area.

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Table 3.5-1

WATER QUALITY, LOS ANGELES RIVER (DRY WEATHER RUNOFF)
MEAN ANNUAL VALUES FOR THE PERIOD 5/88 TO 2/90
(FROM: LACDPW, 1990)

Parameter mg/l	● Firestone Boulevard	● Wardlow Street
Temperature (° F)	63	66
Specific Conductance	1,041	1,067
pH	8.1	8.5
TDS	651	662
Total Hardness	252	272
Calcium	64.7	66.3
Magnesium	21.9	25.8
Sodium	110.4	114.4
Potassium	13.7	13.4
Alkalinity	163	175
Sulfate	163	160
Chloride	119	125
Fluoride	0.53	0.53
Nitrate-Nitrogen	3.84	3.1
Ammonium NH_3+NH_4	4.53	3.0
Phosphate	2.3	1.9
Boron (ug/1)	467	449
BOD	4	8.3
org/100ml		
Total Coliform	149,845	29,808
Fecal Coliform	23,042	7,841
KF Streptococcus	1,643	1,591
Enterococcus (MPN/100ml)	1,031	1,410
ug/l		
Arsenic	20	10
Barium	37	69
Cadmium	<10	<10
Chromium IV	<20	<20
Copper	<10	13.7
Manganese	46	39
Lead	<10	28
Mercury	< 1	< 1
Nickel	16	14
Selenium	< 5	< 5
Zinc	156	62

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3.5.2.2 Groundwater

The groundwater within the immediate vicinity of the channel approximates groundwater characteristics for the entire basin. Since most of the channel has a paved bottom, the recharge from the river is minimal.

3.6 NOISE

3.6.1 Flood plain Noise Considerations

3.6.1.1 Noise Standards

Time variations in noise exposure are typically expressed in terms of a steady-state energy level equal to the energy content of the time varying period (called Leq), or, alternately, as a statistical description of the sound level that is exceeded over some fraction (10, 50 or 90 percent -- called L10, L50 and L90, respectively) of a given observation period. Finally, because community receptors are more sensitive to unwanted noise intrusion during the evening and at night, state law requires that for planning purposes, an artificial dB increment be added to quiet time noise levels to create a 24-hour noise descriptor called the Community Noise Equivalent Level (CNEL). Some communities use a different 24-hour noise descriptor called day-night average level, or Ldn. CNEL and Ldn are statistically similar and usually are calculated to within 1 dB of one another.

A maximum interior CNEL of 45 dB(A) is mandated for multiple family dwellings, and is considered a desirable noise exposure for single family dwelling units as well. Since typical noise attenuation through residential structures with closed windows is 20 dB or more, an exterior noise exposure of 60 dB CNEL is thus typically the design exterior noise for new residential dwellings in California. Because commercial or industrial uses are not occupied on a 24-hour basis, the same exterior noise exposure standard generally does not apply for these less noise-sensitive land uses.

The interior noise exposure guideline and its relationship to acceptable exterior structural noise loading forms the basis for the noise elements or zoning and noise ordinances from the various jurisdictions in the study area. The Southern California Association of Governments (SCAG) has developed a noise/land use compatibility matrix applicable to the study area (see Figure 3.6-1). The land-use compatibility guidelines are exactly that; i.e., they are advisory guidelines.

Noise ordinances generally have specific noise emissions standards on individual sources, and therefore apply most directly to the proposed project elements. Such standards apply at the nearest point of normal site occupancy in outdoor areas or at the closest window/door to the adjacent noise source. Controlling noise emission rates, maintaining an adequate distance buffer between the source and the nearest sensitive receptor, and use of physical line-of-sight breaks are all potential measures by which the standards can be maintained along the project corridor.

However, it should be noted that most communities do not regulate the noise emissions from construction except through controls on the hours of operation. The lack of such standards, plus the fact that the LACDA channels form a boundary between several jurisdictions where it should be difficult to allocate impact responsibility to only one community, suggest the use of SCAG noise/land use compatibility guidelines as a more appropriate source of noise standards for the project noise impact assessment.

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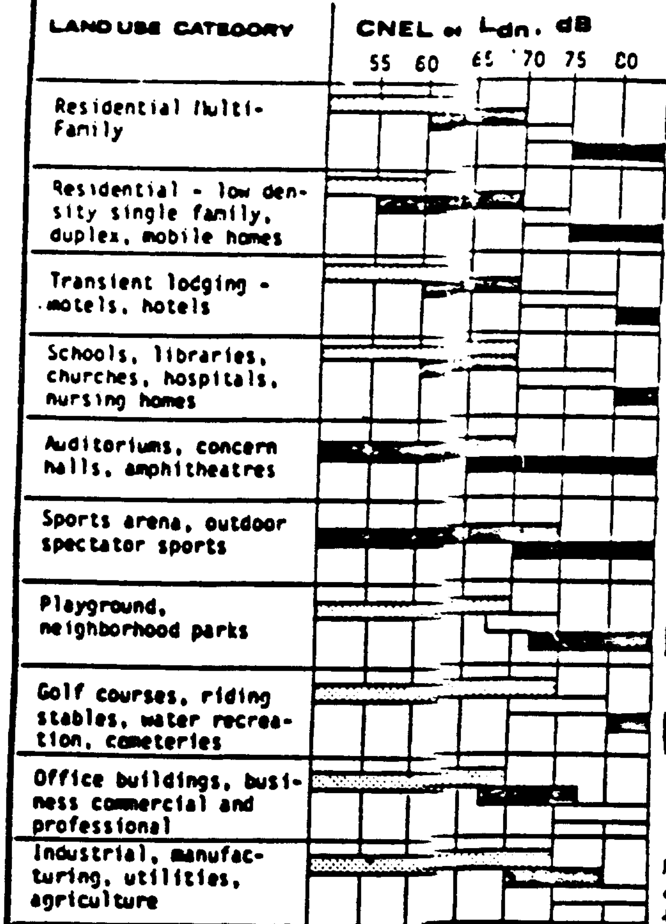

INTERPRETATION

NORMALLY ACCEPTABLE

Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.

CONDITIONALLY ACCEPTABLE

New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features included in the design. Conventional construction, but with closed windows and fresh air supply systems or air conditioning will normally suffice.

NORMALLY UNACCEPTABLE

New construction or development should generally be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design.

CLEARLY UNACCEPTABLE

New construction or development should generally not be undertaken.

SOURCE: In part taken from "Aircraft Noise Impact Planning Guidelines for Local Agencies", U.S. Dept. of Housing and Urban Development, TE/NA-472, November 1972.

LAND USE COMPATIBILITY FOR COMMUNITY NOISE ENVIRONMENTS

FIGURE 3.6-1

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3.6.1.2 Noise Characteristics in Flood Overflow Areas

The channels within the LACDA system are characterized by a wide diversity of ambient noise. Adjacent freeways, railroad crossings, quarry and industrial operations, commercial, residential areas and parks and golf courses run adjacent to the channels. Strong variations in noise levels will occur over relatively short distances as these land uses change. However, even with all these land uses, the primary existing noise source along the flood control channels is almost exclusively from vehicular noise throughout the greater urbanized area. There are some portions of channels which experience high noise levels from traffic as well as other sources. These include the commercial/industrial areas such as Compton Creek, and areas in close proximity to aircraft noise such as channels near Hansen Dam and Sepulveda Dam, which are near local airfields.

The quietest areas in the Los Angeles River system are in the most remote locations such as along the edge of Griffith Park or in Haines Canyon. Areas adjacent to residential areas, and parks and golf courses also tend to have quieter noise levels. However, most of these areas are not much quieter than background noise levels in developed areas in the general vicinity of the channels.

The range of noise levels will vary from 45 dB within the quiet park setting to about 74 dB for those areas adjacent to freeways. Given the logarithmic nature of the decibel scale, the areas near the freeways are 30 times noisier than in the riverbank locations away from intensive traffic noise sources (Mitech, 1988).

3.6.2 <u>Noise Characteristics in Channel Reach Construction Zones</u>

3.6.2.1 Lower Los Angeles River

The most significant noise generator along Reach 4 is the Long Beach Freeway, which traverses adjacent to the river on the west side. Several major arterial streets cross the channel as does the San Diego (Interstate 405) and Artesia (Highway 91) freeways.

These are considered secondary sources of noise. There are also two active railroad bridges which cross Reach 4. Noise levels along the river in proximity to roadways will range from 70 dBA to 75 dBA Ldn.

For purposes of this study, all residential uses and public uses such as schools, hospitals and churches are considered sensitive to noise generation. These uses are mapped on Figure 3.3-1 (see Section 3.3) and occur throughout the reach.

3.6.2.2 Rio Hondo Channel

Major noise generators along Reach 5 include traffic on major arterials which cross the channel and railroad operations which cross Reach 5 at four locations. Traffic is particularly loud in the vicinity of the Santa Ana Freeway (Interstate 5), which crosses the channel. Somewhat more quiet than Reach 4, noise levels are expected to range from 64 to 69 Ldn along this reach.

Land uses adjacent to the reach within sound range of construction activities are mapped on Figure 3.3-2. Numerous residential areas and three schools are considered sensitive noise receptors.

3.7 BIOLOGICAL RESOURCES

3.7.1 Overview of LACDA System

The LACDA system consists of a series of dams and a flood control system that protects the greater metropolitan Los Angeles area. Key components of the system include Lopez, Hansen, Sepulveda, Santa Fe and Whittier Narrows Dams and the Los Angeles, San Gabriel, Rio Hondo and Ballona Channels. The Corps of Engineers (COE/LAD 1986) as well as the U.S. Fish and Wildlife Service (USFWS 1984, USFWS 1987) have inventoried the resources of the entire LACDA system. The purpose of the discussion in this section is to provide a summary of the biological resources of the entire system.

Table 3.7-1 provides an inventory of the listed and candidate plant and animal species known to occur within the LACDA system. The species of most notable concern is the least Bell's vireo, which occurs or potentially occurs at Hansen Dam, Whittier Narrows Dam and Santa Fe Dam, as well as in a portion of the San Gabriel River Channel.

3.7.1.1 Lopez Dam

Lopez Dam is the smallest of the dams within the LACDA system and has undergone considerable siltation. Other than functioning as an open space wildlife habitat, the area has little biological value.

3.7.1.2 Hansen Dam

Hansen Dam contains a rather diverse assemblage of vegetation communities, including willow riparian, riparian scrub, alluvial scrub, coastal sage scrub, oak woodland and old field habitats. The area supports a rather diverse assemblage of wildlife and is an excellent wildlife habitat even though significant portions of the area have been disturbed by sand and gravel extraction activities. The area is a known nesting habitat for the endangered least Bell's vireo and is potential habitat for the endangered slender-horned spineflower.

3.7.1.3 Sepulveda Dam

The Sepulveda Dam basin serves primarily as a recreation area. The area does contain old field habitats and some riparian habitat. It serves as a good open space wildlife habitat and supports many avian species as well as other species adapted to urban influenced environments. The area serves as a wintering area for the Canada goose and also supports populations of the candidate tri-colored blackbird.

Table 3.7-1

SUMMARY OF THREATENED, ENDANGERED AND CANDIDATE SPECIES IN LACDA SYSTEM

Species	Status	Facility: Lopez Dam	Hansen Dam	Sepulveda Dam	Santa Fe Dam	Whittier Narrows Dam	Los Angeles River	San Gabriel River
San Diego Horned Lizard	C	P	P		K			
Least Bell's vireo	E		K		P	K		K[1]
California least tern	E						P[2]	P[2]
Tri-colored blackbird	C							
California brown pelican	E						P[2]	P[2]
Black-tailed gnatcatcher	C	P	P		P			
Slender-horned spineflower	E		P		P			
Nevin's barbery	PE		P					
San Fernando Valley spineflower	PE		P					

KEY - STATUS

C = Candidate species
E = Endangered species
PE = Proposed endangered species

KEY - FACILITY

P = Potentially occurs
K = Known to occur

Notes: [1]Occurs downstream of Whittier Narrows Dam.

[2]Foraging areas only.

Source: ????????

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3.7.1.4 Santa Fe Dam

The Santa Fe Dam basin contains a rather unique assemblage of alluvial scrub -- a brushland area that has adapted to periodic flooding and scouring. The area also contains a small riparian area and old field and turfed areas. A small portion of the basin is potential habitat for the endangered least Bell's vireo and slender-horned spineflower and the candidate San Diego coast horned lizard and black-tailed gnatcatcher.

3.7.1.5 Whittier Narrows Dam

The Whittier Narrows Dam basin consists of rather extensive riparian development due primarily to revegetation efforts within the wildlife sanctuary areas. This area supports a wide variety of avian species and functions as a good wildlife area. The area is known nesting habitat for the least Bell's vireo as well as potential habitat for the candidate black-tailed gnatcatcher and tri-color blackbird.

3.7.1.6 Los Angeles River System

With the exception of the mouth of the river at the Pacific Ocean and a reach near Glendale, the majority of the 55 miles of the Los Angeles River from Sepulveda Basin to the Pacific Ocean contains concrete-lined channels surrounded by urbanized areas. These sections contain only weedy species growing within cracks or joints of the channel. Included in the Los Angeles River system is Compton Creek. This creek contains a soft-bottomed section upstream of its confluence with the Los Angels River.

The soft (unpaved) channel bottom of Compton Creek is characterized by degraded riparian association dominated by bulrush along with groundcover composed of ruderal weed species. Arroyo willow saplings are widely scattered through this strip. Since public access is possible, the vegetation shows sign of continual trampling. Furthermore, heavy accumulations of trash and debris dropped into the channel by illicit dumpers have collected in the vegetation. The willow canopy and understory components necessary for least Bell's vireo habitat are not evident, and there are no potential vireo sites in this reach. Other avian species occupying the channel were shorebirds and some raptors.

The Glendale reach of the Los Angeles River channel is alternately cobblestone and concrete invert. This reach is dominated vegetatively by a highly degraded riparian association, primarily a combination of cattails and bulrush with numerous patches of giant reed. Arboreal vegetation is primarily made up of a few of Gooding's willow, which together do not form an overstory. Mulefat is present but not sufficient to form an understory. Ground cover is a dense mat of grasses, forbs and ruderal species which generally cover the alluvial sediments which support them. In most areas, the riparian habitat community is very narrow with a ribbon of a single width of trees. In some instances, such as in the channel adjacent to Ralphs Grocery Warehouse, the vegetative mantle covers the alluvial deposit so thickly and completely as to obscure the concrete invert along that reach. Here, as in other places, this vegetation is transitory, unable to withstand moderate channel flows. Ability to see the concrete invert is further masked by substantial trash deposits.

Since soft bottom channels are prone to significant scour, a majority of this vegetation would be lost during years with frequent high steam flows. During years when only low to moderate flows occur, this vegetation can become dense.

The area also serves as a wildlife habitat for shore birds and other species. The lower portion of the river is potential foraging habitat for the brown pelican and California least tern.

3.7.1.7 San Gabriel River Channel

The majority of the San Gabriel River channel is paved and therefore contains little in the way of biological resources. An approximately five-mile (8 km) stretch of the river from Santa Fe Dam to Valley Boulevard has a soft bottom but is cobbly and supports only scattered vegetation. An approximately seven-mile (11.3 km) stretch below Whittier

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Narrows Dam contains rather dense riparian vegetation in some areas and supports native wildlife, potentially including the endangered least Bell's vireo. An area in the lower San Gabriel River between Westminster Avenue and the San Diego Freeway supports emergent vegetation of a rather low density. As with the lower Los Angeles River, the lower San Gabriel River is potential foraging habitat for the endangered brown pelican and California least tern.

3.7.2 Biological Resources Within the 100-Year Flood plain of the Los Angeles River

The flood plain within the Los Angeles River is primarily urbanized and contains little native vegetation. The dominant vegetation form includes landscaped areas containing turf and ornamental trees and shrubs. These are associated with landscaping around parks, homes and commercial establishments. Some areas near the riverbed and under power line easements are still in agriculture and grow a variety of ornamental plants and cash crops.

This area supports wildlife typical of urban areas, including such species as English sparrow, starling, crow, blackbirds, mocking bird and domestic pigeon. The larger open space areas near the river could support such species as the American kestrel and burrowing owl.

No threatened or endangered or candidate plant or animal species are expected to occur in this area.

3.7.3 Biological Resources Within the Channel Reach Construction Zones

3.7.3.1 Lower Los Angeles River

Vegetation

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With the exception of an approximately 2.5-mile (4 km) section near the mouth of the river, the entire stretch of river is completely channelized, including pavement of the river bottom. With the exception of an occasional plant growing within cracks as well as ruderal species growing adjacent to the levees, the area is essentially void of vegetation.

An approximately 1.5-mile (2.4 km) stretch of the river from Anaheim Street to Willow Street contains areas along both sides of the banks where siltation has taken place, allowing a 10- to 15-foot (3.1 to 4.6 m) wide belt of vegetation to grow. This area contains rushes, cattail, willow and mulefat, as well as many ruderal species such as castor bean.

Compton Creek is tributary to the lower Los Angeles River. Almost all of Compton Creek, with the exception of a two-mile segment of the creek, is channelized and contains very little, if any, vegetation. The soft-bottom portion of the channel contains both ruderal species such as castor bean and Arundo (giant reed) and some scattered riparian species such as mulefat, bulrush, and a few small willow.

The Glendale reach alternates cobblestone and concrete invert for approximately six miles. These areas are dominated by species common to degraded riparian associations, including cattails, bulrush and Arundo (giant reed). There are scatterings of native sycamores and some willow.

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Wildlife

In general the Los Angeles River channel has only low value for wildlife. It serves as an open space area for wildlife and provides resting habitat for shore birds. The edges of the area in some locations may provide limited foraging for raptor species. The channel may function somewhat as a wildlife movement corridor. The vegetated area near the mouth is nesting habitat for such species as red-wing blackbirds and is considered of moderate to high wildlife value. It may also support shore birds and some riparian obligate species since some cover is afforded in that area.

Most of the Compton Creek Channel and Glendale reach have very low wildlife value. The area with the cobblestone bottom has moderate wildlife value and would be expected to provide habitat for species generally adapted to an urban environment.

The portion of the lower Los Angeles River that has an unlined, soft substrate bed extends from Willow Street to the mouth of the river at Queensway Bay in Long Beach. This area is influenced by tidal waters entering the mouth of the river and fresh water flowing from upriver sources. At high tides the seawater extends upriver to an area approximately midway between Pacific Coast Highway and Willow Street.

Aquatic Resources

The salinity in this section of the river would range from fresh water just below Willow Street to varying degrees of brackish water further down river depending on the amount of fresh water input and the height of the tide.

No recent biological sampling of the area has occurred; however, through discussions with local experts and individuals conducting other scientific studies in the area and from a study of the Santa Ana River, a prediction of the likely aquatic species can be made.

The area of the river near the mouth would be expected to have many of the same fish species found in the adjacent Queensway Bay. These include Engraulis mordax (northern anchovy), Seriphus politus (Queenfish), Genyonemus lineatus (white croaker), Anchoa delicatissima and Anchoa compressa (slough and deep-body anchovys), Paralabrax nebulifer (barred sand bass), Cymatogaster aggregata (shiner surfperch), and young Paralichthys californicus (California halibut). Invertebrates living on the rip-rap rock sides of the channel near the mouth would probably include sea urchins (Stronglyocentrotus purpuratus), snails, and barnacles (Balanus spp.), as well as various species of algae. Polychaete worms, clams, anemones, and tunicates would be expected on the soft bottom.

Further upriver where salinities are more varied, Atherinops affinis (topsmelt), Leptocottus armatus (Pacific staghorn sculpin), Clevelandia ios (arrow goby), Gillichthys mirabilis (longjaw mudsucker), and Hypsopsetta guttulata (diamond turbot) would be likely fish species in addition to E. mordax, C. aggregatta, and P. californicus.

Between Pacific Coast Highway and Willow Street where the river is predominantly freshwater, fish species from upriver could be found. These freshwater and brackish water tolerant species include Ictalurus spp. (catfish and bullhead), Cyprinus carpio (carp), Gambusia affinis (mosquitofish) and Tilapia spp. The presence of these species would depend on the flow volume of the river. After heavy rain storms when the volume in the river is large, it is likely that most freshwater species would be washed out to sea.

Threatened and Endangered Species

The lower river and mouth of the river may be foraging habitat for the endangered brown pelican and California least tern. With these exceptions, no other listed or candidate species is expected to occur in the area.

No threatened, endangered, or candidate plant or wildlife species are known or expected to occur in Compton Creek.

3.7.3.2 Rio Hondo

Vegetation

This section of the Rio Hondo (Reach 5) is channelized with a paved bottom. Except for plants growing in concrete cracks, little vegetation is present.

The spreading grounds adjacent to the channel also contain some ruderal species; however, frequent weed abatement activities tend to limit this vegetation.

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Wildlife

The channel area tends to have very limited wildlife value and functions, at best, as an open space wildlife habitat. The spreading grounds may serve as fair habitat for shorebirds when water is present.

Aquatic Resources

Since the entire channel is paved, no aquatic resources exist in the channel.

Threatened and Endangered Wildlife Species

No threatened, endangered, or candidate plant or animals species are known or have a potential to occur in this area.

3.8 CULTURAL RESOURCES

3.8.1 Flood Overflow Areas

The general flood overflow areas were not surveyed as a part of this study. The area is urbanized, and most cultural resources would have been substantially disturbed. Historic buildings and other structures do exist in the area.

3.8.2 Cultural Resources in Lower Channel Areas

3.8.2.1 Lower Los Angeles River

The portion of the Los Angeles River from Imperial Highway to the Pacific Ocean was surveyed for the presence of historic and cultural resources in 1976 (Stickel 1976). Prior to the field survey, a literature search was conducted through a number of local institutions and individuals. The entire route of the Los Angeles River from the Pacific Ocean to the Rio Hondo was examined in the field by a team of surveyors. No historic resources were identified in this inventory effort.

A records search was conducted in 1984 for this area as part of an overall records search for Los Angeles County Drainage Area (Cottrell et al. 1985). The records search through the UCLA Archaeological Survey revealed that no additional studies had been conducted in this area. An historic records search conducted as part of the LACDA Review Study (Van Wormer 1985) identified no historic properties in the area. As part of the LACDA feasibility study, Hatheway (1986) conducted an architectural and historic assessment of the Southern Pacific "Horseshoe" Bridge in Long Beach and the Union Oil Suspension Pipeline near the 405 Freeway which cross the river in this area. Both of these structures were determined to be too new to be potentially eligible for the National Register.

No properties eligible for the National Register were found to be present along the levees where impacts from flood wall construction would occur. An assessment of the bridges to be affected by the project concluded that none of the 14 bridges to be affected were eligible for listing in the National Register. All of these bridges are less than 50 years old. A field survey was conducted by the Corps of Engineers in 1989 along Compton Creek. No historic properties were encountered along the reach, which is to undergo levee armoring.

3.8.2.2 Rio Hondo Channel

A number of previous studies have been conducted for this stretch of the Rio Hondo (Reach 5). The Rio Hondo channel (a 100-foot [30.5 m] wide corridor along the channel) was surveyed in 1976 (Stickel 1976) with negative results. A historic overview of the Whittier narrows basin revealed that the Battle of the San Gabriel was fought

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along this stretch of the Rio Hondo (Lindsey and Schiesl 1976). A records search was conducted in 1984 for this area as part of an overall records search for LACDA (Cottrell et al. 1985). The records search through the UCLA Archaeological Survey revealed that no additional studies had been conducted in this area. An historic records search conducted as part of the LACDA Review Study (Van Wormer 1985) identified two historic properties in the area. These are the Whittier Narrows Dam and the Whittier Road Bridge. As part of the LACDA Feasibility Study, Hatheway (1986) conducted an architectural and historic assessment of the Union Pacific Railroad bridge which crosses the Rio Hondo.

An additional records search conducted as part of the current study identified the Rio Hondo Spreading Grounds as an historic property. In addition, the Gabrielino village of Chokishnga was identified as possibly having been located in the vicinity.

For the present study, an archaeological and historic survey was conducted on January 17, 1989, by Stephen Dibble and Steven Schwartz, both archaeologists employed by the U.S. Army Corps of Engineers, Los Angeles District. The survey was accomplished by both surveyors walking along each levee and surveying the levee and any open land located adjacent to the levee. For most of the stretch, the levee was abutted by the right-of-way fence, which did not allow for much area beyond the levee to be inspected. However, in a few places, as much as 100 additional feet (30.5 m) were surveyed.

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Each of the previously identified sites, as well as those discovered as part of the present survey, are described by site number.

RH-1 Site of the Battle of San Gabriel River

On January 8, 1847, the battle of the Rio San Gabriel was fought between American forces commanded by Captain Robert F. Stockton, U.S. Navy, Commander in Chief; Brigadier General Stephen W. Kearney, U.S. Army; and Californios commanded by General Jose Maria Flores. American troops, after securing northern California, landed in San Diego and headed north to connect with the northern units and secure the state.

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This was the final battle between American and Mexican forces before Los Angeles was captured by the Americans. The site is listed as California Historical Landmark No. 385. A monument has been placed at Washington Boulevard and Bluff Road. The battle actually appears to have occurred about two miles north of the marker on and below the bluffs between Whittier Boulevard and Mines Avenue.

RH-2 Rio Hondo Spreading Grounds

The spreading grounds are listed as a Landmark of the American Society of Civil Engineers. The Landmark covers all 29 spreading grounds of the Los Angeles County Flood Control District. They are designed to retain and conserve thousands of acre feet of spring runoff annually and return it to the underground water table. The various spreading grounds were constructed beginning in 1917.

RH-3 Union Pacific Rio Hondo Bridge (No. PTD 10.77)

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The structure consists of three steel girder spans which rest on two concrete piers spaced equidistant within the channel. The structure is of well deck design, and wooden sleepers rest on steel girders. On either side of the single track there is a wooden plank walkway. Each end of the structure rests on concrete abutments which are located at the top of the adjacent levees. The structure is in good condition and appears to be altered only by the addition of two oil pipelines which are welded to the side of the structure. The bridge was evaluated by Hatheway in 1986 for the Corps of Engineers. Hatheway concluded that, "This structure is not a rare example of its type, nor does it exhibit any unusual features relating to workmanship, design, scale/span, or materials." Therefore, this structure is not a significant historic property.

RH-4 Firestone Boulevard Bridge

This is a concrete highway bridge across the Rio Hondo. It has the date of 1932 impressed in the concrete of the west abutment. It consists of a concrete roadway on concrete arches. This bridge has yet to have been evaluated as to its National Register eligibility.

RH-5 Southern Pacific Railroad Bridge

The structure is of well deck design with the girder both above and below the deck, with squared ends. The structure has three spans on concrete piers spaced equidistant within the channel. The structure supports a single railroad track. This Bridge has yet to have been evaluated as to its National Register eligibility.

RH-6 Southern Pacific Railroad Bridge

The structure is of plate girder above deck design with squared ends. The structure consists of three spans on concrete piers spaced equidistant within the channel. Bridge has "P.E. Ry." painted on it, perhaps indicating it was at one time part of the Pacific Electric Railway system. This Bridge has yet to have been evaluated as to its National Register eligibility.

RH-7 Atchison Topeka and Santa Fe Railroad Bridge

Steel plate girder above-and-below deck structure with one rounded and one squared end. The structure is supported on three concrete piers placed equidistant within the channel. This Bridge has yet to have been evaluated as to its National Register eligibility.

RH-8 Union Pacific Railroad Bridge

This is a steel plate girder below-deck structure. It consists of six spans with two approaches. It has one track and a steel grate walkway on either side. It is supported on concrete piers placed in the channel and in the spreading basins to the west.

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RH-9 Whittier Boulevard

This structure is composed of four spans of steel truss with a concrete deck. The structure was evaluated by CalTrans (California Bridge Inventory; Route 72, Bridge 4), who determined it ineligible for the National Register of Historic Places (Category 5). Therefore, this structure does not represent a significant historic property.

RH-10 Beverly Boulevard Bridge

This is a steel girder bridge, the center span of which has been replaced with a concrete arch. It is supported on wooden pilings which have concrete reinforcements at the base. It has an asphalt-over-wood deck supporting four lanes of traffic. The integrity of this structure has been significantly compromised. The center span of the bridge is now concrete, and concrete reinforcements have been added to the piers. Due to the compromised integrity, it is unlikely that this structure represents a significant historic property.

RH-11 Chokishnga

The village of Chokishnga has been associated with the site of the Jaboneria (Spanish soap factory) (Reid: Letter 1; Kroeber 1925), however, it is unclear as to the location of the Jaboneria. Johnston (1962:84) lists Chokishnga as an historic Gabrielino village on the west side of the present Rio Hondo, just a little south of Telegraph Road. This village would be in the general vicinity of the study area.

3.9 TRANSPORTATION

3.9.1 Flood Overflow Areas

3.9.1.1 100-Year Overflow Area

Traffic within the LACDA boundaries is notoriously heavy. Peak-hour traffic on major roadways and freeways is usually congested, with stoppages occurring frequently on freeways and traffic backed up at surface street intersections.

The LACDA 100-year flood plain includes areas of heavy urbanization and major roadway and freeway thoroughfares. Some areas wholly or partially contained in the flood plain include the San Fernando Valley, Los Angeles, Pico Rivera, Downey, Lynwood, Compton, Paramount, Bellflower, Lakewood, Carson, and Long Beach. Most Los Angeles area freeways, including Ventura (101, 134), Golden State/Santa Ana (5), Santa Monica (10), Pomona (60), Long Beach (710), Artesia (91), and San Diego (405) cross or run through the 100-year flood plain.

Table 3.9-1 gives the major roadways and freeways that cross or are within the 100-year flood plain, by city. Each of the roadways and freeways listed are heavily utilized, especially during peak-hour commuter traffic. Most freeways are at capacity with no plans for expansion. As the population of the Los Angeles area continues to increase, the volume of traffic and amount of roadway and freeway congestion will also increase. Since flood control channels parallel major freeways (Ventura, Golden State, Long Beach, San Gabriel), potential flood conditions could restrict freeway access from the major roadways which enter these freeways, creating a severe traffic problem.

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Table 3.9-1

MAJOR ROADWAYS AND FREEWAYS
IN CITIES INFLUENCED BY THE 100-YEAR FLOODPLAIN

City	Major Roadways	Freeways
Panorama City	Roscoe Boulevard	
Van Nuys	Sherman Way Burbank Boulevard Coldwater Canyon Avenue	
North Hollywood	Riverside Drive	Ventura Freeway (101)
Studio City	Laurel Canyon Boulevard	
Burbank		Ventura Freeway (134)
Glendale	Victory Boulevard	Ventura Freeway (134) Golden State Freeway (5)
Los Angeles	Spring Street Main Street Macy Street First Street Whittier Boulevard Alameda Street	Golden State Freeway (5) Pasadena Freeway (110) Hollywood Freeway (101) Santa Monica Freeway (10) Pomona Freeway (60)
Pico Rivera	Whittier Boulevard Beverly Boulevard Rosemead Boulevard Washington Boulevard Paramount Boulevard Slauson Avenue	
Downey	Telegraph Road Paramount Boulevard Florence Avenue Firestone Boulevard Lakewood Boulevard Imperial Highway Garfield Avenue	Santa Ana Freeway (5)
Lynwood	Atlantic Avenue	Long Beach Freeway (710)
Hollydale	Paramount Boulevard Garfield Avenue	

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Table 3.9-1 (Continued)

MAJOR ROADWAYS AND FREEWAYS
IN CITIES INFLUENCED BY THE 100-YEAR FLOODPLAIN

City	Major Roadways	Freeways
Compton	Rosecrans Avenue Long Beach Boulevard Alondra Boulevard Compton Boulevard Alameda Street	
Paramount	Atlantic Avenue Rosecrans Avenue Compton Boulevard Alondra Boulevard Garfield Avenue Paramount Boulevard Lakewood Boulevard Downey Avenue	Long Beach Freeway (710) Century Freeway (105) Artesia Freeway (91)
Bellflower	Alondra Boulevard Artesia Bouevard Downey Avenue Woodruff Avenue	Artesia Freeway (91)
Lakewood	Lakewood Boulevard Downey Avenue Del Amo Boulevard Paramount Boulevard	
Carson	Avalon Boulevard Carson Street Santa Fe Avenue Del Amo Boulevard Wardlow Road Wilmington Avenue	Long Beach Freeway (71) San Diego Freeway (405)
Long Beach	Artesia Boulevard Atlantic Avenue Long Beach Boulevard Del Amo Boulevard Wardlow Road Willow Street Pacific Coast Highway Anaheim Street Ocean Boulevard Cherry Avbenue Lakewood Boulevard Woodruff Avenue Los Coyotes Diagonal Studebaker Road Seventh Street	Artesia Freeway (91) Long Beach Freeway (710) San Diego Freeway (405) San Gabriel Freeway (605)

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3.9.1.2 500-Year Overflow Area

The area affected by the LACDA 500-year flood plain includes all of the 100-year flood plain, plus additional areas mainly in Van Nuys, Sherman Oaks, Los Angeles, Norwalk, Los Alamitos, and Seal Beach. Additional areas of freeway covered by the 500-year flood plain include portions of the Hollywood (170), Harbor (110), Santa Monica (10), and San Gabriel (605) freeways.

The number of major roadways and the size of the areas affected is considerably higher within the 500-year flood plain boundaries. These roadways are predominantly located in developed, heavily urbanized areas, and traffic flow is heavy during peak-hour periods.

The additional major roadways and freeways that cross, or are within the 500-year flood plain, are listed in Table 3.9-2. These additional areas are centered around portions of the Hollywood Freeway, Harbor Freeway and San Gabriel Freeway, and any impairment to vehicle access in these areas would create traffic backups and congestion, especially during the commuter rush hour.

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3.9.2 Traffic Conditions Within Channel Reaches

3.9.2.1 Lower Los Angeles River

Six freeway overpasses, eleven roadway bridges and three railroad bridges cross the Los Angeles River from Imperial Highway south to Ocean Boulevard.

Average Daily Traffic counts (ADT) for major roadways and freeways in the vicinity of the Los Angeles River Channel, both crossing the channel and adjacent to it, are shown on Figure 3.9-1. This figure illustrates the heavy amount of existing traffic in this highly urbanized area. During peak traffic hours, the freeways and most major roadways in the area are heavily congested with little, if any, excess traffic carrying capacity available. Traffic speeds on the Long Beach freeway (710) during peak hours are estimated at

35-37 mph, with stoppages and backups commonly occurring in the event of an accident or stopped vehicle (Gus Martin, Information Officer, CALTRANS, February 9, 1989).

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Table 3.9-2

ADDITIONAL MAJOR ROADWAYS AND FREEWAYS
IN CITIES INFLUENCED BY THE 500-YEAR FLOOD PLAIN

City	Major Roadways	Freeways
North Hollywood	Laurel Canyon Boulevard	Hollywood Freeway (170)
	Burbank Boulevard	
	Victory Boulevard	
	Sherman Way	
	Roscoe Boulevard	
	Vineland Avenue	
	Lankershim Boulevard	
Sherman Oaks	Van Nuys Boulevard	Ventura Freeway (101)
	Ventura Boulevard	
	Riverside Drive	
	Woodman Avenue	
	Coldwater Canyon Ave	
Burbank	Riverside Drive	
Los Angeles	Olympic Boulevard	Harbor Freeway (110)
	Washington Street	
	Soto Street	
	Central Avenue	
	San Pedro Street	
	La Cienega Boulevard	
	La Brea Avenue	
	Crenshaw Boulevard	
	Western Avenue	
	Vermont Avenue	
	Jefferson Boulevard	
	Rodeo Road	
	Exposition Boulevard	
	Santa Barbara Avenue	
	Figueroa Street	
	Broadway	
	Hill Street	
	Vernon Avenue	
	Slauson Avenue	
	Florence Avenue	
	Manchester Avenue	
	Century Boulevard	
	Imperial Highway	
Gardena	Artesia Boulevard	San Diego Freeway (405)
	Vermont Avenue	Harbor Freeway (110)

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Table 3.9-2 (continued)

ADDITIONAL MAJOR ROADWAYS AND FREEWAYS
IN CITIES INFLUENCED BY THE 500-YEAR FLOOD PLAIN

City	Major Roadways	Freeways
Torrance	Vermont Avenue Torrance Boulevard	Harbor Freeway (110)
Santa Fe Springs	Whittier Boulevard Washington Boulevard Slauson Avenue Telegraph Road Firestone Boulevard	San Gabriel Freeway (605) Santa Ana Freeway (5)
Norwalk	Imperial Highway Rosecrans Avenue Pioneer Boulevard Norwalk Boulevard Artesia Boulevard Alondra Boulevard	San Gabriel Freeway (605) Artesia Freeway (91)
Cerritos	Norwalk Boulevard Pioneer Boulevard South Street Bloomfield Avenue Carson Street	San Gabriel Freeway (605)
Los Alamitos	Cerritos Avenue Los Alamitos Boulevard	San Diego Freeway (405) San Gabriel Freeway (605)
Seal Beach	Westminster Ave Los Alamitos Boulevard	

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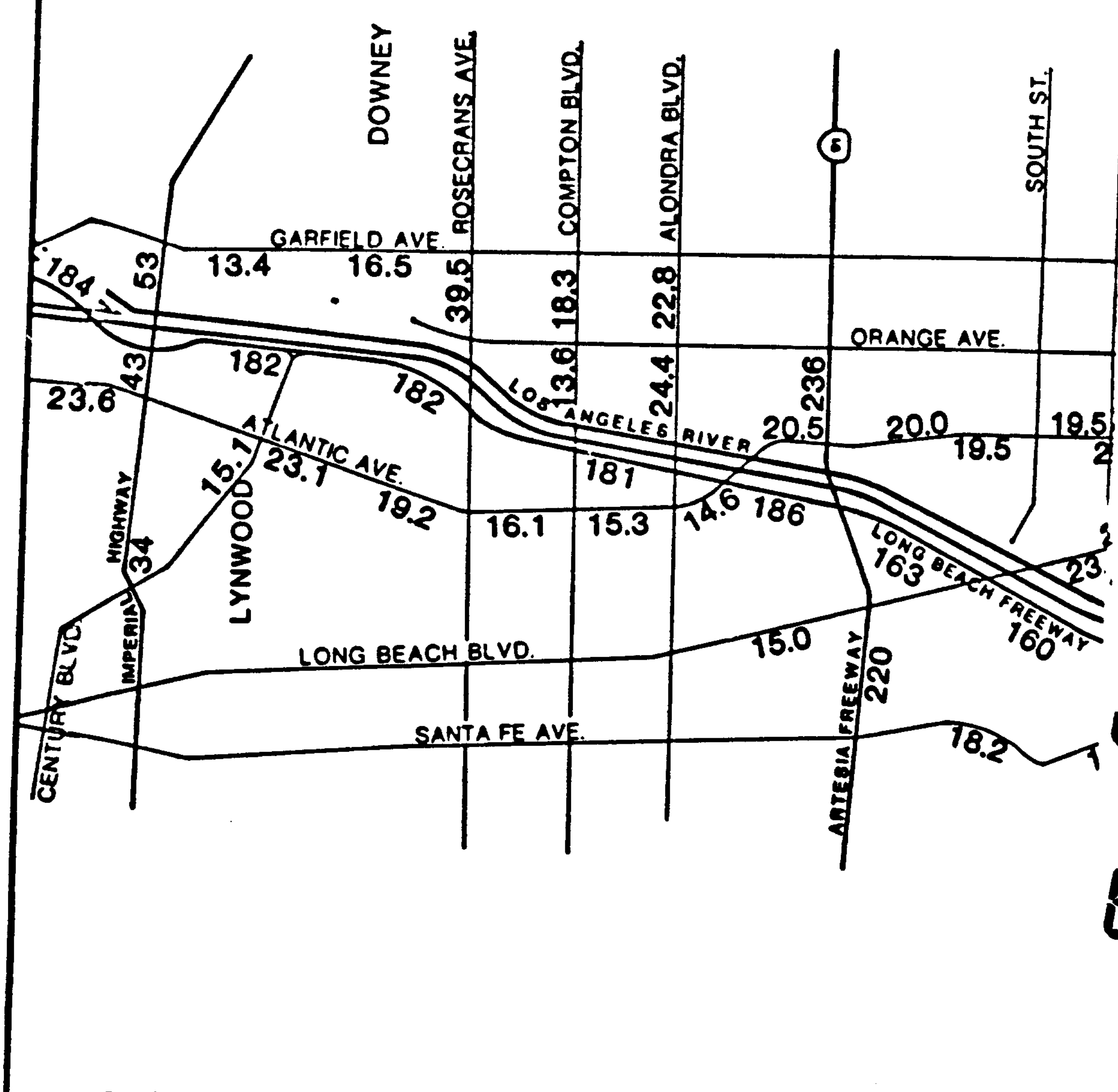

Sources: Compiled from municipal traffic/planning departments and CALTRANS

LOWER LOS ANGELES RIVER – REACH 4 AVERAGE DAILY TRAFFI

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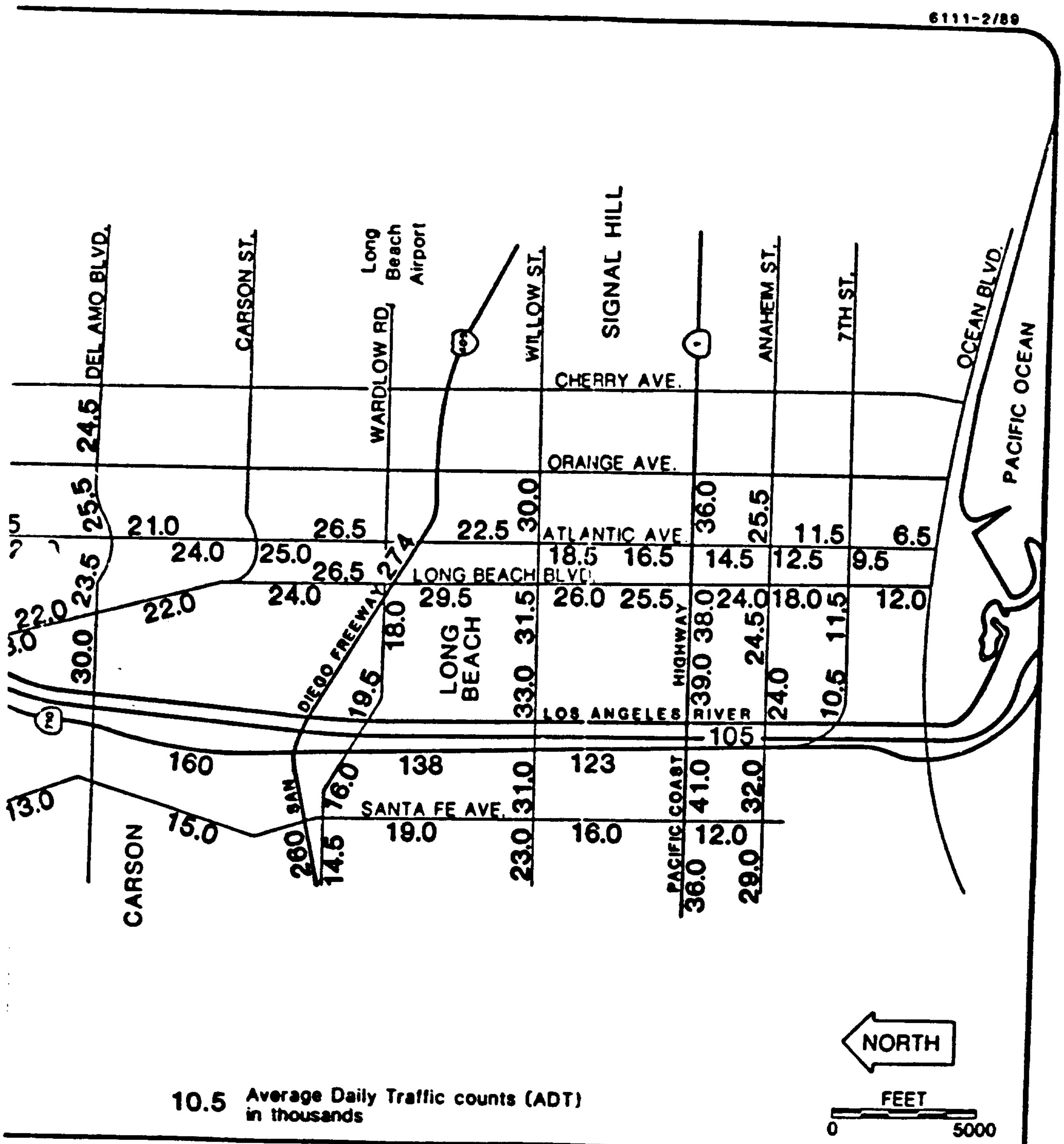

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FIGURE 3.9-1

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Public Works projects currently underway or proposed for the near future which have the potential to affect traffic in the area include construction of the Century freeway (105), which crosses the Los Angeles River Channel south of Imperial Highway and is scheduled for completion in the fall of 1993; the Los Angeles to Long Beach Light Rail, which crosses the channel north of the San Diego Freeway and is also scheduled for completion in 1993; and a joint Port of Long Beach-City of Long Beach project to improve Long Beach Freeway offramps to Ocean Boulevard and Harbor Scenic Drive near the outlet of the Los Angeles River in Long Beach Harbor, scheduled for completion the summer of 1990 (Doug Failing, CALTRANS, February 9, 1989).

Future traffic conditions in the lower Los Angeles River area are expected to be worse than at present. Improvements to surface streets will do little more than maintain the current level of service. At this time there are no plans to increase the capacity of the Long Beach Freeway, the major thoroughfare for commuter traffic in the area (Doug Failing, CALTRANS, February 9, 1989).

3.9.2.2 Rio Hondo Channel

The Rio Hondo Channel improvement area extends from Whittier Narrows Dam southwest to the Los Angeles River. This reach of the LACDA study area passes through the cities of Montebello, Pico Rivera, Bell Gardens, Downey, and South Gate.

From Beverly Boulevard southwest to the Los Angeles River, ten roadways, one freeway, and five railway bridges cross the Rio Hondo Channel.

The existing traffic counts (ADT) for the major roadways and freeways crossing, or in the vicinity of, the Rio Hondo Channel are shown in Figure 3.9-2. Traffic in this highly urbanized area is heavy, with congestion and backups common at major street intersections during peak periods.

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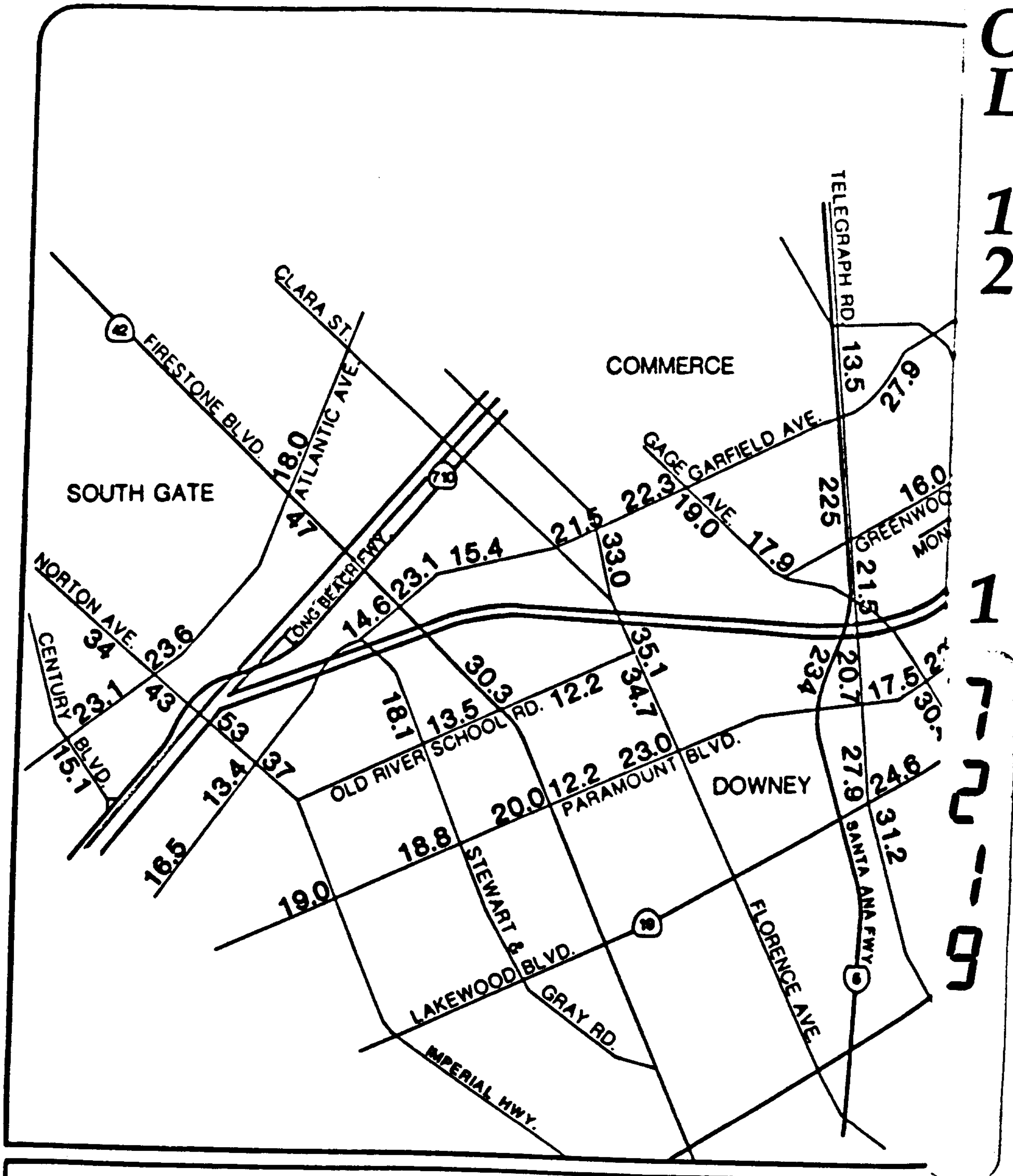

RIO HONDO CHANNEL - REACH 5 AVERAGE DAILY TRAFFIC COU

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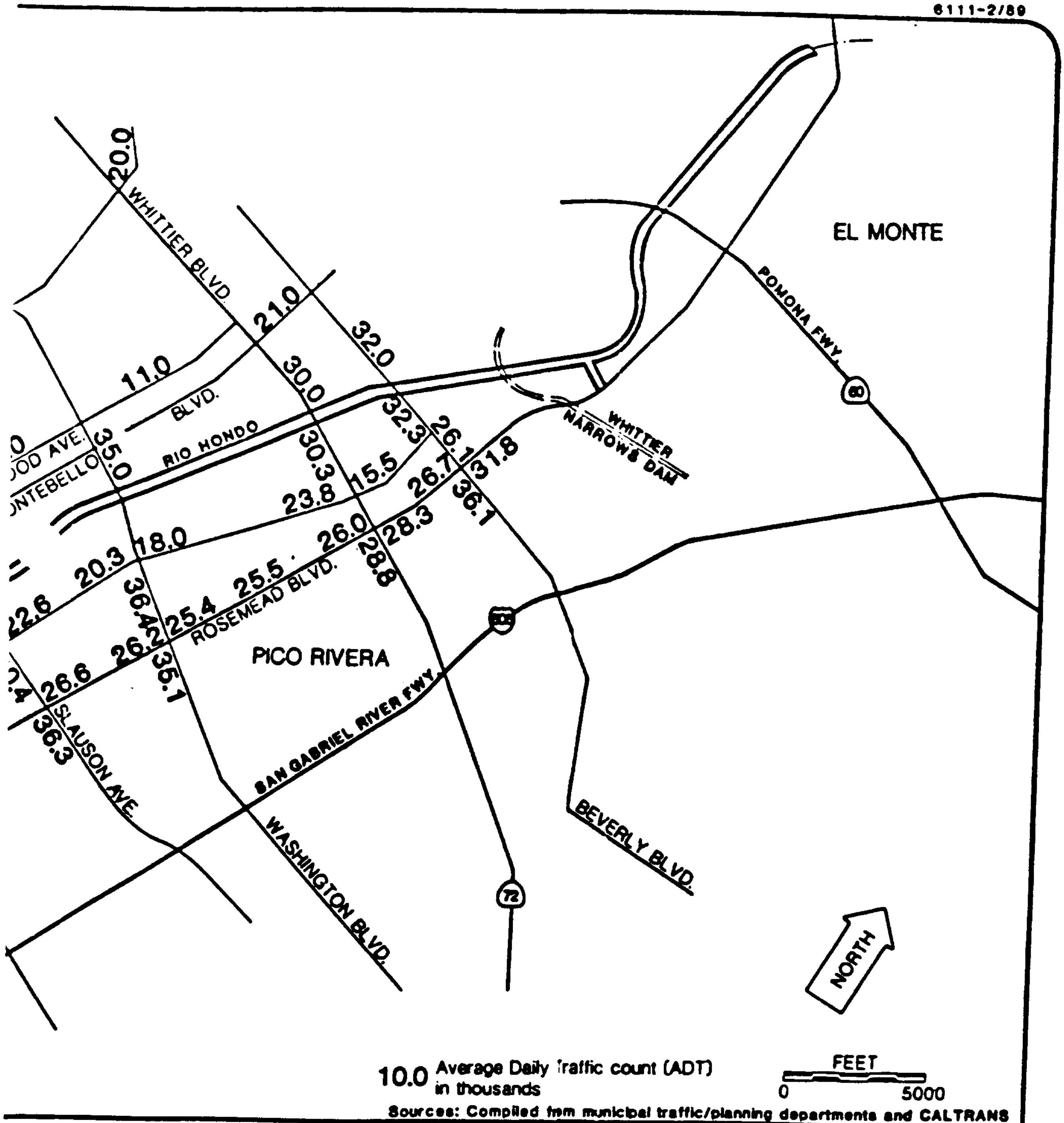

FIGURE 3.9-2

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The Santa Ana Freeway (5), which is the only freeway that crosses the channel, is a heavily utilized commuter link from Los Angeles County to Orange County. Average daily traffic counts are 225,000 vehicles north of the channel and 234,000 vehicles south of the channel. During peak periods, traffic on this freeway is usually heavy.

The volume of traffic in the vicinity of the Rio Hondo Channel is expected to increase. Restrictions to traffic capacity due to construction (or other projects), would aggravate existing situations and increase the level of congestion and vehicle slowing or stopping.

3.10 RECREATION AND AESTHETICS

3.10.1 Flood Plain Overview

Recreation activities within the identified project area include a large variety of parks, community recreation centers and country clubs, public and private golf courses, tennis and racquet facilities, picnic and camping, ballfields, and equestrian facilities. Park areas range from small, local community park/playgrounds to large city and regional parks such as Griffith and Elysian Parks which border the Los Angeles River; El Dorado Park bordering the San Gabriel River; as well as other major recreational park facilities located within the 100-year flood plain.

Bike/pedestrian and equestrian trails and wildlife trails also run through most of the length of the channels and meander through the dam facilities. Trail systems such as the San Gabriel River Trail and Lario Trail include bike paths which use the service roads on top of the channel levees. Equestrian trails also follow these systems separated, where possible, from the bike path, though sometimes only by a narrow unpaved strip of earth. Often the equestrian trails end at undercrossings and horses must share the path at that point with bikes and pedestrians. In many areas the equestrian and bike trails share the same black-topped trail.

Recreational access to the channel bike and equestrian trails is mostly via crossing streets which intersect the channel. A gate in the fencing provides access. Most gates include a bar across the gate which prohibits motorized vehicles from entering the area. Many park and other recreational facilities abut the channel; yet direct access to the channel is mostly very limited. Direct access to the channel is provided by gated access points or from connecting trails.

The general public typically has views of the channel only from freeways and cross streets. At ground level, embankments rise up to the elevation of either bike/pedestrian or maintenance roads on the sides of the channel, effectively blocking views of the channel and structures on the far side of the channel. Only the tops of structures across the channel are sometimes visible. Several power line easements with high towers and lines also parallel the channel in some areas.

Some homes have back fence lines which abut the bike trails with no separation or buffers. These homes either have chain-link or block wall fences. The homes are located at an elevation such that no views of the channel or bike path exist for one-story homes with block walls. Only those homes which are two-story or have chain-link fencing may have some view of the bike path and channel.

3.10.2 Recreation and Access Considerations Along Channel Construction Reaches

A detailed study has been prepared for the purpose of identifying recreation facilities bordering the LACDA flood control system (see LACDA Review Study Technical Documentation Report for Recreation). This inventory describes in detail all facilities located within the basins and channels, including constructed elements that make up each facility. Recreational access (bike and equestrian) routes and links between the system and neighboring facilities are identified and located on detailed maps in the review.

A Final Design Memorandum was also prepared which details the aesthetics and designs for equestrian and bike recreational facilities for the length of the Lario San Gabriel river trail system. This system includes the upper and lower San Gabriel River, the upper and lower Rio Hondo Channel and the lower Los Angeles River systems. Specific design criteria and plans are laid out for not only trails but also access ramps and bridges, rest areas and appropriate landscaping. Some of this design work has been implemented and is shown in the Recreation Technical Documentation Report.

Recreational facilities for those channel corridors and portions of corridors which will be affected by channel construction improvements are in the LACDA Recreation Review study. These activities will primarily affect the lower Los Angeles River (Reach 4) and the Rio Hondo Channel (Reach 5). These facilities are provided in map form in Figures 3.10-1 and 3.10-2.

3.10.2.1 Lower Los Angeles River

The lower Los Angeles River is characterized as a concrete-lined channel surrounded by a highly urbanized/industrialized area. Vegetation in the channel is sparse with only small patches of weeds appearing at cracks or joints in the channel. The exception to this is a wetlands area in the channel from Willow Street south to Anaheim Street.

Bordering the channel is a mix of residential, commercial, industrial areas contrasted with established parks, equestrian facilities and golf courses. The parks, equestrian facilities and golf courses are located primarily along the east border, some having direct access to the bike and equestrian trails.

The bike and equestrian trails run the length of Reach 4, actually extending from the Pacific Ocean north to the confluence with Rio Hondo Channel. North of the Rio Hondo Channel the trails continue on the west levee of the Los Angeles River.

Concrete bike/pedestrian and dirt equestrian paths run along the top of the east levee from Willow Street north. Only a bike trail abuts the channel from the ocean north to Willow Street. Both the bike path and west levee top provide access for maintenance of the channels. The entire channel reach boundary is chain-link fence except where public access to the trail and adjacent facilities is provided.

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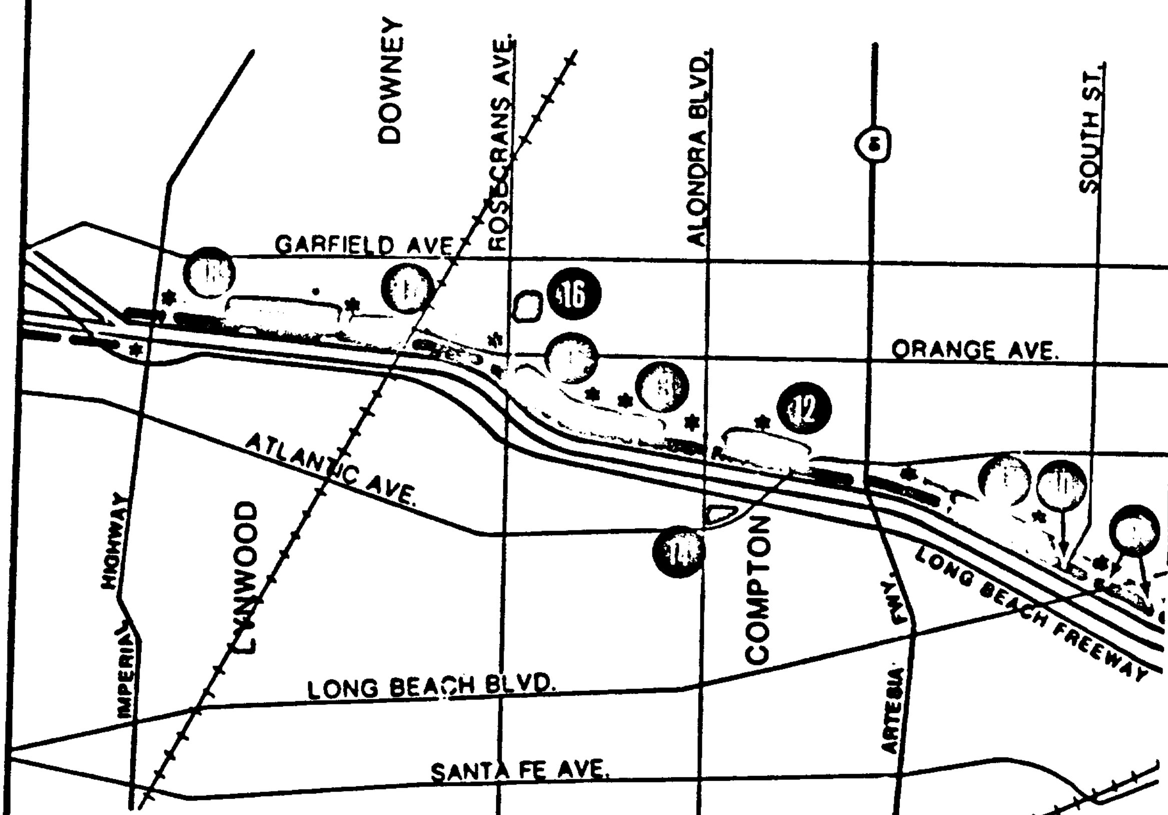

1) Lario Trail
2) Small greenbelt park, pedestrian gate access to ROW
3) Equestrian stables, direct access to trail
4) Private stables, access to west channel
5) Los Cerritos Park, City of Long Beach. playground, tennis, swimming, picnic, no access to channel
6) William Reed Park, Long Beach. private boy scout camp, no access to channel
7) Virginia Country Club (private), no channel access
8) Lario Trail runs through wide natural channel, bike path on east levee
9) Equestrian staging, metal hitching rails in channel ROW
10) Equestrian trails run through 100-ft. wide vacant area
11) DeForest Park, City of Long Beach. community bldg., tennis, ballfield, channel access to midpoint of park
12) Public equestrian riding ring
13) Compton Golf Course, no channel access
14) East Compton Park, Los Angeles County. community room, basketball, tennis, picnic
15) Banana Park, City of Paramount. recreation bldg., basketball, locked gates at north and south ends of park access trail
16) Spane Park, City of Paramount. recreation bldg., ballfield
17) Open equestrian field next to channel ROW
18) Hollydale Park, City of South Gate. play areas, tennis courts, riding ring, trail access

LOWER LOS ANGELES RIVER - REACH 4 RECREATION FACILITIES

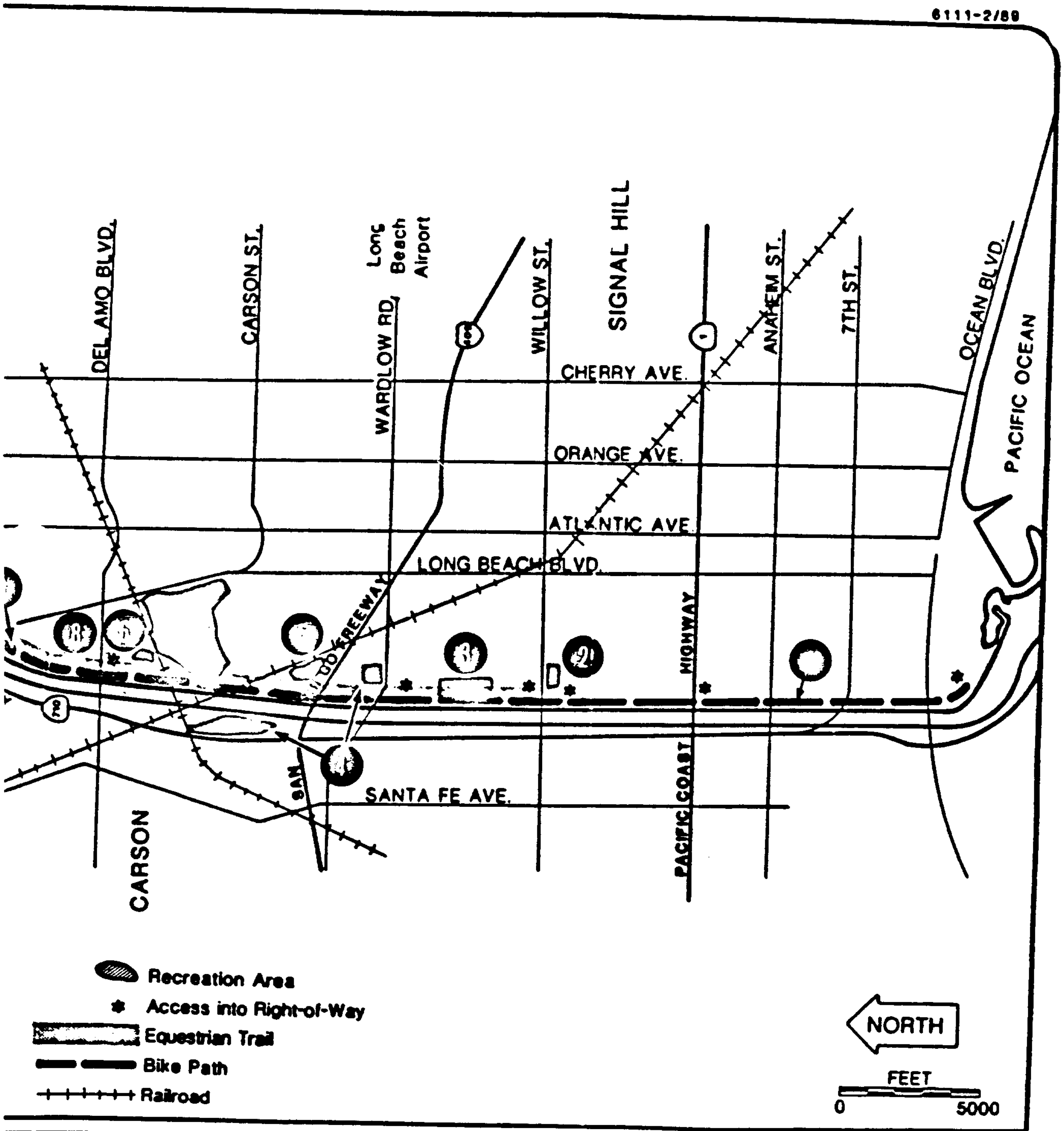

FIGURE 3.10-1

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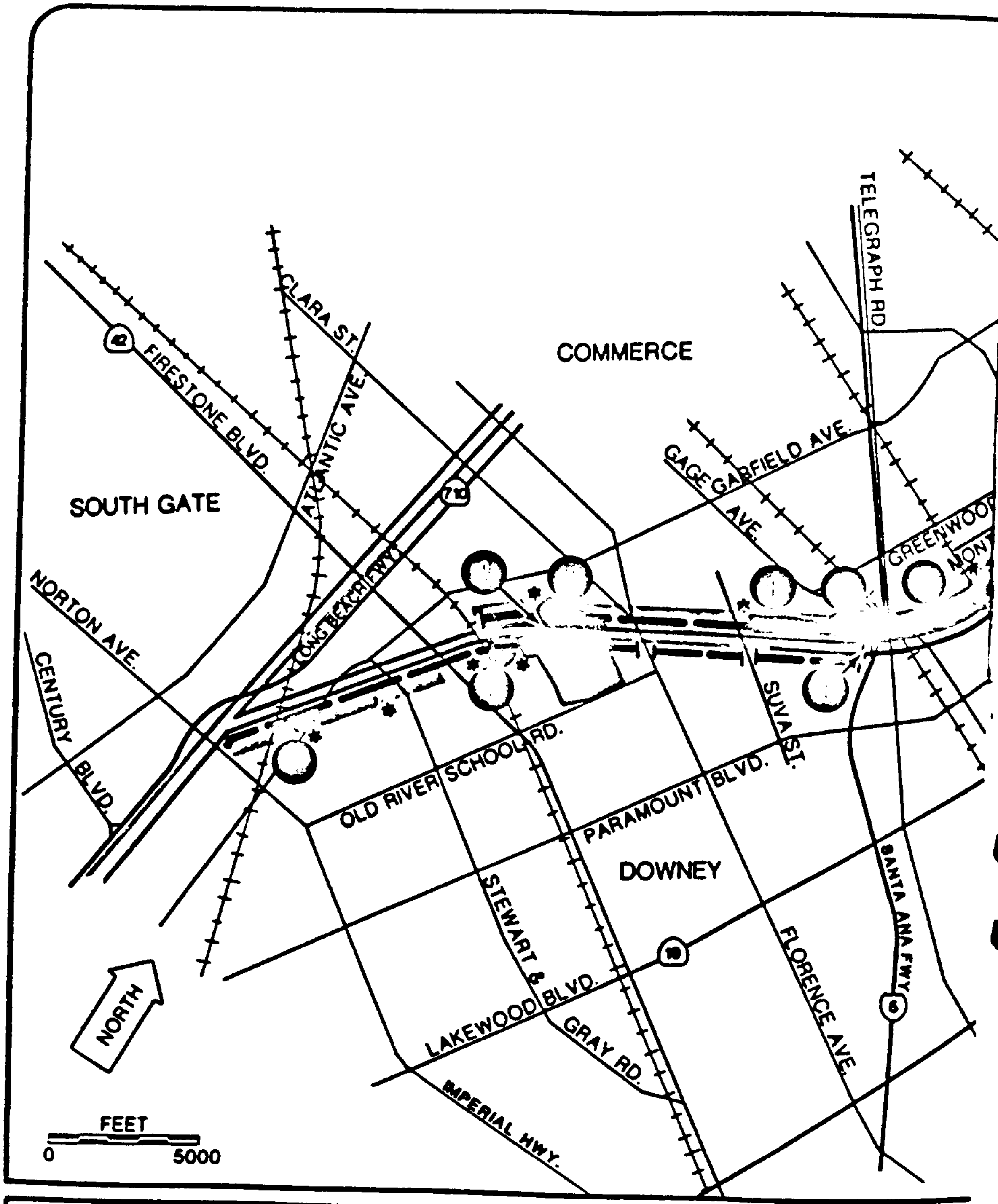

RIO HONDO CHANNEL - REACH 5 RECREATION FACILITIES

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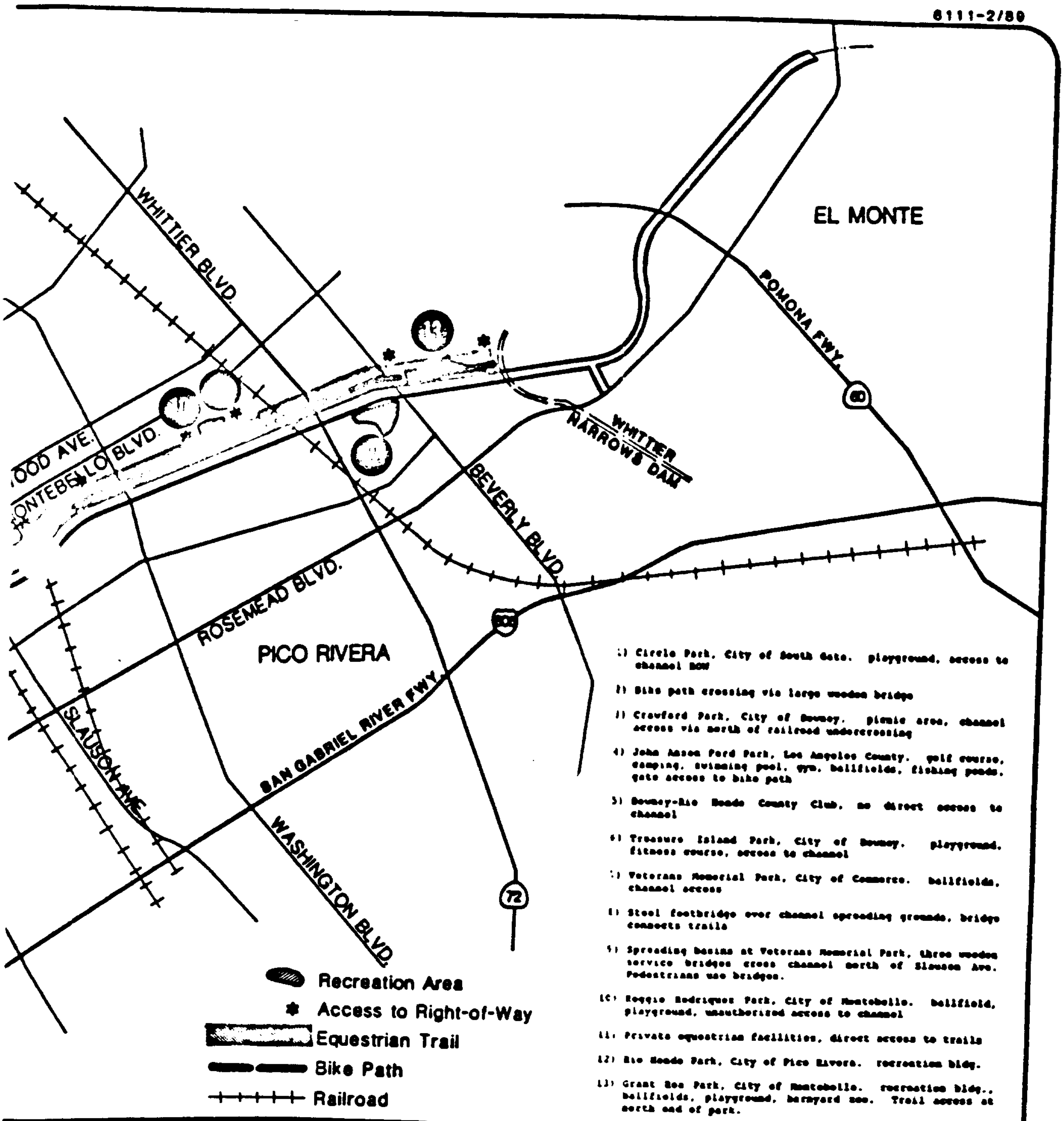

FIGURE 3.10-2

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Some key elements of the lower Los Angeles River which have direct access to the trail system include a small greenbelt park and DeForest Park in Long Beach, East Compton Park, Banana Park in Paramount, Hollydale Park in South Gate and four equestrian facilities. In addition, equestrian staging areas and wide open equestrian fields are located at the midpoint and at the upper end of this reach. Additional access points are provided at cross streets in the area.

Trail users are primarily visually exposed to the concrete channel and surrounding land uses. Except for the wetlands area in the channel between Willow Street and Anaheim Street, areas of aesthetic value include strip park areas abutting the channel to the east such as DeForest Park.

The lower segment of the lower Los Angeles River between Anaheim Street and Ocean Boulevard is within the coastal zone. As such, the proposed project must be reviewed with regard to impacts to recreational use and access to coastal areas, as well as consistency with the Coastal Act. The bike trails provide access to coastal recreation areas, and small boats, and bank fisherman take advantage of the resources of the lower Los Angeles River.

3.10.2.2 Rio Hondo Channel

The Rio Hondo Channel is also characterized as a concrete-lined channel surrounded by a highly urbanized/industrialized area. Weeds are the only vegetation within the channel and typically grow between cracks and joints in the channel. The channel is bordered by a mix of land uses, including residential, commercial, industrial as well as recreational. Spreading basins are located just north of the Santa Ana Freeway on the west side of the channel.

Bike, equestrian and pedestrian trails (Lario Trail system) run most of the length of the Rio Hondo system. Concrete bike and some dirt equestrian trails run on the east side of the channel from the confluence with the Los Angeles River to the Santa Ana Freeway, and bike and equestrian trails run on the west side of the channel from north of

Firestone Boulevard to Whittier Narrows Dam. Between the Southern Pacific Railroad bridge (north of Firestone Boulevard) and the Santa Ana Freeway, the trails run on both sides of the channel. Two bike/pedestrian/equestrian bridges connect the trails with a large wooden bridge at the south end and a steel footbridge just south of the freeway on the north end.

Access to the parks and recreational facilities along the channel are provided through numerous ramps from park areas as well as cross streets. Maintenance vehicles enter the reach at many of the numerous cross streets and use both sides of the channel, including the trails, for maintenance. Maintenance vehicle access to the channels can also be obtained from Whittier Narrows Dam.

Recreational areas having access to Reach 5 include Circle Park in South Gate; Crawford Park and Treasure Island Park in Downey; John Anson Ford Park, under the County of Los Angeles jurisdiction; Veterans Memorial Park in Commerce; and Grant Rea Park in Montebello. Private equestrian facilities near the north end of Reach 5 also access the trails. These areas provide pleasing aesthetics along the trails in addition to being available to trail users as places to relax.

3.11 PUBLIC SAFETY

3.11.1 Flood Plain Overview

The potential of a 100-year and 500-year flood occurring was previously described in Section 3.2. Presently, portions of the LACDA system do not have the capacity to prevent flooding from even a 100-year flood. Large floods occur infrequently, but their magnitude of destruction is enormous. A tabulation of damagable units is presented as Tables 3.3-1 and 3.3-2 in Section 3.3. for the 100- and 500-year events.

Although a flood with a 100-year or greater frequency has not occurred in the 20th Century, there remains a one-in-a-hundred chance that it may be equalled or exceeded in any single year. Such an event could impact almost 82 square miles (212 km^2) with flood waters in localized areas as deep as 8 to 10 feet (2.4 to 3.1 m). Most areas could experience flooding of from 1 to 4 feet (0.3 to 1.2 m).

Significant impacts exist for public safety if a 100-year event were to occur. Potential dangers include being trapped in structures or automobiles, being swept into flood waters, or aftereffects of a major event such as inaccessibility to food and water, and effects of standing water, including the spread of mosquitoes and other pests and disease.

Additional significant public safety and health problems could occur from toxic and hazardous materials being washed into the environment. A large number of industrial facilities are located within the flood plain and at locations adjacent to the channels. Many of the facilities have materials stored in drums or use potentially hazardous materials in their operations.

3.11.2 Public Safety Considerations Along Channel Construction Reaches

The trail systems provide for the safety of recreational users in that the trails separate the users from automobile traffic. Bike trails run along the top levee parallel to the channel with crossings provided underneath roadways and freeways. In general, there is no fencing or protection provided for users riding or falling down the embankments to the channel bottom. This condition has the potential to result in injury to the trail user.

Occasionally, maintenance vehicles will obstruct the trail, causing trail users to have to go around such vehicles. Trails are sometimes closed for major maintenance and construction activity.

In some areas of the trail systems, equestrian as well as bicyclists and pedestrians share the same pathways. While some of the equestrian trails are separated, even if only by narrow strips of earth, most equestrian trails end at undercrossings and share the same pathways with bikes and pedestrians.

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No specific issues of traffic safety on surface streets have been noted. Traffic on surface streets in the areas of proposed construction are comparable to other areas of Los Angeles.

As mentioned above, large numbers of industrial facilities are located adjacent to the channels. Many of the facilities contain materials which may be toxic or hazardous if released.

3.12 PUBLIC UTILITIES

The study area is highly developed, and contains a great diversity of utility systems including natural gas, potable water, electrical lines (above and underground), telephone lines, petroleum lines, and similar utilities. These lines cross the river under the channel, on roadway and highway bridges and on special pipeline bridges. A detailed, comprehensive inventory of all utilities crossing the river has not been conducted. Each of the bridges have vaults which are expected to contain all or most all utilities. Additionally, utilities cross under the channel throughout the two reaches.

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SECTION 4 - ENVIRONMENTAL EFFECTS

(A table of environmental commitments, Table 4.11, can be found at the end of this section.)

4.1 LAND USE AND SOCIAL CONCERNS

Land use impacts are considered significant if the construction activity or completed project is inconsistent with land use policy or planning. The plans include relevant zoning ordinances, general plans, resource management plans, recreation master plans, water supply master plans and redevelopment agency plans. Significant impacts will also occur if a proposed use is inconsistent with existing adjacent land uses in the area, even if both are allowed.

4.1.1 No Action Alternative

4.1.1.1 Impacts

The No Action Alternative will result in no land use impacts to the lower Los Angeles River and Rio Hondo areas. Land use will remain the same as present with no impact on land use planning or policies.

4.1.1.2 Mitigation Measures

No impacts are anticipated so no mitigation is required.

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4.1.2 NED Plan Alternative (Main Report NED Plan)

4.1.2.1 Impacts

Flood Overflow Areas (Main Report NED Plan)

The NED Alternative will have no effects on existing or proposed land use policy or planning. Regarding future planning, including a potential growth management plan, even though project hydrology assumes that some candidate urban areas that are not presently developed will be developed, these areas contribute only 2 percent of the total flow in the project area. This 2 percent figure is considered insignificant from the standpoint of channel design; thus no land use impacts from area development are anticipated.

This alternative will not reduce the area of inundation or the frequency of occurrence of a 500-year flood event, nor will it effect more frequent flooding events in the upper reaches of LACDA. It may, however, reduce the potential depth of inundation of various areas subject to deep flood waters. The NED alternative will nearly eliminate the 100-year area of inundation in Reaches 4 and 5 (Figure 4.1-1). Elimination of the 100-year area of inundation will save 135,931 structures out of a total of 141,508 presently existing within the 100-year overflow area (see Table 3.3-2).

Land Use Adjacent to Channel Construction Reaches (Main Report NED Plan)

Construction activity will be limited to existing right-of-way property where possible. A list of bridge detour locations that may require use of adjacent land is presented in Table 2.3-7. These uses of land are inconsistent with present uses and may result in potential safety impacts. This incompatible land use occurs due to the necessity of providing mitigation for traffic impacts.

Construction activity may also encroach upon certain residential areas, and especially commercial/industrial areas, where the back fences of these properties are directly adjacent to the levees. Construction activity, including the use of heavy equipment and loud equipment, will result in a temporary land use which is inconsistent with adjacent uses. Resultant impacts may include noise, air quality and traffic impacts. The specific impacts and mitigations for these encroachment activities are presented in the appropriate resource sections within this document.

4.1.2.2 Mitigation Measures

Mitigation for use of the various properties for the temporary construction of a traffic detour includes full financial compensation and replacement of the sites after construction activity ceases.

4.1.3 Modified Channel Cross-section Alternative (Main Rpt Alts. Two and Three)

4.1.3.1 Impacts

Flood Overflow Areas

Impacts are identical to those presented for the NED Alternative in Section 4.1.2.1 above. No impacts will occur to land use planning or policy. This alternative will eliminate the 100-year area of inundation in the lower LACDA basin.

Land Use Adjacent to Channel Construction Reaches

Construction activity will generally be limited to available right-of-way property. Construction activity may, however, encroach upon certain residential and commercial/industrial areas, especially where the back fences of these properties are directly adjacent to the levees. Construction activity, including the use of heavy

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equipment and loud equipment, will result in a temporary land use which is inconsistent with adjacent uses. Resultant impacts may include noise, air quality and traffic impacts. The specific impacts and mitigations for these encroachment activities are presented in the appropriate resource sections within this document.

4.1.3.2 Mitigation Measures

Mitigation measures for activities which encroach upon adjacent uses are presented under other resource sections within this document, including noise, air quality and traffic.

4.2 AIR QUALITY

Air quality impacts are considered significant if one or more of the following criteria are exceeded:

- Emissions result in exceedance of state or Federal air quality standards;
- Emissions at or greater than 1 percent of emissions for a potential pollutant within the subarea of the South Coast Air Basin;
- Release of hazardous non-critical pollutants into the atmosphere;
- Generation of dust exceeding SCAQMD Rule 403.

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4.2.1 No Action Alternative

4.2.1.1 Impacts

The No Action alternative would not cause any direct impacts to the existing air quality in the project area.

4.2.1.2 Mitigation Measures

No mitigation is required.

4.2.2 NED Plan Alternative (Main Report NED Plan)

4.2.2.1 Impacts

All air impacts are short term and construction related. No significant long-term, permanent impacts are expected to occur as a result of this project.

Impacts to air quality from the NED alternative could come from dust generated during construction activities and pollutants released from internal combustion engines of on- and off-site construction equipment.

The major sources of dust include soil disturbance, travel on unpaved surfaces, and loading/unloading of dusty material. These scattered sources of particulates, referred to as fugitive dust, are difficult to quantify. Therefore, the impact on the surrounding areas is not easily assessed. If regular watering of potential dust-generating areas is performed, impacts from construction activities should be minimal. However, during Santa Ana wind conditions, construction activities could potentially generate significant levels of suspended dust particles.

Internal combustion engines will produce combustion pollutants from on-site heavy equipment and off-site trucks hauling material and delivering concrete. The daily equipment combustion emissions during a maximum 12 hour workday from project-related mobile source emissions have been calculated in Table 4.2-1. These calculations were based on an estimated equipment list (see Table 2.3-6) which assumes that all

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equipment operates at 60 percent of maximum load. Construction employee commuting and light-duty pickup use was not included, but emissions from these activities are generally much less than on-site heavy equipment and off-site trucks.

Table 4.2-1

MOBILE SOURCE COMBUSTION EQUIPMENT EMISSIONS
MAXIMUM INTENSITY DAY
(pounds/day)

Equipment	Daily Work Hours	CO	ROG	NOx	SOx	TSP
On-highway trucks	70	38.8	13.6	79.7	15.3	14.8
Off-highway trucks	164	295.2	31.2	683.1	74.5	42.0
Wheeled tractors	70	250.4	13.1	88.9	6.3	9.5
Bulldozer	47	84.6	9.0	195.8	16.5	7.8
Motor grader	39	5.9	1.6	2.1	3.3	2.3
Compactor	70	126.0	13.4	291.7	24.5	11.7
Miscellaneous	172	116.3	26.3	291.0	24.6	23.9
Total (lb/day)		917.2	108.2	1632.3	165.0	112.0
Total (tons/day)		0.46	0.05	0.82	0.08	0.06
SRA 4+5+11+12 (tons/day)		1132.2	213.6	213.0	-	-
Project Share of SRAs		0.04%	0.02%	0.38%	-	-

Source: Values based on information in "Air Quality, Noise and Traffic Study for the Santa Ana River Project", MITECH 1988; and SCAQMD, Air Quality Handbook, 1983 Edition.

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Total daily emissions range from about 100 to 150 pounds (45 to 67.5 kg) per day for exhaust particulates, hydrocarbons, and SO_2, to close to 1,000 pounds (450 kg) per day for carbon monoxide and over 1,500 pounds (675 kg) per day for NOx. A large portion of these emissions are from hauling materials such as concrete and other materials. These emissions could be dispersed over a larger area, depending on where material trucked to the site originates from and where material removed will be disposed.

A comparison with existing subregional emissions from AQMD Source Receptor Areas (SRA) 4, 5, 11, and 12 (Long Beach, Whittier, Pico Rivera, and Lynwood, respectively), indicates that the project contribution to the CO, ROG, and NOx burden is adverse, yet below the level of significance (1 percent of the subarea total).

4.2.2.2 Mitigation Measures

Discretionary mitigation measures to control project emissions center primarily on fugitive dust control not amenable to standard dust control technology. Mitigation measures for inclusion in project planning include:

o Frequent watering of the construction area to limit dust emissions from on-site equipment and off-site trucks accessing the project,

o Provisions for terminating operations during strong Santa Ana wind conditions.

In addition to dust control measures, there are mitigation measures from non-particulate sources that will be implemented, and thus should be given consideration where appropriate. Such measures include:

o Good maintenance, including proper tuning of off-road heavy equipment, to reduce combustion source air emissions (especially NOx),

o Control of diesel fuel quality (low sulfur content),

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- Site activity control/termination during Stage II smog episodes,
- Contractor participation in the AQMD mandatory rideshare program (Regulation XV).

4.2.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.2.3.1 Impacts

All air quality impacts are short term and construction related. No significant long-term, permanent impacts are expected as a result of this project.

Excavation of excess material during conversion or widening, travel on unpaved surfaces, and other construction elements have traditionally been associated with dust generation which may create localized dust nuisances near the activity. Improved control technology, however, in conjunction with emission rules and restrictions on certain operations developed by the AQMD, has led to a substantial reduction in emission levels. The major source of emissions from controlled construction activities is therefore from scattered sources not amenable to control (called fugitive emissions).

Dust emissions associated with the proposed project include a wide variety of activities such as excavating the material from the channel sides, moving material to a disposal site, and constructing the new channel walls. In addition to fugitive dust, project activities will entail the generation of combustion emissions from mobile equipment to extract the material, haul material to a disposal site, and bring concrete to construct channel walls. Soft-bottom river sediments will be dredged from the last 2.5 mi (4 km) of the lower Los Angeles River. The diesel dredge employed for this project will contribute additional combustion emissions as will haul trucks or barges used to transport the dredged material to a suitable disposal site.

The daily equipment combustion emissions during a maximum intensity workday from estimated project-related mobile source emissions have been calculated in Table 4.2-2.

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These calculations were taken from the analysis of a similar project proposed on the Santa Ana River (MITECH 1988) with the addition of the dredging activities which are based on emission factors published by the EPA in its "Compilation of Air Pollution Emissions Factors - AP-42", assuming a worst-case scenario of using haul trucks for dredged material disposal.

Total daily emissions range from about 250 pounds (112.5 kg) per day for exhaust particulates, hydrocarbons, and SO_2 to over 800 pounds (360 kg) per day for CO and just under 2,000 pounds (900 kg) per day for NOx. The majority of these emissions are from vehicles used for hauling material. Emission values could possibly be reduced somewhat if dredged material were barged to an ocean disposal site, depending on the distance to that site. Also, emissions could be reduced if an electric dredge can be utilized.

Comparison with existing subarea emissions (SRAs 4, 5, 11, and 12) indicates that the contribution from the project to the CO and NOx burden, while adverse, is below the level of significance (1 percent of the subarea total).

4.2.3.2 Mitigation Measures

The dredging operations associated with modifying the channel cross-section will require an air quality permit from the South Coast AQMD which will establish control limits on emissions. Discretionary mitigation measures to control project emissions center primarily on fugitive dust control not amenable to standard dust control technology. Mitigation measures to be considered for inclusion in project planning include:

- o Frequent watering of the construction area to limit dust emissions from on-site equipment and off-site trucks accessing the project,

- o Provisions for terminating operations during strong Santa Ana wind conditions.

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Table 4.2-2

MODIFIED CHANNEL CROSS-SECTION ALTERNATIVE
MOBILE SOURCE COMBUSTION EQUIPMENT EMISSIONS
MAXIMUM INTENSITY DAY
(pounds/day)

Equipment	Daily Work Hours	CO	ROG	NOx	SOx	TSP
On-highway trucks	932	516.3	180.8	1060.6	203.2	197.6
Off-highway trucks	128	230.5	24.4	533.1	58.1	32.7
Wheeled loaders	28	16.0	7.0	53.0	5.1	4.8
Compactor	8	14.4	1.5	33.3	2.8	1.3
Dredge	10	32.9	10.7	151.4	5.7	10.8
Miscellaneous	12	8.1	1.8	20.3	1.7	1.7
Total (lb/day)		818.2	226.2	1851.7	276.6	248.9
Total (tons/day)		0.41	0.11	0.93	0.14	0.12
SRA 4+5+11+12 (tons/day)		1132.2	213.6	213.0	-	-
Project Share of SRAs		0.04%	0.02%	0.44%	-	-

Source: Values based on information in "Air Quality, Noise and Traffic Study for the Santa Ana River Project", MITECH 1988; SCAQMD, Air Quality Handbook, 1983 Edition, and EPA AP-42, Compilation of Air Pollution Emission Factors 1985.

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In addition to dust control measures, there are mitigation measures from non-particulate sources that may possibly be implemented, and thus should be given consideration where appropriate. Such measures include:

- o Good maintenance, including proper tuning of off-road heavy equipment, to reduce combustion source air emissions (especially NOx),
- o Control of diesel fuel quality (low sulfur content),
- o Site activity control/termination during Stage II smog episodes,
- o Contractor participation in the AQMD mandatory rideshare program (Regulation XV).

4.3 WATER QUALITY AND FLOOD POTENTIAL

Impacts to water quality are considered significant if activities result in a violation of existing water quality standards, result in substantial release of toxic materials or exacerbate existing water quality problems.

Impacts are also considered significant if the project results in an increase in flood potential in a particular reach of the river.

4.3.1 No Action Alternative

4.3.1.1 Impacts

Implementation of the No Action Alternative will result in no increase in sedimentation or creation of any additional water quality impact. The Los Angeles and Rio Hondo rivers would continue to experience water quality problems associated with urban runoff and illegal discharge of toxic materials. No wetlands shall be affected as a result of this alternative.

If the No Action Alternative were implemented, the existing flood potential in the lower Los Angeles and Rio Hondo rivers would continue.

4.3.1.2 Mitigation Measures

Other than continuing flood warning programs and the potential use of upstream retention basins, no mitigation is proposed.

4.3.2 <u>NED Plan Alternative (Main Report NED Plan)</u>

4.3.2.1 Impacts

Since most of the construction activities are proposed to take place on top of the existing channel walls, there would be no sedimentation impacts associated with parapet wall construction. Where channel widening would occur as well as wall construction possibly at bridges, there would be a potential for significant sedimentation impacts associated with excavation and movement of materials. This impact could become significant during moderate river flows. There is also a potential that toxic material such as diesel fuel could be accidentally discharged by construction equipment and operations. This impact could also be significant.

Implementation of this alternative would result in the 100-year flood plain being contained to the lower Los Angeles River channel and the channel of the Rio Hondo river. There would be no change in upstream flood potential. No wetlands shall be effected as a result of this alte rnative.

4.3.2.2 Mitigation Measures

Whenever possible, work within the channel will be confined to low flow periods. Downstream sediment basins will be constructed in order to trap sediments from construction operations. Refueling of equipment near the channel will be limited and closely monitored.

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4.3.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.3.3.1 Impacts

Implementation of this alternative will result in potential significant sedimentation impacts asssociated with both construction of new channel walls and dredging in the downstream portion of the Los Angeles River. Of particular concern is the potential impact of this sedimentation on aquatic resources within the portion of the river near its mouth. This impact is described in Section 4.5.

Depending upon the disposal method employed, there would be a potential impact to water quality if ocean disposal in LA-2 or LA-3 were to occur. Assuming this material meets standards for ocean disposal, no significant impact is anticipated.

As with the NED project, this alternative will contain the 100-year flood plain within the channel of the lower Los Angeles and Rio Hondo rivers. Flood potential within the upper portion of the Los Angeles River will not be changed.

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4.3.3.2 Mitigation Measures

Sedimentation basins will be constructed downstream of construction activities. A hydraulic cutterhead dredge will be used to minimize turbidity in the channel. Use of these methods will reduce impacts to insignificant levels.

Chemical testing and/or bioassays of sediments will be conducted as necessary to assure all materials meet ocean disposal or other disposal standards.

Chemical testing and/or bioassays of sediments will be conducted as necessary to assure all materials meet ocean disposal or other disposal standards.

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4.4 NOISE

Noise impacts are considered significant if they exceed established noise exposure standards, or if there are unique, noise-sensitive receptors within the zone of primary project activity noise impacts.

Because most communities do not regulate noise from construction except through controls on hours of operation, noise/land use compatibility guidelines are used as the standard for the project noise impact assessment (see Section 3.6.1.1).

4.4.1 No Action Alternative

4.4.1.1 Impacts

The No Action Alternative results in no construction activity occuring along the LACDA system. Noise levels remain as in existing conditions with no construction impacts occuring.

4.4.1.2 Mitigation Measures

No mitigation measures are required.

4.4.2 NED Plan Alternative (Main Report NED Plan)

4.4.2.1 Impacts

Land use in the vicinity of the channel corridors proposed for construction were described in Land Use (Section 3.3). Figures 3.3-1 and 3.3-2 show general land uses along the reaches and identify sensitive receptors. Six schools are within 2,000 feet (610 m) of the channel in the lower Los Angeles River, while three schools are within 2,000

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feet (610 m) of the channel along Rio Hondo Channel. No hospitals or churches were identified along either reach. No wetlands shall be effected as a result of this alternative.

A listing of equipment estimated for use for construction of this alternative is presented in Table 2.3-6. Equipment is presented for the various activities of parapet wall construction, armoring and bridge construction.

Parapet Wall Construction (Main Report NED Plan)

The worst-case condition arises from construction activity immediately adjacent to homes and sensitive receptors along the levees. It is assumed that parapet wall construction will occur in phases along the length of the channel on both sides. Construction will entail the drilling and use of a backhoe to form a trench in the levee for a foundation for the wall. While this effort moves to the next section, forming of the wall and placing concrete will occur at the former location. Thus, construction can occur on a continuous basis along the reach. Wall construction in any one location should take several weeks.

Because the number of vehicles that will be working in one section at one time is not exactly determined, an average exposure level of 85 dB for heavy equipment at 50 feet (15.3 m) from the source, and an 80 dB source strength at 50 feet (15.3 m) for haul trucks and ready-mix concrete mixers will be used for analysis. In an assumed situation where two pieces of heavy equipment and two trucks are working in sufficiently close proximity such that they could be considered as a single point source emissions source, then it would take about 3,000 to 4,000 feet (915 to 1,220 m) of normal noise propagation before the construction noise would blend into the environment, depending on other background noise. Noise contours from intensive on-site construction activities are as follows:

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Sound Level	Distance from Source
89 dB	50 feet (15.3 m)
83 dB	100 feet (30.5 m)
77 dB	200 feet (61 m)
65 dB	800 feet (244 m)
63 dB	1,000 feet (305 m)
59 dB	1,470 feet (448 m)
57 dB	1,770 feet (540 m)
55 dB	2,090 feet (637 m)
49 dB	3,140 feet (958 m)

Impacts will vary from being significant adverse impacts to being adverse impacts depending on the specific activity ongoing at any one time and the level of background noise in the immediate area. Significant impacts will occur in areas where residential back fencelines are directly adjacent to the levee. Impacts will be reduced near freeway overcrossings due to the high background levels. Dwellings near the Golden State Freeway (Interstate 5) for example, experience noise intrusion which exceeds noise land use compatability standards without project implementation.

Armoring (Main Report NED Plan)

Noise sources associated with levee armoring activities include bulldozers, backhoes and grout pump trucks in addition to various other equipment and trucks. Noise impacts from armoring will be similar to other construction activities but confined to the specific armoring areas as shown in Figure 2.3-4.

Impacts from armoring will be less adverse at the locations proposed near the Artesia and Century Freeways due to the high background concentration of noise existing in the area from freeway noise and construction noise, respectively. It is possible that impacts will blend in with background noise such that no impacts occur from armoring operations in these two locations. Impacts from armoring will be more adverse along the Rio Hondo, although, again, not as intrusive as construction of parapet walls, due to shielding by channel embankments.

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Bridge Construction (Main Report NED Plan)

Bridge construction encompasses the raising of existing structures and total replacement in some locations. Bridge raising could take as much as 2-1/2 years for each bridge. This entails construction of a temporary bridge to be used as a detour while the existing structure is being demolished and rebuilt. A temporary bridge will most likely be constructed by standard construction techniques except that it will have a temporary, unfinished surface which can be lifted and moved for use in another temporary bridge downstream.

Bridge construction requires the use of large cranes, backhoes, bulldozers, other heavy equipment as presented in Table 2.3-6, and pile drivers for support of the piers. Pile drivers will be required for anchoring of temporary bridges and the widening and anchoring of existing supports for bridges being raised.

Impacts will vary with the level of background noise and land use in the area of bridge construction. Residential areas will experience the greatest impact from bridge construction. The combined impact of several pieces of heavy equipment will raise existing noise levels by 5 to 10 dB during hours of operation adjacent to residential areas. Atop this general noise increase will be a steady "thunk-thunk" when pile drivers are in operation. Pile driver noise will reach 75 dB with each drop of the drive hammer. Such noise is highly irritating because of its repetitive nature.

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4.4.2.2 Mitigation Measures

All noise impacts are short term and construction related. No significant long-term, permanent impacts are expected to occur from this project. Mitigation for construction impacts include incorporation of the following measures:

- A line-of-sight break between noise sources and the nearest sensitive receptors is the critical factor in maintaining project activity noise impacts at unobtrusive levels. This could be accomplished by placement of a temporary berm to shield residences and other receptors from construction activity. In areas where land is accessible and available, a large berm could reduce noise levels by as much as 20 dB.

- In areas of extreme noise conditions where berms are not feasible, either construction of temporary walls to serve as noise barriers or additional limits on work hours may be warranted to protect these sensitive receptors.

- Smaller, and therefore less noisy, construction equipment will be evaluated for use in sensitive construction areas such as parapet walls during the Preconstruction Engineering and Design phase.

- Because of the increased noise sensitivity during quiet hours, time limits on allowable on-site equipment operations are normally made a condition on construction permits. No on-site activities will be permitted before 7:00 AM weekdays, not before 8:00 AM on Saturdays, and not at all on Sundays or holidays because the noise background is lower on those days and project impacts will become more distinct when they are not blended into the background noise environment. No construction activities will occur after 7:00 PM.

No effective mitigation is available for the use of pile drivers.

4.4.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.4.3.1 Impacts

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Reconstruction of Channel Walls (Main Report Alternatives Two and Three)

Under this alternative, the existing trapezoidal walls will be removed from one or both sides of the channels. Either the trapezoidal shape will be retained, but widened, or the shape will be converted from trapezoidal to rectangular. Equipment required includes cranes, excavators and jackhammers for concrete removal. Bulldozers and wheel loaders would be required to fill up to 100 trucks per day with concrete and other material to be hauled away from the site for disposal. Depending on the location, some of this material could be placed behind the existing levee, but most would require trucking off site. It is estimated that up to 100 ready-mix concrete trucks would be required on a daily basis for construction of new vertical walls. Construction would last in any one location for up to one year.

Bridges are not required to be raised; however, modification to some bridge supports will be required.

The impact of any single piece of equipment will not be substantial, but the combined noise effects of a large number of pieces of equipment working in the channel at one time will be significant, raising the existing noise levels behind quiet residential areas by 5 to 10 dB during hours of operations. The impact will lessen for construction operations operating in areas where background levels are already high or already exceed community noise ordinance levels, such as near freeways.

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Dredging Main Report Alternatives Two and Three)

The 2.5-mile (4 km) segment of the Los Angeles River from the river mouth to Willow Street would be dredged a maximum of five feet (1.5 m). A diesel-powered dredge should be used in the channel. Removed material will be either loaded on barges and disposed of at a deep water disposal area or loaded onto trucks and hauled off site. An alternative disposal site for material unsuitable for ocean siposal is Pier J at Long Beach Harbor. This site could be used to completely contain any materials away from exposure to the environment.

Dredging operations will not create significant noise impacts from the Pacific Coast Highway to the ocean mouth. Most land use in this area is industrial. A background humming sound will result from the operation. Impacts from Pacific Coast Highway north to Willow Street will be more noticable to the residential areas bordering the channel. Again, a backgound humming will emanate from the channel. However, trucking operations hauling material off site will result in noise impacts within residential neighborhoods. Impacts will vary in significance with the distance of the receptor from the site and the routing of the trucks.

4.4.3.2 Mitigation Measures

Noise mitigation measures are identical to those described in Section 4.4.2.2 for the NED Alternative except that pile drivers should not be needed and, therefore, there are no concerns of mitigation for that equipment.

4.5 BIOLOGICAL RESOURCES

Impacts to biological resources are considered significant if they result in loss of one or more acres (0.4 ha) of wetland habitat, cause mortality in aquatic organisms or adversely affect the continued existence of an endangered, threatened or candidate species.

4.5.1 No Action Alternative

4.5.1.1 Impacts

Implementation of the No Action Alternative will result in no impact to biological resources since no activites in the channel areas will take place.

4.5.1.2 Mitigation Measures

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No mitigation measures are required.

4.5.2 NED Plan Alternative (Main Report NED Plan)

4.5.2.1 Impacts

Vegetation

Since the construction activities will be primarily limited to the river channels, no impact to vegetation is anticipated with construction of the concrete walls.

There will also be potential disturbance to vegetation on the outside of the river channel due to bridge raising, levee armoring and other construction activities. Because this vegetation is either landscaped or ruderal areas, no significant impact is anticipated assuming that landscaped areas are replaced. There will be an adverse, but not significant, impact to the Compton Creek Channel since this area contains rather sparse and, primarily, introduced species.

Wildlife

No significant adverse direct impacts to wildlife resources are anticipated through the implementation of the alternative since no productive wildlife habitat will be affected. Additionally, noise from construction operations may affect breeding bird species.

Aquatic Resources

Since work in the channel will be limited, no impact to aquatic resources is anticipated as a result of implementation of the alternative from actual construction. If diesel fuel or other toxic material is spilled, impacts in downstream areas could be adverse.

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Threatened and Endangered Species

No loss of foraging habitat of the California least tern and California brown pelican are anticipated. Noise and other activities on the levee walls in the lower portion of the Los Angeles River could affect foraging patterns of these species. This impact is potentially significant, but can be reduced to insignificant (i.e. no threat to continued existence of the species) through conducting activities in the lower channel from September to March on the last one-mile reach of the Los Angeles River. See Appendix C for the biological assessment.

4.5.2.2 Mitigation Measures

The wetland areas in the lower most portion of the Los Angeles River will not be destroyed by construction activities. This area will be monitored to assure that no activites or materials are discharged in this area.

In order to prevent impacts to nesting birds in the wetland as well as not to disturb foraging activities of the least tern and brown pelican, activities will not be conducted from April through September in the last one-mile reach of the river. This would reduce any impact that would adversely affect the species to no effect.

To avoid discharges of pollutants to the stream from refueling and maintenance work on equipment, refueling will be limited near the channel and closely monitored if it must be accomplished near the channel.

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4.5.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.5.3.1 Impacts

Vegetation

Implementation of this alternative may result in the loss of approximately six acres (2.4 ha) of wetland habitat along the lower portion of the Los Angeles River due to dredging activities. This impact is considered significant. Other than loss of ruderal species in the Compton Creek Channel, no other adverse impact is anticipated to vegetation.

Wildlife

There may be a significant impact to wildlife species associated with the loss of the wetland within the lower portion of the Los Angeles River. No other adverse impact is anticipated to wildlife resources.

Aquatic Resources

Removal of sediment from the lower Los Angeles River will create short-term impacts due to dredging. The most direct impact is the destruction of soft-bottom benthic organisms associated with the disturbed sediments. Once dredging is completed, recolonization of the affected area would commence. Field studies of dredged areas have shown that recolonization occurs within two weeks to three years after the dredging stops (McCauley, Parr, and Hancock 1977; Oliver et al. 1977; Rosenberg 1977). It is expected that the benthic community will recover at the shorter end of this range. Oliver et al. (1977) found that shallow water communities inhabiting highly variable and frequently disrupted physical environments rebounded or recovered in less time from experimental disturbances than those found in less variable and more benign conditions.

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The impact to the benthic organisms, although adverse, would be short term and insignificant.

Fishes occupying the proposed dredging area would be impacted, especially those who utilize the benthic environment for foraging. The loss of habitat, physical disruption, and environmental disturbance could cause stress and mortality. Fish and other mobile organisms should, however, avoid the dredging area and relocate to undisturbed areas. Therefore, impacts to fish are considered short term and insignificant.

Potential changes in water quality in the form of pollutants, toxic materials, and trace metals may result due to resuspension of bottom sediments during dredging activities. Temporary increases in turbidity and suspended solids levels, along with associated decreases in dissolved oxygen may also occur. Any appreciable increase in turbidity may cause clogging of gills and feeding appendages of fish and filter feeders. If a cutterhead dredge is utilized for removal of sediment, turbidity should be confined to within 200 to 500 feet (61 to 153 m) of the dredge unless a strong current exists, which would extend the range of turbidity. Should it be necessary to use a clamshell dredge, turbidity could be more extensive.

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The greatest potential for impact generally lies with the resuspension of materials that are toxic or harmful to organisms, either directly or through bioaccumulation. Because the dredging that is proposed in conjunction with this alternative is for an active river bed, potentially harmful suspended material could be discharged to the ocean waters surrounding the river mouth.

Bioassays and bioaccumulation tests were recently performed on sediments located at the mouth of the Los Angeles River in conjunction with possible dredging and disposal at the LA-2 offshore dredged material disposal site (Marine Bioassay Laboratories 1988). Results of these analyses indicated that copepods exposed to elutriates of sediments showed statistically elevated mortalities, while test organisms exposed to sediments during the solid phase bioassay showed no significant mortality. However, bioaccumulation tests on organisms exposed to sediments for a 20-day period revealed elevated levels of cadmium, lead, and zinc in their tissues.

Sediments proposed for dredging under the modified channel cross-section alternative should be similar to the sediments tested from the river mouth. Consequently, the effects of resuspension of material in the sediments should be similar to the effects noted during the bioassay analyses. Increased mortality to copepods and bioaccumulation of certain metals by benthic invertebrates could be expected. Use of a cutterhead dredge could be used to reduce the amount of material resuspended.

Although similar to sediments from the river mouth, bioassays of the sediments from the lower Los Angeles River would be necessary to determine their proper disposal. If these analyses indicated a higher level of contamination, dredging operations could be limited to periods of slack tides and low or no river flow to further reduce the potential impacts of resuspension of contaminants. An alternative exists to dispose of contaminated material at Pier J in Long Beach where it could be completely contained and segregated from the environment.

<u>Threatened and Endangered Species</u>

Dredging activities will have a potential to affect foraging habitat for the California least tern and California brown pelican. Habitat will remain after dredging; however, this impact is considered to be significant but mitigable to insignificant levels (no effect) by conducting dredging operations between late September and March on the last one-mile reach of the Los Angeles River. See Appendix C for the biological assessment.

4.5.3.2 Mitigation Measures

Loss of the wetland area can be mitigated through restoration of habitat near the channel area. Although soft bottom habitat will remain after dredging, the channel will be lowered so that this wetland may not be re-established. Therefore, creation of small pockets of wetlands adjacent to the channel that would support small areas of marsh and/or riparian vegetation would replace wildlife habitat lost by dredging.

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A hydraulic cutterhead dredge should be used to reduce the degree of turbidity. If further bioassays indicate that dredge specimens are highly contaminated, dredging operations should be restricted to periods of slack tide and low or no river flow.

The possibility of adversely affecting the least tern can be reduced to no effect through restriction of dredging operations to September through March in the last one-mile reach of the river.

4.6 CULTURAL RESOURCES

Impacts to cultural resources are considered significant if project implementation results in the loss of a historic, prehistoric or paleontologic resource without proper testing and evaluation.

4.6.1 <u>No Action Alternative</u>

4.6.1.1 Impacts

No impact to cultural resources will occur since construction activites would not occur with this option.

4.6.1.1 Mitigation Measures

No mitigation is required.

4.6.2 <u>NED Plan Alternative (Main Report NED Plan)</u>

4.6.2.1 Impacts

No impact to cultural resources on the Los Angeles River or Compton Creek will occur since no National Register sites are present.

Twelve bridges along the Rio Hondo Channel will have to be modified, which would have an adverse effect on any property eligible for the National Register. The Corps of Engineers has yet to determine the National Register eligibility of four of the bridges. The Corps' eligibility determination will have to be provided to the State Historic Preservation Office (SHPO) for their concurrence pursuant to Section 106. An evaluation will be done by a historian during the Preconstruction Engineering and Design phase.

4.6.2.2 Mitigation Measures

If any bridges are determined to be National Register eligible, mitigation measures will be developed in consultation with the California State Historic Preservation Officer and the Advisory Council on Historic Preservation pursuant to Section 106 of the National Historic Preservation Act (36 CFR 800). These measures would be agreed to in a Memorandum of Agreement. This will be done during the Preconstruction Engineering and Design phase and in place prior to construction.

4.6.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.6.3.1 Impacts

Since construction activities will be limited to the channel, no impact to bridges or other cultural resources will be affected.

4.6.3.2 Mitigation Measures

No mitigation is required.

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4.7 TRANSPORTATION

Some traffic delays on surface streets will occur during raising of the roadway bridges shown in Figures 2.3-5 and 2.3-6. The proposed schedule and estimated impact duration is shown below:

DRAINAGE AREA	BRIDGE	IMPACT DURATION
Rio Hondo	Whittier Blvd.	Oct 1995 to Oct 1997
	Slauson Blvd.	Jul 1997 to Jul 1999
	Florence Blvd.	Apr 1998 to Apr 2000
	Firestone Blvd.	Jan 1997 to Jan 1999
	Washington Blvd.	Jan 1999 to Jan 2001
	Suva Blvd.	Jul 1999 to Jul 2001
Los Angeles R.	Willow Street	Nov 1995 to Nov 1997
	Imperial Hwy.	Nov 1995 to May 1998
	Long Beach Blvd.	Nov 1997 to May 2000
	Compton Blvd.	Nov 1997 to Nov 1999
	Pacific Coast Hwy.	Oct 1997 to Oct 1999
	Del Amo Blvd.	Apr 2000 to Apr 2002
	Atlantic Blvd.	Apr 1998 to Apr 2000
	Rosecrans Ave.	Apr 2000 to Apr 2002

This schedule reflects a staggering of construction times for adjacent bridges, to insure that if a motorist does decide to detour to the next nearest bridge it will not have an impacted traffic flow. Bridge work and detouring patterns will vary according to the local conditions. Proposed detours are summerized in Tables 2.3-3 and 2.3-4. Table 2.3-7 lists the land uses that may be effected by detours.

All traffic impacts are construction related and temporary. It is estimated that actual construction time for each bridge will not exceed twelve (12) months. The maximum length of time for traffic delays in crossing these bridges have been calculated to amount to less than 5 minutes per vehicle, compared to non-construction traffic flow. None of the freeways that cross these drains will need to be modifided for this project.

The railroad bridge crossings scheduled for modification will have temporary structures built to accomodate traffic during construction. The utility crossings of the river will be dealt with, where necessary, by the owner. In all cases the construction process will be handled so that commerce can be carried across the river in an expeditious manner.

Two (2) pedestrian bridges are scheduled to be raised, with construction taking approximately one week. Impacts will be negligible.

4.7.1 No Action Alternative

4.7.1.1 Impacts

If the No Action Alternative is chosen, there would be no significant impacts to traffic directly resulting from the project. No bridges would be closed and no detours imposed. This alternative would not increase the amount of construction vehicles in the area that could add to and increase the level of congestion on surface streets and freeways.

However, indirect impacts to transportation could result from the No Action Alternative. Since no improvements to the LACDA system would be made, the occurrence of flood conditions above the current capacity would result in flooding to a large portion of the Los Angeles Basin (see Figure 3.2-2). This flooding would cause major short-term transportation impacts in addition to other serious damage. Not only would traffic be severely restricted during flood conditions, but the cleanup and reconstruction of damages would prolong the impacts.

4.7.1.2 Mitigation Measures

Mitigation includes flood management planning which, as discussed in Section 2.1.1.13, is not effective enough to prevent major property damage, possible loss of life and serious disruption to traffic patterns. Also it is not practical to incorporate a major flood proofing program in an area as heavily developed as Los Angeles.

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4.7.2 NED Plan Alternative (Main Report NED Plan)

4.7.2.1 Impacts

Parapet Walls (Main Report NED Plan)

Parapet walls would be constructed on the tops of the existing levees for nearly the entire lengths of Reach 4 and Reach 5. Construction vehicles required for this project would typically include backhoes, bulldozers, drilling rigs, graders, concrete trucks, compactors, and water trucks, as well as various light duty trucks (see Tables 2.3-5 and 2.3-6). Significant impacts to existing traffic conditions could result from construction vehicle traffic increasing the level of congestion during the peak traffic periods. This impact could be reduced if construction vehicles traveled to and from the sites during off-peak hours and avoided the use of major commuter thoroughfares whenever possible.

Construction vehicles would access the levees via the bike/ pedestrian trails and service roads which are located on top of the levees. A concrete bike/pedestrian trail runs along the entire length of the east levee on Reach 4 and on parts of the east and west levees of Reach 5, while concrete and dirt service roads are present in areas without bike trails (see Section 3.10.2.1). Access to the service roads is available adjacent to most roadway overpasses, and to the bike/pedestrian trails at irregular intervals along each reach (see Figures 3.10-1 and 3.10-2). Impacts to existing traffic could occur if construction related vehicles blocked traffic lanes on major streets while waiting to enter service road entrances. This can be minimized through the use of signs and signalmen. The bike/ pedestrian trails are accessed from smaller noncommuter roads, often in proximity to recreational facilities. Impacts to existing traffic from vehicles utilizing the bike/pedestrian trails would be adverse but not significant. Impacts to recreational facilities are discussed in Section 4.8.

As noted in Section 2.3.1.3, conversion of the channel from trapezoidal to rectangular to widen the channel would occur only along a short reach. This would involve removal of the concrete lining, excavation of earthen material, and pouring of a vertical concrete retaining wall. This would require the use of jackhammers, earthmoving equipment,

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trucks to haul out the material, and concrete trucks. As stated above, these construction vehicles could cause traffic impacts unless truck traffic was restricted to off-peak hours and the riverbed utilized whenever possible. The project site could be accessed from the bike/pedestrian trails and service roads on the levees and entrances leading into the channels. Under normal non-flood conditions, vehicles could travel along the concrete-lined channels, restricting the area of traffic impacts to the entrance/exit locations of the channels.

Levee Armoring (Main Report NED Plan)

Impacts to traffic as a result of levee armoring would be similar to those for parapet wall construction. Various construction vehicles (see Tables 2.3-5 and 2.3-6) would access the levees from the bike/pedestrian trails and service roads. These would include trucks hauling numerous loads of rock rip-rap. A significant impact to existing traffic could result from construction vehicle commuting during peak-hour periods. Restriction of construction traffic to off-peak hours and utilization of the river channel for construction traffic would reduce impacts to a level of insignificance.

Modification of Existing Bridges (Main Report NED Plan)

The modification of 15 bridges crossing the lower Los Angeles River and 12 spanning the Rio Hondo will cause significant impacts to the traffic flow for a large area surrounding each bridge under construction. Temporary bridges of at least four lanes will be provided as detours for most bridges requiring modification (see Tables 2.3-3 and 2.3-4). Impacts to traffic could occur during the construction of detour bridges, raising of the existing bridges, and removal of the detour bridges.

During construction of the temporary detour bridges, construction vehicle traffic could increase the level of congestion, significantly impacting the existing traffic conditions. This impact could be lessened by restricting construction traffic to off-peak hours and making use of the river channels to move vehicles whenever possible. Additional impacts could occur from incidental slowing as drivers observe the construction process. This type of vehicle slowing, referred to as "rubbernecking", could affect traffic several intersections back if the level of congestion is already high, as during peak commuter periods.

The demolition and reconstruction of a bridge will create similar impacts from construction vehicle traffic as did constructing the temporary bridges. Vehicles coming to and from the site during peak periods could add to the already-congested conditions. Although detour bridges will allow a continuation of the traffic flow, lanes will be narrower and vehicles will have to make an abrupt jog to the side of the existing bridges as they follow the detour, both of which will cause vehicle slowing. This impact will be most severe during heavy traffic periods, with traffic affected several intersections away and on cross streets in the vicinity. The Long Beach (710), Artesia (91), and Santa Ana (5) freeways could be affected since several streets requiring bridge modifications have offramps from one of these freeways. Backups of traffic onto the freeways could occur if the streets are too congested to accommodate the flow of traffic.

After bridge modification is complete and traffic resumes the normal route, the temporary detour bridges will be removed. Construction vehicles associated with this process could impact existing traffic if congestion increases due to their presence. These impacts are similar to construction of the temporary bridges.

As discussed in Section 2.3.1.4, it will take approximately 2-1/2 years to modify each bridge, and construction of bridges will be in three phases to reduce the intensity of cumulative bridge closures. If two or more adjacent bridges were modified simultaneously, impacts to traffic would be greatly increased. Impairment of traffic capacity on two adjacent bridges at the same time will be avoided if possible.

4.7.2.2 Mitigation Measures

Mitigation measures proposed to lessen potential traffic impacts of the proposed NED alternative include:

- Construct adequate detour bridges;
- Schedule construction traffic to off-peak hours, where possible;
- Utilize the river channel, or other off street routes, for construction vehicle traffic and vehicle staging, whenever possible;
- Avoid reducing traffic capacity on two adjacent bridges simultaneously, if possible;
- Utilize signing and flagmen where construction equipment interface with public traffic;
- Restrict the availability of left turn options, and other traffic restricting behaviors, near the construction area;
- Institute public information programs to enable motorists to avoid congested areas:
  - Place large signs far enough in advance of potentially impacted roadway segments to allow drivers the opportunity to alter their routes BEFORE entering the construction area,
  - Place public notices in local newspapers and on cable TV bulletin boards,
  - Distribute mailers in the project area.

4.7.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.7.3.1 Impacts

Reconstruction of Channel Walls (Main Rpt. Alts. Two and Three)

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Widening or conversion of the channel walls will require heavy construction equipment, including cranes, excavators, jackhammers, bulldozers, and loaders, as well as haul trucks and concrete trucks. As stated in Section 2.3.2.1, up to 100 haul trucks a day would be required to remove the concrete and other material from the project, and the same number of ready-mix concrete trucks per day could be necessary to construct the new walls. Construction vehicle traffic could significantly impact existing traffic, most notably during the peak commuter periods.

Construction vehicles confined to the channel, bike/pedestrian trails and service roads should not impact adjacent street traffic. However, haul trucks removing material from the site and concrete trucks delivering material to the site could potentially impact traffic in the area. These impacts would be in the form of increased congestion, causing backups at intersections and freeway onramps, and would add to the high level of congestion currently present on most major roads in the project area. Restricting haul and concrete truck traffic to off-peak hours would lessen the impacts. Establishment of an on-site batch plant for mixing concrete would also reduce the number of construction vehicle trips.

Levee armoring would occur at certain sections of the channel. The impacts on traffic would be similar to those listed for armoring in the NED alternative (Section 4.7.2).

<u>Dredging Operations (Main Report Alternatives Two and Three)</u>

The impact to traffic from dredging operations depends on the mode of sediment disposal. If dredged spoil is loaded on a barge and disposed at an approved offshore dump site, no significant impacts to existing traffic should occur. However, if dredged material is loaded in trucks for disposal at an approved landfill, impacts to existing traffic could occur from the increased congestion from haul trucks. If land disposal is required, haul trucks could be restricted to off-peak hours to reduce impacts to traffic.

4.7.3.2 Mitigation Measures

Mitigation measures proposed to lessen potential traffic impacts of the proposed alternative to widen and dredge the channel include:

- o Schedule construction traffic to off-peak hours, where possible;
- o Utilize the river channel for construction vehicle traffic and vehicle staging whenever possible;
- o Establish an on-site batch plant to mix concrete and haul aggregate to the site at night;
- o Utilize an ocean-dredged material disposal site, if possible;
- o Utilize signing and flagmen where construction equipment interface with public traffic.

4.8 RECREATION AND AESTHETICS

Recreation impacts are considered significant if construction activity interferes with or causes closure of recreational facilities or poses a safety hazard to recreational users, resulting in the need to close a facility.

Visual impacts are considered significant if construction of walls for flood control block existing visually sensitive areas. The problem of constructed walls serving as a potential surface for graffiti is considered an adverse impact in areas of public viewing.

4.8.1 <u>No Action Alternative</u>

4.8.1.1 Impacts

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Under the No Action Alternative, no impacts will occur from construction activities to recreational users. There will be no need to close sections of the trails. No visual impacts will occur, and the wetlands will remain in their present condition in the lower area of the Los Angeles River. There will be no potential for graffiti on parapet walls, as these walls will not be built.

Also, no additional improvements to recreational or visual resources will occur under this alternative, but there may be impacts from the exposure to flooding.

4.8.1.2 Mitigation Measures

No recreational or visual impacts will occur; thus no mitigation measures are required.

4.8.2 <u>NED Plan Alternative (Main Report NED Plan)</u>

4.8.2.1 Impacts

Construction of proposed improvements require that construction vehicles and equipment have access to the channel. In areas where parapet walls will be provided along the tops of existing levees, construction will occur on the levees on both sides of the channel and will require that recreational trails be closed in areas of construction for the duration of construction. This results in significant recreational impacts during the construction period.

Within Reach 4, the wetlands area existing between Willow Street and Anaheim Street will no longer be visible as parapet walls will be constructed along both reaches. This will result in the loss of viewing the wetlands area and is considered a significant visual impact. Parapet walls over three feet (0.9 m) in height will restrict bicyclists' views, and walls over five feet (1.5 m) in height will restrict pedestrian views of the channel and areas across the channel. This also results in an adverse significant impact for a worst-case assumption that views are aesthetically pleasing in and across the channel. Wall construction also results in a loss of the sense of openness or the production of a "closed-in" feeling to trail users. Other visually sensitive areas such as park areas abutting and outside of the channel, will be visible from the trails after construction, and no impacts will occur.

The potential exists for adverse impacts from graffiti on constructed parapet walls along the proposed areas of construction. This will be visible from homes and business along areas of the reach and to users of highways and streets crossing the channel.

Construction activities in the lower area of the lower Los Angeles River will result in policy impacts with the Local Coastal Plan. The inconsistency of the project with the Local Coastal Plan results from problems with recreational access to the coastal recreation areas. These include the temporary impacts that construction activity will have on the closure of the bike path along the river channel and the resultant inaccessibility to the coast by this avenue.

4.8.2.2 Mitigation Measures

No equally satisfactory mitigation exists for the rerouting of recreational trails during construction. While construction occurs on the bike path, the possibility exists of using the west side of the levee and surface streets for bicyclists, although this is less appealing due to the presence of automobiles. No mitigation exists for equestrian users. This impact is temporary for the duration of construction between recreational trail access points.

Mitigation for the loss of aesthetic views includes the design of trails on the levee top such that views are provided of the land areas to the outside of the channels. This could also include the planting of shubbery in accessible areas and the possible development of additional strip park areas. The development of additional park areas could serve to provide additional recreational resources within communities adjacent to the channel and could be developed under a joint agreement with those communities. As an alternative, mitigation could be provided by the strategic setting of areas of large potted plants or built-in planters and designed seating areas/rest stops at areas along the trails. These measures would result in aesthetic conditions which are improved over existing conditions. These options will be evaluated during the Preconstruction Engineering and Design phase when the final designs are available.

Mitigation measures for the problem of graffiti on the parapet walls include providing a textured surface on the walls, coating the walls with a material such that clean up is easier and incorporating a routine graffiti removal program into maintenance activities.

Mitigation includes that a temporary bike path be determined and routed such that access to the coast is still available to recreation users.

4.8.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.8.3.1 Impacts

The conversion of the channel cross-section results in the construction of three-foot (0.9 m) high parapet walls along the channel levees. This construction will result in closure of the recreation trails between major access points and is a significant recreational impact during construction.

Parapet walls of up to three-foot (0.9 m) heights will not block views; therefore, no aesthetic impacts will result. However, safety impacts (see Section 4.11.3) require an additional three to four feet (0.9 to 1.2 m) of chain-link fencing on top of the parapet walls. While this will be adverse, it will not result in significant aesthetic impacts. This alternative does, however, eliminate the wetlands area near Anaheim Street, which results in a significant visual impact. Other visually sensitive areas such as park areas abutting and outside the channel will be visible from the trails after construction, and no impacts will occur.

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The potential exists for adverse impacts from graffiti on constructed parapet walls along the proposed areas of construction. This will be visible from homes and business along areas of the reach and to users of highways and streets crossing the channel.

Project differences with the Local Coastal Plan is the same as that described for the NED Plan Alternative in Section 4.8.2 with the additional, if temporary, impacts from dredging operations which will occur to fisherman and small-craft boaters who use the mouth of the river for fishing and recreation.

4.8.3.2 Mitigation Measures

As described in Section 4.8.2.2, no equally satisfactory alternative exists for mitigation for the rerouting of recreational trails during construction. The possibility exists of using surface streets for bicyclists, although this is less appealing due to the presence of automobiles. No mitigation exists for equestrian users. This impact is temporary for the duration of construction between recreational trail access points.

No loss of aesthetic views will occur except for loss of wetlands areas. General mitigation measures include the design of trails on the levee top such that views are provided of the land areas to the outside of the channels. This could also include the planting of shubbery in accessible areas and the possible development of additional strip park areas. The development of additional park areas could serve to provide additional recreational resources within communities adjacent to the channel and could be developed under a joint agreement with those communities. As an alternative, mitigation could be provided by the strategic setting of areas of large potted plants or built-in planters and designed seating areas/rest stops at areas along the trails. These measures would improve aesthetic conditions over existing conditions. These options will be evaluated in the Preconstruction Engineering and Design phase when the final designs are available.

Mitigation measures for the problem of graffiti on the parapet walls include providing a textured surface on the walls, coating the walls with a material such that clean up is easier and incorporating a routine graffiti removal program into maintenance activities.

Mitigation measures for inconsistency with the Local Coastal Plan are the same as described above in Section 4.8.2.2.

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4.9 PUBLIC SAFETY

Safety impacts are considered significant if construction activity poses a safety hazard to the general public. Safety impacts also are considered significant if the completed structure poses a safety hazard to recreation users and the general public.

4.9.1 No Action Alternative

4.9.1.1 Impacts

Flood Overflow Areas

The area of inundation included within the 100- and 500-year flood events includes a great number of waste and hazardous waste materials which could be released into the environment during an event. This is especially true for the lower Los Angeles River inundation area which includes a great number of industrial areas adjacent to the channel. A significant safety impact could result from release of toxic substances.

Safety Adjacent to Channel Construction Reaches

Safety impacts along the recreational trails include the existing hazard of having no barrier on the trails for the steep trapezoidal embankment and the sharing of some portions of the trails by both bicyclists and equestrian users. No other safety impacts occur in the area.

4.9.1.2 Mitigation Measures

Mitigation for the release of toxic materials in flood overflow areas can be partially accomplished by flood prevention planning. The impact remains significant, however.

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Mitigation of the safety impacts of having no barriers along recreational trails could be eliminated by construction of parapet walls or incorporation of fencing along the levees and the separation of bicycle and equestrian trails by redesign and widening. This would result in an improvement in safety on the existing recreational trails.

4.9.2 NED Plan Alternative (Main Report NED Plan)

4.9.2.1 Impacts

Flood Overflow Areas

The NED Alternative will result in the elimination of the 100-year area of inundation that results from channel failure along Reaches 4 and 5. This will result in the elimination of hazardous and toxic materials being released into the environment during a 100-year or less event. This results in a beneficial impact to public safety.

Safety Adjacent to Channel Construction Reaches

Construction activities which are proposed to occur along the levees on the sides of the channel where recreational trails exist will result in significant safety impacts to trail users during construction.

The existing hazard of having no barrier on the trails along the steep trapezoidal embankment will be eliminated by construction of the parapet walls. This results in an improvement in safety features on the recreational trails.

Safety aspects related to the raising of bridges include impacts to vehicular and pedestrian traffic in the vicinity of construction. Vehicular traffic rerouting to the temporary bridges will be slowed to the point that no significant safety impacts should occur. Construction activity will be primarily confined to existing right-of-way, with the exception of the detour at Del Amo Boulevard where a portion of a school yard will be required. Potential significant safety impacts could occur from children trying to cut across construction areas.

Trucks hauling materials in and out of construction areas also pose potential safety hazards to the general public. A significant safety risk may result in areas of residential neighborhoods and around schools.

4.9.2.2 Mitigation Measures

Mitigation for safety impacts along trails at channel levees requires that the trails be closed between trail access points for the duration of construction along that segment. No equally satisfactory alternative exists for the rerouting of recreational trails during construction. Surface streets provide a less appealing alternative for bicyclists. No mitigation exists for equestrian users. This impact is temporary for the duration of construction between recreational trail access points.

Mitigation includes that fencing and barriers be placed around areas of construction and that construction equipment be placed in areas at night that are secured from the general public. Also, warning signs should be placed in appropriate locations to warn pedestrians and motorists of potential safety hazards.

Mitigation for trucks delivering materials to and taking materials from construction sites includes the limitation of activity during peak traffic hours and during hours when children are traveling to and from school. Additionally, signs and flagmen will be used in areas to direct traffic where necessary.

While not a project impact, an additional measure could be incorporated into project design which would provide for separation of bicycle and equestrian trails. This would further serve as a safety feature for trail users and will be evaluated during the next phase of study.

4.9.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.9.3.1 Impacts

Flood Overflow Areas

The widening and conversion alternative will result in the elimination of the 100-year area of inundation. This will result in the elimination of hazardous and toxic materials being released into the environment during a 100-year or less event. This results in a beneficial impact to public safety.

Safety Adjacent to Channel Construction Reaches

Reconstruction of channel walls and construction of three-foot (0.9 m) high parapet walls proposed for this alternative will result in significant safety impacts to trail users during construction.

With conversion, the vertical concrete walls which will replace the existing trapezoidal walls pose a significant increase in safety hazards to users of the trail. Instead of an angular drop upon which someone could roll down, there will be a straight drop down. This is combined with only a three-foot (0.9 m) high parapet wall, which is not high enough to provide safety to bicycle or equestrian users. This combination results in a significant adverse safety impact.

There would be no increase in safety hazards in areas of channel widening.
No impacts are expected from channel dredging activity.

Trucks hauling materials in and out of construction areas also pose potential safety hazards to the general public. A significant safety risk may result in areas of residential neighborhoods and around schools.

4.9.3.2 Mitigation Measures

Mitigation for safety impacts along trails at channel levees requires that the trails be closed between trail access points for the duration of construction along that segment. No equally satisfactory alternative exists for the rerouting of recreational trails during construction. Surface streets provide a less appealing alternataive for bicyclists. No mitigation exists for equestrian users. This impact is temporary for the duration of construction between recreational trail access points.

Mitigation for the vertical drop of the channel walls associated with conversion includes placing a chain-link or other fencing on top of parapet walls to a minimum combined height of seven feet (2.1 m). This will provide for safe use of the trail system. An alternative would be to build the parapet walls to a height of seven feet (2.1 m), although this results in a "closed-in" feeling, reduces aesthetics and provides more opportunity for graffiti on solid walls.

Mitigation for trucks delivering materials to and taking materials from construction sites includes the limitation of activity during peak traffic hours and during hours when children are traveling to and from school. Additionally, signs and flagmen will be used in areas to direct traffic where necessary.

While not a project impact, an additional measure could be incorporated into project design which would provide for separation of bicycle and equestrian trails. This would further serve as a safety feature for trail users and will be evaluated during the next phase of study.

4.10 UTILITIES

Impacts to public utilities are considered significant if the project results in the replacement or transference of utility lines.

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4.10.1 No Action Alternative

4.10.1.1 Impacts

This alternative will require no construction activity, thus no displacement or replacement of utilities is required. No impacts will occur other than those associated with periodic flooding in the flood plain.

4.10.1.2 Mitigation Measures

No mitigation is required.

4.10.2 NED Plan Alternative (Main Report NED Plan)

4.10.2.1 Impacts

The NED Alternative requires the raising of bridges which includes several utility lines. A listing of identified bridges was presented in Tables 2.3-3 and 2.3-4 in Section 2. Not all utilities have been identified for the reaches proposed for construction. Significant impacts will occur due to the requirement that these lines be moved. Some temporary disruption of service may result.

4.10.2.2 Mitigation Measures

Mitigation includes that the lines be raised or moved in conjunction with the raising of the automobile bridges. Disruption to service will be minimized.

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4.10.3 Modified Channel Cross-section Alternative (Main Rpt. Alts. Two and Three)

4.10.3.1 Impacts

Potential impacts may occur to utilities if such utilities are buried within the trapezoidal portions to be widened or removed from the channels. Significant impacts will occur due to the requirement that the lines be moved. Some temporary disruption of service may result.

4.10.3.2 Mitigation Measures

Mitigation includes that the lines be moved or replaced in conjunction with construction activities. Disruption to service will be minimized.

TABLE 4.11

ENVIRONMENTAL COMMITMENTS
LACDA FEASIBILITY STUDY

RESOURCE IMPACTED	COMMITMENT (NED)	ACTION	WHEN ACTION TO OCCUR	SOURCE OF COMMITMENT
Land Use/Social Concerns	Traffic detour	Financial compensation & restoration to various properties used for detour.	After Constr ceases	S.C.A.G. Local
Air quality	A. Dust control	1. Frequent watering of constr area to limit dust.	During Constr	S.C.A.Q.M.D.
		2. Terminate oprns during strong Santa Ana winds.	During Constr	
	B. Control of nonparticulates	1. Proper maintenance of heavy equipment to reduce combustion emissions 2. Use of low slulfur diesel fuel. 2. Termination during Stage II smog episodes. 4. Participate in AQMD mandatory rideshare program		
Water Quality & Flood Potential	A. Minimize sediment impacts.	1. Confine work to low flow periods. 2. Trap sediments in downstream sed. basins.	During Constr	R.W.Q.C.B.
	B. Avoidance of accidental discharge of pollutants.	3. Limit and monitor refueling of equipment near channel.		

TABLE 4.11 (continued)

ENVIRONMENTAL COMMITMENTS
LACDA FEASIBILITY STUDY

RESOURCE IMPACTED	COMMITMENT (NED)	ACTION	WHEN ACTION TO OCCUR	SOURCE OF COMMITMENT
Noise	Minimize noise to sensitive receptors	1. Berm or construct temporary walls. 2. Confine activities 7am - 7pm M-F and 8am - 7pm Saturday.	Construction	Local Governments
		3. Evaluate use of smaller equipment.	PED Phase	
Biological Resources (NED)	A. Protect wetlands.	Monitor construction activities. Defer activities during Apr. - Sept. in last one-mile reach of Los Angeles River.	Construction	U.S.F.W.S. Cal Fish & Local Agencies
	B. Avoid stream pollution.	Limit and monitor refueling of equipment near channel.	Construction	
Cultural Resources		1. Conduct evaluation of bridges for Nat. Register 2. Develop mitigation measures w/Advisory Council in event that bridges are determined eligible.	PED Phase prior to constr	SHPO Advisory Council
Transportation	Lessen potential traffic impacts.	1. Construct adequate detour bridges. 2. Schedule constr traffic to off-peak hours.	Prior to constr	CALTRANS Local Governments

TABLE 4.11 (continued)

ENVIRONMENTAL COMMITMENTS
LACDA FEASIBILITY STUDY

RESOURCE IMPACTED	COMMITMENT (NED)	ACTION	WHEN ACTION TO OCCUR	SOURCE OF COMMITMENT
		3. Utilize the river channel for construction vehicle traffic and vehicle staging where possible. 4. Establish on-site batch plant to mix concrete at site, if possible. 5. Utilize flagmen and signing where construction equipment interfaces with public traffic. 6. Avoid reducing capacity on two adjacent bridges simultaneously, if possible. 7. Institute public information program on congested areas using mass media.		
Recreation & Aesthetics	A. Keep trails open.	Evaluate the Following: 1. Phased rerouting of rec. trails. 2. Use surface streets for bicyclists.		CAL Coastal Comm./Local Governments
	B. Mitigate for loss of views.	3. Trails designed on top of levee to provide views outside channel. 4. Develop additional park areas - under joint agreement w/local communities.	PED Phase	

SECTION 5 - PUBLIC INVOLVEMENT

5.1 PUBLIC INVOLVEMENT PROGRAM

The Corps of Engineers has conducted several public workshops as well as formal scoping meetings to inform the general public and various agencies of the proposed action and to solicit their comments. A Notice of Intent to prepare an EIS was published in the Federal Register (Appendix B) which requested comments from all parties on the proposed project.

Early in the design process, the Corps of Engineers and the Los Angeles County Department of Public Works hosted a series of public workshops to acquaint the public with the LACDA Review Study. Approximately 150 people attended five workshops held over a three-week period in October of 1987. The meetings were held in Glendale, Studio City, Downey, Carson and Long Beach. A representative of the Federal Emergency Management Agency (FEMA) was present at each meeting to discuss the Federal Flood Insurance Program. A summary of the questions and answers provided at the workshops is included in the Appendix A of this EIS.

On March 9, 1989, the Army Corps of Engineers and the Los Angeles County Department of Public Works held two environmental scoping meetings to give the public an update on the progress of the study and to provide the attendees with an opportunity to identify and comment on potential environmental impacts of the proposed action or alternatives that the Corps should consider in preparing the EIS.

Approximately 60 representatives of Federal, State and local agencies and the general public at large attended the meetings that were held in Los Angeles and Lakewood. A list of persons attending, as well as a summary of the comments made at these scoping meetings, is contained in Appendix A of this EIS.

Public comments received at the scoping meetings centered around four topical areas which included environmental concerns; economic concerns; the National Economic

Development, or NED, Plan; and miscellaneous questions. The Corps of Engineers provided an answer to most of the comments at the meeting and a brief is provided where necessary in Appendix A. In addition, the comments have been considered and information incorporated as appropriate into the various environmental issue sections of the EIS. Comments about project economics and details of the NED Plan have been addressed in the description of the proposed action and in discussion of alternatives considered in the EIS.

Two new alternatives were suggested at the scoping meetings. One alternative involved the injection of polymers into the channels at strategic locations to change the flow of water, possibly avoiding the need to raise bridges. This technology has not been proven on the scale of flows within the Los Angeles River and is not considered feasible.

The other alternative involved construction of a large tunnel to carry flows, as opposed to constructing surface facilities. Tunneling has been considered as a possible component of alternatives involving flow diversion. The disadvantages of tunneling compared to the alternative of parapet walls has to do with magnitude of the construction project and construction cost. To carry the significant portion of the flow of the L.A. River flow, a tunnel would have to be tens of meters in diameter, which would be excessively costly and of questionable feasibility. It would also take much longer to build than most surface alternatives considered and would be more difficult to maintain.
Qualitatively, this alternative has an unfavorable benefit-cost relationship and is considered not feasible.

5.2 REQUIRED COORDINATION

The Corps of Engineers staff has coordinated both formally and informally with various agencies to obtain pertinent information, to inform them of the proposed action and to solicit from them informal comments relative to their areas of jurisdiction or expertise. In some cases, contacts were by letter and represent formal consultations required by various Federal statutes and legislation. Other contacts were informal and done by telephone at the staff level. Contacts were made with the following agencies informally:

- U.S. Department of Agriculture
- California Regional Water Quality Control Board
- California Coastal Commission
- South Coast Air Quality Management District
- Los Angeles County Department of Public Works
- Los Angeles County Department of Parks and Recreation

The Corps is consulting with the following agencies relative to the proposed action:

- U.S. Fish and Wildlife Service
- National Marine Fisheries Service
- California State Historic Preservation Office
- California Department of Fish and Game

Formal coordination of the EIS with the many involved public agencies will continue throughout the EIS review and approval process.

The scoping process and meetings, as described in the previous section, is another element of the required coordination that has been conducted by the Corps. Additionally, the Notice of Intent to prepare an EIS was published in the Federal Register on Monday, February 13, 1989 (See EIS Appendix B for a copy of this notice and the responses received to date).

5.3 STATEMENT RECIPIENTS

EIS Appendix F will contain a list of Draft EIS recipients in the Final Report.

5.4 PUBLIC VIEWS AND RESPONSES

This will be provided in the Final EIS.

SECTION 6 - LIST OF PREPARERS

The following persons participated in the preparation of this document.

Preparer	Discipline	Experience	Role in EIS Preparation
Corps of Engineers Staff			
Pat Luvender	Economics	10 yrs	Project Manager
Jon Sweeten	Engineering	5 yrs	Project Manager
Ira Arzt	Engineering	10 yrs	Project Manager
Ronald Lockmann	Geography	7 yrs	Environmental Coordinator
Marie Campbell	Geography	2 yrs	Environmental Coordinator
Kathleen Kunyz	Geography	5 yrs	Environmental Coordinator
Brian Whelan	Geography	8 yrs	Geographer
Patricia Martz	Archaeology	12 yrs	Senior Archaeologist
D.Stephen Dibble	Archaeology	3 yrs	Archaeologist
Bradley Sturm	Archaeology	3 yrs	Archaeologist
Steven Schwartz	Archaeology	7 yrs	Archaeologist
Terrance Breyman	Ecology	17 yrs	Reviewer
Michael Noah	Ecology	8 yrs	Reviewer
Thomas Keeney	Ecology	12 yrs	Project Biologist
Roberta Soltz	Ecology	4 yrs	Project Biologist
Chambers Group Staff			
John Westermeier	Biologist	15 yrs	Project Manager Project Description Water Quality Biological Resources Cultural Resources
Tom Ryan	Environmental Analyst	15 yrs	Project Description Public Involvement
Linda Brody	Environmental Analyst	9 yrs	Land Use Noise Recreation/Aesthetics Public Safety Public Utilities
Pam Morris	Environmental Analyst	2 yrs	Air Quality Transportation Water Quality

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SECTION 7 - INDEX OF MAIN REPORT

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SECTION 8 - PERSONS CONTACTED AND REFERENCES CITED

8.1 PERSONS CONTACTED

During preparation of the Draft EIS, various agencies and individuals were contacted to determine issues relative to each agency's area of responsibility. A list of the agencies and individuals contacted is included below.

1. State of California
   Regional Water Quality Control Board, Los Angeles Region
   Mr. Mike Sowby

2. California Coastal Commission
   Coastal Consistency
   Mr. Jim Raives

3. South Coast Air Quality Management District
   Office of Planning and Analysis
   Mr. Brian Farris

4. U.S. Department of Agriculture
   Soil Conservation Service
   Mr. Richard L. Campbell

5. County of Los Angeles
   Department of Public Works
   Mr. Larry Ammon
   Mr. Donald Jordan
   Mr. Mike Anderson

6. County of Los Angeles
   Department of Parks and Recreation

Mr. Tom Dittmar

7. City of Los Angeles
Department of Recreations and Parks
Mr. Dave Attaway

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APPENDIX A

PUBLIC COMMENTS AND
QUESTIONS AND ANSWERS ON LACDA

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Questions and Answers
Los Angeles County Drainage Area Study
LACDA

Introduction

In October 1987, the Los Angeles District of the U.S. Army Corps of Engineers (Corps) and the Los Angeles County Department of Public Works (County) hosted a series of public workshops to acquaint the public with the Corps' Los Angeles County Drainage Area (LACDA) Flood Control Study currently underway. A representative of the Federal Emergency Management Agency (FEMA) was present at each meeting to discuss the Federal Flood Insurance Program.

Approximately 150 people attended five workshops held over a three-week period in Glendale, Studio City, Downey, Carson, and Long Beach. Workshop participants were invited to ask questions and express their concerns, ideas, and wishes about what planners should consider in designing improvements to the LACDA system.

This summary presents the questions and answers discussed during the five workshop series, as well as other commonly-asked questions that have been posed to the Corps, County, or FEMA representatives since the workshops occurred.

We first present LACDA study issues of general interest, followed by those concerning particular communities, then by those related to FEMA issues. The material is presented in the form of Questions and Answers or Comments and Responses.

The Need for the Current Study

Q. How did the Corps get involved in this study?

A. The County requested Corps participation in a study to find ways to upgrade the current system. In doing so, the County became the local sponsor of the study. This means that the County and the Corps are study partners, and the Corps coordinates with the County on all aspects of the planning process.

Q. Why is the upgrade necessary?

A. The Corps and the County built the existing flood control system to control the largest flood likely to strike the basin, as predicted in the 1930's, based on the information they had available at that time. Since then, we have accumulated much more data relating to flood size and frequency. In addition, conditions that affect flooding have changed over the years, and the system is no longer capable of protecting large areas of the basin. There are several reasons for this:

- Development over the past 50 years has steadily increased floodwater runoff.
- New storm drains that serve this development discharge into the flood control system and increase peak flows in the flood control channels.
- Trapped sediment flowing into the 20 reservoirs is decreasing their flood control capacity.

Q. How much of the land in the basin is now impermeable, and how is this determined?

A. About 40 percent of the land is considered impermeable. Man-induced impermeability is a result of how the land is used. The more developed an area is, the greater the impermeability. Tables have been developed which assign a percent impermeability to various types of land use. Summing the fractions of the various land uses in the basin results in 40 percent impermeability of the overall area.

Q. How do you know that runoff has actually increased?

A. For many years, we have had rain gauges throughout the basin to measure precipitation and stream gauges in the Los Angeles River to measure flows. Data has been recorded since the late 1800's. Since that time, we have seen a 40 percent increase in runoff created by the same amount of rainfall.

Q. What is a 100-year flood? a 500-year flood?

A. Analysts describe floods of different sizes in terms of their statistically projected frequency. For example, a 100-year flood is the size flood that has a 1 percent chance of occurring each year; a 500-year flood has a 0.2 percent chance of happening in any year.

Q. Is it possible to have two 100-year floods in a single year?

A. Yes. Flooding is caused by a combination of factors: where the storms are located, how many storms there are, how closely together they occur, and the saturation level of the ground prior to the storm. Therefore, although the probabilities are against it, it is possible to have multiple 100-year floods in a single year.

Q. What was the size of the 1938 storm? the 1980 storm?

A. At the time of the 1938 flood, the statistical theory on frequency had not yet been applied to floods. However, based on historical data, we estimate that it was probably about a 50-year flood. The 1980 storm was about a 40-year flood in the downstream portions, and about a 70-year flood in the upper reaches.

Q. Would the water during a 500-year flood be deeper or more shallow than in a 100-year flood?

A. A 500-year flood would be slightly deeper than a 100-year flood and would cover a greater area.

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Q. What is the current release rate from LACDA dams?

A. There is no set rate of release. The LACDA system is very complex, with four flood control dams interacting with and impacting on each other. The amount of water released depends on, among other things, which of the four flood control dams is being considered, the amount of water in the dam, the rate at which additional runoff is coming into the dam, and weather forecasts.

Q. What are current channel capacities?

A. The channel below Sepulveda Dam can convey 17,000 cubic feet of water per second (cfs); in the area of downtown Los Angeles, the channel capacity is 110,000 cfs; at the mouth of the Los Angeles River, the capacity is 130,000 cfs.

Q. What are the flow rates for 100-year and 500 year floods?

A. The 100-year flow rate out of Sepulveda Dam is 17,000 cfs; the 500-year flow rate, 77,600 cfs. In downtown Los Angeles, the 100-year flow rate is 118,000 cfs; the 500-year flow rate, 177,000. At the mouth of the Los Angeles River, the 100-year flow rate is 174,000 cfs; the 500-year flow rate, 227,000 cfs.

Velocities in the channel are approximately 15 to 20 miles per hour; outside the channel, the velocities are minimal.

Q. Why can't you just clean the silt and debris out of the reservoirs—especially at Hansen Dam?

A. Although it is relatively easy to remove large pieces of debris from the reservoirs (something that is done as needed), removing the silt is a slow and costly job. The Corps has issued permits to several sand and gravel companies to mine the silt at Hansen Dam.

Q. Why were the reservoirs built with only a 50-year life in the first place?

A. A project has two kinds of "lives": an economic life and a structural life. The structural life of a dam is indefinite, given a reasonable amount of upkeep and maintenance. The economic life is the period of time used to calculate the economic usefulness of the project. It is a factor in determining the benefit/cost ratio when assessing construction feasibility.

When engineers design a dam, they allow space in the reservoir for the accumulation of sediment over time. The amount of time it takes to fill the sediment storage space in a dam is the economic life. If a longer economic life is desired, a larger sediment storage area is needed, and the cost of building the project is increased. So the economic life has to be a period of time that is practical and yet cost effective. An economic life for dams of 50 years is considered the most efficient for this purpose although in some circumstances a 100-year economic life can be justified.

Hansen Dam, which was built in 1938, is now reaching the end of its economic design life of 50 years. This only means that the sediment storage area is almost full; the reservoir itself is not full. The space in the reservoir reserved for flood control is still fully intact.

Q. How much of the flooding can be attributed to obstructions such as bridge supports?

A. About 90 percent of the overflow can be indirectly related to bridge structures affecting channel flows.

Q. What kind of debris can be expected from a 100-year flood? boulders? houses?

A. Due to the numerous debris basins in the foothills, as well as the flood control dams themselves, very little sediment gets into the channels. Even if there were significant overland flow, its low velocity would carry very little debris into the channels.

Q. Could the debris back up to create its own dam?

A. If there were large enough chunks of debris such as that which would result if a bridge collapsed, yes, the debris could create its own dam. However, this is extremely unlikely. Under normal flooding conditions, there is no chance that debris would build up in the main channels to form a dam, and the chances are very slight on the unregulated streams.

Q. Might some of the debris get all the way to the ocean, creating the need for dredging?

A. As very little debris gets into the channels, there is no concern that a dredging problem will be created at the ocean due to channel flow. However, overland flow from a large flood would pick up a significant amount of trash and debris, which would be carried to the harbor. Whether this would create a need for dredging would depend on the size of the flood and the amount of debris.

Q. Is it possible to remove debris during flood conditions?

A. Yes. However, due to the difficulties involved, the disadvantages far exceed the advantages except in extraordinary circumstances. At the dams, cranes have been used to remove debris from the trash racks if it affects the outflow of water during flood releases.

Q. Are some of the dams in the system not under Corps control?

A. All of the single-purpose flood control dams are under Corps control. The County dams were built for water supply; however, a certain amount of space is reserved for flood control.

Q. Some County dams—for example, Morris and Cogswell—are silting up. What effect does that have on the current level of protection?

A. The silting up of the County dams has no effect on the flood control capacity of the LACDA system because the space for flood control storage is reserved. It is the water conservation storage space that is being impacted.

Q. In 1980 did anyone actually see water up to the top of the channels, or did they see only the debris?

A. There were numerous reports by residents living along the upper channels stating that they did see water to the top of the channels. Along the lower channels, our best evidence is the location of the debris.

Q. Is some of the LACDA system simply in need of repair?

A. Some of the channels do need maintenance, and the County has

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a repair program under way. The Corps is also working to repair channels under our LACDA Rehabilitation Project. However, these repairs are really just part of ongoing operation and maintenance and have nothing to do with the need for the overall system improvements to provide a greater level of protection.

Q. It seems that the acceptable level of damage in Los Angeles is much lower than for other parts of the country that experience major floods almost every year. Does Los Angeles just have higher standards than the rest of the nation?

A. The Corps cannot build a project unless it has a favorable benefit/cost (B/C) ratio. In other words, the benefits of building a project have to be equal to or greater than the cost. The cost of building a given flood control project are about the same throughout the country, but due to the Los Angeles area's dense urbanization and the resultant high land values, favorable B/C ratios are more common than in less-developed areas.

Q. Do you assess damages based on standing or running water?

A. Damages are assessed based on a composite of the depth of the standing water and the velocity of the running water.

Project Costs and Cost-Sharing

Q. How much will this project cost?

A. The cost of the project could range from $50 million to $450 million, depending on the plan selected.

Q. Do you take inflation into account in doing your cost estimates?

A. Yes. We use a weighted average of the Consumer Price Index for the benefits, and we update the costs from the Engineering News Record Construction Cost Index.

Q. What share will be paid by the local sponsor?

A. As a part of the Water Resources Development Act of 1986, Congress has established new guidelines for cost sharing on water resources projects. Non-Federal interests must now pay at least 25 percent, but not more than 50 percent, of the flood control costs of the project. Costs associated with recreation are shared equally between the Federal government and the local sponsor.

To determine the 25 to 50 percent non-Federal share, the guidelines say that local interests must pay for 5 percent of total project costs and for all lands, easements, and rights-of-way, dredged material disposal areas, and relocations, up to a total share of 50 percent.

Q. Where does the local sponsor get its money?

A. The local sponsor may provide its share through use of existing general revenue funds, through reimbursement from the state, or through benefit assessments.

Q. Could money for the project be raised by the sale of air rights over the channels?

A. The issue of whether the Federal Government will consider leasing or selling air rights over the channels will not be addressed until this overview study is completed. Also, the amount of funds that could be raised by this means would be insignificant compared to the total cost.

Q. Is the Federal funding already in place?

A. The Corps has funding to continue its study through 1989. Once the study is completed, the Corps will submit a report recommending solutions. The report will go first to the Corps' South Pacific Division Office in San Francisco, then on to the Office of the Chief of Engineers, the Secretary of the Army, and, finally, to Congress for authorization and funding. It is a long process, and the earliest date at which funding for construction would be available is in the mid-1990's. As such, there are no funds already earmarked for construction.

The Study Itself and Alternatives Under Consideration

Q. What is most economical: widening or deepening the channel?

A. It has been determined that deepening the channel would not be cost efficient due to the fact that the utility lines are located not far beneath the surface. Therefore, raising the levees is being considered, which would have the same practical effect as deepening the channel.

Current estimates are that it would cost $370 million to raise the levees and at least $600 million to widen the channel.

Q. How much higher or wider would the channels be?

A. At this stage in the study, it looks as though we would have to raise the levees from 2 to 8 feet, depending on the area. The average increase in height would be between 2 and 4 feet.

We would probably need to widen the channels from 0 to between 300 and 400 feet—again depending on the area.

Q. How much capacity would you gain by strengthening the walls of the channels?

A. The capacity of the channels, or volume of water they can carry, is not determined by the strength of the walls—it is strictly a problem of channel size.

Q. Will all of the channels be completely concrete?

A. The channels will not be changed from whatever they are now—that is, concrete-bottom channels remain concrete, and soft-bottom (dirt) channels will remain so.

Q. Does the Corps look at high tide and offshore wind to determine how much water goes over the levees during each?

A. Due to the fact that the Los Angeles and San Gabriel river channels slope such that the water almost falls into the ocean at the rivers' mouths, high tides and strong offshore winds do not impede the flow into the ocean.

Q. If the levees are raised, will the pumping flow change?

A. Yes. With the rise in height, pumps with a greater capacity will be needed to raise the water the increased distance.

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Q. Why isn't a tunnel feasible? It appears that $2.5 billion in benefits should justify a $700 million expenditure.

A. $2.5 billion is the total damages that would result from the design flood. The tunnel would not prevent all of the damages, only about $300 million worth. Benefits of $300 million versus costs of $700 million provide a B/C ratio of only 0.4.

Q. What is a baffle block?

A. Baffle blocks are concrete blocks arranged in a checkerboard pattern intended to dissipate the flow energy of the water's potentially destructive force.

C. The Public Utilities Commission and California Department of Transportation should be involved in this study.

R. Both the Public Utilities Commission and the California Department of Transportation will be involved, when appropriate, during the study, detailed design, and construction phases of the project.

C. Some areas of the basin have groundwater located only 2 feet below the surface. The Corps should consider this when estimating runoff.

R. Increased runoff in areas with groundwater close to the surface is not really a factor that needs to be considered. Much of the basin already impervious, resulting in flood flows running off immediately. But even in areas that are not impervious, the water runs off when the soil's infiltration capacity is exceeded. The level of the groundwater only marginally affects the soil's infiltration capacity and would therefore have no effect on the peak flow.

Q. Does the Corps look at tributary areas to assess the potential impacts of runoff and debris? Can any of that be controlled before it reaches the basin?

A. There are 87 debris dams in the foothills surrounding the Los Angeles basin. These debris dams, combined with the county's water supply dams and the Corps' flood control dams, trap almost all of the sediment being contributed by the tributary areas. A very small percentage of the debris reaches the channels.

Regarding runoff, the channels in the tributary areas currently provide 100-year protection. Appropriate sites to further control tributary flow into the rest of the system are already developed. In addition, most of the downstream flooding problem results from uncontrolled inflow from the urban drainage system into the central L.A. basin.

C. The Corps should also take into account the inadequacy of the storm drain system and how that increases flows into the LACDA system.

R. Actually, it is the efficiency of the storm drain system, not its inadequacy, that contributes to the flooding problem on the mainstem channels of the LACDA system. If the storm drain system were less efficient, less water would be conveyed to the channels, and there would be localized ponding in the streets and other poor drainage areas—much like what occurred prior to the upgrading of the storm drain system in the 1960's. At that time, even small storms caused street flooding all over the city.

Q. What control does the Corps have over land use on right-of-way lands, including air rights?

A. The Corps has the ultimate say as to the use of the rights-of-way adjacent to and above the channel.

Q. How long will it take to complete the project once it is begun?

A. Depending on the selected plan, 5 to 7 years.

Q. What if Congress does not authorize the plan?

A. The Corps will identify the most economical plan. If Congress does not authorize the plan, no Federal funds would be available for construction.

Q. If the City of Los Angeles disapproves the plan, but the County, other affected cities, and Congress approve it, would you go ahead with the project?

A. The Corps coordinates with the County of Los Angeles, who is the local sponsor for the project. The County, in turn, coordinates with all the local elements that would be affected by the project and makes sure that their concerns are addressed during planning of the project. This coordination should ensure that the resulting plan is acceptable to all.

Q. How can individuals facilitate the approval process?

A. The best way for individuals to help the planning process along is to continue to make the Corps aware of public desires and concerns at the public workshops it will hold throughout the study and at the formal public meeting that takes place when the Corps issues its draft report.

The public can influence the approval process by letting local and Federal Government representatives know of the importance of the project to their constituents.

Q. Can the public go to the Corps offices and get tracings of the overflow maps?

A. Yes, with an appointment.

Environmental and Recreational Issues

Q. Is the Corps doing an Environmental Impact Statement (EIS) on this project?

A. Yes. We are conducting our environmental studies concurrently with our engineering studies, and our study report will include an EIS.

Q. Will there be continuous bike trails from the dams to the ocean? How much coordination is the Corps doing with the cities along the river and the Bike Advisory Committee on this issue?

A. It is uncertain at this time. Any new recreation would have to be cost shared 50-50 by the local sponsor. Any impacts to existing bike trails due to channel improvement would be mitigated.

Q. Will there be any equestrian trails along the channels?

A. The situation regarding equestrian trails is the same as with bike trails.

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Social Impacts and Public Safety

C. We are concerned about inverse condemnation of our property between the time the new FEMA maps come out and the time the Corps completes its upgrade.

R. Inverse condemnation results when part of a person's lot is condemned by a public agency for a public works project under that agency's power of eminent domain, causing the remaining part of the property to be reduced in value. Neither FEMA (who is merely delineating new flood control maps) nor the Corps (who is only modifying existing channels) expect to be condemning any land.

People may be concerned that the value of their property will decrease—if it is going to be located in the floodplain on the new maps—between the time the maps come out and the LACDA project is completed. Contrary to what one might expect, case studies show that changes in floodplain delineations do not significantly affect property values.

) Are property values near the channels lower than in surrounding areas?

A. According to real estate surveys, there is no noticeable difference in property values between houses near channels and those that are not.

Q. When large predominantly concrete structures such as freeway overpasses and flood control channels and bridges are built in a residential or retail store area, does the area tend to change to primarily industrial use?

A. There is no indication that the area will change its character, unless the zoning laws are changed.

Q. Will the Corps' report include evacuation plans?

A. No. However, the Corps will work with city and county governments, providing information on potential flooding so that local authorities can develop plans for their areas. South Gate, for example, already has a disaster preparedness plan, as does the County Sheriff's Department.

Q. Will the Corps be involved in mobilization during a flood emergency?

A. Yes. The Corps Emergency Operations Center will coordinate with the Sheriff's Department and local police and fire agencies; assist in sandbag and evacuation efforts, and provide technical expertise.

Q. How much advance warning can we expect, and what kind of warning system is there?

A. Due to the hydrology of the L.A. area, the warning time for a major flood would be very short—3 to 6 hours. It is the responsibility of the local government entities, with the help of the Corps, to develop their flood warning systems.

Q. Has the Corps looked at possible seismic activity resulting from the storage of water behind the dams?

A. Yes. Computer modeling and studies have been conducted indicating that, theoretically, retaining water behind a dam can induce seismic activity. However, the amount of water would have be very great (water depth greater than 200 feet), and it would have to be impounded behind the dam for many months. Even then, the size of the quakes would be small—3 to 4 on the Richter scale.

Q. How safe are the dams in the event of a large earthquake while they are full of water?

A. Seismic analyses have been done on all of the dams. The criteria of each analysis include the following conditions: water up to the spillway crest and the maximum credible earthquake for the particular fault (8.5 on the San Andreas, 6.5 on the Whittier-Elsinore faults). The result of the analysis in all cases was that negligible damage to the dam would result under these conditions, with no failure taking place.

C. We are concerned that massive releases of water from the dams could seriously threaten Long Beach.

R. If there is a very large flood event, the dams would spill over the top, and, yes, it is probable that certain areas of Long Beach would be flooded.

Q. What is the difference between dam spillover and dam failure?

A. All dams are designed to include a spillway over which water will flow if the dam's gates cannot let water out of the reservoir as quickly as it is flowing in and the reservoir becomes too full. The spillway is there to protect the dam itself and to help guide excess water into flood control channels (the channels themselves, of course, may be full at that time). Dam failure occurs when the embankment of the dam breaks and water pours uncontrolled and unguided from the reservoir. This event is extremely unlikely. In fact, no dam built by the Corps of Engineers has ever failed.

Q. Can you determine where levees are likely to be breached?

A. The levees would most likely be breached at bridge-sites where the bridge structures themselves could restrict the flow. This would occur, for example, with some of the older bridges that extend downward into the channel area. On the other hand, debris could get caught on a bridge pier in an unpredictable manner and in turn catch more debris, thereby restricting flow and causing an overflow condition. The location of this cause of overflow is impossible to identify.

Q. Since the threat from levee failure is so great, why don't you armor them right now?

A. The Corps must wait for authorization and funding from Congress before it can proceed with any structural improvements on the LACDA system. And, as previously stated, there are many steps, including the completion of an EIS, that we must complete before Congress will give its approval.

Q. If alternative sources of funding can be found, could the levees be armored now? From whom would permission be required?

A. If local funds were raised, the levees could be armored by either (1) the Corps through our *Work for Others* program, or (2) the County, using the Corps plan or securing Corps approval of a County plan.

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Q. Is the Corps looking at companies in the overflow area that store hazardous waste to determine how well protected they are?

A. Yes. This is a major concern to us. However, determining these companies' locations and how they are situated with respect to flooding is a local responsibility. Currently, the local fire departments are charged with the duty of inventorying these companies.

Q. Is the Corps considering in its benefits assessment the loss of land use if land is poisoned by chemical or other hazardous waste?

A. Yes, we are addressing this issue. We are identifying toxic waste dumps within the floodplain and plan to discuss potential damages from their flooding in the Final Report in qualitative terms. It would be very difficult, if not impossible, to try to put this problem into quantitative terms.

Q. What if the system is under construction when a flood occurs?

A. The Corps develops its construction schedules to minimize risk. For example, we schedule construction for the non-flood season (late spring and summer).

Q. Will the Corps' plan include security measures to prevent people from using the channels for recreational purposes (for example, rafting on the river during flood flows)?

A. All of the Corps channels, with the exception of trapezoidal channels used for recreation, are lined with chain-link fence for safety purposes.

Individual Areas of Concern

Sepulveda Basin

Q. How will construction within the Sepulveda Basin—for example, the proposed arts park and the sanitation facility—affect the storage capacity of the reservoir?

A. The impact of building these structures within the basin will be estimated, and any loss of flood control capacity will be compensated through excavation of another part of the basin.

Q. In the event of a flood, is the sanitation facility a threat to groundwater?

A. No. In the event of a flood, the treatment plant will return the untreated material to the main trunk sewer line, which leads to the Hyperion treatment plant.

Glendale Area

Q. Will the levee at Atwater be raised?

A. No.

C. The residents of Elysian Valley are concerned about protecting the natural environment of the area.

R. It is unlikely that this area will be affected by any plan.

Q. Currently, the channel fills up with junk like old shopping carts and appliances, as well as with boulders left by flood waters. This is especially true around the Figueroa Street bridge. Will maintenance improve after new construction?

A. At this time, due to manpower constraints, the Corps can clean up the channels only once a year in the late spring or summer before the flood season starts or if there is a special complaint. The LACDA project will not affect this situation; only allocation of additional funds for maintenance can change it.

Whittier Narrows Dam

Q. What level of protection does Whittier Narrows Dam provide?

A. A dam and its downstream channels are designed to work together as a unit. The dam holds back flood water and then releases it at a rate that the channel can handle. But the dam itself cannot be described as providing a particular level of protection. It can hold a certain volume of water. When that level is exceeded, water begins flowing over the spillway. At that time, the release rate becomes uncontrolled because there are no gates or valves on the spillways. Spillway flow will begin when the dam is full. Although this may result in some flooding downstream, it protects the dam from failing catastrophically.

Q. What damage might be caused by increasing the capacity of the dam?

A. More rights-of-way would be required, creating the need for an acquisition process. However, this alternative is no longer under consideration because of cost considerations.

Q. There is no protection on the east side of the dam. Could the bar erode?

A. There is potential for some small amount of erosion, but the impacts would be so slight that they would not significantly affect the protection provided by the dam.

Q. How much warning time would there be in the event of an overspill or failure of the dam?

A. If the dam were to overspill, there would probably be a warning time of one to three hours, depending on the rate the dam was filling. If the dam failed all at once, there would be no warning. If it failed in stages, there would be more time, depending on the rate of failure. However, the probability of the dam failing is very remote—no Corps dam has ever failed.

Q. What is the significance of cleaning 780,000 cubic feet of sediment out of the dam?

A. Relative to flood control, this is not a significant amount of sediment. However, the County is interested in increasing the size of the water conservation pool, thereby increasing the amount of water that could be conserved.

San Gabriel and Rio Hondo Rivers

Q. Is the Corps studying Rio Hondo and San Gabriel rivers as part of this study?

A. Although the San Gabriel River is part of the LACDA system, it is not a major part of the study because it currently provides 100-year protection. The Rio Hondo, however, is currently being considered for improvements.

Q. Why was surplus land along the San Gabriel River first bought for right-of-way and then sold for development?

A. When a project was first being considered for LACDA, it was thought that the channels would need to be significantly wider. Therefore, the County purchased rights-of-way based on what was deemed to be needed at that time. With the subsequent scaling down

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of the project, the County is returning the extra right-of-way to private use.

South Gate

Q. What is the purpose of the railing along the levees in the South Gate area?

A. The railings are there for safety purposes.

Long Beach

Q. The Long Beach Freeway often floods. Will the project solve that problem?

A. No. The flooding of the Long Beach Freeway is due to local drainage problems and is therefore a local problem.

Q. Because Long Beach is at greatest risk from flooding, will the most money be spent there?

A. Because the damages are highest in Long Beach, providing protection there produces the greatest benefits. Therefore, more costly solutions can be justified for Long Beach compared to other areas.

Carson

Q. There is a lot of street flooding in this area in places not included on the Corps' map. What will be done about that problem?

A. Localized street flooding is a local (county, city) issue. However, in developing its plans, the Corps will make certain that nothing it does will increase the problems of localized street flooding.

Suggested Alternatives

Meeting attendees made the following suggestions for alternatives they want the Corps to consider during its study:

- Reforestation as one way to reduce the flow of sediment into the reservoir.
- The use of polymers to increase flow capacities in existing channels.
- Corps and County coordination with communities in the floodplain to limit development and encourage increased use of open space.
- Incorporation of new spreading grounds and reservoirs into the project to add to the local groundwater supply, as well as to keep some of the runoff from flowing into the flood control channels.
- Rerouting the Los Angeles River to its original path.
- Using freeways as floodways since they are already armored.
- Building another earthen dam out of dredged material from Hansen Dam.
- Coordinating flood control with the sewer system to allow the outflow of some flood water through the sewers to the Hyperion treatment plant.
- Increasing the slope of the channel to increase flows.
- Helping cities develop local flood control plans compatible with the overall Corps plan that local governments can undertake immediately.

The Corps is already looking at some of these alternatives as part of its study. It will consider other suggestions from a cost-benefit standpoint as it must with all alternatives. It appears, for example, that rerouting the Los Angeles River to its original path would be prohibitively expensive because of the enormous amount of development that has taken place along that route.

FEMA and the National Flood Insurance Program

Q. What is the relationship between the Corps and FEMA studies and why don't they use the same overflow maps?

A. They are two independent studies. The Corps produces maps to show average flood depths for relatively large areas only in order to estimate dollar damage—an essential calculation in evaluating the cost effectiveness of alternative flood control improvements under study.

On the other hand, FEMA prepares Flood Insurance Rate Maps (FIRM Maps). These maps consider more specific flood depths for smaller areas in order to make certain that the rates you pay are consistent with the risks you face.

Q. Will the FEMA maps be accurate enough to identify individual land parcels?

A. The FEMA maps will have a scale of 1"= 500', not detailed enough to identify individual parcels. It is possible to gain exemption from paying higher risk insurance rates if an individual parcel is actually higher in elevation than the general area FEMA maps indicate. It is up to the parcel owner to know or find out what the elevation of his property is if this exemption is desired.

Q. Why can't the Corps use the FEMA maps?

A. The FEMA maps will not be completed in time for the Corps to use them in its study.

Q. Is flood insurance required?

A. Flood insurance is required if your local community participates in the National Flood Insurance Program (NFIP) and if you take out a Federally insured loan to buy, refinance, or remodel a structure that is in the 100-year floodplain.

Q. Is it as expensive as earthquake insurance?

A. Flood insurance can cost anywhere from 10¢ to $5.00 per $100 of property value based on which zone the property is located in and how much coverage is desired. By comparison, earthquake insurance generally costs about $2.00 per $1,000 dollars of property insured.

Q. Are insurance companies required to provide flood insurance?

A. No. The insurance companies are not providing the insurance; the NFIP is. The insurance companies simply write the policies and claims and send in the paperwork to the NFIP so that it doesn't have to hire its own policy writers and claims people. The insurance companies charge the NFIP a fee for policy and claim processing.

Q. Who is eligible to participate in the National Flood Insurance Program?

A. Only those people living in a community that is a participant in the program.

Q. Which cities in the LACDA area are *not* participants?

A. Bell Gardens and Downey are not participating today. However, it is likely that they will participate once a the revised FIRM maps have identified a flood threat. The final versions of the maps are due out by early 1991, although the process of reviewing draft revisions will begin during 1989.

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Q. Have all non-participating cities been notified about the program?

A. FEMA sends information about the program to non-participating cities once a year.

Q. What must cities do to become participants?

A. They must agree to institute zoning and permit regulations that reduce future flood risk. For example, they must agree that all new buildings be elevated 1 foot above the 100-year floodplain.

Q. Must both residential and commercial property be elevated 1 foot? That could be very expensive for people building a large structure.

A. All new construction, both residential and business, must be 1 foot above the 100-year floodplain.

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February 1989

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Response Summary

Public Environmental Scoping Meetings
on the
Los Angeles County Drainage Area
Review Study

March 9, 1989

On March 9, 1989, the U.S. Army Corps of Engineers, Los Angeles District, and the Los Angeles County Department of Public Works held two environmental scoping meetings to give the public an opportunity to learn more about a proposed flood control improvement plan for the **Los Angeles County Drainage Area (LACDA)** and to identify and comment on potential environmental impacts from that plan and its alternatives that the Corps should consider in preparing the study **Environmental Impact Statement (EIS)**.

Approximately 60 representatives of Federal, state, and local governments and the public at large attended the meetings that were held in Los Angeles and Lakewood.

Public comments and questions were on the following topics:

- **Environmental concerns - areawide planning, wildlife, aesthetics, recreation, safety, groundwater recharge, and public involvement**
- **Economic concerns**
- **The National Economic Development (NED) Plan**
- **General Questions**

Corps responses, where appropriate, appear in brackets [ ].

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Environmental Concerns

Areawide Planning

Meeting attendees pointed out the following areawide planning and study issues that the Corps should consider in its environmental analyses:

- Potential environmental impacts throughout the LACDA system, not just in the areas to be improved - especially how protection of downstream areas might affect areas upstream.
- The impact of a potential new City of Los Angeles growth management plan on environmental effects examined by the Corps - including the possibility of scaling down the Corps plan if it becomes evident that projected development will not be allowed to take place.
- The interrelation of all development plans in the basin (especially in the constantly changing west San Fernando Valley), so that the assessment of impacts for each plan is not considered in a vacuum.
- Possible changes to Corps findings based on changes brought about by other types of projects.
- The potential for development in the mountains that comprise the LACDA watershed and that potential's effect on Corps environmental findings.
- Long-developed lower reaches of the basin having to bear the impacts of construction instead of the San Fernando Valley where more recent development has overstressed the system.

[The proposed plan addresses an existing system deficiency, and the project design is not affected by potential future development. Other concerns will be addressed, where possible, in the EIS/Final Report.]

Wildlife

Some people, expressing concern that construction near the mouth of the Los Angeles River would have negative effects on the endangered least tern, asked the Corps to address that possibility in its EIS.

[The least tern will not be significantly impacted.]

Aesthetics

Representatives of several cities said that the proposed parapet walls might invite graffiti both during and after construction.

[Unfortunately, this is probably true.]

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Some also wondered how visible the walls would be from local homes, businesses, and streets.

[Visibility would depend on location.]

Representatives of Downey expressed hope that the project would in some way help in their plans to limit growth and provide additional open space.

Recreation

The primary recreation interest people have is in preserving (and perhaps enhancing) the existing equestrian and bicycle trails along the Los Angeles River.

[The project will preserve existing trails.]

Safety

Representatives of cities in the downstream area along the Los Angeles River recommended:

- There be an early warning system in place in the event of a major flood.

  [One is already in place and is continually upgraded.]

- The parapet walls be reinforced and the levees armored to prevent catastrophic failure in the event of overtopping.

  [This is part of the proposed design.]

- The project be designed and built with the potential for a major earthquake in mind.

  [Existing design standards regarding safety during earthquakes have been met.]

An additional safety issue concerned the need for periodic checks of the Sepulveda Dam when the Corps' new water control plan goes into affect.

[The Corps routinely monitors the performance of all of its dams.]

Groundwater Recharge

One person suggested that detention basins built for the project double as groundwater recharge basins.

[This will be done where feasible.]

Public Involvement

Some people expressed dismay that so few members of the public or representatives of special interest and environmental groups had attended the March 9 scoping meetings.

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They asked that the Corps be certain that groups such as the Sierra Club be informed when the draft EIS becomes available.

[They are on the Corps' mailing list and receive notices. If anyone has names of groups or individuals who would be interested, they will be added to the mailing list.]

Economic Concerns

Several people asked about the financial impact the project would have on cities in the 100-year floodplain. Their questions were:

- How much would the cities have to pay as part of the federal/local sponsor cost-sharing agreement?

  [The current county flood district tax levee will be sufficient to pay 30% of the local share. The remaining percentage of the local share would come from a state grant program.]

- What relief from Federal Emergency Management Agency (FEMA) flood insurance costs would the completed project provide?

  [The 100-year floodplain, as officially designated by FEMA in 1990, would essentially be eliminated and structures designated in this area of the floodplain would no longer be required to carry flood insurance.]

A representative of the Los Angeles County Department of Public Works explained the cost-sharing arrangements:

- Local interests would be responsible for at least 25 percent, but not more than 50 percent, of the total project cost. That amount would include purchase of all needed lands and rights-of-way.
- Of the local share, 70 percent would be paid by the State of California.
- The remaining 30 percent of the local share would come from Los Angeles County flood control funds.

Some people at the meetings expressed concern that using the county funds would limit the amount of new construction or repair work the county would be able to do on such things as storm drains.

[The County will not reduce its maintenance efforts and will allocate this project significant resources but will still pursue a variety of construction projects.]

Others said they expected it to be difficult to get the state and Federal funding.

[Funding is always difficult.]

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The other main economic issue dealt with the 100-year flood overflow areas identified by new FEMA maps. Participants stated a great deal of concern about the cost of meeting Federal flood insurance requirements in areas newly identified as at risk. People representing cities in the floodplain encouraged the Corps to move toward construction as quickly as possible and said that they would contact their local Congressional representatives to voice support for the project. One person said that if funding was slow in coming, the Corps should stage its construction to maximize the flood protection achieved in each stage.

[This will be considered in construction scheduling.]

The National Economic Development (NED) Plan

People detailed a number of concerns and asked several question about the potential plan presented by the Corps (the NED plan) and other alternatives.

Expressing preference for the the tunnel alternative, one participant questioned how the Corps arrived at a negative benefit-to-cost ratio for the tunnel when the cost of tunneling would be so much less than the $2-1/2 billion in damages that would be prevented.

[It was explained that benefits and costs have to be annualized for each size flood that could occur. This method results in the cost of tunneling being significantly higher than the benefits provided.]

Another person stated that the Corps plan should be developed to solve the flooding problem permanently--not just for another 50 years or so.

[The Corps has considered probable development in the future.]

People suggested that the Corps consider the following issues in developing the recommended plan:

- The possibility of injecting polymers in selected areas to help pass water more quickly at problem spots.

  [This is not a practical solution. First, it is untested methodology and the logistics of when and how the polymers would be injected have not been determined. In addition, the polymers would eventually flow out to the ocean, generating pollution.]

- Whether the new bridges on the Artesia and Century freeways would be high enough.

  [Yes, they will be.]

- Whether the light-rail track being built between Los Angeles and Long Beach is above the floodplain.

  [It will be after the project is completed.]

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- The use of bridges as dikes by sandbagging or otherwise fortifying their bases.

  [Due to hydraulic considerations, this is not a viable alternative.]

- In calculating flood flows and project life, the siltation of upstream dams, including who is responsible for maintenance of those dams.

  [This is considered during plan formulation.]

- The possibility of assigning air rights over the channel, especially in the Long Beach area where space for housing and new businesses is becoming scarce.

  [Because this limits channel access and future channel improvement possibilities, it is discouraged as a large-scale concept.]

Questions about the potential project included the following:

- What would be the total project cost?

  [Approximately $300 million first cost.]

- Would the project have any effect on the Lakewood storm drain system that is nearing capacity?

  [No. Storm drains are local systems.]

- Why is there no plan for improvements to the San Gabriel River?

  [This river doesn't have a deficiency. It is basically used as a relief system from Whittier Narrows Dam.]

- How much additional right-of-way would be needed through Paramount?

  [None is currently anticipated.]

- What would be done in the Rosecrans/Freeway 91 area?

  [Parapet walls would be raised to the full extent possible and the levees armored.]

- Would all bridges have to be completely rebuilt in order to raise them?

  [Newer bridges are built in a modular fasion and can be jacked up in one piece. Older bridges would have to be rebuilt, however.]

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- What is the projected flow capacity at Firestone Avenue and Imperial Highway?

  [The existing capacity, in cubic feet per second, is as follows:

	Existing	Proposed
Firestone @ LAR	110,000	110,000
Firestone @ RH	36,500	50,300
Imperial @ LAR	132,000	164,000]

General Questions:
the LACDA System and Corps Policy

- Are the mouths of the Los Angeles and San Gabriel rivers the same height above sea level?

  [They are both at sea level.]

- Is the 100-year flood elevation higher than the gates on the Sepulveda Dam?

  [Water does flow over the spillway gates during a 100-year event but in an anticipated and controlled fasion.]

- Does the Corps hire outside contractors to do its construction work?

  [Yes, they do.]

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March 9, 1989 - 1:00p.m. & 7:30p.m.

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Lakewood, CA 90714

Rollie D. Berry
Director of Public Works
City of South Gate
8650 California Ave.
South Gate, CA 90280

Mike Connolly
116 Corinthian Walk
Long Beach, CA 90803

Juan F. Balanay
Project Civil Eng.
City of Pico Rivera
6615 Passons Blvd.
Pico Rivera, CA 90660

Chon Cervantes, Director of
Building Office
City of South Gate
8650 California Ave.
South Gate, CA 90650

William H. DeWitt
Councilman, City of South
Gate
8650 California Ave.
South Gate, CA 90280-3075

Richard W. Burtt
City Engineer
3031 Torrance Blvd.
Torrance, CA 90503

Lewis Mac Adams
Friends of the Los Angeles
River
2414 Moreno Drive
Los Angeles, CA 90039

INTERESTED PARTIES
NOT IN ATTENDANCE

Polly Ward
Studio City Residents Ass.
12303 Hillslope St.
Studio City, CA 91604

Homeowners of Encino
P.O. Box 453
Encino, CA 91426

Elysian Valley Property Owners,
Renters & Businessmen's Ass.
2335 Gatewood St.
Los Angeles, CA 90031

Glenn Bailey
5926 Hesperia Ave.
Encino, CA 91316

The Federation of Hillside &
Canyon Associations
4128 Morro Drive
Woodland Hills, CA 91364

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APPENDIX B

FEDERAL REGISTER NOTICE OF PROJECT

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Office of the Secretary

Defense Science Board Task Force on Technological and Operational Surprise; Closed Meeting

ACTION: Notice of Advisory Committee Meetings.

SUMMARY: The Defense Science Board Task Force on Technological and Operational Surprise in the U.S.-Soviet Military Competition will meet in closed session on March 2-3, 1989 at the DIAC Building, Bolling AFB, Washington, DC.

The mission of the Defense Science Board is to advise the Secretary of Defense and the Under Secretary of Defense for Acquisition on scientific and technical matters as they affect the perceived needs of the Department of Defense. At this meeting the Task Force will evaluate the potential for technological and operational surprise in the U.S.-Soviet military competition.

In accordance with section 10(d) of the Federal Advisory Committee Act, Pub. L. 92-463, as amended (5 U.S.C. App. II (1982)), it has been determined that this DSB Task Force meeting concerns matters listed in 5 U.S.C. 552b(c)(1) (1982), and that accordingly this meeting will be closed to the public.

February 7, 1989.

Linda M. Bynum,

Alternate OSD Federal Register Liaison Officer, Department of Defense.

[FR Doc. 89-3297 Filed 2-10-89; 8:45 am]

BILLING CODE 3810-01-M

Defense Science Board Task Force on Strategic Force Modernization Program; Meeting

ACTION: Change in Date of Advisory Committee Meeting Notice.

SUMMARY: The meeting of the Defense Science Board Task Force on Strategic Force Modernization Program scheduled for March 2-3, 1989 as published in the Federal Register (Vol. 53, No. 248, Page 52213, Tuesday, December 27, 1988, FR Doc. 88-29659) will be held on March 28-29, 1989.

February 7, 1989.

Linda M. Bynum,

Alternate OSD Federal Register Liaison Officer, Department of Defense.

[FR Doc. 89-3298 Filed 2-10-89; 8:45 am]

BILLING CODE 3810-01-M

Special Operations Policy Advisory Group, Closed Meeting

The Special Operations Policy Advisory Group (SOPAG) will meet on 17 February 1989 in the Pentagon, Arlington, Virginia to discuss sensitive, classified topics.

The mission of the SOPAG is to advise the Office of the Secretary of Defense on key policy issues related to the developments and maintenance of effective Special Operations Forces.

In accordance with section 10(d) of P.L. 92-463, the "Federal Advisory Committee Act," and section 552b(c)(1) of Title 5, United States Code, this meeting will be closed to the public.

Linda M. Bynum,

Alternate OSD Federal Register Liaison Department of Defense.

February 7, 1989.

[FR Doc. 89-3299 Filed 2-10-89; 8:45 am]

BILLING CODE 3810-01-M

Corps of Engineers, Department of the Army

Intent To Prepare a Draft Environmental Impact Statement (DEIS) for the Los Angeles County Drainage Area (LACDA) Review Study, Los Angeles County, CA

AGENCY: U.S. Army Corps of Engineers, DoD.

ACTION: Notice of intent.

SUMMARY: This study is designed to develop a system-wide approach to identifying means for improving the capabilities of the Los Angeles County Drainage Area flood control system. During the 40 years since its construction, the ability of the system to provide a very high level of protection has diminished. This has resulted from an increase in surface runoff, loss of groundwater percolation and associated increases in contributory flow from additional storm drains.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed action and Draft Environmental Impact Statement can be answered by Ronald F. Lockmann, CESPL-PD-RN, P.O. Box 2711, Los Angeles, California 90053-2325, (213) 894-5414.

SUPPLEMENTARY INFORMATION:

1. Proposed Action

The tentatively selected plan for flood control in the Los Angeles County Drainage Area system, Los Angeles County, California, consists of the following: Levee armoring and raising channel walls along the Rio Hondo, the Los Angeles River (LAR) from Atlantic Boulevard to the Ocean; and Compton Creek: armoring the backside (outside) of the LAR from Atlantic Blvd. to Pacific Ocean, Rio Hondo (entire) and Compton Creek from Willowbrook to the LAR would avoid catastrophic failure of the levees if they are overtopped. The linear distance of the armoring would be about 28 miles. Accessibility to the channel would not be impacted. Raising the channel walls would also include channel conversion to trapezoidal where necessary and extension of bridge piers where possible. environmental enhancement, habitat improvement, or mitigation will not be included in this plan.

2. Alternatives

Alternatives considered during the planning process include 2 plans with detention or spreading ground possibilities (that of deepening Tujunga and Pacoima Spreading grounds; that of using Santa Fe gravel pit as a detention basin).

3. Scoping Process

A scoping meeting will be held to obtain community input to assure that all concerns are identified and addressed in the EIS/EIR. A separate public scoping notice will be sent to the public to identify time and location of the meeting and to solicit public comment. The specific date, time and meeting location will be published in local newspapers. The Corps has initiated coordination efforts with appropriate federal, state and local agencies to resolve potential problems relating to involved biological resources communities.

4. Future Public Meetings

A public meeting will be scheduled to discuss and obtain public comment.

5. Publication of DEIS

The Draft Environmental Impact Statement is expected to be available to concerned agencies and the interested public for review and comment in mid-1989.

Date: January 19, 1989.

Tadahiko Ono,

Colonel, Corps of Engineers, District Engineer.

[FR Doc. 89-3243 Filed 2-10-89; 8:45 am]

BILLING CODE 3710-KF-M

Office of The Secretary

Per Diem, Travel And Transportation Allowance Committee

AGENCY: Department of Defense.

ACTION: Publication of changes in per diem rates.

SUMMARY: The Per Diem, Travel and Transportation Allowance Committee is publishing Civilian Personnel Per Diem

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APPENDIX C

BIOLOGICAL ASSESSMENT

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BIOLOGICAL ASSESSMENT

I. Introduction

The Los Angeles District of the Army Corps of Engineers (COE), has determined that the proposed Los Angeles County Drainage Area Review will not adversely affect any species listed pursuant to the Endangered Species Act. Those species that occur in the study area include least Bell's vireo, California least tern, California brown pelican and the slender-horned spineflower.

The purpose of a biological assessment is to evaluate the potential effects of a Federal action (project) on listed and proposed listed species and designated and proposed critical habitat and determine whether any such species or habitat are likely to be adversely affected by the Federal action (project). The biological assessment is also used in determining whether formal consultation or a conference is necessary {Federal Register 51(106): Section 402.12(a), pg. 19960, 3 June 1986}. The contents of the biological assessment are at the discretion of the Federal agency and are dependent on the nature of the Federal action.

II. Project Description

Under congressional authority, the Los Angeles District of the U.S. Army Corps of Engineers is conducting a flood control study of the Los Angeles County Drainage Area (LACDA) project. The existing flood control system was constructed by the Corps of Engineers and the Los Angeles County Flood Control District (now part of the Department of Public Works) from the 1930s through the 1960s to protect the City of Los Angeles and other metropolitan areas in Los Angeles County from flood damage. Increased urbanization resulting in increased runoff, as well as changes in design criteria, has resulted in an inadequate level of flood protection afforded by the LACDA system.

The NED Plan (proposed alternative) addresses the area of most critical need in the LACDA: the downstream reaches of the Los Angeles-Rio Hondo system. Planned improvements begin at Whittier Narrows Dam and extend downstream on the Rio

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Hondo to the confluence with the Los Angeles River. Improvements on the Los Angeles River continue from the confluence with the Rio Hondo and extend downstream to the mouth of the river in Long Beach Harbor. A total of about 23 miles of channel is to be improved.

The NED plan consists of five elements: 1) parapet walls, 2) raising bridges, 3) levee armoring, 4) widening a portion of the Rio Hondo and Los Angeles rivers at their confluence, and 5) application of a concrete overlay.

A. Parapet Walls

Parapet walls would be provided on the tops of existing levees on the Rio Hondo Channel and lower Los Angeles River for nearly the entire length of channel from Whittier Narrows to the Pacific Ocean. Wall heights would range from 2 to 8 feet (0.7 to 2.4 m).

B. Raising Existing Bridges

In order to provide parapet walls along the channels, many of the vehicle, railroad and utility bridges which cross the channels must be raised in height. The required height adjustments range from 1.6 to 6.3 feet (0.5 to 1.9 m) for the lower Los Angeles River, and 1.4 to 5.3 feet (0.4 to 1.6 m) along the Rio Hondo.

Of the 25 bridges which cross the lower Los Angeles River, 15 need to be modified. Twelve of the 18 bridges over the Rio Hondo are proposed to be modified.

C. Levee Armoring

Existing levees would be strengthened by armoring the back slope at selected locations with grouted stone. The back sides of levees will be armored to prevent erosion of the earthen levee in case they are overtopped.

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D. Widening Channel at Confluence

At and just downstream of the Rio Hondo-Los Angeles River confluence, a 7000 foot section of the Los Angeles River would be converted from trapezoidal to rectangular cross-section and widened 30 feet. Parapet walls would be constructed on the rebuilt channel walls.

E. Application of Concrete Overlay

The existing grouted stone channel walls in the vicinity of the Rio Hondo-Los Angeles River confluence will be overlaid with concrete to reduce hydraulic friction and improve channel flow characteristics.

III. Species Accounts

A. Slender-Horned Spineflower

1. Natural History

a. Distribution

Dodecahema (Centrostegia) leptoceras (CELE) is a very rare species, known to occur in only four small, isolated populations which together occupy less than 4 hectares (10 acres; U.S. Fed. Reg. 1986). These sites are: 1) near Devore, 2) 1.5 miles east of Valle Vista, 3) Temescal Canyon, and 4) near Highland in the Santa Ana River Wash, and 5) in Bautista Canyon (found by the U.S. Forest Service in 1987).

b. Habitat Requirements/Life History

CELE is generally found on sandy, old-formation benches that are free from introduced annual grasses and lack evidence of surface disturbance (Reveal and Krantz 1979). CELE is most commonly associated with mature soft chaparral or in association with a sparse cover of dwarf annuals, mosses, liverworts, and lichens.

2. "No Effect" Determination

Currently the only location where CELE potentially could occur is behind Hansen Dam in the LACDA system. The proposed alternative does not modify operations or uses in the Hansen Dam basin, so the with-project and without-project conditions are identical. Given no changes or impacts and no known populations, the COE has determined there would be no adverse effect to CELE.

B. California Least Tern

1. Natural History

a. Distribution

The California least tern (Sterna antillarum browni) is sparsely distributed in small colonies from San Francisco Bay to the Mexican border with additional small groups along the west coast of Baja California.

b. Habitat Requirements/Life History

The State and Federally endangered California least tern is a migratory, water-associated bird which returns to coastal California from Central America to breed between April and September. It is dependent upon undisturbed, sandy, open areas near coastal embayments or river mouths for suitable nesting habitat. The embayments, river mouths, and areas upstream of the river mouths within an approximate two mile range of nests serve as primary foraging habitat for least terns during nesting.

2. "No Effect" Determination

The California least tern has been identified as potentially foraging in the project area in association with the Los Angeles River and the San Gabriel River. There were no known or potential nesting sites identified within the study area. The currently proposed project could potentially impact the least tern due to some upstream turbidity associated with bridge raising and noise associated with the construction of the parapet walls in the areas where least terns potentially forage. The COE has determined that the proposed project alternative would have no adverse effect on the California least tern due to a commitment to restrict construction in the lower reaches of the Los Angeles River. Construction would only occur from September to March on the last one-mile reach of the Los Angeles River. The proposed project alternative does not modify the San Gabriel River and as such there will be no adverse effect on the species.

C. California Brown Pelican

1. Natural History

a. Distribution

The California brown pelican (Pelecanus occidentalis californicus) ranges from southern British Columbia to Central America. A major segment of the population of this subspecies occupies the coast from central Baja California to northern California.

b. Habitat Requirements/Life History

The California brown pelican is associated with beaches, bays, and tidal estuaries and only rarely with fresh water. It feeds exclusively on fish. The brown pelican is at its highest numbers along the coast of California from late summer to late fall during the nonbreeding season. The brown pelican nests primarily on offshore islands (e.g. Channel Islands).

2. "No Effect" Determination

The California brown pelican has been identified as potentially foraging in the project area in association with the Los Angeles and San Gabriel Rivers. Foraging is the only activity that could be affected. The potential effects would be the possibility of increased turbidity from construction upstream and noise from construction of

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the parapet walls. The COE has determined that the proposed project alternative would have no adverse effect on the California brown pelican due to a commitment to restrict construction in the lower reaches of the Los Angeles River. Construction would only occur from September to March on the last one-mile reach of the Los Angeles River. The proposed project alternative would not disturb any important brown pelican roosts. The San Gabriel River is not a part of the proposed alternative; hence, there would be no adverse effect on pelican foraging in the area.

D. Least Bell's Vireo

1. Natural History

a. Distribution

The least Bell's vireo (vireo bellii pusillus) is a small migratory bird whose breeding range is restricted to two localities in the Salinas River Valley; one locality along the Amargosa River; numerous small populations in southern California south of the Tehachapi Mountains; and in northwestern Baja California, Mexico.

b. Habitat Requirements/Life History

The least Bell's vireo arrives in its breeding habitat in mid-March to early April and departs in late August and September for its wintering range in Mexico. Least Bell's vireos are known to nest primarily in willows but also use a variety of shrubs, trees and vines. These passerine birds forage in riparian and adjoining chaparral habitat. In addition to loss of habitat, species decline is severely accelerated by nest parasitism by the brown-headed cowbird.

2. "No Effect" Determination

The least Bell's vireo has been identified as being present or possibly present at Hansen Dam, Santa Fe Dam, Whittier Narrows Dam, and in the San Gabriel River downstream of Whittier Narrows Dam. The proposed project alternative for LACDA would not cause any change in the conditions behind the dams or on the San Gabriel

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River; hence not impacting any species present.

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APPENDIX D

404B(1) DETERMINATION

THE EVALUATION OF THE EFFECTS

OF THE DISCHARGE OF DREDGED OR FILL MATERIAL

INTO THE WATERS OF THE UNITED STATES

LACDA REVIEW PROJECT

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THE EVALUATION OF THE EFFECTS
OF THE DISCHARGE OF DREDGED OR FILL MATERIAL
INTO THE WATERS OF THE UNITED STATES
LACDA REVIEW PROJECT

I. INTRODUCTION. The following evaluation is provided in accordance with Section 404(b)(1) of the Federal Water pollution Control Act Amendments of 1972 (Public Law 92-500) as amended by the Clean Water Act of 1977 (Public Law 95-217). Its intent is to succinctly state and evaluate information regarding the effects of discharge of dredged or fill material into the waters of the U.S. As such, it is not meant to stand alone and relies heavily upon information provided in the environmental document to which it is attached.

II. PROJECT DESCRIPTION

A. Location: Los Angeles County Drainage Area (LACDA). Construction is proposed in the lower portion of the Los Angeles River, the portion of the Rio Hondo River below Whittier Narrows and the lower portion of Compton Creek.

B. General Description: Material to be discharged includes sediment from dredged material in the lower Los Angeles River (channel widening alternative only). Other discharges will be incidental to construction activities in the channels.

The National Economic Development (NED) project alternative consists of construction of parapet walls on top of existing levees within the lower Los Angeles River, Rio Hondo Channel and lower Compton Creek. Limited channel widening and extensive bridge modifications will be required for this alternative. No dredging is proposed.

C. Authority and Purpose: Sections 1.1 and 1.3 of the EIS provide a description of the authority and purpose of the proposed action. The authority includes the Emergency Relief Act of 1935 and the Flood Control Acts of June 22, 1936 and August 8, 1941.

D. General Description of Dredged or Fill Material: The dredged material consists of soft sediments in the lower Los Angeles River. These sediments may be

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contaminated from urban runoff. Section 4.5.3 of the EIS discusses these impacts.

E. Description of Proposed Discharge Site: The exact method of disposal has not been determined. It is assumed that the dredged material meeting ocean disposal standards will be disposed of in a deep water disposal site (LA-2 or LA-3). Any material not conforming to standards will be disposed of at an approved onshore disposal site.

F. Description of Disposal Method: It is anticipated that the material will be transported to offshore disposal sites via barge and then dumped directly from the barge. On-land disposal will be via truck delivery to approved disposal facilities.

III. FACTUAL DETERMINATATION

A. Disposal Site Physical Substrate Determinations:

1. Substrate Elevation and Slope:

Impact: __X_ N/A ____ Insignif. _____ Signif.

2. Sediment Type:

Impact: __X_ N/A ____ Insignif. _____ Signif.

3. Dredged/Fill Material Movement:

Impact: __X_ N/A ____ Insignif. _____ Signif.

4. Physical Effects on Benthos (burial, changes in sediment type, composition, etc.):

Impact: ____ N/A __X_ Insignif. _____ Signif.

This material will be disposed of in an approved site where previous environmental documents have been prepared.

5. Other Effects

Impact: __X_ N/A ____ Insignif. _____ Signif.

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6. Actions taken to Minimize Impacts

Needed? __X_ YES ____ NO

If Needed, Taken:

__X_ YES ____ NO

Specific measures to reduce turbidity are proposed.

B. Effect on Water Circulation, Fluctuation, and Salinity Determinations:

1. Effect on Water. The following impacts were considered:

a. Salinity	___N/A	_X_Insignif.	___Signif.
b. Water Chemistry (pH, etc.)	___N/A	_X_Insignif.	___Signif.
c. Clarity	___N/A	_X_Insignif.	___Signif.
d. Color	___N/A	_X_Insignif.	___Signif.
e. Odor	___N/A	_X_Insignif.	___Signif.
f. Taste	___N/A	_X_Insignif.	___Signif.
g. Dissolved gas levels	___N/A	_X_Insignif.	___Signif.
h. Nutrients	___N/A	_X_Insignif.	___Signif.
i. Eutrophication	_X_N/A	___Insignif.	___Signif.
j. Others	_X_N/A	___Insignif.	___Signif.

2. Effect on Current Patterns and Circulation. The potential of discharge or fill on the following conditions were evaluated.

k. Current Pattern and Flow	___N/A	___Insignif.	_X_Signif.
l. Velocity	___N/A	_X_Insignif.	___Signif.
m. Stratification	___N/A	_X_Insignif.	___Signif.
n. Hydrology Regime	___N/A	_X_Insignif.	___Signif.

3. Effect on Normal Water Level Fluctuations. The potential of discharge or fill on the following were evaluated.

o. Tide	_X_N/A	___Insignif.	___Signif.
p. River Stage	_X_N/A	___Insignif.	___Signif.

4. Action Taken to Minimize Effects:

None Required

C. Suspended Particulate/Turbidity Determinations at the Disposal Site

1. Expected Change in Suspended Particulate and Turbidity Levels in Vicinity of Disposal Site

Impact: ___N/A _X_Insignif. ___Signif.
Documentation: Increases of suspended sediments and turbidity will be short term during discharge of dredged material. These levels are expected to return to pre-project levels almost immediately.

2. Effects (degree and duration) on Chemical and Physical Properties of the Water Column:

a. Light Penetration	___N/A	_X_Insignif.	___Signif.
b. Dissolved Oxygen	___N/A	_X_Insignif.	___Signif.
c. Toxic Metals and Organics	_X_N/A	___Insignif.	___Signif.
d. Pathogen	_X_N/A	___Insignif.	___Signif.
e. Esthetics	___N/A	_X_Insignif.	___Signif.
f. Others	_X_N/A	___Insignif.	___Signif.

3. Effects of Turbidity on Biota: The following affects of turbidity on biota were evaluated:

g. Primary Productivity	___N/A	_X_Insignif.	___Signif.
h. Suspension/ Filter Feeders	___N/A	_X_Insignif.	___Signif.
i. Sight Feeders	___N/A	_X_Insignif.	___Signif.

4. Actions Taken to Minimize Impact: Potential for dredging only after slack tide.

D. Contaminant Determination

The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material.

3. Physical characteristics X

4. Hydrography in relation to known or anticipated sources of contaminants X

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5. Results from previous testing of any material or similar material in the vicinity of the project X

6. Known, significant, sources of contaminants (e.g. pesticides) from land runoff or percolation .... --

7. Spill records for petroleum products or designated (Section 311 of CWA) hazardous substances .... --

8. Other public records of significant introduction of contaminants from industries, municipalities or other sources X

9. Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities X

10. Other sources (specify) .... --

An evaluation of the appropriate information above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to constraints. The material meets the testing exclusion criteria.

_X_ YES ___ NO

Impact: ___N/A _X_Insignif. ___Signif.

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A. Effect on Aquatic Ecosystem and Organization Determinations. The following ecosystem effects were evaluated:

1. On Plankton ___N/A _X_Insignif. ___Signif.
2. On Benthos ___N/A _X_Insignif. ___Signif.
3. On Nekton ___N/A _X_Insignif. ___Signif.
4. Food Web ___N/A _X_Insignif. ___Signif.
5. Sensitive Habitats:
   a. Sanctuaries, refuges _X_N/A ___Insignif. ___Signif.
   b. Wetlands _X_N/A ___Insignif. ___Signif.
   c. Mudflats _X_N/A ___Insignif. ___Signif.
   d. Eelgrass beds _X_N/A ___Insignif. ___Signif.
   e. Riffle and Pool Complexes _X_N/A ___Insignif. ___Signif.
6. Threatened & Endangered Species ___N/A _X_Insignif. ___Signif.
7. Other Wildlife (grunion) ___N/A _X_Insignif. ___Signif.
8. Actions to Minimize Impacts
   None necessary as impacts will be short-term.

B. Proposed Disposal Site Determinations. Is the mixing zone for each disposal site confined to the smallest practicable zone?
___N/A _X_Insignif. ___Signif.

C. Determination of Cumulative Effects of Disposal or Fill on the Aquatic Ecosystem.
Impacts: ___N/A _X_Insignif. ___Signif.

D. Determination of Indirect Effects of Disposal or Fill on the Aquatic Ecosystem.
Impacts: ___N/A _X_Insignif. ___Signif.

IV. FINDING OF COMPLIANCE

A review of the proposed project indicates that:

a. The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose

_X_ YES ___ NO

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b. The activity does not appear to: 1) violate applicable state water quality standards or effluence standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of Federally listed endangered or threatened species or their habitat; and 3) violate requirements of any Federally designated marine sanctuary.

_X_ YES ___ NO

c. The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages or organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values;

_X_ YES ___ NO

d. Appropriate and practicable steps have been taken to potential adverse impacts of the discharge on the aquatic ecosystem.

_X_ YES ___ NO

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1 A negative response indicates that the proposed project does not comply with the guidelines.

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APPENDIX E

COASTAL CONSISTENCY DETERMINATION

APPENDIX E - COASTAL CONSISTENCY DETERMINATION

This appendix provides the information necessary to determine the proposed action's consistency with the provisions of the California Coastal Act of 1976. Federal consistency review provisions are provided in the Federal Coastal Zone Management Act.

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I. TYPE AND DESCRIPTION OF THE PROPOSED ACTION

The Army Corps of Engineers proposes to improve the flood conveyance capabilities of the Los Angeles County Drainage Area flood control system. The proposed NED Plan includes construction of concrete parapet walls along the existing channel levees of the Rio Hondo, the lower Los Angeles River and Compton Creek. Selected areas of levee armoring are also associated with the proposed action. Implementation of the NED Plan would also necessitate the raising of numerous street bridges crossing the affected channels.

The coastal zone boundary with respect to the proposed action covers the area from Ocean Boulevard upstream to Anaheim Street. This area is under the jurisdiction of the Port of Long Beach for coastal permitting.

Under the NED Plan alternative, the only modifications made to the Los Angeles River channel within the coastal zone area would be the construction of parapet walls on both channel levees for the entire reach. Wall heights would range between 3 and 5 feet.

The proposed action is considered a direct Federal activity for purposes of coastal consistency determination. Specific details of the proposed action and alternatives, with appropriate illustrations, are included in Section 2 of the main body of this EIS.

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II. COASTAL RESOURCE PLANNING AND MANAGEMENT POLICIES

The coastal resource planning and management policies applicable to the proposed action are listed below along with an analysis of the relationship to proposed alternatives.

A. Public Access

1. Section 30211

Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization, including, but not limited to, the use of dry sand and rocky coastal beaches to the first line of terrestrial vegetation.

Relationship to Policy

NED Plan Alternative - This alternative will not physically interfere with public access to the sea within the coastal zone. Construction of parapet walls along river levees could temporarily restrict use of bicycle trails which provide access to the coastal area. These trails will be fully restored after construction and no long-term effects will occur. Also, efforts will be made to route bicycle traffic around construction areas utilizing existing, available bike trails on streets. This alternative will not significantly impact public access to the coastal zone.

B. Recreation

1. Section 30220

Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.

Relationship to Policy

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NED Plan Alternative - This alternative will not affect the amount of area devoted to water-oriented recreation.

2. Section 30223

Upland areas necessary to support coastal recreational uses shall be reserved for such uses, where feasible.

Relationship to Policy

NED Plan Alternative - The bicycle trail along the eastern Los Angeles River levee is used as an important point of non-vehicular access to the coastal zone recreation resources. Bike trails will be temporarily impacted by parapet wall construction, and will be fully restored after construction. As stated previously, efforts will be made route bicycle traffic around construction areas using existing available bike trails on local streets.

C. MARINE ENVIRONMENT

1. Section 30230

Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of the coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

Relationship to Policy

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NED Plan Alternative - This alternative would not involve any disturbance to marine resources.

2. Section 30231

The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored through, among other means, minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface water flow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.

Relationship to Policy

NED Plan Alternative - No alteration of wetlands will occur as a result of the implementation of this alternative.

3. Section 30233

(a) The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to the following:

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(5) Incidental public service purposes, including but not limited to, burying cables and pipes or inspection of piers and maintenance of existing intake and outfall lines.

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Relationship to Policy

NED Plan Alternative - The proposed project has public service purposes in providing flood control protection to a significant portion of the population within the Los Angeles basin. Use of the existing channel for flood control modifications is necessary in that there are no feasible alternatives that could be implemented which would not utilize the channel. (See also Section 2.1 of the EIS for a description of other alternatives considered but eliminated from consideration.)

(b) Dredging and spoils disposal shall be planned and carried out to avoid significant disruption to marine and wildlife habitats and water circulation. Dredge spoils suitable for beach replenishment should be transported for such purposes to appropriate beaches or into suitable long shore current systems.

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Relationship to Policy

NED Plan Alternative - No dredge spoil disposal is required under this alternative.

4. Section 30236

Channelizations, dams, or other substantial alterations of rivers and streams shall incorporate the best mitigation measures feasible, and be limited to (1) necessary water supply projects, (2) flood control projects where no other method for protecting existing structures in the floodplain is feasible and where such protection is necessary for public safety or to protect existing development, or (3) developments where the primary function is the improvement of fish and wildlife habitat.

Relationship to Policy

NED Plan Alternative - This alternative is a necessary component of the flood protection system for the greater Los Angeles County Drainage Area. The action involves modification of an existing flood control channel.

5. Land Resources

Land Resource policies are not applicable since no land resources within the coastal zone will be affected by project alternatives.

6. Development

The proposed action is not considered new development, thus the policies in this article do not apply.

7. Industrial Development

The proposed action is not considered industrial development thus the policies of this article do not apply.

III. CONSISTENCY DETERMINATION AND CERTIFICATION

It has been determined by the Los Angeles District Corps of Engineers that, based on a review of the applicable sections of the Coastal Zone management, the proposed Los Angeles County Drainage Area Study is consistent with the applicable sections of the

California Coastal Act of 1987 to the maximum extent practicable. The Corp has determined that the proposed plan, the NED plan, is the most feasible alternative and that feasible mitigation measures have been included to minimize adverse environmental effects. This finding is based on the attached Draft Environmental Impact Statement (DEIS) for the Los Angeles County Drainage Area study, appendixes, and coordination.

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APPENDIX F

DRAFT EIS RECIPIENTS

LACDA Report Mailing List

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APPENDIX G

FISH AND WILDLIFE COORDINATION ACT REPORT

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R0050656

United States Department of the Interior

FISH AND WILDLIFE SERVICE

FISH AND WILDLIFE ENHANCEMENT
SOUTHERN CALIFORNIA FIELD STATION
Laguna Niguel Office
Federal Building, 24000 Avila Road
Laguna Niguel, California 92656

In Reply Refer To:
FWE/SCFS-LNO

May 11, 1990

Colonel Charles Thomas
District Engineer
Corps of Engineers, Los Angeles District
P.O. Box 2711
Los Angeles, California 90053

Attn: Ruth Villalobos, Chief, Environmental Resources Branch

Re: Draft Fish and Wildlife Coordination Act Report for the Los Angeles County Drainage Area (LACDA) Review Study, Los Angeles County, California

Dear Colonel Thomas:

Enclosed for your review is our draft Fish and Wildlife Coordination Act Report which evaluates the alternatives currently being considered in the referenced project. A copy of this report has also been provided to the California Department of Fish and Game for their review.

This draft report has been prepared under the authority of, and in accordance with, provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. et seq.). This report is intended to assist your agency in the preparation of the Feasibility Study for this project.

We look forward to continued cooperation on this project. If you have any questions on this draft report, please contact John Hanlon at (714) 643-4270.

Sincerely,

Brooks Harper

Brooks Harper
Office Supervisor

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DRAFT

FISH AND WILDLIFE COORDINATION ACT REPORT
LOS ANGELES COUNTY DRAINAGE AREA
(LACDA) REVIEW STUDY

Los Angeles County

California

Prepared for the

CORPS OF ENGINEERS
LOS ANGELES DISTRICT
Department of the Army
Los Angeles, California

by the

FISH AND WILDLIFE SERVICE
U.S. Department of the Interior
Laguna Niguel Field Office

Brooks Harper, Office Supervisor
John Hanlon, Project Biologist and Author

May 1990

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PREFACE

This document constitutes the U.S. Fish and Wildlife Service's (Service) draft report on the Los Angeles County Drainage Area (LACDA) Review Study, Los Angeles County, California. It is being prepared under the authority of the Fish and Wildlife Coordination Act, P.L. 85-624, Section 2(b) and in keeping with the spirit and intent of the National Environmental Policy Act. This report is expected to have the endorsement of the California Department of Fish and Game.

The goals of the Service in its study involvement are, (1) to evaluate the impact of the principal alternative on fish and wildlife resources, their habitat and their utilization by the public, (2) to identify and evaluate the least environmentally damaging alternative, and (3) to recommend methods for preserving, compensating, and enhancing fish and wildlife resources.

In assessing the environmental conditions, as well as the needs and opportunities for fish and wildlife that would exist under the various alternatives analyzed, the Service employed its best professional judgment, using available research reports and literature.

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A. GENERAL DESCRIPTION OF THE PROJECT AREA AND INTRODUCTION

The Los Angeles Drainage Area (LACDA) encompasses approximately 2,000 square miles. Components of the LACDA system include 5 Corps of Engineers' flood control basins, 16 Los Angeles County flood control basins, and 4 natural sections of streams. Except for the lower reaches of the San Gabriel River, all the components of the LACDA system lie in the San Gabriel Mountains or in the floodplain directly below them. Figure 1 shows the LACDA system. Ultimately, all the water flows into the Los Angeles or San Gabriel Rivers and empties into the Pacific Ocean at Long Beach Harbor.

1 7358

The LACDA Review is a study for flood control. Protection of environmental values within the project area is also to be considered. The LACDA system, built between 1940 and 1960, has been described by the Corps of Engineers (Corps) as outmoded and no longer adequate to meet existing conditions. Urban development has resulted in a decrease in groundwater percolation as ground surfaces were altered and became impervious. This resulted in increased surface runoff into the system and heightened the potential for flooding.

B. PROJECT DESCRIPTION

The Corps originally considered 5 alternatives to address the flood control problem: 1) structural modifications to existing structures (drains and channels); 2) re-regulation of the existing reservoirs; 3) re-regulation of and structural modifications to the existing reservoirs; 4) re-regulation of existing structures and construction of new structures; and 5) re-regulation and modifications to existing structures and construction of new structures.

Alternative 1, structural modifications to existing drains and channels, is the selected alternative. This alternative addresses the downstream reach of the Los Angeles - Rio Hondo system. Improvements will begin at the Rio Hondo outlet from Whittier Narrows and extend the entire length of the Rio Hondo Channel. Improvements on the Los Angeles River begin at the confluence with the Rio Hondo Channel and extend to the mouth of the river in Long Beach Harbor. A total of about 23 miles of channel are to be modified.

The objective of the structural improvements is to provide greater flood protection to the urbanized reaches of the Rio

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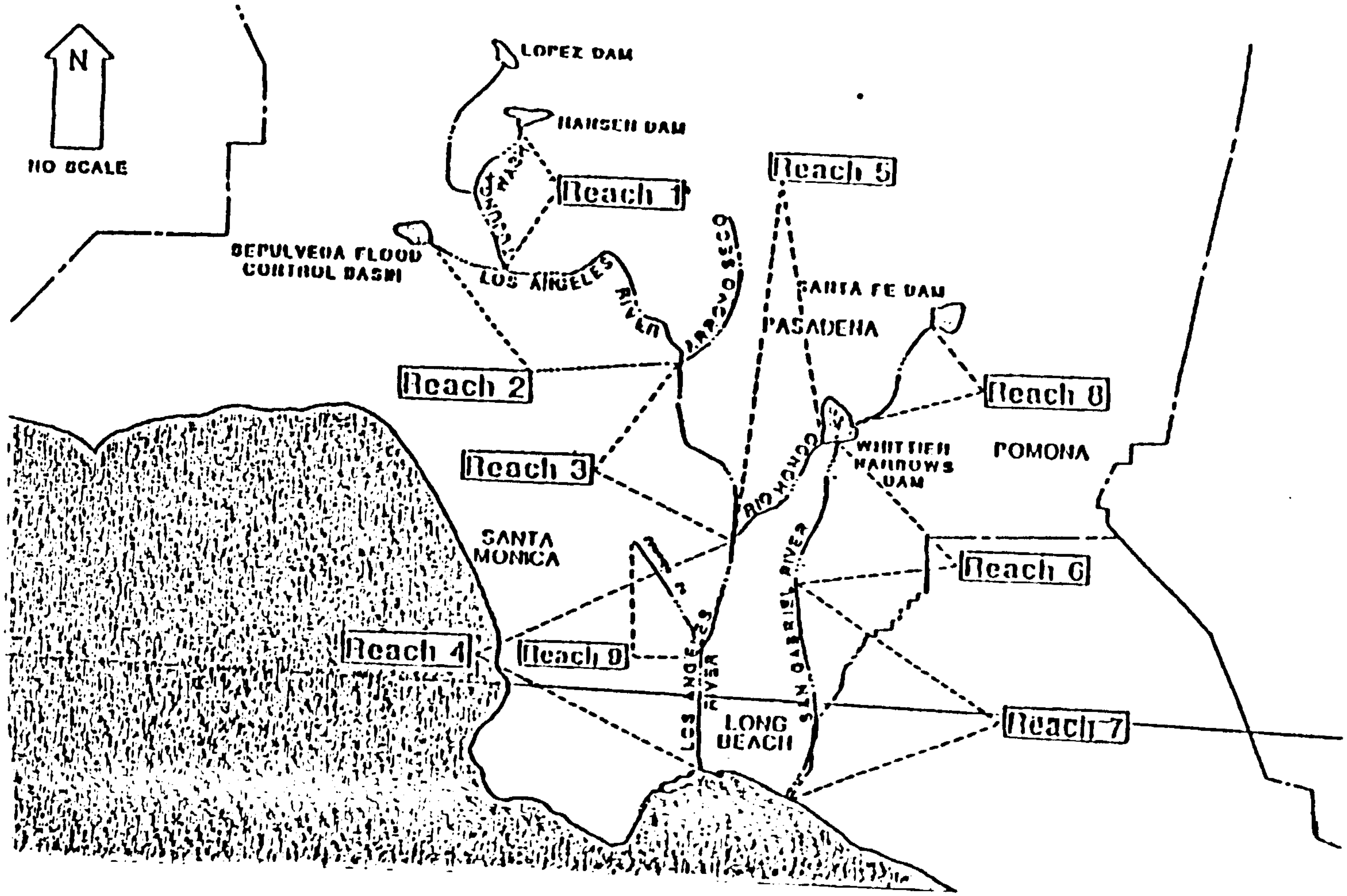

Figure: 1

R0050665

Hondo and lower Los Angeles River. The 133-year level of protection was selected because of its maximum net benefits and the constraints on plan design imposed by the Artesia Freeway overcrossing. Three measures are used individually and in combination to achieve this objective:

1) Vertical reinforced-concrete parapet walls of from 2.0 feet to 8.0 feet in height constructed along the crest of the existing channel levees.

2) Conversion of 6950 feet of concrete trapezoidal to concrete rectangular channel in a reach where parapet walls cannot be raised to the necessary height to provide adequate protection (at and just below the confluence of the Rio Hondo and the Los Angeles River).

3) Raising and modifying bridges which currently are too low to permit 133-year flows to pass underneath them or which have other impacts on the hydraulic characteristics of the channel which make alteration of their design necessary. Twenty-four of forty-one bridges in the project reach will be modified.

4) Armoring of the landward levee slope on both sides of selected reaches (a total of about 2.2 miles) to prevent overflows from eroding the levee.

(PLAN COMPONENTS)

<u>Parapet Walls</u>

Parapet walls will be constructed of one foot thick reinforced concrete. Their height will vary from reach to reach to reflect the changing requirements of the system. Transitions from one reach to another will be accomplished with an instantaneous change in height. In some reaches, where hydraulic analysis indicates wall height would be less than 0.5 feet, no parapet walls will be constructed. The parapet walls will be constructed on the channel side of the existing access road/bicycle trail system to permit continued recreation use along this reach of the river.

The parapet wall system will pass beneath or abut against all bridges. The existing bicycle trails veer channelward and dip into the channel as they pass below many of the bridges. The parapet walls will necessitate that the trails be elevated to the level of the top of the parapet walls to pass over them.

This will be located far enough from the bridge overpasses that the bicycle trail can reconnect with the existing underpass configuration.

Parapet walls would be constructed by connecting the new walls at the immediate junction of the existing channel wall and the asphalt-paved access road and bicycle trail. Walls will be reinforced with 3/4-inch diameter steel dowels sunk nine inches into the existing levee on 4-1/2 foot centers.

Conversion of the Channel to Rectangular Concrete-lined Channel

At the confluence of the Rio Hondo and the Los Angeles River, both parapet walls and the conversion of the channel from trapezoidal to rectangular is required to accommodate flood flows. In this approximately 7,000 foot reach, the anticipated flow of 158,000 ft^3/s is accommodated by converting the existing trapezoidal channel, with a top width of approximately 390 feet, into a rectangular cross-section with a width of 420 feet. In addition to widening the channel approximately 30 feet, parapet walls as high as seven feet will be added to the channel sides.

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This reduces the water surface elevation in the Rio Hondo sufficiently to avoid otherwise necessary modifications to the Union Pacific Railroad bridge.

Bridge Modifications

Twenty-four bridges must be either raised (21), raised and modified (1), modified (1), or moved (1) to permit the design flow to pass underneath the bridge. Only one of these structures has historic value - the railroad bridge near the mouth of the Los Angeles River which will be moved 115 feet downstream but will otherwise not be altered.

Raising of bridges will generally be accomplished in two ways. First, some bridges are suitable for raising using jacks to raise the entire bed while pier extensions are placed beneath them. Some bridges must be demolished and then replaced. The primary criteria for making this decision was the construction of the existing bridge and whether the bridge needed to be raised more than 10 percent of pier height to achieve project objectives. Raising a bridge to a greater height is not considered feasible for structural reasons.

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C. EXISTING CONDITIONS AND FUTURE WITHOUT THE PROJECT

The present environment of the project area consists entirely of concrete-lined channels with access roads and bike trails along one or both sides. No natural habitat exists. It is anticipated that without the project there will be no increase in natural habitats or wildlife values.

D. ANALYSIS OR IMPACTS AND FUTURE WITH THE PROJECT

No fish, wildlife, and habitat impacts are anticipated with the project. Presently there are no natural habitats nor fish and wildlife resources in the project impact area.

E. SUMMARY OF IMPACTS

Due to the fact that there are no fish and wildlife resources nor natural habitats in the project's impact area, there are no ecological impacts.

F. MITIGATION PLAN

Since there are no fish, wildlife, and habitat impacts in the project's impact area, no mitigation is required.

(8)

G. RECOMMENDATIONS FOR THE RECOMMENDED ALTERNATIVE

The Service has no recommendations to offer since there are no ecological values to the existing environment and that the project would not enhance nor degrade the existing environment.

Office Supervisor

Date of Final Report

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APPENDIX H

STATE HISTORIC PRESERVATION OFFICE LETTER

STATE OF CALIFORNIA – THE RESOURCES AGENCY

GEORGE DEUKMEJIAN, Governor

OFFICE OF HISTORIC PRESERVATION
DEPARTMENT OF PARKS AND RECREATION
POST OFFICE BOX 942896
SACRAMENTO, CALIFORNIA 94296-0001
(916) 445-8006

25 October 1989

Reply to: CoE 891010A

Robert S. Joe
Chief, Planning Division
US Army Corps of Engineers
P.O. Box 2711
Los Angeles, California 90053

Re: Flood Control Project Along Compton Creek, Rio Hondo, and Los Angeles Rivers

Dear Mr. Joe:

Thank you for consulting with us under 36 CFR 800.4.

The project as envisioned consists of raising and armoring existing levees along the Rio Hondo and Los Angeles Rivers. This will require raising, or in a few cases moving, 26 bridges.

Some of the bridges have been evaluated under CalTrans' bridge survey, others still require significance evaluations. We suggest you contact Steve Mikesell of Caltrans at (916) 920-7671 concerning bridge evaluations.

Most of the planned levee armoring appears to be taking place along Compton Creek, but little other information is included. Assuming at least some of this area is relatively undisturbed, you should conduct an identification of archaeological resources in areas within the APE likely to yield them.

If you have any questions, please contact Nicholas Del Cioppo, State Archaeologist II, at (916) 322-4419.

Sincerely,

for Kathryn Gualtieri
State Historic Preservation Officer

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1 7 3 5 8 L

R0050673

RESPONSE, CALIFORNIA REGIONAL
WATER QUALITY CONTROL BOARD,
LOS ANGELES
PETITION OF NRDC FOR REVIEW OF
STORMWATER/URBAN RUNOFF DISCHARGE
PERMIT (ORDER NO. 90-079)

START

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R0050674

State of California

Memorandum

To : Ms. Elizabeth Miller Jennings
Senior Staff Counsel, State Board

Date : October 19, 1990

File :

Robert P. Ghirelli

ROBERT P. GHIRELLI, D.Env.
Executive Officer

From : CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD—LOS ANGELES REGION
101 Centre Plaza Drive, Monterey Park, CA 91754-2156
Telephone (213) 266-7500

Subject :

IN THE MATTER OF THE PETITION OF THE NATURAL RESOURCES DEFENSE COUNCIL, INC., FOR REVIEW OF WASTE DISCHARGE REQUIREMENTS STORMWATER/URBAN RUNOFF DISCHARGE ORDER NO. 90-079 FOR LOS ANGELES COUNTY AND CO-PERMITTEES OF THE CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, LOS ANGELES REGION. NPDES PERMIT NO. CA0061654. YOUR FILE NO. A-693.

This memorandum transmits the response of the California Regional Water Quality Control Board, Los Angeles Region, to the petition filed by the Natural Resources Defense Council, Inc., in this matter. The Regional Board's response and exhibits are attached. If you have any questions, please contact Jorge A. Léon, the Regional Board Counsel, at (916) 322-5942, or Xavier Swamikannu of Board staff at (213) 266-7592.

Please note that a current list of interested parties for purposes of mailing notifications is attached.

cc (Response w/ attachments) : Jorge Léon, OCC

(Response w/o attachments) : Joel Reynolds, NRDC
All interested parties

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Los Angeles County Stormwater/Urban Runoff Permit 09/26/90

Interested Parties List

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California Regional Water Quality
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1372

R0050677

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STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

In Re: Petition of Natural Resources Defense Council, Inc., regarding WDR/NPDES Order No. 90-079	REGIONAL BOARD'S RESPONSE TO PETITION FILE No. A-693

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I.

INTRODUCTION

On June 18, 1990, the California Regional Water Quality Control Board, Los Angeles Region (Regional Board) adopted an NPDES permit for Stormwater/Urban Runoff Discharge in Los Angeles County (Order No. 90-079), with the Los Angeles County Department of Public Works as the principal permittee and seventeen municipalities as co-permittees, under the Clean Water Act, Section 402 (p). The permit was the culmination of several months of planning and discussion with the Stormwater Work Group made up of applicants, state and federal representatives, and environmental groups.

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The Regional Board handled the stormwater runoff issue under significant circumstances. First, the EPA's regulations on the subject had not (and still have not) been promulgated, and yet the Regional Board is under a legislative deadline in the Clean Water Act to issue permits for municipal stormwater discharges.

Second, there is a glaring lack of technical data regarding such critical matters as appropriate effluent limitations and control methods, how and where they should be measured, how they can be controlled, what control measures should be applied and where. Despite the lack of applicable EPA regulations and technical information, there was a strong desire among the Stormwater Work Group to develop a permit that will be in place to help control pollutants in stormwater discharges as early as the next rainy season.

The NPDES permit, which is the subject of this petition, enjoys substantial support of several parties, including the eighteen dischargers, several environmental groups[1] notably Heal the Bay, Sierra Club and American Oceans Campaign, as well as the Environmental Protection Agency (EPA.)[2] Despite its shortcomings, the permit represents the Regional Board's best effort, given the circumstances, to establish a programmed approach to deal with a large and complex problem for which there exists sparse guidance. Faced with hard choices, that of issuing no permit and having to go through another rainy season with <u>no controls whatsoever</u>, or issuing a permit which, despite its imperfections, attempts to reduce pollutants in stormwater discharges in a systematic manner,

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1. See Heal the Bay's and American Oceans Campaign's letters of June 18, 1990, to Board staff as well as 'Rainstorms and Ocean Pollution' in Sierra Club's March-April, 1990, issue of Waste Watchers.

2. See letter dated February 28, 1990, from Keith A. Takata, Acting Director, Water Management Division, EPA, to Dr. Robert P. Ghirelli, Executive Officer, Regional Board.

the Regional Board elected the active approach that will make substantial inroads in mitigating this problem.

II.

RESPONSES TO SPECIFIC CONCERNS

1. The Natural Resources Defense Council (NRDC) asserts that the permit fails to impose enforceable standards.

The Regional Board staff agrees that some form of effluent limitations or guidelines will be necessary <u>eventually</u> to ensure that water quality objectives are being met. To this end, the permit provides two surrogate water quality parameters as guidance standards for early action control.[3] The significance is again recognized in Finding 19 by the statement, "water quality objectives will be developed by Board staff, when sufficient information becomes available.[4]

Some Water Quality criteria presently exist, such as the California Ocean Plan[5] standards. However, staff believes that such criteria are inappropriate and ill-suited for translation to stormwater quality criteria or transposition to stormwater

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3. See Waste Discharge Requirements, Stormwater/Urban Runoff Discharge for Los Angeles County and Co-Permittees, Order No. 90-079, NPDES No. CA0061654 (Permit), p. 8.

4. <u>Ibid.</u> Permit, p. 5,6.

5. California Ocean Plan, 1990 (Ocean Plan). State Water Resources Control Board. 23 pp.

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discharge standards. For example, effluent quality requirements set forth in the California Ocean Plan such as "monthly averages, weekly averages, 6-month median, daily maximum, and instantaneous maximum" were developed for non-stormwater runoff applications and cannot be readily translated into criteria for stormwater discharges.[6] There is general agreement on the characteristics of stormwater runoff. Storm water is an intermittent pollutant source representing shock loadings, short in duration, and highly variable in impacts on receiving waters. These characteristics defy the application of traditional water quality criteria to storm water.[7]

Furthermore, water quality objectives cannot be enforced without established points of compliance. The State Water Resources Control Board is currently in the process of adopting regulations to designate "mixing zones" in order to define the points of application of water quality objectives.[8] A mixing zone is a certain volume of receiving water allocated for mixing with waste discharge and within which parameter values greater than water quality objectives are not considered to be violations of requirements. However, for stormwater discharges into rivers and

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6. Ibid. Ocean Plan. Tables A and B.

7. See 'State Perspectives on Water Quality Criteria', E. H. Livingston, In, Design of Urban Runoff Quality Controls, L.A. Roesner, B. Urbonas, and M.B. Sonnen, editors, pp 49-67. ASCE, New York, 1989.

8. Refer to Chapter 3. Functional Equivalent Document: Development of the Water Quality Control Plans for : 1. Inland Surface Waters of California, 2. Enclosed Bays and Estuaries of California. August 6, 1990. Fifth Draft. State Water Resources Control Board.

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streams, the diversity of receiving waters makes a single mixing zone strategy infeasible. Without further guidance on how to determine points of application of water quality standards and points of compliance for stormwater discharges, any numerical limit set will be confusing and futile, especially when the storm drain system includes major waterways which have been modified to facilitate the movement of stormwater, as is the case in Los Angeles County.

In order to put the issues facing the Regional Board into perspective, it is important to note that the storm drainage system in Los Angeles County is designed with several thousand outfalls[9] to reduce the threat of potential flooding from stormwater flows. Such flows are often intermittent and characterized by very high flow rates occurring over short intervals of time. A single storm event with a recurrence interval of less than 2 years (rainfall intensity-duration probability >98%) may discharge as much as five billion gallons to Los Angeles coastal waters over a 48-hour period through the complex system of storm drains. The maximum discharge rate for such a storm may be as much as 8,480 cubic feet per second (cfs) compared to a low flow rate of less than 95 cfs.[10] The pollutants transported in the storm water derive from runoff that drains over lands used for a wide variety of activities. Typical

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9. John Mitchell, Chief, Water Quality Section, Department of Public Works, County of Los Angeles, estimates that there exist more than 5,000 storm drain outfalls that are owned and operated by the County agency alone.

10. Stormwater Runoff in Los Angeles and Ventura Counties. H. Schaefer and R. Gossett, 1988. SCCWRP Contribution C292. 86pp.

pollutant concentrations in storm water in Los Angeles County tend to range over three orders of magnitude during the course of a storm event.[11]

With the present limited information available to the Regional Board staff, it is virtually impossible to establish technically appropriate and enforceable effluent limits. Were the Regional Board staff to attempt to set effluent limits at this time, such limits would be highly vulnerable to challenge as arbitrary, and the exercise would undermine the permittees' efforts to reduce stormwater pollution through a comprehensive stormwater management program.

California Water Code Section 13000 declares that the Legislative Policy is, in part, "... activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible". The incorporation in the permit of inappropriate or burdensome standards is inimical to this policy, because it would defeat the attainment of the highest water quality that is reasonable under the circumstances.

11. Ibid. See Appendix

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2. The Petitioner argues that the permit fails to require that the Dischargers adopt discharge controls to the Maximum Extent Practicable.

The NRDC cites the National Urban Runoff Program (NURP) conducted by EPA between 1978 and 1982. However, that program evaluated only a limited number of techniques, and the effectiveness of control methods tested tended to vary with the characteristics of drainage basins, patterns of pollutant loadings, and multiple site-specific variables.[12] Other subsequently published lists of control measures suitable for stormwater quality management recommend approaches which target available resources and prioritize control programs to site specific conditions.[13] An a priori determination and identification of maximally 'effective management practices' cannot be performed without more complete information on business activities, land use patterns, and other factors that contribute to stormwater contamination within subject drainage areas. Some of this information currently exists but is not in a readily usable form.

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12. For a summary of the control effectiveness of methods tested at the local level in the NURP study, see, Final Report of the Nationwide Urban Runoff Program, Water Planning Div., USEPA, Washington, D.C., 1983. 9-11 - 9-18.

13. See, 'Urban Targeting and BMP Selection: An Information and Guidance Manual for State NPS Program Staff Engineers and Managers', 1989, USEPA, Chicago, IL, No. 68-C8-0034, and 'Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs', T.R. Schueler, 1987, Metropolitan Washington Council of Governments.

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As an example, catch basin cleaning[14] which NRDC cites as an important management practice, may reduce the toxic loading of runoff, but there is no hard evidence to support the view that it is an <u>effective</u> management practice to reduce toxic contamination of storm water[15]. Catch basin cleaning tends to remove visible debris and floatable objects which represent more of an aesthetic problem rather than one of toxicity. Any attempt by Regional Board staff to prescribe stormwater pollution control measures, in the absence of a clear understanding of pollutant sources and site specific characteristics of drainage areas, will frustrate permittees' ability to optimize the use of finite resources in effective management of stormwater pollution.

Board staff will be able to better evaluate the suitability of control measures to be proposed per permit requirements, once studies currently underway have been

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14. NRDC cites catch-basin cleaning as an important management practice that should have been prescribed by the permit. See NRDC's Petition for Review to the State Water Resources Control Board, Pgs. 7 and 8.

15. The City of Los Angeles has proposed to study the nature of catch-basin debris. Sediment analysis will be included in order to evalute pollutant concentrations. Phil Richardson, Division Engineer, Stormwater Division, City of Los Angeles, in an address to the Santa Monica Bay Restoration Project's Management Committee Storm Drain Committee on October 3, 1990.

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completed,[16] and relevant information requested of permittees is submitted.

Additionally, the Regional Board staff is concerned that premature prescriptions may impede the creation of alternative solutions to non-point source pollution problems. For example, the City of Santa Monica is addressing the catch basin issue by painting sign markings and installing covers over catch basins during the dry months. This measure will likely reduce the accumulation of catch-basin debris. The covers will be removed before the onset of the rainy season[17]. Such measures would achieve the same ends as the suggested increased frequency of catch basin cleaning.

3. The Petition asserts that the permit fails to impose a three-year timeline for compliance.

The Clean Water Act provides that stormwater permits shall require compliance with the Act and with regulations to be

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16. A State Best Management Practices Manual is under preparation by the statewide Stormwater Quality Task Force. In addition, the Santa Monica Bay Restoration Project has contracted the University of California at Los Angeles, to develop an early action Best Management Practices program for the Santa Monica Bay watershed under its 'Assessment of Non-Point Sources of Contaminants to Santa Monica Bay'. This report is due to become available in early June, 1991.

17. Stan Scholl, Director, Department of General Services, City of Santa Monica, In a presentation to members of the Santa Monica Bay Restoration Project's Management Committee Storm Drain Committee on August 22, 1990. The Storm Drain Inlet Cover and Signage Program was inaugurated on September 21, 1990.

enacted by EPA within three years following issuance of the permit. The essential elements defining compliance for stormwater discharges are not provided in the Clean Water Act. Rather, the EPA and the States were left to decide on how such discharges ought to be regulated. The permit was issued without benefit of interpretive regulations and without a clear indication of when those regulations might be expected.

The Regional Board interprets "compliance" as instituting a viable stormwater management program to achieve a reduction in stormwater pollution of water bodies in Los Angeles County to the maximum extent practicable. The permit, which, to the Regional Board staff's knowledge, is one of the first of its kind in the nation, contains phased requirements and a schedule for implementation of control activities, which will ensure compliance within three years. Los Angeles County encompasses an area of 4,083 square miles with about 40% of that area consisting of industrial, commercial, and residential sites, and lands under development. The networking storm drain system within this area traverses the jurisdiction of 87 different local governmental entities (the County government and separate cities) which will all eventually be co-permittees. The population that is served by the system numbers more than 8.7 million[18], roughly 35 times the population contemplated in the Clean Water Act. The complexity and enormity of the area subject to the permit necessitates a flexible and

18. Population total based on preliminary estimates by U.S. Department of Commerce, Bureau of Census', 1990 Census.

cooperatively-developed approach towards managing stormwater pollution to achieve the objectives of the Clean Water Act.

III.

CONCLUSION

The permit attempts to come to terms with a massive and complex problem. It represents a voluntary and cooperative approach by the parties to reduce stormwater pollution loadings. More stringent alternatives may realistically be expected to lead to delay, confusion, unenforceability, and litigation, with the practical consequence of no reduction in stormwater pollution loadings. The Regional Board believes that, given the unique characteristics of the area being served by Los Angeles County and co-permittees, and given the likelihood of success over available alternatives, the permit should be upheld by the State Board.

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WASTE DISCHARGE REQUIREMENTS, STORMWATER/URBAN RUNOFF DISCHARGE FOR LOS ANGELES COUNTY AND CO-PERMITTEES (ORDER NO. 90-079)

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STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

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ORDER No. 90-079

NPDES NO. CA0061654 (CI 6948)

WASTE DISCHARGE REQUIREMENTS STORMWATER/URBAN RUNOFF DISCHARGE for LOS ANGELES COUNTY and CO-PERMITTEES

The California Regional Water Quality Control Board, Los Angeles, (Regional Board) finds :

1. The County of Los Angeles, in cooperation with the following cities : Agoura Hills, Beverly Hills, Culver City, El Segundo, Hermosa Beach, Inglewood, Los Angeles, Manhattan Beach, Rancho Palos Verdes, Redondo Beach, Rolling Hills Estates, Rolling Hills, Santa Monica, Torrance, West Hollywood, and Westlake Village, has submitted a report of waste discharge (NPDES permit application) dated March 15, 1990 for issuance of waste discharge requirements for the County of Los Angeles and other cities tributary to Los Angeles County (excluding Antelope Valley) under the National Pollutant Discharge Elimination System. (NPDES Permit No. CA0061654).

2. The discharges consist of surface runoff generated from various land uses in all the hydrologic drainage basins which discharge into water courses flowing into water bodies in Los Angeles County. The quality of these discharges varies considerably and is affected by land use, basin hydrology and geology, season, and the frequency and duration of storm events. The constituents of concern and significance in these discharges are: total and fecal coliform and enterococci bacteria, total suspended solids, biochemical oxygen demand, oil and grease, heavy metals, nutrients, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, pesticides and herbicides, and petroleum hydrocarbons.

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3. The objective of this permit is to develop a timely, comprehensive, and cost-effective stormwater pollution control program to minimize pollutants in urban runoff/stormwater discharges to water bodies in Los Angeles County.

4. Due to the complexity and networking of drainage facilities within and tributary to Los Angeles County, the county and adjacent areas discharging storm water into Los Angeles County are divided and prioritized into five drainage basins for the implementation of the permit. The owners/operators of all facilities impacting stormwater quality will be ultimately a party to these waste discharge requirements. The County of Los Angeles together with the cities identified above, the initial parties filing for the system-wide permit, are 'Permittees', with the County of Los Angeles as the 'Principal Permittee' and the rest as 'Co-Permittees'. All other cities and recognized entities such as Caltrans, college/university campuses, hospitals, parks, agricultural areas, real estate developments and waste disposal facilities identified in this Order, are designated 'Co-Participants'. A 'Co-Participant' will be a 'Co-Permittee' upon becoming an active party to the permit.

Attachments 1 and 2 show, respectively, the list of cities and a partial list of entities designated as Co-Participants for this permit. The list of entities will be revised as necessary.

5. The County of Los Angeles, as the 'Principal Permittee', will obtain the cooperation of 'Co-Participants' to become 'Co-Permittees'. The Regional Board has the discretion and authority to require non-cooperating cities and/or entities to become 'Co-Permittees' or obtain individual stormwater discharge permits, pursuant to 40 CFR 122.26 (a).

6. Los Angeles County as the 'Principal Permittee' is the permit coordinator responsible for general administration of this Order, and coordinating cooperation by 'Co-Permittees', including but not limited to the implementation of local self-monitoring programs and Best Management Practices, and the preparation and submittal of reports required by this Order.

7. Los Angeles County obtains its authority to :

- control pollutants in stormwater discharge
- prohibit illegal discharges and control spills
- require compliance and carry out inspections

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of drainage facilities in the County of Los Angeles from the Los Angeles County Flood Control Act and various county ordinances which address industrial wastes and waste discharges within the unincorporated areas of Los Angeles County and contract cities. 'Co-Permittees' with the status of incorporated cities have various forms of legal authority in place, such as charters, State Code provisions for General Law cities, city ordinances and applicable portions of Municipal Codes and the State Water Code, to regulate stormwater/urban runoff discharges.

8. The division and prioritization of Los Angeles County and adjacent areas into five drainage basins for program implementation are based on hydrological characteristics of the watersheds, perceived importance and beneficial uses of water bodies, and the existence of an adequate infrastructure for program implementation. The five drainage basins are :

I	:	Santa Monica Bay Drainage Basin
II	:	Upstream Los Angeles River Drainage Basin, to and including Sycamore Canyon Channel (San Fernando Valley);
III	:	Upper San Gabriel River (San Gabriel Valley) Drainage Basin.
IV	:	Lower Los Angeles River Drainage Basin
V	:	Lower San Gabriel River Drainage Basin; and Santa Clarita Valley Basin.

Attachment 3 shows a map of Los Angeles County with the boundary delineations of the five drainage basins.

Attachment 4 shows Co-Participant cities in Los Angeles County (and their respective populations).

[Note: Detailed maps of the Los Angeles County storm drain system with boundary delineations of drainage basins are available for review at the Regional Board Office.]

9. A number of studies on stormwater/urban runoff pollution in the permit areas has been conducted by agencies such as the City of Los Angeles, the Southern California Coastal Water Research Project and the Southern California Association of Governments. These studies indicate stormwater/urban runoff contributes significantly to the deterioration of the quality of water bodies in Los Angeles County.

The University of California at Los Angeles, under the sponsorship of the Santa Monica Bay Restoration Project, is currently compiling and summarizing data and information on stormwater/urban runoff discharges for the Santa Monica Bay watershed.

10. The Los Angeles County Department of Public Works has an active surface water quality monitoring program in the permit area, comprising twenty-eight monitoring stations located at principal storm drains and water conservation facilities. The Surface Water Quality Monitoring Program comprises the collection and analysis of dry weather water samples for general minerals, pesticides, total petroleum hydrocarbons, heavy metals and bacteria (total and fecal coliform, KF streptococci and enterococci). Volatile organic constituents are tested semi-annually at selected stations. Stormwater runoff is monitored three to four times annually at twenty-one stations for minerals, pesticides, heavy metals (total and dissolved), bacteria, total and organic suspended solids, oil and grease, biochemical oxygen demand, total organic carbon and volatile organics.

11. The Los Angeles County Department of Public Works and some cities have on-going activities that reduce stormwater/urban runoff pollutant loads. These activities include periodic catch-basin cleaning and street sweeping, public information on proper disposal of household hazardous waste, and emergency responses to reports of illegal dumping, illicit disposal, illegal connections, and industrial waste spills. The Los Angeles County Department of Public Works also participates and coordinates action with local, State, and Federal agencies responding to spills and illegal dumping reports that threaten surface waters.

12. The Regional Board currently regulates industrial process and point source non-process wastewater and stormwater discharges to storm drain systems through NPDES permits. Point source discharges including stormwater will continue to be regulated by the Regional Board. An information system will be developed and maintained to update pollutant loadings to designated

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drainage facilities and water bodies from permitted point source discharges.

13. The State Water Resources Control Board (State Board) adopted a Water Quality Control Policy for the Enclosed Bays and Estuaries of California on May 16, 1974. The policy provides that the discharge of industrial process waters to enclosed bays and estuaries shall be prohibited. Storm water and urban runoff are not considered industrial process waters for the purpose of that policy.

14. The State Board adopted a revised Water Quality Control Plan for Ocean waters of California (Ocean Plan) on March 22, 1990, which amended the Plan adopted on September 22, 1988. The Plan contains water quality objectives for the coastal waters of California.

15. The Regional Board adopted a revised Water Quality Control Plan for the Los Angeles River Basin (Basin Plan) on November 27, 1978. The Basin Plan incorporates the Ocean Plan, and contains water quality objectives for the basin, including the beneficial uses of water bodies.

16. The beneficial uses of water bodies in Los Angeles County and their tributary streams include contact water recreation, non-contact water recreation, wildlife habitat, preservation of rare and endangered species, marine habitat, estuarine habitat, fish migration, fish spawning, industrial service and process supply, agricultural water supply, shellfish harvesting, navigation, commercial and sport fishing, and groundwater recharge.

17. Section 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act of 1972 to require the Environmental Protection Agency (EPA) to establish regulations for stormwater/urban runoff discharge under the National Pollutant Discharge Elimination System (NPDES).

18. The Federal Clean Water Act allows EPA to delegate its NPDES permitting authority to States with an approved environmental regulatory program. The State of California is one of the delegated States. The Porter-Cologne Act (State Water Code) authorizes the State Board, through its Regional Boards, to regulate and control the discharge of pollutants into waters of the state and tributaries thereto.

19. Although Water Code Section 13263 (a) requires that waste discharge requirements issued by Regional Boards shall include provisions to implement water quality based objectives, numerical water quality standards

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are not provided in this Order. Information is not available to establish appropriate numerical limits, and determine locations where permittees shall be made accountable. The requirements in this Order will provide the necessary information while concurrently achieving reductions in pollutant loads to water bodies from stormwater/urban runoff discharges. Numerical water quality objectives will be developed by Board staff for consideration in the permit renewal process and utilized for the evaluation of Best Management Practices.

20. Due to the significance of the Los Angeles County Stormwater/Urban Runoff Program, the Regional Board, in recognition of the need for public involvement and participation in the development and implementation of an effective program will conduct at a minimum an annual workshop, prior to approving plans submitted by Permittees, to solicit comments and to inform the public of the progress of the program. Comments presented will be referred to Los Angeles County for response.

21. Stormwater/urban runoff discharges to drainage facilities that cross County boundaries and Regional Board jurisdictions, and which are regulated under NPDES permits, are the regulatory responsibility of those agencies issuing the permits.

22. The issuance of waste discharge requirements for this discharge is exempt from the provisions of the California Environmental Quality Act (CEQA); Chapter 3 (commencing with Section 21100) of Division 13 of the Public Resources Code in accordance with Water Code Section 13389.

The Board has notified the Permittees and interested agencies and persons of its intent to issue waste discharge requirements for this discharge and has provided them with an opportunity to submit their written views and recommendations.

The Board, in a public hearing, heard and considered all comments pertaining to the discharge and to the tentative requirements.

This Order shall serve as a National Pollutant Discharge Elimination System permit pursuant to Section 402 of the Federal Clean Water Act, or amendments thereto, and shall take effect at the end of ten days from the date of its adoption provided the Regional Administrator, EPA, has no objections.

IT IS HEREBY ORDERED that the Permittees, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder,

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and the provisions of the Clean Water Act as amended and regulations and guidelines adopted thereunder, shall comply with the following:

1.0 COMPLIANCE

1.1 The Permittees and Co-Permittees shall comply with the requirements contained in this Order according to the following schedule:

	DRAINAGE BASIN	STARTING DATE FOR COMPLIANCE WITH REQUIREMENTS
I.	Santa Monica Bay	July 1, 1990
II.	Upper Los Angeles River (San Fernando Valley)	July 1, 1992
III.	Upper San Gabriel River (San Gabriel Valley)	July 1, 1992
IV.	Lower Los Angeles River	July 1, 1993
V.	Lower San Gabriel River and Santa Clarita Valley	July 1, 1993

2.0 REQUIREMENTS - YEAR 1

2.1 For each Drainage Basin, prepare and submit to the Regional Board within 12 months of the starting date for compliance, according to the schedule under 1.1:

2.1.1 Water quality data and flow data from 1980 to the present to facilitate identification of sources of pollutants present in discharges from the prioritized drainage basin. "Drainage areas" in the drainage basin are to be reported and the "drainage areas" associated with each drainage basin clearly identified.

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For purposes of stormwater/urban runoff, a "drainage area" is defined as a subdivision of a drainage basin which is unique in land use patterns, and pollutant characteristics and loadings.

2.1.2 The 90th percentile value for the water quality parameters, (i) Total Suspended Solids (TSS), and (ii) Oil and Grease, from the data set of all wet weather samples collected from 1980 to the present. These data will be used to establish guidance for early action control of stormwater pollution.

The 90th percentile for a given water quality parameter is defined as the concentration value exceeded in ten percent of the samples of the reference data set.

2.1.3 Additional information of a qualitative nature that would contribute to isolating and identifying sources of problems. Such information should include but not be limited to visual observations of factors exacerbating stormwater contamination, principal land use classifications and Standard Industrial Code (SIC) categories of facilities in "drainage areas", and a description of soils, dumps, landfills, waste disposal sites and Resource Conservation and Recovery Act (RCRA) facilities associated with each area.

2.1.4 Monthly precipitation data from rain gauge stations, relevant to the drainage basin, for the years 1980 to the present, and an estimate of the area of impervious surfaces (including paved areas and building roofs) within each "drainage area".

2.1.5 Documentation of existing procedures to detect and address illegal discharges and illicit disposal practices.

2.1.6 Documentation of existing practices and improvement plans to control pollutants in stormwater/urban runoff from construction sites.

2.1.7 Documentation of existing stormwater/urban runoff management practices and existing Best Management Practices (BMPs) for the control of pollutants in discharges from residential, commercial and industrial areas.

For purposes of this permit, a Best Management Practice is defined as a stormwater quality management practice that has been demonstrated to reduce stormwater/urban runoff constituents of concern in studies in the United States and elsewhere, or a stormwater/urban runoff quality management practice that can significantly control stormwater/urban runoff pollution.

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2.1.8 Plan with schedule of implementation, for approval by the Executive Officer, of early action BMPs.

For purposes of this permit, an early action BMP is defined as an existing stormwater/urban runoff quality management practice that is optimized to the maximum extent practicable (MEP) in efficiency for the control of stormwater runoff pollution, such as improving the frequency of storm drain catchment basin cleaning or the stricter enforcement of existing regulations, or a BMP that is not specific to stormwater/urban runoff constituents or "drainage area" in its constituent removal capacity and can be applied on a system-wide basis, such as public outreach and educational programs.

For purposes of this permit, maximum extent practicable means to the maximum extent possible, taking into account equitable considerations of synergistic, additive and competing factors, including but not limited to gravity of the problem, fiscal feasibility, public health risks, societal concern, and social benefits.

The Principal-Permittee, in the submittal of plans and schedules to the Executive Officer, shall demonstrate that public input has been obtained.

For purposes of this permit, public input is demonstrated by, (i) disseminating the notice of availability of plans for review and comment, to the public at large, environmental groups, Federal, State and local officials and other interested parties, and (ii) addressing concerns expressed by the public.

The Board may modify the plans in response to public input received at the Board during its comment/review period. Permittees are required to implement the original or modified plan on approval by the Executive Officer.

2.1.9 A workplan for the development of a stormwater/urban runoff monitoring program, for approval by the Executive Officer, to include but not be limited to the following information :

- listing of constituents and parameters to be monitored and the rationale for their choice.
- listing of monitoring locations and the rationale for their choice.
- listing of sampling methodology of choice and frequency of sampling for both wet weather and dry weather flow.
- supplementary information that influences the design of the monitoring plan.

The Principal-Permittee, in the submittal of the workplan to the Executive Officer, shall demonstrate that public input has been obtained.

2.1.10 Documentation that each Permittee, individually and/or jointly, through the establishment of a joint powers authority or a stormwater utility, possesses adequate legal authority to operate and manage stormwater/urban runoff quality management programs, and/or plans to obtain the necessary legal authority to regulate illegal discharges and illicit disposal practices into storm drains, and to prosecute violators.

3.0 REQUIREMENTS - YEAR 2

3.1 For each Drainage Basin, prepare and submit to the Regional Board, for approval by the Executive Officer, within 24 months of the starting date of compliance, according to the schedule under 1.1:

3.1.1 A monitoring program based on the approved workplan. This program shall be designed to:

- detect accurately the constituents and parameters of concern, in discharges indicated in the workplan, and to identify their possible sources.
- identify illegal dischargers and/or locations of illicit disposal practices.

Monitoring reports for this program shall be submitted according to the format and frequency to be approved by the Executive Officer.

3.1.2 Plan with schedule of implementation for additional BMPs, judged appropriate for each city or drainage basin, to control pollutants from residential, commercial and industrial sites to the maximum extent practicable.

Both structural and non-structural BMP measures are to be evaluated at the MEP standard. Examples of non-structural measures include catch basin cleaning, street sweeping and public education, while controls such as detention/retention basins, first flush diversions, grassy swales and porous pavements are examples of structural measures.

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3.1.3 Plan with schedule of implementation of procedures to detect and eliminate illegal discharges and illicit disposal practices.

3.1.4 Plan with schedule of implementation of measures to control pollutants in surface runoff from construction sites.

The Principal Permittee, in the submittal of plans and schedules (items 3.1.2, 3.1.3, and 3.1.4) to the Executive Officer shall demonstrate that public input has been obtained. The Board may modify the plans in response to public input received at the Board during its comment/review period. Permittees are required to implement the original or modified plans on approval by the Executive Officer.

3.2 Evidence of satisfactory progress of implementation of plan and schedule for early action BMPs.

3.3 Evidence of all requisite legal authority to regulate illegal discharges and illicit disposal practices to drainage facilities, and to prosecute violators.

4.0 REQUIREMENTS - YEAR 3

4.1 For each Drainage Basin, submit to the Regional Board, within 36 months of the starting date of compliance, according to the schedule under 1.1, the following:

4.1.1 Evidence of satisfactory progress of implementation of plan and schedule for early action BMPs and additional BMPs.

4.1.2 Evidence of implementation and progress of procedures to detect and eliminate illegal discharges and eliminate illicit disposal practices.

4.1.3 Evidence of implementation and progress of measures to control pollutants in surface runoff from construction sites.

5.0 EXPIRATION AND RENEWAL

5.1 This Order expires on June 18, 1995.

5.2 The Permittees shall file a report of waste discharge (ROWD), not later than 180 days before the expiration date, as application for reissuance of waste discharge requirements. This report of waste discharge shall include but not be limited to the following:

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5.2.1 Summary of the results of the monitoring program.

5.2.2 Summary of BMPs implemented and evaluations of their effectiveness.

5.2.3 Summary of procedures implemented to detect illegal discharges and illicit disposal practices and an evaluation of their effectiveness.

5.2.4 Summary of measures implemented to control pollutants in surface runoff from construction sites and an evaluation of their effectiveness.

5.2.5 Evaluation of the need for additional BMPs, source control, and/or structural control measures.

5.2.6 Proposed plan of stormwater/urban runoff quality management activities that will be undertaken during the term of the next permit.

I, Robert P. Ghirelli, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an order adopted by the California Regional Water Quality Control Board, Los Angeles Region, on June 18, 1990.

ROBERT P. GHIRELLI, D.Env.
Executive Officer

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ATTACHMENT I

LIST OF CO-PARTICIPANT CITIES

Agoura Hills
Arcadia
Avalon
Baldwin Park
Bellflower
Beverly Hills
Burbank
Cerritos
Commerce
Covina
Culver City
Downey
El Monte
Gardena
Glendora
Hawthorne
Hidden Hills
Industry
Irwindale
La Habra Heights
La Mirada
La Verne
Lawndale
Long Beach
Lynwood
Maywood
Montebello
Norwalk
Palos Verdes Estates
Pasadena
Pomona
Redondo Beach
Rolling Hills Estates
San Dimas
San Gabriel
Santa Clarita
Sant Monica
Signal Hill
South Gate
Temple City
Torrance
Walnut
West Hollywood
Whittier

Alhambra
Artesia
Azusa
Bell
Bell Gardens
Bradbury
Carson
Claremont
Compton
Cudahy
Diamond Bar
Duarte
El Segundo
Glendale
Hawaiian Gardens
Hermosa Beach
Huntington Park
Inglewood
La Canada Flintridge
Lakewood
La Puente
Lancaster
Lomita
Los Angeles
Manhattan Beach
Monrovia
Monterey Park
Palmdale
Paramount
Pico Rivera
Rancho Palos Verdes
Rolling Hills
Rosemead
San Fernando
San Marino
Santa Fe Springs
Sierra Madre
South El Monte
South Pasadena
Thousand Oaks
Vernon
West Covina
Westlake Village

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ATTACHMENT 2

LIST OF ENTITIES (PARTIAL LIST)

Caltrans
Army Corps of Engineers
Railroad Rights of Way
Federal Hospitals
The State University System
University of California Campuses
National Forest Service
Federal Military Facilities

[this list will be updated during the permit process to indicate actual identity of agencies and entities.]

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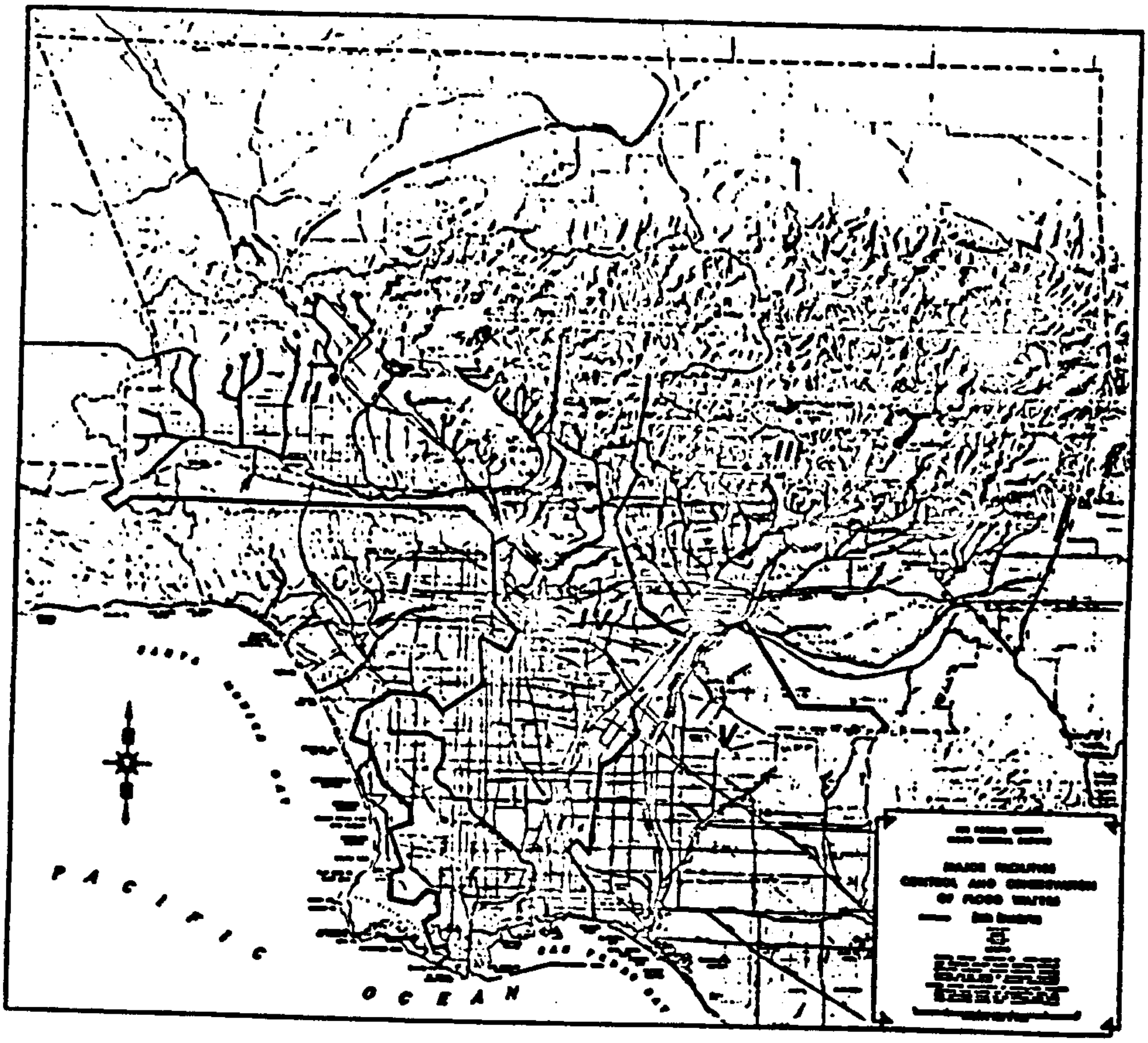
ATTACHMENT 3

DELINEATIONS OF DRAINAGE BASIN BOUNDARIES FOR LOS ANGELES COUNTY



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ATTACHMENT 2

CITIES (AND POPULATIONS) TRIBUTARY TO DRAINAGE BASINS

Santa Monica Bay

Agoura Hills	19,000	Rancho Palos Verdes	46,000
Beverly Hills	34,000	Redondo Beach	64,700
Culver City	40,950	Rolling Hills	2,090
El Segundo	15,750	Rolling Hills Estates	7,875
Hermosa Beach	19,750	Santa Monica	96,500
Inglewood	102,300	Thousand Oaks	104,400
Los Angeles	3,400,500	Torrance	142,200
Manhattan Beach	35,300	West Hollywood	38,400
Westlake Village	8,025	Palos Verdes Estates	15,000

Upper Los Angeles River

Burbank	93,800	Glendale	166,100
Hidden Hills	1,950	Los Angeles	3,310,057
San Fernando	20,700		

Upper San Gabriel River

Alhambra	74,900	Arcadia	49,100
Azusa	38,250	Baldwin Park	63,300
Bradbury	930	Claremont	36,550
Covina	43,250	Diamond Bar	74,120
Duarte	21,350	El Monte	95,400
Glendora	47,400	Industry	370
Irwindale	1,230	La Canada Flintridge	20,800
La Habra Heights	5,450	La Puente	33,550
La Verne	30,500	Monrovia	34,000
Montebello	58,200	Monterey Park	64,600
Pasadena	132,200	Pomona	119,000
Rosemead	47,700	San Dimas	32,500
San Gabriel	34,900	San Marino	13,800
Sierra Madre	11,250	South El Monte	18,700
South Pasadena	24,500	Temple City	31,900
Walnut	26,400	West Covina	94,200

(CONTINUED)

Lower Los Angeles River

Alhambra	74,900	Bell	28,250
Bell Gardens	38,300	Carson	88,800
Commerce	11,700	Compton	93,000
Cudahy	20,700	Downey	86,800
El Segundo	15,750	Gardena	50,900
Glendale	166,100	Hawthorne	67,400
Huntington Park	51,200	Inglewood	102,300
La Canada Flintridge	20,800	Lakewood	76,500
Lawndale	27,300	Lomita	20,300
Los Angeles	3,400,500	Lynwood	53,700
Maywood	24,650	Montebello	58,200
Monterey Park	64,600	Palos Verdes Estates	15,000
Paramount	44,450	Pasadena	132,200
Pico Rivera	57,300	Rancho Palos Verdes	46,000
Redondo Beach	64,700	Rolling Hills	2,090
Rolling Hills Estates	7,875	Signal Hill	8,150
South Gate	79,200	South Pasadena	24,500
Torrance	142,200	Vernon	80

Lower San Gabriel River

Artesia	14,950	Bellflower	60,900
Cerritos	58,400	Downey	86,800
Hawaiian Gardens	12,350	La Habra Heights	5,450
Lakewood	76,500	La Mirada	42,600
Long Beach	419,800	Norwalk	90,800
Paramount	44,450	Pico Rivera	57,300
Santa Clarita	115,700	Santa Fe Springs	16,400
Signal Hill	8,150	Whittier	74,100

Population estimates are taken from Report 89 E-1 published by the State of California Department of Finance.

The cities of Avalon (Pop: 2,490), Lancaster (Pop: 82,200), and Palmdale (Pop: 45,850) which are within Los Angeles County are not part of this permit.

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WRITTEN COMMENTS IN SUPPORT OF WASTE DISCHARGE REQUIREMENTS

Heal the Bay
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TELEPHONE 213 399 1146

VOL 12

Los Angeles Regional Water Quality Control Board
101 Centre Plaza Drive
Monterey Park, CA. 91754-2156

Dear Board Members, June 18, 1990

First of all, I would like to commend the staff of the Regional Board, the Santa Monica Bay Restoration Project, the L.A. County Department of Public Works and the 16 co-permittee cities in the Santa Monica Bay watershed for developing and agreeing to the draft urban runoff discharge permit in record time. Heal the Bay strongly agrees that the development of an NPDES permit separate from the EPA final regulations was the most prudent course of action to follow.

However, we do feel that the permit has the following shortcomings:

1) There are no enforcement provisions spelled out in the permit. These comments refer to Sections 2.1.8 and 3.1.2 (early action BMPs), 2.1.9 and 3.1.1 (monitoring program requirements and implementation), 2.1.10 and 3.3 (development of enforcement authority of permittees and co-permittees), 3.1.3 and 4.1.2 (illegal discharge and illicit disposal control programs and implementation) and 3.1.4 and 4.1.3 (control of runoff from construction and implementation). We understand that all NPDES permits are enforceable under the Clean Water Act by the Regional Boards. However, nowhere in this permit is that stated. Our question is, "Specifically, what are the enforcement powers of the Board if the permitting agency or co-permitting cities are in violation?" For example, if a city agrees to a series of early action BMPs and then refuses to implement them because of budget constraints, what recourse is available to the Board to ensure compliance?

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2) We strongly suggest that a list of BMPs acceptable to the Board is developed as soon as possible. Putting all of the burden of approval of BMPs on a case by case basis for the executive officer makes it extremely difficult to implement a standardized program for pollution reduction in runoff. Please get input on BMPs for the list from the permitting agency, co-permittees, Dr. Mike Stenstrom et al., and various environmental groups.

3) Section 2.1.2 brings up the concept of a 90th percentile value for the water quality parameters, oil and grease (O+G) and total suspended solids (TSS). The first sentence of the section is lacking a verb, so the intent of the sentence is unclear.

Secondly, the whole reason I brought up the concept to begin with was in order for the Board to develop some numerical water quality standards during the life of the initial permit that a) were enforceable, b) made sense, were relatively inexpensive and were feasible, c) only initially required monitoring of those stormdrains (near the outfalls) that discharged to the ocean year round, and d) were conservative enough that only runoff with the worst water quality would be initially impacted. Also, if O+G and TSS are reduced in runoff, then the great majority of the more toxic contaminants are reduced as well. After all, the purpose of this permit is to reduce the mass pollutant load in runoff and toxicity of runoff.

I felt like the proposed numerical standards were an extremely reasonable compromise position. It's not like we demanded for Table B of the California Ocean Plan to become the numerical standards. I have no idea what "guidance for early action control of stormwater pollution" means. I assume that the guidance values for TSS and O+G at least will be used as baseline values to judge the removal efficiencies of the proposed BMPs. Without any numerical TSS and O+G baseline criteria, the Board, the permittee and the co-permittees lose a great deal of enforcement leverage against cities or businesses that are out of compliance with the permit.

The last comment that I have refers to the process of permit development. Heal the Bay played an active role through the Santa Monica Bay Restoration Project in deciding that pursuing an "early" permit was the correct course of action. However, when it came to permit development, we were told that we were not welcome in the process. After the draft of the permit was available for public comment, we made extensive formal comments and provided numerous informal comments to strengthen the permit. Unfortunately, it became abundantly clear that our late inclusion in the permit development process was far too late to make a significant difference.

I did not bring up this point today in order to cause trouble. I brought it up to remind everyone that on this pollution issue, we are all on the same side. Together, we are all learning about the physical, chemical, biological and regulatory characteristics of runoff. Heal the Bay fells like they have a lot to offer on the development of BMPs and the implementation of the permit. In the future, please include us in the process as much as possible.

Sincerely,

Mark Gold

Mark Gold
Staff Scientist at HEAL THE BAY

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AMERICAN OCEANS CAMPAIGN
2219 Main Street Suite 2B Santa Monica, California 90405 (213) 452-2206 FAX (213) 452-5309

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June 18, 1990

Xavier Swamikannu
California Regional Water Quality
Control Board
101 Centre Plaza Drive
Monterey Park, CA 91754-2156

Dear Mr. Swamikannu:

On behalf of American Oceans Campaign, a national environmental organization dedicated to the preservation and protection of our oceans, we submit the following comments on the Regional Board's Draft Order of the NPDES Permit to control urban runoff/stormwater discharges in the Los Angeles area.

Coastal non-point source pollution is the most significant source of water pollution in the Los Angeles area and is constantly increasing in magnitude due to population growth and urban development in this region. In view of this, we are very appreciative of the tremendous efforts of the Board's staff to draft this permit and to bring together all of the entities involved to work in a cooperative manner to address this problem.

Our main concern focuses on the failure to include express enforcement language within the body of the permit. We believe this is absolutely necessary to improve the quality of the water which is certainly the main point of this permit process.

With reference to Item 19 of the Draft Permit, AOC strongly recommends that numerical guidelines be developed by Board staff as soon as possible. Information and data alone will not improve water quality without express numerical guidelines just as monitoring alone will do nothing without strict enforcement provisions. A case in point is the case of the County Public Works Department that has done extensive monitoring over the past twenty years but the data collected was never made known to the public nor has this data done anything to improve the quality of our water.

With reference to Item 2.1.2, AOC strongly believes that the reference to "guidelines" is vague and ambiguous and recommends that the first numerical standards set should be for Total Suspended Solids and Oil and Grease because if you take care of these pollutants first, this addresses most of the problems.

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With reference to Item 2.1.8, AOC believes that it is imperative that all early BMPs be approved by the Executive Director of the Board. AOC also recommends that an enforcement mechanism needs to be expressly provided for in the event that entities fail to comply with the schedule of implementation of the early action BMPs.

On behalf of AOC, we thank the Board for the opportunity to comment on the Draft Permit and appreciate the consideration of our comments.

Sincerely,

Robert H. Sulnick

Robert H. Sulnick
Executive Director

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WASTE WATCHERS

THE NEWSLETTER OF THE CLEAN COASTAL WATERS TASK FORCE
A Subcommittee of the Sierra Club Angeles Chapter Conservation Committee

March/April 1990

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Huntington Oil Spill: Task Force Recommendations

By Bill Holmes

The Clean Coastal Waters Task Force was one of the few groups at the State Lands Commission hearings on March 7 to present tangible recommendations for reducing the impact of future oil spills. When Chairman Gray Davis asked for recommendations for the future, the representatives of the US Coast Guard, the Department of Fish and Game and the Clean Coastal Waters oil industry co-operative were unable to contribute anything. In contrast, our Task Force contended that until the Bush Administration and the US Congress establish a National Energy policy to reduce our dependency on non-renewable sources of energy, risks of tanker oil spills can be reduced in a number of ways:

PREVENTION

1) Establish five mile wide Shipping Safety Lanes along the coast of California as proposed by the US Coast Guard in 1982 and monitor the safety of these lanes.

2) Require all oil tankers entering the California 3 mile zone to be double hulled. This would have prevented the American Trader's anchor from penetrating the oil compartment.

3) Stop the issuance and renewal of Offshore Spread Mooring permits. Harbors are a much safer place for unloading oil.

4) Drastically tighten up regulations pertaining to the operation of an Offshore Spread Mooring by:

a) Setting minimum clearance standards from the bottom of the tanker to the sea floor in the vicinity of a mooring. The American Trader was over 800 feet long with an "average" depth beneath it's hull of less than 15 feet.

b) Prohibiting the unloading of oil in weather conditions that would prevent containment of the oil if a spill was to occur.

c) Approving the stalled legislation granting the State Lands Commission authority to inspect moorings to enforce regulations.

CONTAINMENT

1) Require all tankers to carry sufficient containment booms to hold in place a spill of at least 25% of cargo. Only 2250 feet of containment boom was set in place around the American Trader, not nearly enough to contain a spill of 400,000 gallons (less than 2% of total cargo).

2) Fund research into containment boom technology that will contain oil spills even in high swells. Currently booms are next to useless in anything above a two foot swell (occurring 90% of the time in Southern California).

CLEAN UP

1) Require sufficient skimmers on hand at each Oil Spill Response Center to be capable of cleaning up 100,000

Spill, *continued on page five*

What's Inside:

In it's mysterious past [the ocean] encompasses all the dim origins of life and receives in the end, after, it may be, many transmutations, the dead husks of that same life. For all at last returns to the sea—to Oceanus, the ocean river, like the ever-flowing stream of time, the beginning and the end.

---Rachel Louise Carson, 1907-1964

Rainstorms & Ocean Pollution

Rainstorms in Los Angeles bring much needed water to the LA basin but unfortunately the storm water rushing through drains carries pollution from all over the county to the ocean. A heavy rain often leaves the Los Angeles River and Ballona Creek, two of LA County's principal drainages, carpeted with floating plastic debris washed from streets and roadsides. Storm water scours the paved surfaces and erodible soil at construction sites and carries oil, grease and suspended solids contaminated with heavy metals to wetlands, beaches and the ocean. During heavy storms the total flow and pollutant loading of surface runoff is typically comparable with daily municipal waste water discharges from county sewage treatment facilities.

Storm water is only part of the story since it accounts for about 70% of total annual surface runoff. Outside of the rainy season, a "dry flow," comprised of pavement runoff from irrigation and domestic washdown, permitted commercial and industrial discharges, treated municipal wastewater, and illicit discharges, empties into the ocean. Storm drain effluent is probably the second largest source of pollution to the coast after municipal wastewater discharges. Improvements in contamination levels of sewage effluents from Los Angeles County treatment plants has proportionally increased the contribution of total contaminants to the coast from storm drain effluent. Oil, grease, pesticides, trace metals and coliform bacteria are all contaminants of concern found in storm water. Since storm channels discharge on or near the coast, their impact on surf zone and intertidal ecosystems are probably greater than that of municipal wastewater which is released miles offshore through outfalls.

The full impact of contaminated stormwater on marine resources is very difficult to assess since the sources of pollution are so diverse. Contaminant concentrations during storms vary with the flow level. Consequently, adequate measurements of pollutant flow require extensive sampling throughout the duration of the storm at multiple drainages. Harder still than accurately measuring the amount of contaminants is determination of a particular source's share of the impacts upon marine resources.

Partially because of the difficulty in gathering data on non-point source pollution, the EPA has largely ignored surface runoff contamination while regulating municipal waste water discharges. Soon this situation will change. Late this summer, EPA will issue final Federal Storm Water Regulations requiring permits for the discharge of surface runoff into "the waters of the United States." To facilitate earlier compliance and greater flexibility the EPA has encouraged the L.A. basin to seek an "early permit" prior to EPA's issuance of final regulations. By drafting an early permit - which still would need to be approved by the EPA - the County and all other municipalities would be able to join in the drafting of a plan tailored to LA's needs. The alternative is to seek permits under the evolving complex regulatory structure covering the entire country. Drafting an early permit is a good faith approach to expeditiously begin controlling surface runoff contamination.

The Santa Monica Bay Restoration Project has taken a leading role in encouraging and facilitating the drafting of a storm water permit in Los Angeles since it can provide the forum for all interested parties to participate. A tentative draft has been completed and public hearings are expected to be held in April at the California Regional Water Quality Control Board.

The draft stipulates phased implementation broken down by watershed in Los Angeles County. The Santa Monica Bay watershed would come under regulation first on July 1, 1990 to be followed by the upper San Gabriel River and upper Los Angeles River drainage basins on July 1, 1992. Finally on July 1, 1993, the lower Los Angeles and San Gabriel River basins plus the Santa Clarita Valley would enter compliance.

Provisions of the permit require permittees to survey and document existing knowledge about water flow patterns, water quality and precipitation. Documentation of existing procedures for the control of stormwater runoff at construction sites and the detection of illegal disposal practices is also required in the first year. Under the permit, best management practices (BMP's) for the prevention or reduction of stormwater pollution would be identified and implemented. Monitoring programs for the detection of illegal discharges would also be implemented. The permittee is required to demonstrate that adequate public input has been obtained prior to gaining approval of required workplans from the Executive Officer of the State Regional Water Resources Quality Control Board.

Although change will not be immediate, good faith efforts from all parties will bring us improvements in storm drain effluent quality much faster under the early permit than we might expect under the emerging EPA regulations. The permit should be modified to require the approval of the entire Water Resources Quality Control Board rather than just the Executive Officer. With this modification, the requirements for demonstration of adequate public input concerning implementation of the permit will provide public interest environmental organizations like the Sierra Club and Heal the Bay the opportunity to monitor and influence measures to clean up stormwater effluent in Los Angeles County.

—Rich Blaylock

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June 14, 1990

Dr. Robert Ghirelli
Executive Officer
California Regional Water Quality
Control Board
101 Centre Plaza Dr.
Monterey Park, CA 91754-2156

Santa Monica BAY Restoration PROJECT

101 Centre Plaza Drive
Monterey Park, CA 91754
213/266-7500
Fax 213/266-7600

Dear Dr. Ghirelli:

At its May 24th, 1990 meeting, the Santa Monica Bay Restoration Project Management Committee voted its unanimous support for the Los Angeles County Stormwater/Urban Runoff permit before the Board on June 18th.

The forty-eight member Management Committee is composed of key organizations and individuals embodying the many constituencies of the Bay including environmental groups; dischargers; recreational interest groups; elected officials representing the Bay watershed at the local, state, and federal level; and regulatory agency leaders at the local, state and federal level.

A major objective of the Santa Monica Bay Restoration Project is to reduce stormwater pollution to the Bay. In meeting this objective, the Project was pleased to play a key role in assessing the feasibility of a stormwater management permit, and in negotiating the substance of the permit.

The permit represents a significant commitment on the part of Los Angeles County and the cities within the County to manage stormwater and urban runoff problems that affect not only Santa Monica Bay, but also other valuable water bodies in the County.

Thank you again for your leadership on this important issue! We look forward to the permit's issuance and the beginning of an effective stormwater management program in Los Angeles County.

Sincerely,

Catherine Tyrrell for

TED FINSTER, Co-Chair
Santa Monica Bay Restoration Project
and Member, State Water Resources Control Board

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
215 Fremont Street
San Francisco, CA 94105

28 FEB 1990

In Reply
Refer to: W-5-2

Robert Ghirelli
Executive Officer
California Regional Water Quality
Control Board, Los Angeles Region
101 Centre Plaza Drive
Monterey Park, CA 91754-2156

Dear Mr. Ghirelli:

The purpose of this letter is to summarize Region 9's position with respect to your current efforts to issue an NPDES permit for municipal stormwater discharges in the Los Angeles area prior to promulgation of EPA's permit application regulations.

As you will recall, an initial draft permit for stormwater was prepared by Regional Board staff in November, 1989 and Region 9 expressed certain concerns regarding this permitting activity in a letter from Harry Seraydarian to you dated November 16, 1989. Subsequently, a series of meetings was held to discuss stormwater permitting which involved the City and County of Los Angeles, representatives of the State Board, the Los Angeles Regional Board and Region 9. The initial draft permit was revised several times as a result of the discussions.

We believe that with some relatively minor modifications, the latest draft (Revision #6 dated February 8, 1990) is approvable by Region 9. Two of our major concerns with previous drafts have been the timetable for implementation of the permit requirements and the provisions for public participation in the decision-making.

The latest draft permit adequately addresses our concern regarding the timetable for implementation of the permit requirements. In the implementation schedule for each geographic area, the latest draft permit requires submittal within 2 years (rather than 3) of the plan to reduce pollutant discharges to the "maximum extent practicable." This is now similar to EPA's proposed regulations which would require submittal of a stormwater management plan within 2 years. Of course, we are still concerned that implementation would be delayed for certain areas of the County. However, given the size of the area being

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permitted, we believe that the implementation timetable is acceptable.

With regards to public participation, we would prefer that the Board (rather than the County as proposed) provide for the necessary public participation in the development of the various plans which are required by the permit. However, we could concur with your proposal if certain minimum requirements are specified regarding an adequate demonstration of public participation by the County. In its submittal to the Board, the County should demonstrate for each plan that:

1) a public meeting was held to discuss the plan,
2) notice of the meeting was widely disseminated to the public at large, environmental groups, Federal, State and local officials and other interested parties, and
3) the concerns expressed by the public were addressed by the County. If concerns were raised which were not addressed, the County should provide reasons why these concerns were not addressed.

In addition, the permit should include a statement which requires implementation of the plans after approval/modification by the Regional Board.

In a separate letter to Catherine Tyrrell dated February 9, 1990, we also suggested some minor editorial changes to the permit.

Let me emphasize in closing that Region 9 supports your efforts to issue an NPDES permit for stormwater runoff in the Los Angeles area as soon as possible. We believe that this action will expedite the overall efforts to address existing water quality degradation in the Los Angeles area (and particularly in the sensitive Santa Monica Bay area) which is caused at least in part by pollutants in stormwater runoff.

Should you have any questions, please call me at (415) 705-2079 or refer your staff to Eugene Bromley of the Sludge, Pretreatment and Stormwater Section at (415) 705-2160.

Sincerely,

Keith Takata

Keith A. Takata
Acting Director
Water Management Division

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CALIFORNIA OCEAN PLAN
STATE WATER RESOURCES CONTROL BOARD, 1990

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WATER QUALITY CONTROL PLAN

OCEAN WATERS OF CALIFORNIA

CALIFORNIA OCEAN PLAN

1990

STATE WATER RESOURCES CONTROL BOARD

State of California

STATE WATER RESOURCES CONTROL BOARD

1990

CALIFORNIA OCEAN PLAN

WATER QUALITY CONTROL PLAN

OCEAN WATERS OF CALIFORNIA

Adopted and Effective

March 22, 1990

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STATE WATER RESOURCES CONTROL BOARD
RESOLUTION NO. 90-27

APPROVAL OF AMENDMENT TO THE
WATER QUALITY CONTROL PLAN FOR OCEAN WATERS OF CALIFORNIA
(CALIFORNIA OCEAN PLAN)

WHEREAS:

1. The State Water Resources Control (State Board) adopted the Ocean Plan on July 6, 1972 and revised the plan in 1978, 1983, and 1988.
2. The State Board may adopt water quality control plans for waters for which water quality standards are required by the Federal Clean Water Act in accordance with California Water Code Section 13170.
3. The State Board is responsible for reviewing Ocean Plan water quality standards and for modifying and adopting standards in accordance with Section 303(c)(1) of the Federal Clean Water Act and Section 13170.2(b) of the California Water Code.
4. The State Board has considered relevant management agency agreements in accordance with Section 13170.1 of the California Water Code.
5. Additional information pertinent to water quality objectives for dioxin and related compounds is being developed and reviewed by the scientific community.
6. The State Board prepared and circulated a draft Function Equivalent Document in accordance with the provisions of the California Environmental Quality Act and Title 14, California Code of Regulations 15251(g).
7. The State Board conducted a public hearing in Torrance on August 29, 1989 to solicit comments regarding the proposed amendments of the Ocean Plan and has reviewed and considered carefully all comments and testimony received. The State Board considered the information contained in the Functional Equivalent Document prior to approval of the California Ocean Plan.
8. The California Ocean Plan as approved will not have a significant adverse effect on the environment.

THEREFORE BE IT RESOLVED:

1. That the State Board approves the Functional Equivalent Document for the amendment of the Water Quality Control Plan for Ocean Waters of California.
2. That the State Board hereby adopts amendments to the California Ocean Plan (attached).

3. That the State Board authorizes the Executive Director, or his designee, to transmit the Plan to the U.S. Environmental Protection Agency, Region 9 in compliance with Section 303(c)(1) of the Clean Water Act.

4. That the State Board directs its staff to review the water quality objective for dioxin and related compounds as soon as possible within the next triennial review period.

5. That the State Board declares its intent to require continual monitoring of the marine environment to assure that the Plan reflects the latest available data and that the water quality objectives are adequate to fully protect indigenous marine species and to protect human health.

CERTIFICATION

The undersigned Administrative Assistant to the Board, does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on March 22, 1990.

Maureen Marche
Maureen Marche
Administrative Assistant to the Board

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CALIFORNIA OCEAN PLAN

WATER QUALITY CONTROL PLAN FOR OCEAN WATERS OF CALIFORNIA

INTRODUCTION

In furtherance of legislative policy set forth in Section 13000 of Division 7 of the California Water Code (Stats. 1969, Chap. 482) pursuant to the authority contained in Section 13170 and 13170.2 (Stats. 1971, Chap. 1288) the State Water Resources Control Board hereby finds and declares that protection of the quality of the ocean* waters for use and enjoyment by the people of the State requires control of the discharge of waste* to ocean* waters in accordance with the provisions contained herein. The Board finds further that this plan shall be reviewed at least every three years to guarantee that the current standards are adequate and are not allowing degradation* to marine species or posing a threat to public health.

This plan is applicable, it its entirety, to point source discharges to the ocean*. Nonpoint sources of waste* discharges to the ocean* are subject to Chapter I Beneficial Uses, Chapter II - Water Quality Objectives, Chapter III -General Requirements, Chapter IV - Table B (wherein compliance with water quality objectives shall, in all cases, be determined by direct measurements in the receiving waters) and Chapter V - Discharge Prohibitions.

This plan is not applicable to discharges to enclosed* bays and estuaries* or inland waters nor is it applicable to vessel wastes, or the control of dredging spoil.

Provisions regulating the thermal aspects of waste* discharged to the ocean* are set forth in the Water Quality Control Plan for the Control of Temperature in the Coastal and Interstate Waters and Enclosed* Bays and Estuaries* of California.

Chapter I
BENEFICIAL USES

The beneficial uses of the ocean* waters of the State that shall be protected include industrial water supply, water contact and non-contact recreation, including aesthetic enjoyment, navigation, commercial and sport fishing, mariculture*, preservation and enhancement of Areas of Special Biological Significance, rare and endangered species, marine habitat, fish migration, fish spawning and shellfish* harvesting.

Chapter II
WATER QUALITY OBJECTIVES

This chapter sets forth limits or levels of water quality characteristics for ocean* waters to ensure the reasonable protection of beneficial uses and the prevention of nuisance. The discharge of waste* shall not cause violation of these objectives.

The Water Quality Objectives and Effluent Quality Requirements are defined by a statistical distribution when appropriate. This method recognizes the normally occurring variations in treatment efficiency and sampling and analytical techniques and does not condone poor operating practices.

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* See Appendix I for definition of terms.

Compliance with the water quality objectives of this chapter shall be determined from samples collected at stations representative of the area within the waste field where initial* dilution is completed.

A. Bacterial Characteristics

1. Water-Contact Standards

Within a zone bounded by the shoreline and a distance of 1,000 feet from the shoreline or the 30-foot depth contour, whichever is further from the shoreline, and in areas outside this zone used for water contact sports, as determined by the Regional Board, but including all kelp* beds, the following bacterial objectives shall be maintained throughout the water column:

a. Samples of water from each sampling station shall have a density of total coliform organisms less than 1,000 per 100 ml (10 per ml); provided that not more than 20 percent of the samples at any sampling station, in any 30-day period, may exceed 1,000 per 100 ml (10 per ml), and provided further that no single sample when verified by a repeat sample taken within 48 hours shall exceed 10,000 per 100 ml (100 per ml).

b. The fecal coliform density based on a minimum of not less than five samples for any 30-day period, shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10 percent of the total samples during any 60-day period exceed 400 per 100 ml.

The "Initial* Dilution Zone" of wastewater outfalls shall be excluded from designation as "kelp* beds" for purposes of bacterial standards, and Regional Boards should recommend extension of such exclusion zone where warranted to the State Board (for consideration under Chapter VI.F.). Adventitious assemblages of kelp plants on waste discharge structures (e.g., outfall pipes and diffusers) do not constitute kelp* beds for purposes of bacterial standards.

2. Shellfish* Harvesting Standards

At all areas where shellfish* may be harvested for human consumption, as determined by the Regional Board, the following bacterial objectives shall be maintained throughout the water column:

The median total coliform density shall not exceed 70 per 100 ml, and not more than 10 percent of the samples shall exceed 230 per 100 ml.

B. Bacterial Assessment and Remedial Action Requirements

The requirements listed below shall be used to 1) determine the occurrence and extent of any impairment of a beneficial use due to bacterial contamination; 2) generate information which can be used in the development of an enterococcus standard; and 3) provide the basis for remedial actions necessary to minimize or eliminate any impairment of a beneficial use.

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* See Appendix I for definition of terms.

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Measurement of enterococcus density shall be conducted at all stations where measurement of total and fecal coliforms are required. In addition to the requirements of Section II.A.1., if a shore station consistently exceeds a coliform objective or exceeds a geometric mean enterococcus density of 24 organisms per 100 ml for a 30-day period or 12 organisms per 100 ml for a six-month period, the Regional Board shall require the appropriate agency to conduct a survey to determine if that agency's discharge is the source of the contamination. The geometric mean shall be a moving average based on no less than five samples per month, spaced evenly over the time interval. When a sanitary survey identifies a controllable source of indicator organisms associated with a discharge of sewage, the Regional Board shall take action to control the source.

Waste discharge requirements shall require the discharger to conduct sanitary surveys when so directed by the Regional Board. Waste discharge requirements shall contain provisions requiring the discharger to control any controllable discharges identified in a sanitary survey.

C. <u>Physical Characteristics</u>

1. Floating particulates and grease and oil shall not be visible.
2. The discharge of waste* shall not cause aesthetically undesirable discoloration of the ocean* surface.
3. Natural* light shall not be significantly* reduced at any point outside the initial* dilution zone as the result of the discharge of waste*.
4. The rate of deposition of inert solids and the characteristics of inert solids in ocean* sediments shall not be changed such that benthic communities are degraded*.

D. <u>Chemical Characteristics</u>

1. The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding waste* materials.
2. The pH shall not be changed at any time more than 0.2 units from that which occurs naturally.
3. The dissolved sulfide concentration of waters in and near sediments shall not be significantly* increased above that present under natural conditions.
4. The concentration of substances set forth in Chapter IV, Table B, in marine sediments shall not be increased to levels which would degrade* indigenous biota.
5. The concentration of organic materials in marine sediments shall not be increased to levels which would degrade* marine life.
6. Nutrient materials shall not cause objectionable aquatic growths or degrade* indigenous biota.

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* See Appendix I for definition of terms.

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E. Biological Characteristics

1. Marine communities, including vertebrate, invertebrate, and plant species, shall not be degraded*.

2. The natural taste, odor, and color of fish, shellfish*, or other marine resources used for human consumption shall not be altered.

3. The concentration of organic materials in fish, shellfish* or other marine resources used for human consumption shall not bioaccumulate to levels that are harmful to human health.

F. Radioactivity

1. Discharge of radioactive waste* shall not degrade* marine life.

Chapter III
GENERAL REQUIREMENTS FOR MANAGEMENT OF
WASTE* DISCHARGE TO THE OCEAN*

A. Waste* management systems that discharge to the ocean* must be designed and operated in a manner that will maintain the indigenous marine life and a healthy and diverse marine community.

B. Waste discharged* to the ocean* must be essentially free of:

1. Material that is floatable or will become floatable upon discharge.

2. Settleable material or substances that may form sediments which will degrade* benthic communities or other aquatic life.

3. Substances which will accumulate to toxic levels in marine waters, sediments or biota.

4. Substances that significantly* decrease the natural* light to benthic communities and other marine life.

5. Materials that result in aesthetically undesirable discoloration of the ocean* surface.

C. Waste* effluents shall be discharged in a manner which provides sufficient initial* dilution to minimize the concentrations of substances not removed in the treatment.

D. Location of waste* discharges must be determined after a detailed assessment of the oceanographic characteristics and current patterns to assure that:

1. Pathogenic organisms and viruses are not present in areas where shellfish* are harvested for human consumption or in areas used for swimming or other body-contact sports.

* See Appendix I for definition of terms.

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2. Natural water quality conditions are not altered in areas designated as being of special biological significance or areas that existing marine laboratories use as a source of seawater.

3. Maximum protection is provided to the marine environment.

Waste* that contains pathogenic organisms or viruses should be discharged a sufficient distance from shellfishing* and water-contact sports areas to maintain applicable bacterial standards without disinfection. Where conditions are such that an adequate distance cannot be attained, reliable disinfection in conjunction with a reasonable separation of the discharge point from the area of use must be provided. Disinfection procedures that do not increase effluent toxicity and that constitute the least environmental and human hazard should be used.

Chapter IV
QUALITY REQUIREMENTS FOR WASTE* DISCHARGES (EFFLUENT QUALITY REQUIREMENTS)

This chapter sets forth the quality requirements for waste* discharge to the ocean*.

Table A limitations apply only to publicly owned treatment works and industrial discharges for which Effluent Limitations Guidelines have not been established pursuant to Sections 301, 302, 304, or 306 of the Federal Clean Water Act.

Table B limitations apply to all discharges within the jurisdiction of this plan.

Table A limitations, and effluent concentrations calculated from Table B limitations, shall apply to a discharger's total effluent, of whatever origin (i.e. gross, not net, discharge), except where otherwise specified in this Plan.

The State Board is authorized to administer and enforce effluent requirements established pursuant to the Federal Clean Water Act. Effluent limitations established under Sections 301, 302, 306, 307, 316, 403, and 405 of the aforementioned Federal Act and administrative procedures pertaining thereto, are included in this plan by reference. Compliance with Table A limitations, or Environmental Protection Agency Effluent Limitations Guidelines for industrial discharges, based on Best Practicable Control Technology, shall be the minimum level of treatment acceptable under this plan, and shall define reasonable treatment and waste control technology.

* See Appendix I for definition of terms.

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TABLE A
MAJOR WASTEWATER CONSTITUENTS AND PROPERTIES

	Unit of measurement	Limiting Concentrations: Monthly (30 day Average)	Weekly (7 day Average)	Maximum at any time
Grease and Oil	mg/l	25	40	75
Suspended Solids			see below+	
Settleable Solids	ml/l	1.0	1.5	3.0
Turbidity	NTU	75	100	225
pH	units		within limits of 6.0 to 9.0 at all times	
Acute* Toxicity	TUa	1.5	2.0	2.5

+Suspended Solids: Dischargers shall, as a 30-day average, remove 75% of suspended solids from the influent stream before discharging wastewaters to the ocean*, except that the effluent limitation to be met shall not be lower than 60 mg/l. Regional Boards may recommend that the State Board (Chapter VI.F.), with the concurrence of the Environmental Protection Agency, adjust the lower effluent concentration limit (the 60 mg/l above) to suit the environmental and effluent characteristics of the discharge. As a further consideration in making such recommendation for adjustment, Regional Boards should evaluate effects on existing and potential water* reclamation projects.

If the lower effluent concentration limit is adjusted, the discharger shall remove 75% of suspended solids from the influent stream at any time the influent concentration exceeds four times such adjusted effluent limit.

Effluent limitations shall be imposed in a manner prescribed by the State Board such that the concentrations set forth below as water quality objectives shall not be exceeded in the receiving water upon completion of initial* dilution, except that limitations indicated for radioactivity shall apply directly to the undiluted waste* effluent.

* See Appendix I for definition of terms.

TABLE B
TOXIC MATERIALS LIMITATIONS

	Units of Measurement	Limiting Concentrations: 6-Month Median	Daily Maximum	Instantaneous Maximum
OBJECTIVES FOR PROTECTION OF MARINE AQUATIC LIFE				
Arsenic	ug/l	8	32	80
Cadmium	ug/l	1	4	10
Chromium (Hexavalent) (see below, a)	ug/l	2	8	20
Copper	ug/l	3	12	30
Lead	ug/l	2	8	20
Mercury	ug/l	0.04	0.16	0.4
Nickel	ug/l	5	20	50
Selenium	ug/l	15	60	150
Silver	ug/l	0.7	2.8	7
Zinc	ug/l	20	80	200
Cyanide (see below, b)	ug/l	1	4	10
Total Chlorine Residual (For intermittent chlorine sources, see below, c)	ug/l	2	8	60
Ammonia (expressed as nitrogen)	ug/l	600	2400	6000
Chronic* Toxicity	TUc		1	
Phenolic Compounds (non-chlorinated)	ug/l	30	120	300
Chlorinated Phenolics	ug/l	1	4	10
Endosulfan	ng/l	9	18	27
Endrin	ng/l	2	4	6
HCH*	ng/l	4	8	12
Radioactivity	Not to exceed limits specified in Title 22, Chapter 15, Article 4, Section 64443 of the California Code of Regulations.			

* See Appendix I for definition of terms.

Table B Continued

Chemical	Units of Measurement	30-day Average
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH -- NONCARCINOGENS		
acrolein	ug/l	220
antimony	mg/l	1.2
bis(2-chloroethoxy) methane	ug/l	4.4
bis(2-chloroisopropyl) ether	mg/l	1.2
chlorobenzene	ug/l	570
chromium (III)	mg/l	190
di-n-butyl phthalate	mg/l	3.5
dichlorobenzenes*	mg/l	5.1
1,1-dichloroethylene	mg/l	7.1
diethyl phthalate	mg/l	33
dimethyl phthalate	mg/l	820
4,6-dinitro-2-methylphenol	ug/l	220
2,4-dinitrophenol	ug/l	4.0
ethylbenzene	mg/l	4.1
fluoranthene	ug/l	15
hexachlorocyclopentadiene	ug/l	58
isophorone	mg/l	150
nitrobenzene	ug/l	4.9
thallium	ug/l	14
toluene	mg/l	85
1,1,2,2-tetrachloroethane	mg/l	1.2
tributyltin	ng/l	1.4
1,1,1-trichloroethane	mg/l	540
1,1,2-trichloroethane	mg/l	43
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH -- CARCINOGENS		
acrylonitrile	ug/l	0.10
aldrin	ng/l	0.022
benzene	ug/l	5.9
benzidine	ng/l	0.069
beryllium	ng/l	33
bis(2-chloroethyl) ether	ug/l	0.045
bis(2-ethylhexyl) phthalate	ug/l	3.5
carbon tetrachloride	ug/l	0.90
chlordane*	ng/l	0.023
chloroform	mg/l	0.13
DDT*	ng/l	0.17
1,4-dichlorobenzene	ug/l	18
3,3'-dichlorobenzidine	ng/l	8.1

* See Appendix I for definition of terms.

Table B Continued

Chemical	Units of Measurement	30-day Average
1,2-dichloroethane	mg/l	0.13
dichloromethane	mg/l	0.45
1,3-dichloropropene	ug/l	8.9
dieldrin	ng/l	0.040
2,4-dinitrotoluene	ug/l	2.6
1,2-diphenylhydrazine	ug/l	0.16
halomethanes*	mg/l	0.13
heptachlor*	ng/l	0.72
hexachlorobenzene	ng/l	0.21
hexachlorobutadiene	ug/l	14
hexachloroethane	ug/l	2.5
N-nitrosodimethylamine	ug/l	7.3
N-nitrosodiphenylamine	ug/l	2.5
PAHs*	ng/l	8.8
PCBs*	ng/l	0.019
TCDD equivalents*	pg/l	0.0039
tetrachloroethylene	ug/l	99
toxaphene	ng/l	0.21
trichloroethylene	ug/l	27
2,4,6-trichlorophenol	ug/l	0.29
vinyl chloride	ug/l	36

a) Dischargers may at their option meet this limitation as a total chromium limitation.

b) If a discharger can demonstrate to the satisfaction of the Regional Board (subject to EPA approval) that an analytical method is available to reliably distinguish between strongly and weakly complexed cyanide, effluent limitations for cyanide may be met by the combined measurement of free cyanide, simple alkali metal cyanides, and weakly complexed organometallic cyanide complexes. In order for the analytical method to be acceptable, the recovery of free cyanide from metal complexes must be comparable to that achieved by Standard Methods 412F, G, and H (Standard Methods for the Examination of Water and Wastewater. Joint Editorial Board, American Public Health Association, American Water Works Association, and Water Pollution Control Federation. Most recent edition.).

c) Water quality objectives for total chlorine residual applying to intermittent discharges not exceeding two hours, shall be determined through the use of the following equation:

$$\log y = -0.43 (\log x) + 1.8$$

where: y = the water quality objective (in ug/l) to apply when chlorine is being discharged;
x = the duration of uninterrupted chlorine discharge in minutes.

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* See Appendix I for definition of terms.

Implementation Provisions for Table B

A. Calculation of Effluent Limitations

Effluent limitations for parameters identified in Table B with the exception of Radioactivity, shall be determined through the use of the following equation:

$$Ce = Co + Dm\,(Co - Cs) \quad (1)$$

where:

Ce = the effluent concentration limit,
Co = the concentration to be met at the completion of initial* dilution,
Cs = background seawater concentration (see Table C below),
Dm = minimum probable initial* dilution expressed as parts seawater per part wastewater.

For the purpose of this Plan, minimum initial dilution is the lowest average initial dilution within any single month of the year. Dilution estimates shall be based on observed waste flow characteristics, observed receiving water density structure, and the assumption that no currents, of sufficient strength to influence the initial dilution process, flow across the discharge structure.

The Executive Director of the State Board shall identify standard dilution models for use in determining Dm, and shall assist the Regional Board in evaluating Dm for specific waste discharger. Dischargers may propose alternative methods of calculating Dm, and the Regional Board may accept such method upon verification of its accuracy and applicability.

TABLE C
BACKGROUND SEAWATER CONCENTRATIONS (Cs)

Waste Constituent	Cs (ug/l)
Arsenic	3
Copper	2
Mercury	0.0005
Silver	0.16
Zinc	8

For all other Table B parameters, Cs = 0.

The six-month median effluent concentration limit shall apply as a moving median of daily values for any 180 day period in which daily values represent flow weighted

* See Appendix I for definition of terms.

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average concentrations within a 24-hour period. For intermittent discharges, the daily value shall be considered to equal zero for days on which no discharge occurred.

The daily maximum effluent concentration limit shall apply to flow weighted 24 hour composite samples.

The instantaneous maximum shall apply to grab sample determinations.

If only one sample is collected during the time period associated with the water quality objective (e.g., 30-day average or 6-month median), the single measurement shall be used to determine compliance with the effluent limitation for the entire time period.

Discharge requirements shall also specify effluent requirements in terms of mass emission rate limits utilizing the general formula:

$$lbs/day = 8.34 \times Ce \times Q \quad (2)$$

The six-month median limit on daily mass emissions shall be determined using the six-month median effluent concentration as Ce and the observed flow rate Q in millions of gallons per day. The daily maximum mass emission shall be determined using the daily maximum effluent concentration limit as Ce and the observed flow rate Q in millions of gallons per day.

Any significant change in waste* flow shall be cause for reevaluating effluent quality requirements.

B. Compliance Determination

All analytical data shall be reported uncensored with detection limits and quantitation limits identified. For any effluent limitation, compliance shall be determined using appropriate statistical methods to evaluate multiple samples. Compliance based on a single sample analysis should be determined where appropriate as described below.

When a calculated effluent limitation is greater than or equal to the PQL*, compliance shall be determined based on the calculated effluent limitation and either single or multiple sample analyses.

When the calculated effluent limitation is below the PQL*, compliance determinations based on analysis of a single sample shall only be undertaken if the concentration of the constituent of concern in the sample is greater than or equal to the PQL*.

When the calculated effluent limitation is below the PQL* and recurrent analytical responses between the PQL* and the calculated limit occur, compliance shall be determined by statistical analysis of multiple samples. Sufficient sampling and analysis shall be required to determine compliance.

Published values for MDL*s and PQL*s should be used except where revised MDL*s and PQL*s are available from recent laboratory performance evaluations, in which case the

* See Appendix I for definition of terms.

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revised MDL*s and PQL*s should be used. Where published values are not available the Regional Boards should determine appropriate values based on available information.

If a discharger believes the sample matrix under consideration in the waste discharge requirements is sufficiently different from that used for an established MDL* value, the discharger may demonstrate to the satisfaction of the Regional Board what the appropriate MDL* should be for the discharger's matrix. In this case the PQL* shall be established at the limit of quantitation (equal to 10 standard deviations above the average measured blank used for development of the MDL* in the discharger's matrix).

When determining compliance based on a single sample, with a single effluent limitation which applies to a group of chemicals (e.g., PCBs) concentrations of individual members of the group may be considered to be zero if the analytical response for individual chemicals falls below the MDL* for that parameter.

Due to the large total volume of powerplant and other heat exchange discharges, special procedures must be applied for determining compliance with Table B limitations on a routine basis. Effluent concentration values (Ce) shall be determined through the use of equation 1 considering the minimal probable initial* dilution of the combined effluent (in-plant waste streams plus cooling water flow). These concentration values shall then be converted to mass emission limitations as indicated in equation 2. The mass emission limits will then serve as requirements applied to all inplant waste* streams taken together which discharge into the cooling water flow, except that limitations on total chlorine residual, chronic* toxicity and instantaneous maximum limitations on Table B toxic materials shall apply to, and be measured in, the combined final effluent, as adjusted for dilution with ocean water. The Table B limitation on radioactivity shall apply to the undiluted combined final effluent.

C. **Toxicity Reduction Requirements**

If a discharge consistently exceeds an effluent limitation based on a toxicity objective in Table B, a toxicity reduction evaluation (TRE) is required. The TRE shall include all reasonable steps to identify the source of toxicity. Once the source(s) of toxicity is identified, the discharger shall take all reasonable steps necessary to reduce toxicity to the required level.

The following shall be incorporated into waste discharge requirements: (1) a requirement to conduct a TRE if the discharge consistently exceeds its toxicity effluent limitation, and (2) a provision requiring a discharger to take all reasonable steps to reduce toxicity once the source of toxicity is identified.

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* See Appendix I for definition of terms.

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Chapter V
DISCHARGE PROHIBITIONS

A. Hazardous Substances

The discharge of any radiological, chemical, or biological warfare agent or high-level radioactive waste* into the ocean* is prohibited.

B. Areas of Special Biological Significance

Waste* shall not be discharged to areas designated as being of special biological significance. Discharges shall be located a sufficient distance from such designated areas to assure maintenance of natural water quality conditions in these areas.

C. Sludge

Pipeline discharge of sludge to the ocean* is prohibited by federal law; the discharge of municipal and industrial waste* sludge directly to the ocean*, or into a waste* stream that discharges to the ocean*, is prohibited by this Plan. The discharge of sludge digester supernatant directly to the ocean*, or to a waste* stream that discharges to the ocean* without further treatment, is prohibited.

It is the policy of the State Board that the treatment, use and disposal of sewage sludge shall be carried out in the manner found to have the least adverse impact on the total natural and human environment. Therefore, if federal law is amended to permit such discharge, which could affect California waters, the State Board may consider requests for exceptions to this section under Chapter VI, F. of this Plan, provided further that an Environmental Impact Report on the proposed project shows clearly that any available alternative disposal method will have a greater adverse environmental impact than the proposed project.

D. By-Passing

The by-passing of untreated wastes* containing concentrations of pollutants in excess of those of Table A or Table B to the ocean* is prohibited.

Chapter VI
GENERAL PROVISIONS

A. Effective Date

This Plan is in effect as of the date of adoption by the State Water Resources Control Board.

* See Appendix I for definition of terms.

B. Waste Discharge Requirements

The Regional Boards may establish more restrictive water quality objectives and effluent quality requirements than those set forth in this Plan as necessary for the protection of beneficial uses of ocean* waters.

Regional Boards may impose alternative less restrictive provisions than those contained within Table B of the Plan, provided an applicant can demonstrate that:

Reasonable control technologies (including source control, material substitution, treatment and dispersion) will not provide for complete compliance; or

Any less stringent provisions would encourage water* reclamation;

Provided further that:

a) Any alternative water quality objectives shall be below the conservative estimate of chronic toxicity, as given in Table D below, and such alternative will provide for adequate protection of the marine environment;

b) A receiving water toxicity* objective of 1 TUc is not exceeded; and

c) The State Board grants an exception (Chapter VI.F.) to the Table B limits as established in the Regional Board findings and alternative limits.

TABLE D
CONSERVATIVE ESTIMATES OF CHRONIC TOXICITY

Constituent	Estimate of Chronic Toxicity (ug/l)
Arsenic	19
Cadmium	8
Hexavalent Chromium	18
Copper	5
Lead	22
Mercury	0.4
Nickel	48
Silver	3
Zinc	51
Cyanide	10
Total Chlorine Residual	10.0
Ammonia	4,000.0
Phenolic Compounds (non-chlorinated)	a)(see below)
Chlorinated Phenolics	a)
Chlorinated Pesticides and PCB's	b)

* See Appendix I for definition of terms.

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a. There is insufficient data for phenolics to estimate chronic toxicity levels. Requests for modification of water quality objectives for these waste* constituents must be supported by chronic toxicity data for representative sensitive species. In such cases, applicants seeking modification of water quality objectives should consult the Regional Water Quality Control Board to determine the species and test conditions necessary to evaluate chronic effects.

b. Limitations on chlorinated pesticides and PCB's shall not be modified so that the total of these compounds is increased above the limitations in Table B (6-Month Median = 31 ng/l, Daily Maximum = 62 ng/l, and Instantaneous Maximum = 93 ng/l).

C. Revision of Waste* Discharge Requirements

The Regional Board shall revise the waste* discharge requirements for existing discharges as necessary to achieve compliance with this Plan and shall also establish a time schedule for such compliance.

D. Monitoring Program

The Regional Boards shall require dischargers to conduct self-monitoring programs and submit reports necessary to determine compliance with the waste* discharge requirements, and may require dischargers to contract with agencies or persons acceptable to the Regional Board to provide monitoring reports. Monitoring provisions contained in waste discharge requirements shall be in accordance with the Monitoring Procedures provided in Appendix II.

Where the Regional Board is satisfied that any substance(s) of Table B will not significantly occur in a discharger's effluent, the Regional Board may elect not to require monitoring for such substance(s), provided the discharger submits periodic certification that such substance(s) are not added to the waste* stream, and that no change has occurred in activities that could cause such substance(s) to be present in the waste* stream. Such election does not relieve the discharger from the requirement to meet the limitations of Table B.

The Regional Board may require monitoring of bioaccumulation of toxicants in the discharge zone. Organisms and techniques for such monitoring shall be chosen by the Regional Board on the basis of demonstrated value in waste* discharge monitoring.

E. Areas of Special Biological Significance

Areas of special biological significance shall be designated by the State Board after a public hearing by the Regional Board and review of its recommendations.

F. State Board Exceptions to Plan Requirements

The State Board may, in compliance with the California Environmental Quality Act, subsequent to a public hearing, and with the concurrence of the Environmental Protection Agency, grant exceptions where the Board determines:

* See Appendix I for definition of terms.

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1. The exception will not compromise protection of ocean* waters for beneficial uses, and

2. The public interest will be served.

* See Appendix 1 for definition of terms.

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APPENDIX I

DEFINITION OF TERMS

ACUTE TOXICITY

a. Acute Toxicity (TUa)

Expressed in Toxic Units Acute (TUa)

TUa = 100/96-hr LC 50%

b. Lethal Concentration 50% (LC 50)

LC 50 (percent waste giving 50% survival of test organisms) shall be determined by static or continuous flow bioassay techniques using standard test species. If specific identifiable substances in wastewater can be demonstrated by the discharger as being rapidly rendered harmless upon discharge to the marine environment, but not as a result of dilution, the LC 50 may be determined after the test samples are adjusted to remove the influence of those substances.

When it is not possible to measure the 96-hour LC 50 due to greater than 50 percent survival of the test species in 100 percent waste, the toxicity concentration shall be calculated by the expression:

$$TUa = \frac{\log(100 - S)}{1.7}$$

S = percentage survival in 100% waste. If S > 99, TUa shall be reported as zero.

CHLORDANE shall mean the sum of chlordane-alpha, chlordane-gamma, chlordene-alpha, chlordene-gamma, nonachlor-alpha, nonachlor-gamma, and oxychlordane.

CHRONIC TOXICITY: This parameter shall be used to measure the acceptability of for waters supporting a healthy marine biota until improved methods are developed to evaluate biological response.

a. Chronic Toxicity (TUc)

Expressed as Toxic Units Chronic (TUc)

TUc = 100/NOEL

b. No Observed Effect Level (NOEL)

The NOEL is expressed as the maximum percent effluent or receiving water that causes no observable effect on a test organism, as determined by the result of a critical life stage toxicity test listed in Appendix II.

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* See Appendix I for definition of terms.

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DDT shall mean the sum of 4,4'DDT, 2,4'DDT, 4,4'DDE, 2,4'DDE, 4,4'DDD, and 2,4'DDD.

DEGRADE: Degradation shall be determined by comparison of the waste field and reference site(s) for characteristics species diversity, population density, contamination, growth anomalies, debility, or supplanting of normal species by undesirable plant and animal species. Degradation occurs if there are significant differences in any of three major biotic groups, namely, demersal fish, benthic invertebrates, or attached algae. Other groups may be evaluated where benthic species are not affected, or are not the only ones affected.

DICHLOROBENZENES shall mean the sum of 1,2- and 1,3-dichlorobenzene.

ENCLOSED BAYS are indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

ENDOSULFAN shall mean the sum of endosulfan-alpha and -beta and endosulfan sulfate.

ESTUARIES AND COASTAL LAGOONS are waters at the mouths of streams which serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams which are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include but are not limited to the Sacramento-San Joaquin Delta as defined by Section 12220 of the California Water Code, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

HALOMETHANES shall mean the sum of bromoform, bromomethane (methyl bromide), chloromethane (methyl chloride), chlorodibromomethane, and dichloro-bromomethane.

HEPTACHLOR shall mean the sum of heptachlor and heptachlor epoxide.

HCH shall mean the sum of the alpha, beta, gamma (lindane) and delta isomers of hexachlorocyclohexane.

INITIAL DILUTION is the process which results in the rapid and irreversible turbulent mixing of wastewater with ocean water around the point of discharge.

For a submerged buoyant discharge, characteristic of most municipal and industrial wastes that are released from the submarine outfalls, the momentum of the discharge and its initial buoyancy act together to produce turbulent mixing. Initial

* See Appendix I for definition of terms.

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dilution in this case is completed when the diluting wastewater ceases to rise in the water column and first begins to spread horizontally.

For shallow water submerged discharges, surface discharges, and nonbuoyant discharges, characteristic of cooling water wastes and some individual discharges, turbulent mixing results primarily from the momentum of discharge. Initial dilution, in these cases, is considered to be completed when the momentum induced velocity of the discharge ceases to produce significant mixing of the waste, or the diluting plume reaches a fixed distance from the discharge to be specified by the Regional Board, whichever results in the lower estimate for initial dilution.

KELP BEDS, for purposes of the bacteriological standards of this plan, are significant aggregations of marine algae of the genera *Macrocystis* and *Nereocystis*. Kelp beds include the total foliage canopy of *Macrocystis* and *Nereocystis* plants throughout the water column.

MARICULTURE is the culture of plants and animals in marine waters independent of any pollution source.

MDL (Method Detection Limit) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, as defined in 40 CFR 136 Appendix B.

NATURAL LIGHT: Reduction of natural light may be determined by the Regional Board by measurement of light transmissivity or total irradiance, or both, according to the monitoring needs of the Regional Board.

OCEAN WATERS are the territorial marine waters of the State as defined by California law to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. If a discharge outside the territorial waters of the State could affect the quality of the waters of the State, the discharge may be regulated to assure no violation of the Ocean Plan will occur in ocean waters.

PAHs (polynuclear aromatic hydrocarbons) shall mean the sum of acenaphthylene, anthracene, 1,2-benzanthracene, 3,4-benzofluoranthene, benzo[k]fluoranthene, 1,12-benzoperylene, benzo[a]pyrene, chrysene, dibenzo[ah]anthracene, fluorene, indeno[1,2,3-cd]pyrene, phenanthrene and pyrene.

PCBs (polychlorinated biphenyls) shall mean the sum of chlorinated biphenyls whose analytical characteristics resemble those of Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254 and Aroclor-1260.

PQL (Practical Quantitation Level) is the lowest concentration of a substance which can be consistently determined within +/- 20% of the true concentration by 75% of the labs tested in a performance evaluation study. Alternatively, if performance data are not available, the PQL* for carcinogens is the MDL* x 5, and for noncarcinogens is the MDL* x 10.

SHELLFISH are organisms identified by the California Department of Health Services as shellfish for public health purposes (i.e., mussels, clams and oysters).

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* See Appendix I for definition of terms.

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SIGNIFICANT difference is defined as a statistically significant difference in the means of two distributions of sampling results at the 95 percent confidence level.

TCDD EQUIVALENTS shall mean the sum of the concentrations of chlorinated dibenzodioxins (2,3,7,8-CDDs) and chlorinated dibenzofurans (2,3,7,8-CDFs) multiplied by their respective toxicity factors, as shown in the table below.

Isomer Group	Toxicity Equivalence Factor
2,3,7,8-tetra CDD	1.0
2,3,7,8-penta CDD	0.5
2,3,7,8-hexa CDDs	0.1
2,3,7,8-hepta CDD	0.01
octa CDD	0.001
2,3,7,8 tetra CDF	0.1
1,2,3,7,8 penta CDF	0.05
2,3,4,7,8 penta CDF	0.5
2,3,7,8 hexa CDFs	0.1
2,3,7,8 hepta CDFs	0.01
octa CDF	0.001

WASTE: As used in this Plan, waste includes a discharger's total discharge, of whatever origin, i.e., gross, not net, discharge.

WATER RECLAMATION: The treatment of wastewater to render it suitable for reuse, the transportation of treated wastewater to the place of use, and the actual use of treated wastewater for a direct beneficial use or controlled use that would not otherwise occur.

* See Appendix I for definition of terms.

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APPENDIX II

STANDARD MONITORING PROCEDURES

The purpose of this appendix is to provide direction to the Regional Boards on the implementation of the California Ocean Plan and to ensure the reporting of useful information. It is not feasible to cover all circumstances and conditions that could be encountered by all dischargers. Therefore, this appendix should be considered as the basic components of any discharger monitoring program. Regional Boards can deviate from the procedures required in the appendix only with the approval of the State Water Resources Control Board unless the Ocean Plan allows for the selection of alternate protocols by the Regional Boards. If no direction is given in this appendix for a specific provision of the Ocean Plan, it is within the discretion of the Regional Board to establish the monitoring requirements for the provision.

The appendix is organized in the same manner as the Ocean Plan.

Chapter II. A. Bacterial Standards:

For all bacterial analyses, sample dilutions should be performed so the range of values extends from 2 to 16,000. The detection methods used for each analysis shall be reported with the results of the analysis.

Detection methods used for coliforms (total and fecal) shall be those presented in the most recent edition of Standard Methods for the Examination of Water and Wastewater or any improved method determined by the Regional Board (and approved by EPA) to be appropriate.

Detection methods used for enterococcus shall be those presented in EPA publication EPA 600/4-85/076, Test Methods for Escherichia coli and Enterococci in Water By Membrane Filter Procedure or any improved method determined by the Regional Board to be appropriate.

Chapter IV. Table B. Compliance with Table B objectives:

Procedures, calibration techniques, and instrument/reagent specifications used to determine compliance with Table B shall conform to the requirements of federal regulations (40 CFR 136). All methods shall be specified in the monitoring requirement section of waste discharge requirements.

Where methods are not available in 40 CFR 136, the Regional Boards shall specify suitable analytical methods in waste discharge requirements. Acceptance of data should be predicated on demonstrated laboratory performance.

The State or Regional Board may, subject to EPA approval, specify test methods which are more sensitive than those specified in 40 CFR 136. Total chlorine residual is likely to be a method detection limit effluent requirement in many cases. The limit of detection of total chlorine residual in standard test methods is less than or equal to 20 ug/L.

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* See Appendix I for definition of terms.

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Monitoring for the substances in Table B shall be required periodically. For discharges less than 1 MGD (million gallons per day), the monitoring of all the Table B parameters should consist of at least one complete scan of the Table B constituents one time in the life of the waste discharge requirements. For discharges between 1 and 10 MGD, the monitoring frequency shall be at least one complete scan of the Table B substances annually. Discharges greater than 10 MGD shall be required to monitor at least semiannually.

Chapter IV. Compliance with Toxicity Objectives:

Compliance with the acute toxicity objective (TUa) in Table A shall be determined using an established protocol, e.g., American Society for Testing Materials (ASTM), EPA, American Public Health Association, or State Board.

The Regional Board shall require the use of critical life stage toxicity tests specified in this Appendix to measure TUc. Other species or protocols will be added to the list after State Board review and approval. A minimum of three test species with approved test protocols shall be used to measure compliance with the toxicity objective. If possible, the test species shall include a fish, an invertebrate, and an aquatic plant. After a screening period, monitoring can be reduced to the most sensitive species. Dilution and control water should be obtained from an unaffected area of the receiving waters. The sensitivity of the test organisms to a reference toxicant shall be determined concurrently with each bioassay test and reported with the test results.

Use of critical life stage bioassay testing shall be included in waste discharge requirements as a monitoring requirement for all discharges greater than 100 MGD by January 1, 1991 at the latest. For other major dischargers, critical life stage bioassay testing shall be included as a monitoring requirement one year before the waste discharge requirement is scheduled for renewal. For major dischargers scheduled for waste discharge requirements renewal less than one year after the adoption of the toxicity objective, critical life stage bioassay testing shall be included as a monitoring requirement at the same time as the chronic toxicity effluent limits is established in the waste discharge requirements.

The following tests shall be used to measure TUc. Other tests may be added to the list when approved by the State Board.

Species	Effect	Test Duration	Reference
red alga, Champia parvula	number of cystocarps	7-9 days	1
giant kelp, Macrocystis pyrifera	percent germination; germ tube length	48 hours	2
abalone, Haliotis rufescens	abnormal shell development	48 hours	2

* See Appendix I for definition of terms.

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oyster, Crassostrea gigas; mussel, Mytilus edulis	abnormal shell development; percent survival	48 hours	3
urchins, Strongylocentrotus purpuratus, S. franciscanus; sand dollar, Dendraster excentricus	percent fertilization	1 hour	4
shrimp, Mysidopsis bahia	percent survival; growth; fecundity	7 days	1
silversides, Menidia beryllina	larval growth rate; percent survival	7 days	1

Bioassay References

1. Weber, C.I., W.B. Horning, II, D.J. Klemm, T.W. Neiheisel, P.A. Lewis, E.L. Robinson, J. Menkedick, and F. Kessler (eds.). 1988. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. EPA-600/4-87/028. National Technical Information Service, Springfield, VA.

2. Hunt, J.W., B.S. Anderson, S.L. Turpin, A.R. Conlon, M. Martin, F.H. Palmer, and J.J. Janik. 1989. Experimental Evaluation of Effluent Toxicity Testing Protocols with Giant Kelp, Mysids, Red Abalone, and Topsmelt. Marine Bioassay Project. Fourth Report. California State Water Resources Control Board, Sacramento.

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4. Dinnel, P.J., J. Link, and Q. Stober. 1987. Improved methodology for sea urchin sperm cell bioassay for marine waters. Archives of Environmental Contamination and Toxicology 16: 23-32.

* See Appendix I for definition of terms.

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STATE PERSPECTIVES ON WATER QUALITY
Eric H. Livingston,

VOL 1 2

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Design of
URBAN RUNOFF QUALITY CONTROLS

Proceedings of an
Engineering Foundation Conference on
Current Practice and Design Criteria
for Urban Quality Control

Trout Lodge
Potosi, Missouri
July 10-15, 1988

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Ben Urbonas, co-Chairman
Thomas O. Barnwell, Jr.
Jonathan E. Jones
Michael L. Testriep

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Larry A. Roesner, Ben Urbonas, and Michael B. Sonnen

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Discussion of Dr. Osborne's Paper

Question:

Were the data you discussed measured dynamically?

Answer:

Yes--two years, around the clock.

Question:

Were the major impacts you noticed attributable to point or nonpoint sources?

Answer:

In some cases, even in agricultural areas, the biggest phosphorous impact is caused by point sources from urban areas, exacerbated by urban nonpoint sources.

Question:

Diurnal variations at the point of interest you define for yourself appear to be insufficient characterizations. Spatial variations along the stream are important as well. Determinations of K-rates and the effects of resuspension and sediment oxygen demand appear to have been left out of the relationships you described.

Answer:

The terms you mention do not appear to have been so big a problem. The respiration term I discussed tends to include the net effects of all those things. The more complex unresolved matters appear to be in the hydraulic context--particle flows versus water flows and the like.

State Perspectives on Water Quality Criteria

Eric H. Livingston[1]

ABSTRACT

The Federal Clean Water Act framework for water quality regulation is reviewed. The role of water quality standards in the regulation of stormwater discharges and the protection of beneficial uses is discussed. The relationship between the implementation of best management practices (BMPs) and water quality criteria is explored with emphasis on how Florida's stormwater regulatory program was established. Florida's BMP design and performance standards for stormwater discharges from new developments are summarized. A conceptual program to address the modification of existing stormwater discharges to reduce their pollution loading to receiving waters is proposed.

INTRODUCTION

The Federal Clean Water Act establishes the framework for the nation's water quality management regulations and programs by setting forth a national objective to "restore and maintain the chemical, physical and biological integrity of the nation's waters". Furthermore, the Act sets forth several goals to help achieve this objective including:

- Wherever attainable, water quality shall provide for the protection and propagation of fish, shellfish and wildlife and provide for recreation in and on the water.
- Programs to control nonpoint sources of pollution shall be developed and implemented expeditiously.

To carry out the purposes of the Act, the Environmental Protection Agency and the states have adopted water quality criteria and standards. The word "criterion" should not be used interchangeably with the word "standard" (EPA, 1976). Criterion represent a constituent concentration or level associated with a degree of environmental effect upon which scientific judgement may be based. Within the context of the water environment, criterion has come to mean a designated concentration of a

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constituent that, when not exceeded, will protect an organism, or organism community or a prescribed water use or quality with an adequate degree of safety. Water quality criteria, therefore, reflect a knowledge of the capacity for environmental accumulation, persistence or effects of specific pollutants in specific aquatic systems. In some cases, a criterion may be a narrative statement instead of a constituent concentration.

A water quality standard includes designated beneficial uses (e.g., potable waters, fishable/swimmable waters), the water quality criteria to protect those uses as well as an antidegradation policy. A standard may use a water quality criterion as a basis for regulation or enforcement, but the standard may differ from a criterion because of prevailing local natural conditions or because of the importance of a particular waterway, economic considerations or the degree of safety to a particular ecosystem that may be desired.

Water quality criteria traditionally have been based on acute and chronic toxicity bioassay tests that were derived for continuous pollutant sources. Unfortunately, urban runoff is an intermittent pollutant source which represents a shock loading of relatively short duration with a longer time between exposures. In addition, urban stormwater impacts on receiving waters are highly variable depending on numerous factors such as rainfall and runoff characteristics, water body type, land use, soils, geology, chemistry and topography. Therefore, the validity of applying traditional water quality criteria to urban stormwater pollution sources is highly debatable.

Stormwater also exerts long term impacts on receiving waters thereby raising further questions about the applicability of current water quality criteria. Stormwater carries relatively high levels of suspended solids which alone can cause severe impacts on receiving water biota. Suspended solids also carry many other contaminants (e.g., metals, phosphorus) which accumulate as bottom sediments (a pollutant sink). Exposure to these sediment bound toxicants can pose threats to the aquatic biota and environment and can also impose a sediment oxygen demand. If the pH falls or bottom conditions become anaerobic, these contaminants can also release from the sediments and enter the water (Harper, 1985).

From the foregoing discussion it seems evident that evaluating stormwater impacts on receiving waters, and consequently the design of control programs, cannot be based solely on traditional water quality criteria. Mancini (1983) proposes a methodology for the development of wet weather criteria while Mancini and Plummer (1986) further discuss this concept. While wet weather criteria may be applicable, their development and implementation

would be difficult and impractical. Especially since there is so little information on the toxicity of urban runoff thereby precluding the development of whole effluent information that would be needed for permitting stormwater discharges (EPA, 1983a). Sediment criteria is also essential with different criteria for fresh and marine environments (FDER, 1988). Finally, the basic foundation of any stormwater program should be the protection of beneficial uses.

REGULATORY FRAMEWORK OF FLORIDA'S STORMWATER PROGRAM

Section 208 of the Federal Clean Water Act required the development of areawide water quality management plans to control point and nonpoint sources of pollution. As part of Florida's program conducted during the late 1970's and early 1980's, many investigations were undertaken to assess the impacts of stormwater and the effectiveness of various best management practices (Livingston, 1984). These studies demonstrated that stormwater, whether from agriculture, forestry or urban lands, was the primary source of pollutant loading to Florida's receiving waters. Subsequently, it was concluded that the ability to meet the Clean Water Act objective of fishable and swimmable waters would require the implementation of stormwater programs to reduce the delivery of pollutants from stormwater discharges.

Recognition of this problem, along with the availability of Federal funds, led Florida to draft regulations to control stormwater in the late 1970's. The first official State regulation specifically addressing stormwater was adopted in 1979 as part of Chapter 17-4, Florida Administrative Code (F.A.C.). Chapter 17-4.248 was the first attempt to regulate this source of pollution that, at the time, was not very well understood. Under Chapter 17-4.248 the Department based its decision to order a permit on a determination of the "insignificance" or "significance" of the stormwater discharge. This determination seems reasonable in concept; however, in practice, such a decision can be as variable as the personalities involved. What may appear insignificant to the owner of a shopping center may actually be a significant pollutant load into an already overloaded stream.

In adopting Chapter 17-4.248, the Department intended that the rule would be revised when more detailed information on nonpoint source management became available. About one year after adoption, the Department began reviewing the results of research being conducted under the 208 program. The Department also established a stormwater task force with membership from all segments of the regulated and environmental communities. A revised stormwater rule, Chapter 17-25, F.A.C., was developed after two years, more than 100 meetings between department staff and the regulatory interests, and the dissemination of 29 official rule drafts for review and comment. The adopted rule required a stormwater permit for all new stormwater discharges and for modifications to existing discharges that were modified to increase flow or pollutant loading.

The Stormwater Rule had to be implemented within the framework of the federal Clean Water Act. The Act establishes two types of regulatory requirements to control pollutant discharges--technology-based effluent limitations which reflect the best controls available considering the technical and economic achievability of those controls; and water quality-based effluent limitations which reflect the water quality standards and allowable pollutant loadings set up by state permit (EPA, 1983). The latter approach can be developed and implemented through a biomonitoring approach based on whole effluent toxicity making it very applicable to stormwater. However, Florida's tremendous growth and the accompanying creation of tens of thousands of new stormwater discharges together with our lack of data on stormwater loading toxicity made this approach unimplementable.

Guidance on the development of stormwater regulatory programs and the role of water quality criteria has been issued by the Environmental Protection Agency (1987). The guidance recognizes that BMPs are the primary mechanism to enable the achievement of water quality standards. For the purposes of this paper, a BMP is a control technique that is used for a given set of site conditions to achieve stormwater quality and quantity enhancement at a minimum cost. Further, the guidance recommends that state programs should include the following steps:

1. design of BMPs based on site specific conditions; technical, institutional and economic feasibility; and the water quality standards of the receiving waters.

2. monitoring to ensure that practices are correctly designed and applied.

3. monitoring to determine
   a) the effectiveness of BMPs in meeting water quality standards
   b) the appropriateness of water quality criteria in reasonably assuring protection of beneficial uses.

4. adjustment of BMPs when it is found that water quality standards are not being protected to a designed level and/or evaluation and possible adjustment of water quality standards.

It is intended that proper installation and operation of state approved BMPs will achieve water quality standards. While water quality standards are to be used to measure the effectiveness of BMPs, EPA recognizes that there should be flexibility in water quality standards to address the impact of time and space components of stormwater as well as naturally occurring events. If water quality standards are not met, then the BMPs should be modified, or the discharge cease or, in some cases, reassessment of the water quality standards be undertaken.

RATIONALE FOR STORMWATER RULE STANDARDS

The overriding standards of the Stormwater Rule are the water quality standards and appropriate regulations established in other Department rules. Therefore, an applicant for a stormwater discharge permit must provide reasonable assurance that stormwater discharges will not violate state water quality standards. Because of the potential number of discharge facilities and the difficulties of determining the impact of any facility on a waterbody or the latter's assimilative capacity, the Department decided that the Stormwater Rule should be based on design and performance standards.

The performance standards established a technology-based effluent limitation against which an applicant can measure the proposed treatment system. If an applicant can demonstrate treatment equivalent to the description in the performance standard systems, then the applicant should be able to meet applicable water quality standards. The actual design and performance standards are based on a number of factors which will subsequently be discussed.

Stormwater Management Goals - Stormwater management has multiple objectives including water quality protection, flood protection (volume, peak discharge rate), erosion and sediment control, water conservation and reuse, aesthetics and recreation. The basic goal for new development is to assure that the post-development peak discharge rate, volume, timing and pollutant load does not exceed predevelopment levels. However, BMPs are not 100% effective in removing stormwater pollutants while site variations can also make this goal unachievable at times. Therefore, for the purposes of stormwater regulatory programs, the Department (water quality) and the Water Management Districts (flood control) have established performance standards based on risk analysis and implementation feasibility.

Rainfall Characteristics - An analysis of long term rainfall records was undertaken to determine statistical distribution of various rainfall characteristics such as storm intensity and duration, precipitation volume, time between storms, etc. It was found that nearly 90% of a year's storm events occurring anywhere in Florida produce a total of 2.54 cm (1 inch) of rainfall or less (Anderson, 1982). Also, 75% of the total annual volume of rain falls in storms of 2.54 cm or less.

Runoff Pollutant Loads - The first flush of pollutants refers to the higher concentrations of stormwater pollutants that characteristically occur during the early part of the storm with concentrations decaying as the runoff continues. Concentration peaks and decay functions vary from site to site depending on land use, the pollutants of interest, and the characteristics of the drainage basin. Florida studies (Wanielista and Shannon, 1977; Miller, 1985) indicated that for a variety of land uses the first 1.27 cm (.5 inch) of runoff contained 80-95 percent of the total annual loading of most stormwater pollutants. However, first flush effects generally diminish as the size of the drainage basin increases and the percent impervious area decreases because of the unequal distribution of rainfall over the watershed and the additive phasing of inflows from numerous small drainages in the larger watershed. In fact, as the drainage area increases in size above 40 ha (100 ac) the annual pollutant load carried in the first flush drops below 80% because of the diminishing first flush effect.

BMP Efficiency and Cost Data - Numerous studies conducted in Florida during the Section 208 program generated information about the pollutant removal effectiveness of various BMPs and the costs of BMP construction and operation. Analysis of this information revealed that the cost of treatment increased exponentially after "secondary treatment" (removal of 80% of the annual load) (Wanielista, et al., 1982).

Selection of Minimum Treatment Levels - After review and analysis of the above information, and after extensive public participation, the Department set a stormwater treatment objective of removing at least 80% of the average annual pollutant load for stormwater discharges to Class III (fishable/swimmable) waters. A 95% removal level was set for stormwater discharges to sensitive waters such as potable supply waters (Class I), shellfish harvesting waters (Class II) and Outstanding Florida Waters. The Department believed that these treatment levels would protect beneficial uses and thereby establish a relationship between the rule's BMP performance standards and water quality standards. The actual stormwater treatment volumes for various BMPs are set forth in Table 1.

ADMINISTRATION OF THE STORMWATER RULE

Under the Florida Water Resources Act of 1972, the

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ADMINISTRATION OF THE STORMWATER RULE

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Department of Environmental Regulation, a water quality agency, serves as the umbrella administering agency delegating authority to five regional water management districts whose primary functions historically have been related to water quantity management. Therefore, a second objective in developing the Stormwater Rule was to coordinate the water quality considerations of the Department's stormwater permits with the water quantity aspects of the Districts' surface water management permits.

Table 1. BMP Treatment Volumes for Stormwater Discharges to Class III Waters

SWALES - Infiltrate 80% of the runoff generated by a 3 yr-1 hr storm (typically about 2 inches of runoff)

RETENTION - Off-line infiltration of the first 0.5 inch runoff (DA <100 acres) or the runoff from the first 1 inch of rainfall, whichever is greater (DA >100 acres)

DETENTION WITH FILTRATION - Filtration of retention volume

WET DETENTION - Detention of the first 1 inch of runoff or volume calculated by 2.5 times % impervious, whichever is greater
- Commercial, industrial land uses must pretreat up to 0.5 inch runoff by infiltration BMPs

WETLANDS - Detention and assimilation of retention volume

NOTES:
1. Discharges to sensitive waters must treat 50% more stormwater volume and may require infiltration pretreatment
2. Discharges to sinkhole watersheds must treat first two inches of runoff (SRWMD criterion)

In addition, the delegation of the stormwater permitting program allows for minor adjustments to the Stormwater Rule design and performance standards to better reflect local conditions. Florida is a very diverse state with major differences throughout in soils, geology, topography, rainfall, etc., which can directly affect the usability and treatment effectiveness of a BMP. Such problems can be minimized by adoption by the Districts of slightly different design and performance standards which are approved by the Department prior to implementation. Both the Department's and Districts' stormwater rules essentially require a new development to include a comprehensive stormwater management system. The system should be viewed as a "BMP treatment train" in which a number of different BMPs are integrated into a

comprehensive system that provides aesthetic and recreational amenities in addition to the traditional stormwater management objectives.

BMP GUIDELINES

In addition to the stormwater treatment volumes, other design and performance standards have been set to assure that BMPs function optimally to attain the stormwater treatment goal and other management objectives (Livingston, et al., 1988). These guidelines will be discussed for each of the BMPs currently being used extensively in Florida.

Swales - are defined by Chapter 403, Florida Statutes, as manmade trenches that:

- have a top width-to-depth ratio of the cross section equal to or greater than 6:1, or side slopes equal to or greater than 3 feet horizontal to 1 foot vertical.
- contains contiguous areas of standing or flowing water only following a rainfall event.
- is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment and nutrient uptake.
- is designed to take into account the soil erodibility, soil percolation, slope, slope length and drainage area so as to prevent erosion and reduce pollutant concentration of any discharge.

Swale treatment of stormwater is accomplished primarily by infiltration of runoff and secondarily by adsorption and vegetative filtration and uptake (Yousef, et al., 1985). Recent investigations have concluded that Florida soil, slope and water table conditions essentially preclude the use of swales as the sole BMP to treat stormwater (Wanielista, et al., 1985). Therefore, the greatest utility of swales is as a pretreatment BMP within a BMP treatment train stormwater system. Infiltration pretreatment can be easily accomplished by using raised storm sewer inlets within the swale, or by elevating driveway culverts or using swale blocks to create mini-retention areas.

Retention - Off-line retention areas which receive the first flush volume only while the later runoff is diverted to a flood control BMP are the most effective stormwater treatment practice. Treatment is achieved through diversion and infiltration of the first flush thereby providing total pollutant removal for all stormwater that is retained on-site. To reduce operation needs, increase aesthetics and reduce the land area needed for stormwater treatment, retention areas should be incorporated into a site's landscaping and open space areas. Effectiveness of retention areas can be increased and groundwater impacts decreased by:

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1. Infiltrating the stormwater treatment volume within 72 hours or within 24 hours if the retention area is grassed.
2. Grassing the retention area bottom and side slopes--reduces maintenance and maintains soil infiltration properties.
3. Maintaining at least three feet between the bottom of the retention area and seasonal high water tables or limerock.
4. In Karst sensitive areas, using several small, shallow infiltration areas to prevent formation of solution pipe sinkholes within the system.

Exfiltration trenches typically are used in highly urbanized areas where land is unavailable for retention basins. They consist of a rock filled trench, surrounded by filter fabric, in which a perforated pipe is placed. The stormwater treatment volume is stored within the pipe and exfiltrates out of the perforations into the gravel envelope and into the surrounding soil. Pretreatment with catch basins to remove sediments and other debris is essential to prevent clogging.

Detention with Filtration - systems were proposed as an alternative to retention for those areas of Florida where local conditions, especially flat topography and high water tables, prevent infiltrating the stormwater treatment volume. The filters must consist of two feet of natural soil or other suitable fine textured granular media which meets certain specifications including:

- Filters must have pore spaces large enough to provide sufficient flow capacity so that the filter permeability is equal to or greater than the permeability of the surrounding soil.
- The design shall assure that particles within the filter do not move.
- When sand or other fine textured material other than natural soil are used for filtration, the filter material will meet the following criteria:
  a) Be washed (less than 1 percent silt, clay or organic matter) unless filter cloth is used to retain such materials within the filter
  b) Have a uniformity coefficient between 1.5 and 4.0
  c) Have an effective gain size of 0.20 to 0.55 mm in diameter.
- Be designed with a safety factor of at least two.
- Will recover the treatment volume (bleed down) within 72 hours.

Filters are placed in the bottom or sides of detention areas where the filtered stormwater is collected in an underdrain pipe and then discharged. Experience has shown that these filters are very difficult to design and construct. Operation is also difficult because of low hydraulic head and maintenance is nearly impossible. It

is not a question of if a filter will clog, only when it will clog. In addition, filters are designed to remove particulate pollutants and do not remove dissolved pollutants such as phosphorus or zinc. Therefore, filtration systems are no longer recommended for use except under very special conditions and where a full time maintenance entity such as a local government will assume such responsibilities.

Wet Detention - systems consist of a permanent water pool, an overlying zone in which the stormwater treatment volume temporarily increases the depth while it is stored and slowly released and a shallow littoral zone (biological filter). In addition to their high pollutant removal efficiencies (EPA, 1983b), wet detention systems can also provide aesthetic and recreational amenities, a source of fill for the developer and even "lake front" property which brings a premium price.

Wet detention criteria are listed in Table 2. These have been developed to take full advantage of the biological, physical and chemical assimilation processes occurring within the wet detention system. If the system is designed as a development amenity, the use of pretreatment BMPs integrated into the overall stormwater management system is highly recommended to prevent algal blooms or other perturbations that would reduce the aesthetic value. Placing raised storm sewers in grassed areas such as parking lot landscape islands, using swale conveyances, or a perimeter swale/berm system along the detention lake shoreline are techniques that have been used frequently.

Table 2. Wet Detention Guidelines

- Treatment volume as per Table 1.
- Treatment volume slowly recovered in no less than 120 hours with no more than half of the volume discharged within the first 60 hours following the storm.
- Volume in the permanent pool should provide a residence time of at least 14 days.
- At least 30% of the surface area shall consist of littoral area with slopes of 6:1 or flatter that is established with appropriate native aquatic plants selected to maximize pollutant uptake and aesthetic value.
- Littoral zone plants shall have a minimum 80% survival rate and coverage after two years. Cattails and other undesirable plants shall be removed.
- Littoral zone is concentrated near the outfall or in a series of shallow benches ending at the outfall.
- Side slopes no steeper than 4:1 out to a depth of two feet below the level of the permanent pool.
- Maximum depth of 8-10 feet below the invert of the discharge structure is recommended. Maximum depth

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shall not create aerobic conditions in bottom sediments and waters.

- Maximize flow length possible between inlets and outlet; a length to width ratio of at least 3:1 is recommended. Diversion barriers such as baffles, islands or a peninsula should be used if necessary to increase flow length and length to width ratio.
- An oil and grease skimmer shall be designed into the outlet structure.
- If the system is planned as a "real estate lake", pretreatment by infiltration is recommended.
- Inlet areas should include a sediment sump.

Wetland Treatment - was authorized by the 1984 Henderson Wetlands Protection Act which allows stormwater treatment in wetlands that are connected by an intermittent water course which flows in direct response to rainfall thereby causing the water table to rise above ground surface. Not only does this take advantage of natural treatment mechanisms but it gives another economic value to wetlands, an incentive to the developer to use not destroy the wetland, and it revitalizes ditched and drained wetlands by providing water.

Wetlands may be viewed as nature's kidneys--they store stormwater, dampen floodwaters, and also transform pollutants and even retain them thereby providing natural stormwater treatment (Richardson, 1988). However, care must be taken to protect the numerous assimilation mechanisms within the wetland plants and sediments. In addition, the wetland hydroperiod--the duration that water stays at various levels--must be protected or restored since it determines the form, function and nature of the wetland. Therefore, pretreatment practices to attenuate stormwater volume and peak rate and to reduce oil, grease and especially sediment are essential. Normally, a pretreatment lake is constructed adjacent to the wetland.

The following guidelines are presented for incorporating wetlands into a stormwater management system:

- Treatment volume as per Table 1.
- Treatment volume slowly recovered in no less than 120 hours with no more than half of the volume discharged within the first 60 hours following the storm.
- Stormwater must sheet flow evenly through the wetland to maximize contact with the wetland plants, sediments and microorganisms. Spreader swales, distribution systems or a level spreader between the pretreatment lake and the wetland have been used extensively.
- Swales should be used for stormwater conveyance throughout the development.
- The hydroperiod must be protected or restored. Treatment capacity of the wetland is determined by the storage volume available between the normal low and

high elevations. These elevations are determined by site specific indicators such as lichen and moss lines, water stain lines, adventitious root formation, plant community zonation, hydric soils distribution and rack/debris lines.

- Erosion and sediment control during construction is essential since only a few inches of sediment deposited in the wetland will destroy the wetland filter.
- Inflow/outflow monitoring, sediment metal levels and vegetative transect monitoring is required to help evaluate the effectiveness of these systems and the impacts of stormwater additions to wetlands.

THE CHALLENGE AHEAD

Probably the biggest stormwater management problem facing Florida is how to reduce pollutant loadings discharged by older systems, especially local government master systems, constructed before the Stormwater Rule. These systems were designed solely for flood protection and rapidly deliver untreated stormwater directly to rivers, lakes, estuaries and sinkholes. Retrofitting urban stormwater discharges will become a national priority because of the recently enacted Section 402 of the 1987 Federal Clean Water Act. This section requires the establishment of a NPDES permitting program for stormwater discharges as described elsewhere in these proceedings (Gallop, et al.). The Act requires that these stormwater pollutant discharges be reduced to "the maximum extent practicable". Interpretation, implementation and enforcement of this standard could prove extremely difficult similar to the problems Florida encountered in implementing its first stormwater regulations (17-4.248)

Establishing a stormwater program to retrofit existing systems presents many technical, institutional and financial dilemmas. The unavailability and cost of land in urbanized areas make the use of conventional BMPs infeasible in most instances. Current state laws and institutional arrangements promote piecemeal, crises solving approaches aimed at managing stormwater within political boundaries yet stormwater follows watershed boundaries. Land use planning and management must be fully integrated into the stormwater management scheme. Retrofitting is also prohibitively expensive and many local governments are already short of funds. Therefore, solving our existing urban stormwater problems will require imaginative, innovative approaches.

STORMWATER LEGISLATION

During the next year, stormwater legislation will be proposed in Florida to enhance the state's current program and initiate a long term effort to reduce pollutant

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loadings from older stormwater systems. Following is a brief discussion of some of the essential elements of such a program

Watershed Management - A watershed approach which integrates land use planning with the development of stormwater infrastructure is essential. After all, it is the intensification of land use and the increase in impervious surfaces within a watershed that creates the stormwater and water resources management problems. Consequently, a "watershed management team" effort involving state and local governments together with the private sector is necessary. In fact, local governments are the primary team member since they determine zoning and land use, they issue building permits and inspect projects, and they have code enforcement powers that can help to assure that stormwater systems are properly operated and maintained.

Local governments need to identify and map the existing natural stormwater system--the creeks, wetlands, flood plains, drainageways and natural depressional areas. Once mapped, these areas need to be zoned for conservation or low intensity uses compatible with the functions provided by the natural system. The existing manmade stormwater system must also be mapped and essential characteristics such as pipe size, drainage areas, invert elevations, etc., be determined. This information should then be fully integrated with the existing and future land use plan for the watershed and a master stormwater management plan developed and implemented. The Growth Management Act of 1985, which requires all local governments to adopt comprehensive plans addressing current and future land use with infrastructure needs, establishes a base structure that could promote a watershed management approach.

Treatment Requirements for Older Systems - Numerous problems inherent in a highly urbanized area prevent the application of new development stormwater treatment standards from being imposed on older systems. Instead a "watershed loading" concept is proposed which considers the beneficial uses of the receiving waters, the total stormwater load that can be assimilated by the receiving waters, a hierarchy of treatment levels based on BMP feasibility and local public perceptions about receiving water quality. For example, treatment standards would progressively increase as one moves from the downtown central business district to the suburbs to rural areas. However, the actual treatment level would depend on the watershed s total allowable loading which is based on citizen desires for certain beneficial uses of the receiving water.

Selective Targeting - The extremely high cost of retrofitting older urban stormwater systems also implies a

need for careful evaluation of pollutant reduction goals. A long term (25 years) plan based on prioritization of watersheds such that existing systems are selectively targeted for modification is needed to assure that citizens receive the greatest benefit (pollutant load reduction, flood protection) for the dollar. The upgrading of older systems must also be coordinated with other already planned infrastructure improvements such as road widenings. An excellent example of this approach is the Orlando Streetscape Project. While downtown streets were torn up for this downtown renovation, the existing stormwater system was modified by the addition of off-line exfiltration systems to reduce pollution loads to downtown lakes.

Education - Education programs for the general public and for professionals involved in stormwater management are vital. Citizens must understand how their everyday activities contribute to stormwater pollution. For example, citizens should not discard leaves, grass clippings, used motor oil or other material into swales or storm sewers. Even more importantly, comprehensive training and certification programs are needed for those in the private and public sectors who design, construct, inspect, operate or maintain stormwater management systems.

Funding - The cost of providing needed stormwater infrastructure improvements to address current and future flooding and water quality problems is gigantic. Yet local governments are already struggling financially and traditional revenue sources such as property taxes cannot be relied upon to pay for stormwater management. Instead a dedicated source of revenue based on contributions to the stormwater problem is needed. The stormwater utility can provide this. The City of Tallahassee implemented Florida's first stormwater utility in October 1986 and many other local governments have or are following this example.

Innovative BMPs - The infeasibility of using traditional BMPs to reduce stormwater pollutant loads in highly urbanized areas means that creative and innovative BMPs will be needed such as those discussed in this section.

Alum injection within storm sewers was used in Tallahassee to reduce stormwater loadings to Lake Ella (Harper, et al., 1986). A sonic flow meter measures storm sewer flow causing a flow proportional dose of aluminum sulfate to be injected and mix with the polluted stormwater. As the alum mixes with the stormwater, a small floc is produced which attracts suspended and dissolved pollutants by adsorption and enmeshment into and onto the floc particles. The floc then settles to the lakes bottom sediments, gradually blanketing and incorporating into the sediments thereby reducing internal recycling of nutrients and metals. Other advantages of alum injection include excellent pollutant reduction (>85%) and relatively low construction and operations costs, especially for the highly urbanized areas.

Pervious concrete consists of specially formulated mixtures of Portland cement, uniform open graded coarse aggregate and water. When properly mixed and installed pervious concrete surfaces have a high percentage of void space which allows rapid percolation of rainfall and runoff. Pervious concrete is being used widely in Florida, especially for parking lots, and could be an important BMP to reduce stormwater loadings in highly urbanized areas. Recent field investigations of pervious concrete parking areas that have been in place for up to 12 years, revealed that the infiltration capacity of the concrete has not decreased significantly, a major concern. Further information about the use, design and construction of pervious concrete surfaces is available (FCPA, 1988).

Improved street sweepers that will pick up the small particles (<60 microns) that contain high concentrations of metals and other pollutants could also prove valuable in reducing stormwater loadings, especially from downtown business districts where other BMPs will usually be infeasible. Initial evaluation of an innovative sweeper design indicates that this sweeper can remove these small particles (Stidger, 1988). However, extensive watershed tests to evaluate the machine's cost-effectiveness, pollution removal effectiveness and other advantages or disadvantages will not be undertaken until later this year.

Regional stormwater systems which manage stormwater from several developments or an entire drainage basin offer many advantages over the piecemeal approach that relies upon small, individual on-site systems. They provide economies of scale in construction, operation and maintenance. Regional systems can also help manage stormwater from existing and future land uses and will be a central part of any retrofitting program. Another reason for a watershed management approach that fully integrates land use and stormwater management.

The Southeast Lakes Program--A Model - Many of the above elements of a watershed-wide master stormwater planning approach are being implemented by the City of Orlando. The city has adopted an excellent local stormwater ordinance, developed a fine community education program and a prioritized urban lake management program (Zeno and Palmer, 1986). One of the most innovative programs is the Southeast Lakes Project which is designed to correct flooding problems and to reduce stormwater pollutant loads to 15 urban lakes and 58 drainage wells which currently convey untreated stormwater to an aquifer. A corrective

watershed management plan was cooperatively developed by the city, its consultants, the Department of Environmental Regulation and the St. Johns River Water Management District. The project was initiated not because of enforcement of water quality standards but because of a loss of beneficial uses and local citizen desires and perceptions. Modifications to the existing stormwater systems will be made over a ten-year period with treatment requirements based on "net environmental improvement" and total watershed load.

One of the most important aspects of the project is the use of innovative BMP designs which promote multiple objectives and take advantage of city-owned properties. At Al Coith Park a spreader swale will be built on the park's perimeter. When it rains, runoff will enter and fill the swale, overtopping the sidewalk berm and sheet flow across the grassed parkland where it will percolate into the ground. At Lake Greenwood, the surrounding city-owned land is being converted into an urban wetland and expanded lake. The wetland and lake is a complex treatment train which incorporates many BMPs into a very aesthetically pleasing stormwater system and park. In addition to improved stormwater management, the citizens are receiving added benefits of recreation and open space. In addition, the retrofitting project has stimulated redevelopment and renovation of existing properties thereby providing citizens with economic benefits as property values rise.

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Discussion of Mr. Livingston's Paper

Question:

Have you considered ground water impacts?

Answer:

Yes, in two studies. But I admit there isn't much information for criteria developed yet.

Question:

Do you have a data base for developing sediment-related criteria?

Answer:

Some, in salt water. We're getting an excellent data base on heavy metals on sediments.

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FUNCTIONAL EQUIVALENT DOCUMENT: DEVELOPMENT OF WATER QUALITY CONTROL PLANS FOR:

1. INLAND SURFACE WATERS OF CALIFORNIA,
2. ENCLOSED BAYS AND ESTUARIES OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD, AUGUST, 1990

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STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER QUALITY

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FUNCTIONAL EQUIVALENT DOCUMENT:

DEVELOPMENT OF THE WATER QUALITY CONTROL PLANS FOR:

1. **INLAND SURFACE WATERS OF CALIFORNIA**

   (CALIFORNIA INLAND SURFACE WATERS PLAN)

2. **ENCLOSED BAYS AND ESTUARIES OF CALIFORNIA**

   (CALIFORNIA ENCLOSED BAYS AND ESTUARIES PLAN)

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AUGUST 6, 1990

State of California

STATE WATER RESOURCES CONTROL BOARD

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CALIFORNIA INLAND SURFACE WATERS PLAN

WATER QUALITY CONTROL PLAN FOR INLAND SURFACE WATERS OF CALIFORNIA

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In developing site-specific objectives, all the requirements for of the Porter-Cologne Water Quality Control Act and the federal Clean Water Act must be are met.

Alternate site-specific water quality objectives as established by the Regional Board are not effective until approved by the State Board with the concurrence of EPA.

Chapter III. PROGRAM OF IMPLEMENTATION PROVISIONS

A. Effective Date

This Plan plan is in effect as of the date of adoption by the State Water Resources Control Board.

BC. Mixing Zones, Effluent Limitations, and Monitoring Requirements, and Compliance Determination

The State Board is authorized to issue and enforce NPDES permits and waste discharge requirements established pursuant to the Federal Clean Water Act and the Porter-Cologne Act.

Effluent limitations in WDRs shall be imposed such that the water quality objectives established by this plan in Tables 1, 2, and 3 shall not be exceeded in the receiving water outside any designated mixing* zone. Effluent limitations shall not cause receiving water concentrations of pollutants to exceed levels that existed on the date of adoption of this plan. Where the Regional Board is satisfied that any substance(s) in Tables 1, and 2, and 3 does not occur, or is not likely to occur, in a discharger's effluent, the Regional Board may elect not to establish effluent limitations for such substance(s), provided the discharger conducts periodic monitoring for all pollutants in Tables 1, and 2, and 3 and certifies that such substance(s) are not in the waste* stream, and that no change has occurred that could cause such substance(s) to be present in the waste* stream. Such a determination shall be based on the discharger's certification that the substance is not in the waste* stream and that no source has been identified which would likely result in the presence of such substance in the waste* stream. This certification shall be accompanied, at a minimum, by laboratory analysis of the discharge for substances listed in Tables 1 and 2, and by process and treatment description which demonstrate the absence of such substances in the waste* stream. At a minimum, this monitoring and certification shall be required prior to issue or and reissue of NPDES permits or waste discharge requirements WDRs. The Regional Boards may choose to shall have the discretion to not require periodic monitoring and certification for these pollutants in de minimus low volume discharges determined to be of little threat to water quality.

B1. Application of Mixing* Zones

A mixing* zone is a volume of a receiving water that is allocated for mixing with a wastewater discharge. Mixing* zones will be

* See Appendix I for definition of terms.

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granted or denied by the Regional Boards after consideration of site-specific factors and according to the provisions of this section. ~~If a mixing zone is allowed, numerical water quality objectives must be met at the edge of the mixing zone. Numerical~~ Water quality objectives are to be met throughout a waterbody except within any mixing* zones granted by a Regional Board. A mixing* zone is not a source* of drinking water. To the extent of any conflict between this determination and the Sources of Drinking Water Policy (State Board Resolution No. 88-63), this determination supersedes the provisions of the policy.

All Inland Surface Waters

~~1.~~ o Mixing* zones can only be applied to point source discharges, and nonpoint source discharges with a physically identifiable point of discharge, ~~to surface waters~~ regulated through ~~NPDES permits, waste discharge requirements, or reclamation requirements~~ WDRs issued or waived by the Regional Boards. A mixing* zone shall apply only in the calculation of water* quality-based permit limits and shall not be used to meet technology*-based permit limits.

~~2.~~ o The primary goals when designating a mixing* zone are to ~~limit~~ define areas where ~~numerical~~ water quality objectives need ~~are~~ not be met and to avoid unreasonable wastewater treatment. The Regional Boards must balance these goals before granting a mixing* zone. If a Regional Board allows a mixing* zone, the WDR ~~NPDES permit, waste discharge requirements, or reclamation requirement~~ shall specify the method by which the mixing* zone was derived and either the dilution ratio granted to the discharge or the point in the receiving water at which water quality objectives must be met.

~~3.~~ o The Regional Boards shall deny a mixing* zone if necessary to protect beneficial uses. Careful consideration shall be given to the appropriateness of a mixing* zone where the discharge contains pollutants that are carcinogenic, mutagenic, or teratogenic to humans, and for pollutants that are attractive to aquatic organisms, persistent*, or subject to bioaccumulation*.

~~4.~~ o A mixing* zone shall be as small as practical ~~possible~~. A mixing* zone shall not restrict passage of aquatic life. Pollutants in a mixing* zone shall not create objectionable* bottom deposits. Acute* toxicity shall not occur in a mixing zone.

~~5. A Regional Board may specify more stringent mixing zone provisions than those contained in this plan. Less stringent mixing zone provisions than those contained herein may be allowed by a Regional Board with State Board and EPA concurrence, as indicated under "Exceptions to Plan Requirements".~~

* See Appendix 1 for definition of terms.

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Lakes and Reservoirs

Mixing* zones for discharges to lakes and reservoirs shall extend no greater than 25 feet from the point of discharge. No more than 5 percent of the volume of a lake or reservoir can be allocated for the sum of mixing* zones in that waterbody. Where a Regional Board has identified a site-specific concern with a particular pollutant in a lake or reservoir environment, a maximum* dilution credit may be applied.

Rivers and Streams

Mixing* zones for discharges to rivers and streams shall be based on a designated volume or percentage of stream flow, as determined by the Regional Board. If a Regional Board ~~determines a dilution ratio by~~ allocates~~ing~~ a percentage of the stream flow for mixing, the outfall must be designed for rapid mixing in the receiving waterbody. Regardless of the method used, the mixing* zone shall not extend more than 250 feet from the point of discharge, to ensure rapid mixing, or be located less than 500 feet from an adjacent mixing* zone. A zone* of passage for aquatic life should be provided if, in doing so, adverse impacts on sensitive aquatic species would be minimized. ~~Design flows~~ Dilution ratios for ~~permit~~ effluent limitation derivation can be based on either steady-state* or dynamic* considerations.

2. Calculation of Effluent Limitations

Where a wasteload allocation has not been completed, water quality-based effluent limitations shall be developed using one of the following methods, (a) or (b):

(a) $Ce = Co + D(Co - Cb)$, when $Co > Cb$, and
$Ce = Co$, when $Co < Cb$.

~~Effluent limitations (Ce) for substances identified in Table I shall be determined through the use of the following equation:~~

~~$Ce = Co + D(Co - Cb)$~~

where Ce = the effluent concentration limit for the substance,
Co = the ~~concentration~~ (water quality objective) for the substance to be met in the receiving waterbody ~~at the edge of any designated mixing* zone (Table I objectives)~~
Cb = the ambient background concentration of the substance in the receiving waterbody, and
D = the allocated dilution ratio, expressed as parts receiving water per part wastewater, based on mixing* zone provisions.

* See Appendix I for definition of terms.

Ambient background concentration (Cb) means the median concentration of a substance, in the vicinity of a discharge, which is not influenced by the discharge. Ambient concentrations should be determined using analytical methods at least as sensitive as those used to determine compliance with effluent limitations.

(b) Regional Boards may elect to apply the statistically-based approach to the calculation of effluent limits, as described in EPA's Technical Support Document for Water Quality-Based Toxics Control (EPA-440/4-85-032, September 1985) where sufficient information exists to adequately characterize effluent and receiving water. ~~In situations where a Regional Board determines that the statistically-based approach to calculation of effluent limitations, as described in EPA's Technical Support Document for Water Quality-Based Toxics Control (U.S. EPA, 1985), may appropriately be applied,~~

For discharges to waterbodies which support aquatic habitat beneficial uses solely as a result of the discharge of wastewater, effluent limitations in WDRs for substances for which the aquatic life objectives are limiting shall be applied as follows:

(1) Initial effluent limitations shall be based on the aquatic life objectives in Tables 1 or 2 and calculated by the methods described above.

(2) Within 5 years, revised effluent limitations based on effluent quality may be established for substances other than selenium and endrin, provided the chronic toxicity limitation is consistently met.

(3) Any increase in an effluent limitation as a result of this process shall not constitute backsliding.

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The four-day average shall apply as the mean concentration from samples collected over a four-day period.

The daily average shall apply as the mean concentration from samples collected during a 24-hour period.

The one-hour average shall apply as the mean concentration from samples collected during a one-hour period.

The instantaneous maximum shall apply to any single grab sample.

The 30-day average shall apply as the mean concentration from samples collected over a 30-day period.

The six-month median shall apply as a moving median of daily values for any 180-day period in which daily values represent flow-weighted average concentrations within a 24-hour period. For intermittent discharges, the daily value shall be considered to equal zero for days on which no discharge occurred.

See Appendix I for definition of terms.

State of California

STATE WATER RESOURCES CONTROL BOARD

1990

CALIFORNIA ENCLOSED BAYS AND ESTUARIES PLAN

WATER QUALITY CONTROL PLAN FOR ENCLOSED BAYS AND ESTUARIES OF CALIFORNIA

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recalculation of the objective using measured site-specific bioconcentration factors, fish consumption, body weight, and/or other relevant factors; and

f) the ~~alternate~~ site-specific objectives will provide for the attainment and maintenance of the water quality objectives of downstream waters; ~~and~~ or

g) if the full potential of designated beneficial uses ~~aquatic life~~ is not protected, a use attainability analysis has been conducted.

In developing site-specific objectives, ~~the~~ requirements ~~for~~ of the Porter-Cologne Water Quality Control Act and the federal Clean Water Act must be ~~are~~ met.

~~Alternate site-specific water quality objectives as established by the Regional Board are not effective until approved by the State Board with the concurrence of EPA.~~

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Chapter III. PROGRAM OF IMPLEMENTATION ~~PROVISIONS~~

A. Effective Date

This ~~Plan~~ plan is in effect as of the date of adoption by the State ~~Water Resources Control~~ Board.

B. Mixing Zones, Effluent Limitations, ~~and~~ Monitoring Requirements, and Compliance Determination

~~The State Board is authorized to issue and enforce NPDES permits and waste discharge requirements established pursuant to the federal Clean Water Act and the Porter-Cologne Act.~~

Effluent limitations in WDRs shall be imposed such that the water quality objectives established by this plan ~~in Tables 1, 2, and 3~~ shall not be exceeded in the receiving water outside any designated mixing* zone. ~~Effluent limitations shall not cause receiving water concentrations of pollutants to exceed levels that existed on the date of adoption of this plan.~~ Where the Regional Board is satisfied that any substance(s) in Tables 1~~,~~ and 2~~, and 3~~ does not occur, or is not likely to occur, in a discharger's effluent, the Regional Board may elect not to establish effluent limitations for such substance(s), provided the discharger conducts periodic monitoring for all pollutants in Tables 1~~,~~ and 2, ~~and 3~~ and certifies that such substance(s) are not in the waste* stream~~.~~ and that no change has occurred that could cause such substance(s) to be present in the waste* stream. Such a determination shall be based on the discharger's certification that the substance is not in the waste* stream and that no source has been identified which would likely result in the presence of such substance in the waste* stream. This certification shall be accompanied, at a minimum, by laboratory analysis of the discharge for substances listed in Tables 1 and 2, and by process and treatmentdescription which demonstrate the absence of such substances in the waste* stream. At a minimum, this monitoring and certification shall

* See Appendix 1 for definition of terms.

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be required prior to issue ~~or~~ and reissue of ~~NPDES permits or waste discharge requirements~~ WDRs. The Regional Boards may choose to ~~shall have the discretion to~~ not require periodic monitoring and certification for these pollutants in ~~de minimus~~ low volume discharges determined to be of little threat to water quality.

11. Application of Mixing* Zones

A mixing* zone is a volume of a receiving water that is allocated for mixing with a wastewater discharge. Mixing* zones will be granted or denied by the Regional Boards after consideration of site-specific factors and according to the provisions of this section. ~~If a mixing zone is allowed, numerical water quality objectives must be met at the edge of the mixing zone. Numerical~~ Water quality objectives are to be met throughout a waterbody except within any mixing* zones granted by a Regional Board. A mixing* zone is not a source* of drinking water. To the extent of any conflict between this determination and the Sources of Drinking Water Policy (State Board Resolution No. 88-63), this determination supersedes the provisions of the policy.

All Enclosed Bays and Estuaries

~~1.~~ a Mixing* zones can only be applied to point source discharges, and nonpoint source discharges with a physically identifiable point of discharge, ~~to surface waters~~ regulated through ~~NPDES permits, waste discharge requirements, or reclamation requirements~~ WDRs issued or waived by the Regional Boards. A mixing* zone shall apply only in the calculation of water* quality-based permit limits and shall not be used to meet technology*-based permit limits.

~~2.~~ b The primary goals when designating a mixing* zone are to ~~limit~~ define areas where ~~numerical~~ water quality objectives need ~~are~~ not be met and to avoid unreasonable wastewater treatment. The Regional Boards must balance these goals before granting a mixing* zone. If a Regional Board allows a mixing* zone, the WDR ~~NPDES permit, waste discharge requirements, or reclamation requirement~~ shall specify the method by which the mixing* zone was derived and either the dilution ratio granted to the discharge or the point in the receiving water at which water quality objectives must be met.

~~3.~~ c The Regional Boards shall deny a mixing* zone if necessary to protect beneficial uses. Careful consideration shall be given to the appropriateness of a mixing* zone where the discharge contains pollutants that are carcinogenic, mutagenic, or teratogenic to humans, and for pollutants that are attractive to aquatic organisms, persistent*, or subject to bioaccumulation*.

* See Appendix I for definition of terms.

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~~4~~/o A mixing* zone shall be as small as practical ~~possible~~. A mixing* zone shall not restrict passage of aquatic life. Pollutants in a mixing* zone shall not create objectionable* bottom deposits. Acute* toxicity shall not occur in a mixing zone.

~~5. A Regional Board may specify more stringent mixing zone provisions than those contained in this plan. Less stringent mixing zone provisions than those contained herein may be allowed by a Regional Board with State Board and EPA concurrence, as indicated under "Exceptions to Plan Requirements".~~

Enclosed Bays

Mixing zones for discharges with a high-rate diffuser to enclosed* bays shall not extend beyond the zone* of initial dilution. For discharges without a high-rate diffuser, or where a Regional Board has identified a site-specific concern with a particular pollutant in a bay ~~or estuarine~~ environment, a maximum* dilution credit may be applied.

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Estuarine Rivers and Streams

Mixing* zones for discharges to estuarine rivers and streams shall be based on a designated volume or percentage of stream flow, as determined by the Regional Board. If a Regional Board ~~determines a dilution ratio by~~ allocates~~ing~~ a ~~percentage of the stream flow for~~ mixing* zone, the outfall must be designed for rapid mixing in the receiving waterbody. Regardless of the method used, the mixing* zone shall not extend more than 250 feet from the point of discharge, to ensure rapid mixing, or be located less than 500 feet from an adjacent mixing* zone. A zone* of passage for aquatic life should be provided if, in doing so, adverse impacts on sensitive aquatic species would be minimized. ~~Design flows~~ Dilution ratios for effluent ~~permit~~ limitation derivation can be based on either steady-state* or dynamic* considerations.

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2. Calculation of Effluent Limitations

Where a wasteload allocation has not been completed, water quality-based effluent limitations shall be developed using one of the following methods, (a) or (b):

(a) $Ce = Co + D(Co - Cb)$, when $Co > Cb$, and
$Ce = Co$, when $Co \leq Cb$.

~~Effluent limitations (Ce) for substances identified in Table 1 shall be determined through the use of the following equation:~~

*See Appendix I for definition of terms.

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~~Ce = Co + D(Co - Cb)~~

where Ce = the effluent concentration limit for the substance,
Co = the ~~concentration~~ (water quality objective) for the substance to be met in the receiving waterbody ~~at the edge of any designated mixing zone (Table 1 objectives),~~
Cb = the ambient background concentration of the substance in the receiving waterbody, and
D = the allocated dilution ratio, expressed as parts receiving water per part wastewater, based on mixing* zone provisions.

Ambient background concentration (Cb) means the median concentration of a substance, in the vicinity of a discharge, which is not influenced by the discharge. Ambient concentrations should be determined using analytical methods at least as sensitive as those used to determine compliance with effluent limitations.

(b) Regional Boards may elect to apply the statistically-based approach to the calculation of effluent limits, as described in EPA's Technical Support Document for Water Quality-Based Toxics Control (EPA-440/4-85-032, September 1985) where sufficient information exists to adequately characterize effluent and receiving water. ~~In situations where a Regional Board determines that the statistically-based approach to calculation of effluent limitations, as described in EPA's Technical Support Document for Water Quality-Based Toxics Control (U.S. EPA, 1985), may appropriately be applied.~~

For discharges to waterbodies which support aquatic habitat beneficial uses solely as a result of the discharge of wastewater, effluent limitations in WDRs for substances for which the aquatic life objectives are limiting shall be applied as follows:

(1) Initial effluent limitations shall be based on the aquatic life objectives in Tables 1 or 2 and calculated by the methods described above.

(2) Within 5 years, revised effluent limitations based on effluent quality may be established for substances other than selenium and endrin, provided the chronic toxicity limitation is consistently met.

(3) Any increase in an effluent limitation as a result of this process shall not constitute backsliding.

The four-day average shall apply as the mean concentration from samples collected over a four-day period.

The daily average shall apply as the mean concentration from samples collected during a 24-hour period.

The one-hour average shall apply as the mean concentration from samples collected during a one-hour period.

* See Appendix 1 for definition of terms.

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STORM RUNOFF IN LOS ANGELES AND VENTURA COUNTIES

Henry Schafer and Richard Gossett

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT REPORT, 1988

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Final Report

STORM RUNOFF IN LOS ANGELES AND VENTURA COUNTIES

TO

California Regional Water Quality Control Board
Los Angeles Region
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FROM

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SCCWRP Contribution C292

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State of California

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

Resolution No. 89-002

Regional Board Acceptance of Storm Runoff Report

WHEREAS:

1. The Los Angeles Regional Water Quality Control Board and the Southern California Coastal Water Research Project conducted a cooperative study of storm runoff in Los Angeles and Ventura Counties.

2. Pursuant to terms of the cooperative agreement, the Southern California Water Research Project has completed and submitted a final report entitled Storm Runoff in Los Angeles and Ventura Counties.

3. The study provides new information on the contaminant load that enters the coastal waters off Los Angeles and Ventura Counties.

4. A significant reduction in pollutant discharge to coastal waters can be achieved through better management and control of urban runoff.

NOW, THEREFORE, BE IT RESOLVED:

1. That the Regional Board accepts the report, Storm Runoff in Los Angeles and Ventura Counties; and

2. That the report be distributed to all affected agencies and interested parties; and

3. That staff be directed to work with all appropriate agencies to develop an urban runoff management strategy to control pollutant discharges to coastal waters.

I, Robert P. Ghirelli, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of a resolution adopted by the California Regional Water Quality Control Board, Los Angeles Region, on February 27, 1989.

Robert P. Ghirelli

ROBERT P. GHIRELLI, D.Env.
Executive Officer

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SUMMARY

Forty-nine samples of runoff were collected from eight sites in Los Angeles and Ventura Counties on September 23-25, 1986, during the first rain after the dry season. Six sites were near the mouths of major storm channels and three were spread along the Los Angeles River, the largest source of gaged runoff in Southern California. Suspended solids, oil and grease, total extractable organics (TEO), trace metals, DDT, polychlorinated biphenyl compounds (PCBs), polycyclic aromatic hydrocarbons (PAHs), and n alkanes were measured. Fifteen-minute flow data were obtained for most sites from the county flood control districts. Because the storm was unpredicted and so early in the rain season, samples were not taken as regularly as planned, but low-flow, high-flow, and post high-flow samples were taken at each site.

In general the highest contaminant concentrations occurred near the peak flows and not at the first increase in flow. With few exceptions the highest concentrations appeared at the channels with the greatest flows also making them the greatest sources of contaminant mass emissions.

The two Ventura sites showed minimal increases in flows, probably due to a limited amount of impermeable surface area and the dry status of the soils. The Santa Clara River samples had the highest suspended solids concentrations and DDT levels of any site, but the low volumes produced very low mass emissions.

Accurate flow measurements at the four Los Angeles County sites were obtained only for Ballona Creek and the three sites on the Los Angeles River. There was no gage on the Dominguez Channel and one of two gages required to determine the total flow for the San Gabriel River failed during the storm.

Flows from the Los Angeles River, Ballona Creek and the San Gabriel River were large; each exceeded the daily flow of the largest municipal wastewater treatment plant in the county. The runoff of the Los Angeles River at Willow Street and Ballona Creek had the highest mean concentrations of almost all contaminants. Concentrations of oil and grease, cadmium, chromium, copper, and nickel were similar to Hyperion 1985 five-mile effluent values, while lead, zinc, DDT, and PCB concentrations were higher.

Within the Los Angeles River system, runoff contaminant concentrations increased from the headwaters at Tujunga Wash through the mid-river site at the San Fernando Valley to the mouth near Long Beach. Most contaminants were below detectable limits at Tujunga Wash above any land development.

Downtown Los Angeles and the commercial and industrial area of south Los Angeles County added less than one-half the flow of the upstream drainage but three to five times the mass of contaminants.

Petroleum hydrocarbon characteristics in runoff were not very consistent within or between channels. However gas chromatograms for most samples contained unresolved complex mixtures (UCMs) humps characteristic of crankcase oil inputs. The relative abundances of polycyclic aromatic hydrocarbons (PAHs) in runoff samples at several sites indicated the input of unweathered petroleum and combustion by-products with the latter in greater amounts.

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Previous studies found that the mean concentrations of contaminants in the Los Angeles River did not change much between 1971/72 and 1979/80, except for lead and PCBs. Our preliminary results for the Los Angeles River do not indicate much change since 1979 with the exception of a fourfold decrease in DDT concentrations.

INTRODUCTION

This report is the result of a cooperative study with the Los Angeles Regional Water Quality Control Board to measure runoff contaminant concentrations and to estimate mass emissions during storm flow conditions at several important channels in Los Angeles and Ventura Counties. Three to ten samples were taken at each of seven sites (49 samples total) during a 48-h period in order to sample peak and decreasing flow stages. We measured concentrations of suspended solids, percent volatile solids, oil and grease, TEO, cadmium, chromium, copper, nickel, lead, zinc, DDT, DDD, DDE, PCBs, n-alkanes and PAHs in whole water samples. A subset of samples was analyzed for triterpanes and steranes by UCLA. Rainfall and flow data were obtained from the County Flood Control Districts.

Results from a second storm sampled in January 1987 at these sites are not included in this report but will be reported when complete data become available. This study is part of a long-term Southern California Coastal Water Research Project (SCCWRP) program to update and improve past estimates of contaminant inputs to the Southern California Bight. By the summer of 1988 we will have sampled storm runoff from the largest storm channels in four of the coastal counties of Southern California.

Background Studies

Southern California Bight

Beach closures, pelican reproduction failures, fin rot, contaminated fish seizures, and kelp bed disappearances off the Southern California coast have stimulated interest in anthropogenic inputs of contaminants to Southern California coastal waters since the 1960's. Extensive monitoring of trace metals and chlorinated organics in municipal wastewater effluents, the principal source of most anthropogenic contaminants to the Southern California Bight (20, 26), began around 1970 and has expanded through the 1970's and 1980's. By 1985, source control, improved sludge handling, and increased treatment (additional advanced primary and secondary treatment) combined to reduce wastewater emissions significantly. Silver, cadmium, chromium, copper, mercury, nickel, lead, and zinc discharges were an average of 65% lower than peak (mid-1970's) emissions. DDT and PCB discharges were 99 and 90% lower, respectively. These reductions occurred despite increases in population and effluent flows (21). Recently, completed and planned municipal wastewater effluent improvements should continue to reduce outfall inputs while continued population growth and land development have made and will continue to make runoff a more important pollutant source of contaminants than it was 10 years ago.

Studies of contaminants in Southern California runoff are scarce compared with those available for municipal wastewater outfalls. Among possible reasons are (1) no agency has been responsible for storm drain water quality; (2) storm flow (which is responsible for most runoff volume and contaminant emissions) is unpredictable, highly variable and limited to a few months of the year; and (3) representative samples of storm flow are not easily obtained.

One of the first studies to measure runoff impacts in Southern California was conducted by Chen in the early 1970's at Marina del Rey (4). Water and sediment samples were taken from the marina near two storm drains and Ballona Creek over several stormy periods. It was determined that storm runoff had little direct effect on trace metal and pesticide levels in the water column within the marina. In contrast, sediments near the runoff channels were highly contaminated; sediments near the storm drains with DDE levels up to 5.5 mg/dry kg were 60 times more contaminated than sediments near the Hyperion five-mile outfall.

The most detailed and complete study of runoff emissions was conducted by SCCWRP during 1971/72, an unusually dry year (43% of average annual runoff). Wet and dry weather flows were sampled at four major rivers, and dry flow was sampled at an additional 11 streams in Southern California (20). Based on this limited survey it was concluded that the contribution of contaminants via runoff was less than 10% of that discharged by municipal outfalls in southern California. Exceptions to this generalization included suspended solids, nitrate, nitrogen, iron, manganese, lead, and cobalt. Two contaminants of note were suspended solids (274,000 metric tons, 99% of effluent emissions) and lead (90 metric tons, 43% of effluent emissions). DDT (0.12 metric tons) and PCB (0.25 metric tons) emissions were about 1 and 3%, respectively, of the combined outfall values.

Using the same sampling technique, Young et al. (25) repeated a similar study of three storms at the largest source of runoff in Southern California, the Los Angeles River (30% of the total average annual gaged flow from Southern California) in 1979/80. In that year low flow was responsible for only 5% of the annual discharge, and low-flow contaminant concentrations were approximately one-half of the storm concentrations. This indicates that storm runoff was by far the most important source of mass emissions. The 1979/80 study and the 1971/72 study also showed that with the exception of nickel, 88-99% of the trace metal and chlorinated hydrocarbons were associated with particulates (>0.4 m). A comparison of flow-proportioned mean concentrations of 10 trace metals, DDT, and PCBs between two storms in 1971/72 and three storms in 1979/80 showed that the standard error of 10 of the 12 contaminants was less than 50% (six of the twelve were less than 20%). This suggests that there was not a large difference in mean concentration values between years. Differences in lead and PCB concentrations were much larger than those of the other contaminants, and mean concentrations (between 1971/72 and 1979/80) showed a six- and eightfold reduction, respectively. These reductions were most likely due to legal restrictions on the industrial use of both compounds.

The Los Angeles County Flood Control District (now called the Department of Public Works) has conducted detailed monitoring of storm channel contaminants since the late 1960's. Monthly samples from 30 channel sites were collected from 1967 through 1984 (5). Biochemical oxygen demand (BOD) and levels of oil and grease, nutrients, trace metals, pesticides, and bacteria were measured (5). In 1985, the monthly monitoring program was reduced to 7 stations plus 14 additional stations monitored bimonthly or quarterly and 15 stations sampled twice annually during storm flows (6). Although this is the largest storm channel data base for Southern California and may reveal trends in low flow concentrations, it was not designed for the estimation of mass emissions because corresponding flows have not been recorded. In addition, runoff was rarely sampled during peak flows when

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concentrations are most variable and emissions are most significant. Despite limitations of this data set, Garber (12) has made some preliminary estimates of long-term emissions rates to Santa Monica Bay. He used the annual average concentrations from Flood Control contaminant data and annual flow measurements from four gaged channels and assumed individual storm drains contribute about 40% of the gaged runoff. The single greatest cause of variation in annual emissions is variation in annual water discharge volume.

Figures 1 and 2 show the annual flow and lead emissions between 1967 and 1982 for the Los Angeles River, the total runoff to Santa Monica Bay, and the Hyperion combined outfalls. From the available data, Garber (12) estimated that Santa Monica Bay runoff inputs (1967-1982) of lead, selenium, nickel, copper, mercury, chromium, and total identifiable hydrocarbons to be 40%, 17%, 14%, 6%, 52%, 9%, and 7%, respectively, of the 1987 emissions from Hyperion's two outfalls. These estimates are probably low because storm conditions (which normally lead to much higher contaminant concentrations) were not proportionally sampled. As of the end of 1987 the sludge outfall discharges have been terminated reducing many outfall contaminant inputs by 50% and further increasing the importance of runoff as a source of contaminants.

The Pico-Kenter storm drain in Santa Monica delivered a small but regular flow that accumulated on the beach. This site has been the focus of attention because of petroleum-like discharges that have closed the beach and because of high incidences of cancer in lifeguards who have worked in the area (7). The linkage of storm drain constituents to the incidences of cancer has been investigated (and discounted) and chemical values (nutrients, BOD, chemical oxygen demand (COD), oil and grease, phenols, cyanide, and 14 metals) have been reported (7). Estimates of mass emissions have been made by using Pico-Kenter contaminant data and County Flood Control flow data for all of Santa Monica Bay (18). These calculations estimate that runoff to the bay is responsible for 10% of the oil and grease and 10-50% of the trace metals that the seven-mile sludge line discharged in 1981.

Studies of water and sediment quality in Marina del Rey, the adjacent mouth of Ballona Creek, and storm drains entering the harbor (13) have shown higher levels of contaminants at sites near the storm drains and creek mouth than in the harbor. Elevated contaminant concentrations and reduced dissolved oxygen were detected at most stations after storm runoff. Interestingly, measurements of oil and grease in runoff to Marina del Rey showed no decrease in the concentration ranges through three consecutive storms indicating a large reserve.

Eganhouse and Kaplan (9-11) characterized organics in Los Angeles River water from an early season storm in 1978 and compared constituents and masses of runoff inputs with municipal emissions. They found that 60% of the extractables were petroleum derived, whereas the non-hydrocarbons were mostly biogenic. Although runoff inputs of hydrocarbons were estimated to be one-half of municipal outfall inputs to Southern California, they were estimated to represent 2% of the global inputs from all sources to the ocean.

In 1986 Anderson and Gossett (1) reported on PAHs in marine sediments from the outfall and harbor areas between San Diego and Los Angeles. They found some of the highest levels near the mouths of the Los Angeles River, and the Dominguez Channel and near storm drains in San Diego Bay.

Background Outside Southern California

In comparison to Southern California runoff, the east coast of the United States has been extensively studied (2, 15, 16, 17, 23). There is also considerably more information about sources of contaminants. However, these studies were carried out in areas that receive much more frequent rain than Southern California does, and in most cases rainfall occurs throughout the year with short intervals between runoff events.

In a three-year study of contaminant sources and mass emissions to Narragansett Bay, Hoffman and Quinn (15) determined that runoff was the largest source of petroleum hydrocarbons, high molecular weight PAHs, lead, and zinc to the bay. Municipal outfalls were the major source of low-molecular-weight PAHs. Although highways and industrial areas occupied a relatively small portion of the drainage basin they were important sources because of their very high concentrations. Highways and industrial runoff contained, respectively, 40 and 80 times the petroleum hydrocarbons, 40 and 12 times the copper, 100 and 7 times the lead, and 160 and 15 times the zinc as residential runoff concentrations.

In Richmond, California, Stenstrom et al. (22) measured oil and grease emissions from five different land use areas in a basin that drains into San Francisco Bay. The authors concluded that runoff emissions were an important and growing problem and that 50% of the oil and grease emissions from the studied basin could be eliminated if emissions from industrial and parking facilities (11% of land in the basin) were controlled.

Ebbert and Wagner (8) examined 35 collection sites from eight urban areas throughout the United States, compared rain concentrations of contaminants with runoff concentrations, and found that rain could be a significant source of contaminants. The mean contributions of rain to runoff emissions were 74% for nitrate plus nitrite, 12% for COD, 12% for copper, 6% for lead, and 2% for suspended solids.

Richards and Holloway (19) used Monte Carlo techniques to evaluate the accuracy and precision of tributary load estimates using a 4000 data point sampling set. Hypothetical annual sampling programs with 12 to 600 samples were examined. The results showed that the bias and precision of loading estimates were influenced not only by the frequency and pattern of the sampling plan but also by the size of the drainage basin (smaller channels need more frequent sampling) and the behavior of the constituent measured. Stratified sampling with the bulk of the samples taken during the highest flow will produce the most accurate estimates. Estimates within 20% accuracy are suggested with only a few low flow measurements and careful concentrated sampling during the 2 or 3 greatest flows of the year (24).

OBJECTIVES

The primary objective of this study was to determine the concentrations of contaminants from major runoff sources and to estimate their mass emission rates to the ocean. These data are compared to past estimates of runoff emissions as well as other sources of contamination to the Southern California Bight.

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We also determined how the concentration and mass of contaminants varied throughout the storm events to see if significant portions of the mass emissions were concentrated in a small part of the flow. We sampled sites to see how contaminant levels varied with land use. In addition, we measured polycyclic aromatic hydrocarbons (PAH) concentrations for the first time for several channels to determine which compounds were present in Southern California runoff.

METHODS

Six large runoff sources in Ventura and Los Angeles Counties were sampled (Figure 3). Each channel has a unique drainage basin, and most of the channels (Santa Clara River, Calleguas Creek, Los Angeles River, and San Gabriel River) receive wastewater effluent from one or more municipal wastewater treatment plants. This contributes significantly to dry weather flows.

Sampling locations on each channel were selected for the following reasons: (1) to provide safe sampling; (2) to be used under adverse weather conditions; (3) to provide access to the center channel of the flow; and (4) to be downstream from the major sources of runoff contaminants. In an attempt to sample downstream from potential major sources we located three of our stations (Calleguas Creek, Dominguez Channel, and San Gabriel River) in the upper reaches of the tidal prism.

Santa Clara River

The Santa Clara River drains the second largest basin in Southern California (4,200 km^2) and has produced some of the largest peak flows (165,000 cfs) in Southern California's history. However, the flow near the mouth is poorly correlated with natural weather conditions because water is imported from the California Water Project and flow in the upper and middle river is regulated by releases from the dams at Lake Piru, Lake Pyramid, and Lake Casitas. Diversions and groundwater recharge prevent upstream flows from reaching the ocean except during large storms. Even below the last water diversion the dry sandy riverbed is capable of absorbing most of the flow from early season and small storms.

We sampled on the north side of the channel where Highway 101 crosses the river (H on Figure 3). This site is located about 8 km above the mouth of the river, which is at McGrath State Beach. Our site is the last accessible, safe location to sample moderate or high flow conditions. The channel is over 300 ft wide, and the bed is unlined.

Calleguas Creek

Calleguas Creek drains 650 km^2, including the southern part of the Hueneme Plain, and receives secondary effluent discharge from several treatment plants. This sampling site on Highway 1 is in the middle of the tidal prism and above Mugu Lagoon (I on Figure 3). We decided to sample here because it would allow us to obtain runoff from Calleguas Creek as well as Revlon Slough, which also drains a large portion of the Hueneme Plain that is used intensively to grow vegetables and other cash crops. Unfortunately, between the time we selected this site and when it was sampled, the channels were separated and the junction point moved below our site location. Therefore we collected separate samples from only

Calleguas Creek. Flow data were obtained from the Ventura Department of Public Works from their station at Camarillo, which is about 6 km above the sampling site.

Ballona Creek

Ballona Creek drains 232 km^2 of highly urbanized land in West Los Angeles. The main channel is concrete lined. Oil and tar lines on the banks of the channel are evidence of the occasional discharge of petroleum from freeway tanker spills and other sources. Our sampling station (D on Figure 3) is located 4 km above the mouth of the creek, between the entrance to Marina del Rey and the beach at Playa del Rey. The station on the Inglewood Avenue bridge is above tidal influence except during the highest tides; however, we saw no visual or chemical evidence of saltwater intrusion during any sampling period. Flow data were obtained from the Los Angeles County Department of Public Works recording gauge F 38C-R, which is located near Sawtelle Avenue about 1 km above the sampling site.

Dominguez Channel

The Dominguez Channel drains about 100 km^2 of industrial and urban land in south Los Angeles. In the past, the upper reaches received runoff from the Montrose Chemical Plant. This plant was the source of most of the DDT discharged from municipal outfalls or dumped into Southern California marine waters between the late 1940's and mid-1970's (3). The sides of the Dominguez Channel are covered with riprap, and the lower 10 miles are within the tidal prism and continuously filled with water. There is no recording flow gage in the lower reaches of the channel. The sampling site (C on Figure 3) is located on the railroad bridge just south of Anaheim Street, which was as close to the channel's termination in Los Angeles/Long Beach Harbor as possible. Although this sampling site lacked adequate flow data and was in the lowest section of the tidal prism, we decided to sample here because the 5-6 km of channel immediately above this site is lined with oil refineries. In addition, the harbor sediment just below our sampling site has been shown to have very high levels of petroleum hydrocarbons and pesticides (1). Justification for selecting this site comes from its high potential for producing environmentally significant concentrations of contaminants under rapid flow conditions.

Los Angeles River

The Los Angeles river was sampled because it is responsible for about 30% of the total annual gaged runoff from Southern California and it has been studied twice before by using similar techniques. Three sites were selected in an attempt to separate sources of contaminants to the river. The upper river basin is slightly developed, the middle portion drains the San Fernando Valley and is largely residential, while the lower half of the river drainage is more commercial and industrial. The three sites sampled were Big Tujunga Wash (F on Figure 3), Fletcher Avenue Bridge (E on Figure 3), and the Willow Street Bridge (B on Figure 3).

Big Tujunga Wash is one of three major tributaries draining the foothills above Los Angeles. Our sampling site was located below the Big Tujunga Dam which collects runoff from undeveloped steep-sloped hills. Although the flow in this area is small, we decided to sample here because anthropogenic contaminants in this area could only have been deposited by aerial fallout.

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The Fletcher Avenue Bridge crosses the Los Angeles River about halfway between the headwaters and the mouth. Drainage above this site is mostly from the suburban San Fernando Valley and the less developed foothills. The Los Angeles County Public Works Department maintains a recording gage that records flow at 15-min intervals at this site.

The Willow Street sampling site is located in Long Beach at the end of the concrete-lined channel about 2 km above the river mouth in Long Beach Harbor. The total area drained above this site is about 3200 km^2. Past flows at this site have reached over 100,000 cfs. This section of the channel receives runoff from downtown Los Angeles and the commercial/industrial developments of east and southeast Los Angeles. The Rio Hondo Channel is approximately 16 km above this site and is capable of transferring water from the San Gabriel River to the Los Angeles River at the discretion of the Public Works Department.

Flow data for the three sites were obtained from the Los Angeles County Department of Public Works for stations F168-R, F57C-R, and F319-R (Figure 3). These are within 1 km of their respective sampling sites.

San Gabriel River

The San Gabriel River drains approximately 1600 km^2, but its discharge to the ocean is relatively small. During low flow and small storm flows much of the upper river water is retained for groundwater recharge. Most of the dry weather flow in the lower river is from advanced wastewater effluents.

We intended to sample two sites on the San Gabriel River; however, the first storm occurred so early in the season that we missed sampling the upper station at San Gabriel Parkway.

The lower San Gabriel River was sampled at College Park, (A on Figure 3), which is about 3 km above the river mouth in Long Beach Harbor. Unfortunately, this site was also located about 1 km below the upper end of the tidal prism. The site was selected because it was the nearest point of access below the confluence of the San Gabriel River and Coyote Creek. Storm flows from Coyote Creek to the San Gabriel River can constitute more than one-half of the total flow. We selected this site under the assumption that any significant flow would flush saltwater out even at the highest tides. However, salinity measurements of a few low flow samples taken at high tide indicated the presence of marine water. Consequently, trace metals were not measured for those samples nor were they included in emission estimates. Two Los Angeles County Department of Public Works flow gages were required to measure the total flow from both channels for our site. Gage F428-R on the San Gabriel River malfunctioned during the storm and no data were collected. Gage F354-R, below Spring Street, measured Coyote Creek flow about 3 km above the sampling site. Mass emission estimates are based only on the Coyote Creek flow.

Samples were collected from the center of flow for each channel by lowering an acid-washed kilned 1-gallon bottle in an epoxy covered metal sampler that was equipped with a horizontal and vertical tail stabilizer that kept the bottle opening facing upstream. The bottles passed through the surface layer uncapped. The sampler was submerged about 0.5 meter below the surface, and was filled in about 90 seconds. The sampler was deployed twice for each sampling period, and the sample was proportionally divided into the sample containers for organics (4 liters),

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trace metals (1 liter), suspended solids (1 liter), oil and grease (1 liter), and toxicity (20 ml).

Cumulative rainfall data from 17 sites (Table 1) located within the drainage basins that we were studying were collected from Los Angeles County Department of Public Works files.

River Flow Data

Figure 3 shows gaging stations for Los Angeles County. The gages on Ballona Creek, the Los Angeles River, the San Gabriel River, and Coyote Creek can provide flow data at 15-min intervals. Continuous flow data for Calleguas Creek were provided by the Ventura County Department of Public Works. Data for the Santa Clara River flow are based on field crews observations, which we believe to be acceptable since the flow was low and did not change much during the storm.

RESULTS AND DISCUSSION

A complete listing of flow rates, flow volume, interval volume, contaminant concentrations, and mass emissions for each sample is listed in Appendix A.

Differences Between Sites

Mean concentrations

Flow-proportioned mean contaminant concentrations and ranges for eight sites are summarized in Table 2. Histograms of mean concentrations at the sampling sites are shown in Figure 4, A-N.

Suspended solids mean concentrations for seven sites are shown in Figure 4, C. The highest (1250 mg/liter at the Santa Clara River) and lowest (30 mg/liter at Calleguas Creek) concentrations were found in Ventura County. The sites in Los Angeles County ranged between 200 and 750 mg/liter.

The Los Angeles River at the Willow Street site (Figure 4; B, D-H). generally had the highest concentrations of hydrophobic (oil and grease, total extractable organics, PAH, n-alkanes, PCBs, and DDT) contaminants. Exceptions occurred at Ballona Creek, which had 50% more oil and grease and a DDT concentration 4 times that of the Willow Street site, and Santa Clara, which had a DDT concentration 11 times that of the Willow Street site.

The trace metals concentrations (cadmium, chromium, copper, nickel, lead, and zinc) were all highest at Ballona Creek followed by the LA River at Willow (Figure 4, I-N). Concentrations at Tujunga Wash were consistently below detection, while the other sites had roughly equal levels.

Within the LA River system contaminants increased between upper and lower stations. The Willow runoff had about twice the amount of suspended solids as the upper two stations did. Oil and grease and TEO concentrations quadrupled between Tujunga and Fletcher and again between Fletcher and Willow. Metal concentrations were below detection limits at Tujunga, but metal concentrations at Willow were two to four times higher than those at Fletcher (Figure 4, I-N).

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Mean concentrations per gram of suspended solid

Past studies have shown that most of the contaminants are associated with suspended particulates (9, 21). We have calculated contaminant concentrations per gram of suspended solid in Table 3 assuming that all of the contaminants are particulate bound. This could be a misleading supposition if contaminant levels are very low and dissolved contaminants constitute a significant percent of the total concentration. However, with this caution in mind Table 3 (and Figure 5, A-L) gives an indication of quality of particulates that may accumulate in sediments or be spread in near-shore waters.

Oil and grease measurements at Tujunga and Santa Clara were an order of magnitude less than at the other sites (Figure 5, A). The four sites with moderate to high flows (Willow, Fletcher, Ballona, and San Gabriel) had similar values between 10.5 and 23.6 mg/g. The very high concentrations at Calleguas Creek were a result of the very low concentrations of suspended solids.

DDT and PCBs had two different patterns (Figure 5, E-F). Santa Clara River and Ballona Creek particulates were more contaminated with DDT than were particulates at the other sites, while PCBs were more uniformly distributed at all sites except Tujunga Wash.

The Los Angeles River and Ballona Creek had much higher concentrations of PAHs and n-alkanes than the other sites.

The trace metals concentrations on suspended solids (Figure 5, G-L) were reasonably uniform at four stations (Willow, Fletcher, Ballona, and San Gabriel), while concentrations of metals at Tujunga and the Santa Clara River were much lower.

Los Angeles River System

Within the Los Angeles River stations, the Tujunga samples had the lowest contaminant concentrations but moderately high suspended solids levels. This resulted in very low concentrations per gram of suspended solid. The trace metals, pesticides, PCBs and PAHs were below detection limits while oil and grease and n-alkanes were 4 and 9 times higher than at mid-river. Concentrations of metals, pesticides and PCB on suspended solids are similar for samples from mid-river (Fletcher) and lower river (Willow). However, the lower river samples are 2 to 9 times high in TEO, PAHs and n-alkanes.

Mass Emissions

Calculated flow-proportioned mass emissions are listed in Table 4 and shown in Figure 6, A-N.

The Los Angeles River is the largest source of runoff to the Southern California Bight. The highest flows combined with the high concentrations caused the Willow Street site to have the highest mass emissions of all constituents except DDT.

For all constituents except DDT there is a consistent pattern of greatest emissions coming from the Los Angeles River, then Ballona Creek followed by Fletcher and San Gabriel. The remaining stations have minimal inputs.

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Within the LA River stations, Tujunga emits a miniscule volume of runoff and contaminants. The flow at the Willow site is about 30% greater than that at Fletcher, but contaminant emissions are 3 to 10 times greater, indicating a much greater source, in the lower basin.

The Ballona Creek drainage is only about 10% of the Los Angeles drainage basin, but during this storm its flow was about 40% of the LA River flow. The emissions of most contaminants were approximately 40% of the LA River emissions. Exceptions were lead and zinc, which were about equal to Willow emissions, and DDT and n-alkanes which were twice and one-sixth of the Willow emissions.

We have underestimated the emissions from the San Gabriel River because we only have flow data from Coyote Creek, so our estimates could be low by a factor of 2 or more. The measured flow is three-fourths the size of the Ballona Creek flow, but emissions of oil and suspended solids, oil and grease, TEO, trace metals, and chlorinated hydrocarbons are between 3 and 20% of Ballona's emissions, while PAH and n-alkane emissions are 1 and 3%, respectively.

Trends in flow and contaminant concentrations with time

Figure 7, A-H, shows the flow and concentrations of suspended solids, oil and grease, TEO, lead, total PAHs, total PCBs, and volatile solids for the Los Angeles River during the 48-h of sampling.

There were two peaks in flow about 6 h apart; the first peak exceeded 10,000 cfs, whereas the second peak returned to 9,000 cfs after dropping to 5,000 cfs.

The peak contaminant concentrations (except percent volatile solids) occurred in either sample 6 or 7 before the first peak in flow. Although sample 8 had the highest flow, the concentrations of all contaminants dropped. This may be due to a washout of contaminants.

Trends in Cumulative Emissions

As an example of when contaminant emissions occur, Figure 8, A-D, shows the cumulative percent flow with cumulative percent emissions of suspended solids, oil and grease, combined trace metals, and chlorinated hydrocarbons for the Willow station, and Figure 9, A-D, shows that approximately 80% of the flow and suspended solids were discharged within a 10-h period. Contaminant emissions lagged during the first 5% of flow but rapidly increased after 10% of the flow occurred. In general the first 25% of flow produced 50% of the contaminant emissions, and when 50% of the flow had occurred, 75% of the contaminant emissions had occurred. This pattern is representative of the other sites studied.

Petroleum hydrocarbon characterization

Aliphatic hydrocarbons

Figure 10a represents a typical chromatogram of the aliphatic fraction from our stormwater runoff samples. Generally, most of the samples contained a single hump of varying size (known as the unresolved complex mixture-UCM) and numerous resolved peaks which represent simple alkanes containing from 10 to 30

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carbons. The presence of a UCM maximizing at n-C21-C35 is indicative of crankcase oil in the runoff. The n-alkanes, which are the resolved peaks labelled with their respective number of carbons, showed maxima at n-C17 as well as the higher molecular weight n-alkanes with odd numbers of carbons (i.e., n-C27, C29 and C31). The odd-even carbon chain length predominance of these higher molecular weight species indicates the presence of waxes characteristically associated with the cuticles of higher plants.

There were two notable exceptions to the pattern illustrated in Figure 10a. First, samples taken from Ballona Creek at 6 and 47 hours contained two UCM humps, the first hump being larger and maximizing at n-C18 (Figure 10b). It has been suggested by some researchers that this pattern may be representative of bacterial degradation products. Second, the 31 hour sample taken from the Los Angeles River at Willow Street contained no UCM at all. It did, however, exhibit the highest concentrations of n-alkanes (mostly from the C23-C39 range) with little apparent odd-even predominance. This sample was taken during the second peak in flow at approximately 8500 cubic feet/second (Figure 7a). The distribution we observed is not consistent with a recent biogenic origin, but may be related to dewaxing of petroleum. Similar distributions were not observed in samples taken before or after this one. Therefore, it is unclear whether these results are anomalous, representing the inclusion of a small particle of pure wax, or an indication of a short-term input to the river.

Aromatic hydrocarbons

Figure 11 presents a relative abundance plot for the 26 PAHs measured in this study (see Appendix A for a list of the compounds and their individual concentrations). This sample was taken from the Los Angeles River at Willow Street after 30.8 hours and is indicative of the most common distributional pattern. Most of the samples contained some naphthalenes (compounds 1-4) and phenanthrenes (compounds 9-12) which are the dominant PAHs in unweathered petroleum. However, the compounds with four or more rings (fluoranthene through benzo[g,hi,i]perylene; compound 14-26), which are combustion products, were frequently present at higher concentrations. Therefore, results of this study showed a mixture of both types of hydrocarbons being discharged during this storm with a larger amount of combustion products present.

The PAH composition was variable throughout the storm at a single point on the channel and in samples taken contemporaneously during a storm at different sites in the channel. However, the plot from the Los Angeles River station at Willow Street (Figure 8) is comparable to those obtained by Anderson and Gossett (1) for bottom sediments collected at the mouth of the Los Angeles River as well as those for sediments from the vicinity of Los Angeles County's outfall, suggesting that stormwater runoff and municipal effluent may contain PAHs of similar composition.

CONCLUSION

As the emissions of contaminants from outfalls continue to decrease, runoff emissions become a more important source of marine inputs. Outfall emissions have been steadily reduced over the last 10 years (21), but little has been done to reduce contaminants. Young et al. (25) concluded that variations in runoff concentrations were not significantly different in the Los Angeles River between 1971 and 1979 except for lead and PCBs, which were reduced by factors of 6 and 8, respectively. There do not appear to be many major changes in concentration since

1979. Table 5 shows concentrations for the five storms measured in 1971 and 1979 and the present 1986 results. Between 1979 and 1986 copper and lead concentrations increased by about a factor of 2, while suspended solids and chromium were reduced by two-thirds and one-half, respectively. The rest of the trace metals and PCBs varied by less than one-third. DDT had the largest change and was reduced by a factor of 4.

How the volume of runoff affects contaminant emissions is not clear. Los Angeles River runoff in 1971/72 was about one-half of normal runoff, while 1979/80 produced runoff five times the 15-year average; yet Young and his co-workers found most contaminant concentrations to be similar. Five of the twelve highest concentrations in the year did not occur in the first storm of 1979, and the third storm had cadmium and lead concentrations higher than those of the first storm. Data from the storm we sampled in January 1987 should allow us to determine the changes between storms within a year.

We did have some indication of a washout of contaminants in the Los Angeles River in this year's study because almost all of the contaminant concentrations peaked before our highest flow sample was taken. If the distribution of rain on land use areas did not change significantly there may have been a reduction in available contaminants. Hoffman et al. (14) found that residential, highway, commercial, and industrial areas had different rates of washout during a storm with residential concentrations of petroleum hydrocarbon approaching zero after less than 2 cm of rain, while industrial sites showed no reductions in concentrations after 2 cm of rain.

Large flows from Ballona Creek, Los Angeles River Willow, Los Angeles River Fletcher, and the San Gabriel River exceeded 3.5×10^9 liters (920 million gallons) during the storm, while flows of less than 0.32×10^9 liters (84 million gallons) occurred at the Santa Clara, Tujunga, and Calleguas sites.

During the storm, flows changed very little at Big Tujunga Wash, the Santa Clara River, and Dominguez Channel, while at Ballona Creek, Los Angeles River Willow, and San Gabriel flows varied by about 100x.

The highest concentrations of contaminants are associated with peak flows. Because we sampled the two Ventura sites while they had relatively low flow, this data may be less representative annual emissions of contaminants.

The two channels with the highest flows, Los Angeles River Willow and Ballona Creek, had the highest mean contaminant concentrations and consequently had the highest emissions of oil and grease, TEOs, cadmium, chromium, copper, nickel, lead, zinc, PCBs, PAHs, resolved hydrocarbons, and n-alkanes.

Annual estimate of runoff should be viewed with the awareness of certain limitations, some relevant to all runoff studies and others relevant only to this study. Factors that need further examination include annual variations in total rainfall within a drainage basin, the intentional retention of runoff for groundwater recharge, and diversions between drainage basins. The factors can combine to make each storm and year difficult to compare with other storms and years.

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APPENDIX A
Chemical Data

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	2.67
Location:	Willow Street	Time Interval:	00:00-03:30
Date:	23 Sep 86	IntervalVol(M**3):	3710
Time:	17:55	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	46mG/L	1.753 T	Naphthalene	<21nG/L	0 G
TVS	65%	***	C1-Naphthalenes	<21nG/L	0 G
Total Solids	627mG/L	23.89 T	C2-Naphthalenes	<21nG/L	0 G
Dissolved Solids	581mG/L	22.14 T	C3-Naphthalenes	<45nG/L	0 G
Oil & Grease	.7mG/L	.0267 T	Biphenyl	<21nG/L	0 G
Chloroform Extr.	1.4mG/L	.0533 T	Acenaphthylene	<21nG/L	0 G
Salinity	.5ppt	***	Acenaphthene	<45nG/L	0 G
pH	7	***	Fluorene	<20nG/L	0 G
			Phenanthrene	<20nG/L	0 G
Cadmium	3uG/L	.1143kG	C1-Phenanthrenes	<20nG/L	0 G
Chromium	3uG/L	0kG	C2-Phenanthrenes	<20nG/L	0 G
Copper	12uG/L	.4572kG	C3-Phenenthrenes	<20nG/L	0 G
Nickel	16uG/L	.6096kG	Anthracene	<20nG/L	0 G
Lead	55uG/L	2.096kG	Fluoranthene	<16nG/L	0 G
Zinc	21uG/L	.8001kG	Pyrene	<16nG/L	0 G
Silver	1uG/L	0kG	2,3-Benzofluorene	<48nG/L	0 G
			Benz(a)anthracene	<17nG/L	0 G
o,p'-DDE	1nG/L	.0381 G	Chryseene	<17nG/L	0 G
p,p'-DDE	5nG/L	.1905 G	Benzo(b)fluoranth	14nG/L	0 G
o,p'-DDD	<1nG/L	0 G	Benzo(k)fluoranth	<14nG/L	0 G
p,p'-DDD	<1nG/L	0 G	Benzo(e)pyrene	<14nG/L	0 G
o,p'-DDT	<1nG/L	0 G	Benzo(a)pyrene	<14nG/L	0 G
p,p'-DDT	<1nG/L	0 G	Perylene	<14nG/L	0 G
TOTAL DDT	6nG/L	.2286 G	9,10-Diphenylanth	<14nG/L	0 G
			Dibenz(a,h)anthra	<12nG/L	0 G
Aroclor 1242	44nG/L	1.676 G	Benzo(g,h,i)peryl	<12nG/L	0 G
Aroclor 1254	<1nG/L	0 G	TOTAL PAH	0nG/L	0 G
TOTAL PCB	44nG/L	1.676 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	4nG/L	.1524 G	d8-Naphthalene	41%	***
Lindane	<1nG/L	0 G	d10-Acenaphthene	71%	***
			d10-Phenanthrene	84%	***
Toxicity	NoTest	***	d12-Chryseene	118%	***
			d12-Perylene	122%	***
			Resolved HCs	0nG/L	0 G
			n-alkanes c10-c39	2234nG/L	85.12 G
			Pristane	348nG/L	13.26 G
			Phystane	420nG/L	16.00 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	23 Sep 86
Time:	21:05

Flow (M**3/Sec):	2.78
Time Interval:	03:30-05:45
IntervalVol(M**3):	22,500
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	35mG/L	.896 T
TVS	69%	***
Total Solids	662mG/L	16.95 T
Dissolved Solids	627mG/L	16.05 T
Oil & Grease	2.3mG/L	.0589 T
Chloroform Extr.	1.7mG/L	.0435 T
Salinity	ppt	***
pH		***
Cadmium	2uG/L	.0512 G
Chromium	<3uG/L	0 G
Copper	15uG/L	.384 G
Nickel	[illegible]uG/L	.[illegible]28 G
[illegible]	[illegible]	[illegible]
[illegible]	49[illegible]	[illegible].254 G
Silver	[illegible]	[illegible]
o,p'-DDE	[illegible]nG/L	[illegible]
p,p'-DDE	[illegible]nG/L	0 G
o,p'-DDD	1nG/L	0 G
p,p'-DDD	<1nG/L	0 G
o,p'-DDT	<1nG/L	0 G
p,p'-DDT	<1nG/L	0 G
TOTAL DDT	0nG/L	0 G
Aroclor 1242	<1nG/L	0 G
Aroclor 1254	11nG/L	.2816 G
TOTAL PCB	11nG/L	.2816 G
Hexachlorobenzene	<1nG/L	0 G
Lindane	<1nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<15nG/L	0 G
C1-Naphthalenes	<15nG/L	0 G
C2-Naphthalenes	<15nG/L	0 G
C3-Naphthalenes	<32nG/L	0 G
Biphenyl	<15nG/L	0 G
Acenaphthylene	<15nG/L	0 G
Acenaphthene	<32nG/L	0 G
Fluorene	<14nG/L	0 G
Phenanthrene	14nG/L	0 G
C1-Phenanthrenes	<14nG/L	0 G
C2-Phenanthrenes	14nG/L	0 G
C3-Phenenthrenes	<14nG/L	0 G
Anthracene	14nG/L	0 G
Fluoranthene	[illegible]nG/L	[illegible] G
Pyrene	[illegible]nG/L	0 G
[illegible]	[illegible]4nG/L	0 G
Benz(a)anthracene	[illegible]nG/L	[illegible]
Chrysene	[illegible]nG/L	0 G
Benzo(b)fluoranth	[illegible]nG/L	[illegible]
Benzo(k)fluoranth	10nG/L	0 G
Benzo(e)pyrene	<10nG/L	0 G
Benzo(a)pyrene	<10nG/L	0 G
Perylene	<10nG/L	0 G
9,10-Diphenylanth	<10nG/L	0 G
Dibenz(a,h)anthra	<9nG/L	0 G
Benzo(g,h,i)peryl	<9nG/L	0 G
TOTAL PAH	0nG/L	0 G
SURROGATE RECOVERY		
d8-Naphthalene	0%	***
d10-Acenaphthene	0%	***
d10-Phenanthrene	0%	***
d12-Chrysene	6%	***
d12-Perylene	2%	***
Resolved HCs	0nG/L	0 G
n-alkanes c10-c39	750nG/L	19.2 G
Pristane	375nG/L	9.6 G
Phytane	0nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Los Angeles River
Location: Willow Street
Date: 23 Sep 86
Time: 22:40

Flow (M**3/Sec): 2.83
Time Interval: 06:00-12:00
IntervalVol(M**3): 156,008
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	31mG/L	4.96 T	Naphthalene	<18nG/L	0 G
TVS	39%	***	C1-Naphthalenes	<18nG/L	0 G
Total Solids	661mG/L	105.8 T	C2-Naphthalenes	18nG/L	0 G
Dissolved Solids	630mG/L	100.8 T	C3-Naphthalenes	38nG/L	0 G
Oil & Grease	1.7mG/L	.272 T	Biphenyl	<18nG/L	0 G
Chloroform Extr.	4.1mG/L	.656 T	Acenaphthylene	<18nG/L	0 G
Salinity	ppt	***	Acenaphthene	<38nG/L	0 G
pH		***	Fluorene	<17nG/L	0 G
			Phenanthrene	<17nG/L	0 G
Cadmium	3uG/L	.48kG	C1-Phenanthrenes	<17nG/L	0 G
Chromium	<3uG/L	0kG	C2-Phenanthrenes	<17nG/L	0 G
Copper	16uG/L	2.56kG	C3-Phenanthrenes	<17nG/L	0 G
Nickel	18uG/L	2.88kG	Anthracene	<17nG/L	0 G
Lead	<10uG/L	0kG	Fluoranthene	<14nG/L	0 G
Zinc	46uG/L	7.36kG	Pyrene	<14nG/L	0 G
Silver	<1uG/L	0kG	2,3-Benzofluorene	<41nG/L	0 G
			Benz(a)anthracene	<14nG/L	0 G
o,p'-DDE	<1nG/L	0 G	Chrysene	<14nG/L	0 G
p,p'-DDE	<1nG/L	0 G	Benzo(b)fluoranth	<12nG/L	0 G
o,p'-DDD	<1nG/L	0 G	Benzo(k)fluoranth	<12nG/L	0 G
p,p'-DDD	<1nG/L	0 G	Benzo(e)pyrene	<12nG/L	0 G
o,p'-DDT	<1nG/L	0 G	Benzo(a)pyrene	<12nG/L	0 G
p,p'-DDT	<1nG/L	0 G	Perylene	<12nG/L	0 G
TOTAL DDT	0nG/L	0 G	9,10-Diphenylanth	<10nG/L	0 G
			Dibenz(a,h)anthra	<10nG/L	0 G
Aroclor 1242	<1nG/L	0 G	Benzo(g,h,i)peryl	<10nG/L	0 G
Aroclor 1254	7nG/L	1.12 G	TOTAL PAH	0nG/L	0 G
TOTAL PCB	7nG/L	1.12 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	<1nG/L	0 G	d8-Naphthalene	82%	***
Lindane	<1nG/L	0 G	d10-Acenaphthene	112%	***
			d10-Phenanthrene	99%	***
Toxicity	NoTest	***	d12-Chrysene	102%	***
			d12-Perylene	127%	***
			Resolved HCs	0nG/L	0 G
			n-alkanes c10-c39	901nG/L	144.2 G
			Pristane	386nG/L	61.76 G
			Phytane	398nG/L	63.68 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	24 Sep 86
Time:	09:30

Flow (M**3/Sec):	5.21
Time Interval:	12:15-18:45
IntervalVol(M**3):	154,000
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	106 mG/L	16.75 T	Naphthalene	18 nG/L	0 G
TVS	55 %	***	C1-Naphthalenes	<18 nG/L	0 G
Total Solids	669 mG/L	105.7 T	C2-Naphthalenes	<18 nG/L	0 G
Dissolved Solids	563 mG/L	88.95 T	C3-Naphthalenes	<38 nG/L	0 G
Oil & Grease	3.5 mG/L	.553 T	Biphenyl	16 nG/L	0 G
Chloroform Extr.	5.1 mG/L	.8058 T	Acenaphthylene	<18 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<38 nG/L	0 G
pH	5.5	***	Fluorene	17 nG/L	0 G
			Phenanthrene	<17 nG/L	0 G
Cadmium	3 uG/L	.474kG	C1-Phenanthrenes	<17 nG/L	0 G
Chromium	9 uG/L	1.422kG	C2-Phenanthrenes	<17 nG/L	0 G
Copper	40 uG/L	6.32kG	C3-Phenenthrenes	<17 nG/L	0 G
Nickel	33 uG/L	5.214kG	Anthracene	<17 nG/L	0 G
[illegible]d	42 uG/L	6.636kG	Fluoranthene	<14 nG/L	0 G
[illegible]c	157 uG/L	24.81kG	Pyrene	<14 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<41 nG/L	0 G
			Benz(a)anthracene	<14 nG/L	0 G
o,p'-DDE	2 nG/L	.316 G	Chrysene	14 nG/L	0 G
p,p'-DDE	3 nG/L	.474 G	Benzo(b)fluoranth	12 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<12 nG/L	0 G
p,p'-DDD	2 nG/L	.316 G	Benzo(e)pyrene	<12 nG/L	0 G
o,p'-DDT	1 nG/L	.158 G	Benzo(a)pyrene	<12 nG/L	0 G
p,p'-DDT	2 nG/L	.316 G	Perylene	<12 nG/L	0 G
TOTAL DDT	10 nG/L	1.58 G	9,10-Diphenylanth	<12 nG/L	0 G
			Dibenz(a,h)anthra	<10 nG/L	0 G
Aroclor 1242	5 nG/L	.79 G	Benzo(g,h,i)peryl	<10 nG/L	0 G
Aroclor 1254	24 nG/L	3.792 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	29 nG/L	4.582 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	1 nG/L	.158 G	d8-Naphthalene	83 %	***
Lindane	4 nG/L	.632 G	d10-Acenaphthene	103 %	***
			d10-Phenanthrene	114 %	***
Toxicity	NoTest	***	d12-Chrysene	157 %	***
			d12-Perylene	141 %	***
			Resolved HCs	15844 nG/L	2503. G
			n-alkanes c10-c39	12410 nG/L	1961. G
			Pristane	1292 nG/L	204.1 G
			Phytane	1495 nG/L	236.2 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	7.22
Location:	Willow Street	Time Interval:	19:00-21:15
Date:	24 Sep 86	IntervalVol (M**3):	113000
Time:	12:15	Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	53mG/L	7.761 T
TVS	59%	***
Total Solids	623mG/L	58.25 T
Dissolved Solids	540mG/L	50.48 T
Oil & Grease	3.4mG/L	.3178 T
Chloroform Extr.	16.9mG/L	1.580 T
Salinity	ppt	***
pH		***
Cadmium	4uG/L	.3741 G
Chromium	7uG/L	.6545 G
Copper	53uG/L	4.956 G
Nickel	39uG/L	3.647 G
Lead	58uG/L	5.423 G
Zinc	244uG/L	22.811 G
Silver	1uG/L	0 G
o,p'-DDE	3nG/L	.2805 G
p,p'-DDE	6nG/L	.561 G
o,p'-DDD	[illegible]	[illegible] G
p,p'-DDD	[illegible]	[illegible] G
o,p'-DDT	[illegible]	[illegible] G
p,p'-DDT	[illegible]	[illegible] G
TOTAL DDT	[illegible]	[illegible] G
Aroclor 1242	[illegible]	0 G
Aroclor 1254	[illegible]	3.086 G
TOTAL PCB	[illegible]	3.086 G
Hexachlorobenzene	[illegible]	.0935 G
Lindane	[illegible]	.5415 G
Toxicity	No Test	***

CONSTITUENT	CONC.	MASS
Naphthalene	[illegible]	[illegible]
C1-Naphthalenes	[illegible]	[illegible]
C2-Naphthalenes	[illegible]	0
C3-Naphthalenes	[illegible]	0
Biphenyl	[illegible]	0
Acenaphthylene	[illegible]	0
Acenaphthene	[illegible]	0
Fluorene	[illegible]	0
Phenanthrene	[illegible]	[illegible]
C1-Phenanthrenes	[illegible]	[illegible]
C2-Phenanthrenes	[illegible]	[illegible]
C3-Phenanthrenes	[illegible]	[illegible]
Anthracene	[illegible]	0
Fluoranthene	[illegible]	[illegible]
Pyrene	[illegible]	[illegible]
2,3-Benzofluorene	[illegible]	[illegible]
Benz(a)anthracene	[illegible]	[illegible] G
Chrysene	[illegible]	[illegible] G
Benzo(b)fluoranth	[illegible]	[illegible] G
Benzo(k)fluoranth	[illegible]	[illegible] G
Benzo(e)pyrene	[illegible]	[illegible] G
Benzo(a)pyrene	[illegible]	[illegible] G
Perylene	[illegible]	[illegible] G
1,2,5,6-Dibenzanthr	[illegible]	[illegible] G
Dibenz(a,h)anthra	[illegible]	[illegible] G
Benzo(g,h,i)peryl	[illegible]	[illegible] G
TOTAL PAH	[illegible]	[illegible] G
SURROGATE RECOVERY		
d8-Naphthalene	[illegible]	***
d10-Acenaphthene	[illegible]	***
d10-Phenanthrene	[illegible]	***
d12-Chrysene	[illegible]	***
d12-Perylene	[illegible]	***
Resolved HCs	[illegible]	[illegible] G
n-alkanes C10-C30	[illegible]	[illegible] G
Pristane	5363nG/L	501.4 G
Phytane	5885nG/L	550.2 G

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	24 Sep 86
Time:	14:15

Flow (M**3/Sec): 85.0
Time Interval: 21:15-23:30
IntervalVol (M**3): 703.000
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1850 mG/L	1378. T	Naphthalene	<8 nG/L	0 G
TVS	20 %	***	C1-Naphthalenes	169 nG/L	125.9 G
Total Solids	2280 mG/L	1699. T	C2-Naphthalenes	1350 nG/L	1006. G
Dissolved Solids	430 mG/L	320.4 T	C3-Naphthalenes	6180 nG/L	4604. G
Oil & Grease	21.8 mG/L	16.24 T	Biphenyl	51 nG/L	38.00 G
Chloroform Extr.	48.7 mG/L	36.28 T	Acenaphthylene	<6 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	32 nG/L	23.84 G
pH	6	***	Fluorene	206 nG/L	153.5 G
			Phenanthrene	1810 nG/L	1348. G
Cadmium	21 uG/L	15.65kG	C1-Phenanthrenes	3860 nG/L	2876. G
Chromium	147 uG/L	109.5kG	C2-Phenanthrenes	6070 nG/L	4522. G
Copper	512 uG/L	381.4kG	C3-Phenenthrenes	5790 nG/L	4314. G
Nickel	131 uG/L	97.60kG	Anthracene	278 nG/L	207.1 G
Lead	607 uG/L	452.2kG	Fluoranthene	1940 nG/L	1445. G
Zinc	1971 uG/L	1468.kG	Pyrene	2230 nG/L	1661. G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	1050 nG/L	782.3 G
			Benz(a)anthracene	899 nG/L	669.8 G
o,p'-DDE	62 nG/L	46.19 G	Chrysene	1920 nG/L	1430. G
p,p'-DDE	34 nG/L	25.33 G	Benzo(b)fluoranth	<5 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	2540 nG/L	1892. G
p,p'-DDD	20 nG/L	14.9 G	Benzo(e)pyrene	5 nG/L	0 G
o,p'-DDT	35 nG/L	26.08 G	Benzo(a)pyrene	1420 nG/L	1058. G
p,p'-DDT	<1 nG/L	0 G	Perylene	28 nG/L	20.86 G
TOTAL DDT	151 nG/L	112.5 G	9,10-Diphenylanth	123 nG/L	91.64 G
			Dibenz(a,h)anthra	103 nG/L	76.74 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	213 nG/L	158.7 G
Aroclor 1254	459 nG/L	342.0 G	TOTAL PAH	38200 nG/L	28459 G
TOTAL PCB	459 nG/L	342.0 G			
			SURROGATE RECOVER		
Hexachlorobenzene	7 nG/L	5.215 G	d8-Naphthalene	0 %	***
Lindane	22 nG/L	16.39 G	d10-Acenaphthene	80 %	***
			d10-Phenanthrene	123 %	***
Toxicity	NoTest	***	d12-Chrysene	191 %	***
			d12-Perylene	181 %	***
			Resolved HCs	5.3e5 nG/L	4.0e5 G
			n-alkanes c10-c39	2.5e5 nG/L	1.9e5 G
			Pristane	25698 nG/L	19145 G
			Phytane	32676 nG/L	24344 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Los Angeles River
Location: Willow Street
Date: 24 Sep 86
Time: 17:00

Flow (M**3/Sec): 146
Time Interval: 23:45-27:45
IntervalVol (M**3): 2.93x10^6
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CON	MASS
Suspended Solids	927mG/L	2781 T	Naphthalene	598nG/L	1794 G
TVS	21%	***	C1-Naphthalenes	1460nG/L	4380 G
Total Solids	1220mG/L	3660 T	C2-Naphthalenes	2270nG/L	6810 G
Dissolved Solids	293mG/L	879 T	C3-Naphthalenes	6570nG/L	19710 G
Oil & Grease	14mG/L	42 T	Biphenyl	84nG/L	252 G
Chloroform Extr.	103mG/L	309 T	Acenaphthylene	104nG/L	312 G
Salinity	0ppt	***	Acenaphthene	141nG/L	423 G
pH	5.5	***	Fluorene	255nG/L	765 G
			Phenanthrene	5230nG/L	15690 G
Cadmium	10uG/L	30 G	C1-Phenanthrenes	5200nG/L	15600 G
Chromium	88uG/L	264 G	C2-Phenanthrenes	5280nG/L	15840 G
Copper	273uG/L	819 G	C3-Phenenthrenes	4550nG/L	13650 G
Nickel	75uG/L	225 G	Anthracene	999nG/L	2997 G
Lead	531uG/L	1593 G	Fluoranthene	16900nG/L	50700 G
Zinc	1400uG/L	4200 G	Pyrene	15100nG/L	45300 G
Silver	1uG/L	0 G	2,3-Benzofluorene	2380nG/L	7140 G
			Benz(a)anthracene	6310nG/L	18930 G
o,p'-DDE	39nG/L	117 G	Chrysene	23900nG/L	71700 G
p,p'-DDE	42nG/L	126 G	Benzo(b)fluoranth	10200nG/L	30600 G
o,p'-DDD	.1nG/L	0 G	Benzo(k)fluoranth	6150nG/L	18450 G
p,p'-DDD	30nG/L	90 G	Benzo(e)pyrene	4980nG/L	14940 G
o,p'-DDT	31nG/L	93 G	Benzo(a)pyrene	1740nG/L	5220 G
p,p'-DDT	27nG/L	81 G	Perylene	582nG/L	1746 G
TOTAL DDT	169nG/L	507 G	9,10-Diphenylanth	53nG/L	159 G
			Dibenz(a,h)anthra	261nG/L	783 G
Aroclor 1242	267nG/L	801 G	Benzo(g,h,i)peryl	984nG/L	2952 G
Aroclor 1254	428nG/L	1284 G	TOTAL PAH	1.2e5nG/L	3.6e5 G
TOTAL PCB	695nG/L	2085 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	9nG/L	27 G	d8-Naphthalene	86%	***
Lindane	25nG/L	75 G	d10-Acenaphthene	140%	***
			d10-Phenanthrene	134%	***
Toxicity	Notest	***	d12-Chrysene	184%	***
			d12-Perylene	190%	***
			Resolved HCs	6.0e6nG/L	1.8e7 G
			n-alkanes c10-c39	3.7e5nG/L	1.1e6 G
			Pristane	37119nG/L	1.1e5 G
			Phytane	48395nG/L	1.5e5 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	24 Sep 86
Time:	22:50

Flow (M**3/Sec):	240
Time Interval:	28:00-35:30
Interval Vol (M**3):	4.84x10^6
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	458mG/L	2290 T
TVS	25%	***
Total Solids	692mG/L	3460 T
Dissolved Solids	234mG/L	1170 T
Oil & Grease	8mG/L	40 T
Chloroform Extr.	6.1mG/L	30.5 T
Salinity	0ppt	***
pH	6	***
Cadmium	3uG/L	15 G
Chromium	18uG/L	90 G
Copper	144uG/L	720 G
Nickel	26uG/L	130 G
Lead	139uG/L	695 G
Zinc	348uG/L	1740 G
Silver	<1uG/L	0 G
o,p'-DDE	12nG/L	60 G
p,p'-DDE	18nG/L	90 G
o,p'-DDD	1nG/L	0 G
p,p'-DDD	8nG/L	40 G
o,p'-DDT	12nG/L	60 G
p,p'-DDT	10nG/L	50 G
TOTAL DDT	60nG/L	300 G
Aroclor 1242	[illegible]	[illegible]
Aroclor 1254	76nG/L	380 G
TOTAL PCB	138nG/L	690 G
Hexachlorobenzene	2nG/L	10 G
Lindane	17nG/L	85 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	106nG/L	530 G
C1-Naphthalenes	106nG/L	530 G
C2-Naphthalenes	64nG/L	320 G
C3-Naphthalenes	60nG/L	300 G
Biphenyl	<15nG/L	0 G
Acenaphthylene	<15nG/L	0 G
Acenaphthene	<32nG/L	0 G
Fluorene	<14nG/L	0 G
Phenanthrene	274nG/L	1370 G
C1-Phenanthrenes	230nG/L	1150 G
C2-Phenanthrenes	217nG/L	1085 G
C3-Phenenthrenes	80nG/L	400 G
Anthracene	<15nG/L	0 G
Fluoranthene	301nG/L	1505 G
Pyrene	253nG/L	1265 G
2,3-Benzofluorene	<34nG/L	0 G
Benz(a)anthracene	71nG/L	355 G
Chrysene	163nG/L	815 G
Benzo(b)fluoranth	169nG/L	845 G
Benzo(k)fluoranth	39nG/L	195 G
Benzo(e)pyrene	90nG/L	450 G
Benzo(a)pyrene	42nG/L	210 G
Perylene	10nG/L	0 G
9,10-Diphenylanth	10nG/L	0 G
Dibenz(a,h)anthra	9nG/L	[illegible] G
Benzo(g,h,i)peryl	15nG/L	575 G
TOTAL PAH	[illegible]	[illegible]
SURROGATE RECOVERY		
d8-Naphthalene	79%	***
d10-Acenaphthene	136%	***
d10-Phenanthrene	122%	***
d12-Chrysene	147%	***
d12-Perylene	116%	***
Resolved HCs	1.6e6nG/L	7.8e6 G
n-alkanes c10-c39	1.0e6nG/L	5.0e6 G
Pristane	9328nG/L	46640 G
Phytane	11333nG/L	56665 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	25 Sep 86
Time:	08:25

Flow (M**3/Sec):	49.3
Time Interval:	35:30-44:00
IntervalVol (M**3):	1.52×10^{6}
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	383 mG/L	727.7 T
TVS	9.7 %	***
Total Solids	596 mG/L	1132. T
Dissolved Solids	213 mG/L	404.7 T
Oil & Grease	4.5 mG/L	8.55 T
Chloroform Extr.	4.7 mG/L	8.93 T
Salinity	ppt	***
pH		***
Cadmium	2 uG/L	3.8kG
Chromium	28 uG/L	53.2kG
Copper	83 uG/L	157.7kG
Nickel	34 uG/L	64.6kG
Lead	131 uG/L	248.9kG
Zinc	330 uG/L	627kG
Silver	<1 uG/L	0kG
o,p'-DDE	<1 nG/L	0 G
p,p'-DDE	5 nG/L	9.5 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	2 nG/L	3.8 G
o,p'-DDT	10 nG/L	19 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	17 nG/L	32.3 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	49 nG/L	93.1 G
TOTAL PCB	49 nG/L	93.1 G
Hexachlorobenzene	1 nG/L	1.9 G
Lindane	<1 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	96 nG/L	182.4 G
C1-Naphthalenes	193 nG/L	366.7 G
C2-Naphthalenes	251 nG/L	476.9 G
C3-Naphthalenes	162 nG/L	307.8 G
Biphenyl	<6 nG/L	0 G
Acenaphthylene	<6 nG/L	0 G
Acenaphthene	12 nG/L	0 G
Fluorene	31 nG/L	58.9 G
Phenanthrene	255 nG/L	484.5 G
C1-Phenanthrenes	185 nG/L	351.5 G
C2-Phenanthrenes	201 nG/L	381.9 G
C3-Phenenthrenes	72 nG/L	136.8 G
Anthracene	<6 nG/L	0 G
Fluoranthene	241 nG/L	457.9 G
Pyrene	239 nG/L	454.1 G
2,3-Benzofluorene	19 nG/L	36.1 G
Benz(a)anthracene	50 nG/L	95 G
Chrysene	154 nG/L	292.6 G
Benzo(b)fluoranth	184 nG/L	349.6 G
Benzo(k)fluoranth	<4 nG/L	0 G
Benzo(e)pyrene	86 nG/L	163.4 G
Benzo(a)pyrene	53 nG/L	100.7 G
Perylene	12 nG/L	22.8 G
9,10-Diphenylanth	<4 nG/L	0 G
Dibenz(a,h)anthra	<3 nG/L	0 G
Benzo(g,h,i)peryl	102 nG/L	193.8 G
TOTAL PAH	2590 nG/L	4921 G
SURROGATE RECOV.		
d8-Naphthalene	73 %	***
d10-Acenaphthene	134 %	***
d10-Phenanthrene	129 %	***
d12-Chrysene	112 %	***
d12-Perylene	95 %	***
Resolved HCs	66921 nG/L	1.3e5 G
n-alkanes c10-c39	38369 nG/L	72901 G
Pristane	5072 nG/L	9637. G
Phytane	5494 nG/L	10439 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	25 Sep 86
Time:	16:05

Flow (M**3/Sec):	21.6
Time Interval:	44:15-56:00
IntervalVol(M**3):	3[illegible]
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	187 mG/L	165.7 T
TVS	6.3 %	***
Total Solids	390 mG/L	345.5 T
Dissolved Solids	[illegible] mG/L	179.9 T
Oil & Grease	[illegible] mG/L	[illegible] T
Chloroform Extr.	[illegible] mG/L	[illegible].949 T
Salinity	0 ppt	***
pH	[illegible]	***
Cadmium	[illegible] uG/L	[illegible]
Chromium	7 uG/L	6.202 G
Copper	27 uG/L	23.92 G
Nickel	15 uG/L	13.29 G
Lead	37 uG/L	32.78 G
Zinc	116 uG/L	102.8 G
Silver	<1 uG/L	0 G
o,p'-DDE	3 nG/L	2.658 G
p,p'-DDE	4 nG/L	3.544 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	1 nG/L	.886 G
o,p'-DDT	1 nG/L	0 G
p,p'-DDT	1 nG/L	.886 G
TOTAL DDT	9 nG/L	7.974 G
Aroclor 1242	27 nG/L	23.92 G
Aroclor 1254	24 nG/L	21.26 G
TOTAL PCB	51 nG/L	45.19 G
Hexachlorobenzene	1 nG/L	.886 G
Lindane	9 nG/L	7.974 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	15 nG/L	0 G
C1-Naphthalenes	15 nG/L	0 G
C2-Naphthalenes	15 nG/L	0 G
C3-Naphthalenes	32 nG/L	0 G
Biphenyl	15 nG/L	0 G
Acenaphthylene	15 nG/L	[illegible] G
Acenaphthene	33 nG/L	[illegible] G
Fluorene	15 nG/L	[illegible] G
Phenanthrene	15 nG/L	[illegible] G
C1-Phenanthrenes	15 nG/L	0 G
C2-Phenanthrenes	[illegible]	[illegible]
C3-Phenanthrenes	15 nG/L	0 G
Anthracene	15 nG/L	0 G
Fluoranthene	12 nG/L	0 G
Pyrene	47 nG/L	41.64 G
2,3-Benzofluorene	35 nG/L	0 G
Benz(a)anthracene	<12 nG/L	0 G
Chrysene	<12 nG/L	0 G
Benzo(b)fluoranth	10 nG/L	0 G
Benzo(k)fluoranth	10 nG/L	0 G
Benzo(e)pyrene	10 nG/L	0 G
Benzo(a)pyrene	10 nG/L	0 G
Perylene	10 nG/L	0 G
9,10-Diphenylanth	10 nG/L	0 G
Dibenz(a,h)anthra	9 nG/L	0 G
Benzo(g,h,i)peryl	9 nG/L	0 G
TOTAL PAH	47 nG/L	41.64 G
SURROGATE RECOV.		
d8-Naphthalene	78 %	***
d10-Acenaphthene	108 %	***
d10-Phenanthrene	109 %	***
d12-Chrysene	117 %	***
d12-Perylene	97 %	***
Resolved HCs	10278 nG/L	9106. G
n-alkanes c10-c39	10350 nG/L	9170. G
Pristane	2093 nG/L	1854. G
Phytane	1862 nG/L	1650. G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	23 Sep 86
Time:	18:00

Flow (M**3/Sec):	2.7
Time Interval:	00:00-09:45
IntervalVol(M**3):	1.0 x 10^5
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	693 mG/L	69.3 T
TVS	31 %	***
Total Solids	1296 mG/L	129.6 T
Dissolved Solids	603 mG/L	60.3 T
Oil & Grease	6.7 mG/L	.87 T
Chloroform Extr.	20.5 mG/L	2.05 T
Salinity	0 ppt	***
pH	5.5	***
Cadmium	28 uG/L	2.8kG
Chromium	107 uG/L	10.7kG
Copper	366 uG/L	36.6kG
Nickel	92 uG/L	9.2kG
Lead	335 uG/L	33.5kG
Zinc	954 uG/L	95.4kG
Silver	<1 uG/L	0kG
o,p'-DDE	<1 nG/L	0 G
p,p'-DDE	125 nG/L	12.5 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	125 nG/L	12.5 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	261 nG/L	26.1 G
TOTAL PCB	261 nG/L	26.1 G
Hexachlorobenzene	15 nG/L	1.5 G
Lindane	14 nG/L	1.4 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	31 nG/L	3.1 G
C1-Naphthalenes	77 nG/L	7.7 G
C2-Naphthalenes	32 nG/L	3.2 G
C3-Naphthalenes	<23 nG/L	0 G
Biphenyl	<11 nG/L	0 G
Acenaphthylene	<11 nG/L	0 G
Acenaphthene	<23 nG/L	0 G
Fluorene	<10 nG/L	0 G
Phenanthrene	305 nG/L	30.5 G
C1-Phenanthrenes	160 nG/L	16 G
C2-Phenanthrenes	137 nG/L	13.7 G
C3-Phenenthrenes	117 nG/L	11.7 G
Anthracene	11 nG/L	0 G
Fluoranthene	376 nG/L	37.6 G
Pyrene	401 nG/L	40.1 G
2,3-Benzofluorene	55 nG/L	5.5 G
Benz(a)anthracene	174 nG/L	17.4 G
Chrysene	488 nG/L	48.8 G
Benzo(b)fluoranth	526 nG/L	52.6 G
Benzo(k)fluoranth	203 nG/L	20.3 G
Benzo(e)pyrene	366 nG/L	36.6 G
Benzo(a)pyrene	278 nG/L	27.8 G
Perylene	71 nG/L	7.1 G
9,10-Diphenylanth	8 nG/L	.8 G
Dibenz(a,h)anthra	54 nG/L	5.4 G
Benzo(g,h,i)peryl	541 nG/L	54.1 G
TOTAL PAH	4400 nG/L	440 G
SURROGATE RECOV.		
d8-Naphthalene	33 %	***
d10-Acenaphthene	53 %	***
d10-Phenanthrene	49 %	***
d12-Chrysene	72 %	***
d12-Perylene	102 %	***
Resolved HCs	3.4e5 nG/L	33924 G
n-alkanes c10-c39	1.2e5 nG/L	12080 G
Pristane	8895 nG/L	889.5 G
Phytane	10063 nG/L	1006. G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	24 Sep 86
Time:	09:50

Flow (M**3/Sec): 2.78
Time Interval: 10:00-18:45
IntervalVol (M**3): 90,600
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	17 mG/L	1.370 T	Naphthalene	<26 nG/L	0 G
TVS	29 %	***	C1-Naphthalenes	<26 nG/L	0 G
Total Solids	387 mG/L	31.19 T	C2-Naphthalenes	<26 nG/L	0 G
Dissolved Solids	370 mG/L	29.82 T	C3-Naphthalenes	<53 nG/L	0 G
Oil & Grease	2.3 mG/L	.1854 T	Biphenyl	<26 nG/L	0 G
Chloroform Extr.	1.6 mG/L	.1290 T	Acenaphthylene	<26 nG/L	0 G
Salinity	2 ppt	***	Acenaphthene	<53 nG/L	0 G
pH	5.5	***	Fluorene	<24 nG/L	0 G
			Phenanthrene	<24 nG/L	0 G
Cadmium	2 uG/L	.1612kG	C1-Phenanthrenes	<24 nG/L	0 G
Chromium	<2 uG/L	0kG	C2-Phenanthrenes	<24 nG/L	0 G
Copper	33 uG/L	2.660kG	C3-Phenenthrenes	<24 nG/L	0 G
Nickel	18 uG/L	1.451kG	Anthracene	<24 nG/L	0 G
Lead	43 uG/L	3.466kG	Fluoranthene	<19 nG/L	0 G
Zinc	217 uG/L	17.49kG	Pyrene	<19 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<58 nG/L	0 G
			Benz(a)anthracene	<20 nG/L	0 G
o,p'-DDE	3 nG/L	.2418 G	Chrysene	<20 nG/L	0 G
p,p'-DDE	8 nG/L	.6448 G	Benzo(b)fluoranth	<16 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<16 nG/L	0 G
p,p'-DDD	1 nG/L	.0806 G	Benzo(e)pyrene	<16 nG/L	0 G
o,p'-DDT	1 nG/L	.0806 G	Benzo(a)pyrene	<16 nG/L	0 G
p,p'-DDT	3 nG/L	.2418 G	Perylene	<17 nG/L	0 G
TOTAL DDT	16 nG/L	1.290 G	9,10-Diphenylanth	<17 nG/L	0 G
			Dibenz(a,h)anthra	<14 nG/L	0 G
Aroclor 1242	14 nG/L	1.128 G	Benzo(g,h,i)peryl	<14 nG/L	0 G
Aroclor 1254	44 nG/L	3.546 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	58 nG/L	4.675 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	.0806 G	d8-Naphthalene	0 %	***
Lindane	13 nG/L	1.048 G	d10-Acenaphthene	0 %	***
			d10-Phenanthrene	0 %	***
Toxicity	NoTest	***	d12-Chrysene	10 %	***
			d12-Perylene	18 %	***
			Resolved HCs	19316 nG/L	1557. G
			n-alkanes c10-c39	8331 nG/L	671.5 G
			Pristane	1240 nG/L	99.94 G
			Phytane	1463 nG/L	117.9 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Los Angeles River
Location: Fletcher Avenue
Date: 24 Sep 86
Time: 11:50

Flow (M**3/Sec): 13.4
Time Interval: [illegible]:00-20:45
IntervalVol (M**3): 1.05x10^6
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	469 mG/L	52.06 T
TVS	31 %	***
Total Solids	796 mG/L	88.36 T
Dissolved Solids	327 mG/L	36.30 T
Oil & Grease	7.1 mG/L	.7881 T
Chloroform Extr.	0 mG/L	0 T
Salinity	2 ppt	***
pH	5.5	***
Cadmium	10 uG/L	1.11kG
Chromium	55 uG/L	6.105kG
Copper	213 uG/L	23.64kG
Nickel	46 uG/L	5.106kG
Lead	165 uG/L	18.32kG
Zinc	791 uG/L	87.80kG
Silver	<1 uG/L	0kG
o,p'-DDE	22 nG/L	2.442 G
p,p'-DDE	26 nG/L	2.886 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	8 nG/L	.888 G
o,p'-DDT	13 nG/L	1.443 G
p,p'-DDT	14 nG/L	1.554 G
TOTAL DDT	83 nG/L	9.213 G
Arochlor 1242	74 nG/L	8.214 G
Arochlor 1254	188 nG/L	20.87 G
TOTAL PCB	262 nG/L	29.08 G
Hexachlorobenzene	7 nG/L	.777 G
Lindane	15 nG/L	1.665 [illegible]
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	175 nG/L	19.43 G
C1-Naphthalenes	80 nG/L	8.88 G
C2-Naphthalenes	29 nG/L	0 G
C3-Naphthalenes	60 nG/L	0 G
Biphenyl	29 nG/L	0 G
Acenaphthylene	29 nG/L	0 G
Acenaphthene	60 nG/L	0 G
Fluorene	27 nG/L	0 G
Phenanthrene	323 nG/L	35.85 G
C1-Phenanthrenes	205 nG/L	22.76 G
C2-Phenanthrenes	237 nG/L	26.31 G
C3-Phenenthrenes	102 nG/L	11.32 G
Anthracene	27 nG/L	0 G
Fluoranthene	502 nG/L	55.72 G
Pyrene	542 nG/L	60.16 G
2,3-Benzofluorene	65 nG/L	0 G
Benz(a)anthracene	237 nG/L	26.31 G
Chrysene	470 nG/L	52.17 G
Benzo(b)fluoranth	309 nG/L	34.30 G
Benzo(k)fluoranth	119 nG/L	13.21 G
Benzo(e)pyrene	237 nG/L	26.31 G
Benzo(a)pyrene	143 nG/L	15.87 G
Perylene	19 nG/L	0 G
9,10-Diphenylanth	19 nG/L	0 G
Dibenz(a,h)anthra	16 nG/L	0 G
Benzo(g,h,i)peryl	186 nG/L	20.65 G
TOTAL PAH	3867 nG/L	429.2 G
SURROGATE RECOV.		
d8-Naphthalene	75 %	***
d10-Acenaphthene	[illegible] %	***
d10-Phenanthrene	112 %	***
d12-Chrysene	[illegible]	***
d12-Perylene	112 %	***
Resolved HCs	65179 nG/L	7235. G
n-alkanes c10-c39	21524 nG/L	2389. G
Pristane	1313 nG/L	145.7 G
Phytane	1985 nG/L	220.3 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	24 Sep 86
Time:	14:00

Flow (M**3/Sec):	22.8
Time Interval:	21:00-22:45
IntervalVol (M**3):	1[illegible] 000
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	193 mG/L	33.97 T	Naphthalene	76 nG/L	13.38 G
TVS	24 %	***	C1-Naphthalenes	<23 nG/L	0 G
Total Solids	536 mG/L	94.34 T	C2-Naphthalenes	23 nG/L	0 G
Dissolved Solids	343 mG/L	60.37 T	C3-Naphthalenes	47 nG/L	0 G
Oil & Grease	5.7 mG/L	1.003 T	Biphenyl	<23 nG/L	0 G
Chloroform Extr.	Lost mG/L	0 T	Acenaphthylene	<23 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<47 nG/L	0 G
pH		***	Fluorene	<21 nG/L	0 G
			Phenanthrene	123 nG/L	21.65 G
Cadmium	5 uG/L	.88kG	C1-Phenanthrenes	<21 nG/L	0 G
Chromium	18 uG/L	3.168kG	C2-Phenanthrenes	<21 nG/L	0 G
Copper	146 uG/L	25.70kG	C3-Phenenthrenes	<21 nG/L	0 G
Nickel	49 uG/L	8.624kG	Anthracene	<22 nG/L	0 G
Lead	144 uG/L	25.34kG	Fluoranthene	161 nG/L	28.34 G
Zinc	1358 uG/L	239.0kG	Pyrene	162 nG/L	28.51 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<51 nG/L	0 G
			Benz(a)anthracene	44 nG/L	7.744 G
o,p'-DDE	Lost nG/L	0 G	Chrysene	200 nG/L	35.2 G
p,p'-DDE	Lost nG/L	0 G	Benzo(b)fluoranth	44 nG/L	7.744 G
o,p'-DDD	Lost nG/L	0 G	Benzo( )fluoranth	<14 nG/L	0 G
p,p'-DDD	Lost nG/L	0 G	Benzo(e)pyrene	34 nG/L	5.984 G
o,p'-DDT	Lost nG/L	0 G	Benzo(a)pyrene	14 nG/L	0 G
p,p'-DDT	Lost nG/L	0 G	Perylene	<15 nG/L	0 G
TOTAL DDT	Lost nG/L	0 G	9,10-Diphenylanth	<15 nG/L	0 G
			Dibenz(a,h)anthra	<13 nG/L	0 G
Aroclor 1242	Lost nG/L	0 G	Benzo(g,h,i)peryl	<13 nG/L	0 G
Aroclor 1254	Lost nG/L	0 G	TOTAL PAH	844 nG/L	148.5 G
TOTAL PCB	Lost nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	Lost nG/L	0 G	d8-Naphthalene	73 %	***
Lindane	Lost nG/L	0 G	d10-Acenaphthene	103 %	***
			d10-Phenanthrene	108 %	***
Toxicity	NoTest	***	d12-Chrysene	99 %	***
			d12-Perylene	83 %	***
			Resolved HCs	98906 nG/L	17407 G
			n-alkanes c10-c39	41550 nG/L	7313. G
			Pristane	3552 nG/L	625.2 G
			Phytane	4099 nG/L	721.4 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	64.6
Location:	Fletcher Avenue	Time Interval:	2[illegible]:4[illegible]-24:15
Date:	24 Sep 86	IntervalVol (M**3):	364 ooc
Time:	15:30	Storm #:	1

CONSTITUENT	CC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	553 mG/L	199.1 T	Naphthalene	91 nG/L	32.76 G
TVS	30 %	***	C1-Naphthalenes	142 nG/L	51.12 G
Total Solids	935 mG/L	336.6 T	C2-Naphthalenes	213 nG/L	76.68 G
Dissolved Solids	382 mG/L	137.5 T	C3-Naphthalenes	778 nG/L	280.1 G
Oil & Grease	7.5 mG/L	2.7 T	Biphenyl	<14 nG/L	0 G
Chloroform Extr.	18.7 mG/L	6.732 T	Acenaphthylene	<14 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<29 nG/L	0 G
pH	5.5	***	Fluorene	23 nG/L	8.28 G
			Phenanthrene	681 nG/L	245.2 G
Cadmium	7 uG/L	2.52kG	C1-Phenanthrenes	744 nG/L	267.8 G
Chromium	34 uG/L	12.24kG	C2-Phenanthrenes	941 nG/L	338.8 G
Copper	179 uG/L	64.44kG	C3-Phenenthrenes	574 nG/L	206.6 G
Nickel	56 uG/L	20.16kG	Anthracene	<13 nG/L	0 G
Lead	248 uG/L	89.28kG	Fluoranthene	678 nG/L	244.1 G
Zinc	733 uG/L	263.9kG	Pyrene	710 nG/L	255.6 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	224 nG/L	80.64 G
			Benz(a)anthracene	160 nG/L	57.6 G
o,p'-DDE	23 nG/L	8.28 G	Chrysene	432 nG/L	155.5 G
p,p'-DDE	24 nG/L	8.64 G	Benzo(b)fluoranth	467 nG/L	168.1 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<9 nG/L	0 G
p,p'-DDD	10 nG/L	3.6 G	Benzo(e)pyrene	260 nG/L	93.6 G
o,p'-DDT	23 nG/L	8.28 G	Benzo(a)pyrene	143 nG/L	51.48 G
p,p'-DDT	10 nG/L	3.6 G	Perylene	<9 nG/L	0 G
TOTAL DDT	90 nG/L	32.4 G	9,10-Diphenylanth	<9 nG/L	0 G
			Dibenz(a,h)anthra	<8 nG/L	0 G
Aroclor 1242	108 nG/L	38.88 G	Benzo(g,h,i)peryl	292 nG/L	105.1 G
Aroclor 1254	190 nG/L	68.4 G	TOTAL PAH	7553 nG/L	2719. G
TOTAL PCB	298 nG/L	107.3 G			
			SURROGATE RECOV.		
Hexachlorobenzene	3 nG/L	1.08 G	d8-Naphthalene	72 %	***
Lindane	23 nG/L	8.28 G	d10-Acenaphthene	124 %	***
			d10-Phenanthrene	129 %	***
Toxicity	Notest	***	d12-Chrysene	115 %	***
			d12-Perylene	89 %	***
			Resolved HCs	2.6e5 nG/L	95325 G
			n-alkanes c10-c39	1.3e5 nG/L	46450 G
			Pristane	10979 nG/L	3952. G
			Phytane	14529 nG/L	5230. G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	76.5
Location:	Fletcher avenue	Time Interval:	24:?? -26:30
Date:	24 Sep 86	IntervalVol (M**3):	619,000
Time:	17:00	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1190 mG/L	761.6 T	Naphthalene	152 nG/L	97.28 G
TVS	22 %	***	C1-Naphthalenes	413 nG/L	264.3 G
Total Solids	822 mG/L	526.7 T	C2-Naphthalenes	375 nG/L	240 G
Dissolved Solids	-367 mG/L	-235. T	C3-Naphthalenes	1956 nG/L	1252. G
Oil & Grease	10.9 mG/L	6.976 T	Biphenyl	<37 nG/L	0 G
Chloroform Extr.	29 mG/L	18.56 T	Acenaphthylene	<37 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<78 nG/L	0 G
pH	5.5	***	Fluorene	<35 nG/L	0 G
			Phenanthrene	1259 nG/L	805.8 G
Cadmium	9 uG/L	5.76k G	C1-Phenanthrenes	1703 nG/L	1090. G
Chromium	46 uG/L	29.44k G	C2-Phenanthrenes	1528 nG/L	977.9 G
Copper	667 uG/L	426.9k G	C3-Phenenthrenes	1189 nG/L	761.0 G
Nickel	67 uG/L	42.88k G	Anthracene	<36 nG/L	0 G
d	347 uG/L	222.1k G	Fluoranthene	1720 nG/L	1101. G
nc	1365 uG/L	873.6k G	Pyrene	1727 nG/L	1105. G
Silver	<1 uG/L	0k G	2,3-Benzofluorene	304 nG/L	194.6 G
			Benz(a)anthracene	572 nG/L	366.1 G
o,p'-DDE	60 nG/L	38.4 G	Chrysene	1316 nG/L	842.2 G
p,p'-DDE	78 nG/L	49.92 G	Benzo(b)fluoranth	1513 nG/L	968.3 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<24 nG/L	0 G
p,p'-DDD	33 nG/L	21.12 G	Benzo(e)pyrene	810 nG/L	518.4 G
o,p'-DDT	59 nG/L	37.76 G	Benzo(a)pyrene	458 nG/L	293.1 G
p,p'-DDT	19 nG/L	12.16 G	Perylene	78 nG/L	49.92 G
TOTAL DDT	249 nG/L	159.4 G	9,10-Diphenylanth	<24 nG/L	0 G
			Dibenz(a,h)anthra	87 nG/L	55.68 G
Aroclor 1242	<2 nG/L	0 G	Benzo(g,h,i)peryl	1108 nG/L	709.1 G
Aroclor 1254	352 nG/L	225.3 G	TOTAL PAH	18268 nG/L	11692 G
TOTAL PCB	352 nG/L	225.3 G			
			SURROGATE RECOV.		
Hexachlorobenzene	9 nG/L	5.76 G	d8-Naphthalene	79 %	***
Lindane	29 nG/L	18.56 G	d10-Acenaphthene	109 %	***
			d10-Phenanthrene	130 %	***
Toxicity	Notest	***	d12-Chrysene	142 %	***
			d12-Perylene	135 %	***
			Resolved HCs	5.7e5 nG/L	3.6e5 G
			n-alkanes c10-c39	2.8e5 nG/L	1.8e5 G
			Pristane	24090 nG/L	15418 G
			Phytane	32347 nG/L	20702 G

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Los Angeles River
Location: Fletcher Avenue
Date: 24 Sep 86
Time: 20:00

Flow (M**3/Sec): 58.3
Time Interval: 26:45-35:00
IntervalVol (M**3): 2.33 x 10^6
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	257 mG/L	616.8 T
TVS	22 %	***
Total Solids	398 mG/L	955.2 T
Dissolved Solids	141 mG/L	338.4 T
Oil & Grease	3.8 mG/L	9.12 T
Chloroform Extr.	7.8 mG/L	18.72 T
Salinity	ppt	***
pH		***
Cadmium	1 uG/L	2.4kG
Chromium	12 uG/L	28.8kG
Copper	84 uG/L	201.6kG
Nickel	21 uG/L	50.4kG
Lead	80 uG/L	192kG
Zinc	302 uG/L	724.8kG
Silver	<1 uG/L	0kG
o,p'-DDE	18 nG/L	43.2 G
p,p'-DDE	23 nG/L	55.2 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	11 nG/L	26.4 G
o,p'-DDT	13 nG/L	31.2 G
p,p'-DDT	10 nG/L	24 G
TOTAL DDT	75 nG/L	180 G
Aroclor 1242	<2 nG/L	0 G
Aroclor 1254	93 nG/L	223.2 G
TOTAL PCB	93 nG/L	223.2 G
Hexachlorobenzene	2 nG/L	4.8 G
Lindane	38 nG/L	91.2 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<39 nG/L	0 G
C1-Naphthalenes	<39 nG/L	0 G
C2-Naphthalenes	<39 nG/L	0 G
C3-Naphthalenes	81 nG/L	0 G
Biphenyl	<39 nG/L	0 G
Acenaphthylene	<39 nG/L	0 G
Acenaphthene	<81 nG/L	0 G
Fluorene	<37 nG/L	0 G
Phenanthrene	127 nG/L	304.8 G
C1-Phenanthrenes	<37 nG/L	0 G
C2-Phenanthrenes	<37 nG/L	0 G
C3-Phenenthrenes	<37 nG/L	0 G
Anthracene	<37 nG/L	0 G
Fluoranthene	265 nG/L	636 G
Pyrene	198 nG/L	475.2 G
2,3-Benzofluorene	<87 nG/L	0 G
Benz(a)anthracene	<30 nG/L	0 G
Chrysene	123 nG/L	295.2 G
Benzo(b)fluoranth	41 nG/L	98.4 G
Benzo(k)fluoranth	<25 nG/L	0 G
Benzo(e)pyrene	33 nG/L	79.2 G
Benzo(a)pyrene	<25 nG/L	0 G
Perylene	<25 nG/L	0 G
9,10-Diphenylanth	<25 nG/L	0 G
Dibenz(a,h)anthra	<22 nG/L	0 G
Benzo(g,h,i)peryl	<22 nG/L	0 G
TOTAL PAH	787 nG/L	1889. G
SURROGATE RECOV.		
d8-Naphthalene	73 %	***
d10-Acenaphthene	107 %	***
d10-Phenanthrene	105 %	***
d12-Chrysene	126 %	***
d12-Perylene	112 %	***
Resolved HCs	1.2e5 nG/L	3.0e5 G
n-alkanes c10-c39	58169 nG/L	1.4e5 G
Pristane	6210 nG/L	14904 G
Phytane	6272 nG/L	15053 G

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	25 Sep 86
Time:	10:00

Flow (M**3/Sec):	4.44
Time Interval:	35:[illegible] -[illegible]600
IntervalVol (M**3):	5.47x10^6
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	126 mG/L	89.96 T
TVS	29 %	***
Total Solids	313 mG/L	223.5 T
Dissolved Solids	187 mG/L	133.5 T
Oil & Grease	1.2 mG/L	.8568 T
Chloroform Extr.	2.6 mG/L	1.856 T
Salinity	ppt	***
pH		***
Cadmium	<1 uG/L	0 G
Chromium	4 uG/L	2.856 G
Copper	26 uG/L	18.56 G
Nickel	12 uG/L	8.568 G
Lead	24 uG/L	17.14 G
Zinc	116 uG/L	82.82 G
Silver	<1 uG/L	0 G
o,p'-DDE	4 nG/L	2.856 G
p,p'-DDE	8 nG/L	5.712 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	3 nG/L	2.142 G
o,p'-DDT	2 nG/L	1.428 G
p,p'-DDT	4 nG/L	2.856 G
TOTAL DDT	21 nG/L	14.99 G
Aroclor 1242	38 nG/L	27.13 G
Aroclor 1254	32 nG/L	22.85 G
TOTAL PCB	70 nG/L	49.98 G
Hexachlorobenzene	1 nG/L	.714 G
Lindane	21 nG/L	14.99 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<20 nG/L	0 G
C1-Naphthalenes	<20 nG/L	0 G
C2-Naphthalenes	<20 nG/L	0 G
C3-Naphthalenes	<42 nG/L	0 G
Biphenyl	<20 nG/L	0 G
Acenaphthylene	<20 nG/L	0 G
Acenaphthene	<42 nG/L	0 G
Fluorene	<19 nG/L	0 G
Phenanthrene	<19 nG/L	0 G
C1-Phenanthrenes	<19 nG/L	0 G
C2-Phenanthrenes	<19 nG/L	0 G
C3-Phenenthrenes	<19 nG/L	0 G
Anthracene	<19 nG/L	0 G
Fluoranthene	25 nG/L	17.85 G
Pyrene	<15 nG/L	0 G
2,3-Benzofluorene	<46 nG/L	0 G
Benz(a)anthracene	<16 nG/L	0 G
Chrysene	<16 nG/L	0 G
Benzo(b)fluoranth	<13 nG/L	0 G
Benzo(k)fluoranth	<13 nG/L	0 G
Benzo(e)pyrene	<13 nG/L	0 G
Benzo(a)pyrene	<13 nG/L	0 G
Perylene	<13 nG/L	0 G
9,10-Diphenylanth	<13 nG/L	0 G
Dibenz(a,h)anthra	<11 nG/L	0 G
Benzo(g,h,i)peryl	<11 nG/L	0 G
TOTAL PAH	25 nG/L	17.85 G
SURROGATE RECOV.		
d8-Naphthalene	16 %	***
d10-Acenaphthene	60 %	***
d10-Phenanthrene	94 %	***
d12-Chrysene	126 %	***
d12-Perylene	117 %	***
Resolved HCs	8963 nG/L	6400. G
n-alkanes c10-c39	10932 nG/L	7805. G
Pristane	1775 nG/L	1267. G
Phytane	1882 nG/L	1344. G

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1530

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VOL 12

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Big Tujunga Wash
Date:	24 Sep 86
Time:	11:30

Flow (M**3/Sec):	0.0[illegible] m^3/s
Time Interval:	00:00-21:00
IntervalVol(M**3):	596
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	3 mG/L	0 T
TVS	%	***
Total Solids	398 mG/L	0 T
Dissolved Solids	395 mG/L	0 T
Oil & Grease	1.3 mG/L	0 T
Chloroform Extr.	.05 mG/L	0 T
Salinity	2 ppt	***
pH	5.5	***
Cadmium	<1 uG/L	0kG
Chromium	<2 uG/L	0kG
Copper	3 uG/L	0kG
Nickel	<2 uG/L	0kG
Lead	<6 uG/L	0kG
Zinc	3 uG/L	0kG
Silver	<1 uG/L	0kG
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	4 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	1 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	6 nG/L	0 G
Aroclor 1242	16 nG/L	0 G
Aroclor 1254	15 nG/L	0 G
TOTAL PCB	31 nG/L	0 G
Hexachlorobenzene	<1 nG/L	0 G
Lindane	4 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<33 nG/L	0 G
C1-Naphthalenes	<33 nG/L	0 G
C2-Naphthalenes	<33 nG/L	0 G
C3-Naphthalenes	<68 nG/L	0 G
Biphenyl	<33 nG/L	0 G
Acenaphthylene	<33 nG/L	0 G
Acenaphthene	<68 nG/L	0 G
Fluorene	31 nG/L	0 G
Phenanthrene	<31 nG/L	0 G
C1-Phenanthrenes	<31 nG/L	0 G
C2-Phenanthrenes	<31 nG/L	0 G
C3-Phenenthrenes	<31 nG/L	0 G
Anthracene	<31 nG/L	0 G
Fluoranthene	<25 nG/L	0 G
Pyrene	<25 nG/L	0 G
2,3-Benzofluorene	<74 nG/L	0 G
Benz(a)anthracene	<25 nG/L	0 G
Chrysene	<25 nG/L	0 G
Benzo(b)fluoranth	<21 nG/L	0 G
Benzo(k)fluoranth	<21 nG/L	0 G
Benzo(e)pyrene	<21 nG/L	0 G
Benzo(a)pyrene	<21 nG/L	0 G
Perylene	<21 nG/L	0 G
9,10-Diphenylanth	<21 nG/L	0 G
Dibenz(a,h)anthra	<18 nG/L	0 G
Benzo(g,h,i)peryl	<18 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	49 %	***
d10-Acenaphthene	92 %	***
d10-Phenanthrene	102 %	***
d12-Chrysene	115 %	***
d12-Perylene	116 %	***
Resolved HCs	7990 nG/L	0 G
n-alkanes c10-c39	6349 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	0.01
Location:	Big Tujunga Wash	Time Interval:	21:00-24:15
Date:	24 Sep 86	IntervalVol(M**3):	92.4
Time:	14:45	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	4 mG/L	0 T	Naphthalene	<42 nG/L	0 G
TVS	16 %	***	C1-Naphthalenes	<42 nG/L	0 G
Total Solids	350 mG/L	0 T	C2-Naphthalenes	<42 nG/L	0 G
Dissolved Solids	346 mG/L	0 T	C3-Naphthalenes	<88 nG/L	0 G
Oil & Grease	.7 mG/L	0 T	Biphenyl	<42 nG/L	0 G
Chloroform Extr.	0 mG/L	0 T	Acenaphthylene	<42 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<88 nG/L	0 G
pH	6	***	Fluorene	<40 nG/L	0 G
			Phenanthrene	<40 nG/L	0 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<40 nG/L	0 G
Chromium	<3 uG/L	0kG	C2-Phenanthrenes	<40 nG/L	0 G
Copper	3 uG/L	0kG	C3-Phenenthrenes	<40 nG/L	0 G
Nickel	<2 uG/L	0kG	Anthracene	<40 nG/L	0 G
Lead	<8 uG/L	0kG	Fluoranthene	<32 nG/L	0 G
Zinc	22 uG/L	0kG	Pyrene	<32 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<95 nG/L	0 G
			Benz(a)anthracene	<33 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<33 nG/L	0 G
p,p'-DDE	5 nG/L	0 G	Benzo(b)fluoranth	<27 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<27 nG/L	0 G
p,p'-DDD	4 nG/L	0 G	Benzo(e)pyrene	<27 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<27 nG/L	0 G
p,p'-DDT	2 nG/L	0 G	Perylene	<27 nG/L	0 G
TOTAL DDT	12 nG/L	0 G	9,10-Diphenylanth	<27 nG/L	0 G
			Dibenz(a,h)anthra	<24 nG/L	0 G
Aroclor 1242	22 nG/L	0 G	Benzo(g,h,i)peryl	<24 nG/L	0 G
Aroclor 1254	19 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	41 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	54 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	96 %	***
			d10-Phenanthrene	91 %	***
Toxicity	Notest	***	d12-Chrysene	85 %	***
			d12-Perylene	89 %	***
			Resolved HCs	3474 nG/L	0 G
			n-alkanes c10-c39	3392 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Big Tujunga Wash
Date:	24 Sep 86
Time:	18:30

Flow (M**3/Sec): 0.01 m³/s
Time Interval: 24:15-27:45
IntervalVol (M**3): 99.6
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	4 mG/L	0 T
TVS	%	***
Total Solids	300 mG/L	0 T
Dissolved Solids	296 mG/L	0 T
Oil & Grease	.1 mG/L	0 T
Chloroform Extr.	1.85 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	1 uG/L	0 G
Chromium	<3 uG/L	0 G
Copper	4 uG/L	0 G
Nickel	2 uG/L	0 G
Lead	7 uG/L	0 G
Zinc	4 uG/L	0 G
Silver	<1 uG/L	0 G
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	2 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G
o,p'-DDT	2 nG/L	0 G
p,p'-DDT	2 nG/L	0 G
TOTAL DDT	7 nG/L	0 G
Aroclor 1242	6 nG/L	0 G
Aroclor 1254	16 nG/L	0 G
TOTAL PCB	22 nG/L	0 G
Hexachlorobenzene	<1 nG/L	0 G
Lindane	2 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<32 nG/L	0 G
C1-Naphthalenes	<32 nG/L	0 G
C2-Naphthalenes	<32 nG/L	0 G
C3-Naphthalenes	<67 nG/L	0 G
Biphenyl	<32 nG/L	0 G
Acenaphthylene	<32 nG/L	0 G
Acenaphthene	<67 nG/L	0 G
Fluorene	<31 nG/L	0 G
Phenanthrene	<31 nG/L	0 G
C1-Phenanthrenes	<31 nG/L	0 G
C2-Phenanthrenes	<31 nG/L	0 G
C3-Phenenthrenes	<31 nG/L	0 G
Anthracene	<31 nG/L	0 G
Fluoranthene	<25 nG/L	0 G
Pyrene	<25 nG/L	0 G
2,3-Benzofluorene	<73 nG/L	0 G
Benz(a)anthracene	<25 nG/L	0 G
Chrysene	<25 nG/L	0 G
Benzo(b)fluoranth	<21 nG/L	0 G
Benzo(k)fluoranth	<21 nG/L	0 G
Benzo(e)pyrene	<21 nG/L	0 G
Benzo(a)pyrene	<21 nG/L	0 G
Perylene	<21 nG/L	0 G
9,10-Diphenylanth	<21 nG/L	0 G
Dibenz(a,h)anthra	<18 nG/L	0 G
Benzo(g,h,i)peryl	<18 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	0 %	***
d10-Acenaphthene	0 %	***
d10-Phenanthrene	0 %	***
d12-Chrysene	2 %	***
d12-Perylene	8 %	***
Resolved HCs	3045 nG/L	0 G
n-alkanes c10-c39	2304 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	0.011
Location:	Big Tujunga Wash	Time Interval:	27:45-34:30
Date:	24 Sep 86	IntervalVol (M**3):	161
Time:	20:45	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	7 mG/L	0 T	Naphthalene	41 nG/L	0 G
TVS	50 %	***	C1-Naphthalenes	41 nG/L	0 G
Total Solids	1260 mG/L	0 T	C2-Naphthalenes	41 nG/L	0 G
Dissolved Solids	1250 mG/L	0 T	C3-Naphthalenes	86 nG/L	0 G
Oil & Grease	<.1 mG/L	0 T	Biphenyl	41 nG/L	0 G
Chloroform Extr.	3.87 mG/L	0 T	Acenaphthylene	41 nG/L	0 G
Salinity	ppt	***	Acenaphthene	86 nG/L	0 G
pH		***	Fluorene	39 nG/L	0 G
			Phenanthrene	39 nG/L	0 G
Cadmium	<1 uG/L	0 G	C1-Phenanthrenes	39 nG/L	0 G
Chromium	<3 uG/L	0 G	C2-Phenanthrenes	39 nG/L	0 G
Copper	4 uG/L	0 G	C3-Phenenthrenes	39 nG/L	0 G
Nickel	2 uG/L	0 G	Anthracene	39 nG/L	0 G
ad	<8 uG/L	0 G	Fluoranthene	31 nG/L	0 G
nc	2 uG/L	0 G	Pyrene	31 nG/L	0 G
Silver	<1 uG/L	0 G	2,3-Benzofluorene	93 nG/L	0 G
			Benz(a)anthracene	32 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	32 nG/L	0 G
p,p'-DDE	1 nG/L	0 G	Benzo(b)fluoranth	26 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	26 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<26 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<26 nG/L	0 G
p,p'-DDT	2 nG/L	0 G	Perylene	<27 nG/L	0 G
TOTAL DDT	3 nG/L	0 G	9,10-Diphenylanth	<27 nG/L	0 G
			Dibenz(a,h)anthra	23 nG/L	0 G
Aroclor 1242	<2 nG/L	0 G	Benzo(g,h,i)peryl	23 nG/L	0 G
Aroclor 1254	2 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	2 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	0 %	***
Lindane	2 nG/L	0 G	d10-Acenaphthene	0 %	***
			d10-Phenanthrene	0 %	***
Toxicity	Notest	***	d12-Chrysene	0 %	***
			d12-Perylene	5 %	***
			Resolved HCs	4587 nG/L	0 G
			n-alkanes c10-c39	4270 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	0.0.
Location:	Big Tujunga Wash	Time Interval:	34:30-36:00
Date:	25 Sep 86	IntervalVol (M**3):	383
Time:	08:30	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MAS
Suspended Solids	826 mG/L	0 T	Naphthalene	<33 nG/L	
TVS	9 %	***	C1-Naphthalenes	<33 nG/L	
Total Solids	345 mG/L	0 T	C2-Naphthalenes	<33 nG/L	
Dissolved Solids	-481 mG/L	0 T	C3-Naphthalenes	<69 nG/L	
Oil & Grease	.1 mG/L	0 T	Biphenyl	<33 nG/L	
Chloroform Extr.	2.12 mG/L	0 T	Acenaphthylene	<33 nG/L	
Salinity	ppt	***	Acenaphthene	<69 nG/L	
pH		***	Fluorene	<31 nG/L	
			Phenanthrene	<31 nG/L	
Cadmium	<1 uG/L	0 G	C1-Phenanthrenes	<31 nG/L	
Chromium	8 uG/L	0 G	C2-Phenanthrenes	<31 nG/L	
Copper	28 uG/L	0 G	C3-Phenenthrenes	<31 nG/L	
Nickel	5 uG/L	0 G	Anthracene	<32 nG/L	
Lead	<7 uG/L	0 G	Fluoranthene	<25 nG/L	
Zinc	47 uG/L	0 G	Pyrene	<25 nG/L	
Silver	<1 uG/L	0 G	2,3-Benzofluorene	<75 nG/L	
			Benz(a)anthracene	<26 nG/L	
o,p'-DDE	1 nG/L	0 G	Chrysene	<26 nG/L	
p,p'-DDE	2 nG/L	0 G	Benzo(b)fluoranth	<21 nG/L	
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<21 nG/L	
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<21 nG/L	
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<21 nG/L	
p,p'-DDT	2 nG/L	0 G	Perylene	<21 nG/L	
TOTAL DDT	5 nG/L	0 G	9,10-Diphenylanth	<21 nG/L	
			Dibenz(a,h)anthra	<19 nG/L	
Aroclor 1242	12 nG/L	0 G	Benzo(g,h,i)peryl	<19 nG/L	
Aroclor 1254	23 nG/L	0 G	TOTAL PAH	0 nG/L	
TOTAL PCB	35 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	34 %	***
Lindane	2 nG/L	0 G	d10-Acenaphthene	73 %	***
			d10-Phenanthrene	96 %	***
Toxicity	Notest	***	d12-Chrysene	177 %	***
			d12-Perylene	163 %	***
			Resolved HCs	5310 nG/L	
			n-alkanes c10-c39	1442 nG/L	
			Pristane	0 nG/L	
			Phytane	0 nG/L	

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Ballona Creek	Flow (M**3/Sec):	.51
Location:	Inglewood Avenue	Time Interval:	00:00-12:15
Date:	23 Sep 86	IntervalVol(M**3):	1° 40c
Time:	21:55	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	331 mG/L	.2274 T	Naphthalene	62 nG/L	.0426 G
TVS	30 %	***	C1-Naphthalenes	48 nG/L	.0330 G
Total Solids	6070 mG/L	4.170 T	C2-Naphthalenes	125 nG/L	.0859 G
Dissolved Solids	5741 mG/L	3.944 T	C3-Naphthalenes	632 nG/L	.4342 G
Oil & Grease	4.5 mG/L	.0031 T	Biphenyl	<6 nG/L	0 G
Chloroform Extr.	59.6 mG/L	.0409 T	Acenaphthylene	<6 nG/L	0 G
Salinity	6 ppt	***	Acenaphthene	<12 nG/L	0 G
pH	6	***	Fluorene	58 nG/L	.0398 G
			Phenanthrene	228 nG/L	.1566 G
Cadmium	2 uG/L	.0014kG	C1-Phenanthrenes	1222 nG/L	.8395 G
Chromium	12 uG/L	.0082kG	C2-Phenanthrenes	1411 nG/L	.9694 G
Copper	112 uG/L	.0769kG	C3-Phenenthrenes	1480 nG/L	1.017 G
Nickel	33 uG/L	.0227kG	Anthracene	34 nG/L	.0234 G
Lead	113 uG/L	.0776kG	Fluoranthene	626 nG/L	.4301 G
Zinc	376 uG/L	.2583kG	Pyrene	685 nG/L	.4706 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	273 nG/L	.1876 G
			Benz(a)anthracene	177 nG/L	.1216 G
o,p'-DDE	14 nG/L	.0096 G	Chrysene	387 nG/L	.2659 G
p,p'-DDE	11 nG/L	.0076 G	Benzo(b)fluoranth	419 nG/L	.2879 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<4 nG/L	0 G
p,p'-DDD	6 nG/L	.0041 G	Benzo(e)pyrene	239 nG/L	.1642 G
o,p'-DDT	10 nG/L	.0069 G	Benzo(a)pyrene	100 nG/L	.0687 G
p,p'-DDT	<1 nG/L	0 G	Perylene	65 nG/L	.0447 G
TOTAL DDT	41 nG/L	.0282 G	9,10-Diphenylanth	17 nG/L	.0117 G
			Dibenz(a,h)anthra	41 nG/L	.0282 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	303 nG/L	.2082 G
Aroclor 1254	116 nG/L	.0797 G	TOTAL PAH	8632 nG/L	5.930 G
TOTAL PCB	116 nG/L	.0797 G			
			SURROGATE RECOV.		
Hexachlorobenzene	5 nG/L	.0034 G	d8-Naphthalene	86 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	125 %	***
			d10-Phenanthrene	114 %	***
Toxicity	NoTest	***	d12-Chrysene	99 %	***
			d12-Perylene	93 %	***
			Resolved HCs	4.2e5 nG/L	295.9 G
			n-alkanes c10-c3?	177254 nG/L	0 G
			Pristane	33237 nG/L	22.83 G
			Phytane	41442 nG/L	28.47 G

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY

VOL 12

17536

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

VOL 12

Channel: Ballona Creek
Location: Inglewood Avenue
Date: 24 Sep 86
Time: 10:50

Flow (M**3/Sec): 56.6
Time Interval: 12:30-21:45
IntervalVol(M**3): 7.14 x10⁶
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	2500 mG/L	17.58 T	Naphthalene	815 nG/L	5.729 G
TVS	20 %	***	C1-Naphthalenes	1298 nG/L	9.125 G
Total Solids	5250 mG/L	36.91 T	C2-Naphthalenes	1451 nG/L	10.20 G
Dissolved Solids	2750 mG/L	19.33 T	C3-Naphthalenes	4447 nG/L	31.26 G
Oil & Grease	36.4 mG/L	.2559 T	Biphenyl	86 nG/L	.6046 G
Chloroform Extr.	76.6 mG/L	.5385 T	Acenaphthylene	<15 nG/L	0 G
Salinity	.25 ppt	***	Acenaphthene	195 nG/L	1.371 G
pH	5.5	***	Fluorene	352 nG/L	2.475 G
			Phenanthrene	4635 nG/L	32.58 G
Cadmium	22 uG/L	.1547kG	C1-Phenanthrenes	4426 nG/L	31.11 G
Chromium	248 uG/L	1.743kG	C2-Phenanthrenes	6754 nG/L	47.48 G
Copper	860 uG/L	6.046kG	C3-Phenanthrenes	7675 nG/L	53.96 G
Nickel	261 uG/L	1.835kG	Anthracene	765 nG/L	5.378 G
Lead	1829 uG/L	12.86kG	Fluoranthene	7731 nG/L	54.35 G
Zinc	4398 uG/L	30.92kG	Pyrene	8064 nG/L	56.69 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	2596 nG/L	18.25 G
			Benz(a)anthracene	3768 nG/L	26.49 G
o,p'-DDE	346 nG/L	2.432 G	Chrysene	6671 nG/L	46.90 G
p,p'-DDE	354 nG/L	2.489 G	Benzo(b)fluoranth	<9 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	8375 nG/L	58.88 G
p,p'-DDD	151 nG/L	1.062 G	Benzo(e)pyrene	<9 nG/L	0 G
o,p'-DDT	330 nG/L	2.320 G	Benzo(a)pyrene	4088 nG/L	28.74 G
p,p'-DDT	179 nG/L	1.258 G	Perylene	70 nG/L	.4921 G
TOTAL DDT	1360 nG/L	9.561 G	9,10-Diphenylanth	248 nG/L	1.743 G
			Dibenz(a,h)anthra	395 nG/L	2.777 G
Aroclor 1242	4 nG/L	.0281 G	Benzo(g,h,i)peryl	789 nG/L	5.547 G
Aroclor 1254	628 nG/L	4.415 G	TOTAL PAH	75694 nG/L	532.1 G
TOTAL PCB	632 nG/L	4.443 G			
			SURROGATE RECOV.		
Hexachlorobenzene	9 nG/L	.0633 G	d8-Naphthalene	77 %	***
Lindane	49 nG/L	.3445 G	d10-Acenaphthene	126 %	***
			d10-Phenanthrene	126 %	***
Toxicity	NoTest	***	d12-Chrysene	201 %	***
			d12-Perylene	164 %	***
			Resolved HCs	7.7e6 nG/L	54123 G
			n-alkanes c10-c39	4.4e5 nG/L	3104. G
			Pristane	39421 nG/L	277.1 G
			Phytane	47000 nG/L	330.4 G

1 7537

R0050842

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Ballona Creek
Location:	Inglewood Avenue
Date:	24 Sep 86
Time:	16:55

Flow (M**3/Sec): 63.7
Time Interval: 22:00-27:15
IntervalVol (M**3): 1.67 x 10⁶
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	234 mG/L	395.5 T	Naphthalene	264 nG/L	446.2 G
TVS	15 %	***	C1-Naphthalenes	748 nG/L	1264. G
Total Solids	306 mG/L	517.1 T	C2-Naphthalenes	659 nG/L	1114. G
Dissolved Solids	72 mG/L	121.7 T	C3-Naphthalenes	738 nG/L	1247. G
Oil & Grease	9.3 mG/L	15.72 T	Biphenyl	<21 nG/L	0 G
Chloroform Extr.	16.5 mG/L	27.89 T	Acenaphthylene	<21 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<43 nG/L	0 G
pH		***	Fluorene	46 nG/L	77.74 G
			Phenanthrene	857 nG/L	1448. G
Cadmium	3 uG/L	5.07kG	C1-Phenanthrenes	1160 nG/L	1960. G
Chromium	13 uG/L	21.97kG	C2-Phenanthrenes	1326 nG/L	2241. G
Copper	86 uG/L	145.3kG	C3-Phenanthrenes	741 nG/L	1252. G
Nickel	23 uG/L	38.87kG	Anthracene	<20 nG/L	0 G
Lead	96 uG/L	162.2kG	Fluoranthene	980 nG/L	1656. G
Zinc	613 uG/L	1036.kG	Pyrene	991 nG/L	1675. G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	227 nG/L	383.6 G
			Benz(a)anthracene	314 nG/L	530.7 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	673 nG/L	1137. G
p,p'-DDE	13 nG/L	21.97 G	Benzo(b)fluoranth	636 nG/L	1075. G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<13 nG/L	0 G
p,p'-DDD	9 nG/L	15.21 G	Benzo(e)pyrene	354 nG/L	598.3 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	174 nG/L	294.1 G
p,p'-DDT	22 nG/L	37.18 G	Perylene	<13 nG/L	0 G
TOTAL DDT	44 nG/L	74.36 G	9,10-Diphenylanth	<13 nG/L	0 G
			Dibenz(a,h)anthra	41 nG/L	69.29 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	443 nG/L	748.7 G
Aroclor 1254	220 nG/L	371.8 G	TOTAL PAH	11372 nG/L	19219 G
TOTAL PCB	220 nG/L	371.8 G			
			SURROGATE RECOV.		
Hexachlorobenzene	2 nG/L	3.38 G	d8-Naphthalene	46 %	***
Lindane	10 nG/L	16.9 G	d10-Acenaphthene	137 %	***
			d10-Phenanthrene	125 %	***
Toxicity	NoTest	***	d12-Chrysene	148 %	***
			d12-Perylene	124 %	***
			Resolved HCs	3.1e5 nG/L	5.2e5 G
			n-alkanes c10-c39	1.2e5 nG/L	2.1e5 G
			Pristane	11238 nG/L	18992 G
			Phytane	12621 nG/L	21329 G

1 7538

R0050843

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Ballona Creek	Flow (M**3/Sec):	140
Location:	Inglewood Avenue	Time Interval:	27:15-34:45
Date:	24 Sep 86	IntervalVol(M**3):	1.57 x 10^6
Time:	21:30	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	112 mG/L	180.3 T	Naphthalene	<15 nG/L	0 G
TVS	17 %	***	C1-Naphthalenes	<15 nG/L	0 G
Total Solids	165 mG/L	265.7 T	C2-Naphthalenes	<15 nG/L	0 G
Dissolved Solids	53 mG/L	85.33 T	C3-Naphthalenes	<32 nG/L	0 G
Oil & Grease	6.3 mG/L	10.14 T	Biphenyl	<15 nG/L	0 G
Chloroform Extr.	1.6 mG/L	2.576 T	Acenaphthylene	<15 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<32 nG/L	0 G
pH	5.5	***	Fluorene	<15 nG/L	0 G
			Phenanthrene	79 nG/L	127.2 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<15 nG/L	0 G
Chromium	5 uG/L	8.05kG	C2-Phenanthrenes	<15 nG/L	0 G
Copper	43 uG/L	69.23kG	C3-Phenenthrenes	<15 nG/L	0 G
Nickel	14 uG/L	22.54kG	Anthracene	<15 nG/L	0 G
Lead	68 uG/L	109.5kG	Fluoranthene	203 nG/L	326.8 G
Zinc	237 uG/L	381.6kG	Pyrene	179 nG/L	288.2 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<35 nG/L	0 G
			Benz(a)anthracene	21 nG/L	33.81 G
o,p'-DDE	6 nG/L	9.66 G	Chrysene	101 nG/L	162.6 G
p,p'-DDE	6 nG/L	9.66 G	Benzo(b)fluoranth	55 nG/L	88.55 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<10 nG/L	0 G
p,p'-DDD	1 nG/L	1.61 G	Benzo(e)pyrene	34 nG/L	54.74 G
o,p'-DDT	5 nG/L	8.05 G	Benzo(a)pyrene	<10 nG/L	0 G
p,p'-DDT	7 nG/L	11.27 G	Perylene	<10 nG/L	0 G
TOTAL DDT	25 nG/L	40.25 G	9,10-Diphenylanth	<10 nG/L	0 G
			Dibenz(a,h)anthra	<9 nG/L	0 G
Aroclor 1242	44 nG/L	70.84 G	Benzo(g,h,i)peryl	<9 nG/L	0 G
Aroclor 1254	31 nG/L	49.91 G	TOTAL PAH	672 nG/L	1082. G
TOTAL PCB	75 nG/L	120.8 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	1.61 G	d8-Naphthalene	0 %	***
Lindane	8 nG/L	12.88 G	d10-Acenaphthene	57 %	***
			d10-Phenanthrene	98 %	***
Toxicity	NoTest	***	d12-Chrysene	142 %	***
			d12-Perylene	128 %	***
			Resolved HCs	7.8e5 nG/L	1.3e6 G
			n-alkanes c10-c39	2.6e5 nG/L	4.1e5 G
			Pristane	15381 nG/L	24763 G
			Phytane	29166 nG/L	46957 G

17539

R0050844

VOL 12

17540

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Ballona Creek	Flow (M**3/Sec):	1.09
Location:	Inglewood Avenue	Time Interval:	35:00-43:30
Date:	25 Sep 86	IntervalVol(M**3):	52960
Time:	08:06	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	13 mG/L	.7059 T	Naphthalene	140 nG/L	7.602 G
TVS	46 %	***	C1-Naphthalenes	80 nG/L	4.344 G
Total Solids	284 mG/L	15.42 T	C2-Naphthalenes	<15 nG/L	0 G
Dissolved Solids	271 mG/L	14.72 T	C3-Naphthalenes	<32 nG/L	0 G
Oil & Grease	2.2 mG/L	.1195 T	Biphenyl	<15 nG/L	0 G
Chloroform Extr.	5.7 mG/L	.3095 T	Acenaphthylene	<15 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<32 nG/L	0 G
pH		***	Fluorene	<14 nG/L	0 G
			Phenanthrene	120 nG/L	6.516 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<14 nG/L	0 G
Chromium	<3 uG/L	0kG	C2-Phenanthrenes	<14 nG/L	0 G
Copper	28 uG/L	1.520kG	C3-Phenanthrenes	<14 nG/L	0 G
Nickel	7 uG/L	.3801kG	Anthracene	<15 nG/L	0 G
Lead	23 uG/L	1.249kG	Fluoranthene	33 nG/L	1.792 G
Zinc	187 uG/L	10.15kG	Pyrene	27 nG/L	1.466 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<34 nG/L	0 G
			Benz(a)anthracene	<12 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	<12 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G	Benzo(b)fluoranth	<10 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<10 nG/L	0 G
p,p'-DDD	1 nG/L	.0543 G	Benzo(e)pyrene	<10 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<10 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	10 nG/L	0 G
TOTAL DDT	[illegible]	[illegible]	9,10-Diphenylanth	<10 nG/L	0 G
			Dibenz(a,h)anthra	<9 nG/L	[illegible]
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<9 nG/L	0 G
Aroclor 1254	18 nG/L	.9774 G	TOTAL PAH	400 nG/L	21.72 G
TOTAL PCB	18 nG/L	.9774 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	71 %	***
Lindane	7 nG/L	.3801 G	d10-Acenaphthene	103 %	***
			d10-Phenanthrene	105 %	***
Toxicity	NoTest	***	d12-Chrysene	114 %	***
			d12-Perylene	100 %	***
			Resolved HCs	17727 nG/L	962.6 G
			n-alkanes c10-c39	8910 nG/L	483.8 G
			Pristane	1889 nG/L	102.6 G
			Phytane	2033 nG/L	110.4 G

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Ballona Creek
Location: Inglewood Avenue
Date: 25 Sep 86
Time: 15:15

Flow (M**3/Sec): .538
Time Interval: 43:45-46:00
IntervalVol (M**3): 4770
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	184 mG/L	4.250 T	Naphthalene	<14 nG/L	0 G
TVS	18 %	***	C1-Naphthalenes	<14 nG/L	0 G
Total Solids	1760 mG/L	40.66 T	C2-Naphthalenes	<14 nG/L	0 G
Dissolved Solids	1580 mG/L	36.50 T	C3-Naphthalenes	<28 nG/L	0 G
Oil & Grease	2.9 mG/L	.0670 T	Biphenyl	<14 nG/L	0 G
Chloroform Extr.	2.4 mG/L	.0554 T	Acenaphthylene	<14 nG/L	0 G
Salinity	2 ppt	***	Acenaphthene	<28 nG/L	0 G
pH	6	***	Fluorene	<13 nG/L	0 G
			Phenanthrene	156 nG/L	3.604 G
Cadmium	2 uG/L	.0462kG	C1-Phenanthrenes	<13 nG/L	0 G
Chromium	19 uG/L	.4389kG	C2-Phenanthrenes	29 nG/L	.6699 G
Copper	44 uG/L	1.016kG	C3-Phenenthrenes	<13 nG/L	0 G
Nickel	19 uG/L	.4389kG	Anthracene	<13 nG/L	0 G
Lead	27 uG/L	.6237kG	Fluoranthene	138 nG/L	3.188 G
Zinc	172 uG/L	3.973kG	Pyrene	81 nG/L	1.871 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<31 nG/L	0 G
			Benz(a)anthracene	<11 nG/L	0 G
o,p'-DDE	6 nG/L	.1386 G	Chrysene	79 nG/L	1.825 G
p,p'-DDE	8 nG/L	.1848 G	Benzo(b)fluoranth	<9 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<9 nG/L	0 G
p,p'-DDD	2 nG/L	.0462 G	Benzo(e)pyrene	<9 nG/L	0 G
o,p'-DDT	5 nG/L	.1155 G	Benzo(a)pyrene	<9 nG/L	0 G
p,p'-DDT	3 nG/L	.0693 G	Perylene	<9 nG/L	0 G
TOTAL DDT	24 nG/L	.5544 G	9,10-Diphenylanth	<9 nG/L	0 G
			Dibenz(a,h)anthra	<8 nG/L	0 G
Aroclor 1242	22 nG/L	.5082 G	Benzo(g,h,i)peryl	<8 nG/L	0 G
Aroclor 1254	45 nG/L	1.040 G	TOTAL PAH	483 nG/L	11.16 G
TOTAL PCB	67 nG/L	1.548 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	.0231 G	d8-Naphthalene	68 %	***
Lindane	5 nG/L	.1155 G	d10-Acenaphthene	99 %	***
			d10-Phenanthrene	111 %	***
Toxicity	Notest	***	d12-Chrysene	121 %	***
			d12-Perylene	92 %	***
			Resolved HCs	93659 nG/L	2164. G
			n-alkanes c10-c39	42711 nG/L	986.6 G
			Pristane	5341 nG/L	123.4 G
			Phytane	4300 nG/L	99.33 G

17541

R0050846

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Santa Clara River	Flow (M**3/Sec):	0.15
Location:	Highway 101	Time Interval:	00:00-21:45
Date:	24 Sep 86	IntervalVol(M**3):	1970
Time:	13:10	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1090 mG/L	0 T	Naphthalene	106 nG/L	0 G
TVS	12 %	***	C1-Naphthalenes	78 nG/L	0 G
Total Solids	1420 mG/L	0 T	C2-Naphthalenes	124 nG/L	0 G
Dissolved Solids	330 mG/L	0 T	C3-Naphthalenes	<31 nG/L	0 G
Oil & Grease	6.8 mG/L	0 T	Biphenyl	<15 nG/L	0 G
Chloroform Extr.	1.1 mG/L	0 T	Acenaphthylene	15 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<31 nG/L	0 G
pH	5.5	***	Fluorene	<14 nG/L	0 G
			Phenanthrene	193 nG/L	0 G
Cadmium	2 uG/L	0kG	C1-Phenanthrenes	286 nG/L	0 G
Chromium	68 uG/L	0kG	C2-Phenanthrenes	226 nG/L	0 G
Copper	74 uG/L	0kG	C3-Phenenthrenes	50 nG/L	0 G
Nickel	48 uG/L	0kG	Anthracene	<14 nG/L	0 G
Lead	134 uG/L	0kG	Fluoranthene	178 nG/L	0 G
Zinc	391 uG/L	0kG	Pyrene	214 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<34 nG/L	0 G
			Benz(a)anthracene	<12 nG/L	0 G
o,p'-DDE	13 nG/L	0 G	Chrysene	232 nG/L	0 G
p,p'-DDE	177 nG/L	0 G	Benzo(b)fluoranth	66 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	30 nG/L	0 G
p,p'-DDD	25 nG/L	0 G	Benzo(e)pyrene	76 nG/L	0 G
o,p'-DDT	21 nG/L	0 G	Benzo(a)pyrene	25 nG/L	0 G
p,p'-DDT	60 nG/L	0 G	Perylene	<10 nG/L	0 G
TOTAL DDT	296 nG/L	0 G	9,10-Diphenylanth	<10 nG/L	0 G
			Dibenz(a,h)anthra	<8 nG/L	0 G
Aroclor 1242	70 nG/L	0 G	Benzo(g,h,i)peryl	67 nG/L	0 G
Aroclor 1254	86 nG/L	0 G	TOTAL PAH	1951 nG/L	0 G
TOTAL PCB	156 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	62 %	***
Lindane	7 nG/L	0 G	d10-Acenaphthene	125 %	***
			d10-Phenanthrene	131 %	***
Toxicity	NoTest	***	d12-Chrysene	157 %	***
			d12-Perylene	134 %	***
			Resolved HCs	1.2e5 nG/L	0 G
			n-alkanes c10-c39	51516 nG/L	0 G
			Pristane	36160 nG/L	0 G
			Phytane	4516 nG/L	0 G

VOL 12

17542

R0050847

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Santa Clara River	Flow (M**3/Sec):	0.15
Location:	Highway 101	Time Interval:	00:00-21:45
Date:	24 Sep 86	IntervalVol(M**3):	197[illegible]
Time:	13:10	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1090 mG/L	0 T	Naphthalene	106 nG/L	0 G
TVS	12 %	***	C1-Naphthalenes	78 nG/L	0 G
Total Solids	1420 mG/L	0 T	C2-Naphthalenes	124 nG/L	0 G
Dissolved Solids	330 mG/L	0 T	C3-Naphthalenes	<31 nG/L	0 G
Oil & Grease	6.8 mG/L	0 T	Biphenyl	<15 nG/L	0 G
Chloroform Extr.	1.1 mG/L	0 T	Acenaphthylene	<15 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<31 nG/L	0 G
pH	5.5	***	Fluorene	<14 nG/L	0 G
			Phenanthrene	193 nG/L	0 G
Cadmium	2 uG/L	0 kG	C1-Phenanthrenes	286 nG/L	0 G
Chromium	68 uG/L	0 kG	C2-Phenanthrenes	226 nG/L	0 G
Copper	74 uG/L	0 kG	C3-Phenanthrenes	50 nG/L	0 G
Nickel	48 uG/L	0 kG	Anthracene	<14 nG/L	0 G
Lead	134 uG/L	0 kG	Fluoranthene	178 nG/L	0 G
Zinc	391 uG/L	0 kG	Pyrene	214 nG/L	0 G
Silver	<1 uG/L	0 kG	2,3-Benzofluorene	<34 nG/L	0 G
			Benz(a)anthracene	<12 nG/L	0 G
o,p'-DDE	13 nG/L	0 G	Chrysene	232 nG/L	0 G
p,p'-DDE	177 nG/L	0 G	Benzo(b)fluoranth	66 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	30 nG/L	0 G
p,p'-DDD	25 nG/L	0 G	Benzo(e)pyrene	76 nG/L	0 G
o,p'-DDT	21 nG/L	0 G	Benzo(a)pyrene	25 nG/L	0 G
p,p'-DDT	60 nG/L	0 G	Perylene	<10 nG/L	0 G
TOTAL DDT	296 nG/L	0 G	9,10-Diphenylanth	<10 nG/L	0 G
			Dibenz(a,h)anthra	<8 nG/L	0 G
Aroclor 1242	70 nG/L	0 G	Benzo(g,h,i)peryl	67 nG/L	0 G
Aroclor 1254	86 nG/L	0 G	TOTAL PAH	1951 nG/L	0 G
TOTAL PCB	156 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	62 %	***
Lindane	7 nG/L	0 G	d10-Acenaphthene	125 %	***
			d10-Phenanthrene	131 %	***
Toxicity	NoTest	***	d12-Chrysene	157 %	***
			d12-Perylene	134 %	***
			Resolved HCs	1.2e5 nG/L	0 G
			n-alkanes c10-c39	51516 nG/L	0 G
			Pristane	36160 nG/L	0 G
			Phytane	4516 nG/L	0 G

VOL 12

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Santa Clara River	Flow (M**3/Sec): 0.28
Location: Highway 101	Time Interval: 21:45-34:15
Date: 24 Sep 86	IntervalVol(M**3): 9630
Time: 14:30	Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1920 mG/L	0 T	Naphthalene	125 nG/L	0 G
TVS	8.4 %	***	C1-Naphthalenes	45 nG/L	0 G
Total Solids	2470 mG/L	0 T	C2-Naphthalenes	22 nG/L	0 G
Dissolved Solids	550 mG/L	0 T	C3-Naphthalenes	<25 nG/L	0 G
Oil & Grease	3 mG/L	0 T	Biphenyl	<12 nG/L	0 G
Chloroform Extr.	7.5 mG/L	0 T	Acenaphthylene	<12 nG/L	0 G
Salinity	ppt	***	Acenaphthene	112 nG/L	0 G
pH		***	Fluorene	44 nG/L	0 G
			Phenanthrene	375 nG/L	0 G
Cadmium	1 uG/L	OkG	C1-Phenanthrenes	62 nG/L	0 G
Chromium	80 uG/L	OkG	C2-Phenanthrenes	46 nG/L	0 G
Copper	106 uG/L	OkG	C3-Phenenthrenes	<11 nG/L	0 G
Nickel	18 uG/L	OkG	Anthracene	<11 nG/L	0 G
Lead	124 uG/L	OkG	Fluoranthene	237 nG/L	0 G
Zinc	337 uG/L	OkG	Pyrene	182 nG/L	0 G
Silver	<1 uG/L	OkG	2,3-Benzofluorene	<27 nG/L	0 G
			Benz(a)anthracene	<9 nG/L	0 G
o,p'-DDE	22 nG/L	0 G	Chrysene	150 nG/L	0 G
p,p'-DDE	879 nG/L	0 G	Benzo(b)fluoranth	64 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	21 nG/L	0 G
p,p'-DDD	151 nG/L	0 G	Benzo(e)pyrene	37 nG/L	0 G
o,p'-DDT	103 nG/L	0 G	Benzo(a)pyrene	<8 nG/L	0 G
p,p'-DDT	417 nG/L	0 G	Perylene	<8 nG/L	0 G
TOTAL DDT	1572 nG/L	0 G	9,10-Diphenylanth	<8 nG/L	0 G
			Dibenz(a,h)anthra	<7 nG/L	0 G
Aroclor 1242	47 nG/L	0 G	Benzo(g,h,i)peryl	35 nG/L	0 G
Aroclor 1254	203 nG/L	0 G	TOTAL PAH	1557 nG/L	0 G
TOTAL PCB	250 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	74 %	***
Lindane	38 nG/L	0 G	d10-Acenaphthene	123 %	***
			d10-Phenanthrene	126 %	***
Toxicity	Notest	***	d12-Chrysene	100 %	***
			d12-Perylene	74 %	***
			Resolved HCs	70900 nG/L	0 G
			n-alkanes c10-c39	33965 nG/L	0 G
			Pristane	2349 nG/L	0 G
			Phytane	3246 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Santa Clara River
Location:	Highway 101
Date:	25 Sep 86
Time:	12:15

Flow (M**3/Sec):	0.14
Time Interval:	34:15-[illegible]:00
IntervalVol (M**3):	11,970
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	16 mG/L	0 T	Naphthalene	<26 nG/L	0 G
TVS	88 %	***	C1-Naphthalenes	<26 nG/L	0 G
Total Solids	2780 mG/L	0 T	C2-Naphthalenes	<26 nG/L	0 G
Dissolved Solids	2760 mG/L	0 T	C3-Naphthalenes	<54 nG/L	0 G
Oil & Grease	1 mG/L	0 T	Biphenyl	<26 nG/L	0 G
Chloroform Extr.	2.1 mG/L	0 T	Acenaphthylene	<26 nG/L	0 G
Salinity	3 ppt	***	Acenaphthene	<54 nG/L	0 G
pH	6	***	Fluorene	<24 nG/L	0 G
			Phenanthrene	<24 nG/L	0 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<24 nG/L	0 G
Chromium	<2 uG/L	0kG	C2-Phenanthrenes	<24 nG/L	0 G
Copper	<2 uG/L	0kG	C3-Phenenthrenes	<24 nG/L	0 G
Nickel	4 uG/L	0kG	Anthracene	<25 nG/L	0 G
Lead	<8 uG/L	0kG	Fluoranthene	<20 nG/L	0 G
Zinc	7 uG/L	0kG	Pyrene	<20 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<58 nG/L	0 G
			Benz(a)anthracene	<20 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<20 nG/L	0 G
p,p'-DDE	3 nG/L	0 G	Benzo(b)fluoranth	<17 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<17 nG/L	0 G
p,p'-DDD	3 nG/L	0 G	Benzo(e)pyrene	<17 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<17 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	<17 nG/L	0 G
TOTAL DDT	8 nG/L	0 G	9,10-Diphenylanth	<17 nG/L	0 G
			Dibenz(a,h)anthra	<14 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<14 nG/L	0 G
Aroclor 1254	12 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	12 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	67 %	***
Lindane	2 nG/L	0 G	d10-Acenaphthene	111 %	***
			d10-Phenanthrene	97 %	***
Toxicity	Notest	***	d12-Chrysene	127 %	***
			d12-Perylene	117 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	0 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

VOL 12

1 7545

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Calleguas Creek
Location:	Highway 1
Date:	24 Sep 86
Time:	12:20

Flow (M**3/Sec):	.82
Time Interval:	00:00-21:45
IntervalVol (M**3):	41,515
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	2 mG/L	0 T
TVS	60 %	***
Total Solids	1251 mG/L	0 T
Dissolved Solids	1249 mG/L	0 T
Oil & Grease	6.8 mG/L	0 T
Chloroform Extr.	1.1 mG/L	0 T
Salinity	.5 ppt	***
pH	6.5	***
Cadmium	<1 uG/L	0 G
Chromium	<3 uG/L	0 G
Copper	3 uG/L	0 G
Nickel	9 uG/L	0 G
Lead	<9 uG/L	0 G
nc	6 uG/L	0 G
iver	<1 uG/L	0 G
o,p'-DDE	<1 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	1 nG/L	0 G
TOTAL DDT	1 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	13 nG/L	0 G
TOTAL PCB	13 nG/L	0 G
Hexachlorobenzene	<1 nG/L	0 G
Lindane	<1 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<11 nG/L	0 G
C1-Naphthalenes	<11 nG/L	0 G
C2-Naphthalenes	<11 nG/L	0 G
C3-Naphthalenes	<23 nG/L	0 G
Biphenyl	<11 nG/L	0 G
Acenaphthylene	<11 nG/L	0 G
Acenaphthene	<23 nG/L	0 G
Fluorene	<10 nG/L	0 G
Phenanthrene	<10 nG/L	0 G
C1-Phenanthrenes	<10 nG/L	0 G
C2-Phenanthrenes	<10 nG/L	0 G
C3-Phenanthrenes	<10 nG/L	0 G
Anthracene	<10 nG/L	0 G
Fluoranthene	<8 nG/L	0 G
Pyrene	<8 nG/L	0 G
2,3-Benzofluorene	<25 nG/L	0 G
Benz(a)anthracene	23 nG/L	0 G
Chrysene	112 nG/L	0 G
Benzo(b)fluoranth	<7 nG/L	0 G
Benzo(k)fluoranth	<7 nG/L	0 G
Benzo(e)pyrene	<7 nG/L	0 G
Benzo(a)pyrene	<7 nG/L	0 G
Perylene	<7 nG/L	0 G
9,10-Diphenylanth	<7 nG/L	0 G
Dibenz(a,h)anthra	<6 nG/L	0 G
Benzo(g,h,i)peryl	<6 nG/L	0 G
TOTAL PAH	135 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	66 %	***
d10-Acenaphthene	88 %	***
d10-Phenanthrene	82 %	***
d12-Chrysene	92 %	***
d12-Perylene	87 %	***
Resolved HCs	0 nG/L	0 G
n-alkanes c10-c39	0 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Calleguas Creek	Flow (M**3/Sec):	1.53
Location:	Highway 1	Time Interval:	21:45-24:15
Date:	24 Sep 86	Interval Vol (M**3):	165,000
Time:	15:10	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	2 mG/L	0 T	Naphthalene	7 nG/L	0 G
TVS	60 %	***	C1-Naphthalenes	7 nG/L	0 G
Total Solids	1820 mG/L		C2-Naphthalenes	7 nG/L	0 G
Dissolved Solids	1820 mG/L	0 T	C3-Naphthalenes	14 nG/L	0 G
Oil & Grease	1.6 mG/L	0 T	Biphenyl	7 nG/L	0 G
Chloroform Extr.	1.3 mG/L	0 T	Acenaphthylene	7 nG/L	0 G
Salinity	ppt	***	Acenaphthene	14 nG/L	0 G
pH		***	Fluorene	6 nG/L	0 G
			Phenanthrene	6 nG/L	0 G
Cadmium	1 uG/L	0 G	C1-Phenanthrenes	6 nG/L	0 G
Chromium	3 uG/L	0 G	C2-Phenanthrenes	6 nG/L	0 G
Copper	4 uG/L	0 G	C3-Phenanthrenes	6 nG/L	0 G
Nickel	3 uG/L	0 G	Anthracene	3 nG/L	0 G
Lead	9 uG/L	0 G	Fluoranthene	5 nG/L	0 G
Zinc	6 uG/L	0 G	Pyrene	5 nG/L	0 G
Silver	<1 uG/L	0 G	2,3-Benzofluorene	15 nG/L	0 G
			Benz(a)anthracene	5 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	5 nG/L	0 G
p,p'-DDE	2 nG/L	0 G	Benzo(b)fluoranth	4 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	4 nG/L	0 G
p,p'-DDD	1 nG/L	0 G	Benzo(e)pyrene	<4 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<4 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	<4 nG/L	0 G
TOTAL DDT	5 nG/L	0 G	9,10-Diphenylanth	<4 nG/L	0 G
			Dibenz(a,h)anthra	<4 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<4 nG/L	0 G
Aroclor 1254	11 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	11 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	18 %	***
Lindane	1 nG/L	0 G	d10-Acenaphthene	33 %	***
			d10-Phenanthrene	31 %	***
Toxicity	NoTest	***	d12-Chrysene	38 %	***
			d12-Perylene	33 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	24 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Callequas Creek
Location:	Highway 1
Date:	25 Sep 86
Time:	13:22

Flow (M**3/Sec):	2.41
Time Interval:	34:15-4?:00
IntervalVol (M**3):	109,000
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	85 mG/L	0 T	Naphthalene	<14 nG/L	0 G
TVS	28 %	***	C1-Naphthalenes	<14 nG/L	0 G
Total Solids	931 mG/L	0 T	C2-Naphthalenes	<14 nG/L	0 G
Dissolved Solids	846 mG/L	0 T	C3-Naphthalenes	<30 nG/L	0 G
Oil & Grease	1.7 mG/L	0 T	Biphenyl	<14 nG/L	0 G
Chloroform Extr.	1.6 mG/L	0 T	Acenaphthylene	<14 nG/L	0 G
Salinity	2 ppt	***	Acenaphthene	<30 nG/L	0 G
pH	5.5	***	Fluorene	13 nG/L	0 G
			Phenanthrene	<13 nG/L	0 G
Cadmium	<1 uG/L	0 G	C1-Phenanthrenes	<13 nG/L	0 G
Chromium	5 uG/L	0 G	C2-Phenanthrenes	<13 nG/L	0 G
Copper	46 uG/L	0 G	C3-Phenenthrenes	<13 nG/L	0 G
Nickel	12 uG/L	0 G	Anthracene	<14 nG/L	0 G
Lead	<9 uG/L	0 G	Fluoranthene	<11 nG/L	0 G
Zinc	14 uG/L	0 G	Pyrene	<11 nG/L	0 G
Silver	<1 uG/L	0 G	2,3-Benzofluorene	<32 nG/L	0 G
			Benz(a)anthracene	<11 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<11 nG/L	0 G
p,p'-DDE	5 nG/L	0 G	Benzo(b)fluoranth	<9 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<9 nG/L	0 G
p,p'-DDD	3 nG/L	0 G	Benzo(e)pyrene	<9 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<9 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	<9 nG/L	0 G
TOTAL DDT	10 nG/L	0 G	9,10-Diphenylanth	<9 nG/L	0 G
			Dibenz(a,h)anthra	<8 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<8 nG/L	0 G
Aroclor 1254	19 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	19 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	0 %	***
Lindane	6 nG/L	0 G	d10-Acenapnthene	17 %	***
			d10-Phenanthrene	58 %	***
Toxicity	Notest	***	d12-Chrysene	101 %	***
			d12-Perylene	104 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	0 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

1 7548

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: San Gabriel River
Location: College [illegible]
Date: 23 Sep 86
Time: 19:45

Flow (M**3/Sec): .564
Time [illegible]
IntervalVol(M**3): 2,126
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	16 mG/L	0 T	Naphthalene	<10 nG/L	0 G
TVS	31 %	***	C1-Naphthalenes	<10 nG/L	0 G
Total Solids	6180 mG/L	0 T	C2-Naphthalenes	<10 nG/L	0 G
Dissolved Solids	6160 mG/L	0 T	C3-Naphthalenes	<22 nG/L	0 G
Oil & Grease	3.2 mG/L	0 T	Biphenyl	<10 nG/L	0 G
Chloroform Extr.	1.43 mG/L	0 T	Acenaphthylene	<10 nG/L	0 G
Salinity	6 ppt	***	Acenaphthene	<22 nG/L	0 G
pH	5.5	***	Fluorene	<10 nG/L	0 G
			Phenanthrene	<10 nG/L	0 G
Cadmium	salty uG/L	0 G	C1-Phenanthrenes	<10 nG/L	0 G
Chromium	salty uG/L	0 G	C2-Phenanthrenes	<10 nG/L	0 G
Copper	salty uG/L	0 G	C3-Phenenthrenes	<10 nG/L	0 G
Nickel	salty uG/L	0 G	Anthracene	<10 nG/L	0 G
Lead	salty uG/L	0 G	Fluoranthene	<8 nG/L	0 G
Zinc	salty uG/L	0 G	Pyrene	<8 nG/L	0 G
Silver	salty uG/L	0 G	2,3-Benzofluorene	<24 nG/L	0 G
			Benz(a)anthracene	<8 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<8 nG/L	0 G
p,p'-DDE	1 nG/L	0 G	Benzo(b)fluoranth	<7 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<7 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<7 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<7 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	<7 nG/L	0 G
TOTAL DDT	2 nG/L	0 G	9,10-Diphenylanth	<7 nG/L	0 G
			Dibenz(a,h)anthra	<6 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<6 nG/L	0 G
Aroclor 1254	13 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	13 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	16 nG/L	0 G	d8-Naphthalene	0 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	0 %	***
			d10-Phenanthrene	0 %	***
Toxicity	Notest	***	d12-Chrysene	7 %	***
			d12-Perylene	6 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	993 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

VOL 12

17549

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: San Gabriel River
Location: College Pl Bridge
Date: 24 Sep 86
Time: 10:00

Flow (M**3/Sec): 4.92
Time Interval: 11:00-19:30
IntervalVol (M**3): 95,000
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	5 mG/L	0 T	Naphthalene	<22 nG/L	0 G
TVS	100 %	***	C1-Naphthalenes	<22 nG/L	0 G
Total Solids	27300 mG/L	0 T	C2-Naphthalenes	<22 nG/L	0 G
Dissolved Solids	27300 mG/L	0 T	C3-Naphthalenes	<46 nG/L	0 G
Oil & Grease	.2 mG/L	0 T	Biphenyl	<22 nG/L	0 G
Chloroform Extr.	1.83 mG/L	0 T	Acenaphthylene	<22 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<46 nG/L	0 G
pH		***	Fluorene	<21 nG/L	0 G
			Phenanthrene	<21 nG/L	0 G
Cadmium	Salty uG/L	0kG	C1-Phenanthrenes	<21 nG/L	0 G
Chromium	Salty uG/L	0kG	C2-Phenanthrenes	<21 nG/L	0 G
Copper	Salty uG/L	0kG	C3-Phenenthrenes	<21 nG/L	0 G
Nickel	Salty uG/L	0kG	Anthracene	<21 nG/L	0 G
Lead	Salty uG/L	0kG	Fluoranthene	<17 nG/L	0 G
Zinc	Salty uG/L	0kG	Pyrene	<17 nG/L	0 G
Silver	Salty uG/L	0kG	2,3-Benzofluorene	<50 nG/L	0 G
			Benz(a)anthracene	<17 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	<17 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G	Benzo(b)fluoranth	<14 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<14 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<14 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<14 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	<14 nG/L	0 G
TOTAL DDT	0 nG/L	0 G	9,10-Diphenylanth	<14 nG/L	0 G
			Dibenz(a,h)anthra	<12 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<12 nG/L	0 G
Aroclor 1254	7 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	7 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	62 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	111 %	***
			d10-Phenanthrene	99 %	***
Toxicity	NoTest	***	d12-Chrysene	120 %	***
			d12-Perylene	110 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	921 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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R0050855

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	San Gabriel River
Location:	College Pk Bridge
Date:	23 Sep 86
Time:	19:45

Flow (M**3/Sec):	.564
Time Interval:	00:00-11:00
IntervalVol (M**3):	252,000
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	16 mG/L	0 T
TVS	31 %	***
Total Solids	6180 mG/L	0 T
Dissolved Solids	6160 mG/L	0 T
Oil & Grease	3.2 mG/L	0 T
Chloroform Extr.	1.43 mG/L	0 T
Salinity	6 ppt	***
pH	5.5	***
Cadmium	salty uG/L	0k G
Chromium	salty uG/L	0k G
Copper	salty uG/L	0k G
Nickel	salty uG/L	0k G
Lead	salty uG/L	0k G
Zinc	salty uG/L	0k G
Silver	salty uG/L	0k G
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	1 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	2 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	13 nG/L	0 G
TOTAL PCB	13 nG/L	0 G
Hexachlorobenzene	16 nG/L	0 G
Lindane	<1 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<10 nG/L	0 G
C1-Naphthalenes	<10 nG/L	0 G
C2-Naphthalenes	<10 nG/L	0 G
C3-Naphthalenes	<22 nG/L	0 G
Biphenyl	10 nG/L	0 G
Acenaphthylene	<10 nG/L	0 G
Acenaphthene	<22 nG/L	0 G
Fluorene	<10 nG/L	0 G
Phenanthrene	<10 nG/L	0 G
C1-Phenanthrenes	<10 nG/L	0 G
C2-Phenanthrenes	<10 nG/L	0 G
C3-Phenenthrenes	<10 nG/L	0 G
Anthracene	<10 nG/L	0 G
Fluoranthene	<8 nG/L	0 G
Pyrene	<8 nG/L	0 G
2,3-Benzofluorene	<24 nG/L	0 G
Benz(a)anthracene	<8 nG/L	0 G
Chrysene	<8 nG/L	0 G
Benzo(b)fluoranth	<7 nG/L	0 G
Benzo(k)fluoranth	<7 nG/L	0 G
Benzo(e)pyrene	<7 nG/L	0 G
Benzo(a)pyrene	<7 nG/L	0 G
Perylene	<7 nG/L	0 G
9,10-Diphenylanth	<7 nG/L	0 G
Dibenz(a,h)anthra	<6 nG/L	0 G
Benzo(g,h,i)peryl	<6 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	0 %	***
d10-Acenaphthene	0 %	***
d10-Phenanthrene	0 %	***
d12-Chrysene	7 %	***
d12-Perylene	6 %	***
Resolved HCs	0 nG/L	0 G
n-alkanes c10-c39	993 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: San Gabriel River
Location: College Park Bridg
Date: 24 Sep 86
Time: 14:50

Flow (M**3/Sec): 26.2
Time Interval: 21:45-24:15
IntervalVol (M**3): [illegible]
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	222 mG/L	0 T
TVS	26 %	***
Total Solids	9060 mG/L	0 T
Dissolved Solids	8840 mG/L	0 T
Oil & Grease	6.2 mG/L	0 T
Chloroform Extr.	8.1 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	3 uG/L	0kG
Chromium	15 uG/L	0kG
Copper	65 uG/L	0kG
Nickel	39 uG/L	0kG
Lead	104 uG/L	0kG
Zinc	364 uG/L	0kG
Silver	<1 uG/L	0kG
o,p'-DDE	6 nG/L	0 G
p,p'-DDE	7 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	4 nG/L	0 G
o,p'-DDT	7 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	24 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	57 nG/L	0 G
TOTAL PCB	57 nG/L	0 G
Hexachlorobenzene	2 nG/L	0 G
Lindane	22 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	214 nG/L	0 G
C1-Naphthalenes	251 nG/L	0 G
C2-Naphthalenes	35 nG/L	0 G
C3-Naphthalenes	<33 nG/L	0 G
Biphenyl	<16 nG/L	0 G
Acenaphthylene	<16 nG/L	0 G
Acenaphthene	<33 nG/L	0 G
Fluorene	<15 nG/L	0 G
Phenanthrene	132 nG/L	0 G
C1-Phenanthrenes	<15 nG/L	0 G
C2-Phenanthrenes	<15 nG/L	0 G
C3-Phenanthrenes	<15 nG/L	0 G
Anthracene	<15 nG/L	0 G
Fluoranthene	177 nG/L	0 G
Pyrene	163 nG/L	0 G
2,3-Benzofluorene	<35 nG/L	0 G
Benz(a)anthracene	<12 nG/L	0 G
Chrysene	155 nG/L	0 G
Benzo(b)fluoranth	89 nG/L	0 G
Benzo(k)fluoranth	<10 nG/L	0 G
Benzo(e)pyrene	130 nG/L	0 G
Benzo(a)pyrene	76 nG/L	0 G
Perylene	<10 nG/L	0 G
9,10-Diphenylanth	<10 nG/L	0 G
Dibenz(a,h)anthra	<9 nG/L	0 G
Benzo(g,h,i)peryl	109 nG/L	0 G
TOTAL PAH	1531 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	71 %	***
d10-Acenaphthene	104 %	***
d10-Phenanthrene	105 %	***
d12-Chrysene	163 %	***
d12-Perylene	157 %	***
Resolved HCs	56412 nG/L	0 G
n-alkanes c10-c39	37536 nG/L	0 G
Pristane	3846 nG/L	0 G
Phytane	4683 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: San Gabriel River	Flow (M**3/Sec): 40.5
Location: College Park Bridg	Time Interval: 24:15-28:00
Date: 24 Sep 86	IntervalVol (M**3): 42?,5??
Time: 17:45	Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	484 mG/L	0 T	Naphthalene	51 nG/L	0 G
TVS	30 %	***	C1-Naphthalenes	<21 nG/L	0 G
Total Solids	534 mG/L	0 T	C2-Naphthalenes	<21 nG/L	0 G
Dissolved Solids	50 mG/L	0 T	C3-Naphthalenes	<45 nG/L	0 G
Oil & Grease	7.8 mG/L	0 T	Biphenyl	<21 nG/L	0 G
Chloroform Extr.	5 mG/L	0 T	Acenaphthylene	<21 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<45 nG/L	0 G
pH	5.5	***	Fluorene	<20 nG/L	0 G
			Phenanthrene	127 nG/L	0 G
Cadmium	4 uG/L	0kG	C1-Phenanthrenes	<20 nG/L	0 G
Chromium	40 uG/L	0kG	C2-Phenanthrenes	<20 nG/L	0 G
Copper	158 uG/L	0kG	C3-Phenanthrenes	<20 nG/L	0 G
Nickel	61 uG/L	0kG	Anthracene	<20 nG/L	0 G
Lead	201 uG/L	0kG	Fluoranthene	176 nG/L	0 G
Zinc	744 uG/L	0kG	Pyrene	110 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	48 nG/L	0 G
			Benz(a)anthracene	<17 nG/L	0 G
o,p'-DDE	6 nG/L	0 G	Chrysene	64 nG/L	0 G
p,p'-DDE	6 nG/L	0 G	Benzo(b)fluoranth	37 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<14 nG/L	0 G
p,p'-DDD	2 nG/L	0 G	Benzo(e)pyrene	<14 nG/L	0 G
o,p'-DDT	4 nG/L	0 G	Benzo(a)pyrene	<14 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	<14 nG/L	0 G
TOTAL DDT	18 nG/L	0 G	9,10-Diphenylanth	<14 nG/L	0 G
			Dibenz(a,h)anthra	<12 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<12 nG/L	0 G
Aroclor 1254	22 nG/L	0 G	TOTAL PAH	565 nG/L	0 G
TOTAL PCB	22 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	64 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	126 %	***
			d10-Phenanthrene	125 %	***
Toxicity	Notest	***	d12-Chrysene	101 %	***
			d12-Perylene	81 %	***
			Resolved HCs	72117 nG/L	0 G
			n-alkanes c10-c39	42489 nG/L	0 G
			Pristane	3925 nG/L	0 G
			Phytane	4072 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
SURVEY
SAMPLE DATA SHEET

Channel:	San Gabriel River	Flow (M**3/Sec):	122
Location:	College P. Bridge	Time Interval:	28:00-34:45
Date:	24 Sep 86	Interval Vol (M**3):	2 x10⁶
Time:	22:2	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	mG/L	0 T	Naphthalene	62 nG/L	0 G
TVS	16 %	***	C1-Naphthalenes	35 nG/L	0 G
Total Solids	1160 mG/L	0 T	C2-Naphthalenes	13 nG/L	0 G
Dissolved Solids	mG/L	0 T	C3-Naphthalenes	<27 nG/L	0 G
Oil & Grease	5 mG/L	0 T	Biphenyl	<13 nG/L	0 G
Chloroform Extr.	1.8 mG/L	0 T	Acenaphthylene	<13 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<27 nG/L	0 G
pH	.	***	Fluorene	<12 nG/L	0 G
			Phenanthrene	130 nG/L	0 G
Cadmium	2 uG/L	0kG	C1-Phenanthrenes	61 nG/L	0 G
Chromium	30 uG/L	0kG	C2-Phenanthrenes	42 nG/L	0 G
Copper	78 uG/L	0kG	C3-Phenanthrenes	<12 nG/L	0 G
Nickel	26 uG/L	0kG	Anthracene	<12 nG/L	0 G
Lead	111 uG/L	0kG	Fluoranthene	247 nG/L	0 G
Zinc	477 uG/L	0kG	Pyrene	233 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<29 nG/L	0 G
			Benz(a)anthracene	42 nG/L	0 G
o,p'-DDE	6 nG/L	0 G	Chrysene	149 nG/L	0 G
p,p'-DDE	6 nG/L	0 G	Benzo(b)fluoranth	114 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	74 nG/L	0 G
p,p'-DDD	2 nG/L	0 G	Benzo(e)pyrene	80 nG/L	0 G
o,p'-DDT	4 nG/L	0 G	Benzo(a)pyrene	31 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	<8 nG/L	0 G
TOTAL DDT	19 nG/L	0 G	9,10-Diphenylanth	<8 nG/L	0 G
			Dibenz(a,h)anthra	<7 nG/L	0 G
Aroclor 1242	42 nG/L	0 G	Benzo(g,h,i)peryl	89 nG/L	0 G
Aroclor 1254	33 nG/L	0 G	TOTAL PAH	1389 nG/L	0 G
TOTAL PCB	75 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	2 nG/L	0 G	d8-Naphthalene	63 %	***
Lindane	6 nG/L	0 G	d10-Acenaphthene	120 %	***
			d10-Phenanthrene	119 %	***
Toxicity	NoTest	***	d12-Chrysene	125 %	***
			d12-Perylene	100 %	***
			Resolved HCs	52786 nG/L	0 G
			n-alkanes c10-c39	28740 nG/L	0 G
			Pristane	2348 nG/L	0 G
			Phytane	3256 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
SURVEY
SAMPLE DATA SHEET

Channel: San Gabriel River
Location: College Pl Bridge
Date: 25 Sep 86
Time: 07:00

Flow (M**3/Sec): 10.6
Time Interval: 34:45-43:15
IntervalVol(M**3): 345,000
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1080 mG/L	0 T	Naphthalene	94 nG/L	0 G
TVS	6.5 %	***	C1-Naphthalenes	69 nG/L	0 G
Total Solids	1300 mG/L	0 T	C2-Naphthalenes	46 nG/L	0 G
Dissolved Solids	220 mG/L	0 T	C3-Naphthalenes	<14 nG/L	0 G
Oil & Grease	2.8 mG/L	0 T	Biphenyl	<7 nG/L	0 G
Chloroform Extr.	11.9 mG/L	0 T	Acenaphthylene	<7 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<14 nG/L	0 G
pH	6	***	Fluorene	<7 nG/L	0 G
			Phenanthrene	167 nG/L	0 G
Cadmium	4 uG/L	0kG	C1-Phenanthrenes	33 nG/L	0 G
Chromium	68 uG/L	0kG	C2-Phenanthrenes	35 nG/L	0 G
Copper	143 uG/L	0kG	C3-Phenanthrenes	<7 nG/L	0 G
Nickel	67 uG/L	0kG	Anthracene	<7 nG/L	0 G
Lead	200 uG/L	0kG	Fluoranthene	218 nG/L	0 G
Zinc	385 uG/L	0kG	Pyrene	214 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<16 nG/L	0 G
			Benz(a)anthracene	54 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	176 nG/L	0 G
p,p'-DDE	3 nG/L	0 G	Benzo(b)fluoranth	223 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<4 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	90 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	73 nG/L	0 G
p,p'-DDT	4 nG/L	0 G	Perylene	12 nG/L	0 G
TOTAL DDT	7 nG/L	0 G	9,10-Diphenylanth	<4 nG/L	0 G
			Dibenz(a,h)anthra	7 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	106 nG/L	0 G
Aroclor 1254	68 nG/L	0 G	TOTAL PAH	1617 nG/L	0 G
TOTAL PCB	68 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	2 nG/L	0 G	d8-Naphthalene	75 %	***
Lindane	9 nG/L	0 G	d10-Acenaphthene	138 %	***
			d10-Phenanthrene	122 %	***
Toxicity	Notest	***	d12-Chrysene	124 %	***
			d12-Perylene	102 %	***
			Resolved HCs	60992 nG/L	0 G
			n-alkanes c10-c39	35793 nG/L	0 G
			Pristane	3483 nG/L	0 G
			Phytane	4149 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: San Gabriel River
Location: College Pk Bridge
Date: 25 Sep 86
Time: 15:30

Flow (M**3/Sec): 2.11
Time Interval: 43:15-50:00
IntervalVol(M**3): 25,456
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	158 mG/L	0 T	Naphthalene	152 nG/L	0 G
TVS	17 %	***	C1-Naphthalenes	<17 nG/L	0 G
Total Solids	462 mG/L	0 T	C2-Naphthalenes	<17 nG/L	0 G
Dissolved Solids	304 mG/L	0 T	C3-Naphthalenes	<35 nG/L	0 G
Oil & Grease	1.5 mG/L	0 T	Biphenyl	<17 nG/L	0 G
Chloroform Extr.	2.5 mG/L	0 T	Acenaphthylene	<17 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<35 nG/L	0 G
pH	6	***	Fluorene	<16 nG/L	0 G
			Phenanthrene	<16 nG/L	0 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<16 nG/L	0 G
Chromium	6 uG/L	0kG	C2-Phenanthrenes	<16 nG/L	0 G
Copper	17 uG/L	0kG	C3-Phenanthrenes	<16 nG/L	0 G
Nickel	13 uG/L	0kG	Anthracene	<16 nG/L	0 G
Lead	23 uG/L	0kG	Fluoranthene	<13 nG/L	0 G
Zinc	80 uG/L	0kG	Pyrene	<13 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<37 nG/L	0 G
			Benz(a)anthracene	<13 nG/L	0 G
o,p'-DDE	4 nG/L	0 G	Chrysene	<13 nG/L	0 G
p,p'-DDE	12 nG/L	0 G	Benzo(b)fluoranth	<11 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<11 nG/L	0 G
p,p'-DDD	7 nG/L	0 G	Benzo(e)pyrene	<11 nG/L	0 G
o,p'-DDT	3 nG/L	0 G	Benzo(a)pyrene	<11 nG/L	0 G
p,p'-DDT	9 nG/L	0 G	Perylene	<11 nG/L	0 G
TOTAL DDT	35 nG/L	0 G	9,10-Diphenylanth	<11 nG/L	0 G
			Dibenz(a,h)anthra	<9 nG/L	0 G
Aroclor 1242	8 nG/L	0 G	Benzo(g,h,i)peryl	<9 nG/L	0 G
Aroclor 1254	30 nG/L	0 G	TOTAL PAH	152 nG/L	0 G
TOTAL PCB	38 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	83 %	***
Lindane	16 nG/L	0 G	d10-Acenaphthene	105 %	***
			d10-Phenanthrene	113 %	***
Toxicity	Notest	***	d12-Chrysene	144 %	***
			d12-Perylene	113 %	***
			Resolved HCs	3727 nG/L	0 G
			n-alkanes c10-c39	8830 nG/L	0 G
			Pristane	1273 nG/L	0 G
			Phytane	1167 nG/L	0 G

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7556

R0050861

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Dominquez Channel
Location: Ford Street
Date: 24 Sep 86
Time: 11:45

Flow (M**3/Sec):
Time Interval: 00:00-22:00
IntervalVol (M**3):
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	32 mG/L	0 T	Naphthalene	<18 nG/L	0 G
TVS	50 %	***	C1-Naphthalenes	<18 nG/L	0 G
Total Solids	35900 mG/L	0 T	C2-Naphthalenes	<18 nG/L	0 G
Dissolved Solids	35900 mG/L	0 T	C3-Naphthalenes	<38 nG/L	0 G
Oil & Grease	.2 mG/L	0 T	Biphenyl	<18 nG/L	0 G
Chloroform Extr.	.73 mG/L	0 T	Acenaphthylene	<18 nG/L	0 G
Salinity	32 ppt	***	Acenaphthene	<38 nG/L	0 G
pH	6.5	***	Fluorene	<17 nG/L	0 G
			Phenanthrene	<17 nG/L	0 G
Cadmium	Salty uG/L	OkG	C1-Phenanthrenes	<17 nG/L	0 G
Chromium	Salty uG/L	OkG	C2-Phenanthrenes	<17 nG/L	0 G
Copper	Salty uG/L	OkG	C3-Phenanthrenes	<17 nG/L	0 G
Nickel	Salty uG/L	OkG	Anthracene	<17 nG/L	0 G
Lead	Salty uG/L	OkG	Fluoranthene	<14 nG/L	0 G
Zinc	Salty uG/L	OkG	Pyrene	<14 nG/L	0 G
Silver	Salty uG/L	OkG	2,3-Benzofluorene	<41 nG/L	0 G
			Benz(a)anthracene	<14 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	<14 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G	Benzo(b)fluoranth	<12 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<12 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<12 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<12 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	<12 nG/L	0 G
TOTAL DDT	0 nG/L	0 G	9,10-Diphenylanth	<12 nG/L	0 G
			Dibenz(a,h)anthra	<10 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<10 nG/L	0 G
Aroclor 1254	15 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	15 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	38 %	***
Lindane	2 nG/L	0 G	d10-Acenaphthene	77 %	***
			d10-Phenanthrene	79 %	***
Toxicity	Notest	***	d12-Chrysene	112 %	***
			d12-Perylene	122 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	0 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

VOL 12

1757

R0050862

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Dominguez Channel
Location: Ford Street
Date: 24 Sep 86
Time: 16:35

Flow (M**3/Sec):
Time Interval: 22:00-26:30
IntervalVol (M**3):
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	11 mG/L	0 T
TVS	54 %	***
Total Solids	30600 mG/L	0 T
Dissolved Solids	30600 mG/L	0 T
Oil & Grease	1.8 mG/L	0 T
Chloroform Extr.	5.1 mG/L	0 T
Salinity	28 ppt	***
pH	5.5	***
Cadmium	Salty uG/L	0 G
Chromium	Salty uG/L	0 G
Copper	Salty uG/L	0 G
Nickel	Salty uG/L	0 G
Lead	Salty uG/L	0 G
Zinc	Salty uG/L	0 G
Silver	Salty uG/L	0 G
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	3 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	4 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	11 nG/L	0 G
TOTAL PCB	11 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	<1 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	14 nG/L	0 G
C1-Naphthalenes	14 nG/L	0 G
C2-Naphthalenes	14 nG/L	0 G
C3-Naphthalenes	28 nG/L	0 G
Biphenyl	14 nG/L	0 G
Acenaphthylene	14 nG/L	0 G
Acenaphthene	28 nG/L	0 G
Fluorene	13 nG/L	0 G
Phenanthrene	75 nG/L	0 G
C1-Phenanthrenes	31 nG/L	0 G
C2-Phenanthrenes	13 nG/L	0 G
C3-Phenenthrenes	13 nG/L	0 G
Anthracene	13 nG/L	0 G
Fluoranthene	157 nG/L	0 G
Pyrene	89 nG/L	0 G
2,3-Benzofluorene	31 nG/L	0 G
Benz(a)anthracene	11 nG/L	0 G
Chrysene	76 nG/L	0 G
Benzo(b)fluoranth	<9 nG/L	0 G
Benzo(k)fluoranth	<9 nG/L	0 G
Benzo(e)pyrene	9 nG/L	0 G
Benzo(a)pyrene	<9 nG/L	0 G
Perylene	<9 nG/L	0 G
9,10-Diphenylanth	9 nG/L	0 G
Dibenz(a,h)anthra	<8 nG/L	0 G
Benzo(g,h,i)peryl	<8 nG/L	0 G
TOTAL PAH	442 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	69 %	***
d10-Acenaphthene	102 %	***
d10-Phenanthrene	101 %	***
d12-Chrysene	135 %	***
d12-Perylene	129 %	***
Resolved HCs	88051 nG/L	0 G
n-alkanes c10-c39	7517 nG/L	0 G
Pristane	1079 nG/L	0 G
Phytane	1170 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Dominguez Channel
Location:	Ford Street
Date:	24 Sep 86
Time:	20:35

Flow (M**3/Sec):
Time Interval: 26:30-34:15
IntervalVol(M**3):
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	43 mG/L	0 T
TVS	35 %	***
Total Solids	14400 mG/L	0 T
Dissolved Solids	14400 mG/L	0 T
Oil & Grease	2.9 mG/L	0 T
Chloroform Extr.	1.6 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	Salty uG/L	0kG
Chromium	Salty uG/L	0kG
Copper	Salty uG/L	0kG
Nickel	Salty uG/L	0kG
Lead	salty uG/L	0kG
Zinc	Salty uG/L	0kG
Silver	Salty uG/L	0kG
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	4 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	2 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	2 nG/L	0 G
TOTAL DDT	9 nG/L	0 G
Aroclor 1242	13 nG/L	0 G
Aroclor 1254	21 nG/L	0 G
TOTAL PCB	34 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	4 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<9 nG/L	0 G
C1-Naphthalenes	<9 nG/L	0 G
C2-Naphthalenes	<9 nG/L	0 G
C3-Naphthalenes	<19 nG/L	0 G
Biphenyl	<9 nG/L	0 G
Acenaphthylene	9 nG/L	0 G
Acenaphthene	<19 nG/L	0 G
Fluorene	<9 nG/L	0 G
Phenanthrene	30 nG/L	0 G
C1-Phenanthrenes	23 nG/L	0 G
C2-Phenanthrenes	33 nG/L	0 G
C3-Phenenthrenes	<9 nG/L	0 G
Anthracene	<9 nG/L	0 G
Fluoranthene	72 nG/L	0 G
Pyrene	79 nG/L	0 G
2,3-Benzofluorene	<20 nG/L	0 G
Benz(a)anthracene	<7 nG/L	0 G
Chrysene	33 nG/L	0 G
Benzo(b)fluoranth	6 nG/L	0 G
Benzo(k)fluoranth	<6 nG/L	0 G
Benzo(e)pyrene	12 nG/L	0 G
Benzo(a)pyrene	<6 nG/L	0 G
Perylene	<6 nG/L	0 G
9,10-Diphenylanth	<6 nG/L	0 G
Dibenz(a,h)anthra	<5 nG/L	0 G
Benzo(g,h,i)peryl	<5 nG/L	0 G
TOTAL PAH	282 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	51 %	***
d10-Acenaphthene	85 %	***
d10-Phenanthrene	92 %	***
d12-Chrysene	116 %	***
d12-Perylene	111 %	***
Resolved HCs	13400 nG/L	0 G
n-alkanes c10-c39	8538 nG/L	0 G
Pristane	1867 nG/L	0 G
Phytane	2046 nG/L	0 G

17559

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Dominguez Channel
Location:	Ford Street
Date:	25 Sep 86
Time:	07:50

Flow (M**3/Sec):
Time Interval: 34:15-56:00
IntervalVol (M**3):
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	76 mG/L	0 T	Naphthalene	137 nG/L	0 G
TVS	28 %	***	C1-Naphthalenes	220 nG/L	0 G
Total Solids	1360 mG/L	0 T	C2-Naphthalenes	16 nG/L	0 G
Dissolved Solids	1280 mG/L	0 T	C3-Naphthalenes	<33 nG/L	0 G
Oil & Grease	2.8 mG/L	0 T	Biphenyl	<16 nG/L	0 G
Chloroform Extr.	1.4 mG/L	0 T	Acenaphthylene	<16 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<33 nG/L	0 G
pH		***	Fluorene	<15 nG/L	0 G
			Phenanthrene	76 nG/L	0 G
Cadmium	Salty uG/L	0 G	C1-Phenanthrenes	<15 nG/L	0 G
Chromium	Salty uG/L	0 G	C2-Phenanthrenes	<15 nG/L	0 G
Copper	Salty uG/L	0 G	C3-Phenanthrenes	<15 nG/L	0 G
Nickel	Salty uG/L	0 G	Anthracene	15 nG/L	0 G
Lead	Salty uG/L	0 G	Fluoranthene	22 nG/L	0 G
Zinc	Salty uG/L	0 G	Pyrene	<12 nG/L	0 G
Silver	Salty uG/L	0 G	2,3-Benzofluorene	<36 nG/L	0 G
			Benz(a)anthracene	<12 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	<12 nG/L	0 G
p,p'-DDE	2 nG/L	0 G	Benzo(b)fluoranth	<10 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<10 nG/L	0 G
p,p'-DDD	3 nG/L	0 G	Benzo(e)pyrene	<10 nG/L	0 G
o,p'-DDT	1 nG/L	0 G	Benzo(a)pyrene	<10 nG/L	0 G
p,p'-DDT	2 nG/L	0 G	Perylene	<10 nG/L	0 G
TOTAL DDT	8 nG/L	0 G	9,10-Diphenylanth	<10 nG/L	0 G
			Dibenz(a,h)anthra	<9 nG/L	0 G
Aroclor 1242	14 nG/L	0 G	Benzo(g,h,i)peryl	<9 nG/L	0 G
Aroclor 1254	14 nG/L	0 G	TOTAL PAH	455 nG/L	0 G
TOTAL PCB	28 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	59 %	***
Lindane	5 nG/L	0 G	d10-Acenaphthene	101 %	***
			d10-Phenanthrene	109 %	***
Toxicity	NoTest	***	d12-Chrysene	113 %	***
			d12-Perylene	98 %	***
			Resolved HCs	5.5e5 nG/L	0 G
			n-alkanes c10-c39	2.4e5 nG/L	0 G
			Pristane	336 nG/L	0 G
			Phytane	449 nG/L	0 G

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17560

R0050865

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Revlon Slough
Location: Highway 1
Date: 25 Sep 86
Time: 12:40

Flow (M**3/Sec):
Time Interval: [illegible]
IntervalVol (M**3):
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	56 mG/L	0 T
TVS	52 %	***
Total Solids	1330 mG/L	0 T
Dissolved Solids	1270 mG/L	0 T
Oil & Grease	1.2 mG/L	0 T
Chloroform Extr.	1.2 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	1 uG/L	0 G
Chromium	4 uG/L	0 G
Copper	4 uG/L	0 G
Nickel	6 uG/L	0 G
Lead	<6 uG/L	0 G
Zinc	12 uG/L	0 G
Silver	1 uG/L	0 G
o,p'-DDE	2 nG/L	0 G
p,p'-DDE	11 nG/L	0 G
o,p'-DDD	1 nG/L	0 G
p,p'-DDD	6 nG/L	0 G
o,p'-DDT	1 nG/L	0 G
p,p'-DDT	1 nG/L	0 G
TOTAL DDT	21 nG/L	0 G
Aroclor 1242	9 nG/L	0 G
Aroclor 1254	35 nG/L	0 G
TOTAL PCB	44 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	1 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<6 nG/L	0 G
C1-Naphthalenes	<6 nG/L	0 G
C2-Naphthalenes	<6 nG/L	0 G
C3-Naphthalenes	15 nG/L	0 G
Biphenyl	6 nG/L	0 G
Acenaphthylene	<6 nG/L	0 G
Acenaphthene	16 nG/L	0 G
Fluorene	6 nG/L	0 G
Phenanthrene	<6 nG/L	0 G
C1-Phenanthrenes	<6 nG/L	0 G
C2-Phenanthrenes	<6 nG/L	0 G
C3-Phenanthrenes	<6 nG/L	0 G
Anthracene	6 nG/L	0 G
Fluoranthene	7 nG/L	0 G
Pyrene	7 nG/L	0 G
2,3-Benzofluorene	21 nG/L	0 G
Benz(a)anthracene	7 nG/L	0 G
Chrysene	27 nG/L	0 G
Benzo(b)fluoranth	<6 nG/L	0 G
Benzo(k)fluoranth	<6 nG/L	0 G
Benzo(e)pyrene	<6 nG/L	0 G
Benzo(a)pyrene	<6 nG/L	0 G
Perylene	<6 nG/L	0 G
9,10-Diphenylanth	<6 nG/L	0 G
Dibenz(a,h)anthra	<5 nG/L	0 G
Benzo(g,h,i)peryl	<5 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	[illegible] %	***
d10-Acenaphthene	84 %	***
d10-Phenanthrene	100 %	***
d12-Chrysene	[illegible] %	***
d12-Perylene	121 %	***
Resolved HCs	0 nG/L	0 G
n-alkanes c10-c39	0 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

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R0050866

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VOL 12

17562

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Revlon Slough
Location:	Highway 1
Date:	24 Sep 86
Time:	15:25

Flow (M**3/Sec):
Time Interval: 00:00-24:00
IntervalVol (M**3):
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	2 mG/L	0 T
TVS	100 %	***
Total Solids	7840 mG/L	0 T
Dissolved Solids	7840 mG/L	0 T
Oil & Grease	.3 mG/L	0 T
Chloroform Extr.	2.3 mG/L	0 T
Salinity	7 ppt	***
pH	6	***
Cadmium	N/A uG/L	N/A G
Chromium	N/A uG/L	N/A G
Copper	N/A uG/L	N/A G
Nickel	N/A uG/L	N/A G
Lead	N/A uG/L	N/A G
Zinc	N/A uG/L	N/A G
Silver	N/A uG/L	N/A G
o,p'-DDE	<1 nG/L	0 G
p,p'-DDE	2 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	4 nG/L	0 G
o,p'-DDT	1 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	7 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	21 nG/L	0 G
TOTAL PCB	21 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	3 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	21 nG/L	0 G
C1-Naphthalenes	21 nG/L	0 G
C2-Naphthalenes	21 nG/L	0 G
C3-Naphthalenes	45 nG/L	0 G
Biphenyl	<21 nG/L	0 G
Acenaphthylene	21 nG/L	0 G
Acenaphthene	45 nG/L	0 G
Fluorene	<20 nG/L	0 G
Phenanthrene	23 nG/L	0 G
C1-Phenanthrenes	<20 nG/L	0 G
C2-Phenanthrenes	<20 nG/L	0 G
C3-Phenanthrenes	<20 nG/L	0 G
Anthracene	<21 nG/L	0 G
Fluoranthene	16 nG/L	0 G
Pyrene	16 nG/L	0 G
2,3-Benzofluorene	48 nG/L	0 G
Benz(a)anthracene	17 nG/L	0 G
Chrysene	17 nG/L	0 G
Benzo(b)fluoranth	14 nG/L	0 G
Benzo(k)fluoranth	14 nG/L	0 G
Benzo(e)pyrene	14 nG/L	0 G
Benzo(a)pyrene	14 nG/L	0 G
Perylene	14 nG/L	0 G
9,10-Diphenylanth	14 nG/L	0 G
Dibenz(a,h)anthra	12 nG/L	0 G
Benzo(g,h,i)peryl	12 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	72 %	***
d10-Acenaphthene	93 %	***
d10-Phenanthrene	100 %	***
d12-Chrysene	137 %	***
d12-Perylene	148 %	***
Resolved HCs	0 nG/L	0 G
n-alkanes c10-c39	1667 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

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TABLES

R0050868

Table 1. Rainfall total for selected stations during the storm of September 24, 1986.

Station	Rain in Centimeters
1. La Mirada- Standard Oil	2.9
2. Signal Hill	2.9
3. San Pedro - City Reservoir	2.9
4. Inglewood Fire Station	4.8
5. Baldwin Park Station	2.9*
6. Cloudcroft Debris Station	5.7
7. Encino Reservoir	1.9
8. Chatsworth- Twin Lakes	2.0
9. La Tuna Canyon	2.2*
10. Big Tujuga Canyon	---
11. Big Tujunga Dam	3.3
12. Brand Park	3.3
13. Los Angeles, Alcazar	3.6
14. Rio Hondo Spreading Grounds	3.7*
15. San Gabriel Canyon	7.3*
16. La Fresa	3.7
17. Crystal Lake	5.1

All data are from the Los Angeles Department of Public Works.
* measurable rain fell the following day.

[Ta]ble 2. Flow proportioned average concentrations and ranges of actual concentrations for storm runoff samples collected from the 23-25 September storm.

CONSTITUENT	LA RIVER WILLOW	LA RIVER FLETCHER	LA RIVER TUJUNGA	BALLONA CREEK	SANTA CLARA	CALLEGUAS CREEK	SAN GABRIEL	DOMINGUEZ CHANNEL	HYPERION 5-MILE[1]	OXNARD PLANT[1]
	10	8	5	6	3	3	8	4	1985 AVE	1985 AV
Flow(CF/S)	•	•	•	•	•	•	•	•	•	•
Min	95	157	•	19	•	2	75	•	•	•
Max	8,000	2200	•	4960	•	85	4300	•	•	•
TSS(mG/L)	648	246	229	755	1250	30	206	206	•	•
Min	31	17	3	13	16	3	5	11	•	•
Max	1850	1190	826	2500	1920	88	1000	76	•	•
% Vol. Solids	•	•	•	•	•	•	•	•	•	•
Min	5.4	21.6	9.0	15.8	8.4	27.6	6.5	27.6	•	•
Max	68.6	30.6	90.0	46.2	87.5	60.0	100	54.5	•	•
O & G(mG/L)	10.0	2.6	0.6	14.9	2.8	2.3	4.9	•	20.3	4.3
Min	0.7	1.2	<0.1	2.2	1.0	0.2	0.2	0.2	•	•
Max	21.8	10.9	1.3	36.4	4.8	1.7	7.8	2.9	•	•
TEOx(mG/L)	34.5	5.7	1.3	26.7	5.0	1.4	3.7	•	•	•
Min	1.4	1.6	<0.1	1.6	1.1	0.4	0.4	0.7	•	•
Max	103	29.8	3.9	99.6	7.5	1.6	11.9	8.1	•	•
Cadmium (G/L)	5.8	1.7	•	6.7	•	•	2.3	•	10.9	13.8
Min	<1	<1	<1	<1	<1	<1	<1	•	•	•
Max	21	28	•	22	1	•	4	•	•	•
Chromium G/L	40.4	11.4	•	67	50.2	1.0	31.4	•	80.9	11.4
Min	<3	<2	<2	<3	<2	<3	6	•	•	•
Max	147	107	8	248	80	8	68	•	•	•
[C]opper G/L	182	96.1	•	267	40.7	10.5	85.7	•	197	57
Min	12	36	3	43	<2	3	17	•	•	•
[Max]	512	667	28	800	106	46		•	•	•
[Nic]kel G/L	47.3	30.8	•	80.0	10.9	6.3	34.3	•	81.6	87.0
Min	13	12	<2	7	4	3	13	•	•	•
Max	134	93	5	364	48	12	64	•	•	•
Lead G/L	264	71.4	•	530	87.5	•	120	•	80.4	205
Min	<8	34	<6	23	8	<9	23	•	•	•
Max	607	348	•	1830	134	•	300	•	•	•
Zinc G/L	718	299	•	1420	230	30	407	•	279	71
Min	21	116	2	172	7	6	80	•	•	•
Max	1970	1300	47	4400	390	14	744	•	•	•
DDTs(nG/L)	84.5	48.5	•	378	938	6.3	16.0	•	28.4	•
Min	<1	21	3	1	8	1	<1	<1	•	•
Max	169	249	12	1300	1870	10	38	9	•	•
PCBs(nG/L)	291	180	•	267	142	14	57	•	102	<1000
Min	11	58	2	18	12	11	<1	15	•	•
Max	695	352	41	632	250	19	75	34	•	•
PAHs G/L	36.4	1.9	•	24.4	1.1	0.02	1.2	•	•	•
Min	<0.01	<0.01	<0.02	0.4	<0.01	<0.01	<0.01	•	•	•
Max	120	18	•	76	1.9	0.14	0.5	•	•	•
Alkanes G/L	572	40.5	4.2	244	5.9	0.01	28.6	•	•	•
Min	0.8	8.0	1.4	8.9	<0.01	<0.01	0.9	<0.01	•	•
Max	1000	280	6.4	440	51.5	•	42.6	240	•	•

1 Based on 1985 monitoring data

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Table 3. Calculated concentrations of contaminants per dry gram of suspended solids using the flow-weighted mean data from Table 2

CONSTITUENT	LA RIVER WILLOW	LA RIVER FLETCHER	LA RIVER TUJUNGA	BALLONA CREEK	SANTA CLARA	CALLEGUAS CREEK	SAN GABRIEL	HYPERION 5-Mile *	OXNARD PLANT *
Total Solids (mG/G)	1410	1680	2090	2030	1950	47400	11670	•	•
Oil & Grease (mG/G)	15.5	10.5	2.0	19.7	2.2	76.3	23.6	181	130
TEOs (mG/G)	53.5	23.2	5.6	35.3	4.0	45.4	18.0	•	•
Cadmium (mG/G)	.009	.007	•	.009	0	0	.011	.067	.391
Chromium (mG/G)	.070	.046	•	.083	.045	.052	.153	.370	.348
Copper (mG/G)	.282	.389	•	.353	.055	.598	.417	1.22	1.74
Nickel (mG/G)	.073	.084	•	.106	.015	.227	.167	.504	1.74
Lead (mG/G)	.408	.289	•	.706	.070	0	.583	.546	.870
Zinc (mG/G)	1.11	1.21	•	1.88	.19	.32	2.22	1.72	2.17
Total DDTs (uG/G)	.131	.184	•	.500	.750	.206	.078	.126	•
Total PCBs (uG/G)	.451	.437	•	.353	.130	.464	.278	.630	•
HCB (uG/G)	.006	.008	•	.004	0	.010	.008	•	•
Lindane (uG/G)	.025	.084	•	.025	.020	.082	.031	•	•
Total PAHs (uG/G)	56.3	7.9	•	32.3	.9	.6	5.6	•	•
n-Alkanes (uG/G)	887	168	18	324	20	<1	139	•	•

* Daily emissions based on 1985 monitoring data

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Table 4. Mass emission rates (Metric Tons) for several runoff constituents in the 23-25 September, 1986 storm.

STATION	LA RIVER WILLOW	LA RIVER FLETCHER	LA RIVER TUJUNGA	BALLONA CREEK	SANTA CLARA	CALLEGUAS CREEK	SAN GABRIEL	HYPERION 5-MILE	OXNARD PLANT
Total Volume (L x 10^9)	11	7.7	0.0014	4.5	0.016	0.32	3.5	1.47	0.070
Sus. Solids	7100	1900	0.32	3400	20	9.7	720	238	2.3
Total Solids	10000	3200	0.67	6900	39	460	8000	*	*
Oil & Grease	110	20	0.0009	67	0.045	0.74	17	43	0.030
TEOs	300	44	0.0018	120	0.080	0.44	13	*	*
Cadmium	.064	.013	ND	0.030	ND	ND	0.0082	0.016	0.0009
Chromium	0.50	0.088	ND	0.31	0.0009	0.0005	0.11	0.088	0.0008
Copper	2.0	0.74	ND	1.2	0.0011	0.0058	0.30	0.29	0.004
Nickel	0.52	0.16	ND	0.36	0.0003	0.0022	0.12	0.12	0.004
Lead	2.9	0.55	ND	2.4	0.0014	ND	0.42	0.13	0.002
Zinc	7.9	2.3	ND	6.4	0.0038	0.0031	1.6	0.41	0.005
Total DDTs (kG)	0.93	0.35	ND	1.7	0.015	0.002	0.056	0.030	*
Total PCBs (kG)	3.2	0.83	ND	1.2	0.0026	0.0045	0.20	0.15	<0.07
HCB (kG)	0.044	0.015	ND	0.015	ND	0.0001	0.0068	*	*
Lindane (kG)	0.18	0.16	ND	0.006	0.0004	0.0008	0.022	*	*
Total PAHs (kG)	400	15	ND	110	0.018	0.0056	4.8	*	*
n-Alkanes (kG)	6300	320	0.0057	1100	0.41	0.0040	100	*	*

* Daily emissions based on 1985 monitoring data

Table 5. Flow weighted mean concentrations of trace metals and chlorinate hydrocarbons in Los Angeles River storm runoff.

Constituent	1971/72		1979/80			1986/87
	Storm 1	Storm 2	Storm 1	Storm 2	Storm 3	Storm 1
(ug/liter)						
Silver	1.9	2.6	1.3	0.7	0.4	--
Cadmium	16	9.3	1.6	8.7	1.8	5.8
Chromium	86	80	140	120	52	45.4
Copper	120	140	110	110	44	182
Mercury	-	-	1.8	0.4	0.2	-
Nickel	83	72	73	77	34	47.3
Lead	910	980	74	210	180	164
Zinc	940	1100	760	450	230	718
Iron mg/l	10	25	68	57	28	-
Maganese	450	500	640	860	450	-
DDT	-	0.93 -	0.51	0.38	0.10	0.08
PCB	-	2.6 -	0.35	0.47	0.12	0.29
Volume 10^9 liters	1.4	7.2	2.8	21.8	14.5	11
Sus Solids mg/l	-	-	2700	1900	1500	645

from Young, et al (25)

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FIGURES

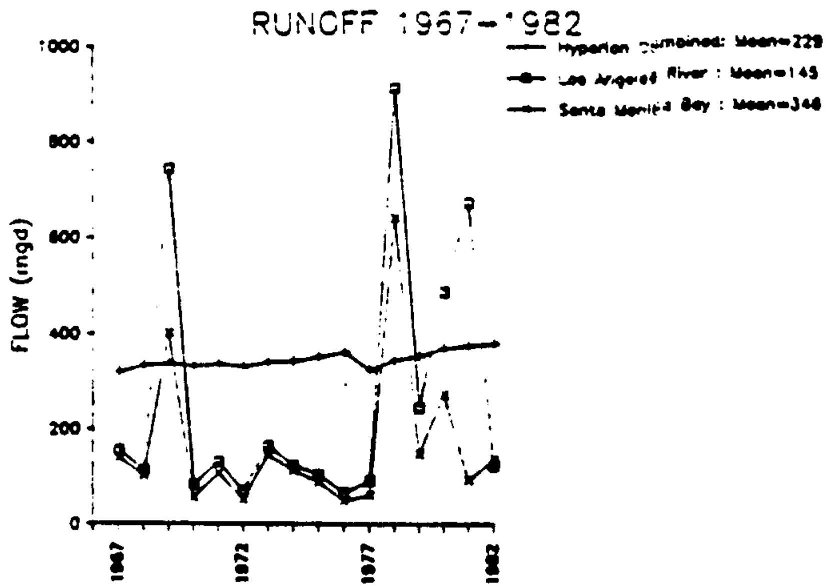

Figure 1. Annual flows from the Los Angeles River, storm channels around Santa Monica Bay (assumes ungaged flows are equal to 40% of gaged flows) and the combined Hyperion outfalls (from Garber (12)).

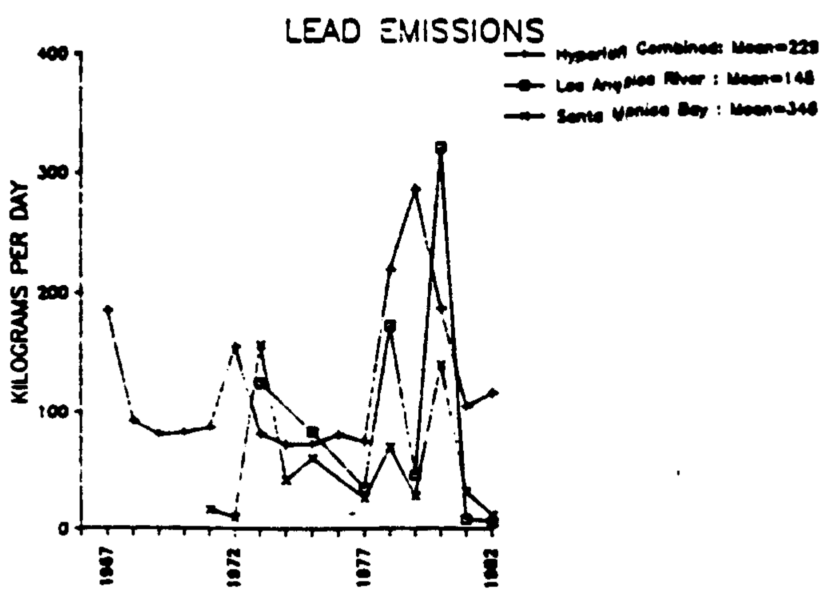

Figure 2. Average daily emissions of lead from the Los Angeles River, storm drains around Santa Monica Bay and combined Hyperion outfalls (from Garber (12)).

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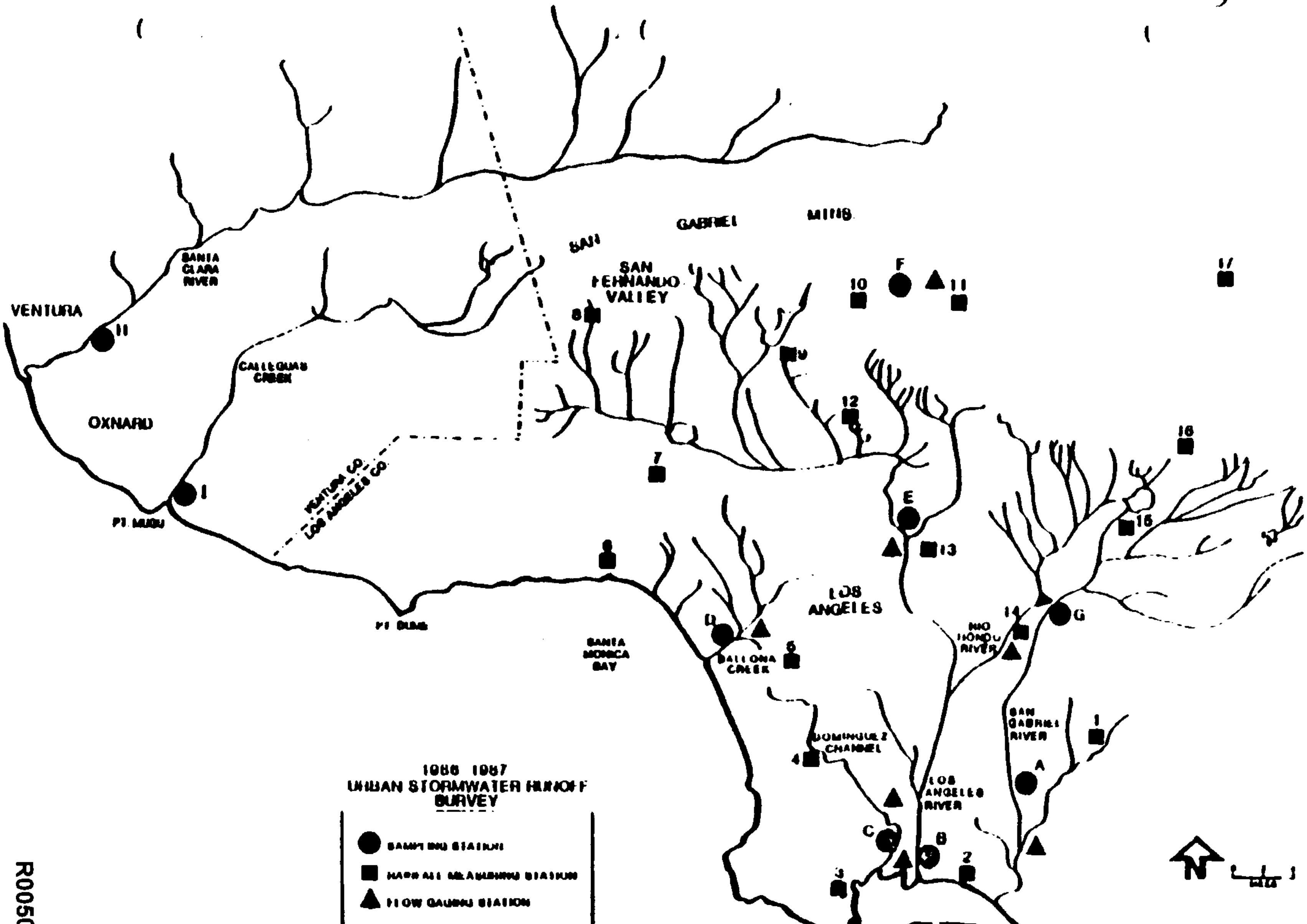

Figure 3. 1986/87 runoff study station locations

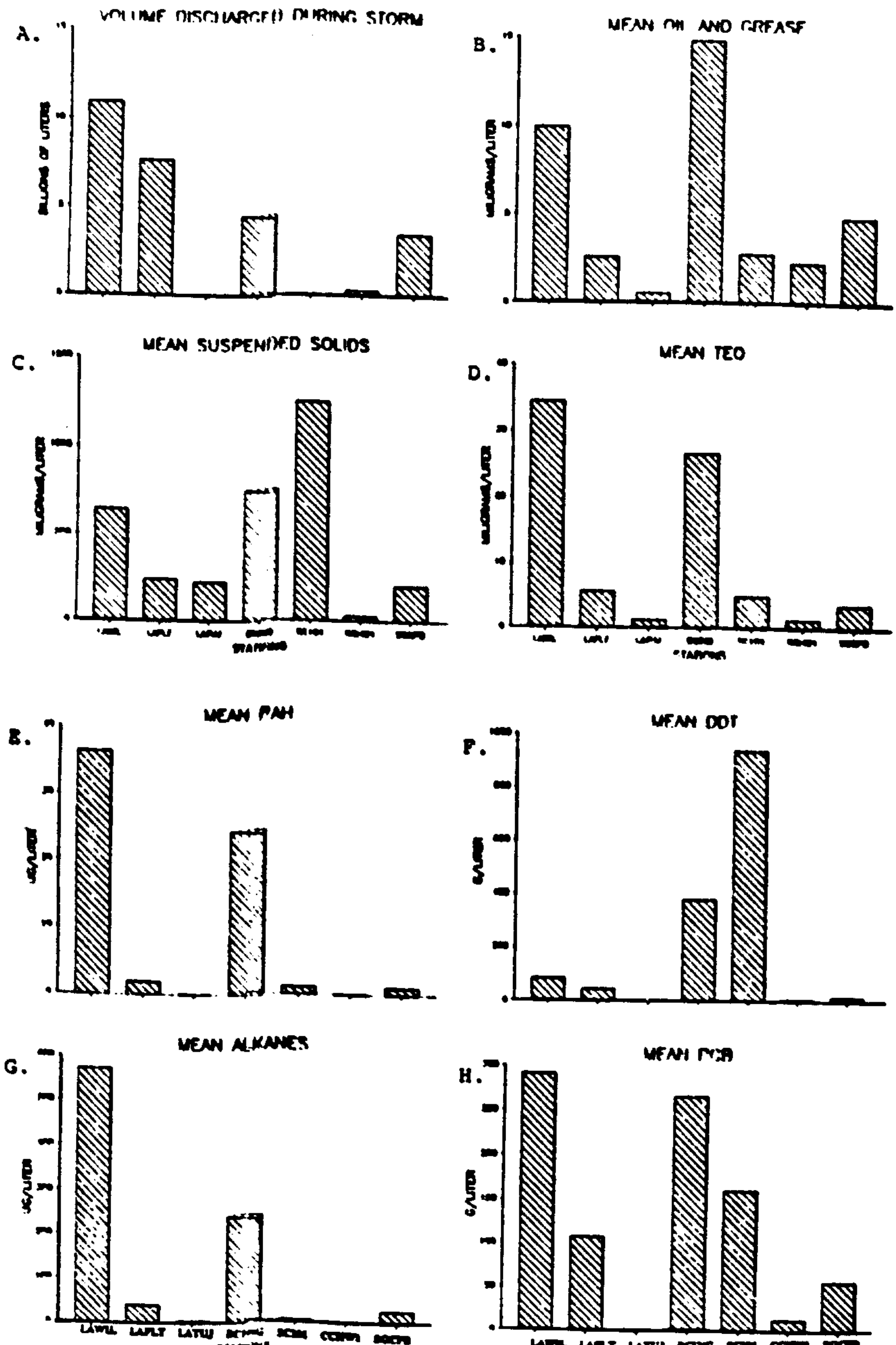

Figure 4. a-n Flow weighted mean concentrations of contaminants at the LA River at Willow (LAWIL), FLETCHER (LAFLT), TUNJUNGA Wash (LATUJ), Ballona Creek (BCING), Santa Clara River (SC101), Calleguas Creek (CCHW1) and the San Gabriel River (SGCPB).

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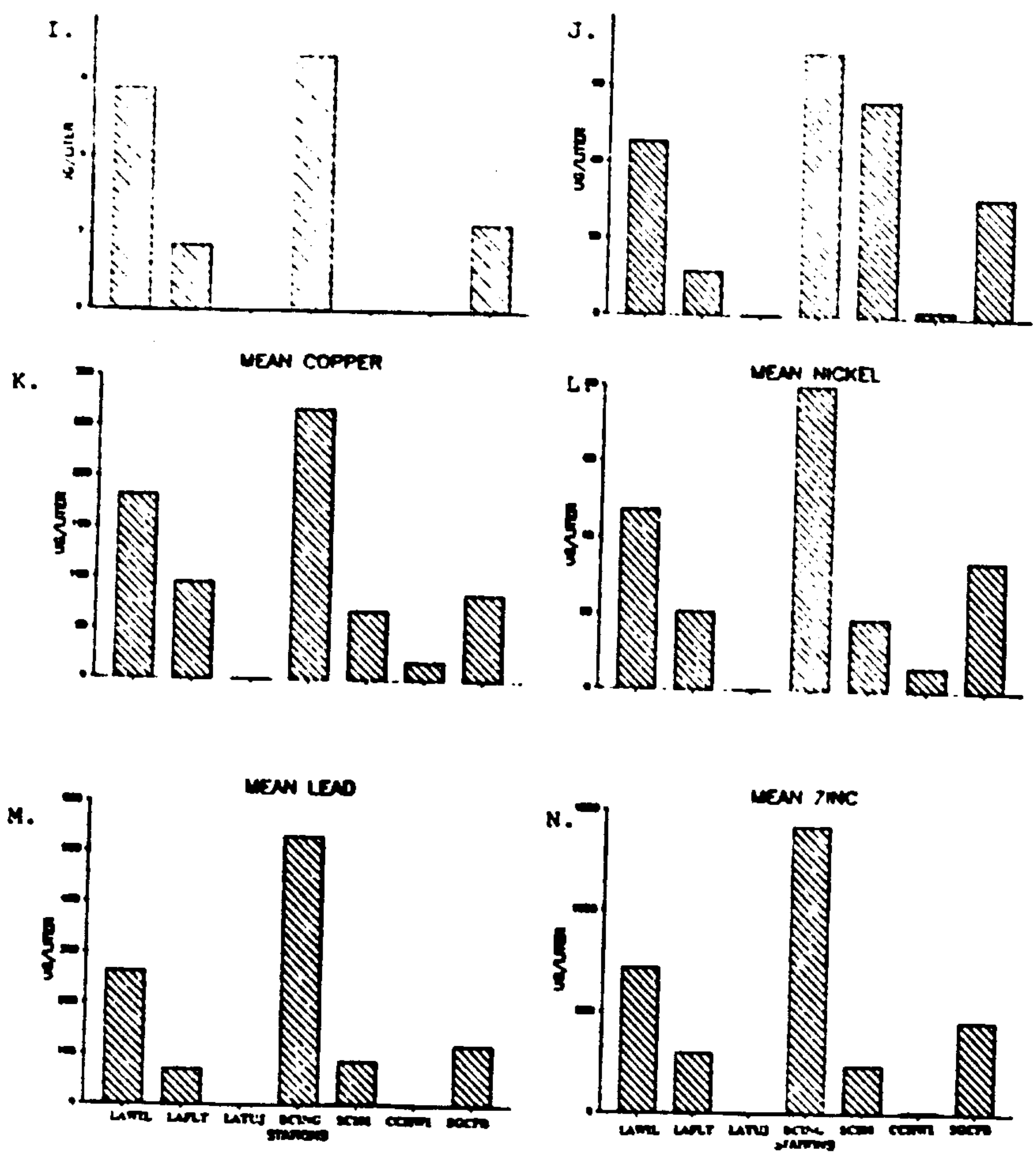

Figure. 4 I-N

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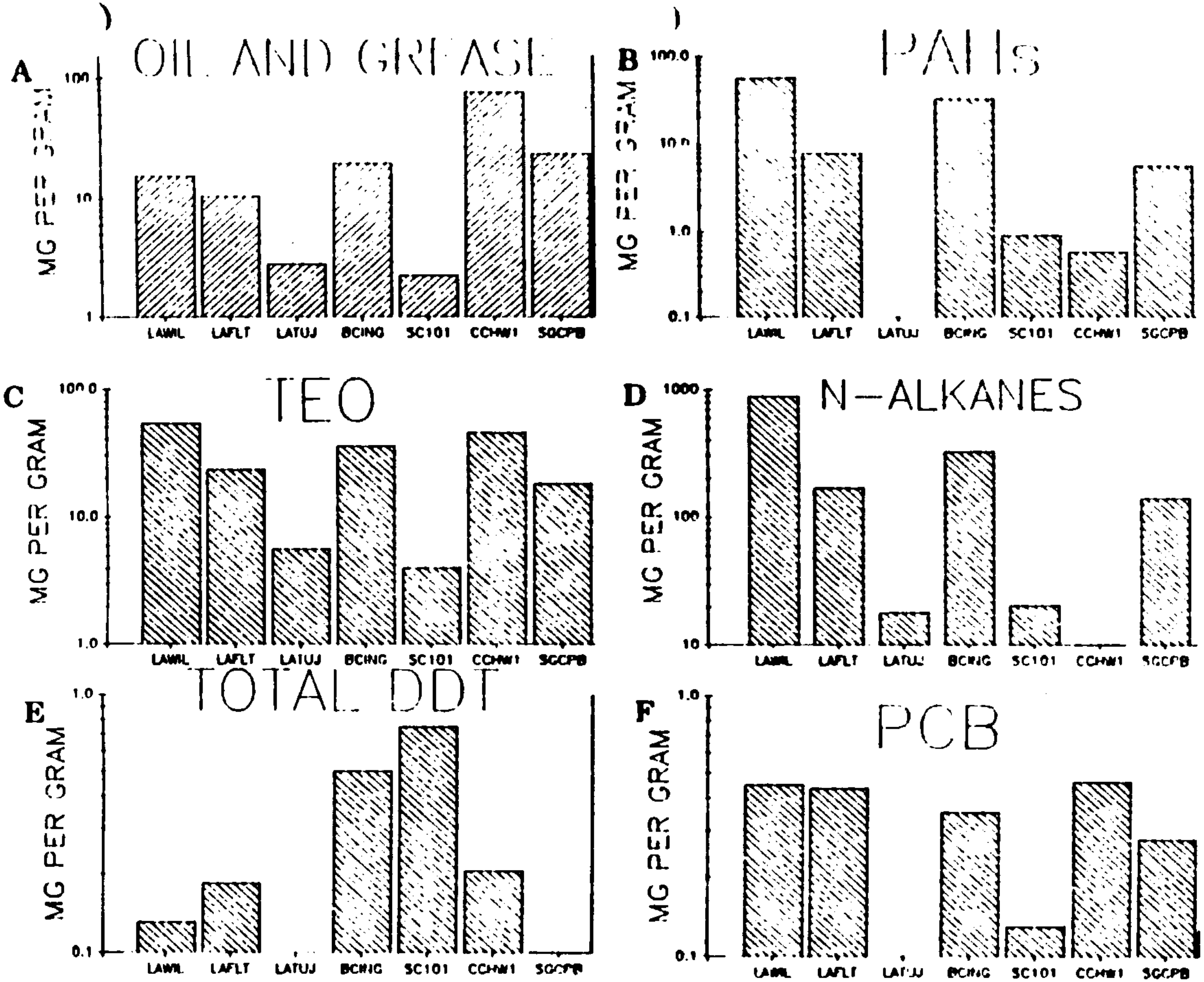

Figure 5 A-L. Concentrations of contaminants calculated on a per gram of suspended solids basis at the Los Angeles River at Willow (LAWIL), Fletcher (LAFLT), Tujunga Wash (LATUJ), Ballona Creek (BCING), Santa Clara River (SC101), Calleguas Creek (CCHW1) and San Gabriel River (SGCPB).

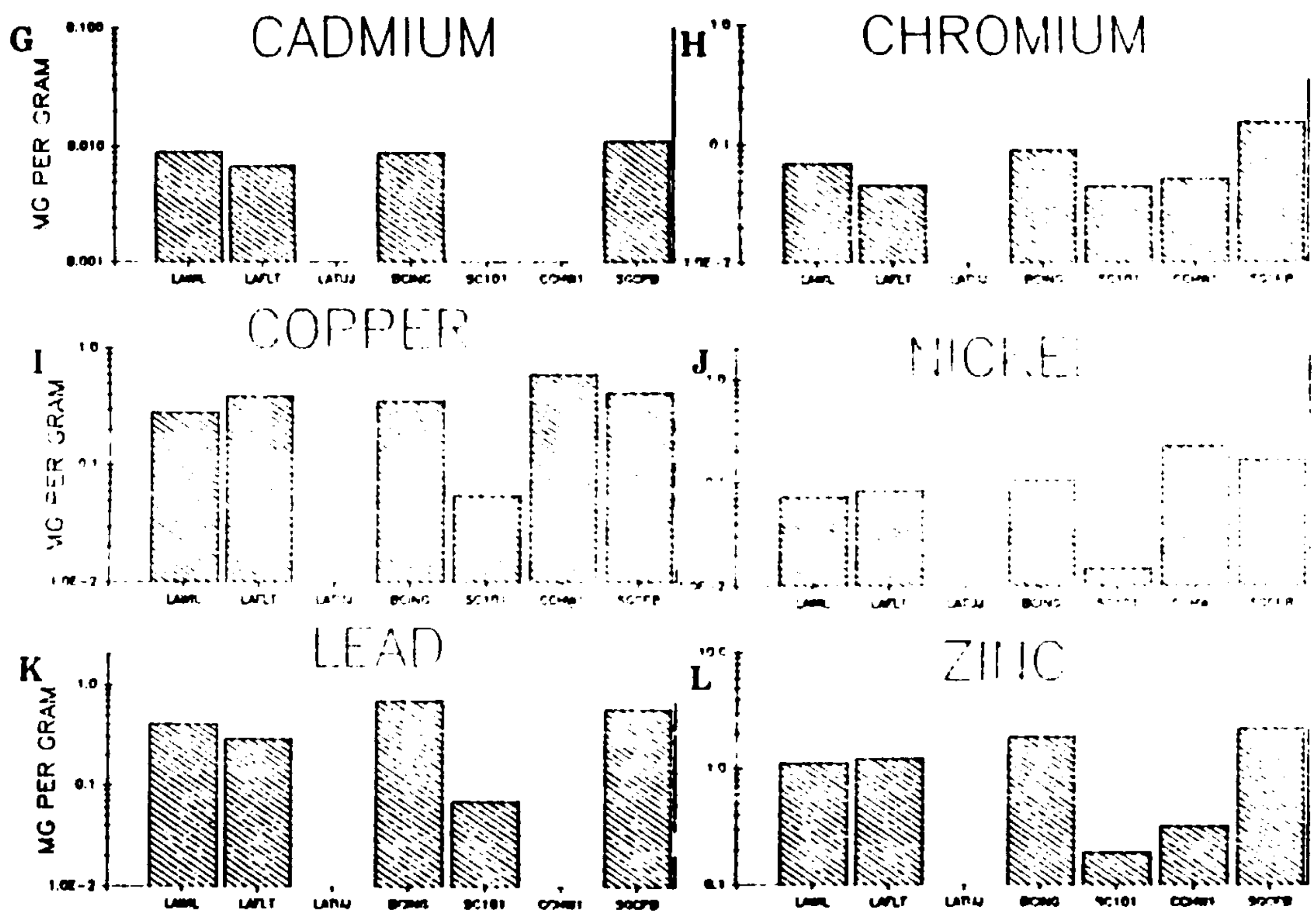

Figure 5. continued

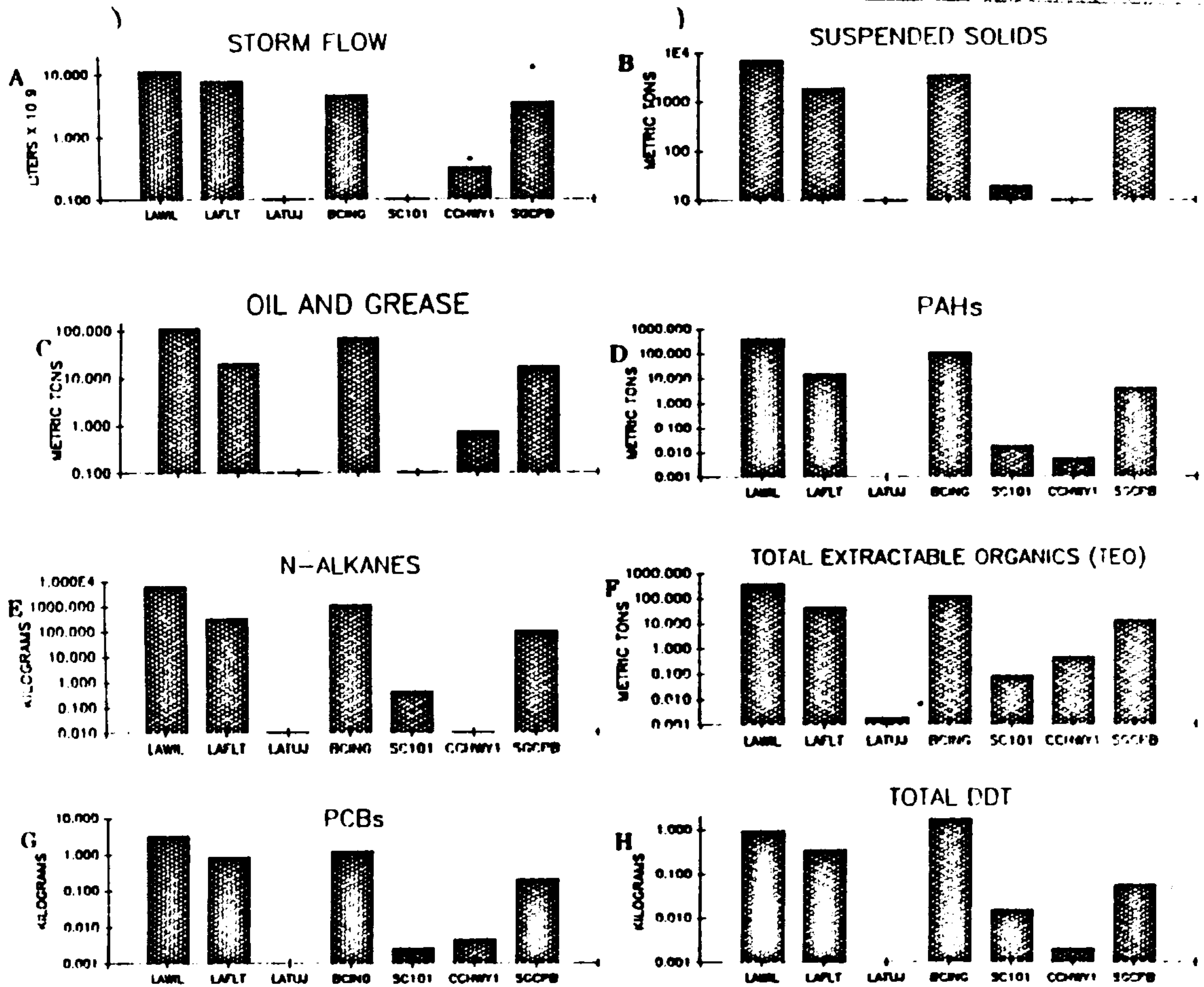

Figure 6 A-H. Calculated contaminant mass emissions from September 23-24, 1986 storm.

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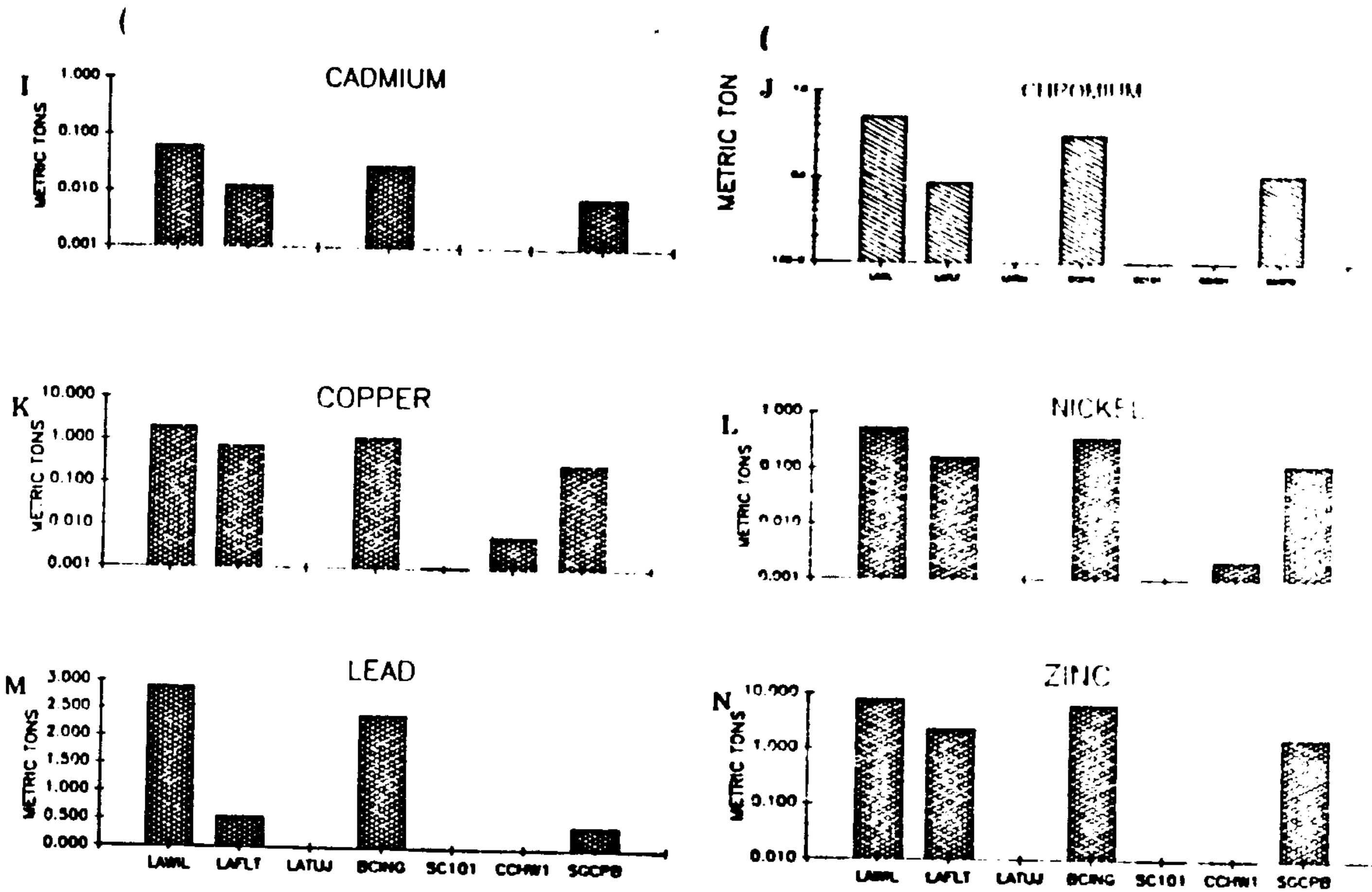

Figure 6. continued

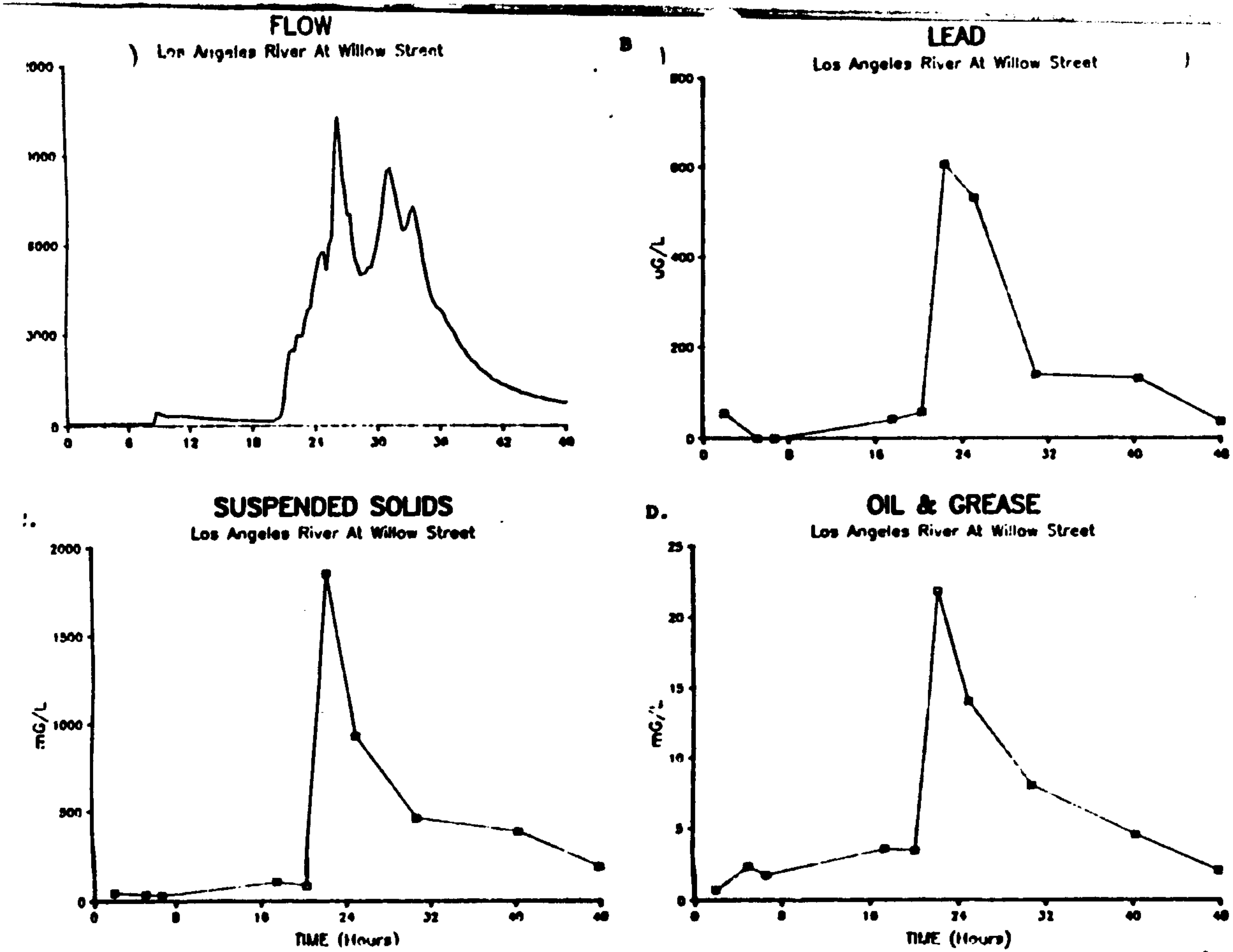

Figure 7.A-H Flow and contaminant concentrations at the Los Angeles River at Willow Street during the September 23-25, 1986 storm.

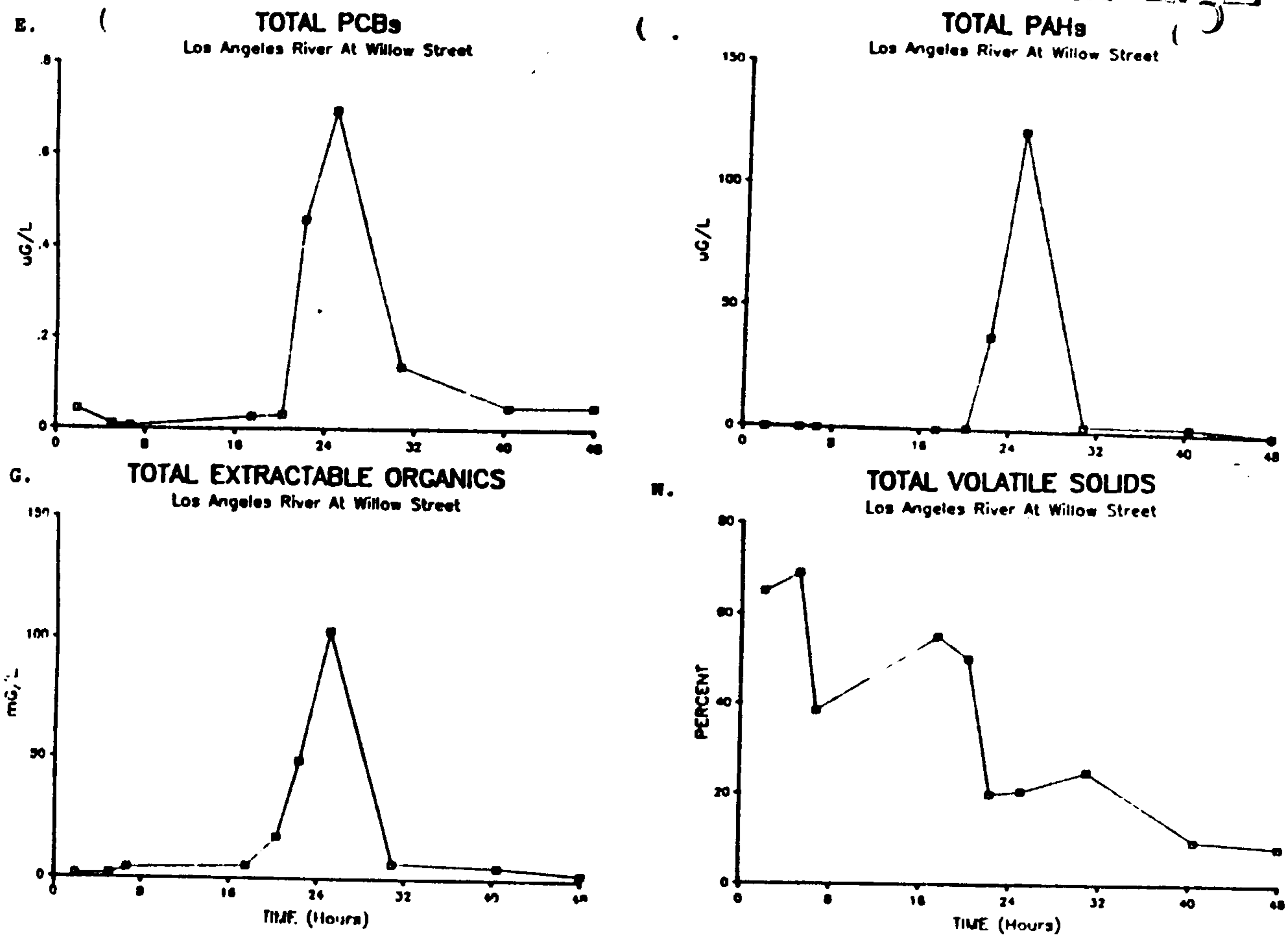

Figure 7 continued

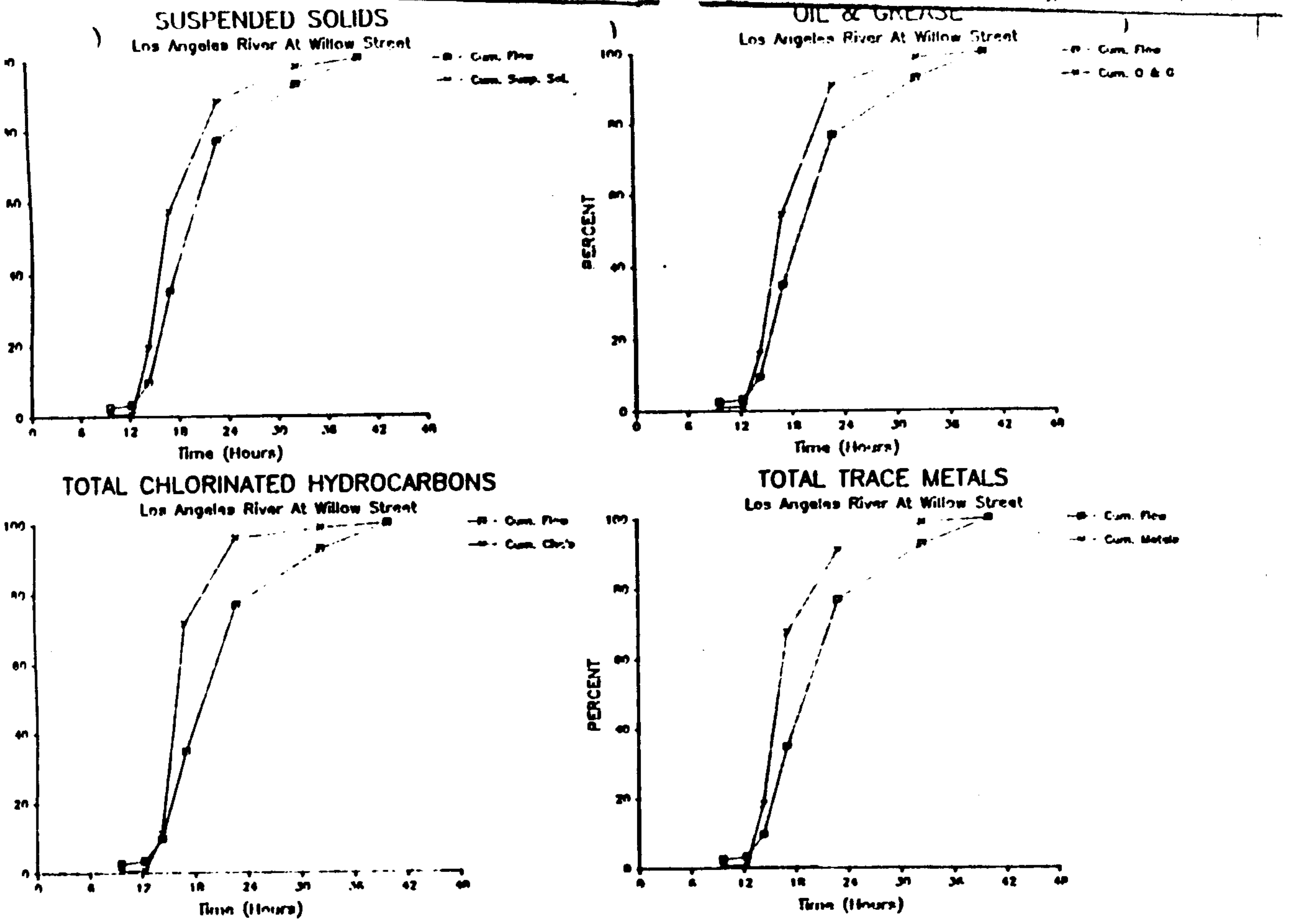

Figure 8 A-D Cummulative percentage of flow and contaminants for the Willow station

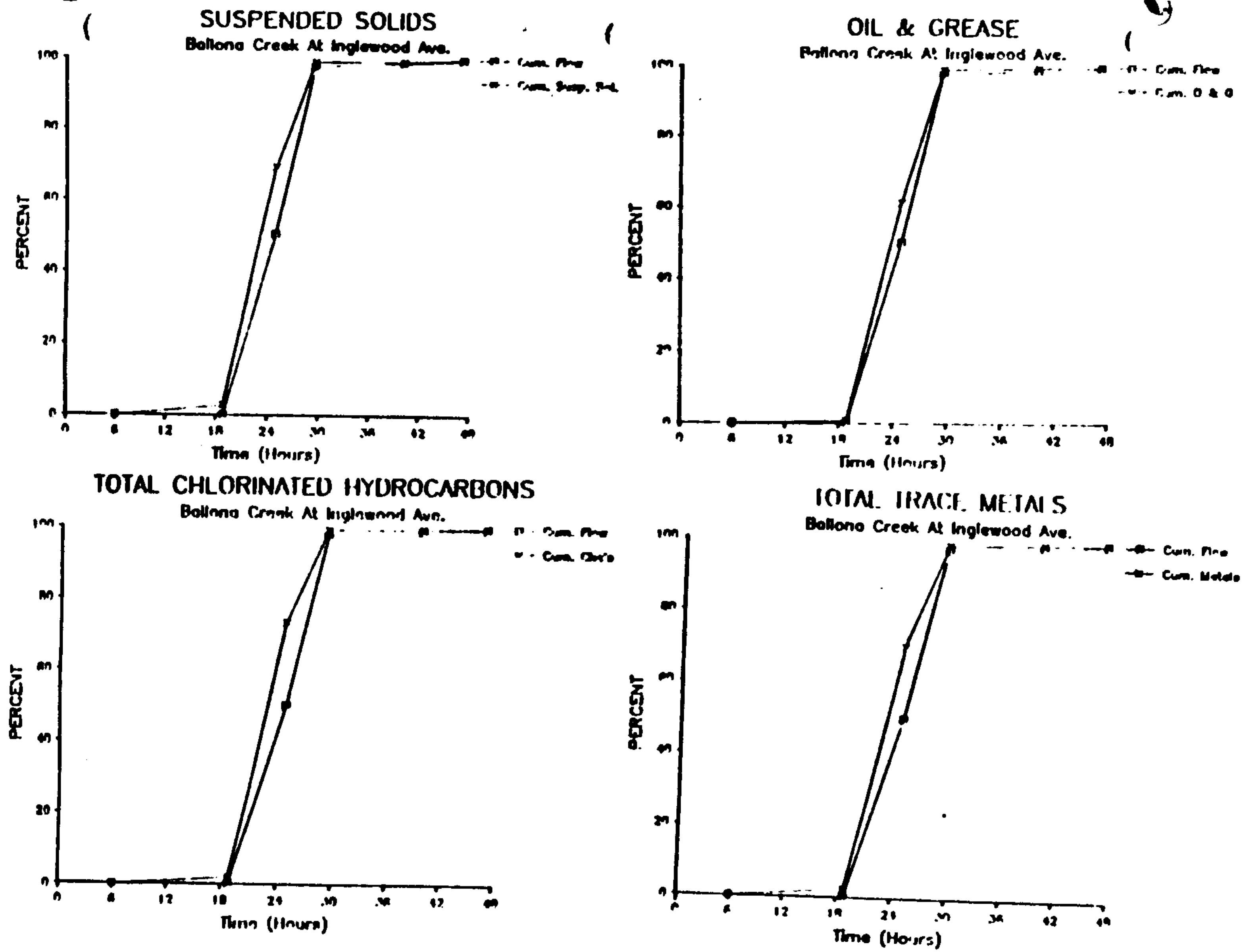

Figure 9 A-D Cummulative percentage of flow and contaminants at the Ballona Creek station

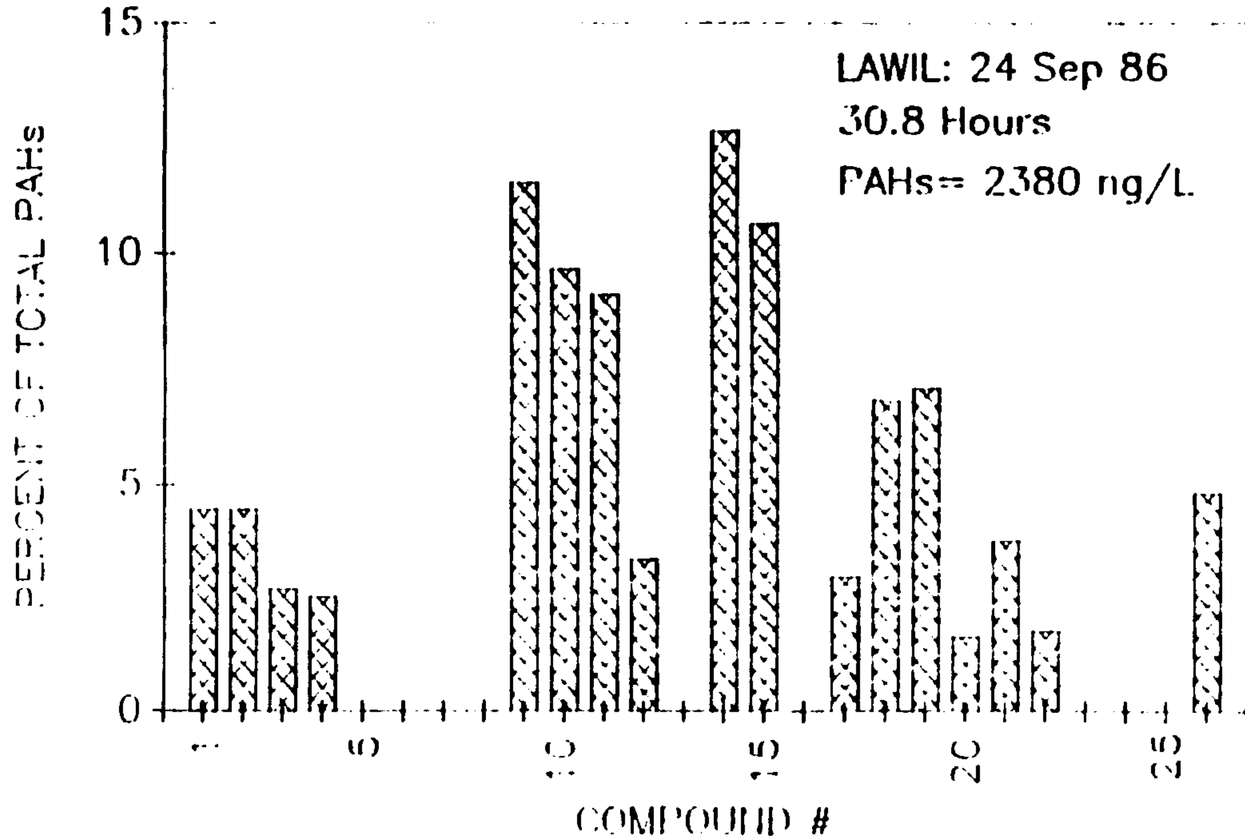

Figure 11. Relative abundances of 26 PAH compounds in runoff sampled at Willow Street on the Los Angeles River. (Compounds listed in Appendix A)

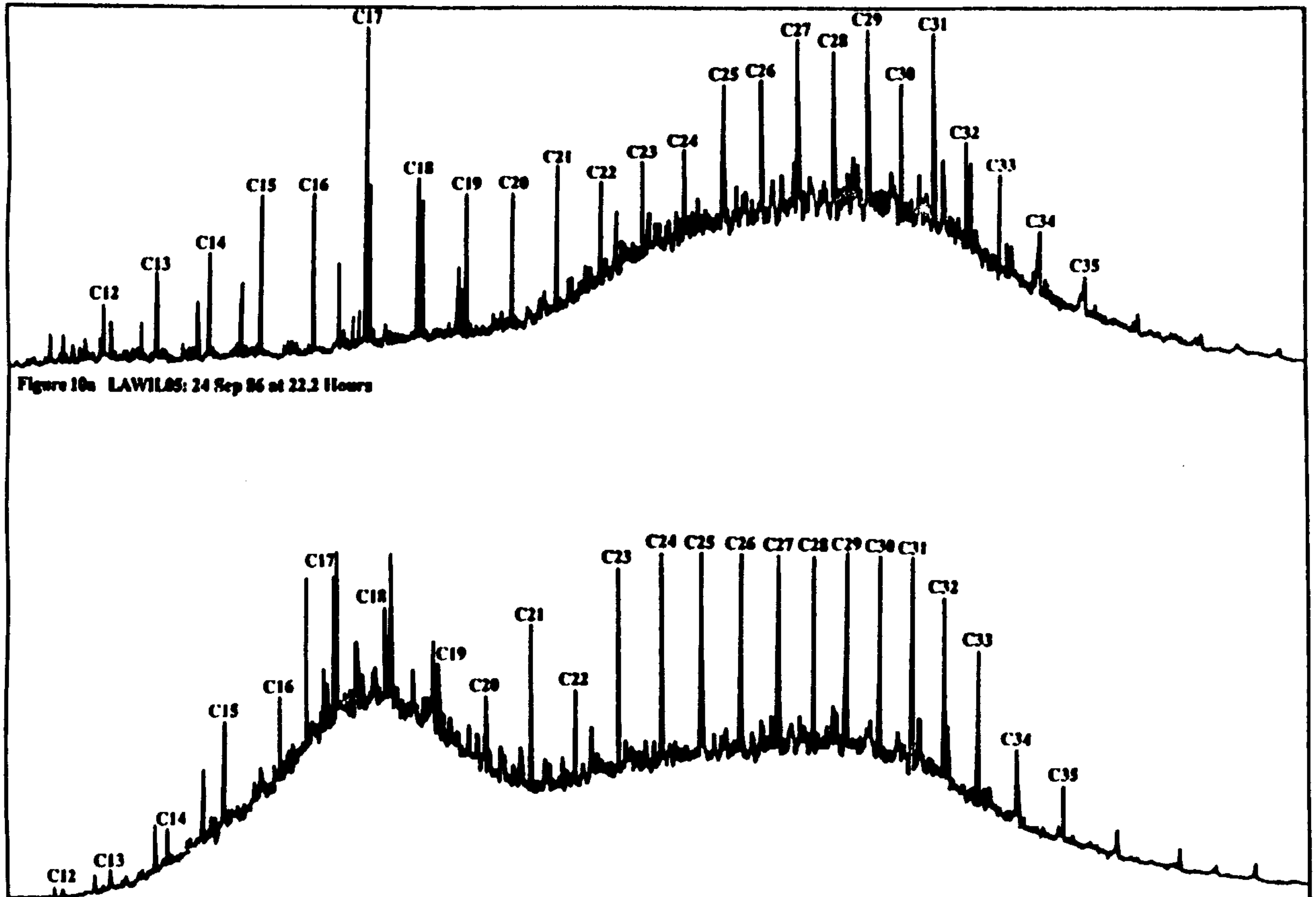

Figure 10a LAWIL05: 24 Sep 86 at 22.2 Hours

Figure 10b BCING01: 23 Sep 86 at 5.9 Hours

Figure 10a and 10b. Aliphatic hydrocarbon chromatograms of stormwater runoff samples.

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NATIONAL URBAN RUNOFF PROGRAM: SUMMARY OF CONTROL EFFECTIVENESS OF METHODS TESTED (EXCERPTS FROM THE FINAL REPORT)

U.S. ENVIRONMENTAL PROTECTION AGENCY, WASHINGTON, D.C., 1983

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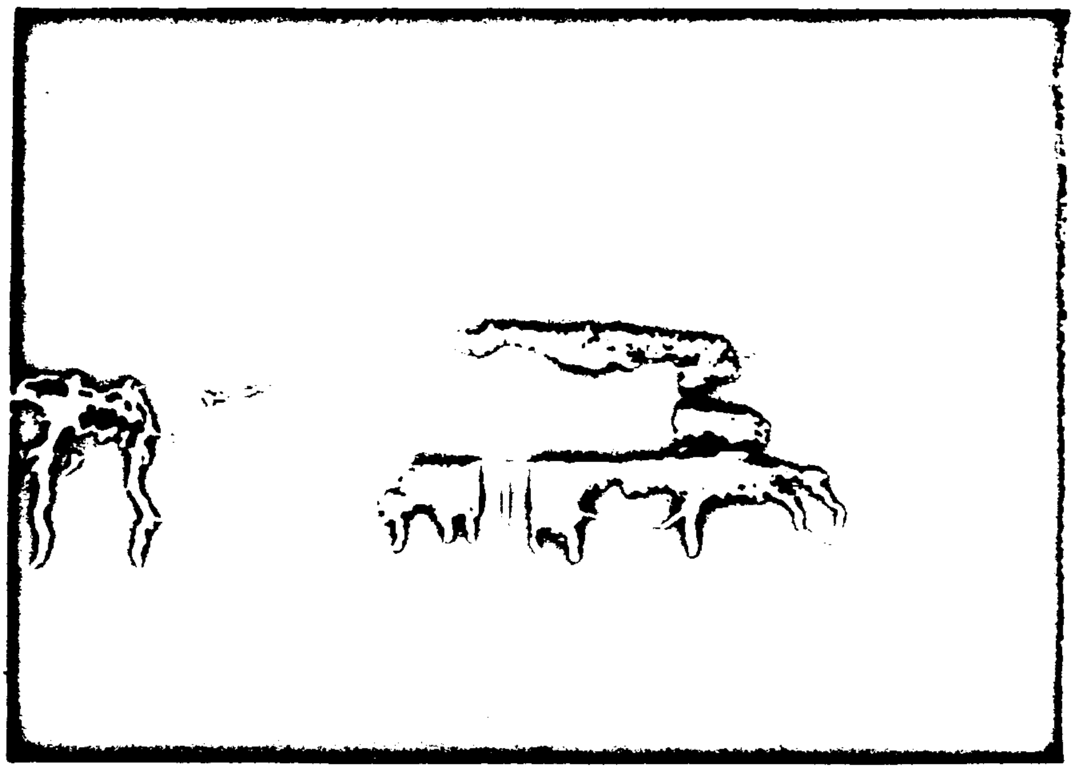
FINAL REPORT

OF THE

NATIONWIDE URBAN RUNOFF PROGRAM



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WATER PLANNING DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

The significant impact of urban runoff on shellfish harvesting has been well documented by the Long Island, New York NURP project. In this project, stormwater runoff was identified as the major source of bacterial loading to marine waters and, thus, the indirect cause of the denial of certification by the New York State Department of Conservation for about one-fourth of the shellfishing area. Much of this area is along the south shore, where the annual commercial shellfish harvest is valued at approximately $17.5 million.

The Myrtle Beach, South Carolina NURP project found that stormwater discharges from the City of Myrtle Beach directly onto the beach showed high bacterial counts for short durations immediately after storm events. In many instances these counts violated EPA water quality criteria for aquatic life and contact recreation. The high bacteria counts, however, were associated with standing pools formed at the end of collectors for brief periods following the cessation of rainfall and before the runoff percolated into the sand. Consequently, the threat to public health was not considered great enough to warrant closure of the beach.

Groundwater Aquifers

1. Groundwater aquifers that receive deliberate recharge of urban runoff do not appear to be imminently threatened by this practice at the two locations where it was investigated.

   Two NURP projects (Long Island and Fresno) are situated over sole source acquifers. They have been practicing recharge with urban runoff for two decades or more at some sites, and extensively investigated the impact of this practice on the quality of their groundwater. They both found that soil processes are efficient in retaining urban runoff pollutants quite close to the land surface, and concluded that no change in the use of recharge basins is warranted.

   Despite the fact that some of these basins have been in service for relatively long periods of time and pollutant breakthrough of the upper soil layers has not occurred, the ability of the soil to continue to retain pollutants is unknown. Further attention to this issue is recommended.

CONTROL EFFECTIVENESS

General

A limited number of techniques for the control of urban runoff quality were evaluated by the NURP program. The set is considerably smaller than previously published lists of potential management practices. Since the control approaches that were investigated were selected at the local level, the choices may be taken as an initial indication of local perceptions regarding practicality and feasibility from the standpoint of implementation.

Conclusions

1. Control measures selected at the local level for detailed investigation reflected a strong preference for detention devices, street sweeping, and recharge devices. Interest was also shown in grass swales and wetlands.

   Six NURP projects monitored the performance of a total of 14 detention devices. Five separate projects conducted in-depth studies of the effectiveness of street sweeping on the control of urban runoff quality. A total of 17 separate study catchments were involved in this effort. Three NURP projects examined either the potential of recharge devices to reduce discharges of urban runoff to surface waters or the potential of the practice to contaminate groundwaters. A total of 12 separate sites were covered by this effort.

   Grass swales were studied by two NURP projects. Two swales in existing residential areas, and one experimental swale constructed to serve a commercial parking lot were studied.

   A number of NURP projects indicated interest in wetlands for improving urban runoff quality at early stages of the program. Only one allocated monitoring activity to this control measure, however.

   Various other management practices were identified as having local interest by individual NURP projects, but none of them was allocated the necessary resources to be pursued to a point which allowed an evaluation of their ability to control pollution from urban runoff. Management practices in this category included urban housekeeping (e.g., litter programs, catch basin cleaning, pet ordinances) and public information programs.

2. Detention basins are capable of providing very effective removal of pollutants in urban runoff. Both the design concept and the size of the basin in relation to the urban area served have a critical influence on performance capability.

   Wet basins (designs which maintain a permanent water pool) have the greatest performance capabilities. Observed pollutant reductions varied from excellent to very poor in the basins which were monitored. However, when basins are adequately sized, particulate removals in excess of 90 percent (TSS, lead) can be obtained. Pollutants with significant soluble fractions in urban runoff show lower reductions; on the order of 65 percent for total P and approximately 50 percent for BOD, COD, TKN, Copper, and Zinc. Results indicate that biological processes which are operative in the permanent pool produce significant reductions (50 percent or more) in soluble nutrients, nitrate and soluble phosphorus. These performance characteristics are indicated by both the NURP analysis results and conclusions reached by individual projects.

   Dry basins, (conventional stormwater management basins), which are designed to attenuate peak runoff rates and hence only very briefly detain portions of flow from the larger storms, are indicated by NURP data to be essentially ineffective for reducing pollutant loads.

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Dual-purpose basins (conventional dry basins with modified outlet structures which significantly extend detention time) are suggested by limited NURP data to provide effective reductions in urban runoff loads. Performance may approach that of wet ponds; however, the additional processes which reduce soluble nutrient forms do not appear to be operative in these basins. This design concept is particularly promising because it represents a cost effective approach to combining flood control and runoff quality control and because of the potential for converting existing conventional stormwater management ponds.

Approximate costs of wet pond designs are estimated to be in the order of $500 to $1500 per acre of urban area served, for on-site applications serving relatively small urban areas, and about $100 to $250 per acre of urban area for off-site applications serving relatively large urban areas. The costs reflect present value amounts which include both capital and operating costs. The difference is due to an economy of scale associated with large basin volumes. The range reflects differences in size required to produce particulate removals in the order of 50 percent or 90 percent. Annual costs are estimated at $60 to $175, and $10 to $25 respectively.

3. Recharge Devices are capable of providing very effective control of urban runoff pollutant discharges to surface waters. Although continued attention is warranted, present evidence does not indicate that significant groundwater contamination will result from this practice.

Both individual project results and NURP screening analyses indicate that adequately sized recharge devices are capable of providing high levels of reduction in direct discharges of urban runoff to surface waters. The level of performance will depend on both the size of the unit and the soil permeability.

Application will be restricted to areas where conditions are favorable. Soil type, depth to groundwater, land slopes, and proximity of water supply wells will all influence the appropriateness of this control technique.

Surface accumulations which result from the high efficiency of soils to retain pollutants, suggest further attention in applications where dual purpose recharge areas also serve as recreational fields or playground areas.

4. Street sweeping is generally ineffective as a technique for improving the quality of urban runoff.

Five NURP projects evaluated street sweeping as a management practice to control pollutants in urban runoff. Four of these projects concluded that street sweeping was not effective for this purpose. The fifth, which had pronounced wet and dry seasons, believed that sweeping just prior to the rainy season could produce some benefit in terms of reduced pollution in urban runoff.

A large data base on the quality of urban runoff from street sweeping test sites was obtained. At 10 study sites selected for detailed analysis, a total of 381 storm events were monitored under control conditions, and an additional 277 events during periods when street sweeping operations were in effect. Analysis of these data indicated that no significant reductions in pollutant concentrations in urban runoff were produced by street sweeping.

There may be special cases in which street cleaning applied at restricted locations or times of year could provide improvements in urban runoff quality. Some examples that have been suggested, though not demonstrated by the NURP program, include periods following snow melt or leaf fall, or urban neighborhoods where the general level of cleanliness could be significantly improved.

5. Grass swales can provide moderate improvements in urban runoff quality. Design conditions are important. Additional study could significantly enhance the performance capabilities of swales.

Concentration reductions of about 50 percent for heavy metals, and 25 percent for COD, nitrate, and ammonia were observed in one of the swales studied. However the swale was ineffective in reducing concentrations of organic nitrogen, phosphorus, or bacterial species. Two other swales studied failed to demonstrate any quality improvements in the urban runoff passing through them.

Evaluations by the NURP projects involved concluded, however, that this was an attractive control technique whose performance could be improved substantially by application of appropriate design considerations. Additional study to develop such information was recommended.

Design considerations cited included slope, vegetation type and maintenance, control of flow velocity and residence time, and enhancement of infiltration. The latter factor could produce load reductions greater than those inferred from concentration changes and effect reductions in those pollutant species which are not attenuated by flow through the swale.

6. Wetlands are considered to be a promising technique for control of urban runoff quality. However, neither performance characteristics nor design characteristics in relation to performance were developed by NURP.

Although a number of projects indicated interest, only one assigned NURP monitoring activity to a wetland. This was a natural wetland, and flows passing though it were uncontrolled. Results suggest its potential to improve quality, but the investigation was not adequate to associate necessary design factors to performance capability. Additional attention to this control technique would be useful, and should include factors such as the need for maintenance harvesting to prevent constituent recycling.

quite high indeed. The opportunities for control in central business districts are quite limited, however, and the only practicable option in many cases may be to route this portion of a locality's urban runoff to a treatment plant via the sanitary sewers. More study is required before such a recommendation can be made, however, because this practice could either create a combined sewer overflow situation or aggrevate one which already exists.

Socio-Economic Effects

Although the NURP data in this area are quite limited, they strongly suggest that the runoff from disadvantaged neighborhoods contains dramatically higher levels of pollutants than does the runoff from more affluent parts of an urban area. Unique control opportunities may exist in such situations, but further study will be required before this issue can be dealt with in an adequate fashion.

Physical Effects

Several projects concluded that the physical impacts of urban runoff upon receiving waters have received too little attention and, in some cases, are more important determinants of beneficial use attainment than chemical pollutants. This contention requires much more detailed documentation.

Synergy

NURP did not evaluate the synergistic effects that might result from pollutant concentrations experienced in stormwater runoff, in association with pH and temperature ranges that occur in the receiving waters. This type of investigation might reveal that control of a specific parameter, such as pH, would adequately reduce an adverse synergistic effect caused by the presence of other pollutants in combination and be the most cost effective solution. Further investigations should include this issue.

Opportunities for Control

Based upon the results of NURP's evaluation of the performance of urban runoff controls, opportunities for significant control of urban runoff quality are much greater for newly developing areas. Institutional considerations and availability of space are the key factors. Guidance on this issue in a form useful to States and urban planning authorities should be prepared and issued.

Wet Weather Water Quality Standards

The NURP experience suggests the desirability of EPA supporting efforts to develop "wet weather" standards, criteria, or modifications to ambient criteria to reflect differences in impact due to the intermittent, short duration exposures characteristic of urban runoff and other nonpoint source discharges.

Coliform Bacteria

The appropriateness of using coliform bacteria as indicator organisms for human health risk where the source is exclusively urban runoff warrants further investigation.

Wetlands

The use of wetlands as a control measure is of great interest in many areas, but the necessary information on design performance relationships required before cost effective applications can be considered has not been adequately documented. The environmental impacts of such use upon wetlands is a critical issue which, at present, has been addressed marginally, if at all.

Swales

The use of grass swales was suggested by two NURP projects to represent a very promising control opportunity. However, their performance is very dependent upon design features about which information is lacking. Further work to address this deficiency and appropriate maintenance practices appears warranted.

Illicit Connections

A number of the NURP projects identified what appeared to be illicit connections of sanitary discharges to stormwater sewer systems, resulting in high bacterial counts and dangers to public health. The costs and complications of locating and eliminating such connections may pose a substantial problem in urban areas, but the opportunities for dramatic improvement in the quality of urban stormwater discharges certainly exist where this can be accomplished. Although not emphasized in the NURP effort, other than to assure that the selected monitoring sites were free from sanitary sewage contamination, this BMP is clearly a desirable one to pursue.

Erosion Controls

NURP did not consider conventional erosion control measures because the information base concerning them was considered to be adequate. They are effective, and their use should be encouraged.

Combined Sewer Overflows

In order to address urban runoff from separate storm sewers, NURP avoided any sites where combined sewers existed. However, in view of their relative levels of contamination, priority should be given to control of combined sewer overflows.

Implementation Guidance

The NURP studies have greatly increased our knowledge of the characteristics of urban runoff, its effects upon designated uses, and of the performance efficiencies of selected control measures. They have also confirmed earlier

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impressions that some States and local communities have actually begun to develop and implement stormwater management programs incorporating water quality objectives. However, such management initiatives are, at present, scattered and localized. The experience gained from such efforts is both needed and sought after by many other States and localities. Documentation, evaluation, refinement and transfer of management and financing mechanisms/arrangements, of simple and reliable problem assessment methcdologies, and of implementation guidance which can be used by planners and officials at the State and local level are urgently needed as is a forum for the sharing of experiences by those already involved, both among themselves and with those who are about to address nonpoint source issues.

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URBAN TARGETING AND BMP SELECTION: AN INFORMATION AND GUIDANCE MANUAL FOR STATE NPS PROGRAM STAFF ENGINEERS AND MANAGERS

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URBAN TARGETING AND BMP SELECTION

AN INFORMATION AND GUIDANCE MANUAL FOR STATE NPS PROGRAM STAFF ENGINEERS AND MANAGERS

FINAL REPORT

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CHAPTER 1
INTRODUCTION

There is general agreement as indicated in State 305(b) reports, nonpoint source (NPS) Assessment Reports, and in the proposed Stormwater NPDES permitting requirements that urban runoff can be a significant contributor to degraded water quality in receiving waters. It may therefore be necessary to implement controls to prevent any further deterioration or to improve receiving water quality. Moreover, the focus on implementation is at the local level as federal legislation and state stormwater management planning efforts stipulate that a municipality is responsible for the quality and quantity of runoff within its jurisdiction.

In some cases, sufficient resources may not be available to implement all of the controls that may be required. In other cases, a staged approach to the implementation of a comprehensive management program may be appropriate. For either of these possibilities, there is a need to target the available resources and to prioritize the control program based on site specific conditions, so that the greatest water quality benefit is realized for the resources expended.

However, much of the available information (data and procedures) that would facilitate the required effort are currently not available in an appropriately organized and consolidated format, and hence are not conveniently accessible by State and local personnel involved in addressing NPS issues.

To assist State and local agency personnel in targeting areas within their jurisdiction, this manual consolidates existing information and develops a methodology for targeting urban areas for control. This manual addresses the following aspects related to NPS pollutant discharges from urban areas:

1. The nature and characteristics of urban runoff, and the types of water quality problems that are most likely to occur. (Chapter 2)
2. The types of best management practices (BMP's) that are appropriate for control of NPS pollutant loads from urban and developing areas, and guidance for their selection. (Chapter 3)
3. A procedure for prioritizing urban areas for control. (Chapter 4)

This manual has a technical orientation with a level of detail appropriate for local and state agency use. The information and procedures presented are expected to be suitable for developing local planning strategies for controlling the quality of urban runoff and associated receiving water effects. It does not provide comprehensive and exhaustive treatment of technical aspects. For more detailed information, selected references are provided.

CHAPTER 2
URBAN NONPOINT SOURCE POLLUTANTS

In this manual, urban runoff is defined as any discharge from a pipe, channel, or other conveyance that removes stormwater from an urban area. Combined sewers, which convey sanitary sewage as well as stormwater, are specifically excluded from consideration here.

Urban runoff quantity and quality are significantly affected by watershed development and, in particular, drainage systems that are constructed for human safety, health, and convenience. Urbanization alters the natural vegetation and natural infiltration characteristics of the watershed, causing runoff from an urban area to have a much higher surface flow component, a much smaller interflow component, and a somewhat reduced baseflow component. Urbanization also can cause water quality problems because activities associated with urbanization create sources of pollutants (e.g., automobile emissions) for surface runoff. Thus urbanization tends to increase runoff and pollutant loadings to the receiving water body. Specifically, some effects of urbanization are to:

- increase peak discharges (typically by about two to five times)
- increase runoff volume from a given storm (volume increases of 50% or more are common)
- decrease the watershed response time (the time of concentration)
- reduce streamflow in dry weather periods (especially during prolonged dry spells; urbanization can actually cause small headwater perennial streams to become ephemeral)
- increase runoff velocity during storms
- increase the discharge of pollutants
- significantly modify the type and nature of pollutants

The following sections discuss these effects and provide methods of estimating those effects (runoff volume and water quality) that are required for the targeting methodology presented in Chapter 4.

2.1 URBAN RUNOFF HYDROLOGY

2.1.1 Regional Precipitation Characteristics

Precipitation causes runoff which in turn mobilizes and transports pollutants from the urban area to the receiving water. Storm event characteristics and patterns vary considerably in different regions of the country, and can influence the nature and extent of the receiving water impacts. For example, in the East and Southeast, short duration - high intensity summer thunderstorms tend to increase the erosion potential compared to the Pacific Northwest, where the prevailing rainfall pattern is one of longer duration - low intensity events. Receiving water impacts are also affected by the characteristics of the receiving water body. In streams and rivers, water quality effects are associated with the individual storm events; whereas in the case of lakes and impoundments, the impact produced is usually the result of the cumulative effect of NPS discharges over an extended period of time. Regions with greater annual precipitation amounts will contribute higher pollutant loadings to these waterbodies, than areas with low annual precipitation.

A recent EPA study characterizes storm event properties that are useful for preliminary planning assessments (Driscoll, et al, 1989). Table 2-1 tabulates the statistics of a set of storm event properties for various rain zones shown in Figure 2-1, and are based on the analysis of rain gage data for the locations shown on the map. Specific information on the individual sites is provided in the referenced document. The data presented is based on those storm events that produce storm volumes greater than 0.1 inch, because experience indicates that very small storms do not produce runoff. As a result, the statistics shown are for runoff-producing storm events. For these events the annual statistics show the average and year-to-year variability (expressed as the coefficient of variation) of the number of storms per year and the annual precipitation volume. The "event" statistics show the average and variability of the characteristics of individual storms. These data indicate significant regional differences which must be taken into account in NPS assessments. For example, as discussed earlier, note the four-fold difference in average storm intensity between the Pacific Northwest (0.035 in/hr) and the Southeast (0.122 in/hr).

2.1.2 Estimating Runoff Volume

<u>Percent Imperviousness</u>

An important element in targeting watersheds for control is the runoff volume from the respective watersheds within a jurisdiction. The following describes various simplified methods that may be used for estimating runoff volume.

The single most important factor in determining the quant[illegible] of runoff that will result from a given storm event is the percent imperviousness of the [illegible]nd cover. Other factors include soil infiltration properties, topography (which defines [illegible]atershed slopes and depression storage capacity), vegetative cover , and anteceden[illegible] conditions.

Impervious areas include paved streets, sidewalks, driveways, parking areas, rooftops, patios, decks, and similar man-made structures. Obviously, the extent of imperviousness is a function of local development customs and zoning requirements such as lot sizes, single- or multiple-level construction, preferences for garages, use of alleyways, curb and gutter versus swale drainage, and similar factors. Such customs vary widely across the country due to climate, land cost, and a host of other reasons. Even within a given region or municipality, they are typically not uniform and may vary by land use and, even within a given land use, by the age of the development or its location within the city.

Given the importance of percent imperviousness in NPS assessments, it is strongly recommended that the percent imperviousness for a given study area be determined from site specific information. For example, the impervious area can be estimated from site plans, maps, and aerial photographs. This method does involve some degree of uncertainty (for example, rooftops may or may not drain to other impervious areas). An alternative or complimentary method would treat the percent imperviousness as a "calibration factor" to be determined utilizing a simple runoff model and rainfall and runoff records.

For preliminary screening purposes, prior to obtaining detailed site specific information, initial estimates of percent imperviousness can be made based upon land use category. While useful for larger urban areas where things tend to "average out," caution is

TABLE 3-1. TYPICAL VALUES OF ANNUAL STORM EVENT STATISTICS FOR RAIN ZONES

RAIN ZONE	Annual Statistics: No. of Storms Avg	No. of Storms COV	Precip Avg (in)	Precip COV	Independent Storm Event Statistics: Duration Avg (hrs)	Duration COV	Intensity Avg (in/hr)	Intensity COV	Volume Avg (in)	Volume COV	DELTA Avg (hr)	DELTA COV
NORTH EAST	70	0.13	34.6	0.16	11.2	0.81	0.067	1.23	0.50	0.95	126	0.94
NORTH EAST - COASTAL	63	0.12	41.4	0.21	11.7	0.77	0.071	1.05	0.66	1.03	140	0.87
MIDATLANTIC	62	0.13	39.5	0.18	10.1	0.84	0.092	1.20	0.64	1.01	143	0.97
CENTRAL	68	0.14	41.9	0.19	9.2	0.85	0.097	1.09	0.62	1.00	133	0.99
NORTH CENTRAL	55	0.16	29.8	0.22	9.5	0.83	0.087	1.29	0.55	1.01	167	1.17
SOUTHEAST	65	0.15	49.0	0.20	8.7	0.92	0.122	1.09	0.75	1.10	136	1.03
EAST GULF	68	0.17	53.7	0.23	6.4	1.05	0.178	1.03	0.80	1.19	130	1.25
EAST TEXAS	41	0.22	31.2	0.29	8.0	0.97	0.137	1.08	0.76	1.18	213	1.28
WEST TEXAS	30	0.27	17.3	0.33	7.4	0.98	0.121	1.13	0.57	1.07	302	1.53
SOUTHWEST	20	0.30	7.4	0.37	7.8	0.88	0.079	1.16	0.37	0.88	473	1.46
WEST INLAND	14	0.38	4.9	0.43		0.75	0.055	1.06	0.36	0.87	786	1.54
PACIFIC SOUTH	19	0.36	10.2	0.42	9.4	0.78	0.054	0.78	0.54	0.90	476	2.09
NORTHWEST INLAND	31	0.23	11.5	0.29	11.9	0.82	0.057	1.20	0.37	0.93	304	1.43
PACIFIC CENTRAL	32	0.25	10.4	0.33	13.7	0.80	0.040	0.85	0.58	1.05	265	2.00
PACIFIC NORTHWEST	71	0.15	35.7	0.19	15.9	0.80	0.035	0.73	0.50	1.09	123	1.50

COV = Coefficient of Variation = Standard Deviation / Mean

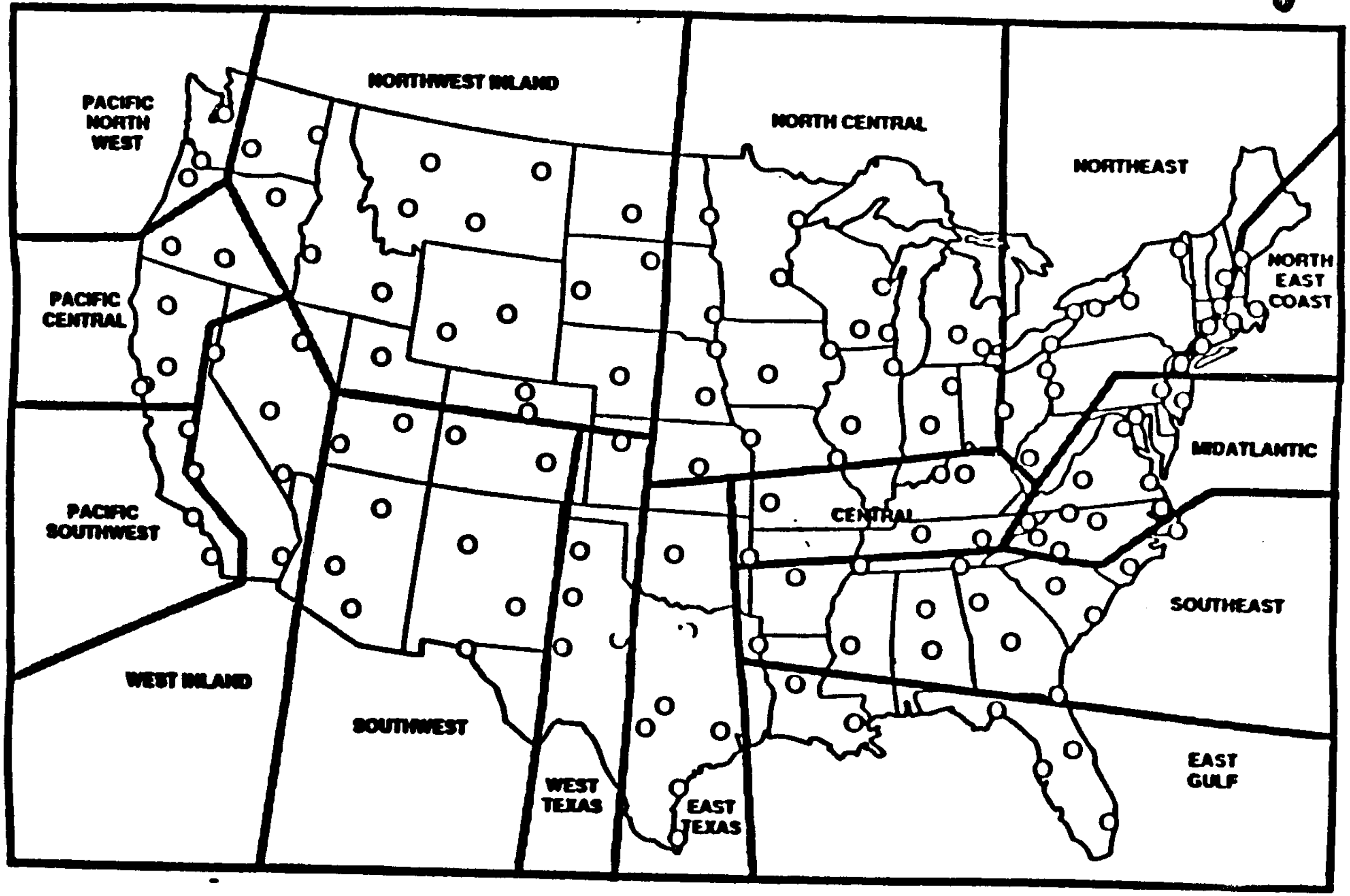

FIGURE 2-1. RAIN ZONES OF THE UNITED STATES.

called for in inferring such values for small specific sites. Use local data where there is any question.

The largest single land use in most metropolitan areas is residential, which typically accounts for between 50% and 70% of the total area. Lacking any other information, it is suggested that an initial estimate of 60% be used. If population data is available, an estimate of the percent imperviousness can be obtained using the following expression (Shelley, 1988):

$$PI = 9(PD)^{0.5} \qquad (2\text{-}1)$$

where

PI = percent impervíuosness [%]
PD = population density [persons/acre]

Note the population density can be estimated by first determining the population from census data or other sources and dividing this by the area of the residential land use. Equation (2-1) is based upon extensive examination of all residential land use sites in the NURP and USGS runoff data bases.

Commercial land use typically represents from 5% to 15% of the total urban area; a value of 10% is suitable as a first approximation. The imperviousness of commercial areas varies considerably, from around 50% for shopping malls with considerable landscaping and associated undeveloped space to over 90% for central business districts. In the absence of specific information, the use of 75% to 80% impervious area is suggested for commercial land use.

Industrial land use will vary considerably with the region of the country and the nature of the community, being rather high for older heavily industrialized communities. Typical values range from 10% to 20% of the total urban area; with 15% recommended for use as a first approximation. Here also, the percent imperviousness varies considerable, but often is between 40% and 70%. A preliminary estimate of 55% to 60% impervious area is suggested for use in lieu of site specific data.

The land use for the remaining portions of the urban area consists largely of open areas such as parks, golf courses, cemeteries, and undeveloped land. Typically, this land use category is around 15%, and this value is suggested as a preliminary estimate. Here also, the percent imperviousness can vary widely (from 5% to over 40%); a value between 10% to 20% is a reasonable first estimate.

The foregoing procedure can be used to arrive at a composite estimate of overall percent inperviousness for an urban area, by developing a weighted average based upon allocating the total urban area to the four major land uses just discussed and using the preliminary percent imperviousness estimates as suggested. To illustrate, consider a medium sized urban area with a population density of 9 persons per acre.

Land Use	% of Total Area	% Impervious	Net Impervious Fraction
Residential	60%	27%	0.162
Commercial	10%	75%	0.075
Industrial	15%	55%	0.0825
Open/Other	15%	15%	0.0225
TOTAL IMPERVIOUSNESS			0.342

This value of 34.2% imperviousness is in the typical range of 30% to 35% for moderate sized urban areas and is a reasonable first approximation.

Runoff Coefficient

The runoff coefficient is the measure of the watershed response to rainfall events. It is a dimensionless number obtained by dividing the total storm runoff by the total rainfall volume.

Thus,

$$Rv = Qs / I \quad (2\text{-}2)$$

where
Rv = the runoff coefficient [dimensionless]
Qs = runoff [inches]
I = rainfall [inches]

For a given site, the value for Rv will vary from event to event depending upon the characteristics of the rainfall event (intensity, duration, etc.) as well as the antecedent conditions. However, the variability can be statistically characterized from which mean seasonal or annual values can be estimated. From site to site, the variability in Rv can largely be attributed to differences in the percent imperviousness. Thus, a method is needed for estimating Rv based upon the percent imperviousness. As a very simplistic first approximation, the percent imperviousness can be used as the estimate of the runoff coefficient, with a lower bound of around 0.1 and an upper bound of around 0.95. Thus, in the example just cited, the runoff coefficient would be taken to be 0.342.

An alternative and preferred method for estimating the runoff coefficient from the percent imperviousness utilizes the following regression equation (Shelley, 1988):

$$Rv = 0.050 + 0.009\,(PI) \quad (2\text{-}3)$$

where PI is estimated from land use information (as in the above table) or from population density (Equation 2-1). The correlation coefficient for the regression is 0.71, indicating that over 70% of the variance between Rv and percent impervious is explained by the regression. For the example just discussed, the refined estimate of the runoff coefficient would be 0.358 [= 0.050 + (0.009)(34.2)].

Given a rainfall event of a certain size, Rv is used to estimate the runoff volume that will result. This is the general approach used to estimate runoff quantity. It must be emphasized again that this approach only provides an estimate for the wet weather runoff portion of the urban runoff flow. Dry weather and base flow contributions, to the extent that they are present, must be determined from site-specific information.

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2.2 URBAN RUNOFF WATER QUALITY

2.2.1 Pollutants in Urban Runoff

The net effect of urbanization is to increase pollutant runoff loads by at least an order of magnitude over pre-development levels. The impact is felt not only on adjacent streams and lakes, but also on downstream receiving waters. The following discussion identifies the principal types of pollutants found in urban runoff and describes their potential adverse effects on receiving waters.

Sediment: Suspended sediment concentrations and mass loads are the highest of any of the pollutant types discharged by urban runoff. Sediment has both short- and long-term impacts on receiving waters. Among the immediate adverse impacts of high concentrations of sediment are increased turbidity, reduced light penetration, reduced prey capture for sight feeding predators, clogging of gills/filters of fish and aquatic invertebrates, reduced spawning and juvenile fish survival, and reduced angling success. Additional impacts result after sediment is deposited in slower moving receiving waters and include smothering of the benthic community, changes in the composition of the bottom substrate, more rapid filling of small impoundments (necessitating more frequent dredging), and reduction in aesthetic values. Sediment having a high organic or clay content is also an efficient carrier of trace metals and toxicants. Once deposited, pollutants in these enriched sediments can be remobilized under suitable environmental conditions, posing a risk to benthic and other aquatic life.

Oxygen Demanding Substances: Decomposition of organic matter by microorganisms depletes dissolved oxygen (DO) levels in receiving waters, especially slower moving streams and lakes and estuaries. There are several measures of the degree of potential DO depletion, the most common of which are the Biochemical Oxygen Demand (BOD) test and the Chemical Oxygen Demand (COD) test. Both of these tests have problems associated with their use in urban runoff, but it is clear that urban runoff can severly depress DO levels after large storms.

Nutrients: The levels of phosphorus and nitrogen in urban runoff can lead to accelerated eutrophication in downstream receiving waters. Generally, phosphorus is the controlling nutrient in freshwater systems. The greatest risk of eutrophication is in urban lakes and impoundments with long detention times (say two weeks or greater). Surface algal scums, water discoloration, strong odors, depressed oxygen levels (as the bloom decomposes), release of toxins, and reduced palatability to aquatic consumers are among the problems encountered. High nutrient levels can also promote the growth of dense mats of green algae that attach to rocks and cobbles in shallow, unshaded headwater streams.

Heavy metals: Heavy metals are of concern because of their toxic effects on aquatic life and their potential to contaminate drinking water supplies. The heavy metals having the highest concentrations in urban runoff are copper, lead, and zinc with cadmium a distant fourth. Howver, when inappropriate connections between sanitary and storm sewers are present, other heavy metals such as arsenic, beryllium, chromium, mercury, nickel, selenium, and thallium can be found. A large fraction of the heavy metals in urban runoff are adsorbed to particulates and thus are not readily available for biological uptake and subsequent bioaccumulation. Also, the typical periods of exposure are those of urban runoff events (typically under 8 hours), which are much shorter than the exposure periods used in bioassay tests (typically 24 to 96 hours for toxicity testing). Nonetheless, it is likely that the heavy metals in urban runoff are toxic to aquatic life in certain situations,

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particularly for the more soluble metals such as copper and zinc. Compared to risks to aquatic life, human health risks appear to be more remote.

Bacteria : Fecal coliform levels in urban runoff usually will exceed public health standards for water contact recreation and shellfish harvesting. Furthermore, because bacteria multiply faster during warm weather, it is not uncommon to find a twenty-fold difference in bacterial levels between summer and winter in colder climates. The substantial seasonal differences do not correspond with comparable variations in urban activities, which suggests that in addition to temperature effects, sources of coliform unrelated to those traditionally associated with human health risk may be significant. Thus, despite the high numbers of coliforms found in urban runoff, in the absence of contamination from sanitary sewage, the health implications are unclear. The current literature suggests that fecal coliform may not be useful in identifying health risks from urban runoff pollution.

Oil and Grease : Oil and grease contain a wide variety of hydrocarbon compounds, some of which (e.g., polynuclear aromatic hydrocarbons) are known to be toxic to aquatic life at low concentrations. Hydrocarbons are often initially found as a rainbow colored film or sheen on the water's surface. Other hydrocarbons, especially weathered crankcase oil, appear in solution or in emulsion and have no sheen. However, hydrocarbons have a strong affinity for sediment, and much of the hydrocarbon load eventually adsorbs to particles and settles out. Hydrocarbons tend to accumulate rapidly in the bottom sediments of lakes and estuaries, where they may persist for long periods of time and exert adverse impacts on benthic organisms. The precise impacts of hydrocarbons on the aquatic environment are not well understood. Bioassay data which do exist are largely confined to laboratory exposure tests for specific hydrocarbon compounds. Remarkably few toxicity tests have been performed to examine the effect of urban runoff hydrocarbon loads on aquatic communities under the typical exposure conditions fou . in urban streams.

Other Pollutants : Other toxic chemicals are rarely found .n urban runoff from residential and commercial land use areas in concentrations that exceed current water quality criteria. Pesticide concentrations in runoff from such areas, wh.n they are found at all, tend to be near their detection limits. However, it should be noted that there has been relatively little sampling of runoff from industrial areas, where toxic compounds might be expected to be more prevalent.

2.2.2 Characterizing Urban Runoff Water Quality

Pollutant concentrations in urban runoff vary considerably, both during the course of a storm event as well as from event to event at a given site, from site to site within a given city, and from city to city across the country. This variability is the natural result of high variations in rainfall characteristics, differing watershed features that affect runoff quantity and quality, and variable antecedent conditions. In many situations, where interevent variability is not important and the focus is on urban runoff loads, the event mean concentration (defined as the total constituent mass discharge divided by the total runoff volume) is frequently used as the representative measure of pollutant concentration. The event mean concentation values at a given site tend to be well represented by the lognormal probability distribution, which means that two parameters can be used to characterize a given pollutant at a given site. These parameters are the site median (a measure of central tendency or location for which half of the values are higher and half are lower) and the coefficient of variation (a dimensionless measure of variability computed by dividing the standard deviation by the mean). Because the underlying distributions are lognormal, the appropriate statistic to employ for comparisons between individual sites or groups of sites is the median value. This is because the median is less influenced by the small number of large values typical of lognormal distributions and, hence is a more robust measure of central tendency. However, for comparisons with published data where average values are reported and for certain computations and analyses (such as annual mass loads), the mean value is more appropriate. For a lognormal distribution, the mean is calculated by multiplying the median by the square root of one plus the square of the coefficient of variation, i.e.,

$$\text{Mean} = \text{Median} * [1+CV*CV]^{0.5} \qquad (2\text{-}4)$$

Utilizing the lognormal distribution to characterize water quality has a number of important benefits (WCC, 1989), including:

- Concise summaries of highly variable data can be developed and the variability can be quantified and dealt with appropriately.
- Comparisons of results from different sites, events, etc. are convenient and more easily understood.
- Statements can be made about frequency of occurrence, i.e., one can express how often values will exceed various magnitudes of interest.
- A more useful and informative method of reporting data than the use of ranges is provided; one that is less subject to misinterpretation.
- A framework is provided for examining the transferrability of data in a quantitative manner.

Based upon the results of considerable analysis of the NURP data, it was determined that geographic location, land use category, rainfall characteristics, and other factors did not adequately explain the site-to-site variability of EMCs. Therefore, the EMC data for all urban sites were pooled and examined statistically. It was found that the lognormal distribution was an adequate representation of this pooled data set also. The results, given in Table 2-2, provide an initial basis for estimating pollutant concentrations in urban runoff. The median EMC values are given for the median urban site in the NURP data set, along with the median values for the 90th percentile site (i.e., median values that would be exceeded by only 10% of the urban sites). The event to event variability (not site to site variability) in the EMCs is given as an expected range in the coefficient of variation. For planning level purposes, these values are believed to provide the best description of the quality characteristics of urban runoff. For constituents that do not appear in Table 2-2, the NURP data base was too sparse to allow the analytical treatment just described, and local estimates must be provided.

2.2.3 Sources of Urban Runoff Pollutants

Erosion : Soil erosion can be an important source of pollutants in runoff from urban areas, either because of stream bank erosion or as a result of the disturbance of land surfaces. For example, initial clearing and grading operations during construction expose much of the surface soils. Unless adequate erosion controls are installed and maintained at the site, large quantities of sediment can be delivered to the stream channel, along with attached soil nutrients, organic matter, and other adsorbed pollutants. Uncontrolled construction site sediment loads on the order of 40 tons/acre/year and higher have been reported (Novotny and Chesters, 1981; Wolman and Schick, 1967; Yorke and Herb, 1976

TABLE 2-2. WATER QUALITY CHARACTERISTICS OF URBAN RUNOFF

Constituent		Event to Event Variability in EMCs (Coef. of Variation)	Site Median EMC	
			For Median Urban Site	For 90th Precentile Urban Site
TSS	(mg/l)	1 - 2	100	300
BOD	(mg/l)	0.5 - 1.0	9	15
COD	(mg/l)	0.5 - 1.0	65	140
Tot. P	(mg/l)	0.5 - 1.0	0.33	0.70
Sol. P	(mg/l)	0.5 - 1.0	0.12	0.21
TKN	(mg/l)	0.5 - 1.0	1.5	3.30
NO2+3-N	(mg/l)	0.5 - 1.0	0.6	1.75
Tot. Cu	(µg/l)	0.5 - 1.0	34	83
Tot. Pb	(µg/l)	0.5 - 1.0	144	350
Tot. Zn	(µg/l)	0.5 - 1.0	160	500

and 1978). Such loads are one to two orders of magnitude higher than from agricultural or stabilized urban land uses respectively.

Atmospheric Deposition : A significant source of pollutants in urban areas is atmospheric deposition in the form of both as wetfall and dryfall. In almost all cases, some of the pollutants from atmospheric sources are trapped and remain on the land surface, rather than washing off in ordinary storm events. If source control of atmospheric deposition is desired, control stategies based on automobile and industrial emission controls are required.

Construction Materials : The various surfaces of the urban landscape are another major source of pollutants. Metals, for example, are a common element in many urban structures, such as flashing and shingles, gutters and downspouts, galvanized pipes, metal plating, paints, wood preservatives, etc. Over time, these surfaces corrode, flake, dissolve, decay, or are subject to leaching thereby allowing metals to be carried away in urban runoff. The process is often exacerbated by the acidity of the rainfall.

Manufactured Products : The use of a variety of manufactured products represents a source of some pollutants in urban runoff. For example, most copper found in urban runoff originate from various anthropogenic sources including oxides and sulfates of copper used for insecticides, algicides, and fungicides. Copper is frequently incorporated into paints and wood preservatives to inhibit growth of algae and invertebrate organisms. Copper salts are used in water supply systems for controlling biological growths. Primary sources of copper in industrial wastewater are metal process pickling and plating baths. Other sources include mine drainage, pulp and paper mills, fertilizer manufacturing, petroleum refining, and certain rayon processes. Copper is used in the automobile industry in brake linings, clutch facings, and certain tire compounds. Smelters may release copper to the atmosphere which is eventually returned to surface wate The variety of potential sources for copper explains why it is almost invariably found : urban runoff at levels of concern.

Many pollutants which derive from manufactured produc: are toxic or hazardous materials. The more significant potential sources of some of these substances are given in Table 2-3. Note that automobile use contributes significantly to many of these constituents. Polycyclic aromatic hydrocarbons (PAHs), the most commonly detected toxic organic compounds found in urban runoff (EPA, 1982), originate from oil and combustion products. Phthalate esters, a relatively common toxic organic compounds, are derived primarily from plastics. Pentachlorophenol, also frequently found, comes from wood preservatives.

Plants and Animals : Other sources of pollutants that accumulate and subsequently wash off urban surfaces include plant debris (leaves,etc.) and animal excrement which in natural systems are recyled. For example, trees and shrubs deposit pollen and leaves which, no longer able to be converted to humus on the forest floor, enter into urban runoff. During the growing season, nutrients leach from tree leaves and stems during storms and are quickly conveyed to the stream if the ground is saturated or the tree's drip line extends over an impervious area.

Non-Stormwater Connections : An important potential source of toxic and other pollutants in urban runoff is through non-stormwater discharges to stormwater drainage systems. Inadvertent or deliberate discharges of sanitary sewage and industrial waters to storm drains has been identified as a widespread and serious occurence. The detection and elimination of such discharges is a major focus of the NPDES Stormwater Permit program.

TABLE 2-3. POTENTIAL SOURCES OF TOXIC AND HAZARDOUS SUBSTANCES IN URBAN RUNOFF

	AUTOMOBILE USE	PESTICIDE USE	INDUSTRIAL/OTHER USE
Heavy Metals			
Copper	metal corrosion	algicide	paint, wood preservative electroplating
Lead	gasoline, batteries		paint
Zinc	metal corrosion tires, road salt	wood preservative	paint, metal corrosion
Chromium	metal corrosion		paint, metal corrosion electroplating
Halogenated Aliphatics			
Methylene chloride		fumigant	plastics, paint remover solvent
Methyl chloride	gasoline	fumigant	refrigerant, solvent
Phthalate Esters			
Bis (2-ethyhexyl) phthalate			plasticizer
Butylbenzyl phthalate			plasticizer
Di-N-butyl phthalate		insecticide	plasticizer, printing inks paper, stain, adhesive
Polycylic Aromatic Hydrocarbons			
Chrysene	gasoline, oil, grease		
Phenanthrene	gasoline		wood/coal combustion
Pyrene	gasoline, oil, asphalt	wood preservative	wood/coal combustion
Other Volatiles			
Benzene	gasoline		solvent
Chloroform	formed from salt, gasoline & asphalt	insecticide	solvent, formed from chlorination
Toluene	gasoline, asphalt		solvent
Pesticides and Phenols			
Lindane (gamma-BHC)		mosquito control seed pretreatment	
Chlordane		termite control	
Dieldrin		insecticide	
Pentachlorophenol		wood preservative	wood processing paint
PCBs			electrical, insulation

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As an illustrative example of how heavy metals can enter flows from industrial areas, consider the use of heat exchangers in plating tanks at metal finishing and electro-plating shops. It is not uncommon to have condensate return lines discharge directly to storm drains. As long as the heat exchangers are intact, this operating condition has no impact on discharge water quality. However, heat exchangers used in such applications typically develop pin-hole leaks, and as a result, plating solutions with high heavy metal concentrations can leak into the storm sewer system. In other instances, what is believed by a manufacturing firm to be non-contact cooling water, and appropriate to discharge to a storm drain, may in reality be a process cooling water with a significant concentration of heavy metals and other pollutants.

Cross-connections delivering sanitary sewage to storm drains can, like industrial contamination, occur in many different ways. There was a case reported where the sanitary lines from a high rise building were tied into the storm drain rather than the sanitary sewer. Locations with hyraulically overloaded sewage treatment plants or undersized sewers may provide relief points that transfer excess flow into storm drains. This type of situation is more likely in areas with aging sewer systems with excessive infiltration/inflow.

Accidental Spills: Another source of pollutants in urban runoff is accidental spills. Here, virtually any pollutant can be found, depending upon the nature of the spill. Deliberate dumping into storm sewers and catch basins (used crankcase oil is especially common) is yet another common source. Leaking underground storage tanks, leachate from sanitary landfills and hazardous waste treatment, storage, and disposal sites can also contribute to pollutants in storm sewers.

This discussion of sources of urban runoff pollutants indicates the types of activities that are believed to be the principal generators of urban runoff pollution. Once a particular receiving water body or segment of concern has been identified, there is an obvious need to identify the areas that contribute to it. As a rule of thumb, greater concentrations of pollutants will be found in urban runoff from industrial areas and older parts of the city. Given the role of the automobile in generating pollutants within the urban landscape, areas of high automobile density can be expected to have increased levels of pollution. The need to look for cross-connections and other illegal or inappropriate connections to separate storm drains cannot be overemphasized.

2.3 RECEIVING WATER PROBLEMS

2.3.1 Water Quantity Problems.

The two principal concerns relating to the quantity of stormwater runoff are the total volume of runoff discharged, and the peak rates of flow that are produced. Problems associated with runoff quantity include flooding and erosion/sedimentation impacts. Historically, drainage has been the principal local-level concern regarding urban runoff. Flooding concerns can be divided into two basic categories; nuisance flooding and major flooding. Nuisance flooding (e.g., temporary ponding of water on streets, road closings, minor basement flooding), rarely affects the entire urban populace and is seldom life-threatening. Nonetheless, the concerns of affected citizens commonly requires that local action be taken to minimize the recurrence of such events. Such mitigation activities are usually locally determined, funded, and implemented because the affected public and government decision makers perceive and concur that such flooding constitutes a problem. Catastrophic flood events, on the other hand, have to be thought about differently for several reasons:

- They typically affect the majority of the urban populace.

- Mitigation measures often involve engineering improvements extending well beyond local jurisdictions.

- Mitigation measures often cost more than the local community can afford. In such cases, water quantity problems are readily observable, the degree of damage as well as the benefits of alternative flood control projects can be estimated. Thus, decision makers face a relatively low risk in prescribing courses of action and justifying the associated costs in light of the benefits. As will be discussed later, decision making in the case of water quality concerns is less straightforward.

Erosion concerns may be the result of a relatively short-term condition produced by disturbance of the land surface during construction activity, or a longer term condition of stream bank erosion and scour and deposition of the stream bed produced by peak flow rates. Although erosion and sedimentation are storm-event related, their resultant problems are not exclusively either water "quantity" problems or water "quality" problems. When sediment loads from undeveloped areas are discharged into receiving waters, the effects are primarily physical and only secondarily chemical, because the mineral constituents which make up the primary sediment load are relatively benign in most cases. Among the physical problems in receiving waters subjected to increased sediment loads are:

- Excess turbidity reduces light penetration, thereby interfering with sight feeding and photosynthesis.

- Particulate matter clogs gills and filter systems in aquatic organisms, resulting, for example, in retarded growth, systemic disfunction, or asphyxiation in extreme cases.

- Benthal deposition can bury bottom dwelling organisms, reduce habitat for juveniles, and interefere with egg deposition and hatching.

- degradation of general habitat.

Urbanization accelerates erosion through alteration of the land surface. Disturbing the land cover, altering natural drainage patterns, and increasing imperviousness all increase the quantity and rate of runoff, thereby increasing both flooding and erosion potential. Furthermore, the sedimentation products that result from urban activities are generally not as benign as the natural mineral sediments which result from soil erosion from undeveloped areas. Atmospheric deposition (associated with industrial and energy production activities) and added surface particulates (resulting from tire wear, automobile exhaust, road surface decomposition, and the like) are incorporated in the sediments discharged from urbanized areas. Their effects on receiving waters tend to be more chemical than physical. This is also true of natural mineral sediments that become contaminated by the adsorption of toxics and other chemicals present in the urban environment.

2.3.2 Water Quality Problems

The following are three considerations in evaluating water quality problems in surface waters subjected to urban runoff.

- the nature of the designated <u>beneficial uses</u>, e.g., drinking water supply, recreation, fisheries, wildlife and associated <u>water quality objectives</u>.

- water quality characteristics, i.e., the physical, chemical, and biological data resulting from analytical determinations made in the field or laboratory.

- ecological effects associated with a discharge, e.g., toxicity, carcinogenicity, disease, eutrophication, altered vegetation and succession, reproductive disorders, etc.

Water quality is what is typically measured, although laboratory and in situ toxicity testing using representative aquatic species is a tool for addressing ecological effects. Ecological effects determine how well a designated beneficial use is met. Although Congress has established fishable and swimmable waters as a goal, water quality planning activities will be more cost effective when the specific beneficial uses are supported by the local community. This is because the determination of the most appropriate beneficial use is strongly influenced by local attitudes, beliefs, needs and expectations. Unlike water quantity problems, water quality problems tend to be elusive because their definition involves subjective considerations. Also water quality problems are often not immediately obvious and are less dramatic than floods. They also tend to vary markedly with locality and geographic regions within the country.

For evaluating urban runoff impacts, three possible approaches for identifying the presence of a problem can be considered.

1. Actual impairment or denial of a designated beneficial use;
2. Violation of a water quality criterion;
3. Local public perception and concern.

The first type of problem would be where a determination has been made that some specific use, such as shellfishing, should be attained but that present aquatic tissue contamination is such harvesting and eating the organisms poses a health risk causing shellfishing ito be banned for part or all of the year.

The second type of problem refers to violations of an applicable water quality criterion. An example would be a case where some measure of water quality characteristics (e.g., trace metal concentration) exceeds recommended or mandatory levels for the receiving water classification (e.g., EPA toxic criteria for aquatic life). This problem definition is less exact than the preceeding problem definition in that the receiving water classification may not be appropriate, the beneficial use may not be impaired or denied, and the water quality criteria associated with that classification may or may not be overly conservative or directly related to the desired use.

The third basis for problem identification involves public perception. This may be expressed in a number of ways, such as telephone calls to public officials complaining about receiving water color, odor, or general aesthetic appearance. Public perception of receiving water problems is highly variable, further complicating this level of problem definition.

The foregoing approaches provide a framework which permits water quality problems associated with urban runoff to be defined in a way that will assist in the formulation of a management plan, the implementation of an effective control strategy, and establishing a means of assessing its effectiveness.

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2.3.3 Examples of Urban Runoff Receiving Water Impacts

Stormwater discharges into urban streams can dramatically change the character of a stream as it passes through an urban area. Some examples of the nature of the problems that can be produced, based on actual cases reported in the literature, are described below. These cases provide background on the types of things to look for in a local assessment of the significance of urban NPS discharges.

In-stream monitoring of Village Creek in Birmingham, Alabama (Water Quality Engineers, 1981) provides a classic example of stream degradation due to intense urban development. At the stream's origin at Roebuck Springs, the creek has excellent physical and chemical characterictics, supporting watercress and other vegetation. By the time the stream passes under Vanderbilt Road it has turned grey-green and has an oily sheen and significant debris. Further downstream at the western limits of Birmingham, the creek is dark green, has a putrid odor and contains considerable oil and grease. At this point the creek is often anaerobic and contains no fish or other biological life. This study found that, on an annual basis, more than 90 percent of the copper loadings, more than 75 percent of the chromium and zinc loadings, and about 40 percent of the lead loadings originated from urban runoff.

A study (Dong et al., 1979, and Southeastern Wisconsin Planning Commission, 1976) of the Menomonee River near Milwaukee, Wisconsin indicated that the upper, more rural reaches of the river had an average of 40 times more fish than the lower, urbanized reach. The urban segments of the river supported a significantly reduced and scattered fish population and some segments were virtually devoid of even very pollution tolerant species. These conditions are the combined result of higher concentrations of toxic pollutants and poorer habitat conditions resulting from increased flow velocities and channelization. Further, the watershed benthic community is i· "poor" condition in the urban area. The Menomonee study concluded that a relatively nall degree of urbanization, less than 20 percent, is sufficient to cause significant receiving ᴧater degradation.

Studies at other locations have produced results similar to :hose cited above. Interestingly, toxic pollutants or long-term oxygen depletion has been found to cause more serious receiving water problems than short-term, event-related oxygen depletion or other concentration excursions. The accumulation of toxics in sediments and their subsequent movement through the food chain is especially pronounced in urban receiving waters. Studies on the Saddle River near Lodi, New Jersey (Wilber and Hunter, 1980) found significant enrichment of heavy metals (two to seven times) in lower Saddle River sediments (affected by urbanization) as compared to upper rural reaches. Similar results were found in a stream near Champaign-Urbana, Illinois (Rolfe anf Reinhold, 1977), where the upper two inches of sediment in an urban stream reach had much higher lead concentrations (almost 400 ug/g) than sediments in the rural stream reaches. Species diversity of plants and animals were found to be lower in urban streams as compared to streams in rural areas. This impact is likely to be influenced by habitat and temperature changes, as well as pollutant levels.

Long-term biological, chemical, and physical investigations of Coyote Creek near San Jose, California (Pitt and Bozeman, 1982) revealed distinctive urban-rural differences in the composition and relative abundance of aquatic biota. A comparison of urban Kelsey Creek to rural Bear Creek near Bellevue, Washington (Pitt and Bissonette, 1984; Perkins, 1982; Scott et al. 1982) indicated significant interrelationships among the physical, biological, and chemical characteristics. The urban creek was significantly degraded when compared to the rural creek, but it still supported a limited and unhealthy salmon fishery. Most fish in the urban creek had respiratory anomalies attributed to carcinogens in the water

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associated with urban runoff. Although Kelsey Creek did not appear to be as polluted as some of the urban creeks cited earlier, flooding caused by increased runoff from urban development increased dramatically, with the result that the large amounts of toxic pollutants discharged to the stream during wet weather, were diluted to very low concentrations by the increased runoff volumes. The large flows that produced habitat problems diverted attention away from the long-term toxic accumulation potential and to the physical effects of accelerated runoff. The dilemma here is that if the flows were to be reduced in order to improve habitat conditions, the stream's assimilative capacity would decline, and the effects of toxic pollutants could become even more pronounced.

As the foregoing examples indicate, urban runoff can produce both water quantity and water quality problems, and the two are often interrelated. The water quantity problems include but are not limited to flooding, streambank erosion, habitat impairment and altered salinity. The water quality problems depend on (i) the type of receiving water involved (stream, lake, etc.) and its characteristics, (ii) the beneficial use or uses to be protected, and (iii) the specific pollutants involved. These in turn depend upon the intensity and the nature of the activities in the urbanized watershed.

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CHAPTER 3
BMPs FOR CONTROL OF URBAN NPS

The term BMP, or Best Management Practice, has gained wide acceptance as a general term designating any method for controlling the quantity and quality of stormwater runoff. For the purposes of this manual, a "best management practice" (BMP) is considered to be either (1) a practice (routine procedure) that reduces the pollutants available for transport by the normal rainfall-runoff process, or (2) a device that reduces the amount of pollutants in the runoff before it is discharged to a surface water body.

It is almost impossible technically and economically to completely eliminate NPS pollutant discharges to a receiving water body. Realistic objectives of an urban NPS management program are either (1) to sufficiently reduce pollutant levels to eliminate or mitigate an existing water quality problem, or (2) to avoid the creation of a future problem where none exists now.

This chapter identifies and presents an overview of the different types of BMPs that may be considered in the development of urban NPS management plans. Sufficient information is provided to support a planning level assessment of control options, but other appropriate studies and reports should be reviewed for additional detail on design, installation and operating aspects of specific BMPs. The chapter organization is structured to address BMP types individually, but in practice, BMPs can and should be considered in combination. Some examples include vegetated filter strips for pretreatment of inflows to infiltration systems, and detention basins to reduce sediment loads to a wetland. The specific characteristics of the site will determine the BMP types and combinations that are most appropriate in each case.

Institutional aspects of the development of an effective urban NPS management program are not emphasized in this manual, but planning activities must include a recognition of the need to develop an understanding of the issues at several levels of local government, and provide support for the resolution of institutional issues. This may involve the identification of the relationships between NPS management plan features and existing programs, plans and activities of City Managers, Planning Directors, and Public Works Directors, whose departments and responsibilities will provide the institutional framework for implementation of many of the important elements of a NPS management plan.

3.1 TYPES OF URBAN BMPs

Effective techniques for the control of nonpoint runoff pollutant discharges from urban areas, are identified below. These techniques are grouped into four categories, based on the operating principle or the physical mechanism that reduces the amount of runoff pollutants discharged to surface waters.

- **Detention basins** - The term "detention" applies when the runoff is temporarily stored and, apart from relatively minor incidental losses due to evaporation or percolation, is subsequently discharged to a surface water. Control results from a reduction in pollutant concentrations due to settling during the period the runoff is detained.

- **Retention devices** - The term "retention" applies when runoff is permanently captured so that it never discharges directly to a surface water. The usual mechanism by which stormwater controls permanently "capture" surface runoff is by infiltration. These techniques are often referred to as infiltration BMPs.

- **Vegetative controls** - Vegetative controls provide contact between stormwater runoff and vegetated areas and accomplish pollutant removal by a combination of filtration, sedimentation and biological uptake that reduce pollutant concentrations, and/or by a reduction in runoff volume due to infiltration or evapo-transpiration. Figure 3-1 provides a schematic illustration of various types of vegetative BMPs that can be considered in urban areas.

- **Source controls** - Source Control techniques include any practice that either (1) reduces the amounts of accumulated pollutants on the land surface available for washoff by rainfall, or (2) regulates the amount of impervious area to reduce the portion of rainfall that will appear as runoff, or (3) excludes inappropriate discharges to storm drains.

There is no generic method by which these different control techniques can be ranked either qualitatively or quantitatively. Site-specific conditions determine which practices are best, and even whether a particular approach is appropriate. Key factors that influence the suitability of a particular BMP include the following.

- **Drainage area served** - The feasibility of a particular control measure depends on the drainage area. There tend to be upper and/or lower bounds of the urban drainage area that can be served with a particular control practice. These bounds are based on design features, size requirements, as well as the operating characteristics of the BMP. Figure 3-2 presents a number of BMPs and the associated range of feasible drainage areas.

- **Soil permeability** - The soil type, that effectively governs the long-term percolation rate, is an important feature, which can limit the applicability of a technique at a site. Figure 3-3 illustrates typical ranges of infiltration rates associated with different soil types and their impact on the feasibility of different BMPs.

- **Local acceptance** - The acceptability of particular types of BMPs in different urban areas may vary considerably and will influence selection.

- **Other restricting factors** - In addition to the factors discussed above, Figure 3-4 summarizes several other factors that typically limit the applicability of a control practice.

Consideration of the factors discussed above will usually permit a planner to significantly reduce the choice of control practices appropriate for a detailed evaluation.

The following sections discuss each of the BMP categories identified above. The level of detail is limited to that considered appropriate for a planning-level assessment of the general features of a NPS urban pollutant control program. An annotated list of selected references is provided for a detailed evaluation. Key design features of the different control techniques are identified, but it should be recognized that other variations are possible. The discussion is limited to the size of a device and the density or intensity of application of a source control practice, because these factors are most important at the planning or assessment stage. Many of the detailed design and implementation features are critical to the ultimate success of a program, but are generally beyond the scope of a planning level assessment. Similarly, the discussion of performance is limited to the range in removal

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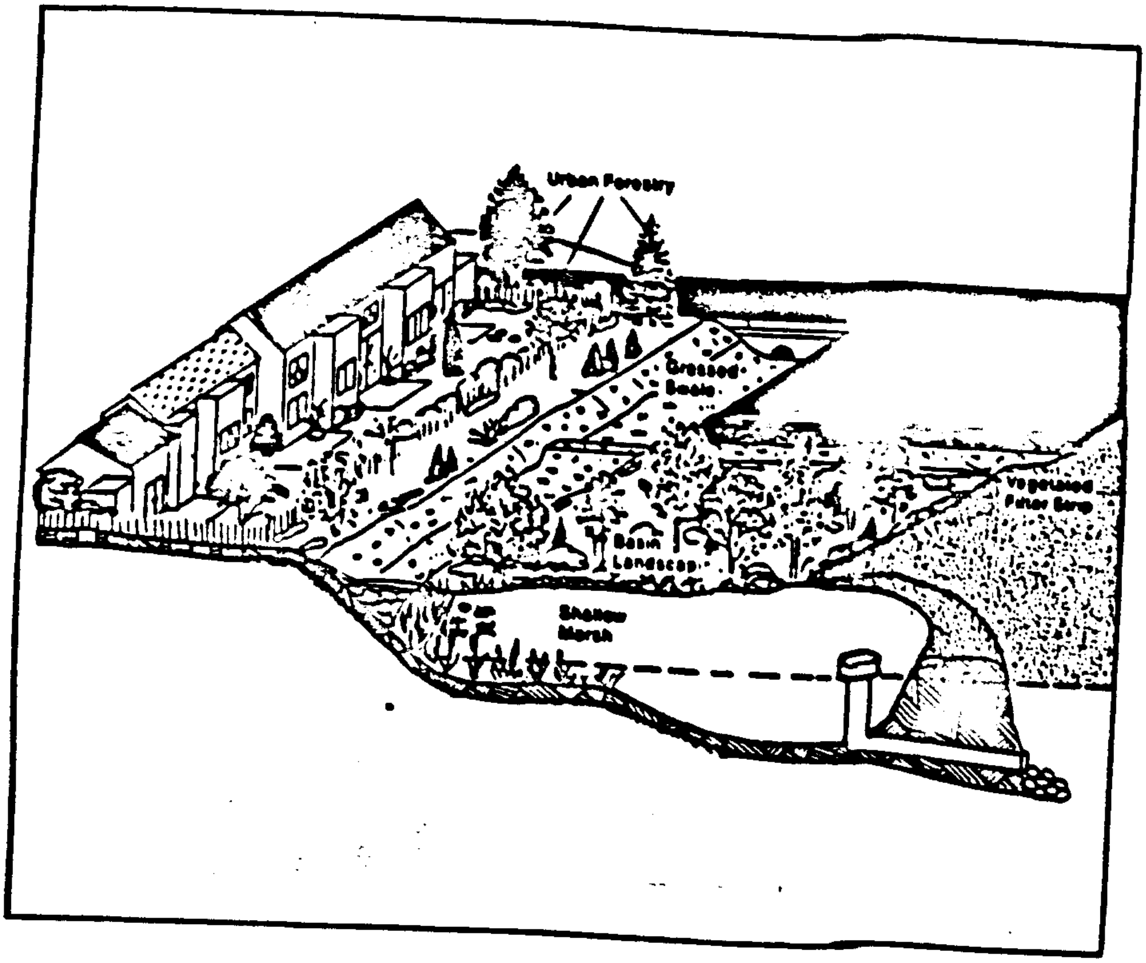
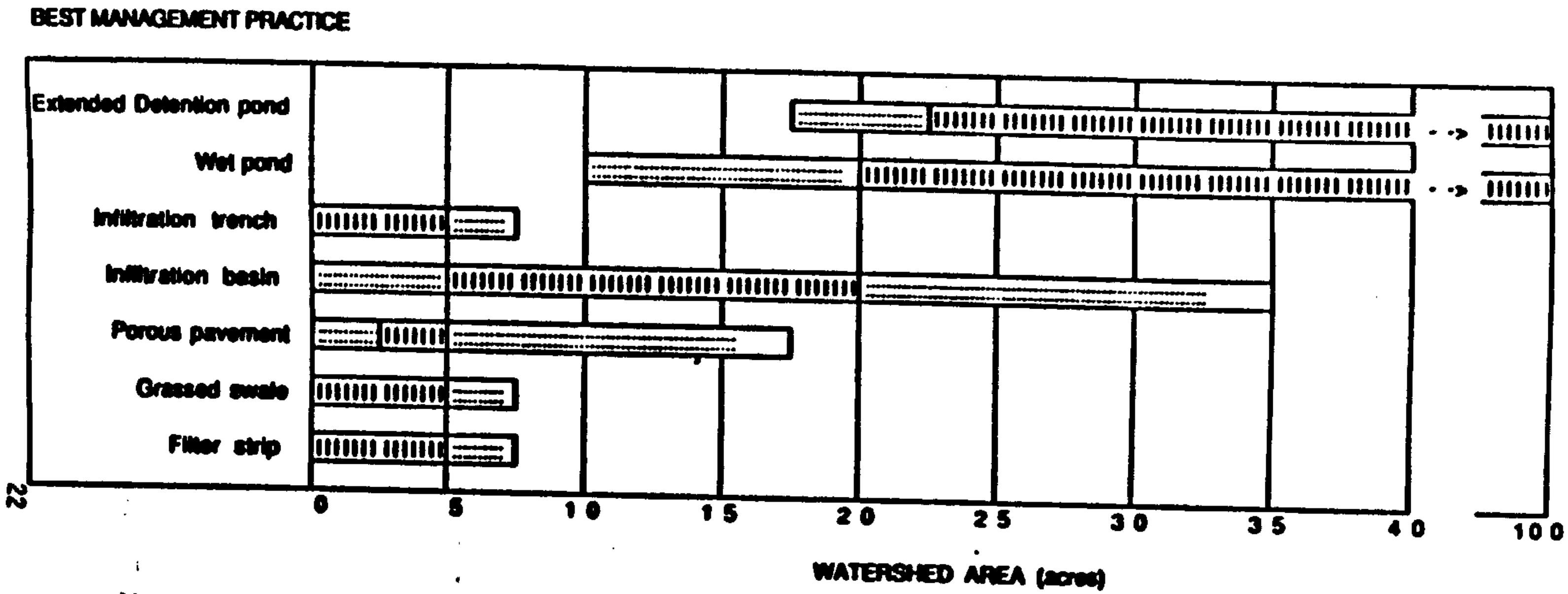


From: CONTROLLING URBAN RUNOFF: A Practical Manual for Planning and Designing Urban BMPs.

Source: Schueler (1987)

FIGURE 3-1. SCHEMATIC ILLUSTRATION OF VEGETATIVE BMPs.



LEGEND:

= FEASIBLE range for applic.....n of the indicated practice

= MARGINAL range for an application.

Source: Schueler (1987)

FIGURE 3-2. FEASIBLE BMP TYPES FOR DIFFERENT SIZES OF WATERSHED

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BEST MANAGEMENT PRACTICE	SAND	LOAMY SAND	SANDY LOAM	LOAM	SILT LOAM	SANDY CLAY-LOAM	CLAY LOAM	SILTY CLAY-LOAM	SANDY CLAY	SILTY CLAY	CLAY
Extended Detention pond	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE			
Wet pond	MARGINAL	MARGINAL	MARGINAL	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE
Infiltration trench	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	MARGINAL						
Infiltration basin	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	MARGINAL						
Porous pavement	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	MARGINAL						
Grassed swale	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	MARGINAL	MARGINAL	MARGINAL	MARGINAL
Filter strip	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	FEASIBLE	MARGINAL	MARGINAL	MARGINAL	MARGINAL
minimum infiltration rate (inches per hour)	8.27	2.41	1.02	0.52	0.2[illegible]	0.17	0.09	0.06	0.05	0.04	0.02

SOIL TYPE

LEGEND:

[feasible pattern] = FEASIBLE range for application of the indicated practice

[marginal pattern] = MARGINAL range for an application

Source: Schueler (1987)

FIGURE 3-3. RESTRICTIONS FOR APPLICATION OF BMPs BASED ON SOIL PERMEABILITY

BMP	SLOPE	HIGH WATER TABLE	CLOSE TO BEDROCK	NEAR TO FOUNDATIONS	SPACE REQUIREMENTS	MAXIMUM DEPTH	RESTRICT LAND USES	HIGH SEDIMENT INPUT
Extended Detention pond	+++	+++	+/-	+++	---	+++	+++	+/-
Wet pond	+++	+++	+/-	+++	---	---	+++	+/-
Infiltration trench	---	---	---	---	+++	---	+++	---
Infiltration basin	+/-	---	---	+/-	+/-	---	+++	---
Porous pavement	---	---	---	---	---	---	---	---
Grassed swale	---	---	+/-	+/-	+++	+++	---	---
Filter strip	+/-	+/-	+/-	+/-	+++	+++	+/-	---

LEGEND:

+++ = GENERALLY NOT A RESTRICTION

+/- = CAN BE OVERCOME WITH CAREFUL DESIGN

--- = MAY PRECLUDE USE OF THE BMP

Source: Schueler (1987)

FIGURE 3-4. OTHER COMMON RESTRICTIONS FOR BMPs efficiency that can be achieved by a BMP type. Finally general benefits and common limitations or constraints of the particular practice are discussed briefly.

3.2 DETENTION BASINS

The dominant treatment mechanism is the reduction of pollutant concentrations by sedimentation, so that this practice is most effective for suspended solids and the fraction of a pollutant associated with particulate matter. For example, most of the lead that is present in urban stormwater is present in particulate form. The soluble fraction of total lead is typically on the order of only about 10 percent, and as a result the removal efficiency for lead in comparable to that for sediment. In contrast, as much as 40 or 50 percent of a pollutant such as copper in runoff may be present in a dissolved form, and not susceptible to removal by sedimentation.

Although the main benefit results from the reduction of pollutants concentrations in the runoff, water quality impacts may also be reduced by the delayed release of stormwater runoff volumes. The resulting reduction in peak discharge flows will tend to reduce stream bank erosion and place less stress on the physical habitat. A slower release of stormwater to a flowing stream may also result in lower concentrations of runoff pollutants in the stream because of higher dilution in the stream.

Depending on the design of the inlet and outlet structures, detention basins can be classified into the following three catgories.

Dry ponds - These are basins with the outlet located at the bottom. They are almost always dry, except infrequently and for relatively short periods following larger storm events. The outlet size is restricted to limit the maximum flow rate. Dry ponds are used for flood and erosion control and are not effective for water quality control purposes. They may often be retrofitted to achieve water quality control.

Wet ponds - These basins employ outlet structures designed to maintain a permanent pool of water. They can provide high removal efficiencies for particulates, and have also been observed to be effective in significantly reducing soluble nitrogen and phosphorus concentrations by means of biological activity such as algal growth in the pool of water.

Extended detention dry ponds - These basins employ an outlet structure that will cause most storms to pond in the basin. Following a storm these basins drain in about 24 to 40 hour and will be dry at all other times. The outlet structures may be either perforated risers or subsurface drains. They provide a practical technique for retrofitting dry ponds to obtain water quality benefits, and can provide particulate (and the associated pollutant) removal efficiency equivalent to that for wet ponds.

3.2.1 Design Features

Pollutant removal efficiency of an otherwise properly designed and maintained detention basin may be influenced by seasonal factors such as algal growth, shoreline vegetation, and ice formation. However, overall efficiency is determined principally by the size of the basin (the available storage volume provided) relative to the amount of runoff it receives during storm events. For any storm event, the volume of runoff will depend primarily on the size of the contributing drainage area, and the proportion of impervious area. The latter is influenced by land use. Since performance of a basin will vary with storm size, pollutant removal estimates reflect the long-term average removal efficiency over all storms.

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A variety of basin sizing rules are in current use, depending on the experience and/or preference of the jurisdiction. In some of the agencies that have been active in the implementation of urban stormwater controls for a number of years, the sizing rules have changed over time, or alternate rules have been adopted for different situations. There is no generally accepted rule or standard for the size of a detention basin. Four commonly used basin sizing rules are discussed below.

Design storm basis - Basin volume is set equal to the runoff produced by a specified design storm. For example, the 1 year or the 2 year, 24 hour duration storm event is sometimes used to specify the size of an extended detention basin where a reduction of flooding and peak flow are important. The volume of rainfall must be converted to the amount of runoff it will produce, and this will vary with the land use distribution (percent impervious area) of the watershed.

First flush basis - Basin volume is designed to store 1/2 inch of runoff per impervious acre of the contributing watershed. This is the most common rule, but the same rule, using 1 inch, is sometimes used. This rule is attractive, because it is simple to use and apply.

Mean storm volume basis - Basin volume is specified as a multiple of the mean runoff volume of all storms. The value of mean runoff is determined by a statistical analysis of the rainfall records. This method has the advantages of being able to base the size on the desired level of performance, and to account for regional rainfall characteristics. For example, the storm that produces 1/2 inch of runoff per impervious acre is a more frequent event in the southeast, than it is in the midwest, and there would be corresponding differences in the long-term pollutant removal efficiencies for otherwise similarly sized basins in the two regions. For some jurisdictions, this approach has been used (with local rainfall characteristics) to determine the storage volume required to produce a particular performance level (e.g., 70% TSS (Total Suspended Solids) reduction), and then translated to a simple-to-apply sizing rule for everyday use.

Residence time basis - Basin volume is designed to provide a specified residence time. Where this is used, long residence times (typically 14 days) are used. This rule generally results in larger basins that provide higher levels of reduction of most pollutants. However the principal objective is to enhance the removal of soluble nutrients by improving conditions favorable for growth of algae and aquatic plants.

A comparative evaluation of the above four approaches to determine basin size can be obtained by the approximate ratio of the basin volume (VB) and the mean runoff volume (VR). This requires an appropriate analysis of the rainfall record and the characteristics of the contributing drainage area. For different regions of the country, the rainfall volume for the mean storm event ranges from about 0.2 to 0.5 inches. This can be taken as an approximation of the runoff volume if we consider only the impervious acres. On this basis, a basin with a VB/VR ratio of 1.0 would provide between 700 and 1800 cubic feet of storage per impervious acre in the watershed. Note that the design volume of a basin is directly proportional to the value of VB/VR. Approximate values of VB/VR for different basin sizing rules are presented in Table 3-1.

Note in general the larger the basin volume, the greater the removal efficiency. However basins with VB/VR ratios larger than 2.5 or 3 yield diminishing returns.

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TABLE 3-1

RATIO OF BASIN VOLUME TO THE MEAN RUNOFF VOLUME FOR DIFFERENT DESIGN RULES

RULE	CHARACTERISTIC VALUE	VOLUME RATIO (VB/VR)
First flush	1/2 inch per impervious acre	1 to 2
Mean storm volume	1 inch per impervious acre	2 to 4
Residence time	14 day residence time	4 to 5
Design storm	1 year storm	7 to 8
Design storm	2 year storm	8 to 9

3.2.2 Performance

Depending on the size selected, wet ponds and extended detention ponds can reduce suspended solid concentrations in stormwater runoff by 50 to 95 percent. Removal efficiency for other pollutants is generally proportional to the pollutant fraction associated with (adsorbed on to) the particulates. For screening level analysis, approximate removal ranges that can be expected for detention basins are shown in Table 3-2. The performance levels shown are estimates of the approximate order of the removal efficiency for different pollutant types and basin sizes. Note that there is very limited data available on the removal of bacteria. The high removal efficiencies shown in Table 3-2 may be deceptive, because the water quality criteria levels are very low relative to the concentrations usually present in stormwater.

3.2.3 Advantages and Limitations

Advantages:

- Detention basins are effective runoff control devices, and there is an appreciable body of experience that attests to their performance capabilities, and provides a source of guidance for many important design details.
- They are suitable for relatively large drainage areas, and can be readily incorporated into the overall plans for new developments.
- Properly designed detention basins can enhance the value of the surrounding property.
- Existing dry ponds, previously installed for flow control, can often be economically converted to serve as extended dete· :on basins and provide water quality control.

Limitations:

- It is important to note that detention basins can become unsightly if routine maintenance is not performed.
- Removal of accumulated sediments will be required after 10 to 20 years of service, and can be quite expensive.
- The availability of sufficient land area at an appropriate location in the watershed can be a problem.
- Finally, it is usually difficult and often impossible to construct detention ponds in an existing built-up area.

3.3 RETENTION DEVICES

Retention or infiltration devices enable a fraction of the runoff volume to percolate into the ground, and hence reduce the discharge to a surface water body. Consequently, the removal efficiency is the same for all pollutants, and is proportional to the percentage of the total runoff volume that infiltrates. Many of the pollutants in urban runoff are effectively trapped in the upper soil layers, and do not reach the subsurface aquifer. This filtration or adsorption mechanism is particularly effective in the case of suspended solids, bacteria, heavy metals and phosphorus. Note that some of the percolating runoff may reach the surface water body, usually after a considerable delay, and after being "treated" by contact with the soil. Retention devices can be classified into the following three catgories.

TABLE 3-2

TYPICAL PERCENT POLLUTANT REMOVED FOR DIFFERENT RATIOS OF BASIN VOLUME TO MEAN RUNOFF VOLUME

POLLUTANT	PERCENT REMOVAL FOR INDICATED VB/VR 1	2.5	5	7.5
Suspended solids	50-60	70-80	85-90	90-95
Organics (BOD, COD)	25-30	35-40	40-45	45-50
Total N and total P	30-40	40-50	50-60	60-70
Lead	45-50	60-70	70-80	80-90
Other heavy metals	30-35	40-45	40-50	45-60
Bacteria	about 90 percent to about 99 percent			

Infiltration basins - These are relatively large open depressions, produced by either natural site topography or by excavation, in which runoff is temporarily stored while percolation occurs through the bottom or the sides. Outlet devices to allow overflow of excess inflows are generally provided but are elevated so to maximize the storage volume. Infiltration basins are normally designed so that any stored runoff will percolate in no more than a day or two. Thus such basins are generally dry.

Infiltration trenches and dry wells - The design of infiltration trenches and dry wells is similar. The major difference is in the size and the configuration. These are essentially excavated holes filled with coarse aggregate and then covered. Drywells are used primarily for roof drainage from residential and commercial sites. Trenches or modifications of trenches serve larger drainage areas, and are particularly applicable for streets and parking lots in commercial areas.

Porous pavement - The main practical application is for parking lots. Heavy traffic and heavy loads that would tend to occur in most streets would compact the surface and reduce the infiltration rate over time. Also, the vacuum sweeping to remove fine sediments from the pavement, that is an important recommended maintenance procedure, is most realistic for parking lot areas.

3.3.1 Design Features

Key design factors that determine performance are the hydraulic conductivity of the underlying soil and the size of the device relative to the contributing drainage area. In this case, the size refers to the surface area available for percolation, and to the storage volume. Examples of typical sizing rules that have been applied include the following:

- Storage volume for 1/2 inch of runoff per impervious acre, or storage volume for 1 inch of runoff from the entire watershed. These rules are usually applied for infiltration trenches. Generally, trenches are made relatively wide and shallow, and percolation rates range from 0.5 to 1 inches per hour.
- Storage volume equal to the volume of runoff from a 2 year storm. This sizing rule is usually limited to infiltration basins, and makes assumptions comparable to the preceeding rule.
- Percolating area and storage volume may be determined by analyzing the rainfall records and soil percolation rates for the site or area.

3.3.2 Performance

For retention basins, "treatment rate" can be thought of as the product of the percolation rate and the available percolating area. Performance improves as the treatment rate increases and efficiency can be enhanced by the amount of storage volume provided. If large runoff volumes do not have time to drain between storms, basin performance may decrease because the soil column does not dry out during the period between storms.

Depending on the size and the soil characteristics, infiltration devices are capable of achieving removal efficiencies up to 99 percent. The removal of pollutants for different sizes and designs in the Maryland-Northern Virginia area are listed in Table 3-3. Note that the indicated performance can be expected to differ for areas with different rainfall and soil types, but the indicated efficiencies are typical of infiltration BMPs.

TABLE 3-3

TYPICAL PERCENT POLLUTANT REMOVAL FOR RETENTION DEVICES

POLLUTANT	PERCENT REMOVAL FOR INDICATED SIZE		
	1/2 inch per impervious acre	1 inch from total area	2 yr runoff vol
Suspended solids	75	90	99
Organics (BOD, COD)	70	80	90
Total N and total P	45-55	55-70	60-75
Heavy metals	75-80	85-90	95-99
Bacteria	75	90	98

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3.3.3 Advantages and Limitations

Advantages:

- Infiltration devices are capable of very high pollutant removals.
- In many cases they can be built in developed areas.
- In addition to water quality control, they also reduce stormwater runoff to surface water bodies during and after storm events and provide desirable subsurface recharge resulting in an increase in low, dry-weather stream flows. This has the desirable effect of reducing flow variations in streams.

Limitations:

- A variety of site specific factors (impermeable soils, high water table, bedrock, etc) restrict the applicability of this type of BMPs.
- Care during installation is necessary to prevent compaction of soil by construction machinery, or the sealing of infiltration surfaces by sediment generated during construction activities.
- Even during normal operating conditions, infiltration devices require pretreatment (e.g., grass filter strips, geo-textile cloth) to reduce the amount of coarse sediment reaching the infiltration surface.

3.4 VEGETATIVE CONTROLS

Vegetative BMPs include a variety of landscaping arrangements that serve to increase the contact of rainfall and stormwater runoff with appropriate types of vegetation. Vegetative control practices have the ability to reduce pollutant discharges by reducing the quantity of runoff through enhanced infiltration, and to reduce concentrations through a combination of filtration, sedimentation and biological uptake. The major types of vegetative BMPs include the following.

Basin landscaping - Basin landscaping can be addressed during early development of a watershed and can have a significant effect on the control of NPS pollutants. The objectives of basin landscaping include but are not limited to minimization of impervious surface area; protection and utilization of existing wetlands; provision for green-belt buffers along stream banks; routing of runoff flow through vegetated areas and away from erosion-prone steep slopes. Careful selection of vegetation most suitable for site conditions has an important bearing on physical appearance and the long-term performance of basin landscaping.

Wetlands - As part of site landscaping, it is possible to create new shallow marsh wetlands specifically designed to operate as an urban runoff control measure. In rare cases, there may be an existing wetland of appropriate type, size and location, to warrant its consideration as a BMP for urban runoff. However, in such cases, issues that will be difficult to resolve with current knowledge, such as the potential of urban runoff flows or pollutants to damage the existing wetland ecosystem need to be addressed.

Grassed swales - Grassed swales are a shallow grass covered channel, rather than a buried storm drain, that is used to convey stormwater. Grass channels are mostly applicable in residential areas. They require shallow slopes, and soils that drain well.

Often grassed swales are used to provide "pretreatment" of runoff to other controls, particularly infiltration devices.

Filter strips - These are similar in concept to grass swales, but are designed to distribute runoff across the entire width and result in an overland sheet flow. These strips should have relatively low slopes, adequate length, and should be planted with erosion resistant plant species. They are often used as pretreatment for other BMPs, for example, by being placed in the flow path between a parking lot and an infiltration trench.

3.4.1 Design Features

Performance of vegetative controls is strongly influenced by the depth and velocity of flow through or across the device (determined by slope and flow distribution), and by contact time (determined by the length of the flow path). Soil with higher infiltration rates, and the use of small check dams to produce temporary ponding of runoff improves performance by enhancing the infiltration rates. Care in selecting plant species appropriate for site specific conditions, and routine maintenance to maintain optimum height are important maintenance requirements.

3.4.2 Performance

The pollutant reduction capabilities of vegetative controls are not documented as well for the other types of BMPs. Available information suggests that under favorable conditions, vegetative controls can achieve moderate removals of particulates such as sediment and heavy metals. They are generally not effective in reducing nutrients.

Many of the important design features are determined by physical characteristics of the site, over which the planner or designer has little or no control. Thus, both the applicability and the degree of performance that can be expected are highly site-specific.

3.4.3 Advantages and Limitations

Advantages:

- The costs for vegetative controls tend to be lower than those for detention and infiltration practices.
- With appropriate planning and design, they can enhance the visual attractiveness of a site.
- Vegetative controls are usually most appropriate to provide pretreatment of runoff in order to improve the operation and maintenance of other BMPs.

Limitations:

- Vegetative controls are usually not adequate to serve as the only runoff control practice for a site.
- The overall pollutant reduction that can be obtained from vegetative practices is usually limited, and depends to a substantial degree on the physical characteristics of individual sites.
- Seasonal differences in performance can be important. Removal effectiveness for some pollutants can be markedly different during growing and dormant periods.

• Information on removal efficiencies for the range of conditions that might be encountered is relatively limited.

3.5 SOURCE CONTROLS

This category of BMPs includes any practice that (a) reduces the amounts of accumulated pollutants on the land surface available for washoff by rainfall, or (b) regulates the amount of impervious area to reduce the amount of runoff, or (c) excludes inappropriate discharges from storm drains.

Source controls address one or more of the above objectives. Depending on the basic nature of a practice, it may apply at a local level or on an areawide basis. In most cases, a management plan will incorporate an array of different source controls that are applicable for the area. All source controls involve each of the following "implementation" aspects, to a greater or lesser degree.

Education - Since many source control practices require either active public participation, or general public acceptance, public education elements are an important feature. Developing a public understanding of the need for an action, the benefit it can produce, and the pertinent details of its implementation, will be critical to success, and wil require a specific program element that addresses this requirement.

Regulation - In many cases appropriate legal authority will have to be developed and assigned to an appropriate agency. There may be a need for redefining roles or establishing new agencies or departments. For example, an appropriate regulation against a particular form of pollutant discharge and legal enforcement authority may exist. If however, the enforcement authority resides in the Police Department, the situation may fall so far down on the priorities dictated by the general mission of a police agency, as to preclude any realistic expectation of active enforcement. This is an example of one of the variety of issues that will have to be resolved, that may not be apparent in a simple listing of the elements of a particular NPS control action.

Guidance - For some source controls, specific formal technical guidance may have to be developed and distributed to assure effective implementation. Examples include details of erosion control practices, oil separators that may be required for service stations, or detention facilities for new residential developments.

3.5.1 Design Features

There is no consistent way to characterize the salient design features of the variety of different types of practices that can be included in the source control BMP category. An important factor is the "application density". This generally (depending on the nature of the particular practice) addresses how actively, frequently and/or thoroughly the practice is pursued, and over how much of the total urban area it is applied. For example, the frequency at which each catch basins is cleaned; the number of streets or parking areas that are swept and how often the sweeper returns to a particular location are examples of application density, and ultimately of how effective a source control practice will be in reducing NPS pollutant loads from an overall urban area.

Source controls that have broad general applicability are identified below, with examples of some of the more important elements that are necessary for effective implementation. The list is not exhaustive; local situations can be expected to suggest other

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practices that are not included in this discussion. In addition, some of those that have been included in the list may not be applicable in all areas.

A. **Exclude Inappropriate Discharges to Storm Drains**

- **Eliminate illicit connections** - This is one of the more important source controls. The NPS stormwater permit regulations emphasize the detection and elimination of non-stormwater discharges to storm drainage systems. Elements of such a measure include the following:

  - Research, strengthen (if necessary), and enforce existing regulations which give local jurisdictions the legal authority to eliminate cross-connections that result in sanitary sewage or industrial wastewater entering the storm drainage systems.

  - Develop and implement an aggressive field program to search for, detect and control domestic, commercial or industrial cross-connections and illegal dumping.

  - Develop and implement an aggressive field program to search for, detect, and control sanitary sewer leaks and areas where surcharging or overflows would be most likely to occur.

- **Prevent rainfall and runoff from contacting potential contaminants** - This is a well established standard practice that has obvious benefit. It applies primarily to industrial or commercial sites.

  - Educate regarding the need to keep rainfall and runoff from contacting potential contaminants. Describe typical examples of the problem and practical solutions.

  - Develop and implement regulations to require covers for outdoor storage areas that contain contaminants. Keep runoff from passing over areas that contain contaminants. Emphasize good housekeeping for open loading-unloading areas.

  - Develop and implement an aggressive field program to search for, detect and correct situations where rainfall or runoff presently contact potential contaminants.

- **Encourage Proper use and disposal of materials by homeowners** - The contaminants addressed by this control activity include materials such as fertilizers, pesticides and herbicides, oil and antifreeze, paints, and solvents. Specific actions for preventing the discharge of household contaminants include the following.

  - Educate regarding the proper storage and use of fertilizers, herbicides and pesticides; application methods, rates and frequency appropriate for the area; and the potential environmental damage that can be caused by these materials. Identify alternative methods for controlling insects and weeds (e.g., physical controls, biological controls, less toxic chemicals).

  - Educate regarding the need to keep oils, paints and similar contaminants out of storm drains; the potential environmental damage that can be caused by these materials; and acceptable disposal methods.

  - Develop and implement programs and set up receiving facilities and procedures for specific pollutants such as crankcase oil, pesticide or paint containers, and other potentially harmful chemicals. Recycle if possible. The success of such a practice depends on the number and location (convenience) of stations and the awareness of the community about the effect of pollutants on the environment.

- Research, strengthen (if necessary), and enforce existing regulations which give local jurisdictions the legal authority to prevent improper disposal of pollutants into storm drainage systems.

- Label storm drain inlets and provide signs along the banks of drainage channels and creeks explaining the environmental impacts of dumping wastes.
- Develop and implement an agressive field program to search for, detect and prevent dumping or routinely discharging pollutants into storm sewers, drainage channels and urban streams. This should involve reevaluating previous decisions to allow certain relatively clean waters to be discharged to the stormwater system.

B. Reduce Street and Land Surface Sources of Pollutants -

- **Control littering and improper waste disposal practices -** In addition to its pollution control benefits, an effective litter control program will improve the general aesthetic appearance of the area. Because such programs have easily achieved public acceptance, with visibile effects, they can assist in developing interest and acceptance of other BMPs where the relation between practice and benefit may be less obvious. Specific actions might include the following.

  - Educate regarding the NPS pollution impacts that result from littering and improper waste disposal practices.

  - Research, strengthen (if necessary), and enforce existing regulations which give local jurisdictions the legal authority to control littering and the improper disposal of potentially harmful or aesthetically objectionable materials.

  - Provide litter bags for use in cars. Work with citizen action programs to facilitate efforts to report littering incidents and illegal dumping.

  - Develop and implement regularly scheduled cleanup days and corresponding curbside collection of trash and household debris.

  - Provide, collect and maintain an adequate number of litter recepticles in strategic public areas, and during major public events.

  - Coordinate with efforts (by others) to establish practical controls regarding potentially harmful packaging of consumer products.

- **Control animal wastes -** The specific practices considered should consider both household pets and where appropriate, suburban livestock such as horses and chickens.

  - Educate regarding the need to clean up and properly dispose of pet wastes, and where appropriate, the need for proper management of wastes from suburban livestock and agricultural operations in the watershed.

  - Provide informational signs and dispense doggie litter bags in parks and other selected areas.

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- implement and enforce leash laws and pet waste cleanup ordinances in selected public-use areas.

- **Improve the maintenance of major paved areas** - Activities in this category include both physical repairs to maintain pavement surfaces in good condition so that pavement debris and degradation products are not washed into storm drains, and street cleaning practices that remove litter and externally generated dust and associated pollutants that accumulate on paved surfaces.
  - Improve pavement repair and maintenance programs on streets and parking areas (e.g., fill potholes, seal cracks, apply surface treatments).
  - Develop and implement sufficiently intensive street sweeping programs for strategic locations. For example, paved surfaces in central business districts, shopping malls, major parking lots and industrial areas tend to produce more concentrated surface sources of heavy metals, oil and similar contaminants.
  - Implement street parking regulations (e.g., alternate side parking days) where necessary for effectiveness of street sweeping programs.

- **Institute programs to remove accumulations of litter and debris** - Floatables and accumulations of debris represent an important aesthetic problem for urban streams in many areas.
  - Sponsor periodic stream bank cleanup programs to remove accumulations of litter and debris in urban streams or on their banks. Floatable materials often accumulate behind roadway culverts. Encourage participation by suitable community groups (e.g., Boy Scouts, etc.). Coordinate with Public Works Departments for hauling and disposal of removed materials.
  - Provide for routine sweeping of streets that border urban stream courses.
  - Provide surveillance and enforce regulations against dumping.

- **Control airborne pollutants** - A significant source of many of the pollutants present in urban stormwater runoff is the deposition of atmospheric particles that originate from a variety of sources, on land surfaces in the urban area. Source control activities that can address this situation include the following.
  - Educate regarding the relationship between air pollution and NPS water quality problems, and the need to coordinate with programs (by others) that seek to reduce particulate atmospheric emissions of pollutants from individual, public, commercial and industrial sources.
  - Educate regarding the potential benefits of reduced automobile use by various means (e.g., ride sharing, carpooling, public transportation), and the importance of frequent vehicle inspection and maintenance efforts to reduce atmospheric emissions.
  - Educate regarding the proper operation of fireplaces and wood burning stoves to minimize the emissions of particulate matter.

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- Cooperate with public transportation agencies, public agency motorpools, and public works departments to provide effective air pollution controls on publically owned vehicles and motorized equipment, and, where practical, on the use of alternative clean-burning fuels.

C. **Control Erosion** -

- **Control erosion at construction sites** - These actions suggested here are directed at the control of erosion from land disturbed during construction, or the prevention of eroded materials from leaving the site.
  - Educate architects, engineers, contractors, and public works personnel about the need for and practical methods for erosion control, sediment control, groundwater disposal, and site waste management and disposal.
  - Develop and implement effective erosion and sediment control regulations, and requirements for corresponding construction inspection programs. These should apply to public-sector as well as private-sector construction programs.
  - Develop and implement improved erosion and sediment control policies in the environmental elements of all general Plans (develop and adopt General Plan ammendments, when needed).
  - Adopt policies that require all CEQA compliance documents and all site development plans to explicitly address the topics of erosion potential, proposed erosion and sediment control plans, and enforceable mitigation measures to minimize environmental impacts.
  - Require contractors to post bonds to cover potential damages from erosion or sediment deposition.
- **Control erosion of undeveloped land and park land** - These efforts are directed at the control of erosion from essentially undisturbed urban land areas, to reduce potential adverse impacts on urban water bodies.
  - Educate public works personnel and managers of parks and open-space lands about the need for and practical methods for erosion control and sediment control.
  - Develop and implement programs to actively search for, identify, evaluate, and prioritize erosion problems on undeveloped land, park land or open-space urban land use areas.
  - Develop and implement programs to work with landowners, tenants, and public agencies to apply practical erosion and sediment control practices.
  - Develop and implement practical programs for revegetating and otherwise restoring eroding areas (e.g., areas damaged by fires, off-road vehicle use).
  - Educate managers and users of park lands and open-space lands concerning the need to restrict off-trail activities. Establish and enforce practical, site specific regulations to control harmful off-trail activities.

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D. **Implement Land Use Planning -**

- **Implement Zoning regulations** - Appropriate zoning ordinances may be used in sensitive areas to provide for development patterns that are compatible with control of NPS discharges and the protection of receiving waters.
  - Zone to limit dwelling unit density and control the amount of on-site pollutants generated and control the amount of runoff by limiting the impervious surface area created.
  - Restrict development adjacent to streambanks. Require vegetated buffer strips along streambanks.
  - Restrict development on sites with soils and slopes that are susceptible to serious erosion.
- **Limit the directly connected impervious area -**
  - Develop planning guidelines illustrating favorable development techniques.
  - Use grass swales for drainage in preference to curbs and gutters and piped drains, where feasible
  - Encourage use of cluster housing, buffer strips, open space, or other patterns that reduce the quantity of runoff from the site.
  - Avoid direct connection of roof leaders to drain pipes or paved surfaces.
- **Require physical controls for new developments -**
  - Require the installation of detention basins or infiltration devices as BMPs for the control of the quality and/or quantity of runoff and for control of peak flows on all new development sites.
  - Develop specific guidelines for design and construction of these devices.
  - Provide for the necessary supervision, inspection and enforcement of regulations to insure compliance.

E. **Other Control Measures -**

- **Control oil and grease** - Automobile operation and maintenance is the principal source of oil and grease that can result in objectionable films and sheens on the surface of receiving waters. Fractions that remain in solution may contribute toxic contaminants. Food service facilities may contribute animal fats and greases (vs hydrocarbon based) to runoff.
  - Educate regarding the effective use of "housekeeping" practices, oil and grease traps, the use of adsorbents and cleaning compounds for controlling oil and grease at gas stations, automotive repair shops, parking areas, commercial and industrial facilities, and food service facilities.

- Educate regarding the need to provide adequate and sufficiently frequent vehicle inspection, and to maintain efforts to reduce leakage of oil, antifreeze, hydraulic fluid, etc.

- Research, strengthen (if necessary), and enforce regulations which give local jurisdictions the legal authority to require oil and grease controls in areas that are significant sources (e.g., gas stations, automotive repair shops, parking areas, commercial and industrial facilities, and food service facilities).

- Develop technical guidance that will facilitate efforts by responsible parties to comply with regulations requiring oil and grease controls (e.g., oil traps, plate separators, synthetic adsorbent material, grassed swales).

• **Control leaks from gasoline, fuel oil, and chemical storage tanks** - The actions listed can help to control pollutant contributions from leaking storage tanks.

- Educate regarding the environmental impacts that result from leaks and spills from gasoline, fuel oil, and chemical tanks, above and below ground.

- Coordinate with efforts (by others) to intensify the implementation of existing regulations which call for improved design of new tanks,(e.g., double walls, monitoring facilities); replacement of tanks over a specified age; self-monitoring programs; and implementation of a strategically focused spot-check program to search for, identify, test, and control leaking storage tanks.

• **Intensify the maintenance and repair of stormwater drainage systems** - These actions are directed at removing the pollutants that tend to be retained, and accumulate at specific locations in the stormwater drainage system.

- Determine the effectiveness of increasing the frequency of cleaning out storm sewer inlets, catchbasins, storm sewer pipes and drainage channels in areas where sediments, debris, or floatable materials tend to accumulate. Develop and implement improved programs where appropriate.

- Develop and implement an aggressive field program to search for, test, remove, and properly dispose of sediment deposits in drainage channels and streams, which contain relatively high concentrations of pollutants.

- Develop and implement a program which provides a means of recording the observations of field inspection and maintenance personnel, so that this information can be used to help locate the sources of pollutants.

3.5.2 Performance

There is no realistic way to accurately estimate the effect such practices may have on area-wide pollutant loads or to problems in specific water bodies. There is a high degree of uncertainty associated with the ability to define what these practices really do in terms of load reduction. In addition, even assuming performance levels could be defined, the extent to which the public at large would be faithful in applying a practice will generally be uncertain.

3.5.3 Advantages and Limitations

Advantages:

- Some source control actions will be very visible and will involve high level of public awareness and involvement. They can help to generate a sense of active community participation in an overall NPS control program, and may help secure the implementation of other, less obvious, elements of a management plan.
- In addition to reducing pollutant discharges to water bodies, many will have attendant aesthetic or cosmetic benefits.

Limitations:

- Adoption (with or without enforcement) of the necessary ordinances may create negative public reactions that may have an adverse effect on other areas of the program.
- In most cases, there is no reliable way to estimate the effect of a particular source control measure on the urban NPS pollutant loads.
- Effectiveness of a practice depends on the degree to which it is applied and the geographical extent of the application. Even with appropriate regulations in place, there is no positive assurance of compliance to the extent desired.
- Developing and assigning the necessary legal authority, and adding new responsibilities to established public agencies whose budget, experience, and priorities may not relate directly to NPS control may be difficult to resolve.

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CHAPTER 4
TARGETING TO PRIORITIZE URBAN AREAS FOR CONTROL

4.1 INTRODUCTION

This chapter presents a ranking procedure for identifying the area (or areas) within an urban jurisdiction where it is most appropriate to focus initial NPS pollutant control efforts. While the ultimate goal may be fishable and swimmable quality for all surface waters, technical, economic and timing considerations usually require a staged management effort. The methodology ranks areas relative to the other areas in the jurisdiction and is not intended to imply that areas receiving lower ranking do not require controls.

A large urban jurisdiction will commonly involve a network of streams differing in size, use and sensitivity to urban runoff, and which receive discharges from different parts of the jurisdiction. A few of these may have greater local importance than others because of the nature and visibility of the resource, or the type or level of the its use. In addition some urban NPS control practices will generally apply to the entire jurisdiction (e.g., an anti-litter ordinance), but in many cases the control choices will tend to be either site-specific or land use-specific. For example appropriate pollutant control practices for industrial areas will usually be quite different than those suitable for residential areas. Further, factors such as topography, soil conditions, land availability and cost will often influence the selection of controls even for similar land uses in different parts of the jurisdiction.

For large urban areas it is necessary to develop a targeting procedure for implementing NPS controls for the following reasons:

- Implementation of NPS controls over the entire urban jurisdiction at once is not usually possible . Thus a phased approach will generally be necessary.
- Development of a rational basis for ranking different areas within the jurisdiction will be desireable.
- Accounting for relevant site-specific attributes and documenting the decision process is necessary. This will be particularly useful for describing the specific targeting decisions to the public
- Assist the urban jurisdiction in meeting the requirements of Sections 319 and 402 of the Clean Water Act.

4.2 ELEMENTS OF THE TARGETING PROCEDURE

The procedure described in this chapter provides a way to prioritize urban watersheds so that an NPS program can be sequentially implemented based on general and site-specific considerations. The approach consists of the following elements:

1. Identify discrete watersheds within the overall urban area, and the corresponding receiving stream segment. The necessary information could be developed from topographic or drainage system maps.
2. Determine relevant physical characteristics and other attributes of each watershed, and of the receiving stream segment.
3. Tabulate pertinent data in summary form.

4. Complete a "targeting table" by assigning a relative ranking value to each attribute. Assign weights to the attributes to reflect their relative importance in the local decision process.

5. Prioritize urban drainage areas in accordance with the resulting weighted sum of ranks.

There is no standard or generally accepted set of attributes that are used for establishing priorities for NPS control programs. A few attributes which are generally important are presented in Section 4.3. Note that any additional attributes that may be appropriate to consider for the local situation should be added to the procedure. The relative importance of each factor is accounted for by assigning different weights to each factor.

4.3 FACTORS USED FOR PRIORITIZATION

The factors in the ranking process are discussed below.

Waterbody Importance - This factor describes the general importance, and the ability of the waterbody to support a variety of beneficial uses. Since aquatic life populations and diversity as well as citizen use are likely to be greater for large streams (or lakes) with appreciable amounts of water, than for very small water bodies with low flows and small surface areas, flow or watershed size can be used as a surrogate for waterbody importance. Since measured flow data is not likely to be available at all points of interest, total drainage area of the watershed upstream of the location of interest can be used for comparison purposes. Absolute values of drainage area are thus assigned an appropriate rank in the 1 to 9 range. Note the larger the stream size is, the larger is the rank.

Type of Use - In order to provide a comparative measure of the importance of the type of use of the waterbody, the following types of primary beneficial uses are suggested.

RANK	LOW		--------------------------->	HIGH
USE	urban drainage	aquatic life	recreation - aesthetic	recreation - contact

Status of Use - This factor accounts for the present status of beneficial uses of the water body. In assigning a ranking to this factor, it is assumed that an EXISTING use in fairly good condition (or a threatened water), should have a lower priority than one for which the use is present but IMPAIRED. The highest rank would be assigned to a use whose degree of impairment is so great that it is effectively DENIED. While the foregoing is suggested as the recommended way to rank in terms of use status, it may be reasonable in some cases to assign a higher rank to an IMPAIRED use than to a DENIED use. The relative ease and cost of reclaiming the IMPAIRED use might be such that demonstrable control program benefits would be achieved more rapidly, and there might be a greater impact on health and safety (if there is,in fact, no actual use of the denied resource).

Level of Use - Although the stream size factor affects the level of use, this independent factor is included to make an important additional distinction that recognizes local factors. There will be cases where even a stream that would otherwise be considered quite small, will have a disproportionately high level of use, e.g., a small stream that flows through a park or recreational area and is popular with children for wading. The assigned rank for this factor should be based on whether the level of use is low, moderate or high - relative to the other waterbodies in the target area.

Pollutant Loads - The difference in annual pollutant load contributed by runoff from the different watersheds can be used as a surrogate for the potential to cause water quality problems that result in the impairment of a beneficial use. The procedure described below for estimating these loads, is useful for a comparative evaluation of pollutant sources for a screening type analysis. It is not designed to estimate actual loads for the area. Considerable site-specific refinements would be required to estimate the loads accurately.

The pollutant mass load in urban runoff is determined by (i) the amount of rainfall (ii) the total area of the watershed, and (iii) the distribution of land use types in the watershed. The rainfall should be assumed to be the same in all parts of the urban jurisdiction. The land use type influences the typical fraction of impervious surface area, which determines how much of the rain is converted to surface runoff. Land use also influences the average concentration of a pollutant in the runoff.

The annual rainfall typical for the urban jurisdiction will normally be known. However the exact value assigned will not be important because the comparison to be made is one of relative differences between different watersheds in the jurisdiction. The total area and the distribution of land use categories for each urban watershed being considered, must be extracted from local maps. For selected land use categories Table 4-1 provides typical values for impervious fraction and pollutant concentration in urban runoff (in milligrams per liter). It also lists values for runoff coefficient (Rv), which is computed from the impervious fraction, and represents the fraction of the rainfall that becomes surface runoff.

Impervious percent values are presented in Table 4-1 based on data from EPA's NURP program, and are suitable for a screening type analysis. However, they should be modified as appropriate if local information is available or if site-specific factors are likely to modify them. Note that the NURP study was not designed to provide definitive information on the differences between land use types, and provided no information on industrial runoff. The variation in concentration with land use shown in Table 4-1, is based on judgement concerning the relative differences that are likely to be associated with the general differences in the land uses. The values shown are considered appropriate for an analysis designed to estimate a relative comparision of mass loads. In particular, the values shown for industrial land use should be used with caution, because they are very sensitive to the type of industrial activity.

In Table 4-1, runoff concentrations for only four pollutants are presented. However, these can be used as surrogates for other pollutants for which data may not be readily available. For example, total suspended solids (TSS) can serve as a general surrogate for sediment deposition and siltation in streams and lakes. Oil and grease can be used as a surrogate for the potential for problems associated with degraded aesthetic values. The heavy metal copper (Cu) can be used as a surrogate for potential toxic impacts on aquatic life.

The mass load (pounds) of a pollutant from runoff is computed by :

$$M = RainV * Rv * Area * Conc * 0.227 \quad (4.1)$$

where:

M	= mass load [pounds]
RainV	= rainfall amount [inches]
Rv	= runoff coefficient [unitless]
Area	= drainage area [acres]
Conc	= average concentration in runoff [mg/l]
0.227	= unit conversion factor

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TABLE 4-1

TYPICAL VALUES OF PERCENT IMPERVIOUS AREA AND POLLUTANT CONCENTRATIONS

LAND USE	% IMP	Rv	POLLUTANT CONCENTRATION (mg/l)			
			TSS	TP	O&G	Cu
Open -Developing	5	0.1	150	0.800	0	0.010
Open- Park	5	0.1	50	0.800	0	0.010
Resid - LOW DENS	20	0.2	100	0.600	5	0.030
Resid - HIGH DENS	50	0.4	90	0.400	10	0.040
Commercial	90	0.8	80	0.200	15	0.050
Industrial	70	0.6	120	0.200	20	0.050

If the rainfall amount used is the annual rainfall, the load computed would be pounds per year. However, since the analysis requires only comparative loads, a rainfall amount of 1 inch may be used for convenience. Loads should be computed for each land use within a watershed, and then combined to provide the total watershed pollutant mass load to be used for comparison. Rank values would be assigned to each watershed based on the range of mass values computed.

Implementability of Controls - This factor is designed to reflect the fact that an effective management program may be easier to implement for certain watersheds than for others. The prioritization scheme takes this into account. Differences may be based on institutional factors, existing ordinances, or technical factors. For example, it will usually be much easier to implement effective runoff controls for a newly developing area, than to retrofit controls in an existing central business district. Similarly, control requirements may be institutionally easier to implement for an industrial area than for scattered residential areas.

4.4 DESCRIPTION OF TARGETING PROCEDURE

A rank between 1 and 9 is assigned to each of the above factors to reflect increasing value or importance of the selected factor. It is emphasized that in each case, the rank is not an absolute measure of importance, but rather a comparative measure. Rank values are assigned so that the higher the value, the higher will be the priority for action. Scale ranges other than 1 to 9 could obviously be used as well. Very high ranges (e.g., 0 to 100) imply an ability to make fine distinctions and gradations that will not usually be possible. A very small range (e.g., 1 to 3) may represent the realistic level at which distinctions can be made in a screening analysis of this type, but constrains the sensitivity of the comparisons. The range of 1 to 9 is suggested as a reasonable compromise.

It is recognized that some factors will be more important than others. The relative importance of different factors is accounted for by assigning different weights to each factor. This helps to avoid the choice of factors from forcing the results in a particular direction. The assignment of weights also permits the emphasis of locally important considerations. For example, if the planning body determined that it was most important to get an implementation program started at an early stage, the "ability to implement" factor could be given a high weight. In a case where the main concern is the violation of water quality standards for fishable, swimmable waters, the relative weights would emphasize the "use status" and "pollutant load" factors. It is important that the sum of the weights add up to 100. This would help in balancing the assignment of relative importance to the different targeting factors.

It is important to bear in mind that there is considerable subjective element involved in the selection of factors, the assignment of ranks and relative weights. Presumably these will be developed as a result of group discussions involving interested parties. The methodology presented here provides a useful framework for balancing priorities and forming a collective judgement.

The targeting procedure is best illustrated by an example. Figure 4-1 presents a schematic illustration of a hypothetical urban jurisdiction. Watersheds and land use types are delineated and their spatial relationship to important use locations are shown. Table 4-2 presents a summary of the information that describes the urban area and is used to compute the runoff pollutant loads from the different watersheds in the urban area. This table also contains data to calculate the mass loads, which are computed using Equation 4.1. The runoff coefficient (Rv) is computed from the percentage of impervious area as described in Chapter 2. The percent impervious area must be estimated from appropriate local maps or inspections, or from the approximate relationship described in Chapter 2. Mass loading results for total suspended solids are presented in Table 4-3.

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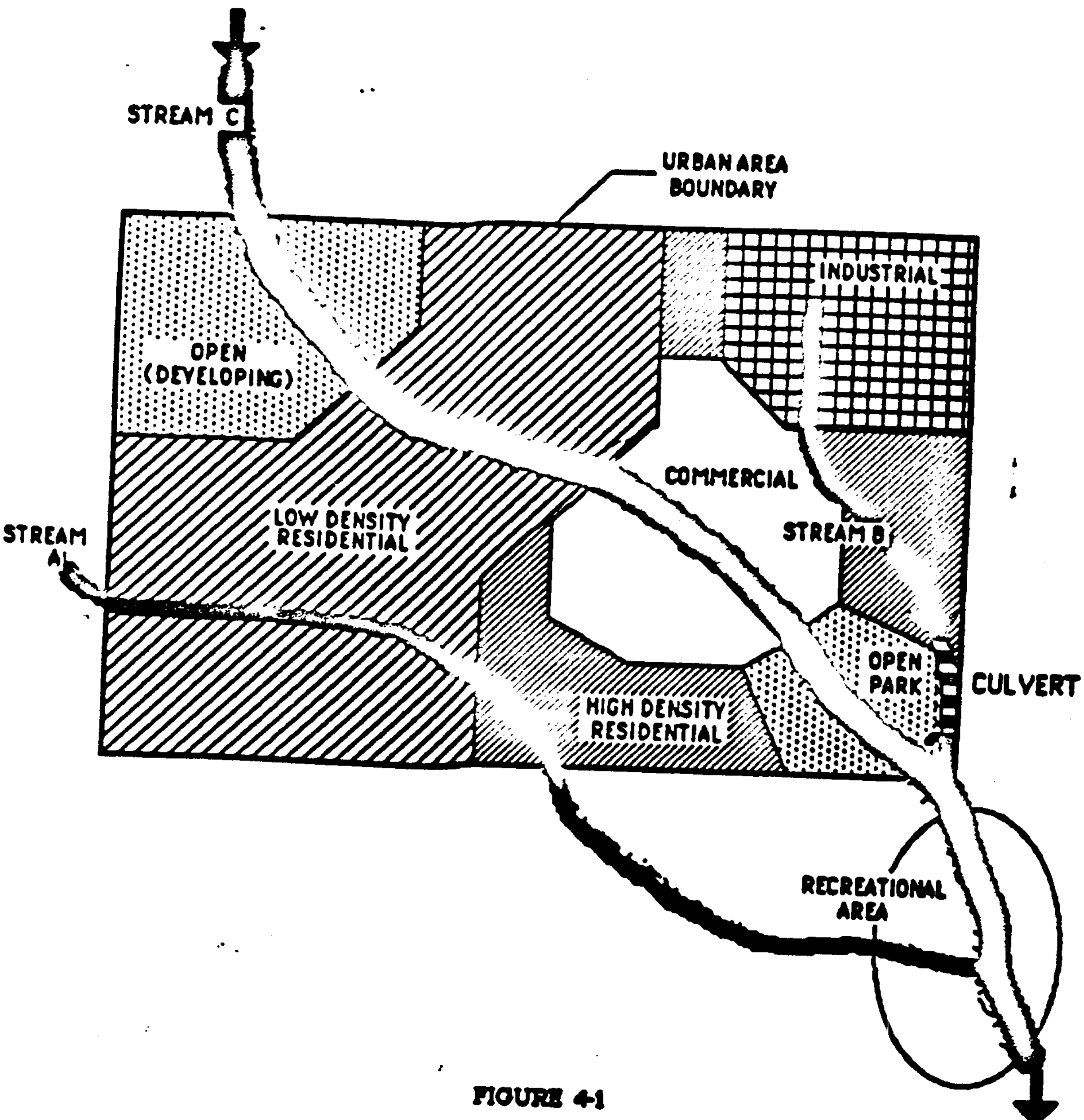

FIGURE 4-1

SCHEMATIC REPRESENTATION OF URBAN AREA, LAND USE AND DRAINAGE

TABLE 4-2. CHARACTERISTICS OF THE TARGETED AREAS AND ESTIMATED CONCENTRATION LOADS.

LAND USE CATEGORY	Rv	AVG CONC IN RUNOFF mg/l TSS	O&G	TP	Cu	DRAINAGE AREA IN ACRES STREAM A	STREAM B	STREAM C	URBAN TOTAL
INDUSTRIAL	0.8	120	20	0.20	0.05	0	150	0	150
COMMERCIAL	0.6	80	15	0.20	0.05	10	80	110	200
RESIDENTIAL - HD	0.4	90	10	0.40	0.04	100	100	50	250
RESIDENTIAL - LD	0.2	100	5	0.60	0.03	200	0	200	400
OPEN - DEVELOPING	0.1	150	0	0.80	0.01	0	0	150	150
OPEN - URBAN PARK	0.1	50	0	0.80	0.01	0	0	50	50

	STREAM A	STREAM B	STREAM C	URBAN TOTAL
TOTAL URBAN AREA	310	330	560	1200
UPSTREAM DRAINAGE AREA	600	0	20,000	20,800
TOTAL DRAINAGE AREA	910	330	20,560	21,800

TABLE 4-3. ESTIMATED TSS LOADS FOR THE TARGETED AREA.

TSS LOAD per inch of rain
POUNDS

LAND USE CATEGORY	STREAM A	STREAM B	STREAM C		URBAN TOTAL
INDUSTRIAL	0	2452	0		2452
COMMERCIAL	145	1162	1598		2906
RESIDENTIAL - HD	817	817	409		2043
RESIDENTIAL - LD	908	0	908		1816
OPEN - DEVELOPING	0	0	511		511
OPEN - URBAN PARK	0	0	57		57
WATERSHED TOTAL	1870	4431	3482		9784
WATERSHED RANK VALUE	1.7	4.1	3.2		9.0

The information on comparative loads and comparative stream size is converted to a set of rank values and are presented in Table 4-4. Rank values are also assigned and entered for the additional targeting factors as shown in the table.

To illustrate the use of the prioritization scheme, and the rank values assigned for this hypothetical case, the following considerations are assumed to have been the concensus reached in planning discussions.

- Ranks for the stream size factor are assigned in proportion to the total drainage area (urban and upstream) providing flow to the stream.

- Beneficial use "type" ranks are based on providing a mid-range value to stream A, whose actual use is a habitat for aquatic life, with little or no direct human contact. Stream B has a low rank because, although water quality is the poorest, the stream is viewed primarily as an urban drain. Stream C (as well as the combination of the urban streams) are assigned a high rank because of the recreational use (actual or potential) at the city park or the downstream recreational area.

- Use "status" ranks are based on the following. Streams A's use is still a viable one, but is somewhat impaired, and it is felt that it can be improved and protected by control of the runoff loads. It is assigned a high rank compared to the others. B and C receive low ranks for two different reasons. Stream B has had poor quality water for so long that the denial of any use other than conveyance of drainage water has long been accepted. There is no current biota or human contact to be protected. The part flowing through the city park is in a buried culvert. Stream C is given a low rank because the quality is still good. The combined flow below town is higher than C because it is affected by the loads coming from A and B.

- Use "level" ranks are a reflection of the relative number of people using or affected by the different stream segments.

- Pollutant load ranks are assigned in proportion to the loads from each area that were developed on Table 4-1. For illustrative purposes, TSS is used as the general indicator of runoff pollutants. The analysis could be repeated using the other pollutants to determine whether the targeting decision is affected.

- Ability to implement ranks assume that control would be easiest to apply in watershed B, because a major part of the area is industrial. Watershed C, and the total urban watershed are given lower ranks than A because there is a greater area to control. In practice, physical factors such as steep slopes, high groundwater, rock, etc. - would also influence the rank value assigned.

For this analysis, equal weights are assigned to the four factors. Since beneficial use has three sub-categories, weights are assigned so that they total to 25 to be consistent with the others.

On the basis of the site data and the series of value judgements discussed above, the prioritization results shown by Table 4-4 suggests that pollutant controls be applied first to watershed C, then to A, and finally to B. Although the "total urban area" has the second highest score, it implies control of the entire urban area.

TABLE 4-4. PRIORITIZATION ANALYSIS FOR URBAN AREA TARGETING

URBAN WATERSHED	STREAM SIZE	BENEFICIAL USE			POLLUTANT LOAD TSS	ABILITY TO IMPLEMENT	TARGET SCORE
		TYPE	STATUS	LEVEL			
WEIGHTS	25	10	10	5	25	25	100
WATERSHED A	4	5	7	4	1.7	5	4.08
WATERSHED B	2	2	2	1	4.1	7	3.73
WATERSHED C	8	8	2	6	3.2	3	4.85
TOTAL URBAN WATERSHEDSHED	8	8	5	8	9.0	2	8.45

TARGET SCORE = WEIGHTED AVERAGE OF RANK POINTS = SUM (RANK SCORE * WEIGHT) / SUM (WEIGHTS)

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Using this targeting methodology sensitivity analyses are easy to perform, and are recommended. In addition to repeating the analysis with other pollutants as mentioned earlier, the ranks (or weights) can be modified to determine the sensitivity of the targeting decision.

If all uses were considered equally important, and in about the same condition (good or poor) then zero weights could be assigned to everything but pollutant loads. In this case, the higher loads from watershed B would put it at the top of the targeting list.

4.5 DISCUSSION

There is no "magic formula" that can be applied that will "decide" for a user, the most appropriate priority to assign for a general implementation program. The degree of subjectivity in assigning both rank values and weights will be apparent as the targeting procedure is applied. The principal value of a formal procedure for an analysis with this unavoidable degree of subjectivity, is that it provides a way to document the decision process. Equally useful is the fact that it provides a framework to organize the thought process and provides a structure to the intermediate decision elements that determine the relative importance of different factors in the local situation.

Some urban jurisdictions will have relatively unique features that cannot be realistically reflected in a generalized procedure. In such a case, additional factors may be added to the assessment.

Similarly, the procedure could be made more complex in terms of the estimation of loads and relating them to the nature and severity or the water quality impact they cause. This consideration was rejected in the interest of keeping the procedure simple, and because value judgements on elements that are not subject to formal computation are also important in the targeting process.

Some judgement is required in the interpretation of the computed pollutant loads. They should not be used to infer either the presence or absence of an actual problem,which will also depend on a number of other factors. The loads computed are based on an arbitrary one inch of rainfall in an attempt to emphasize that they reflect only the comparative pollution potential of the different areas.

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CONTROLLING URBAN RUNOFF: A PRACTICAL MANUAL FOR PLANNING AND DESIGNING URBAN BMPs

T.R. Schueler

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CONTROLLING URBAN RUNOFF:

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by

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Department of Environmental Programs
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prepared for

Washington Metropolitan Water Resources Planning Board

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CHAPTER 2: CHOOSING THE BEST BMP OPTION FOR A SITE

This chapter outlines factors that planners and engineers need to consider when choosing an urban best management practice (BMP) for a particular development site. It begins with a brief discussion of the minimum objectives that a BMP plan for a site should meet. The next section provides a series of screening tools that can be used to select the most appropriate BMP for a particular development site. These screening tools can be used to evaluate the following:

- BMP options that are suitable for a site, given its physical condition and development status.
- Stormwater control benefits provided by each BMP option.
- The expected pollutant removal capability for each BMP option, under several different design scenarios.
- Environmental and human amenity values associated with the BMP option selected.

The screening tools can be used in any order, or may be used as an overall summary of BMP performance. Several examples of how the screening tools can be used for a particular development site are presented. The chapter concludes with a summary index that shows where more information on the design, cost and maintenance of a BMP option can be found elsewhere in the manual.

OBJECTIVES IN BMP PLANNING

Over the past two decades, a number of urban BMPs have been developed and refined to mitigate some of the adverse impacts associated with development activity. Experience has shown that each BMP option has both unique capabilities and persistent limitations. These, in turn, must be balanced with both the physical constraints imposed by the development site and the overall management objectives for the watershed. In practice, this balance is achieved through a negotiating process between the engineering consultant and the local planner. Typically, the engineering consultant is responsible for developing the initial BMP plan, and represents the interests of the developer. The planner reviews the plan to ensure that it conforms with local policies and design standards, and represents the interests of the community.

During the BMP review process, it is important to identify the ultimate objectives for managing runoff from the site. The objectives in nonpoint source pollution and stormwater management have gradually evolved over the years, and may vary considerably among jurisdictions. However, the local planner and engineering consultant often do recognize several common and general goals which should be incorporated into a BMP plan. At a minimum, the BMP plan jointly developed for a site should accomplish the following goals:

- Reproduce, as nearly as possible, the hydrological conditions in the stream prior to development.
- Provide a moderate level of removal for most urban pollutants.
- Be appropriate for the site, given physical constraints.
- Be reasonably cost-effective in comparison with other BMPs.
- Have an acceptable future maintenance burden.
- Have a neutral impact on the natural and human environment.

Reproduce Pre-development Hydrological Conditions

The historical concern in stormwater management has been to reduce the frequency and severity of downstream floods. In most areas, this goal is achieved by controlling the peak discharge computed for a specific design storm to pre-development levels. In reality, however, floods are but one of a series of hydrological changes brought about by watershed development. Other hydrological changes can have equally profound impacts on the quality of downstream aquatic habitat and/or the severity of streambank erosion. Some BMP options are capable of mitigating these impacts through artificial groundwater recharge or the control of small to intermediate storm events. Both the planner and the engineer should check the condition of stream channels downstream to determine if such options should be required.

Provide Moderate Pollutant Removal Capability

In recent years, BMP designs have been adapted to enhance pollutant removal during storms, and thereby, improve the quality of stormwater runoff delivered to receiving waters. BMPs differ markedly in the pollutant removal mechanisms they employ, and consequently, their performance in removing different pollutants can vary significantly. However, the engineer has some ability to enhance removal rates by increasing the volume of runoff effectively treated by the BMP, or by adding extra design features. The planner's responsibility is to provide specific guidance to the engineer on which urban pollutants are to be targeted for removal in the watershed.

Feasibility for the Site

A surprisingly high number of BMPs are constructed on sites for which they are not suitable. As a consequence, some BMPs are often plagued with chronic maintenance problems or nuisance conditions, and in extreme cases, may no longer function as designed. To prevent these sorts of problems from occurring, both the planner and engineer should clearly understand the physical restrictions associated with each BMP. In addition, the engineer should perform field tests to verify the physical condition of the site. Depending on the results, the engineer may have to modify the BMP plan or incorporate preventative design features.

Cost-effectiveness

The construction costs for different BMP options can vary substantially, even on similar sites. This is due to inherent differences in the methods and materials used for BMPs, as well as certain economies-of-scale. Since BMP costs are eventually passed on to the consumer, cost-minimization should

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be a priority for both the engineering consultant and the planner. Generally, the engineering consultant, who has a legitimate interest in developing the least cost plan for his or her client, will perform the needed cost analyses.

Acceptable Future Maintenance Burden

Like any other pollution control device, BMPs can only continue to be effective if they are regularly inspected and maintained. Maintenance tasks for most BMPs include both low cost routine tasks and more expensive non-routine tasks, such as rehabilitation or sediment removal. Maintenance costs for BMPs are significant. Over a twenty year interval they will often equal or exceed the initial construction cost. However, the cost and responsibility for maintenance is normally passed on to future residents or the public sector, and not the original developer.

Consequently, the planner must clearly vest responsibility for maintenance: How and when tasks will be performed, how it is to be financed, and who will inspect the BMP. In most cases, the maintenance burden of a BMP is ultimately rooted in the initial design and construction of the facility. Planners and engineers should work together in this phase to anticipate future maintenance problems at the site and develop designs that can alleviate them. If maintenance requirements are addressed during the design and construction phases, both the scope and cost of future maintenance activities can be sharply reduced.

Neutral Impact on the Environment

Urban BMPs nearly always represent a significant modification to both the natural environment and the adjacent community. As such, BMPs can either enhance or degrade the amenity values that both provide. Comparatively small investments in design, landscaping and maintenance can make a BMP an attractive feature of a community, or at least an unobtrusive one. Without such efforts, many BMPs become "dead space" in a development; that is, they appear unsightly or discordant, provide no habitat or recreational opportunities, and are plagued by nuisance problems. The importance of enhancing the amenity values of a BMP cannot be overemphasized, as resident perceptions about a BMP are generally formed by the amenities they do or do not provide. These perceptions, in turn, strongly influence their acceptance of and support for BMPs, which is critical if the same residents are expected to pay for maintenance.

BMP SCREENING TOOLS

To aid the planner or engineer in choosing the best BMP for a site, a series of screening tools have been developed to compare the capabilities and limitations of each BMP. The first screening tool can be used to identify which BMP options are physically feasible for the site (Figures 2.1 and 2.2). These help the designer to shorten the list of BMP options that need be considered at a site. The second screening tool (Figure 2.3) summarizes the stormwater benefits which are provided by each BMP option. The third screening tool (Figure 2.4) provides rapid guidance on the relative pollutant removal capability of BMPs for a number of urban pollutants of concern. Finally, the fourth screening tool (Figure 2.5) indicates what natural or human amenities, if any, can be provided by the BMP.

Assuming that one or more BMP option has been selected, final design can then begin. More detailed information on the specific design methods, maintenance requirements and cost estimating techniques for the BMP option can be found using the summary index (Table 2.1). The reader is also encouraged to refer to each individual BMP chapter during all phases of the design.

SCREENING BMPs BASED ON PHYSICAL SUITABILITY

The first step in choosing a BMP is to identify which BMPs are actually suitable for physical conditions of the site. The two most important physical factors to consider in this assessment are the total contributing watershed area, and the infiltration rate of the soils of the site. Most BMPs can only be applied within relatively narrow ranges of watershed area and soil types. Figure 2.1 shows these ranges in schematic fashion. Solid black bars indicate when these two factors do not pose a problem, and the absence of a bar denotes that the BMP probably should not be applied under the specified condition. In cases where the bar becomes narrow, the BMP may or may not be feasible for the site depending on local design standards, development intensity, or the expected level of future maintenance.

Figure 2.2 presents a matrix that shows whether a BMP is also subject to other physical restrictions. In these cases, a solid dot indicates that the factor is not normally a restriction, whereas an open dot suggests that it is a restriction. In most cases, these restrictions do not necessarily prevent the use of a BMP option, but may affect where a BMP is located on a site, or how it is designed. As a general rule, pond BMPs normally face fewer of these site restrictions than infiltration BMPs.

The nature of each of the physical factors outlined in these screening tools are described below.

Watershed Area Served

Pond BMPs normally require a significant contributing watershed area (greater than ten acres) to ensure proper operation. The lower range of suitability for ponds is set by the minimum orifice size for dry extended detention ponds, or the capacity to maintain water levels in wet ponds and wet extended detention ponds. By way of contrast, infiltration and vegetative BMPs are generally only applicable on sites less than ten acres, due to space, economic or flow velocity constraints.

It should be noted that the contributing area of a site does not always have to be fixed. By creatively using local topography and drainage, site area can be increased or decreased to better accommodate a particular BMP. For example, additional runoff generated away from the site (off-site runoff) can be routed to the BMP, thereby increasing total site area and making pond options more feasible. Conversely, various portions of the total runoff from a site can be routed to individual BMPs (decreasing site area, and making infiltration and vegetative BMPs more practical).

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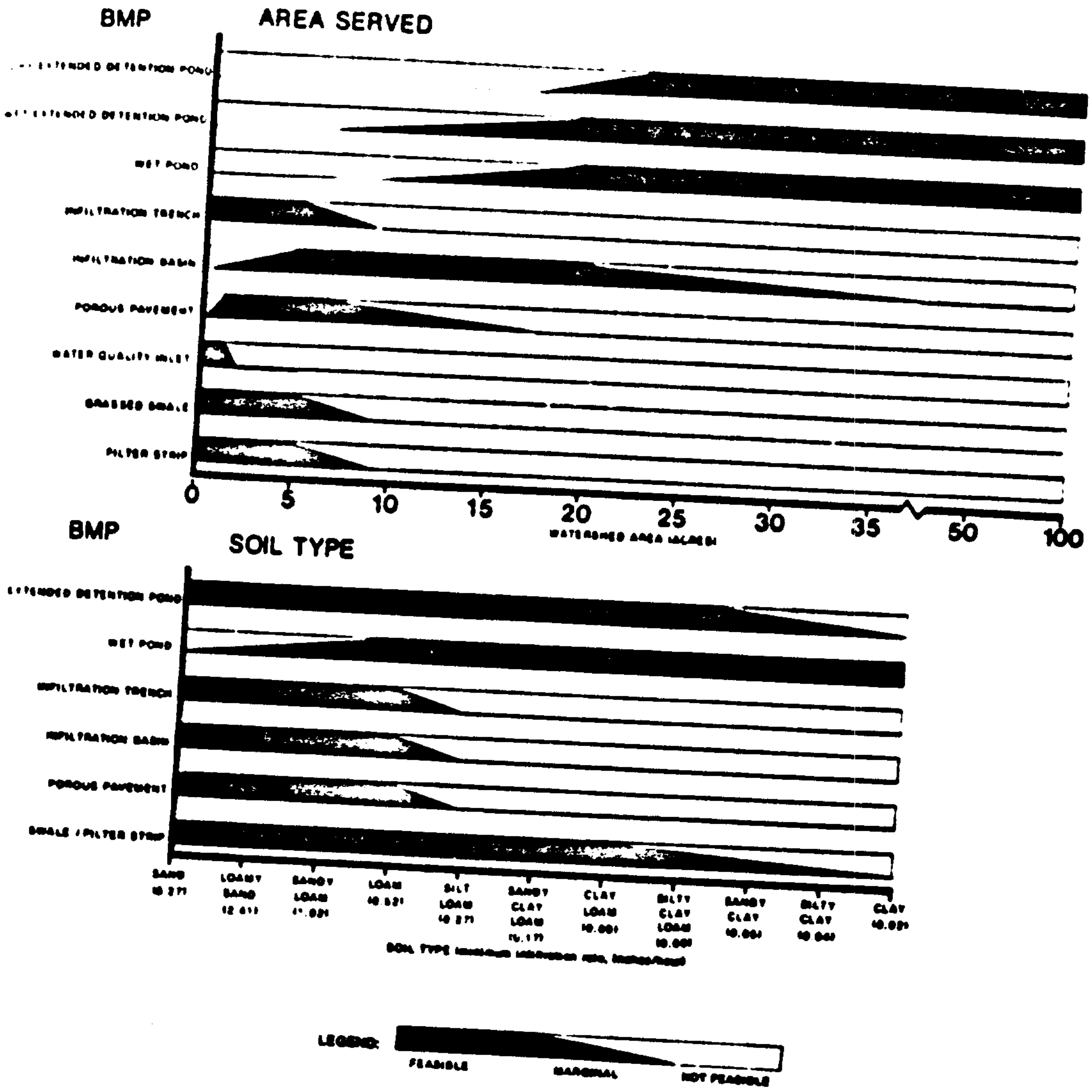
Figure 2.1: Watershed Area and Soil Permeability Restrictions for BMPs



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Soil Type

The permeability of the soil underlying a BMP has a profound influence on its effectiveness. This is particularly true for infiltration BMPs, which cannot be applied on sites with soils that have infiltration rates (fc) less than 0.27 inches/hour, as defined by the least permeable layer in the soil profile. This excludes most "C" and "D" soils which cannot exfiltrate enough runoff through the subsoil.

Pond BMPs tolerate a much broader range of soil conditions. Extremely permeable sandy soils may make it difficult to maintain water levels in wet ponds, and clayey soils may cause standing water problems in dry extended detention ponds.

Figure 2.2: Other Common Restrictions on BMPs

BMP	SLOPE	HIGH WATER TABLE	CLOSE TO BEDROCK	PROXIMITY TO FOUNDATIONS	SPACE CONSUMPTION	MAXIMUM DEPTH	RESTRICTED LAND USES	HIGH SEDIMENT INPUT	THERMAL IMPACTS
EXTENDED DETENTION POND	●	●	◐	●	○	●	●	◐	●
WET POND	●	●	◐	●	○	○	●	◐	○
INFILTRATION TRENCH	○	○	○	○	●	○	●	○	●
INFILTRATION BASIN	◐	○	○	◐	◐	○	●	○	●
POROUS PAVEMENT	○	○	○	○	○	○	○	○	●
WATER QUALITY INLET	●	●	○	○	●	○	○	○	●
GRASSED SWALE	○	○	◐	◐	●	●	○	○	●
FILTER STRIP	◐	◐	◐	◐	●	●	◐	○	●

○ MAY PRECLUDE THE USE OF A BMP
◐ CAN BE OVERCOME w/ CAREFUL SITE DESIGN
● GENERALLY NOT A RESTRICTION

Slope

Steep slopes restrict the use of several BMPs. For example, porous pavement and grassed swales must be situated in sites with slopes of 5% or less. Also, infiltration trenches and filter strips are not practical when slopes exceed 20%.

High Water Table

The water table acts as an effective barrier to exfiltration and can sharply reduce the ability of an infiltration BMP to drain properly. If the height of the seasonally high water table extends to within four feet of the bottom of an infiltration BMP, the site is seldom considered suitable.

Close to Bedrock

The downward exfiltration of storm runoff is also impeded if the bedrock layer lies too close to the soil surface. As with a high water table, a close bedrock layer prevents an infiltration BMP from draining properly. Therefore, if the bedrock layer extends to within 2 to 4 feet of the bottom of an infiltration BMP, the site is not feasible. Similarly, pond BMPs are often not feasible if bedrock lies within the area that must be excavated to provide stormwater storage.

Proximity to Foundations and Wells

Since infiltration BMPs divert runoff back into the soil, some sites may experience problems with local seepage. This can be a real problem if the BMP is located too close to a building foundation. Another risk is that the runoff and pollutants diverted into the groundwater may contaminate water supplies. While relatively little research has been performed to evaluate this risk, it is advisable to keep infiltration BMPs located at least 100 feet away from drinking water wells.

Land Consumption

Some sites are so small or so intensively developed that no room is available for BMP options that consume a large amount of space. Pond BMPs and porous pavement both require a large surface area and a generous buffer, and consequently may not fit into extremely tight sites.

Maximum Depth

To preserve storage capacity and provide optimal pollutant removal conditions, infiltration BMPs must be designed to completely drain within 2 to 3 days after a storm. If the infiltration rates of the underlying soils are marginal, the depth of the infiltration facility may be limited. These restrictions vary depending on whether the facility is a trench, basin or porous pavement facility.

Wet ponds are also subject to a maximum depth limit as well. Extremely deep ponds (greater than 8 feet deep) may stratify during the summer and create low oxygen conditions near the bottom of the pond. This in turn, creates the potential for the release of pollutants from the sediments back into the water column.

Restricted Land Uses

Certain BMPs can only be applied to particular land uses, and are not broadly applicable for all development sites. Porous pavement, for example, can only be used for sites with parking lots not expected to receive heavy car or truck traffic. Similarly, grassed swales can only be used in conjunction with low density residential areas or roads.

High Sediment Input

Most BMPs are unable to handle the large loads of sediment eroded during the construction phase of development. Infiltration BMPs are particularly susceptible to rapid clogging and subsequent failure if significant sediment loads are allowed to enter the structure. As a general rule, these BMPs should not be installed until all of the land disturbed by construction in the contributing watershed is effectively stabilized. Contractors must often take unusual steps during the actual installation of the infiltration BMPs to prevent soil compaction or sediment contamination. Although sediment loads drop sharply after the construction phase, gradual clogging of infiltration BMPs can still occur, so many designs call for the use of a pre-treatment device to filter out sediment and other coarse particles before they reach the facility.

Pond BMPs can be used for sediment control during the construction phase of development, with proper conversion, clean-out and regrading. After the site is stabilized, significant amounts of pond storage capacity can still be lost due to the gradual accumulation of deposited sediments. After 5 to 20 years, the sediment deposits are large enough to impair the function of a pond, and must be removed. The cost and scope of sediment removal can be reduced by preventative design, extra storage and/or sediment forebays.

Thermal Enhancement

Shallow marshes and wet ponds warm up rapidly during the summer months. Under certain circumstances, runoff leaving these BMPs can be 5 to 10 degrees warmer than the runoff entering the structure. Such warm water release can be a lethal thermal shock to aquatic organisms that are adapted to coldwater conditions. Thus, the use of wet ponds and shallow marshes should be avoided in watersheds with sensitive coldwater streams.

SCREENING BMPs BASED ON STORMWATER BENEFITS PROVIDED

The objective of stormwater management is to attempt to reproduce the pre-development hydrology of the site. As noted earlier, this can be done through a combination of peak discharge control, volume control, groundwater recharge and streambank erosion control. Figure 2.3 shows the extent to which common BMP designs provide these benefits. A solid dot indicates that the BMP normally provides the benefit; an open dot indicates that it does not; and a half dot suggests that the benefit might be provided in certain sites or with special design modifications. As can be seen, very few BMP options can achieve the full spectrum of desirable stormwater benefits. This is because a different flow condition and/or frequency must be controlled to provide each benefit. As an example, the designer needs to control very large, infrequent storms to attain peak discharge control, yet must concentrate on much smaller and more frequent storms to provide groundwater recharge.

The design variations for infiltration BMPs shown in Figure 2.3 deserve some additional explanation. The term "exfiltration" refers to the amount of runoff that is effectively infiltrated through the soil profile. Full exfiltration occurs when all of the runoff delivered to an infiltration BMP is completely exfiltrated back into the soil. As one might imagine, full exfiltration BMPs need to be very large in volume. Partial exfiltration BMPs only divert a fixed volume of runoff into the soil (the remaining runoff is conveyed through the BMP, but may be detained long enough to provide some peak discharge control). In water quality exfiltration BMPs, a small, fixed runoff volume is diverted into the soil. The remaining runoff is conveyed away, and is not detained long enough to provide any peak discharge control.

Peak Discharge Control

As shown in Figure 2.3, peak discharge control is often required for one or more design storms under local regulations. The most common design storm used is the 2 year storm, which is a flood that occurs, on average, every two years. In natural watersheds, the two year storm produces a flood that fills a stream to the top of its banks (i.e., the bankfull flood). Some jurisdictions also require control of the 10 or 100 year design storms, particularly if there is unprotected development further downstream on the floodplain. Even if a BMP does not control these larger design storms, they must still be designed to safely pass them through (e.g., using an emergency spillway or an overflow pipe).

Peak discharge control is accomplished in pond BMPs by temporarily detaining a large portion of the runoff volume for the design storm, and then releasing it at the lower pre-development rate. This is done by using a vertical riser with a control orifice or weir. A single pond can control a series of design storms by using a series of orifices and weirs at progressively higher elevations. In general, pond BMPs are an excellent means of providing peak discharge control.

Infiltration BMPs have a more limited capacity to control peak discharges. Full exfiltration systems are normally only capable of controlling peak discharges for the 2 year storm (and in rare cases, the 10 year storm). Most partial exfiltration systems can control the 2 and 10 year storm, and pass the 100 year storm. Water quality exfiltration systems, water quality inlets, swales, and filter strips normally have little or no capacity to control peak discharges.

Volume Control

Infiltration BMPs can help to reduce the increased runoff volumes generated from small and intermediate storms, since they divert a significant fraction of storm runoff volume back into the soil. Pond BMPs, on the other hand, are ineffective in reducing runoff volume. Ponds only detain or retain runoff for a short period of time before releasing it downstream.

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Figure 2.3: Comparative Stormwater Benefits Provided by Urban BMPs

BMP	Peak Discharge Control: 2 Year Storm	Peak Discharge Control: 10 Year Storm	Peak Discharge Control: 100 Year Storm	Volume Control	Groundwater Recharge	Streambank Erosion Control
EXTENDED DETENTION						
DRY	●	●	●	○	○	●
DRY w/ MARSH	●	●	●	◐	○	●
WET	●	●	●	○	○	●
WET POND	●	●	●	◐	○	○
INFILTRATION TRENCH						
FULL EXFILTRATION	●	◐	○	●	●	●
PARTIAL EXFILTRATION	●	●	○	●	●	●
WATER QUALITY TRENCH	○	○	○	●	●	●
INFILTRATION BASIN						
FULL EXFILTRATION	●	◐	○	●	●	●
INFILTRATION/DETENTION	●	●	●	●	●	◐
OFF-LINE BASIN	○	○	○	●	●	◐
POROUS PAVEMENT						
FULL EXFILTRATION	●	◐	○	●	●	●
PARTIAL EXFILTRATION	●	●	◐	●	●	◐
WATER QUALITY	○	○	○	●	●	◐
WATER QUALITY INLET	○	○	○	○	○	○
GRASSED SWALE	◐	○	○	◐	◐	○
FILTER STRIP	◐	○	○	◐	◐	○

○ SELDOM OR NEVER PROVIDED
◐ SOMETIMES PROVIDED w/ CAREFUL DESIGN
● USUALLY PROVIDED

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Groundwater Recharge

Infiltration BMPs are an excellent means of providing for groundwater recharge, which is often lost as a consequence of watershed development. "Natural" levels of groundwater recharge can be duplicated by diverting a significant fraction of the runoff from frequent small and moderate storms back into the soils. Most exfiltration designs recharge the groundwater sufficiently to sustain normal low flows in headwater streams during the critical summer months. Vegetative BMPs, such as grassed swales and filter strips have a more limited capability, and pond BMPs generally have little or none.

Streambank Erosion Control

All BMPs that control peak discharges for the 2 year storm provide some degree of streambank erosion control. However, the 2 year storm creates an erosive condition in natural channels (i.e., a bankfull discharge). To adequately protect downstream channels, it is necessary to control both the post-development increase in the 2 year bankfull flood and the increased frequency with which it occurs. This normally entails the control of storm events of intermediate size (less than the 2 year storm and greater than the mean storm). Some preliminary design suggestions for minimizing the increased frequency of bankfull flooding are provided in Appendix B. Based on this analysis, it appears that extended detention ponds and some infiltration BMPs can effectively reduce the frequency with which bankfull flooding occurs, if sized properly. Wet ponds (without extended detention), vegetative BMPs, and water quality inlets show little capability in this regard.

SCREENING BMPs BASED ON POLLUTANT REMOVAL BENEFITS

The pollutant removal capability of a BMP is primarily governed by three interrelated factors: 1) the removal mechanisms used, 2) the fraction of the annual runoff volume that is effectively treated, and 3) the nature of the urban pollutant being removed. The designer has a limited ability to control the first two factors, but has no influence on the third.

Figure 2.4 illustrates the comparative pollutant removal capabilities of BMP options. The removal rates shown are inferred from field performance monitoring, laboratory experiments, modeling analyses and theoretical considerations. Due to the inherent uncertainties involved, removal rates are expressed in 20 percent increments. A removal rate has been estimated for several design variations of each BMP. The design variations for each BMP are arrayed in order of increasing fractions of annual runoff volume treated.

As noted earlier, the nature of the pollutant being removed often sets an upper limit on the potential removal rate that can be achieved. From an operational standpoint, pollutants can be said to exist in either particulate or soluble forms, or more commonly, as a mix of both forms (MWCOG, 1987). Particulate pollutants, such as sediment and lead, are relatively easy to remove by common BMP removal mechanisms, including settling and filtering. Soluble pollutants, such as nitrate, phosphate, and some trace metals, are much more difficult to remove. Settling and filtering removal mechanisms have little or no effect, and biological mechanisms, such as uptake by bacteria, algae, rooted aquatic plants or terrestrial vegetation, must be used.

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The importance of pollutant form can clearly be seen in Figure 2.4. Most BMPs can achieve an extremely high removal rate for suspended sediment and trace metals that exist largely in particulate forms. Much lower removal rates are generally obtained for total phosphorus, oxygen-demanding materials and total nitrogen, since they typically exist as a mix of particulate and soluble forms.

The following sections summarize the pollutant removal capability of BMPs, with an emphasis on their major removal mechanisms, and design enhancements which can be used to improve their performance.

Extended Detention Ponds

Dry extended detention ponds rely primarily on settling to remove pollutants. Depending on how much and how long runoff is detained, it is possible to achieve moderate or high removal rates for particulate pollutants that are relatively easy to settle. However, removal rates for most soluble pollutants are quite low for dry extended detention ponds, although it is possible to enhance rates by incorporating biological removal mechanisms into the design of the pond (e.g., by establishing a shallow marsh in the bottom stage of a dry extended detention pond, or by using extended detention in combination with a wet pond).

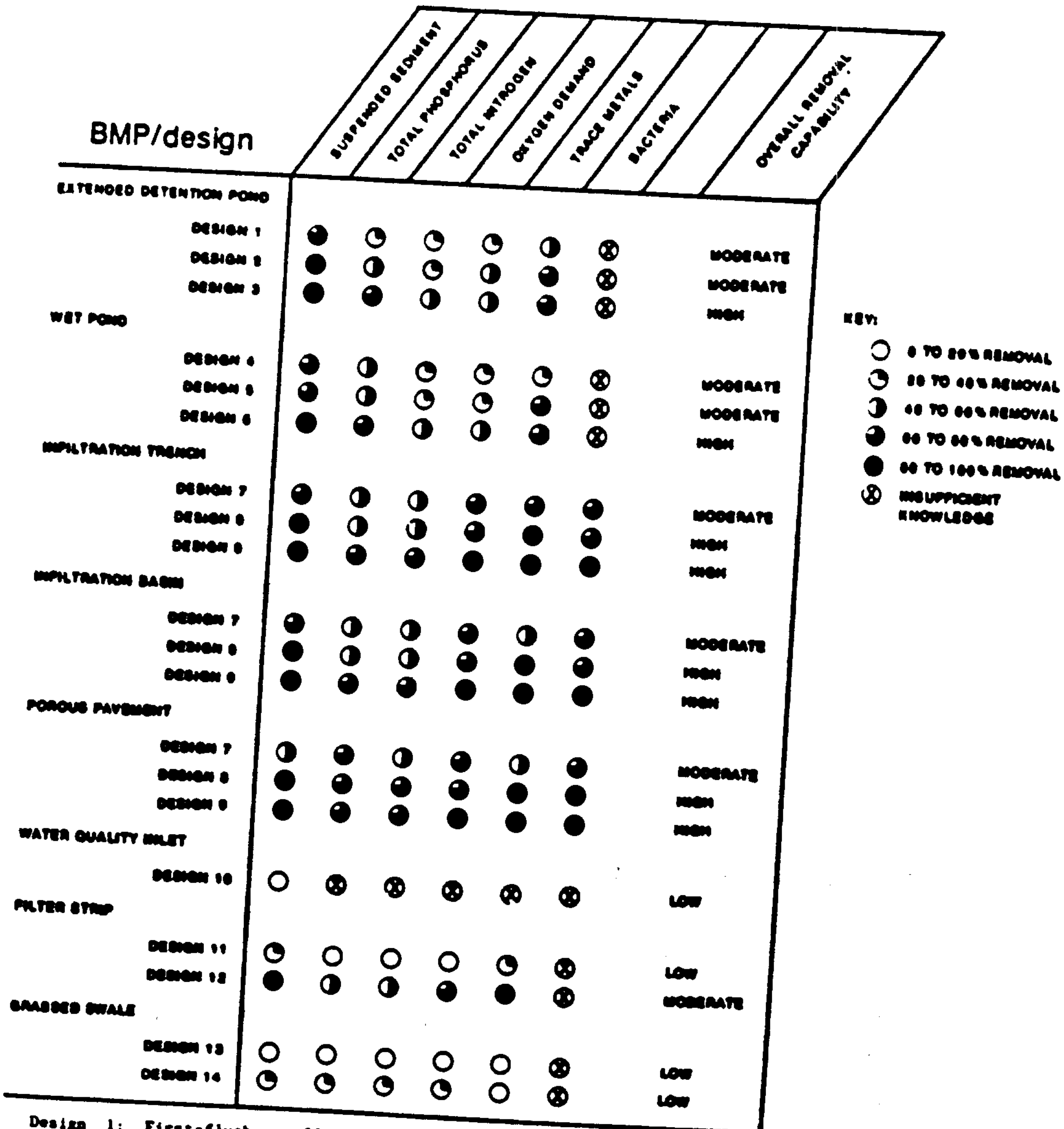
Wet Ponds

Wet ponds have a moderate to high capability of removing most urban pollutants, depending on how large the volume of the permanent pool is in relation to the runoff produced from the surrounding watershed. Wet ponds utilize both settling and biological uptake, and are capable of removing both particulate and soluble pollutants. In addition to increasing the volume of the permanent pool, wet pond removal rates can be enhanced by establishing marshes around the perimeter, and by adjusting the geometry of the pond.

Infiltration Practices (trenches, basins, porous pavement)

From a pollutant removal standpoint, infiltration trenches, basins, and porous pavement behave in a similar manner, and can be treated as a group. Infiltration practices filter runoff through the soil layer, where a number of physical, chemical and biological removal processes occur. Infiltration practices have a moderate to high removal capability for both particulate and soluble urban pollutants, depending how much of the annual runoff volume is effectively exfiltrated through the soil layer. Removal rates can be further enhanced by increasing the surface area reserved for exfiltration and adjusting the geometry of the practice to achieve a draining time of less than 3 days. It should be noted that infiltration practices should not be relied on to achieve high levels of particulate pollutant removal (particularly sediments), since these particles can rapidly clog the device. Rather, particulate pollutants should be removed before they enter the structure by means of a filter strip, sediment trap or other pretreatment device.

Figure 2.4: Comparative Pollutant Removal Of Urban BMP Designs



Design 1: First-flush runoff volume detained for 6-12 hours.
Design 2: Runoff volume produced by 1.0 inch, detained 24 hours.
Design 3: As in Design 2, but with shallow marsh in bottom stage.
Design 4: Permanent pool equal to 0.5 inch storage per impervious acre.
Design 5: Permanent pool equal to 2.5 (Vr); where Vr=mean storm runoff.
Design 6: Permanent pool equal to 4.0 (Vr); approx. 2 weeks retention.
Design 7: Facility exfiltrates first-flush; 0.5 inch runoff/imper. acre.
Design 8: Facility exfiltrates one inch runoff volume per imper. acre.
Design 9: Facility exfiltrates all runoff, up to the 2 year design storm.
Design 10: 400 cubic feet wet storage per impervious acre.
Design 11: 20 foot wide turf strip.
Design 12: 100 foot wide forested strip, with level spreader.
Design 13: High slope swales, with no check dams.
Design 14: Low gradient swales with check dams.

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Water Quality Inlets

Current designs of water quality inlets appear to have low to moderate removal rates for particulate pollutants, and low to zero rates for soluble pollutants. Water quality inlets rely primarily on settling for removal, and given their small storage capacity and brief residence times, it is likely that only coarse grit, sand, and some silts will be trapped. Inlets do show some promise in removing hydrocarbons, such as oil, gas and grease, from runoff. Due to resuspension problems, however, pollutant removal can only be attained in water quality inlets if they are cleaned regularly.

Filter Strips

Filter strips have a low to moderate capability of removing pollutants in urban runoff, and exhibit higher removal rates for particulate rather than soluble pollutants. Removal mechanisms include filtering (through vegetation and/or soil), settling/deposition and uptake by vegetation. Forested buffer strips appear to have a higher removal capability than grass buffer strips. However, length, slope and soil permeability are critical factors which influence the effectiveness of any strip. Another practical design problem is how to prevent runoff from concentrating and thereby "short-circuiting" the strip. Special design modifications and regular maintenance are needed to provide optimal removal rates in the field.

Grassed Swales

Grassed swales have a low capability of removing urban pollutants, except under site conditions which are unusual in the Washington metropolitan area (e.g., extremely gentle slopes, permeable and uncompacted soils, installation of check dams and maintenance of a dense grass turf). If constructed under these conditions, pollutants can be removed through the filtering action of the grass, by deposition in low velocity areas, and by exfiltration through the soil layer. Moderate removal of particulate pollutants, and low removal of soluble pollutants can be expected under these optimal conditions.

SCREENING BMPs FOR ENVIRONMENTAL AMENITIES

Figure 2.5 is a screening tool that shows the environmental and human amenities which can be provided by a particular BMP. In most cases, these amenities are not automatically provided when a BMP is built. Rather, they are a result of thoughtful design, regular maintenance, and creative landscape planting. In this matrix, a solid dot indicates that there is a strong potential for a BMP to provide the amenity; an open dot indicates the BMP has little or no potential; and a half dots suggests that a BMP might provide the amenity with some design modifications or as a result of unusual site conditions.

The first five headings in Figure 2.5 refer to amenities related to the improvement of the natural environment, while the last five headings pertain to amenities which are provided to the adjacent community. As might be expected, community amenities are quite subjective, and often adjacent residents hold widely divergent opinions as to their value. However, based on opinion surveys and less formal surveys of complaints to public works officials, some generalities have been made.

Figure 2.5: Environmental and Community Amenities Provided by BMPs

BMP	LOW FLOW MAINTENANCE	STREAMBANK EROSION CONTROL	AQUATIC HABITAT CREATION	WILDLIFE HABITAT CREATION	NO THERMAL ENHANCEMENT	LANDSCAPE ENHANCEMENT	RECREATIONAL BENEFITS	HAZARD REDUCTION	AESTHETICS	COMMUNITY ACCEPTANCE
DRY EXTENDED DETENTION	○	●	◐	●	●	◐	◐	◐	◐	◐
EXTENDED DETENTION w/ MARSH	○	●	●	●	○	◐	○	◐	◐	◐
WET EXTENDED DETENTION	○	●	●	●	○	●	●	◐	◐	●
WET POND	○	○	●	●	○	●	●	◐	◐	●
INFILTRATION TRENCH	●	◐	○	○	●	○	○	●	○	●
INFILTRATION BASIN	●	◐	○	●	●	◐	◐	●	○	◐
POROUS PAVEMENT	●	◐	○	○	●	○	○	●	○	●
WATER QUALITY INLET	○	○	○	○	●	○	○	●	○	●
GRASSED SWALE	◐	○	○	◐	●	◐	○	●	◐	●
FILTER STRIP	◐	○	○	●	●	◐	○	●	◐	●
SHALLOW MARSH	○	○	●	●	○	◐	○	◐	◐	◐

○ SELDOM PROVIDED

◐ SOMETIMES PROVIDED (w/ Design Modifications)

● USUALLY PROVIDED

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Low Flow Maintenance

Downstream aquatic life can be jeopardized when the natural low flow levels experienced during the summer months decline even further because of reduced infiltration in urbanized watersheds. Infiltration BMPs contribute significantly to groundwater recharge and appear to be capable of sustaining low flows during the critical summer months if widely applied in a watershed. Vegetative BMPs, such as swales and filter strips, appear to have modest potential in this regard, and pond BMPs have little effect in maintaining low flows.

Streambank Erosion Control

Streambank erosion not only contributes large sediment loads to receiving waters, but also has an adverse impact on the habitat quality for downstream aquatic life. Some BMPs, such as extended detention ponds and full exfiltration BMPs, can control erosive stormflows enough to keep downstream channels and banks relatively stable, whereas most other BMPs have only marginal capabilities.

Aquatic Habitat Creation

Some BMP options are attractive in that they can create wetland or open water areas utilized by waterfowl, marsh birds, and other wildlife. Shallow marshes and wet ponds are particularly well suited for this role, if relatively small investments are made in landscaping design and plant selection. "Volunteer" wetland plants may also colonize these BMPs (and poorly drained extended detention ponds) without intentional planting efforts, but may not provide high quality habitat. Tips for enhancing aquatic habitat are presented in the Chapter 4 and the Basin Landscaping Guide (Chapter 9).

Wildlife Habitat Creation

BMPs with generous buffers (wet ponds, extended detention ponds, infiltration basins and filter strips) present good opportunities for creating terrestrial wildlife habitat. The buffer areas (and sometimes the basin floors) can be managed as wet meadows, thus reducing mowing costs for the facility. Relatively diverse biological communities can be further enhanced through judicious planting of trees, shrubs and grasses that provide food and cover for wildlife (see Chapter 9). These communities have added value because of the general scarcity of wildlife habitat in urbanized areas.

No Thermal Enhancement

As noted earlier, wet ponds can be detrimental in some watersheds as they heat water passing through the structure during the summer months. Their use is often restricted in watersheds that contain sensitive coldwater fisheries, such as those that support native trout populations.

Landscape Enhancement

Few BMPs will be an attractive feature of a community unless serious efforts are directed toward natural grading, landscaping and regular maintenance. If properly designed, pond options probably have the most potential to enhance the urban landscape. Wet ponds are frequently used to create a waterfront effect in residential developments, and may actually increase the value of adjacent property. Vegetative BMPs have a less dramatic effect on landscape values, and most infiltration BMPs and dry extended detention ponds have a neutral or negative effect.

Recreational Benefits

With the exception of large wet ponds, few BMPs provide active recreational opportunities (e.g., fishing, swimming, or skating). In fact most jurisdictions generally do not encourage such activities, as they may invite vandalism or liability problems. However, if properly landscaped, pond BMP options can provide passive recreation opportunities for adjacent residents, such as walking, birdwatching, or nature enjoyment, particularly when combined with bike or jogging paths, picnic areas, and tot-lots situated in nearby open space. In rare instances, the floors of extended detention ponds can even be used for ballfields and play areas.

Hazard Reduction

Careful design of pond BMPs is needed to reduce potential safety hazards. Plans should be analyzed to eliminate obvious hazards, such as steep side-slopes, deep water, sudden drop-offs from the shore, or dangerous outlet/pipe configurations. Most infiltration BMPs entail little if any safety risks, and some (porous pavement) are thought to reduce certain traffic safety problems.

Aesthetic Value

As shown in Figure 2.5, most pond options have the potential to be either an attractive or an unattractive feature of a community, depending on the attention paid to their design, landscaping ,and maintenance. Artificial contours should be avoided, and control structures (risers, low flow channels, outlets and riprap) should be concealed in the embankment, or by vegetation where feasible. Infiltration BMPs generally have little potential to be attractive, but can at least be designed to be unobtrusive.

Community Acceptance

Surveys of resident perceptions about adjacent BMPs have revealed that most BMPs are acceptable if regular cosmetic maintenance is performed. Residents often indicate a preference for wet ponds over dry ponds. Their response to infiltration BMPs is not well documented. Residents' primary concerns often center around perceived nuisance conditions (algae blooms, odors, mosquitos, weeds, trash, turbidity, etc.), most of which are temporary conditions which should seldom occur if the BMP is properly designed and maintained.

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HOW TO USE THE SCREENING TOOLS

The following examples provide illustrations of how the screening tools provided in this Chapter are best used.

EXAMPLE 2-1: USE OF THE SCREENING TOOLS

A developer has a 5 acre parcel which will be converted into an office complex and parking lot. The site has low slopes and permeable, sandy loam soils. The management objectives for the site are; 1) 2 year peak discharge control, 2) groundwater recharge, and 3) moderate to high removal of all urban pollutants.

Step 1. Using Figure 2.1 the following BMPs are suitable, given the area and soil characteristics of the site:

1. Infiltration Trench
2. Infiltration Basin
3. Porous Pavement
4. Grassed Swale
5. Filter Strip

After checking the other site restrictions contained in Figure 2.2, and the accompanying text, it is apparent that grassed swales and filter strips are not appropriate, given the proposed high land-use intensity. The remaining BMP options appear feasible, but must have some kind of pretreatment device to protect them from high sediment inputs.

Step 2. Full or partial exfiltration designs of the infiltration BMP options can provide the desired 2 year peak discharge control and groundwater recharge benefits:

1. Infiltration trench
2. Infiltration basin
3. Porous pavement

Step 3. If the infiltration BMPs are sized according to design rules 8 or 9, high levels of pollutant removal can be expected for all of the remaining options (see Figure 2.4).

Step 4. All of the remaining BMP options provide a similar level of environmental amenities (Figure 2.5).

Step 5. A final BMP option can now be selected on the basis of costs or maintenance requirements. Estimation of both can be found elsewhere in the text using Table 2.1.

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EXAMPLE 2-2: USE OF THE SCREENING TOOLS

A developer is planning to build a residential subdivision on a 40 acre parcel of land, with moderate slopes (5%) and sandy clay loam soils. Local ordinances require peak discharge control for the 2 and 10 year design storm. In addition, the planning review agency has specified that the BMP should provide a high level of streambank erosion control, and provide a moderate to high level of nutrient removal. Because of the intended character of the residential area, the developer would like the BMP to provide environmental amenities. Using the screening tools, identify the BMP option(s) which are physically suitable for the site, and determine whether they can provide the desired benefits.

Step 1. From Figure 2.1, it is evident that most infiltration BMPs are not feasible because of watershed area and soil permeability restrictions. The remaining options are:

1. Dry extended detention pond
2. Wet extended detention pond
3. Wet pond

Based on Figure 2.2, which shows other common site restrictions for BMPs, it appears that no other insurmountable limitations exist for the use of the BMPs listed above.

Step 2. Using Figure 2.3, it is evident that all these BMPs can control peak discharges from the 2 and 10 year storm. However, only dry and wet extended detention ponds can provide the desired level of streambank erosion control.

Step 3. From a nutrient removal standpoint, dry extended detention (design 3, with marsh) and wet extended detention (design 6) both have the potential to provide high levels of removal (Figure 2.4).

Step 4. As shown in Figure 2.5, both dry extended detention with marsh, and wet extended detention ponds provide several natural environmental amenities, with proper landscaping and maintenance. These include streambank erosion control, and wildlife and aquatic habitat creation. From the standpoint of community amenities, wet extended detention appears to be preferable, as it gets higher marks for landscaping, recreation, and resident acceptance.

Based on the screening tool, and the stated management objectives for the site, the most appropriate BMP would be a wet extended detention pond. Methods for estimating construction costs and maintenance requirements for the BMP can be found by referring to the appropriate section of this manual, as outlined in Table 2.1.

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FINAL DESIGN CONSIDERATIONS

Once a BMP has been selected for the site, more detailed design of the facility can begin. As noted earlier, the designer should consider a number of design features that can enhance pollutant removal, reduce maintenance needs and costs, reduce construction costs, and provide desired environmental and community amenities. Table 2.1 provides a summary index on where such design information can be found within this manual.

Tips for Enhancing Pollutant Removal

Each BMP chapter in this manual contains a section that provides a series of design tips to maximize the pollutant removal capability of a BMP. These guidelines include: ways of adjusting the size and geometry of a BMP to create ideal removal conditions; how vegetation can be effectively used to promote biological removal; how optimum detention/draining times can be achieved; and other means of achieving high pollutant removal requirements.

Table 2.1: Summary Index for BMP Design

	TIPS FOR ENHANCING POLLUTANT REMOVAL	MAINTENANCE REQUIREMENTS FOR THE BMP	TIPS FOR REDUCING MAINTENANCE NEEDS	PROJECTING BMP CONSTRUCTION COSTS	DESIGN VARIATIONS FOR THE BMP	DETAILED DESIGN METHODS FOR THE BMP	DESIGN SUMMARIES
EXTENDED DETENTION	3.14	3.21	3.24	3.20	3.2	3.26	3.27
WET PONDS	4.4	4.13	4.16	4.12	4.4	4.20	4.21
INFILTRATION TRENCH	5.16	5.21	5.23	5.16	5.2	5.25	5.20
INFILTRATION BASIN	6.9	6.14	6.15	6.13	6.2	6.17	6.18
POROUS PAVEMENT	7.10	7.17	7.20	7.13	7.2	7.22	7.23
WATER QUALITY INLET	8.5	8.6	8.8	8.8	8.2	8.6	8.9
GRASSED SWALE	9.3	8.6	9.6	9.6	-	9.10	-
FILTER STRIP	9.7	9.9	9.9	9.9	-	9.10	-
SHALLOW MARSH	-	-	-	9.5	-	9.18	-

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Common Maintenance Requirements

Both the regular and non-routine maintenance requirements for each BMP are described in detail elsewhere in this manual. Where data is available, estimates of the costs associated with maintenance are provided, as are inspection schedules and methods. Where construction methods are critical to the successful operation of the BMP, recent specifications on materials and workmanship are also provided.

Tips For Reducing Maintenance Needs

Engineers should make maintenance reduction a major element of every BMP design. A significant amount of future maintenance activities and costs can be eliminated through preventative design. Each BMP chapter includes a series of tips which should be carefully reviewed. These include suggestions on how to reduce maintenance needs by providing access, using long-lasting construction materials, trapping sediment inputs, creative use of the geometry of the BMP to make routine maintenance easier, providing backup drainage systems, and proper stabilization of erosion-prone areas.

Projecting BMP Construction Costs

Each BMP chapter presents a method for computing a rapid planning estimate of the construction costs of a BMP. Unit costs for major construction components are provided for infiltration and pond BMPs (see Table 7.4). Cost equations are also provided for a number of BMPs. The cost-effectiveness of each BMP, in relation to watershed size, development intensity, and other BMP options, is also discussed (see also MWCOG, 1983a; Wiegand et al, 1986).

Design Variations

Each BMP chapter begins with a section that describes several variations in the basic design of a BMP. These designs, drawn from applications around the Washington, D.C. area, illustrate innovative ways to fit a BMP into a particular development site and combine BMPs together to improve performance or minimize maintenance needs.

Design Methods

This manual does not provide step-by-step methods for the hydrological design of BMPs, nor does it give specific models or equations that can be used to accurately determine the necessary storage requirements, geometry and configuration of a BMP at a particular site. These technical aids, used for the final BMP design, are provided by reference at the end of each chapter.

Design Summary

Each chapter concludes with a brief design summary that highlights some of the recommended BMP design features that should be included in every site plan. Both the engineering consultant and the site-plan reviewer can use these summaries as a checklist to ensure that the BMP plan for the site will be effective.

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PRESS CONFERENCE ANNOUNCEMENT: CITY OF SANTA MONICA'S STORM DRAIN COVER AND SIGNAGE PROGRAM, SEPTEMBER 21, 1990

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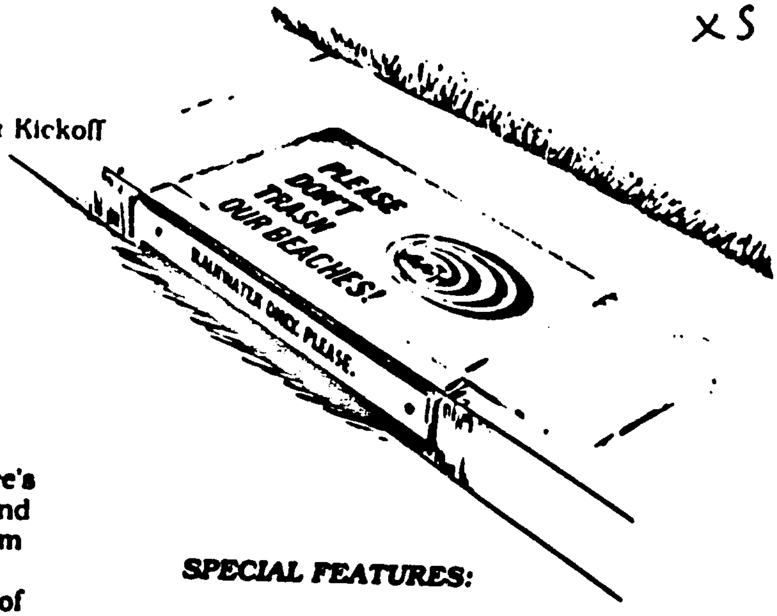
R0050982

¯RESS CONFERENCE:

City of Santa Monica
Dept. of General Services
Storm Drain Inlet Cover and
Signage Program Unveiling & Kickoff



DATE: September 21, 1990

TIME: 10:00 AM

PLACE: Colorado Blvd. South Side between 4th & Main (in front of Sears), Santa Monica

EVENT: Unveiling and kick-off of the Department of General Service's new storm drain inlet cover and signage program. The program is a comprehensive effort intended to reduce the amount of waste dumped into Santa Monica's storm drain system – waste that ends up in the Santa Monica Bay and beaches.

New designs for storm drain inlets with signs and decals will be unveiled. These signs and decals will be painted on storm drains throughout the City. The signage dramatically appeals to pedestrians and motorists not to throw waste into the drain system.

SPECIAL FEATURES:

- Speech by Mayor Dennis Zane.
- Video tour of Santa Monica's storm drains made by the City's unique "Tunnel-Kam" camera system.
- Santa Monica and L.A. City Council members, State Representatives, DWP and MWD Representatives in attendance.
- Sign and decal unveiling.

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Progress Update 1990

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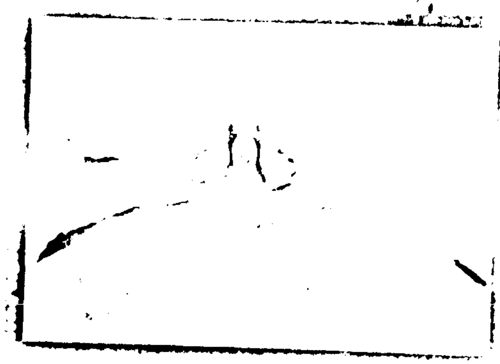
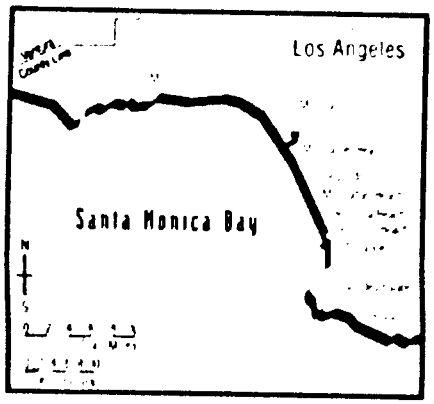


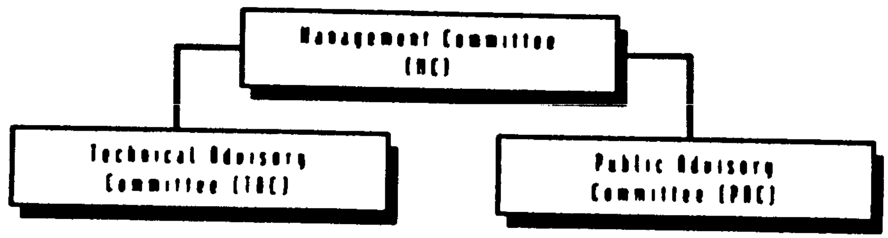
AN INTRODUCTION TO THE SANTA MONICA BAY RESTORATION PROJECT

Santa Monica Bay adjoins one of the most densely populated coastlines and popular playgrounds in America. In areas once inhabited by the Gabrieleno and Chumash Indians, today we find an urban and industrial landscape that is home to nearly 9 million people. Not surprisingly, the demands from recreational, municipal and industrial uses have resulted in an environmentally troubled Santa Monica Bay.

In 1988, Santa Monica Bay was recognized by the Environmental Protection Agency and the State of California as a natural resource that must be protected and preserved. The Santa Monica Bay Restoration Project (SMBRP) was formed under the National Estuary Program (NEP) to assess the pollution problems and develop solutions for restoring and protecting the Bay. The SMBRP, whose boundaries stretch from the Ventura County line to Point Fermin in Palos Verdes,



Santa Monica Bay



Santa Monica Bay Restoration Project Management Conference

will address the questions that so many of us have about Santa Monica Bay:

- Is it safe to swim in Santa Monica Bay?
- Is it safe to eat fish caught in the waters of Santa Monica Bay?
- Are the fish and wildlife protected?
- What is the future of Santa Monica Bay?

The SMBRP's **Management Conference** is organized into three primary committees. The **Management Committee (MC)**, composed of more than 50 members, is the decision-making body responsible for finding the solutions to the Bay's problems which will be detailed in a document called the **Comprehensive Conservation and Management Plan (CCMP)**. The MC's membership includes elected and appointed policy-making officials from the federal, state and local levels of government, government agencies, environmental groups, industry and the general public. The **Technical Advisory Committee (TAC)** is made up of scientists. Its role is to ensure that the Management Conference has the appropriate scientific and technical basis for decision making. **The Public Advisory Committee (PAC)** includes interested members of the public and provides guidance on educating, informing, and involving the public in SMBRP activities.

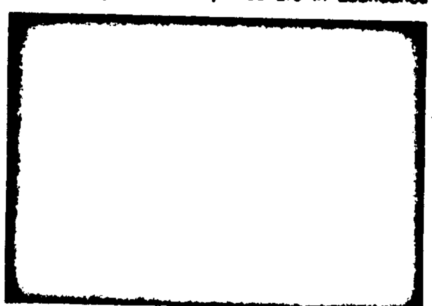
The CCMP, to be developed by 1994, will determine how Santa Monica Bay will be restored and protected. It will be based on scientific and technical information, as well as an assessment of the present regulatory programs designed to protect the Bay. Included in this document will be a series of Action Plans that will identify who should be responsible for implementing these programs and how they should be financed.

USES OF THE BAY

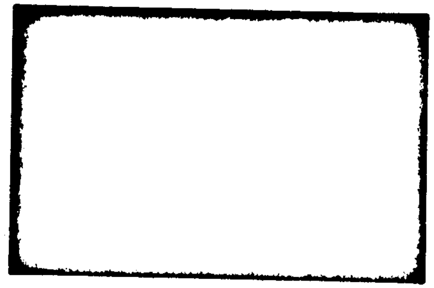
We are fortunate to live alongside one of America's greatest natural resources, the California coastline. The beaches are vast and the scenery is spectacular. In addition to the people who inhabit Los Angeles County, millions of tourists come from all over the world to enjoy this rich coastal area. While Santa Monica Bay is intensely utilized by the surrounding human population, it also supports a wide variety of marine life. All too often, these multiple uses have created conflict.

Habitats of the Bay

Santa Monica Bay is home to many types of fish and wildlife that live in the Bay's various habitats. The **pelagic**, or open-ocean community, is inhabited by marine life living in the water column such as schools of fish, plankton, whales migrating through the Bay and dolphins cruising up and down the coastline. Bird populations at Santa Monica Bay include shore birds such as willets and spotted sandpipers, and water birds such as the California brown pelican, least terns and gulls. Many of these species are in abundance



California brown pelican

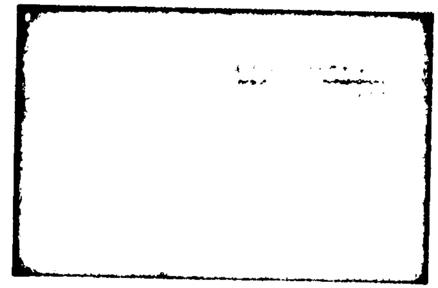


throughout the fall and winter when they arrive during their migrations, and scarce during the summer as they continue on their way. The **benthic**, or bottom-dwelling community, is made up of hundreds of plant, fish and invertebrate species such as crabs, clams, mussels, mollusks, sea urchins and sand dollars.

The remaining natural wetlands in Los Angeles County are salt and brackish marshes. These areas provide an essential natural habitat for migratory and resident birds. Fish and invertebrates use the wetlands for feeding, and many fish use the calm shallow waters as nurseries. The wetlands host a variety of vegetation, and the mudflats support many species of clams, snails and crabs.

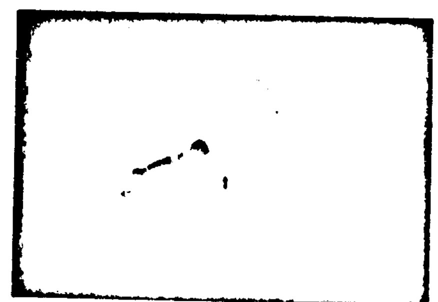
Recreational Activities

Santa Monica Bay is a playground for residents and tourists alike. At the beach, generations of surfers have skillfully maneuvered their surfboards on the swelling waves. People visit the beach to read, swim,



or ride their bicycles along the 21 miles of bike paths. Professional beach volleyball games are now world famous, and athletic competitions between lifeguards are an annual event. The marinas are busy with weekend sailors gently gliding across the Bay, mingling with the dolphins and sea birds. Santa Monica Bay finds many sport fishermen catching their evening meals off boats or from one of the six piers located on the Bay.

Santa Monica Bay offers a rare combination of outdoor excitement and relaxation, and millions each year crowd the beaches to take advantage.

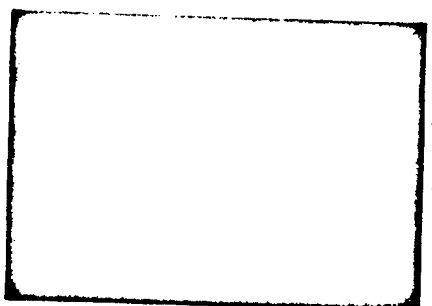


SOURCES OF POLLUTION

In addition to supporting an abundant marine life and providing a recreational wonderland, Santa Monica Bay has been used for other purposes which have led to its current degraded state. Numerous substances enter the waters of Santa Monica Bay. Some are harmless, but many damage the Bay's environment.

Municipal and Industrial Discharges

Six point sources directly discharge contaminants into Santa Monica Bay. Each day, two municipal sewage treatment plants discharge nearly 800 million gallons of treated wastewater from domestic, commercial and industrial sources into the Bay. This amount would fill the Los Angeles Coliseum almost twice each day. In the past, these treatment plants have contributed the greatest amounts of contaminants to the Bay. However, as source control, treatment technology and monitoring of discharges have improved, the concentration and amount of contaminants from these facilities have decreased substantially.



Sewage treatment facility

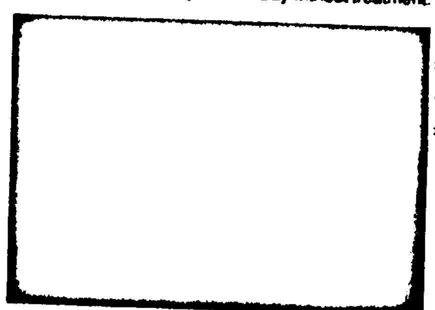
Hyperion Treatment Plant

Before their use was banned in the 1970s, the organic chemicals DDT and PCB were regularly discharged off the Palos Verdes Peninsula through the sewage system. These chemicals have caused extensive damage to the marine life, and we are still seeing the effects today.

Industrial sources of discharge include three electric power generating stations that use seawater to cool condensers and an oil refinery that discharges treated water from its manufacturing process into the Bay.

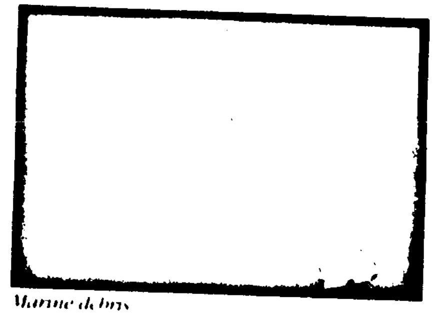
Storm Drain Runoff

With better control of municipal and industrial sewage treatment discharges, runoff from storm drains is now the pollution source of greatest concern. The storm drain system is separate from the sewer system. Although storm drains were created to prevent flooding, they also collect excess fertilizer, pesticides, litter, car washing water, animal and human waste, anti-freeze and motor oil. Approximately 60 storm drains carry these pollutants directly into the Bay without treatment.



Storm drain catch basin

Mary Sue Maurer



Marine debris

Center For Marine Conservation

During a major storm, the volume of untreated discharge can increase by up to 1000 times. These chemical pollutants and bacterial contaminants from storm drain runoff are of particular concern because they empty near the shoreline where swimmers and surfers gather.

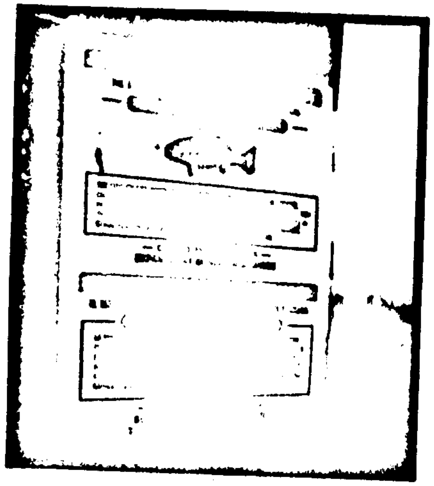
Non-point Sources

Other sources of pollution aside from municipal and industrial discharges and storm drains are called non-point sources. These include air pollution, legal and illegal ocean dumping, operation and maintenance of recreational and commercial vessels, natural crude oil seeps, marine debris and materials carried by ocean currents. Oil spills from nearby shipping lanes are another potential source of pollution.

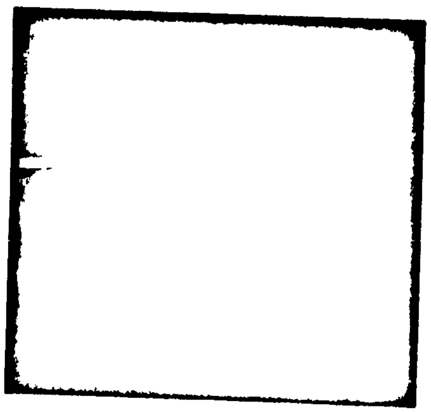
All of these different point and non-point sources of pollution have contributed to complex problems that the members of the Santa Monica Bay Restoration Project are working to solve.

AREAS OF CONCERN

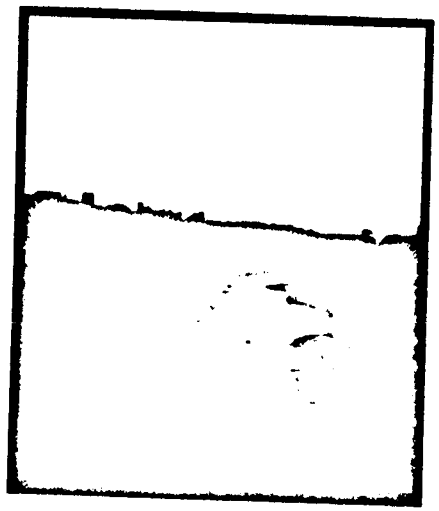
Pollution is impacting [illegible] in numerous ways. The [illegible] concentrations of DDT and PCB [illegible] ments, reports of [illegible] contaminated [illegible] and polluted storm drain runoff [illegible] to concern about human health [illegible] threats posed to the Bay's [illegible]. To address these problems, the SMBRP [illegible] the following areas of [illegible] Early Action Plan [illegible]. These areas include:



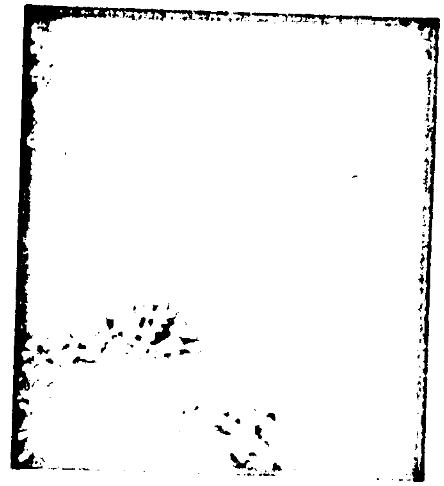
HUMAN HEALTH RISKS ASSOCIATED WITH EATING CONTAMINATED SEAFOOD



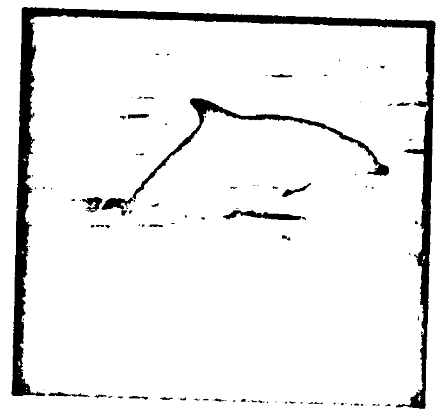
HUMAN HEALTH RISKS ASSOCIATED WITH DISEASE - CAUSING VIRUSES IN THE SURFZONE



LOSS AND DEGRADATION OF WETLANDS



IMPACT OF POLLUTION ON THE BENTHIC (BOTTOM-DWELLING) COMMUNITY



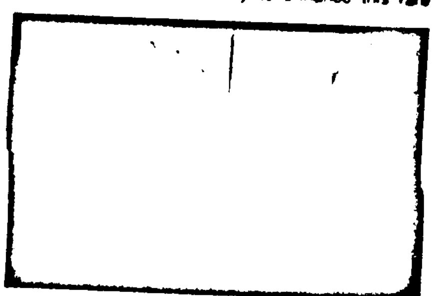
IMPACT OF POLLUTION ON THE PELAGIC (OPEN-OCEAN) COMMUNITY

EARLY ACTION PROJECTS

When completed the CCMP will include Action Plans that define a specific problem identify the cause or source and recommend possible solutions In the meantime the SMBRP has already taken a number of steps called **Early Action Projects** to address some of the areas of concern

Wetlands Restoration

One project involves revitalizing the 16-acre Ballona Lagoon wetlands. Ballona Lagoon is a natural tidal lagoon situated in the midst of an urban area. It lies parallel to the coastline of the Santa Monica Bay, forming a connection between the Marina del Rey boat channel and the Venice canals. In addition to providing habitat for many species of wildlife, the lagoon offers the public valuable opportunity for aesthetic, educational and recreational activities. Unfortunately, this rare aquatic ecosystem has suffered environmental harm with extensive damage to the native vegetation, the marine life of the mudflats, and the quality of its water. Plans are underway to enhance this rare remaining wetland, and the SMBRP is helping to implement those plans.



Sea hare at Ballona Lagoon

Urban Runoff – Early NPDES Permit Program

A milestone for the Project has been the development of a landmark storm water program tailored to the distinct structure and conditions of L.A. County and its 86 cities. After lengthy negotiations initiated by the SMBRP, L.A. County and cities were issued an unprecedented storm water discharge permit in June 1990. The County and 16 of 18 Santa Monica Bay watershed cities are included in the first phase of the program set forth in the National Pollutant Discharge Elimination System (NPDES) permit that requires local governments to begin controlling water pollution discharged from storm drains. The effort represents a significant accomplishment by regulatory and implementation agencies to address urban runoff.

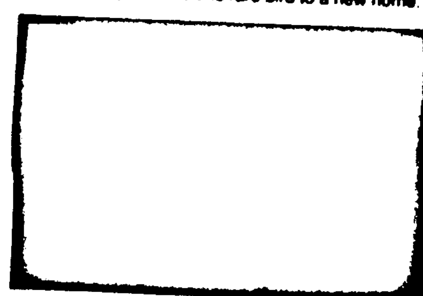
Urban Runoff – Ozonation Treatment Program

A pilot program being tested in the City of Santa Monica involves treatment of urban runoff from storm drains. The City has been treating the water with varying doses of ozone, a gas used to disinfect drinking water. Hopes are high that if the process is successful, a plant to treat the storm drain water will be constructed and the reclaimed water will be used to irrigate freeway landscapes.

Banding a newly hatched least tern chick

Least Tern Colony Project

A project to bring an endangered species back to the beaches is also in development. The least tern is an endangered water bird that once appeared in great numbers. Their nests were found in the white sandy beaches and dunes. Increased beach use destroyed the least terns' nesting grounds, and their population declined. Today, there is a breeding colony on Venice Beach, and a new site in Playa del Rey has been set aside by SMBRP to allow for expansion of the least tern population. With decoys and recorded mating calls, scientists hope to lure this rare bird to a new home.



Ozonation treatment facility

TECHNICAL STUDIES

The SMBRP continues to conduct studies to assess the Bay's pollution problems. This information will assist the SMBRP in developing programs that form the groundwork for the CCMP.

Environmental Monitoring and Data Management

Because there are as many as fourteen different governmental and private agencies conducting research in the Santa Monica Bay area, the SMBRP is designing a system to better monitor the marine environment in the Bay. This Monitoring and Data Management System will ultimately ensure that all information collected is beneficially used by all organizations involved in helping the Bay.

Sediment Dynamics

Historical deposits of DDT and PCBs off the Palos Verdes Peninsula are a cause for concern because of their potential effects on the ecosystem, marine food web, and humans (through consumption of contaminated seafood). However, cleaning up sediment contamination is extremely expensive, and considerable information is needed to develop viable and effective options for clean up.

In a first step, the SMBRP began studies aimed toward gaining a better understanding of sediment dynamics -- past and present levels of sediment contamination, patterns of sediment movement, and natural rates of burial and removal. In addition, a workshop was held with ten of the foremost experts in the field of sediment resuspension who recommended additional studies that would be necessary to develop restoration programs.

Mackerel, a popular sport fish

Human Health Risks Associated With Eating Seafood

High levels of DDT and PCBs still continue to work their way into the food chain. A Seafood Consumption Survey will identify the number and types of fish and shellfish being caught, and profile who is eating them. Combined with the Seafood Contamination Survey, these two studies will enable an assessment of health risks associated with eating contaminated seafood from the Bay.

Human Health Risks Associated With Pathogens

The goal of this long term study is to determine the relationship between storm drain runoff and illnesses in swimmers and surfers. The first phase of the study unexpectedly found disease-causing viruses (pathogens) in Santa Monica's Pico-Kenter storm drain. The second phase of the study will develop techniques for locating the sources of the viruses.

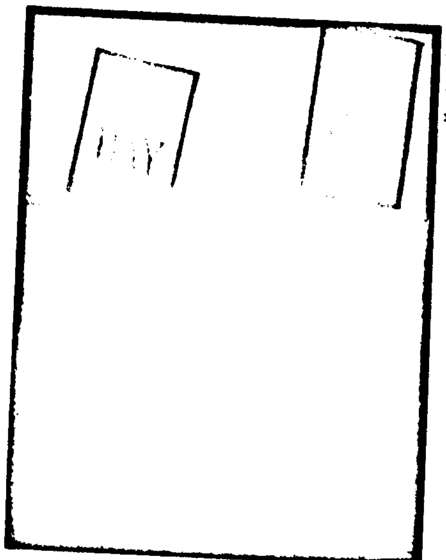
Posted signs warn swimmers when there are unhealthy conditions in the water near storm drains. The County Department of Health advises against ocean swimming for two days after a rainstorm due to the heavily polluted runoff that flows through storm drains into the Bay.

PUBLIC INVOLVEMENT ACTIVITIES

Informing the public of the Bay's problems and encouraging community involvement in possible solutions are crucial if we are to successfully restore and protect this prized natural resource for future generations. During 1990, SMBRP planned special activities to inform, educate and involve the public in the progress being made to clean up the Bay.

Earth Day 1990

On Earth Day 1990, SMBRP, with the help of the Teenage Mutant Ninja Turtles, kicked off a campaign to educate the public about storm drain misuse. The creators of the Turtles designed an original, eight-page "Storm Drain Savers" comic book exclusively for the SMBRP. The comic books, along with a special appearance by the Turtles, generated an incredible amount of excitement at Los Angeles County Earth Day events, where more than 40,000 copies of the booklet were distributed.



Teenage Mutant Ninja Turtles support storm drain education

Storm Drain Savers

Coastal Cleanup Day

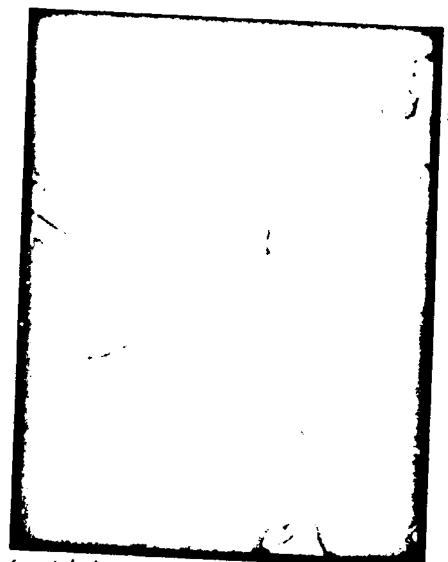
Thousands of Los Angeles County residents flocked to the beaches in September to pick up debris and learn about marine pollution. This statewide program was sponsored locally by SMBRP in conjunction with Los Angeles County Department of Beaches and Harbors and Heal the Bay. The cleanup resulted in the collection of 12,000 pounds of trash and 3,000 pounds of recyclable material! The debris collected was documented on data cards so that the origin of the pollution could be determined and stopped.

Health Risks Study Release

When a SMBRP study unexpectedly found disease-causing viruses (pathogens) in the Pico-Kenter storm drain in Santa Monica, the information was quickly released to the public. The SMBRP will release new information about its studies to keep the public as informed as possible about developments related to the Bay.

Public Advisory Committee Meetings

People who are interested in learning more about SMBRP's agenda or want to get involved in finding solutions to Santa Monica Bay's environmental problems are invited to attend the monthly meetings of the Public Advisory Committee.



Coastal Cleanup volunteer documenting collected trash

WHAT'S NEXT?

The Santa Monica Bay Restoration Project has many things to accomplish in the near future. As this report makes clear, the Project's major focus for the coming year is the development of the Comprehensive Conservation and Management Plan (CCMP).

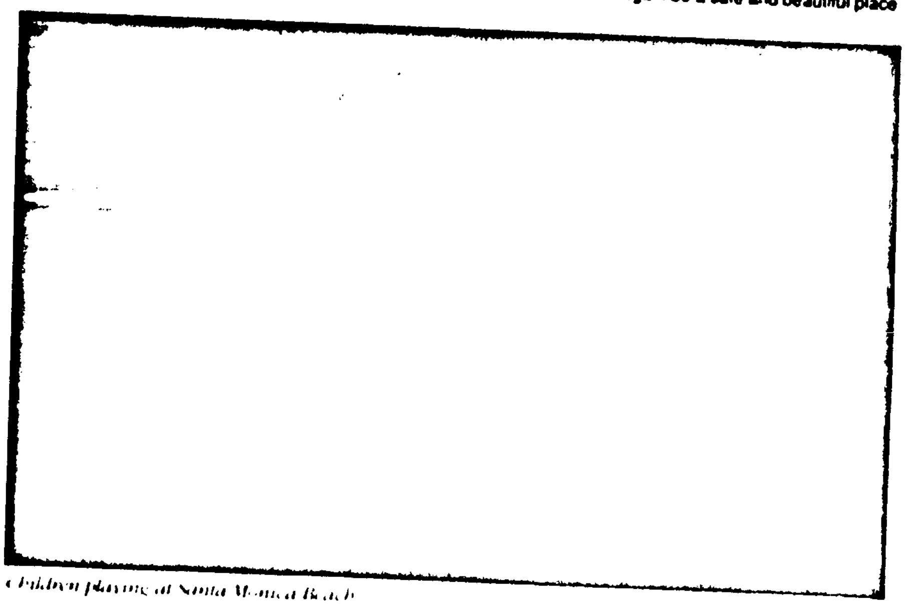
To develop a successful plan, however, requires the involvement and support of those who will be responsible for carrying out the CCMP's various Action Plans — the members of the Management Committee, Technical Advisory Committee, Public Advisory Committee and the general public. To more actively involve these crucial players, the Project will be entering a new phase, focusing its efforts on the newly formed CCMP subcommittees and on an expanded public involvement program.

The job of the subcommittees will be to focus on specific components of the CCMP. They will examine the management and policy issues relevant to those components and recommend options for action. In this way the SMBRP will be able to channel the activity into the hands of those who possess the particular expertise and who, eventually, will be responsible for implementation. To date, subcommittees have been established to address point sources, non-point sources, wetlands, marine habitats and watershed management issues.

In expanding its public involvement and information activities, the SMBRP will endeavor to generate greater public awareness and support for the CCMP and other Project activities.

A recent development that promises future benefits is the establishment of the Santa Monica Bay Restoration Foundation. The Foundation, a non-profit corporation, is an independent fund-raising vehicle that allows the Project to accept and distribute funds received from cities, counties, special districts, private foundations and industry. These funds are for use in research projects, planning, and implementation activities that complement CCMP development.

Although the Santa Monica Bay Restoration Project has made progress in identifying solutions for Santa Monica Bay's environmental problems, its success in protecting this coastal area and its living resources will be realized in the future. Accompanying the full implementation of the CCMP will be a revitalized, thriving Santa Monica Bay. This area, around which we and so many other creatures make our homes, will once again be a safe and beautiful place.



Children playing at Santa Monica Beach

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Santa Monica
BAY
Restoration

Santa Monica Bay Restoration Project
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Heal the Bay

1993
State of the Marina Report
Marina del Rey

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Heal the Bay's State of the Marina Report Marina del Rey

July 9, 1993

Prepared by:

Roger Gorke
Aimée Bower

With technical review
by Mark Gold

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Heal the Bay: Who We are

Heal the Bay is a non-profit environmental organization working through a variety of research, education, public outreach, and advocacy programs to make Santa Monica Bay and Southern California beaches safe and healthy again for people and marine life. We do this by educating the media, the public and our elected officials about sources of pollution and possible remedies; monitoring government to ensure that the law is enforced; intervening legally when necessary; and helping set the standards for the future of our Bay. Our goals include: reducing the flow and toxicity of storm drain waters; pressuring the County of Los Angeles to meet the sewage treatment standards of the Clean Water Act; helping to develop permanent household hazardous waste dropoff sites; and initiating an innovative environmental education program throughout Southern California schools.

The State of the Marina
Marina del Rey

I. Introduction

Urban Los Angeles is home to the largest man-made marina in the world, Marina del Rey (MDR), which has over 6,000 boat slips, over 30 restaurants and is home to nearly 11,000 residents. Marina del Rey is a valuable resource to the variety of recreational boaters, bathers and tourists who visit each year. It is also an important source of revenue for Los Angeles County and many local businesses as the Marina generates an estimated $1.4 billion per year (Rabin, 1992). In addition, MDR is an important habitat for marine life as it functions as a shallow water habitat for fish eggs, larvae and young adults. The Marina's value as a nursery is especially important because over ninety percent of the coastal wetlands in the Los Angeles area have been lost because of urban development (Soule et al. 1992).

The area's large commercial and recreational use, along with the continual input of urban runoff from adjacent storm drains, has impacted the Marina's ecological health. The extent of the Marina's pollution goes far beyond the trash and oily sheen commonly seen floating on the water's surface. Toxic sediments from Ballona Creek have accumulated (shoaled) at the mouth of MDR, creating navigational problems and reducing tidal flushing. Divers responsible for boat maintenance complain about severe water pollution caused by illegal discharges from vessel holding tanks (Butler per. comm. 1993) and from input from the Oxford Street flood control basin. Equally disturbing are the strikingly high indicator bacteria counts found in parts of the marina which have been responsible for historic closures of the popular bathing area, Mother's Beach.

Because the public is unaware of the Marina's pollution problems, and the lack of public attention focused on them, Heal the Bay's State of the Marina report was produced to raise awareness of environmental problems at the Marina and provide the public and County decision makers with recommendations on pollution prevention and disposal. The report is intended to augment the momentum created by the recent Santa Monica Bay Restoration Project/Center for Marine Conservation "Boaters for the Bay" conference to clean up pollution problems in the Marina. Heal the Bay's position is that, with the proper attention and action, the condition of Marina del Rey can be improved so that it is not one of the most polluted areas in the southern California Bight. The National Oceanic and Atmospheric Administration has stated that "the most contaminated sites for sediment, mussels, and fish [in the southern California Bight] have occurred in bays and harbors." (Mearns et al. 1991)

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II. BACKGROUND

The Marina was constructed between 1960 and 1962 on the site of the degraded Ballona Wetlands. Prior to the 1920's, runoff from most of the Los Angeles basin flowed into the Ballona wetlands through Ballona Creek. The wetlands served as flood control and water purification for runoff until Ballona Creek was concreted and channeled for stormwater control along with the other major rivers in southern California in the 1930's. The wetlands were gradually degraded as they were filled and drained for use as farmland, oil and gas fields, and industrial development.

In 1954, construction of MDR became an authorized federal project. The $40 million cost of construction (Fawcett per comm. 1993) was split between the federal government and the County of Los Angeles. Local funds were raised through a statewide bond issue. Today it is maintained and funded primarily by the Los Angeles County Department of Beaches and Harbors, although periodic dredging is performed by the Army Corps of Engineers. The Department of Beaches and Harbors and Army Corps must comply with the dredge disposal requirements of various regulatory agencies including the Environmental Protection Agency (EPA), California Coastal Commission and the Regional Water Quality Control Board.

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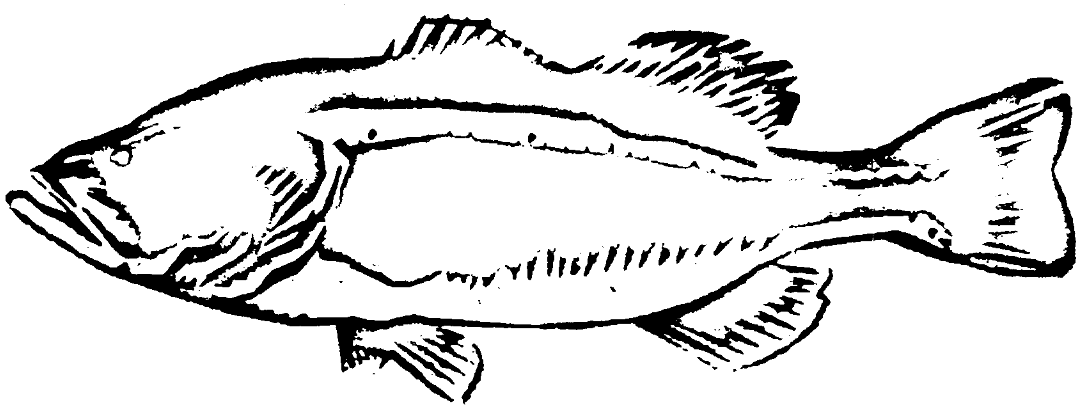


III. Pollution Problems

The ecology, and water and sediment quality of Marina del Rey have been studied since the mid 1970's by marine scientists at the University of Southern California (USC). Since 1985, the Department of Beaches and Harbors has spent an average of $158,000 per year on a monitoring program to determine the pollution levels and marine organism toxicity of the water and sediments. This program has been conducted by USC's Hancock Institute for Marine Studies by Drs. Dorothy Soule, Mikihiko Oguri and Burton H. Jones. Key findings from the Hancock Institute's studies are discussed below. The National Oceanic and Atmospheric Administration (NOAA) has also compiled data on the entire southern California Bight, including Marina del Rey (Mearns et. al. 1991).

Sediment Quality

The Soule-Oguri studies indicate that there have been high levels of a variety of toxic contaminants in the Marina over the past several years. These contaminants include heavy metals such as copper, lead, zinc, and mercury, as well as organic compounds including chlordane, PCB's and DDT. Although specific guidelines regulating sediment contamination have not yet been established by the U.S. Environmental Protection Agency (EPA) or the State Water Resources Control Board, NOAA suggests using certain general sediment quality criteria: low and medium effects level guidelines (ER-L and ER-M respectively). These criteria are based on the levels of contaminants that are high enough to cause detrimental effects in marine life. Soule and Oguri have found that the most chronically contaminated sediments in the Marina are located in its inner recesses, specifically basins D, E and F and the area near Oxford Basin (see figures). Although no tests have been completed that demonstrate a direct linkage between any particular metal or contaminant and its effects on the Marina's benthic (bottom dwelling) population of marine animals, laboratory sediment tests have shown that these contaminants above ER-L and ER-M levels have chronic (but not lethal) inhibitory effects on certain species (Soule et al. 1992).

Chlordane and DDT are highly toxic pesticides that have been banned from manufacture; however, chlordane has not been banned from use. Levels of DDT exceeded the NOAA ER-L of 1 ppb (parts per billion) at most stations in the 1991 - 1992 study period. Chlordane levels exceeded NOAA ER-L and ER-M throughout the entire Marina with the highest concentrations at the entrance to the Marina and at the Oxford Basin. In 1991, the range of levels of contamination ranged from less than 10 ppb to 360 ppb. The ER-L and ER-M for chlordane are 0.5 and 6 ppb respectively (see figures in this report).

In 1991, levels of PCBs were considerably higher than in past years of sampling, but they returned to background levels in 1992. The most probable reason for this sudden PCB spike was runoff from a large construction site located just east of MDR and adjacent to the Oxford flood control basin. There were also high concentrations of PCBs near the mouth of the main channel. The source of these PCBs in the main channel is uncertain because levels of PCBs in Ballona Creek, a large source of contaminated sediments, were not as elevated as the sediments at the Marina's entrance. PCB concentrations are now below the level of detection for most of the Marina (see figures).

Marina sediments also are contaminated with various heavy metals. The most significant contamination problem is with lead. All stations within the Marina, except in the main channel, were above the NOAA ER-L of 35 ppm for lead. Levels of lead, 1040 ppm, found by Army Corps consultants near the terminus of Ballona Creek were above levels considered hazardous waste (1000 ppm, State of California, Code of Regulations, Title 22). Levels of lead in Oxford basin were the highest within the Marina at 487 ppm in 1991 (Soule et al. 1993) (see figures).

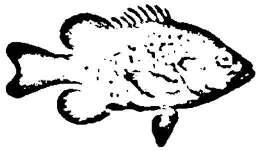
Zinc has remained high throughout the study period which began in 1978, with an upward trend in contaminant level. The entire Marina is above the NOAA ER-L level with approximately 1/3 of the sampling locations above the ER-M of 270 ppm (Soule et al. 1992). High levels of lead and zinc in sediments are often found near areas of high automobile use. The probable source of lead and zinc in the Marina's sediments is the storm drain system (see figures).

Tributyltin (TBT) was used in anti-fouling paints to prevent biological growth on boat hulls until 1988 when it was banned for use on most boats. Since then, TBT in MDR sediments has decreased by three orders of magnitude from a peak of 1070 ppm in 1987 to between 0.4 and 0.53 ppm (Soule, p. vi). The active ingredient now commonly used in anti-fouling paints is copper. Copper levels in the 1991-1992 survey increased to the highest levels of the past seven years. The rise in copper levels has probably occurred because of the ban on TBT as an anti-fouling agent. Approximately 1/2 of the sampling locations were above the NOAA ER-L level of 70 ppm (Soule et al. 1992) (see figures).

Mercury and nickel have not shown any trend toward reduction or increase. They do persist in concentrations that have low range effects at some sampling locations.

The other metals of concern, chromium, cadmium and arsenic, are not in sufficient concentrations to pose any low range effects on marine organisms throughout the Marina.

Impacts on Marine Life



MDR is an important marine resource because it serves as a habitat for several wetland fish species and as a nursery for several juvenile fish species, such as halibut. The swimming beach in Basin D, also know as Mother's Beach, has a gentle, sloping, soft substrate that is otherwise not present in Marina del Rey or in other local recreational harbors. Basin D used to be home to sea grass beds that offered a refuge for species such as the California killifish, the staghorn sculpin, and the brown smoothhound. The most probable cause of the recent disappearing grass beds was an influx of pollutants or smothering caused by fine sediments washed in from storm water (Soule per. comm. 1993). Studies currently underway suggest that the grass beds are recovering because the fine sediments have recently washed away (Soule per. comm. 1993). Other wetland species fish in the Marina include the yellowfin goby, the deepbody anchovy and the California needlefish (Stephans et al. 1991). The number of fish species and total abundance of fish have remained relatively unchanged over the last fifteen years.

Although studies have shown that fish muscle tissue caught in this area is safe for human consumption, they have also shown that the concentrations of chlorinated organic contaminants in liver and gonads are high enough to impair liver and reproductive functions in these fish species (Soule et al. 1992).

Studies of the marine benthic (bottom dwelling) population demonstrate that the Marina's pollution problems are having adverse effects on the marine invertebrates, as both the species diversity and the total abundance were lower in 1989-1991 than the long-term mean from 1976 to 1992. In 1991, the benthic population density was at an all time low at Station 6, and was fifty percent below the lowest previous records at Station 8 and Station 10. The loss of sea grass beds and the influx of pollutants has had detrimental effects on populations of both benthic and fish species. The primary benthic species found in the Marina is a type of nematode worm (round worm), which can tolerate contaminants, while other groups of organisms which are commonly found locally in healthy benthic communities, such as crustaceans and molluscs, are scarce. Although the abundances of molluscs and crustaceans still remain low, their appearance in new areas is a sign that the bans on TBT and the cessation of the PCB contamination are having beneficial effects on benthic populations (Soule et al. 1992).

Water Quality

Several indicators useful in assessing the quality of water for recreational contact and for adequate marine life survival are discussed below.

1. Dissolved Oxygen

The amount of dissolved oxygen (DO) in water is an indication of the suitability of the water to support aquatic life. Because DO is used to decompose organic material, low levels of DO, below five parts per million (ppm), suggest the presence of large amounts of organic matter and poor tidal circulation in the Marina. Organic matter can come from dead sea life (plants and animals), vessel holding tanks, or outside sources, such as storm drains.

The levels of DO along California's coast range from 6.0 to 8.5 parts per million (ppm). However, levels of DO often fall below the regulatory agencies' minimum level of five ppm for survival of fish species at some stations in the Marina (Soule et al. 1992). The most recent data demonstrates that DO levels were higher in 1992. There are many species of invertebrates that can survive very low levels of DO down to the point of anoxia (without oxygen). DO levels are typically higher in the fall and winter and lower in the spring and summer. The areas of the Marina most prone to low DO are the inner recesses, which do not have adequate flushing and are subject to input from storm drains. Specifically, E basin, where the Oxford Street flood control basin discharges, and the mouth of Ballona Creek have had DO problems. Soule and Oguri also found that biological oxygen demand (BOD), an indicator of the amount of organic degradable material in the water, was highest in the inner recesses of the Marina.

2. Nutrients

The amount of ammonia nitrogen and phosphorus are other indicators of water quality. High levels of ammonia-N and phosphorus can lead to algal blooms, eutrophication (high nutrient levels leading to algal overgrowth), and low DO levels in both fresh and marine waters.

Areas of high nutrient levels correspond with areas of low DO and high BOD. These areas are located at the terminus of each basin, near storm drain outlets and at the furthest distances from the main channel. Levels of ammonia-N in the main channel were not significantly higher than levels commonly found in the open ocean (Soule et al. 1992).

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3. Bacteriology

Certain types of bacteria, called indicator bacteria, are useful in assessing the presence of pathogenic microbes which can cause infection and disease. According to the Soule-Oguri studies, there have been numerous violations of State Ocean Plan standards for indicator bacteria in the Marina over the last several years. Also, the Los Angeles County Department of Health Services weekly indicator monitoring program demonstrates that the most significant source of bacterial contamination appears to be from stormwater runoff as the entire Marina exceeds their Health Warning and Beach Closure Protocol bacterial objectives for beach closures during wet weather. The area known as Mother's Beach received a "D" grade in 1989, an "F" grade in 1990 and an "F" grade in 1991 during wet weather, according to Heal the Bay's Annual Beach Pollution Report Cards. Mother's Beach "improved" to a F, C & C, during dry weather in 1989, 1990, and 1991 respectively. The data used for these reports was data obtained directly from the Department of Health Services. Despite the history of bacterial contamination, the Department of Health Services and the Los Angeles County Department of Beaches and Harbors have kept Mother's Beach open to swimmers. Another source of bacterial contamination may be illegal discharges of vessel holding tanks.

Although violations in 1992 were reduced from the 1990-1991 study period, the Oxford Street flood control basin was almost always contaminated with high bacteria counts. High bacteria counts primarily occurred during or after rainy weather, and stations near Ballona Creek and near the Oxford Street flood control channel continued to have the most violations (Soule-Oguri, 1992).

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IV. Dredging

Adequate tidal circulation is mandatory for the Marina's health because it mitigates the effects of pollution by continually washing out pollutants and washing in new oxygenated ocean water. When there is not adequate circulation, contaminants build up and water quality deteriorates within the Marina as demonstrated by the pollutant hot spots at the inner recesses of the Marina.

When the Marina was developed in the early sixties, engineers erred by constructing the Marina directly adjacent to Ballona Creek, the largest source of nearshore pollution to the Santa Monica Bay. The Creek has an average dry weather flow of over 15 million gallons per day. During wet weather, Ballona Creek's flow can exceed ten billion gallons per day. The sediments that are discharged by Ballona Creek accumulate (shoal) at the entrance to the Marina because the

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breakwater in front of both the main channel and the storm drain slows down stormwater flow enough to cause sediments to settle on the Marina floor. In addition to reducing tidal circulation, these sediments interfere with navigation. To reduce the buildup, regular maintenance dredging of MDR is necessary. The Army Corps is responsible for dredging the Marina to keep the channels of the marina navigable and to allow adequate tidal flushing.

Before dredging, the Army Corps must have the sediment tested for contaminant levels and toxicity. The results of these tests, along with suggested methods for sediment disposal, are then sent to the EPA for approval. If the sediments are considered 'safe,' they can be used for beach replenishment, or can be disposed of at an offshore dump site over six miles southwest of the Palos Verdes peninsula. If the EPA determines that the sediments are toxic, they must be treated as such and disposed of appropriately in an environmentally responsible manner.

The tests performed on Marina sediment from around the south jetty have caused a very high bioaccumulation of lead and chlordane in the tissues of two test animals (worms and clams), indicating high levels of biologically available contaminants in the sediment. The potential biological impacts of such contaminants raises the question of what should be done with the sediment after dredging. The typical methods of disposal, such as ocean disposal and beach replenishment, are not appropriate or environmentally responsible, but the treatment of the sediment and its responsible disposal is extremely costly. Because of the numerous advantages and disadvantages of the various options, the subject of dredging has become controversial, and long term management decisions regarding the fate of dredge spoils have been postponed.

As the sediment disposal controversy continued, the south entrance of the Marina approached 70 percent closure in 1992. The Department of Beaches and Harbors asked for and received permission to implement a temporary emergency "knockdown" in the summer. This meant that instead of removing the accumulated sediments, a contractor leveled the shoaled material from the south jetty to the terminus of Ballona Creek. Although a myriad of potential environmental problems associated with the knockdown (the possibility of increased turbidity, smothering of benthic organisms, a reduced visibility for visual feeders such as terns, and biological problems caused by resuspension of contaminated sediments) never materialized because of the use of an innovative, enclosed knockdown technique, the success was overshadowed by the practical problems of the operation. Within months after the knockdown was performed, a barrage of storms caused the reaccumulation of sediment and shoaling problems at the Marina entrance. The $400 thousand spent on the knockdown provided at best a three-month solution to tidal circulation and navigational problems. This expenditure demonstrates the great need for a long term solution to the shoaling problem at the mouth of MDR.

V. Los Angeles County Responsibilities

Marina del Rey is the largest source of non-tax income for all of Los Angeles County. The Marina generates an annual income of approximately $25 million dollars for the County, most of which comes from percentages of boat slip fees, office and apartment rentals, and restaurant receipts (Smith, per comm. 1991). Despite the large revenues the Marina generates, little money is reinvested in the Marina, and a very small fraction of that is spent on actual operations and maintenance costs. Only a little over two percent of the total revenues generated by the Marina, $600,000 is set aside for major maintenance; the rest goes to L.A. County's general fund.

With extensive contaminated sediment problems, poor tidal flushing, and frequently sighted marine floating debris, Heal the Bay contends that $600,000 is not sufficient to properly maintain the Marina, which has resulted in its degradation. For example, there is a question about claimed maintenance for which there is little visible evidence. The Department of Beaches and Harbors operates a debris skimming boat that is responsible for picking up any floating trash or debris in the main channels of the Marina. Heal the Bay has been informed that the Department of Beaches and Harbors performs debris skimming five days a week; however, sources from the boating community have repeatedly stated that they have rarely seen this boat functioning. Boating groups, such as the Pioneer Skippers are beginning to form coalitions that will retrieve trash that has accumulated in the inner recesses of each basin.

VI. RECOMMENDATIONS

Indisputably, there is a significant pollution problem in the Marina. Although part of the problem is caused by factors which are difficult to control, such as contaminants from the Oxford Street flood control channel and the Ballona Creek storm drain, an effort must be made to improve the water quality and restore the marine habitat of MDR. There are actions that the County and Marina users can take that will, if properly implemented and stringently followed, significantly reduce the pollution problem in the Marina. The recommendations below came from the Center for Marine Conservation, San Diego's Environmental Health Coalition, the EPA, local boating groups, Sound Watch: An Environmental Guide for Boaters, and Heal the Bay staff. In order to expedite the enhancement process, Heal the Bay makes the following recommendations:

General Recommendations:

The most significant sources of pollution to the Marina are the Oxford Street flood control basin, urban run-off from nearby streets and the Ballona Creek storm drain. These sources are responsible for many of the contaminants present in the Marina, including toxic sediments and organic matter. The pollution within the Marina will persist if there is not a long-term plan to reduce the influx of contaminants from these sources. Because of the high value of the Marina for commercial and recreational uses and the Marina's important biological function as a shallow water habitat, it should be targeted for an intensive, Marina specific, County stormwater management effort designed to reduce the amount of pollution in urban runoff. Plans should include full compliance by the County of Los Angeles and all other co-permittee cities in the Ballona Creek watershed under the National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit. The NPDES permit is designed to reduce the flow and pollutant loads of stormwater urban runoff. The County has begun stenciling catch basins in the Marina area with the "No Dumping-This Drains to Ocean" logo. All recommendations of the County's Ballona Creek Task Force should be implemented as soon as possible.

Another possibility that needs serious long term consideration is the reconfiguration of the entrance to MDR or Ballona Creek. Reconfiguration is needed to reduce the deposition of contaminated sediments from Ballona Creek at the mouth of the Marina. A short term solution to the problem would be to implement a regular sediment removal program in Ballona Creek before the rainy season.

Strongly support Senate Bill 1084, (Calderon, Los Angeles). The bill will continue funding the State's Bay protection and Toxic Cleanup Act. SB 1084 will enable the State Water Board to identify, characterize, priority rank and develop remediation plans for toxic hot spots like Marina del Rey.

County:

The County should impose an Environmental Protection Fee that would pay for more pumpouts, hazardous waste facilities and maintenance of these facilities. This fee does not have to be onerous. A modest five dollars per month would raise approximately $350,000 for environmental protection within MDR. The five dollars could come from existing slips fees if the money was categorically designated or funds could come from a new environmental surcharge to existing slip fees.

Clearly labeled recycling containers with lids are needed at each dock to reduce the possibility of illegal trash disposal and to encourage recycling of at least plastics, aluminum and glass. Under the International Marine Pollution Treaty (MARPOL ANNEX V) and the U.S. legislation that implements this treaty in our waters, it is illegal to dispose of plastic anywhere in the waters of the United States. It is also illegal to dispose of any garbage from vessels within 3 miles of shore.

A program (permanent facility or periodic household hazardous waste roundups) for responsible disposal of the many hazardous materials used in boat maintenance (such as anti-fouling paint, motor oil, antifreeze and batteries) is desperately needed to reduce the temptation of illegal dumping and improper disposal. A permanent used motor oil disposal facility is needed to provide boaters and Marina workers a safe, convenient and inexpensive place for oil disposal. Some opposition has suggested that use of an underground tank as a disposal facility may result in a spill, but the possible advantages far outweigh the threat. Santa Barbara has a used motor oil tank that has been successfully and safely utilized for oil disposal since 1990.

The Department of Beaches and Harbors needs to publicize the recently installed public holding tank pump out facility, as illegal discharges may be a significant source of pollution to the Marina. Adequate pumpout facilities are not available in MDR. EPA recommends one pumpout facility for every 300 boats: equivalent to over 20 pumpouts in MDR. Disposal facilities for portable toilets are also needed.

Other businesses that operate in the Marina should be targeted for education on pollution problems. Although there has not been an inspection program, restaurants and charter boat services may contribute significant amounts of pollution to areas within MDR by improper food and septic waste disposal.

The Harbor Master should be given the authority to spot inspect any vessel for illegal discharges of holding tanks and adequate numbers of life preservers.

Heal the Bay believes Mother's Beach should be closed for recreational swimming. For years, this stretch of beach has repeatedly been in violation of the Department of Health Services beach closure and health warning objectives for indicator bacteria. A bathing beach in close proximity to so many sources of pollution puts swimmers at a potential health risk. At a minimum, the beach should be permanently posted with large health warning signs.

The Los Angeles County Department of Beaches and Harbors should reinstate their quarterly newsletter to educate and inform all slip lessees about using the Marina in an environmentally responsible manner. The Pioneer Skippers, a local association of boaters, have graciously offered to publish this newsletter which would provide regular public education to Marina users.

Each time a boater renews his or her slip lease, the boater should have to pass a simple test that is similar to a driver's license test. Any new lessee should take an education class consisting of lessons on general boater safety, Marina rules and regulations, and environmental concerns (especially advising boaters about the vessel holding tank pumpout and anti-fouling techniques).

Although there's never been a demonstrated significant problem, dye tablets should be placed in every vessel equipped with a holding tank as a precautionary measure to catch illegal dumpers. The dye tablets are a cost-effective way (seven and one-half cents per tablet) to identify any leaking holding tanks or illegal discharges. This technique is recommended in EPA's Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters to deter illegal discharges and has been successfully used in Avalon harbor on Santa Catalina Island. Each dockmaster would be responsible for his or her own anchorage (responsibilities would include passing out dye tablets, periodic inspections, etc.), thereby reducing the staffing needs of the County.

Automatic shut-off valves should be placed on fuel pumps at fueling docks in the Marina. Boaters should be encouraged to install devices that would prevent overflows of their tanks and signal when the tank is full. Moreover, fueling should only be done by trained fuel dock employees. Over-filling and spillage are a common occurrence during boat refueling at the fuel docks as demonstrated by the often reported hydrocarbon sheen that extends from the fuel docks across the main channel.

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Boaters

When scraping or preparing the hull of a boat for painting or varnishing occurs over water, a tarp should be affixed to the hull to trap any debris. The debris from the tarp should be collected and disposed of properly before the tarp is removed.

Oil absorbent towels should be placed under the engine to prevent oil from dripping into the bilge water. These towels are very inexpensive ($1.50) and will greatly reduce the amount of oil in bilge water. Any bilge water possessing a sheen should not be discharged into surface waters. Oil-absorbent materials should be placed in the bilge to soak up oily bilge water if there is any sign of an oil sheen on the bilge water surface. Oil, bilge and absorbent should either be placed in a shoreside bilge collection system or removed by a private bilge collection vendor. Keeping oil out of bilge water will also reduce the chance of an on board fire.

Boaters should minimize the use of toxic chemicals for cleaning their vessels and should use safe substitutes whenever possible.

A pamphlet on methods for keeping boats bottoms clean should be developed and distributed to each boater. The pamphlet should include information on the paints that are the most environmentally sensitive and it should offer methods of removing slime and barnacles from hulls. This type of information would be ideal for the reinstated quarterly newsletter.

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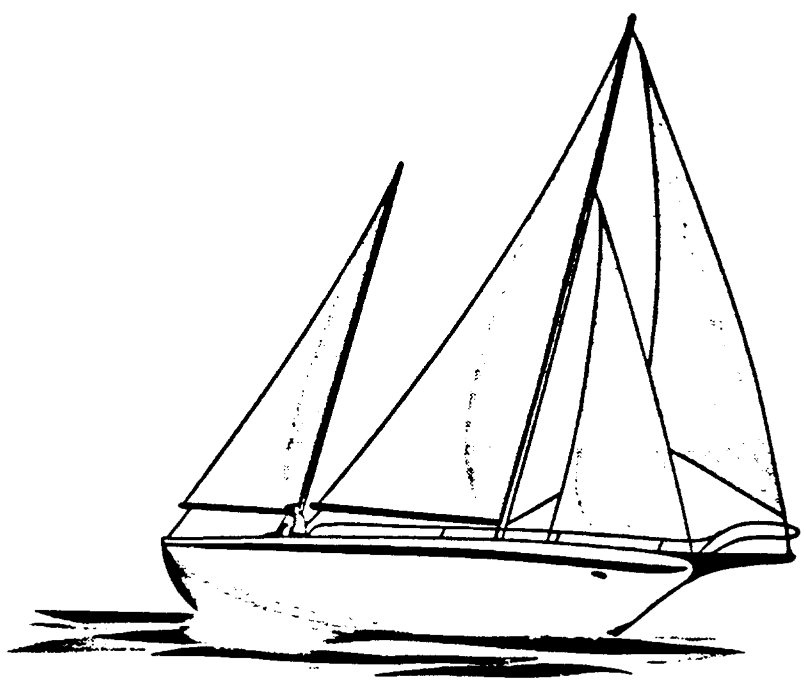
VII. Conclusion

Marina del Rey is more than just a recreational harbor. As a refuge and nursery for fish in Santa Monica Bay and a large source of income and jobs for Los Angeles County, more funds and Best Management Practices (proven management techniques for pollution reduction) are needed to enhance and protect this valuable resource. Soule and Oguri's yearly monitoring reports indicate that the quality of water in the Marina is vital to the survival of many aquatic species and is slowly beginning to improve. Although this is encouraging news, significant pollution problems still exist and need to be remedied. Successful Marina enhancement and protection only will occur with the help and cooperation of all stakeholders in the quality of the resource; the County, boaters, the Army Corps of Engineers, the local business community, and all those who value the Marina as a recreational and biological resource. Heal the Bay will push for rapid implementation of the report's recommendations in the coming months. Heal the Bay has offered solutions to the Marina's pollution problems. Now it is up to everyone in the region to make Marina del Rey clean and healthy for people and marine life.



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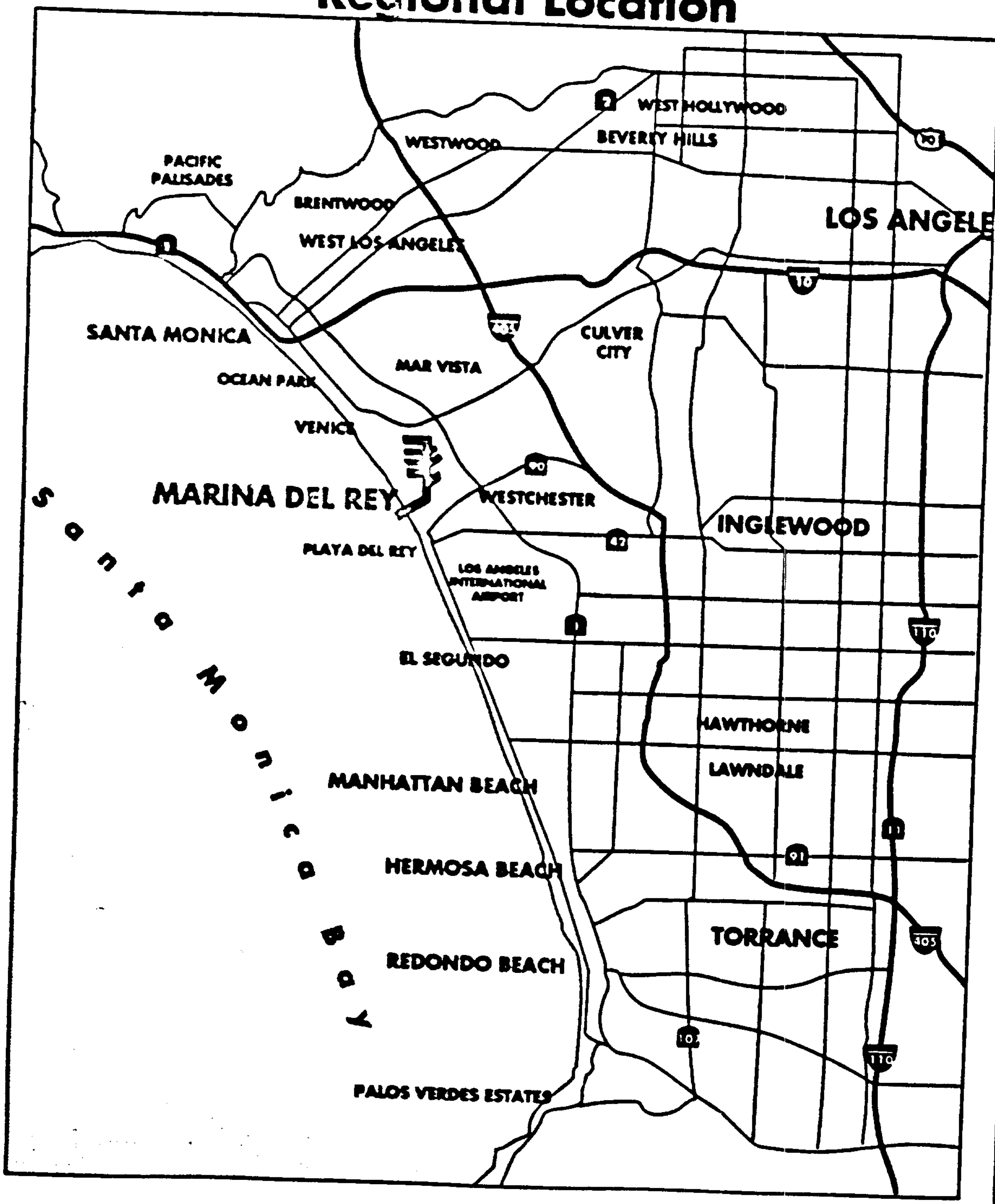
Regional Location



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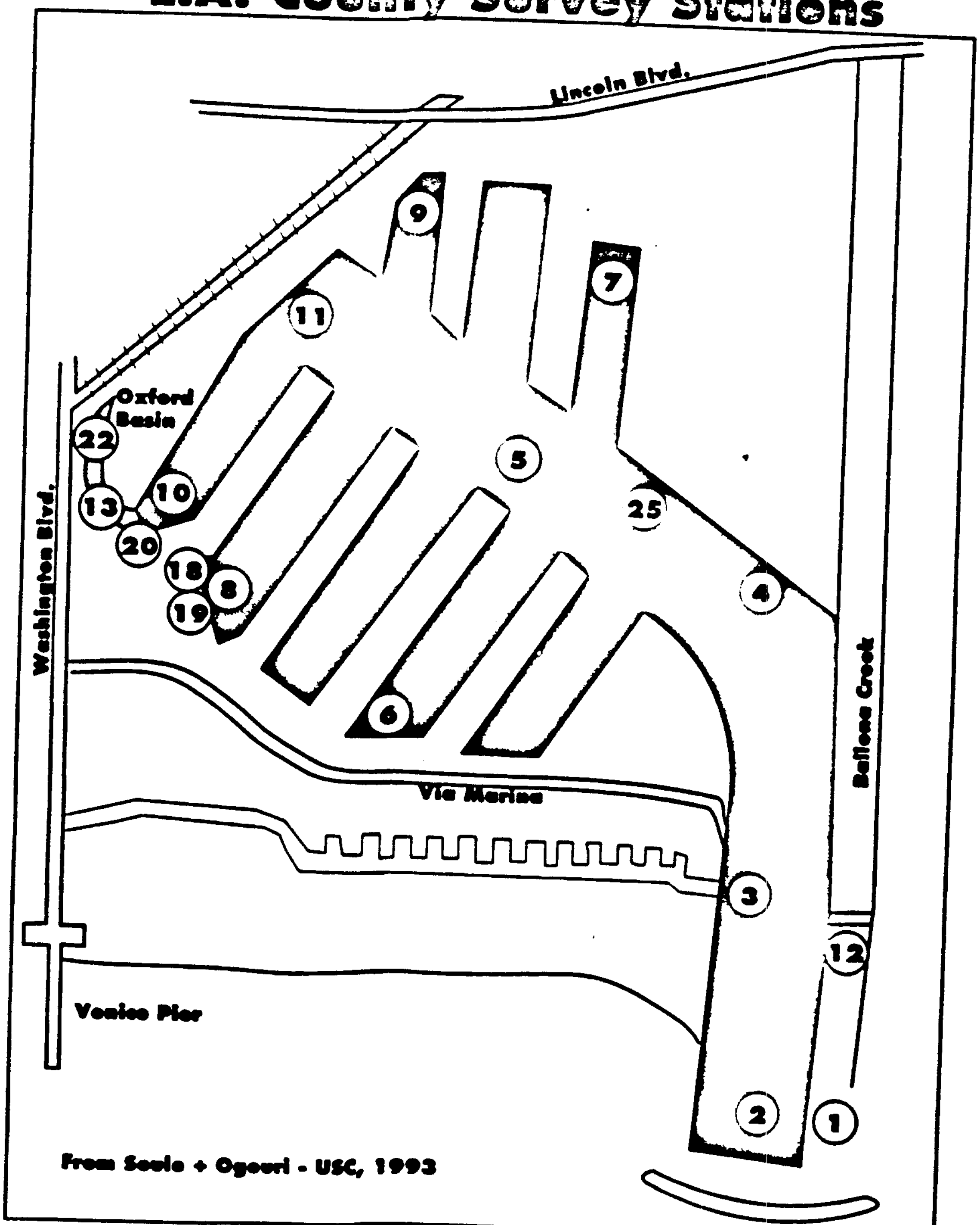
L.A. County Survey Stations



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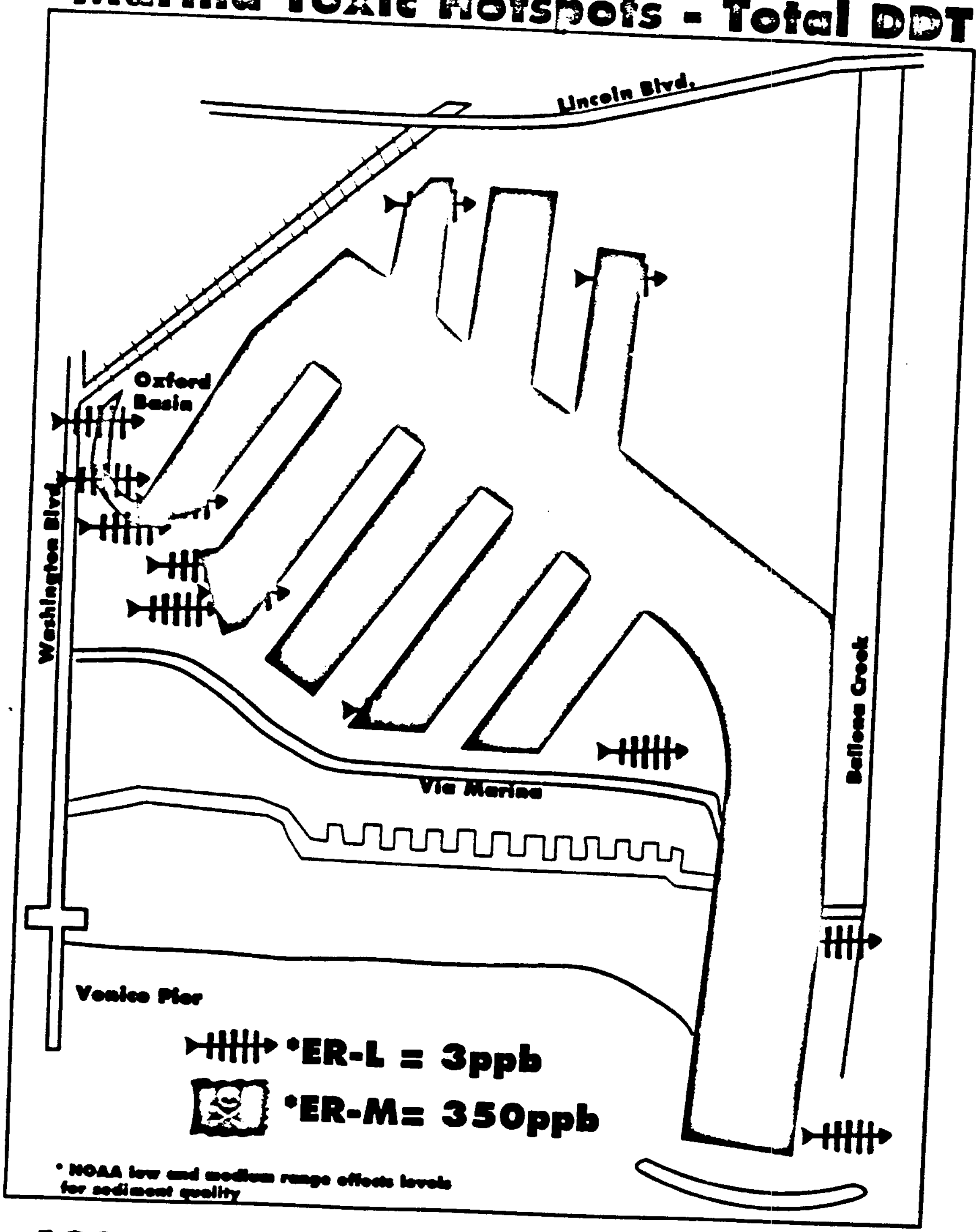
Marina Toxic Hotspots - Total DDT



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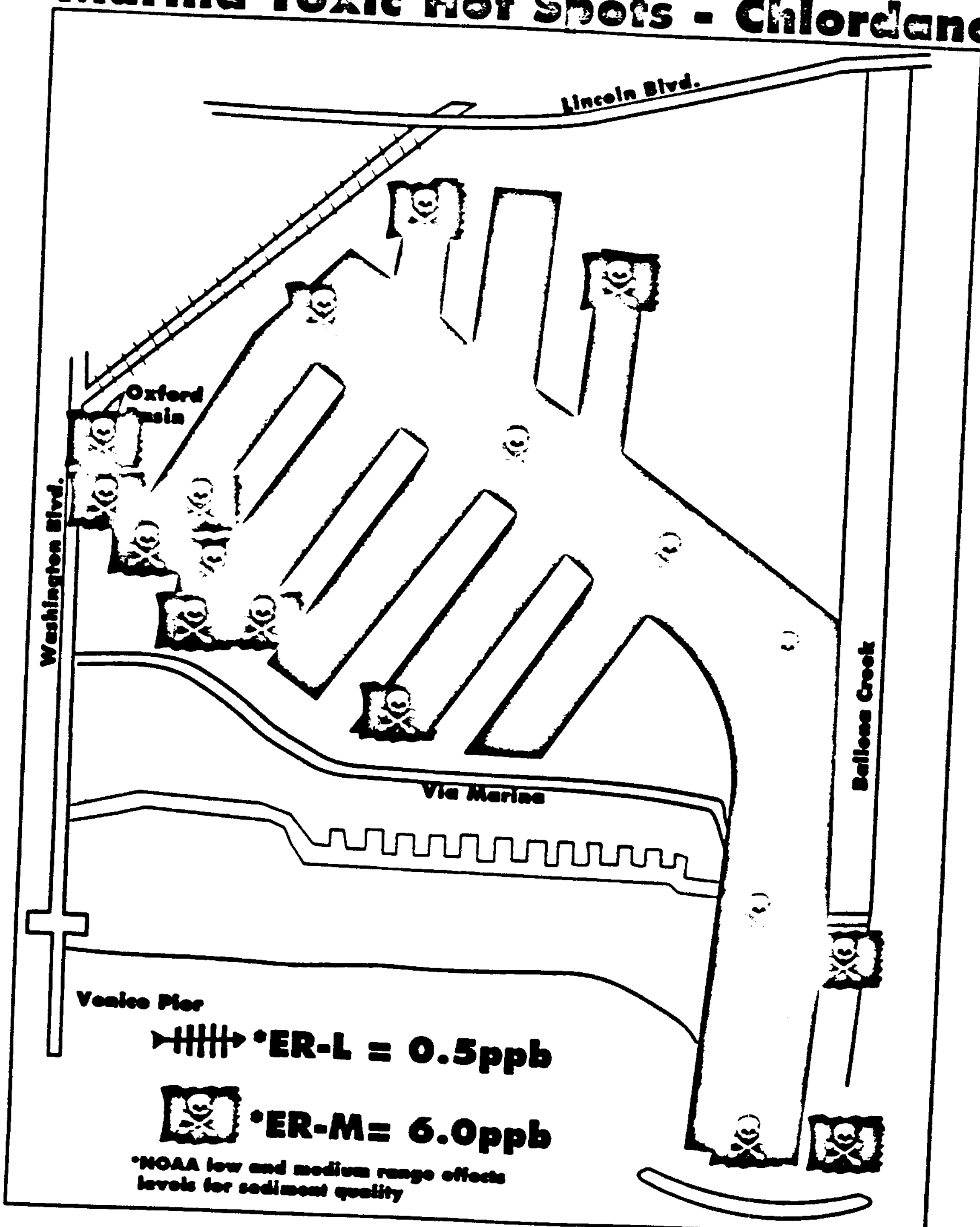
Marina Toxic Hot Spots - Chlordane



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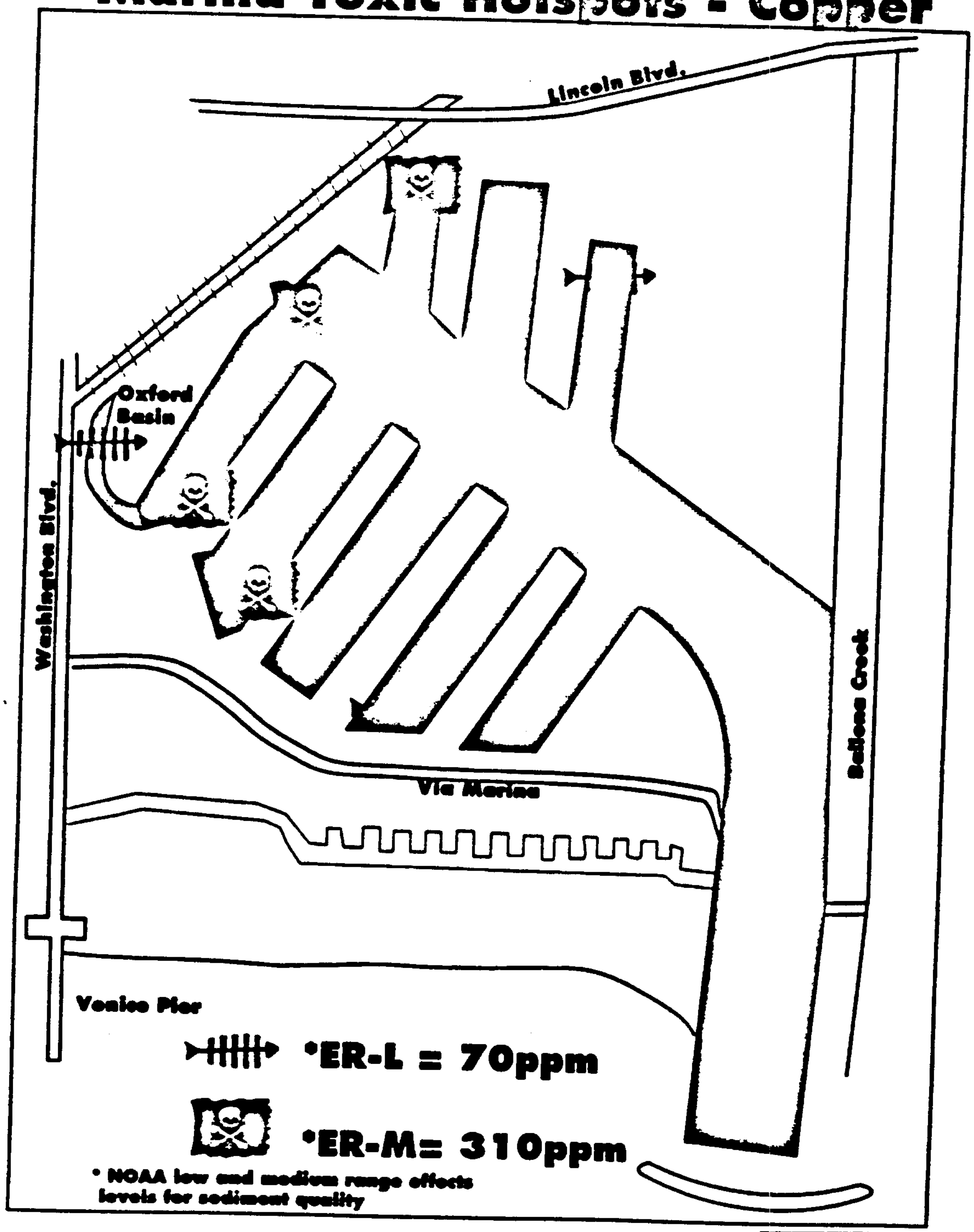
Marina Toxic Hotspots - Copper



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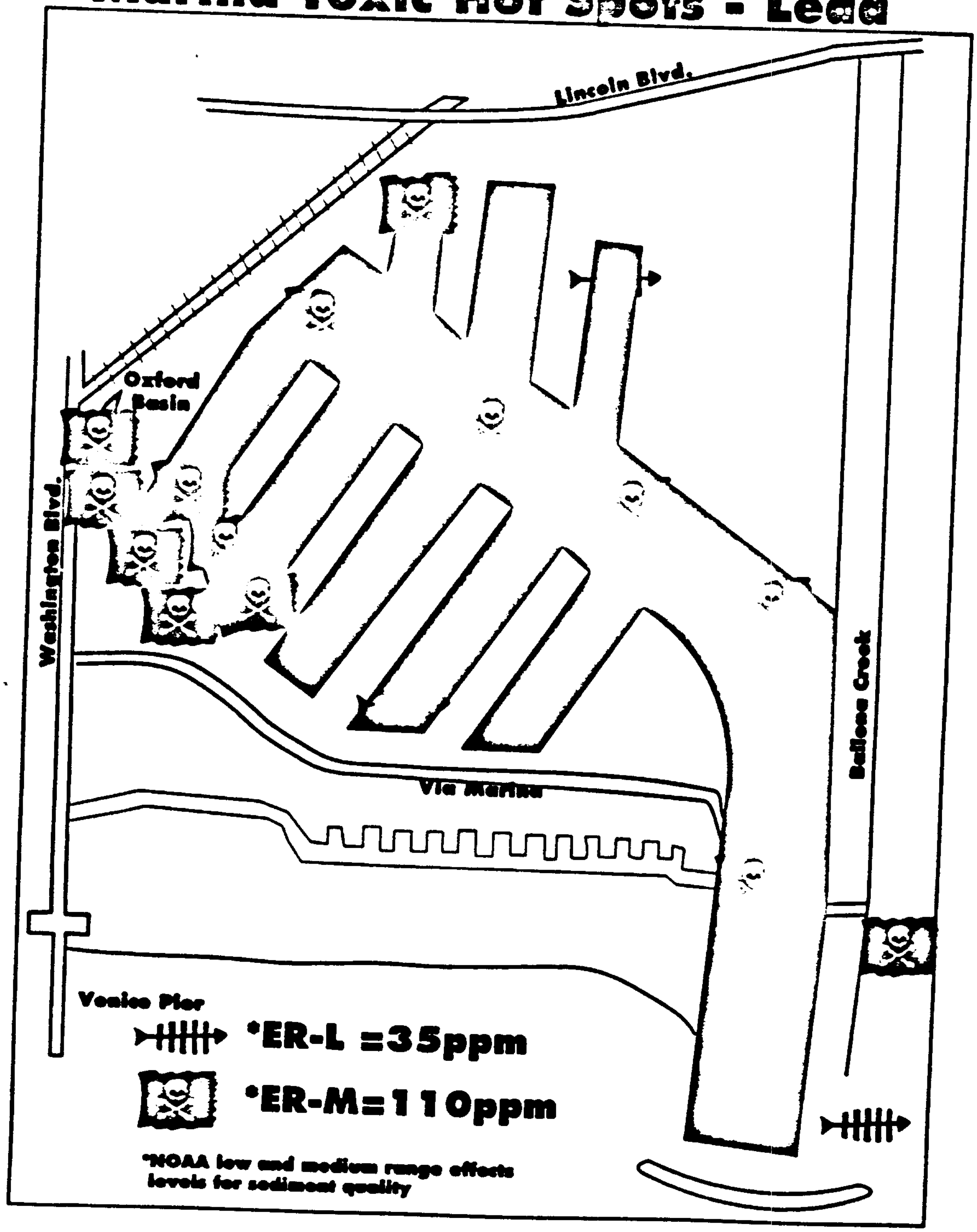
Marina Toxic Hot Spots - Lead



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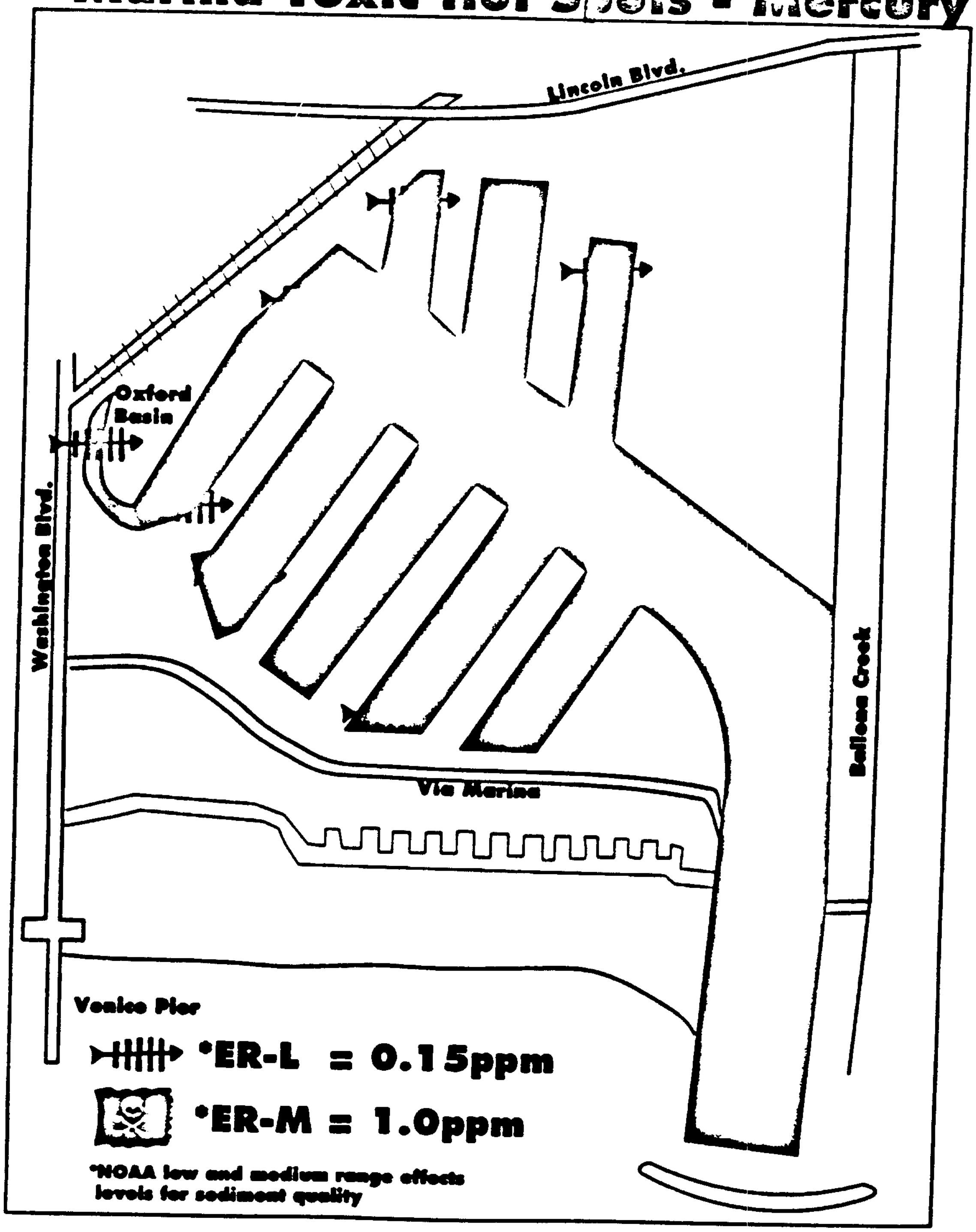
Marina Toxic Hot Spots - Mercury



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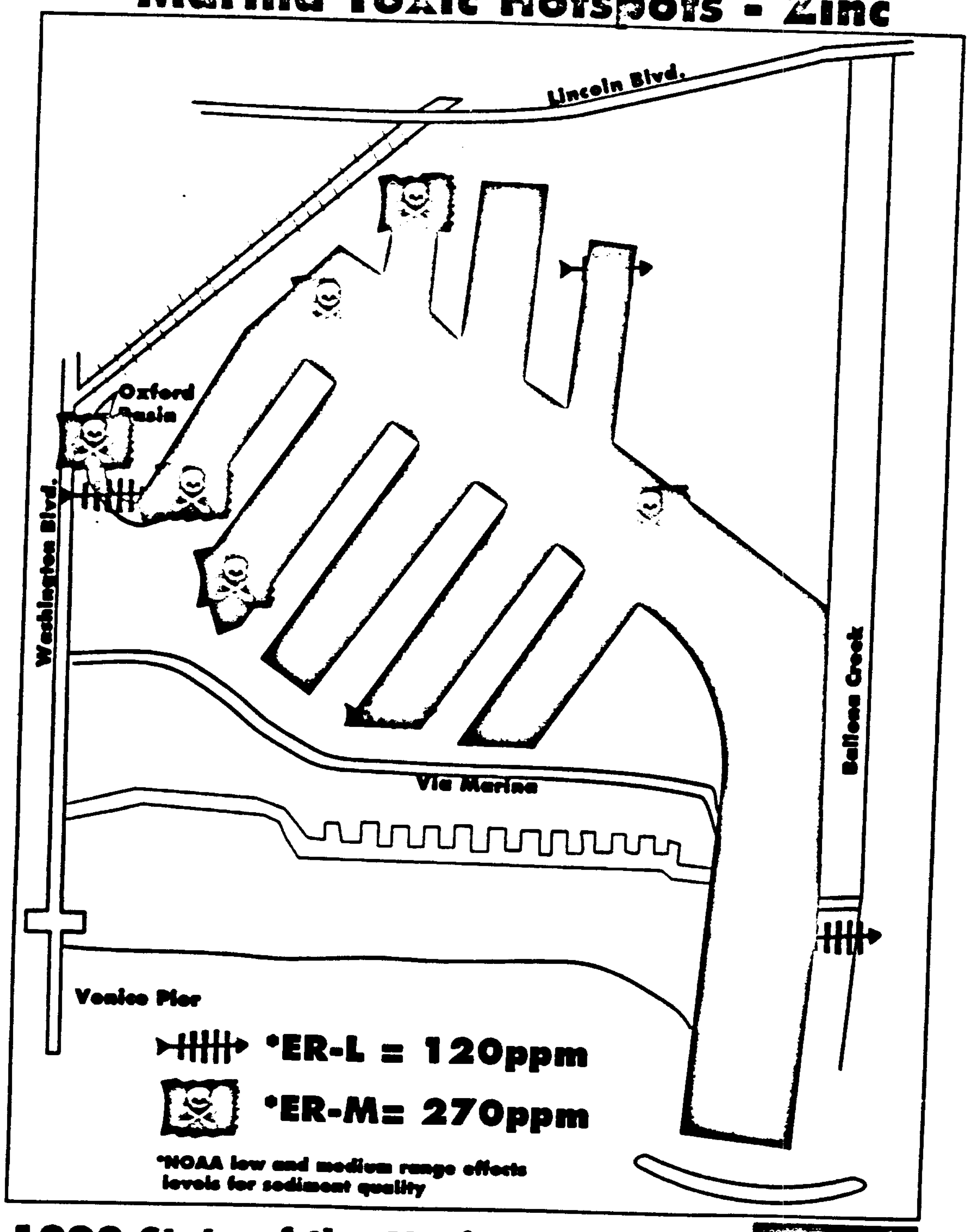
Marina Toxic Hotspots - Zinc



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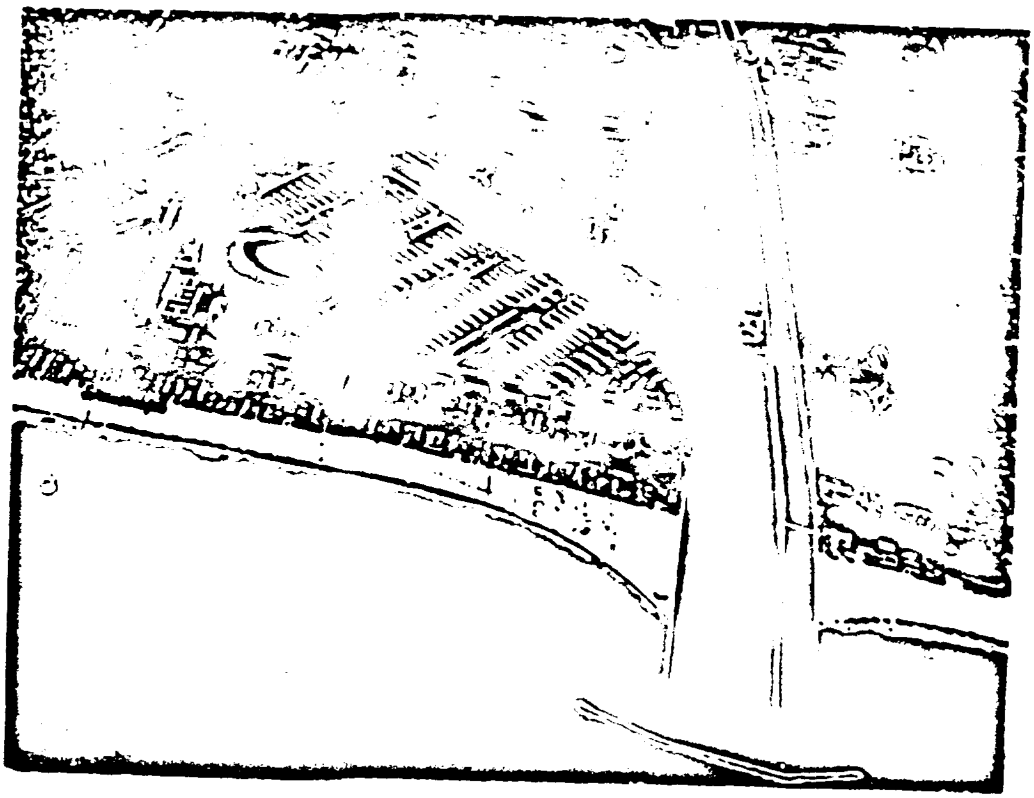
MARINE STUDIES OF SAN PEDRO BAY, CALIFORNIA Part 20II

THE MARINE ENVIRONMENT OF MARINA DEL REY

October 1991 - June 1992



A Report to the Department of Beaches and Harbors

County of Los Angeles

by

Dorothy F. Soule, Mikihiko Oguri, and Burton H. Jones
Harbors Environmental Projects
University of Southern California
Los Angeles, California 90089-0371

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MARINE STUDIES OF SAN PEDRO BAY, CALIFORNIA Part 20H

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ERRATA IN MARINE STUDIES OF SAN PEDRO BAY PART 20G, APRIL 1992

IN PART 20G;

PAGE IV.7. — Error in October 1990 scores, corrected on page IV.7 October 1992, Volume 20H.

PAGE IV.20. — Typo; Oil & Grease, Station 8 should read 520 ppm.

PAGES IV.60.61. — Typos should read:

Chlordane; Sta. 5, 78.0; Sta 9, 98.0.

p.p'DDD; Sta. 9, 3( ).

p.p'DDE; Sta. 13, 5.., Sta. 22, 990; Sta. 25, 104.0.

Total Pesticide; Sta. 5, 140.0.

Aroclor 1254; Sta 7, 119.0; Sta 8, 61.0.

Total Chem; Sta 5, 262.0; Sta. 7, 166.0; Sta. 8, 150.0; Sta. 9, 334.0.

PAGE IV.67. — Figure IV.47 should read p.p.DDD in sediment, ug/kg (ppb). May 1991.

PAGE IV.48. — Figure IV.48 should read p.p'DDE in sediment, ug/kg (ppb). May 1991.

PAGE IV.68. — Figure IV.50 should read Aroclor 1260 in sediment, ug/kg (ppb). October 1991.

PAGE V.3. — Line 1 should read Cross and Hose (1988).
Line 23 should read in May only 14 specimens of 8 species... .

PAGE VIII.9. — All counts have been recalculated in Table VIII.1 in 20H, October 1992, page VIII.4 to update information on egg - larvae identification, and eliminate duplications.

PATE VIII.15-17. — Table VIII.6. All counts recalculated as above , Pages VIII 14-16 in 20H.

EXECUTIVE SUMMARY

HISTORICAL BACKGROUND

Marina del Rey, the largest manmade marina in the world, has some 5,800 boat slips and a resident population of about 11,000 people, along with numerous shops, some 28 restaurants, four hotels, and two motels which draw people from the surrounding urban megalopolis as well as from international tourist groups.

Wetlands Function

Sited on a degraded wetlands, the marina replaced an area of mud and sand flats with small drainage channels, said to have been populated by molluscs, crustaceans, echinoderms and benthic worms, although no environmental inventory studies were ever performed there. The marina benthos is now dominated by worms, some of which provide food for fish larvae, juveniles and adults. The soft, unconsolidated bottom, straight sided concrete walls and low flushing rate make the area more optimal for a marina than for a marine habitat. The use of antifouling compounds and potential for spillage of oil and grease also detract from faunal diversity and production. In spite of this, the marina is productive and serves as a valuable refuge and nursery ground for some marine fish species, important factors in light of the severe reduction of more natural wetlands in the greater Los Angeles area.

NON-POINT SOURCE IMPACTS ON THE MARINA

By far the largest impact on the marina comes from the Oxford Street flood control channel, which drains into the marina through a tide gate in Basin E. The soil in some adjacent terrestrial areas is apparently highly contaminated with trace metals, pesticides and polychlorinated biphenyls (PCBs) accumulated from earlier dumping or from World War II industrial contamination, so that, when soils are excavated during construction and erode during rainstorms, pollutants are carried into the marina attached or complexed chemically with the suspended sediments. Runoff from storm drains carries a miscellaneous burden of organic and inorganic contaminants and coliform bacteria.

Ballona Creek flood control channel, although carrying a much larger volume of water from a larger area, seems to have less impact on the marina than Oxford Street basin flow. The creek receives a large amount of debris: yard clippings, Christmas trees, fast food plastic containers, waste motor oil, beer cans and the like. Street runoff carries the metal, rubber and oil residues from highways, and garden runoff carries pesticides. Heavy wet weather flow will carry much of the debris into Santa Monica Bay, but during dry weather low flow, debris will enter the marina on rising tides. Storms or extreme high tides carry material washed off the jetties, such as dog, bird and people feces, into the marina.

ENVIRONMENTAL STUDIES

Effects of El Niño on Water Quality

This report covers the period from 1 October 1991 to 30 June 1992 because of a change in the fiscal year for the contract. One of the principal physical factors influencing water quality during that period was a warm water influx in October and November and in the spring in March and April due to a moderate tropical El Niño-Southern Oscillation (ENSO) event. The ENSO events in the equatorial Pacific, with a pool of very warm tropical water moving eastward toward the Americas and a cessation of normal Trade winds, caused rainfall patterns to change, and produced more rainfall than in any year since the very strong ENSO of 1982-1983.

The impacts of rainfall on the marina were more obvious in 1990-1991, when only two storms occurred, each of which occurred just prior to a monthly cruise. The influences on dissolved oxygen, nutrients and bacterial contamination were quite apparent, in addition to the expected temperature, salinity, pH and turbidity effects.

Rainfall in 1991-1992 occurred over longer periods of time and thus impacts were more diffuse and not quite as dramatic as they were in the previous year, when almost all of the rainfall occurred in the two storms. It was very clear, however, that rainfall, with its associated runoff, has serious impacts on the marina.

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The minima for dissolved oxygen due to chemical and biological oxygen demand (COD, BOD) during oxidation by bacteria and other microbial populations occurred most surveys in Oxford Street flood control basin. The exceptions were during spring rainy periods; in March, when bottom waters were below the regulatory 5.0 ppm in Basin D near the marina beach and in Basin E near the tide gate for Oxford Street basin, and in April when bottom waters were below 5.0 ppm at Stations 6, 8, 10, 18 and 20 as well as in Oxford Street basin. Bottom waters continued to have low DO values in May at Stations 6, 7, 10 and 20, and in June at Stations 6,7,8 and 10, as well as in Oxford Street basin. Los Angeles County Life Guards attributed the May and June problems to runoff and debris from the fires associated with the riots at the end of April, which could have stimulated blooms that had died off, to toxicity, or to COD and BOD.

Changes in nutrients were not quite as distinctive as in 1990-1991. For the most part the ranges in concentrations of ammonia-nitrogen, nitrate and nitrite, and phosphate were similar, as were the seasonal trends. Silicate showed a narrower range, however. Nutrients have a negative correlation with salinity, since they are primarily associated with the influx of fresh water into the marina from runoff. Ammonia showed a large increase in average levels and an extreme maximum in February, with a lesser peak in April; nitrate plus nitrite showed high maxima in January, February, April and June with the highest averages in January and April, while phosphate maxima occurred in February and April, with the highest average in February. Maxima occurred most often in Oxford Street basin. Normally it is expected that higher average values will occur in the winter when phytoplankton populations may be smaller, using less of the available supply.

<u>Sediment Contaminants</u>

Only one sediment survey could be performed in the period, in October 1991, due to budget reductions. Rainfall in the previous spring increased greatly the percentage of the finest sediments, to which a large proportion of contaminants are attached or complexed, causing increases in many trace metals and some other parameters. The finest grain size sediments continued to increase during dry weather, which may be indicative of the reduced flushing caused by partial occlusion of the mouth of the marina by accumulated sand and sediments trapped by that barrier.

In October 1991, there had been improvement in sediment content of immediate oxygen demand, phosphate, and sulfide, while volatile solids, chemical oxygen demand and organic nitrogen had worsened somewhat. Among trace metals, levels of arsenic, cadmium and chromium have not in the past reached levels of low environmental effects determined by the National Oceanographic and Atmospheric Administration (NOAA) and have decreased in recent surveys. Tributyl tin, banned in 1988 for most antifouling paint use except on aluminum hulls and on vessels longer than 25 meters, has shown a decrease of three orders of magnitude. Contamination with nickel have declined to where only Stations 9 and 10 are slightly over the NOAA level for low environmental effects range (ER-L). Copper, lead and zinc have fluctuated in the marina, but of these, lead and zinc show increases after heavy rainfall, indicating terrestrial sources. Copper seems to have increased over dry seasons as well as wet ones to the highest levels in the 1984-1991 surveys. This may represent increased use as an antifoulant since tributyl tin was banned. Control of copper, lead and zinc emissions would improve the marina biota greatly.

One of the most important changes was the reduction of polychlorinated biphenyls (PCBs) to below the limits of detection. Aroclor 1254 and 1260, highly toxic, long lasting substances used as lubricants in transformers and other electrical equipment, in printing and other industrial processes, first were detected in the marina in October 1989 in large amounts. Some Aroclor 1260 was still present in May 1991, but all had disappeared by October, 1991. The relatively sudden appearance of Aroclors in the marina may have been due to runoff from large scale excavation and grading at terrestrial sites near the marina or to some unidentified accidental spill, although no records of such an accident have been found. Its disappearance within two years is indicative of flushing because the material does not biodegrade well.

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Pesticides continue to be a problem in the marina. Chlordane has been banned since 1988, but appears to continue entering the marina. Levels exceeded the low (ER-L), medium (ER-M) and higher levels of environmental effects (apparent effects threshold, AET) indicated by NOAA at all stations. Chlordane was highest at Station 2, at the sand bar, possibly indicating that it is flushed from Ballona Lagoon where many wooden structures may have had Chlordane applied for termite control, and is high in Oxford Street basin as well.

The DDTs decreased from Oct ıer 1990 to October 1991, but had been lower in May 1991 than in October 1991, indicating a dry weather increase. The largest accumulation is at the sand bar at Station 2, as it was with Chlordane. DDTs exceed the NOAA low effects range at most stations, indicating the potential for continuing impact on the larval and juvenile organisms and for bioaccumulation in the food chain.

Fish Tissue Contamination

Levels of pesticides and PCBs in fish taken at the Fisherman's Village fishing docks are well below levels deemed to be a public health risk. Levels of pesticides vary greatly in fish, depending on the reproductive period since these fat soluble substances accumulate in muscle and liver but are mobilized into the liver and gonad prior to reproduction, much of it leaving the body in the egg yolks on spawning. This is of course harmful to liver function and reproductive capacity of the fish, but protects consumers of cleaned, gutted fish. Levels of pesticides can also vary between individuals of the same species at the same season, presumably influenced on the diet of the individual fish. The mean level of PCB Aroclor 1260 in fish tissues appeared to be increased but the liver/gonad level was much decreased, suggesting that reproduction had occurred in some of the fish sampled on 2 November 1991. A similar trend was seen for Chlordane contamination. Levels of p.p'DDT and p.p'DDD appear to be decreasing, but the amount p.p'DDE has fluctuated and o.p'DDE has increased greatly, suggesting that the metabolites of DDT are being recycled rather than new DDT being introduced into diets of the fish.

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Bacterial Contamination

Effects of rainfall on bacteria in marina waters were indicated by the rise in total coliforms, fecal coliforms and enterococcus bacteria during or after rains. Violations of Public Health standards occurred within the marina at several stations in the wet months of January, February, March and April, and only two violations of fecal coliform standards occurred in dry weather. The marina should be considered unsafe for body contact during storms and for a few days afterward, with risks of gastroenteritis and sometimes other infections.

There is little evidence of violations of sanitation regulations by vessels in the marina, other than an occasional unexplained peak during dry weather. Violations of Public Health standards were reduced in 1991-1992 as compared to the previous year.

Although Oxford Street flood control basin and Ballona Creek flood control channel are not body contact water areas, waters flow from these sources into the marina and present problems of contamination. Oxford Street basin almost always has high coliform counts. During the rainy periods, both the creek and the basin exceeded public health standards for total and fecal coliforms and for enterococcus.

Benthic Populations

The rains of the spring of 1991 may have cleared contamination from Ballona Creek and swept benthic organisms to sea, but the two stations in the creek responded differently. Station 12, near the footbridge, was recolonized by very large numbers of freshwater tolerant, opportunistic nematodes, while Station 1 at the mouth of Ballona Creek was apparently recolonized by polychaetes, and also by some molluscs and crustaceans not usually seen in marina surveys.

The mean number of individuals in the marina was a record high, but consisted mostly of nematodes at Stations 12 and 2; without the nematodes the mean was above that of the previous six years if Station 12 is excluded. At Station 2, at the sand bar where sediments contaminated with pollutants have accumulated, nematodes were dominant.

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The sand bar may partially occlude circulation in the marina, reducing flushing in the main channel and inner marina basins. Populations were at an all time low at Station 6 in Basin B, and were 50 percent or more below the lowest previous records at Station 8 in Basin D and Station 10 in Basin E. No single contaminant is associated with these distributions, and it is probable that different parameters are affecting different locations. Stations 6 and 8 had large increases in the finest sediments, with their contaminant burdens, and Station 10 is very much influenced by the Oxford Street basin runoff, with its sediment and pollutant burden, coupled with the low levels of circulation in all th locations.

Fish Populations

The marina is an important habitat for fish eggs, larvae and young adults, serving as a warm water, low energy, high nutrient environment where turbidity shelters them from predation. Thus the marina fulfills functions of a wetlands. The mean number of fish species in the marina is stabilized at about 39, with slightly more species present in the spring (May) than in the fall (October), although there is considerable annual variation. This serves to indicate the need for long term surveys to determine actual trends. The total number of species, or higher taxa where identifications of eggs or larvae are not possible, is over 90 for the 16 surveys conducted since techniques were standardized in 1984.

Progress has been made in the ensuing years on identification of eggs and larvae so that some taxa that were found to be duplicated as adults were deleted from the master list of occurrences. Diver transect observations in the Entrance Channel and at the breakwater indicate that is the richest area for diverse fauna, although large schools of smelt in Basin D have in the past dominated the numbers.

Coincidentally, since the disappearance of the seagrass beds in Basin D at marina beach in 1991, no large numbers of smelt have been found in October 1991, May 1992, or October 1992. These are populations that move in and out of the marina rapidly, depending on food, predators, temperature and salinity, and therefore may not coincide with the infrequent surveys.

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I. INTRODUCTION

HISTORICAL BACKGROUND

The site of Marina del Rey, the largest manmade marina in the world, was a degraded wetlands that once extended through the communities of Venice on the north, southwest through La Ballona, eastward almost to the site of the San Diego Freeway and south of the present Culver Boulevard to the Westchester Bluffs. In earlier years, the Ballona wetlands joined the wetlands leading to the Los Angeles River, inland of th Palos Verdes Peninsula, which was once an island. The Los Angeles River sometimes di·erged from its course, exiting where the Port of Los Angeles is now, to flow through the Ballona estuary (Bancroft, 1884; Beecher, 1915).

Ballona wetlands had numerous small, meandering channels, with a large pond where Basin D beach is now located, and waters exited into what is now the remains of Ballona Lagoon and Del Rey Lagoon, behind a large barrier beach. Historically, river flow there had helped to cut Santa Monica Canyon into the alluvial shelf of Santa Monica Bay (Figure I.1). Major rivers in southern California were concrete lined in the 1920s and 1930s to control disastrous flooding and loss of life that occurred during heavy winter rains in some years.

By the time the marina was built in 1960-1962, large areas of the wetlands were degraded, having been filled or drained to provide industrial development, access to oil and gas fields, salt pannes, disposal areas, and a measure of control over mosquito and black fly infestations. Construction of the marina began with the building of dry walls and dredging of basins followed. Land between the Entrance Channel and Basin A and between Fiji Way and Ballona Creek were used to dewater the hydraulically dredged soils. When the basins were completed the coast highway road was closed, leaving the bridge over Ballona Creek as a footbridge, the roadway embankment was breached and the opening eroded tidally to form the Entrance Channel. Soule and Oguri (1990) showed a series of aerial photographs

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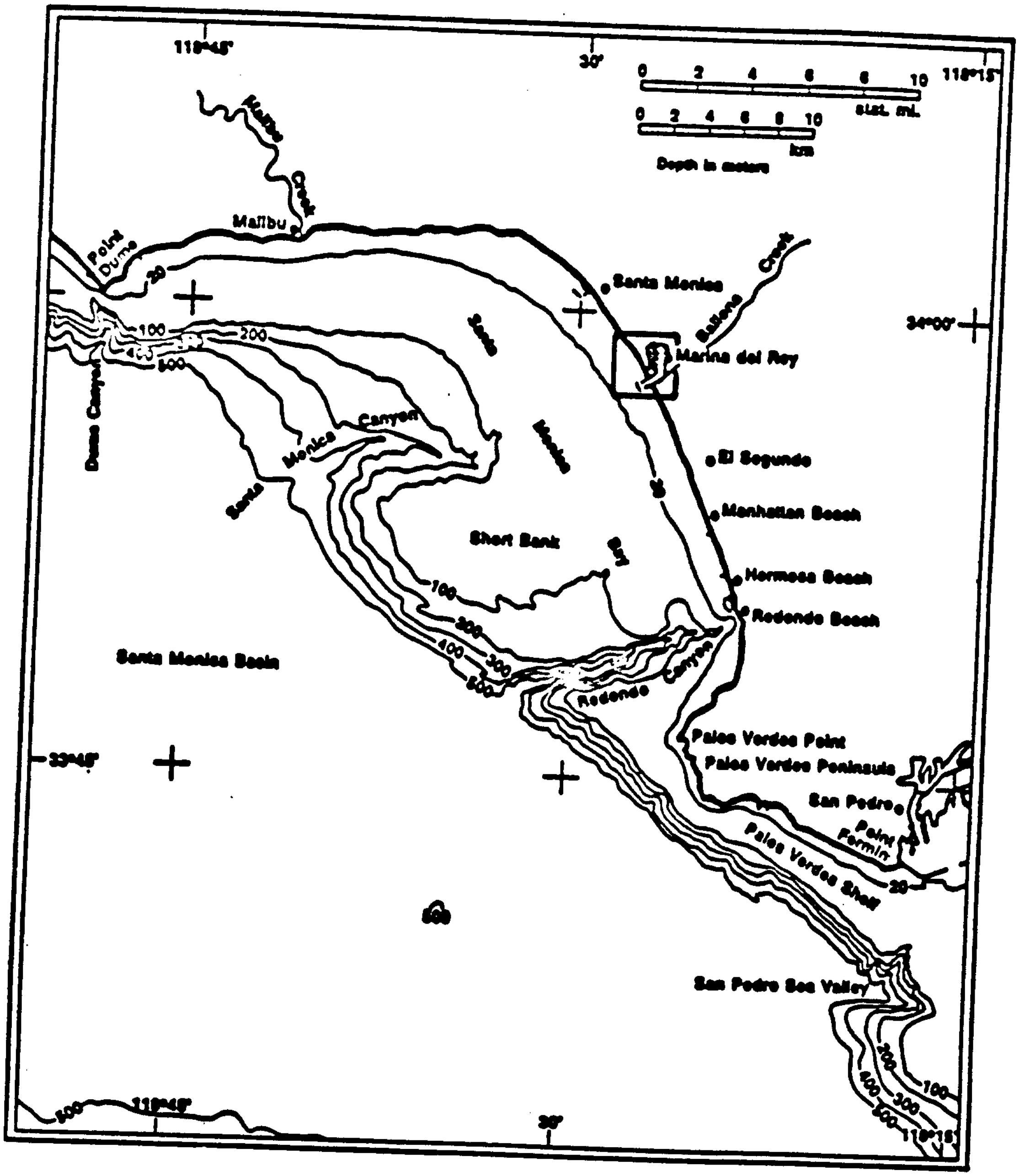

Figure I.1. Location of Marina del Rey within Santa Monica Bay.

of the sequence of construction. The residential areas along the Westchester bluffs and inland in Culver City developed greatly after World War II, making the marina a truly urban development (Figure 1.2).

ENVIRONMENTAL STUDIES

Although the U.S. Army Corps of Engineers modeled various configurations for the marina at the Waterways Experiment Station in Vicksburg, Mississippi, no environmental studies were performed to evaluate the impact on existing biota in the wetlands in the dec: 'e prior to passage of the National Environmental Policy Act in 1970. The con. . .ration selected was supposed to prevent storm damage from the prevailing wave and surge patterns, but the first year when Basin A was opened, storm surge came up the Entrance Channel, reflected off the walls in the area of the present Administration docks and caused great damage to boats in Basin A, across the Main Channel.

Environmental baseline studies in the marina were not undertaken until 14 years after its construction. From July 1976 to June 1979, an extensive program of physical, chemical and biological surveys at 13 stations was performed by the University of Southern California (USC) Harbors Environmental Projects with funding from the federal Sea Grant Program at USC (NOAA, Department of Commerce) and the Los Angeles County Department of Small Craft Harbors, now the Department of Beaches and Harbors (Soule and Oguri, 1977, 1980). This provided the first detailed information on the marina as an important biological resource in addition to its recreational function.

Limited surveys were resumed in 1984 in the spring and fall, with a reduced scope which included monthly measurements of water quality, biannual surveys of benthic organisms and fish, and annual analyses of sediment chemistry. Surveys were then reduced to one period a year, In October, November and December (Soule and Oguri, 1985, 1986, 1987, 1988).

In October 1988, year round monthly surveys were resumed and four more stations added (Figure I.3), Stations 18, 19, 20 and 22. In 1989, Station 25 was added between the

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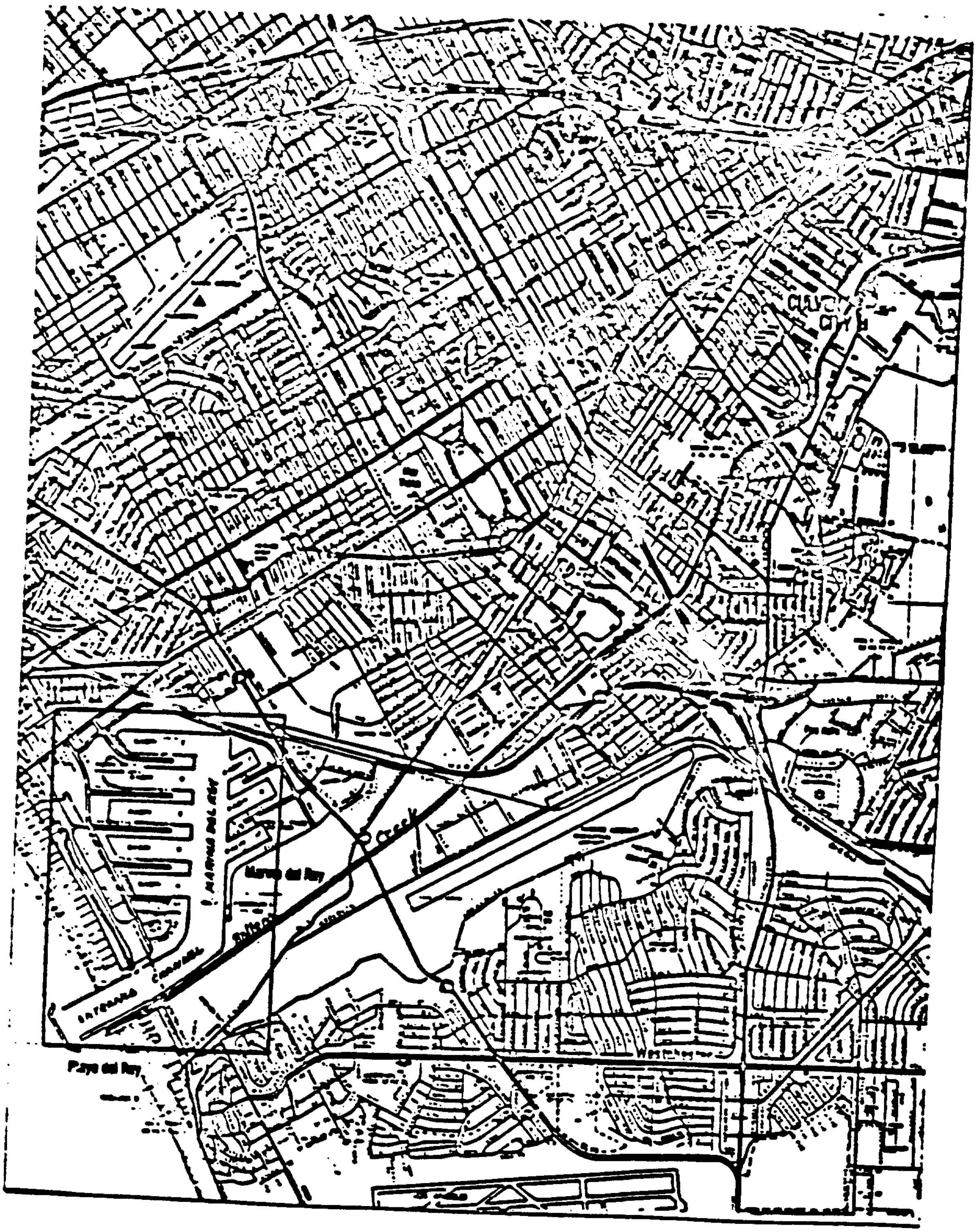

Figure I.2. Study Site, Marina del Rey, California.

(base map courtesy of Automobile Club of Southern California)

fishing docks and the Administration docks where the entrance to the future Playa Vista marina may be. Special projects have also been performed which include bioassay/toxicity studies of the effects of contaminated bottom sediments on local species, effects of tributyltin in antifouling paints, body burden of PCBs and DDTs in fish caught at the local docks and the incidence of coliform organisms at the marina beach, as well as at other marina sites.

Station locations are shown in Figure I.3 and descriptions are listed below. Depths vary according to tide stage and i· egularities in the bottom that develop due to storm deposition or erosion, runoff, tidal . . w and to propeller wash.

STATION LOCATIONS AND DESCRIPTIONS

MDR-1. Located midway between the breakwater at the east entrance to the Marina and the beach, at the mouth of Ballona Creek flood control channel. The area is subjected to discharges from the creek, to severe impacts from storm water flow and to deposition or erosion from storm wave action. Depth irregular, 2-6 meters.

MDR-2. At the entrance of the Marina, midway between the two Marina jetties. The area is protected from most storm waves but subject to weak coastal currents. Sands have been deposited from storms and blown from the adjacent beach resulting in severe, irregular deposition. Heavy flow in Ballona Creek flood control channel also carries sediment and debris into the mouth of the Marina. Dredging was undertaken in February 1987 to reestablish the channel and is scheduled for "knockdown" again in October 1992. Depths 4-6 meters.

MDR-3. On the north (west) side of the entrance channel, in front of the tide gates to Ballona Lagoon and the Venice Canal system. Protected from all but severe storm waves, the site is subjected to discharge of waters from the canal system. Shell mounds present during the 1976-1979 surveys disappeared, replaced first with fine sediment and then sand. Depths 3-6 meters.

MDR-4. Seaward of the Administration/ Coast Guard dock on the south (east) side of the entrance channel at junction with main channel. Subject to heavy boat use. Protected from most surge, the area was heavily damaged by 1983 storms and docks were rebuilt in 1985. Depths 3-6 meters.

MDR-5. In the center of the Main Channel, subject to heavy boat traffic. Sediment from the basins accumulates there . Depth 3-6 meters.

MDR-6. At the innermost end of Basin B; protected from westerly winds by seawall, circulation reduced. Depth 3-5 meters.

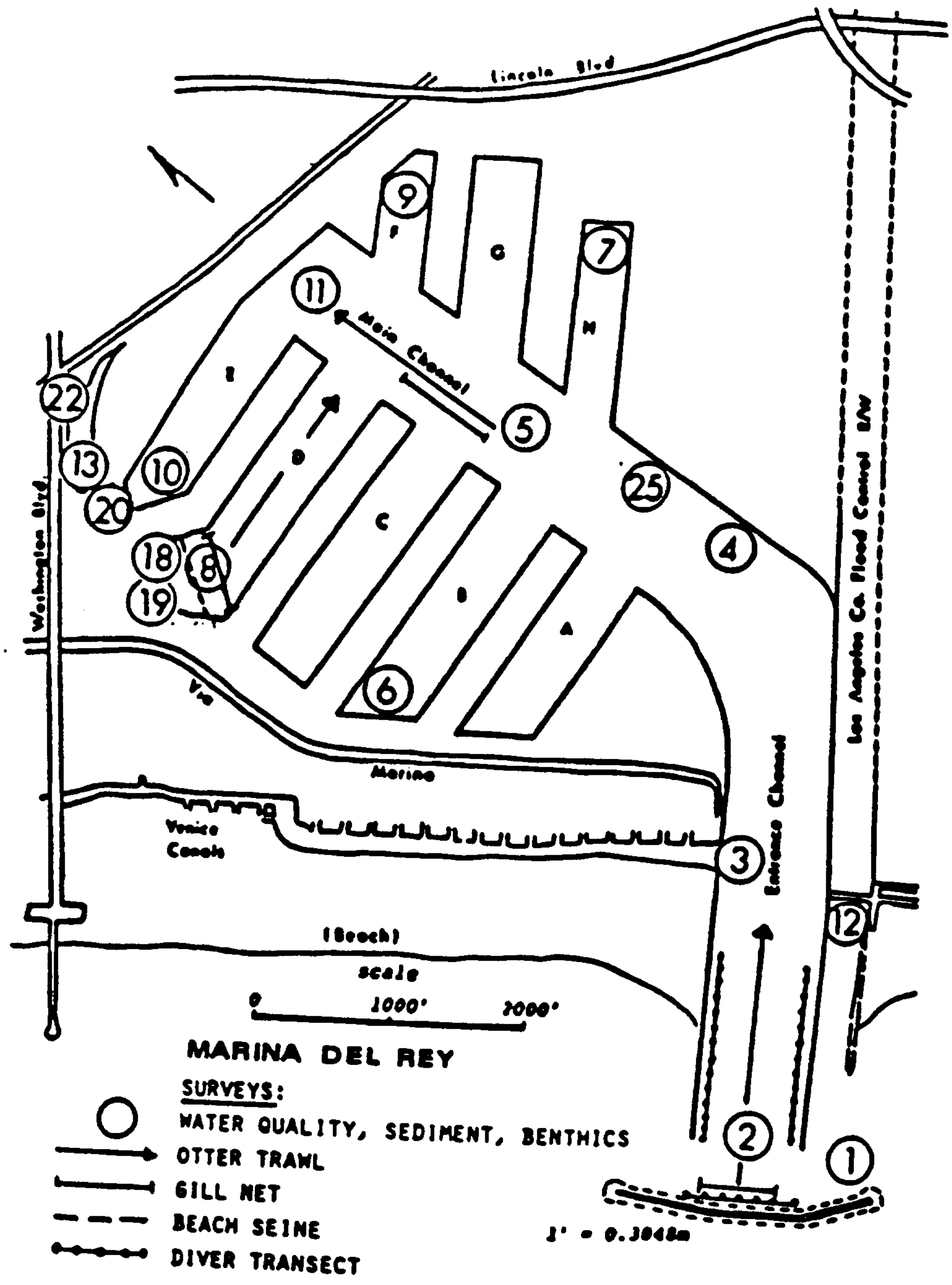

Figure I.3. Survey stations in Marina del Rey.

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MDR-7. At the end of Basin H near the work yard dock. Large storm drain present; exposed to afternoon westerly winds. Depth 3-4 meters.

MDR-8. Off the swimming beach in Basin D near first slips. Exposed to afternoon winds. Depth 3-4 meters.

MDR-9. At the innermost end of Basin F. Large storm drain present; protected by slips and sea wall. Depth 2-4 meters.

MDR-10. Innermost end of Basin E; subject to daily flushing from the Oxford Street flood control basin through tide gates and to storm water runoff. Depth 3-4 meters.

MDR-11. At end of Main Channel; subjected to storm drain flow and to influx from Station 10; impacted by reduced flushing due to .creased slip capacity. Depth 3-5 meters.

MDR-12. Ballona Creek, sampled from beneath the Pacific Avenue foot bridge. Subject to tidal flushing and continuing freshwater discharge into the flood control channel; also subjected to illegal dumping of trash upstream and to sewage overflow. Depths 1-4 meters.

MDR-13. Inside tide gates of Oxford Street flood control basin; subject to minimal daily tidal flushing, storm water runoff and drainage, surface only. Inaccessible at times.

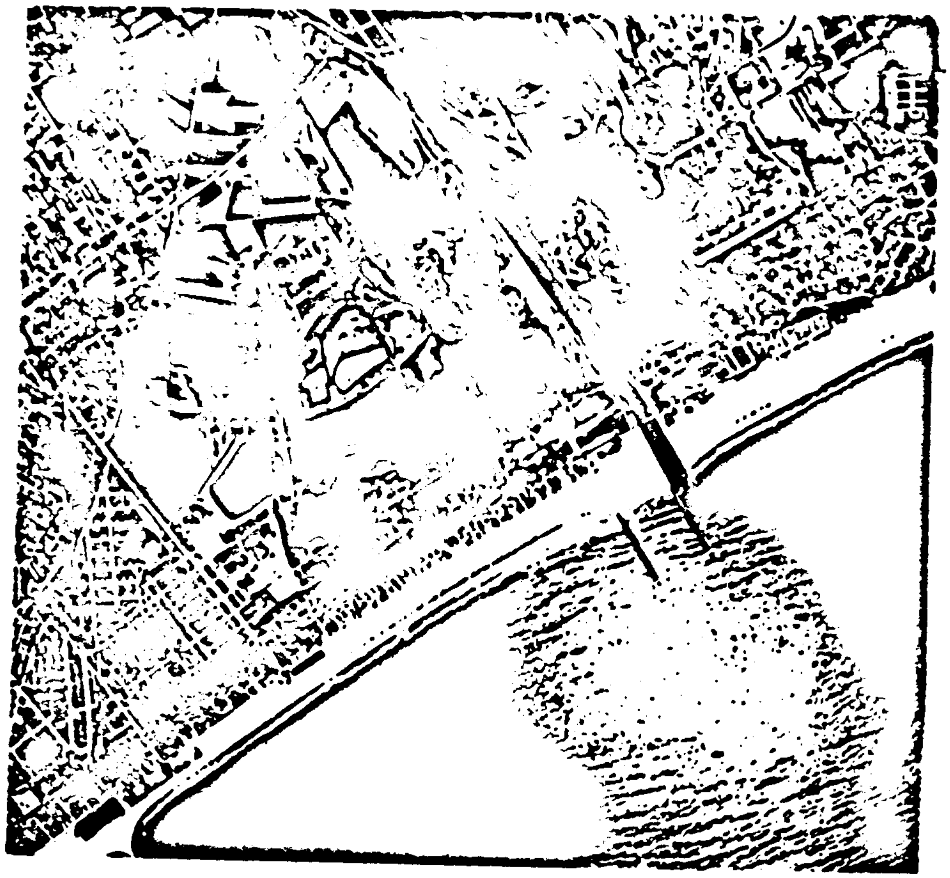
MDR-18. Twenty meters off wheelchair ramp in basin D perimeter of swimming area. Depths 1-3 meters

MDR-19. At end of wheel chair ramp, surface only.

MDR-20. At innermost end of Basin E where Oxford Street basin flow enters Marina. Depths 1-4 meters; flow partially obstructed by large vessel docked there.

MDR-22. Inner end of Oxford Basin at Washington Street culvert, surface only.

MDR-25 Between the Administration - Life Guard docks and the public fishing dock.



Site of Marina del Rey, May 1959 (Photo courtesy of Dr. D.J. Reish)

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II. PHYSICAL WATER QUALITY

INTRODUCTION

The water quality of Marina del Rey is influenced by a number of factors including both point source and non-point source discharges which enter either the marina or adjacent and contiguous waters. These waterways include Ballona Creek, Ballona Lagoon and the Oxford Flood Control Basin, which serve as collectors of runoff from non-marina urban areas. Waters from these collectors enter the marina either as a result of tidal exchange or, during and after rainfall, as a result of drainage from adjacent surfaces or from the storm drains. During the period covered by this report, the long-standing drought was broken by rainfall during or shortly prior to the January through April sampling periods. The May survey may have been influenced by terrestrial runoff from the Los Angeles area in late April. The runoff may have decreased dissolved oxygen and increased BOD in certain stations in the marina survey, as discussed in the following pages.

PROCEDURES

The data discussed in this report cover the period from October 1991 through June 1992. Sampling and data collection for water quality assessment were carried out at monthly intervals. The monthly dates were selected, when possible, to permit the early part of the sampling to occur during or near peak tides to permit boat access in shallow areas such as Station 12 in Ballona Creek.

Temperature, conductivity, later converted to salinity, dissolved oxygen and pH were measured at one meter intervals through the water column using a Martek Mark XVII water quality monitor. Beam transmittance was measured at the same depths using a modified HydroProducts transmissometer with a 0.1 meter light path. Both instruments were calibrated immediately prior to each field excursion and, if any data were considered questionable, immediately after the instruments were returned to the laboratory. Visual observations of ambient light penetration and water color were measured using a Secchi disk and comparing the water color to a Forel-Ule water color scale. The field log is presented in Appendix A and complete water quality data tables are contained in Appendix B.

TEMPERATURE

1991-1992 Ranges

The temperatures encountered in surface waters of Marina del Rey during this sampling period ranged from a high of 23.7° C to a low of 11.0° C. The highest water temperature, 23.7° C, was found at Station 22 in April 1992. The temperature at Station 13 during that monthly sampling period was 22.7° C. In six of the nine months during this monitoring period Station 22 or Station 13 had the highest temperature and both were usually warmer than all other stations. The lowest temperature encountered during this period, 11.0°C, also occurred Station 13 in January 1992, following a period of heavy rains. The temperature at Station 22 was 12.9°C, the next lowest at that time.

The monthly averages of near surface water temperatures at all stations in Marina del Rey during the period ranged from winter low temperatures of 13.8°C in December 1991 and 13.3°C in January 1992 to a high of 21.4°C in October 1991. Average temperatures for April, May and June were 19.3° C, 21.6°C and 22.1°C. These temperatures, particularly for April, are higher than in immediately preceding years, indicating the El Niño conditions prevailing in the area at that time.

Historical Quarterly Ranges

Seasonal ranges in temperatures from 1976 to 1979 and 1984 to 1992 are shown in Table II.1. The data indicate that the temperature range for the autumn months of 1991 does not depart from the pattern of previous years. The range noted for the winter of 1991-1992, however, was slightly cooler than preceding winters. The temperatures reported for the spring months showed a warmer range than in years 1989-1991, possibly reflecting the mild El Niño that occurred then. The temperature range in June 1992, the only summer month included in this report, was similar to the ranges reported for previous years.

Historical Monthly Records

Figures II.1 through II.3 present the near surface average temperature data for

Table II.1. Temperature Ranges (°C) by season and year*

	Spring Mar, Apr, May	Summer Jun, Jul, Aug	Autumn Sep, Oct, Nov	Winter Dec, Jan, Feb
1976		20.3-23.0	19.2-20.9	16.0-18.3
1977	15.7-18.3	19.8-22.0	16.1-19.7	15.0-15.9
1978	17.1-20.7	18.9-22.6	18.2-19.7	12.8-14.1
1979	16.4-18.4	19.3-20.9		
1984	17.7-20.2[1]	19.4-23.3[2]	16.8-25.5	
1985			18.0-21.8[2]	12.4-14.3[1]
1986			16.5-20.8[2]	14.5-16.5[1]
1987			17.2-21.4[2]	15.3-16.6[1]
1988			15.9-21.4[2]	11.2-14.3
1989	14.1-22	15.6-24.0	15.4-23.4	11.8-16.2
1990*	14.0-20	17.4-25.3	14.0-23.6	11.8-16.8
1991	13.3-18.3	17.0-22.1	16.5-22.3	11.0-14.8
1992	15.9-22.7	16.8-21.7[1]		

[1] = one month only
[2] = two months only
* = Inner Oxford St. basin station 22 added in 1989, station 25 added in 1990.

October of 1989 through 1991, 1984 though 1988 and 1976 through 1978, respectively. Temperatures during this month are among the highest in the years reported here. The range was narrowest in the 1976-1978 period. Temperatures are also among the most uniformly distributed throughout the pattern of stations. The expected pattern of warmer temperatures as distance of the station from the breakwater increases is clear in the gentle upward slope from lows in the 18° C to 20° C nearest the breakwater to the typical 20°-23° C range at the stations farthest from the breakwater. This is due to insolation of the shallow waters within the marina and the relatively slow exchange rate with the waters of Santa Monica Bay. October of 1991, although showing warmer than usual temperatures in Ballona Creek, is otherwise typical.

The pattern of temperature distribution through the marina in November, as seen in Figures II.4 through II.6 for the years 1989-1991, 1984-1988 and 1976-1978, respectively, shows a wider divergence in temperature ranges for 1976-1978, with a narrower range in 1984-1988 and the narrowest range in 1989-1991. There was a lowering of the ranges of about 2° C to 3°C. As in October the pattern of temperature increasing with distance from the breakwater is apparent. In November 1991, temperatures encountered, as shown in Figure II.4, were more uniform throughout the marina, compared to the years 1989 and 1990, exceeding the range of 16.5° C to 17.6° C only at stations in, and immediately adjacent to, the Oxford Street flood control basin.

December of 1991, the first of the winter months, had cooler temperatures and as expected, the relatively even temperature distribution at all stations during the period of 1989-1991 and 1985-1988, as shown in Figures II.7 and II.8. The temperatures encountered in 1976 through 1978, Figure II.9, indicate that the 1976 period was warmer by about 2° to 4°. In contrast to the pattern for October and November, in December the temperature of surface waters tended to be cooler in Ballona Creek, Station 12, than that at other locations in Marina del Rey during the years 1985, 1987, 1988, 1990 and 1991. This may reflect the effects of seasonal lowering of temperature of Santa Monica Bay and/or lower air temperatures affecting temperatures in runoff from the area drained by Ballona Creek.

The data for January temperatures, shown for 1989-1992 and 1977-1979 in Figures II.10 and II.11, respectively, continue the pattern of relative uniformity of temperatures throughout the marina that was noted for December, with generally lower temperatures than in December. The major departure from the pattern of uniform temperatures occurred in the relatively impounded waters of the Oxford Street flood control basin, where increased seasonal runoff and atmospheric temperatures would have the most pronounced effect.

The February data, particularly for 1977, indicate that 1977-1978 were warmer than 1989-1992 (Figures II.12 and II.13). A mild El Niño (El Niño-Southern Oscillation or ENSO) event occurred in 1977-1978, with the intrusion of warm equatorial waters carried north as a countercurrent, exhibiting variations as to the strength and extent northward. It is normal for the countercurrent to surface somewhere in southern California in winter, but the extent of northern flow, sometimes as far as British Columbia, the strength of linkage with the equatorial Pacific countercurrent and the intrusion of warm equatorial waters into South America determine whether it will be considered an El niño event. A strong El Niño occurred in 1984, lingering into 1985 as a pool of warmer water in the southern California bight and a milder El Niño extended intermittently into southern California in 1991-1992. In February 1992, data for Stations 8, 10, 20, 13, and 22 were incomplete due to probe malfunction in the rain, and Stations 7, 9, and 11 were not sampled when the Life Guard vessel being used was called on an emergency.

March temperatures in Marina del Rey, during the years for which we have data, show a warming trend. The data are presented in Figure II.14 for the years 1989-1992 and in Figure II.15 for 1977-1979. The higher ranք ıoted for February 1977 and 1978 and March of 1978, 1979 and 1992 were indicative of El Niño conditions. However the relatively warm temperatures of February 1977 were succeeded in March of that year by the coolest range of the March 1977 through 1979 annual series of measurements.

April temperatures, as shown in Figure II.16 for 1989-1992 and Figure II.17 for 1977-1979, displayed the seasonal warming that appears in all the years for which data are presented, except in 1978, when waters were warmer in March than in April. The differences in range from year to year are due to the differences from year to year in seasonal patterns in atmospheric and oceanic temperatures. Temperatures for April 1992 are probably due to the El Niño condition, although it was weakening in the tropics at that time. The upward slope of the temperatures according to distance from the breakwater that may be seen in these figures, as compared to those for earlier months, suggests that reduced flushing caused by the seasonally lower tidal range also increases solar heating of the shallow resident water in the marina. The effect of the insolation is most notable on waters within the Oxford Street flood control basin, Stations 13 and 22, where residence time of the contained waters is higher than elsewhere in the marina itself.

The trends noted for April are also present in May, Figure II.18 for 1989-1992 and II.19 for 1977-1979, and in June, shown in Figures II.20 for 1989-1992 and II.21 for 1977 and 1978. Seasonal warming trends led to higher temperatures than in previous months, a slope upward is apparent as distance from the breakwater increases and the temperatures at

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the Oxford Street flood control basin were higher than in the adjacent waters of the marina. The warmer waters noted in Ballona Creek for the autumn months are also in evidence in April in 1977-1978, in May and June 1978 and to a lesser extent in June 1990. Cloud cover is usually heavy in May and June, sometimes leading to cooler temperatures in those months than in April in ocean waters, as can be seen in 1977. In the spring of 1991 there were lower air temperatures than normal in the United States due to high atmospheric particulates and associated clouds due to volcanic eruptions of Mt. Pinatubo in the Philippines.

Monthly Depth Profiles in 1991-1992

Figures II.22 through II.30 present the data for average temperature of surface to 2 meters and bottom temperatures. Convergence of the two lines indicates that the there is no vertical stratification of the water column that might impede mixing of the usually well aerated surface with the underlying waters. This is usually typical of the colder months, when higher seasonal tides, increased winds and reduced insolation tend to promote more rapid exchange of the marina waters with the adjacent deeper waters of Santa Monica Bay and greater mixing of the waters during their residence within the marina. This pattern is evident in November, December, February, and March.

A second pattern, more typical of warmer months, shows a divergence of the temperatures for the superficial waters of the marina from the temperatures of the bottom waters. This is caused by the reversal of the conditions that lead to the isothermal waters of the cooler months and is evident in the temperatures for October, April, May and June, respectively (Figures II.22, II.28, II.29 and II.30).

A third pattern is shown in Figure II.25, the temperatures for January of 1992 and at Station 12, Ballona Creek in December and February. In these cases a thermal inversion may be seen, with the cooler waters of 0-2 meters overlying the warmer deep waters.

The density of sea water is determined by the combination of salinity and temperature. Cooler water may be less dense than warm water if it is less saline and higher salinity waters may be less dense than fresher water if it is warmer. The thermal inversion noted for January is due to the runoff from the winter storms reaching and overlying the more saline deep waters of the marina. In December and February this is apparent only locally within Ballona Creek.

Temperature Extremes and Means

The extremes and means of temperature in October 1991 to June 1992 are shown in Table II.II.2. The lowest temperatures are generally nearest the bay except in November and December, and the highest are generally in Oxford Street basin except for December, January and February.

Table II.2. Monthly temperature minimum, maximum and mean (in °C).

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
October	18.2	2	22.7	22	20.8	falling
November	16.3	1	18.3	13	16.9	falling
December	13.3	8	14.3	1	13.7	falling
January	11.0	13	14.6	9	13.7	rising/falling
February*	14.4	12	14.9	5	14.7	rising/falling
March	15.8	1	17.6	13	16.4	high/falling
April	16.1	1	23.7	22	18.5	falling
May	18.0	1	21.6	13	20.0	falling
June	15.8	1	22.1	22	19.4	falling

* Incomplete data at Stations 8, 10, 13, 20, 22 due to probe malfunction during rain; Stations 7, 9, 11 not sampled due to emergency call for Life Guard vessel being used in survey.

Figure II.31 presents the maximum, mean and minimum temperatures averaged for all data for each month. The seasonal patterns are clear, of autumn warm waters cooling off to winter lows and then warming through the spring into summer. Also evident are the countercurrent El Niño warm water of March and April, where the maxima appear to be atypically high.

The extreme low minimum in January, despite more closely related average and maximum temperatures, highlights the thermal inversion noted throughout the marina during that month.

Figure II.32 shows the average for all depths at each location sampled during all months. The characteristic low points, reflecting the ambient temperatures of Santa Monica Bay, are at Stations 1 and 2. Station 12 would be included in this group were it not for the variability in runoff temperatures. Otherwise, distance from the breakwater appears to be the determinant for relative warmth of the water at the different stations, indicating that the shallower depths and increased residence time of waters in the basins, with the resultant increased insolation, are governing factors in distribution of temperature throughout the marina.

Comparison of Marina del Rey monthly averages with those from Catalina Island, Newport Bay and Pt. Dume indicate that the marina was the warmest of these in October 1991, and March through June 1992, while Catalina was warmest in December through February. The marina was colder in December and January than the other sites. In February there was little difference among the four sites.

SALINITY

Salinity in the marina is strongly influenced by the fresh water flow from drainage into Ballona creek and the Oxford Street flood control basin. If it were not for these two sources, the inner basins would have higher salinities due to evaporation from the longer residence time there during warm weather, while during cold weather higher salinities would be likely in Santa Monica Bay. During wet weather, storm drain runoff into the basins from parking lots and streets influences the distribution of high or low salinities as well. Tide phase also influences salinity distribution, since a rising or high tide in dry weather will cause bay waters to extend inland past Station 12 in Ballona Creek and also influence Stations 1 and 2 more extensively.

Salinity in the marina can be considered as marine, but the much of the fauna is probably euryhaline, tolerant of occasional fresh water intrusions. Fish that are not euryhaline probably move out of the marina as salinity decreases and there is positive flow seaward. Some benthic worm populations are apparently killed or washed out to sea by storms, but they recolonize rapidly from adjacent populations (see Chapter VII). Since fresh water tends to layer on the surface, deeper waters may not be affected unless there is mixing.

In Table II.3, the salinity means and extremes of the monthly data from October to June are presented, along with the predominant tidal phase during the surveys. While the maxima and means do not vary greatly the minima are quite striking in the months with (ensive rainfall and runoff, such as January, March and April, 1992. The Cruise Log (Appendix A) gives the rainfall preceding and during each cruise.

Table II.3. Monthly salinity minimum, maximum and mean (in parts per thousand, converted from conductivity).

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
October	30.1	22	33.4	7	33.0	falling
November	30.1	12	32.8	7,8,9,10	32.5	falling
December	31.0	12	33.5	1	33.3	falling
January	17.4	13	32.6	7	31.3	rising/falling
February*	22.3	22	32.5	5,25	31.8	rising/falling
March	1.4	22	32.3	1,2	31.7	high/falling
April	7.3	22	33.2	1	31.7	falling
May	31.5	12	32.3	2,3,4,25, 5,6,18,8	32.2	falling
June	25.5	22	33.1	1	32.6	falling

Figure II.33 illustrates the relatively narrow range of the maxima and means, while there is great deviation in the minima due to the influx of rainfall runoff. The average of at salinities at all depths and all months (Figure II.34) indicates the large influx of low salinity waters in Oxford Street basin at Station 22 and the smaller reduction at Station 12.

DISSOLVED OXYGEN

Dissolved oxygen (DO) is introduced into the water by plant metabolism, primarily by single celled algae, the phytoplankton, or by physical aeration due to turbulence in the surf zone and along rocky shorelines. Oxygen depletion occurs during respiration of marine plants and animals, or due to the bacterial degradation of dead biota, or to the oxidation of organic and inorganic chemicals introduced into the waters. When nutrient input is high, phytoplankton may increase exponentially, forming a bloom and causing DO first to rise well above theoretical saturation and then to plummet when the bloom dies off.

Dissolved oxygen along the coast usually ranges between 6.0 and 8.5 ppm, and regulatory agencies have specified 5.0 ppm as the minimum DO necessary for the sustenance of fish populations, although many invertebrates can survive on much lower levels, down almost to the point of anoxia. If DO is totally depleted, hydrogen sulfide (H_2S) is released from chemical reduction of sulfates in sediments and water; noxious odors result and H_2S is toxic to some organisms.

Monthly Depth Profiles in 1991-1992

Monthly profiles of the surface to 2 m depth average DO and the bottom meter DO are illustrated in Figures II.35 to II.43. Water depth varies with tide and location from 4 to 6 m at Stations 1 through 5 and from 3 to 4 m in the rest of the marina.

The monthly profiles figured indicate that the waters are generally well mixed. In the cool months of the year there are fairly uniform DO levels, as is seen in November and February, but rainfall can change this pattern. During the warmer months when a thermocline is apt to be present the DO tends to differ in surface and bottom waters. Also, bloom conditions can occur at almost any time, and sometimes in very limited areas, as indicated by high DO values (e.g., above 8.5 ppm). Low DO values may be indicative of death of a bloom, with oxygen being consumed in the breakdown of the cells by microbial action, or by an influx of chemicals or debris during rainfall runoff that are oxidized chemically or by microbials, or by insolation in shallow waters, when increasing temperature decreases solubility and drives oxygen from the water.

In October 1991, bloom conditions appeared to be in effect throughout much of the marina, with values exceeding 8.5 ppm except in Basin E and Oxford Street basin. In

November, DO values were again high in the entrance channel, declining slightly in the inner channels and basins; at a number of stations the bottom waters had higher DO levels than the surface, especially at Station 5 (Figure 36). A similar pattern occurred in December, with a deviation at Station 5, this time with the surface values higher than the bottom. Bloom conditions again seemed to be occurring in the entrance and main channels.

In January 1992, bottom DO values were higher at most stations, with a wider spread. This may have been due to rainfall prior to the survey, but blooms apparently continued in the outer marina. February, only Stations 12, 1 and 2 had excessive DO levels but this may have been due .. turbulence because of storms. Data were incomplete in that survey, since Stations 7, 9, and 11 had to be skipped when the Life Guard vessel from which the surveys are performed was called out on an emergency. In March 1992, there was a distinct change in the regime and bottom waters were below 5.0 ppm at Stations 8, 10 and 20 following substantial rains in the previous few days.

In April, bottom waters in the outer marina were again higher than those at the surface; it had rained the previous day. The lowest DO values of the survey, 2.0 ppm and 3.0 ppm, occurred in Oxford Street basin at Stations 13 and 22 respectively, indicating the impact of street runoff. May DO levels, when blooms might be expected to return to the marina, may have been lower than normal due to storm drain runoff from the Los Angeles area. There were low DO values in bottom waters at Stations 6, 7, 10, and 20 and at Station 22 (surface sample only). In June, bottom waters were near or below the minimum at Stations 6, 7, 8, 18, 10, 13 and 20. This is unusual, and may still represent chemical oxygen demand or toxicity from debris carried into the marina or the death of a phytoplankton bloom. Complete data are presented in Appendix B.

<u>Historical Monthly Records</u>

Comparative data from 1976-1979 and 1984 to 1991 are illustrated in Figures II.44 to II.61 for October, November and December, the months with the largest data base.

In comparing October 1991 DO data with that of previous years (Figures II.44-

II.49), the 1991 data have among the higher averages, exceeding most of the 1980s data. The exception is that of 1989, which was higher except at Stations 12 and 1. The 1977 averages were well above most of those in 1976 and 1978. Bloom conditions may thus have increased over the 1980s levels but low oxygen episodes do not approach those of the 1970s. Bottom water DO values in October 1991 were also better than those of the 1980s.

Comparison of November averages (Figures II.50-II.55) indicate that the DO values were higher in both surface and bottom waters in 1991 than they were in any other years surveyed except for 1977.

The year July 1977-June 1978 had the highest rainfall, 33.44 in, since 1889-1890. Whether algal blooms can be linked to rainfall and the accompanying nutrient input is open to question. Increased oxygen levels may be associated with storm related turbulence at the breakwater but the high oxygen demand from debris and chemicals in runoff may negate such increases.

In December 1991 surface DO levels were the highest in all surveys except for 1977, when data were incomplete. The 1990 data showed a higher level at Ballona Creek in surface waters and in bottom waters at almost all stations. In 1984-1988 data were much more similar to one another and more uniform throughout the marina, but in 1989 and 1990 the decline from outer to inner marina were more pronounced.

The minimum, maximum and mean DO in October 1991 through June 1992 are listed in Table II.4, along with the tide phase during the sampling period.

The averages of all stations for minimum, maximum and mean DO by month are illustrated in Figure II.62. The general trend in the mean is downward from October to April, after which it rises. None of the monthly means for all stations approached the regulatory minimum standard of 5.0 ppm, but minima in March, April, May and June were below it, as discussed above.

The average DO for all depths and all months by station (Figure II.63) illustrates the general trend of decreasing DO from the marina entrance to the innermost basins, with

Oxford Street basin being the lowest.

Table II.4. Monthly dissolved oxygen minimum, maximum and mean (in ppm).

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
October	5.6	22	10.2	1	8.5	falling
November	6.3	13	9.8	1	8.3	falling
December	7.3	13	10.1	1	8.8	falling
January	5.5	13	9.4	12	7.7	rising/falling
February	5.7	22	9.6	1	8.0	rising/falling
March	4.4	20	8.2	12	5.5	high/falling
April	2.0	13	8.8	1	6.1	falling
May	3.0	10	7.8	1	6.4	falling
June	4.3	20	8.8	2	6.6	falling

FIVE DAY BIOCHEMICAL DEMAND (BOD_5)

Biochemical oxygen demand is a comparative measure of the amount of biological or chemical material in the water column that will use up dissolved oxygen during microbial degradation. Sample bottles must be filled completely so that only oxygen dissolved in the water will be measured. The BOD_5 is measured in an arbitrary five day incubation period at 20 °C, predicated on the laboratory work week rather than any scientific basis and is not considered to be a very dependable method, although it is a widely used, traditional public water quality method. Samples from areas such as sewage and industrial waste plumes or in harbors and estuaries where loadings are high must be diluted to be certain that the oxygen is not depleted before the incubation period is over, leading to calculation of a falsely low estimate of demand.

The minimum, maximum and mean BOD_5 are illustrated in Figure II.64 for all stations and depths from October to June, and the data are tabulated in Table II.5.

The minimum for the period of October 1991 through June 1992 was 0.4 mg/l, which occurred three times at Station 7. The minimum was 0.1 mg/l higher than in 1990-1991. The minimum for the month occurred at Station 7 five out of nine months surveyed,

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at Station 5 in three surveys, at Stations 11 and 25 in two surveys and at Station 6 in one survey. This is in contrast to the previous period when the minimum was at Station 6 in four surveys. The highest minima occurred during May and June.

Table II.5. Monthly biochemical oxygen demand minimum, maximum and mean (mg/l).

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
October	0.4	7	2.8	22	0.9	falling
November	0.6	7,11	6.1	19	1.3	falling
December	0.4	7	2.4	22	0.9	falling
January	0.4	7	5.9	13	1.3	rising/falling
February*	0.6	10	18.9	22	2.2	rising/falling
March	0.5	25,5,7	2.7	22	1.0	high/falling
April	0.5	5	6.0	22	1.4	falling
May	0.7	6	7.8	12	2.3	falling
June	0.7	25,5,11,9	4.6	22	1.5	falling

* survey not completed at Stations 7,9,11 due to Life Guard emergency call.

The maxima showed no seasonal trend; the highest value was 18.9 mg/l in February 1992 at Station 22 during rain and storm turbulence. The peak in 1990-1991 was also in February but not during a rainy period and was only 15.3 mg/l. The second highest in 1992 was 7.8 mg/l in May at Station 12 in Ballona Creek, when storm drains may have been carrying runoff and debris from the Los Angeles area. The maxima were at Station 22 at the inner end of Oxford Street basin in six of nine months, and once at Station 13, at the outer end of Oxford Street basin. The only true marina station with a maximum was at Station 19, the wheel chair ramp at the beach in Basin D in November. Coliform and enterococcus bacteria levels were elevated at that station at the time, but higher levels occurred at Station 22 so the BOD would not appear to be due to fecal material. The low mean for that month indicates that the other values are low. The February maximum is quite distinct and the mean was correspondingly higher in the marina.

In Figure II.65, the average for all depths and all months surveyed is presented by

Station in distance from the breakwater. The influence of Oxford Street basin at Station 22 is pronounced. There is a gradient from Stations 12 and 1 in Ballona Creek through stations in the entrance and main channels which probably indicates the influence of Ballona Creek loadings as they extend, declining, into the marina as far as Station 5.

Monthly profiles of BOD_5 that are illustrated in Figures II.66 through II.74 show the trends in the averages for the entire period surveyed, but the monthly plots do not show the declining values from Ballona Creek as distinctively. Individual deviations, such as those around the Administration dock at Stations 4 and 25 in December illustrate a localized event, perhaps drainage there from the storm drain or from bait boat activity at the fishing dock.

HYDROGEN ION CONCENTRATION (pH)

The pH of sea waters generally ranges from 7.3 to 8.4 on a scale based on the negative logarithm of the hydrogen ion in gram atoms per liter, measurable on a hydrogen electrode but usually expressed without units other than number; the lower numbers are acidic and the higher ones basic chemically. Sea water is in the basic range. In October 1990-September 1991 the range was from 6.8 to 8.4, with the lowest values occurring at Stations 13 or 22 in Oxford Street flood control basin. In October 1991-June 1992, the range was slightly narrower, from 7.3 to 8.3, and with few exceptions the lowest values were again in Oxford Street basin. The maxima are usually found at Stations 12, 1 and 2, nearest the bay, as can be seen in Table II.6, below.

In spite of the large volume of storm water runoff carried by Ballona Creek, the pH was much more lower in runoff in Oxford Street basin, regardless of the tide phase. Figure II.75 illustrates the monthly minimum, maximum and mean calculated without Ballona Creek and Oxford Street basin, showing a relatively uniform range throughout the period, while Figure II.76 illustrates the same values when Ballona Creek and Oxford Street basin are included. The fluctuations are largely due to the latter; absence of data at the Oxford Street stations in February no doubt produced an artificially high minimum.

Table II.6. Monthly minimum, maximum and mean pH values.

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
October	7.8	13	8.3	12,1-4	8.2	falling
November	8.0	17,13,22	8.3	12,1-3	8.2	falling
December	7.9	13	8.3	1,2	8.1	falling
January	7.5	13,22	8.2	12,1-5,25,7	8.1	rising/falling
February*	7.9	6	8.1	12,1-3,18	8.0	rising/falling
March	no data due to probe malfunction					
April	7.1	22	8.3	12,1,2	8.1	falling
May	7.9	22	8.2	1-5,25	8.1	falling
June	7.3	22	8.2	12,1-4	8.1	falling

* Data incomplete, Stations 8-22, due to probe failure in rain; Stations 7, 9, 11 not sampled due to Life Guard emergency call.

There were rains for several days prior to the surveys in January, March and April, while it was raining during the February cruise. The February cruise was aborted without sampling Stations 7, 9, and 11 because the Life Guard vessel that provides transport for the survey was called on an emergency, the first time that this has happened since the surveys were resumed in 1984. The supposedly waterproof electronic readout panel had shorted out in the rain after the survey of Stations 12 and 1-6 was completed. The equipment was repaired but failed again in March, necessitating replacement of some equipment.

WATER COLOR (FOREL-ULE SCALE)

Water color is indicative of physical factors such as depth, substrate and suspended particulates, chemical factors, and biological factors such as bacteria and other microbials, and phytoplankton densities. Suspended particulates in turn are influenced by tide phase, winds, surf, and terrestrial runoff.

Color is measured by the Forel-Ule (FU) scale, which consists of a series of small vials filled with various marine colors or shades that are compared to the seawater viewed above a white Secchi disk suspended beneath the surface. Numbers 1 to 3 are deep sea blue, numbers 4 to 5 are blue green, 5 to 11 are increasingly darker greens, 12 to 15 are greenish browns, and 16 to 22 are increasingly darker browns. Color is a very subjective measure and it is essential to have the same person perform the observations in all surveys. It is not appropriate to use the FU scale in the shallow, restricted waters of Oxford Street basin. The complete FU data are included in Appendix B, Physical Water Quality. The monthly minimum, maximum and means are presented in Table II.7, below.

The lowest values, 4 and 5, generally occurred nearest the bay, although they were by no means restricted to that area. The highest value was a 17 at Station 12 in April, following se[illegible] l days of rain. Red tides may have been responsible for the high values throughout m[illegible] of the marina in May; runoff in the flood control channels in the previous two weeks from the Los Angeles area may have stimulated a general bloom, or may have added to turbidity, causing further discoloration.

Table II.7. Monthly color, Forel-Ule scale, minimum, maximum and mean[1].

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
October	5	1	10	2-4,5,7-10,18	8.7	falling
November	6	1,5,7,11	12	8	7.4	falling
December	5	1,2,6,7,20	10	18	6.5	falling
January	7	5-7,9,11	14	12	8.5	rising/falling
February*	10	4,25,6,8,10	15	12	11.6	rising/falling
March	6	1,2	12	7,8,10,18,20	9.5	high/falling
April	7	5,6	17	12	9.9	falling
May	10	6	14	12	12.3	falling
June	4	12	12	18	7.8	falling

* Stations 7, 9, 11 not sampled due to Life Guard emergency call.
[1] Forel-Ule not done at Stations 13, 22; water too shallow to determine marine colors.

Figure II.77 presents the minimum, maximum and mean for all stations surveyed by month, excluding the Oxford Street basin stations. There was rainfall runoff prior to the surveys in January, March and April, and it was raining in February when the surveys could not be completed. Figure II.78 illustrates the FU data for all months by station, excluding Oxford Street stations. Higher values are found at Ballona Creek Station 12 and in the restricted waters of Basin D, Stations 8 and 18, and in Basin E, Stations 10 and 20. The reduced flushing of those areas is probably a factor in the genesis of blooms.

WATER TRANSPARENCY

Water transparency varies with the amount of particulate matter or density of microbial and phytoplankton organisms. It is evaluated in two ways: by electronic measurement of percent light transmittance and by visual observation with a Secchi disk. A modified HydroProducts transmissometer having a self contained, white light with a 0.1 meter path, a constant length. Secchi disk observations, made as a white disk is lowered through the water column to a depth where it disappears from sight, are dependent on ambient light and the visual acuity of the observer.

Percent Light Transmission

Tables II.8 and II.9, below, present the minimum, maximum and means for percent light transmittance (%T) and Secchi disk respectively. Complete data are in Appendix B. As in other electronically measured parameters, that for %T are incomplete in February, perhaps skewing the data.

The narrowest ranges for %T were in November and December when waters were cooler and were clearer prior to turbidity produced by the rains of January through April. The minima (most turbid water with reduced light penetration) occurred at Stations 7, 9, 10, or 11. High %T (clearest water) was most often observed at stations 12 and 1, where it would be influenced by the clearer bay waters.

Secchi Disk

Minimum Secchi disk depths occurred primarily in the inner basins, where phytoplankton blooms are likely to be concentrated, except during the rainy periods of February, March, and April, and the possible fire-related runoff in May, which may have stimulated a general bloom. The value of 8 percent in April at Station 9 is anomalous; one

Table II.8. Monthly minimum, maximum and mean percent light transmittance (%T).

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
October	59	10	90	12,1	78.4	falling
November	72	11	90	12,1	82.5	falling
December	73	11	90	12,1	81.7	falling
January	68	10	86	18	79.0	rising/falling
February*	38	12	82	4,25	75.6	rising/falling
March	no data due to probe malfunction					
April	8	9	86	1,7	57.8	falling
May	56	7	84	2	72.0	falling
June	59	7	91	12	78.5	falling

* Stations 7, 9, 11 not sampled due to Life Guard emergency call.
Probe malfunction after Stations 1-6 due to rain.

Table II.9. Minimum, maximum and mean Secchi disk readings (in meters).

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
October	2.0	7,9,10	5.5	1	3.0	falling
November	2.0	8	5.0	1	3.1	falling
December	1.5	9,11,20	5.0	1	2.8	falling
January	1.5	10	3.0	3-9,18	2.6	rising/falling
February*	1.0	12	2.5	4,5,8,10,18	2.1	rising/falling
March	2.0	12,1-4,25	2.5	5,7,9,11 8,10,18,20	2.2	high/falling
April	0.5	12,1	3.0	4,25,5,7	2.2	falling
May	2.0	12,3,7,9,18	3.0	6	2.3	falling
June	1.5	18	4.5	1	2.9	falling

* Stations 7,9,11 not sampled due to Life Guard emergency call.

Rainfall preceded survey days in January, February, March and April.
Possibly influenced by runoff from Los Angeles area.

would conclude that the probe was fouled; the Secchi disk depth is more consistent with those of other stations. The maximum depths of visibility occurred at Station 1, at the entrance to the bay, in non-rainy months but the maximum depths were scattered through the marina during low runoff periods.

Figure II.79 illustrates the minimum, maximum and mean percent light transmittance values, while Figure II.80 illustrates the Secchi disk depths for comparison. While the maxima and minima seem to diverge considerably, due in part to the anomalous April %T reading at Station 9, the averages are very similar.

CONCLUSIONS

Water quality in the marina is most strongly influenced by drainage from Oxford Street flood control basin and less so by waters from Ballona Creek flood control channel. Rainfall and consequent drainage produces the most obvious impacts on all parameters measured. Bloom conditions, as evidenced by high dissolved oxygen levels, were more pronounced in 1991-1992. There were several episodes of low dissolved oxygen in bottom waters in Basin E in March through June, but averages were not below 5.0 ppm.

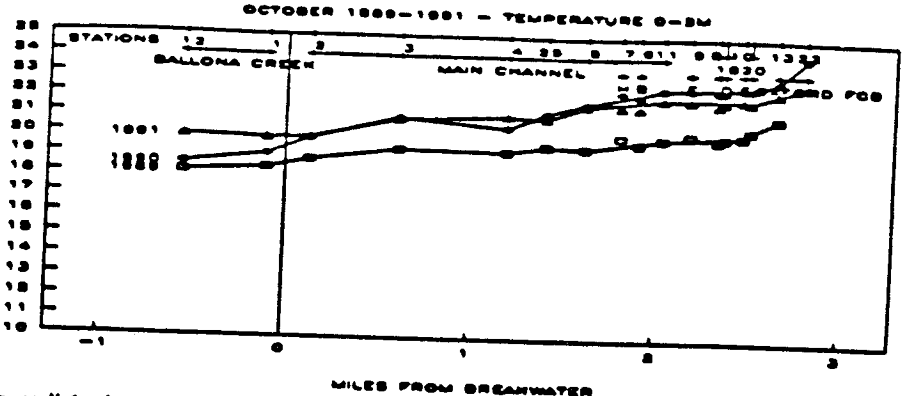

Figure II.1. Average temperature (°C) surface to 2m, in October 1989–1991 surveys.

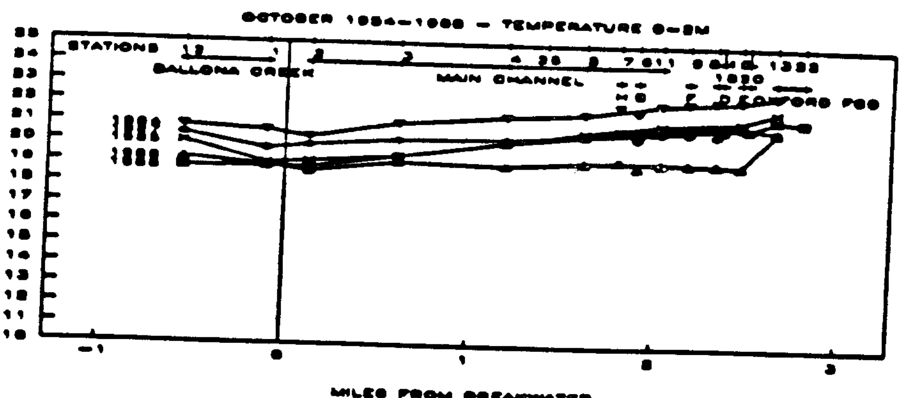

Figure II.2. Average temperature (°C) surface to 2m, in October 1984–1988 surveys.

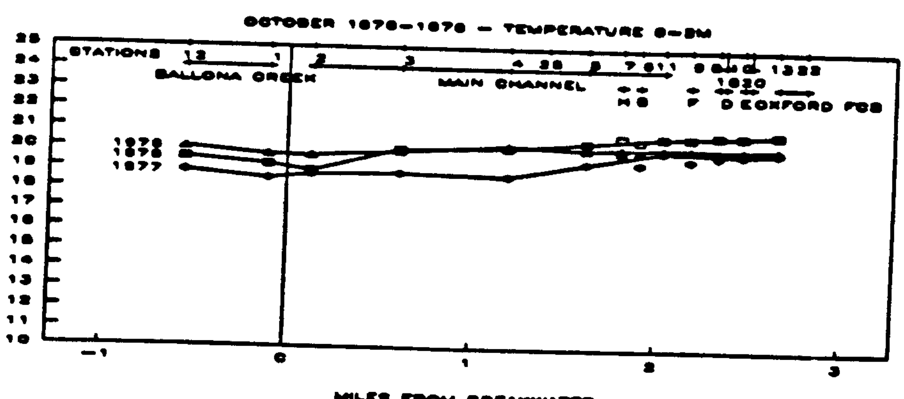

Figure II.3. Average temperature (°C) surface to 2m, in October 1976–1978 surveys.

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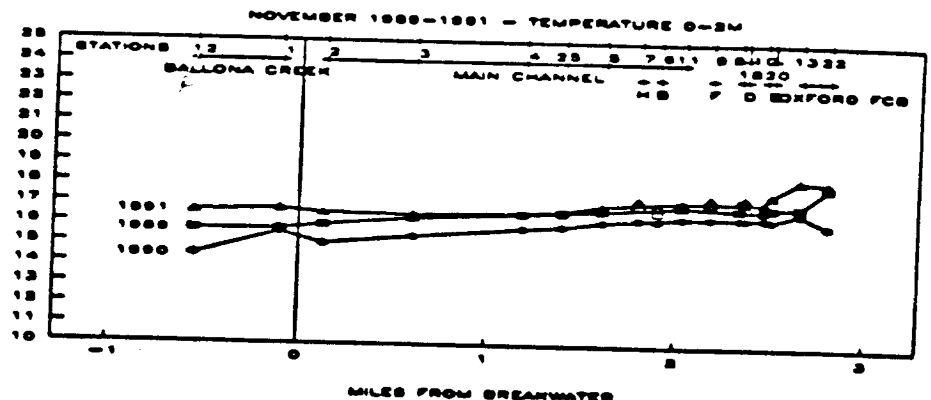

Figure II.4. Average temperature (°C) surface to 2m, November 1989–1991 surveys.

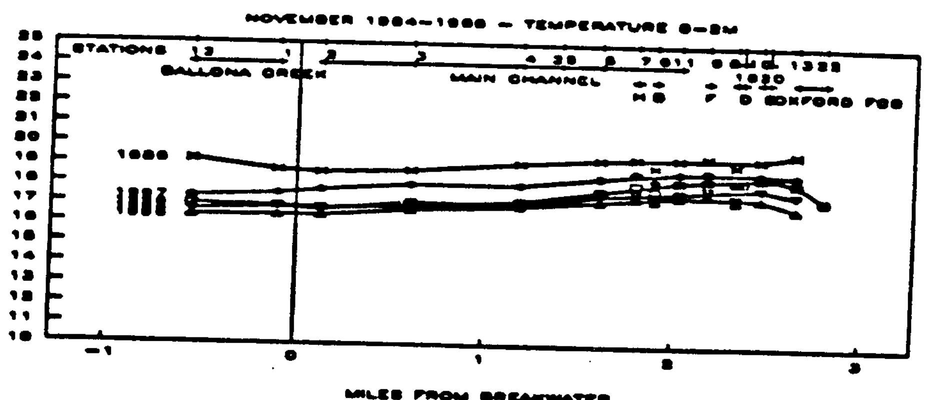

Figure II.5. Average temperature (°C) surface to 2m, November 1984–1988 surveys.

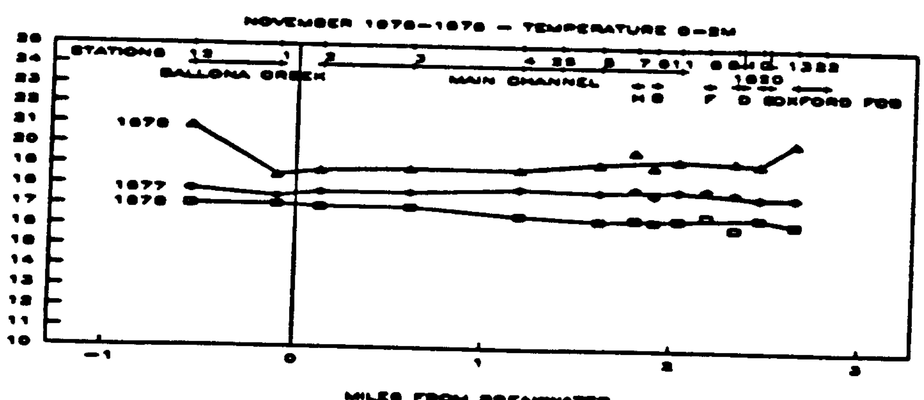

Figure II.6. Average temperature (°C) surface to 2m, November 1976–1978 surveys.

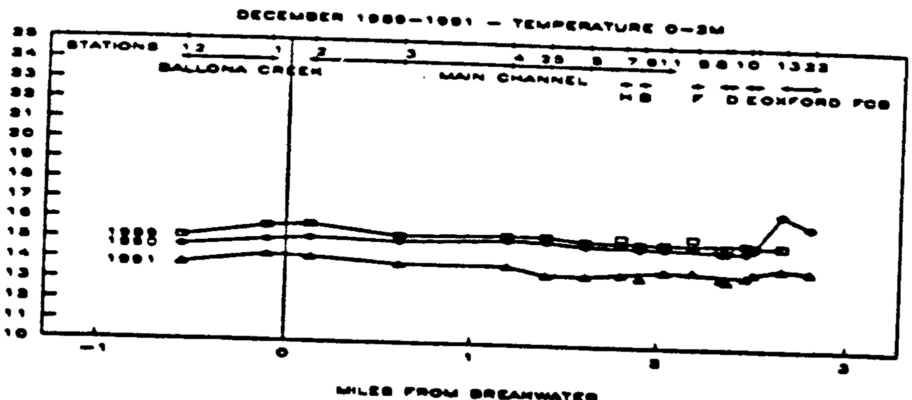

Figure II.7. Average temperature (°C) surface to 2m, December 1989–1991.

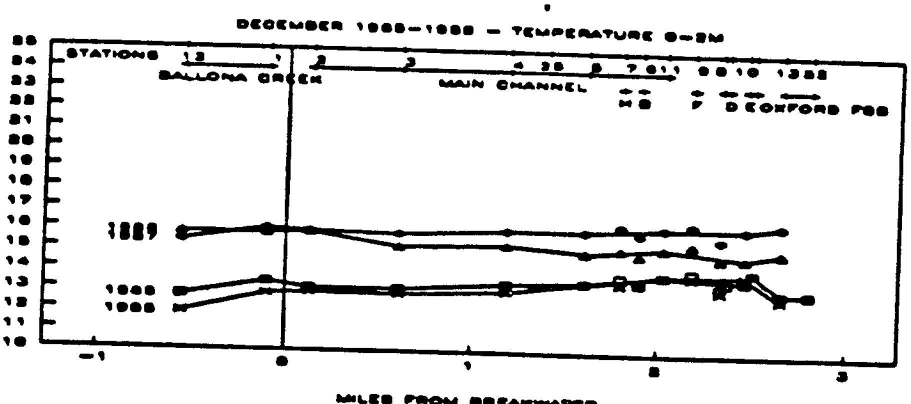

Figure II.8. Average temperature (°C) surface to 2m, December 1985–1988.

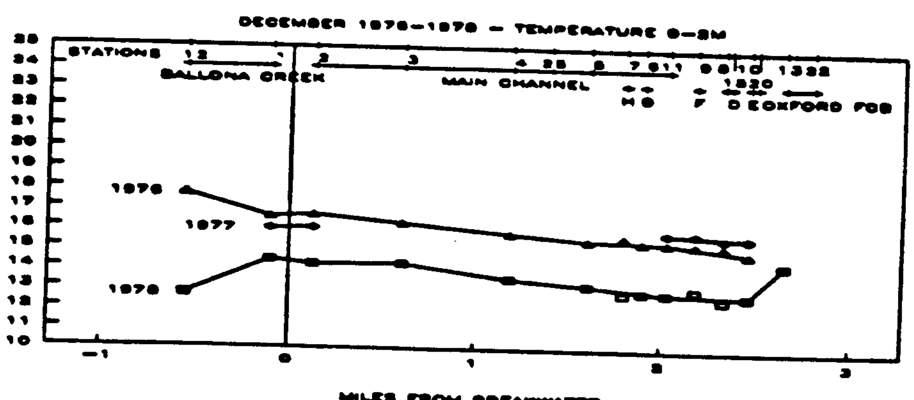

Figure II.9. Average temperature (°C) surface to 2m, December 1976–1978. The 1977 data set is incomplete.

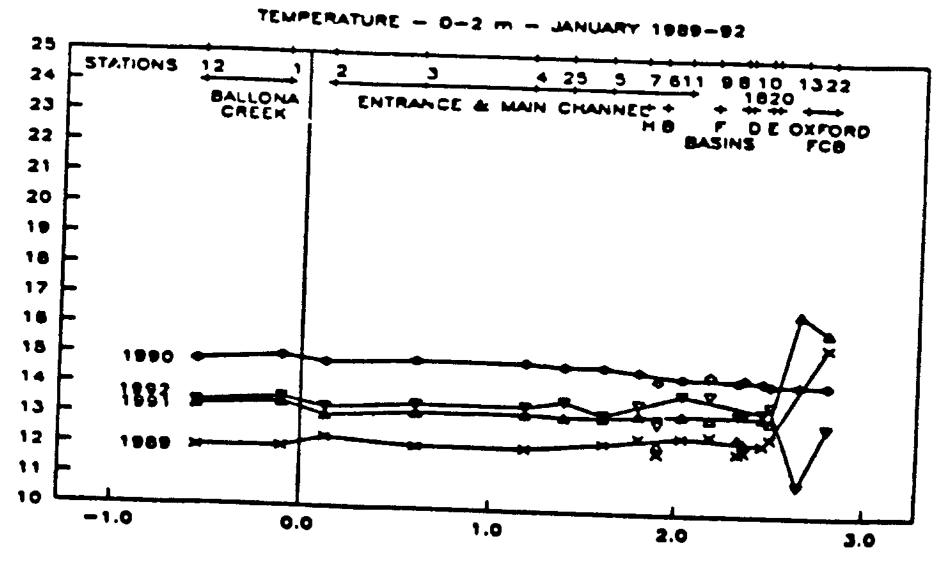

Figure II.10. Average water temperature (°C), surface to 2m, January 1989–1992.

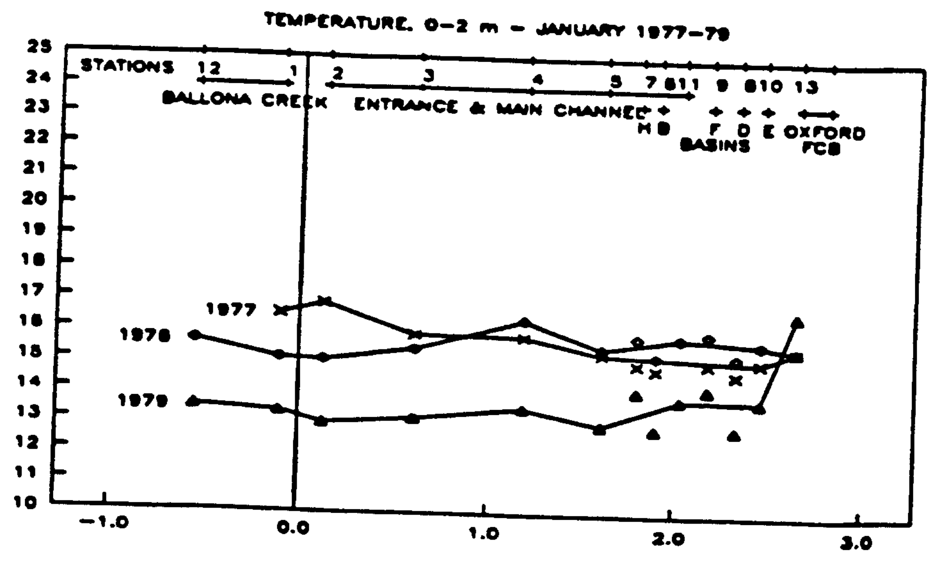

Figure II.11. Average water temperature (°C), surface to 2m, January 1977–1979.

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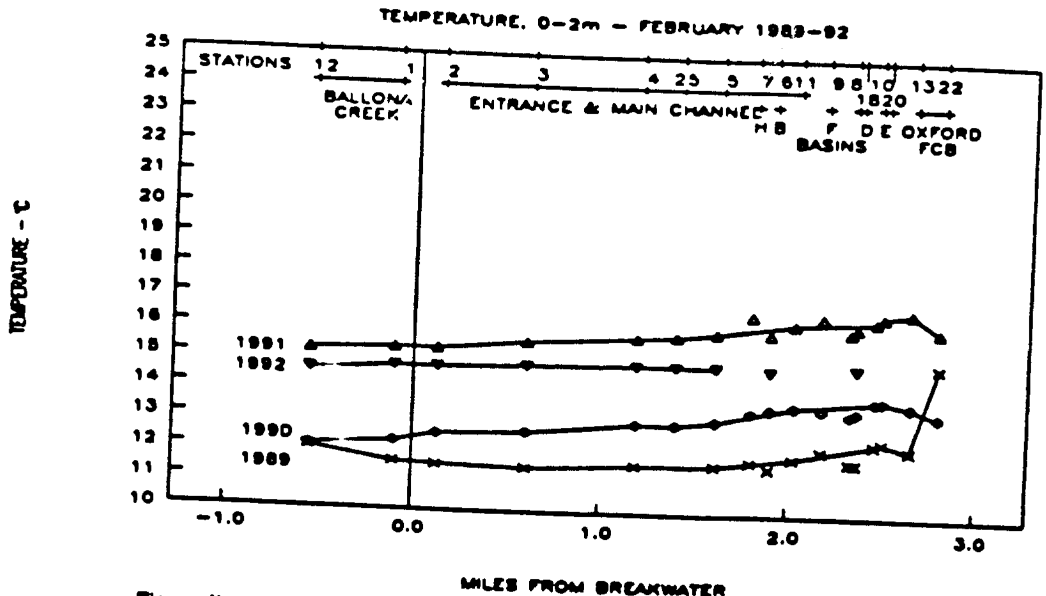

Figure II.12. Average temperature (°C), surface to 2m, February 1989–1992. Probe malfunction in 1992 and Life Guard vessel emergency call resulted in no data for stations 7–11, 13 and 22.

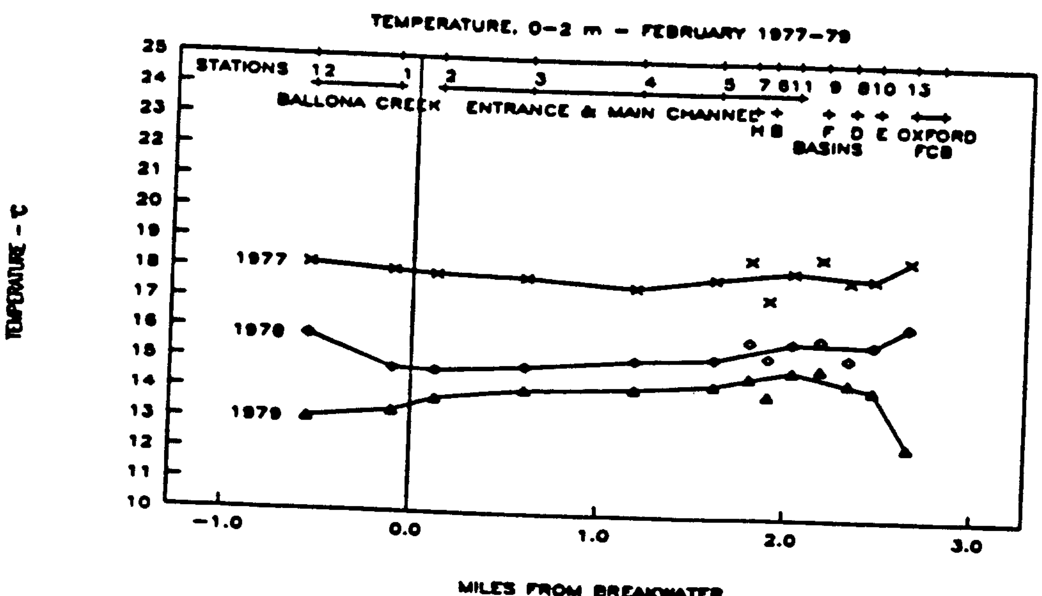

Figure II.13. Average temperature (°C), surface to 2m, February 1977–1979.

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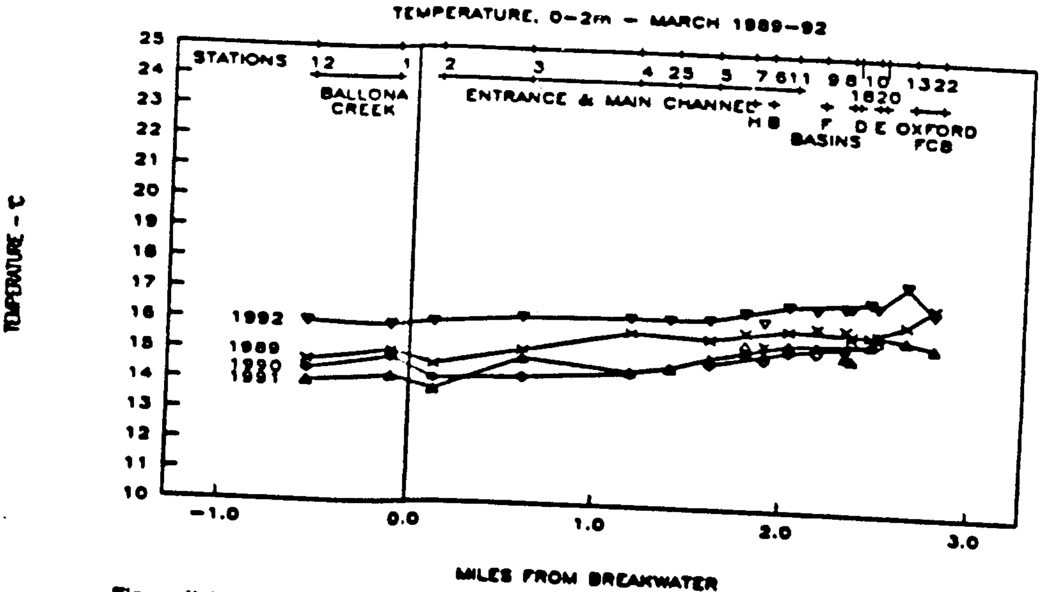

Figure II.14. Average temperature (°C), surface to 2m, March 1989–1992.

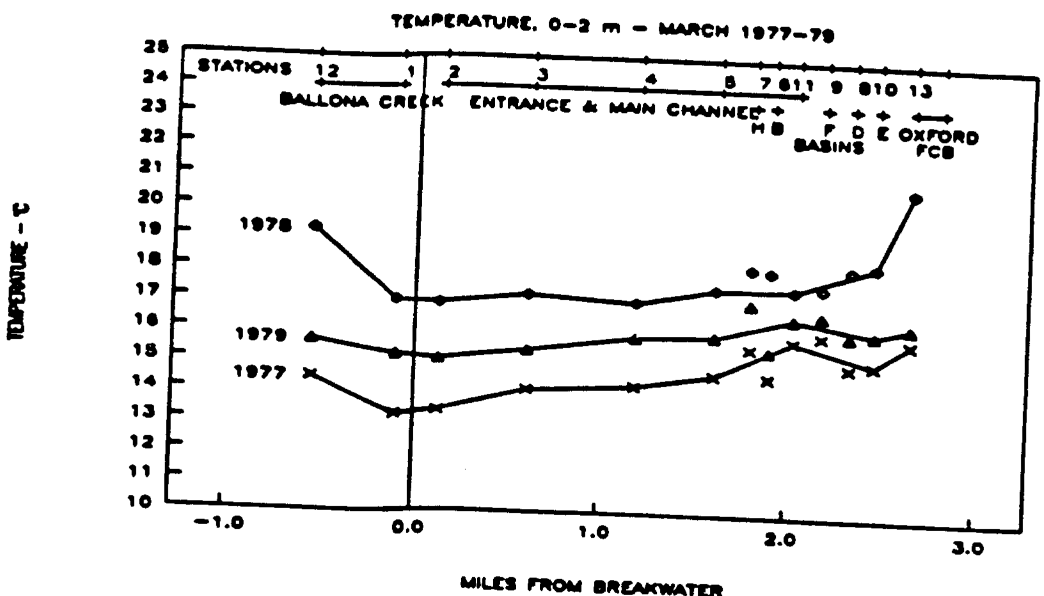

Figure II.15. Average temperature (°C), surface to 2m, March 1977–1979.

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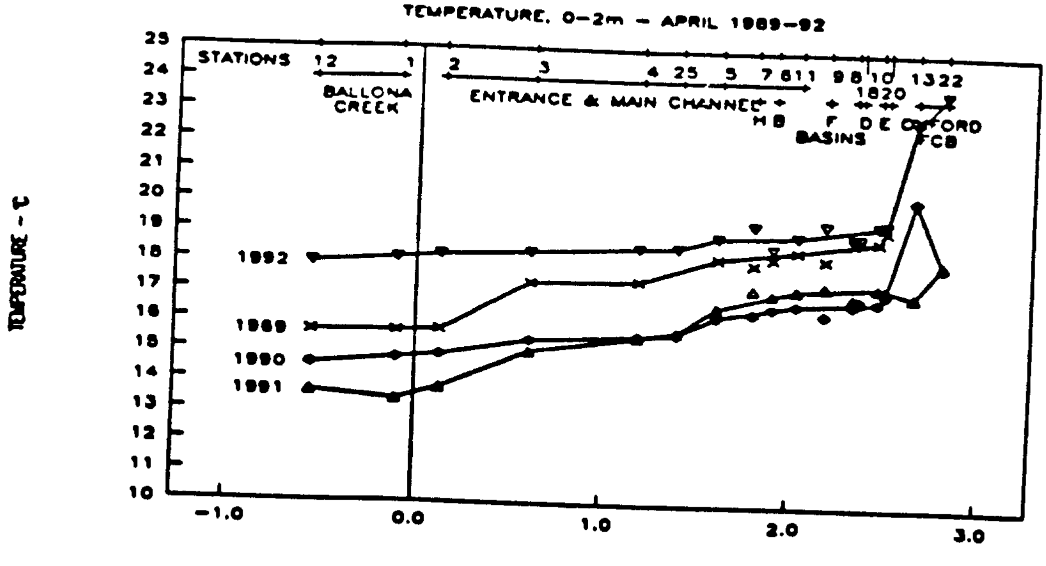

Figure II.16. Average water temperature (°C), surface to 2m, April 1989–1992.

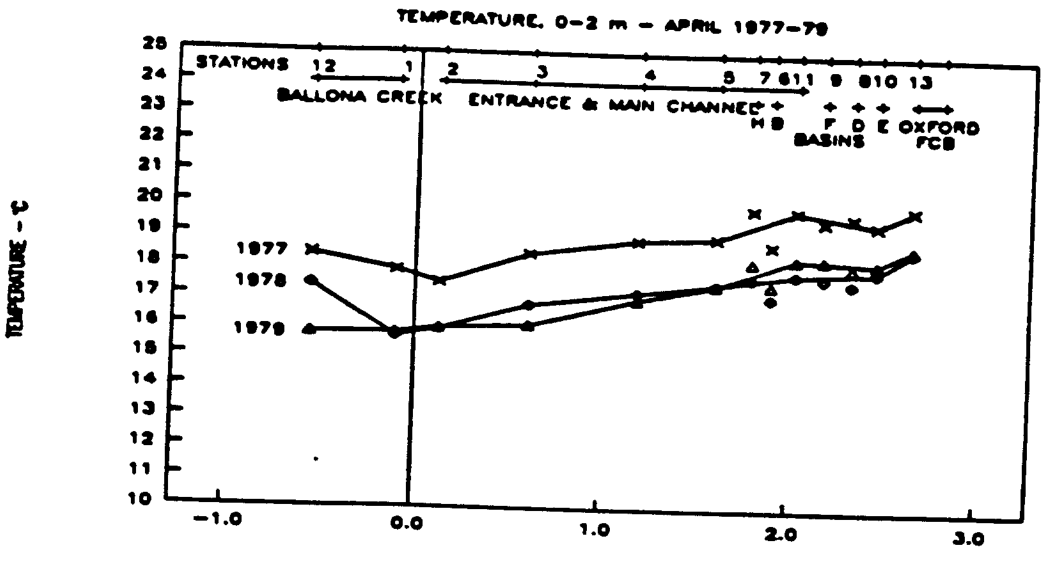

Figure II.17. Average water temperature (°C), surface to 2m, April 1977–1979.

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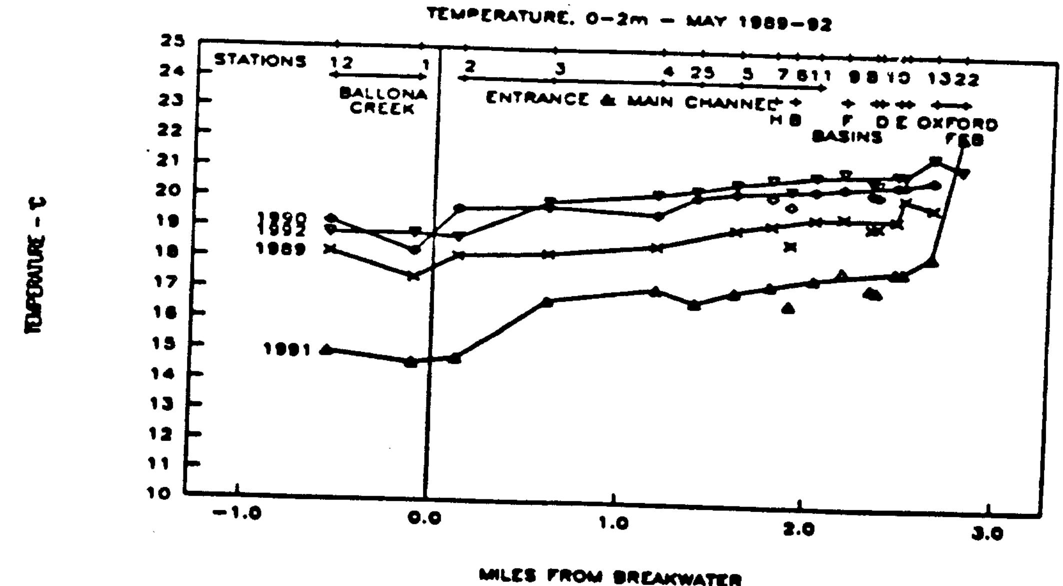

Figure II.18. Average temperature (°C), surface to 2m, May 1989–1992.

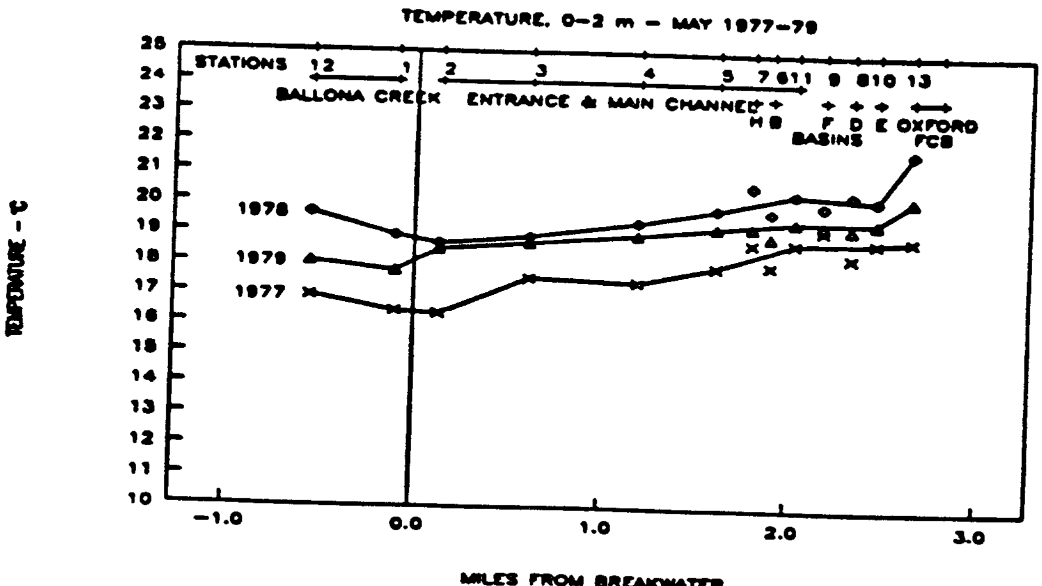

Figure II.19. Average temperature (°C), surface to 2m, May 1977–1979.

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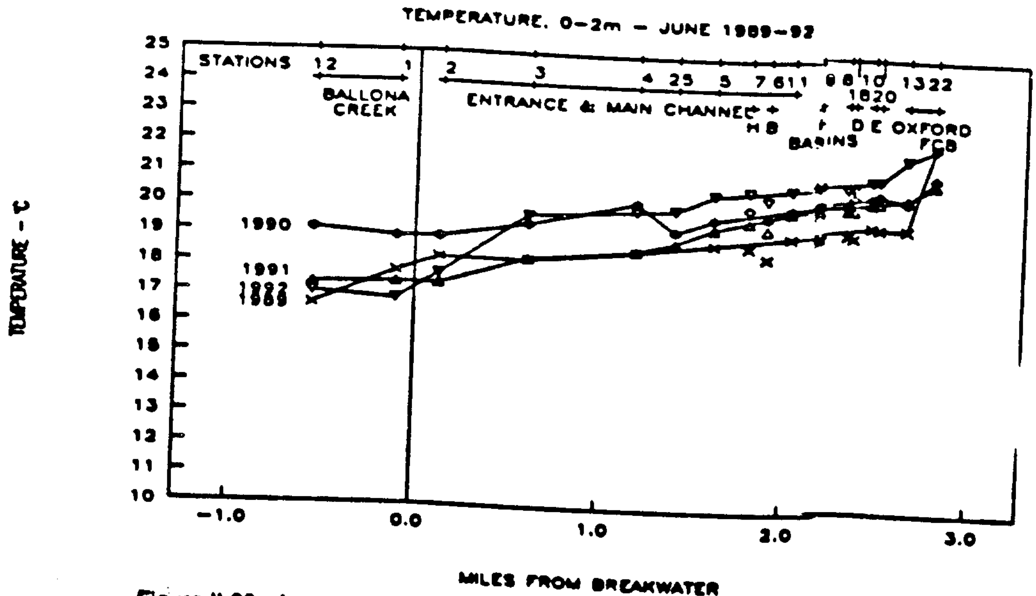

Figure II.20. Average temperature (°C), surface to 2m, June 1989–1992.

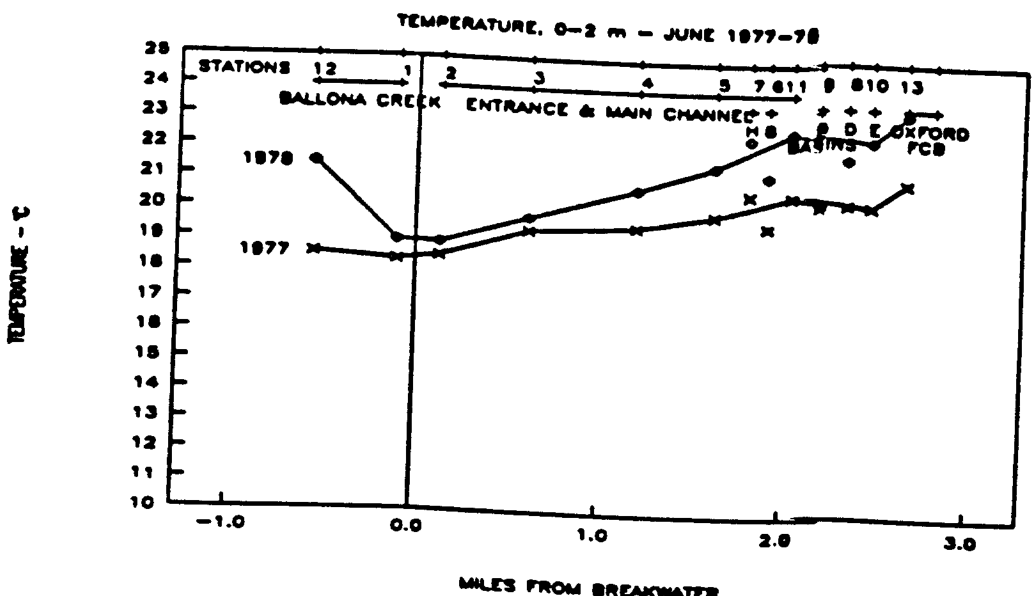

Figure II.21. Average temperature (°C), surface to 2m, June 1977–1978.

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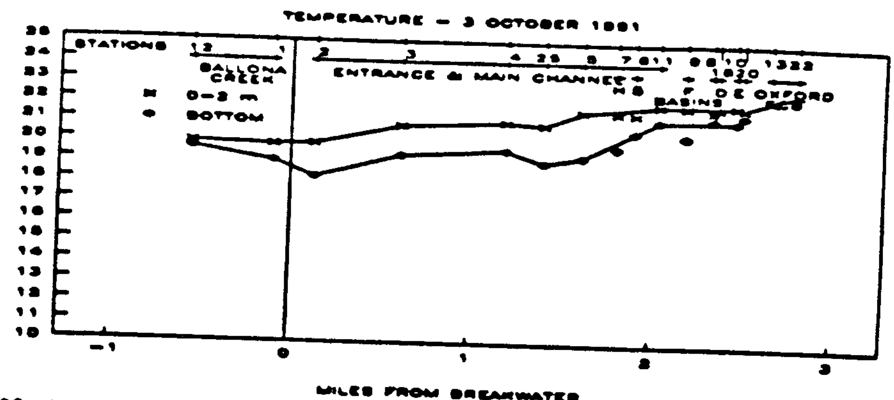

Figure II.22. Average water temperature (°C), surface to 2m, and bottom, 3 October 1991.

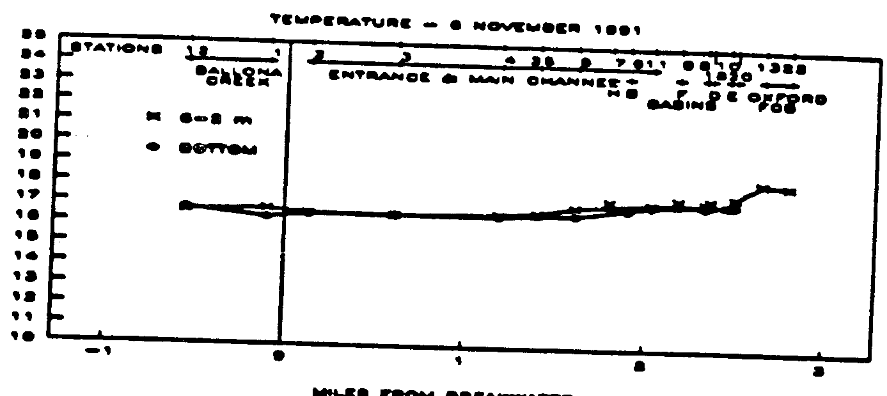

Figure II.23. Average water temperature (°C), surface to 2m, and bottom, 6 November 1991.

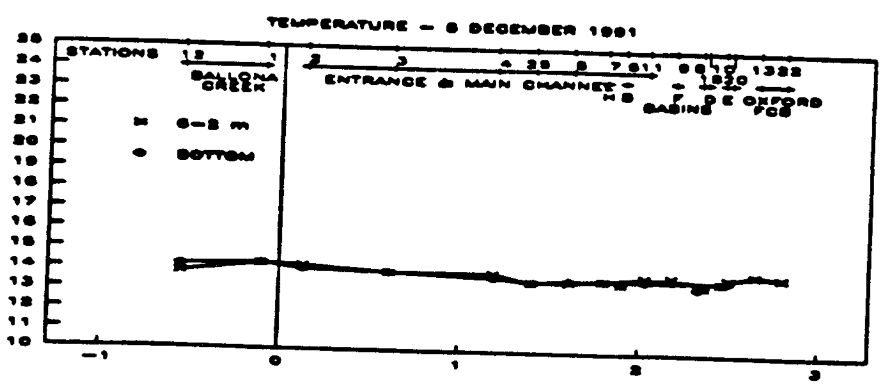

Figure II.24. Average water temperature (°C), surface to 2m, and bottom, 5 December 1991.

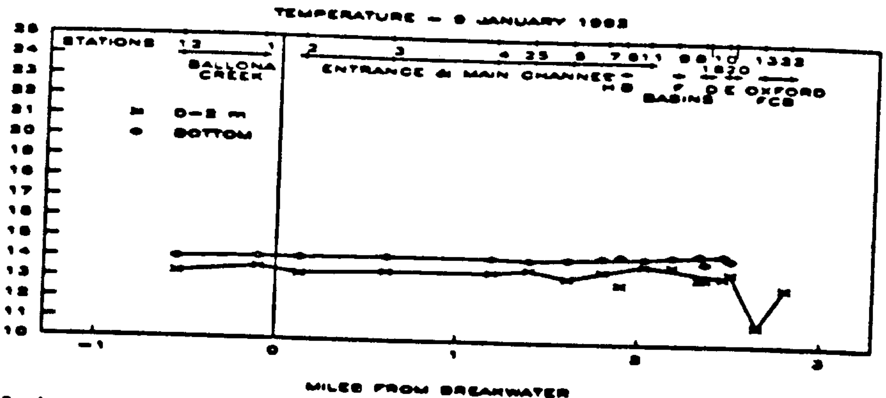

Figure :5. Average water temperature (°C), surface to 2m, and bottom, 9 January 1992.

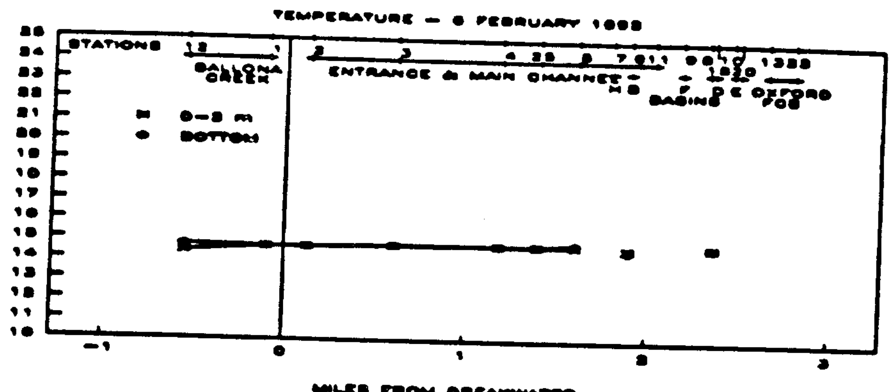

Figure II.26 Average water temperature (°C), surface to 2m, and bottom, 6 February 1992. Data for stations 7-11, 13 and 22 were not acquired due to probe malfunction and Life Guard vessel emergency call.

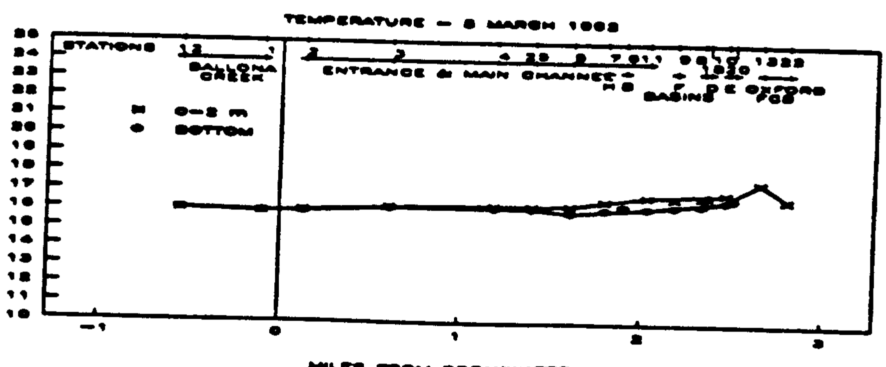

Figure II.27. Average water temperature (°C), surface to 2m, and bottom, 5 March 1992.

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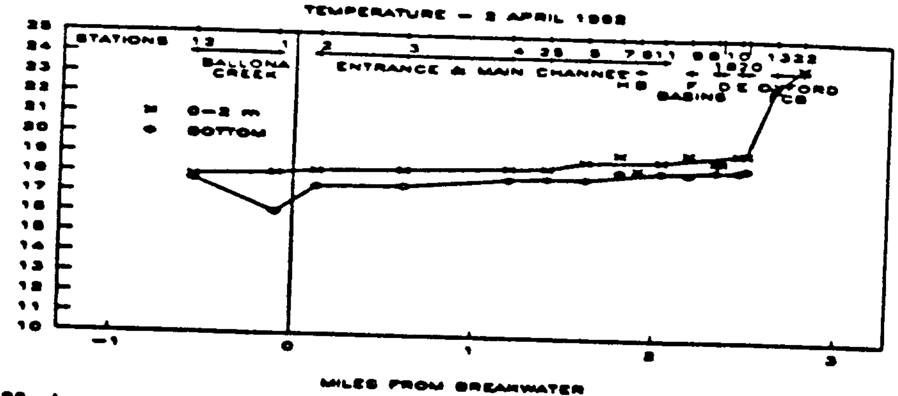

Figure II.28. Average water temperature (°C), surface to 2m, and bottom, 2 April 1992.

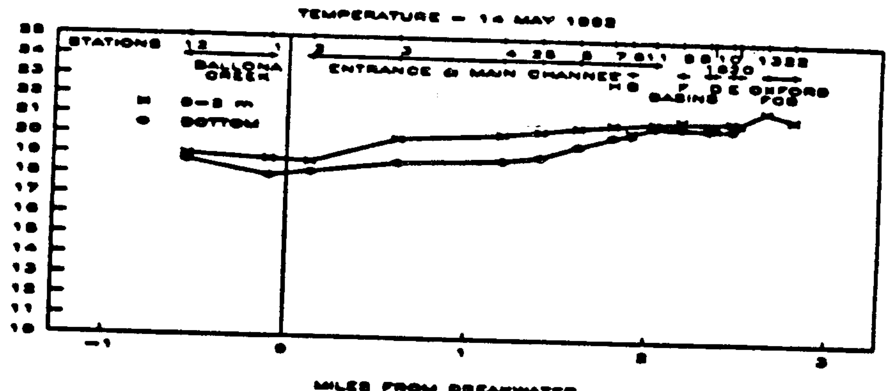

Figure II.29. Average water temperature (°C), surface to 2m, and bottom, 14 May 1992.

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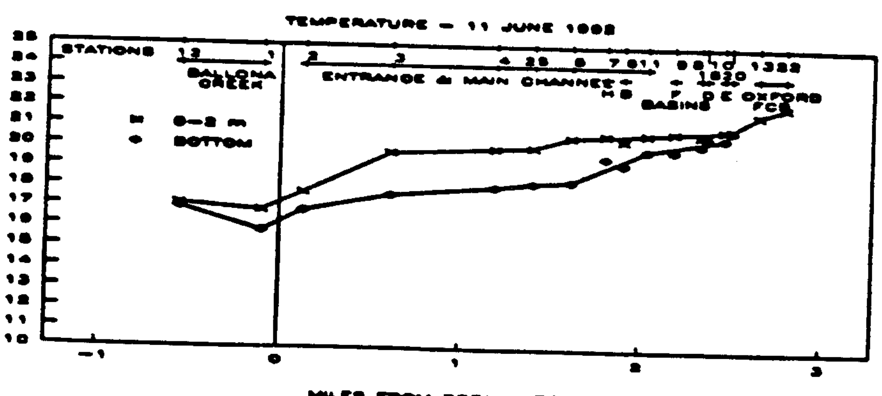

Figure II.30. Average water temperature (°C), surface to 2m, and bottom, 11 June 1992.

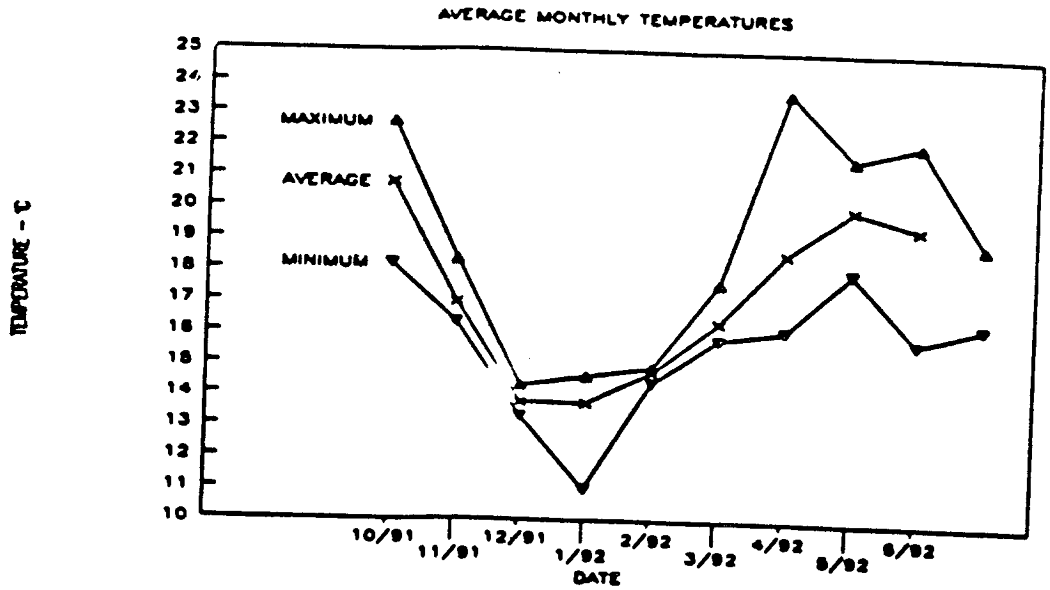

Figure II.31. Minimum,maximum and average temperature (°C) for all stations and depths by month during October 1991 through June 1992.

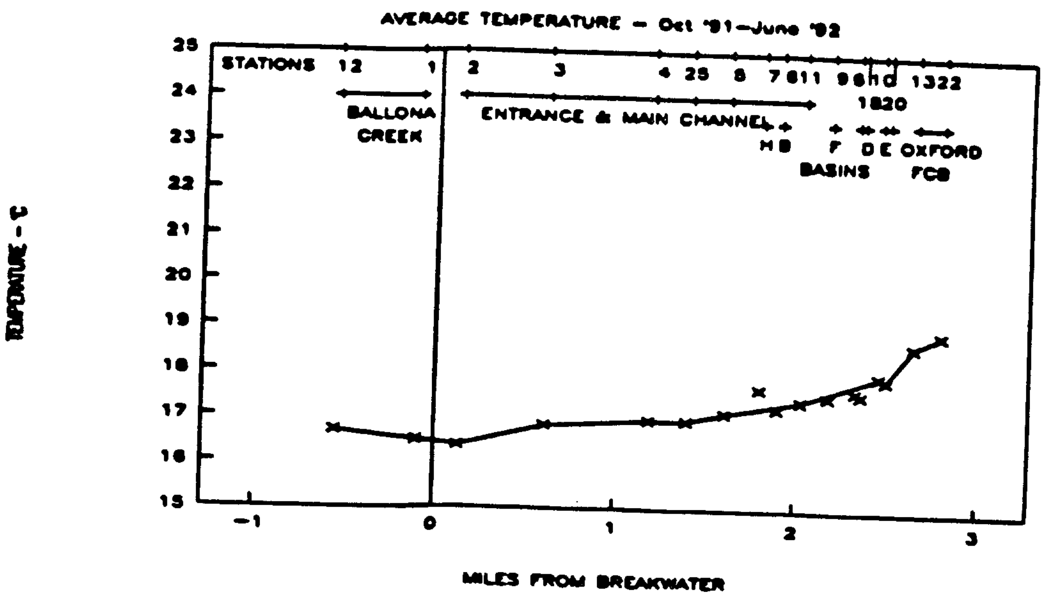

Figure II.32. Average temperature (°C) for all depths and all months by station during October 1991 through June 1992.

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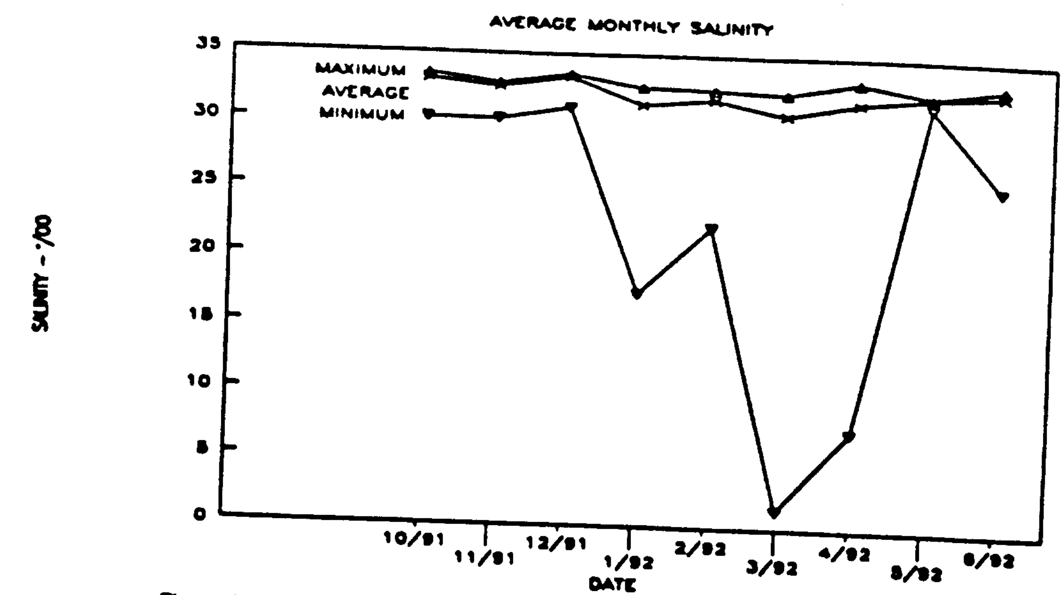

Figure II.33. Minimum,maximum and average salinity (°/oo) for all stations and depths by month during October 1991 through June 1992.

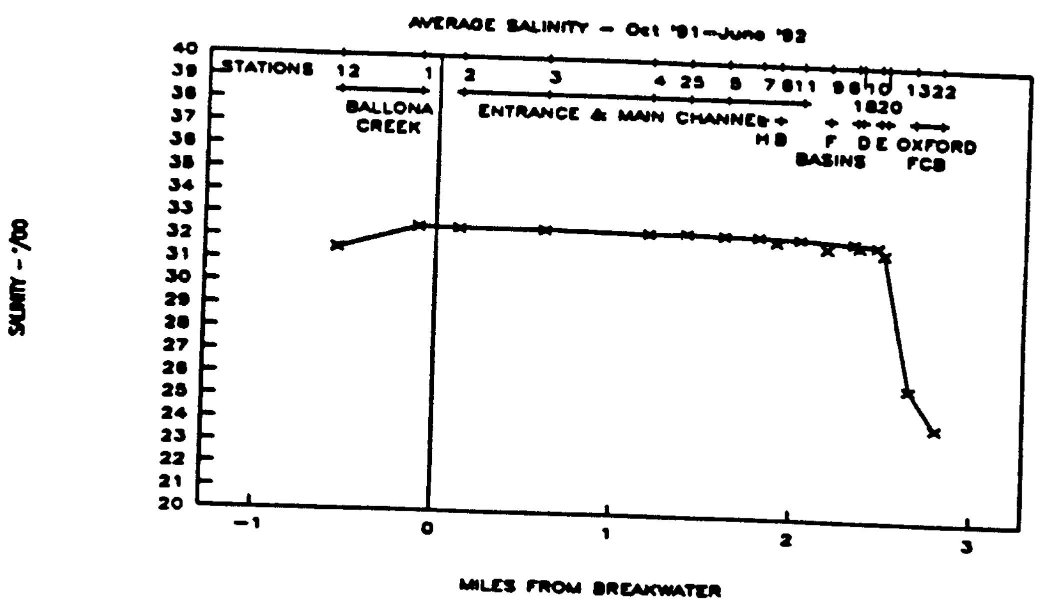

Figure II.34. Average salinity (°/oo) for all depths and all months by station during October 1991 through June 1992.

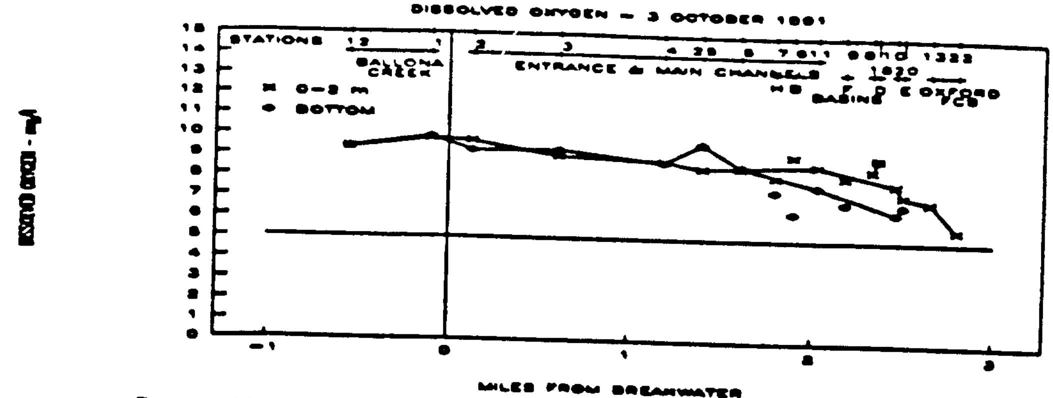

Figure II.35. Average dissolved oxygen (ppm), surface to 2m and b[illegible]om, 3 October 1991.

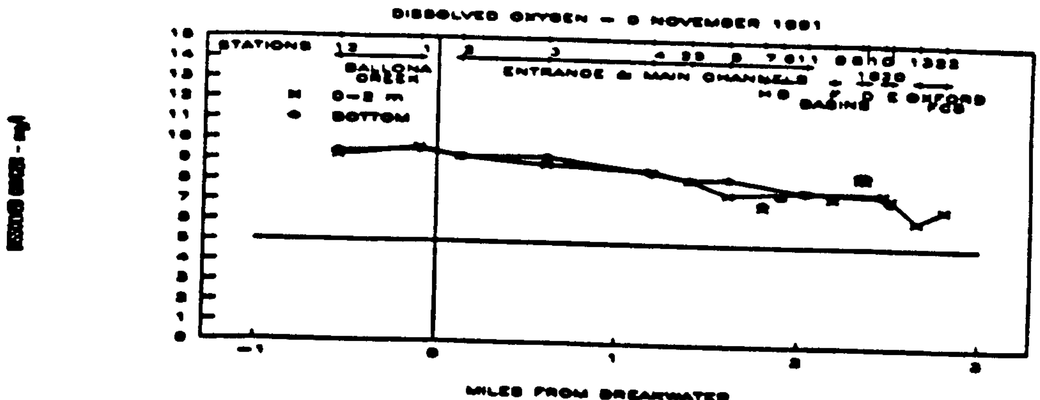

Figure II.36. Average dissolved oxygen (ppm), surface to 2m and bottom, 6 November 1991.

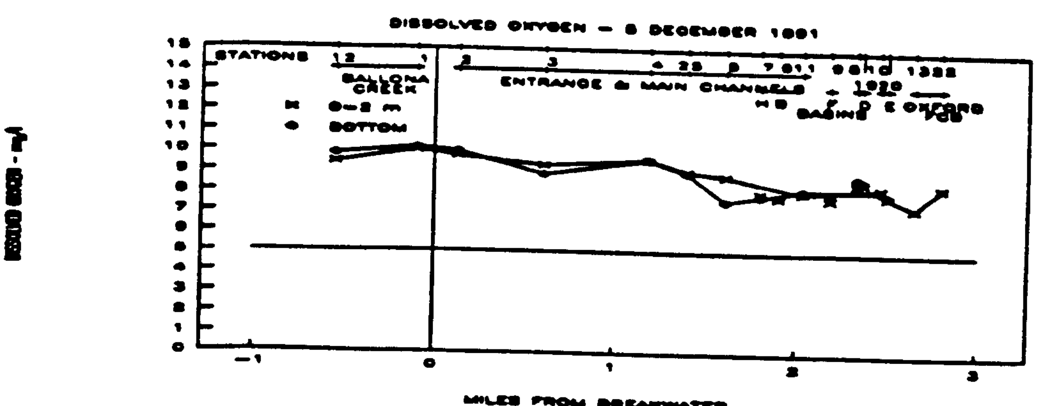

Figure II.37. Average dissolved oxygen (ppm), surface to 2m and bottom, 5 December 1991.

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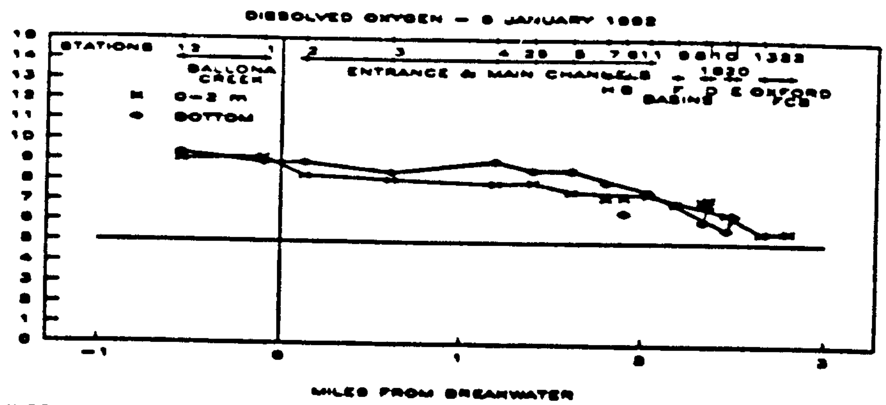

Figure II.38. Average dissolved oxygen (ppm), surface to 2m and bottom, 9 January 1992.

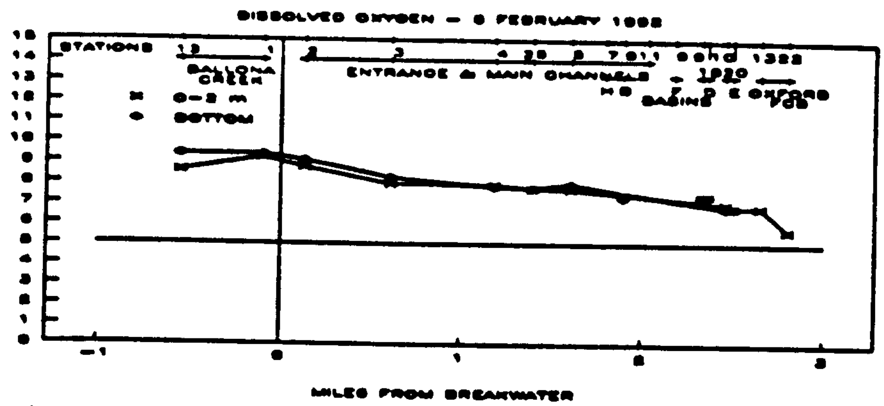

Figure II.39. Average dissolved oxygen (ppm), surface to 2m and bottom, 6 February 1992. Data not available for stations 7-11, 13 and 22.

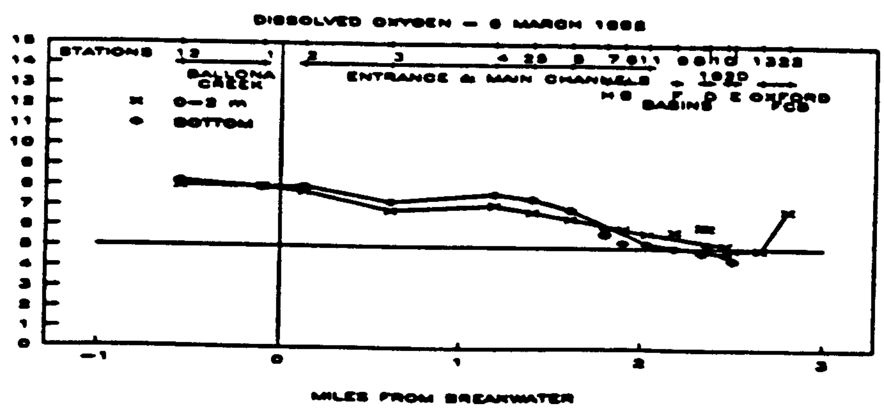

Figure II.40. Average dissolved oxygen (ppm), surface to 2m and bottom, 5 March 1992.

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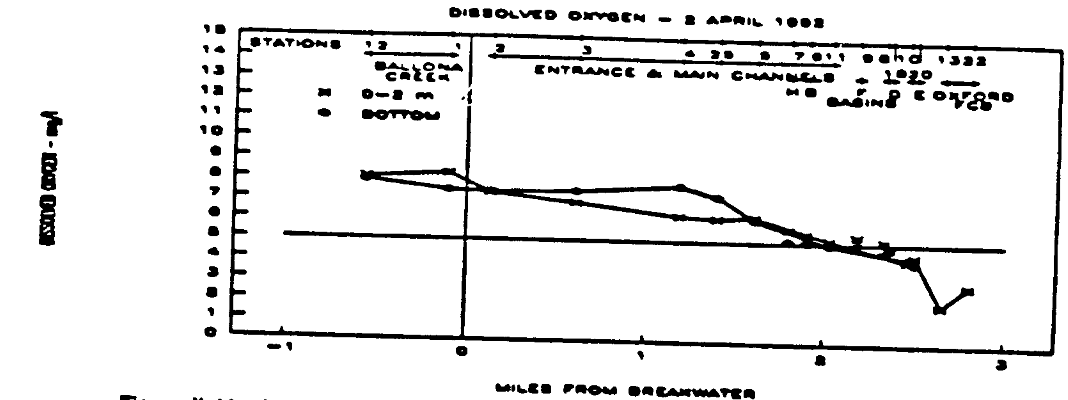

Figure II.41. Average dissolved oxygen (ppm), surface to 2m and bottom, 2 April 1992.

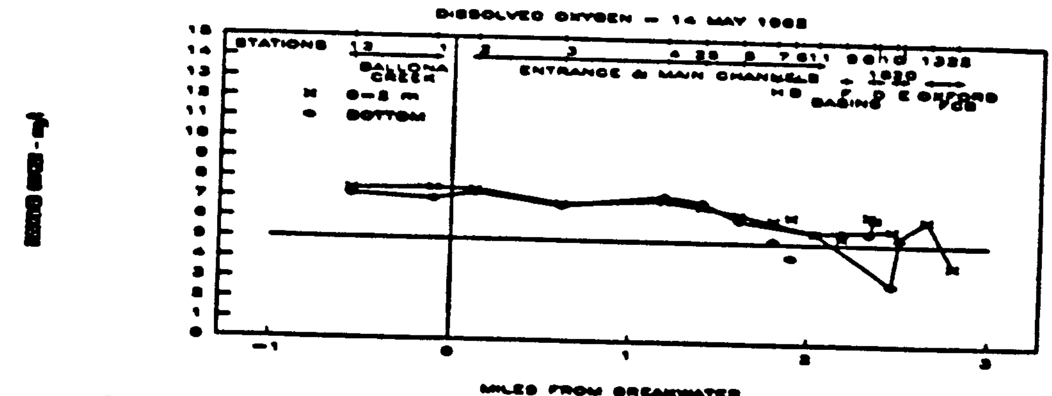

Figure II.42. Average dissolved oxygen (ppm), surface to 2m and bottom, 14 May 1992.

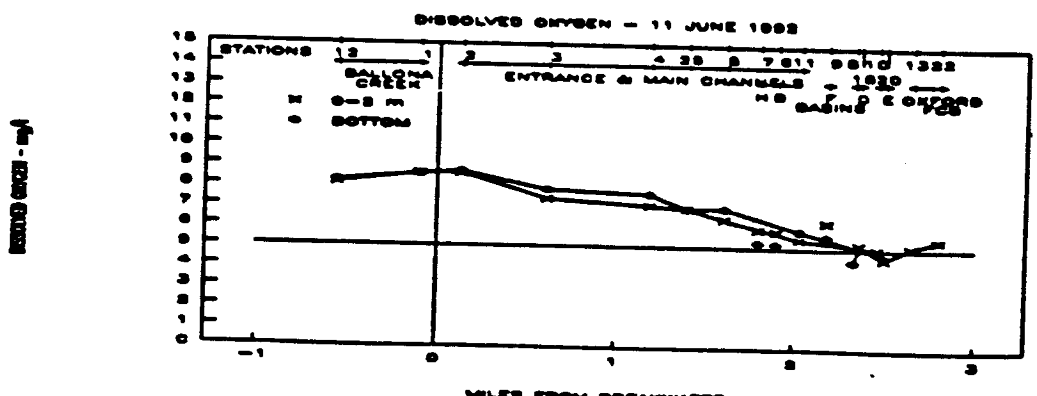

Figure II.43. Average dissolved oxygen (ppm), surface to 2m and bottom, 11 June 1992.

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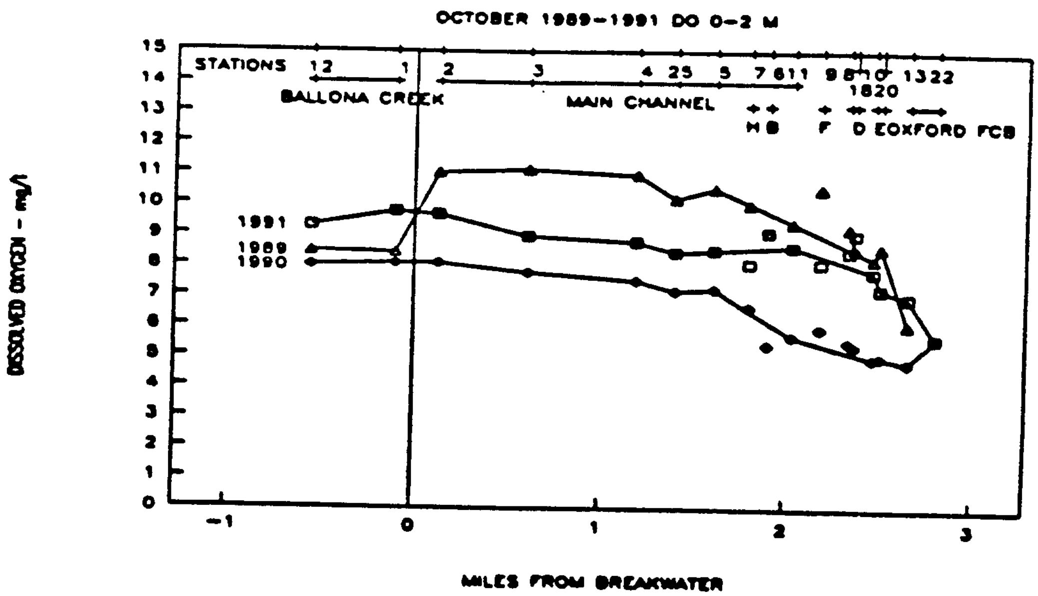

Figure II.44. Average dissolved oxygen (ppm), surface-2m, October 1989-1991.

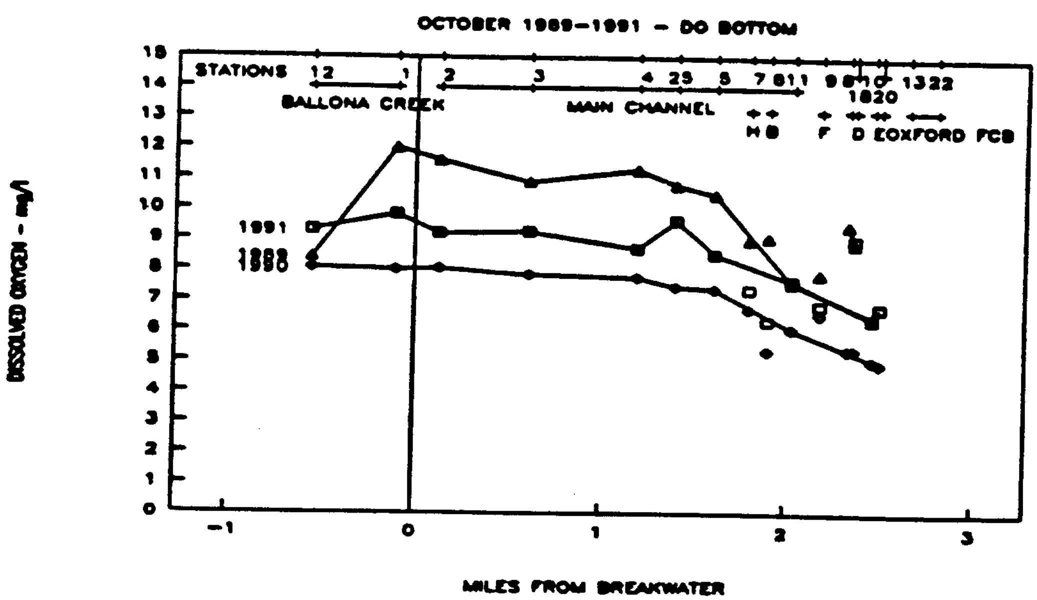

Figure II.45. Average dissolved oxygen (ppm) in bottom water, October 1989-1991.

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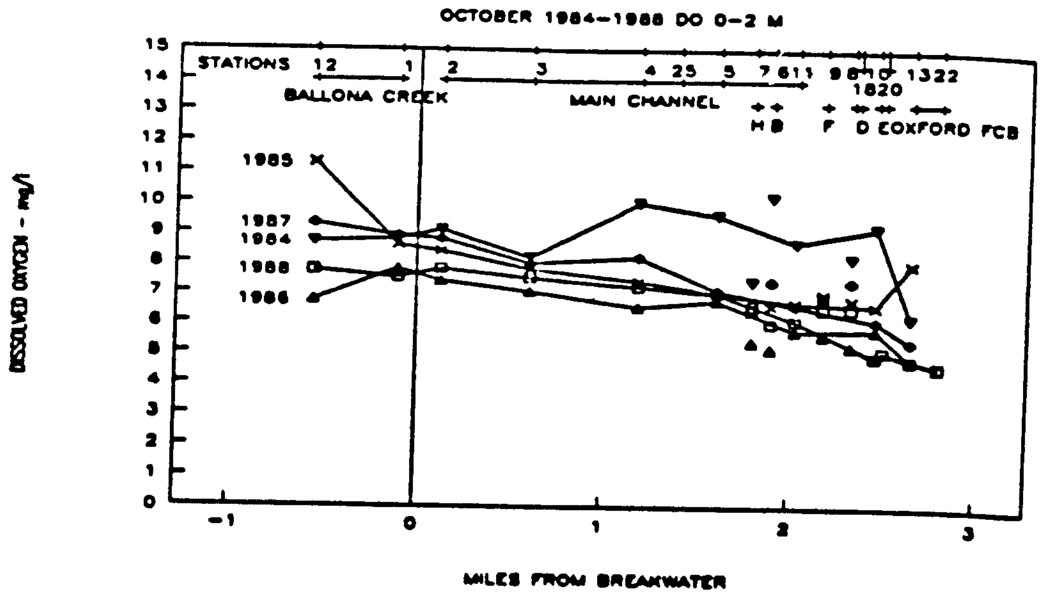

Figure II.46. Average dissolved oxygen (ppm), surface–2m, October 1984–1988.

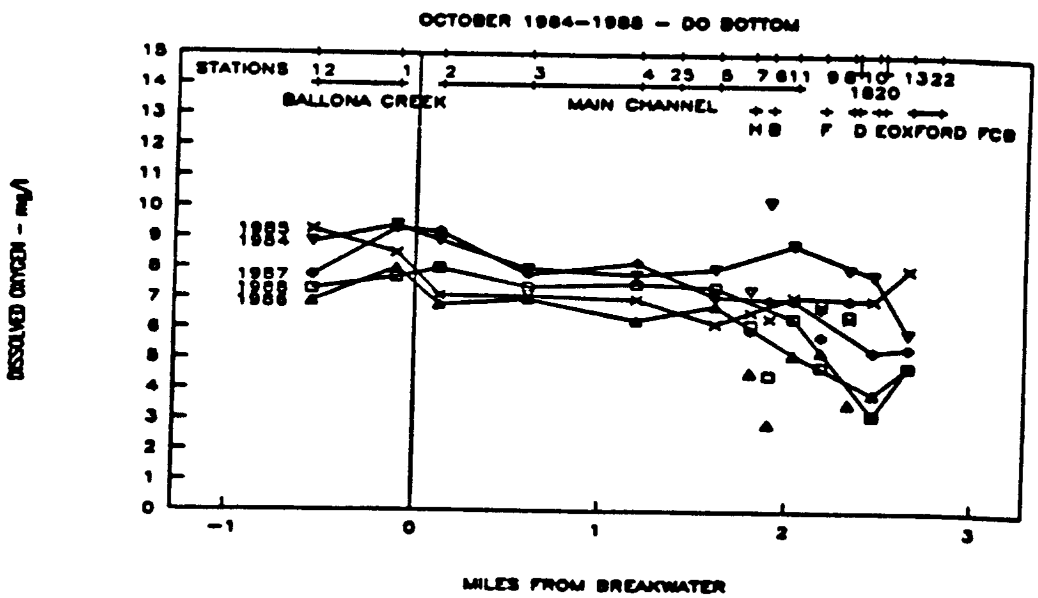

Figure II.47. Average dissolved oxygen (ppm) in bottom water, October 1984–1988.

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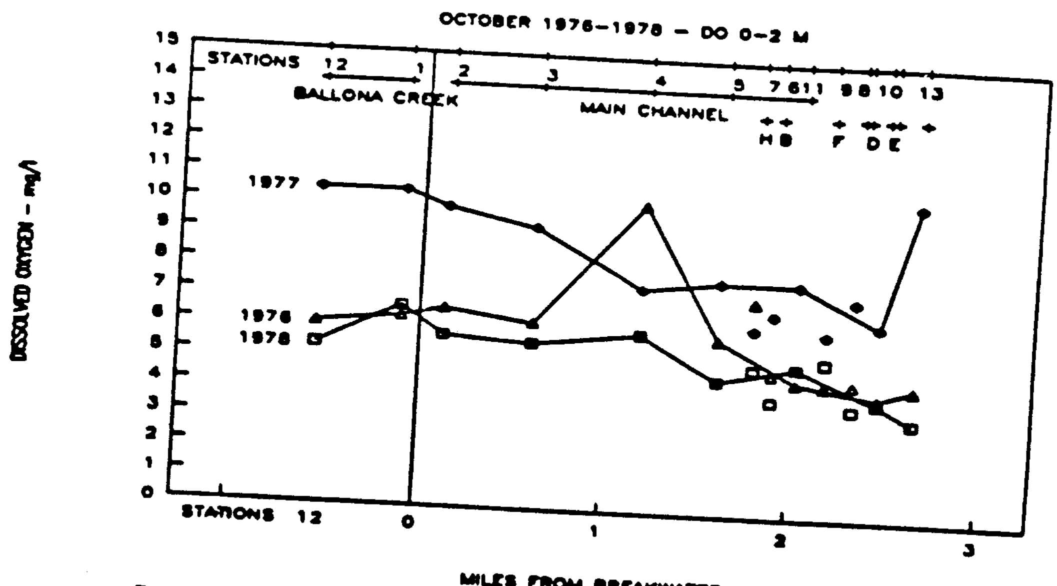

Figure II.48. Average dissolved oxygen (ppm), surface–2m, October 1976–1978.

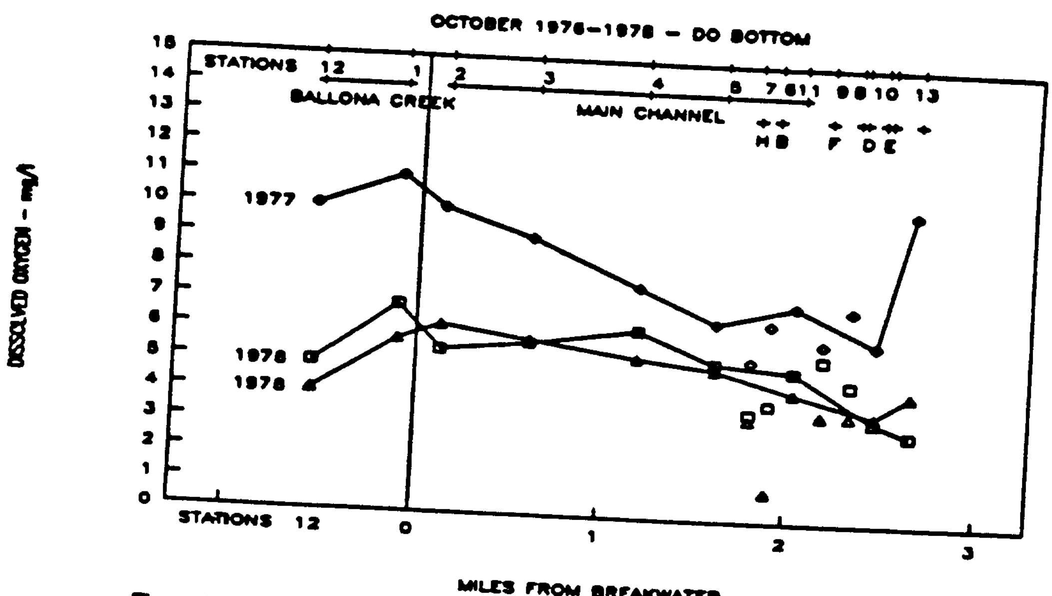

Figure II.49. Average dissolved oxygen (ppm) in bottom water, October 1976–1978.

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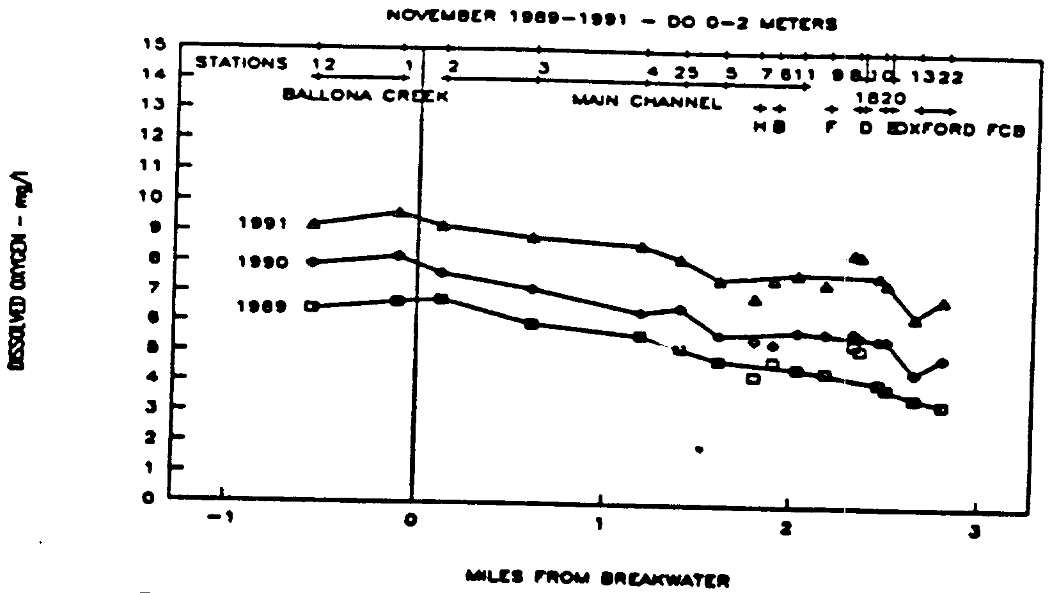

Figure II.50. Average dissolved oxygen (ppm), surface–2m, November 1989–1991.

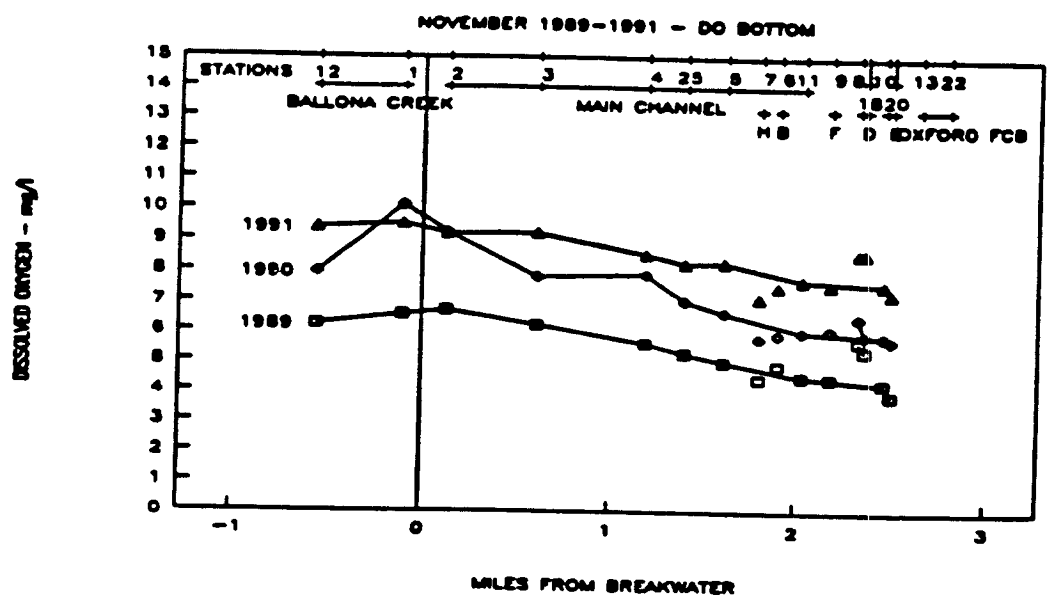

Figure II.51. Average dissolved oxygen (ppm) in bottom water, November 1989–1991

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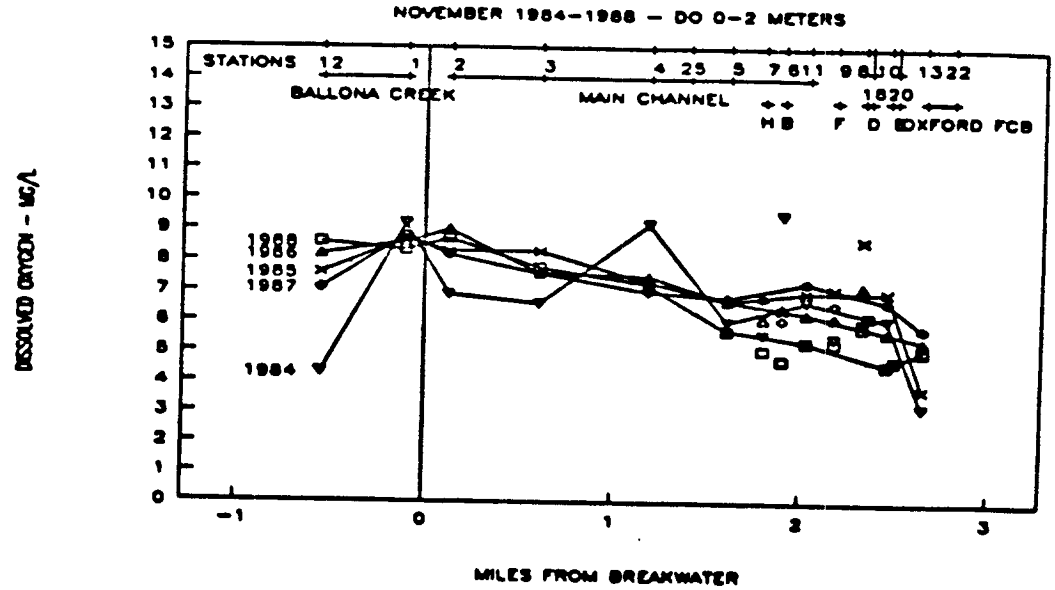

Figure II.52. Average dissolved oxygen (ppm), surface to 2m, November 1984-1988.

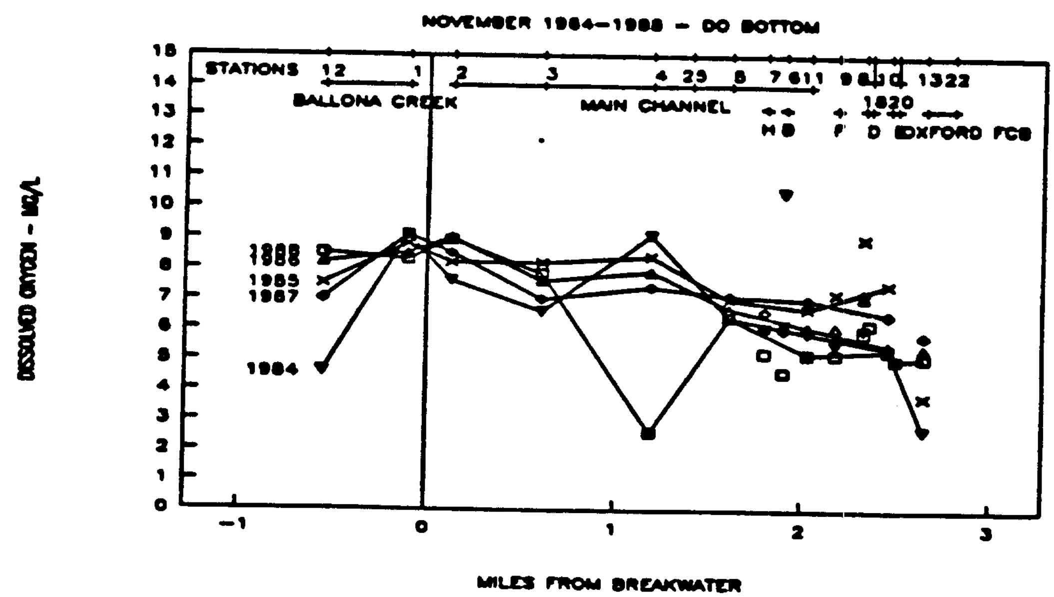

Figure II.53. Dissolved oxygen (ppm) in bottom water, November 1984-1988.

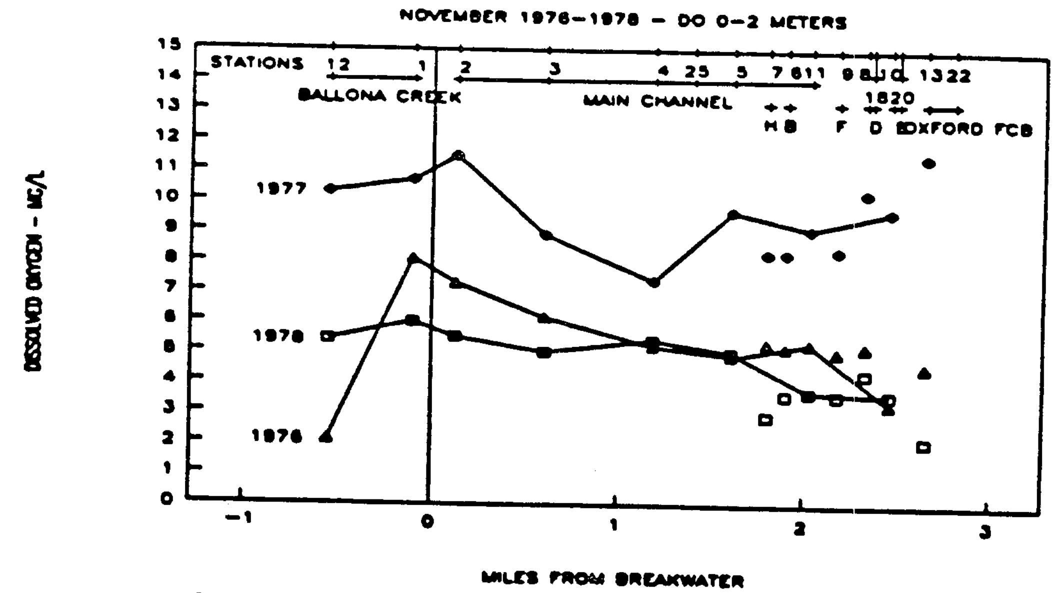

Figure II.54. Average dissolved oxygen (ppm), surface to 2m, November 1976–1978.

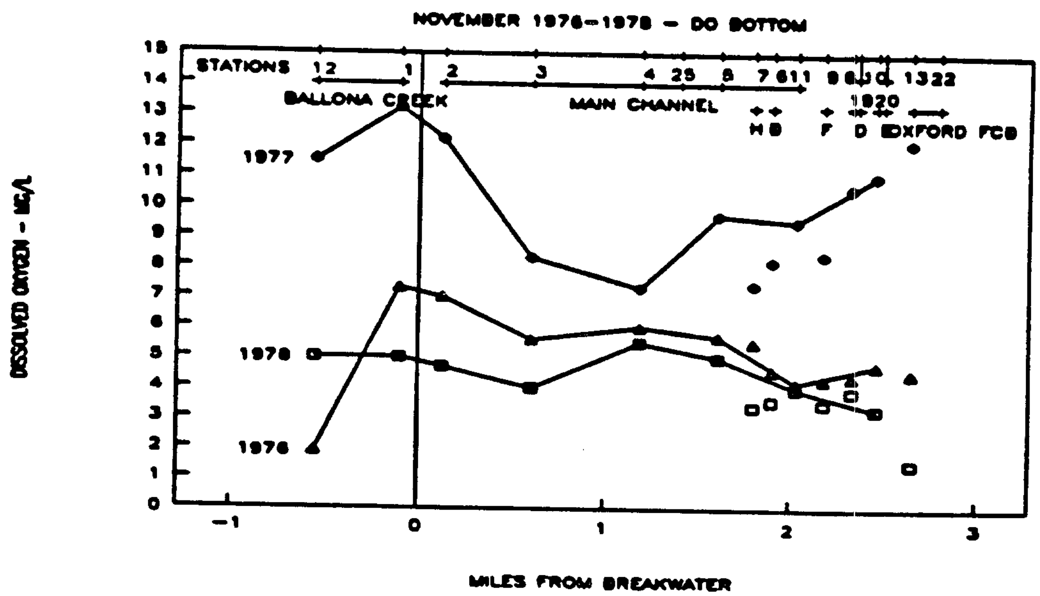

Figure II.55. Dissolved oxygen (ppm) in bottom water, November 1976–1978.

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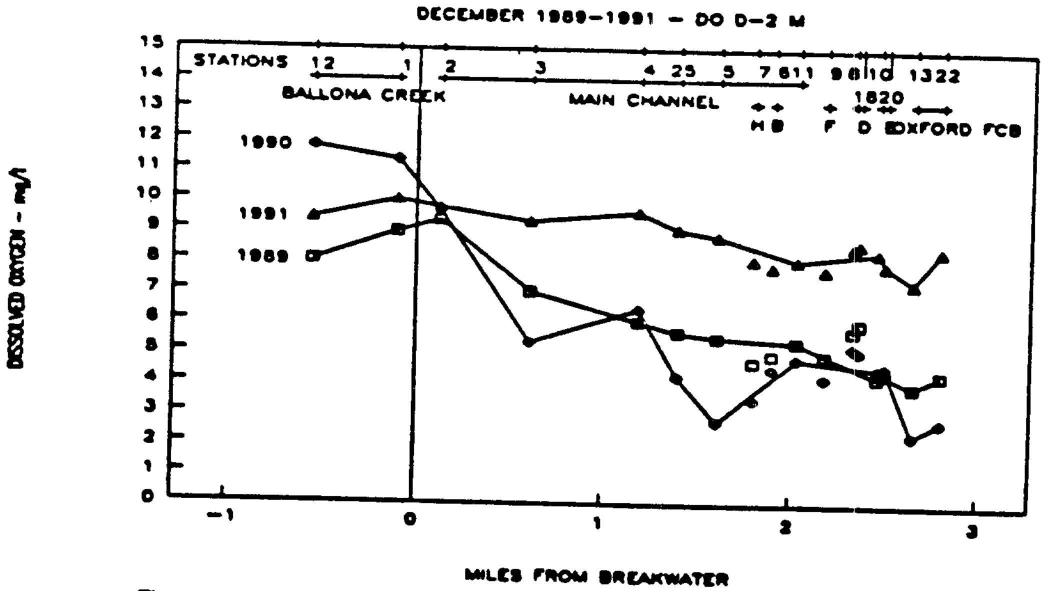

Figure II.56. Average dissolved oxygen (ppm), surface–2m, December 1989–1991.

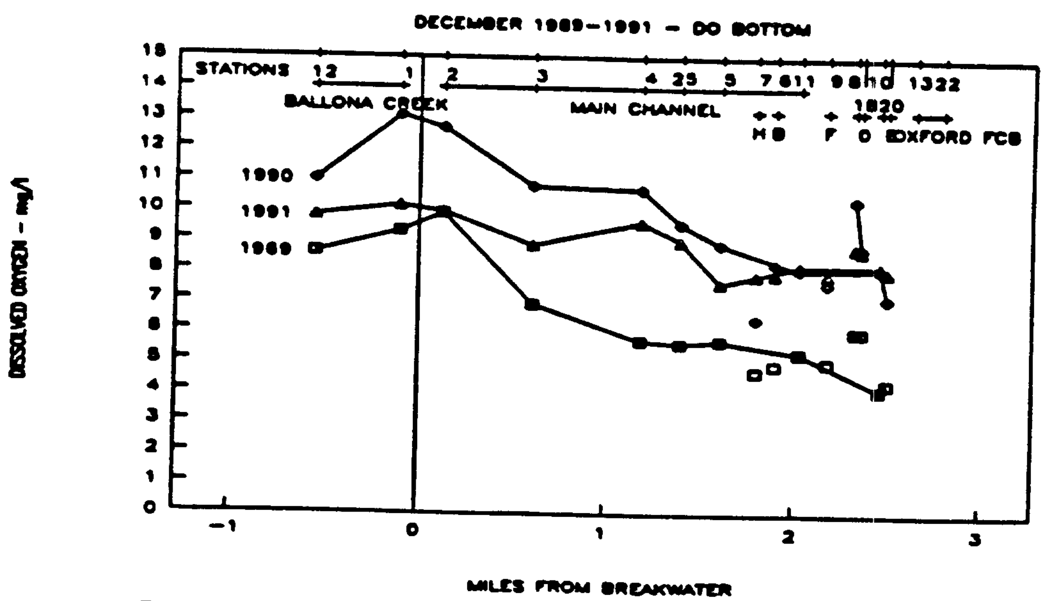

Figure II.57. Average dissolved oxygen (ppm) in bottom water, December 1989–1991

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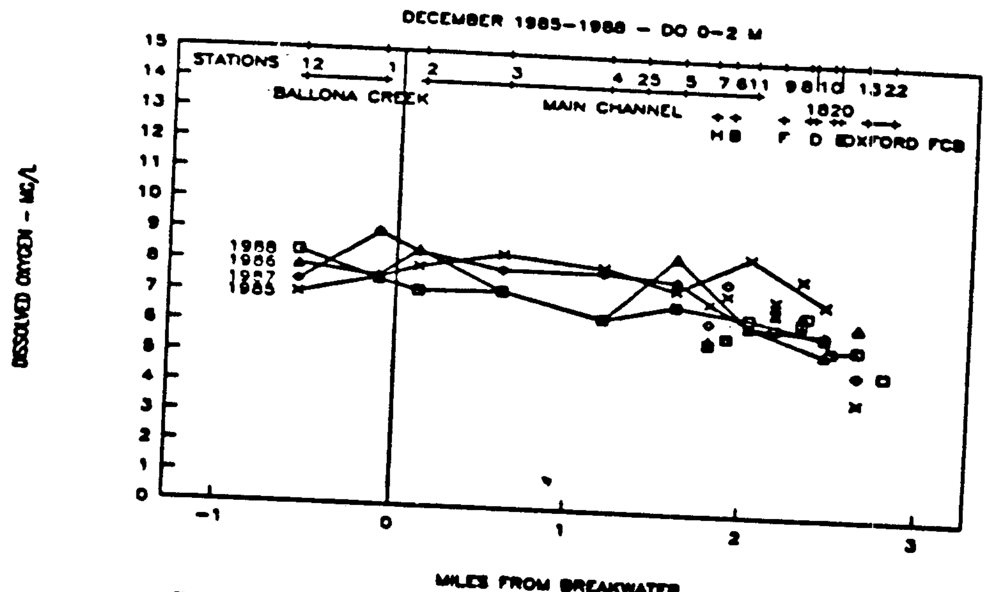

Figure II.58. Average dissolved oxygen (ppm), surface to 2m, December 1985-1988.

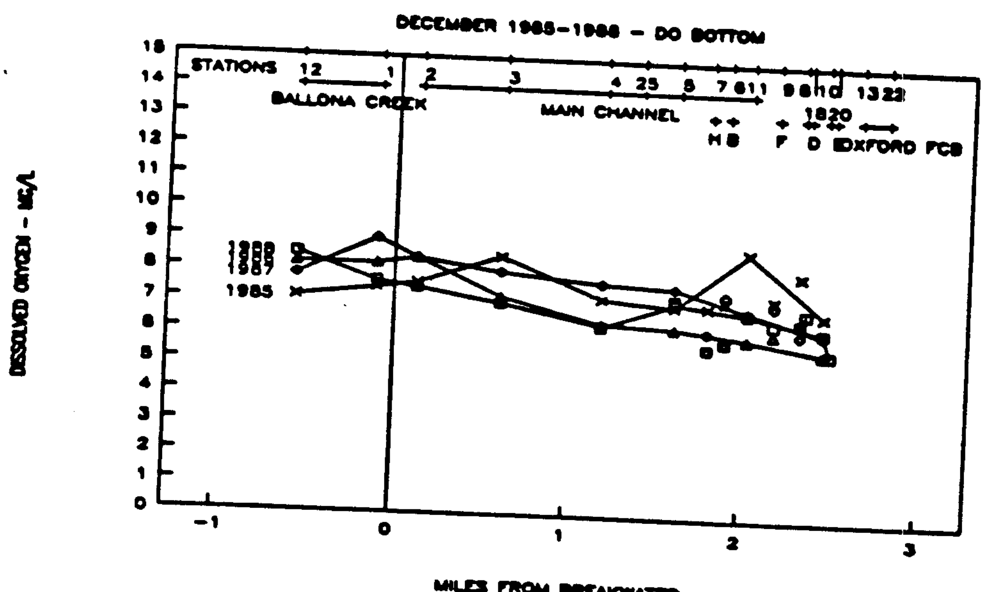

Figure II.59. Dissolved oxygen (ppm) in bottom water, December 1985-1988.

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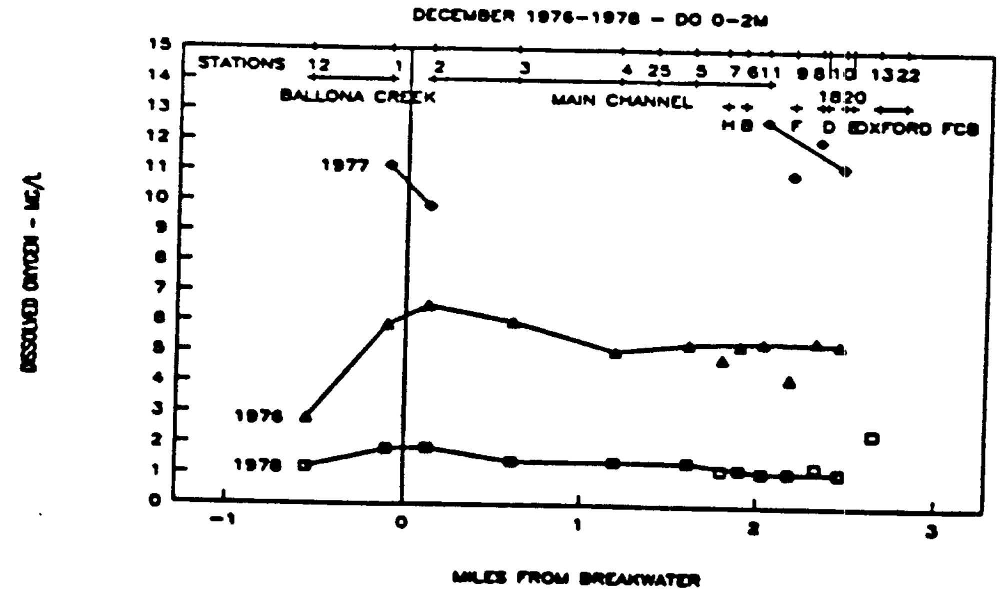

Figure II.60. Average dissolved oxygen (ppm), surface to 2m, December 1976-1978.

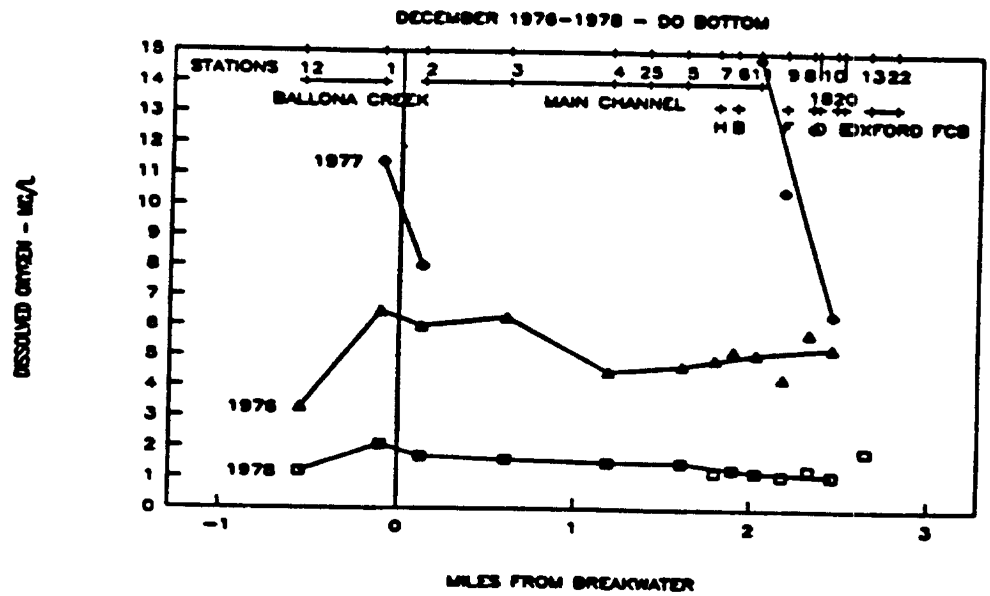

Figure II.61. Dissolved oxygen (ppm) in bottom water, December 1976-1978.

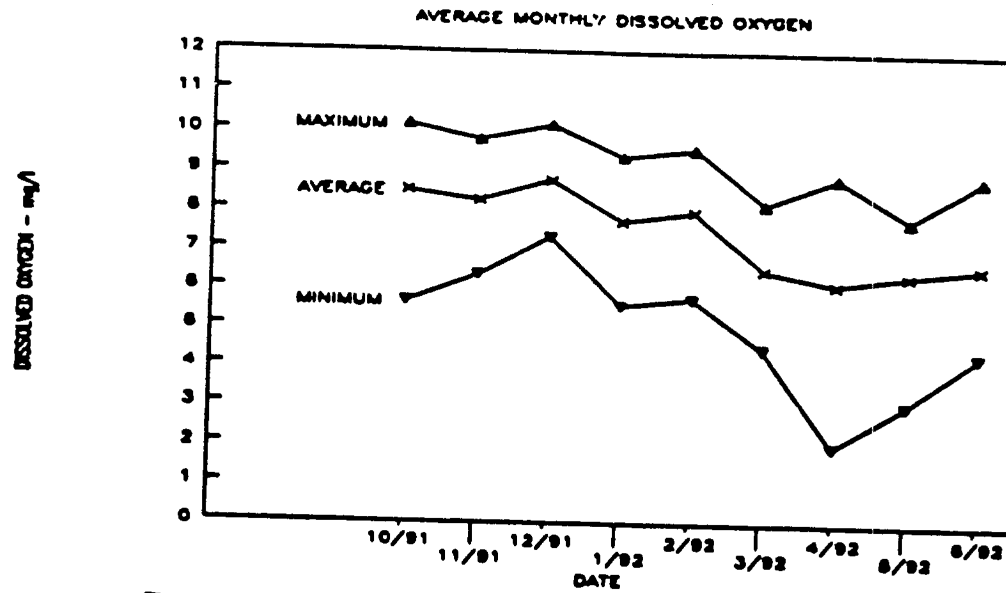

Figure II.62. Minimum, maximum and average dissolved oxygen for all stations and depths during October 1991 through June 1992.

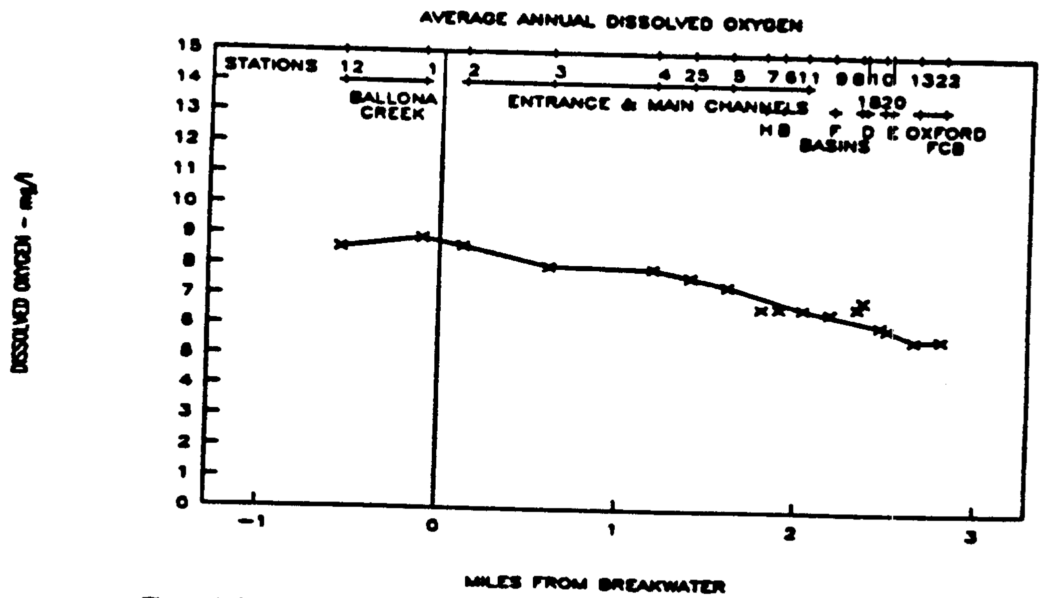

Figure II.63. Average dissolved oxygen for all depths and all months by station during October 1991 through June 1992.

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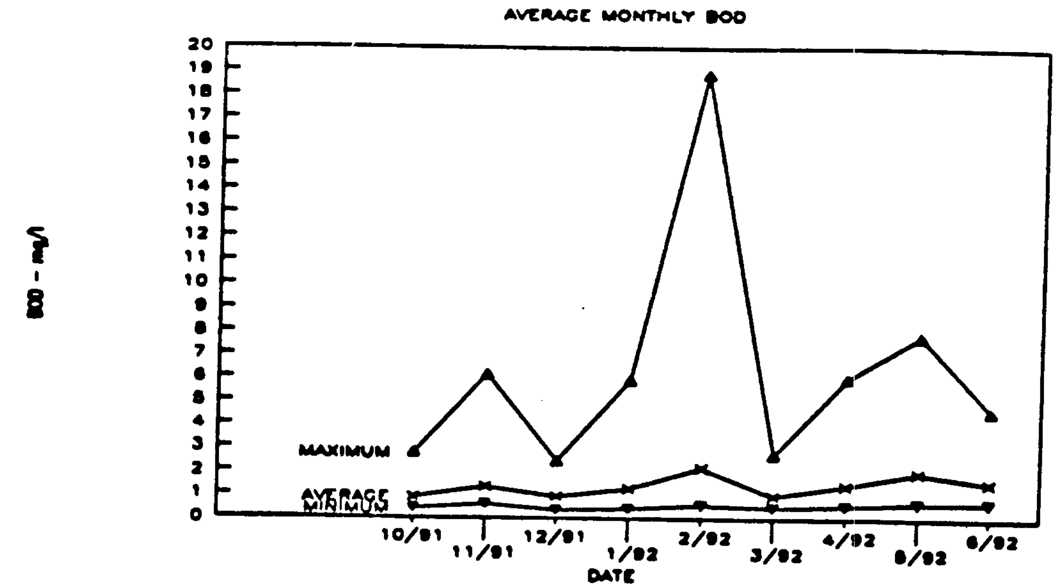

Figure II.64. Minimum, maximum and average 5-day BOD for all stations and depths during October 1991 through June 1992.

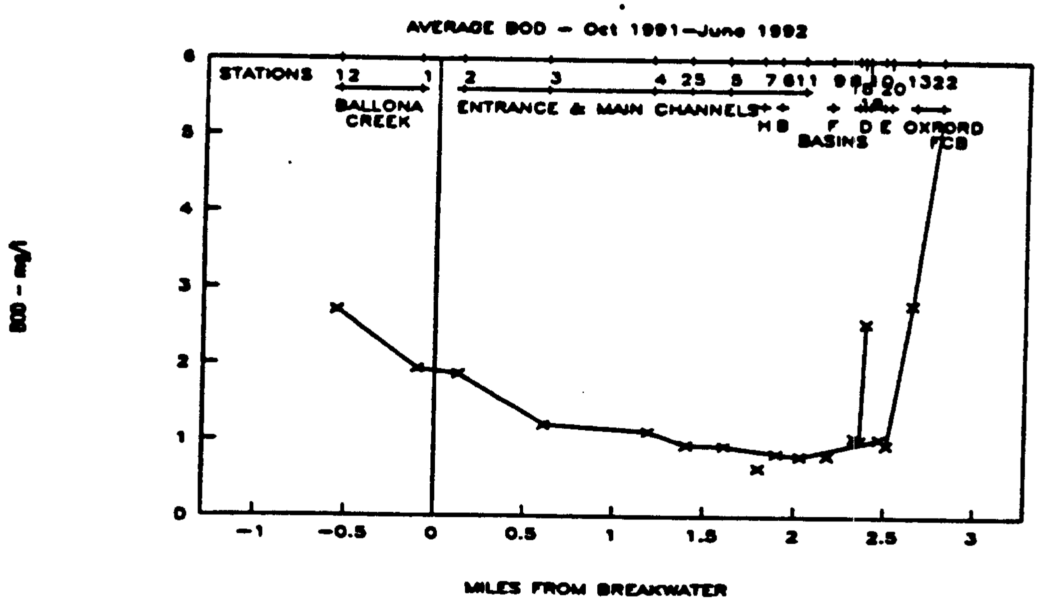

Figure II.65. Average 5-day BOD for all depths and all months by station during October 1991 through June 1992.

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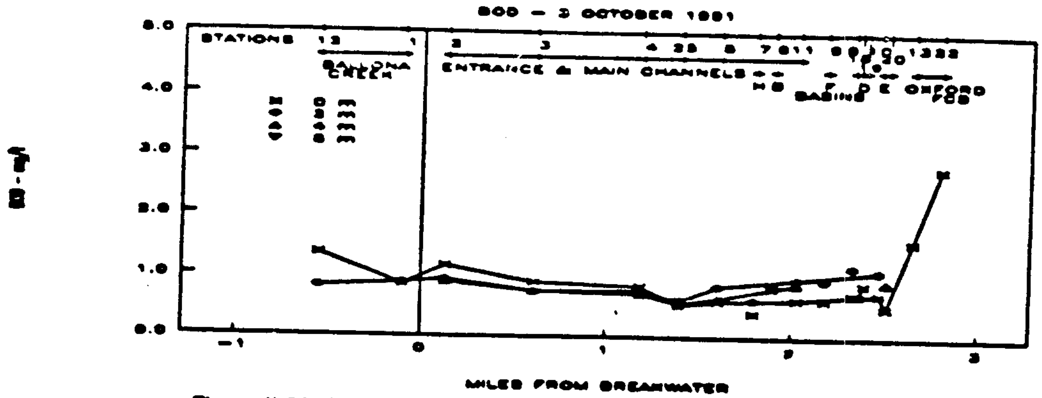

Figure II.66. Five–day biochemical oxygen demand (mg/[illegible] October 1991.

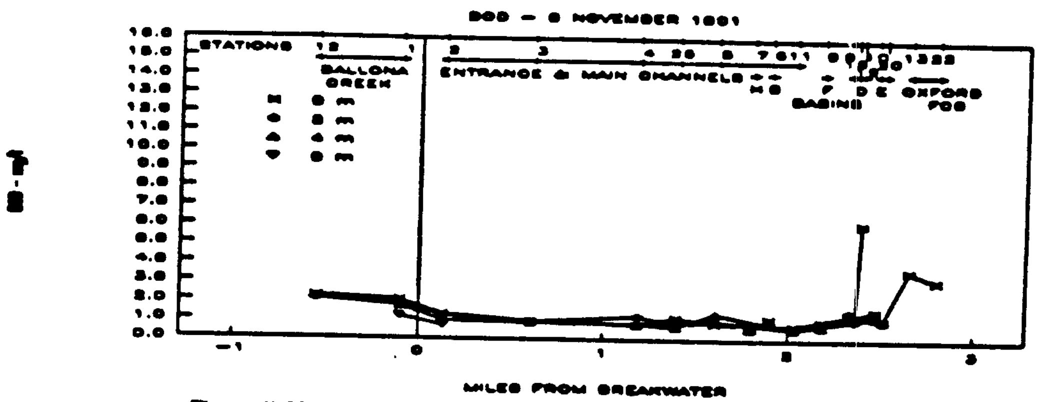

Figure II.67. Five–day biochemical oxygen demand (mg/l), 6 November 1991.

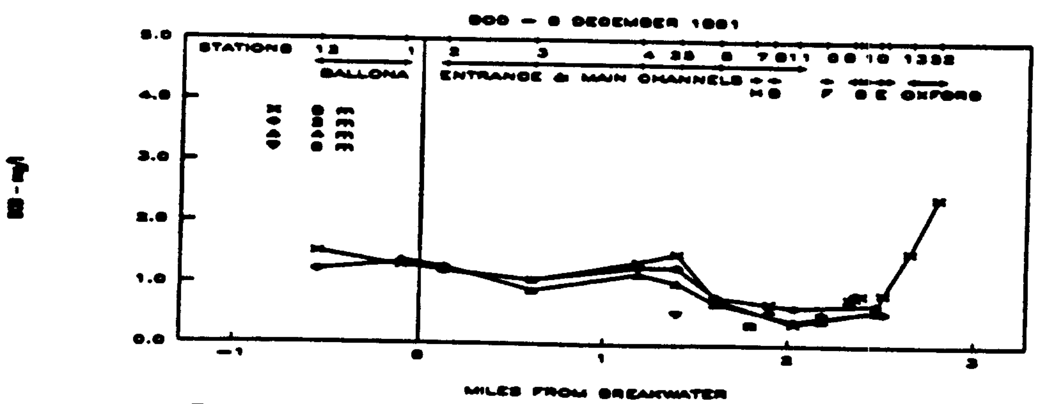

Figure II.68. Five–day biochemical oxygen demand (mg/l), 5 December 1991.

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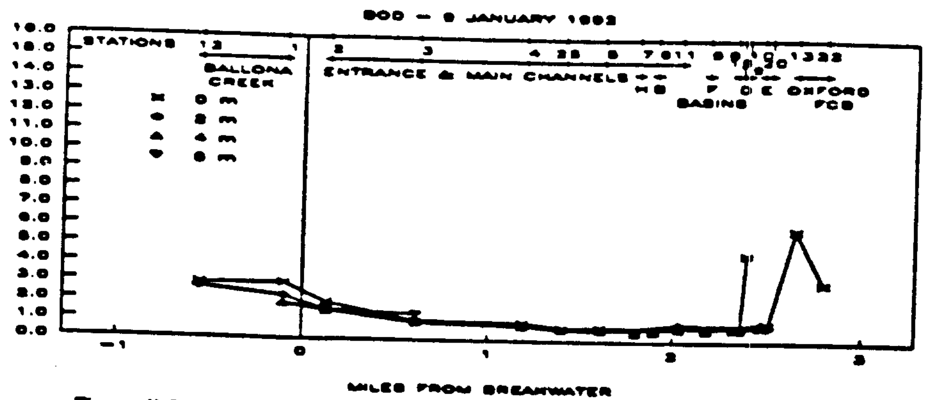

Figure II.69. Five-day biochemical oxygen demand (mg/l), 9 January 1991.

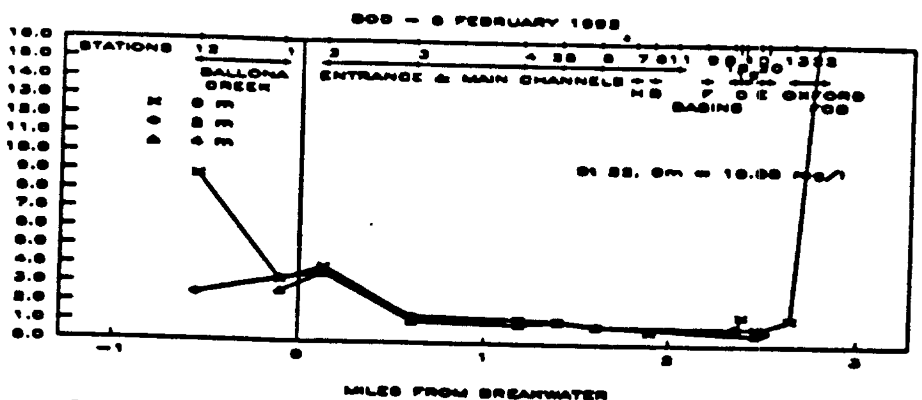

Figure II.70. Five-day biochemical oxygen demand (mg/l), 6 February 1991.

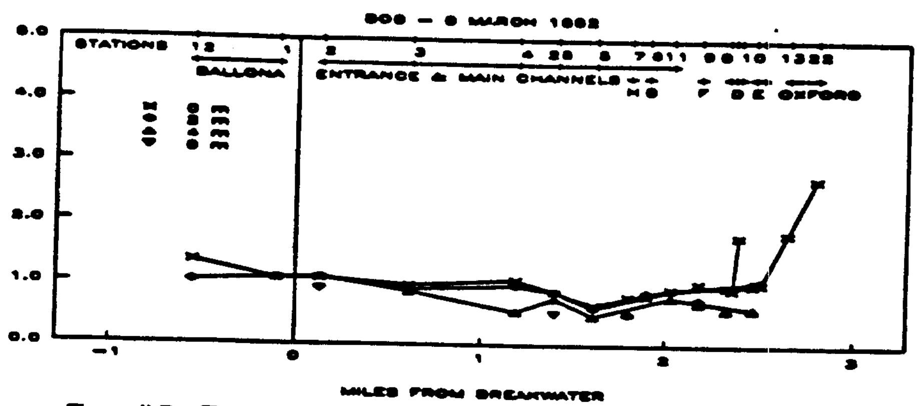

Figure II.71. Five-day biochemical oxygen demand (mg/l), 5 March 1991.

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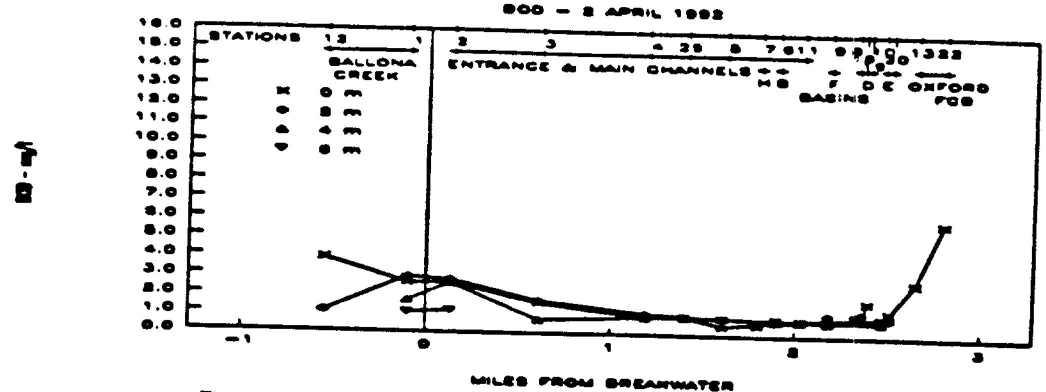

Figure II.72. Five-day biochemical oxygen demand (mg/l), 2 April 1992.

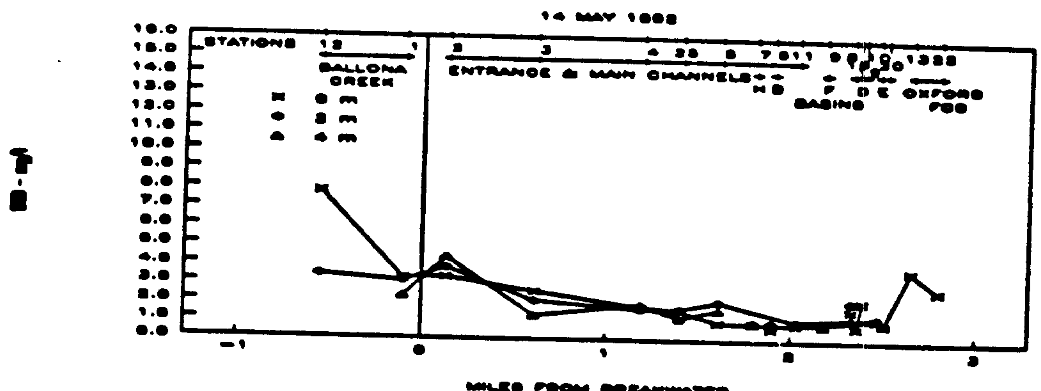

Figure II.73. Five-day biochemical oxygen demand (mg/l), 14 May 1992.

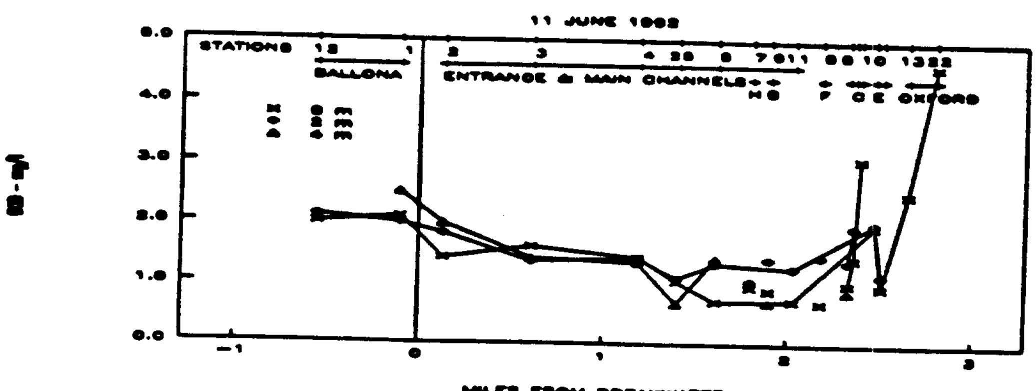

Figure II.74. Five-day biochemical oxygen demand (mg/l), 11 June 1992.

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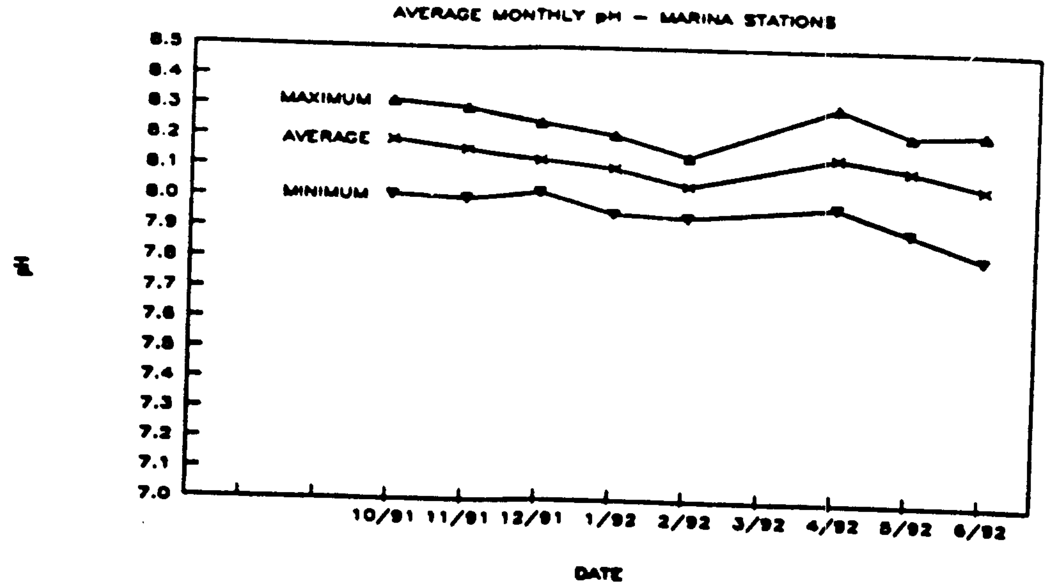

Figure II.75. Monthly minimum, maximum and average pH for all stations and depths within the marina excluding Ballona Creek and Oxford Street Basin. (February data incomplete, March data not taken due to probe malfunction)

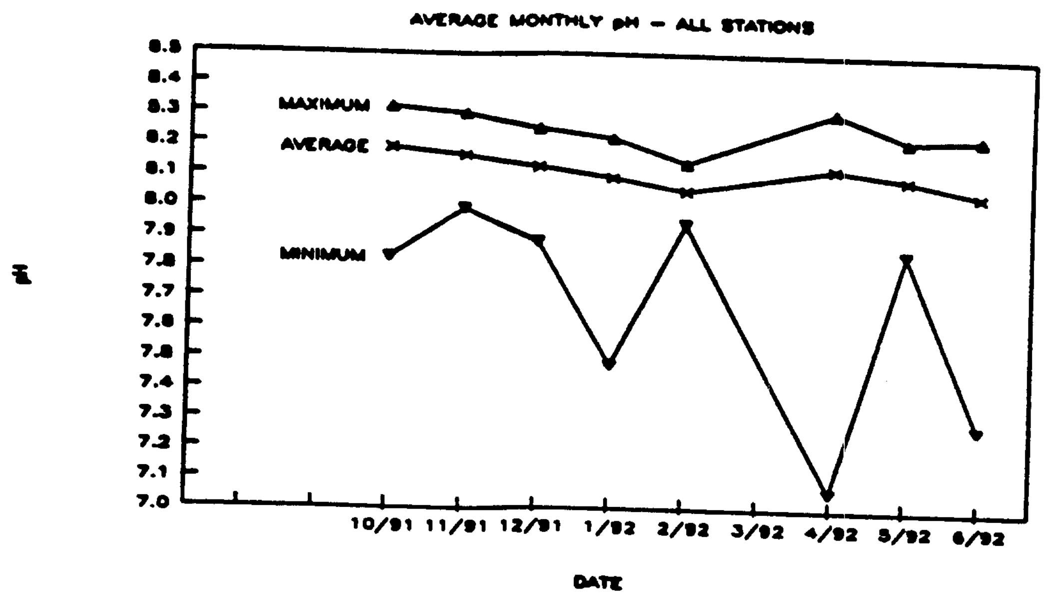

Figure II.76. Monthly minimum, maximum and average pH for all stations and depths within the marina including Ballona Creek and Oxford Street Basin. (February data incomplete, March data not taken due to probe malfunction)

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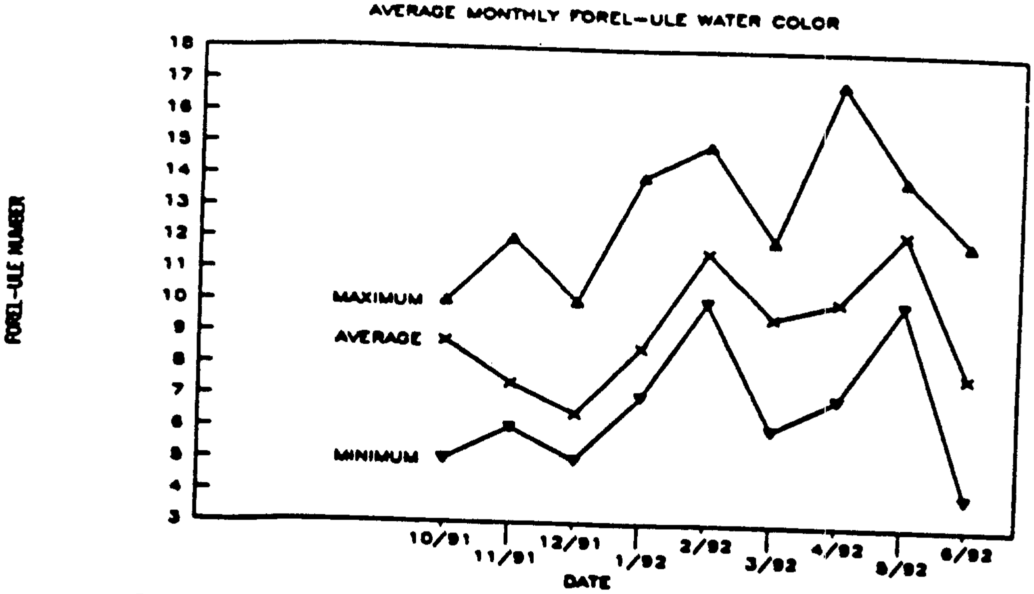

Figure II.77. Minimum, maximum and average monthly Forel-Ule water color values for all stations by month except Oxford Street basin stations. February data are incomplete.

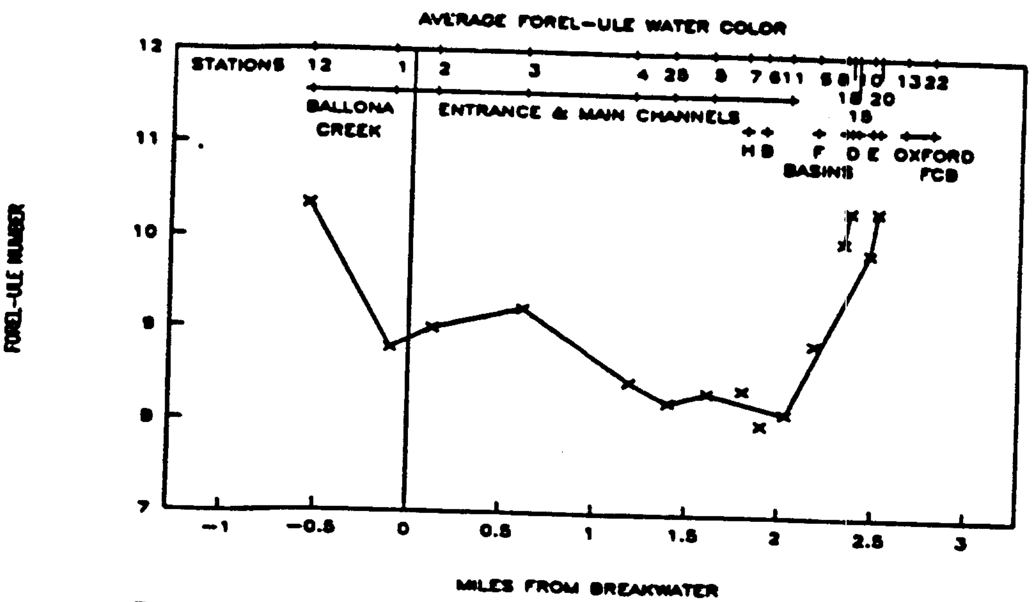

Figure II.78. Average Forel-Ule water color for all months by station, October 1991 through June 1992. Higher numbers are green to brown. Oxford Street basin stations are not included. February data are incomplete.

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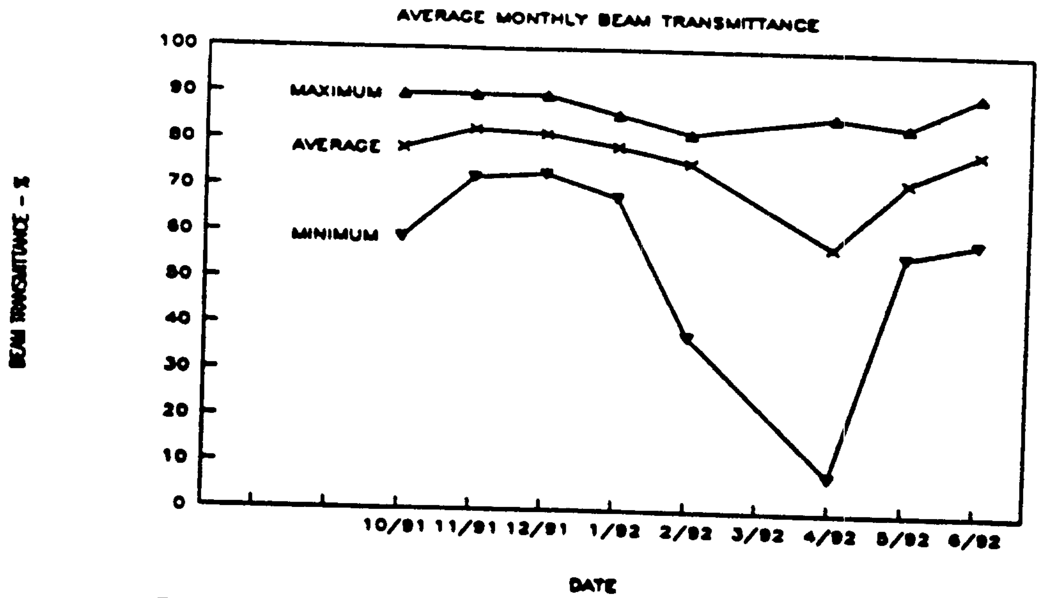

Figure II.79. Minimum, maximum and average water transmittance (%T) for all stations by month. February data are incomplete. March data were not taken due to probe malfunction.

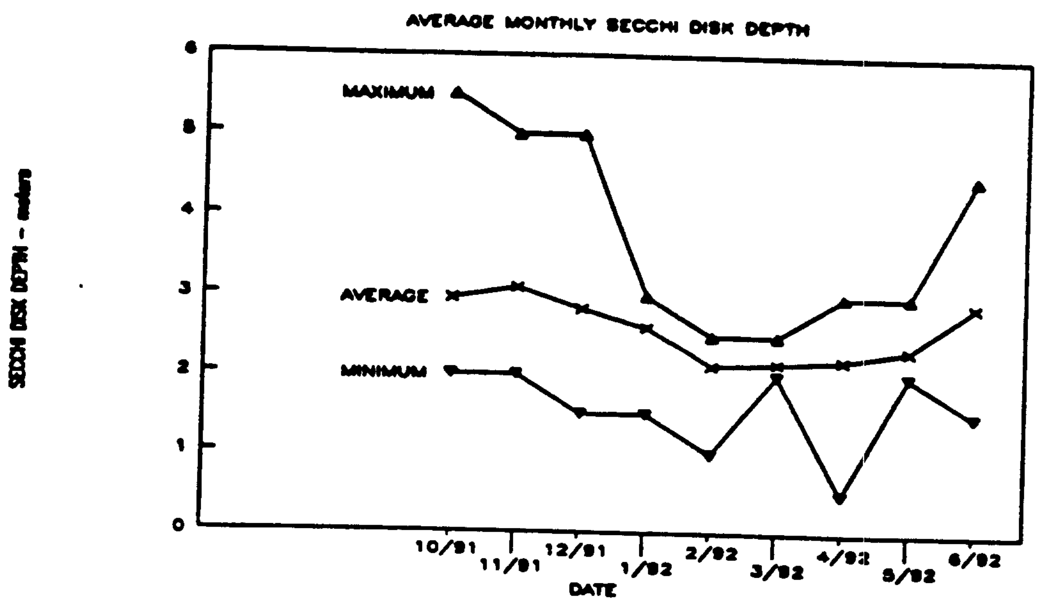

Figure II.80. Minimum, maximum and average Secchi disk depth (meters) for all stations by month. February data are incomplete. March data were not taken due to probe malfunction.

III. NUTRIENTS

SOURCES AND FATES

Inorganic nutrients are necessary for supporting the normal functioning of marine ecosystems by providing the necessary raw materials for plant growth. The plant nutrients that are most likely to limit or regulate phytoplankton growth include nitrogen sources (nitrate, nitrite, and ammonia), phosphate and silicate. Carbon is also essential but is usually in sufficient quantity that it is seldom found to limit or regulate ph· plankton growth in marine systems. When the concentrations of these nutrients become exc. ive, a major algal bloom may occur. While this bloom may have an initial positive effect on the local ecosystem by photosynthetically increasing oxygen concentration in the water column and providing food for herbivorous organisms, the die-off of a massive bloom may result in decomposition and microbial respiration that consumes far more oxygen than the bloom left dissolved in the water column. Thus high concentrations of nutrients could be considered as pollutants if they occur in sufficient concentrations to produce such a bloom. Additional effects of blooms can include the blooming of toxic phytoplankton species including some dinoflagellates, and providing food for other organisms that may not be desirable for the ecosystem.

The functioning of phytoplankton and other forms of algae in a marine ecosystem also depends on the availability of light. While the organisms themselves affect the light field by absorbing the available light, other factors such as high turbidity caused by detritus and inorganic particulate material will strongly attenuate the light and limit the growth of the algae (Kirk, 1983). Thus light availability could become a regulating factor of nutrient cycling within the ecosystem. Although turbidity and light penetration are not the focus of this section, they are important to the fate of the nutrients within a given ecosystem.

In estuarine and coastal systems, nutrient sources are likely to include fresh water sources, in contrast to open ocean systems where the nutrient supply derives primarily from natural recycling processes. Where recycling is the primary nutrient source animals and microorganisms break down the organic matter of the phytoplankton, often releasing the nitrogen as ammonia (NH_3). Ammonia nitrogen may be taken up directly by plants to synthesize new organic matter or it may be oxidized first to nitrite (NO_2), then to the more stable form of nitrate (NO_3). Plants may take up nitrogen in any of these forms, but ammonia may be more readily taken up than oxidized forms of nitrogen because it can be directly incorporated into amino acids. Organic phosphate (PO_4), which is used for energy transfer, for synthesis of proteins and for nucleic acids, is rapidly cycled within the water column since the form that it occurs as most frequently within organisms, ortho-phosphate, is also the most abundant form in seawater. Dissolved ortho-silicate comes from both recycling and river input.

METHODS

Water samples for nutrient analysis were obtained at all stations with a Nauman sampler, a PVC, self-closing sampler, at two meter intervals beginning at the surface. One subsample was immediately acidified in the field with concentrated hydrochloric acid and held for later laboratory analysis with an Orion ammonia electrode. A second subsample was immediately frozen in dry ice for later analysis in the laboratory. This sample was thawed and analyzed for silicate, phosphate, nitrate, and nitrite on an AlpKem Rapid Flow Analyzer (RFA) 300 automated analytical chemistry instrument using methods described by Sakomoto et al. (1990). Subsamples for BOD determinations and for microbiological counts were chilled for analysis upon return to the laboratory.

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RESULTS AND DISCUSSION

Ammonia-Nitrogen

Ammonia nitrogen (NH_3) is formed by the breakdown of organic material and recycling into inorganic nitrogen. In most ocean waters, the concentration of ammonia nitrogen is very low, usually less than 1 µg-at/l (1 µg-at/l = 14 µg ammonia nitrogen per liter). In southern California higher concentrations of ammonia (up to 25-30 µg-at/l) may be observed in association with anthropogenic sources such as ocean outfalls (e.g. Eppley et al., 1979; Jones et al., 1990). Therefore, high ammonia concentrations are often indicative of sources of pollutants. When ammonia nitrogen is present, it may be more readily consumed by phytoplankton than other inorganic forms of nitrogen because it can be used directly in the synthesis of amino acids within the cells.

Ammonia-nitrogen concentrations within Marina Del Rey are always higher than concentrations typically observed in Santa Monica Bay and the adjacent ocean waters (0-0.5 µg-at/l; Eppley, et al., 1979; Jones, et al., 1990, 1991), except near the Hyperion and Whites Point sewage outfalls. Minimum concentrations within the marina during October 1991 to June 1992, occurred most often near the marina entrance (Stations 1 and 2; Figure 12) where the proportion of Santa Monica Bay water is likely to be the greatest. These monthly minima ranged from 1 to 4 µg-at/l. The highest concentrations during this nine month period consistently occurred within the Oxford Street basin (Stations 13 and 22; Figures III.1-9 and III.12). Ammonia concentrations within Ballona Creek were not predictably higher than within the marina, and on three occasions, December 5, March 5, and June 11, the concentrations at Station 12 in Ballona Creek were among the lowest observed for the entire Marina sampling. There is a consistent annual average spatial pattern through the last three years of sampling that shows

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slightly higher concentrations of ammonium at the end of the basins where tidal exchange is lowest (Stations 6, 7, 8, 9, 10, 11, 18, 19 and 20). However, the pattern is not apparent for every month. In November 1991, May and June 1992, the concentrations at these inner basin stations were actually lower than in the main channel. However, on average ammonia concentrations were generally lowest within the Main channel and at the marina entrance (Stations 1, 2, 3, 4, 5, and 25), regions where tidal exchange should be greatest. The accumulation of ammonia at these inner basin stages may simply be due to increased nutrient recycling in these areas coupled with weak tidal exchange.

The monthly average ammonia concentrations for the entire basin during the preceding two years have generally been higher during June through January, and lower during February through May. For the nine month period from October 1991 through June 1992 the pattern is not clear. The average ammonia concentration in the basin rose steadily from October through January, followed by a decrease in February (Table III.1; Figure III.10). However, the concentrations then rose again in March and April and fell again in May and June. The highest average concentration within the marina was observed in January 1992, similar to the seasonal maximum that has been observed in the previous two years. There was no apparent relationship between the concentrations within Oxford Street basin and the average concentrations within the marina. The highest ammonia concentration (200 μg-at/l) observed in recent years occurred in Oxford Street Basin in February at Station 22 (Figure 5), when average concentrations within the marina were the second lowest for the nine month period. It was raining during this cruise, and sampling was incomplete; Stations 7, 9, and 11 had to be omitted due to an emergency call for the Life Guard vessel in use.

In comparison to previous years (1984-1990), the October 1991 ammonia concentrations were on average the lowest observed; October 1990 had been the previously lowest value in this series. The November and December 1991 observations were slightly higher than the concentrations observed in November and December 1990.

Table III.1. Ammonia Ranges in Concentration, µg-at/l, October 1991 to June 1992.

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-91	3.1	1	29.0	13	5.7	4.9
Nov-91	3.8	18	23.0	13	6.1	5.4
Dec-91	2.7	1, 2	11.0	13	6.0	5.9
Jan-92	2.1	2	29.7	13	7.8	6.8
Feb-92	2.1	1, 2	200.0	22	10.0	3.6
Mar-92	1.8	2	15.7	11	5.2	5.2
Apr-92	2.5	3	31.7	22	6.7	5.6
May-92	1.4	6	15.0	22	3.0	2.5
Jun-92	2.1	1	11.1	22	4.2	4.0

* Excluding Oxford Street Basin and Ballona Creek, Stations 12,13, and 22.

Nitrate plus Nitrite - Nitrogen

Nitrate (NO_3) is usually the most abundant form of inorganic nitrogen in the ocean. However, in the surface mixed layer nitrate concentrations may often be less than 0.1 µg-at/l and nitrite may have a similar range. Below this layer, often separated by the seasonal thermocline, nitrate concentrations may reach 30-40 µg-at/l. In the San Pedro-Santa Monica Basin, NO_3 concentrations reach 35 µg-at/l at depths of 600 m (Williams, 1986). Low surface concentrations are due to phytoplankton utilization and a low rate of supply of nitrate from

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below. Surface concentrations may reach values of 5-30 μg-at/l in coastal upwelling regions that are common to much of the California coast. Coastal upwelling is not a dominant process within Santa Monica Bay, but it does predictably occur off of Point Dume and Point Fermin when winds are favorable for upwelling. Within Santa Monica Bay, concentrations of 10-20 μg-at/l may occur at depths as shallow as 20 meters and can be transported to the surface by either wind-induced mixing or by local upwelling. The concentrations of nitrate plus nitrite (N+N) in sewage wastewater and sludge are two to three orders of magnitude less than the concentration of ammonia (Morel and Schiff, 1983). Thus, the impact of ocean outfall effluents on the coastal ocean nitrate plus nitrite concentrations is much less than for ammonia (e.g. Jones et al., 1991).

The measurement technique for nitrate requires that nitrate first be converted to nitrite (NO_2) which is then measured colorimetrically (Whitledge et al., 1981). The NO_3 concentration is derived from this by correcting for the efficiency of converting NO_3 to NO_2 and correcting for the ambient NO_2 concentration. Since NO_2 concentrations are generally much less than 1μg-at/l the correction is generally not large. In the following text, nitrate will be used in place of nitrate plus nitrite for brevity.

The average spatial pattern of nitrate within the marina tends to remain similar year to year. As in the October 1990-September 1991 data set, the nitrate concentration was, on average, lowest at Station 2 near the breakwater and increased toward the inner Marina basin and into Ballona Creek (Figure 24). As with ammonia, the highest nitrate concentrations usually occurred in Oxford Street basin. The low values at Station 2, and sometimes Station 1, reflect the influence of Santa Monica Bay water where near-surface nitrate concentration is low except during strong mixing or coastal upwelling events. When the nitrate concentrations reached their minima in May and June 1992, concentrations within the central channel (Stations 3, 4, 5, and

25) were <1 μg-at/l. Higher concentrations of nitrate were often observed at the ends of the basins, similar to the patterns observed in ammonia.

The highest nitrate concentrations during October 1991 through June 1992 occurred in Oxford Street basin, in Basin E near the flood gate from Oxford Street basin, or in Ballona Creek (Table III.2; Figures III.22-23). Concentrations at Station 12 in Ballona Creek were higher than nitrate concentrations at stations within the main channel of the marina, except in June 1992. At station 12, the high concentrations were usually from the surface sample indicating that the high NO_3 was associated with the freshwater coming down Ballona Creek. As in previous years, the highest concentrations within the marina occurred concentrations at Station 10 or 20 in Basin E, where water enters the marina from Oxford Street basin. A large, live-aboard vessel has been docked adjacent to the flood gate from Oxford Street basin (Station 20) until June of this year, partially obstructing flow into Oxford Street basin.

Table III.2. Nitrate + Nitrite Ranges in Concentration, μg-at/l, October 1991 to June 1992.

Month	Min.	Sta.	Max.	Sta.	Average	Average•
Oct-91	1.0	1	8.0	12	3.1	3.0
Nov-91	0.9	1	9.3	13	5.3	5.2
Dec-91	1.9	1	8.5	20	5.4	5.4
Jan-92'	1.4	2	28.8	13	6.2	4.8
Feb-92'	0.5	1	58.5	12	5.1	3.0
Mar-92'	0.6	2	6.5	10	2.6	2.5
Apr-92'	0.5	1	99.2	22	7.5	4.0
May-92	0.4	18, 19	10.3	12	1.1	0.8
Jun-92	0.4	1, 2	28.4	22	1.9	1.2

• Excluding Oxford Street basin and Ballona Creek, Stations 12,13, and 22.
' Rainfall during or prior to survey

The seasonal pattern of nitrate concentration within the marina during October 1991 through June 1992, was similar to the pattern for the previous two years. As in previous years, the average concentrations within the basin were highest during the early winter period, November through January (Table III.2 and Figure III.22). The nitrate began to decrease from its winter maximum in February and reached its minimum in May and June 1992. This trend was interrupted only in April when there was an increase to about 4 μg-at/l.

The highest individual concentrations observed during this nine month period (58 and 99 μg-at/l) are comparable to the maximum concentrations observed during the previous two years. These high concentrations are significantly greater than concentrations observed in the deep open ocean. The 58 μg-at/l peak occurred in February, during a 2.2 in. rainfall. There had been about 6 in. of rain early in January as well (see Appendix A). The rains may have resulted in a significant increase in nutrients within the marina. As stated in previous reports, higher concentrations may also result, in part, from reduced phytoplankton growth and nutrient uptake rates resulting from lower temperatures and lower available light levels. The deeper average secchi depths and increased beam transmission in the winter months (see Physical Water Quality, Chapter II) are consistent with lower phytoplankton abundance during this period. However, direct measurements of phytoplankton growth and nutrient utilization would be required to verify this possibility. The lower average NO_3 concentrations observed during May and June may reflect the reduced inflow from storm drain sources and higher phytoplankton productivity within the marina as day length and, therefore, light availability increase and temperature increases which enables higher phytoplankton growth rates (Eppley, 1972). During

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this period the concentrations in both Ballona Creek and especially in Oxford Street basin were much lower than during winter.

In comparison to the previous several years of observations, the nitrate plus nitrite concentrations during October-December (Figures 13-15), the period for which there are several years of observations, were relatively characteristic for each of the three months. The extremely high values in Ballona Creek and Oxford Street basin did not appear until January, similar to the pattern that has existed in previous years.

The absolute value of nitrate concentrations was generally less than ammonia concentrations during the October 1991-June 1992 period. In addition, the average spatial pattern was somewhat different between the two nitrogen-based nutrients (see Figure III.12 for NH_3 and 24 for N+N). In general, nitrate increased by a larger proportion in the inner basins relative to the main channel than did the ammonia concentrations. Also, the ratio of nitrate concentration in Ballona Creek to the concentrations in the main channel was usually greater than the same ratio for ammonia concentration. While the average distributions for both nutrients indicate high concentrations in Oxford Street basin (Figures 12 and 24), comparison of the monthly patterns (Figures III.1-9 for ammonia, and Figures III.13-21 for nitrate) shows that ammonia was almost always significantly higher in Oxford Street basin, while there were several months (September, October, December, and May) when the nitrate in Oxford Street basin was only marginally higher than in the inner basins of the marina.

<u>Total Dissolved Inorganic Nitrogen</u>

Total dissolved inorganic nitrogen (DIN) is the sum of the three measured nitrogen based nutrients: nitrate, nitrite, and ammonia. While there may be other forms of inorganic nitrogen which may contribute to the DIN we have assumed that these additional contributions are minimal and that the overall DIN concentration can be characterized by these three nutrients. The DIN thus provides an estimate of the total nitrogen available to the phytoplankton and attached algae for their growth. The monthly spatial distributions of DIN are shown in Figures 25-33.

The monthly average DIN concentrations listed in Table III.3 indicate that the highest concentrations within the marina occurred during the winter months, especially November through January. The lowest concentrations, similar to the 1990-91 observations occurred in May and June. Based on previous years, we would expect the lower concentrations to persist through the summer. The overall range of values for the October 1991-June 1992 period is comparable to previous data from the marina.

Table III.3. Total Dissolved Inorganic Nitrogen Ranges in Concentration, µg-at/l, October 1991 to June 1992.

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-91	4.1	1	34.1	13	8.9	7.8
Nov-91	5.2	1	32.3	13	11.4	10.6
Dec-91	4.6	1	15.9	20	11.3	11.3
Jan-92'	4.7	1	58.5	13	13.9	11.6
Feb-92'	2.7	1	217.4	22	15.0	6.6
Mar-92'	2.5	2	17.8	11	7.8	7.8
Apr-92	3.5	1	130.9	22	14.2	9.6
May-92	2.2	18	16.3	22	4.1	3.3
Jun-92	2.6	1	39.4	22	6.1	5.2

* Excluding Oxford Street basin and Ballona Creek, Stations 12,13, and 22.
' Rainfall during or prior to survey

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Phosphate

Inorganic phosphate in the ocean of the Southern California Bight region ranges from more than 3.5 µg-at/l at depths of 800-900 meters in the basins to less than 0.5 µg-at/l in surface waters (Williams, 1986). As with the other nutrients, local variations may be mediated by ocean outfalls, coastal upwelling and turbulent mixing processes. Unlike nitrate, phosphate is seldom depleted in the surface waters of the ocean and few situations occur where phosphate is likely to regulate or limit the primary production of phytoplankton. Phosphates are readily used by the bacteria, as well as by phytoplankton. Phosphorous is important for proteins, nucleic acids and energy transfer within organisms.

The spatial distributions of phosphate (Figures III.34-42) are generally similar to the spatial patterns of nitrate. High phosphate concentrations were always observed in Oxford Street basin. Relatively high concentrations usually occurred in the surface sample at Station 12; March and June were exceptions to this pattern when Station 12 was among the stations lowest in phosphate. As with nitrate and ammonia, the lowest phosphate concentrations within the basin usually occurred at Station 1 or 2, near the breakwater (Table III.4; Figures III.34-42 and III.45). Phosphate concentrations usually increased at the inner basins (Stations 6, 7, 8, 9, 10, 18, 19, and 20) relative to the Main Channel. In most cases, the highest concentrations in the marina itself occurred at Stations 10 and 20 in Basin E, near the flood gate from Oxford Street basin.

The seasonal range of average phosphate concentrations within the marina during October 1991-June 1992 (0.8-1.4 µg-at/l; Table III.4 and Figure 43) was similar to the range for the same period during the previous year (0.7-1.4 µg-at/l; Soule, et al., 1992). The two highest average concentrations occurred during the winter months of December and January. This was much less than the relative range of the average concentrations for either nitrate or silicate. The minimum average concentration occurred in May 1992, when rainfall runoff was low.

The general range of concentrations for the October 1991- June 1992 period is similar to the range for the previous two years. The clearest pattern that emerges from these three years of observations is that the highest concentrations occur during the winter months, but the annual cycle of phosphate variation does not appear to be as clear and repeatable as does that annual cycle of average nitrate concentration within the marina.

Table III.4. Phosphate Ranges in Concentration, μg-at/l, October 1991 to June 1992.

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-91	0.1	1	5.7	22	1.0	0.9
Nov-91	0.4	1	1.8	22	1.0	0.9
Dec-91	0.7	1, 2	2.0	20	1.4	1.4
Jan-92⁺	0.7	1	5.7	13	1.4	1.3
Feb-92⁺	0.5	1	13.7	22	1.5	1.1
Mar-92⁺	0.5	2	1.8	10	1.0	1.0
Apr-92⁺	0.4	1	6.1	22	1.2	1.0
May-92	0.4	1	1.6	22	0.8	0.8
Jun-92	0.6	1, 2	1.7	13, 20	1.1	1.1

* Excluding Oxford Street Basin and Ballona Creek, Stations 12,13, and 22.
⁺ Rainfall during or prior to survey

Silicate

Silicate concentrations in the ocean surrounding Los Angeles are often relatively low at the surface, ranging from nearly unmeasurable concentrations to several microgram-atoms per liter. In the deep basins, silicate concentrations may approach 100 μg-at/l at depths of 800-900 meters (Williams, 1986). Low silicate concentrations in the upper layer result primarily from uptake by diatoms when nitrate and phosphate are sufficient to promote their growth (e.g. Broecker and Peng, 1982). It is not uncommon in the oceanic euphotic zone for residual silicate concentrations of 2-5 µg-at/l to occur after phytoplankton have reduced the available nitrogen to <0.1 µg-at/l. Silicate concentrations are often high in freshwater inflows into the coastal environment.

The spatial patterns for silicate were very similar to the patterns for phosphate and nitrate (nine month erage distribution is shown in Figure III.57 and monthly distributions in Figures III.46-54). . :latively high concentrations were usually observed in the Oxford Street basin and at the surface at Station 12 in Ballona Creek. Silicate concentrations within the marina were generally low at Stations 1 and 2, near the breakwater, and increased toward the inner basins.

The average silicate concentrations within the marina were highest in October 1991 and June 1992. The minimum average concentrations occurred in March and April (Table III.5 and Figures III.55-56), despite the heavy rainfall that occurred in the Los Angeles area in the months preceding both of these cruises. Similar patterns have been seen in previous years when the minimum appeared in the spring and, also when there were rains preceding the monthly sampling. However, the minimum monthly averages in 1992 were at least 50 percent greater than the minima observed in the past two years. In 1990 the spring minimum was about 4 µg-at/l and in 1991 the minimum was about 6 µg-at/l. While the minimum average concentrations were higher during October 1991-June 1992, the maximum average concentrations were lower than in the previous two years. The maximum concentrations for the basin were >13 µg-at/l in October 1991 and June 1992, but the maximum average concentration 1989 was >20 µg-at/l, and in June 1991 it was >17 µg-at/l. Although, the complete summer data

(July-September 1992) are not available, the trend that is apparent with high concentrations in October 1991, at the end of the 1991 summer period, and in June 1992 at the beginning of the 1992 summer period, is similar to the pattern of high concentrations in the summers of 1990 and 1991. We do not have a clear explanation of this seemingly repeatable annual cycle. Whether high summer concentrations are due to increased input of silicate into the marina from an unknown source, or to decreased uptake of silicate possibly due to a shift from a diatom dominated phytoplankton community that requires silicate for growth to a dinoflagellate community that does not require silicate, remains unknown to us.

Silicate concentrations and distributions during for the fall period, October-December, for which there is the greatest amount of historical data, compare well with observations from previous years. Both the general spatial patterns and the magnitude of concentrations are similar.

Table III.5. Silicate Ranges in Concentration, µg-at/l, October 1991 to June 1992.

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-91	2.7	1	49.0	22	15.1	13.6
Nov-91	4.0	1	17.6	22	10.5	10.1
Dec-91	4.5	1	17.5	20	11.9	11.9
Jan-92+	5.7	1	54.6	12	12.9	11.1
Feb-92+	5.3	1	72.9	22	14.9	11.8
Mar-92+	2.7	2	19.9	10	9.6	9.6
Apr-92+	2.3	1	35.6	22	10.4	9.3
May-92	5.2	1	68.3	12	12.3	10.7
Jun-92	6.4	1	107.0	22	15.4	13.3

* Excluding Oxford Street Basin and Ballona Creek, Stations 12, 13, and 22.
\+ Rainfall during or prior to survey

CORRELATIONS WITH OTHER VARIABLES

We have examined the interrelationships of nutrients with other variables in an attempt to understand the processes that may affect the variability of nutrients within Marina Del Rey, and hence the potential large phytoplankton blooms and their associated consequences. In the ocean there are usually predictable relationships of one nutrient with another and of nutrients with physical variables such as temperature and salinity. For example, nitrate concentrations can usually be correlated with temperature, particularl; low the euphotic zone (e.g. Zentara and Kamykowski, 1977).

The relationship between nutrients and temperature within the marina is not as direct as it is for coastal and open ocean situations. The clearest temperature/nutrient relationship for the October 1991-June 1992 data set is between temperature and phosphate. Phosphate decreased from a high value of about 1.5 µg-at/l at 14°C to 0.8-1.0 µg-at/l for temperatures 17°C and warmer. Other nutrients had a less clear pattern. However, the phosphate/temperature relationship was similar in pattern to the nitrate/temperature relationship in the October 1990-September 1991 data set.

Another relationship that would seem likely to provide insight into the nutrient variability is the relationship between salinity and nutrients. Over the past several years we have observed that nutrient concentrations within the marina often increase immediately after a substantial rainfall. This would suggest that nutrient concentrations within the marina would tend to increase with decreasing salinity. When the monthly average nutrient concentrations are correlated with the monthly average salinity concentrations for the basin, very little relationship seems to exists between salinity and the nutrient concentrations. However, if we consider the nine-month average of nutrients and salinity at each sampling point, which provides the nine-month average spatial distributions for the marina, then nutrient concentrations generally tend to increase with decreasing salinity. This suggests that a major portion of the nutrients within the marina comes from the inputs from Oxford Street basin and Ballona Creek. This is not an unexpected result.

Other relationships have been explored within the available data set. Nutrients have been compared with the physical variables of temperature and salinity, the chemical variables of dissolved oxygen and pH, and the microbiological and BOD measurements. At this time, we have not found any clear relationships between the monthly basin averages of these variables other than discussed above. This last nine month period, has coincided with a major El Nino event which resulted in warmer temperatures in Santa Monica Bay and changes in some of the fish populations observed in the local ocean. However, nutrient variability within the marina appears to be relatively uncoupled from Santa Monica Bay and therefore this large scale variation in the ocean does not have a strong effect on the nutrients within the marina.

When the nine month averages for each sampling point (location and depth) of the different variables are intercompared, then there are some definable relationships between nutrients and other variables. The most basic relationship is with salinity. There is generally a negative correlation between salinity and nutrients, i.e. higher nutrient concentrations are found in fresher water. In addition, the nutrients generally correlate well with each other in this spatial pattern. When compared with phosphate, the other nutrients increase relatively linearly with respect to phosphate concentration.

CONCLUSIONS

In most respects the nutrient variability within Marina Del Rey was similar during October 1991-June 1992, to observations from previous years. For most of the nutrients the ranges of nutrient concentration were similar. Silicate was the one nutrient that seemed to have a narrower range of average concentrations than in previous years. Seasonal patterns of nutrient variability were less well defined during this period than in previous years. Phosphate demonstrated the clearest seasonal pattern: concentrations were high during the winter months and were at a minimum of 0.8-1.0 μg-at/l during the warmer (T>17°C) months.

As we have concluded in previous reports, the primary input of nutrients into the marina is from freshwater sources, especially Oxford Street basin and Ballona Creek. The observation of increased nutrients immediately after episodes of measurable rainfall that has been seen in previous years was not as apparent in this year's data set. Perhaps, because there was significantly more rain during the winter (see cruise logs, Appendix A) the effect of any one rain event was not as large as it might have been in previous years where rain events were relatively infrequent. Nutrient measurements in the coastal ocean off of Palos Verdes during the February storms did not demonstrate large nutrient concentrations associated with the freshwater runoff layers, in contrast to what we had expected.

The nine month period of October 1991 through June 1992 was anomalous in comparison to the recent years. The seasonal patterns of nutrient variability were less pronounced, and the relationships between different variables were less clear. It is possible that the major El Nino that occurred during this period could have had an affect on these observations. However, as we stated above, the nutrient variability within the marina appears to be uncoupled from the coastal ocean where El Niño effects were very apparent.

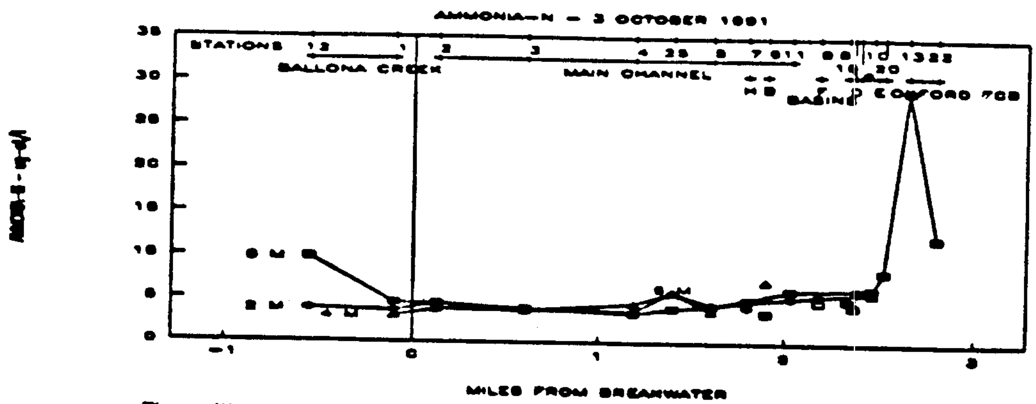

Figure III.1. Ammonia-N (ug-at/l), 3 October 1991.

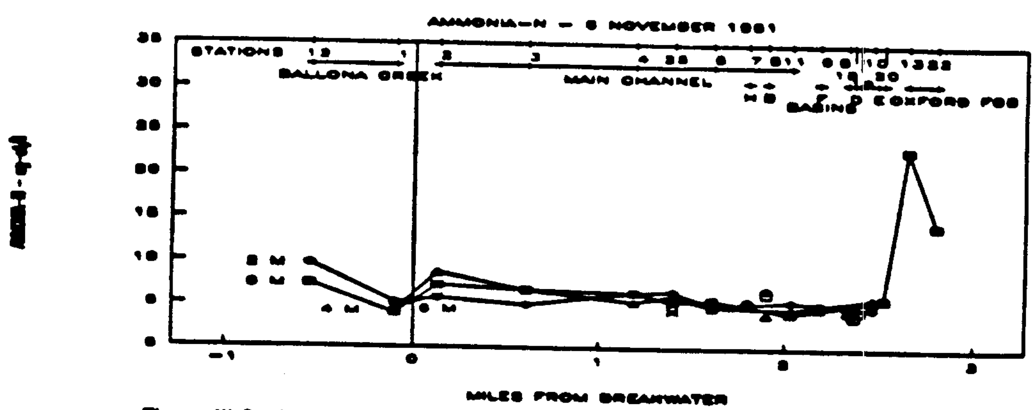

Figure III.2. Ammonia-N (ug-at/l), 5 November 1991.

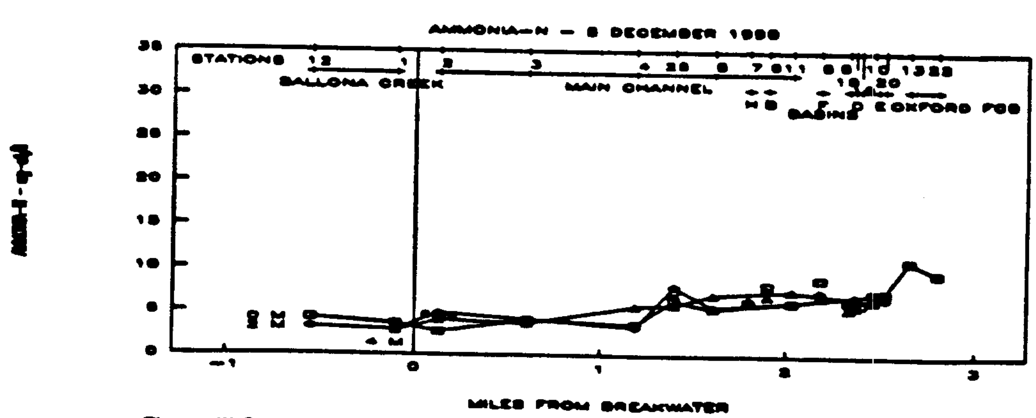

Figure III.3. Ammonia-N (ug-at/l), 5 December 1991.

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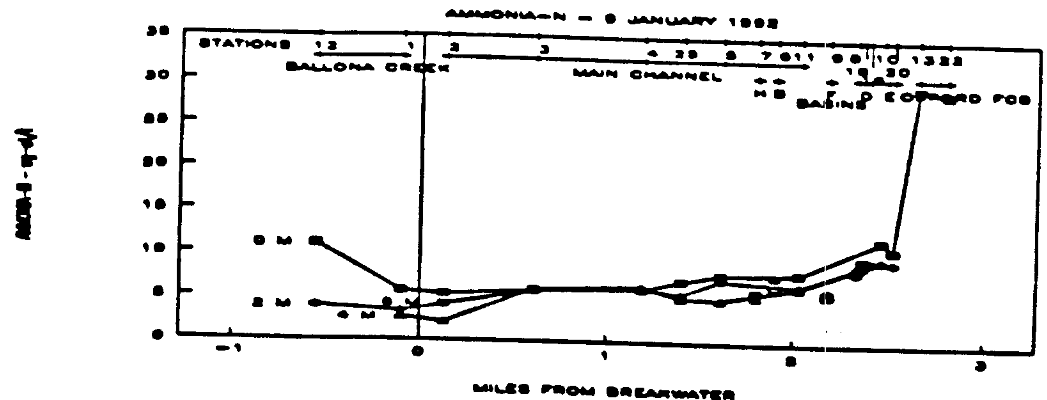

Figure III.4. Ammonia-N (ug-at/l), 9 January 1992.

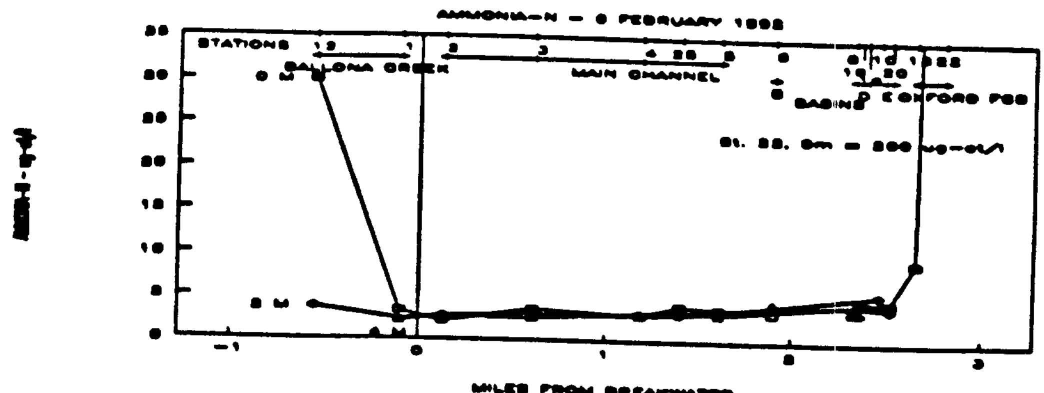

Figure III.5. Ammonia-N (ug-at/l), 6 February 1992.

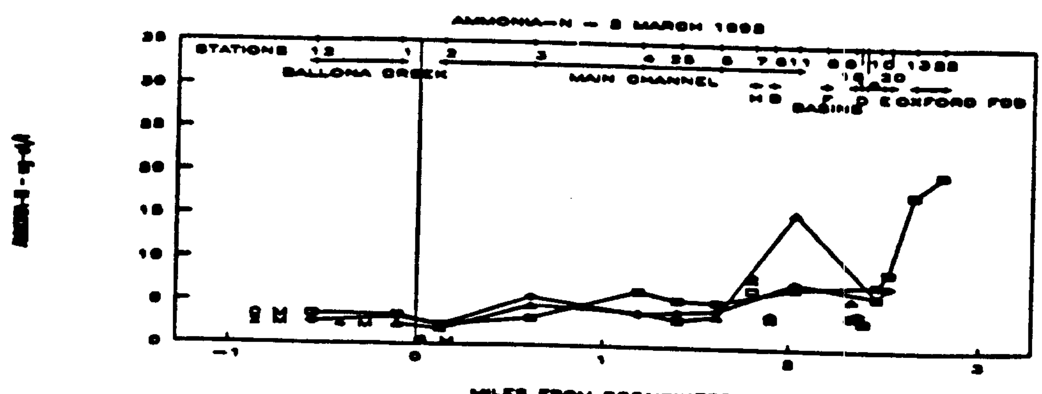

Figure III.6. Ammonia-N (ug-at/l), 5 March 1992.

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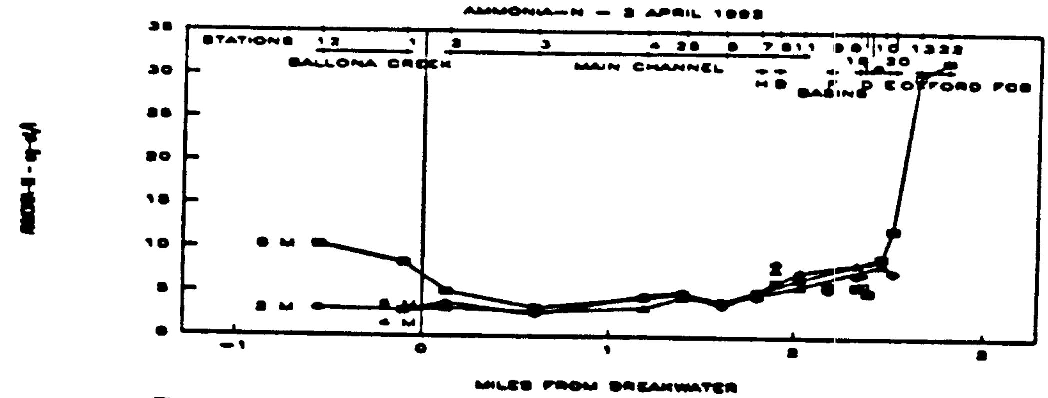

Figure III.7. Ammonia-N (ug-at/l), 2 April 1992.

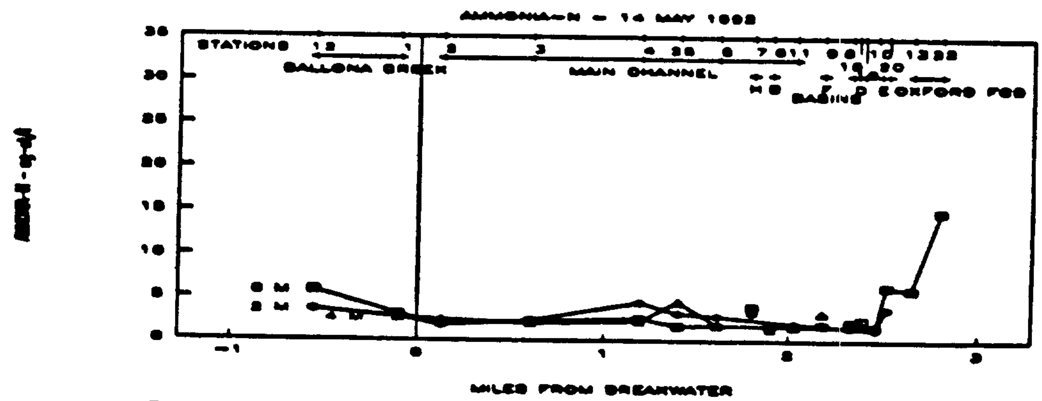

Figure III.8. Ammonia-N (ug-at/l), 14 May 1992.

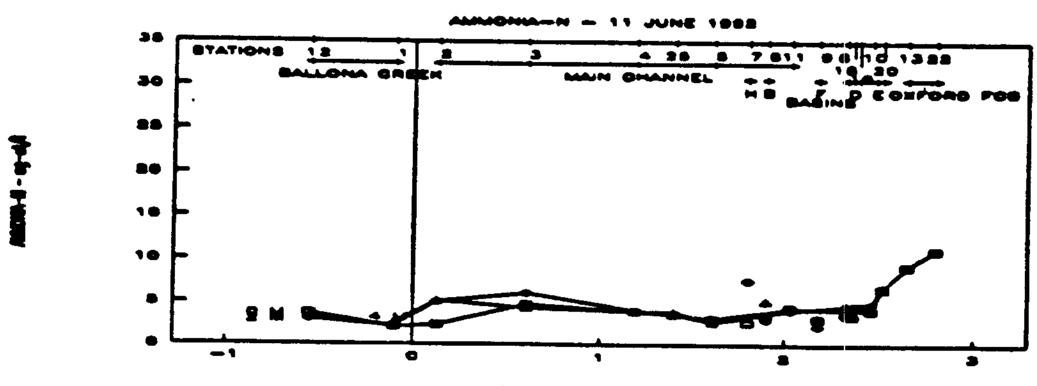

Figure III.9. Ammonia-N (ug-at/l), 11 June 1992.

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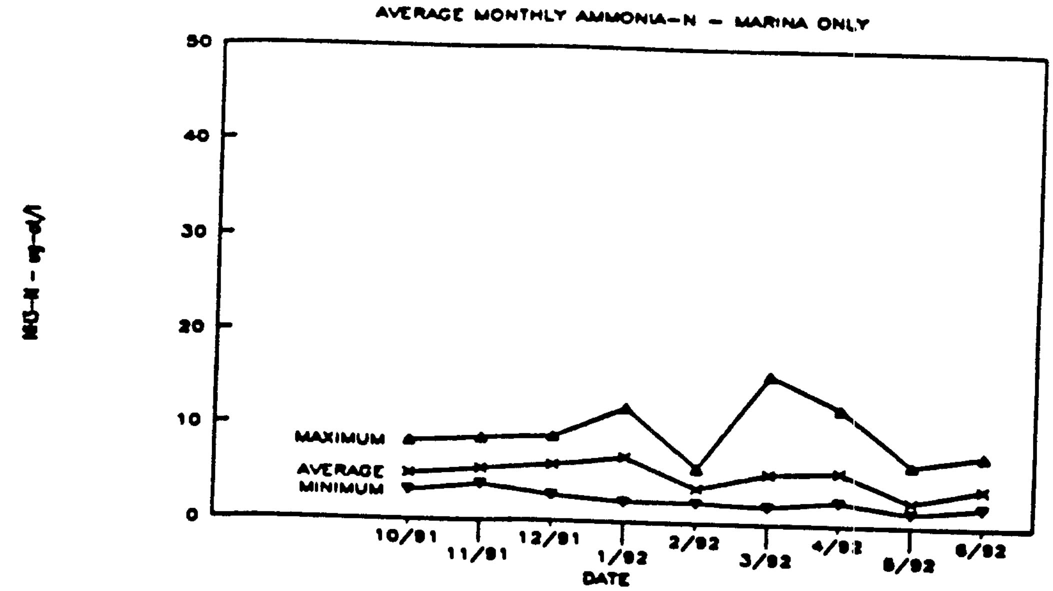

Figure III.10. Minimum, mean and maximum ammonia-N (ug-at/l) for all depths and all marina stations, excluding Ballona Creek and Oxford Street basin.

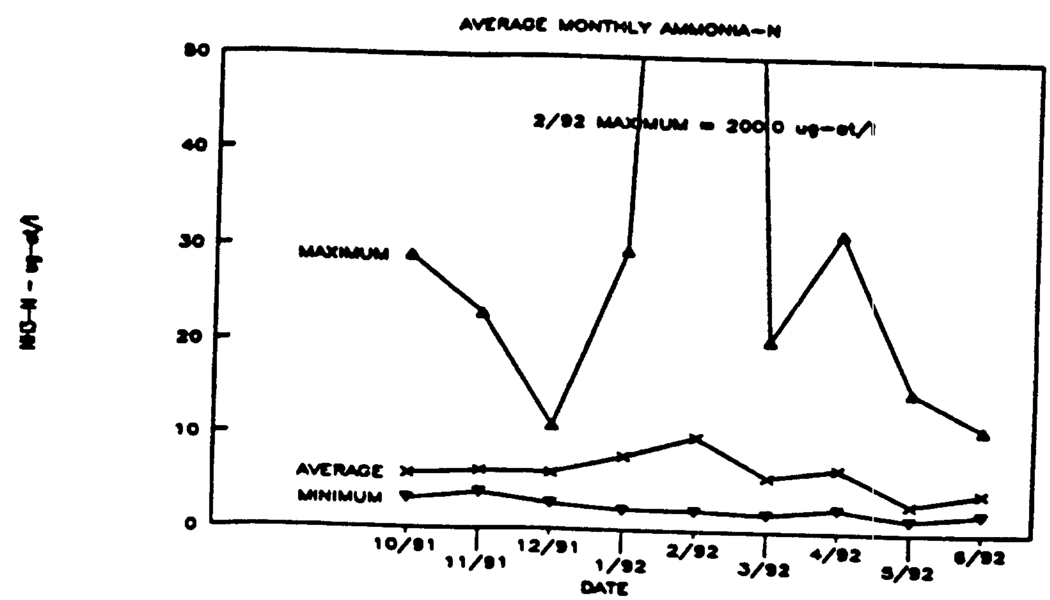

Figure III.11. Minimum, mean and maximum ammonia-N (ug-at/l) for all depths and all marina stations, including Ballona Creek and Oxford Street basin.

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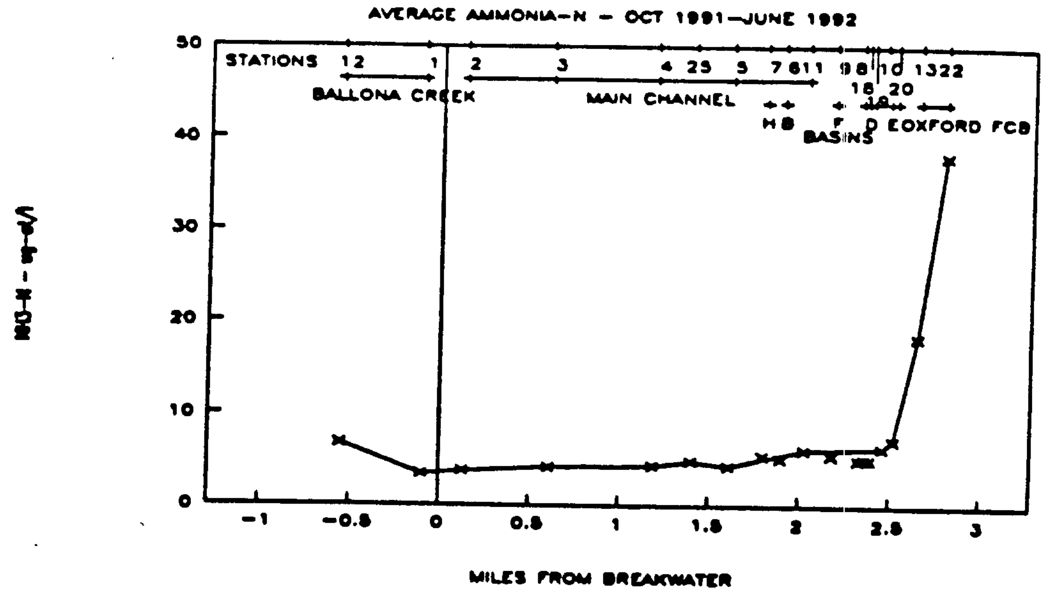

Figure III.12. Average ammonia-N (ug-at/l) for all depths and all months by station during October 1991 through June 1992.

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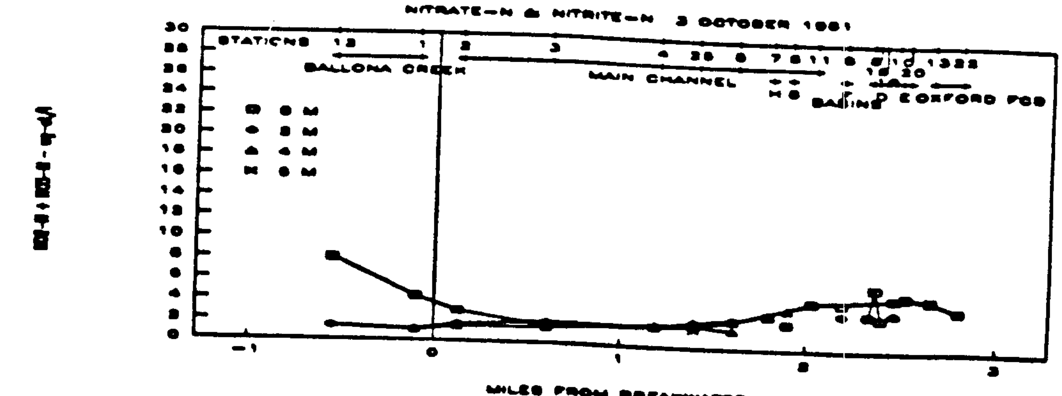

Figure I. 13. Nitrate-N and Nitrite-N (ug-at/l), 3 October 1991.

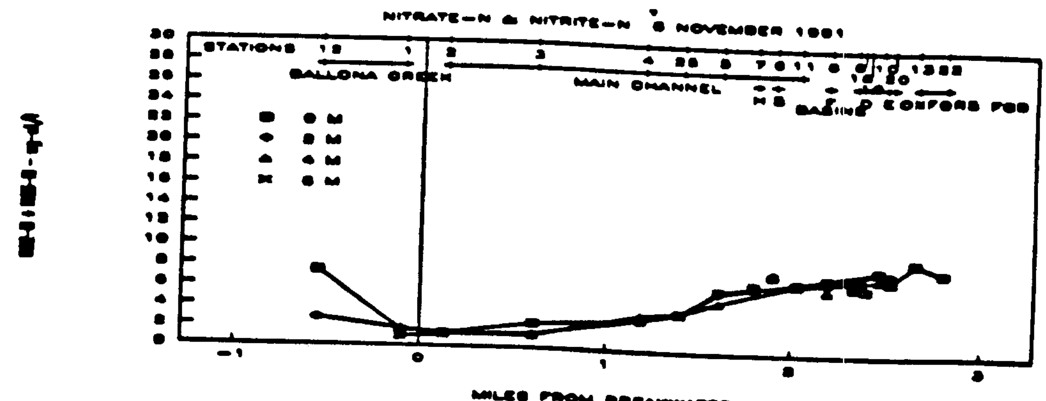

Figure III.14. Nitrate-N and Nitrite-N (ug-at/l), 6 November 1991.

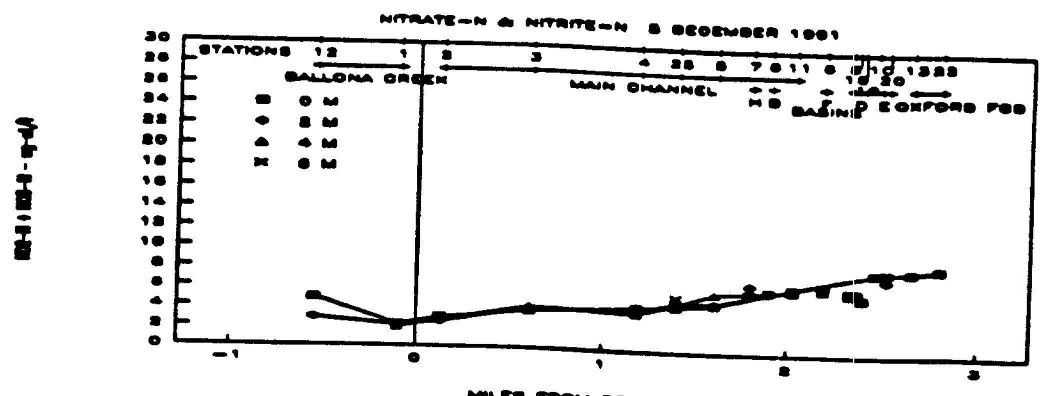

Figure III.15. Nitrate-N and Nitrite-N (ug-at/l), 5 December 1991.

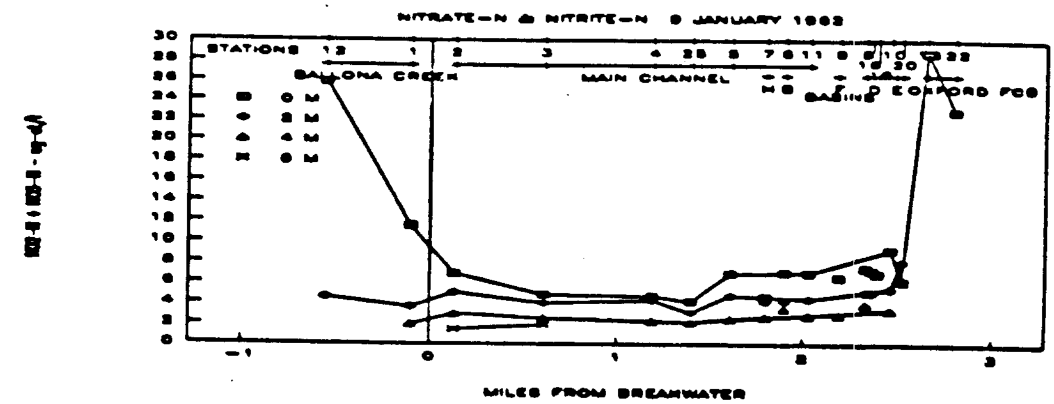

Figure III.16. Nitrate-N and Nitrite-N (ug-at/l), 9 January 1992.

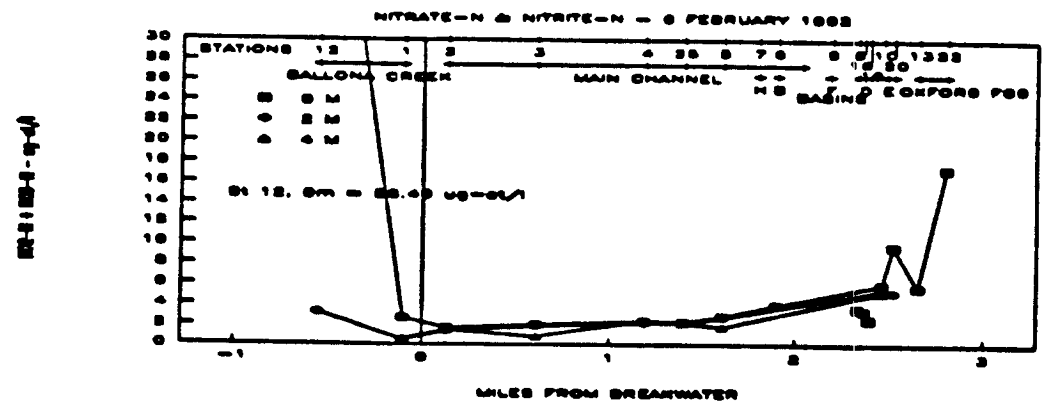

Figure III.17. Nitrate-N and Nitrite-N (ug-at/l), 6 February 1992.

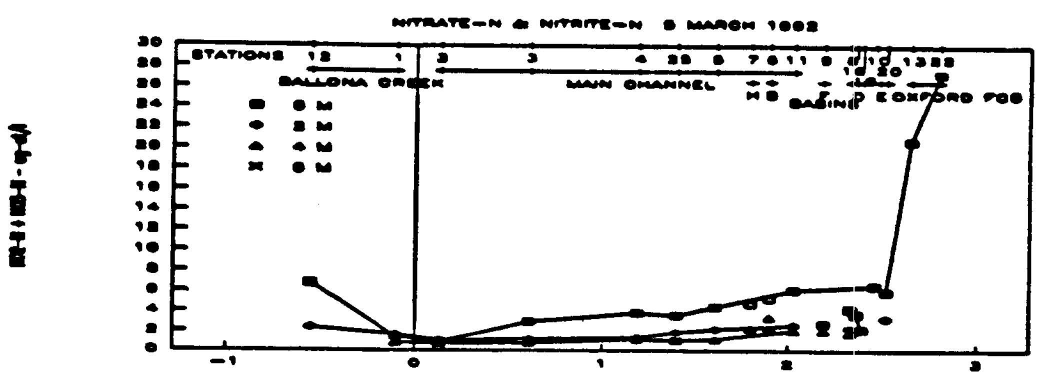

Figure III.18. Nitrate-N and Nitrite-N (ug-at/l), 5 March 1992

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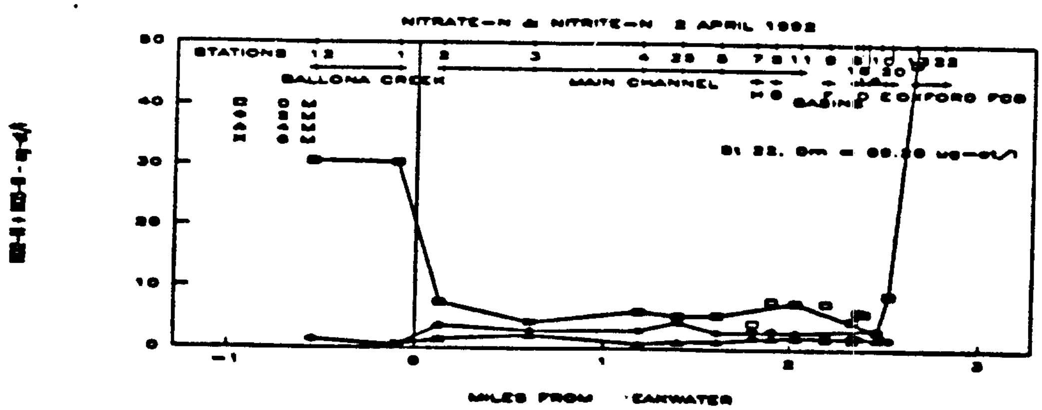

Figure III.19. Nitrate–N and Nitrite–N (ug- ./l), 2 April 1992.

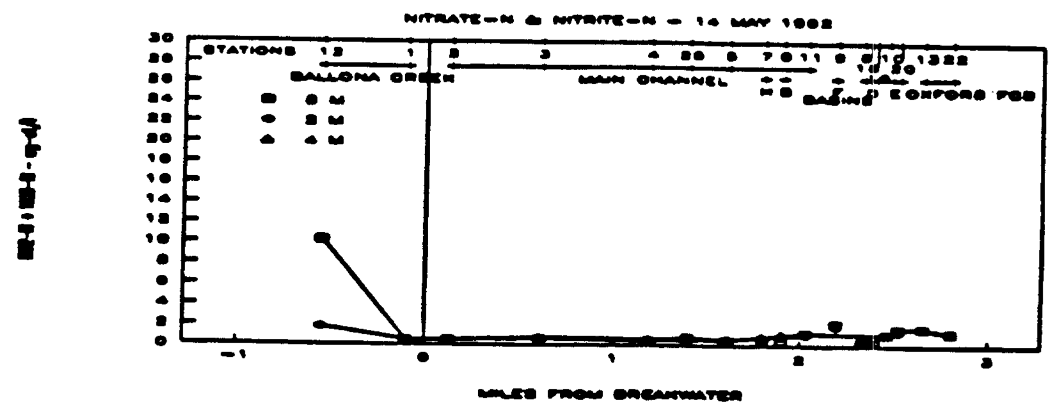

Figure III.20. Nitrate–N and Nitrite–N (ug–at/l), 14 May 1992.

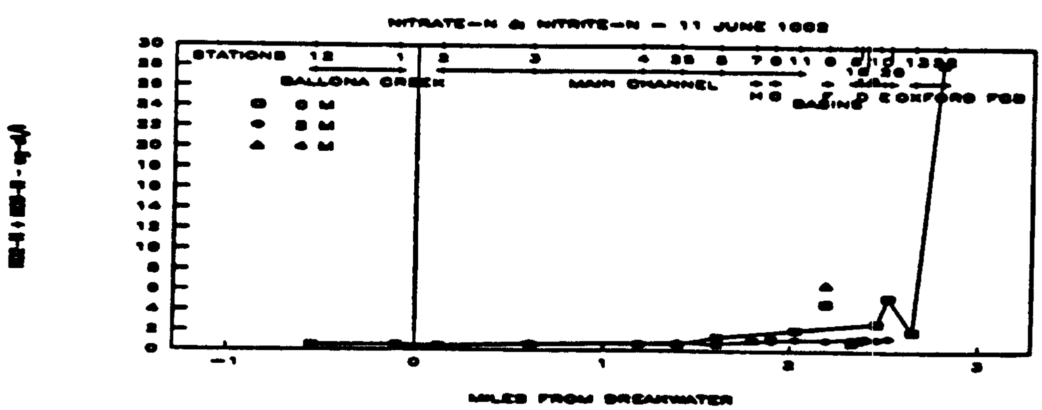

Figure III.21. Nitrate–N and Nitrite–N (ug–at/l), 11 June 1992.

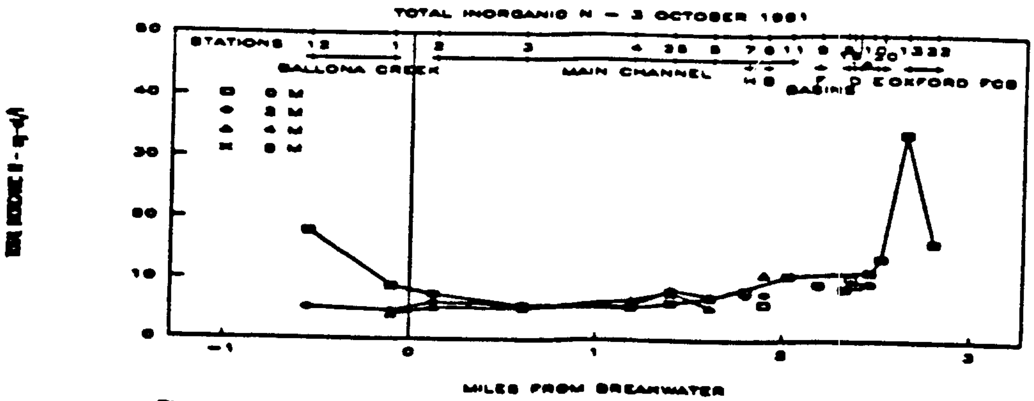

Figure III.25. Dissolved inorganic nitrogen (ug–at/l), 3 October 1991.

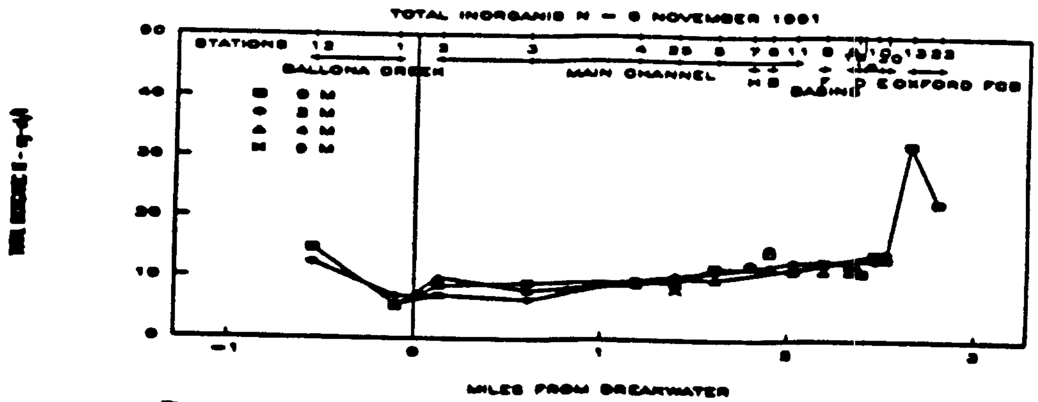

Figure III.26. Dissolved inorganic nitrogen (ug–at/l), 6 November 1991.

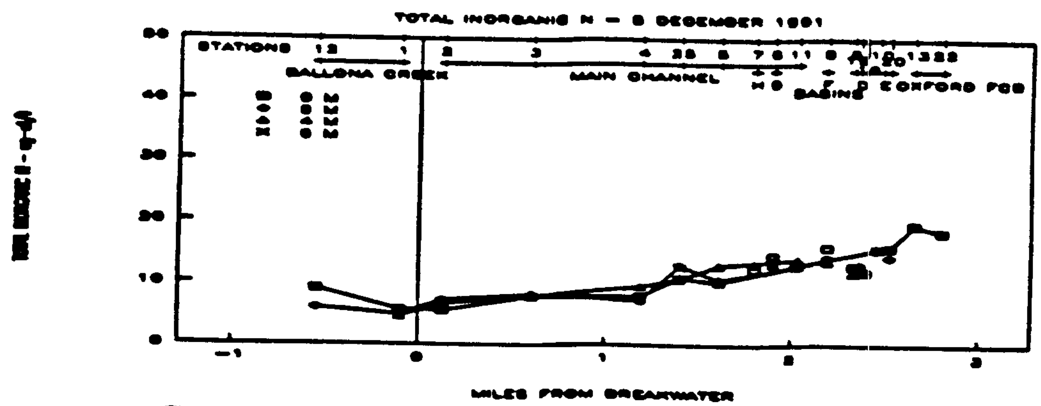

Figure III.27. Dissolved inorganic nitrogen (ug–at/l), 5 December 1991.

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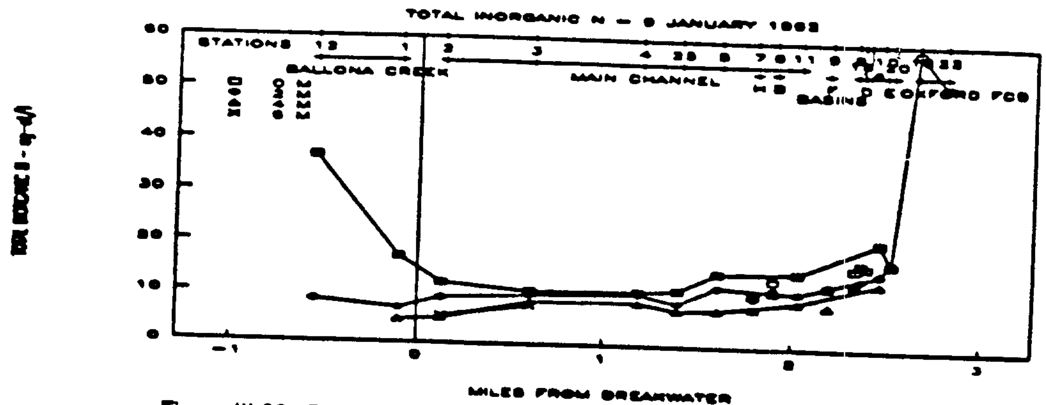

Figure III.28. Dissolved inorganic nitrogen (ug-at/l), 9 January 1992.

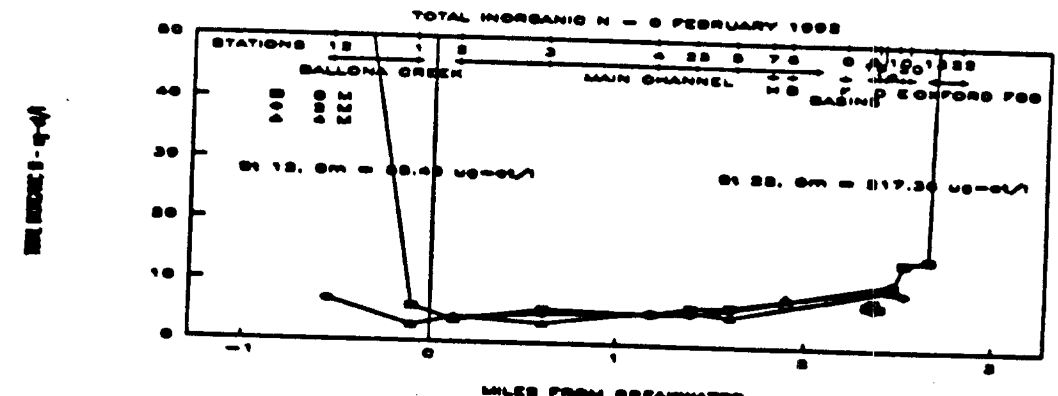

Figure III.29. Dissolved inorganic nitrogen (ug-at/l), 6 February 1992.

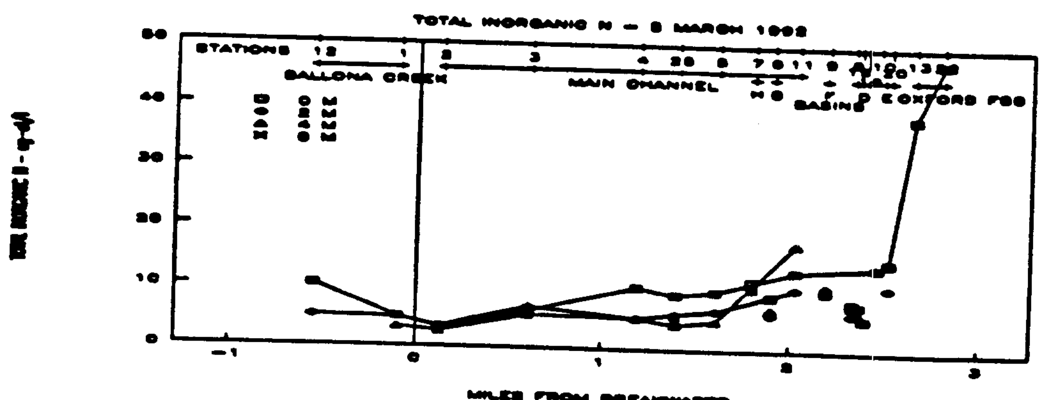

Figure III.30. Dissolved inorganic nitrogen (ug-at/l), 5 March 1992.

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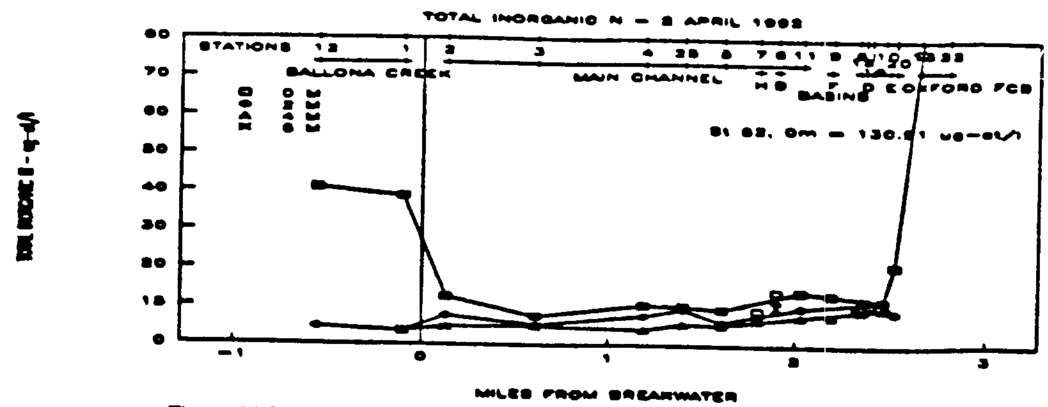

Figure III.31. Dissolved inorganic nitrogen (ug–at/l), 2 April 1992.

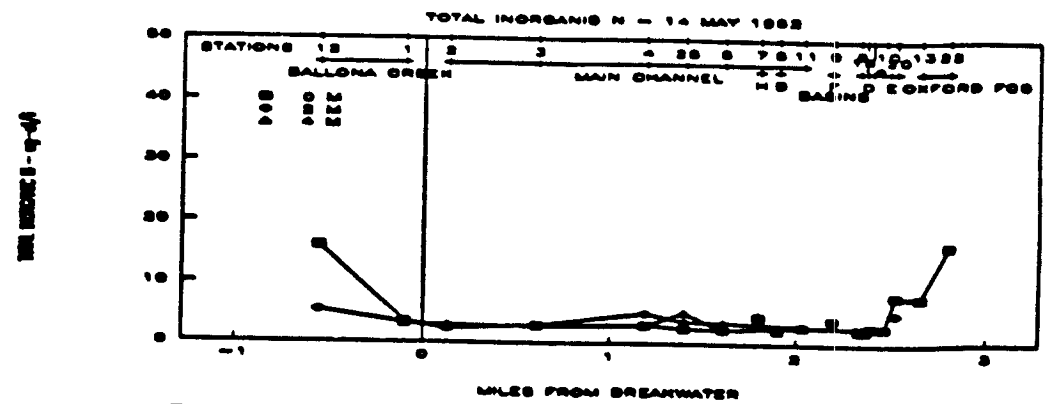

Figure III.32. Dissolved inorganic nitrogen (ug–at/l), 14 May 1992.

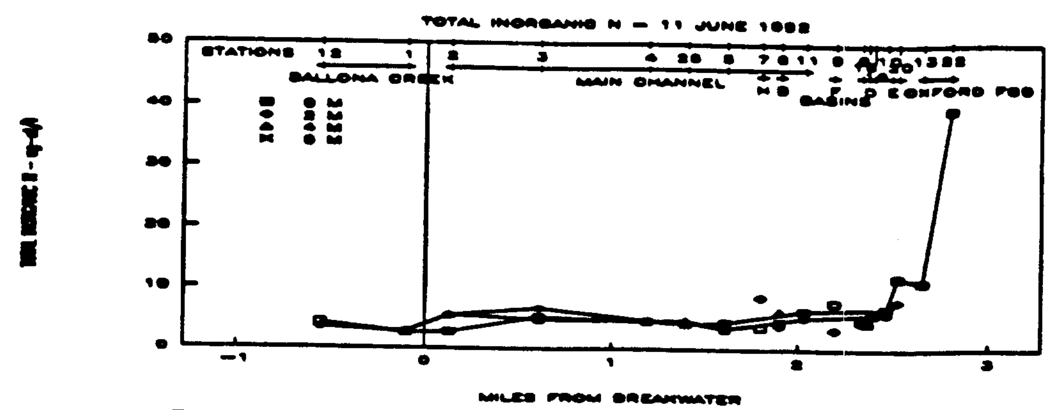

Figure III.33. Dissolved inorganic nitrogen (ug–at/l), 11 June 1992.

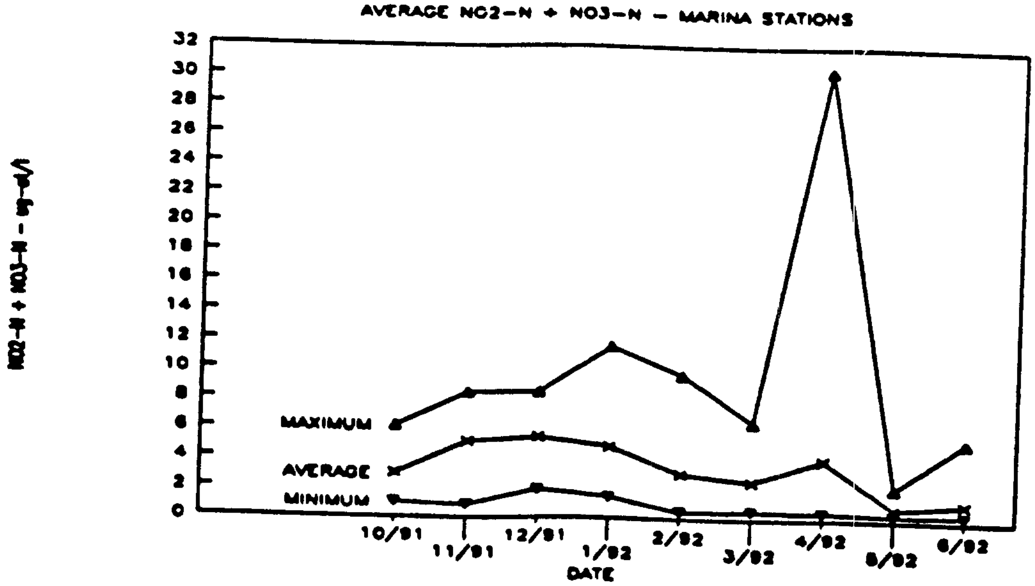

Figure III.22. Minimum, maximum and average nitrite-nitrogen and nitrate-nitrogen for all stations and depths at stations within the marina, excluding Ballona Creek and Oxford Street basin.

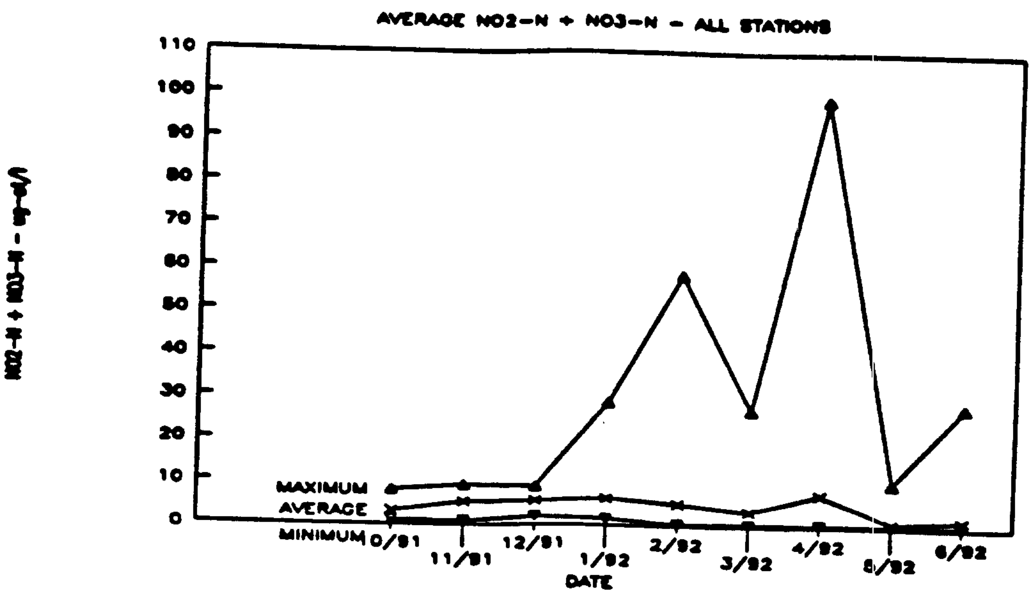

Figure III.23. Minimum, maximum and average nitrite-nitrogen and nitrate-nitrogen for all stations and depths at stations within the marina, excluding Ballona Creek and Oxford Street basin.

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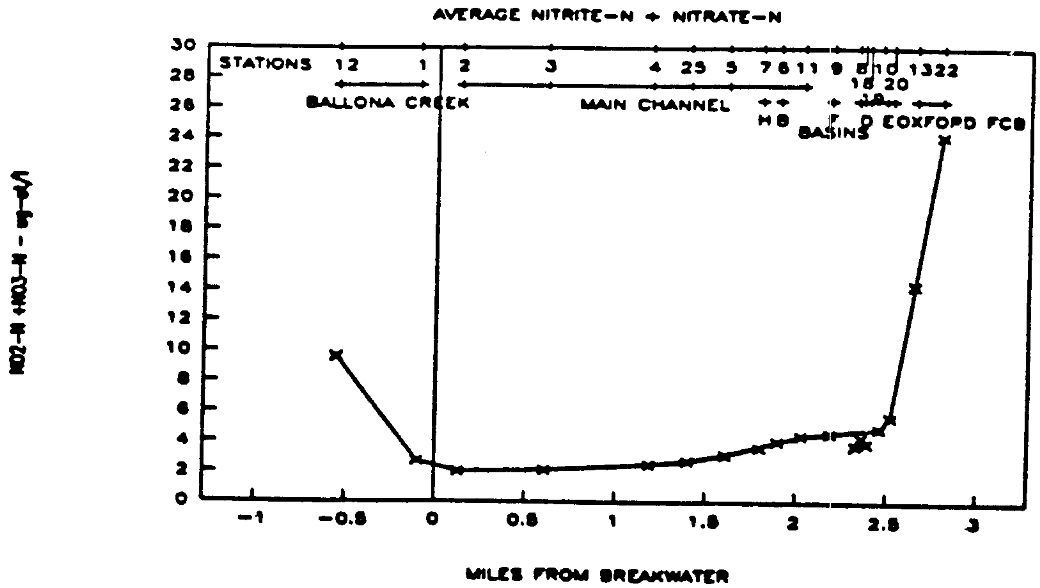

Figure III.24. Average nitrite-N plus nitrate-N (ug-at/l) for all depths and months by station during October 1991 through June 1992.

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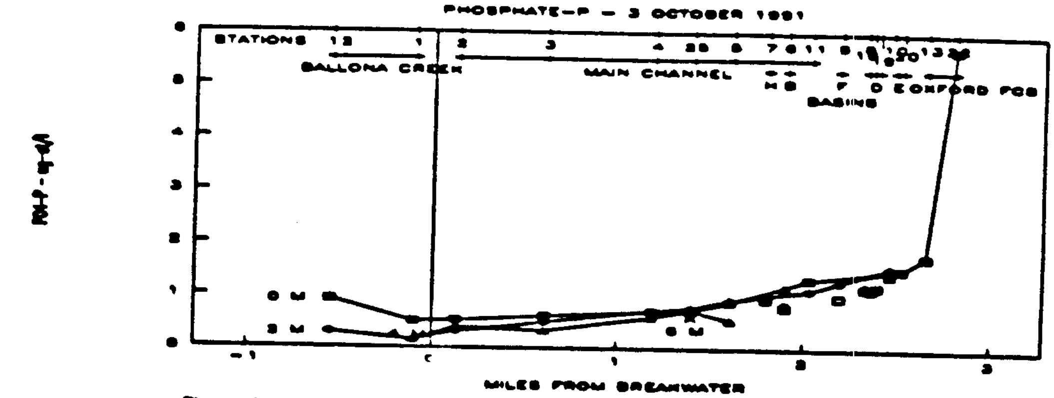

Figure III.34. Phosphate-P (ug-at/l), 3 October 1991.

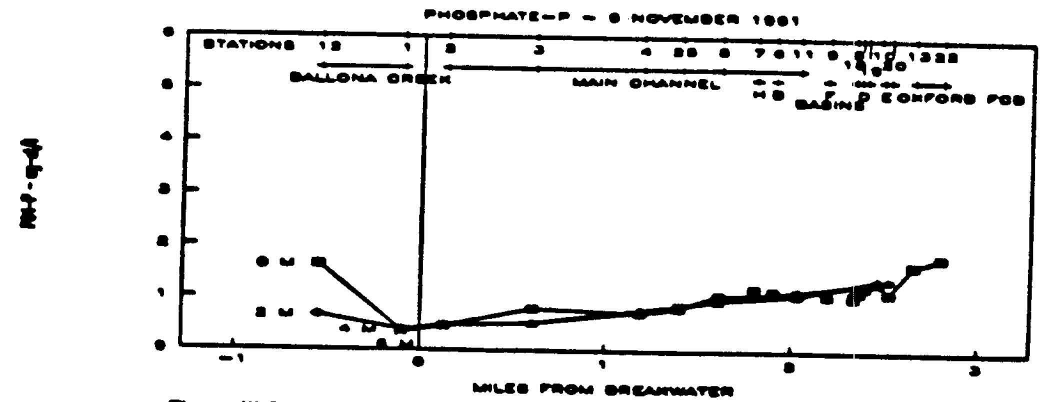

Figure III.35. Phosphate-P (ug-at/l), 6 November 1991.

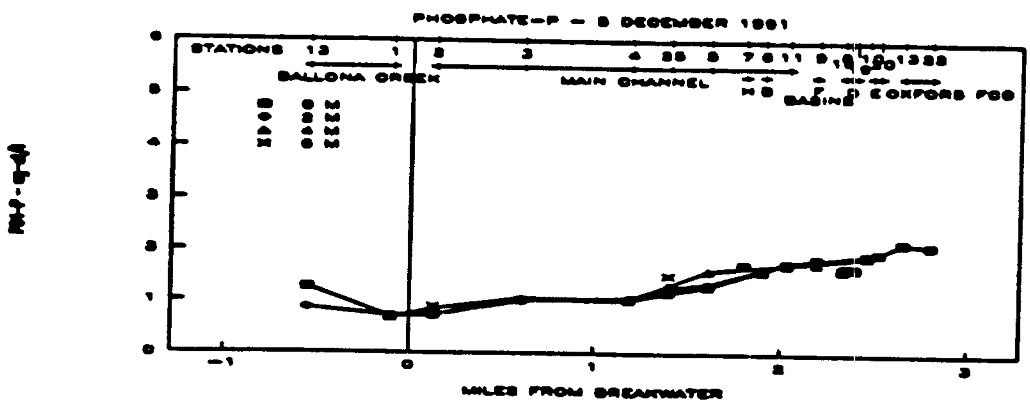

Figure III.36. Phosphate-P (ug-at/l), 5 December 1991.

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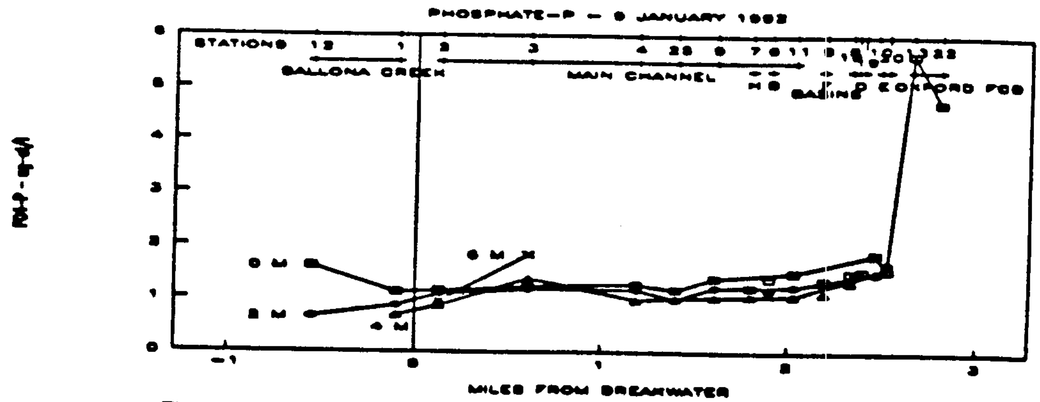

Figure III.37. Phosphate-P (ug-at/l), 9 January 1992.

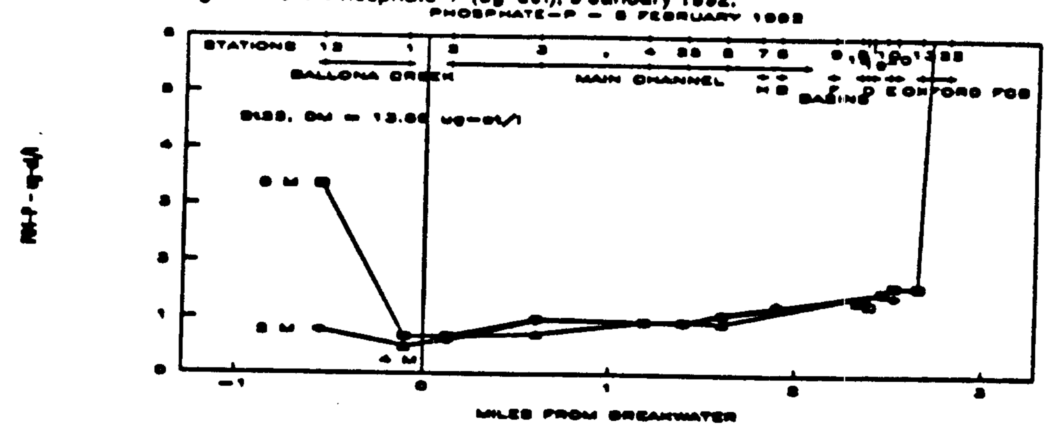

Figure III.38. Phosphate-P (ug-at/l), 6 February 1992.

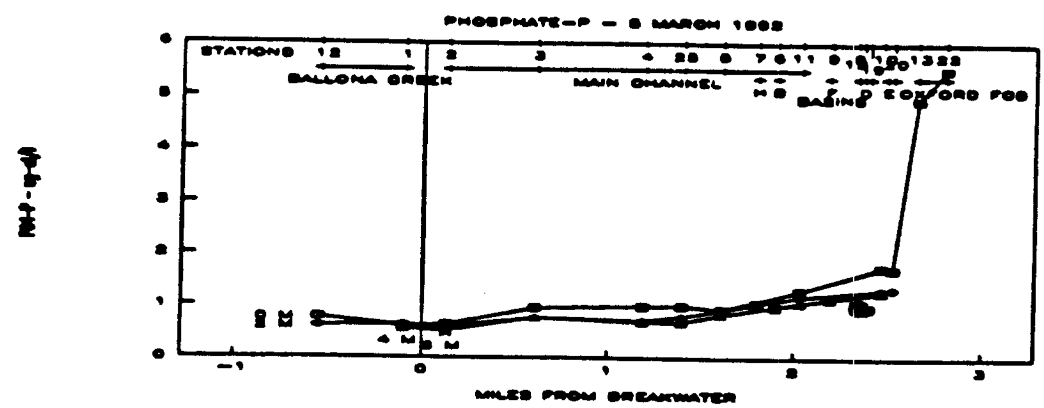

Figure III.39. Phosphate-P (ug-at/l), 5 March 1992.

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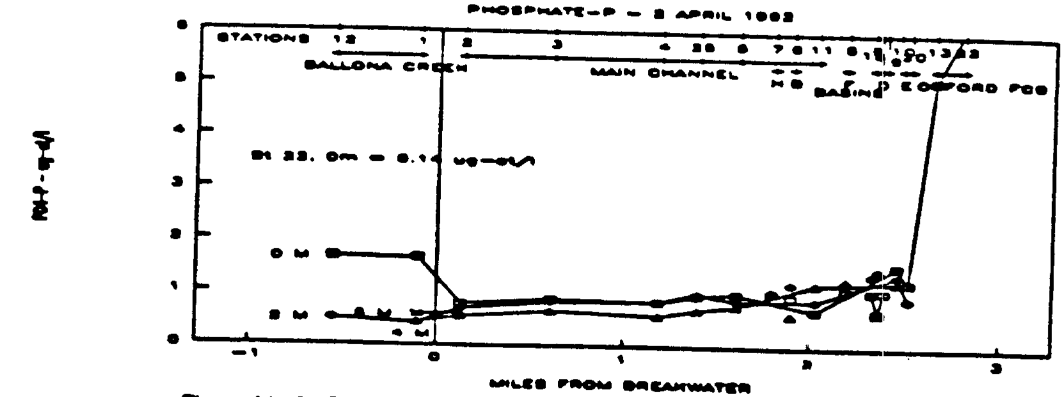

Figure III.40. Phosphate-P (ug-at/l), 2 April 1992.

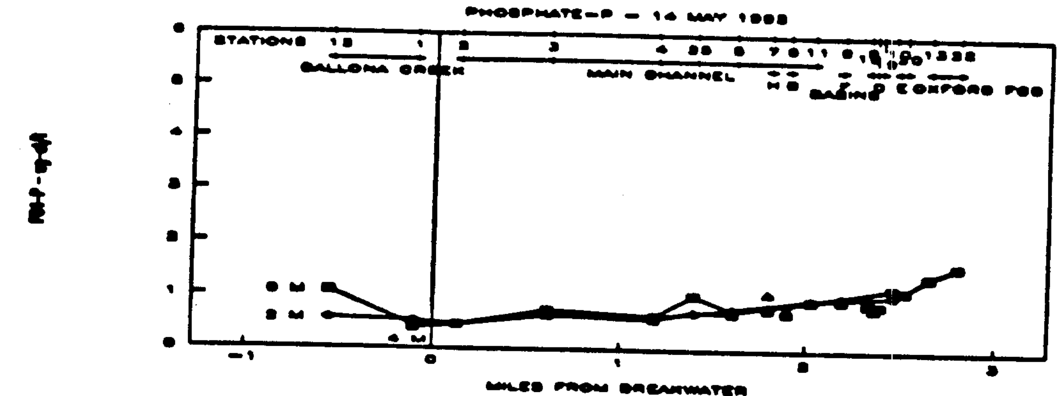

Figure III.41. Phosphate-P (ug-at/l), 14 May 1992.

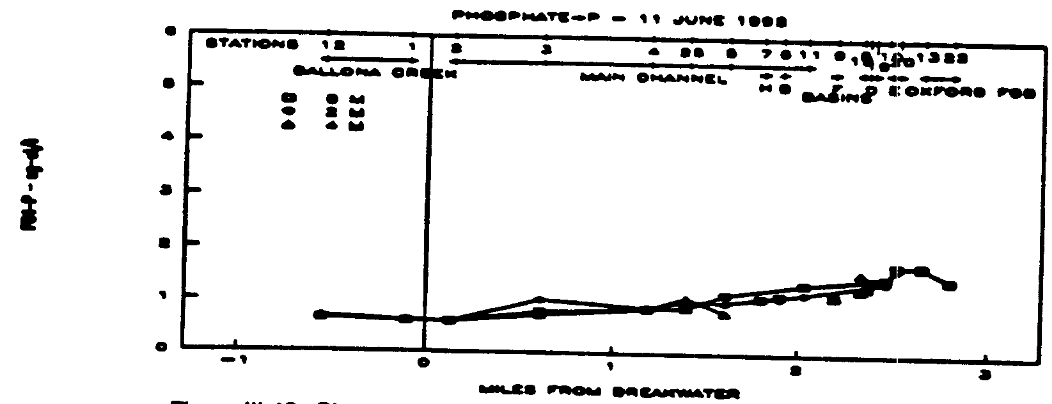

Figure III.42. Phosphate-P (ug-at/l), 11 June 1992.

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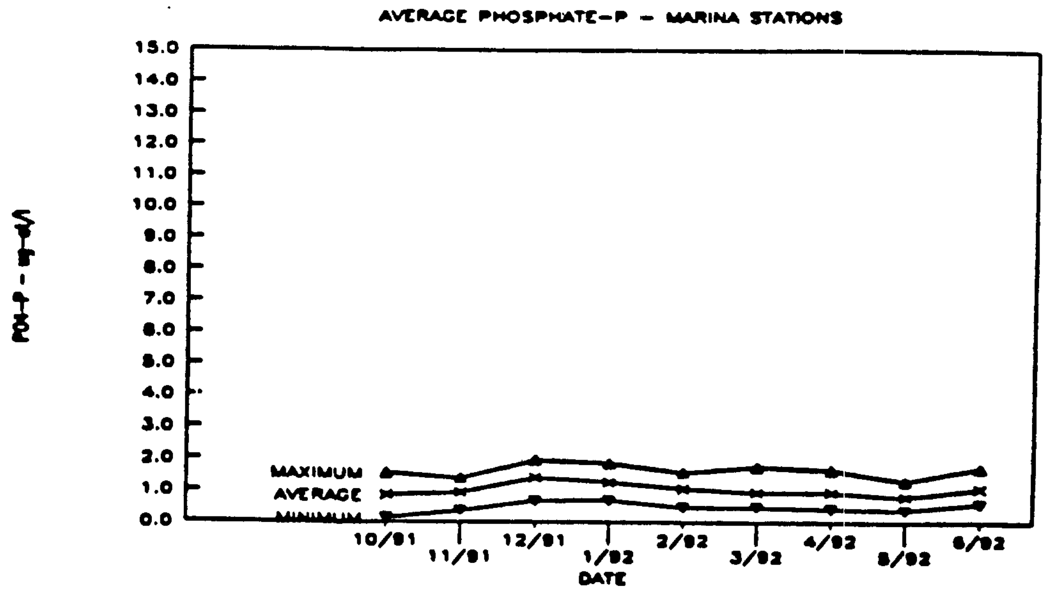

Figure III.43. Monthly minimum, maximum and average phosphate-phosphorus for all stations and depths excluding Ballona Creek and Oxford Street basin.

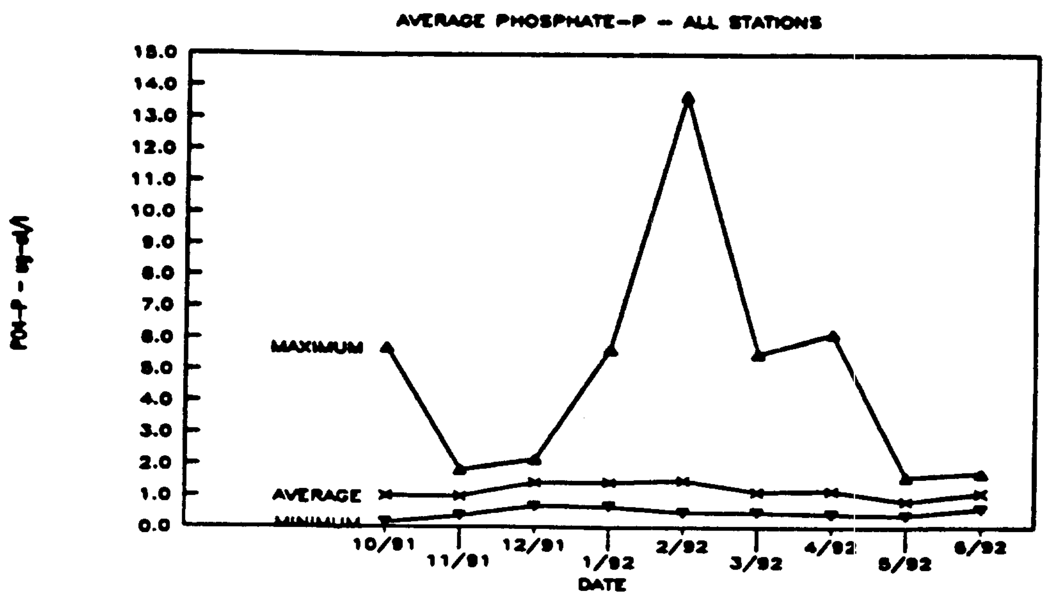

Figure III.44. Monthly minimum, maximum and average phosphate-phosphorus for all stations and depths including Ballona Creek and Oxford Street basin.

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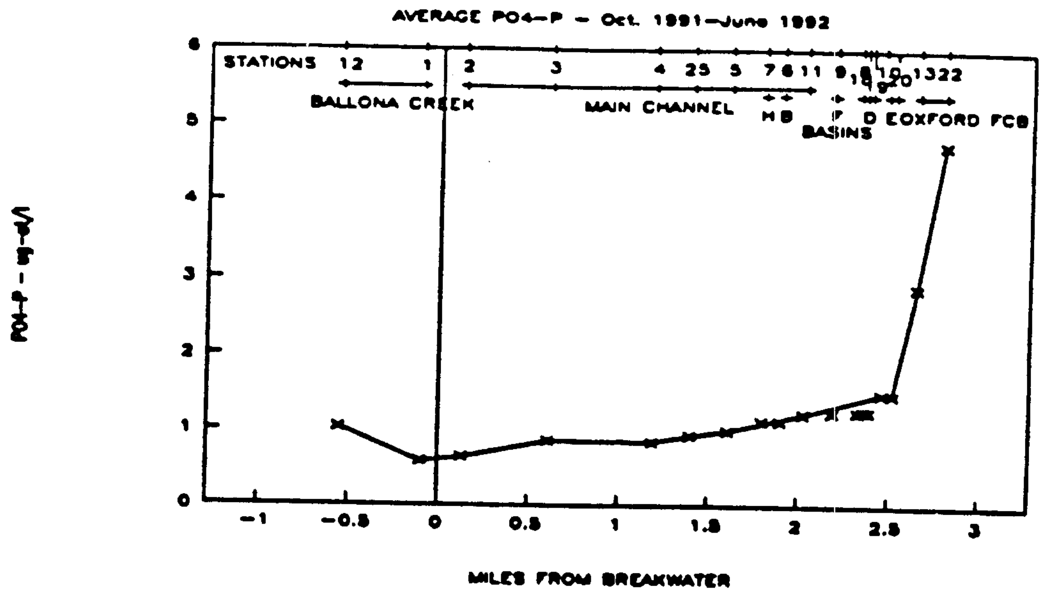

Figure III.45. Average phosphate-phosphorus for all depths and all months by station during October 1991 through June 1992.

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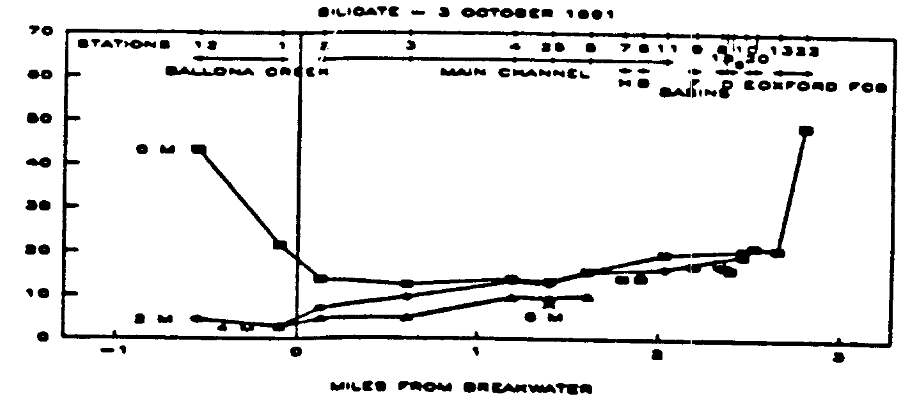

Figure III.46. Silicate (ug-at/l), 3 October 1991.

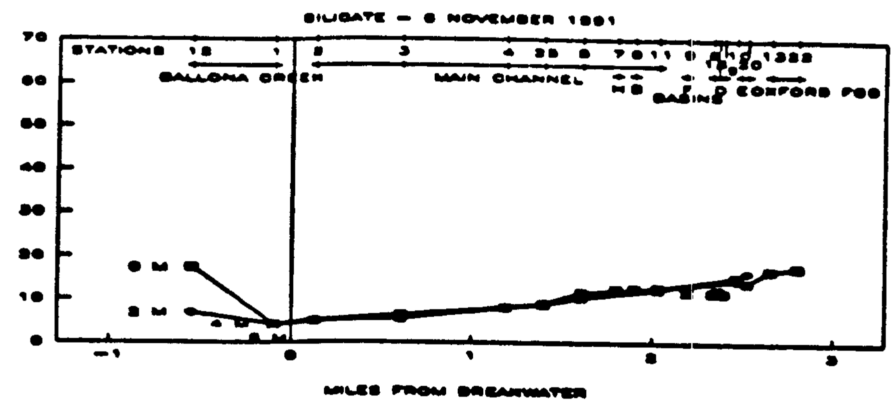

Figure III.47. Silicate (ug-at/l), 6 November 1991.

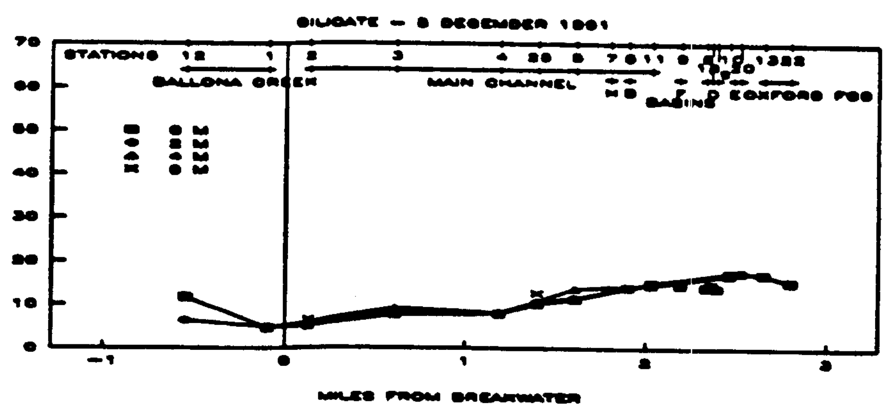

Figure III.48. Silicate (ug-at/l), 5 December 1991.

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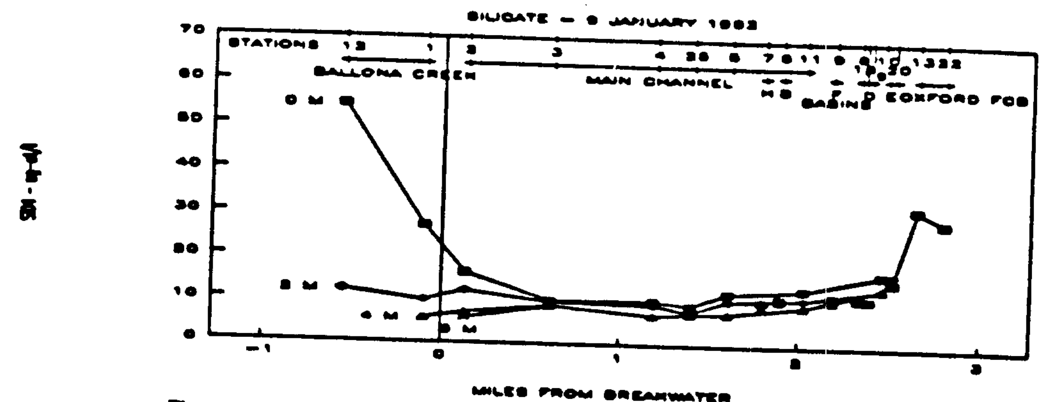

Figu   II.49. Silicate (ug-at/l), 9 January 1992.

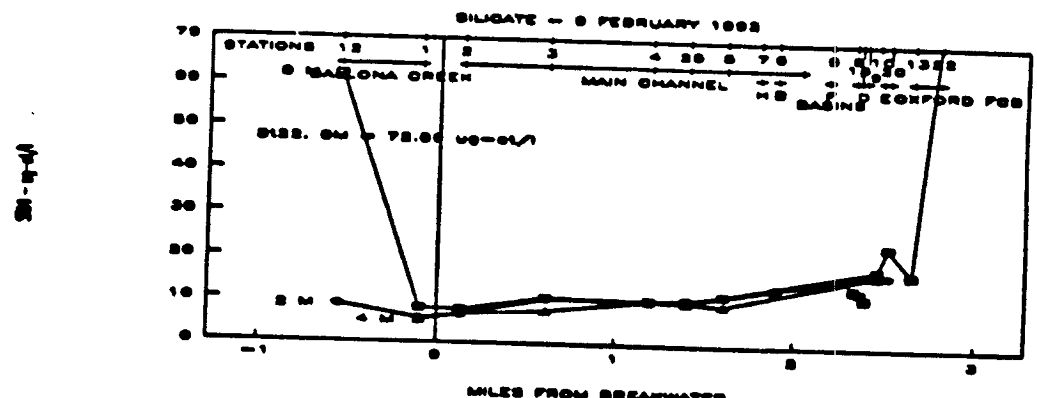

Figure III.50. Silicate (ug-at/l), 6 February 1992.

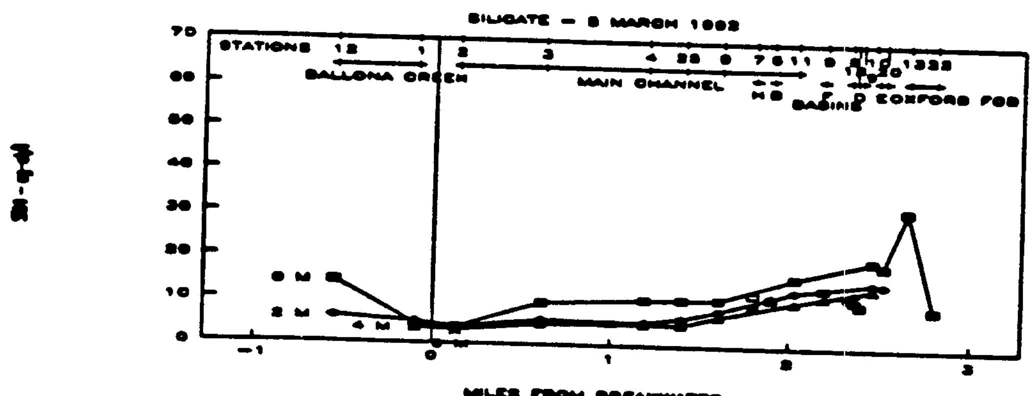

Figure III.51. Silicate (ug-at/l), 5 March 1992.

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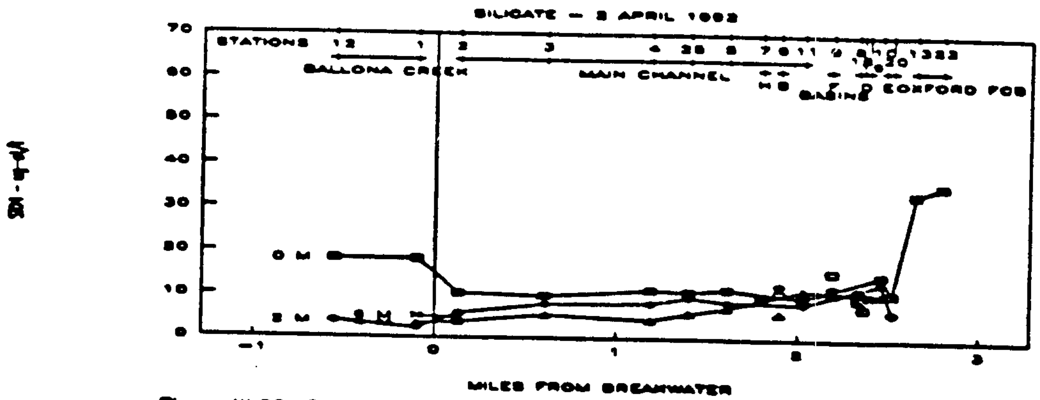

Figure III.52. Silicate (ug-at/l), 2 April 1992.

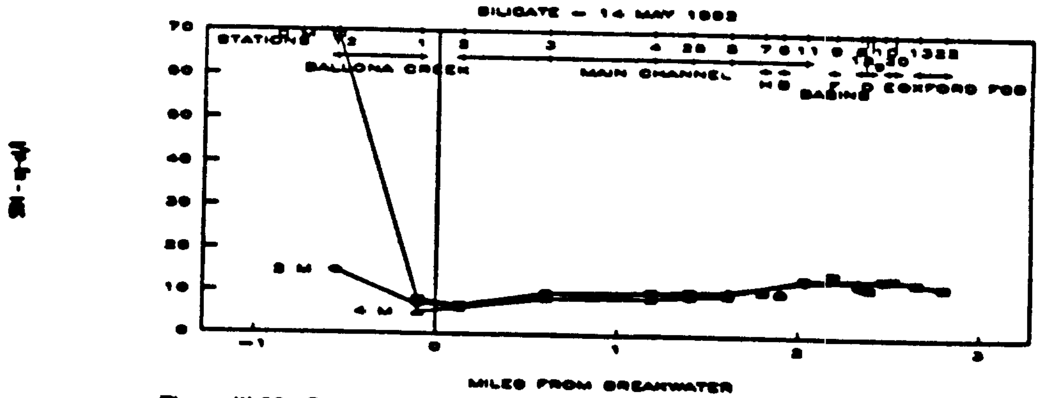

Figure III.53. Silicate (ug-at/l), 14 May 1992.

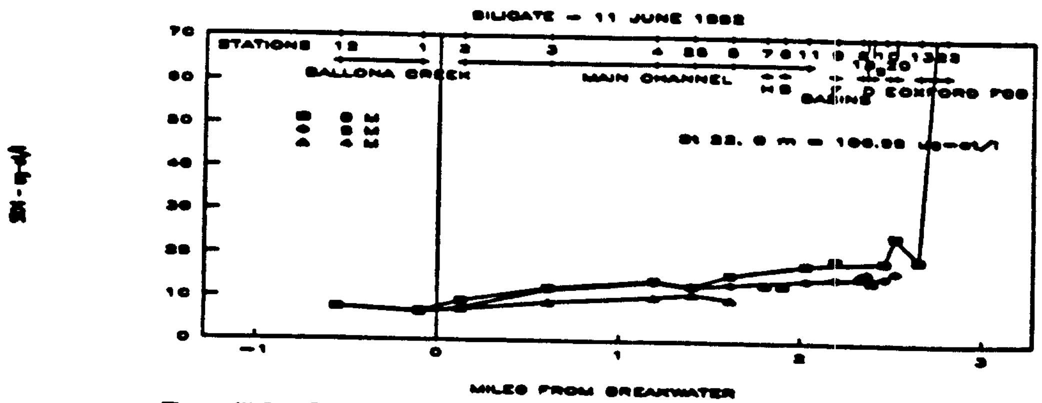

Figure III.54. Silicate (ug-at/l), 11 June 1992.

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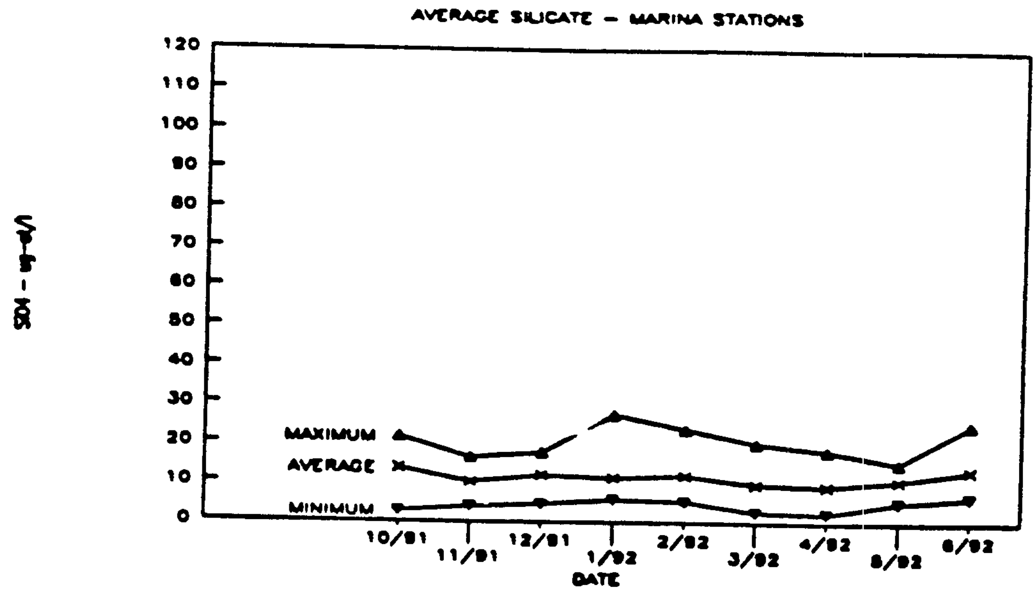

Figure III.55. Monthly minimum, maximum and average silicate for all stations and depths excluding Ballona Creek and Oxford Street basin.

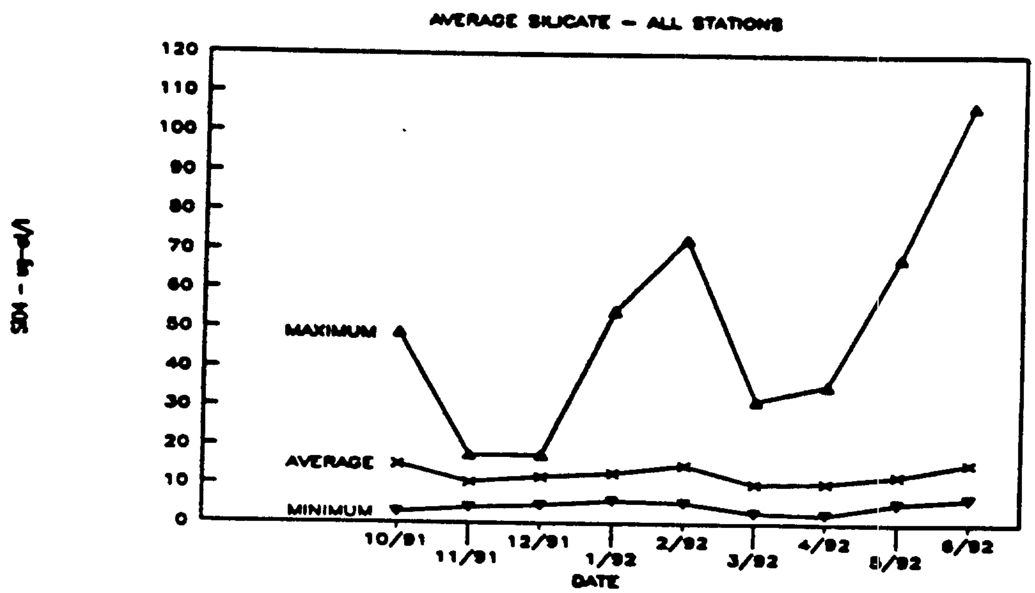

Figure III.56. Monthly minimum, maximum and average silicate for all stations and depths including Ballona Creek and Oxford Street basin.

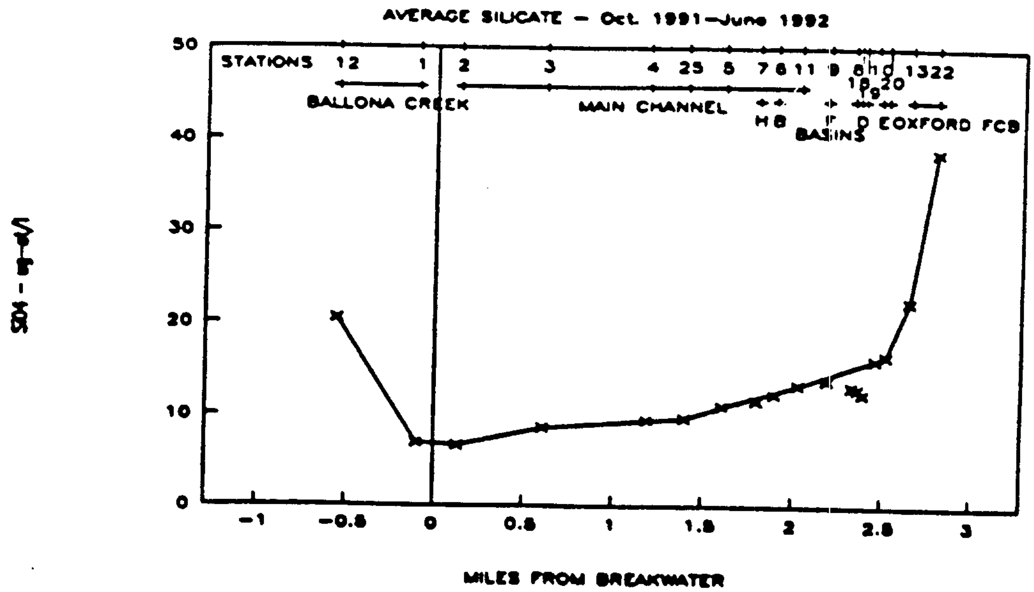

Figure III.57. Average silicate or all depths and all months by station during October 1991 through June 1992.

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IV. SEDIMENT COMPOSITION AND CONTAMINATION

INTRODUCTION

Sediments in the marina area before construction were a mixture of large grained barrier beach sands and fine grained sediments that had accumulated in the slowly draining wetlands. The marina benthos is largely composed of finer sediments due to seaward movement of heavier sands where flushing is relatively good and the settling of finer materials in the low energy basins and inner channels. No extensive deposition of sediment has occurred in the inner basins, but coastal sand transport has caused large sandbars to accumulate at the entrance of the marina trapping finer sediments behind them. This further reduces flushing in the marina and caused increased deposition of fine sediments. Since contaminants adhere to or complex with the finer grained sediments, the distribution of fines will, in large measure, affect the distribution of contaminants in the marina. The lack of substantial rainfall for several years further reduced flushing. Two major storms in the spring of 1991 may have flushed the marina but brought other sediments in to accumulate additional fine grained material and associated contaminants.

PROCEDURES

Sediment samples were taken at 15 stations on 17 October 1991 from the University of Southern California R.V *Golden West* by Campbell grab (modified Van Veen), which samples a 0.1 m^2 of surface. Budget cuts precluded performing a May 1992 survey for comparison. Aliquots of sediment samples were taken for determination of grain size, trace metals and nonmetallic contaminants, and pesticides and chlorinated hydrocarbons before screening for benthic fauna. Samples for chemical analysis were placed in clean plastic containers, frozen with dry ice on board and transported to Associated Laboratories in Orange, California where they were kept frozen until analyzed. Techniques used are those specified by the U.S. Environmental Protection Agency or Standard Methods (APHA, 1985).

GRAIN SIZE

Grain size is a relative measurement of sediment size determined by sieving sediments through a series of screens of graded mesh size. The larger the screen mesh number, the finer the sediments are that will pass through the screen, with the finest grain size determined as passing through a 200 mesh screen (<200). The size of sediment grains determines whether the benthos will consolidate and remain stable, or will be subject to disturbances and redistribution, whether chemicals will attach to particles in quantity, and what kinds of fauna will live in or on the substrate.

RESULTS: GRAIN SIZE

Comparison of the October 1991 results with those of October 1990 and May 1991 (Tables IV. 1-3) show that there were increases in the finest grained sediments, in May 1991 following spring storms at Stations 1, 3, 5, 7, 8, and 13; the increases were especially large at Stations 3, 8 and 13. Each station may be responding to combinations of different factors depending on the area drained into the marina.

Table IV.1. Percent Grain Size in Marina del Rey, 18 October 1990 (particle size decreases with increasing mesh size).

Mesh size / Station	25	35	60	100	200	<200
1	0.15	0.92	2.61	17.90	47.30	31.13
2	0.44	1.15	2.34	9.81	19.14	67.12
3	2.41	31.40	47.60	10.07	0.53	7.97
4	0.28	0.34	1.50	3.88	20.05	73.45
5	0.00	0.14	0.42	0.74	4.95	93.73
6	0.60	0.22	1.44	11.99	35.05	50.44
7	0.22	8.27	1.02	5.16	25.77	67.56
8	1.49	3.57	4.44	12.74	26.87	50.69
9	0.08	0.08	0.08	0.08	0.24	99.44
10	0.34	0.51	1.11	3.08	0.17	94.79
11	0.00	0.07	0.14	0.34	0.07	99.38
12	2.54	10.23	32.32	22.61	2.89	29.41
13	67.49	11.34	8.81	6.42	3.86	2.08
22	3.26	4.20	7.87	9.43	3.08	71.96
25	0.29	0.36	0.72	1.87	3.31	93.45

Table IV.2. Percent grain size in Marina del Rey, 16 May 1991 (particle size decreases with increasing mesh size).

Mesh size Station	25	35	60	100	200	<200
1	0.23	0.36	2.19	10.30	44.91	42.01
2	0.41	0.41	3.16	11.30	30.40	54.34
3	0.11	0.22	6.31	3.56	6.44	85.36
4	0.05	0.05	1.02	10.61	26.89	61.58
5	0.00	0.07	0.20	0.46	2.38	96.89
6	0.11	0.22	6.48	17.21	28.96	49.02
7	0.06	0.12	0.66	2.57	12.69	83.96
8	0.08	0.40	2.54	2.94	7.16	86.90
9	1.38	2.16	3.65	1.72	1.55	89.76
10	3.16	1.00	7.17	6.67	6.67	75.33
11	0.16	0.89	2.18	1.13	2.42	93.22
12	6.18	14.28	36.30	14.20	6.30	22.76
13	43.93	3.83	10.15	7.40	7.81	26.88
22	13.50	4.30	12.60	7.90	7.90	53.80
25	0.28	0.17	0.60	1.76	13.34	83.79

Table IV.3. Percent grain size in Marina del Rey, 17 October 1991 (particle size decreases with increasing mesh size).

Mesh size Station	25	5	60	100	200	<200
1	1.30	0.10	3.91	10.45	22.57	61.67
2	0.15	0.12	1.00	7.40	20.69	70.64
3	0.08	0.26	6.02	2.20	2.50	90.96
4	0.00	0.02	0.14	1.36	12.84	85.64
5	0.00	0.00	0.00	0.05	0.44	99.51
6	0.02	0.08	3.72	10.89	5.60	79.69
7	0.00	0.00	0.53	0.81	6.78	91.88
8	0.04	0.06	0.27	0.23	0.59	98.81
9	0.00	0.00	0.01	0.06	0.17	99.76
10	0.02	0.01	0.05	0.14	0.42	99.36
11	0.00	0.00	0.02	0.02	0.04	99.92
12	4.44	4.73	17.49	11.77	4.28	57.27
13	32.11	3.87	8.77	6.14	4.98	44.13
22	0.14	0.07	0.40	0.64	0.84	91.91
25	0.02	0.02	0.07	0.26	2.48	97.15

Dry weather runoff, drainage flow and extremes in tidal action carry sediment laden waters into the marina where low flushing causes fine sediments to settle out. This is illustrated by results from the October 1991 survey, which showed increases in the finest component (<200) at every station over the May 1991 levels. Large increases occurred in Ballona Creek and the entrance channel, at Stations 12, 1, 2, and 4, in Basin B, at station 6, and in Oxford Street basin at Stations 13 and 22.

There was a loss of larger grained sediments and sand (25 mesh screen size). In October 1990 the only stations lacking the largest grain sizes were Stations 5 and 11, which had no sand. In May 1991, only Station 5 had no sand, but fines accumulated during dry weather so that by October 1991, Stations 4, 5, 7, 9 and 11 had no sand, while Stations 5, 7, 9, and 11 had no slightly smaller particles (mesh size 5) and Station 5 had no mesh size 60 particles (Table IV.3). Station 5, in mid-main channel, appears to accumulate fines moving out of the basins nearby, as is also indicated by sulfide buildup there. The only station to show a slight increase in sand was Station 1, at the mouth of Ballona Creek.

CONCLUSIONS: GRAIN SIZE

The accumulation of fine sediments during and following a period of heavy rainfall is not surprising. The larger accumulation during dry weather is indicative of reduced flow volume and velocity in the flood control channels; increased deposition in the marina may be caused by the occlusion of the entrance of the marina. The siltation of Basin D is of concern because it represents a considerable change in that valuable habitat which may be associated with the destabilizing effects of loss of the seagrass bed.

SEDIMENT CONTAMINANTS

INTRODUCTION

Sources of contaminants in the marina have been reviewed extensively in earlier reports (e.g., Soule et al., 1992), and range from the minor spillage of oil and grease associated with vessel fueling and operation, to coastal oil spills, marina storm drain runoff, sewage leaks or overflows and drainage from the flood control channels. These channels are recipients of street runoff and illegal dumping of trash, particularly plastic containers, yard debris including Christmas trees, and contaminants such as used motor oil, paint and pesticides.

Oxford Street flood control basin seems to carry a heavier load of contaminants which is quite out of proportion to the relatively small volume of drainage that enters the marina from that source, as compared with the very large volume of water carried by Ballona Creek, especially during wet weather flow. Drainage from the Oxford Street basin will be increased by the Los Angeles County Flood Control District to ameliorate surface street flooding adjacent to the basin, which may wash more contaminants into the marina, or could help to flush it, depending on the sources of the present contamination. Terrestrial sediments in adjacent properties sometimes carry a heavy burden of contaminants due to earlier industrial use or unregulated dumping in the area.

Contaminated sediments tend to be carried through the tide gate opening at a greater velocity near Station 13 than is found at either Station 22 at the inner end of the Oxford Street basin, or at Station 10 at the end of the slips in Basin E. Additional docks constructed recently to serve restaurants at the inner end of the basin seem to have become occupied docks, further reducing the already very poor rate of flow in Basin E. Sediments accumulate under the docks and slip facilities where water velocities are lowest.

Ballona Creek drains a large section of the northwestern Los Angeles basin. Overflow of partially treated (screened) sewage into Ballona Creek during dry weather seems to have been controlled in the last few years by construction of holding tanks; however, such waters are released during storms to prevent overwhelming the Los Angeles

City Hyperion waste treatment plant facilities. Chlorination is performed as a public health measure, which is given paramount importance over considerations of habitat, but if residual chlorine remains in the waters after treatment, it can be harmful to marine organisms exposed to it, particularly to sensitive larval and juvenile stages.

RESULTS: METALS AND NONMETALLIC CONTAMINANTS

Reported in this section are results from samples at 15 stations analyzed for 20 metals and nonmetallic indicators of pollution; analyses for pesticides and chlorinated hydrocarbons are discussed in the subsequent section. As has been done in previous reports, stations were ranked from 1, the cleanest, to 15, the most contaminated, for the 20 parameters. Rankings were then added up to develop scores for each station. The highest possible score would be 300 under this system.

In Table IV.4, rankings for October 1990, May 1991 and October 1991 are compared (in Soule et al., 1992, a typographical error led to a slightly different ranking of a few stations; this has been corrected in the present table).

Of particular importance is the large increase in contamination at Station 8 in Basin D, near the marina beach. Its score has risen from 137 in October 1990 to 178 in May 1991 and to 205 in October 1991. Another large increase occurred at Station 3, which rose from 46, the lowest, to 178, medium high and dropped a small amount to 164 over the three surveys. These scores can be compared with the Ballona Creek scores of 108, 97 and 87 at Station 12 and the scores of 147, 64 and 55 at Station 1 at the mouth of the Creek, over the same periods. There was a decrease at Station 2, at the sandbar, from 150 in May to 96 in October 1991, perhaps due to extreme low tides, up to -1.5 ft, in June and July.

As is usual, the most contaminated were Stations 10 and 9, followed by either Station 11 or 25. The three inner marina stations, 9, 10, and 11, receive extensive drainage and have the poorest circulation. Station 25 is probably the busiest location in the marina, with the U.S Coast Guard, Los Angeles County Sheriff's Patrol and Lifeguard *Bay Watch* vessels operating there, the day excursion fishing vessels and dock fishing adjacent, and drainage from parking lots.

Table IV.4. Ranking of stations by sediment trace metals and contaminant scores.

Group	October 1990 Station	October 1990 Score	May 1991 Station	May 1991 Score	October 1991 Station	October 1991 Score
High	10	259	10	249	10	266
	9	243	9	232	9	217
	25	219	11	212	11	209
	11	217	25	203	8	205
	22	214				
Medium High	5	185	22	188	22	198
			3	178	5	196
			8	178	25	193
	1	147	5	168	3	164
	2	147	2	150		
Moderate	8	137	7	140	7	129
	7	128			4	125
	4	123				
	12	108	4	109	6	109
Medium Low	13	93	12	97	2	96
			13	93		
	6	84	6	95	12	87
			13	85		
Low	3	46	1	64	1	55

NONMETALLIC CONTAMINANTS

Distribution and concentrations of nonmetallic contaminants are illustrated in Figures IV.1-9, and the data are presented in Table IV.5. Table IV.6 gives ranges of contaminants from 1985 through 1991. In general, there were higher mean levels in these parameters in October 1991 than there were in October 1990, but the larger increases had occurred in the spring prior to the May 1991 survey after rainstorms, indicating that some dry weather decrease occurred. Exceptions were in percent Volatile Solids, Total Organic Carbon and Immediate Oxygen Demand, where means increased from May to October 1991.

<u>Percent Moisture</u>

Among the nonmetallic contaminants listed, percent moisture is indicative of the

Table IV.5. Non-metallic sediment contaminants and trace metals, 17 October 1991

Station Parameter*	1	2	3	4	5	6	7	8
Moisture %	27.82	37.25	43.99	40.40	52.16	42.90	42.43	62.70
Vol. Solid %	5.83	5.39	6.76	5.27	8.82	3.78	4.46	8.20
TOC %	2.33	2.16	2.70	2.11	3.53	1.51	1.78	3.30
BOD	44	108	137	86	188	130	96	367
COD	17100	54400	74300	46700	56400	31100	33700	68600
Oil & Grease	1510	2870	3850	1180	1500	1080	1160	3900
PO_4	ND<1	ND<1	ND<1	1.70	ND<1	43.50	1.80	2.90
Org. N	382	1010	1400	1020	1350	797	870	1800
Sulfide	0.65	3.38	ND<0.1	ND<0.1	6.33	5.36	4.52	0.54
Arsenic	2.22	2.40	4.75	5.51	4.42	4.06	4.62	4.19
Cadmium	0.50	0.83	1.50	0.45	0.86	0.47	0.47	0.99
Chromium	14.30	22.50	46.80	33.60	51.20	24.28	32.50	50.90
Copper	13.80	33.50	100.30	89.80	203.60	168	143	410
Iron	8270	12270	30500	24200	44900	15100	29100	55200
Lead	64	107	146	115	129	62.20	69.50	113
Manganese	86.30	130	178	151	238	114	193	225
Mercury	ND<0.11	ND<0.13	0.27	0.18	0.46	0.63	0.33	0.96
Nickel	8.02	15.67	22.80	16.80	26.50	13.20	18.80	27.60
Tributyltin	ND<0.02	ND<0.02	ND<0.05	0.04	0.09	ND<0.06	ND<0.06	ND 0.18
Zinc	55.80	131	255	173	228	141	162	330

* in mg/kg dry wt. (ppm) unless otherwise indicated
ND< = less than limits of detection

Table IV.5. cont.

Station Parameter*	9	10	11	12	13	22	25	Mean
Moisture %	62.79	65.52	60.46	28.18	22.42	70.03	50.32	47.29
Vol. Solid %	9.71	9.95	8.34	3.05	2.22	16.12	8.14	7.07
TOC %	3.08	3.98	3.34	1.22	0.88	6.45	3.25	2.77
IOD	363	557	281	76	26	257	254	198
COD	65100	91100	54100	31300	15500	188300	70800	59900
Oil & Grease	2110	4740	1650	1900	1410	8700	2000	2637
PO_4	ND<1	10.20	2.80	ND<1	ND<1	ND<1	ND<1	11.15
Org.N	1750	2210	1570	576	334	4910	1870	1456
Sulfide	1.18	1.91	0.61	0.46	ND<0.1	1.23	0.58	2.23
Arsenic	4.41	3.94	3.93	3.42	3.87	2.49	4.92	3.96
Cadmium	ND<0.67	1.10	ND<0.63	1.06	0.92	3.00	0.85	1.08
Chromium	57.20	56.80	57.90	20.50	12.50	43.00	32.50	38.43
Copper	338	455	319	25.98	127	194	187	187.49
Iron	60200	58600	63200	10300	20100	14600	61300	32683
Lead	146	205	114	161	176	487	161	151.50
Manganese	265	230	263	139	143	121	223	178
Mercury	0.72	0.87	0.66	ND<0.10	ND<0.09	ND<0.23	0.16	0.52
Nickel	32.00	31.30	29.30	10.90	8.98	25.20	26.20	28.88
Tributyltin	0.23	0.28	0.53	ND<0.03	ND<0.03	ND<0.07	0.11	0.21
Zinc	312	464	298	139	240	634	298	259

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Table IV.6. Ranges of contaminants and trace metal levels in sediments and highest stations by years (station 13 data added in 1987; station 22 data added in 1989)

Parameter*	Oct 85		Feb 87		Oct 87		Oct 88	
Vol. solid %	1.69-16.84	1,2	1.07-7.87	1,2	3.6-9.7	10,13	0.88-7.19	11,9
IOD	75-850	10,11	ND<1-220	10,11	63-315	10,11	18-330	10,9
TOC	1.01-10.10	1,2	0.6-4.7	1,2	2.1-5.6	10,13	0.51-4.17	11,9
COD (1000s)	3.4-194.6	1,2	3.75-131.5	1,2	25.3-96.8	2,10	8.3-87.6	10,9
Oil & Grease (1000s)	0.10-16.9	1,2	1.00-20.7	1,2	0.80-2.8	2,3	0.50-3.5	11,8,9
PO_4	12600-47700	5,9	6200-45000	9,10	1900-5300	6,5	ND<1-3100	9,4
Org-N	650-5900	1,10	216-3900	1,10	1200-3000	10,13	135-1840	10,8
Sulfide	0.09-16.9	1,9	0.3-8.9	1,9	0.5-4.7	3,1	0.2-12.1	2,13
Arsenic	NA		NA		3.3-9.6	6,10	1.86-12.0	10,9
Cadmium	ND<1.0	ND	ND<1.0-5.8	11,1	ND<1.0-34	13	0.19-1.10	10,4
Chromium	5.9-72	11,10	6.5-70.4	9,11	27.9-89.1	12,5	7.2-70.5	10,11
Copper	11.8-245.6	10,11	10.3-359	10,9	34.8-383.0	10,8	6.0-342	10,8
Iron (1000s)	15.15-45.6	11,10	4.0-49.5	11,9	12.5-40.9	11,10	4.2-50.1	10,11
Lead	10.1-376.6	10,9	11.0-537	1,12	6.0-563	13,10	25.4-206	10,9
Manganese	NA	NA	46-285	11,9,1	110-340	13,12,5	34.0-276	11,5,10
Mercury	0.09-1.26	10,9	ND<0.1-1.47	9,10	ND<0.1-1.18	10,6	0.11-1.70	11,9
Nickel	ND<1.0-39.3	10,9	4.4-41.6	11,9	14.6-59.6	12,10	4.0-37.4	10,11
TBT	NA		NA		ND<80-1070	6,10	ND<.01-5.57	11,10
Zinc	42-490.4	1,10	25-460	1,10	76-587	13,18	42.6-435	10,8

IOD = Immediate Oxygen Demand; TOC = Total Organic Carbon; COD = Chemical Oxygen Demand
* in mg/kg dry wt. unless otherwise indicated; ND< = below limits of detection; NA = not analyzed

[1] Station 25 added in 1989. [2] Station 22 added in 1990.

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Table VI.6. cont.

Parameter*	Oct 89[1]		Oct 90[2]		May 91		Oct 91	
Vol. solids %	0.84-13.91	12,2,10	1.3-11.78	22,10,11	2.96-11.45	13,10,3	8.22-16.12	22,2,3,4
ICD	12-461	12,2,10	12-374	11,10,25	15-432	10,9,11	86-557	10,8,9
TOC	0.28-8.07	12,2,10,11	0.52-4.71	22,10,11	1.18-4.58	13,10,2	0.88-6.45	22,10,5
COD (1000s)	2.44-215.6	12,2,10	6.77-153.1	22,10,25	3.44-120	2,13,10	19.5-188.3	22,10,3
Oil & Grease (1000s)	8.8 [illegible]1.09	12,2,10	0.36-4.86	22,2,1	1.28-7.3	2,10,3	1.08-8.7	22,10,8,4
PO_4	1900-11600	9,5,11	1.51-179	22,11,9	3.24-101.1	12,9	ND<1-43.50	6,10,7
Org N	380-4770	12,2.10	235-4125	22,25,10	1060-3125	13,2,10	534-4910	22,10,25
Sulfide	0.7-40.7	12,9,2	<0.2-3.22	1,22.3	0.13-14.44	7,4,25	ND<1-6.33	5,6,7
Arsenic	1.13-10.8	11,10	2.99-13.80	10,9,11	2.62-10.54	11,9,5	8.22-5.51	4,25,3
Cadmium	ND<.26-2.12	13,12,2,10	0.32-2.13	22,10,25	0.43-5.54	13,3,2	ND<0.63-3.00	22,3,10
Chromium	11.4-65.2	11,12,10	6.78-69.80	9,11,10	14.5-67.8	9,11,5	18.50-57.90	11,9,10,25
Copper	8.19-333	10,9	10.4-399	10,9,11	22.6-348	10,8,9	13.80-418	8,10,9
Iron (1000s)	3.29-47.1	11,10	3.84-71.5	7,9,11	14.4-62.8	11,9,10	8.27-63.2	11,9,10,8
Lead	17.0-305	13,2,10	7.95-325	12,10,22	41.3-575	13,10,12	62.20-487	22,10,13
Manganese	27.5-283	11,9,5,10	30.30-273	9,11,5,10	147-315	11,9,5,8	86.30-263	11,9,5
Mercury	ND<0.15-0.65	8,9	ND<0.10-1.80	9,1,10	ND<0.07-1.2	8,9,10	ND<0.09-0.94	8,10,9
Nickel	3.88-36.4	11,10	4.18-41.20	10,9,11	12-43.2	13,9,11	8.02-32.00	9,18
TBT	ND<0.1-0.4	10,7	ND<0.03-0.52	10,25,9	ND<0.03-0.44	3,10,5	ND<0.02-0.53	11,18,9
Zinc	20.3-444	10,13,2	28-491	22,10,9	102-640	13,10,8	55.80-624	22,10,8,9

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amount of moisture retained by sediment samples and roughly indicative of the texture of the sediment. The finer the grain size and sometimes the greater the amount of organic material, the more moisture will usually be retained. Sieved grain size is a much more accurate determination of the sediment sizes present, as can be seen by comparing data in Tables IV.1-3.

Percent Volatile Solids

Percent Volatile Solids (VS%) is a measure of the amount of carbonaceous material in sediments that can be driven off by combustion in a furnace. The mean and maximum amount of volatile solids increased in October 1991 over those of recent years except 1985, as is indicated in Table IV.6. The highest value, 16.84 ppm, occurred in October 1985 at the Ballona Creek mouth, Station 1, and was almost equaled by 16.12 ppm at Station 22 in October 1991 after several years of lower peaks. Ranges were lower in 1977 and 1978 (Soule and Oguri, 1988).

Percent Total Organic Carbon

Percent Total Organic Carbon (TOC%) is a more advanced measure of the amount of material derived from plant and animal sources. Total organic carbon increased, as did VS%, in October 1991, although levels were higher in 1985 and 1989. The peak value of 10.10 ppm was at Station 1 in October 1985, higher than the 1977-1978 levels.

Oxygen Demand

Immediate Oxygen Demand (IOD) (in mg/kg) is related to the amount of oxygen utilized during exposure of a sample to an oxidizing agent for a limited time, usually 15 minutes; it is a measure of inorganic and organic content, as is Chemical Oxygen Demand (COD). The latter is measured over a longer time, usually two hours in the presence of a strong oxidizer, usually potassium dichromate in sulfuric acid. These measures give a relative value of the amount of oxygen removed from the water column by bacterial action and/or chemical reaction upon exposure of the sediments to oxidation by resuspension, or from changes in chemistry due to transition from a freshwater to seawater environment. Sediments are low in oxygen, or without it (anoxic) below the surface of the benthos. This measure is a very important factor in dredging because resuspension of anoxic sediments in the water column can cause removal of dissolved oxygen, depleting the amount available for fish and other organisms. IOD and COD are also related to Biochemical Demand (BOD) in the water column, discussed in Chapter II.

The IOD levels in the marina have decreased by an order of magnitude since the 1977-1978 surveys. This probably has improved the oxygen levels under stressed conditions such as summer temperature maxima. The peak IODs were 5,010 ppm in March 1977 at Station 5 and 4,590 ppm at Station 8 in March 1978. Although the peaks increased between 1990-1991, the increase was from 374 to 557 ppm, well below the earlier maxima (Soule and Oguri, 1980,1988).

The COD maximum peaked in 1989 at Station 12, but the 1991 maximum value was the second highest since 1985. This occurred at Station 22, which has been highest in COD, TVS and TOC since measurements were begun there in 1990. Such a result is not unexpected since a large amount of organic debris is usually present in Oxford Street basin. Station 10, which receives flow from that basin, was highest in IOD and second highest in TOC and COD. The mean COD increased from 57,010 ppm in October 1990 to 67,100 ppm in May 1991, concomitant with a large increase at Station 3, indicative of the influx and deposition of sediments there. The mean decreased to 59,900 ppm in October 1991, in spite of the extreme value of 188,300 ppm at Station 22. Station 8 showed an increase from 34,130 ppm in October 1990 to 60,500 ppm in May 1991 and to 68,600 ppm in October 1991. This may have been related to the demise of the seagrass bed there, although other, oxygen demanding parameters such as oil and grease have changed as well.

Oil and Grease

The range in oil and grease levels was slightly higher in October 1991 than those of the previous two years (Table IV.6), with a range of 1,080 ppm to 8,700 ppm; however the maxima were higher in 1985, 1987 and 1989, years in which Station 22 was not included. In October 1991, Stations 22 and 10 had the highest levels, followed by Stations 8 and 4. The mean for the marina was higher than the October 1990 mean but decreased from the May 1991 level (Soule et al., 1992). The variations from year to year suggest that oil and grease levels have not changed appreciably since the 1970s. Some oil may occur in the marina because natural oil seeps were a part of the bay and wetlands areas prior to construction of the marina, and may still be active enough to cause some emissions.

Phosphate

Phosphate is found on the natural environment as orthophosphate (PO_4) in sediments, in water and in organic compounds of all living organisms. Phosphate contamination increased above the 1970s levels in the surveys from October 1984 to February 1987 but since then it has decreased by three orders of magnitude presumably due to the decrease or removal of phosphate in detergents. It is commonly introduced into receiving waters from treated or untreated sewage effluent, from fertilizer in runoff and from decay of organic matter. The range in October 1991 was the lowest it has been, at <1-43.50 ppm, perhaps reflecting the control of sewage overflows up Ballona Creek. The reason for the maximum to appear in Basin B, Station 6, is unclear since it is not usually one of the heavily contaminated sites.

Organic Nitrogen

Organic nitrogen (Org-N) levels ranged from 334 to 4,910 ppm in October 1991, a range similar to that in 1989 but lower than that in 1985 (Table IV.6). In contrast to levels on October 1990 and May 1991, levels were much lower at Stations 12, 1, and 13 (Table IV.5) in October 1991 after the dry season. Mean Org-N was higher than it was in October 1990 but lower than the high May 1991 value (Soule et al., 1992). Org-N maximum values have exceeded those of the 1977-1978 period throughout all 1980s and 1990s surveys.

Sulfide

Sulfide is a measure of the breakdown of organic matter, characterized by the odor of rotten eggs due to release of hydrogen sulfide gas, and is an indicator of anoxic sediments. As reported by Soule et al., (1992) sulfide was below the limits of detection at Stations 4, 5, 6, 7, 8, and 9 in October 1990 before the spring rainstorms, but levels were among the highest in May 1991 at Stations 4-8 and 11 after the rains. In October 1991, levels had dropped throughout the marina, but Stations 5, 6 and 7 retained sulfide levels only a little lower than those found in May. This may be part of the reason why the benthic populations have been poor at those stations, and fish almost nonexistent at Station 5. Apparently material flushed from the basins is accumulating in mid-channel under anoxic conditions rather than being carried out to sea. However, the peak sulfide level was two to three orders of magnitude lower in the 1990s than in 1977.

TRACE METAL CONTAMINATION

The data for trace metal contamination in October 1991 for all stations is presented in Table IV.5, and the distribution of the various metals is illustrated in Figures IV.10 through IV.20. In Table IV.6, ranges of metal contamination are compared from 1985 through 1991. With a few exceptions, there were increases in the mean value of metals from October 1990 to May 1991, following the rainy season; October 1991 mean levels were higher than in October 1990 but lower than those in May 1991, indicative of some dry weather flushing.

The National Oceanographic and Atmospheric Administration (NOAA) examined published literature and unpublished data on toxicity of trace metals (Long and Morgan, 1990), developing a system of evaluating toxicity based on background levels, sediment-water equilibrium partitioning, spiked sediment bioassays, and the co-occurrence of fauna and contaminants in the field. They developed ranges of toxicity as follows: From threshold to the tenth percentile of effects is called the Effects Range-Low (ER-L), followed by the Effects Range-Medium (ER-M) and an Apparent Effects Threshold (AET). NOAA is currently updating these ranges with a much enlarged data base, but the ranges are not changing appreciably as a result of the new data according to E.R. Long (pers. comm.)

Table IV.7 tabulates the published NOAA ranges and also those developed by the National Research Council (NRC, 1989), based on data from EPA, the U.S. Geological Survey and other sources. The ranges in marina trace metal values are compared with these criteria.

Arsenic

The maximum for arsenic decreased from 13.80 ppm in October 1990 to 10.54 ppm in May 1991 and to 5.51 ppm in October 1991, rather than showing an increase in the May maximum as did other parameters. The mean for the marina decreased from 8.00 ppm to 3.96 ppm during that period (Soule et al., 1992), which may be considered a beneficial trend, although arsenic levels have not approached the ER-L value of 33 ppm since surveys began in 1977. Most values may in fact be below background levels in the Southern California Bight which were estimated by Mearns et al (1991) to be about 10 ppm.

Cadmium

Cadmium is widely used in electroplating, paint pigments, plastics and batteries. Point source control and waste treatment have reduced emissions to local waters. In the bight, the background level is estimated to be 0.4 ppm (Mearns et al., 1991). Cadmium was marginally lower in the 1970s, but the highest value recorded of 34 ppm in October 1987 at Station 13 represents by far the highest, and probably was the result of illegal dumping or erosion of contaminated terrestrial sediment (Station 22 was not being sampled at that time). The ER-L of 5.0 ppm was not reached at any station in October 1991; the range was from below the limits of detection to 3.00 ppm, with a mean of 1.00 ppm. The highest value of 3.00 ppm was found at Station 22 in Oxford Street basin, indicating terrestrial input.

Chromium

While chromium is a common component in the earth's crust, its use in metal finishing and many industrial processes has introduced it into urban effluents and runoff. Minute quantities of chromium are necessary to form certain enzymes in some invertebrates and in mammalian physiology and as oxygen carrying blood pigments. The background

Table IV.7. Concentrations of metals in sediments producing biological effects compared with levels in Marina del Rey in October 1990, May 1991 and October 1991.*

Parameter	ER-L	ER-M	AET	NRC	MDR Range	Stations Equal/Exceeding ER-L	ER-M	AET
Arsenic	33	85	50	33				
Oct 90					2.99 - 13.80	—	—	—
May 91					2.62 - 10.54	—	—	—
Oct 91					2.22 - 5.51	—	—	—
Cadmium	5	9	5	31				
Oct 90					0.32 - 2.13	—	—	—
May 91					0.43 - 5.54	13	—	13
Oct 91					<0.63 - 3.00	—	—	—
Chromium	80	145	–	–				
Oct 90					6.78 - 69.80	—	—	—
May 91					16.50 - 67.80	—	—	—
Oct 91					12.50 - 57.90	—	—	—
Copper	70	310	300	136				
Oct 90					10.40 - 399	all but 12,1,2,3,4,13	10	10
May 91					22.60 - 348	all but 12,1,2,22	8,10 —	8,10 —
Oct 91					13.80 - 410	all but 12,1,2	— 8,9,10,11	— 8,9,10,11
Lead	35	110	300	132				
Oct 90					7.95 - 325	all but 2,3,13	12,25,6, 9,10,22	12
May 91					41.30 - 575	all stations	all but 1,4,6,7,22	13
Oct 91					62.20 - 487	all stations	all but 1,2,6,7	22 —
Mercury	0.15	1.0	1.0	0.8				
Oct 90					<.12 - 1.08	all but 12,2,3	9	9
May 91					<.07 - 1.20	all but 12,3,22	8	8
Oct 91					<0.09 - 0.94	all but 1,2,12,13	—	—
Nickel	30	50	NSD	20				
Oct 90					4.18 - 41.2	25,5,9,10,11	—	—
May 91					12.00 - 43.2	5,8,9,10,11,13	—	—
Oct 91					8.02 - 32.0	9,10	—	—
Zinc	120	270	260	760				
Oct 90					28.00 - 491	all but 3,6	25,9,10, 11,22	25,9,10, 11,22
May 91					102 - 640	all but 22	25,8,9, 10,11,13	25,8,9, 10,11,13
Oct 91					55.80 - 624	all but 1	8,9,10,11, 22,25	8,9,10,11 22,25

* Units are in Effects Range-Low (ER-L), Effects Range-Medium (ER-M), Apparent Effects Threshold (AET) (Long and Morgan, 1990 for NOAA) and National Research Council (NRC) EPA Threshold Toxic Levels. In ppm. (NSD = Not sufficient data).

level in the bight is estimated at 5 to 40 ppm by Mearns et al. (1991). The mean chromium value in the marina was 38.43 ppm in October 1991, very similar to the 38.35 ppm in October 1990 but lower than the 46.76 ppm of May 1991. The maximum values declined from 129 ppm in March 1977 to level off at about 70 ppm until the decline in October 1991 to 57.90 ppm. This is an encouraging trend.

Copper

Copper is another trace metal necessary to living organisms in minute amounts. It is bioaccumulated by some molluscs and crustaceans but is not bioamplified in the food chain. Copper is toxic in larger trace quantities, particularly to invertebrate larvae, and is one of the oldest substances used in antifouling compounds. Concentrations in coastal sediments depend on depth and sediment grain size, and the coastal background level is about 10 ppm (Mearns et al., 1991). The mean copper level increased from 145.29 ppm in October 1990 to 169.85 ppm in May 1991 and to 187.49 ppm in October 1991, the highest mean of all the 1984-1991 surveys; the highest maximum was in October 1991 at 410 ppm at Station 8. All stations except Stations 12, 1, and 2 exceeded the ER-L and Stations 8, 9, 10, and 11 exceed the ER-M and AET. The increase in copper might be due to increased use in antifouling paint because of the ban on tributyltin (TBT).

Iron

There is no ER-L or ER-M for iron in marine sediments and no data base indicating toxicity. In micro amounts it is essential to living organisms. Levels in the marina increased to a peak of 71,500 ppm at Station 7 in 1990 and decreased to 63,200 at Station 11 in October 1991, but this is higher than any other peak values.

Lead

Lead is of serious concern in urban areas where it is a prominent airborne pollutant. It is not required in trace quantities by organisms and causes acute and chronic illnesses, either from inhalation or ingestion. Lead concentrations in non-urban coastal areas range from 2.4 to 29 ppm whereas median levels in bays and harbors have ranged from 8 to 994 ppm (Mearns et al., 1991). Marina del Rey has some of the highest levels, exceeded only by the area of the Newport Bay shipyards.

The minimum level of lead increased from 7.95 ppm in October 1990 to 41.3 ppm in May 1991 and to 62.2 ppm in October 1991. In the same period the maximum rose from 325 ppm to 575 ppm after the rains, and decreased to 487 ppm during dry weather. By far the largest quantity was in the Oxford Street basin, at Stations 22, 13, and at Station 10 in the marina, which indicates the terrestrial source for high lead levels. The highest mean level, 169 ppm, was in 1985 and the lowest in 1988 with 99.98 ppm, before Station 22 was added in 1990. The mean in May 1991 was 168 ppm after the rains, decreasing to 151.58 in October 1991, and the mean for all periods, 1984-1991 is 144.67 ppm.

All stations exceeded the ER-L of 35 ppm, and all stations except Stations 1, 2, 6 and 7 exceeded the ER-M of 110 ppm, but only Station 22 exceeded the AET of 300 ppm. In spite of the drop in lead use in gasoline in the 1980s, the lowest maximum was in October 1988 and the maxima have increased since then, exceeding 1977-1978 maxima. The range of variation, however, may be so great that the general level is stable. The extremes in maxima were 88.8 and 359 ppm in 1977-1978.

<u>Manganese</u>

There are no ER-l and ER-M values for manganese, and it is not considered to be a problem as a contaminant. Manganese, like iron, is essential to living organisms in micro quantities. The peak value of 340 ppm was found at Station 13 in October 1987, but the peak values seem generally to lie in a range of 260 to 285 ppm while the minimum had been quite varied.

<u>Mercury</u>

Mercury is a common trace element in the earth's crust, and has been extensively mined in California. The background level is estimated to be 0.05 ppm (Mearns et al,. 1991). Mercury is extremely toxic in the methylmercury form, but formation of

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methylmercury is dependent on a number of factors, including temperature, and the presence of organic compounds, sulfide and fresh water.

The range in October 1991 was from below the limits of detection (<0.09) to 0.94 ppm, with the maximum being lower than it has been since 1977. Levels at all stations except Stations 12, 1, 2, and 13 were above the ER-L of 0.15 ppm, but none were above the ER-M of 1.0 ppm. This can, however, be considered a positive trend.

Nickel

The principal sources of nickel in marine sediments are from steel alloys and plating works, although nickel is a natural element in the environment. The range in the marina for October 1991 was 8.02 to 32.0 ppm; this was the highest minimum since October 1987 but the lowest maximum of all the surveys performed. The peak nickel value was 145 ppm in March 1978. The ER-L is 30 ppm, which was slightly exceeded only at Stations 9 and 10, and did not approach the ER-M of 50 ppm. This is also a positive trend for improvement.

Tin

Toxicity of tin and organotins, especially tributyltin (TBT) in water has been well documented, being toxic in parts per trillion concentrations to larvae of some molluscan species (reviewed in Soule and Oguri, 1988). Long and Morgan did not establish an ER-L or ER-M for TBT in sediments because of inadequacy of the data base, including lack of standardized methods of analysis which make comparisons difficult. There is at present no documentation of toxicity in sediments. Bioassays of seawater spiked with TBT indicated that concentrations of TBT in sea water were toxic at much lower levels than normally at much higher concentrations.

The range concentrations in sediments have ranged from below the limits of detection to a peak of 1,070 ppm in October 1987, declining to a peak of 5.57 ppm in October 1988 and thereafter being between 0.4 and 0.53 ppm.

Zinc

Zinc is an essential element in trace quantities and is ubiquitous in the natural environment. Zinc enters the marine environment as airborne particulates, in runoff, or in municipal effluents. Levels at all except Station 1 exceeded the ER-L of 120 in October 1991, and six stations exceeded the ER-M and AET (Table IV.7). Peak levels have varied between about 400 ppm to 660 ppm, with the highest occurring in October 1987; in October 1991 the peak was 491 ppm, rising to 640 ppm in May 1991 and dropping slightly to 624 ppm in October 1991. Mean levels of zinc have varied from 267.92 ppm in October 1984 down to 206.25 ppm in October 1988, rising to 279 ppm in May 1991, following the rains, and declining to 259 ppm by October 1991. The mean f all surveys in 1984-1991 is 248.88 ppm.

CONCLUSIONS: NONMETALLIC CONTAMINANTS AND TRACE METALS

Of the non-metallic contaminants, there has been improvement in Immediate Oxygen Demand, phosphate, and sulfide in the marina, while volatile solids, Chemical Oxygen Demand, and Organic-Nitrogen have worsened somewhat.

Among the trace metals, levels of arsenic, cadmium and chromium have not been a problem, remaining below the ER-L levels in all surveys and have shown declines in the most recent surveys. The maxima for tin as tributyltin have declined dramatically, by more than three orders of magnitude since October 1987. Levels of nickel have declined to where only Stations 9 and 10 exceed the ER-L slightly. Contamination with copper, lead and zinc has fluctuated over a considerable range during the 1984-1991 surveys, but we conclude that zinc and lead have not changed appreciably except following large rainfall periods. The lowest means for the series for lead and zinc were in October 1988, while the lowest mean for copper was in October 1985. The mean for copper increased in May 1991 after the rains but continued to increase in the dry season to the highest mean of the series. This suggests that copper may have increased both from rainfall runoff and/or from increased antifouling use in the marina. The low frequency of sampling and number of samples precludes more precise indication of sources and trends. Copper, lead and zinc are substances that must be controlled to improve conditions in the marina benthos.

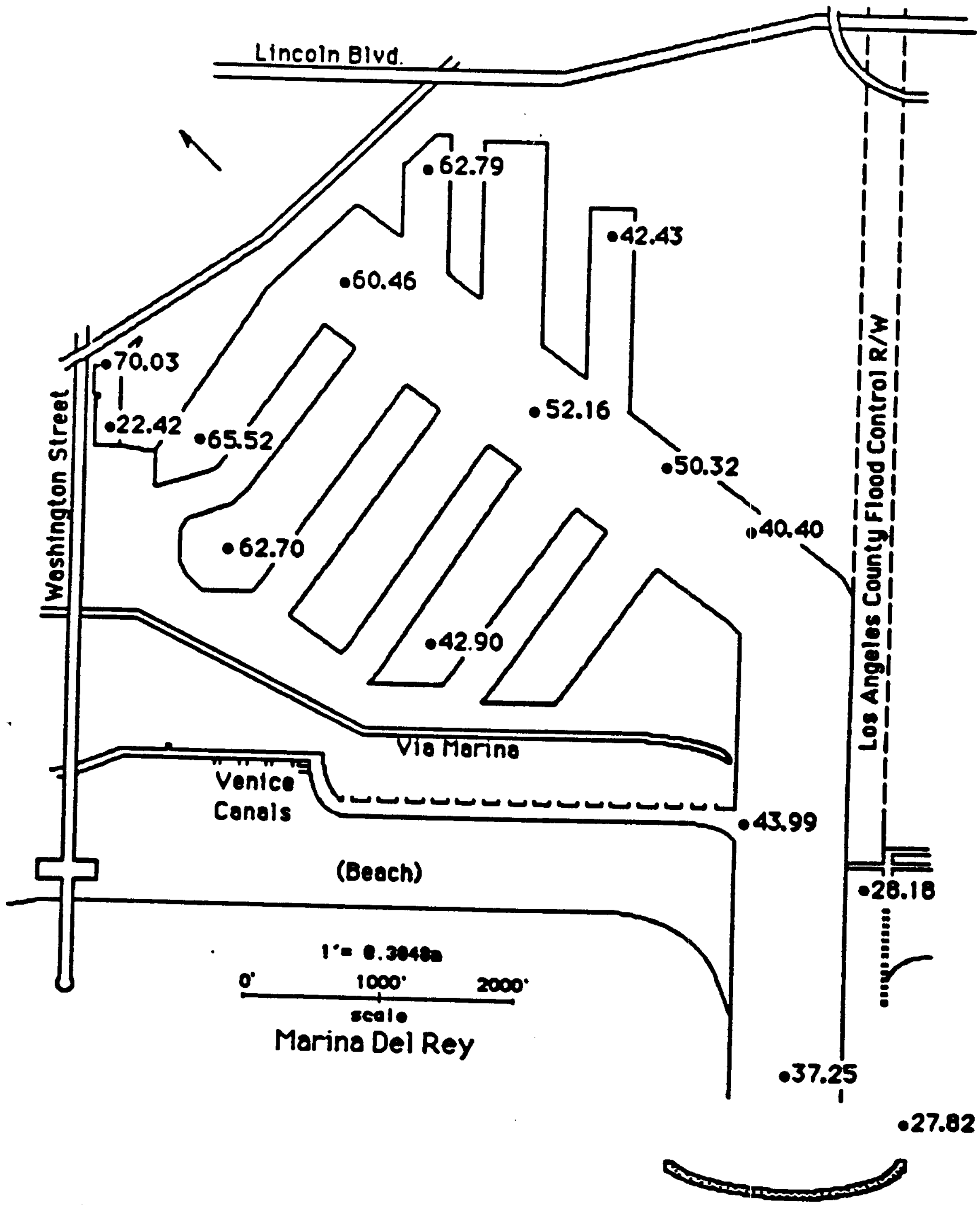

Figure IV.1. Percent Moisture in sediments. October 1991

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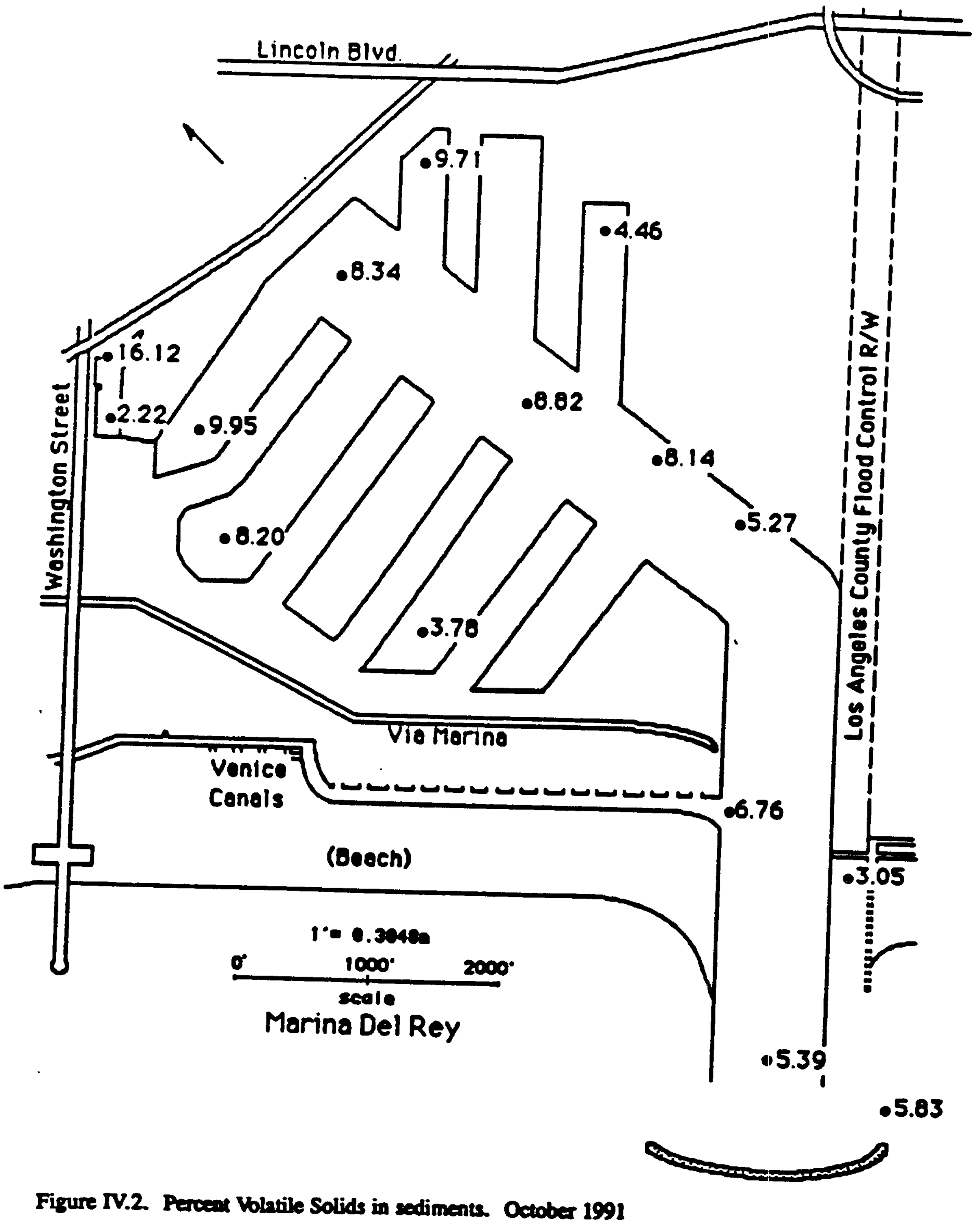

Figure IV.2. Percent Volatile Solids in sediments. October 1991

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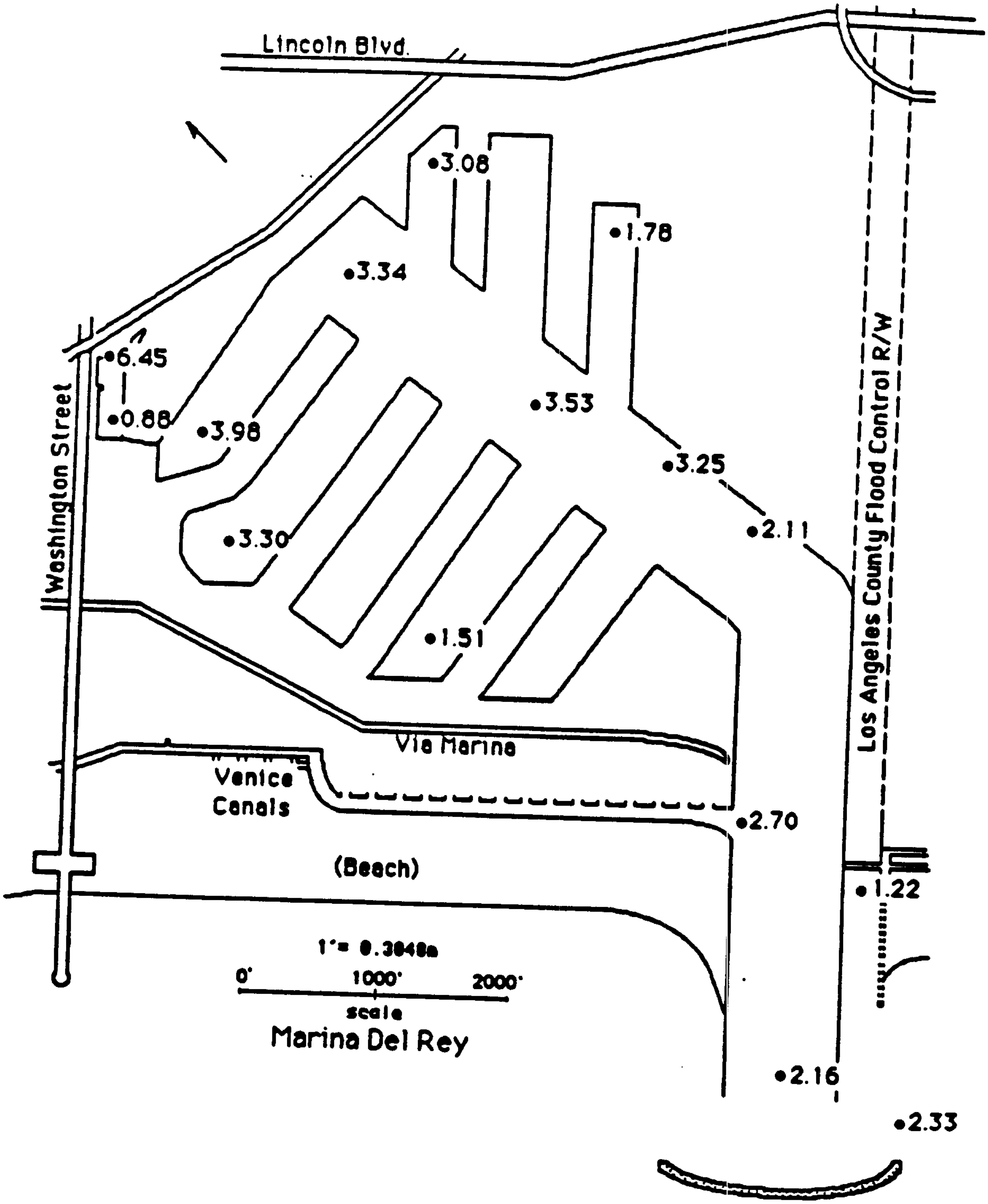

Figure IV.3. Percent Total Organic Carbon in sediments. October 1991.

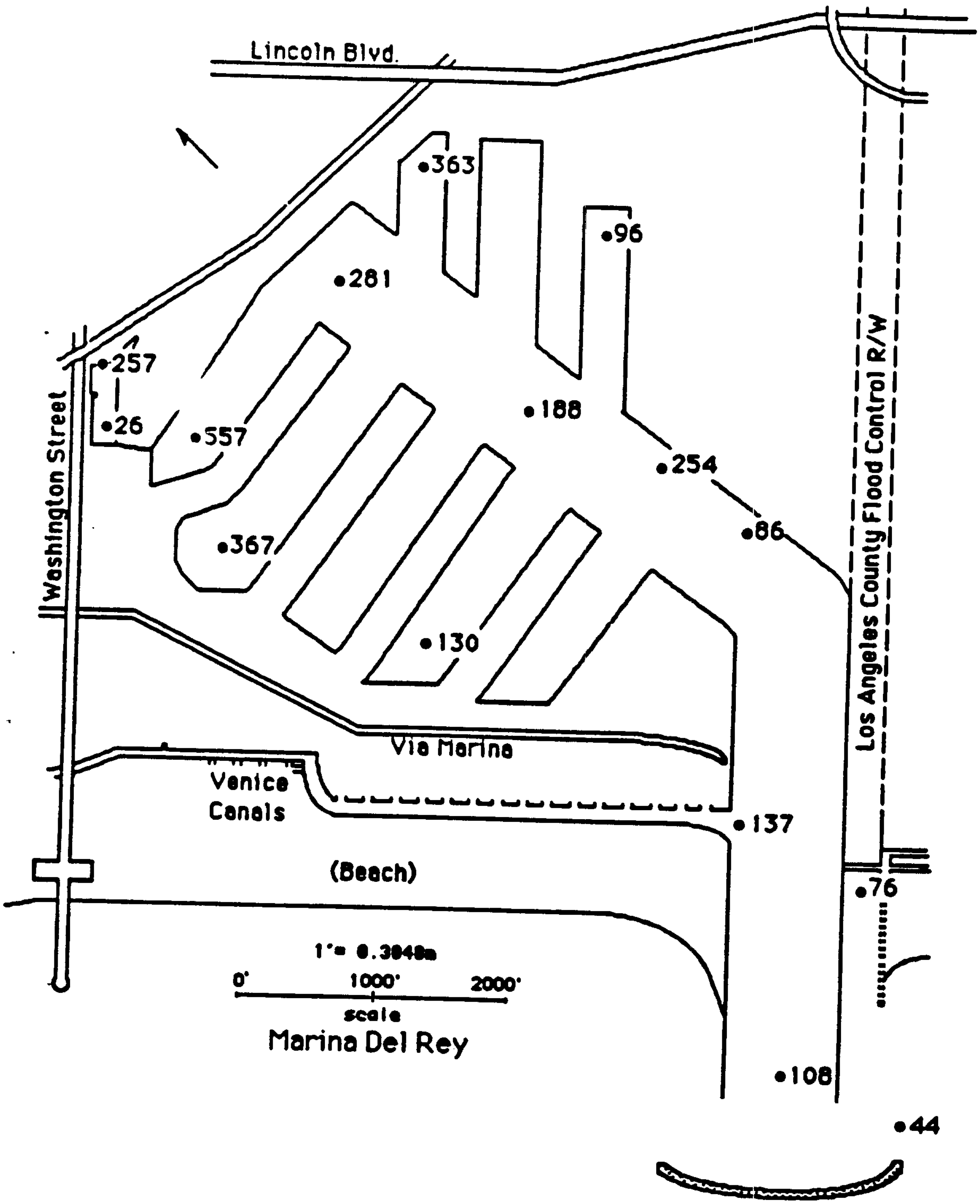

Figure IV.4. Immediate Oxygen Demand in mg/kg dry wt (ppm) in sediment October 1991.

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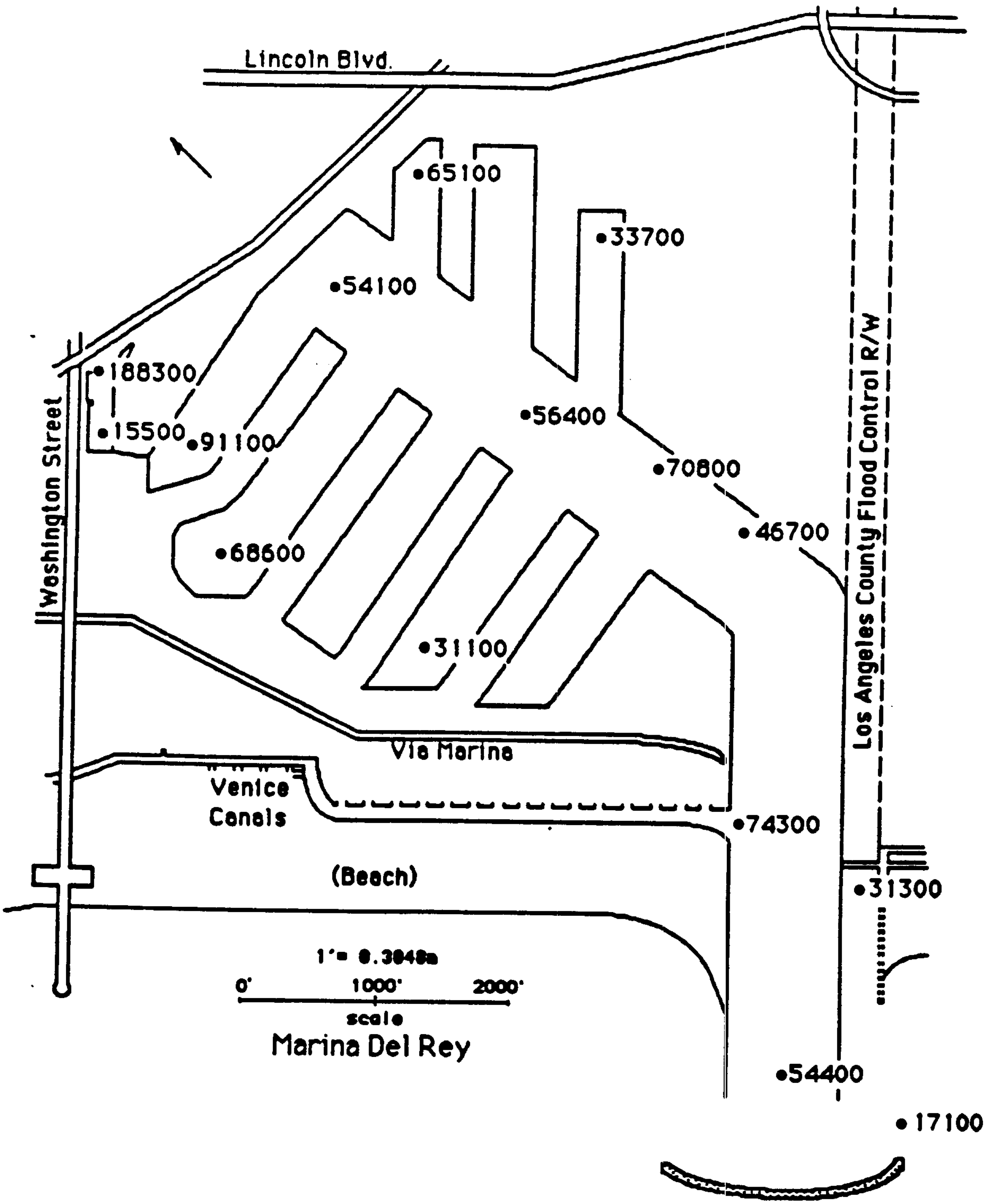

Figure IV.5. Chemical Oxygen Demand in mg/kg dry wt (ppm) in sediment. October 1991.

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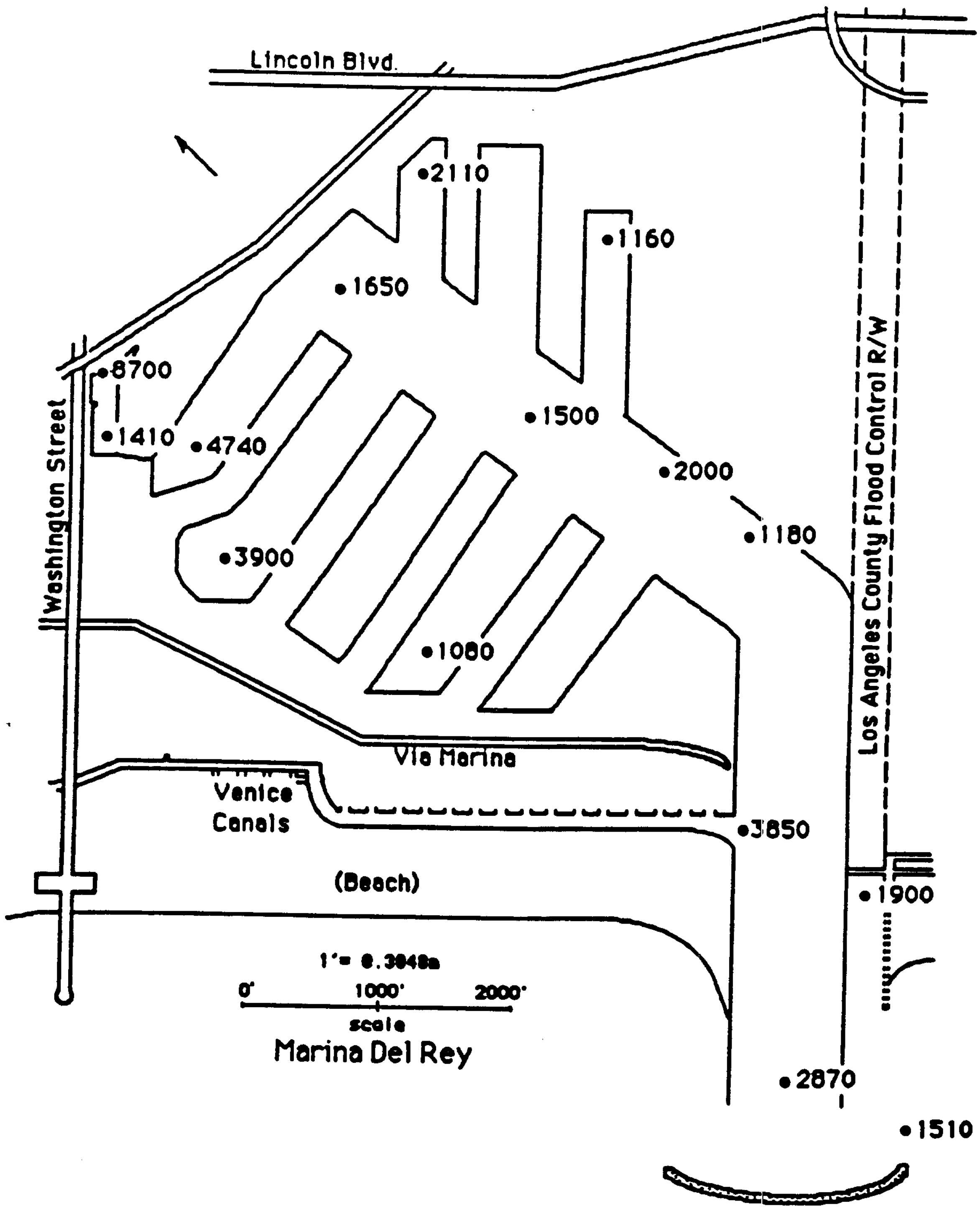

Figure IV.6. Oil and grease in mg/kg dry wt (ppm) in sediment. October 1991

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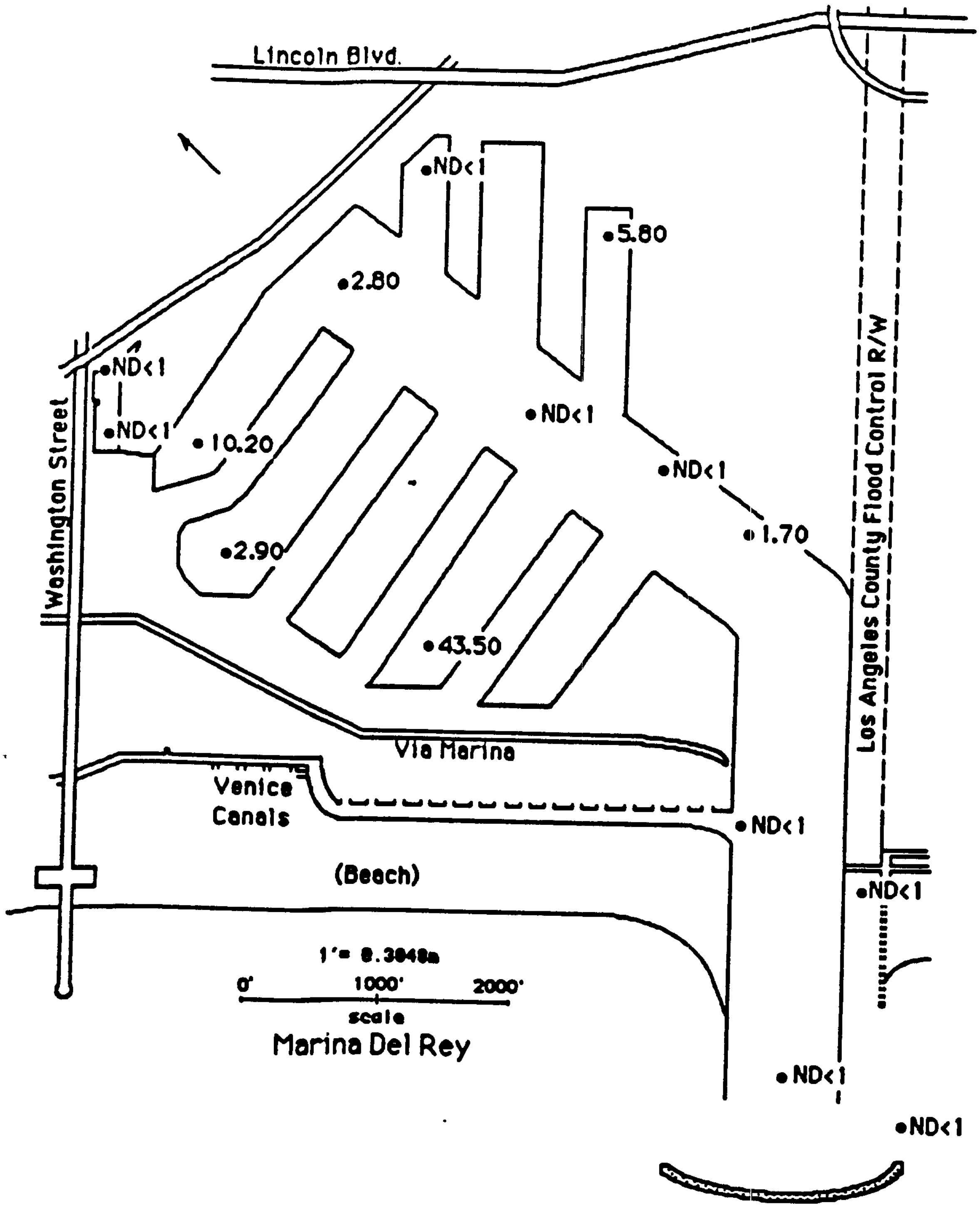

Figure IV.7. Total Phosphorus in mg/kg dry wt (ppm) in sediment. October 1991.

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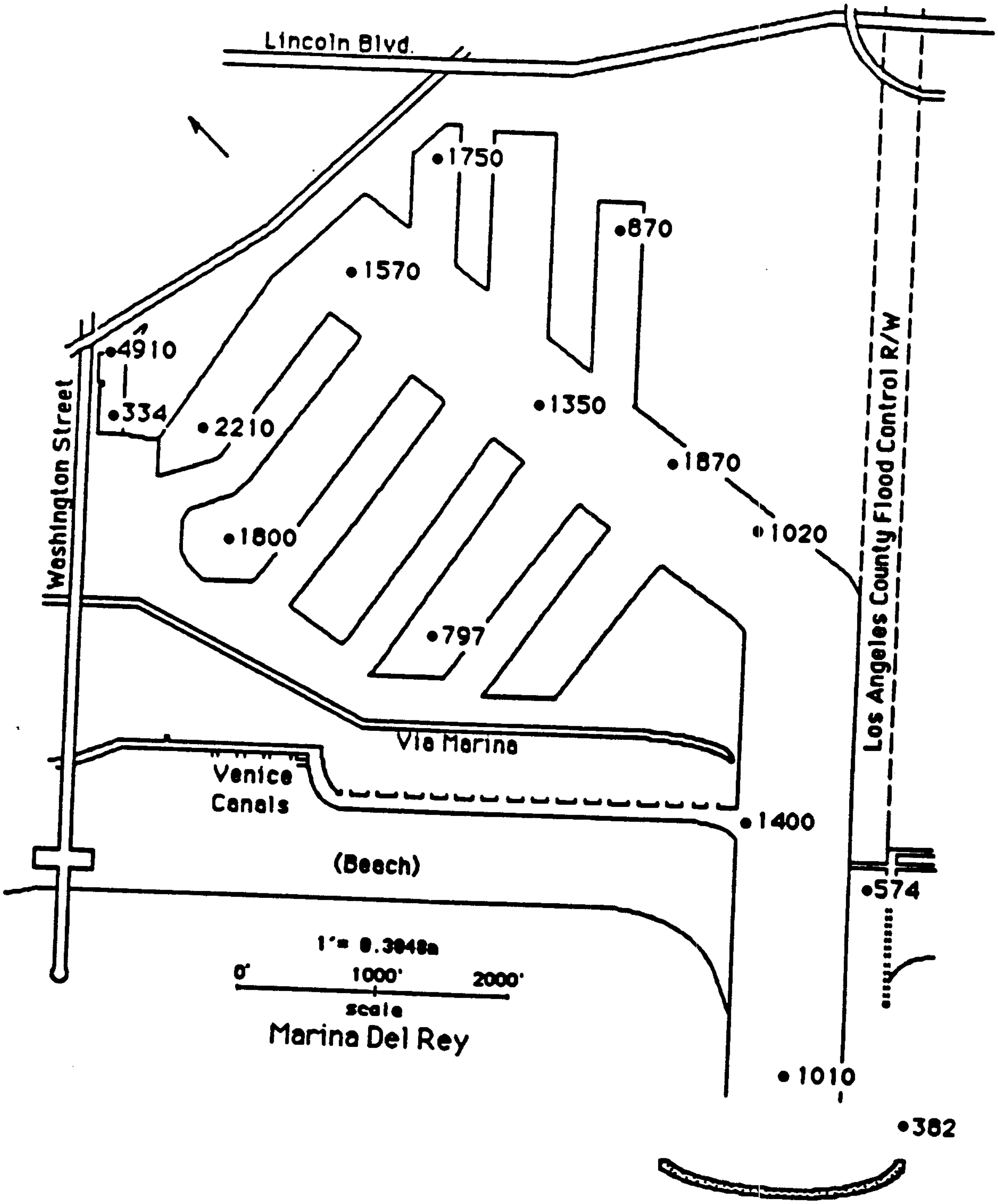

Figure IV.8. Organic Nitrogen in mg/kg dry wt (ppm) in sediment. October 1991.

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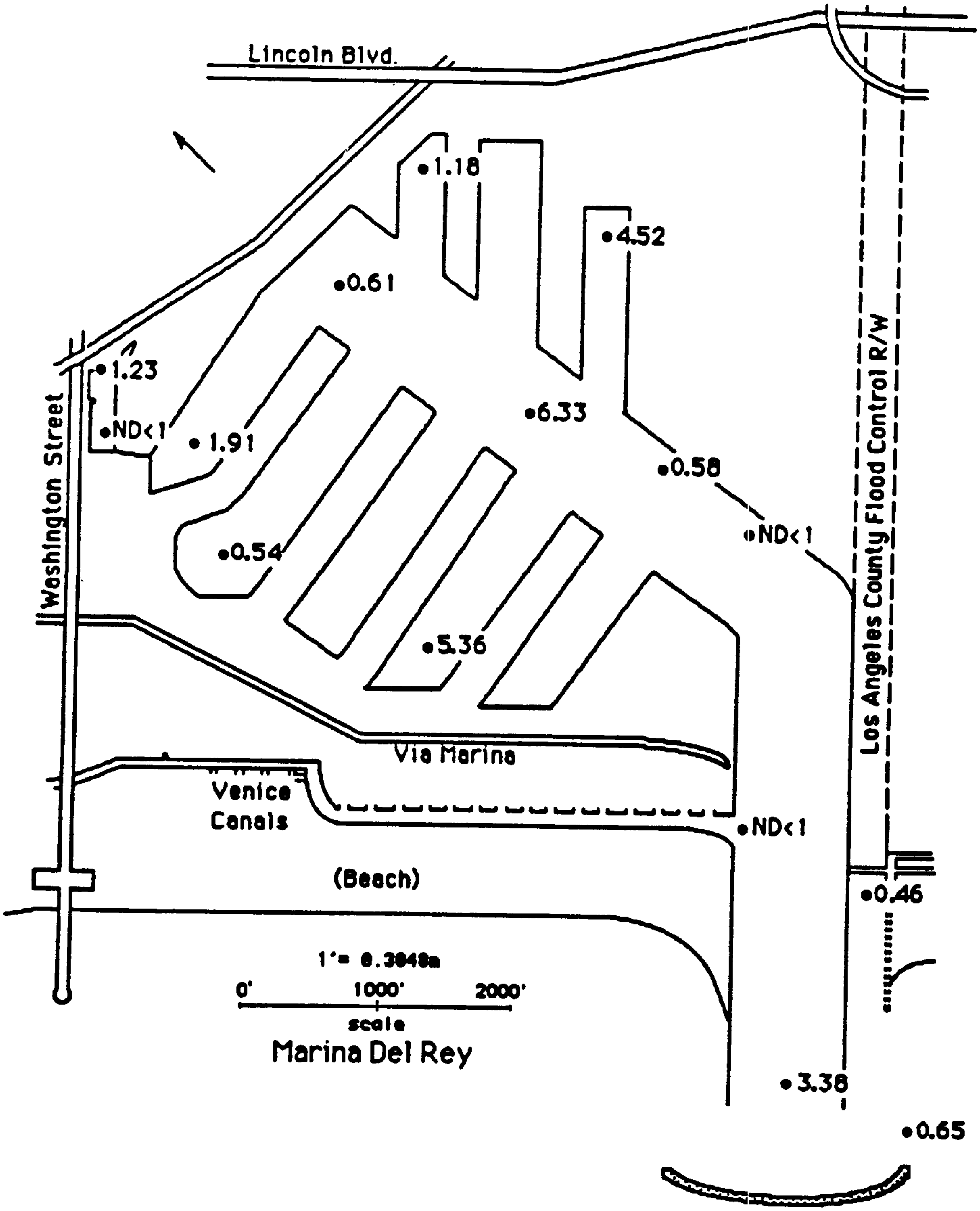

Figure IV.9. Hydrogen Sulfide in mg/kg dry wt (ppm) in sediment. October 1991

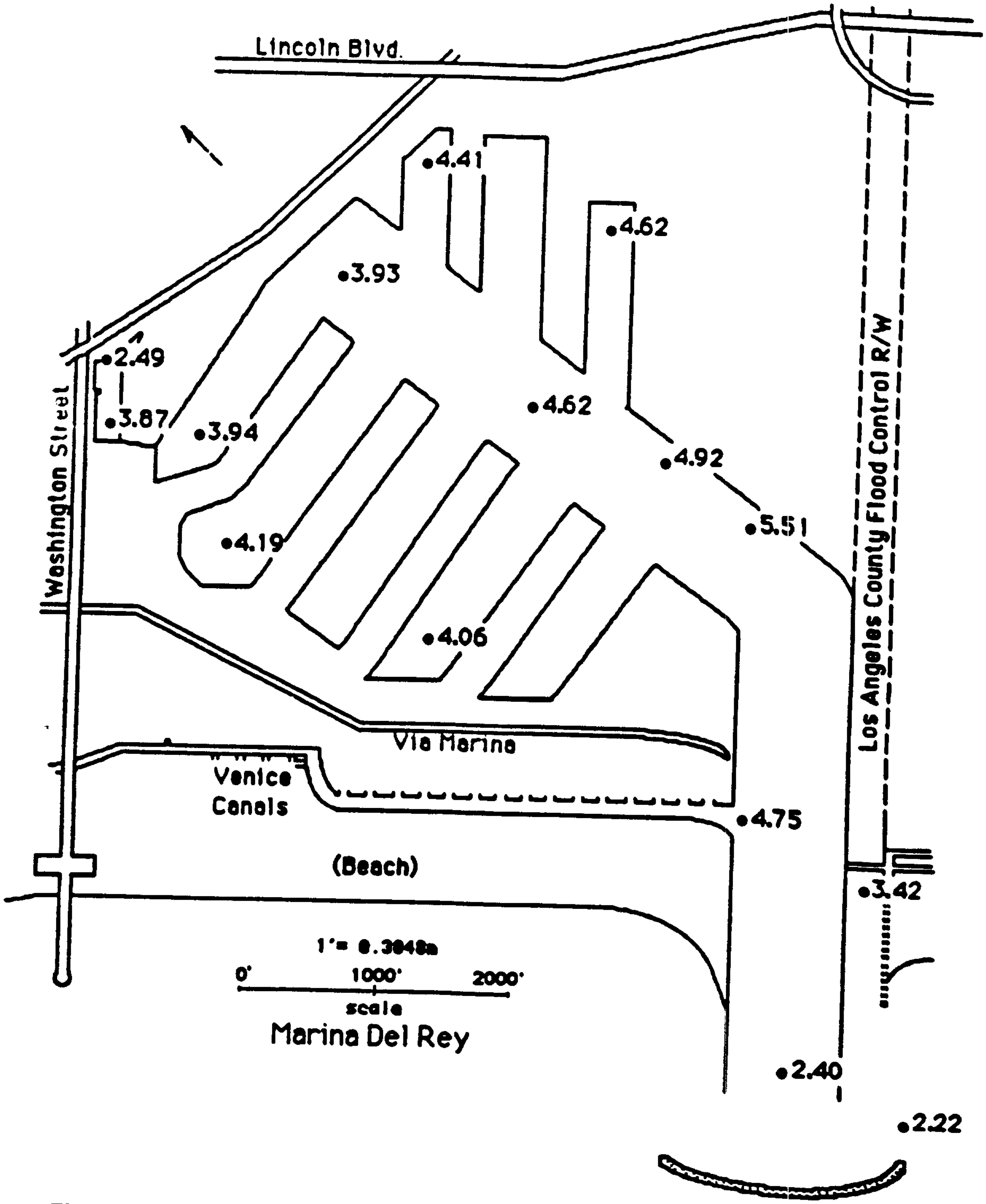

Figure IV.10. Arsenic in mg/kg dry wt (ppm) in sediment. October 1991.

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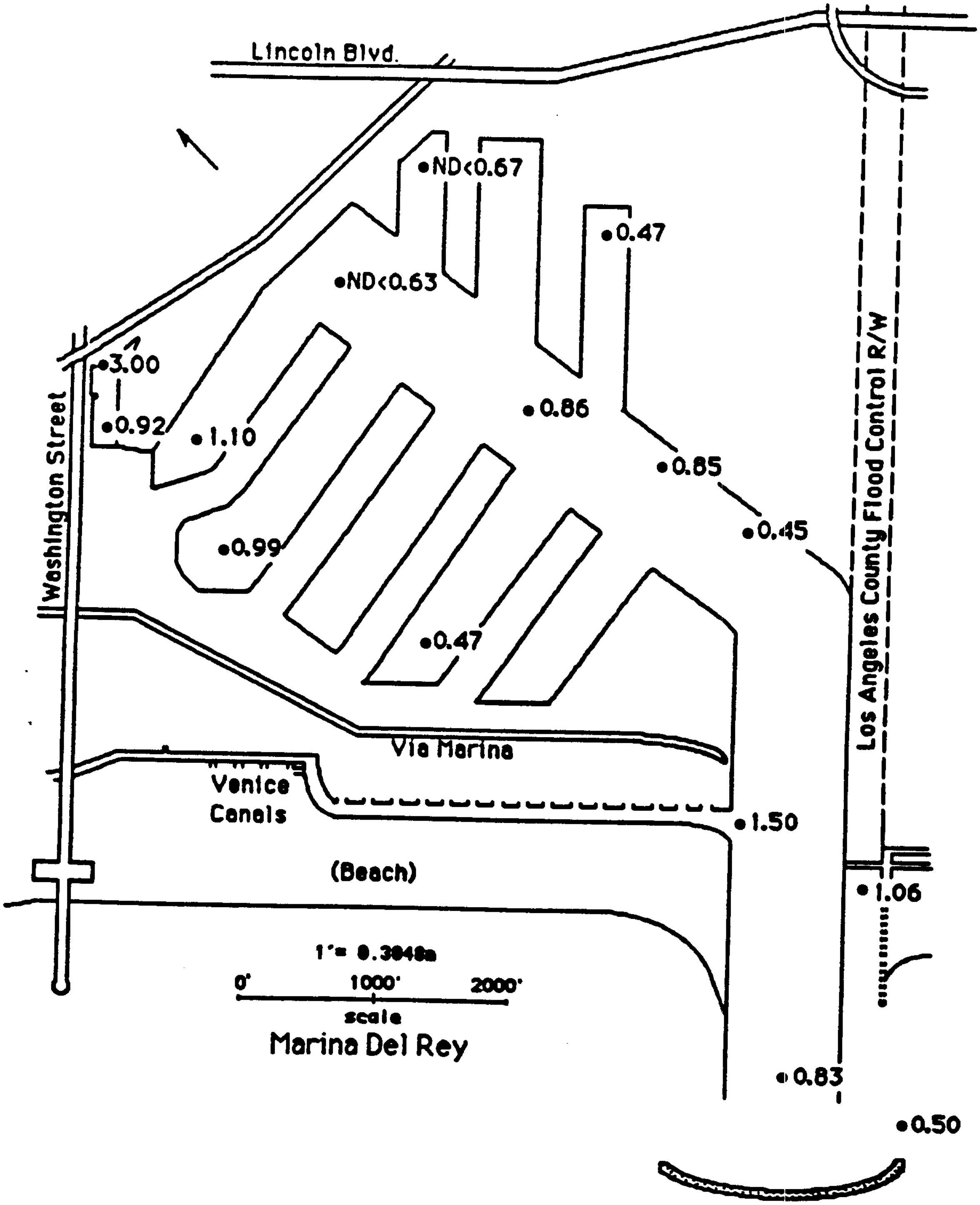

Figure IV.11. Cadmium in mg/kg dry wt (ppm) in sediment. October 1991.

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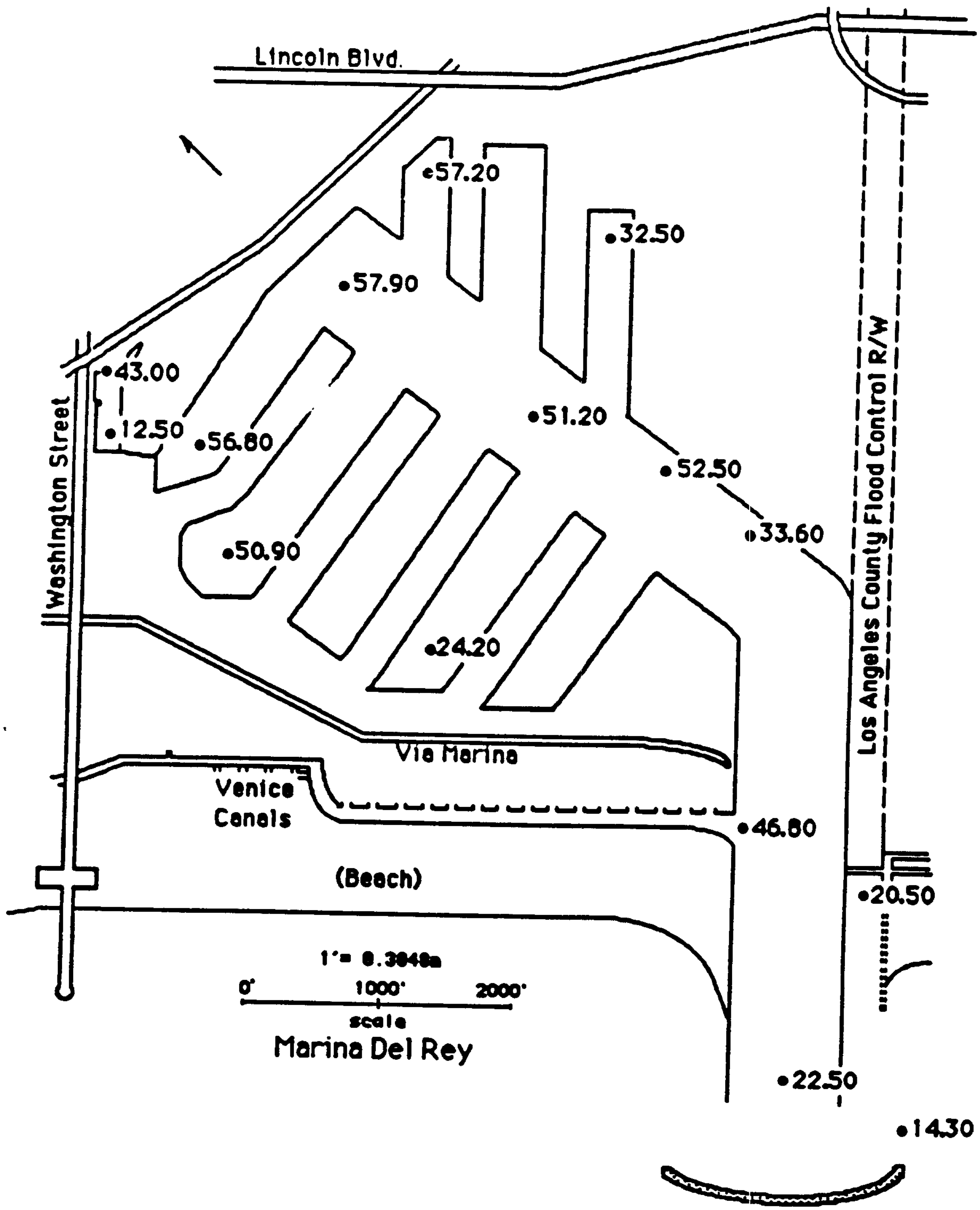

Figure IV.12. Chromium in mg/kg dry wt (ppm) in sediment. October 1991.

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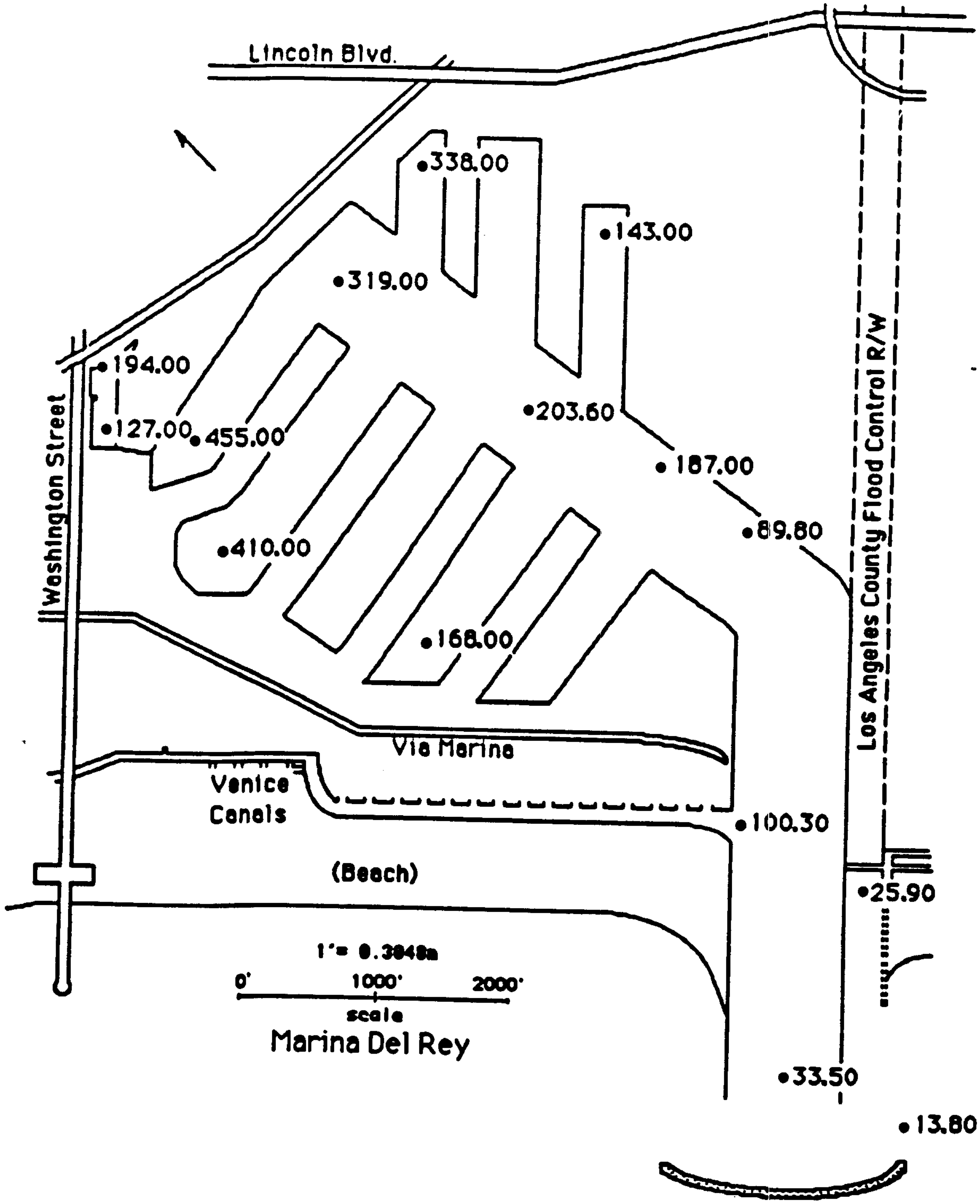

Figure IV.13. Copper in mg/kg dry wt (ppm) in sediment. October 1991.

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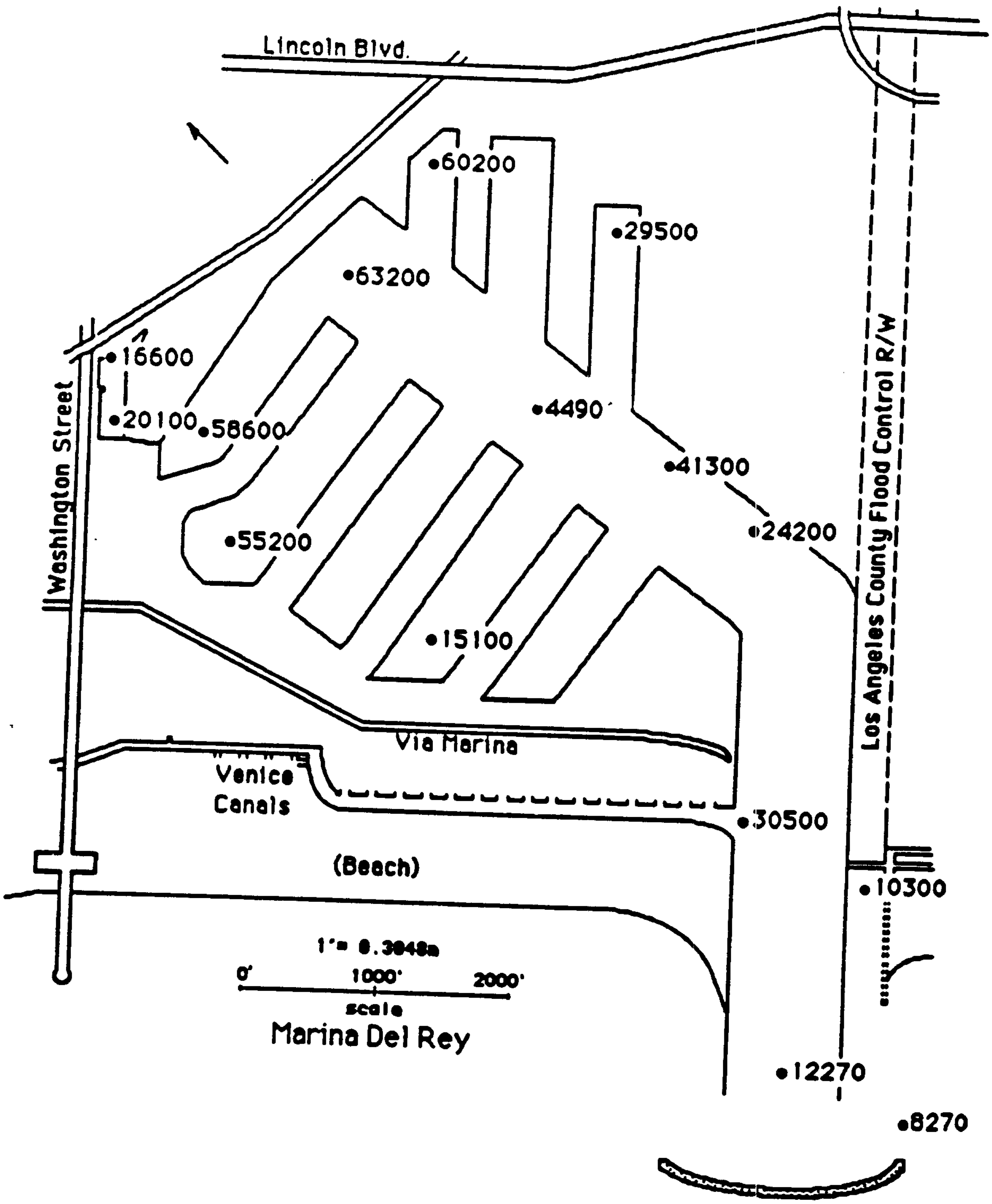

Figure IV.14. Iron in mg/kg dry wt (ppm) in sediment. October 1991.

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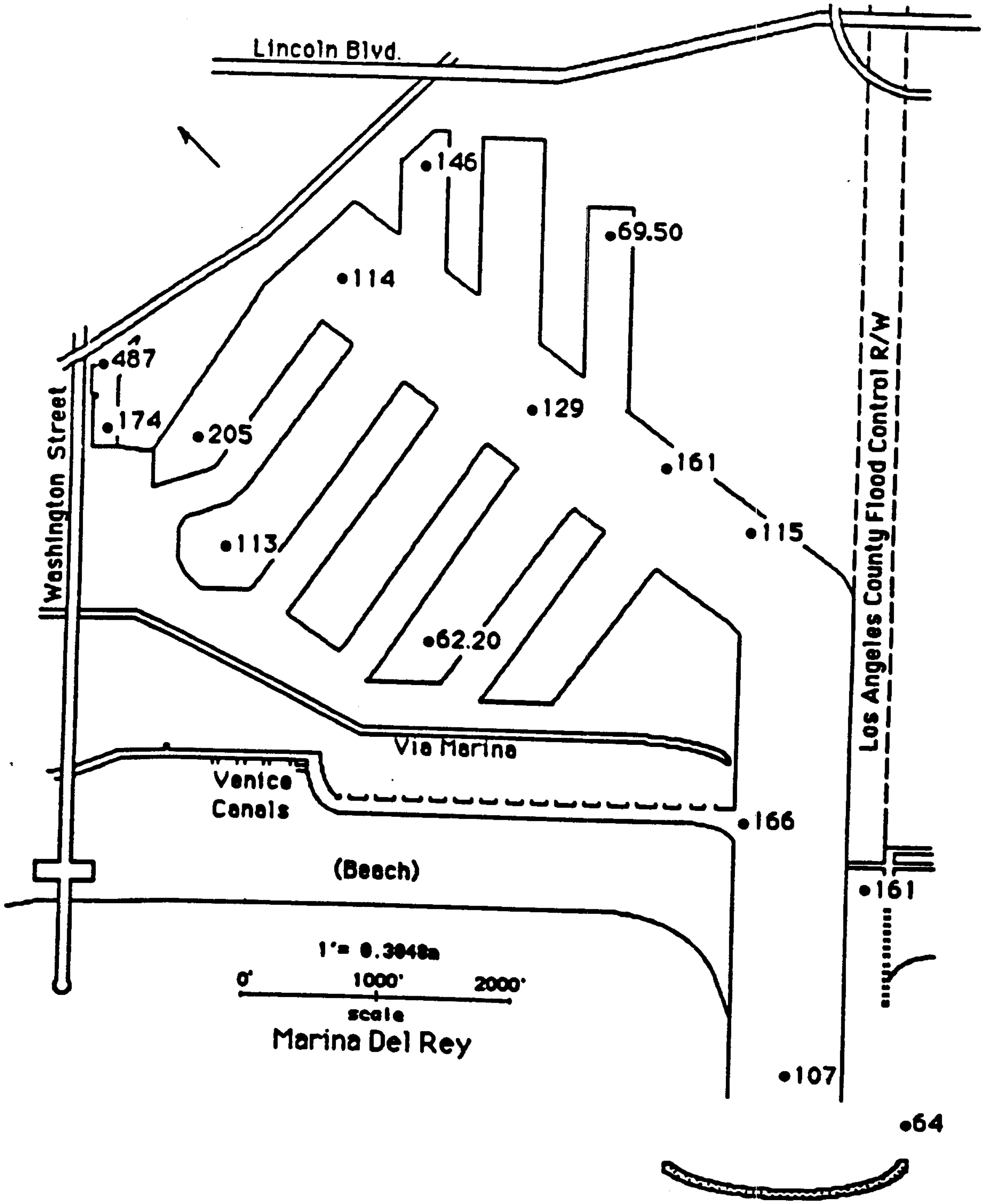

Figure IV.15. Lead in mg/kg dry wt (ppm) in sediment. October 1991,

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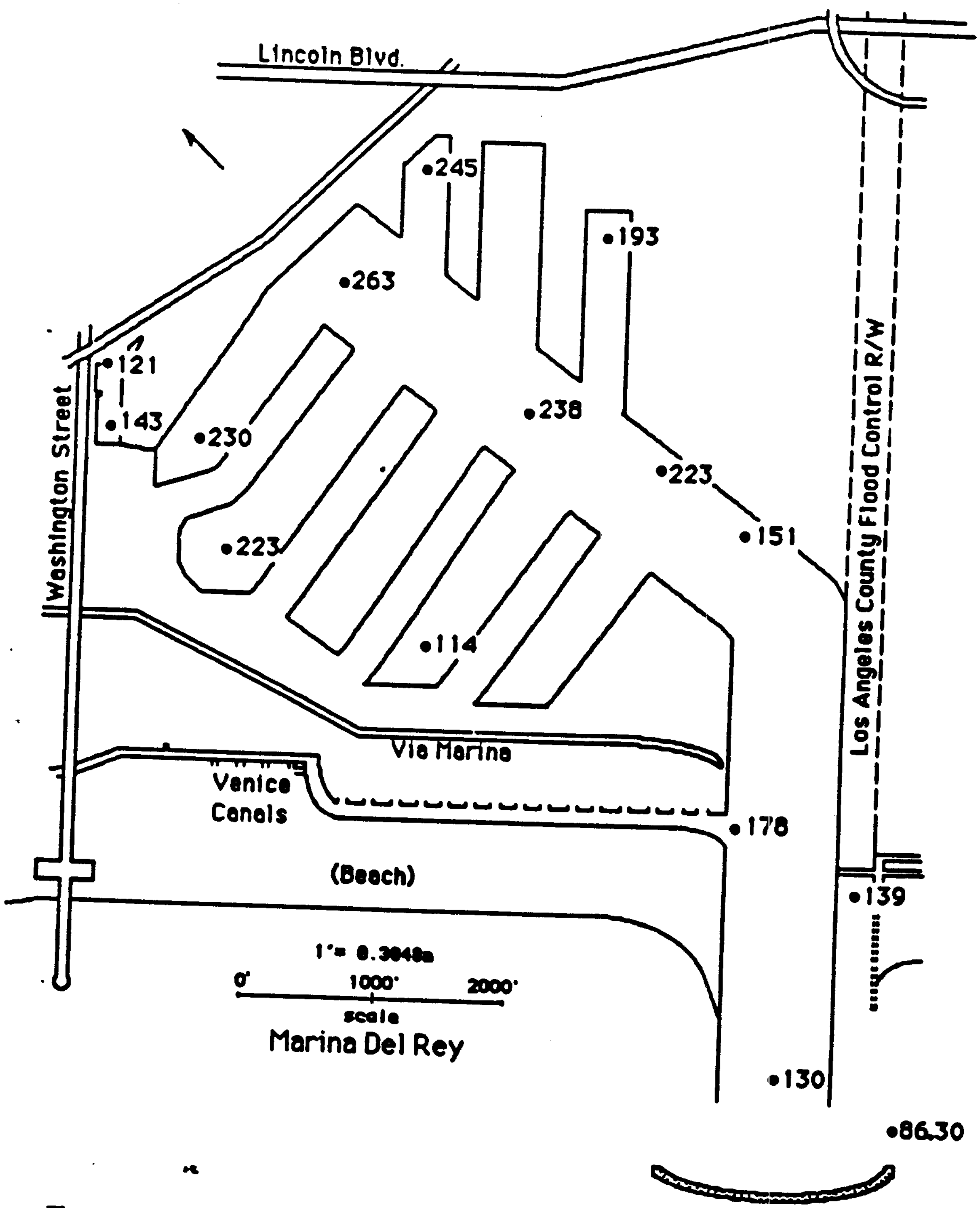

Figure IV.16. Manganese in mg/kg dry wt (ppm) in sediment. October 1991.

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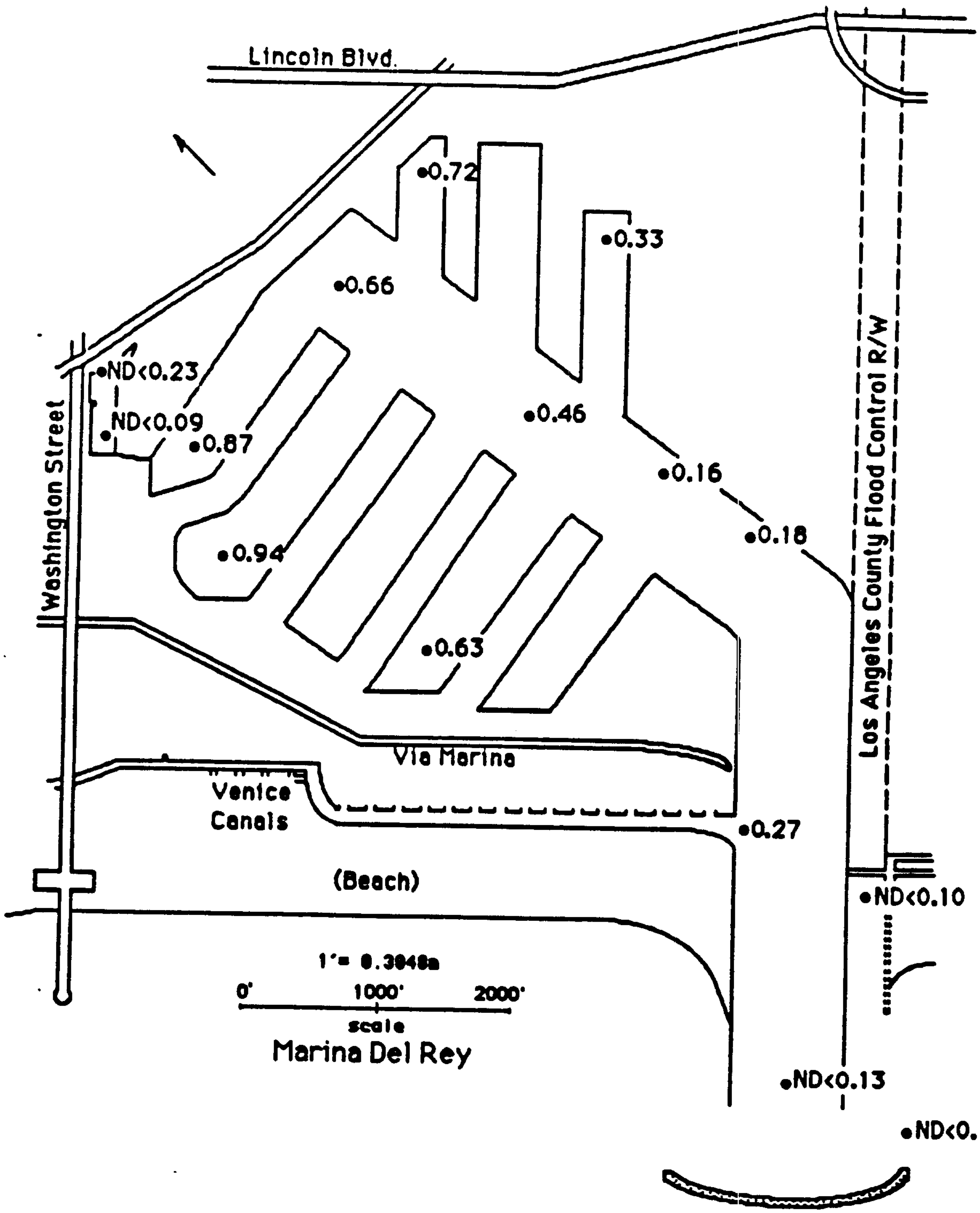

Figure IV.17. Mercury in mg/kg dry wt (ppm) in sediment. October 1991

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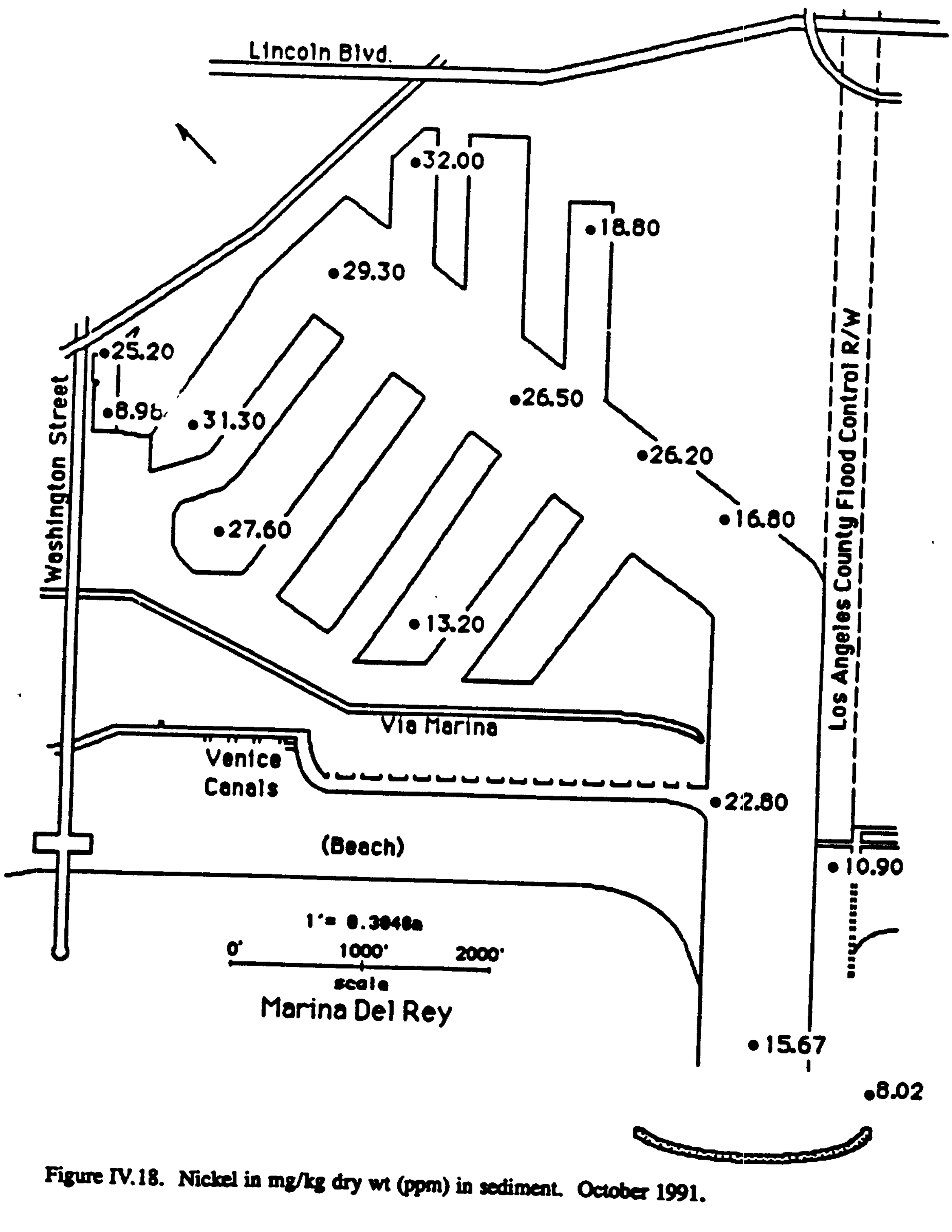

Figure IV.18. Nickel in mg/kg dry wt (ppm) in sediment. October 1991.

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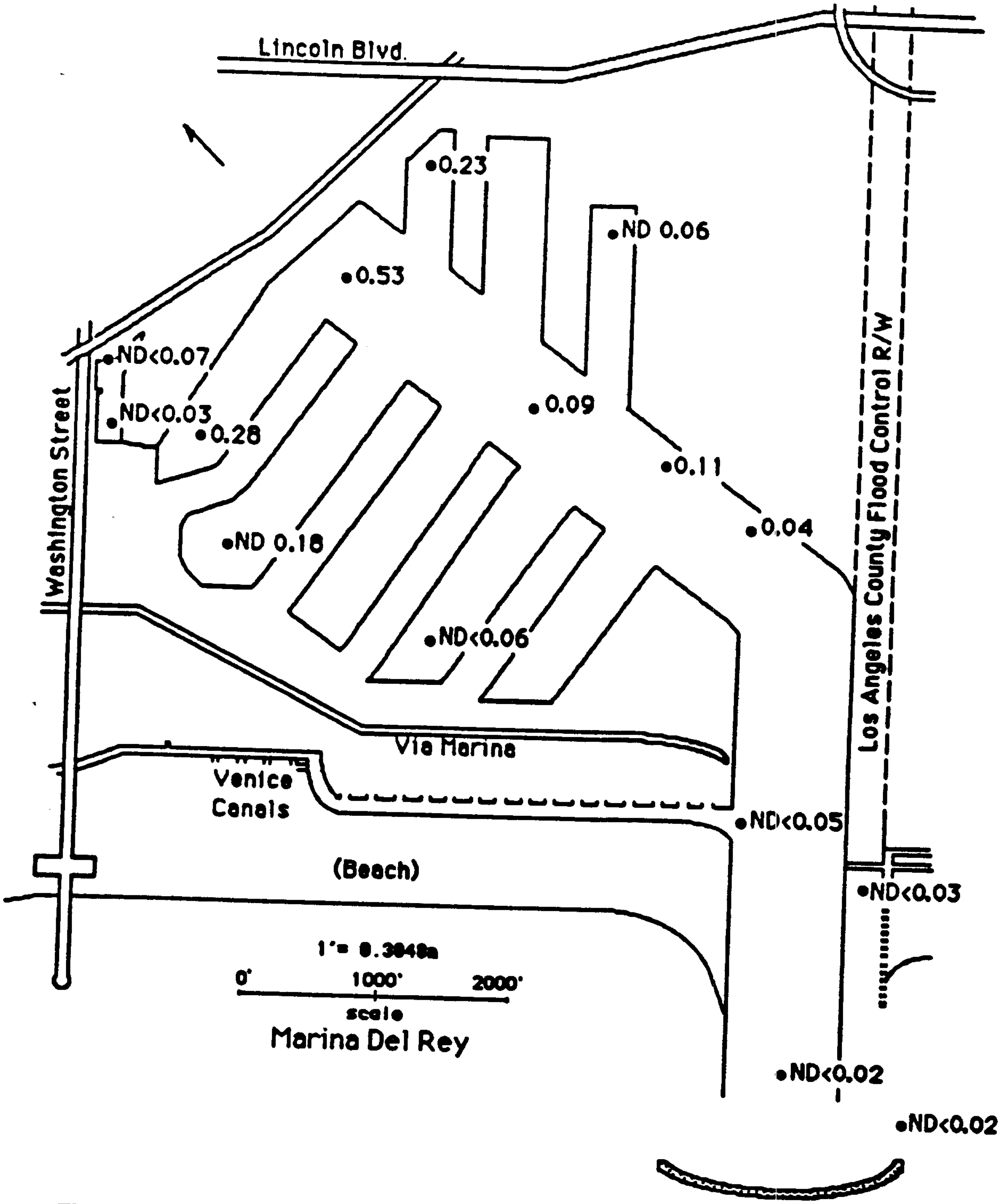

Figure IV.19. Tributyl tin in mg/kg dry wt (ppm) in sediment. October 1991.

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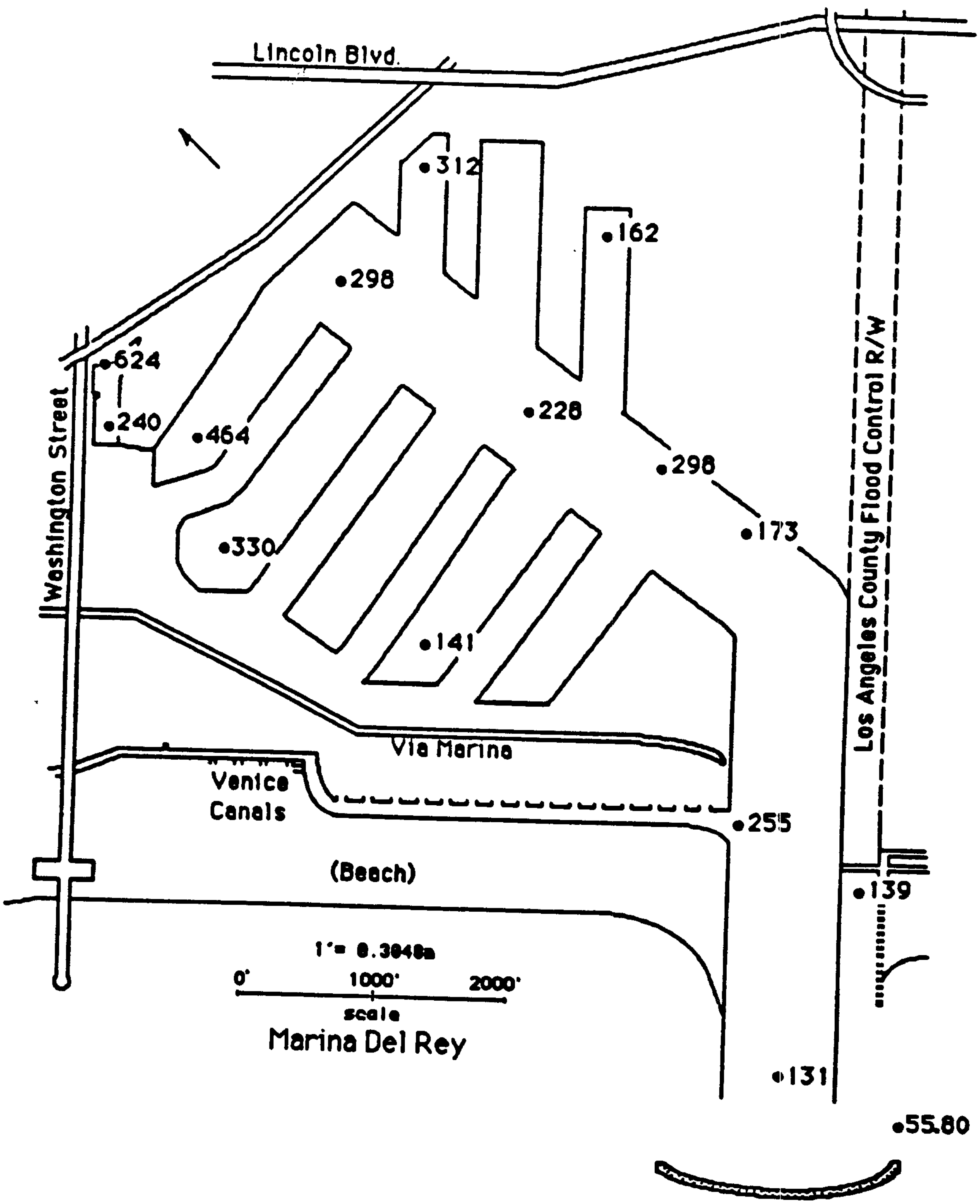

Figure IV.20. Zinc in mg/kg dry wt (ppm) in sediment. October 1991.

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PESTICIDES AND CHLORINATED HYDROCARBONS

INTRODUCTION

A few pesticides have been prominent contaminants in Marina del Rey, existing in quantities sufficient to have affected the presence/absence of some species by inhibition of reproduction or by exerting chronic effects on distribution and growth of mature organisms. Pesticide analysis has been conducted in all sediment surveys since 1984, but only DDTs were analyzed in the 1977 baseline studies due to technology limitations. Aldrin, BHCs, Lindane, Endrin, Toxaphene, Heptachlor and Heptachlor Epoxide have been absent from all 1984-1991 surveys. Dieldrin has not been found since October 1987; production was halted in the U.S. in the 1970s, but it continued to be imported until 1985, and all use was banned in the U.S. in 1987. Although the DDTs have been banned since the early 1970s and Chlordane since the early 1980s, they have persisted in Marina del Rey, as they have in local coastal waters, exerting a variety of effects on the local fauna.

RESULTS

Station Rankings

Stations in the marina have been ranked according to the total pesticides and chlorinated hydrocarbons in sediments sampled in October 1991. In Table IV.8, the total scores are tabulated for October 1989 and 1990, May 1991 and October 1991. Because of typographical errors in the previous report (Table IV.11, in Soule et al., 1992) a few of the total pesticide and chlorinated hydrocarbon totals were changed but the only ranking changed was that of Station 8 which moved from low to medium low. Table IV.8 incorporates the corrected data and compares it with the October 1991 data.

The outstanding difference in the October 1991 results was the disappearance of the chlorinated hydrocarbon Aroclors 1254 and 1260, which first appeared in our surveys in October 1988. Aroclor levels were highest in the October 1989 survey, and those totals have been included in Table IV.8 for comparison. Figure IV.21 illustrates the absence of Aroclors in 1988, followed by the dramatic maximum reached in October 1989, the decrease

Table IV.8. Rankings of stations by total of pesticides and chlorinated hydrocarbons.

Group	October 1989 Station	October 1989 ppb	October 1990 Station	October 1990 ppb	May 1991 Station	May 1991 ppb	October 1991 Station	October 1991 ppb
Highest	2	1121						
	12	809						
			22	731				
					2	569	2	541
High			10	494	11	496		
			2	473	10	487		
			11	443	1	429		
	10	419						
					3	401	3	409
Medium High	11	380						
	25	354						
							22	345
	5	324	9	334				
	7	324	25	327	13	324		
	9	306			12	303		
Moderate			5	262				
					25	248		
	13	236			8	232		
			4	206	4	218		
			1	205				
Medium Low			6	178			25	173
			7	166	9	167		
			8	150			12	152
	4	147	12	135	7	141	4	141
			6	120				
							5	103
							6	103
Low							7	92
							10	91
							11	91
	8	86					9	71
	1	58			22	54	1	57
							8	55
					6	35	13	34
			13	22				
	3	17	3	21				

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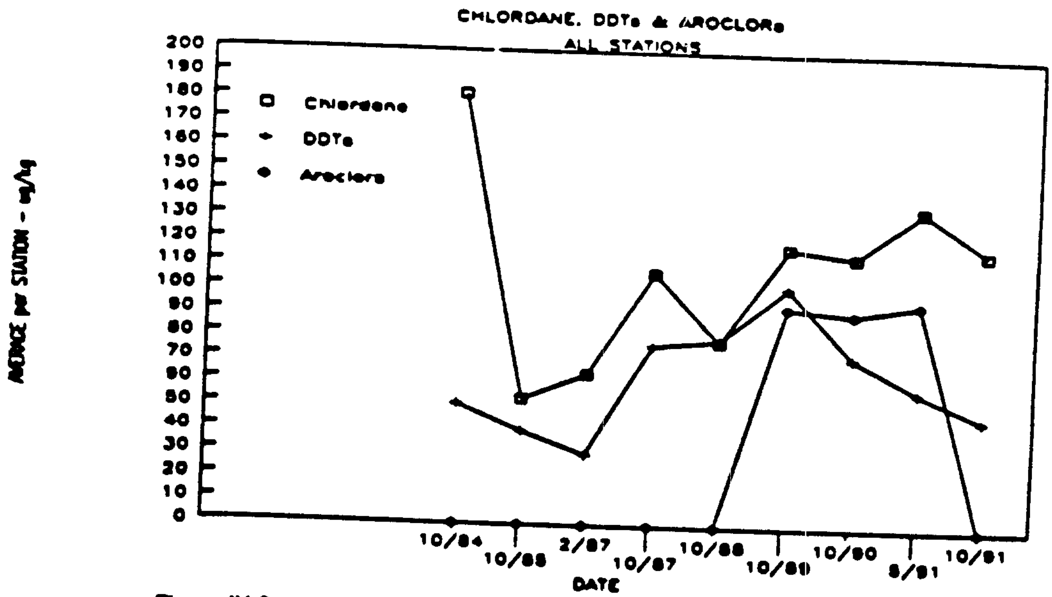

Figure IV.21. Average Chlordane, DDTs and Aroclor PCBs in sediments from all stations, October 1984 through October 1991.

Chlordane is the principal component of the non-DDT pesticides; there was 11.0 ppb of Dieldrin in October 1985 and 32.5 ppb in February 1987; but it was undetected thereafter. The maxima in PCBs coincided with high Chlordane levels in 1989 and 1990, increasing potential for ecological impact. PCBs were below limits of detection in October 1991.

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in May 1991, and the disappearance of Aroclors by October 1991.

Extreme variation in contaminant loading according to the flushing characteristics of particular stations can be noted in rankings in Table IV.8. Station 12 was in the highest group in October 1989, dropped to medium low in October 1990, rose to medium high on May 1991 and decreased again to medium low in October 1991. Station 1, nearer the bay, was in the lowest category in October 1989, rose to moderate ranking in October 1990 and to the high category in May 1991, after which it dropped back to the low ranking. Station 2, at the sandbar, had the highest total pesticides and chlorinated hydrocarbons ever recorded in the marina in October 1989, and while the total decreased to 473 ppb, or 42 percent of that in

October 1990, the total remained in the high category and had increased to 541 ppb by October 1991, indicating dry weather accumulation at the sandbar.

Station 22, at the inner end of Oxford Street basin, was not a sampling station in October 1989, but took top ranking when it was added in October 1990. It dropped to the next lowest in May 1991 after the rains but rebounded to the medium high ranking in October 1991. Station 13, at the outer end of Oxford Street basin functioned inversely to Station 22, moving from low to medium high and back to low in the same period. Stations 10 and 11 had relatively high totals from October 1989 through May 1991, after which both dropped to the low category. In contrast, these two stations stayed in the high category for trace metals and non-metallic contaminants during the October 1990-1991 period, illustrating the differences in the behavior of the pesticides, related perhaps to differences in sources, solubilities and/or complexing with sediments.

Station 3, which was the cleanest in total pesticides and chlorated hydrocarbons in October 1989 and 1990, jumped to the high category in May 1991 and continued to remain in that position, indicative either of input from Ballona Lagoon and the surrounding terrestrial area or spreading of accumulation behind the sandbar, or both. In non-metallic contaminants (Table IV.4) and trace metals, Station 3 had the lowest rank in October 1990 but rose to medium high in May 1991 and remained there through October 1991.

Seven stations were included in the low category of pesticides and chlorinated hydrocarbons in October 1991, the largest number of sites in recent years, but no stations reached the lows below 30 ppb that occurred in 1989 and 1990.

Toxic Effects

NOAA determined the Effects Range-Low (ER-L), Effects Range-Medium (ER-M), and Apparent Effects Threshold (AET) by extensive data analysis (Long and Morgan, 1990), while the National Research Council (NRC) has provided other estimates of effects levels. The NOAA data on pesticides are not as extensive in some cases as they are for trace metals.

In Table IV.9, the effects levels are compared with the ranges of pesticides and

Table IV.9. Concentrations of metals in sediments producing biological effects in October 1991 compared with levels in Marina del Rey in October 1990 and May 1991.*

Parameter	ER-L	ER-M	AET	NRC	MDR Range	Stations Equal/Exceeding ER-L	ER-M	AET
Chlordane	0.5	6	2?	20				
Oct 90					10 - 410	all stations	all stations	all stations
May 91					<ND10 - 360	all but 6? (<ND)	same	same
Oct 91					31 - 436	all stations	all stations	all stations
p.p'DDT	1	7	6?	6				
Oct 90					<ND 4 - 29	all but 3,12,13,22, 25, (<ND)	same	same
May 91					<ND 4 - 14	all stations	all but 3,4,6,7,25	same
Oct 91					<ND 4 - 48	all but 1,13 (<ND)	same	same
p.p'DDD	2	20	?	13000				
Oct 90					<ND 4 - 100	all but 3,6,7,12,13,(<ND)	2,9,11,22,25	—
May 91					<ND 4 - 15	all but 22 (<ND)	—	—
Oct 91					<ND 4 - 23	all but 6,8,10,13	2,3	—
p.p'DDE	2	15	2?	28000				
Oct 90					<ND 4 - 104	all but 3 (<ND)	all but 3,12,13	all but 3 (<ND)
May 91					3.5 - 110	all stations	all but 22,9	all stations
Oct 91					3.0 - 67	all stations	all but 1,8,12,13	all stations
Total DDTs	3	350	—	—				
Oct 90					<ND 4 - 199	all but 3 (<ND)	—	—
May 91					33 - 134	all stations	—	—
Oct 91					3.0 - 136	all stations	—	—
Aroclor total*	50	400	3?	280				
Aroclor 1254*								
Oct 90					<ND 1 - 153	all but 2,4,5,6,7,8	—	all but 2,4,5,6,7,8,
May 91					<ND10			
Oct 91					<ND10? -		—	—
Aroclor 1260*								
Oct 90					<ND 1 - 172	all but 9,10,11,22,25	—	all but 9,10,11,22,25
May 91					<ND10 - 300	all but 6,13,22	—	all but 6,13,22 (ND<10)
Oct 91					<ND10?	—	—	—

* No station had both Aroclor 1254 and 1260 at the same time.
Units are in Effects Range-Low (ER-L), Effects Range-Median (ER-M), Apparent Effects Threshold (AET) (NOAA: Long and Morgan, 1990); National Research Council (NRC) EPA Threshold Levels. In ppb.

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chlorinated hydrocarbons in the marina for October 1990, May 1991 and October 1991, along with stations which exceed the various levels. The ranges for surveys from 1985 to 1991 are listed in Table IV.10. Complete data for October 1990, with corrections, and October 1991 are presented in Tables IV.11 and 12.

<u>Chlordane</u>

Chlordane is an insecticide persistent in the marine environment which has been used extensively in termite control and was supposedly banned in 1988. However, the substance seems to continue to enter the marina. The behavior of Aroclors, also persistent chemicals, which were introduced between October 1988 and October 1989 and disappeared (were below the limits of detection) by October 1991 after having been very high, is indicative that flushing does occur. However Chlordane (Figure 22) has not similarly been eliminated as would be expected if its use has really been discontinued, although leaching or seepage from wood structures may be occurring. Station 2 again showed the peak value, decreasing from the maximum of 630 ppm in October 1989, when Aroclors also peaked at Station 2. Chlordane decreased to 410 ppb at Station 2 in October 1990 and to 360 ppb by May 1991, but increased to 436 ppb in October 1991. The level was second highest at Station 22 in October, as it was in October 1990, and third at Station 3, suggesting major terrestrial sources such as drainage into Oxford Street basin and the Ballona Lagoon area. Station 3 may receive Chlordane from Ballona Lagoon and also be the major source that deposited at Station 2.

The ER-L for Chlordane is 0.5 ppb, the ER-M is 6 ppb, the AET is tentatively given as 2 ppb and the NRC limit is 20 ppb. All survey stations exceed these limits for Chlordane, which had a low value of 31 ppb, the highest minimum in recent surveys.

<u>DDTs</u>

DDT was formulated just prior to World War II and its use for malaria control stimulated application as an insecticide in a wide variety of habitats, causing its entry into marine ecosystems. DDT continued to be manufactured locally by the Montrose Chemical

Table IV.10. Chlorinated hydrocarbon ranges in sediment and highest stations by years in 1985, 1987 - 1991.

Parameter ug/kg (ppb)	Oct 85*		Oct 87		Oct 88		Oct 89		Oct 90		May 91		Oct 91	
Chlordane	<LD-335	2,1	ND<2.0	2,1	13.5-283	2,4	ND<2.0-630	2,12	10-410	22,2	ND<10-360	2,3	31.0-436	2,22,3
Dieldrin	ND<4.04-11	1	ND<1.0		ND<1.0		ND<1.0		ND<1.0		ND<1.0		ND<1.0	
p.p'DDT	<LD-93.4	10,5	6-57	2,10	ND<4.0-29.1	8,11	3.0-200	12,9	ND<4.0-29	2,9	ND<4-16	2,22	ND<4.0-48.0	3,2
p.p'DDD	<LD-14.1	9,7	2-34	9,2	ND<4.0-46.7	9,4	2.0-40	12,2	4-100	22,25	ND<4-15	11,10	ND<4.0-23.0	2,3
p.p'DDE	<LD-39.2	10,5	10-105	9,10	ND<4.0-109	9,10	ND<4.0-77	11,10	ND<4-104	25,22	3.5-110	13,11	3.0-67.0	3,2
1254	<LD		ND<1.0		ND<1.0		ND<1.0-350	2,10	ND<1.0-155	2,6	ND<1.0		ND<10.0	
1260	<LD		ND<1.0		ND<1.0		ND<1.0-200	25,12	ND<1.0-172	11,10	ND<10-300	11,1	ND<10.0	

Station 12 not sampled in 1988.
Station 22 added in 1990.
* <LD See Soule and Oguri (1986) for Limits of Detection.
ND< = Less than limits of detection:
<1.0 Aldrin, Lindane, Dieldren, Heptachlor, Heptachlor Epoxide;
<.2 Alpha BHC, Beta BHC, Endrin;
<10 Toxaphene, Aroclors 1016, 1221, 1232, 1241, 1248, 1254, 1260.

Table IV.11. Sediment pesticides and chlorinated hydrocarbons (in ug/kg = ppb), 18 October 1990

Station Parameters	1	2	3	4	5	6	7	8	9	10	11	12	13	22	25	Mean
Chlordane	142.0	232.0	21.0	82.0	78.0	12.0	10.0	48.0	98.0	200.0	178.0	90.0	17.0	410.0	106.0	115.1
p.p'DDT	22.0	29.0	ND<4.0	16.0	21.0	12.0	13.0	12.0	25.0	22.0	12.0	ND<4.0	ND<4.0	ND<4.0	ND<4.0	10.4
p.p'DDD	15.0	27.0	ND<4.0	4.0	7.0	ND<4.0	ND<4.0	5.0	30.0	15.0	25.0	ND<4.0	ND<4.0	100.0	47.0	27.5
p.p'DDE	26.0	32.0	ND<4.0	27.0	34.0	17.0	24.0	24.0	75.0	88.0	56.0	12.0	5.0	99.0	104.0	44.5
Total Pest. Detected	205.0	320.0	21.0	129.0	140.0	41.0	47.0	89.0	228.0	325.0	271.0	102.0	22.0	609.0	257.0	205.9
Aroclor 1254	ND<1.0	153.0	ND<1.0	77.0	122.0	137.0	119.0	61.0	ND<1.00	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	102.2
160	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	126.0	169.0	172.0	33.0	ND<1.0	122.0	70.0	115.3
Total Chem. Detected	205.0	473.0	21.0	206.0	262.0	178.0	166.0	150.0	334.0	494.0	443.0	135.0	22.0	731.0	327.0	272.5

Not Detected: <10.0, Toxaphene, Aroclor 1016, 1221, 1232, 1242, 1248 1254, 1260; <4.0, o.p'DDT, o.p'DDD; <2.0, Alpha BHC, Beta BHC, Endrin.

Table IV.12. Sediment pesticides and chlorinated hydrocarbons (in ug/kg = ppb), 17 [illegible]ber 1991

Station Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	22	25	Mean
Chlordane	46.0	436.0	273.0	95.0	62.0	71.0	43.0	38.0	33.0	62.0	41.0	124.0	31.0	296.0	107.0	117.20
p.p'DDT	ND<4.0	40.0	48.0	16.0	12.0	16.0	16.0	8.0	8.0	8.0	16.0	8.0	ND<4.0	21.0	20.0	18.23
p.p'DDD	4.0	23.0	21.0	4.0	5.0	ND<4.0	8.0	ND<4.0	6.0	ND<4.0	8.0	11.0	ND<4.0	10.0	8.0	9.82
p.p'DDE	7.0	42.0	67.0	26.0	24.0	16.0	25.0	9.0	23.0	21.0	26.0	9.0	3.0	18.0	38.0	23.60
Total Pest. Detected	57.0	541.0	409.0	141.0	103.0	103.0	92.0	55.0	70.0	91.0	91.0	152.0	34.0	345.0	173.0	162.00

Not Detected: <10.0, Toxaphene, Aroclor 1016, 1221, 1232, 1242, 1248 1254, 1260; <4.0 o.p'DDT, o.p'DDD; <2.0, Alpha BHC, Beta BHC, Endrin.

Company until 1982, even though its use in the United States was banned in 1972 after it was demonstrated that it interfered with calcium metabolism and caused thinning of bird eggshells, leading to reproductive failure. The carcinogenicity and toxicity of DDTs are open to question. In the 1950s waste residues were dumped in quantity in the Catalina Channel from barges, and large amounts passed through the Los Angeles County sewer system, causing deposition along the Palos Verdes shelf (Chartrand et al., 1985; Mearns et al., 1991).

Sources in the marina are unknown, but the highest levels of DDT, DDD and DDE were at Stations 2 and 3 in October 1991, although there has been a variety of stations with the maximum levels (Table IV.10). Sources of non-degraded p.p'DDT are not known, although new DDT may be finding its way into the marina, or DDT that has been buried and not biodegraded but was perhaps recently uncovered in terrestrial excavations may have been carried into the marina via storm drains. The range increased from below the limits of detection (<ND 4.0) to 29 ppb in October 1990 to <ND 4.0 to 48 ppb in October 1991, although the means were similar at 18.23 and 18.4 ppb; the mean had been reduced to 8.8 ppb in May 1991 following the spring rains. All stations exceeded the p.p'DDT ER-L of 1 ppb except Stations 1 and 13 and also exceeded the ER-M, AET and NRC concentrations for effects in October 1991. Figure 23 shows the distribution in October 1991.

For p.p'DDD, the October 1991 (Figure 24) range was <ND 4.0 to 23 ppb, with a higher maximum than in May 1991 but considerably lower than the 100 ppb of October 1990. All except Stations 6, 8, 10 and 13 exceeded the ER-L of 2 ppb, and Stations 2 and 3 exceeded the ER-M as well. The very large NRC number of 13,000 ppb indicates the contradictory nature of the evidence about the toxicity of this form.

The range in October 1991 for p.p'DDE was 3.0 to 67 ppb (Figure 25). All stations exceeded the ER-L for p.p'DDE of 2 ppb, and all except Stations 1, 8, 12 and 13 exceeded the ER-M as well. The NRC number of 28,000 indicates the difference in data base and opinion. Long and Morgan (1991) also calculated a total DDT ER-L of 3 ppb and of 350 ppb for the ER-M. The October 1991 range for total DDTs was from 3.0 ppb to 136 ppb, indicating that all stations equaled or exceeded the ER-L but none approached the ER-M.

Aroclors

The appearance of Aroclors 1254 and 1260 at high concentrations in the October 1989 survey and subsequent distribution throughout the marina was the subject of much concern because of the obvious introduction of these toxic substances into the marina where it had previously not been detected. The maximum Aroclor 1254 value was 330 ppb at Station 2 in October 1989, decreasing to 153 ppb, also at Station 2, in October 1990, and was below limits of detection in May 1991. Aroclor 1260 had a maximum of 200 ppb at Station 25 in October 1989, and a peak of 300 ppb at Station 11 in May 1991 (table IV.10). After possibly being introduced at more than one drainage source, the substances appeared to move around in the marina and then disappeared (were below the limits of detection) by October 1991.

Massive grading for development occurred along Lincoln Boulevard northeast of the marina, while smaller grading projects on Washington Street and along Ballona Lagoon took place at about the same time. Runoff could have carried sediments into Ballona Creek, Oxford Street basin and/or into storm drains in the marina. Sediments on the north side of Ballona Creek are known to have been contaminated by industrial activity during World War II and dumping also occurred in the area. Disturbance of contaminated sediments that might have been covered for years could cause contamination of runoff.

CONCLUSIONS: PESTICIDES AND CHLORINATED HYDROCARBONS

The remarkable introduction of chlorinated hydrocarbons in the form of Aroclors 1254 and 1260 sometime between October 1989 and October 1990 represents a very large environmental insult to the ecology of the marina, since it is toxic to organisms at about 50 ppb while levels were in some locations as much as six times that amount (Table IV.9). The equally striking disappearance (levels below the limits of detection) by October 1991 indicates the ability of the marina to be flushed of some constituents, since these chemicals do not biodegrade rapidly.

Of the pesticides, chlordane and the DDTs continue to be present in ecologically harmful levels. Chlordane is a continuing problem throughout the marina, with all stations showing concentrations about one or two orders of magnitude above the low effects range (ER-L) and exceeding the medium and apparent effects ranges (ER -M, AET respectively) defined by NOAA (Long and Morgan, 1991). In spite of the ban on Chlordane, it is either still being applied widely, leached from previously treated structures, or dumped into the marina.

DDTs exceed the ER-L range at most stations. The p.p'DDT levels exceed the ER-M and AET levels at all except Stations 1 and 13, and p.p'DDD exceeds the ER-L at most stations. The p.p'DDE levels exceed the ER-L at all stations and most exceed the ER-M range. The maxima have decreased in October 1991 from October 1990, but were lower in May 1991 after the spring rains than in either of the October periods. This indicates continuing input of DDTs from terrestrial drainage or from marina usage. The pesticide profile is thus not as encouraging as the PCB scenario.

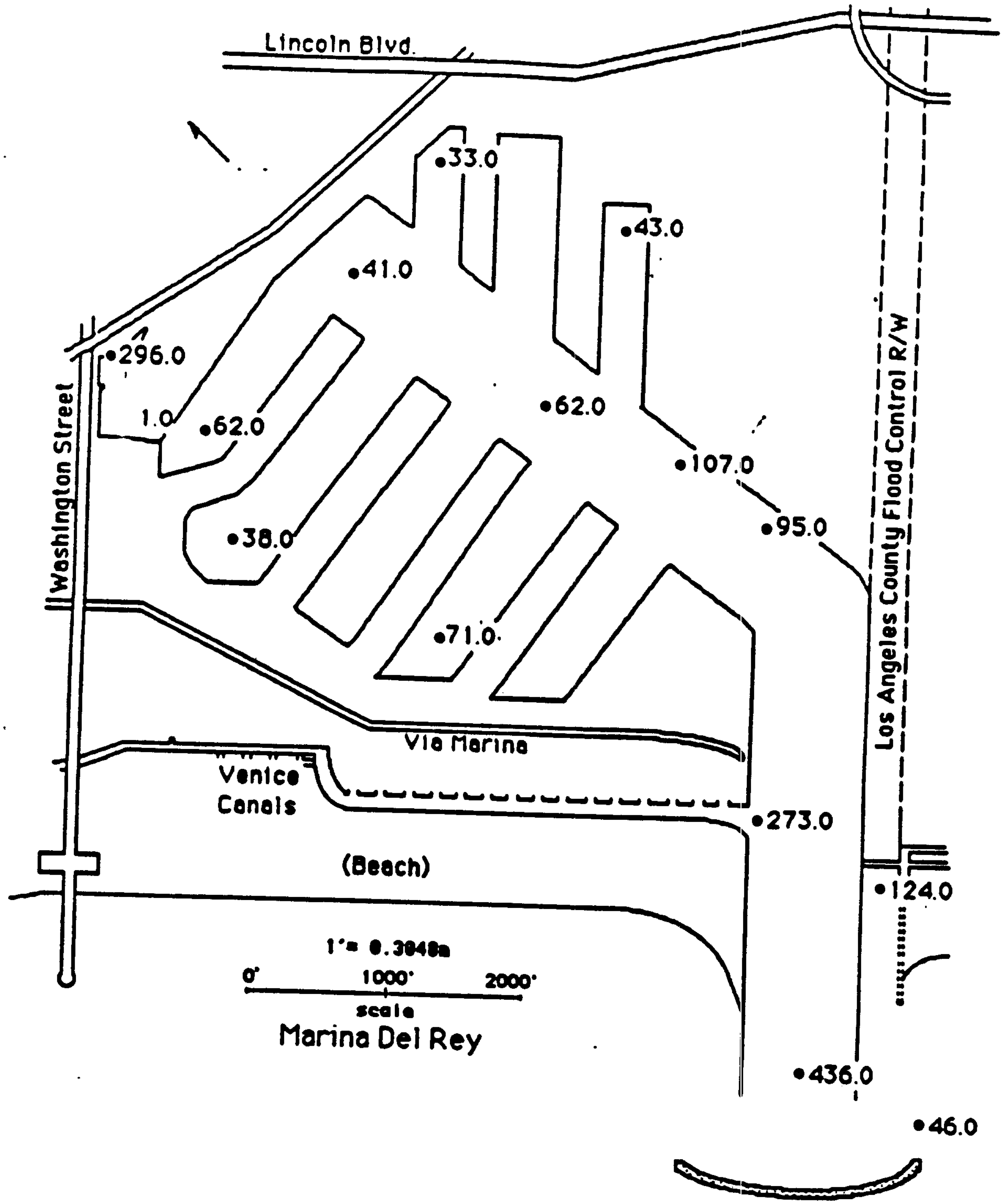

Figure IV.22. Chlordane in ug/kg dry wt (ppb) in sediment. October 1991.

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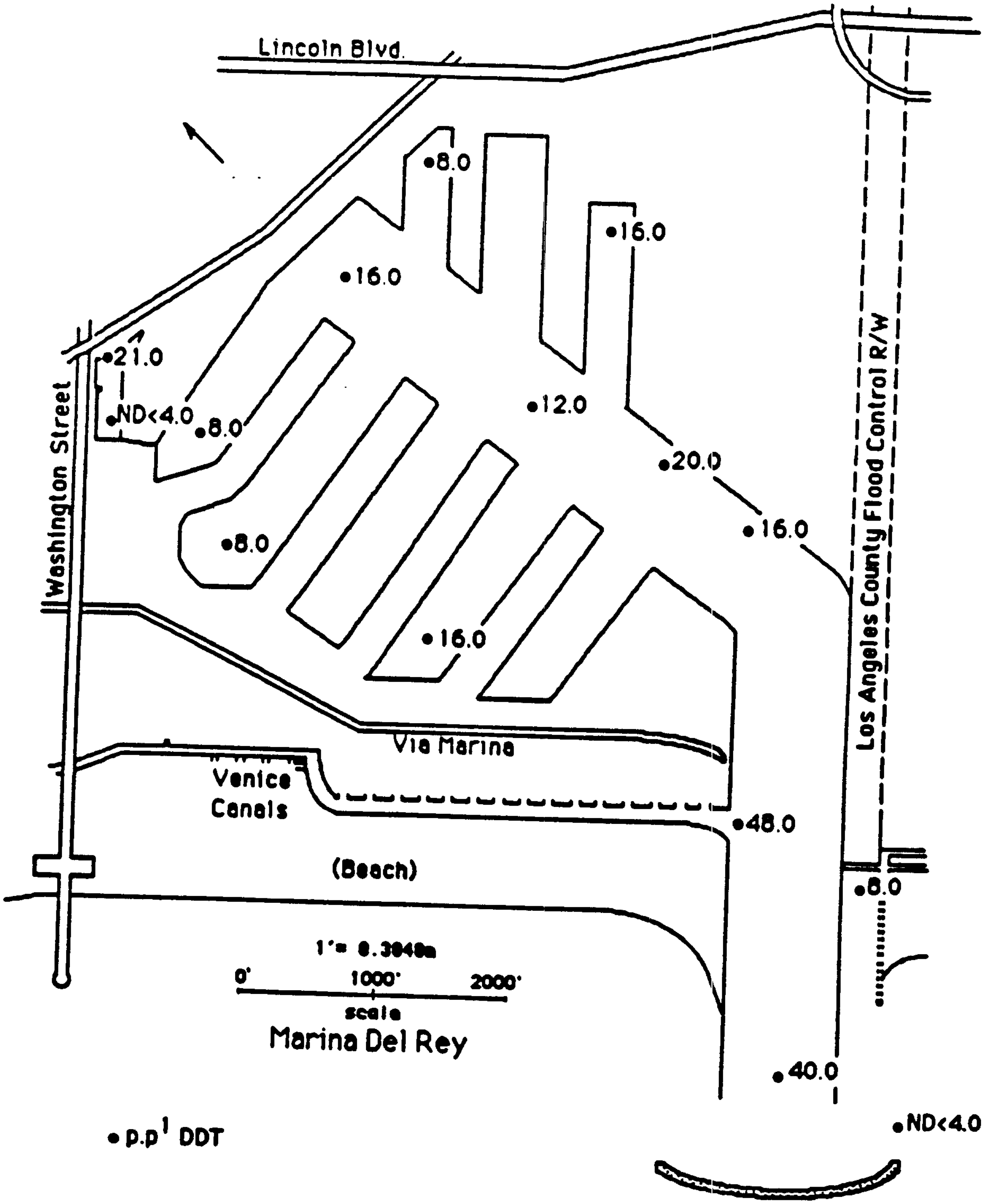

Figure IV.23. p.p'DDT ug/kg dry wt (ppb) in sediment. October 1991.
(< = below limits of detection)

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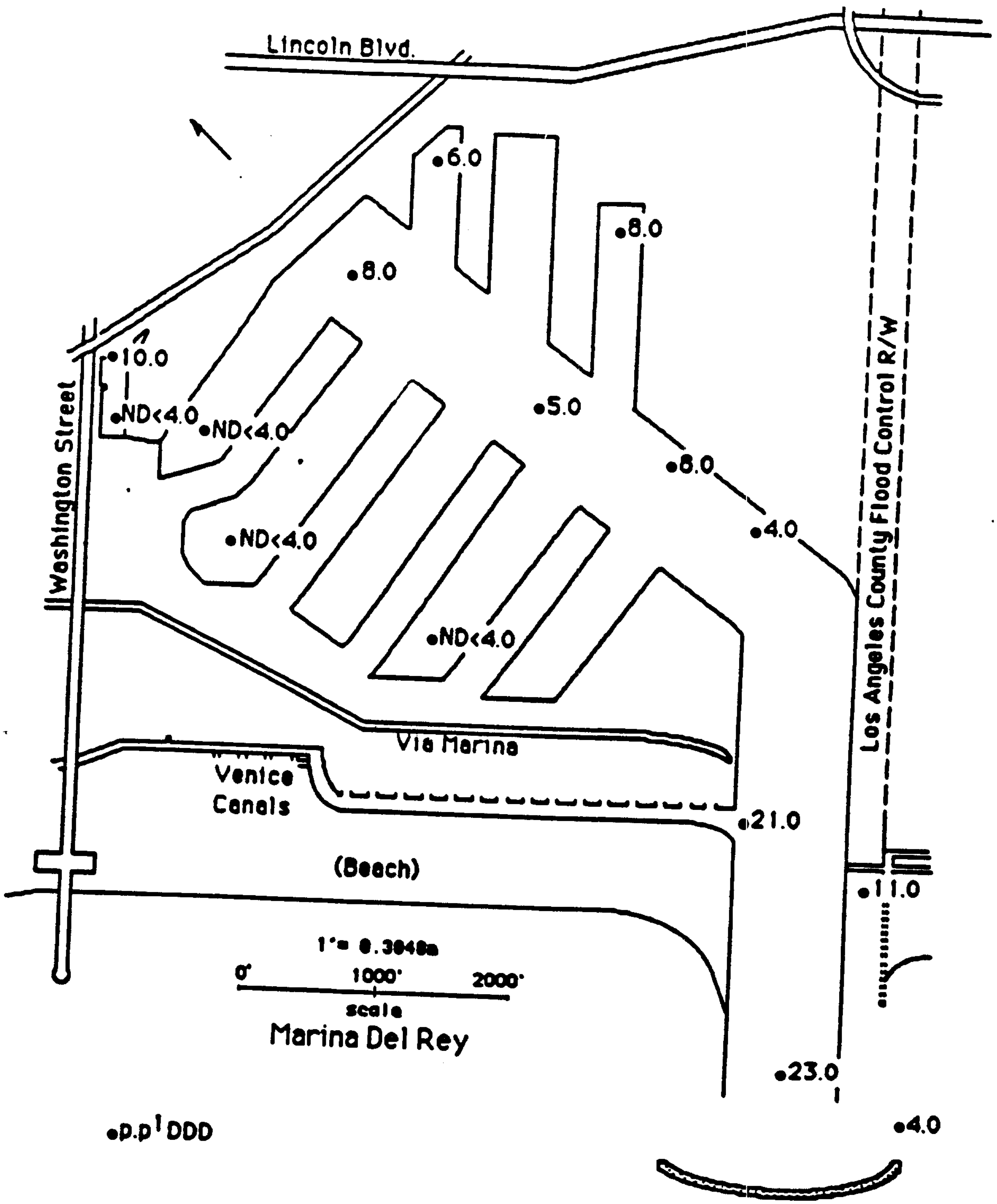

Figure IV.24. p.p'DDD ug/kg dry wt (ppb) in sediment. October 1991.
(< = below limits of detection)

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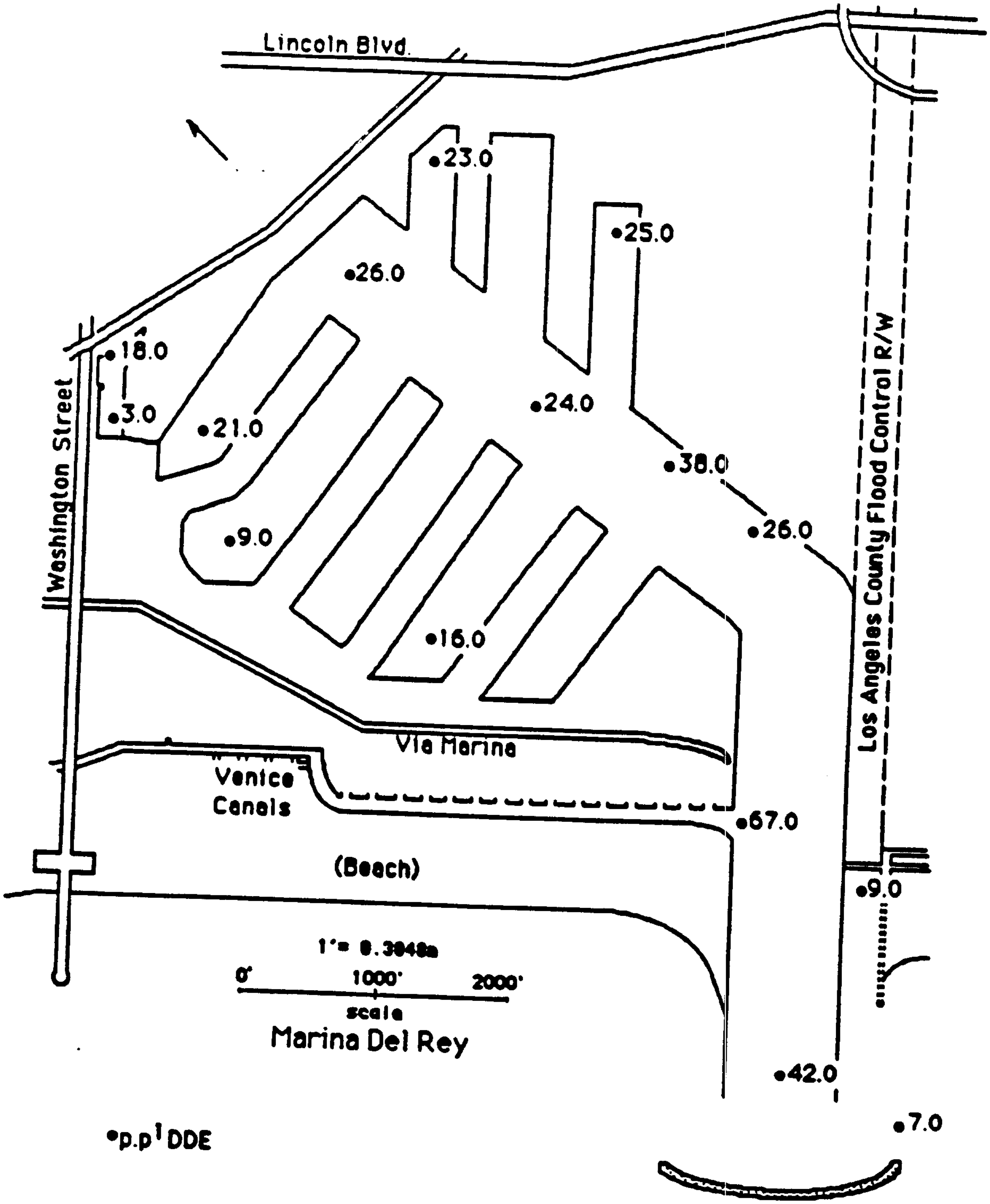

Figure IV.25. p.p'DDE ug/kg dry wt (ppb) in sediment. October 1991.

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V. FISH TISSUE ANALYSIS FOR PCBs, DDTs AND CHLORDANE

INTRODUCTION

Fish living in the Southern California Bight are exposed to a variety of contaminants at some locations, and the potential exists for them to accumulate pesticides and chlorinated hydrocarbons that are considered to be hazardous to human health at certain concentrations. Exposure varies since some species are widely ranging, while others are limited to small areas, some are water column fish while others are bottom feeders that are exposed more closely to contaminated sediments, and some ingest prey or browse on contaminated biota, accumulating substances through the food web. Some species seem not to accumulate contaminants, or are able to eliminate them metabolically.

There is often a wide range of variation in the body burden of accumulated contaminants among individuals of the same species that do bioaccumulate (e.g., Lee, 1984). Body burden also varies with the season. Fat soluble pesticides and chlorinated hydrocarbon contaminants are deposited in fats in the body tissue or stored in the liver, potentially damaging the liver; when fats are mobilized for supplying eggs with yolk, contaminants enter the eggs, potentially damaging eggs or larvae but depurating the adult fish of its body burden to some extent (Cross, 1986; Cross and Hose, 1988).

Since fish are usually gutted before consumption and liver and gonads not generally eaten, the public is protected from higher concentrations that occur in the organs. Birds that pursue the offal from fish cleaned by fishermen on the dock may receive a high dose of pesticides or PCBs, as might the family cat that dines on scraps.

The bight is known to have been contaminated with pesticides, such as Chlordane and DDTS, and polychlorinated biphenyls (PCBs) which were released into the ocean largely by industrial disposal through storm drains, sewage outfalls or ocean dumping (Chartrand et al., 1985), or in runoff via rivers and storm drains. Manufacture and/or use of these chemicals has been greatly restricted or banned, but some release continues, legally

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chemicals are very slow to degrade in the environment.

The California Environmental Protection Agency (CEPA) Office of Environmental Health Hazard Assessment (OEHHA) issued advisories in 1991 which suggest limiting consumption of eight species of fish caught at various locations between Pt. Dume and Newport Pier, as listed in Table V.1. OEHHA did not give the actual concentrations found in tissues nor the extent of variation in the 4,000 samples from 15 species taken from 24 locations.

Marina del Rey was not among the areas listed for restriction although the same species of fish listed by CEPA occur in the marina. Their conclusion is consistent with conclusions reached by USC Harbors Environmental Projects, based on specimens collected in January-February 1990, October-November 1990, May 1991 (Soule et al., 1991, 1992) and 2 November 1991, reported herein.

METHODS

Only one small survey of fish body burden could be conducted in the fall of 1991 due to budgetary constraints, but results offered good comparison to previous surveys. Fish were collected at the public dock in Fishermen's Village, purchased from anglers on 2 November 1991. Fish were iced in the field and returned to the USC Fish Harbor Laboratory where they were gutted. Samples of muscle tissue and combined samples of liver and gonad were wrapped separately for each fish specimen, labeled and frozen. Chemical analyses were performed by Associated Laboratories in Orange, California according to EPA approved methods. Nine fish of six species were analyzed for both body tissue and liver/gonad content, a total of 18 specimens.

In the initial survey in January 1990, the focus was on contamination of fish species by polychlorinated biphenyls (PCBs) that had been identified for the first time in the marina in the fall of 1989 (Soule et al., 1991), causing concern for both human health and also for the ecosystem. DDTs were added to the scope at that time because there was no information on body burden of the pesticide complex that has been so prominent in fish off

Table V.1. California Environmental Protection Agency recommended limitations of fish consumption published summer of 1991.

Site	Fish Species	Recommendations*
Newport Pier	Corbina	One meal every two weeks
Redondo Pier	Corbina	One meal every two weeks
Belmont Pier	Surfperch	One meal every two weeks
Pier J (Queen Mary)	Surfperch	One meal every two weeks
Malibu Pier	Queenfish	One meal a month
Short Bank	White croaker	One meal every two weeks
Malibu	White croaker	Do not consume
Point Dume	White croaker	Do not consume
Point Vicente	White croaker	Do not consume
Palos Verdes (Northwest)	White croaker	Do not consume
White's Point	White croaker	Do not consume
	Sculpin Rockfish Kelp bass	One meal every two weeks**
Los Angeles and Long Beach Harbors (esp. Cabrillo Pier)	White croaker	Do not consume
	Queenfish Black croaker Surfperch	One meal every two weeks
Los Angeles and Long Beach Breakwater (ocean side)	White croaker Queenfish Surfperch Black croaker	One meal a month
Horseshoe Kelp	Sculpin White croaker	One meal a month**

NOTE: in the following locations, no restrictions are recommended: Marina del Rey; Huntington Beach; Fourteen Mile Bank; Laguna Beach; Redondo Beach; Emma/Eva oil platforms; Catalina (Twin Harbors); Santa Monica Pier; Venice Beach; Venice Pier; Dana Point.

* This category represents maximum recommended frequency; one meal is about six ounces. ** Consumption recommendation is for all species combined.

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Palos Verdes due to emissions from Montrose Chemical Co. through the Los Angeles County Sanitation system, and in pelagic fish elsewhere due to ocean dumping in the bight. Chlordane was added in the fall of 1990 (Soule et al., 1991) because there is increasing concern internationally about the effects of this long lasting pesticide complex (Mearns et al., 1991). Twelve species of fish were represented in 32 specimens of body tissue and of three liver/gonad samples in that survey.

Other surveys were made on 20 October and 3-4 November 1990, when 21 specimens of body tissue and 13 of liver/gonad from 10 species were collected for analysis, and on 25 May 1991, when 14 specimens each of body tissue and of liver/gonad from eight species were collected.

RESULTS AND DISCUSSION

The number of species and specimens available at the dock in November 1991 was very limited; only one specimen each of *Paralichthys californicus* (California halibut), *Phanerodon furcatus* (white surfperch), and *Xenistius californiensis* (salema) was found, and two each of *Seriphus politus* (queenfish), *Sphyraena argentea* (California barracuda) and *Atherinops californiensis*, jacksmelt, were collected. Results are presented in Table V.2. *Phanerodon* had not been obtained in previous pesticide-chlorinated hydrocarbon surveys and is a wide ranging species. *Xenistius* was found in the fall 1990 chemical survey, *Atherinopsis* was collected in all but the fall 1990 chemical survey, and the other species mentioned were collected in all chemical survey periods. For incidence of these species in diver surveys, and trawl, gill net, plankton net and beach seine in the marina see Table VIII.8, Chapter VIII in this volume.

The pesticides Aldrin, Alpha BHC, Lindane, Heptachlor, Heptachlor Epoxide, Beta BHC, Dieldrin, Endrin, Toxaphene, o.p'DDT and o.p'DDD were not detected, as has been true in previous surveys. Of the chlorinated hydrocarbons, no Aroclor 1016, 1221, 1232, 1242, 1248 or 1254 were detected (See Table V.2 footnote for limits of detection).

Table V.2. Fish tissue body burdens of pesticides and PCB Aroclor 1260, ug/kg (ppb) collected from fishing docks, Fishermans Village 2 November 1991.

Specimen Number	Species	Chlordane	PCB1260	p.p'DDT	p.p'DDD	p.p'DDE	o.p'DDE
06	*Atherinops californiensis* (Jacksmelt)						
	body tissue	—.—	—.—	6.0	5.0	190.0	8.0
	liver/gonad	—.—	—.—	7.0	6.0	460.0	10.0
07	*Atherinops californiensis*						
	body tissue	—.—	—.—	5.0	—.—	98.0	5.0
	liver/gonad	—.—	—.—	9.0	5.0	9.0	9.0
05	*Paralichthys californicus* (California halibut)						
	body tissue	160.0	150.0	12.0	9.0	140.0	17.0
	liver/gonad	270.0	690.0	120.0	88.0	1,320.0	100.0
03	*Phanerodon furca...* (White surfperch)						
	body tissue	2,010.0	150.0	6.0	31.0	87.0	—.—
	liver/gonad	1,580.0	—.—	66.0	62.0	420.0	87.0
02	*Seriphus politus* (Queenfish)						
	body tissue	—.—	220.0	15.0	17.0	720.0	66.0
	liver/gonad	240.0	—.—	210.0	100.0	3,160.0	340.0
04	*Seriphus politus*						
	body tissue	77.0	180.0	9.0	15.0	510.0	56.0
	liver/gonad	180.0	—.—	63.0	44.0	1,240.0	120.0
08	*Sphyraena argentea* (California barracuda)						
	body tissue	—.—	—.—	—.—	—.—	67.0	6.0
	liver/gonad	70.0	—.—	22.0	10.0	520.0	36.0
10	*Sphyraena argentea*						
	body tissue	—.—	—.—	—.—	12.0	440.0	41.0
	liver/gonad	110.0	290.0	100.0	55.0	2,730.0	250.0
01	*Xenistius californiensis* (Salema)						
	body tissue	—.—	150.0	9.0	11.0	310.0	23.0
	liver/gonad	110.0	—.—	63.0	45.0	960.0	89.0

Limits of Detection (—.— = none detected)	Body Tissue	Liver/Gonad
None Detected:		
Aldrin, Alpha BHC, Lindane, Heptachlor, Heptachlor Epoxide	<0.001	<0.10
Beta BHC, Dieldrin, Endrin, Toxaphene	<0.002	<0.20
o.p'DDT	<0.004	<0.10
Aroclors 1016, 1221, 1232, 1242, 1248, 1254:		
Specimen No. 01,04,05	<0.02	<0.10
06,07,08,10	<0.02	<0.20
02,03	<0.02	<0.50
Detected:		
Chlordane	<0.005	<0.05
p.p'DDD	<0.004	<0.005
o.p'DDE	<0.005	<0.087
Aroclor 1260	<0.02	(see Aroclor specimen numbers above)

Chlordane (Synthetic polycyclic hydrocarbon)

Levels of Chlordane in *Atherinopsis* muscle were below limits of detection in the fall survey, whereas they had been high in liver and gonad in the spring 1991 survey, before their spawning season, apparently. The level in body tissue of *Paralichthys* was about the same as in previous samples but the level was lower in liver/gonad tissue than it was in the fall of 1990 or the spring of 1991 (Soule et al., 1992). In *Seriphus*, Chlordane levels in November 1991 were similar to some in October 1990 and May 1991, but levels in liver/gonad tissue were an order of magnitude lower than in one specimen in October 1990, perhaps indicative of prespawning condition. In *Sphyraena*, levels were much lower in fall 1991 than in the previous October survey, when one liver/gonad had 3,000 ppb, and the *Xenistius* specimen also had lower values.

In contrast, the single species of *Phanerodon furcatus* that has been taken in any of these surveys had very high levels in both muscle tissue (2,010 ppb) and liver/gonad (1,580 ppb). The species is not seen frequently in the marina, but has been present in the warm water year surveys (Table VIII.8).

Levels detected in marina fish seem to be an order of magnitude higher than in the local Regional Water Quality Control Board survey in 1985 of mussels and fish, but similar to levels found in NOAA surveys in 1984 and 1984 (Mearns et al., 1991), although the marina data base is small.

The mean Chlordane in marina fish muscle and liver/gonad combined was higher at 255 ppb (N=18) in the fall of 1991 than in May 1991, when it was 207.5 ppb (N=28) after the spring reproductive period. However, both were lower than the mean in the fall of 1990, when the mean was 618 ppb (N=34), and some liver/gonad tissue had very high levels. Whether this is an indication of accumulation for a later reproductive season or a genuine change is not known, but mean sediment levels for the two fall periods were almost identical (Tables IV.11 and 12, this volume). The mean level in body tissue decreased from 143.5 ppb in October 1990 to 54.3 ppb in May 1991 but increased to 249.7 ppb in

November 1991. In the same periods, the liver/gonad tissue had 1384.6 ppb, 360.7 ppb and 284.4 ppb respectively.

Table V.3 shows the mean levels of pesticides and chlorinated hydrocarbons in the four surveys. It must be recognized, however, that variation in species and in stage of reproduction make it difficult to identify trends.

Table V.3. Mean levels of pesticides and chlorinated hydrocarbons in fish muscle (M) and liver/gonad (L/G) tissue.

	1990 25 Jan / 2 Feb		1990 20 Oct / 3-4 Nov		1991 25 May		1991 2 Nov	
	M N=29	L/G N=3	M N=21	L/G N=13	M N=14	L/G N=14	M N=9	L/G N=9
Aroclor1260	150.8	1972.7	58.6	223.1	ND	495.7	94.4	108.9
Chlordane	NA	NA	143.5	1384.6	54.3	360.7	249.7	284.4
p.p'DDT	31.7	132.7	12.0	90.1	17.0	90.7	6.9	73.0
p.p'DDD	43.0	201.7	ND	ND	7.8	60.9	11.1	46.1
p.p'DDE	247.3	2866.3	170.6	2788.7	233.4	1425.0	248.7	1202.1
o.p'DDE	ND	ND	ND	ND	29.0	173.6	24.7	445.8
total DDTs	322.0	3200.7	182.6	2878.8	435.3	1750.2	327.3	1767.3

NA = not analyzed ND = none detected (in ppb N = number of specimens)

PCBs (Polychlorinated biphenyls)

Of the PCBs, only Aroclor 1260 has been detected in the fish surveys. Body tissue levels in January 1990 (Soule et al., 1991) ranged from 15 ppb to 298 ppb, the latter occurring in *Paralichthys* (halibut), and in October 1990 ranged from below the limits of detection to a maximum of 230 ppb, in *Umbrina roncador* (yellow fin croaker), while it was below the limits of detection in body tissue in all 14 specimens in May 1991 (Soule et al., 1992). In liver/gonad samples the Aroclor 1260 levels were much higher than in tissues, up to a maximum of 4,270 ppb in January 1990 in *Synodus leucoceps* (California lizardfish). In October 1990, the range in liver/gonad tissue was from below limits of detection to 610 ppb, in *Seriphus* (queenfish) and 820 ppb in *Paralichthys*. Although there was no PCB detected in 16 of the total of 28 specimens (57%), including two liver/gonad tissues, other liver/gonad tissue ranged up to 1,010 ppb in *Myelobatis* (bat ray) and 6,790 ppb in one *Paralichthys*, apparently in prespawning condition.

In November 1991, both muscle and liver/gonad PCB levels were higher than in October 1990 in *Paralichthys* at 150 ppb and 690 ppb for the respective tissues, while in some other species liver/gonad levels were lower than in October 1990 or May 1991. However, in the fall of 1990 the body tissue levels in one *Seriphus* was 140 ppb but PCB was absent in the other, while one liver/gonad contained 140 ppb and was not detectable in the other, probably indicating depletion by reproduction. In May 1991, the *Seriphus* specimens had no detectable PCB in either tissue. In November 1991, two specimens of *Seriphus* had 180 and 220 ppb in body tissue but none in liver/gonad tissues. The maximum in November 1991 was 290 ppb in lever/gonad tissue of *Sphyraena* (barracuda).

The mean level of Aroclor 1260 in all tissues in January 1990 was 321.6 ppb, with the mean muscle tissue 150.8 ppb while the liver mean of three specimens was 1972.7 ppb. In the fall of 1990 the mean for all samples was 121.5 ppb, with a mean of 58.6 ppb in muscle and 223.1 ppb in liver/gonad. In the spring of 1991 the mean of all samples rose to 247.9 ppb, with none detected in muscle and 495.7 ppb in liver/gonad tissue, after which, in the fall of 1991, the mean of all tissues decreased to 90.7 ppb, but there was a mean of 94.4 ppb in muscle and 108.9 ppb in liver/gonad tissue, indicating a post spawning condition with storage in muscle tissue.

From the mid-1970s to the mid-1980s, data from the bight showed some extremes in fish tissue from 8.0 ppb in pelagic anchovy up to 14,815 ppb and in liver up to 162,072 ppb (Mearns et al., 1991). There are difficulties in comparing results due to differences in analytical techniques, especially in some of the earlier data, but it appears that there has been a large decrease in the PCBs in the bight.

The U.S. Food and Drug Administration limit for PCBs in edible tissue of 2.0 ppm

(2,000 ppb) far exceeds the mean of 90.7 ppb in 18 specimens (9 tissue, 9 liver/gonad), or 170 ppb in the six of nine fish body tissue samples in which PCB was detected. There is movement toward lowering the action level but marina fish, gutted and cleaned would still be judged safe even if an order of magnitude decrease to 0.2 ppm (200 ppb) were to be established by regulatory agencies.

<u>DDTs (Dichlorodiphenyltrichloroethane)</u>

In January 1990, one specimen of *Genyonemus lineatus* (white croaker) had no detectable body tissue DDT, DDD or DDE, one *Myliobatus californica* (bat ray) had no detectable DDT and one *Hyperprosopon argenteum* (walleye surfperch) had no DDE; all others of the 34 samples had all three forms. The maximum in body tissue was 1,665 ppb DDE in *Sphyraena argentea* (barracuda) and the maximum in liver/gonad was 6,806 ppb in the same *Synodus leucoceps* (lizardfish) that had the highest Aroclor 1260.

In the fall 1990 survey, no p.p'DDD or o.p'DDE were detected, and about half of the specimens had no detectable p.p'DDT, but 33 of 34 samples contained p.p'DDE. Of the seven specimens containing body tissue p.p'DDT, the mean concentration was 36 ppb, or if the total of 21 specimens are included, the mean is 12 ppb. Of the nine specimens containing liver/gonad p.p'DDT, the mean was 196.9 ppb, or 90.1 ppb for the total of 13 liver/gonad specimens. The mean body tissue level of p.p'DDE in fall 1990 was 179 ppb in the 20 of 21 fish sampled, or a mean of 170.6 ppb in the 21. All 13 liver/gonad tissues had p.p'DDE, with a mean of 2,788.7 ppb and a range from 16 ppb to 10,800 ppb (Table V.3).

In May 1991, following the spring rains, 11 of 28 specimens (39%) contained p.p'DDD, ranging where detected from 4.0 ppb in *Genyonemus* (white croaker) body tissue to 440 ppb in an *Atherinopsis* (jacksmelt) liver/gonad sample. The mean concentration in the seven samples having muscle p.p'DDD was 15.6 ppb, or the mean for all samples was 7.8 ppb. In liver/gonad tissue, the mean for the four contaminated samples was 213 ppb while it was 60.9 ppb for the 14 total samples.

The p.p'DDT concentrations in May 1991, found in 14 of 28 samples (50%), ranged from 4.0 ppb in *Genyonemus* (white croaker) body tissue to 430 ppb in *Paralichthys* (halibut) liver. The mean p.p'DDT concentration in the eight out of 14 muscle tissue specimens contaminated was 17 ppb, or for all 14 specimens, 9.7 ppb. In liver/gonad tissue the mean was 211.6 ppb in the six contaminated specimens, or 90.7 ppb in all 14 specimens.

The p.p'DDE in May 1991 occurred in all but five of 28 samples (82%), with concentrations, where detected, ranging from 27 ppb in *Paralichthys* (halibut) body tissue to 3,370 ppb in *Atractoscion* (white sea bass) liver/gonad; seven of the liver/gonad samples had concentrations above 1,000 ppb. The mean concentration in 10 contaminated muscle samples was 326.7 ppb, or 233.4 ppb in all 14 samples.

Not detected previously, the o.p'DDE found in May 1991 occurred in 18 of 28 samples (64%) in concentrations, where detected, that ranged from 4.0 ppb in *Paralichthys* (halibut) to 420 ppb in *Sphyraena* (barracuda). The mean in ten muscle tissue specimens contaminated was 40.6 ppb, or 29.0 ppb for all 14 specimens. Liver/gonad tissue had a mean of 347 ppb for seven contaminated specimens, or 173.6 ppb for all 14 specimens.

In November 1991, after the dry season, DDTs were more widespread but maximum concentrations were lower; p.p'DDT was found in 16 of 18 samples (88.9%), with concentrations where detected ranging from 5.0 ppb in jacksmelt body tissue to 210 ppb in *Seraphus* (queenfish) liver. The mean muscle tissue level among seven contaminated specimens out of nine total was 8.9 ppb, or 6.9 ppb for all nine specimens. All nine liver/gonad tissue samples were contaminated with a mean of 73.0 ppb.

The p.p'DDD also occurred in 16 of 18 specimens (88.9%), with concentrations ranging from 5.0 ppb in *Atherinops* (jacksmelt) both muscle tissue and liver/gonad to a maximum of 100 ppb in *Seriphus* liver/gonad. The mean in muscle tissue in seven contaminated specimens out of nine is 14.3 ppb, or 11.1 ppb in all nine specimens. In liver/gonad tissue, all nine specimens were contaminated, with a mean of 46.1 ppb.

Eighteen of 18 samples (100%) contained p.p'DDE, with concentrations ranging from 9.0 ppb in *Atherinops* liver/gonad tissue to 3,160 ppb in *Seriphus* liver/gonad tissue, with four of 18 samples containing more than 1,000 ppb. The mean muscle concentration 248.7 ppb while the mean of liver/gonad tissue was 1,202.1 ppb.

Not found in sediments, o.p'DDT first appeared in fish in the May 1991 survey. In October 1991, the o.p'DDE occurred in 17 of 18 specimens (94%), in concentrations ranging from 5.0 ppb in *Atherinops* body tissue to 340 ppb in *Seriphus* liver/gonad tissue. The mean for all 18 specimens was 70.2 ppb. For eight out of nine muscle specimens the mean was 27.8 ppb, or 24.7 ppb for all nine specimens, while the mean for liver/gonad tissue was 445.8 ppb where all nine were contaminated.

Mearns et al. (1991) summarized total DDTs (tDDTs) measured in white croaker, a bottom feeder, off Palos Verdes in the 1975-1977 period which had a mean tissue concentration of 39,200 ppb and a range of 5,230 ppb to 176,400 ppb; in 1980 the mean was 7,630 ppb with a range of 3,570 to 13,100 ppb. Fish collected offshore by commercial fishermen in 1979 contained from 40 to 480 ppb tDDTs, suggesting a general contamination with DDTs at relatively low levels; DDTs are apparently recycled in the environment rather than biodegraded completely.

Total DDTs in January/February 1990 were 322.0 ppb in 29 muscle tissue specimens and 3200.7 ppb in three liver/gonad specimens. In October/November 1990 the mean for muscle was 182.6 ppb in 21 muscle tissue specimens and 2,878.8 ppb in 13 liver/gonad specimens. In May 1991 in 14 muscle tissue specimens the mean tDDTs was 279.9 ppb and in 14 liver/gonad specimens the mean was 1750.2 ppb, with by far the largest amount being composed of p.p'DDE. In November 1991, tDDTs had a mean in muscle of 327.3 ppb in nine samples and 1,767.3 ppb in liver/gonad tissue. Total DDTs cannot be said to be declining, although it appears that p.p'DDT and p.p'DDD have declined while the incidence of DDEs has stayed about the same or increased.

CONCLUSIONS

There is a very large range of variation in pesticide concentrations between species, and between individuals of the same species, those with high fat (lipid) content in muscle contain much higher levels than those that have low lipid content. There are also seasonal differences in muscle content, depending on whether lipids are stored in the liver or being mobilized from muscle tissue to gonads for reproduction, which may result in a three to four orders of magnitude or more differences in some species between concentrations in muscle and in lever/gonad tissue. Generally, the difference is closer to one order or magnitude in marina specimens.

Aroclor 1260 seems to have a decreasing trend, although it was absent in 12 muscle tissue specimens in May 1991 but reappeared in the nine specimens sampled in November 1991.

Chlordane showed no clear trend, with increases in muscle tissue but decreases in liver/gonad tissue.

The levels of p.p'DDT and p.p'DDD appeared to be decreasing, while first appeared in May 1991 and has increased, o.p'DDE and p.p'DDE appears to fluctuate. This suggests that more of the metabolites are being recycled as compared to new DDT being assimilated. Total DDTs, however, cannot be said to be declining.

While the marina levels of pesticides in muscle are below FDA Action levels for human consumption, the levels in liver/gonad are undoubtedly harmful to fish physiology and reproduction. Also, when invertebrates, fish and birds feed on contaminated live or dead fish, they consume the organs as well as the muscle and thus accumulate much higher concentrations than would humans consuming cleaned and gutted fish. Thus it is important to the ecological system to control as much as is possible the continuing input of these harmful chemicals into the marina.

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VI. BACTERIOLOGY

PUBLIC HEALTH

Public health standards for enteric bacterial contamination are important to a marina even though body contact with waters of the marina is not implicit in boating usage. However, the marina beach in Basin D is a body contact area, and boat owners and maintenance persons must also be protected from fecal bacterial exposure in marina waters. The Los Angeles County Depart :nt of Health Services is responsible for monitoring the beach area and for following u, n reported contamination from sewage line leakage, breaks or overflows.

Because water percolates into sewer lines during heavy rainfall periods, it is necessary at times for flow to be diverted into overflow facilities to protect the treatment plants from being overwhelmed. The City of Los Angeles Hyperion Plant Jackson Avenue facility is one such location that sometimes overflows into Ballona Creek during major storms, which could contaminate marina waters, although increased holding capacity built in recent years has ameliorated that emission.

Coliform bacteria occur everywhere naturally in soil and are washed down storm drains. Fecal coliforms are normal inhabitants of the intestinal tracts of warm blooded animals such as mammals, birds and some fish, and cold blooded vertebrates including other fish species. For many years coliforms were considered harmless indicators of fecal contamination which might include more serious pathogens such as those causing typhoid fever and dysentery. Now it is known that they can cause infections and diarrhea. Fecal coliforms are supposed to be more specific as evidence of human fecal wastes and the enterococcus bacteria were supposed to be more specific of recent human contamination because they die off faster on exposure to the air or receiving waters. These premises have not proven to be accurate, because fecal coliforms and enterococci have been also found in birds and other animals, but public health personnel feel that the suite of tests give a better picture of what may be occurring in the environment (R. Kebabjian, pers. comm.).

Birds are a major source of bacterial contamination on beaches, vessels and docks, with the feces containing very high counts of the enteric organisms. To control contamination, it was necessary to string monofilament or polypropylene lines between poles near marina beach to deter seagulls from roosting on the sands, particularly in the off season when few people were present (Soule and Oguri, 1989; Charness and Smith, 1990).

Fecal wastes can reach the marina from a number of sources including dogs, cats, horses and wild animals when wastes are washed into storm drains and down the channels, or when high tides sweep the breakwaters where people fishing have no sanitary facilities, or where visitors abandon disposable diapers. Some wastes may be illegally released from vessel heads or tanks may be bypassed or leak. Land which drains into Oxford Street basin receives street drainage, including rinsings from trash trucks, and hosts impromptu games and picnics where no sanitary facilities are available.

It is rainfall that produces the greatest rise in coliform and enterococcus counts in the marina, flushing storm drains and streets. It is essential that body contact with marina waters be avoided during storms and for several days afterward.

STANDARDS

Total Coliforms

Federal and County public health standards for total coliforms in recreations waters are that no single sample, when verified by a sample repeated in 45 hours, shall exceed 10,000 MPN (most probable number) per 100 ml. If daily monitoring were done, not more than 20 percent of the samples could exceed 1,000 MPN per 100 ml, but sampling is not normally done with this frequency unless there is a high contamination episode.

Fecal Coliforms

Standards for fecal coliforms provide that a minimum of five samples for any 30 day period shall not exceed the geometric mean of 200 per ml, or that not more than 10 percent of samples within a 60 day period may exceed 400 MPN per 100 ml. Since our monitoring is monthly, and the County Department of Health Services monitors irregularly, we have applied the 400 MPN per 100 ml as the standard for evaluating our data.

Enterococcus

Enterococcus bacteria are part of the *Streptococcus* species that occur in warm blooded animals, but were thought not to be present in farm animals such as cattle, horses and chickens, although they are not exclusive to humans. Later tests have shown their presence in fresh seagull feces, but they apparently die off rapidly. The enterococcus standard has been a geometric mean of 35 colonies (C) per 100 ml, or that no single sample shall exceed 100 C per ml. The State Water Resources Board Ocean Plan (1990) recommended a standard of a geometric mean of 24 C per ml for a 30 day period or 12 per ml for a six month period but this has not been implemented as a standard.

RESULTS AND DISCUSSION

Violations in the standards that were found in monthly monitoring are indicated in Table IV.1. With only two exceptions, violations within the marina occurred on days when it rained within a few days prior to the cruise or during it.

Table VI.1. Violations of public health standards, October 1991-June 1992

	Stations in Marina			Stations Outside Marina		
	Coliforms Total	Coliforms Fecal	Enterococcus	Coliforms Total	Coliforms Fecal	Enterococcus
October				22	13,22	13
November		11		22		
December		20				12
January[1]	2	2,3,11,19,20	2,10,20	1,13,22	1,12,13,22	1,12,13,22
February[2*]		20		1,12,22	1,12,22	1,12,22
March[1]	10,20	5,10,11,20	20,25	13,22	12,13,22	13,22
April[1]	2,3,4,8,10	2,3,4,6,8, 11,18,19,20	4,8,19	1,12,13,22	1,12,13,22	1,12,13
May					22	
June				22	22	

[1] rain prior to sampling day. [2] rain during sampling.
* no sample at Sta. 7,9,11 due to Life Guard vessel emergency call.

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Since two stations that are monitored in Ballona Creek and two in Oxford Street flood control basin are not within the marina, it should be noted that most of the excessive counts were recorded there. At the same time, however, violations occurred at marina stations during the rainy periods in January, February, March and April. Oxford Street basin was in violation, either at Station 13 or 22, in all months. There were only two violations in the marina in the nine months surveyed which did not occur during rainy periods, one in November at Station 11 and one in December at Station 20. Whether these indicate vessel violations or strategic bird droppings is unknown. We have observed that a single gull dropping in water can visibly contaminate a cubic meter of water within seconds.

Complete monitoring data are presented in Tables VI.2 through VI.6, along with the minima, maxima and averages, and the number of samples included, with the standard deviation. Figures VI.1 through VI.9 illustrate the monthly profiles through the marina for the three parameters, along with lines indicating the standards applied.

CONCLUSIONS

The principal sources of contamination in the marina are associated with influx of material during rainy periods, and body contact with waters should be avoided during rains or for a few days afterward. There is little or no evidence that boat owners are violating regulations, although monitoring would have to be much more frequent and extensive to catch occasional violations. If consistent leakage or flushing occurred from a vessel, it would probably be evident; in the past a vessel suspected of such activity was noted because of consistently higher levels of coliforms, and ammonia and other nutrients at a station beside it.

Violations in the marina were much reduced from the 1990-1991 period (Soule et al., 1992). As has been emphasized previously, the Oxford Street flood control basin is almost always contaminated with high fecal coliform counts, as well as the trace and heavy metal contaminants discussed elsewhere in this report. The Los Angeles County Flood Control District has been informed of this contamination but has no plans for amelioration.

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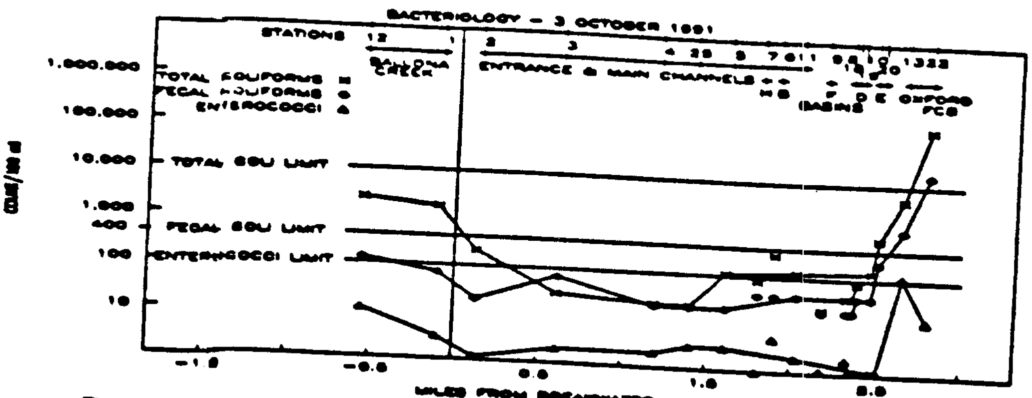

Figure VI.1. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 3 October 1991. Public health limits are indicated by transverse lines.

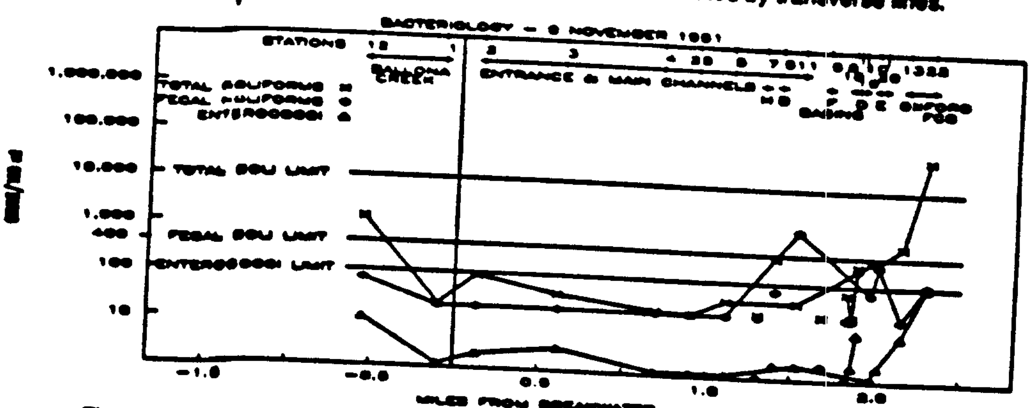

Figure VI.2. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 5 November 1991. Public health limits are indicated by transverse lines.

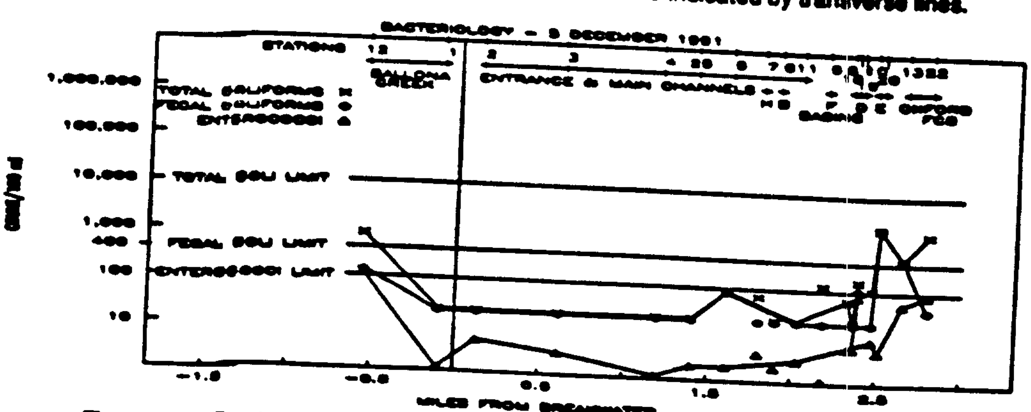

Figure VI.3. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 5 December 1991. Public health limits are indicated by transverse lines.

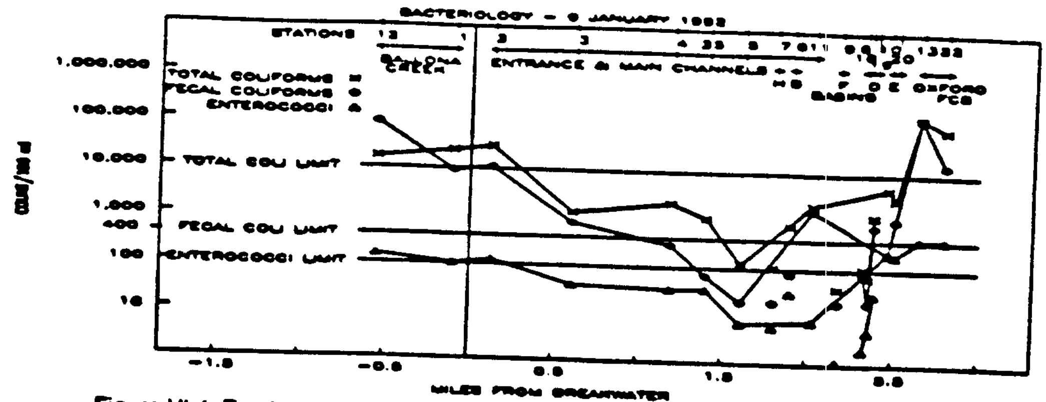

Figure VI.4. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 9 January 1992. Public health limits are indicated by transverse lines.

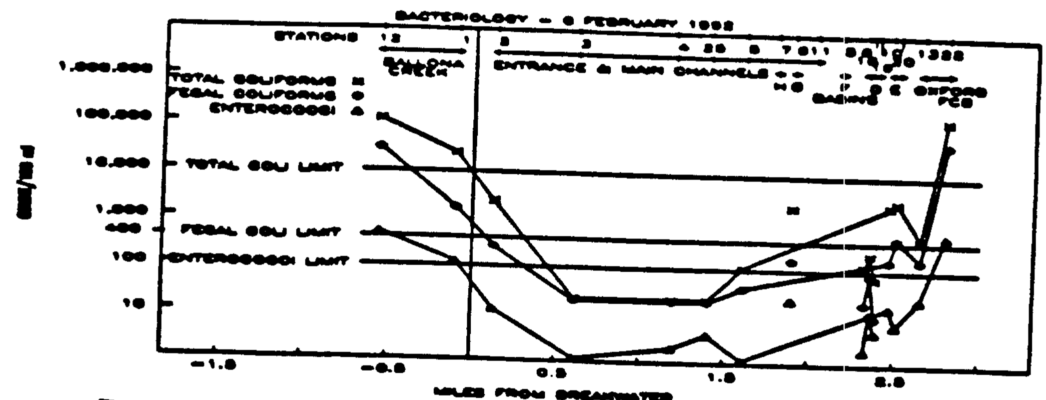

Figure VI.5. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 6 February 1992. Public health limits are indicated by transverse lines.

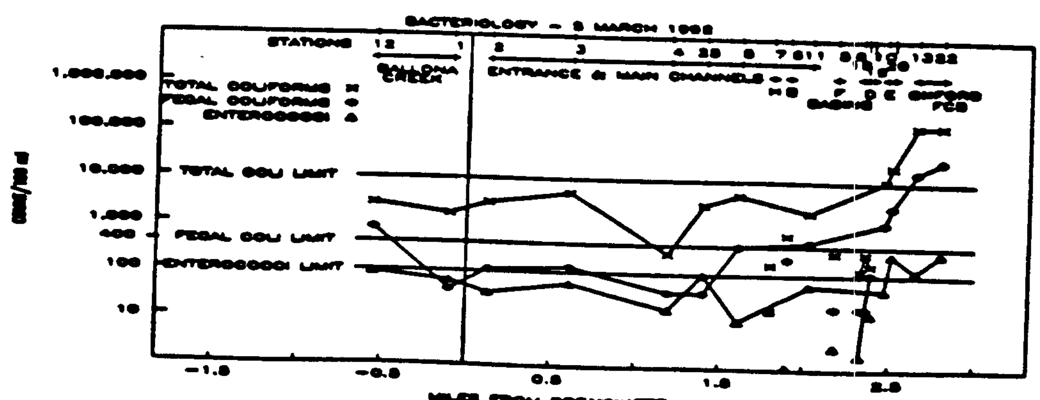

Figure VI.6. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 5 March 1992. Public health limits are indicated by transverse lines.

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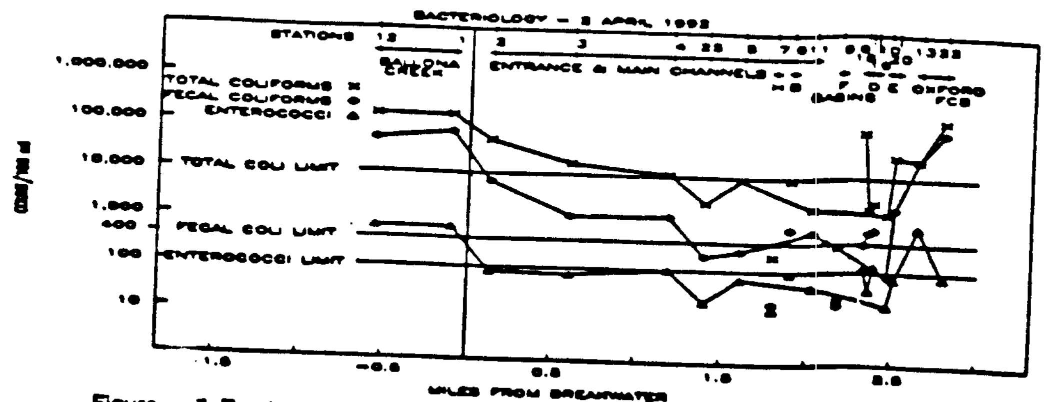

Figure 7. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 2 April 1992. Public health limits are indicated by transverse lines.

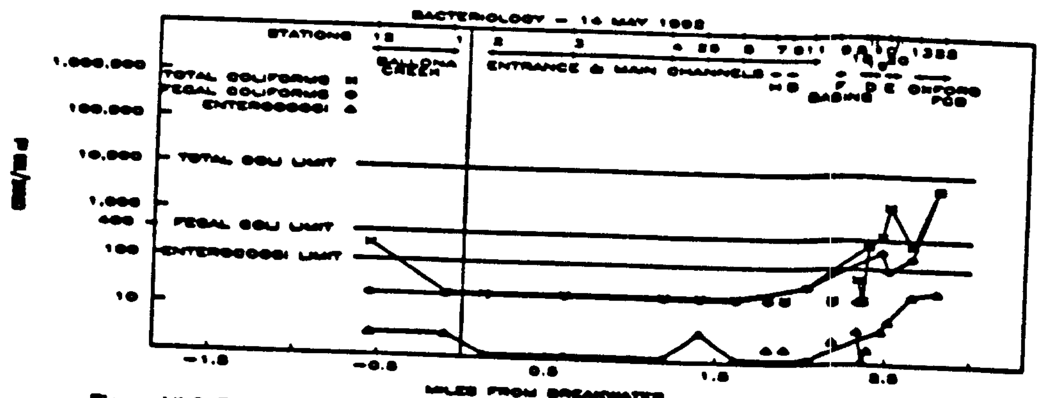

Figure VI.8. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 14 May 1992. Public health limits are indicated by transverse lines.

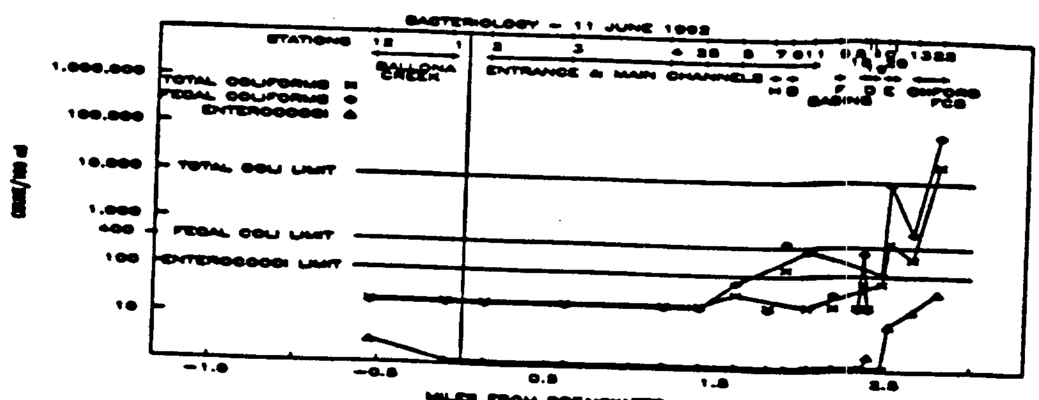

Figure VI.9. Total and fecal coliform (MPN/100ml) and enterococcus (colonies/100ml). 11 June 1992. Public health limits are indicated by transverse lines.

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Table VI.2. Coliform and enterococcus bacteria in surface waters, October, November 1991.

3 October 1991

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	1,700	70	3
2	210	<20	1
3	30	70	2
4	<20	<20	2
5	110	<20	3
6	300	40	5
7	80	40	1
8	40	<20	2
9	<20	<20	<1
10	140	40	1
11	130	40	2
12	2,400	130	11
13	5,000	1,100	117
18	40	20	<1
19	80	40	<1
20	700	220	1
22	>160,000	17,000	14
25	20	20	3
Avg	9,501	1,052	10
Num	18	18	18
Std	36,522	3,876	26
Max	160,000	17,000	111
Min	20	<20	<1

6 November 1991

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	<20	<20	<1
2	90	<20	2
3	40	<20	3
4	<20	<20	<1
5	40	20	<1
6	340	70	2
7	20	<20	<1
8	70	<20	1
9	<20	<20	2
10	330	10	<1
11	40	1,300	2
12	1,300	70	10
13	700	30	9
18	20	<20	2
19	270	220	10
20	330	270	2
22	50,000	110	98
25	20	20	<1
Avg	2,982	129	8
Num	18	18	18
Std	11,408	295	18
Max	50,000	1,300	98
Min	20	20	1

Table VI.3. Coliform and enterococcus bacteria in surface waters, December 1991, January 1992.

5 December 1991

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	20	<20	<1
2	<20	<20	5
3	<20	<20	3
4	<20	<20	1
5	80	40	2
6	30	30	2
7	70	30	4
8	60	60	6
9	130	<20	<1
10	110	<20	9
11	<20	<20	3
12	800	140	115
13	500	500	95
18	<20	<20	6
19	170	110	78
20	2,200	2,200	5
22	1,700	40	87
25	<20	<20	2
Avg	332	186	21
Num	18	18	18
Std	611	501	35
Max	2,200	2,200	115
Min	20	20	1

9 January 1992

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	24,000	9,000	102
2	30,000	11,000	126
3	1,300	400	39
4	2,200	300	34
5	130	20	7
6	800	80	32
7	110	30	6
8	110	80	2
9	40	<20	1
10	5,000	220	240
11	2,200	1,700	8
12	1,700	90,000	130
13	>160,000	>160,000	404
18	70	20	5
19	1,300	800	30
20	3,000	1,100	202
22	90,000	>16,000	430
25	1,100	70	35
Avg	18,790	16,170	105
Num	18	18	18
Std	40,245	40,450	137
Max	160,000	160,000	430
Min	40	20	1

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Table VI.4. Coliform and Enterococcus Bacteria in Surface Waters, February, March 1992

6 February 1992

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	24,000	1,700	121
2	2,400	270	12
3	<20	<20	<1
4	20	20	2
5	110	40	1
6	2,200	163	23
7	No sample taken		
8	130	20	2
9	No sample taken		
10	2,400	170	17
11	No sample taken		
12	160,000	30,000	493
13	500	170	25
18	230	80	13
19	70	<10	5
20	3,000	500	7
22	>160,000	50,000	500
25	20	<20	4
Avg	21,087	5,546	80
Num	15	15	15
Std	47,597	14,005	181
Max	160,000	50,000	500
Min	20	10	1

5 March 1992

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	1,700	40	63
2	3,000	110	35
3	5,000	130	50
4	270	40	17
5	5,000	400	10
6	700	220	<1
7	170	<20	10
8	130	<20	2
9	300	<20	3
10	11,000	1,300	40
11	2,200	500	61
12	2,000	800	80
13	160,000	17,000	125
18	300	<10	20
19	170	110	15
20	22,000	3,000	201
22	>160,000	30,000	305
25	3,000	40	100
Avg	20,986	2,987	60
Num	18	18	18
Std	49,420	7,602	86
Max	160,000	30,000	305
Min	130	20	1

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Table VI.5. Coliform and Enterococcus Bacteria in Surface Waters, April, May 1992

2 April 1992

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	<160,000	71,600	691
2	50,000	7,000	82
3	17,000	1,300	73
4	11,000	1,370	100
5	9,000	270	67
6	9,000	800	89
7	210	20	15
8	90,000	400	123
9	340	20	29
10	1,700	80	19
11	2,200	700	46
12	>160,000	50,000	487
13	24,000	24,000	912
18	2,200	700	41
19	3,000	800	137
20	28,000	2,200	71
22	>160,000	90,000	79
25	2,800	200	21
Avg	40,581	13,970	182
Num	18	18	18
Std	57,600	26,718	265
Max	160,000	90,000	912
Min	210	20	15

14 May 1992

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	20	20	3
2	20	<20	1
3	<20	<20	1
4	<20	<10	<1
5	20	<10	<1
6	20	<10	2
7	20	<10	2
8	60	<20	5
9	<20	<20	3
10	500	220	5
11	40	40	1
12	220	20	3
13	300	170	27
18	<20	<20	1
19	300	300	2
20	2,100	90	8
22	5,000	5,000	33
25	<20	<20	4
Avg	484	337	6
Num	18	18	18
Std	1,194	1,134	9
Max	5,000	5,000	33
Min	20	20	1

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Table VI.6. Coliform and enterococcus bacteria in surface waters, June 1992

6 June 1992

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	<20	<20	<1
2	20	20	<1
3	<20	<20	<1
4	20	20	<1
5	40	70	1
6	140	500	1
7	<20	<20	<1
8	<20	20	1
9	<20	40	<1
10	70	110	<1
11	20	340	<1
12	<20	<20	3
13	230	800	19
18	70	300	1
19	<20	<20	2
20	500	9,800	9
22	22,000	90,000	46
25	<20	<20	<1
Avg	1,293	5,630	5
Num	18	18	18
Std	5,026	20,564	11
Max	22,000	90,000	46
Min	20	20	1

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VII. BENTHIC FAUNA

INTRODUCTION

Benthic fauna, those organisms living in or on the bottom of the sea (benthos), are very important to the ecology of soft bottomed estuaries, harbors and marinas. The fauna of such areas are usually dominated by polychaetous annelid worms, molluscs and crustaceans, although in polluted areas or those disturbed by natural or manmade events, nematode round wor   polychaetes and oligochaete worms may dominate, at least temporarily. A change in grain size of sediments may also encourage a change in fauna.

Because some worms and crustaceans have short life spans, and consequently, short reproductive periods, they are able to recolonize very quickly an area that has been subjected to a disturbance such as heavy storm runoff. Many are able to tolerate a fairly wide range of salinity or temperature. Benthic organisms are good indicators of environmental stress since most are sedentary, sessile or attached, and thus are subjected to any environmental changes that occur. Some species had planktonic larvae which are moved about with tides and currents, offering potential for rapid recolonization of impacted areas. Dominant species are those that reproduce rapidly and year around.

PROCEDURES

Field sampling was conducted only once, on 17 October 1991. It is unfortunate that no May 1992 survey could be performed due to budgetary cutbacks, since the survey period included the heaviest rainy season in recent years and a strong El Niño event.

Field sampling was performed from the University of Southern California research vessel *Golden West* at 13 stations using a Campbell grab (modified Van Veen), which samples 0.1m^2 of bottom surface. Although a Reinecke box corer is a more accurate sampling device, it is not possible to operate the larger vessel needed to support it in the confines of some of the station locations.

Samples were washed through 1.0 and 0.5 mm screens at outer marina stations where debris and larger sand grains may be found, and through the 0.5 mm. screen at the inner marina stations where sediments are much finer. Animals retained on the screens are preserved in 10 percent buffered formalin in the field and transferred to 70 percent alcohol in the laboratory where they are rough sorted until identification and enumeration are performed by taxonomists. Numbers of individuals are multiplied by 10 to estimate the numbers per square meter of bottom sampled.

Numbers of species and total numbers of organisms are calculated, after which species are ranked according to the most numerous individuals at each station and for the entire marina. These lists can then be compared with those of previous surveys (Soule and Oguri, 1977, 1980, 1985, 1986, 1987, 1988, 1990; Soule, Oguri and Jones, 1991, 1992). The species diversity index (SDI) is calculated by two methods, the Shannon Wiener SDI and the Gleason's SDI; the Gleason SDI was used in the 1970s and the Shannon Wiener SDI was added in 1984. The Gleason SDI tends to be more influenced by large numbers of a given species than is the Shannon Wiener SDI.

RESULTS AND DISCUSSION

Complete benthic data for October 1991 are presented in Appendix D. There is a large data base for the fall season for annual comparisons, beginning with September 1977, and extending from October 1984 to October 1991.

Population Density

The mean number of individuals per m^2 in October 1991 for the 11 stations comprising the longest data base was 34,281, down slightly from 34,521 in October 1990 but well above the mean for eight autumn periods since 1984 of 18,613 individuals per m^2. The mean number in October 1991 for all stations, including Stations 12 and 25 which were added in 1989, was 50,872 per m^2, an exceedingly high number (Table VII.1). The mean for all stations including Stations 12 and 25 was 32,003 per m^2 for the three years the stations were sampled.

Unfortunately the high mean and total values represent an enormous increase in

Table VII.1. Numbers of benthic taxa or species/individuals per square meter in fall season.

Station	16 Sept 1977	25 Oct 1984	18 Oct 1985	23 Oct 1986	22 Oct 1987	20 Oct 1988	12 Oct 1989	18 Oct 1990	17 Oct 1991
1	31/29,210	60/ 6,800	38/ 5,490	55/225,520	39/ 6,530	31/11,550	25/ 1,640	38/71,990	121/ 26,700
2	41/75,060	48/12,260	38/ 6,190	*	39/ 3,840	76/56,510	34/76,100	54/97,410	76/310,060
3	25/23,920	52/12,270	51/ 9,690	79/ 36,830	50/42,160	56/ 9,195	72/24,230	69/48,150	33/ 10,020
4	67/28,700	43/ 9,750	32/ 5,820	37/ 4,820	44/ 5,900	33/ 3,040	37/ 2,760	37/ 9,070	40/ 11,050
5	31/15,760	37/ 7,800	21/ 1,960	30/ 2,750	22/ 2,840	19/ 1,200	16/ 2,350	38/ 9,230	30/ 4,270
6	25/ 8,400	23/ 9,290	25/ 4,710	33/ 11,060	29/11,510	26/12,940	25/ 6,380	18/ 3,400	19/ 3,170
7	32/32,760	31/12,700	27/ 6,130	39/ 18,870	28/ 4,700	16/14,760	26/ 4,590	23/14,970	20/ 6,100
8	9/ 5,390	19/ 4,090	29/ 7,240	35/ 14,950	21/ 3,040	16/ 1,990	13/ 2,760	29/12,780	14/ 850
9	26/ 8,220	21/ 2,420	22/ 7,220	18/ 11,150	12/ 1,800	15/ 2,440	12/ 780	18/ 3,860	19/ 2,220
10	11/ 2,540	21/ 6,870	34/15,280	33/ 14,280	26/ 4,150	38/ 9,610	17/ 2,418	28/ 7,390	15/ 1,090
11	28/20,060	28/ 3,450	20/ 5,180	22/ 6,120	16/ 2,650	11/ 630	10/ 360	1,530	16/ 1,560
Mean 1-11	29/22,733	34/ 7,972	31/ 6,811	38/ 34,635	29/ 8,117	30/11,260	26/11,306	34/34,521	37/ 34,281
12							21/10,320	38/33,330	82/272,070
25							43/ 8,530	32/22,550	44/ 12,170
Mean all stations							27/11,630	34/33,500	41/ 50,872
Mean without Nematodes				37/ 20,480	28/ 5,261	29/11,280	25/ 7,654	33/20,618	41/ 14,055

* No sample taken due to dredging

nematode worms at Stations 12 and 2, with lesser amounts at Station 1. The total number of nematodes extrapolated for the marina in October 1990 was 167,570, comprising 49.93 percent of the total fauna. In May 1991, following heavy rains in March, the nematodes totaled only 27,960 in the marina, but in October 1991 the total had burgeoned to 478,610 or 72.37 percent of the total fauna but located at only three stations. There was a large decrease in total numbers of individuals at most other stations. This may have been ameliorated in the spring of 1992, as it was in 1991, by the heavy rains, but the stressed conditions of warm El Niño waters and contaminants suggest that recolonization by nematodes would have been repeated.

Whereas the only station that showed a decrease in population in October 1990 from the previous year was Station 6, large decreases occurred at a number of stations in October 1991: Station 1 had only 37 percent of the population of the previous autumn; Station 3 had 21 percent, Station 25, 54 percent; Station 5, 46 percent; Station 7, 41 percent; Station 9, 57 percent; Station 8 was seriously depleted with only 7 percent; and Station 10 had only 15 percent of the previous year's population. The changes in Station 8 are especially disconcerting since that area has been so important to the juvenile fishery resource in the past. The demise of the seagrass beds and the increase in contaminants at that location are causes for concern. Because of the nematodes, Station 12 had an eightfold increase in population and Station 2 had a greater than threefold increase.

Number of Species

The mean number of species per m^2, or of higher taxa where organisms cannot be identified to species level, was higher in October 1991 than in previous years with 41 species per m^2, due to a very large increases at Station 1, from 38 to 122, at Station 12, from 38 to 82, and at Station 2, from 54 to 76 species per m^2 (Table VII.1). Stations 12, 1, and 4 had shown increases in number of species in May 1991, (Soule et. al., 1991) as did inner marina stations, following the spring rains. The enormous increase in number of species at Stations 12, 1 and

2 in October 1991 also included appearances of species not previously seen in the marina, perhaps due to the warmer El Niño waters and to the deposition of new sediments during the previous spring rains.

Figures VII. 1, 2, and 3 illustrate the historical record of numbers of species; October 1991 had the highest recorded values for the marina at Stations 12 and 1. The previous high was 79 species at Station 3 in 1986. Station 3 often has had high numbers of species, but the number varies considerably from year to year.

The barrier to flushing in the Entrance Channel, which causes low circula in the inner marina and basins, may also account for the large decrease in numbers of species at Station 3 from 69 to 33. A large decrease there is not characteristic of that site; the prior low number recorded there was 25 species in September 1977, when the population was, however, more than double the 1991 figure. Whether drainage or illegal dumping activities on Ballona Lagoon caused decreases in both species and total population is not known. Construction in the area may have disturbed contaminated sediments.

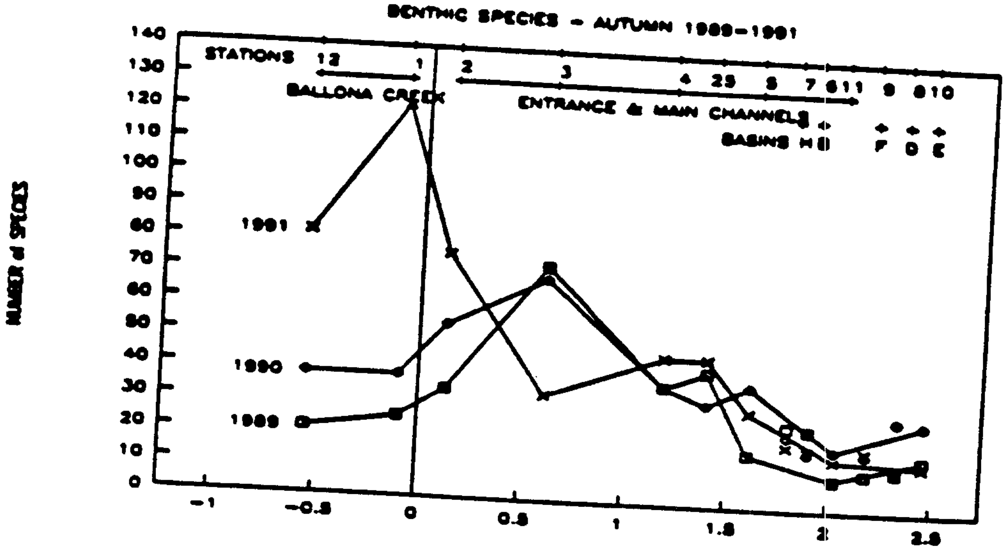

Figure VII.1. Numbers of benthic species per station in autumn months, 1989–1991.

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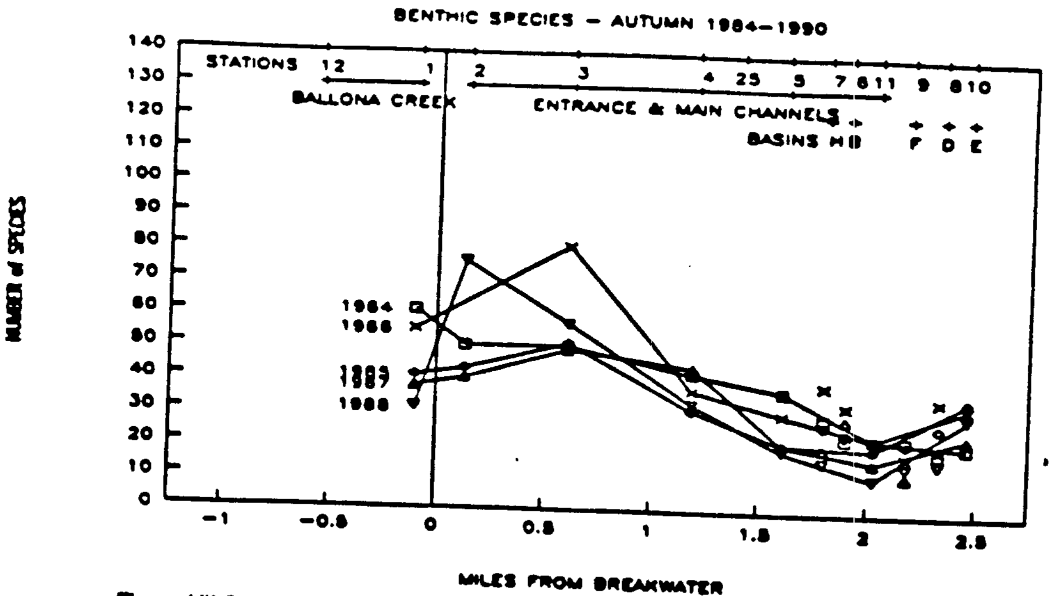

Figure VII.2. Numbers of benthic species per station in autumn months, 1984–1988.

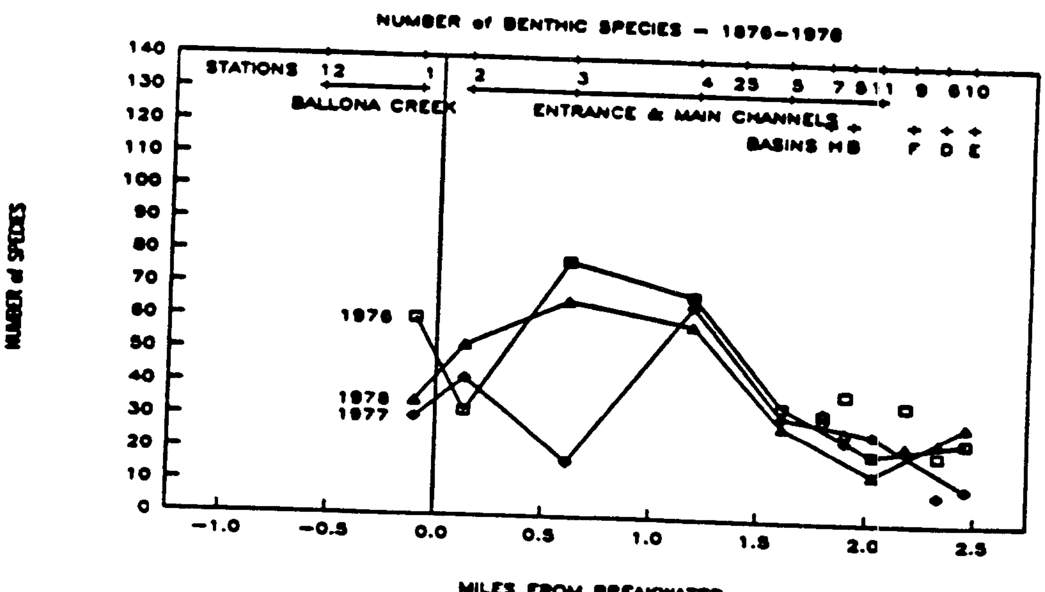

Figure VII.3. Numbers of benthic species per station in autumn months, 1976–1978.

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Species Diversity

The range in species diversity as measured by the Shannon-Wiener Diversity Index (SWDI) was from 0.44 at Station 2 to 2.34 at Station 1, with a mean of 1.91 (Table VII.2). The theoretical SWDI in the marina should range from 2.4 to 4.3, but the maximum reached was 3.09 at Station 1 in October 1984, also a warm water post-El Niño year. The previous lows were 0.55 and 0.58 at Stations 12 and 2 respectively in October 1989.

The SWDI presented a mixed picture, with a large improvement in 1991 over 1990 at Stati . and increases at Stations 3, 4, 25, 7 and 9; minor increases occurred at Stations 8 and 10 but differences were too small to be important. Figures VII. 4, 5 and 6 illustrate the variation in SWI, with the 1990s generally demonstrating low values at Station 2, at the channel sandbar and wide variation at Stations 12 and 1. In the 1980s, Station 2 was much more consistent and there was wide variation at Station 1 (Station 12 was not being sampled at that time). The profile was most consistently high in 1978.

The weakness of using the diversity indices lies in the supposed improvement when total numbers at most stations are much reduced over the previous year but the numbers of species occurring are relatively stable, such as at Stations 8 and 10. This gives a higher index than is warranted by conditions.

The Gleason Diversity Index (GDI) showed the influence of the unprecedented high number of species at Station 1, reaching 11.77, and exceeding the previous October high of 7.03 at Station 3 in 1989. The low GDI in 1991 was 1.93 at Station 8, as compared to the lowest values of 1.46 at Station 9 in October 1987 and 1.52 at Station 8 in October 1989. Increases in both diversity indices occurred at Stations 4, 25 and 9, while decreases in both occurred at Stations 5 and 11 in October 1991. Thus the indices were not consistent at the other stations, but the means for all stations showed small increases in both indices in October 1991, due largely to conditions at Station 1, with its large increase in number of species and a relatively small population.

Table VII.2. Shannon-Weiner (SWI) and Gleason (GI) Species Diversity Indices, fall seasons.

Station	25 Oct '84 SWI	25 Oct '84 GI	18 Oct '85 SWI	18 Oct '85 GI	23 Oct '86 SWI	23 Oct '86 GI	22 Oct '87 SWI	22 Oct '87 GI	20 Oct '88 SWI	20 Oct '88 GI	12 Oct '89 SWI	12 Oct '89 GI	18 Oct '90 SWI	18 Oct '90 GI	17 Oct '91 SWI	17 Oct '91 GI
1	3.09	5.30	1.71	4.30	1.49	4.38	2.41	4.33	0.88	3.21	1.76	3.26	0.82	3.31	2.34	11.77
2	2.25	4.02	2.19	4.61	*		2.40	4.60	2.02	6.67	0.58	2.96	1.19	4.61	0.44	5.93
3	2.44	4.35	2.78	5.45	1.86	7.42	1.46	4.60	2.95	6.03	2.84	7.03	1.90	6.31	2.11	3.47
4	2.20	3.66	2.10	3.58	2.48	4.25	2.76	4.96	2.55	3.99	2.99	4.54	2.25	3.95	2.25	6.19
5	2.25	3.20	2.13	2.64	1.90	3.66	2.06	2.64	2.23	2.56	1.62	1.93	2.23	4.05	2.17	3.67
6	1.96	1.92	2.29	2.86	2.27	3.44	1.22	2.99	1.43	2.43	1.60	2.76	2.33	2.09	2.13	2.23
7	1.87	2.55	1.67	2.90	2.12	3.86	1.96	2.25	0.76	1.56	2.18	2.97	1.62	2.29	1.66	2.10
8	1.81	1.78	1.89	3.15	2.30	3.54	1.76	2.49	1.61	1.97	1.10	1.52	1.90	2.96	2.02	1.93
9	1.83	1.90	1.06	2.36	1.50	1.82	1.19	1.44	1.70	1.79	1.88	1.65	1.62	2.06	2.09	2.34
10	1.82	1.80	2.19	3.36	2.26	3.36	2.10	2.76	2.22	3.16	1.58	2.06	2.01	3.03	2.07	2.00
11	2.06	1.82	1.39	2.22	1.91	2.41	1.39	1.90	1.90	1.56	1.99	1.53	2.13	2.46	1.76	2.06
Mean 1-11	2.14	2.93	1.96	3.42	2.00	3.01	1.88	2.90	1.88	3.17	1.81	2.92	1.81	3.37	1.91	3.79
12											0.55	2.06	1.65	3.56	1.31	6.97
25											2.37	4.64	2.86	3.89	2.29	4.78
Mean all stations											1.76	2.99	1.81	3.37	1.90	4.07

* No sample taken due to dredging

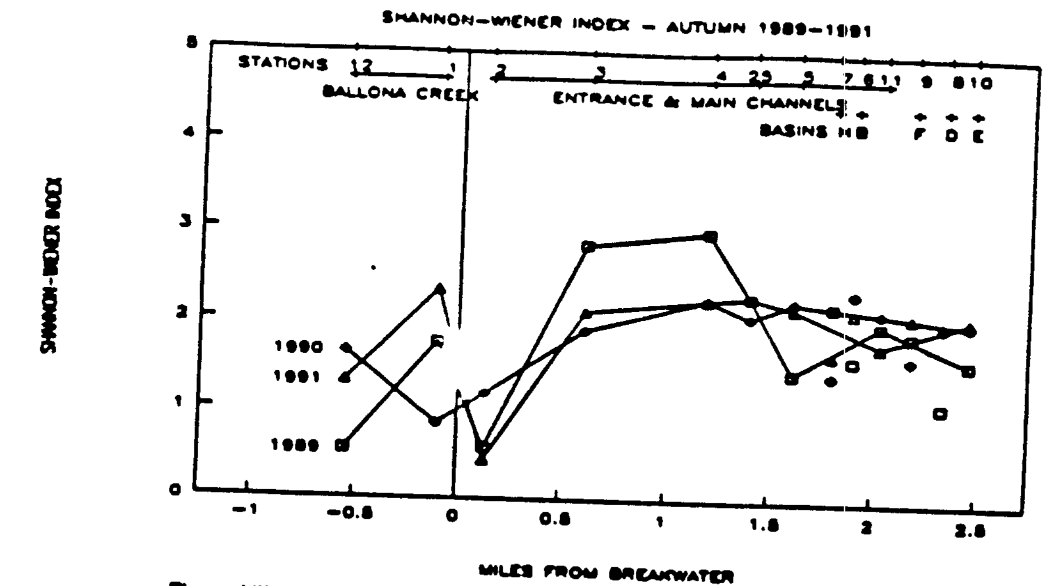

Figure VII.4. Shannon-Wiener Species Diversity Index, autumn 1989-1991.

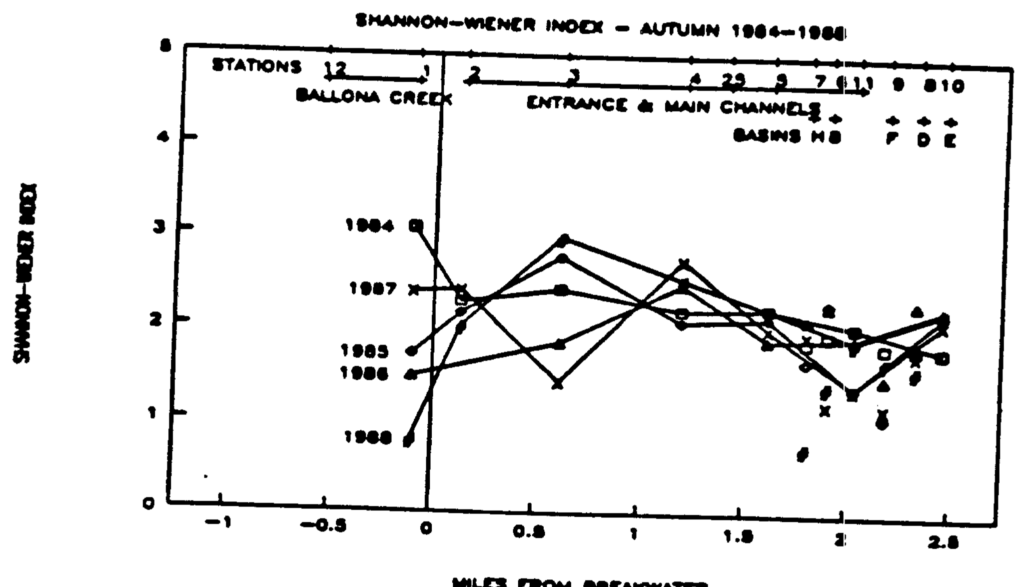

Figure VII.5. Shannon-Wiener Species Diversity Index, autumn 1984-1988.

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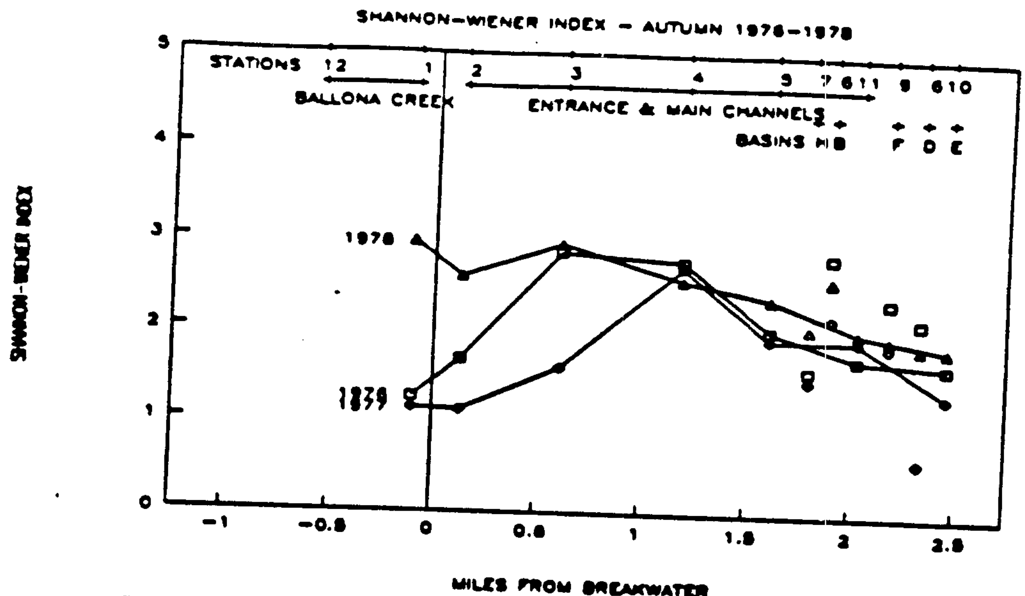

Figure VII.6. Shannon-Wiener Species Diversity Index, autumn 1976-1978.

SPATIAL DISTRIBUTION AND DOMINANT SPECIES

As was the case in October 1990, the nematode round worms dominated the total numbers of individuals with even larger numbers, 479,110 per m^2 in October 1991 as compared to 190,570 per m^2 the previous year. Nematodes were limited in distribution at Stations 12, 1, and 2 in 1991, stations which were disturbed by the spring storms, with flushing at Stations 12 and 1 and deposition of new sediments at Station 2. Nematodes represented 49.9 percent of the total fauna in October 1990 whereas they formed only 12.3 percent in May 1991 soon after the flushing (Soule et al., 1991), but exploded to form 72.4 percent of the total fauna in October 1991 (Table VII.3).

The fact that the total for the entire marina was dominated by the nematodes at Station 2, with 43.5 percent of the total fauna, in turn emphasizes the reduced numbers at most other stations, which showed decreases of up to 93 percent, which occurred at Station 8.

The usually dominant polychaete species such as *Mediomastus*, *Pseudopolydora* *paucibranchiata* and *Prionospio heterobranchia* were again distributed throughout the entire marina but in much smaller numbers than usual forming only about 15 percent of the total (Table VII.3). Larger numbers of species which occurred in Ballona Creek at Station 12 included polychaetes, molluscs and crustaceans that often do not occur there. This suggests that the heavy rainfall, including waters released by the Los Angeles City Sanitation District and Los Angeles County storm drains during flood flow, flushed the channel, providing new sediments and nutrients that benefited the habitat. It also indicates that areas that at times are considered highly contaminated with metals and pesticides can support a diverse fauna a short time later, provided that flushing is good.

Flushing throughout most of the marina is inherently low, a condition which is exacerbated by failure of regulatory agencies to permit dredging of the channel entrance. This is probably responsible, at least in part, for the increase at all stations in the finest sediments the size of which are determined by screen mesh size. The finest is expressed as grain size of less than 200 mesh (<200). A decrease in sand (screen size 25) at all stations except Station 1 may represent deposition of fines during and after rains, which remain there due to the low flow rate during dry weather. This could impact the benthic fauna composition, and in turn perhaps affect the rest of the food chain organisms that feed on those species.

Station 12

Station 12 is located on the seaward side of the Ballona Creek footbridge that was formerly part of the coast highway before the marina entrance was constructed. Fauna at this station varies greatly, depending on the amount of rainfall, dry weather flow volume, overflows of primary treated sewage water, tide height and state and the accumulation of rubbish. Since there was unusually heavy rainfall in the basin in February and March 1992, the Ballona Creek Channel was flushed and supplied with new sediments, nutrients and contaminants from upstream with the finest sediments (<200) forming only 57 percent.

Station 12 had a moderate score for trace metals and non-metallic contaminants

Table VII.3. Dominant benthic species/taxa ranked by percent, 17 October 1991. Counts per m² are given by station and for the entire marina. Stations are listed by distance from the breakwater, with Station 12 in Ballona Creek and Station 1 off the mouth of Ballona Creek.

Taxa \ Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	
Nematoda, unid.	180,100	10,590	287,920											478,610	72.37%
Mediomastus sp.	47,640	7,240	4,950	4,330	1,410	3,530	580	400	290	710	190	20	10	71,300	10.78%
Pseudopolydora paucibranchiata	10,220	10	1,370	70	3,990	300	10	550	590	310	690	170	300	18,580	2.81%
Prionospio heterobranchia	6,460	140	600	1,670	230	1,010	380	310	550	20	80	140	130	11,720	1.77%
Leitoscoloplos pugettensis		90	80	620	1,080	3,290	300	570	900	30	290	280	90	7,620	1.15%
Oligochaeta, unid.	10	60	5,870		10	620				10		10		6,590	1.00%
Armandia bioculata (*brevis*)	3,670	540	1,660	160		60								6,090	0.92%
Tagelus californianus	4,960	60	120	140	410	250	10							5,950	0.90%
Oxyurostylus pacifica	2,700	120	2,610		10	10								5,450	0.82%
Aphelochaeta parvus						460	1,470	3,260	160		10	10		5,370	0.81%
Mayerella banksia	2,390	50	620	420	630	50	10							4,170	0.63%
Lumbrineris minima			50	370	450	760	250	590	50	110	230	20	210	3,090	0.47%
Prionospio lighti	1,710	560	30	360	50	40	10			30	10			2,800	0.42%
Euchone limnicola				670	1,290	40	100	180	80	10	40	30	90	2,530	0.38%
Laevicardium substriatum	1,590	60	410	90	20	20	10	20						2,220	0.34%
Cirriformia spirabrancha	420		10			240	660	10	20	200	370			1,930	0.29%
Protothaca staminea	1,620	70	80	10	10	120								1,910	0.29%
Schistomeringos rudolphi	1,290	10	260	30		10		30	10		10	20	20	1,690	0.26%
Ericthonis brasiliensis	40	1,290	80											1,410	0.21%
Polyophthalmus pictus	1,310	40	60											1,410	0.21%
Neanthes acuminata	150	10	700						30	10				900	0.14%
Cossura candida					380	430					10		20	840	0.13%
Paraleocapitella sp.	790													790	0.12%
Rudilemboides stenopropodus	300	90	10	280	50	40								770	0.12%
Chaetozone corona	60			60	90	110	170	20		20	190	10		730	0.11%
Aoroides inermis	30	600	10											640	0.10%
Gammaropsis thompsoni		330	230											560	0.09%
Brania sp.	500		40											540	0.08%
Tellina sp., juv.	500													500	0.08%

(Chapter IV), slightly higher than it was in October 1990 and May 1991, and about 35 percent lower than it was in October 1989. Total pesticides and chlorinated hydrocarbons dropped nearly 50 percent from May 1991, but still exceeded the October 1990 level slightly. In October 1989, the total was more than five times as high, with high Chlordane, DDTs, and Aroclor 1260.

Included in the unprecedented 82 species/taxa present at Station 12, was the usual component of common polychaete species plus a number of species represented by a few individuals of arthropods: gammerids, cummaceans, caprellids, and decapods. Also, a number of mollusc species, particularly pelecypods which seek enriched soft bottom habitats, occurred in small numbers and even included the gastropod *Bulla gouldiana* (the bubble shell) that used to be found in large numbers in outer Newport Bay and elsewhere along the coast in sandy bottoms. Table VII.4 indicates the ranking of species by number of occurrances in the marina, and shows the large number of species with only one or two occurrences is clear.

The dominant group was the nematodes, which formed 61.5% in October 1991 but were virtually gone in May 1991 (Soule et al, 1992). The pelecypod *Tagelus californianus* replaced *Protothaca staminea* in the top six, with the latter in tenth place and *Laevicardium substrianum* in eleventh in October 1991. Dominant species were as follows:

Species	Percent
Nematoda (unid.)	66.2
Mediomastus, sp.	17.5
Polydora paucibranchiata	3.8
Prionospio heterobranchia	2.4
Tagelus californianus	1.8
Armandia bioculata (=brevis)	1.4

Station 1

Station 1 is situated between the southern end of the breakwater and the south jetty of Ballona Creek. There, waters from the creek, the marina and Santa Monica Bay are mixed by tidal flow, drainage and wave action. Flushing is impeded by the sandbar deposition around the end of the jetty separating Ballona Creek from the marina entrance

Table VII.4. Benthic species ranked by number of station occurrences, 17 October 1991. Station order is based on distance of the station from the breakwater, with Station 12 located in Ballona Creek and Station 1 off the mouth of Ballona Creek. Not included are species with counts of less than 100 at one station.

Taxa \ Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	Total	Station Occurrences
Mediomastus sp.	47,640	7,240	4,950	4,330	1,410	3,530	580	400	290	710	190	20	10	71,300	13
Pseudopolydora paucibranchiata	10,220	10	1,370	70	3,990	300	10	550	590	310	690	170	300	18,580	13
Prionospio heterobranchia	6,460	140	600	1,670	230	1,010	380	310	550	20	80	140	130	11,720	13
Leitoscoloplos pugettensis		80	80	620	1,080	3,290	300	570	900	30	290	280	90	7,620	12
Lumbrineris minima			50	370	450	760	250	590	50	110	230	20	210	3,090	11
Euchone limnicola				670	1,290	40	100	180	80	10	40	30	90	2,530	10
Schistomeringos rudolphi	1,290	10	280	30		10		30	10		10	20	20	1,690	10
Prionospio lighti	1,710	560	30	360	50	40	10			30	10			2,800	9
Chaetozone corona	60			60	90	110	170	20		20	190	10		730	9
Laevicardium substriatum	1,590	60	410	90	20	20	10	20						2,220	8
Cirriformia spirabrancha	420		10			240	660	10	20	200	370			1,930	8
Lumbrineris sp.	40	250	30			30		50		20	10		10	440	8
Oligochaeta, unid.	10	60	5,870		10	620				10		10		6,590	7
Tagelus californianus	4,960	60	120	140	410	250	10							5,950	7
Mayerella banksia	2,390	50	620	420	630	50	10							4,170	7
Lumbrineris tetraura	30	40				30	20	30		20	40			210	7
Aphelochaeta parvus						460	1,470	3,260	160		10	10		5,370	6
Protothaca staminea	1,620	70	80	10	10	120								1,910	6
Rudilemboides stenopropodus	300	90	10	280	50	40								770	6
Exogone sp. A				130	170	10		10	20		10			350	6
Capitella capitata	80	10	20	200		10	10							330	6
Clevelandia ios	30				10	20	20	10				20		110	6
Bathyleberis sp.	20	10	10	10	10	10								70	6
Armandia bioculata (*brevis*)	3,670	540	1,660	160		60								6,090	5
Oxyurostylis pacifica	2,700	120	2,610		10	10								5,450	5
Neanthes acuminata	150	10	700						30	10				900	5
Paranemertes sp. A	280	40	40	50		10								420	5
Monticellina tesselata	160	40		40	70	10								320	5
Tubulanus polymorphus	10			80	10	10	20							130	5
Mysidopsis sp. A		10					30	20		40	10			110	5
Monticellina sp. A (SCAMIT)		20		30	20	20							10	100	5

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Table VII.4 Benthic species ranked by total number of station occurrences, 17 October 1991. (continued)

Taxa \ Stations	12	1	2	3	4	25	5	7	6	11	9	6	10	Total	Station Occurrences
Scolelepis tridentata			20			40			10	10			10	90	5
Nephtys caecoides	30	10	20		10			10						80	5
Cossura candida					380	430					10		20	840	4
Phorinida, unid.	10						10		230		10			260	4
Scolelepis foliosa occidentalis	50			50	140			10						250	4
Goniada littorea	30	190		10	10									240	4
Cylichnella inculta	10	10							110			30		160	4
Micrura sp.		40	20	50	10									120	4
Spiophanes missionensis	10	70		10		20								110	4
Apoprionospio pygmaea		50	10		20	10								90	4
Polydora ligni	30		30		10			10						80	4
Glycera americana			10		10	10	10							40	4
Nematoda, unid.	180,100	10,590	287,920											478,610	3
Ericthonis brasiliensis	40	1,290	80											1,410	3
Polyophthalmus pictus	1,310	40	60											1,410	3
Aoroides inermis	30	600	10											640	3
Photis sp.	10	300	110											420	3
Tellina modesta	300	80				10								390	3
Lumbrineris erecta									30		70	160		260	3
Corophium acherusicum	20	20	210											250	3
Notomastus sp.	190	10	40											240	3
Macoma nasuta	20	50	120											190	3
Microphthalmus sp.	150	10	10											170	3
Leptosynapta sp.					20	70	20							110	3
Platynereis bicanaliculata	50	30	30											110	3
Caprella californis	70	20	20											110	3
Grandidierella japonica	60	30	20											110	3
Phyllodoce longipes	10	20	30											60	3
Phoronis sp.					10						20	10		40	3
Gammaropsis thompsoni		350	230											580	2
Brania sp.	500		40											540	2
Ampharete labrops	10	390												400	2
Diastylopsis tenuis		350	10											360	2

Table VII.4 Benthic species ranked by total number of station occurrences, 17 October 1991. (continued)

Taxa \ Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	Total	Station Occurrences
Amphideutopus oculatus		10			280									290	2
Leporimetis obesa	270					10								280	2
Synchelidium shoemakeri		120	130											250	2
Protodorvillea gracilis	220	10												230	2
Anatanais normani	10		170											180	2
Exogone lourei		10	160											170	2
Harpacticoida, unid.		10	150											160	2
Pelecypoda, unid. juv.	140							10						150	2
Tharyx sp.							60		60					120	2
Nereis latescens	10	100												110	2
Podocerus cristatus	10		100											110	2
Tubulanus sp.		90	10											100	2
Leptopecten latiauratus		90	10											100	2
Glycera convoluta		80	10											90	2
Diopatra ornata		60	10											70	2
Theora lubrica					50		20							70	2
Phyllodoce hartmanae	10		50											60	2
Monoculoides hartmanae		20	40											60	2
Callianassa californiensis			40				10							50	2
Lineidae, unid.	40	10												50	2
Alia carinata		10	30											40	2
Lyonsia californica							30		10					40	2
Amaeana occidentalis		30			10									40	2
Nemertea, unid.						30					10			40	2
Amphiporus rubellus	10	20												30	2
Notomastus tenuis				20	10									30	2
Podarkeopsis glabra			20			10								30	2
Cerebratulus californiensis	10	20												30	2
Phyllodoce sp.		20	10											30	2
Paguridae, unid.	10		20											30	2
Acmira catherinae				10	10									20	2
Cyclaspis nubila		10	10											20	2
Parvilucina tenuisculpta		10		10										20	2

Table VII.4. Benthic species ranked by total number of station occurrences, 17 October 1991. (continued)

Taxa \ Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	Total	Station Occurences
Spiochaetopterus costarum		10		10										20	2
Portunus xantusii		10	10											20	2
Cumingia californica	10					10								20	2
Cooperella subdiaphana	10				10									20	2
Parapleustes sp., juv.		10	10											20	2
Loxorhynchus sp.	10	10												20	2
Alpheus sp.						10	10							20	2
Hydroides elegans	10	10												20	2
Campylaspis sp C	10	10												20	2
Polycladida, unid.	10		10											20	2
Cylichnella culcitella		10								10				20	2
Paleanotus bellis		10	10											20	2
Macoma sp., juv.							10						10	20	2
Tellina carpenteri	10					10								20	2
Paraleiocapitella sp.	790													790	1
Tellina sp., juv.	500													500	1
Chaetozone nr. *setosa*		390												390	1
Bulla gouldiana	310													310	1
Streblospio benedicti						290								290	1
Pycnogonida, unid.	190													190	1
Nassarius fossatus			170											170	1
Capitellidae, unid.	160													160	1
Spisula sp.		150												150	1
Cyclopoidea, unid.			110											110	1
Melita sulca	110													110	1
Atylus tridens	90													90	1
Lacuna unifasciata		80												80	1
Photis brevipes		80												80	1
Aoroides sp.		80												80	1
Tivela stultorum						70								70	1
Crepidula cori		70												70	1
Mitrella aurantiaca			60											60	1
Tricolia compta		60												60	1

channel. The finest sediments (<200) formed 62 percent of the sediments in October 1991 as compared with 31 percent in October 1990.

Station 1 had the lowest levels of trace metals-contaminants of all the stations in May 1991 after the rainy season, having been in the moderately contaminated category in October 1990. It remained the cleanest in October 1991 (Chapter IV). Levels of total pesticides/chlorinated hydrocarbons, rose from 58 ppb in October 1989 to 205 ppb in October 1990, to a peak of429 ppb in May 1991 and dropped back to 57 ppb in October 1991, due mostly to changes in Chlordane and DDTs levels. This also indicates a difference in the influx and movement of trace metal/contaminants and pesticides.

The large number of nematodes at Station 1 indicates a disturbed or stressed environment, such as would occur with the heavy freshwater rainfall runoff that impacted the habitat during the spring. The numbers of nematodes obscures the fact that an unprecedented 121 species occurred there, by far the largest number ever recorded for the marina. The previous high was 79 species at Station 3 in 1986. The large number of species found that rarely occur there indicates that the sediments were not inhibitory, which may be related to the reduction in pesticides.

Table VII.4 lists a large number of species having small numbers of individuals, that occurred at Station 1 and not elsewhere in the marina. Following are the dominant species:

Species	Percent
Nematoda (unid.)	39.7
Mediomastus, sp.	27.1
Ericthonis brasiliensis	4.8
Aoroides inermis	2.3
Prionospio lighi	2.1
Armandia bioculata (=brevis)	2.0

Station 2

Station 2 is located between the north and south jetties and the breakwater. It has for some years been degraded by the accumulation of sand, which has acted as a trap for fine, contaminant bearing sediments flushed from the marina or settled out from Ballona Creek waters carried on tidal exchanges. The grain size of surface sediments is now more than 90 percent fines (<200).

Trace metal and contaminant scores placed the station in the medium low range, improved over the October 1990 and May 1991 medium high levels, indicating that both wet and dry weather flushing had occurred. It ranked highest in total pesticide-chlorinated hydrocarbons, in October 1991 as it did in May 1991 and was third highest in October 1990. In spite of the disappearance of Aroclor 1254, it still ranked highest due to 436 ppb of Chlordane. However, total pesticides-chlorinated hydrocarbons decreased fr[illegible] 1121 ppb in October 1989, to 473 ppb in October 1990, rose to 569 in May 1991 and rem[illegible]ned at 541 ppb in October 1991. There is either differential flushing there or a continuing input, probably from Ballona Lagoon.

The population had deteriorated further in October 1991, with nematodes increasing to 92.9 percent from 71.2 percent of the population in October 1990 and 55.3 percent in May 1991. The total numbers, 278,610 nematodes and 5,870 oligochaetes out of a total of 310,060 individuals, gives a very low diversity, indicating a very poor ecological environment, probably impacted by the influx of freshwater runoff from Ballona Creek during the spring. The large number of species present there in very small numbers (Table VII.4) indicates good potential for recolonization if deposition of pesticides could be lessened.

The dominant species are listed as follows:

Species	Percent
Nematoda (unid.)	92.9
Oligochaeta (unid.)	1.9
Mediomastus, sp.	1.6
Oxyurostylus pacifica	0.8
Armandia bioculata (=brevis)	0.5
Pseudopolydora paucibranchiata	0.4

Station 3

Station 3 is located at the buoy marking the tide gate to Ballona Lagoon. The site is usually well flushed due to the tide gate but terrestrial and marine sediments disturbed in the

Lagoon area can impact the station. There was great change in the sediment characteristics, moving from 7.97 percent in October 1990 to 90.98 percent finest sediments (<200) in October 1991.

The trace metal and contaminant score rose from a low of 46 in October 1990 to 178 in May 1991 and dropped only slightly to 164 in October 1991. The pesticide-chlorinated hydrocarbon levels increased from 21 ppb in October 1990 to 401 ppb in May 1991 and 409 ppb in October 1991. This indicates a radical increase in the input of the major constituent, Chlordane, which may originate in soils or buildings surrounding Ballona Lagoon or the Venice Canals.

The number of species was less than half those of recent years, being more similar to 1977 numbers than to any others. The number of individuals fluctuates greatly at Station 3, but was less than 25 percent of that found in October 1990, similar to totals found in 1988 and 1985. The dominant species were typical of the open channels of the marina, as follows:

Species	Percent
Mediomastus, sp.	43.2
Prionospio heterobranchia	16.7
Euchone limnicola	6.7
Leitoscoloplos pugettensis	6.2
Mayerella banksia	4.2
Lumbrineris minima	3.7

Station 4

Station 4 is located off the riprap in front of the apartment houses seaward of the Coast Guard docks near the juncture of the entrance channel and the main channel. For several years it seems to have had a depression that trapped fine sediments and pollutants. The score for trace metals and contaminants increased but remained in the moderate level, along with an increase in the percentage of the finest grained sediments. Total pesticides and chlorinated hydrocarbons dropped from 206 ppb in October 1990 to 141 ppb in October 1991, chiefly due to the disappearance of Aroclor 1254.

The station improved in both numbers of species and individuals, the highest since

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the 1977 survey. The dominant species were as follows:

Species	Percent
Pseudopolydora paucibranchiata	36.1
Mediomastus, sp.	12.8
Euchone limnicola	11.7
Leitoscoloplos pugettensis	9.8
Mayerella banksia	5.7
Lumbrineris minima	4.1

Station 25

Added to the survey stations in 1989, Station 25 lies between the Bay Watch docks at the County Administration Building and the public fishing docks at Fisherman's Village. Drainage from the restaurant, Village and Administration parking lots enters the marina there, and vessel activity is high, although oil and grease levels in sediments are moderate. The sediment is 97.15 percent of the finest sediment (<200). The trace metal-contaminant score decreased slightly from the high range in October 1990 and May 1991 to the medium high range in October 1991. The pesticide-chlorinated hydrocarbon level dropped from 354 ppm in October 1989 to 327 ppm in October 1990, to 248 ppb on May 1991 and then to 173 ppm in October 1991, due largely to the disappearance of Aroclor 1260.

The number of species increased in October 1991, but the number of individuals decreased by about 46 percent from October 1990, although it was about the same as in May 1991. While the dominant species, listed below, show a better balanced diversity than most marina stations, even more important was the appearance in smaller numbers of several mollusc species such as *Protothaca staminea*, *Tivela stultorum*, and *Laevicardium substriatum* that have not been seen there previously (Table VII.4.).

Species	Percent
Mediomastus, sp.	29.0
Leitoscoloplos pugettensis	27.0
Prionospio heterobranchiata	8.3
Lumbrineris minima	6.2
Oligochaeta (unid.)	5.1
Aphelochaeta parvus (=*Tharyx*)	3.8

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Station 5

Located in the center of the main channel off Burton Chace Park, Station 5 accumulates sediments and contaminants flushed from the basins during dry or low flow weather conditions but may be flushed by heavier rainfall. The finest grained sediment increased from 94 percent to 99.5 percent between October 1990 and October 1991. In May 1991, following heavy rains in March, contaminants and trace metal scores were increased over levels in October 1990, and in October 1991 increased again, but remained in the medium high category. Pesticide-chlorinated hydrocarbon levels changed from 324 ppb in October 1989 to 271 ppb in October 1990, and then dropped greatly to 218 ppb in May 1991 and 103 ppb in October 1991. The pesticide reduction was due mostly to a decrease in Chlordane and the disappearance of Aroclor 1254.

Small numbers of molluscs and crustaceans occurred at Station 5 (Table VII.4), but the following polychaete worm species dominated the fauna:

Species	Percent
Aphelochaeta parvus (=*Tharyx*)	34.4
Cirriformia spirabrancha	15.5
Mediomastus, sp.	29.0
Prionospio heterobranchia	8.9
Leitoscoloplos pugettensis	27.0
Lumbrineris minima	6.2

Station 6

Station 6 is located at the inner end of Basin B and has been among the cleaner stations in the marina. The percentage of the finest sediments increased from 50.44 percent in October 1990 to 79.69 in October 1991, after a decrease to 49.02 percent in May 1991. The contaminant-trace metal scores are usually in the medium low range with 73 in October 1990, increasing to 95 in May 1991 and moving up to the moderate level with 109 in October 1991, due to increases in IOD, COD, oil and grease, phosphate, organic nitrogen and sulfide. The pesticide-chlorinated hydrocarbon levels declined from 178 ppb in October 1990 to 35 ppb in May 1991 after the rainy season due to the disappearance of Aroclor 1254 by May; the total rose to 103 ppb in October 1991, due to a large increase in

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Chlordane during dry weather.

The number of species decreased by around 30 percent in 1990 and 1991 while the number of individuals has decreased from a peak of 12,940 in October 1988 to only 3,170 per m^2, close to a 75 percent decrease. This basin seems to be under stress from general pollution for unknown reasons, possibly decreased flushing. The species list is short (Table VII.4), but the dominant species are fairly typical of the low flushing inner basins, as is shown in the following list:

Species	Percent
Leitoscoloplos pugettensis	28.4
Pseudopolydora paucibranchiata	18.6
Prionospio heterobranchia	17.4
Mediomastus, sp.	9.2
Phoronida, unid.	7.3
Aphelochaeta parvus (=*Tharyx*)	5.1

Station 7

Station 7, located at the boat launch ramp at the inner end of Basin H, is subjected to dry and wet weather flow from storm drains and parking lots. In spite of the proximity of boatyards and the exposure to oil and grease from launchings, the contaminant-trace metal score is in the moderate range, although levels rose following the spring rains and then declined somewhat. The pesticide-chlorinated hydrocarbon total is usually in the medium low group. Levels decreased from 324 ppb in October 1989 to 150 ppb in October 1990, 141 ppb in May 1991 and to 92 ppb in October 1991. This was due primarily to the disappearance of Aroclors. The grain size increased from 67.56 percent finest sediments in (<200) October 1991 to 83.96 percent in May 1991 and increased slightly to 91.88 percent in October 1991.

The number of species ranged from 27 to 39 through 1986 but has ranged from 16 to 26 since, while the numbers of individuals has ranged from 18,870 to 4,590 since 1984, down from 32,740 in 1977. Dominant species are polychaetes, as follows:

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Species	Percent
Aphelochaeta parvus (=*Tharyx*)	53.4
Lumbrineris minima	9.7
Leitoscoloplos pugettensis	9.3
Pseudopolydora paucibranchiata	9.0
Mediomastus, sp.	6.6
Prionospio heterobranchia	5.1

Station 8

Located off the only beach in the marina, Station 8 which was close to a sea grass (*Ruppia*) bed that had disappeared by October 1991, being replaced by filamentous enteromorpha algae and hydroids characteristic of eutrophic environments. The grass bed was an important habitat for larval and juvenile fish. The character of the bottom changed from being composed of sand and finer sediments down to 50 percent of the smallest grain size (<200), to 98.81 percent finest sediments. Whether this influx of fine sediments caused the change is unknown.

Contaminant-trace metal scores moved from moderate in October 1990 to medium high in May 1991 to high in October 1991, with increases in many parameters over the period. Total pesticide/chlorinated hydrocarbon levels moved from 86 ppb in October 1989 and October 1990, mostly of Aroclor 1254 and DDTs, to a high of 232 ppb in May 1991, due to increases in Chlordane, p.p'DDE and Aroclor 1260. The total dropped to 55 ppb in October 1991, with decreases in those parameters. However, damage may have been done to the sensitive sea grass beds by the influx of contaminant-trace metals and/or pesticides and chlorinated hydrocarbons, and/or by the influx of fine sediments.

The number of species has ranged from 9 in 1977 to 35 in 1986 while the previous range for numbers of individuals was from 1,990 per m^2 in 1988 to 14,950 in 1986, but the drop from 29 species and 12,780 individuals per m^2 in October 1990 to 14 species and 850 individual species in October 1991 is an extreme loss of food for the food chain, a 15 fold loss in population. The following are the dominant species:

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Species	Percent
Leitoscoloplos pugettensis	32.9
Pseudopolydora paucibranchiata	20.0
Prionspio heterobranchia	16.5
Lumbrineris erecta	8.2
Euchone limnicola	3.5
Cylichnella inculta	3.5

Station 9

Station 9 is located at the inner end of Basin F and receives runoff from storm drains and parking lots. A station that usually has a sediment size of 9[illegible] percent fines (<200) showed a decrease to 89.74 percent fines following the spring ra... in 1991 but increased during dry weather to 99.76 percent fines in October 1991.

Station 9 was ranked second highest in contaminant-trace metal scores in October 1990, May 1991 and October 1991. Total pesticide/chlorinated hydrocarbons increased from 306 ppb in October 1989, to 354 ppb in October 1990, decreasing to 167 ppb in May 1991 and to a low of 70 ppb in October 1991. This was due to large decreases in DDTs and the disappearance of Aroclor 1260.

The number of species increased by one but the number of individuals dropped 43 percent between October 1990 and October 1991. Numbers have fluctuated considerably at this station. The following polychaetes are the dominant species in October 1991:

Species	Percent
Pseudopolydora paucibranchiata	31.1
Cirriforma spirabrancha	16.7
Leitoscoloplos pugettensis	13.1
Lumbrineris minima	10.4
Chaetozone corona	8.6
Mediomastus, sp.	8.6

Station 10

Station 10 is located at the inner end of Basin E, subjected to the runoff and tidal flushing from the Oxford Street flood control basin which enters the marina via a tide gate. The percentage of the finest grain size (<200) at Station 10 was 94.79 in October 1990, was reduced to 75.33 percent by flushing from the spring rainstorms, and increased to

99.36 percent in October 1991. This indicates deposition during dry weather which may be related to progressively poorer flushing in the entire marina due to partial blockage at the entrance. Although the open part of the basin may flush, considerable accumulation of contaminated sediments occurs beneath the docks.

The trace metal-contaminant score at Station 10 continued to be the highest in the marina, ranking first or second in 14 of 20 parameters measured, indicative of the influx and deposition from the Oxford Street flood control basin. Total pesticides-chlorinated hydrocarbons rose from 419 ppb in October 1989 to 494 ppb in October 1990 and 487 ppb in May 1991, due to increases in Chlordane and Aroclors. This pattern was altered completely in October 1991, by a drop to 91 ppb due to movement of Chlordane out of the area and the disappearance of Aroclors.

The number of benthic species decreased from 28 to 15, about a 47 percent drop, and the number of individuals decreased from 7,390 per m^2, to 1,090 per m^2 an 85 percent decrease from October 1990 to October 1991. The population had been in good shape in May 1991 so the great decrease occurred during dry weather flow from Oxford Street basin. The following polychaete species were dominant in October 1991:

Species	Percent
Pseudopolydora paucibranchiata	27.5
Lumbrineris minima	19.3
Lumbrineris erecta	14.7
Prionospio heterobranchia	11.9
Leitoscoloplos pugettensis	8.3
Euchone limnicola	8.3

Station 11

Station 11 is located at the inner end of the main channel, which was open water before construction of new docks there about five years ago. The station scored in the high group in trace metals-contaminants in October 1989, October 1990, May 1991, and October 1991. Pesticide-chlorinated hydrocarbon totals have moved from 380 ppb to 443 and to 496 before dropping to 91 ppb in the same periods of time. Chlordane decreased and Aroclors disappeared, indicating the movement of these pollutants out of the area.

There has been modest improvement in the total numbers of species and individuals since the very low numbers in 1988 and 1989, but the fauna is still depauperate, ranking third above that of Stations 8 and 10 in low numbers. The following were dominant species at this station:

Species	Percent
Mediomastus, sp.	45.5
Pseudopolydora paucibranchiata	19.9
Cirriforma spirabrancha	12.8
Lumbrineris minima	7.1
Mysidopsis, sp.A	2.6
Leitoscoloplos pugettensis	1.9

CONCLUSIONS

The increase in numbers of species per m^2 at the entrance of Ballona Creek is encouraging, and indicates that conditions there were improved, whether by flushing during the heavy storms of March, or by upstream pollution control, or a combination of these and other, unknown factors. The increase in mean numbers of individuals per m^2 would be considered outstanding were it not due to enormous numbers of nematodes at Stations 12 and 2 that indicate a disturbed environment. During heavy runoff, many organisms are swept from surficial muds, and species capable of rapid recolonization will at first dominate; if newly deposited sediments contain toxicants, colonization and growth of many species will be inhibited. The mean number of individuals, including nematodes was a record high; without nematodes, it was slightly above the mean for the last six years.

The appearance of species not previously reported in Ballona Creek and at other stations, particularly of molluscs and crustaceans, may be associated with the reduction in DDTs and the disappearance of Aroclor 1254 and 1260, which were introduced into the marina sometime between October 1988 and October 1989. The continuing presence of Chlordane may be a very important inhibitory factor in the outer marina.

Reduction in flushing may an important factor in the inner marina basins, which already had limited circulation due to the marina configuration. The continued accretion of sand at the marina entrance could reduce water exchange sufficiently to inhibit the fauna, which would cause more settling of fine sediments carrying contaminants and retention of water or oil soluble pollutants. Fauna were decreased at Station 6, in Basin B, and were 50 percent below the lowest year of 1988 at Station 8 in Basin D, and were more than 50 percent below the previous low in 1989 at Station 10 in Basin E. The influx of pollutants into Basin D and the loss of the seagrass beds has seriously impacted this important habitat. Populations were low at Stations 5,7 and 9 but these have also fluctuated in past years.

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VIII. FISH FAUNA

INTRODUCTION

Marina del Rey is an important habitat for fish eggs, larvae and young adults, serving as a shallow, warm water, high nutrient environment where turbidity offers some shelter from predators, and fulfilling the functions of wetlands (Stephens et al., 1991; Soule et al., 1991, 1992). It has been estimated that ninety percent of the natural wetlands in the Los Angeles a have been lost to development, making the marina of particular importance.

Fish surveys of the marina were first conducted by Harbors Environmental Projects, University of Southern California, in 1977-1979 when baseline studies were performed and techniques explored with funding assistance from the federal Sea Grant Program at USC. Five surveys were conducted in that period and four surveys were performed in 1980-81. After a hiatus, surveys were resumed in 1984, in cooperation with the *Vantuna* Research Group at Occidental College under the direction of Dr. John S. Stephens, Jr. and his staff. Semiannual surveys have been performed since then, with the exception of 1985, when only an annual October survey was conducted due to funding limitations.

More than 90 species, or higher taxa if not identifiable to species level, have been found in the marina during the survey periods. The mean number of species or higher taxa for the 16 surveys conducted under standardized techniques since 1984 is 39.25, about the same as the mean if the 1977-1981 surveys are included, indicating that the number of species in the marina in the spring and fall are relatively stable. Some fish eggs cannot be identified to species but others, previously not identified, have been placed in species more recently, altering the number of larval taxa slightly.

The mean for eight surveys conducted in October is 38.5 species, and for eight surveys conducted in May is 40, suggesting a slight seasonal variation, although such factors as turbidity can easily alter the total number of species on a given date. If monitoring were more frequent, such events would not affect the means as much.

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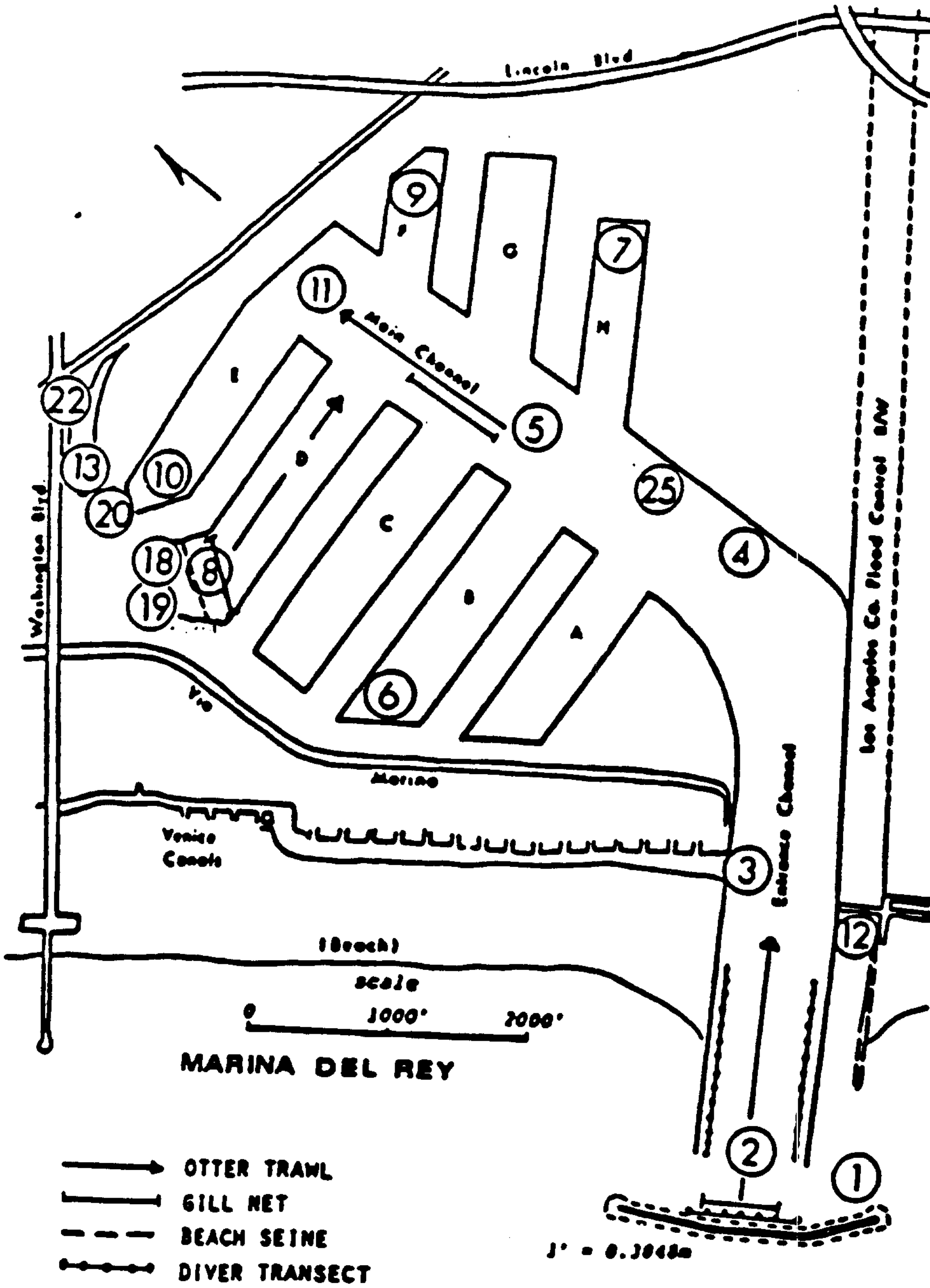

Figure VIII.1. Fish Sampling Stations for Marina del Rey.

PROCEDURES

Fish surveys were conducted on 17 and 18 October 1991, and on 21 and 22 May 1992 courtesy of Occidental College, at the stations indicated in Figure VIII.1. Techniques have been standardized since 1984, with otter trawls performed using a 15 ft semiballoon trawl towed for 10 minutes at three locations. A 100 ft multimesh gill net is deployed at three locations for 45 minutes each, and a 100 ft beach seine is deployed at an 8 ft depth about 30 yds from the beach in Basin D an[illegible]hed to the shore. Diver surveys are performed at the breakwater and along the jettie[illegible] of the entrance channel. Fish eggs and larvae (ichthyoplankton) are collected by towing a 333 μm mesh plankton net at 1 m depth for two minutes and on the bottom for three minutes. A diver assisted benthic sled is used to keep the net on the bottom in spite of variations in boat speed. Ichthyoplankton counts are standardized to counts per 100 m^3.

RESULTS AND DISCUSSION

October 1991

A total of 37 species was observed or captured by one or more techniques in October 1991: 18 from diver surveys; 8 from the beach seine; 3 from the gill net; 7 from the otter trawls and 11 from the ichthyoplankton.

Although the mean number of species/taxa is 38.5 for all October surveys, the mean numbers have been slightly below that since October 1988 (36.75), when unusually cold waters were present after a mild El Niño year (Table VIII.1). However, results of the diver surveys in October 1991 took place at a time of extreme tides, and the number of species sighted by divers was slightly lower than in October 1990.

The number of individuals captured in October 1991 was down about 22 percent from October 1990, due to a decrease in numbers of *Atherinops affinis* (topsmelt) usually caught by beach seine (Table VIII.2). However, otter trawl and gill net numbers were much higher.

In diver transects, the total number of fishes was 756 in October 1991, down about

Table VIII. 1. Number of fish species and larval taxa by month and year by sampling technique

	1977 1979*	1980 1981+	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90	Oct 90	May 91	Oct 91	May 92
Transects	14	-	20	24	19	22	20	10	24	15	24	22	22	13	20	22	18	20
Beach Seine	2	-	7	5	5	10	17	10	8	8	5	5	7	8	7	8	8	9
Gill Net	3	-	6	4	4	9	6	6	8	6	2	1	2	2	1	1	3	3
Otter Trawl	13	7	14	4	4	6	4	7	8	9	10	12	8	12	7	7	7	9
Ichthyoplankton (larvae only)	-	30+	10	7	10	11	6	9	11	8	4	12	3	14	11	13	11	9
Drop Net	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cryptic Fl	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Creel Census or visual sighting	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL NO SPECIES	36	44	45	37	38	44	42	41	44	32	39	43	35	36	36	40	37	39

* 5 surveys in 1977-79 (June, Oct, Jan, June, Apr)
+ 4 surveys in 1980-81 (Aug, Sept, Jan, Apr)

Table VIII. 2. Number of individuals captured, by month and year by sampling technique

	Jun 77	Oct 77	Jun 78	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90	Oct 90	May 91	Oct 91	May 92
Beach Seine	---	---	---	186	303	241	476	400	791	70	14135	486	1253	554	3550	740	10760	213	531
Gill Net	---	---	---	80	19	17	42	13	56	27	65	49	20	5	263	1	197	77	21
Otter Trawl	618	212	238	136	14	6	17	13	26	20	95	251	34	59	33	213	46	451	12
TOTAL FISH				402	336	264	535	426	873	117	14295	786	1307	618	3846	954	11003	741	384

Table VIII. 3. Number of individuals by month and year sampled as ichthyoplankton

	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90	Oct 90	May 91	Oct 91	May 92
TOTAL ICHTHYOPLANKTON (standardized per 1000 m³)	45462	16065	10600	15171	9000	60423	13535	12837	5556	14120	1714	15368	14887	59354	26400	27164

74 percent from 2,953 counted in October 1990 (Soule et al., 1991). The number of ichthyoplankton was the highest seen in October surveys at 26,688 per m^3 (Table VIII.3), although it was less than half the record number of 59,359 per m^3 caught in May 1991. May numbers are usually higher than October numbers.

Table VIII. 4, at the end of this section, lists the totals of all species caught or observed with the various techniques in October 1991. Of particular interest was the record capture in the beach seine of 11 *Mustelus californicus*, the gray smoothhound shark, out of a school of about 25 adults in the swimming area. While these sharks, about one meter long, are harmless to humans, this would easily account for the low numbers of *Atherinops affinis* (topsmelt), a favorite forage fish, in the seine. Also, the disappearance of the sea grass bed near the beach might have affected the numbers of *Atherinops*. Diversity was good in the seine nevertheless.

Numbers of gill net species have been low since 1988, and the numbers of individuals has varied greatly. No fish were caught at gill net stations 2 and 5 in October, in the entrance channel and main channel respectively, where catches have been poor in recent years. Eleven species or taxa of ichthyoplankton were recorded (Table VIII.5).

Table VIII.6 lists the species that have been recorded in the marina since surveys began. Returning after an absence were *Atractoscion nobilis*, white sea bass, absent since 1987, and *Hyperprosopon argenteum*, walleye surfperch, absent since 1986; *Ilypnus gilberti*, cheekspot goby is sometimes present in May, but has not been observed in October since 1986. Species that are usually present but were not seen in October 1991, perhaps due to limited visibility, were *Heterostichus rostratus* giant kelp fish, *Paralabrax maculofasciatus*, spotted sand bass, and *Pleuronichthys ritteri*, spotted turbot.

May 1992

There were 39 species and higher taxa recorded in the May 1992 surveys: 20 in the diver survey, 9 by beach seine, 3 by gill net, 9 by otter trawl and 9 in the ichthyoplankton. The 3 gill net species caught in May 1992 equalled the number caught in October 1992 and were the highest since 1988 (Table VIII. 1).

The numbers of individuals were the lowest for any spring survey since 1984, primarily influenced by low catches of *Atherinops affinis*, topsmelt, and *Seriphus politus*, queenfish. Numbers of individuals were also low in May 1984 and May 1986 surveys (there was no May 1985 survey), possibly due to the impacts of the 1982-1983 warm El Niño waters which lingered in the Southern California Bight in 1984, followed by a radical cooling in October 1984. In March and April 1992 waters were warmer than normal due to an El Niño event, which may have affected thermal cues for the spring spawn.

While ichthyoplankton larval totals were high, second only to those in May 1991, egg totals were very low and no eggs were found in Basin D. That area is of great concern because of this and other indications that the habitat has deteriorated there, such as increases in pollutants and fine sediments and the demise of the sea grass bed. Because of the observed wide range of variation in numbers of species and individuals and the infrequency of surveys, it could be difficult to determine a downward trend in a timely fashion.

Both *Mugil cephalus*, striped mullet, which has been in the marina in almost all surveys, and *Strongylura exilis*, California needlefish, which has occurred frequently, returned to the species list after being absent in May 1991. A new record for marina surveys was the diver observed kelp surfperch, *Brachyistius frenatus*. *Mustelus californicus*, gray smoothhound shark, occurred for the first time in October 1991 and recurred in May 1992, perhaps due to the warm waters. An important reappearance was of the uncommon species *Albula vulpes*, the bonefish. In May, for the first time *Rhacochilus vacca*, pile surf perch, was not observed.

Ichthyoplankton and Numbers of Species

Since ichthyoplankton surveys were reinstituted in 1984, more larval taxa have been recognized as species, creating some redundancy with the species also enumerated as adults. The species list (Table VIII.6) has been revised and all published records rechecked against original data lists to reflect this. For example, the category Clinidae Type A theoretically includes larvae of several species of *Gibbonsia*, but *Gibbonsia elegans* is the only species of that genus observed in the marina. Gobiidae Type A/C includes larvae of *Ilypnus gilberti*, *Quietula y-cauda*, and *Clevelandia ios* in an early (preflexion) stage, all of which have the possibility of being found in the marina so this category must be maintained. Gobiidae may include any of eight or more local species, but Gobiidae Type D larvae are generally recognized as being *Lepidogobius lepidus*; that species was collected in the marina as an adult only once, in a beach seine in May 1986. Cottidae is used for sculpins which are too immature or damaged so that they cannot be identified, but may be one or more of four species that are found in the marina, *Scorpaenichthys marmoratus*, *Leptocottus armatus*, *Clinocottus analis*, and rarely, *Chitonotus pugetensis*. *Oligocottus/Clinocottus* A are also sculpin larvae. In early surveys Complex 2, consisting of larvae too young to be identified to species, was reported; this group may include one or more of four local species of croakers, *Atractoscion nobilis*, *Cheilotrema saturnum*, *Menticirrhus undulatus* and *Umbrina roncador*.

Long Term Occurrences

Now that 16 survey periods have been performed from May 1984 to May 1992 using the same techniques, it is of interest to list species that can be considered residents of the marina. While a mean of 40 species has been found in the marina, composition of the fish fauna varies seasonally and annually. Some 20 species can be considered to be year around residents or users of the marina. Of these, seven species and two larval taxa have been present in all surveys, five more species have been present in all but one survey, two species have been present in all but two surveys, and six species have been present in all but three surveys, as is listed below:

Present in all surveys :

Atherinops affinis	topsmelt
Embiotoca jacksoni	black surfperch
Girella nigrans	opaleye
Gobiidae A/C larvae	gobies
Hypsoblennius, spp. larvae	blennies
Micrometrus minimus	dwarf surfperch
Paralabrax clathratus	kelp bass
Paralabrax nebulifer	barred sand bass
Rachochilus vacca	pile surfperch

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Present in all but one survey:

Halichoeres semicinctus	rock wrasse
Mugil Cephalus	striped mullet
Paralichthys californicus	kelp bass
Rachochilus vacca	pile surfperch
Seriphus politus	queenfish

Present in all but two surveys:

Heterostichus rostratum	giant kelpfish
Hypsypops rubicundus	garibaldi

Present in all but three s[illegible]ys:

Cheilotrem[illegible] saturnum	black croaker
Chromis punctipinnis	blacksmith
Engraulis mordax	northern anchovy
Hypopsetta guttulata	diamond turbot
Oxyjulis californica	señorita
Paralabrax maculofasciatus	spotted sand bass

A few species exhibit some seasonality. For example, *Ilypnus gilberti*, cheekspot goby, was found in only three October surveys but was present in six May surveys while *Leptocottus armatus* was also found in three October surveys but occurred in seven May surveys. Others more often collected in May than October were *Menticirrhus undulatus*, California corbina, *Pleuronichthys verticalis*, hornyhead turbot, *Quietula y-cauda*, shadow goby, *Sardinops sagax caeruleus*, Pacific sardine, and *Urolophus halleri*, round ray. *Scorpaena guttata*, sculpin/spotted scorpionfish, and *Typhlogobius californiensis*, blind goby, were found only in May, while *Semicossyphus pulcher*, California sheephead, was seen twice, only in October. *Chromis punctipinnis* was present in all October surveys but missing in three May surveys.

CONCLUSIONS

The fish fauna of the marina as a whole has been stabilized around a mean number of 39 species, although there has been a wide range of variation seasonally and annually (Figure VIII.2).

There is a basic group of about twenty species and larval taxa that have always been present during all or most spring and fall surveys. Within the system, a number of other

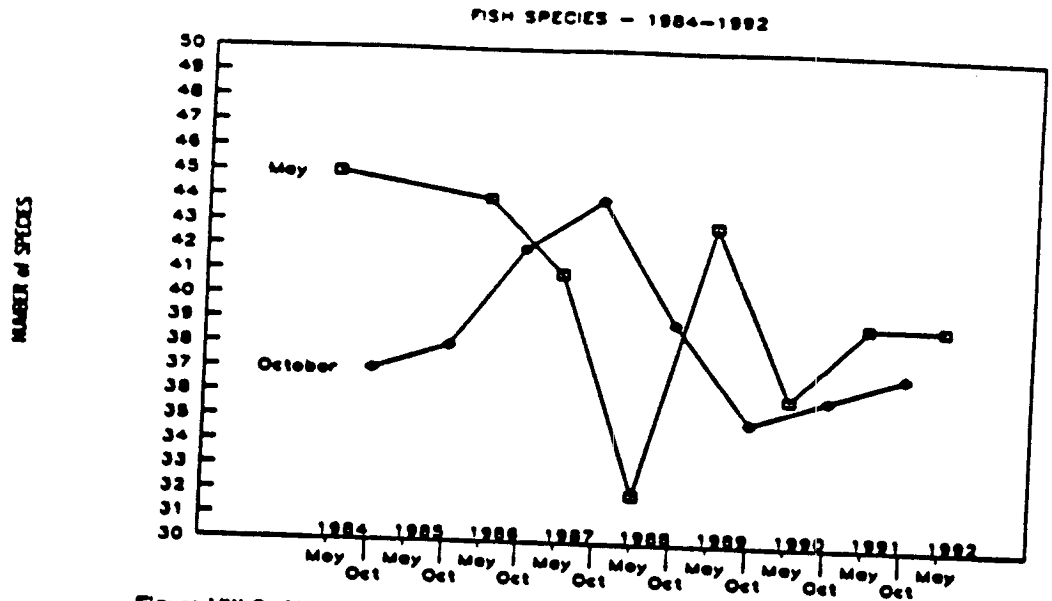

Figure VIII.2. Number of fish species/taxa by month and year.

species have appeared for several years and then disappeared, with no definitive pattern. Much of the variation is probably associated with the thermal fluctuations in warm winters associated with El Niño events. When the May 1984 survey was undertaken, a large warm water mass still lingered in the southern California Bight from the 1982-1983 El Niño, which dispersed in the fall of 1984. The influx of cooler water may have affected fall numbers of species until the faunal composition adjusted with more cool tolerant species. A smaller El Niño occurred in the winter of 1987, which may have affected the May 1988 survey and the subsequent October surveys. Although a strong El Niño event was in progress near the equator in January 1992, its effects on water temperature in the marina were not evident until above normal warming in March and April (Chapter II), after which it was cooler than in 1991. Such a shift in spring thermal patterns could alter spawning and recruitment patterns and might be at least partially responsible for low abundance. Because of the complexity of the thermal reproductive cues and the availability of food at the essential period, it is not possible to be

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certain which factors are driving the system when monitoring is not conducted at least monthly.

The impact of other factors such as pollutants is difficult to determine, due to the lack of records generally regarding small or large spills or influxes of contaminants through the storm drain system. It is of interest to note, however, that the only periods in which both the October and May surveys were low were in October 1989, May 1990 and October 1990. Coincidentally, this was the period in which the PCB spills/ releases were recorded, along with high Chlordane and DDTs (see Chapter IV).

Conditions at Station 8 in Basin D have deteriorated, with the loss of the sea grass bed, which provided shelter and foraging for larval and juvenile fish as well as forage fish schools. Sea grass has been replaced by filamentous algae and hydroids indicative of eutrophic environments. The finest fraction of sediment increased from 50 percent to over 98 percent in 1991, with a concomitant increase in trace metals and nonmetallic contaminants. Total pesticides and Aroclors increased, from 86 ppb in October 1989 to reach a high of 232 ppb in May 1991 and then decreased to a low of 55 ppb, in October 1991, but damage may well have been done to the delicate ecology of the basin by levels toxic to some plant and animal species. Sources of this influx of sediments, trace metals and other pollutants have not been identified, although they were probably associated with rainfall runoff. That area does not have large storm drain systems entering it and therefore should have been more protected from impact.

Table VIII. 4. Fish species and numbers collected, by technique, October 1991

SPECIES	DIVER TRANSECTS Breakwater Terminal	South	North	BEACH SEINE	GILL NET STATIONS 2	5	8	OTTER TRAWL STATIONS 2	5	8
Anisotremus davidsonii	7J									
Atherinops affinis	10A			183			72			
Atractoscion nobilis										
Cheilotrema saturnum	2J						1			
Chromis punctipinnis	137J	55S								
Embiotoca jacksoni	9A,6S	8A,20S	4A							
Fundulus parvipinnis				1						
Genyonemus lineatus										
Gibbonsia elegans	1A	1A							1	
Girella nigricans	42A,93S 22J	37A,23S	7A,12S 41J							
Halichoeres semicinctus	13A,12S	3A,9S								
Hyperprosopon argenteum	1A									
Hypsopsetta guttulata										
Hypsypops rubicundus	2A									1
Leptocottus armatus				1						
Micrometrus minimus		5A	8A							
Mugil cephalus										
Mustelus californicus				11			4			
Myliobatis californica										
Oxyjulis californica		10S 8S,6J								1
Paralabrax clathratus	12A,6S	3A,13S								
Paralabrax nebulifer	16A,5S	4A,8S	10S	1						
Paralichthys californicus		1A		1				5	7	1
Phanerodon furcatus		8S						1	5	3
Rhacochilus vacca	1A,1A	6A,33S								
Sebastes serranoides	7J	7J								
Seriphus politus										409
Urolophus halleri				9						
Strongylura exilis				6						
Xystreurys liolepis								3		
Species/Station	11	15	5	8	0	0	3	3	2	5
No Individuals/Station	387	286	83	213	0	0	77	9	13	415
Species/Technique		18		8		3			7	

A = Adult, J = Juvenile, S = Subadult

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Table VIII. 5. Ichthyoplankton survey, 17-18 October 1991

Species		Stations 2 S	2 B	5 S	5 B	8 S	8 B	TOTAL
Clindae type A*	L		70					
Engraulis mordax	E		23				626	
	L	93	15				38	
Gobiesox rhessodon	L						10	
Gobiidae A/C+	L	41	3195	167	2093	726	14577	
Gobiidae D++ (*Lepidogobius lepidus*)	L		170		59		10	
Hypsoblennius spp.	L	10	23	814	3543	343	636	
Hypsopsetta guttulata	L	10				10		
Ilypnus gilberti	L				12			
Cottidae	L				12			
Paralabrax clathratus	L		8					
Seriphus politus	L		15		12		66	
Unknown	E	2911	1323	177	105		11626	
SUBTOTALS	L	154	1516	981	5731	1089	15237	24708
	E	2911	1346	177	105		12252	16791

L = larvae E = egg S = surface B = bottom

* Clinidae type A = *Gibbonsia elegans*
\+ Gobiidae AC = *Ilypnus gilberti, Quietula y-cauda or Clevelandia ios larvae*
\+\+ Gobiidae D = *Leptogobius lepidus*

Table VIII 6. Incidence of fish species and larval taxa in Marina del Rey, 1977-1992

Species	1977-1979	1980 1981	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90	Oct 90	May 91	Oct 91	May 92
Acanthogobius flavimanus		x					x		x	x	x	x						
Albula vulpes			x							x								x
Anchoa compressa			x		x	x		x			x							
Anchoa delicatissima									x									
Anisotremus davidsoni		x	x	x	x	x	x	x				x	x		x		x	x
Atherinops affinis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Atherinopsis californiensis	x					x	x	x	x			x						
Atractoscion nobilis			x			x	x	x									x	
Brachyistius frenatus																		x
Cheilotrema saturnum		x		x	x	x	x	x	x	x	x	x	x	x		x	x	
Chitonotus pugetensis											x							
Chromis punctipinnis				x	x	x	x	x	x	x	x		x		x	x	x	x
Citharichthys stigmaeus	x	x	x					x					x					
Clevelandia ios	x	x	x			x	x	x		x			x		x			
Clinocottus analis	x	x	x		x		x			x	x	x				x		
Coryphopterus nicholsii								x				x						
Cottidae		x											x				x	
Cymatogaster aggregata	x			x		x		x				x	x	x	x	x		x
Embiotoca jacksoni	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Engraulis mordax	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x	x
Fundulus parvipinnis	x		x	x	x		x	x		x	x		x	x	x	x	x	
Genyonemus lineatus	x	x	x		x	x		x	x		x	x		x		x	x	
Gibbonsia elegans	x		x		x		x		x			x	x	x	x	x	x	x
Gillichthys mirabilis		x					x									x		
Girella nigricans	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Gobiesox rhessodon		x			x	x		x				x		x	x	x	x	x
Gobiidae A/C*		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Halichoeres semicinctus			x	x	x	x	x	x	x	x	x	x	x		x	x	x	x
Hermosilla azurea				x	x		x				x	x			x			x

* = Clevelandia ios, Ilypnus gilberti and/or Quietula Y-cauda; if one or more species is also present as adult, duplicate count would result.

Table VIII. 6 cont.

Species	1977-1979	1980 1981	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90	Oct 90	May 91	Oct 91	May 92
Heterodontus francisci			x	x										x		x		
Heterostichus rostratus		x	x		x	x	x	x	x	x	x	x	x	x	x	x		x
Hippoglossina stomata		x				x												
Hyperprosopon argenteum				x		x											x	
Hypsoblennius spp.*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hypsoblennius gentilis					x	x	x		x									
Hypsoblennius gilberti		x					x											
Hypsoblennius jenkinsi			x	x				x		x		x						
Hypsopsetta guttulata	x	x	x	x			x	x	x		x	x	x	x	x	x	x	x
Hypsurus caryi																x		x
Hypsypops rubicundus	x		x	x	x		x	x	x	x	x	x		x	x	x	x	x
Ilypnus gilberti			x	x		x	x	x		x				x		x	x	
Lepidogobius lepidus		x	x	x	x	x ◆			x		x						x	x
(= Gobiidae B larvae)																		
Leptocottus armatus	x					x	x	x		x		x	x	x		x	x	x
Lythrypnus dalli		x																
Medialuna californiensis									x									
Menticirrhus undulatus						x	x		x	x		x				x		
Micrometrus minimus		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mugil cephalus			x	x	x	x	x	x	x	x	x		x	x	x		x	x
Mustelus sp.																		x
Mustelus californicus																	x	x
Mustelus henlei	x								x									
Myliobatis californica	x					x	x	x	x		x	x	x	x		x	x	x
Neoclinus stephensae	x	x																
Oligocottus/Clinocottus A													x				x	
Oxyjulis californica	x		x	x	x	x		x	x		x	x	x		x	x	x	x
Oxylebius pictus														x				
Paraclinus integripinnis		x			x		x					x		x	x			
Paralabrax clathratus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
P. maculatofasciatus	x		x	x	x	x	x	x	x			x	x	x	x	x		x
Paralabrax nebulifer	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

* = a mix of H. gentilis and H. jenkinsi larvae too young to identify separately

◆ the only adult caught

Table VIII. 6. cont.

Species	1977-1979	1980 1981	May 84	Oct 84	Sept 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90	Oct 90	May 91	Oct 91	May 92
Paralichthys californicus	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Phanerodon furcatus	x					x			x		x	x		x		x	x	
Pleuronichthys coenosus					x				x									
Pleuronichthys ritteri			x		x		x	x	x	x	x	x	x		x	x		x
Pleuronichthys verticalis		x				x			x					x		x		
Quietula y-cauda			x			x	x	x		x		x	x	x		x		
Rhacochilus toxotes	x	x		x					x		x			x	x			
Rhacochilus vacca		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Rhinobatis productus			x															
Rimicola muscarum	x																	
Sarda chiliensis	x		x	x			x		x									
Sardinops sagax caeruleus		x	x	x	x	x	x	x	x	x		x			x	x		x
Sciaenidae complex 2											x							
Scorpaena guttata						x						x						x
Scorpaenichthys marmoratus			x									x	x			x		
Sebastes auriculatus			x															
Sebastes serranoides	x		x		x	x			x	x	x		x				x	
Semicossyphus pulcher									x		x							
= Pimelometopon pulchrum																		
Seriphus politus	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Sphyraena argentea	x			x	x	x			x	x				x	x			
Squatina californica					x													
Stenobrachius leucopsarus		x				x									x			
Strongylura exilis				x		x		x			x		x	x	x		x	x
Symphurus atricauda	x	x		x														
Syngnathus sp.	x				=									x		x		
Syngnathus leptorhynchus	x		x					x	x			x			x			
Synodus lucioceps	x	x									x							
Typhlogobius californiensis		x	x			x								x				x
Umbrina roncador			x	x	x		x	x	x		x							x
Urolophus halleri	x	x	x				x	x		x		x				x	x	x
Xenistius californiensis				x					x				x		x			
Xystreurys liolepis		x	x								x						x	

Table VIII. 7. Fish species and numbers collected, by technique, 21-22 May 1992

SPECIES	DIVER TRANSECT Terminal	DIVER TRANSECT Breakwater South	DIVER TRANSECT Breakwater North	BEACH SEINE	GILL NET STATIONS 2	GILL NET STATIONS 5	GILL NET STATIONS 8	OTTER TRAWL STATIONS 2	OTTER TRAWL STATIONS 5	OTTER TRAWL STATIONS 8
Albula vulpes				1						
Anisotremus davidsonii	1A									
Atherinops affinis	30A,130J	21A,2S	230A,27J	273			16			
Brachyistius frenatus			9A,2J							
Chromis punctipinnis	7S									
Cymatogaster aggregata		38A,20S 66J	19S,20J							
Embiotoca jacksoni	10A,3S,6J	11A,18J	2A,2J							
Engraulis mordax									1	
Girella nigricans	27A,62S		27A,14S							
Gobiidae type A/C									1	
Halichoeres semicinctus	34A,12S	3A								
Hermosilla azurea			1A							
Heterostichus rostratus		1A								
Hypsopsetta guttulata								1		
Hypsurus caryi			1A							
Hypsypops rubicundus	6A									
Leptocottus armatus				1						
Micrometrus minimus		1A	1A,1S							
Mugil cephalus				51						
Mustelus sp.	1A									
Mustelus californicus				1						
Myliobatis californica	1A								2	
Oxyjulis californica		2A,13S,2J								
Paralabrax clathratus	17A,2S	9A,1J								
P. maculatofasciatus	5A,3S	1A	5A	3						
Paralabrax nebulifer	7A,3S	2S		3				1		
Paralichthys californicus			1S						2	1
Pleuronichthys ritteri								1		
Sardinops sagax caeruleus					4					
Scorpaena guttata								1		
Seriphus politus									1	
Strongylura exilis							1			
Umbrina roncador				11						
Urolophus halleri				7						
Species/Station	12	10	10	9	1	0	2	4	5	1
No Individuals/Station	367	211	362	351	4	0	17	4	7	1
Species/Technique		20		9		3			9	

A = Adult, J = Juvenile, S = Subadult

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Table VIII. 8. Ichthyoplankton survey, 21-22 May 1992

Species		Stations 2 S	2 B	5 S	5 B	8 S	8 B	
Engraulis mordax	E		12					
Gobiesox rhessodon	L		189					
Gobiidae A/C+	L	2085	336	46	10557	149	6634	
Gobiidae D++ (*Lepidogobius lapidus*)	L	60	48		95		143	
Hypsoblennius spp.	L		48	46	1136	100	1193	
Pleuronichthys ritteri	L	60						
Seriphus politus	L				47			
Typhlogobius californiensis	L		48					
Unknown	E	1549	1777	603	95	0	0	
SUBTOTALS								TOTAL
	L	1561	1777	603	95	0	0	
	E	2265	528	92	12024	249		7970

L = larvae E = egg S = surface B = bottom

* Clinidae type A = *Gibbonsia elegans*
\+ Gobiidae AC = *Ilypnus gilberti, Quietula y-cauda or Clevelandia ios larvae*
\+\+ Gobiidae D = *Leptogobius lapidus*

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APPENDIX A
CRUISE LOGS

October 1991 - June 1992

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CRUISE: MDR 91-92 Date: 3 October 1991 Type: Water Quality

PERSONNEL:		VESSEL:		
D. Soule, PI	USC	*Bay Watch*		Martek, NH_3, Nutrients, BOD
M. Oguri	USC	S. Butler		Transmissometer, Sal. DO, pH,
R. Bester	USC	H. Thatcher		Secchi Disk, FU, Coliform
B. Jones	USC			
P. Hentschke	USC			

TIDE: HIGH 0719 4.7 ft - LOW 1243 2.0 ft

LEFT DOCK: 0802 WEATHER: Clear

SAMPLING STATIONS:

TIME/WIND K		STATIONS	OBSERVATIONS	COMMENTS
0821		12		
0829		1		
0836		2		
0845	SW 5k	3		
0854	SW 5k	4		
0902	SW 5k	25		
0912	SW 5k	5		
0923	S 6k	6		
0943	SW 5k	18		
0943		19		Hand sampled from beach
0947	SW 5k	8		
0957	SW 4k	10		
1011		20		
1021	SW 5k	11		
1030	SW 5k	9		
0947	SW 5k	7		
1115		13		Hand sampled from shore
1125		22		Hand sampled from shore

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CRUISE: MDR 91-92   Date: 17 October 1991   Type: Benthic organisms, metals, pesticides

PERSONNEL: D. Soule, PI USC; M. Oguri USC; R. Bester USC; B. Jones USC; P. Hentschke USC; A. Zellars USC

VESSEL: *Golden West*

D. Reynoso
B. Wastell
T. Healy

ASSOCIATED LABORATORIES: Robert Webber

TIDE: High 0706 4.3 ft - Low 1230 2.6 ft

LEFT DOCK: 0830   WEATHER: Overcast

SAMPLING STATIONS:

SAMPLER: Campbell Grab, 1/2 & 1 ml Screens

STATION	TIME	PROCEDURE	COMMENTS
12	0837	Bottom sediment metals, pesticides. Benthic organisms	Took 12 grabs pooled samples Very sandy, would not sieve well.
1	0937		Strong sulfide odor. Pooled 6 grabs. Very sandy. Sun coming out
2	1016		Strong sulfide odor. Oily, plant debris plentiful. Sun fully out
3	0157		Not the usual amount sand. Sieved very well
4	1128		1st and 2nd grabs empty, 3rd grab successful
25	1143		1 Grab taken
5	1219		1 Grab taken
6	1252		1 Grab taken
8	0152		1 Grab taken
10	0143		1 Grab taken
11	0212		1 Grab taken
9	0237		1 Grab taken
7	0300		1 Grab taken
13	0320	West and Oxford Flood Control	Hand sampled from shore
22	0340	East and Oxford Flood Control, near Washington Blvd. culvert	Hand sampled from shore

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CRUISE: MDR 91-92

Date: 6 November 1991

Type: Water Quality

PERSONNEL: D. Soule, PI USC
M. Oguri USC
R. Bester USC
B. Jones USC
P. Hentschke USC

VESSEL: *Bay Watch*
S. Butler
H. Thatcher

Martek, NH_3, Nutrients, BOD
Transmissometer, Sal. DO, pH,
Secchi Disk, FU, Coliform

TIDE: HIGH 0719 4.7 ft - LOW 1243 2.0 ft

LEFT DOCK 0805

WEATHER: Clear, warm, sunny
Rainfall in basin: 10/26/92 - 0.5"

SAMPLING STATIONS:

TIME/WIND K		STATIONS	OBSERVATIONS	COMMENTS
0821		12	Trash floating all the way up stream	Pictures taken
0831	NE 2k	1	Heavy swells	Water temperature down.
0840	NE 5k	2		
0850	NE 6k	3		Much trash still floating
0902	NE 2k	4		
0910		25		Water calm and glassy
0922	NE 2k	5		
0934		6		
0955	NE 2k	18		
0955		19		Hand sampled from beach
1001		8		
0957		10		
1027		20	Large amount of heavy scum floating on water	
1037		11		
1054	SW 6k	9		
1108	SW 5l	7		
1140		13		Hand sampled from shore
1146		22		Hand sampled from shore

CRUISE: MDR 91-92 | Date: 5 December 1991 | Type: Water Quality

PERSONNEL: D. Soule, PI USC
M. Oguri USC
R. Bester USC
B. Jones USC
P. Hentschke USC

VESSEL: *Bay Watch*
S. Butler
H. Thatcher

Martek, NH_3, Nutrients, BOD
Transmissometer, Sal. DO, pH,
Secchi Disk, FU, Coliform

TIDE: HIGH 0749 6.3 ft - LOW 1510 0.8 ft

LEFT DOCK: 0800 WEATHER: Overcast, cool, crisp

SAMPLING STATIONS:

TIME/WIND K		STATIONS	OBSERVATIONS	COMMENTS
0808		12		Water very glassy
0816	SE 7k	1		Many pelicans on breakwater
0818		2		
0840		3		
0851		4		
0859		25		
0910	E 3k	5		
0922		6		
0940		18		
0940		19		Hand sampled from beach
0947		8		
1007	NE 3k	10		
1005		20		
1025		11		Sun coming out
1035		9		
1050		7		
1121		13		Hand sampled from shore
1127		22		Hand sampled from shore

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CRUISE: MDR 91-92 Date: 9 January 1992 Type: Water Quality

PERSONNEL: M. Oguri USC; R. Baster USC; B. Wastell USC

VESSEL: *Bay Watch*; S. Butler; M. Alexander

Martek, NH_3, Nutrients, BOD, Transmissometer, Sal. DO, pH, Secchi Disk, FU, Coliform

TIDE: HIGH 1051 4.6 ft - LOW 0509 2.3 ft

LEFT DOCK 0800

WEATHER: Sunny, clear, cold
Rainfall in basin: 12/8/91 0.2"; 12/9 0.1"; 12/28 1.1"; 12/29 2.3"; 1/3/92 0.4"; 1/5 1.5"; 1/6 0.1"; 1/7 0.4"

SAMPLING STATIONS:

TIME/WIND K		STATIONS	OBSERVATIONS	COMMENTS
0812	N 5k	12		Water very clean
0866	NNE 6k	1		
0822	NE 6.75k	2		
0841	NE 6.5k	3		6m sample cloudy
0854	N 1.5k	4		Water glassy, calm
0904		25		Scum floating on water
0915		5		
0927		6		Rubbish floating in water
0950		18		Scum on water
0940		19		Hand sampled from beach
1000	E 1k	8		
1017		10		Very grungy water
1005		20		
1025		11		Sun coming out
1035		9		
1050		7		
1121		13		Hand sampled from shore
1127		22		Hand sampled from shore

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R0051275

CRUISE: MDR 91-92 Date: 6 February 1992 Type: Water Quality

PERSONNEL: M. Oguri USC, R. Bester USC, B. Jones USC, P. Hentschke USC

VESSEL: *Bay Watch* S. Butler, M. Alexander

Martek, NH_3, Nutrients, BOD Transmissometer, Sal. DO, pH, Secchi Disk, FU, Coliform

TIDE: HIGH 1004 4.9 ft - LOW 0408 -1.5 ft

LEFT DOCK 0810

WEATHER: Cloudy, rainy, cold - 3-5' swells, rough water
Rainfall in Basin: 2/5/92 0.5"; 2/6 2.2"

SAMPLING STATIONS:

TIME/WIND K		STATIONS	OBSERVATIONS	COMMENTS
0828	NE 9k	12	Lot of bottom resuspension	
0835	NE 9k	1	Abundance of foam on surface	
0843	E 9.5k	2		
0854	E 9.5k	3		
0903		4		
0911		25		
0922	NE 9k	5		
0932	NE 8k	6		
0951	E 6k	18		
0951		19		Hand sampled from beach
1958		8		
1010		10		
1020		20		
Station 11, 9, 7, were not sampled due to an emergency call to the Life Guards.				
1100		13		Hand sampled from shore
1111		22		Hand sampled from shore

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R0051276

CRUISE: MDR 91-92 Date: 5 March 1992 Type: Water Quality

PERSONNEL: M. Oguri USC
B. Jones USC
P. Hentschke USC
D. Reynoso USC

VESSEL: Bay Watch
S. Butler
R. Brown

Martek, NH_3, Nutrients, BOD
Transmissometer, Sal. DO, pH,
Secchi Disk, FU, Coliform

TIDE: LOW: 0320 0.7 ft - HIGH 0923 4.9 ft - LOW 1533 0.4 ft

LEFT DOCK 0759

WEATHER: Partly cloudy
Rainfall in basin: 2/6/92 2.2"; 2/9 0.7"; 2/10 2.9"; 2/11 1.4"; 2/12 2.6"; 2/13 0.6"; 3/2 0.9"; 3/3 2.3"

SAMPLING S TIONS:

TIME/WIND k		STATIONS	OBSERVATIONS	COMMENTS
0810	SW 3k	12		
0818	SW 3k	1	Water color green	Phytoplankton like
0826	SW 2k	2		
0835		3		Increasingly overcast
0844		4		
0852		25	Floatables & surface oil	
0903		5	Surface clear	Plastic & oil 100 m before station
0914		6	Water color green	No debris at this location
0951	SW 4.5k	18		
0933		19		Hand sampled from beach
0939	WSW 5k	8		
0957	SW 4k	10		
1005	SW 2k	20		
1015	SW 2k	11		
1026	SW 5.5k	9		
1039	SW 7k	7		
1109		13		Hand sampled from shore
1118		22		Hand sampled from shore

R0051277

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CRUISE: MDR 91-92 Date: 2 April 1992 Type: Water Quality

PERSONNEL: M. Oguri USC; B. Jones USC; Yu Hong Teng USC; J. Nauman J Naumann & Assoc.

VESSEL: *Bay Watch* S. Butler, R. Brown

Martek, NH_3, Nutrients, BOD, Transmissometer, Sal. DO, pH, Secchi Disk, FU, Coliform

TIDE: HIGH 0839 4.5 ft - LOW 1428 0.7 ft

LEFT DOCK 0812

WEATHER: Mild & clear
Rainfall in basin: 3/6/92 0.7"; 3/7 0.2"; 3/20 1.7"; 3/21 0.7"; 3/22 0.5"; 3/23 1.3"; 3/26 1.2"; 3/27 0.1"; 4/1 0.5"

SAMPLING STATIONS:

TIME/WIND K		STATIONS	OBSERVATIONS	COMMENTS
0822		12		
0830		1		
0841	SW 3k	2		
0851		3		
0902	W 3k	4		
0912	W 2k	25		
0926		5		
0937	SW 5k	6		
0958	W 4-6k	18		
0958		19		Hand sampled from beach
1004	W 4-6k	8		
1021	W 3-6k	10		
1029	W 2-5k	20		
1040	W 2-5k	11		
1049	W 6-7k	9		
1101	W 7-10k	7		
1132		13		Hand sampled from shore
1140		22		Hand sampled from shore

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CRUISE: MDR 91-92

Date: 14 May 1992

Type: Water Quality

PERSONNEL: M. Oguri USC
B. Jones USC
R. Bester USC
S. Sapper USC

VESSEL: *Bay Watch*
S. Butler
B. Hague

Martek, NH_3, Nutrients, BOD
Transmissometer, Sal. DO, pH,
Secchi Disk, FU, Coliform

TIDE: HIGH 0853 4.0 ft - LOW 1404 1.2 ft

LEFT DOCK 0915

WEATHER: Overcast & calm
May 12-13 Red Tide

SAMPLING STATIONS:

TIME/WIND K		STATIONS	OBSERV... ONS	COMMENTS
0921	S 3k	12		
0931	S 3k	1		
0940	S 1.5k	2		
0950		3		
1000		4		
1007		25		
1016	S 6k	5		
1027		6		
1048		18		
1048		19		Hand sampled from beach
1053	S 6k	8		
1105		10		
1117		20		
1126		11		
1136	SW 6k	9		
1149	SW 7k	7		
1235		13		Hand sampled from shore
1245		22		Hand sampled from shore

Oxford Street Basin has green growth over surface

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CRUISE: MDR 91-92

Date: 11 June 1992

Type: Water Quality

PERSONNEL: M. Oguri USC
B. Jones USC
R. Bester USC
P. Hentschke USC

VESSEL: *Bay Watch*
S. Butler
B. Hague

Martek, NH_3, Nutrients, BOD
Transmissometer, Sal. DO, pH
Secchi Disk, FU, Coliform

TIDE: HIGH 1010 3.5 ft - LOW 1353 1.8 ft

LEFT DOCK 0810

WEATHER: Cloudy, warm, slight breeze

SAMPLING STATIONS:

TIME/WIND K		STATIONS	OBSERVATIONS	COMMENTS
0827	W 7k	12	Water very clear	Large numbers of pelicans feeding
0837	W 6k	1		
0844	W 6k	2		
0852	W 6k	3		
0903	W 6k	4		
0911		25		
0921	SW 5k	5		
0933	SW 4k	6		
0953	W 5k	18		
0953		19		Hand sampled from beach
0958	W 5k	8		
1014	W 5k	10		
1023		20		5 boats moored here now
1034	W 6k	11		
1040	W 6k	9		
1059	W 6k	7		
1129		13		Hand sampled from shore
1137		22		Hand sampled from shore

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APPENDIX B
PHYSICAL WATER QUALITY DATA

October 1991 - June 1992

Table B1. Physical Water Quality Data.

3 October 1991

CRUISE: MDR 91-92
WEATHER: Clear

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	0719	4.7
Low	1143	2.0

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12	0851	0	19.9	31.2	9.2	8.3	89	7	4.0	1.4
		1	19.9	31.5	9.2	8.3	90			
		2	19.8	31.9	9.5	8.3	90			0.8
		3	19.6	33.0	9.3	8.2	90			
1	0829	0	19.8	32.8	9.6	8.3	89	5	5.5	0.9
		1	19.8	32.9	9.8	8.3	89			
		2	19.8	33.1	10.0	8.3	89			0.9
		3	19.8	33.3	10.2	8.3	90			
		4	19.7	33.3	10.1	8.3	90			0.9
		5	19.5	33.3	10.1	8.3	90			
		6	19.0	33.3	9.8	9.3	88			
2	0836	0	19.9	32.6	9.6	8.3	85	10	3.5	1.2
		1	19.9	32.8	9.7	8.3	85			
		2	19.8	32.9	9.7	8.3	86			0.9
		3	19.5	33.1	9.6	8.3	87			
		4	18.8	33.3	9.5	8.3	88			0.8
		5	18.2	33.3	9.2	9.3	87			
3 5k SW	0845	0	20.8	33.0	8.9	8.2	76	10	3.5	0.9
		1	20.8	33.1	9.0	8.3	77			
		2	20.8	33.1	9.0	8.3	77			0.8
		3	19.8	33.1	9.4	8.3	79			
		4	20.3	33.1	9.1	8.3	79			0.7
		5	19.3	33.1	9.3	8.3	85			
4 5k SW	0854	0	21.1	32.8	8.8	8.2	78	10	2.5	0.8
		1	21.0	33.0	8.9	8.2	78			
		2	20.9	33.1	8.7	8.2	78			0.8
		3	20.9	33.1	8.6	8.2	78			
		4	20.0	33.3	8.7	8.3	79			0.6
		5	19.6	33.3	8.7	8.3	81			
25 5k SW	0902	0	20.9	32.7	8.5	8.2	79	8	2.5	0.5
		1	20.9	33.1	8.5	8.2	80			
		2	20.9	33.1	8.3	8.2	82			0.6
		3	20.5	33.1	8.2	8.2	80			
		4	19.8	33.3	8.4	8.2	78			0.7
		5	19.6	33.2	8.5	8.2	78			
		6	19.0	33.2	8.6	8.2	73			0.6

Table B1. 3 October 1991 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
5 5k SW	0912	0	21.7	33.2	8.7	8.2	79	10	2.5	0.6
		1	21.6	33.3	8.7	8.2	76			
		2	21.5	33.2	8.1	8.2	76			0.8
		3	21.0	33.3	8.6	8.2	73			
		4	20.2	33.3	8.5	8.2	75			0.9
		5	19.3	33.3	8.5	8.3	78			
6 6k S	0923	0	21.5	33.1	9.2	8.2	82	8	3.0	0.8
		1	21.5	33.1	9.1	8.2	81			
		2	21.5	33.2	9.1	8.2	80			0.9
		3	21.3	33.2	7.1	8.2	76			
		4	20.6	33.2	6.4	8.1	69			0.8
19	0943	0	Sampled by hand from beach							0.9
18 5k SW	0943	0	21.8	33.1	9.1	8.2	79	10	2.0	0.7
		1	21.9	33.3	9.0	8.2	78			
8 5k SW	0947	0	21.7	33.1	8.9	8.2	76	10	2.5	0.7
		1	21.8	33.2	8.9	8.2	73			
		2	21.6	33.2	7.6	8.1	74			1.2
		3	21.3	33.3	6.8	8.1	65			
10 4K SW	0957	0	22.2	32.8	8.1	8.1	81	10	2.0	0.7
		1	22.0	33.0	8.3	8.1	78			
		2	21.7	33.1	6.9	8.1	72			1.1
		3	21.4	33.1	6.7	8.1	64			
		4	21.2	33.1	6.4	8.1	59			0.9
20	1011	0	22.0	31.5	7.5	8.0	81	8	2.0	0.5
		1	22.1	32.8	7.4	8.1	78			
		2	21.5	33.1	6.8	8.1	69			
11 5k SW	1021	0	22.0	33.1	8.7	8.1	79	5	2.5	0.6
		1	22.0	33.1	8.6	8.1	78			
		2	21.9	33.1	8.6	8.1	78			1.0
		3	21.2	33.3	7.7	8.1	68			
9 5K SW	1030	0	22.1	33.1	8.5	8.1	76	10	2.0	0.6
		1	22.1	33.1	8.2	8.1	76			
		2	21.5	33.1	7.6	8.1	72			1.0
		3	20.8	33.3	7.4	8.1	65			
		4	20.4	33.3	6.9	8.1	66			

Table B1. 3 October 1991 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
7 5k SW	1044	0	21.7	33.2	8.4	8.1	76	10	2.0	0.4
		1	21.6	33.2	8.1	8.1	76			
		2	21.4	33.2	7.8	8.1	74			
		3	20.5	33.4	7.6	8.1	67			0.6
		4	19.8	33.4	7.4	8.1	65			
13	1115	0	22.3	32.7	7.0	7.8				1.6
22	1125	0	22.7	30.1	5.6	7.9				2.8
	Average		20.8	33.0	8.5	8.2	78.4	8.7	3.0	0.9
	Number		77	77	77	77	75	15	15	40
	Sta Dev		1.0	0.5	1.0	0.1	7.1	1.8	1.1	0.4
	Maximum		22.7	33.4	10.2	8.3	90.0	10.0	5.5	2.8
	Minimum		18.2	30.1	5.6	7.8	59.0	5.0	2.0	0.4

Table B2. Physical Water Quality Data.

6 November 1991

CRUISE: MDR 91-92
WEATHER: Clear, warm and sunny

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	0815	6.4
Low	1515	-0.6

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12	0821	0	16.5	30.1	8.8	8.3	90	7	3.0	2.2
		1	16.6	30.9	9.4	8.3	90			
		2	16.7	31.2	9.4	8.3	90			2.1
1 2k NE	0837	0	16.8	31.9	9.5	8.3	90	6	5.0	2.1
		1	16.7	32.0	9.6	8.3	90			
		2	16.7	32.0	9.7	8.3	90			
		3	16.7	32.1	9.8	8.3	90			1.8
		4	16.7	32.1	9.8	8.3	90			
		5	16.7	32.1	9.7	8.3	90			1.7
		6	16.6	32.1	9.6	8.3	90			
		7	16.3	32.2	9.5	8.3	86			1.2
2 5k NE	0840	0	16.6	32.3	9.2	8.3	85	7	4.0	1.3
		1	16.5	32.3	9.2	8.3	86			
		2	16.5	32.3	9.2	8.3	86			
		3	16.5	32.3	9.2	8.3	86			1.3
		4	16.5	32.3	9.3	8.3	86			
		5	16.5	32.3	9.3	8.3	86			1.0
		6	16.5	32.4	9.2	8.3	86			0.7
3 6k NE	0850	0	16.5	32.5	8.6	8.3	86	7	3.5	1.0
		1	16.5	32.6	8.9	8.3	86			
		2	16.5	32.6	9.1	8.3	85			
		3	16.5	32.6	9.1	8.3	84			1.0
		4	16.5	32.6	9.2	8.3	83			
		5	16.5	32.6	9.2	8.3	82			0.9
4 2k NE	0902	0	16.7	32.5	8.5	8.2	84	7	3.5	0.8
		1	16.6	32.5	8.6	8.2	84			
		2	16.5	32.6	8.7	8.2	84			
		3	16.5	32.6	8.7	8.2	84			1.2
		4	16.5	32.6	8.6	8.2	84			
		5	16.5	32.6	8.5	8.2	85			0.8
		6	16.5	32.6	8.5	8.2	85			

Table B2. 6 November 1991 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
25	0910	0	16.7	32.6	8.1	8.2	83	7	3.5	1.2
		1	16.7	32.6	8.3	8.2	84			
		2	16.6	32.6	8.3	8.2	84			0.9
		3	16.6	32.6	8.3	8.2	84			
		4	16.6	32.6	8.2	8.2	84			0.7
		5	16.6	32.6	8.2	8.2	83			
		6	16.6	32.6	8.2	8.2	81			0.7
5 2k NE	0922	0	17.1	32.6	7.3	8.1	77	6	2.5	0.9
		1	17.0	32.6	7.5	8.1	81			
		2	16.9	32.6	7.8	8.1	80			1.0
		3	16.9	32.6	8.0	8.2	80			
		4	16.8	32.6	8.1	8.2	79			1.4
		5	16.7	32.6	8.2	8.2	81			
		6	16.6	32.6	8.3	8.2	77			
6	0934	0	17.1	32.6	7.6	8.1	82	7	3.0	1.1
		1	17.0	32.6	7.6	8.1	82			
		2	17.0	32.7	7.5	8.1	82			1.1
		3	16.9	32.7	7.5	8.1	81			
		4	16.9	32.7	7.5	8.1	81			1.1
19	0955	0	Hand sampled from shore							6.1
18 2k NE	0955	0	17.6	32.8	8.0	8.1	83	10	2.5	1.2
		1	17.4	32.8	8.5	8.2	84			
		2	17.3	32.8	8.6	8.2	83			1.1
		3	17.2	32.7	8.6	8.2	81			
8	1001	0	17.3	32.6	8.3	8.2	80	12	2.0	1.4
		1	17.3	32.8	8.4	8.2	80			
		2	17.3	32.8	8.5	8.2	79			1.5
		3	17.2	32.8	8.6	8.2	76			
		4	17.1	32.8	8.6	8.2	75			1.2
10	1020	0	17.2	32.7	7.5	8.1	82	8	3.0	1.6
		1	17.2	32.6	7.7	8.1	81			
		2	17.2	32.6	7.8	8.1	81			1.5
		3	17.2	32.6	7.8	8.1	78			
		4	17.2	32.6	7.6	8.1	77			1.3
20	1027	0	18.0	32.6	7.5	8.1	83	7	3.0	1.1
		1	17.5	32.6	7.5	8.1	84			
		2	17.2	32.6	7.3	8.1	84			1.0
		3	17.2	32.7	7.3	8.1	83			

Table B2. 6 November 1991 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
11	1037	0	17.3	32.8	7.8	8.1	77	6	3.0	0.8
		1	17.2	32.8	7.7	8.1	75			
		2	17.2	32.8	7.7	8.1	74			0.6
		3	17.2	32.8	7.7	8.1	74			
		4	17.1	32.8	7.7	8.1	72			0.6
9 6k SW	1054	0	17.5	32.7	7.4	8.1	80	8	2.5	1.0
		1	17.4	32.8	7.4	8.1	80			
		2	17.4	32.8	7.5	8.1	79			0.9
		3	17.3	32.7	7.5	8.1	77			
		4	17.2	32.8	7.7	8.1	77			0.8
7 5k SW	1108	0	17.4	32.7	6.9	8.0	82	6	2.5	0.7
		1	17.4	32.8	7.0	8.0	81			
		2	17.2	32.8	7.0	8.0	80			0.6
		3	17.1	32.8	7.0	8.0	79			
		4	17.1	32.8	7.1	8.0	77			0.6
13	1140	0	18.3	32.1	6.3	8.0				3.7
22	1146	0	18.2	31.9	6.9	8.0				3.2
	Average		16.9	32.5	8.3	8.2	82.5	7.4	3.1	1.3
	Number		85	85	85	85	83	15	15	48
	Sta Dev		0.4	0.4	0.8	0.1	4.2	1.6	0.7	0.9
	Maximum		18.3	32.8	9.8	8.3	90.0	12.0	5.0	6.1
	Minimum		16.3	30.1	6.3	8.0	72.0	6.0	2.0	0.6

Table B3. Physical Water Quality Data.

5 December 1991

CRUISE: MDR 91-92
WEATHER: Overcast, cool, crisp

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	0749	6.3
Low	1510	-0.8

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12	0808	0	13.6	31.0	9.1	8.2	76	8	3.0	1.5
		1	13.8	31.6	9.4	8.2	81			
		2	14.1	32.7	9.7	8.2	89			1.2
		3	14.2	33.0	9.8	8.2	90			
1 7k SE	0816	0	14.2	33.5	10.0	8.2	87	5	5.0	1.3
		1	14.3	33.5	10.0	8.3	87			
		2	14.3	33.5	10.0	8.3	88			1.3
		3	14.3	33.5	10.1	8.3	88			
		4	14.3	33.4	10.1	8.3	88			1.4
		5	14.3	33.4	10.1	8.3	90			
2	0828	0	14.2	33.4	9.6	8.2		5	5.0	1.2
		1	14.2	33.4	9.7	8.3				
		2	14.2	33.4	9.9	8.2				1.2
		3	14.1	33.4	10.0	8.2				
		4	14.1	33.4	10.0	8.2				1.3
		5	14.0	33.4	10.0	8.2				
		6	14.0	33.4	10.0	8.2				1.2
3	0840	0	13.9	33.4	9.2	8.2	84	6	3.5	1.1
		1	13.9	33.4	9.4	8.2	86			
		2	13.9	33.4	9.4	8.2	86			1.1
		3	13.9	33.4	9.3	8.2	86			
		4	13.9	33.4	9.3	8.2	85			0.9
		5	13.9	33.4	8.9	8.2	85			
4	0851	0	13.9	33.0	9.6	8.2	86			1.4
		1	13.9	33.0	9.6	8.2	86			
		2	13.9	33.0	9.7	8.2	86			1.3
		3	13.8	33.1	9.6	8.2	87			
		4	13.8	33.1	9.6	8.2	87			1.2
		5	13.7	33.1	9.6	8.2	86			
25	0859	0	13.5	33.4	9.0	8.2	85	6	2.5	1.5
		1	13.5	33.4	8.9	8.2	86			
		2	13.5	33.4	9.3	8.2	85			1.3
		3	13.5	33.4	9.1	8.2	85			
		4	13.5	33.4	8.9	8.1	85			1.0
		5	13.5	33.4	9.0	8.1	84			
		6	13.5	33.4	9.0	8.1	85			0.5

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Table B3. 5 December 1991 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
5 3k E	0910	0	13.5	33.3	9.1	8.2	83	5	2.5	0.8
		1	13.5	33.3	8.7	8.1	83			
		2	13.5	33.3	8.7	8.1	83			0.8
		3	13.5	33.3	8.8	8.1	83			
		4	13.6	33.4	7.6	8.1	81			0.7
		5	13.6	33.4	7.6	8.0	79			
		6	13.6	33.4	7.6	8.1	75			
6	0922	0	13.4	33.4	7.7	8.1	83	5	2.5	0.7
		1	13.5	33.4	7.8	8.1	82			
		2	13.5	33.4	7.9	8.1	82			0.7
		3	13.5	33.4	7.9	8.1	82			
		4	13.5	33.4	7.9	8.1	82			0.6
19	0940	0	Hand sampled from beach							0.8
18	0940	0	13.4	33.2	8.5	8.1	80	10	2.5	0.8
		1	13.4	33.3	8.6	8.1	80			
		2	13.4	33.4	8.7	8.1	80			0.9
8	0947	0	13.5	33.4	8.3	8.1	80	8	2.5	0.8
		1	13.5	33.4	8.5	8.1	80			
		2	13.5	33.4	8.6	8.1	80			0.7
		3	13.5	33.4	8.7	8.1	80			
		4	13.4	33.4	8.9	8.1	81			0.7
		5	13.3	33.5	8.8	8.1	82			
10 3k NE	1007	0	13.6	33.5	8.3	8.1	78	7	2.0	0.6
		1	13.6	33.5	8.4	8.1	79			
		2	13.6	33.5	8.4	8.1	79			0.7
		3	13.6	33.5	8.4	8.1	78			
		4	13.6	33.5	8.2	8.1	77			0.6
20	1015	0	13.7	32.1	7.9	8.0	79	6	1.5	0.9
		1	14.0	33.2	7.8	8.0	78			
		2	13.7	33.3	8.0	8.1	78			0.6
		3	13.7	33.3	8.0	8.1	78			
11	1025	0	13.8	33.3	7.9	8.1	74	7	1.5	0.4
		1	13.8	33.4	8.0	8.1	73			
		2	13.8	33.4	8.1	8.1	73			0.6
		3	13.7	33.4	8.2	8.1	74			
		4	13.6	33.4	8.2	8.1	76			0.4

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Table B3. 5 December 1991 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
9	1035	0	13.8	33.4	7.6	8.1	75	7	1.5	0.5
		1	13.8	33.4	7.8	8.0	74			
		2	13.9	33.4	7.9	8.0	74			0.5
		3	13.8	33.4	7.9	8.1	74			
		4	13.7	33.4	7.9	8.1	74			0.4
7	1050	0	13.6	33.4	8.1	8.1	81	5	3.5	0.4
		1	13.6	33.4	8.1	8.1	81			
		2	13.6	33.4	7.9	8.0	82			0.4
		3	13.6	33.4	7.9	8.0	83			
		4	13.6	33.4	7.9	8.0	82			0.4
13	1121	0	14.0	33.4	7.3	7.9				1.6
22	1127	0	13.9	33.1	8.4	8.0				2.4
	Average		13.7	33.3	8.8	8.1	81.7	6.5	2.8	0.9
	Number		83	83	83	83	74	15	15	47
	Sta Dev		0.3	0.4	0.8	0.1	4.5	1.4	1.1	0.4
	Maximum		14.3	33.5	10.1	8.3	90.0	10.0	5.0	2.4
	Minimum		13.3	31.0	7.3	7.9	73.0	5.0	1.5	0.4

Table B4. Physical Water Quality Data.

9 January 1992

CRUISE: MDR 91-92
WEATHER: Sunny, clear,cold
Rain 1/7/92

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	1051	4.6
Low	0509	2.3

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12 5k N	0812	0	12.1	25.4	8.6	8.2	75	14	2.5	2.9
		1	13.7	30.1	9.2	8.2	84			
		2	14.0	31.6	9.3	8.2	84			2.7
		3	14.0	32.0	9.4	8.2	84			
1 6k NNE	0822	0	13.4	30.6	9.2	8.2	82	12	2.0	3.0
		1	13.5	31.5	9.1	8.2	82			
		2	13.9	32.0	9.1	8.2	82			2.3
		3	14.0	32.3	8.9	8.2	84			
		4	14.0	32.4	8.9	8.2	85			1.9
		5	14.1	32.5	8.9	8.2	85			
2 6.75k NE	0830	0	13.3	30.9	8.0	8.2		10	2.0	1.9
		1	13.2	31.3	8.2	8.1				
		2	13.4	31.5	8.6	8.2				1.5
		6	13.8	32.0	8.7	8.2				
		4	14.0	32.3	8.8	8.2				1.5
		5	14.0	32.4	8.9	8.2				
		6	14.1	32.5	8.9	8.2				1.6
3 6.5k NE	0841	0	13.1	31.2	7.8	8.1	84	8	3.0	1.0
		1	13.2	31.3	7.9	8.1	84			
		2	14.0	31.9	8.5	8.1	82			1.1
		3	14.0	32.2	8.5	8.2	80			
		4	14.2	32.4	8.5	8.2	79			0.9
		5	14.2	32.5	8.5	8.2	79			
		6	14.2	32.6	8.5	8.2	75			1.4
4 1.5k N	0854	0	13.3	31.5	7.8	8.1	85	8	3.0	1.0
		1	13.4	31.6	7.8	8.1	85			
		2	13.6	31.7	8.1	8.1	85			0.8
		3	13.9	32.0	8.6	8.2	84			
		4	14.1	32.3	8.8	8.2	82			0.8
		5	14.2	32.4	9.0	8.2	82			
25	0904	0	13.4	31.2	7.7	8.1	84	8	2.5	0.7
		1	13.6	31.5	7.8	8.1	83			
		2	13.9	31.8	8.3	8.2	82			0.6
		3	14.0	32.0	8.5	8.2	80			
		4	14.1	32.1	8.6	8.2	78			0.6
		5	14.1	32.3	8.6	8.2	78			

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Table B4. 9 January 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
5	0915	0	12.6	30.8	7.3	8.1	82	7	3.0	0.8
		1	13.1	30.9	7.5	8.1	81			
		2	14.0	31.5	7.7	8.1	80			0.6
		3	14.1	31.9	8.2	8.1	79			
		4	14.2	32.3	8.5	8.2	79			0.6
		5	14.2	32.5	8.6	8.2	77			
6	0927	0	12.4	30.6	7.4	[illegible]	76	7	3.0	0.6
		1	12.4	30.7	7.2	[illegible]	84			
		2	14.1	31.4	7.2	8.1	82			0.6
		3	14.3	32.0	6.9	8.1	77			
		4	14.4	32.3	6.5	8.1	74			0.5
19	0950	0	Hand sampled from beach							4.6
18	0950	0	12.3	30.4	7.5	8.0	86	7	3.0	0.7
		1	13.6	30.5	7.1	8.0	85			
		2	14.1	30.9	6.8	8.0	80			0.7
8	1000	0	12.9	30.0	7.3	8.0	85	8	3.0	0.7
1k E		1	13.2	30.5	7.4	8.0	84			
		2	13.8	30.7	6.6	8.0	83			0.8
		3	14.5	31.9	6.5	8.0	76			
		4	14.5	32.2	6.1	8.0	72			0.8
10	1017	0	12.2	28.4	6.3	8.0	79	8	1.5	0.8
		1	13.8	30.1	6.6	8.0	74			
		2	14.2	31.0	6.5	8.0	72			0.9
		3	14.4	31.6	6.0	8.0	68			
		4	14.5	32.1	5.7	8.0	69			1.0
20	1026	0	12.7	28.9	6.2	8.0	77	10	2.0	1.0
		1	13.8	30.1	6.2	8.0	75			
		2	14.3	31.2	6.4	8.0	72			0.8
11	1038	0	13.5	30.8	7.4	8.1	79	7	2.5	0.8
1.5k NE		1	14.0	31.5	7.4	8.1	77			
		2	14.3	32.0	7.3	8.1	74			1.0
		3	14.4	32.3	7.5	8.1	73			
		4	14.3	32.4	7.5	8.1	71			0.7
9	1047	0	13.6	30.9	7.2	8.0	79	7	3.0	0.6
3k ENE		1	13.6	31.0	7.3	8.0	81			
		2	14.6	31.2	6.5	8.1	72			0.6
		3	14.4	32.3	7.2	8.1	70			
		4	14.4	32.4	7.0	8.1	69			0.6

Table B4. 9 January 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
7	1104	0	13.6	31.2	7.3	8.1	74	7	3.0	0.4
		1	13.6	31.2	7.3	8.1	80			
		2	13.6	31.5	7.2	8.1	80			0.4
		3	14.2	32.3	8.1	8.1	75			
		4	14.3	32.6	8.1	8.2	75			0.5
		5	14.3	32.6	8.0	8.2	72			
13	1135	0	11.0	17.4	5.5	7.5				5.9
22	1144	0	12.9	19.7	5.6	7.5				3.1
	Average		13.7	31.3	7.7	8.1	79.0	8.5	2.6	1.3
	Number		81	81	81	81	72	15	15	47
	Sta Dev		0.7	1.9	1.0	0.1	4.8	2.0	0.6	1.1
	Maximum		14.6	32.6	9.4	8.2	86.0	14.0	3.0	5.9
	Minimum		11.0	17.4	5.5	7.5	68.0	7.0	1.5	0.4

Table B5. Physical Water Quality Data.

6 February 1992

CRUISE: MDR 91-92 Vessel: Bay Watch

WEATHER: Cloudy, rainy, cold
3-5ft swells, rough water

TIDE	TIME	HEIGHT (ft)
Low	0408	1.5
High	1004	4.9
Low	1637	0.3

Notes: No data taken at Stations 7,9,11 due to emergency call for Life Guard vessel used in survey.
Data incomplete at Stations 8,10,12,20,22 due to probe malfunction in rain.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12 9k NE	0828	0	14.4	22.6	7.8	8.1	38	15	1.0	8.8
		1	14.6	28.1	8.7	8.1	61			
		2	14.6	31.4	9.3	8.1	68			
		3	14.7	32.0	9.4	8.1	70			2.5
1 9k NE	0835	0	14.7	31.7	8.8	8.1	65	14	1.5	3.3
		1	14.7	32.2	9.3	8.1	69			
		2	14.7	32.3	9.6	8.1	72			3.3
		3	14.7	32.3	9.5	8.1	73			
		4	14.7	32.3	9.5	8.1	73			2.7
		5	14.7	32.3	9.4	8.1	75			
2 9k E	0843	0	14.7	31.9	8.5	8.1	74	14	2.0	4.0
		1	14.7	32.0	8.7	8.1	74			
		2	14.7	32.3	9.1	8.1	75			3.6
		3	14.7	32.3	9.2	8.1	76			
		4	14.7	32.3	9.2	8.1	77			3.6
		5	14.7	32.3	9.1	8.1	77			
		6	14.7	32.3	9.1	8.1	77			
3 9.5k E	0854	0	14.7	32.0	7.8	8.0	77	12	2.0	1.3
		1	14.8	32.2	7.9	8.0	79			
		2	14.8	32.3	8.1	8.0	79			1.4
		3	14.8	32.3	7.9	8.0	80			
		4	14.8	32.3	8.1	8.1	79			1.1
		5	14.8	32.4	8.3	8.1	77			
4	0903	0	14.8	32.0	7.9	8.0	80	10	2.5	1.3
		1	14.8	32.2	7.9	8.0	80			
		2	14.8	32.2	7.9	8.0	80			1.3
		3	14.8	32.2	7.9	8.0	80			
		4	14.8	32.3	7.9	8.0	80			1.0
		5	14.8	32.3	7.9	8.0	81			
		6	14.8	32.3	7.8	8.0	82			

Table B5. 6 February 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
25	0911	0	14.8	32.4	7.7	8.0	81	10	2.3	1.2
		1	14.8	32.5	7.7	8.0	81			
		2	14.8	32.5	7.8	8.0	82			1.2
		3	14.8	32.5	7.8	8.0	82			
		4	14.8	32.5	7.8	8.0	82			1.2
		5	14.8	32.5	7.8	8.0	82			
		6	14.8	32.5	7.8	8.0	81			
5 9k NE	0922	0	14.8	31.9	7.8	8.0	80	12	2.5	0.9
		1	14.8	31.9	7.7	8.0	80			
		2	14.8	32.3	7.7	8.0	80			10.0
		3	14.8	32.3	7.7	8.0	80			
		4	14.8	32.3	7.8	8.0	80			10.0
		5	14.9	32.5	8.0	8.1	74			
		6	14.9	32.5	8.0	8.1	72			
6 8k NE	0932	0	14.7	30.5	7.6	7.9	76	10	2.3	0.7
		1	14.7	30.5	7.4	7.9	78			
		2	14.7	30.7	7.4	7.9	78			0.7
		3	14.6	32.0	7.3	7.9	78			
		4	14.6	32.1	7.3	7.9	78			0.8
		5	14.6	32.1	7.3	7.9	78			
19	0951	0	Hand sampled from beach							1.5
18 6k E	0951	0	14.8	32.0	7.5	8.1		10	2.5	0.8
		1	14.8	32.1		8.1				
		2	14.8	32.2	7.4	8.1				10.0
		3	14.8	32.2		8.1				
8	0958	0		32.1	7.4			10	2.5	0.7
		1		32.2						
		2		32.3	7.4					0.8
		3		32.3						
		4		32.3	7.3					0.8
10	1010	0		31.4	7.1			10	2.5	0.9
		1		31.9						
		2		32.0	6.9					0.6
		3		32.0						
		4		32.0	6.8					0.6
		5		32.0						

Table B5. 6 February 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
20	1020	0		31.8	6.9			12	2.5	0.9
		1		32.0						
		2		32.0	6.8					
		3		32.1						0.7
13	1100	0		32.3	6.9					1.4
22	1111	0		22.3	5.7					18.9
	Average		14.7	31.8	8.0	8.1	75.6	11.6	2.1	2.2
	Number		54	72	62	54	50	12	12	36
	Sta Dev		0.1	1.7	0.8	0.1	8.9	1.8	0.5	3.2
	Maximum		14.9	32.5	9.6	8.1	82.0	15.0	2.5	18.9
	Minimum		14.4	22.3	5.7	7.9	38.0	10.0	1.0	0.6

Table B6. Physical Water Quality Data.

5 March 1992

CRUISE: MDR 91-92
WEATHER: Partly cloudy
Mar 1,2,3, 2.5" rain

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	0923	4.9
Low	0320	0.7

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12	0810	0	16.0	31.5	7.9			7	2.0	1.4
		1	15.9	31.7	7.9					
		2	16.0	32.0	8.1					1.0
		3	16.0	32.0	8.2					
1	0818	0	15.9	32.2	7.9			6	2.0	1.1
		1	15.8	32.2	8.0					
		2	15.9	32.3	8.0					1.1
		3	15.9	32.3	7.9					
		4	15.9	32.3	7.9					1.1
		5	15.9	32.3	7.9					
2 2k SW	0826	0	16.0	32.3	7.5			6	2.0	1.1
		1	16.0	32.3	7.6					
		2	15.9	32.2	7.8					1.1
		3	15.9	32.3	7.9					
		4	15.9	32.3	8.0					1.1
		5	15.9	32.3	8.0					
		6	15.9	32.2	8.0					0.9
3 2k SW	0835	0	16.1	30.9	6.7			8	2.0	1.0
		1	16.2	31.4	6.9					
		2	16.2	31.7	6.9					0.9
		3	16.2	32.0	7.1					
		4	16.1	32.1	7.2					0.9
		5	16.1	32.1	7.2					
4	0844	0	16.2	31.6	6.8			8	2.0	1.1
		1	16.3	31.5	7.1					
		2	16.2	32.0	7.3					1.0
		3	16.1	32.0	7.5					
		4	16.1	32.0	7.6					0.6
		5	16.1	32.0	7.6					
25	0852	0	16.2	30.7	6.7			8	2.0	0.9
		1	16.3	30.9	6.7					
		2	16.2	31.3	6.9					0.9
		3	16.2	31.9	7.3					
		4	16.1	32.0	7.4					0.8
		5	16.1	32.0	7.4					
		6	16.1	32.0	7.4					0.5

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Table B6. 5 March 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
5	0903	0	16.2	29.9	6.5			10	2.5	0.7
		1	16.3	30.0	6.5					
		2	16.3	31.0	6.4					0.6
		3	16.2	31.7	7.2					
		4	16.1	32.0	7.1					0.5
		5	15.9	32.1	6.9					
6	0914	0	[illegible]	30.1	6.3			10	2.3	0.8
		1	16.2	30.1	6.3					
		2	16.5	31.7	5.5					0.9
		3	16.5	31.8	5.4					
		4	16.3	31.9	5.3					0.8
19	0933	0	Hand sampled from beach							1.8
18 5k WSW	0933	0	16.6	29.0	6.5			12	2.0	0.9
		1	17.0	29.9	6.4					
		2	16.9	30.8	5.2					1.0
8 5k WSW	0939	0	16.5	29.3	6.4			12	2.0	1.0
		1	16.9	29.9	6.4					
		2	17.0	30.7	5.5					1.0
		3	16.6	31.7	5.1					
		4	16.4	31.9	4.8					0.6
10 4k SW	0957	0	17.0	29.6	5.1			12	2.0	1.0
		1	17.0	29.9	5.3					
		2	17.0	31.2	5.1					1.0
		3	16.7	31.8	4.8					
		4	16.6	32.0	4.8					0.6
20 2k SW	1005	0	16.7	29.0	4.7			12	2.0	1.0
		1	16.9	29.6	5.1					
		2	17.0	30.8	5.1					1.1
		3	16.7	31.7	4.4					
11 3k SW	1015	0	16.8	29.6	6.0			10	2.5	0.9
		1	16.9	30.1	5.9					
		2	16.7	31.6	5.4					0.9
		3	16.5	31.9	5.5					
		4	16.2	32.0	5.3					0.8

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Table B6. 5 March 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
9 5.5k SW	1026	0	16.7	28.9	6.3			10	2.5	1.0
		1	16.8	29.5	6.0					
		2	16.7	31.6	5.2					0.8
		3	16.4	32.1	5.1					
		4	16.3	32.2	5.0					0.7
7 7k SW	1039	0	16.6	29.6	6.2			12	2.5	0.8
		1	16.6	30.1	5.9					
		2	16.4	31.6	5.6					0.5
		3	16.2	32.0	5.7					
		4	16.1	32.2	5.7					0.6
13	1109	0	17.6	11.8	5.0					1.8
22	1118	0	16.7	1.4	6.9					2.7
	Average		16.4	31.7	6.5			9.5	2.2	1.0
	Number		80	80	80			15	15	47
	Sta Dev		0.4	4.1	1.1			2.2	0.2	0.4
	Maximum		17.6	32.3	8.2			12.0	2.5	2.7
	Minimum		15.8	1.4	4.4			6.0	2.0	0.5

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Table B7. Physical Water Quality Data.

2 April 1992

CRUISE: MDR 91-92
WEATHER: Mild and clear
April 1st 1/2" rain

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	0839	4.5
Low	1428	0.7

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12	0822	0	17.9	25.9	7.5	8.3	40	17	0.5	3.9
		1	17.9	32.0	8.2	8.3	58			
		2	17.9	32.1	8.3	8.3	60			1.1
		3	17.7	32.9	8.0	8.3	60			
1	0830	0	18.1	29.5	7.4	8.2	32	14	0.5	2.6
		1	18.1	32.6	8.5	8.3	55			
		2	18.0	33.1	8.8	8.3	72			2.9
		3	17.8	33.2	8.7	8.3	78			
		4	17.5	33.1	8.2	8.3	84			1.7
		5	17.4	33.2	7.9	8.3	86			
		6	16.1	33.2	7.4	8.3	80			1.1
2 3k SW	0841	0	18.3	31.5	6.7	8.2	55	12	1.5	2.6
		1	18.2	31.6	7.4	8.2	55			
		2	18.1	32.2	7.9	8.3	46			2.8
		3	17.9	32.8	8.2	8.3	58			
		4	17.8	32.8	8.3	8.3	66			2.6
		5	17.7	33.0	7.7	8.3	68			
		6	17.4	33.1	7.4	8.2	65			1.2
3	0851	0	18.3	31.7	6.5	8.2	69	10	2.0	1.6
		1	18.3	32.0	7.0	8.2	66			
		2	18.3	32.1	7.1	8.2	63			1.7
		3	18.1	32.6	7.2	8.2	56			
		4	17.6	32.8	7.3	8.2	56			0.7
		5	17.5	33.0	7.5	8.2	48			
4 3k W	0902	0	18.5	31.0	6.3	8.1	70	8	3.0	0.9
		1	18.4	31.8	6.2	8.1	73			
		2	18.5	32.2	6.3	8.2	73			1.1
		3	18.3	32.6	7.1	8.2	66			
		4	18.0	32.9	7.6	8.2	47			0.9
		5	18.0	32.9	7.8	8.2	48			
		6	17.9	32.9	7.8	8.3	45			

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Table B7. 2 April 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
25 2k W	0912	0	18.6	31.7	6.2	8.1	74	8	3.0	1.0
		1	18.5	31.8	6.2	8.1	76			
		2	18.4	32.0	6.2	8.1	76			1.0
		3	18.2	32.6	6.7	8.2	48			
		4	18.1	32.8	7.0	8.2	35			1.0
		5	18.0	32.8	7.1	8.2	35			
		6	18.0	32.8	7.3	8.2	30			
5	0926	0	19.0	31.5	6.1	8.1	67	7	3.0	0.9
		1	18.9	31.8	6.1	8.1	67			
		2	18.7	32.3	6.7	8.1	64			0.9
		3	18.3	32.6	6.9	8.2	60			
		4	18.1	32.8	6.6	8.2	54			0.5
		5	18.0	32.8	6.1	8.2	35			
6 5k SW	0937	0	18.2	31.0	6.2	8.1	69	7	2.5	0.9
		1	18.5	31.5	6.1	8.1	73			
		2	18.9	32.3	4.2	8.0	70			0.9
		3	18.6	32.5	4.8	8.1	60			
		4	18.4	32.6	5.1	8.1	44			0.8
19	0958	0	Hand sampled from shore							1.8
18 4-6k W	0958	0	18.7	31.6	5.2	8.1	70	10	2.5	1.1
		1	19.1	31.9	4.5	8.0	71			
		2	19.0	32.3	4.7	8.0	54			1.3
8 4-6k W	1004	0	18.7	31.2	5.9	8.1	72	8	3.0	1.1
		1	19.0	31.7	5.2	8.1	72			
		2	19.1	32.2	4.4	8.1	65			1.2
		3	18.7	32.6	4.8	8.1	47			
		4	18.5	32.7	4.6	8.1	24			1.1
10 3-6k W	1021	0	19.8	29.5	4.3	8.0	47	12	1.5	1.0
		1	19.4	31.5	4.0	8.0	52			
		2	18.8	32.4	4.3	8.0	38			0.9
		3	18.6	32.6	4.5	8.1	26			
		4	18.5	32.6	4.3	8.1	20			0.8
20 2-5k W	1029	0	19.6	30.1	4.5	8.0	55	12	2.0	1.3
		1	19.5	31.5	4.5	8.0	61			
		2	19.0	32.2	4.3	8.0	55			1.0
		3	18.6	32.4	4.1	8.0	41			

Table B7. 2 April 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
11 2-5k W	1040	0	19.1	31.7	5.4	8.1	66	8	2.5	0.9
		1	18.9	32.3	5.2	8.1	63			
		2	18.8	32.4	5.0	8.1	61			0.8
		3	18.6	32.6	5.0	8.0	43			
		4	18.4	32.6	4.9	8.1	36			0.8
9 6-7k W	1049	0	19.5	31.7	5.5	8.1	63	10	2.5	0.8
		1	19.3	32.0	5.5	8.1	62			
		2	19.2	32.2	5.1	8.1	57			1.1
		3	18.6	32.5	5.1	8.1	45			
		4	18.3	32.6	5.0	8.1	8			0.8
7 7-10k W	1109	0	19.5	31.8	5.9	8.1	86	8	3.0	0.6
		1	19.2	32.0	5.7	8.1	84			
		2	19.1	32.0	5.5	8.1	79			0.7
		3	18.7	32.1	5.8	9.1	69			
		4	18.4	32.4	5.2	8.1	57			0.7
13	1132	0	22.7	18.6	2.0	7.3				2.9
22	1140	0	23.7	7.3	3.0	7.1				6.0
	Average		18.5	31.7	6.1	8.1	57.8	9.9	2.2	1.4
	Number		83	83	83	83	81	15	15	47
	Sta Dev		1.0	3.2	1.4	0.2	15.9	2.9	0.9	1.0
	Maximum		23.7	33.2	8.8	8.3	86.0	17.0	3.0	6.0
	Minimum		16.1	7.3	2.0	7.1	8.0	7.0	0.5	0.5

Table B8. Physical Water Quality Data.

14 May 1992

CRUISE: MDR 91-92
WEATHER: Overcast, calm

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	0853	4.0
Low	1404	1.2

April 29-runoff from fires - May 12-13 Red Tide

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12 3k S	0921	0	18.9	31.6	7.4	7.9	81	14	2.0	7.8
		1	18.9	31.5	7.4	8.0	81			
		2	18.8	32.0	7.6	8.0	81			
		3	18.8	32.0	7.2	8.0	83			3.4
1 3k S	0931	0	19.0	32.1	7.8	8.2	82	12	2.5	3.3
		1	18.8	32.1	7.7	8.2	81			
		2	18.6	32.1	7.1	8.1	81			
		3	18.4	32.2	7.0	8.1	80			3.1
		4	18.2	32.2	7.1	8.1	79			
		5	18.0	32.3	7.0	8.1	79			2.3
2 1.5k S	1940	0	18.7	32.3	7.5	8.2	84	12	2.5	3.3
		1	18.7	32.3	7.5	8.2	82			
		2	18.7	32.3	7.4	8.2	82			
		3	18.6	32.2	7.5	8.2	81			3.8
		4	18.4	32.2	7.6	8.2	81			
		5	18.2	32.3	7.3	8.2	82			4.4
3	0950	0	20.0	32.2	6.7	8.2	74	14	2.0	2.6
		1	19.9	32.3	6.8	8.2	74			
		2	19.8	32.3	7.0	8.2	72			
		3	19.4	32.3	6.7	8.2	75			2.1
		4	19.0	32.3	6.8	8.2	76			
		5	18.7	32.3	6.7	8.2	75			1.3
4	1000	0	20.2	32.3	7.1	8.2	74	12	2.5	1.8
		1	20.2	32.3	7.0	8.2	74			
		2	20.2	32.3	7.0	8.2	74			
		3	19.5	32.3	7.0	8.2	73			1.7
		4	19.2	32.3	7.0	8.2	73			
		5	18.9	32.3	7.3	8.2	75			1.9
25	1007	0	20.4	32.3	6.9	8.1	75	12	2.5	1.6
		1	20.4	32.3	6.8	8.2	73			
		2	20.3	32.3	6.6	8.1	73			
		3	20.2	32.3	6.6	8.2	74			1.7
		4	19.4	32.3	6.9	8.2	64			
		5	19.1	32.3	7.0	8.2	63			1.2

Table B8. Physical Water Quality Data.

14 May 1992

CRUISE: MDR 91-92
WEATHER: Overcast, calm

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	0853	4.0
Low	1404	1.2

April 29-runoff from fires - May 12-13 Red Tide

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12 3k S	0921	0	18.9	31.6	7.4	7.9	81	14	2.0	7.8
		1	18.9	31.5	7.4	8.0	81			
		2	18.8	32.0	7.6	8.0	81			3.4
		3	18.8	32.0	7.2	8.0	83			
1 3k S	0931	0	19.0	32.1	7.8	8.2	82	12	2.5	3.3
		1	18.8	32.1	7.7	8.2	81			
		2	18.6	32.1	7.1	8.1	81			3.1
		3	18.4	32.2	7.0	8.1	80			
		4	18.2	32.2	7.1	8.1	79			2.3
		5	18.0	32.3	7.0	8.1	79			
2 1.5k S	1940	0	18.7	32.3	7.5	8.2	84	12	2.5	3.3
		1	18.7	32.3	7.5	8.2	82			
		2	18.7	32.3	7.4	8.2	82			3.8
		3	18.6	32.2	7.5	8.2	81			
		4	18.4	32.2	7.6	8.2	81			4.4
		5	18.2	32.3	7.3	8.2	82			
3	0950	0	20.0	32.2	6.7	8.2	74	14	2.0	2.6
		1	19.9	32.3	6.8	8.2	74			
		2	19.8	32.3	7.0	8.2	72			2.1
		3	19.4	32.3	6.7	8.2	75			
		4	19.0	32.3	6.8	8.2	76			1.3
		5	18.7	32.3	6.7	8.2	75			
4	1000	0	20.2	32.3	7.1	8.2	74	12	2.5	1.8
		1	20.2	32.3	7.0	8.2	74			
		2	20.2	32.3	7.0	8.2	74			1.7
		3	19.5	32.3	7.0	8.2	73			
		4	19.2	32.3	7.0	8.2	73			1.9
		5	18.9	32.3	7.3	8.2	75			
25	1007	0	20.4	32.3	6.9	8.1	75	12	2.5	1.6
		1	20.4	32.3	6.8	8.2	73			
		2	20.3	32.3	6.6	8.1	73			1.7
		3	20.2	32.3	6.6	8.2	74			
		4	19.4	32.3	6.9	8.2	64			1.2
		5	19.1	32.3	7.0	8.2	63			

Table B7. 2 April 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
11 2-5k W	1040	0	19.1	31.7	5.4	8.1	66	8	2.5	0.9
		1	18.9	32.3	5.2	8.1	63			
		2	18.8	32.4	5.0	8.1	61			0.8
		3	18.6	32.6	5.0	8.0	43			
		4	18.4	32.6	4.9	8.1	36			0.8
9 6-7k W	1049	0	19.5	31.7	5.5	8.1	63	10	2.5	0.8
		1	19.3	32.0	5.5	8.1	62			
		2	19.2	32.2	5.1	8.1	57			1.1
		3	18.6	32.5	5.1	8.1	45			
		4	18.3	32.6	5.0	8.1	8			0.8
7 7-10k W	1109	0	19.5	31.8	5.9	8.1	86	8	3.0	0.6
		1	19.2	32.0	5.7	8.1	84			
		2	19.1	32.0	5.5	8.1	79			0.7
		3	18.7	32.1	5.8	9.1	69			
		4	18.4	32.4	5.2	8.1	57			0.7
13	1132	0	22.7	18.6	2.0	7.3				2.9
22	1140	0	23.7	7.3	3.0	7.1				6.0
	Average		18.5	31.7	6.1	8.1	57.8	9.9	2.2	1.4
	Number		83	83	83	83	81	15	15	47
	Sta Dev		1.0	3.2	1.4	0.2	15.9	2.9	0.9	1.0
	Maximum		23.7	33.2	8.8	8.3	86.0	17.0	3.0	6.0
	Minimum		16.1	7.3	2.0	7.1	8.0	7.0	0.5	0.5

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Table B8. 14 May 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
5 6k S	1016	0	20.6	32.3	6.4	8.1	72	12	2.5	1.0
		1	20.6	32.3	5.4	8.1	71			
		2	20.6	32.3	6.4	8.1	72			2.1
		3	20.4	32.3	6.5	8.1	71			
		4	19.8	32.3	6.6	8.2	67			1.6
		5	19.7	32.3	6.1	8.2	62			
6	10[illegible]	0	20.4	32.3	6.4	8.1	74	10	3.0	0.7
		1	20.5	32.3	6.5	8.1	74			
		2	20.4	32.3	6.2	8.1	73			1.0
		3	20.3	32.3	5.3	8.0	73			
		4	20.3	32.3	4.3	8.0	74			0.9
19	1048	0	Hand sampled from shore							2.2
18	1048	0	20.7	32.3	6.3	8.1	68	12	2.0	0.8
		1	20.7	32.3	6.3	8.1	67			
8 6k S	1053	0	20.8	32.3	6.3	8.1	67	12	2.5	1.7
		1	20.8	32.3	7.0	8.1	67			
		2	20.7	32.3	6.1	8.1	63			2.1
		3	20.7	32.3	5.8	8.0	63			
		4	20.6	32.3	5.6	8.0	62			1.3
10 5k SW	1105	0	21.0	32.1	5.8	8.1	70	12	2.5	1.2
		1	21.0	32.2	5.9	8.1	70			
		2	21.0	32.2	5.5	8.0	70			1.3
		3	20.9	32.2	5.4	8.0	70			
		4	20.6	32.2	3.0	7.9	60			
20	1117	0	21.0	32.1	5.6	8.0	76	14	2.3	1.0
		1	21.0	32.1	5.5	8.0	74			
		2	20.9	32.1	5.3	8.0	68			1.0
11	1126	0	21.0	32.2	5.6	8.0	71	12	2.3	0.9
		1	20.9	32.2	5.6	8.0	71			
		2	20.8	32.1	5.6	8.0	70			1.1
		3	20.7	32.1	5.6	8.0	63			
9 3k SW	1136	0	21.1	32.1	5.5	8.0	65	12	2.0	0.9
		1	21.1	32.1	5.3	8.0	65			
		2	21.0	32.1	5.3	8.0	59			0.9
		3	20.7	32.2	5.6	8.1	61			

1 8001

R0051306

Table B8. 14 May 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
7	1149	0	20.9	32.3	5.7	8.0	68	12	2.0	1.0
7k SW		1	20.8	32.3	6.9	8.0	69			
		2	20.7	32.3	5.9	8.1	68			1.0
		3	20.4	32.3	5.5	8.0	61			
		4	20.2	32.2	5.2	8.0	56			1.1
13	1235	0	21.6	32.2	6.3	8.0				3.8
22	1245	0	21.2	32.3	4.0	7.9				2.8
			Green growth on surface							
	Average		20.0	32.2	6.4	8.1	72.0	12.3	2.3	2.0
	Number		75	75	75	75	73	15	15	41
	Sta Dev		0.9	0.1	0.9	0.1	6.6	1.0	0.3	1.3
	Maximum		21.6	32.3	7.8	8.2	84.0	14.0	3.0	7.8
	Minimum		18.0	31.5	3.0	7.9	56.0	10.0	2.0	0.7

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Table B9. Physical Water Quality Data.

11 June 1992

CRUISE: MDR 91-92
WEATHER: Overcast, water calm

Vessel: Bay Watch

TIDE	TIME	HEIGHT (ft)
High	0910	3.5
Low	1253	1.8

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
12 3k W	0827	0	17.2	32.9	7.7	8.2	90	4	3.0	2.0
		1	17.0	32.8	8.4	8.2	90			
		2	17.0	32.8	8.3	8.2	91			2.1
		3	16.9	32.8	8.2	8.2	89			
1 6k W	0837	0	16.9	33.1	8.4	8.2	90	5	4.5	2.1
		1	16.8	32.9	8.5	8.2	90			
		2	16.7	32.8	8.6	8.2	90			2.0
		3	16.6	32.8	8.7	8.2	90			
		4	16.5	32.8	8.7	8.2	88			2.5
		5	15.8	32.8	8.6	8.2	88			
2 6k W	0844	0	17.8	32.5	8.8	8.2	88	5	4.0	1.4
		1	17.8	32.8	8.5	8.2	88			
		2	17.5	32.8	8.4	8.2	88			1.8
		3	17.2	32.8	8.5	8.2	88			
		4	17.0	32.8	8.6	8.2	88			2.0
		5	16.8	32.8	8.7	8.2	87			
3 6k W	0852	0	19.8	32.9	7.2	8.1	81	8	2.5	1.6
		1	19.7	32.8	7.4	8.1	80			
		2	19.6	32.8	7.5	8.1	80			1.4
		3	19.3	32.8	7.0	8.1	77			
		4	17.8	32.8	8.3	8.2	81			1.4
		5	17.6	32.8	7.8	8.2	75			
4 6k W	0903	0	19.9	32.5	7.1	8.1	84	6	3.0	1.4
		1	19.9	32.6	7.1	8.1	84			
		2	19.9	32.6	7.1	8.1	83			1.4
		3	19.0	32.6	7.2	8.1	82			
		4	18.2	32.8	7.4	8.2	78			1.4
		5	18.0	32.8	7.6	8.2	75			
25	0911	0	20.0	32.4	7.0	8.1	81	7	2.5	1.1
		1	20.0	32.5	6.9	8.1	81			
		2	19.9	32.6	6.9	8.1	82			1.1
		3	19.8	32.6	6.8	8.1	82			
		4	18.5	32.8	6.8	8.1	72			0.7
		5	18.2	32.8	7.0	8.1	62			

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Table B9. 11 June 1992 cont

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
5 5k SW	0921	0	20.5	32.8	6.5	8.0	81	6	3.5	0.7
		1	20.5	32.7	6.3	8.0	81			
		2	20.5	32.6	6.4	8.0	82			1.3
		3	20.4	32.6	6.7	8.1	80			
		4	20.1	32.7	6.8	8.1	78			1.4
		5	18.8	32.9	7.2	8.1	76			
		6	18.3	32.8	7.0	8.1	76			
6 4k SW	0933	0	20.4	32.5	5.8	8.0	82	8	3.0	0.9
		1	20.4	32.7	5.9	8.0	82			
		2	20.3	32.7	5.9	8.0	79			1.4
		3	19.6	32.7	5.2	8.0	74			
		4	19.2	32.8	5.3	8.0	70			0.7
19	0953	0	Hand sampled from shore							3.1
18 5k W	0953	0	20.8	32.8	5.5	8.0	71	12	1.5	1.4
		1	20.7	32.8	5.3	7.9	67			
		2	20.6	32.8	5.1	7.9	66			2.0
8 5k W	0958	0	20.7	32.8	5.4	7.9	77	10	2.5	1.0
		1	20.7	32.8	5.1	7.9	76			
		2	20.6	32.8	5.0	7.9	72			1.4
		3	20.4	32.8	4.7	7.9	68			
		4	20.2	32.7	4.4	7.9	62			0.9
10 5k W	1014	0	21.0	32.0	5.1	7.9	66	10	2.5	2.0
		1	21.1	32.3	4.9	7.9	70			
		2	20.7	32.7	5.3	7.9	68			2.0
		3	20.6	32.7	5.0	7.9	69			
		4	20.5	32.7	4.9	7.9	67			
20	1023	0	21.0	31.9	4.3	7.8	78	12	2.5	1.0
		1	21.0	32.6	4.7	7.9	76			
		2	20.9	32.6	4.7	7.9	73			1.2
11 6k W	1034	0	21.0	32.6	5.2	7.9	82	10	2.5	0.7
		1	20.9	32.6	5.4	7.9	80			
		2	20.2	32.8	5.8	8.0	72			1.3
		3	19.9	32.8	5.9	8.0	73			

Table B9. 11 June 1992 cont.

Station/ Wind k	Time	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
9 6k W	1040	0	21.1	32.6	6.4	8.0	80	7	2.5	0.7
		1	20.1	32.6	6.5	8.0	80			
		2	20.2	32.8	6.1	8.0	72			1.5
		3	19.9	32.8	5.7	8.0	70			
7 6k W	1059	0	20.7	32.8	6.0	8.0	78	7	3.5	1.0
		1	20.6	32.6	6.0	8.0	78			
		2	20.6	32.6	5.9	8.0	77			1.1
		3	20.4	32.7	5.6	8.0	75			
		4	19.5	32.8	5.3	8.0	59			
13	1129	0	21.7	32.3	5.14	7.8				2.5
22	1137	0	22.1	25.5	5.5	7.3				4.6
	Average		19.4	32.6	6.6	8.1	78.5	7.8	2.9	1.5
	Number		77	77	77	77	75	15	15	41
	Sta Dev		1.5	0.8	1.3	0.1	7.7	2.4	0.7	0.7
	Maximum		22.1	33.1	8.8	8.2	91.0	12.0	4.5	4.6
	Minimum		15.8	25.5	4.3	7.3	59.0	4.0	1.5	0.7

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B30

APPENDIX C
NUTRIENT CHEMISTRY DATA

October 1990 - June 1991

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8008

Table C1. MDR Nutrient Chemistry Data (in ug-at/L) 3 October 1991

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NO3+NH4
12	0	0.92	43.31	7.98	1.26	6.73	9.80
	2	0.29	4.54	1.35	0.32	1.03	3.83
1	0	0.51	21.54	4.30	0.65	3.65	4.56
	2	0.14	2.99	1.11	0.27	0.84	3.65
	4	0.14	2.70	1.02	0.25	0.78	3.05
2	0	0.53	1 .75	2.97	0.77	2.20	4.49
	2	0.31	7.03	1.70	0.31	1.39	4.50
	4	0.40	4.70	1.49	0.31	1.18	3.83
3	0	0.62	12.48	1.71	0.35	1.35	3.96
	2	0.49	9.60	2.07	0.45	1.62	3.78
	4	0.33	4.89	1.52	0.30	1.21	3.70
4	0	0.71	13.81	1.99	0.49	1.50	3.42
	2	0.73	13.24	1.97	0.44	1.54	3.48
	4	0.60	9.66	2.18	0.46	1.72	4.52
25	0	0.73	13.14	2.15	0.43	1.72	4.00
	2	0.70	12.69	2.53	0.54	0.99	5.93
	4	0.74	9.53	2.18	0.47	1.71	5.88
	6	0.60	8.08	1.80	0.37	1.43	5.67
5	0	0.89	15.93	2.75	0.66	2.08	4.27
	2	0.93	15.42	2.88	0.87	2.00	4.49
	4	0.55	10.83	1.86	0.41	1.45	3.69
6	0	0.80	14.02	2.61	0.60	2.01	3.50
	2	0.86	14.07	2.58	0.53	2.05	5.30
	4	1.19	15.23	3.95	0.69	3.26	7.16
19	0	1.21	16.02	3.25	0.53	2.72	6.10
18	0	1.15	16.40	6.18	0.63	5.55	6.31
0	0	1.18	17.79	3.56	0.62	2.95	5.07
	2	1.22	16.71	3.62	0.02	2.80	5.01
10	0	1.49	20.30	5.16	0.76	4.40	6.31
	2	1.56	19.33	3.76	0.70	3.06	5.96
	4	1.42	19.06	3.85	0.91	2.94	5.80
20	0	1.52	21.07	5.39	0.76	4.63	8.28

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Table C1. cont.

STA	DEPTH (m)	PO_4	SiO_4	NO_3+NO_2	NO_2	NO_3	NO_3+NH_4
11	0	1.33	19.41	4.68	0.64	4.04	6.12
	2	1.13	16.13	3.50	0.67	2.83	5.26
9	0	1.00	16.86	4.59	0.73	3.86	6.81
	2	1.28	16.76	3.59	0.79	2.80	5.37
7	0	0.96	14.09	3.33	0.70	2.63	5.03
	2	0.94	14.06	3.44	0.76	2.68	4.23
13	0	1.77	20.68	5.06	0.77	4.30	29.00
22	0	5.70	40.99	4.04	1.13	2.90	12.26
	Average	0.99	13.14	3.14	0.60	2.58	5.76
	Number	40	40	40	40	40	40
	Standard	0.85	8.71	1.40	0.22	1.30	4.12
	Maximum	5.70	40.99	7.99	1.26	6.73	29.00
	Minimum	0.41	2.70	1.03	0.25	0.70	3.05

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Table C2. MDR Nutrient Chemistry Data (in ug-at/L) 6 November 1991

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	1.64	17.35	7.43	0.91	6.51	7.36
	2	0.67	6.95	2.70	0.49	2.21	9.66
1	0	0.39	4.38	1.57	0.36	1.21	3.95
	2	0.40	4.28	1.71	0.44	1.27	5.27
	4	0.39	4.32	0.95	0.35	0.60	4.24
	6	0.36	4.02	0.87	0.31	0.[illegible]6	4.56
2	0	0.47	4.95	1.34	0.35	0.99	7.20
	2	0.47	5.03	1.35	0.36	0.99	5.72
	4	0.50	5.21	1.25	0.27	0.98	8.67
	6	0.46	5.00	1.15	0.24	0.91	5.87
3	0	0.80	6.46	2.43	0.33	2.11	6.71
	2	0.53	5.54	1.40	0.28	1.12	5.01
	4	0.53	5.46	1.27	0.24	1.04	6.67
4	0	0.73	0.04	3.10	0.38	2.72	6.39
	2	0.75	0.05	3.16	0.36	2.80	6.40
	4	0.79	8.25	3.58	0.46	3.12	5.40
25	0	0.82	9.02	3.87	0.47	3.40	5.40
	2	0.85	8.86	3.82	0.47	3.35	6.60
	4	0.87	8.84	3.89	0.44	3.45	6.10
	5	0.88	8.72	3.75	0.54	3.21	4.40
5	0	1.08	11.73	6.19	0.68	5.50	5.60
	2	1.04	11.31	5.99	0.69	5.30	5.80
	4	0.97	10.41	5.09	0.60	4.49	4.80
6	0	1.16	12.68	7.78	0.73	7.06	6.33
	2	1.16	12.60	8.04	0.80	7.25	6.86
	4	1.17	12.53	7.95	0.80	7.15	4.85
18	0	1.15	12.41	7.44	0.80	6.65	3.78
	2	1.13	12.28	7.40	0.77	6.63	4.72
19	0	1.25	11.64	6.68	0.90	5.78	4.37
8	0	1.04	11.76	7.12	0.75	6.37	5.85
	2	1.15	12.36	7.45	0.71	6.74	4.20
	4	1.10	11.71	6.82	0.76	6.06	4.42
10	0	1.34	15.29	8.40	0.73	7.76	5.55
	2	1.35	14.51	8.23	0.84	7.39	4.76
	4	1.40	15.44	7.65	0.77	6.88	5.90

Table C2. cont.

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NO3+NH4
20	0	1.14	14.10	7.44	0.61	6.83	5.82
	2	1.38	16.34	8.24	0.74	7.50	6.05
11	0	1.13	12.87	7.11	0.62	6.49	4.12
	2	1.16	12.62	7.15	0.66	6.49	5.50
	4	1.09	12.36	6.97	0.71	6.26	4.62
9	0	1.10	13.00	7.58	0.65	6.92	5.04
	2	1.14	12.55	7.09	0.65	6.44	5.17
	4	1.08	11.82	6.47	0.53	5.94	4.78
7	0	1.21	12.52	6.86	0.60	6.26	5.31
	2	1.19	12.49	6.93	0.68	6.25	5.54
	4	1.15	12.39	6.64	0.59	6.04	5.36
13	0	1.67	16.85	9.27	0.94	0.33	23.00
22	0	1.82	17.57	0.20	0.84	7.44	14.34
	Average	0.98	10.52	6.31	0.59	4.72	6.08
	Number	48	48	48	48	48	48
	Standard	0.33	3.01	2.64	0.20	2.45	3.00
	Maximum	1.82	17.67	9.27	0.94	0.33	23.00
	Minimum	0.36	4.82	0.87	0.24	0.46	3.78

Table C3. MDR Nutrient Chemistry Data (in ug-at/L) 5 December 1991

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	1.26	11.65	4.86	0.94	3.91	4.24
	2	0.86	6.34	2.82	0.57	2.25	3.16
1	0	0.70	4.67	2.20	0.60	1.60	3.58
	2	0.71	4.84	2.09	0.45	1.64	2.88
	4	0.67	4.54	1.90	0.45	1.44	2.71
2	0	0.72	4.95	2.93	0.70	2.23	2.64
	2	0.74	5.43	2.51	0.59	1.92	4.00
	4	0.85	6.01	2.68	0.57	2.11	3.99
	6	0.89	6.46	3.03	0.54	2.49	3.99
3	0	1.02	7.55	3.75	0.80	2.95	4.08
	2	1.00	8.40	4.00	0.79	3.22	4.18
	4	1.06	9.09	4.17	0.71	3.46	3.67
4	0	1.01	7.79	4.39	1.04	3.34	3.57
	2	1.05	7.99	3.97	0.70	3.28	3.27
	4	1.02	8.09	3.77	0.88	2.89	5.70
25	0	1.17	10.16	4.55	0.69	3.86	6.33
	2	1.27	10.70	5.01	1.07	3.94	7.97
	4	1.31	10.73	4.86	0.75	4.12	5.87
	6	1.50	12.56	5.58	0.77	4.81	7.12
5	0	1.29	11.25	4.91	0.76	4.16	5.41
	2	1.33	11.55	5.03	0.73	4.30	5.64
	4	1.39	13.67	5.98	0.64	5.34	7.08
6	0	1.61	14.01	6.37	0.70	5.67	8.20
	2	1.61	13.89	6.21	0.57	5.63	7.70
	4	1.58	13.91	6.42	0.67	5.74	6.90
18	0	1.67	14.83	6.45	0.72	5.74	5.80
	2	1.69	14.62	6.16	0.67	5.49	7.08
19	0	1.66	13.99	5.83	0.81	5.02	6.10
8	0	1.65	14.33	6.52	0.79	5.73	6.30
	2	1.69	14.40	6.52	0.70	5.82	6.20
	4	1.63	14.12	6.25	0.66	5.60	5.50

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Table C3. cont.

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NO3+NH4
10	0	1.92	17.38	8.40	1.17	7.23	7.30
	2	1.93	17.53	8.19	0.90	7.29	7.30
	4	1.89	16.86	7.68	0.69	6.99	6.50
20	0	1.96	17.53	8.50	1.41	7.09	7.40
	2	1.96	17.50	7.71	0.78	6.92	6.78
11	0	1.76	14.99	6.70	0.67	6.03	6.20
	2	1.77	15.06	6.60	0.70	5.90	6.20
	4	1.72	14.62	6.44	0.59	5.84	7.50
9	0	1.85	15.01	6.99	0.79	6.21	8.85
	2	1.79	14.93	6.88	0.90	5.98	7.44
	4	1.75	14.62	6.66	0.68	5.99	6.96
7	0	1.73	13.70	6.18	0.60	5.58	6.25
	2	1.72	13.71	6.95	1.39	5.57	6.66
	3	No results received for 3 meters, sample lost					
13	0	2.16	17.14	8.56	0.80	7.76	11.80
22	0	2.11	15.43	8.84	0.82	8.02	9.58
	Average	1.43	11.92	5.50	0.76	4.76	5.95
	Number	46	46	46	46	46	47
	Standard	0.42	4.00	1.87	0.20	1.79	1.84
	Maximum	2.16	17.53	8.84	1.41	8.02	11.80
	Minimum	0.67	4.54	1.90	0.45	1.44	2.46

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Table C4. MDR Nutrient Chemistry Data (in ug-at/L) 9 January 1992

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	1.61	54.61	25.78	2.52	23.26	11.08
	2	0.66	12.17	4.58	0.63	3.96	3.90
1	0	1.13	27.19	11.61	1.24	10.37	5.60
	2	0.87	9.92	3.69	0.50	3.19	3.30
	4	0.69	5.70	1.90	0.30	1.60	2.70
2		1.16	16.38	6.88	0.81	6.08	5.30
	2	1.10	12.21	5.08	0.69	4.40	4.10
	4	0.87	7.19	2.98	0.86	2.12	2.10
	6	0.96	5.86	1.44	0.29	1.15	4.23
3	0	1.26	10.07	4.82	0.54	4.28	5.88
	2	1.19	9.69	4.06	0.57	3.49	5.82
	4	1.39	0.93	2.59	0.53	2.06	5.97
	6	1.84	8.73	1.92	0.43	1.49	5.80
4	0	1.28	10.20	4.73	0.55	4.19	6.08
	2	1.18	9.31	4.29	0.46	3.83	6.09
	4	0.98	6.87	2.30	0.39	1.91	6.40
25	0	1.18	9.31	4.19	0.54	3.64	7.08
	2	1.80	7.82	3.15	0.42	2.73	5.58
	4	1.82	7.32	2.19	0.32	1.87	5.11
5	0	1.40	12.26	6.95	0.73	6.22	7.82
	2	1.23	10.55	4.78	0.59	4.19	7.25
	4	1.84	7.60	2.52	0.44	2.08	5.01
6	0	1.39	11.26	7.04	0.71	6.33	6.51
	2	1.19	10.63	4.21	0.50	3.71	7.70
	4	1.20	10.81	3.56	0.50	3.06	7.78
18	0	1.49	11.43	7.28	0.77	6.51	9.82
	2	1.46	11.40	5.12	0.71	4.41	8.90
19	0	1.54	11.20	6.95	0.97	5.98	9.55
8	0	1.51	11.41	7.54	0.76	6.77	8.48
	2	1.40	11.42	5.13	0.65	4.47	8.26
	4	1.34	11.70	3.96	0.59	3.37	9.82
10	0	1.86	16.90	9.29	0.96	8.33	12.08
	2	1.50	13.51	5.48	0.65	4.83	9.67
	4	1.52	13.80	3.39	0.51	2.88	9.84

Table C4. cont.

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NO3+NH4
20	0	1.69	17.07	8.12	0.85	7.28	10.91
	2	1.56	15.37	6.19	0.61	5.58	9.49
11	0	1.51	13.20	7.01	0.75	6.25	7.90
	2	1.25	11.10	4.45	0.54	3.91	6.60
	4	1.08	9.39	2.86	0.42	2.44	6.47
9	0	1.37	11.65	6.57	0.67	5.89	5.80
	2	1.30	11.82	6.63	0.66	5.98	6.14
	4	1.13	10.85	2.95	0.58	2.43	5.77
7	0	1.23	10.41	4.68	0.62	4.06	5.90
	2	1.23	10.68	4.20	0.51	3.69	5.84
	4	1.07	8.95	2.72	0.46	2.26	5.36
13	0	5.65	32.25	28.77	3.94	24.83	29.70
22	0	4.74	29.18	22.96	3.32	19.63	29.00
	Average	1.43	12.92	6.16	0.78	5.38	7.76
	Number	47	47	47	47	47	47
	Standard	0.84	8.00	5.57	0.69	4.91	5.84
	Maximum	5.65	54.61	28.77	3.94	24.83	29.70
	Minimum	0.46	5.70	1.44	0.29	1.15	2.10

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Table C5. MDR Nutrient Chemistry Data (in ug-at/L) 6 February 1992

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	3.36	61.82	58.46	7.99	50.47	30.00
	2	0.78	0.74	3.10	0.53	2.65	3.70
1	0	0.67	0.10	2.66	0.48	2.18	3.30
	2	0.51	5.75	0.48	0.15	0.33	2.30
	4	0.47	5.25	0.60	0.29	0.31	2.10
2	0	0.60	7.70	1.65	0.30	1.35	2.10
	2	0.60	6.63	1.34	0.34	1.01	2.00
	4	0.66	6.83	1.47	0.29	1.19	2.76
3	0	0.99	10.73	2.00	0.30	1.71	3.60
	2	0.96	10.35	1.80	0.27	1.53	3.02
	4	0.72	7.65	0.83	0.24	0.59	2.54
4	0	0.95	10.47	2.35	0.37	1.97	3.80
	2	0.95	10.20	2.20	0.37	1.83	3.04
	4	0.94	10.25	2.40	0.40	2.01	3.19
25	0	0.94	10.57	2.25	0.35	1.90	4.10
	2	0.93	10.30	2.21	0.36	1.85	3.10
	4	0.95	10.00	2.17	0.31	1.86	3.30
5	0	1.07	11.72	2.84	0.35	2.49	3.80
	2	1.10	11.63	2.67	0.35	2.33	3.90
	4	0.93	9.49	1.78	0.34	1.45	3.30
6	0	1.23	13.29	3.95	0.43	3.52	3.40
	2	1.25	13.72	4.00	0.41	3.59	4.10
	4	1.28	13.58	3.95	0.40	3.55	4.60
10	0	1.37	13.22	3.39	0.47	2.92	4.70
	2	1.37	13.11	3.18	0.43	2.75	3.60
19	0	1.27	11.65	2.54	0.42	2.12	4.60
8	0	1.36	14.07	3.68	0.47	3.21	3.80
	2	1.38	13.79	3.73	0.46	3.27	4.10
	4	1.33	13.61	3.57	0.53	3.04	3.70

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Table C5. cont.

STA	DEPTH (m)	PO_4	SiO_4	NO_3+NO_2	NO_2	NO_3	NH_3+NH_4
10	0	1.49	18.22	6.00	0.60	5.40	4.50
	2	1.46	17.42	5.40	0.52	4.87	5.70
	4	1.50	16.88	5.20	0.47	4.73	4.77
20	0	1.59	23.47	9.70	0.72	8.98	4.73
	2	1.41	14.96	5.25	0.48	4.78	4.07
13	0	1.58	17.24	5.72	0.44	5.29	9.40
22	0	13.69	72.89	17.38	12.59	4.79	200.00

Stations 7,9,11 were not sampled. Life guards were called on an emergency.

	PO_4	SiO_4	NO_3+NO_2	NO_2	NO_3	NH_3+NH_4
Average	1.49	14.93	5.06	0.95	4.11	9.96
Number	36	36	36	36	36	36
Standard	2.12	13.34	9.49	2.33	8.02	32.43
Maximum	13.69	72.89	50.46	12.59	50.47	200.00
Minimum	0.47	5.25	0.48	0.15	0.31	2.10

Table C6. MDR Nutrient Chemistry Data (in ug-at/L) 5 March 1992

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	0.77	14.23	6.77	0.48	6.09	3.47
	2	0.61	5.99	2.37	0.23	2.15	2.53
1	0	0.59	4.31	1.41	0.22	1.20	3.40
	2	0.63	5.00	1.67	0.22	1.45	3.11
	4	0.58	3.45	0.84	0.17	0.67	2.32
2	0	0.63	3.75	0.86	0.21	0.65	2.32
	2	0.58	3.88	1.01	0.17	0.85	2.33
	4	0.51	3.08	0.74	0.12	0.62	1.83
	6	0.48	2.78	0.55	0.10	0.44	1.96
3	0	0.95	9.44	2.93	0.38	2.54	3.16
	2	0.76	5.63	1.19	0.16	1.04	5.60
	4	0.76	4.56	0.77	0.17	0.60	4.63
4	0	0.98	10.41	3.82	0.40	3.42	6.39
	2	0.71	5.30	1.34	0.21	1.13	3.78
	4	0.68	4.01	1.16	0.13	1.03	4.04
25	0	0.99	10.46	3.59	0.33	3.26	5.45
	2	0.79	6.32	1.85	0.29	1.56	4.07
	4	0.68	4.88	1.05	0.15	0.90	3.15
	6	0.72	4.94	1.07	0.17	0.90	3.80
5	0	0.93	10.64	4.39	0.43	3.96	5.27
	2	0.92	8.12	2.20	0.35	1.85	4.31
	4	0.83	6.76	1.15	0.21	0.94	3.76
6	0	0.99	11.15	5.27	0.39	4.88	3.48
	2	0.99	11.50	2.15	0.30	1.85	3.94
	4	0.98	11.05	3.43	0.40	3.03	3.95
19	0	0.90	9.88	2.21	0.31	1.90	3.27
18	0	0.93	10.85	3.69	0.42	3.26	4.10
	2	1.10	12.63	2.82	0.35	1.67	4.26
8	0	0.99	11.03	4.25	0.42	3.83	3.92
	2	0.93	11.33	2.29	0.28	2.01	3.90
	4	1.16	11.83	1.80	0.27	1.53	5.06
10	0	1.76	19.96	6.53	0.54	5.99	7.51
	2	1.32	14.93	3.45	0.38	3.07	6.20
	4	1.28	13.60	1.98	0.31	1.60	6.14

Table C6. cont.

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
20	0	1.73	18.09	5.96	0.53	5.43	9.00
	2	1.34	14.61	3.30	0.35	2.95	7.38
11	0	1.30	15.88	6.11	0.49	5.62	7.06
	2	1.19	12.77	2.60	0.33	2.27	7.65
	4	1.07	10.32	2.07	0.22	1.85	15.69
9	0	1.17	13.49	2.78	0.28	2.50	7.19
	2	1.15	13.50	2.76	0.28	2.48	8.01
	4	1.14	11.63	2.07	0.22	1.85	8.53
7	0	1.07	11.98	4.71	0.39	4.32	6.80
	2	1.03	9.73	2.26	0.30	1.96	8.38
	4	1.02	9.16	2.27	0.21	2.07	8.05
13	0	4.94	31.68	20.68	2.81	17.87	17.97
22	0	5.51	9.01	27.31	3.04	23.47	20.36
	Average	1.13	10.04	3.56	0.43	3.12	5.73
	Number	47	47	47	47	47	47
	Standard	0.91	5.24	4.64	0.83	4.02	3.78
	Maximum	5.51	31.68	27.31	3.04	23.47	20.38
	Minimum	0.48	2.78	0.55	0.10	0.44	1.83

Table C7. MDR Nutrient Chemistry Data (in ug-at/L) 4 April 1992

STA	DEPTH (m)	PO_4	SiO_4	NO_3+NO_2	NO_2	NO_3	NH_3+NH_4
12	0	1.67	10.20	30.58	1.87	28.71	10.35
	2	0.50	3.90	1.38	0.23	1.15	3.10
1	0	1.66	10.17	30.43	1.95	28.48	8.40
	2	0.42	2.31	0.49	0.09	0.40	3.01
	4	0.44	3.30	0.65	0.19	0.46	2.84
	6	0.58	5.06	0.67	0.12	0.56	3.02
2	0	0.79	10.36	7.49	0.72	6.77	5.10
	2	0.70	5.80	3.73	0.35	3.39	3.02
	4	0.56	3.79	1.55	0.21	1.34	3.24
	6	0.62	4.79	1.38	0.22	1.16	3.15
3	0	0.88	9.88	4.22	0.48	3.74	3.27
	2	0.82	7.90	2.96	0.39	2.57	2.47
	4	0.66	5.47	2.16	0.37	1.78	3.30
4	0	0.83	11.21	6.00	0.70	5.30	4.37
	2	0.84	0.22	2.91	0.44	2.47	4.70
	4	0.58	4.30	0.83	0.19	0.64	2.79
25	0	0.96	10.86	5.31	0.49	4.82	4.91
	2	1.00	9.68	4.32	0.45	3.88	5.12
	4	0.60	6.03	1.18	0.19	0.99	4.53
5	0	1.00	11.49	5.44	0.81	4.63	4.05
	2	0.87	0.61	2.73	0.48	2.25	3.53
	4	0.77	7.26	1.38	0.21	1.18	4.04
6	0	0.96	10.85	7.88	0.65	7.23	6.20
	2	1.20	12.52	3.10	0.53	2.56	0.40
	6	0.62	6.21	1.97	0.15	1.82	7.70
19	0	1.88	10.39	5.96	0.53	5.43	5.20
18	0	0.68	7.51	6.16	0.81	5.35	6.00
	2	1.48	10.99	2.10	0.36	1.74	7.20
8	0	1.07	9.78	4.73	0.47	4.27	5.80
	2	1.38	11.81	2.33	0.45	1.89	7.80
	4	1.07	9.43	1.61	0.36	1.26	8.30
10	0	1.55	14.92	2.94	0.41	2.53	9.07
	2	1.38	13.14	3.27	1.37	1.90	8.74
	4	1.25	10.57	1.78	0.47	1.31	8.25

Table C7. cont.

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NO3+NH4
20	0	1.25	10.70	8.87	1.55	7.32	12.26
	2	0.93	6.52	1.69	0.48	1.21	7.43
11	0	0.70	9.71	7.61	0.82	6.79	6.58
	2	0.88	8.41	2.71	0.44	2.26	7.38
	4	1.20	11.48	1.95	0.38	1.57	5.80
9	0	1.10	15.70	7.49	0.60	6.89	5.97
	2	1.26	12.23	2.55	0.39	2.16	5.42
	4	1.29	10.89	1.78	0.41	1 37	6.10
7	0	1.02	10.13	4.26	0.50	3.76	5.12
	2	1.07	9.93	3.12	0.47	2.65	4.95
	4	1.04	9.63	2.17	0.35	1.82	4.70
13	0	5.13	33.51	47.10	3.90	43.20	30.00
22	0	6.14	35.58	99.20	7.32	91.88	31.71
	Average	1.16	10.41	7.49	0.75	6.76	6.60
	Number	47	47	47	47	47	47
	Standard	1.00	6.18	15.97	1.15	14.86	5.54
	Maximum	6.14	35.58	99.20	7.32	91.88	31.71
	Minimum	0.42	2.32	0.49	0.09	0.40	2.47

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Table C8. MDR Nutrient Chemistry Data (in ug-at/L) 14 May 1992

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	1.09	68.27	10.27	1.81	0.45	5.83
	2	1.57	14.82	1.76	0.43	1.33	3.62
1	0	0.44	0.14	0.56	0.15	0.41	3.09
	2	0.54	6.77	0.58	0.18	0.40	2.77
	4	0.39	5.15	0.49	0.17	0.32	2.64
2	0	0.4[illegible]	6.80	0.53	0.18	0.36	1.96
	2	0.46	6.78	0.57	0.18	0.39	1.75
	4	0.46	6.24	0.55	0.18	0.38	2.50
3	0	0.75	9.88	0.68	0.30	0.38	2.33
	2	0.71	9.76	0.70	0.26	0.44	2.35
	4	0.66	01.53	0.79	0.30	0.49	1.97
4	0	0.65	10.30	0.50	0.20	0.31	2.61
	2	0.65	9.89	0.57	0.23	0.34	4.44
	4	0.58	0.62	0.67	0.27	0.40	2.26
25	0	1.05	10.42	0.81	0.33	0.49	1.73
	2	0.70	10.33	0.56	0.21	0.35	3.20
	4	0.76	9.21	0.68	0.27	0.41	4.95
5	0	0.76	9.96	0.54	0.18	0.36	1.86
	2	0.79	10.60	0.66	0.24	0.43	2.88
	4	0.70	9.55	0.55	0.21	0.34	1.87
6	0	0.72	10.24	0.46	0.16	0.30	1.89
	2	0.87	10.78	0.86	0.26	0.60	1.48
	2	0.79	10.87	1.17	0.24	0.93	1.39
19	0	0.88	11.70	0.43	0.22	0.21	2.30
18	0	0.81	12.13	0.41	0.20	0.21	1.82
8	0	0.90	12.56	0.49	0.23	0.25	2.15
	2	1.02	13.06	0.63	0.28	0.34	1.86
	4	0.98	13.52	0.59	0.26	0.36	1.78
10	0	1.28	13.81	1 13	0.26	0.87	1.69
	2	1.06	13.63	0.92	0.29	0.62	1.39
20	0	1.15	13.95	1.74	0.39	1.35	6.37
	2	1.30	16.06	1.41	0.33	1.08	3.80

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Table C7. cont.

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NO3+NH4
11	0	0.95	13.68	1.23	0.36	0.88	1.77
	2	0.97	12.96	1.10	0.29	0.81	2.03
9	0	0.97	14.80	2.19	0.29	1.91	1.95
	2	1.02	14.18	1.88	0.31	1.57	2.07
7	0	0.79	10.57	0.65	0.27	0.38	3.96
	2	0.85	10.72	0.66	0.26	0.40	3.26
	4	1.10	11.21	0.91	0.38	0.53	4.03
13	0	1.61	13.10	1.75	0.23	1.52	6.08
22	0	1.61	12.12	1.30	0.32	0.99	15.00
	Average	0.84	12.31	1.10	0.29	0.80	3.03
	Number	41	41	41	41	41	41
	Standard	0.27	9.19	1.52	0.25	1.28	2.27
	Maximum	1.61	68.27	10.27	1.81	0.43	15.00
	Minimum	0.39	5.15	0.41	0.15	0.21	1.39

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Table C9. MDR Nutrient Chemistry Data (in ug-at/L) 11 June 1992

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NO3+NH4
12	0	0.64	7.53	0.55	0.14	0.41	3.46
	2	0.68	7.51	0.49	0.14	0.34	2.97
1	0	0.60	6.78	0.53	0.14	0.39	2.07
	2	0.61	6.44	0.54	0.09	0.46	2.19
	4	0.61	6.47	0.42	0.11	0.31	2.52
2	0	0.60	9.17	0.42	0.09		2.33
	2	0.60	9.50	0.45	0.09	[illegible]	5.00
	4	0.59	7.22	0.46	0.11	0.36	5.10
3	0	0.79	12.23	0.60	0.16	0.44	4.70
	2	1.01	11.73	0.71	0.20	0.52	6.00
	4	0.72	8.96	0.55	0.11	0.44	4.30
4	0	0.86	14.03	0.60	0.16	0.52	3.90
	2	0.80	13.76	0.75	0.14	0.60	4.00
	4	0.85	10.26	0.73	0.14	0.59	3.90
25	0	0.80	12.82	0.64	0.14	0.50	3.60
	2	1.01	12.52	0.83	0.18	0.65	3.67
	4	1.09	11.05	0.90	0.21	0.60	3.93
5	0	1.15	15.44	1.30	0.22	1.16	3.12
	2	0.99	13.30	0.75	0.11	0.64	2.70
	4	0.80	9.92	0.67	0.09	0.57	2.60
6	0	1.15	13.15	1.24	0.14	1.09	3.32
	2	1.10	13.30	1.00	0.13	0.87	3.01
	4	1.31	12.99	1.19	0.22	0.97	5.20
19	0	1.46	14.47	1.29	0.23	1.06	4.99
18	0	1.31	15.45	1.11	0.19	0.92	3.39
	2	1.46	16.46	1.19	0.24	0.95	3.50
8	0	1.26	15.31	1.14	0.20	0.94	3.78
	2	1.30	15.63	1.17	0.25	0.93	3.30
	4	1.58	16.07	0.82	0.45	0.36	4.76
10	0	1.49	18.79	2.80	0.35	2.45	4.86
	2	1.42	15.31	1.25	0.32	0.93	4.80
20	0	1.72	24.59	5.38	0.40	4.99	6.63
	2	1.68	16.63	1.39	0.31	1.08	6.76

Table C9. cont.

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NH3+NH4
11	0	1.36	17.83	2.09	0.29	1.80	4.36
	2	1.18	14.39	1.21	0.22	0.99	4.07
9	0	1.13	19.03	4.67	0.25	4.40	3.06
	2	1.10	14.91	1.15	0.26	0.90	2.26
7	0	1.09	13.36	1.07	0.17	0.90	2.68
	2	1.08	13.26	1.15	0.23	0.92	7.50
13	0	1.72	19.30	2.04	0.37	1.67	9.20
22	0	1.46	106.99	28.36	3.76	24.59	11.09
	Average	1.08	15.42	1.85	0.29	1.56	4.26
	Number	41	41	41	41	41	41
	Standard	0.34	15.01	4.31	0.56	3.76	1.83
	Maximum	1.72	106.99	28.36	3.76	24.59	11.09
	Minimum	0.59	6.44	0.42	0.09	0.31	2.07

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APPENDIX D
BENTHIC DATA

October 1990 - June 1991

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D2

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1981. The total number of stations at which the species occurred is listed.

Phylum Subphylum Class Subclass Division Order Suborder Section Family Genus & species	STATIONS 12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURR-ENCES
ANNELIDA															
OLIGOCHAETA															
Oligochaeta, unid.	10	60	5870		10	620				10		10		6590	7
POLYCHAETA															
Ampharetidae															
Ampharete labrops	10	390												400	2
Amphicteis scaphobranchiata		10												10	1
Capitellidae															
Anotomastus gordiodes		30												30	1
Capitellidae, unid.	160													160	1
Capitella capitata	80	10	20	200		10	10							330	6
Mediomastus sp.	47840	7240	4950	4330	1410	3530	580	400	290	710	190	20	10	71300	13
Notomastus tenuis				20	10									30	2
Notomastus sp.	190	10	40											240	3
Paraleiocapitella sp.	790													790	1
Chaetopteridae															
Chaetopterus variopedatus			10											10	1
Spiochaetopterus costarum		10		10										20	2
Chrysopetalidae															
Paleanotus bellis		10	10											20	2

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1991. (continued)

Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURR-ENCES
Cirratulidae															
Cirratulidae unid.	30													30	1
Chaetozone corona	60			60	90	110	170	20		20	190	10		730	9
Chaetozone nr. *setosa*		390												390	1
(= *Chaetozone setosa*)															
Cirriformia spirabranchia	420		10			240	660	10	20	200	370			1930	8
Aphelochaeta parvus						460	1470	3260	160		10	10		5370	8
(= *Tharyx parvus*)															
Monticellina tesselata	160	40		40	70	10								320	5
(= *Tharyx tesselata*)															
Monticellina sp. *A* (SCAMIT)		20		30	20	20							10	100	5
(= *Tharyx* sp. *A* (SCAMIT))															
Tharyx sp.							60		60					120	2
Cossuridae															
Cossura candida					380	430					10		20	840	4
Dorvilleidae															
Protodorvillea gracilis	220	10												230	2
Schistomeringos rudolphi	1290	10	280	30		10		30	10		10	20	20	1690	10
Glyceridae															
Glycera americana			10		10	10	10							40	4
Glycera convoluta		80	10											90	2
Goniadidae															
Goniada littorea	30	190		10	10									240	4
Hesionidae															
Microphthalmus sp.	150	10	10											170	3
Micropodarke dubia		10												10	1
Podarkeopsis glabra			20			10								30	2
(= *Gyptis brevipalpa*)															
Lumbrineridae															
Lumbrineris erecta									30			70	160	260	3
Lumbrineris limicola					10									10	1
Lumbrineris minima			50	370	450	760	250	590	50	110	230	20	210	3090	11
Lumbrineris tetraura	30	40				30	20	30		20	40			210	7
Lumbrineris sp. (Grp. I)					20									20	1
Lumbrineris sp.	40	250	30			30		50		20	10		10	440	8
Magelona sacculata		20												20	1

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1991. (continued)

Stations	12	1	2	3	4	25	5	7	8	11	9	6	10	TOTAL	OCCURR-ENCES
Nephtyidae															
Nephtys caecoides	30	10	20		10			10						80	5
Nephtys cornuta franciscana											10			10	1
Nereididae (= Nereidae)															
Nereididae, unid. juv.	10													10	1
Neanthes acuminata (= *Neanthes arenaceodentata*)	150	10	700						30	10				900	5
Nereis latescens	10	100												110	2
Nereis procera		50												50	1
Nereis sp., juv.		50												50	1
Platynereis bicanaliculata	50	30	30											110	3
Onuphidae															
Diopatra ornata		60	10											70	2
Opheliidae															
Armandia bioculata (*brevis*)	3670	540	1660	160		60								6090	5
Polyophthalmus pictus	1310	40	60											1410	3
Orbiniidae															
Leitoscoloplos pugettensis		90	80	620	1080	3290	300	570	900	30	290	280	90	7620	12
Oweniidae															
Owenia collaris		20												20	1
Paraonidae															
Acmira catherinae (= *Acesta catherinae*)				10	10									20	2
Acmira horikoshii (= *Acesta horikoshii*)		10												10	1
Paraonella platybranchia (= *Paraonides platybranchia*)	10													10	1
Pectinariidae															
Pectinaria californiensis (= *P. c. newportensis*)		10												10	1

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1981. (continued)

Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURR-ENCES
Phyllodocidae															
Phyllodocidae, unid.		10												10	1
Eulalia quadrioculata		30												30	1
Eumida sp.	30													30	1
Phyllodoce hartmanae	10		50											60	2
Phyllodoce longipes	10	20	30											60	3
Phyllodoce sp.		20	10											30	2
Sabellidae															
Chone albocincta		20												20	1
Chone mollis	30													30	1
Euchone limnicola				670	1290	40	100	180	80	10	40	30	90	2530	10
Serpulidae															
Hydroides elegans (= *Hydroides pacifica*)	10	10												20	2
Sigalionidae															
Stherelais tertiaglabra		10												10	1
Spionidae															
Apoprionospio pygmaea (= *Prionospio pygmaeus*)		50	10		20	10								90	4
Paraprionospio pinnata		20												20	1
Polydora ligni	30		30		10			10						80	4
Polydora nuchalis		50												50	1
Polydora socialis		30												30	1
Prionospio heterobranchia (= *P. h. newportensis*)	6460	140	600	1670	230	1010	380	310	550	20	80	140	130	11720	13
Prionospio lighti	1710	560	30	380	50	40	10			30	10			2800	9
Pseudopolydora paucibranchiata	10220	10	1370	70	3990	300	10	550	590	310	690	170	300	18580	13
Rhynchospio glutaea	10													10	1
Scolelepis foliosa occidentalis	50			50	140			10						250	4
Scolelepis tridentata			20			40			10	10			10	90	5
Spiophanes bombyx		10												10	1
Spiophanes missionensis	10	70		10		20								110	4
Streblospio benedicti						290								290	1

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1981. (continued)

Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURRENCES
Syllidae															
Brania sp.	500		40											540	2
Exogone lourei		10	160											170	2
Exogone sp *A*				130	170	10		10	20		10			350	6
Terebellidae															
Amaeana occidentalis		30			10									40	2
Polycirrus sp.		10												10	1
ARTHROPODA															
CRUSTACEA															
CEPHALOCARIDA															
COPEPODA															
CYCLOPOIDEA															
Cyclopoidea, unid.			110											110	1
HARPACTICOIDEA															
Harpacticoida, unid.		10	150											160	2
OSTRACODA															
Bathyleberis sp.	20	10	10	10	10	10								70	6
Euphilomedes carcharodonta		10												10	1
Rutiderma lomae			10											10	1
MALACOSTRACA															
EUCARIDA															
DECAPODA															
Anomura															
Callianassidae															
Callianassa californiensis			40				10							50	2
Paguridae															
Paguridae, unid.	10		20											30	2
Canceridae															
Cancer antennarius		50												50	1
Cancer jordani	40													40	1
Cancer sp., juv.			10											10	1
Goneplacidae															
Malacoplax californiensis				10										10	1

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1981. (continued)

Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURR-ENCES
Majidae															
Loxorhynchus sp.	10	10												20	2
Pinnotheridae															
Portunus xantusii		10	10											20	2
Scleroplax granulata			20											20	1
Xanthidae															
Xanthidae, unid.					10									10	1
Caridea															
Alpheidae, unid.			10											10	1
Alpheus sp.						10	10							20	2
Palaemon ritteri							10							10	1
PERACARIDA															
AMPHIPODA															
CAPRELLIDEA															
Caprella californica	70	20	20											110	3
GAMMARIDEA															
Aeginellidae															
Mayerella banksia	2380	50	620	430	630	50	10							4170	7
Pontogeneidae															
Pontogeneia rostrata						10								10	1
Aoroidea															
Aoroides columbiae		30												30	1
Aoroides inermis	30	600	10											640	3
Aoroides intermedius		40												40	1
Aoroides sp.		80												80	1
Grandidierella japonica	60	30	20											110	3
Melita sulca	110													110	1
Corophiidae															
Corophiidae, unid.			30											30	1
Amphideutopus oculatus		10			280									290	2
Corophium acherusicum	20	20	210											250	3
Gammaropsis thompsoni		350	230											580	2
Photis brevipes		80												80	1
Photis californica		10												10	1
Photis sp.	10	300	110											420	3
Rudilemboides stenopropodus	300	80	10	280	50	40								770	6

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1981. (continued)

Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURR-ENCES
Ischyroceridae															
Ericthonia brasiliensis	40	1290	80											1410	3
Liljeborgiidae															
Rhepoxynius menziesi		30												30	1
Listriella melanica				10										10	1
Gibberosus myersi		10												10	1
Oedicerotidae															
Monoculoides hartmanae		20	40											60	2
Synchelidium shoemakeri		120	130											250	2
Tiron biocellata		10												10	1
Phoxocephalidae															
Rhepoxynius stenodes		10												10	1
Pleustidae															
Parapleustes pugettensis		60												60	1
Parapleustes sp., juv.		10	10											20	2
Atylus tridens	90													90	1
Podoceridae															
Podocerus cristatus	10		100											110	2
CUMACEA															
Cumella sp *A* (SCAMIT)		10												10	1
Campylaspis sp *C*	10	10												20	2
Cyclaspis nubila		10	10											20	2
Diastylopsis tenuis		350	10											360	2
Oxyurostylus pacifica	2700	120	2610		10	10								5450	5
Lamprops quadriplicata		10												10	1
ISOPODA															
Edotea sublittoralis	40													40	1
Serolis carinata				10										10	1
MYSIDACEA															
Mysidopsis sp *A*		10					30	20		40	10			110	5
TANAIDACEA															
Anatanais normani (= *Zeuxo normani*)	10		170											180	2
Leptochelia dubia		10												10	1

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1991. (continued)

Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURR-ENCES
CHELICERATA															
PYCNOGONIDA															
Pycnogonida, unid.	190													190	1
Anoplodactylus sp.			10											10	1
ASCHELMINTHES															
Nematoda, unid.	180100	10590	287920											478610	3
BRACHIOPODA															
Glottidia albida						10								10	1
CHORDATA															
VERTEBRATA															
OSTEICHTHYS															
Gobiidae															
Clevelandia ios	30				10	20	20	10				20		110	6
CNIDARIA (= COELENTERATA)															
HYDROZOA															
HYDROIDA															
Tubularia sp.													10	10	1
ECHINODERMATA															
HOLOTHUROIDEA															
Leptosynapta sp.					20	70	20							110	3
MOLLUSCA															
GASTROPODA															
Lacuna unifasciata		80												80	1
PROSOBRANCHIA															
ARCHAEOGASTROPODA															
Phasianellidae															
Tricolia compta		60												60	1
MESOGASTROPODA															
Caecidae															
Caecum californicum		10												10	1
Calyptraeidae															
Crepidula cori		70												70	1
Crepidula dorsata (= *Crepipatella lingulata*)		30												30	1
Crepidula sp., juv.	10													10	1

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1981. (continued)

Stations	12	1	2	3	4	25	5	7	8	11	9	6	10	TOTAL	OCCURR-ENCES
Naticidae															
Neverita recluziana		10												10	1
NEOGASTROPODA															
Columbellidae															
Alia carinata (= *Mitrella carinata*)		10	30											40	2
Mitrella aurantiaca			60											60	1
Nassariidae															
Nassarius fossatus			170											170	1
Nassarius perpinguis		60												60	1
Nassarius tegula									10					10	1
Olividae															
Olivella baetica		10												10	1
OPHISTHOBRANCHIA															
Aglajidae															
Melanochlamys diomedea		50												50	1
Bullidae															
Bulla gouldiana	310													310	1
Haminoeidae (= Atyidae)															
Haminoea vesicula									10					10	1
Scaphandridae															
Cylichnella culcitella		10								10				20	2
Cylichnella inculta	10	10							110			30		160	4
PELECYPODA (=BIVALVIA)															
Pelecypoda, unid. juv.	140							10						150	2
Cardiidae															
Laevicardium substriatum	1590	60	410	90	20	20	10	20						2220	8
Cooperellidae															
Cooperella subdiaphana	10				10									20	2

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1991. (continued)

Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURR-ENCES
Lucinidae															
Parvilucina tenuisculpta (= *Parvilucina* sp.)		10		10										20	2
Lyonsiidae															
Lyonsia californica							30		10					40	2
Mactridae															
Mactra sp.							10							10	1
Spisula sp.		150												150	1
Mytilidae															
Modiolus rectius		10												10	1
Musculus senhousei	20													20	1
Pectinidae															
Leptopecten latiauratus		90	10											100	2
Semelidae															
Cumingia californica	10					10								20	2
Theora lubrica					50		20							70	2
Solecurtidae															
Tagelus californianus	4960	60	120	140	410	250	10							5950	7
Tellinidae															
Leporimetis obesa	270					10								280	2
Macoma nasuta	20	50	120											190	3
Macoma sp., juv.							10						10	20	2
Tellina carpenteri	10					10								20	2
Tellina modesta	300	80				10								390	3
Tellina sp., juv.	500													500	1
Veneridae															
Protothaca staminea	1620	70	80	10	10	120								1910	6
Transennella tantilla		10												10	1
Tivela stultorum						70								70	1

Table D1. Benthic fauna by station in order of distance from the breakwater, 17 October 1991. (continued)

	Stations	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL	OCCURR-ENCES
NEMERTEA																
	Lineidae, unid.	40	10												50	2
	Nemertea, unid.						30					10			40	2
	Amphiporus cruentatus		10												10	1
	Amphiporus rubellus	10	20												30	2
	Carinoma mutabilis		10												10	1
	Cerebratulus californiensis	10	20												30	2
	Micrura sp.		40	20	50	10									120	4
	Monostylifera sp.			10											10	1
	Paranemertes sp A	280	40	40	50		10								420	5
	Tubulanus nothus							10							10	1
	Tubulanus polymorphus	10			80	10	10	20							130	5
	Tubulanus sp.		80	10											100	2
PHORONIDA																
	Phorinida, unid.	10						10		230		10			260	4
	Phoronis sp.					10							20	10	40	3
PLATHYHELMINTHES																
	Polycladida, unid.	10		10											20	2
SIPUNCULIDA																
	Golfingia sp.			20											20	1
	NUMBER of SPECIES	82	121	76	33	40	46	30	20	19	16	19	14	15	225	
	INDIVIDUALS	272070	28700	310080	10020	11050	12170	4270	6100	3170	1560	2220	850	1090	661330	

VOL 12

Final Report

To

American Oceans Campaign
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CHEMICAL CONTAMINANT RELEASE INTO THE SANTA MONICA BAY: A PILOT STUDY

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PROJECT ORGANIZATION AND RESPONSIBILITIES

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Drs. Froines and Suffet were assisted by five Task Leaders. MS. SIM-LIN LAU, and Mr KEN WONG of UCLA's, Department of Civil Engineering, Los Angeles, California 90024, Telephone: 310-825-7433, were the Field Task Leader and aid, respectively. MS. SIM-LIN LAU was responsible for coordination and logistics of the field sampling activities and sample tracking and control. She was also responsible for all laboratory activities related to water quality analysis of the aqueous samples. As Analysis Task Leader, MR. MARIO CAPANGPANGAN, UCLA, Department of Environmental Health Science, Telephone: 310-206-1242, oversaw all laboratory activities and data management. He reviewed and evaluated all analytical data generated during the project, and was responsible for the management, storage, retrieval, and manipulation of that data. MARIO was responsible for all laboratory activities related to the organic analysis of the suspened sediment samples. MS. LINDA SCHWEITZER, UCLA, Department of Environmental Health Science, Telephone: 310-206-1242, was responsible for all laboratory activities related to the organic analysis of the aqueous samples.

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INTRODUCTION

The overall objective of this pilot study is to gather data on the identity and quantity of chemical constituents that are present in urban runoff storm drains during dry weather flow. These data are to amplify our limited understanding of the nature of the chemicals that are transported from the storm drains into the Santa Monica Bay. The results of this study will be combined with the review of the literature being conducted by EOA, Inc. to facilitate development of a plan which will define additional urban runoff sampling objectives, sampling procedures, and provide a basis to assess the potential health and ecological risks associated with urban runoff into the Santa Monica Bay.

US EPA National Water Quality Inventory 1990 report to Congress (EPA,1992) found that storm sewer runoff was responsible for 12-31 % of the impared rivers, lakes and estuaries in the US. Urban storm drains collect water from non-point sources and can pose a public health hazard [Leadership Needed to Reduce Nonpoint Source Pollution GAC DOC # RCED 91-10; Water 2000, 1991) to the final receiving water. All urban sources from street runoff to a home or an industrial lot can add a pollutant load to the receiving body of water, both during dry weather and wet weather flow (>10,000 gal per min). The hazard of chronic chemical exposure to human population as well as the ecology of receiving water from storm drains is still an open question.

The study results are divided into the following major sections:

1. Results of volatile organic analyses by EPA Method 524/624* equivalent method using a Capillary GC/MS final step. QA/QC evaluation of sampling and analysis are included in the Appendix section. A Method Detection Limit is defined for all targeted chemicals that were quantitatively analyzed. The MDL was modified to exclude any background blank problems. A group of tentitive identifications are reported also for a series of non-target volatile organic compounds that were present in some of the samples that were analyzed. Further work outside the scope of this project would be needed for a complete evaluation of the non-target compounds that would include their positive identification and quantification.

2. Results of a total base neutral organic analysis of a filtered aqueous phase and the associated suspended solids were completed by EPA Method 608/625*

equivalent method using a Capillary GC/MS final step. The suspended solids were extracted by a newly developed supercritical carbon dioxide isolation method. QA/QC evaluation of sampling and analysis are included in the Appendix section. A Method Detection Limit is defined for all targeted chemicals that were quantitatively analyzed. The MDL was modified to exclude any background blank problems. A group of tentitive identifications are reported also for a senes of non-target base neutral organic compounds that were present in some of the samples that were analyzed. Further work ouside the scope of this project would be needed for a complete evaluation of the non-target compounds that would include their positive identification and quantification.

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DESCRIPTION OF SAMPLING SITES

Figure 1 shows a map of the monitoring sites and associated watershed for the study. A description of each sampling site follows.

Pico-Kenter Storm Channel at the bike path before the beach at Pico and Kenter Avenues in Santa Monica (See Figure 1). Figure 2, (Picture Set 1) shows the storm drain condition when the flow channel is open to the ocean. Figure 2 & 3, (Picture Sets 2 & 3) shows the sampling conditions of this study, which occurred during pumping of the dry weather flow to the Hyperion Wastewater Treatment Plant. Before May 30, 1992, the water in the Pico-Kenter Storm Channel flowed directly into the ocean. Large quantities of algal growth and trash were observed in the storm drain. After May 30, 1992, the storm drain was re-routed by a pumping station placed in the storm sewer line which directed the storm water at low flow conditions to the treatment plant at Hyperion. The maximum amount of water that could flow to Hyperion was set at 0.3 MGD.

After the pump system was installed, water was collected from a manhole just on the beach off the bike path next to the closed storm drain, Figures 3 & 4, (Picture Sets 2 & 3). The water was colored and smelled of decaying organic matter. Occasionally, Styrofoam "peanuts" were seen floating at the surface. During the sampling period, high water levels would overwhelm the pump system and some water was seen bypassing the diversion and once again moving through the storm water channel into the ocean. The pump system at Pico was set up to pump a maximum of 0.3 MGD to Hyperion. Any greater than this was bypassed to the ocean. The flow rate was not measured during sampling.

The 10 to 12 foot diameter Pico/Kenter storm drain at the Promenade under Pico Blvd. is the terminus to the ocean of the Kenter Caynon drain, Pico Blvd. drain and the Santa Monica Freeway or CA Department of Transportation drain. The dry weather flow is estimated to be 0.1 to 3 MGD. ("The Ecology of the Southern CA Bright," SCCWRP, 1973). At present, the dry weather flow is estimated to be 0.1 - 0.3 MGD (G. Green, Santa Monica, Personnal Communication, 1993).

Appendix I shows the background water data collected at Pico-Kenter. Figure 5 shows the conductivity; a measure of salinity and total background ion

Figure 1. Map - Monitoring Sites And Associated Watersheds

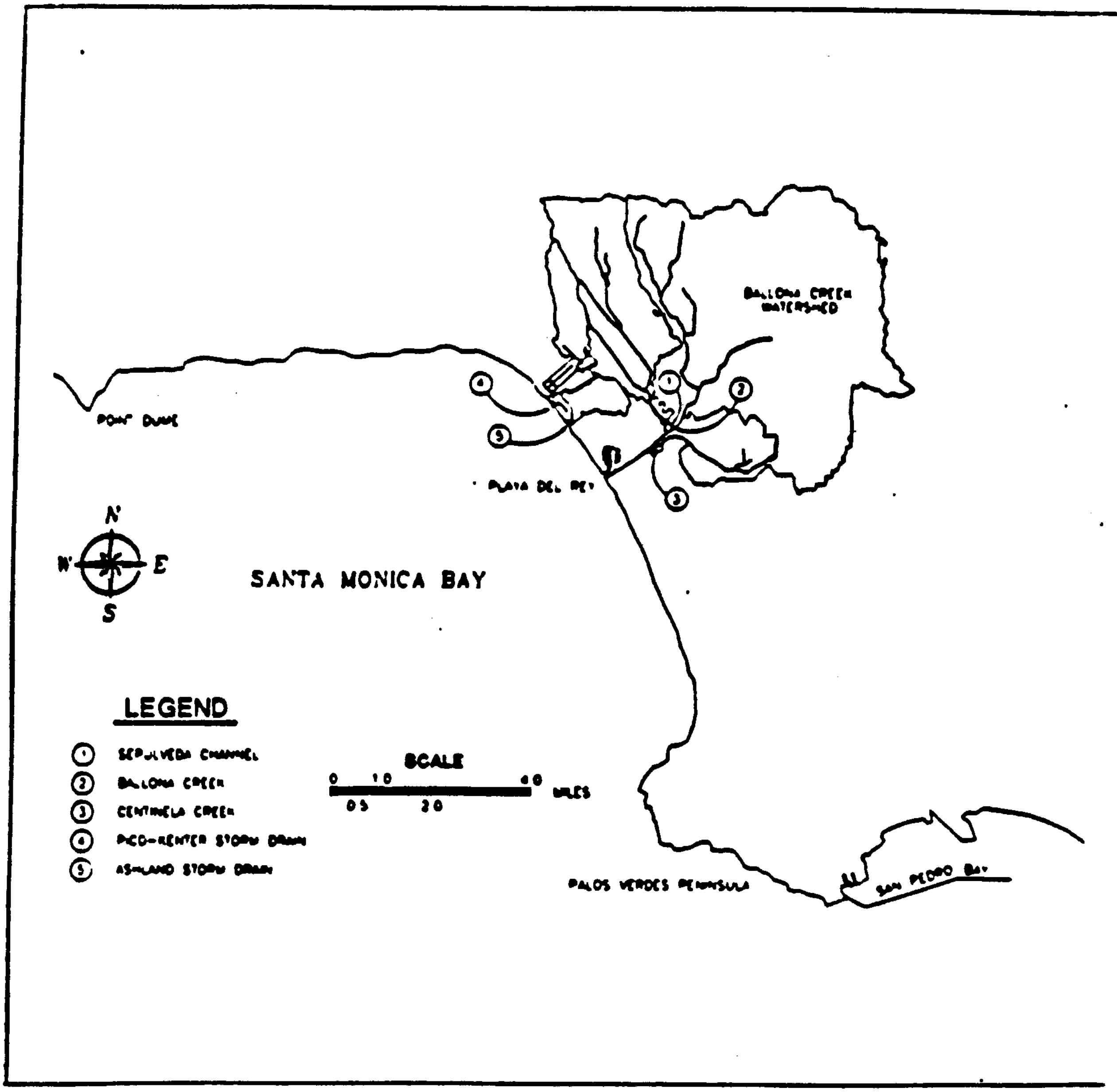
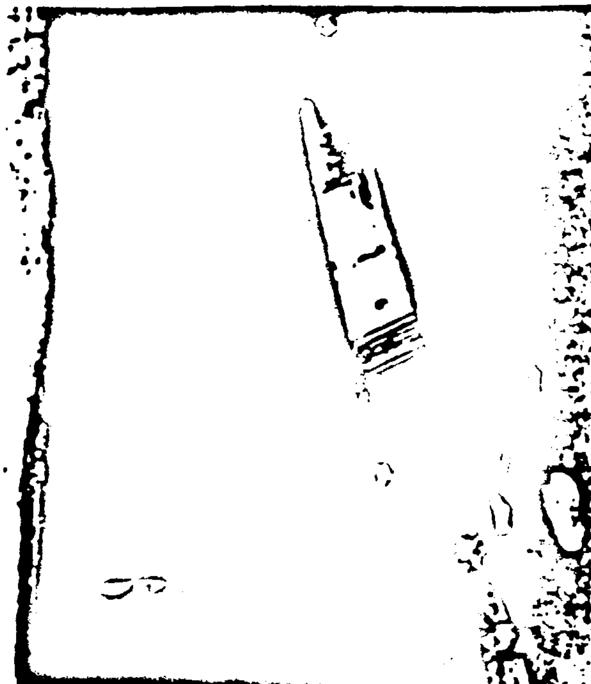


Figure 2. Picture Set 1 Of Sampling Location -- Pico-Kenter
Storm Drain Channel Open To Ocean

PICO-KENTER

Picture Set I - Pico-Kenter

refer to
original
photos



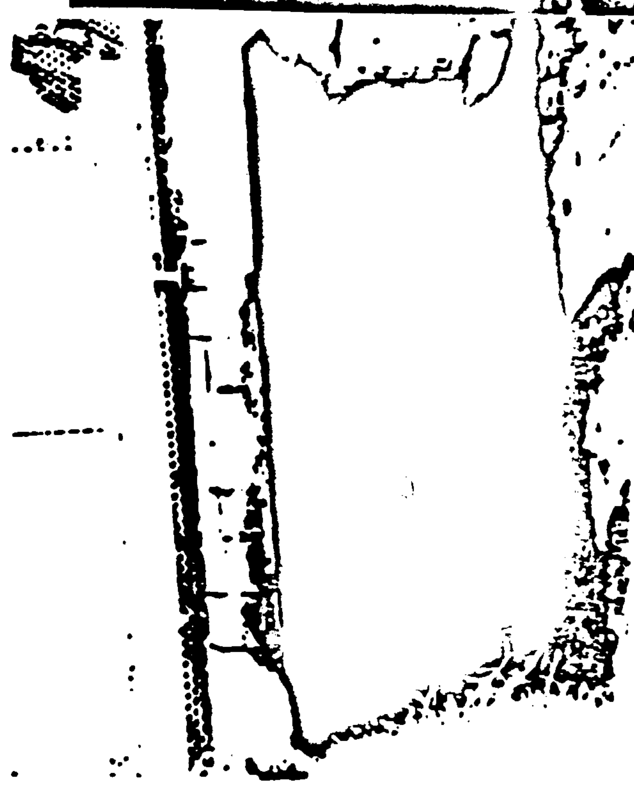


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Figure 3 Picture Set 2 Of Sampling Location -- Pico-Kenter Storm Drain Closed To Ocean And Pumping Of Dry Weather Flow To The Hyperion Wastewater Treatment Plant

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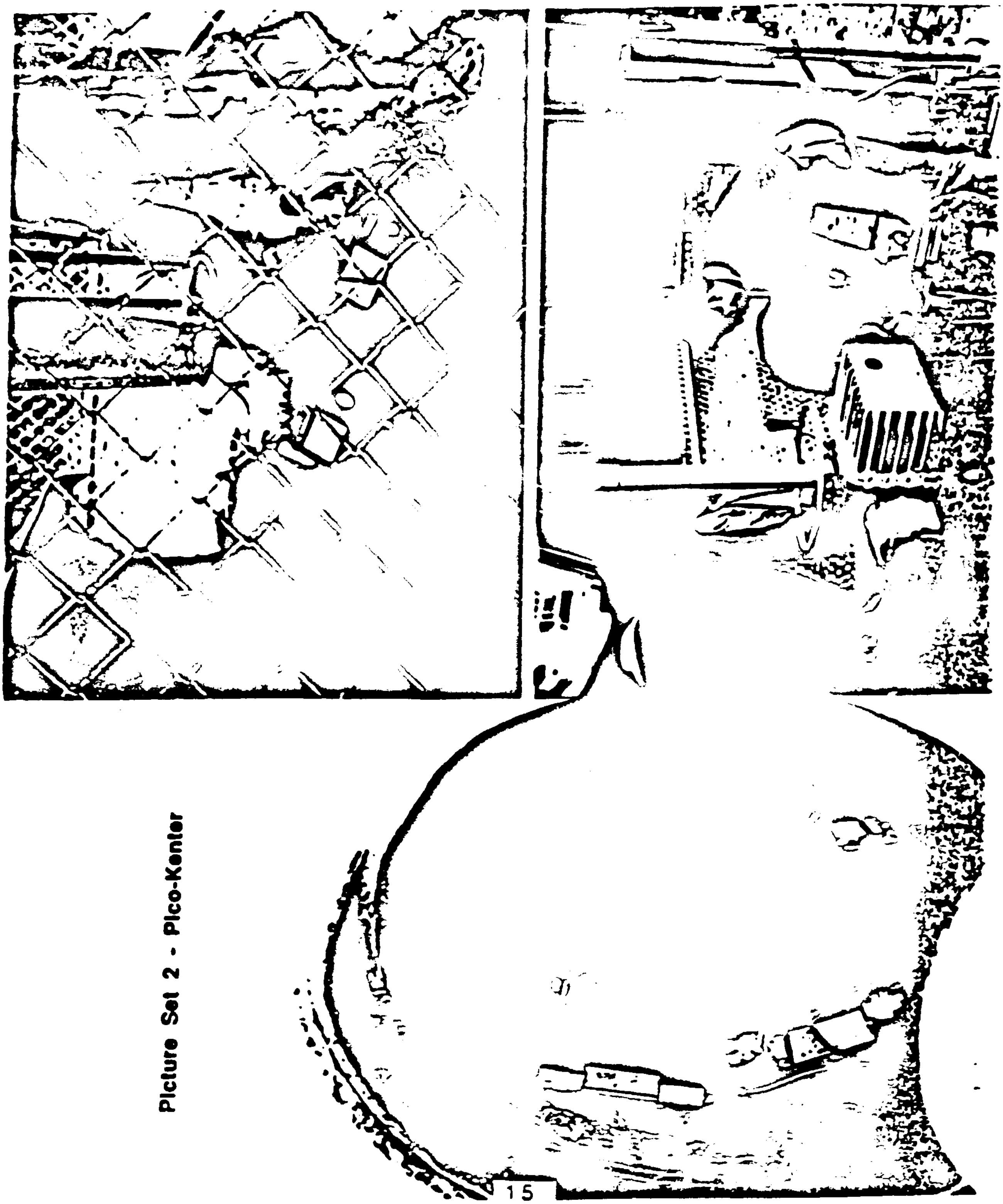
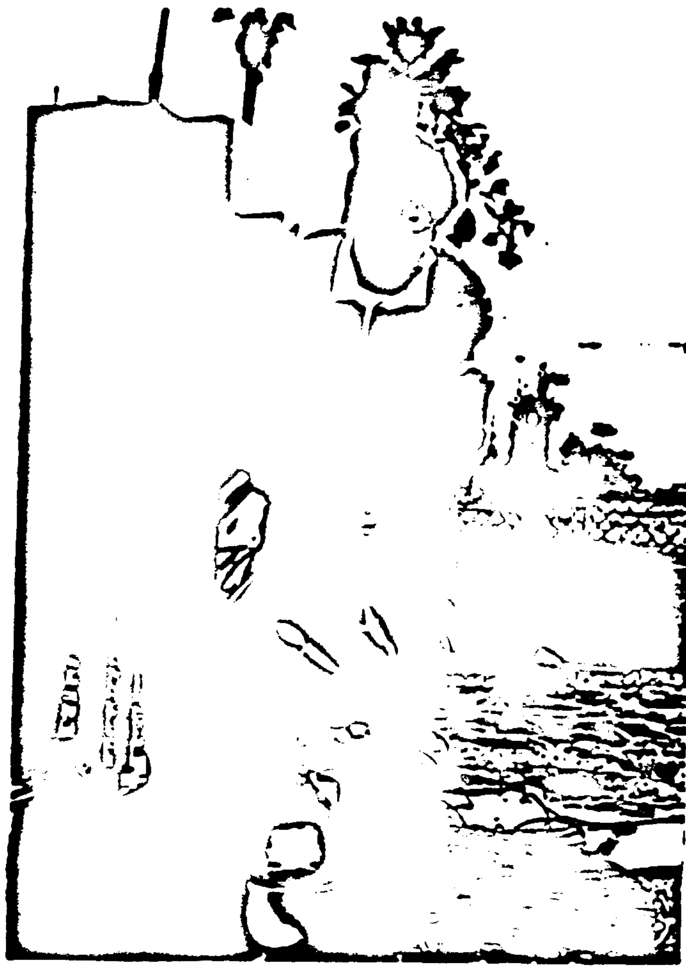


Picture Set 2 - Pico-Kenter

Figure 4. Picture Set 3 Of Sampling Location -- Pico-Kenter Sampling From Bypass Manhole

icture Set 3 - Pico-Kenter



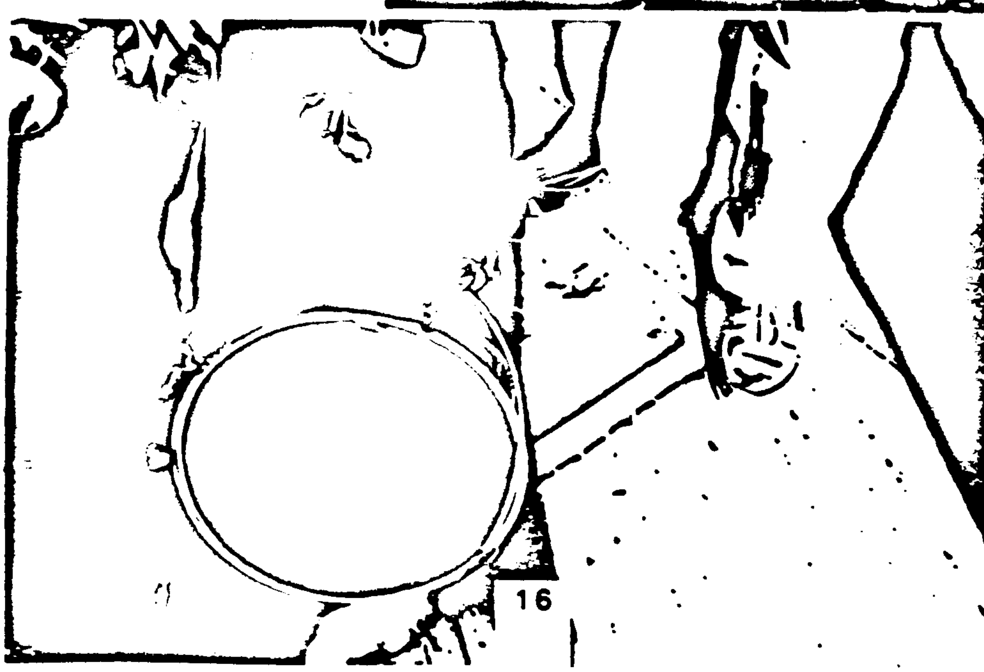
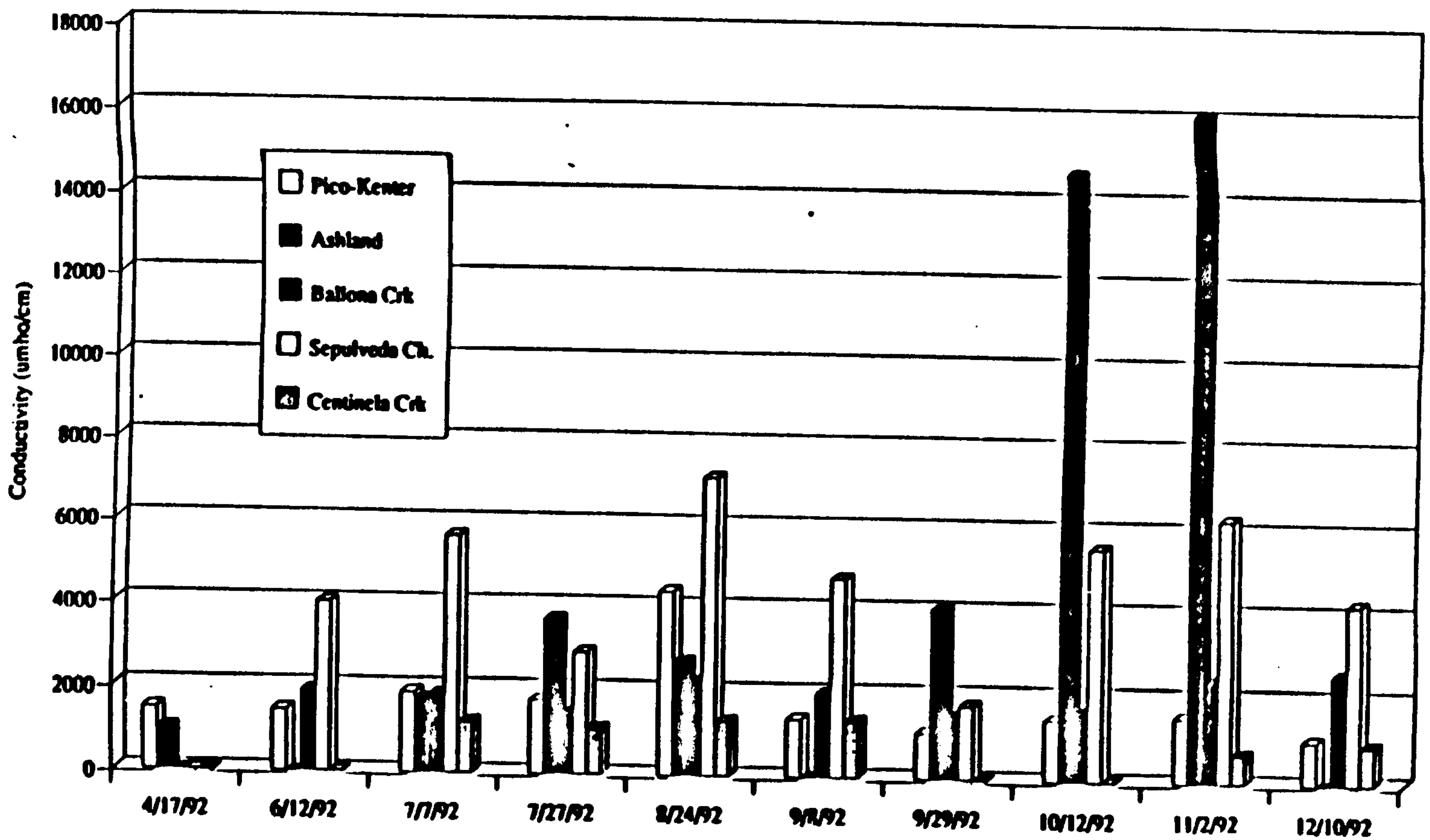


Figure 5

Conductivity Data of Storm Drains at Time of Sampling



concentration is relatively low at Pico-Kenter indicating a fresh water flow. Figure 6 shows the dissolved organic carbon analysis at Pico-Kenter during the time of sampling. The values for July through October were low at < 20 mg/l where as higher values of 70 to 90 mg/l were observed in November and December.

Ashland Avenue at a manhole at Ashland Ave and Ocean Boulevard. (See Figure 1 and Figures 7 & 8 (Picture Sets 4-5). This location is one block from the Santa Monica bike path on the sidewalk on Ocean Avenue in front of the parking lot entrance to the Santa Monica Shores apartment building (See Figure 1). Sometimes the levels in the manhole were too low to sample. Often there were a lot of leaves and other organic material present including mosquito larvae. Always a foul stench was detectable. Several times salt water intrusion was shown by the high conductivity levels. This site was the greatest problem area for collection of samples. Originally, we inspected the area where the Ashland Avenue Drain deposits onto the beach, as shown in Figure 8 (Picture Set 5). Continuous salt water intrusion made it impossible to sample there.

Appendix I shows the background water data collected at Ashland. Figure 9 shows the conductivity is lower at Ashland during April to September than October and November. The Ashland drain is under tidal control at the sampling location as observed in Figure 8, (Picture Set 5) and indicated in Figures 5 and 9. A comparison of Figures 5 and 9 show that a conductivity of 14,000 umhos/cm translates to about 3 % salinity whereas a conductivity of 2,100 umhos/cm corresponds to 1% salinity. Figures 5 and 9 shows the salinity at Ashland at the time of sampling was under a fresh water flow before October but partially under a tidal input during the October and November sampling dates . The tidal influence with concurrent increases of bromide ion in the water can change the distribution of THMs in these samples. Figure 9 shows a unique phenomenon of the Ashland Storm Drain at this sampling location. The dissolved oxygen concentration is low, <3.0 mg/l usually and very low on 8/24 and 7/27at <1.5 mg/l. This indicates that anoxic conditions can prevail from a stagnant water at this drain under low flow and the organic compounds present in the samples can also be of a reduced nature. Figure 6 shows the dissolved organic carbon analysis at Ashland during the time of sampling. The DOC values for the Ashland drain indicate that they are the highest of all the sampling locations except for one sampling occassion , 11/2/92. The TOC values range from 25 to 95, which

Figure 6

DOC Concentration at the Storm Drains at Time of Sampling

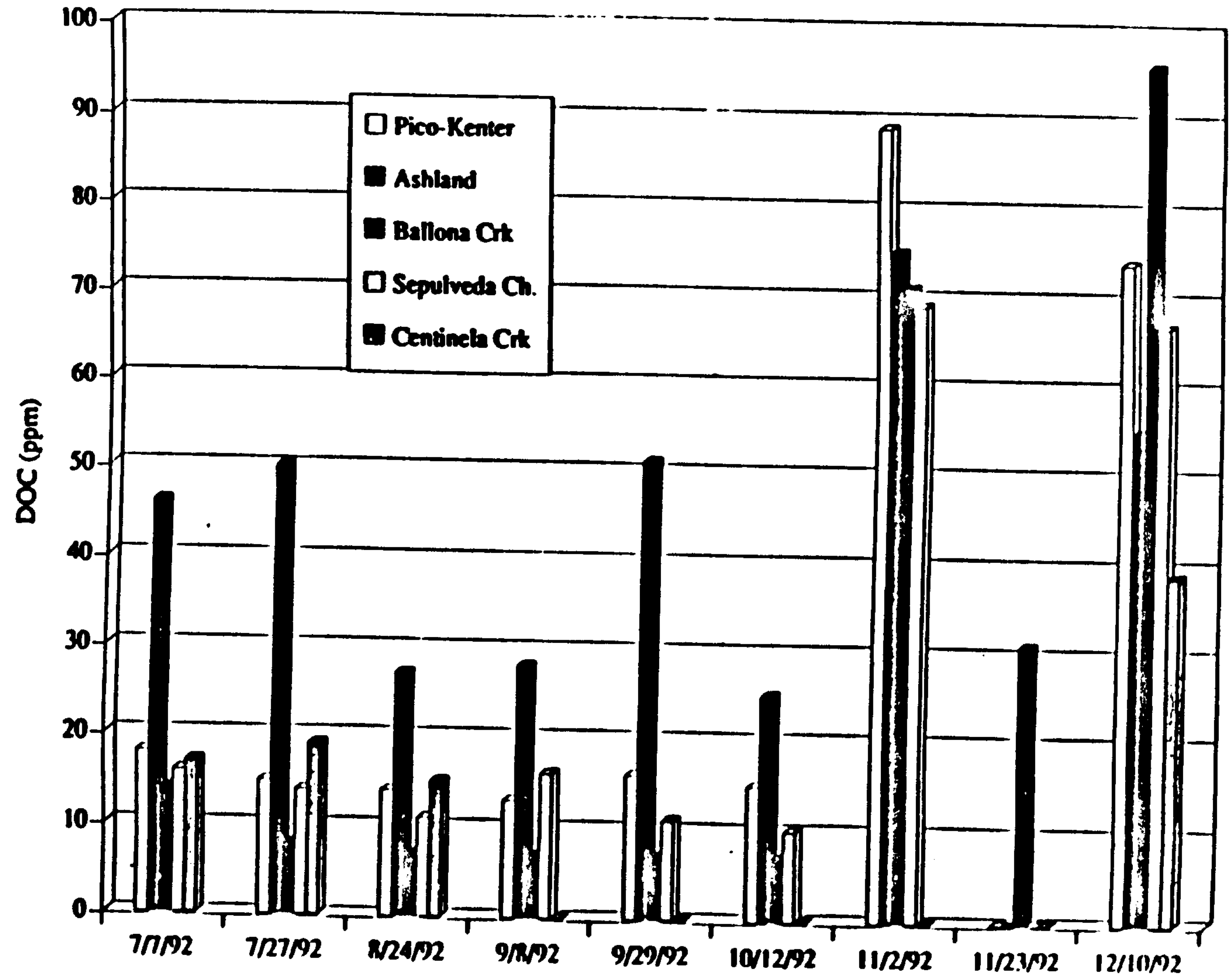
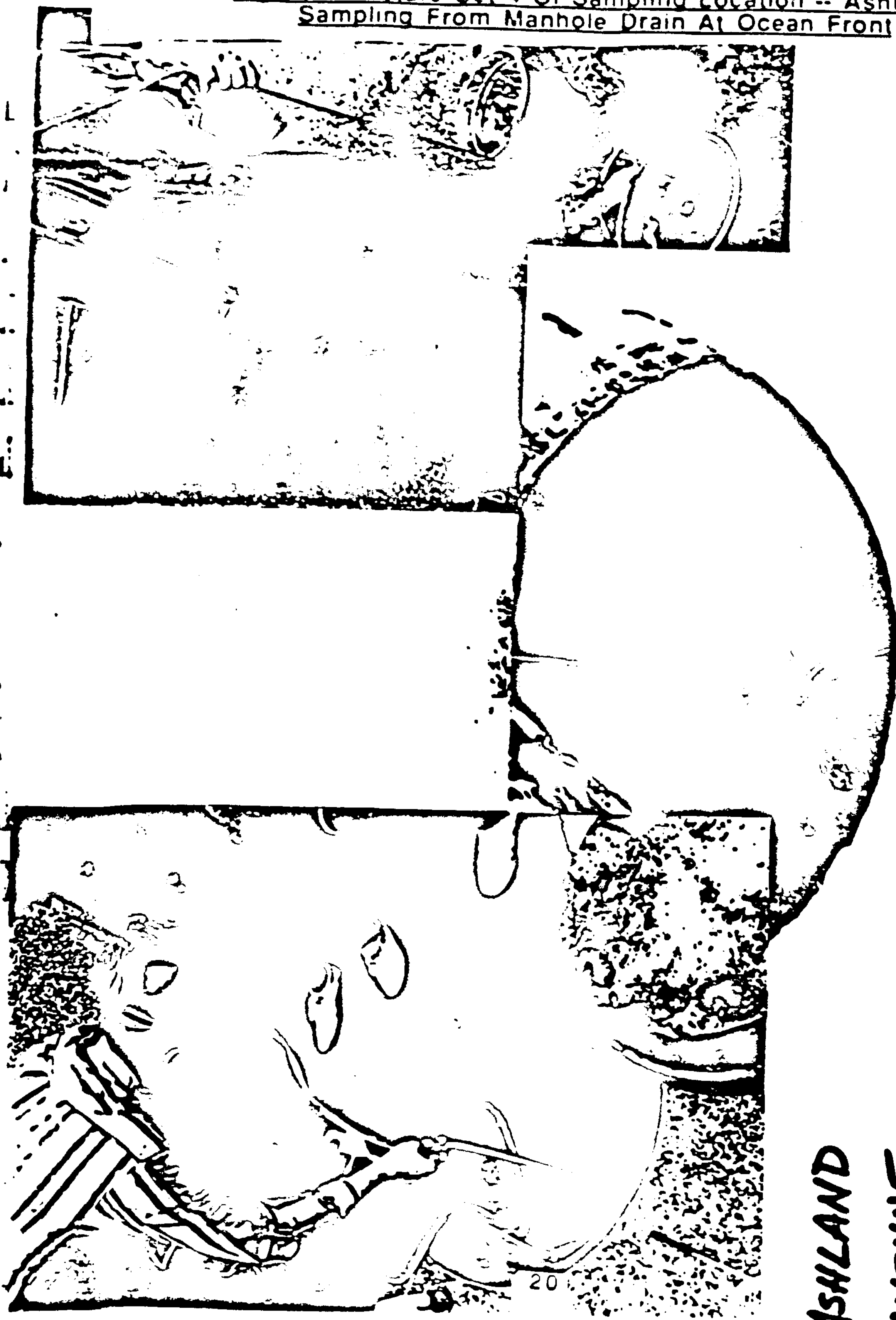


Figure 7. Picture Set 4 Of Sampling Location -- Ashland -- Sampling From Manhole Drain At Ocean Front



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ASHLAND AVENUE

Picture Set 4 - Ashland

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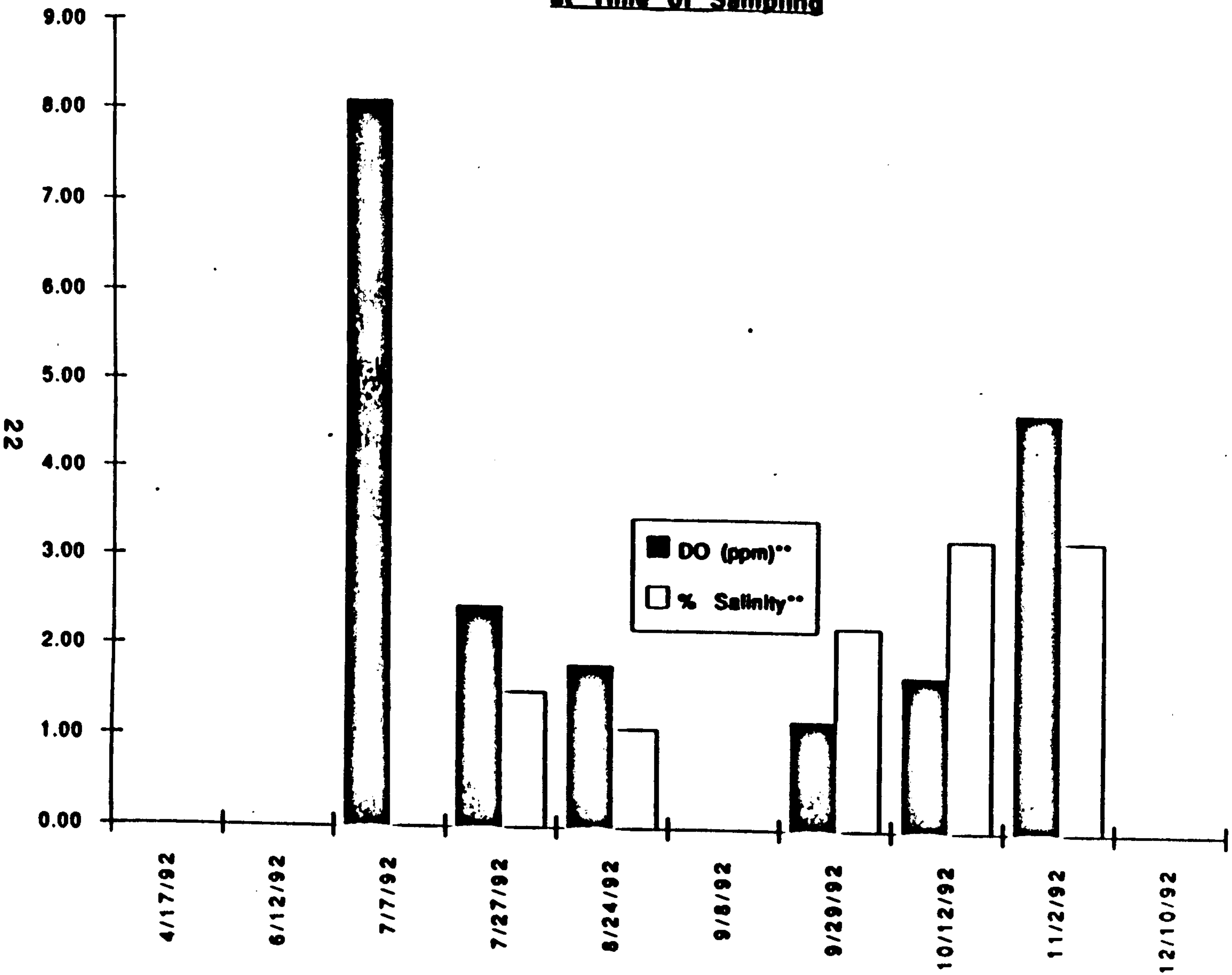
Picture Set 5- Ashland

Figure 8. Picture Set 5 Of Sampling Location -- Ashland -- Drain At Ocean Front

Figure 9

Ashland Avenue - Percent Salinity and Dissolved Concentration at Time of Sampling



are very high also indicate a stagnant water that is slowly accumulating chemicals.

Sepulveda Channel at the point just before the junction of Sepulveda Channel and Ballona Creek (See Figure 1 and Figure 10, Picture Set 6). The sampling location is behind the Mar Vista Gardens Apartments. Often the channel contained abandoned shopping carts, furniture, discarded toys and shoes, etc. Water levels were consistently low but always sufficient for sampling. Figure 11 shows the 35 foot cross-section of the Sepulveda Channel has a depth of 1.5 - 4 inches (average depth 2.5 inches) during low flow. Figure 12 shows the average flow rate varied between 0.56 - 2.14 ft^3/sec. at the Sepulveda Channel Site during the time of each sampling. Since the sampling location is difficult to reach, sampling equipment was lowered down by ropes to a person who was wading in the channel for samples collection.

Appendix I shows the background water data collected at Sepulveda. Figure 5 shows the conductivity is 4,00 to 6,000 umhos/cm at Sepulveda over the time of sampling. This indicates input of inorganic ions to this drain is not significant. The DOC values for the Sepulveda drain are low (< 10 mg/l) except for the November and December samples which are < 65 to 70 mg/l.

Ballona Creek at the point just below the junction of Sepulveda Channel and Ballona Creek (See Figure 1 and Figures 13 & 14, Picture Sets 7 & 8). Figure 11 shows that Ballona Creek cross-section is 35 feet wide with a depth of 1 -12 inches (average depth 5 inches). The typical low flow conditions are shown on Figure 12 (0.33 - 3.10 ft^3/sec.). Figure 13, (Picture Set 7) shows that during the early sampling dates, myriad styrofoam cups lined the channel as well as cigarette butts and other trash including occasional syringes. Later in the summer, altruistic environmentalists cleaned the trash periodically eliminating most of the visible urban contamination. This sampling area is easily accessible and unfortunately serves as a playground for children. A bike path also runs the length of the north side of the channel. Figure 14, (Picture Set 8) indicates where the settleable solids occur at this sampling site.

Appendix I shows the background water data collected at Ballona. Figure 5 shows the conductivity is low < 2,000 umhos/cm at Ballona over the time of

SEPULVEDA CHANNEL

Picture Set 6 - Sepulveda

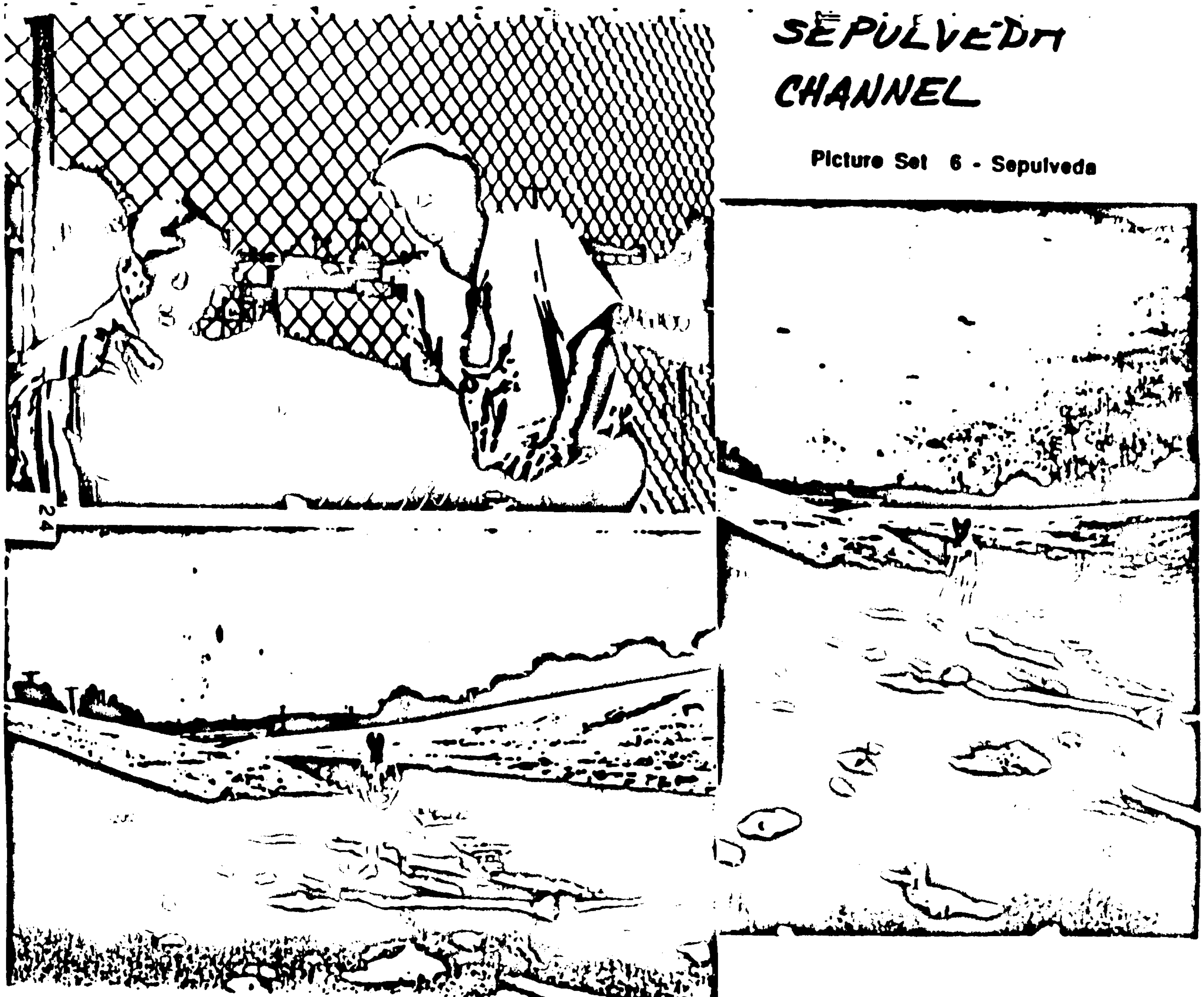


Figure 10. Picture Set 6 Of Sampling Location -- Sepulveda

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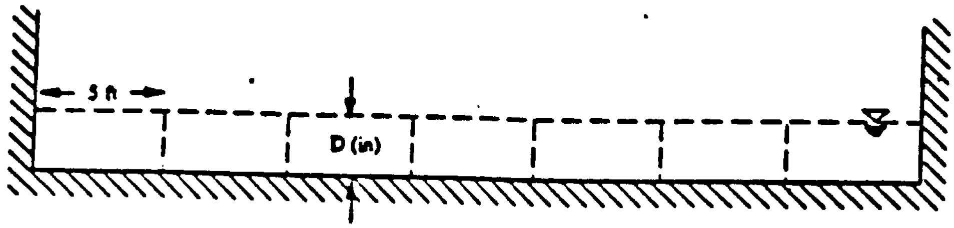
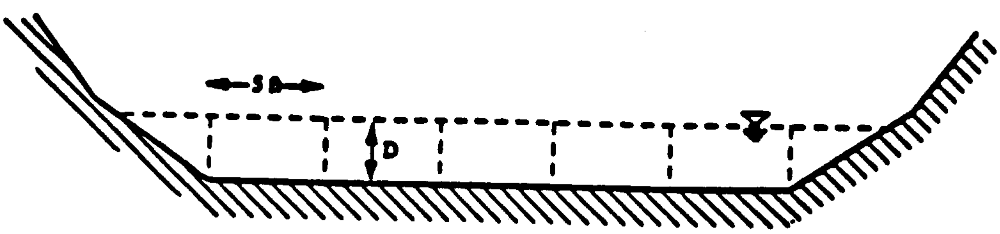
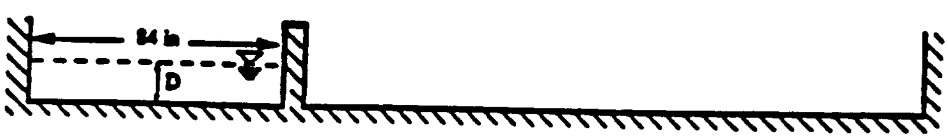


Cross-section of Sepulveda Channel



Cross-section of Ballona Creek



Cross-section of Centinela Creek

Figure 11

Cross-Section Areas of the Three Storm Drains at the Sample Locations

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Figure 12

Average Flow Rate of the Three Sampling Points in the Storm Drains at Time of Sampling

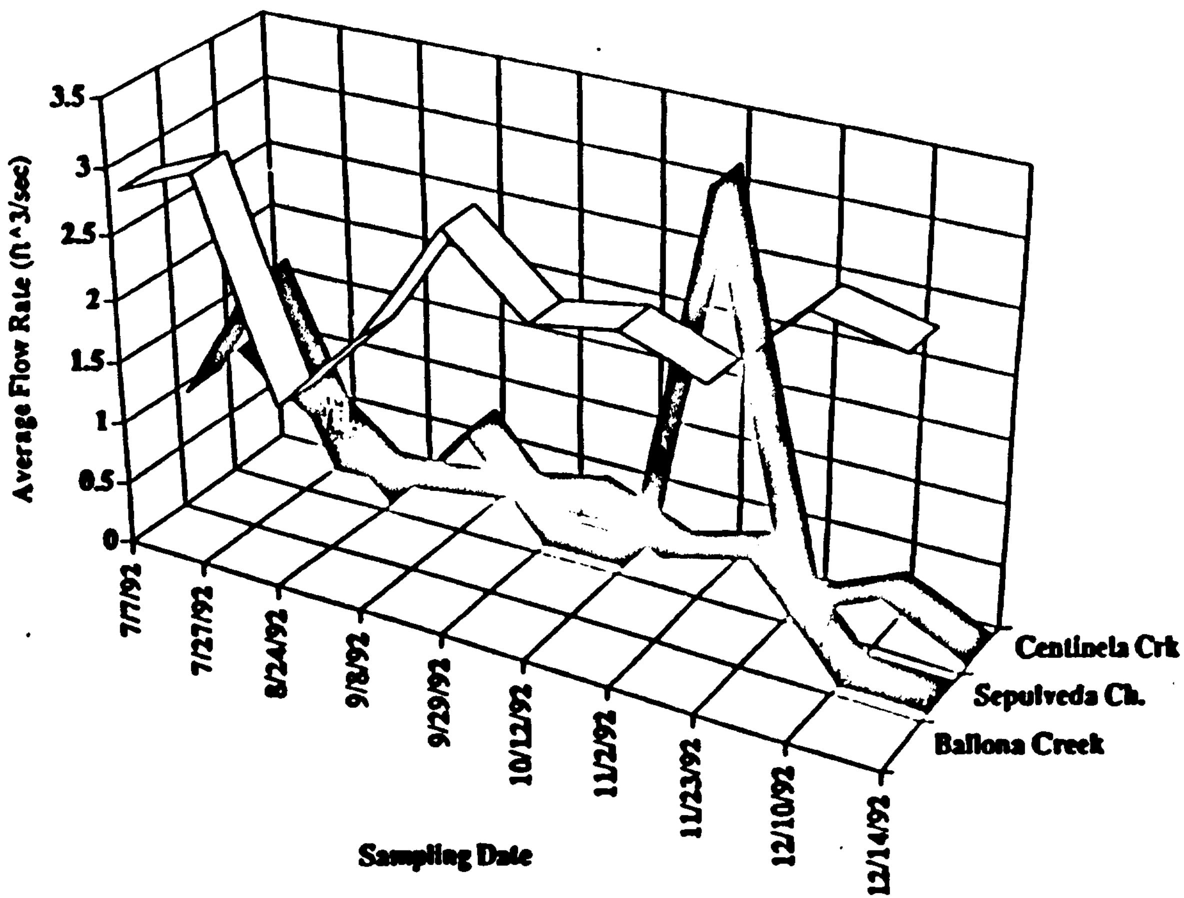

Figure 13. Picture Set 7 Of Sampling Location -- Ballona I

Picture Set 7 - Ballona

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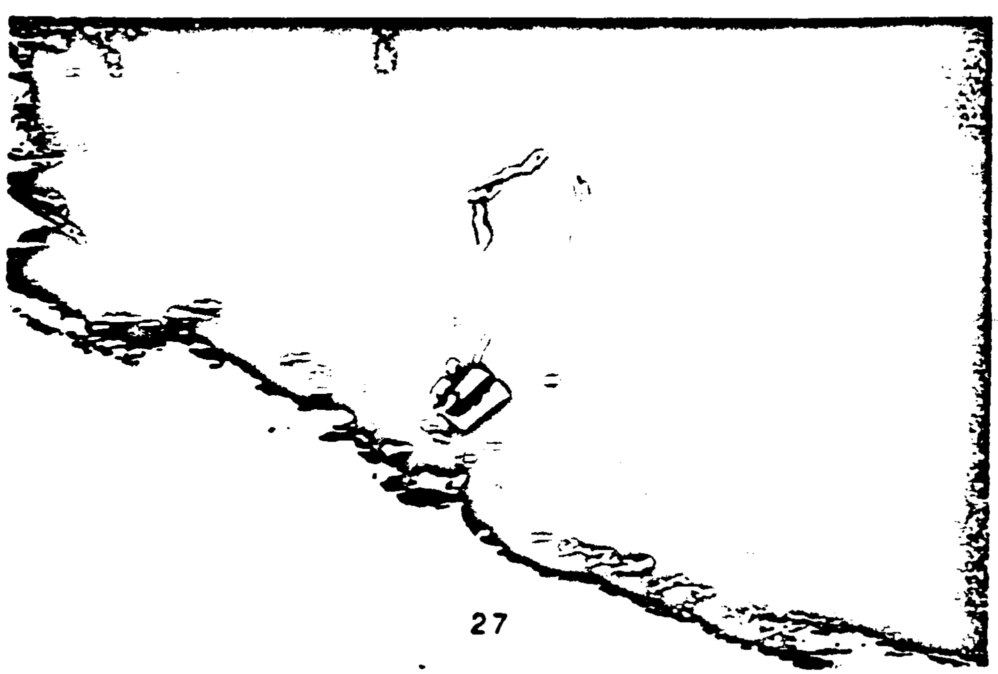
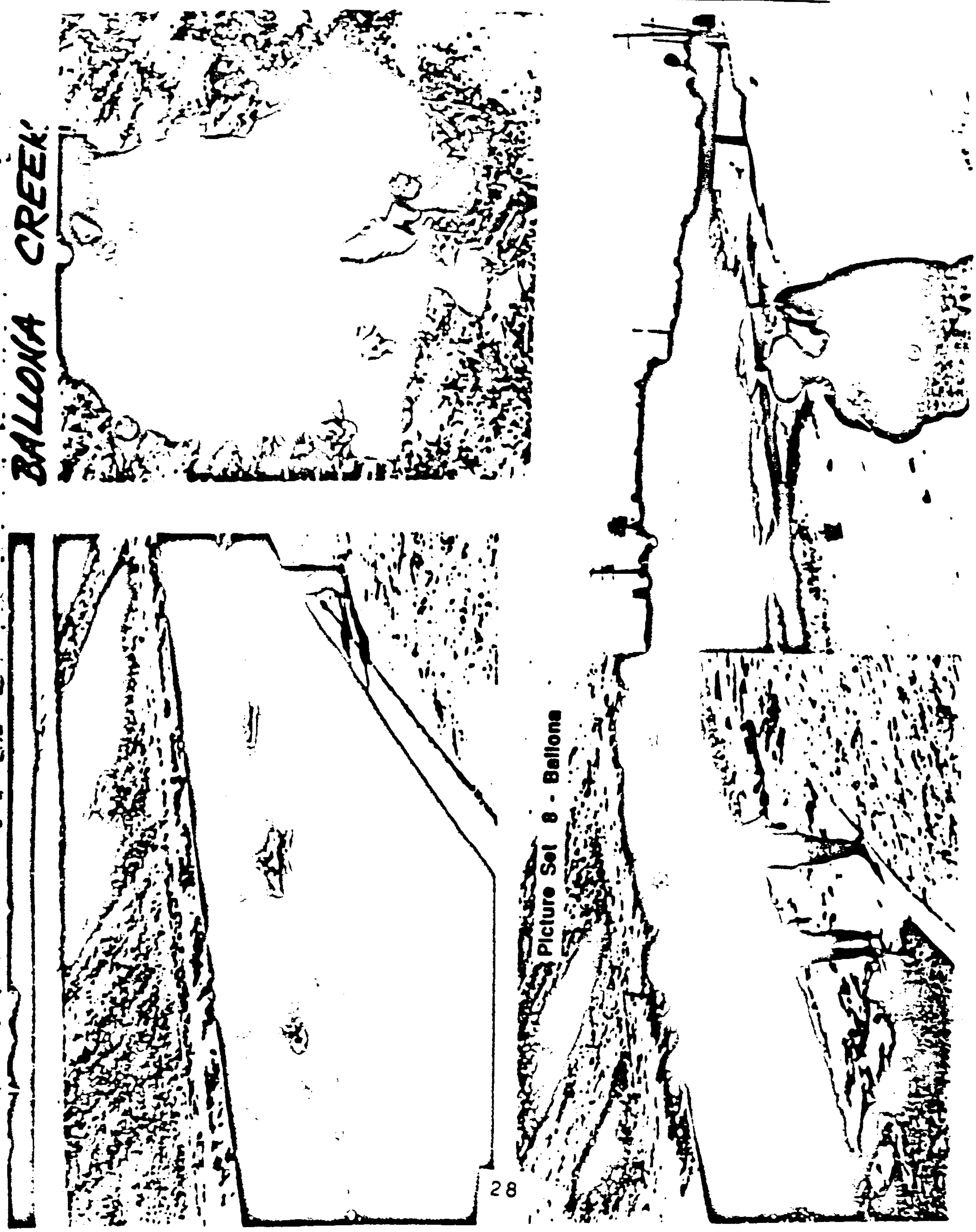


Figure 14. Picture Set 8 Of Sampling Location -- Ballona II



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sampling. The DOC values for the Ballona drain indicate that they are <12 mg/l except for two samplings times in November and December. The DOC values are 30 to 95 mg/l indicating a buildup of organic material during the spring term.

Centinela Creek at the Inglewood Avenue Bridge. This drain sampling site is in the drain itself, inaccessible to the public. A ladder was used with ropes as safety precautions to lower down the person who samples. Figure 11 shows that this is a narrow 7 foot storm channel of 1.75 to 5.34 inch average depth under typical low flow conditions shown on Figure S5 (0.33 - 3.10 ft^3/sec.). Sampling equipment was lowered down by ropes for sample collection.

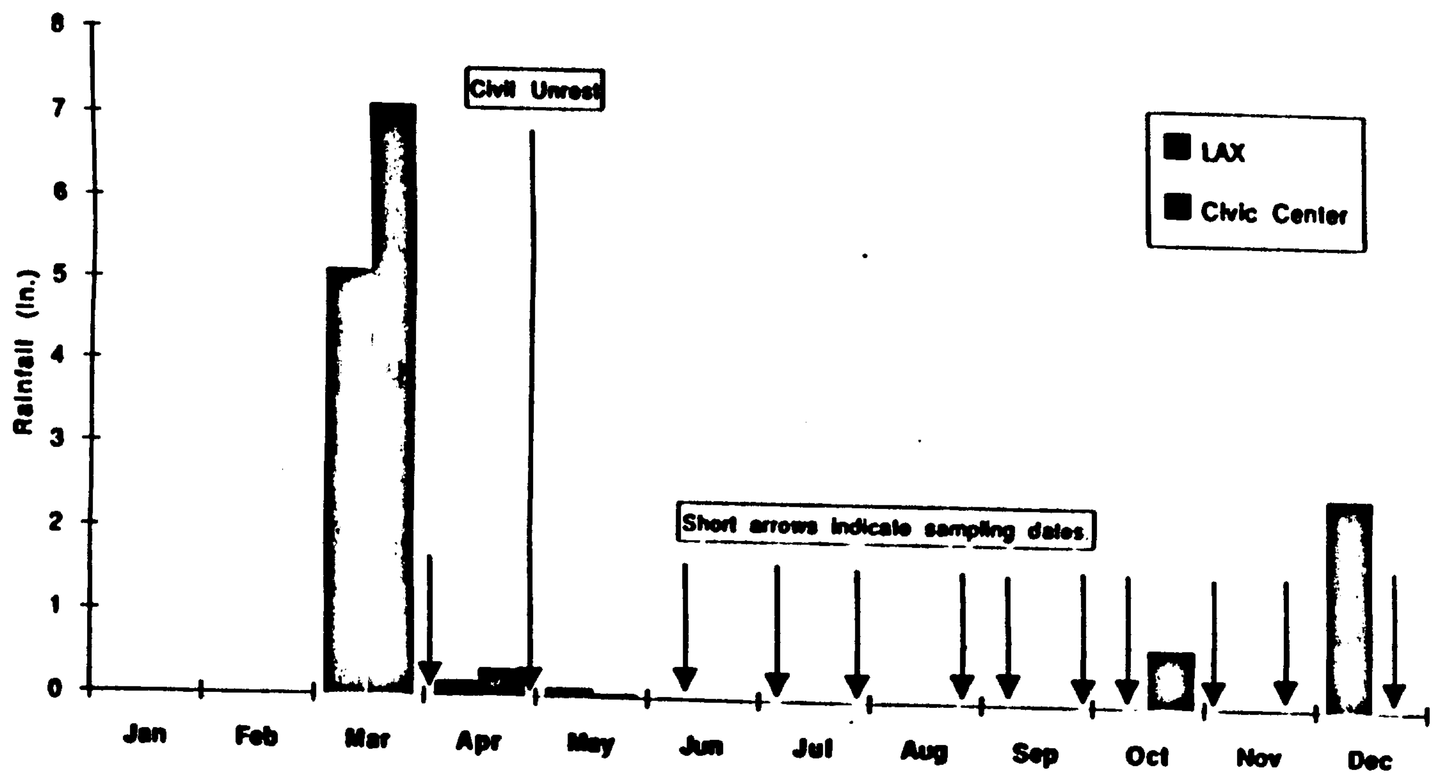
Appendix I shows the background water data collected at Centinela. Figure 5 shows the conductivity is low < 2,000 umhos/cm at Centinela. The DOC values for the Centinela drain indicate that they are <20 mg/l except for two samplings times in November and December. The DOC values are 65 to 70 mg/l indicating a buildup of organic material during the spring term.

Rainfall

Figure 15 presents the rainfall data that are applicable to the dates that the storm drains were sampled. Most of the rain for the year fell during March, one month before the first sample was taken. The sampling dates largely represent dry weather conditions. The "civil unrest" in Los Angeles occured April 29 to May 3 after the bulk of the rain. The significance of this is that the water from the fire fighting entered the storm drains and would have generated an unusual abundance of chemical pollutants which would appear in the samples. Therefore, the sampling was suspended until June 12 to assure that the drains had cleared the debris from the civil unrest. The sampling period between June 12 and October 12 was under dry weather flow. The November 2 sample was after a 0.5 inches of rain in late October and the sample on December 10 was after 2 inches of rain in early December.

Figure 15

1992 Total Rainfall (LAX and Civic Center)



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EXPERIMENTAL

Field Sampling Techniques

Water samples were collected by holding a bucket pointed downstream in front and upstream from the person sampling. This bucket was used to "scoop" water and to fill a second bucket which would be transferred to a second person for bottling. The buckets of water would either be handed directly to another person or else lifted by rope to a person above the storm channel in the case of Sepulveda and Centinela. Picture set 6 shows the sampling method at Sepulveda.

Manholes were sampled by lowering buckets by rope down into the hole. The sampling bucket has a handle at the side of the base as well as the usual handle at the top. A rope at the base is used to tip the bucket at an angle so that the bucket can be filled and then the rope on the top handle is used to lift the bucket out of the manhole (sites Pico/Kenter and Ashland). Figure 7, (Picture set 4) shows the sampling method at Ashland.

Sample Storage

1. Water: Samples were stored at 4°C (usually less than two weeks) then filtered and extracted. A large walk-in refrigerator was used to store the water exclusively. Only water samples were kept in the refrigerator and no methylene chloride or other solvents were present in the refrigerator.

2. Suspended Sediments: After filtration, the filters containing the sediments were placed individually in glass jars with teflon-lined screw-cap lids. Analysis was completed after filtration by supercritical fluid extraction.

3. Purge and Trap Samples - Volatiles: Purge and Trap samples were either taken immediately to Dr. Ed Ruth's lab in the Institute of Geophysics and Planetary Science the day of sampling or the next day. When stored at our lab in the School of Public Health, they were stored in the same refrigerator as the water samples to be extracted.

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4. Liquid-Liquid Extracts and Suspended Solid Extracts: Samples were stored in 2 ml screw-cap vials, some with septa and others without septa but with a solid teflon-lined lid. Teflon tape was wrapped around the lids. Sample extracts were stored in a small laboratory refrigerator and then stored in a similar refrigerator at Dr. Ed Ruth's lab until analysis.

Field and Laboratory Sampling Parameters

Table 1 shows the field and laboratory sampling parameters. The sample volume, sample container and processing and storage information is presented on the table. Table 2 shows the laboratory analysis parameters.

Purgeable Volatile Organics Analysis

Volatile organics with low water solubility were analyzed by purge and trap capillary gas chromatography/mass spectrometry (GC/MS) following EPA 524/624° methodology. The method was modified slightly by including additional target analytes from the EPA Method 624 and hazardous substance lists as shown in Table 3 and utilizing capillary GC. While in the custody of the GC/MS facility, samples were stored refrigerated at 4°C in a room free of organic vapors adjoining the laboratory. Standards were stored in a separate freezer.

The following procedure was used to introduce the sample on the purge and trap device (Tekmar 4000). The plungers were removed from 5 ml and 25 ml syringes. The sample was removed from the refrigerator, the cap was removed, and 10-15 ml was poured into the 25 ml syringe. The syringe plunger was replaced, the syringe was inverted and the remaining air was displaced. A 25 mm 0.45 µm nylon acrodisc (Gelman) filter was fitted onto the syringe and the sample filtered into the 5 ml syringe, the syringe plunger was replaced, the syringe was inverted and the volume was adjusted to 5 ml. Five µl of fortification solution (one internal and two surrogate standards at 5 µg/ml each) was added to the sample through the luerlock opening. A second syringe was filled in an identical manner from the same sample bottle and reserved for reanalysis, if necessary. Initially, 25 ml aliquots of samples were used. However, because of severe foaming on one of the first four samples analyzed, 5 ml aliquots were used for all subsequent samples.

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Table 1

Field and Sampling Parameters

Parameter	Sample Volume	Sample Containers	Processing & Storage
Field			
Temperature	25 ml	plastic, glass	determine on site, record to the nearest 0.1°C
pH	25 ml	plastic, glass	determine on site, record to the nearest 0.1°C
Conductivity	100 ml	plastic, glass	determine on site, record to the nearest 0.1 mmho
DO (Probe)	300 ml	glass only	determine on site, record to the nearest 0.1 mg/L DO
Flow Rate	—	—	determine on site, record as L/S
Velocity	—	—	determine on site, record as M/S
Laboratory			
Total suspended solids (TSS)	100-1000 ml	glass only	refrigerate at 4°C (analyzed within 7 days)
Volatile suspended solids (VSS)	100-1000 ml	glass only	refrigerate at 4°C (analyzed within 7 days)
Dissolved organic carbon (DOC)	10 ml	Amber glass bottle with TFE-lined cap	refrigerate at 4°C (analyzed within 3 days)
Turbidity	100 ml	plastic, glass	refrigerate at 4°C (analyzed within 7 days)
Alkalinity	100 ml	plastic, glass	refrigerate at 4°C (analyzed within 4 days)
Hardness	100 ml	plastic, glass	refrigerate at 4°C (analyzed within 7 days)
Ammonia (NH_3-N)	100 ml	plastic, glass	refrigerate at 4°C (analyzed within 24 hours)
Ultraviolet absorption	100 ml	glass only	refrigerate at 4°C (analyzed within 3 days)

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Table 1

Field and Laboratory Sampling Parameters - Continued

Parameter	Sample Volume	Sample Containers	Processing & Storage
Laboratory - continued			
Base-Neutral Organics in aqueous filtrate, EPA Method 608/625* (Liquid-Liquid Extraction with Capillary GC/MS)@	2 - 8 liters	Amber solvent bottle (filled to the top; no air bubble; no head space)	store in the dark; refrigerate at 4°C (extract within 7 days, analyze within 40 days)
Total Extractable Organics (Volatile Organics) EPA Method 524/624* (Purge and Trap with Capillary GC/MS)	20 - 50 ml	Amber solvent bottle (filled to the top; no air bubble; no head space)	store in the dark; refrigerate at 4°C (analyze within 7 days)
Suspended Solids collected on filters and Supercritical Fluid Extraction of filters with Capillary GC/MS	2-8 liters	Water sample -amber solvent bottle (filled to the top; no air bubble; no head space)	refrigerate at 4°C for 7 days maximum (extract within 7 days, analyze within 40 days)

@ This method also isolates Chlorinated Hydrocarbon Pesticides and PCBs which are analyzed by Dual Column Capillary GC with an Electron Capture Detector

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Table 2
Laboratory Analysis Parameters

Parameter	Matrix	Units	Modified Methods (1)	Maximum Holding Time	Preservation
Total suspended solids (TSS)	water	mg/L	2540.D	7 days	refrigerate at 4°C
Volatile suspended solids (VSS)	water	mg/L	2540.D	7 days	refrigerate at 4°C
Dissolved organic carbon (DOC)	water	mgC/L	5310.B	3 days	refrigerate at 4°C
Turbidity	water	NTU	2130.B	7 days	refrigerate at 4°C
Alkalinity	water	mg $CaCO_3$/L	2320.B	14 days	refrigerate at 4°C
Hardness	water	mg $CaCO_3$/L	2340.C	7 days	refrigerate at 4°C
Ammonia (NH_3-N)	water	mg NH_3-N/L	4500-NH_3.F	24 hours	refrigerate at 4°C
Ultraviolet absorption	water	Absorbance	—	3 days	refrigerate at 4°C
Base-Neutral Organics	water	ng/L	6440B (2) (Liquid-Liquid Extraction isolation and EPA 608/625* Analysis)	7 days before extraction 40 days after extraction	refrigerate at 4°C protect from light
Base-Neutral Organic Compounds	Solids on 0.45u filter from filtered water sample	ng/g	Super-critical Fluid Extraction Method (3) and EPA 608/625* Analysis)	7 days before extraction 40 days after extraction	refrigerate at 4°C protect from light
Volatile Organics Compounds (VOCs)	water	ug/L	EPA 524/624* (purge and trap analysis)	7 days before extraction	refrigerate at 4°C protect from light

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Table 2

Laboratory Analysis Parameters -Continued

Parameter	Matrix	Units	Modified Methods (1)	Maximum Holding Time	Preservation
Suspended Solids by 0.45u Filtration	Solids on 0.45u filter from filter-ed water sample	ng/g	2540.D	7 days	refrigerate at 4°C protect from light
Base-Neutral Organic Compounds	Solids on 0.45u filter from filtered water sample	ng/g	(3)	7 days	refrigerate at 4°C protect from light
Dissolved Organic Carbon	water	mg/L	EPA 9060	7 days	refrigerate at 4°C protect from light

(1) Modified Standard Methods of Water and Wastewater Research; see attached One-Step™ extractor/concentrator - Fowler, H., "Applications of a "One-step" Extractor/concentrator in Environmental Testing", American Laboratory, 39, 1991.

(2) Standard Methods for the Examination of Water and Wastewater 17th Edition, 1990.

(3) Isolation Method under development from Pipkin, W. "Fundamental Considerations for Supercritical Fluid Extraction Method Development (Analytical Finish by EPA Method 625) LC-GC, Vol. 10, No. 1, 1992.

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Table 3

MDLs AND STANDARDS FOR DRINKING WATER AND THE CALIFORNIA OCEAN PLAN

TARGET VOLATILE ORGANIC COMPOUNDS BY THE UPGRADED EPA METHOD 524/624*

CHEMICAL NAME:	Water MDL (ng/L)	DRINKING WATER MCLs ug/l(a)	CALIFORNIA OCEAN PLAN: HUMAN HEALTH CARCINOGEN ng/l	CALIFORNIA OCEAN PLAN: HUMAN HEALTH NON-CARCINOGEN ng/l	CALIFORNIA OCEAN PLAN: MARINE AQUATIC LIFE ng/l
Dichlorodifluoromethane	180				
Chloromethane	140				
Vinyl Chloride	230	2	36,000		
Bromomethane	640				
1,1-Dichloroethene	140	7		7,100,000	
Chloroethane	210				
1,1-Dichloroethane	170				
Carbon Disulfide	110				
Methylene Chloride	70	5	4,500		
Trans-1,2-Dichloroethene	120	100			
1,1-Dichloropropane	?				
2,2-Dichloropropane	190				
Cis-1,2-Dichloroethene	270	70			
2-Butanone	?				
Bromochloromethane	160				
Chloroform	110	100 THMs	130,000		
1,1,1-Trichloroethane	60	200		540,000,000	
Carbon Tetrachloride	70	5	900		
Benzene	40	5	5,900		
1,2-Dichloroethane	40	5	130,000		
Trichloroethene	40	5	27,000		
Dibromomethane	30				
Bromodichloromethane	60	100 THMs	130,000		
1,2-Dichloropropane	40	5			
Cis-1,3-Dichloropropene	50				
4-Methyl-2-Pentanone	120				
Toluene	50	1000		85,000,000	
Trans-1,3-Dichloropropene	50		8.90		
1,1,2-Trichloroethane	60	5			
Tetrachloroethene	50	5	99,000	43,000,000	
2-Hexanone	90				
1,3-Dichloropropane	40				
Dibromochloromethane	90	100 THMs	130,000		

Table 3

MDLs AND STANDARDS FOR DRINKING WATER AND THE CALIFORNIA OCEAN PLAN

TARGET VOLATILE ORGANIC COMPOUNDS BY THE UPGRADED EPA METHOD 524/624*

			CALIFORNIA OCEAN PLAN		
			HUMAN HEALTH		
CHEMICAL NAME:	Water MDL (ng/L)	DRINKING WATER MCLs ug/l(a)	CARCINOGEN ng/l	NON-CARCINOGEN ng/l	MARINE AQUATIC LIFE ng/l
1,2-Dibromoethane	40				
Chlorobenzene	40	100		570,000	
1,1,1,2-Tetrachloroethane	50				
Ethyl Benzene	50	700		4,100,000	
(m+p)-Xylene	100	10,000 (Total			
o-Xylene	40	Xylenes)			
Styrene	40	100			
Bromoform	60	100 THMs	130,000		
Isopropylbenzene	50				
Bromobenzene	40				
1,1,2,2-Tetrachloroethane	40			1,200,000	
1,2,3-Trichloropropane	50				
n-Propylbenzene	50				
1,3,5-Trimethylbenzene	50				
2-Chlorotoluene	40				
4-Chlorotoluene	40				
Tert-Butylbenzene	60				
1,2,4-Trimethylbenzene	40				
p-Isopropyltoluene	60				
1,4-Dichlorobenzene	40	75	18,000		
n-Butylbenzene	60				
1,2-Dibromo-3-Chloropropane	70				
Hexachlorobutadiene	90	14000			
Napthalene	250				
1,2,3-Trichlorobenzene	60				
Trichlorofluoromethane	120				
1,1-Dichloropropene	60				
Isopropylbenzene	?				
Sec-Butylbenzene	60				
1,3-Dichlorobenzene	40			5100000(c)	
1,2-Dichlorobenzene	40	600		5100000(c)	
1,2,4-Trichlorobenzene	60	70			

Table 3 CONT.

* The EPA Method 524/624 was upgraded by use of a capillary GC Column and more analytes were added to the quantification list.

(a) USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b) California Ocean Plan, 1990. State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and Effective March 22, 1990. The lowest value is reported. All standards are 30 day average values.

(c) Sum of 1,2 and 1,3 dichlorobenzenes

The syringe was attached to the syringe valve on the purging device and the sample was injected into the sparger. The valve was closed and the sample was purged with helium at a rate of 40 ml/min for 11 minutes at ambient temperature. The trap (Supelco, Carbopack/Carbosieve) was then dry purged for 11 minutes at 4 ml/min to remove water. At the completion of the purge cycle, the apparatus was switched to the desorb mode. The cryogenic interface, located at the beginning of the capillary column, was cooled to -150°C and the trap was rapidly heated to 220°C while it was back-flushed with helium at 4 ml/min for 4 minutes. At the end of the 4 minute desorption cycle, the cryogenic trap was ballistically heated for 11 seconds, the temperature program of the gas chromatograph (Finnigan 9610) started and mass spectrometer (Finnigan 4000) data acquisition was begun.

Data were acquired (Superincos Data System, Finnigan) and stored over the mass range m/z 35-300 with a total scan cycle time of one second. Five or more spectra were measured during the elution of each GC peak. The gas chromatograph used a 30 meter narrow bore (0.32 mm) DB-624 (J&W Scientific) fused silica capillary column. The helium carrier gas flow rate was 40 cm/sec. The initial column temperature was 10°C and held for 5 minutes from the beginning of vaporization from the cryogenic trap, programmed at 6°C/min to 70°C, then heated to 200°C at 15°C/min and held at that temperature for 2 minutes. After desorbing the sample, the trap was reconditioned by returning it to the purge mode and heating it to 260°C for 10 minutes. The heater was turned off, the gas flow stopped, and the trap allowed to cool. The sparging vessel was rinsed two times with 25 ml volumes of reagent water (4 canister Milli-Q unit, Millpore Corp.) between each sample.

Compounds eluting from the gas chromatographic column were identified by comparing their measured mass spectra and retention times to reference spectra and retention times in a data base compiled by the user from the measurement of authentic standard compounds under the same conditions used for samples. Calibration standards were measured at six concentration levels (0.5, 2, 4, 6, 8 and 10 µg/l) and response factors calculated for each compound quantitation ion using linear regression analysis. The concentration of each identified compound was measured by relating the mass spectral response of the quantitation ion produced by that compound to the mass spectral response of the quantitation ion produced by a compound that was used as an internal standard. Calculation of the target analyte concentrations was made by the Autoquan Software package (Finnigan Corporation) using a linear fit of the three

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closest points in the multi-point response list for each analyte from the plot of area of unknown/area of standard versus amount of standard. For a compound to be quantitated, its spectra must match the library spectra by exceeding the fit threshold value of 900 out of 1000 and it must occur within the specified 10 second retention time window. Surrogate analytes, whose concentrations were known, were measured with the same internal standard calibration procedure.

Table 3 shows the Method detection limits (MDLs) were compound dependent and varied from 0.03-0.64 µg/l (ppb). The MDLs were determined based on the seventeenth edition of Standard Methods of Water and Waste Water (American Public Health Association, 1990). Analytes that were inefficiently purged from water could not be detected at low concentrations, but could be measured when present in sufficient amounts. Coeluting compounds with very similar mass spectra, typically structural isomers, were reported as a group. Trihalomethane concentrations were calculated individually.

Table 3 compares the MDLs with the US EPA Drinking Water Standards and the California Ocean Plan Standards for human health carcinogens and non-carcinogens as well as for marine aquatic life. The MDL values for the Drinking Water Standards are less than the California Ocean Plan Standards.

Analysis of Suspended Sediment and Filtered Water Extracts

Extractable organics were analyzed by capillary gas chromatography/mass spectrometry (GC/MS) following EPA 525/625* methodology as modified in USEPA Contract Laboratory Program (CLP) August 1991 Statement of Work. Organic compounds analyzed by this procedure are listed in Table 4. Table 4 shows the Method detection limits (MDLs) were compound dependent and varied. Analytes that were inefficiently extracted from water or suspended sediment could not be detected at low concentrations, but could be measured when present in sufficient amounts. Coeluting compounds with very similar mass spectra, typically structural isomers, were reported as a group.

Aliquots of 250 µl for filtered water extracts and 500 µl for suspended solids extracts were used for GC/MS analysis. All extracts were in methylene chloride and delivered in 1.5 ml glass vials. While in the custody of the GC/MS facility, sample

Table 4

MDLs AND STANDARDS FOR DRINKING WATER AND THE CALIFORNIA OCEAN PLAN

- TARGET BASE NEUTRAL COMPOUNDS BY THE UPGRADED EPA METHOD 608/625*

				CALIFORNIA OCEAN PLAN		
				HUMAN HEALTH		
CHEMICAL NAME:	Water MDL (ng/L)	S.S. MDL (ng/g)	DRINKING WATER MCLs ug/l(a)	CARCINOGEN ng/l	NON-CARCINOGEN ng/l	MARINE AQUATIC LIFE
Phenol	1510	1.51				f
2-Chlorophenol						e
2-Methylphenol	443	0.443				f
4-Methylphenol	491	0.491				f
2-Nitrophenol	639	0.639				f
2,4-Dimethylphenol	404	0.404				f
2,4-Dichlorophenol	608	0.608				e
Benzoic Acid	4000	4				
4-Chloro-3-methylphenol	548	0.548				e
2,4,6-Trichlorophenol	579	0.579		290		e
2,4,5-Trichlorophenol	2100	2.1				e
2,4-Dinitrophenol	4100	4.1			4,000	f
4-Nitrophenol	6200	6.2				f
2-Methyl-4,6-dinitrophenol	2700	2.7			220,000	f
Pentachlorophenol	3100	3.1				e
N-Nitrosodimethylamine	828	0.828				
Aniline	2100	2.1				
Bis(2-chloroethyl) ether	345	0.345		45		
1,3-Dichlorobenzene	422	0.422			5,100,000(c)	
1,4-Dichlorobenzene	84	0.084	75	18,000		
1,2-Dichlorobenzene	80	0.08	600		5,100,000(c)	
Benzyl alcohol	808	0.808				
Bis(2-chloroisopropyl) ether	83	0.083			1,200,000	
Hexachloroethane	167	0.167		2,500		
N-Nitrosodi-n-propylamine	329	0.329				
Nitrobenzene	666	0.666			4,900	
Isophorone	123	0.123			150,000,000	
Bis(2-chloroethoxy)methane	328	0.328			4,400	
1,2,4-Trichlorobenzene			70			
Naphthalene	68	0.068				
4-Chloroaniline	1270	1.27				
Hexachlorobutadiene	791	0.791				
2-Methylnaphthalene	125	0.125				

Table 4 CONT.

CHEMICAL NAME:	Water MDL (ng/L)	S.S. MDL (ng/g)	DRINKING WATER MCLs ug/l(a)	CALIFORNIA OCEAN PLAN HUMAN HEALTH CARCINOGEN ng/l	NON-CARCINOGEN ng/l	MARINE AQUATIC LIFE
Hexachlorocyclopentadiene	2430	2.43	50		58,000	
2-Chloronaphthalene	126	0.126				
2-Nitroaniline	1240	1.24				
Acenaphthylene	56	0.056		8.8(d)		
Dimethyl phthalate	64	0.064			820,000,000	
2,6-Dinitrotoluene	1170	1.17				
3-Nitroaniline	943	0.943				
Acenaphthene	64	0.064				
Dibenzofuran	57	0.057				
2,4-Dinitrotoluene	1160	1.16		2,600		
Fluorene	62	0.062		8.8(d)		
Diethyl phthalate	60	0.06			33,000,000	
4-Chlorophenyl phenyl ether	346	0.346				
4-Nitroaniline	1320	1.32				
N-Nitrosodiphenylamine	206	0.206		2,500		
Azobenzene	63	0.063				
4-Bromophenyl phenyl ether	619	0.619				
Hexachlorobenzene	602	0.602	1			
Phenanthrene	64	0.064		8.8(d)		
Anthracene	70	0.07		8.8(d)		
Di-n-butyl phthalate	60	0.06			3,500,000	
Fluoranthene	61	0.061			15,000	
Benzidine	51400	51.4		0.069		
Pyrene	69	0.069		8.8(d)		
Butyl benzyl phthalate	300	0.3				
Benz(a)anthracene	62	0.062				
3,3'-Dichlorobenzidine	1340	1.34		8.10		
Chrysene	68	0.068		8.8(d)		
Bis(2-ethylhexyl) phthalate	48	0.048	6	3,500		
Di-n-octyl phthalate	64	0.064				
Benzo(b)fluoranthene	137	0.137				
Benzo(k)fluoranthene	145	0.145		8.8(d)		
Benzo(a)pyrene	73	0.073	0.2	8.8(d)		
Indeno(1,2,3,4-c,d)pyrene	374	0.374		8.8(d)		
Dibenzo(a,h)anthracene	395	0.395		8.8(d)		
Benzo(g,h,i)perylene	370	0.37				
Carbazole						

Table 4 CONT.

* The EPA Method 608/625 was upgraded by use of a capillary GC Column and more analytes were added to the quantification list.

(a) USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b) California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and Effective March 22, 1990. The lowest value is reported. All standards are 30 day average values.

(c) Sum of 1,2 and 1,3 dichlorobenzenes

(d) Sum of Polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2-benzanthracene and 3,4-benzflouranthene = < 8.8 ng/l)

(e) Phenolic compounds, chlorinated- 6 month median =1 ug/l; daily maximum = 4 ug/l; instantaneous maximum = 10 ug/l.

(f) Phenolic compounds, nonchlorinated- 6 month median = 30 ug/l; daily maximum = 120 ug/l; instantaneous maximum = 300 ug/l.

extracts were protected from light and stored in a refrigerator at 4°C away from potential contaminants in a room adjacent to the laboratory. Standards were stored in a separate refrigerator. Just prior to analysis the extract was allowed to warm to room temperature and the appropriate volume of internal standard mixture at 200 μg/ml added to the vial. Five μl was used in the 250 μl extract and 10 μl was used for the 500 μl extract to give a final concentration in the vial of 40 ng/μl. Using a 10 μl syringe, 1-1.2 μl of extract was injected splitless on the Finnigan 9610 gas chromatograph (GC) initiating the GC temperature program and the data acquisition on the Finnigan 4000 mass spectrometer (MS).

Data were acquired (Superincos Data System, Finnigan) and stored over the mass range m/z 35-500 with a total scan cycle time of one second. Five or more spectra were measured during the elution of each GC peak. The gas chromatograph used a 30 meter narrow bore (0.25 mm) DB-5MS (J&W Scientific) fused silica capillary column. The helium carrier gas flow rate was 40 cm/sec. The initial column temperature was 30°C and held for 4 minutes, programmed at 6°C/min to 300°C, and held at that temperature for 30 minutes.

Compounds eluting from the GC column were identified by comparing their measured mass spectra and retention times to reference spectra and retention times to reference spectra and retention times in a data base compiled by the user from the measurement of authentic standard compounds under the same conditions used for samples. Calibration standards were measured at five concentration levels (5, 10, 20, 50 and 80 ng/μl) and response factors calculated for each compound quantitation ion using linear regression analysis. The concentration of each identified compound was measured by relating the MS response of the quantitation ion produced by that compound to the MS response of the quantitation ion produced by a compound that was used as an internal standard. Calculation of the target analyte concentrations was made by the Autoquan Software package (Finnigan Corp.) using a linear fit of the three closest points in the multi-point response list for each analyte from the plot of area of unknown/area of standard versus amount of standard. For a compound to be quantitated, its spectra must match the library spectra by exceeding the fit threshold value of 900 out of 1000 and it must occur within the specified 10 second retention time window. Surrogate analytes, whose concentrations were known, were measured with the same internal standard calibration procedure.

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Table 4 compares the MDLs of water and suspended sediments with the US EPA Drinking Water Standards and the California Ocean Plan Standards for human health carcinogens and non-carcinogens as well as for marine aquatic life. The MDL values for water plus suspended sediments or total concentration of a chemical in the sample are about the same order of magnitude as the Drinking Water Standards and the California Ocean Plan Standards when 3-8 liters of water and the associated suspended sediments are extracted as were completed in the study. All quantitative calculations for the total concentration of chemical present in the water and suspended sediment phases were adjusted to a one liter water sample basis to enable a direct comparison to Drinking Water Standards and the California Ocean Plan Standards. All tables of results for base-neutal compounds are presented to directly compare the Drinking Water Standards and the California Ocean Plan Standards with the concentration of the chemical in a water sample of one liter with its associated suspended sediments.

Non-Target Compound Identification

Many of the compounds elucidated by GC/MS are not on either the volatile or semi-volatile target analyte list. These non-target analytes are tentatively identified using several techniques such as a) matching the unknown spectra to spectra in the 40,000 compound EPA/NIH Mass Spectral Data Base and b) interpretation of mass spectra by the mass spectroscopist and finally confirmation by coinjection of authentic compound standards. Determining chromatographic peaks on which identifications will be attempted can either be selected manually by the operator or be selected by using a modified Biller-Biemann type peak detection algorithm to search for compounds. The algorithm assumes that a compound is present whenever it finds the elution of more than three simultaneous masses which maximize within a single scan. Scans that are flagged as peaks are then searched against the EPA/NIH Mass Spectral Data Base and if the fit threshold is greather than 850 out of 1000, the spectra and tentative identification are presented to the spectroscopist for evaluation. All identifications are tentative until authentic compounds have been analyzed or coinjected under the same analytical conditions as the unknown.

Sample Preparation Techniques

Purge and Trap Analysis for Volatiles- Analytical Finish by EPA 524/624* Equivalent

Initially some 15 and 25 ml samples were analyzed, however, foaming occurred in these samples. Ashland samples had the heaviest foaming problem. These analyses and the remaining analyses were completed with 5 ml samples. The Method Detection Limit (MDL) is based upon 5 ml samples. All samples are filtered before analysis. See Table E3a for the MDL's that were determined for this study. All samples initially run at 15 to 25 ml were repeated at 5 ml. The percent recovery of surrogate standards are completed by comparison to the internal standard flourobenzene at 5 ug/l. Table 5 shows the percent recovery of surrogate standards.

Liquid-Liquid Extraction Method for Isolation of Base Neutral Compounds from Aqueous Phase Samples; Analytical Finish by EPA Method 608/625* Equivalent

A Corning Pyrex One-Step Continuous Extractor/concentrator (Fowler,1991) was used for continuous extraction of the base-neutral organic compounds in the water phase. In choosing glassware, a major consideration was that the apparatus has no susceptible breaking points such as glass-to-tubing connections which are a recipe for disaster. The Corning one-step apparatus was tested against others for practical utility.

1. Water:methylene chloride ratio (vol./vol.): (1L : 450 ml)
2. Water bath temp.: 95 ^{o}C.
3. Final volume of extract: extract to 5-10ml in extractor, then evaporate to 0.5 ml in concentrator tube with Kontes tube heater
4. Duration of extraction: 10 hours
5. Volume of sample for each extraction apparatus: 1 liter
6. Volume of sample needed for extraction to identify base-neutral compounds: 3-8 liters

The liquid-liquid extraction of water from the storm drains was done using a modied version of the Fowler method. To each extractor body, 450 ml of methylene chloride was poured in followed by one liter of water sample. It was

Table 5

Percent Recoveries of Volatile Organic Compound Surrogate Standards For Selected Sample Dates

[(a)Bromoflourobenzene and (b)1,2-Dichlorobenzene-D4]

		Ashland	Ballona	Centinela	Pico/ Kenter	Sepulveda
7/27/92	a)	81.9	80.8	82.9	81.2	86.0
	b)	119.1	98.3	94.5	102.6	103.1
8/24/92	a)	80.2	95.1	78.7	87.2	80.0
	b)	96.9	102.2	90.8	108.7	105.0
12/10/92	a)	98.7	102.0	102.0	101.1	99.6
	b)	96.7	105.8	105.8	105.3	105.8

Mean of Table Values = 95.9 % with 11.0 % variation

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ascertained that as much as 450 ml of methylene chloride was needed to prevent crossover of water flowing from the extractor body to the side where the extracted sample is isolated since some solvent escapes from the system from evaporation in spite of the condensor.

To the water phase, 5 ul of base-neutral surrogate (1000 ppm) was added. After the two layers separated, the stopcock on the side-arm was opened and the methylene chloride allowed to move over to the side containing the concentrator tube. The concentrator tube was heated by water bath or heating block. (see below). During extraction, the methylene chloride extract refluxes gently with a condensation rate of 6 drops per minute. At this rate, the Snyder balls chatter gently leaving the sample in the concentrator tube and presumably only distilled methylene chloride reaches the condensor and collects back in the extractor body. The duration of extraction was ten hours. After this, the stopcock on the side-arm was closed and the sample in the concentrator tube concentrated to approximately 5 ml.

The 5 ml extracts from each site were combined and further concentrated in a Kontes tube heater to 0.5 ml. The sample was then dried (residual water remove) in a column of sodium sulfate; (0.5 gram of sodium sulfate previously dried in the oven was put into a Pasteur pipette with glass wool as plugs). The drying column was prewashed with three bed volumes of methylene chloride before eluting the sample. The column was then washed with three more bed volumes of methylene chloride. The extracts were evaporated with the Kontes tube heater with condensers attached to the concentrator tubes.

The samples were analyzed by GC. If the concentration of chemicals in the samples was low and the chromatogram only showed surrogates, more water was extracted and all the extracts combined and worked up again so that a sufficient sample volume was extracted for GC/MS and quantitative analysis.

A water bath was used as a heating source for all of the extractions except the 12-10-92 samples. The disadvantage of the water bath is that it has to be refilled every half hour or so in order to maintain the temperature. The temperature of the water bath is lowered slightly at this time. If the water level was allowed to drop more than a liter or more and large volumes of water were

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required to refill it, the lowered temperature could have altered the rate of extraction. This happened occasionally as it was impractical to always moniter the extraction continuously.

A water bath was not used as a heating source for the extractions 12-10-92 samples. Instead, a Supelco heating block system, which is made of aluminum and is designed to hold one concentrator tube each was used. Four blocks were placed on a hot plate and the heat conducted to the blocks. The temperature of the outside surface of the concentrator tube was 110 °C as measured with a thermometer through a slot in the block. The advantage of the heating block is that since there is no water bath to have to fill, it is more likely that the temperature will remain constant throughout the extraction. However, overheating can occur at low volumes of methylene chloride in the concentrator tube and bumping can occur.

The percent recovery of surrogate standards are completed by comparison to a standard solution of the surrogate standards. Table 6A shows the percent recovery of surrogate standards. The grand mean average of 105 water samples was 56.2%, which was within EPA guidelines of EPA Method for surrogate analysis (33 - >100%).

Supercritical Fluid Extraction of Filtered Suspended Sediments;
Analytical Finish by EPA Method 6081/625 Equivalent

The supercritical fluid extraction (SFE) of suspended sediments from storm drains was done by compacting the air-dried filter with sediment into a 10-ml sample cartridge. Recovery standard solution (200 ppm mixture of 1-chlorodecane and 1-chlorooctadecane in methanol) was then spiked into the sample in the cartridge at a ratio of 50 µl per 1.0 ml final volume of extract. In this case, the final volume of extract was planned to be 0.5 ml, so the recovery standard spiked was 25 µl. An ISCO SFX™ 2-10 Supercritical Fluid Extractor, (Lincoln Nebraska) was used in this study. The sediment was extracted under the following optimum conditions:

Pressure = 200 atm.	Temperature = 50 °C
Volume of CO_2 = 25 ml	Flow Rate = 1.2 to 1.4 ml/min

The extracts were collected in a 10-ml (initial volume) of methylene chloride contained in 30 ml round bottom culture tubes with screw caps (ISCO SFX™ 2-10

Table 6 A

Percent Recoveries of Base Neutral Surrogate Standards From Filtered Water by Liquid-Liquid Extraction For Selected Samples

[(a) Nitrobenzene -D5 (b) 2-Fluorobiphenyl (c) p-Terphenyl-D14]

	Ashland	Ballona	Centinela	Pico/ Kenter	Sepulveda
7/27/92 a)	77.8	61.7	74.7	25.1	60.2
b)	80.2	58.9	71.6	27.5	63.2
c)	99.8	68.6	75.5	54.1	71.9
8/24/92 a)	50.4	56.9	29.4	45.0	47.1
b)	73.5	80.9	42.8	87.8	57.5
c)	101.0	124.2	98.2	111.0	106.1
12/1092 a)	60.5	23.6	30.6	51.2	36.6
b)	61.7	31.6	31.7	56.2	37.6
c)	92.4	86.7	57.0	98.9	72.6

Grand mean of all samples = 56.2 %
Range = 12.7 - 124.2 %
Number of samples = 105

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accessory). During extraction, the bubbling of CO_2 into the collection solvent caused much of it to evaporate to around 0.5 ml. After extraction, the final volume was adjusted to exactly 0.5 ml, followed by spiking of the internal standard mixture (1000 ppm mixture of 1-chlorotetradecane and 1-chlorohexadecane in methanol) at a ratio of 5 µl per 0.5 ml sample. The sample was prescreened by gas chromatography and then analyzed by GC/MS. Table 7 shows the percent recovery of surrogate standards in different samples calculated by GC analysis with a flame ionization detector by a standard curve procedure. The grand mean average of 20 suspended sediment samples was 87 % as shown in Table 6B.

Chlorinated Pesticides and PCB Analysis By EPA Method 608

Chlorinated Pesticides and PCB were isolated by the same method for suspended sediments and filtered water extracts as described above for EPA Method 525/625*. The methylene chloride extracts from the EPA Method 525/625* was solvent-exchanged with hexane. The hexane extracts were analyzed by EPA Method 608, with a Varian 3500 GC equipped with a Dual Electron Capture Detector (ECD). A detector temperature of 330°C was used with a splitless injector at 280°C. The programming temperature used was 1 min at 60°C, 15°C/min to 150°C, 2°C/min to 200°C, 5°C/min to 280°C hold 10 min. A 1 µl sample in hexane was injected into a single injector and then split using a 1 meter 0.32 mm fused silica retention gap and glass Y connector to two analytical columns. Column 1 was connected to channel A Electron Capture Detector J&W 30 meter DB-5 0.032 mm diameter and Column 2 was connected to channel B ECD J&W 30 meter DB-5 0.032 mm. diameter. A Varian Star Integrator/ Workstation Ver. A2 was used for data collection and processing. Quantitation from Channel A with confirmation from Channel B were used with an external calibration:

$$M_x = M_{STD} \times A_x / A_{STD}$$

M_x = amount compound in unknown run; A_x = area compound in unknown run
M_{STD} = amount compound in standard run; A_{STD} = area compound in standard run

Sample concentration was reported as ng/l of water sample. Table 8 shows the chlorinated pesticides and PCBs that were analyzed.

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Table 6 B

Percent Recoveries of Surrogate Standard From Suspended Sediments by Supercritical Fluid Extraction For Selected Samples
(1-chlorodecane)

	Ashland	Ballona	Centinela	Pico-Kenter	Sepulveda
7/27/92	100 %	68 %	102 %	112 %	94 %
8/24/92	97 %	77 %	76 %	84 %	75 %
9/8/92	96 %	90 %	86 %	81 %	81 %
12/10/92	80 %	76 %	92 %	84 %	85 %

Grand Mean of all samples in this table = 86.8%
Range = 68% - 112%
Number of samples = 20

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Table 7

EPA 608* TARGET CHLORINE COMPOUNDS

CHLORINATED PESTICIDES	PCBS
Aldrin	2,4'-Dichlorobiphenyl
Alpha-Chlordane (cis-chlordane)	2,2',5-Trichlorobiphenyl
2,4'-DDD (o.p'TDE)	2,4,4'-Trichlorobiphenyl
4,4'-DDD (p.p'TDE)	2,2',3,5'-Tetrachlorobiphenyl
2,4'-DDE	2,2',5,5'-Tetrachlorobiphenyl
4,4-DDE	2,3',4,4'-Tetrachlorobiphenyl
2,4'DDT	3,3',4,4'-Tetrachlorobiphenyl
4,4'-DDT	2,2',4,5,5'-Pentachlorobiphenyl
Dieldrin	2,3,3'4,4'-Pentachlorobiphenyl
Heptachlor	2,3',4,4',5-Pentachlorobiphenyl
Heptachlor epoxide	3,3',4,4',5-Pentachlorobiphenyl
Hexachlorobenzene	2,2',3,3',4,4'-Hexachlorobiphenyl
Llindane (gamma-BHC)	2,2',3,4,4',5'-Hexachlorobiphenyl
Mirex	2,2',4,4',5,5'-Hexachlorobiphenyl
Trans-Nonachlor	2,2',3,3',4,4',5-Heptachlorobiphenyl
Endrin	2,2',3,4,4',5,'-Heptachlorobiphenyl
alpha--BHC	2,2',3,4',5,5',6-Heptachlorobiphenyl
beta--BHC	2,2',3,3',4,4',5,6-Octachlorobiphenyl
Delta--BHC	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl
Endosulfan I	2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl
Endosulfan II	
Endosulfan Sulfate	
Endrin Aldehyde	
Endrin Ketone	
Methoxychlor	

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RESULTS

All compounds that are on the volatile organic chemical and base neutral analysis quantitative list, (Tables 3 and 4) were analyzed by GC/MS. Some compounds were analyzed by both methods, e.g. naphthalene. Volatile organic analysis data is for soluble compounds only, whereas base neutral data is for total concentration (soluble plus suspended sediment) to reflect the maximum load on the environment as sample dilution with the ocean will facilitated desorption from the sediments phase. The data obtained is compared to the drinking water standards e.g. THMs (Trihalomethanes = the sum of chloroform, dichlorobromomethane, chlorodibromomethane and bromoform), whose sum must be less that 100 ug/l in the final drinking water. The base neutral analyses are also compared to the California Ocean Plan's 30-day average discharge standards, which are based upon the criteria of human health - carcinogenic or noncarcinogens. The use of the concept of minimum initial dilution is used (the lowest average initial dilution within a single month of the year). We could assume that the storm drain discharge is from one discharger to the ocean. However, the initial dilution will vary with low (dry weather) flow vs higher (wet weather) flow. A set of possible dilution factors can be compared e.g. a minimum of 5 to 10 vs. 100, 1,000 or even 10,000-fold dilutions can be evaluated. No standard approach has been defined in the Ocean Plan, thus, it is up to interpretation of the flow data and mixing in the ocean. It should be remembered that the California Ocean Plan has no guidelines specifically for a storm drain.

Volatile Organic Chemicals

Tables 8 - 12 show the soluble, targeted volatile organic compounds (VOCs) that were quantified in storm drain samples from the 5 storm drains under dry weather flow from 6/12/92 to 12/10/92. Field and lab blank data (Appendix II) and MDLs were used to define the compounds that could be quantified. Tables 8 - 12 present the summary of the VOCs (b.p. <150 °C) that were quantified at the ug/l (ppb) level to two significant figures. The tables list the minimum detectable level for each compound as determined in our laboratory. (See Table 3). The only compounds that are quantified are those above the MDL. Appendix Tables IV.1a - 5a show the individual analyses by sample data in ng/l (ppt).

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Table 8

Volatile Organic Analysis - Ballona Creek (6/12-12/10/92)

CHEMICAL NAME	MDL ug/l	FIELD & LAB BLANK ug/l	NUMBER FOUND ABOVE MDL & BL'K	AVERAGE ug/l	RANGE ug/l	DRINKING WATER MCLs ug/l
Dichlorodifluoromethane	0.18	0.15-0.20	1	-	0.21	
Chloromethane	0.14	0.14-0.17	12	0.51	0.26 - 2.17	
Carbon Disulfide	0.11	0.11-0.14	15	0.20	0.14 - 0.29	
Methylene Chloride (1)	0.07	0.11-0.14	13	?	0.19 - 2.12	5*
Trans-1,2-Dichloroethene	0.12		1	-	0.13	100
2-Butanone	?	0.24-0.33	11	0.60	0.34 - 1.58	
Bromochloromethane	0.16		1	-	0.52	
Chloroform	0.11		17	0.63	0.21 - 2.16	100 THMs
1,1,1-Trichloroethane	0.06		15	0.55	0.11 - 0.96	200
Benzene	0.04		13	0.08	0.04 - 0.22	5
Trichloroethene	0.04		11	0.05	0.05 - 0.08	5
Dibromomethane	0.30		3	0.06	0.04 - 0.26	
Bromodichloromethane	0.06		16	0.23	0.11 - 0.57	100 THMs
4-Methyl-2-Pentanone	0.12		10	0.27	0.15 - 0.59	
Toluene	0.05		13	0.10	0.05 - 0.17	1000
Tetrachloroethene	0.05		16	0.24	0.07 - 0.41	5
2-Hexanone	0.09		2	0.14	0.07 - 0.20	
Dibromochloromethane	0.09		16	0.28	0.11 - 0.82	100 THMs
Styrene	0.04		3	0.05	0.04 - 0.07	1000
Bromoform	0.06		18	0.18	0.07 - 0.42	100 THMs
1,2,4-Trimethylbenzene	0.04		2	0.04	0.04	
Napthalene	0.25		1	-	0.26	
1,1-Dichloropropene	0.06		1	-	0.10	

17 Samples - 6/12 to 12/10/92 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed only

MDL - Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs - Trihalomethanes

(1) Note- Methylene chloride in the 6/12 and 9/8 AM samples of 129.41 and 154.22 ug/l, respectively are considered artifacts and are not included in the data. Fifteen samples were completed for methylene chloride

Table 9

Volatile Organic Analysis - Pico/Kenter (6/12-12/10/92)

CHEMICAL NAME	MDL ug/l	FIELD & LAB BLANK ug/l	NUMBER FOUND ABOVE MDL & BL'K	AVERAGE ug/l	RANGE ug/l ug/l	DRINKING WATER MCLs ug/l
Dichlorodifluoromethane	0.18	015-0.20	4	0.22	0.20 - 0.25	
Chloromethane	0.14	0.14-0.17	13	0.42	0.29 - 0.94	
Carbon Disulfide	0.11	0.11-0.14	11	0.30	0.15 - 0.71	
Methylene Chloride(1)	0.07	0.11-0.14	14	2.18	0.18 - 12.82	5*
2-Butanone	?	0.24-0.33	8	0.61	0.33 - 1.24	
Chloroform	0.11		15	0.35	0.11 - 0.98	100 THMs
Benzene	0.04		12	0.09	0.04 - 0.25	5
Dibromomethane	0.03		5	0.05	0.03 - 0.07	
Bromodichloromethane	0.06		2	0.16	0.11 - 0.22	100 THMs
4-Methyl-2-Pentanone	0.12		11	0.30	0.13 - 1.30	
Toluene	0.05		12	0.16	0.06 - 0.35	1000
2-Hexanone	0.09		4	0.21	0.12 - 0.30	
Dibromochloromethane	0.09		2	0.21	0.19 - 0.23	100 THMs
Styrene	0.04		5	0.05	0.04 - 0.05	100
Bromoform	0.06		6	0.39	0.07 - 1.49	100 THMs
1,2,4-Trimethylbenzene	0.04		1	0.05	-	
p-Isopropyltoluene	0.06		3	0.07	0.06 - 0.08	

15 Samples - 6/12 to 12/10/9 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed MDL only

MDL - Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs - Trihalomethanes

(1) Note- Methylene chloride in the 6/12 sample (33.448 ug/l) is considered an artifact and is not included in the data. Fourteen samples were completed for methylene chloride.

Table 10

Volatile Organic Analysis - Sepulveda (6/12-12/10/92)

CHEMICAL NAME	MDL ug/l	FIELD & LAB BLANK ug/l	NUMBER FOUND ABOVE MDL & BL'K	AVERAGE ug/l	RANGE ug/l	RANGE ug/l	DRINKING WATER MCLs ug/l
Dichlorodifluoromethane	0.18	0.15-0.20	1	0.20		0.20	
Chloromethane	0.14	0.14-0.17	14	0.58	0.20	- 2.90	
Carbon Disulfide	0.11	0.11-0.14	8	0.23	0.14	- 0.34	
Methylene Chloride (1)	0.07	0.11-0.14	12	0.52	0.14	- 1.75	5*
Trans-1,2-Dichloroethene	0.12		1	0.19		0.19	100
2-Butanone	?	0.24-0.33	9	0.77	0.36	- 3.15	
Bromochloromethane	0.16		1	0.31		0.31	
Chloroform	0.11		14	0.57	0.14	- 2.13	100 THMs
1,1,1-Trichloroethane	0.06		1	0.09		0.09	200
Benzene	0.04		13	0.10	0.04	- 0.25	5
Dibromomethane	0.03		9	0.07	0.03	- 1.29	
Bromodichloromethane	0.06		4	0.82	0.06	- 1.54	100 THMs
4-Methyl-2-Pentanone	0.12		5	0.25	0.15	- 0.62	
Toluene	0.05		11	0.10	0.06	- 0.37	1000
2-Hexanone	0.09		2	0.13	0.11	- 0.14	
Dibromochloromethane	0.09		4	1.18	0.18	- 2.14	100 THMs
(m+p)-Xylene	0.10		1	0.15		0.15	100,000 /
o-Xylene	0.04		1	0.06		0.06	TOTAL
Styrene	0.04		3	0.05	0.04	- 0.05	1000
Bromoform	0.06		15	0.40	0.13	- 1.09	100 THMs
Naphthalene	0.25		1	0.29		0.29	

15 Samples - 6/12 to 12/10/92 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed only

MDL - Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs - Trihalomethanes

(1) Note- Methylene chloride in the 6/12 and 9/8 AM samples of 75.115 and 4 696 ug/l, respectively are considered artifacts and are not included in the data. Twelve samples were completed for methylene chloride

Table 11

Volatile Organic Analysis - Centinela (7/12-12/10/92)

CHEMICAL NAME	MDL ug/l	FIELD & LAB BLANK ug/l	NUMBER FOUND ABOVE MDL & BL'K	AVERAGE ug/l	RANGE ug/l ug/l	DRINKING WATER MCLs ug/l
Dichlorodifluoromethane	0.18	0.15-0.20	2	0.22	0.21 - 0.23	
Chloromethane	0.14	0.14-0.17	11	0.32	0.19 - 0.47	
Carbon Disulfide	0.11	0.11-0.14	10	0.21	0.16 - 0.29	
Methylene Chloride	0.07	0.11-0.14	11	1.90	0.20 - 8.19	5*
2-Butanone	?	0.24-0.33	4	0.57	0.34 - 1.28	
Bromochloromethane	0.16		1	0.16	-	
Chloroform	0.11		11	0.78	0.23 - 2.01	100 THMs
Benzene	0.04		8	0.09	0.04 - 0.19	5
Bromodichloromethane	0.06		5	0.42	0.07 - 1.24	100 THMs
4-Methyl-2-Pentanone	0.12		5	9.48	0.16 - 45.79	
Toluene	0.05		8	0.10	0.06 - 0.17	1000
2-Hexanone	0.09		8	0.03	0.09 - 0.18	
Dibromochloromethane	0.09		4	0.88	0.11 - 2.24	100 THMs
Styrene	0.04		3	0.05	0.04 - 0.05	1000
Bromoform	0.06		5	0.34	- 1.12	100 THMs
Napthalene	0.25		1	0.46	-	

11 Samples - 7/12 to 12/10/92 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed only

MDL -Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs- Trihalomethanes

Table 12

Volatile Organic Analysis - Ashland Ave. (6/12-12/10/92)

CHEMICAL NAME	MDL ug/l	FIELD & LAB BLANK ug/l	NUMBER FOUND ABOVE MDL & BL'K	AVERAGE ug/l	RANGE ug/l ug/l	DRINKING WATER MCLs ug/l
Dichlorodifluoromethane	0.18	0.15-0.20	2	0.27	0.20 - 0.33	
Chloromethane	0.14	0.14-0.17	14	0.42	0.22 - 0.91	
1,1-Dichloroethane	0.17		1	0.19	-	
Carbon Disulfide	0.11	0.11-0.14	14	1.10	0.16 - 5.80	
Methylene Chloride (1)	0.07	0.11-0.14	13	6.30	0.24 - 65.74	5*
2-Butanone	?	0.24-0.33	9	1.09	0.29 - 3.73	
Bromochloromethane	0.16		4	0.45	0.17 - 1.05	
Chloroform	0.11		11	4.07	0.13 - 19.11	100 THMs
Benzene	0.04		13	0.09	0.05 - 0.22	5
1,2-Dichloroethane	0.04		1	0.05	-	5
Trichloroethene	0.04		3	0.07	0.06 - 0.08	5
Dibromomethane	0.03		9	0.74	0.11 - 2.00	
Bromodichloromethane	0.06		5	1.68	0.10 - 7.42	100 THMs
4-Methyl-2-Pentanone	0.12		11	0.57	0.16 - 1.40	
Toluene	0.05		11	0.75	0.09 - 6.63	1000
2-Hexanone	0.09		5	0.23	0.15 - 0.41	
Dibromochloromethane	0.09		4	4.88	0.11 - 18.54	100 THMs
Ethyl Benzene	0.05		1	0.06	-	700
o-Xylene	0.04		2	0.15	0.05 - 0.09	10000 (Total)
Styrene	0.04		5	0.05	0.04 - 0.08	1000
Bromoform	0.06		5	10.56	0.04 - 50.52	100 THMs
1,3,5-Trimethylbenzene	0.05		2	0.67	0.07 - 1.27	
1,2,4-Trimethylbenzene	0.04		8	0.08	0.04 - 0.17	
p-Isopropyltoluene	0.06		6	0.69	0.06 - 2.51	
n-Butylbenzene	0.06		1	0.06	-	
Naphthalene	0.25		1	0.40	-	
1,2-Dichlorobenzene	0.04		1	0.07	-	600

14 Samples - 6/12 to 12/10/9 (Dry Weather Flow)
No. & Average are above MDL and Blank Values
* Proposed MDL only

MDL - Minimum Detectable Limit
Average = Values above MDL and Blank / No. Found
THMs - Trihalomethanes

(1) Note- Methylene chloride in the 9/8 AM sample (11.862 ug/l) is considered an artifact and is not included in the data. Thirteen samples were completed for methylene chloride.

Other compounds on the VOC quantifiable list (Table 3) were qualitatively identified by mass spectrometry in the samples, but are below the MDL and are not quantified. Appendix IV, Tables IV.1b - 5b shows the complete VOC analyses including date of analyses, the concentration of the compounds that were identified above their MDLs in ng/l and the identification of the compounds found below their MDLs presented as <MDL.

Table 13 compare the average tabulated VOC data for each site and overall grand average for all sites based upon occurrence >MDL. Tables 8 - 12 compare the VOC average data at each sites and the drinking water maximum contamination limits developed by the U.S. EPA (See Table 3). Only methylene chloride (a notorious laboratory artifact) was found in the storm drains of Pico/Kenter, Centinela and Ashland to exceed the MCL. Even assuming no dilution and a one-month average value represented by each sampling date, no California Ocean Plan standards are exceeded as these standards are much higher that the EPA drinking water standards for VOCs (See Table 3).

Table 14 shows the identification of non-targeted VOCs in some samples. Non-targeted VOCs were identified by the criteria that was presented in the experimental section. These compounds are not quantified and they are called "tentatively identified" compounds. Tentatively identified compounds are not compared with the GC retention time of the true compound or the mass spectrum of the true compounds obtained on the same GC/MS system as the targeted compounds. The term "tentative" means that further studies are needed to confirm their identification and to quantify them by use of references standards. Total ion current chromatograms from the mass spectrometric determination results are presented in Appendix V. Future evaluation of the non-targeted tentatively identified compounds falls into the category of future research.

Quality Assurance - VOC Laboratory Blanks, Field Blanks and Replicate Analysis

Appendix II., Table II.1 shows VOC samples suspected of methylene chloride contamination. Methylene chloride is a notorious laboratory artifact that can permeate into water samples stored in a refrigerator for purge and trap volatile organic compound analysis (Eichelberger and Budde, EPA Method 524.2, Revision 3, Section 4.3, 1989, Appendix Methods Section 1). Methylene chloride was the solvent used in

Table 13

Volatile Organic Analysis - Grand Total (6/12-12/10/92)

CHEMICAL	Ashland Average Conc ng/L	Pico/Kenter Average Conc ng/L	Sepulveda Average Conc ng/L	Ballona Average Conc ng/L	Cent. Ave Conc ng/L	GRAND AVE. Conc ng/L	GRAND S.D. ng/L	NUMBER OF SAMPLES >MDL
Benzene	90	91	109	77	91	90	61	59
Bromochloromethane	454		309	519	164	401	310	7
Bromodichloromethane	1,683	160	772	293	420	554	1,307	32
Bromoform	10,555	390	401	179	337	1,351	7,179	49
2-Butanone = MEK	1,191	423	477	602	423	673	656	48
n-Butyl Benzene	60					60	0	1
Carbon Disulfide	1,102	299	227	299	213	442	775	58
Chloroform	4,066	366	568	636	779	1,152	2,647	67
Chloromethane	418	421	578	421	324	526	589	65
2-Chlorotoluene	89					89	0	1
4-Chlorotoluene	148					148	0	1
Dibromochloromethane	4,877	205	1,179	281	883	1,089	3,348	30
Dibromomethane	740	50	74	50		298	465	26
1,2-Dichlorobenzene	74					74	0	1
Dichlorodifluoromethane	267	210	200	210	221	221	39	12
1,1-Dichloroethane	187					187	0	1
1,2-Dichloroethane	53					53	0	1
Dichloromethane	8,298	2,177	525	2,163	1,905	2,325	8,422	63
1,1-Dichloropropene				102		102	0	1
Ethyl Benzene	57			50		54	5	2
2-Hexanone	225	213	127	213	135	193	84	14
p-isopropyltoluene	687	72		72		482	834	9
4-Methyl-2-Pentanone	573	295	232	295	9,478	1,422	6,935	43
Naphthalene	401		287	256	464	352	76	4
Styrene	54	48	47	46	47	49	9	19
Tetrachloroethene = PCE				242		242	90	16
Toluene	747	158	107	149	104	126	78	54
Trans 1,2-Dichloroethene			191	130		161	43	2
1,1,1-Trichloroethane			94	564		558	292	15
Trichloroethene = TCE	69			53		56	12	15
1,2,4-Trimethylbenzene	77	52		52		68	42	11
1,3,5-Trimethylbenzene	672					672	852	2
o-xylene	71		59			67	21	3

Dichloromethane = methylene chloride TCE = Trichloroethylene PCE = Perchloroethylene

Note: Only compounds that were found >MDL were averaged

Grand Average = Concentrations of compounds that are found >MDL/number of samples.

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Table 14

Nontargeted Volatile Organic Chemicals Found in Selected Samples

Location →	Cent.	Pico/K	Pico/K	Ash	Ash	Ash	Ash	Ash
Date →	8-Sep	12-Jun	2-Nov	7-Jul	7-Jul	7-Jul	8-Sep	12-Oct
Sample Number →	F7972	7924	8143	8008	7932	8009	7977	8012
Sample Volume (ml) →	15	5	5	5	15	5	5	5
Time of Day →	PM	PM	AM	AM	AM	PM	AM	AM
COMPOUNDS								
Hexanal					x		x	
Heptanal				x			x	
Octanal				x			x	x
Nonanal	x	x	x	x	x	x	x	x
Decanal		x		x			x	
2-Ethyl hexanal				x				
Dodecanal					x			
3-Octanone						x		
2-Heptanone						x		
2-Propyl-1-octanol						x		
4-Methyl-2-pentanol	x							
3-Dodecanol					x			
Dodecanal			x		x		x	
Dimethyl disulfide					x			
2-Methyl furan						x		
N-Phenyl benzamide					x			
C8 Alkene				x				x
Branched alkene					x		x	x
C8 Alkane, branched					2			
C9 Alkane, branched				x		x		x
Octane					x	x		
Methyl decane					x			
C11 Branched alkane					x			
C12 Alkane, branched				x				
C13 Alkane, branched					x			
5-Dodecene					x			
C6 Alkene, branched					x			
C8 Alkene, branched						x		
C9 Alkene, branched						x		

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Table 14 cont.

Location →	Cent.	Pico/K	Pico/K	Ash	Ash	Ash	Ash	Ash
Date →	8-Sep	12-Jun	2 Nov	7-Jul	7-Jul	7-Jul	8 Sep	12 Oct
Sample Number →	F7972	7924	8143	8008	7932	8009	7977	8012
Sample Volume (ml) →	15	5	5	5	15	5	5	5
Time of Day →	PM	PM	AM	AM	AM	PM	AM	AM
COMPOUNDS								
Alkene, branched					x	x		
Octahydro-1-methylpentalene					x			
Cyclododecene					x			
C3 Alkyl benzene					3	4		
C4 Alkyl benzene		x			4	5		
C5 Alkyl benzene					4	3		
Octahydro-1-Methylpentalene						x		
Propyl cyclohexane					x			
1,2,3-Trimethyl cyclohexane					x			
C3-Alkyl cyclohexane					x	x		
C3-Alkyl Cyclohexane						x		
C4 Alkyl cyclohexadiene								
C4 Alkyl cyclohexane								
C5 Alkyl cyclopentane					x	x		
2-Methyl naphthalene					x			
1-Methyl naphthalene					x			
Tetrahydronaphthalene					x	x		
Tetrahydro methyl naphthalene					3	2		
Decahydronapthalene					x			
Beta-Phellandrene[C10H16]					x			
2,3-Dihydro-1,2-dimethyl-1H-indene						x		
2,3-Dihydro-1,6-dimethyl-1H-indene					x	x		
Dihydro-dimethyl-1H-indene					x			
2,6-Bis(1,1-dimethylethyl)-4-methyl phenol					x			
2-(1,1-Dimethylethyl)-3-methyl phenol					x			
Cyclododecane					x			
9,10-Dihydro-9,9-dimethyl acridine					x			
3-Chlorodecane					x			
3,5-Dimethyl benzene methanol					x			
3-Carene [C10H16]					x			
(#) Number of Isomers Present								

our studies for base neutral organic analysis and is present in the laboratory. The methylene chloride solvent extracts and water samples containing methylene chloride are stored in different refrigerators and processed as far away from each other in the laboratory as described in the Experimental Section. The methylene chloride contamination is so pervasive that "...... clothing previously exposed to methylene chloride during common liquid/liquid extraction procedures can contribute to sample contamination." In the present study, all initial VOC analyses from the 3 different sites on 6/12/92 were found to be contaminated by methylene chloride at levels of 129, 33, and 75 ppb. These analyses are noted as artifacts in our data evaluation. Quality control procedures were carefully monitored after this initial sampling period. Only on one other occasion 9/8/92 in 3 of the 5 AM samples can we say with assurance that contamination is suspected (See Appendix Table II. 1). The three 6/12/92 and three 9/8 AM samples are not included in the sample evaluations because of suspected artifact values.

Appendix Table II.2 shows that 5 compounds were present in the blanks above their MDL. The range of concentrations for the analysis of 5 laboratory and field blanks taken over the course of the study are shown to be within 0.1 ppb and within 0.03 ug/l of the MDLs. Only methylene chloride is as large as 0.07 ug/l of the MDL. Appendix Table III.2 shows that replicate analysis of two independent volatile organic analysis samples collected on 10/12/92 at Ballona Creek were in excellent agreement. All the targeted compounds that were identified and quantified are presented. Even compounds that were qualitatively identified and below their MDL are observed in both samples. The difference between quantitative values are within a 0.1 ppb even for the compounds identified by GC/MS below their MDLs; only bromomethane and chloroethane were identified in one sample and not in the other, however both were at extremely low concentrations, near their instrument detection limit at < 20% of their MDL.

Ballona Creek - Volatile Organic Compounds (VOCs)

Table 8 shows that 23 targeted VOCs were present above their MDLs in 17 samples collected over a 6 month dry weather flow period 6/12-12/10/92. Methylene chloride is a notorious laboratory contaminant and the analysis of the samples for 6/12 and 9/8 AM do not include data for methylene chloride (See Appendix Table II.1). Table 8 shows that the range of concentrations for each targeted quantifiable compounds for 9 days of sampling sometimes twice a day for 6 months were within an order of magnitude at the 0.1 to 1 ppb level including methylene chloride (after artifacts samples are removed from the data base). Only chloromethane, 2-butanone, methylene chloride and chloroform were quantified to be above 1 ppb in any of the 17 samples. The drinking water MCLs are shown on Table 8 indicate that no compound exceeded its standard. The compounds were greater than an order of magnitude less than the MCL for any sample except for methylene chloride. Even assuming no dilution and a one-month average value represented by each sampling date, the data are further below the proposed Ocean Plan Standards (California State Water Resources Control Board,1990a and b) as these standards are usually 5 times higher than drinking water standards.

The levels of VOCs present from targeted quantifiable compounds are from 2-6.5 ug/l in the 17 samples analyzed. Trihalomethanes (THMs) or haloforms - chloroform, dichlorobromomethane, dibromochloromethane and bromoform - are a significant portion of the VOCs as shown on Figure 16. (Please note that the "C" after the 12/10/92 sample in Figure 16 indicates a composite of a morning and afternoon sample.) Figure 16 shows that the total haloforms account for > 25 % of the VOCs present in 16 of the 17 samples. Five samples showed THMs to be > 50 % of the VOCs. Sources of THMs include any chlorinated water that contains natural organic matter measured as organic carbon in mg C/l. This includes drinking water sources and cooling waters that are chlorinated for disinfection purposes. It is estimated by NPDS permits that 10% of Ballona Creek water is from cooling tower runoff (Stenstrom, Private Communication, 1993).

Figure 17 shows that methylene chloride concentrations are < 2.2 ppb with 3 samples > 0.75 ppb. Total aromatic hydrocarbons from fuel emissions e.g. benzene and toluene were < 0.03 ug/l. Total ketones representing natural biota sources and oxygenated solvents are below 1 ug/l for 16 of 17 samples. The three oxygenated ketones, common names are 4-methyl-2-pentanone (methyl isobutyl ketone [MIBK]), 2-hexanone (methyl butyl ketone [MBK]) and 2-butanone (methyl ethyl ketone[MEK]) are industrial solvents and common products of ozonation of natural waters. Chlorinated solvents as represented by tetrachloroethene from sources as dry cleaning were also low (below 0.5 ug/l).

Figure 16

THMs and Total Volatiles (ng/l) - Ballona

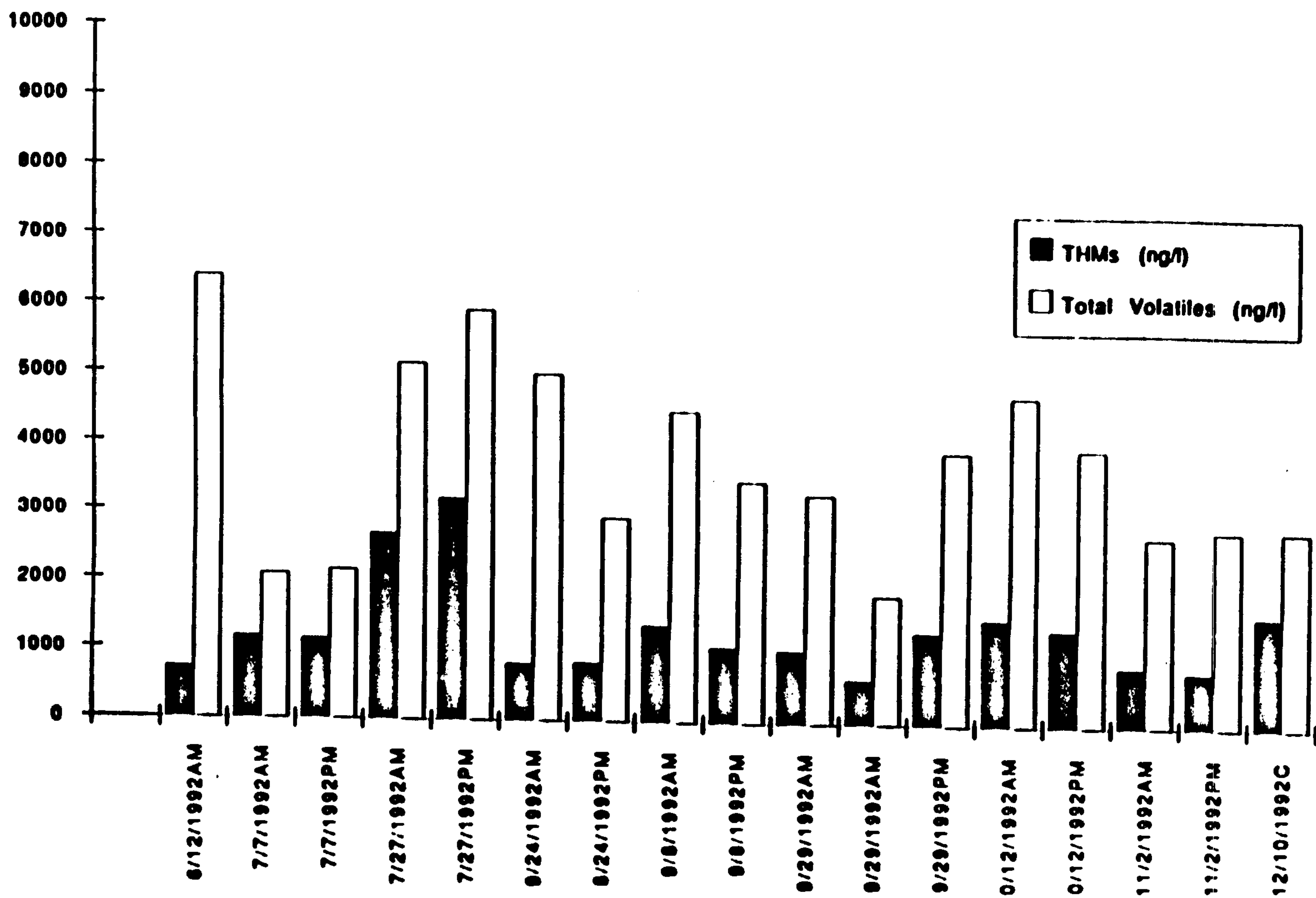
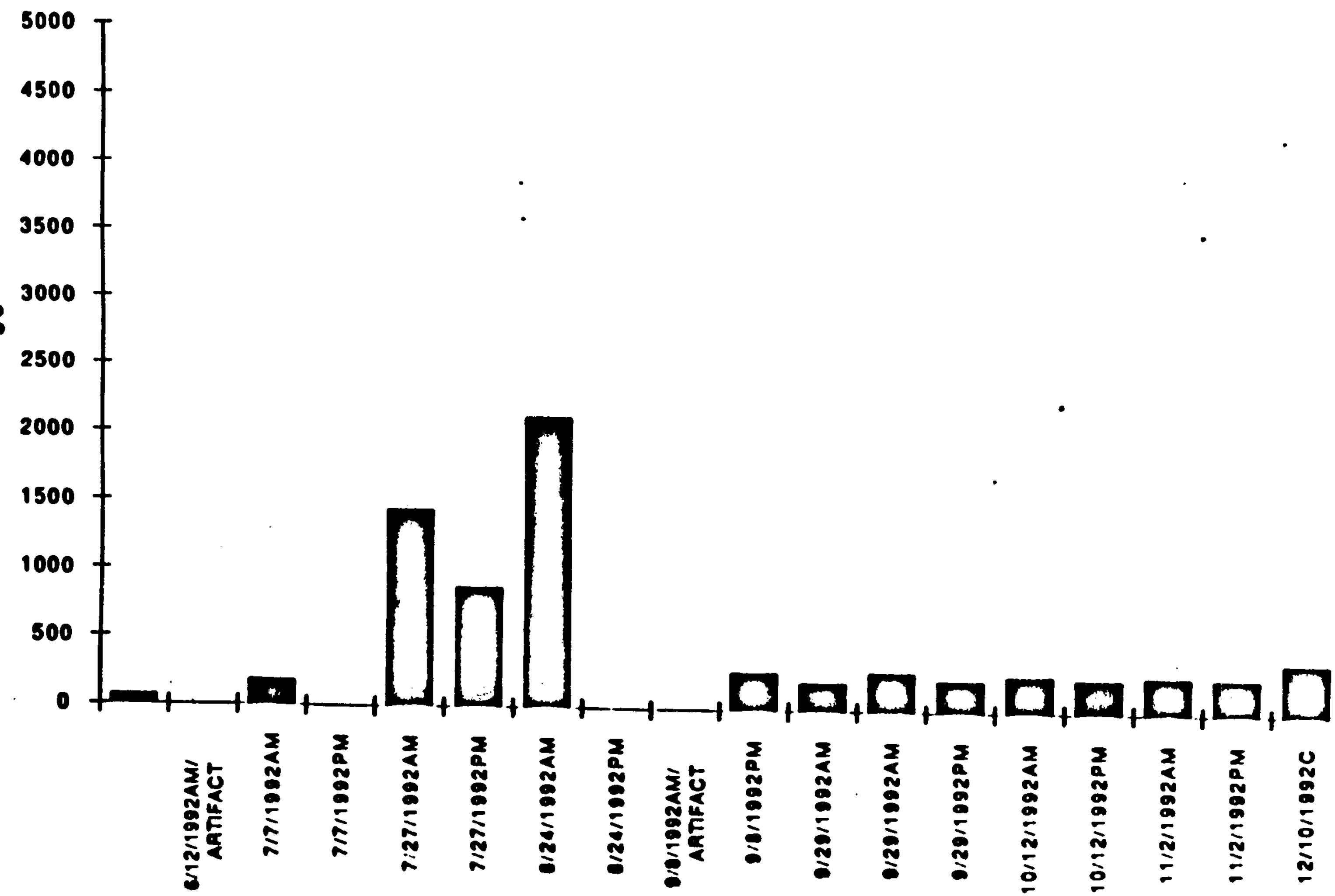


Figure 17

Methylene Chloride (ng/l) - Ballona



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The variability of the data for AM vs PM samples as well as for weekly and monthly samples are shown for total volatiles and THMs (Figure 16), methylene chloride (Figure 17) and for 2 low molecular weight volatiles (chloromethane and carbon disulfide) found in many of the samples in ng/l concentrations (Figure 18). The AM/PM variability for targeted quantifiable compounds was observed to be 1-2 ppb for total volatiles and the relative THMs/total volatiles concentration was consistent. THMs varied within a ppb for all AM/PM samples. Two samples were tested that were collected on 9/29 AM within 45 minutes of each other. The total volatiles varied as the other AM/PM samples within a ppb, (See Appendix, Table II.2). The weekly variability for targeted quantifiable compounds was observed to be 2-6 ppb for total volatiles. The THMs concentration varied within 3 ppb for 9 weeks of sampling over 6 months. Interestingly the largest variability was between two July samples of 2 ppb.

In contrast to the low ug/l levels of VOCs, Figure 6 shows that the dissolved organic carbon levels are greater than 1,000 times this level at 7-12 mg/l for the first six samples collected and near 10,000 times for the last two samples collected. Apparently, higher molecular weight chemicals are making up the bulk of the chemicals present. Probably, humic materials, algal metabolites and oily materials are associated with the DOC. A new study is needed to assess the type of DOC present.

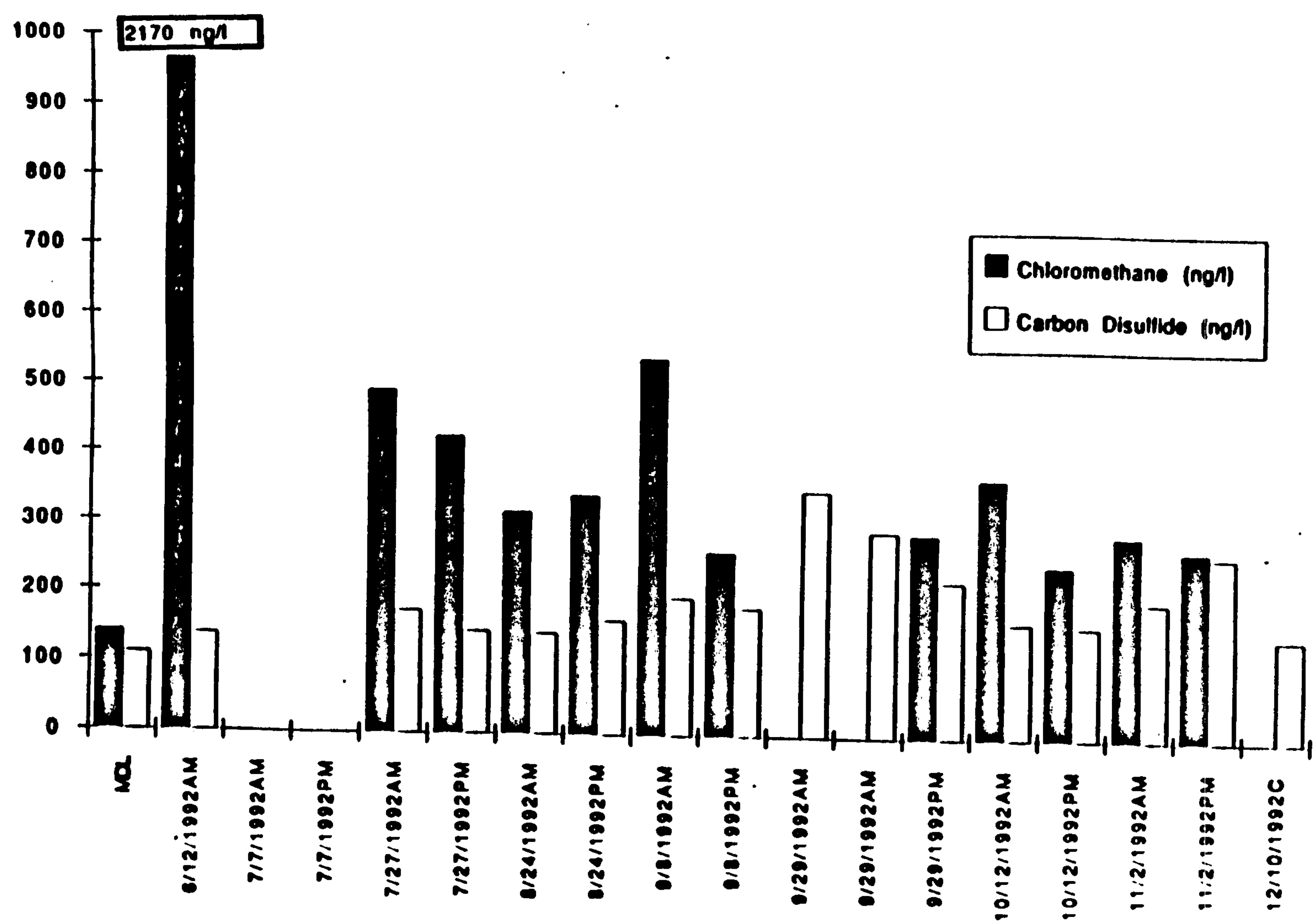
Figure 15 shows that the only significant rain that occurred during the sampling period was a half inch before the November 2 sample and almost 3 inches before the the December 10 sample. The DOC of these samples were ten times higher than the rest of the samples, yet, the total VOCs were lower than the rest of the samples. This indicates that the rain probably brought higher concentrations of humic materials and oily materials from the runoff of soil organic matter and petroleum products on the street into the storm drains while aeration and dilution decreased the VOCs concentrations.

Pico/Kenter Drain - Volatile Organic Compounds (VOCs)

Table 9 shows that 17 targeted VOCs were present above their MDLs in 15 samples collected over a 6 month dry weather flow period 6/12-12/10/92. Methylene chloride is a notorious laboratory contaminant and the analysis of the sample for 6/12 do not include data for methylene chloride (See Appendix, Table II.1). Table 9 shows that the range of concentrations for each targeted quantifiable compounds for 9 days

Figure 18

Chloromethane and Carbon Disulfide (ng/l) - Ballona



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of sampling sometimes twice a day for 6 months was within an order of magnitude at the 0.1 to 1.5 ppb level except for methylene chloride (9/8 PM sample). Methylene chloride was the only compound that averaged above a ppb even after a sample considered an artifact was removed from the data base. Besides methylene chloride, only 2-butanone, 4-methyl-2-pentanone and bromoform were quantified to be above 1 ppb in any of the 15 samples. The drinking water MCLs are shown on Table 9 and indicate that only methylene chloride is within an order of magnitude of its proposed standard. The remaining compounds were over an order of magnitude less than the MCL for any sample. The data is further below the proposed Ocean Plan Standards (California State Water Resources Control Board, 1990a and b) as these standards are usually 5 X higher than drinking water standards even assuming no dilution and a one-month average value represented by each sampling date.

The levels of VOCs present from targeted quantifiable compounds are from 1 - 8 ug/l in the 17 samples analyzed. One sample - 9/8/92 PM shows that much higher levels of VOCs were present 14.27 ug/l due to a methylene chloride level of 12.81 ug/l. The trihalomethanes portion of the VOCs are shown on Figure 19. Figure 19 shows that the total haloforms account for <25% of the VOCs present in any sample except for the 7/7 AM sample (>50%). Lower relative THM/VOC levels are present at Pico/Kenter as compared to Ballona. Thus, a lower proportion of the sources of THMs, which include any chlorinated water, such as drinking water and cooling waters that are chlorinated for disinfection purposes are present.

Figure 20 shows that methylene chloride was predominant in this sample at 12.81 ug/l. There is no clear cut justification to eliminate this value from the data base except that it is possibly an artifact. In all the samples, the aromatic hydrocarbons from fuel emissions e.g. benzene and toluene were low (<0.6 ppb), as were the chlorinated solvents as represented by chloroethene (<1 ug/l). The targeted ketones representing natural biota sources and oxygenated solvents were also low (<2 ppb). Also, some non-targeted aldehydes were found at low levels in the Pico-Kenter samples (See Table 14 and Appendix IV.

The variability of the data for AM vs PM samples as well as weekly and monthly variability are shown for total volatiles and THMs (Figure 19), methylene chloride (Figure 20) and for 2 low molecular weight volatiles chloromethane and carbon disulfide found in many of the samples in ng/l concentrations (Figure 21). The AM/PM

Figure 19

THMs and Total Targeted Volatiles (ng/l) - Pico/Kenter

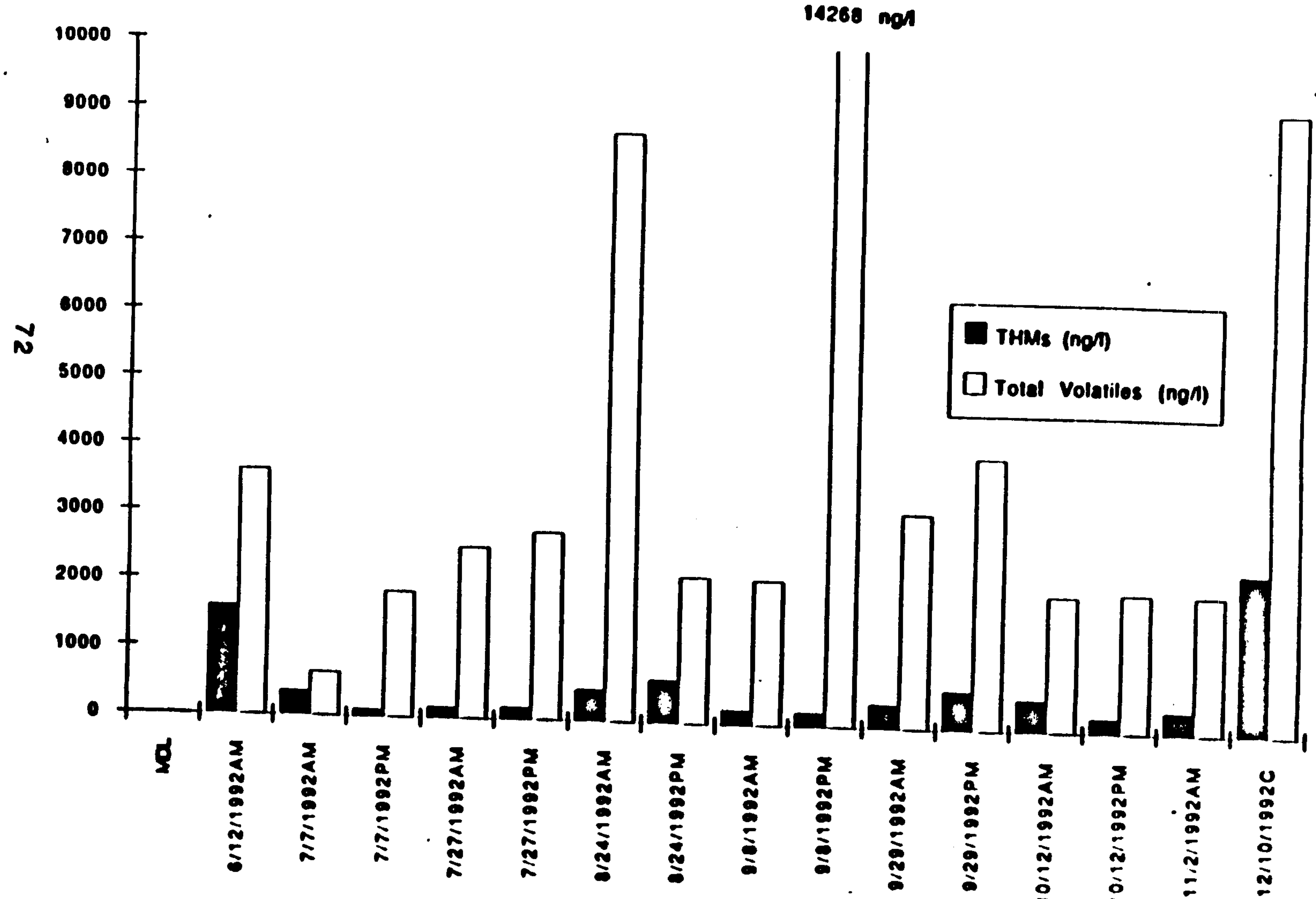


Figure 20

Methylene Chloride (ng/l) - Pico/Kenter

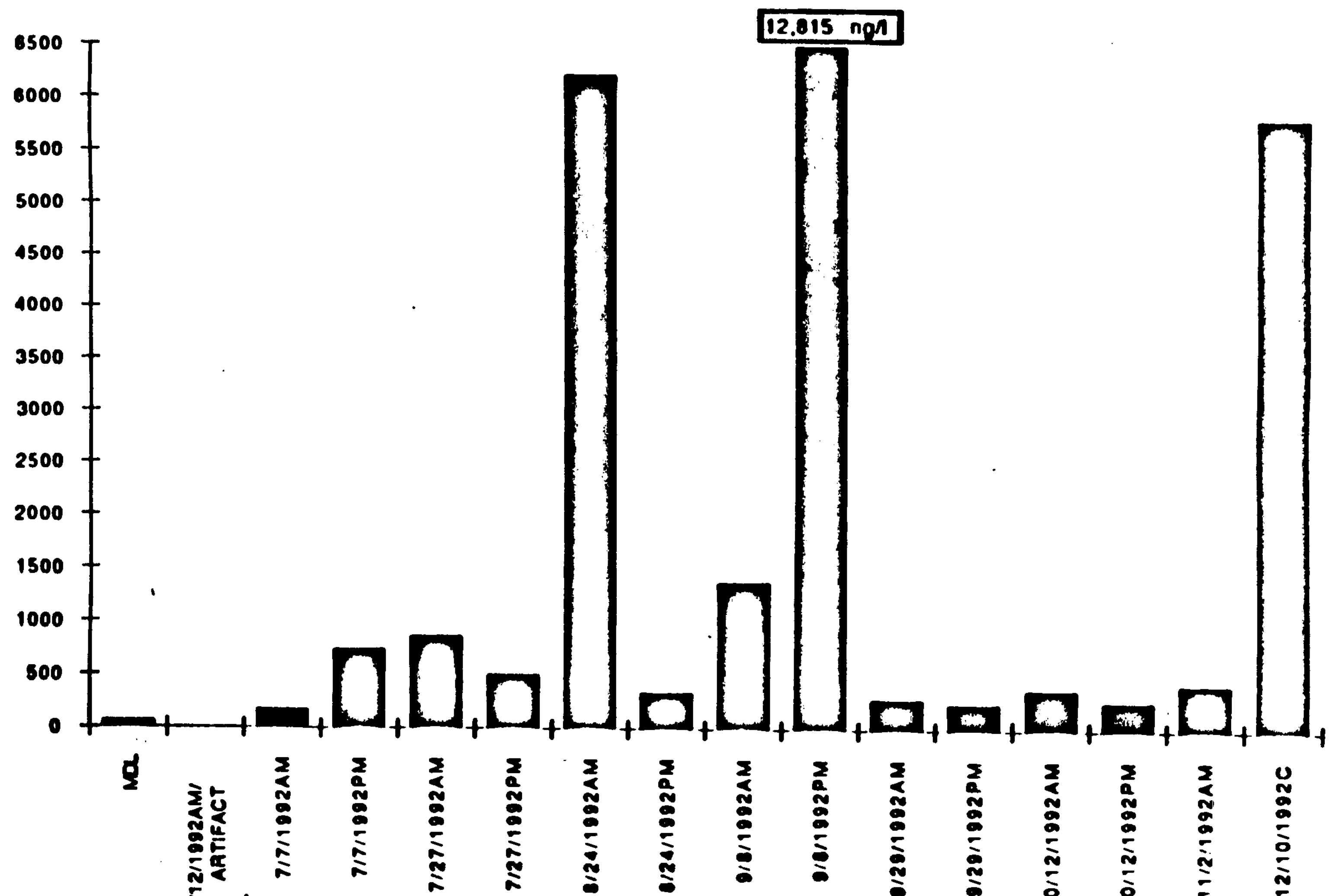
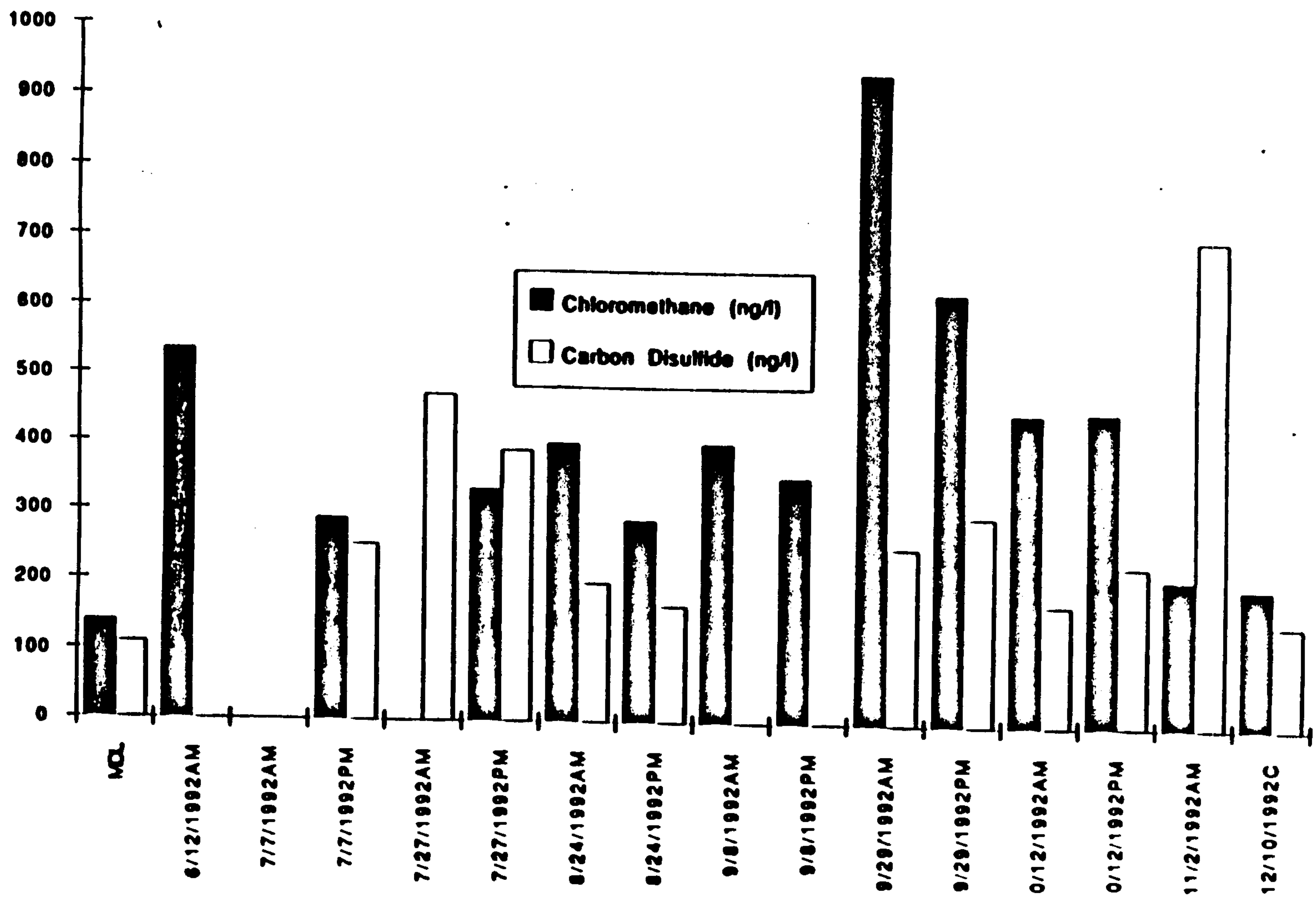


Figure 21

Chloromethane and Carbon Disulfide (ng/l) - Pico/Kenter



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variability for targeted quantifiable compounds was observed to be 1-2 ppb for total volatiles except for the 8/24 and 9/8 with the high concentration of methylene chloride present in the PM sample. The relative THMs/total volatiles concentration was not consistent for these 2 days. The weekly variability for targeted quantifiable compounds was observed to be 0.5-9 ppb for total volatiles. The THMs concentration varied within 1 ppb for 8 weeks of sampling over 5 months. Only the December sample showed an increase to 3 ppb (See Appendix Table II.2).

In contrast to the low ug/l levels of VOCs, Figure 6 shows that the dissolved organic carbon levels are greater than 1,000 times this level at 11-18 mg/l for the first six samples collected and near 10,000 times for the last two samples collected. Apparently, as for Ballona, a higher molecular weight chemicals such a humic materials, algal metabolites and oily materials are associated with the DOC. A new study is needed to assess the type of DOC present.

Figure 15 shows that the only significant rain that occurred during the sampling period was a half inch before the November 2 sample and almost 3 inches before the the December 10 sample. The DOC of these samples were ten times higher than the rest of the samples, however, the total VOCs remained in the same concentration range as the other samples.

Sepulveda - Volatile Organic Compounds (VOCs)

Table 10 shows 21 targeted VOCs were present above their MDLs in 15 samples collected over a 6 month dry weather flow period 6/12-12/10/92. Two methylene chloride analysis were eliminated due to suspected artifacts - 6/12 and 9/8 AM (See Appendix Table II.1). Only methylene chloride, chloromethane, 2-butanone, and all 4 haloforms were quantified to be above 1 ppb in at least one of the 15 samples. The drinking water MCLs are shown on Table 10 and indicate that only, methylene chloride is within an order of magnitude of its proposed standard. The remaining compounds were over an order of magnitude less than the MCL for any sample. The data are further below the proposed Ocean Plan Standards (California State Water Resources Control Board, 1990a and b) as these standards are usually 5 times higher than drinking water standards even assuming no dilution and a one-month average value represented by each sampling date.

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The range of concentrations for each targeted VOC compound for 9 days of sampling, sometimes twice a day for 6 months, varied between 1 and 9 ug/l in the 15 samples analyzed. This amount of targeted quantifiable VOCs is about the same as that at Pico/Kenter and Ballona samples. Figure 22 shows that the total haloforms account for > 30% of the total volatiles present in 8 of the 15 samples, including the four samples of 7/27/92 AM and PM, 9/8/92 AM and 12/10/92 which are over >50%. However, a much smaller number of the samples at Sepulveda are over 30% THMs than for samples from Ballona Creek (See Figure 16). This indicates that less drinking water or cooling water effluent on a relative basis enters the Sepulveda storm drain than Ballona except for the sample days noted.

Total aromatic hydrocarbons from fuel emissions e.g. benzene and toluene were below 0.5 ug/l, as were ketones (below 0.8 ug/l) representing natural biota sources and oxygenated solvents. The Sepulveda samples contained about the same magnitude of aromatic hydrocarbons as the Pico/Kenter storm drain, but this was still very low at <0.5 ppb. Total chlorinated solvents as represented by chloromethane were also low (< 1 ug/l).

The variability of the data for AM vs PM samples as well as for weekly and monthly samples are shown for total volatiles and THMs (Figure 22, methylene chloride (Figure 23) and for 2 low molecular weight volatiles (chloromethane and carbon disulfide) found in many of the samples in ng/l concentrations (Figure 24). (The true value for the 6/12/92 sample of chloromethane on Figure R9 is off-scale at 2,890 ng/l. The AM/PM variability for targeted quantifiable compounds was observed to be within 1 ppb for total volatiles except for the 7/7 samples containing 70% THMs and the 11/2 sample that contains 5 ug/l. The weekly variability for targeted quantifiable compounds was observed to be 1 - 8 ug/l for total volatiles. The THMs concentration varied within 8 ppb for 9 weeks of sampling over 6 months. Interestingly, the largest weekly variability were for the two July 27 samples. The last two samples had the lowest VOCs levels probably because of rainfall before each sampling that aerated and diluted the storm water.

In contrast to the low ug/l levels of VOCs, Figure 6 shows that the dissolved organic carbon levels are greater than 1,000 times this level at 10-18 mg/l for the first six samples (dry weather flow) collected and near 10,000 times for the last two samples collected after some rainfall. Apparently, higher molecular weight chemicals

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<u>Figure 22</u>

THMs and Total Targeted Volatiles (ng/l) - Sepulveda

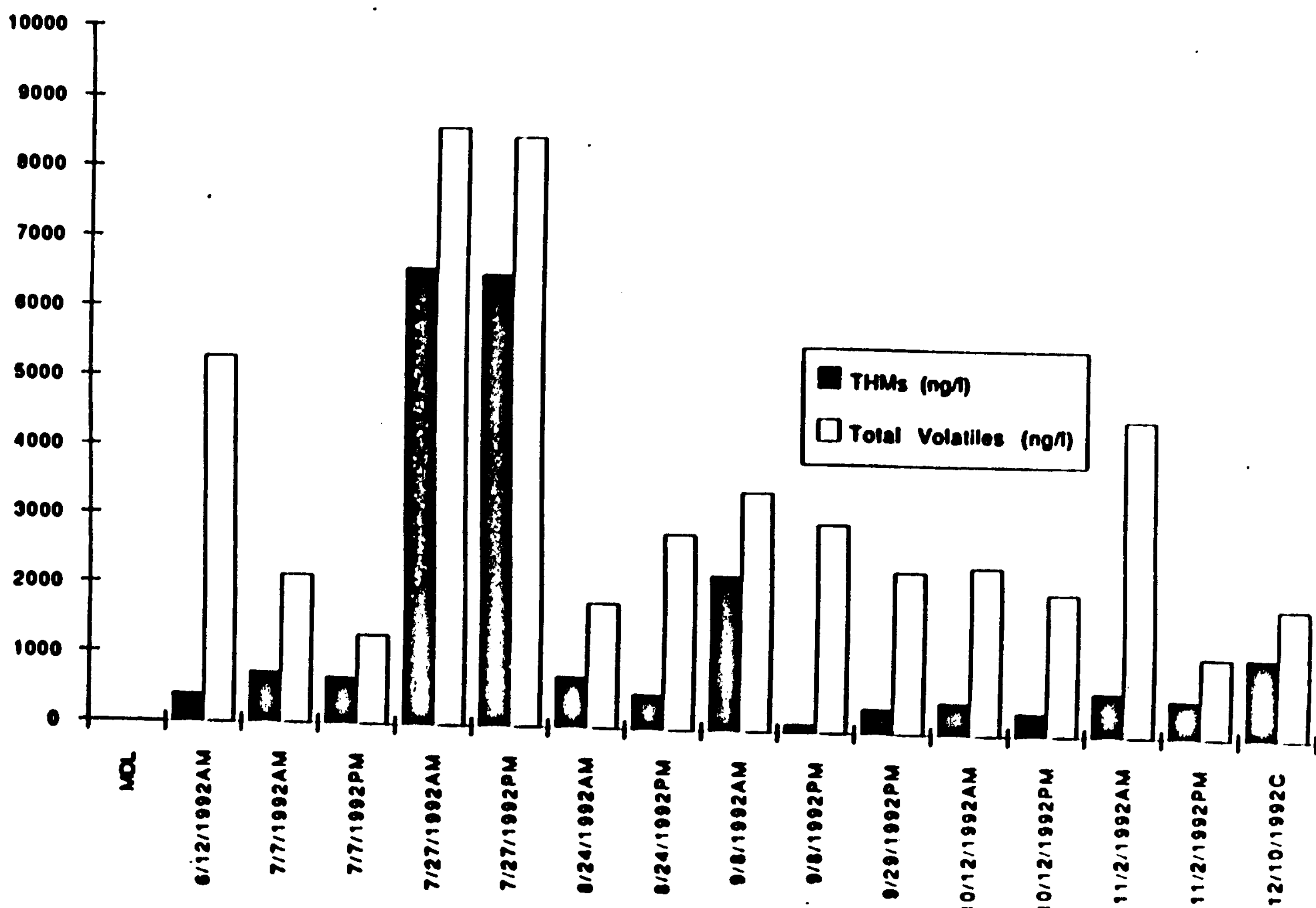

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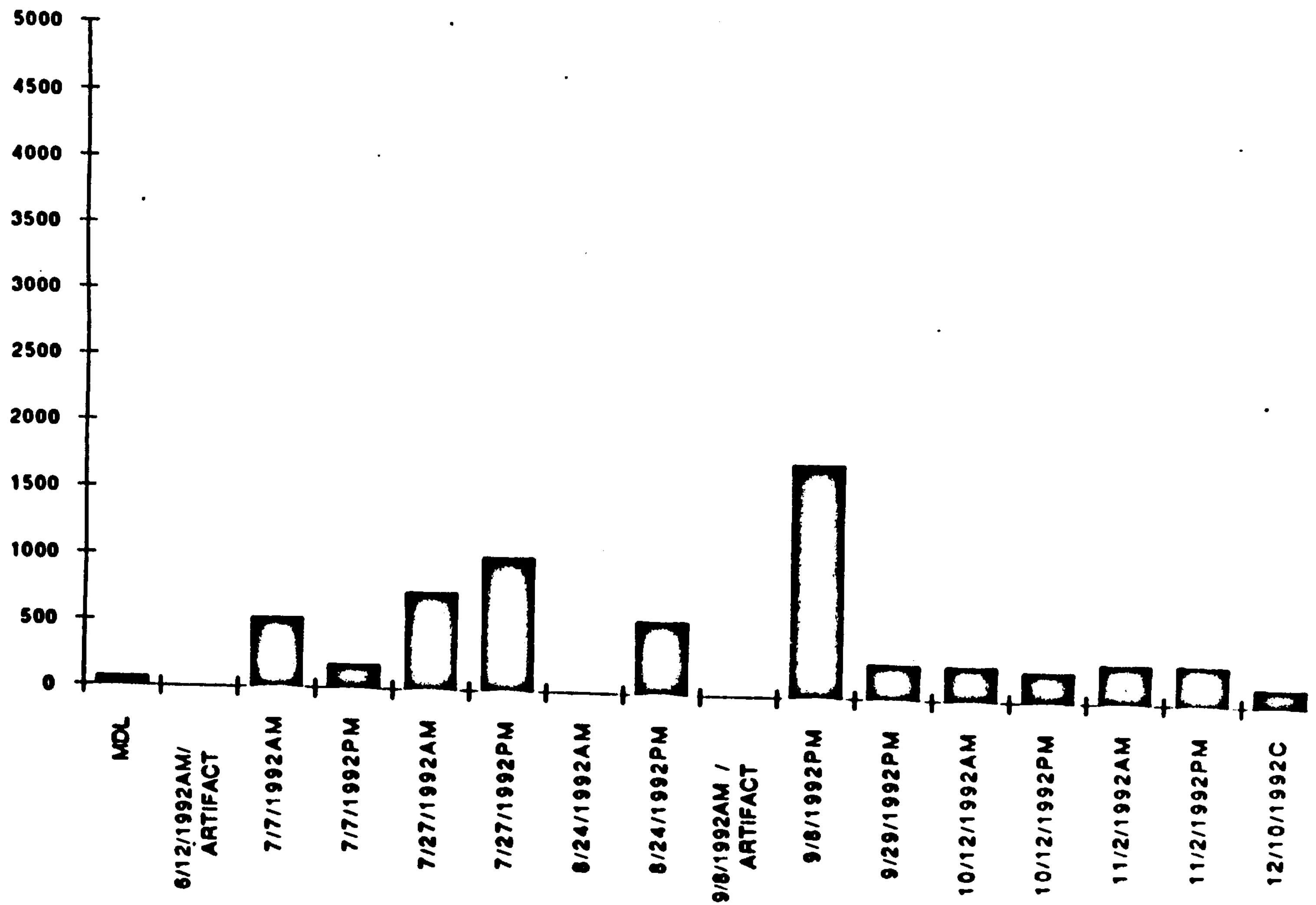
Figure 23

Methylene Chloride (ng/l) - Sepulveda



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such as, humic materials, algal metabolites and oily materials are making up the bulk of the chemicals present. A new study is needed to assess the type of DOC present.

Centinela - Volatile Organic Compounds (VOCs)

Table 11 shows 16 targeted VOCs were present above their MDLs in 11 samples collected over a 5 month dry weather flow period 7/7-12/10/92. Methylene chloride, a notorious laboratory contaminant and 4-methyl-2-pentanone averaged above a ppb. Also, 2-butanone, and the 4 haloforms were quantified to be above 1 ppb in some of the individual 11 samples. The concentration of 4-methyl-2-pentanone in the 9/8/92 PM sample was 45.79 ppb. This is the highest concentration of a non-chlorinated targeted compound that was found in any of the samples.

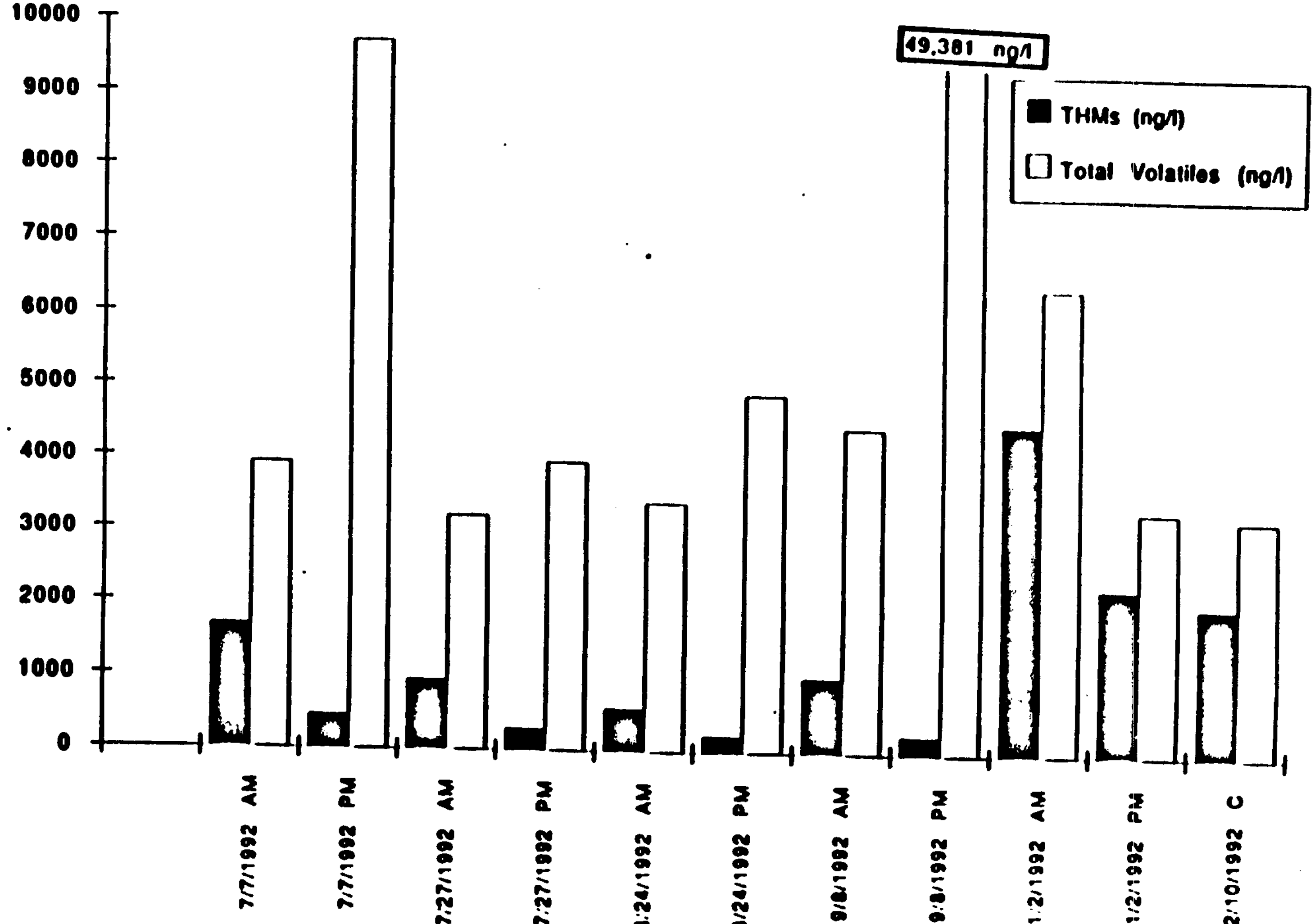
The drinking water MCLs are shown on Table 11 and indicate that the average value of the compound in these samples do not exceed their MCLs. One sample of methylene chloride does exceed its proposed standard in the 7/7 PM sample. The VOC compounds were over an order of magnitude less than the MCL for all the VOCs in each sample except for methylene chloride in the 7/7 PM sample. The data are also below the proposed Ocean Plan Standards (California State Water Resources Control Board, 1990a and b) as these standards are usually 5 times higher than drinking water standards even assuming no dilution and a one-month average value represented by each sampling date.

The levels of VOCs present from targeted quantifiable compounds are from 3 - 10 ug/l in 10 of the 11 samples analyzed in 6 days of sampling sometimes twice a day. Only in the sample with the 45.71ug/l, 4-methyl-2-pentanone is it higher (49.38ug/l). Figure 25 shows that the total haloforms account for > 50% of the targeted VOCs for 4 of the 11 samples. Sources of THMs include any chlorinated water that contains natural organic matter measured as organic carbon in mg C/l. This includes drinking water sources and cooling waters that are chlorinated for disinfection purposes. Haloform/Total VOC variability was the largest in these sets of storm drain samples as shown when comparing Figure 25 to Figures 16,19 and 22.

Figure 25 shows that the samples 7/7PM (high methylene chloride concentration) and 9/8/92 PM (high 4-methyl-2-pentanone concentration) have the highest levels of VOCs. Figure26 shows that methylene chloride was predominant in

Figure 25

THMs and Total Volatiles (ng/l) - Centinela



the 7/7 PM sample at the 8.2 ug/l level. Total aromatic hydrocarbons from fuel emissions like benzene and toluene were < 0.3 ug/l, less than Sepulveda and equivalent to the Pico/Kenter and Ballona samples. Ketones were below 1 ug/l for all the samples representing natural biota sources and oxygenated solvents except where the high level of 4-methyl-2-pentanone was present. Chlorinated solvents as represented by chloromethane were below 0.5 ug/l in all samples (Figure 27).

The variability of the data for AM vs PM samples as well as for weekly and monthly samples are shown for total volatiles and THMs (Figure 25), methylene chloride (Figure 26) and for 2 low molecular weight volatiles (chloromethane and carbon disulfide) found in many of the samples in ng/l concentrations (Figure 27). The AM/PM variability for total targeted quantifiable compounds was observed to be within a ppb for the 3 sample days that did not contain the high concentration of methylene chloride present (7/7) and 4-methyl-2-pentanone (11/2). THMs varied within 1-2 ppb for all AM/PM samples even when it was >50 % of the targeted VOCs (12/2). The weekly variability for THMs was observed to be 3 - 6 ppb. The weekly variability for methylene chloride was 0.5 - 5 ug/l.

Table 14 shows some non-targeted VOCs tentatively identified in a Centinela sample of 9/8/92. Figure 28 shows the unique GC/MS total ion current chromatogram of the sample with the high concentration of the ketone, 4-methyl-2-pentanone (common name = methyl, isobutyl ketone [MIBK]). Also, note that a tentatively identified GC/MS peak next to it is tentatively identified as 4-methyl-2-pentanol an oxidation product of the ketone. The internal standard (IS) in the sample is set at 5 ug/l. Thus, the pentanol is estimated to be at least 120 ug/l in this sample. The source of these compounds is not yet defined. MIBK is an industrial solvent. No drinking water or California ocean standards are available for these compounds.

In contrast to the low ug/l levels of VOCs, Figure 6 shows that the dissolved organic carbon levels are greater than 1,000 times. Apparently, higher molecular weight chemicals such as, humic materials, algal metabolites and oily materials are present. A new study is needed to assess the type of DOC present.

Figure 26

Methylene Chloride (ng/l) - Centinela

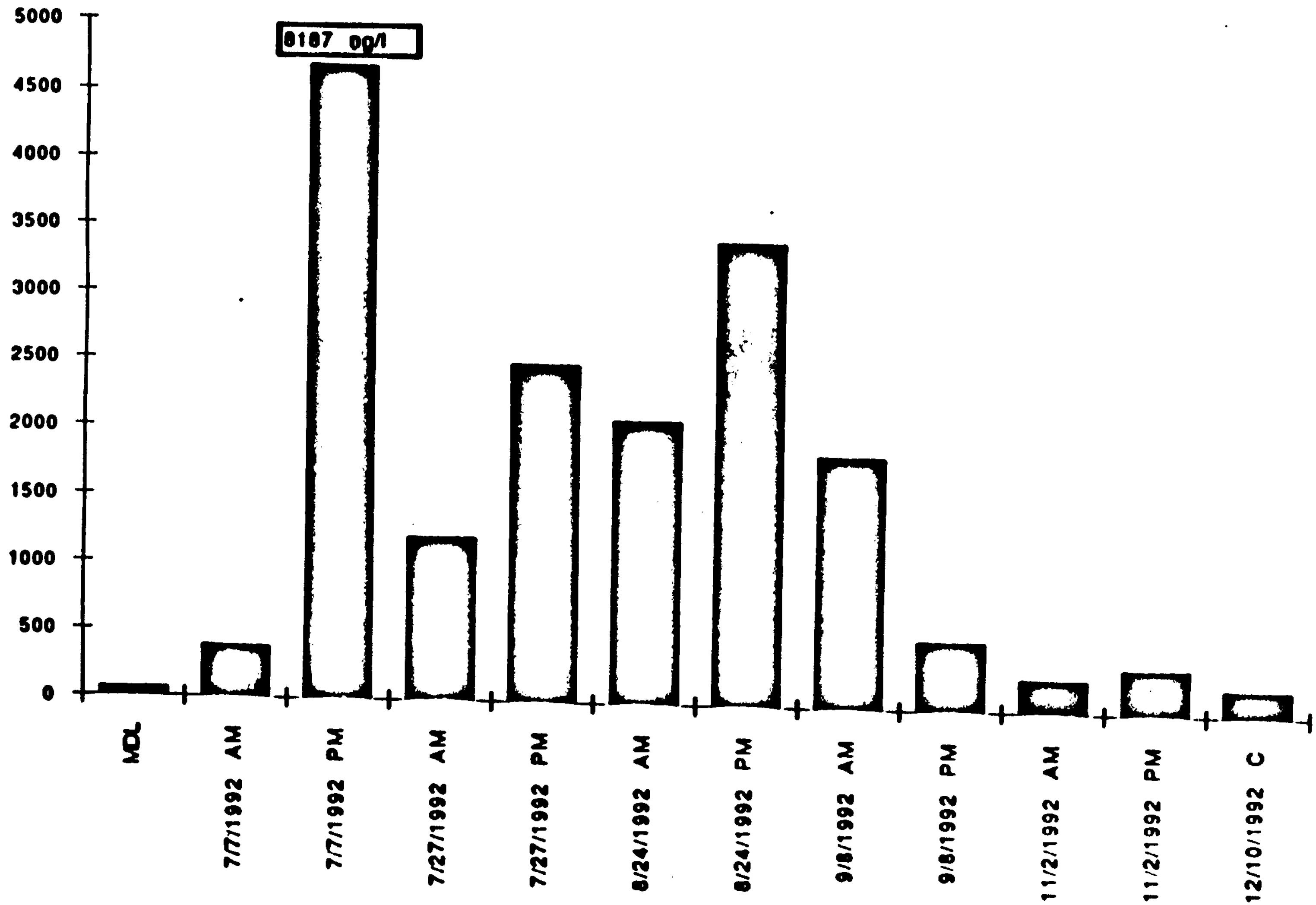


Figure 27

Chloromethane and Carbon Disulfide (ng/l) - Centinela

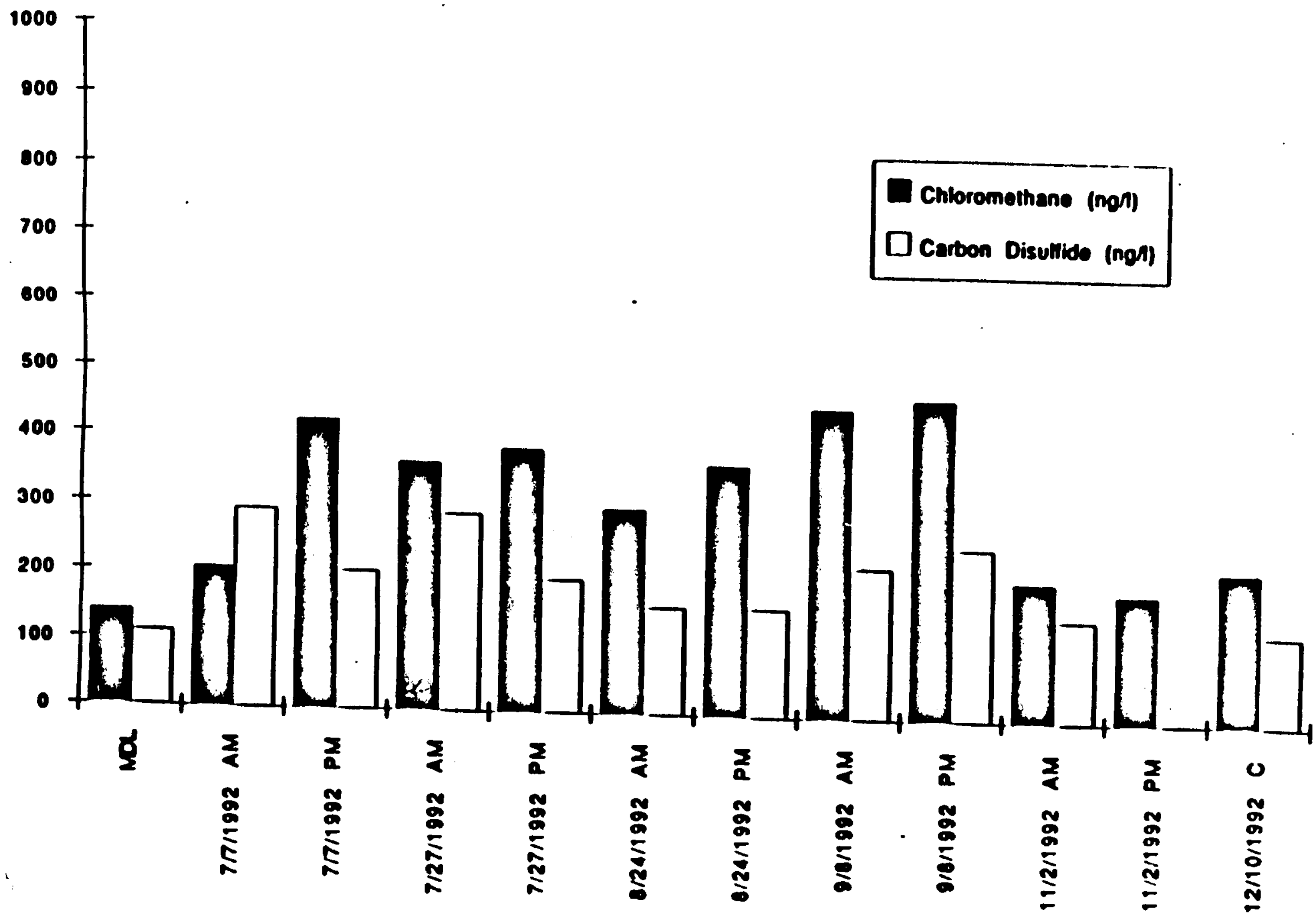
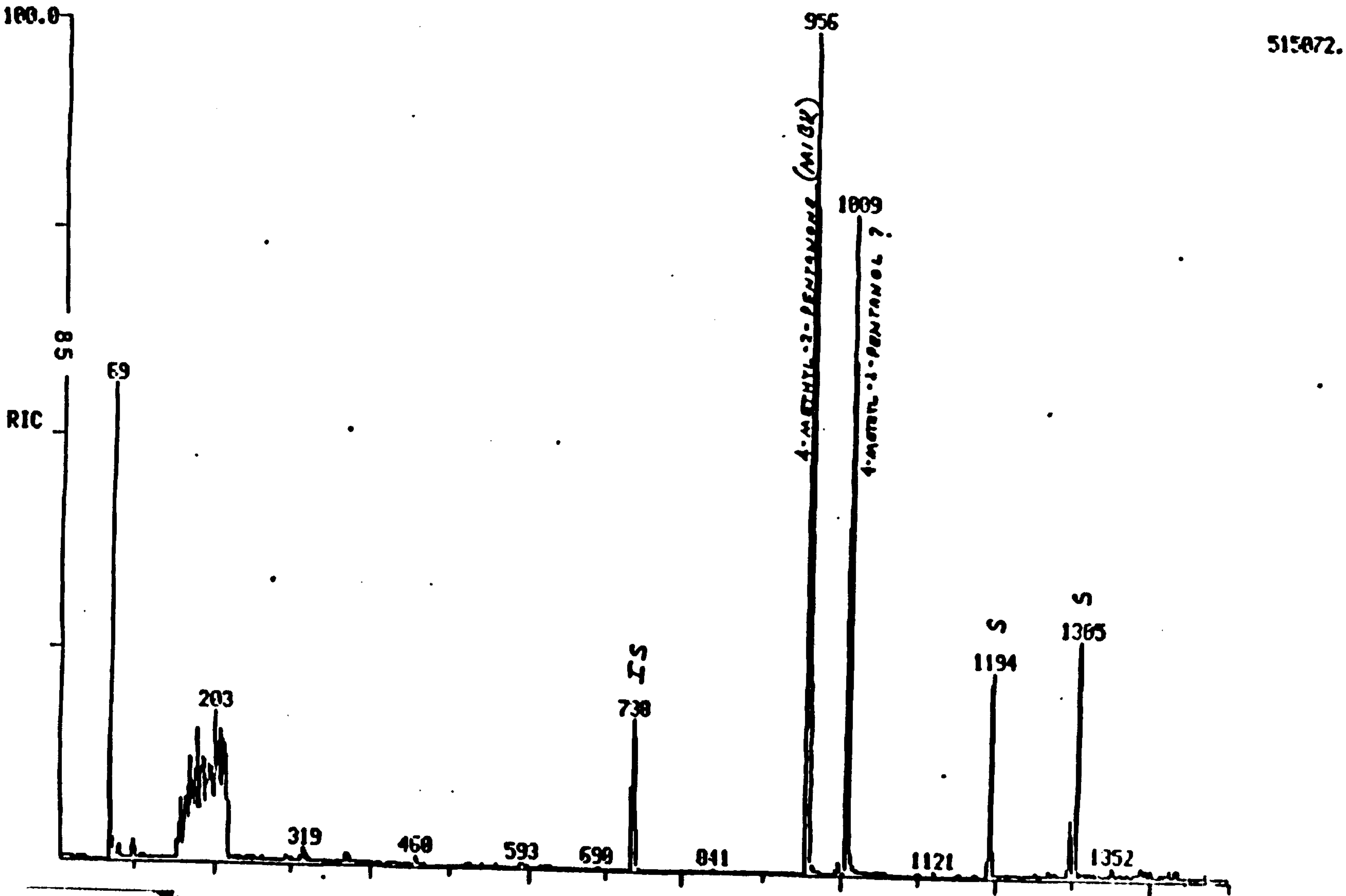


Figure 28

GC/MS Total Ion Chromatogram of a VOC of 9/8/92 -- Centinela



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Ashland - Volatile Organic Compounds (VOCs)

The Ashland storm drain was the only drain that indicated high tidal influence as observed by measurements of salinity and conductivity, Figures 9 and 5, respectively and low oxygen content of the water, Figure 9. This effects the dilution of the sample, the types of trihalomethanes that are present in the sample and the chemicals effected by low oxygen content. The salt concentration in the samples also enables more efficient purge and trap analysis which would increase the concentration of volatiles found by analysis of those samples. Also, Ashland was the only drain which must fill sufficiently before it can flow to the ocean. The residence time in the storm drain and the associated oxygen content of the water present effected the type of chemical present in the storm drain as chemical and microbiological reactions can occur. Sampling could only be completed when sufficient sample was present. Sampling was not possible on 9/8 and 6/12/92. It was beyond the scope of this study to devote the manpower and time to clearly define the flow pattern, filling time, discharge time, anerobiosis or sea water tidal effect during this study, except by measurement of dissolved solids, conductivity and dissolved oxygen in the sample itself when it was taken in the field. A complete study of these factors as it relates to chemicals is suggested for further study. A continuous flow and chemical parameter monitoring station would be needed with sufficient control of the site to minimize vandalism at a highly visible location.

Table 12 shows 27 targeted VOCs were present above their MDLs in 14 samples collected over a 6 month dry weather flow period 6/12-12/10/92. This represents the most compounds identified in a storm drain site. Methylene chloride, a notorious laboratory contaminant, was 1 of 8 compounds that averaged above a ppb. Thirteen compounds in different samples were quantified to be above 1 ppb; methylene chloride, carbon disulfide, the 3 ketones, 7 aromatic hydrocarbons, dibromomethane, and the 4 haloforms. The drinking water MCLs are shown on Table 12 and indicate that only, methylene chloride exceeded its proposed standard. However, care for the potential artifact methylene chloride should be exercised before conclusions are drawn about methylene chloride. Further analysis of of this specific compound under rigorously controlled field and lab conditions are warranted in a special study to confirm these findings. Some of the remaining compounds were within an order of magnitude of the MCL for any sample. The Ashland drain represents the most contaminated drain, yet the drain with the lowest flow rate. The quantitative data are

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further below the proposed Ocean Plan Standards (California State Water Resources Control Board, 1990a and b) as these standards are usually 5 times higher than drinking water standards even assuming no dilution and a one-month average value represented by each sampling date.

Table 12 shows that the range of concentrations for each targeted quantifiable compounds for 8 days of sampling sometimes twice a day for 6 months was larger than for the other storm drains. The total volatiles varied from 3 to 11 ug/l for 7 sampling days of 8. The two 7/7/92 sample showed a much higher level (34 and 156 ug/l) of VOCs were present. Figure 29 shows that the total haloforms account for >50 % for 6 samples of the 14 samples with 877 and 19 ug/l of THMs in the two 7/7/92 samples. Figure 30 shows that methylene chloride was predominant in the sample of 7/7 AM. The concentrations present was 66 ug/l.

Total aromatic hydrocarbons from fuel emissions such as benzene and toluene were the highest in any storm drain at > 1 ug/l with a higher level in the 9/8 AM sample of 7 ppb (Figure 31) as were ketones which were 1 ug/l for 10 of 14 samples (See Figure 32) representing natural biota sources and oxygenated solvents. Chlorinated solvents from sources as dry cleaning were also the highest levels present in the storm drains.

The variability of the data for AM vs PM samples as well as for weekly and monthly samples are shown for total volatiles and THMs (Figure 29), methylene chloride (Figure 30) for total aromatic hydrocarbons (Figure 31), total ketones (Figure 32) and for 2 low molecular weight volatiles (chloromethane and carbon disulfide) found in many of the samples in ng/l concentrations (Figure 33). The AM/PM variability for targeted quantifiable compounds was observed to be 1-6 ppb for total volatiles (excluding sample 7/7), again the largest for any drain. The relative THMs/total volatiles concentration and THMs varied more between AM and PM samples than for any other drain especially for the samples of 7/7/92.

Figure 34 shows that the 7/7 AM sample contained >60% bromoform and the 11/2 PM sample contained >25% bromoform. It is hypothesized that this indicates that sea water reacted with haloforms and this may be the cause of more bromoform in this sample. The source of the sea water can be as small as a pool in the drain during low flow.

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Figure 29

THMs and Total Targeted Volatiles (ng/l) - Ashland

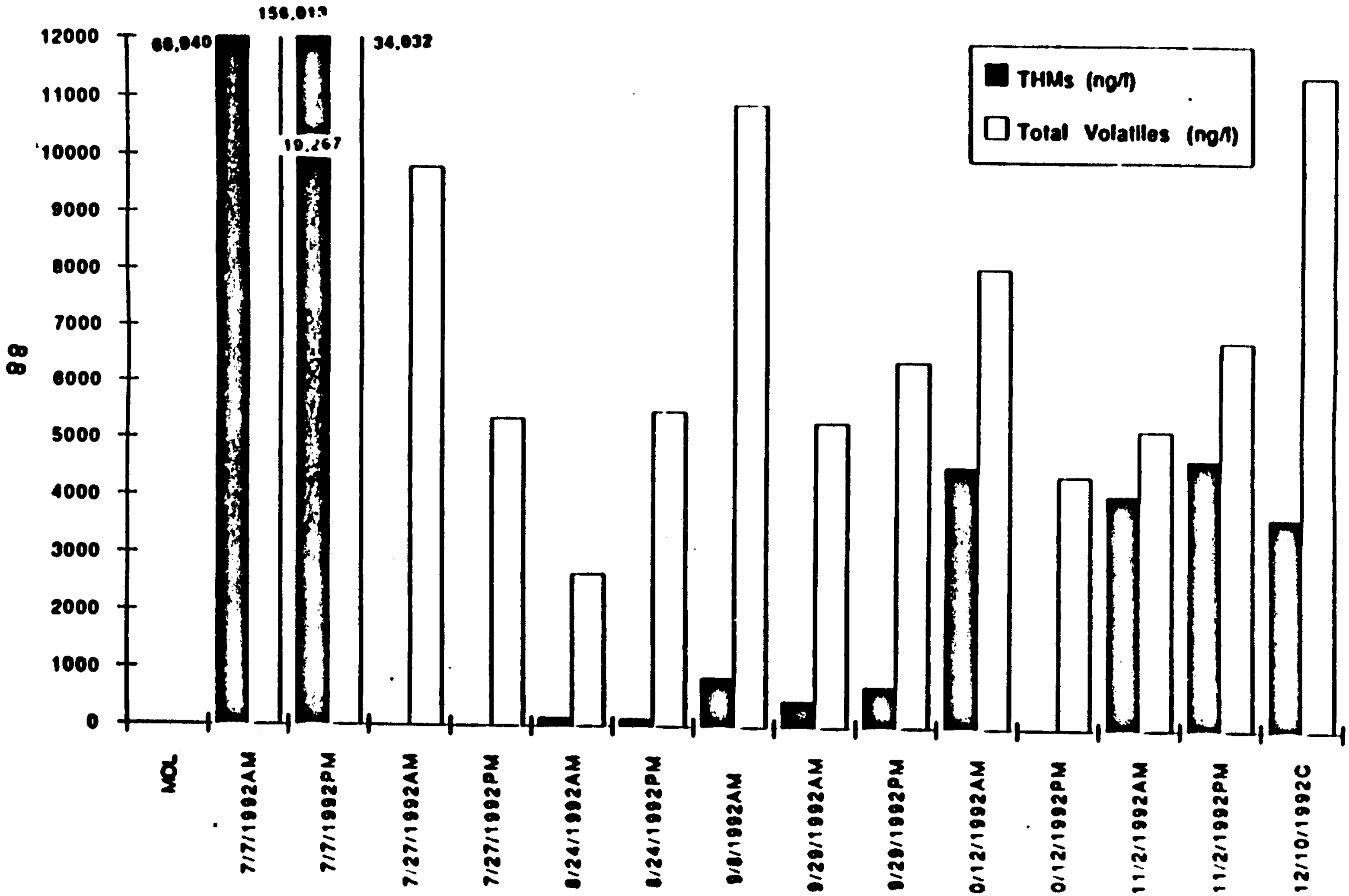

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Figure 30

Methylene Chloride (ng/l) - Ashland

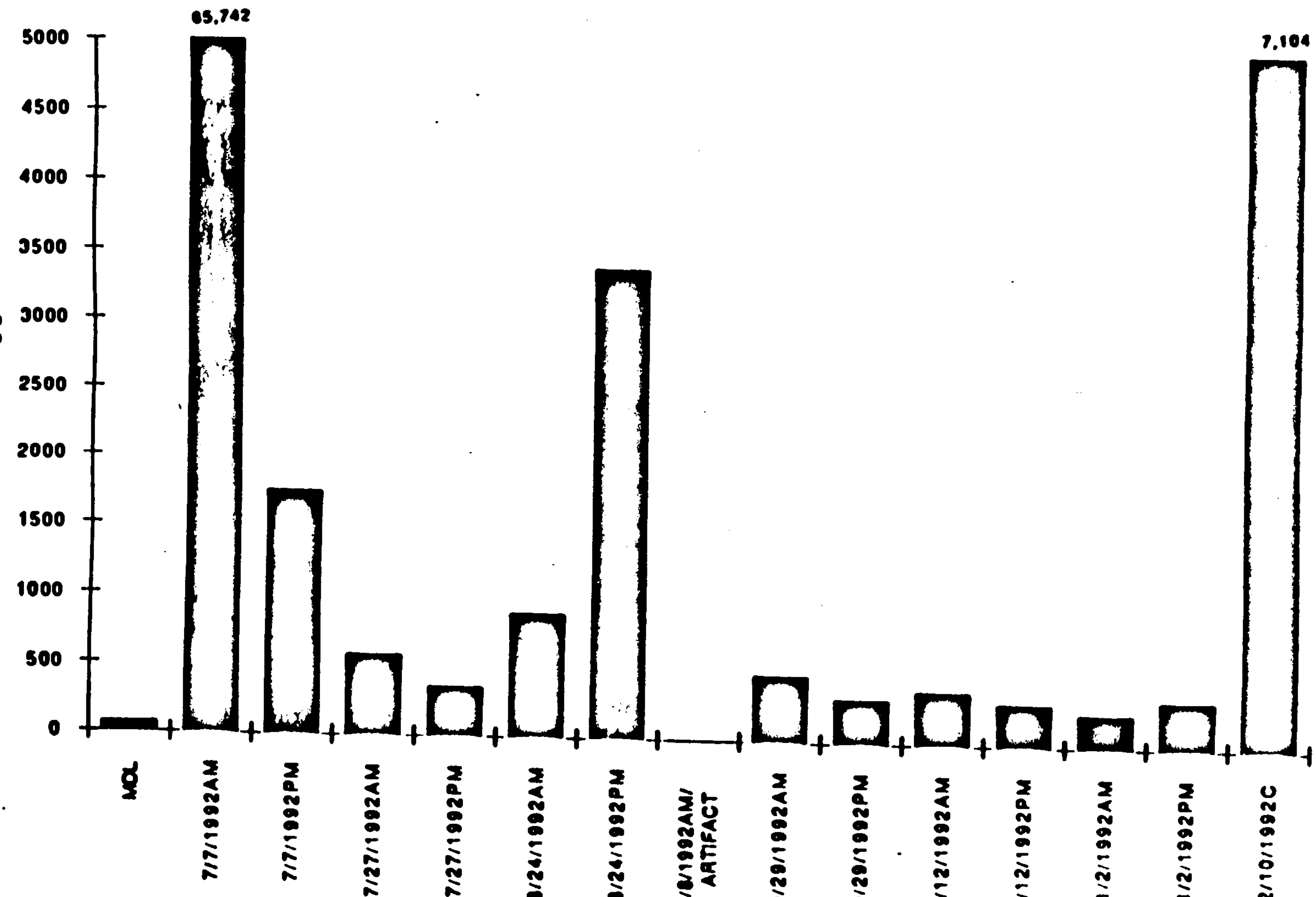

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Figure 31

Total Aromatic Hydrocarbons (ng/l) - Ashland

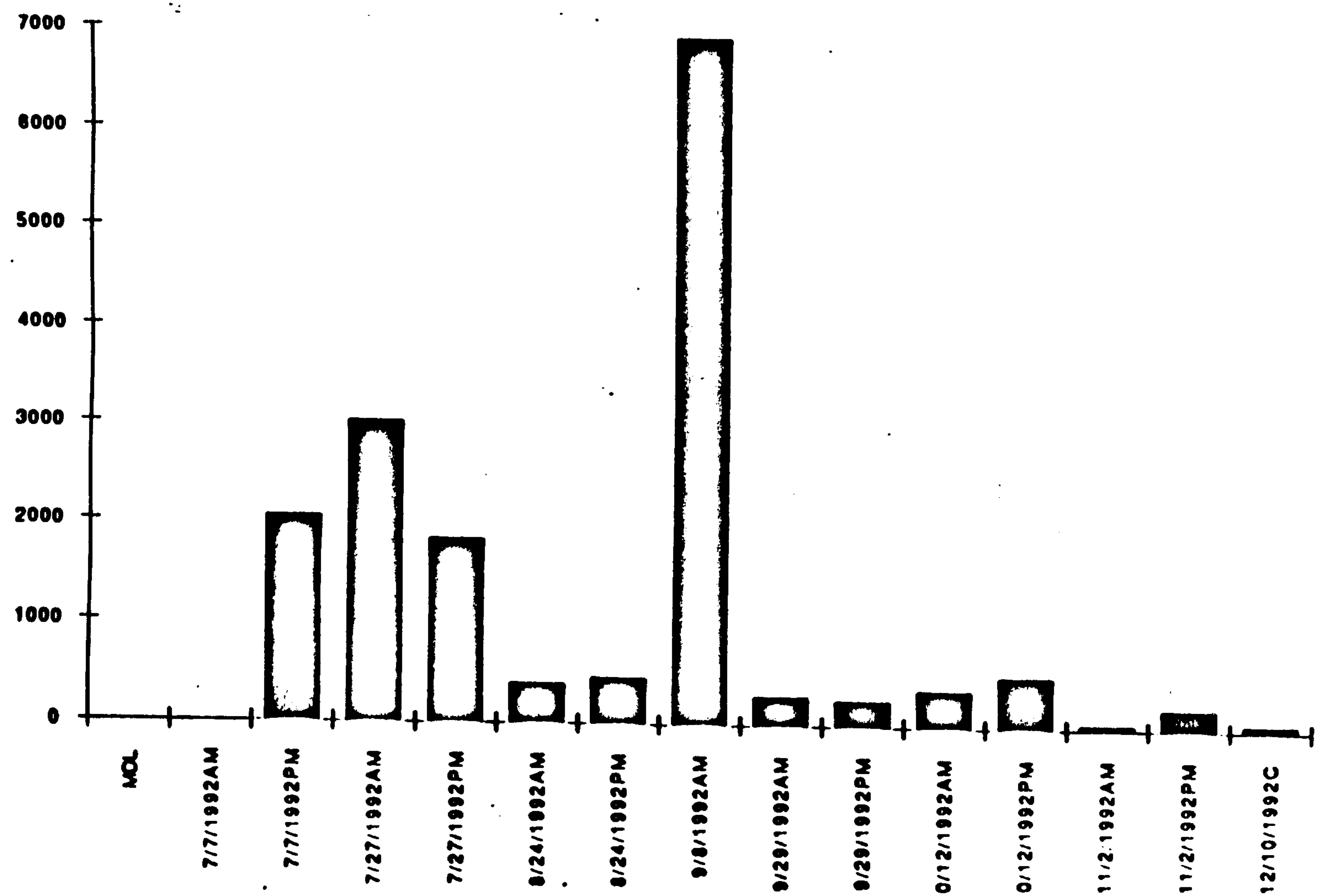

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Figure 32

Total Ketones (ng/l) - Ashland

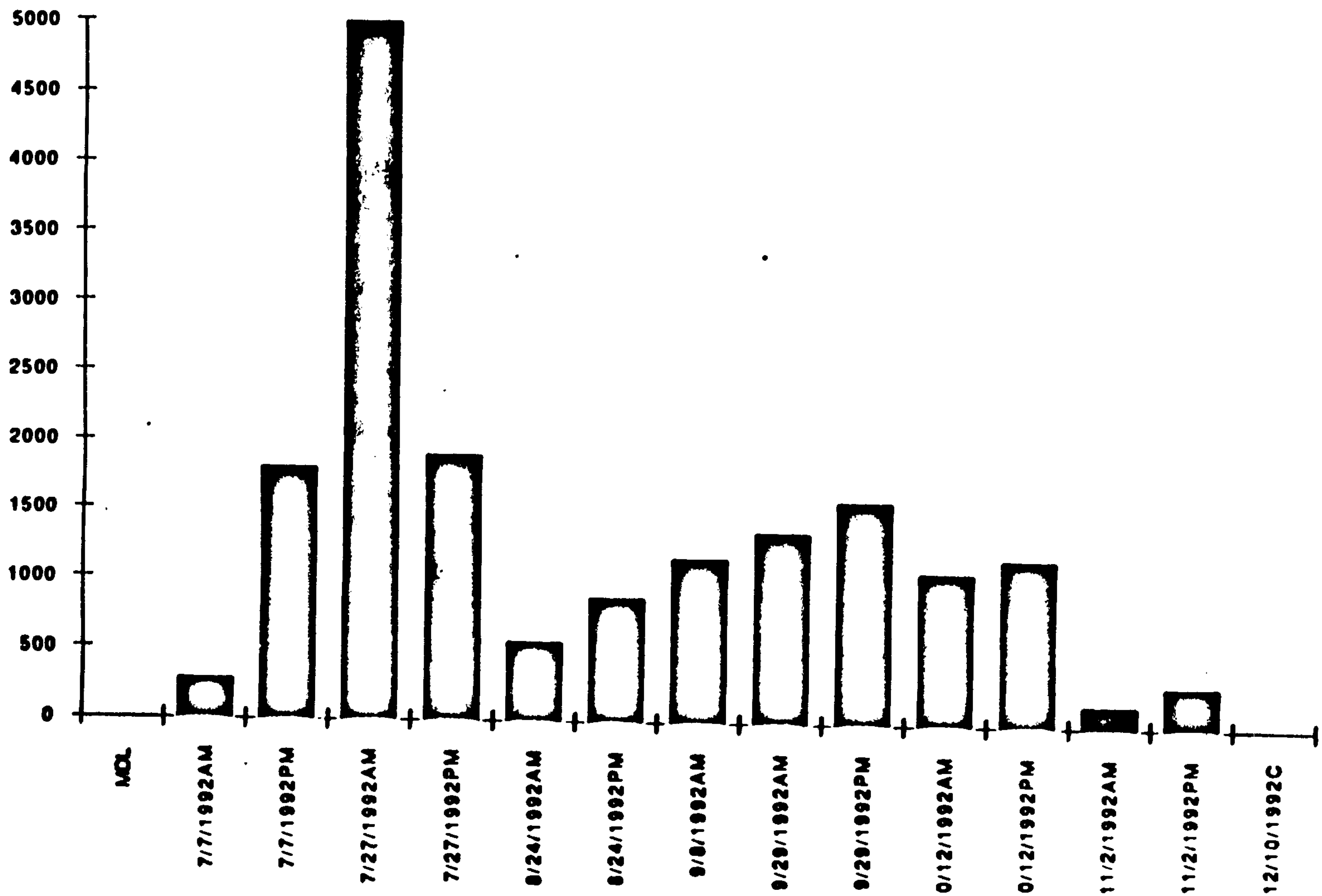

Figure 33

Chloromethane and Carbon Disulfide (ng/l) - Ashland

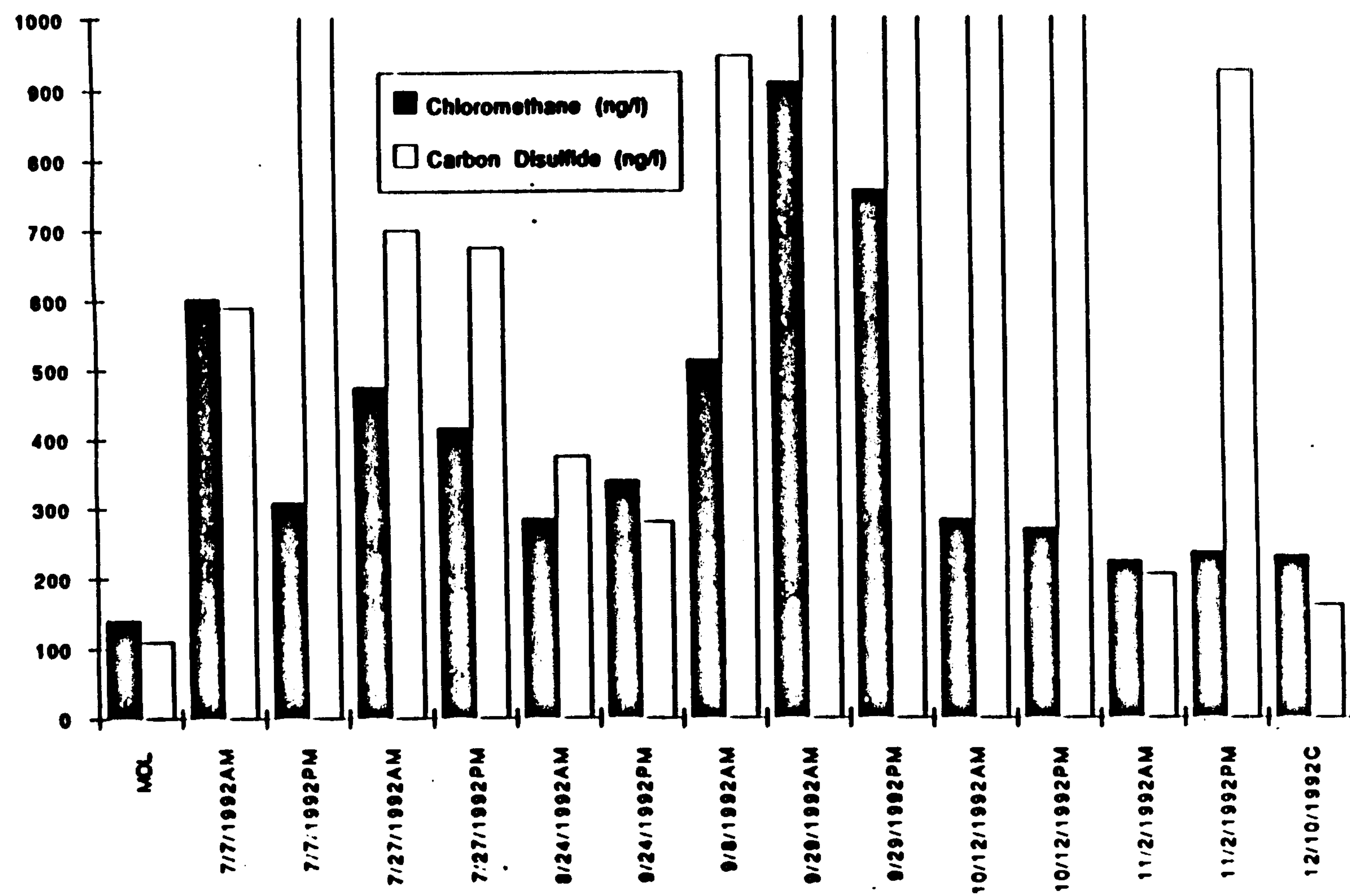

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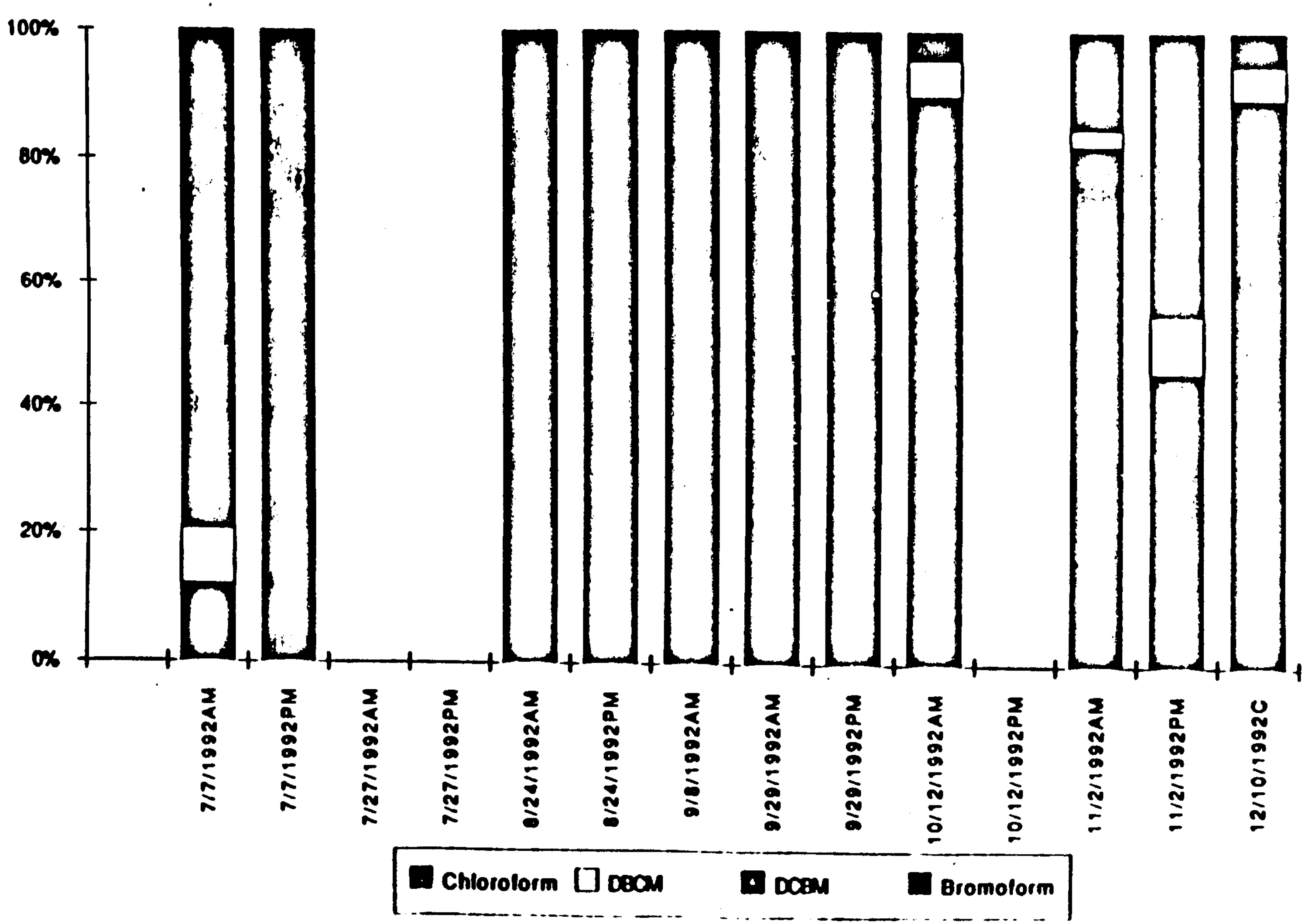
Figure 34

Form of Trihalomethanes - Ashland



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Ashland samples were selected for more complete analysis of non-targeted compounds to obtain an indication of what other compounds could be present. The complex total ion chromatograms in Appendix V and Table 14 show that some interesting 70 non-targeted compounds were tentatively identified by GC/MS in these samples. The primary type of compounds present were complex oily/petroleum hydrocarbon related alkanes and alkenes of straight chain, cyclic and aromatic nature. Also, sulfur compounds, dimethyl disulfide and 2-methyl furan were observed. Dimethyl disulfide is an anoxic product of biological decay. Naphthalenes, from potential street tar runoff and octyl and nonyl phenols possibly from detergent break-down were also observed. This suit of compounds indicates higher concentrated materials than the other drains due to the configuration and flow pattern of the drain.

Comparison of All Sample Sites - Volatile Organic Compounds

Table 13 compares the average tabulated VOC data for each site and overall grand average for all sites based upon occurrence >MDL. The drinking water MCLs are shown on Table 3 and indicate that only methylene chloride (dichloromethane) exceeds its MCL standard at Ashland Avenue. Resampling for the potential artifact methylene chloride should be completed before conclusions are drawn about it. The Ashland drain represents the most contaminated drain, yet it is the drain with the lowest flow rate. Some of VOCs present were within an order of magnitude of the EPA Drinking Water MCLs for a given sample. The quantitative data for each drain and the grand averages are below the proposed California Ocean Plan Standards (CA State Water Resources Control Board, 1990 a and b) even assuming no dilution and a one-month average value represented by each sampling date. This data indicates the targeted VOCs under dry weather flow are not a major problem. Primary interest is the further evaluation of nontarget compounds in other samples.

Base Neutral Organic Chemical Analysis

Tables 15 - 20 present the summary of the total concentrations of Base Neutral (BN) Organic Compounds (b.p. >100 °C) that were quantified at the ng/l level (ppt). Appendix VI (Table VI. 1-5) shows the complete data set for each sampling day at each site. The total concentration is the soluble chemicals plus the chemicals associated with the particulates that are present in the sample. Samples from the 5

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Table 15

BASE NEUTRALS ANALYSIS - PICO-KENTER SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (11 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Phenol	7	1,204	30-4073		
2-Methylphenol	1	8	-		
4-Methylphenol	6	2,649	38-9749		
2-Nitrophenol	8	455	9-3451		
Benzoic Acid	6	920	196-1707		
4-Chloro-3-methylphenol	0	<MDL	-		
4-Nitrophenol	1	3,903	-		
1,4-Dichlorobenzene(*)	10	66	33-127	75,000	18,000(c)
N-Nitrosodi-n-propylamine	0	<MDL	-		
Nitrobenzene	2	30	15-46		
Isophorone	1	1	-		4,900(d)
Naphthalene(*)	10	98	37-160		150,000,000(d)
2-Methylnaphthalene	10	57	23-105		
Acenaphthylene	0	<MDL	-		
Dimethyl phthalate	3	14	2-28		8.8(c,f)
Acenaphthene	1	4	-		820,000,000(d)
Dibenzofuran	4	5	4-7		
Fluorene	7	4	2-8		
Diethyl phthalate(*)	10	187	76-236		8.8(c,f)
4-Chlorophenyl phenyl ether	8	37	14-82		33,000,000(d)
N-Nitrosodiphenylamine	1	161	-		
Azobenzene	9	25	12-47		2,500(c)
Phenanthrene	9	46	6-165		
Anthracene	5	22	1-33		8.8(c,f)
Di-n-butyl phthalate(*)	10	1,046	445-1,905		8.8(c,f)
Fluoranthene	8	59	5-327		
Pyrene	8	69	6-211		
Butyl benzyl phthalate(*)	11	962	265-1,006		8.8(c,f)
Benz(a)anthracene	4	32	10-75		

Table 15 CONTINUATION

BASE NEUTRALS ANALYSIS - PICO-KENTER SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (11 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Chrysene(*)	4	69	1-185		8.8(c,f)
Bis(2-ethylhexyl) phthalate(*)	11	6,800	1,241-28,173	6,000	3,500(c)
Di-n-octyl phthalate(*)	10	4,249	11-39,206		
Benzo(b)fluoranthene	2	37	10-64		
Benzo(k)fluoranthene	3	14	2-30		8.8(c,f)
Benzo(a)pyrene	4	41	4-128	200	8.8(c,f)
Indeno(1,2,3,4-c,d)pyrene	1	7	-		8.8(c,f)
Dibenzo(a,h)anthracene	0	<MDL	-		8.8(c,f)
Benzo(g,h,i)perylene	0	<MDL	-		

(a) USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b) California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27 Adopted and effective March 22, 1990.

(c) California Ocean Plan, Carcinogen

(d) California Ocean Plan, Non-Carcinogen

(e) Sum of 1,2 and 1,3-dichlorobenzenes

(f) Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*) Values are compared versus blank instead of the MDL.

Table 16

BASE NEUTRALS ANALYSIS - CENTINELA SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (8 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Phenol	3	83	6-125		
2-Nitrophenol	5	30	7-49		
Benzoic Acid	5	584	38-1194		
4-Chloro-3-methylphenol	0	<MDL	-		
1,4-Dichlorobenzene(*)	7	44	2-77	75,000	18,000(c)
Nitrobenzene	1	29	-		
Isophorone	2	52	37-68		
Bis(2-chloroethoxy)methane	0	<MDL	-		4,400(d)
Naphthalene(*)	7	90	6-130		
2-Methylnaphthalene	7	53	3-73		
2-Chloronaphthalene	0	<MDL	-		
Dimethyl phthalate	3	20	3-31		820,000,000(d)
Acenaphthene	3	5	3-7		
Dibenzofuran	4	8	2-16		
Fluorene	3	13	4-24		8.8(c,f)
Diethyl phthalate(*)	8	216	6-730		33,000,000(d)
4-Chlorophenyl phenyl ether	6	24	1-37		
Azobenzene	6	14	1-20		
Phenanthrene	5	23	1-65		8.8(c,f)
Anthracene	4	107	1-406		8.8(c,f)
Di-n-butyl phthalate(*)	8	816	70-1931		3,5000,000(d)
Fluoranthene	5	9	1-17		15,000(d)
Pyrene(*)	5	145	1-665		8.8(c,f)
Butyl benzyl phthalate(*)	8	708	62-1606		
Benz(a)anthracene	3	22	10-38		
Chrysene(*)	4	181	11-654		8.8(c,f)
Bis(2-ethylhexyl) phthalate(*)	8	6240	807-32055	6,000	3,500(c)
Di-n-octyl phthalate(*)	8	59	4-147		
Benzo(b)fluoranthene	2	2	2-3		

Table 16 CONTINUATION

BASE NEUTRALS ANALYSIS - CENTINELA SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (8 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Benzo(k)fluoranthene	2	2	1-3		8.8(c,f)
Benzo(a)pyrene	4	145	4-546	200	8.8(c,f)

(a) USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b) California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90 Adopted and effective March 22, 1990.

(c) California Ocean Plan, Carcinogen

(d) California Ocean Plan, Non-Carcinogen

(e) Sum of 1,2 and 1,3-dichlorobenzenes

(f) Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*) Values are compared versus blank instead of the MDL.

Table 17

BASE NEUTRALS ANALYSIS - SEPULVEDA SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (9 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Phenol	5	100	33-290		
2-Nitrophenol	5	27	13-49		
Benzoic Acid	5	501	226-810		
1,4-Dichlorobenzene(*)	8	58	34-117	75,000	18,000(c)
Isophorone	1	17	-		150,000,000(d)
Naphthalene(*)	8	102	38-153		
2-Methylnaphthalene	8	58	26-100		
2-Chloronaphthalene	1	1	-		
2-Nitroaniline	0	<MDL	-		
Dimethyl phthalate	2	26	23-30		820,000,000(d)
Acenaphthene	2	30	8-53		
Dibenzofuran	4	7	2-12		
Fluorene	5	43	2-190		8.8(c,f)
Diethyl phthalate(*)	8	201	88-420		33,000,000(d)
4-Chlorophenyl phenyl ether	7	22	15-34		
Azobenzene	4	21	9-29		
Phenanthrene	7	26	8-43		8.8(c,f)
Anthracene	4	1046	2-4,177		8.8(c,f)
Di-n-butyl phthalate(*)	8	1223	570-2,782		
Fluoranthene	6	19	5-33.		15,000(d)
Pyrene(*)	8	956	4-7,560		8.8(c,f)
Butyl benzyl phthalate(*)	9	1148	408-3,271		
Benz(a)anthracene	4	14	9-17		
Chrysene(*)	4	2016	3-8,032		8.8(c,f)
Bis(2-ethylhexyl) phthalate(*)	9	4349	2,783-5,400	6,000	3500(c)
Di-n-octyl phthalate(*)	8	391	2-1,902		
Benzo(b)fluoranthene	2	20	1-38		
Benzo(k)fluoranthene	1	39	-		8.8(c,f)
Benzo(a)pyrene	3	1803	3-5,398	200	8.8(c,f)

Table 17 CONTINUATION

BASE NEUTRALS ANALYSIS - SEPULVEDA SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (9 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Indeno(1,2,3,4-c,d)pyrene	1	71	-		8.8(c,f)
Dibenzo(a,h)anthracene	1	59	-		8.8(c,f)
Benzo(g,h,i)perylene	1	58	-		

(a) USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b) California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c) California Ocean Plan, Carcinogen

(d) California Ocean Plan, Non-Carcinogen

(e) Sum of 1,2 and 1,3-dichlorobenzenes

(f) Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*) Values are compared versus blank instead of the MDL.

Table 18

BASE NEUTRALS ANALYSIS - BALLONA SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (10 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Phenol	7	166	29-749		
2-Methylphenol	0	<MDL	-		
4-Methylphenol	0	25	-		
2-Nitrophenol	7	42	27-72		
Benzoic Acid	5	543	111-961		
1,4-Dichlorobenzene(*)	9	75	38-146	75,000	18,000(c)
Benzyl alcohol	1	459	-		
N-Nitrosodi-n-propylamine	1	3	-		
Nitrobenzene	2	24	7-40		
Isophorone	2	33	19-47		4,900(d)
Naphthalene(*)	9	99	61-138		150,000,000(d)
2-Methylnaphthalene	9	53	33-60		
Acenaphthylene	0	<MDL	-		
Dimethyl phthalate	4	27	4-70		8.8(c,f)
Acenaphthene	1	3	-		820,000,000(d)
Dibenzofuran	3	7	6-10		
Fluorene	4	5	3-6		
Diethyl phthalate(*)	10	214	99-378		8.8(c,f)
4-Chlorophenyl phenyl ether	7	28	7-53		33,000,000(d)
Azobenzene	7	17	5-26		
Phenanthrene	9	17	5-39		
Anthracene	2	23	6-39		8.8(c,f)
Di-n-butyl phthalate(*)	10	1337	679-1,947		8.8(c,f)
Fluoranthene	8	9	3-21		3,500,000(d)
Pyrene(*)	9	21	2-126		15,000(d)
Butyl benzyl phthalate(*)	10	1248	217-2245		8.8(c,f)
Benz(a)anthracene	5	22	9-46		
Chrysene(*)	3	61	13-145		
Bis(2-ethylhexyl) phthalate(*)	9	4518	2,248-7,120	6,000	8.8(c,f) 3,500

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Table 18 CONTINUATION

BASE NEUTRALS ANALYSIS - BALLONA SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (10 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Di-n-octyl phthalate(*)	9	1442	17-3,655		
Benzo(b)fluoranthene	1	4	-		
Benzo(k)fluoranthene	1	5	-		8.8(c,f)
Benzo(a)pyrene	4	47	18-106	200	8.8(c,f)
Indeno(1,2,3,4-c,d)pyrene	0	<MDL	-		8.8(c,f)
Dibenzo(a,h)anthracene	0	<MDL	-		8.8(c,f)
Benzo(g,h,i)perylene	0	<MDL	-		

(a) USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.
(b) California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.
(c) California Ocean Plan, Carcinogen
(d) California Ocean Plan, Non-Carcinogen
(e) Sum of 1,2 and 1,3-dichlorobenzenes
(f) Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L
(*) Values are compared versus blank instead of the MDL.

Table 19

BASE NEUTRALS ANALYSIS - ASHLAND AVE SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (8 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Phenol	5	162	65-375		
2-Methylphenol	0	<MDL	-		
4-Methylphenol	3	1042	20-2764		
2-Nitrophenol	5	38	21-74		
2,4-Dimethylphenol	2	365	238-492		
Benzoic Acid	6	472	60-1518		
4-Chloro-3-methylphenol	1	9	-		
2,4,6-Trichlorophenol	0	<MDL	-		290(c)
2,4,5-Trichlorophenol	0	<MDL	-		
1,4-Dichlorobenzene(*)	6	68	32-107	75,000	18,000(c)
1,2-Dichlorobenzene	0	<MDL	-	600,000	5,100,000(e)
Benzyl alcohol	2	896	533-1258		
Nitrobenzene	2	230	204-257		4,900(d)
Isophorone	3	42	10-75		150,000,000(d)
Naphthalene(*)	7	85	48-126		
2-Methylnaphthalene	7	43	30-57		
2-Nitroaniline	1	463	-		
Dimethyl phthalate	4	31	2-102		820,000,000(d)
Acenaphthene	2	6	5-6		
Dibenzofuran	4	11	5-16		
Fluorene	3	13	6-18		8.8(c,f)
Diethyl phthalate(*)	7	463	124-1110		33,000,000(d)
4-Chlorophenyl phenyl ether	7	34	19-44		
Azobenzene	6	34	11-63		
Phenanthrene	7	62	20-152		8.8(c,f)
Anthracene	4	38	4-125		8.8(c,f)
Di-n-butyl phthalate(*)	7	3050	637-13,667		3,500,000(d)
Fluoranthene	7	49	10-94		15,000(d)
Pyrene(*)	7	87	14-295		8.8(c,f)

Table 19 CONTINUATION

BASE NEUTRALS ANALYSIS - ASHLAND AVE SAMPLES (JULY 7 - DEC 10, 1992)

CHEMICAL NAME	Number Found Above MDL & Blank (8 Samples)	Average (ng/L)	Range (ng/L)	Drinking Water Standards(a) (ng/L)	Ocean Standards(b) (ng/L)
Butyl benzyl phthalate(*)	7	1486	631-2,500		
Benz(a)anthracene	3	32	21-51		
3,3'-Dichlorobenzidine	0	<MDL	-		
Chrysene(*)	4	126	11-391		8.8(c,f)
Bis(2-ethylhexyl) phthalate(*)	5	14765	8,445-24,668	6,000	3,500(c)
Di-n-octyl phthalate(*)	6	3054	406-15,488		
Benzo(b)fluoranthene	4	24	8-49		
Benzo(k)fluoranthene	3	25	10-46		8.8(c,f)
Benzo(a)pyrene	3	162	19-393	200	8.8(c,f)
Indeno(1,2,3,4-c,d)pyrene	3	40	5-95		8.8(c,f)
Dibenzo(a,h)anthracene	3	39	8-97		8.8(c,f)
Benzo(g,h,i)perylene	2	71	16-125		

(a) USEPA Drinking Water Standards reported by the AWWA Journal, Feb. 1993, p. 48.

(b) California Ocean Plan, 1990, State of California, State Water Resources Control Board, Resolution No. 90-27, Adopted and effective March 22, 1990.

(c) California Ocean Plan, Carcinogen

(d) California Ocean Plan, Non-Carcinogen

(e) Sum of 1,2 and 1,3-dichlorobenzenes

(f) Sum of polynuclear aromatic hydrocarbons (PAHs) including all PAHs listed and 1,2 benzanthracene and 3,4-benzofluoranthene = 8.8 ng/L

(*) Values are compared versus blank instead of the MDL.

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Table 20

Base Neutral Analysis - Grand Total (6/12-12/10/92)

CHEMICAL	Ashland Average Conc ng/L	Pico Kenter Average Conc ng/L	Sepulveda Average Conc ng/L	Ballona Average Conc ng/L	Cent. Ave Conc ng/L	GRAND AVE. Conc ng/L	GRAND S.D. ng/L	NUMBER OF SAMPLES >MDL
Acenaphthene*	6	4	30	3	5	10	16	9
Anthracene*	38	22	1,046	23	107	257	954	19
Azobenzene	34	25	21	17	14	21	14	23
Benz(a)anthracene*	32	32	14	22	22	27	19	15
Benzo(b)fluoranthene*	24	37	20	4	2	20	21	11
Benzo(k)fluoranthene*	25	14	39	5	2	18	18	7
Benzoic acid	472	920	501	543	584	523	393	21
Benzo(g,h,i)perylene*	71		58			66	55	3
Benzo(a)pyrene*	162	41	1,803	47	145	400	1,297	17
Benzyl alcohol	896			459		750	441	3
Bis(2-ethylhexyl)phthalate	14,765	6,800	4,349	4,518	6,240	6,627	7,013	42
Butyl benzyl phthalate	1,486	962	1,148	1,248	708	1,088	730	44
4-Chloro-3-methylphenol	9					9	0	1
2-Chloronaphthalene			1			1	0	1
4-Chlorophenyl phenyl ether	34	37	22	28	24	30	16	34
Chrysene*	126	69	2,016	61	181	513	1,828	19
Dibenzo(a,h) anthracene*	39		59			44	43	4
Dibenzofuran*	11	5	7	7	8	8	4	19
Di-n-butyl pththalate	3,050	1,046	1,223	1,337	816	1,421	1,967	44
1,4-Dichlorobenzene	68	66	58	75	44	63	31	40
Diethyl phthalate	463	187	201	214	216	247	209	43
2,4-Dimethylphenol	365					365	180	2
Dimethyl phthalate	31	14	26	27	20	22	28	16
Di-n-octyl phthalate	3,054	4,249	391	1,442	59	1,888	6,504	41
Fluoranthene*	49	59	19	9	9	31	58	34
Fluorene*	13	4	43	5	13	22	49	27
Indeno(1,2,3,4-c,d)pyrene*	40	7	71			39	41	5
Isophorone	42	1	17	33	52	35	26	9
2-Methylnaphthalene*	43	57	58	53	53	54	21	41
2-Methylphenol		8				8	0	1
4-Methylphenol	1,042	2,649		25		1,905	3,317	10
Naphthalene*	85	98	102	99	90	98	38	34
2-Nitroaniline	463					463	0	1
Nitrobenzene	230			24	29	51	70	7
2-Nitrophenol	38	455	27	42	30	147	624	30
4-Nitrophenol		3,903				3,903	0	1
N-Nitrosodiphenylamine		161				161	0	1
N-Nitrosodi-n-propylamine				3		3	0	1
Phenanthrene*	62	46	26	17	23	29	31	30
Phenol	162	1,204	100	166	83	465	1,145	22
Pyrene*	87	69	956	21	145	263	1,239	37

Grand Average = Concentrations of compounds that are found >MDL/number of samples.

Note: Only compounds that were found >MDL were averaged

* = Polyaromatic Hydrocarbon (PAH)

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Table 21

TARGET LIST OF BASE NEUTRAL COMPOUNDS

Base Neutral Target List CHEMICAL NAME:	Water MDL (ng/L)	Water Blank (ng/L)	Sus.Sed. MDL (ng/g)	Sus.Sed. Blank (ng/g)
Phenol	1510		1.51	
2-Chlorophenol	?		?	
2-Methylphenol	443		0.443	
4-Methylphenol	491		0.491	
2-Nitrophenol	639		0.639	
2,4-Dimethylphenol	404		0.404	
2,4-Dichlorophenol	608		0.608	
Benzoic Acid	4000		4	
4-Chloro-3-methylphenol	548		0.548	
2,4,6-Trichlorophenol	579		0.579	
2,4,5-Trichlorophenol	2100		2.1	
2,4-Dinitrophenol	4100		4.1	
4-Nitrophenol	6200		6.2	
2-Methyl-4,6-dinitrophenol	2700		2.7	
Pentachlorophenol	3100		3.1	
N-Nitrosodimethylamine	828		0.828	
Aniline	2100		2.1	
Bis(2-chloroethyl) ether	345		0.345	
1,3-Dichlorobenzene	422		0.422	
1,4-Dichlorobenzene	**84**	**257**	**0.084**	**0.257**
1,2-Dichlorobenzene	80		0.08	
Benzyl alcohol	808		0.808	
Bis(2-chloroisopropyl) ether	83		0.083	
Hexachloroethane	167		0.167	
N-Nitrosodi-n-propylamine	329		0.329	
Nitrobenzene	666		0.666	
Isophorone	123		0.123	
Bis(2-chloroethoxy)methane	328		0.328	
1,2,4-Trichlorobenzene	?		?	
Naphthalene	**68**	**252**	**0.068**	**0.252**
4-Chloroaniline	1270		1.27	
Hexachlorobutadiene	791		0.791	
2-Methylnaphthalene	125		0.125	
Hexachlorocyclopentadiene	2430		2.43	
2-Chloronaphthalene	126		0.126	
2-Nitroaniline	1240		1.24	
Acenaphthylene	56		0.056	

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sample. Samples from the 5 storm drains under dry weather flow from 6/12/92 to 12/10/92 were analyzed. Field and lab blank data (Appendix III) and MDLs (Table 21) were used to define the compounds that could be quantified.

The solid phase and the water phase were separated by filtration and analyzed for Base Neutral Organic Compounds as described in the experimental section. The data were then combined to present total concentration, which was necessary for quality control considerations. The total concentration values obtained in this study are presented as quality assured data. Adsorption of soluble compounds on the filters during the filtration process is suspected. Other research projects that are not part of the scope of this study are defining this analytical chemistry problem. The best data to present are the total concentration data since any compound adsorbed to the filter would be quantified as part of the suspended material.

Table 21 lists the minimum detectable level for each compound as determined in our laboratory. The only compounds that are quantified are those above the MDL. Other compounds on the Base Neutral Organic Compound quantifiable list (Table 4) were qualitatively identified by mass spectrometry in the samples, but are below the MDL and are not quantified. Appendix VI, Tables VI.1 - 5 shows the complete list of Base Neutral Organic Compounds analyzed including date of analysis, the concentration of the compounds that were identified above their MDLs in ng/l and the identification of the compounds found below their MDLs presented as <MDL.

Quality Assurance - Laboratory Blanks, and Field Blanks

Appendix III, Table III-1 shows the GC/MS System Blanks for the targeted Base Neutral Organic Compound including the rules used for quantitative calculations. Di-n-butyl phthalate was the only targeted compound identified above its MDL. Phthalates especially Di-n-butyl phthalate are laboratory artifacts from plasticizers present in many laboratory products. Appendix III, Table III-2 shows the targeted Base Neutral Organic Compounds found in the filters used to isolate the suspended solids in the samples. The maximum value observed in the total blank (system + suspended solid blank) was used as the most conservative (worst case) choice for a blank to compare to MDLs. Nine targeted Base Neutral

Table 21 Cont.

TARGET LIST OF BASE NEUTRAL COMPOUNDS

Base Neutral Target List	Water	Water	Sus.Sed.	Sus.Sed.
	MDL	Blank	MDL	Blank
CHEMICAL NAME:	(ng/L)	(ng/L)	(ng/g)	(ng/g)
Dimethyl phthalate	64		0.064	
2,6-Dinitrotoluene	1170		1.17	
3-Nitroaniline	943		0.943	
Acenaphthene	64		0.064	
Dibenzofuran	57		0.057	
2,4-Dinitrotoluene	1160		1.16	
Fluorene	62		0.062	
Diethyl phthalate	60	623	0.06	0.623
4-Chlorophenyl phenyl ether	346		0.346	
4-Nitroaniline	1320		1.32	
N-Nitrosodiphenylamine	206		0.206	
Azobenzene	63		0.063	
4-Bromophenyl phenyl ether	619		0.619	
Hexachlorobenzene	602		0.602	
Phenanthrene	64		0.064	
Anthracene	70		0.07	
Di-n-butyl phthalate	60	3640	0.06	3.64
Fluoranthene	61		0.061	
Benzidine	51400		51.4	
Pyrene	69	189	0.069	0.189
Butyl benzyl phthalate	300	646	0.3	0.646
Benz(a)anthracene	62		0.062	
3,3'-Dichlorobenzidine	1340		1.34	
Chrysene	68	124	0.068	0.124
Bis(2-ethylhexyl) phthalate	48	4803	0.048	4.803
Di-n-octyl phthalate	64	112	0.064	0.112
Benzo(b)fluoranthene	137		0.137	
Benzo(k)fluoranthene	145		0.145	
Benzo(a)pyrene	73		0.073	
Indeno(1,2,3,4-c,d)pyrene	374		0.374	
Dibenzo(a,h)anthracene	395		0.395	
Benzo(g,h,i)perylene	370		0.37	
Carbazole	?		?	

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Organic Compounds (Table 21) were found in the system and suspended solids blanks that were above their MDLs and the values of the blank are used instead of the MDLs to complete all quantitative analyses as was done for VOCs . These nine compounds are always presented as bold chemical names on all data tables to indicate that the blank value is used for comparison for quantitation and not the MDL. Five of the nine compounds are phthalate [diethyl, di-n-butyl, butylbenzyl, bis(2-ethylhexyl) and di-n-octyl] with the bis(2-ethylhexyl) phthalate the highest at 4.8 ug/l. Three low level concentrations of polynuclear aromatic hydrocarbons (PAHs) were also found in 1 of the 5 blanks studied. This could be caused by adsorption of the PAH compounds from the air when a filter is left open to the laboratory air for a time period. Quality control procedures were carefully monitored throughout the study.

Water blanks were studied as were water travel blanks as shown on Appendix Tables III-3 and 4. High concentration levels of the 5 common phthalates described above were found in these samples. No other targeted compounds were identified. The Milli-Q water system tubing made of Tygon was isolated as the source of the contamination. The tubing was changed and an all-glass activated carbon filter was installed to eliminate this problem.

Pico-Kenter - Base Neutral Organic Compounds

Table 15 shows that 38 targeted Base Neutral Organic Compounds were present above their MDLs in 11 samples collected over a 6 month dry weather flow period 6/12-12/10/92. The range of concentrations for each targeted quantifiable compound represents 9 days of sampling, sometimes twice a day for 6 months. Three phenols, benzoic acid, and 4 phthalates were quantified to be above 1 ppb in some of the 11 samples. The drinking water MCLs in Table 15 indicate that no compound exceeded the drinking water standard. Some samples with bis(2-ethylhexyl) phthalate exceed the proposed California Ocean Plan Standards if no dilution is included (California State Water Resources Control Board, 1990a and b). However, dilution is always considered in the California Ocean Plan. The relationship between the PAHs in these samples and the proposed California Ocean Plan Standards will be evaluated below. Other non-targeted base neutral compounds were identifed in selected base neutral samples (Table 22).

Table 22

NON TARGET BASE NEUTRAL COMPOUNDS FOUND IN SELECTED SAMPLES

LOCATION ---------->	Ballona	Sepulv	Sepulv	Centin	Centin	Pico/K	Pico/K	Pico/K	Ash	Ash
SAMPLE DATE ——>	10-Dec	29-Nov	24-Aug	24-Aug	24-Aug	27-Jul	10-Dec	10-Dec	27-Jul	29-Sep
SAMPLE NUMBER ——>	8270	8239	8067	8066	8073	8105	8272	8252	8114	8191
SAMPLE TYPE ——>	SS	SS	Water	Water	SS	Water	SS	SS 2nd	SS	Water
COMPOUND										
Tris(2-butoxyethyl) phosphate	X		X				X		X	X
Styrene		X								
4-Penten-2-ol			X							
4,5-Dimethyl-1-hexane			X							
Benzothiozole			X				X			
[2-Methyl propanoic acid,2,2-(2-hydroxy-1-methylethyl) propyl ester			X							
2-Methyl propanoic acid,3-hydroxy-2,4,4-trimethylphenyl ester			X							
2(Methylthio)-benzothiozole			X							
2(3H)-Benzothiozole			X							
1-Bromododecane			X							
Butyl citrate			X							
Cholesterol			X							
Dimethylformamide				X						
1-(2-Methoxy-1-methylethoxy)-2-propanol				X		X				X
1-(2-Methoxypropoxy)-2-propanol										X
1-(1-Methyl-2-[2-propenyloxy] ethoxy)-2-propanol				X						
2-Methyl-2,4-pentanediol										X
2,2,4-Trimethyl-1,3-pentanediol										X
2-Methyl propanoic acid,3-hydroxy-2,4,4-trimethylphenyl ester				X						
Phosphoric acid, tributyl ester				X						
Paraaldehyde				X						
2-Chloroethanol phosphate				X						
2-Hydroxy-4-methoxyphenyl (methanone)				X						
Tris(2-butoxyethyl) phosphate				X						
Triphenyl phosphine oxide				X						
2-Octadecanone					X					
nC29 Alkane					X		X	X		
nC31 Alkane					X			X		
Heptadecanoic acid									X	X
Tridecanoic acid						X				
9 Hexadecanoic Acid						X				
nC33 Alkane								X	X	

Table 22

NON TARGET BASE NEUTRAL COMPOUNDS FOUND IN SELECTED SAMPLES

LOCATION --------->	Ballona	Sepulv	Sepulv	Contin	Contin	Pico/K	Pico/K	Pico/K	Ash	Ash
SAMPLE DATE ------>	10 Dec	29 Nov	24 Aug	24 Aug	24 Aug	27 Jul	10 Dec	10 Dec	27 Jul	29 Sep
SAMPLE NUMBER ------>	8270	8239	8067	8066	8073	8105	8272	8252	8114	8191
SAMPLE TYPE ------>	SS	SS	Water	Water	SS	Water	SS	SS 2nd	SS	Water
COMPOUND										
nC34 Alkane									•	
Molecular S			•			•			•	•
4-(2,2,3,3-Tetramethylbutyl) phenol						•			•	•
4-Nonyl phenol									•	
Nonyl phenol									•	
2,2,4-Trimethyl-3-cyclohexene-1-methanol										•
Caffeine						•				•
Dimethyl trisulfide						•				
2,3-Dihydro-4-methyl-1H-indole						•				
Nitrobenzene							•			
Heptane, 4-methylene							•			
1-Methyl naphthalene							•			
4-Hydroxy-3-methoxy benzaldehyde							•			
Bis(1-Methylethyl) adipate							•			
2,6-Bis(1,1-Dimethylethyl)-4-methyl phenol							•			
[2-Methyl propanoic acid-1-1,1-dimethyl ethyl-2-methyl-1,3-propanediyl ester							•			
Benzophenone							•			
2-Methyl-n-phenyl-2-acrylamide							•			
nC18 Fatty acid methyl ester							•			

Centinela - Base Neutral Organic Compounds

Table 16 shows that 31 targeted Base Neutral Organic Compounds were present above their MDLs in 8 samples collected over a 6 month dry weather flow period 6/12-12/10/92. The range of concentrations for each targeted quantifiable compound represents 8 days of sampling for 6 months. Benzoic acid, and 3 phthalates were quantified to be above 1 ppb in some of the 8 samples. The drinking water MCLs in Table 16 indicate that bis(2-ethylhexyl) phthalate exceeded the drinking water standard. Bis(2-ethylhexyl) phthalate was found in the distilled water and suspended sediment blanks, Table 21, at 4.8 ug/l. Therefore, to assure that the levels are over drinking water standards, further verification is suggested. Bis(2-ethylhexyl) phthalate also exceeds the proposed California Ocean Plan Standards if no dilution is included (California State Water Resources Control Board, 1990a and b). However, dilution is always considered in the California Ocean Plan. The relationship between the PAHs in these samples and the proposed California Ocean Plan Standards will be evaluated below. Other non-targeted base neutral compounds were identifed in selected base neutral samples, (Table 22).

Sepulveda - Base Neutral Organic Compounds

Table 17 shows that 32 targeted Base Neutral Organic Compounds were present above their MDLs in 9 samples collected over a 6 month dry weather flow period 6/12-12/10/92. The range of concentrations for each targeted quantifiable compound represents 8 days of sampling for 6 months. Four phthalates were quantified to be above 1 ppb in some of the 9 samples. The drinking water MCLs in Table 17 indicate that bis(2-ethylhexyl) phthalate exceeded the drinking water standard and the proposed California Ocean Plan Standards if no dilution is included (California State Water Resources Control Board, 1990a and b). Bis(2-ethylhexyl) phthalate was found in the distilled water and suspended sediment blanks, Table 21, at 4.8 ug/l. Therefore, to assure that the levels are over drinking water standards, further verification is suggested as at Centinela. Bis(2-ethylhexyl) phthalate also exceeds the proposed California Ocean Plan Standards if no dilution is included. However, dilution is always considered in the California Ocean Plan. The relationship between the PAHs in these samples and the proposed California Ocean Plan Standards will be evaluated below. Other non-targeted base neutral compounds were identifed in selected base neutral samples, (Table 22).

Ballona - Base Neutral Organic Compounds

Table 18 shows that 36 targeted Base Neutral Organic Compounds were present above their MDLs in 10 samples collected over a 6 month dry weather flow period 6/12-12/10/92. The range of concentrations for each targeted quantifiable compound represents 8 days of sampling, sometimes twice a day for 6 months. Four phthalates were quantified to be above 1 ppb in some of the 9 samples with bis(2-ethylhexyl) phthalate exceeded the drinking water standard and the proposed California Ocean Plan Standards if no dilution is included (California State Water Resources Control Board, 1990a and b). Bis(2-ethylhexyl) phthalate was found in the distilled water and suspended sediment blanks, Table 21, at 4.8 ug/l. Therefore, to assure that the levels are over drinking water standards, further verification is suggested as at Centinela and Sepulveda. Bis(2-ethylhexyl) phthalate also exceeds the proposed California Ocean Plan Standards if no dilution is included. However, dilution is always considered in the California Ocean Plan. The relationship between the PAHs in these samples and the proposed California Ocean Plan Standards will be evaluated below. Other non-targeted base neutral compounds were identifed in selected base neutral samples, (Table 22).

Ashland Avenue - Base Neutral Organic Compounds

Table 19 shows that 41 targeted Base Neutral Organic Compounds were present above their MDLs in 8 samples collected over a 6 month dry weather flow period 6/12-12/10/92. The range of concentrations for each targeted quantifiable compound represents 8 days of sampling. Benzoic acid, 4-methylphenols, benzyl alcohol and 5 phthalates were quantified to be above 1 ppb in some of the 8 samples with bis(2-ethylhexyl) phthalate exceeded the drinking water standard and the proposed California Ocean Plan Standards if no dilution is included (California State Water Resources Control Board, 1990a and b) in all 8 samples. However, dilution is always considered in the California Ocean Plan. Bis(2-ethylhexyl) phthalate was found in the distilled water and suspended sediments blank, Table 21, at 4.8 ug/l. Therefore, to assure that the levels are over drinking water standards, further verification is suggested as at Centinela, Sepulveda and Ballona. Bis(2-ethylhexyl) phthalate also exceeds the proposed California Ocean Plan Standards if no dilution is included. However, dilution is always considered in the California Ocean Plan. The relationship between the PAHs in these samples and the proposed California Ocean Plan Standards will be evaluated below. The PAHs were the highest in this storm drain. Over 120 compounds were found at the Ashland Storm Drain as targeted (Table 19) and non-targeted Base Neutrals Compounds (Table 22).

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Comparison of All Sampling Sites - Base Neutral Organic Compounds

Figures 35 - 38 compare the total targeted base neutral concentrations found at each site during each sampling period from July 7 to Dec 10, 1992. Figure 35 show that the total targetted base neutral concentration range from 2 ug/l to 174 ug/l with all but 2 of 36 samples between 2 ug/l to 42 ug/l and all but 5 of 36 samples between 2 ug/l and 21 ug/l. The primary type of base neutral found were phthalates, Figure 36. Phthalates make up the most significant part of the base neutral varying from 50 to 97 % of the base neutrals found in any sample. Figure 37 shows the total PAHs are from 0.017 - 26 ug/l. The total PAHs are < 1.6 ug/l except for 1 sample of 26 ug/l as Sepulveda on August 24, 1992. Figure 38 shows the total phenols are the lowest fraction of the total base neutrals with only one sample higher than 10 ug/l.

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In Figure 39, pyrene is highlighted as an exemplary PAH to help describe how the PAHs vary in concentration from sample to sample. The August 24 samples from all locations show the highest concentrations of pyrene (0.12 - 7.56 ug/l). Figure 15 shows that a dry weather flow condition was prevalent in this sampling period. Samples from Ashland contain the highest level of pyrene concentration with 2 samples above 0.1 ug/l on July 27 during dry weather flow and on December 10 after about 3 inches of rain a week before. The complete PAH data presented in Appendix VI show the variation of the other PAHs with sampling data.

Figure 40 shows the concentrations of the phthalate, butyl benzyl phthalate that was not present as a phthalate in any blanks. The Aug. 24 sample also

Figure 35 TOTAL BASE-NEUTRALS CONCENTRATION PROFILE

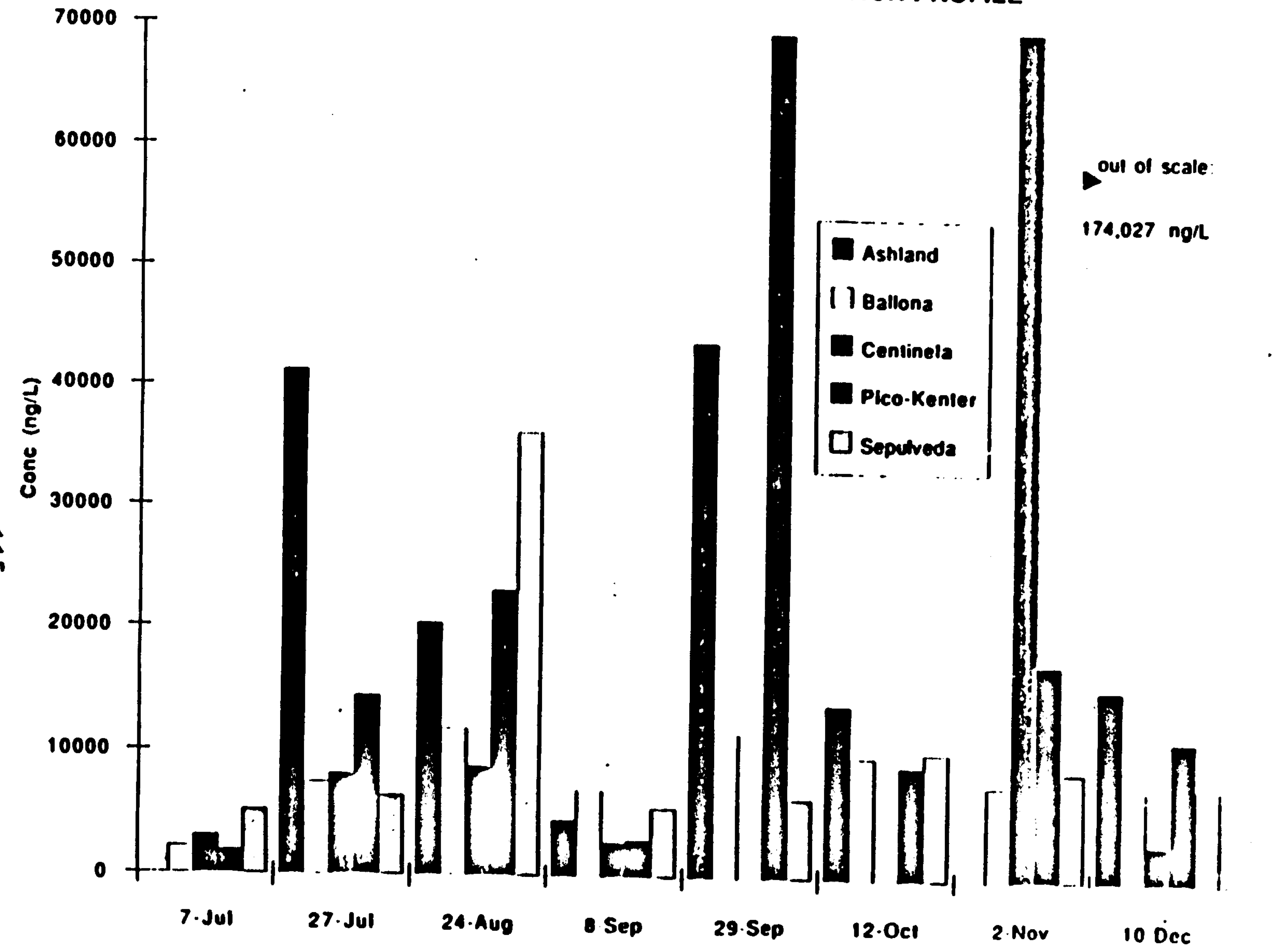

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Figure 36 TOTAL PHTHALATES CONCENTRATION PROFILE

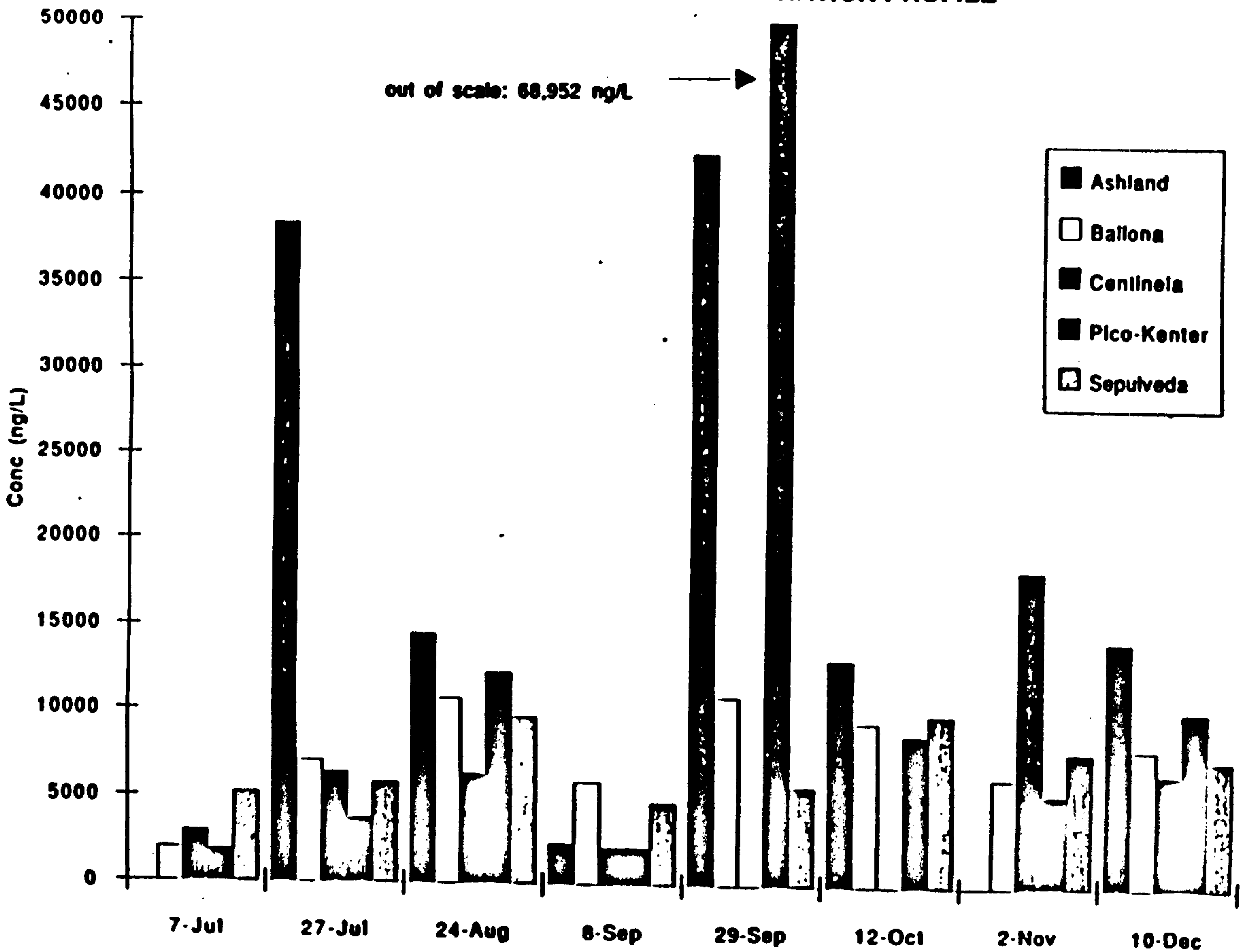

Figure 37 TOTAL PAHs CONCENTRATION PROFILE

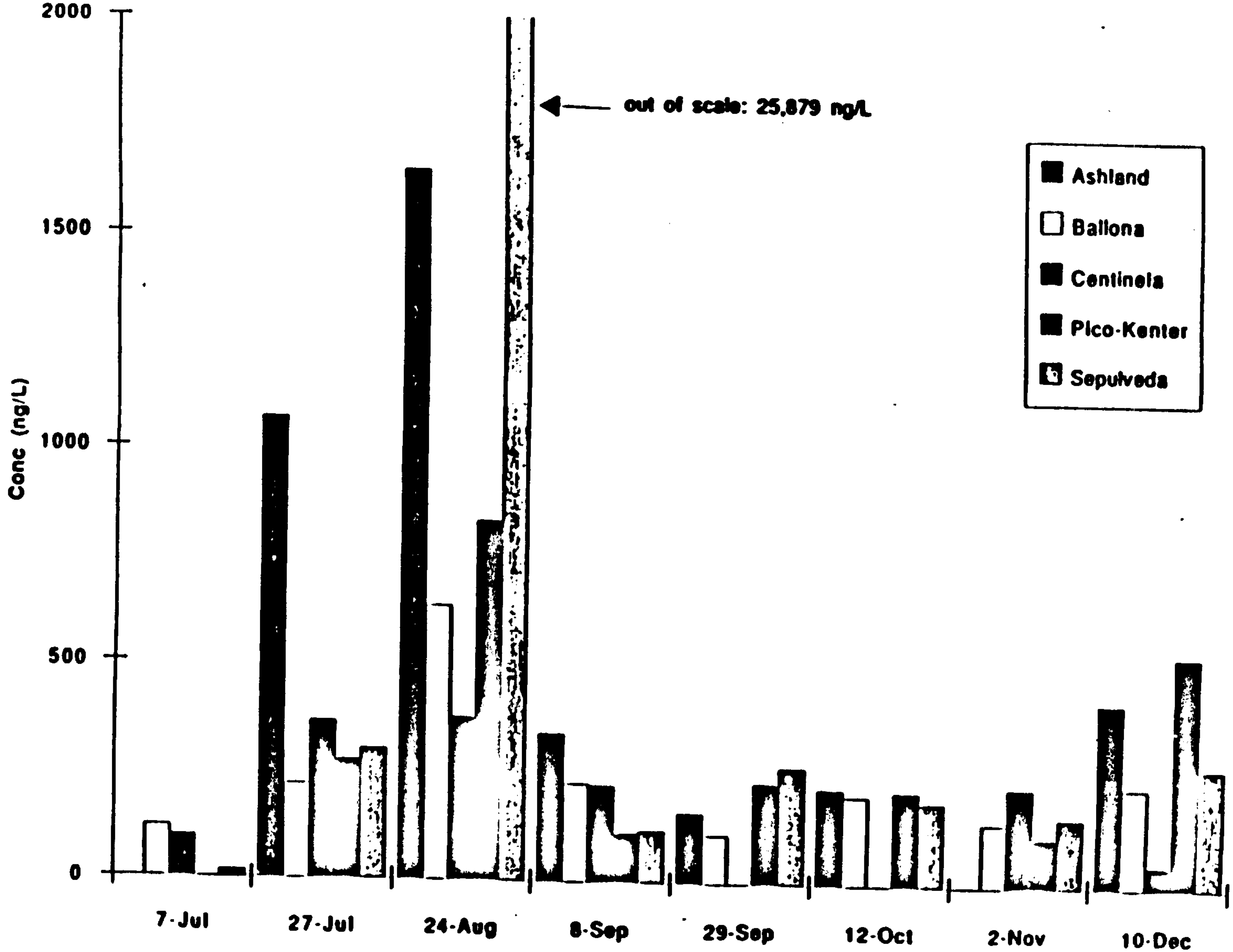

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Figure 38 TOTAL PHENOLS CONCENTRATION PROFILE

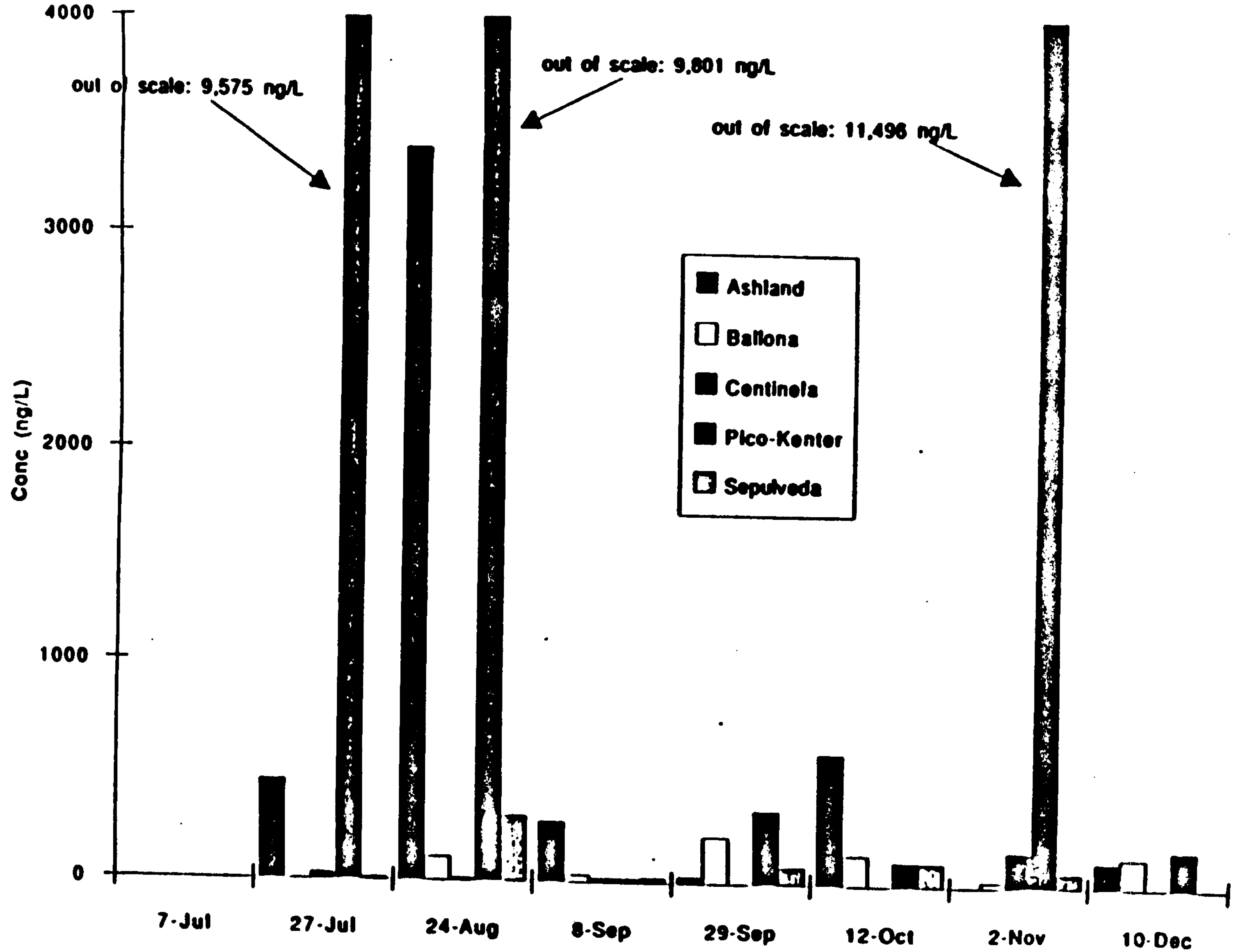


Figure 39

CONCENTRATION PROFILE: PYRENE

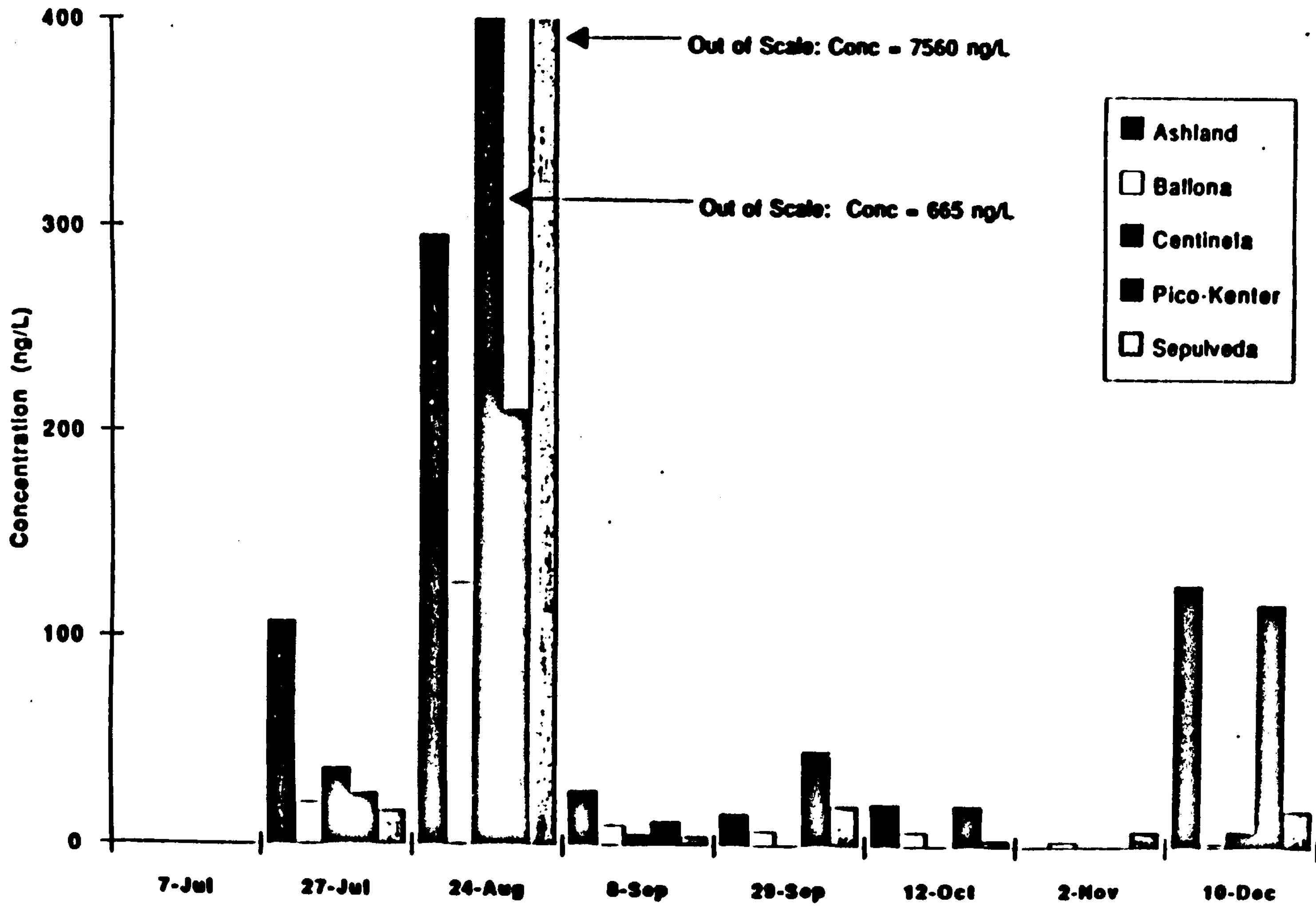
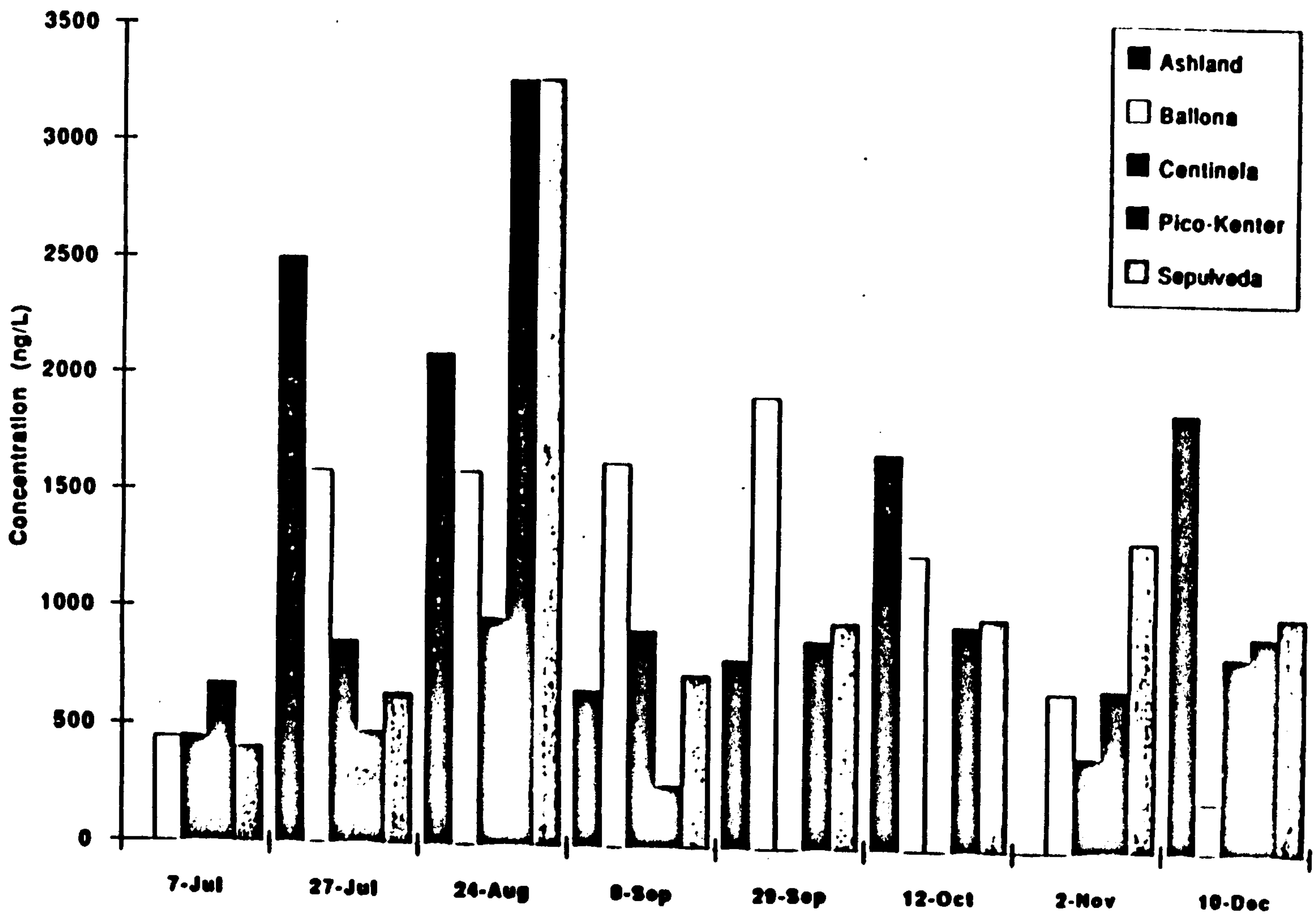


Figure 40

CONCENTRATION PROFILE: BUTYL BENZYL PHTHALATE



shows that the highest concentrations were found the same day as the highest concentration of PAHs.

California Ocean Plan Standards
(California State Water Resources Control Board, 1990a and b)

Tables 15-20 compares the tabulated Base Neutral Organic Chemical data and the drinking water maximum contamination limits developed by the U.S. EPA and the proposed California Ocean Plan Standards (California State Water Resources Control Board, 1990a and b). Tables 15-20 shows that the total concentrations of each chemical quantified does not exceed any of the EPA drinking water standards except for bis(2-ethylhexyl) phthalate at all but Pico-Kenter. Bis(2-ethylhexyl) phthalate was found in the suspended sediment and distilled water blanks, Table 21, at 4.8 ug/l. Therefore, to assure that the levels are over drinking water standards, further verification is suggested. This is a similar problem to the ubiquitious VOC- methylene chloride problem which also needs further verification.

Tables 15-20 indicate that most samples analyzed for Base Neutral Organic Compounds exceed the proposed 30-day average California Ocean Plan Standards especially for total PAHs without consideration of dilution. The proposed California Ocean Plan Standard for PAHs is a total PAH concentration of 8.8 ng/l. The sum of the PAHs includes all PAHs analyzed plus 2 additional PAHs that were not analyzed in the present study.

The following facts must be considered when evaluating the data in this report versus the California Ocean Plan. The CA Ocean Plan includes an <u>initial dilution clause</u> (pp. 18-19 of CA Ocean Plan), which implies it is for point sources of municipal and industrial origin and not from storm water runoff which this work has considered a non-point pollution source. "The process which results in the rapid and irreversible turbulent mixing of wastewater with ocean water around the point discharge" is the initial dilution and this factor is applied to the standard. Permits are developed around models which define the dilution at the outfall. The State Water Resources Control Board, Division of Water Quality, Ocean Plan Unit, completed a California Ocean Plan Triennial Review 1991-4, (Doc 92-5WQ, October 22, 1992). On page 37 the "staff concluded that the Ocean Plan

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should be amended to clarify its applicability to stormwater discharges. A schedule of compliance for dischargers similar to the schedule in the Inland Surface Waters and the Enclosed Bays and Estuary Plans should be considered." It is for this reason that the quantitative data presented in this report cannot be directly evaluated for dilution and impact on health via the California Ocean Plan. It is our opinion that the California Ocean Plan can be considered a state opinion of what chemicals are important to evaluate, but, not as having a direct quantitative relationship to the compounds that are present.

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Non-Target Base Neutral Organic Compounds

Table 22 shows the identification of non-targeted Base Neutral Organic Chemicals in selected samples. Non-targeted Base Neutrals were identified by the criteria that were presented in the experimental section. These compounds are not quantified and they are called "tentatively identified" compounds. Tentatively identified compounds are not compared with the GC retention time of the true compound or the mass spectrum of the true compounds obtained on the same GC/MS system as the targeted compounds. The term "tentative" means that further studies are needed to confirm their identification and to quantify them by use of references standards. Total ion current chromatograms from the mass spectrometric determination results are presented in Appendix VII. Future evaluation of the non-targeted tentatively identified compounds falls into the category of future research. Selected n-alkanes and fatty acid methyl esters (FAMES), tris(2-butoxyethyl) phosphate, diazinon, dimethoate (organophospahate pesticides), and chlorinated pesticides and polychlorinated biphenyls (PCBs) have been confirmed by comparison to authentic standards.

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Organophosphate Pesticides Analysis

Table 23 shows diazinon and dimethoate, 2 organophosphate pesticides, were found in 6 of the base neutral samples that were analyzed. These two compounds are part of the nontarget base neutral compounds that need further investigation. They have not been included in Table 22 as they were found in different samples. Further evaluation of the source of these compounds is needed.

Table 23

ANALYSIS OF ORGANOPHOSPHORUS PESTICIDES IN BASE NEUTRAL SAMPLES FROM DIFFERENT LOCATIONS*

Compound	Sample Type	Sample No.	Location	Date	Conc (ng/L)
Diazinon:					
	Water	F8078	Centinela	7/7/92	-
	Water	F8104	Ashland	7/27/92	-
	Water	F8106	Centinela	7/27/92	-
	Water	F8191	Ashland	9/29/92	1135
	Water	F8195	Pico-Kenter	9/29/92	858
	Water	F8208	Ashland	10/12/92	185
	Water	F8213	Ashland	12/10/92	252
Dimethoate:					
	Water	F8192	Ballona	9/29/92	3197
	Water	F8193	Ballona	9/29/92	1079

* Selected samples were analyzed.

Chlorinated Pesticides and PCBs Identification

Table 24 shows chlorinated pesticides and PCB analyses that were determined in the 9/8/92 samples from the five drains. The data from each drain indicates the presence of chlorinated pesticides and PCBs to be greater than their MDLs of 0.5 ng/l. Tables 25 and 26 show blank analyses by GC/MS and GC-Electron Capture Detection (ECD) with two GC columns, respectively. The blank analyses for unexposed filters that are directly analyzed by supercritical fluid extraction show that chlorinated pesticides and PCBs are present at 1 - 2 ng/l. On the other hand, the blank analyses for filters that were analyzed by supercritical fluid extraction after exposure in the hood for one day show an order of magnitude increase of chlorinated pesticides and PCB contamination. The levels of chlorinated pesticides and PCBs are present in these blanks at 1 - 20 ng/l. The source of the blank contamination in the room and hood space at the ng/l level is unknown. The pesticide dieldrin was found in concentrations above background at two sites, Pico Kenter and Centinela. Alpha-chlordane was eight times the background at Ashland. The storm drain with consistent PCB concentrations greater than the blank level was Ashland. Assuming a minimum background level of 1 ng/L, the concentrations at Ashland were as high as 88 times greater than the blank levels. PCBs were also identified at Centinela with the concentrations ranging from one to 17 times the background. 2,4,4'-trichlorobiphenyl, 3,3',4,4'-tetrachlorobiphenyl, 2,2',3,4,4',5-hexachlorobiphenyl and 2,2',3,4,4',5,5'-heptachlorobiphenyl were positively identified in the samples, and there was no quantifiable contamination in the blank. These compounds were found at several of the sites. Two decachlorobiphenyls were also identified, but at one site each only. The source of the 1-20 ng/l contamination of the blanks is currently being investigated.

Hydrocarbon Characterization In Urban Runoff

Dry weather and storm water runoff from urban areas such as the Los Angeles Basin contain hydrocarbons from diverse origins such as street and river runoff, atmospheric fallout, terrestrial dust, etc. Yet, several of the principal sources for hydrocarbon input can be distinguished, since fossil fuels have a hydrocarbon signature different from those of biogenic sources. For example, aromatic hydrocarbons show distinct characteristics in combustion and petroleum-based sources. Combustion PAHs are dominated by parent compounds, whereas the methylated homologs dominate in petroleum (Youngblood and Blumer, 1975).

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Table 24

Chlorinated Pesticide and PCB Analysis of Suspended Sediments from Filtered Water of 9/8/92 by Supercritical Fluid Extraction.

Site	Pico Kenter	Ballona	Ashland	Centinela	Sepulveda
Aqueous Volume Filtered	8 L	4 L	4 L	4 L	8 L
Suspended Solids (mg)	71.6	43.2	241	86.7	215
CHEMICAL	ng/L	ng/L	ng/L	ng/L	ng/L
Chlorinated Pesticides					
Alpha-Chlordane	3	4	24	5	4
Hexachlorobenzene (a)(c)	1				
Dieldrin (c)	5			10	
Lindane (a)	1	2			1
Trans-Nonachlor	1	2		2	2
Heptachlor (a)(c)	1	1	2		1
Heptachlor Epoxide (a)	1	3		3	3
PCBs					
2,4'-Dichlorobiphenyl	16*	(+)*		22	(+)*
2,2',5-Trichlorobiphenyl	14	11		20	
2,4,4'-Trichlorobiphenyl	7*	11*	(+)*	16*	9*
2,2',3,5'-Tetrachlorobiphenyl	7	13	(+)*	13	11
2,2',5,5'-Tetrachlorobiphenyl	9*	15*	(+)*	16*	14*
2,3',4,4'-Tetrachlorobiphenyl			74*		
3,3',4,4'-Tetrachlorobiphenyl	4				15
2,2',4,5,5'-Pentachlorobiphenyl	13*	22*	85*	24*	19*
2,3',4,4',5-Pentachlorobiphenyl	4*	9	38*	9*	7
2,2',3,3'4,4'-Hexachlorobiphenyl	1	2		2	1
2,2',3,4,4',5'-Hexachlorobiphenyl	10	18	88*	17	
2,2',4,4',5,5'-Hexachlorobiphenyl	16*	21	87*	26*	18*
2,2',3,3',4,4',5-Heptachlorobiphenyl	4	11		8	
2,2',3,4,4',5,5'-Heptachlorobiphenyl	6	12	48*	11	8
2,2',3,4',5,5',6-Heptachlorobiphenyl	5	10	33	8	7
2,2',3,3',4,4',5,6-Octachlorobiphenyl	2	1			1
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl		1			
2,2',3,3',4,4',5,5'6-Nonachlorobiphenyl				2	
Unknown Dichlorobiphenyl				(+)*	
Unknown Dichlorobiphenyl				(+)*	
Unknown Trichlorobiphenyl				(+)*	
Unknown Tetrachlorobiphenyl					(+)*
Unknown Pentachlorobiphenyl	(+)*	(+)*	(+)*	(+)*	(+)*
Unknown Pentachlorobiphenyl			(+)*	(+)*	(+)*
Unknown Hexachlorobiphenyl			(+)*	(+)*	(+)*
PCBs Total Amount(ng/l) (b)(c)	119	155	451	170	110

ng/L = nanogram per liter of water containing suspened solids

All analyses were confirmed on 2 GC columns

* Confirmed by GC/MS in an equivalent aliquot

No pesticide or PCB's were detected in the filter blanks from 9/8/92

(a) EPA Drinking Water Standards - Lindane & Heptachlor Epoxide = 200 ng/l; Heptachlor = 400 ng/l and Hexachlorobenzene = 1000 ng/l

(b) EPA Drinking Water Standards - Total PCBs = 500 ng/l

(c) CA Ocean Standards - Dieldrin = 0.04 ng/l; Heptachlor = 0.72 ng/l; Hexachlorobenzene = 0.21 ng/l; Total PCBs = 0.019 ng/l

Table 25

Blank Analysis of PCBs by GC/MS

PCB's	Unexposed Filters (Direct From Box)		Filters Exposed in Hood (Before Filtration) (1 Day)		Filters Exposed in Hood (During Drying of Filters) (1 Day)		Filters Used in Filtration (To Filter BN Solution)** (2 Days)	
	Set A*	Set B	Set A	Set B	Set A	Set B	Set A	Set B
2,4'-Dichlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
2,2',5-Trichlorobiphenyl	-	-	♦	♦	-	-	♦	-
2,4,4'-Trichlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
Unknown Trichlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
Unknown Trichlorobiphenyl	-	-	♦	♦	-	-	♦	-
2,2',5,5'-Tetrachlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
2,2',3,5'-Tetrachlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
Unknown Tetrachlorobiphenyl	-	-	-	-	-	-	♦	♦
Unknown Tetrachlorobiphenyl	-	-	-	-	-	-	♦	-
2,3',4,4'-Tetrachlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
Unknown Pentachlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
Unknown Tetrachlorobiphenyl	-	-	-	-	-	-	♦	♦
Unknown Pentachlorobiphenyl	-	-	♦	-	-	-	♦	-
2,2',4,5,5'-Pentachlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
Unknown Pentachlorobiphenyl	-	-	♦	♦	-	-	♦	-
2,2',3,4,5'-Pentachlorobiphenyl	-	-	♦	-	-	-	♦	♦
Unknown Hexachlorobiphenyl	-	-	-	-	-	-	♦	-
Unknown Pentachlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
Unknown Hexachlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
2,3',4,4',5-Pentachlorobiphenyl	-	-	♦	♦	-	-	♦	♦
2,2',4,4',5,5'-Hexachlorobiphenyl	-	-	♦	♦	♦	♦	♦	♦
2,2',3,4,4',5'-Hexahachlorobiphenyl	-	-	♦	♦	-	♦	♦	♦
2,2',3,4',5,5',6-Heptachlorobiphenyl	-	-	♦	-	-	-	♦	♦
2,2',3,4,4',5,5'-Heptachlorobiphenyl	-	-	-	-	-	-	♦	-

*Each set of filters consists of 1 glass fiber pre-filter (Gelman Extra Thick) and 1 membrane filter (Gelman Supor-450).

**BN = Base/Neutrals

MDL = approximately 5 ng/l on the basis of filtration of a 4 liter aqueous sample.

Table 26

Blank Analysis of PCBs and Chlorinated Pesticides by Dual Column GC-ECD by EPA Method 608.

PCBs	Unexposed Filters (Direct From Box) Set A*	Set B	Filters Exposed In Hood (Before Filtration) (1 Day) Set A	Filters Exposed In Hood (During Drying of Filters) (1 Day) Set A	Solvent Blank (No Filters)
	ng/L**		ng/L	ng/L	ng/L
2,4'-Dichlorobiphenyl	2	-	13(a)	10(a)	-
2,2',5-Trichlorobiphenyl	-	2	13(a)	10	-
2,4,4'-Trichlorobiphenyl	-	-	UTQ***(a)	UTQ(a)	-
2,2',5,5'-Tetrachlorobiphenyl	1	2	12(a)	10(a)	-
2,2',3,5'-Tetrachlorobiphenyl	-	1	12(a)	8(a)	-
2,3',4,4'-Tetrachlorobiphenyl	-	-	16(a)	10(a)	-
2,2',4,5,5'-Pentachlorobiphenyl	1	2	20(a)	13(a)	-
2,2',3,4,5'-Pentachlorobiphenyl	-		-	-	-
2,3',4,4',5-Pentachlorobiphenyl	0	-	8(a)	4	-
2,2',3,3',4,4'-Hexachlorobiphenyl	0	-	-	1	-
2,2',4,4',5,5'-Hexachlorobiphenyl	1	0	7(a)	11(a)	-
2,2',3,4,4',5'-Hexahachlorobiphenyl	-	-	(b)	-	-
2,2',3,3',4,4',5-Heptachlorobiphenyl	-	-	-	5	-
2,2',3,4',5,5',6-Heptachlorobiphenyl	1	-	8(a)	5	-
2,2',3,4,4',5,5'-Heptachlorobiphenyl	1	1	9(a)	6	-
2,2',3,3',4,4',5,6-Octachlorobiphenyl	1	1	1	1	-
Chlorinated Pesticides					
Hexachlorobenzene	-	-	-	1	0
gamma-BHC (Lindane)	-	-	2	2	-
Heptachlor	-	-	1	1	-
Heptachlor Epoxide	1	-	UTQ	2	-
cis-Chlordane	-	-	UTQ	3	-
trans-Nonachlor	-	-	1	1	-

*Each set of filters consists of 1 glass fiber pre-filter (Gelman Extra Thick) and 1 membrane filter (Gelman Supor-450).
**ng/L of water filtered on the basis of 4L extraction
***Unable to quantify MDL = approximately 5 ng/l on the basis of filtration of a 4 liter aqueous sample.
(a) Confirmed by GC-MS
(b) Confirmed by GC-MS but not by Dual Column GC-ECD. May be a co-eluting Cl-6 congener on GC-MS.

Fossil fuel and petroleum hydrocarbons, complex mixtures of organic compounds, also contain unique compounds often referred to as biomarkers. These compounds are very stable structurally-specific molecules that usually can be related to precursor compounds in a specific type of source material As the source material is converted to fossil fuel, the precursor molecules are chemically altered to form biomarkers. Two common types of biomarkers, often used to provide information on source and maturity of crude oils and the existence of which indicates the presence of fossil fuel or petroleum hydrocarbons, are steranes and triterpanes (Philip, 1985). Steranes are tetracyclic aliphatic hydrocarbons derived primarily from C27 to C29 sterols. Triterpanes are pentacyclic aliphatic hydrocarbons derived from cell wall precursors in certain plants and microorganisms. One of the most ubiquitous groups of pentacyclic triterpane biomarkers are those based on the hopane structure.

Sterane and hopane biomarkers can be detected at very low concentrations by using GC/MS to monitor the molecular ion decomposition fragments m/z 217 and m/z 191 respectively. The distributions obtained can be used to confirm the presence of fossil fuel and petroleum hydrocarbons and in some cases, e.g., large spills, their source.

The biomarker fingerprints for an Ashland 07-27-92 filter extract are shown in Figures 41 and 42. The associated compounds are listed in Table 27. These data indicate the presence of petroleum hydrocarbons in the Ashland sample. The abundance of both C27 and C29 steranes indicates both a marine and terrestrial source material while the presence of 17a(H), 18a(H),21B(H)-28,30-bisnorhopane suggests hydrocarbon contribution from California crude (Siefert et al., 1978). Both the lack of unsaturated biomarkers (sterenes and triterpenes) and the presence of rearranged steranes (diasteranes) and 20S and 20R epimers of extended hopanes is consistent with mature petroleum. Little biodegradation has taken place as evidenced by the lack of 25-norhopane homologs and the lack of removal of the 5a(H), 14a(H), 17a(H) 20R isomers from the C27-C29 steranes. The unusually high abundance of extended tricyclic diterpanes may indicate again a terrestrial contribution to the oil or source rock but may also indicate a source of hydrocarbons to the Ashland runoff from resins of higher plants (Table 27). Further evaluation of the sample for petroleum hydrocarbon odors is needed.

Table 27

Hydrocarbon Characterization In Urban Runoff.
Triterpane Biomarkers From Ashland 07-27-92 Filter Extract

Scan	Formula	MW	Assignment
2884	C28H52	388	C28 extended tricyclic diterpane
2893	C28H52	388	C28 extended tricyclic diterpane
2928	C29H54	402	C29 extended tricyclic diterpane
2939	C29H54	402	C29 extended tricyclic diterpane
2990	C27H46	370	17a(H), 18a(H), 21ß(H)-25,28-30-trisnorhopane
3012	C30H56	416	C30 extended tricyclic diterpane
3019	C27H46	370	17ß(H), 18a(H), 21a(H)-25,28-30-trismoretane
3025	C30H56	416	C30 extended tricyclic diterpane
3084	C28H48	384	17a(H), 18a(H), 21ß(H)-28,30-bisnorhopane
3120	C29H50	398	17a(H), 21ß(H)-30-norhopane
3181	C30H52	412	18a(H)-oleanane
3195	C30H52	412	17a(H), 21ß(H)-hopane
3235	C30H52	412	17ß(H), 21a(H)-moretane
3297	C31H54	426	22S-17a(H), 21ß(H)-30-homohopane
3309	C31H54	426	22R-17a(H), 21ß(H)-30-homohopane
3338	C31H54	426	17ß(H), 21a(H)-homomoretane
3386	C32H56	440	22S-17a(H), 21ß(H)-30,31-bishomohopane
3407	C32H56	440	22R-17a(H), 21ß(H)-30,31-bishomohopane
3460	C32H56	440	17ß(H), 21a(H)-30,31-bishomomoretane
3516	C33H58	454	22S-17a(H), 21ß(H)-30,31,32-trishomohopane
3549	C33H58	454	22R-17a(H), 21ß(H)-30,31,32-trishomohopane
3681	C34H60	468	22S-17a(H), 21ß(H)-30,31,32,33-tetrakishomohopane
3727	C34H60	468	22R-17a(H), 21ß(H)-30,31,32,33-tetrakishomohopane

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Table 27 Cont.

Hydrocarbon Characterization in Urban Runoff - Triterpane Biomarkers From Ashland 07-27-92 Filter Extract

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Scan	Formula	MW	Assignment
2807	$C_{27}H_{48}$	372	13ß,17a-diacholestane (20S)
2832	$C_{27}H_{48}$	372	13ß,17a-diacholestane (20R)
2853	$C_{27}H_{48}$	372	13a,17ß-diacholestane (20S)
2867	$C_{27}H_{48}$	372	13a,17ß-diacholestane (20R)
2874	$C_{28}H_{50}$	386	24-Methyl-13ß,17a-diacholestane (20S) Prob. 24 S&R isomers
2878	$C_{28}H_{50}$	386	24-Methyl-13ß,17a-diacholestane (20S)
2904	$C_{28}H_{50}$	386	24-Methyl-13ß,17a-diacholestane (20R) Prob. 24 S&R isomers
2928	$C_{27}H_{48}$	372	5ß(H)-Cholestane (5ß,14a,17a-coprostane [20R])
2931	$C_{29}H_{52}$	400	24-Ethyl-13ß,17a-diacholestane (20S)
2933	$C_{27}H_{48}$	372	5a,14ß,17ß-Cholestane (20R) (isocholestane)
2941	$C_{27}H_{48}$	372	5a,14ß,17ß-Cholestane (20S) (isocholestane)
2957	$C_{27}H_{48}$	372	5a(H)-Cholestane (5a,14a,17a-cholestane [20R])
2962	$C_{28}H_{50}$	386	C28 sterane
2979	$C_{29}H_{52}$	400	24-Ethyl-13ß,17a-diacholestane (20R)
2998	$C_{29}H_{52}$	400	24-Ethyl-13a,17ß-diacholestane (20R)
3001	$C_{28}H_{50}$	386	24-Methyl-5ß,14a,17a-cholestane (20R) (5ß-ergostane 20R)
3007	$C_{28}H_{50}$	386	24-Methyl-14ß,17ß-cholestane (20R) (isoergostane 20R)
3013	$C_{28}H_{50}$	386	24-Methyl-14ß,17ß-cholestane (20S) (isoergostane 20S)
3034	$C_{28}H_{50}$	386	24-Methyl-5a,14a,17a-cholestane (20R) (5a-ergostane 20R)
3058	$C_{29}H_{52}$	400	24-Ethyl-5ß,14a,17a-cholestane (20R) (5ß-stigmastane 20R)
3069	$C_{29}H_{52}$	400	24-Ethyl-14ß,17ß-cholestane (20R) (isostigmastane 20R)
3075	$C_{29}H_{52}$	400	24-Ethyl-14ß,17ß-cholestane (20S) (isostigmastane 20S)
3084	$C_{30}H_{54}$	414	C30 sterane
3103	$C_{29}H_{52}$	400	24-Ethyl-5a-14a,17a-cholestane (20R) (5a-stigmastane 20R)

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Figure 41

M/Z 217 Mass Chromatogram Showing Steranes in Ashland 7-27-92 Filter Extract.

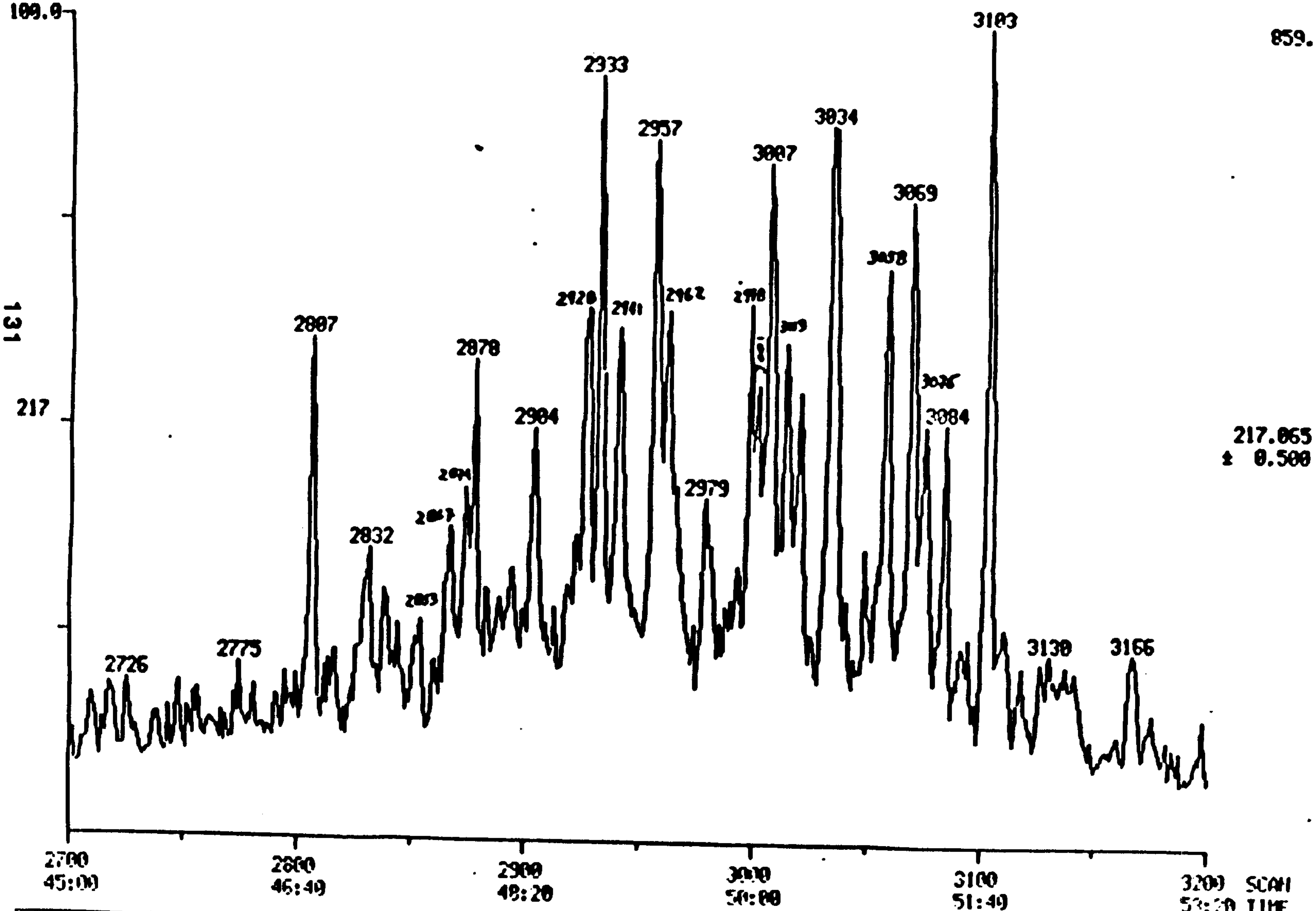
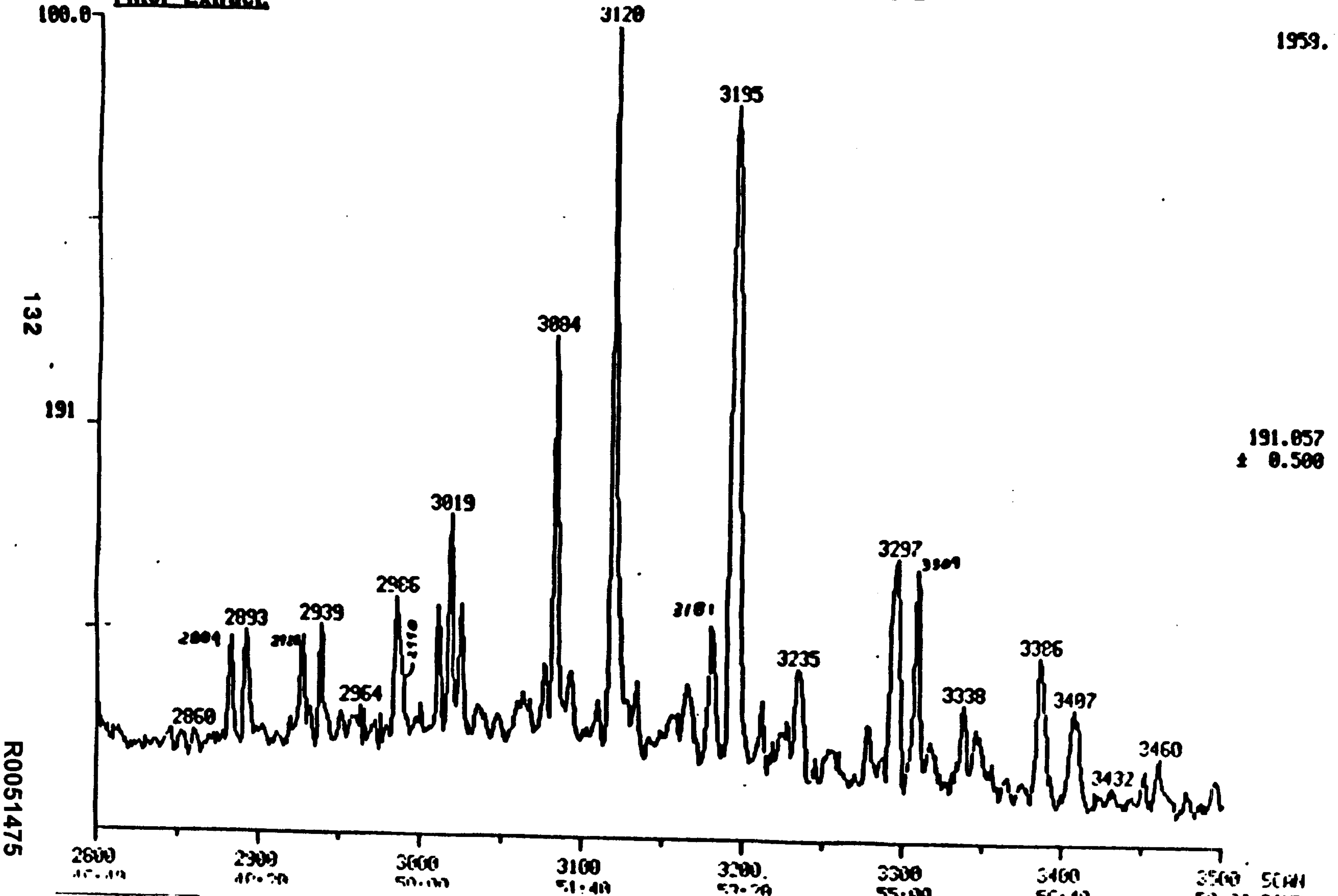


Figure 42

M/Z 191 Mass Chromatogram Showing Triterpanes in Ashland 7-27-92 Filter Extract.



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In summary, Tables 15-20 compare the data that are greater than the minimal detectable limit versus EPA Drinking Water Standards and the California Ocean Plan Standards placing the quantitative data in perspective. Most samples analyzed for Base Neutral Organic Compounds (See Tables 15-20) exceed the proposed California Ocean Plan Standards for PAHs of 8 ng/l. A few samples exceed the EPA Drinking Water Standards for methylene chloride and the California Ocean Plan for Bis(2-ethylhexyl) phthalate; however both of these are notorious laboratory contaminants. The data presented show that the phthalates data are sufficiently quality assured as the concentrations are an order of magnitude greater than any of the blank values. However, the methylene chloride data need further confirmation with discrete sampling for it alone under meticulously controlled conditions. The CA Ocean Plan was not designed for evaluation of non-point source storm water runoff as discussed on page 121 of this report. Therefore, the CA Ocean Plan Standards can only be used to guide which compounds are considered to be important for future evaluations. The Ocean Plan should be amended to clarify its applicability to storm water discharge.

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DISCUSSION

There are 64 storm drains that terminate in the Santa Monica Bay. During the winter rainy season, the storm drains provide access to the Bay for large quantities of rain water. During the dry season, water from urban runoff, construction, illegal dumping, and other sources results in a continuous influx of chemical contaminants to the Santa Monica Bay. Unlike many other coastal areas around the United States such as the San Francisco Bay area, the Chesapeake Bay, and New York-New Jersey area, there is no major source of river water into the Bay. The effluent from storm drains then represents a major contributor of potentially contaminated water to the Santa Monica Bay.

This pilot study is the most comprehensive investigation to date of chemical releases from storm drains into the Santa Monica Bay. This is also one of the first studies to consider the relationship between chemicals in the water and those bound to sediment. The findings in this study should form the basis for follow-up studies to further characterize the chemical releases, address their impact on the ecology of the Bay, identify the sources of the contamination, further characterize flow patterns into the Bay, quantitatively assess health risk, and establish monitoring protocols and limits for chemical releases into the Santa Monica Bay.

This investigation must be viewed as a pilot study since resource limitations prevented us from determining the potential sources of the contamination, examining a larger number of storm drains, investigating the concentration of metals, and evaluating a wider range of toxicants. Additional studies are required to address a number of unanswered questions. These will be discussed below.

The overall objective of this study was to gather data on the identity and quantity of potential toxic constituents that are present in urban runoff storm drains. These data are to amplify our limited understanding of the nature of chemicals that are transported from storm drains into Santa Monica Bay. The storm drains studied were "Pico/Kenter", "Ballona", "Sepulveda", "Ashland" and "Centinela". The analyses were completed over a six month "dry weather" flow period June 12 to December 10, 1992. Before the November 2 and December 10 sampling days, 0.5 and 3 inches rain fell, respectively. The complete data base is tabulated in Appendices IV and VI for volatile organic chemicals and base neutral organic chemicals, respectively.

A minimum of 50 trace organic compounds was identified in each storm drain with over 120 compounds found at the Ashland Storm Drain. Included in this evaluation are 16 - 27 targeted Volatile Organic Chemicals (VOCs), 31 - 41 targeted Base Neutral Organic Compounds (semi-volatiles), over 65 non-targeted VOCs and over 50 semi-volatiles. The individual concentrations ranged from ng/L to ug/L in the storm drain samples. Compounds with toxicologic significance were the phthalates, polycyclic aromatic hydrocarbons (PAHs), chlorinated hydrocarbons, phenols, and other carcinogenic organic compounds. Some of these compounds were found in small quantities. See discussion below.

Special quantitative analyses were conducted for two organophosphate pesticides, diazinon and dimethoate, as well as chlorinated pesticides, and PCBs. Diazinon and dimethoate were found in some of the base neutral sample extracts. The chlorinated pesticides, alpha-chlordane and dieldrin and a number of PCBs were identified in the storm drain samples. The greatest concentrations were found at Ashland, but there was evidence for PCBs at other sites as well. Further work is required to quantify the PCBs found in storm drain effluent with particular attention to elimination of laboratory blank contamination.

These results raise an important issue: what is the source of these compounds? Perhaps the organophosphates pesticides are from readily available home garden products, but there is no obvious point source that can be readily identified that would account for the PCB releases, alpha-chlordane and dieldrin. Presumably the PCBs identified in this study, and the dioxins and chlorinated naphthalenes identified by Fisher et al. (1993) are products of combustion from chlorine and carbon containing compounds. PCBs can derive from settling of PCB-associated aerosols from the ambient air environment into the open storm drains. Evaluation of ambient air concentrations should be conducted to determine the potential for airborne PCBs to enter storm drains. Studies to further characterize these compounds and their origins should be a high priority for state and local officials as some of these compounds have the potential to bioaccumulate and are both toxic and/or carcinogenic. Thus, such studies would represent the most important contributor to any risk assessment carried out on the compounds identified in this study.

In contrast to the ng/l to ug/l levels of Base Neutrals and VOCs, the dissolved organic carbon (DOC) levels are greater than 1,000 times this level (mg/l) for the first six samples collected and near 10 times more for the last two samples collected. Apparently, higher molecular weight chemicals are making up the bulk of the chemicals present. Probably, humic materials, algal metabolites, and oily materials are associated with the DOC. A new study is needed to assess the type of DOC present and its interaction with the trace organic chemicals present. There is no evidence on the toxicity of these currently uncharacterized organic compounds although concerns have been raised about the toxicity of products of chlorination from the humic materials.

A recent study by the City of Santa Monica focused on an evaluation of the use of ozone to reduce or mitigate the flow of chemical constituents into the Santa

Monica Bay via the Pico-Kenter storm drain (Ozone Disinfection and Treatment of Urban Storm Drain Dry-Weather Flows, Santa Monica Bay Restoration Project, June 1992). In addition there are two unpublished reports in the grey literature that have investigated chemical contamination of storm drain effluent. The first report by Young and Bodeen, EPA Report #600/X-91/030, April 1991, summarized data from a number of studies conducted between 1970 and 1985. DDT, dieldrin, and PCBs were observed in storm drain effluent from Ballona Creek. A second study by Schafer and Gossett, June 1988, entitled "Storm Runoff in Los Angeles and Ventura County" conducted for the California Regional Water Quality Control Board (LA region-SCCWRP C292) also identified DDT, PCBs, PAHs, and alkanes in storm drain effluent from Ballona Creek. It appears that little attention has been given to the findings from these studies. More recently, Fisher et al., (1993 as per Stentstrom, personal communication) in a paper being prepared for publication, have reported the presence of dioxins, furans, and polychlorinated naphthalenes in storm drain effluent entering the Santa Monica Bay.

This latter study has direct relevance to the results reported here insofar as the more complex chlorinated products, e.g., dioxins, are generally associated with PCBs. Further investigation of the concentration of both dioxins and PCBs is necessary to determine if both classes of compounds can be detected and quantified in the same storm drain effluent. Secondly, a study of this nature may also provide a basis to use one species of chlorinated hydrocarbon as a surrogate to estimate the concentration of other chlorinated compounds for purposes of exposure and risk assessment.

Volatile Organic Compounds

In this study, 33 volatile organic compounds were found in the effluent from the 5 storm drains. Five compounds, bromoform, chloroform, dibromochloromethane, dichloromethane(methylene chloride), and 4-methyl-2-pentanone had overall averages in the part per billion range (Table 13), whereas the concentration of the remaining compounds was in the part per trillion range. The largest number of compounds and the greatest concentrations were found at Ashland Avenue where 29 compounds were found. The concentrations of the trihalomethanes, bromoform, chloroform, and dibromochloromethane, and of methylene chloride, were 10.6, 4.1, 4.9, and 6.3 ppb at this site. The site with the fewest identified volatiles was Pico-

Kenter where 17 compounds were identified, of which only methylene chloride was greater than one ppb. There was significant variability between sites in terms of the concentrations of volatiles identified. For example, the concentrations of bromoform ranged from 10.6 ppb at Ashland to 0.2 ppb at Ballona.

These data are consistent with earlier work conducted by UCLA under contract to the City of Santa Monica where samples were collected from the Pico-Kenter storm drain. During a 1986 monitoring study conducted by Los Angeles County Public Works, the concentration of methylene chloride ranged from 0.3 to 1.6 ppb, while the 1989-90 City of Santa Monica study found a range of 0.03 to 18 ppb with an average of 1.4 ppb. This latest study found the concentration range to be 0.2 to 12.8 ppb with an average of 2.2 ppb. There are similar results for the other volatiles collected in the City of Santa Monica study and this study.

The compounds bromodichloromethane, bromoform, chloroform, 1,2-dichloroethane (ethylene dichloride), methylene chloride, trichloroethene (trichloroethylene-TCE), and tetrachloroethene (tetrachloroethylene or perchloroethylene-PCE), all of which were identified in effluent, are considered probable human carcinogens by EPA, and dibromochloromethane is considered a possible carcinogen. Benzene is recognized as a human carcinogen by EPA. The identified compounds, benzene, bromochloromethane, bromodichlorometh- ane, bromoform, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, methylene chloride, trichloroethylene and perchloroethylene are classified as chemicals known to cause cancer under the State of California's Proposition 65 (The Safe Drinking Water and Toxic Enforcement Act of 1986). Carbon disulfide, chloroform, and toluene are listed under Proposition 65 as reproductive toxicants. Styrene oxide, a metabolite of styrene, is listed as a carcinogen under Proposition 65.

The trihalomethanes (bromodichloromethane, bromoform, chloroform) and the solvent, methylene chloride were found at all 5 sites. The trihalomethane concentrations identified in the study are well below those generally found in chlorinated drinking water. For example, the range of bromoform in U.S. surface waters ranges from 133 to 27,000 ng/L, and the level of chloroform ranges from 267 to 198,000 ng/L. The EPA National Organics Reconnaissance study (Preliminary Assessment of Suspected Carcinogens in Drinking Water, Report to Congress, U.S. Environmental Protection Agency, 1975) found the median levels of bromoform and chloroform in finished water to be 5,000 and 21,000 ng/L respectively. These values can be compared to the levels of bromoform (1,350 ng/L) and chloroform (1,150 ng/L) found in this study. The risk of cancer from ingestion of 2 liters of water/day containing 1,000 ng/L of bromoform has been estimated to be 5.6×10^{-8} and the corresponding risk for chloroform would be 4.3×10^{-8} (Froines et. al., 1991; "Evaluation of the Potential Health Risks Presented by Chemical Agents Associated with the San Diego Total Resource Recovery Program - Final Report", Prepared by the University of California, Los Angeles for the Western Consortium for Public Health, June 1991). The cancer risk from dermal contact with storm drain effluent containing trihalomethanes would be well below these values.

The VOCs identified in this study are toxic compounds, but they are not likely to exert their systemic or acute toxicity at the levels found in this study. Whether they would have adverse health effects in combination with other contaminants is not known. For example, it is not known whether trace quantities of organic solvents will facilitate absorption of larger organic molecules through dermal contact.

The data indicate that a number of volatile organic compounds recognized as being potential human carcinogens or reproductive toxicants were identified as being present in the effluent from the five storm drains. All the identified toxicants are capable of absorption through dermal contact as well as via inhalation or ingestion. The actual concentrations of the volatile organic compounds are relatively low as might be anticipated by the fact that these compounds are volatile and likely to evaporate from the storm drain effluent. In general these data and those derived from earlier studies demonstrate that small amounts of volatile organic compounds, some with well recognized toxicity/carcinogenicity, are routinely found in storm drain effluent.

The actual risk associated with any one compound would be low, for example, relative to drinking water standards. However, a quantitative risk assessment would evaluate risk as the sum of the individual risks, and the contribution of the volatile organic compounds would then be evaluated in terms of their contribution to the overall risk to the most highly exposed individual. It is beyond the scope of this project to conduct such a risk assessment, but it is likely that the risk from the volatile organic compounds would remain low relative to that derived from the phthalates, PAHs, PCBs, and chlorinated pesticides (see below).

If a State monitoring program were to be established for storm drains, the trihalomethanes, PCE, TCE, methylene chloride, benzene, and the dichloroethanes should be included as compounds of interest.

Base Neutral Compounds

The chemical compounds identified as "base neutral compounds" are organic compounds of higher molecular weight than the volatile organic compounds and as a result they generally have a lower vapor pressure and are significantly less volatile. They are often described as "semi-volatile compounds". The base neutral analysis includes compounds such as polycyclic aromatic hydrocarbons (PAHs), phthalates, phenols, some chlorinated aromatic compounds, and other miscellaneous compounds. These compounds are particularly important insofar as there is considerable evidence for their toxicity, and we anticipated finding significant quantities of a number of the chemical compounds.

Phthalates

Six phthalates were identified as being present in the storm drain effluent from all five sites. The most important compound identified and characterized was bis(2-ethylhexyl)phthalate. This compound was found in the greatest quantity of all the phthalates. Bis(2-ethylhexyl)phthalate (DEHP) is classified as a probable human carcinogen by U.S. EPA, the National Toxicology Program, and the International Agency for Research on Cancer (IARC). It has produced cancers in both rats and mice as a result of oral administration of DEHP. It is classified as a carcinogen and reproductive toxicant under Proposition 65 in California. It is considered a chemical teratogen and may damage the testes. Repeated exposure may result in neurological consequences. It has acute toxicity and produces irritation of the eyes, nose, and throat. Exposure to DEHP can occur through inhalation, ingestion, or dermal contact. The maximum contaminant level (MCL) established for DEHP in drinking water by EPA is 4 ppb. The California Ocean Water Plan limit is 3.5 ppb.

The average concentration found for DEHP in this study was 6.6 ppb. The greatest concentration, 14.8 ppb was found at Ashland and the lowest concentration identified was at Sepulveda with a value of 4.3 ppb. In our view, these concentrations of the suspected carcinogen require additional follow-up. Based on the concentration of DEHP and the other phthalates, phthalates should be considered candidates if a monitoring program is established.

This compound would not be expected to bioaccumulate although the data are far from complete in this respect. There is potential for dermal contact and absorption which is likely to be the source of greatest exposure.

The toxicity of the remaining phthalates has not been well characterized with the exception of butyl benzyl phthalate. EPA is considering establishing a drinking water standard for this compound. EPA considers it a possible human carcinogen on the basis of a chronic animal bioassay conducted by the National Toxicology Program where there was evidence for mononuclear cell leukemia in female rats.

The largest average concentration of butyl benzyl phthalate was found at Ashland, 1.5 ppb, and the lowest, 0.7 ppb, was at Centinela Avenue. The overall average concentration was 1.1 ppb.

The other phthalates have not been characterized with respect to their carcinogenicity or reproductive toxicity. No other chronic toxicity has been described. The phthalates appear to be genotoxic in some assays. For example, dimethyl phthalate and diethyl phthalate were found to be weak direct-acting mutagens in forward and reverse assays. Dimethylphthalate was active in the mouse lymphoma forward mutation assay in the presence of metabolic activation. Therefore, additional research must be conducted to evaluate their potential as human carcinogens. Their presence in storm drain effluent is a matter of concern even through the experimental data is regrettably limited.

Phthalates are widely used in industrial applications and are particularly widespread contaminants as a result of their use as plasticizers. They are likely to be found wherever there are plastics found, and generally are considered ubiquitous contaminants. The phthalates are often found as laboratory contaminants and any identification and quantification of these compounds always has a degree of uncertainty associated with their analysis. Further studies would be valuable to further confirm the concentrations of these substances in storm drain effluent.

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Further attention to these compounds should be given in the development of any monitoring protocol.

Polycyclic Aromatic Hydrocarbons

PAHs represent one of the most important groups of chemical compounds found in this study. There were 17 PAHs identified in the storm drain effluent: acenaphthene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3,4-c,d)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene (Table 20). The average concentrations ranged from 8 ng/L for dibenzofuran to 513 ng/L for chrysene. The concentration of benzo(a)pyrene was 400 ug/L.

The greatest concentration of PAHs was found at Sepulveda where the benzo(a)pyrene, chrysene and pyrene concentrations were 1,803 ng/L, 2,016, and 956 ng/L respectively. These values may be compared to the California Ocean Plan guidelines which seeks to limit PAH concentrations to 8.8 ng/L. These comparisons are made for illustrative purposes only. The comparisons are made without considering dilution of effluent in ocean water, and we hesitate to make any quantitative comparison between the standards and our findings.

The concentrations of PAHs identified in this study are lower than those found in the 1989-90 investigation of Pico-Kenter storm drain by the City of Santa Monica. There is no obvious explanation for the differences. The laboratory conducting the analyses for both studies was the same - UCLA.

Seven of these compounds, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3,4-c,d)pyrene are considered possible human carcinogens by EPA. All seven are classified as compounds known to cause cancer under California's Proposition 65, and an eighth compound, fluoranthene, is also so named. Five of the seven compounds were identified at all five storm drain sites. Two compounds, dibenzo(a,h)anthracene and indeno(1,2,3,4-c,d)pyrene were found at two and three sites, respectively. The primary health risk that would be associated with PAHs in water would probably derive from dermal contact. The carcinogenicity of this class of compounds was originally recognized as a result of studies which focused on dermal contact.

The information on the toxicity/carcinogenicity of the other PAHs is more equivocal than for the 7 identified above, but there is evidence that these and other PAHs not sampled in this study are carcinogenic. Of those not sampled for in the study, nitro-PAHs are found in important quantities in ambient air in southern California, and they are considered more carcinogenic than PAHs. For example, 6-nitrochrysene, a product of nitration of chrysene in the atmosphere, is considered an order of magnitude more potent than benzo(a)pyrene. We were not able to sample for these substituted PAHs nor other more polar PAHs. The dibenzopyrenes were also not sampled for in this study, and they are considered by the State of California to be approximately ten times more potent carcinogens than benzo(a)pyrene. Thus, it is possible that unsampled PAHs may be present in storm drain effluent. Further studies to enlarge the scope of the PAH characterization are necessary and important.

The PAHs found in this study are partitioned between water and sediment in the water. The PAHs are usually associated with the sediment phases. The amount that would be available for dermal absorption to a swimmer/surfer/wader is not well understood. There are very few studies that have characterized on a quantitative basis the desorption of contaminants from suspended sediments into ocean water when a contaminated sediment comes in contact with uncontaminated ocean water. Further studies are necessary to determine the kinetics of the desorption or release of PAHs from sediment in storm drain effluent to ocean water.

The following studies should be conducted to improve our understanding of the processes influencing the transport and fate of sparingly soluble organic pollutants such as PAHs in flowing surface waters and estuarine systems.

1. Further studies to characterize the nature of the suspended solids (SS) and dissolved organic matter (DOM) in each storm drain.
2. Improved definition of the equilibrium state of the storm drain systems.
3. Studies to determine the kinetics of sorption and desorption using the SS/DOM characteristic of each venue and characterization of the dry weather and rainfall runoff.

There are a wide range of sources of PAHs to the storm drains and it was not surprising to find them in significant concentrations. PAHs do not derive from a point source. They represent products of an urban society which emphasizes the use of petroleum based transport. They are often products of incomplete combustion and are ubiquitous in the environment. They may emanate from exhaust, tires, used motor oil, or other transport-related processes as well as from industrial sources which create products of incomplete combustion. PAHs represent important toxic air contaminants and are particle associated. This study examined a relatively small number of PAHs. In general, PAHs are widely recognized as being carcinogenic and the finding of meaningful quantities in storm drain effluent is a matter for further consideration. They have been found in other studies of storm drain effluent in the U.S. and abroad.

The primary issue with PAHs is not whether they are going to be found, but the degree of contamination, the necessity of monitoring for their presence, and ultimately the control of their releases to the Bay. In a society with an emphasis on petroleum based products, the control of releases to the Bay may prove difficult, but it requires attention since there are potential health and environmental consequences from the contamination by PAHs. The scope of any monitoring program will of necessity follow additional characterization of the number and quantities of PAHs not sampled for in this study. It would be useful to determine if a surrogate PAH could be established that would enable estimation of a wide range of PAHs based on the assessment of a few.

Other Carcinogens Identified

Azobenzene, 1,4-dichlorobenzene, N-nitrosodiphenylamine, and N-nitrosodi-n-propylamine were identified in some storm drains. These compounds are considered to be carcinogens under Proposition 65 by the State of California. They are not regulated by U.S. EPA in the context of drinking water. With the exception of 1,4-dichlorobenzene, EPA classifies these compounds as probable human carcinogens. Azobenzene and 1,4-dichlorobenzene were identified at all 5 sites. The concentrations of these compounds were generally low, and their contribution to the overall risk associated with storm drain effluent would probably be insignificant in

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relation to the PAHs, phthalates, and chlorinated organic compounds such as the chlorinated pesticides, PCBs and dioxins.

Phenols

Seven phenols were identified as being present in storm drain effluent in this study. Phenol and 2-nitrophenol were found at all five sites, 4-methyl phenol at 3 sites, and 4-chloro-3-methyl phenol, 2-methyl phenol, 4-nitrophenol, and 2,4-dimethyl phenol were found at one site. 2-Methyl phenol is classified as a possible human carcinogen by EPA. All these phenols are known to possess acute toxicity. Acute toxicity would not be anticipated at the levels found in the study, but acute toxicity could be anticipated when phenols are combined with the myriad of other chemicals identified in the study depending on the degree of dilution by ocean water. There is less evidence of their capacity to produce chronic toxicity although the data are somewhat limited. There is evidence from animal studies of reproductive toxicity associated with exposure to phenols, and phenol is classified as a reproductive toxicant under Proposition 65. This class of compounds would be important in any monitoring program that was established as a result of this and other studies.

Pesticides and Polychlorinated Biphenyls

The evaluation of pesticides and polychlorinated biphenyls was not a central feature of this investigation. However, selected samples were analyzed for pesticide and PCB content. The organophosphate pesticide diazinon was identified in water from Centinela, Ashland, and Pico-Kenter, while dimethoate was found at Ballona (Table 23). These are commonly used pesticides, and it is not surprising that they were identified.

We recommend that monitoring for pesticides be considered in the future, although until further studies are conducted to further characterize pesticide releases, we would not recommend routine monitoring. We have no direct knowledge of the persistence of these pesticides in aqueous media such as the Santa Monica Bay.

The finding of alpha-chlordane, dieldrin and PCBs, the latter especially in the Ashland drain, represents an important finding in this study (Table 24). These substances are of particular significance because of their potential toxicity, persistence, and potential for bioaccumulation in the environment. This contracted study did not include the evaluation of the storm drain effluent for PCBs and chlorinated pesticides, but we chose to investigate them, albeit in a preliminary manner, to expand the scope of the investigation. Earlier studies of Ballona had identified PCBs in effluent from that storm drain. The source of the PCBs is not apparent, but it seems likely they are products of combustion of compounds containing chlorine and carbon or derive from the PCB-associated aerosols from the ambient air environment. Our findings clearly indicate the need for follow-up studies to further characterize the releases of these compounds to the Santa Monica Bay.

PCBs are considered to be probable carcinogens by EPA and IARC. They are classified as 2A ("probable carcinogen") by IARC on the basis of limited human evidence and sufficient animal evidence. PCBs are listed as chemicals known to cause cancer and reproductive toxicity under Proposition 65. In addition to PCBs the analysis identified the chlorinated pesticides, chlordane and dieldrin. Chlordane is considered possible carcinogens by IARC. Chlordane and dieldrin are listed as carcinogens under Proposition 65 in California.

Some PCBs were identified in all the storm drains although the vast majority was found at Ashland. The concentrations of the PCBs identified in the study may be compared to the California Ocean Plan for purposes of discussion. The California Ocean Plan limit for PCBs is 0.019 ng/L. Many of the PCBs identified in this study exceed that value by a factor greater than a thousand. For example, the total PCBs found in the Ashland drain was 451 ng/L (Table 24). Assuming a background of approximately 125 ng/L, the concentration of identified PCBs is approximately 325 ng/L which is 17,000 times the California Ocean Plan limit. These values must be interpreted very carefully because the actual quantification of the PCBs is incomplete especially given the background laboratory contamination identified in the study, and the appropriate level of dilution to be assumed in going from the storm drain to ocean water is not obvious. We conclude that PCBs were identified in the storm drain effluent and the concentrations in at least one storm drain was a matter requiring followup. PCBs are found in aerosols in the ambient air, and the contribution of airborne PCBs to the bay and storm drains requires further followup studies.

A quantitative risk assessment would combine the health risk from the chlorinated pesticides, PCBs, PAHs, volatile organic compounds, phthalates, and other identified carcinogens and toxicants in order to develop a total risk characterization and to determine the relative risks from each constituent. This represents a major undertaking that does not lie within the scope of this project but is an essential element of any future research. A quantitative risk assessment methodology should be developed to investigate the risk to swimmers/surfers, waders as well as addressing the consequences of the bioaccumulation of toxicants in fish and other sea life. The latter exposure, bioaccumulation in sea life, may represent the most important route of exposure for PCBs whereas the PAH exposure via dermal contact may be most important for that class of compounds. Toxicity studies that examine the impact of the release of toxicants on sea life and the ecology of the Bay are clearly desirable.

Non-target Chemicals

The focus of this study was on the identification and characterization of volatile organic compounds and semi-volatile organic compounds. During the course of the study a large number of these substances was identified and quantified in the effluents from the five storm drains. In addition to the compounds that were originally examined using the EPA analytical methodology, a large number of non-target chemicals was also identified. These are listed in Table 22 and 25. Characterization of the toxicity of these compounds is almost non-existent. Thus, we do not know whether the parent compounds or their breakdown products constitute a health risk to humans or may have adverse consequences to marine life or the environment at their concentrations in storm drain effluents. Some of the compounds are toxic, but whether the concentrations of these agents is significant remains to be determined. However, this preliminary work demonstrates that the original focus on specific substances may have been too limited, and that further studies in the future to identify and characterize these non-target substances may be a reasonable priority as California moves forward to develop a monitoring plan and control program for its storm drains.

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CONCLUSIONS

This pilot study has identified and quantified the existence of a large number of organic compounds in five storm drains. The study has demonstrated that the problem of chemical contamination is not limited to any single storm drain and suggests the need to investigate other storm drain effluent to the Santa Monica Bay.

The study also demonstrated that many of the compounds identified are widely recognized as being probable or possible carcinogens, reproductive toxicants, or having other chronic and acute toxicities. In some cases, for example, volatile organic compounds, the concentrations of the most toxic of the compounds, namely the trihalomethanes, benzene, methylene chloride, perchloroethylene, and trichloroethylene were very low, and reflected the high volatility of the compounds combined with the high surface area for evaporation. In other cases the concentrations of the toxicants appeared to be more substantial. The concentrations of certain phthalates, PAHs, chlorinated pesticides and PCBs appear to be a matter of concern.

We did not attempt to conduct a quantitative risk assessment, because there were too many uncertainties in the available data to justify actual calculations of risk. For example, we were aware that PAHs are associated with sediment in the storm drain effluent. Whether those PAHs are desorbed from the sediment when the storm drain reaches the Bay is a question that will require additional investigation. It is likely that the PAHs will remain adsorbed to sediment even while some partition to the ocean water and become available for dermal contact with a human or other sea life. A series of studies are required to determine the desorption of contaminants from the suspended sediment. Second, we did not have an estimate of the dilution that would occur in going from the storm drain to the Bay. Finally, the permeability characteristics of some of the toxicants are incompletely understood. The development of methodology to conduct a quantitative risk assessment should be a priority in any follow-up studies. These studies could make use of EPA guidelines on the estimation of dermal uptake, and it is possible to develop a number of different exposure scenarios that would result in a range of risk estimates. Subsequent analysis would also need to include an estimation of the uncertainty in the range of risk values.

In addition to the limitations described above the data are not available to describe the mass flux under dry and wet weather flows and to use these findings as a model. We have only studied dry weather flows, and wet weather flows are necessary to broaden the scope of the data available to characterize the releases to the environment. We lack information on flow rates, currents, dilution and dilution speed into the Santa Monica Bay. Some of these issues have been pointed out by Eisenberg, Olivieri, & Associates (EOA) in their initial document to American Oceans, and these remarks and the others raised by EOA deserve further attention.

Throughout this discussion section we have made numerous recommendations for additional studies, and we have attempted to identify those compounds which would form the basis for an ongoing monitoring program. These recommendations should now be combined with those developed by EOA in their preliminary report to develop a more comprehensive strategy for addressing the flow of chemical contaminants into the Santa Monica Bay. Previous studies in the grey literature have also identified similar compounds to those described here, although those reports seem to have been given little attention. It is important that the results of all the studies be combined and both a long term and short term strategy be developed to address the consequences of storm drain runoff into the Santa Monica Bay.

In this study we have emphasized those compounds for which there is ample evidence for chronic toxicity associated with long term exposure to the toxicants in question. We have not addressed the issue of acute toxicity associated with these same and other toxicants. There have been numerous reports of acute toxicity associated with contact with water in the Bay and whether these illustrations of acute toxicity are derived from bacterial contamination or chemical toxicity or both is unclear.

It is not apparent whether the concentrations of chemical contaminants identified in storm drain effluent in this and other studies meet or exceed water quality objectives developed by the State of California or local jurisdictions. With the exception of the California Ocean Plan guidelines, there appear to be no defined objectives which we could use for comparison purposes. If these values exist we could then determine if the concentrations are greater than the water quality objectives, how much are they exceeded, and how frequently they are being exceeded. The approaches used by these various agencies in the setting of water quality objectives and how are they evaluated, enforced, or reviewed is a matter of importance from the standpoint of public policy. The EOA report discusses these and other issues in greater detail, but the fundamental question is how government agencies are addressing the monitoring and control of the flow of toxic chemicals into the Santa Monica Bay and what additional studies are relevant to provide an improved data base for policy decisions concerning the need to protect the public health and the environment.

Finally, the ultimate issue is how are we going to protect the Santa Monica Bay from chemical contamination? These are not easily answered questions, but it is clear that we need greater attention to identifying the scope and magnitude of the potential problems, conducting important scientific studies to better and more thoroughly characterize the issues before us, and to develop the means to monitor and control the effluent into the Bay. As stated at the outset of this discussion, the storm drains that empty into the Santa Monica Bay are an important source of chemical contaminants that may have adverse effects on humans who use the Bay for recreation, food, and other purposes as well as having negative consequences for marine life and the overall natural environment. The Santa Monica Bay is a natural resource of untold beauty and benefit to the citizens of Southern California, and we believe that continued effort is necessary to maintain this environment from the consequences of chemical pollution. The preservation of this natural resource should have the highest priority for our officials and scientists. This study reported here represents only a first step in an effort to develop a series of investigations that will enable State and local officials to take proactive steps in terms of monitoring and control to limit chemical releases tc the Bay.

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Appendix I

Water Quality Data Collected at Each Sampling Site

Sampling Site - Ballona Creek @ Inglewood

Sampling Site - Sepulveda Channel @ Ballona Creek

Sampling Site - Pico Kenter

Sampling Site - Ashland

Sampling Site - Centinela Creek @ Inglewood

BALLONA-CREEK @ INGLEWOOD

Parameter	6/12/92	7/7/92	7/27/92	8/24/92	9/8/92	9/29/92	10/12/92	11/2/92	11/23/92	12/10/92
Sample Type	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Grab (pm)	Composite
Alk (mg/L as CaCO3)	220	250	165	185	205	215	215	275	175	275
Hardness (mg/L as CaCO3)	480	494	356	628	594	1082	492	720	388	[illegible]
pH*	8.9	8.7	9.5	9.15	8.6	8.8	9	8.5	9.6	8.2
Conductivity (umho/cm)*	1900	1855	1419	2210	1975	3140	1630	[illegible]	1126	2540
Ammonia (mg/L as NH3 N)	-	0.11	0.0629	0.0821	0.1	0.0136	0.0287	0.0255	0.1	0.6486
Nitrite (mg/L NO2 N)	0.072	0.0493	0.0153	0.0588	0.0171	0.0929	[illegible]	0.1479	0.0296	0.1347
TDS (mg/L)	980	886	856	1362	1414	2328	1134	1526	817	1901
TSS (mg/L)	173	22	14	8	8	13	3	5	3	16
VSS (mg/L)	-	12	10	6	4	9	2	4	2.6	6
COD (mg/L)	-	35	33	48	17	65	70	34	13	45
DOC (ppm)	-	14	8	7	8	12	7	71	31	96
Detergent (ppm as LAS)	-	-	-	0.75	1.5	0.5	0.25	-	-	-
uv absorbance (at 254nm)	0.17	0.20	0.13	0.18	0.15	0.16	0.22	0.15	0.10	0.13
Turbidity (NTU)	9.5	1.78	3.8	2.6	3.4	3.08	2.4	1.8	2.1	2.8
% Salinity **	-	-	1.33	1.78	1.22	1.22	1.07	1.23	0.85	1.51
DO (ppm) **	-	13.6	> 15	> 15	> 15	14.7	> 15	> 15	> 15	14.2

BALLONA-CREEK @ INGLEWOOD

Parameter	12/14/92 am	12/14/92 pm	1/12/93 am	1/19/93 am	1/19/93 pm
Sample Type	Grab	Grab	Grab	Grab	Grab
Alk (mg/L as CaCO3)	285	285	235	254	255
Hardness (mg/L as CaCO3)	854	1725	500	510	480
pH*	8.4	8.15	8	8.1	8.1
Conductivity (umho/cm)*	2180	4620	1644	1053	1054
Ammonia (mg/L as NH3 N)	1.0636	0.705	0.5179	0.2795	0.1278
Nitrite (mg/L NO2 N)	0.2593	0.1737	0.2453	0.0624	0.0795
TDS (mg/L)	1770	3810	1202	829	839
TSS (mg/L)	6	174	19	97	148
VSS (mg/L)	4	37	4	12	16
COD (mg/L)	28	70	37	37	46
DOC (ppm)	-	-	-	-	-
Detergent (ppm as LAS)	-	-	-	-	-
uv absorbance (at 254nm)	0.12	0.27	0.11	0.25	0.23
Turbidity (NTU)	2.8	146	9.4	55.5	102
% Salinity **	0.92	-	-	-	-
DO (ppm)**	12.3	-	-	-	-

* measured in lab ** measured in the field - no sample taken/no analysis done

SEPULVEDA CHANNEL@ BALLONA CREEK

Parameter	6/12/92	7/7/92	7/21/92	8/24/92	9/8/92	9/29/92	10/12/92	11/2/92	12/10/92
Sample Type	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
Alk (mg/L as CaCO3)	85	212	160	145	145	170	215	205	245
Hardness (mg/L as CaCO3)	1364	1570	250	2100	1434	818	1524	3113	1444
pH*	9	8.5	9	8.8	8.7	9.1	8.6	8.5	8.1
Conductivity (umho/cm) *	4000	5650	2870	7150	4720	3270	5530	6260	4220
Ammonia (mg/L as NH3 N)	-	0.063	0.0629	0.0675	0.0681	0.0136	0.0162	0.0137	1.4251
Nitrite (mg/L NO2 N)	0.095	0.0989	0.0248	0.2129	0.0605	0.0525	0.1296	0.5093	0.2185
TDS (mg/L)	3246	3548	1846	4657	4071	1931	3721	3027	3267
TSS (mg/L)	15	41	15	12	13	11	5	2	104
VSS (mg/L)	-	19	8	7	7	7	3	2	17
COD (mg/L)	-	62	73	88	73	40	90	61	71
DOC (ppm)	-	16	14	11	16	-	10	69	67
Detergent (ppm as LAS)	-	-	-	1	0.5	0.5	0.75	-	-
uv absorbance (at 254nm)	0.10	0.24	0.10	0.20	0.18	0.18	0.16	0.14	0.25
Turbidity (NTU)	2.3	3.4	5.6	3.1	4.22	2.64	3.35	1.34	39.7
% Salinity **	-	-	1.18	3.17	2.12	2.02	1.85	2.12	1.57
DO (ppm) **	-	13.6	14.8	>15	>15	14.9	14.9	>15	14.5

* measured in lab

- no sample taken/no analysis done

PICO-KENTER

Parameter	4/17/92	6/12/92	7/1/92	7/21/92	8/24/92	9/8/92	9/29/92	10/12/92	11/2/92	12/10/92
Sample Type	Grab	Grab	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
Alk (mg/L as CaCO3)	304	250	325	275	244	230	260	275	295	285
Hardness (mg/L as CaCO3)	298	234	256	242	536	234	284	239	272	270
pH*	8.5	8.4	8.4	7.9	7.6	7.6	7.7	7.65	7.9	8.4
Conductivity (umho/cm)*	1477	1460	1902	1743	4350	1380	1620	1450	1540	1025
Ammonia (ppm as NH3 N)	-	-	0.28	0.0522	0.2154	0.6813	0.0801	0.0287(?)	0.0177	0.0906(?)
Nitrite (mg/L NO2 N)	0.114	0.056	0.0686	0.1607	0.2021	0.049(?)	0.0496	0.0695	0.1024	0.0419
TDS (mg/L)	886	791	1055	751	2456	876	1123	900	941	721
TSS (mg/L)	-	9	13	29	149	40	138	21	4	39
VSS (mg/L)	-	-	6	12	65	15	56	4	4	8
COD (as mg/L)	-	-	93	66	132	43	69	63	41	19
DOC (ppm)	-	-	18	15	14	7	16	15	89	74
Detergent (ppm as LAS)	-	-	-	-	0.75	0.5	0.5	1	-	9.7
uv absorbance (at 254nm)	-	0.36	0.40	0.38	0.46	0.47	0.57	0.43	0.4	0.19
Turbidity (NTU)	2.05	7.3	3.67	22	45	17.4	16.9	24.8	4.8	11.3
% Salinity**	-	-	-	0.75	1.5	0.25	0.9	0.3	0.0175	0.625
DO (ppm)**	-	-	7.9	6.5	5.7	5.8	7.2	6.85	5.95	9.7

TDS = 0.6 x umho/cm

* measured in lab

** measured in the field

- no sample taken/no analysis done

ASHLAND

Parameter	4/17/92	6/12/92	7/7/92	7/27/92	8/24/92	9/8/92	9/29/92	10/12/92	11/2/92	12/10/92
Sample Type	Grab	-	Composite	Composite	Composite	-	Composite	Composite	Composite	-
Alk (mg/L as CaCO3)	198	-	310	370	355	-	370	345	265	-
Hardness (mg/L as CaCO3)	3310	-	224	388	274	-	1286	1680	1868	-
pH*	7 6	-	7	8	7 75	-	7 75	7 4	7 7	-
Conductivity (umho/cm)*	1000	-	1751	3640	2680	-	11170	14630	16660	-
Ammonia (mg/L as NH3 N)	-	-	0 052	2 578	1 2915	-	0 4711	0 5109	0 1215	-
Nitrate (mg/L NO2 N)	0 079	-	0 0418	0 0171	0 5176	-	0 0308	0 0266	0 1195	-
TDS (mg/L)	587	-	910	2008	1615	-	7012	9527	10650	-
TSS (mg/L)	36	-	446	1169	849	-	28 55	19	10	-
VSS (mg/L)	21	-	80	237	221	-	23	13	8	-
COD (mg/L)	-	-	163	274	202	-	231	324	297	-
DOC (ppm)	-	-	46	50	27	-	51	25	75	55
Detergent (ppm as LAS)	-	-	-	-	3	. .	4	3	-	-
uv absorbance (at 254 nm)	-	-	0 71	1.19	1 23	-	0 73	1 02	0 34	-
Turbidity (NTU)	2 6	-	88	505	380	-	11 8	23 9	6 1	-
% Salinity**	-	-	-	1 50	1 10	-	2 25	3 25	3 25	-
DO (ppm)**	-	-	8 1	2 45	1 80	-	1.20	1 70	4 70	-

TDS = 0.587 x umho/cm
* measured in lab
** measured in the field
- no sample taken/no analysis done

CENTINELA CREEK @ INGLEWOOD

Parameter	7/7/92	7/27/92	8/24/92	9/8/92	9/29/92	10/12/92	11/2/92	12/10/92
Sample Type	Composite	Composite	Composite	Composite		.	Composite	Composite
Alk (mg/L as CaCO3)	184	145	155	155	.	.	145	125
Hardness (mg/L as CaCO3)	268	244	276	312	.	.	200	130
pH*	9.2	9.6	9.4	9.1	.	.	9	8.8
Conductivity (umho/cm)*	1214	1090	1300	1318	.	.	681	915
Ammonia (mg/L as NH3 N)	0.11	0.0434	0.0455	0.0562	.	.	0.0255	0.0412
Nitrite (mg/L NO2 N)	0.0273	0.0221	0.0129	0.0454	.	.	0.0157	0.0149
TDS (mg/L)	743	660	728	910	.	.	390	680
TSS (mg/L)	7	2	7	8	.	.	2	4
VSS (mg/L)	4	.	5	5	.	.	2	2
COD (mg/L)	58	75	66	60	.	.	19	48
DOC (ppm)	17	19	15	12	.	.	.	39
Detergent (ppm as LAS)	.	.	1	1	.	.	.	-
uv absorbance (at 254nm)	0.42	0.33	0.43	0.30	.	.	0.06	0.24
Turbidity (NTU)	4.07	3.9	4.2	4.27	.	.	1.96	4.6
% Salinity **	.	0.70	0.50	0.75	.	.	0.20	0.25
DO (ppm)**	13.6	14.7	> 15	> 15	.	.	12.5	11.3

* measured in lab

** measured in the field

. no sample taken/no analysis done

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Appendix II

Volatile Organic Chemical Analysis - Quality Control Data

Table II-1. Volatile Organic Chemical Analysis - Samples with Suspected Methylene Chloride Contamination

Table II-2. Volatile Organic Chemical Analysis - Laboratory Blanks, Field Blanks and Replicate Analysis at Ballona

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Table II-1.

Volatile Organic Chemical Analysis - Samples with Suspected Methylene Chloride Contamination

	Ashland	Ballona	Centinela	Pico/ Kenter	Sepulveda
6/12/92 AM	33.4 ppb	129.4 ppb			75.1 ppb
9/8/92 AM	11.9 ppb	154.2 ppb			4.7 ppb

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Table II-2.
Volatile Organic Chemical Analysis - Laboratory Blanks, Field Blanks and Replicate Analysis at Ballona

CHEMICAL NAME	MDL ng/1	LAB & Field 9/30-12/28 BLANK ng/L	SAMPLE Ballona 10/12/92 14:00 # 8018	SAMPLE Ballona 10/12/92 14:00 # 8019
Dichlorodifluoromethane	180	154-196	162	171
Chloromethane	140	140-168	263	245
Bromomethane	640		122	
1,1-Dichloroethene	140			12
1,1-Dichloroethane	170		53	59
Carbon Disulfide	110	110-136	265	159
Methylene Chloride	70	114-138	224	245
Cis-1,2-Dichloroethene	270		28	33
2-Butanone	7	237-334	702	630
Chloroform	110		665	676
1,1,1-Trichloroethane	60		736	688
Benzene	40		60	52
Fluorobenzene	-	Standard	5000	5000
Trichloroethene	40		44	49
Bromodichloromethane	60		264	268
4-Methyl-2-Pentanone	120		148	156
Toluene	50		121	119
Tetrachloroethene	50		270	270
Dibromochloromethane	90		305	306
Ethyl Benzene	50		14	13
(m+p)-Xylene	100		36	32
o-Xylene	40		19	16
Styrene	40		30	29
Bromoform	60		133	131
Bromofluorobenzene	-	Standard	4295	4272
n-Propylbenzene	50		3	
1,3,5-Trimethylbenzene	50		9	
4-Chlorotoluene	40		5	
1,2,4-Trimethylbenzene	40		30	29
p-Isopropyltoluene	60			8
1,4-Dichlorobenzene	40		15	14
n-Butylbenzene	60		17	
1,2-Dichlorobenzene-D4	-	Standard	5153	5044
Napthalene	250		67	68

All values are reported as determined even if < MDL

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Appendix III

Base Neutral Organic Chemical Analysis - Quality Control Data

Table III.1

GC/MS SYSTEM BLANKS - BASE NEUTRAL ANALYSIS

SAMPLE NUMBER	MDL	F8194B	F8220	F8205	F8248	F8256	F8279	AVG.	RANGE
BLANK DATE	-			1/27/93	2/8/93	2/10/93	2/16/93		
CHEMICAL NAME	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
Naphthalene	68	< MDL	< MDL	< MDL				<MDL	-
Di-n-Butyl Phthalate	60	130	276		<MDL	591	607	401	130-607
Pyrene	69		< MDL					<MDL	-
Benz(a)Anthracene	62	< MDL		<MDL				<MDL	-
Chrysene	68		<MDL					<MDL	-
Benzo(k)Fluoranthene	145		< MDL					<MDL	-

RULES FOR QUANTITATIVE CALCULATIONS -

1) ASSUME 100% EXTRACTION OF 1 L Of WATER INTO 0.5 ML SOLVENT FOR ALL BLANKS.

THIS IS NANOGRAMS TOTAL FOR MDL.

2) IF BLANKS ARE >MDL, THEN DETERMINE THE AVERAGE BLANK VALUE AND RANGE OF BLANK VALUES.

REPORT SAMPLE VALUE IF SAMPLE VALUE IS >MAXIMUM BLANK VALUE. THIS IS THE CONSERVATIVE APPROACH.

3) IF THE SAMPLE VALUE IS >MDL, THE VALUE ALSO MUST BE >MAXIMUM BLANK VALUE TO BE REPORTED.

4) IF THE SAMPLE VALUE IS <MDL AND THERE IS NONE FOUND IN A BLANK, IT IS REPORTED AS <MDL.

5) IF THE SAMPLE VALUE IS <MAXIMUM BLANK VALUE, IT IS REPORTED AS <MDL AS IT MAY BE IN THE SAMPLE.

TABLE III.2

SUSPENDED SOLIDS BLANKS - BASE NEUTRAL ANALYSIS (FILTERS PLUS BACKING TREATED AS A SAMPLE)

SS Blanks - Filters + Backing		Mem+Gl	Mem+Gl	Mem Only	Mem+Gl	Mem+Gl			Table	Combined System and Suspended Solids Blank	
Vol. of SCF Solvent Extract		0.5 ml	0.5 ml	0.5 ml	0.5 ml	0.5 ml			BN-1		
SAMPLE TYPE		Filter Bl	Filter Bl	Filter Bl	Filter Bl	Filter Bl	Avg.	Range	Avg.	Avg.	MAX Value
BLANK DATE	MDL	29-Sep	12-Oct 10-Dec	2-Nov 10-Dec	24-Aug	8-Sep	SS Blank	SS Blank	System Blank	Total Blank	Total Blank
CHEMICAL NAME	ng/L	F8240	F8241	F8276	F8074	F8120	ng/L	ng/L	ng/L	ng/L	ng/L
Phenol	1510	.	.	<MDL	.	.	<MDL	.	.	<MDL	.
4-Methylphenol	401	.	.	<MDL	.	.	<MDL	.	.	<MDL	.
Benzoic Acid	4000	.	.	<MDL	.	.	<MDL	.	.	<MDL	.
1,4-Dichlorobenzene	64	.	.	257	.	.	257	.	.	257	257
Nitrobenzene	666	.	.	.	<MDL	.	<MDL	.	.	<MDL	.
Naphthalene	60	<MDL	<MDL	252	<MDL	<MDL	252	.	<MDL	252	252
2-Methylnaphthalene	125	.	.	<MDL	.	.	<MDL	.	.	<MDL	.
Diethyl Phthalate	60	207	245	255	623	100	302	180-623	.	302	623
4-Chlorophenyl Phenyl Ether	346	.	.	<MDL	.	<MDL	<MDL	.	.	<MDL	.
Azobenzene	63	.	.	.	<MDL	.	<MDL	.	.	<MDL	.
Phenanthrene	64	<MDL	<MDL	.	<MDL	<MDL	<MDL	.	.	<MDL	.
Anthracene	70	.	.	.	<MDL	.	<MDL	.	.	<MDL	.
Di-n-Butyl Phthalate	60	1067	3640	1617	1451	625	1720	625-3640	461	1134*	3640
Fluoranthene	61	.	.	.	<MDL	.	<MDL	.	.	<MDL	.
Pyrene	60	.	.	.	160	.	160	.	<MDL	160	160
Butylbenzyl Phthalate	300	<MDL	646	487	<MDL	<MDL	572	487-646	572	646	646
Benzo(a) Anthacene	62	.	.	.	.	.	<MDL	.	<MDL	<MDL	.
Chrysene	60	.	.	.	124	.	124	.	<MDL	124	124
Bis(2-Ethylhexyl)Phthalate	46	2580	3698	1410	2518	650	2167	650-4003	.	2167	4003
Di-n-Octyl Phthalate	64	112	<MDL	<MDL	.	<MDL	112	.	.	112	112
Benzo(k) Fluoranthene	145						<MDL	.	<MDL	.	.
Benzo(a) Pyrene	73	.	.	.	<MDL	.	<MDL	.	.	.	.

* Average of 4 system blank samples and 5 suspended sediment sample blanks.

RULES FOR QUANTITATIVE CALCULATIONS -

1) ASSUME 100% EXTRACTION OF 1 L OF WATER OR 1 GRAM OF SUSPENDED SEDIMENT(SS) INTO 0.5 ML SOLVENT FOR ALL BLANKS
THIS IS NANOGRAMS TOTAL FOR MDL. THE WEIGHT OF SS PRESENT WERE 0.003 TO 0.0 GRAMS.
2) IF BLANKS ARE >MDL, THEN DETERMINE THE AVERAGE BLANK VALUE AND RANGE OF BLANK VALUES
REPORT SAMPLE VALUE IF SAMPLE VALUE IS >MAXIMUM BLANK VALUE. THIS IS THE CONSERVATIVE APPROACH.
3) IF THE SAMPLE VALUE IS >MDL, THE VALUE ALSO MUST BE >MAXIMUM BLANK VALUE TO BE REPORTED.
4) IF THE SAMPLE VALUE IS <MDL AND THERE IS NONE FOUND IN A BLANK, IT IS REPORTED AS <MDL.
5) IF THE SAMPLE VALUE IS <MAXIMUM BLANK VALUE, IT IS REPORTED AS <MDL AS IT MAY BE IN THE SAMPLE

Table III. 3

WATER BLANKS - BASE NEUTRAL ANALYSIS

SAMPLE NUMBER	MDL	F8237	F8221	AVG.	RANGE
		Field Blank	H20,Tv1 Blank		
DATE		DATE ??	12/10/93		
Volume of Solvent Extract		0.5	0.5		
Volume of Water		4	4		
CHEMICAL NAME	ng/L	ng/L	ng/L	ng/L	ng/L
Diethyl Phthalate	60	165	122	143	122-165
Di-n-Butyl Phthalate	60	1958	1772	1865	1772-1958
Butylbenzyl Phthalate	300	1082	2775	1928	1082-2775
Bis(2-Ethylhexyl) Phthalate	48	5110	4496	4803	4496-5110
Di-n-Octyl Phthalate	64	114		114	-

1) FIELD BLANK - LABORATORY MILLI-Q WATER IS POURED INTO A SAMPLING BUCKET IN THE FIELD AND TREATED AS A REAL SAMPLE.

2) WATER BLANK - LABORATORY MILLI-Q WATER IS TAKEN TO THE FIELD AND RETURNED TO THE LAB. THE SEALED WATER BOTTLE IS THEN RETURNED TO THE LAB FOR ANALYSIS.

3) THESE SAMPLES WERE NOT FILTERED BEFORE EXTRACTION AND REPRESENT THE COMPOUNDS FOUND IN THE LABORATORY DISTILLED WATER.

TABLE III-4

GC/MS WATER AND SYSTEM BLANKS - BASE NEUTRAL ANALYSIS

SYSTEM AND WATER BLANKS CHEMICAL NAME	MDL MDL ng/L	AVG. WATER BLANK AVG. ng/L	RANGE WATER BLANK RANGE ng/L	SYSTEM BLANK AVG. ng/L	SYSTEM BLANK RANGE ng/L
Naphthalene	68			<MDL	
Diethyl Phthalate	60	143	122-165		
Di-n-Butyl Phthalate	60	1865	1772-1958	401	130-607
Pyrene	69			<MDL	
Butylbenzyl Phthalate	300	1928	1082-2775		
Benz(a)Anthracene	62			<MDL	
Chrysene	68			<MDL	
Bis(2-Ethylhexyl)Phthalate	48	4803	4496-5110		
Di-n-Octyl Phthalate	64	114	-		
Benzo(k)Fluoranthene	145			<MDL	

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Appendix IV

Complete Targeted Volatile Organic Chemical Data for Each Storm Drain by Date.

a. Long Form--Reported Concentrations Including all Data < MDL

b. Short Form--Reported Concentrations > MDL Only

Table IV 1.a. and b. Volatile Organic Chemicals in Ballona 6/12 to 12/10, 1992

Table IV 2.a. and b. Volatile Organic Chemicals in Pico/Kenter 6/12 to 12/10, 1992

Table IV 3.a. and b. Volatile Organic Chemicals in Sepulveda 6/12 to 12/10, 1992

Table IV 4.a. and b. Volatile Organic Chemicals in Centinela 6/12 to 12/10, 1992

Table IV 5.a. and b. Volatile Organic Chemicals in Ashland 6/12 to 12/10, 1992

Table IV 1.a. VOLATILE ORGANIC CHEMICALS IN BALLONA 6/12 TO 12/10 1992

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	1/23/93		2 5ml	25ml	25ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml
2	Ballona Final Data		B-Fm	B-Fm	B-Fm	B	B	B	B	B	B	B	B	B	Ballon	Ballona	Ballon	Ballon	Ballon
3	Date		12-Jun	7-Jul	7-Jul	27-Jul	27-Jul	24-Aug	24 Aug	8 Sep	8 Sep	29 Sep	29 Sep	29 Sep	12 Oct	12 Oct	2 Nov	2 Nov	10 Dec
4	Time	CDL	Repl.	10AM	PM	10 40	14 55	10 30	15 25	10 20	14 15	10 45	11 30	14 45	10 20	14 00	AM	PM	C
5	CHEMICAL NAME	ng1	F7923	F7929	F7928	F8003	F7993	F7900	F7980	F7973	F7970	F7963	F7967	F7969	F8015	F8019	F8146	F8137	F8151
6	Dichlorodifluoromethane	180								212									
7	Chloromethane	140	2170			492	426	317	842	541	261			290	371	245	290	269	
8	Chloroethane	210																	
9	Carbon Disulfide	110	138			174	145	143	162	195	181	351	294	222	163	159	194	261	145
10	Methylene Chloride	70		187		1441	876	2118			278	205	285	231	267	245	268	257	376
11	Trans-1,2-Dichloroethene	120	130																
12	2-Butanone	7	1576					339	364		395	525	413	691	611	630		379	
13	Bromochloromethane	160	519																
14	Chloroform	110	212	475	499	867	2158	409	524	774	696	476	420	747	549	676	339	323	522
15	1,1,1-Trichloroethane	60	155	127	189		162	594	635	899	661	534		524	955	688	876	728	497
16	Benzene	40	41			52	77	224	65	71	54	71	79	71	73	52			53
17	Trichloroethene	40	46	46			50	48	54	80	54	54		45	64	49			
18	Dibromomethane	30			43	82							44						
19	Bromodichloromethane	60	106	216	191	573	380	117	96	187	150	204		229	334	268	151	145	309
20	4-Methyl-2-Pentanone	120	445	227	530		193	148		590	184				184	156			
21	Toluene	50		54	56	57	148	75	93	108	85	120	101	169	161	119			
22	Tetrachloroethene	50	73	275	187	170	284	139	343	414	244	254		189	374	270	247	146	161
23	2-Hexanone	90	203											66					
24	Dibromochloromethane	90	174	267	223	824	441	136	114	244	132	237		239	452	306	212	189	477
25	Styrene	40					67	46	42										
26	Bromoform	60	238	217	237	419	221	153	100	180	110	128	211	109	189	131	145	130	295
27	1,2,4-Trimethylbenzene	40					43					40							
28	Napthalene	250					256							111					
29	1,1-Dichloropropene	60	174									102							

Table IV 1.b. Volatile Organic Chemicals in Ballona 6/12 to 12/10, 1992

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	A	B	C	D	E	F	G	H
[illegible]								
48	Location : Ballona		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50	[illegible]	[illegible]	BLANK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
51	CHEMICAL NAME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
52	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
53	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
54	[illegible]	[illegible]			[illegible]	[illegible]		
55	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
56	[illegible]	[illegible]			[illegible]	[illegible]		
57	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
58	[illegible]	[illegible]			[illegible]	[illegible]		[illegible]
59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	174	168
60	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	1441	[illegible]
61	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
62	[illegible]	[illegible]						
63	[illegible]	[illegible]						
64	[illegible]	[illegible]			[illegible]			[illegible]
65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
66	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
67	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
68	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		[illegible]
69	[illegible]	[illegible]						
70	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
71	[illegible]	[illegible]			[illegible]			
72	[illegible]	[illegible]						
73	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	
75	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
76	[illegible]	[illegible]						
77	[illegible]	[illegible]						
78	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
79		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	[illegible]	[illegible]						
81	[illegible]	[illegible]						
82	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
83	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]
84	[illegible]	[illegible]						
85	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
86	[illegible]	[illegible]						
87		[illegible]						
88	[illegible]	[illegible]						
89	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
90	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
91	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
92		[illegible]					[illegible]	[illegible]
93	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
94	[illegible]	[illegible]						
95	[illegible]	[illegible]						
96	[illegible]	[illegible]						
97	[illegible]	[illegible]						
98	[illegible]	[illegible]						
99	[illegible]	[illegible]				[illegible]		[illegible]
100	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
101	[illegible]	[illegible]						
102	[illegible]	[illegible]			[illegible]	[illegible]		
103	[illegible]	[illegible]						
104	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
105	[illegible]	[illegible]				[illegible]		[illegible]
106	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
107	[illegible]	[illegible]			[illegible]	[illegible]		
108	[illegible]	[illegible]						
109	[illegible]	[illegible]						
110	[illegible]	[illegible]						
111	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]
112	[illegible]	[illegible]						[illegible]
113	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
114	[illegible]	[illegible]						
115	[illegible]	[illegible]						
116	[illegible]	[illegible]			[illegible]	[illegible]		
117	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
118	[illegible]	[illegible]						
119	[illegible]	[illegible]						[illegible]

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I	J	K	L	M	N	O	P	Q	R
26									
48 Location - [illegible]		LAB B	B	B	Before	Before	Before	Before	Before
49 Date 1997		Proc	26-Aug	26-Aug	6-Sep	6-Sep	29-Sep	29-Sep	29-Sep
50 6/12/97-12/10/1997	MDL	BLANK	10:30	15:30	10:30	14:19	12:43	11:30	16:43
51 CHEMICAL NAME	ug/l	ug/l	Free	Free	Free	Free	Free	Free	Free
52 Dichlorodifluoromethane	10C	150-180	<DL	<DL	212	<DL	<DL		<DL
53 Chloromethane	[illegible]	160-180	211	342	361	281		<DL	28C
54 Vinyl Chloride	[illegible]								
55 Bromomethane	[illegible]		<DL	<DL	<DL	<DL	<DL		<DL
56 Chloroethane	[illegible]		<DL		<DL	<DL	<DL	<DL	
57 Trichlorofluoromethane	[illegible]								
58 1,1-Dichloroethene	[illegible]		<DL		<DL		<DL		
59 Carbon Disulfide	[illegible]	112-130	161	102	109	101	291	2??	277
60 Methylene Chloride	[illegible]	114-130	2110	<DL		270	203	283	221
61 trans-1,2-Dichloroethene	[illegible]								
62 1,1-Dichloroethane	[illegible]								
63 2,2-Dichloropropane	[illegible]								
64 cis-1,2-Dichloroethene	[illegible]		<DL	<DL	<DL	<DL	<DL		<DL
65 2-Butanone	[illegible]	271-304	279	284	<DL	301	221	413	601
66 Bromochloromethane	[illegible]								
67 Chloroform	[illegible]		620	374	774	600	670	42C	761
68 1,1,1-Trichloroethane	8C		594	637	690	601	534		534
69 Carbon Tetrachloride	[illegible]								
70 Benzene	4C		224	63	71	34	71	79	71
71 1,2-Dichloroethane	4C								
72 [illegible]	13								
73 Trichloroethene	4C		44	34	8C	34	34	<DL	44
74 [illegible]	[illegible]						<DL	44	
75 Bromodichloromethane	8C		117	89	107	130	204		239
76 [illegible]	[illegible]								
77 cis-1,3-Dichloropropene	[illegible]								
78 4-Methyl-2-Pentanone	[illegible]		146	<DL	38C	180	<DL	<DL	<DL
79 Toluene	9C		79	83	108	83	12C	101	180
80 trans-1,3-Dichloropropene	8C								
81 1,1,2-Trichloroethane	[illegible]								
82 Tetrachloroethene	[illegible]		130	343	414	244	214		180
83 2-Hexanone	8C		<DL	<DL	<DL	<DL	<DL	<DL	<DL
84 1,3-Dichloropropane	4C								
85 Dibromochloromethane	8C		130	114	244	132	237	<DL	230
86 1,2-Dibromoethane	4C								
87 Chlorobenzene	[illegible]								
88 1,1,1,2-Tetrachloroethane	[illegible]								
89 Ethylbenzene	9C		<DL	<DL	<DL	<DL	<DL	<DL	<DL
90 m,p-Xylene	10C		<DL	<DL	<DL	<DL	<DL	<DL	<DL
91 o-Xylene	4C		<DL	<DL	<DL	<DL	<DL	<DL	<DL
92 Styrene	[illegible]		40	41			<DL		
93 [illegible]	6C		153	10C	180	110	129	211	180
94 [illegible]	5C								
95 Bromofluorobenzene	3								
96 Bromoform	4C								
97 1,1,2,2-Tetrachloroethane	[illegible]								
98 1,2,3-Trichloropropane	[illegible]								
99 n-Propylbenzene	[illegible]								
100 1,3,5-Trimethylbenzene	5C		<DL	<DL		<DL	<DL	<DL	
101 2-Chlorotoluene	4C								
102 4-Chlorotoluene	4C								
103 Tert-Butylbenzene	6C								
104 1,2,4-Trimethylbenzene	4C		<DL	<DL	<DL	<DL	40	<DL	<DL
105 p-Isopropyltoluene	6C					<DL	<DL		<DL
106 1,4-Dichlorobenzene	4C		<DL	<DL	<DL	<DL	<DL	<DL	<DL
107 n-Butylbenzene	6C					<DL			
108 1,2-Dichlorobenzene-D4	5								
109 1,2-Dibromo-3-Chloropropane	7C								
110 Hexachlorobutadiene	8C								
111 Naphthalene	25C		<DL	<DL	<DL	<DL	<DL	<DL	<DL
112 1,2,3-Trichlorobenzene	6C								
113 Trichlorotrifluoroethane	15C					<DL		<DL	
114 1,1-Dichloropropene	8C						197		
115 Isopropylbenzene	1								
116 Sec-Butylbenzene	8C					<DL			
117 1,3-Dichlorobenzene	4C					<DL			
118 1,2-Dichlorobenzene	4C								
119 1,2,4-Trichlorobenzene	8C								

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	S	T	U	V	W	X	Y	Z
26								
48	[illegible] - Batch		LAB 6	Batch	Batch	Batch RF[illegible]	Batch	Batch
49	[illegible]		Final	12-Oct	12-Oct	12-Oct	2 Nov	2 Nov
50	[illegible]	MQL	BLANK	12:[illegible]	14:[illegible]	14:[illegible]	PM	AM
51	CHEMICAL NAME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
52	[illegible]	1[illegible]	11[illegible]-1[illegible]	<MQL	<MQL	<MQL	<MQL	<MQL
53	[illegible]	1[illegible]	1[illegible]-1[illegible]	271	2[illegible]	2[illegible]	288	290
54	[illegible]	[illegible]						
55	[illegible]	[illegible]		<MQL	<MQL		<MQL	<MQL
56	[illegible]	[illegible]				<MQL		
57	[illegible]	[illegible]						
58	[illegible]	[illegible]		<MQL	<MQL	<MQL	<MQL	<MQL
59	[illegible]	[illegible]	110-130	1[illegible]	[illegible]	190	261	194
60	[illegible]	[illegible]	116-130	[illegible]	2[illegible]	[illegible]	287	288
61	[illegible]	[illegible]						
62	[illegible]	[illegible]						
63	[illegible]	[illegible]						
64	[illegible]	[illegible]		<MQL	<MQL	<MQL		<MQL
65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	370	<MQL
66	[illegible]	[illegible]						
67	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	333	339
68	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	728	878
69	[illegible]	[illegible]						
70	[illegible]	[illegible]		73	[illegible]	82	<MQL	<MQL
71	[illegible]	[illegible]						
72	[illegible]	[illegible]						
73	[illegible]	[illegible]		84	44	40	<MQL	<MQL
74	[illegible]	[illegible]						
75	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	148	181
76	[illegible]	[illegible]						
77	[illegible]	[illegible]						
78	[illegible]	[illegible]		104	148	180	<MQL	<MQL
79	[illegible]	[illegible]		101	1[illegible]	119	<MQL	<MQL
80	[illegible]	[illegible]						
81	[illegible]	[illegible]						
82	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	149	247
83	[illegible]	[illegible]					<MQL	<MQL
84	[illegible]	[illegible]						
85	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	180	212
86	[illegible]	[illegible]						
87	[illegible]	[illegible]						
88	[illegible]	[illegible]						
89	[illegible]	[illegible]		<MQL	<MQL	<MQL	<MQL	<MQL
90	[illegible]	[illegible]		<MQL	<MQL	<MQL	<MQL	<MQL
91	[illegible]	[illegible]		<MQL	<MQL	<MQL	<MQL	<MQL
92	[illegible]	[illegible]		<MQL	<MQL	<MQL	<MQL	<MQL
93	[illegible]	[illegible]		149	123	1[illegible]	130	149
94	[illegible]	[illegible]					<MQL	
95	[illegible]	[illegible]						
96	[illegible]	[illegible]						
97	[illegible]	[illegible]						
98	[illegible]	[illegible]						
99	[illegible]	[illegible]			<MQL		<MQL	
100	[illegible]	[illegible]			<MQL		<MQL	<MQL
101	[illegible]	[illegible]					<MQL	
102	[illegible]	[illegible]			<MQL		<MQL	
103	[illegible]	[illegible]						
104	[illegible]	[illegible]		<MQL	<MQL	<MQL	<MQL	<MQL
105	[illegible]	[illegible]		<MQL		<MQL	<MQL	
106	[illegible]	[illegible]		<MQL	<MQL	<MQL	<MQL	<MQL
107	[illegible]	[illegible]			<MQL		<MQL	<MQL
108	1,2-Dichlorobenzene-D4	[illegible]						
109	1,2-Dibromo-3-Chloropropan	[illegible]						
110	[illegible]	[illegible]						
111	[illegible]	[illegible]		<MQL	<MQL	<MQL	<MQL	<MQL
112	[illegible]	[illegible]					<MQL	
113	[illegible]	[illegible]						
114	[illegible]	[illegible]						
115	[illegible]	[illegible]						
116	[illegible]	[illegible]					<MQL	
117	[illegible]	[illegible]					<MQL	
118	[illegible]	[illegible]					<MQL	
119	[illegible]	[illegible]					<MQL	

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Table IV 2.a. VOLATILE ORGANIC CHEMICALS IN PICO/KENTER 6/12 TO 12/10 1992

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1			Foam	Foam													
2	Pico/Kenter		25 ml	25 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml	5 ml
3	Final Data		P	P	P	P	P	P	P	Pico	Pico	Pico	Pico	P	P	Pico	Pico
4	2/1/93		12-Jun	7-Jul	7-Jul	27-Jul	27-Jul	24 Aug	24-Aug	8 Sep	8 Sep	29 Sep	29 Sep	12 Oct	12 Oct	2 Nov	10 Dec
5	Time	CDL	AM	8:45	13 25	8 43	14 05	9 05	14 30	9 15	13 35	9 07	14 05	9 15	12 55	AM	C
6	CHEMICAL NAME	ng/l	F7924	F7926	F8007	F7999	F7991	F7986	F7980	F7974	F7979	F7961	F7966	8014	F8017	F8143	F8148
7	Dichlorodifluoromethane	180									201	227	197				253
8	Chloromethane	140	535		290		333	401	290	402	353	935	624	450	453	211	199
9	Carbon Disulfide	110			253	472	391	199	167			253	299	173	229	705	148
10	Methylene Chloride	70		180	744	868	504	6219	341	1376	12815	288	245	378	268	428	5821
11	2-Butanone	7	1235			335	563	633			343	428	602		428		334
12	Chloroform	110	978	194	114	169	182	471	578	224	212	286	579	104	222	330	581
13	Benzene	40				41	45	246	82	70	228	83	64	59	45	52	78
14	Dibromomethane	30		43	38	73	43	62									
15	Bromodichloromethane	60	220														105
16	4-Methyl-2-Pentanone	120	253		177	186	339	131	200			151	1304	187	158	162	
17	Toluene	50		64		347	318	118	89	64	72	329	99	191	128	72	
18	2-Hexanone	90			246			189	300						115		
19	Dibromochloromethane	90	225														185
20	Styrene	40				45	53	40	49		44						
21	Bromoform	60	182	166					68			69		371			1486
22	1,2,4-Trimethylbenzene	40										52					
23	p-Isopropyltoluene	60										64		83		70	

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Table IV 2.b. Volatile Organic Chemicals in Pico/Kenter 6.12 to 12.10, 1990

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Location Pico/Kenter		25m Fm	35m Fm	P	P	P	P	P	Pico	Pico	Pico	Pico	P	P	Pico	Pico
2	Date 1990		12-Jun	7-Jul	7-Jul	27-Jul	27-Jul	24-Aug	24-Aug	6-Sep	6-Sep	28-Sep	28-Sep	12-Oct	12-Oct	2-Nov	10-Dec
3	[illegible]	MCL		8:43	13:25	8:43	14:08	9:05	14:0[illegible]	9:15	12:[illegible]	9:[illegible]	14:[illegible]	9:15	12:54	AM	C
4	CHEMICAL NAME	ppt	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	Dichlorodifluoromethane	190	<QL	<QL	<QL	<QL	<QL	194	<QL	<QL	277	277	1[illegible]	<QL	<QL	189	253
6	Chloromethane	140	838	<QL	280	<QL	320	401	220	432	370	[illegible]	[illegible]	440	440	2[illegible]	189
7	Vinyl Chloride	200									<QL						
8	Bromomethane	640			<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL
9	1,1 Dichloroethene	140	<QL	<QL						<QL							
10	Chloroethane	270	<QL														
11	1,1 Dichloroethane	170															
12	Carbon Disulfide	110	<QL	<QL	253	477	391	189	187	<QL		290	[illegible]	173	230	706	146
13	Methylene Chloride	70		103	744	[illegible]	504	6218	341	1570	12010	[illegible]	348	378	[illegible]	470	842
14	Trans 1,2 Dichloroethene	120	<QL														
15	1,1 Dichloropropanone	9															
16	2,2 Dichloropropane	190															
17	Cis 1,2 Dichloroethene	270															
18	2-Butanone	9	1235	120	348	330	880	833	170	314	343	428	802	384	428	302	334
19	Bromochloromethane	160															
20	Chloroform	110	970	184	116	189	182	471	870	224	212	[illegible]	879	<QL	222	300	84
21	1,1,1 Trichloroethane	80	<QL	<QL												<QL	
22	Carbon Tetrachloride	70															
23	Benzene	40	<QL	<QL	<QL	41	48	348	82	70	228	80	64	88	48	82	70
24	1,2 Dichloroethane	40															
25	Fluorobenzene	15															
26	Trichloroethene	40	<QL				<QL	<QL			<QL	<QL	<QL				
27	Dibromomethane	30		43	30	73	43	82								<MQL	
28	Bromodichloromethane	60	220	<QL													180
29	1,2 Dichloropropane	40															
30	Cis 1,3 Dichloropropene	50															
31	4-Methyl-2-Pentanone	120	283	<QL	177	188	330	131	200	<QL	<QL	181	1304	187	188	162	<QL
32	Toluene	80	<QL	64	<QL	347	318	110	88	84	72	320	88	181	128	77	<QL
33	Trans 1,3 Dichloropropene	60															
34	1,1,2 Trichloroethane	60															
35	Tetrachloroethene	50	<QL					<QL		<QL		<QL					
36	2-Hexanone	80	<QL	<QL	348		<QL	189	300	<QL				<QL	118	<QL	
37	1,3 Dichloropropane	40															
38	Dibromochloromethane	80	225	<QL					<QL				<QL	<QL			188
39	1,2 Dibromoethane	40															
40	Chlorobenzene	40															
41	1,1,1,2 Tetrachloroethane	10															
42	Ethylbenzene	80	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL
43	m,p-Xylene	100	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL
44	o-Xylene	40	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL
45	Styrene	40	<QL		<QL	48	53	40	43		64			<QL	<QL	<QL	<QL
46	Bromoform	60	182	186					[illegible]	<QL	<QL	[illegible]	<QL	371			148
47	Isopropylbenzene	80	<QL	<QL			<QL									<QL	
48	Bromofluorobenzene	5															
49	Bromobenzene	40															
50	1,1,2,2 Tetrachloroethane	40															
51	1,2,3 Trichloropropane	10															
52	n-Propylbenzene	80	<QL	<QL												<QL	
53	1,3,5 Trimethylbenzene	80	<QL	<QL			<QL					<QL				<QL	<QL
54	2-Chlorotoluene	40	<QL	<QL													
55	4-Chlorotoluene	40		<QL												<QL	
56	Tert-Butylbenzene	60														<QL	
57	1,2,4 Trimethylbenzene	40	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	82	<QL	<QL	<QL	<QL	<QL
58	p-Isopropyltoluene	80	<QL	<QL	<QL		<QL		<QL			64	<QL	80	<QL	70	
59	1,4 Dichlorobenzene	40	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL
60	n-Butylbenzene	80	<QL	<QL												<QL	<QL
61	1,2 Dichlorobenzene-D4	5															
62	1,2 Dibromo-3-Chloropropane	70															
63	Hexachlorobutadiene	80															
64	Naphthalene	250	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL	<QL
65	1,2,3 Trichlorobenzene	60															
66	Trichlorofluoromethane	120	<QL	<QL													
67	1,1-Dichloropropene	80															
68	Isopropylbenzene	9															
69	Sec-Butylbenzene	80	<QL	<QL													
70	1,3 Dichlorobenzene	40	<QL	<QL				<QL									
71	1,2 Dichlorobenzene	40															
72	1,2,4 Trichlorobenzene	80															

Table IV 3.a. VOLATILE ORGANIC CHEMICALS IN SEPULVEDA 6/12 TO 12/10 1992

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
83			25-ml		25-ml												
84	Location		Foam	S	Foam	S	S	S	S	S	S	S	S	S	S	S	S
85	Date		12-Jun	7-Jul	7-Jul	27-Jul	27-Jul	24-Aug	24-Aug	8-Sep	8-Sep	29 Sep	12 Oct	12 Oct	2 Nov	2 Nov	10 Dec
86	Time	MDL		10:35	PM	11:25	15:25	11:05	15:50	10:45	14:40	15:15	10:50	14:40	AM	PM	C
87	CHEMICAL NAME	mg/l	F7925	F8003	F7930	F7994	F7990	F7983	F7987	F7976	F7978	F7968	8013	8011	F8140	F8141	F8149
88	Dichlorodifluoromethane	160															200
89	Chloromethane	140	2895	360		406	502	324	617	404	355	642	589	307	285	199	206
90	Carbon Disulfide	110		344			268		220		186	222	249	180	143		
91	Methylene Chloride	70		532	188	738	1012		559		1754	267	267	235	299	302	144
92	Trans-1,2-Dichloroethene	120	191														
93	2-Butanone	7				390		381	526	428	363	626	534	570	3150		
94	Bromochloromethane	160	309														
95	Chloroform	110	139	340	203	1822	2134	368	207	1060		179	185	144	311	277	576
96	1,1,1-Trichloroethane	60			94												
97	Benzene	40	105	45		86	49	233	88	250	174	63	64	50	40		53
98	Dibromomethane	30		129	119	86	72	33		45	38	33					107
99	Bromodichloromethane	60				1539	1397			289					63		
100	4-Methyl-2-Pentanone	120	619		161	151			178				142				
101	Toluene	50	365		56	109	66	91	86	76		105	87	67			
102	2-Hexanone	90	142													112	
103	Dibromochloromethane	90				2140	1948			444							182
104	(m+p)-Xylene	100	149														
105	o-Xylene	40	59														
106	Styrene	40	49			49			43								
107	Bromoform	60	267	381	453	1086	1036	362	295	439	127	185	287	189	258	260	396
108	Naphthalene	250												287			

#	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1	Location Sepulveda		25m Fm	5	25m Fm	5	5	5	5	5	5	5	5	5	5	5	5
2	Date 1993		12-Jun	7-Jul	7-Jul	27-Jul	27-Jul	24-Aug	24-Aug	8-Sep	8-Sep	28-Sep	12-Oct	12-Oct	2-Nov	2-Nov	15-Dec
3	(6/12/93 to 12/15/1993)	MDL		10:35	PM	11:25	15:25	11:20	13:50	10:43	14:40	13:13	10:50	14:40	AM	PM	C
4	CHEMICAL NAME	ng/l	F7825	F8008	F780C	F7884	F7888	F7980	F7987	F7979	F7978	F7978	8C13	8C11	F8140	F8141	F8140
5	Dichlorodifluoromethane	180	<MDL		<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	270
6	Chloromethane	140	2805	380	<MDL	408	522	324	617	424	388	642	869	307	285	180	208
7	Vinyl Chloride	270															
8	Bromomethane	640		<MDL		<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
9	1,1-Dichloroethene	140	<MDL		<MDL												
10	Chloroethane	270	<MDL	<MDL	<MDL												
11	1,1-Dichloroethane	170									<MDL						
12	Carbon Disulfide	110	<MDL	344	<MDL	<MDL	284	<MDL	270		188	272	240	180	143		
13	Methylene Chloride	70		832	186	738	1012	<MDL	560		1734	267	287	236	288	302	144
14	Trans 1,2 Dichloroethene	170	181														
15	1,1-Dichloropropane	?															
16	2,2-Dichloropropane	180															
17	Cis 1,2 Dichloroethene	270															
18	2-Butanone	?		<MDL		380	<MDL	381	576	478	383	636	834	670	3180	<MDL	<MDL
19	Bromochloromethane	180	308		<MDL	<MDL	<MDL										
20	Chloroform	110	139	340	203	1820	2134	388	207	1080		170	108	144	311	277	376
21	1,1,1-Trichloroethane	80			84					<MDL							
22	Carbon Tetrachloride	70															
23	Benzene	40	106	45	<MDL	88	40	220	88	250	174	63	84	80	40	<MDL	53
24	1,2-Dichloroethane	40															
25	Fluorobenzene	15															
26	Trichloroethene	40			<MDL				<MDL	<MDL	<MDL	<MDL					
27	Dibromomethane	30		170	110	88	72	33		46	38	33					107
28	Bromodichloromethane	60	<MDL		<MDL	1630	1287	<MDL		288					83	<MDL	
29	1,2-Dichloropropane	40															
30	Cis 1,3 Dichloropropene	50															
31	4-Methyl-2-Pentanone	170	610	<MDL	181	181	<MDL	<MDL	170	<MDL	<MDL	130	142	<MDL	<MDL	<MDL	<MDL
32	Toluene	60	385	<MDL	98	108	88	81	88	78	67	108	87	67	<MDL	<MDL	<MDL
33	Trans 1,3 Dichloropropene	50															
34	1,1,2-Trichloroethane	60															
35	Tetrachloroethene	50	<MDL		<MDL												
36	2-Hexanone	80	142	<MDL		<MDL		<MDL	<MDL		<MDL	<MDL				112	<MDL
37	1,3-Dichloropropane	40															
38	Dibromochloromethane	80	<MDL	<MDL	<MDL	2140	1848	<MDL	<MDL	444	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	182
39	1,2-Dibromoethane	40															
40	Chlorobenzene	40	<MDL														
41	1,1,1,2-Tetrachloroethane	50															
42	Ethyl Benzene	50	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
43	m,p-Xylene	100	140	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
44	o-Xylene	40	50	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
45	Styrene	40	48	<MDL		40	<MDL	43	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
46	Bromoform	80	267	381	453	1086	1036	352	204	430	127	185	287	180	250	280	386
47	Isopropylbenzene	50	<MDL														
48	Bromofluorobenzene	5															
49	Bromobenzene	40															
50	1,1,2,2-Tetrachloroethane	40															
51	1,2,3-Trichloropropane	50	<MDL														
52	n-Propylbenzene	50	<MDL										<MDL		<MDL		
53	1,3,5-Trimethylbenzene	50	<MDL		<MDL							<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
54	2-Chlorotoluene	40	<MDL										<MDL				
55	4-Chlorotoluene	40	<MDL		<MDL								<MDL		<MDL		
56	Tert-Butylbenzene	60	<MDL														
57	1,2,4-Trimethylbenzene	40	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
58	p-Isopropyltoluene	80	<MDL	<MDL	<MDL						<MDL	<MDL	<MDL				
59	1,4-Dichlorobenzene	40	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL		
60	n-Butylbenzene	60			<MDL								<MDL		<MDL	<MDL	<MDL
61	1,2-Dichlorobenzene-D4	5															
62	1,2-Dibromo-3-Chloropropane	70															
63	Hexachlorobutadiene	80															
64	Naphthalene	250		<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	287	<MDL	<MDL	<MDL
65	1,2,3-Trichlorobenzene	80						<MDL						<MDL			
66	Trichlorofluoromethane	120			<MDL												
67	1,1-Dichloropropene	80															
68	Isopropylbenzene	?	28														
69	Sec-Butylbenzene	80			<MDL							<MDL					
70	1,3-Dichlorobenzene	40			<MDL			<MDL				<MDL		<MDL			
71	1,2-Dichlorobenzene	40															
72	1,2,4-Trichlorobenzene	80												<MDL			

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Table IV 4.a. VOLATILE ORGANIC CHEMICALS IN CENTINELLA 6/12 TO 12/10 1992

	A	B	C	D	E	F	G	H	I	J	K	L	M
100	1/24/93		C	C	C	C	C	C	C	C	C	C	C
101	Location Centinella		7/7/92	7/7/92	7/27/92	7/27P	8/24/92	8/24/92	9/8/92	9/8/92	11/2/92	11/2/92	12/10/92
102	Time	MDL	8:45	15 45	AM	15 55	11 50	16 25	11 35	15 15	AM	PM	C
103	CHEMICAL NAME	ng/l	F7927	F8005	F7997	F7995	F7981	F7985	F7975	F7972	F8138	F8142	F8150
104	Dichlorodifluoromethane	180		232					209				
105	Chloromethane	140	204	422	362	384	299	365	450	465	202	187	221
106	Carbon Disulfide	110	291	203	289	196	158	159	219	249	149		
107	Methylene Chloride	70	384	8187	1208	2497	2093	3426	1862	514	249	336	197
108	2-Butanone	?				336		420	450	1280			370
109	Bromochloromethane	160	164										
110	Chloroform	110	1110	388	718	230	587	227	1018	254	1151	858	2031
111	Benzene	40		47	50	74	170	186	70	92	41		
112	Bromodichloromethane	60			70				69		1244	548	168
113	4-Methyl-2-Pentanone	120	1095	168	160					45791			175
114	Toluene	50	171		77	117	61	123	109	93			82
115	2-Hexanone	90	90							179			
116	Dibromochloromethane	90	207		113						2244	967	
117	Styrene	40			46	53	42						
118	Bromoform	60	207	73	120	63					1117	441	
119	Napthalene	250								464			

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	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Location Comments		C	C	C	C	C	C	C	C	C	C	C
2	Date 1993		[illegible]	[illegible]	[illegible]	[illegible]	24 Aug	24 Aug	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	MDL	0:45	13:45	AM	13:56	11:52	16:25	11:25	13:15	AM	PM	C
4	CHEMICAL NAME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	Dichlorodifluoromethane	150	<MDL	[illegible]	<MDL	<MDL	<MDL	<MDL	[illegible]	<MDL	<MDL	<MDL	<MDL
6	Chloromethane	140	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	Vinyl Chloride	[illegible]											
8	Bromomethane	[illegible]		<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
9	1,1-Dichloroethene	140				<MDL							
10	Chloroethane	[illegible]	<MDL										
11	1,1-Dichloroethene	[illegible]	<MDL										
12	Carbon Disulfide	[illegible]	[illegible]	[illegible]	[illegible]	186	186	156	[illegible]	240	160		<MDL
13	Methylene Chloride	[illegible]	384	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	814	246	[illegible]	[illegible]
14	Trans-1,2-Dichloroethene	[illegible]											
15	1,1-Dichloroethane	[illegible]											
16	2,2-Dichloropropane	[illegible]											
17	cis-1,2-Dichloroethene	[illegible]											
18	2-Butanone	1	<MDL	<MDL	<MDL	[illegible]	<MDL	[illegible]	[illegible]	[illegible]	<MDL	<MDL	[illegible]
19	Bromochloromethane	[illegible]	164										
20	Chloroform	[illegible]	[illegible]	[illegible]	718	[illegible]	[illegible]	[illegible]	1018	[illegible]	[illegible]	[illegible]	[illegible]
21	1,1,1-Trichloroethane	[illegible]	<MDL										
22	Carbon Tetrachloride	[illegible]											
23	Benzene	[illegible]	<MDL	[illegible]	[illegible]	74	170	188	70	[illegible]	41	<MDL	<MDL
24	1,2-Dichloroethane	[illegible]											
25	[illegible]	[illegible]											
26	Trichloroethene	[illegible]		<MDL			<MDL	<MDL					
27	[illegible]	[illegible]			<MDL								
28	Bromodichloromethane	[illegible]			[illegible]				[illegible]		[illegible]	[illegible]	[illegible]
29	1,2-Dichloropropane	[illegible]											
30	cis-1,3-Dichloropropene	[illegible]											
31	4-Methyl-2-Pentanone	[illegible]	1086	[illegible]	[illegible]	<MDL	<MDL	<MDL	<MDL	[illegible]	<MDL	<MDL	[illegible]
32	Toluene	[illegible]	[illegible]	<MDL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<MDL	<MDL	[illegible]
33	Trans-1,3-Dichloropropene	[illegible]											
34	1,1,2-Trichloroethane	[illegible]											
35	Tetrachloroethene	[illegible]	<MDL							<MDL			
36	2-Hexanone	[illegible]	[illegible]	<MDL			<MDL	<MDL	<MDL	[illegible]	<MDL		<MDL
37	1,3-Dichloropropane	[illegible]											
38	Dibromochloromethane	[illegible]	[illegible]	<MDL	113	<MDL	<MDL		<MDL	<MDL	[illegible]	[illegible]	<MDL
39	1,2-Dibromoethane	[illegible]								<MDL			
40	Chlorobenzene	[illegible]											
41	1,1,1,2-Tetrachloroethane	[illegible]											
42	Ethylbenzene	[illegible]	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
43	m,p-Xylene	[illegible]	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
44	o-Xylene	[illegible]	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
45	Styrene	[illegible]	<MDL	<MDL	44	[illegible]	[illegible]	<MDL		<MDL	<MDL	<MDL	<MDL
46	Bromoform	[illegible]	[illegible]	73	120	[illegible]	<MDL		<MDL	<MDL	1117	[illegible]	<MDL
47	Isopropylbenzene	[illegible]	<MDL							<MDL			
48	Bromofluorobenzene	5											
49	Bromobenzene	[illegible]											
50	1,1,2,2-Tetrachloroethane	[illegible]								<MDL			
51	1,2,3-Trichloropropane	[illegible]								<MDL			
52	n-Propylbenzene	[illegible]	<MDL			<MDL				<MDL	<MDL		<MDL
53	1,3,5-Trimethylbenzene	[illegible]	<MDL						<MDL	<MDL	<MDL		<MDL
54	2-Chlorotoluene	[illegible]									<MDL		
55	4-Chlorotoluene	[illegible]	<MDL										
56	Tert-butylbenzene	[illegible]											
57	1,2,4-Trimethylbenzene	[illegible]	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
58	p-Isopropyltoluene	[illegible]	<MDL	<MDL	<MDL	<MDL		<MDL	<MDL	<MDL	<MDL		<MDL
59	1,4-Dichlorobenzene	[illegible]	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL		<MDL
60	n-Butylbenzene	[illegible]	<MDL	<MDL							<MDL	<MDL	<MDL
61	1,2-Dichlorobenzene-D4	5											
62	1,2-Dibromo-3-Chloropropane	[illegible]											
63	Hexachlorobutadiene	[illegible]											
64	Naphthalene	[illegible]	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	[illegible]	<MDL	<MDL	<MDL
65	1,2,3-Trichlorobenzene	[illegible]								<MDL			
66	Trichlorofluoromethane	[illegible]	<MDL										
67	1,1-Dichloropropene	[illegible]											
68	Isopropylbenzene	[illegible]											
69	Sec-butylbenzene	[illegible]	<MDL							<MDL			
70	1,3-Dichlorobenzene	[illegible]	<MDL							<MDL	<MDL		
71	1,2-Dichlorobenzene	[illegible]											
72	1,2,4-Trichlorobenzene	[illegible]								<MDL			

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Table IV 5.a. VOLATILE ORGANIC CHEMICALS IN ASHLAND 6/12 TO 12/10 1992

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	1/24/93															
2	Ashland		A	A	A	A	A	A	A	A	A	A	A	A	A	A
3	Date	MDL	7-Jul	7-Jul	27-Jul	27-Jul	24-Aug	24-Aug	8-Sep	29-Sep	29-Sep	12 Oct	12 Oct	2 Nov	2 Nov	10 Dec
4	Time	MDL	9.15	13 20	9 40	14 00	9 30	14 05	9 40	9 55	13 30	9 40	12 30	AM	PM	C
5	CHEMICAL NAME	ng/l	F8003	8009	F8004	F7996	F7990	F7984	F7977	F7965	F7964	8012	8016	F8144	F8139	F8147
6	Dichlorodifluoromethane	180	331													203
7	Chloromethane	140	602	309	475	416	285	341	513	908	755	284	270	223	236	230
8	1,1-Dichloroethane	170				187										
9	Carbon Disulfide	110	590	5801	700	675	376	282	945	1290	1382	1019	1067	205	925	161
10	Methylene Chloride	70	65742	1749	579	353	894	3401		478	314	381	303	238	336	7104
11	2-Butanone	7			3730	760		451	1010	1059	928	706	883		290	
12	Bromochloromethane	160	298	1051							299		168			
13	Chloroform	110	10458	19112			147	128	858	452	705	4082		3348	2154	3283
14	Benzene	40		56	66	63	59	222	244	78	63	59	60	47	72	63
15	1,2-Dichloroethane	40	53													
16	Trichloroethene	40	79								65		62			
17	Dibromomethane	30	1100	2001					465	462	1021	381	843	274	109	
18	Bromodichloromethane	60	7422									256		97	443	196
19	4-Methyl-2-Pentanone	120	280	1398	1129	973	310	426		302	664	373	298	155		
20	Toluene	50		89	168	307	117	138	6630	138	127	263	152		90	
21	2-Hexanone	90		406	148	167	246		160							
22	Dibromochloromethane	90	18536											105	721	147
23	Ethyl Benzene	50				57										
24	o-Xylene	40		91		51										
25	Styrene	40			44	77	50	54	44							
26	Bromoform	60	50524	155								204		519	1373	43
27	1,3,5-Trimethylbenzene	50		1274	69											
28	1,2,4-Trimethylbenzene	40		79	172	123	56	43				47	56		42	
29	p-Isopropyltoluene	60			2506	1129	112			70	63		240			
30	n-Butylbenzene	60		60												
31	Napthalene	250		401												
32	1,2-Dichlorobenzene	40								74						

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Table IV 5.0 Volatile Organic Chemicals ...

1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
200	Location - Ashland		A	A	A	A	A	A	A	A	A	A	A	A	A	A
201	Date 3.1.93		7-Jul	7-Jul	27-Jul	27-Jul	24-Aug	24-Aug	6-Sep	28-Sep	28-Sep	12-Oct	12-Oct	2-Nov	2-Nov	10-Dec
202	[illegible]	EQL	9:15	12:27	9:45	14:00	9:30	14:28	9:45	9:14	12:30	9:40	12:30	AM	PM	C
203	CHEMICAL NAME	ug/l	F6008	8008	F6004	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8C12	8C18	F6144	F6138	F6147
204	Dichlorodifluoromethane	180	331	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	250
205	Chloromethane	140	802	309	475	416	225	341	613	808	784	284	270	223	238	230
206	Vinyl Chloride	[illegible]														
207	Bromomethane	640	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
208	1,1 Dichloroethene	140								<MDL						
209	Chloroethane	210														
210	1,1 Dichloroethane	170			<MDL	161				<MDL					<MDL	
211	Carbon Disulfide	110	980	801	720	675	378	282	848	1280	1382	1018	1087	235	675	181
212	Methylene Chloride	70	65142	1749	579	383	884	3431		478	314	381	300	238	308	7104
213	Trans 1,2 Dichloroethene	120														
214	1,1 Dichloropropane	9														
215	2,2 Dichloropropane	180														
216	Cis 1,2 Dichloroethene	270														
217	2 Butanone	9	<MDL	<MDL	3730	780	<MDL	481	1010	1086	828	708	880	<MDL	<MDL	<MDL
218	Bromochloromethane	180	296	1051					<MDL	<MDL	288	<MDL	168	<MDL	<MDL	
219	Chloroform	110	10448	16112	<MDL	<MDL	167	138	888	442	708	4082		3048	2184	2283
220	1,1,1 Trichloroethane	80												<MDL	<MDL	<MDL
221	Carbon Tetrachloride	70														
222	Benzene	40	<MDL	84	88	83	94	222	244	79	63	88	80	47	72	93
223	1,2 Dichloroethane	40	83													
224	Fluorobenzene	15														
225	Trichloroethene	40	79			<MDL			<MDL	<MDL	88	<MDL	62	<MDL	<MDL	
226	Dibromomethane	30	1100	2001			<MDL		488	482	1021	381	843	274	108	
227	Bromodichloromethane	80	7422									254		87	443	188
228	1,2 Dichloropropane	40														
229	Cis 1,3 Dichloropropene	80														
230	4 Methyl 2 Pentanone	120	380	1388	1179	873	310	478		302	884	373	288	188	<MDL	<MDL
231	Toluene	80	<MDL	88	188	307	117	138	8800	138	127	383	153	<MDL	90	<MDL
232	Trans 1,3 Dichloropropene	80														
233	1,1,2 Trichloroethane	80														
234	Tetrachloroethene	80	<MDL	<MDL						<MDL				<MDL	<MDL	
235	2 Hexanone	80		438	148	187	248	<MDL	180	<MDL	<MDL			<MDL	<MDL	
236	1,3 Dichloropropane	40														
237	Dibromochloromethane	80	18536	<MDL								<MDL		108	721	147
238	1,2 Dibromoethane	40														
239	Chlorobenzene	40														
240	1,1,1,2 Tetrachloroethane	80														
241	Ethyl Benzene	80	<MDL	<MDL	<MDL	57	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
242	m+p Xylene	100	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
243	o Xylene	40	<MDL	81	<MDL	81	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
244	Styrene	40	<MDL	<MDL	44	77	80	84	44		<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
245	Bromoform	80	50524	153								204		810	1373	<MDL
246	Isopropylbenzene	80		<MDL		<MDL									<MDL	
247	Bromofluorobenzene	5														
248	Bromobenzene	40														
249	1,1,2,2 Tetrachloroethane	40														
250	1,2,3 Trichloropropane	80													<MDL	
251	n-Propylbenzene	80	<MDL		<MDL	<MDL	<MDL	<MDL							<MDL	
252	1,3,5 Trimethylbenzene	80	<MDL	1274	88		<MDL	<MDL	<MDL		<MDL	<MDL		<MDL	<MDL	<MDL
253	2 Chlorotoluene	40	<MDL	63											<MDL	
254	4 Chlorotoluene	40	<MDL	148	<MDL	<MDL									<MDL	
255	Tert Butylbenzene	60													<MDL	
256	1,2,4 Trimethylbenzene	40	<MDL	79	172	123	88	43	<MDL	<MDL	<MDL	47	88	<MDL	42	<MDL
257	p-Isopropyltoluene	80		<MDL	2508	1129	112	<MDL	<MDL	79	83		348	<MDL		
258	1,4 Dichlorobenzene	40	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
259	n-Butylbenzene	80		63										<MDL	<MDL	<MDL
260	1,2 Dichlorobenzene D4	5														
261	1,2 Dibromo-3-Chloropropane	70														
262	Hexachlorobutadiene	80														
263	Naphthalene	250	<MDL	401	<MDL	<MDL		<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
264	1,2,3 Trichlorobenzene	60														<MDL
265	Trichlorofluoromethane	120														
266	1,1 Dichloropropene	80														
267	Isopropylbenzene	9														
268	Sec Butylbenzene	60														
269	1,3 Dichlorobenzene	40							74							
270	1,2 Dichlorobenzene	40														
271	1,2,4 Trichlorobenzene	80														

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1 8214

R0051519

VOL 12

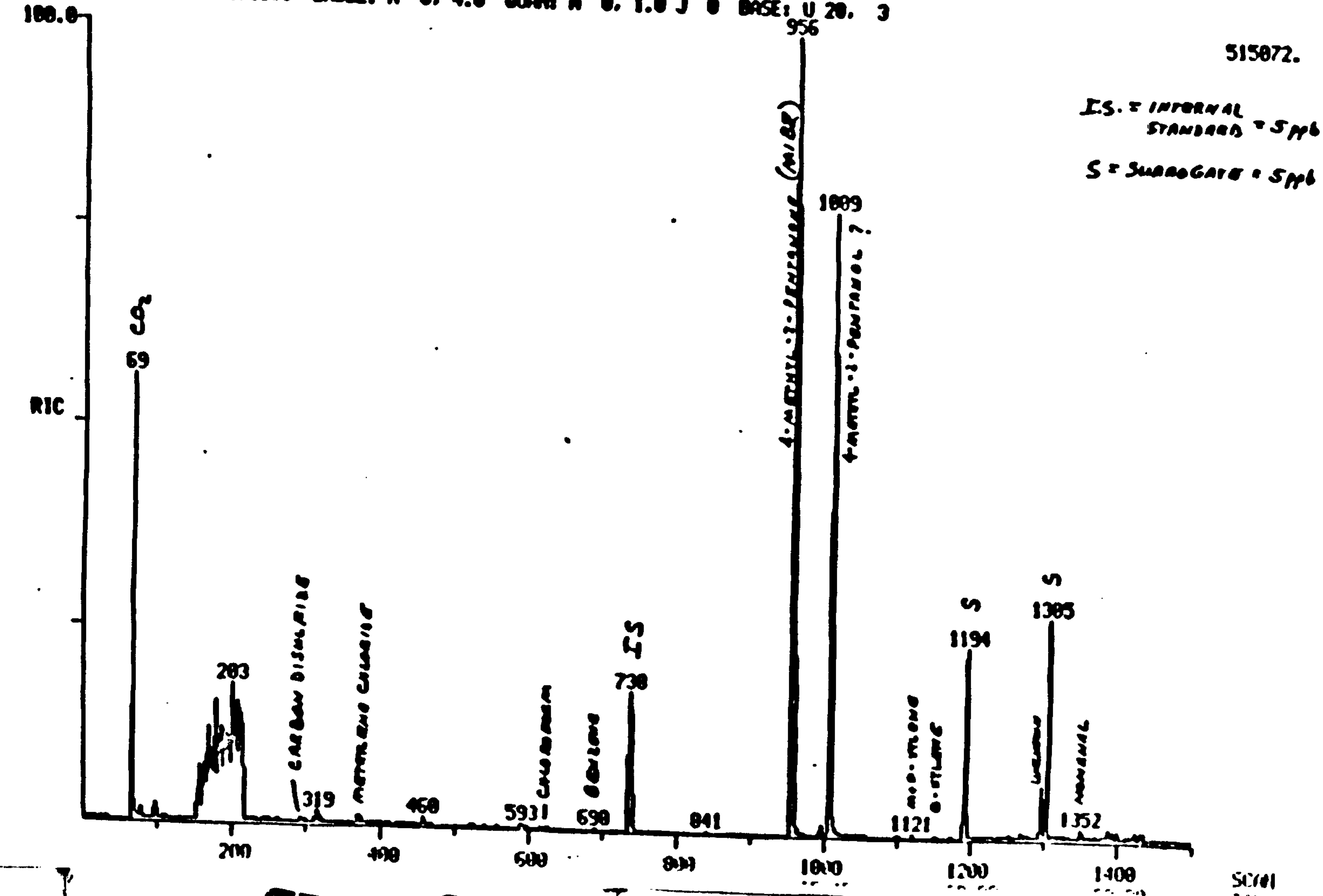
1 8215

Appendix V

GC/MS Total Ion Chromatograms Showing Targeted and Non-Targeted Volatile Organic Compounds for Selected Samples (All 5 ml Analysis Except Where Noted)

1. Sample F7972--Centinela Creek 9/8/92, 1515 hrs 2nd Grab
2. Sample F7924--Pico-Kenter 6/12/92
3. Sample F8143--Pico-Kenter 11/2/92, 0910 hrs 1st Grab
4. Sample F8008--Ashland 7/7/92, 0915 hrs 1st Grab
5. Sample F7932--Ashland 7/7/92 1320 (15 ml sample)
6. Sample F8009--Ashland 7/7/92 1320 hrs 2nd Grab
7. Sample F7977--Ashland 9/8/92 0940 hrs 1st Grab
8. Sample F8012--Ashland 10/12/92 0940 hrs 1st Grab

RIC
10/06/92 10:30:00 DATA: F7972 01 SCANS 1 TO 1500
CALI: F7922 02
SAMPLE: CENTINELA CREEK 09-08-92 1515 HRS 2ND GRAB
CONDS.: 5 MIN @ 10, 6/MIN TO 70, 15/MIN TO 200 30M DB-624 COLUMN
RANGE: G 1,1500 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



R0051521

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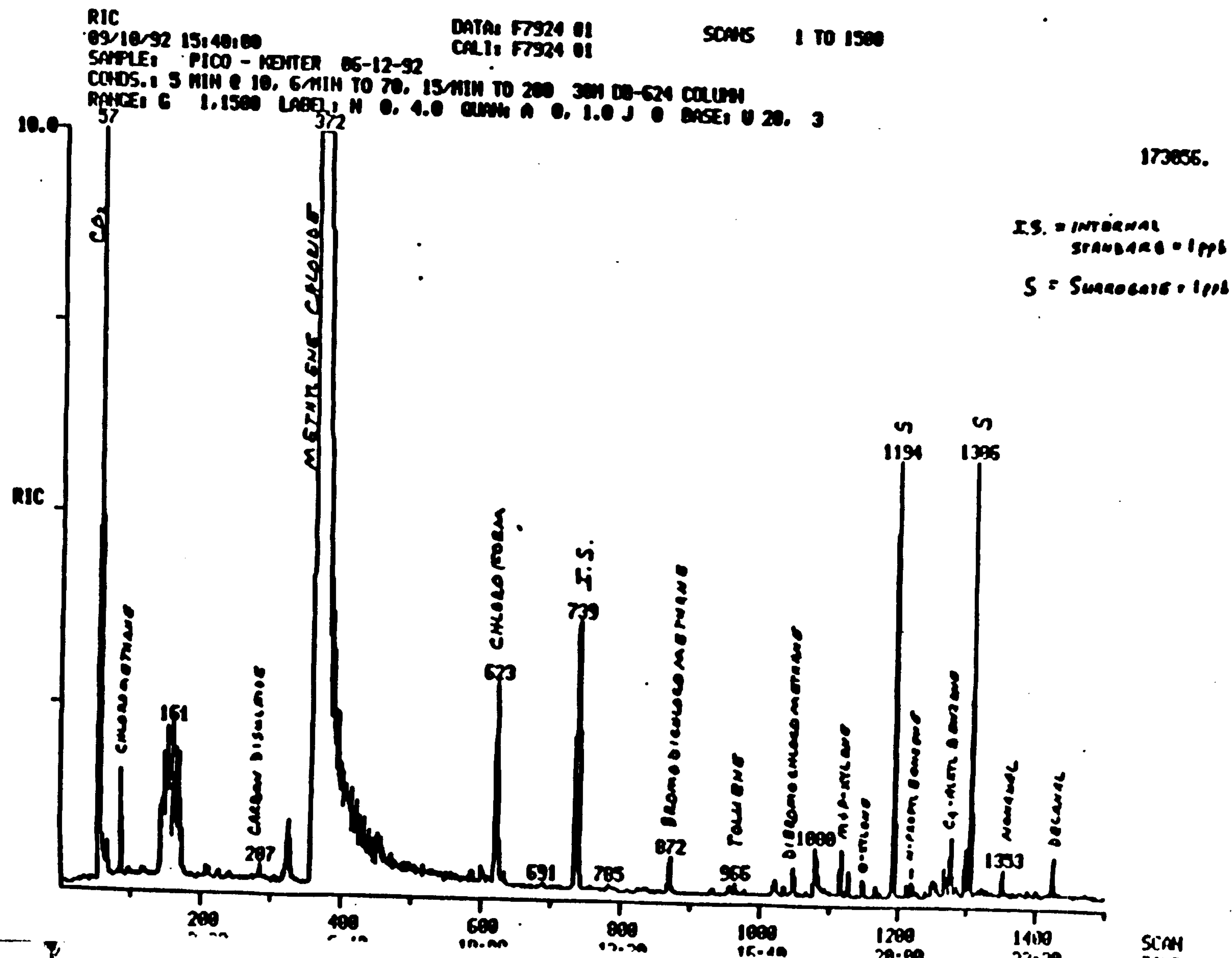
1 VOL 12

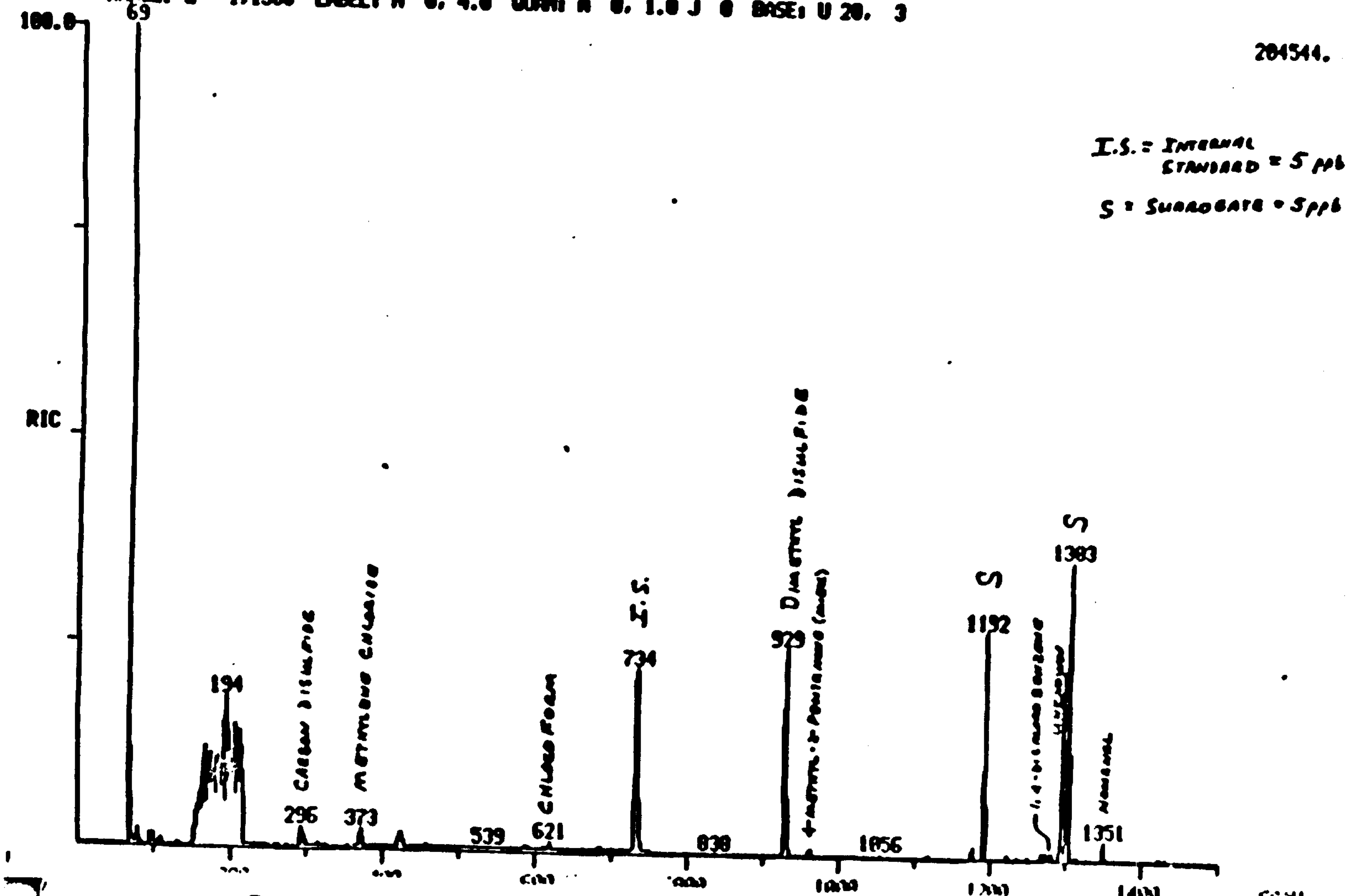


R0051522

1128 1

VOL 12

RIC
12/17/92 11:20:00 DATA: F8143 01 SCANS 1 TO 1500
CALI: F8143 01
SAMPLE: PICO-KENTER 11-02-92 0910 HRS 1ST GRAB
CONDS.: 5 MIN @ 10, 6/MIN TO 70, 15/MIN TO 200 30M DB-624 COLUMN
RANGE: G 1,1500 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



8-28 1

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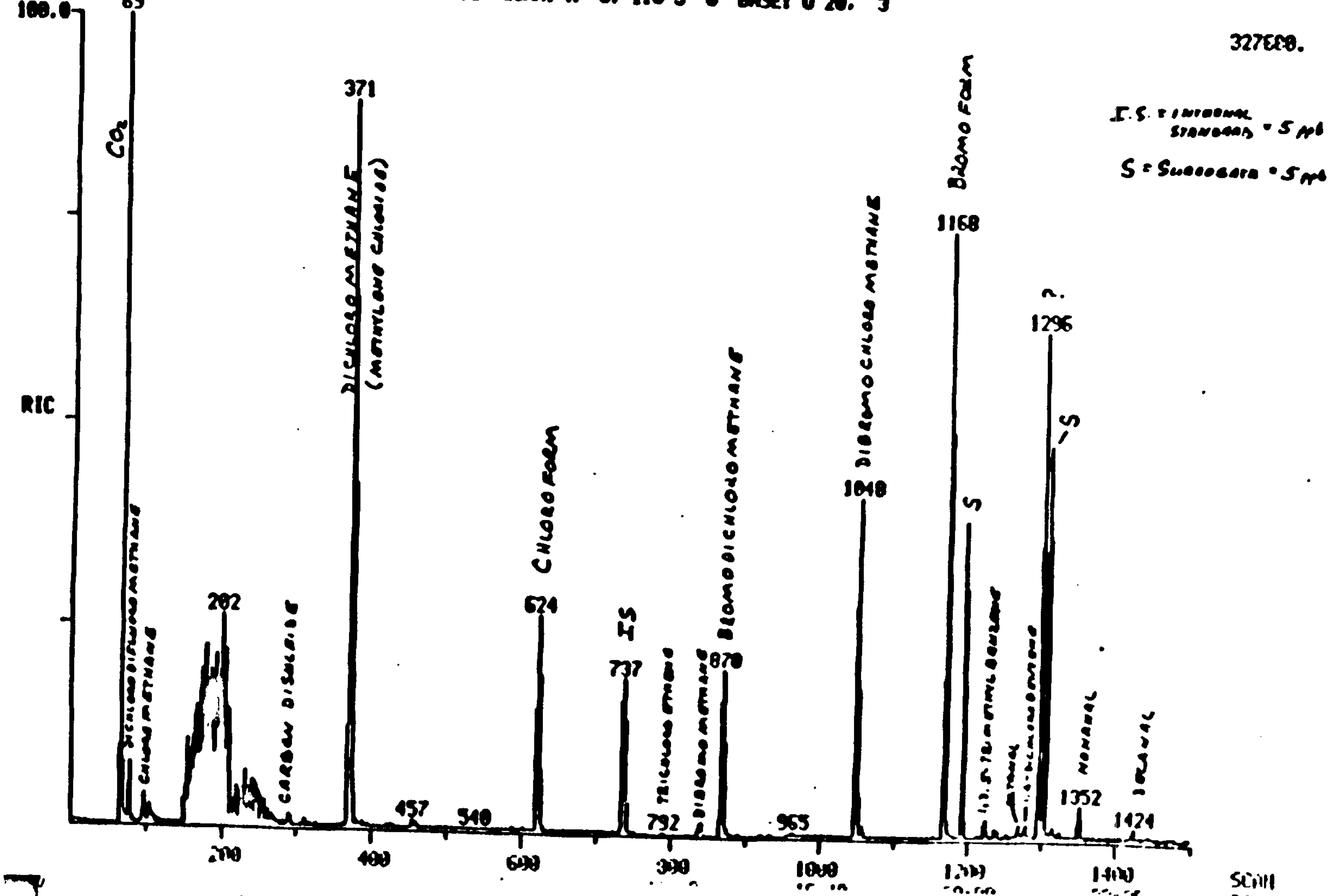
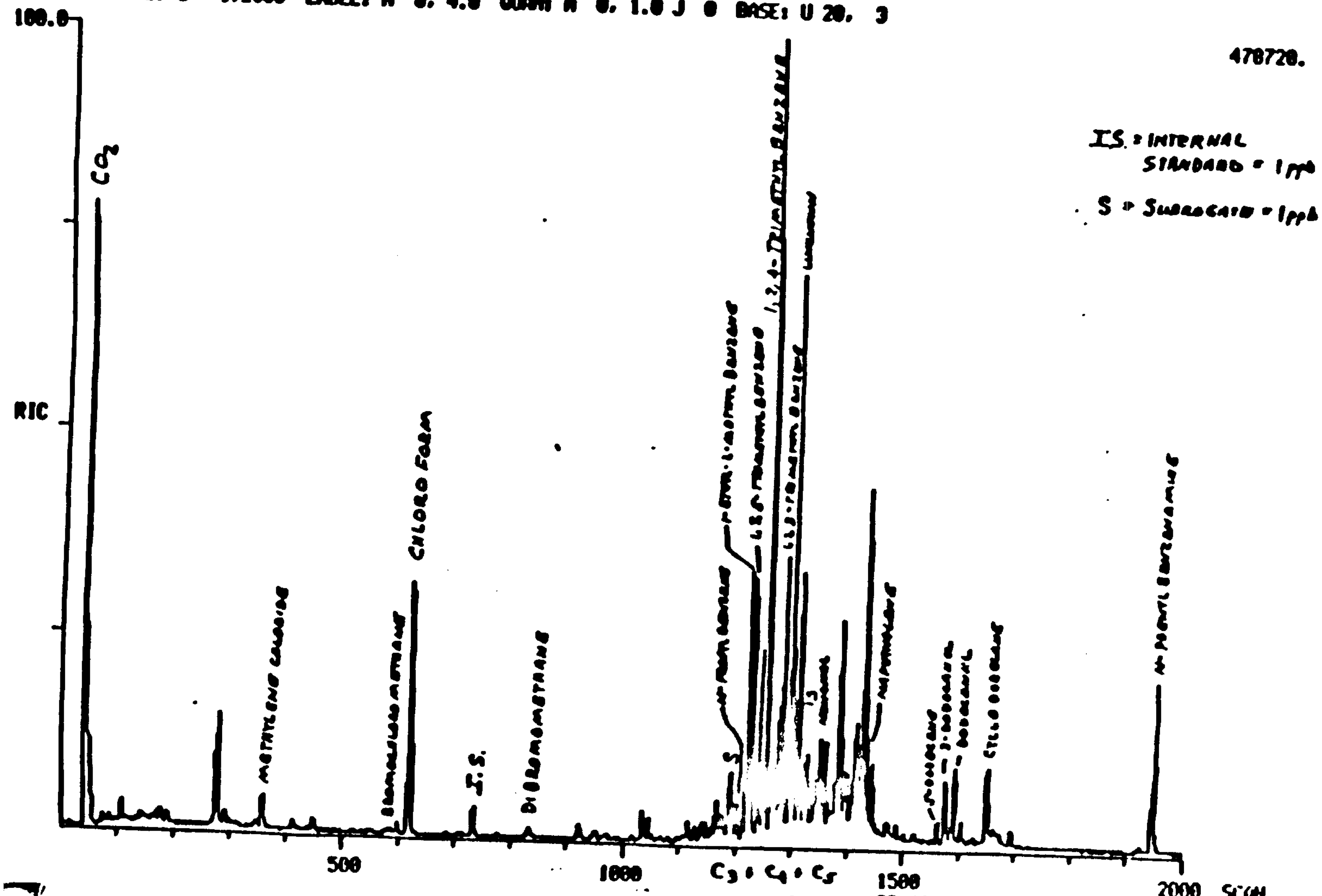
R0051523

RIC
10/12/92 16:45:00 DATA: F0008 01 SCANS 1 TO 1500
CALI: F0008 03
SAMPLE: ASHLAND# 07-07-92 0315 HRS ·1ST GRAB
CONDS.: 5 MIN @ 10, 6/MIN TO 70, 15/MIN TO 200 30M DB-624 COLUMN
RANGE: G 1,1500 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



RIC
09/14/92 10:08:00 DATA: F7932 #1 SCANS 1 TO 2000
SAMPLE: ASHLAND 07-07-32 / 1320 CAL1: F7932 #1
(15 ML SAMPLE)
CONDS.: 5 MIN @ 10, 6/MIN TO 70, 15/MIN TO 200 30M DB-624 COLUMN
RANGE: G 1,2000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



0228 1

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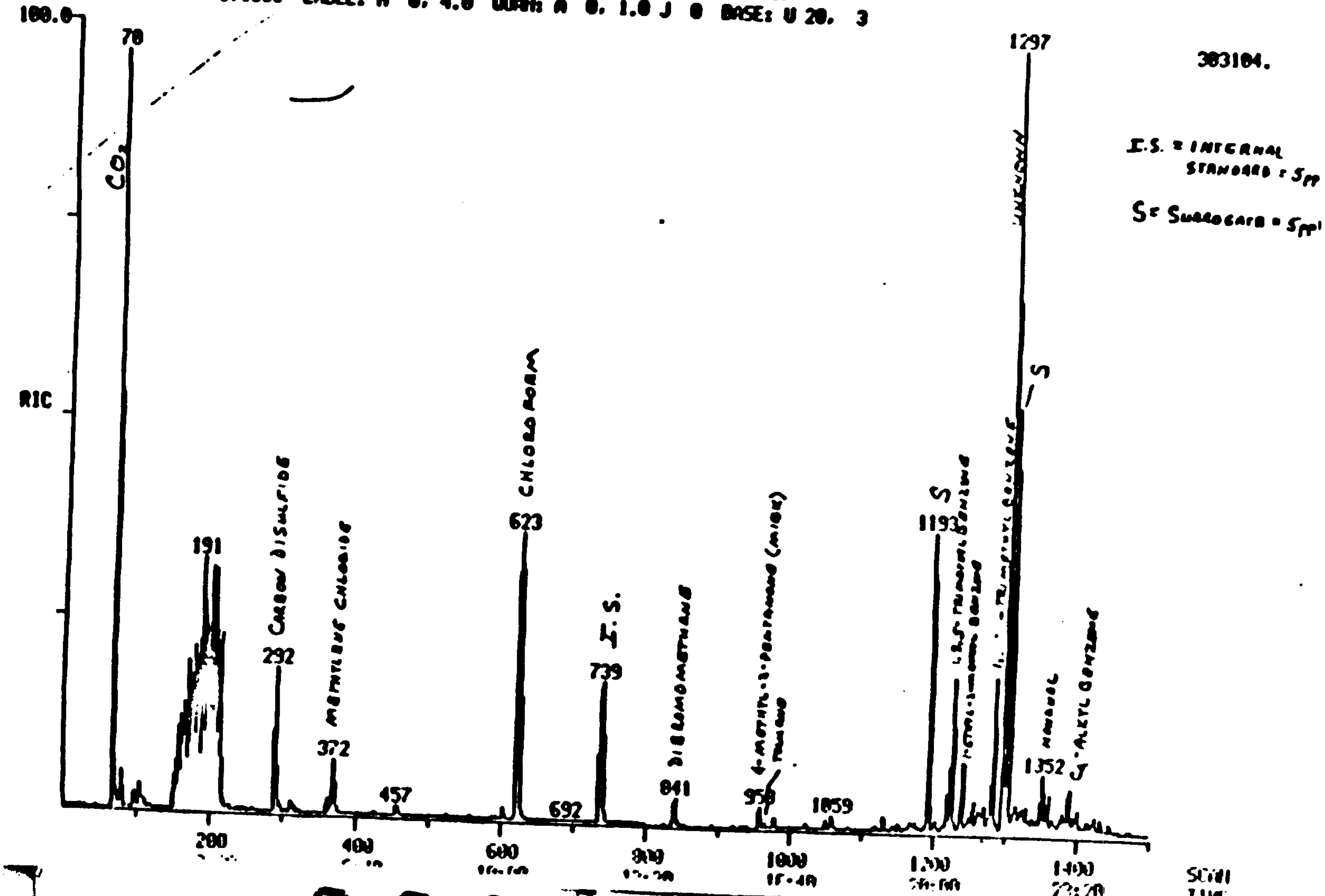
R0051525

RIC
10/12/92 17:37:00 DATA: F0009 #1 SCANS 1 TO 1500
SAMPLE: ASHLAND: 07-07-92 1320 HRS 2ND GRAB CALI: F0009 #3
CONDS.: 5 MIN @ 10, 6/MIN TO 70, 15/MIN TO 200 30M DB-624 COLUMN
RANGE: G 1,1500 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



-228 1

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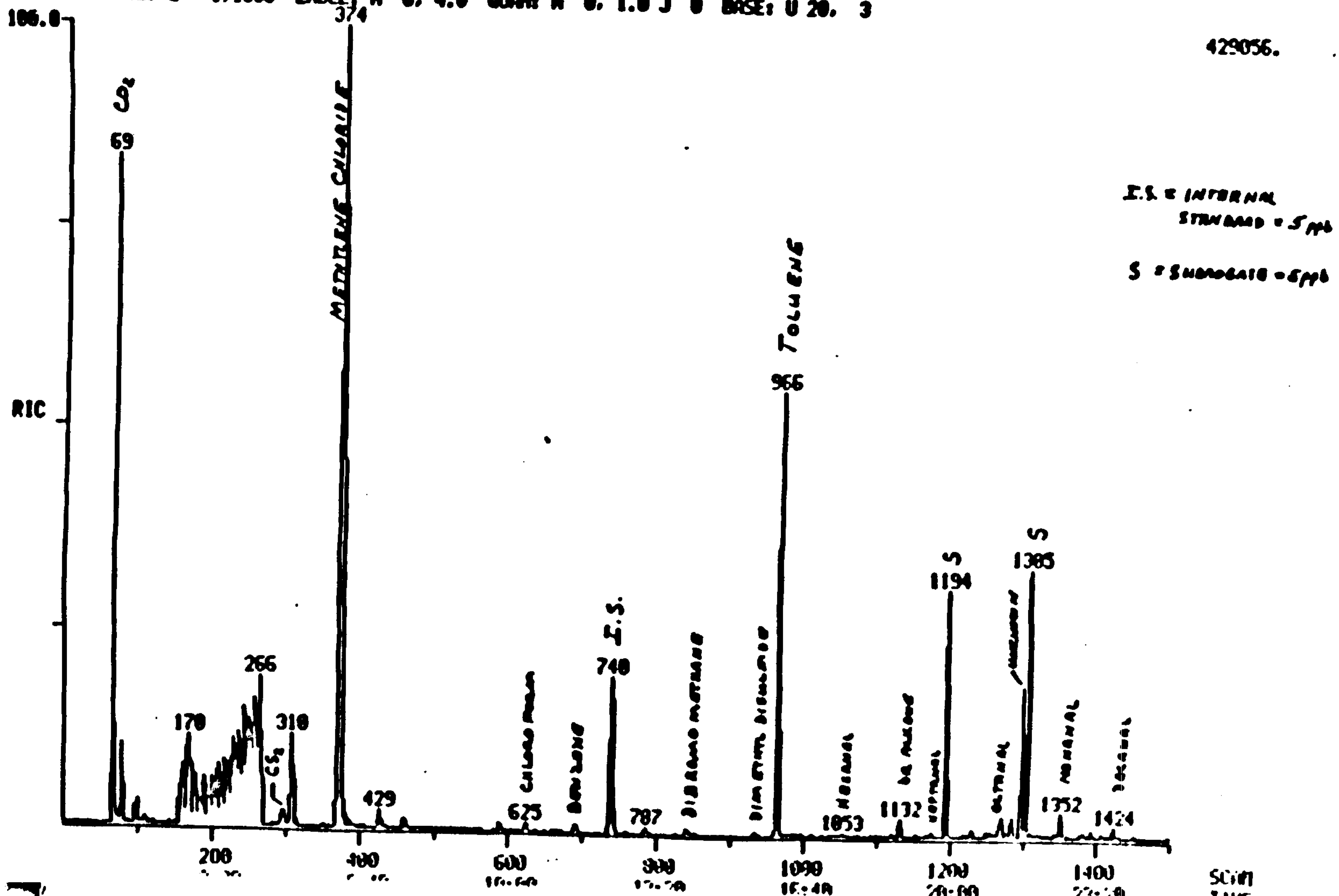
R0051526

RIC
10/06/92 14:53:00
DATA: F7977 01
CALI: F7977 02
SCANS 1 TO 1500
SAMPLE: ASHLAND 09-08-92 0940 HRS 1ST GRAB
CONDS.: 5 MIN @ 10, 6/MIN TO 70, 15/MIN TO 200 30M DB-624 COLUMN
RANGE: G 1,1500 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



22281

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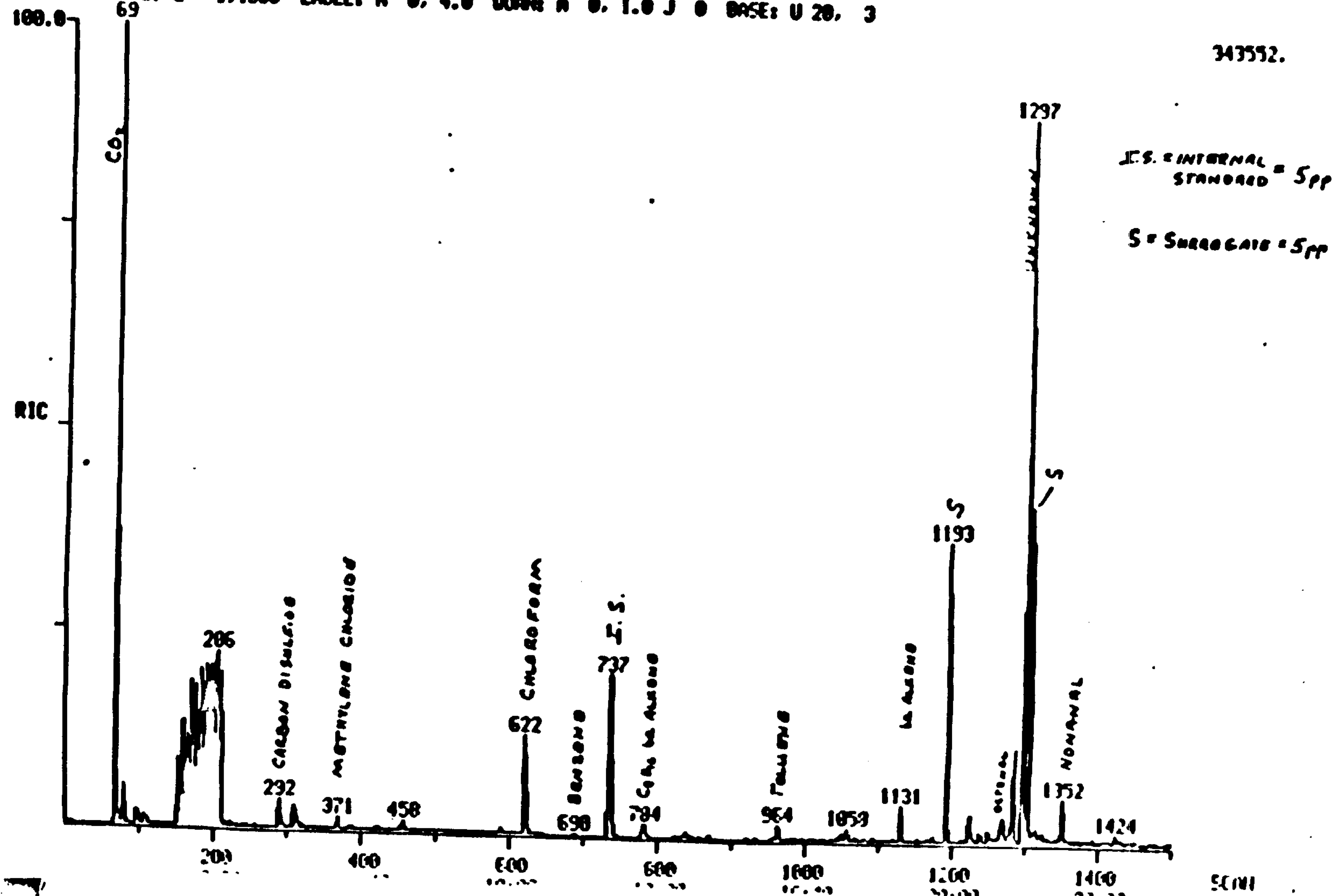
R0051527

RIC
10/13/92 10:05:00 DATA: F8012 #1 SCANS 1 TO 1500
CALI: F8012 #1
SAMPLE: ASHLAND 10-12-92 0940 HRS 1ST GRAB
CONDS.: 5 MIN @ 10, 6/MIN TO 70, 15/MIN TO 200 30M DB-624 COLUMN
RANGE: G 1,1500 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



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Appendix VI

Complete Targeted Base Neutral Analysis for Each Storm Drain by Date

a. Long Form--Reported Concentrations of All Compounds Under Study
b. Short Form--Reported Concentrations of Only Compounds Detected

Table VI 1.a. and b.--BN-1	Ballona-Base Neutrals
Table VI 2.a. and b.--BN-2	Pico-Kenter Samples--Base Neutrals
Table VI 3.a. and b.--BN-3	Sepulveda Samples--Base Neutrals
Table VI 4.a. and b.--BN-4	Centinela Samples--Base Neutrals
Table VI 5.a. and b.--BN-5	Ashland Ave. Samples--Base Neutrals

18224

Appendix, Table VI 1.a. –BN-1

TABLE BN

BALLONA SAMPLES- BASE NEUTRALS

File Code —>	F8102	8108+	8070+	8189+	8193+	8192+	8209+	8210+	8211+8232+	8225+
File Code —>		8110	8071	8119	8224	8225	8244	8243	8277+8280	8270
Location —>	Ballona	Ballona	Ballona	Ballona	Bal(1)	Bal(2)	Bal(1)	Bal(2)	Ballona	Ballona
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	29-Sep	12-Oct	12-Oct	2-Nov	10-Dec
Phase —>	Water	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS
	Only					Dup		Dup		
Volume of Water (L) —>	4	4	7	4	3	4	4	4	4	4
Weight of Sediment (mg)->	.	28 4	42 8/4	43.2	41 6/4	48 8	60 1	57 5	60 4	104 2
	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc
CHEMICAL NAME:	(ng/l)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)
Phenol			81		67	749	63	85	29	86
2-Chlorophenol										
2-Methylphenol					<MDL					
4-Methylphenol			<MDL		<MDL	<MDL				25
2-Nitrophenol			31	34	31	27	65	72		31
2,4-Dimethylphenol										
2,4-Dichlorophenol										
Benzoic Acid	<MDL	111	297	961	<MDL	<MDL			507	841
4-Chloro-3-methylphenol										
2,4,6-Trichlorophenol										
2,4,5-Trichlorophenol										
2,4-Dinitrophenol										
4-Nitrophenol										
2-Methyl-4,6-dinitrophenol										
Pentachlorophenol										
N-Nitrosodimethylamine										
Aniline										
Bis(2-chloroethyl) ether	<MDL									
1,3-Dichlorobenzene										
1,4-Dichlorobenzene	<MDL	38	54	61	82	62	146	107	61	69
1,2-Dichlorobenzene										
Benzyl alcohol						459				
Bis(2-chloroisopropyl) ether										
Hexachloroethane										
N-Nitrosodi-n-propylamine						3				
Nitrobenzene						7			<MDL	40
Isophorone		47	19		<MDL					
Bis(2-chloroethoxy)methane										
1,2,4-Trichlorobenzene										
Naphthalene	<MDL	61	68	97	112	97	119	138	88	113
4-Chloroaniline	<MDL									
Hexachlorobutadiene										
2-Methylnaphthalene	<MDL	33	58	54	60	46	50	62	57	59
Hexachlorocyclopentadiene										
2-Chloronaphthalene										
2-Nitroaniline										
Acenaphthylene	<MDL									

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Appendix, Table VI 1.a. –BN-1

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TABLE BN Cont.

BALLONA SAMPLES- BASE NEUTRALS

File Code —>	F8102	8108+	8070+	8189+	8193+	8192+	8209+	8210+	8211+8232+	8236+
File Code —>		8110	8071	8119	8224	8225	8244	8243	8277+8280	8270
Location —>	Ballona	Ballona	Ballona	Ballona	Ba(1)	Ba(2)	Ba(1)	Ba(2)	Ballona	Ballona
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	29-Sep	12-Oct	12-Oct	2-Nov	10-Dec
Phase —>	Water	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS
	Only					Dup		Dup		
Volume of Water (L) —>	4	4	7	4	3	4	4	4	4	4
Weight of Sediment (mg)->	-	28.4	428/4	43.2	416/4	48.8	60.1	57.5	60.4	104.2
	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc
CHEMICAL NAME:	(ng/l)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)
Dimethyl phthalate	70	6	28							4
2,6-Dinitrotoluene										
3-Nitroaniline										
Acenaphthene			3							
Dibenzofuran			10	6						6
2,4-Dinitrotoluene										
Fluorene	<MDL	6	6	3	3					
Diethyl phthalate	378	316	390	285	120	108	119	177	152	99
4-Chlorophenyl phenyl ether		22	53	24	27	24			7	39
4-Nitroaniline										
N-Nitrosodiphenylamine										
Azobenzene	<MDL		26	9	20	15	<MDL	22	5	22
4-Bromophenyl phenyl ether										
Hexachlorobenzene										
Phenanthrene	19	21	39	20	15	10	7	14		5
Anthracene	<MDL	6	39	<MDL	<MDL	<MDL				<MDL
Di-n-butyl phthalate	1127	1655	1202	1747	812	1947	1737	1624	843	679
Fluoranthene	21	9	17	8	6	3	4	5		<MDL
Benzidine										
Pyrene	<MDL	20	126	10	8	6	7	8	3	2
Butyl benzyl phthalate	445	1587	1585	1628	1597	2245	1152	1353	673	217
Benz(a)anthracene	46	9	9	17	<MDL	<MDL				31
3,3'-Dichlorobenzidine										
Chrysene	<MDL	26	145	13					<MDL	<MDL
Bis(2-ethylhexyl) phthalate		3507	7120	2248	3446	5426	3433	3187	5295	6999
Di-n-octyl phthalate	35		435	17	587	5571	3655	2565	29	83
Benzo(b)fluoranthene	<MDL		4	<MDL						<MDL
Benzo(k)fluoranthene	<MDL		5	<MDL						<MDL
Benzo(a)pyrene	33	29	106	<MDL						18
Indeno(1,2,3,4-c,d)pyrene	<MDL		<MDL	<MDL						<MDL
Dibenzo(a,h)anthracene	<MDL		<MDL	<MDL						<MDL
Benzo(g,h,i)perylene	<MDL			<MDL						<MDL
Carbazole										
Blank Value and Not MDL was used for comparison										

1 8226

Appendix, Table VI 1.b. –BN-1

TABLE BN

BALLONA SAMPLES- BASE NEUTRALS

File Code —>	F8102	8108+	8070+	8189+	8193+	8192+	8209+	8210+	8211+8232+	8236+
File Code —>		8110	8071	8119	8224	8225	8244	8243	8277+8280	8270
Location —>	Ballona	Ballona	Ballona	Ballona	Ba(1)	Ba(2)	Ba(1)	Ba(2)	Ballona	Ballona
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	29-Sep	12-Oct	12-Oct	2-Nov	10-Dec
Phase —>	Water	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS
	Only					Dup		Dup		
Volume of Water (L) —>	4	4	7	4	3	4	4	4	4	4
Weight of Sediment (mg)->	-	28 4	42 8.4	43 2	41 6/4	48 8	60 1	57.5	60 4	104 2
	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc
CHEMICAL NAME:	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)
Phenol			81		67	749	63	85	29	86
2-Methylphenol					<MDL					
4-Methylphenol			<MDL		<MDL	<MDL				25
2-Nitrophenol			31	34	31	27	65	72		31
Benzoic Acid	<MDL	111	297	961	<MDL	<MDL			507	841
1,4-Dichlorobenzene	<MDL	38	54	61	82	62	146	107	61	69
Benzyl alcohol						459				
N-Nitrosodi-n-propylamine						3				
Nitrobenzene						7			<MDL	40
Isophorone		47	19		<MDL					
Naphthalene	<MDL	61	68	97	112	97	119	138	88	113
2-Methylnaphthalene	<MDL	33	58	54	60	46	50	62	57	59
Acenaphthylene	<MDL									
Dimethyl phthalate	70	6	28							4
Acenaphthene			3							
Dibenzofuran			10	6						6
Fluorene	<MDL	6	6	3	3					
Diethyl phthalate	378	316	390	285	120	108	119	177	152	99
4-Chlorophenyl phenyl ether		22	53	24	27	24			7	39
Azobenzene	<MDL		26	9	20	15	<MDL	22	5	22
Phenanthrene	19	21	39	20	15	10	7	14		5
Anthracene	<MDL	6	39	<MDL	<MDL	<MDL				<MDL
Di-n-butyl phthalate	1127	1655	1202	1747	812	1947	1737	1624	843	679
Fluoranthene	21	9	17	8	6	3	4	5		<MDL
Pyrene	<MDL	20	126	10	8	6	7	8	3	2
Butyl benzyl phthalate	445	1587	1585	1628	1597	2245	1152	1353	673	217
Benz(a)anthracene	46	9	9	17	<MDL	<MDL				31
Chrysene	<MDL	26	145	13					<MDL	<MDL
Bis(2-ethylhexyl) phthalate		3507	7120	2248	3446	5426	3433	3187	5295	6999
Di-n-octyl phthalate	35		435	17	587	5571	3655	2565	29	83
Benzo(b)fluoranthene	<MDL		4	<MDL						<MDL
Benzo(k)fluoranthene	<MDL		5	<MDL						<MDL
Benzo(a)pyrene	33	29	106	<MDL						18
Indeno(1,2,3,4-c,d)pyrene	<MDL		<MDL	<MDL						<MDL
Dibenzo(a,h)anthracene	<MDL		<MDL	<MDL						<MDL
Benzo(g,h,i)perylene	<MDL			<MDL						<MDL
Blank Value and Not MDL was used for comparison										

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Appendix, Table VI 2.a. –BN-2

TABLE BN
PICO-KENTER SAMPLES- BASE NEUTRALS

File Code —>		8105+	8065+		8195+	8208+	8233+	8215+	8216+	8234+	8273+
File Code —>	F8080	8109	8072	F8118	8226	8245	8283	8251	8252	8271+8272	8274
Location —>	Pico K.	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	PK 2G
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	12-Oct	2-Nov	10-Dec	10-Dec	10-Dec	10-Dec
Phase —>	Water Only	W+SS	W+SS	SS Only	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS1+ SS2	SS1&2 Only
Volume of Water (L) —>	4	4	8	.	4	4	3	4	2	4	4
Weight of Sediment (mg)—>	.	37 1	145 8 4	71 6 8	697 9	86 1	0 1/8	55 8	209 3 4	61 2 8	187 8/4
CHEMICAL NAME:	Conc (ng/l)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)
Phenol	<MQL	3867	34		30	57	4073		<MQL	151	217
2-Chlorophenol											
2-Methylphenol		<MQL					8				
4-Methylphenol		5690	9749		301		61			38	56
2-Nitrophenol		18	18	18	9	57	3451			21	50
2,4-Dimethylphenol											
2,4-Dichlorophenol											
Benzoic Acid		858	196	548			625			1684	1707
4-Chloro-3-methylphenol		<MQL									
2,4,6-Trichlorophenol											
2,4,5-Trichlorophenol											
2,4-Dinitrophenol											
4-Nitrophenol		<MQL	<MQL				3903				
2-Methyl-4,6-dinitrophenol	.										
Pentachlorophenol											
N-Nitrosodimethylamine											
Aniline											
Bis(2-chloroethyl) ether											
1,3-Dichlorobenzene											
1,4-Dichlorobenzene		61	48	33	37	127	64	50	45	105	91
1,2-Dichlorobenzene											
Benzyl alcohol											
Bis(2-chloroisopropyl) ether											
Hexachloroethane											
N-Nitrosodi-n-propylamine			<MQL								
Nitrobenzene							15			46	
Isophorone	<MQL	<MQL	1		<MQL						
Bis(2-chloroethoxy)methane											
1,2,4-Trichlorobenzene											
Naphthalene	<MQL	77	58	37	46	128	75	140	116	160	146
4-Chloroaniline											
Hexachlorobutadiene											
2-Methylnaphthalene		38	45	23	25	53	40	80	67	105	97
Hexachlorocyclopentadiene											
2-Chloronaphthalene											
2-Nitroaniline											
Acenaphthylene		<MQL									
Dimethyl phthalate	<MQL	10	28						<MQL	2	
2,6-Dinitrotoluene											
3-Nitroaniline											

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Appendix, Table VI 2.a. –BN-2

TABLE BN Cont.

PICO-KENTER SAMPLES- BASE NEUTRALS

File Code —>		8105+	8065+		8195+	8208+	8233+	8215+	8216+	8234+	8273+
File Code —>	F8080	8109	8072	F8118	8226	8245	8283	8251	8252	8271+8272	8274
Location —>	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	PK 2G
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	12-Oct	2-Nov	10-Dec	10-Dec	10-Dec	10-Dec
Phase —>	Water Only	W+SS	W+SS	SS Only	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS1+ SS2	SS1&2 Only
Volume of Water (L) —>	4	4	8	.	4	4	3	4	2	4	.
Weight of Sediment (mg)->	.	37 1	145 8 4	71 8/8	697 9	86 1	0 1/8	55 8	209 3/4	61 2/8	187 8/4
CHEMICAL NAME:	Conc (ng/l)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)
Acenaphthene			4								
Dibenzofuran			7	4							
2,4-Dinitrotoluene							4			6	
Fluorene		7	6	2	4	2	2		8		
Diethyl phthalate	<MDL	236	497	76	118	147	97	154	128	211	209
4-Chlorophenyl phenyl ether		25	31	14			21	31	24	82	69
4-Nitroaniline											
N-Nitrosodiphenylamine				161							
Azobenzene	<MDL	<MDL	47	12	17	18	23	18	25	33	36
4-Bromophenyl phenyl ether											
Hexachlorobenzene											
Phenanthrene	<MDL	61	47	15	58	22		21	165	6	16
Anthracene	<MDL	2	72	1	3				33	<MDL	
Di-n-butyl phthalate	<MDL	1123	1905	445	573	1534	480	1070	862	1323	1148
Fluoranthene	<MDL	20	24	7	51	12		28	327	<MDL	5
Benzidine											
Pyrene	<MDL	25	211	12	46	20		33	202	<MDL	6
Butyl benzyl phthalate	673	479	3289	265	882	953	687	791	970	1006	614
Benz(a)anthracene	<MDL	15	26	10	<MDL				75		
3,3'-Dichlorobenzidine											
Chrysene	<MDL	20	185	1					72	<MDL	
Bis(2-ethylhexyl) phthalate	1241	1922	6319	1307	28173	4377	4078	5285	9415	8620	4065
Di-n-octyl phthalate	<MDL	11	262	18	39206	1754	93	323	347	325	155
Benzo(b)fluoranthene			10	<MDL					64		
Benzo(k)fluoranthene		<MDL	10	2					30		
Benzo(a)pyrene	<MDL	12	128	4					21		
Indeno(1,2,3,4-c,d)pyrene			7								
Dibenzo(a,h)anthracene			<MDL								
Benzo(g,h,i)perylene			<MDL								
Carbazole											
Blank value and not MDL was used for comparison											

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Appendix, Table VI 2.b. –BN-2

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TABLE BN

PICO-KENTER SAMPLES- BASE NEUTRALS

File Code —>		8105+	8065+		8195+	8208+	8233+	8215+	8216+	8234+	8273+
File Code —>	F8080	8109	8072	F8118	8226	8245	8283	8251	8252	8271+8272	8274
Location —>	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	Pico K	PK 2G
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	12-Oct	2-Nov	10-Dec	10-Dec	10-Dec	10-Dec
Phase —>	Water Only	W+SS	W+SS	SS	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS1+ SS2	SS1&2 Only
Volume of Water (L) —>	4	4	8	.	4	4	3	4	2	4	.
Weight of Sediment (mg)—>	.	37 1	145 8.4	71 6.8	697 9	86 1	0 1/8	55 8	209 3/4	81 2.9	187 8 4
CHEMICAL NAME	Conc (ng/l)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)
Phenol	<MDL	3867	34		30	57	4073		<MDL	151	217
2-Methylphenol		<MDL					8				
4-Methylphenol		5690	9749		301		61			38	56
2-Nitrophenol		18	18	18	9	57	3451			21	50
Benzoic Acid		258	196	548			525			1684	1707
4-Chloro-3-methylphenol		<MDL									
4-Nitrophenol		<MDL	<MDL				3903				
1,4-Dichlorobenzene		61	48	33	37	127	64	50	45	105	91
N-Nitrosodi-n-propylamine			<MDL								
Nitrobenzene							15			46	
Isophorone	<MDL	<MDL	1		<MDL						
Naphthalene	<MDL	77	58	37	46	128	75	140	116	160	146
2-Methylnaphthalene		38	45	23	25	53	40	80	67	105	97
Acenaphthylene		<MDL									
Dimethyl phthalate	<MDL	10	28						<MDL	2	
Acenaphthene			4								
Dibenzofuran			7	4			4			5	
Fluorene		7	6	2	4	2	2		8		
Diethyl phthalate	<MDL	236	497	76	118	147	97	154	128	211	209
4-Chlorophenyl phenyl ether		25	31	14			21	31	24	82	69
N-Nitrosodiphenylamine				161							
Azobenzene	<MDL	<MDL	47	12	17	18	23	18	25	33	38
Phenanthrene	<MDL	61	47	15	58	22		21	165	6	16
Anthracene	<MDL	2	72	1	3				33	<MDL	
Di-n-butyl phthalate	<MDL	1123	1905	445	573	1534	480	1070	862	1323	1146
Fluoranthene	<MDL	20	24	7	61	12		28	327	<MDL	5
Pyrene	<MDL	25	211	12	46	20		33	202	<MDL	6
Butyl benzyl phthalate	673	479	3269	265	882	953	687	791	970	1006	614
Benz(a)anthracene	<MDL	15	26	10	<MDL				75		
Chrysene	<MDL	20	185	1					72	<MDL	
Bis(2-ethylhexyl) phthalate	1241	1922	6319	1307	28173	4377	4078	5285	9415	8820	4065
Di-n-octyl phthalate	<MDL	11	262	18	39206	1754	93	323	347	325	155
Benzo(b)fluoranthene			10	<MDL					64		
Benzo(k)fluoranthene		<MDL	10	2					30		
Benzo(a)pyrene	<MDL	12	128	4					21		
Indeno(1,2,3,4-c,d)pyrene			7								
Dibenzo(a,h)anthracene			<MDL							.	
Benzo(g,h,i)perylene			<MDL								
Blank value and not MDL was used for comparison											

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Appendix, Table VI 3.a. –BN-3

TABLE BN
SEPULVEDA SAMPLES- BASE NEUTRALS

File Code —>	F8103	8107+	8067+	8188+8190+	8198+8238+	8207+	8230+8284+	8217+	8218+
File Code —>		8112	8076	8118	8239	8246	8275	8254	8253
Location —>	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sep
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	12-Oct	2-Nov	10-Dec	10-Dec
Phase —>	Water	W+SS	W+SS	W1+W2+SS	W+SS1+SS2	W+SS	W+SS1+SS2	W+SS	W+SS
	Only								Dup
Volume of Water (L) —>	4	4	8	8	4	4	4	4	4
Weight of Sediment (mg) —>	-	94 3	158 7/4	215 3	848 89	187 7	139 99	380 6	81 4
	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc
CHEMICAL NAME:	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)
Phenol			290	<MQL	81	63	33	33	
2-Chlorophenol									
2-Methylphenol									
4-Methylphenol									
2-Nitrophenol		13	16	24		49	36	<MQL	
2,4-Dimethylphenol									
2,4-Dichlorophenol									
Benzoic Acid		226	361	731	378		810		
4-Chloro-3-methylphenol									
2,4,6-Trichlorophenol									
2,4,5-Trichlorophenol									
2,4-Dinitrophenol									
4-Nitrophenol									
2-Methyl-4,6-dinitrophenol									
Pentachlorophenol									
N-Nitrosodimethylamine									
Aniline									
Bis(2-chloroethyl) ether									
1,3-Dichlorobenzene									
1,4-Dichlorobenzene		58	45	34	50	117	77	49	39
1,2-Dichlorobenzene									
Benzyl alcohol									
Bis(2-chloroisopropyl) ether									
Hexachloroethane									
N-Nitrosodi-n-propylamine									
Nitrobenzene									
Isophorone		<MQL	17	<MQL	<MQL	<MQL			
Bis(2-chloroethoxy)methane									
1,2,4-Trichlorobenzene									
Naphthalene	<MQL	111	56	38	113	124	99	153	119
4-Chloroaniline									
Hexachlorobutadiene									
2-Methylnaphthalene		56	58	26	57	55	55	100	59
Hexachlorocyclopentadiene									
2-Chloronaphthalene			1						
2-Nitroaniline		<MQL							
Acenaphthylene									
Dimethyl phthalate	<MQL	23	30		<MQL				
2,6-Dinitrotoluene									

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Appendix, Table VI 3.a. –BN-3

TABLE BN Cont.

SEPULVEDA SAMPLES- BASE NEUTRALS

File Code —>	F8103	8107+	8067+	8188+8190+	8196+8238+	8207+	8230+8284+	8217+	8218+
File Code —>		8112	8076	8116	8239	8248	8275	8254	8253
Location —>	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sep
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	12-Oct	2-Nov	10-Dec	10-Dec
Phase —>	Water	W+SS	W+SS	W1+W2+SS	W+SS1+SS2	W+SS	W+SS1+SS2	W+SS	W+SS
	Only								Dup
Volume of Water (L) —>	4	4	8	8	4	4	4	4	4
Weight of Sediment (mg) —>	-	94 3	158 7/4	215 3	849 8/8	187 7	139 9/8	38 6	81 4
	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc
CHEMICAL NAME:	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)
3-Nitroaniline									
Acenaphthene		8	53						
Dibenzofuran		12	10	4	2				
2 4-Dinitrotoluene									
Fluorene		18	190	2	2			8	
Diethyl phthalate	<MDL	420	379	91	155	165	151	164	88
4-Chlorophenyl phenyl ether		34	24	15		16	18	28	22
4-Nitroaniline									
N-Nitrosodiphenylamine									
Azobenzene		<MDL		<MDL	29	23	9	<MDL	23
4-Bromophenyl phenyl ether									
Hexachlorobenzene									
Phenanthrene	<MDL	36	33	18	34	11		43	8
Anthracene	<MDL	3	4177	<MDL	2			3	
Di-n-butyl phthalate	<MDL	928	2782	570	1080	1477	935	1078	938
Fluoranthene	<MDL	15	33	5	21			31	8
Benzidine									
Pyrene	<MDL	17	7860	8	20	4	8	28	9
Butyl benzyl phthalate	408	637	3271	730	961	988	1322	1063	852
Benz(a)anthracene	17	9	14	17					
3,3'-Dichlorobenzidine									
Chrysene	<MDL	10	8032	3	20		<MDL		
Bis(2-ethylhexyl) phthalate	4822	3827	3203	3385	2783	5400	5360	5297	8084
Di-n-octyl phthalate	<MDL	2	54	13	769	1902	65	197	122
Benzo(b)fluoranthene	<MDL		38	1					
Benzo(k)fluoranthene			39	<MDL					
Benzo(a)pyrene	<MDL	10	5398	3					
Indeno(1,2,3,4-c,d)pyrene			71	<MDL					
Dibenzo(a,h)anthracene			59	<MDL					
Benzo(g,h,i)perylene			58	<MDL					
Carbazole	<MDL		?						
Blank Value and Not MDL was used for comparison									

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Appendix, Table VI 3.b. –BN-3

TABLE BN
SEPULVEDA SAMPLES- BASE NEUTRALS

File Code —>	F8103	8107+	8067+	8184+8190+	8196+8238+	8207+	8230+8264+	8217+	8218+
File Code —>		8112	8076	8116	8239	8248	8275	8254	8253
Location —>	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sepulv	Sep
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	12-Oct	2-Nov	10-Dec	10-Dec
Phase —>	Water	W+SS	W+SS	W1+W2+SS	W+SS1+SS2	W+SS	W+SS1+SS2	W+SS	W+SS
	Only								Dup
Volume of Water (L) —>	4	4	8	8	4	4	4	4	4
Weight of Sediment (mg)->	-	84.3	158.7/4	215.3	849.8/8	167.7	139.9/8	380.6	81.4
	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc	Conc
CHEMICAL NAME:	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)
Phenol			290	<MDL	81	63	33	33	
2-Nitrophenol		13	16	24		49	36	<MDL	
Benzoic Acid		226	361	731	378		810		
1,4-Dichlorobenzene		58	45	34	50	117	77	49	39
Isophorone		<MDL	17	<MDL	<MDL	<MDL			
Naphthalene	<MDL	111	56	38	113	124	89	153	119
2-Methylnaphthalene		56	58	26	57	55	55	100	59
2-Chloronaphthalene			1						
2-Nitroaniline		<MDL							
Dimethyl phthalate	<MDL	23	30		<MDL				
Acenaphthene		8	53						
Dibenzofuran		12	10	4	2				
Fluorene		16	190	2	2			8	.
Diethyl phthalate	<MDL	420	379	91	155	165	151	184	88
4-Chlorophenyl phenyl ether		34	24	15		16	18	26	22
Azobenzene		<MDL		<MDL	29	23	9	<MDL	23
Phenanthrene	<MDL	38	33	16	34	11		43	8
Anthracene	<MDL	3	4177	<MDL	2			3	
Di-n-butyl phthalate	<MDL	928	2782	570	1080	1477	935	1078	938
Fluoranthene	<MDL	15	33	5	21			31	8
Pyrene	<MDL	17	7560	8	20	4	8	29	9
Butyl benzyl phthalate	408	637	3271	730	961	988	1322	1063	952
Benz(a)anthracene	17	9	14	17					
Chrysene	<MDL	10	8032	3	20		<MDL		
Bis(2-ethylhexyl) phthalate	4822	3827	3203	3365	2783	5400	8360	8297	8084
Di-n-octyl phthalate	<MDL	2	54	13	769	1902	65	197	122
Benzo(b)fluoranthene	<MDL		38	1					
Benzo(k)fluoranthene			39	<MDL					
Benzo(a)pyrene	<MDL	10	5398	3					
Indeno(1,2,3,4-c,d)pyrene			71	<MDL					
Dibenzo(a,h)anthracene			59	<MDL					
Benzo(g,h,i)perylene			58	<MDL					
Blank Value and Not MDL was used for comparison									

TABLE BN

CENTINELA SAMPLES- BASE NEUTRALS

File Code -->		8106+	8066+	8256+	8212+	8231+	8214+	
File Code -->	8078	8111	8073	8117	8281	8232	8249	8250
Location -->	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.
Date -->	7-Jul	27-Jul	24-Aug	8-Sep	2-Nov	2-Nov	10-Dec	10-Dec
Phase -->	Water	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	SS Only
	Only				AM	AM Dup		2nd Grab
Volume of Water (L) -->	4	4	8	4	4	4	4	•
Weight of Sediment (mg) -->	•	72.9	79.5	56.7/8	<0.1	13.5	29.4	42.1/4
	Conc	Conc	Conc	Conc.	Conc	Conc.	Conc.	Conc
CHEMICAL NAME:	(ng/l)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)
Phenol	<MDL	<MDL	6	<MDL	118	125	<MDL	
2-Chlorophenol								
2-Methylphenol								
4-Methylphenol								
2-Nitrophenol	<MDL	33	7	20	41	49	<MDL	
2,4-Dimethylphenol								
2,4-Dichlorophenol								
Benzoic Acid	<MDL	1194	38	473	749	466		
4-Chloro-3-methylphenol		<MDL						
2,4,6-Trichlorophenol								
2,4,5-Trichlorophenol								
2,4-Dinitrophenol								
4-Nitrophenol								
2-Methyl-4,6-dinitrophenol								
Pentachlorophenol								
N-Nitrosodimethylamine								
Aniline								
Bis(2-chloroethyl) ether								
1,3-Dichlorobenzene								
1,4-Dichlorobenzene	<MDL	77	22	4	75	75	2	51
1,2-Dichlorobenzene								
Benzyl alcohol								
Bis(2-chloroisopropyl) ether								
Hexachloroethane								
N-Nitrosodi-n-propylamine	<MDL							
Nitrobenzene					29	<MDL	<MDL	
Isophorone	<MDL	68	37	<MDL	0			
Bis(2-chloroethoxy)methane			<MDL					
1,2,4-Trichlorobenzene								
Naphthalene	<MDL	124	34	99	126	110	6	130
4-Chloroaniline								
Hexachlorobutadiene								
2-Methylnaphthalene		62	20	72	73	70	3	72
Hexachlorocyclopentadiene								
2-Chloronaphthalene			<MDL					
2-Nitroaniline								
Acenaphthylene								

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Appendix, Table VI 4.a. –BN-4

TABLE BN Cont.
CENTINELA SAMPLES- BASE NEUTRALS

File Code —>		8106+	8066+	8286+	8212+	8231+	8214+	
File Code —>	8078	8111	8073	8117	8281	8232	8249	8250
Location —>	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	2-Nov	2-Nov	10-Dec	10-Dec
Phase —>	Water Only	W+SS	W+SS	W+SS	W+SS AM	W+SS AM Dup	W+SS	SS Only 2nd Grab
Volume of Water (L) —>	4	4	8	4	4	4	4	•
Weight of Sediment (mg) —>	•	72.9	79.5	56.7/8	<0.1	13.5	29.4	42.1/4
CHEMICAL NAME:	Conc (ng/l)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc. (ng/L)	Conc. (ng/L)	Conc (ng/L)
Dimethyl phthalate	26	31	3		0			
2,6-Dinitrotoluene								
3-Nitroaniline								
Acenaphthene		4	7	3				
Dibenzofuran		16	2	8	5			
2,4-Dinitrotoluene								
Fluorene	<MDL	10	24	4				
Diethyl phthalate	253	730	229	59	134	133	8	183
4-Chlorophenyl phenyl ether		33	9		36	37	1	26
4-Nitroaniline								
N-Nitrosodiphenylamine								
Azobenzene	<MDL	<MDL	18	12	17	15	1	20
4-Bromophenyl phenyl ether								
Hexachlorobenzene								
Phenanthrene		65	12	11			1	25
Anthracene	18	3	406	1				
Di-n-butyl phthalate	544	1931	861	247	545	602	70	1732
Fluoranthene	<MDL	17	6	3			1	15
Benzidine								
Pyrene	<MDL	37	665	6			1	15
Butyl benzyl phthalate	451	858	962	916	292	520	62	1606
Benz(a)anthracene		18	38	10				
3,3'-Dichlorobenzidine								
Chrysene	58	11	654				1	
Bis(2-ethylhexyl) phthalate	1686	2868	4179	807	32055	2417	2908	2997
Di-n-octyl phthalate	17	4	92	66	67	73	7	147
Benzo(b)fluoranthene	<MDL	<MDL	3	2				
Benzo(k)fluoranthene	<MDL	<MDL	3	1				
Benzo(a)pyrene	20	10	546	4				
Indeno(1,2,3,4-c,d)pyrene								
Dibenzo(a,h)anthracene								
Benzo(g,h,i)perylene								
Carbazole								
Blank Value and Not MDL was used for comparison								

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Appendix, Table VI 4.b. –BN-4

TABLE BN
CENTINELA SAMPLES- BASE NEUTRALS

File Code —>		8104+	8066+	8286+	8212+	8231+	8214+	
File Code —>	8078	8111	8073	8117	8281	8282	8249	8250
Location —>	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent.	Cent
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	2-Nov	2-Nov	10-Dec	10-Dec
Phase —>	Water	W+SS	W+SS	W+SS	W+SS	W+SS	W+SS	SS Only
	Only				AM	AM Dup		2nd Grab
Volume of Water (L) —>	4	4	8	4	4	4	4	.
Weight of Sediment (mg) ->	.	72.9	79.5	56.78	<0.1	13.5	29.4	42.1/4
	Conc	Conc	Conc	Conc	Conc.	Conc	Conc	Conc
CHEMICAL NAME:	(ng/l)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)	(ng/L)
Phenol	<MDL	<MDL	6	<MDL	118	125	<MDL	
2-Nitrophenol	<MDL	33	7	20	41	49	<MDL	
Benzoic Acid	<MDL	1194	38	473	749	466		
4-Chloro-3-methylphenol		<MDL						
1,4-Dichlorobenzene	<MDL	77	22	4	75	75	2	51
Nitrobenzene					29	<MDL	<MDL	
Isophorone	<MDL	68	37	<MDL				
Bis(2-chloroethoxy)methane			<MDL					
Naphthalene	<MDL	124	34	99	126	110	6	130
2-Methylnaphthalene		82	20	72	73	70	3	72
2-Chloronaphthalene			<MDL					
Dimethyl phthalate	26	31	3					
Acenaphthene		4	7	3				
Dibenzofuran		16	2	8	5			
Fluorene	<MDL	10	24	4				
Diethyl phthalate	253	730	229	59	134	133	6	183
4-Chlorophenyl phenyl ether		33	9		36	37	1	26
Azobenzene	<MDL	<MDL	18	12	17	15	1	20
Phenanthrene		65	12	11			1	25
Anthracene	18	3	406	1				
Di-n-butyl phthalate	544	1931	861	247	545	602	70	1732
Fluoranthene	<MDL	17	6	3			1	15
Pyrene	<MDL	37	665	6			1	15
Butyl benzyl phthalate	451	858	962	916	292	520	62	1606
Benz(a)anthracene		18	38	10				
Chrysene	58	11	654				1	
Bis(2-ethylhexyl) phthalate	1686	2868	4179	807	32055	2417	2908	2997
Di-n-octyl phthalate	17	4	92	66	67	73	7	147
Benzo(b)fluoranthene	<MDL	<MDL	3	2				
Benzo(k)fluoranthene	<MDL	<MDL	3	1				
Benzo(a)pyrene	20	10	546	4				
Blank Value and Not MDL was used for comparison								

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Appendix, Table VI 5.a. –BN-5

TABLE BN

ASHLAND AVE. SAMPLES- BASE NEUTRALS

File Code -->		8104+	8069+		8191+		8206+	8213+
File Code -->	8079	8114	8077	8115	8222	8223	8242	8269
Location -->	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland
Date -->	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	29-Sep	12-Oct	10-Dec
Phase -->	Water Only	W+SS	W+SS	SS Only	W+SS	SS Only	W+SS	W+SS
Volume of Water (L) -->	3	4	6	-	4	-	4	4
Weight of Sediment (mg)-->	-	816 9	444 94	241 1/4	488 4	148 2/4	321 6	89[illegible] 8
CHEMICAL NAME:	Conc (ng/l)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc. (ng/L)	Conc (ng/L)	Conc (ng/L)
Phenol		100	375	198			65	73
2-Chlorophenol								
2-Methylphenol							<MDL	
4-Methylphenol		342	2,764		<MDL			20
2-Nitrophenol		21	21	74			47	26
2,4-Dimethylphenol			238				492	
2,4-Dichlorophenol								
Benzoic Acid		644	121	1,518	<MDL	103	60	389
4-Chloro-3-methylphenol				9				
2,4,6-Trichlorophenol		<MDL						
2,4,5-Trichlorophenol		<MDL						
2,4-Dinitrophenol								
4-Nitrophenol								
2-Methyl-4,6-dinitrophenol								
Pentachlorophenol								
N-Nitrosodimethylamine								
Aniline								
Bis(2-chloroethyl) ether								
1,3-Dichlorobenzene								
1,4-Dichlorobenzene	<MDL	64		63	32	80	107	62
1,2-Dichlorobenzene					<MDL			
Benzyl alcohol			533		1,258			
Bis(2-chloroisopropyl) ether								
Hexachloroethane								
N-Nitrosodi-n-propylamine								
Nitrobenzene			204					257
Isophorone		75		10	40		<MDL	<MDL
Bis(2-chloroethoxy)methane								
1,2,4-Trichlorobenzene								
Naphthalene	<MDL	79	48	83	59	126	110	92
4-Chloroaniline								
Hexachlorobutadiene								
2-Methylnaphthalene	<MDL	44	36	50	30	57	41	46
Hexachlorocyclopentadiene								
2-Chloronaphthalene								
2-Nitroaniline		463	<MDL					
Acenaphthylene								
Dimethyl phthalate	<MDL	13	102		2			7

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Appendix, Table VI 5.a. –BN-5

TABLE BN Cont.

ASHLAND AVE. SAMPLES- BASE NEUTRALS

File Code —>		8104+	8069+		8191+		8206+	8213+
File Code —>	8079	8114	8077	8115	8222	8223	8242	8269
Location —>	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	29-Sep	29-Sep	12-Oct	10-Dec
Phase —>	Water Only	W+SS	W+SS	SS Only	W+SS	SS Only	W+SS	W+SS
Volume of Water (L) —>	3	4	6	.	4	.	4	4
Weight of Sediment (mg)->	.	816 9	444 9.4	241.1/4	488 4	148.2/4	321 6	890 8
CHEMICAL NAME:	Conc (ng/l)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)
2,6-Dinitrotoluene								
3-Nitroaniline								
Acenaphthene		6	5					
Dibenzofuran		16	11	11				5
2,4-Dinitrotoluene								
Fluorene	<MDL	15	18	6				
Diethyl phthalate	<MDL	1,110	489	180	678	222	441	124
4-Chlorophenyl phenyl ether		34	41	44	19	43	25	31
4-Nitroaniline								
N-Nitrosodiphenylamine								
Azobenzene	<MDL	63	35		11	24	45	29
4-Bromophenyl phenyl ether								
Hexachlorobenzene								
Phenanthrene	<MDL	152	115	42	20	24	29	49
Anthracene		17	125	4	<MDL		<MDL	6
Di-n-butyl phthalate	<MDL	13,667	2,020	1,035	637	1,232	1,672	1,092
Fluoranthene	<MDL	82	91	35	14	10	21	94
Benzidine								
Pyrene	<MDL	108	295	27	18	14	20	127
Butyl benzyl phthalate	<MDL	2,500	2,089	659	967	631	1,681	1,873
Benz(a)anthracene		51	<MDL	24	21		<MDL	
3,3'-Dichlorobenzidine					<MDL			
Chrysene	<MDL	36	391	11			<MDL	64
Bis(2-ethylhexyl) phthalate	<MDL	20,730	9,258	777	24,668		8,445	10,725
Di-n-octyl phthalate	<MDL	406	582	456	15,488		903	493
Benzo(b)fluoranthene		27	49	8	<MDL			14
Benzo(k)fluoranthene		46	19	10	<MDL			
Benzo(a)pyrene	<MDL	75	393	19	<MDL			
Indeno(1,2,3,4-c,d)pyrene		95	21	5				
Dibenzo(a,h)anthracene		97	11	8				
Benzo(g,h,i)perylene		125	16					
Carbazole		?						
BLANK VALUE AND NOT THE MDL WAS USED FOR COMPARISON								

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Appendix, Table VI 5.b. –BN-5

TABLE BN

ASHLAND AVE SAMPLES- BASE NEUTRALS

File Coce —>		8104-	8069-		8191-		8206-	8213-
File Code —>	8079	8114	8077	8115	8222	8223	8242	8269
Location —>	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland	Ashland
Date —>	7-Jul	27-Jul	24-Aug	8-Sep	25-Sep	29-Sep	12-Oct	10-Dec
Phase —>	Water Only	W+SS	W+SS	SS Only	W+SS	SS Only	W+SS	W+SS
Volume of Water (L) —>	3	4	6	.	4	.	4	4
Weight of Sediment (mg)—>	.	816 9	444 8.4	241 1/4	488 4	148 2/4	321.6	890 8
CHEMICAL NAME	Conc (ng/l)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)	Conc (ng/L)
Phenol		100	375	198			65	73
2-Methylphenol							<MDL	
4-Methylphenol		342	2,764		<MDL			20
2-Nitrophenol		21	21	74			47	26
2,4-Dimethylphenol			238				492	
Benzoic Acid		644	121	1,518	<MDL	103	60	389
4-Chloro-3-methylphenol				9				
2,4,6-Trichlorophenol		<MDL						
2,4,5-Trichlorophenol		<MDL						
1,4-Dichlorobenzene	<MDL	64		63	32	80	107	62
1,2-Dichlorobenzene					<MDL			
Benzyl alcohol			533		1,258			
Nitrobenzene			204					257
Isophorone		75		10	40		<MDL	<MDL
Naphthalene	<MDL	79	48	83	59	128	110	92
2-Methylnaphthalene	<MDL	44	38	50	30	57	41	46
2-Nitroaniline		463	<MDL					
Dimethyl phthalate	<MDL	13	102		2			7
Acenaphthene		6	5					
Dibenzofuran		16	11	11				5
Fluorene	<MDL	15	18	6				
Diethyl phthalate	<MDL	1,110	489	180	678	222	441	124
4-Chlorophenyl phenyl ether		34	41	44	19	43	25	31
Azobenzene	<MDL	63	35		11	24	45	29
Phenanthrene	<MDL	152	115	42	20	24	29	49
Anthracene		17	125	4	<MDL		<MDL	6
Di-n-butyl phthalate	<MDL	13,667	2,020	1,035	637	1,232	1,672	1,092
Fluoranthene	<MDL	82	91	35	14	10	21	94
Pyrene	<MDL	108	295	27	18	14	20	127
Butyl benzyl phthalate	<MDL	2,500	2,089	659	967	631	1,681	1,873
Benz(a)anthracene		51	<MDL	24	21		<MDL	
3,3'-Dichlorobenzidine					<MDL			
Chrysene	<MDL	36	391	11			<MDL	64
Bis(2-ethylhexyl) phthalate	<MDL	20,730	9,258	777	24,668		8,445	10,725
Di-n-octyl phthalate	<MDL	406	582	456	15,488		903	493
Benzo(b)fluoranthene		27	49	8	<MDL			14
Benzo(k)fluoranthene		46	19	10	<MDL			
Benzo(a)pyrene	<MDL	75	393	19	<MDL			
Indeno(1,2,3,4-c,d)pyrene		95	21	5				
Dibenzo(a,h)anthracene		97	11	9				
Benzo(g,h,i)perylene		125	16					
BLANK VALUE AND NOT THE MDL WAS USED FOR COMPARISON								

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Appendix VII

GC/MS Total Ion Chromatogram Showing Targeted and Non-Targeted Base Neutral Compound for Selected Samples

Table VII 1. F8270 Ballona 12/10/92, SFE-SS

Table VII 2. F8239 Sepulveda (B) 11/29/92 duplicate, SFE-SS

Table VII 3. F8067 Sepulveda 8/24/92, water extract

Table VII 4. F8066 Centinela 8/24/92, water extract

Table VII 5. F8073 Centinela 8/24/92, SFE-SS

Table VII 6. F8105 Pico-Kenter 7/27/92, water extract 1.2/250 ul inj.

Table VII 7. F8272 (4 pager) Pico-Kenter 12/10/92, 1st grab, 2nd filt, SFE-SS

Table VII 8. F8252 Pico-Kenter 12/10/92, 2nd grab, SFE-SS

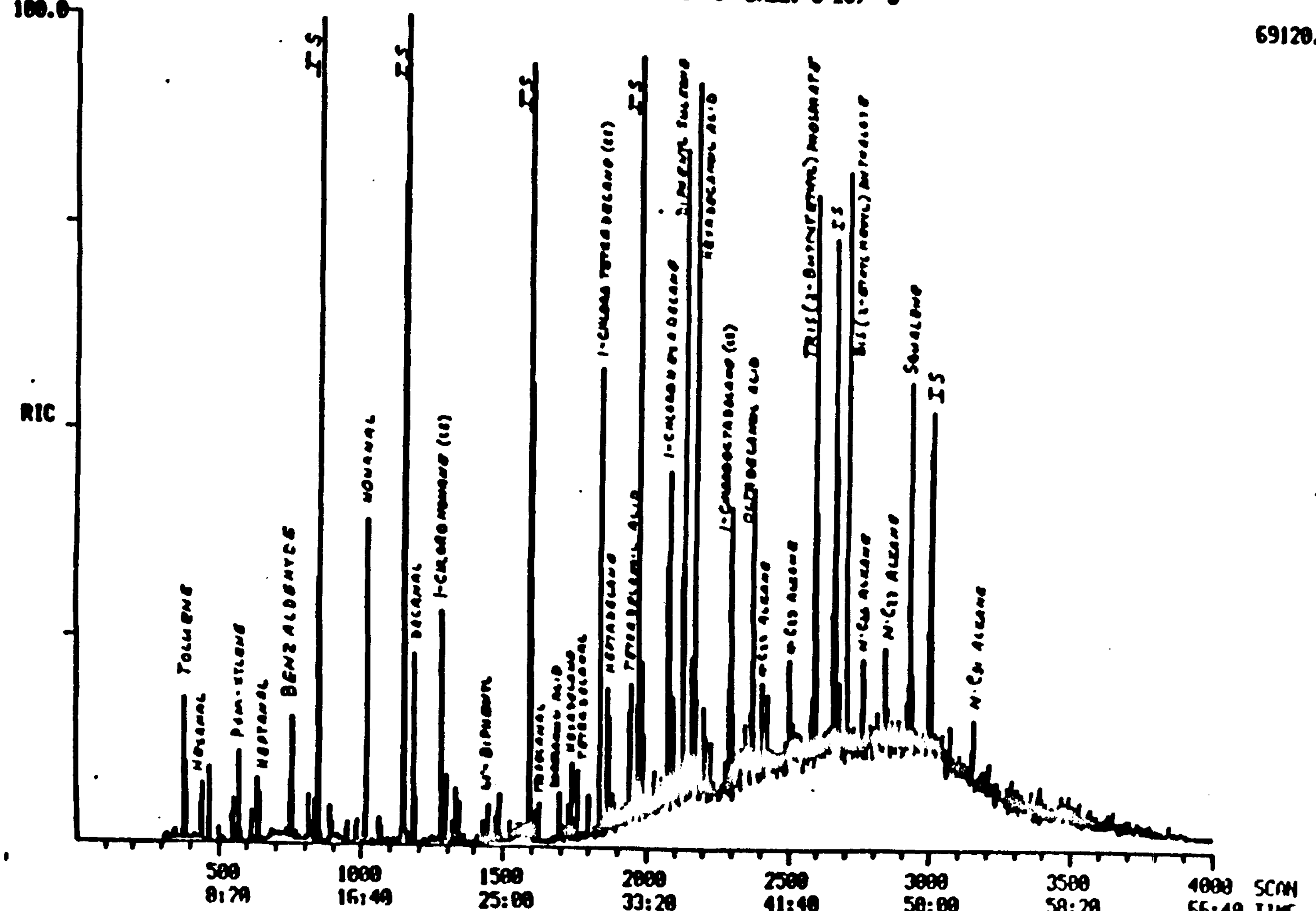
Table VII 9. F8114 Ashland 7/27/92, SFE-SS

Table VII 10. F8191 Ashland 9/29/92, water extract

SFE = Super Fluid Extraction
SS = Suspended Solids

1
8240

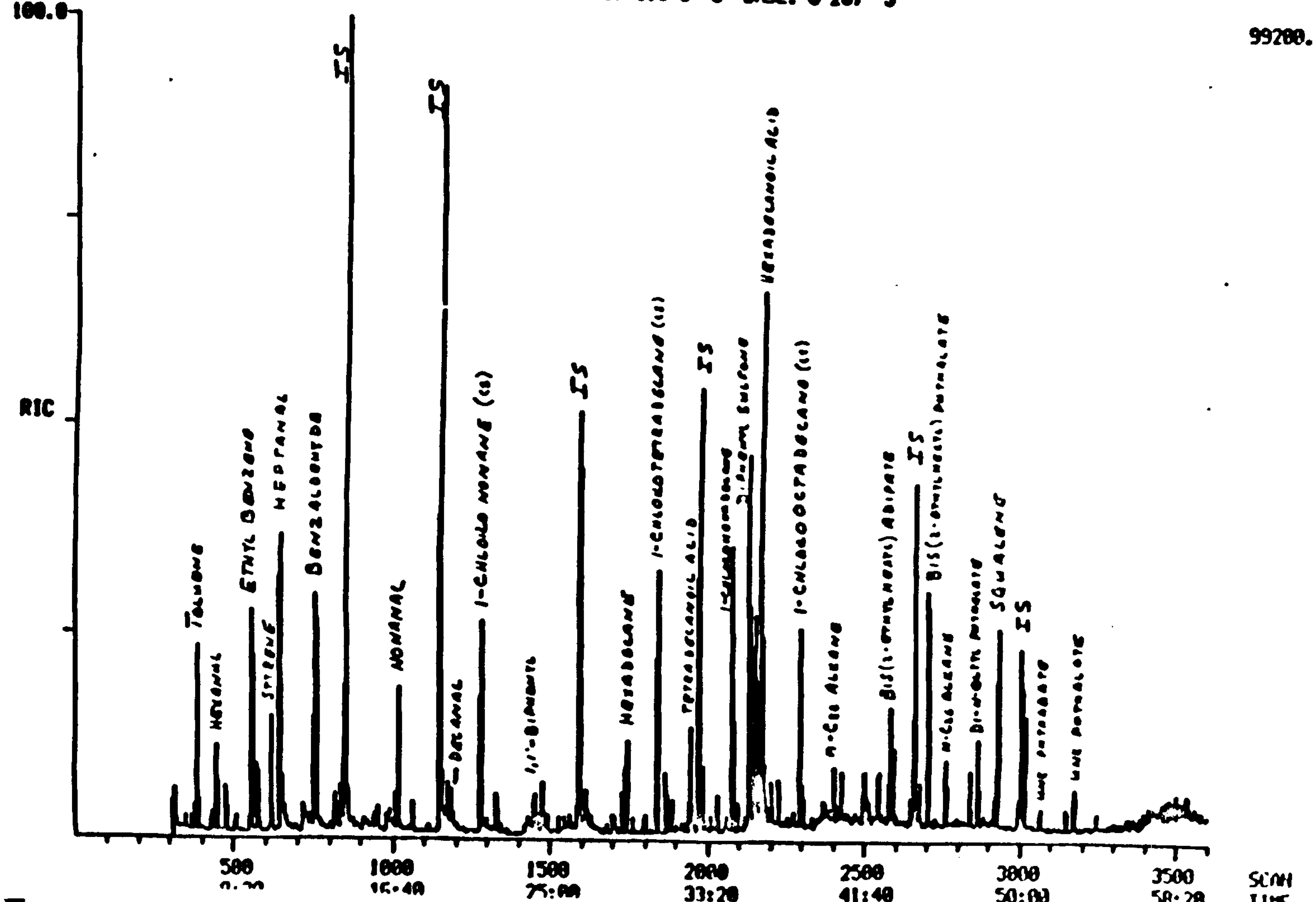
RIC
02/11/93 10:34:00 DATA: F0270 01 SCANS 1 TO 4000
SAMPLE: BALLONA 12-10-92 SFE-SS CALI: F0270 03
1.5 OF 250/500 UL
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,4000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



VOL 12
1
824-1

R0051546

RIC
02/03/93 15:11:00 DATA: F0239 01 SCANS 1 TO 3600
CALI: F0239 04
SAMPLE: SEPULVEDA (B) 11-29-92 DUP, SFE-SS 1.5 OF 250/500 UL
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,3600 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

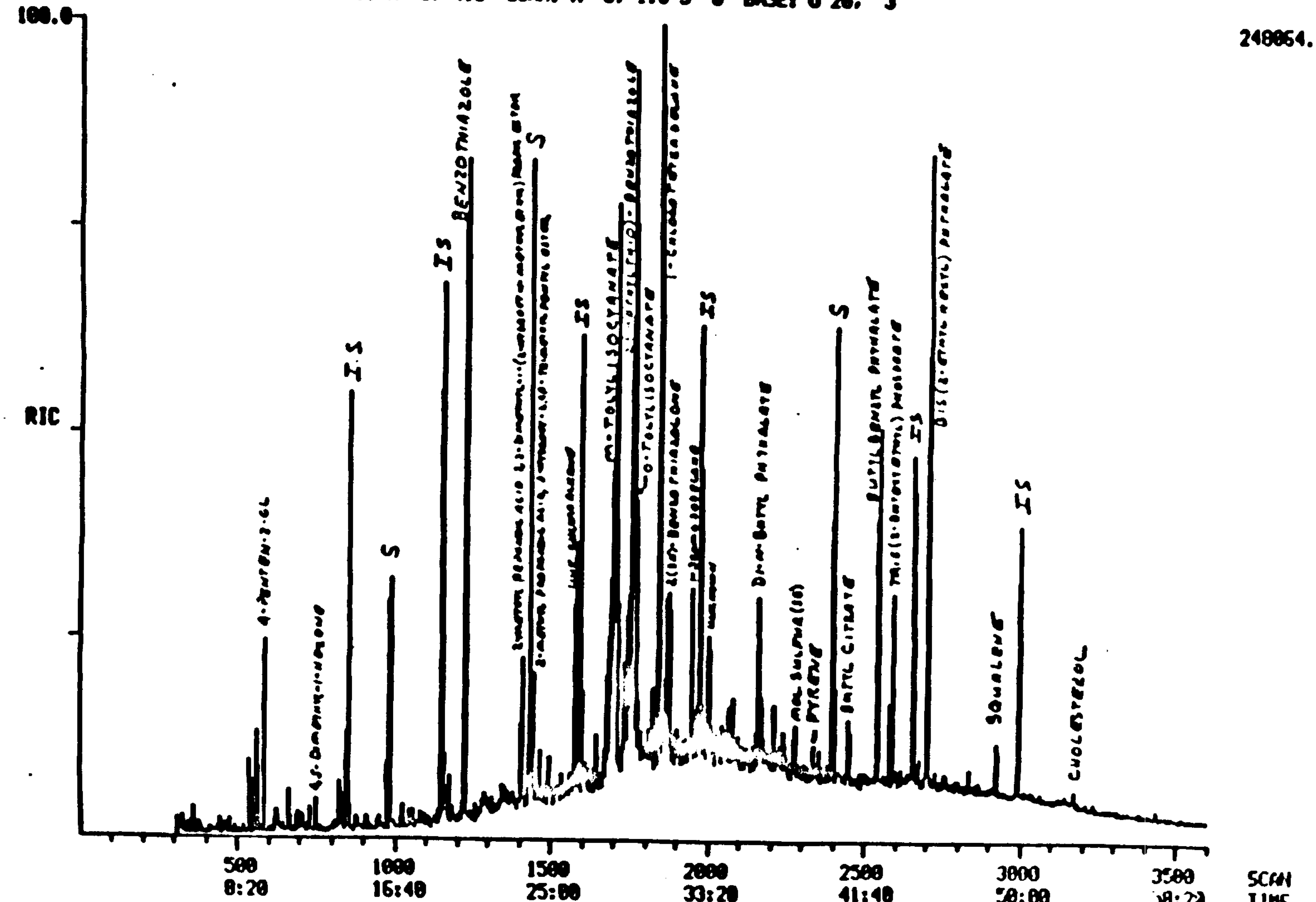


2428 1

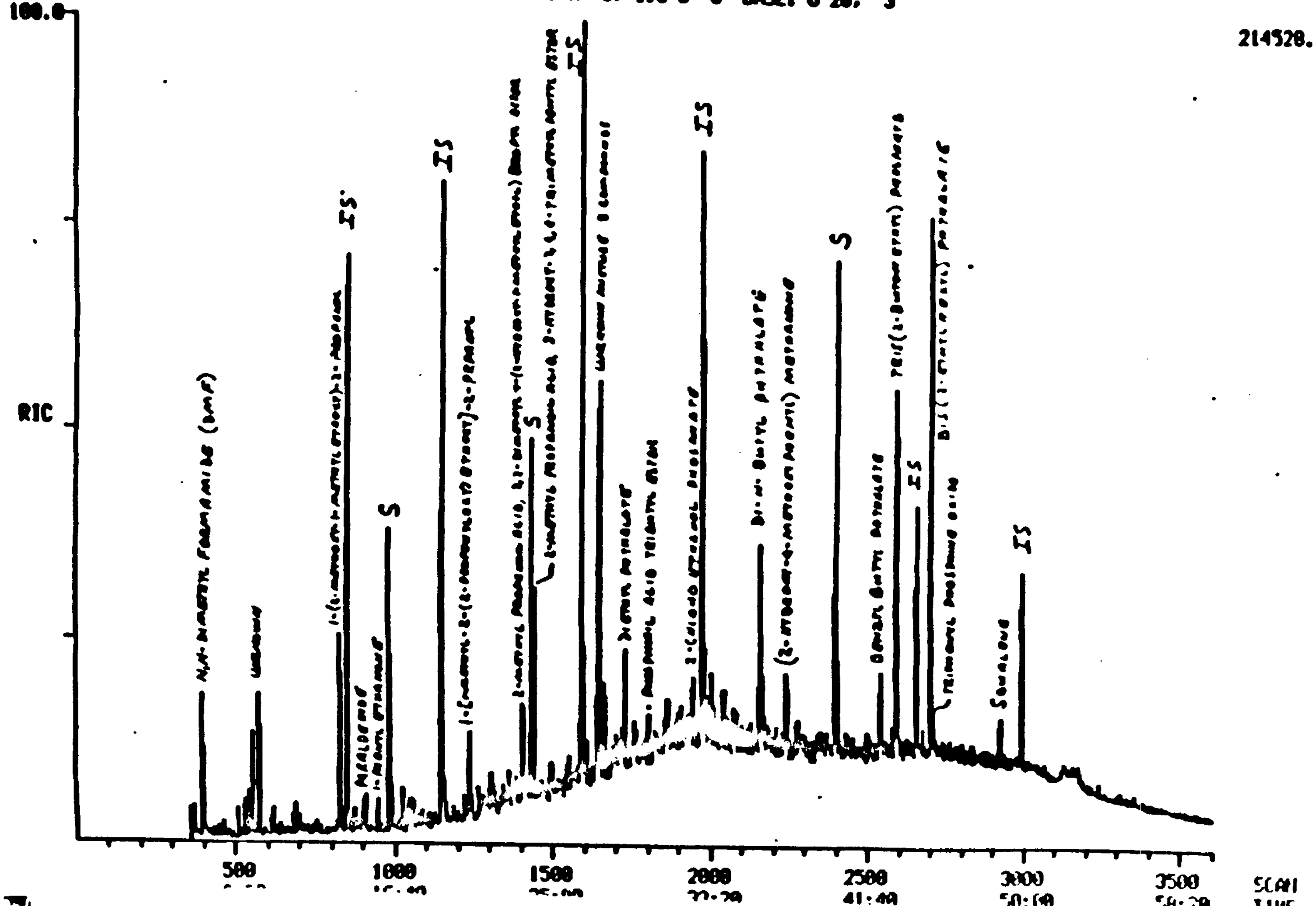
VOL 12

R0051547

RIC
11/03/92 16:42:00 DATA: F0067 01 SCANS 1 TO 3600
CALI: F0067 01
SAMPLE: SEPULVEDA 08-24-92 WATER EXTRACT 1.2/250 UL INJ.
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,3600 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



RIC
11/03/92 15:21:00 DATA: F0066 01 SCANS 1 TO 3600
CALI: F0066 01
SAMPLE: CENTINELA 08-24-92 WATER EXTRACT 1.2/250 UL INJ.
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,3600 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



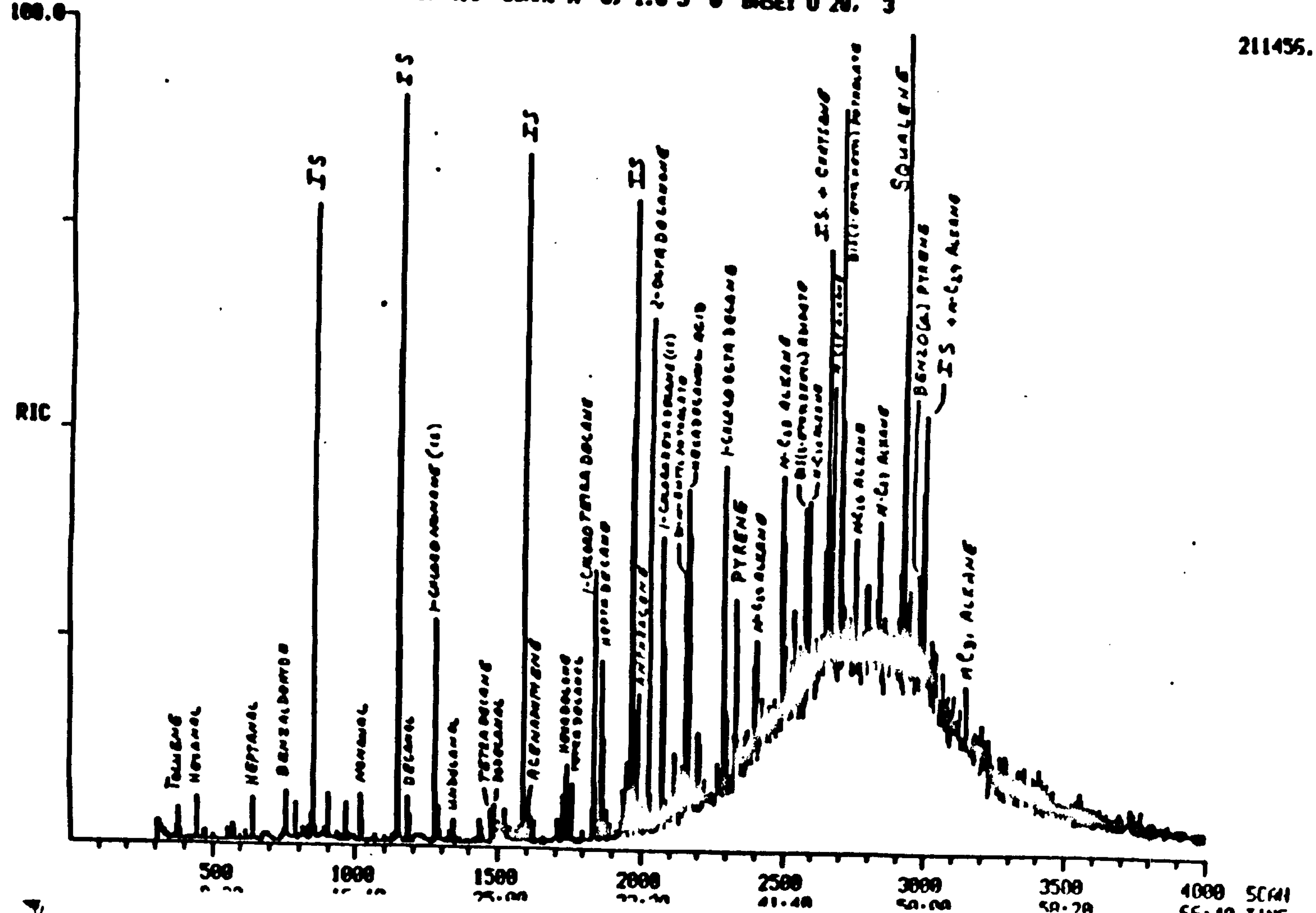
VOL 12

1

8244

R0051549

RIC
11/04/92 14:16:00 DATA: F0073 01 SCANS 1 TO 4000
CALI: F0073 02
SAMPLE: CENTINELA 08-24-92 FILTER EXTRACT 1.2/500 UL INJ.
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,4000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



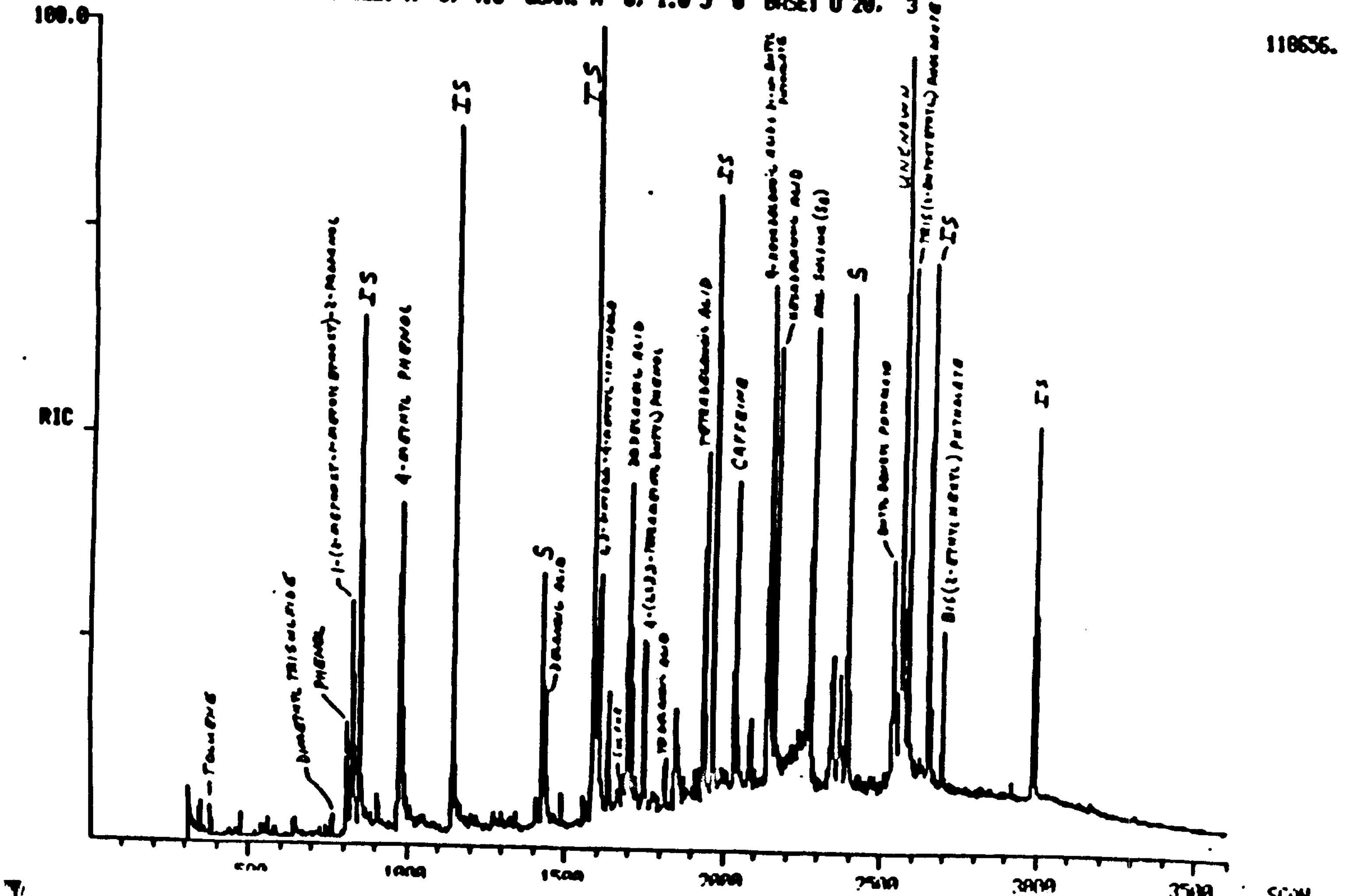
VOL 12

1

8245

R0051550

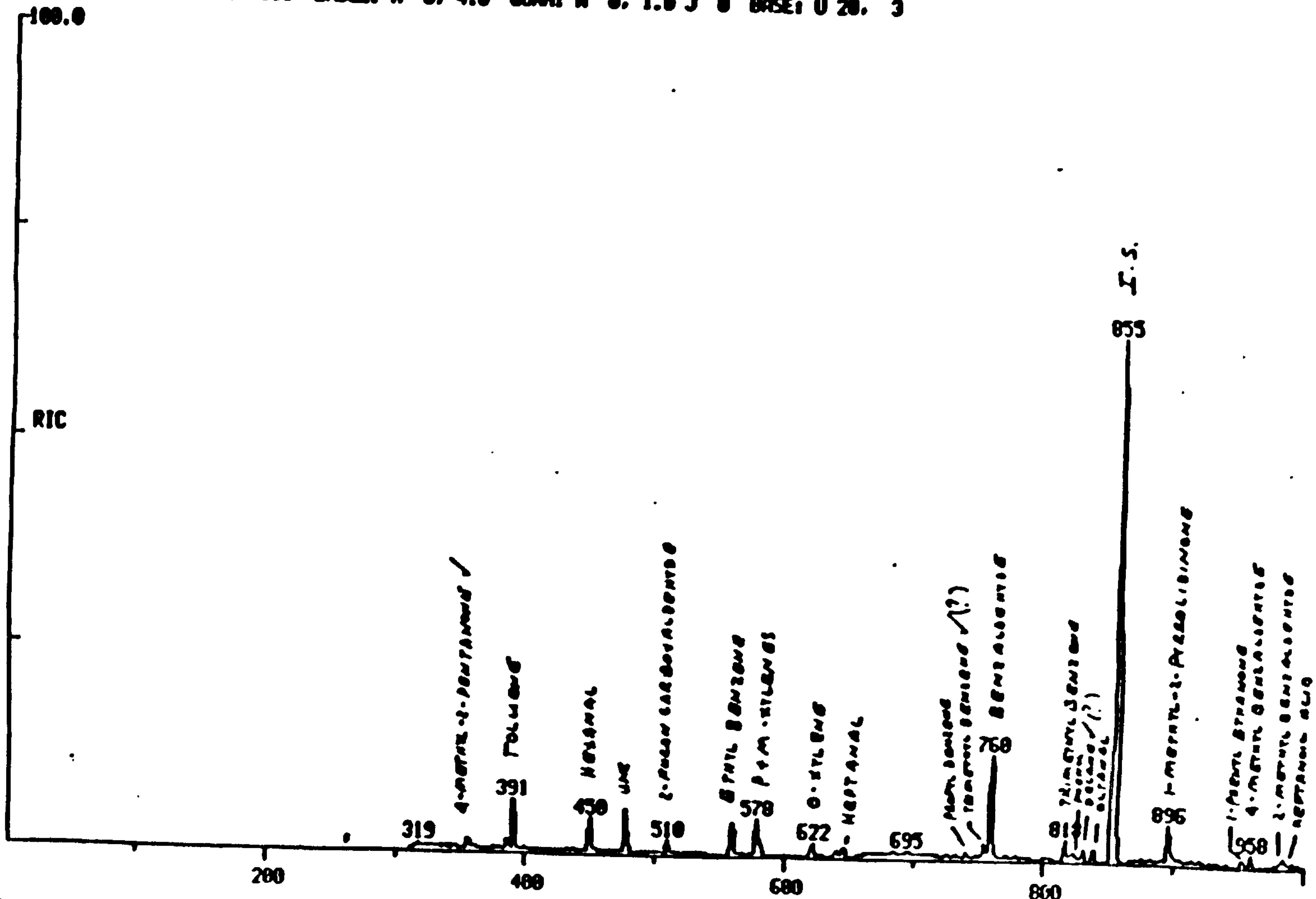
RIC
11/17/92 7:18:00 DATA: F8105 01 SCANS 1 TO 3600
CALI: F8105 04
SAMPLE: PICO KENTER 07-27-92 WATER EXTRACT 1.2/250 UL INJ.
CONDS.: 4 MIN @ 30, 6/MIN TO 300 30M DB-5MS COLUMN .25MM
RANGE: G 1,3600 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



VOL 12 1 8246

R0051551

RIC
02/11/93 20:55:00 DATA: F8272 01 SCANS 1 TO 1001
CALI: F8272 01 OUT OF 1 TO 4000
SAMPLE: PICO/KENTER 12-10-92 1ST GRAB 2ND FILT SFE-SS 1.5/250/500
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,4000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



1 7428

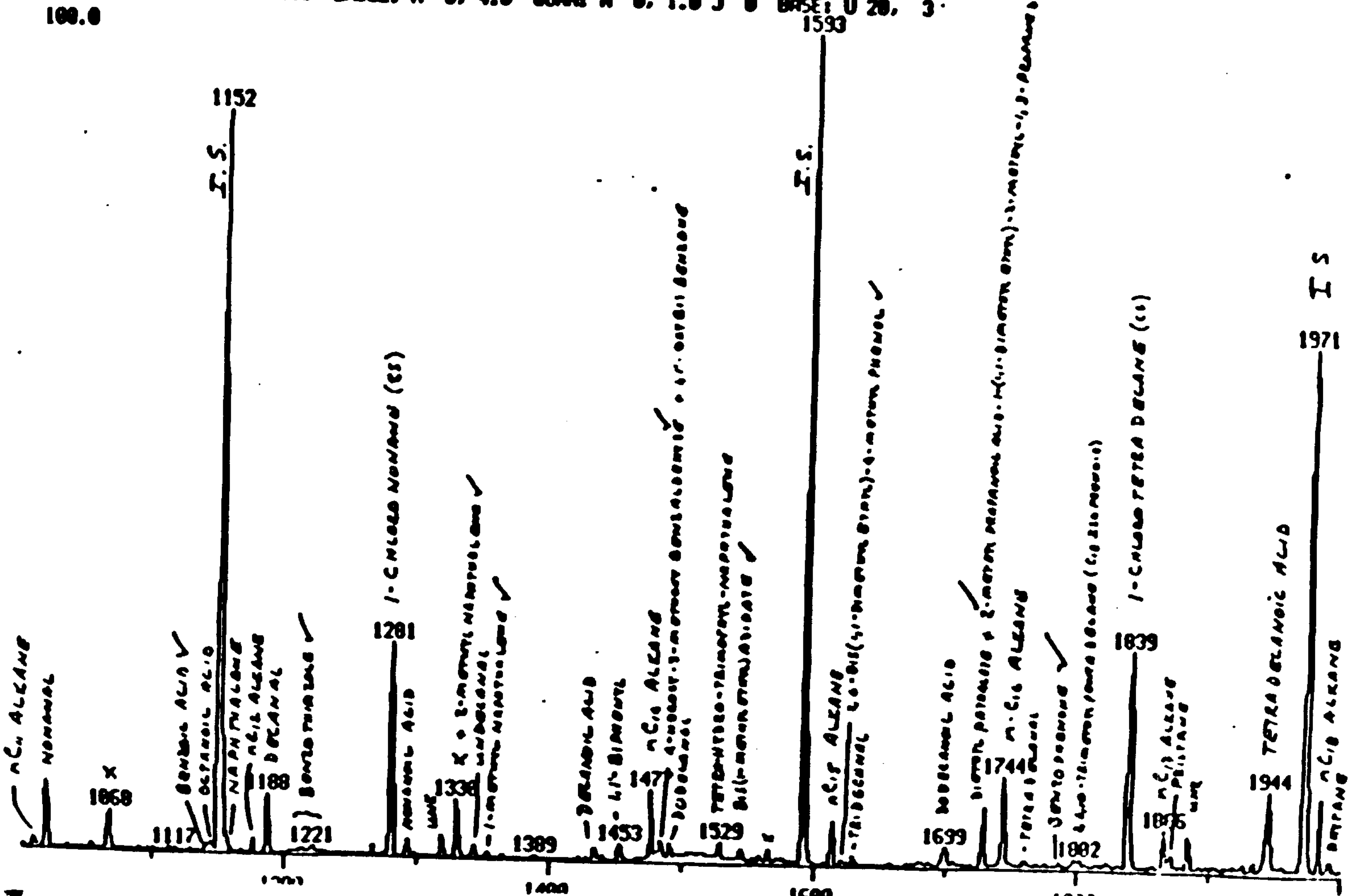
VOL 12

R0051552

RIC
02/11/93 20:55:00
SAMPLE: PICO/KENTER 12-10-92 1ST GRAB 2ND FILT SFE-55 1.5/250/500
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,4000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

DATA: F8272 01
CALI: F8272 01

SCANS 1001 TO 2001
OUT OF 1 TO 4000



VOL 12

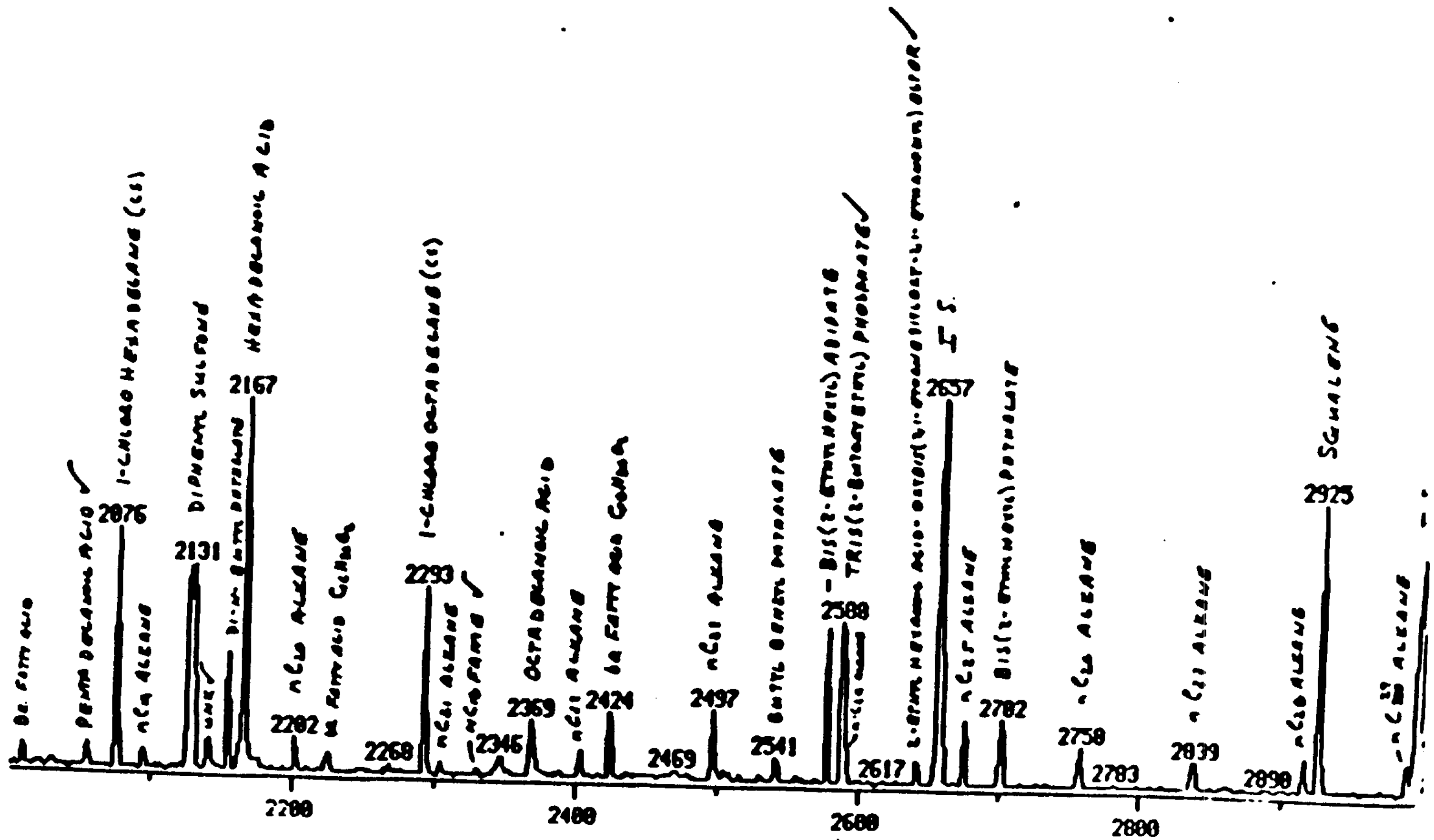
1

8248

R0051553

RIC
02/11/93 20:55:00 DATA: F0272 01 SCANS 2001 TO 3001
SAMPLE: PICO/KENTER 12-10-92 1ST GRAB 2ND FILT SFE-SS CALI: F0272 01 OUT OF 1 TO 4000
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN 1.5/250/500
RANGE: G 1.4000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

100.0



1 8249

VOL 12

R0051554

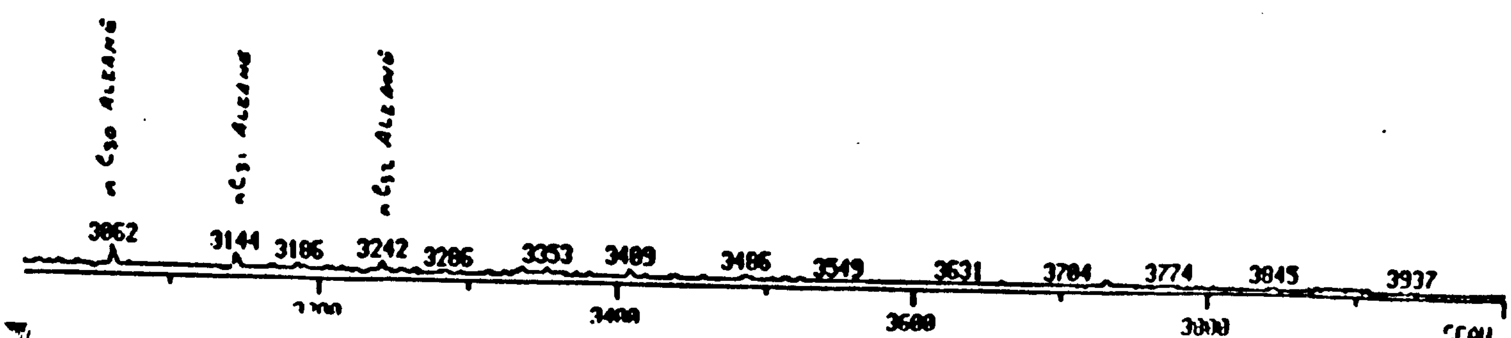
RIC
02/11/93 20:55:00
SAMPLE: PICO/KENTER 12-10-92 1ST GRAB 2ND FILT SFE-55 1.5/250/500
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,4000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

DATA: F8272 01
CALI: F8272 01

SCANS 3001 TO 4000
OUT OF 1 TO 4000

100.0

124672.



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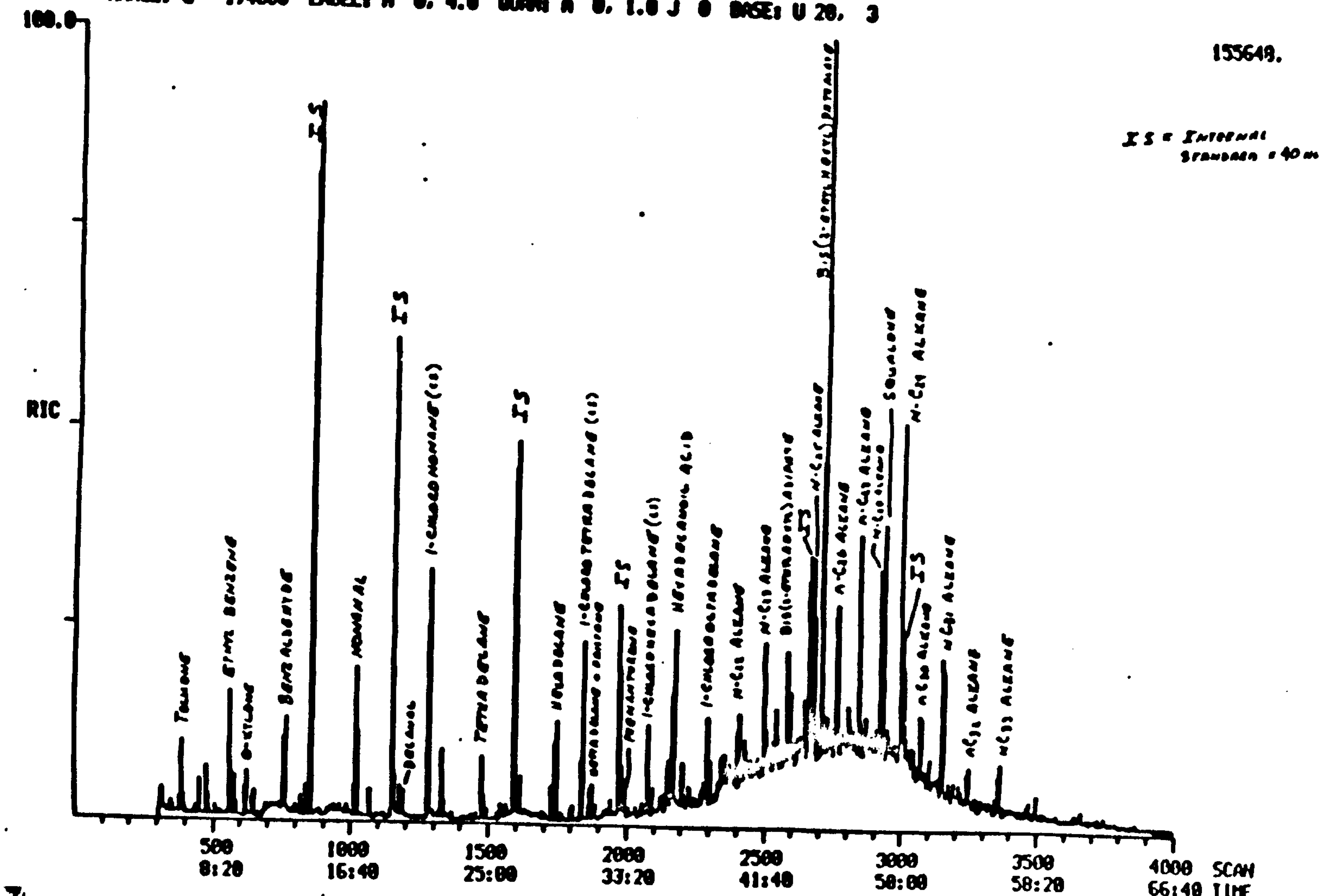
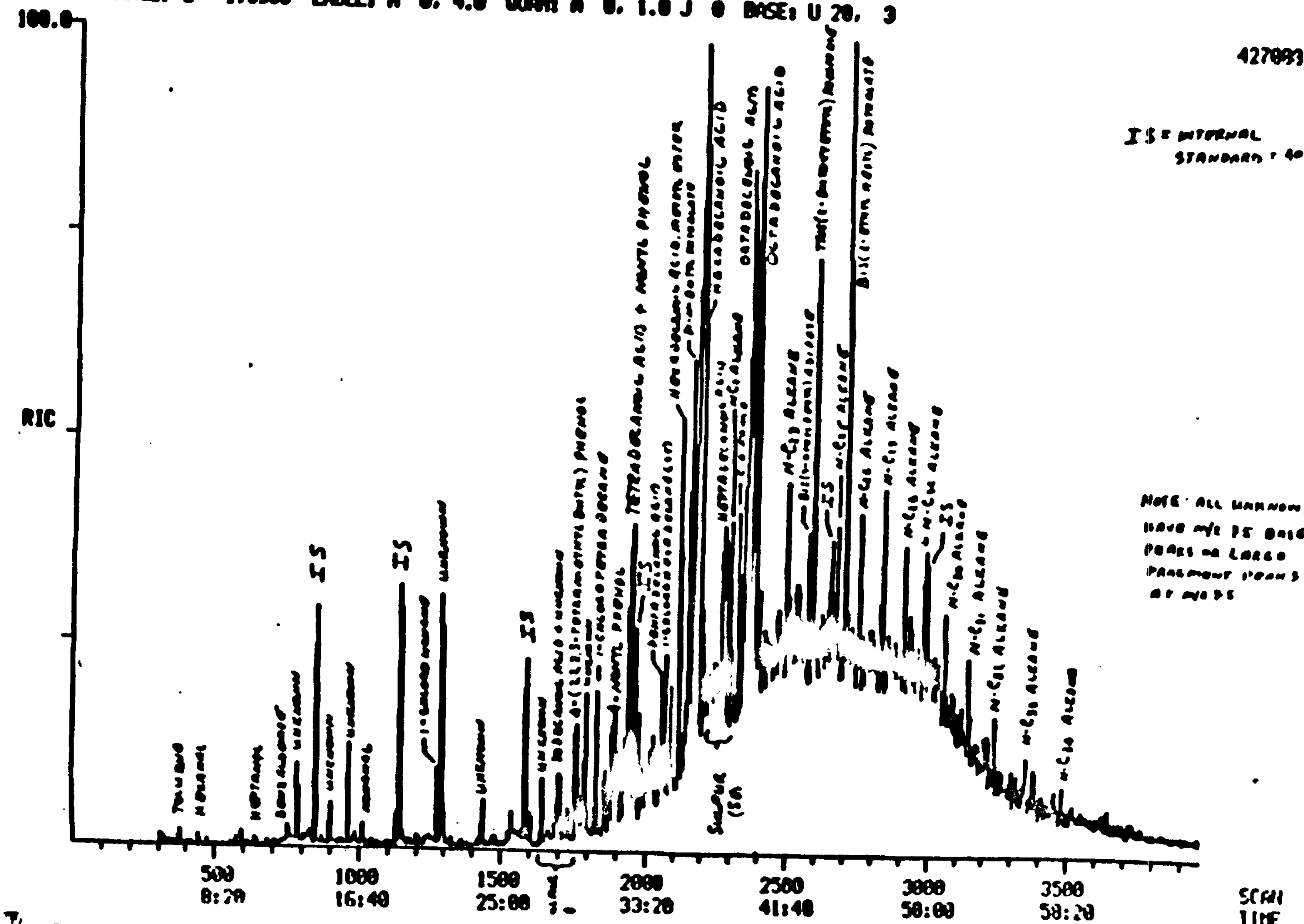
RIC
02/08/93 12:59:00 DATA: F8252 01 SCANS 1 TO 4000
CALI: F8252 01
SAMPLE: PICO/KENTER 12-10-92 2ND GRAB SFE-SS 1.5 OF 250/500 UL
CONDS.: 4 MIN @ 30, 6/MIN TO 300, HOLD 30 30M DB-5MS COLUMN
RANGE: G 1,4000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



R0051556

RIC
11/18/92 7:58:00 DATA: FB114 01 SCANS 1 TO 3965
CALI: FB114 03
SAMPLE: ASHLAND 07-27-92 FILTER EXTRACT 1.2/250 UL INJ.
CONDS.: 4 MIN @ 30, 6/MIN TO 300 30M DB-5MS COLUMN .25MM
RANGE: G 1,3965 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3



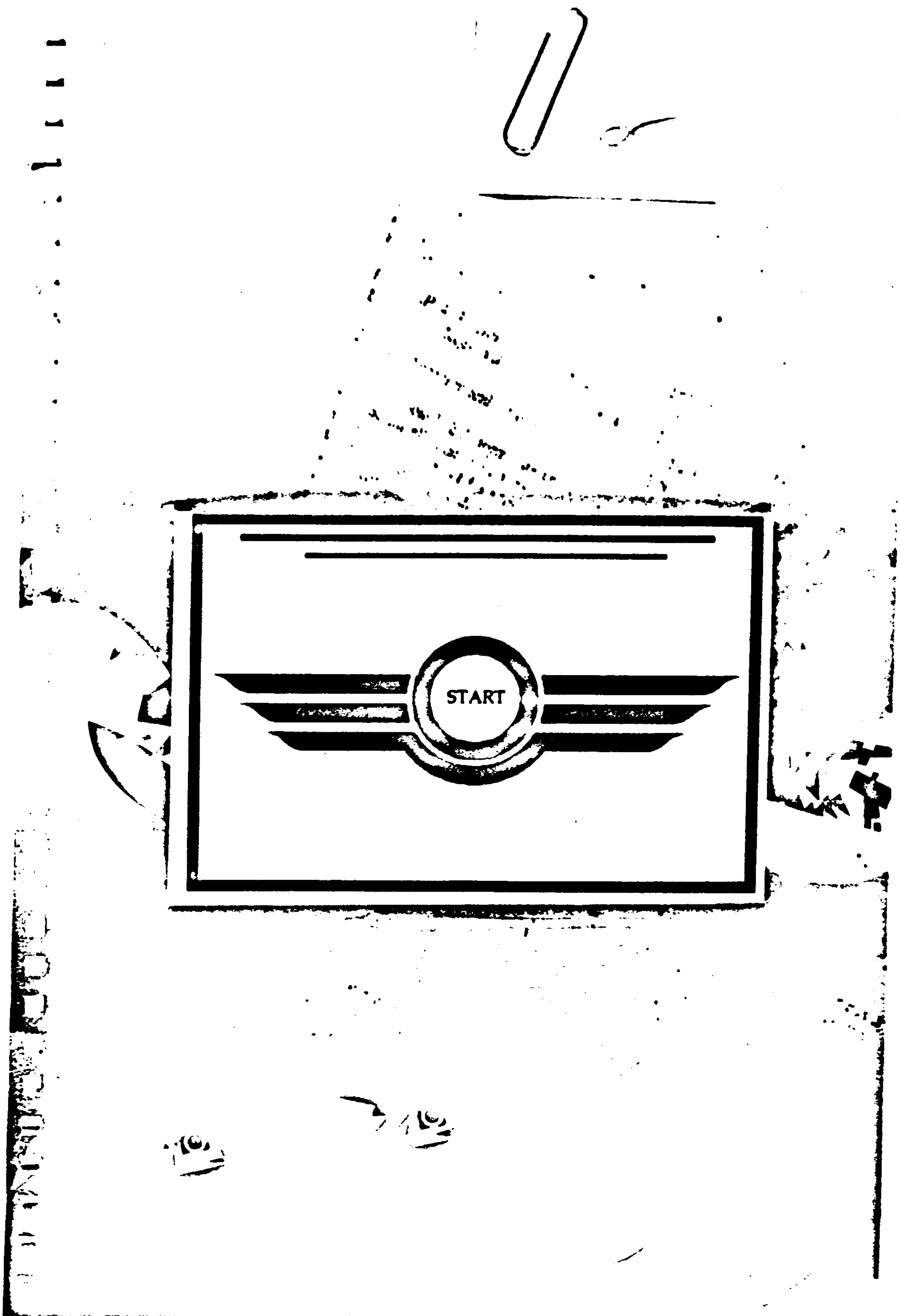
IS = INTERNAL STANDARD : 40 ug/l

NOTE: ALL UNKNOWNS HAVE m/e 75 BASE PEAKS OR LARGE FRAGMENT PEAKS AT m/e 75

R0051557

L 25528 1

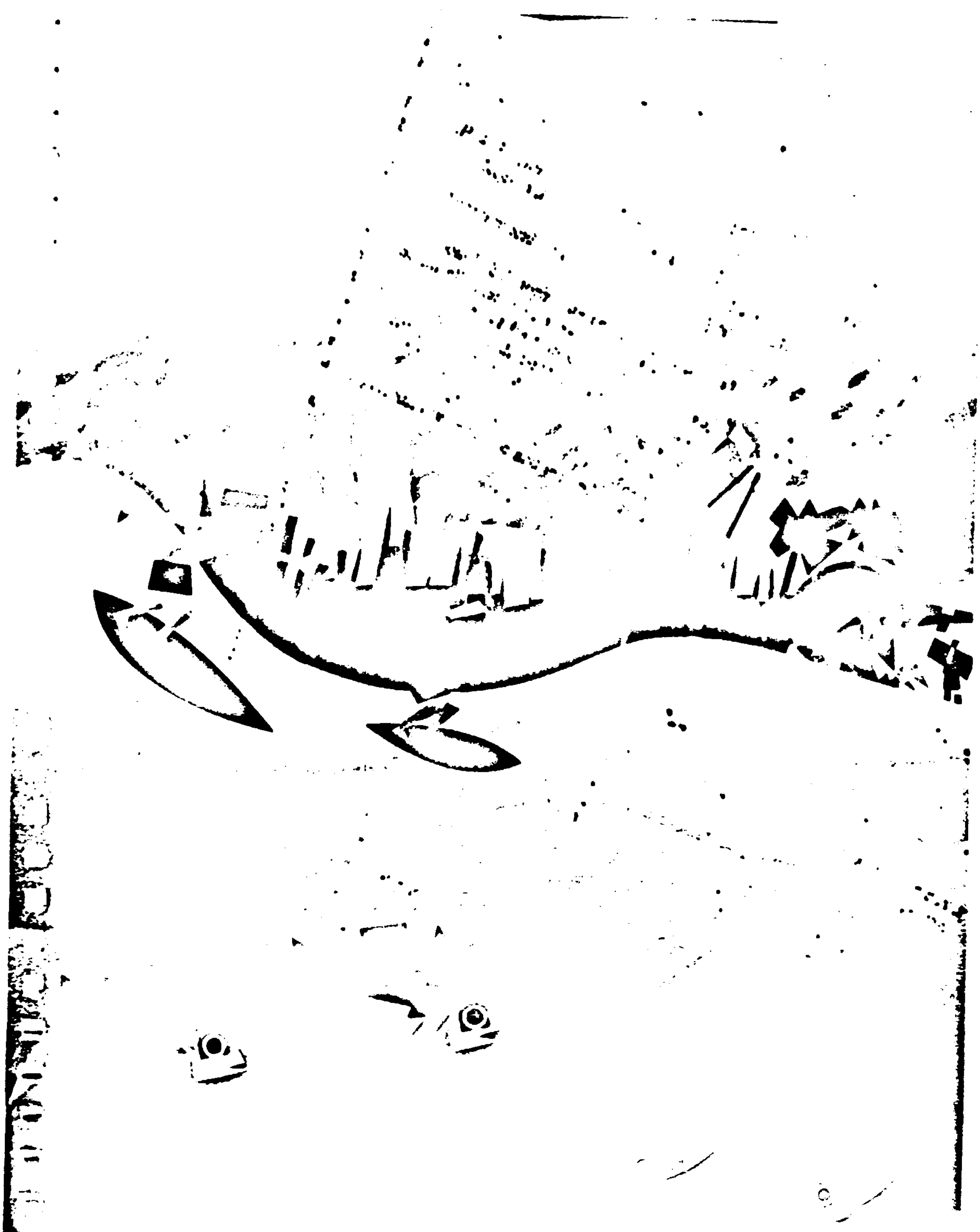
VOL 12



VOL 12

1 8253 F

R0051558



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R0051559

Public Summary of the Santa Monica Bay Restoration Plan

December 1994

Santa Monica BAY Restoration PROJECT

Santa Monica Bay Restoration Project
101 Centre Plaza Drive
Monterey Park, CA 91754
(213) 266-7516

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Preface

The Santa Monica Bay is an extraordinary natural resource. It is home to unique wetland, sand dune and open ocean ecosystems that support a rich diversity of wildlife and serve as migration stopovers for marine mammals and birds. The Bay's beaches are invaluable recreational resources and important sources of revenue for the region. Yet, the Bay is at risk. It has been stressed by the daily activities of a region where nearly nine million people live within an hour's drive of its shores. Here, as elsewhere in the United States, a burgeoning human population brings with it increasing pollution and causes impacts which threaten the health of coastal waters.

The Santa Monica Monica Bay Restoration Project (SMBRP) was formed in 1988 under the National Estuary Program in response to the crucial problems of the Bay. The SMBRP was charged with the responsibility of assessing the Bay's problems, developing solutions and putting them into action. Under a five year development process outlined in the Clean Water Act, a plan of action was structured with the involvement of talented and dedicated individuals representing a diverse group of stakeholders organized into SMBRP's Management Committee, Technical Advisory Committee and Public Advisory Committee. The Santa Monica Bay Restoration Plan is the product of this partnership of government, environmentalists, scientists, industry and the general public.

This Public Summary brings together the scientific characterization of the Bay described in the SMBRP's "State of the Bay 1993" report and other technical investigations, along with the Project's recommendations for action that comprise the Bay Restoration Plan. With over 200 actions, the Plan addresses the need for pollution prevention, public health protection, habitat restoration and comprehensive resource management. Implementing the Bay Restoration Plan will fulfill the goal of a Santa Monica Bay that is protected and restored as a valued resource for people, and as a healthy environment for the fish, plants and wildlife that live in its waters and along its shores.

Acknowledgments

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PHOTOGRAPHS

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Pg. 17 *View from Palos Verdes Peninsula.* Santa Monica Bay Restoration Project.
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THE RESOURCES AND VALUES OF SANTA MONICA BAY

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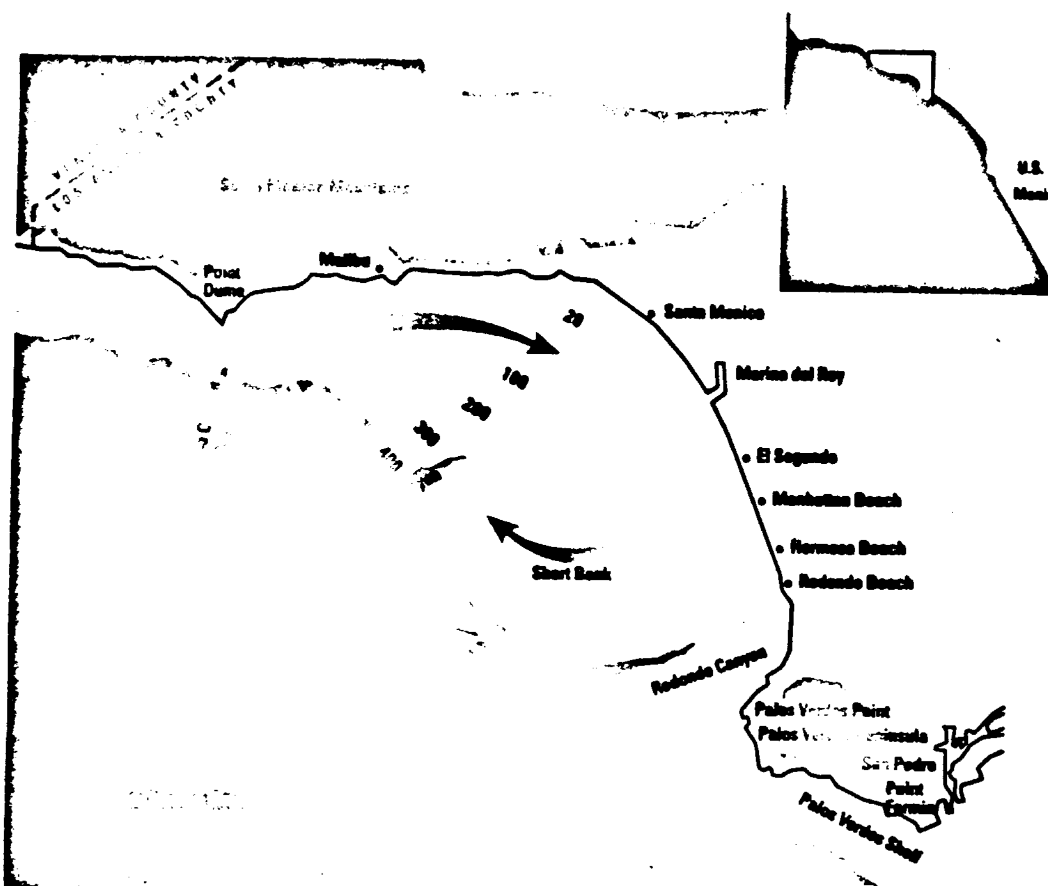
Where Land Meets Sea

In Southern California, as everywhere on earth, life begins with water. The history of our region is the history of water: water's action upon the land as it moves from clouds to highlands to the sea; water's nurturing of life from microscopic to human to gray whales and sequoias; and the actions of humans to obtain water and to control its course.

In the beginning, to paraphrase the sacred stories of many cultures, the earth was covered by water. This was about 5 billion years ago. Over the next few billion years, land rose from the waters, and took its time gliding, sliding and colliding until it assumed its present configuration.

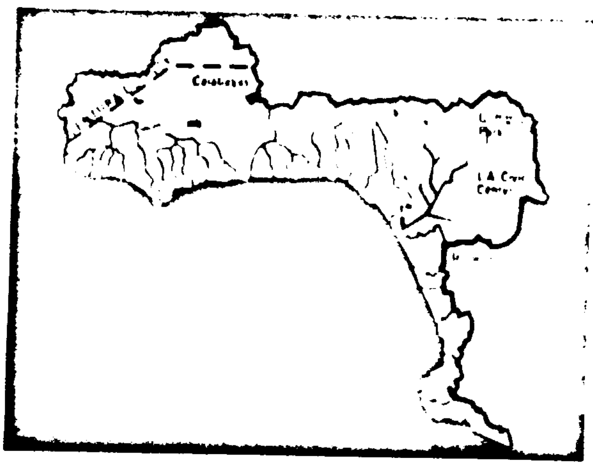
Today's Santa Monica Bay is a relatively small feature in a larger geographic region – the offshore, submerged lands from Point Conception, California to

Santa Monica Bay and the Southern California Bight (inset).



Cape Colnett, Baja California and 100 miles seaward to the Patton Escarpment (ridge). This larger region is known as the Southern California Bight[1], the seaward boundary of which is the California Current.

Southern California's mountainous land form is largely the result of the slow grind of the Pacific tectonic plate against the North American tectonic plate, with the San Andreas fault marking the point of friction between the two. Sediments[2] eroding from four surrounding ranges (the Santa Monica, San Gabriel, San Bernardino and Santa Ana Mountains) over the last two million years have filled the habitable portion of the Los Angeles Coastal Plain to its present elevation, near sea level.



The 414-square-mile Santa Monica Bay Watershed.

Santa Monica Bay is the submerged portion of the Los Angeles basin. It has a gently sloping (about 0.5) continental shelf which extends seaward to the shelf break about 265 feet underwater, then drops more steeply to the floor of the Santa Monica Basin, at about 2,630 feet. The shelf ranges in width from a few hundred yards to about 12 miles. It is broadest off El Segundo, narrowest off Redondo Beach, and is transected by three submarine canyons: Dume Submarine Canyon off Point Dume; Santa Monica Submarine Canyon seven miles offshore of Ballona Creek; and Redondo Submarine Canyon, a few hundred yards off King Harbor.

The Bay floor is of two types, hard-bottom and soft bottom, with different kinds of plant and marine life considered native to each type. Sea bottom is formed by the movement and strength of currents, although the proximity of the sediment source can be important. Coarse sand and gravel are found under swiftly moving water; fine silt and clay settle to the bottom in quiet water. In most parts of Santa Monica Bay the sea floor consists primarily of fine to moderately coarse sediments, though some areas have "hard" bottoms of bedrock, gravel, and phosphorite.

The Watershed

The area that drains naturally into the Bay—the Bay watershed[3]—follows the crest of the Santa Monica Mountains on the north from the Ventura-Los Angeles County line to Griffith Park. From there it extends south and west across the Los Angeles plain to include the area east of Ballona Creek and north of the Baldwin Hills. South of Ballona Creek the natural drainage is a narrow coastal strip between Playa del Rey and Palos Verdes.

Less than 300 years ago, much of what is now the City of Los Angeles was a vast rolling plain of grassland scattered with oak trees. In low-lying areas

[1] bight: a. A bend or curve, esp. in a shoreline. b. A wide bay formed by such a bend or curve.

[2] sediment: Material that settles to the bottom or is suspended in water.

[3] watershed: The region draining into a river, river system, or body of water.

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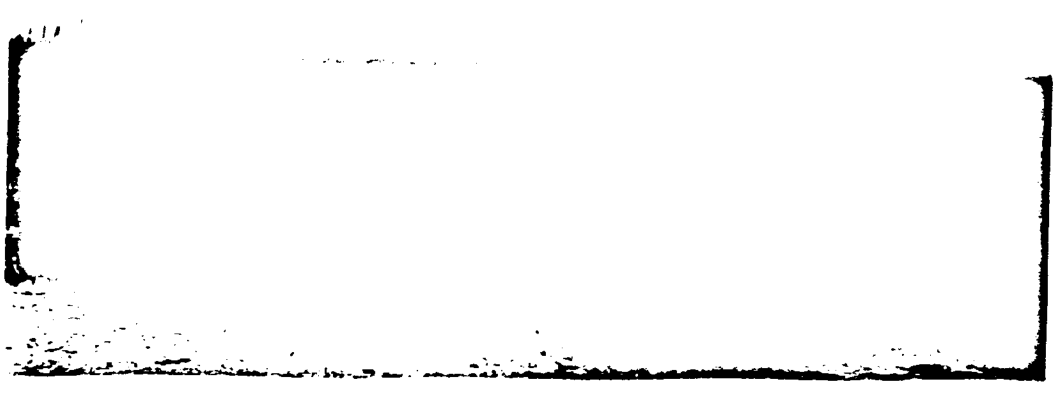
between hills and bluffs, a major river (now called the Los Angeles) and dozens of lesser streams meandered through broad valleys to the sea. They carried so much fresh water to the sea that when the explorer Juan Cabrillo first anchored in San Pedro Bay in 1542, he could haul fresh water, which floats on heavier seawater, aboard ship with a bucket.

Sprinkled across the plain to the coast were eight different kinds of wetlands, vital ecosystems that provided flood control, groundwater recharge, sediment retention and wildlife habitat. There were riverside forests of sycamore, cottonwood and alder, interspersed with marshes, ponds and lakes, and impenetrable thickets of willow, wild grape, and brambles. The highest points of land were the peaks of the Baldwin and Palos Verdes hills. Chaparral vegetation covered the north-facing slopes of these peaks, while oak savannah blanketed the drier south-facing slopes. In even drier spots, edible yucca grew, and wild sage.

The coastal areas we've given names like Malibu and Santa Monica and El Segundo were a mixture of sand dunes, sagebrush, scrub, fresh and saltwater marshes, and lagoons. These areas teemed with life, from the microscopic to resident and migratory birds, to dozens of kinds of mussels, to fish such as tuna, trout, halibut, ling-cod and sardine. Thousands of porpoises, sea lions, sea otters and seals dwelt in colonies along the coast and on the offshore islands.

In Southern California, rainfall varies with elevation; the coastal plain can receive as few as 12 inches a year, on average, while the nearby San Gabriels

Duck hunting in the coastal marshes south of Santa Monica, circa 1903.



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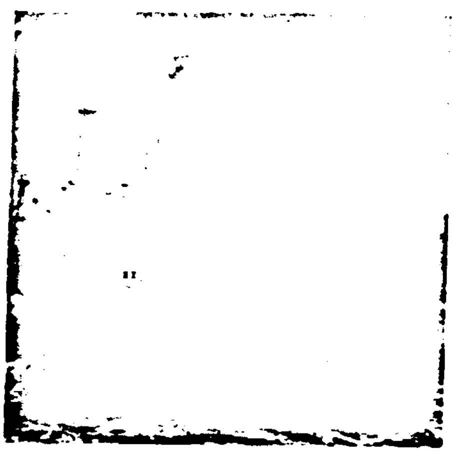
can receive as much as 40. In the winter, much of the coastal plain was a vast lake, stretching from the silt-rich highland of present-day Culver City west to the ocean; and freshwater springs bubbled year-round in modern Beverly Hills.

During heavy rains, torrents from the mountains would flood the area, and the swollen Los Angeles River would change its course, sometimes emptying into Santa Monica Bay at Ballona Creek, sometimes emptying into San Pedro Bay, always depositing rich, dark soil across the plain.

Venice-Del Rey oil field, circa 1930.



The land absorbed more water in those days, before humans laid a concrete skin over it; and it supported a wider variety of plants and animals, both year-round and seasonal. The region's larger animals included deer, antelope, coyote, mountain lion, and bear.

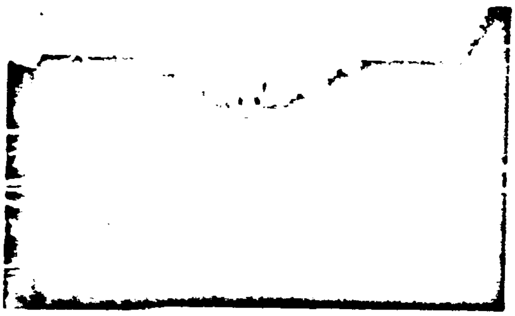
It was this ability to support life that made the coastal plain so desirable, and more exploitable than the rugged northern portion of the watershed, where the mountains drop precipitously to the sea. The plain's suitability for agriculture and grazing led to the first of many waves of human activity that has transformed the southern portion of the watershed into one of the world's most populous urban areas.

The Urban Era

The first of these modern-day human waves were Spanish settlers who occupied the land of the native Chumash and Gabrieleno peoples and carved the plain into ranchos for cattle and for crops like grapes, corn, beans, barley and wheat. To support these farms, they dammed the rivers and streams that fed the *cienegas*, or swamps. Many low-lying flood plains were diked and free-flowing watercourses channelized with crudely dug ditches. Not only did the course of the waters change, and the wetlands disappear, but a process was begun that would change the nature of the coastal beaches, by thwarting the sediment flows that replenish beach sands.

After the plain was sectioned for ranchos, it was bisected again and again by wagon roads. Later, railroads were built to carry the crops and the cattle east and to bring more settlers west. To complement the railroad, the Anglo settlers, who had wrested political control from the Spanish, envisioned a major port, first at Ballona, then at Wilmington; thus many more acres of coastal wetlands disappeared in the service of commerce.

In 1892, oil was discovered. It seemed, for a time, that every back yard had a derrick. More wetlands were drained and filled to support infrastructure for the booming industry, an industry that didn't peak until the 1920's. Constant spills further polluted and destroyed the freshwater wetlands. Echo Lake, near downtown Los Angeles, caught fire and burned for three days after one oil spill. The coastal regions near the salt water marshes like Ballona and Del Rey Lagoons were particularly rich, and derricks sprung up there in numbers to rival (and choke off) the sea grasses.



Gondoliers along Aldebaran Canal, now Market Street, 1908.

The coast also became desirable real estate, as a network of electric trolley cars was developed to bring people to newly-subdivided Playa del Rey, Santa Monica, and Venice. The construction of the latter community, begun in 1905, consumed 160 acres of marsh as cigarette magnate Abbott Kinney sought to realize his dream of reproducing the ancient Italian city of canals on the Southern California coast. It was an era when anything seemed possible, and profitable.

By 1915, the new residents of the coastal plain had enough of the flooding that plagued them during wet years. They formed the Los Angeles County Flood Control District to begin transforming the first crude rancho ditches into a system of storm drains, concrete ditches, covered culverts, and corrugated pipes that today stretches over 5,000 miles and carries millions of gallons of water each day (billions on rainy days) directly to the ocean.

What builders and planners of the growing flood control system may not have taken into account was how these channels would also speed the flow of man-made pollutants to the sea. Los Angeles was in a hurry in those days, not only to stop the devastation caused by floods, but to capitalize on the nation's growing fascination with sunny California by building an urban infrastructure that would accommodate massive immigration.

The "taming" of the Los Angeles River and its tributaries was finally accomplished after World War II, and most of our wetlands were history. Today only five percent remains of what existed 300 years ago.

The Values of the Bay

Healthy Bay, Healthy City

As humans tamed the land and the rivers and the streams, first on the coastal plain, then gradually across the more rugged parts of the watershed, the impact of "civilization" was immediately visible. But each new wave of immigrants also saw the region through new eyes; they did not know what life forms their predecessors had displaced. As the immigrants lived their dreams, their actions had an equal, but less visible impact on the Bay waters. That impact will be discussed at length in later chapters; first, it's important to place the value of the Bay in context, and to define what we mean by the *values* of the Bay.

Consider a tide pool. While nine million humans live within an hour's drive of the Bay, more than nine million living things, visible and invisible, can be found in a single mile-long stretch of rocky shoreline. The rocky shore at low tide is possibly the most prolific life zone in the world—a roiling Gold Rush-era fantasy of interspecies homesteaders, claim jumpers and tide pool poachers.

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[illegible] DIVERSITY

Science professor Edward O Wilson writes of the importance of diversity in his book, The Diversity of Life[c]. He begins by asking, "What difference does it make if some species are extinguished, even if half the species on Earth disappear?" He then answers

"Let me count the ways. New sources of scientific information will be lost. Vast potential biological wealth will be destroyed. Still undeveloped medicines, crops, pharmaceuticals, timber, fibers, pulp, soil-restoring vegetation, petroleum substitutes, and other products and amenities will never come to light. It is fashionable in some quarters to wave aside the small and obscure, the bugs and weeds....

The life-sustaining matrix is built of green plants with legions of microorganisms and mostly small, obscure animals—in other words, weeds and bugs. Such organisms support the world with efficiency because their diversity allows them to divide labor and swarm over every meter of the earth's surface. Field studies show that as biodiversity is reduced, so is the quality of the services provided by ecosystems; the descent can be unpredictably abrupt. As extinction spreads, some of the lost forms prove to be keystone species, whose disappearance brings down other species and triggers a ripple effect among the demographics of the survivors. The loss of a keystone species is like a drill accidentally striking a power line. It causes lights to go out all over."

Not only is every square inch of tide pool used by some plant or animal, but the competition for attachment sites is so keen that residents set up housekeeping on top of each other.

So what? If we've never seen a tide pool, never watched a saddleback or bottlenosed dolphin arc through the waters off Topanga Beach, never swum in the water, or eaten a California halibut, or worked in the tourist industry; of what possible value is the Bay to us?

A healthy Santa Monica Bay helps sustain life in Los Angeles County. It is a building block upon which many other values important to the people of Los Angeles—industry, tourism, recreation, aesthetics—depend. At a time when Southern California must cope with a plague of critical social and economic challenges, the health of Santa Monica Bay is far from a luxury. Its waters are where much of life in this region begins.

Oxygen: A Source of Life

Bay waters are a major source of oxygen, without which there is no human life. Because the world's seas produce more than 40 percent of the world's oxygen, the Pacific Ocean is like a giant rainforest off our coast, creating oxygen in incredible quantity as a byproduct of photosynthesis[a].

The ocean water that circulates through the Bay every three to four days contains, within about the first 150 feet, microscopic plants called phytoplankton[b] upon which the rest of life, from the smallest fish to the largest humans, depends for food and oxygen. The phytoplankton use sunlight, which penetrates to a depth of approximately 150 feet when the water is clear, to create food and oxygen by photosynthesis. All living things create some "waste" products, and the waste product of plants is the oxygen necessary to animal life. If the ocean's phytoplankton die, humans will eventually follow.

Habitat and Species Diversity

The Bay also provides habitat, a home to such a diversity of species—at least 5000 at last count—that some are not yet catalogued, classified or named.

Why is diversity important? It's another building block supporting human life.

The diverse ecosystems in the Santa Monica Bay watershed include the land habitats previously mentioned, from semi-wilderness areas in the Santa Monica Mountains that still shelter coyote and wild rabbits, to wetlands which support

[a] photosynthesis: the production of organic substances, chiefly sugars, from carbon dioxide and water occurring in green plant cells supplied with enough light to allow chlorophyll to aid in the transformation of the radiant energy to a chemical form.

[b] phytoplankton: Minute plant life that lives in water. Similar minute animal life is called zooplankton. Zooplankton feed on phytoplankton and, in many cases, on each other.

[c] *The Diversity of Life* by Edward O. Wilson. The Belknap Press of Harvard University Press. 1992

Santa Monica Bay Habitats

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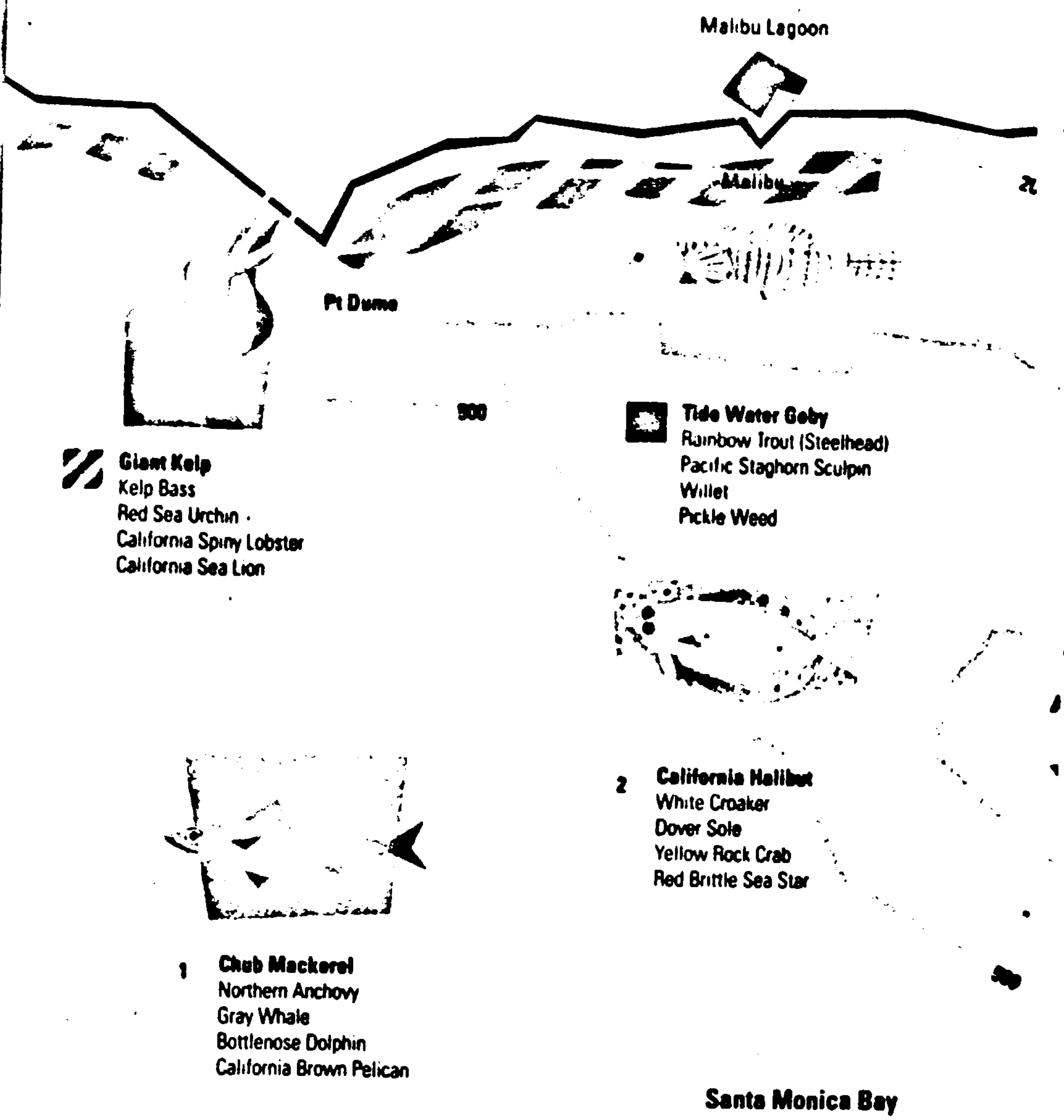
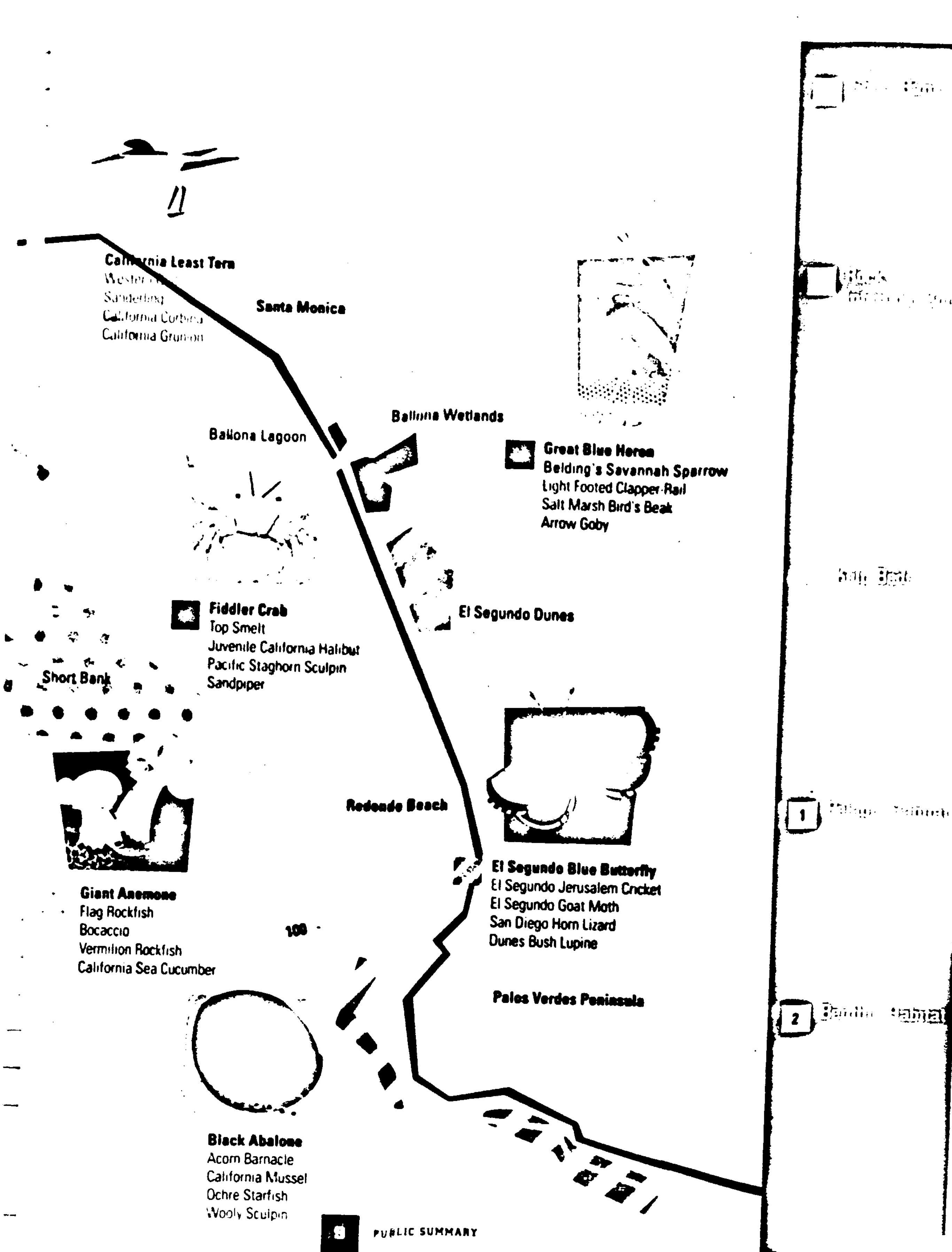


More than 5,000 species of plants, fish, birds and other wildlife call Santa Monica Bay and its environs "home." Each bay habitat is unique and can boast a variety of species, including those listed above.


California Least Tern
California Corbina
California Grunion
Santa Monica
Ballona Wetlands
Ballona Lagoon
Great Blue Heron
Belding's Savannah Sparrow
Light Footed Clapper Rail
Salt Marsh Bird's Beak
Arrow Goby
Fiddler Crab
Top Smelt
Juvenile California Halibut
Pacific Staghorn Sculpin
Sandpiper
El Segundo Dunes
Short Bank
Redondo Beach
El Segundo Blue Butterfly
El Segundo Jerusalem Cricket
El Segundo Goat Moth
San Diego Horn Lizard
Dunes Bush Lupine
Giant Anemone
Flag Rockfish
Bocaccio
Vermilion Rockfish
California Sea Cucumber
100
Palos Verdes Peninsula
Black Abalone
Acorn Barnacle
California Mussel
Ochre Starfish
Wooly Sculpin
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resident and migrant birds, dozens of varieties of worms and snails and other "small, obscure animals" who, through their lives, process and cleanse the water.

The *pelagic*, or open-ocean habitat is the primary home to fish such as the Pacific sardine, northern anchovy, Pacific mackerel, and Pacific bonito; as well as marine mammals such as seals and sea lions. The pelagic habitat is also home to the eggs and larvae of many invertebrates. Phytoplankton are the dominant plant life there.

The dominant *benthic* (sea-floor) habitat in Santa Monica Bay is soft-bottom. Few attached plants live in this habitat but invertebrates are abundant and diverse. Denizens include crabs and shrimp, snails, worms and echinoderms (sea urchins, starfish, and sea cucumbers).

Santa Monica Bay is home to a number of rare, threatened or endangered species. They include:

California brown pelican
California least tern
Belding's savannah sparrow
California gnatcatcher
El Segundo blue butterfly
Lyon's pentachaeta
Santa Monica Mountains dudleya
Conejo buckwheat
Santa Susanna tarweed
Valley oak

Hard-bottom areas includes kelp beds in Santa Monica Bay west of Malibu and around the Palos Verdes Peninsula. Giant kelp attaches itself to the hard bottom and grows in luxurious forests toward the sunlight above.

Intertidal zones, including mud flats, tide pools, sandy beaches, and wave-swept rocks, provide important habitat and breeding grounds for a variety of plants and animals such as marine algae, some fishes, and invertebrates such as snails, worms, mussels, crabs, clams. These organisms are an important link in the aquatic food web to larger marine animals (fishes, lobsters, and octopi) and some terrestrial animals, especially birds.

Both the beaches and other intertidal zones of Santa Monica Bay are important nesting and feeding grounds for migratory waterfowl and shorebirds. Egrets, herons, gulls, terns, sanderlings, marbled godwits, willets, kildeer, plovers, grebes, mallards and many other birds depend upon these areas for food, rest, and/or breeding grounds. For example, the federally-listed, endangered California least tern comes to Venice Beach and the Marina del Rey area each April to nest and rear its young in the sand, leaving in September to winter in Central and South America.

Wetlands and *mudflats* of Santa Monica Bay support a variety of marine and terrestrial life. Wetlands are especially important as nursery grounds for species such as California halibut. *Riparian* habitats, alongside watercourses across the watershed, provide food, cover and water for many diverse species as well.

Santa Monica Bay habitats are home to a number of rare, threatened or endangered species. Birds include California brown pelican (marine), California least tern and western snowy plover (beach nesting species), Belding's savannah sparrow (wetlands), and the American peregrine falcon and California gnatcatcher (watershed habitats). Butterflies include the El Segundo blue,

SANTA MONICA BAY: A VITAL ECONOMIC RESOURCE

The Bay is a Major Tourist Destination

Number of tourists who visited Santa Monica Bay beaches in 1990. 3 8 million people

Rank of tourism as a Regional Industry : Second largest, behind business and management services

Number of tourist industry jobs: 437,000 full and part-time

Contribution of tourism jobs to the region's payroll: $4 25 billion annually

Tourist dollars contributed directly to the region (1991): $7.1 billion

The Bay is One of the Region's Primary Recreational Resources

Number of public beaches along the Bay: 22

Length of shoreline: 50 miles

Annual attendance at Bay beaches: 45 to 60 million

Average number of visitors per summer weekend: 620,000

Busiest beach in the County: Santa Monica Beach

Length of coastal bike path: 22 miles

World's largest man-made small craft marina: Marina Del Rey; 6,000 slips

Number of sport fishing trips made in Southern California (1989): 5.5 million

Expenditures on saltwater fishing in Southern California (1989): $536 million

Value of cargo going through L.A./Long Beach ports (1990): $1 trillion

Palos Verdes blue, and wandering skipper. Plants include Santa Monica Mountains dudleya, Lyon's pentachaeta, Conejo buckwheat, and Santa Susanna tarweed. Valley oaks receive special attention in the Santa Monica Mountains because most individuals are very old and this is the southernmost extent of their range.

The Bay's Other Benefits

The Bay's values are also defined according to the economic benefits of its water-dependent activities, such as tourism, boating, fishing, shell fishing, and recreation; shipping; and its contribution to the cultural and the aesthetic qualities of Los Angeles County.

TOURISM

Tourism is the Los Angeles region's second largest industry, with 392,000 full and part-time jobs. It contributes $3.6 billion annually to the region's payroll.

In 1991, 25.3 million people visited Los Angeles County, contributing $7.2 billion in direct expenditures. Many of these visitors flock to the region's primary recreation resource, Santa Monica Bay. In the City of Santa Monica alone, 85 percent of the tourists (more than 2.1 million people) visit the beach.

Tourist facilities and activities are abundant around Santa Monica Bay. Hotels, motels, weekly rental apartments, restaurants, shops, and conference facilities all cater to local and out-of-town visitors. In addition, Los Angeles International Airport funnels a large percentage of its 48 million annual passengers into the Santa Monica Bay area for at least a portion of their stay.

RECREATION

Recreational features and activities can be either natural or developed, commercially or non-commercially operated. Undeveloped natural recreation areas are scarce along the predominantly urban coastline; pristine wildlife conditions no longer exist. Yet significant natural resources remain. For example, the Ballona Wetlands Complex (between Marina del Rey and Playa del Rey at the mouth of Ballona Creek) is a surviving wetland area that contributes not only to species diversity but also provides open space and aesthetic enjoyment in an otherwise urban area.

Some relatively undisturbed marsh and riparian habitat is also found in the Malibu Creek drainage, where local residents hope to restore the steelhead run,

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and the Santa Monica Mountains offer a wide range of natural habitats, especially inland and west of the Malibu coast.

Activities at the 22 public beaches along the 50-mile shoreline include sunbathing, swimming, boating, and surfing, as well as skin- and SCUBA-diving. Over 45 million people visit Santa Monica Bay beaches each year.

Other developed natural recreation facilities include the 22-mile-long beach bike path, which extends from Santa Monica to Redondo Beach, and several bluff-top parks overlooking the Bay.

Commercial recreation opportunities range from bicycle and roller skate rentals, to "fun zone" arcades, restaurants, bars, and art galleries. Some areas have evolved into recreation attractions of their own: Main Street and Santa Monica Pier in Santa Monica; the Venice Boardwalk; Malibu Pier; Fisherman's Village in Marina del Rey; and King Harbor in Redondo Beach.

Over 45 million people visit Santa Monica Bay beaches each year.

SPORT FISHING

Fishing is one of the most fundamental human uses of the Bay and includes commercial passenger fishing vessels (party boats), pier fishing, private boat fishing, scientific collecting, and limited commercial fishing.

While sport fishing is allowed throughout the Bay, commercial fishing has been prohibited in the Bay (east of a line between Malibu Point and Palos Verdes Point) to protect local fish populations, which could be depleted by a combination of both commercial and sport fishing.[1] Commercial fishing activity in the rest of the Bay centers around gill-netting for California halibut west of Malibu and south of Palos Verdes Point. Commercial catches from Santa Monica Bay are negligible.

Although statistics are not available for Santa Monica Bay alone, 5.5 million sport fishing trips were made in Southern California in 1989. In 1991-1992 the Bay's sport fishery was dominated by chub mackerel, barred sand bass, and kelp bass. California spiny lobster is an important invertebrate also frequently caught.

The sport fishery catch has some economic value as food, but fees paid to charter operators and other onshore expenditures have a much greater impact on the local economy. Expenditures on saltwater fishing in Southern California totaled $536.3 million in 1989, 16 percent on licenses and gear, 23 percent on boat related expenses, and 61 percent on trip-related expenses. Los Angeles County residents accounted for 37 percent of that total. About 465,000 of the 6.1 million households in Southern California coastal counties included at least one member who went sport fishing in 1989.

Recreational fishing facilities in the Bay area include piers at Malibu, Santa Monica, Venice, Manhattan Beach, Hermosa Beach, and Redondo Beach and a

[1] However, commercial bait boats are allowed, under experimental gear permits, to fish for live bait throughout the bay.

fishing barge off Redondo Beach. There are small craft harbors at Marina del Rey and at King Harbor in Redondo Beach. Fourteen artificial reefs designed to enhance marine life and improve sport fishing opportunities have been installed offshore (at Malibu, Paradise Cove, Santa Monica, Marina del Rey, Manhattan Beach, Hermosa Beach, and Redondo Beach) since 1958 and nine of these remain. Commercial passenger fishing vessels (party boats) depart from Marina del Rey, Redondo Beach and Malibu.

SHIPPING

The Bay is also used for shipping petroleum to and from the Chevron refinery in El Segundo. While the Ports of Los Angeles and Long Beach are located in San Pedro Bay, ships heading into and out of those ports use shipping lanes directly adjacent to the Bay. The two ports constitute the fastest growing major cargo center in the world. The value of import-export cargo going through the ports increased from $61.8 billion in 1986 to $1 trillion in 1990.

> **Essayist Wendell Berry speaks of those junctures of soul and territory that take place at edges like the coastline when he writes "This is the phenomenon of edge or margin that we know to be one of the powerful attractions of a diversified landscape, both to wildlife and to humans. The human eye itself seems drawn to such margins, hungering for the difference made in the countryside by a hedgy fencerow, a stream, or a grove of trees. And we know that these margins are biologically rich, the meeting of two kinds of habitat."**

AESTHETIC AND SPIRITUAL RESOURCE

The Santa Monica Bay shore offers great physical beauty: broad beaches, boardwalks, and piers; vistas of Palos Verdes Peninsula, Malibu, and Santa Catalina Island; and a variety of public and private facilities and spaces.

These aesthetic resources make an intangible but important contribution to the local economy. They tend to boost tourism and recreation and provide spectacular locations for television and motion picture filming, two staples of the regional economy.

Finally, the Bay is a spiritual resource. The inner connection to the natural world has moved at least as many humans over the years as have the efforts of governments to mandate change. The natural environment speaks to something deep in all of us. The Bay's ability to touch that deep place is one of its greatest gifts.

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THE URBAN

ENCOUNTER: HUMAN

IMPACTS ON THE BAY

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[illegible] Impacts on the Bay

Scientific Characterization — The Basis for Action

Chapter One of this summary described the most significant physical as well as social features of the Santa Monica Bay. Chapters Two and Three will characterize the environmental condition of the Bay in order to give a better understanding of the basis for the actions recommended in the Santa Monica Bay Restoration Plan (BRP).

Those recommendations, summarized in Chapter Four, are based in part on a comprehensive scientific characterization of the Bay conducted by the Santa Monica Bay Restoration Project (SMBRP). The "State of the Bay 1993" report examined the various sources of pollutants that enter the Santa Monica Bay, the fate of those contaminants once they enter the Bay, and the impact of pollution on the health of marine life, as well as on the health of humans who use the Bay as a source of food or recreation.

Like many scientific inquiries, the SMBRP's characterization studies could not answer all questions conclusively. But much is now known that was not known before the SMBRP was formed, and the accumulated information serves as a reliable guide for those public agencies that intend to fulfill the public's c[illegible] policies that protect the Bay and its resources.

[illegible] specifically on the sources and causes of pollution, beginning with the region's explosive population growth and the building of the region's infrastructure to accommodate this growth. It also presents a general framework for setting priorities for action against specific types and sources of pollution. Chapter Three focuses on the Bay itself, and the way in which human activities have changed the Bay's natural processes to put marine life as well as human users at risk. We also take a look at the progress and gains in Bay health that have occurred in recent years.

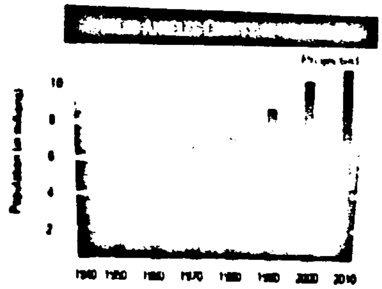
Human Impacts: Population and Land Use

"The Spanish explorers were attracted to Los Angeles and San Diego by their natural harbors," author Peter Steinhart wrote in 1991. "But the abundance of food in the sea off our coasts was what allowed them to stay. The richness of the marine environment enabled the cities of Southern California to take root and grow."

And grow. And grow. The population shift to California since 1880 is one of the largest in history, with at least five distinct waves of migration adding up to a population of 30 million people who now call the Golden State home. Nine million people live within an hour's drive of Santa Monica Bay, and those numbers threaten the rich marine environment that drew settlers in the first place.

Many of the problems facing the Bay's habitats and natural resources can be traced to the proximity of the large human population and its impact on the physical, chemical and biological characteristics of the Bay.

In short, what happens "upstream" affects the ecosystem "downstream." Intensified land uses bring intensified pressures, including contaminated urban runoff; increased domestic and industrial waste disposal; conversion of open space to residential, commercial, and transportation system development; stream alteration; introduction of non-native plant and animal species; and increasing use of natural habitats for recreation.



More than 11 million people will be living in Los Angeles County by the year 2010.

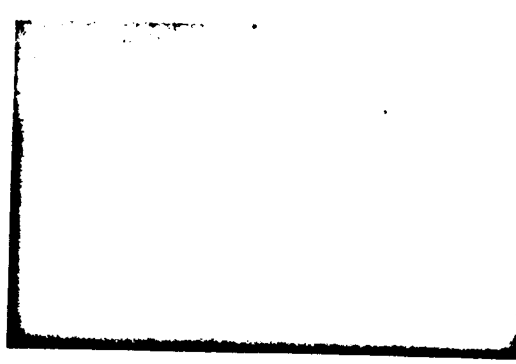
The population of Los Angeles County has increased over 300 percent since 1940, and is predicted to grow another 30 percent by the year 2010. This growth has dramatically affected land use as homes, buildings and roads have been built upon what was once open land. Population increases into the next century, projected to come less from immigration than from the descendants of those already living here, will require a substantial increase in infrastructure to support them.

Watershed Development

Los Angeles, the second largest city in the United States, is one of the world's most sprawling and built-out metropolitan areas. If we are generous with our definition of "watershed," the impact of Los Angeles' build-out can be felt as far away as the Feather, Sacramento and Colorado Rivers and the slopes of the Eastern Sierras, whence we draw most of our water supply.

As the second largest city in the United States, Los Angeles is one of the world's most sprawling and built-out metropolitan areas.

But even limiting our definition of watershed to the 414 square miles that drain into the Bay, it is obvious that build-out has indelibly altered the landscape. Natural rivers and creeks have been confined in concrete channels, wetlands have been drained and filled, and the flood plains and hillsides have been covered by asphalt streets, parking lots and buildings.



Our growth has resulted in the loss of natural functions that are critical to the health of the ecosystem—open areas for groundwater recharge; buffers or undisturbed areas that can trap and assimilate contaminants; vegetation that moderates stream temperatures and provides cover and food supplies for fish and wildlife populations. While these incremental changes, viewed separately, may seem insignificant, their cumulative impact over time and throughout the watershed may be quite substantial.

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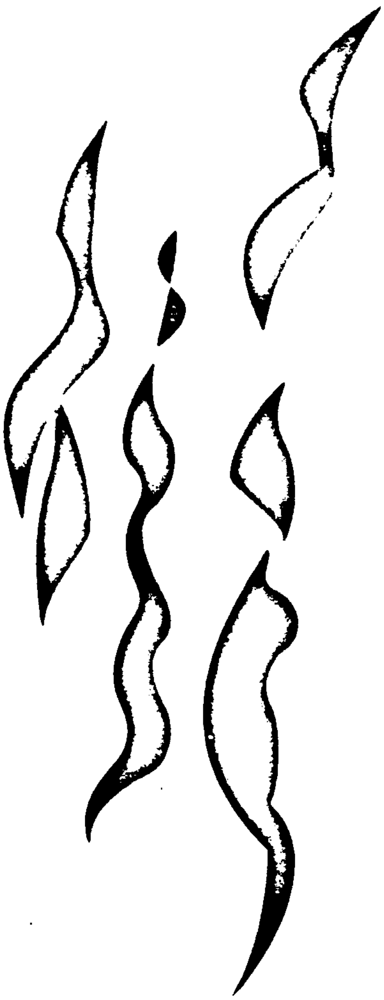

Impacts of Growth—Pollution

Population growth and land development have had serious consequences for Santa Monica Bay. As the numbers of humans living and working in the watershed grew, so did the waste products—pollutants[1]—generated. The problem of pollution increased until deliberate policies were enacted that slowed or reversed that trend while continuing to accommodate growth.

Pollutants enter the Bay through numerous pathways, including flood control channels, streams, sewage treatment plant outfalls, and aerial fallout. Most often, they are carried by water. As water cycles through the watershed, it brings with it a wide mix of contaminants—sediment and nutrients from open land and building sites; oils, grease and litter from roads and parking lots; fertilizers and pesticides from yards and parks; heavy metals from industrial sites; human waste and household chemicals from homes and businesses.

Understanding the effect that pollutants have on the environment is complicated because pollutants are influenced by many interactive factors. The manner in which contaminants are introduced into the environment, their chemical and physical properties, and the types of processes that operate on them all control their dispersal, accumulation and ultimate fate in the environment.

A polluted Santa Monica Bay is not acceptable to the people of Southern California. Neglecting our duty to be stewards of the Bay's ecological health will bring both economic and environmental damage to the region. It is important, however, to come to an understanding not only of what key factors led to pollution of the Bay, but also to establish a framework by which the most damaging pollutants and pollution sources will be addressed first, and in a manner that most effectively preserves the myriad values of the Bay.

Pollutants of Concern

Hundreds of known pollutants exist in the urban environment and may enter the Bay on a regular or irregular basis. Since it is neither feasible nor necessary to control all types and sources of pollutants, the SMBRP has focused on those that pose the greatest problems. SMBRP's analysis suggests that 19 pollutants are of most immediate concern in Santa Monica Bay. These **Pollutants of Concern**—which include toxic organic compounds, heavy metals, pathogens, nutrients and sediments, trash and debris, and others—were identified based on the following factors:

- Current loadings or historic deposits of those contaminants currently affect the Bay's beneficial uses (e.g. recreational use, wildlife habitat, etc.);
- Elevated levels of the contaminant are found in Bay sediments; and/or have the potential to bioaccumulate[2];
- There are detectable inputs of the contaminants at a level that is potentially toxic to marine life and/or humans.

1 Substances are classified as pollutants when they are present in the environment in such quantities or concentrations that they become harmful to human health, marine life or the ecosystem. While the California Water Code distinguishes between "pollutant" (substances that affect any beneficial use) and "contaminant" (substances that affect public health), these terms are used interchangeably in this document.

2 Bioaccumulation: The accumulation of a substance (usually a contaminant) in the tissues of an organism. This usually occurs with substances that organisms cannot easily break down, which are often transferred intact to organisms at higher levels of the food chain.

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Toxic Organic Compounds	
DDT	Was a widely used pesticide prior to ban in 1972. An animal and potential human carcinogen; persistent in environment, biomagnifies. Major source to Bay was Montrose Chemical Co. via Los Angeles County sewage treatment system until 1970. Although mostly buried, levels in ocean sediments remain high in certain locations and certain fishes.
PCBs (polychlorinated biphenyls)	Wide range of industrial applications prior to 1970s (transformers, capacitors, etc.). Among the most persistent and toxic of organic compounds; biomagnifies. Accumulated in sediments and caused contamination of seafood.
PAHs (polycyclic aromatic hydrocarbons)	Found in crude oil, fuel oil, crankcase oil; released during combustion. Many are potent carcinogens or mutagens.
Chlordane	Environmentally persistent insecticide used extensively in termite control. Potentially toxic to sensitive marine species. Still found in sediments although banned in 1987.
TBT (tri-butyl tin)	Widely used as an antifouling agent in vessel paints until restricted in 1987. Very toxic and bioaccumulates in all organisms.
Heavy Metals Cadmium / Chromium Copper / Lead/Nickel Silver / Zinc	Heavy metals are utilized in a large variety of industrial applications. Often associated with fuel combustion, vehicle tire and brake wear and decay of products such as batteries, paints and plastics. Potentially toxic in high concentrations and can accumulate in the tissues of plants and animals. Present in wastewater and surface runoff and have accumulated in sediments in many areas.
Pathogenic Bacteria and Viruses	Disease-causing organisms that may pose potential health risks to swimmers and waders. Sources include leaking sewer lines, illegal sewer connections or dumping, malfunctioning septic tanks, outdoor campers. Carried to beaches via stormdrain runoff.
Nutrients and Sediments	Nutrient sources include fertilizers, runoff from livestock areas, detergents, etc. Sediments result from erosion, land grading activities. Excessive nutrients can cause eutrophication (algae growth); sediments can smother tidepools and artificial reefs, resulting in sedimentation of coastal lagoons. Can be a problem in some areas with limited circulation.
Trash and Debris	Caused by littering, dumping of trash into storm drains, at beaches, into marine environment. Impairs aesthetic value of Bay, some (like plastics) can injure or kill marine life.
Oil and Grease	Sources include waste oil dumping, natural oil seeps, oil spills and food waste. Some components of oil and grease (e.g. PAHs) are known to be toxic.
Biological and Chemical Oxygen Demand	Sources include organic material from human and animal waste. Can deplete oxygen content of receiving waters.
Chlorine	Used in sewage disinfection, swimming pools. Harmful to most marine organisms. Also forms toxic chlorinated organic compounds.

The consequences of these pollutants can be seen around the Bay. Historic discharges of DDT and PCBs have accumulated in Bay sediments and caused contamination of certain seafood species. Popular swimming beaches are posted with warnings due to high pathogen levels found near storm drain outlets. Copper, lead, tri butyl tin and chlordane have been found in sediments and biota in marina areas. These are but a few examples of pollutant impacts on Santa Monica Bay. Finding solutions to these problems requires that we understand where these pollutants come from (their sources), how they reach the Bay (the pathways) and how they impact Bay resources.

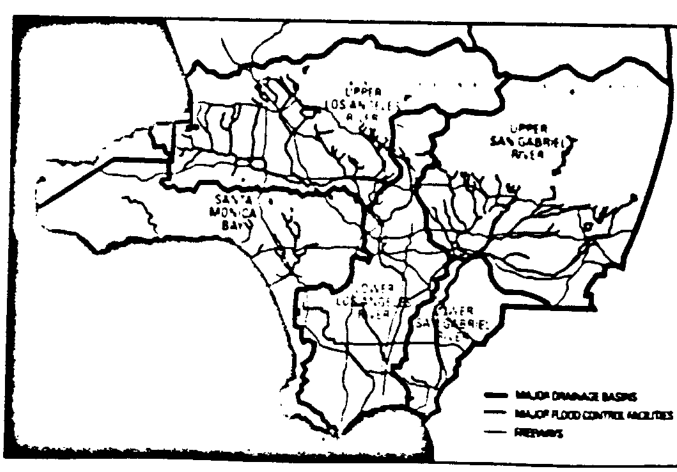
Following the Pollution Trail: Pollutant Sources and Pathways

Contaminants entering the Bay may originate on land, in the air, or at sea outside of the Bay itself. Although the sources of pollution are numerous and disparate, they are ultimately the product of all the people who live, work and play in this region. Everyday human activities—the way we manage our households, care for our cars, manufacture and consume products—directly influence the amounts and types of pollutants that enter the Bay, and do varying degrees of environmental damage.

The effects of these activities are transmitted to the Bay via numerous pathways—runoff to creeks and storm drains, municipal wastewater treatment and industrial discharges, boating and shipping activities, aerial fallout, dredging, ocean dumping and advection.

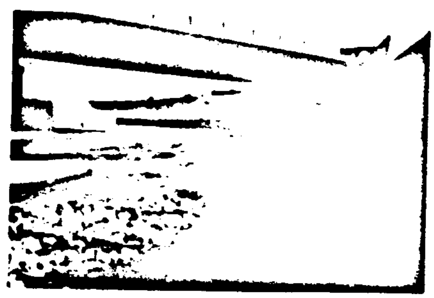
The Santa Monica Bay Restoration Project's attempt to develop and set forth effective policies to safeguard the environmental values of the Bay has required the Project to look closely at how pollutants get from here to there, with "here" representing the source of each potentially harmful pollutant, and "there" representing the impacts on a key Bay resource. The trails lead in one direction—downstream—but to many different policy conclusions.

The Los Angeles County storm drain system includes over 5000 miles of open channels and underground storm drains that carry floodwaters and urban runoff to the ocean.



Storm Water Urban Runoff Pollution

Urban and storm water runoff—carried to the Bay through the region's massive storm drain system—is a serious concern, in both dry and rainy seasons. These waters, which flow over rooftops, parking lots, freeways, construction sites, industrial facilities and other impervious surfaces, collect and carry an assortment of pollutants through open channels and underground storm drains directly to the ocean without treatment[3]. The 5,000 mile storm drain network, built to move flood waters quickly to the ocean, is completely separate from the sewer system, which conveys wastewater from households and businesses to wastewater treatment facilities.



Storm water and urban runoff contribute about one-fourth of the total pollutant load to the ocean.

Storm water runoff is controlled primarily through the use of source control programs known as Best Management Practices (BMPs). This approach is embodied in the municipal storm water National Pollutant Discharge Elimination System (NPDES) permit issued to Los Angeles County (as principal permittee) and the 89 cities and other governmental entities (as co-permittees) by the Los Angeles Regional Water Quality Control Board in 1990. General storm water discharge permits for industrial facilities and construction sites were issued by the State Water Resources Control Board in the summer of 1992. The municipal permit provides a new regulatory framework considered practical, cost-effective and adapted to the distinct structure of the region's storm water drainage system—its large size, proximity of cities and the overlapping jurisdiction over drainage facilities.

URBAN RUNOFF FLOWS

Urban runoff is a daily problem. Ten to 25 million gallons of water flow through storm drains into Santa Monica Bay every day, even in dry weather. Ten *billion* gallons can flow through the system on a rainy day, which amounts to more than one-third of the daily flow of such major U.S. rivers as the Arkansas, the Susquehanna or the Willamette—rivers that flow in states where rain is a year-round phenomenon. Each year an average of 30 billion gallons of storm water and urban runoff are discharged through more than 200 outlets—some as large as a 370 feet-wide concrete channel, some so small that they are hard to detect—into Santa Monica Bay.

Storm water pollutant runoff volumes and pollutant concentrations are often comparable to effluent flows from municipal wastewater treatment facilities. As the quality of sewage discharges has improved, the relative contribution of storm water and urban runoff to the total pollutant load to the Bay has increased. Currently, is it estimated that one-fourth of the total pollutant inputs to the Bay are attributable to pollutants carried by storm water and urban runoff. A 1990 SMBRP study concluded that significant quantities of many pollutants

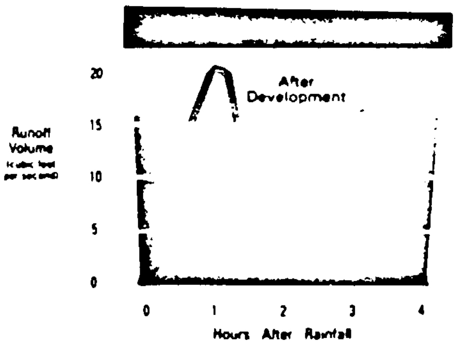
3 with the exception of the dry-weather diversion of runoff from the Pico-Kenter storm drain

of concern were discharged annually through the storm drain system to the Bay, and that the concentrations of some of these pollutants were among the highest in the nation.

Storm water/urban runoff is known or suspected to be responsible for water quality impairment in nearshore areas close to the mouths of storm drains, and in some lagoons and marinas. The SMBRP storm water toxicity study performed by the University of California at Los Angeles (UCLA) and the Southern California Coastal Waters Research Project (SCCWRP) found that urban runoff in several storm drains during dry weather was toxic to marine organisms even at diluted levels. Other studies found high levels of bacterial indicators at mouths of storm drains, and evidence that human fecal waste was contaminating storm drain waters at least some of the time.

Modifications of the natural landscape through traditional urban development patterns can profoundly change runoff characteristics. Altering naturally vegetated lands to impervious surfaces such as roadways, roofs, and parking lots results not only in increased pollutant runoff but also in higher flow velocities.

While it is generally recognized that increased pollutant loads have impacts on the integrity of stream, wetland and nearshore environments, the physical action of higher stream flow velocities alone also contribute to habitat degradation.



RUNOFF SOURCES AND LOADS

Urban and storm water runoff is made up of infinitely variable types of matter—the by-products of human activity in the watershed.

Land use is one of the major variables in runoff pollution, and has therefore been the focus of most urban runoff source studies performed in the nation to date. The type of land use strongly influences the type and concentration of pollutants found in urban runoff. Runoff quantities and velocities increase when roads, buildings or pavement ("impervious surfaces") cover land that once absorbed and filtered rainfall. The more impervious area, the greater the runoff. For example, there is more runoff from industrial areas where 90 percent of the surfaces are impervious compared to single-family residential areas where an average of 55 percent of the surfaces are impervious.

Pollutant loads originate from human activities that occur within each type of land use. As the adjoining table shows, the origins of the pollutants from each land use are as varied as the diversity of the region's economy and population. Metal-plating and auto repair shops, construction worksites, lawns overtreated with fertilizers and pesticides, "do-it-yourselfers" who dump motor oil, paints or solvents into the street, drivers and pedestrians who toss cups, plastic bags, "disposable" diapers, cigarette butts and other trash on the ground—these are just a few of the sources of PAHs, heavy metals, suspended solids, phosphates, oil and grease, pathogens and debris which constitute what we call "urban runoff." A land use analysis simply relates each of these activities to the areas within the watershed where they occur most commonly.

[illegible]ANTS[illegible]AND USE

Pollutant of Concern	Industrial/ commercial	Transportation	Residential	Construction	Public	Other
PAHs	Oil leaks, spills	Fuel and oil combustion, spills	Motor oil dumping	Fuel and oil combustion, leaks		Natural oil seeps; brush fires
Chlordane	Stored product discharge		Stored product discharge			
Cadmium	Metal plating	Fuel combustion; tire wear	Batteries; paint	Paint		Water supply
Copper	Metal plating, antifouling paints, manufacturing	Fuel leaks, combustion, auto part wear	Insecticides, fungicides		Insecticides, fungicides	Water supply
Lead	Lead metal, chemicals; paint	Leaded fuel combustion, coolant leaks	Paint; batteries	Paint		Water supply
Nickel	Metal plating, industrial applications	Fuel combustion, auto part wear				
Zinc	Galvanizing; pigments	Fuel, oil and coolant leaks; tire wear	Paint	Paint		Water supply
Pathogens			Septic tank or sewer leaks, illegal connections, pets		Sewer leaks, dumping or illegal connections, human waste	Wildlife
Total Suspended Solids	Dust and dirt	Pavement wear	Erosion	Erosion from land grading	Soil runoff	Natural erosion
Nutrients	Detergents, facility cleaning	Fertilizers	Fertilizers, detergents		Fertilizers, livestock manure	Natural erosion
Debris	Trash dumping	Litter	Yard waste, litter	Trash dumping	Litter	Natural vegetation
Oil and Grease	Waste oil dumping, oil leaks	Oil leaks, spills	Waste oil dumping	Oil leaks	Oil leaks	Natural oil seep

An SMBRP study, "Assessment of Urban Runoff Pollution," resulted in the development of the first maps of the 28 Santa Monica Bay sub-watersheds and the land uses associated with them, and calculated pollutant loadings from storm water/urban runoff to Santa Monica Bay.

Overall, it was found that residential and open land uses together comprise 90 percent of the total Santa Monica Bay watershed area, and contribute 82 percent of the total runoff and the largest pollutant loads to the Bay. Sub-watersheds in the undeveloped northern section of the Bay have the lowest concentrations of pollutants; the urbanized South Bay and West Los Angeles drainages have the highest loads and concentrations of pollutants. On a land use basis, single-family residential areas contributed the largest loads of heavy metals and nutrients, open areas[4] supplied the largest load of total suspended solids (TSS), and the largest quantities of oil and grease were associated with multi-family and commercial areas.

However, a better picture of urban runoff characteristics is illustrated by comparing the Bay's two major sub-watersheds—**Ballona Creek and Malibu Creek**. The present drainage of Ballona Creek is located in the heavily urbanized coastal plain of the Santa Monica Bay watershed; the more "rural"

4 It is important to note however that runoff from open areas with natural vegetative cover is not necessarily at levels that are harmful to the environment.

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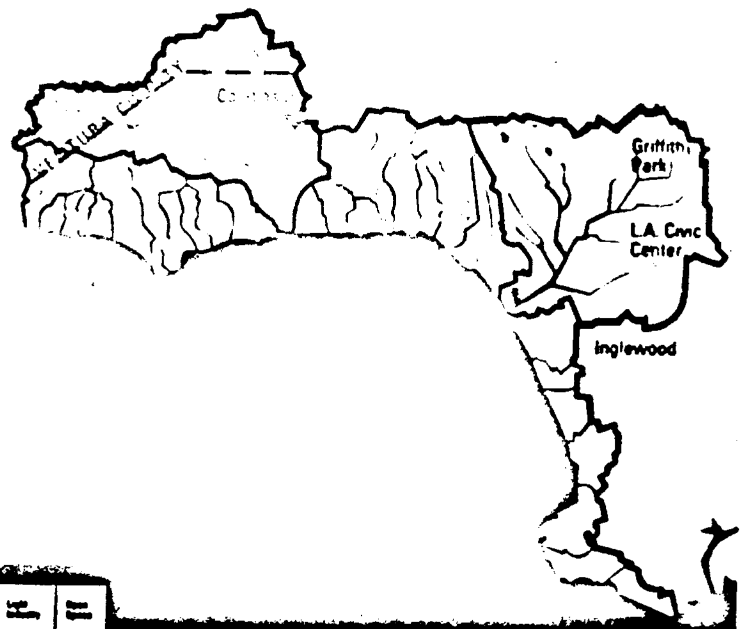
The Santa Monica Bay watershed is comprised of 28 sub-watersheds, the largest of which are Ballona and Malibu Creeks. Land uses in the watershed are 33 percent residential, 10 percent commercial industrial and 57 percent open-undeveloped.



[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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By determining land uses and associated pollutant loads, pollution reduction programs can be designed to focus on the most problematic sources within the watershed.

Malibu Creek drainage encompasses parklands in the Santa Monica Mountains as well as the rapidly urbanizing cities of the Ventura Freeway corridor. Although these areas are similar in size, the focus of pollutant reduction efforts will vary due to the differences in land use mix and the resulting differences in the loadings of Pollutants of Concern in each area.

Actions taken in the **Ballona Creek** sub-watershed, with its large population and developed economy, will need to focus on abating litter and debris, pathogens, heavy metals (especially lead), PAHs, oil and grease and other pollutants associated with its heavily urbanized setting. In **Malibu Creek**, dominated by open lands (some of which are being developed) efforts must focus on pollutants associated with land grading and construction, malfunctioning septic systems, agriculture, and improperly disposed human wastes. Sediment, nutrients and pathogens are the primary pollutants of concern in this area.

Municipal and Industrial Discharges

Outfalls for municipal wastewater discharges, power plant cooling water discharges and industrial waste effluent are generally referred to as "point sources." There are seven major point source facilities in the Santa Monica Bay watershed: three municipal waste treatment plants, three coastal generating stations, and one oil refinery. In addition, over 160 smaller commercial

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and industrial facilities discharge non-process wastewaters to storm drain channels that flow to the Bay.

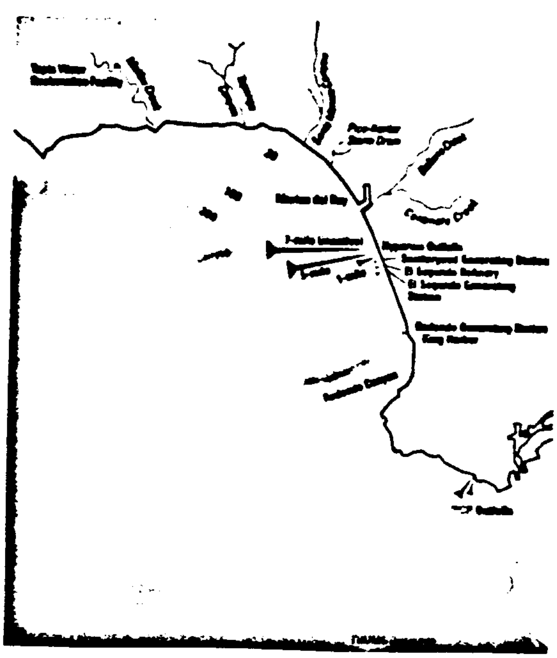
Each major point source facility has a variety of responsibilities for managing wastewater discharges. All must meet requirements set forth in their National Pollutant Discharge Elimination System (NPDES) permits, monitor their discharges for compliance with their permits, and submit monthly reports to the Los Angeles Regional Water Quality Control Board (LARWQCB) and the U.S. Environmental Protection Agency (EPA).

MUNICIPAL FACILITIES

Municipal wastewater facilities receive sewered wastes from domestic, commercial, and industrial sources. Residential wastewater (sewage) contains a variety of household cleaners and detergents; oil, grease, and solvents; food wastes; and enteric (intestinal) bacteria from human fecal waste. It is estimated that each person in the region generates approximately 100 gallons of wastewater per day. Commercial and industrial wastes include oils and grease, metals, and a variety of synthetic organic substances.

Municipal wastes are collected by an extensive network of main and feeder sewers which drain into central treatment plants where they undergo various levels of treatment (see sidebar). In the Los Angeles area, about 85 percent of the flow to treatment plants is domestic sewage and about 15 percent is industrial.

Major point sources and drainage channels in the Santa Monica Bay area.



A primary by-product of the treatment process is sewage sludge (also referred to as biosolids). Sludge production increases significantly as plants upgrade to secondary treatment. Sludge can be a valuable resource (as it is often rich in nutrients) or a hazardous product if it contains high levels of contaminants such as metals and pathogens. Pollution prevention and source control programs that minimize contaminants in wastewater therefore increase opportunities to effectively use this resource.

The region's municipal treatment plants provide service to over seven million people in portions of Los Angeles and Ventura counties. The City of Los Angeles' Hyperion Treatment Plant (Hyperion) and the County Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) discharge treated wastewaters directly into Santa Monica Bay. The Las Virgenes Municipal Water District's Tapia Water Reclamation Facility periodically discharges tertiary treated wastewaters into Malibu Creek.

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Each day, about 645 million gallons of treated municipal wastewater are discharged to Santa Monica Bay from Hyperion and the JWPCP. During exceptionally heavy rains, this volume increases due to infiltration of storm water runoff.

Hyperion Treatment Plant

Los Angeles' first ocean outfall was completed in 1894 and discharged raw (untreated) sewage across the beach near Playa del Rey. Today, the Hyperion Treatment Plant discharges a non-chlorinated mixture of primary and secondary effluent through an outfall located five miles offshore at a depth of 190 feet. Pursuant to a Consent Decree, the Hyperion Plant is undergoing a $1.1 billion upgrade to full secondary treatment levels, scheduled to be in place by 1998.

SEWAGE TREATMENT

1 Sewage treatment occurs in several stages. Preliminary sewage treatment consists of screening, pulverization, and grit removal. **Primary treatment** usually consists of clarification with or without chemical treatment, in most cases by settling solids and skimming. At the end of this stage substantially all floating and settled solids have been removed and half of the metals and conventional pollutants are eliminated.

2

The City of Los Angeles' wastewater collection and treatment system serves over three million residents in a 480 square mile area. The Hyperion Plant is the largest of the City's four major wastewater treatment facilities and provides solids treatment for sludge discharged from two upstream facilities located in the San Fernando Valley. In 1991, Hyperion discharged 315 million gallons per day (mgd) of treated wastewater into the Bay, of which nearly 58 percent underwent secondary treatment and sludge digestion.

Before its termination in 1987, digested sewage sludge was discharged through a seven-mile outfall at the head of the Santa Monica Submarine Canyon. Presently, about 1100 wet tons per day of biosolids are being used for city composting, land applications, chemical solidification and in Hyperion's energy recovery system.

The flows and levels of contaminants discharged by Hyperion have fluctuated over the years. Annual flow increased from about 340 mgd in 1974 to about 410 mgd in 1983. Between 1988 and 1992, average flow was 339 mgd, a reduction attributed to water conservation measures and increased capacity at an upstream water reclamation plant.

Mass emissions of most constituents have decreased in recent years due to better source control, improved chemical treatment and an increase in secondary treatment from 100 mgd in 1986 to 200 mgd in 1991. Between 1981 and 1991, emissions of total suspended solids were reduced by 83 percent. Annual emissions of oil and grease declined over two-thirds, and various heavy metals were reduced by 74-97 percent from 1981 levels. In 1992, Hyperion reached secondary treatment levels for all constituents except biological oxygen demand (BOD).

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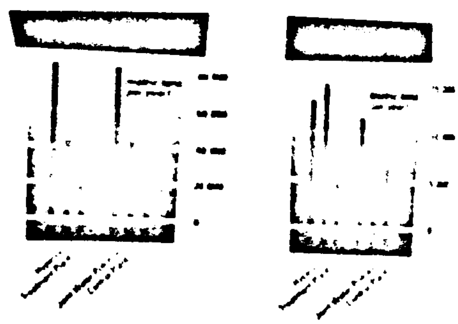
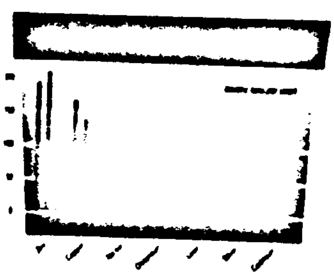
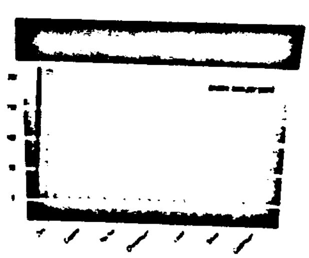


Annual mass emissions of total suspended solids and oil and grease from Santa Monica Bay wastewater treatment facilities.



Estimated mass emissions of various heavy metals from the Hyperion Treatment Plant in 1981, 1986, and 1991.



Estimated mass emissions of various heavy metals from the Joint Water Pollution Control Plant in 1981, 1986, and 1991.

Joint Water Pollution Control Plant

Until the 1920s, most of the communities in Los Angeles County not serviced by Hyperion used cesspools and septic tanks. In the late 1920s, the County Sanitation Districts of Los Angeles County (CSDLAC) were formed and Whites Point on the Palos Verdes Peninsula was selected as an ocean outfall site, in part because it was far from the popular beaches of Santa Monica Bay.

The CSDLAC Joint Outfall System presently treats the wastewaters of more than four million people and 10,000 businesses and industries in a service area of approximately 583 square miles. Approximately 30 percent of the sewage in the Joint Outfall System is treated to tertiary standards in water reclamation plants and 70 percent is treated at the JWPCP in Carson. The JWPCP is the largest of the Districts' wastewater treatment facilities and processes solids from five upstream water reclamation plants.

In 1991, the JWPCP discharged an average of 330 million gallons of wastewater per day, 58 percent of which was subject to secondary treatment. (This flow is about 12 percent less than the average daily discharge of 356 million gallons during 1974 to 1987.) The combined flow is chlorinated and discharged through outfalls located approximately two miles off shore at a depth of 200 feet. The JWPCP residuals are sold as soil amendment or land spread or are disposed of in a landfill.

Like the Hyperion Plant, the quality of the JWPCP effluent has also improved. Since 1981, annual mass emissions of total suspended solids have declined by 62 percent and oil and grease by 48 percent. Significant reductions (ranging from 77 to 94 percent) in emissions of heavy metals have also occurred.

Until 1972, the JWPCP outfall discharged extremely high levels of DDT, a result of the disposal of DDT process waste into the sewerage system. Following the termination of these inputs and the subsequent ban on its manufacture and use, DDT emissions have declined precipitously. A comparable pattern is seen with emissions of PCBs, which have dropped to non-detectable levels since 1987.

Fifteen years after applying for a waiver from full secondary treatment, LACSD agreed in a lawsuit settlement to build

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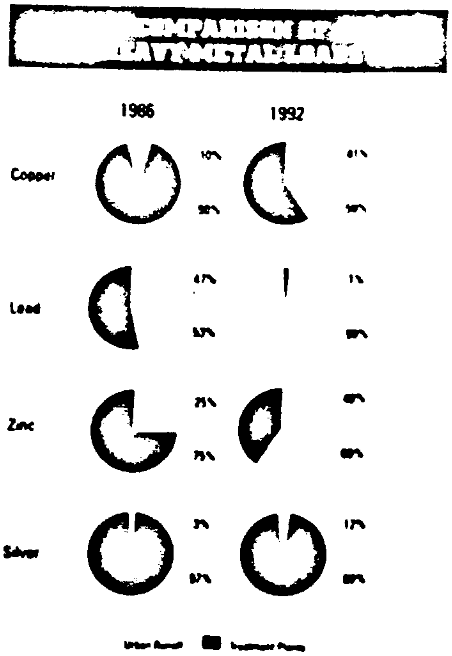


Urban runoff contributes an increasingly greater proportion of the pollutants discharged to the Bay

As significant reductions in emission of heavy metals have occurred at sewage treatment plants, urban runoff correspondingly represents a larger percentage of heavy metal loadings to the Bay.

In 1986, loadings of the heavy metals copper, lead, zinc, and silver from sewage treatment plants in Santa Monica Bay were 160, 72, 290, and 25 metric tons respectively. By 1992, they had been reduced to 26, 4.7, 65, and 6 metric tons, respectively. Rough estimates of annual loadings for the same heavy metals carried to the Bay in urban runoff are a constant 18 metric tons of copper, 65 of lead, 96 of zinc, and 0.8 of silver. These charts show the relative contribution of pollutants from each source.

While the database is still insufficient to evaluate trends in urban runoff loading rates, the above estimates are illustrative of the need to shift greater attention to the myriad of diffuse pollutant sources that contribute to urban runoff.

a $400 million advanced treatment system. A full secondary treatment system is to be operational at the JWPCP by July 2002.

Tapia Water Reclamation Facility

The Tapia Water Reclamation Facility (Tapia) was constructed in 1965 as a joint venture agreement between the Las Virgenes Municipal Water District and the Triunfo County Sanitation District. The joint venture now also runs Rancho Las Virgenes, which grows feed crops for animals using dewatered sludge as fertilizer. Tapia serves a population of 80,000 from three cities, the western portion of Los Angeles County and a small portion of Ventura County.

The Tapia plant currently provides tertiary treatment of wastewater. Tertiary treated wastewater is reclaimed and used for irrigation, dust control and fire suppression. Sludge is currently digested and either pumped to land injection farms or dewatered and hauled to landfills.

Tapia has 10 mgd of treatment capacity, although flows have averaged about 2.5 mgd. The facility does not discharge on a daily basis, particularly in summer, since it can reuse much of the reclaimed water it produces. Annual mass emissions of total suspended solids, BOD, and certain metals have generally been low. Because flows in Malibu Creek are subject to human contact, Tapia's discharged wastewater must be completely pathogen-free.

An expansion of Tapia and Rancho Las Virgenes begun in 1991 will allow for the handling of 16.1 mgd of wastewater and dewatered sludge by 1994. Additional sludge from expansion will be composted for use in landscaping.

INDUSTRIAL DISCHARGES TO SEWERS AND STORM DRAINS

More than 160 commercial and industrial facilities discharge into storm drain channels in the Santa Monica Bay watershed, and over 16,000 discharge into municipal sewer systems that flow to the Bay.

Industries that discharge into the storm drain system must provide on-site treatment and are subject to NPDES permit limitations; only non-process wastewaters can be discharged. Industrial stormwater discharges to storm drain systems are also subject to NPDES permit limitations.

Facilities that rely on municipal systems are generally controlled under pretreatment or industrial waste discharge permits issued by the publicly-owned treatment works (POTWs) in accordance with federal, state and local source control regulations. Pretreatment processes remove toxic and conventional pollutants before they are discharged into sewage systems. Recent improvements in POTW effluent and sludge quality can largely be attributed to pretreatment and pollution prevention programs.

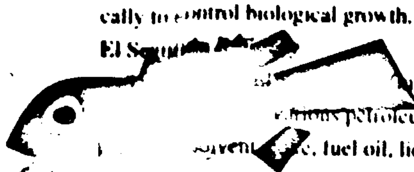
INDUSTRIAL DISCHARGES TO THE BAY

Four major industrial facilities discharge treated wastewaters directly into the Bay. They include three electric power generating stations (the City of Los Angeles Department of Water and Power's Scattergood Plant, and Southern California Edison's El Segundo and Redondo Plants) and Chevron's El Segundo Refinery.

Power Stations

The power generating stations use seawater from Santa Monica Bay to cool steam condensers. Cool seawater is pumped into the station, circulated through noncontact heat exchangers, and discharged at temperatures above the intake temperature. In addition to elevated temperatures, the once-through cooling water may include treated wastewater which is determined to be non hazardous as defined by state and federal regulations. Chlorine is also injected periodically to control biological growth.

El Segundo Refinery



...ery has been in operation since 1911 and ... petroleum products including gasoline, jet fuel, ... solvent..., fuel oil, liquefied petroleum gases and propylene polymer.

Since the early 1970s, Chevron has discharged secondary treated wastewater through an outfall 500 feet offshore of the beach at Grand Avenue. The refinery discharges six to seven mgd of treated water during dry weather and up to 20 mgd during wet conditions. In February 1993, Chevron announced that it would extend the outfall pipe to a distance of two-thirds of a mile, effectively removing the last point source discharge from the nearshore environment.

Nonpoint Sources

MARINE DEBRIS AND BEACH LITTER

Marine debris is more than just a litter problem; it kills marine wildlife, damages the Bay's aesthetic qualities and is expensive for coastal communities to clean up. Over 4000 tons of trash are collected from beaches annually, at a cost of $3.6 million to Santa Monica Bay communities in fiscal year 1988-89 alone. While much of it is left by the millions of beachgoers who visit the Bay annually, much is carried there through storm drains.

Debris includes plant remains such as trees, kelp, and grass clippings as well as the shells, bones, and carcasses of animals. It also includes aesthetic nuisances such as paper, plastic, and wood, as well as fishing line and nets. More dangerous items include glass and metal objects which pose physical hazards on the beaches and on the bottom of the Bay, and some plastic items

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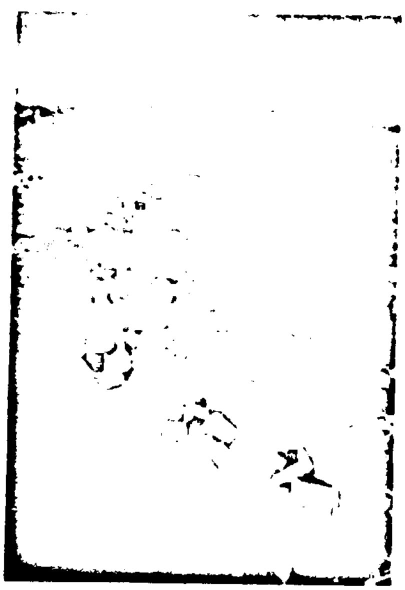
which can harm or kill marine life if they are eaten or if animals become entangled in them.

MARINAS AND BOATING

Most of the Bay's small craft traffic is concentrated in Marina del Rey and King Harbor, which together have approximately 7,500 berths and hundreds more dry-docks. Marinas act as collecting basins for a variety of substances, such as raw and chemically treated sewage, fish wastes, antifouling paint additives, oil and grease, wash water, urban runoff and trash.

The contaminants of most concern from boats include antifouling bottom paints which can contain copper and trace amounts of mercury, arsenic and PCBs. In addition, paint primers may contain zinc, chromium and lead, and most recently, tri-butyl tin (TBT). Although TBT can no longer be used on most recreational boats, TBT from earlier applications may slough off or be scraped off boats and is found in harbors and marina sediments.



Beach debris, much of it carried there by storm drains, costs local communities millions of dollars to clean up.

AERIAL FALLOUT

Automobiles are the largest single generator of smog in California, contributing about 60 percent of the total. Each car produces its own weight in hydrocarbons each year. California motor vehicles also emit more than 10,000 pounds of carbon monoxide each day. Given that some seven million motor vehicles are registered in Los Angeles County alone, aerial fallout is a potentially significant contributor of contaminants to the Bay.

Relatively few studies have been conducted to assess the types and amounts of contaminants which enter the ocean via aerial fallout but some recent studies indicate that it may be an important source of lead, nickel, zinc and some PAHs[5].

OIL AND HAZARDOUS MATERIALS SPILLS

Crude oil and refined petroleum products can enter the marine environment through tanker accidents, fueling, tank cleaning, bilge pumping, improper disposal or on-land spills into storm drains. Other hazardous substances may also be spilled as a result of transportation, industrial accidents or illegal disposal practices.

Spills of oil and other hazardous materials occur every year in the Bay and its watershed, each with the potential for serious impacts on the water quality and marine resources. Spills can kill marine organisms outright through smothering, hypothermia or acute toxicity. The animals and populations that survive may display symptoms of stress or chronic poisoning, such as increased mortality rates or reproductive failures.

5 PAHs: Polycyclic (or polynuclear) aromatic hydrocarbons

Two natural seeps, one about 2.3 miles off Redondo Beach, the other about 4.5 miles off Manhattan Beach, also release oil into the Bay. Daily flow from these is estimated at 2 to 18 barrels (84 to 756 gallons), but may be several times this amount during and after local earthquakes.

DREDGING AND DISPOSAL

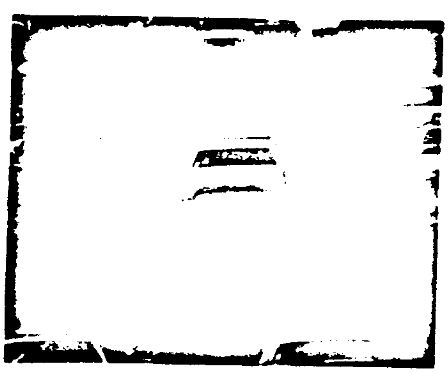
Dredged materials from built-up sediments around harbor entrances may be discarded into the ocean off Southern California in large quantities, if these sediments meet Ocean Dumping Act requirements. Dredged material can also be used for beach replenishment, landfill in harbors for new construction, or disposed of in sanitary landfill sites.

Two areas of historical sediment buildup and dredging activity are the Marina del Rey entrance channel and Redondo Beach King Harbor. Dumping of dredged materials can reintroduce buried contaminants into the ocean at the dumpsite. These can then be carried by currents into the Bay.

There is currently one permitted ocean dump site nearby the Bay. Known as LA-2, this site receives dredge materials from maintenance and construction activities at Los Angeles and Long Beach harbors that must be tested for toxicity. If found to be toxic, the dredge spoils cannot be disposed of at this site.

With over seven million vehicles registered in Los Angeles County alone, aerial fallout is a potentially significant source of contaminants to the Bay.

Prior to 1972, there was also dumping of DDT from the Montrose Chemical Company at a site (known as LA-1) in the San Pedro Channel 10 miles north-west of Catalina Island in 2500 feet of water. Some DDT and other industrial wastes may also have been illegally dumped before reaching the LA-1 site.



ADVECTION

Advection refers to the movement of substances from one area to another via ocean currents. While Bay current patterns are complex and require further study, we do know that oil slicks and contaminants in the surface layer of ocean water can float into the Bay on wind-generated currents and waves, and that tar from the Santa Monica Channel is carried into the Bay. Contaminants from the Los Angeles-Long Beach Harbor may enter the Bay from the south in a subsurface current that flows north along the Palos Verdes Shelf.

Conclusions

In our examination of the human impacts on the Bay, what we have found gives us both cause for concern and cause for hope. While the major pollutants of concern, DDT and PCBs, are no longer discharged into the Bay, they still remain at the top of the list of concerns because they decay so slowly. On the positive side, public and governmental pressure has succeeded in greatly reducing contaminants that enter Santa Monica Bay from local sewage treatment plants, power generating stations and heavy industry. With

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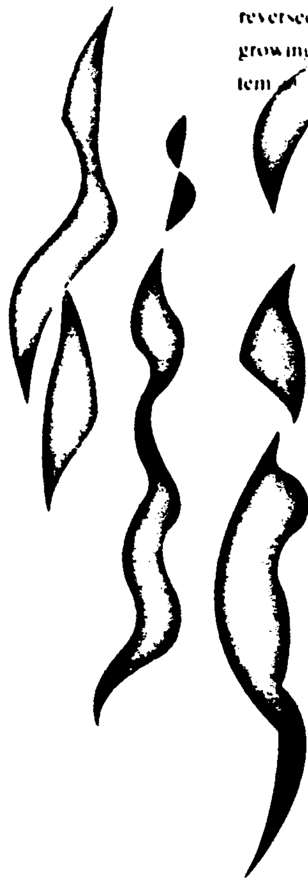
better control of these traditional "point sources," pollution reduction efforts are now focusing on urban and storm water runoff.

For all the human use and overuse, the Bay's health is improving, as we will learn in the next chapter. However, the gains that have been made could be reversed without vigilant efforts to offset the environmental effects of our growing human population. Our watershed is a complex, interrelated ecosystem and wherever you live, work or play, you are an integral part of it.



THE HEALTH

OF

SANTA MONICA BAY

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Survey after survey has shown that people throughout the Los Angeles region place a high value on protecting the marine life that depends on Santa Monica Bay. Moreover, millions of people consider swimming, surfing and fishing in Santa Monica Bay as rewarding experiences that they want to be able to enjoy without fearing for their health.

People throughout this region place a high value on protecting the marine life of Santa Monica Bay.

In this chapter, we conclude the summary of the scientific characterization of the Bay. Whereas Chapter Two described growth and urbanization of the region, the origins of pollutants and the pathways of transmission to the Bay, Chapter Three tells the rest of the story—what happens to pollutants once they enter the Bay, the effects of human activities on water quality and habitats, and how marine life and human health are affected.

Chapter Three's examination of the Bay's health moves from a general description of pollutant distribution to a more specific examination of threatened resources and values. Combined with Chapter Two, this portion of the summary sets the stage for the Bay Restoration Plan (BRP), which is presented in abridged form in Chapter Four.

Distribution of Contaminants

Contaminants are supplied to Santa Monica Bay from a variety of sources, as described in Chapter Two. Having entered the Bay, numerous physical, chemical and biological processes can act upon them and affect their distribution and impact on the environment. Contaminants move into three physical reservoirs in the marine environment: the sea-surface microlayer, the water column and sediments. The tissues of living organisms—marine plants and animals, and humans—constitute a potential fourth reservoir.

THE SEA-SURFACE MICROLAYER

The sea-surface microlayer is a critical habitat—only two-thousandths of an inch thick. It is a nursery for both eggs and larval stages of fish and other pelagic organisms. Accumulation of metals and organic compounds in the microlayer can be toxic or cause biological abnormalities in these life forms.

Pollutants that do not dissolve in water and are buoyant—such as petroleum hydrocarbons—tend to accumulate in the sea-surface microlayer, forming the surface slicks seen most frequently in calm waters near shore and in harbors. Contaminants like PAHs (hydrocarbons) have been observed in the microlayer at concentrations 100 to 10,000 times greater than in other parts of the water column.

Atmospheric pollutants also contaminate the sea-surface microlayer. However, aerial fallout is difficult to quantify and relatively few studies have been conducted to assess the kinds and amounts of pollutants which enter the Bay from this source.

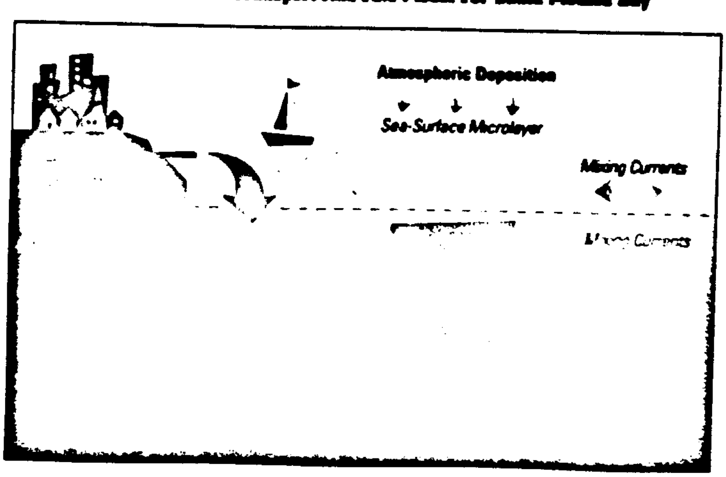
THE WATER COLUMN

Visualize a pillar of water reaching up from the Bay bottom to the surface, like a core sample of the Bay at a single moment in time. While the nature of this imaginary pillar changes constantly, this cross-section of a body of water is what scientists call the water column. Contaminants in the water column can include heat, turbidity, nutrients and pathogens. (Most trace metals and many toxic organics are bound to particles and eventually sink rather than remain in the water column.)

There is no single measure by which to assess the quality of the Bay's waters; it can be polluted in terms of some substances and be otherwise perfectly normal. There are, however, state and federal standards for water quality (e.g. the California Ocean Plan and Federal Marine Water Quality Criteria) that are designed to protect the marine environment. In general, water quality in Santa Monica Bay meets these standards. However, in certain areas, such as lagoons and marinas where water circulation and exchange are low, and areas near storm drain outlets, standards may not be met on a consistent basis.

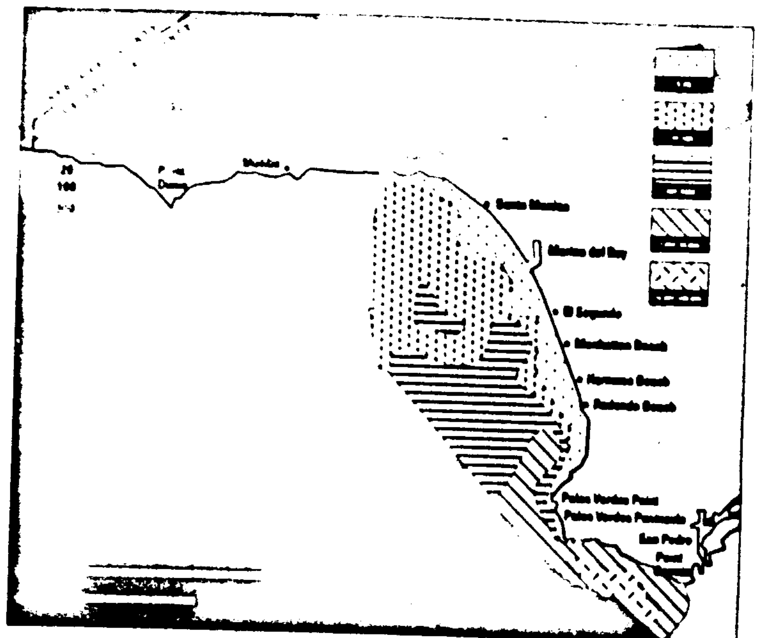
The majority of water in the Santa Monica Bay is healthy, partly because it is an open embayment with major currents that regularly change the water every three to four days, and also because of significant reductions in pollutant loadings from sewage treatment facilities. The major threat to Bay water quality today is pollution from urban runoff.

Generalized Contaminant Transport And Fate Model For Santa Monica Bay



Numerous physical, chemical and biological processes can act upon contaminants and affect their fate in the environment.

While areas with high levels of contaminants such as DDT still remain, the top layer of sediment over most of the Bay is actually cleaner than it was in the 1980's.



Concentrations of DDT in surface sediments of Santa Monica Bay, 1988.

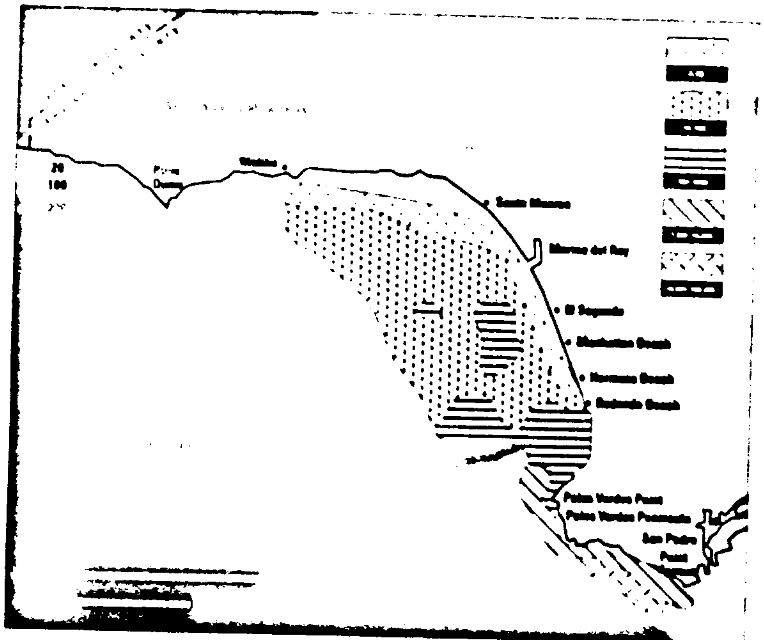
SEDIMENTS

Remember the childhood riddle, "Where does a fish keep his money?" The answer: "A riverbank."

A simple play on words, but in a sense, sediments are a bank, where contaminants and pollutants are deposited to be dispersed, buried and resuspended over time through the action of waves, currents, dredging or bottom-feeding organisms. Because many contaminants are bound to particles, contamination is far more concentrated and more readily measured in sediments than in the water column.

Organic compounds such as DDT, PCBs, PAHs, chlordane and TBTs (see Pollutants of Concern table, Chapter Two), are found in sediments at various locations in the Bay. These contaminants are a major concern because they are present in concentrations that are harmful to marine organisms. DDT, PCBs and chlordane are of particular concern because they biomagnify, meaning that they increase in concentration at higher levels of the food chain. That's why dolphins and sea lions can have DDT concentrations in their tissues up to 80 times higher than we find in sediments.

DDT in white croaker is an example of the overall problem of contaminated sediments. DDT is a cancer-causing chemical that was discharged in large quantities off the Palos Verdes Shelf during the 1950s and '60s. Although banned in 1972, deposits of DDT and its derivatives, DDD and DDE, remain in



Total DDT concentrations in surface sediments of Santa Monica Bay and Palos Verdes Shelf, 1989. (Map contours contain areas of measurement).

Bay sediments where they very slowly degrade or disperse.

White croaker (a commonly caught sportfish) are bottom-feeders; they eat small sediment-dwelling organisms that have ingested DDT and thereby accumulate the chemical in their tissues. Hence the posted warnings against eating white croaker caught in Santa Monica Bay.

Also found in Bay sediments are a set of heavy metals: cadmium, copper, chromium, nickel, silver, zinc and lead. The major sources of sediment contamination have been wastewater treatment facilities; thus the accumulations are highest near treatment plant outfalls off Palos Verdes and Playa del Rey. Fortunately, successful source control programs have decreased discharges of most heavy metals (with the exception of silver) and resulted in declining levels of contaminants in sediments.

While areas with high levels of contaminants such as DDT, PCBs and lead still remain, the top layer of sediment over most of the Bay is actually cleaner than it was in the 1980s. Wastewater pretreatment programs, improved treatment technology, and efforts to educate the public and businesses about preventing pollution have all contributed to this improvement.

Habitat Impacts

Human activities—agriculture, urbanization, commercial and industrial development—have significantly degraded and altered the Bay's habitats since the era of Spanish missions and ranchos. Pollution of the marine environment, as well as natural variability and phenomena such as the climate and water temperature changes wrought by El Niño events, have also contributed to changes in the Bay's plant and animal communities.

THE PELAGIC HABITAT

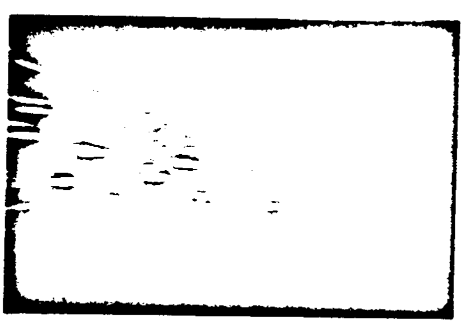
The open water (*pelagic*) habitat of Santa Monica Bay sustains an abundance of life. It is affected by nutrients, sunlight, currents, fresh water, sediments, temperature fluctuations and weather. Due in part to these ever-changing factors, the Bay's 306 square miles of pelagic habitat supports a great variety of organisms. The smallest include bacteria, phytoplankton and zooplankton. The largest are whales, dolphins, sharks and large fishes. In the middle of the pelagic food web are anchovies, sardines, mackerels and squid. As with all food chains, the smaller organisms tend to be food for the larger, and variation or loss of any part of the chain affects all parts.

The Bay's pelagic habitat varies on a fairly regular, seasonal basis. Two factors which probably most affect the abundance of pelagic animals are temperature and phytoplankton production.

THE BENTHIC HABITAT

Another name for the bottom of the Bay is the *benthic* habitat. Scientists have been measuring the effects of pollution on the plants and animals of the benthic habitat, particularly near the sewage outfalls from Hyperion and the JWPCP, since the early 1950s. Benthic organisms are considered good indicators of environmental health because they are not as mobile as fish and they live in the sediments where contaminant concentrations are generally the highest.

Most of the Santa Monica Bay sea floor consists of soft sediments, which are a mixture of sand, silt and clay. This subtidal, soft-bottom habitat supports a diverse number of organisms, including more than 100 species of bottom-dwelling (*demersal*) fish. Major members of the fish community in the Bay's shallow soft-bottom regions include white croaker, queenfish, surfperches, California halibut and barred sandbass.



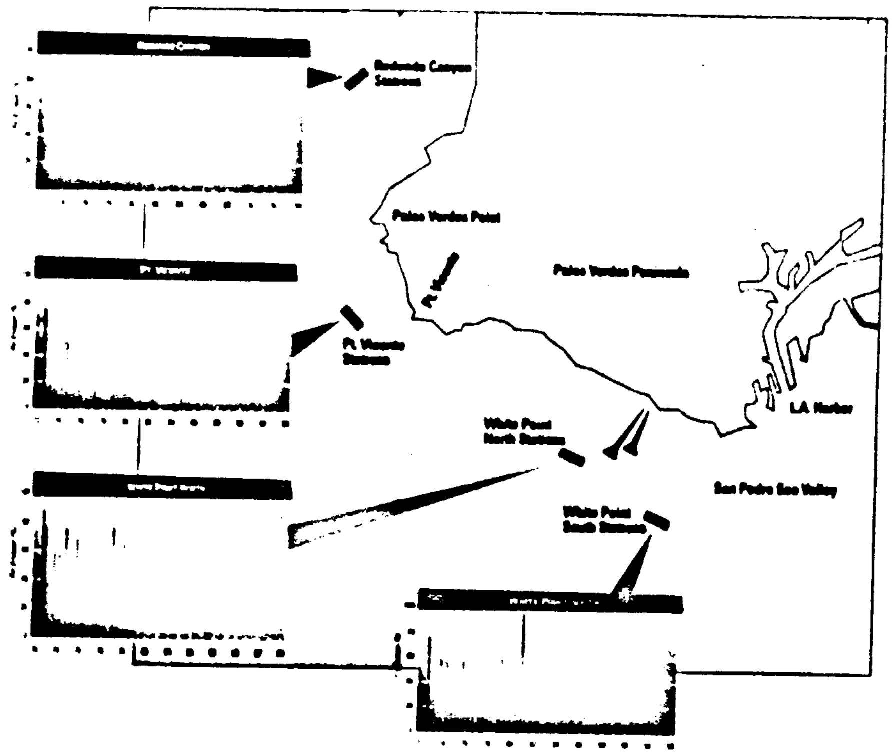
The pelagic habitat of the Bay sustains an abundance of life.

Through the 1970s, the Bay's benthic habitat appeared more changed and degraded the closer one measured to the sewage outfall discharge areas. This meant that these areas of Bay bottom supported far fewer numbers and types of species of plants and animals; in short, the environment was unhealthy and lacked diversity.

Today, the ocean floor areas affected directly by wastewater outfalls have become significantly smaller. Although the effects of the wastewater on surrounding fish and invertebrate communities are still noticeable, environmental monitoring programs show that marine life communities near outfalls are beginning to resemble those in more pristine areas.

Tumors, fin erosion and other diseases—at one time common—are now only rarely observed in demersal fish such as Dover sole. Sensitive species are returning to areas from which they were long absent. Even the severely

The incidence of fish diseases such as fin erosion has declined significantly over the past two decades.



degraded environment around the now-closed Hyperion seven-mile sludge pipe is slowly recovering, as evidenced by declining contaminant concentrations in sediments and increased species diversity.

The benthic environment can also be impacted by trash and debris that sink to the bottom of the Bay. One particular section of the Bay floor, to the north of Hyperion's seven-mile outfall, has a reef of old beer and soda cans at a depth of about 175 feet, refuse dumped for decades by fishermen and pleasure boaters.

KELP BEDS

Over the years, kelp bed canopies have varied considerably in size and extent. The reasons for fluctuations in both the size of kelp bed canopies and the health of the plants have been studied and debated for decades. Over-harvesting, waste discharge, storms, oil spills, turbidity and warm water are all thought to have contributed to the loss of kelp beds. To date, no single cause has been identified and the luxuriant regrowth of kelp in areas from which it had disappeared has reassured many that declines are reversible.

However, it does seem that nutrient availability is a major influence on the health and survival of kelp. This is also true of large, destructive storms, the impact of which was clear in 1983 and 1988 when storms decimated the kelp canopy.

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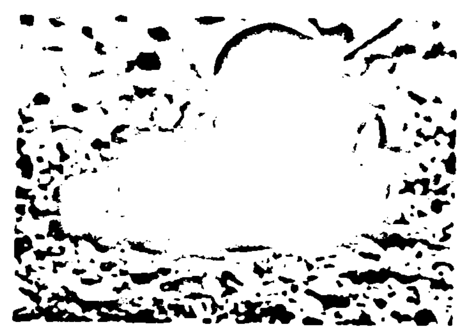
BEACHES AND ROCKY INTERTIDAL HABITATS

Prior to development, the coast between Santa Monica and the Palos Verdes Peninsula consisted primarily of sand dunes and sandy beaches which shifted due to the action of air and water currents. The process of urban development over the years has changed the way beaches are created, both because jetties and other man-made structures interfere with the coastal distribution pattern, and because the sediments which help replenish beach sands are now held back by dams or diverted into flood control channels and deposited elsewhere on the coast.



Certain species are of particular concern specifically because of the loss or degradation of Southern California beach habitat. These include the endangered California least tern, El Segundo blue butterfly and Western snowy plover.

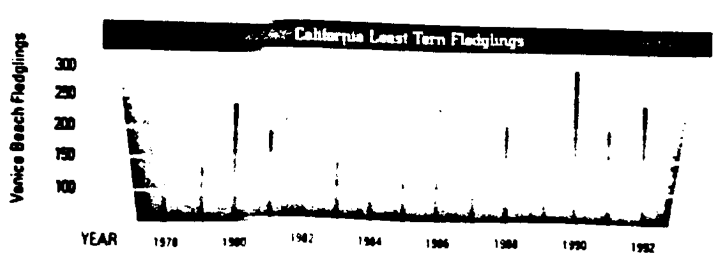
Projects underway to protect the California least tern include providing protected nesting habitat near suitable foraging areas. Venice Beach has one of the most successful breeding sites in California. The SMBRP has worked with other local agencies to establish a second colony near Playa del Rey.

The El Segundo dunes, habitat for the El Segundo blue butterfly, are a remnant of a once vast coastal ecosystem. Over 900 species of plants and animals have recently been recorded on these dunes, at least 11 of which exist only within its boundaries. Restoration of this unique habitat has begun and plans are underway to establish a Dune Habitat Preserve.

Oil spills are also a potential threat to beach and intertidal habitats, especially to such species as the California grunion, which lays its eggs on sandy beaches.

The recovery of the endangered California least tern population depends on the availability of protected nesting habitat.

With intense and increasing human use of the beaches and waters of Santa Monica Bay, both trash and the need for beach clean-up have increased. Finally, beaches and rocky intertidal habitats are vulnerable to the contaminants often contained in urban runoff. Filter-feeding intertidal organisms have a particularly high potential for bioaccumulating toxic organic compounds. The susceptibility of intertidal communities can be inferred from the high concentrations of trace metals such as lead and chromium found in the tissues of California mussels near Marina del Rey.



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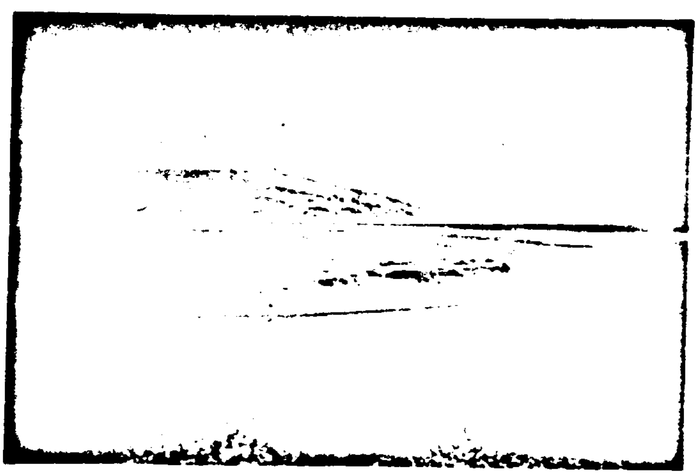
WETLANDS

Wetlands in Southern California include freshwater, saltwater and brackish-water marshes, swamps and mud flats. Marine wetlands develop where streams enter the ocean across a low, flat coast and are modified by differences in salinity and by the tidal cycle. Wetlands help mitigate flooding, filter and recharge groundwater, and provide feeding and breeding habitat for fish and waterfowl.

There are ten brackish wetlands along the edge of Santa Monica Bay, the largest of which are the Ballona Wetlands Complex (Ballona Wetlands, Ballona Lagoon, Del Rey Lagoon) and Malibu Lagoon.

At one time, the Ballona Complex was 2,100 acres of coastal estuary and wetlands. With the development of Marina del Rey, the Venice canals, and other residential and commercial properties; the draining of wetlands for agricultural use and to control insects; and the channelization of Ballona Creek; the Ballona Complex has been reduced to approximately 430 acres. The 260-acre Ballona Wetland is the largest remaining wetland within this complex. The site is a mixture of habitats dominated by coastal salt marsh. The 16-acre Ballona Lagoon is an artificially confined tidal channel that connects the Venice canals to the Pacific Ocean.

Malibu Lagoon is the most significant coastal lagoon in the Santa Monica Bay area, providing habitat for fish and resident and migratory birds.



The 40-acre Malibu Lagoon, at the mouth of Malibu Creek, is also a remnant of a larger system.

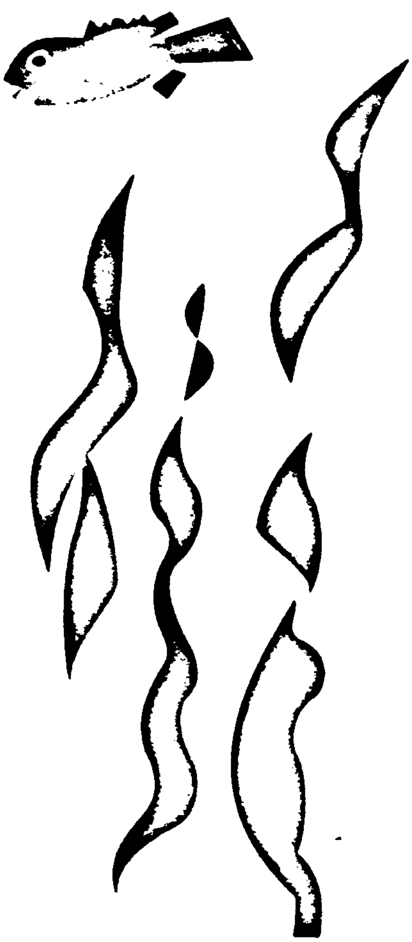
Most local wetlands support less biological diversity and are less productive because of their degraded condition. Restricted water flow, which results in poor water quality (high levels of nutrients and/or contaminants), is the main concern at most sites. Additional adverse impacts include the lack of shallow water habitat, disruption of upstream flow, introduction of non-native plants and animals, debris and bacteria from urban runoff, and recreational over-use.

The wetlands of Santa Monica Bay support a variety of marine and terrestrial life; however, many of the species characteristic of pristine salt marshes of Southern California are lacking. Vegetation is often sparse and includes or is dominated by introduced species which often compete with native species. The salt-marsh bird's beak (a federally- and state-listed endangered plant) is no longer found in the area. Belding's savannah sparrow (a state-listed endangered species) is a year-round resident of salt marshes, foraging and nesting in pickleweed, a dominant plant of the upper marsh. The population of this sparrow was low but stable until 1990, when it began to decline, in part because of predation by introduced red foxes. Attempts to remove the foxes have met with limited success.

Other "listed" birds which have not been seen for some time (due to the absence of cordgrass) are the light-footed clapper rail and the black rail. The black-necked stilt, another species of concern, has not nested recently in the local wetlands.

Animal communities in the sediments, lagoons and channels of local wetlands are also less diverse than in the past; some of the most abundant invertebrates found now are indicators of stressed conditions. Populations of some fish species, such as steelhead trout, have decreased to precariously low numbers. The tidewater goby was recently reintroduced to its original habitat at Malibu Lagoon, although its survival is far from guaranteed.

Although several plans have been developed to preserve and restore Santa Monica Bay wetlands, attempts have often been hampered by the complex issues associated with wetlands restoration. The SMBRP has mapped and inventoried the Bay's remaining wetlands and has targeted key areas for restoration, enhancement, and protection. Habitat restoration plans are an important feature of the BRP, and are described in Chapter Four of this summary.



Potential Human Health Impacts

Throughout millenia, humans have used nearby bodies of water for food and recreation. The loss of the ability to enjoy fishing, swimming or surfing in Santa Monica Bay because of potential human health risks would deprive many people of this important natural and economic resource. Yet surveys indicate that in the minds of many residents as well as potential tourists, Santa Monica Bay has been essentially closed due to pollution. While the perception of danger is often exaggerated, it is based on real problems that must be resolved through effective action.

Seafood Consumption

Synthetic organic contaminants such as PCBs and DDT (and its derivatives DDD and DDE) present the greatest risk to individuals who consume seafood from Santa Monica Bay. Over the past 25 years, several species (especially filter-feeding invertebrates and demersal fishes) from contaminated areas have exhibited very high levels of PCBs and DDTs. After the discharge of these chemicals was stopped in the early 1970s, contaminant levels in fish tissues declined steeply. However, since about 1982, no additional decreases have been observed.

Because of the presence of these chemicals in fish from the Palos Verdes Shelf and northern Santa Monica Bay, the state Office of Environmental Health Hazard Assessment (OEHHA) conducted a comprehensive seafood contamina-

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[illegible] RECOMMENDATIONS

Location	Do Not Consume	No more than one meal a month	No more than one meal every two weeks	No restrictions
Pt. Dume	White Croaker			
Malibu Pier		Queenfish		
Malibu (offshore)	White Croaker			
Santa Monica/ Venice Piers				All species
Venice Beach				All species
Marina Del Rey				All species
Short Bank			White Croaker	
Redondo Piers			Corbina	
Redondo Beach				All species
Palos Verdes (Northwest Side)	White Croaker			
Pt. Vicente	White Croaker		Sculpin, Rockfishes, Kelp bass+	
Cabrillo Pier	White Croaker		Queenfish, Black Croaker, Surfperches+	
Pier J (Queen Mary)			Surfperches	
LA/LB Harbor Breakwater		White Croaker, Queenfish, Surfperches, Black Croaker+		
Belmont Pier			Surfperches	
Horseshoe Kelp		Sculpin, White Croaker+		

+ for all species combined

Note: One meal is about six ounces (170g)

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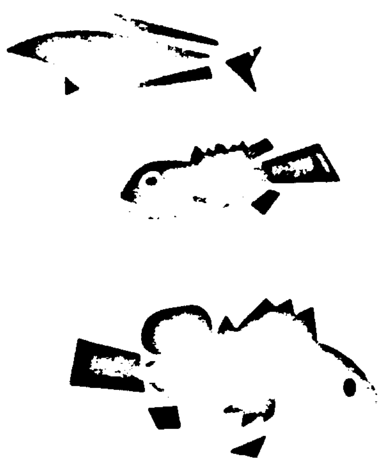
tion study and risk assessment in 1991. OEHHA measured levels of several contaminants (including PCBs and DDTs) in fishes from the Bay and assessed the potential health hazards of consuming various fish species.

The OEHHA report was supplemented by a SMBRP study of local seafood contamination released in 1992. This survey examined the extent of contamination in yellow rock crab and white croaker at several Bay locations.



White croaker is generally considered to be the most contaminated fish in the Bay, especially those from areas such as the Palos Verdes Shelf. Other species found to be relatively contaminated at certain locations are California corbina, queenfish, surfperches and California scorpionfish. Contaminant concentrations in Pacific bonito, chub mackerel, Pacific sanddab, Pacific barracuda, opaleye, halfmoon and California halibut are generally very low. Site- and species-specific consumption recommendations for the most frequently caught and consumed fishes in the Santa Monica Bay area are shown on the previous page.

In general, metal levels in edible tissue of fishes and invertebrates from near the JWPCP and HTP outfalls in the last ten years have not been substantially higher than at reference (clean) sites elsewhere in Southern California. Although sediments near the outfalls often contain high metal concentrations, there does not appear to be an appreciable health risk from metals contamination because metals do not bioaccumulate or biomagnify in fish.

An SMBRP-funded study will describe seafood consumption rates and patterns of Santa Monica Bay anglers by ethnic group, fishing site and fish species. This information will ultimately be used to calculate the potential health risks specific to consumption of Santa Monica Bay seafood and to develop warnings and educational materials that are targeted to particular user groups.

Swimming

Reports from the public, environmental organizations, political leaders, the news media and others indicate that swimmers increasingly complain about ear, eye, wound and intestinal infections, skin rashes and other illnesses that allegedly occur as a result of contact with Bay waters.

Generally, these reports are anecdotal from the perspective of public health officials, inasmuch as they are generally made second-hand, or long after the incidents took place—i.e. circumstances which do not allow a researcher to form even the most preliminary conclusions. Therefore, no clear evidence that swimmers are in fact experiencing increased rates of such illnesses due to Bay pollution is available. At the same time, there is no basis for discounting the anecdotal evidence either.

One thing is clear: the reports of illness from swimming in the Bay have contributed to the public's alienation from this most accessible recreational resource. Beach closures due to sewage spills and warnings of contaminated storm drain runoff have heightened this concern. Indeed, the Bay has developed a reputation for severe pollution—an undeservedly extreme characterization of the Bay's pollution problems—largely because of the continuing perception that swimming in the Bay is hazardous. An SMBRP survey of 500 Los Angeles County adults showed that 41 percent of the public does not visit the Bay because of their concern about water pollution, with many claiming, "I might get sick if I swim in the water."

In investigating sources of pollutants that could be responsible for possible adverse health effects, SMBRP researchers have found evidence that points to pathogens (enteric viruses and possibly pathogenic bacteria) that may be carried by urban runoff through storm drains into the Bay. In studies completed between 1989 and 1991, enteric viruses were found in the effluent at three widely-dispersed locations during dry-weather periods: Pico-Kenter and Herondo storm drains and Malibu Lagoon. These outlets collect flow from scattered locations and varied land uses around the watershed.

Warning signs near flowing storm drain outlets are part of an effort to alert beachgoers of potential pathogen contamination in urban runoff.

This was a disturbing and curious finding, inasmuch as enteric viruses are associated with human excrement. Why would pathogens be present in the storm drain system, given that it is completely separate from the sewer system? Possible sources include illegal sewer connections to the storm drain, leaking sewer lines, malfunctioning septic tanks, inadequate waste disposal by recreational vehicles, campers or transients. Research thus far has yet to yield a final answer.

Although high indicator bacteria counts have been found in nearshore waters surrounding storm drain outlets, no scientific studies have been undertaken to investigate the possible links between incidence of illness and swimming in urban runoff-contaminated waters. Additional sources of human pathogens in nearshore areas include sewage overflows into storm drains (especially during heavy rains), small boat waste discharges and bathers themselves.

Several approaches to address pathogen contamination have been implemented or are being investigated. One obvious and needed approach is to prevent pathogens and pathogen-contaminated runoff from entering the storm drain system.

Alternatively, pathogens in runoff can be diverted away from nearshore areas, as is the case at the Pico-Kenter storm drain, where the cities of Los Angeles and Santa Monica reached an agreement and in 1992 began to treat the drain's dry-weather flow at the Hyperion Treatment Plant.

A third, ongoing approach is to minimize public exposure to pathogens with warnings and advisories. SMBRP has been instrumental in placing updated warning signs near storm drain outlets and advising beachgoers 1) not to swim within 100 yards of flowing storm drains; and 2) not to swim in the Bay during and for up to three days after a storm.

As long as swimmers follow these warnings, the Bay's waters should be considered safe to swim in, and not a health risk as far as pathogens are concerned. Potential health risks associated with exposure to chemical contaminants are generally difficult to establish and are considered by public health officials to be relatively low. Obviously, this risk would be greater if a hazardous substance spill occurred.

Monitoring Location	Total Coliform		Enterococcus	
	1991 1992	1992 1993	1991 1992	1992 1993
Zuma Beach	--	*	*	
Latigo Beach (26800 block Latigo Shore Dr.)	16	*	30	15
Malibu Beach (at Malibu Point)	*	15.6		
Malibu Beach (at Malibu Lagoon)	7.5		25	
Topanga Beach	--	*	5	
Will Rogers Beach (at Sm Canyon south)	27.3	27.5	20.5	37.5
Santa Monica Beach (at Santa Monica Pier)	10.2	30	8.1	12.5
Santa Monica Beach (at Pico-Kenter drain south)	10.2	*	11.4	10
Santa Monica Beach (at Ashland drain south)	13.6	22.5	8.1	*
Venice Beach (at Venice Blvd.)	--	7.7	8	
Marina del Rey Beach (Lifeguard Tower)	13.6	10	31.8	8
Dockweiler Beach (at Ballona Creek)	38.3	50.2	63.8	88.9
Dockweiler Beach (at Imperial Hwy.)	6.8	17.5	*	7.5
Manhattan Beach (at 8th St.)	--	*	34.5	
Hermosa Beach (at Hermosa Pier)	--	*	*	
Redondo Beach (at Redondo Pier south)	75	20.5	17.5	
Arroyo Circle	--	7.4	5	

(*) less than five percent. Weekly data, except daily sampling locations

Percentage of dry-weather days that bacterial indicators exceeded levels of concern.

Where Do We Go From Here?

In the first three chapters of this public summary, we've examined the history of the Santa Monica Bay watershed, the impacts of pollution on it, and what we know about its present health. Given what we know, how can we learn more about what we don't know, rectify the mistakes we've made, and rehabilitate and restore this fragile but resilient ecosystem?

The first three chapters of this summary have illustrated that what we do to the web of life affects us all. In view of this truth, what specific actions can we take to protect Santa Monica Bay and its environs? How can we more effectively promote pollution prevention? How can we ensure Bay seafood is safe to eat, and that it is safe to swim in Bay waters? In short, how can we be sure that the health of this valuable and treasured ecosystem is adequately protected? These questions are addressed in the remaining pages of this summary.

[1]Enteric: intestinal

[2]Indicator: a species of plant, animal, or bacterium whose presence is associated with or indicative of, a particular environmental condition

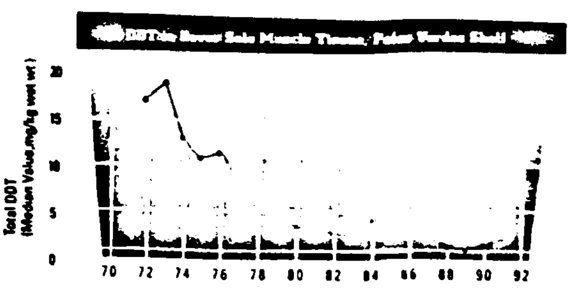
W IS THE BAY DOING?

It is difficult to analyze the effect that human activities have on the condition of the Bay because of the presence of numerous and complex variables. The following indicators nonetheless provide quick "snapshots" of Bay health. They relate back to the basic concerns of how safe it is to swim in and eat seafood from the Bay, and about the health of Bay marine life.

In Chapter 2, we saw that Pollutant Loads to the Bay from sewage treatment facilities continue their decade-long decline. As a result, urban runoff contributes an increasingly greater proportion of pollutants discharged to the Bay.

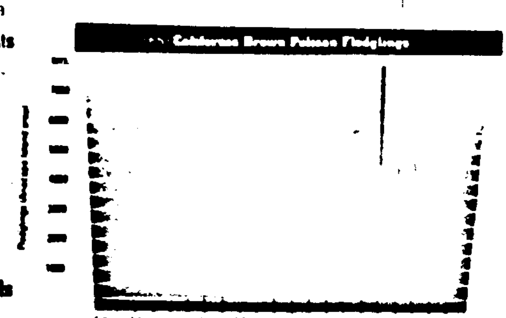
Species Diversity and Benthic Organism Health have improved. Areas of the ocean floor showing species diversity and healthy "normal" creatures have increased. Page 39 shows how incidences of fish diseases such as fin erosion and tumors are now only rarely observed and sensitive species are returning to areas where they were previously absent.

Contamination of Bay Sediments can be assessed by examining concentrations of toxic compounds in fish tissue. Dover sole is one type of fish that is used to measure sediment contamination because it feeds at the bottom of the Bay and remains in a localized area. Although DDT concentrations in Dover sole tissue has declined since the 1970's, it has not changed significantly over the last decade, especially on the Palos Verdes Shelf where DDT remains in ocean floor sediments. Once clean-up decisions about the DDT contamination are finalized, we can expect to see improvements in this indicator as well.



Population Trends of Endangered Bird Species are also measures of Bay health.

The California brown pelican nearly became extinct due to almost complete reproductive failure caused by extreme eggshell thinning induced by the pesticide DDT. This pollutant magnified in the food web and was ingested by pelicans through the fish that they consumed. Reproductive success of the pelican has increased substantially since the termination of DDT disposal into coastal waters.



The California least tern visits Southern California in mid-April to breed. California beaches once teemed with these little birds but human encroachment on their favorite nesting sites had reduced the population of these terns to an estimated 600 nesting pairs statewide by 1975. The establishment of protected nesting sites, such as the one at Venice Beach, has helped the birds bounce back to nearly 1,800 nesting pairs between the San Francisco Bay and the Mexican border.

Bacterial Contamination in the Surf Zone indicates where swimming in the Bay may be more or less problematic. It is not a perfect guide because the bacterial indicators—coliform and enterococcus—could indicate the presence of animal waste or plant decay, as well as human fecal waste, which is of greater concern. Nonetheless, the chart on page 46 focuses on bacterial indicator measurements during dry weather—traditionally the time of greatest use of the Bay by swimmers. It shows that the standards for these indicators are exceeded on numerous occasions at certain storm drains and piers around the Bay during the summer season.

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ACTIONS

FOR BAY

RESTORATION

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Actions for Bay Restoration

The Public Summary has thus far explored Santa Monica Bay's physical and biological features and the effects of human activity on the Bay ecosystem. This chapter provides an overview of the Restoration Project's recommended actions to restore, protect and improve the Bay.

This summary follows the structure of the Bay Restoration Plan. The condensed chapter format states the **Problem** to be solved; describes the **Actions**; and highlights the **Priorities** in easy-to-read, bullet form. For reasons of space, we do not list every individual action item, implementor and timeframe. Instead, we provide a narrative that focuses on the intent and scope of the recommended actions. The full, comprehensive set of recommendations is available in the companion Bay Restoration Plan, available on request.

PLAN CONTENTS

The Santa Monica Bay Restoration Project

In 1988, the U.S. Environmental Protection Agency and the State of California recognized Santa Monica Bay as a natural resource that must be protected and preserved. As a result, the Santa Monica Bay Restoration Project was nominated and accepted into the National Estuary Program (NEP). As an NEP, the Santa Monica Bay Restoration Project (SMBRP) is charged with assessing the Bay's problems and with producing a Bay Restoration Plan (BRP) to serve as a blueprint for the Bay's recovery.

Summary of the Bay Restoration Plan

PREVENTING POLLUTION AT THE SOURCE

Pollutants clearly pose the most significant problem to the Bay, its users and its inhabitants. The first section of the Plan addresses the problem of Bay pollution by delineating management strategies and programs that apply to pollutants that are of concern in Santa Monica Bay, as well as the major sources and pathways by which they enter the Bay.

Reducing pollutant loadings to the Bay in a manner that prevents degradation to the marine ecosystem, protects beaches and minimizes risks to human health is a key goal of the Plan. Integrated and comprehensive management and control of various pollutant sources is another.

The Plan recognizes that it is neither feasible nor necessary to control all types and sources of pollutant inputs and therefore focuses on those that present the greatest problems to the

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Bay. This Plan's approach to comprehensive pollution management therefore identifies 19 "pollutants of concern" as the priorities for action during the five-year Plan implementation period. This approach emphasizes prevention at the source, targets pollutant reduction measures on an area-specific basis, addresses historic contamination separately from new contaminant sources, and calls for a revised regulatory approach utilizing the concept of mass emissions. Each of these strategies applies to specific, but often overlapping, sets of pollutants. Pollutant sources are also targeted in accordance with their impacts on the marine environment and on human health.

Integral to "preventing pollution at the source" are effective public education and involvement programs, as well as a comprehensive monitoring program that assesses the environmental condition of Santa Monica Bay and the effects of human activities on it.

Integrated Pollution Management

Problem: Historically, water quality management addressed pollution problems that were most visible and most readily fixed. Pollution reduction measures therefore focused primarily on end-of-the-pipe solutions to discharges from individual municipal and industrial point sources of pollution. Although this approach has successfully dealt with significant pollution problems, a new management framework is necessary to integrate control of point and nonpoint pollutant sources such as storm water discharges, urban runoff and atmospheric deposition.

Actions: Integrated pollution management is a two-pronged approach that provides a framework to more cohesively and efficiently address water quality issues. The Plan calls for **watershed-based coordination** of permitting and other water quality regulatory functions. Some of the expected outcomes include concurrent development and renewal of discharge permits by watershed, standardized monitoring requirements and more cost-effective implementation of control measures.

Integrated pollution management provides a framework to more cohesively and efficiently address water quality issues.

The second integral component of improved water quality management is implementation of a **"mass emissions" approach.** This approach, which would apply to 12 pollutants of concern, would complement the existing concentration-based regulatory system by establishing non-punitive performance goals to measure progress made toward protection of the Bay's beneficial uses.

Priorities:

- Coordinate all components of the NPDES program with other regulatory functions on a watershed or sub-watershed basis.
- Revise current NPDES permits to incorporate new pollutant management approaches and develop new enforcement mechanisms if necessary.
- Develop and implement a mass emissions approach. Also establish initial mass loading discharge performance goals for pollutants of concern that

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accumulate in the marine environment and for which there are reasonable mass loadings estimates and feasible control measures.

Pollution Prevention and Source Reduction

Problem: Pollutants originate from many diffuse but potentially significant sources in the Santa Monica Bay watershed. People, cars, boats and businesses send pollutants to the Bay through indirect channels such as sewer and storm drain systems, as well as through direct discharges such as industrial outfalls. Toxic pesticides and chemicals, metals, waste oils, plastics and debris are among the many types of pollutants released into the environment from these sources.

Managing and controlling pollutants that come from many small, diverse sources is a difficult task. With a projected population of about 12 million people in Los Angeles County by the year 2010, it can be expected that the generation of pollutants will increase unless we continue our efforts to reduce and prevent these discharges.

Actions: The Plan is based on the simple principle that it is more effective to reduce or eliminate pollutants at their source, **before** they are created. Pollution prevention, unlike control methods which capture waste only **after** it is created, requires re-thinking how polluting substances and products are used in the home and in the workplace. Fortunately, practices such as reducing toxics use on land and conserving water also help improve conditions in the Bay. Programs that reduce pollutant loads to sewage treatment plants, reduce household hazardous wastes, educate the public about the impacts of marine debris and litter on the ocean ecosystem, reduce air pollution and encourage the development of innovative approaches to pollution prevention are all part of a comprehensive strategy to prevent and reduce pollutant discharges into the environment.

Priorities:

- Coordinate and expand public education programs that focus on reducing generation of household toxics.
- Expand programs for recycling and collection of household hazardous wastes.
- Encourage creation of markets for use of recycled hazardous materials.
- Continue support of annual Coastal Cleanup Day and Adopt-a-Beach activities.
- Implement measures that prevent discharges of pollutants into marina waters.

PRINCIPLES

Over the last five years, seven principles served as the foundation on which the Bay Restoration Plan was built

Environmental Stewardship: Our generation has inherited the responsibility to act as stewards of the Earth's natural resources

Consensus Planning: The Plan was developed collaboratively with the Bay's many stakeholders, using the best available scientific and technical information.

Enhanced Regulatory Enforcement: It is essential to first improve implementation of existing laws and regulations before creating new ones.

Fiscal Responsibility: The Plan recognizes the fiscal limits of public agencies and the importance of balancing investments in Bay restoration with the need for economic development, public safety, and other social and environmental goals.

Respect For Diversity: The diversity of life in the Bay and its watershed richly contributes to the region's environment, economy and quality of life.

Community Involvement: The Plan incorporates the views and interests not only of the Management Conference but also of the communities that its members represent.

Watershed Perspective: The Santa Monica Bay watershed is viewed as a single hydrological entity and the political jurisdictions within it recognize that the Bay unites them.

Nearly 50,000 households around the Los Angeles basin participated in hazardous waste roundup days in 1993.

- Ensure that sufficient pumpout facilities are available, maintained and used at moorage facilities in marinas.

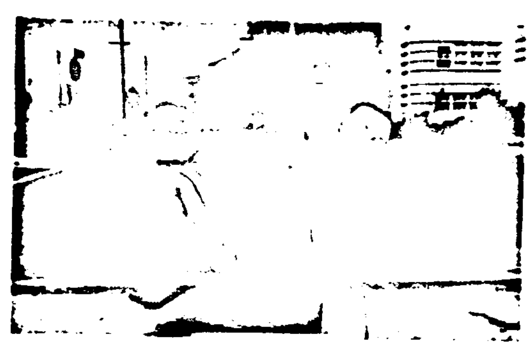
Storm Water/Urban Runoff

Problem: Storm water/urban runoff is the most significant source of "nonpoint" pollution to Santa Monica Bay. Twelve of the Bay's 19 pollutants of concern are found in urban runoff including pathogens, toxic metals, nutrients and trash. Pollutants found in storm drain runoff originate from a vast array of activities in the watershed and discharge into nearshore areas of the Bay mostly without treatment, degrading the Bay's recreational, biological and aesthetic values.

Efforts to manage storm water/urban runoff are carried out under municipal, industrial and construction National Pollutant Discharge Elimination System (NPDES) permits. In 1990, the municipal NPDES permit was issued to Los Angeles County, its 89 cities and other governmental entities and directed them to select and develop Best Management Practices (BMPs) to prevent pollutant discharges. The term of the current permit will expire in 1995.

Actions: Many innovative approaches to address the distinct issues associated with management of storm water/urban runoff pollution are presented in Chapter 3 of the Plan. It is proposed that the current NPDES permit framework be strengthened by improving coordination of the program and by implementing management measures on a watershed basis. A major challenge of the storm water permit is to ensure the implementation of the most effective BMPs. Examples of BMPs include land use ordinances that control construction site erosion, and public education campaigns. The Plan establishes a selection hierarchy, recommending that economical, non-structural measures with watershed-wide benefits be implemented first.

Programs such as storm drain stenciling involve the public in reducing urban runoff pollution.



Priorities:

- Revise and incorporate new program elements into the storm water NPDES permits.

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ACCOMPLISHMENTS

The SMBRP has undertaken many significant projects and programs that support and further the goals of Bay restoration and protection. They include:

- Initiation of Los Angeles County's first municipal stormwater permit.
- Restoration of the Zuma Creek wetland.
- A 14-point program of "early actions" to jump-start the Bay restoration process.
- A mini-grants program which provides funding to schools, inner-city youth, environmental groups, and municipalities to involve the public in Bay resource protection and pollution prevention efforts.
- An innovative research project that found human enteric viruses in several storm drain outlets to the Bay. Design of the first epidemiological study to assess human heath risk of swimming in contaminated runoff on the West Coast.
- A seafood contamination study and analysis of local sportfish consumption patterns which will lead to better information about potential health risks of consuming of Bay seafood.
- Creation of a nation-wide campaign for school-age children (utilizing the Teenage Mutant Ninja Turtles) to raise awareness about urban runoff and storm drain pollution.
- A demonstration project on ozone treatment of dry weather storm drain flows.
- Marine debris educational displays and recycling stations on Bay beaches. Tripled volunteer participation in Coastal Cleanup Day.
- A public opinion survey that gauged attitudes about the Bay and the public's willingness to participate in its restoration.
- Creation of the non-profit Santa Monica Bay Restoration Foundation.

- Increase staffing for regulatory oversight of the storm water NPDES program and for local agency coordination and compliance activities.
- Develop mechanisms to address small discharges of contaminated runoff.
- Investigate technically achievable and cost-effective strategies to ensure better compliance with existing storm water regulations and achieve water quality improvements in areas impaired by storm water discharges.
- Review environmental impact documents to ensure that impacts of storm water discharges are addressed and mitigated.
- Reduce impacts of transportation activities on storm water/urban runoff pollutant loads.
- Develop and implement a five-year urban runoff education strategy.
- Implement "tested" Best Management Practices (Menu "A" BMPs) by 1996.
- Adopt and enforce land use ordinances that reduce runoff from commercial and industrial facilities and at construction sites.
- Conduct pilot projects to assess the effectiveness and applicability of additional (Menu "B" and "C") BMPs.
- Conduct research on dry-weather, wet-weather and sediment toxicity of urban runoff, and recommend necessary changes to monitoring programs.

Municipal and Industrial Discharges

Problem: Los Angeles County's nine million residents utilize the Bay for a wide variety of purposes, including the discharge of treated domestic, commercial and industrial wastes. Currently about 645 million gallons of treated municipal wastewater are discharged to the Bay by the region's two major sewage treatment systems.

Although municipal wastewaters have been a significant source of contaminants to the Bay, extensive and continuing improvements in treatment processes along with stringent industrial waste controls have reduced contaminant levels to a fraction of former levels. Effects of wastewater outfalls on surrounding fish and invertebrate communities are still noticeable, however, environmental monitoring programs show that these marine life communities are beginning to resemble those in more pristine areas. Nonetheless, future population

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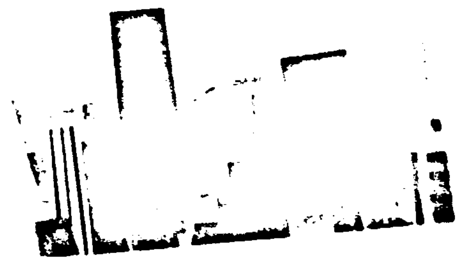
and economic growth could offset these gains unless a continuing, comprehensive pollutant reduction strategy is implemented.

Actions: The Plan calls for a variety of actions to reduce pollutant discharges and improve management and control of pollution from municipal and industrial sources. Completing upgrades to full secondary treatment of all direct municipal wastewater discharges to Santa Monica Bay is a primary element of this program. The Plan also outlines the necessity of beneficially using both the resultant reclaimed water and biosolids from wastewater treatment. Reclaimed (tertiary treated) water, which is currently generated at many upstream treatment plants, is a reliable, drought-proof water source that can help meet the region's vast needs for landscape and agricultural irrigation, industrial cooling water supply, and most importantly, groundwater recharge. Concurrently, water reuse can significantly reduce wasteloads discharged to the ocean.



Recommendations for improved management of point source discharges include ensuring adequate staffing and resources for NPDES permit enforcement activities; revamping of permit processing and record keeping procedures; implementing the comprehensive monitoring and data management program; and enhancing industrial pretreatment programs.

A priority of the Plan is to ensure that the Hyperion and JWPCP wastewater treatment facilities attain full secondary treatment levels.

Priorities:

- Complete construction of full secondary facilities at the Hyperion Treatment Plant and remedy storm-related sewage overflow problems by 1998.
- Install full secondary treatment facilities at the County Sanitation Districts' Joint Water Pollution Control Plant by 2002.
- Continue to develop markets and opportunities for use of reclaimed water.
- Explore alternative mechanisms/strategies to ensure adequate staff and resources, legal support for NPDES and pretreatment permit activities.

Oil and Hazardous Materials Spills

Problem: Hazardous materials spills, including oil, can cause massive ecological damage in a very short time. Moreover, the cumulative effect of numerous minor spills can also adversely impact the Bay's ecosystem.

Actions: Using a four-part strategy, the Plan addresses both land spills (which make their way to the Bay via the storm drain system), and marine spills. The focus is on spill prevention, effective response, restoration of resources to their pre-spill condition and public education. The Plan calls for reducing the spillable inventory of hazardous materials in the watershed, speedy mobilization through improved inter-agency coordination, establishment of animal rehabilitation centers, compilation of a natural resources data base, and spill response training for fishermen and other volunteers.

Priority:

- Sign a Memorandum of Understanding (MOU) that authorizes cross-jurisdictional entry into storm drains to investigate spill incidents.

Contaminated Sediments

Problem: Hazardous amounts of toxic PCBs and DDT were dumped and/or discharged into the Bay between the 1940s and mid-1970s. Subsequent federal bans on these and other toxic substances have resulted in their overall decline, however, they persist in Bay sediments, where they are a source of contaminants to the marine ecosystem.

DDT and PCB toxic hot spots on the Palos Verdes Shelf are the subject of a federal lawsuit concerning damages to the Bay's natural resources.

Actions: In order to protect human health and the environment, specific "hot spots" caused by historic and present contaminant sources must be targeted for cleanup. The toxic hot spots of DDTs and PCBs around the JWPCP outfalls on the Palos Verdes Shelf and Slope are the subject of a pending lawsuit filed by the National Oceanic and Atmospheric Administration (NOAA). A natural resource damage assessment is currently underway and settlements will be used to remediate the damages to those resources.

Long-term protection of the Bay's sediments requires the development of sediment quality criteria based on research on the relationships between toxic discharges, sediment contamination and effects on the Bay's ecosystem.

PROTECTING THE PUBLIC FROM POTENTIAL HEALTH RISK

The question of potential health risk associated with eating Bay seafood and swimming in the Bay has been a major public concern. Such concern stems from reports that certain local sportfish are contaminated and accounts of swimmers experiencing illnesses due to contact with Bay waters. Chapter Three of this summary provides a detailed look at these public health issues, describing the current state of knowledge based on recent scientific studies.

The overriding goal is to protect and inform the public about potential health risks associated with fishing and swimming in the Bay. Identifying and eliminating the pollutant sources that impact these activities is the first step to achieving public health protection. However, reducing risks also means

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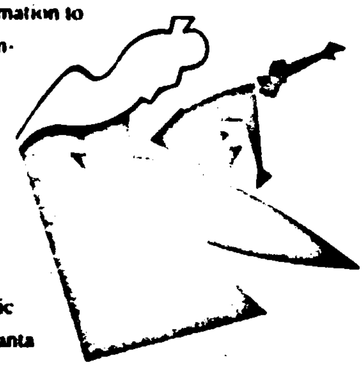
providing the public with information about the extent of potential health hazards, so that all potential consumers and users are well-informed enough to make choices.

SMBRP research efforts will lead to definitive health risk guidelines for Santa Monica Bay anglers.

Seafood Consumption

Problem: Eating contaminated seafood is the primary means by which humans are exposed to toxic substances in the marine environment. While recent studies have shown that health risks are limited to certain seafood species at certain locations, the public perception remains that all seafood in the Bay is contaminated.

Actions: Linking seafood consumption with possible adverse health effects requires a scientific evaluation known as "risk assessment." Risk assessments attempt to evaluate how chemical dosages are correlated with physical responses. The SMBRP is currently evaluating information about fish contaminant levels and consumption patterns in the Bay, which will lead to definitive health risk guidelines for Santa Monica Bay anglers. Long-term needs are for periodic updates of seafood risks, integration of seafood contamination information into the regional monitoring program, and development of a program to more effectively communicate information to the public about the benefits and risks of consuming Bay seafood.



Priority:

- Update and effectively disseminate seafood health risk information to Santa Monica Bay anglers on a regular basis.

Swimming in Bay Waters

Problem: It is clear that pathogens, or microscopic agents that cause illness, periodically enter the Santa Monica Bay surf zone. However, determining the sources of contamination, preventing pathogens from entering into swimming areas, and accurately assessing and informing the public about potential health risks associated with contaminated runoff remain a challenge.

Actions: Finding and removing pathogens where they originate is the primary means for reducing potential health risks to Santa Monica Bay swimmers. The Plan therefore calls for the development of a practical tool to identify these sources. Alternatively, under certain conditions, it is possible to divert or treat dry-weather flows, as is now being done with the flow from the Pico-Kenter storm drain.

An epidemiology study is regarded as the ultimate step necessary to answer the question, "How safe is it to swim in the Bay?"

An assessment of health risks (otherwise known as an epidemiology study) is regarded as the ultimate step necessary to answer the question, "How safe is it to swim in the Bay?" With this study, we will finally know if a risk exists and whether that risk differs accord-

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ing to where you swim. Together with a yet-to-be-developed bacterial indicator system, the "epi" study will also provide the basis for revising public health standards and water quality objectives.

As long as prevention and treatment measures do not sufficiently remove pathogen inputs, swimmers need to be properly warned about where and when pollution occurs.

Priorities:

- Develop a methodology for and conduct a sanitary survey to identify sources of human pathogen contamination.
- Conduct inspections and correct problems such as malfunctioning septic tanks, illegal connections to storm drains, and sewer line leaks.
- Divert and treat urban runoff where appropriate.
- Conduct an epidemiology study to assess health risk of recreational exposure to storm drain runoff in Santa Monica Bay.
- Accurately communicate health risk information to the public to minimize exposure to pathogens and to encourage use of safe swimming areas.

RESTORING, PROTECTING AND MANAGING BAY HABITATS AND RESOURCES

Restoration of degraded habitats, rebuilding of key species, and increased enforcement of marine resource protection laws are crucial for a healthy Santa Monica Bay.

Santa Monica Bay and its watershed are comprised of unique yet interdependent habitats that support an abundance and diversity of life. The Bay's aquatic ecosystem is made up of the marine ecosystem, wetlands, beaches and intertidal zones. The marine ecosystem is a collective term for three of the Bay's aquatic habitats—pelagic (open ocean), subtidal soft-bottom (seafloor sediments), and subtidal hard-bottom (seafloor reefs or outcrops). The transition areas between land and sea are the beaches, intertidal zones and coastal wetlands. Freshwater wetlands and riparian corridors are key elements of the freshwater ecosystem.

Despite the relative abundance of both aquatic and terrestrial life in and around the Bay, habitats in the Bay's watershed have been significantly degraded, altered and lost since the time that California was settled by Spanish missionaries. The marine ecosystem has been impacted by pollution, with declines of certain species and accumulation of persistent toxins in fish, birds and marine mammals. The goals for habitat restoration, protection and management respond to the need for a healthy and diverse ecosystem, while also recognizing the need for wise human use of these resources.

In order to ensure long-term protection of Bay resources, comprehensive habitat management strategies are needed. Reducing pollutant inputs into the ecosystem, restoring and increasing the quantity and quality of habitats, reversing declines in native species, increasing enforcement of natural resource regulations and promoting public stewardship of the Bay's environment are all vital to successful habitat protection and restoration.

Marine Ecosystem

Problem: Throughout the years, both natural and human-induced actions have resulted in degradation and, in some cases, elimination of particular habitats within the Bay's ecosystem. Loss of natural shoreline habitat and wetlands have reduced nursery areas for fish. Poaching and overharvesting have impacted species populations. Deep-water discharges of treatment plant effluents adversely affected large areas of the seafloor community through the 1970s. Biomagnification of toxins such as DDT and PCBs severely impaired the reproductive success of California brown pelicans. Natural events such as storms, elevated water temperatures associated with El Niños, and landslides also alter the marine environment.

Nevertheless, improvements are seen in certain Bay marine habitats, as evidenced by the now-lush kelp forests and rocky intertidal plant and animal communities off Palos Verdes, and by the ongoing recovery of fish and invertebrate communities near wastewater outfalls.

Actions: At this point, emphasis must be placed on the restoration of many of the degraded habitats around the Bay, as well as the enhancement of impacted species. Declining populations of key species need to be rebuilt, greater protection must be provided for unique and sensitive habitats, and increased enforcement of marine resource protection laws and regulations is necessary. Increasing the public's awareness of the importance of the Bay's marine resources and the impact that human actions can have on them is a crucial link to a restored and healthy marine ecosystem.

Priorities:

- Identify cost-effective methods to rebuild declining populations of key species such as abalone, Pismo clam, California spiny lobster, California halibut and white seabass.
- Characterize and map Santa Monica Bay's unique and sensitive habitats and other natural resources of special significance to ensure better long-term protection.
- Increase the number of Wildlife Protection Officers along Santa Monica Bay to enhance enforcement and education activities.
- Encourage citizen monitoring and reporting of wildlife violations.

The Plan focuses on restoring the ecological diversity and productivity of existing wetlands to increase both their function and value.

Wetlands

Problem: Wetlands are one of the most productive ecosystems in nature, providing essential habitat for a vast number of diverse species of plants and animals. The major impact to Santa Monica Bay wetlands has been the direct loss of habitat through draining, dredging, filling, diking and channelization to

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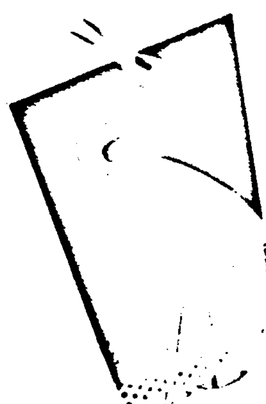
make way for farms, port/harbor facilities, housing and commercial development. It is estimated that more than 95% of the historic wetlands acreage of the Santa Monica Bay watershed has been destroyed.

What remains today are a few small coastal wetlands and lagoons, and some riparian (streamside) freshwater wetlands in the canyon areas of the northern part of the watershed. The coastal wetlands and lagoons are located in and near urban areas and are thus subject to intense human activity (intrusion, trash and invasive non-native plant species), while riparian wetlands are threatened by nonpoint source pollution and development pressures. Many species of animals and plants, some of which are listed as threatened and endangered, depend upon these habitats, making restoration and protection of these wetlands vital to a healthier Bay ecosystem.



Actions: Enhancement of wetland habitat in the Santa Monica Bay watershed focuses on restoring the ecological diversity and productivity of existing wetlands to increase both their function and value. Innovative actions to acquire and create wetland acreage, establishment of local land use ordinances to protect wetlands, and development of special area management plans are all called for in the Plan. A local/regional focus that complements state and federal wetland protection actions should result in comprehensive wetland management.

Priorities:

- Restore Ballona Wetlands. Determine the type and amount of habitat value to be attained through restoration and determine mitigation requirements based on the proposed development. Reach agreement on the "best" overall restoration design to achieve these habitat values. Develop a funding package to restore and maintain the wetlands and provide for long-term management and monitoring.
- Restore Ballona Lagoon to enhance its tidal flow and increase its habitat value.
- Restore Malibu Lagoon to enhance its habitat values and to ensure safe recreational use of the adjacent beach and ocean waters.
- Develop a special area management plan (SAMP) to protect and restore wetlands and riparian areas of the Santa Monica Bay watershed.

Beaches and Intertidal Zones

Problem: Beaches and intertidal zones are unique coastal habitats and home to hundreds of species of birds, fish, mammals and other wildlife. Development and urbanization of the Los Angeles basin has destroyed much of the original coastal habitat which once consisted of narrow beaches, rocky shore, sand dunes and wetlands rich in biological diversity and abundance.

Intertidal zones are also affected by storm drain discharges of debris and sediment, as well as beach litter and marine debris. Trash and other objects can

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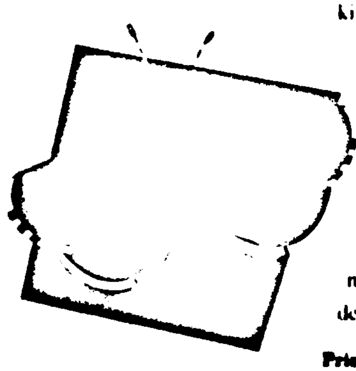

kill marine wildlife, degrade the aesthetic values of the Bay, and pose serious health and safety problems for Bay users.

Actions: The Plan calls for enhancing the protection of beach and intertidal habitats for threatened and endangered species and other species of concern. Protection entails providing safe habitat areas for species such as the California least tern, and increasing the enforcement of existing regulations concerning harvesting of marine life/tidepool organisms. Improved beach litter cleanup methods and public education and involvement to reduce trash and debris are also necessary to protect intertidal habitats.

Priority:

- Augment ongoing efforts to restore the El Segundo Dunes and create a Dunes Habitat Preserve.

WATERSHED PLANNING

Water quality, resource protection and human health issues related to swimming and fishing in the Bay need to be managed in an integrated fashion in order to achieve watershed-wide planning and management goals. The first three sections of the Plan describe actions that apply to and are coordinated within the entire Santa Monica Bay watershed. This section focuses on the need for integrated planning at the watershed and sub-watershed levels, and is followed by a practical example—the Malibu Creek Watershed Pilot Plan. This new planning strategy furthers the goal of enhanced Bay protection.

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Planning and Management for Sub-Watersheds

Comprehensive watershed planning cuts across political boundaries and is based on the cooperative effort of many stakeholders.

Problem: Many people are unaware that activities occurring inland, or "upstream," have an impact on coastal areas "downstream." Until recently, land use planning was treated separately from managing the quality of receiving waters. As a result, water quality and environmental resources have deteriorated, particularly in rapidly urbanizing areas. Environmental resource protection has also been hindered by the fact that human activities have not generally been organized and managed around hydrologic or watershed boundaries, resulting in fragmented mandates and management priorities which have made it difficult to effectively solve problems. These problems call for a comprehensive watershed planning approach that cuts across political boundaries and is based on the cooperative effort of many stakeholders.

Actions: Successful watershed-wide management planning is affected by actions that occur in each of the Bay's sub-watersheds. Planning at the sub-watershed level acknowledges the distinctions among sub-watersheds and can more accurately reflect the particular needs of each area. Development of sub-watershed management plans should occur in areas where there is current or potential impairment of beneficial uses in receiving waters, where there is a prevalence of biologically sensitive habitats, and where there is high likelihood of intensified land use.

Priority:

- Explore the feasibility of creating Joint Powers Authorities, Watershed Commissions, special districts, or other cooperative entities to effectively implement watershed-based environmental management.

Malibu Creek Pilot Plan

Problem: The Malibu Creek sub-watershed, which incorporates the relatively rural Santa Monica Mountains and the cities in the Ventura Freeway corridor and on the coast, has more than doubled its population in the last 20 years. It has consequently changed from low-intensity land uses that contributed few, if any, human-generated contaminants, to urban developments that significantly increase the pollutant load to the Bay. At the terminus of Malibu Creek, Malibu Lagoon receives the natural and artificial runoff from the entire sub-watershed. The Malibu Creek sub-watershed's environmental quality is impaired by three major causes: pollutant inputs, modifications of natural stream flows and loss of sensitive habitats.

Actions: Significant local interest in finding solutions to problems made the Malibu Creek sub-watershed particularly suitable as a test case for developing and implementing a specific management plan. With funding from the SMBRP, a facilitated mediation process was employed to identify the basic environmental and management concerns of the various stakeholders in the watershed, and to come to agreement on how to resolve existing or perceived problems and how to prevent further environmental degradation.

A watershed-based approach must be taken to protect the sensitive Bay environment since it can be affected by building activities taking place miles inland.

The actions and concepts described in the Malibu Creek Pilot Plan have been partially derived from this fact-finding and consensus-building process, although specific agreements about implementation priorities and specific language on certain actions have yet to be worked out. Early actions should be undertaken to reduce pollutant impacts in the lower sub-watershed and lagoon and to protect key species while long-term options are being evaluated. Both short- and long-term plans must include a program for restoring and protecting the native biodiversity, and creation of specific BMPs to reduce sediment and other pollutant loads from hillside developments.

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Once the success of the Pilot Plan has been determined, applicable elements of the Plan should be utilized to develop management plans for the Bay's other priority sub-watersheds.

Priorities:

- Conduct a source survey to identify and eliminate major sources of human pathogens into Malibu Lagoon and the adjacent surfzone.
- Agree on a near-term means of regulating water levels in the lagoon and improving the breaching/management protocol.
- Investigate the relationships between groundwater movement into the creek and lagoon and the role of septic tanks in contributing pollutants to the creek, lagoon and surfzone.
- Develop a plan to minimize and mitigate water quality and quantify impacts on the lagoon that result from surface discharge of groundwater pollution abatement programs.
- Pursue increased capacity for seasonal storage of reclaimed water and other effluent disposal options to reduce unseasonable flows to Malibu Creek and restore a more natural hydrologic regime.
- Develop site-specific BMPs for hillside developments.
- Create buffer zones adjacent to sensitive habitats and evaluate the adequacy of current standards.
- Enhance and restore the lower portions of Malibu Creek.
- Develop and implement a lagoon restoration plan.

CROSS-CUTTING ISSUES

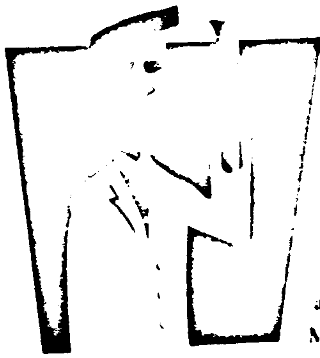
Monitoring, research, and public outreach are essential components in all chapters of the Plan. This section combines the recommendations contained in each chapter and describes the framework to coordinate and implement them.

Public Education and Involvement

The PIE Program reaches out to the Bay's many communities and encourages innovative public education regarding Bay issues.

Problem: Increased public awareness and education are integral to the successful restoration and protection of the Santa Monica Bay environment. Public education programs identified in the Plan center around several themes: increasing awareness about how our actions can have a direct impact on the Bay; enhancing public appreciation for the Bay's many environmental and economic values; communicating potential health risks, and gaining public support for and involvement in Bay restoration efforts.

Actions: With a wealth and diversity of programs that are currently reaching out to the public, it appears that the most effective—and most *cost-effective*—way to conduct public outreach concerning Santa Monica Bay is to unite existing efforts under one umbrella. Coordination through a Bay Information and Education Council would bring non-profit environmental groups, government agencies, and private sector organizations together to share programs and ensure that efforts are not needlessly duplicated. Encouraging and supporting innovative public outreach activities through the Public Involvement and Education (PIE) mini-grants program of the Santa Monica Bay Restoration Foundation is also recommended.



Priority:

- Implement the PIE mini-grants program.

Comprehensive Monitoring Program

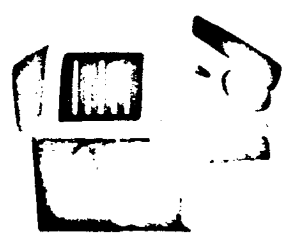
Problem: Environmental monitoring is one of the primary methods of collecting information in order to evaluate trends over time. Although about $2 million is expended each year for monitoring activities in Santa Monica Bay, this investment has not resulted in answers to the public's concerns about human health risks and the health of the Bay.

The Comprehensive Monitoring Framework provides a blue print for restructuring current monitoring activities to provide answers to the public's concerns about human health risks and the health of Santa Monica Bay.

Action: Over the past several years, a framework for the Comprehensive Monitoring Program has been developed. This framework provides a blueprint for how the current monitoring system could be restructured to provide more meaningful information, and how data generated by individual monitoring programs should be linked into a comprehensive whole. A pilot program, focused on entities that conduct ambient compliance monitoring, will test some of the redesigned and standardized components of the whole program. Natural resource and public health components will be phased in at later stages of program development. An effective system for information management and exchange is also being developed.

Priorities:

- Involve all appropriate entities in a "retooled" Santa Monica Bay monitoring program.
- Design a "user-friendly" Santa Monica Bay data management system with a centralized index but with a decentralized database system.
- Actively maintain the index and documentation, and coordinate the efforts of the various sources and users.



Research Needs

Problem: The SMBRP has undertaken a number of technical studies that have greatly enhanced our level of knowledge about Bay conditions and about potential health risks associated with swimming or consuming seafood. These research efforts have also formed the basis of many Plan actions. However, several important information gaps remain. Further research is still necessary to address issues such as sediment quality objectives, impacts of nonpoint pollutant sources on beneficial uses, sanitary surveys, swimming-related health risks and improvement of bacterial indicator systems.

Action: The Monitoring and Research Implementation Committee will oversee and coordinate priority research efforts identified in the Plan.

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MAKING THE PLAN WORK

The success of the Bay Restoration Plan (BRP) is largely dependent upon the establishment of an effective oversight and management strategy for assuring its implementation. Without such a strategy, the BRP is destined to be just another "plan on the shelf." An oversight committee structure to assure effective management and a finance strategy to implement the Plan's priority actions are therefore proposed.

Oversight and Management of Plan Implementation

Ensuring that a plan is implemented is a challenging undertaking. The Bay Watershed Council will facilitate coordination of action implementation, promote financing for Plan actions, and ensure that the Plan is consistently implemented. The Council will also continue the public/private and federal/state/local partnership that has been forged through the SMBRP, and will promote accountability for Plan implementation.

The Bay Watershed Council will continue the partnership that has been forged through the SMBRP and will promote accountability for Plan implementation.

Priorities:

- Carry out activities to assure Plan implementation: pursue financing strategies, monitor Plan progress, prepare State of the Bay reports, convene and staff meetings of the Bay Watershed Council and staff the Santa Monica Bay Restoration Foundation.
- Carry out the public education and involvement and comprehensive Bay monitoring programs; coordinate research activities; coordinate wetlands restoration and watershed planning efforts under the guidance of the Watershed Implementation Committees.

Finance Summary

More than 200 actions are presented in the Bay Restoration Plan, totaling approximately $131 million. Seventy-four of them have been designated as "priority actions." These 74 priorities are the focus of the Plan's financing strategy. Thirty-three have funding which is considered "within existing resources," meaning that they (a) have already been funded from within existing budgets; (b) have funds that have been earmarked for their implementation; (c) can be accomplished by shifting of internal resources, or (d) can be financed by the funding of another priority action. The remaining 41 priority actions carry a total price tag of $64.7 million, and must be financed from other sources.

The strategy for funding these actions focuses on three potential sources: state and federal grant and loan programs, existing and proposed bond measures, and private sector fundraising through the Santa Monica Bay Restoration Foundation. Experienced members of the region's financial community will also be brought together on a Blue Ribbon Finance Committee to provide guidance on additional innovative funding opportunities.

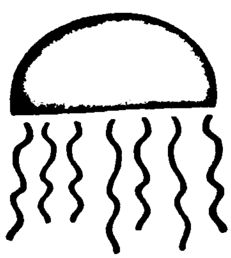
The preceding sections give an indication of the breadth of the actions needed to restore Santa Monica Bay. Within the Plan itself, important additional information is provided regarding implementors, timeframe for action and cost. The larger questions to be addressed now are: Who will oversee the implementation of the plan, and who will pay for it?

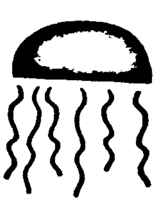
The short answer to this question is: YOU. Members of the public whose demands for a healthier Bay brought the Santa Monica Bay Restoration Project (SMBRP) into existence must take responsibility for supporting the Plan, and for supporting mechanisms to fund it.

Some things you can do now to help implement the Plan and to do your share to improve Santa Monica Bay are:

- Call your elected officials to ask for their support of the Plan.
- Vote for bond measures which provide funding for Bay cleanup and restoration.
- Encourage your neighborhood schools to add curriculum about Bay ecology and restoration.
- Read and implement the "Nine Simple Things to Do for the Bay" fact sheet, available from the SMBRP.
- Request a copy of the Plan by telephoning or writing us at the address on the back cover.

Conclusion





In this Public Summary we have surveyed much about Santa Monica Bay: its many natural resources, its biological and human values, the impacts of human activities on its health, and in this chapter, a plan for its protection and restoration. We have found that the Bay is out of balance, primarily because of the steep rise in population which began a century ago, and the concomitant introduction of human products that pollute the Bay. A heavy toll was taken on the Bay's ecosystem—wetlands destroyed, fisheries decimated, beaches closed by sewage spills and storm water contamination.

The power of humans to destroy an ecosystem is awesome, but it is matched by the power of humans to protect and restore it. We see that the Bay is making a comeback, and the balance is being restored—slowly but surely. While the Bay will never again be pristine, and progress could easily be

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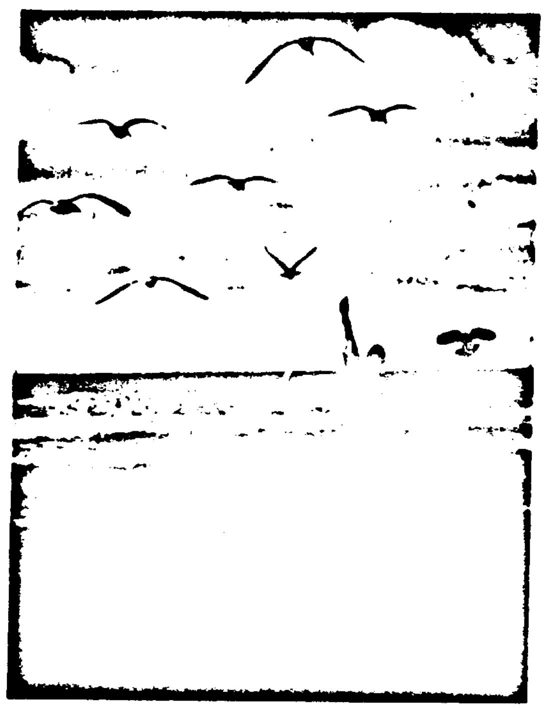
reversed, the actions of humans to mitigate pollution and other harmful effects of our growth are having a decisive effect. Remaining wetlands are being protected and revived. Sewage plants are discharging cleaner effluent, and programs are in place to reduce runoff pollution.

While tremendous progress has been made, a great deal still remains to be done to safeguard this precious resource—to right the balance. We now have the tool to carry out these tasks comprehensively, and with your support of the Bay Restoration Plan, we may begin our work.



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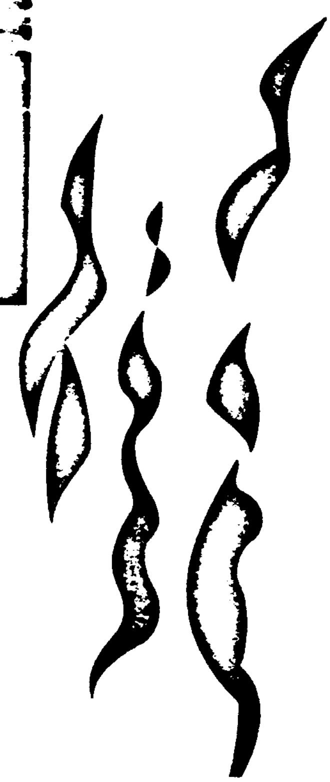

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Text, maps, graphics and tables contained in this Public Summary were derived from the SMBRP's Characterization Study, State of the Bay 1993, SMBRP technical reports and the Santa Monica Bay Restoration Plan. Additional references are noted below.

Pg. 11 — *Economic resources data:* SMBRP, State of the Bay 1993; Los Angeles Convention and Visitors Bureau, 1992.

Pg. 17 — *Los Angeles County population data:* Southern California Association of Governments (SCAG), "Regional comprehensive plan city survey comparison to 1990 census and summed city projections by county," 1991.

Pg. 20 — *Storm drain system map:* Los Angeles County Department of Public Works, 1994.

Pg. 22 — *Urban runoff flows chart:* Sarasota Bay National Estuary Project, 1992 Framework for Action.

Pg. 35 — *Generalized transport and fate model for Santa Monica Bay:* SCAG, State of the Bay, Scientific Assessment, 1988.

Pg. 36 — *Concentration of DDT in surface sediments, 1985:* Hyperion Treatment Plant, unpubl. data; Stull 1988, County Sanitation Districts of Los Angeles County (CSDLAC), pers. comm.

Pg. 37 — *Total DDT concentrations in surface sediments, 1990:* Soule, et al. 1992, "The marine environment of Marina del Rey," October 1991 to June 1992, in Marine Studies of San Pedro Bay, Calif., Part 20H, Harbors Environmental Projects, University of Southern California; City of Los Angeles Department of Public Works, unpubl. data; CSDLAC, unpubl. data.

Pg. 39 — *Fin erosion data:* Stull, J.K. in press. "Two decades of marine biological monitoring, Palos Verdes, California, 1972 to 1992," Journal of Southern California Academy of Sciences.

Pg. 40 — *Least tern fledglings data:* Massey and Fancher, "Renesting by California least terns," J. Field Ornithol. 60(3) 350-357, 1989; California Department of Fish and Game (CDFG), unpubl. data; Jurek, R. CDFG, pers. comm. 1992.

Pg. 43 — *Sport fish consumption recommendations:* Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, A Study of Chemical Contamination of Marine Fish from Southern California, 1991.

Pg. 46 — *Bacterial indicator measurements:* Los Angeles County Department of Health Services (weekly data); City of Los Angeles Environmental Monitoring Division (daily data).

Pg. 47 — *DDT in Dover Sole tissue data:* Southern California Coastal Waters Research Project (1970s data); County Sanitation Districts of Los Angeles County (1980s and 1990s data). *California brown pelican fledgling data:* Anderson and Gress, "Status of a northern population of California brown pelicans," Condor 85:79-88, 1983; Davis, G., National Park Service, pers. comm., 1988.

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SANTA MONICA BAY DRAINAGE BASIN

PROPOSED STORMWATER/URBAN RUNOFF MONITORING PROGRAM

LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS

WASTE MANAGEMENT DIVISION

WATER QUALITY MANAGEMENT SECTION

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I. INTRODUCTION

As required by National Pollutant Discharge Elimination System (NPDES) Permit No. CA0061654, a proposed Stormwater/Urban Runoff Monitoring Program for the Santa Monica Bay Drainage Basin was submitted to the Regional Water Quality Control Board, Los Angeles Region (RWCQB), for approval on March 26, 1992. On January 11, 1993, as part of the RWQCB's overall review of our second-year compliance, tentative approval of the monitoring program was received by the RWQCB pending revision of the program to incorporate specific recommendations made by the RWQCB.

On June 17, 1993, a revised review of second-year compliance was received from the RWQCB. This revision was to incorporate comments submitted to the RWQCB by the various Co-Permittees on the RWQCB's original second-year compliance review. In its June 17, 1993 letter, the RWQCB staff proposed the following revisions to the monitoring program:

	Tasks	Completion Date	Report of Compliance to Regional Board
a.	Develop methodology to make refined estimates of pollutants discharged to Santa Monica Bay	July 1, 1993	July 15, 1993
b.	Make a first estimate of pollutant loads to Santa Monica Bay on the basis of monitoring	July 1, 1994	July 15. 1994
c.	Complete a basic QA/QC plan for the Storm Water Monitoring Program	July 1, 1993	July 15, 1993
d.	Develop and implement a pilot project to establish monitoring of long-term trends in stormwater quality	July 1, 1993	Jan. 15, 1994
e.	Develop monitoring for identification of sources of pollutants	July 1, 1993	Jan. 15, 1994
f.	Develop and implement a monitoring program to evaluate the effectiveness of BMPs	Jan. 1, 1994	Jan. 15, 1994
g.	Develop and implement a monitoring program to identify locations of illegal practices and elimination sources of pollutants	Jan. 1, 1994	Jan. 15, 1994
h.	Develop and implement a program to evaluate stormwater impacts on selected receiving waters	July 1, 1994	July 15, 1994

The revised monitoring program described herein addresses tasks "a" through "e". Tasks "f" through "h" will be developed as future amendments to the program. It should be noted, however, that a number of concerns were presented to the RWQCB staff regarding Tasks "f" through "h" as part of our comments on their second-year compliance review. Resolution of our concerns will be needed prior to completion of these tasks.

The monitoring program described herein includes the establishment of nine monitoring sites for both mass emissions and individual land-use monitoring. Storm samples will be collected for five storms per year. Dry-weather samples will be collected bimonthly. Samples will be tested for a wide range of constituents including Bacteria; General Minerals; Biochemical Oxygen Demand; Total Organic Carbon and total Petroleum Hydrocarbons; Volatile Organic Compounds and Suspended Solids; Volatile Suspended Solids; and Semi-volatile Organic Compounds.

Automated refrigerated water samplers will be used for the collection of flow-composite samples. These samplers will be located on the ground surface in secure enclosures allowing easy access for retrieval of samples. The samplers have large (10 gallon) water collection capacity, and, thus, can be programmed in advance to cover a wide range of storm sizes without requiring one or more bottle change outs during a storm event.

Data collected by the program will be utilized by water quality modelling to estimate pollutant loads to receiving waters. Also, questions concerning what types of pollutants emanate from various land uses will be addressed. Lastly, data collected over the years under this program can be used in an attempt to assess any long-term trends in water quality.

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II. PROPOSED MONITORING SITES

<u>SITE SELECTION CRITERIA</u>

A. Monitoring Site Selection Overview

In order to characterize the quality of runoff from the Santa Monica Bay Drainage Basin, a combination of single land-use sites and large watersheds representing multiple land uses ("mass emissions" sites) have been selected.

For the Santa Monica Bay Drainage Basin nine monitoring sites have been proposed. Four of the nine sites will be mass emissions stations. Five will be land-use specific stations. The remaining site will function as both a mass emissions and land-use specific monitoring station. Additional land-use specific monitoring stations will be proposed as part of the monitoring program to be developed for Phase III of the NPDES Permit. As stated in our third-year report, dated July 1, 1993, we estimated submittal of the proposed monitoring program for Phase II to the RWQCB by February 28, 1994.

The proposed monitoring sites represent an effort to select the most suitable locations based on our established criteria for sampling. Where feasible, we have incorporated into the program those storm drains which have water quality issues which are of concern to the community.

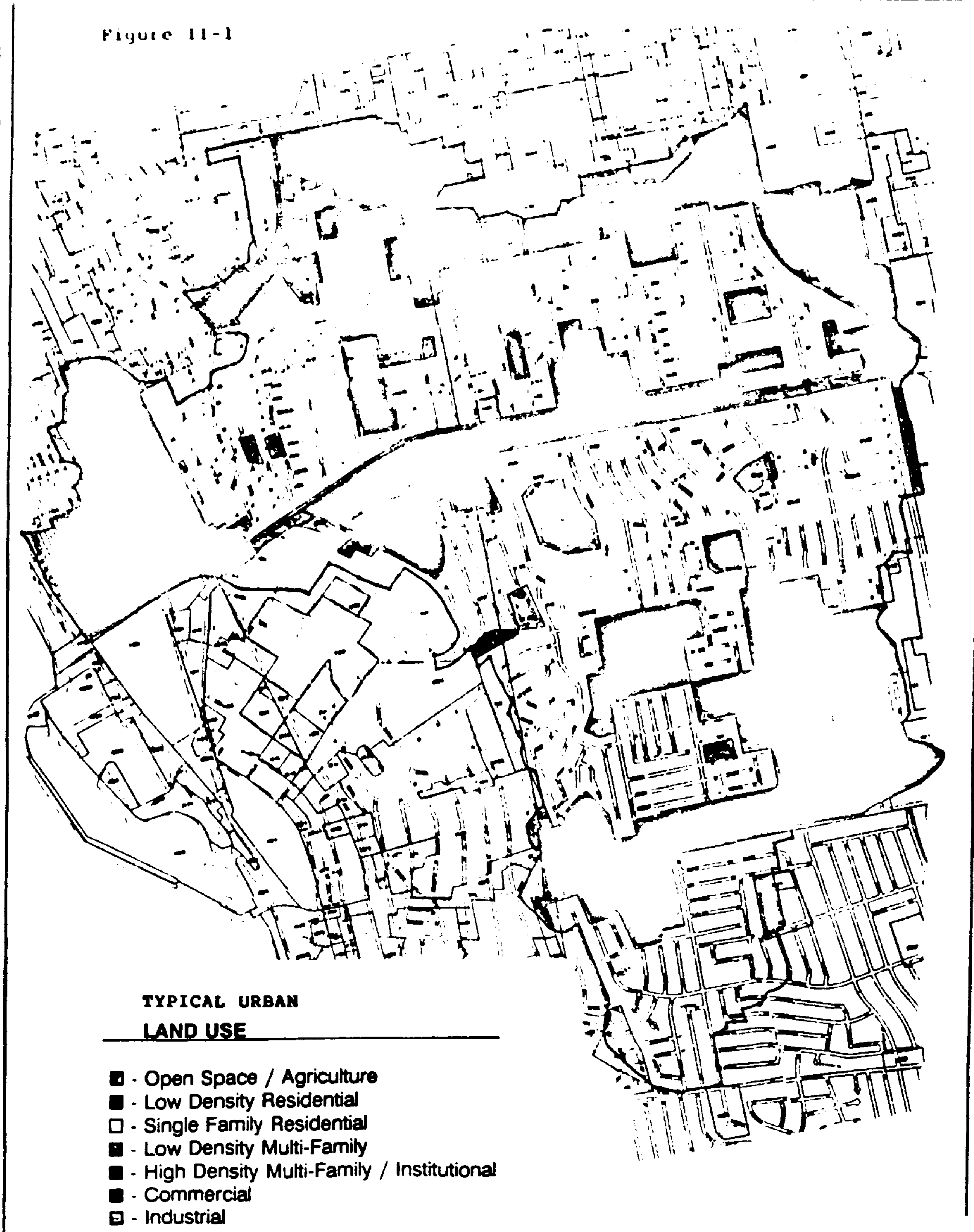
B. Specific Criteria for Mass Emissions Monitoring Sites

Mass emissions monitoring sites shall be located at the outlet (or the furthest downstream position practicable) of watersheds contributing the largest relative inputs to the Santa Monica Bay. These watersheds will typically have a complex multiple land-use composition. See Figure II-1.

C. Specific Criteria for Land-Use Specific Monitoring Sites

Land use-specific monitoring sites shall be located in watersheds where the upstream tributary area is comprised predominantly of one land use. It is important that the contributing watershed be at least 50 acres in size, in order to produce effective runoff characteristics.

Figure II-1



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D. Criteria for both Mass Emissions and Land-Use Specific Sites

In selecting a specific storm drain for inclusion as either a mass emissions or land-use specific site, the following technical and operational requirements were addressed:

- What type of sampling equipment is to be used, and what limitations exist?
- What are the hydraulics of the underground storm drain, open channel/natural watercourse? What is the Design Q?
- Is there past flow data available for the given stream?
- What past hydrology studies have been performed in the watershed?. What is the hydrologic Q?
- If the storm drain is underground, is it currently under designed? Could it experience surcharge conditions?
- Within the watershed, what is the corresponding land use? Is land use uniform and homogenous throughout the upper tributary area? If yes, this is a possible land-use site.
- Has previous sampling in the potential watershed been conducted in the past? Where? When? Why?
- Are tidal or backwater influences a concern?
- Is the location selected the only outfall point for the upstream watershed, or are there multiple outfall points?
- Is the storm drain structurally sound at present? Will installation of sampling equipment compromise the stability of the storm drain?
- Will the monitoring equipment impede flow or reduce flood protection?
- For natural watercourses, is there an existing improved section where a rating curve can be easily established?
- What is the practicable design distance from the storm drain invert (low flow) to the location where the sampler shall be placed?
- Can electric power be provided, in a cost- effective manner, to the site?

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- Will additional right-of-way be required?
- Will the sampler installation interfere with projects planned or in progress in the general vicinity?
- If located in a residential neighborhood, will the location of the automated sampler and its operation result in any objections from the local residents?

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PROPOSED MASS EMISSIONS AND LAND-USE SPECIFIC MONITORING SITES

A. The following locations have been proposed as Mass Emissions sites:

1. Ballona Creek at Los Angeles County Department of Public Works Stream Gauge No. F38C-R in the City of Los Angeles.

   The Ballona Creek station will be located at the existing stream gauge station between Sawtelle Boulevard and Sepulveda Boulevard. This facility currently measures stream flow and precipitation. At this location, the upstream tributary watershed of Ballona Creek is 88.7 square miles. The entire Ballona Creek watershed at its outlet to the ocean is 127.1 square miles, but because of tidal influences the sampling site must be located upstream. Therefore, the actual sampled watershed is less.

   The land-use breakdown is as follows:

Open Space/Agriculture	19%
Low Density Residential	1%
Single Family Residential	25%
Low Density Multi-Family	5%
High Density Multi-Family/Institutional	32%
Commercial	14%
Industrial	4%

   The overall impervious factor for this watershed is 53%.

   Ballona Creek, at the gaging station, is an improved (concrete lined) trapezoidal channel. The vertical lift from the invert of the channel to the sampler location is approximately 30 feet. The horizontal distance is approximately 100 feet. Due to the elevation difference, an auxiliary pump will be required. See Figure III-3 for the proposed sampler installation.

   This proposal replaces the existing County Department of Public Works Surface Water Quality Monitoring Station at the Sawtelle Boulevard bridge.

2. Malibu Creek at County Stream Gauge No. F130-R in Unincorporated County of Los Angeles.

   The Malibu Creek monitoring station will be located at the existing stream gauge station, off of Malibu Canyon Road, south of Piuma Road. The existing facility provides flow measurement only. Because of

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tidal influences and the lack of any downstream improved section, the sampling site must be located here. Constructing an improved section at a location downstream would be costly, and would yield little difference in results. At this location, the tributary watershed to Malibu Creek is 104.9 square miles. The entire Malibu Creek watershed at its outlet to the ocean is 109.9 square miles. Therefore the actual sampled watershed is less.

The land-use breakdown is as follows:

Open Space/Agriculture	54%
Low Density Residential	29%
Single Family Residential	7%
Low Density Multi-Family	4%
High Density Multi-Family/Institutional	1%
Commercial	4%
Industrial	1%

The overall impervious factor for this watershed is 13%.

There are at least seven agencies, presently, that are monitoring the quality of surface water, sediment, groundwater and/or the overall health of the ecosystem (bioassessment and biomonitoring) within the Malibu Creek watershed. This proposed sampling location will replace the existing County Department of Public Works Surface Water Quality Sampling Station at Cross Creek Road.

3. **County of Los Angeles Kenter Canyon Storm Drain in the City of Santa Monica.**

Kenter Canyon Storm Drain is an underground brick arch drain. It outlets at the west end of Pico Boulevard. The outlet structure is commonly referred to as the Pico-Kenter storm drain. This outlet is the combination of three storm drains: Kenter Canyon, Caltrans 10 Freeway Storm Drain, and County Bond Issue Project No. 249, Pico Boulevard Drain, Line B. Only flows from the Kenter Canyon Storm Drain will be sampled.

The location where sampling will be conducted is upstream of the outlet structure. The tributary watershed area for Kenter Canyon Storm Drain is 6.4 square miles (the tributary area of the Caltrans drain and Pico Boulevard Drain is 0.8 square miles).

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The land-use breakdown is as follows:

Open Space/Agriculture	5%
Low Density Residential	39%
Single Family Residential	22%
Low Density Multi-Family	8%
High Density Multi-Family/Institutional	10%
Commercial	12%
Industrial	4%

The overall impervious value for this watershed is 39%.

The Pico-Kenter Drain has been a focal point for Santa Monica Bay with regards to the quality of dry-weather flows. The City of Santa Monica is currently pumping dry-weather flows to a City of Los Angeles sanitary sewer line, existing below The Promenade.

The County Department of Public Works presently samples the Pico-Kenter outlet structure. This proposed sampling location replaces the existing County Department of Public Works Surface Water Quality Monitoring Station at the Pico-Kenter outlet structure.

4. **County of Los Angeles Bond Issue Project No. 1105, Line A, in the Cities of Hermosa and Redondo Beach.**

Project No. 1105, Line A is an underground box/pipe in Herondo Street from Hermosa Avenue/Harbor Drive to Pacific Coast Highway. The proposed sampling location is near the intersection of Herondo Street and Valley Drive. At this location, the tributary watershed area is 4.23 square miles.

The land-use break down is as follows:

Open Space/Agriculture	2%
Low Density Residential	0%
Single Family Residential	63%
Low Density Multi-Family	16%
High Density Multi-Family/Institutional	4%
Commercial	10%
Industrial	5%

The overall impervious value for this watershed is 50%.

It is proposed that the sampling station be placed in the center median of Herondo Street. This is due to the lack of adequate sidewalk clearance. Tidal influences, depth to storm drain invert, and surcharge effects are the major factors impacting the selection of this site.

B. The following locations have been chosen as Land-Use Specific sites:

1. Trancas Canyon at Private Drain No. 658 in the City of Malibu.

   The Trancas Canyon watershed is proposed for the monitoring of open space. The upstream watershed of Private Drain (PD) No. 658 is virtually undeveloped, with the only significant development being the Malibu Country Club in the upper reach. The Santa Monica Mountains National Recreation Area is the largest land holder in the watershed.

   The proposed monitoring site is to be located at the upstream end of PD No. 658, adjacent to the northerly end of Paseo Canyon Drive. PD No. 658 is a reinforced concrete trapezoidal channel. Immediately upstream exists a small debris basin which will provide protection for the sampler. The residential area surrounding PD No. 658 is privately maintained. Installation of the monitoring station will be dependent on our ability to satisfy the requirements of the local homeowners association. The tributary watershed area is 7.45 square miles.

   The land-use breakdown is as follows:

Open Space/Agriculture	97%
Low Density Residential	3%
Single Family Residential	0%
Low Density Multi-Family	0%
High Density Multi-Family/Institutional	0%
Commercial	0%
Industrial	0%

   The overall impervious value for this watershed is 1%.

   It is anticipated that because of the size, impervious value, soil types, and vegetation within the watershed, little to no dry-weather flows will exist. This has been previously observed.

2. County Bond Issue Project No. 5401, Line A in the City of Manhattan Beach.

   Project No. 5401 is proposed for the monitoring of a single family residential area.

At the proposed monitoring location, Project No. 5401 is an underground box drain. This storm drain discharges to a pond in Polliwog Park. During a storm, the pond serves as a detention basin for flood control. After reaching a certain elevation, stormwater in the pond is pumped over a hill, under Manhattan Beach Boulevard, to the west to Project No. 552. One potential location for placement of the sampler appears to be in the park, however, because stormwater may back up into the drain, an alternative location for sampling is at Redondo Avenue and 11th Street. The tributary watershed area is approximately 200 acres.

The land-use breakdown is as follows:

Open Space/Agriculture	0%
Low Density Residential	0%
Single Family Residential	98%
Low Density Multi-Family	0%
High Density Multi-Family/Institutional	0%
Commercial	2%
Industrial	0%

The overall impervious value for this watershed is 42%.

Homes and lots are generally similar in type and size throughout the tributary drainage area, providing an ideal homogenous land use.

3. City of Los Angeles Storm Drain No. D-2361 located in downtown Los Angeles.

The City's Storm Drain No. D-2361 is proposed for the monitoring of a commercial/industrial land use.

The proposed monitoring site is near the intersection of 21st Street and Grand Avenue. Storm Drain No. D-2361 is a 48" diameter pipe. The tributary watershed area is about 150 acres.

The land-use breakdown is as follows:

Open Space/Agriculture	0%
Low Density Residential	0%
Single Family Residential	0%
Low Density Multi-Family	0%
High Density Multi-Family/Institutional	0%
Commercial	49%
Industrial	51%

The overall impervious value for this watershed is 91%.

It is believed with all certainty that this storm drain will experience, at some time, surcharge conditions. The storm drain is more than 50 years old and is undersized. Based on our research, however, this would be the only location available in the Santa Monica Bay Drainage Basin for the monitoring of a sizeable industrial area.

4. **City of Santa Monica Pier Storm Drain adjacent to the Santa Monica Mall.**

The City's Pier Storm Drain is proposed to be a monitoring site for commercial land use.

The monitoring site will be located at the intersection of Second Street and Colorado Avenue. The section of drain under consideration is from Ocean Avenue to 2nd Street in Colorado Avenue. This reach of drain empties into a manhole shaft of a deeper storm drain which subsequently discharges below the Santa Monica Pier. The tributary watershed area is approximately 50 acres.

The land-use breakdown is as follows:

Open Space/Agriculture	0%
Low Density Residential	0%
Single Family Residential	0%
Low Density Multi-Family	0%
High Density Multi-Family/Institutional	4%
Commercial	96%
Industrial	0%

The overall impervious value for this watershed is 92%.

This watershed is dominated by the Santa Monica Mall. The remaining land-use elements are commercial office buildings, small shops, restaurants and high density apartments/hotels.

5. **County Bond Issue Project No. 558, Line A in the City of Palos Verdes Estates.**

The monitoring location proposed for Project 558 will not only be utilized as a mass emissions station, but also function as a single family residential land-use site.

The monitoring site for this storm drain will be in the vicinity of the intersection of Paseo Lunado and Palos Verdes Drive West. The tributary watershed area is approximately 1.7 square miles.

The land-use breakdown is as follows:

Open Space/Agriculture	14%
Low Density Residential	0%
Single Family Residential	81%
Low Density Multifamily	3%
High Density Multifamily/Institutional	0%
Commercial	2%
Industrial	0%

The overall impervious value for the watershed is 40%.

It is anticipated that because of the size, impervious value, soil types, and vegetation within the watershed, little to no dry-weather flows will exist. This has been previously observed.

Monitoring Site Installation

The monitoring sites have been prioritized for installation as follows:

Ballona Creek
Malibu Creek
Trancas Canyon (Private Drain 658)
Kenter Canyon
Herondo Drain (Bond Issue Project 1105)
Bond Issue Project 558
Bond Issue Project 5401
City of Santa Monica Storm Drain
City of Los Angeles Storm Drain

Priority has been given to the open channel sites, which are the easiest to install plus serve as the mass emissions stations. The remaining sites involve the underground drains. We are targeting to have as many sites as possible operational by the onset of the rainy season, with the remainder to follow as soon as possible during the rainy season.

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III. MONITORING EQUIPMENT

WATER QUALITY SAMPLERS

Refrigerated Water Quality Samplers

Stormwater sampling for this NPDES permit must include a technique for collecting flow composite samples for storms as well as time composite samples for dry-weather applications. The utilization of automatic refrigerated water quality samplers (Figure III-1) represent the best available technology at present to meet the goals of the Permit.

The water quality samplers to be utilized at each of the nine monitoring sites must be AC powered to carry the load needed to provide refrigeration. All samples will be stored at 4°C.

Each sampler will incorporate a peristaltic pump for sample collection. Due to the inability of the peristaltic pump to effectively pump flows beyond a vertical lift of between 15-20 feet, an explosion proof auxiliary pump will be required. Most of our sites have vertical lifts in excess of 15 feet. Auxiliary pumps will be needed. This factor will complicate the installation of our sampling equipment at many locations, especially in the underground drains.

Each sampler will be securely stored in a steel box, similar to a traffic signal controller enclosure. Samplers will be located on the sidewalk or secured right-of-way for closed conduits or along the banks of open channels and natural watercourses.

FLOW MONITORING

Flow monitoring equipment is a fundamental aspect of water quality sampling. Because the Monitoring Program proposal includes flow composite sampling during storms and dry weather, flow monitoring equipment must be utilized with the sampler. There are various makes and models of flow meters. Some of the various flow meters available utilize pressure transducers, ultrasonic sensors, bubblers, stilling wells, etc.

The above-mentioned flow measuring devices are designed for open-channel flow conditions. The water elevation in a storm drain is measured by the equipment and then, from either a rating table previously established, or from an equation such as Manning's equation, the flow rate is determined. The County's Department of Public Works uses rating tables which are generated from analysis of storm drain cross sections and upstream/downstream flow characteristics. The rating tables are modified if it is demonstrated in the field that the stream velocity measurements indicate a non-uniform

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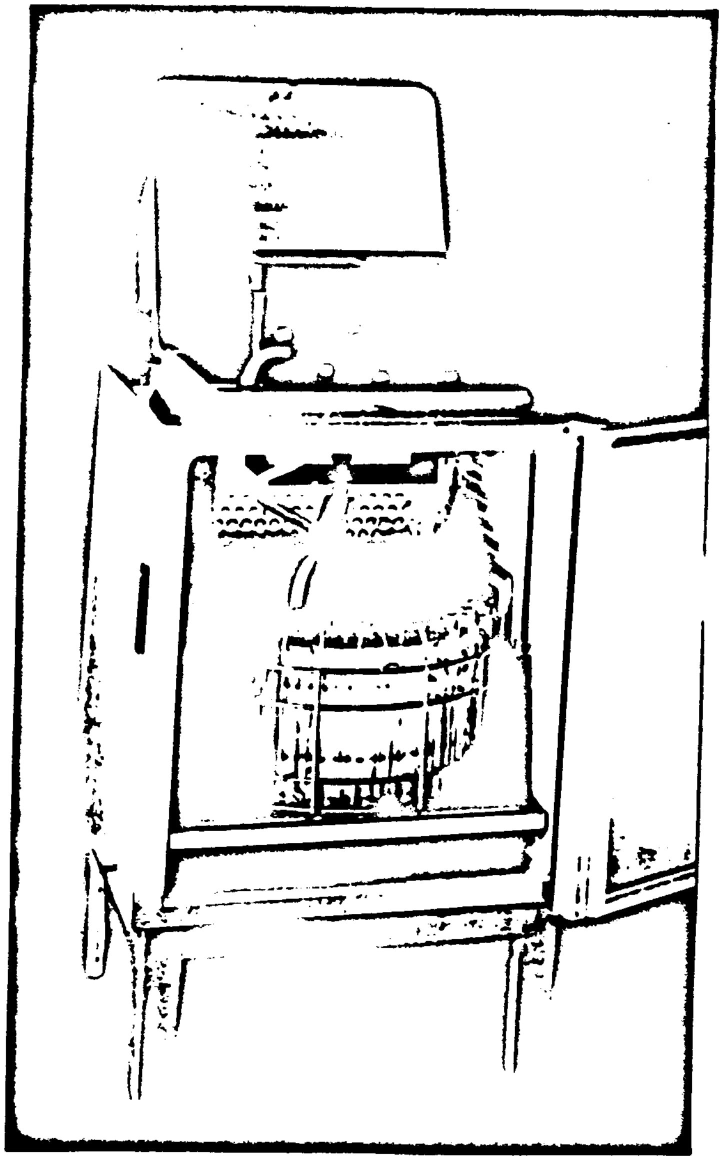

Figure III-1

Refrigerated Water Quality Sampler

relationship with the calculated table values. Past efforts in stormwater flow measurement indicates that all of the proposed stations will require time and multiple storm events to gather necessary data needed for calibration of the measurement devices.

The type of flow measurement device selected for use is the pressure transducer. The maximum depth of flow for the proposed nine sites approaches 22 feet. With the pressure transducer fixed at the bottom of the drain, a depth range from dry condition to 22 feet will have to be measured. The flow meter incorporating the pressure transducer will be compatible with the sampler.

Closed conduits, however, present an additional problem. Many closed conduits surcharge during storm conditions, usually caused by the conduit being undersized for its tributary watershed. The frequency of surcharging is dependent on the degree to which the storm drain is undersized. When surcharge conditions are reached, the drain now functions under pressure flow. The flow measurement devices discussed above are only accurate under open channel flow conditions. The measurement of flow under pressure would require the use of velocity meters. These are very costly devices that would need to be located directly in the flow stream. Therefore, efforts were made to select storm drains that do not surcharge, or do so infrequently to an extent that flow measurements are not significantly compromised.

RAIN GAUGE

For every monitoring station, a minimum of one automatic (intensity measuring) rain gauge will be placed within the upper tributary watershed. Los Angeles County Department of Public Works operates various automatic rain gauges throughout the Santa Monica Drainage Basin. Existing gauges in close proximity to the proposed monitored watersheds will be utilized in calculating stormwater runoff and shall be essential to developing runoff characteristics of these watersheds.

Large watersheds such as Malibu and Ballona Creeks will require multiple rain gauges to accurately characterize the rainfall. The number and location of these additional rain gauges is currently being researched.

EQUIPMENT INSTALLATION

The approach taken for the installation of sampling equipment is important to those who will maintain it. Access, ease of operation, safety, protection from the elements, etc., are typical design considerations. Each stations design must take into account at least these basic elements.

Figures III-2, III-3, and III-4 are generic drawings which show typical installations of sampling equipment in storm drains utilized in the Monitoring Program.

Selected site conditions will dictate the approach taken with regards to installation of the monitoring equipment.

The automated samplers intake hose and the flow meter pressure transducer cable must be protected from trash and debris, vandalism, and the physical forces of the flow velocity during storm events. It must also be installed to allow routine inspection and maintenance. In some instances, the intake hose and pressure transducer cable will be placed in a separate conduit casing (or in a small channel with a bolted cover) in a cored notch, a few inches below the channel's finished surface. In other locations, the intake line and pressure transducer cable will be placed in a separate protective conduit casing, bolted in the storm drain pipe or box conduit.

The strainer and pressure transducer will likewise be located within a protective enclosure to shield them from trash and debris and to minimize vandalism.

An auxiliary peristaltic pump will be needed at many sites due to the hydraulic lift requirements. This will complicate installation and maintenance. An auxiliary pump will be placed in a waterproof enclosure for most applications. The waterproof enclosure will be above the low-flow, dry-weather level to ensure that it will not be continuously submerged.

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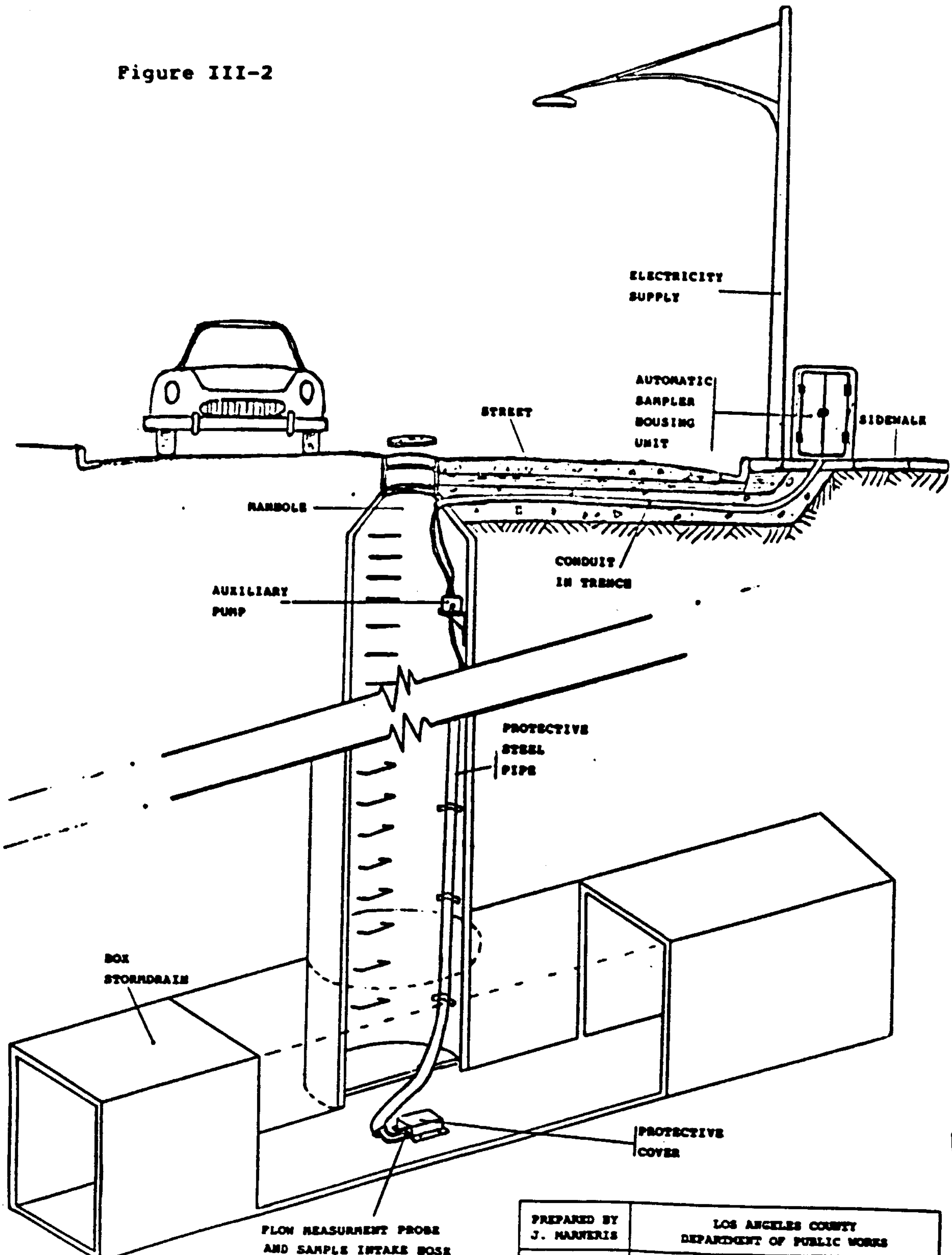
Figure III-2



PREPARED BY J. MARNERIS	LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DATE 02/10/93	CONCEPTUAL DRAWING FOR AUTOMATED SAMPLING SYSTEM INSTALLATION IN BOX STORM DRAIN
NOT TO SCALE	

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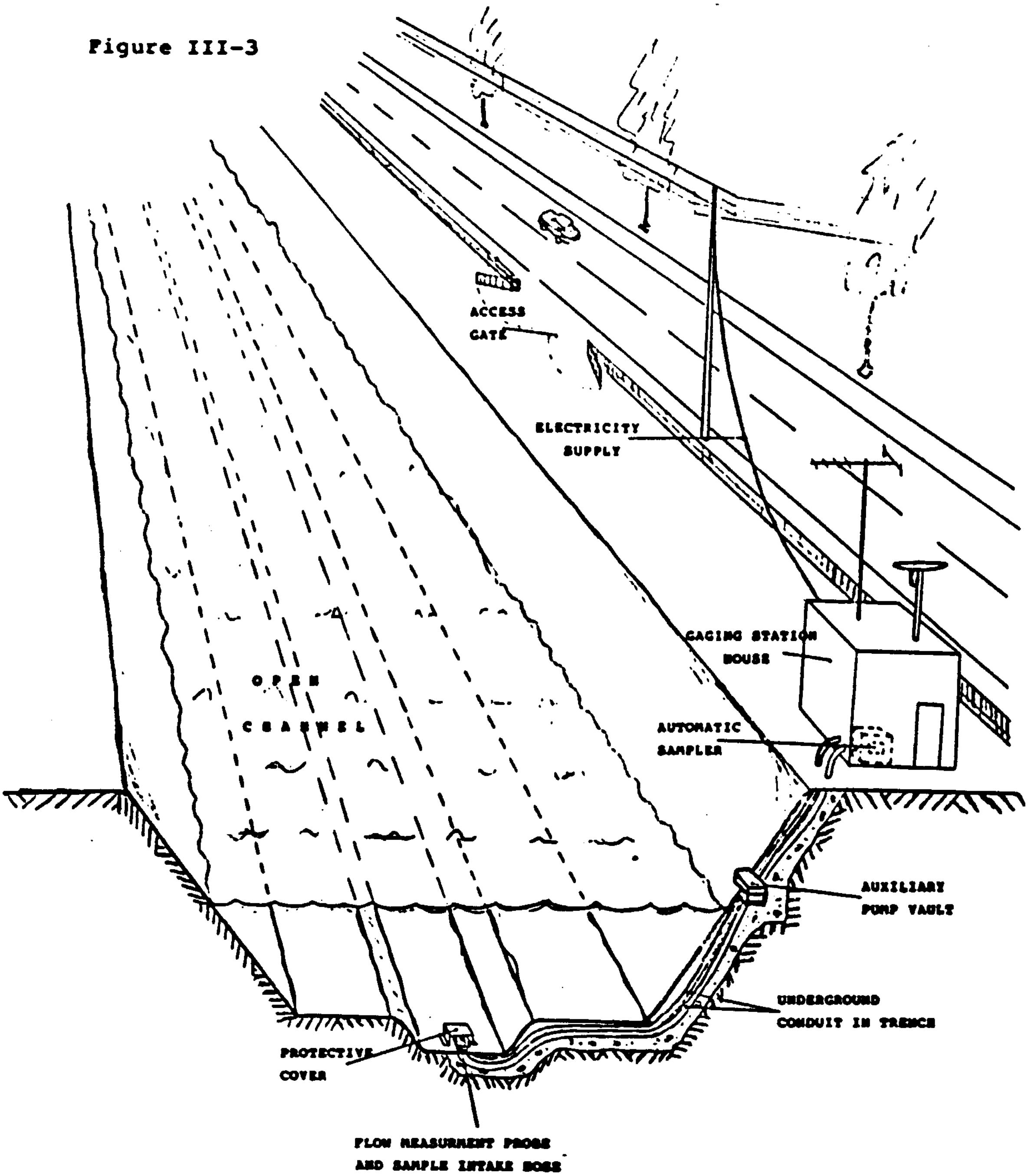
R0051655

Figure III-3



PREPARED BY J. MANNERIS	LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DATE 02/10/93	CONCEPTUAL DRAWING FOR AUTOMATED SAMPLING SYSTEM INSTALLATION IN OPEN CHANNEL
NOT TO SCALE	

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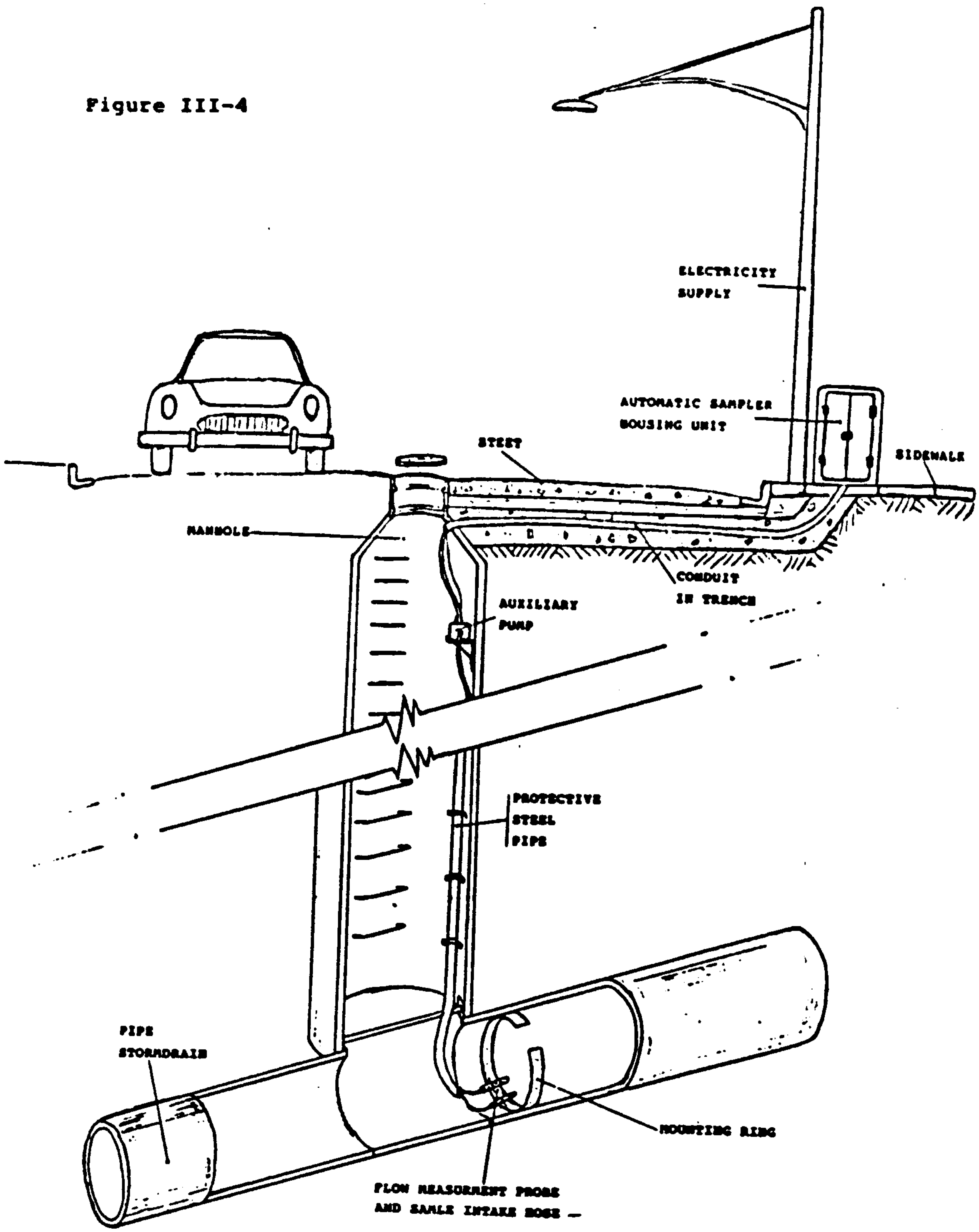
Figure III-4



PREPARED BY J. MARKERIS	LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DATE 02/10/93	CONCEPTUAL DRAWING FOR AUTOMATED SAMPLING SYSTEM INSTALLATION IN PIPE STORM DRAIN
NOT TO SCALE	

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IV. MONITORING EQUIPMENT PROGRAMMING

1. Storm Weather Sampling

The automated sampler will need to be properly programmed in order to collect a representative flow-composite sample.

To program the sampler, the following information is needed: target storm size, flow rate to trigger sampling, estimate of runoff volumes, total sample volume required, number of sample intervals desired, sample volume to be collected at each interval, and flow rate to end sampling.

2. Storm Size to be Sampled

The "Surface Drainage Water Quality Monitoring Program" report, prepared by Woodward-Clyde Consultants for the Santa Monica Bay Restoration Project, analyzed local rainfall data to determine the appropriate storm size to be targeted for monitoring. Based on their analysis, targeted storm events should be between 6 and 25 hours in duration and average rainfall of about 0.4 to 1.7 inches.

3. Minimum Sample Volume to be Collected

The minimum volume of stormwater needed to perform the necessary analyses is shown below, (for composite flow-weighted samples only):

Constituent	Quantity
Semivolatile Organic Compounds	1 L
Pesticides and PCBs	1 L
Herbicides	1 L
Soluble Metals	500 mls
Other Constituents	4,325 mls
	7,825 mls ≈ 8 liters or approximately 2 gallons

The refrigerated automated sampler has a total capacity of 10 gallons. Subtracting the two gallons required for analysis, the sampler will have an eight-gallon reserve capacity. Therefore, the sampler will be programmed to collect two gallons of stormwater from a 0.4" storm. With the eight-gallon excess capacity, the sampler would theoretically have adequate capacity to handle storms up to two inches in size (0.4" x 5 = 2.0"). This will significantly reduce the need to change bottles during a storm event.

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4. <u>Estimate of Runoff Volume</u>

To program the sampler, the estimated runoff volume from a minimum precipitation of a 0.4-inch storm event over the entire area of a watershed must be calculated. The procedure used to estimate the runoff volume of the above storm is taken from the Los Angeles County Department of Public Works Hydrology Manual, which is generally accepted by agencies within Los Angeles County for the performance of hydrology studies.

The procedure to be used is briefly described below.

a) Calculate the Overall Runoff Coefficient for the Watershed:

$$C_D = 0.9\ IMP + Cu\ (1 - IMP)$$

where:

IMP = Proportion impervious for the land use comprising the watershed.

C_u = Undeveloped area runoff coefficient (based on soil type and rainfall intensity).

C_D = Developed area runoff coefficient.

For watersheds with multiple land-use types, the overall C_D for the watershed is the weighted average of the C_D for each land-use type:

$$C_D = \frac{\Sigma_1^n\ C_{Dx}\ A_x}{\Sigma_1^n\ A_x}$$

b) Calculate the rainfall volume for the watershed:

The rainfall volume is calculated by multiplying the storm size, in inches, by the area of the watershed.

c) Calculate the runoff volume for the watershed:

The resultant runoff volume is determined from the following formula:

Runoff Volume = Rainfall Volume x (C_D)

(A detailed example of the above procedure can be found in Appendix 1).

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5. Determination of Sampling Parameters

As discussed previously, eight liters of stormwater runoff will need to be collected by composite sampling. A minimum of 20 aliquots will be collected from each storm to obtain the eight-liter composite sample. Therefore, the volume of sample to be collected at each aliquot is:

8 liters/20 aliquots = 400 mls

The 20 aliquots will be spaced at equal runoff volume intervals throughout the storm. Therefore, the size of the runoff volume interval (Δ runoff volume) for a specific watershed would be determined as follows:

$$\Delta \text{ runoff volume} = \frac{\text{total runoff volume}}{20}$$

where:

total runoff volume = total estimated runoff volume for targeted storm.

The flow rate at which storm sampling would be initiated at each station would be dependent on whether the site has any consistent dry weather or base flow.

For stations that do not have any dry-weather flow, sampling would be initiated upon detection of flow. For those having dry-weather flow, sample collection would begin after detecting a flow rate above the maximum-observed, yearly dry-weather flow level. Sampling would halt when the flow returns to 120 percent of pre-storm base flow. As the monitoring program progresses, more specific operational criteria for the samplers at each station can be developed based on site-specific flow information.

6. Dry-Weather Sampling

Dry-weather flow samples will be collected at all sites exhibiting significant dry-weather flow. For those sites with continuous dry-weather flow, a 24-hour composite sample will be collected. For those with intermittent flow, a sample will be collected as flow is available.

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V. MONITORING CONSTITUENTS

1. List of Constituents

The selection of the monitoring constituents was based on an evaluation of the EPA final stormwater regulations and the existing monitoring program of the LACDPW. Initially, the constituents monitored during dry weather and under storm conditions will be the same. As water quality data is gathered over time and analyzed, revisions to the list of constituents monitored for both dry weather and under storm conditions may be made as deemed appropriate.

2. Constituents and Sample Collection Methods

The sample collection methods proposed for use are a combination of grab sampling and composite sampling. The details of each method will be elaborated in Part VI: Sampling Procedures. The definition of each type of sample is:

Grab Sample - a discrete, individual sample taken within a short period of time, usually less than 15 minutes.

Composite Sample - a mixed or combined sample that is formed by combining a series of individual and discrete samples (aliquots) of specific volume, collected at specific volume intervals.

The time required to complete the cycle of compositing a sample covers a wide range, from a few hours to over to over 24 hours.

However, certain constituents have very short holding times and specific collection or preservation needs. The existence of and concentration of these constituents cannot be tested by composite samples and must be analyzed from grab samples.

All constituents listed in Table V-1 will be tested by composite sampling. Those listed in Table V-2 must be collected manually by grab samples.

Grab samples are preferred for certain water quality tests because field measurements such as pH and temperature should be instantaneous measurements of stormwater; bacteria have a short holding time; oil and grease tends to adhere on the surfaces that it contacts; volatile organic compounds (VOCs) have a tendency to volatilize when in contact with air; and, cyanide is very reactive and unstable.

3. Chemical Analysis Methods

The chemical analysis methods for each constituent is listed in Tables V-1 and V-2. Also listed are the associated detection limits, sample volumes, preservation needs, and holding times required of each analysis method.

Weather forecasting and estimation of storm size is an inexact science. Therefore, rainstorms may occur where the total sample volume collected via composite sampling is insufficient to perform all the desired analyses. Table V-3 presents a prioritized list of the water quality tests to be performed on the composite sample. For those storms where an insufficient total sample volume has been collected, the tests to be performed will be in accordance with the priority listed on Table V-3.

TABLE V-1

CONSTITUENTS TO BE TESTED FROM FLOW-COMPOSITE SAMPLES

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT	SAMPLE VOLUME	HOLDING TIME	PRESERVATION
<u>Semivolatile Organic Compounds</u>					
Acid					
Benzoic acid	8250		1 Liter	Samples must be extracted within 7 days and extract must be completely analyzed within 40 days. See footnote[7]	Cool, 4°C [illegible] of $Na_2S_2O_3$ See footnote[8]
Benzyl alcohol		≤5			
2-Chlorophenol		≤5			
2,4-Dichlorophenol		≤3			
2,6-Dichlorophenol		≤2			
2,4-Dimethylphenol		≤2			
4,6-Dinitro-2-methylphenol		≤2			
2,4-Dinitrophenol		≤2			
2-Methylphenol		≤3			
4-Methylphenol		≤3			
2-Nitrophenol		≤2			
4-Nitrophenol		≤2			
4-Chloro-3-methylphenol		≤3			
Pentachlorophenol		≤3			
Phenol		≤2			
2,3,4,6-Tetrachlorophenol		≤1			
2,4,5-Trichlorophenol		≤1			
2,4,6-Trichlorophenol		≤1			
		≤1			
Base/Neutral					
Acenaphthene					
Acenaphthylene		≤0.5			
Acetophenone		≤0.1			
Aniline		≤2			
Anthracene		≤2			
4-Aminobiphenyl		≤0.2			
Benzidine		≤3			
Benzo(a)anthracene		≤2			
4-Chloroaniline		≤1			
1-Chloronaphthalene		≤1			
p-Dimethylaminoazobenzene		≤1			
7,12-Dimethylbenz(a)-anthracene		≤2			
a-,a-Dimethylphenethylamine		≤1			
Benzo(a)pyrene		≤3			
Benzo(b)fluoranthene		≤3			
Benzo(k)fluoranthene		≤1			
Chlordane		≤1			
Bis(2-chloroethoxy)methane		≤1			
Bis(2-chloroethyl)ether		≤1			
Bis(2-chloroisopropyl)ether		≤1			
Bis(2-ethylhexyl)phthalate		≤1			
		≤2			

TABLE V-1

CONSTITUENTS TO BE TESTED FROM FLOW-COMPOSITE SAMPLES

LIST OF CONTITUENTS	EPA METHOD	DETECTION LIMIT (ug/l)	SAMPLE VOLUME	HOLDING TIME	PRESERVATION
Base/Neutral (cont.)					
4-Bromophenyl phenyl ether	8250	<1	1 Liter	Samples must be extracted within 7 days and extract must be completely analyzed within 40 days. See footnote[7]	Cool, 4°C [illegible] of $Na_2S_2O_3$ See footnote[8]
Butyl benzyl phthalate		<2			
2-Chloronaphthalene		<1			
4-Chlorophenyl phenyl ether		<1			
Chrysene		<1			
Dibenz(a,j)acridine		<2			
Dibenz(a,h)anthracene		<1			
1,3-Dichlorobenzene		<0.5			
1,4-Dichlorobenzene		<0.5			
1,2-Dichlorobenzene		<0.8			
3,3'-Dichlorobenzidine		<2			
Diethylphthalate		<0.5			
Dimethylphthalate		<0.5			
Di-n-butylphthalate		<2			
2,4-Dinitrotoluene		<0.5			
2,6-Dinitrotoluene		<0.5			
Diphenylamine		<2			
1,2-Diphenylhydrazine		<2			
Di-n-octylphthalate		<2			
Ethyl methanesulfonate		<2			
Fluoranthene		<1			
Fluorene		<1			
Hexachlorobenzene		<0.5			
Hexachlorobutadiene		<1			
Hexachlorocyclopentadiene		<2			
Hexachloroethane		<1			
Indeno(1,2,3-cd)pyrene		<1			
Isophorone		<0.5			
3-Methylcholanthrene		<2			
Methyl methanesulfonate		<2			
Naphthalene		<0.5			
1-Naphthylamine		<2			
2-Naphthylamine		<2			
2-Nitroaniline		<2			
3-Nitroaniline		<2			
4-Nitroaniline		<2			
Nitrobenzene		<0.5			
N-Nitroso-di-n-butylamine		<2			
N-Nitrosodimethylamine		<2			
N-Nitrosodiphenylamine		<2			
N-Nitroso-di-N-propylamine		<2			
N-Nitrosopiperidine		<2			
Pentachlorobenzene		<2			
Phenacetin		<2			
Phenanthrene		<0.6			

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TABLE V-1

CONSTITUENTS TO BE TESTED FROM FLOW-COMPOSITE SAMPLES

LIST OF CONTITUENTS	EPA METHOD	DETECTION LIMIT (µg/l)	SAMPLE VOLUME	HOLDING TIME	PRESERVATION
Base/Neutral (cont.)			↑		Cool, 4°C 10mg of $Na_2S_2O_3$[1]
2-Picoline	8250	<2			
Pronamide	8250	<5			
Pyrene	8250	<0.5			
1,2,4,5-Tetrachlorobenzene	8250	<1			
1,2,4-Trichlorobenzene	8250	<0.5			
Pesticides			1 Liter	Samples must be extracted within 7 days and extract must be completely analyzed within 40 days. See footnote[2]	See footnote [8]
Aldrin	8250	<2	1 Liter		
α-BHC	8250	<1	1 Liter		
β-BHC	8250	<5	1 Liter		
δ-BHC	8250	<4	1 Liter		
γ-BHC (Lindane)	8250	<1	1 Liter		
Chlordane	8250	<2	1 Liter		
4,4'-DDD	8250	<1	1 Liter		
4,4'-DDE	8250	<1	1 Liter		
4,4'-DDT	8250	<1	1 Liter		
Dieldrin	8250	<0.5	1 Liter		
Endosulfan I	8250	<1	1 Liter		
Endosulfan II	8250	<1	1 Liter		
Endosulfan sulfate	8250	<1	1 Liter		
Endrin	8250	<1	1 Liter		
Endrin aldehyde	8250	<1	1 Liter		
Endrin ketone	8250	<1	1 Liter		
Heptachlor	8250	<0.5	1 Liter		
Heptachlor epoxide	8250	<0.5	1 Liter		
Methoxychlor	8250	<2	1 Liter		
Toxaphene	8250	<1	1 Liter		
Polychlorinated Biphenyls			1 Liter		Cool, 4°C Adjust pH 5-9[1] 10mg of $Na_2S_2O_3$[4]
Aroclor-1016	8250	<1	1 Liter		
Aroclor-1221	8250	<1	1 Liter		
Aroclor-1232	8250	<1	1 Liter		
Aroclor-1242	8250	<1	1 Liter		
Aroclor-1248	8250	<1	1 Liter		
Aroclor-1254	8250	<1	1 Liter		
Aroclor-1260	8250	<1	1 Liter		

TABLE V-1

CONSTITUENTS TO BE TESTED FROM FLOW-COMPOSITE SAMPLES

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LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT	SAMPLE VOLUME	HOLDING TIME	PRESERVATION
		(μg/l)			
Pesticides					
Aldrin	608	≤0.05	1 Liter	Samples must be extracted within 7 days and extract must be completely analyzed within 40 days. See footnote[2]	Cool, 4°C Adjust pH 5-9[1] Mg of $Na_2S_2O_3$[4] See footnote 8
α-BHC		≤0.05			
β-BHC		≤0.05			
δ-BHC		≤0.05			
γ-BHC		≤0.05			
Chlordane		≤0.05			
4,4'-DDD		≤0.1			
4,4'-DDE		≤0.1			
4,4'-DDT		≤0.1			
Dieldrin		≤0.1			
Endosulfan I		≤0.1			
Endosulfan II		≤0.1			
Endosulfan sulfate		≤0.1			
Endrin		≤0.1			
Endrin aldehyde		≤0.1			
Heptachlor		≤0.05			
Heptachlor epoxide		≤0.05			
Methoxychlor		≤0.5			
Toxaphene		≤1.0			
Polychlorinated Biphenyls					
Aroclor 1016		≤0.5			
Aroclor 1221		≤0.5			
Aroclor 1232		≤0.5			
Aroclor 1242		≤0.5			
Aroclor 1248		≤0.5			
Aroclor 1254		≤1.0			
Aroclor 1260		≤1.0			
Herbicides tested at spreading grounds					
Prometryn	610	< 2 mg/l	1 Liter		Cool, 4°C
Atrazine					
Simazine					
Cyanazine					

TABLE V-1

CONSTITUENTS TO BE TESTED FROM FLOW-COMPOSITE SAMPLES

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT	SAMPLE VOLUME	HOLDING TIME	PRESERVATION
Metals (Total and Soluble)					
Antimony,	204.2	10ppb	500 mls	6 months	HNO3 to pH < 2
Arsenic,	206.2	10ppb			
Barium	208.2	100ppb			
Beryllium,	210.2	5ppb			
Boron	212.3	250ppb			
Cadmium,	213.2	10ppb			
Calcium	215.2	200ppb			
Chromium,	218.2	10ppb			
Copper,	218.2	10ppb			
Iron	236.2	100ppb			
Lead,	239.2	10ppb			
Magnesium	242.1	200ppb			
Manganese	243.2	30ppb			
Mercury,	245.1	1ppb			
Nickel,	249.2	10ppb			
Potassium	258.1	1ppm			
Selenium,	270.2	5ppb			
Silver,	272.2	10ppb			
Sodium	273.1	5ppm			
Thallium,	279.2	10ppb			
Zinc,	289.2	50ppb			
Others					
Dissolved Phosphorus	300	0.05ppm	50ml	24hrs.	Filter on site, Cool, 4°C, H_2SO_4 to pH<2
Total Phosphorus	300	0.05ppm	50 mls	28 days	4°C, H2SO4 to pH < 2
Turbidity	180.1	0.1NTU	100 mls	48 hours	Cool 4°C
Total Suspended Solids	160.2	2ppm	100 mls	7 days	Cool 4°C
Total Dissolved Solids	160.1	2ppm	100 mls	7 days	Cool 4°C
Volatile Suspended Solids	160.4	2ppm	100 mls	7 days	Cool 4°C
Total Organic Carbon	415.1	1ppm	25 mls	28 days	Cool, 4°C, H2SO4 to pH < 2
Total Petroleum Hydrocarbon	418.1	1ppm	1L	See footnote[7] 28 days[7]	5ml of 50% HCl
Biochemical Oxygen Demand	405.1	2ppm	1L	48 hours	Cool, 4°C
Chemical Oxygen Demand	410.4	20-800ppm	500 mls	28 days	Cool, 4°C, H2SO4 to pH < 2
Total Ammonia Nitrogen	350.2	0.1ppm	500 mls	28 days	4°C, H2SO4 to pH < 2
Total Kjeldahl Nitrogen	351.3	0.1ppm	100 mls	28 days	4°C, H2SO4 to pH < 2
Nitrate-Nitrite	*4110*	0.1ppm	100 mls	14 days	Cool 4°C
Alkalinity	310.1	2ppm	100 mls	28 days	Cool 4°C
Specific Conductance	120.1	1µmho/cm	100 mls	6 months	H2SO4 to pH < 2
Total Hardness	130.2	2ppm			
Chloride	*4110*	2ppm	50 mls	28 days	None
Fluoride	*4110*	0.1ppm	300 mls	28 days	None
Sulfate	*4110*	2ppm	50 mls	28 days	Cool 4°C
			TOTAL 7,925 mls		See footnote[8]

* Standard Methods for the Examination of Water and Wastewater, 1989, 17th Edition, published jointly by APHA, AWWA, and WPCF.

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TABLE V-2

CONSTITUENTS TO BE TESTED FROM GRAB SAMPLES

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LIST OF CONTITUENTS	EPA METHOD	DETECTION LIMIT (µg/l)	SAMPLE VOLUME	HOLDING TIME	PRESERVATION
Volatile Organic Compounds					
Acetonitrile	8240A	10.0	40ml	14 days	Cool, 4°C, 10mg of $Na_2S_2O_3$[1]
Acrolein		10.0			
Acrylonitrile		0.5			
Benzene		0.5			
Bromoform		0.5			
2-Butanone		10.0			
Carbon Disulfide		10.0			
Carbon tetrachloride		0.5			
Chlorobenzene		0.5			
Chlorodibromomethane		0.5			
Chloroethane		0.5			
2-Chloroethyl vinyl ether		1.0			
Chloroform		0.5			
Dibromomethane		0.5			
1,4-Dichloro-2-butene		10.0			
Dichlorobromomethane		0.5			
Dichlorodifluoromethane		0.5			
1,1-Dichloroethane		0.5			
1,2-Dichloroethane		0.5			
1,1-Dichloroethene		0.5			
trans-1,2-Dichloroethene		0.5			
1,2-Dichloropropane		0.5			
cis-1,3-Dichloropropene		0.5			
trans-1,3-Dichloropropene		0.5			
Ethanol		10.0			
Ethylbenzene		1.0			
Ethylene Oxide		10.0			
Ethyl methacrylate		0.5			
2-Hexanone		5.0			
Iodomethane		0.5			
Methyl Bromide		5.0			
Methyl Chloride		5.0			
Methylene chloride		1.0			
4-Methyl-2-pentanone		5.0			
Styrene		0.5			
1,1,2,2-Tetrachloroethane		0.5			
Tetrachloroethene		0.5			
Toluene		1.0			
Trichlorofluoromethane		1.0			
1,2,3-Trichloropropane		0.5			
1,1,1-Trichloroethane		1.0			
1,1,2-Trichloroethane		1.0			
Trichloroethene		0.5			
Vinyl acetate		5.0			
Vinyl chloride		0.5			
Xylene (Total)		0.5			

TABLE V-2

CONSTITUENTS TO BE TESTED FROM GRAB SAMPLES

LIST OF CONTITUENTS	EPA METHOD	DETECTION LIMIT	SAMPLE VOLUME	HOLDING TIME	PRESERVATION
Bacteria					
1. Total Coliform	*9221B*	<20MPN/100ml	100 mls	6 hours	4 °C, 0.008% $Na_2S_2O_3$
2. Fecal Coliform	*9221C*	<20MPN/100ml	100 mls	6 hours	4 °C, 0.008% $Na_2S_2O_3$
3. Fecal Streptococcus	*9230B*	<20mpn/100ml	100 mls	6 hours	4 °C, 0.008% $Na_2S_2O_3$
Oil and Grease	413.2	1ppm	1L/1000mls	28 days	4 °C, H_2SO_4 to pH < 2
Total Phenols	420.1	0.1ppm	500 mls	28 days	4 °C, H_2SO_4 to pH < 2
Cyanide	335.2	0.01ppm	500ml	14 days[5]	Cool, 4 °C NaOH to pH>12 0.6g ascorbic acid[1]
pH	150.1	0-14	25ml	immediately	none
Temperature				immediately	none
			TOTAL 2,355 m[illegible]		

* Standard Methods for the Examination of Water and Wastewater, 1989, 17th Edition, published jointly by APHA, AWWA, and WPCF.

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FOOTNOTES (Tables V-1 and V-2)

[1] Should be added to empty sample container to be used for collection of sample _if_ residual chlorine is present in the sample.

[2] Samples must be extracted within seven days and extract must be completely analyzed within 40 days.

[3] Use NaOH or H_2SO_4, as needed, to adjust the pH. Volume of acid of base must be noted.

[4] If aldrin is one of the pesticides to be tested and the sample is known to have residual chlorine present, then this preservative should in the empty sample container to be used for the collection of the sample.

[5] Maximum holding time is 24 hours when sulfide is present. Optionally, sample may be tested with lead acetate paper before pH adjustment, to determine if sulfide is present. If sulfide is present, it can be removed with the addition of cadmium nitrate powder until a negative spot is obtained. The sample then should be filtered and NaOH added to adjust the pH to >12.

[6] Should only be used in the presence of residual chlorine.

[7] This is an arbitrary holding time selected. None is given in EPA method 418.1 - the approved method to use for TPH testing.

[8] According to 40 CFR 136.3 Table II Notes, Note (2): "For composite chemical samples, each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed."

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TABLE V-3

MONITORING PROGRAM TEST PRIORITY

Order of Preference for Stormwater Testing

Constituent	EPA Method	Sample Quantity (mls)
1. Heavy Metals (dissolved and Total)	200 Series	500
2. Total Petroleum Hydrocarbons (TPH)	418.1	1000
3. Semivolatile Organic Compounds	8250	1000
4. Pesticides (PCBs)	8250 or 608	1000
5. Total Suspended Solids (TSS)	160.1	100
6. Volatile Suspended Solids (VSS)	160.1	100
7. Total Organic Carbon (TOC)	415.1	25
8. Chemical Oxygen Demand (COD)	410.4	500
9. Specific Conductance	120.1	100
10. Total Dissolved Solids (TDS)	160.1	100
11. Turbidity	180.1	100
12. Biochemical Oxygen Demand (BOD)	405.1	1000
13. Dissolved Phosphorus	300	50
14. Total Phosphorus	300	50
15. Total Ammonia Nitrogen	350.2	500
16. Total Kjeldahl Nitrogen	351.3	100
17. Nitrate - Nitrite	4110*	100
18. Alkalinity	310.1	100
19. Chloride	4110*	50
20. Fluoride	4110*	300
21. Sulfate	4110*	50
22. Herbicides at Spreading Grounds	619	1000
	Total	7825 mls**

* Standard Methods for the Examination of Water and Wastewater, 1989, 17th Edition, published jointly by APHA, AWWA, and WPCF.

** Volatile Organic Compounds, Bacteria, Oil & Grease, Total Phenols, Cyanide, pH, and Temperature will be tested from grab samples to a total quantity of 2,365 mls.

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VI. SAMPLING PROCEDURES

This Stormwater/Urban Runoff Monitoring Program is divided into two sub-programs, namely: the dry-weather flow monitoring sub-program, and the storm flow monitoring sub-program. For each of these sub programs, two types of samples will be collected at each monitoring location: Grab samples and composite samples. The constituents to be analyzed for either a grab or composite sample are discussed in Section V, and the automated sampling equipment to be used is described in Section III.

1. Storm Sampling

a. <u>Pre-storm Preparation</u>

In preparing and mobilizing personnel and equipment for a given sampling event, LACDPW will utilize the weather forecasts from the National Weather Service and also from Pacific Weather Analysis, as well as other Department resources such as the LACDPW Alert System. The Alert System is a system of rain and stream flow gauges within the LACDPW flood control system which predicts/measures runoff amounts at key locations and transmits the data via telemetry to LACDPW headquarters. Important deciding factors in mobilizing for a storm sampling event include the probability of rainfall, its expected amount, and its intensity. When a representative storm is expected, sampling personnel will prepare for collection of grab samples as well as verify that the automated samplers are activated for composite flow sampling.

b. <u>Grab Samples</u>

All attempts will be made to collect grab samples during the beginning of the storm on the rising limb of the hydrograph. Such timing is expected to provide concentrations reflecting the higher levels of contaminants which are expected to be observed in the first part of a storm event as compared to those observed during the remainder of the event.

Grab samples will normally be collected using manual sampling equipment such as bucket with rope, dipper, funnel, etc. For manual grab sampling, please refer to Appendix 2 - "Surface Water Sampling Instruction Manual". Grab sample bottles, however, would have to be filled using manual operation of the automated samplers if sample points are inaccessible, such as the closed conduit sampling stations.

c. <u>Flow-Composite Samples</u>

Flow-composite storm samples will be obtained using an automated sampler to collect samples at flow paced intervals. Samples collected at each station will be combined in the laboratory to create a single flow-weighted sample from each station for analysis.

During a storm event, the sampler is programmed to activate automatically when the water level in the channel or storm drain exceeds the maximum diurnal water surface elevation. A sample will be collected each time a set volume of water has passed the monitoring point. The sample will be distributed into glass containers within the refrigerated sampler. The containers will need to accumulate a minimum of eight liters of runoff during each storm, so as to ensure a sufficient sample volume available to perform the necessary laboratory analyses. The automated sampler will deactivate when the water level in the channel or storm drain falls to about 120 percent of the observed maximum diurnal water surface elevation. For detailed discussion on the automated sampler programming, please see Section IV.

Upon conclusion of the storm event, samples will be retrieved from the automated samplers. Samples will be retrieved within the maximum allowable holding times required of the various test methods.

At the same time samples are collected, rainfall and runoff data collected by the sampler will be downloaded for transfer to the office.

2. **Dry-Weather Sampling**

The frequency of dry-weather sampling is once every other month. This frequency was established based on the assumption that the majority of the flow during dry weather comes from discharges that are presently covered by an NPDES permit. The deviation in test results from time to time would therefore be expected to be minor.

As water quality data is gathered under this program, it may be necessary to increase the frequency of monitoring of some constituents, and likewise may be necessary to decrease or eliminate the monitoring frequency of other constituents, shown not to be of a concern.

a. <u>Grab Samples</u>

Grab samples will normally be collected using manual sampling equipment such as bucket with rope, dipper, funnel, etc. For manual grab sampling, please refer to Appendix 2 - "Surface Water Sampling Instruction Manual". Grab sample bottles, however, would have to be filled using automated samplers if sample points are inaccessible, such as closed conduit sampling stations. Specific grab samples will be collected each time composite samples are retrieved.

b. Flow-Composite Samples

During dry weather, an eight-liter composite sample will be collected over a 24-hour period.

Samples will be retrieved and delivered to the laboratory within the maximum allowable holding times of all the various test methods.

3. **Sample Transfer and Chain of Custody**

The LACDPW contracts for laboratory services with the Los Angeles County Agricultural Commission Laboratory, located at 11012B Garfield Avenue, South Gate, CA 90280.

LACDPW maintains a sampling protocol involving appropriate procedures for manually collecting surface water samples and transferring custody of samples. This sampling protocol is detailed in the attached Surface Water Sampling Instruction Manual (Appendix 2). In addition LACDPW maintains frequent contact with our contract laboratory as to the proper containers and handling of samples in order to effect appropriate analyses of the constituents of interest. A chain of custody record shown in the Instruction Manual will be completed to allow step-by-step accounting of the sampling path from origin to analysis. Important information on the custody form includes:

- Name of Person(s) collecting the sample
- Sample Laboratory ID numbers
- Date and Time of Sample Collections
- Names and signatures of all persons handling the samples in the field and in the laboratory.

4. **Personnel Training**

LACDPW's Surface Water Sampling Instruction Manual (Appendix 2) deals with procedures and equipment used in surface water sampling for both manual and automated sampling, grab samples and composite samples, chain-of-custody, and safety of the field personnel. A copy of this manual is issued to all field personnel.

Prior to sampling, all water quality field personnel are provided training that includes familiarization with all the sampling areas, procedures for proper labeling, handling and storage of sample bottles, getting samples from each monitoring site to the laboratory, handling chain-of-custody, performing manual sampling, and operating automatic sampling equipment.

5. **Health and Safety**

General health and safety issues and concerns when performing water quality monitoring is also addressed in the LACDPW Health & Safety Program for all its employees. The program requires each employee to complete a safety matrix, which details hazards, that could be encountered in performing his/her duties. Safety Directives covering instructions on how to deal with said hazards are issued each employee. Example of hazards on a field sampler's safety matrix include: hazardous weather conditions, working in confined spaces, hazards associated with chemicals, snakes, poison ivy, traffic, falling, drowning, etc.

It is also LACDPW policy to require field sampling personnel to undergo a minimum of 40 hours of Hazardous Materials Awareness training, and subsequent required review courses. This training includes instructions on how to evaluate potentially hazardous situations and safety concerns.

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VII. QUALITY ASSURANCE/QUALITY CONTROL PLAN

Field Quality Assurance/Quality Control

1. Overview

Properly performed monitoring station set up, water sample collection, transport, and laboratory analysis are vital to the collection of accurate data. Quality Assurance / Quality Control is an essential component of the Monitoring Program.

It is important to note that this Quality Assurance/Quality Control Plan is for the fixed sites described in the Monitoring Plan, Section II, and not for the planned Illegal/Illicit Discharge Investigation Program which will have its own QA/QC plan.

This QA/QC Plan describes the procedures for bottle labeling, chain-of-custody tracking, field setup, the sampler equipment check and setup, sample collection, the use of field blanks to assess field contamination, the use of field duplicate samples, and transportation to the lab. The QA/QC Plan shall be in place and enforced at all times.

An important part of this QA/QC Plan is the continued learning process of all field personnel. Field personnel must be adequately trained from the onset and must continue to have new information about stormwater sampling techniques shared with them. During the early stages of implementation, field personnel will evaluate the field activities and the possible effects on the QA/QC Plan. Enhancement of the Plan, if needed, will be implemented and an updated QA/QC Plan submitted to the Regional Water Quality Control Board for their use.

2. Bottle Preparation

Bottles will be grouped in sets. For each monitoring station, a minimum of three sets will exist in order to guarantee a consistent rotation of bottles. All bottle labels will be generic in appearance and will look similar to the example on the following page.

BOTTLE NUMBER: ____ of ____	DATE:
STATION NAME:	TIME:
☐ GRAB ☐ COMPOSITE OTHER: ____________	PRESERVATIVES:
LABORATORY ANALYSIS REQUESTED:	COLLECTED BY:
	RECEIVED BY:

Figure VII-1

Bottles shall be cleaned at the laboratory. After the bottles are returned, they will be labeled and stored away as a set package. Each station will have the same number, size and types of bottles existing for each rotation. Clean bottles utilized for composite sampling will be replaced in the sampler at the time of each bottle collection, assuring a pre-setup sampling routine. All bottles not in use will be stored in plastic ice chests used for transporting bottles. The size of composite sample bottles has been limited to a maximum of 2½ gallons each, to ensure ease of handling.

3. **Chain-of-Custody Procedure**

Chain-of-custody procedures and forms provide legal evidence that a sample has not been tampered with. This is achieved by establishing a written record tracing possession of the sample from collection through its final analysis. Primarily we are interested in field chain-of-custody procedures. The contract laboratory's own QA/QC includes chain-of-custody procedures which are in agreement with the field procedures. (See attached Laboratory QA/QC plan.) The chain-of-custody forms will remain at all times with the corresponding samples. Chain-of-custody forms shall be filled out and signed by field staff before actual physical possession of water samples has been turned over either to other staff or to the laboratory. A sample chain-of-custody form is presented as Figure VII-2.

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Figure VII - 2
CHAIN-OF-CUSTODY RECORD

Date ____________ Page ___ of ___

PROJECT NAME: ____________________

DEPARTMENT NAME: LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DIVISION NAME: WASTE MANAGEMENT/STORMWATER SECTION

SAMPLERS SIGNATURE: ____________________

SAMPLE NUMBER	DATE	TIME	LOCATION SAMPLED	METHODS										NO. OF CONTAINERS	COMMENTS/ CONTAINER TYPE

1. RELINQUISHED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	3. RELINQUISHED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	5. RELINQUISHED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	- TOTAL NUMBER OF CONTAINERS SAMPLE CONDITIONS RECEIVED ON ICE YES / NO SEALED YES / NO
2. RECEIVED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	4. RECEIVED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	6. RECEIVED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	SPECIAL SHIPMENT/HANDLING OR STORAGE REQUIREMENTS:

4. **Field Setup Procedures**

All field sampling locations are fixed sites, with the sampler placed on public road rights of way or flood control rights of way. One field staff can conduct the sampler setup and sample collection at each monitoring station. After each sample collection, field staff will prepare the sampler to collect samples either in storm mode or in dry-weather mode. The staff member will also inspect visible hoses and cables to ensure proper working conditions in accordance with manufacturing specifications. Inspection of the strainer, pressure transducer and auxiliary pump can only occur during daylight hours in non-storm conditions.

During a storm event, grab samples will be collected during the initial portion of the storm (on the rising limb of the hydrograph) and subsequently taken directly to the lab. The automated sampler will be checked at the time grab samples are collected to ensure proper working conditions at the site (to see if flow composite samples are being collected). Dry-weather collection techniques will be similar with a 24-hour composite sample and subsequent grab samples being collected.

After a sampling event, all bottles will be collected and samples packed with ice and foam insulation inside individually marked ice chest(s). Field personnel will transport these samples to the Department of Public Works headquarters. Chain-of-custody forms will be completed by field staff before relinquishing them to other staff personnel for transportation of the samples to the laboratory. Under no circumstance will samples be removed from the ice chest during transportation from the field to the laboratory. All samples transported to the laboratory will meet the holding time criteria described in Section V.

5. **Travel Blanks and Field Duplicates**

Potential field contamination will be assessed through analysis of travel blanks and duplicate composite samples. The use of field travel blanks for each monitoring station during every sampling event, represents an attempt to quantify post sampling contamination. The Monitoring Program will also include the use of field duplicates to assess the accuracy of lab results. The collection of a field duplicate will occur for each sampling event. The duplicate will be for one sampling station, unknown to the laboratory. At the present time, this methodology for assessing post sampling contamination and the accuracy of laboratory testing procedures will provide adequate data to measure the accuracy of the results provided to us from the laboratory.

LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

The Los Angeles County Department of Public Works has contracted with the Office of the County Agricultural Commissioner/Weights and Measures Environmental Toxicology Laboratory for all laboratory analysis. A part of this Quality Assurance/Quality Control Plan for the Monitoring Program includes the QA/QC for the Laboratory which is enclosed as two documents (see Appendices 3 and 4). The Laboratory QA/QC Plan is a part of the Monitoring Program.

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VIII. DATA STORAGE AND REPORTING

The following categories of data are being collected as part of the monitoring program:

- Rainfall
- Runoff
- Water Quality Test Data
- Quality Assurance/Quality Control Data

All of the data will be stored in electronic format to allow for ease of retrieval interpretation, and graphic presentation.

Rainfall and runoff data will be collected from each monitoring station after each storm event and stored in a central file. The data will be arranged by monitoring station to show the total rainfall amount and total runoff volume, plus a hydrograph for each sampled storm event.

Water quality data for each monitoring station will be stored in a PC database. The data will also be entered into the EPA's STORET database. QA/QC data will be stored in a PC database.

For each sampled storm event, a report will be prepared summarizing the rainfall, runoff, and water quality data. At the end of each storm season (July 1 to June 30), a yearly monitoring report will be prepared summarizing the data collected.

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IX. PROGRAM MANAGEMENT

Implementation and overall coordination of the Monitoring Program activities, including evaluation of the contract laboratory services will be the responsibility of the Program Manager. The Program Manager will assign field sampling personnel from a pool of technical staff (10 currently available) trained in sampling procedures and methods.

The Program Manager is responsible for evaluation of weather forecasts as provided by our storm forecasting service, and will decide on which storms warrant mobilization for the sampling activities. The Program Manager will assign one of the Field Engineers as an Event Coordinator, who will coordinate the sampling event with the designated field personnel.

For storm sampling, the stations have been divided into three groups as shown below. The stations have been apportioned based on anticipated difficulty of sampling as well as travel to and from each station.

GROUP	MONITORING STATIONS
1	Trancas Canyon Station
	Malibu Creek Station
2	Ballona Creek Station
	Kenter Drain Station
	City of Santa Monica Storm Drain Station
3	Herondo Drain Storm Drain Station
	Palos Verdes Station
	Manhattan Beach Station
	Downtown L.A. Storm Drain Station

One individual will also be assigned to perform field sampling for each group. Each individual will be responsible for all the sampling activities needed at each site within each group.

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For dry-weather sampling, the stations have been grouped as follows:

GROUP	MONITORING STATIONS
1	Ballona Creek Station
	Trancas Canyon Station
	Malibu Creek Station
	Kenter Drain Station
	City of Santa Monica Storm Drain Station
2	Herondo Drain Station
	Palos Verdes Station
	Manhattan Beach Station
	Downtown L.A. Storm Drain Station

Each staff member assigned a Group of stations will be responsible for: Field equipment maintenance and operation; proper collection and handling of samples; and field QA/QC and field sampling protocol.

The Program Manager will be responsible for on-going review, and evaluation of the overall QA/QC program related to sampling and laboratory procedures.

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X. ESTIMATION OF POLLUTANT LOADINGS

One of the objectives of the monitoring program is to assess the annual pollutant loadings to Santa Monica Bay. Knowing the types and quantities of pollutants discharged into the Bay are important in assessing the impacts of stormwater on the Bay.

Model Selection

The model to be utilized to calculate basin-wide mass pollutant loadings is the Simple Method as described in the EPA's "Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems." Due to the size of the Santa Monica Bay Drainage Basin (411 square miles), this method will provide a good estimate of pollutant loadings, without requiring the extensive amount of detailed hydrologic and hydraulic data needed by more sophisticated models. Once pollutant loads have been estimated basin wide, an initial assessment can be made as to their potential impacts on the Bay. Subsequently, more detailed, dynamic modelling of select, representative watersheds in the Bay can be performed to more accurately track and assess pollutant impacts.

Calculation Procedure

Calculation of annual pollutant loadings will be performed as follows:

1. Calculate annual pollutant loads for each drainage area.

   Utilizing the formula below, calculate annual pollutant loads for each drainage area:

   Equation 1: $$L_i = \frac{(P)(CF)(Rv_i)}{12}(C_i)(A_i)(2.72)$$

   where:

   - L_i = Annual pollutant load (lb/drainage area/yr)
   - P = Annual precipitation (in/yr)
   - CF = Correction factor that adjusts for storms where no runoff occurs
   - Rv_i = Weighted-average runoff coefficient for the drainage area
   - C_i = Event mean concentration of pollutant (mg/L)
   - A_i = Drainage area (acres)

   The numbers 12 and 2.72 are conversion factors that account for unit conversions.

Each of the parameters in Equation 1 is defined below:

- Annual pollutant load is the total amount of a specific pollutant discharged in pounds per time period (in this case, per year) for the particular drainage area being modeled.

- Annual precipitation is the total inches of rainfall occurring in a single year. Estimates of the annual rainfall are calculated utilizing the historical rainfall data compiled for Los Angeles County by the Los Angeles County Flood Control District and, subsequently, the LACDPW.

- Correction factor is an adjustment factor for the number of storm events that do not actually produce any runoff (i.e., the percentage of storm events that have a total accumulation greater than a specific threshold value). This value will be calculated based on a review of historic rainfall data for Los Angeles County.

- Weighted-average runoff coefficient is a relative measure of the percentage of rainfall that becomes surface runoff. Runoff coefficients will be calculated utilizing the procedure described in Section IV.

- Event mean concentration of pollutant is the event mean concentration value for the specific pollutant determined from an analysis of the flow-weighted composite samples obtained by the monitoring program.

- Drainage area is the size of the area being modeled.

2. Use the per-drainage area annual pollutant loads to calculate per-watershed annual pollutant loads.

   The following equation will be used to calculate per-watershed annual pollutant loads.

   Equation 2 $L_w = \Sigma L_i$

   where:

   L_w = Annual pollutant load for a particular watershed

   ΣL_i = Summation of individual annual pollutant loadings from all drainage areas within a specific watershed

3. Use the per-watershed annual pollutant loadings to calculate basin-wide annual pollutant loads.

   The following equation will be used to calculate basin-wide annual pollutant loads.

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Equation 3 $L_a = \Sigma L_w$

where:

L_a = Annual pollutant load for entire basin

ΣL_w = Summation of individual annual pollutant loadings from all watersheds within the basin

The above procedure can also be utilized to estimate seasonal pollutant loads and per storm event pollutant loads as needed.

Constituents to be Modeled

Annual pollutant loadings will be calculated for the following constituents:

BOD_5
COD
TSS
Dissolved Solids
Total Nitrogen
Total ammonia plus organic nitrogen
Total Phosphorus
Dissolved Phosphorus
Cadmium
Copper
Lead
Zinc

Development of Annual Pollutant Loadings

We are targeting installation of our monitoring stations for operation during the 1993-94 storm season. Upon completion of the storm season by the end of April 1994, and assuming sufficient storms have occurred for sampling, event mean concentrations will be calculated. We estimate that the pollutant loads for the Bay will be developed by August 1, 1994.

XI. LONG-TERM TRENDS IN STORMWATER/URBAN RUNOFF QUALITY

As discussed in Section II, nine fixed-station monitoring sites are proposed for the Santa Monica Bay Drainage Basin. The locations of these sites have been chosen to be representative of the various watersheds and land uses within the Basin.

In addition to providing data necessary for calculation of the event mean concentrations, long-term data from these sites can be evaluated for any trends. The objective of this evaluation is to determine if there are any statistically significant differences in pollutant concentrations and loadings which could be related to the implementation of Best Management Practices (BMPs) as opposed to random variability in hydrologic factors such as the frequency, intensity, and duration of storm events.

Complicating this evaluation is the fact that there is no, location specific, baseline data available prior to the implementation of BMPs. Monitoring at the nine stations will be commencing concurrently with implementation of various BMPs. Therefore, dependent on the number of storms available, at least five or more years of data will be needed before reasonable statistical analysis of trends could be performed due to the large degree of natural variability. Therefore, we recommend that any statistical analysis of trends be performed after the conclusion of the fifth year of monitoring.

XII. SOURCES OF STORMWATER POLLUTANTS

It is suspected that different land uses contribute certain types and amounts of pollutants to the storm drain system. Therefore, monitoring sites will be located to characterize runoff from individual land uses. As discussed in Section II, the following stations are being proposed for individual land-use monitoring.

STATION	LAND USE
Private Drain No. 658 (Trancas Canyon)	Open Space
Project No. 5401, Line A (Manhattan Beach)	Single Family
City of Los Angeles Storm Drain No. D-2361 (Downtown Los Angeles)	Commercial/Industrial
City of Santa Monica Pier Storm Drain	Commercial
Project No. 558, Line A (Palos Verdes Estates)	Single Family

Evaluating the quality of runoff from highway surfaces is also important. We are working with Caltrans to locate a section of freeway where runoff from the road surface would be isolated from surrounding land uses and is collected by a storm drain that meets the physical requirements for location of a sampling station. Establishment of this site is estimated to occur around Fall of 1994 prior to the 1994-95 rainy season.

Up to five storm samples per year will be collected from each site. Dry-weather flow samples will be collected bimonthly. Both storm and dry-weather samples will be tested for all constituents listed in Section V.

As discussed in Section XI, upon conclusion of the 1993-94 rainy season, event mean concentrations will be calculated for sampled constituents and mass pollutant loads determined for the specific constituents described in the aforementioned section. This will provide an initial assessment of the type and quantity of constituents present in the runoff from these specific land uses.

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APPENDIX 1

STEP-BY-STEP PROCEDURE

FOR

RUNOFF ESTIMATION

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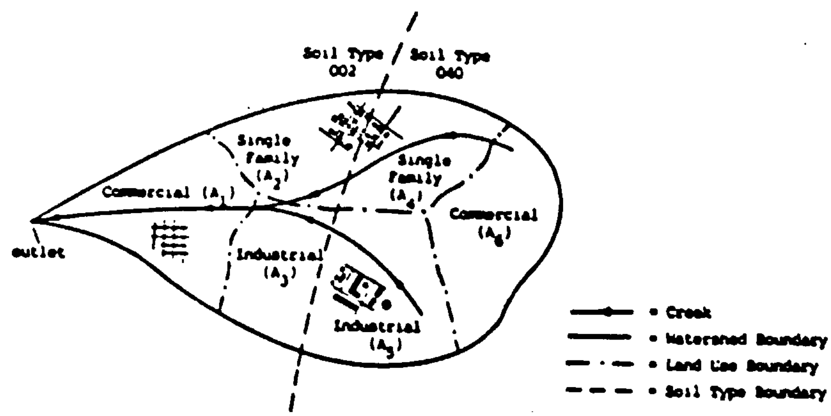
EXAMPLE

1. Calculate the Runoff Coefficient for a Study Area

   Typical Example: The Study Area shown is comprised of two soil types and three land-use types.



Upon examining the Study Area, there are six unique soil types - land-use type combination areas. The areas are numbered 1 through 6. The data for these areas is summarized below:

Area Number	Soil Type	Land Use	Imp.	Area (Square Miles)
1	002	COM	.95	6
2	002	SF	.42	2
3	002	IND	.90	3
4	040	SF	.42	3
5	040	IND	.90	2
6	040	COM	.95	3

In general, the runoff coefficient is first calculated for each individual area. A weighted average calculation is performed to arrive at the overall runoff coefficient for the Study Area.

The detailed procedures is described below:

a) First the Undeveloped Runoff Coefficient (C_u) is determined for each area from the runoff coefficient curve for the soil type for the area. This is done by first choosing the rainfall intensity (in/hr). With this rainfall intensity value go to the runoff coefficient curve and select C_u.

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b) The developed Runoff Coefficient (C_D) is then calculated for each area based on the following formula:

$$C_D = .9IMP + C_U\ (1-IMP)$$

The IMP is the imperviousness value assigned to the land use within each area.

c) After calculating C_D for each individual area, a weighted average calculation is performed to come up with the average C_D for the entire Study Area.

Now we will calculate C_D for the Study Area:

Select rainfall intensity

The rainfall intensity to be used will be 1.5 in/hr. If the rainfall intensity is not known or no specific value is to be used, then C_U automatically goes to the minimum or default value of 0.1 which is the same for all soil types. The calculation process should be established to use the default value unless a user specified rainfall intensity is provided.

Determine C_U

The Study Area is comprised of two soil types. C_U for these soil types is:

Soil type	C_U
002	.79
040	.75

Calculate C_D

Calculate C_D for each area:

Area No.	C_U	Imp.	C_D
1	.79	.95	.89[1)]
2	.79	.42	.83
3	.79	.90	.79
4	.75	.42	.81
5	.75	.90	.89
6	.75	.95	.89

1) C_D for Area 1 = .9(.95) + .79(1-.95) = 0.89

Therefore, C_D for the Study Area is:

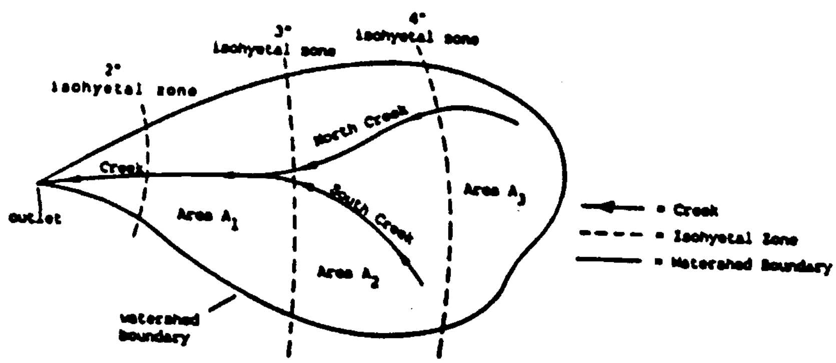
$$C_D \text{ Study Area} = \frac{C_{D1}\text{ Area}_1 + C_{D2}\text{ Area}_2 + C_{D3}\text{ Area}_3 \ldots}{(\text{Area}_1, + \text{Area}_2 + \text{Area}_3 \ldots)}$$

$$= \frac{.89(6) + .83(2) + .79(3) + .81(3) + .89(2) + .89(3)}{(6+2+3+3+2+3)}$$

$$= .86$$

2. **Calculate Rainfall Volume Over the Study Area**

The Study Area is shown below and encompasses the indicated isohyetal zones.



The total area of the Study Area is 10 mi^2. The portion of the Study Area encompassed by each isohyetal zone is listed below:

Zone	Area(mi^2)
2"	3
3"	7
4"	9

The total rainfall volume deposited on the study area is:

$$\text{rainfall volume} = [2(3) + 3(7) + 4(9)]\ (640\ \tfrac{acres}{mile^2})\ (1/12)$$

$$= 3360 \text{ Acre}\cdot\text{feet}$$

$$\text{or } \frac{3360\ \ 12\ (\frac{inches}{foot})}{19(mi^2)\ (640\ \frac{acre}{mile^2})} = 3.3\text{" depth over the entire study area}$$

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3. **Calculate the Runoff Volume for a Study Area**

For the Study Area used in this example, the runoff coefficient (C_D)=0.86.

runoff volume = Rainfall Volume (C_D)

= 3360 Acre•feet (0.86)

= 2890 Acre•feet

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APPENDIX 2

SURFACE WATER SAMPLING

INSTRUCTION MANUAL

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SURFACE WATER SAMPLING INSTRUCTION MANUAL

PUBLIC WORKS

LOS ANGELES COUNTY

"Public Service That Works"

LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS

WASTE MANAGEMENT DIVISION

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I. INTRODUCTION

This manual covers collection of surface water samples for the Department's Stormwater/Urban Runoff Monitoring Program, and compliments the sampling procedures contained in the Work Plan for the Stormwater/Urban Runoff Monitoring Program (Work Plan).

Two sampling techniques, Manual Sampling (sampling by hand) and Automated Sampling (sample collection by use of powered devices such as the Automated sampler) are used in the monitoring program. Both manual sampling and automated sampling techniques are discussed in this sampling manual, with reference to the above-mentioned Work Plan.

Samples collected for both dry weather and storm flow monitoring programs are typed either "Grab" or "Composite". Grab sample is an individual discreet sample collected for characterizing water quality at a particular time. Grab samples normally would be collected using manual sampling techniques, unless sampling collection can only be achieved using automatic samplers, such as at manhole stations that are very deep and not accessible using manual grab sampling equipment. Composite samples are series of individual samples collected at paced intervals and combined to create a single weighted composite. Composite samples would normally be obtained, using automated sampling techniques.

The following instructions will help you collect samples and transport water samples safely and correctly. Safety is of the utmost importance, but if a sample is not collected or transported correctly, the subsequent lab analysis results will be compromised or invalidated.

It should be noted that these instructions are merely a guide to meet the specific needs of the Department. They are not intended to be a comprehensive guide to water quality sampling. Numerous textbooks, handbooks, and manuals are available for those interested in more detailed information on sampling methodology.

II. COLLECTION OF SAMPLES

Water samples will be collected in bottles supplied by the contract laboratory. All sample bottles, except bacteria bottles have been acid-washed and thoroughly rinsed with distilled water to eliminate contamination. Bacteria bottles contain a dechlorinating chemical. DO NOT RINSE THE SAMPLE BOTTLES BEFORE FILLING.

However, the bucket, dipper and funnel should be rinsed at each new sampling location. Use the water at each new site to rinse off any contaminates left in the bucket from prior sites.

DO NOT USE SOAP OR ANY OTHER DETERGENTS TO CLEAN SAMPLING EQUIPMENT.

A. Manually Collecting Grab Samples

A Manual grab is collected by inserting a container (bucket, dipper, etc.) under the surface of the water body to be sampled and/or dipping a container down current of a discharge with the container opening facing upstream. The following manual sampling procedures should be followed, in accordance with the source of the sample as well as requirements for certain analyses:

1. Nonflowing - Reservoirs, Lakes, and Ponds

   The sampling technique will depend on the location and purpose of the investigation. The following general rules should be observed:

   a. Select a location away from areas where water may tend to be stagnant.

   b. Take samples at a location that is definable in plan and depth so that subsequent samples can be taken from the same location. This is important where a study is to be made regarding water quality changes with time.

2. Flowing Water

   a. When sampling with a bucket and line from above the streamflow, first attach the line to the bridge railing or some other firmly fixed object. Lower the bucket gently into the center of the channel. Make sure the bucket is submerged to avoid the collection of floating debris.

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b. When sampling for oil and grease, sample should be collected at the air/water interface to insure collection of representative samples.

c. Avoid hitting the bottom of the channel so that deposited sediments are not collected.

d. When using the bucket and line adjacent to the low-flow channel, gently swing the bucket into the center of the flow to collect the sample.

e. After raising the bucket, take the temperature of the sample immediately for at least 30 seconds.

f. Pour off any floating debris and decant the water from the bucket into the sample bottles.

3. Bacteriological Samples

Bacteriological samples should be taken under sterile conditions, observing the following precautions (also refer to Section C 2. Sample Bottles):

a. Do not rinse the bottle. The bacteria bottle contains a dechlorinating chemical which must mix with the sample.

b. Do not fill the bottle completely; leave about 1/2 inch to allow mixing of the contents.

c. When sampling, prevent contaminating the lip and cover of the sampling bottle by avoiding contact with anything but the sample or the source of the sample.

B. Collecting Grab Samples By Automated Sampler

Collection of grab samples can also be accomplished by using the automated samplers. This is accomplished by temporarily bypassing the automated sampling program and utilizing the pumping unit of the automated sampler to fill the grab sample bottles. This sampling technique may be used if sample points for grab samples are inaccessible, such as at sampling stations that are very deep below the ground surface and cannot be accessed using manual grab sampling equipment. However, once the grab samples are collected, the automated sampling system must be restored to its ready mode for performing its programmed functions.

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C. Flow Composite Samples

Flow weighted composite samples are collected using the automated samplers, programmed to collect samples for Storm Sampling (at flow paced intervals), and for Dry Weather Sampling (at fixed time intervals). For both storm sampling and dry-weather sampling, sample bottles must be retrieved within the maximum holding times required of the various test methods. Sample bottles are to be placed in coolers with frozen blue ice for transport to the laboratory for compositing and analysis.

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C. Flow Composite Samples

Flow weighted composite samples are collected using the automated samplers, programmed to collect samples for Storm Sampling (at flow paced intervals), and for Dry Weather Sampling (at fixed time intervals). For both storm sampling and dry-weather sampling, sample bottles must be retrieved within the maximum holding times required of the various test methods. Sample bottles are to be placed in coolers with frozen blue ice for transport to the laboratory for compositing and analysis.

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III. SAMPLING EQUIPMENT

You will be provided with the sampling equipment necessary for your assignment. The equipment may consist of the following items:

- Bucket and rope
- Sample bottles
- Thermometer
- Personal equipment: (if applicable)
  - Hard hat and vest
  - Flashlight
  - Thomas Guide and location sketch
  - Rubber Gloves

A. Bucket and Rope

All surface samples collected manually by the Water Quality Management/Storm Water Section are of the type known as "grab samples". Under this procedure a sample may be collected in a bucket at a randomly selected time, over a period of time not to exceed 15 minutes.

B. Sample Bottles

You will be provided with the appropriate sample bottles and containers by the contract laboratory. Sample containers are easy to contaminate, therefore, AVOID TOUCHING the mouth of the bottle or the inner surface of the cap. Except when otherwise stated all containers should be filled to within 1" of the top NEVER TO OVERFLOWING. Identify the sample and provide necessary information requested on the container label using a waterproof ink pen. Place all glass containers into plastic protective bubble pack bags, and/or pack the containers in the cooler with shock absorbing materials to minimize the possibility of breakage. Add frozen blue ice, and deliver to the contract laboratory.

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1. CONTAINER IDENTIFICATION

Group	I.D.	Container Type
A	Gen Min	1 L Plastic
B	Gen Min	1 L Plastic
	Micro	125 ml Plastic (Sterile)
	TPH	1 L Glass
C	Gen Min	1 L Plastic
	Micro	125 ml Plastic (sterile)
	TPH, Cr+6	1 L Glass
	Metals	500 ml Plastic w/ HN03
	O & G	1 L Glass
	Pest	2 L Glass
D	Gen Min	1 L Plastic
	Micro	125 ml Plastic (sterile)
	TPH, Cr+6	1 L Glass
	Metals	500 ml Plastic w/ HN03
	O & G	1 L Glass w/ H2S04
	Pest	2 L Glass
	TOC	125 ml Glass
	BOD	250 ml Plastic
E	Gen Min	1 L Plastic
	Micro	125 ml Plastic (sterile)
	TPH, Cr+6	1 L Glass
	Metals	500 ml Plastic w/ HN03
	O & G	1 L Glass w/ H2S04
	Pest	2 L Glass
	TOC	125 ml Glass
	BOD	250 ml Plastic
		VOA(2) 40 ml Glass Vial
F	Gen Min	1 L Plastic
	Micro	125 ml Plastic (sterile)
	TPH, Cr+6	1 L Glass
	Metals	500 ml Plastic w/ HN03
	O & G	1 L Glass w/ H2S04
	Pest	2 L Glass
	TOC	125 ml Glass
	BOD, Solids	250 ml Plastic
	VOA	(2) 40 ml Glass Vial

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G	Gen Min	1 L Plastic
	Micro	125 ml Plastic (sterile)
	TPH, Cr+6	1 L Glass
	Metals	500 ml Plastic w/ HN03
	O & G	1 L Glass w/ H2S04
	Pest	2 L Glass
	Herb	2 L Glass
	BNA	2 L Glass
	TOC	125 ml Glass
	BOD, Solids	250 ml Plastic
	VOA	(2) 40 ml Glass Vial
H	Gen Min	1 L Plastic
	Micro	125 ml Plastic (sterile)
	TPH, Cr+6	1 L Glass
	Metals	500 ml Plastic w/ HN03
	O & G	1 L Glass w/ H2S04
I	Gen Min	1 L Plastic
	Micro	125 ml Plastic (sterile)
	TPH, Cr+6	1 L Glass
	Metals	500 ml Plastic w/ HN03
	O & G	1 L Glass w/ H2S04
	TOC	125 ml Glass
	BOD	250 ml Plastic

2. **SPECIFIC INSTRUCTIONS**

a. General Mineral (Gen Min):

Fill unpreserved container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage.

b. Microbiology (Micro):

Fill unpreserved 1 Liter plastic container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. Place container in cooler with "Blue Ice" to minimize the effect of high temperatures on deaths of microbes. The maximum holding time for bacteria samples is six hours from the time of collection. Therefore, the samples must immediately be transported to the laboratory. Also, refer to preceding Section B 3. Bacteriological Samples.

c. Total Petroleum Hydrocarbon (TPH or TPH, Cr+6):

Fill unpreserved container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

d. Metals:

Fill preserved container to within 1" of the top. DO NOT RINSE OUT OR OVERFILL. Contains Nitric Acid as a preservative. Tighten cap to prevent leakage.

e. Oil and Grease (O & G) :

Fill preserved container to within 1" of the top. DO NOT RINSE OUT OR OVERFILL. Contains Sulfuric Acid as a preservative. Tighten cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

f. Pesticide-PCB's (Pest-PCB):

Fill unpreserved container to within 3" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

g. Total Organic Carbon (TOC):

Fill unpreserved container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

h. Biological Oxygen Demand (BOD):

Fill unpreserved container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage.

i. Volatile Organics (EPA 601/602):

Slowly fill the two 40ml vials to overflowing, being careful not to aerate the sample. Carefully place the cap onto the vial and tighten to prevent leakage. Make sure that the teflon surface of the septum (hard white side) is facing the sample, the soft silicon side of the septum should be visible from the top of the cap. Invert the vials to confirm proper sample collection (bubbles should not be observed). If bubbles are present, open the vials, add more sample, reseal the vials, and recheck for air bubbles. Place the glass vials into the plastic protective bubble bag and, if possible, store in a cooler with "Blue Ice".

j. Base-Neutral-Acid Extractables (BNA):

Fill unpreserved container to within 3" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

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k. Herbicides (Herb):

Fill unpreserved container to within 3" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

3. SPECIAL SAMPLES

a. Organic Nitrogen (TKN):

Fill preserved 250 ml plastic container to within 1" of the top. DO NOT RINSE OUT OR OVERFILL. Contains Sulfuric Acid as a preservative. Tighten cap to prevent leakage.

b. Radioactivity (Gross alpha & beta):

Fill preserved 1 Liter plastic container to within 1" of the top. DO NOT RINSE OUT OR OVERFILL. Contains Nitric Acid as a preservative. Tighten cap to prevent leakage.

c. Asbestos:

Fill unpreserved 1 Liter plastic container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage.

d. Chlorinated Organic Substances (COS):

Use same sampling procedure as for EPA 601/602. The EPA reference manual is available in the Water Quality Section.

e. Nitrite-N (1 ppb DL):

Fill unpreserved 125 ml plastic container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage.

C. Thermometer

Water temperatures are always taken during sampling, and you will be provided with a thermometer for this purpose.

D. Dissolved Oxygen Meter

If your assignment requires the measurement of dissolved oxygen, you will be provided with a DO meter and instructions on its use. Calibration of the meter is essential prior to each use. Instructions to operate the DO meter will be provided prior to usage.

E. <u>Personal Equipment</u>

Before leaving on a sampling assignment, make sure that you have all of the personal equipment necessary to carry out your assignment. This would include your hard hat and vest, gloves,flashlight if necessary, Thomas Guide, etc, and location sketches showing the various surface sampling stations and access points.

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IV. SAFETY

Safety Reminders:

1. Safety is more important than the samples. Never place yourself in a dangerous or unsafe sampling situation.

2. Always park your vehicle where it is safe. Pull into an access road or park your vehicle on a street where parking is permitted and walk to the site. NEVER PARK ON A BRIDGE.

3. Wear your hard hat and a high-visibility vest when you leave your vehicle.

4. Wear waterproof boots with high-traction soles when walking or standing on wet surfaces. Slippery surfaces should be avoided.

5. Never stand or walk in moving water.

6. Never get too close to a low-flow channel. Use your bucket and line to obtain a surface sample.

7. **Never enter an enclosed drain, tunnel, or a confined space.**

8. If waters are flowing outside the low-flow channel, lower the bucket and line from a bridge.

9. When sampling from a bridge, always tie one end of your rope to the railing or some other firmly fixed object. Do not lean excessively over the guard rail.

10. Be alert for hazardous situations. Your personal safety is your first responsibility. Common sense safety precautions must be exercised if you come upon an unusual material, discharge, smell, dumping, etc. Take note of your observations. Your notes may be used in follow-up investigations and/or supporting future analytical findings. Sample must not be taken if common sense judgement indicate that your safety is jeopardized.

11. Wear gloves when handling samples and wash your hands with soap and water when finished.

12. Wash all equipment, boots, gloves, bucket, etc., when finished.

13. When ascending or descending unstable or slippery slopes and embankments, avoid holding breakable bottles, and pointed or sharp objects with bare hands.

14. Each employee has Physical Class Limitations established under the Occupational Health Manual of Policies and Procedures of the Department. Exerting physical efforts or lifting weights over your physical class limit must be avoided to prevent physical injury. Ice chests with full sample bottles may exceed the weight-class requirements; in such cases, the ice chest must be transported by a minimum of two persons.

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V. LABELING AND FIELD OBSERVATIONS

Each sample bottle will normally be pre-labeled by the Water Quality Unit. It is important, however, that each sample be identified as to the source, date, and time of acquisition. If a sample is taken from a large body of water, for example, the location should be described in such a way as to enable the same sample point to be relocated in the future if it becomes necessary.

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VI. DELIVERY OF SAMPLES

Samples should be delivered to the contract laboratory as soon as possible to prevent alteration of the sample between time of sampling and time of analysis. In order to avoid the need to preserve the samples overnight, samples should be delivered to the contract laboratory no late than 5:00 p.m., unless prior arrangement with the contract laboratory is made.

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VII. CHAIN OF CUSTODY

The Chain-of-Custody Record form shown must be completed for each delivery of samples to the contract laboratory. When sampling for potential court case litigation, consult the laboratory for the appropriate testing procedures, splitting and sealing of samples, and chain of custody.

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Figure VII - 2

CHAIN-OF-CUSTODY RECORD

Date ____________ Page ___ of ___

PROJECT NAME: ______________________

DEPARTMENT NAME: LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DIVISION NAME: WASTE MANAGEMENT/STORMWATER SECTION

SAMPLERS SIGNATURE: ______________________

SAMPLE NUMBER	DATE	TIME	LOCATION SAMPLED	METHODS										NO. OF CONTAINERS	COMMENTS/ CONTAINER TYPE

1. RELINQUISHED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	3. RELINQUISHED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	5. RELINQUISHED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	- TOTAL NUMBER OF CONTAINERS SAMPLE CONDITIONS RECEIVED ON ICE YES / NO SEALED YES / NO
2. RECEIVED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	4. RECEIVED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	6. RECEIVED BY: SIGNATURE PRINTED NAME DEPARTMENT / DIVISION / COMPANY	DATE TIME	SPECIAL SHIPMENT/HANDLING OR STORAGE REQUIREMENTS:

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VIII. PHONE LIST

The following are some frequently-used phone numbers:

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

Waste Management Division Water Quality Management Section	(818) 458-6972

Flood Maintenance Division

Field Offices

Eaton Yard	(818) 798-6761
Hansen Yard	(818) 896-0594
Imperial Yard	(310) 861-0316
83rd Street Yard	(213) 776-7610

AGRICULTURAL COMMISSIONER/WEIGHTS & MEASURES

Environmental Toxicology Lab	(310) 940-6778

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APPENDIX 3

QUALITY ASSURANCE MANUAL

COUNTY OF LOS ANGELES
OFFICE OF
Agricultural Commissioner/
Weights and Measures

VOL 12

ENVIRONMENTAL TOXICOLOGY LABORATORY

Quality Assurance Manual

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8410

11012 Garfield Avenue, Bldg. B South Gate, Ca 90280

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COUNTY OF LOS ANGELES
OFFICE OF
Agricultural Commissioner/
Weights and Measures

ENVIRONMENTAL TOXICOLOGY LABORATORY

Quality Assurance Manual

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QA OBJECTIVES

1. Establish the laboratory's ability to qualitatively and quantitatively analyzed various types of environmental samples for pollutants by:

   - identifying the qualifications and responsibilities of laboratory personnel;

   - enumerating the existing laboratory instrumentation and equipment together with the procedures for their sevice and maintenance to assure proper operation:

   - providing sources of analytical methods accepted by regulatory agencies for use in the laboratory.

2. Provide guidelines pertaining to sampling protocols, chain-of-custody, and storage of samples to maitain sample integrity prior to analyses.

3. Define the laboratory's calibration procedures and frequency of calibration.

4. Identify all the necessary steps to validate the laboratory's results.

5. Define all the necessary quality control checks that must be followed prior to the analysis and/or in the course of analyzing samples.

6. Identify all laboratory records and information needed to document the quality of analyses performed in the laboratory.

COUNTY OF LOS ANGELES
Office of Agricultural Commissioner/Weights and Measures
ENVIRONMENTAL TOXICOLOGY LABORATORY

<u>Organizational Chart</u>

- Agricultural Commissioner
  - Chief Deputy
    - Deputy Director
      - Secretary I
      - Laboratory Chief
        - Intermediate Typist Clerk
        - Senior Toxicologist
          - Toxicologist (4)
            - H/P Technologist
              - Lab. Support Supervisor I
        - Senior Industrial Hygiene Chemist
          - Industrial Hygiene Chemist
            - Tox. Technologist
              - Laboratory Assistant

1. Organization

A. Minimum Personnel Qualification and Background

1. Deputy Director Graduation from an accredited college with specialization in chemistry, biochemistry, biology, or agricultural chemistry, and three years experience in analytical chemistry, biochemistry, pharmacology, or toxicology laboratory. An advanced degree in chemistry or biochemistry will be accepted for the required experience on the basis of one year for Master's degree and two years for a Ph.D.

2. Chief-A Bachelor of Science degree and at least three years experience in chemistry, biochemistry, pharmacology, biology, or toxicology, one year of which must have involved the chemical analysis of environmental samples. An advanced degree in chemistry or biochemistry will be accepted for the required experience on the basis of one year for a Master's degree and two years for a Ph.D.

3. Senior Toxicologist-Graduation from an accredited college with specialization in chemistry or biochemistry, and two years experience in analytical chemistry, biochemistry, pharmacology, or toxicology. An advanced degree in chemistry or biochemistry will be accepted for the required experience on the basis of one year for a Master's degree and two years for a Ph.D.

4. Senior Industrial Hygiene Chemist-Master of science degree with a major in general or physical chemistry and five years experience as a professional chemist conducting basic analytical research in chemistry, or four years experience as as Industrial Hygienu Chemist.

5. Toxicologist-Graduation from an accredited college with specialization in chemistry or biochemistry, and one year experience in analytical chemistry, biochemistry, pharmacology, or toxicology. Completion of one year graduate work in an accredited college with specialization in chemistry or biochemistry will be accepted for the required experience.

6. Industrial Hygiene Chemist-Bachelor of science degree with major in chemistry a biochemistry, and either (1) a Master's degree in chemistry, biochemistry, or a related field of environmental chemistry and two years experience as a professional chemist doing increasingly complex analytical procedures, or (2) four years experience as a professional chemist doing increasingly complex analytical procedures.

7. Herbicide Pesticide Technologist-Graduation from an accredited college with specialization in chemistry, biochemistry, toxicology, biological & natural sciences and six months experience performing chemical analyses or completion of sixty semester units of which 16 must have been in chemistry and two years experience performing toxicological analyses.

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8. Toxicological Technologist-same as Herbicide/Pesticide Technologist.

9. Senior Laboratory Assistant-Six months experience at the laboratory assistant level.

10. Laboratory Assistant-Six months experience in laboratory work in a public health, medical, chemical, or biological laboratory, or completion of a course in laboratory science such as general chemistry or bacteriology.

B. Personnel Responsibilities

1. Deputy Director

-Directs, plans, assigns, reviews and evaluates work performed by laboratory personnel.

-Provides consultation in environmental toxicology to DHS, Agriculture Comm. and other agencies.

-Testifies as an expert witness for Los Angeles County on the analysis and interpretation of findings.

-Supervises the analysis and interpretation of laboratory data and correlates this with biochemical and metabolic effects.

-Publish scientific papers and reports. Make presentations concerning H/P contamination in our community. Attends and participates in conventions, meetings and conferences of professional organizations concerning H/P.

2. Chief

-Assists in the planning, assignment, supervision, and review of the work of laboratory personnel.

-Provides technical direction to laboratory personnel in performing a variety of chemical analyses of water, soil, plant, animal and other environmental samples utilizing various techniques such as spectrophotometry, chromatography, gravimetric, and volumetric analyses.

-Establishes and sets up special test procedures for detecting pesticides and other chemicals for which the laboratory has minimal or no experience, including all required and necessary quality control steps in such procedures.

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-Establishes minimum quality control guidelines for all methods and tests performed in the laboratory.

-Develops laboratory statistics and reports on analytical procedures in assisting laboratory personnel in making the more difficult or unusual determinations, to identify priorities, and to establish work flow measures.

-Conducts training of laboratory personnel.

-May testify as an expert witness for the Chief Environmental Toxicologist.

3. Senior Toxicologist

-Provides technical guidance to laboratory personnel and performs chemical analyses to determine the presence and quantity of pesticides and other chemicals of interest in samples submitted to the laboratory for study utilizing wet and instrumental methods.

-Develops procedures for and conducts non-routine analysis on samples involving new and uncommon pesticides where standard methods are not established.

-Routinely monitors at regular intervals the accuracy and precision of laboratory results by checking quality control data obtained by laboratory personnel as part of their daily workload.

-Ensures that all quality control guidelines of the laboratory are met and recorded in specific quality control record books.

-Prepares daily work assignments of lower level laboratory personnel.

-Engages in continuing research and experimentation to develop and improve analytical procedures.

-Writes reports on analyses outlining methods used and results.

-Assists the Supervising Toxicologist in performing an analysis of unknown substances.

-Contacts pathologists, law enforcement officers, pharmacists and others to obtain information on cases as necessary.

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4. Senior Industrial Hygiene Chemist

-Prepares work schedules, assigns and rotates Industrial Hygiene Chemists to various jobs, evaluates work performance and recommends resolutions to employee relations problems.

-Tests or directs the testing of new equipment, prepares written evaluations, and makes recommendations for its acquisition; prepares written instructions on the application and oper tion of new equipment for the procedure manual.

-Supervises a program of quality control to ensure the accuracy of test reports.

-Orients new employees to the overall operations of the section and trains or supervises their training.

-Serves as the consultant to Public Health Programs staff on problems relating to toxic and potentially dangerous chemicals.

-Analyzes samples that require the highest level of technical skill, experience and knowledge.

-Instructs environmental health personnel in the proper procedures for collecting field samples.

-Calibrates all laboratory equipment for the section.

5. Toxicologist

-Performs chemical analyses of water, soil, plant, animal, and other samples utilizing standard laboratory techniques such as spectrophotometry, chromatography and gravimetric and volumetric analysis.

-Follows accepted procedures and required quality control measures for conducting routine analyses such as determinations for pesticides and other organic/inorganic compounds.

-Writes reports on analyses outlining methods used and results.

-Contacts inspectors, law enforcement officers, and others to obtain information on cases as necessary.

-Assists the Senior Toxicologist in performing analysis of unknown substances.

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-Prepares standard chemical solutions and reagents to specific requirements.

6. Industrial Hygiene Chemist

-Collects field samples and conducts surveys regarding industrial hygiene, sanitation, and exposure of workers to health hazards.

-Conducts laboratory and field analyses of abrasives, solvents, and other materials used in industrial plants and makes specialized measurements of air samples to identify and measure contaminants.

-Maintains and operates a chemical laboratory, anticipating needs for ordering chemicals and equipment.

-Develops new and special methods, procedures and equipment to be used for chemical and physical determinations in laboratory and field studies.

-Conducts research on problems of toxicology and other chemical problems as necessary for industry, County and other governmental agencies.

-Maintains laboratory records and prepares reports on results of studies and projects.

-Interprets data and confers with engineers, various divisions of the Health Department, and industrial managers to solve chemical problems concerning industrial health and hazards to workers.

-Operates a variety of laboratory and field testing equipment.

7. Herbicide/Pesticide Technologist

-Performs chemical procedures requiring the use of analytical apparatus to confirm existence of herbicides and pesticides in plant, soil, water, and animal tissue specimens.

-Utilizes techniques such as gas chromatography in chemical analyses of various specimens to determine the quantity of herbicides and pesticides present.

-Follows quality control guidelines on all chemical procedures and analyses performed.

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-Conducts preliminary research contributing to the development of new methods and procedures for the purpose of enhancing the quality of test analysis.

-Prepares standard chemical solutions and reagents to specific requirements.

-Performs routine maintenance on laboratory equipment and apparatus including cleaning and calibration.

-Prepares written reports delineating technical procedures exercised during analysis and test findings.

-Interprets gas chromatography graphs to determine specimen findings and submits interpretations to a Senior Toxicologist for review.

8. Toxicological Technologist

-Performs chemical analysis of environmental and biological samples using established procedures to determine the presence or absence of pesticides.

-Utilizes known instrumentation techniques such as gas and high pressure liquid chromatographs to determine the quality and quantity of pesticides present.

-Follows quality control guidelines on all chemical procedures and analyses performed.

-Prepares reference standards, chemical solutions, and reagents to specific requirements.

-Performs routine maintenance on laboratory equipment and apparatus including cleaning and calibration.

-Interprets charts and reading generated by various laboratory instruments used and submits interpretations to a toxicologist or senior toxicologist for review.

-Maintains register of all samples which includes detailed information on the methods used and findings.

-Assist in the development of new methods and procedures to improve the quality and reliability of test results.

-Follows experimental procedures under the guidance of a senior toxicologist to test for new pesticides.

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9. Senior Laboratory Assistant

- Trains laboratory assistants in the specific procedures established by the laboratory for the preparation of samples for analysis by toxicological technologists and toxicologists, the preparation of reagents, and the performance of other such laboratory tasks.

- Observes the performance of other laboratory assistants of their assigned tasks both in training and on-the-job situations, and makes corrections necessary to assure maintenance to established quality and quantity standards.

- Prepares samples for laboratory testing by adding reagents, solvents, and/or standards using prescribed techniques and instruments appropriate to the type of sample.

- Processes samples for subsequent analysis by higher level personnel by performing duties such as extractions and filtrations.

- Operates laboratory equipment pre-calibrated by qualified personnel to perform assigned tasks such as platform shakers, rotovaporators, and pH meters.

- Prepares specific quantities of reagents and solutions of compounds including acids and bases, following written procedures, by mixing components to standard ratios using such laboratory apparatus as weighing balances and volumetric glasswares; lifts and moves containers holding several gallons or other substantial quantities of constituent parts or compounds produced.

- Performs routine maintenance on miscellaneous devices such as water baths, rotovaporators, and platform balances.

- Cleans and treats glassware used in laboratory testing following steps and procedures prescribed by higher level personnel.

- Stores apparatus, glassware, and other supplies in designated areas when not is use.

- Stores reagents and chemicals in designated areas as required by safety rules and regulations.

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10. Laboratory Assistant

- Receives samples such as water, soil, plant, etc. together with standard laboratory request form providing information such as sample I.D. and tests to be performed; verifies sample I.D. and assigned laboratory I.D. number by matching information on request form and sample container.

- Assigns laboratory identification to all samples received and writes this I.D. number on request forms and corresponding sample containers.

- Logs in sample information such as sample I.D., laboratory I.D. number, and tests to be performed in laboratory record book.

- Stores all samples received in appropriate storage locations and submit corresponding laboratory request forms to senior toxicologist.

- Prepares samples for analyses by chopping, weighing, and/or measuring where appropriate.

- Performs preliminary work on samples such as adding solvents and reagents, setting-up necessary glassware, and loading on platform shakers.

- Operates automatic laboratory equipment pre-calibrated by qualified personnel such as a pH meter to perform specific test.

- Transcribes laboratory test results from laboratory worksheets into permanent record book.

- Cleans & treats glassware used in laboratory testing following steps & procedures prescribed by higher level personnel.

- Cleans and stores apparatus, glassware and other supplies in designated areas when not in use.

- Stores reagents and chemicals in designated areas as required by safety rules and regulations.

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II. Sampling Procedures

A. Hazardous Waste

1. Organochlorine pesticides, Polychlorinated Biphenyls, and Organophosphorous Pesticides.

   Wide mouth borosilate or soda glass container of 16 oz. size should be used. The container must have tight, screw-type lid with teflon liner. Sample bottle must not be prewashed with the sample before collection. Composite sample should be collected in refrigerated glass container.

   The sample must be iced or refrigerated from the time of collection until extraction. Preservatives should not be used in the field unless more than 24 hour will be elapse before delivery to laboratory. If the sample will not be extracted within 48 hours of collection, the sample should be adjusted to pH range of 6.0 to 8.0 with sodium hydroxide or sulfuric acid. Note the volume of acid or base added to the sample.

   All samples must be extracted within 7 days and completely analyzed within 30 days of collection for organochlorine, pesticide and polychlorinated biphenyls, and analyzed within 14 days of collection for organophosphorous pesticides.

2. Phenols

   Wide mouth borosilate or soda glass container must be used, and the container must not be prewashed with sample before collection. Composite samples should be collected in refrigerated glass container.

   The sample must be iced or refrigerated from the time of collection until extraction. If free chlorine is present in the sample, add 35 mg. of sodium thiosulfate per ppm free chlorine per liter/kg. Adjust the sample pH to approximately 2, as measured by pH paper with sulfuric acid solution or 10 N sodium hydroxide. record the weight of sodium thiosulfate and volume of sulfuric acid or sodium hydroxide used.

   All samples must be extracted within 7 days and completely analyzed within 30 days of collection.

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3. Halogenated Volatile Organics, Non-Halogenated Volatile Organics, and Acrolein, Acrylonitrile, Acetonitrile.

Samples must be collected in glass containers of at least 25 ml. size. Fill the sample container in such a manner that no air bubbles pass through the sample as the container is being filled. Seal the bottle so that no air bubbles are entrapped in it. Solid and semisolid samples are to be taken in the same way.

The samples must be iced or refrigerated from the time of collection until extraction. If the sample may contain free or combined chlorine, add 10 mg. sodium thiosulfate per. 40 ml./gm. for up to 5 ppm. chlorine. Fill the container with sample just to overflowing, seal the container, and shake vigorously for 1 minute.

All the samples must be analyzed within 14 days of collection.

4. Base, neutral, acid extractables.

All samples must be collected in glass container with teflon-lined screw caps. The samples must be iced or refrigerated at 4°c from time of collection until extraction. All samples must be extracted within 14 days of collection and completely analyzed within 40 days of extraction.

5. Phthalate Esters, Nitroaromatics, Cyclic Ketones, Poly nuclear Aromatic Hydrocarbons and Chlorinated Hydrocarbons.

All samples must be collected in refrigerated glass containers and the containers must not be prewashed with sample before collection. The sample must be iced or refrigerated from time of collection until extraction. Chemical preservative should not be used unless more than 24 hour will elapse before delivery to the laboratory. If the samples will not be extracted within 48 hours of being collected, the sample should be adjusted to a pH range of 6.0-8.0 with sodium hydroxide or sulfuric acid. Record the amount of acid or base used.

All samples must be extracted within 7 days and completely analyzed within 30 days of collection.

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6. Toxic Metals

All sample containers must be prewashed with detergents, acids and deionized water. Plastic and glass containers are acceptable. Aqueous samples must be acidified to pH less than 2 with nitric acid. Non-aqueous sample shall be refrigerated. The maximum holding time of sample for mercury is 38 days in glass container and 13 days in plastic container.

7. Non-metallic

a. Cyanide

Oxydizing agents decompose most cyanides. To test the presence of oxidizing agents, test a drop of liquid sample with potassium iodidestarch test paper: a blue color indicates the need for treatment. Add ascorbic acid a few crystals at a time until a drop of sample produce no color on the test paper. Then add an additional 0.6 gm. of ascorbic acid for each liter of liquid sample.

Samples must be preserved with 2 ml. of 10 N. sodium hydroxide per liter of sample at time of collection (pH is greater than or equal to 12).

Samples should be refrigerated at 4°c and analyzed as soon as possible.

Sample could be stored in glass or plastic container.

b. Fluoride

Sample should be collected in glass or plastic container.
Maximum holding time is 28 days.

c. Sulfide

Sample should be collected in glass or plastic container. Aqueous samples must be preserved with zinc acetate or the analysis must be started immediately.

8. Physical property testing

All samples should be collected in glass container with teflon liner and stored at 4°c.

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B. Drinking Water

1. Organochlorine Pesticides and Nitrogen - and Phosphorus-Containing Pesticides

Use 1-L borosilicate glass bottle with TEF-fluorocarbon lined screw cap, add 10 mL. of mercuric chloride as preservative to the bottle for a concentration of 10 mg/L.

When sampling tap water, allow the system to flush for about 10 minutes to stabilize temperature. Adjust the water flow to approx. 500 ml./min. befor collecting the sample. Note that the bottle must not be pre-rinsed with the sample. If a well is to be sample, collect the water in a wide-mouth beaker then transfer to the sample bottle with preservative. Seal the bottle then shake vigorously for 1 minute.

Store the sample at 4°c. Extract within 7 days of collection and analyze within 40 days of extraction.

2. Volatile Organic Compounds

Use 40 ml. vials with screw caps equipped with PTFE-faced silicone septum. These vials maybe ordered from Pierce or equivalent pre-cleaned and ready to use. Carry a field blank filled with reagent water to the sampling site with empty vials.

Fill sample bottles to overflowing. No air bubbles should pass through the samples as the bottle is filled, or be trapped in the bottle when the bottle is sealed.

When sampling tap water, allow the system to flush for about 10 minutes to reach stable temperature. Adjust water flow to about 500 ml./min. them collect the sample. If a well is to be sampled, collect the water in a wide-mouth beaker then transfer to the sample vial.

Collect all samples in duplicate.

Adjust pH of sample to < 2 by the addition of 2 drops of 50% HCl. Seal the sample bottle with the PTFE-face down and shake vigorously for 1 minute. Immediately store sample at 4°c after collection. Analyze samples within 14 days of collection.

3. Carbamate Pesticides

Use 100-ml. or larger capacity glass or plastic bottle equipped with screw cap. Carry a field blank filled with TypeII water to the sampling site with the empty sample bottle. Add 7 mg/100 ml. of sodium thiosulfate to the empty bottles and field blanks as preservative.

Do not pre-rinse container with sample before sampling.

When sampling tap water, allow the system to flush for about 10 minutes to obtain stable temperature. Adjust the flow to approx. 500 ml./min. then collect water in a wide-mouth beaker the carefully transfer the sample to the bottle. Fill the bottle within 2 cm. of the top.

In the laboratory, samples to be analyzed for oxamyl, 3-hydroxycarbofuran, and carbaryl must be further preserved immediately at the laboratory by adjusting pH to 3. This maybe done with the addition of 50% HCL.

Store samples at 4°c and extract within 7 days of collection and complete the analysis within 40 days of extraction.

4. **Trace Metals**

Use 125-ml. polyethylene bottles with screw caplid. Prior to use, wash bottle with detergent and tap water; rinse with 1:1 nitric acid, tap water, 1:1 hydrochloric acid, tap water, and finally de-ionized water in that order.

For determination of dissolved or suspended metals, no preservative need be added at the time of collection. For determination of total metals, both dissolved and suspended, acidfy sample to pH 2 or less with the addition of 1:1 redistilled HNO_3 at the time of collection. For determination of total recoverable metal acidify sample at the time of collection with 0.625 ml. of conc. HNO_3 for 125 ml. of sample. Analyze sample within 30 days of collection.

C. Sample Labeling and Identification

Immediately after collection, the sample must be sealed, labeled, and the sample analysis request form filled out for each sample.

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1. Sample Labels

Sample labels are used for the specific identification of samples. Gummed paper labels affixed to the containers are adequate, but it should not be affixed to the sample lids. The labels should be filled out at time of collection and should include the following information:

Field Number
Name of Collector
Date and Time
Place of Collection

2. Sample Seals

Sample seals are used to detect unauthorized tampering of samples ater collection, upto the time of analysis. The seals must be affixed to the sample container in a way that it has to be broken in order to open the sample container.

Seals must be affixed to the container by the collector.

3. Sample Analysis Request Form

Sample analysis request form accompanies the sample when it is delivered to the laboratory. The field portion of this form should be completed by the collector. The laboratory section is for completion by the laboratory analyst. The sample request form should include at the minimum:

Name of Collector
Date and Time of Collection
Location of Sampling Site
Field Number
Type of Sample
Analysis Requested
Date Received by the Laboratory
Laboratory Number
Results of Analysis
Date of Analytical Report
Name of Analyst
Remarks on Sample

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III. Sample Custody

When a sample arrives, it should be logged in immediately. The laboratory receiving personnel should look at the sample to verify:

- -Is the proper container used?
- -Is the container properly filled?
- -Is the quantity sufficient?
- -Is the sample seal intact?
- -Is the sample request form filled properly?

If the answer to any of the above question is no, the laboratory supervisor must be notified immediately. Also, the receiving personnel must verify if the sample had been appropriately preserved. If not, if must be preserved according to instructions in Table 1. This Table is posted for reference in the receiving area.

All samples received must be logged in a logbook and a unique laboratory number must be noted on the sample container, sample analysis request form, and log-book. In addition, the logbook must include information of laboratory sample number, sample identification information, type and condition of sample, and analysis requested. The recipient of the sample should sign the chain of custody form (see below).

Chain of Custody

Chain of Custody is a documentation of the sample history form collection to data reporting. A sample is considered under a person's custody if (1) it is in a person's physical possession, (2) in view of the person after he has taken possission, (3) secured by that person so that no one can tamper with the sample, or (4) secured by that person in an area which is restricted to authorized personnel.

The chain of custody form records the history of sample possession from collection, to analysis, and finally, to sample disposal. The form is printed on the same sheet as the sample request form. It must accompany the sample upon delivery to the laboratory. Information on the chain of custody form should include at least the following:

Name of the person in possession of sample
Affiliation of the person in possession
Date in possession

Once the sample has been logged in and the laboratory assume responsibility for it, the sample must be stored in a secure location. Whether the location should be refrigerated or not depends on the type

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of sample or analysis requested. Refer to Table 1 for storage conditions. Typically, all samples for organic analyses must be stored in the refrigerator/freezer. Samples for trace metal analysis maybe stored at room temperature except those requiring Chromium VI analysis. The latter must be refrigerated.

Refrigerator/Freezer used for sample storage must be different from those used for storing standards. In addition, samples for volatile analysis must be stored separately form non-volatiles. On each refrigerator/freezer, a chart is posted outside to record daily temperature readings, date, and name of person monitoring the temperature.

After properly receiving and securing the sample, worksheets are written up providing information on sample laboratory number, type, analysis requested, received date, and maximum holding time. Table 1 posted in the receiving area also contain information on holding times as a guide in preparing the work sheets.

A copy of this section on sample custody is posted in the receiving area to serve as a guide for the receiving personnel.

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Table 1

A. Hazardous Waste

Analysis Requested	Storage & Preservation	Maximum Holding Time
Inorganic Tests:		
Cyanide, total & amenable to chlorination	P, G Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid	14 days
Fluoride	P None required	28 days
Hydrogen ion (pH)	P, G None required	analyze immed.
Metals:		
Chromium VI	P, G 4°C	24 hours
Mercury	P, G HNO_3 to pH 2	28 days
Metals except chromium VI and mercury	P, G HNO_3 to pH 2	6 months
Phenols	G only Filter immediately, Cool, 4°C cool, 4 C, H_2SO_4 to ph 2	28 days
Sulfide	P, G Cool, 4°C, zinc acetate plus sodium hydroxide to pH 9	7 days
Organic Tests:		
Purgeable Halocarbons	G, Teflon-lined septum Cool, 4°C 0.008% $Na_2S_2O_3$	14 days
Purgeable aromatic hydrocarbons	G, Teflon-lined septum Cool, 4°C 0.008% $Na_2S_2O_3$, HCl to pH2	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum Cool, 4°C 0.008% $Na_2S_2O_3$, adjust ph to 4-5	14 days
Phenols	G, Teflon-lined cap Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction 40 days after extracti
Phthalate esters	G, Teflon-lined cap Cool, 4°C	7 days until extraction 40 days after extractio
PCBs acrylonitrile	G, Teflon-lined cap Cool, 4°C	40 days after extracti
Nitroaromatics and isophorone	G, Teflon-lined cap Cool, 4°C, 0.008% $Na_2S_2O_3$ store in dark	40 days after extracti
Polynuclear aromatic hydrocarbons	G, Teflon-lined cap Cool, 4°C 0.008% $Na_2S_2O_3$ store in dark	40 days after extracti
Chlorinated hydrocarbons	G, Teflon-lined cap Cool, 4°C	40 days after extracti
Pesticides Tests:		
Pesticides	G, Teflon-lined cap Cool, 4°C, pH 5-9	40 days after extracti

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B. Drinking Water

Analysis Requested	Storage & Preservation	Maximum Holding Time
Volatile Organic Chemicals	4°C, Acidify to pH 2 with 1+1 HCl (1 drop/20 mL sample)	14 days
Base/Neutral and Acid Extractables, Non-purgeable Organic Chemicals	4°C, Protected from light, For chlorinated waters add Sodium Thiosulfate, 80 mg/L of sample	Extract within 7 days; complete analysis with: 40 days of extraction
Ethylene Dibromide (EDB) Dibromochloropropane (DBCP)	4°C, No chemical Preservative	28 days
Organohalide Pesticides and Aroclors	4°C, Sodium Thiosulfate, 3 mg crystals/	Extract within 7 days; complete analysis with: 40 days of extraction
Nitrogen or phosphorus Containing Pesticides	4°C, *Mercuric Chloride to 10 mg/L	14 days
Chlorinated Pesticides	4°C, *Mercuric Chloride to 10 mg/L	Extract within 7 days; complete analysis with: 40 days of extraction
Chlorinated Herbicides	4°C, No chemical preservative	Extract within 7 days; complete analysis with: 40 days of extraction
N-Methyl Carbamoyloximes	4°C**, Sodium Thiosulfate, 7 mg/100 mL; Acidity to pH3 with HCl (1+1) (Samples for Aldicarb and Endothall must be frozen)	Extract within 7 days; complete analysis with: 40 days of extraction
Bentazon	4°C, No chemical preservative	Extract within 7 days; complete analysis with: 40 days of extraction

*Use caution in handing this toxic chemical. Dispose of contaminated sample in appropriate manner.

IV. Calibration Procedures and Frequency of Calibration

A. Standards and References

1. Sources of Standards

99% of our standards come from the following sources:

Quality Assurance Branch
EMSL - Cincinnati
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

U.S. Environmental Protection Agency
Pesticides & Industrial Chemical Repository
(MD-8)
Research Triangle Park, NC 27711

Supelco, Inc.
Supelco Park
Belleforte, PA 16823-0048

Aldrich Chemicals
P.O. Box 2060
Milwaukee, Wisconsin 53201

National Bureau of Standards
Gaithersburg, Maryland 20899

All standards are obtained from reliable sources who can certify the purity of the materials.

Upon receipt, all neat standards are entered into an inventory book which includes the date received, who received it, source or supplier, lot number, conc./purity, expiration date, date opened, and who opened the bottle. The bottle itself containing the neat standard is labelled with the date received and initialled, expiration date, and date opened and initialled.

2. Preparation of Standards

Standards are prepared as outlined in the laboratory's specific Standard Operating Procedures (SOP) Manual. All information pertinent in the preparation of the standard are entered in the laboratory's Standard Preparation Book. Which include the following:

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PREPARATION OF CONCENTRATED STOCK STANDARDS

No.________ Date___/___/___ Chemist ____________________

Compound__________________ Lot No.________ Purity__________

Final Gross Wt__________g Dilution Vol__________ml

*Tare Wt__________g Concentr.__________ng/µl

Net Wt__________g

**Adj. Net Wt__________ng

PREPARATION OF STANDARDS OF INTERMEDIARY CONCENTRATION

NO.________ Date___/___/___ Chemist__________________

Compound____________________

Strength of Concentrated Stock__________ng/µl

Aliquot of Concentrated Stock __________ml

Dilution Volume __________ml

Final Concentration __________ng/µl

PREPARATION OF FINAL WORKING STANDARD SOLUTIONS

No.________ Date___/___/___ Chemist__________________

	Compound	Parent Sol. Number	Conc. of Parent Sol. ng/µl	Aliq. Vol. ml	Dilution Vol. (ml)	Final Conc. pg/µl
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

Standard solution bottles are also labelled individually with the concentration, solvent used, date prepared, expiration date and initials of the preparer.

3. Storage of Standards

All degradable and volatile organic compounds are stored in a freezer at below 0°C. This is true for any concentration: neat or solution.

Trace metal standards, except chromium VI, are stored at room temperature. Chromium VI is refrigerated.

4. External Reference Standards

Whenever possible, check standards are ordered from the EPA or NIST. These are used to verify the accuracy of the working standards. If unavailable from EPA or NIST, standards from another supplier or different lot number from the same supplier are used as check standards.

B. Calibration Procedures and Frequency

Specific calibration procedures are included in the analytical method and in the operator manual of that instrument. Each analytical instrument is calibrated at least daily when in use. The analyst is responsible for calibration. All the calibration data are kept in specific QC books.

There are calibration guidelines in the use of gas chromatographs, HPLC's, and atomic absorption spectrophotometers. These guidelines are applicable regardless of the instruments' make and model.

GC and HPLC Calibration Guidelines

1. Calibration Curve

Initially before use, a 5-point calibration curve must be established for each analyte of interest in order to determine the linearity of the concentration range of interest in the GC system to be used. A calibration curve is established by plotting the system response, as in peak height or peak area, versus the concentration of the standard applied to the system. The concentration of the standards used must correspond to the expected range of concentration in real samples, or must define the working range of the detector used. One standard concentration that must be included should be near but above the method detection limit (check individual method references for tabulated list of MDLs). An alternative to establishing a calibration curve is

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the definition of calibration factors (CFs) for the analyte of of interest at each standard concentrations.

$$CF = \frac{\text{Total Peak Area/Height}}{\text{Mass Injected (ng)}}$$

For each analyte, five CFs would be obtained. Calculate the percent relative standard deviation of the CFs. If the %RSD is less than 20%, it can be assumed that the line defined by the CFs is linear through the origin and that the CF can be used instead of a calibration curve for calculation of the concentration of the analyte in real samples.

2. Calibration Standard

On a daily basis, a calibration standard must be injected and analyzed in the GC system to be used in the analysis. The response of the standards must fall within ±15% of the established calibration curve or factor (see appropriate QC Record Book for current values). If outside the ±15% limit, the cause of change must be determined and corrected, if possible. If the problem is one that is inherent in the system and cannot be corrected, then a new 5-point calibration curve must be established (see Pre-Analysis QC Requirements) before any real sample can be analyzed. Monitor the response of the calibration standard every 10 samples. The ±15% limit must be met with every injection of the standard. Record daily calibration parameter in Form 2.

3. Retention Time (RT) Windows

Prior to any new analyte testing and each time a new GC column is installed, retention time windows must be defined initially for each analyte and its corresponding surrogate and matrix spike standards there after. To determine the RT windows, make a minimum of three injections of all single analyte standard mixture and multiresponse analyte like chlordane over a 71-hour period. Calculate the standard deviation of the absolute RTs of each analyte with every injection. For multiresponse analyte, choose a major peak from the group of peaks and calculate the standard deviation of its absolute RTs from every injection. The RT windows are defined as the ±3S, where S is the standard deviation, of the absolute retention time for each analyte. Record all Rts and windows in Form 2. From the injection of the calibration standard of the analyte of interest, determine the retention time and make certain it falls within the established windows.

AA spectrophotometer Calibration Guidelines

Calibration Curve

- must be prepared each day with a minimum of a reagent blank and three standards at different levels of concentrations. Determine the absorbances of each blank and standards. Plot the absorbances versus the concentrations. This plot establishes the linear curve for the day of the atomic absorption spectrophotometer used. Follow themanufacturer's instructions in preparing the calibration curve for the particular instrument used. Verify the curve every ten samples by analyzing a blank and a mid-level standard. The results of the verification should be within +20% of the original curve. If not a new curve must be generated. Use form 3 to record calibration data.

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for____________________

Date	Conc. (ng)	Response	Acceptable CFs	Remarks

Form 1

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Gas Chromatographic Conditions:
System: ____________________
Column: ____________________
Col. Temp.: ____________________

Carrier Flow: ____________________
Detector: ____________________

Date / Analyte	RETENTION TIMES								WINDOWS

Form 2

_______ ATOMIC ABSORPTION CALIBRATION CURVE

DATE/ ANALYST	STANDARD CONCENTRATION					CORRECTIVE ACTION/ COMMENTS
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
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	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	

[illegible]

Form 3

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V. Analytical Procedures

A. Methods Used

All the analytical procedures used are from published sources from the following list:

1. Test Methods for Evaluating Solid Waste, SW-846, 3rd Edition, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. November, 1986.
2. Methods for Chemical Analysis of Water and Wastewater, EPA-600/4-79-020, 1984 U.S. Environmental Protection Agency.
3. Standard Methods for the Examination of Water and Wastewater, 15th and 16th Edition, APHA-AWWA-WPCF, Washington, D.C. (1980-1085).
4. The Determination of Inorganic Anions in Water by Ion Chromatograph - Method 300.0, EPA-600/4-84-017, March 1984, U.S. Environmental Protection Agency.
5. EPA Drinking Water Methods, 500 Series.

If applicable; certain methods are written in out line form for routine use in the laboratory. They are included in the laboratory's Standard Operating Procedure (SOP) Manual. For any analyst using methods for the first time, it is recommended that references noted on the upper right hand corner of the outlined form be thoroughly studied prior to the use of the outline.

B. Detection Limit

Method Detection Limit (MDL)

Method detection limit is the lowest concentration level detectable in the laboratory instrument. It corresponds to an analyte signal-to-noise ratio of two with the analyte being introduced to the instrument in clean solution, i.e., reagent water or reagent grade organic solvent. Typically, the laboratory has the same MDL as those listed under specific analytical methods such as the EPA 500 series. The laboratory verifies that the listed MDLs are indeed applicable by directly injecting or introducing standards at the MDL level to the instrument and obtaining a signal-to-noise ratio of at least two from the injection.

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Practical Quantitation Limit (PQL)

Practical quantitation limit (PQL) is the lowest quantifiable level that can be reliably achieved during a routine laboratory analysis of an analyte in a given matrix. This value is typically higher than the MDLs because it is matrix dependent. In determining PQLs, the laboratory follows the method given in the publication EPA-600/4-82-057, Appendix A.

C. Record of Analysis

For each analytical batch, all pertinent data related to the analysis including method used, sample weight or volume, dilutions, standard concentrations, description of instruments used and name of analypt are entered into a permanent log-book (Hazardous Waste) or worksheets (drinking water) which are filed as permanent records of the laboratory.

D. The laboratory maintains Standard Operating Procedures (SOP) Manual for both hazardous waste and drinking water analyses. These manuals contain the different analytical methods used in the laboratory in outline form. This is a cookbook-type outline generated from published methods which includes, whenever applicable, the following:

1. Scope and Applications
2. Detection limits (instrument and method)
3. Precision and Bias
4. Working range
5. Summary of Method
6. Sample collection, preservation, and holding times
7. Comments
    A. Interferences
    B. Helpful hints
8. Safety issues (specific to the method)
9. Apparatus
10. Reagents and standards
11. Procedure (detailed step-by-step)
    A. Sample preparation
    B. Calibration
    C. Analysis
12. QA/QC requirements
    A. QC samples
    B. Acceptance criteria (precision and accuracy)
    C. Correction action required
13. Calculations
14. Reporting
    A. Reporting units
    B. Reporting limits
    C. Significant figures and reporting values below detection limit
15. References
    A. Method source
    B. Deviations from source method and rationale

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VI. Data Reduction, Validation and Reporting

A. Data Reduction

Equations and calculation procedures are included in the laboratory's SOPs. All the calculations must be attached to the copy of laboratory report for filing. Corrections for the blanks maybe made where appropriate. Calculations by the instrument/integrator is acceptable.

B. Data Validation

All results generated by the laboratory must be validated through the simultaneous analyses of required quality control (QC) samples/standards with the unknown sample. These include:

1. Instrument calibration with three concentration levels of standard and continuing single standard calibration every ten sample of an analytical batch.
2. Analysis of a method blank every batch of 20 samples for hazardous waste (every batch of 10 samples for drinking water) or type of matrix, which ever is more frequent.
3. Analysis of matrix spiked samples in duplicate at least once for every batch of 20 samples for hazardous waste (every batch of 10 samples for drinking water) or type of matrix which ever is more frequent.
4. Once during the analysis, an external reference standard should be used to check the concentration of the calibration standard.

After completing the analyses of an analytical batch, results of the above QCs must be recorded and plotted in the appropriate quality control chart (see form 4). Precision and accuracy control charts are maintained to determine if the QC results of an analysis are within established control limits. Control limits are initially set after the analysis of ten matrix spike and duplicate samples.

Thereafter, they are periodically set to reflect current performance.

It is the responsibility of the analyst to determine that all appropriate quality control operations have been performed and that all QC results fall within established limits. If any of the required QC is out of control the analyst must initiate corrective actions.

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C. Data Reporting

Analytical results are ready to be reported as soon as it is verified that all quality control data fall within the laboratory's established limits. All data generated, both for the actual sample and the quality control sample must be entered in the appropriate worksheet, log-book and QC books. All information related to the sample analysis such as weight, volume, and QC results must be recorded. All results reported to the submitting agency would be presented with the appropriate number of significant figures, proper units such as ppm, method used, and practical quantitation limits. Worksheets, instrument out puts (e.g. chromatogram), analytical results, sample request for and report of analysis form are put together in a file and submitted to the laboratory supervisor for review. The supervisor signifies his/her approval by signing the report of analysis form to be sent to the submitting agency.

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PRESICION AND ACCURACY DATA

Matrix/Unit ____________________

Analyte: ____________________

	1	2	3	4	5	6	7	8	9	10	11	12
Batch #												
Date												
amt. spike												
unspiked												
spike 1												
spike 2												
ave.												
spike recovery												

Accuracy

	1	2	3	4	5	6	7	8	9	10	11	12
Ave.												

Precision

	1	2	3	4	5	6	7	8	9	10	11	12
Ave.												

Form 4

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VII. Internal Quality Control Procedures

In order to document the laboratory's ability to test for the analyte of interest, certain quality control procedures are followed. These procedures are divided into two: (1) pre-analysis QC requirements and (2) daily or on-going QC requirements.

1. Pre-Analysis QC Requirements - QC Check Samples

   The laboratory's ability to generate results with acceptable accuracy and precision using a published method must first be verified before the analysis of actual samples. This is done through the analysis of four QC check samples prepared according to Sec. 8.6.2, Method 8000, SW-846. Briefly, QC check samples are prepared by spiking four aliquots of reagent water with known amounts of the analytes in the method to be used. The average recovery ($\bar{R}$) of the analytes in ug/L and the standard deviation (s) in ug/L of the recoveries are calculated and compared with those listed under the QC Acceptance Criteria Table found at the end of each published method. If the $\bar{R}$ and s values calculated fall within the limits defined in the table, then the system performance is acceptable and analysis of actual samples can begin. If any individual analyte's $\bar{R}$ or s fall outside the limit, then the system performance in unacceptable for that analyte. QC check samples must then be analyzed just for the analyte that failed. If re-analysis produced results within limits, then the system performance is acceptable. Repeated failure signifies a general problem with the measurement system. If this occurs, the source of the problem must be located and corrected - then QC check samples must again be ran for all the analytes.

2. Daily QC Requirements

   On a daily basis or each time a sample or batch of samples is analyzed, certain quality control samples must be ran: method blanks, duplicates, and matrix spike/matrix spike duplicates. From these quality control samples, control charts may then be generated which would allow for the establishment of accuracy and precision limits for the laboratory.

   Method Blank

   The analytical result of the method blank (or reagent blank) must be free of any analyte contamination. If contaminated, the source of contamination must be determined and corrected. After correction, the batch must then be re-analyzed if the sample quantity permits; or

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if not, results of the analysis maybe released with appropriate warnings on the nature of the contamination.

Hazardous waste - blanks must be ran once every analytical batch of 20 samples or less or each type of matrix whichever is more frequent. Since it is impossible to obtain a universal matrix blank for non-aqueous/ solid samples, only reagent water is used.

Drinking water - blanks must be ran once every analytical batch of ten or less. Reagent grade water is used as blank.

Duplicate Samples

Duplicate samples are prepared by dividing a sample in two and analyzing them separately. Duplicate samples serve the purpose of monitoring the precision of measurement system. The results of the duplicate analyses must be within 20% of each other. If not an error has occured and it must be determined and corrected. The batch must then be re-analyzed. If the duplicate samples are negative for the analytes tested, then the matrix spike (see below) must be ran in duplicate to measure the precision. Duplicates must be ran once for every batch of 20 hazardous waste samples or less or each matrix type whichever is more frequent. Drinking water analysis requires duplicates to be ran every 10 samples.

Matrix Spike/Matrix Spike Duplicates (MS/MSD)

A predetermined amount of the analyte standard is added to a sample matrix to prepare the matrix spike sample. If the unknown samples to be analyzed are expected to be negative, then the sample matrix for spiking is first split into duplicates prior to the addition of the standard. Both matrix spike and matrix spike duplicate are analyzed simultaneously with the unknown samples. Recoveries of the analyte from the spike samples measure the accuracy of the method and the percent difference between the matrix spike and matrix spike duplicate assesses the precision of the analysis. The level of standard for spiking must be at the regulatory level or the method quantification limit. Samples with analyte concentration greater than 0.1% do not require the analysis of matrix spikes. Matrix spike and matrix spike duplicates must be ran for 5 % of the total analytical batch or each matrix type of hazardous waste. Drinking water requires the analysis of MS/MSD for 10% of the analytical batch. The accuracy and precision obtained from the MS/MSD must fall within the established lower and upper control limits of the laboratory. Continuing spike recoveries are recorded in form 4.

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3. Other QC Requirements

Periodically, samples are re-analyzed by another analyst. This is especially true in situations wherein a seemingly valid result is obtained but does not agree with the history of the sample.

Good Laboratory Practices

Good laboratory practices are followed to assure continued production of reliable results. These include not only topics previously discussed, i.e., sample custody, calibration, analytical procedures, data handling, and internal quality control procedures, but also glassware cleaning, verification that the sample containers, reagents and laboratory water are free of contamination, local and state safety codes are followed, fume hoods are routinely monitored, and hazardous waste are disposed of properly.

1. Glassware cleaning - glassware used for metal analysis should be acid washed. Refer to the published analytical methods for detailed procedures. Glassware used for organic analysis should be washed with solvent used in the analytical procedure. If trace amount of the organic contamination is found, it maybe necessary to clean the glassware in a muffle furnace.

2. Only reagent grade chemicals are used.

3. Type II deionized water is used in the analytical method and for method blanks.

4. Sample containers must be verified to be free of contamination. To accomplish this, a container from every lot received is rinsed with water or methanol, whichever is applicable, and analyzed.

5. Air flow in the fume hoods are monitored periodically by qualified personnel. The maximum operating height of the fume hood door is marked accordingly.

6. Safety procedures are adhered to. The laboratory has a safety manual that is distributed to all personnel. It covers topics on emergency procedures as in cases of fire or chemical spills, laboratory safety procedures with regards to handling different types of chemicals and executing certain laboratory tasks, and state-required hazardous material communication procedures.

7. Local and state safety codes are incorporated in the laboratory safety manual. As with all other safety procedures in the manual, they must be adhered to.

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VIII. Performance and Sytem Audits

The laboratory undergoes periodic performance and system audits through external and internal proficiency samples.

External Proficiency Samples

Currently, the laboratory has three sources of external proficiency samples. They are the California Dept. of Food and Agriculture, California Dept. of Health Services, and the Environmental Protection Agency.

CDFA Proficiency Samples

On a quarterly basis, the CDFA sends a minimum of four proficiency samples to the laboratory. Fifty percent of these are plant tissues and the other 50% are environmental samples such as water, soil, and swabs. The samples are spiked with pesticides from the organochlorine, organophosphorus, and/or carbamate group. Results of the proficiency sample analyses are sent back to CDFA for evaluation and they in turn mailback to the laboratory statistical analysis of results as compared with theoretical valves and other laboratories' results.

CDHS

Periodically, the laboratory had received performance evaluation samples from the CDHS. The samples received were for both hazardous waste and drinking water analysis. The samples were spiked with some of the analytes the laboratory was accredited for. As with the CDFA proficiency samples, after submitting the P.E. sample results to CDHS, the laboratory receives a statistical analysis of the results reflecting the comparison of results with the CDHS's accept/reject criterion.

EPA

On January 1990, the laboratory enrolled with the EPA to participate with the latter's Performance Evaluation Sample Program in water pollution. As a result, the laboratory anticipates receiving and analyzing P.E. sample for waste water periodically in the future.

Internal Proficiency Sample

Effective January 1990, the laboratory, on a quarterly basis, prepares and analyzes internal proficiency samples. A minimum of three samples are involved representing any of the environmental samples such as water, soil, plant, and wipe. The proficiency samples are spiked with some of the analytes typically ran in the laboratory. Reports are prepared from the results of the proficiency samples and compiled in the appropriate QC record book.

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IX. Preventive Maintenance

All minor maintenance and repair needed are accomplished by laboratory personnel. For major breakdowns, sufficient funds are budgeted annually to enable the laboratory to obtain service calls from qualified manufacturer's service engineers. The laboratory maintains a log book on any repair or maintenance of instruments.

All microbalance and platform balance are calibrated annually by qualified service engineers. On a weekly basis, the calibration of the balances are verified with standard weights.

All other service and maintenance needed by our laboratory for instruments and equipments are referred to their corresponding manufacturers. Based on yearly service expenses of the past years, sufficient amount budgeted annually to cover any future costs.

With the exception of Tracor Instruments which is located in Texas, all other manufacturers of our instruments could provide service within 48 hours after notification. Tracor has no local service representative so they take approximately one week before they send a serviceman.

The laboratory maintains a log book on instrument maintenance and repair for all major equipment used in the laboratory. It contains records on when an instrument is maintained and/or serviced, who provided the service, and what actions were taken.

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X. Assessment of Accuracy and Precision

Accuracy

Accuracy means the nearness of a result or the average of a set of result to the true value. Accuracy is represented by the percent recovery (R) if an analyte from a given matrix using a specific method. The percent recovery may be calculated as:

$$R = \frac{A-B}{T} \times 100\%$$

where: A is the calculated concentration of the analyte in the spiked matrix after analysis

B is the background concentration of the analyte in the matrix blank, if any.

T is the known value of the analyte spiked in the matrix blank.

To set the accuracy control limits of an analyte in a given matrix using a specific method, calculate the average of R values ($\bar{R}$) and their standard deviation (S_r). The accuracy control limit as recommended by the EPA is then defined as:

$$RLCL = \bar{R} - 2S_r$$

$$RUCL = \bar{R} + 2S_r$$

where: RLCL is the accuracy lower control limit
RUCL is the accuracy upper control limit.

Precision

Precision is the measurement of agreement of a set of replicate results among themselves without the assumption of any prior information as to the true value. Precision is measured using replicate or duplicate sample analysis. Precision as relative percent difference (RPD) is calculated as:

$$RPD = \frac{X_1 - X_2}{X} \times 100\%$$

where: X_1 and X_2 are results of duplicate analyses

X is the average of X_1 and X_2

As recommended by EPA, the laboratory's precision limit is ±20%.

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Control Charts

Precision and accuracy control charts are maintained for at least 10% of the analytes (min. 3 and max. 10) for a given method using form 4. Control limits are initially set after 10 data points. Thereafter, limits are periodically set to reflect current performance.

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XI. Corrective Action

Corrective action is initiated in out-of-control situations. A situation is considered out-of-control if any of the laboratory's internal quality control samples (see section VII) are outside established limits, i.e.:

1. Method blanks are coming out positive for the analyte of interest signifying that the analytical system is contaminated.

2. Results of duplicate samples are outside the 20% limit.

3. Spike recoveries fall outside the established laboratory's accuracy control limits.

For any of the above conditions, the senior personnel assigned to the unit will be notified immediately. It is his/her responsibility to decide which of the following corrective actions must be taken:

1. The analyst provides additional information or recalculations.

2. Instrument calibration and operation are checked. Calibration standards are checked and new ones are prepared if necessary. Instrument malfunctions are corrected.

3. New reagents are used if needed.

4. The analyst repeats the analysis of spiked samples using the same method.

5. A different analyst repeats the analysis of spiked samples using the same method.

6. The analyst repeats the analysis of spiked samples using a modified or new method.

No laboratory result will be sent until the problem is solved. All out-of-control situations and the corrective actions taken are documented by the senior personnel and submitted to the laboratory supervisor and/or chief for review.

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XII. Quality Assurance Report

On a monthly basis, senior personnel assigned to different units submit quality assurance reports for review by laboratory supervisor/chief. The reports contain a summary of the unit's QA activities during the period. The report includes the following information:

1. Date of analysis
2. Number of samples in the batch
3. Analytical batch number
4. Type of matrix
5. Analyte tested
6. Number of method blanks and results.
7. Number of matrix spikes and results
8. Number of dupilcates and results
9. Detection limits
10. Name of analyst

In additon a copy of reports on out-of-control situations and corrective actions taken during the period are attached. The laboratory supervisor and/or chief reviews the QA report, signifies approval by signing them, and the reports are filed accordingly.

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APPENDIX I

Calculation of standard deviation s from replicate measurements. e.g. lead in soil in mg/kg.

x	$(x-\bar{x})$	$(x-\bar{x})^2$
49.8	0.80	0.64
48.9	-0.10	0.01
51.3	2.3	5.29
51.3	2.3	5.29
45.9	-3.1	9.61
44.3	-4.7	22.09
52.2	3.2	10.24
50.0	1.0	1.0
47.6	-1.4	1.96

$\bar{x} = 49.0$ $\Sigma = 56.13$

$n = 9$

$$s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$$

$$s = \sqrt{\frac{56.13}{9-1}}$$

$$s = \sqrt{7.016}$$

$$s = 2.65$$

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APPENDIX 4

SUPPLEMENTAL QUALITY ASSURANCE MANUAL

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COUNTY OF LOS ANGELES
Office of
Agricultural Commissioner/
Weights and Measures

ENVIRONMENTAL TOXICOLOGY LABORATORY

MICROBIOLOGY

Supplemental Quality Assurance Manual

11012 Garfield Avenue, Bldg. B South Gate, CA. 90280

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NOTE: This is a supplemental manual to be used in conjunction with the Laboratory's previous Quality Assurance Manual.

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TABLE OF CONTENTS

QA OBJECTIVES

1. Establish the laboratory's ability to perform qualitative and quantitative microbiology testing of drinking water and wastewater by:

   - identifying the qualifications and responsibilities of laboratory personnel (in previous QA Manual);
   - enumerating the existing laboratory instrumentation and equipment used in microbiology testing together with the procedures for their service and maintenance to assure proper operation;
   - providing sources of analytical methods accepted by regulatory agencies for use in the laboratory.

2. Provide guidelines pertaining to sampling protocols, chain-of custody, and storage of samples to maintain sample integrity prior to analyses.

3. Define the laboratory's calibration procedures and frequency of calibration.

4. Identify all the necessary steps to validate the laboratory's results.

5. Define all the necessary quality control checks that must be followed prior to the analysis and/or in the course of analyzing samples.

6. Identify all laboratory records and information needed to document the quality of analyses performed in the laboratory.

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SAMPLING PROCEDURES

Containers

Approved container for bacteriological sampling are presterilized Nasco Whirl-Pak bag or 4 oz. sterilized Nalgene or glass bottles. All samples containers must contain two drops of 10% sodium thiosulfate. One sample bottle from each batch of bottles prepared must be checked for sterility by adding several sterile tubes of single strenght lauryl tryptose and incubating for 48 hours and checking for growth.

Collection

Samples must be representative of the potable water distribution system. Water taps used for sampling are free of aerators, strainers, hose attachments, mixing type faucets, and purification devices. Maintain a steady water flow for at least 2 minutes to clear the service line before sampling. Collect at least a 100 mL sample volume, allow at least ½ inch air space to facilitate mixing of sample by shaking. Do not rinse sample container!

Holding/travel time between sampling and analysis is not to exceed 30 hours for potable water samples. If laboratory is required by State regulation to analyze samples after 30 hours and up to 48 hours, the laboratory is to indicate that the data may be invalid because of excessive delay before sample processing. No samples received after 48 hours are to be analyzed. Sample collectors who deliver samples directly to the laboratory should ice samples immediately after sample collection. All samples received in the laboratory are to be analyzed on the day of receipt.

Waste and surface water sample holding time is not to exceed 6 hours.

Labeling and Identification

Immediately after collection, the sample bottle must be labeled and the sample analysis request and report form filled out for each sample.

1. Sample Labels

   Samples labels are used for the specific identification of samples collected. Gummed paper labels affixed to the containers are adequate, but it should not be affixed to the sample lids. The labels should be filled

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out at the time of collection and should include the following information:

Sampling Site
Name of Collector
Date and Time of Collection

2. <u>Sample Analysis Request and Report Form</u>

The sample analysis request and report form (exhibit 1) accompanies the sample when it is delivered to the laboratory. The collector should complete the field portion of this form by providing information on sample site location, sample type, purpose of the sample, date and time of collection, free chlorine residual, collector's initial, and any remains.

Upon receipt of the sample the laboratory will log-in the sample and at the minimum, the following information will be stored and maintained:

Date of Collection, Receipt, and Analysis
Time of Collection, Receipt, and Analysis
Receiving personnel initial
Client and/or System name
Sample Site location and/or description
Purpose of the sample
Assigned individual laboratory identify number
Name of the Analyst
Analysis Requested
Results of Analysis
Remarks on the sample (if any)

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COUNTY OF LOS ANGELES
Agricultural Commissioner/Weights & Measures
Environmental Toxicology Laboratory
11012B Garfield Ave., South Gate, Ca. 90280

SAMPLE FOR MICROBIOLOGICAL EXAMINATION

Date	Time	Lab No.

Laboratory Use Only

Purveyor and Address	County / Date/Hour Collected
Sampling Point — System Number	Collected By / Bottle Cap Number
Type of Sample: __ Drinking (Any Source) __ Sewage __ Surface __ Other ____	Send Report To: Name: ____ Agency: ____ Address: ____ Phone Number: ____
Analysis Requested and Remarks: __ Coliform __ SPC __ Fecal Coliform __ Other ____	

(To be filled in by laboratory only)

Tube/Portion Number	(hr.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Results
Portions in ml																						Coliform/100ml
Presumptive Test	24																					__ MPN
	48																					__ MF
Confirmed Test	24																					Fecal Coliform/100ml
	48																					__ MPN
E. C.	24																					__ MF

Laboratory Remarks
__ Leaked in transit
__ Unsufficient sample

SPC/ml at 35C — Cl_2 Res. mg/liter

Analyst	Date	Director	Date

Exhibit 1

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EQUIPMENT TEMPERATURE AND USE RECORD

Incubator Temperature

The total coliform incubator are maintained at 35± 0.5°c and have a thermometer graduated in at least 0.5°c increments. A daily log of the temperatures read to 0.1°c are kept together with the date the entry was made and the initial of the person making the entry (see exhibit 2).

Water Bath Temperature (For Fecal Coliform)

Similarly, the fecal coliform water bath are maintained at 44.5± 0.2°c and have a thermometer graduated in at least 0.2°c increments. A log of the temperatures when the water bath is in use read to 0.1°c are kept together with the date the entry is made and the initials of the person making the entry (see exhibit 3).

Sterilizing Oven Temperature

A thermometer immersed in a sand bath is kept inside the sterilizing over to monitor the temperature. Records of all items being sterilized, total sterilization time, and temperature are kept (see exhibit 4).

Autoclave

An autoclave/Sterilization log is maintained. The log includes the date, time in, time out, total elapsed time, sterilization time, items sterilized, sterility controls, maximum temperature reached, and any maintenance performed (see exhibit 5).

Certified Thermometer

All thermometers used in laboratory are crosschecked against a certified thermometer annually. Records of calibrations and corrections are maintained (see exhibit 6).

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INCUBATOR # ____

Make/Model ____________

DATE	TIME	TEMP.	INITIAL	DATE	TIME	TEMP.	INITIAL

Exhibit 2

WATER BATH # ____
Make/Model # ________

DATE	TIME	TEMP.	INITIAL	DATE	TIME	TEMP.	INITIAL

Exhibit 3

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STERILIZING OVEN # ____
Make/Model ____________

DATE	ITEMS STERILIZED	TOTAL TIME	TEMP.	INITIAL	REMARKS

Exhibit 4

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AUTOCLAVE
Make/Model__________

DATE	TIME IN	TIME OUT	TOTAL TIME	ITEMS STERILIZED	MAX. TEMP.	CONTROL	INITIAL

Exhibit 5

THERMOMETER CALIBRATION

DATE	THERMOMETER NUMBER	CERTIFIED THERMOMETER #	CALIBRATION/ CORRECTION	INITIAL	REMARKS

Exhibit 6

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LABORATORY WATER QUALITY MONITORING

Bottled water is purchased from an outside source with an accompanying certificate of suitability. This is the water used to prepare the media. The parameters in the certificate include:

PARAMETER	LIMITS	FREQUENCY
Conductivity	>0.5 megohms resistance or <2 micromhos/cm at 25°c	Monthly
Pb, Cd, Cr, Cu, Ni, and Zn	Not greater than 0.05 mg/L per contaminant. Collectively, no greater than 0.1mg/L	Annually
Total Chlorine Residual	Nondetectable	Monthly
Heterotrophic	<500/mL	Monthly
Quality of Reagent	Ratio 0.8 - 3.0	Annually

Copies of the certificates of suitability are kept and maintained on file.

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MEDIA PREPARATION

The attached exhibit 7 is completed for each batch of media prepared. The information included in the form are:

- Data of preparation
- Preparer's initial
- Media prepared
- Weight of dehydrated media taken
- pH of autoclaved media
- Test of media with positive/negative cultures
- Sterility check

All completed media preparation forms are kept in a binder for easy reference.

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DATE

MEDIA PREPARATION

PREPARED BY:				
BATCH NO.:				
Manufacturer:				
Control Number:				
Quantity Desired:				
Weight of Media Needed:				
Date Dry Media Opened:				
Weight of Beaker & Dry Media:				
Tare Weight of Beaker:				
Weight of Media:				
Distilled Water: pH				
Spec. Conductance:				
Standard Plate Count:				
Chlorine Residual:				
pH Meter Standardized:				
pH of Media Desired:				
pH Before Sterilization:				
pH After Sterilization:				
Autoclave Condition:				
Autoclave Temperature:				
Time of Run: On				
Off				
Length of Time on Sterilize:				
Manner Dispensed:				
No. of Pipetter Used:				
Volume in mL:				

Exhibit 7

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ANALYTICAL PROCEDURES

Methods

The methods followed by the laboratory taken from Standard Methods for the Examination of Water and Wastewater, 16th edition, 1985 are:

Total Coliform by Multi-Tube Fermentation (MPN)	Method 908A
Fecal Coliform by MPN	Method 908C
Total Coliform by Membrane Filter (MF)	Method 909A
Fecal Coliform by MF	Method 909C

The outline forms of the above methods are attached as Appendix A of this supplemental manual.

Quality Control

1. For each bottle of media positive, negative, and sterile checks will be performed and a log of the check results will be maintained (see exhibit 8).

2. Positive and sterile checks will be performed for every batch of prepared media and a log of the check results will be maintained (see exhibit 9).

3. Positive and negative controls are ran with each analytical batch for EC test.

4. For each analytical batch tested by membrane filtration technique, a sterile control is ran at the beginning and end of the sample run, and a positive control is ran after the last sample.

5. For each lot of membrane filters, sterile and positive checks are ran.

6. The Completed Test must be done every three months or every positive confirmed potable water sample, which ever applies. A log of all positive potable confirmed sample is maintained.

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DRY MEDIA QC

DATE REC'D.	TYPE OF MEDIA	MANUFAC-TURER	LOT NUMBER	CHECK DATE	POSITIVE CHECK	NEGATIVE CHECK	STERILE CHECK	INITIAL

Exhibit 8

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PREPARED MEDIA QC

CHECK DATE	BATCH NUMBER	POSITIVE CHECK	STERILE CHECK	INITIAL	CHECK DATE	BATCH NUMBER	POSITIVE CHECK	STERILE CHECK	INITIAL

Exhibit 9

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MEMBRANE FILTER QC

DATE RECEIVED	MANUFAC-TURER	LOT NUMBER	CHECK DATE	POSITIVE CHECK	STERILE CHECK	INITIAL	REMARKS

Exhibit 10

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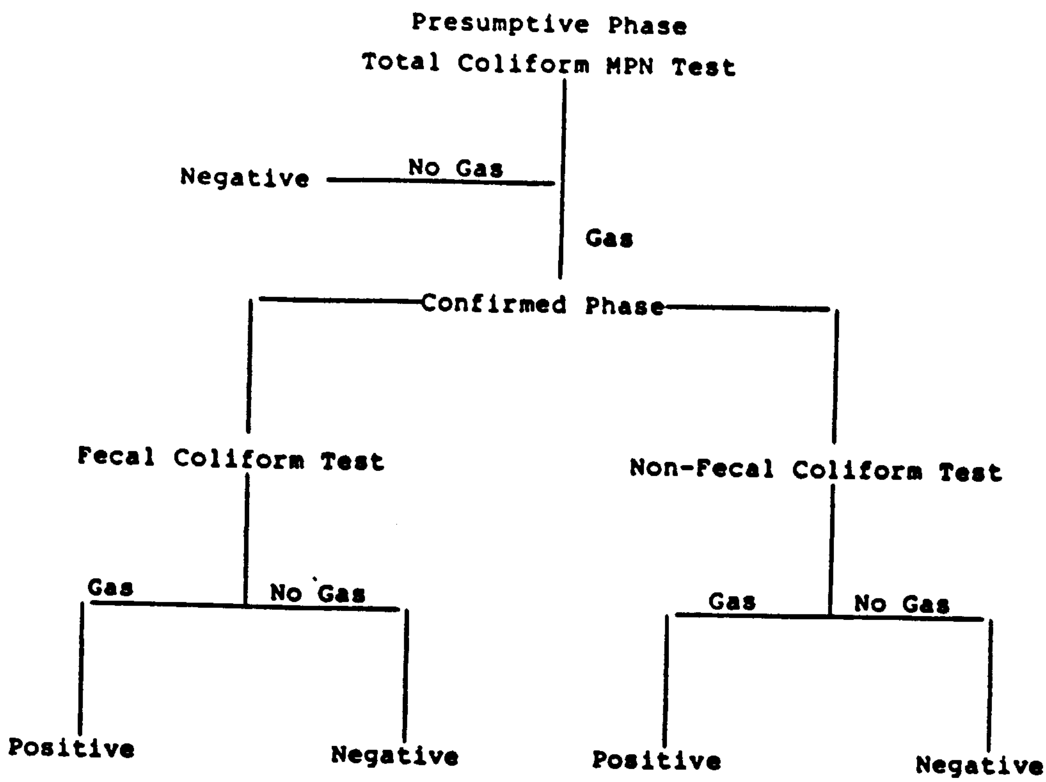
APPENDIX A: Methodology Outline

SUMMARY
OF
MULTIPLE-TUBE FERMENTATION TECHNIQUE
FOR THE COLIFORM GROUP



Effective Date: May 1991
Reference: Standard Method 908A

Total Coliform Multiple Tube Test

Reagents: Presumptive phase fermentation tubes with lauryl tryptose broth.

Quality Control:

Perform duplicate analyses on 10% of samples or at least one sample per test run.

Procedure:

1. Pipet ten 10 ml portions of the sample in a series of presumptive phase fermentation tubes; mix thoroughly.
2. Incubate fermentation tubes at 35± 0.5°c.
3. After 24± 2h, shake the tubes and examine for gas formation then take the following steps:

Gas Formation	Step To Proceed
Yes	Positive Test - continue to test for fecal and non-fecal coliforms.
No	Continue to step 4 below.

4. Continue incubating up to 48± 3h then again reexamine for gas formation.

Gas Formation	Steps To Proceed
Yes	Positive Test - continue to test for fecal and non-fecal coliform.
No	Negative Test - procedure completed

NOTE: For drinking and recreational water samples with heavy growth but no gas formation, continue on to test for non-fecal coliforms.

Calculation: See Calculation: Estimation of Bacterial Density

Effective Date: May 1991
Reference: Standard Method 908

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Fecal Coliform Test

<u>Reagent</u>: EC Medium Tubes

<u>Quality Control</u>:

Run one each positive and negative controls for each analytical batch.

<u>Procedure</u>:

1. Gently shake or rotate presumptive tube.
2. With a sterile 3 mm metal loop, transfer one loopful of culture to EC medium tubes.
3. Incubate tubes in a water bath at 44.5± 0.2°c for 24± 2hr. Be certain to Place all EC tubes in the water bath within 30 minutes after the transfer of the culture.
4. Periodically check the EC medium tube during the incubation period for any gas formation.

Gas Formation	Steps To Proceed
Yes	Positive - fecal coliforms present
No	Coliforms present are of non-fecal origin and next step will depend on the result of the non-fecal coliform test.

<u>Calculation</u>: See Calculation: Estimation of Bacterial Density

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Effective Date: May 1991
Reference: Standard Method 908A

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Non-Fecal Coliform Test

Reagent: Brilliant Green Lactose Bile Broth (BGB) fermentation tube.

Procedure:

1. Gently shake or rotate primary fermentation tube showing gas.
2. With a sterile metal loop 3 mm in diameter, transfer one loopful of culture to a BGB fermentation tube.
3. Incubate BGB tube for 48± 3 hr. at 35± 0.5°c.
4. Periodically check BGB tubes during the incubation period for any gas formation.

Gas Formation	Steps To Proceed
Yes	Positive Confirmed Test - proceed to completed test for 10% of positive samples or at least one positive source water every quarter.
No	Negative Confirmed Test - procedure completed.

Calculation: See Calculation: Estimation of Bacterial Density

Effective Date: May 1991
Reference: Standard Method 9221D, 16th ed.

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Calculation: Estimation of Bacterial Density

This method is used to calculate the Most Probable Number (MPN) of coliform/100 ml of sample.

No. of Tubes Giving Positive Reaction Out of 10 of 10 ml Each	MPN Index/100 ml	95% Confidence Limits (Approximate) Lower	Upper
0	<1.1	0	3.0
1	1.1	0.03	5.9
2	2.2	0.26	8.1
3	3.6	0.69	10.6
4	5.1	1.3	13.4
5	6.9	2.1	16.8
6	9.2	3.1	21.1
7	12.0	4.3	27.1
8	16.1	5.9	36.8
9	23.0	8.1	59.5
10	>23.0	13.5	Infinite

No. of Tubes Giving Positive Reaction Out of 5 of 10 ml each	MPN Index/100 ml	95% Confidence Limits Lower	Upper
0	2.2	0	6.0
1	2.2	0.1	12.6
2	5.1	0.5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	16.0	8.0	Infinite

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For volumes other 5ml or 10ml, use the following equation to solve for the MPN value:

$$\text{MPN value (from table)} \times \frac{10}{\text{Largest vol. tested}} = \text{MPN/100ml}$$

Note: MPN value is taken from table 9221:V of the Standard Methods.

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Total Coliform Membrane Filter Procedure

Reagents: LES Endo Agar in petri dishes

Quality Control:

Run a sterile control at the beginning and end of the analytical batch and a positive control after the last sample.

Procedure:

1. Assemble filtration apparatus according to manufacturer's instruction.
2. Filter 100 ml sample under partial vacuum.
3. Rinse filtration apparatus with filter still in place with three 20 ml partions of sterile dilution water.
4. Remove membrane filter with a sterile forcep and place it on LES Endo Agar-filled petri dishes with a rolling motion to prevent entrapment of air.
5. Incubate dish for 22 to 24 hr. at 35± 0.5°c.
6. Count colonies that have pink to dark-red color with a metallic green-gold surface sheen using low-powered dissecting microscope.
7. Confirm all sheen colonies counted or a minimum of five colonies from drinking water samples by transferring growth from each colony to parallel tubes of lauryl tryptose broth and brilliant green lactose bile (BGB) broth.
8. Incubate both tubes at 35± 0.5°c for 48 hr.
9. Formation of gas in the BGB tubes confirms the colony as coliform. If only the lauryl tryptose broth showed any gas production, then transfer to a second BGB tubes. This second BGB tube must produce gas at 35± 0.5°c with 48 hr. to verify the colony as coliform.

Calculation:

$$\frac{\text{(Total) Coliform Colonies}}{\text{100 ml}} = \frac{\text{Coliform Colonies Counted X100}}{\text{ml sample filtered}}$$

95% Confidence Limits Using 100 ml Sample.

Number of Coliform Colonies Counted	95% Confidence Limits Lower	Upper
1	0.025	3.0
2	0.35	4.7
3	0.81	6.3
4	1.4	7.7
5	1.6	11.7
10	4.8	18.4

For counts, c, greater than 20 organism, the above limits maybe calculated by:

Upper Limit= $c + [2(2 + \sqrt{c})]$
Lower Limit= $c - [2(1 + \sqrt{c})]$

Effective Date: May 1991
Reference: Standard Method 909C

Fecal Coliform Membrane Filter Procedure

Reagents: M-FC Broth

Quality Control:

Run a Sterile control at the beginning and end of the analytical batch and a positive control after the last sample.

Procedure:

1. Preparation of culture dish: Place a sterile absorbent pad in each culture dish and pipet approximately 2 ml M-FC broth to saturate the pad. carefully remove any excess liquid from culture dish.

2. Assemble filtration apparatus according to manufacturer's instruction.

3. filter 100 ml sample under partial vacuum.

4. Rinse filtration apparatus with filter still in place with three 20 ml partions of sterile dilution water.

5. Remove membrane filter with sterile forcep and place it on prepared culture dish in a rolling motion to prevent entrapment of air.

6. Seal petri dishes, submerge in water bath, and incubate for 24± 2h at 44.5± 0.2°c. Anchor dishes below water surface to maintain critical temperature requirements. Make certain that the petri dishes are in the water bath within 30 minutes after filtration.

7. Count colonies in various shades of blue using low powered microscope. These are colonies produced by fecal coliform bacteria.

Calculation:

$$\text{(Total) Coliform Colonies/100 ml} = \frac{\text{Coliform Colonies Counted X100}}{\text{ml sample filtered}}$$

95% Confidence Limits: The same as for Total Coliform Membrane Filter Technique.

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Effective Date: September 1991
Reference: Standard Method
14th Edition
Method 910A

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Presumptive Test for Fecal Streptococcus Group

(Multiple-Tube Technique)

Reagents: Presumptive Phase Tubes with Azide Dextrose Broth

Quality Control:

1. Perform duplicate analyses on 10% of samples or at least one sample per test run.
2. Run Sterility Check and Positive Control with each batch of samples.

Procedure:

1. Pipet ten 10ml sample in a series of presumptive phase tubes: mix thoroughly.
2. Incubate tubes at 35 deg C ± 0.5 deg C.
3. After 24±2 hours, shake and examine tubes for turbidity then take the following steps:

Turbid	Step to Proceed
yes	Positive Test - continue to test fecal and non-fecal streptococcus.
no	Continue to step 4 below.

4. Continue incubating up to 48±3 hours then again re-examine for turbidity.

Turbid	Step to Proceed
yes	Positive Test - continue to test for fecal and non-fecal streptococcus.
no	Negative - procedure completed.

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Effective Date: September 1991
Reference: Standard Method
14th Edition
Method 910A

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Confirmed Test for Fecal Streptococcus

Reagent: Petri dishes with Enterococcesel (BBL trade name)

Quality Control:

Run one each of positive and sterile controls with each batch.

Procedure:

1. Gently shake or rotate presumptive tube.
2. With a sterile 3mm metal loop, streak a portion of the growth from each positive presumptive tube (with azide dextrose broth) on a petri dish containing enteroccocosel agar.
3. Incubate the dish inverted at 35±0.5 deg C for 24±2 hours.
4. Brownish-black colonies with brown halos confirm the presence of fecal streptococcus.

Calculation: See Calculation: Estimation of Bacterial Density

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Effective Date: September 1991
Reference: Standard Methods 14th edition Method 910A

Confirmed Test for the Enterococcus Group

Reagent: Brain Heart Infusion Broth tubes containing 6.5% Sodium Chloride.

Procedures:

1. Transfer brownish-black colonies with brown halos to a tube of brain heart infusion broth containing 6.5% NaCl.

2. Incubate at 45 deg C for 24 hours.

3. Periodically check the tubes during incubation for growth.

4. Growth in 6.5% NaCl broth indicates that the colony belongs to the enterococcus group.

Calculation: See Calculation: Estimation of Bacterial Density

Effective Date: September 1991
Reference: Standard Methods
14th edition
Method 910B

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Membrane Filter Procedure for Fecal Streptococcus

Reagents: KF Streptococcus Agar

Quality Control:

Run a sterile control at the beginning and end of the analytical batch and a positive control after the last sample.

Procedure:

1. Assemble filtration apparatus according to manufacturer's instructions.
2. Filter 100ml of sample under partial vacuum.
3. Remove membrane filter with a sterile forcep and place it on directly to KF Streptococcus agar medium in petri dish with a rolling motion to prevent entrapment of air.
4. Invert culture plates and incubate at 35±0.5 deg C for 48 hours.
5. Count colonies that have dark red to pink color using a low power binocular, wide field dissecting microscope.

Calculation:

$$\frac{\text{Total Colonies}}{\text{100ml}} = \frac{\text{Colonies Counted X 100}}{\text{ml sample filtered}}$$

For 95% Confidence Limits using 100ml sample, check Standard Method 909A.6.

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NPDES PERMIT NO. CA0061654
PHASES II & III

PROPOSED STORMWATER/URBAN RUNOFF MONITORING PROGRAM (Mass Emissions Sites)

1 8492 F

LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS

WASTE MANAGEMENT DIVISION
WATER QUALITY MANAGEMENT SECTION

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R0051799

I. INTRODUCTION

As required by National Pollutant Discharge Elimination System (NPDES) Permit No. CA0061654, a proposed Stormwater/Urban Runoff Monitoring Program for Phase II and III of the Permit, the Upper Los Angeles River (II), Upper San Gabriel River (III), Lower Los Angeles River (IV), Lower San Gabriel River (V), and Santa Clara River Drainage Basins is hereby submitted to the Regional Water Quality Control Board, Los Angeles Region (RWCQB), for approval. Comments and concerns made by the RWQCB in its December 21, 1993 letter to the Los Angeles County Department of Public Works (LACDPW) related to our proposed Santa Monica Bay Stormwater/Urban Runoff Monitoring Program, have been incorporated into this report.

The monitoring program described herein includes the establishment of fifteen monitoring sites for both mass emissions and individual land use monitoring. Five mass emissions sampling sites are identified in this report. One other mass emission sampling site will be located in the Santa Clarita Valley Basin (Santa Clara River Watershed), and will be identified later this year in a supplemental report to the RWQCB. Eight land use specific sites will likewise be identified in the supplemental report to be submitted later this year to the RWQCB.

Storm samples will be collected for five storms per year. Dry-weather samples will be collected bimonthly. Samples will be tested for a wide range of constituents including Bacteria; General Minerals; Biochemical Oxygen Demand; Total Organic Carbon and total Petroleum Hydrocarbons; Volatile Organic Compounds and Suspended Solids; Volatile Suspended Solids; and Semi-volatile Organic Compounds.

Automated refrigerated water samplers will be utilized in the collection of flow-composite samples. These samplers will be located on the ground surface in secure enclosures allowing easy access for retrieval of samples. The samplers have large (10 gallon) water collection capacity, and, thus, can be programmed in advance to cover a wide range of storm sizes without requiring one or more bottle change outs during a storm event.

Data collected by the program will be used for water quality modelling to estimate pollutant loads to receiving waters. Also, questions concerning what types of pollutants emanate from various land uses will be addressed. Lastly, data collected over the years under this program can be used in an attempt to assess any long-term trends in water quality.

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II. PROPOSED MONITORING SITES

A. SITE SELECTION CRITERIA

15 Sites

1. Monitoring Site Selection Overvi

6 / mass emission (1 missing)
9 Land-use (missing?)

In order to characterize the qu ... reas, a combination of large watersheds r ... " sites) and single land use sites are to be

For these Drainage Basins fifteen ... n sites will be mass emissions stations (o ... d sites will be land use specific statio ... maller homogenous land use watersheds ·

The proposed monitoring sites re ... ations based on our established criteria fo ... incorporated into the program those storm drains which have water quality issues which are of concern to the community.

2. Specific Criteria for Mass Emissions Monitoring Sites

Mass emissions monitoring sites have been proposed along drainage systems covering the largest tributary watershed area feasible within each drainage basin. These watersheds will typically have a complex multiple land use composition.

In selecting a specific storm drain for inclusion as either a mass emissions or land use specific site, the following technical and operational requirements were addressed:

- What type of sampling equipment is to be used, and what limitations exist?
- What are the hydraulics of the underground storm drain, open channel/natural watercourse? What is the Design Q?
- Is there past flow data available for the given stream?
- What past hydrology studies have been performed in the watershed?. What is the hydrologic Q?
- If the storm drain is underground, is it currently under designed? Could it experience surcharge conditions?
- Within the watershed, what is the corresponding land use? Is land use uniform and homogenous throughout the upper tributary area? If yes, this is a possible land use site.
- Has previous sampling in the potential watershed been conducted in the past? Where? When? Why?

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II. PROPOSED MONITORING SITES

A. SITE SELECTION CRITERIA

1. Monitoring Site Selection Overview

In order to characterize the quality of runoff from the Phase II and III areas, a combination of large watersheds representing multiple land uses ("mass emissions" sites) and single land use sites are to be selected.

For these Drainage Basins fifteen monitoring sites are proposed. Six of the fifteen sites will be mass emissions stations (one to be submitted at a later date). Nine proposed sites will be land use specific stations (to be submitted at a later date) where smaller homogenous land use watersheds will be sampled.

The proposed monitoring sites represent an effort to select the most suitable locations based on our established criteria for sampling. Where feasible, we have incorporated into the program those storm drains which have water quality issues which are of concern to the community.

2. Specific Criteria for Mass Emissions Monitoring Sites

Mass emissions monitoring sites have been proposed along drainage systems covering the largest tributary watershed area feasible within each drainage basin. These watersheds will typically have a complex multiple land use composition.

In selecting a specific storm drain for inclusion as either a mass emissions or land use specific site, the following technical and operational requirements were addressed:

- What type of sampling equipment is to be used, and what limitations exist?
- What are the hydraulics of the underground storm drain, open channel/natural watercourse? What is the Design Q?
- Is there past flow data available for the given stream?
- What past hydrology studies have been performed in the watershed?. What is the hydrologic Q?
- If the storm drain is underground, is it currently under designed? Could it experience surcharge conditions?
- Within the watershed, what is the corresponding land use? Is land use uniform and homogenous throughout the upper tributary area? If yes, this is a possible land use site.
- Has previous sampling in the potential watershed been conducted in the past? Where? When? Why?

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- Are tidal or backwater influences a concern?
- Is the location selected the only outfall point for the upstream watershed, or are there multiple outfall points?
- Is the storm drain structurally sound at present? Will installation of sampling equipment compromise the stability of the storm drain?
- Will the monitoring equipment impede flow or reduce flood protection?
- For natural watercourses, is there an existing improved section where a rating curve can be easily established?
- What is the practicable linear distance from the storm drain invert (low flow) to the location where the sampler shall be placed?
- Can electric power be provided, in a cost-effective manner, to the site?
- Will additional right-of-way be required?
- Will the sampler installation interfere with projects planned or in progress in the general vicinity?
- If located in a residential neighborhood, will the location of the automated sampler and its operation result in any objections from the local residents?

B. Monitoring Site Installation

The monitoring sites have been prioritized for installation as follows:

Los Angeles River @ Wardlow Road
Rio Hondo Channel @ Beverly Boulevard
San Gabriel River @ San Gabriel River Parkway
Coyote Creek @ Spring Street
Los Angeles River @ Tujunga Avenue

We propose to have these sites operational by the onset of the 1995-96 rainy season.

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C. PROPOSED MASS EMISSIONS MONITORING SITES

1. **LOS ANGELES RIVER downstream of Wardlow Road at Los Angeles County Department of Public Works Stream Gage No. F319-R in the City of Long Beach.**

The Los Angeles River monitoring station will be located at the existing stream gage station between Willow Street and Wardlow Road. This facility currently measures stream flow and precipitation. At this location, the total upstream tributary drainage area for Los Angeles River is 815 square miles. This river is the largest watershed outletting to the Pacific Ocean in Los Angeles County. Tidal influences dictate the position for the sampling site.

Los Angeles River, at the gaging station, is an improved (concrete lined) trapezoidal channel. The vertical lift from the invert of the low-flow channel to a sampler location above the western levee is approximately 23 feet. Since the vertical lift exceeds 15 feet, an auxiliary pump will be needed to perform automated sampling. The linear distance from the top of the river levee to the low-flow channel exceeds 200 feet. The linear distance posses some concern. Pump wear and tear for reverse and forward pump cycles for this linear distance would be excessive. Since it is typical to find dry weather flows uniformly across the channel at this location (the low-flow channel can no longer carry the volume of flow found in the river), it maybe feasible to locate the strainer along the invert near the side of the river as the preferred design. Another option for placement of the automated sampler involves lowering the sampling equipment adjacent to the toe of the levee slope, and jacking the necessary conduits through the levee. This design may eliminate the need for an auxiliary pump if the strainer is positioned near the side of the river, however, it cannot compromise the levee by allowing storm water to migrate through the conduits.

The Los Angeles River sampling location below the Wardlow Road bridge (Old TG PG 70B-6/ New TG PG 795C-1) has been an active stream gaging station since 1931.

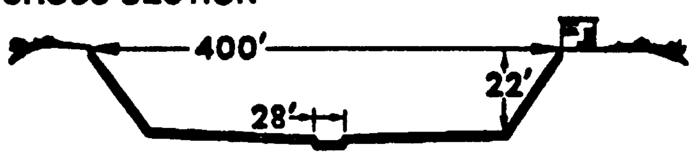
Flows in the River are partially regulated by the following: Sepulveda, Pacoima, Big Tujunga, Hansen, Devil's Gate, Lopez Debris Dam, as well as Whittier Narrows, Santa Anita, Sawpit, Eaton, Sierra Madre, and Santa Fe Dams; Project No. 85 Diversion; as well several spreading grounds, and debris basins. This will require an immense coordination effort in gathering, collecting and interpreting water quality data collected from this station. Because these dams and spreading grounds serve as flood control and water conservation facilities, small storms may not produce significant runoff from particular areas within the watershed, and therefore not contribute to the flow which is measured at the Wardlow Road gaging station. Large storms which produce significant runoff maybe detained, only to be released at a time when it is believed that potential flooding hazard conditions have subsided. There are numerous other scenarios which may occur, all impacting our water quality monitoring efforts at this site.

The overwhelming majority of the flows found in the River during dry weather periods are the result of NPDES permitted point discharges regulated by the California Regional Water Quality Control Board.

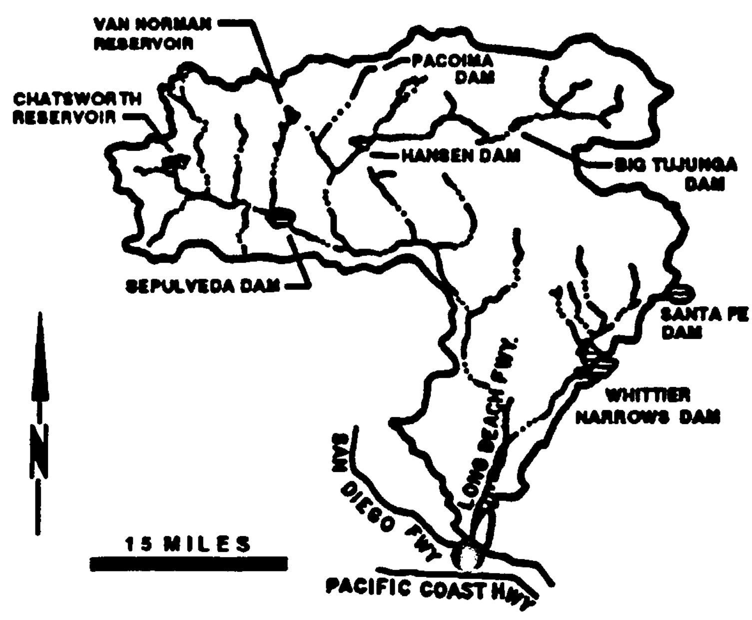
Various land uses exist within the River's tributary watershed area. Residential areas of various sizes and densities include single family, duplexes, condominiums / townhomes, and apartments. Commercial strips of many uses, malls, office buildings, etc., can be found within the watershed. Industrial developments of all types and sizes are identified within the tributary watershed. Undeveloped or open space properties are typically found in the foothill areas, but are not limited specifically to these areas. A percentage breakdown for these land uses will be included in the supplemental Monitoring Program Report to be submitted later this year.

This proposal will replace the existing County Department of Public Works surface water grab sampling site at Wardlow Road.

CROSS-SECTION



DRAINAGE AREA



LOS ANGELES RIVER AT WARDLOW ROAD

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2. **COYOTE CREEK below Spring Street at Los Angeles County Department of Public Works Stream Gage No. F354-R in the City of Long Beach.**

The Coyote Creek station will be located at the existing stream gage station below Spring Street. This facility currently measures stream flow and precipitation. At this location the upstream tributary area is 185 square miles (extending into Orange County). The confluence with San Gabriel River dictates the position for the sampling site.

Coyote Creek, at the gaging station, is an improved (concrete lined) trapezoidal channel. The vertical lift from the invert of the low-flow channel to a sampler location above the western levee is approximately 20 feet. Since the vertical lift exceeds 15 feet, an auxiliary pump will be needed to perform automated sampling. The linear distance to the low-flow channel is nearly 60 feet, and does not appear to be a problem. The strainer and pressure transducer can be mounted in the low-flow channel. Another option being explored for placement of the automated sampling equipment involves lowering the equipment along the backside of the levee towards the toe of the levee slope, and jacking the necessary conduits through the levee. This design may eliminate the need for an auxiliary pump, however, it cannot compromise the levee by allowing storm water to migrate through the conduits during a storm.

The Coyote Creek sampling location below the Spring Street (Old TG PG 76F-1 / New TG PG 796H-2) has been an active stream gaging station since 1963.

Flows in the River are partially regulated by the following: Fullerton, Brea, and Carbon Canyon Dams. This factor will require coordination with Orange County in gathering, collecting and interpreting water quality data collected from this station. Because these dams, as well as other facilities serve as flood control structures, small storms may not produce significant runoff from particular areas within the watershed, and therefore not contribute to the flow which is measured at the Spring Street gaging station. Large storms which produce significant runoff maybe detained, only to be released at a time when it is believed that potential flooding hazard conditions have subsided. There are numerous other scenarios which may occur, all impacting our water quality monitoring efforts at this site.

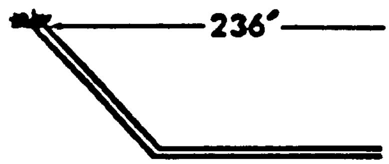
The overwhelming majority of the flows found in the Creek during dry weather periods are the result of NPDES permitted point discharges regulated by the California Regional Water Quality Control Board.

Various land uses exist within the Creek's tributary watershed area. Residential areas of various sizes and densities include single family, duplexes, condominiums / townhomes, and apartments. Commercial strips of many uses, malls, office buildings, etc., can be found within the watershed. Industrial developments of all types and sizes are identified within the tributary watershed. Undeveloped or open space properties are typically found in the foothill areas, but are not limited specifically to these areas. A percentage breakdown for these land uses will be included in the supplemental Monitoring Program Report to be submitted later this year.

This proposed sampling location will replace the existing LACDPW surface water quality grab sampling stations at Orangethorpe Boulevard and at Willow Street.

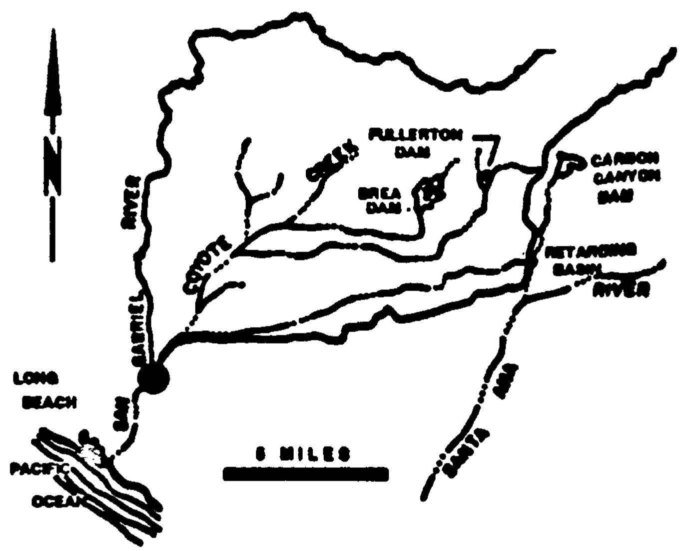
1850

CROSS-SECTION



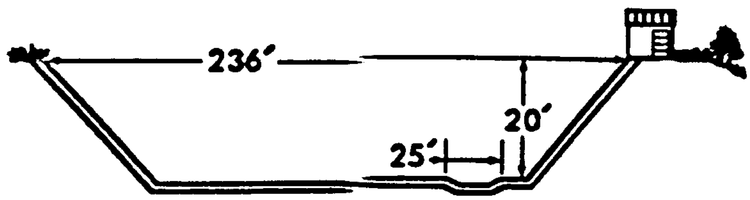
why coyote creek? landuse.

DRAINAGE AREA

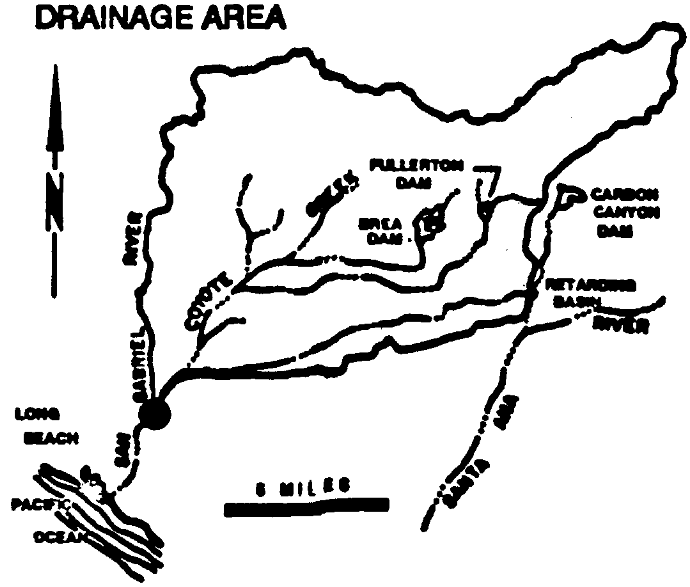


COYOTE CREEK BELOW SPRING STREET

CROSS-SECTION



DRAINAGE AREA



COYOTE CREEK BELOW SPRING STREET

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3. **LOS ANGELES RIVER at Tujunga Avenue at Los Angeles County Department of Public Works Stream Gage No. F300-R in the City of Los Angeles.**

This Los Angeles River station will be located at the existing stream gage station above Tujunga Avenue. This facility currently measures stream flow. At this location the upstream tributary area is 401 square miles (almost half of the entire Los Angeles River watershed area).

Los Angeles River, at the gaging station, is an improved (concrete lined) open box channel. The vertical lift from the invert of the low-flow channel to a sampler location above the northerly wall of the channel is approximately 19 feet. Since the vertical lift exceeds 15 feet, an auxiliary pump will be needed to perform automated sampling. The linear distance to the low-flow channel is nearly 90 feet, and does not appear to pose a problem. The strainer and pressure transducer can be mounted in the low-flow channel. The auxiliary pump would have to be mounted in a vault in the channels northern wall between 10 and 15 feet above the invert.

The Los Angeles River proposed sampling location above the Tujunga Avenue bridge (Old TG PG 23D-4 / New TG PG 562J-6), and downstream of the Tujunga Wash outfall has been an active stream gaging station since 1950.

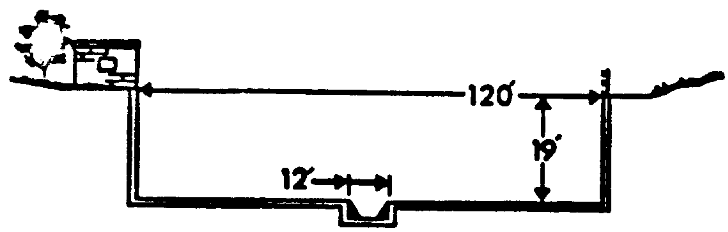
Flows in the River are partially regulated by the following: Sepulveda, Pacoima, Big Tujunga, Hansen, Lopez Debris Dams; also Project No. 85 Diversion; as well as several spreading grounds and debris basins. This will require an immense coordination effort in gathering, collecting and interpreting water quality data collected from this station. Because these dams and spreading grounds serve as flood control and water conservation facilities, small storms may not produce significant runoff from particular areas within the watershed, and therefore not contribute to the flow which is measured at the Tujunga Avenue gaging station. Large storms which produce significant runoff maybe detained, only to be released at a time when it is believed that potential flooding hazard conditions have subsided. There are numerous other scenarios which may occur, all impacting our water quality monitoring efforts at this site.

The overwhelming majority of the flows found in the River during dry weather periods are the result of NPDES permitted point discharges regulated by the California Regional Water Quality Control Board.

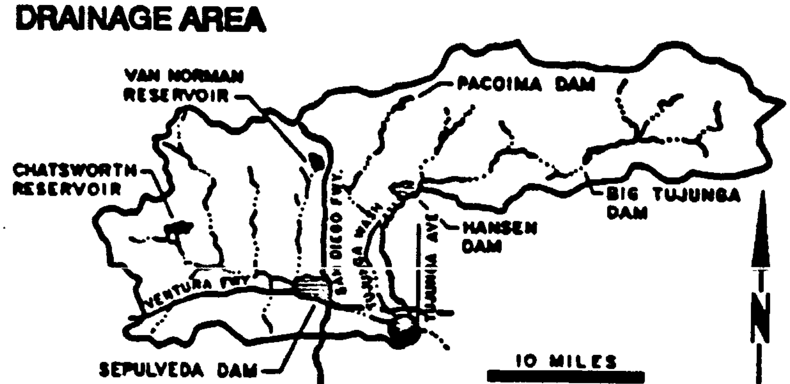
Various land uses exist within the River's tributary watershed area. Residential areas of various sizes and densities include single family, duplexes, condominiums / townhomes, and apartments. Commercial strips of many uses, malls, office buildings, etc., can be found within the watershed. Industrial developments of all types and sizes are identified within the tributary watershed. Undeveloped or open space properties are typically found in the foothill areas, but are not limited specifically to these areas. A percentage breakdown for these land uses will be included in the supplemental Monitoring Program Report to be submitted later this year.

This proposal will replace the existing LACDPW surface water quality grab sampling station at Tujunga Avenue.

CROSS-SECTION



DRAINAGE AREA



LOS ANGELES RIVER AT TUJUNGA AVENUE

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4. RIO HONDO CHANNEL - Above Beverly Boulevard, and downstream of Whittier Narrows Dam, at U.S.G.S. - U.S. Army Corps of Engineers Stream Gage No. 11102300 or E327-R.

Rio Hondo Channel station will be located at the existing stream gage station above Beverly Boulevard. This facility currently measures stream flow. At this location the upstream tributary area is 124 square miles (excluding the area above Santa Fe Dam).

Rio Hondo Channel, at the gaging station, is an improved (concrete lined) trapezoidal channel. The vertical lift from the invert of the low-flow channel to a sampler location above the western levee is approximately 19 feet. Since the vertical lift exceeds 15 feet, an auxiliary pump will be needed to perform automated sampling. The linear distance to the channel's invert (there is no low-flow channel) is nearly 50 feet and does not appear to be a problem. The strainer and pressure transducer can be mounted in the invert of channel. Another option for placement of the automated sampler involves lowering the equipment along the backside of the levee towards the toe of the levee slope, and jacking the necessary conduits through the levee. This design may eliminate the need for an auxiliary pump, however, it cannot compromise the levee by allowing storm water to migrate through the conduits. The U.S.G.S. indicates that discharges below 100 cfs are poor for stream gaging.

The Rio Hondo Channel sampling location above the Beverly Boulevard bridge (Old TG PG 54F-1 / New TG PG 676F-1) has been an active stream gaging station since 1965 and is operated by the U.S.G.S. and the U.S. Army Corps of Engineers.

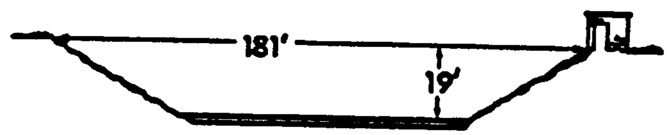
Flows in the Channel are partially regulated by the following: Sierra Madre, Santa Anita, Sawpit, Eaton, Santa Fe and Whittier Narrows Dams; as well as several spreading grounds and debris basins. This factor will require an immense coordination effort in gathering, collecting and interpreting water quality data collected from this station. Because these dams, as well as other facilities serve as flood control structures, small storms may not produce significant runoff from particular areas within the watershed, and therefore not contribute to the flow which is measured at the Beverly Boulevard gaging station. Large storms which produce significant runoff maybe detained, only to be released at a time when it is believed that potential flooding hazard conditions have subsided. There are numerous other scenarios which may occur, all impacting our water quality monitoring efforts at this site.

The overwhelming majority of the flows found in the Channel during dry weather periods are the result of NPDES permitted point discharges regulated by the of California Regional Water Quality Control Board.

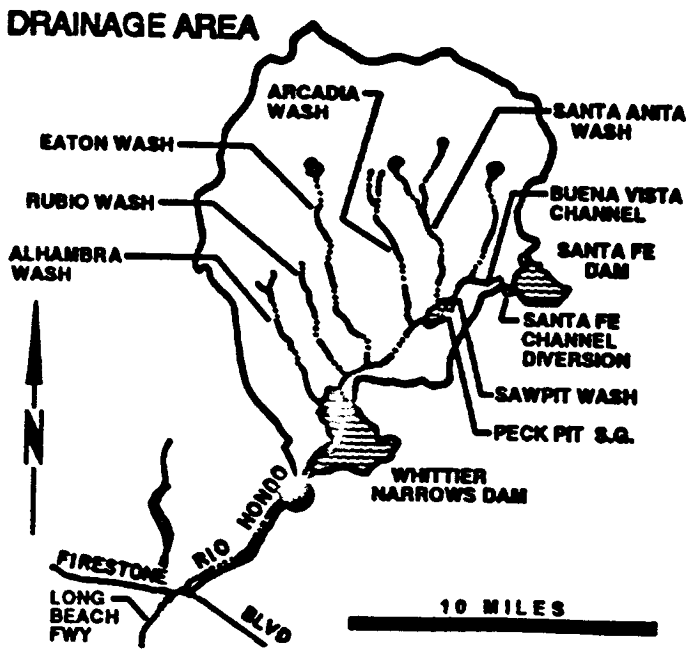
Various land uses exist within the Channel's tributary watershed area. Residential areas of various sizes and densities include single family, duplexes, condominiums / townhomes, and apartments. Commercial strips of many uses, malls, office buildings, etc., can be found within the watershed. Industrial developments of all types and sizes are identified within the tributary watershed. Undeveloped or open space properties are typically found in the foothill areas, but are not limited specifically to these areas. A percentage breakdown for these land uses will be included in the supplemental Monitoring Program Report to be submitted later this year.

This proposal will replace the existing LACDPW surface water quality grab sampling station at Stewart & Gray.

CROSS-SECTION



DRAINAGE AREA



RIO HONDO CHANNEL ABOVE BEVERLY BOULEVARD

5. **SAN GABRIEL RIVER - Downstream of San Gabriel River Parkway, downstream of Whittier Narrows Dam at Los Angeles County Department of Public Works Stream Gage No. F263C-R.**

The San Gabriel River monitoring station will be located at the existing stream gage station, below San Gabriel River Parkway. This facility currently measures stream flow. At this location the upstream tributary area is 460 square miles.

San Gabriel River, at the gaging station, is a grouted rock-concrete stabilizer along the western levee, and a natural section on the eastern side. Flow measurement and water sampling will occur in the grouted rock area along the western levee of the river. The vertical lift from the invert of the concrete stabilizer to a sampler location above the western levee is approximately 15 feet. Since the vertical lift to the sampler would be in excess of 15 feet, an auxiliary pump to perform automated sampling may be warranted. The linear distance to the concrete stabilizer is nearly 70 feet. The linear distance to the concrete stabilizer does not appear to be a problem. The strainer and pressure transducer will be mounted in the concrete stabilizer.

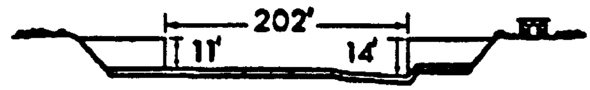
The San Gabriel River sampling location below the San Gabriel River Parkway bridge (Old TG PG 55C-1 / New TG PG 676J-2) has been an active stream gaging station since 1968.

Flows in the River are partially regulated by the following: Whittier Narrows, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek, Santa Fe, Morris, San Gabriel, and Cogswell Dams; as well several spreading grounds; and debris basins. This will require an immense coordination effort in gathering, collecting and interpreting water quality data collected from this station. Because these dams and spreading grounds serve as flood control and water conservation facilities, small storms may not produce significant runoff from particular areas within the watershed, and therefore not contribute to the flow which is measured at the San Gabriel River Parkway gaging station. Large storms which produce significant runoff maybe detained, only to be released at a time when it is believed that potential flooding hazard conditions have subsided. There are numerous other scenarios which may occur, all impacting our water quality monitoring efforts at this site.

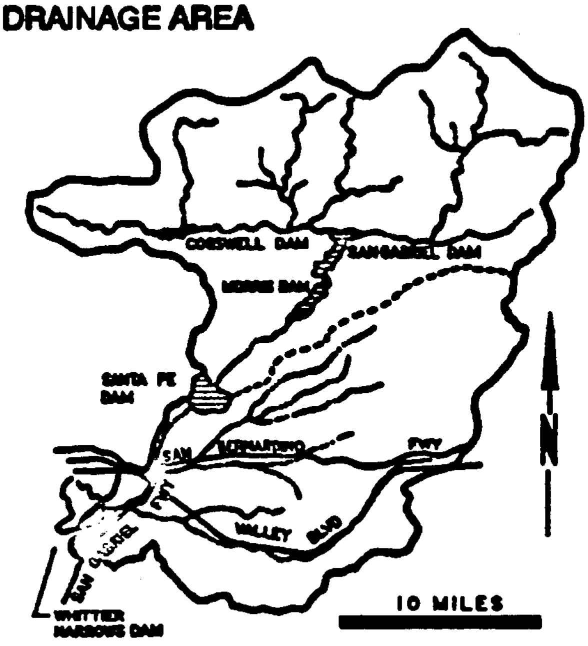
The overwhelming majority of the flows found in the River during dry weather periods are the result of NPDES permitted point discharges regulated by the California Regional Water Quality Control Board.

Various land uses exist within the River's tributary watershed area. Residential areas of various sizes and densities include single family, duplexes, condominiums / townhomes, and apartments. Commercial strips of many uses, malls, office buildings, etc., can be found within the watershed. Industrial developments of all types and sizes are identified within the tributary watershed. Undeveloped or open space properties are typically found in the foothill areas, but are not limited specifically to these areas. A percentage breakdown for these land uses will be included in the supplemental Monitoring Program Report to be submitted later this year.

CROSS-SECTION



DRAINAGE AREA



SAN GABRIEL RIVER DOWNSTREAM OF SAN GABRIEL PARKWAY

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III. MONITORING EQUIPMENT

A. WATER QUALITY SAMPLERS

Refrigerated Water Quality Samplers

Stormwater sampling for this NPDES permit must include a technique for collecting flow composite samples for storms as well as time composite samples for dry weather applications. The utilization of automatic refrigerated water quality samplers (Figure III-1) represent the best available technology at present to meet the goals of the Permit.

The water quality samplers to be utilized at each of the monitoring sites will be AC powered to carry the load needed to provide refrigeration. All samples will be stored at 4°C.

Each sampler will incorporate a peristaltic pump for sample collection. Due to the inability of the peristaltic pump to effectively pump beyond a vertical lift of 15 feet, a water tight auxiliary pump will be required at all stations. The reason for the the auxiliary pump to be water tight is that it may become submerged for periods of time during a storm. For underground drains the auxiliary pump needs also to be rated explosion proof. The explosion proof rating is required for the auxiliary pump because gases in a confined space, such as an underground storm drain, may excite the pumps motor causing an explosion. Most of our sites have vertical lifts in excess of 15 feet, requiring auxiliary pumps.

Each sampler will be securely stored in a steel box, similar to a traffic signal controller enclosure. Samplers will be located on the sidewalk or secured right-of-way for closed conduits or along the banks of open channels and natural watercourses.

B. FLOW MONITORING

Flow monitoring equipment is a fundamental aspect of water quality sampling. Because the Monitoring Program proposal includes flow composite sampling during storms, flow monitoring equipment must be utilized with the sampler. There are various makes and models of flow meters. Some of the various flow meters available utilize pressure transducers, ultrasonic sensors, bubblers, stilling wells utilizing a float, etc.

The above mentioned flow measuring devices are designed for open-channel flow conditions. The water elevation in a storm drain is measured by the flow monitoring equipment and then, from either a rating table previously established at the site, or from an equation such as Manning's a flow rate is determined. The County's Department of Public Works uses rating tables which are generated from analysis of storm drain cross sections and upstream/downstream flow characteristics. The rating tables are modified if it is demonstrated in the field that the stream velocity measurements indicate a non-uniform relationship with the calculated table values. Past efforts in stormwater flow measurement indicates that all of the proposed stations will require time and multiple storm events to gather necessary data needed for calibration of the measurement devices.

The type of flow measurement device selected for use is a pressure transducer. The maximum depth of flow for the proposed five sites approaches 23 feet. With the pressure transducer fixed at the bottom of the drain, a depth range from dry condition to 23 feet will have to be measured. The flow meter incorporating the pressure transducer must be compatible with the sampler.

Closed conduits, however, present an additional problem (none of the proposed five sampling sites identified in this report are within enclosed drains). Many closed conduits surcharge during storm conditions, usually caused by the conduit being undersized for its tributary watershed. The frequency of surcharging is dependent on the degree to which the storm drain is undersized. When surcharge conditions are reached, the drain now functions under pressure flow. The flow measurement devices discussed above are only operable under open channel flow conditions. The measurement of flow under pressure would require the use of velocity meters. These are very costly devices that would need to be located directly in the flow stream. Therefore, efforts were made to select storm drains that do not surcharge, or do so infrequently to an extent that flow measurements are not significantly compromised.

C. RAIN GAGE

For every monitoring station, a minimum of one automatic (intensity measuring) rain gage will be placed within the upper tributary watershed. Los Angeles County Department of Public Works operates various automatic rain gages throughout the County. Existing gages in close proximity to the proposed monitored watersheds will be utilized in calculating stormwater runoff and shall be essential to developing runoff characteristics of these watersheds.

Large watersheds such as those identified in this Report will require multiple rain gages to accurately characterize the rainfall. The number and location of these additional rain gages is currently being researched.

D. EQUIPMENT INSTALLATION

The approach taken for the installation of sampling equipment is important to those who will maintain it. Access, ease of operation, safety, protection from the elements, etc., are typical design considerations. Each station's design must take into account at least these basic elements.

Figures III-2, III-3, and III-4 show typical installations of sampling equipment in storm drains utilized in the Monitoring Program.

Selected site conditions will dictate the approach taken with regards to installation of the monitoring equipment.

The automated sampler intake hose and the flow meter pressure transducer cable must be protected from trash and debris, vandalism, and the physical forces of the flow velocity during storm events. It must also be installed to allow routine inspection and maintenance. Therefore, the intake hose and pressure transducer cable will be placed in separate conduits below the invert surface, a few inches below the channel's finished surface.

The strainer and pressure transducer will likewise be located within a protective enclosure to shield them from trash and debris and to minimize vandalism.

As stated before an auxiliary peristaltic pump will be needed at many sites due to the hydraulic lift requirements. This will complicate installation, maintenance and operations. The auxiliary pump will be placed above the low-flow, dry weather level to ensure that it will not be continuously submerged. A seperate conduit will be utilized to run power to the auxiliary pump.

Figure III-1

Refrigerated Water Sampler

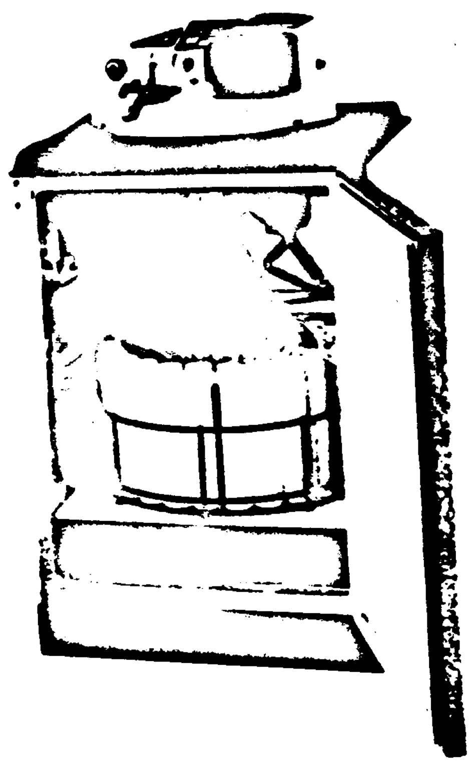
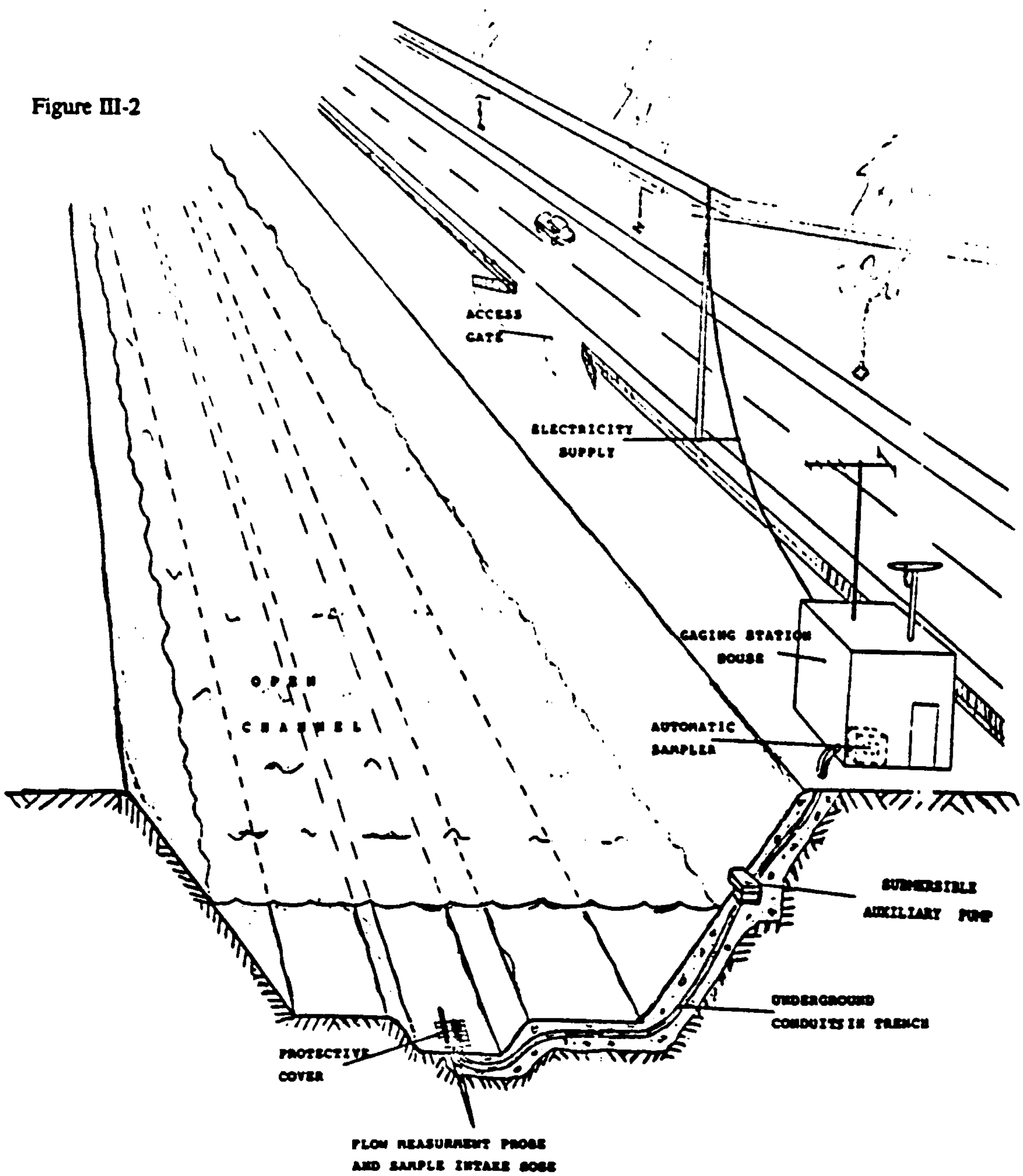


Figure III-2



MODIFIED BY: TJS	LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DATE 04/15/94	CONCEPTUAL DRAWING FOR AUTOMATED SAMPLING SYSTEM INSTALLATION IN AN OPEN CHANNEL
NOT TO SCALE	

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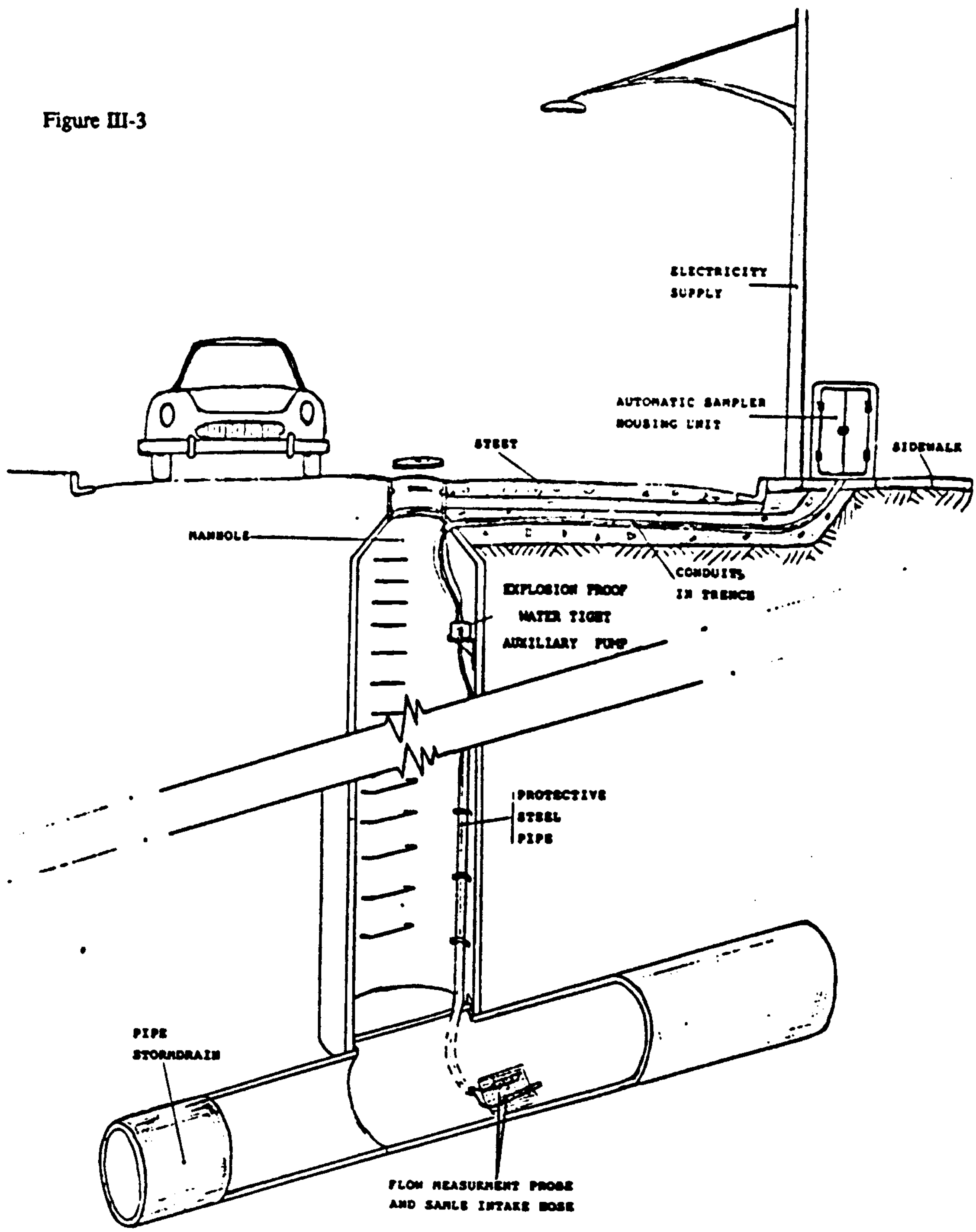
Figure III-3



MODIFIED BY: TJS	LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DATE 04/15/94	CONCEPTUAL DRAWING FOR AUTOMATED SAMPLING SYSTEM INSTALLATION IN A PIPE STORM DRAIN
NOT TO SCALE	

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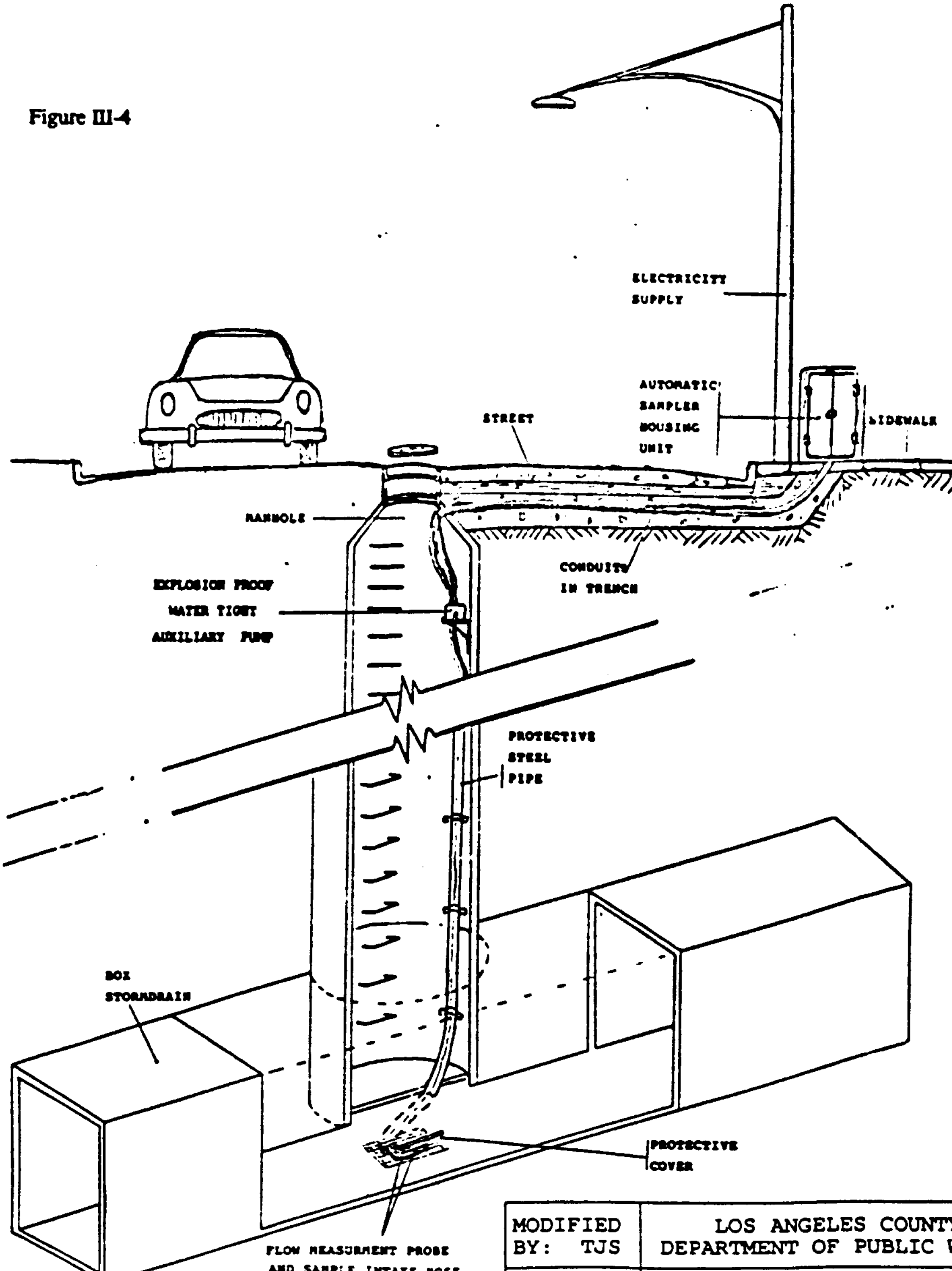
Figure III-4



MODIFIED BY: TJS	LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DATE 04/15/94	CONCEPTUAL DRAWING FOR AUTOMATED SAMPLING SYSTEM INSTALLATION IN A BOX STORM DRAIN
NOT TO SCALE	

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IV. MONITORING EQUIPMENT PROGRAMMING

A. Storm Weather Sampling

The automated sampler will need to be properly programmed in order to collect a representative flow-composite sample.

To program the sampler, the following information is needed: target storm size, flow rate to trigger sampling, estimate of runoff volumes, total sample volume required, number of sample intervals desired, sample volume to be collected at each interval, and flow rate to end sampling.

B. Storm Size to be Sampled

The "Surface Drainage Water Quality Monitoring Program" report, prepared by Woodward-Clyde Consultants for the Santa Monica Bay Restoration Project, analyzed local rainfall data to determine the appropriate storm size to be targeted for monitoring. Based on their analysis, targeted storm events should be between 6 and 25 hours in duration and average rainfall of about 0.4 to 1.7 inches.

C. Minimum Sample Volume to be Collected

The minimum volume of stormwater needed to perform the necessary analyses is shown below, (for composite flow-weighted samples only):

Constituent	Quantity
Semivolatile Organic Compounds	1 L
Pesticides and PCBs	1 L
Herbicides	1 L
Soluble Metals	500 ml
Other Constituents	4,325 ml
	7,825 ml = 8 Liters or approx. 2 Gallons

The refrigerated automated sampler has a total capacity of 10 gallons. Subtracting the two gallons required for analysis, the sampler will have an eight gallon reserve capacity. Therefore, the sampler will be programmed to collect two gallons of stormwater from a 0.4" storm. With the eight gallon excess capacity, the sampler would theoretically have adequate capacity to handle storms up to two inches in size (0.4" x 5 = 2.0"). This will significantly reduce the need to change bottles during a storm event.

D. <u>Estimate of Runoff Volume</u>

To program the sampler, the estimated runoff volume from a minimum precipitation of a 0.4-inch storm event over the entire area of a watershed must be calculated. The procedure used to estimate the runoff volume of the above storm is taken from the Los Angeles County Department of Public Works Hydrology Manual, which is generally accepted by agencies within Los Angeles County for the performance of hydrology studies.

The procedure to be used is briefly described below.

a) Calculate the Overall Runoff Coefficient for the Watershed:

$$C_D = 0.9\ IMP + Cu\ (1 - IMP)$$

where:

IMP = Proportion impervious for the land use comprising the watershed.

C_u = Undeveloped area runoff coefficient (based on soil type and rainfall intensity).

C_D = Developed area runoff coefficient.

For watersheds with multiple land use types, the overall C_D for the watershed is the weighted average of the C_D for each land use type:

$$C_D = \frac{\Sigma_{1-n}\ C_{Dx}\ A_x}{\Sigma_{1-n}\ A_x}$$

b) Calculate the rainfall volume for the watershed:

The rainfall volume is calculated by multiplying the storm size, in inches, by the area of the watershed.

c) Calculate the runoff volume for the watershed:

The resultant runoff volume is determined from the following formula:

$$\textit{Runoff Volume} = \textit{Rainfall Volume} \times (C_D)$$

(A detailed example of the above procedure can be found in Appendix 1).

E. Determination of Sampling Parameters

As discussed previously, eight liters of stormwater runoff will need to be collected by composite sampling. A minimum of 20 aliquots will be collected from each storm to obtain the eight liter composite sample. Therefore, the volume of sample to be collected at each aliquot is:

$$\textit{8 liters/20 aliquots} = \textit{400 ml}$$

The 20 aliquots will be spaced at equal runoff volume intervals throughout the storm. Therefore, the size of the runoff volume interval (Δ runoff volume) for a specific watershed would be determined as follows:

$$\Delta \textit{ runoff volume} = \textit{total runoff volume} / 20$$

where:

total runoff volume = total estimated runoff volume for targeted storm.

The flow rate at which storm sampling would be initiated at each station would be dependent on whether the site has any consistent dry weather or base flow.

For stations that do not have any dry weather flow, sampling would be initiated upon detection of flow. For those having dry weather flow, sample collection would begin after detecting a flow rate above the maximum-observed, yearly dry weather flow level. Sampling would halt when the flow returns to 120 percent of pre-storm base flow. As the monitoring program progresses, more specific operational criteria for the samplers at each station can be developed based on site specific flow information.

F. Dry Weather Sampling

Dry weather flow samples will be collected at all sites exhibiting adequate dry weather flow. For those sites with continuous dry weather flow, a 24-hour composite sample will be collected. For those with intermittent flow, a sample will be collected as flow is available.

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V. MONITORING CONSTITUENTS

A. List of Constituents

The selection of the monitoring constituents was based on an evaluation of the EPA final stormwater regulations and the existing monitoring program of the LACDPW. Initially, the constituents monitored during dry weather and under storm conditions will be the same. As water quality data is gathered over time and analyzed, revisions to the list of constituents monitored for both dry weather and under storm conditions may be made as deemed appropriate.

B. Constituents and Sample Collection Methods

The sample collection methods proposed for use are a combination of grab sampling and composite sampling. The details of each method will be elaborated in Part VI: Sampling Procedures. The definitions of sample types are:

- **Grab Sample** - a discrete, individual sample taken within a short period of time, usually less than 15 minutes.
- **Composite Sample** - a mixed or combined sample formed by combining a series of individual and discrete samples (aliquots) of specific volume, collected at specific volume intervals.

The time required to complete the cycle of compositing a sample covers a wide range, from a few hours to over to over 24 hours.

However, certain constituents have very short holding times and specific collection or preservation needs. The existence of and concentration of these constituents cannot be tested by composite samples and must be analyzed from grab samples.

All constituents listed in Table V-1 will be tested by composite sampling. Those listed in Table V-2 must be collected manually by grab samples.

Grab samples are preferred for certain water quality tests because field measurements such as pH and temperature should be instantaneous measurements of stormwater; bacteria have a short holding time; oil and grease tends to adhere on the surfaces that it contacts; volatile organic compounds (VOCs) have a tendency to volatilize when in contact with air; and cyanide is very reactive and unstable.

C. Chemical Analysis Methods

The chemical analysis methods for each constituent is listed in Tables V-1 and V-2. Also listed are the associated detection limits, sample volumes, preservation needs, and holding times required of each analysis method.

Weather forecasting and estimation of storm size is an inexact science. Therefore, rainstorms may occur where the total sample volume collected via composite sampling is insufficient to perform all the desired analyses.

Table V-3 presents a prioritized list of the water quality tests to be performed on the composite sample. For those storms where an insufficient total sample volume has been collected, the tests to be performed will be in accordance with the priority listed on Table V-3.

TABLE V - 1

CONSTITUENTS TO BE TESTED (FLOW COMPOSITE SAMPLES)

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT	SAMPLE VOLUME	HOLDING TIME	PRESERVATIVE
<u>Semivolatile Organic Compounds</u>		(ug/l)			
Acids	8250				
Benzoic Acid	8250	≤5			
Benzyl Alcohol	8250	≤5			
2-Chlorophenol	8250	≤2			
2, 4-Dichlorophenol	8250	≤2			
2, 6-Dichlorophenol	8250	≤2			
2, 4-Dimetylphenol	8250	≤2			
4, 6-Dinitro-2-metylphenol	8250	≤3			
2,4-Dinitrophenol	8250	≤3			
2-Methylphenol	8250	≤3			
4-Methylphenol	8250	≤3			
2-Nitrophenol	8250	≤3			
4-Nitrophenol	8250	≤3			
4-Chloro-3-methylphenol	8250	≤3			
Pentachlorophenol	8250	≤2			
Phenol	8250	≤1			
2,3,4,6-Tetrachlorophenol	8250	≤1	1 LITER Total For All Constituents For EPA Method 8250	Samples must be extracted within 7 days and extract must be completely analyzed within 40 days. See footnote 2 Page 33	Cool 4° C 80 mg of NA2S2031 See footnote 8 Page 33
2,4,5-Trichlorophenol	8250	≤1			
2,4,6-Trichlorophenol	8250	≤1			
	8250				
Base/Neutral	8250				
Acenapthene	8250	<0.5			
Acenapthylene	8250	≤0.5			
Acetophenone	8250	≤3			
Aniline	8250	≤3			
Anthracene	8250	≤0.5			
4-Aminobiphenyl	8250	≤3			
Benzidine	8250	≤3			
Benzo(a)anthracene	8250	≤1			
4-Chloroaniline	8250	≤1			
1-Chloronapthalene	8250	≤1			
p-Dimethylaminoazobenzene	8250	≤3			
7,12-Dimethylbenz(a)-anthracene	8250	≤1			
a-,a-Dimethylphenethylamine	8250	≤3			
Benzo(a)pyrene	8250	≤1			
Benzo(b)flouranthene	8250	≤1			
Benzo(k)flouranthene	8250	≤1			
Chlordane	8250	≤1			
Bis(2-chloroethoxy)methane	8250	≤1			
Bis(2-chlorisopropyl)ether	8250	≤1			
Bis(2-chloroethyl)ether	8250	≤1			
Bis(2-ethylhexyl)phtalate	8250	≤3			

TABLE V - 1

CONSTITUENTS TO BE TESTED (FLOW COMPOSITE SAMPLES)

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT (ug/l)	SAMPLE VOLUME	HOLDING TIME	PRESERVATIVE
Base/Neutral (continued)	8250		1 LITER Total For All Constituents For EPA Method 8250	Samples must be extracted within 7 days and extract must be completely analyzed within 40 days. See footnote 2 Page 33	Cool 4° C 80 mg $Na_2S_2O_3$ See footnote 8 Page 33
4-Bromophenyl phenyl ether------	8250	------ <1			
Butyl benzyl phthalate	8250	<3			
2-Chloronapthalene	8250	<1			
4-Chlorophenyl phenyl ether	8250	<1			
Chrysene--------------------	8250	------ <1			
Dibenz(a,j)acridine	8250	<3			
Dibenz(a,h)anthracene	8250	<1			
1, 3-Dichlorobenzene	8250	<0.5			
1, 4-Dichlorobenzene	8250	<0.5			
1, 2-Dichlorobenzene----------	8250	------ <0.5			
3, 3-Dichlorobenzidine	8250	<3			
Diethylphthalate	8250	<0.5			
Dimethylphthalate	8250	<0.5			
Di-n-butylphthalate	8250	<3			
2,4-Dinitrotoluene------------	8250	------ <0.5			
2, 6-Dinitrotoluene	8250	<0.5			
Diphenylamine	8250	<3			
1, 2-Diphenylhydrazine	8250	<3			
Di-n-octylphtalate	8250	<3			
Ethyl methanesulfonate----------	8250	------ <3			
Fluoranthene	8250	<1			
Fluorene	8250	<1			
Hexachlorobenzene	8250	<0.5			
Hexachlorobutadiene	8250	<1			
Hexachlorocyclopentadiene-------	8250	------ <3			
Hexachloroethane	8250	<1			
Indeno(1, 2, 3-cd)pyrene	8250	<1			
Isophorone	8250	<0.5			
3-Methylcholanthrene	8250	<3			
Methyl methanesulfonate----------	8250	------ <3			
Napthalene	8250	<0.5			
1-Napthylamine	8250	<3			
2-Napthylamine	8250	<3			
2-Nitroaniline	8250	<3			
3-Nitroaniline--------------	8250	------ <3			
4-Nitroaniline	8250	<3			
Nitrobenzene	8250	<0.5			
N-Nitroso-di-n-butylamine	8250	<3			
N-Nitrosodimethylamine	8250	<3			
N-Nitrosodiphenylamine--------	8250	------ <3			
N-Nitroso-di-N-propylamine	8250	<1			
N-Nitrosopiperidine	8250	<3			
Pentachlorobenzene	8250	<3			
Phenacitin	8250	<3			
Phenanthrene---------------	8250	------ <0.5			

TABLE V-1

CONSTITUENTS TO BE TESTED (FLOW COMPOSITE SAMPLES)

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT (ug/l)	SAMPLE VOLUME	HOLDING TIME	PRESERVATIVE
Base/Neutral (continued)	8250		1 LITER Total For All Constituents For EPA Method 8250		Cool 4° C 80 mg NA2S2O3
2-Picoline	8250	<3			
Pronamide	8250	<5			
Pyrene	8250	<0.5			
1,2,4,5-Tetrachlorobenzene	8250	<3			
1,2,4,-Trichlorobenzene	8250	<0.5			
Pesticides	8250		1 LITER Total For All Constituents For EPA Method 8250	Samples must be extracted within 7 days and extract must be completely analyzed within 40 days. See footnote 2 Page 33	Cool 4° C 80 mg Na2S2O3
Aldrin	8250	<2			
alpha-BHC	8250	<1			
beta-BHC	8250	<3			
delta-BHC	8250	<4			
gamma-BHC (Lindane)	8250	<1			
Chlordane	8250	<2			
4,4'-DDD	8250	<1			
4,4'-DDE	8250	<1			
4,4'-DDT	8250	<1			
Dieldrin	8250	<0.5			
Endosulfan I	8250	<1			
Endosulfan II	8250	<1			
Endosulfan sulfate	8250	<1			
Endrin	8250	<1			
Endrin aldehyde	8250	<1			
Endrin ketone	8250	<1			
Heptachlor	8250	<0.5			
Heptachlor epoxide	8250	<0.5			
Methoxychlor	8250	<2			
Toxaphene	8250	<1			
Polychlorinated Biphenyls	8250				Cool 4° C Adjust pH 5-9 80 mg Na2S2O3
Aroclor-1016	8250	<1			
Aroclor-1221	8250	<1			
Aroclor-1232	8250	<1			
Aroclor-1242	8250	<1			
Aroclor-1248	8250	<1			
Aroclor-1254	8250	<1			
Aroclor-1260	8250	<1			

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TABLE V-1

CONSTITUENTS TO BE TESTED (FLOW COMPOSITE SAMPLES)

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT (ug/l)	SAMPLE VOLUME	HOLDING TIME	PRESERVATIVE
Pesticides	608		1 LITER Total For All Constituents For EPA Method 608	Samples must be extracted within 7 days and extract must be completely analyzed within 40 days. See footnote 2 Page 33	Cool 4° C Adjust Ph 5-9 80 mg NA2S203 See footnote 8 Page 33
Aldrin	608	0.05			
alpha-BHC	608	0.05			
beta-BHC	608	0.05			
delta-BHC	608	0.05			
gamma-BHC (Lindane)	608	0.05			
Chlordane	608	0.05			
4,4'-DDD	608	<0.1			
4,4'-DDE	608	<0.1			
4,4'-DDT	608	<0.1			
Dieldrin	608	<0.1			
Endosulfan I	608	<0.1			
Endosulfan II	608	<0.1			
Endosulfan sulfate	608	<0.1			
Endrin	608	<0.1			
Endrin aldehyde	608	<0.1			
Heptachlor	608	0.05			
Heptachlor epoxide	608	0.05			
Methoxychlor	608	<0.5			
Toxaphene	608	<1.0			
Polychlorinated Biphenyls	608				
Aroclor-1016	608	<1			
Aroclor-1221	608	<1			
Aroclor-1232	608	<1			
Aroclor-1242	608	<1			
Aroclor-1248	608	<1			
Aroclor-1254	608	<1			
Aroclor-1260	608	<1			
Herbicides tested at spreading grounds			1 LITER Total For EPA Method 619		Cool 4°C
Prometryn	619	≤2 mg/l			
Altrazine	619				
Simazine	619				
Cyanazine	619				

TABLE V - 1

CONSTITUENTS TO BE TESTED (FLOW COMPOSITE SAMPLES)

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT	SAMPLE VOLUME	HOLDING TIME	PRESERVATIVE
Metals (Total and Soluble)					
Antimony	204.2	10ppb			
Arsenic	206.2	10ppb			
Barium	208.2	100ppb			
Beryllium	210.2	5ppb			
Boron	212.3	250ppb			
Cadmium	213.2	10ppb			
Calcium	215.2	200ppb			
Chromium	218.2	10ppb			
Copper	219.2	10ppb			
Iron	236.2	100ppb	500 mls	6 months	HNO3 to pH <2
Lead	239.2	10ppb			
Magnesium	242.1	200ppb			
Manganese	243.2	30ppb			
Mercury	245.1	1ppb			
Nickel	249.2	10ppb			
Potassium	258.1	1ppm			
Selenium	270.2	5ppb			
Silver	272.2	10ppb			
Sodium	273.1	5ppb			
Thallium	279.2	10ppb			
Zinc	289.2	30ppb			
Others					
Dissolved Phosphorus	300	0.05ppm	50mls	24 hrs	Filter on site, Cool 4°C, H2SO4 to pH <2
Total Phosphorus	300	0.05ppm	50mls	28 days	Cool 4°C, H2SO4 to pH <2
Turbidity	180.1	0.1NTU	100mls	48 hrs	Cool 4°C
Total Suspended Solids	160.2	2ppm	100mls	7 days	Cool 4°C
Total Dissolved Solids	160.1	2ppm	100mls	7 days	Cool 4°C
Volatile Suspended Solids	160.4	2ppm	100mls	7 days	Cool 4°C
Total Organic Carbon	415.1	1ppm	25mls	28 days	Cool 4°C, H2SO4 to pH <2
Total Petroleum Hydrocarbon	418.1	1ppm	1L	28 days	5ml of 50% HCL
Biochemical Oxygen Demand	405.1	2ppm	1L	48 hrs	Cool 4°C
Chemical Oxygen Demand	410.4	20-900ppm	500mls	28 days	Cool 4°C, H2SO4 to pH <2
Total Ammonia Nitrogen	350.2	0.1ppm	500mls	28 days	Cool 4°C, H2SO4 to pH <2
Total Kjeldahl Nitrogen	351.2	0.1ppm	100mls	28 days	Cool 4°C, H2SO4 to pH <2
Nitrate-Nitrate	"4110"	0.1ppm	100mls	14 days	Cool 4°C
Alkalinity	310.1	2ppm	100mls	28 days	Cool 4°C
Specific Conductance	120.1	1umho/cm	100mls	6 months	H2SO4 to pH <2
Total Hardness	130.2	2ppm			
Chloride	"4110"	2ppm	2ppm	28 days	None
Fluoride	"4110"	0.1ppm	0.1ppm	28 days	None
Sulfate	"4110"	2ppm	2ppm	28 days	Cool 4°C
					See footnote 8 Page 33

"Standard Methods for the Examination of Water and Wastewater, 1989, 17th Edition, published jointly by APHA, AWWA, and WPCF."

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TABLE V - 2

CONSTITUENTS TO BE TESTED (GRAB SAMPLES)

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT (ug/l)	SAMPLE VOLUME	HOLDING TIME	PRESERVATIVE
Volatile Organic Compounds	8240A		40 ml Total For All Constituents For Method 8240A	14 days	Cool 4°C 10 mg of Na_2SO_3
Acetonitrile	8240A	10.0			
Acrolein	8240A	100			
Acrylonitrile	8240A	0.5			
Benzene	8240A	0.5			
Bromoform	8240A	0.5			
2-Butanone	8240A	10.0			
Carbon Disulfide	8240A	10.0			
Carbon Tetrachloride	8240A	0.5			
Chlorobenzene	8240A	0.5			
Chlorodibromomethane	8240A	0.5			
Chloroethane	8240A	0.5			
2-Chloroethyl vinyl ether	8240A	1.0			
Chloroform	8240A	0.5			
Dibromomethane	8240A	0.5			
1,4-Dichloro-2-butene	8240A	10.0			
Dichlorobromomethane	8240A	0.5			
Dichlorodifluoromethane	8240A	0.5			
1,1-Dichloroethane	8240A	0.5			
1,2-Dichloroethane	8240A	0.5			
1,1-Dichloroethene	8240A	0.5			
trans-1,2-Dichloroethene	8240A	0.5			
1,2-Dichloropropane	8240A	0.5			
cis-1,3-Dichloropropene	8240A	0.5			
trans-1,3-Dichloropropene	8240A	0.5			
Ethanol	8240A	10.0			
Ethylbenzene	8240A	1.0			
Ethylene Oxide	8240A	100			
Ethyl Metacrylate	8240A	0.5			
2-Hexanone	8240A	5.0			
Iodomethane	8240A	0.5			
Methyl Bromide	8240A	5.0			
Methyl Chloride	8240A	5.0			
Methylene chloride	8240A	1.0			
4-Methyl-2-pentanone	8240A	5.0			
Styrene	8240A	0.5			
1,1,2,2-Tetrachloroethane	8240A	0.5			
Tetrachloroethane	8240A	0.5			
Toluene	8240A	1.0			
Trichlorofluoromethane	8240A	1.0			
1,2,3-Trichloropropane	8240A	0.5			
1,1,1-Trichloroethane	8240A	1.0			
1,1,2-Trichloroethane	8240A	1.0			
Trichloroethene	8240A	0.5			
Vinyl acetate	8240A	5.0			
Vinyl chloride	8240A	0.5			
Xylene (Total)	8240A	0.5			

TABLE V - 2

CONSTITUENTS TO BE TESTED (GRAB SAMPLES)

LIST OF CONSTITUENTS	EPA METHOD	DETECTION LIMIT	SAMPLE VOLUME	HOLDING TIME	PRESERVATIVE
Bacteria					
1. Total Coliform	*9221B*	<20mpn/100ml	100 mls	6 hours	4°C, .008% Na2SO3
2. Fecal Coliform	*9221B*	<20mpn/100ml	100 mls	6 hours	4°C, .008% Na2SO3
3. Fecal Streptococcus	*9221B*	<20mpn/100ml	100 mls	6 hours	4°C, .008% Na2SO3
Oil and Grease	413.2	1 ppm	1L/1000mls	28 days	4°C, H2SO4 to pH <2
Total Phenols	420.1	0.1 ppm	500 mls	28 days	4°C, H2SO4 to pH <2
Cyanide	335.2	0.01 ppm	500 mls	14 days	Cool 4°C, NaOH to pH <2 0.6g ascorbic acid
pH	150.1	0 - 14	25 mls	immediately	none
Temperature	----------	----------	----------	immediately	none

* Standard Methods for the Examination of Water and Wastewater, 1989, 17th Edition, published jointly by APHA, AWWA, and WPCF.

FOOTNOTES (Tables V-1 and V-2)

1. Should be added to empty sample container to be used for collection of sample if residual chlorine is present in the sample.

2. Samples must be extracted within seven days and extract must be completely analyzed within 40 days.

3. Use NaOH or H_2SO_4, as needed, to adjust the pH. Volume of acid of base must be noted.

4. If Aldrin is one of the pesticides to be tested and the sample is known to have residual chlorine present, then this preservative should in the empty sample container to be used for the collection of the sample.

5. Maximum holding time is 24 hours when sulfide is present. Optionally, sample may be tested with lead acetate paper before pH adjustment, to determine if sulfide is present. If sulfide is present, it can be removed with the addition of Cadmium nitrate powder until a negative spot is obtained. The sample then should be filtered and NaOH added to adjust the pH to > 12.

6. Should only be used in the presence of residual chlorine.

7. This is an arbitrary selected holding time. None is given in EPA method 418.1 - the approved method to use for TPH testing.

8. According to 40 CFR 136.3 Table II Notes, Note (2): "For composite chemical samples, each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed."

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TABLE V-3

MONITORING PROGRAM TEST PRIORITY

Order of Preference for Stormwater Testing

Constituent	EPA Method	Sample Quantity (ml)
1. Heavy Metals (dissolved and Total)	200 Series	500
2. Total Petroleum Hydrocarbons (TPH)	418.1	1000
3. Semivolatile Organic Compounds	8250	1000
4. Pesticides (PCBs)	8250 or 608	1000
5. Total Suspended Solids (TSS)	160.1	100
6. Volatile Suspended Solids (VSS)	160.1	100
7. Total Organic Carbon (TOC)	415.1	25
8. Chemical Oxygen Demand (COD)	410.4	500
9. Specific Conductance	120.1	100
10. Total Dissolved Solids (TDS)	160.1	100
11. Turbidity	180.1	100
12. Biochemical Oxygen Demand (BOD)	405.1	1000
13. Dissolved Phosphorus	300	50
14. Total Phosphorus	300	50
15. Total Ammonia Nitrogen	350.2	500
16. Total Kjeldahl Nitrogen	351.3	100
17. Nitrate - Nitrite	4110*	100
18. Alkalinity	310.1	100
19. Chloride	4110*	50
20. Fluoride	4110*	300
21. Sulfate	4110*	50
22. Herbicides at Spreading Grounds	619	1000
	Total	7825 ml**

* Standard Methods for the Examination of Water and Wastewater, 1989, 17th Edition, published jointly by APHA, AWWA, and WPCF.

** Volatile Organic Compounds, Bacteria, Oil & Grease, Total Phenols, Cyanide, pH, and Temperature will be tested from grab samples to a total quantity of 2,365 ml.

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VI. SAMPLING PROCEDURES

This Stormwater/Urban Runoff Monitoring Program is divided into two sub-programs, namely: the dry weather flow monitoring sub-program, and the storm weather flow monitoring sub-program. For each of these sub-programs, two types of samples will be collected at each monitoring location: Grab samples and composite samples. The constituents to be analyzed for either a grab or composite sample are discussed in Section V, and the automated sampling equipment to be used is described in Section III.

A. Storm Sampling

1. Pre-storm Preparation

In preparing and mobilizing personnel and equipment for a given sampling event, LACDPW will utilize the weather forecasts from the National Weather Service and from Pacific Weather Analysis, along with other Department resources such as the LACDPW Alert System. The Alert System is a system of rain and stream flow gages within the LACDPW flood control system which predicts/measures runoff amounts at key locations and transmits the data via telemetry to LACDPW headquarters. Important deciding factors in mobilizing for a storm sampling event include the probability of rainfall, its expected amount, and its intensity. When a representative storm is expected, sampling personnel will prepare for collection of grab samples and verify that the automated samplers are activated for composite flow sampling.

2. Grab Samples

All attempts will be made to collect grab samples during the beginning of the storm on the rising limb of the hydrograph. Such timing is expected to provide concentrations reflecting the higher levels of contaminants which are expected to be observed in the first part of a storm event as compared to those observed during the remainder of the event.

Grab samples will normally be collected using manual sampling equipment such as bucket with rope, dipper, funnel, etc. For manual grab sampling, please refer to Appendix 2 - "Surface Water Sampling Instruction Manual". Grab sample bottles, however, would have to be filled using manual operation of the automated samplers if sample points are inaccessible, such as the closed conduit sampling stations.

3. Flow-Composite Samples

Flow-composite storm samples will be obtained using an automated sampler to collect samples at flow paced intervals. Samples collected at each station will be combined in the laboratory to create a single flow-weighted sample from each station for analysis.

During a storm event, the sampler is programmed to activate automatically when the water level in the channel or storm drain exceeds the maximum annual dry weather flow rate. A sample will be collected each time a set volume of water has passed the monitoring point. The sample will be distributed into glass containers within the refrigerated sampler. The containers will need to accumulate a minimum of eight liters of runoff during each storm, so as to ensure a sufficient sample volume available to perform the necessary laboratory analyses. The automated sampler will deactivate when the water level in the channel or storm drain falls to about 120 percent of the observed maximum annual dry weather flow rate. For detailed discussion on the automated sampler programming, please see Section IV.

Upon conclusion of the storm event, samples will be retrieved from the automated samplers. Samples will be retrieved within the maximum allowable holding times required of the various test methods. At the same time samples are collected, rainfall and runoff data will be logged and stored for transfer to the office.

B. <u>Dry Weather Sampling</u>

The frequency of dry weather sampling is once every other month. This frequency was established based on the assumption that the majority of the flow during dry weather is from discharges that are presently covered by permits issued by the RWQCB. The deviation in test results from time to time would therefore be expected to be minor.

As water quality data is gathered under this program, it may be necessary to increase the frequency of monitoring of some constituents, and likewise may be necessary to decrease or eliminate the monitoring frequency of other constituents, shown not to be of a concern.

1. **Grab Samples**

Grab samples will normally be collected using manual sampling equipment such as bucket with rope, dipper, funnel, etc. For manual grab sampling, please refer to Appendix 2 - "Surface Water Sampling Instruction Manual". Grab sample bottles, however, would have to be filled using automated samplers if sample points are inaccessible, such as closed conduit sampling stations. Specific grab samples will be collected each time composite samples are retrieved.

2. **Flow-Composite Samples**

During dry weather, an eight liter composite sample will be collected over a 24-hour period.

Samples will be retrieved and delivered to the laboratory within the maximum allowable holding times of all the various test methods.

C. <u>Sample Transfer and Chain of Custody</u>

The LACDPW contracts for laboratory services with the Los Angeles County Agricultural Commission Laboratory, located at 11012B Garfield Avenue, South Gate, CA 90280.

LACDPW maintains a sampling protocol involving appropriate procedures for manually collecting surface water samples and transferring custody of samples. This sampling protocol is detailed in the attached Surface Water Sampling Instruction Manual (Appendix 2). In addition LACDPW maintains frequent contact with our contract laboratory as to the proper containers and handling of samples in order to effect appropriate analyses of the constituents of interest. A chain of custody record will be completed for each sample collected to allow step-by-step accounting of the sampling path from origin to analysis. Important information on the custody form includes:

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- Name of Person(s) collecting the sample
- Sample Laboratory ID numbers
- Date and Time of Sample Collections
- Names and signatures of all persons handling the samples in the field and in the laboratory.

D. Personnel Training

LACDPW's Surface Water Sampling Instruction Manual (Appendix 2) deals with procedures and equipment used in surface water sampling for both manual and automated sampling, grab samples and composite samples, chain-of-custody, and safety of the field personnel. A copy of this manual is issued to all field personnel.

Prior to sampling, all water quality field personnel are provided training that includes familiarization with all the sampling areas, procedures for proper labeling, handling and storage of sample bottles, getting samples from each monitoring site to the laboratory, handling chain-of-custody, performing manual sampling, and operating automatic sampling equipment.

E. Health and Safety

General health and safety issues and concerns when performing water quality monitoring is also addressed in the LACDPW Health & Safety Program for all its employees. The program requires each employee to complete a safety matrix, which details hazards, that could be encountered in performing his/her duties. Safety Directives covering instructions on how to deal with said hazards are issued each employee. Example of hazards on a field sampler's safety matrix include: hazardous weather conditions, working in confined spaces, hazards associated with chemicals, snakes, poison ivy, traffic, falling, drowning, etc.

It is also LACDPW policy to require field sampling personnel to undergo a minimum of 40 hours of Hazardous Materials Awareness training, and subsequent required review courses. This training includes instructions on how to evaluate potentially hazardous situations and safety concerns.

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VII. FIELD QUALITY ASSURANCE/QUALITY CONTROL PLAN

A. Overview

Properly performed monitoring station set up, water sample collection, transport, and laboratory analysis are vital to the collection of accurate data. Quality Assurance / Quality Control is an essential component of the Monitoring Program.

It is important to note that this Quality Assurance/Quality Control Plan is for the fixed sites described in the Monitoring Plan, Section II, and not for the planned Illegal/Illicit Discharge Investigation Program which will have its own QA/QC plan.

This QA/QC Plan describes the procedures for bottle labeling, chain-of-custody tracking, field setup, the sampler equipment check and setup, sample collection, the use of field blanks to assess field contamination, the use of field duplicate samples, and transportation to the lab. The QA/QC Plan shall be in place and enforced at all times.

An important part of this QA/QC Plan is the continued learning process of all field personnel. Field personnel must be adequately trained from the onset and must continue to have new information about stormwater sampling techniques shared with them. During the early stages of implementation, field personnel will evaluate the field activities and the possible effects on the QA/QC Plan. Enhancement of the Plan, if needed, will be implemented and an updated QA/QC Plan submitted to the Regional Water Quality Control Board for their use.

B. Bottle Preparation

Bottles will be grouped in sets. For each monitoring station, a minimum of three sets will exist in order to guarantee a consistent rotation of bottles. All bottle labels will be generic in appearance and will look similar to the following example:

BOTTLE NUMBER: ____ of ____	DATE:
STATION NAME:	TIME:
☐ GRAB OTHER: ☐ COMPOSITE ____________	PRESERVATIVES:
LABORATORY ANALYSIS REQUESTED:	TEMPERATURE:
	COLLECTED BY:

Figure VII-1

Bottles shall be cleaned at the laboratory. After the bottles are returned, they will be labeled and stored away as a set package. Each station will have the same number, size and types of bottles existing for each rotation, unless special grab samples are requested. Clean bottles utilized for composite sampling will be replaced in the sampler at the time of each bottle collection, assuring a pre-setup sampling routine. All bottles not in use will be stored in plastic ice chests used for transporting bottles. The size of composite sample bottles has been limited to a maximum of 2½ gallons each, to ensure ease of handling.

C. <u>Chain-of-Custody Procedure</u>

Chain-of-custody procedures and forms provide legal evidence that a sample has not been tampered with. This is achieved by establishing a written record tracing possession of the sample from collection through its final analysis. Primarily we are interested in field chain-of-custody procedures. The contract laboratory's own QA/QC includes chain-of-custody procedures which are in agreement with the field procedures. (See attached Laboratory QA/QC plan.) The chain-of-custody forms will remain at all times with the corresponding samples. Chain-of-custody forms shall be filled out and signed by field staff before actual physical possession of water samples are turned over either to other staff or to the laboratory. A sample chain-of-custody form is presented as Figure VII-2.

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COUNTY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
WASTE MANAGEMENT DIVISION
900 SOUTH FREMONT AVENUE, ALHAMBRA, CA 91803
PHONE NO. (818) 458-6972, FAX NO. (818) 458-3534

DATE ________ PAGE ____ OF ____

FIGURE VII – 2
CHAIN – OF – CUSTODY RECORD

PROJECT NAME ______________________
COMPANY NAME DEPARTMENT OF PUBLIC WORKS
REFERENCE WASTE MANEMENT DIVISION
ADDRESS 900 SOUTH FREMONT AVENUE
ALHAMBRA, CA 91803 – 1331
SAMPLERS (SIGNATURE)

SAMPLE I.D.	DATE	TIME	LOCATION	STA. NO	METHODS								NUMBER OF CONTAINERS	COMMENTS/ CONTAINER TYPE

1 RELINQUISHED BY	DATE	3 RELINQUISHED BY	DATE	5 RELINQUISHED BY	DATE
SIGNATURE		SIGNATURE		SIGNATURE	
PRINTED NAME	TIME	PRINTED NAME	TIME	PRINTED NAME	TIME
COMPANY		COMPANY		COMPANY	
2 RECEIVED BY	**DATE**	**4 RECEIVED BY**	**DATE**	**6 RECEIVED BY**	**DATE**
SIGNATURE		SIGNATURE		SIGNATURE	
PRINTED NAME	TIME	PRINTED NAME	TIME	PRINTED NAME	TIME
COMPANY		COMPANY		COMPANY	

TOTAL NUMBER OF CONTAINERS

SAMPLE CONDITIONS
RECEIVED ON ICE YES/NO
SEALED YES/NO

SPECIAL SHIPMENT/HANDLING OR STORAGE REQUIREMENTS:

D. Field Setup Procedures

All field sampling locations are fixed sites, with the sampler placed on public road rights of way or flood control rights of way. One field staff member can conduct the sampler setup, but two staff members are necessary for sample collection at each monitoring station. After each sample collection, field staff will prepare the sampler to collect samples either in storm mode or in dry weather mode. Staff members will also inspect visible hoses and cables to ensure proper working conditions in accordance with site design. Inspection of the strainer, pressure transducer and auxiliary pump can only occur during daylight hours in non-storm conditions.

During a storm event, grab samples will be collected during the initial portion of the storm (on the rising limb of the hydrograph) and subsequently taken directly to the lab. The automated sampler will be checked at the time grab samples are collected to ensure proper working conditions at the site (to see if flow composite samples are being collected). Dry weather collection techniques will be similar with a 24-hour composite sample and subsequent grab samples being collected.

After a sampling event, all bottles will be collected and samples packed with ice and foam insulation inside individually marked ice chest(s). Field personnel will transport these samples to the Department of Public Works headquarters. Chain-of-custody forms will be completed by field staff before relinquishing them to other staff personnel for transportation of the samples to the laboratory. Under no circumstance will samples be removed from the ice chest during transportation from the field to the laboratory. All samples transported to the laboratory will meet the holding time criteria described in Section V.

E. Travel Blanks and Field Duplicates

Potential field contamination will be assessed through analysis of travel blanks and duplicate composite samples. The use of field travel blanks for each monitoring station during every sampling event, represents an attempt to quantify post sampling contamination. The Monitoring Program will also include the use of field duplicates to assess the accuracy of lab results. The collection of a field duplicate will occur for each sampling event. The duplicate will be for one sampling station, unknown to the laboratory. At the present time, this methodology for assessing post sampling contamination and the accuracy of laboratory testing procedures will provide adequate data to measure the accuracy of the results provided to us from the laboratory.

LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

The Los Angeles County Department of Public Works has contracted with the Office of the County Agricultural Commissioner/Weights and Measures Environmental Toxicology Laboratory for all laboratory analysis. A part of this Quality Assurance/Quality Control Plan for the Monitoring Program includes the QA/QC for the Laboratory which is enclosed as two documents (see Appendices 3 and 4). The Laboratory QA/QC Plan is a part of the Monitoring Program.

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VIII. DATA STORAGE AND REPORTING

The following categories of data are being collected as part of the monitoring program:

- Rainfall
- Runoff
- Water Quality Test Data
- Quality Assurance/Quality Control Information

All of the data will be stored in electronic format to allow for ease of retrieval interpretation, and graphic presentation.

Rainfall and runoff data will be collected from each monitoring station after each storm event and stored in a central file. The data will be arranged by monitoring station to show the total rainfall amount and total runoff volume, plus a hydrograph for each sampled storm event.

Water quality data for each monitoring station will be stored in a PC database. QA/QC information will be stored in a PC database.

For each sampled storm event, a report will be prepared summarizing the rainfall, runoff, and water quality data. At the end of each storm season (July 1 to June 30), a yearly monitoring report will be prepared summarizing the data collected.

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IX. PROGRAM MANAGEMENT

Implementation and overall coordination of the Monitoring Program activities, including evaluation of the contract laboratory services will be the responsibility of the Program Manager. The Program Manager will assign field sampling personnel from a pool of technical staff (14 currently available) trained in sampling procedures and methods.

The Program Manager is responsible for evaluation of weather forecasts as provided by our storm forecasting service, and will decide on which storms warrant mobilization for the sampling activities. The Program Manager will assign one of the Field Engineers as an Event Coordinator, who will coordinate the sampling event with the designated field personnel.

For storm weather and dry weather sampling, the stations have been divided into two groups as shown below. The stations have been apportioned based on anticipated difficulty of sampling as well as travel to and from each station.

GROUP	MONITORING STATIONS
1	Los Angeles River @ Tujunga Avenue
	Los Angeles River @ Wardlow Road
2	San Gabriel River @ San Gabriel River Parkway
	Rio Hondo Channel @ Beverly Boulevard
	Coyote Creek @ Spring Street

Two individuals will be assigned to perform field sampling for each group. Each sampling crew will be responsible for all the sampling activities needed at each site within each group. Each staff member assigned to a Group of stations will be responsible for: Field equipment maintenance and operation; proper collection and handling of samples; and field QA/QC and field sampling protocol.

The Program Manager will be responsible for on-going review, and evaluation of the overall QA/QC program related to sampling and laboratory procedures.

X. ESTIMATION OF POLLUTANT LOADINGS

One of the objectives of the monitoring program is to assess the annual pollutant loadings from large watersheds within these Drainage Basins. Knowing the types and quantities of pollutants discharged from these watersheds are important in assessing the impacts of stormwater on receiving waters.

A. Model Selection

The model to be utilized to calculate basin-wide mass pollutant loadings is the Simple Method as described in the EPA's "Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems." Due to the size of these Drainage Basins, this method will provide a good estimate of pollutant loadings, without requiring the extensive amount of detailed hydrologic and hydraulic data needed by more sophisticated models. Once pollutant loads have been estimated basin wide, an initial assessment can be made as to their potential impacts on receiving waters. Subsequently, more detailed, dynamic modelling of select, representative watersheds in these Drainage Basins can be performed to more accurately track and assess pollutant impacts.

B. Calculation Procedure

Calculation of annual pollutant loadings will be performed as follows:

1. **Calculate annual pollutant loads for each drainage area.**

Utilizing the formula below, calculate annual pollutant loads for each drainage area:

Equation 1:

$$L_i = \frac{(P)\ (CF)\ (Rv_i)}{12}\ (C_i)\ (A_i)\ (2.72)$$

where:

L_i = Annual pollutant load (lb/drainage area/yr)
P = Annual precipitation (in/yr)
CF = Correction factor that adjusts for storms where no runoff occurs
Rv_i = Weighted-average runoff coefficient for the drainage area
C_i = Event mean concentration of pollutant (mg/L)
A_i = Drainage area (acres)

The numbers 12 and 2.72 are conversion factors that account for unit conversions.

Each of the parameters in Equation 1 is defined below:

- **Annual pollutant load** is the total amount of a specific pollutant discharged in pounds per time period (in this case, per year) for the particular drainage area being modeled.
- **Annual precipitation** is the total inches of rainfall occurring in a single year. Estimates of the annual rainfall are calculated utilizing the historical rainfall data

compiled for Los Angeles County by the Los Angeles County Flood Control District and, subsequently, the LACDPW.

- **Correction factor** is an adjustment factor for the number of storm events that do not actually produce any runoff (i.e., the percentage of storm events that have a total accumulation greater than a specific threshold value). This value will be calculated based on a review of historic rainfall data for Los Angeles County.

- **Weighted-average runoff coefficient** is a relative measure of the percentage of rainfall that becomes surface runoff. Runoff coefficients will be calculated utilizing the procedure described in Section IV.

- **Event mean concentration of pollutant** is the event mean concentration value for the specific pollutant determined from an analysis of the flow-weighted composite samples obtained by the monitoring program.

- **Drainage area** is the size of the area being modeled.

2. Use the per-drainage area annual pollutant loads to calculate per-watershed annual pollutant loads.

The following equation will be used to calculate per-watershed annual pollutant loads.

Equation 2:

$$L_w = \Sigma L_i$$

where:

L_w = Annual pollutant load for a particular watershed

ΣL_i = Summation of individual annual pollutant loadings from all drainage areas within a specific watershed

3. Use the per-watershed annual pollutant loadings to calculate basin-wide annual pollutant loads.

The following equation will be used to calculate basin-wide annual pollutant loads.

Equation 3:

$$L_B = \Sigma L_w$$

where:

L_n = Annual pollutant load for entire basin

ΣL_w = Summation of individual annual pollutant loadings from all watersheds within the basin

The above procedure can also be utilized to estimate seasonal pollutant loads and per storm event pollutant loads as needed.

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Constituents to be Modeled

Annual pollutant loadings will be calculated for the following constituents:

BOD_5	Total Phosphorus
COD	Dissolved Phosphorus
TSS	Cadmium
Dissolved Solids	Copper
Total Nitrogen	Lead
Total ammonia plus organic nitrogen	Zinc

Development of Annual Pollutant Loadings

We are targeting installation of our monitoring stations to commence May 1995. Upon completion of the storm season, April 1996, and assuming sufficient storms have occurred for sampling and that sampling equipment can be calibrated, event mean concentrations will be calculated. We estimate that the pollutant loads could be developed by August 1, 1996.

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XI. LONG-TERM TRENDS IN STORMWATER/URBAN RUNOFF QUALITY

As discussed in Section II, a total of fifteen fixed-station monitoring sites are proposed for the Upper and Lower Los Angeles River, Upper and Lower San Gabriel River, and the Santa Clarita Valley (Santa Clara River) Drainage Basins. The locations of five of these sites have been chosen to be representative of the various watersheds within the Basin. The locations to be selected and included in a supplemental submittal, one mass emissions sampling site in the Santa Clarita Valley Basin and nine land use specific sites, will meet the same criteria as established in this Monitoring Program Report.

In addition to providing data necessary for calculation of the event mean concentrations, long-term data from these sites can be evaluated for trends. The objective of this evaluation is to determine if there are any statistically significant differences in pollutant concentrations and loadings which could be related to the implementation of Best Management Practices (BMPs) as opposed to random variability in hydrologic factors such as the frequency, intensity, and duration of storm events.

Complicating this evaluation is the fact that there is no, location specific, baseline data available prior to the implementation of BMPs. Monitoring at these selected sites will commence concurrently with implementation of various BMPs. Therefore, dependent on the number of storms available, at least five or more years of data will be needed before reasonable statistical analysis of trends could be performed due to the large degree of natural variability. Therefore, we recommend that any statistical analysis of trends be performed after the conclusion of the fifth year of monitoring.

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APPENDIX 1

STEP-BY-STEP PROCEDURE

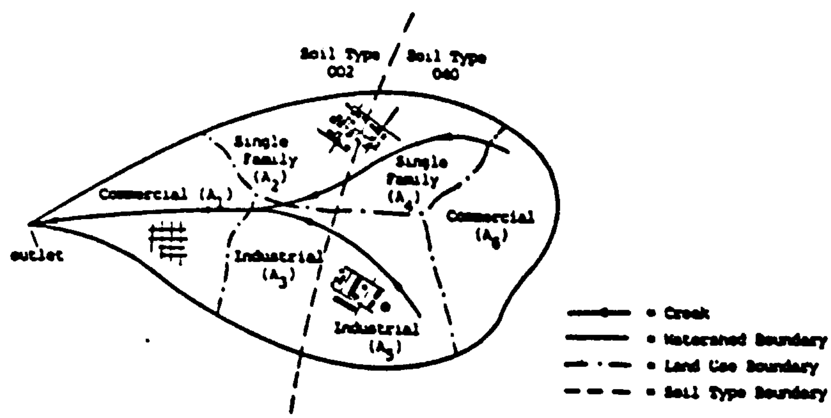
FOR

RUNOFF ESTIMATION

EXAMPLE

1. **Calculate the Runoff Coefficient for a Study Area**

Typical Example: The Study Area shown is comprised of two soil types and three land-use types.



Upon examining the Study Area, there are six unique soil types - land-use type combination areas. The areas are numbered 1 through 6. The data for these areas is summarized below:

Area Number	Soil Type	Land Use	Imp.	Area (Square Miles)
1	002	COM	.95	6
2	002	SF	.42	2
3	002	IND	.90	3
4	040	SF	.42	3
5	040	IND	.90	2
6	040	COM	.95	3

In general, the runoff coefficient is first calculated for each individual area. A weighted average calculation is performed to arrive at the overall runoff coefficient for the Study Area.

The detailed procedures is described below:

a) First the Undeveloped Runoff Coefficient (C_U) is determined for each area from the runoff coefficient curve for the soil type for the area. This is done by first choosing the rainfall intensity (in/hr). With this rainfall intensity value go to the runoff coefficient curve and select C_U.

b) The developed Runoff Coefficient (C_D) is then calculated for each area based on the following formula:

$$C_D = .9IMP + C_U (1\text{-}IMP)$$

The IMP is the imperviousness value assigned to the land use within each area.

c) After calculating C_D for each individual area, a weighted average calculation is performed to come up with the average C_D for the entire Study Area.

Now we will calculate C_D for the Study Area:

Select rainfall intensity

The rainfall intensity to be used will be 1.5 in/hr. If the rainfall intensity is not known or no specific value is to be used, then C_U automatically goes to the minimum or default value of 0.1 which is the same for all soil types. The calculation process should be established to use the default value unless a user specified rainfall intensity is provided.

Determine C_U

The Study Area is comprised of two soil types. C_U for these soil types is:

Soil type	C_U
002	.79
040	.75

Calculate C_D

Calculate C_D for each area:

Area No.	C_U	Imp.	C_D
1	.79	.95	.89[1)]
2	.79	.42	.83
3	.79	.90	.79
4	.75	.42	.81
5	.75	.90	.89
6	.75	.95	.89

1) C_D for Area 1 = .9(.95) + .79(1-.95) = 0.89

Therefore, C_D for the Study Area is:

$$C_D \text{ Study Area} = \frac{C_{D1}\,\text{Area}_1 + C_{D2}\,\text{Area}_2 + C_{D3}\,\text{Area}_3 \ldots}{(\text{Area}_1, + \text{Area}_2 + \text{Area}_3 \ldots)}$$

$$= \frac{.89(6) + .83(2) + .79(3) + .81(3) + .89(2) + .89(3)}{(6+2+3+3+2+3)}$$

$$= 0.86$$

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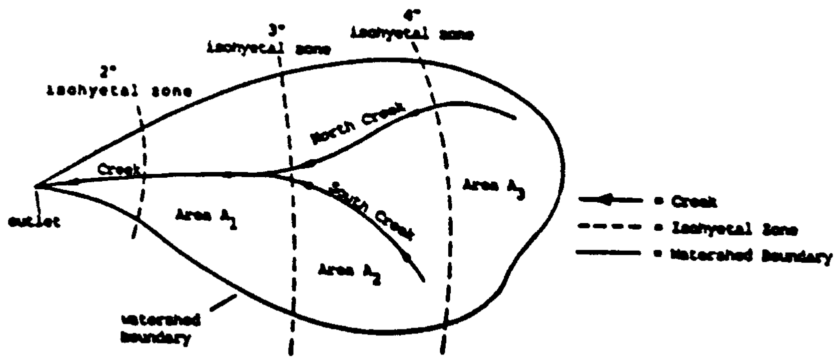
2. **Calculate Rainfall Volume Over the Study Area**

The Study Area is shown below and encompasses the indicated isohyetal zones.



The total area of the Study Area is 10 mi². The portion of the Study Area encompassed by each isohyetal zone is listed below:

Zone	Area(mi²)
2"	3
3"	7
4"	9

The total rainfall volume deposited on the study area is:

rainfall volume = $[2(3) + 3(7) + 4(9)]\ (640\ \frac{acres}{mile})\ (1/12)$

= 3360 Acre•feet

or $\frac{3360\ 12\ (\frac{inches}{foot})}{19(mi^2)\ (640\ \frac{acres}{mile})}$ = 3.3" depth over the entire study area

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3. **Calculate the Runoff Volume for a Study Area**

For the Study Area used in this example, the runoff coefficient (C_D) = 0.86.

runoff volume = Rainfall Volume (C_D)

= 3360 Acre-feet (0.86)

= 2890 Acre-feet

NOTE: Drainage Basins II, III, IV, and V have many flood control facilities such as dams which may detain flood waters and/or reduce runoff projected for a watershed.

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APPENDIX 2

SURFACE WATER SAMPLING

INSTRUCTION MANUAL

I. INTRODUCTION

This manual covers collection of surface water samples for the Department's Stormwater/Urban Runoff Monitoring Program, and compliments the sampling procedures contained in the Work Plan for the Stormwater/Urban Runoff Monitoring Program (Work Plan).

Two sampling techniques, Manual Sampling (sampling by hand) and Automated Sampling (sample collection by use of powered devices such as the Automated sampler) are used in the monitoring program. Both manual sampling and automated sampling techniques are discussed in this sampling manual, with reference to the above-mentioned Work Plan.

Samples collected for both dry weather and storm flow monitoring programs are typed either "Grab" or "Composite". Grab sample is an individual discreet sample collected for characterizing water quality at a particular time. Grab samples normally would be collected using manual sampling techniques, unless sampling collection can only be achieved using automatic samplers, such as at manhole stations that are very deep and not accessible using manual grab sampling equipment. Composite samples are series of individual samples collected at paced intervals and combined to create a single weighted composite. Composite samples would normally be obtained, using automated sampling techniques.

The following instructions will help you collect samples and transport water samples safely and correctly. Safety is of the utmost importance, but if a sample is not collected or transported correctly, the subsequent lab analysis results will be compromised or invalidated.

It should be noted that these instructions are merely a guide to meet the specific needs of the Department. They are not intended to be a comprehensive guide to water quality sampling. Numerous textbooks, handbooks, and manuals are available for those interested in more detailed information on sampling methodology.

II. COLLECTION OF SAMPLES

Water samples will be collected in bottles supplied by the contract laboratory. All sample bottles, except bacteria bottles have been acid-washed and thoroughly rinsed with distilled water to eliminate contamination. Bacteria bottles contain a dechlorinating chemical. DO NOT RINSE THE SAMPLE BOTTLES BEFORE FILLING.

However, the bucket, dipper and funnel should be rinsed at each new sampling location. Use the water at each new site to rinse off any contaminates left in the bucket from prior sites.

DO NOT USE SOAP OR ANY OTHER DETERGENTS TO CLEAN SAMPLING EQUIPMENT.

A. Manually Collecting Grab Samples

A Manual grab is collected by inserting a container (bucket, dipper, etc.) under the surface of the water body to be sampled and/or dipping a container down current of a discharge with the container opening facing upstream. The following manual sampling procedures should be followed, in accordance with the source of the sample as well as requirements for certain analyses:

1. Nonflowing - Reservoirs, Lakes, and Ponds

The sampling technique will depend on the location and purpose of the investigation. The following general rules should be observed:

a. Select a location away from areas where water may tend to be stagnant.

b. Take samples at a location that is definable in plan and depth so that subsequent samples can be taken from the same location. This is important where a study is to be made regarding water quality changes with time.

2. Flowing Water

a. When sampling with a bucket and line from above the streamflow, first attach the line to the bridge railing or some other firmly fixed object. Lower the bucket gently into the center of the channel. Make sure the bucket is submerged to avoid the collection of floating debris.

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b. When sampling for oil and grease, sample should be collected at the air/water interface to insure collection of representative samples.

c. Avoid hitting the bottom of the channel so that deposited sediments are not collected.

d. When using the bucket and line adjacent to the low-flow channel, gently swing the bucket into the center of the flow to collect the sample.

e. After raising the bucket, take the temperature of the sample immediately for at least 30 seconds.

f. Pour off any floating debris and decant the water from the bucket into the sample bottles.

3. <u>Bacteriological Samples</u>

Bacteriological samples should be taken under sterile conditions, observing the following precautions (also refer to Section C 2. Sample Bottles):

a. Do not rinse the bottle. The bacteria bottle contains a dechlorinating chemical which must mix with the sample.

b. Do not fill the bottle completely; leave about 1/2 inch to allow mixing of the contents.

c. When sampling, prevent contaminating the lip and cover of the sampling bottle by avoiding contact with anything but the sample or the source of the sample.

B. <u>Collecting Grab Samples By Automated Sampler</u>

Collection of grab samples can also be accomplished by using the automated samplers. This is accomplished by temporarily bypassing the automated sampling program and utilizing the pumping unit of the automated sampler to fill the grab sample bottles. This sampling technique may be used if sample points for grab samples are inaccessible, such as at sampling stations that are very deep below the ground surface and cannot be accessed using manual grab sampling equipment. However, once the grab samples are collected, the automated sampling system must be restored to its ready mode for performing its programmed functions.

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C. Flow Composite Samples

Flow weighted composite samples are collected using the automated samplers, programmed to collect samples for Storm Sampling (at flow paced intervals), and for Dry Weather Sampling (at fixed time intervals). For both storm sampling and dry-weather sampling, sample bottles must be retrieved within the maximum holding times required of the various test methods. Sample bottles are to be placed in coolers with frozen blue ice for transport to the laboratory for compositing and analysis.

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III. SAMPLING EQUIPMENT

You will be provided with the sampling equipment necessary for your assignment. The equipment may consist of the following items:

- Bucket and rope
- Sample bottles
- Thermometer
- Personal equipment: (if applicable)
  - Hard hat and vest
  - Flashlight
  - Thomas Guide and location sketch
  - Rubber Gloves

A. Bucket and Rope

All surface samples collected manually by the Water Quality Management/Storm Water Section are of the type known as "grab samples". Under this procedure a sample may be collected in a bucket at a randomly selected time, over a period of time not to exceed 15 minutes.

B. Sample Bottles

You will be provided with the appropriate sample bottles and containers by the contract laboratory. Sample containers are easy to contaminate, therefore, AVOID TOUCHING the mouth of the bottle or the inner surface of the cap. Except when otherwise stated all containers should be filled to within 1" of the top NEVER TO OVERFLOWING. Identify the sample and provide any necessary information requested on the pre-printed computer generated container label by using a waterproof ink pen. Place all glass containers into plastic protective bubble pack bags, and/or pack the containers in the cooler with shock absorbing materials to minimize the possibility of breakage. Add frozen blue ice, and deliver to the contract laboratory.

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1. CONTAINER IDENTIFICATION

GROUP	QTY CONTAINER TYPE	PRESERVATIVE
A	1 - 250 ml Glass	w/ ½ ml of H_2SO_4
	1 - 250 ml Glass	wop
B	1 - 1 L Glass	w/ 2 ml of H_2SO_4
	1 - 250 ml Plastic	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
C	1 - 1 L Glass	w/ 2 ml of H_2SO_4
	1 - 1 L Amber Glass	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
D	1 - 1 L Glass	w/ 2 ml of H_2SO_4
	1 - 1 Gallon Amber Glass	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
E	1 - 1 L Glass	w/ 2 ml of H_2SO_4
	1 - 1 Gallon Amber Glass	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
	2 - 40 ml Septumed Glass Vial	w/ 3mg of $Na_2S_2O_3$
F	1 - L Glass	w/ 2 ml of H_2SO_4
	1 - 250 ml Plastic	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
G	1 - 1 L Glass	w/ 2 ml of H_2SO_4
	1 - 2 L Plastic	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
H	1 - 1 L Glass	w/ 2 ml of H_2SO_4
	1 - 1 Gallon Amber Glass	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
	2 - 40 ml Septumed Glass Vial	w/ 3mg of $Na_2S_2O_3$
I	1 - 1 L Glass	w/ 2 ml of H_2SO_4
	1 - 2 L Plastic	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
	2 - 40 ml Septumed Glass Vial	w/ 3mg of $Na_2S_2O_3$
	1 - 2 L Amber Glass	w/ 160mg of $Na_2S_2O_3$
J	1 - 250 ml Glass	w/ ½ ml of H_2SO_4
	1 - 250 ml Plastic	wop
	2 - 40 ml Septumed Glass Vial	w/ 3mg of $Na_2S_2O_3$
K	1 - 2 L Plastic	wop
	1 - 100 ml Sterilized Plastic	w/ 0.1 ml of 10% $Na_2S_2O_3$
	1 - 1 L Glass	w/ 2 ml of H_2SO_4

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GROUP	QTY CONTAINER TYPE	PRESERVATIVE
N	1 - 1 Gallon Glass	w/ 8 mℓ of H_2SO_4
	1 - 2 L Plastic	wop
	1 - 100 mℓ Sterilized Plastic	w/ 0.1 mℓ of 10% $Na_2S_2O_3$
	2 - 40 mℓ Septumed Glass Vial	w/ 3mg of $Na_2S_2O_3$
	1 - 2 L Amber Glass	w/ 160mg of $Na_2S_2O_3$
	1 - 500 mℓ Plastic	w/ NaOH

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2. SPECIFIC INSTRUCTIONS

a. General Mineral (Gen Min):

Fill unpreserved container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage.

b. Microbiology (Micro):

Fill unpreserved 1 Liter plastic container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. Place container in cooler with "Blue Ice" to minimize the effect of high temperatures on deaths of microbes. The maximum holding time for bacteria samples is six hours from the time of collection. Therefore, the samples must immediately be transported to the laboratory. Also, refer to preceding Section B 3. Bacteriological Samples.

c. Total Petroleum Hydrocarbon (TPH or TPH, Cr+6):

Fill unpreserved container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

d. Metals:

Fill preserved container to within 1" of the top. DO NOT RINSE OUT OR OVERFILL. Contains Nitric Acid as a preservative. Tighten cap to prevent leakage.

e. Oil and Grease (O & G):

Fill preserved container to within 1" of the top. DO NOT RINSE OUT OR OVERFILL. Contains Sulfuric Acid as a preservative. Tighten cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

f. Pesticide-PCB's (Pest-PCB):

Fill unpreserved container to within 3" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

g. Total Organic Carbon (TOC):

Fill unpreserved container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

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h. Biological Oxygen Demand (BOD):

Fill unpreserved container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage.

i. Volatile Organics (EPA 601/602):

Slowly fill the two 40 ml vials to overflowing, being careful not to aerate the sample. Carefully place the cap onto the vial and tighten to prevent leakage. Make sure that the teflon surface of the septum (hard white side) is facing the sample, the soft silicon side of the septum should be visible from the top of the cap. Invert the vials to confirm proper sample collection (bubbles should not be observed). If bubbles are present, open the vials, add more sample, reseal the vials, and recheck for air bubbles. Place the glass vials into the plastic protective bubble bag and, if possible, store in a cooler with "Blue Ice".

j. Base-Neutral-Acid Extractables (BNA):

Fill unpreserved container to within 3" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

k. Herbicides (Herb):

Fill unpreserved container to within 3" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage. This container is glass and, if possible, should be placed into a bubble bag for transportation to prevent breakage.

3. SPECIAL SAMPLES

a. Organic Nitrogen (TKN):

Fill preserved 250 ml plastic container to within 1" of the top. DO NOT RINSE OUT OR OVERFILL. Contains Sulfuric Acid as a preservative. Tighten cap to prevent leakage.

b. Radioactivity (Gross alpha & beta):

Fill preserved 1 Liter plastic container to within 1" of the top. DO NOT RINSE OUT OR OVERFILL. Contains Nitric Acid as a preservative. Tighten cap to prevent leakage.

c. Asbestos:

Fill unpreserved 1 Liter plastic container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage.

d. Chlorinated Organic Substances (COS):

Use same sampling procedure as for EPA 601/602. The EPA reference manual is available in the Water Quality Section.

e. Nitrite-N (1 ppb DL):

Fill unpreserved 125 ml plastic container to within 1" of the top. It is not necessary to rinse out the container with the sample. Tighten the cap to prevent leakage.

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C. Thermometer

A thermometer is provided because water temperatures are required for each sampling site location.

D. Dissolved Oxygen Meter

If your assignment requires the measurement of dissolved oxygen, a DO meter will be provided with the necessary instructions on its use. Calibration of the meter is essential prior to each use. Instruction classes on the DO meter's operation will be provided prior to usage.

E. Personal Equipment

Before leaving on a sampling assignment, make sure that all personal equipment necessary to carry out the assignment packed and stored in the vehicle. This would include a hard hat and vest, gloves, flashlight if necessary, Thomas Guide, etc., thermometer, and location sketches showing the various surface sampling stations and access points.

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IV. SAFETY

Safety Reminders:

1. Safety is more important than the samples. Never place oneself in a dangerous or unsafe sampling situation.

2. Always park vehicles where it is safe. Pull into an access road or park the vehicle on a street where parking is permitted and walk to the site. NEVER PARK ON A BRIDGE.

3. Wear a hard hat and a high-visibility vest when leaving the vehicle.

4. Wear waterproof boots with high-traction soles when walking or standing on wet surfaces. Slippery surfaces should be avoided.

5. Never stand or walk in moving water.

6. Never get too close to a low-flow channel. Use a bucket and line to obtain a surface sample.

7. **Never enter an enclosed drain, tunnel, or a confined space.**

8. If waters are flowing outside the low-flow channel, lower the bucket and line from a bridge.

9. When sampling from a bridge, always tie one end of a rope to the railing or some other firmly fixed object. Do not lean excessively over the guard rail.

10. Be alert for hazardous situations. Personal safety is an employee's first responsibility. Common sense safety precautions must be exercised if one comes upon an unusual material, discharge, smell, dumping, etc. Take notes on all observations. Notes may be used in follow-up investigations and/or supporting future analytical findings. A sample must not be taken if common sense judgment indicates that ones safety is jeopardized.

11. Wear gloves when handling samples and wash hands with soap and water when finished.

12. Wash all equipment, boots, gloves, bucket, etc., when finished.

13. When ascending or descending unstable or slippery slopes and embankments, avoid holding breakable bottles, and pointed or sharp objects with bare hands.

14. Each employee has Physical Class Limitations established under the Occupational Health Manual of Policies and Procedures of the Department. Exerting physical efforts or lifting weights exceeding ones physical class limit must be avoided to prevent physical injury. Ice chests with full sample bottles and ice may exceed the weight-class requirements; in such cases, the ice chest must be transported by a minimum of two persons.

V. LABELING AND FIELD OBSERVATIONS

Each sample bottle will normally be pre-labeled by the Water Quality Unit. It is important, however, that each sample be identified as to the source, date, and time of acquisition. If a sample is taken from a large body of water, for example, the location should be described in such a way as to enable the same sample point to be relocated in the future if and when it becomes necessary.

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VI. DELIVERY OF SAMPLES

Samples should be delivered to the contract laboratory as soon as possible to prevent alteration of the sample between time of sampling and time of analysis. In order to avoid the need to preserve the samples overnight, samples should be delivered to the contract laboratory no later than 5:00 p.m., unless prior arrangement with the contract laboratory has been made.

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VII. CHAIN OF CUSTODY

The Chain-of-Custody Record form shown must be completed for each delivery of samples to the contract laboratory. When sampling for potential court case litigation, consult the laboratory for the appropriate testing procedures, splitting and sealing of samples, and chain of custody.

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VIII. PHONE LIST

The following are some frequently-used phone numbers:

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

Waste Management Division Water Quality Management Section	(818) 458-6972
Flood Maintenance Division	
Field Offices	
Eaton Yard	(818) 798-6761
Hansen Yard	(818) 896-0594
Imperial Yard	(310) 861-0316
83rd Street Yard	(213) 776-7610

AGRICULTURAL COMMISSIONER/WEIGHTS & MEASURES

Environmental Toxicology Lab	(310) 940-6778

SWS
3/22/94

APPENDIX 3

QUALITY ASSURANCE MANUAL

COUNTY OF LOS ANGELES
OFFICE OF
Agricultural Commissioner/
Weights and Measures

VOL 12

ENVIRONMENTAL TOXICOLOGY.LABORATORY

Quality Assurance Manual

1 8565

11012 Garfield Avenue, Bldg. B South Gate, Ca 90280

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QA OBJECTIVES

1. Establish the laboratory's ability to qualitatively and quantitatively analyzed various types of environmental samples for pollutants by:

   - identifying the qualifications and responsibilities of laboratory personnel;

   - enumerating the existing laboratory instrumentation and equipment together with the procedures for their sevice and maintenance to assure proper operation;

   - providing sources of analytical methods accepted by regulatory agencies for use in the laboratory.

2. Provide guidelines pertaining to sampling protocols, chain-of-custody, and storage of samples to maitain sample integrity prior to analyses.

3. Define the laboratory's calibration procedures and frequency of calibration.

4. Identify all the necessary steps to validate the laboratory's results.

5. Define all the necessary quality control checks that must be followed prior to the analysis and/or in the course of analyzing samples.

6. Identify all laboratory records and information needed to document the quality of analyses performed in the laboratory.

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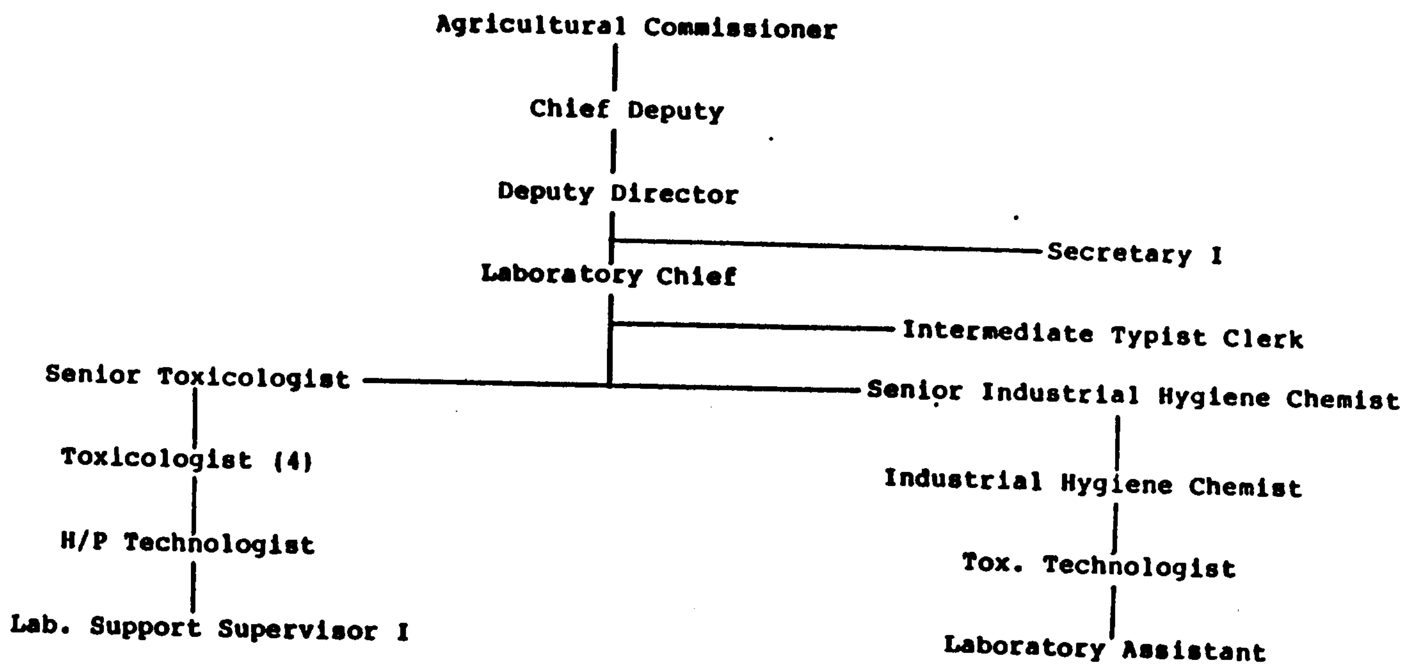
COUNTY OF LOS ANGELES
Office of Agricultural Commissioner/Weights and Measures
ENVIRONMENTAL TOXICOLOGY LABORATORY

Organizational Chart



1. Organization

A. Minimum Personnel Qualification and Background

1. Deputy Director Graduation from an accredited college with specialization in chemistry, biochemistry, biology, or agricultural chemistry, and three years experience in analytical chemistry, biochemistry, pharmacology, or toxicology laboratory. An advanced degree in chemistry or biochemistry will be accepted for the required experience on the basis of one year for Master's degree and two years for a Ph.D.

2. Chief-A Bachelor of Science degree and at least three years experience in chemistry, biochemistry, pharmacology, biology, or toxicology, one year of which must have involved the chemical analysis of environmental samples. An advanced degree in chemistry or biochemistry will be accepted for the required experience on the basis of one year for a Master's degree and two years for a Ph.D.

3. Senior Toxicologist-Graduation from an accredited college with specialization in chemistry or biochemistry, and two years experience in analytical chemistry, biochemistry, pharmacology, or toxicology. An advanced degree in chemistry or biochemistry will be accepted for the required experience on the basis of one year for a Master's degree and two years for a Ph.D.

4. Senior Industrial Hygiene Chemist-Master of science degree with a major in general or physical chemistry and five years experience as a professional chemist conducting basic analytical research in chemistry, or four years experience as as Industrial Hygiene Chemist.

5. Toxicologist-Graduation from an accredited college with specialization in chemistry or biochemistry, and one year experience in analytical chemistry, biochemistry, pharmacology, or toxicology. Completion of one year graduate work in an accredited college with specialization in chemistry or biochemistry will be accepted for the required experience.

6. Industrial Hygiene Chemist-Bachelor of science degree with major in chemistry a biochemistry, and either (1) a Master's degree in chemistry, biochemistry, or a related field of environmental chemistry and two years experience as a professional chemist doing increasingly complex analytical procedures, or (2) four years experience as a professional chemist doing increasingly complex analytical procedures.

7. Herbicide Pesticide Technologist-Graduation from an accredited college with specialization in chemistry, biochemistry, toxicology, biological & natural sciences and six months experience performing chemical analyses or completion of sixty semester units of which 16 must have been in chemistry and two years experience performing toxicological analyses.

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8. Toxicological Technologist-same as Herbicide/Pesticide Technologist.

9. Senior Laboratory Assistant-Six months experience at the laboratory assistant level.

10. Laboratory Assistant-Six months experience in laboratory work in a public health, medical, chemical, or biological laboratory, or completion of a course in laboratory science such as general chemistry or bacteriology.

B. Personnel Responsibilities

1. Deputy Director

-Directs, plans, assigns, reviews and evaluates work performed by laboratory personnel.

-Provides consultation in environmental toxicology to DHS, Agriculture Comm. and other agencies.

-Testifies as an expert witness for Los Angeles County on the analysis and interpretation of findings.

-Supervises the analysis and interpretation of laboratory data and correlates this with biochemical and metabolic effects.

-Publish scientific papers and reports. Make presentations concerning H/P contamination in our community. Attends and participates in conventions, meetings and conferences of professional organizations concerning H/P.

2. Chief

-Assists in the planning, assignment, supervision, and review of the work of laboratory personnel.

-Provides technical direction to laboratory personnel in performing a variety of chemical analyses of water, soil, plant, animal and other environmental samples utilizing various techniques such as spectrophotometry, chromatography, gravimetric, and volumetric analyses.

-Establishes and sets up special test procedures for detecting pesticides and other chemicals for which the laboratory has minimal or no experience, including all required and necessary quality control steps in such procedures.

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-Establishes minimum quality control guidelines for all methods and tests performed in the laboratory.

-Develops laboratory statistics and reports on analytical procedures in assisting laboratory personnel in making the more difficult or unusual determinations, to identify priorities, and to establish work flow measures.

-Conducts training of laboratory personnel.

-May testify as an expert witness for the Chief Environmental Toxicologist.

3. Senior Toxicologist

-Provides technical guidance to laboratory personnel and performs chemical analyses to determine the presence and quantity of pesticides and other chemicals of interest in samples submitted to the laboratory for study utilizing wet and instrumental methods.

-Develops procedures for and conducts non-routine analysis on samples involving new and uncommon pesticides where standard methods are not established.

-Routinely monitors at regular intervals the accuracy and precision of laboratory results by checking quality control data obtained by laboratory personnel as part of their daily workload.

-Ensures that all quality control guidelines of the laboratory are met and recorded in specific quality control record books.

-Prepares daily work assignments of lower level laboratory personnel.

-Engages in continuing research and experimentation to develop and improve analytical procedures.

-Writes reports on analyses outlining methods used and results.

-Assists the Supervising Toxicologist in performing an analysis of unknown substances.

-Contacts pathologists, law enforcement officers, pharmacists and others to obtain information on cases as necessary.

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4. Senior Industrial Hygiene Chemist

-Prepares work schedules, assigns and rotates Industrial Hygiene Chemists to various jobs, evaluates work performance and recommends resolutions to employee relations problems.

-Tests or directs the testing of new equipment, prepares written evaluations, and makes recommendations for its acquisition; prepares written instructions on the application and oper tion of new equipment for the procedure manual.

-Supervises a program of quality control to ensure the accuracy of test reports.

-Orients new employees to the overall operations of the section and trains or supervises their training.

-Serves as the consultant to Public Health Programs staff on problems relating to toxic and potentially dangerous chemicals.

-Analyzes samples that require the highest level of technical skill, experience and knowledge.

-Instructs environmental health personnel in the proper procedures for collecting field samples.

-Calibrates all laboratory equipment for the section.

5. Toxicologist

-Performs chemical analyses of water, soil, plant, animal, and other samples utilizing standard laboratory techniques such as spectrophotometry, chromatography and gravimetric and volumetric analysis.

-Follows accepted procedures and required quality control measures for conducting routine analyses such as determinations for pesticides and other organic/inorganic compounds.

-Writes reports on analyses outlining methods used and results.

-Contacts inspectors, law enforcement officers, and others to obtain information on cases as necessary.

-Assists the Senior Toxicologist in performing analysis of unknown substances.

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-Prepares standard chemical solutions and reagents to specific requirements.

6. Industrial Hygiene Chemist

- -Collects field samples and conducts surveys regarding industrial hygiene, sanitation, and exposure of workers to health hazards.
- -Conducts laboratory and field analyses of abrasives, solvents, and other materials used in industrial plants and makes specialized measurements of air samples to identify and measure contaminants.
- -Maintains and operates a chemical laboratory, anticipating needs for ordering chemicals and equipment.
- -Develops new and special methods, procedures and equipment to be used for chemical and physical determinations in laboratory and field studies.
- -Conducts research on problems of toxicology and other chemical problems as necessary for industry, County and other governmental agencies.
- -Maintains laboratory records and prepares reports on results of studies and projects.
- -Interprets data and confers with engineers, various divisions of the Health Department, and industrial managers to solve chemical problems concerning industrial health and hazards to workers.
- -Operates a variety of laboratory and field testing equipment.

7. Herbicide/Pesticide Technologist

- -Performs chemical procedures requiring the use of analytical apparatus to confirm existence of herbicides and pesticides in plant, soil, water, and animal tissue specimens.
- -Utilizes techniques such as gas chromatography in chemical analyses of various specimens to determine the quantity of herbicides and pesticides present.
- -Follows quality control guidelines on all chemical procedures and analyses performed.

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-Conducts preliminary research contributing to the development of new methods and procedures for the purpose of enhancing the quality of test analysis.

-Prepares standard chemical solutions and reagents to specific requirements.

-Performs routine maintenance on laboratory equipment and apparatus including cleaning and calibration.

-Prepares written reports delineating technical procedures exercised during analysis and test findings.

-Interprets gas chromatography graphs to determine specimen findings and submits interpretations to a Senior Toxicologist for review.

8. Toxicological Technologist

-Performs chemical analysis of environmental and biological samples using established procedures to determine the presence or absence of pesticides.

-Utilizes known istrumentation techniques such as gas and high pressure liquid chromatographs to determine the quality and quantity of pesticides present.

-Follows quality control guidelines on all chemical procedures and analyses performed.

-Prepares reference standards, chemical solutions, and reagents to specific requirements.

-Performs routine maintenance on laboratory equipment and apparatus including cleaning and calibration.

-Interprets charts and reading generated by various laboratory instruments used and submits interpretations to a toxicologist or senior toxicologist for review.

-Maintains register of all samples which includes detailed information on the methods used and findings.

-Assist in the development of new methods and procedures to improve the quality and reliability of test results.

-Follows experimental procedures under the guidance of a senior toxicologist to test for new pesticides.

9. Senior Laboratory Assistant

- Trains laboratory assistants in the specific procedures established by the laboratory for the preparation of samples for analysis by toxicological technologists and toxicologists, the preparation of reagents, and the performance of other such laboratory tasks.

- Observes the performance of other laboratory assistants of their assigned tasks both in training and on-the-job situations, and makes corrections necessary to assure maintenance to established quality and quantity standards.

- Prepares samples for laboratory testing by adding reagents, solvents, and/or standards using prescribed techniques and instruments appropriate to the type of sample.

- Processes samples for subsequent analysis by higher level personnel by performing duties such as extractions and filtrations.

- Operates laboratory equipment pre-calibrated by qualified personnel to perform assigned tasks such as platform shakers, rotovaporators, and pH meters.

- Prepares specific quantities of reagents and solutions of compounds including acids and bases, following written procedures, by mixing components to standard ratios using such laboratory apparatus as weighing balances and volumetric glasswares; lifts and moves containers holding several gallons or other substantial quantities of constituent parts or compounds produced.

- Performs routine maintenance on miscellaneous devices such as water baths, rotovaporators, and platform balances.

- Cleans and treats glassware used in laboratory testing following steps and procedures prescribed by higher level personnel.

- Stores apparatus, glassware, and other supplies in designated areas when not in use.

- Stores reagents and chemicals in designated areas as required by safety rules and regulations.

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10. Laboratory Assistant

- Receives samples such as water, soil, plant, etc. together with standard laboratory request form providing information such as sample I.D. and tests to be performed; verifies sample I.D. and assigned laboratory I.D. number by matching information on request form and sample container.

- Assigns laboratory identification to all samples received and writes this I.D. number on request forms and corresponding sample containers.

- Logs in sample information such as sample I.D., laboratory I.D. number, and tests to be performed in laboratory record book.

- Stores all samples received in appropriate storage locations and submit corresponding laboratory request forms to senior toxicologist.

- Prepares samples for analyses by chopping, weighing, and/or measuring where appropriate.

- Performs preliminary work on samples such as adding solvents and reagents, setting-up necessary glassware, and loading on platform shakers.

- Operates automatic laboratory equipment pre-calibrated by qualified personnel such as a pH meter to perform specific test.

- Transcribes laboratory test results from laboratory worksheets into permanent record book.

- Cleans & treats glassware used in laboratory testing following steps & procedures prescribed by higher level personnel.

- Cleans and stores apparatus, glassware and other supplies in designated areas when not in use.

- Stores reagents and chemicals in designated areas as required by safety rules and regulations.

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II. Sampling Procedures

A. Hazardous Waste

1. Organochlorine pesticides, Polychlorinated Biphenyls, and Organophosphorous Pesticides.

   Wide mouth borosilate or soda glass container of 16 oz. size should be used. The container must have tight, screw-type lid with teflon liner. Sample bottle must not be prewashed with the sample before collection. Composite sample should be collected in refrigerated glass container.

   The sample must be iced or refrigerated from the time of collection until extraction. Preservatives should not be used in the field unless more than 24 hour will be elapse before delivery to laboratory. If the sample will not be extracted within 48 hours of collection, the sample should be adjusted to pH range of 6.0 to 8.0 with sodium hydroxide or sulfuric acid. Note the volume of acid or base added to the sample.

   All samples must be extracted within 7 days and completely analyzed within 30 days of collection for organochlorine, pesticide and polychlorinated biphenyls, and analyzed within 14 days of collection for organophosphorous pesticides.

2. Phenols

   Wide mouth borosilate or soda glass container must be used, and the container must not be prewashed with sample before collection. Composite samples should be collected in refrigerated glass container.

   The sample must be iced or refrigerated from the time of collection until extraction. If free chlorine is present in the sample, add 35 mg. of sodium thiosulfate per ppm free chlorine per liter/kg. Adjust the sample pH to approximately 2, as measured by pH paper with sulfuric acid solution or 10 N sodium hydroxide. record the weight of sodium thiosulfate and volume of sulfuric acid or sodium hydroxide used.

   All samples must be extracted within 7 days and completely analyzed within 30 days of collection.

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3. Halogenated Volatile Organics, Non-Halogenated Volatile Organics, and Acrolein, Acrylonitrile, Acetonitrile.

Samples must be collected in glass containers of at least 25 ml. size. Fill the sample container in such a manner that no air bubbles pass through the sample as the container is being filled. Seal the bottle so that no air bubbles are entrapped in it. Solid and semisolid samples are to be taken in the same way.

The samples must be iced or refrigerated from the time of collection until extraction. If the sample may contain free or combined chlorine, add 10 mg. sodium thiosulfate per. 40 ml./gm. for up to 5 ppm. chlorine. Fill the container with sample just to overflowing, seal the container, and shake vigorously for 1 minute.

All the samples must be analyzed within 14 days of collection.

4. Base, neutral, acid extractables.

All samples must be collected in glass container with teflon-lined screw caps. The samples must be iced or refrigerated at 4°c from time of collection until extraction. All samples must be extracted within 14 days of collection and completely analyzed within 40 days of extraction.

5. Phthalate Esters, Nitroaromatics, Cyclic Ketones, Poly nuclear Aromatic Hydrocarbons and Chlorinated Hydrocarbons.

All samples must be collected in refrigerated glass containers and the containers must not be prewashed with sample before collection. The sample must be iced or refrigerated from time of collection until extraction. Chemical preservative should not be used unless more than 24 hour will elapse before delivery to the laboratory. If the samples will not be extracted within 48 hours of being collected, the sample should be adjusted to a pH range of 6.0-8.0 with sodium hydroxide or sulfuric acid. Record the amount of acid or base used.

All samples must be extracted within 7 days and completely analyzed within 30 days of collection.

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6. Toxic Metals

All sample containers must be prewashed with detergents, acids and deionized water. Plastic and glass containers are acceptable. Aqueous samples must be acidified to pH less than 2 with nitric acid. Non-aqueous sample shall be refrigerated. The maximum holding time of sample for mercury is 38 days in glass container and 13 days in plastic container.

7. Non-metallic

a. Cyanide

Oxyidizing agents decompose most cyanides. To test the presence of oxidizing agents, test a drop of liquid sample with potassium iodidestarch test paper: a blue color indicates the need for treatment. Add ascorbic acid a few crystals at a time until a drop of sample produce no color on the test paper. Then add an additional 0.6 gm. of ascorbic acid for each liter of liquid sample.

Samples must be preserved with 2 ml. of 10 N. sodium hydroxide per liter of sample at time of collection (pH is greater than or equal to 12).

Samples should be refrigerated at 4°c and analyzed as soon as possible.

Sample could be stored in glass or plastic container.

b. Fluoride

Sample should be collected in glass or plastic container.
Maximum holding time is 28 days.

c. Sulfide

Sample should be collected in glass or plastic container. Aqueous samples must be preserved with zinc acetate or the analysis must be started immediately.

8. Physical property testing

All samples should be collected in glass container with teflon liner and stored at 4°c.

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B. Drinking Water

1. Organochlorine Pesticides and Nitrogen - and Phosphorus-Containing Pesticides

   Use 1-L borosilicate glass bottle with TEF-fluorocarbon lined screw cap, add 10 mL. of mercuric chloride as preservative to the bottle for a concentration of 10 mg/L.

   When sampling tap water, allow the system to flush for about 10 minutes to stabilize temperature. Adjust the water flow to approx. 500 ml./min. befor collecting the sample. Note that the bottle must not be pre-rinsed with the sample. If a well is to be sample, collect the water in a wide-mouth beaker then transfer to the sample bottle with preservative. Seal the bottle then shake vigorously for 1 minute.

   Store the sample at 4°c. Extract within 7 days of collection and analyze within 40 days of extraction.

2. Volatile Organic Compounds

   Use 40 ml. vials with screw caps equipped with PTFE-faced silicone septum. These vials maybe ordered from Pierce or equivalent pre-cleaned and ready to use. Carry a field blank filled with reagent water to the sampling site with empty vials.

   Fill sample bottles to overflowing. No air bubbles should pass through the samples as the bottle is filled, or be trapped in the bottle when the bottle is sealed.

   When sampling tap water, allow the system to flush for about 10 minutes to reach stable temperature. Adjust water flow to about 500 ml./min. them collect the sample. If a well is to be sampled, collect the water in a wide-mouth beaker then transfer to the sample vial.

   Collect all samples in duplicate.

   Adjust pH of sample to <2 by the addition of 2 drops of 50% HCl. Seal the sample bottle with the PTFE-face down and shake vigorously for 1 minute. Immediately store sample at 4°c after collection. Analyze samples within 14 days of collection.

3. Carbamate Pesticides

Use 100-ml. or larger capacity glass or plastic bottle equipped with screw cap. Carry a field blank filled with TypeII water to the sampling site with the empty sample bottle. Add 7 mg/100 ml. of sodium thiosulfate to the empty bottles and field blanks as preservative.

Do not pre-rinse container with sample before sampling.

When sampling tap water, allow the system to flush for about 10 minutes to obtain stable temperature. Adjust the flow to approx. 500 ml./min. then collect water in a wide-mouth beaker the carefully transfer the sample to the bottle. Fill the bottle within 2 cm. of the top.

In the laboratory, samples to be analyzed for oxamyl, 3-hydroxycarbofuran, and carbaryl must be further preserved immediately at the laboratory by adjusting pH to 3. This maybe done with the addition of 50% HCL.

Store samples at 4°c and extract within 7 days of collection and complete the analysis within 40 days of extraction.

4. **Trace Metals**

Use 125-ml. polyethylene bottles with screw caplid. Prior to use, wash bottle with detergent and tap water; rinse with 1:1 nitric acid, tap water, 1:1 hydrochloric acid, tap water, and finally de-ionized water in that order.

For determination of dissolved or suspended metals, no preservative need be added at the time of collection. For determination of total metals, both dissolved and suspended, acidify sample to pH 2 or less with the addition of 1:1 redistilled HNO_3 at the time of collection. For determination of total recoverable metal acidify sample at the time of collection with 0.625 ml. of conc. $HN O_3$ for 125 ml. of sample. Analyze sample within 30 days of collection.

C. Sample Labeling and Identification

Immediately after collection, the sample must be sealed, labeled, and the sample analysis request form filled out for each sample.

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1. Sample Labels

Sample labels are used for the specific identification of samples. Gummed paper labels affixed to the containers are adequate, but it should not be affixed to the sample lids. The labels should be filled out at time of collection and should include the following information:

Field Number
Name of Collector
Date and Time
Place of Collection

2. Sample Seals

Sample seals are used to detect unauthorized tampering of samples ater collection, upto the time of analysis. The seals must be affixed to the sample container in a way that it has to be broken in order to open the sample container.

Seals must be affixed to the container by the collector.

3. Sample Analysis Request Form

Sample analysis request form accompanies the sample when it is delivered to the laboratory. The field portion of this form should be completed by the collector. The laboratory section is for completion by the laboratory analyst. The sample request form should include at the minimum:

Name of Collector
Date and Time of Collection
Location of Sampling Site
Field Number
Type of Sample
Analysis Requested
Date Received by the Laboratory
Laboratory Number
Results of Analysis
Date of Analytical Report
Name of Analyst
Remarks on Sample

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III. Sample Custody

When a sample arrives, it should be logged in immediately. The laboratory receiving personnel should look at the sample to verify:

- -Is the proper container used?
- -Is the container properly filled?
- -Is the quantity sufficient?
- -Is the sample seal intact?
- -Is the sample request form filled properly?

If the answer to any of the above question is no, the laboratory supervisor must be notified immediately. Also, the receiving personnel must verify if the sample had been appropriately preserved. If not, if must be preserved according to instructions in Table 1. This Table is posted for reference in the receiving area.

All samples received must be logged in a logbook and a unique laboratory number must be noted on the sample container, sample analysis request form, and log-book. In addition, the logbook must include information of laboratory sample number, sample identification information, type and condition of sample, and analysis requested. The recipient of the sample should sign the chain of custody form (see below).

Chain of Custody

Chain of Custody is a documentation of the sample history form collection to data reporting. A sample is considered under a person's custody if (1) it is in a person's physical possession, (2) in view of the person after he has taken possission, (3) secured by that person so that no one can tamper with the sample, or (4) secured by that person in an area which is restricted to authorized personnel.

The chain of custody form records the history of sample possession from collection, to analysis, and finally, to sample disposal. The form is printed on the same sheet as the sample request form. It must accompany the sample upon delivery to the laboratory. Information on the chain of custody form should include at least the following:

Name of the person in possession of sample
Affiliation of the person in possession
Date in possession

Once the sample has been logged in and the laboratory assume responsibility for it, the sample must be stored in a secure location. Whether the location should be refrigerated or not depends on the type

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of sample or analysis requested. Refer to Table 1 for storage conditions. Typically, all samples for organic analyses must be stored in the refrigerator/freezer. Samples for trace metal analysis maybe stored at room temperature except those requiring Chromium VI analysis. The latter must be refrigerated.

Refrigerator/Freezer used for sample storage must be different from those used for storing standards. In addition, samples for volatile analysis must be stored separately form non-volatiles. On each refrigerator/freezer, a chart is posted outside to record daily temperature readings, date, and name of person monitoring the temperature.

After properly receiving and securing the sample, worksheets are written up providing information on sample laboratory number, type, analysis requested, received date, and maximum holding time. Table 1 posted in the receiving area also contain information on holding times as a guide in preparing the work sheets.

A copy of this section on sample custody is posted in the receiving area to serve as a guide for the receiving personnel.

Table 1

A. Hazardous Waste

Analysis Requested	Storage & Preservation	Maximum Holding Time
Inorganic Tests:		
Cyanide, total & amenable to chlorination	P, G Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid	14 days
Fluoride	P None required	28 days
Hydrogen ion (pH)	P, G None required	analyze immed.
Metals:		
Chromium VI	P, G 4°C	24 hours
Mercury	P, G HNO_3 to pH 2	28 days
Metals except chromium VI and mercury	P, G HNO_3 to pH 2	6 months
Phenols	G only Filter immediately, Cool, 4°C cool, 4 C, H_2SO_4 to ph 2	28 days
Sulfide	P, G Cool, 4°C, zinc acetate plus sodium hydroxide to pH 9	7 days
Organic Tests:		
Purgeable Halocarbons	G, Teflon-lined septum Cool, 4°C 0.008% $Na_2S_2O_3$	14 days
Purgeable aromatic hydrocarbons	G, Teflon-lined septum Cool, 4°C 0.008% $Na_2S_2O_3$, HCI to pH2	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum Cool, 4°C 0.008% $Na_2S_2O_3$, adjust ph to 4-5	14 days
Phenols	G, Teflon-lined cap Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction 40 days after extractio
Phthalate esters	G, Teflon-lined cap Cool, 4°C	7 days until extraction 40 days after extractic
PCBs acrylonitrile	G, Teflon-lined cap Cool, 4°C	40 days after extractic
Nitroaromatics and isophorone	G, Teflon-lined cap Cool, 4°C, 0.008% $Na_2S_2O_3$ store in dark	40 days after extractic
Polynuclear aromatic hydrocarbons	G, Teflon-lined cap Cool, 4°C 0.008% $Na_2S_2O_3$ store in dark	40 days after extractic
Chlorinated hydrocarbons	G, Teflon-lined cap Cool, 4°C	40 days after extractic
Pesticides Tests:		
Pesticides	G, Teflon-lined cap Cool, 4°C, pH 5-9	40 days after extractio

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B. Drinking Water

Analysis Requested	Storage & Preservation	Maximum Holding Time
Volatile Organic Chemicals	4°C, Acidify to pH 2 with 1+1 HCl (1 drop/20 ml. sample)	14 days
Base/Neutral and Acid Extractables, Non-purgeable Organic Chemicals	4°C, Protected from light, For chlorinated waters add Sodium Thiosulfate, 80 mg/l. of sample	Extract within 7 days; complete analysis within 40 days of extraction
Ethylene Dibromide (EDB) Dibromochloropropane (DBCP)	4°C, No chemical Preservative	28 days
Organohalide Pesticides and Aroclors	4°C, Sodium Thiosulfate, 3 mg crystals/	Extract within 7 days; complete analysis within 40 days of extraction
Nitrogen or phosphorus Containing Pesticides	4°C, *Mercuric Chloride to 10 mg/l.	14 days
Chlorinated Pesticides	4°C, *Mercuric Chloride to 10 mg/l.	Extract within 7 days; complete analysis within 40 days of extraction
Chlorinated Herbicides	4°C, No chemical preservative	Extract within 7 days; complete analysis within 40 days of extraction
N-Methyl Carbamoyloximes	4°C**, Sodium Thiosulfate, 7 mg/100 ml.; Acidity to pH3 with HCl (1+1) (Samples for Aldicarb and Endothall must be frozen)	Extract within 7 days; complete analysis within 40 days of extraction
Bentazon	4°C, No chemical preservative	Extract within 7 days; complete analysis within 40 days of extraction

*Use caution in handing this toxic chemical. Dispose of contaminated sample in appropriate manner.

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IV. Calibration Procedures and Frequency of Calibration

A. Standards and References

1. Sources of Standards

99% of our standards come from the following sources:

Quality Assurance Branch
EMSL - Cincinnati
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

U.S. Environmental Protection Agency
Pesticides & Industrial Chemical Repository
(MD-8)
Research Triangle Park, NC 27711

Supelco, Inc.
Supelco Park
Belleforte, PA 16823-0048

Aldrich Chemicals
P.O. Box 2060
Milwaukee, Wisconsin 53201

National Bureau of Standards
Gaithersburg, Maryland 20899

All standards are obtained from reliable sources who can certify the purity of the materials.

Upon receipt, all neat standards are entered into an inventory book which includes the date received, who received it, source or supplier, lot number, conc./purity, expiration date, date opened, and who opened the bottle. The bottle itself containing the neat standard is labelled with the date received and initialled, expiration date, and date opened and initialled.

2. Preparation of Standards

Standards are prepared as outlined in the laboratory's specific Standard Operating Procedures (SOP) Manual. All information pertinent in the preparation of the standard are entered in the laboratory's Standard Preparation Book. Which include the following:

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PREPARATION OF CONCENTRATED STOCK STANDARDS

No.________ Date___/___/___ Chemist ________________

Compound________________ Lot No.________ Purity________

Final Gross Wt.________g Dilution Vol.________ml

*Tare Wt.________g Concentr.________ng/ul

Net Wt.________g

**Adj. Net Wt.________ng

PREPARATION OF STANDARDS OF INTERMEDIARY CONCENTRATION

NO.________ Date___/___/___ Chemist________________

Compound________________

Strength of Concentrated Stock ________ng/ul

Aliquot of Concentrated Stock ________ml

Dilution Volume ________ml

Final Concentration ________ng/ul

PREPARATION OF FINAL WORKING STANDARD SOLUTIONS

No.________ Date___/___/___ Chemist________________

	Compound	Parent Sol. Number	Conc. of Parent Sol. ng/ul	Aliq. Vol. ml	Dilution Vol. (ml)	Final Conc. pg/ul
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

Standard solution bottles are also labelled individually with the concentration, solvent used, date prepared, expiration date and initials of the preparer.

3. Storage of Standards

All degradable and volatile organic compounds are stored in a freezer at below 0°C. This is true for any concentration: neat or solution.

Trace metal standards, except chromium VI, are stored at room temperature. Chromium VI is refrigerated.

4. External Reference Standards

Whenever possible, check standards are ordered from the EPA or NIST. These are used to verify the accuracy of the working standards. If unavailable from EPA or NIST, standards from another supplier or different lot number from the same supplier are used as check standards.

B. Calibration Procedures and Frequency

Specific calibration procedures are included in the analytical method and in the operator manual of that instrument. Each analytical instrument is calibrated at least daily when in use. The analyst is responsible for calibration. All the calibration data are kept in specific QC books.

There are calibration guidelines in the use of gas chromatographs, HPLC's, and atomic absorption spectrophotometers. These guidelines are applicable regardless of the instruments' make and model.

GC and HPLC Calibration Guidelines

1. Calibration Curve

Initially before use, a 5-point calibration curve must be established for each analyte of interest in order to determine the linearity of the concentration range of interest in the GC system to be used. A calibration curve is established by plotting the system response, as in peak height or peak area, versus the concentration of the standard applied to the system. The concentration of the standards used must correspond to the expected range of concentration in real samples, or must define the working range of the detector used. One standard concentration that must be included should be near but above the method detection limit (check individual method references for tabulated list of MDLs). An alternative to establishing a calibration curve is the definition of calibration factors (CFs) for the analyte of of interest at each standard concentrations.

$$CF = \frac{\text{Total Peak Area/Height}}{\text{Mass Injected (ng)}}$$

For each analyte, five CFs would be obtained. Calculate the percent relative standard deviation of the CFs. If the %RSD is less than 20%, it can be assumed that the line defined by the CFs is linear through the origin and that the CF can be used instead of a calibration curve for calculation of the concentration of the analyte in real samples.

2. Calibration Standard

On a daily basis, a calibration standard must be injected and analyzed in the GC system to be used in the analysis. The response of the standards must fall within ±15% of the established calibration curve or factor (see appropriate QC Record Book for current values). If outside the ±15% limit, the cause of change must be determined and corrected, if possible. If the problem is one that is inherent in the system and cannot be corrected, then a new 5-point calibration curve must be established (see Pre-Analysis QC Requirements) before any real sample can be analyzed. Monitor the response of the calibration standard every 10 samples. The ±15% limit must be met with every injection of the standard. Record daily calibration parameter in Form 2.

3. Retention Time (RT) Windows

Prior to any new analyte testing and each time a new GC column is installed, retention time windows must be defined initially for each analyte and its corresponding surrogate and matrix spike standards there after. To determine the RT windows, make a minimum of three injections of all single analyte standard mixture and multiresponse analyte like chlordane over a 71-hour period. Calculate the standard deviation of the absolute RTs of each analyte with every injection. For multiresponse analyte, choose a major peak from the group of peaks and calculate the standard deviation of its absolute RTs from every injection. The RT windows are defined as the ±3S, where S is the standard deviation, of the absolute retention time for each analyte. Record all Rts and windows in Form 2. From the injection of the calibration standard of the analyte of interest, determine the retention time and make certain it falls within the established windows.

AA spectrophotometer Calibration Guidelines

Calibration Curve

- must be prepared each day with a minimum of a reagent blank and three standards at different levels of concentrations. Determine the absorbances of each blank and standards. Plot the absorbances versus the concentrations. This plot establishes the linear curve for the day of the atomic absorption spectrophotometer used. Follow themanufacturer's instructions in preparing the calibration curve for the particular instrument used. Verify the curve every ten samples by analyzing a blank and a mid-level standard. The results of the verification should be within +20% of the original curve. If not a new curve must be generated. Use form 3 to record calibration data.

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for____________________

Date	Conc. (ng)	Response	Acceptable CFs	Remarks

Form 1

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Gas Chromatographic Conditions:
System: ______________________ Carrier Flow: ______________________
Column: ______________________ Detector: ______________________
Col. Temp.: ______________________

Analyte \ Date	RETENTION TIMES								WINDOWS

Form 2

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______ ATOMIC ABSORPTION CALIBRATION CURVE

DATE/ ANALYST	STANDARD CONCENTRATION					CORRECTIVE ACTION/ COMMENTS
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
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	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	
	0 ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	ppm/ abs	

[illegible]

[illegible]

Form 3

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V. Analytical Procedures

A. Methods Used

All the analytical procedures used are from published sources from the following list:

1. Test Methods for Evaluating Solid Waste, SW-846, 3rd Edition, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. November, 1986.

2. Methods for Chemical Analysis of Water and Wastewater, EPA-600/4-79-020, 1984 U.S. Environmental Protection Agency.

3. Standard Methods for the Examination of Water and Wastewater, 15th and 16th Edition, APHA-AWWA-WPCF, Washington, D.C. (1980-1085).

4. The Determination of Inorganic Anions in Water by Ion Chromatograph - Method 300.0, EPA-600/4-84-017, March 1984, U.S. Environmental Protection Agency.

5. EPA Drinking Water Methods, 500 Series.

If applicable; certain methods are written in out line form for routine use in the laboratory. They are included in the laboratory's Standard Operating Procedure (SOP) Manual. For any analyst using methods for the first time, it is recommended that references noted on the upper right hand corner of the outlined form be thoroughly studied prior to the use of the outline.

1
8
5
9
5

B. Detection Limit

Method Detection Limit (MDL)

Method detection limit is the lowest concentration level detectable in the laboratory instrument. It corresponds to an analyte signal-to-noise ratio of two with the analyte being introduced to the instrument in clean solution, i.e., reagent water or reagent grade organic solvent. Typically, the laboratory has the same MDL as those listed under specific analytical methods such as the EPA 500 series. The laboratory verifies that the listed MDLs are indeed applicable by directly injecting or introducing standards at the MDL level to the instrument and obtaining a signal-to-noise ratio of at least two from the injection.

Practical Quantitation Limit (PQL)

Practical quantitation limit (PQL) is the lowest quantifiable level that can be reliably achieved during a routine laboratory analysis of an analyte in a given matrix. This value is typically higher than the MDLs because it is matrix dependent. In determining PQLs, the laboratory follows the method given in the publication EPA-600/4-82-057, Appendix A.

C. Record of Analysis

For each analytical batch, all pertinent data related to the analysis including method used, sample weight or volume, dilutions, standard concentrations, description of instruments used and name of analypt are entered into a permanent log-book (Hazardous Waste) or worksheets (drinking water) which are filed as permanent records of the laboratory.

D. The laboratory maintains Standard Operating Procedures (SOP) Manual for both hazardous waste and drinking water analyses. These manuals contain the different analytical methods used in the laboratory in outline form. This is a cookbook-type outline generated from published methods which includes, whenever applicable, the following:

1. Scope and Applications
2. Detection limits (instrument and method)
3. Precision and Bias
4. Working range
5. Summary of Method
6. Sample collection, preservation, and holding times
7. Comments
   A. Interferences
   B. Helpful hints
8. Safety issues (specific to the method)
9. Apparatus
10. Reagents and standards
11. Procedure (detailed step-by-step)
    A. Sample preparation
    B. Calibration
    C. Analysis
12. QA/QC requirements
    A. QC samples
    B. Acceptance criteria (precision and accuracy)
    C. Correction action required
13. Calculations
14. Reporting
    A. Reporting units
    B. Reporting limits
    C. Significant figures and reporting values below detection limit
15. References
    A. Method source
    B. Deviations from source method and rationale

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VI. Data Reduction, Validation and Reporting

A. Data Reduction

Equations and calculation procedures are included in the laboratory's SOPs. All the calculations must be attached to the copy of laboratory report for filing. Corrections for the blanks maybe made where appropriate. Calculations by the instrument/integrator is acceptable.

B. Data Validation

All results generated by the laboratory must be validated through the simultaneous analyses of required quality control (QC) samples/standards with the unknown sample. These include:

1. Instrument calibration with three concentration levels of standard and continuing single standard calibration every ten sample of an analytical batch.

2. Analysis of a method blank every batch of 20 samples for hazardous waste (every batch of 10 samples for drinking water) or type of matrix, which ever is more frequent.

3. Analysis of matrix spiked samples in duplicate at least once for every batch of 20 samples for hazardous waste (every batch of 10 samples for drinking water) or type of matrix which ever is more frequent.

4. Once during the analysis, an external reference standard should be used to check the concentration of the calibration standard.

After completing the analyses of an analytical batch, results of the above QCs must be recorded and plotted in the appropriate quality control chart (see form 4). Precision and accuracy control charts are maintained to determine if the QC results of an analysis are within established control limits. Control limits are initially set after the analysis of ten matrix spike and duplicate samples.

Thereafter, they are periodically set to reflect current performance.

It is the responsibility of the analyst to determine that all appropriate quality control operations have been performed and that all QC results fall within established limits. If any of the required QC is out of control the analyst must initiate corrective actions.

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C. Data Reporting

Analytical results are ready to be reported as soon as it is verified that all quality control data fall within the laboratory's established limits. All data generated, both for the actual sample and the quality control sample must be entered in the appropriate worksheet, log-book and QC books. All information related to the sample analysis such as weight, volume, and QC results must be recorded. All results reported to the submitting agency would be presented with the appropriate number of significant figures, proper units such as ppm, method used, and practical quantitation limits. Worksheets, instrument out puts (e.g. chromatogram), analytical results, sample request for and report of analysis form are put together in a file and submitted to the laboratory supervisor for review. The supervisor signifies his/her approval by signing the report of analysis form to be sent to the submitting agency.

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PRESICION AND ACCURACY DATA

Matrix/Unit ______________________

Analyte: ______________________

	1	2	3	4	5	6	7	8	9	10	11	12
Batch #												
Date												
amt.spike												
unspiked												
spike 1												
spike 2												
ave.												
spike %recovery												

Accuracy

	1	2	3	4	5	6	7	8	9	10	11	12
Ave.												

Precision

	1	2	3	4	5	6	7	8	9	10	11	12
Ave.												

Form 4

VII. Internal Quality Control Procedures

In order to document the laboratory's ability to test for the analyte of interest, certain quality control procedures are followed. These procedures are divided into two: (1) pre-analysis QC requirements and (2) daily or on-going QC requirements.

1. **Pre-Analysis QC Requirements - QC Check Samples**

   The laboratory's ability to generate results with acceptable accuracy and precision using a published method must first be verified before the analysis of actual samples. This is done through the analysis of four QC check samples prepared according to Sec. 8.6.2, Method 8000, SW-846. Briefly, QC check samples are prepared by spiking four aliquots of reagent water with known amounts of the analytes in the method to be used. The average recovery ($\bar{R}$) of the analytes in ug/L and the standard deviation (s) in ug/L of the recoveries are calculated and compared with those listed under the QC Acceptance Criteria Table found at the end of each published method. If the $\bar{R}$ and s values calculated fall within the limits defined in the table, then the system performance is acceptable and analysis of actual samples can begin. If any individual analyte's $\bar{R}$ or s fall outside the limit, then the system performance in unacceptable for that analyte. QC check samples must then be analyzed just for the analyte that failed. If re-analysis produced results within limits, then the system performance is acceptable. Repeated failure signifies a general problem with the measurement system. If this occurs, the source of the problem must be located and corrected - then QC check samples must again be ran for <u>all</u> the analytes.

2. **Daily QC Requirements**

   On a daily basis or each time a sample or batch of samples is analyzed, certain quality control samples must be ran: method blanks, duplicates, and matrix spike/matrix spike duplicates. From these quality control samples, control charts may then be generated which would allow for the establishment of accuracy and precision limits for the laboratory.

   Method Blank

   The analytical result of the method blank (or reagent blank) must be free of any analyte contamination. If contaminated, the source of contamination must be determined and corrected. After correction, the batch must then be re-analyzed if the sample quantity permits; or

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if not, results of the analysis maybe released with appropriate warnings on the nature of the contamination.

Hazardous waste - blanks must be ran once every analytical batch of 20 samples or less or each type of matrix whichever is more frequent. Since it is impossible to obtain a universal matrix blank for non-aqueous/solid samples, only reagent water is used.

Drinking water - blanks must be ran once every analytical batch of ten or less. Reagent grade water is used as blank.

Duplicate Samples

Duplicate samples are prepared by dividing a sample in two and analyzing them separately. Duplicate samples serve the purpose of monitoring the precision of measurement system. The results of the duplicate analyses must be within 20% of each other. If not an error has occured and it must be determined and corrected. The batch must then be re-analyzed. If the duplicate samples are negative for the analytes tested, then the matrix spike (see below) must be ran in duplicate to measure the precision. Duplicates must be ran once for every batch of 20 hazardous waste samples or less or each matrix type whichever is more frequent. Drinking water analysis requires duplicates to be ran every 10 samples.

Matrix Spike/Matrix Spike Duplicates (MS/MSD)

A predetermined amount of the analyte standard is added to a sample matrix to prepare the matrix spike sample. If the unknown samples to be analyzed are expected to be negative, then the sample matrix for spiking is first split into duplicates prior to the addition of the standard. Both matrix spike and matrix spike duplicate are analyzed simultaneously with the unknown samples. Recoveries of the analyte from the spike samples measure the accuracy of the method and the percent difference between the matrix spike and matrix spike duplicate assesses the precision of the analysis. The level of standard for spiking must be at the regulatory level or the method quantification limit. Samples with analyte concentration greater than 0.1% do not require the analysis of matrix spikes. Matrix spike and matrix spike duplicates must be ran for 5 % of the total analytical batch or each matrix type of hazardous waste. Drinking water requires the analysis of MS/MSD for 10% of the analytical batch. The accuracy and precision obtained from the MS/MSD must fall within the established lower and upper control limits of the laboratory. Continuing spike recoveries are recorded in form 4.

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3. Other QC Requirements

Periodically, samples are re-analyzed by another analyst. This is especially true in situations wherein a seemingly valid result is obtained but does not agree with the history of the sample.

Good Laboratory Practices

Good laboratory practices are followed to assure continued production of reliable results. These include not only topics previously discussed, i.e., sample custody, calibration, analytical procedures, data handling, and internal quality control procedures, but also glassware cleaning, verification that the sample containers, reagents and laboratory water are free of contamination, local and state safety codes are followed, fume hoods are routinely monitored, and hazardous waste are disposed of properly.

1. Glassware cleaning - glassware used for metal analysis should be acid washed. Refer to the published analytical methods for detailed procedures. Glassware used for organic analysis should be washed with solvent used in the analytical procedure. If trace amount of the organic contamination is found, it maybe necessary to clean the glassware in a muffle furnace.

2. Only reagent grade chemicals are used.

3. Type II deionized water is used in the analytical method and for method blanks.

4. Sample containers must be verified to be free of contamination. To accomplish this, a container from every lot received is rinsed with water or methanol, whichever is applicable, and analyzed.

5. Air flow in the fume hoods are monitored periodically by qualified personnel. The maximum operating height of the fume hood door is marked accordingly.

6. Safety procedures are adhered to. The laboratory has a safety manual that is distributed to all personnel. It covers topics on emergency procedures as in cases of fire or chemical spills, laboratory safety procedures with regards to handling different types of chemicals and executing certain laboratory tasks, and state-required hazardous material communication procedures.

7. Local and state safety codes are incorporated in the laboratory safety manual. As with all other safety procedures in the manual, they must be adhered to.

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VIII. Performance and Sytem Audits

The laboratory undergoes periodic performance and system audits through external and internal proficiency samples.

External Proficiency Samples

Currently, the laboratory has three sources of external proficiency samples. They are the California Dept. of Food and Agriculture, California Dept. of Health Services, and the Environmental Protection Agency.

CDFA Proficiency Samples

On a quarterly basis, the CDFA sends a minimum of four proficiency samples to the laboratory. Fifty percent of these are plant tissues and the other 50% are environmental samples such as water, soil, and swabs. The samples are spiked with pesticides from the organochlorine, organophosphorus, and/or carbamate group. Results of the proficiency sample analyses are sent back to CDFA for evaluation and they in turn mailback to the laboratory statistical analysis of results as compared with theoretical valves and other laboratories' results.

CDHS

Periodically, the laboratory had received performance evaluation samples from the CDHS. The samples received were for both hazardous waste and drinking water analysis. The samples were spiked with some of the analytes the laboratory was accredited for. As with the CDFA proficiency samples, after submitting the P.E. sample results to CDHS, the laboratory receives a statistical analysis of the results reflecting the comparison of results with the CDHS's accept/reject criterion.

EPA

On January 1990, the laboratory enrolled with the EPA to participate with the latter's Performance Evaluation Sample Program in water pollution. As a result, the laboratory anticipates receiving and analyzing P.E. sample for waste water periodically in the future.

Internal Proficiency Sample

Effective January 1990, the laboratory, on a quarterly basis, prepares and analyzes internal proficiency samples. A minimum of three samples are involved representing any of the environmental samples such as water, soil, plant, and wipe. The proficiency samples are spiked with some of the analytes typically ran in the laboratory. Reports are prepared from the results of the proficiency samples and compiled in the appropriate QC record book.

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IX. Preventive Maintenance

All minor maintenance and repair needed are accomplished by laboratory personnel. For major breakdowns, sufficient funds are budgeted annually to enable the laboratory to obtain service calls from qualified manufacturer's service engineers. The laboratory maintains a log book on any repair or maintenance of instruments.

All microbalance and platform balance are calibrated annually by qualified service engineers. On a weekly basis, the calibration of the balances are verified with standard weights.

All other service and maintenance needed by our laboratory for instruments and equipments are referred to their corresponding manufacturers. Based on yearly service expenses of the past years, sufficient amount budgeted annually to cover any future costs.

With the exception of Tracor Instruments which is located in Texas, all other manufacturers of our instruments could provide service within 48 hours after notification. Tracor has no local service representative so they take approximately one week before they send a serviceman.

The laboratory maintains a log book on instrument maintenance and repair for all major equipment used in the laboratory. It contains records on when an instrument is maintained and/or serviced, who provided the service, and what actions were taken.

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X. Assessment of Accuracy and Precision

Accuracy

Accuracy means the nearness of a result or the average of a set of result to the true value. Accuracy is represented by the percent recovery (R) if an analyte from a given matrix using a specific method. The percent recovery may be calculated as:

$$R = \frac{A-B}{T} \times 100\%$$

where: A is the calculated concentration of the analyte in the spiked matrix after analysis

B is the background concentration of the analyte in the matrix blank, if any.

T is the known value of the analyte spiked in the matrix blank.

To set the accuracy control limits of an analyte in a given matrix using a specific method, calculate the average of R values ($\bar{R}$) and their standard deviation (S_r). The accuracy control limit as recommended by the EPA is then defined as:

$$RLCL = \bar{R} - 2S_r$$

$$RUCL = \bar{R} + 2S_r$$

where: RLCL is the accuracy lower control limit
RUCL is the accuracy upper control limit.

Precision

Precision is the measurement of agreement of a set of replicate results among themselves without the assumption of any prior information as to the true value. Precision is measured using replicate or duplicate sample analysis. Precision as relative percent difference (RPD) is calculated as:

$$RPD = \frac{X_1 - X_2}{X} \times 100\%$$

where: X_1 and X_2 are results of duplicate analyses

X is the average of X_1 and X_2

As recommended by EPA, the laboratory's precision limit is ±20%.

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Control Charts

Precision and accuracy control charts are maintained for at least 10% of the analytes (min. 3 and max. 10) for a given method using form 4. Control limits are initially set after 10 data points. Thereafter, limits are periodically set to reflect current performance.

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XI. Corrective Action

Corrective action is initiated in out-of-control situations. A situation is considered out-of-control if any of the laboratory's internal quality control samples (see section VII) are outside established limits, i.e.:

1. Method blanks are coming out positive for the analyte of interest signifying that the analytical system is contaminated.

2. Results of duplicate samples are outside the 20% limit.

3. Spike recoveries fall outside the established laboratory's accuracy control limits.

For any of the above conditions, the senior personnel assigned to the unit will be notified immediately. It is his/her responsibility to decide which of the following corrective actions must be taken:

1. The analyst provides additional information or recalculations.

2. Instrument calibration and operation are checked. Calibration standards are checked and new ones are prepared if necessary. Instrument malfunctions are corrected.

3. New reagents are used if needed.

4. The analyst repeats the analysis of spiked samples using the same method.

5. A different analyst repeats the analysis of spiked samples using the same method.

6. The analyst repeats the analysis of spiked samples using a modified or new method.

No laboratory result will be sent until the problem is solved. All out-of-control situations and the corrective actions taken are documented by the senior personnel and submitted to the laboratory supervisor and/or chief for review.

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XII. Quality Assurance Report

On a monthly basis, senior personnel assigned to different units submit quality assurance reports for review by laboratory supervisor/chief. The reports contain a summary of the unit's QA activities during the period. The report includes the following information:

1. Date of analysis
2. Number of samples in the batch
3. Analytical batch number
4. Type of matrix
5. Analyte tested
6. Number of method blanks and results.
7. Number of matrix spikes and results
8. Number of duplicates and results
9. Detection limits
10. Name of analyst

In additon a copy of reports on out-of-control situations and corrective actions taken during the period are attached. The laboratory supervisor and/or chief reviews the QA report, signifies approval by signing them, and the reports are filed accordingly.

APPENDIX I

Calculation of standard deviation s from replicate measurements. e.g. lead in soil in mg/kg.

x	$(x-\bar{x})$	$(x-\bar{x})^2$
49.8	0.80	0.64
48.9	-0.10	0.01
51.3	2.3	5.29
51.3	2.3	5.29
45.9	-3.1	9.61
44.3	-4.7	22.09
52.2	3.2	10.24
50.0	1.0	1.0
47.6	-1.4	1.96

$\bar{x} = 49.0$ $\Sigma = 56.13$

$n = 9$

$$s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$$

$$s = \sqrt{\frac{56.13}{9-1}}$$

$$s = \sqrt{7,016}$$

$$s = 2,65$$

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APPENDIX 4

SUPPLEMENTAL QUALITY ASSURANCE MANUAL

VOL 12

COUNTY OF LOS ANGELES
Office of
Agricultural Commissioner/
Weights and Measures

ENVIRONMENTAL TOXICOLOGY LABORATORY

MICROBIOLOGY

Supplemental Quality Assurance Manual

1986

11012 Garfield Avenue, Bldg. B South Gate, CA. 90280

VOL 12

1

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NOTE: This is a supplemental manual to be used in conjunction with the Laboratory's previous Quality Assurance Manual.

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QA OBJECTIVES

1. Establish the laboratory's ability to perform qualitative and quantitative microbiology testing of drinking water and wastewater by:

   - identifying the qualifications and responsibilities of laboratory personnel (in previous QA Manual);
   - enumerating the existing laboratory instrumentation and equipment used in microbiology testing together with the procedures for their service and maintenance to assure proper operation;
   - providing sources of analytical methods accepted by regulatory agencies for use in the laboratory.

2. Provide guidelines pertaining to sampling protocols, chain-of custody, and storage of samples to maintain sample integrity prior to analyses.

3. Define the laboratory's calibration procedures and frequency of calibration.

4. Identify all the necessary steps to validate the laboratory's results.

5. Define all the necessary quality control checks that must be followed prior to the analysis and/or in the course of analyzing samples.

6. Identify all laboratory records and information needed to document the quality of analyses performed in the laboratory.

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SAMPLING PROCEDURES

Containers

Approved container for bacteriological sampling are presterilized Nasco Whirl-Pak bag or 4 oz. sterilized Nalgene or glass bottles. All samples containers must contain two drops of 10% sodium thiosulfate. One sample bottle from each batch of bottles prepared must be checked for sterility by adding several sterile tubes of single strenght lauryl tryptose and incubating for 48 hours and checking for growth.

Collection

Samples must be representative of the potable water distribution system. Water taps used for sampling are free of aerators, strainers, hose attachments, mixing type faucets, and purification devices. Maintain a steady water flow for at least 2 minutes to clear the service line before sampling. Collect at least a 100 mL sample volume, allow at least ½ inch air space to facilitate mixing of sample by shaking. Do not rinse sample container!

Holding/travel time between sampling and analysis is not to exceed 30 hours for potable water samples. If laboratory is required by State regulation to analyze samples after 30 hours and up to 48 hours, the laboratory is to indicate that the data may be invalid because of excessive delay before sample processing. No samples received after 48 hours are to be analyzed. Sample collectors who deliver samples directly to the laboratory should ice samples immediately after sample collection. All samples received in the laboratory are to be analyzed on the day of receipt.

Waste and surface water sample holding time is not to exceed 6 hours.

Labeling and Identification

Immediately after collection, the sample bottle must be labeled and the sample analysis request and report form filled out for each sample.

1. Sample Labels

   Samples labels are used for the specific identification of samples collected. Gummed paper labels affixed to the containers are adequate, but it should not be affixed to the sample lids. The labels should be filled

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out at the time of collection and should include the following information:

Sampling Site
Name of Collector
Date and Time of Collection

2. <u>Sample Analysis Request and Report Form</u>

The sample analysis request and report form (exhibit 1) accompanies the sample when it is delivered to the laboratory. The collector should complete the field portion of this form by providing information on sample site location, sample type, purpose of the sample, date and time of collection, free chlorine residual, collector's initial, and any remains.

Upon receipt of the sample the laboratory will log-in the sample and at the minimum, the following information will be stored and maintained:

Date of Collection, Receipt, and Analysis
Time of Collection, Receipt, and Analysis
Receiving personnel initial
Client and/or System name
Sample Site location and/or description
Purpose of the sample
Assigned individual laboratory identify number
Name of the Analyst
Analysis Requested
Results of Analysis
Remarks on the sample (if any)

Exhibit 1

COUNTY OF LOS ANGELES
Agricultural Commissioner/Weights & Measures
Environmental Toxicology Laboratory
11012B Garfield Ave., South Gate, Ca. 90280

SAMPLE FOR MICROBIOLOGICAL EXAMINATION

Date	Time	Lab No.

Laboratory Use Only

Purveyor and Address	County	Date/Hour Collected
Sampling Point — System Number	Collected By	Bottle Cap Number

Type of Sample: __ Drinking (Any Source) __ Sewage __ Surface __ Other ______

Send Report To:
Name: ______
Agency: ______
Address: ______
Phone Number: ______

Analysis Requested and Remarks:
__ Coliform __ Fecal Coliform
__ SPC __ Other ______

(To be filled in by laboratory only)

Tube/Portion Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Results
Portions in ml	(hr.)																					Coliform/100ml
Presumptive Test	24																					__ MPN
	48																					__ MF
Confirmed Test	24																					Fecal Coliform/100ml
	48																					__ MPN
E. C.	24																					__ MF

Laboratory Remarks
__ Leaked in transit
__ Unsufficient sample

SPC/ml at 35C | Cl2 Res. mg/liter

Analyst	Date	Director	Date

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EQUIPMENT TEMPERATURE AND USE RECORD

Incubator Temperature

The total coliform incubator are maintained at 35± 0.5°c and have a thermometer graduated in at least 0.5°c increments. A daily log of the temperatures read to 0.1°c are kept together with the date the entry was made and the initial of the person making the entry (see exhibit 2).

Water Bath Temperature (For Fecal Coliform)

Similarly, the fecal coliform water bath are maintained at 44.5± 0.2°c and have a thermometer graduated in at least 0.2°c increments. A log of the temperatures when the water bath is in use read to 0.1°c are kept together with the date the entry is made and the initials of the person making the entry (see exhibit 3).

Sterilizing Oven Temperature

A thermometer immersed in a sand bath is kept inside the sterilizing over to monitor the temperature. Records of all items being sterilized, total sterilization time, and temperature are kept (see exhibit 4).

Autoclave

An autoclave/Sterilization log is maintained. The log includes the date, time in, time out, total elapsed time, sterilization time, items sterilized, sterility controls, maximum temperature reached, and any maintenance performed (see exhibit 5).

Certified Thermometer

All thermometers used in laboratory are crosschecked against a certified thermometer annually. Records of calibrations and corrections are maintained (see exhibit 6).

INCUBATOR # ____

Make/Model ____________

DATE	TIME	TEMP.	INITIAL	DATE	TIME	TEMP.	INITIAL

Exhibit 2

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WATER BATH # ____
Make/Model #__________

DATE	TIME	TEMP.	INITIAL	DATE	TIME	TEMP.	INITIAL

Exhibit 3

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STERILIZING OVEN # ____
Make/Model ____________

DATE	ITEMS STERILIZED	TOTAL TIME	TEMP.	INITIAL	REMARKS

Exhibit 4

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AUTOCLAVE

Make/Model__________

DATE	TIME IN	TIME OUT	TOTAL TIME	ITEMS STERILIZED	MAX. TEMP.	CONTROL	INITIAL

Exhibit 5

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THERMOMETER CALIBRATION

DATE	THERMOMETER NUMBER	CERTIFIED THERMOMETER #	CALIBRATION/ CORRECTION	INITIAL	REMARKS

Exhibit 6

1 8623

R0051928

LABORATORY WATER QUALITY MONITORING

Bottled water is purchased from an outside source with an accompanying certificate of suitability. This is the water used to prepare the media. The parameters in the certificate include:

PARAMETER	LIMITS	FREQUENCY
Conductivity	>0.5 megohms resistance or <2 micromhos/cm at 25°c	Monthly
Pb, Cd, Cr, Cu, Ni, and Zn	Not greater than 0.05 mg/L per contaminant. Collectively, no greater than 0.1mg/L	Annually
Total Chlorine Residual	Nondetectable	Monthly
Heterotrophic	<500/mL	Monthly
Quality of Reagent	Ratio 0.8 - 3.0	Annually

Copies of the certificates of suitability are kept and maintained on file.

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MEDIA PREPARATION

The attached exhibit 7 is completed for each batch of media prepared. The information included in the form are:

Data of preparation
Preparer's initial
Media prepared
Weight of dehydrated media taken
pH of autoclaved media
Test of media with positive/negative cultures
Sterility check

All completed media preparation forms are kept in a binder for easy reference.

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8625

DATE MEDIA PREPARATION

PREPARED BY:				
BATCH NO.:				
Manufacturer:				
Control Number:				
Quantity Desired:				
Weight of Media Needed:				
Date Dry Media Opened:				
Weight of Beaker & Dry Media:				
Tare Weight of Beaker:				
Weight of Media:				
Distilled Water: pH				
Spec. Conductance:				
Standard Plate Count:				
Chlorine Residual:				
pH Meter Standardized:				
pH of Media Desired:				
pH Before Sterilization:				
pH After Sterilization:				
Autoclave Condition:				
Autoclave Temperature:				
Time of Run: On				
Off				
Length of Time on Sterilize:				
Manner Dispensed:				
No. of Pipetter Used:				
Volume in mL:				

Exhibit 7

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ANALYTICAL PROCEDURES

Methods

The methods followed by the laboratory taken from Standard Methods for the Examination of Water and Wastewater, 16th edition, 1985 are:

Total Coliform by Multi-Tube Fermentation (MPN)	Method 908A
Fecal Coliform by MPN	Method 908C
Total Coliform by Membrane Filter (MF)	Method 909A
Fecal Coliform by MF	Method 909C

The outline forms of the above methods are attached as Appendix A of this supplemental manual.

Quality Control

1. For each bottle of media positive, negative, and sterile checks will be performed and a log of the check results will be maintained (see exhibit 8).

2. Positive and sterile checks will be performed for every batch of prepared media and a log of the check results will be maintained (see exhibit 9).

3. Positive and negative controls are ran with each analytical batch for EC test.

4. For each analytical batch tested by membrane filtration technique, a sterile control is ran at the beginning and end of the sample run, and a positive control is ran after the last sample.

5. For each lot of membrane filters, sterile and positive checks are ran.

6. The Completed Test must be done every three months or every positive confirmed potable water sample, which ever applies. A log of all positive potable confirmed sample is maintained.

DRY MEDIA QC

DATE REC'D.	TYPE OF MEDIA	MANUFAC-TURER	LOT NUMBER	CHECK DATE	POSITIVE CHECK	NEGATIVE CHECK	STERILE CHECK	INITIAL

Exhibit 8

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PREPARED MEDIA QC

CHECK DATE	BATCH NUMBER	POSITIVE CHECK	STERILE CHECK	INITIAL	CHECK DATE	BATCH NUMBER	POSITIVE CHECK	STERILE CHECK	INITIAL

Exhibit 9

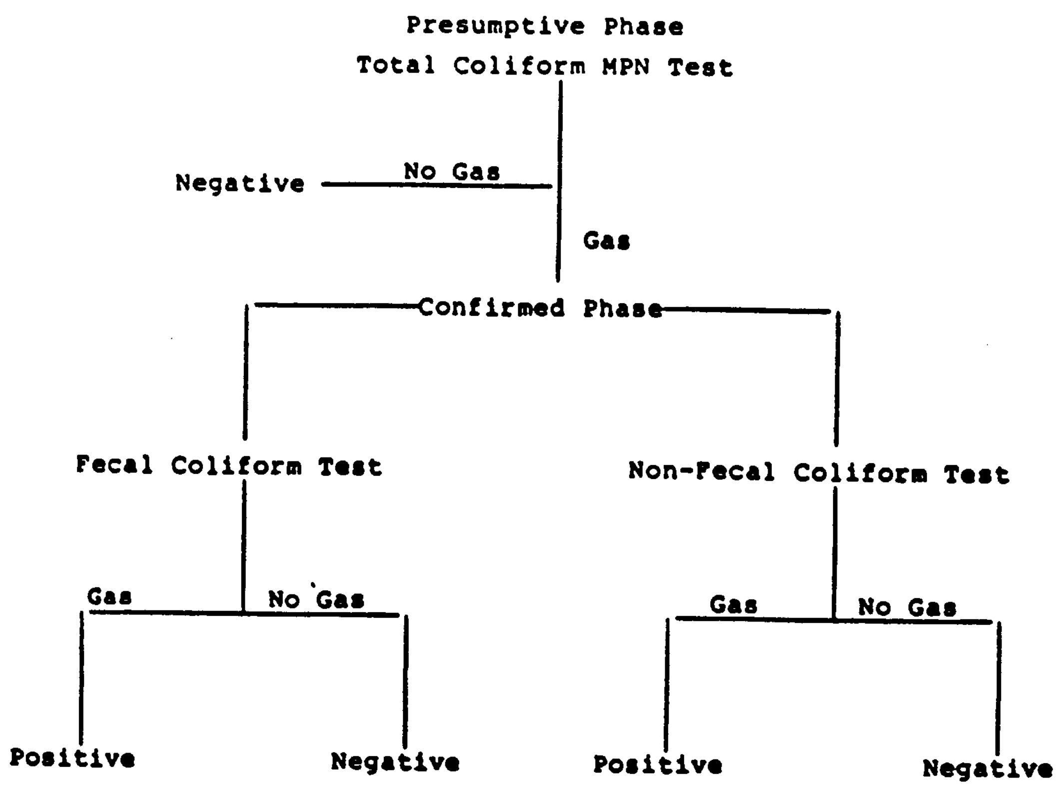
MEMBRANE FILTER QC

DATE RECEIVED	MANUFAC-TURER	LOT NUMBER	CHECK DATE	POSITIVE CHECK	STERILE CHECK	INITIAL	REMARKS

Exhibit 10

APPENDIX A: Methodology Outline

SUMMARY
OF
MULTIPLE-TUBE FERMENTATION TECHNIQUE
FOR THE COLIFORM GROUP



Effective Date: May 1991
Reference: Standard Method 908A

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Total Coliform Multiple Tube Test

Reagents: Presumptive phase fermentation tubes with lauryl tryptose broth.

Quality Control:

Perform duplicate analyses on 10% of samples or at least one sample per test run.

Procedure:

1. Pipet ten 10 ml portions of the sample in a series of presumptive phase fermentation tubes; mix thoroughly.
2. Incubate fermentation tubes at 35± 0.5°c.
3. After 24± 2h, shake the tubes and examine for gas formation then take the following steps:

Gas Formation	Step To Proceed
Yes	Positive Test - continue to test for fecal and non-fecal coliforms.
No	Continue to step 4 below.

4. Continue incubating up to 48± 3h then again reexamine for gas formation.

Gas Formation	Steps To Proceed
Yes	Positive Test - continue to test for fecal and non-fecal coliform.
No	Negative Test - procedure completed

NOTE: For drinking and recreational water samples with heavy growth but no gas formation, continue on to test for non-fecal coliforms.

Calculation: See Calculation: Estimation of Bacterial Density

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Effective Date: May 1991
Reference: Standard Method 908

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Fecal Coliform Test

Reagent: EC Medium Tubes

Quality Control:

Run one each positive and negative controls for each analytical batch.

Procedure:

1. Gently shake or rotate presumptive tube.
2. With a sterile 3 mm metal loop, transfer one loopful of culture to EC medium tubes.
3. Incubate tubes in a water bath at 44.5± 0.2°c for 24± 2hr. Be certain to Place all EC tubes in the water bath within 30 minutes after the transfer of the culture.
4. Periodically check the EC medium tube during the incubation period for any gas formation.

Gas Formation	Steps To Proceed
Yes	Positive - fecal coliforms present
No	Coliforms present are of non-fecal origin and next step will depend on the result of the non-fecal coliform test.

Calculation: See Calculation: Estimation of Bacterial Density

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Effective Date: May 1991
Reference: Standard Method 908A

Non-Fecal Coliform Test

Reagent: Brilliant Green Lactose Bile Broth (BGB) fermentation tube.

Procedure:

1. Gently shake or rotate primary fermentation tube showing gas.
2. With a sterile metal loop 3 mm in diameter, transfer one loopful of culture to a BGB fermentation tube.
3. Incubate BGB tube for 48± 3 hr. at 35± 0.5°c.
4. Periodically check BGB tubes during the incubation period for any gas formation.

Gas Formation	Steps To Proceed
Yes	Positive Confirmed Test - proceed to completed test for 10% of positive samples or at least one positive source water every quarter.
No	Negative Confirmed Test - procedure completed.

Calculation: See Calculation: Estimation of Bacterial Density

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R0051940

Effective Date: May 1991
Reference: Standard Method 9221D, 16th ed.

Calculation: Estimation of Bacterial Density

This method is used to calculate the Most Probable Number (MPN) of coliform/100 ml of sample.

No. of Tubes Giving Positive Reaction Out of 10 of 10 ml Each	MPN Index/ 100 ml	95% Confidence Limits (Approximate) Lower	Upper
0	<1.1	0	3.0
1	1.1	0.03	5.9
2	2.2	0.26	8.1
3	3.6	0.69	10.6
4	5.1	1.3	13.4
5	6.9	2.1	16.8
6	9.2	3.1	21.1
7	12.0	4.3	27.1
8	16.1	5.9	36.8
9	23.0	8.1	59.5
10	>23.0	13.5	Infinite

No. of Tubes Giving Positive Reaction Out of 5 of 10 ml each	MPN Index/ 100 ml	95% Confidence Limits Lower	Upper
0	2.2	0	6.0
1	2.2	0.1	12.6
2	5.1	0.5	19.2
3	9.2	1.6	29.4
4	16.0	3.3	52.9
5	16.0	8.0	Infinite

For volumes other 5ml or 10ml, use the following equation to solve for the MPN value:

$$\text{MPN value (from table)} \times \frac{10}{\text{Largest vol. tested}} = \text{MPN/100ml}$$

Note: MPN value is taken from table 9221:V of the Standard Methods.

Total Coliform Membrane Filter Procedure

Reagents: LES Endo Agar in petri dishes

Quality Control:

Run a sterile control at the beginning and end of the analytical batch and a positive control after the last sample.

Procedure:

1. Assemble filtration apparatus according to manufacturer's instruction.
2. Filter 100 ml sample under partial vacuum.
3. Rinse filtration apparatus with filter still in place with three 20 ml partions of sterile dilution water.
4. Remove membrane filter with a sterile forcep and place it on LES Endo Agar-filled petri dishes with a rolling motion to prevent entrapment of air.
5. Incubate dish for 22 to 24 hr. at 35± 0.5°c.
6. Count colonies that have pink to dark-red color with a metallic green-gold surface sheen using low-powered dissecting microscope.
7. Confirm all sheen colonies counted or a minimum of five colonies from drinking water samples by transferring growth from each colony to parallel tubes of lauryl tryptose broth and brilliant green lactose bile (BGB) broth.
8. Incubate both tubes at 35± 0.5°c for 48 hr.
9. Formation of gas in the BGB tubes confirms the colony as coliform. If only the lauryl tryptose broth showed any gas production, then transfer to a second BGB tubes. This second BGB tube must produce gas at 35± 0.5°c with 48 hr. to verify the colony as coliform.

Calculation:

$$\frac{\text{(Total) Coliform Colonies}}{\text{100 ml}} = \frac{\text{Coliform Colonies Counted X100}}{\text{ml sample filtered}}$$

95% Confidence Limits Using 100 ml Sample.

Number of Coliform Colonies Counted	95% Confidence Limits Lower	Upper
1	0.025	3.0
2	0.35	4.7
3	0.81	6.3
4	1.4	7.7
5	1.6	11.7
10	4.8	18.4

For counts, c, greater than 20 organism, the above limits maybe calculated by:

Upper Limit= $c + [2(2 + \sqrt{c})]$
Lower Limit= $c - [2(1 + \sqrt{c})]$

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Effective Date: May 1991
Reference: Standard Method 909C

Fecal Coliform Membrane Filter Procedure

Reagents: M-FC Broth

Quality Control:

Run a Sterile control at the beginning and end of the analytical batch and a positive control after the last sample.

Procedure:

1. Preparation of culture dish: Place a sterile absorbent pad in each culture dish and pipet approximately 2 ml M-FC broth to saturate the pad. carefully remove any excess liquid from culture dish.

2. Assemble filtration apparatus according to manufacturer's instruction.

3. filter 100 ml sample under partial vacuum.

4. Rinse filtration apparatus with filter still in place with three 20 ml partions of sterile dilution water.

5. Remove membrane filter with sterile forcep and place it on prepared culture dish in a rolling motion to prevent entrapment of air.

6. Seal petri dishes, submerge in water bath, and incubate for 24± 2h at 44.5± 0.2°c. Anchor dishes below water surface to maintain critical temperature requirements. Make certain that the petri dishes are in the water bath within 30 minutes after filtration.

7. Count colonies in various shades of blue using low powered microscope. These are colonies produced by fecal coliform bacteria.

Calculation:

$$\text{(Total) Coliform Colonies/100 ml} = \frac{\text{Coliform Colonies Counted X100}}{\text{ml sample filtered}}$$

95% Confidence Limits: The same as for Total Coliform Membrane Filter Technique.

VOL 12 1 8639

Effective Date: September 1991
Reference: Standard Method
14th Edition
Method 910A

VOL 12

<u>Presumptive Test for Fecal Streptococcus Group</u>

(Multiple-Tube Technique)

<u>Reagents</u>: Presumptive Phase Tubes with Azide Dextrose Broth

<u>Quality Control</u>:

1. Perform duplicate analyses on 10% of samples or at least one sample per test run.
2. Run Sterility Check and Positive Control with each batch of samples.

<u>Procedure</u>:

1. Pipet ten 10ml sample in a series of presumptive phase tubes: mix thoroughly.
2. Incubate tubes at 35 deg C ± 0.5 deg C.
3. After 24±2 hours, shake and examine tubes for turbidity then take the following steps:

Turbid	Step to Proceed
yes	Positive Test - continue to test fecal and non-fecal streptococcus.
no	Continue to step 4 below.

4. Continue incubating up to 48±3 hours then again re-examine for turbidity.

Turbid	Step to Proceed
yes	Positive Test - continue to test for fecal and non-fecal streptococcus.
no	Negative - procedure completed.

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Effective Date: September 1991
Reference: Standard Method
14th Edition
Method 910A

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Confirmed Test for Fecal Streptococcus

Reagent: Petri dishes with Enterococcesel (BBL trade name)

Quality Control:

Run one each of positive and sterile controls with each batch.

Procedure:

1. Gently shake or rotate presumptive tube.
2. With a sterile 3mm metal loop, streak a portion of the growth from each positive presumptive tube (with azide dextrose broth) on a petri dish containing enteroccocosel agar.
3. Incubate the dish inverted at 35±0.5 deg C for 24±2 hours.
4. Brownish-black colonies with brown halos confirm the presence of fecal streptococcus.

Calculation: See Calculation: Estimation of Bacterial Density

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Effective Date: September 1991
Reference: Standard Methods
14th edition
Method 910A

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Confirmed Test for the Enterococcus Group

Reagent: Brain Heart Infusion Broth tubes containing 6.5% Sodium Chloride.

Procedures:

1. Transfer brownish-black colonies with brown halos to a tube of brain heart infusion broth containing 6.5% NaCl.
2. Incubate at 45 deg C for 24 hours.
3. Periodically check the tubes during incubation for growth.
4. Growth in 6.5% NaCl broth indicates that the colony belongs to the enterococcus group.

Calculation: See Calculation: Estimation of Bacterial Density

1 8642

Effective Date: September 1991
Reference: Standard Methods 14th edition Method 910B

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Membrane Filter Procedure for Fecal Streptococcus

Reagents: KF Streptococcus Agar

Quality Control:

Run a sterile control at the beginning and end of the analytical batch and a positive control after the last sample.

Procedure:

1. Assemble filtration apparatus according to manufacturer's instructions.

2. Filter 100ml of sample under partial vacuum.

3. Remove membrane filter with a sterile forcep and place it on directly to KF Streptococcus agar medium in petri dish with a rolling motion to prevent entrapment of air.

4. Invert culture plates and incubate at 35±0.5 deg C for 48 hours.

5. Count colonies that have dark red to pink color using a low power binocular, wide field dissecting microscope.

Calculation:

$$\frac{\text{Total Colonies}}{\text{100ml}} = \frac{\text{Colonies Counted X 100}}{\text{ml sample filtered}}$$

For 95% Confidence Limits using 100ml sample, check Standard Method 909A.6.

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Waterbodies, Wetlands and their Beneficial Uses in the Los Angeles Region (4)

VOL 12

Volume 1. Waterbodies and their Beneficial Uses

A Report Presented to
L.A. Regional Water Quality Control Board

1 8645

Prem K Saint, Ted L. Hanes, William J. Lloyd
California State University, Fullerton

July, 1993

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EXECUTIVE SUMMARY

As a part of the Basin Plan update all the waterbodies, under the jurisdiction of the Regional Water Quality Control Board, Los Angeles Region, were evaluated for beneficial use designation. The investigation combined record search, field investigations and geographic information systems to recommend additions to the list of waterbodies and to designate appropriate beneficial uses. The study period, between summer 1991 and spring 1993, covered the last two years of a six-year drought and a winter of above normal precipitation and runoff in southern California.

The national Geographical Named Index System (GNIS) was utilized to compare their lists with the current waterbody inventory in the Basin Plans to produce a list of waterbodies to be added. We recommend an addition of 126 rivers, 44 lakes and reservoirs, 45 groundwater basins, 9 coastal features and 108 wetlands to the revised basin plan.

Wetlands are a new category of waterbodies as well as beneficial uses for the Los Angeles Region. Using the information in the National Wetland Inventory maps, the California Department of Fish and Game Natural Diversity Database we surveyed over 350 field sites for ecological and hydrological characteristics. We recommend the designation of WETLAND beneficial use for 15 estuarine and coastal wetlands, 14 lacustrine wetlands and 79 riparian wetlands.

During the last hundred years, as result of agricultural and urban development, the coastal plains of the Los Angeles Basin have experienced a loss of 90 % of the coastal marshes and 95-97 % of the riparian wetlands. The remaining wetlands provide habitat for rare and endangered species and sanctuaries for recreation for a dense urban population.

We recommend the expansion of the BIOL (Areas of Special Biological Significance), WILD (Wildlife Habitat) and GWR (Groundwater Recharge) designations as these apply to a highly urban Region such as Los Angeles. The uniqueness of the several remnant wilderness habitats in the waterbodies, especially with Rare and Endangered Species of animals and plants, would further protect water quality in these areas from pressures of urbanization.

We have identified and listed all the major groundwater basins and designated appropriate beneficial uses after consultations with managers of the water basins. We also acknowledge that the groundwater basins are recharged through influent streams and lakes in areas of bedrock in the surrounding hills and mountains. In order to protect the quality of our groundwater resources, which provide up to 70-80% of thr region's water supplies, we recommend that all those waterbodies in the recharge zones be designated as GWR.

Waterbodies, Wetlands and Beneficial Uses
of the Los Angeles Region

Volume 2: WATERBODIES AND THEIR BENEFICIAL USES

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R0051952

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LIST OF FIGURES

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LIST OF TABLES

Acknowledgement

This project has been funded wholly or in part by the United States Environmental Protection Agency using Federal 201(G)(I)(B) grant funds under Assistance Agreement No. C9009532-90-2 to the State Water Resources Control Board and by Agreement No. 0-169-254-0 in the amount of $129,178 to conduct a Waterbody Identification and Update of Beneficial Use Designation study. The contents of this document do not necessarily reflect the views and policies of the U.S. Environmental Protection Agency and the State Water Resources Control Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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1. UPDATING THE WATER QUALITY BASIN PLAN

1.1. INTRODUCTION

Federal and State laws establish the requirements for adequate planning, implementation, management and enforcement for control of water quality. Two Federal laws that specifically address the water quality management are the Water Pollution Control Act of 1972, and the Clean Water Act of 1977. The state law that governs water quality in California is the Porter-Cologne Water Quality Act of 1969.

The Federal and State water quality planning requirements call for the development, and periodic update of, Water Quality Control Basin Plans. The Basin Plans for the Los Angeles Regional Water Quality Control Board were last updated in 1978.

According to the section 13050 of the California Water Code, a Basin Plan for an area consists of three components:

1. Establishment of Beneficial Uses that are to be protected,
2. Water Quality Objectives that protect those uses, and
3. Implementation Plan that achieves those objectives.

This project report deals with the first part of the process and evaluates the existing beneficial uses in the 1978 Basin Plans and recommends beneficial uses for additional waterbodies of the region.

1.2. SCOPE AND OBJECTIVES:

The study covers the Los Angeles Hydrologic Basin Planning Area, Region 4, of the State Water Resources Control Board. The region is roughly coterminous with Los Angeles and Ventura Counties (Fig 1.1). The objectives of the study are to evaluate all the waterbodies and their beneficial uses in the region and recommend additional waterbodies, designate and update beneficial uses.

The various tasks performed to achieve these objectives are as follows:

1. Comparison of Waterbody Inventories in the Basin Plans with the U.S. Geological Survey Geographical Named Index System (GNIS) and other available inventories, to produce a list of additional surface waterbodies to be added. The surface waterbodies consist of rivers, lakes, bays, harbors, estuaries and wetlands. The groundwater basins were classified according to the State Water Resources Bulletin No. 118.

2. Identification and Field Survey of Wetlands, as identified in the National Wetland Inventory Maps and in reports

of other agencies.

3. Selection of Waterbodies and recommendations for Wetlands, to be added to the 1993 Basin Plan.

4. Determination of lengths and areal extent of all existing and recommended waterbodies.

5. Determination of Beneficial Use Designations (Existing, Potential, Intermittent) for each of the newly added waterbody or segment, using field surveys and agency surveys.

6. Re-evaluation of Existing Beneficial Uses in the 1978 Basin Plans, using field surveys and agency surveys.

7. Preliminary Assessment of the portions of the Los Angeles and San Gabriel Rivers, to characterize the vegetation and other biota related to occurrence of fish in these reaches.

2. ORGANIZATION AND METHODS

The fieldwork, data analysis and mapping of the waterbodies was carried out from July, 1991 to March, 1993. An interdisciplinary team from the Departments of Biological Sciences, Geography and Geological Sciences at California State University, Fullerton, performed most of the tasks. The supervision of the various tasks was as follows:

Biology tasks by Dr. Ted Hanes,

Geographic Information System and Cartography tasks by Dr. Bill Lloyd,

Groundwater basin mapping and assessment tasks by Dr. John Foster, who also acted as the Co-Principal Investigator, and

Surface Water Hydrology and Water Quality tasks by Dr. Prem Saint, who also acted as the Principal Investigator.

Beneficial Use Designation and Update was a cooperative effort between members of the various teams.

Several graduate and undergraduate students were involved in doing field surveys, data assessment and cartographic work; the listing on the inside front cover identifies all those who participated in this project.

2.0. METHODOLOGY

Apart from literature review and data collection from agency surveys, most new information for decision making came from field surveys and Geographic Information System (GIS) Analysis.

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2.1. GIS Methodology

Creation of GIS Layers

Study Area:

The boundaries of the GIS study area was constructed by combining the boundaries of the various hydrologic subdivisions that comprise Region 4 of the Water Quality Control Board. The boundaries of the individual Hydrologic Units, Hydrologic Areas and Hydrologic Subareas were digitized from mylar reproductions of U.S.G.S. 7.5 minute U.S.G.S. quadrangle maps provided by the W.Q.C.B. Basin boundaries and basin identifiers were clearly marked on the mylar maps for all areas except the Channel Islands. Island boundaries were digitized from U.S.G.S. 1:100000 scale topographic maps and assigned identifiers based on existing reports from the W.Q.C.B. All basins with identifiers beginning with the number "4" were included in a DRBASIN layer. These individual basins were then collapsed into a SUBREGIONS layer containing 10 groups of closely related basins, and a STUDY AREA layer containing all of the Region 4 basins.

Basin boundaries and all other geographic information in the GIS data base were projected into Universal Transverse Mercator (UTM) Zone 11 coordinates where necessary.

Streams:

STREAMS layers for each of the individual basins were created by clipping out all of the stream features for each basin from the U.S.G.S. 1:100000 digital line graphs. Stream segments were numbered in upstream order for each separate drainage contained within a basin. A computer program was developed which permitted naming of the streams through reference to data contained in the U.S.G.S. Geographic Names digital file. Names were cross-checked by referring to the 7.5 minute U.S.G.S. topographic quadrangle maps. Any named stream appearing on the 7.5 minute quad which was not included in the 1:100000 digital line graph data was added to the STREAMS layer by digitizing from the 7.5 minute quads.

In many cases, the precise channel followed by a tributary when it reaches a main stream cannot be determined and have not been mapped by the U.S.G.S. Where the gap between tributary and main stream was less than approximately 500 meters, the tributary was extended to the nearest point on the main stream. In rare instances where the gap was substantially larger than 500 meters, the tributary was retained as a separate, unconnected drainage.

Information from the digital line graph data and from the 7.5 minute quads was used to classify each stream as either permanent or intermittent.

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Lakes:

A LAKES layer for each of the basins was created by digitizing all lake and reservoir features for each basin from the U.S.G.S. 7.5 minute topographic quadrangle maps. Lake and reservoir features from the U.S.G.S. 1:100000 digital line graphs were added to the data base in cases where the date of the DLG data was later than that of the 7.5 minute quad. Lakes and ponds with areas less than 1 acre were omitted from the LAKES coverage. All features for each basin were assigned a unique number and all named features were also assigned their name based on the U.S.G.S. Geographic Names file and the U.S.G.S. 7.5 minute topographic maps.

Information from the digital line graph data and from the 7.5 minute quads was used to classify each feature as either permanent or intermittent, manmade or natural.

Coastal Features:

Coastal features were selected from a list of all named coastal features contained in the U.S.G.S. Geographic Names file. The locations of shoreline features were digitized into a COASTAL layer from 7.5 minute U.S.G.S. topographic quadrangle maps.

Features were classified as either estuaries, oceans\bays or harbors.

Wetlands:

Riparian wetlands were digitized from U.S. Fish and Wildlife Service 7.5 minute quadrangle maps into a RIPARIAN layer. Coastal wetlands were outlined on 7.5 minute U.S.G.S. topographic quadrangle maps and digitized into an AREA WETLAND layer in the GIS data set. Inland lacustrine wetlands were copied into the AREA WETLAND layer from the LAKES layer.

Water Quality Monitoring Stations:

The locations of water quality sampling and monitoring stations were derived from latitude and longitude information contained in a list of all stations within the study area. The latitude and longitude values were projected into UTM Zone 11 coordinates in a SAMSTN layer.

Field Sites:

The locations of field photograph sites were digitized directly into an FSITES layer from site locations indicated on U.S.G.S. 7.5 minute topographic quadrangle maps.

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Identification of Included and Proposed Features

All streams and lakes were classified as either "included" or "missing" based on whether or not they were identified by name in the existing Beneficial Use plan of the Regional Water Quality Control Board. Some streams which were indirectly included in the existing plan by virtue of the tributary rule were given the designation "tributary." The classification was accomplished by developing a computer program which compared the names of all features in each basin with a list of features that has been assigned beneficial uses in the existing plan. Reports were then created listing all streams and tributaries in upstream order by basin. Separate reports were prepared for all lakes. These reports, containing the feature name, included/missing designation, and a permanent/intermittent designation, were then used in the identification of candidate features for inclusion in the revised Beneficial Use plans.

A small number of the "missing" streams and lakes were changed to "proposed" when a decision was made to include them in the new Beneficial Use plans. All "included" and "proposed" streams and lakes were then merged into a single BENEFICIAL USE GIS data base spanning all of Region 4.

"Included" and "proposed" coastal features were identified directly from the master list of all coastal features. These features were then merged into the BENEFICIAL USE data base.

"Included" and "proposed" wetland features were also merged into the BENEFICIAL USE data base.

Finally, the SAMPSTN and FSITES layers were merged into the BENEFICIAL USE data base.

18556

Attaching Beneficial Uses

Each "included" or "proposed" stream, lake, coastal features and wetland was assigned a unique GIS identifier. A data base file was then created which contained the identifier, the feature name, feature type and basin identifier. This data base file was then expanded to include existing and proposed beneficial use designations. After completion of the beneficial use tables, the data can then be joined back into the GIS using the unique GIS identifier as a linking field.

2.2. FIELD SURVEYS

During the summer of 1991, field survey forms were designed (Appendix A.1.), and several field ecologists were trained by Dr. Hanes to carry out field surveys. As part of the survey, field stations were photographed and data collected on hydrological and ecological characteristics of the site. USGS 7.5 minute topographic maps were used in the field to record field sites. All field forms and photographs are presented as Appendix 1 (bound separately).

Hydrological observations included the presence of water, depth, width and flow characteristics. Approximate discharge was measured using float method, and in some cases, current meter method. Channel characteristics, including degree of erosion were also recorded. Occasionally water quality was measured for field temperature and electrical conductivity.

Ecological observations included floral and faunal information. For vegetation surveys sites were reconnoitered by driving or hiking a large enough area to become familiar with the communities present. Stands best representing each community were chosen and sampled by quadrant- or belt-transect method, for estimating species composition by percent cover. Techniques described in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands, 1989,* was used in the determination of the presence of hydrophytes.

Animal observations consisted of bird sightings (especially obligate wetland habitat birds, like Belted Kingfisher and Osprey), and noting the presence of fish and amphibians.

After summer 1993, more intensive surveys of beneficial uses were carried out using form type Appendix A2. Over 350 sites were surveyed as part of the field investigations.

2.3. AGENCY AND INTEREST GROUP SURVEYS

A list of 50 agencies and interest groups was compiled in cooperation with the Regional Water Quality Control Board staff. Three surveys were conducted using the survey forms, included in Appendix B.1.

(i) Existing Beneficial Use Survey for existing waterbodies,
(ii) Proposed Beneficial Use Survey for Coastal Waters,
(iii) Proposed Beneficial Use Survey for Groundwater Basins.

There were 27 responses and the summary of responses is included in Appendix B.2.There were follow-up telephone calls for clarification of comments, as indicated in the summary of responses. The comments were incorporated in planning future field surveys for beneficial use investigations. Copies of the agency survey responses are included in Appendix 2, bound separately.

3. HYDROLOGIC AREAS AND SUB-AREAS OF THE LOS ANGELES REGION SUB-REGIONS OF THE REGION 4

For the purposes of this investigation, the Region 4, Los Angeles Region, was subdivided into ten subregions (Fig 1.0). The subregions are:

A. Pitas Point Ventura

B. Sespe Creek

C. Piru Creek

D. Upper Santa Clara River

E. Oxnard Plain- Santa Paula- Calleuguas- Conejo

F. San Fernando Valley

G. Raymond- San Gabriel- Spadra- Anaheim

H. Coastal Plain

I. Malibu

J. Channel Islands

Each sub-region is divided into a number of Hydrological Units(HUs), Hydrological Areas (Has) and Hydrological SubAreas (HSAs). The boundaries of these divisions for each sub-region are shown in Fig 1.1- 1.10. The criteria for the division into the sub-regions included uniformity of hydrological and landuse and water use conditions as well as convenience of sizes for map reproduction purposes. Many of the subregions are similar to those identified and described in the 1978 Basin Plans (LARWQCB, 1978).

3.1. EXISTING AND PROPOSED WATERBODIES

Fig 1.1- 1.10 also identify the streams, lakes and reservoirs that were listed in the 1978 Basin Plan and those that are proposed for addition to the 1993 Basin Plan. The additional waterbodies, listed as proposed, were agreed upon between the Regional Board staff and California State University, Fullerton investigation team. The criteria used for proposed waterbodies were:

(a) perennial flows,
(b) size of the tributary,
(c) areas of special biological significance,
(d) areas with wilderness and wetland habitats,
(e) areas with reported rare and endangered species,
(f) waterbodies with stream gaging and water quality monitoring stations,
(g) waterbodies with significant landuse or wateruse.

Table 1.0 lists all the named surface waterbodies of the Region 4, by Hydrologic Units, and indicates whether a given waterbody is included in the 1978 Plan, or is proposed for the 1993 Plan. The table also indicates the type of waterbody, according to the following scheme:

stream, includes rivers and streams, without significant riparian wetlands.

riparian stream, includes rivers and streams, with riparian wetlands (riverine and palustrine), proposed for inclusion in the wetland category.

lake, includes lakes and reservoirs, without significant lacustrine wetlands.

inland wetland, includes mostly lakes, reservoirs and swamps, with lacustrine and palustrine wetlands, proposed for inclusion in the wetland category.

beach/bay, estuary, include coastal features, without significant coastal wetlands. These also include tidal prisms of the 1978 Plan.

coastal wetland, includes estuarine and palustrine wetlands, proposed for inclusion in the coastal wetland category.

islands, includes waterbodies of the Channel Islands, with no significant streams, lakes and reservoirs.

biolsig refers to areas of special biological significance, as approved by the Regional Water Quality Control Board.

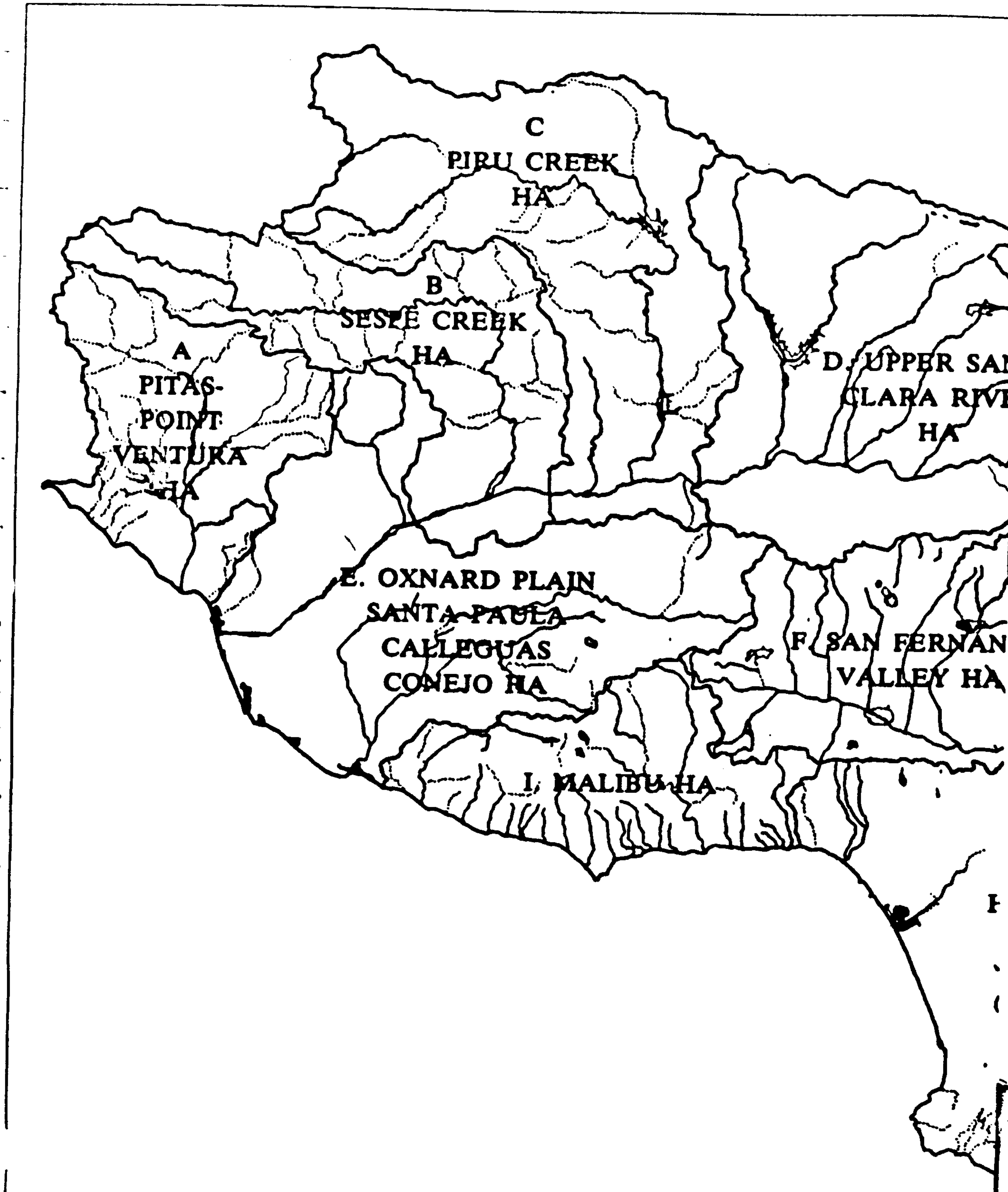
3.2. WATERBODY DIMENSIONS AND FLOW CHARACTERISTICS

Table 2.1. lists all the named rivers and streams, included or proposed, and with measures of stream length and channelized streams, in miles. Channelized streams include portions with concrete sides and/or bottoms.
The table also lists streams that are intermittent (I), or permanent (perm), identified by interpretation of USGS 7.5 minute maps, and several verified through field inspections. The table also identifies streams with significant riparian wetlands, proposed for inclusion in the wetland category.

Table 2.2 lists all the lakes and reservoirs, included or proposed, with areal extent, in acres. It also lists lakes and reservoirs that are intermittent or permanent, as identified by map interpretation and several verified through field inspections. The table also identifies lacustrine wetlands, proposed for inclusion the wetland category.

Other tables include: Table 2.3 Groundwater Basins
Table 2.4 Wetlands

The computer aided measures of lengths and areas were checked for accuracy, using manual instruments like planimeter and stadiometer. The calculations were found to be within the domain of reasonable accuracy.


C
PIRU CREEK
HA
B
SESPE CREEK
HA
A
PITAS-
POINT
VENTURA
HA
D. UPPER SAN
CLARA RIVE
HA
E. OXNARD PLAIN
SANTA PAULA
CALLEGUAS
CONEJO HA
F. SAN FERNAN
VALLEY HA
I. MALIBU HA

VOL 12 1 8660

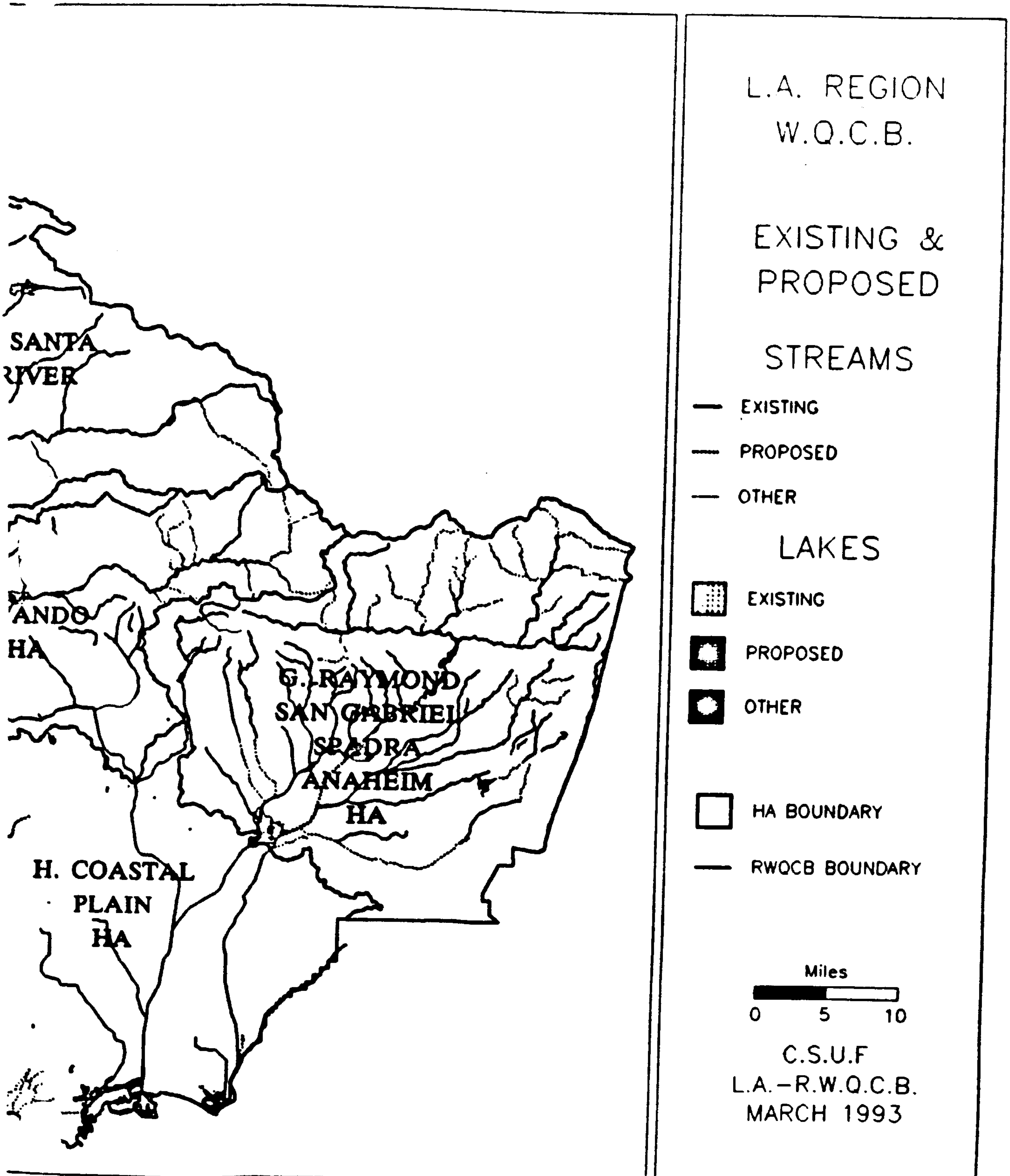


FIG 1.0.

VOL 12 1 8661

R0051966

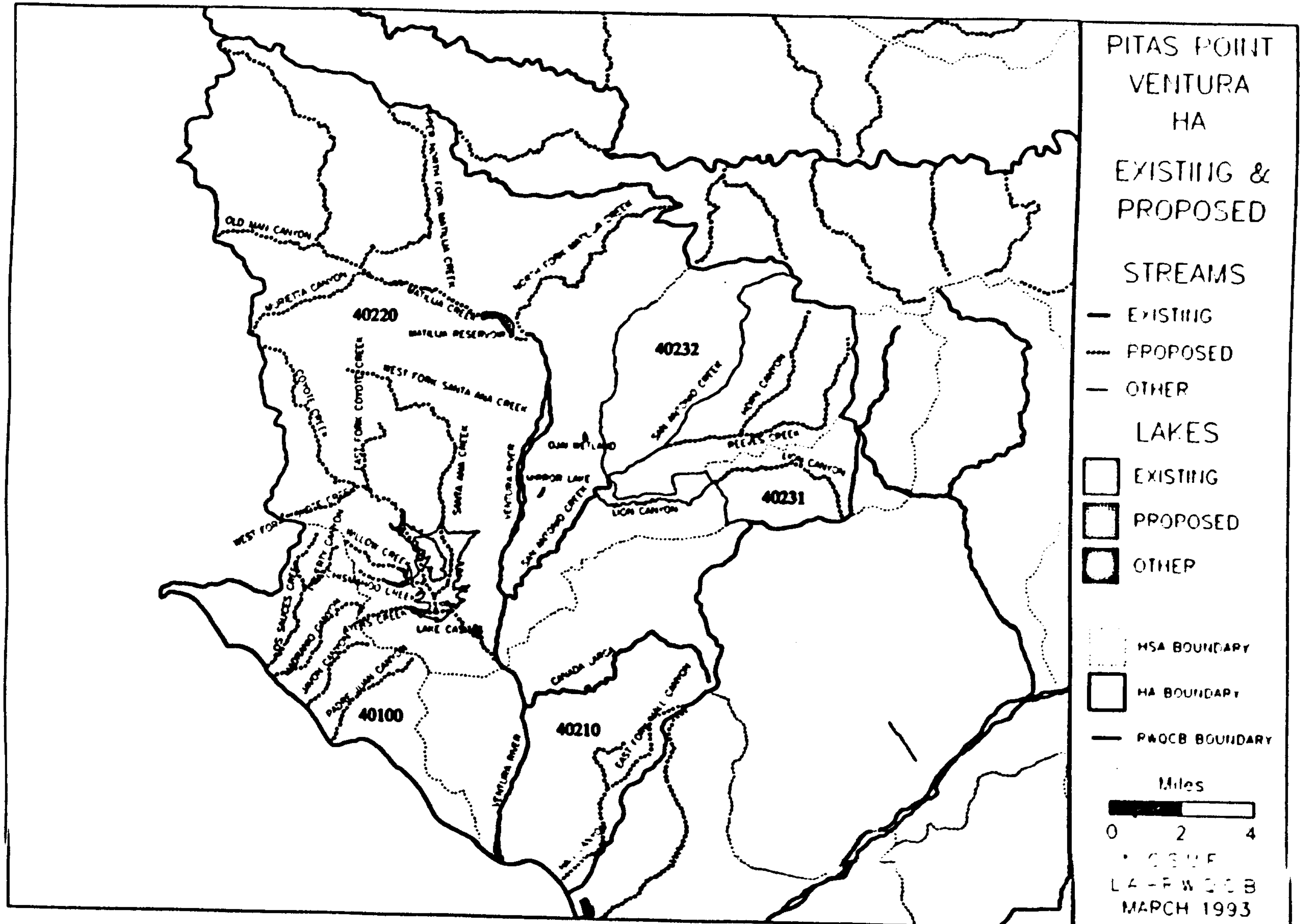

PITAS POINT
VENTURA
HA
EXISTING &
PROPOSED
STREAMS
EXISTING
PROPOSED
OTHER
LAKES
EXISTING
PROPOSED
OTHER
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
MARCH 1993
40220
40232
40231
40100
40210
OLD MAN CANYON
MATILIJA RESERVOIR
WEST FORK SANTA ANA CREEK
SANTA ANA CREEK
VENTURA RIVER
SAN ANTONIO CREEK
LION CANYON
LAKE CASITAS
CANADA LARGA

FIG 1.1.

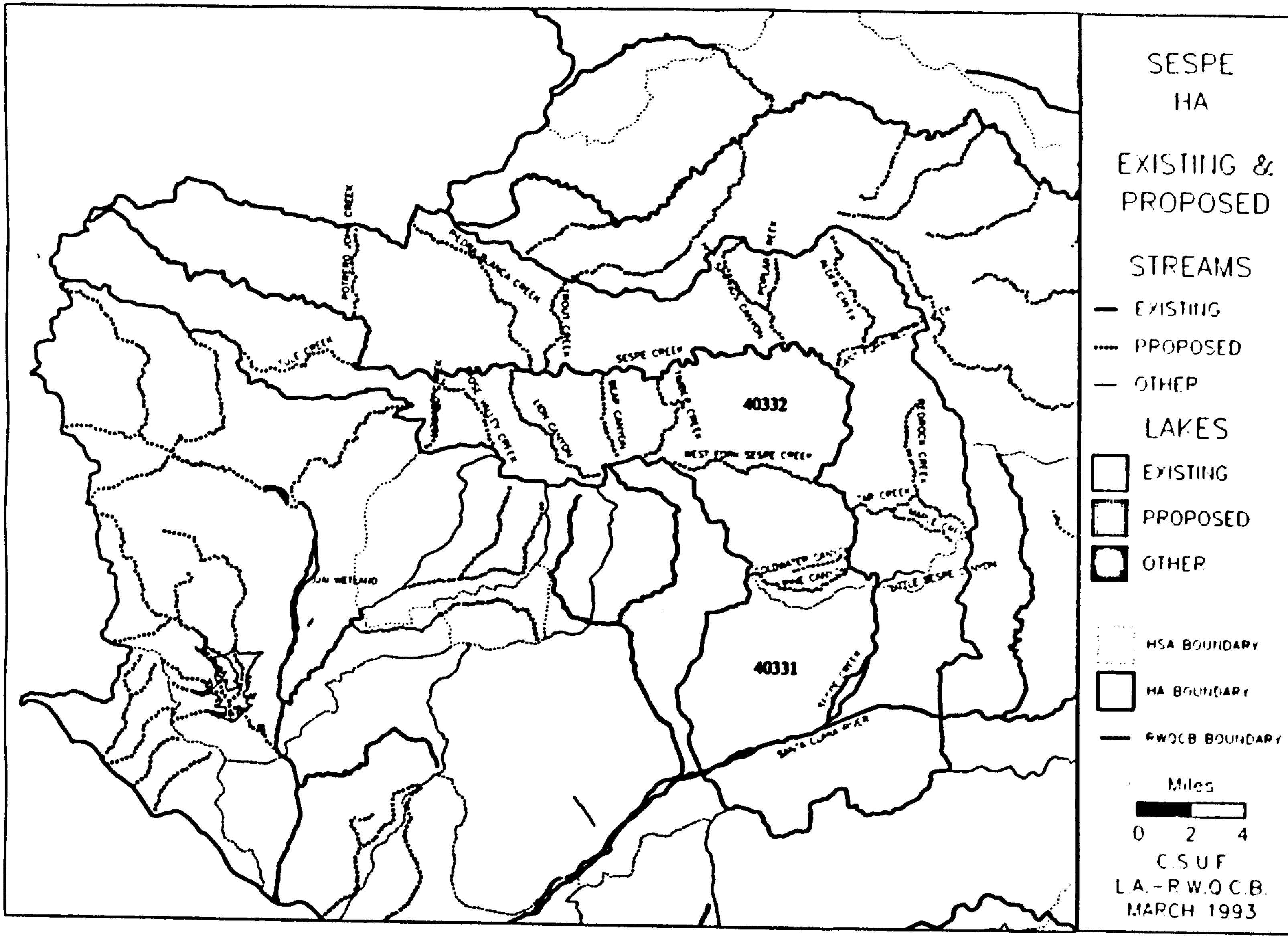
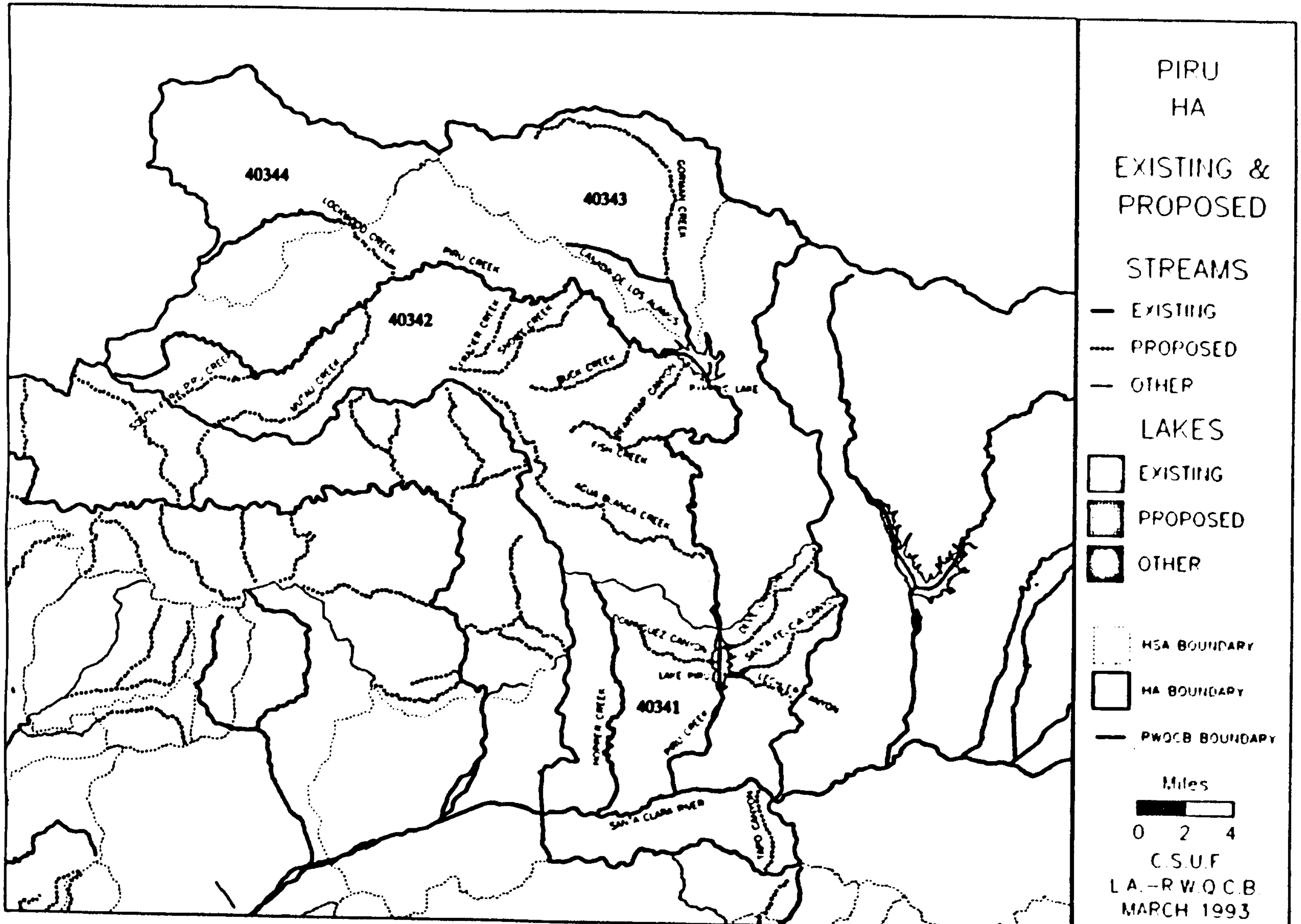

SESPE
HA
EXISTING &
PROPOSED
STREAMS
EXISTING
PROPOSED
OTHER
LAKES
EXISTING
PROPOSED
OTHER
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
40332
40331
SESPE CREEK
WEST FORK SESPE CREEK
SANTA CLARA RIVER
TULE CREEK
PIEDRA BLANCA CREEK
TROUT CREEK
LION CANYON
BEAR CANYON
ROSE VALLEY CREEK
POTRERO JOHN CREEK

FIG 1.2.



40344
40343
40342
40341
LOCKWOOD CREEK
PIRU CREEK
GORMAN CREEK
CANADA DE LOS ALAMOS
FISH CREEK
AGUA BLANCA CREEK
BUCK CREEK
LAKE PIRU
SANTA CLARA RIVER
HOPPER CREEK
PIRU
HA
EXISTING &
PROPOSED
STREAMS
EXISTING
PROPOSED
OTHER
LAKES
EXISTING
PROPOSED
OTHER
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
C.S.U.F
L.A.-R.W.Q.C.B
MARCH 1993

FIG 1.3.

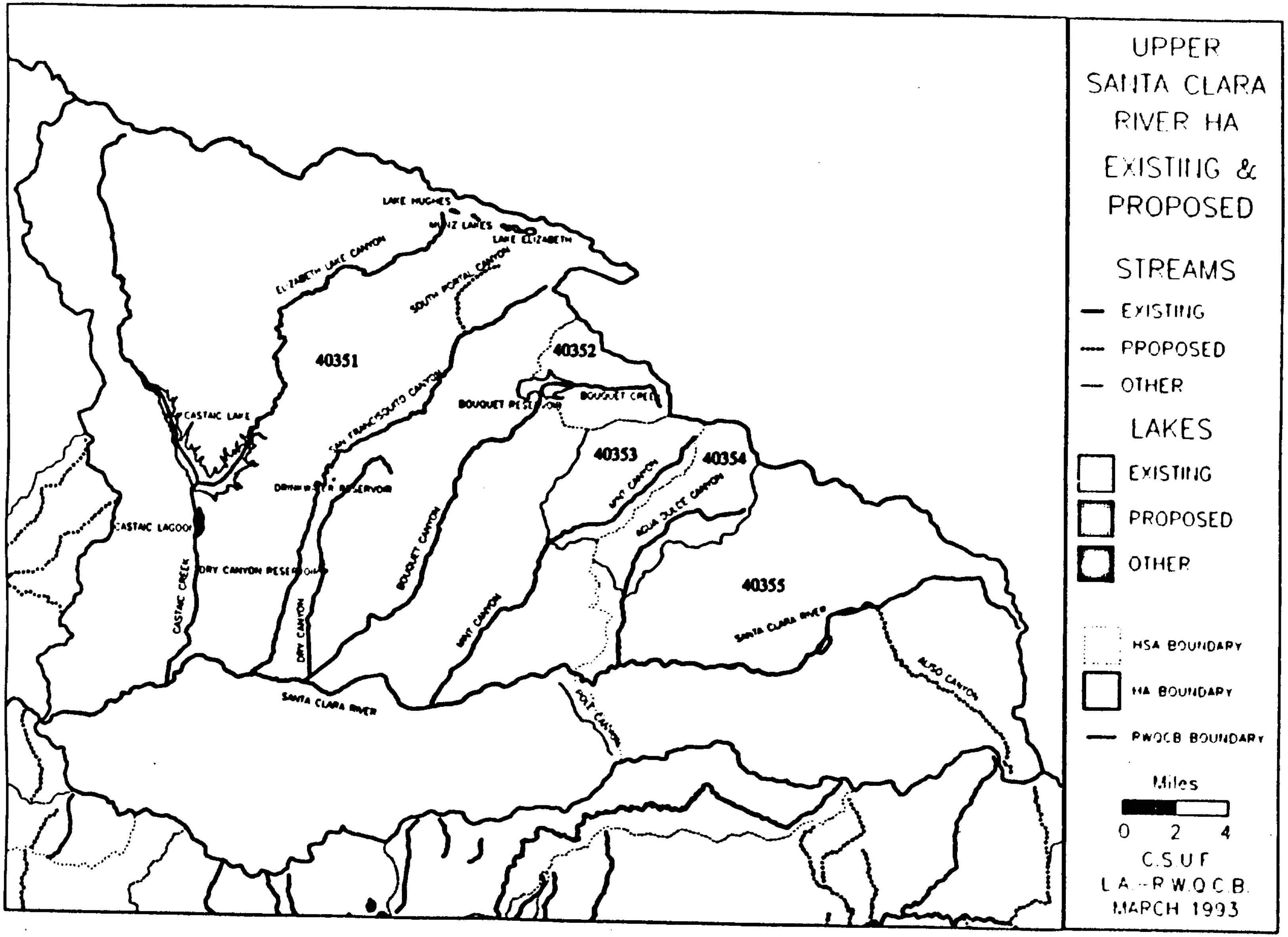

UPPER
SANTA CLARA
RIVER HA
EXISTING &
PROPOSED
STREAMS
EXISTING
PROPOSED
OTHER
LAKES
EXISTING
PROPOSED
OTHER
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
C.S.U.F
L.A.-R.W.Q.C.B.
MARCH 1993
40351
40352
40353
40354
40355
LAKE HUGHES
LAKE ELIZABETH
ELIZABETH LAKE CANYON
SOUTH PORTAL CANYON
CASTAIC LAKE
CASTAIC LAGOON
CASTAIC CREEK
DRY CANYON RESERVOIR
DRY CANYON
SAN FRANCISQUITO CANYON
BOUQUET CREEK
BOUQUET CANYON
MINT CANYON
AGUA DULCE CANYON
SANTA CLARA RIVER
ALISO CANYON

FIG 1.4.

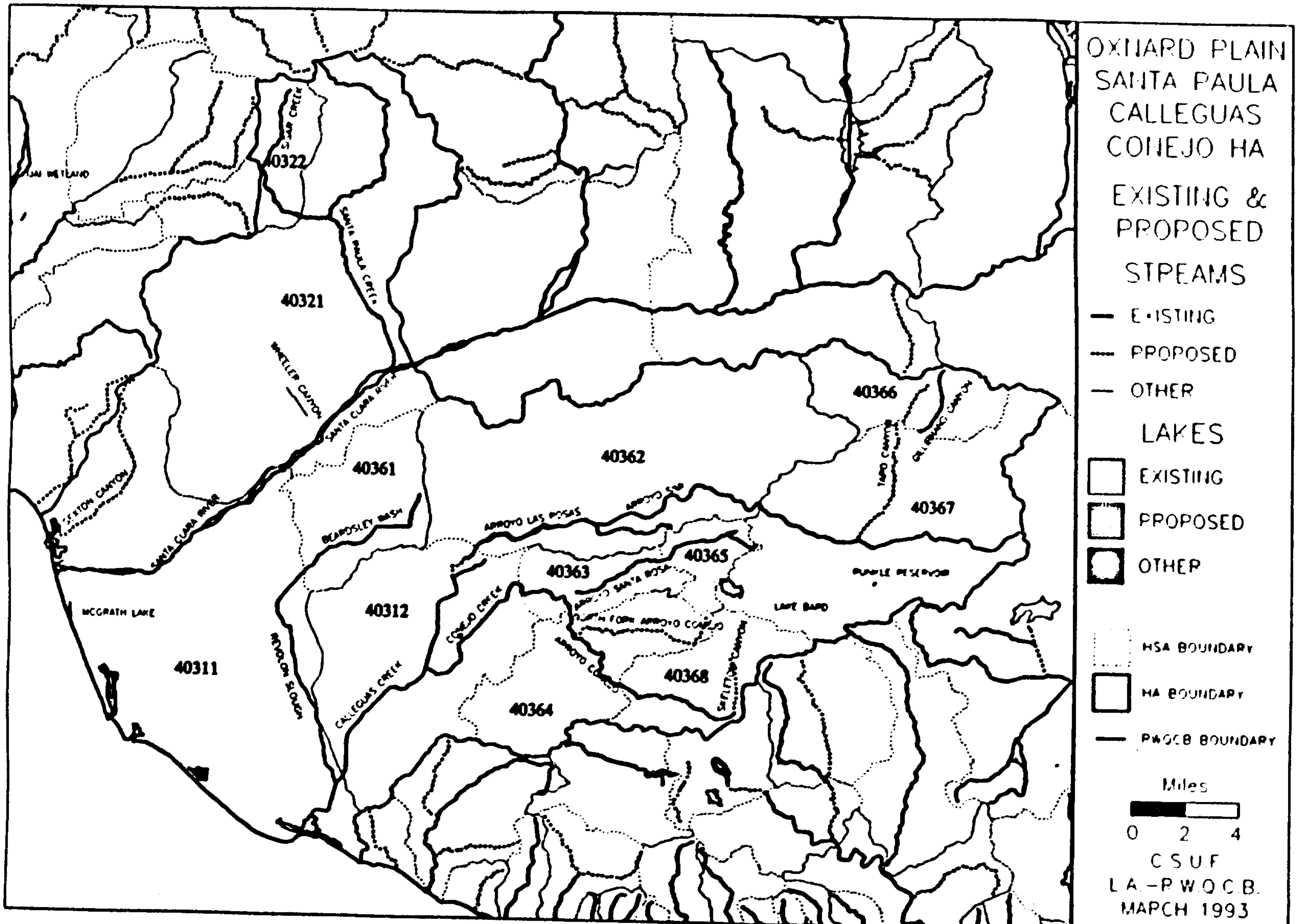
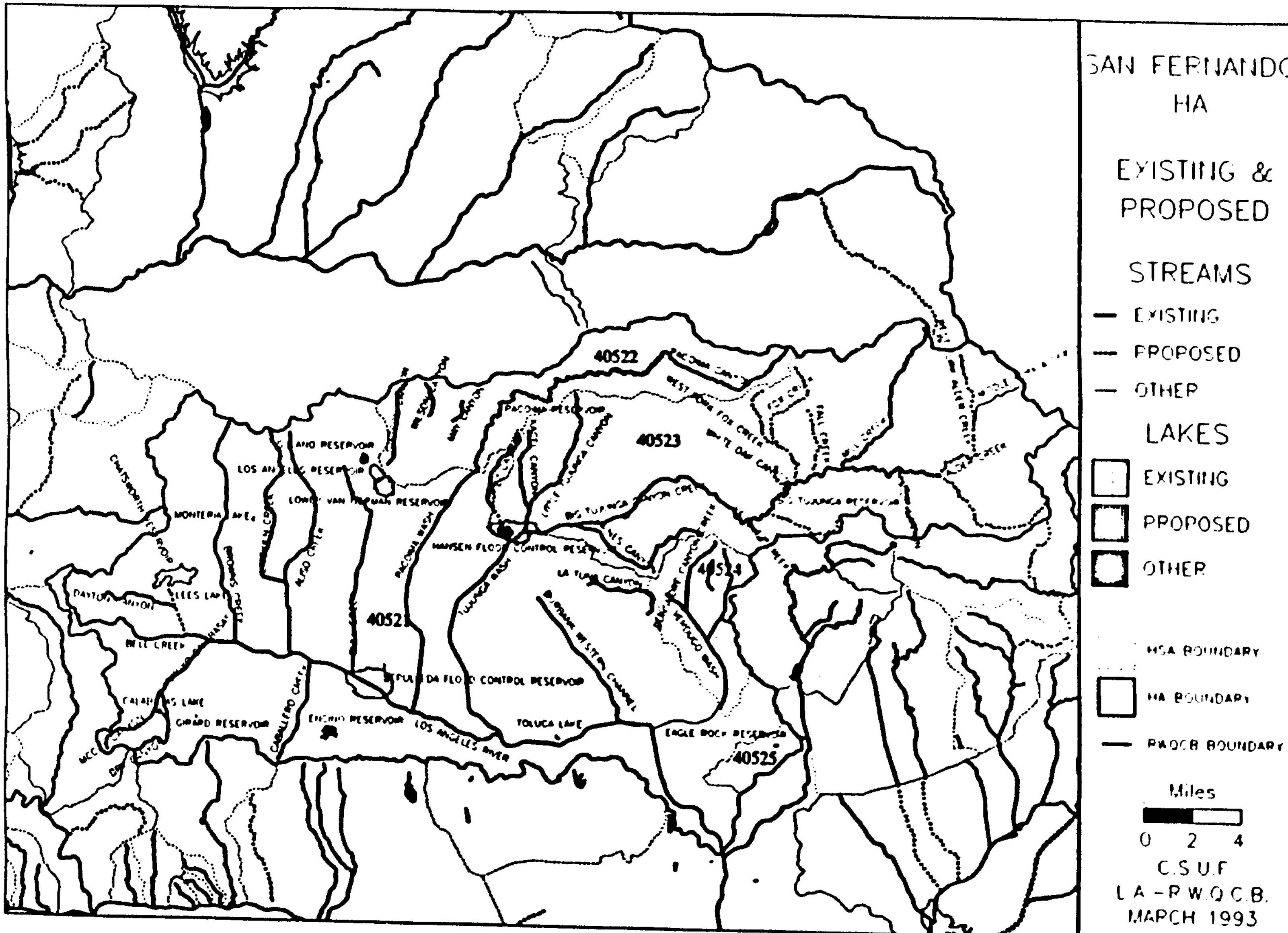


FIG 1.5.

R0051971


SAN FERNANDO
HA
EXISTING &
PROPOSED
STREAMS
EXISTING
PROPOSED
OTHER
LAKES
EXISTING
PROPOSED
OTHER
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
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L.A.-R.W.Q.C.B.
MARCH 1993
40522
40523
40521
40524
40525
PACOIMA RESERVOIR
LOS ANGELES RIVER
TOLUCA LAKE
ENCINO RESERVOIR
EAGLE ROCK RESERVOIR
SEPULVEDA FLOOD CONTROL RESERVOIR
HANSEN FLOOD CONTROL RESERVOIR
GIRARD RESERVOIR
BELL CREEK
LA TUNA CANYON

FIG 1.6.

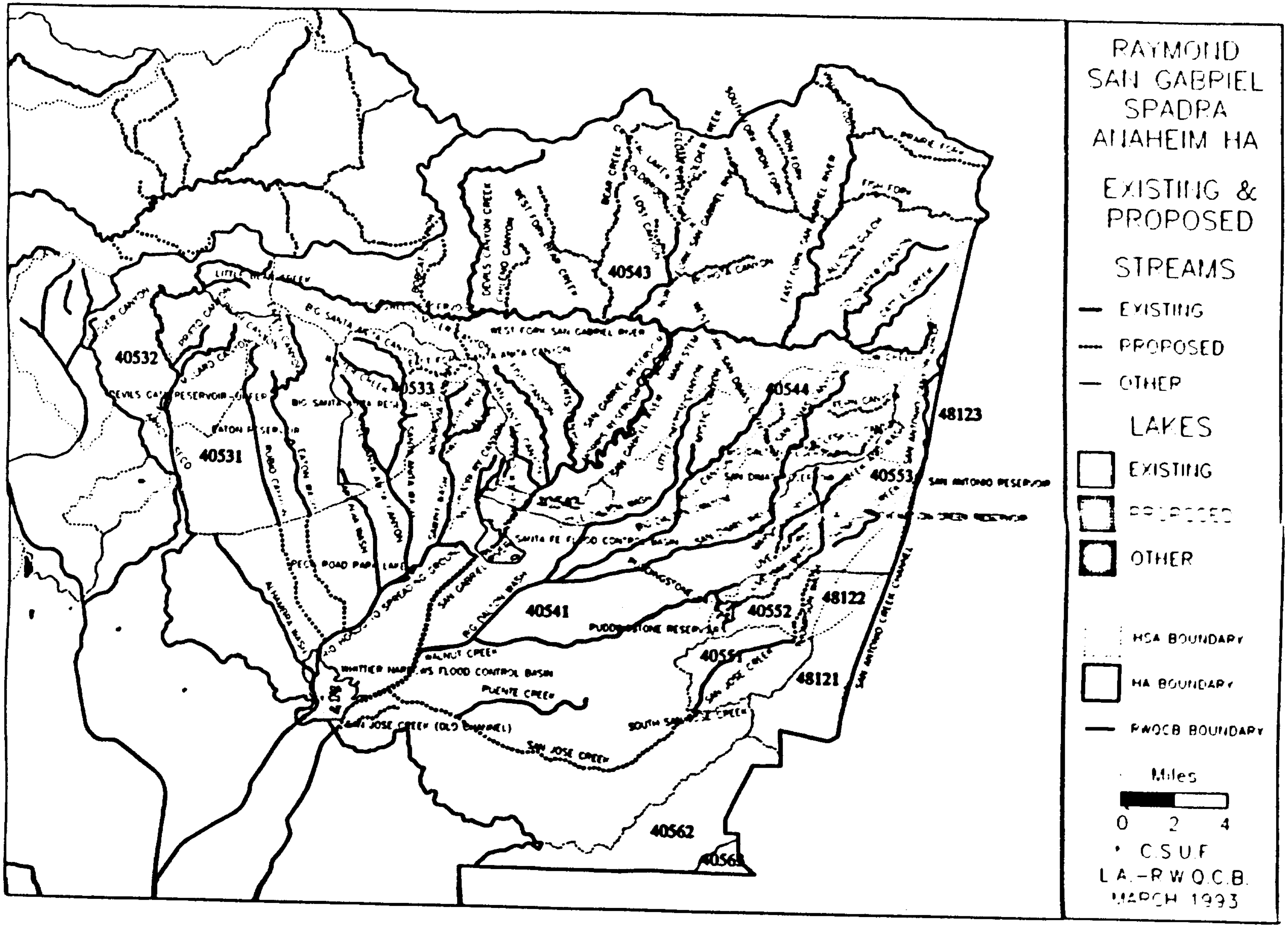
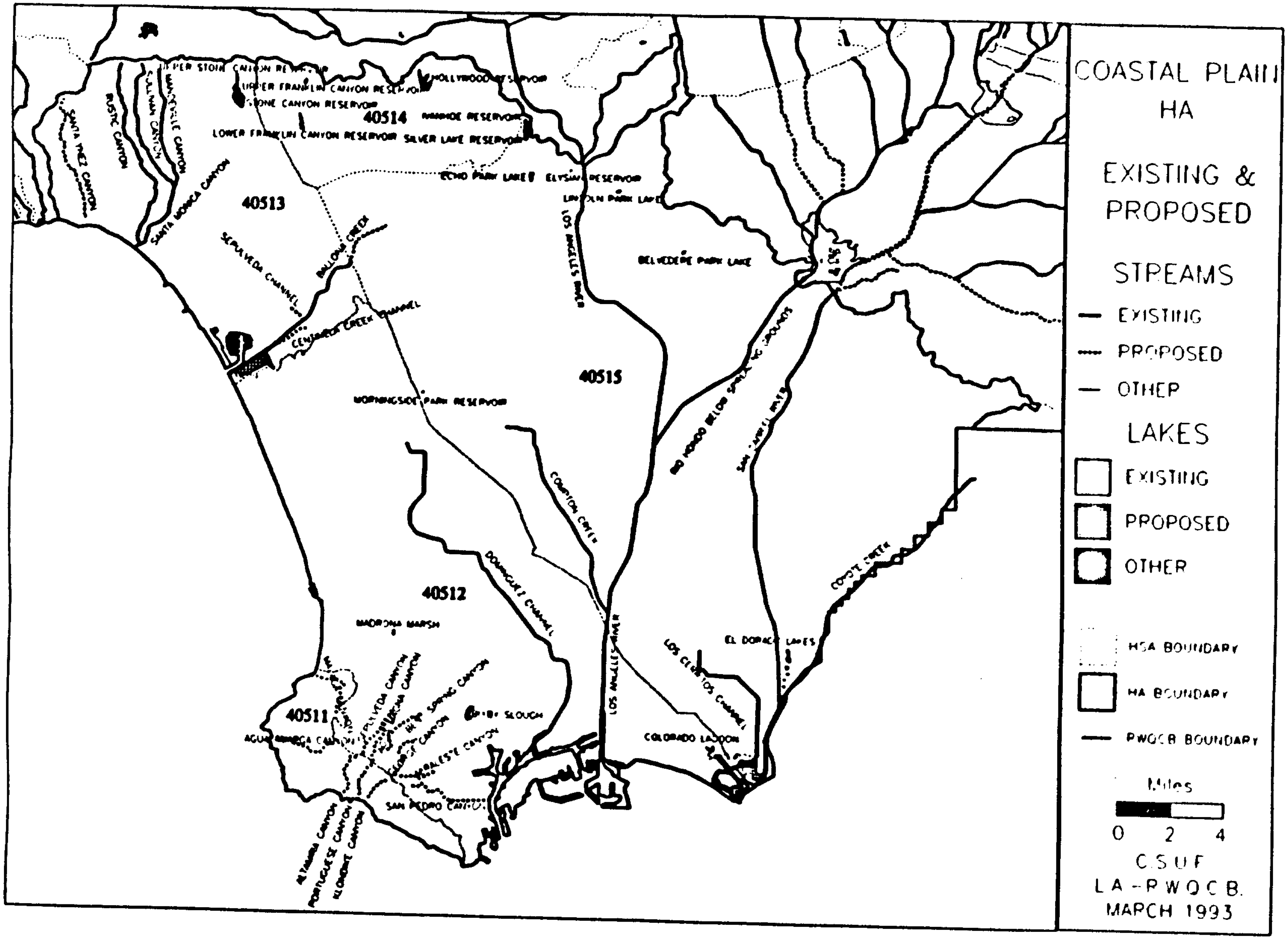

RAYMOND
SAN GABRIEL
SPADRA
ANAHEIM HA
EXISTING &
PROPOSED
STREAMS
EXISTING
PROPOSED
OTHER
LAKES
EXISTING
PROPOSED
OTHER
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
40532
40531
40533
40543
40544
40553
48123
40542
40541
40552
48122
40551
48121
40562
40563
SAN ANTONIO RESERVOIR
WEST FORK SAN GABRIEL RIVER
SANTA FE FLOOD CONTROL BASIN
PUDDINGSTONE RESERVOIR
WALNUT CREEK
WHITTIER NARROWS FLOOD CONTROL BASIN
PUENTE CREEK
SAN JOSE CREEK (OLD CHANNEL)
SAN JOSE CREEK
EATON RESERVOIR
DEVILS CANYON CREEK
SAN ANTONIO CREEK CHANNEL

FIG 1.7.

16


COASTAL PLAIN HA
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STREAMS
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LAKES
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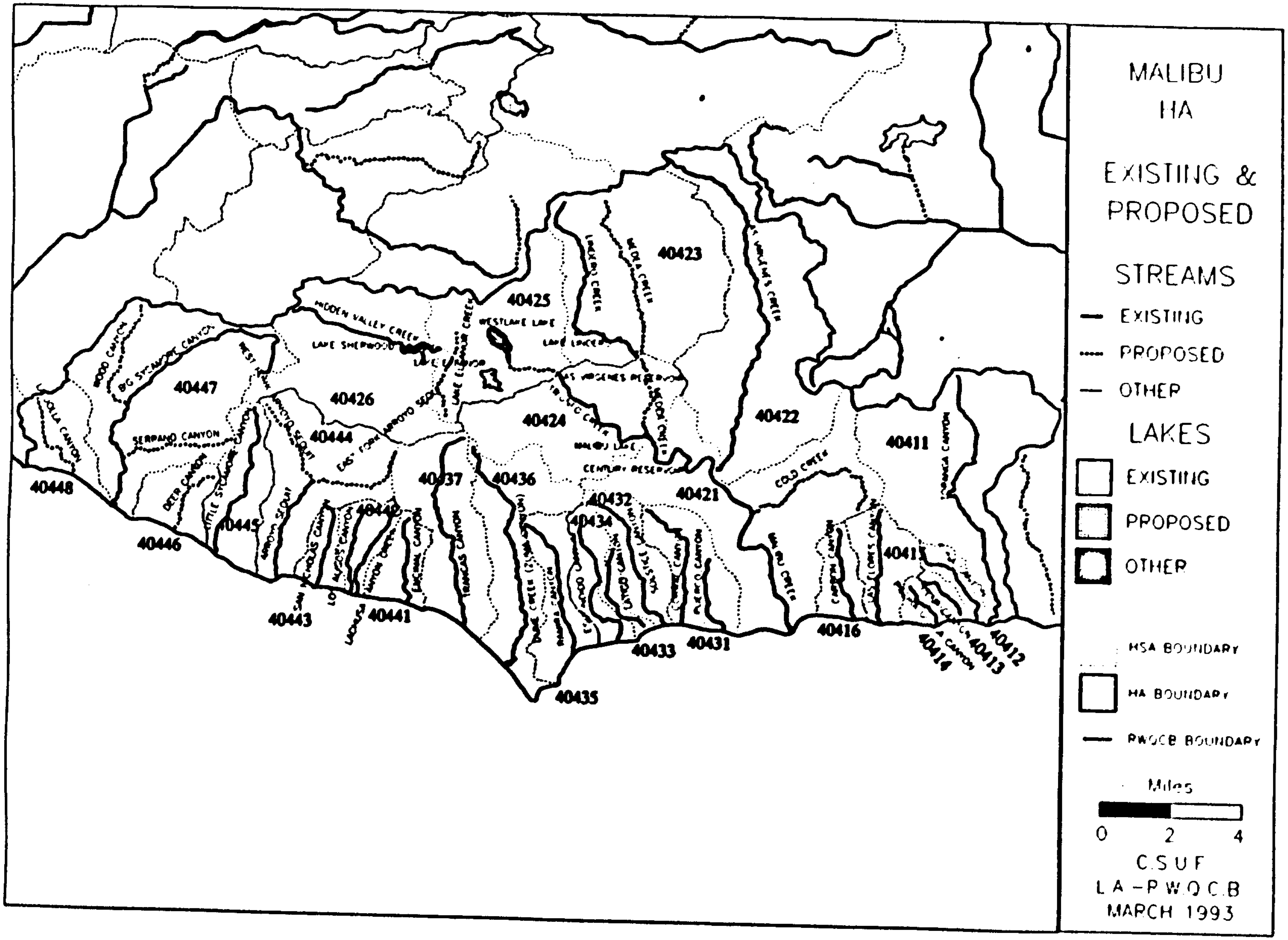
MARCH 1993
40511
40512
40513
40514
40515
LOWER FRANKLIN CANYON RESERVOIR
SILVER LAKE RESERVOIR
ECHO PARK LAKE
ELYSIAN RESERVOIR
BELVEDERE PARK LAKE
SANTA MONICA CANYON
SEPULVEDA CHANNEL
BALLONA CREEK
CENTINELA CREEK CHANNEL
MORNINGSIDE PARK RESERVOIR
COMPTON CREEK
DOMINGUEZ CHANNEL
LOS ANGELES RIVER
RIO HONDO BELOW SPREADING GROUNDS
SAN GABRIEL RIVER
COYOTE CREEK
MADRONA MARSH
EL DORADO LAKES
LOS CERRITOS CHANNEL
COLORADO LAGOON
SAN PEDRO CANYON

FIG 1.8.


MALIBU
HA
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PROPOSED
STREAMS
EXISTING
PROPOSED
OTHER
LAKES
EXISTING
PROPOSED
OTHER
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0
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L.A.-R.W.Q.C.B
MARCH 1993
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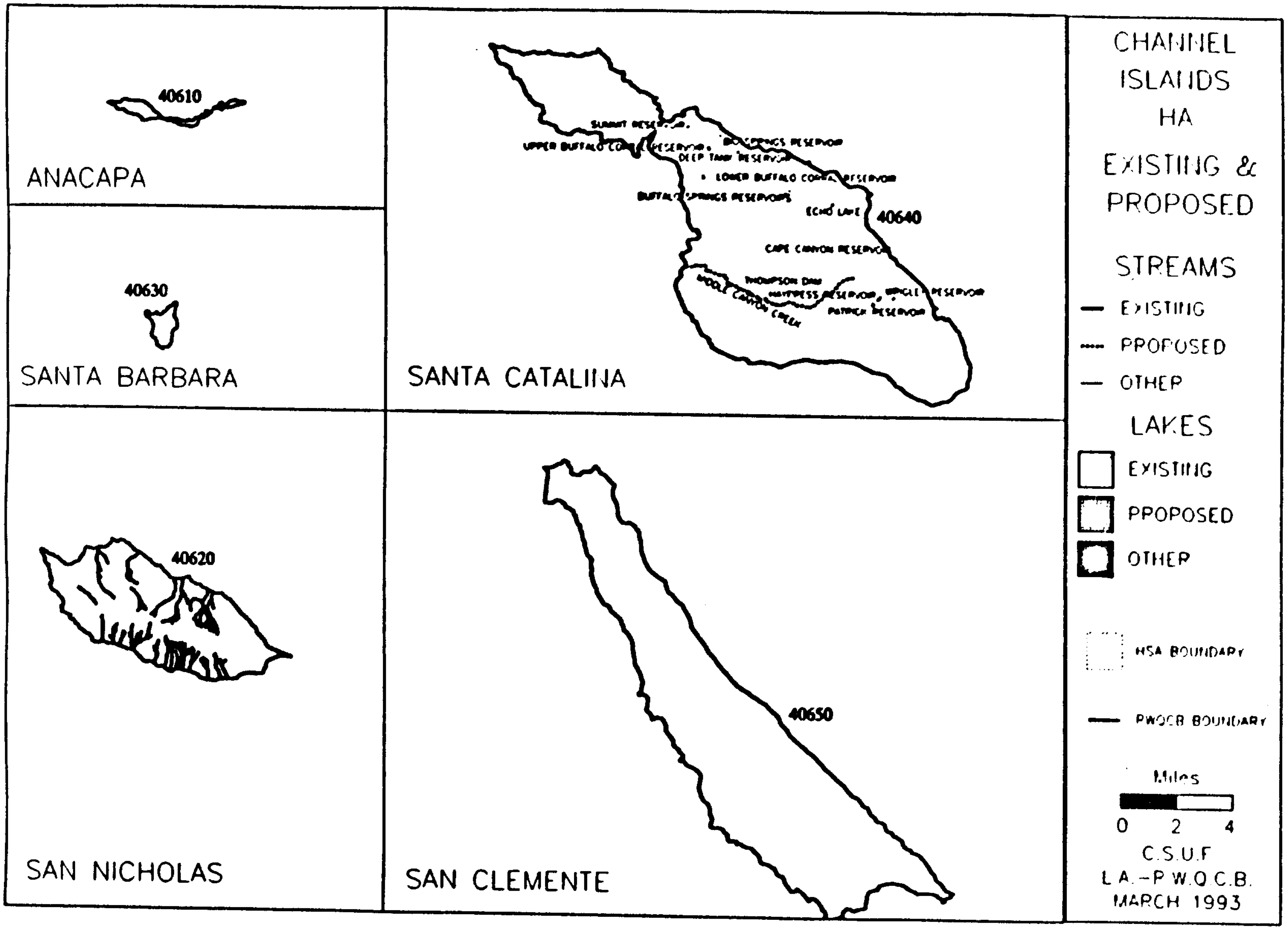
40432
40421
40434
40446
40445
40442
40443
40441
40433
40431
40416
40435
40414
40413
40412
WESTLAKE LAKE
LAKE SHERWOOD
HIDDEN VALLEY CREEK
SERRANO CANYON
MALIBU LAKE
CENTURY RESERVOIR
COLD CREEK
MALIBU CREEK

FIG 1.9.



ANACAPA
40610
SANTA BARBARA
40630
SANTA CATALINA
40640
SUMMIT RESERVOIR
UPPER BUFFALO CORRAL RESERVOIR
BUFFALO SPRINGS RESERVOIRS
ECHO LAKE
THOMPSON DAM
PATRICK RESERVOIR
SAN NICHOLAS
40620
SAN CLEMENTE
40650
CHANNEL ISLANDS HA
EXISTING & PROPOSED
STREAMS
EXISTING
PROPOSED
OTHER
LAKES
EXISTING
PROPOSED
OTHER
HSA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
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FIG 1.10

TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
** PITAS POINT HU				
401.00	RIP. STREAM	JAVON CANYON	PROPOSED	*
401.00	STREAM	LOS SAUCES CREEK	PROPOSED	
401.00	STREAM	MADRANIO CANYON	PROPOSED	
401.00	STREAM	PADRE JUAN CANYON	PROPOSED	
401.00	STREAM	POVERTY CANYON	PROPOSED	
401.00	BEACH/BAY	NEARSHORE &	INCLUDED	
401.00	BEACH/BAY	OTHER NEARSHORE ZONE	PROPOSED	
401.00	BEACH/BAY	RINCON BEACH	PROPOSED	
** CHINO HSA				
401.21	STREAM	CHINO CREEK		
401.21	STREAM	SAN ANTONIO CREEK CHANNEL	INCLUDED	
** CLAREMONT HEIGHTS HSA				
401.23	STREAM	BEAR CANYON		
401.23	STREAM	CAT CANYON		
401.23	STREAM	DRY LAKE CANYON		
401.23	STREAM	EVEY CANYON		
401.23	STREAM	SAN ANTONIO CANYON CREEK	INCLUDED	
401.23	STREAM	SAN ANTONIO CREEK CHANNEL		
401.23	STREAM	SPRUCE CANYON		
401.23	STREAM	WEST FORK BEAR CANYON		
401.23	LAKE	SAN ANTONIO RESERVOIR	INCLUDED	
** LOWER VENTURA RIVER HA				
402.10	STREAM	CANADA DE LAS ENCINAS		
402.10	STREAM	CANADA DE RODRIGUES		
402.10	STREAM	CANADA DEL ALISO		
402.10	STREAM	CANADA DEL DIABLO		
402.10	STREAM	CANADA DEL SAN JOAQUIN		
402.10	STREAM	CANADA LARGA CREEK	INCLUDED	
402.10	STREAM	CANADA SECA		
402.10	STREAM	COCHE CANYON		
402.10	STREAM	EAST FORK HALL CANYON	PROPOSED	
402.10	STREAM	HALL CANYON	PROPOSED	
402.10	STREAM	HAMMOND CANYON		
402.10	STREAM	LEON CANYON		
402.10	STREAM	MANUEL CANYON		
402.10	STREAM	SANLON BARRANCA		
402.10	STREAM	SULPHUR CANYON		
402.10	RIP. STREAM	VENTURA RIVER & TRIBUTARIES	INCLUDED	*
402.10	STREAM	WELDON CANYON		
402.10	BEACH/BAY	NEARSHORE ZONE	INCLUDED	
402.10	COASTAL WETLAND	VENTURA RIVER TIDAL PRISM	INCLUDED	*
** UPPER VENTURA RIVER HA				
402.20	STREAM	AYERS CREEK	PROPOSED	
402.20	STREAM	CHISMAHOO CREEK	PROPOSED	
402.20	STREAM	COOPER CANYON		
402.20	RIP. STREAM	COYOTE CREEK	PROPOSED	*
402.20	STREAM	COZY DELL CANYON		
402.20	RIP. STREAM	EAST FORK COYOTE CREEK	PROPOSED	*
402.20	STREAM	FRESNO CANYON		
402.20	STREAM	KENNEDY CANYON		

TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
402.20	STREAM	LIME CANYON		
402.20	STREAM	LION CANYON		
402.20	RIP. STREAM	MATILIJA CREEK	PROPOSED	*
402.20	STREAM	MCDONALD CANYON		
402.20	RIP. STREAM	MURIETTA CANYON	PROPOSED	*
402.20	STREAM	NORTH FORK MATILIJA CREEK	PROPOSED	
402.20	STREAM	NORTH FORK SANTA ANA CREEK		
402.20	RIP. STREAM	OLD MAN CANYON	PROPOSED	*
402.20	STREAM	POPLIN CREEK		
402.20	STREAM	RICE CANYON		
402.20	RIP. STREAM	SAN ANTONIO CREEK & TRIBUTARIES	INCLUDED	*
402.20	RIP. STREAM	SANTA ANA CREEK	PROPOSED	*
402.20	STREAM	UPPER NORTH FORK MATILIJA CREEK	PROPOSED	
402.20	RIP. STREAM	VENTURA RIVER & TRIBUTARIES	INCLUDED	*
402.20	STREAM	WEST FORK COYOTE CREEK	PROPOSED	
402.20	RIP. STREAM	WEST FORK SANTA ANA CREEK	PROPOSED	*
402.20	STREAM	WILLOW CREEK	PROPOSED	
402.20	STREAM	WILLS CANYON		
402.20	LAKE	LAKE CASITAS	INCLUDED	
402.20	INLAND WETLAND	MATILIJA RESERVOIR	INCLUDED	*
402.20	INLAND WETLAND	MIRROR LAKE	PROPOSED	*
402.20	INLAND WETLAND	OJAI WETLAND	PROPOSED	*
** UPPER OJAI HSA				
402.31	STREAM	BIG CANYON		
402.31	STREAM	LION CANYON	PROPOSED	
402.31	STREAM	SYCAMORE CREEK		
** OJAI VALLEY HSA				
402.32	STREAM	GRIDLEY CANYON		
402.32	STREAM	HORN CANYON	PROPOSED	
402.32	STREAM	REEVES CREEK	PROPOSED	
402.32	STREAM	SAN ANTONIO CREEK	INCLUDED	
402.32	STREAM	STEWART CANYON		
** OXNARD HSA				
403.11	STREAM	BARLOW CANYON		
403.11	STREAM	CALLEGUAS CREEK	INCLUDED	
403.11	STREAM	HARMON CANYON		
403.11	STREAM	LAKE CANYON		
403.11	STREAM	REVOLON SLOUGH	INCLUDED	
403.11	RIP. STREAM	SANTA CLARA RIVER	INCLUDED	*
403.11	STREAM	SEXTON CANYON	PROPOSED	
403.11	LAKE	MCGRATH LAKE	INCLUDED	
403.11	ESTUARY	MUGU LAGOON	INCLUDED	
403.11	HARBOR	CHANNEL ISLANDS MARINA	INCLUDED	
403.11	HARBOR	MANDALAY BAY (MARINA)	INCLUDED	
403.11	HARBOR	PORT HUENEME (HARBOR)	INCLUDED	
403.11	HARBOR	VENTURA KEYS (MARINA)	INCLUDED	
403.11	HARBOR	VENTURA MARINA	INCLUDED	
403.11	BEACH/BAY	MANDALAY BEACH	PROPOSED	
403.11	BEACH/BAY	NEARSHORE ZONE (TIDAL PRISM)	INCLUDED	
403.11	ESTUARY	CALLEGUAS CREEK (TIDAL PRISM)	INCLUDED	
403.11	ESTUARY	EDISON CANAL (TIDAL PRISM)	INCLUDED	
403.11	COASTAL WETLAND	MCGRATH LAKE (TIDAL PRISM)	INCLUDED	*

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
403.11	COASTAL WETLAND	MUGU LAGOON (TIDAL PRISM)	INCLUDED	*
403.11	COASTAL WETLAND	ORMOND BEACH	PROPOSED	*
403.11	COASTAL WETLAND	SANTA CLARA RIVER (TIDAL PRISM)	INCLUDED	*
** PLEASANT VALLEY HSA				
403.12	STREAM	ARROYO LAS POSAS	PROPOSED	
403.12	STREAM	CALLEGUAS CREEK	INCLUDED	
403.12	STREAM	CONEJO CREEK	INCLUDED	
403.12	STREAM	LONG GRADE CANYON		
** SULPHUR SPRINGS HSA				
403.21	STREAM	ADAMS CANYON		
403.21	STREAM	ALISO CANYON		
403.21	STREAM	ANLAUF CANYON		
403.21	STREAM	EAST FORK SANTA PAULA CANYON		
403.21	STREAM	ECHO FALLS CANYON		
403.21	STREAM	FAGAN CANYON		
403.21	STREAM	HAMPTON CANYON		
403.21	STREAM	LA BROCHE CANYON		
403.21	STREAM	LONG CANYON		
403.21	STREAM	MORGAN CANYON		
403.21	STREAM	MUD CREEK CANYON		
403.21	STREAM	O'HARA CANYON		
403.21	STREAM	PEPPERTREE CANYON		
403.21	STREAM	RICHARDSON CANYON		
403.21	STREAM	SALTMARSH CANYON		
403.21	RIP. STREAM	SANTA CLARA RIVER	INCLUDED	*
403.21	STREAM	SANTA PAULA CREEK	INCLUDED	
403.21	RIP. STREAM	SISAR CREEK	INCLUDED	*
403.21	STREAM	WHEELER CANYON		
** SISAR HSA				
403.22	STREAM	BEAR CANYON		
403.22	RIP. STREAM	SISAR CREEK	INCLUDED	*
** FILLMORE HSA				
403.31	STREAM	BALCOM CANYON		
403.31	STREAM	BOULDER CREEK		
403.31	STREAM	GRIMES CANYON		
403.31	STREAM	LOFTUS CANYON		
403.31	STREAM	ORCUTT CANYON		
403.31	STREAM	POLE CREEK		
403.31	RIP. STREAM	SANTA CLARA RIVER	INCLUDED	*
403.31	RIP. STREAM	SESPE CREEK	INCLUDED	*
403.31	STREAM	SNOW CANYON		
403.31	STREAM	TIMBER CANYON		
403.31	STREAM	WILLARD CANYON		
** TOPA TOPA HSA				
403.32	STREAM	ABADI CREEK		
403.32	STREAM	ADOBE CREEK		
403.32	STREAM	ALDER CREEK	PROPOSED	
403.32	RIP. STREAM	BEAR CANYON	PROPOSED	*
403.32	STREAM	BEAR CREEK	PROPOSED	
403.32	STREAM	BURRO CREEK		

TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
403.32	STREAM	CENTENNIAL CREEK		
403.32	STREAM	CHERRY CREEK		
403.32	STREAM	CHORRO GRANDE CANYON		
403.32	RIP. STREAM	COLDWATER CANYON	PROPOSED	*
403.32	STREAM	COLDWATER FORK		
403.32	STREAM	DERRYDALE CREEK		
403.32	STREAM	EAST FORK ALDER CREEK	PROPOSED	
403.32	STREAM	ELM CREEK		
403.32	STREAM	FOURFORK CREEK		
403.32	STREAM	GODWIN CANYON		
403.32	STREAM	HOT SPRINGS CANYON	PROPOSED	
403.32	STREAM	HOWARD CREEK	PROPOSED	
403.32	STREAM	LADYBUG CREEK		
403.32	STREAM	LION CANYON	PROPOSED	
403.32	STREAM	LITTLE SESPE CREEK		
403.32	STREAM	MAPLE CREEK	PROPOSED	
403.32	STREAM	MUNSON CREEK		
403.32	STREAM	NORTH FORK PIEDRA BLANCA CREEK		
403.32	STREAM	PARK CREEK		
403.32	RIP. STREAM	PIEDRA BLANCA CREEK	PROPOSED	*
403.32	RIP. STREAM	PINE CANYON	PROPOSED	*
403.32	STREAM	POPLAR CREEK	PROPOSED	
403.32	RIP. STREAM	POTRERO JOHN CREEK	PROPOSED	*
403.32	STREAM	RED REEF CANYON		
403.32	RIP. STREAM	REDROCK CREEK	PROPOSED	*
403.32	RIP. STREAM	ROSE VALLEY CREEK	PROPOSED	*
403.32	RIP. STREAM	SESPE CREEK & TRIBUTARIES	INCLUDED	*
403.32	STREAM	SPRING CANYON		
403.32	STREAM	STONE CORRAL CREEK		
403.32	STREAM	SYCAMORE CREEK		
403.32	STREAM	TAR CREEK	PROPOSED	
403.32	RIP. STREAM	TIMBER CREEK	PROPOSED	*
403.32	RIP. STREAM	TROUT CREEK	PROPOSED	*
403.32	RIP. STREAM	TULE CREEK	PROPOSED	*
403.32	RIP. STREAM	WEST FORK SESPE CREEK	PROPOSED	*
** SANTA FELICIA HSA				
403.41	STREAM	BLANCHARD CANYON		
403.41	STREAM	CALUMET CANYON		
403.41	STREAM	DEVIL CANYON	PROPOSED	
403.41	STREAM	DOMINGUEZ CANYON	PROPOSED	
403.41	STREAM	EDWARDS CANYON		
403.41	STREAM	EUREKA CANYON		
403.41	STREAM	FAIRVIEW CANYON		
403.41	STREAM	FREY CANYON		
403.41	STREAM	HOLSER CANYON		
403.41	STREAM	HOPPER CREEK	INCLUDED	
403.41	STREAM	LECHLER CANYON	PROPOSED	
403.41	STREAM	LIME CANYON		
403.41	STREAM	MAPLE CANYON		
403.41	STREAM	MODELO CANYON		
403.41	STREAM	NUEVO CANYON		
403.41	STREAM	OAK CANYON		
403.41	RIP. STREAM	PIRU CREEK & TRIBUTARIES	INCLUDED	*
403.41	STREAM	RAMONA CANYON		

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
403.41	STREAM	REAL WASH		
403.41	STREAM	REASONER CANYON		
403.41	RIP. STREAM	SANTA CLARA RIVER	INCLUDED	•
403.41	STREAM	SANTA FELICIA CANYON	PROPOSED	
403.41	STREAM	SHIELLS CANYON		
403.41	STREAM	SMITH CANYON		
403.41	STREAM	TAPO CANYON	PROPOSED	
403.41	STREAM	TOMS CANYON		
403.41	STREAM	TORREY CANYON		
403.41	STREAM	WARRING CANYON		
403.41	STREAM	WILEY CANYON		
403.41	LAKE	LAKE PIRU	INCLUDED	
** UPPER PIRU HSA				
403.42	STREAM	AGUA BLANCA CREEK	PROPOSED	
403.42	STREAM	ALAMO CREEK		
403.42	STREAM	BEAR GULCH		
403.42	STREAM	BEARTRAP CANYON	PROPOSED	
403.42	STREAM	BIG CEDAR CREEK		
403.42	STREAM	BUCK CREEK	PROPOSED	
403.42	STREAM	CANTON CANYON		
403.42	STREAM	CARLOS CANYON		
403.42	STREAM	CEDAR CREEK		
403.42	STREAM	CHERRY CANYON		
403.42	STREAM	DEAD HORSE CREEK		
403.42	STREAM	DRY CREEK		
403.42	STREAM	FISH CREEK	PROPOSED	
403.42	STREAM	FRAZIER CREEK	PROPOSED	
403.42	STREAM	LACOSCA CREEK		
403.42	STREAM	LIEBRE GULCH		
403.42	STREAM	LITTLE MUTAU CREEK		
403.42	STREAM	LOCKWOOD CREEK	PROPOSED	
403.42	STREAM	LONG DAVE CANYON		
403.42	STREAM	MICHAEL CREEK		
403.42	STREAM	MUTAU CREEK	PROPOSED	
403.42	STREAM	NORTH FORK FISH CREEK		
403.42	STREAM	OSITO CANYON		
403.42	RIP. STREAM	PIRU CREEK & TRIBUTARIES	INCLUDED	•
403.42	STREAM	POSEY CANYON		
403.42	STREAM	ROCK CREEK		
403.42	STREAM	ROSE CREEK		
403.42	STREAM	RUBY CANYON		
403.42	STREAM	SHARPS CANYON		
403.42	STREAM	SHEEP CREEK		
403.42	STREAM	SMITH FORK		
403.42	STREAM	SNOWY CREEK	PROPOSED	
403.42	STREAM	SOUTH FORK PIRU CREEK	PROPOSED	
403.42	STREAM	SULPHUR CREEK		
403.42	STREAM	TRAIL CANYON		
403.42	STREAM	TURTLE CANYON		
403.42	STREAM	WEST FORK LIEBRE GULCH		
403.42	LAKE	LAKE PIRU	INCLUDED	
403.42	LAKE	PYRAMID LAKE	INCLUDED	

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
** HUNGRY VALLEY HSA				
403.43	STREAM	APPLE CANYON		
403.43	STREAM	CANADA DE LOS ALAMOS & TRIBUTARIES	INCLUDED	
403.43	STREAM	COYOTE CANYON		
403.43	STREAM	FREEMAN CANYON		
403.43	STREAM	GORMAN CREEK	PROPOSED	
403.43	STREAM	HUNGRY VALLEY		
403.43	STREAM	MAXY CANYON		
** STAUFFER HSA				
403.44	STREAM	AMARGOSA CREEK		
403.44	STREAM	LOCKWOOD CREEK & TRIBUTARIES	INCLUDED	
403.44	STREAM	MIDDLE FORK LOCKWOOD CREEK		
403.44	STREAM	NORTH FORK LOCKWOOD CREEK		
403.44	STREAM	SAN GUILLERMO CREEK		
403.44	STREAM	SEYMOUR CREEK		
** EASTERN HSA				
403.51	STREAM	ABRAMS CANYON		
403.51	STREAM	BAIRD CANYON		
403.51	STREAM	BEAR CANYON		
403.51	STREAM	BEE CANYON		
403.51	STREAM	BITTER CANYON		
403.51	RIP. STREAM	BOUQUET CREEK & TRIBUTARIES	INCLUDED	*
403.51	STREAM	BURNS CANYON		
403.51	STREAM	BURNT PEAK CANYON		
403.51	STREAM	BURRO CANYON		
403.51	STREAM	CASTAIC CREEK & TRIBUTARIES	INCLUDED	
403.51	STREAM	CHARLIE CANYON		
403.51	STREAM	CHERRY CANYON		
403.51	STREAM	CIENAGA CANYON		
403.51	STREAM	CLEARWATER CANYON		
403.51	STREAM	COARSE GOLD CANYON		
403.51	STREAM	COLD CANYON		
403.51	STREAM	COYOTE CANYON		
403.51	STREAM	DEER CANYON		
403.51	STREAM	DEWITT CANYON		
403.51	STREAM	DRINKWATER CANYON		
403.51	STREAM	DRY CANYON	INCLUDED	
403.51	STREAM	DRY GULCH		
403.51	STREAM	EAST CANYON		
403.51	STREAM	EAST FORK FISH CANYON		
403.51	STREAM	EAST FORK SALT CANYON		
403.51	STREAM	ELDERBERRY CANYON		
403.51	STREAM	ELIZABETH LAKE CANYON & TRIB.	INCLUDED	
403.51	STREAM	ELSMERE CANYON		
403.51	STREAM	FALL CANYON		
403.51	STREAM	FISH CANYON		
403.51	STREAM	FISH CREEK		
403.51	STREAM	FORSYTHE CANYON		
403.51	STREAM	GAVIN CANYON		
403.51	STREAM	GORMAN CANYON		
403.51	STREAM	GRASSHOPPER CANYON		
403.51	STREAM	HASKELL CANYON		
403.51	STREAM	HASLEY CANYON		

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
403.51	STREAM	HIATT CANYON		
403.51	STREAM	IRON CANYON		
403.51	STREAM	KLEINE CANYON		
403.51	STREAM	LEAMING CANYON		
403.51	STREAM	LION CANYON		
403.51	STREAM	LOS PINETOS CANYON		
403.51	STREAM	LUCKY CANYON		
403.51	STREAM	LYON CANYON		
403.51	STREAM	MARPLE CANYON		
403.51	STREAM	MINT CANYON & TRIBUTARIES	INCLUDED	
403.51	STREAM	MUNZ CANYON		
403.51	STREAM	MYSTIC CANYON		
403.51	STREAM	NECKTIE CANYON		
403.51	STREAM	NEWHALL CREEK		
403.51	STREAM	NORTH FORK		
403.51	STREAM	OAK SPRING CANYON		
403.51	STREAM	OAKDALE CANYON		
403.51	STREAM	ORO FINO CANYON		
403.51	STREAM	ORR SPRING CANYON		
403.51	STREAM	PALOMAS CANYON		
403.51	STREAM	PETTINGER CANYON		
403.51	STREAM	PICO CANYON		
403.51	STREAM	PINE CANYON		
403.51	STREAM	PLACERITA CREEK		
403.51	STREAM	PLUM CANYON		
403.51	STREAM	POLE CANYON		
403.51	STREAM	POTRERO CANYON		
403.51	STREAM	PROSPECT CANYON		
403.51	STREAM	QUIGLEY CANYON		
403.51	STREAM	RATTLESNAKE CANYON		
403.51	STREAM	RED FOX CANYON		
403.51	STREAM	REDROCK CANYON		
403.51	STREAM	REYNIER CANYON		
403.51	STREAM	RICE CANYON		
403.51	STREAM	ROMERO CANYON		
403.51	STREAM	RUBY CANYON		
403.51	STREAM	RUSH CANYON		
403.51	STREAM	SALT CANYON		
403.51	STREAM	SALT CREEK		
403.51	RIP. STREAM	SAN FRANCISQUITO CANYON & TRIB.	INCLUDED	*
403.51	STREAM	SAN MARTINEZ CHIQUITO CANYON		
403.51	STREAM	SAN MARTINEZ GRANDE CANYON		
403.51	STREAM	SAND CANYON		
403.51	STREAM	SANTA CLARA RIVER & TRIBUTARIES	INCLUDED	
403.51	STREAM	SHAKE CANYON		
403.51	STREAM	SLOAN CANYON		
403.51	STREAM	SOUTH PORTAL CANYON	PROPOSED	
403.51	STREAM	SOUTH TULE CANYON		
403.51	STREAM	SPRING CANYON		
403.51	STREAM	SPRUCE DRAW		
403.51	STREAM	STEINER CANYON		
403.51	STREAM	TAPIA CANYON		
403.51	STREAM	TAPIE CANYON		
403.51	STREAM	TEXAS CANYON		
403.51	STREAM	TICK CANYON		

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
403.51	STREAM	TOWSLEY CANYON		
403.51	STREAM	TROUGH CANYON		
403.51	STREAM	TULE CANYON		
403.51	STREAM	TURKEY CANYON		
403.51	STREAM	VASQUEZ CANYON		
403.51	STREAM	VILLA CANYON		
403.51	STREAM	VIOLIN CANYON		
403.51	STREAM	WARM SPRINGS CANYON		
403.51	STREAM	WAYSIDE CANYON		
403.51	STREAM	WHITNEY CANYON		
403.51	STREAM	WICKHAM CANYON		
403.51	STREAM	WILEY CANYON		
403.51	LAKE	CASTAIC LAGOON	PROPOSED	
403.51	LAKE	CASTAIC LAKE & ELDERBERRY FOREBAY	INCLUDED	
403.51	LAKE	DRINKWATER RESERVOIR	PROPOSED	
403.51	LAKE	DRY CANYON RESERVOIR	INCLUDED	
403.51	LAKE	ELDERBERRY FOREBAY	INCLUDED	
403.51	LAKE	LAKE ELIZABETH	INCLUDED	
403.51	LAKE	LAKE HUGHES	INCLUDED	
403.51	LAKE	MUNZ LAKES	PROPOSED	
** BOUQUET HSA				
403.52	STREAM	BOUQUET CREEK & TRIBUTARIES	INCLUDED	
403.52	STREAM	MARTINDALE CANYON		
403.52	STREAM	SPUNKY CANYON		
403.52	LAKE	BOUQUET RESERVOIR	INCLUDED	
** MINT CANYON HSA				
403.53	STREAM	MINT CANYON & TRIBUTARIES	INCLUDED	
403.53	STREAM	ROWHER CANYON		
403.53	STREAM	SPADE CANYON		
403.53	STREAM	SPADE SPRING CANYON		
** SIERRA PELONA HSA				
403.54	STREAM	AGUA DULCE CANYON & TRIBUTARIES	INCLUDED	
403.54	STREAM	HAUSER CANYON		
403.54	STREAM	LETTEAU CANYON		
403.54	STREAM	WILLOW SPRINGS CANYON		
** ACTON HSA				
403.55	STREAM	ACTON CANYON		
403.55	STREAM	AGUA DULCE CANYON & TRIBUTARIES	INCLUDED	
403.55	RIP. STREAM	ALISO CANYON	PROPOSED	*
403.55	STREAM	ARRASTRE CANYON		
403.55	STREAM	BEAR CANYON		
403.55	STREAM	BEARTRAP CANYON		
403.55	STREAM	BOBCAT CANYON		
403.55	STREAM	BOOTLEGGERS CANYON		
403.55	STREAM	CABIN CANYON		
403.55	STREAM	ESCONDIDO CANYON		
403.55	STREAM	FRYER CANYON		
403.55	STREAM	GLEASON CANYON		
403.55	STREAM	HUGHES CANYON		
403.55	STREAM	INDIAN CANYON		
403.55	STREAM	JONES CANYON		

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
403.55	STREAM	KASHMERE CANYON		
403.55	STREAM	KENTUCKY SPRINGS CANYON		
403.55	STREAM	LONG CANYON		
403.55	STREAM	MAHER CANYON		
403.55	STREAM	MATTOX CANYON		
403.55	STREAM	MILL CANYON		
403.55	STREAM	MOODY CANYON		
403.55	STREAM	NELLUS CANYON		
403.55	STREAM	NELSON CANYON		
403.55	STREAM	SANTA CLARA RIVER & TRIBUTARIES	INCLUDED	
403.55	STREAM	TIE CANYON		
403.55	STREAM	YOUNG CANYON		
** WEST LAS POSAS HSA				
403.61	STREAM	ARROYO COLORADO		
403.61	STREAM	HONDA BARRANCA		
403.61	STREAM	MILLIGAN BARRANCA		
403.61	STREAM	REVOLON SLOUGH (BEARDSLEY WASH)	INCLUDED	
** EAST LAS POSAS HSA				
403.62	STREAM	ALAMOS CANYON		
403.62	STREAM	ARROYO SIMI	INCLUDED	
403.62	STREAM	BOONE CANYON		
403.62	STREAM	CALLEGUAS CREEK & TRIB. (ARROYO LAS POSAS)	INCLUDED	
403.62	STREAM	COYOTE CANYON		
403.62	STREAM	FOX BARRANCA		
403.62	STREAM	FOX CANYON		
403.62	STREAM	HAPPY CAMP CANYON		
403.62	STREAM	LONG CANYON		
** ARROYO SANTA ROSA HSA				
403.63	STREAM	ARROYO SANTA ROSA	INCLUDED	
403.63	STREAM	CONEJO CREEK	INCLUDED	
** CONEJO VALLEY HSA				
403.64	STREAM	ARROYO CONEJO & TRIBUTARIES	INCLUDED	
403.64	STREAM	NORTH FORK ARROYO CONEJO	PROPOSED	
403.64	STREAM	SOUTH BRANCH ARROYO CONEJO		
** TIERRA REJADA VALLEY HSA				
403.65	STREAM	ARROYO SANTA ROSA	INCLUDED	
** GILLIBRAND HSA				
403.66	STREAM	GILLIBRAND CANYON & TRIBUTARIES	INCLUDED	
403.66	STREAM	IRON TROUGH CANYON		
403.66	STREAM	TAPO CANYON	PROPOSED	
403.66	STREAM	TRIPAS CANYON		
403.66	STREAM	WINDMILL CANYON		
** SIMI VALLEY HSA				
403.67	STREAM	ARROYO SIMI & TRIBUTARIES	INCLUDED	
403.67	STREAM	BREA CANYON		
403.67	STREAM	BUS CANYON		
403.67	STREAM	DRY CANYON		
403.67	STREAM	EL TORO CANYON		

TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
403.67	STREAM	LAS LLAJAS CANYON		
403.67	STREAM	LONE OAK CANYON		
403.67	STREAM	LONG CANYON		
403.67	STREAM	MEIER CANYON		
403.67	STREAM	MONTGOMERY CANYON		
403.67	STREAM	OAK CANYON		
403.67	STREAM	RUNKLE CANYON		
403.67	STREAM	SULPHUR CANYON		
403.67	STREAM	SYCAMORE CANYON		
403.67	STREAM	TAPO CANYON	PROPOSED	
403.67	STREAM	TROUGH CANYON		
403.67	LAKE	LAKE BARD (WOOD RANCH RESERVOIR)	INCLUDED	
403.67	LAKE	RUNKLE RESERVOIR	PROPOSED	
** THOUSAND OAKS HSA				
403.68	STREAM	ARROYO CONEJO & TRIBUTARIES	INCLUDED	
403.68	STREAM	SKELETON CANYON	PROPOSED	
** TOPANGA CANYON HSA				
404.11	STREAM	BROOKSIDE CANYON		
404.11	STREAM	DIX CANYON		
404.11	STREAM	GARAPITO CANYON		
404.11	STREAM	GREENLEAF CANYON		
404.11	STREAM	HONDO CANYON		
404.11	STREAM	OLD TOPANGA CANYON		
404.11	STREAM	RED ROCK CANYON		
404.11	STREAM	SANTA MARIA CREEK		
404.11	STREAM	TOPANGA CANYON CREEK	INCLUDED	
404.11	BEACH/BAY	TOPANGA BEACH	PROPOSED	
404.11	COASTAL WETLAND	TOPANGA LAGOON	PROPOSED	*
** TUNA CANYON HSA				
404.12	STREAM	TUNA CANYON CREEK	INCLUDED	
404.12	BEACH/BAY	LAS TUNAS BEACH	PROPOSED	
** PENA CANYON HSA				
404.13	STREAM	PENA CANYON CREEK	INCLUDED	
** PIERDO GORDA CANYON HSA				
404.14	STREAM	PIEDRA GORDA CANYON CREEK	INCLUDED	
** LAS FLORES CANYON HSA				
404.15	STREAM	LAS FLORES CANYON CREEK	INCLUDED	
404.15	STREAM	LITTLE LAS FLORES CANYON		
** CARBON CANYON HSA				
404.16	STREAM	CARBON CANYON CREEK	INCLUDED	
404.16	BEACH/BAY	CARBON BEACH	PROPOSED	
404.16	BEACH/BAY	LA COSTA BEACH	PROPOSED	
** MONTE NIDO HSA				
404.21	RIP. STREAM	COLD CREEK	PROPOSED	*
404.21	STREAM	DARK CANYON		
404.21	RIP. STREAM	MALIBU CREEK	INCLUDED	*
404.21	STREAM	SLEEPER CANYON		

TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
404.21	INLAND WETLAND	CENTURY RESERVOIR	PROPOSED	•
404.21	BEACH/BAY	AMARILLO BEACH	PROPOSED	
404.21	BEACH/BAY	MALIBU BEACH	PROPOSED	
404.21	COASTAL WETLAND	MALIBU LAGOON (TIDAL PRISM)	INCLUDED	•
** LAS VIRGENES CANYON HSA				
404.22	STREAM	EAST LAS VIRGENES CANYON		
404.22	STREAM	GATES CANYON		
404.22	STREAM	LAS VIRGENES CREEK	INCLUDED	
404.22	STREAM	LIBERTY CANYON		
404.22	STREAM	STOKES CANYON		
** LINDERO CANYON HSA				
404.23	STREAM	CHEESEBORO CANYON		
404.23	STREAM	LINDERO CREEK	INCLUDED	
404.23	RIP. STREAM	MEDEA CREEK	PROPOSED	•
404.23	STREAM	PALO COMADO		
** TRUINFO CANYON HSA				
404.24	STREAM	LA SIERRA CANYON		
404.24	STREAM	LOBO CANYON		
404.24	STREAM	MEDEA CREEK	PROPOSED	
404.24	STREAM	TRIUNFO CREEK	INCLUDED	
404.24	STREAM	TROUGH CANYON		
404.24	LAKE	LAKE ENCHANTO	PROPOSED	
404.24	INLAND WETLAND	MALIBU LAKE	INCLUDED	•
** RUSSELL VALLEY HSA				
404.25	STREAM	LAKE ELEANOR CREEK	PROPOSED	
404.25	STREAM	POTRERO VALLEY CREEK		
404.25	STREAM	SCHOOLHOUSE CANYON		
404.25	STREAM	TRIUNFO CREEK	PROPOSED	
404.25	STREAM	WINDMILL CANYON		
404.25	INLAND WETLAND	LAKE ELEANOR	PROPOSED	•
404.25	LAKE	LAS VIRGENES RESERVOIR (WEST LAKE RESERVOIR)	INCLUDED	
404.25	LAKE	WESTLAKE LAKE	INCLUDED	
** SHERWOOD HSA				
404.26	STREAM	HIDDEN VALLEY CREEK	INCLUDED	
404.26	INLAND WETLAND	LAKE SHERWOOD	INCLUDED	•
** CORRAL CANYON HSA				
404.31	STREAM	CORRAL CANYON CREEK	INCLUDED	
404.31	STREAM	MARIE CANYON		
404.31	STREAM	PUERCO CANYON	INCLUDED	
404.31	BEACH/BAY	ALL OTHER NEARSHORE	PROPOSED	
404.31	BEACH/BAY	CORRAL BEACH	PROPOSED	
404.31	BEACH/BAY	PUERCO BEACH	PROPOSED	
** SOLSTICE CANYON HSA				
404.32	STREAM	DRY CANYON		
404.32	STREAM	SOLSTICE CANYON CREEK	INCLUDED	
** LATIGO CANYON HSA				
404.33	STREAM	LATIGO CANYON CREEK	INCLUDED	

TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
** ESCONDIDO CANYON HSA				
404.34	STREAM	ESCONDIDO CANYON CREEK	INCLUDED	
404.34	BEACH/BAY	ESCONDIDO BEACH	PROPOSED	
** RAMERA CANYON				
404.35	STREAM	RAMIRA CANYON CREEK	INCLUDED	
404.35	STREAM	WALNUT CANYON		
404.35	BIOLSIG	POINT MUGU TO LATIGO POINT		
** ZUMA CANYON HSA				
404.36	STREAM	DUME CREEK (ZUMA CANYON)	INCLUDED	
404.36	STREAM	NEWTON CANYON		
404.36	BEACH/BAY	POINT DUME BEACH	PROPOSED	
404.36	BEACH/BAY	WESTWARD BEACH	PROPOSED	
404.36	BEACH/BAY	ZUMA COUNTY BEACH	PROPOSED	
404.36	COASTAL WETLAND	DUME LAGOON	PROPOSED	*
** TRANCAS CANYON HSA				
404.37	STREAM	STEEP HILL CANYON		
404.37	STREAM	TRANCAS CANYON CREEK	INCLUDED	
404.37	BEACH/BAY	TRANCAS BEACH	PROPOSED	
** ENCINAL CANYON HSA				
404.41	STREAM	ENCINAL CANYON CREEK	INCLUDED	
** LOS ALISOS CANYON HSA				
404.42	STREAM	LACHUSA CANYON CREEK	INCLUDED	
404.42	STREAM	LOS ALISOS CANYON CREEK	INCLUDED	
** NICHOLAS CANYON HSA				
404.43	STREAM	SAN NICHOLAS CANYON CREEK	INCLUDED	
404.43	BEACH/BAY	NICHOLAS CANYON BEACH	PROPOSED	
** ARROYO SEQUIT HSA				
404.44	RIP. STREAM	ARROYO SEQUIT	INCLUDED	*
404.44	STREAM	EAST FORK ARROYO SEQUIT	PROPOSED	
404.44	STREAM	WEST FORK ARROYO SEQUIT	PROPOSED	
404.44	STREAM	WILLOW CREEK		
** LITTLE SYCAMORE CANYON HSA				
404.45	STREAM	LITTLE SYCAMORE CANYON CREEK	INCLUDED	
** DEER CANYON HSA				
404.46	STREAM	DEER CANYON	PROPOSED	
** BIG SYCAMORE CANYON HSA				
404.47	RIP. STREAM	BIG SYCAMORE CANYON CREEK	INCLUDED	*
404.47	STREAM	SERRANO CANYON	PROPOSED	
404.47	STREAM	WOOD CANYON	PROPOSED	
** LA JOLLA VALLEY HSA				
404.48	STREAM	LA JOLLA CANYON	PROPOSED	

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H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
** PALOS VERDES HSA				
405.11	STREAM	AGUA AMARGA CANYON	PROPOSED	
405.11	STREAM	ALTAMIRA CANYON	PROPOSED	
405.11	STREAM	KLONDIKE CANYON	PROPOSED	
405.11	STREAM	MALAGA CANYON	PROPOSED	
405.11	STREAM	PORTUGUESE CANYON	PROPOSED	
405.11	BEACH/BAY	ABALONE COVE	PROPOSED	
405.11	BEACH/BAY	POINT VICENTE BEACH	PROPOSED	
405.11	BEACH/BAY	ROYAL PALMS BEACH	PROPOSED	
405.11	BEACH/BAY	WHITES POINT BEACH	PROPOSED	
** WEST COAST HSA				
405.12	STREAM	AGUA MAGNA CANYON	PROPOSED	
405.12	STREAM	AVERILL CANYON	PROPOSED	
405.12	STREAM	BENT SPRING CANYON	PROPOSED	
405.12	STREAM	DOMINGUEZ CHANNEL TO TIDAL PRISM	INCLUDED	
405.12	STREAM	GEORGE CANYON	PROPOSED	
405.12	STREAM	LOS ANGELES RIVER	INCLUDED	
405.12	STREAM	MIRALESTE CANYON	PROPOSED	
405.12	STREAM	SAN PEDRO CANYON	PROPOSED	
405.12	STREAM	SEPULVEDA CANYON	PROPOSED	
405.12	INLAND WETLAND	BIXBY SLOUGH AND HARBOR LAKE	INCLUDED	*
405.12	LAKE	COLORADO LAGOON	PROPOSED	
405.12	INLAND WETLAND	MADRONA MARSH	PROPOSED	*
405.12	LAKE	PALOS VERDES RESERVOIR		
405.12	HARBOR	KING HARBOR-REDONDO BEACH	INCLUDED	
405.12	HARBOR	L.A./L.B. ALL OTHER INNER AREAS	INCLUDED	
405.12	HARBOR	L.A./L.B. OUTER HARBOR	INCLUDED	
405.12	HARBOR	L.A./L.B./HARBOR, MARINAS	INCLUDED	
405.12	HARBOR	L.B. MARINA - ALL OTHER AREAS	INCLUDED	
405.12	HARBOR	L.B. MARINA, STADIUM, & ALAMITOS BAY	INCLUDED	
405.12	BEACH/BAY	CABRILLO BEACH	PROPOSED	
405.12	BEACH/BAY	DOCKWEILER BEACH	PROPOSED	
405.12	BEACH/BAY	HERMOSA BEACH	PROPOSED	
405.12	BEACH/BAY	L.A./L.B. HARBOR/PUBLIC BEACH AREAS	INCLUDED	
405.12	BEACH/BAY	L.B. MARINA - PUBLIC BEACH AREAS	INCLUDED	
405.12	BEACH/BAY	LONG BEACH	PROPOSED	
405.12	BEACH/BAY	MANHATTAN BEACH	PROPOSED	
405.12	BEACH/BAY	OTHER NEARSHORE	PROPOSED	
405.12	BEACH/BAY	REDONDO BEACH	PROPOSED	
405.12	BEACH/BAY	TORRANCE BEACH	PROPOSED	
405.12	ESTUARY	DOMINGUEZ CHANNEL (TIDAL PRISM)	INCLUDED	
405.12	ESTUARY	LOS ANGELES RIVER (TIDAL PRISM)	INCLUDED	
405.12	ESTUARY	LOS CERRITOS CHANNEL (TIDAL PRISM)	PROPOSED	
405.12	COASTAL WETLAND	ALAMITOS BAY	PROPOSED	*
** SANTA MONICA HSA				
405.13	STREAM	BALLONA CREEK TO TIDAL PRISM	INCLUDED	
405.13	STREAM	CENTINELA CREEK CHANNEL	PROPOSED	
405.13	STREAM	GRAND CANAL		
405.13	STREAM	KENTER CANYON		
405.13	STREAM	MANDEVILLE CANYON CREEK	INCLUDED	
405.13	STREAM	PULGA CANYON		
405.13	STREAM	QUARRY CANYON		
405.13	STREAM	RUSTIC CANYON CREEK	INCLUDED	

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H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.13	STREAM	SANTA MONICA CANYON CHANNEL	INCLUDED	
405.13	STREAM	SANTA YNEZ CANYON	PROPOSED	
405.13	STREAM	SEPULVEDA CANYON		
405.13	STREAM	SEPULVEDA CHANNEL	PROPOSED	
405.13	STREAM	STONE CANYON		
405.13	STREAM	SULLIVAN CANYON CREEK	INCLUDED	
405.13	STREAM	TEMESCAL CANYON		
405.13	STREAM	TRAILER CANYON		
405.13	LAKE	DEL REY LAGOON		
405.13	LAKE	SANTA YNEZ LAKE (LAKE SHRINE)	PROPOSED	
405.13	LAKE	STONE CANYON RESERVOIR	PROPOSED	
405.13	LAKE	UPPER STONE CANYON RESERVOIR	PROPOSED	
405.13	HARBOR	MARINA DEL REY - ALL OTHER AREAS	INCLUDED	
405.13	HARBOR	MARINA DEL REY HARBOR	PROPOSED	
405.13	BEACH/BAY	MARINA DEL REY - PUBLIC BEACH AREAS	INCLUDED	
405.13	BEACH/BAY	OTHER NEARSHORE ZONE	PROPOSED	
405.13	BEACH/BAY	SANTA MONICA BEACH	PROPOSED	
405.13	BEACH/BAY	VENICE BEACH	PROPOSED	
405.13	BEACH/BAY	WILL ROGERS BEACH	PROPOSED	
405.13	ESTUARY	BALLONA CREEK (TIDAL PRISM)	INCLUDED	
405.13	ESTUARY	MARINA DEL REY - ENTRANCE CHANNEL	INCLUDED	
405.13	COASTAL WETLAND	BALLONA LAGOON	PROPOSED	•
405.13	COASTAL WETLAND	BALLONA WETLANDS	PROPOSED	•
405.13	COASTAL WETLAND	DEL REY LAGOON	PROPOSED	•
405.13	COASTAL WETLAND	VENICE CANALS - BALLONA CREEK (TIDAL PRISM)	INCLUDED	•
** HOLLYWOOD HSA				
405.14	STREAM	BRUSH CANYON		
405.14	STREAM	FRANKLIN CANYON		
405.14	STREAM	HIGGINS CANYON		
405.14	LAKE	HOLLYWOOD RESERVOIR	PROPOSED	
405.14	LAKE	LOWER FRANKLIN CANYON RESERVOIR	PROPOSED	
405.14	INLAND WETLAND	UPPER FRANKLIN CANYON RESERVOIR	PROPOSED	•
** CENTRAL HSA				
405.15	STREAM	ARROYO SALINAS		
405.15	STREAM	ARROYO SECO S. OF DEVIL'S GATE RES. (L)	INCLUDED	
405.15	STREAM	BACON CREEK		
405.15	STREAM	BALLONA CREEK	PROPOSED	
405.15	STREAM	COMPTON CREEK	INCLUDED	
405.15	STREAM	COYOTE CREEK TO BEGINNING OF TIDAL PRISM	INCLUDED	
405.15	STREAM	JALISCO, ARROYO		
405.15	STREAM	LA CANADA LEFFINGWELL		
405.15	STREAM	LA CANADA VERDE CREEK (LOWER)		
405.15	STREAM	LA CANADA VERDE CREEK *		
405.15	STREAM	LA MIRADA CREEK		
405.15	STREAM	LEFFINGWELL CREEK		
405.15	STREAM	LOS ANGELES RIVER TO TIDAL PRISM	INCLUDED	
405.15	STREAM	LOS CERRITOS CHANNEL TO TIDAL PRISM	INCLUDED	
405.15	STREAM	PESCADERO, ARROYO		
405.15	STREAM	RIO HONDO BELOW SPREADING GROUNDS	INCLUDED	
405.15	STREAM	RIO HONDO TO SPREADING GROUNDS	INCLUDED	
405.15	STREAM	SAN GABRIEL RIVER-FIRESTONE BLVD. TO TID. PRISM	INCLUDED	
405.15	STREAM	SAN MIGUEL, ARROYO		
405.15	STREAM	SAVAGE CREEK		

TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.15	STREAM	SORENSEN AVENUE DRAIN		
405.15	STREAM	SYCAMORE CANYON		
405.15	STREAM	TACOBI CREEK		
405.15	STREAM	TURNBULL CANYON		
405.15	STREAM	WORSHAM CREEK		
405.15	LAKE	ASCOT RESERVOIR		
405.15	LAKE	BOUTON LAKE		
405.15	INLAND WETLAND	EL DORADO LAKES	PROPOSED	*
405.15	LAKE	ELYSIAN RESERVOIR	PROPOSED	
405.15	LAKE	IVANHOE RESERVOIR	PROPOSED	
405.15	LAKE	MORNINGSIDE PARK RESERVOIR	PROPOSED	
405.15	LAKE	SILVER LAKE RESERVOIR	PROPOSED	
405.15	INLAND WETLAND	SIMS POND	PROPOSED	*
405.15	ESTUARY	SAN GABRIEL RIVER (TIDAL PRISM)	INCLUDED	
405.15	COASTAL WETLAND	LOS CERRITOS LAGOON	PROPOSED	*
405.15	COASTAL WETLAND	LOS CERRITOS WETLANDS	PROPOSED	*
** BULL CANYON HSA				
405.21	STREAM	ALISO CREEK	INCLUDED	
405.21	STREAM	ARROYO CALABASAS	INCLUDED	
405.21	STREAM	BEE CANYON		
405.21	STREAM	BELL CREEK	INCLUDED	
405.21	STREAM	BERRY CANYON		
405.21	STREAM	BLIND CANYON		
405.21	STREAM	BRACE CANYON		
405.21	STREAM	BRAND CANYON		
405.21	STREAM	BROCKMAN CANYON		
405.21	STREAM	BROWNS CREEK	INCLUDED	
405.21	STREAM	BULL CREEK	INCLUDED	
405.21	STREAM	BURBANK WESTERN CHANNEL	INCLUDED	
405.21	STREAM	CABALLERO CREEK	INCLUDED	
405.21	STREAM	CABRINI CANYON		
405.21	STREAM	CENTRAL BRANCH TUJUNGA WASH		
405.21	STREAM	CHANDLER CANYON		
405.21	STREAM	CHATSWORTH CREEK	PROPOSED	
405.21	STREAM	CHILDS CANYON		
405.21	STREAM	CRAIG CANYON		
405.21	STREAM	DARK CANYON		
405.21	STREAM	DAYTON CANYON CREEK	INCLUDED	
405.21	STREAM	DEAD HORSE CANYON		
405.21	STREAM	DEER CANYON		
405.21	STREAM	DEVIL CANYON		
405.21	STREAM	DRY CANYON CREEK	INCLUDED	
405.21	STREAM	EAST CANYON CHANNEL		
405.21	STREAM	ELMWOOD CANYON		
405.21	STREAM	ENCINO CREEK		
405.21	STREAM	FALLS CREEK		
405.21	STREAM	FERN CANYON		
405.21	STREAM	FISHER CANYON		
405.21	STREAM	GRAPEVINE CANYON		
405.21	STREAM	HANSEN HEIGHTS CHANNEL		
405.21	STREAM	HILLCREST CANYON		
405.21	STREAM	IDLEWOOD CANYON		
405.21	STREAM	INDIAN CANYON		
405.21	STREAM	IREDELL CANYON		

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H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.21	STREAM	JEFFRIES CANYON		
405.21	STREAM	LA TUNA CANYON CREEK	INCLUDED	
405.21	STREAM	LA TUNA CANYON LATERAL		
405.21	STREAM	LIMEKILN CREEK	INCLUDED	
405.21	STREAM	LOPEZ CANYON CREEK	INCLUDED	
405.21	RIP. STREAM	LOS ANGELES RIVER	INCLUDED	•
405.21	STREAM	MAND CANYON		
405.21	STREAM	MCCLURE CANYON		
405.21	STREAM	MCCOY CANYON CREEK	INCLUDED	
405.21	STREAM	MCDONALD CREEK		
405.21	STREAM	MORMON CANYON		
405.21	STREAM	PACOIMA DIVERSION CHANNEL		
405.21	STREAM	PACOIMA WASH	INCLUDED	
405.21	STREAM	POMEROY CANYON		
405.21	STREAM	SANTA SUSANA PASS WASH		
405.21	STREAM	SENNET CANYON		
405.21	STREAM	SHERER CANYON		
405.21	STREAM	SOUTH BRANCH BELL CREEK		
405.21	STREAM	STORY CANYON		
405.21	STREAM	STOUGH CANYON		
405.21	STREAM	SUNSET CANYON		
405.21	STREAM	SYCAMORE CANYON		
405.21	STREAM	TOLL CANYON		
405.21	STREAM	TUJUNGA WASH	INCLUDED	
405.21	STREAM	VERDUGO WASH		
405.21	STREAM	WELDON CANYON		
405.21	STREAM	WILBUR WASH		
405.21	STREAM	WILDWOOD CANYON		
405.21	STREAM	WOOLSEY CANYON		
405.21	STREAM	YBARRA CANYON		
405.21	LAKE	CHATSWORTH RESERVOIR	INCLUDED	
405.21	LAKE	ENCINO RESERVOIR	PROPOSED	
405.21	LAKE	GIRARD RESERVOIR	PROPOSED	
405.21	LAKE	GREEN VERDUGO RESERVOIR		
405.21	LAKE	HANSEN SPREADING GROUNDS		
405.21	LAKE	LEES LAKE	PROPOSED	
405.21	LAKE	LOS ANGELES RESERVOIR	INCLUDED	
405.21	LAKE	LOWER VAN NORMAN RESERVOIR	INCLUDED	
405.21	LAKE	MONTERIA LAKE	PROPOSED	
405.21	LAKE	PACOIMA SPREADING GROUNDS		
405.21	LAKE	SEPULVEDA FLOOD CONTROL RESERVOIR	INCLUDED	
405.21	LAKE	SOLANO RESERVOIR	PROPOSED	
405.21	LAKE	TOLUCA LAKE	PROPOSED	
405.21	LAKE	TUJUNGA SPREADING GROUNDS -1		
** SYLMAR HSA				
405.22	STREAM	ANT CANYON		
405.22	STREAM	BAD CANYON		
405.22	STREAM	BEE CANYON		
405.22	STREAM	BUCK CANYON		
405.22	STREAM	CHIMNEY CANYON		
405.22	STREAM	COUGAR CANYON		
405.22	STREAM	DAGGER FLAT CANYON		
405.22	STREAM	DOROTHY CANYON		
405.22	STREAM	GOOSEBERRY CANYON		

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H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.22	STREAM	GORDON CANYON		
405.22	STREAM	HOG CANYON		
405.22	STREAM	IRON CANYON		
405.22	STREAM	LAUREL CANYON		
405.22	STREAM	LIMEKILN CANYON		
405.22	STREAM	LONETREE CANYON		
405.22	STREAM	LOOP CANYON		
405.22	STREAM	MAPLE CANYON		
405.22	STREAM	MAY CANYON CREEK	INCLUDED	
405.22	STREAM	NOEL CANYON		
405.22	STREAM	NORTH FORK PACOIMA CANYON		
405.22	RIP. STREAM	PACOIMA CANYON CREEK	INCLUDED	*
405.22	STREAM	RATTLESNAKE CANYON		
405.22	STREAM	SCHOOLHOUSE CANYON		
405.22	STREAM	SOLD CANYON		
405.22	STREAM	SOUTH FORK PACOIMA CANYON		
405.22	STREAM	SPRING CREEK		
405.22	STREAM	STETSON CANYON CREEK	INCLUDED	
405.22	STREAM	WEST FORK SOMBRERO CANYON		
405.22	STREAM	WHITEWATER CANYON		
405.22	STREAM	WILSON CANYON CREEK	INCLUDED	
405.22	LAKE	PACOIMA RESERVOIR	INCLUDED	
405.22	LAKE	SCHOOLHOUSE DEBRIS BASIN		
405.22	LAKE	WILSON DEBRIS BASIN		
** TUJUNGA HSA				
405.23	STREAM	AKENS CANYON		
405.23	RIP. STREAM	ALDER CREEK	PROPOSED	*
405.23	STREAM	ALDER CREEK		
405.23	STREAM	BARTHOLOMAUS CANYON		
405.23	STREAM	BIG CIENEGA		
405.23	RIP. STREAM	BIG TUJUNGA CANYON CREEK	INCLUDED	*
405.23	STREAM	BLUEGUM CANYON		
405.23	STREAM	BOULDER CANYON		
405.23	STREAM	BREAKNECK CANYON		
405.23	STREAM	BRYANT CANYON		
405.23	STREAM	BUCK CANYON		
405.23	STREAM	CASSARA CANYON		
405.23	STREAM	CENTER CREEK		
405.23	STREAM	CHILAO CREEK		
405.23	RIP. STREAM	CLEAR CREEK	PROPOSED	*
405.23	STREAM	COLDWATER CANYON		
405.23	STREAM	CONDOR CANYON		
405.23	STREAM	COTTONWOOD CANYON		
405.23	STREAM	DELTA CANYON		
405.23	STREAM	DOANE CANYON		
405.23	STREAM	EAST FORK ALDER CREEK		
405.23	STREAM	EBEY CANYON		
405.23	STREAM	FALL CREEK	PROPOSED	
405.23	STREAM	FOX CREEK	PROPOSED	
405.23	STREAM	FUSIER CANYON		
405.23	STREAM	GOLD CREEK		
405.23	STREAM	GROTTO CREEK		
405.23	STREAM	HAINES CANYON CREEK	INCLUDED	
405.23	STREAM	HANSEN CANYON		

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
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H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.23	STREAM	JOSEPHINE CREEK		
405.23	STREAM	KAGEL CANYON CREEK	INCLUDED	
405.23	STREAM	LIMEROCK CANYON		
405.23	STREAM	LITTLE TUJUNGA CANYON CREEK	INCLUDED	
405.23	STREAM	LOPEZ CANYON	PROPOSED	
405.23	STREAM	LOVELL CANYON		
405.23	STREAM	LUCAS CREEK		
405.23	STREAM	LYNX GULCH		
405.23	STREAM	MAREK CANYON		
405.23	STREAM	MCKINLEY CANYON		
405.23	STREAM	MIDDLE FORK ALDER CREEK	PROPOSED	
405.23	STREAM	MIDDLE FORK MILL CREEK		
405.23	RIP. STREAM	MILL CREEK	INCLUDED	*
405.23	STREAM	MONTE CRISTO CREEK		
405.23	STREAM	MULE FORK		
405.23	STREAM	NEHR CANYON		
405.23	STREAM	NORTH FORK ALDER CREEK		
405.23	STREAM	NORTH FORK MILL CREEK		
405.23	STREAM	NORTH FORK TRAIL CANYON		
405.23	STREAM	OAK SPRING CANYON		
405.23	STREAM	OLIVER CANYON		
405.23	STREAM	PINE CANYON		
405.23	STREAM	PIPE CANYON		
405.23	STREAM	ROWLEY CANYON		
405.23	STREAM	SCHWARTZ CANYON		
405.23	STREAM	SILVER CREEK		
405.23	STREAM	SLAUGHTER CANYON		
405.23	STREAM	STONE CANYON		
405.23	STREAM	TRAIL CANYON		
405.23	RIP. STREAM	UPPER BIG TUJUNGA CANYON CREEK	PROPOSED	*
405.23	RIP. STREAM	VASQUEZ CREEK	PROPOSED	*
405.23	STREAM	VOGEL CANYON		
405.23	STREAM	WEST FORK ALDER CREEK	PROPOSED	
405.23	STREAM	WEST FORK FOX CREEK	PROPOSED	
405.23	STREAM	WHITE OAK CANYON	PROPOSED	
405.23	STREAM	WICKIUP CANYON	PROPOSED	
405.23	STREAM	WILDCAT GULCH		
405.23	STREAM	YBARRA CANYON		
405.23	STREAM	ZACHAU CANYON		
405.23	LAKE	BIG TUJUNGA RESERVOIR	INCLUDED	
405.23	LAKE	HANSEN FLOOD CONTROL RESERVOIR	INCLUDED	
405.23	LAKE	HANSEN LAKE	PROPOSED	
405.23	LAKE	MIDDLE LAKE	PROPOSED	
** VERDUGO HSA				
405.24	STREAM	AYARS CANYON		
405.24	STREAM	BLANCHARD CANYON		
405.24	STREAM	COOKS CANYON		
405.24	STREAM	CUNNINGHAM CANYON		
405.24	STREAM	DEER CREEK		
405.24	STREAM	DUNSMORE CANYON CREEK	INCLUDED	
405.24	STREAM	EAGLE CANYON		
405.24	STREAM	ENGLEHEARD CANYON		
405.24	STREAM	GOSS CANYON		
405.24	STREAM	HALLS CANYON CHANNEL		

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.24	STREAM	HENDERSON CANYON		
405.24	STREAM	LAS BARRAS CANYON		
405.24	STREAM	MULLALLY CANYON		
405.24	STREAM	PICKENS CANYON - BEFORE SNOVER CYN	INCLUDED	
405.24	STREAM	PICKENS CANYON CHANNEL BELOW FOOTHILL	INCLUDED	
405.24	STREAM	PICKENS CANYON-SNOVER CYN. TO FOOTHILL	INCLUDED	
405.24	STREAM	SHIELDS CANYON	INCLUDED	
405.24	STREAM	SUTTON CANYON		
405.24	STREAM	VERDUGO WASH	INCLUDED	
405.24	STREAM	WARD CANYON		
** EAGLE ROCK HSA				
405.25	LAKE	EAGLE ROCK RESERVOIR	PROPOSED	
** PASADENA HSA				
405.31	STREAM	ALHAMBRA WASH		
405.31	STREAM	ARCADIA WASH		
405.31	STREAM	ARROYO SECO S. OF DEVIL'S GATE RES. (U)	INCLUDED	
405.31	STREAM	BAILEY CANYON		
405.31	STREAM	CASTLE CANYON		
405.31	STREAM	DEER PARK BRANCH		
405.31	RIP. STREAM	EATON CANYON CREEK	INCLUDED	*
405.31	STREAM	EATON WASH (BELOW DAM)	INCLUDED	
405.31	STREAM	HARVARD BRANCH		
405.31	STREAM	HASTINGS CANYON		
405.31	STREAM	PASADENA GLEN		
405.31	RIP. STREAM	RUBIO CANYON	INCLUDED	*
405.31	STREAM	RUBIO WASH		
405.31	LAKE	DEVILS GATE RESERVOIR (LOWER)	INCLUDED	
405.31	LAKE	EATON DAM AND RESERVOIR	INCLUDED	
405.31	LAKE	SUNSET RESERVOIR -N		
405.31	LAKE	SUNSET RESERVOIR -S		
** MONK HILL HSA				
405.32	STREAM	AGUA CANYON		
405.32	RIP. STREAM	ARROYO SECO CANYON	INCLUDED	*
405.32	STREAM	BEAR CANYON		
405.32	STREAM	BROWN CANYON		
405.32	STREAM	CHIQUITA CANYON		
405.32	STREAM	CLOUDBURST CANYON		
405.32	STREAM	COLBY CANYON		
405.32	STREAM	DAISY CANYON		
405.32	STREAM	DARK CANYON		
405.32	STREAM	EL PRIETO CANYON CREEK	INCLUDED	
405.32	STREAM	FALLS CANYON		
405.32	STREAM	FERN CANYON		
405.32	STREAM	GOULD CANYON		
405.32	STREAM	GRAND CANYON		
405.32	STREAM	HALL BECKLEY CANYON		
405.32	STREAM	HAY CANYON		
405.32	STREAM	LADYBUG CANYON		
405.32	STREAM	LAS FLORES CANYON		
405.32	RIP. STREAM	LITTLE BEAR CREEK	INCLUDED	*
405.32	STREAM	LONG CANYON		
405.32	STREAM	MILLARD CANYON CREEK	INCLUDED	

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.32	STREAM	PICKENS CANYON		
405.32	STREAM	PINE CANYON		
405.32	STREAM	SAUCER BRANCH		
405.32	STREAM	SNOVER CANYON	INCLUDED	
405.32	STREAM	TWIN CANYON		
405.32	STREAM	WEBBER CANYON		
405.32	STREAM	WEST RAVINE		
405.32	STREAM	WINERY CANYON		
405.32	STREAM	WOODWARDIA CANYON		
405.32	LAKE	DEVIL'S GATE RESERVOIR (UPPER)	INCLUDED	
** SANTA ANITA HSA				
405.33	STREAM	ARCADIA WASH (UPPER)	INCLUDED	
405.33	RIP. STREAM	BIG SANTA ANITA CANYON CREEK	INCLUDED	*
405.33	STREAM	CLAMSHELL CANYON		
405.33	STREAM	EAST BRANCH ARCADIA WASH		
405.33	STREAM	EAST FORK SANTA ANITA CANYON	PROPOSED	
405.33	STREAM	LITTLE SANTA ANITA CANYON CREEK	INCLUDED	
405.33	STREAM	NORTH FORK SANTA ANITA CANYON		
405.33	STREAM	SAN OLENE CANYON		
405.33	STREAM	SANTA ANITA WASH (UPPER)	INCLUDED	
405.33	RIP. STREAM	WINTER CREEK	INCLUDED	*
405.33	LAKE	BIG SANTA ANITA RESERVOIR	INCLUDED	
** MAIN SAN GABRIEL HSA				
405.41	STREAM	ALHAMBRA WASH	INCLUDED	
405.41	STREAM	ARCADIA WASH (LOWER)	INCLUDED	
405.41	STREAM	AVOCADO CREEK		
405.41	STREAM	BELL CANYON	INCLUDED	
405.41	RIP. STREAM	BIG DALTON CANYON CREEK	INCLUDED	*
405.41	STREAM	BIG DALTON WASH	INCLUDED	
405.41	STREAM	BLISS CANYON		
405.41	STREAM	BRADBURY CANYON CREEK	INCLUDED	
405.41	STREAM	CHARTER OAK CREEK		
405.41	STREAM	DIAMOND BAR CREEK		
405.41	STREAM	EAST BRANCH BIG DALTON WASH		
405.41	STREAM	EATON WASH	PROPOSED	
405.41	STREAM	ENGLEWILD CANYON		
405.41	STREAM	GORDON CANYON		
405.41	STREAM	HACIENDA CHANNEL		
405.41	STREAM	HARROW CANYON		
405.41	STREAM	KERIL CANYON		
405.41	STREAM	LEMON CREEK		
405.41	STREAM	LEWIS PAUL CANYON		
405.41	RIP. STREAM	LITTLE DALTON CANYON CREEK	INCLUDED	*
405.41	STREAM	LITTLE DALTON WASH	INCLUDED	
405.41	STREAM	LUGUNA CHANNEL		
405.41	STREAM	MAPLE CANYON		
405.41	STREAM	MARSHALL CREEK	PROPOSED	
405.41	STREAM	MISSION CREEK		
405.41	STREAM	MONROE CANYON		
405.41	RIP. STREAM	MONROVIA CANYON CREEK	INCLUDED	*
405.41	STREAM	MORGAN CANYON		
405.41	STREAM	MULL CANYON		
405.41	STREAM	MYSTIC CANYON	INCLUDED	

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.41	STREAM	PINE CANYON		
405.41	STREAM	POWDER CANYON		
405.41	STREAM	PUDDINGSTONE WASH	INCLUDED	
405.41	STREAM	PUENTE CREEK	INCLUDED	
405.41	RIP. STREAM	RIO HONDO	INCLUDED	*
405.41	STREAM	RUBIO WASH	PROPOSED	
405.41	STREAM	RUBY CANYON		
405.41	STREAM	SAN DIMAS WASH (LOWER)	INCLUDED	
405.41	STREAM	SAN GABRIEL RIVER	PROPOSED	
405.41	STREAM	SAN JOSE CREEK	PROPOSED	
405.41	STREAM	SAN JOSE CREEK (OLD CHANNEL)	PROPOSED	
405.41	STREAM	SANTA ANITA WASH (LOWER)	INCLUDED	
405.41	STREAM	SAWPIT CANYON	INCLUDED	
405.41	STREAM	SAWPIT WASH	INCLUDED	
405.41	STREAM	SHAY CANYON		
405.41	STREAM	SOUTH SAN JOSE CREEK	PROPOSED	
405.41	STREAM	SPANISH CANYON		
405.41	STREAM	SPINKS CANYON CREEK	INCLUDED	
405.41	STREAM	SPRING CANYON		
405.41	STREAM	SYCAMORE CANYON		
405.41	STREAM	TWIN SPRINGS CANYON		
405.41	STREAM	VASSAR CANYON		
405.41	STREAM	VINE CREEK		
405.41	STREAM	VOLFE CANYON		
405.41	RIP. STREAM	WALNUT CREEK WASH	INCLUDED	*
405.41	STREAM	WILDWOOD CANYON		
405.41	LAKE	BIG DALTON DAM AND RESERVOIR	INCLUDED	
405.41	LAKE	GARVEY RESERVOIR		
405.41	INLAND WETLAND	LEGG LAKE	INCLUDED	*
405.41	LAKE	LEGG LAKE (SOUTH)		
405.41	INLAND WETLAND	SANTA FE FLOOD CONTROL BASIN	INCLUDED	*
405.41	LAKE	SAWPIT DAM AND RESERVOIR	INCLUDED	
405.41	LAKE	WHITTIER NARROWS FLOOD CONTROL BASIN (RESERVOIR)	INCLUDED	
** LOWER CANYON HSA				
405.42	STREAM	SAN GABRIEL RIVER	INCLUDED	
** UPPER CANYON HSA				
405.43	STREAM	ALDER GULCH		
405.43	RIP. STREAM	ALLISON GULCH	PROPOSED	*
405.43	STREAM	ALPINE CANYON		
405.43	RIP. STREAM	BEAR CREEK	PROPOSED	*
405.43	STREAM	BEAR GULCH		
405.43	STREAM	BEATTY CANYON		
405.43	STREAM	BICHOTA CANYON	PROPOSED	
405.43	STREAM	BIG MERMAIDS CANYON		
405.43	STREAM	BLIND CANYON		
405.43	STREAM	BOBCAT CANYON	PROPOSED	
405.43	STREAM	BROWNS GULCH		
405.43	STREAM	BURRO CANYON		
405.43	STREAM	BUTTERFIELD CANYON		
405.43	STREAM	CAPE HORN CANYON		
405.43	RIP. STREAM	CATTLE CREEK	INCLUDED	*
405.43	STREAM	CEDAR CANYON		
405.43	STREAM	CEDAR CREEK	PROPOSED	

TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.43	STREAM	CHILENO CANYON	PROPOSED	
405.43	STREAM	CLARK GULCH		
405.43	STREAM	CLOUDBURST CANYON		
405.43	STREAM	COLD SPRINGS CANYON		
405.43	STREAM	COLDBROOK CRKEK	PROPOSED	
405.43	RIP. STREAM	COLDWATER CANYON CREEK	INCLUDED	*
405.43	RIP. STREAM	COW CREEK	INCLUDED	*
405.43	STREAM	DEVIL GULCH		
405.43	RIP. STREAM	DEVILS CANYON CREEK	INCLUDED	*
405.43	STREAM	DIME CANYON		
405.43	STREAM	DRY GULCH		
405.43	STREAM	EAST FORK HORSE CANYON		
405.43	RIP. STREAM	EAST FORK SAN GABRIEL RIVER	INCLUDED	*
405.43	STREAM	EAST FORK SUSANNA CANYON		
405.43	STREAM	FALLS CANYON		
405.43	STREAM	FALLS GULCH		
405.43	STREAM	FERN CANYON		
405.43	RIP. STREAM	FISH CANYON	INCLUDED	*
405.43	RIP. STREAM	FISH FORK	PROPOSED	*
405.43	STREAM	FOSSIL CANYON		
405.43	STREAM	GARCIA CANYON		
405.43	STREAM	GLEN CANYON		
405.43	STREAM	GRAVEYARD CANYON		
405.43	STREAM	HORSE CANYON		
405.43	RIP. STREAM	IRON FORK	PROPOSED	*
405.43	STREAM	ISLIP CANYON		
405.43	STREAM	LAUREL GULCH		
405.43	STREAM	LITTLE MERMAIDS CANYON		
405.43	STREAM	LOBO CANYON		
405.43	STREAM	LOST CANYON	PROPOSED	
405.43	STREAM	MADDOCK CANYON CREEK	INCLUDED	
405.43	STREAM	MAPLE CANYON		
405.43	STREAM	MINE GULCH		
405.43	STREAM	MINERO CANYON		
405.43	RIP. STREAM	NORTH FORK SAN GABRIEL RIVER	INCLUDED	*
405.43	STREAM	OAK CANYON		
405.43	STREAM	PEACOCK CANYON		
405.43	STREAM	PERSINGER CANYON		
405.43	STREAM	PHIPPS CANYON		
405.43	STREAM	PINE CANYON		
405.43	STREAM	POLECAT GULCH		
405.43	RIP. STREAM	PRAIRIE FORK	PROPOSED	*
405.43	STREAM	RATTLESNAKE CANYON		
405.43	STREAM	RINCON CANYON		
405.43	STREAM	ROBBS GULCH		
405.43	RIP. STREAM	ROBERTS CANYON	INCLUDED	*
405.43	STREAM	ROCKBOUND CANYON		
405.43	STREAM	ROSS GULCH		
405.43	STREAM	RUSH CREEK		
405.43	RIP. STREAM	SAN GABRIEL RIVER - MAIN STEM	INCLUDED	*
405.43	STREAM	SHARPS CANYON		
405.43	STREAM	SHOEMAKER CANYON		
405.43	STREAM	SHORTCUT CANYON		
405.43	STREAM	SNOWSLIDE CANYON		
405.43	STREAM	SOLDIER CREEK	PROPOSED	

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.43	STREAM	SOUTH FORK IRON FORK	PROPOSED	
405.43	STREAM	STRAYNS CANYON		
405.43	STREAM	SUSANNA CANYON		
405.43	STREAM	TRAIL FORK		
405.43	STREAM	TUMBLER CANYON	PROPOSED	
405.43	STREAM	VALLEY FORGE CANYON		
405.43	STREAM	VAN TASSEL CANYON	INCLUDED	
405.43	STREAM	VENEDO CANYON		
405.43	STREAM	VINCENT GULCH	PROPOSED	
405.43	STREAM	WATER CANYON		
405.43	STREAM	WEST FORK BEAR CREEK	PROPOSED	
405.43	RIP. STREAM	WEST FORK SAN GABRIEL RIVER	INCLUDED	*
405.43	STREAM	WILLIAMS CANYON		
405.43	LAKE	COGSWELL RESERVOIR	INCLUDED	
405.43	LAKE	CRYSTAL LAKE	INCLUDED	
405.43	LAKE	MORRIS RESERVOIR	INCLUDED	
405.43	LAKE	SAN GABRIEL RESERVOIR	INCLUDED	
** FOOTHILL HSA				
405.44	STREAM	EAST FORK SAN DIMAS CANYON		
405.44	RIP. STREAM	FERN CANYON	PROPOSED	*
405.44	STREAM	HAM CANYON		
405.44	STREAM	HUMMINGBIRD CREEK		
405.44	STREAM	LODI CANYON		
405.44	RIP. STREAM	SAN DIMAS CANYON CREEK	INCLUDED	*
405.44	STREAM	SAN DIMAS WASH (UPPER)	INCLUDED	
405.44	STREAM	SYCAMORE CANYON		
405.44	STREAM	TANBARK CREEK		
405.44	STREAM	WEST FORK SAN DIMAS CANYON	PROPOSED	
405.44	RIP. STREAM	WOLFSKILL CANYON	PROPOSED	*
405.44	LAKE	SAN DIMAS DAM AND RESERVOIR	INCLUDED	
** SAN JOSE HSA				
405.51	STREAM	SAN JOSE CREEK	INCLUDED	
405.51	STREAM	SOUTH SAN JOSE CREEK		
** POMONA HSA				
405.52	STREAM	LIVE OAK WASH	PROPOSED	
405.52	STREAM	THOMPSON WASH	PROPOSED	
405.52	LAKE	PUDDINGSTONE DAM AND RESERVOIR	INCLUDED	
** LIVE OAK HSA				
405.53	STREAM	BURBANK CANYON		
405.53	STREAM	CHICKEN CANYON		
405.53	STREAM	COBAL CANYON		
405.53	STREAM	EMERALD CREEK AND WASH	INCLUDED	
405.53	STREAM	GAIL CANYON		
405.53	STREAM	LIVE OAK CREEK AND WASH	INCLUDED	
405.53	RIP. STREAM	MARSHALL CREEK AND WASH	INCLUDED	*
405.53	STREAM	PALMER CANYON		
405.53	STREAM	THOMPSON CREEK	INCLUDED	
405.53	STREAM	THOMPSON WASH		
405.53	STREAM	WEBB CANYON		
405.53	STREAM	WEST FORK PALMER CANYON		
405.53	STREAM	WILLIAMS CANYON		

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
405.53	LAKE	LIVE OAK DAM AND RESERVOIR	INCLUDED	
405.53	LAKE	THOMPSON CREEK DAM AND RESERVOIR	INCLUDED	
** LA HABRA HSA SPLIT				
405.62	STREAM	BREA CANYON		
405.62	STREAM	DIAMOND BAR CREEK		
405.62	STREAM	TONNER CANYON		
** YORBA LINDA HSA SPLIT				
405.63	STREAM	LIONS CANYON		
405.63	STREAM	SONOME CANYON		
**				
406.01	BEACH/BAY	NEARSHORE ZONE	INCLUDED	
406.01	BEACH/BAY	OFFSHORE ZONE c	INCLUDED	
** ANACAPA ISLAND HA				
406.10	BEACH/BAY	NEARSHORE	INCLUDED	
406.10	ISLAND	ISLANDS	INCLUDED	
** SAN NICOLAS ISLAND HA				
406.20	STREAM	SURFACE WATERCOURSES	INCLUDED	
406.20	BEACH/BAY	BEGG-ROCK NEARSHORE ZONE	INCLUDED	
406.20	BEACH/BAY	NEARSHORE ZONE	INCLUDED	
** SAN NICHOLAS ISLAND HA				
406.20	BIOLSIG	SAN NICHOLAS ISLAND		
** SANTA BARBARA ISLAND HA				
406.30	ISLAND	SANTA BARBARA ISLAND	INCLUDED	
406.30	BIOLSIG	SANTA BARBARA ISLAND		
** SANTA CATALINA ISLAND HA				
406.40	STREAM	BIG SPRINGS CANYON		
406.40	STREAM	CAPE CANYON		
406.40	STREAM	COTTONWOOD CANYON		
406.40	STREAM	LITTLE SPRINGS CANYON		
406.40	STREAM	MIDDLE CANYON CREEK	PROPOSED	
406.40	STREAM	SILVER CANYON		
406.40	LAKE	BIG SPRINGS RESERVOIR	PROPOSED	
406.40	LAKE	BUFFALO SPRINGS RESERVOIRS	PROPOSED	
406.40	LAKE	CAPE CANYON RESERVOIR	PROPOSED	
406.40	LAKE	DEEP TANK RESERVOIR	PROPOSED	
406.40	LAKE	ECHO LAKE	PROPOSED	
406.40	LAKE	HAYPRESS RESERVOIR	PROPOSED	
406.40	LAKE	LOWER BUFFALO CORRAL RESERVOIR	PROPOSED	
406.40	LAKE	PATRICK RESERVOIR	PROPOSED	
406.40	LAKE	SUMMIT RESERVOIR	PROPOSED	
406.40	LAKE	THOMPSON DAM	PROPOSED	
406.40	LAKE	UPPER BUFFALO CORRAL RESERVOIR	PROPOSED	
406.40	LAKE	WRIGLEY RESERVOIR	PROPOSED	
406.40	ESTUARY	AVALON CANYON CREEK	PROPOSED	
406.40	ESTUARY	BIG SPRINGS CANYON	PROPOSED	
406.40	ISLAND	SANTA CATALINA ISLAND	INCLUDED	
406.40	BIOLSIG	SANTA CATALINA ISLAND - SUBAREA 1		

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TABLE 1.0 NAMED WATERBODIES OF REGION 4
By Hydrologic Unit

H.U.	TYPE	NAME	INCLUDED/ PROPOSED	WETLAND DESIGN.
406.40	BIOLSIG	SANTA CATALINA ISLAND - SUBAREA 2		
406.40	BIOLSIG	SANTA CATALINA ISLAND - SUBAREA 3		
406.40	BIOLSIG	SANTA CATALINA ISLAND - SUBAREA 4		
** SAN CLEMENTE ISLAND HA				
406.50	ISLAND	SAN CLEMENTE ISLAND	INCLUDED	
406.50	BIOLSIG	SAN CLEMENTE ISLAND		
**				
481.21	STREAM	SAN ANTONIO CREEK CHANNEL	PROPOSED	
481.23	RIP. STREAM	SAN ANTONIO CANYON CREEK	INCLUDED	*
481.23	STREAM	SAN ANTONIO CREEK CHANNEL	PROPOSED	
481.23	LAKE	SAN ANTONIO DAM AND RESERVOIR	INCLUDED	

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
401.00	JAVON CANYON	PROPOSED	2.8		I	*
401.00	LOS SAUCES CREEK	PROPOSED	4.7		I	
401.00	MADRANIO CANYON	PROPOSED	3.9		I	
401.00	PADRE JUAN CANYON	PROPOSED	3.6		I	
401.00	POVERTY CANYON	PROPOSED	1.7		I	
401.21	CHINO CREEK		2.0		I	
401.21	SAN ANTONIO CREEK CHANNEL	INCLUDED	1.0		I	
401.23	BEAR CANYON		0.9		I	
401.23	CAT CANYON		1.0		I	
401.23	DRY LAKE CANYON		1.0		I	
401.23	EVEY CANYON		2.2		I	
401.23	SAN ANTONIO CANYON CREEK	INCLUDED	6.2		I	
401.23	SAN ANTONIO CREEK CHANNEL		2.8		I	
401.23	SPRUCE CANYON		1.3		I	
401.23	WEST FORK BEAR CANYON		1.2		I	
402.10	CANADA DE LAS ENCINAS		1.2		I	
402.10	CANADA DE RODRIGUES		2.3		I	
402.10	CANADA DEL ALISO		3.3		I	
402.10	CANADA DEL DIABLO		5.0		I	
402.10	CANADA DEL SAN JOAQUIN		2.4		I	
402.10	CANADA LARGA CREEK	INCLUDED	8.0		I	
402.10	CANADA SECA		1.8		I	
402.10	COCHE CANYON		3.5		I	
402.10	EAST FORK HALL CANYON	PROPOSED	3.6		PERM	
402.10	HALL CANYON	PROPOSED	4.7		PERM	
402.10	HAMMOND CANYON		4.5		I	
402.10	LEON CANYON		2.8		I	
402.10	MANUEL CANYON		2.4		I	
402.10	SANLON BARRANCA		1.5		I	
402.10	SULPHUR CANYON		3.1		I	
402.10	VENTURA RIVER & TRIBUTARIES	INCLUDED	5.9		PERM	*
402.10	WELDON CANYON		3.2		I	
402.20	AYERS CREEK	PROPOSED	2.3		PERM	
402.20	CHISMAHOO CREEK	PROPOSED	2.0		PERM	
402.20	COOPER CANYON		1.3		I	
402.20	COYOTE CREEK	PROPOSED	14.1		PERM	*
402.20	COZY DELL CANYON		4.2		I	
402.20	EAST FORK COYOTE CREEK	PROPOSED	2.5		PERM	*
402.20	FRESNO CANYON		2.8		I	
402.20	KENNEDY CANYON		2.1		I	
402.20	LIME CANYON		1.7		I	
402.20	LION CANYON		4.6		I	
402.20	MATILIJA CREEK	PROPOSED	15.9		PERM	*
402.20	MCDONALD CANYON		4.9		I	
402.20	MURIETTA CANYON	PROPOSED	4.1		PERM	*
402.20	NORTH FORK MATILIJA CREEK	PROPOSED	7.7		PERM	
402.20	NORTH FORK SANTA ANA CREEK		2.7		I	
402.20	OLD MAN CANYON	PROPOSED	3.2		I	*
402.20	POPLIN CREEK		2.9		I	
402.20	RICE CANYON		1.5		I	
402.20	SAN ANTONIO CREEK & TRIBUTARIES	INCLUDED	5.4		PERM	*
402.20	SANTA ANA CREEK	PROPOSED	6.1		PERM	*
402.20	UPPER NORTH FORK MATILIJA CREEK	PROPOSED	7.0		PERM	

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
402.20	VENTURA RIVER & TRIBUTARIES	INCLUDED	10.4		PERM	*
402.20	WEST FORK COYOTE CREEK	PROPOSED	2.5		PERM	
402.20	WEST FORK SANTA ANA CREEK	PROPOSED	3.5		PERM	*
402.20	WILLOW CREEK	PROPOSED	2.3		PERM	
402.20	WILLS CANYON		2.4		I	
402.31	BIG CANYON		1.7		I	
402.31	LION CANYON	PROPOSED	4.8		I	
402.31	SYCAMORE CREEK		2.1		I	
402.32	GRIDLEY CANYON		4.1		I	
402.32	HORN CANYON	PROPOSED	6.5		I	
402.32	REEVES CREEK	PROPOSED	5.5		I	
402.32	SAN ANTONIO CREEK	INCLUDED	9.0		PERM	
402.32	STEWART CANYON		3.1		I	
403.11	BARLOW CANYON		3.6		I	
403.11	CALLEGUAS CREEK	INCLUDED	2.2		PERM	
403.11	HARMON CANYON		8.1		I	
403.11	LAKE CANYON		2.5		I	
403.11	REVOLON SLOUGH	INCLUDED	8.9		PERM	
403.11	SANTA CLARA RIVER	INCLUDED	9.8		PERM	*
403.11	SEXTON CANYON	PROPOSED	8.2		PERM	
403.12	ARROYO LAS POSAS	PROPOSED	1.7		I	
403.12	CALLEGUAS CREEK	INCLUDED	10.9		I	
403.12	CONEJO CREEK	INCLUDED	5.5		I	
403.12	LONG GRADE CANYON		4.3		I	
403.21	ADAMS CANYON		9.1		I	
403.21	ALISO CANYON		10.6		I	
403.21	ANLAUF CANYON		2.1		I	
403.21	EAST FORK SANTA PAULA CANYON		3.3		I	
403.21	ECHO FALLS CANYON		2.7		I	
403.21	FAGAN CANYON		4.9		I	
403.21	HAMPTON CANYON		2.4		I	
403.21	LA BROCHE CANYON		2.1		I	
403.21	LONG CANYON		4.5		PERM	
403.21	MORGAN CANYON		1.5		I	
403.21	MUD CREEK CANYON		3.7		I	
403.21	O'HARA CANYON		6.2		I	
403.21	PEPPERTREE CANYON		6.5		I	
403.21	RICHARDSON CANYON		1.8		I	
403.21	SALTMARSH CANYON		3.5		I	
403.21	SANTA CLARA RIVER	INCLUDED	6.7		PERM	*
403.21	SANTA PAULA CREEK	INCLUDED	16.5		PERM	
403.21	SISAR CREEK	INCLUDED	1.2		PERM	*
403.21	WHEELER CANYON		1.3	1.3	I	
403.22	BEAR CANYON		3.1		I	
403.22	SISAR CREEK	INCLUDED	6.4		PERM	*
403.31	BALCOM CANYON		4.1		I	
403.31	BOULDER CREEK		6.5		I	
403.31	GRIMES CANYON		5.0		I	
403.31	LOFTUS CANYON		0.8		I	
403.31	ORCUTT CANYON		5.9		I	
403.31	POLE CREEK		9.2		I	
403.31	SANTA CLARA RIVER	INCLUDED	9.7		PERM	*
403.31	SESPE CREEK	INCLUDED	6.0		I	*
403.31	SNOW CANYON		3.6		I	

TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
403.31	TIMBER CANYON		4.9		I	
403.31	WILLARD CANYON		1.2		I	
403.32	ABADI CREEK		6.5		I	
403.32	ADOBE CREEK		3.8		I	
403.32	ALDER CREEK	PROPOSED	7.1		PERM	
403.32	BEAR CANYON	PROPOSED	3.2		PERM	*
403.32	BEAR CREEK	PROPOSED	0.9		I	
403.32	BURRO CREEK		3.4		I	
403.32	CENTENNIAL CREEK		1.5		I	
403.32	CHERRY CREEK		2.7		I	
403.32	CHORRO GRANDE CANYON		3.4		I	
403.32	COLDWATER CANYON	PROPOSED	2.2		PERM	*
403.32	COLDWATER FORK		3.9		I	
403.32	DERRYDALE CREEK		3.3		I	
403.32	EAST FORK ALDER CREEK	PROPOSED	2.9		PERM	
403.32	ELM CREEK		1.5		I	
403.32	FOURFORK CREEK		1.7		I	
403.32	GODWIN CANYON		3.9		I	
403.32	HOT SPRINGS CANYON	PROPOSED	6.0		PERM	
403.32	HOWARD CREEK	PROPOSED	3.5		PERM	
403.32	LADYBUG CREEK		1.2		I	
403.32	LION CANYON	PROPOSED	7.0		PERM	
403.32	LITTLE SESPE CREEK		2.2		I	
403.32	MAPLE CREEK	PROPOSED	2.8		I	
403.32	MUNSON CREEK		3.5		I	
403.32	NORTH FORK PIEDRA BLANCA CREEK		3.2		I	
403.32	PARK CREEK		4.7		I	
403.32	PIEDRA BLANCA CREEK	PROPOSED	9.0		PERM	*
403.32	PINE CANYON	PROPOSED	4.7		PERM	*
403.32	POPLAR CREEK	PROPOSED	2.3		PERM	
403.32	POTRERO JOHN CREEK	PROPOSED	3.6		PERM	*
403.32	RED REEF CANYON		2.5		I	
403.32	REDROCK CREEK	PROPOSED	4.0		PERM	*
403.32	ROSE VALLEY CREEK	PROPOSED	3.5		PERM	*
403.32	SESPE CREEK & TRIBUTARIES	INCLUDED	52.9		PERM	*
403.32	SPRING CANYON		2.5		I	
403.32	STONE CORRAL CREEK		3.7		I	
403.32	SYCAMORE CREEK		3.0		I	
403.32	TAR CREEK	PROPOSED	5.9		I	
403.32	TIMBER CREEK	PROPOSED	4.9		PERM	*
403.32	TROUT CREEK	PROPOSED	4.1		PERM	*
403.32	TULE CREEK	PROPOSED	5.3		PERM	*
403.32	WEST FORK SESPE CREEK	PROPOSED	6.3		PERM	*
403.41	BLANCHARD CANYON		2.5		I	
403.41	CALUMET CANYON		2.0		I	
403.41	DEVIL CANYON	PROPOSED	6.9		PERM	
403.41	DOMINGUEZ CANYON	PROPOSED	4.2		PERM	
403.41	EDWARDS CANYON		2.9		I	
403.41	EUREKA CANYON		4.8		I	
403.41	FAIRVIEW CANYON		2.2		I	
403.41	FREY CANYON		2.6		I	
403.41	HOLSER CANYON		4.0		I	
403.41	HOPPER CREEK	INCLUDED	13.6		I	
403.41	LECHLER CANYON	PROPOSED	3.0		PERM	

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
403.41	LIME CANYON		3.5		I	
403.41	MAPLE CANYON		0.8		I	
403.41	MODELO CANYON		2.8		I	
403.41	NUEVO CANYON		1.3		I	
403.41	OAK CANYON		2.1		I	
403.41	PIRU CREEK & TRIBUTARIES	INCLUDED	8.5		PERM	*
403.41	RAMONA CANYON		0.8		I	
403.41	REAL WASH		2.5		I	
403.41	REASONER CANYON		4.3		I	
403.41	SANTA CLARA RIVER	INCLUDED	11.2		PERM	*
403.41	SANTA FELICIA CANYON	PROPOSED	7.1		PERM	
403.41	SHIELLS CANYON		1.6		I	
403.41	SMITH CANYON		2.5		I	
403.41	TAPO CANYON	PROPOSED	4.0		I	
403.41	TOMS CANYON		3.9		I	
403.41	TORREY CANYON		2.0		I	
403.41	WARRING CANYON		3.6		I	
403.41	WILEY CANYON		2.2		I	
403.42	AGUA BLANCA CREEK	PROPOSED	17.1		PERM	
403.42	ALAMO CREEK		5.2		I	
403.42	BEAR GULCH		2.1		I	
403.42	BEARTRAP CANYON	PROPOSED	2.3		PERM	
403.42	BIG CEDAR CREEK		1.3		I	
403.42	BUCK CREEK	PROPOSED	5.4		PERM	
403.42	CANTON CANYON		9.2		I	
403.42	CARLOS CANYON		2.0		I	
403.42	CEDAR CREEK		1.9		PERM	
403.42	CHERRY CANYON		2.7		I	
403.42	DEAD HORSE CREEK		1.9		I	
403.42	DRY CREEK		6.9		I	
403.42	FISH CREEK	PROPOSED	6.1		PERM	
403.42	FRAZIER CREEK	PROPOSED	3.3		PERM	
403.42	LACOSCA CREEK		2.8		I	
403.42	LIEBRE GULCH		8.3		I	
403.42	LITTLE MUTAU CREEK		5.3		I	
403.42	LOCKWOOD CREEK	PROPOSED	4.2		PERM	
403.42	LONG DAVE CANYON		2.9		I	
403.42	MICHAEL CREEK		2.3		I	
403.42	MUTAU CREEK	PROPOSED	10.8		PERM	
403.42	NORTH FORK FISH CREEK		3.0		I	
403.42	OSITO CANYON		3.5		I	
403.42	PIRU CREEK & TRIBUTARIES	INCLUDED	60.0	0.6	PERM	*
403.42	POSEY CANYON		2.8		I	
403.42	ROCK CREEK		2.6		I	
403.42	ROSE CREEK		1.6		I	
403.42	RUBY CANYON		3.1		I	
403.42	SHARPS CANYON		2.8		I	
403.42	SHEEP CREEK		3.5		I	
403.42	SMITH FORK		2.5		I	
403.42	SNOWY CREEK	PROPOSED	7.8		PERM	
403.42	SOUTH FORK PIRU CREEK	PROPOSED	4.2		PERM	
403.42	SULPHUR CREEK		3.0		PERM	
403.42	TRAIL CANYON		1.5		I	
403.42	TURTLE CANYON		2.7		I	

TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
403.42	WEST FORK LIEBRE GULCH		8.4		I	
403.43	APPLE CANYON		4.6		I	
403.43	CANADA DE LOS ALAMOS & TRIBUTARIES	INCLUDED	7.8		PERM	
403.43	COYOTE CANYON		2.3		I	
403.43	FREEMAN CANYON		6.2		I	
403.43	GORMAN CREEK	PROPOSED	12.2		PERM	
403.43	HUNGRY VALLEY		5.5		I	
403.43	MAXY CANYON		8.4		I	
403.44	AMARGOSA CREEK		7.0		I	
403.44	LOCKWOOD CREEK & TRIBUTARIES	INCLUDED	7.7		PERM	
403.44	MIDDLE FORK LOCKWOOD CREEK		7.1		I	
403.44	NORTH FORK LOCKWOOD CREEK		8.0		I	
403.44	SAN GUILLERMO CREEK		6.7		I	
403.44	SEYMOUR CREEK		8.3		I	
403.51	ABRAMS CANYON		1.7		I	
403.51	BAIRD CANYON		1.1		I	
403.51	BEAR CANYON		5.0		I	
403.51	BEE CANYON		5.6		I	
403.51	BITTER CANYON		3.1		I	
403.51	BOUQUET CREEK & TRIBUTARIES	INCLUDED	14.3		PERM	*
403.51	BURNS CANYON		1.2		I	
403.51	BURNT PEAK CANYON		4.9		I	
403.51	BURRO CANYON		2.2		I	
403.51	CASTAIC CREEK & TRIBUTARIES	INCLUDED	24.4	0.7	I	
403.51	CHARLIE CANYON		9.8		I	
403.51	CHERRY CANYON		4.0		I	
403.51	CIENAGA CANYON		2.7		I	
403.51	CLEARWATER CANYON		2.4		I	
403.51	COARSE GOLD CANYON		1.3		I	
403.51	COLD CANYON		2.8		I	
403.51	COYOTE CANYON		1.8		I	
403.51	DEER CANYON		2.0		I	
403.51	DEWITT CANYON		1.6		I	
403.51	DRINKWATER CANYON		1.7		I	
403.51	DRY CANYON	INCLUDED	8.9		I	
403.51	DRY GULCH		2.9		I	
403.51	EAST CANYON		1.7		I	
403.51	EAST FORK FISH CANYON		3.5		I	
403.51	EAST FORK SALT CANYON		2.0		I	
403.51	ELDERBERRY CANYON		3.7		I	
403.51	ELIZABETH LAKE CANYON & TRIB.	INCLUDED	19.1		PERM	
403.51	ELSMERE CANYON		2.8		I	
403.51	FALL CANYON		2.8		I	
403.51	FISH CANYON		13.0		I	
403.51	FISH CREEK		4.4		I	
403.51	FORSYTHE CANYON		1.3		I	
403.51	GAVIN CANYON		7.6		I	
403.51	GORMAN CANYON		1.4		I	
403.51	GRASSHOPPER CANYON		5.5		I	
403.51	HASKELL CANYON		8.9		I	
403.51	HASLEY CANYON		5.5		I	
403.51	HIATT CANYON		1.9		I	
403.51	IRON CANYON		4.9		I	
403.51	KLEINE CANYON		1.9		I	

TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
403.51	LEAMING CANYON		1.1		I	
403.51	LION CANYON		1.2		I	
403.51	LOS PINETOS CANYON		1.4		I	
403.51	LUCKY CANYON		0.8		I	
403.51	LYON CANYON		3.2		I	
403.51	MARPLE CANYON		6.8		I	
403.51	MINT CANYON & TRIBUTARIES	INCLUDED	8.2		I	
403.51	MUNZ CANYON		1.7		I	
403.51	MYSTIC CANYON		2.4		I	
403.51	NECKTIE CANYON		4.2		I	
403.51	NEWHALL CREEK		4.4		I	
403.51	NORTH FORK		1.7		I	
403.51	OAK SPRING CANYON		5.2		I	
403.51	OAKDALE CANYON		0.9		I	
403.51	ORO FINO CANYON		2.0		I	
403.51	ORR SPRING CANYON		0.7		I	
403.51	PALOMAS CANYON		2.4		I	
403.51	PETTINGER CANYON		2.7		I	
403.51	PICO CANYON		7.7		I	
403.51	PINE CANYON		9.0		I	
403.51	PLACERITA CREEK		7.2		I	
403.51	PLUM CANYON		4.1		I	
403.51	POLE CANYON		3.6		I	
403.51	POTRERO CANYON		4.7		I	
403.51	PROSPECT CANYON		1.5		I	
403.51	QUIGLEY CANYON		1.2		I	
403.51	RATTLESNAKE CANYON		3.3		I	
403.51	RED FOX CANYON		1.6		I	
403.51	REDROCK CANYON		3.5		I	
403.51	REYNIER CANYON		0.8		I	
403.51	RICE CANYON		1.7		I	
403.51	ROMERO CANYON		3.0		I	
403.51	RUBY CANYON		4.3		I	
403.51	RUSH CANYON		1.3		I	
403.51	SALT CANYON		6.7		I	
403.51	SALT CREEK		7.8		I	
403.51	SAN FRANCISQUITO CANYON & TRIB.	INCLUDED	21.7		PERM	
403.51	SAN MARTINEZ CHIQUITO CANYON		4.9		I	
403.51	SAN MARTINEZ GRANDE CANYON		3.8		I	
403.51	SAND CANYON		8.5		I	
403.51	SANTA CLARA RIVER & TRIBUTARIES	INCLUDED	23.8		PERM	
403.51	SHAKE CANYON		1.8		I	
403.51	SLOAN CANYON		3.5		I	
403.51	SOUTH PORTAL CANYON	PROPOSED	1.3		PERM	
403.51	SOUTH TULE CANYON		2.6		I	
403.51	SPRING CANYON		3.3		I	
403.51	SPRUCE DRAW		0.4		I	
403.51	STEINER CANYON		0.8		I	
403.51	TAPIA CANYON		4.2		I	
403.51	TAPIE CANYON		2.4		I	
403.51	TEXAS CANYON		8.0		I	
403.51	TICK CANYON		5.5		I	
403.51	TOWSLEY CANYON		4.7		I	
403.51	TROUGH CANYON		4.0		I	

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
403.51	TULE CANYON		4.8		I	
403.51	TURKEY CANYON		3.0		I	
403.51	VASQUEZ CANYON		4.8		I	
403.51	VILLA CANYON		2.0		I	
403.51	VIOLIN CANYON		7.1		I	
403.51	WARM SPRINGS CANYON		2.9		I	
403.51	WAYSIDE CANYON		3.3		I	
403.51	WHITNEY CANYON		3.3		I	
403.51	WICKHAM CANYON		1.5		I	
403.51	WILEY CANYON		1.3		I	
403.52	BOUQUET CREEK & TRIBUTARIES	INCLUDED	5.3		I	
403.52	MARTINDALE CANYON		4.6		I	
403.52	SPUNKY CANYON		3.3		I	
403.53	MINT CANYON & TRIBUTARIES	INCLUDED	7.4		I	
403.53	ROWHER CANYON		4.3		I	
403.53	SPADE CANYON		2.8		I	
403.53	SPADE SPRING CANYON		4.6		I	
403.54	AGUA DULCE CANYON & TRIBUTARIES	INCLUDED	6.6		I	
403.54	HAUSER CANYON		3.4		I	
403.54	LETTEAU CANYON		2.6		I	
403.54	WILLOW SPRINGS CANYON		1.7		I	
403.55	ACTON CANYON		3.9		I	
403.55	AGUA DULCE CANYON & TRIBUTARIES	INCLUDED	2.9		I	
403.55	ALISO CANYON	PROPOSED	9.4		PERM	•
403.55	ARRASTRE CANYON		4.9		I	
403.55	BEAR CANYON		5.0		I	
403.55	BEARTRAP CANYON		2.2		PERM	
403.55	BOBCAT CANYON		2.0		I	
403.55	BOOTLEGGERS CANYON		1.8		I	
403.55	CABIN CANYON		1.1		I	
403.55	ESCONDIDO CANYON		6.7		I	
403.55	FRYER CANYON		1.1		I	
403.55	GLEASON CANYON		5.9		PERM	
403.55	HUGHES CANYON		2.9		I	
403.55	INDIAN CANYON		3.3		I	
403.55	JONES CANYON		1.9		I	
403.55	KASHMERE CANYON		2.0		I	
403.55	KENTUCKY SPRINGS CANYON		7.1		I	
403.55	LONG CANYON		2.0		I	
403.55	MAHER CANYON		3.1		I	
403.55	MATTOX CANYON		2.6		I	
403.55	MILL CANYON		5.7		I	
403.55	MOODY CANYON		3.8		I	
403.55	NELLUS CANYON		1.5		I	
403.55	NELSON CANYON		2.0		I	
403.55	SANTA CLARA RIVER & TRIBUTARIES	INCLUDED	21.5		PERM	
403.55	TIE CANYON		1.3		I	
403.55	YOUNG CANYON		3.1		I	
403.61	ARROYO COLORADO		4.4		I	
403.61	HONDA BARRANCA		4.9		I	
403.61	MILLIGAN BARRANCA		4.7		I	
403.61	REVOLON SLOUGH (BEARDSLEY WASH)	INCLUDED	6.2	2.6	I	
403.62	ALAMOS CANYON		6.1		I	
403.62	ARROYO SIMI	INCLUDED	7.6		I	

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
403.62	BOONE CANYON		1.7		I	
403.62	CALLEGUAS CREEK & TRIB. (ARROYO LAS POSAS)	INCLUDED	8.4		I	
403.62	COYOTE CANYON		6.1		I	
403.62	FOX BARRANCA		5.1		I	
403.62	FOX CANYON		3.6		I	
403.62	HAPPY CAMP CANYON		10.5		I	
403.62	LONG CANYON		6.6		I	
403.63	ARROYO SANTA ROSA	INCLUDED	4.1		I	
403.63	CONEJO CREEK	INCLUDED	2.7		I	
403.64	ARROYO CONEJO & TRIBUTARIES	INCLUDED	4.9		I	
403.64	NORTH FORK ARROYO CONEJO	PROPOSED	6.5		I	
403.64	SOUTH BRANCH ARROYO CONEJO		6.3		I	
403.65	ARROYO SANTA ROSA	INCLUDED	4.6		I	
403.66	GILLIBRAND CANYON & TRIBUTARIES	INCLUDED	2.8		I	
403.66	IRON TROUGH CANYON		1.4		I	
403.66	TAPO CANYON	PROPOSED	1.8		I	
403.66	TRIPAS CANYON		4.9		I	
403.66	WINDMILL CANYON		2.9		I	
403.67	ARROYO SIMI & TRIBUTARIES	INCLUDED	11.1		I	
403.67	BREA CANYON		3.2		I	
403.67	BUS CANYON		4.2		I	
403.67	DRY CANYON		4.4		I	
403.67	EL TORO CANYON		1.8		I	
403.67	LAS LLAJAS CANYON		6.4		I	
403.67	LONE OAK CANYON		1.5		I	
403.67	LONG CANYON		1.5		I	
403.67	MEIER CANYON		3.1		I	
403.67	MONTGOMERY CANYON		0.8		I	
403.67	OAK CANYON		5.3		I	
403.67	RUNKLE CANYON		4.0		I	
403.67	SULPHUR CANYON		2.4		PERM	
403.67	SYCAMORE CANYON		4.3		I	
403.67	TAPO CANYON	PROPOSED	5.2		I	
403.67	TROUGH CANYON		1.2		I	
403.68	ARROYO CONEJO & TRIBUTARIES	INCLUDED	4.2		I	
403.68	SKELETON CANYON	PROPOSED	2.2		I	
404.11	BROOKSIDE CANYON		1.3		I	
404.11	DIX CANYON		1.7		I	
404.11	GARAPITO CANYON		2.6		I	
404.11	GREENLEAF CANYON		2.0		I	
404.11	HONDO CANYON		1.5		I	
404.11	OLD TOPANGA CANYON		3.8		I	
404.11	RED ROCK CANYON		1.7		I	
404.11	SANTA MARIA CREEK		1.5		I	
404.11	TOPANGA CANYON CREEK	INCLUDED	8.6		I	
404.12	TUNA CANYON CREEK	INCLUDED	3.0		I	
404.13	PENA CANYON CREEK	INCLUDED	1.6		I	
404.14	PIEDRA GORDA CANYON CREEK	INCLUDED	1.5		I	
404.15	LAS FLORES CANYON CREEK	INCLUDED	3.6		I	
404.15	LITTLE LAS FLORES CANYON		1.6		I	
404.16	CARBON CANYON CREEK	INCLUDED	3.1		I	
404.21	COLD CREEK	PROPOSED	5.2		PERM	*
404.21	DARK CANYON		2.0		I	
404.21	MALIBU CREEK	INCLUDED	9.7		PERM	*

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
404.21	SLEEPER CANYON		1.1		I	
404.22	EAST LAS VIRGENES CANYON		2.0		I	
404.22	GATES CANYON		1.6		I	
404.22	LAS VIRGENES CREEK	INCLUDED	11.5		I	
404.22	LIBERTY CANYON		3.5		I	
404.22	STOKES CANYON		4.7		I	
404.23	CHEESEBORO CANYON		5.3		I	
404.23	LINDERO CREEK	INCLUDED	6.9		I	
404.23	MEDEA CREEK	PROPOSED	5.4		I	
404.23	PALO COMADO		6.8		I	
404.24	LA SIERRA CANYON		2.6		I	
404.24	LOBO CANYON		3.3		I	
404.24	MEDEA CREEK	PROPOSED	3.0		I	
404.24	TRIUNFO CREEK	INCLUDED	4.1		I	
404.24	TROUGH CANYON		0.8		I	
404.25	LAKE ELEANOR CREEK	PROPOSED	2.7		I	
404.25	POTRERO VALLEY CREEK		2.5		I	
404.25	SCHOOLHOUSE CANYON		4.4		I	
404.25	TRIUNFO CREEK	PROPOSED	2.0		I	
404.25	WINDMILL CANYON		1.0		I	
404.26	HIDDEN VALLEY CREEK	INCLUDED	4.8		I	
404.31	CORRAL CANYON CREEK	INCLUDED	4.1		I	
404.31	MARIE CANYON		1.8		I	
404.31	PUERCO CANYON	INCLUDED	2.4		I	
404.32	DRY CANYON		2.1		I	
404.32	SOLSTICE CANYON CREEK	INCLUDED	4.8		I	
404.33	LATIGO CANYON CREEK	INCLUDED	2.9		I	
404.34	ESCONDIDO CANYON CREEK	INCLUDED	4.6		I	
404.35	RAMIRA CANYON CREEK	INCLUDED	4.2		I	
404.35	WALNUT CANYON		1.5		I	
404.36	DUME CREEK (ZUMA CANYON)	INCLUDED	7.5		I	
404.36	NEWTON CANYON		2.0		I	
404.37	STEEP HILL CANYON		1.3		I	
404.37	TRANCAS CANYON CREEK	INCLUDED	6.4		I	
404.41	ENCINAL CANYON CREEK	INCLUDED	2.7		I	
404.42	LACHUSA CANYON CREEK	INCLUDED	2.9		I	
404.42	LOS ALISOS CANYON CREEK	INCLUDED	2.9		I	
404.43	SAN NICHOLAS CANYON CREEK	INCLUDED	2.4		I	
404.44	ARROYO SEQUIT	INCLUDED	3.2		PERM	
404.44	EAST FORK ARROYO SEQUIT	PROPOSED	3.1		PERM	
404.44	WEST FORK ARROYO SEQUIT	PROPOSED	2.8		I	
404.44	WILLOW CREEK		1.1		I	
404.45	LITTLE SYCAMORE CANYON CREEK	INCLUDED	4.8		I	
404.46	DEER CANYON	PROPOSED	2.2		I	
404.47	BIG SYCAMORE CANYON CREEK	INCLUDED	9.8		I	
404.47	SERRANO CANYON	PROPOSED	3.5		I	
404.47	WOOD CANYON	PROPOSED	3.6		I	
404.48	LA JOLLA CANYON	PROPOSED	2.7		I	
405.11	AGUA AMARGA CANYON	PROPOSED	2.8		I	
405.11	ALTAMIRA CANYON	PROPOSED	2.1		I	
405.11	KLONDIKE CANYON	PROPOSED	1.1		I	
405.11	MALAGA CANYON	PROPOSED	2.6		I	
405.11	PORTUGUESE CANYON	PROPOSED	1.4		I	
405.12	AGUA MAGNA CANYON	PROPOSED	1.7		I	

TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.12	AVERILL CANYON	PROPOSED	0.6		I	
405.12	BENT SPRING CANYON	PROPOSED	2.1		I	
405.12	DOMINGUEZ CHANNEL TO TIDAL PRISM	INCLUDED	17.2	17.2	PERM	
405.12	GEORGE CANYON	PROPOSED	2.2		I	
405.12	LOS ANGELES RIVER	INCLUDED	5.9	5.9	PERM	
405.12	MIRALESTE CANYON	PROPOSED	1.6		I	
405.12	SAN PEDRO CANYON	PROPOSED	2.0		I	
405.12	SEPULVEDA CANYON	PROPOSED	2.2		I	
405.13	BALLONA CREEK TO TIDAL PRISM	INCLUDED	8.7	8.7		
405.13	CENTINELA CREEK CHANNEL	PROPOSED	1.3	1.3	PERM	
405.13	GRAND CANAL		1.8		PERM	
405.13	KENTER CANYON		1.2		I	
405.13	MANDEVILLE CANYON CREEK	INCLUDED	2.0	2.0	I	
405.13	PULGA CANYON		2.9		I	
405.13	QUARRY CANYON		0.9		I	
405.13	RUSTIC CANYON CREEK	INCLUDED	7.8	0.4	I	
405.13	SANTA MONICA CANYON CHANNEL	INCLUDED	3.0	3.0	I	
405.13	SANTA YNEZ CANYON	PROPOSED	5.0		I	
405.13	SEPULVEDA CANYON		1.1		I	
405.13	SEPULVEDA CHANNEL	PROPOSED	6.8	6.8	PERM	
405.13	STONE CANYON		1.8		I	
405.13	SULLIVAN CANYON CREEK	INCLUDED	5.3	0.4	I	
405.13	TEMESCAL CANYON		4.2		I	
405.13	TRAILER CANYON		1.3		I	
405.14	BRUSH CANYON		1.1		I	
405.14	FRANKLIN CANYON		1.6		I	
405.14	HIGGINS CANYON		1.3		I	
405.15	ARROYO SALINAS		0.8		I	
405.15	ARROYO SECO S. OF DEVIL'S GATE RES. (L)	INCLUDED	7.0	7.0	I	
405.15	BACON CREEK		0.6		I	
405.15	BALLONA CREEK	PROPOSED	2.1	2.1	PERM	
405.15	COMPTON CREEK	INCLUDED	8.5	8.5	I	
405.15	COYOTE CREEK TO BEGINNING OF TIDAL PRISM	INCLUDED	11.9	11.9	I	
405.15	JALISCO, ARROYO		0.5		I	
405.15	LA CANADA LEFFINGWELL		2.8		I	
405.15	LA CANADA VERDE CREEK (LOWER)		5.3		I	
405.15	LA CANADA VERDE CREEK *		2.7		I	
405.15	LA MIRADA CREEK		8.8		I	
405.15	LEFFINGWELL CREEK		1.1		I	
405.15	LOS ANGELES RIVER TO TIDAL PRISM	INCLUDED	19.3	19.3	PERM	
405.15	LOS CERRITOS CHANNEL TO TIDAL PRISM	INCLUDED	6.0	6.0	PERM	
405.15	PESCADERO, ARROYO		2.3		I	
405.15	RIO HONDO BELOW SPREADING GROUNDS	INCLUDED	6.9	6.9	I	
405.15	RIO HONDO TO SPREADING GROUNDS	INCLUDED	1.4	1.4	I	
405.15	SAN GABRIEL RIVER-FIRESTONE BLVD. TO TID. PRISM	INCLUDED	22.0	22.0	I	
405.15	SAN MIGUEL, ARROYO		1.9		I	
405.15	SAVAGE CREEK		1.1		I	
405.15	SORENSEN AVENUE DRAIN		2.5		I	
405.15	SYCAMORE CANYON		3.3		I	
405.15	TACOBI CREEK		1.7		I	
405.15	TURNBULL CANYON		2.0		I	
405.15	WORSHAM CREEK		1.5		I	
405.21	ALISO CREEK	INCLUDED	10.1	10.1	I	

TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.21	ARROYO CALABASAS	INCLUDED	3.3	1.8	I	
405.21	BEE CANYON		3.4		I	
405.21	BELL CREEK	INCLUDED	9.8	3.1	I	
405.21	BERRY CANYON		0.8		I	
405.21	BLIND CANYON		2.2		I	
405.21	BRACE CANYON		0.6		I	
405.21	BRAND CANYON		1.5		I	
405.21	BROCKMAN CANYON		0.3		I	
405.21	BROWNS CREEK	INCLUDED	10.0	6.1	I	
405.21	BULL CREEK	INCLUDED	9.3	4.9	PERM	
405.21	BURBANK WESTERN CHANNEL	INCLUDED	6.3	6.3	I	
405.21	CABALLERO CREEK	INCLUDED	4.4	2.8	I	
405.21	CABRINI CANYON		1.0		I	
405.21	CENTRAL BRANCH TUJUNGA WASH		3.4		I	
405.21	CHANDLER CANYON		0.7		I	
405.21	CHATSWORTH CREEK	PROPOSED	3.5	1.6	I	
405.21	CHILDS CANYON		1.0		I	
405.21	CRAIG CANYON		0.3		I	
405.21	DARK CANYON		0.4		I	
405.21	DAYTON CANYON CREEK	INCLUDED	3.4	0.9	I	
405.21	DEAD HORSE CANYON		1.0		I	
05.21	DEER CANYON		0.9		I	
5.21	DEVIL CANYON		6.3		I	
5.21	DRY CANYON CREEK	INCLUDED	3.9		I	
.21	EAST CANYON CHANNEL		2.3		I	
05.21	ELMWOOD CANYON		0.8		I	
405.21	ENCINO CREEK		2.0		I	
405.21	FALLS CREEK		2.6		I	
405.21	FERN CANYON		0.6		I	
405.21	FISHER CANYON		1.1		I	
405.21	GRAPEVINE CANYON		3.0		I	
405.21	HANSEN HEIGHTS CHANNEL		1.7		I	
405.21	HILLCREST CANYON		0.2		I	
405.21	IDLEWOOD CANYON		0.3		I	
405.21	INDIAN CANYON		1.2		I	
405.21	IREDELL CANYON		0.3		I	
405.21	JEFFRIES CANYON		0.3		I	
405.21	LA TUNA CANYON CREEK	INCLUDED	4.0		I	
405.21	LA TUNA CANYON LATERAL		2.3		I	
405.21	LIMEKILN CREEK	INCLUDED	7.9	6.8	I	
405.21	LOPEZ CANYON CREEK	INCLUDED	3.7		I	
405.21	LOS ANGELES RIVER	INCLUDED	26.8	26.8	PERM	•
405.21	MAND CANYON		0.2		I	
405.21	MCCLURE CANYON		0.8		I	
405.21	MCCOY CANYON CREEK	INCLUDED	3.6		I	
405.21	MCDONALD CREEK		1.2		I	
405.21	MORMON CANYON		2.2		I	
405.21	PACOIMA DIVERSION CHANNEL		2.8		I	
405.21	PACOIMA WASH	INCLUDED	8.3	4.8	I	
405.21	POMEROY CANYON		1.2		I	
405.21	SANTA SUSANA PASS WASH		5.5		I	
405.21	SENNET CANYON		1.7		I	
405.21	SHERER CANYON		0.8		I	
405.21	SOUTH BRANCH BELL CREEK		0.6		I	

TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.21	STORY CANYON		0.4		I	
405.21	STOUGH CANYON		0.5		I	
405.21	SUNSET CANYON		0.9		I	
405.21	SYCAMORE CANYON		0.9		I	
405.21	TOLL CANYON		0.2		I	
405.21	TUJUNGA WASH	INCLUDED	9.7	6.8	I	
405.21	VERDUGO WASH		3.4	3.4	I	
405.21	WELDON CANYON		5.7		I	
405.21	WILBUR WASH		3.0		I	
405.21	WILDWOOD CANYON		1.3		I	
405.21	WOOLSEY CANYON		1.6		I	
405.21	YBARRA CANYON		2.5		I	
405.22	ANT CANYON		0.6		I	
405.22	BAD CANYON		2.7		I	
405.22	BEE CANYON		0.6		I	
405.22	BUCK CANYON		0.9		I	
405.22	CHIMNEY CANYON		1.3		I	
405.22	COUGAR CANYON		0.9		I	
405.22	DAGGER FLAT CANYON		2.1		I	
405.22	DOROTHY CANYON		1.9		I	
405.22	GOOSEBERRY CANYON		1.2		I	
405.22	GORDON CANYON		0.8		I	
405.22	HOG CANYON		2.0		I	
405.22	IRON CANYON		1.8		I	
405.22	LAUREL CANYON		1.4		I	
405.22	LIMEKILN CANYON		1.9		I	
405.22	LONETREE CANYON		1.5		I	
405.22	LOOP CANYON		1.7		I	
405.22	MAPLE CANYON		1.0		I	
405.22	MAY CANYON CREEK	INCLUDED	1.2		I	
405.22	NOEL CANYON		0.9		I	
405.22	NORTH FORK PACOIMA CANYON		2.0		I	
405.22	PACOIMA CANYON CREEK	INCLUDED	23.3		I	•
405.22	RATTLESNAKE CANYON		2.0		I	
405.22	SCHOOLHOUSE CANYON		2.6		I	
405.22	SOLD CANYON		0.9		I	
405.22	SOUTH FORK PACOIMA CANYON		2.5		I	
405.22	SPRING CREEK		1.7		I	
405.22	STETSON CANYON CREEK	INCLUDED	3.8		I	
405.22	WEST FORK SOMBRERO CANYON		1.3		I	
405.22	WHITEWATER CANYON		0.6		I	
405.22	WILSON CANYON CREEK	INCLUDED	1.7		I	
405.23	AKENS CANYON		1.2		I	
405.23	ALDER CREEK	PROPOSED	3.6		PERM	•
405.23	ALDER CREEK		2.7		I	
405.23	BARTHOLOMAUS CANYON		1.3		I	
405.23	BIG CIENEGA		0.7		I	
405.23	BIG TUJUNGA CANYON CREEK	INCLUDED	24.1		PERM	•
405.23	BLUEGUM CANYON		1.1		I	
405.23	BOULDER CANYON		1.7		I	
405.23	BREAKNECK CANYON		0.9		I	
405.23	BRYANT CANYON		2.0		I	
405.23	BUCK CANYON		2.6		I	
405.23	CASSARA CANYON		0.8		I	

TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.23	CENTER CREEK		1.2		I	
405.23	CHILAO CREEK		3.7		I	
405.23	CLEAR CREEK	PROPOSED	3.7		PERM	*
405.23	COLDWATER CANYON		1.2		I	
405.23	CONDOR CANYON		1.2		I	
405.23	COTTONWOOD CANYON		1.1		I	
405.23	DELTA CANYON		2.2		I	
405.23	DOANE CANYON		2.5		I	
405.23	EAST FORK ALDER CREEK		4.2		I	
405.23	EBEY CANYON		1.4		I	
405.23	FALL CREEK	PROPOSED	3.1		PERM	
405.23	FOX CREEK	PROPOSED	7.3		PERM	
405.23	FUSIER CANYON		2.8		I	
405.23	GOLD CREEK		6.3		I	
405.23	GROTTO CREEK		1.5		I	
405.23	HAINES CANYON CREEK	INCLUDED	7.1		I	
405.23	HANSEN CANYON		1.0		I	
405.23	JOSEPHINE CREEK		1.4		I	
405.23	KAGEL CANYON CREEK	INCLUDED	3.8		I	
405.23	LIMEROCK CANYON		1.9		I	
405.23	LITTLE TUJUNGA CANYON CREEK	INCLUDED	7.2		I	
405.23	LOPEZ CANYON	PROPOSED	1.5		PERM	
405.23	LOVELL CANYON		1.0		I	
405.23	LUCAS CREEK		2.3		I	
405.23	LYNX GULCH		3.2		I	
405.23	MAREK CANYON		2.2		I	
405.23	MCKINLEY CANYON		1.4		I	
405.23	MIDDLE FORK ALDER CREEK	PROPOSED	2.8		PERM	
405.23	MIDDLE FORK MILL CREEK		4.3		I	
405.23	MILL CREEK	INCLUDED	8.3		PERM	*
405.23	MONTE CRISTO CREEK		3.4		I	
405.23	MULE FORK		2.1		I	
405.23	NEHR CANYON		1.4		I	
405.23	NORTH FORK ALDER CREEK		2.1		I	
405.23	NORTH FORK MILL CREEK		5.7		I	
405.23	NORTH FORK TRAIL CANYON		1.2		I	
405.23	OAK SPRING CANYON		2.0		I	
405.23	OLIVER CANYON		0.7		I	
405.23	PINE CANYON		0.6		I	
405.23	PIPE CANYON		1.5		I	
405.23	ROWLEY CANYON		1.5		I	
405.23	SCHWARTZ CANYON		0.8		I	
405.23	SILVER CREEK		1.1		I	
405.23	SLAUGHTER CANYON		1.0		I	
405.23	STONE CANYON		1.2		I	
405.23	TRAIL CANYON		5.1		I	
405.23	UPPER BIG TUJUNGA CANYON CREEK	PROPOSED	6.4		PERM	*
405.23	VASQUEZ CREEK	PROPOSED	1.2		PERM	*
405.23	VOGEL CANYON		3.0		I	
405.23	WEST FORK ALDER CREEK	PROPOSED	3.1		PERM	
405.23	WEST FORK FOX CREEK	PROPOSED	3.2		PERM	
405.23	WHITE OAK CANYON	PROPOSED	1.2		PERM	
405.23	WICKIUP CANYON	PROPOSED	3.3		PERM	
405.23	WILDCAT GULCH		2.1		I	

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.23	YBARRA CANYON		2.9		I	
405.23	ZACHAU CANYON		1.7		I	
405.24	AYARS CANYON		0.6		I	
405.24	BLANCHARD CANYON		2.6		I	
405.24	COOKS CANYON		3.0		I	
405.24	CUNNINGHAM CANYON		0.8		I	
405.24	DEER CREEK		1.0		I	
405.24	DUNSMORE CANYON CREEK	INCLUDED	3.4	1.6	I	
405.24	EAGLE CANYON		2.9		I	
405.24	ENGLEHEARD CANYON		1.4		I	
405.24	GOSS CANYON		0.8		I	
405.24	HALLS CANYON CHANNEL		1.2		I	
405.24	HENDERSON CANYON		1.4		I	
405.24	LAS BARRAS CANYON		0.6		I	
405.24	MULLALLY CANYON		1.2		I	
405.24	PICKENS CANYON - BEFORE SNOVER CYN	INCLUDED	2.2		I	
405.24	PICKENS CANYON CHANNEL BELOW FOOTHILL	INCLUDED	1.0	1.0	I	
405.24	PICKENS CANYON-SNOVER CYN. TO FOOTHILL	INCLUDED	1.0	1.0	I	
405.24	SHIELDS CANYON	INCLUDED	1.4		I	
405.24	SUTTON CANYON		1.2		I	
405.24	VERDUGO WASH	INCLUDED	5.5	5.5	I	
405.24	WARD CANYON		0.4		I	
405.31	ALHAMBRA WASH		0.1		I	
405.31	ARCADIA WASH		0.5		I	
405.31	ARROYO SECO S. OF DEVIL'S GATE RES. (U)	INCLUDED	2.5	2.5	I	
405.31	BAILEY CANYON		1.5		I	
405.31	CASTLE CANYON		0.5		I	
405.31	DEER PARK BRANCH		1.1		I	
405.31	EATON CANYON CREEK	INCLUDED	4.5		PERM	*
405.31	EATON WASH (BELOW DAM)	INCLUDED	6.5	3.2	I	
405.31	HARVARD BRANCH		1.0		I	
405.31	HASTINGS CANYON		1.1		I	
405.31	PASADENA GLEN		1.5		I	
405.31	RUBIO CANYON	INCLUDED	3.5		I	*
405.31	RUBIO WASH		0.1		I	
405.32	AGUA CANYON		0.8		I	
405.32	ARROYO SECO CANYON	INCLUDED	14.4		PERM	*
405.32	BEAR CANYON		3.5		I	
405.32	BROWN CANYON		1.0		I	
405.32	CHIQUITA CANYON		1.3		I	
405.32	CLOUDBURST CANYON		0.7		I	
405.32	COLBY CANYON		1.7		I	
405.32	DAISY CANYON		1.1		I	
405.32	DARK CANYON		1.7		PERM	
405.32	EL PRIETO CANYON CREEK	INCLUDED	2.6		I	
405.32	FALLS CANYON		1.0		I	
405.32	FERN CANYON		2.2		I	
405.32	GOULD CANYON		2.1		I	
405.32	GRAND CANYON		1.4		I	
405.32	HALL BECKLEY CANYON		2.5		I	
405.32	HAY CANYON		1.5		I	
405.32	LADYBUG CANYON		1.5		I	
405.32	LAS FLORES CANYON		1.1		I	
405.32	LITTLE BEAR CREEK	INCLUDED	1.9		PERM	*

TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.32	LONG CANYON		1.2		I	
405.32	MILLARD CANYON CREEK	INCLUDED	3.9		I	
405.32	PICKENS CANYON		0.8		I	
405.32	PINE CANYON		1.2		I	
405.32	SAUCER BRANCH		1.0		I	
405.32	SNOVER CANYON	INCLUDED	0.9	0.8	I	
405.32	TWIN CANYON		0.7		I	
405.32	WEBBER CANYON		0.7		I	
405.32	WEST RAVINE		0.8		I	
405.32	WINERY CANYON		1.7		I	
405.32	WOODWARDIA CANYON		0.7		I	
405.33	ARCADIA WASH (UPPER)	INCLUDED	0.6	0.6	I	
405.33	BIG SANTA ANITA CANYON CREEK	INCLUDED	4.8		PERM	•
405.33	CLAMSHELL CANYON		1.7		I	
405.33	EAST BRANCH ARCADIA WASH		0.8		I	
405.33	EAST FORK SANTA ANITA CANYON	PROPOSED	3.1		PERM	
405.33	LITTLE SANTA ANITA CANYON CREEK	INCLUDED	5.1	1.9	I	
405.33	NORTH FORK SANTA ANITA CANYON		1.4		PERM	
405.33	SAN OLENE CANYON		1.0		I	
405.33	SANTA ANITA WASH (UPPER)	INCLUDED	3.3	1.5	I	
405.33	WINTER CREEK	INCLUDED	3.2		PERM	•
405.41	ALHAMBRA WASH	INCLUDED	6.7	6.7	I	
405.41	ARCADIA WASH (LOWER)	INCLUDED	3.9	3.9	I	
405.41	AVOCADO CREEK		1.5		I	
405.41	BELL CANYON	INCLUDED	2.3		I	
405.41	BIG DALTON CANYON CREEK	INCLUDED	3.8		I	•
405.41	BIG DALTON WASH	INCLUDED	10.4	9.5	I	
405.41	BLISS CANYON		2.2		I	
405.41	BRADBURY CANYON CREEK	INCLUDED	1.0		I	
405.41	CHARTER OAK CREEK		3.1		I	
405.41	DIAMOND BAR CREEK		2.9		I	
405.41	EAST BRANCH BIG DALTON WASH		2.7		I	
405.41	EATON WASH	PROPOSED	5.0	5.0	I	
405.41	ENGLEWILD CANYON		1.2		I	
405.41	GORDON CANYON		0.9		I	
405.41	HACIENDA CHANNEL		2.8		I	
405.41	HARROW CANYON		0.7		I	
405.41	KERIL CANYON		0.8		I	
405.41	LEMON CREEK		3.4		I	
405.41	LEWIS PAUL CANYON		1.4		I	
405.41	LITTLE DALTON CANYON CREEK	INCLUDED	4.0		I	•
405.41	LITTLE DALTON WASH	INCLUDED	7.1	7.1	I	
405.41	LUGUNA CHANNEL		0.9		I	
405.41	MAPLE CANYON		1.0		I	
405.41	MARSHALL CREEK	PROPOSED	0.9	0.7	I	
405.41	MISSION CREEK		1.4		I	
405.41	MONROE CANYON		2.3		I	
405.41	MONROVIA CANYON CREEK	INCLUDED	2.9		I	•
405.41	MORGAN CANYON		1.8		I	
405.41	MULL CANYON		1.0		I	
405.41	MYSTIC CANYON	INCLUDED	1.5		I	
405.41	PINE CANYON		0.5		I	
405.41	POWDER CANYON		4.7		I	
405.41	PUDDINGSTONE WASH	INCLUDED	0.5		I	

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.41	PUENTE CREEK	INCLUDED	5.8	3.5	I	
405.41	RIO HONDO	INCLUDED	12.1	12.1	I	*
405.41	RUBIO WASH	PROPOSED	4.9	4.9	I	
405.41	RUBY CANYON		0.8		I	
405.41	SAN DIMAS WASH (LOWER)	INCLUDED	7.9	7.7	I	
405.41	SAN GABRIEL RIVER	PROPOSED	11.4	9.0	I	
405.41	SAN JOSE CREEK	PROPOSED	13.1	13.1	I	
405.41	SAN JOSE CREEK (OLD CHANNEL)	PROPOSED	2.9		I	
405.41	SANTA ANITA WASH (LOWER)	INCLUDED	3.6	3.6	I	
405.41	SAWPIT CANYON	INCLUDED	4.5		I	
405.41	SAWPIT WASH	INCLUDED	3.8		I	
405.41	SHAY CANYON		0.3		I	
405.41	SOUTH SAN JOSE CREEK	PROPOSED	0.7		I	
405.41	SPANISH CANYON		2.3		I	
405.41	SPINKS CANYON CREEK	INCLUDED	1.4		I	
405.41	SPRING CANYON		0.3		I	
405.41	SYCAMORE CANYON		1.5		I	
405.41	TWIN SPRINGS CANYON		1.3		I	
405.41	VASSAR CANYON		1.0		I	
405.41	VINE CREEK		2.4		I	
405.41	VOLFE CANYON		1.8		I	
405.41	WALNUT CREEK WASH	INCLUDED	13.9	8.9	I	*
405.41	WILDWOOD CANYON		1.3		I	
405.42	SAN GABRIEL RIVER	INCLUDED	0.8		I	
405.43	ALDER GULCH		1.6		I	
405.43	ALLISON GULCH	PROPOSED	2.5		PERM	*
405.43	ALPINE CANYON		2.2		I	
405.43	BEAR CREEK	PROPOSED	11.2		PERM	*
405.43	BEAR GULCH		1.3		I	
405.43	BEATTY CANYON		0.9		I	
405.43	BICHOTA CANYON	PROPOSED	4.1		PERM	
405.43	BIG MERMAIDS CANYON		2.9		I	
405.43	BLIND CANYON		0.7		I	
405.43	BOBCAT CANYON	PROPOSED	3.8		PERM	
405.43	BROWNS GULCH		4.0		I	
405.43	BURRO CANYON		2.1		I	
405.43	BUTTERFIELD CANYON		2.2		I	
405.43	CAPE HORN CANYON		1.5		I	
405.43	CATTLE CREEK	INCLUDED	9.0		PERM	*
405.43	CEDAR CANYON		0.8		I	
405.43	CEDAR CREEK	PROPOSED	2.4		PERM	
405.43	CHILENO CANYON	PROPOSED	3.5		PERM	
405.43	CLARK GULCH		1.4		I	
405.43	CLOUDBURST CANYON		1.6		I	
405.43	COLD SPRINGS CANYON		2.0		I	
405.43	COLDBROOK CREEK	PROPOSED	1.9		PERM	
405.43	COLDWATER CANYON CREEK	INCLUDED	7.4		PERM	*
405.43	COW CREEK	INCLUDED	5.0		I	*
405.43	DEVIL GULCH		3.5		I	
405.43	DEVILS CANYON CREEK	INCLUDED	10.8		PERM	*
405.43	DIME CANYON		0.8		I	
405.43	DRY GULCH		1.6		I	
405.43	EAST FORK HORSE CANYON		1.3		I	
405.43	EAST FORK SAN GABRIEL RIVER	INCLUDED	16.5		I	*

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.43	EAST FORK SUSANNA CANYON		1.3		I	
405.43	FALLS CANYON		1.6		I	
405.43	FALLS GULCH		1.2		I	
405.43	FERN CANYON		0.8		I	
405.43	FISH CANYON	INCLUDED	6.9		I	•
405.43	FISH FORK	PROPOSED	7.3		PERM	•
405.43	FOSSIL CANYON		1.1		I	
405.43	GARCIA CANYON		1.1		I	
405.43	GLEN CANYON		1.9		I	
405.43	GRAVEYARD CANYON		3.9		I	
405.43	HORSE CANYON		2.4		I	
405.43	IRON FORK	PROPOSED	6.2		PERM	•
405.43	ISLIP CANYON		1.9		I	
405.43	LAUREL GULCH		1.3		I	
405.43	LITTLE MERMAIDS CANYON		2.5		I	
405.43	LOBO CANYON		1.6		I	
405.43	LOST CANYON	PROPOSED	2.1		PERM	
405.43	MADDOCK CANYON CREEK	INCLUDED	0.7		I	
405.43	MAPLE CANYON		1.1		I	
405.43	MINE GULCH		2.3		I	
405.43	MINERO CANYON		1.2		I	
405.43	NORTH FORK SAN GABRIEL RIVER	INCLUDED	4.6		PERM	•
405.43	OAK CANYON		1.8		I	
405.43	PEACOCK CANYON		1.0		I	
405.43	PERSINGER CANYON		2.6		I	
405.43	PHIPPS CANYON		1.1		I	
405.43	PINE CANYON		1.1		I	
405.43	POLECAT GULCH		1.3		I	
405.43	PRAIRIE FORK	PROPOSED	6.2		PERM	•
405.43	RATTLESNAKE CANYON		1.1		I	
405.43	RINCON CANYON		1.3		I	
405.43	ROBBS GULCH		1.0		I	
405.43	ROBERTS CANYON	INCLUDED	6.6		I	•
405.43	ROCKBOUND CANYON		1.9		I	
405.43	ROSS GULCH		1.1		I	
405.43	RUSH CREEK		1.3		I	
405.43	SAN GABRIEL RIVER - MAIN STEM	INCLUDED	11.6	0.3	PERM	•
405.43	SHARPS CANYON		1.4		I	
405.43	SHOEMAKER CANYON		1.4		I	
405.43	SHORTCUT CANYON		2.3		I	
405.43	SNOWSLIDE CANYON		1.5		I	
405.43	SOLDIER CREEK	PROPOSED	3.0		PERM	
405.43	SOUTH FORK IRON FORK	PROPOSED	4.4		PERM	
405.43	STRAYNS CANYON		1.9		I	
405.43	SUSANNA CANYON		3.2		I	
405.43	TRAIL FORK		2.1		I	
405.43	TUMBLER CANYON	PROPOSED	1.7		PERM	
405.43	VALLEY FORGE CANYON		1.6		I	
405.43	VAN TASSEL CANYON	INCLUDED	3.2		I	
405.43	VENEDO CANYON		1.8		I	
405.43	VINCENT GULCH	PROPOSED	3.1		PERM	
405.43	WATER CANYON		1.4		I	
405.43	WEST FORK BEAR CREEK	PROPOSED	4.7		PERM	
405.43	WEST FORK SAN GABRIEL RIVER	INCLUDED	20.0		PERM	•

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TABLE 2.1 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Rivers

H.U.	NAME	INCLUDE/ PROPOSED	LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.43	WILLIAMS CANYON		1.7		I	
405.44	EAST FORK SAN DIMAS CANYON		5.8		I	
405.44	FERN CANYON	PROPOSED	2.8		I	•
405.44	HAM CANYON		2.2		I	
405.44	HUMMINGBIRD CREEK		0.8		I	
405.44	LODI CANYON		2.2		I	
405.44	SAN DIMAS CANYON CREEK	INCLUDED	6.7		I	•
405.44	SAN DIMAS WASH (UPPER)	INCLUDED	3.3		I	
405.44	SYCAMORE CANYON		1.6		I	
405.44	TANBARK CREEK		2.4		I	
405.44	WEST FORK SAN DIMAS CANYON	PROPOSED	3.1		I	
405.44	WOLFSKILL CANYON	PROPOSED	4.1		I	•
405.51	SAN JOSE CREEK	INCLUDED	4.9	4.9	I	
405.51	SOUTH SAN JOSE CREEK		2.6		I	
405.52	LIVE OAK WASH	PROPOSED	4.5	4.5	I	
405.52	THOMPSON WASH	PROPOSED	2.9	2.9	I	
405.53	BURBANK CANYON		1.1		I	
405.53	CHICKEN CANYON		2.0		I	
405.53	COBAL CANYON		1.5		I	
405.53	EMERALD CREEK AND WASH	INCLUDED	1.1		I	
405.53	GAIL CANYON		0.8		I	
405.53	LIVE OAK CREEK AND WASH	INCLUDED	4.4	1.0	I	
405.53	MARSHALL CREEK AND WASH	INCLUDED	3.8		I	•
405.53	PALMER CANYON		3.0		I	
405.53	THOMPSON CREEK	INCLUDED	2.4	3.6	I	
405.53	THOMPSON WASH		2.2		I	
405.53	WEBB CANYON		1.5		I	
405.53	WEST FORK PALMER CANYON		1.1		I	
405.53	WILLIAMS CANYON		1.0		I	
405.62	BREA CANYON		5.2		I	
405.62	DIAMOND BAR CREEK		2.2		I	
405.62	TONNER CANYON		3.3		I	
405.63	LIONS CANYON		0.4		I	
405.63	SONOME CANYON		0.8		I	
406.20	SURFACE WATERCOURSES	INCLUDED	43.6		I	
406.40	BIG SPRINGS CANYON		2.9		I	
406.40	CAPE CANYON		3.6		I	
406.40	COTTONWOOD CANYON		5.5		I	
406.40	LITTLE SPRINGS CANYON		3.9		I	
406.40	MIDDLE CANYON CREEK	PROPOSED	7.9		I	
406.40	SILVER CANYON		3.1		I	
481.21	SAN ANTONIO CREEK CHANNEL	PROPOSED	1.0	1.0	I	
481.23	SAN ANTONIO CANYON CREEK	INCLUDED	6.4		I	•
481.23	SAN ANTONIO CREEK CHANNEL	PROPOSED	2.8		I	

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TABLE 2.2 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Lakes and Reservoirs

H.U.	NAME	INCLUDE/ PROPOSED	AREA ACRES	INTERMIT/ PERMANENT	WETLND DESIGN
401.23	SAN ANTONIO RESERVOIR	INCLUDED	48.0	I	
402.20	LAKE CASITAS	INCLUDED	1729.4	PERM	
402.20	MATILIJA RESERVOIR	INCLUDED	126.9	PERM	*
402.20	MIRROR LAKE	PROPOSED	7.6	PERM	*
402.20	OJAI WETLAND	PROPOSED	7.5	I	*
403.11	MCGRATH LAKE	INCLUDED	10.3	PERM	
403.41	LAKE PIRU	INCLUDED	922.1	PERM	
403.42	LAKE PIRU	INCLUDED	144.9	I	
403.42	PYRAMID LAKE	INCLUDED	1234.7	PERM	
403.51	CASTAIC LAGOON	PROPOSED	182.5	PERM	
403.51	CASTAIC LAKE & ELDERBERRY FOREBAY	INCLUDED	2632.6	PERM	
403.51	DRINKWATER RESERVOIR	PROPOSED	3.0	PERM	
403.51	DRY CANYON RESERVOIR	INCLUDED	47.1	I	
403.51	ELDERBERRY FOREBAY	INCLUDED	386.2	I	
403.51	LAKE ELIZABETH	INCLUDED	71.0	I	
403.51	LAKE HUGHES	INCLUDED	21.8	PERM	
403.51	MUNZ LAKES	PROPOSED	7.6	PERM	
403.52	BOUQUET RESERVOIR	INCLUDED	772.2	PERM	
403.67	LAKE BARD (WOOD RANCH RESERVOIR)	INCLUDED	205.4	PERM	
403.67	RUNKLE RESERVOIR	PROPOSED	3.8	PERM	
404.21	CENTURY RESERVOIR	PROPOSED	6.0	PERM	*
404.24	LAKE ENCHANTO	PROPOSED	3.3	PERM	
404.24	MALIBU LAKE	INCLUDED	44.4	PERM	*
404.25	LAKE ELEANOR	PROPOSED	7.8	I	*
404.25	LAS VIRGENES RESERVOIR (WEST LAKE RESERVOIR)	INCLUDED	123.0	PERM	
404.25	WESTLAKE LAKE	INCLUDED	118.8	PERM	
404.26	LAKE SHERWOOD	INCLUDED	136.6	PERM	*
405.12	BIXBY SLOUGH AND HARBOR LAKE	INCLUDED	44.7	PERM	*
405.12	COLORADO LAGOON	PROPOSED	13.2	PERM	
405.12	MADRONA MARSH	PROPOSED	6.9	I	*
405.12	PALOS VERDES RESERVOIR		14.6	I	
405.13	DEL REY LAGOON		5.3	I	
405.13	SANTA YNEZ LAKE (LAKE SHRINE)	PROPOSED	1.0	PERM	
405.13	STONE CANYON RESERVOIR	PROPOSED	135.5	PERM	
405.13	UPPER STONE CANYON RESERVOIR	PROPOSED	13.2	PERM	
405.14	HOLLYWOOD RESERVOIR	PROPOSED	75.2	PERM	
405.14	LOWER FRANKLIN CANYON RESERVOIR	PROPOSED	27.4	PERM	
405.14	UPPER FRANKLIN CANYON RESERVOIR	PROPOSED	5.8	PERM	*
405.15	ASCOT RESERVOIR		7.1	PERM	
405.15	BOUTON LAKE		10.6	PERM	
405.15	EL DORADO LAKES	PROPOSED	36.5	I	*
405.15	ELYSIAN RESERVOIR	PROPOSED	1.1	I	
405.15	IVANHOE RESERVOIR	PROPOSED	7.3	PERM	
405.15	MORNINGSIDE PARK RESERVOIR	PROPOSED	2.6	PERM	
405.15	SILVER LAKE RESERVOIR	PROPOSED	73.9	PERM	
405.15	SIMS POND	PROPOSED	2.7	I	*
405.21	CHATSWORTH RESERVOIR	INCLUDED	543.1	I	
405.21	ENCINO RESERVOIR	PROPOSED	133.8	PERM	
405.21	GIRARD RESERVOIR	PROPOSED	2.0	PERM	
405.21	GREEN VERDUGO RESERVOIR		3.4	I	
405.21	HANSEN SPREADING GROUNDS		115.8	I	
405.21	LEES LAKE	PROPOSED	4.5	PERM	
405.21	LOS ANGELES RESERVOIR	INCLUDED	164.3	I	

TABLE 2.2 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Lakes and Reservoirs

H.U.	NAME	INCLUDE/ PROPOSED	AREA ACRES	INTERMIT/ PERMANENT	WETLND DESIGN
405.21	LOWER VAN NORMAN RESERVOIR	INCLUDED	306.0	I	
405.21	MONTERIA LAKE	PROPOSED	4.0	PERM	
405.21	PACOIMA SPREADING GROUNDS		145.1	I	
405.21	SEPULVEDA FLOOD CONTROL RESERVOIR	INCLUDED	1171.4	I	
405.21	SOLANO RESERVOIR	PROPOSED	66.4	PERM	
405.21	TOLUCA LAKE	PROPOSED	4.3	PERM	
405.21	TUJUNGA SPREADING GROUNDS -1		6.0	I	
405.22	PACOIMA RESERVOIR	INCLUDED	58.9	PERM	
405.22	SCHOOLHOUSE DEBRIS BASIN		1.7	PERM	
405.22	WILSON DEBRIS BASIN		6.2	I	
405.23	BIG TUJUNGA RESERVOIR	INCLUDED	90.2	PERM	
405.23	HANSEN FLOOD CONTROL RESERVOIR	INCLUDED	682.1	I	
405.23	HANSEN LAKE	PROPOSED	117.7	PERM	
405.23	MIDDLE LAKE	PROPOSED	3.2	PERM	
405.25	EAGLE ROCK RESERVOIR	PROPOSED	7.5	PERM	
405.31	DEVILS GATE RESERVOIR (LOWER)	INCLUDED	3.9	I	
405.31	EATON DAM AND RESERVOIR	INCLUDED	42.2	I	
405.31	SUNSET RESERVOIR -N		1.9	PERM	
405.31	SUNSET RESERVOIR -S		1.0	PERM	
405.32	DEVIL'S GATE RESERVOIR (UPPER)	INCLUDED	117.2	I	
405.33	BIG SANTA ANITA RESERVOIR	INCLUDED	13.1	PERM	
405.41	BIG DALTON DAM AND RESERVOIR	INCLUDED	21.4	PERM	
405.41	GARVEY RESERVOIR		30.2	PERM	
405.41	LEGG LAKE	INCLUDED	8.2	PERM	*
405.41	LEGG LAKE (SOUTH)		27.8	PERM	
405.41	SANTA FE FLOOD CONTROL BASIN	INCLUDED	1020.9	I	*
405.41	SAWPIT DAM AND RESERVOIR	INCLUDED	6.5	I	
405.41	WHITTIER NARROWS FLOOD CONTROL BASIN (RESERVOIR)	INCLUDED	2102.4	I	
405.43	COGSWELL RESERVOIR	INCLUDED	144.7	PERM	
405.43	CRYSTAL LAKE	INCLUDED	3.7	PERM	
405.43	MORRIS RESERVOIR	INCLUDED	283.2	PERM	
405.43	SAN GABRIEL RESERVOIR	INCLUDED	524.7	PERM	
405.44	SAN DIMAS DAM AND RESERVOIR	INCLUDED	35.4	PERM	
405.52	PUDDINGSTONE DAM AND RESERVOIR	INCLUDED	245.0	PERM	
405.53	LIVE OAK DAM AND RESERVOIR	INCLUDED	10.5	I	
405.53	THOMPSON CREEK DAM AND RESERVOIR	INCLUDED	18.1	I	
406.40	BIG SPRINGS RESERVOIR	PROPOSED	0.1	I	
406.40	BUFFALO SPRINGS RESERVOIRS	PROPOSED	0.3	I	
406.40	CAPE CANYON RESERVOIR	PROPOSED	0.5	I	
406.40	DEEP TANK RESERVOIR	PROPOSED	0.4	I	
406.40	ECHO LAKE	PROPOSED	1.6	I	
406.40	HAYPRESS RESERVOIR	PROPOSED	3.9	I	
406.40	LOWER BUFFALO CORRAL RESERVOIR	PROPOSED	1.9	I	
406.40	PATRICK RESERVOIR	PROPOSED	3.8	I	
406.40	SUMMIT RESERVOIR	PROPOSED	1.0	I	
406.40	THOMPSON DAM	PROPOSED	10.6	I	
406.40	UPPER BUFFALO CORRAL RESERVOIR	PROPOSED	2.0	I	
406.40	WRIGLEY RESERVOIR	PROPOSED	1.5	I	
481.23	SAN ANTONIO DAM AND RESERVOIR	INCLUDED	48.1	I	

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TABLE 2.3 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Groundwater Basins

H.U.	NAME	INCLUDED/ PROPOSED	AREA ACRES
401.00	PITAS POINT HU		
	LOWER VENTURA GW BASIN	PROPOSED	4843.2
402.10	LOWER VENTURA RIVER HA		
	LOWER VENTURA GW BASIN	PROPOSED	4843.2
402.20	UPPER VENTURA RIVER HA		
	UPPER VENTURA GW BASIN	PROPOSED	698.9
402.31	UPPER OJAI HSA		
	UPPER OJAI WEST GW BASIN	PROPOSED	2619.3
	UPPER OJAI EAST GW BASIN	PROPOSED	1383.8
402.32	OJAI VALLEY HSA		
	OJAI WEST GW BASIN	PROPOSED	10921.8
	OJAI EAST GW BASIN	PROPOSED	4077.2
403.11	OXNARD HSA		
	OXNARD PLAIN GW BASIN	INCLUDED	54510.3
	MOUND GW BASIN	PROPOSED	16605.1
403.12	PLEASANT VALLEY HSA		
	PLEASANT VALLEY G.W. BASIN	PROPOSED	23276.8
403.21	SULPHUR SPRINGS HSA		
	SANTA PAULA GW BASIN	PROPOSED	27106.9
403.31	FILLMORE HSA		
	FILLMORE GW BASIN	PROPOSED	19768.0
403.41	SANTA FELICIA HSA		
	PIRU GW BASIN	PROPOSED	9291.0
403.43	HUNGRY VALLEY HSA		
	HUNGRY VALLEY GW BASIN	INCLUDED	5460.9
	PEACE VALLEY GW BASIN	PROPOSED	5683.3

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TABLE 2.3 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Groundwater Basins

H.U.	NAME	INCLUDED/ PROPOSED	AREA ACRES
403.44 STAUFFER HSA			
	LOCKWOOD VALLEY GW BASIN	INCLUDED	8376.7
403.51 EASTERN HSA			
	SANTA CLARA-CASTAIC GW BASIN	PROPOSED	7017.6
	SANTA CLARA EAST GW BASIN	PROPOSED	7071.0
	SANTA CLARA SOUTH FORK GW BASIN	PROPOSED	3978.3
	GREEN VALLEY GW BASIN	PROPOSED	1136.7
403.52 BOUQUET HSA			
	BOUQUET CANYON GW BASIN	INCLUDED	2050.9
403.53 MINT CANYON HSA			
	MINT CANYON GW BASIN	PROPOSED	3755.9
403.54 SIERRA PELONA HSA			
	SIERRA PELONA GW BASIN	PROPOSED	7067.1
403.55 ACTON HSA			
	ACTON VALLEY GW BASIN	PROPOSED	16753.4
403.61 WEST LAS POSAS HSA			
	NORTH LAS POSAS VALLEY GW BASIN	PROPOSED	26340.9
403.62 EAST LAS POSAS HSA			
	SOUTH LAS POSAS VALLLEY GW BASIN	PROPOSED	13961.2
403.63 ARROYO SANTA ROSA HSA			
	ARROYO SANTA ROSA GW BASIN	PROPOSED	3459.4
403.64 CONEJO VALLEY HSA			
	CONEJO VALLEY GW BASIN	PROPOSED	5881.0

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TABLE 2.3 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Groundwater Basins

H.U.	NAME	INCLUDED/ PROPOSED	AREA ACRES
403.65	TIERRA REJADA VALLEY HSA		
	TIERRA REJADA GW BASIN	PROPOSED	1556.7
403.66	GILLIBRAND HSA		
	GILLIBRAND GW BASIN	PROPOSED	4472.5
403.67	SIMI VALLEY HSA		
	SIMI VALLEY GW BASIN	PROPOSED	12132.6
403.68	THOUSAND OAKS HSA		
	THOUSAND OAKS GW BASIN	PROPOSED	7338.9
404.21	MONTE NIDO HSA		
	MALIBU CREEK GW BASIN	PROPOSED	815.4
404.25	RUSSELL VALLEY HSA		
	RUSSELL VALLEY GW BASIN	PROPOSED	5806.9
404.26	SHERWOOD HSA		
	HIDDEN VALLEY GW BASIN	PROPOSED	2439.3
405.12	WEST COAST HSA		
	WEST COAST GW BASIN	PROPOSED	90043.2
405.13	SANTA MONICA HSA		
	SANTA MONICA GW BASIN	PROPOSED	25401.9
405.14	HOLLYWOOD HSA		
	HOLLYWOOD GW BASIN	PROPOSED	13022.2
405.15	CENTRAL HSA		
	CENTRAL GW BASIN	INCLUDED	177541.4
405.21	BULL CANYON HSA		
	SAN VERNANDO VALLEY GW BASIN	PROPOSED	121795.6

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TABLE 2.3 NAMED WATERBODIES OF REGION 4
By Waterbody Type
Groundwater Basins

H.U.	NAME	INCLUDED/ PROPOSED	AREA ACRES
405.22 SYLMAR HSA			
	SYLMAR GW BASIN	PROPOSED	6301.1
405.24 VERDUGO HSA			
	VERDUGO GW BASIN	PROPOSED	7190.6
405.25 EAGLE ROCK HSA			
	EAGLE ROCK GW BASIN	PROPOSED	1507.3
405.31 PASADENA HSA			
	RAYMOND-PASADENA GW BASIN	PROPOSED	16506.3
405.32 MONK HILL HSA			
	RAYMOND-MONK HILL GW BASIN	PROPOSED	4793.7
405.33 SANTA ANITA HSA			
	RAYMOND-SANTA ANITA GW BASIN	PROPOSED	2767.5
405.41 MAIN SAN GABRIEL HSA			
	MAIN SAN GABRIEL GW BASIN	INCLUDED	90142.1
	PUENTE GW BASIN	INCLUDED	9958.1
405.51 SAN JOSE HSA			
	SPADRA GW BASIN	INCLUDED	3830.1
405.52 POMONA HSA			
	POMONA GW BASIN	PROPOSED	5782.1
405.53 LIVE OAK HSA			
	LIVE OAK GW BASIN	PROPOSED	3237.0
481.21 CHINO HSA			
	CHINO GW BASIN	PROPOSED	6350.5
481.23 CLAREMONT HEIGHTS HSA			
	CLAREMONT HEIGHTS GW BASIN	PROPOSED	4274.8

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TABLE 2.4a COASTAL WETLANDS OF REGION 4

H.U.	NAME	# INCLUDE/ PROPOSED	@ AREA ACRES	WETLND DESIGN
**	COASTAL WETLAND			
402.10	VENTURA RIVER TIDAL PRISM	INCLUDED	35.6	*
403.11	MCGRATH LAKE (TIDAL PRISM)	INCLUDED	19.5	*
403.11	MUGU LAGOON (TIDAL PRISM)	INCLUDED	323.3	*
403.11	ORMOND BEACH	PROPOSED	136.5	*
403.11	SANTA CLARA RIVER (TIDAL PRISM)	INCLUDED	55.7	*
404.11	TOPANGA LAGOON	PROPOSED	5.0	*
404.21	MALIBU LAGOON (TIDAL PRISM)	INCLUDED	20.9	*
404.36	DUME LAGOON	PROPOSED	17.4	*
405.12	ALAMITOS BAY	PROPOSED	320.0	*
405.13	BALLONA LAGOON	PROPOSED	13.2	*
405.13	BALLONA WETLANDS	PROPOSED	355.2	*
405.13	DEL REY LAGOON	PROPOSED	5.4	*
405.13	VENICE CANALS - BALLONA CREEK (TIDAL PRISM)	INCLUDED	17.7	*
405.15	LOS CERRITOS LAGOON	PROPOSED	22.2	*
405.15	LOS CERRITOS WETLANDS	PROPOSED	226.0	*

TABLE 2.4b LACUSTRINE WETLANDS OF REGION 4

H.U.	NAME	# INCLUDE/ PROPOSED	@ AREA ACRES	c INTERMIT/ PERMANENT	WETLND DESIGN
402.20	MATILIJA RESERVOIR	INCLUDED	126.9	PERM	*
402.20	MIRROR LAKE	PROPOSED	7.6	PERM	*
402.20	OJAI WETLAND	PROPOSED	7.5	I	*
404.21	CENTURY RESERVOIR	PROPOSED	6.0	PERM	*
404.24	MALIBU LAKE	INCLUDED	44.4	PERM	*
404.25	LAKE ELEANOR	PROPOSED	7.8	I	*
404.26	LAKE SHERWOOD	INCLUDED	136.6	PERM	*
405.12	BIXBY SLOUGH AND HARBOR LAKE	INCLUDED	44.7	PERM	*
405.12	MADRONA MARSH	PROPOSED	6.9	I	*
405.14	UPPER FRANKLIN CANYON RESERVOIR	PROPOSED	5.8	PERM	*
405.15	EL DORADO LAKES	PROPOSED	36.5	I	*
405.15	SIMS POND	PROPOSED	2.7	I	*
405.41	LEGG LAKE	INCLUDED	8.2	PERM	*
405.41	SANTA FE FLOOD CONTROL BASIN	INCLUDED	1020.9	I	*

Included means that the waterbody was included in the 1978 Basin Plan of the Los Angeles Regional Water Quality Control Board.

@ The area includes the areal extent of the whole lake, reservoir or estuary, not all of which has wetland vegetation.

c Intermittent means that the lake or reservoir has seasonal water supply.

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TABLE 2.4c RIPARIAN WETLANDS OF REGION 4

H.U.	NAME	INCLUDE/ PROPOSED #	LENGTH MILES @	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
401.00	JAVON CANYON	PROPOSED	2.8		I	*
402.10	VENTURA RIVER & TRIBUTARIES	INCLUDED	5.9		PERM	*
402.20	COYOTE CREEK	PROPOSED	14.1		PERM	*
402.20	EAST FORK COYOTE CREEK	PROPOSED	2.5		PERM	*
402.20	MATILIJA CREEK	PROPOSED	15.9		PERM	*
402.20	MURIETTA CANYON	PROPOSED	4.1		PERM	*
402.20	OLD MAN CANYON	PROPOSED	3.2		I	*
402.20	SAN ANTONIO CREEK & TRIBUTARIES	INCLUDED	5.4		PERM	*
402.20	SANTA ANA CREEK	PROPOSED	6.1		PERM	*
402.20	VENTURA RIVER & TRIBUTARIES	INCLUDED	10.4		PERM	*
402.20	WEST FORK SANTA ANA CREEK	PROPOSED	3.5		PERM	*
403.11	SANTA CLARA RIVER	INCLUDED	9.8		PERM	*
403.21	SANTA CLARA RIVER	INCLUDED	6.7		PERM	*
403.21	SISAR CREEK	INCLUDED	1.2		PERM	*
403.22	SISAR CREEK	INCLUDED	6.4		PERM	*
403.31	SANTA CLARA RIVER	INCLUDED	9.7		PERM	*
403.31	SESPE CREEK	INCLUDED	6.0		I	*
403.32	BEAR CANYON	PROPOSED	3.2		PERM	*
403.32	COLDWATER CANYON	PROPOSED	2.2		PERM	*
403.32	PIEDRA BLANCA CREEK	PROPOSED	9.0		PERM	*
403.32	PINE CANYON	PROPOSED	4.7		PERM	*
403.32	POTRERO JOHN CREEK	PROPOSED	3.6		PERM	*
403.32	REDROCK CREEK	PROPOSED	4.0		PERM	*
403.32	ROSE VALLEY CREEK	PROPOSED	3.5		PERM	*
403.32	SESPE CREEK & TRIBUTARIES	INCLUDED	52.9		PERM	*
403.32	TIMBER CREEK	PROPOSED	4.9		PERM	*
403.32	TROUT CREEK	PROPOSED	4.1		PERM	*
403.32	TULE CREEK	PROPOSED	5.3		PERM	*
403.32	WEST FORK SESPE CREEK	PROPOSED	6.3		PERM	*
403.41	PIRU CREEK & TRIBUTARIES	INCLUDED	8.5		PERM	*
403.41	SANTA CLARA RIVER	INCLUDED	11.2		PERM	*
403.42	PIRU CREEK & TRIBUTARIES	INCLUDED	60.0	0.6	PERM	*
403.51	BOUQUET CREEK & TRIBUTARIES	INCLUDED	14.3		PERM	*
403.51	SAN FRANCISQUITO CANYON & TRIB.	INCLUDED	21.7		PERM	*
403.55	ALISO CANYON	PROPOSED	9.4		PERM	*
404.21	COLD CREEK	PROPOSED	5.2		PERM	*
404.21	MALIBU CREEK	INCLUDED	9.7		PERM	*
404.23	MEDEA CREEK	PROPOSED	5.4		I	*
404.44	ARROYO SEQUIT	INCLUDED	3.2		PERM	*
404.47	BIG SYCAMORE CANYON CREEK	INCLUDED	9.8		I	*
405.21	LOS ANGELES RIVER	INCLUDED	26.8	26.8	PERM	*
405.22	PACOIMA CANYON CREEK	INCLUDED	23.3		I	*
405.23	ALDER CREEK	PROPOSED	3.6		PERM	*
405.23	BIG TUJUNGA CANYON CREEK	INCLUDED	24.1		PERM	*
405.23	CLEAR CREEK	PROPOSED	3.7		PERM	*
405.23	MILL CREEK	INCLUDED	8.3		PERM	*
405.23	UPPER BIG TUJUNGA CANYON CREEK	PROPOSED	6.4		PERM	*
405.23	VASQUEZ CREEK	PROPOSED	1.2		PERM	*
405.31	EATON CANYON CREEK	INCLUDED	4.5		PERM	*
405.31	RUBIO CANYON	INCLUDED	3.5		I	*
405.32	ARROYO SECO CANYON	INCLUDED	14.4		PERM	*
405.32	LITTLE BEAR CREEK	INCLUDED	1.9		PERM	*
405.33	BIG SANTA ANITA CANYON CREEK	INCLUDED	4.8		PERM	*
405.33	WINTER CREEK	INCLUDED	3.2		PERM	*

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TABLE 2.4c RIPARIAN WETLANDS OF REGION 4

H.U.	NAME	INCLUDE/ PROPOSED #	LENGTH MILES @	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.41	BIG DALTON CANYON CREEK	INCLUDED	3.8		I	*
405.41	LITTLE DALTON CANYON CREEK	INCLUDED	4.0		I	*
405.41	MONROVIA CANYON CREEK	INCLUDED	2.9		I	*
405.41	RIO HONDO	INCLUDED	12.1	12.1	I	*
405.41	WALNUT CREEK WASH	INCLUDED	13.9	8.9	I	*
405.43	ALLISON GULCH	PROPOSED	2.5		PERM	*
405.43	BEAR CREEK	PROPOSED	11.2		PERM	*
405.43	CATTLE CREEK	INCLUDED	9.0		PERM	*
405.43	COLDWATER CANYON CREEK	INCLUDED	7.4		PERM	*
405.43	COW CREEK	INCLUDED	5.0		I	*
405.43	DEVILS CANYON CREEK	INCLUDED	10.8		PERM	*
405.43	EAST FORK SAN GABRIEL RIVER	INCLUDED	16.5		I	*
405.43	FISH CANYON	INCLUDED	6.9		I	*
405.43	FISH FORK	PROPOSED	7.3		PERM	*
405.43	IRON FORK	PROPOSED	6.2		PERM	*
405.43	NORTH FORK SAN GABRIEL RIVER	INCLUDED	4.6		PERM	*
405.43	PRAIRIE FORK	PROPOSED	6.2		PERM	*
405.43	ROBERTS CANYON	INCLUDED	6.6		I	*
405.43	SAN GABRIEL RIVER - MAIN STEM	INCLUDED	11.6	0.3	PERM	*
405.43	WEST FORK SAN GABRIEL RIVER	INCLUDED	20.0		PERM	*
405.44	FERN CANYON	PROPOSED	2.8		I	*
405.44	SAN DIMAS CANYON CREEK	INCLUDED	6.7		I	*
405.44	WOLFSKILL CANYON	PROPOSED	4.1		I	*
405.53	MARSHALL CREEK AND WASH	INCLUDED	3.8		I	*
481.23	SAN ANTONIO CANYON CREEK	INCLUDED	6.4		I	*

Included means that the waterbody was included in the 1978 Basin Plan of the Los Angeles Water Quality Control Board.

@ The length includes the total length of the river. Wetland conditions exist in portions of the rivers.

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3.3. COASTAL FEATURES

The coastal features, shown in Fig. 2.1- 2.5, and listed in Table 2.5. include beaches, bays, harbors, estuaries, and coastal wetlands of the mainland and islands of the Channel Islands.

The names of these features are obtained from:
- 1978 Basin Plan
- USGS Maps
- L.A. Department of Beaches and Harbors maps.

Also shown on the maps are features called 'nearshore zones', 'other nearshore zones', and Areas of Special Biological Significance (ASBS).

The 'nearshore zone', as defined in the 1978 Basin Plan (LARWQCB, 1978), is " bounded by the shoreline and a line 1,000 feet from the shoreline or the 30-foot depth contour, whichever is further from the shoreline." The 'other nearshore zone' would be the nearshore area other than the coastal features named on the maps.

An estuary is a semi-enclosed coastal feature, with a free connection with the open sea, and within which seawater is mixed with freshwater, derived from land. Estuarine conditions exist at the mouths of the Ventura River(Fig 2.1), the Santa Clara River and the Calleuguas Creek (Fig 2.2), Zuma Creek and Malibu Creek (Fig 2.3), Ballona Creek, Dominguez Channel, Los Angeles River and San Gabriel River (Fig 2.4). The 'tidal prism' feature, listed in the 1978 Basin Plan, is the salt water wedge along the bottom of the river mouth, due to density differential, and is a part of the estuary. We recommend that the 'tidal prism' be correctly referred to as the 'estuary', and that an estuarine (EST) beneficial use be assigned accordingly.

The Areas of Special Biological Significance (ASBS), shown on the coastal feature maps, were selected by the Regional Water Quality Control Board. These ASBS contain "biological communities of such extraordinary, even though unquantifiable, value that no acceptable risk of change in their environment as a result of man's activities can be entertained." (SWRCB, 1972) The waterbodies contained in the ASBS would qualify for BIOL as a beneficial use.

The Coastal Wetlands, listed in Table 2.4a include estuarine and palustrine (and not marine) wetlands and are described, in detail in the Volume 2 of the report subtitled: Wetlands and their Beneficial Uses.

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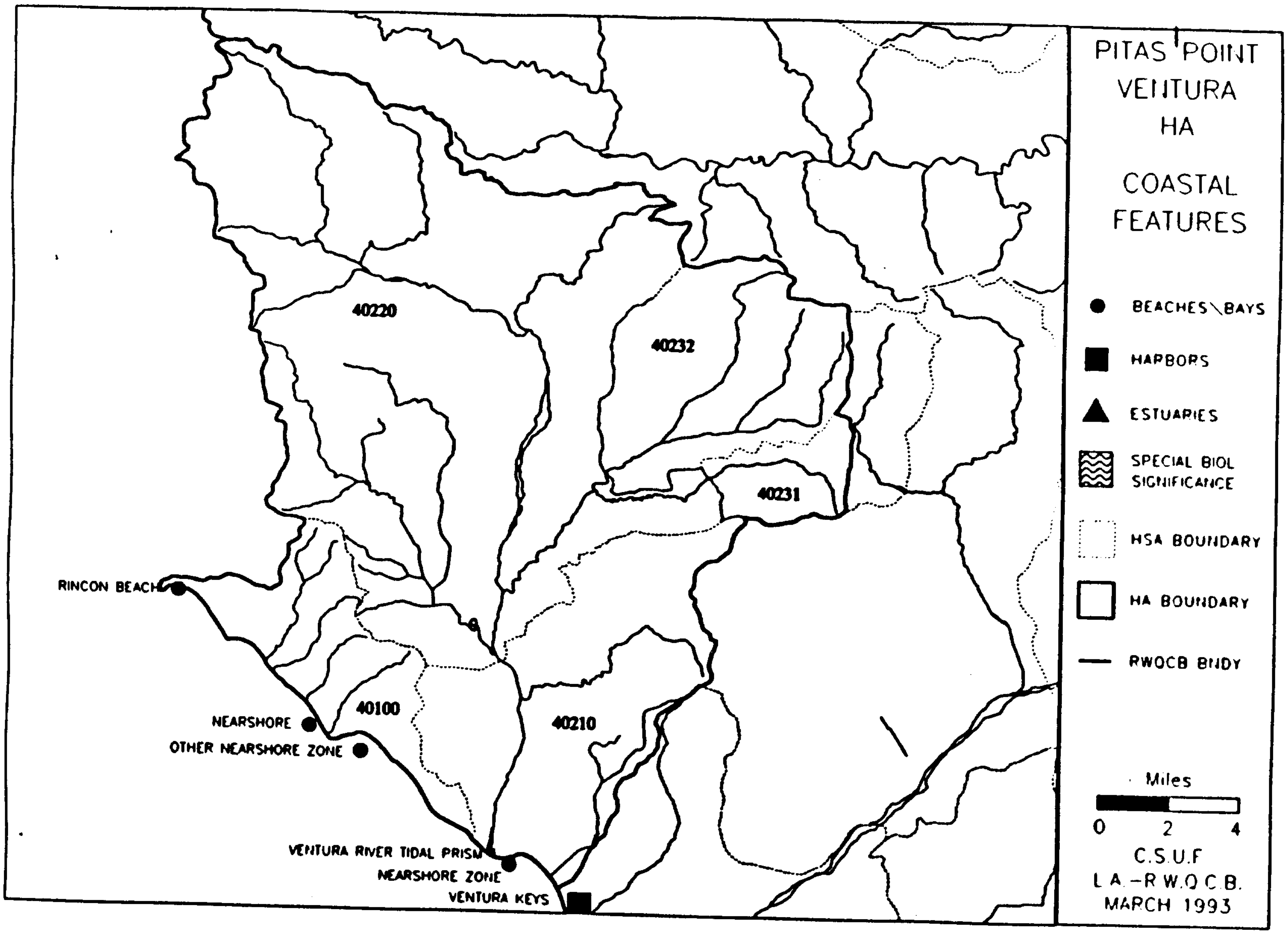
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BEACHES\BAYS
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RINCON BEACH
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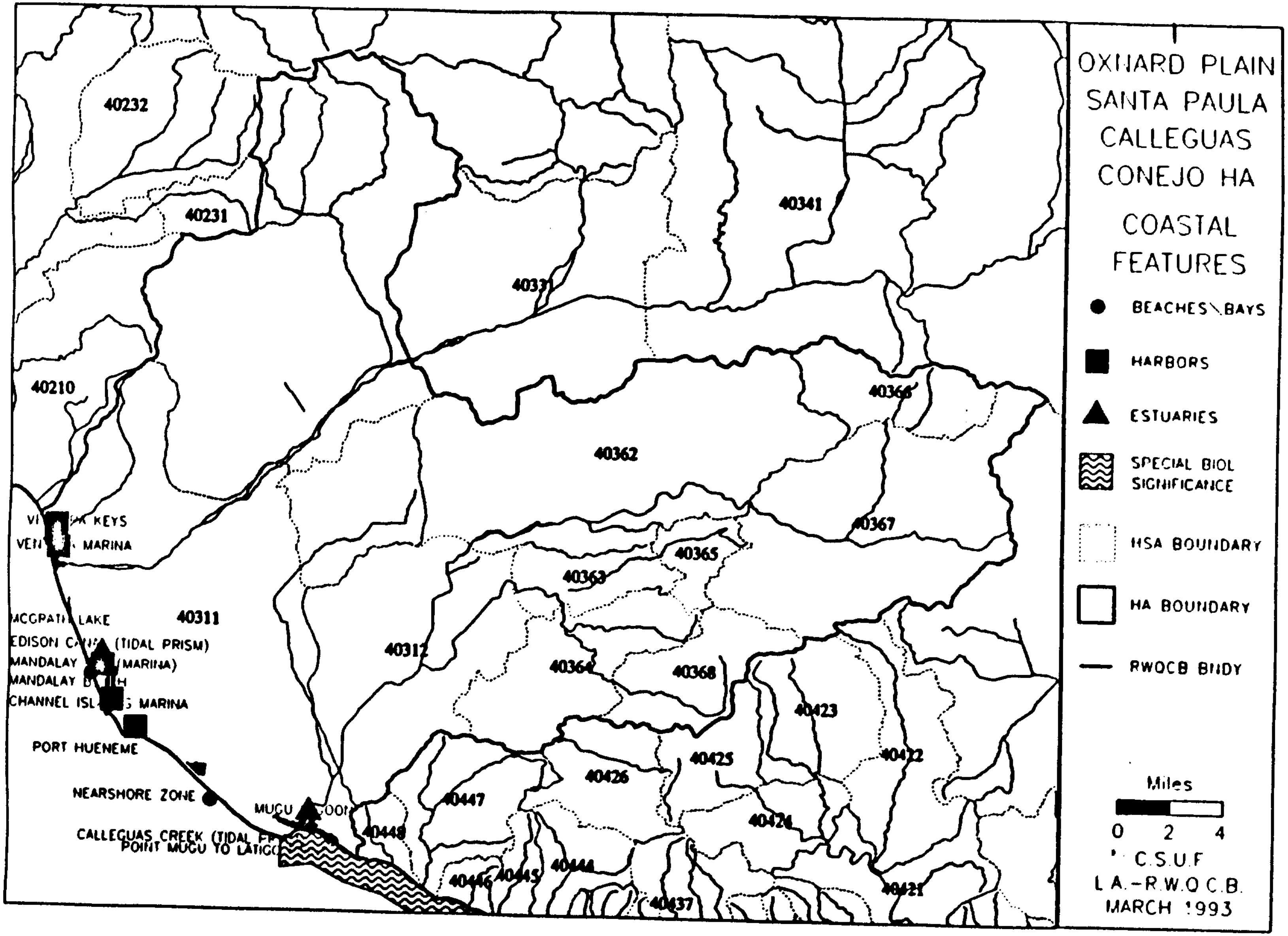
OTHER NEARSHORE ZONE
VENTURA RIVER TIDAL PRISM
NEARSHORE ZONE
VENTURA KEYS

FIG 2.1.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CALLEGUAS
CONEJO HA
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BEACHES\BAYS
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SPECIAL BIOL SIGNIFICANCE
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RWQCB BNDY
Miles
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C.S.U.F
L.A.-R.W.Q.C.B.
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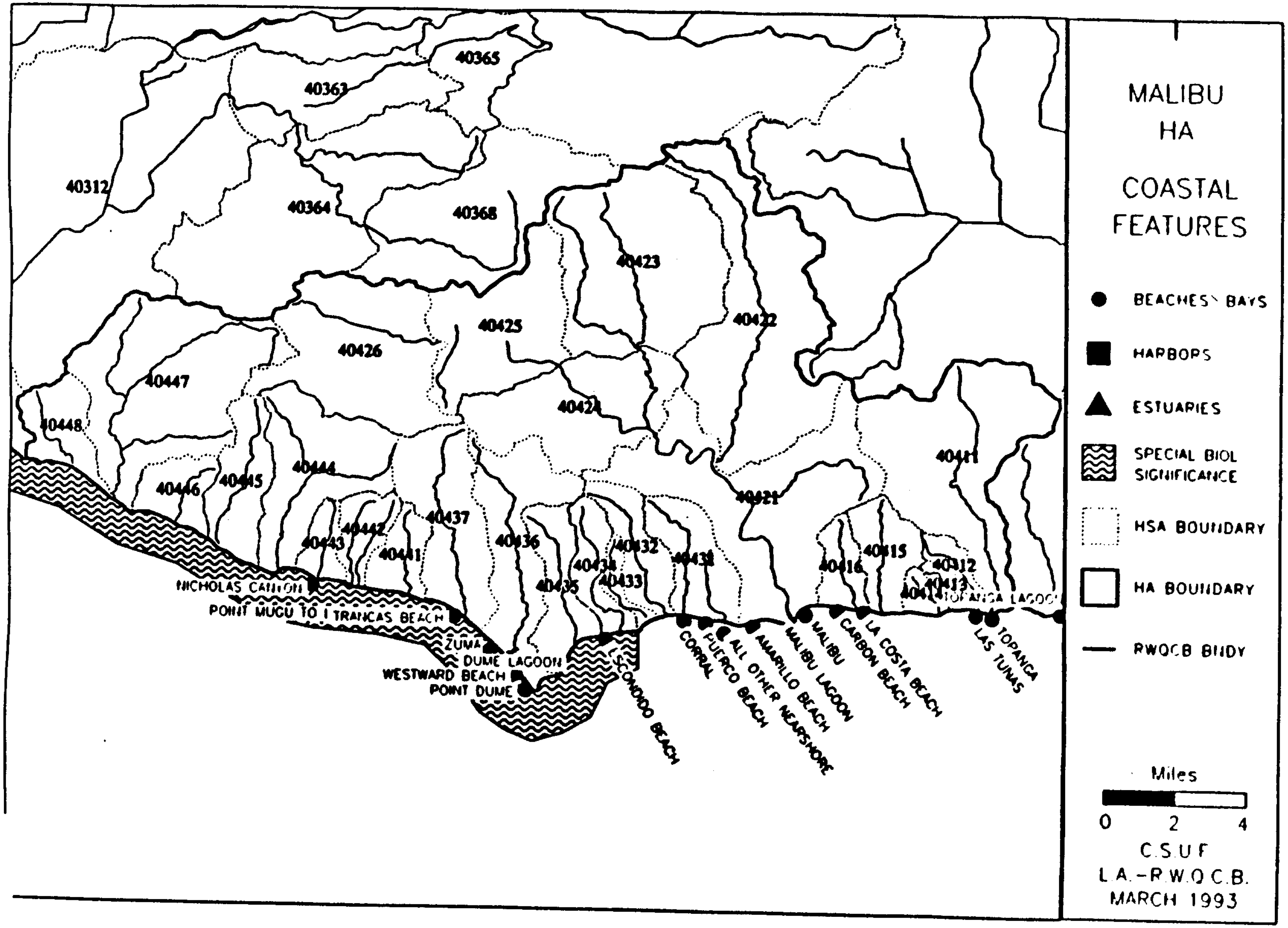
40437
40421
KEYS
MARINA
MCGRATH LAKE
EDISON CANAL (TIDAL PRISM)
MANDALAY
(MARINA)
MANDALAY
CHANNEL ISL
MARINA
PORT HUENEME
NEARSHORE ZONE
MUGU
CALLEGUAS CREEK (TIDAL
POINT MUGU TO LATIGO

FIG 2.2.


MALIBU
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COASTAL
FEATURES
BEACHES \ BAYS
HARBORS
ESTUARIES
SPECIAL BIOL SIGNIFICANCE
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HA BOUNDARY
RWQCB BNDY
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L.A.-R.W.Q.C.B.
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40413
NICHOLAS CANYON
POINT MUGU TO TRANCAS BEACH
ZUMA
DUME LAGOON
WESTWARD BEACH
POINT DUME
ESCONDIDO BEACH
CORRAL
PUERCO BEACH
ALL OTHER NEARSHORE
AMARILLO BEACH
MALIBU
MALIBU LAGOON
CARBON BEACH
LA COSTA BEACH
LAS TUNAS
TOPANGA
TOPANGA LAGOON

FIG 2.3.

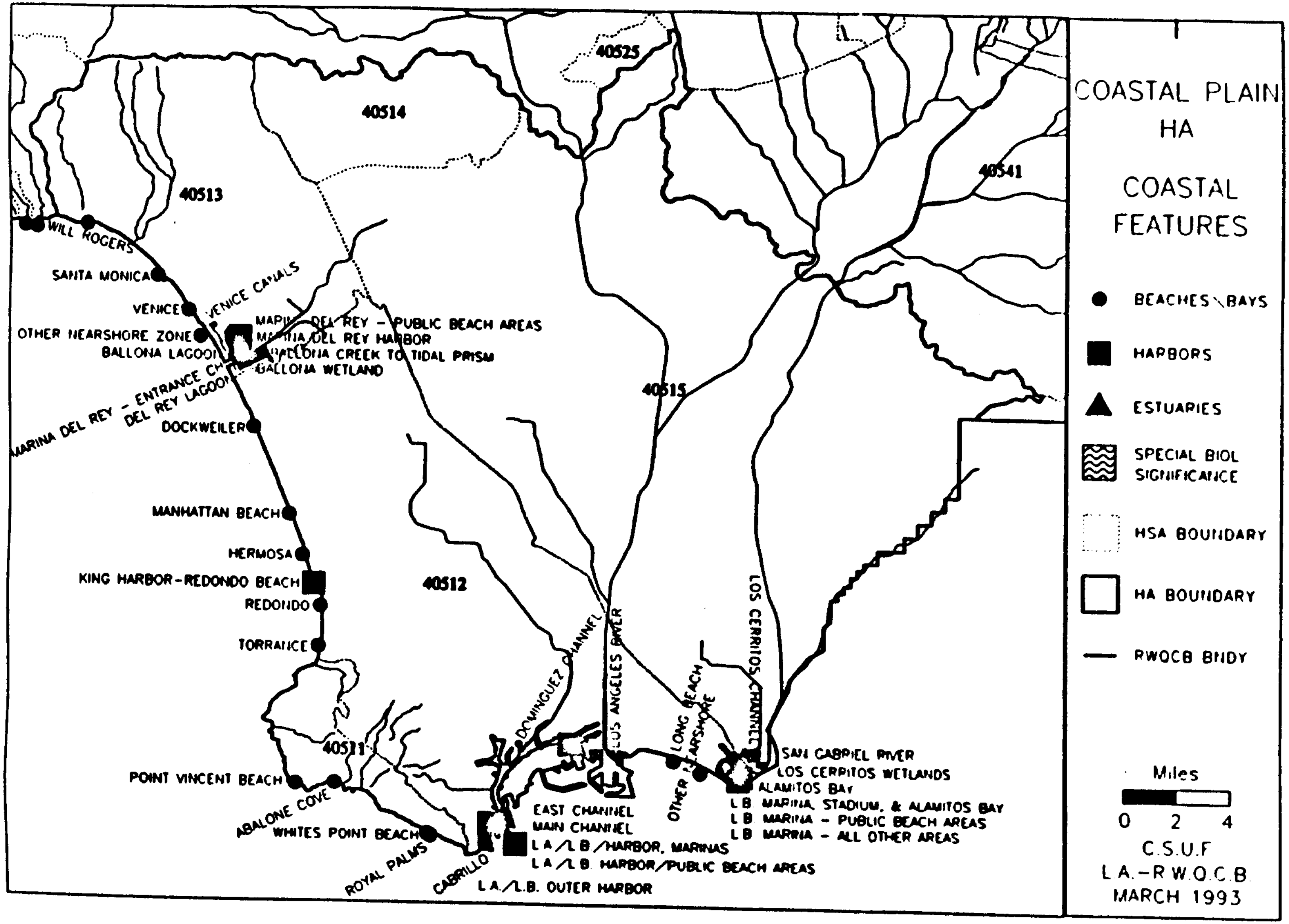

FIG 2.4.

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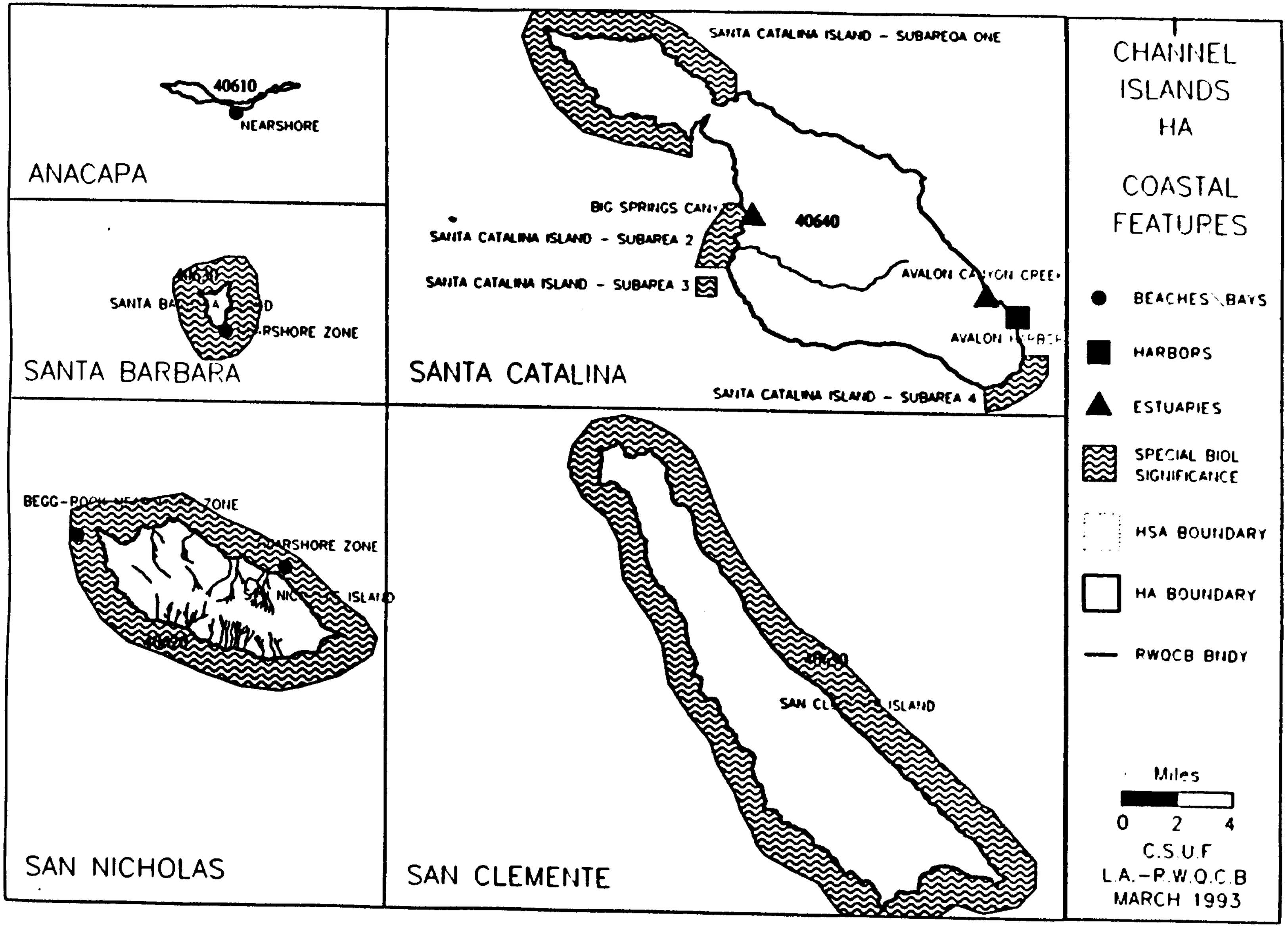

ANACAPA
40610
NEARSHORE
SANTA BARBARA
SANTA CATALINA
SANTA CATALINA ISLAND - SUBAREOA ONE
BIG SPRINGS CANY
40640
SANTA CATALINA ISLAND - SUBAREA 2
SANTA CATALINA ISLAND - SUBAREA 3
AVALON CANYON CREE
SANTA CATALINA ISLAND - SUBAREA 4
SAN NICHOLAS
BEGG-ROCK
NEARSHORE ZONE
SAN CLEMENTE
CHANNEL ISLANDS HA
COASTAL FEATURES
BEACHES BAYS
HARBORS
ESTUARIES
SPECIAL BIOL SIGNIFICANCE
HSA BOUNDARY
HA BOUNDARY
RWQCB BNDY
Miles
0 2 4
C.S.U.F
L.A.-R.W.Q.C.B
MARCH 1993

FIG 2.5.

TABLE 2.5 WATERBODIES OF REGION 4
By Waterbody Type
Coastal Features

H.U.	NAME	INCLUDE/ PROPOSED	AREA ACRES	WETLND DESIGN
**	HARBOR			
403.11	CHANNEL ISLANDS MARINA	INCLUDED		
403.11	MANDALAY BAY (MARINA)	INCLUDED		
403.11	PORT HUENEME (HARBOR)	INCLUDED		
403.11	VENTURA KEYS (MARINA)	INCLUDED		
403.11	VENTURA MARINA	INCLUDED		
405.12	KING HARBOR-REDONDO BEACH	INCLUDED		
405.12	L.A./L.B. ALL OTHER INNER AREAS	INCLUDED		
405.12	L.A./L.B. OUTER HARBOR	INCLUDED		
405.12	L.A./L.B./HARBOR, MARINAS	INCLUDED		
405.12	L.B. MARINA - ALL OTHER AREAS	INCLUDED		
405.12	L.B. MARINA, STADIUM, & ALAMITOS BAY	INCLUDED		
405.13	MARINA DEL REY - ALL OTHER AREAS	INCLUDED		
405.13	MARINA DEL REY HARBOR	PROPOSED		
**	BEACH/BAY			
401.00	NEARSHORE &	INCLUDED		
401.00	OTHER NEARSHORE ZONE	PROPOSED		
401.00	RINCON BEACH	PROPOSED		
402.10	NEARSHORE ZONE	INCLUDED		
403.11	MANDALAY BEACH	PROPOSED		
403.11	NEARSHORE ZONE (TIDAL PRISM)	INCLUDED		
404.11	TOPANGA BEACH	PROPOSED		
404.12	LAS TUNAS BEACH	PROPOSED		
404.16	CARBON BEACH	PROPOSED		
404.16	LA COSTA BEACH	PROPOSED		
404.21	AMARILLO BEACH	PROPOSED		
404.21	MALIBU BEACH	PROPOSED		
404.31	ALL OTHER NEARSHORE	PROPOSED		
404.31	CORRAL BEACH	PROPOSED		
404.31	PUERCO BEACH	PROPOSED		
404.34	ESCONDIDO BEACH	PROPOSED		
404.36	POINT DUME BEACH	PROPOSED		
404.36	WESTWARD BEACH	PROPOSED		
404.36	ZUMA COUNTY BEACH	PROPOSED		
404.37	TRANCAS BEACH	PROPOSED		
404.43	NICHOLAS CANYON BEACH	PROPOSED		
405.11	ABALONE COVE	PROPOSED		
405.11	POINT VICENTE BEACH	PROPOSED		
405.11	ROYAL PALMS BEACH	PROPOSED		
405.11	WHITES POINT BEACH	PROPOSED		
405.12	CABRILLO BEACH	PROPOSED		
405.12	DOCKWEILER BEACH	PROPOSED		
405.12	HERMOSA BEACH	PROPOSED		
405.12	L.A./L.B. HARBOR/PUBLIC BEACH AREAS	INCLUDED		
405.12	L.B. MARINA - PUBLIC BEACH AREAS	INCLUDED		
405.12	LONG BEACH	PROPOSED		
405.12	MANHATTAN BEACH	PROPOSED		
405.12	OTHER NEARSHORE	PROPOSED		
405.12	REDONDO BEACH	PROPOSED		
405.12	TORRANCE BEACH	PROPOSED		
405.13	MARINA DEL REY - PUBLIC BEACH AREAS	INCLUDED		
405.13	OTHER NEARSHORE ZONE	PROPOSED		

TABLE 2.5 WATERBODIES OF REGION 4
By Waterbody Type
Coastal Features

H.U.	NAME	INCLUDE/ PROPOSED	AREA ACRES	WETLND DESIGN
405.13	SANTA MONICA BEACH	PROPOSED		
405.13	VENICE BEACH	PROPOSED		
405.13	WILL ROGERS BEACH	PROPOSED		
406.01	NEARSHORE ZONE	INCLUDED		
406.01	OFFSHORE ZONE c	INCLUDED		
406.10	NEARSHORE	INCLUDED		
406.20	BEGG-ROCK NEARSHORE ZONE	INCLUDED		
406.20	NEARSHORE ZONE	INCLUDED		
**	ESTUARY			
403.11	CALLEGUAS CREEK (TIDAL PRISM)	INCLUDED		
403.11	EDISON CANAL (TIDAL PRISM)	INCLUDED		
405.12	DOMINGUEZ CHANNEL (TIDAL PRISM)	INCLUDED	93.0	
405.12	LOS ANGELES RIVER (TIDAL PRISM)	INCLUDED	234.0	
405.12	LOS CERRITOS CHANNEL (TIDAL PRISM)	PROPOSED	34.8	
405.13	BALLONA CREEK (TIDAL PRISM)	INCLUDED	153.4	
405.13	MARINA DEL REY - ENTRANCE CHANNEL	INCLUDED		
405.15	SAN GABRIEL RIVER (TIDAL PRISM)	INCLUDED	74.5	
406.40	AVALON CANYON CREEK	PROPOSED		
406.40	BIG SPRINGS CANYON	PROPOSED		
**	COASTAL WETLAND			
402.10	VENTURA RIVER TIDAL PRISM	INCLUDED	35.6	•
403.11	MCGRATH LAKE (TIDAL PRISM)	INCLUDED	19.5	•
403.11	MUGU LAGOON (TIDAL PRISM)	INCLUDED	323.3	•
403.11	ORMOND BEACH	PROPOSED	136.5	•
403.11	SANTA CLARA RIVER (TIDAL PRISM)	INCLUDED	55.7	•
404.11	TOPANGA LAGOON	PROPOSED	5.0	•
404.21	MALIBU LAGOON (TIDAL PRISM)	INCLUDED	20.9	•
404.36	DUME LAGOON	PROPOSED	17.4	•
405.12	ALAMITOS BAY	PROPOSED	320.0	•
405.13	BALLONA LAGOON	PROPOSED	13.2	•
405.13	BALLONA WETLANDS	PROPOSED	355.2	•
405.13	DEL REY LAGOON	PROPOSED	5.4	•
405.13	VENICE CANALS - BALLONA CREEK (TIDAL PRISM)	INCLUDED	17.7	•
405.15	LOS CERRITOS LAGOON	PROPOSED	22.2	•
405.15	LOS CERRITOS WETLANDS	PROPOSED	226.0	•
**	ISLAND			
406.10	ISLANDS	INCLUDED	716.2	
406.30	SANTA BARBARA ISLAND	INCLUDED	641.8	
406.40	SANTA CATALINA ISLAND	INCLUDED	48057.2	
406.50	SAN CLEMENTE ISLAND	INCLUDED	36331.9	

TABLE 2.6 WATERBODIES OF REGION 4
By Waterbody Type
Areas of Biological Significance

H.U.	NAME	AREA ACRES
404.35	POINT MUGU TO LATIGO POINT	64792.0
406.20	SAN NICHOLAS ISLAND	14491.9
406.30	SANTA BARBARA ISLAND	641.8
406.40	SANTA CATALINA ISLAND - SUBAREA 1	10197.3
406.40	SANTA CATALINA ISLAND - SUBAREA 2	1669.0
406.40	SANTA CATALINA ISLAND - SUBAREA 3	309.1
406.40	SANTA CATALINA ISLAND - SUBAREA 4	1466.0
406.50	SAN CLEMENTE ISLAND	36331.9

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3.4. GEOLOGY AND GROUNDWATER RESOURCES

Geology plays an important role in defining the physiography, surface water and groundwater hydrology and water quality in the region. There may also be some correlation between the occurrence of various riparian vegetation wetland habitats (Fig 6.0-6.9) and physiography and geology. The general geology of the Region 4 is depicted in Fig 3.0-3.9 and the associated groundwater basins are shown in Fig 4.0-4.9.

The pre-Cretaceous Pelona Schist and igneous and metamorphic rocks form the basement complex, are exposed in the San Gabriel Mountains, Sierra Pelona, Liebre and Alamo Mountains. These mountains are the source areas and upper reaches of San Gabriel River, Santa Clara River and Piru Creek. Surface water and groundwater associated with these rocks has low total dissolved solids and are largely calcium-bicarbonate type waters. Groundwater occurs and moves through fractures, and becomes part of deep percolation, with recharge from precipitation and stream infiltration. Most of the streams in these areas would qualify for groundwater recharge (GWR) as their beneficial use.

Cretaceous and Tertiary sediments consist largely of marine shales, siltstones, sandstones and conglomerates, exposed in the Puente Hills, Palos Verdes Hills, Santa Monica Mountains, Simi Valley, Topa Topa and Sulphur Mountains and in the upper reaches of the Ventura River and Sespe Creek. The waters are largely calcium-sulphate and calcium-bicarbonate types. The Tertiary volcanics, exposed in the Santa Monica and Conejo Mountains, are sources of local groundwater in these regions.

Most of the usable groundwater occurs in the Quaternary non-marine and alluvial sediments, which occur in the alluvial filled valleys and coastal basins. The groundwater basins, shown in Fig 4.0-4.9, are named after California Department of Water Resources (DWR) Bulletin 118. The bedrock, with dark shading, surrounding the groundwater basins, with light shading, has been labeled as 'Non-water bearing' in most DWR bulletins. This is a reflection of the 1950s thinking when resource hydrogeology was of major concern. Major solid waste disposal landfills (Puente Hills, BKK, Stringfellow Quarry, and others) were sited on the bedrock and some have become sources of groundwater pollution through fracture flow in connection with the alluvial filled valleys and basins. We recommend the use of the term 'mostly bedrock' in preference to 'non-water bearing' in the groundwater maps.

In the Ventura and Santa Clara River valleys,(Fig 4.0-4.4), groundwater basins form a string of alluvial filled basins, where groundwater movement is largely from the upper basin to the lower basin. The basins of the Ventura River (Fig 4.1) are: Upper Ojai, Ojai, Upper Ventura and Lower Ventura. In the Santa Clara River, from upstream to downstream, these include Acton Valley, Bouquet, Placerita and Castaic Canyons (Fig 4.4), Piru, Filmore and Santa

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Paula, Mound Basin and Oxnard Plain (Fig 4.5). In the Colleguas-Conejo valleys, the tributary groundwater basins to the Oxnard Plain are Simi, Las Posas and Pleasant Valleys. In the upper valleys the aquifer thickness is shallow, (100-300 ft.), with mostly unconfined aquifers. There are several reaches of rising groundwater in the Santa Clara River, giving rise to a corridor of continuous riparian vegetation (Fig 6.0).

In the coastal Oxnard Plain groundwater basin, site of agricultural, industrial and urban development, there are multiple aquifers and most of the groundwater is under confined conditions. Groundwater formations within the basin, from top to bottom, are the semi-perched zone, the Oxnard, Mugu, Hueneme, Fox Canyon and Grimes Canyon aquifers. This is one of the few areas in Region 4 where hydrogeologic information is available to allocate distinct beneficial uses to each aquifer.

The major groundwater basins, in the eastern part of the Los Angeles county, belong to two inland valleys, San Fernando Valley and San Gabriel Valley, and a coastal plain, with Central, West Coast and Santa Monica Basins (Fig 4.0).

The San Fernando subregion, consists of Upper Los Angeles River Area(ULARA), with four distinct groundwater basins: the Sylmar, Verdugo, Eagle Rock and San Fernando Valley (Fig 4.6). The Sylmar and Verdugo are tributary groundwater basins to the San Fernando Valley. Groundwater occurs under unconfined conditions in the alluvium and confined conditions in the bedrock. San Fernando Valley is a major groundwater basin, supplying water for municipal (MUN), industrial(IND), processing(PRO) and agricultural (AGR) uses, and recharged through a number of artificial recharge basins, located in the Tujunga and Pocoima Washes. Groundwater flow is largely from west to east, towards pumping well fields in the Crystal Springs area, near Griffith Park. South of the well field, groundwater flows towards the Los Angeles narrows, an area of rising groundwater resulting from shallow bedrock. The area supports riparian wetland vegetation in the unlined channel of the Los Angeles River.

The Main San Gabriel Basin (Fig 4.7), with its tributary Raymond, Chino, Spadra and Puente Basins, is a major groundwater producer for municipal, industrial, processing and agricultural uses. Groundwater movement is towards pumping well fields, and south towards Whittier Narrows, an area of rising groundwater, due to shallow bedrock. The area supports riparian and lacustrine wetland vegetation.

The Coastal Plain subregion has four groundwater basins: Central, West Coast, Santa Monica and Hollywood Basins (Fig 4.8). The Central Basin, separated from the West Coast Basin by Newport-Inglewood Fault, is recharged by percolating waters from the San Gabriel River, the Rio Hondo and the Los Angeles River in the Montebello and Los Angeles Forebay areas. Beyond the forebays, the groundwater is under confined conditions and flows towards pumping well fields and towards the West Coast Basin. As in the Central Basin, groundwater occurs in a number of deep aquifers. Rising groundwater from shallow aquifers were responsible for extensive historical coastal and inland wetlands. Ballona Estuary and Wetlands are fed by groundwater flows from Santa Monica Groundwater Basin.

Groundwater in the Malibu subregion (Fig 4.9) occurs in the thin alluvial fill valleys of the coastal streams, in the volcanics and in fractures of the Topanga and Modelo bedrock formations. Groundwater resources are limited. They are recharged from precipitation and urban runoff, and flow south, along the stream gradient, towards the ocean.

3.5. STREAM CHANNELIZATION

As a result of urbanization of the region, flood control measures resulted in the construction of several dams and concrete channels. Figures 5.0-5.9 depict the location of the channelized and natural stretches of the streams. Channelized streams include river sections, with or without concrete linining. The information for these maps was obtained from Los Angeles County and Ventura County Flood Control District offices, U.S. Geological Survey maps, and verified through field surveys,

The stretches of maximum channelization are in Oxnard Plain (Fig 5.5), San Fernando Valley (Fig 5.6), San Gabriel Valley (Fig 5.7) and the Coastal Plain (Fig 5.8).

The beneficial use effects of channelization are:

(a) Loss of groundwater recharge capabilities, as in the foothills in San Gabriel and San Fernando Valleys,

(b) Loss of Riparian Wetlands, as in the middle reaches of San Gabriel and Los Angeles Rivers,

(c) Loss of Recreation (REC-1 and REC-2) facilities in fenced off, concrete-lined channels, with precipitous side slopes.

4.0 OTHER MAPS RELATED TO BENEFICIAL USE DETERMINATION

4.1. RARE FIND MAPS

Figures 6.0-6.9 are depiction of riparian and other wetland vegetation and sitings of rare and endangered species of animals, as contained in the Rare Find database. The Rare Find computer database is a part of the California Department of Fish and Game Natural Diversity Database. It contains 1:100,000 basemaps, with computer printouts, containing information on endangered, threatened and rare plants and animals, and vegetation communities considered to be of special concern. The database is updated on an annual basis; the one used for this study covered the period of

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June 1991 to June, 1992.

The species represented on the map are: birds, insects, fish, reptiles, mammals and plants. The vegetation communities of concern represented are varieties of marsh, scrub, forest and woodland. Some of these communities are described in detail in the wetland volume the report. Since the Rare Find database is limited to the sitings reported by various investigators, inaccessible areas, like the Condor Sanctuary, the Piru and Sespe Creek Basins have major data gaps. Similar gaps may exist in the Santa Monica Mountains and the San Gabriel Mountains.

The Rare Find database was used to allocate RARE, WILD and BIO beneficial uses to waterbodies, covered by these maps. These could also be used to demarcate stretches of streams that may contain riparian wetlands.

4.2. WETLAND MAPS

As described in the wetland section of this report, a number of waterbodies are recommended for allocation of wetland (WET) beneficial use. Three types of wetlands depicted on these maps are: Riparian Wetlands, Lacustrine Wetlands and Coastal Wetlands. Figures 7.0-7.9 show the location of recommended wetlands. Since the coastal and lacustrine wetlands have a limited areal extent, their location is accurate on these maps. For riparian wetlands, the maps show the whole stream or tributary containing significant wetland stretches. The approximate location of the stretches can be determined by comparing the information on Rare Find maps (Figure 6.0-6.9). Table 2.4 gives a list of recommended wetlands and their acreage or mileage.

4.3. WATER QUALITY SAMPLING STATIONS

Water Quality Sampling is performed on a regular basis by the LA Regional Water Quality Control Board. This is a part of the water quality assessment program, under the California Clean Water Strategy and the Federal Clean Water Act.

Figure 9.0 shows the location of Water Quality Sampling Stations in Region 4.

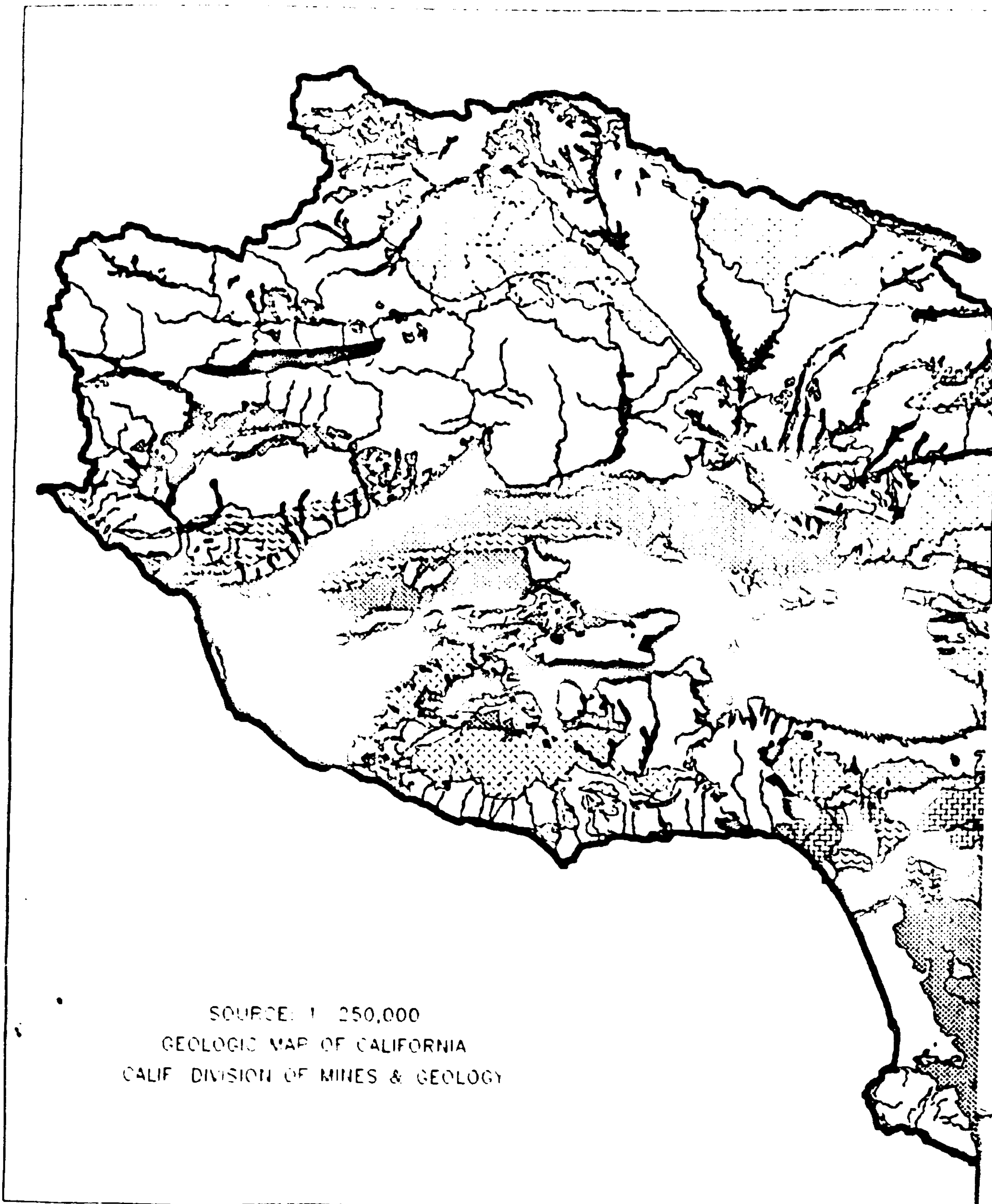
4.4. WATER QUALITY ASSESSMENT MAPS

Figures 10.0 to 10.9 show the water quality assessment designation for various waterbodies in Region 4. The classifications are defined as follows:

Good: Water supports and enhances the designated water use,

Intermediate: Water generally supports beneficial use, with occasional degradation in water quality,

Impaired: Waterbodies cannot reasonably be expected to attain or maintain applicable water quality standards.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GEOLOGIC MAP OF CALIFORNIA
CALIF. DIVISION OF MINES & GEOLOGY

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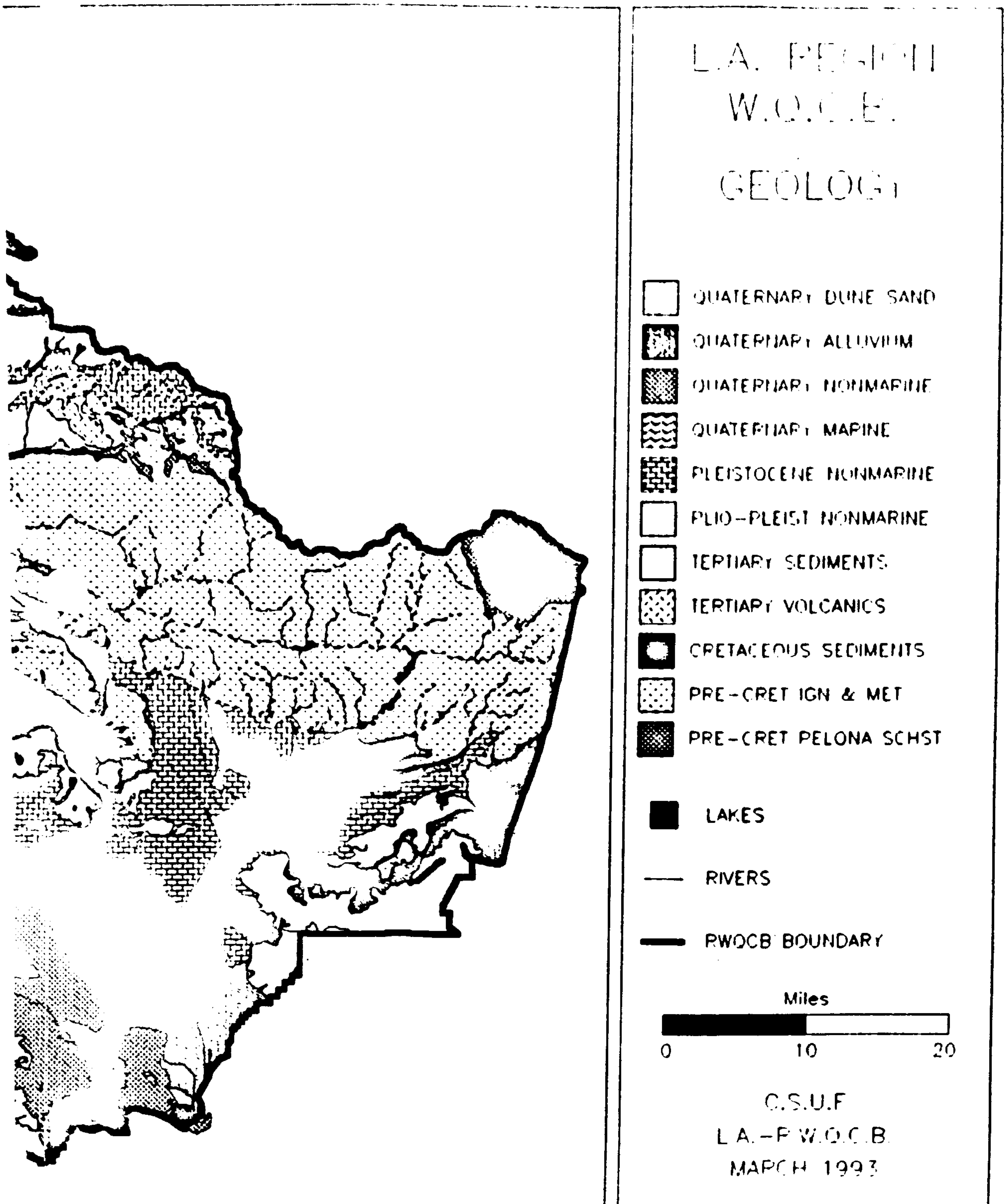

FIG 3.0.

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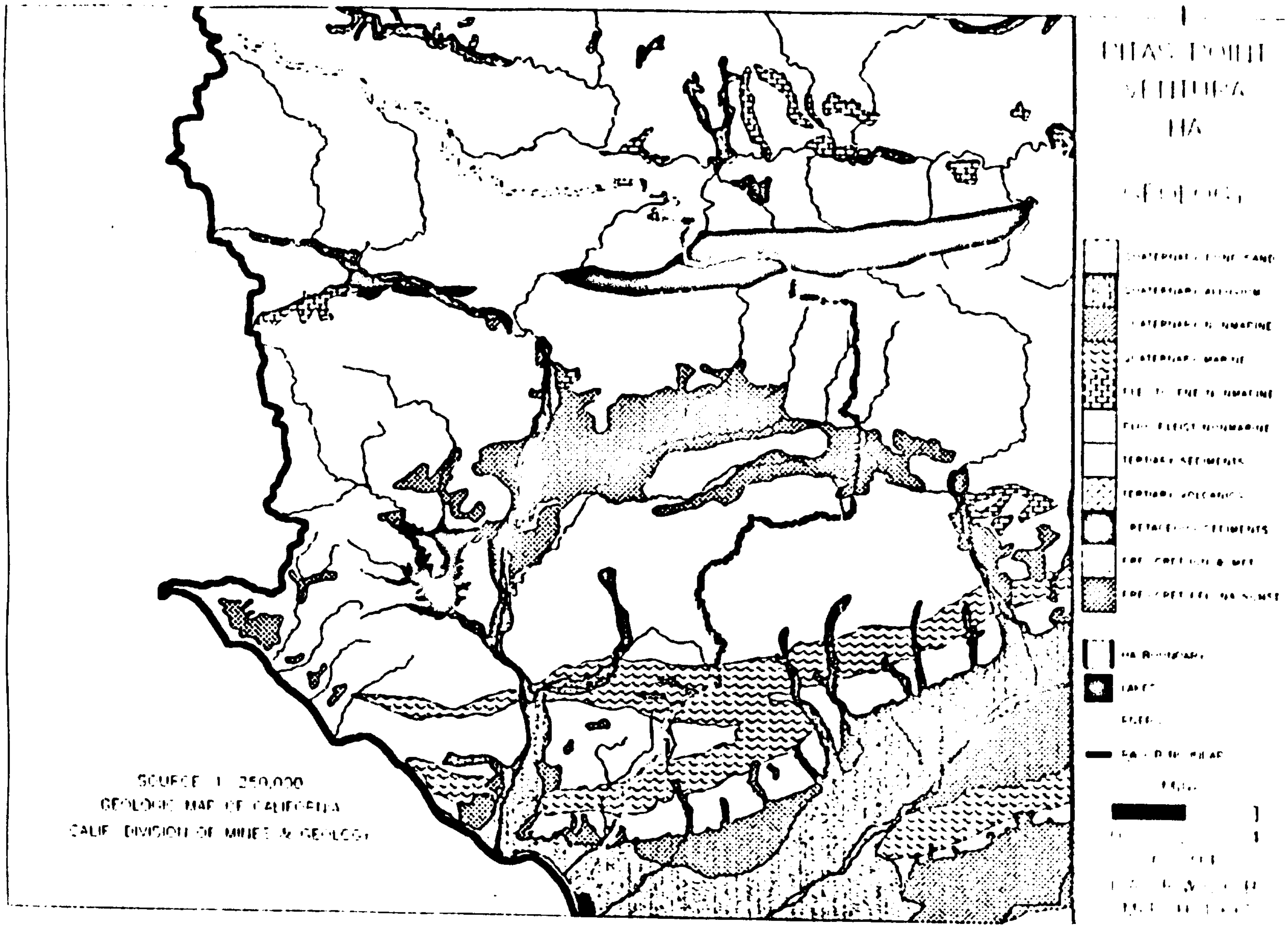
PITAS POINT
VENTURA
HA
SOURCE 1:250,000
GEOLOGIC MAP OF CALIFORNIA
CALIF. DIVISION OF MINES & GEOLOGY

FIG 3.1.

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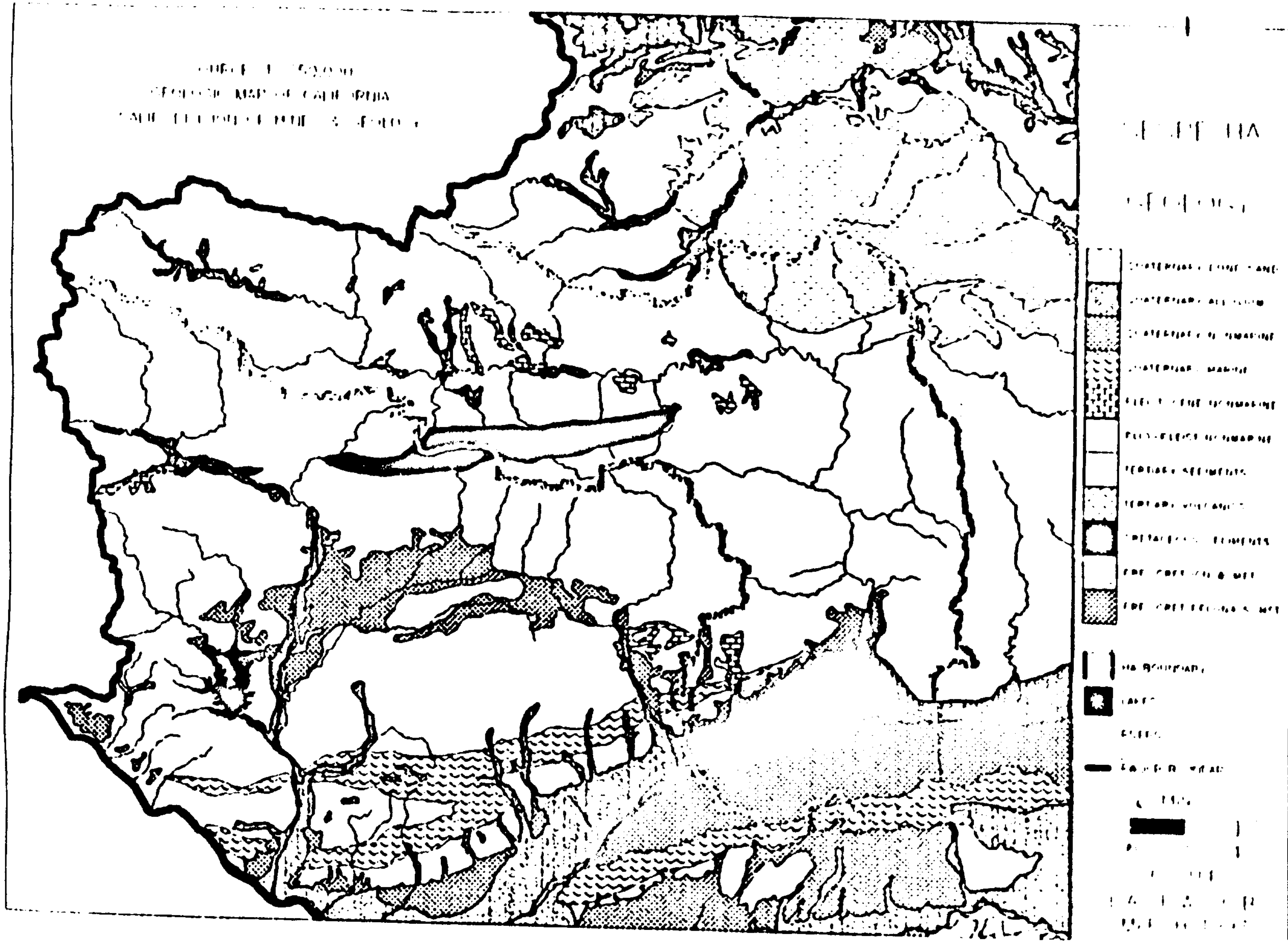

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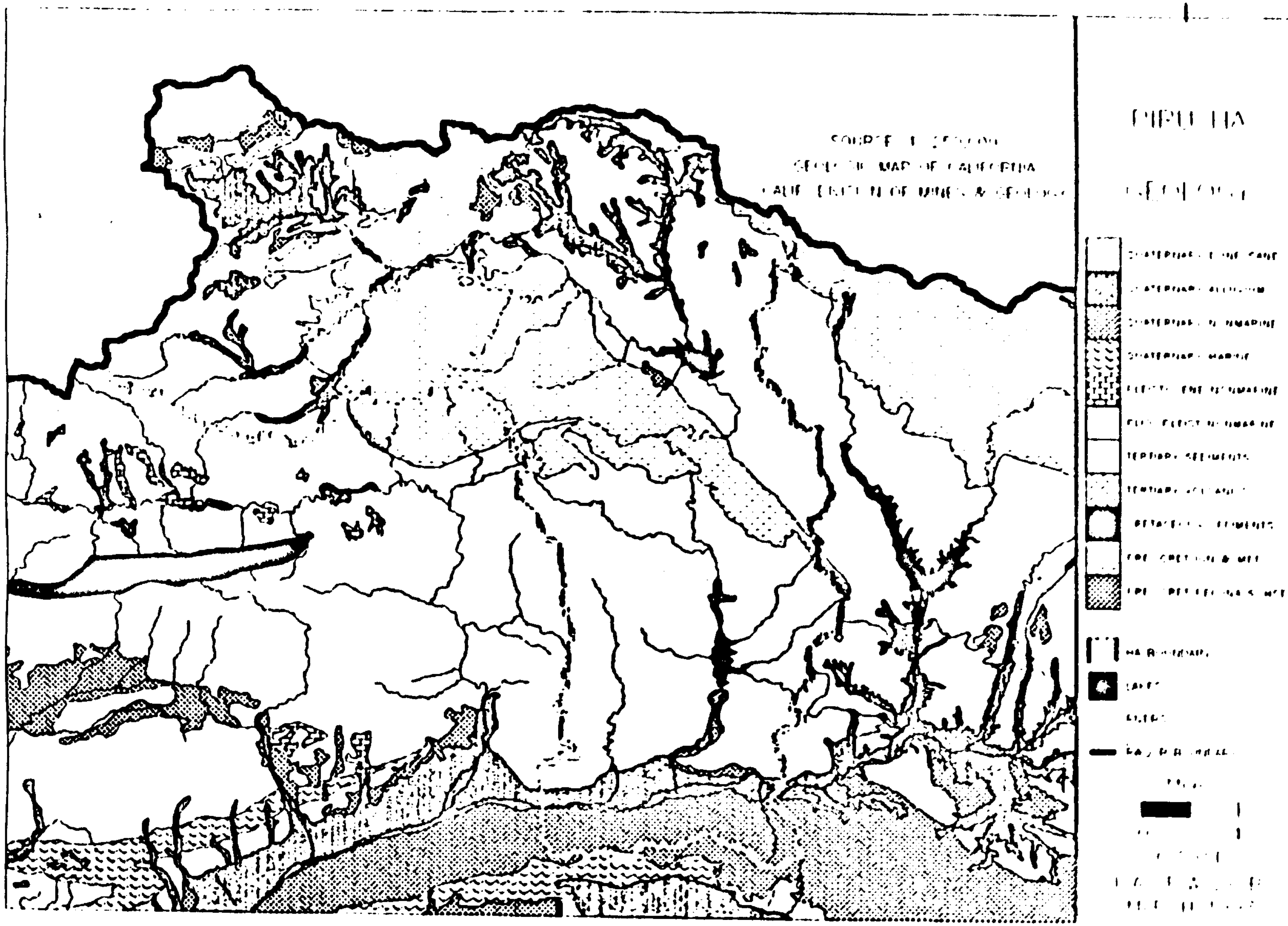


FIG 3.3.

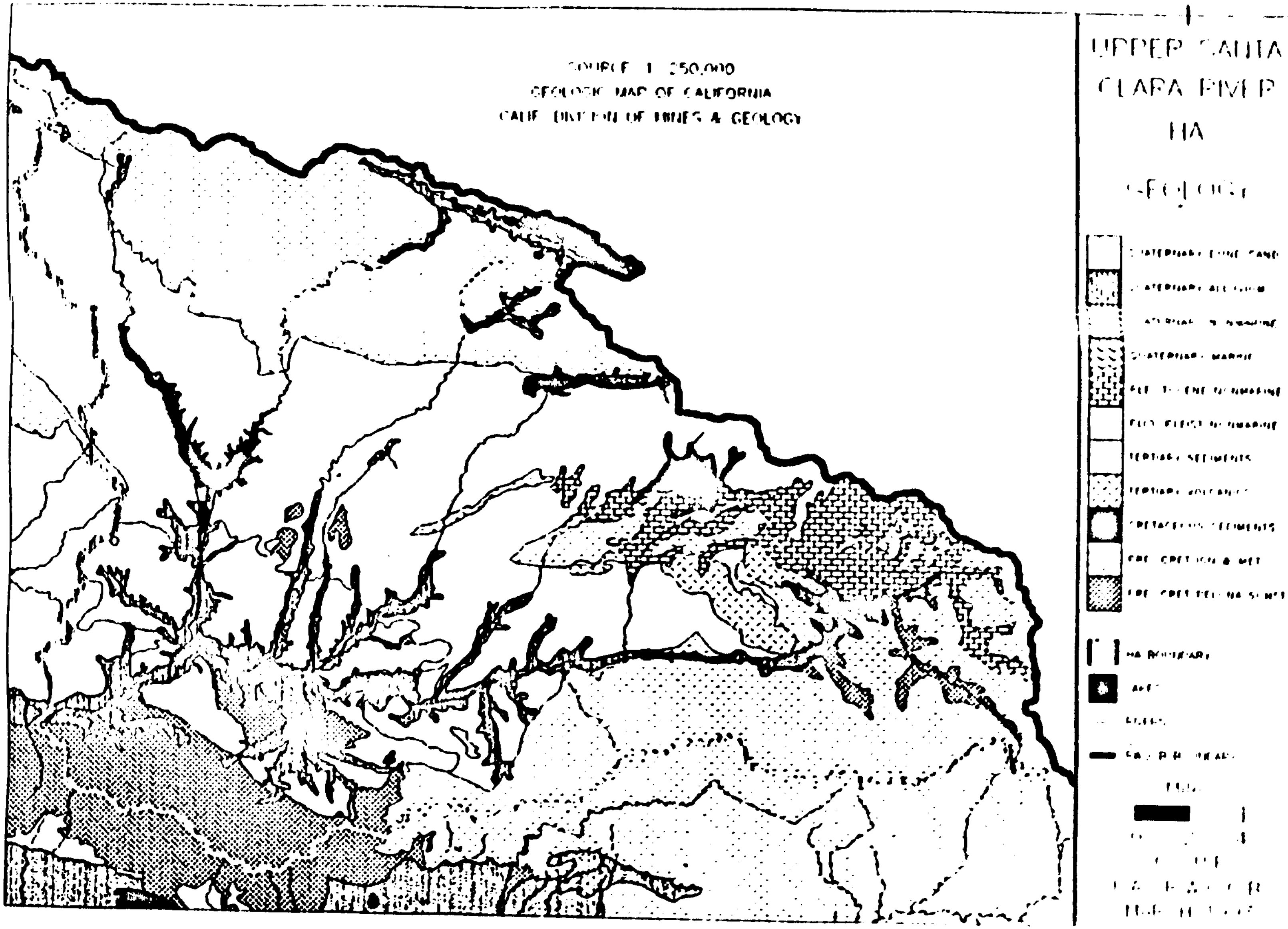
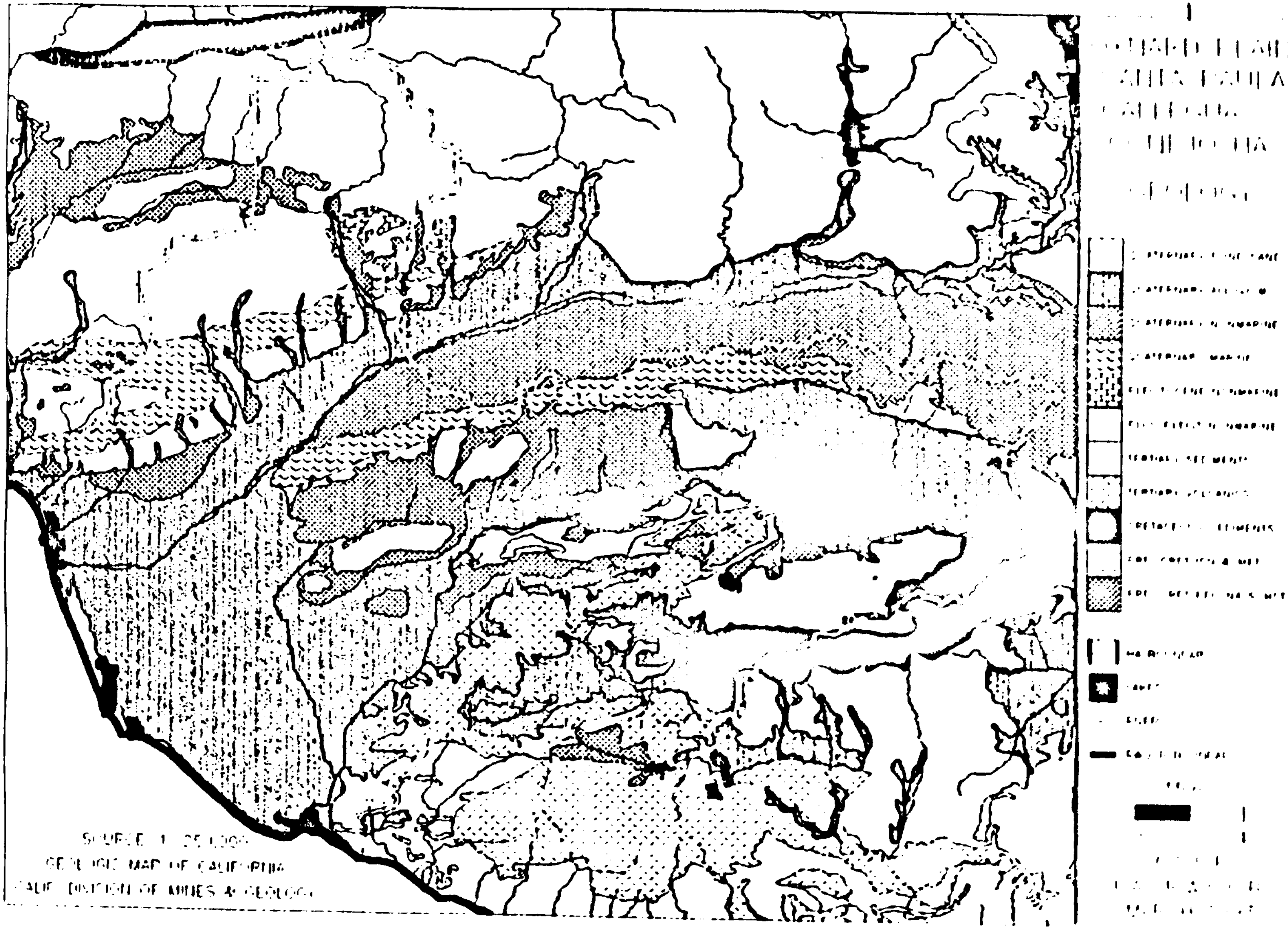

SOURCE 1:250,000
GEOLOGIC MAP OF CALIFORNIA
CALIF. DIVISION OF MINES & GEOLOGY
UPPER SANTA
CLARA RIVER
HA
GEOLOGY
TERTIARY SEDIMENTS

FIG 3.4.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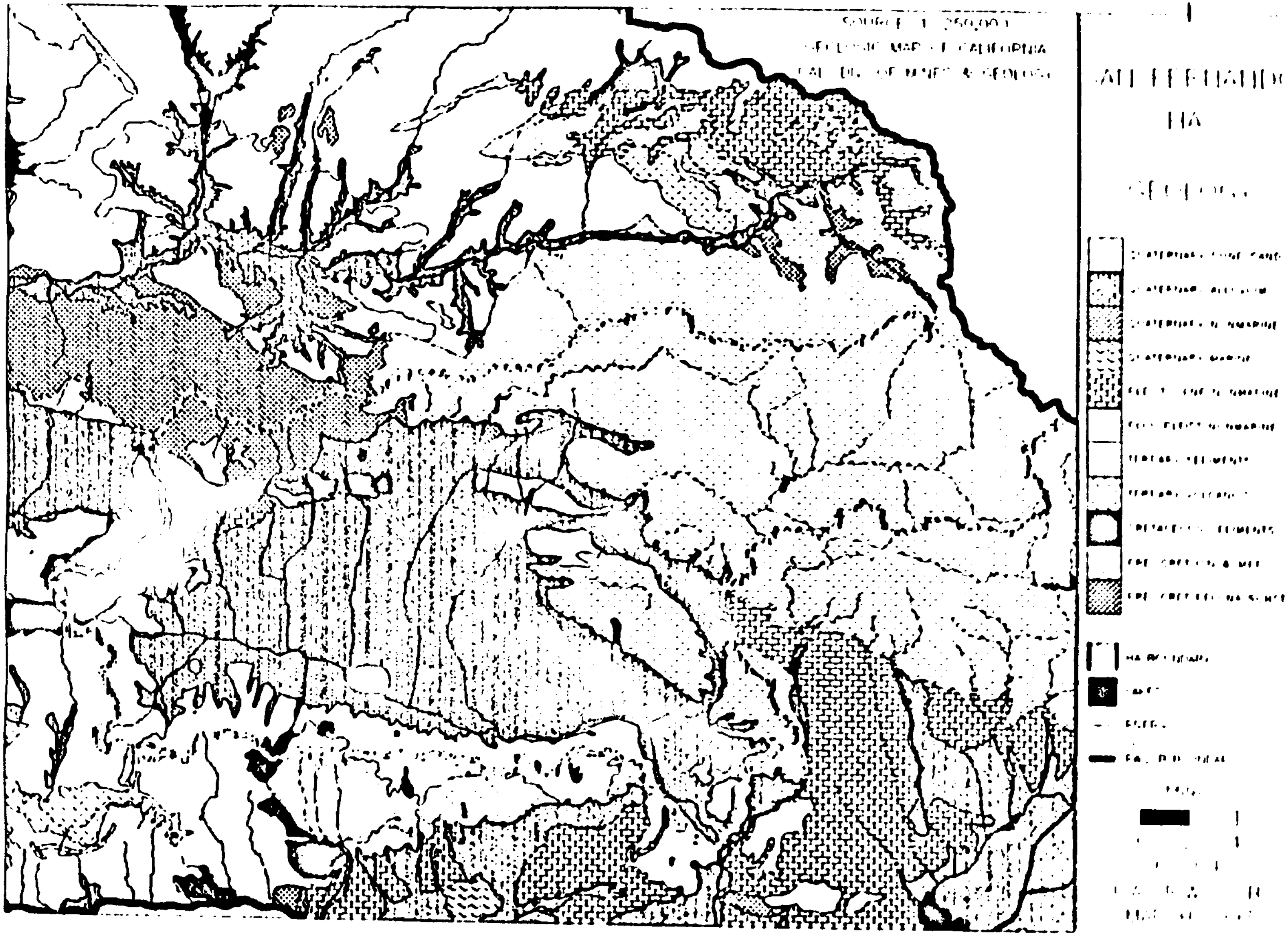
GEOLOGIC MAP OF CALIFORNIA
CALIF. DIVISION OF MINES & GEOLOGY

FIG 3.5.



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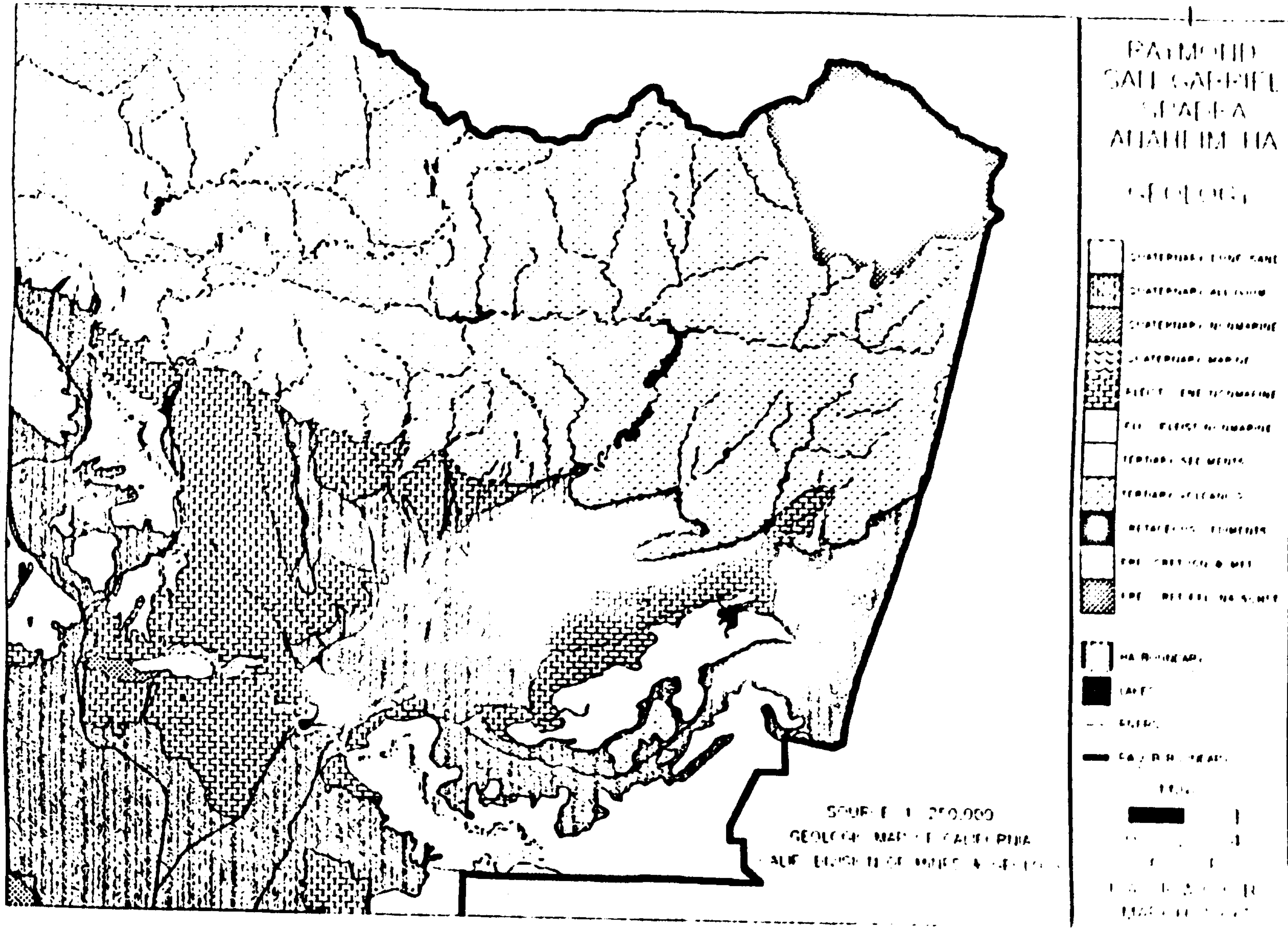

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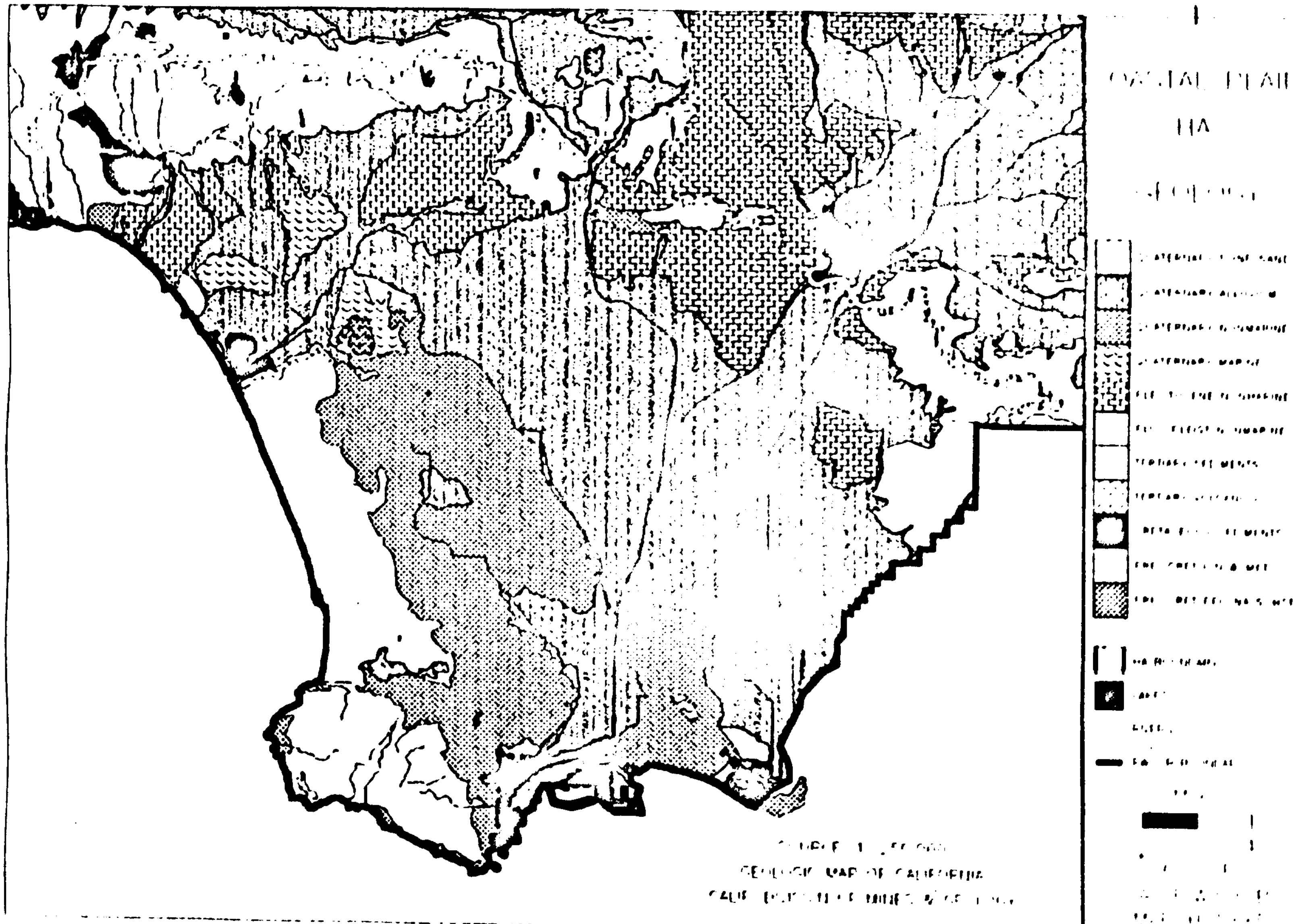

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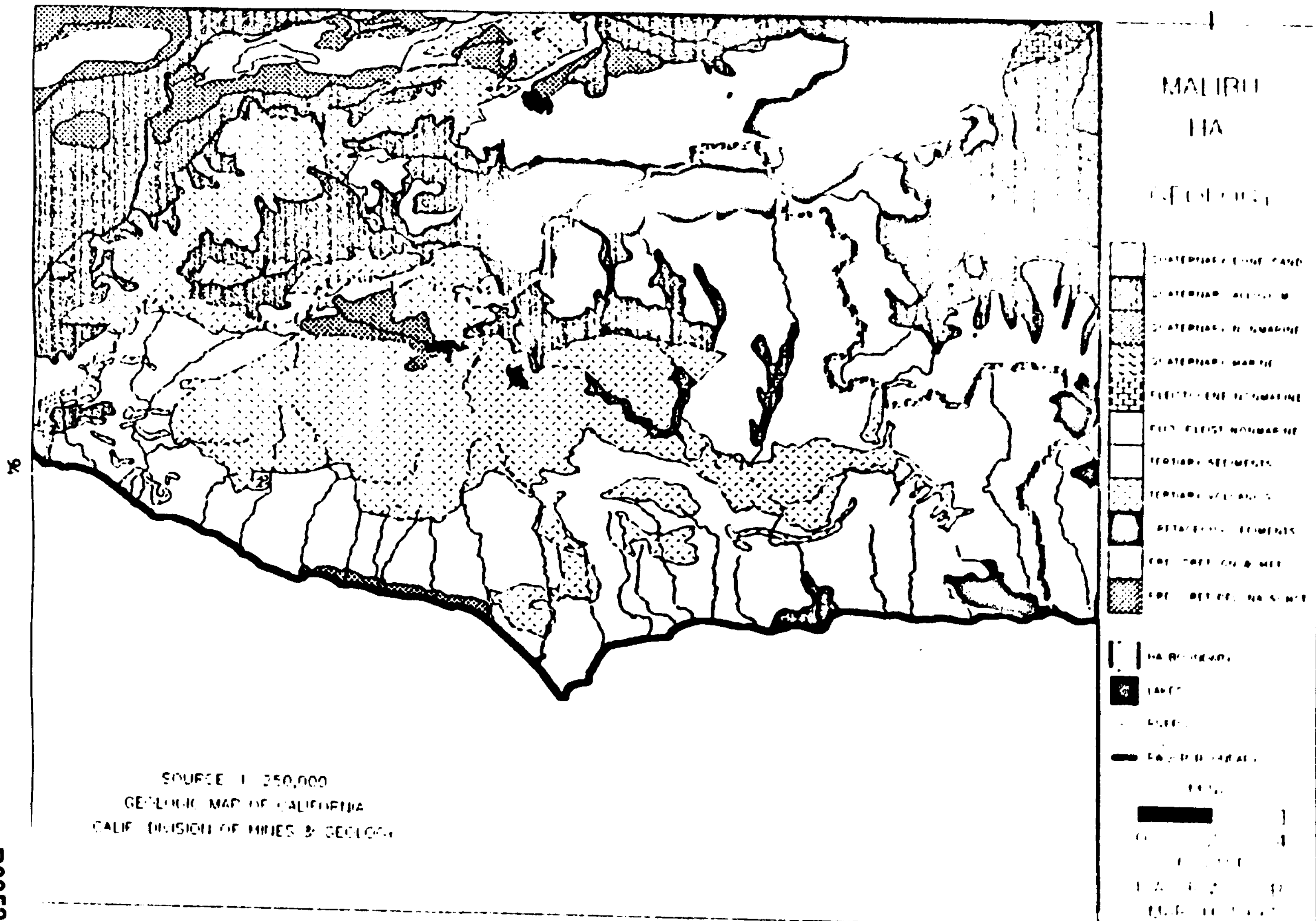
MALIBU
HA
SOURCE 1:250,000
GEOLOGIC MAP OF CALIFORNIA
CALIF. DIVISION OF MINES & GEOLOGY

FIG 3.9.

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UPPER OJAI EAST
OJAI WEST
FILLMORE
PIRU
UPPER VENTURA
SANTA PAULA
LOWER VENTURA
N LAS POSAS VLY
LAS POSAS VLY
MOUND BASIN
SIMI VLY
ARROYO STA ROSA
PLEASANT VLY
OXNARD PLAIN
THOUSAND OAKS
SAN FERNANDO V BASIN
SYLMAR
HOLLYWOOD
MALIBU VLY
SANTA MONICA
WEST COAST

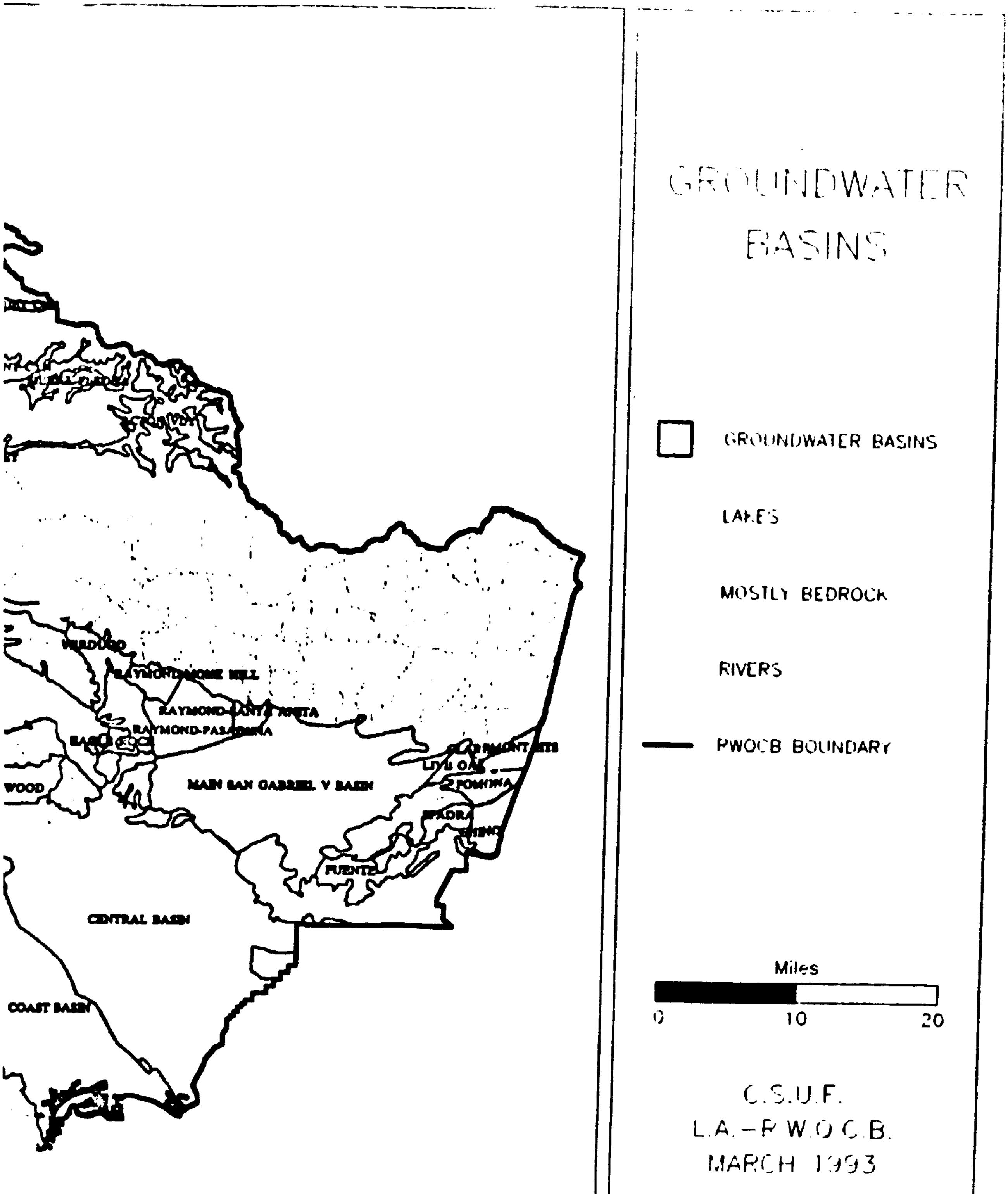

FIG 4.0.

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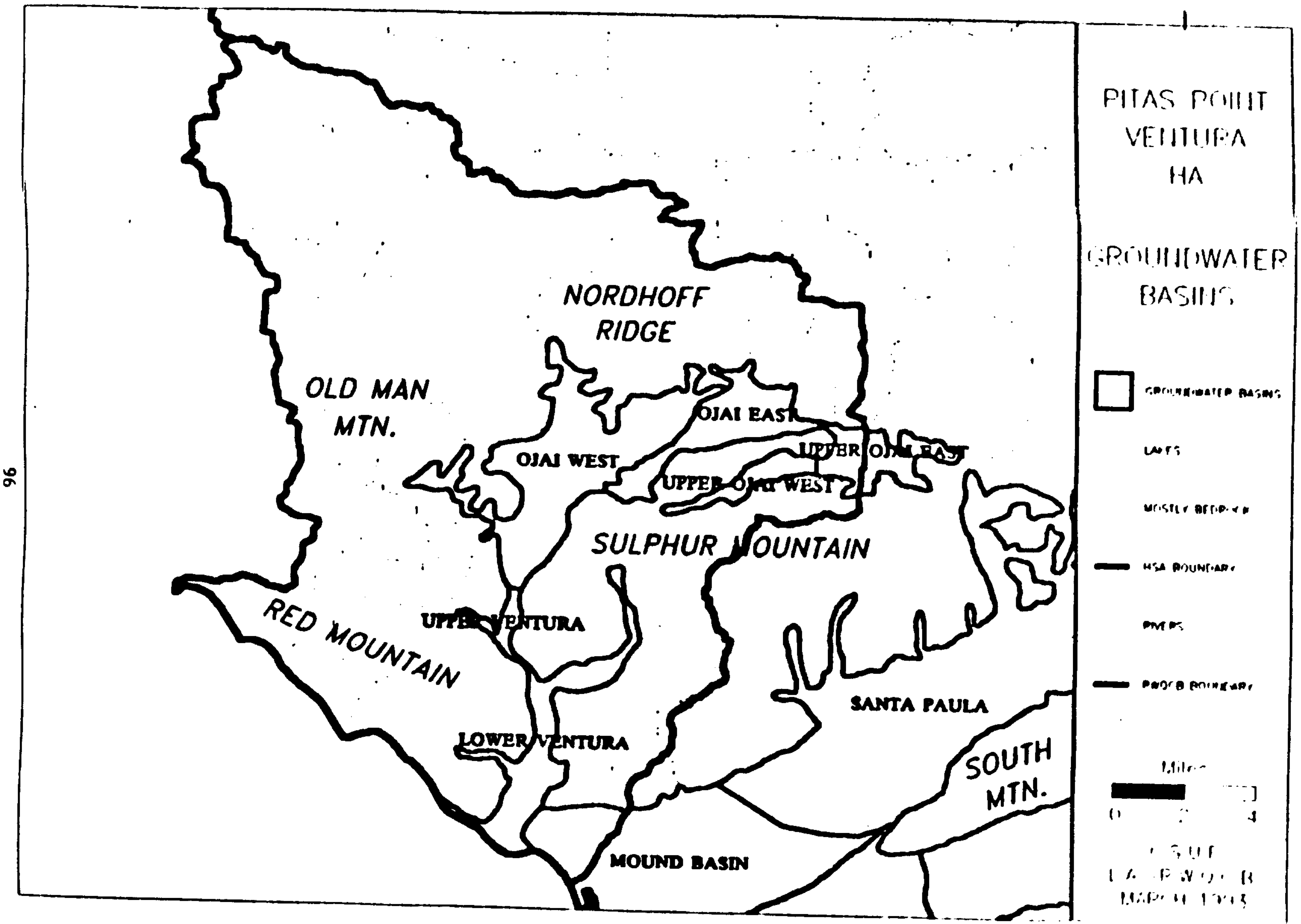
PITAS POINT
VENTURA
HA
GROUNDWATER
BASINS
NORDHOFF
RIDGE
OLD MAN
MTN.
OJAI EAST
OJAI WEST
UPPER OJAI EAST
UPPER OJAI WEST
SULPHUR MOUNTAIN
RED MOUNTAIN
UPPER VENTURA
LOWER VENTURA
SANTA PAULA
SOUTH
MTN.
MOUND BASIN
Miles
0
2
4

FIG 4.1.

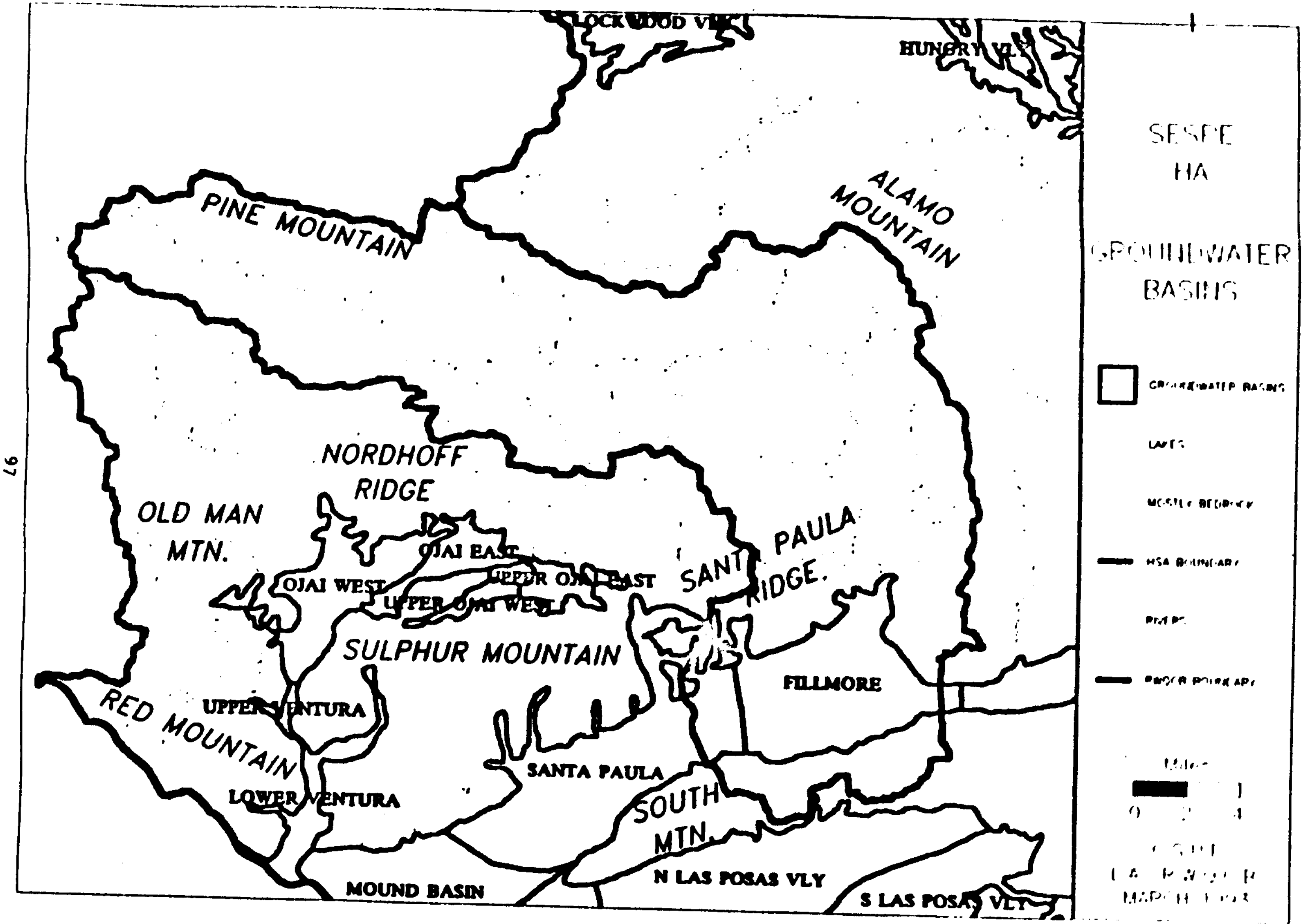
LOCKWOOD VLY
HUNGRY VLY
SESPE
HA
GROUNDWATER
BASINS
ALAMO
MOUNTAIN
PINE MOUNTAIN
NORDHOFF
RIDGE
OLD MAN
MTN.
OJAI EAST
OJAI WEST
UPPER OJAI EAST
UPPER OJAI WEST
SANTA PAULA
RIDGE.
SULPHUR MOUNTAIN
FILLMORE
UPPER VENTURA
RED MOUNTAIN
SANTA PAULA
LOWER VENTURA
SOUTH
MTN.
MOUND BASIN
N LAS POSAS VLY
S LAS POSAS VLY
Miles
0
2
4

FIG 4.2.

97

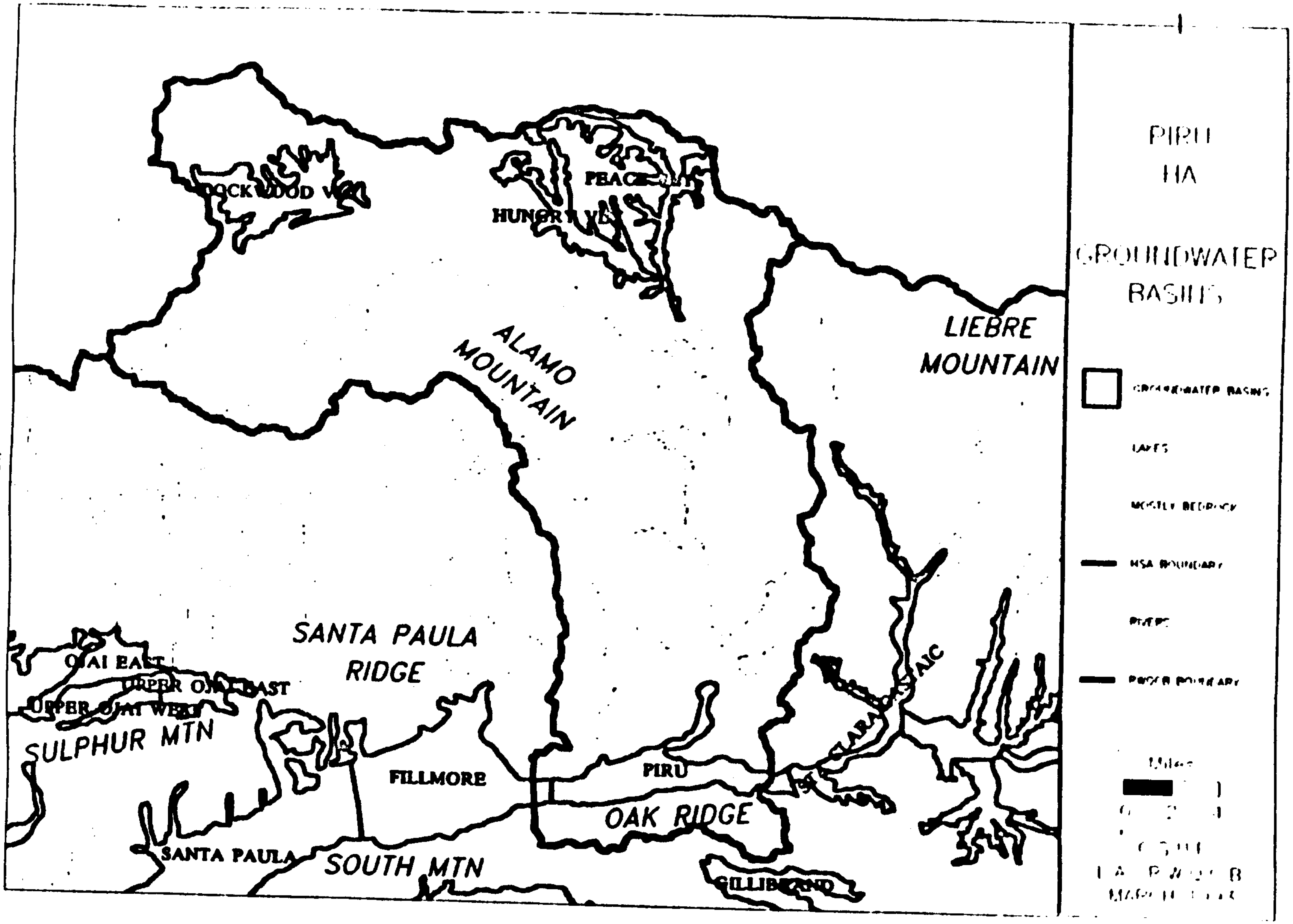
PIRU
HA
GROUNDWATER
BASINS
GROUNDWATER BASINS
LAKES
MOSTLY BEDROCK
HSA BOUNDARY
RIVERS
Miles
LIEBRE
MOUNTAIN
ALAMO
MOUNTAIN
HUNGRY VLY
SANTA PAULA
RIDGE
OJAI EAST
UPPER OJAI EAST
UPPER OJAI WEST
SULPHUR MTN
FILLMORE
PIRU
OAK RIDGE
SANTA PAULA
SOUTH MTN

FIG 4.3.

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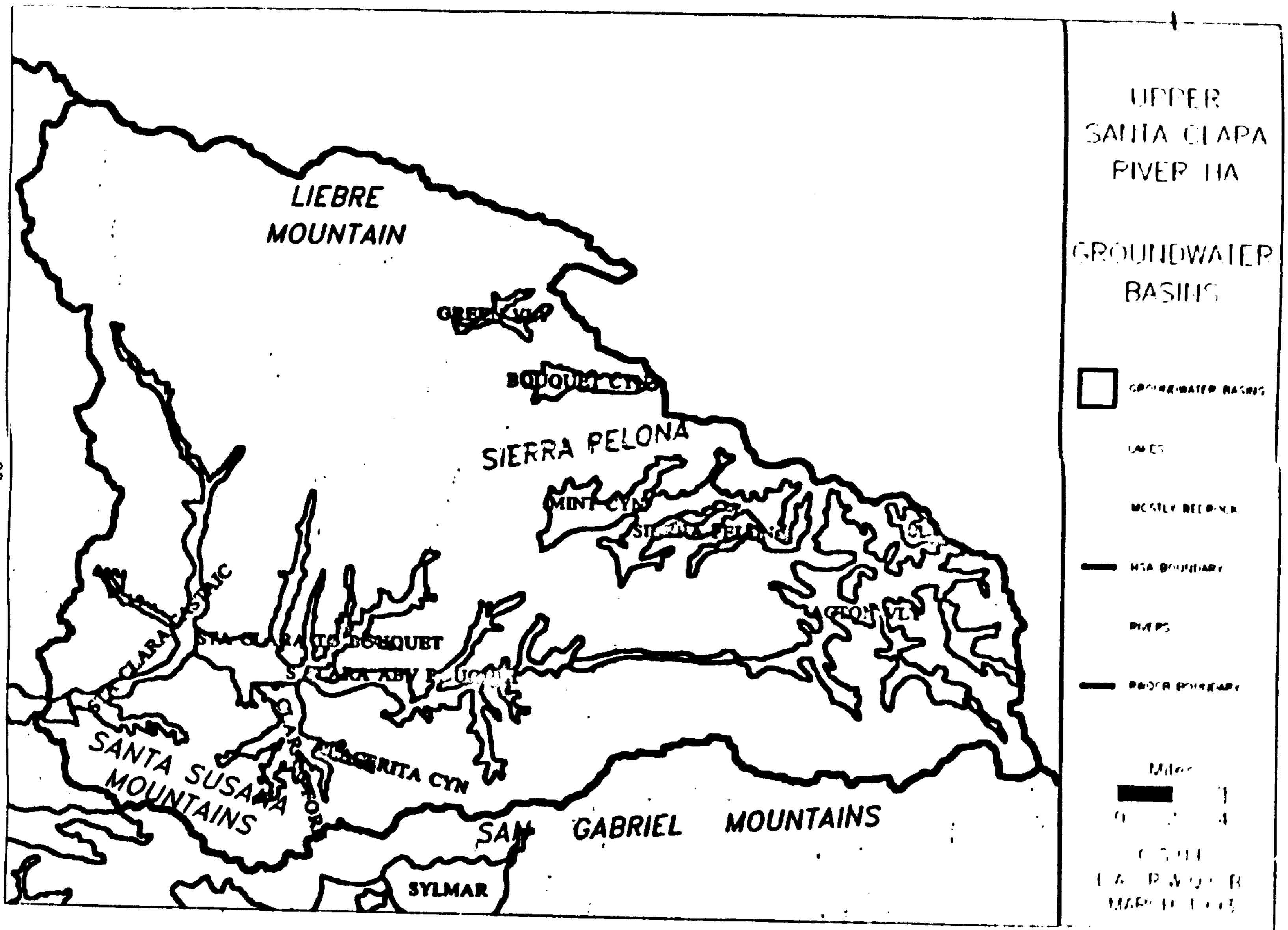
UPPER
SANTA CLARA
RIVER HA
GROUNDWATER
BASINS
LIEBRE
MOUNTAIN
BOUQUET CYN
SIERRA PELONA
MINT CYN
STA CLARA TO BOUQUET
PLACERITA CYN
SANTA SUSANA
MOUNTAINS
SAN GABRIEL MOUNTAINS
SYLMAR
Miles

FIG 4.4.

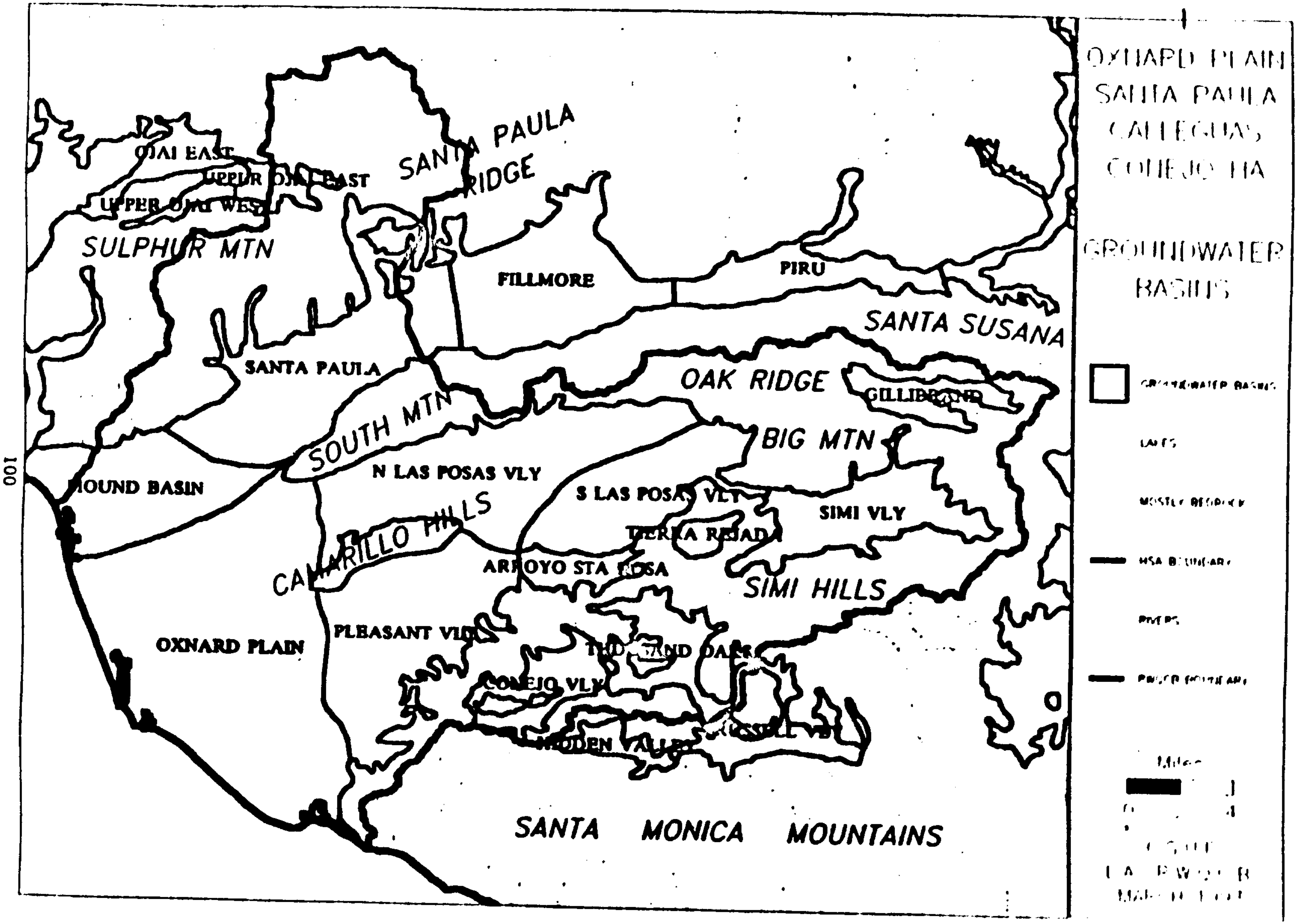

FIG 4.5.

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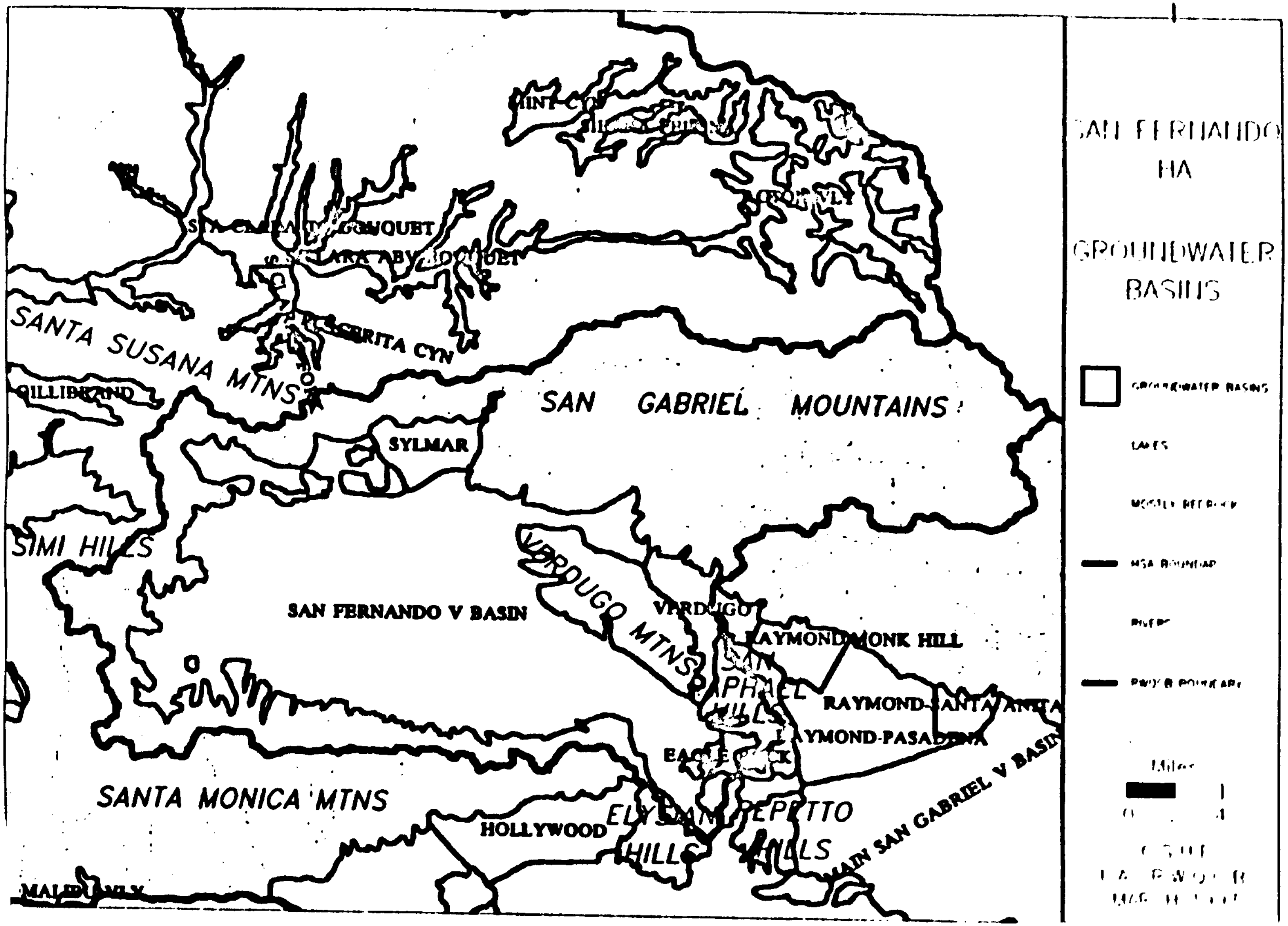
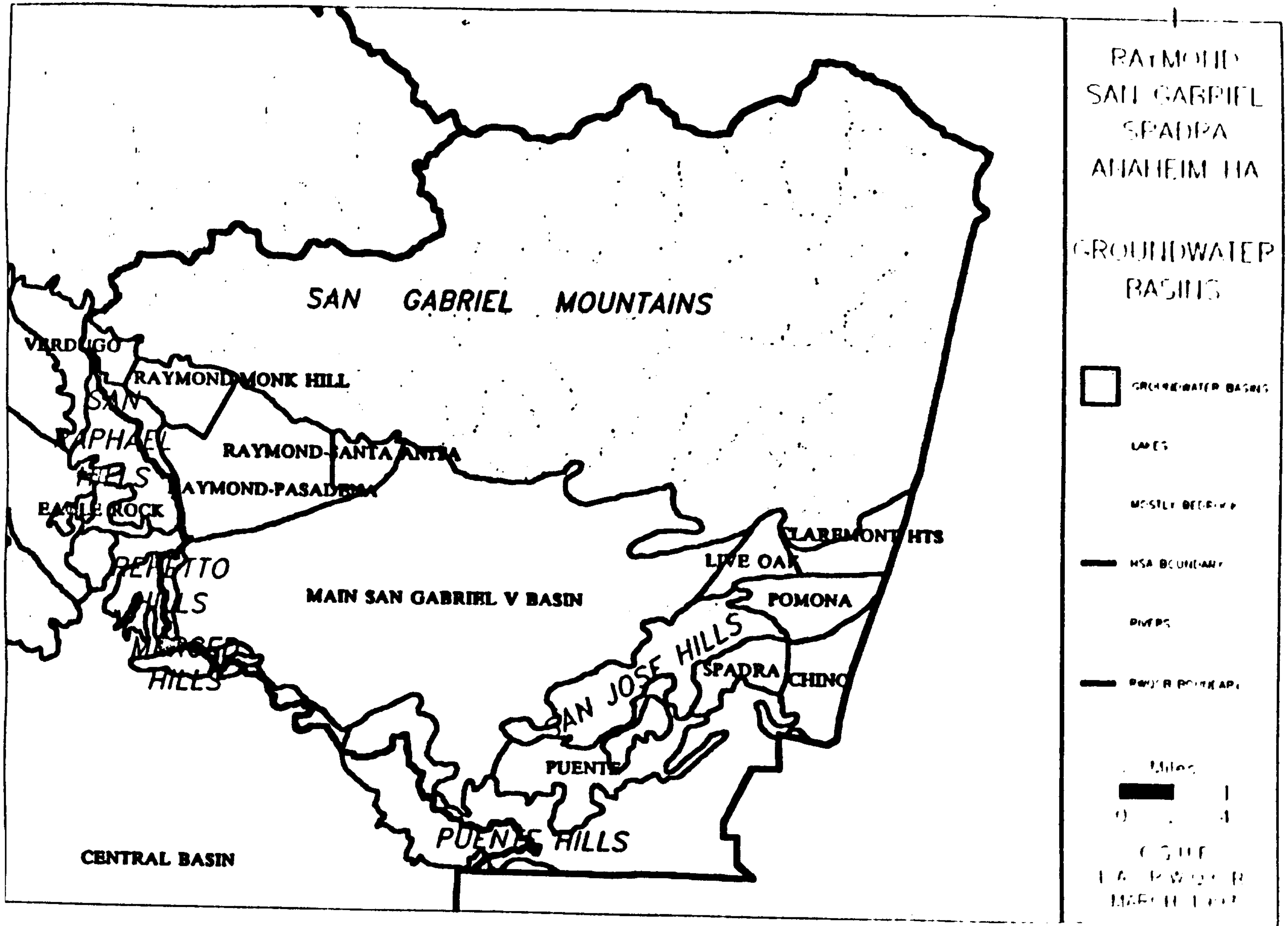
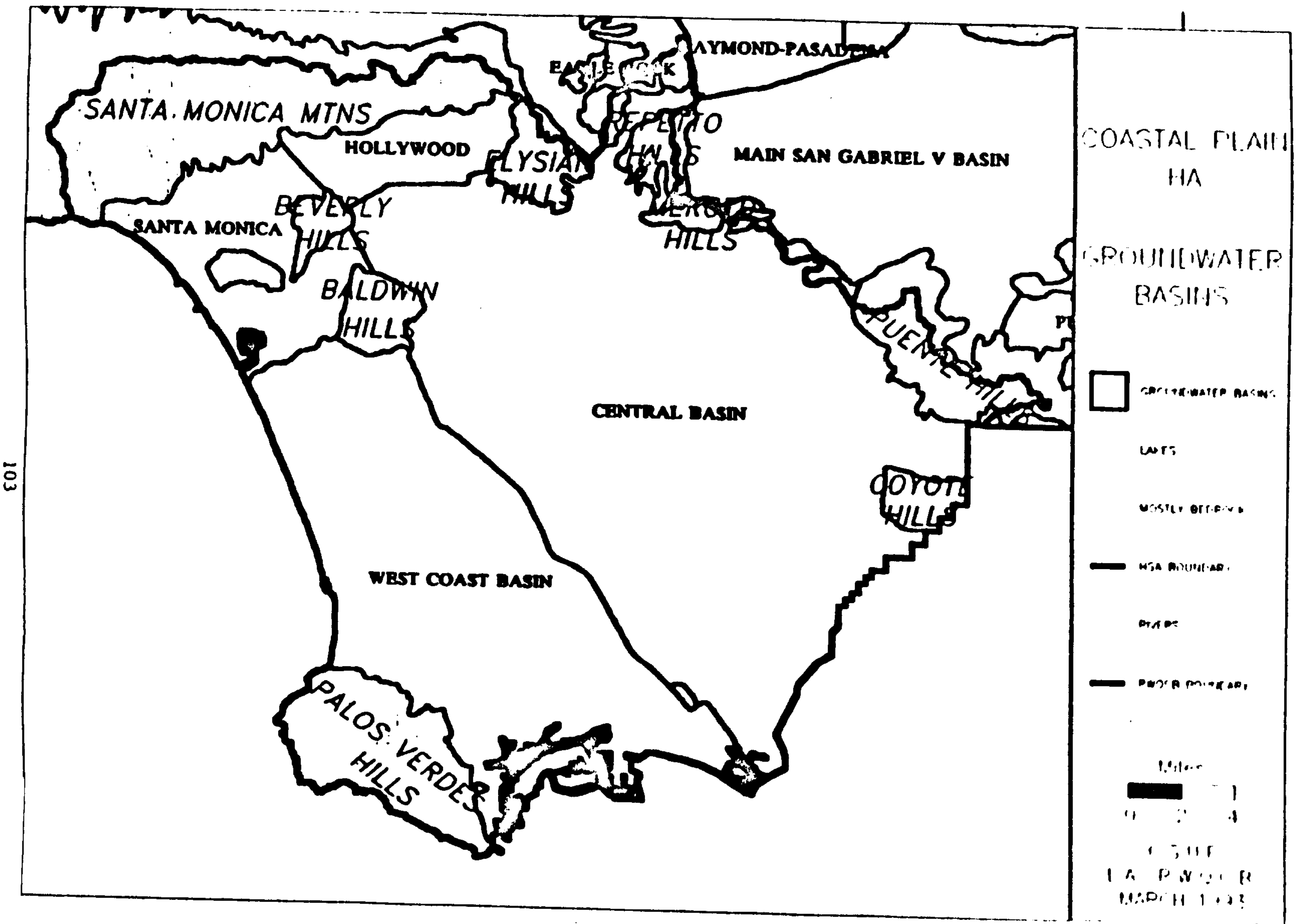

SAN FERNANDO HA
GROUNDWATER BASINS
Miles
SAN GABRIEL MOUNTAINS
SANTA SUSANA MTNS
PLACERITA CYN
SYLMAR
SIMI HILLS
SAN FERNANDO V BASIN
VERDUGO MTNS
VERDUGO
RAYMOND-MONK HILL
RAYMOND-SANTA ANITA
RAYMOND-PASADENA
EAGLE ROCK
SANTA MONICA MTNS
HOLLYWOOD
ELYSIAN HILLS
REPETTO HILLS
MAIN SAN GABRIEL V BASIN
GILLIBRAND
101

FIG 4.6.



RAYMOND
SAN GABRIEL
SPADRA
ANAHEIM HA
GROUNDWATER
BASINS
SAN GABRIEL MOUNTAINS
VERDUGO
RAYMOND-MONK HILL
SAN RAPHAEL HILLS
RAYMOND-SANTA ANITA
RAYMOND-PASADENA
EAGLE ROCK
MAIN SAN GABRIEL V BASIN
CLAREMONT HTS
LIVE OAK
POMONA
SAN JOSE HILLS
SPADRA
CHINO
PUENTE
PUENTE HILLS
CENTRAL BASIN
MERCED HILLS

FIG 4.7.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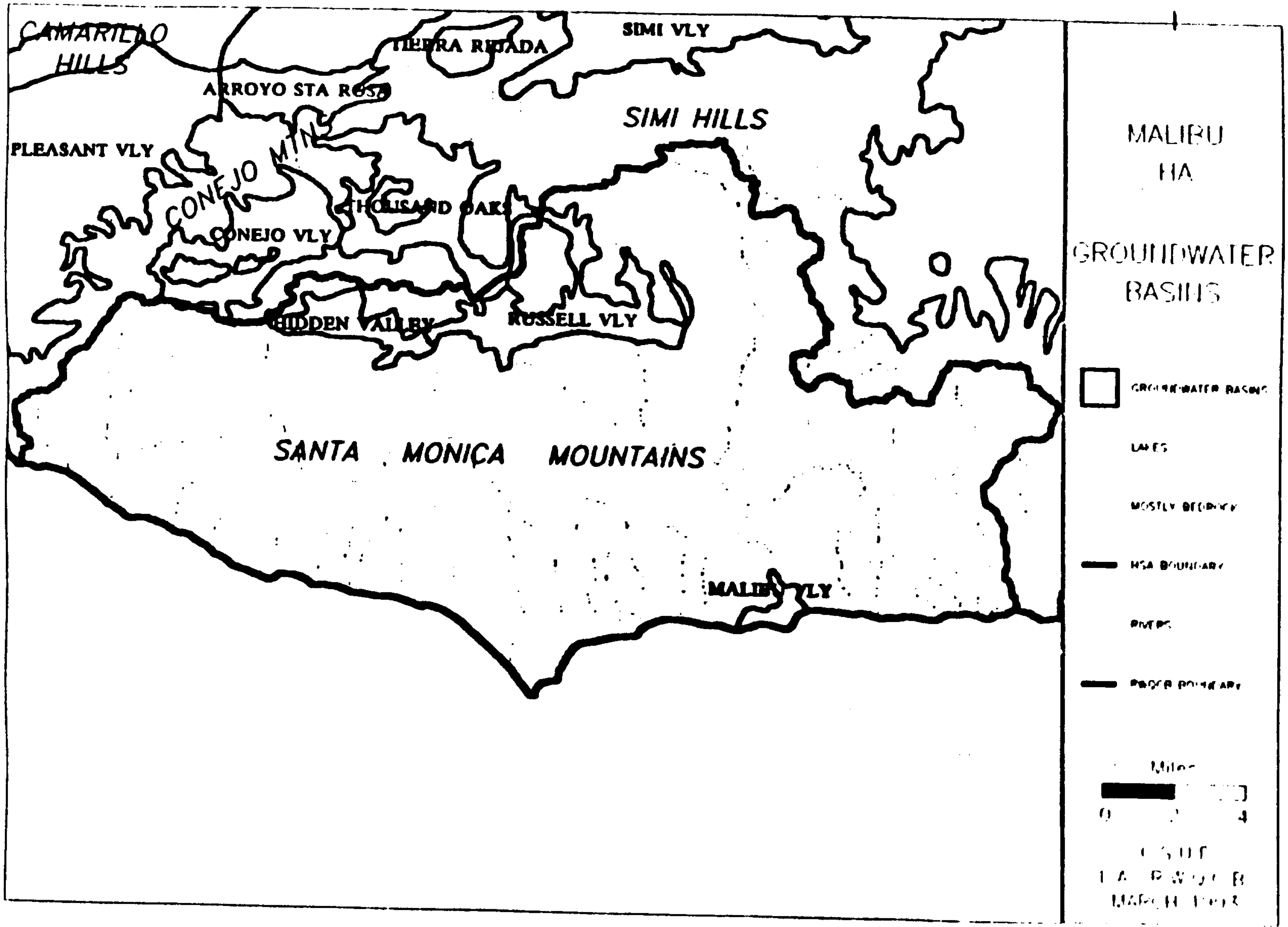
EAGLE ROCK
SANTA MONICA MTNS
HOLLYWOOD
ELYSIAN HILLS
REPETTO HILLS
MAIN SAN GABRIEL V BASIN
BEVERLY HILLS
SANTA MONICA
MERCED HILLS
BALDWIN HILLS
PUENTE HILLS
CENTRAL BASIN
COYOTE HILLS
WEST COAST BASIN
PALOS VERDES HILLS
COASTAL PLAIN HA
GROUNDWATER BASINS
GROUNDWATER BASINS
LAKES
MOSTLY BEDROCK
HSA BOUNDARY
RIVERS
Miles

FIG 4.8.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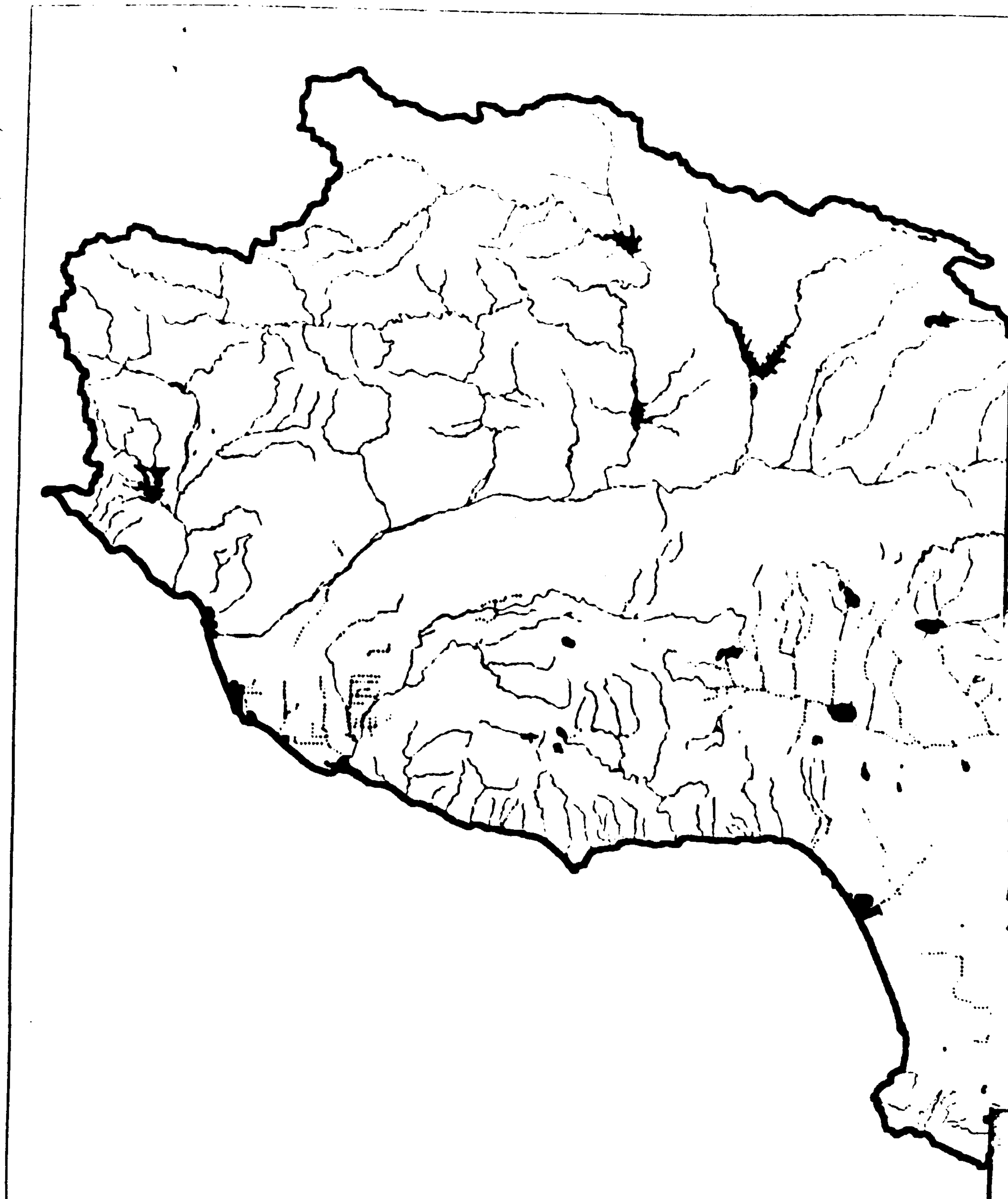
TIERRA REJADA
SIMI VLY
ARROYO STA ROSA
SIMI HILLS
PLEASANT VLY
CONEJO MTN
THOUSAND OAKS
CONEJO VLY
HIDDEN VALLEY
RUSSELL VLY
SANTA MONICA MOUNTAINS
MALIBU VLY
MALIBU
HA
GROUNDWATER
BASINS
Miles
0
4

FIG 4.9.



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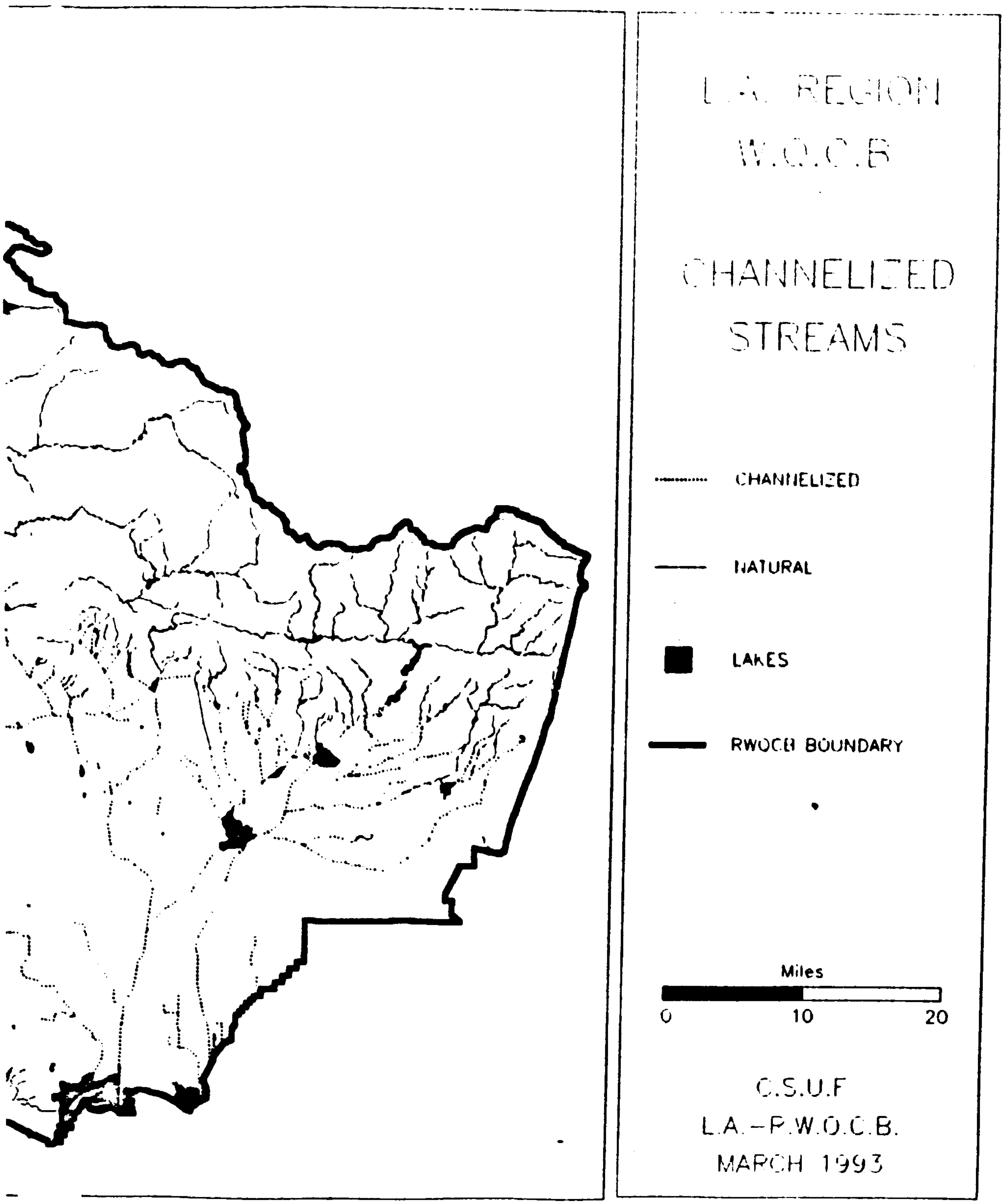
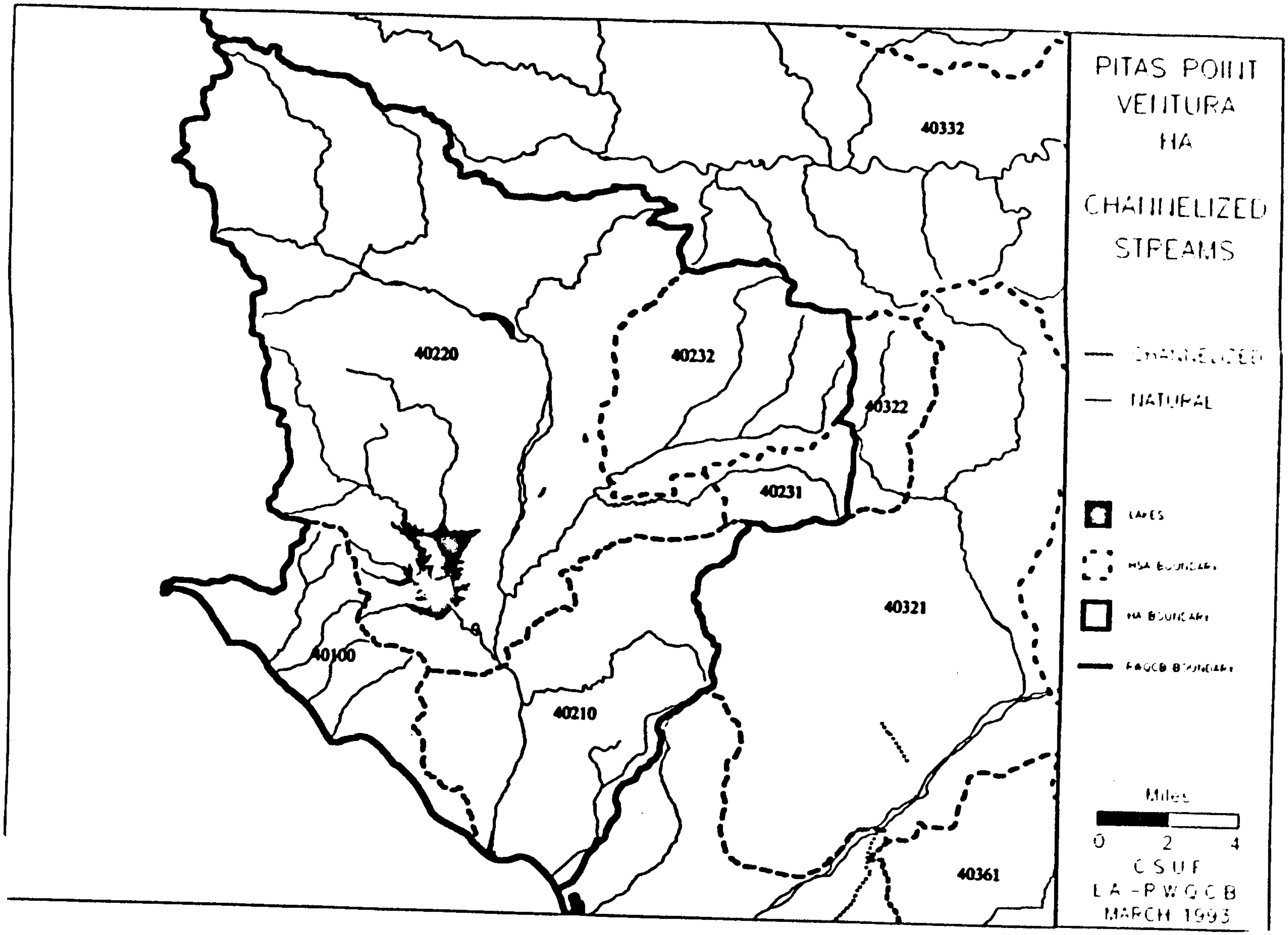


FIG 5.0.

R0052065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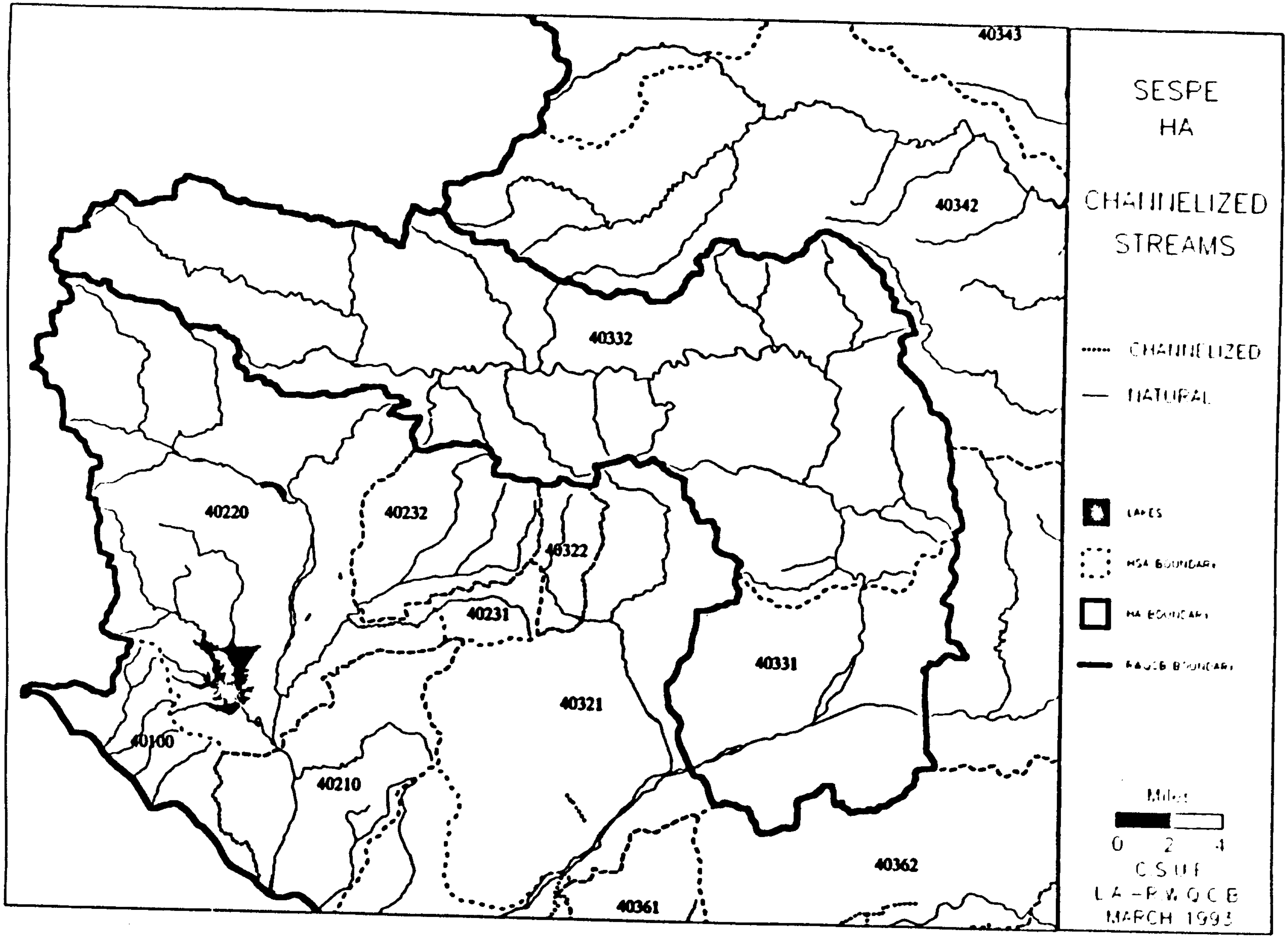
VENTURA
HA
CHANNELIZED
STREAMS
NATURAL
40332
40220
40232
40322
40231
40321
40100
40210
40361
Miles
0
2
4
C S U F
L A - R W Q C B
MARCH 1993

FIG 5.1.


SESPE
HA
CHANNELIZED
STREAMS
CHANNELIZED
NATURAL
Miles
0
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C S U F
L A - R W Q C B
MARCH 1993
40343
40342
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40331
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40100
40210
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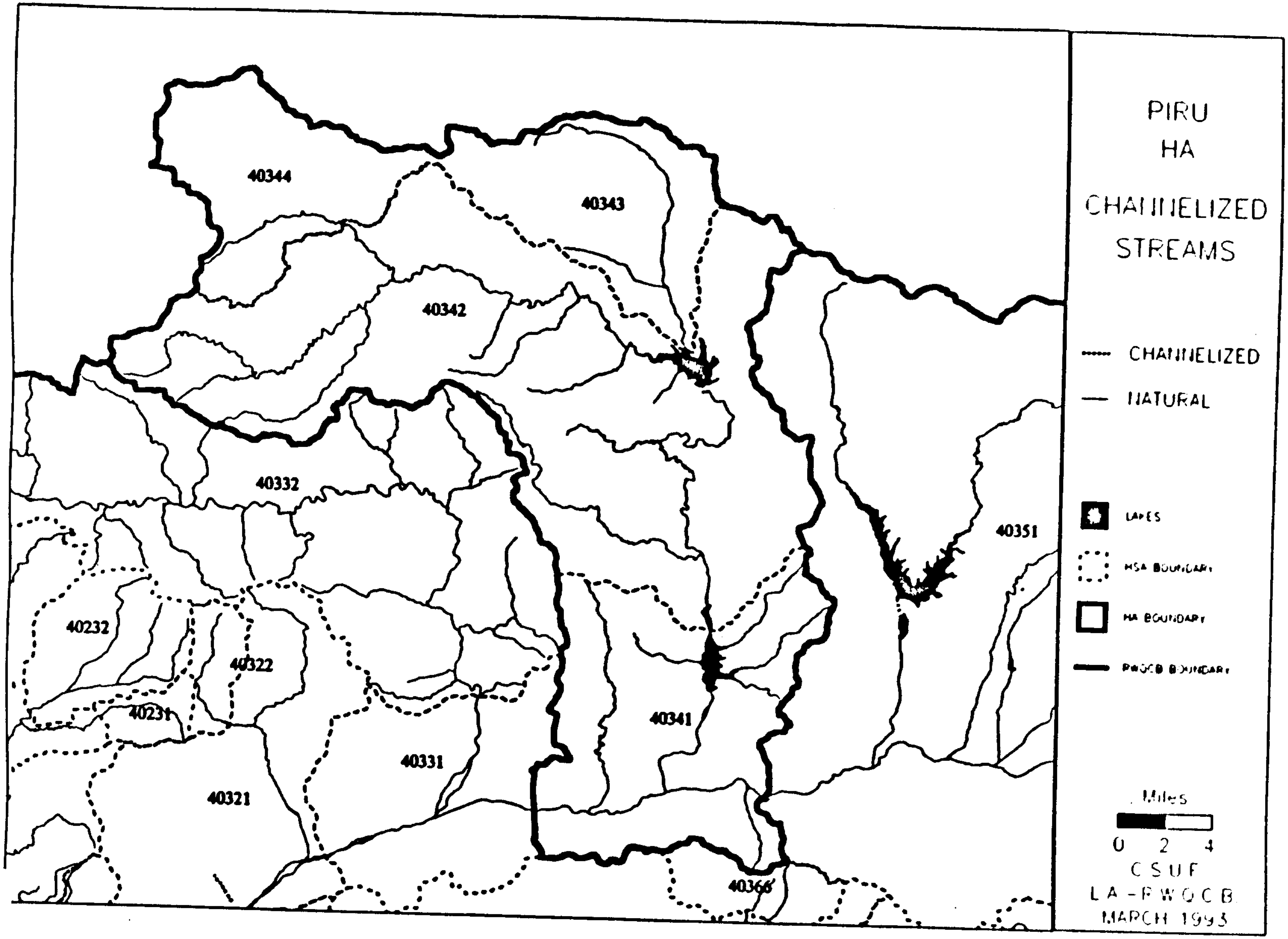
FIG 5.2.


PIRU
HA
CHANNELIZED
STREAMS
CHANNELIZED
NATURAL
LAKES
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
CSUF
LA-RWQCB
MARCH 1993
40344
40343
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40351
40232
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40341
40331
40321
40366

FIG 5.3.

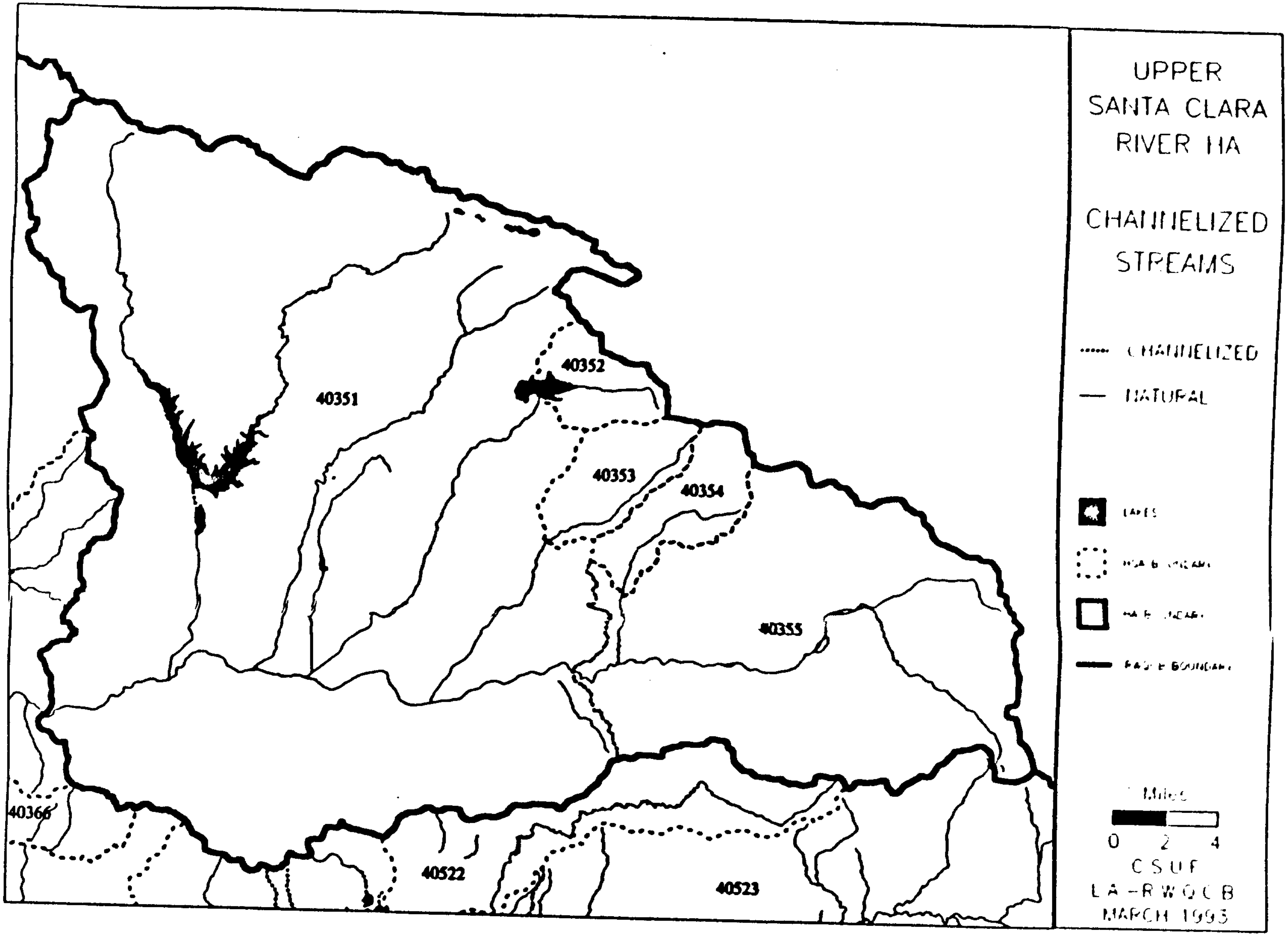
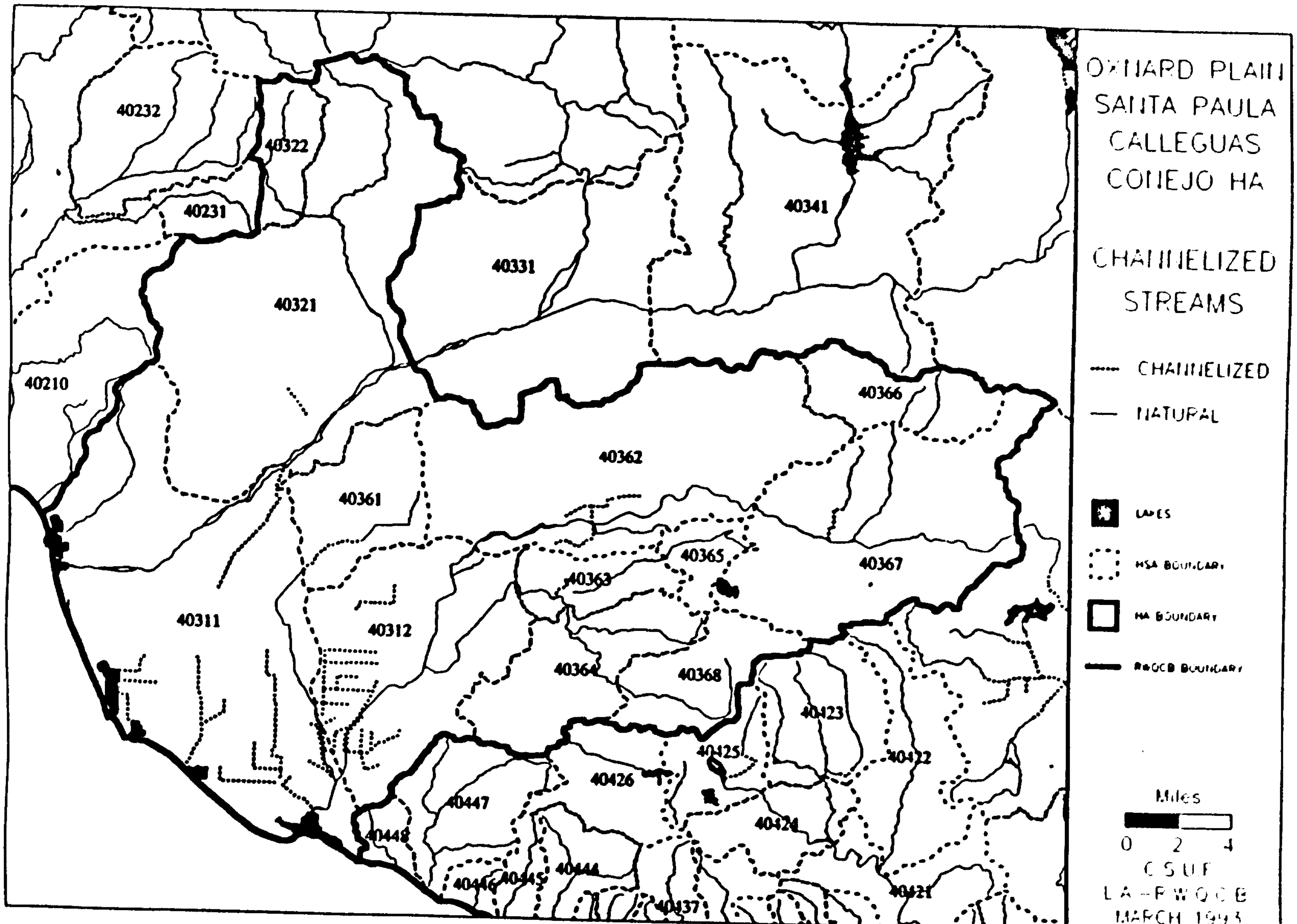

UPPER
SANTA CLARA
RIVER HA
CHANNELIZED
STREAMS
CHANNELIZED
NATURAL
40351
40352
40353
40354
40355
40366
40522
40523
Miles
0 2 4
CSUF
LA-RWQCB
MARCH 1993

FIG 5.4.


OXNARD PLAIN
SANTA PAULA
CALLEGUAS
CONEJO HA
CHANNELIZED
STREAMS
CHANNELIZED
NATURAL
LAKES
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
C S U F
L A - R W Q C B
MARCH 1993
40232
40322
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40311
40312
40364
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40423
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40446
40445
40444
40437
40421

FIG 5.5.

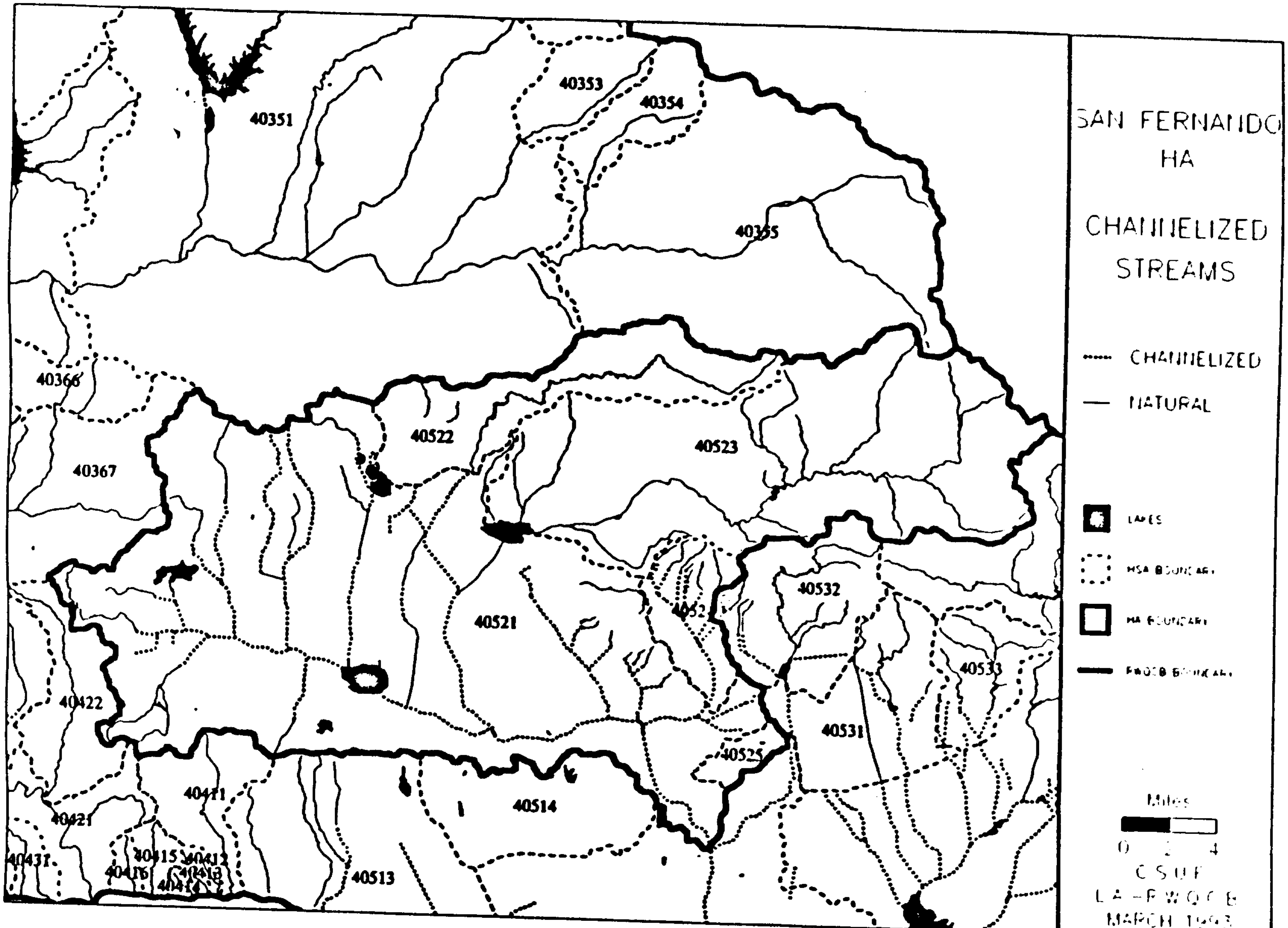
SAN FERNANDO
HA
CHANNELIZED
STREAMS
CHANNELIZED
NATURAL
Miles
0
4
C S U F
MARCH
40351
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FIG 5.6.

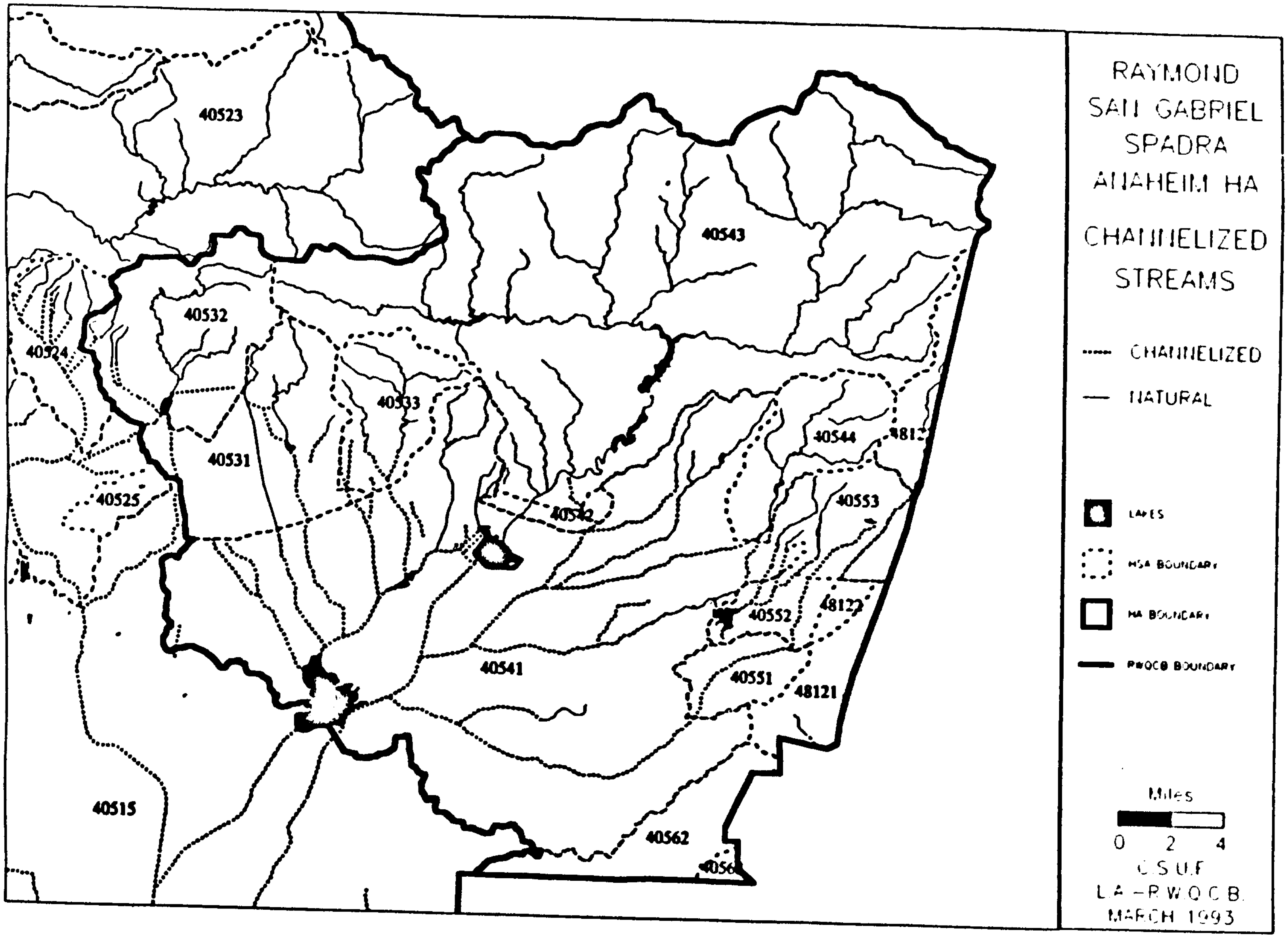
RAYMOND
SAN GABRIEL
SPADRA
ANAHEIM HA
CHANNELIZED
STREAMS
CHANNELIZED
NATURAL
LAKES
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
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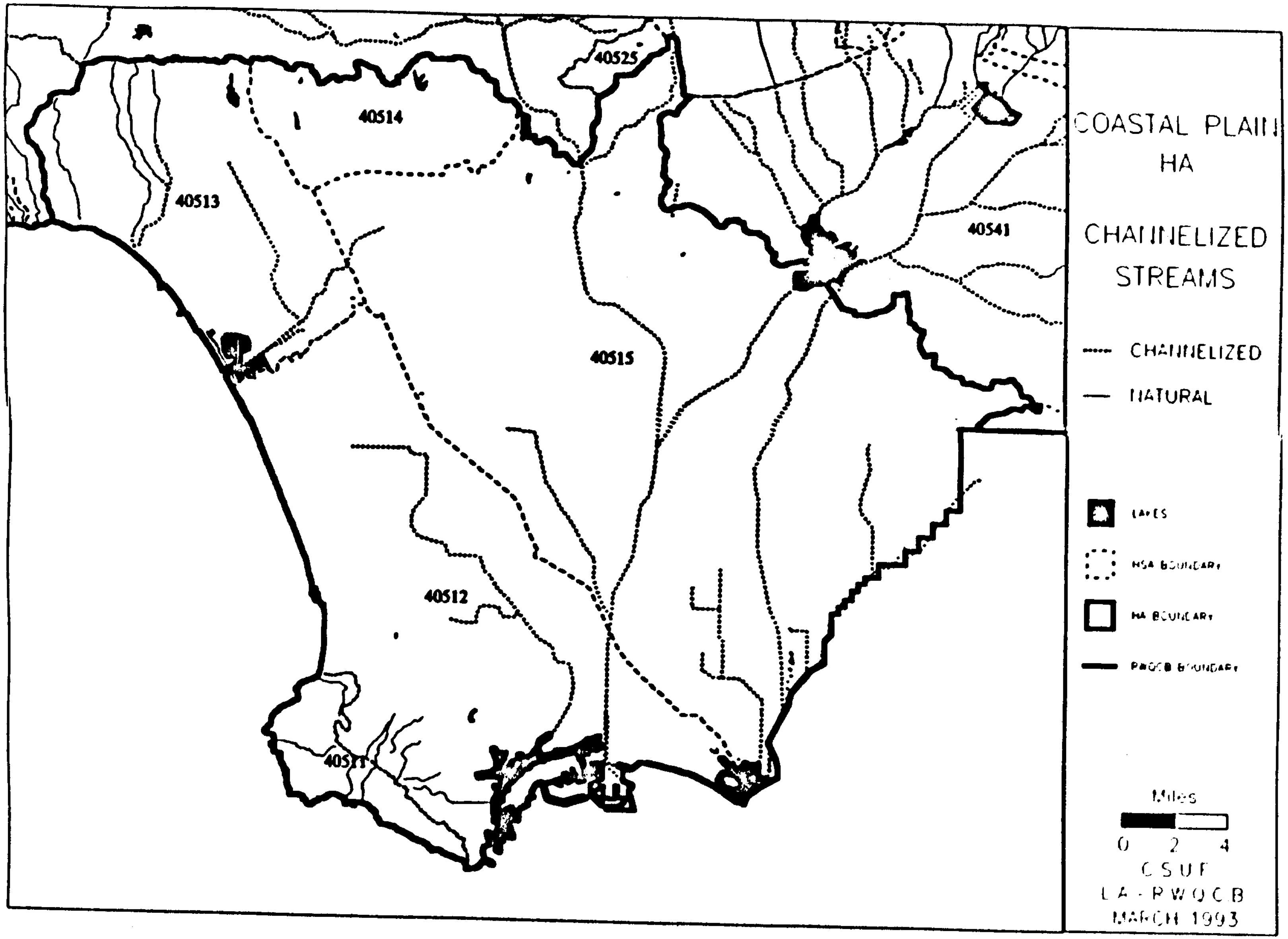
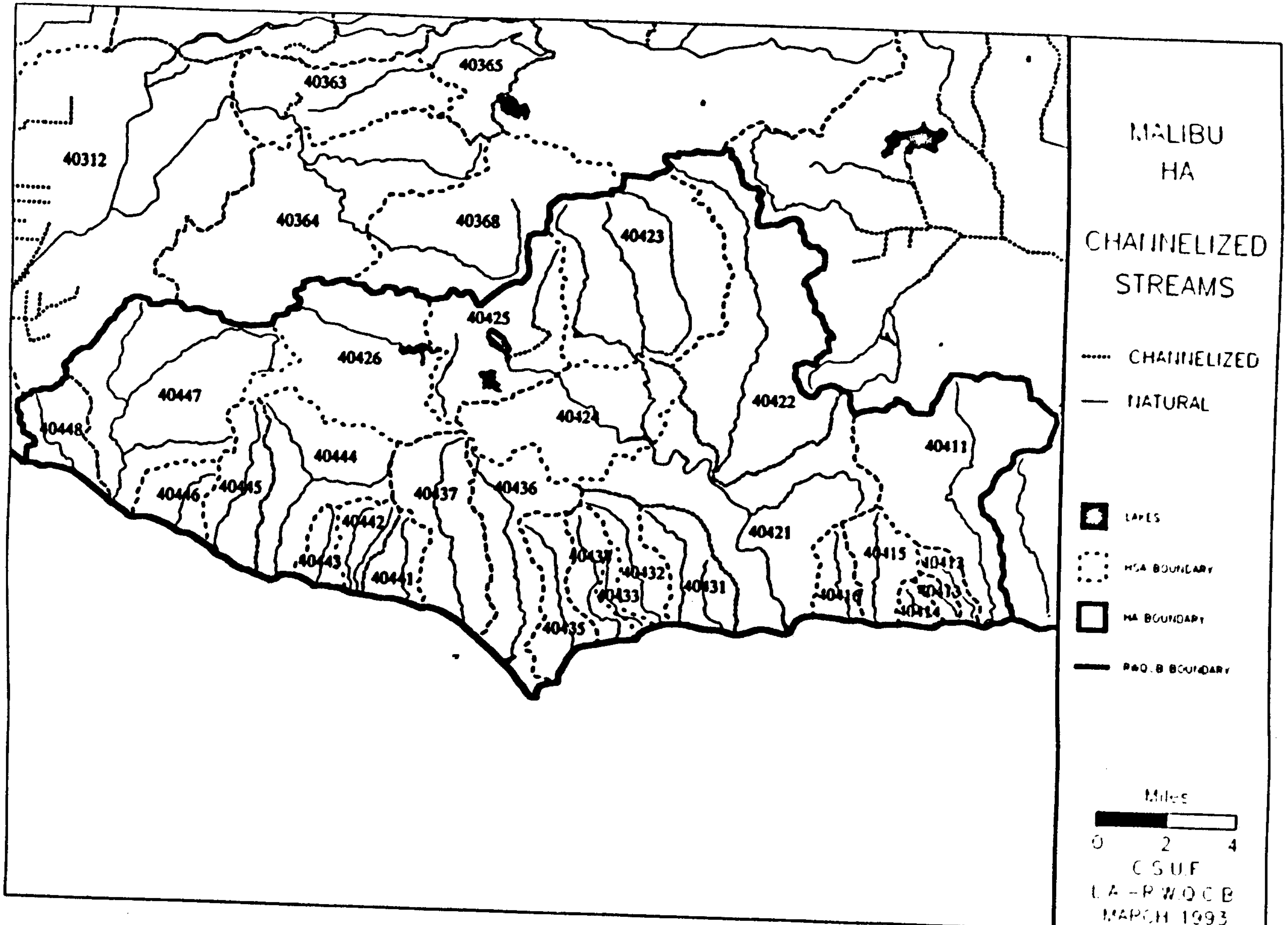
FIG 5.7.



40525
40514
40513
40541
40515
40512
40511
COASTAL PLAIN HA
CHANNELIZED STREAMS
CHANNELIZED
NATURAL
LAKES
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993

FIG 5.8.


MALIBU
HA
CHANNELIZED
STREAMS
CHANNELIZED
NATURAL
LAKES
HSA BOUNDARY
HA BOUNDARY
Miles
0
2
4
C.S.U.F
L.A. - R.W.Q.C.B
MARCH 1993
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40435

FIG 5.9.

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ESTUARIES IN REGION 4

A. <u>River and Canal Mouths:</u>

402.10	Ventura River Estuary
403.11	Calleguas Creek Tidal Prism
403.11	Santa Clara River Estuary
403.11	Edison Canal Tidal Prism
404.21	Malibu Creek Estuary
405.12	Los Angeles River Estuary
405.12	East Channel Tidal Prism
405.12	Dominguez Channel Tidal Prism
405.12	Los Cerritos Channel Tidal Prism
405.12	Main Channel
405.13	Ballona Creek Tidal Prism
405.13	Marina del Rey
405.15	San Gabriel River Estuary
406.40	Middle Canyon Mouth
406.40	Big Spring Canyon Mouth
406.40	Avalon Creek Mouth

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B. <u>COASTAL LAGOONS</u>

403.11	Mc Grath Lake
403.11	Mugu Lagoon
404.11	Topanga Lagoon
404.36	Dume Lagoon
405.12	Sim's Pond
405.13	Ballona Lagoon

C. <u>TIDAL WETLANDS</u>

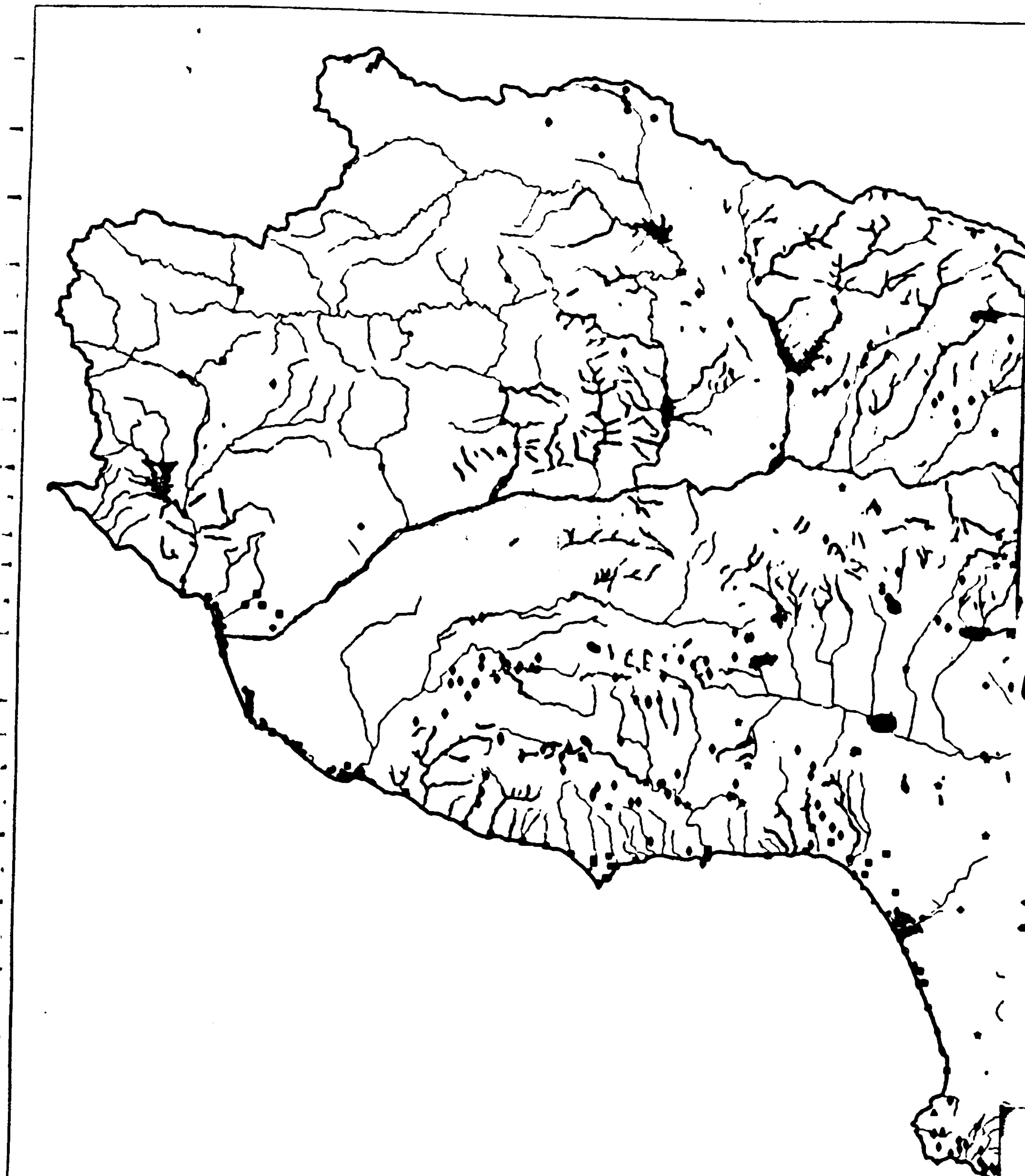
405.12	Ballona Wetlands
405.12	Los Cerritos Wetland
405.13	Venice Canals

TABLE 2.7 WATERBODIES OF REGION 4
By Waterbody Type
Wetlands

H.U.	NAME	INCLUDED/ PROPOSED	FEATURE TYPE
401.00	JAVON CANYON	PROPOSED	RIP. STREAM
402.10	VENTURA RIVER & TRIBUTARIES	INCLUDED	RIP. STREAM
402.10	VENTURA RIVER TIDAL PRISM	INCLUDED	COASTAL WETLAND
402.20	COYOTE CREEK	PROPOSED	RIP. STREAM
402.20	EAST FORK COYOTE CREEK	PROPOSED	RIP. STREAM
402.20	MATILIJA CREEK	PROPOSED	RIP. STREAM
402.20	MATILIJA RESERVOIR	INCLUDED	INLAND WETLAND
402.20	MIRROR LAKE	PROPOSED	INLAND WETLAND
402.20	MURIETTA CANYON	PROPOSED	RIP. STREAM
402.20	OJAI WETLAND	PROPOSED	INLAND WETLAND
402.20	OLD MAN CANYON	PROPOSED	RIP. STREAM
402.20	SAN ANTONIO CREEK & TRIBUTARIES	INCLUDED	RIP. STREAM
402.20	SANTA ANA CREEK	PROPOSED	RIP. STREAM
402.20	VENTURA RIVER & TRIBUTARIES	INCLUDED	RIP. STREAM
402.20	WEST FORK SANTA ANA CREEK	PROPOSED	RIP. STREAM
403.11	MCGRATH LAKE (TIDAL PRISM)	INCLUDED	COASTAL WETLAND
403.11	MUGU LAGOON (TIDAL PRISM)	INCLUDED	COASTAL WETLAND
403.11	ORMOND BEACH	PROPOSED	COASTAL WETLAND
403.11	SANTA CLARA RIVER	INCLUDED	RIP. STREAM
403.11	SANTA CLARA RIVER (TIDAL PRISM)	INCLUDED	COASTAL WETLAND
403.21	SANTA CLARA RIVER	INCLUDED	RIP. STREAM
403.21	SISAR CREEK	INCLUDED	RIP. STREAM
403.22	SISAR CREEK	INCLUDED	RIP. STREAM
403.31	SANTA CLARA RIVER	INCLUDED	RIP. STREAM
403.31	SESPE CREEK	INCLUDED	RIP. STREAM
403.32	BEAR CANYON	PROPOSED	RIP. STREAM
403.32	COLDWATER CANYON	PROPOSED	RIP. STREAM
403.32	PIEDRA BLANCA CREEK	PROPOSED	RIP. STREAM
403.32	PINE CANYON	PROPOSED	RIP. STREAM
403.32	POTRERO JOHN CREEK	PROPOSED	RIP. STREAM
403.32	REDROCK CREEK	PROPOSED	RIP. STREAM
403.32	ROSE VALLEY CREEK	PROPOSED	RIP. STREAM
403.32	SESPE CREEK & TRIBUTARIES	INCLUDED	RIP. STREAM
403.32	TIMBER CREEK	PROPOSED	RIP. STREAM
403.32	TROUT CREEK	PROPOSED	RIP. STREAM
403.32	TULE CREEK	PROPOSED	RIP. STREAM
403.32	WEST FORK SESPE CREEK	PROPOSED	RIP. STREAM
403.41	PIRU CREEK & TRIBUTARIES	INCLUDED	RIP. STREAM
403.41	SANTA CLARA RIVER	INCLUDED	RIP. STREAM
403.42	PIRU CREEK & TRIBUTARIES	INCLUDED	RIP. STREAM
403.51	BOUQUET CREEK & TRIBUTARIES	INCLUDED	RIP. STREAM
403.51	SAN FRANCISQUITO CANYON & TRIB.	INCLUDED	RIP. STREAM
403.55	ALISO CANYON	PROPOSED	RIP. STREAM
404.11	TOPANGA LAGOON	PROPOSED	COASTAL WETLAND
404.21	CENTURY RESERVOIR	PROPOSED	INLAND WETLAND
404.21	COLD CREEK	PROPOSED	RIP. STREAM
404.21	MALIBU CREEK	INCLUDED	RIP. STREAM
404.21	MALIBU LAGOON (TIDAL PRISM)	INCLUDED	COASTAL WETLAND
404.23	MEDEA CREEK	PROPOSED	RIP. STREAM
404.24	MALIBU LAKE	INCLUDED	INLAND WETLAND
404.25	LAKE ELEANOR	PROPOSED	INLAND WETLAND
404.26	LAKE SHERWOOD	INCLUDED	INLAND WETLAND
404.36	DUME LAGOON	PROPOSED	COASTAL WETLAND
404.44	ARROYO SEQUIT	INCLUDED	RIP. STREAM

TABLE 2.7 WATERBODIES OF REGION 4
By Waterbody Type
Wetlands

H.U.	NAME	INCLUDED/ PROPOSED	FEATURE TYPE
404.47	BIG SYCAMORE CANYON CREEK	INCLUDED	RIP. STREAM
405.12	ALAMITOS BAY	PROPOSED	COASTAL WETLAND
405.12	BIXBY SLOUGH AND HARBOR LAKE	INCLUDED	INLAND WETLAND
405.12	MADRONA MARSH	PROPOSED	INLAND WETLAND
405.13	BALLONA LAGOON	PROPOSED	COASTAL WETLAND
405.13	BALLONA WETLANDS	PROPOSED	COASTAL WETLAND
405.13	DEL REY LAGOON	PROPOSED	COASTAL WETLAND
405.13	VENICE CANALS - BALLONA CREEK (TIDAL PRISM)	INCLUDED	COASTAL WETLAND
405.14	UPPER FRANKLIN CANYON RESERVOIR	PROPOSED	INLAND WETLAND
405.15	EL DORADO LAKES	PROPOSED	INLAND WETLAND
405.15	LOS CERRITOS LAGOON	PROPOSED	COASTAL WETLAND
405.15	LOS CERRITOS WETLANDS	PROPOSED	COASTAL WETLAND
405.15	SIMS POND	PROPOSED	INLAND WETLAND
405.21	LOS ANGELES RIVER	INCLUDED	RIP. STREAM
405.22	PACOIMA CANYON CREEK	INCLUDED	RIP. STREAM
405.23	ALDER CREEK	PROPOSED	RIP. STREAM
405.23	BIG TUJUNGA CANYON CREEK	INCLUDED	RIP. STREAM
405.23	CLEAR CREEK	PROPOSED	RIP. STREAM
405.23	MILL CREEK	INCLUDED	RIP. STREAM
405.23	UPPER BIG TUJUNGA CANYON CREEK	PROPOSED	RIP. STREAM
405.23	VASQUEZ CREEK	PROPOSED	RIP. STREAM
405.31	EATON CANYON CREEK	INCLUDED	RIP. STREAM
405.31	RUBIO CANYON	INCLUDED	RIP. STREAM
405.32	ARROYO SECO CANYON	INCLUDED	RIP. STREAM
405.32	LITTLE BEAR CREEK	INCLUDED	RIP. STREAM
405.33	BIG SANTA ANITA CANYON CREEK	INCLUDED	RIP. STREAM
405.33	WINTER CREEK	INCLUDED	RIP. STREAM
405.41	BIG DALTON CANYON CREEK	INCLUDED	RIP. STREAM
405.41	LEGG LAKE	INCLUDED	INLAND WETLAND
405.41	LITTLE DALTON CANYON CREEK	INCLUDED	RIP. STREAM
405.41	MONROVIA CANYON CREEK	INCLUDED	RIP. STREAM
405.41	RIO HONDO	INCLUDED	RIP. STREAM
405.41	SANTA FE FLOOD CONTROL BASIN	INCLUDED	INLAND WETLAND
405.41	WALNUT CREEK WASH	INCLUDED	RIP. STREAM
405.43	ALLISON GULCH	PROPOSED	RIP. STREAM
405.43	BEAR CREEK	PROPOSED	RIP. STREAM
405.43	CATTLE CREEK	INCLUDED	RIP. STREAM
405.43	COLDWATER CANYON CREEK	INCLUDED	RIP. STREAM
405.43	COW CREEK	INCLUDED	RIP. STREAM
405.43	DEVILS CANYON CREEK	INCLUDED	RIP. STREAM
405.43	EAST FORK SAN GABRIEL RIVER	INCLUDED	RIP. STREAM
405.43	FISH CANYON	INCLUDED	RIP. STREAM
405.43	FISH FORK	PROPOSED	RIP. STREAM
405.43	IRON FORK	PROPOSED	RIP. STREAM
405.43	NORTH FORK SAN GABRIEL RIVER	INCLUDED	RIP. STREAM
405.43	PRAIRIE FORK	PROPOSED	RIP. STREAM
405.43	ROBERTS CANYON	INCLUDED	RIP. STREAM
405.43	SAN GABRIEL RIVER - MAIN STEM	INCLUDED	RIP. STREAM
405.43	WEST FORK SAN GABRIEL RIVER	INCLUDED	RIP. STREAM
405.44	FERN CANYON	PROPOSED	RIP. STREAM
405.44	SAN DIMAS CANYON CREEK	INCLUDED	RIP. STREAM
405.44	WOLFSKILL CANYON	PROPOSED	RIP. STREAM
405.53	MARSHALL CREEK AND WASH	INCLUDED	RIP. STREAM
481.23	SAN ANTONIO CANYON CREEK	INCLUDED	RIP. STREAM



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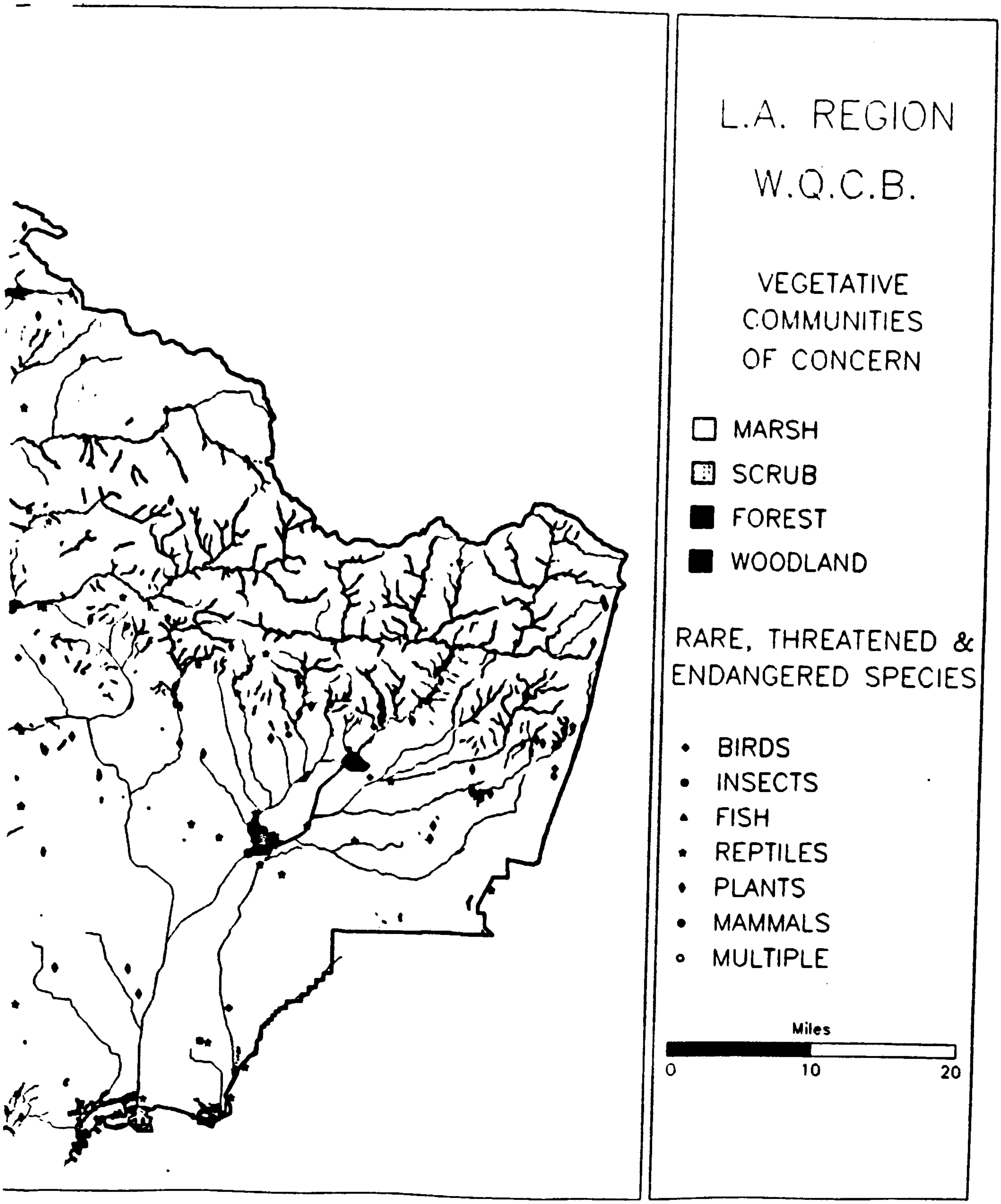

FIG 6.0.

VOL 12

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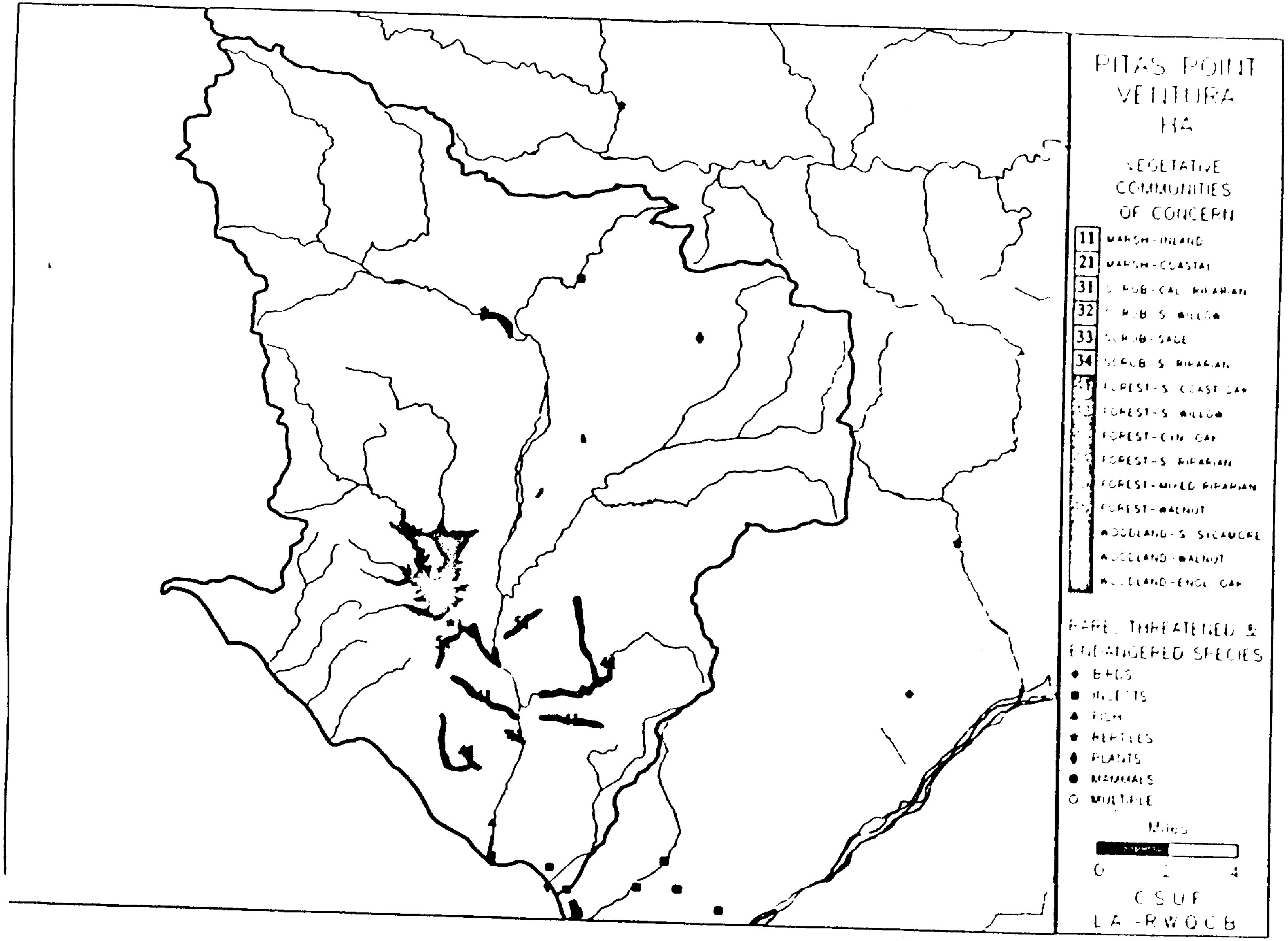
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VENTURA
HA
VEGETATIVE
COMMUNITIES
OF CONCERN
11 MARSH-INLAND
21 MARSH-COASTAL
31
32
33
34
FOREST-S. COAST OAK
FOREST-S. WILLOW
FOREST-CTN. OAK
FOREST-S. RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S. SYCAMORE
WOODLAND-WALNUT
RARE, THREATENED &
ENDANGERED SPECIES
INSECTS
REPTILES
PLANTS
MAMMALS
MULTIPLE
Miles
0
2
4
C S U F
L A - R W Q C B

FIG 6.1.

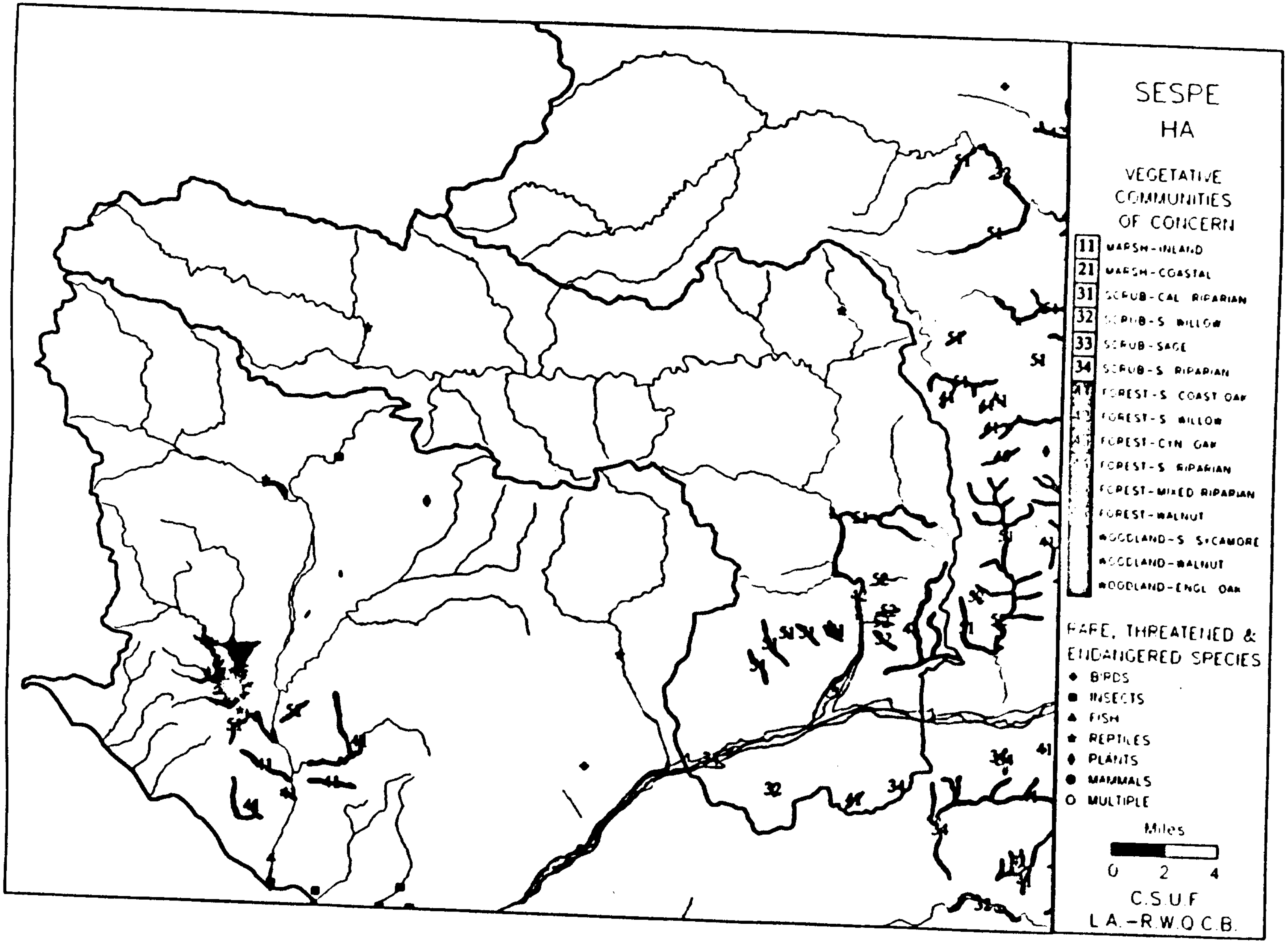

SESPE
HA
VEGETATIVE
COMMUNITIES
OF CONCERN
11 MARSH-INLAND
21 MARSH-COASTAL
31 SCRUB-CAL RIPARIAN
32 SCRUB-S WILLOW
33 SCRUB-SAGE
34 SCRUB-S RIPARIAN
FOREST-S COAST OAK
FOREST-S WILLOW
FOREST-CYN OAK
FOREST-S RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S SYCAMORE
WOODLAND-WALNUT
WOODLAND-ENGL OAK
RARE, THREATENED &
ENDANGERED SPECIES
BIRDS
INSECTS
FISH
REPTILES
PLANTS
MAMMALS
MULTIPLE
Miles
0 2 4
C.S.U.F
L.A.-R.W.Q.C.B.

FIG 6.2.

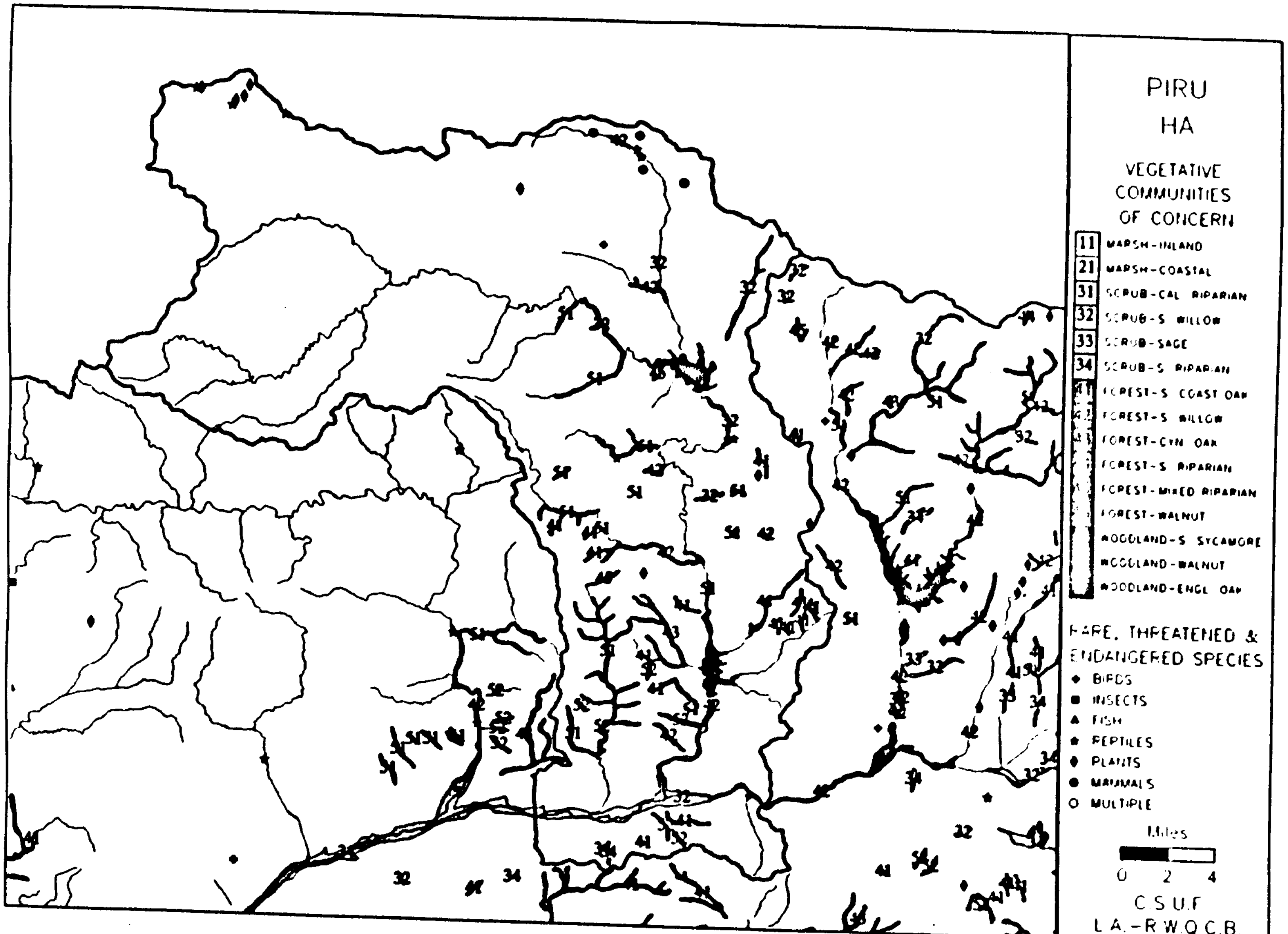

PIRU
HA
VEGETATIVE
COMMUNITIES
OF CONCERN
11 MARSH-INLAND
21 MARSH-COASTAL
31 SCRUB-CAL RIPARIAN
32 SCRUB-S WILLOW
33 SCRUB-SAGE
34 SCRUB-S RIPARIAN
FOREST-S COAST OAK
FOREST-S WILLOW
FOREST-CYN OAK
FOREST-S RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S SYCAMORE
WOODLAND-WALNUT
WOODLAND-ENGL OAK
RARE, THREATENED & ENDANGERED SPECIES
BIRDS
INSECTS
FISH
REPTILES
PLANTS
MAMMALS
MULTIPLE
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.

FIG 6.3.

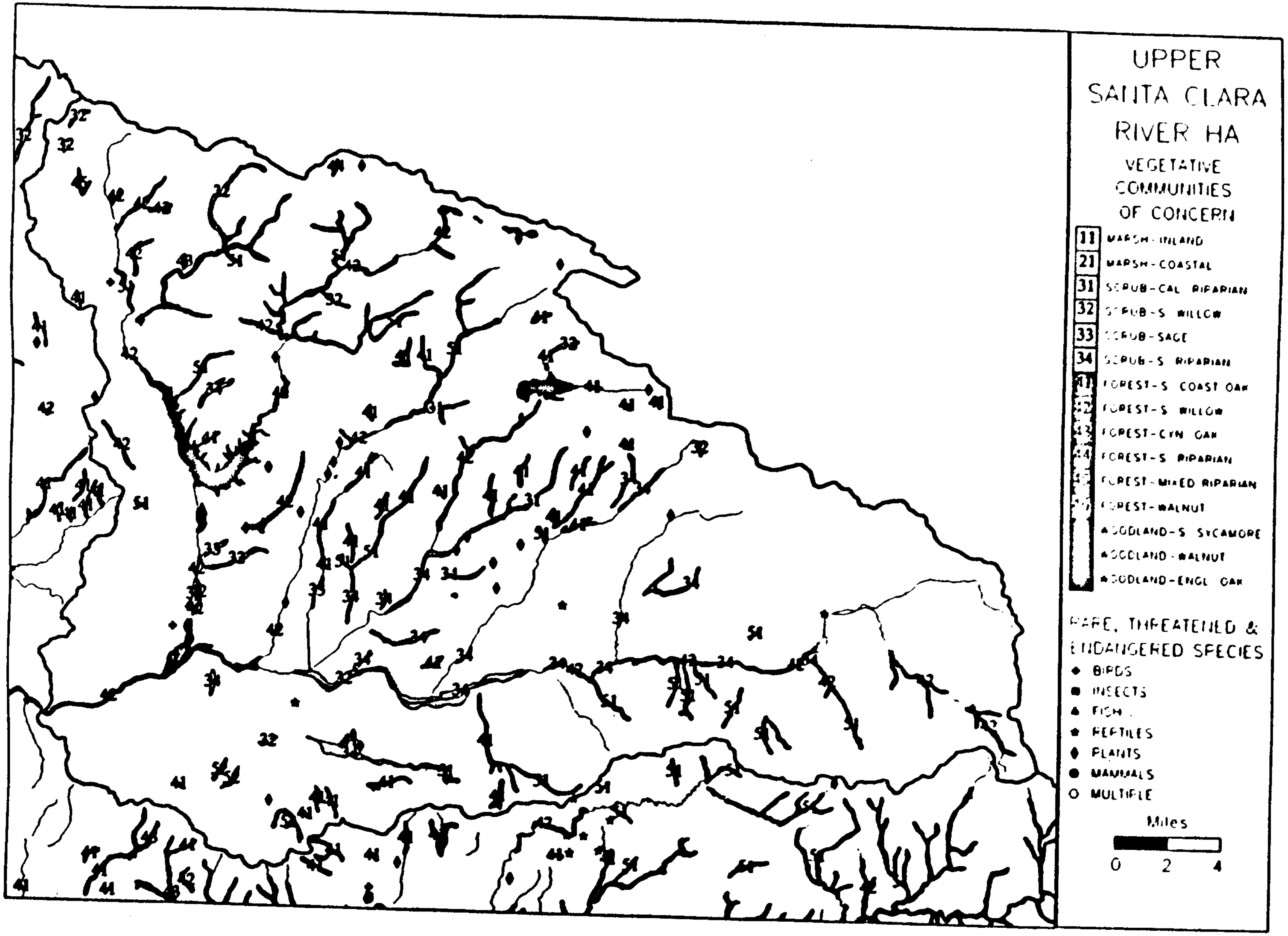

UPPER
SANTA CLARA
RIVER HA
VEGETATIVE
COMMUNITIES
OF CONCERN
11 MARSH-INLAND
21 MARSH-COASTAL
31 SCRUB-CAL RIPARIAN
32 SCRUB-S WILLOW
33 SCRUB-SAGE
34 SCRUB-S RIPARIAN
FOREST-S COAST OAK
FOREST-S WILLOW
FOREST-CYN OAK
FOREST-S RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S SYCAMORE
WOODLAND-WALNUT
WOODLAND-ENGL OAK
RARE, THREATENED &
ENDANGERED SPECIES
BIRDS
INSECTS
FISH
REPTILES
PLANTS
MAMMALS
MULTIPLE
Miles
0 2 4

FIG 6.4.

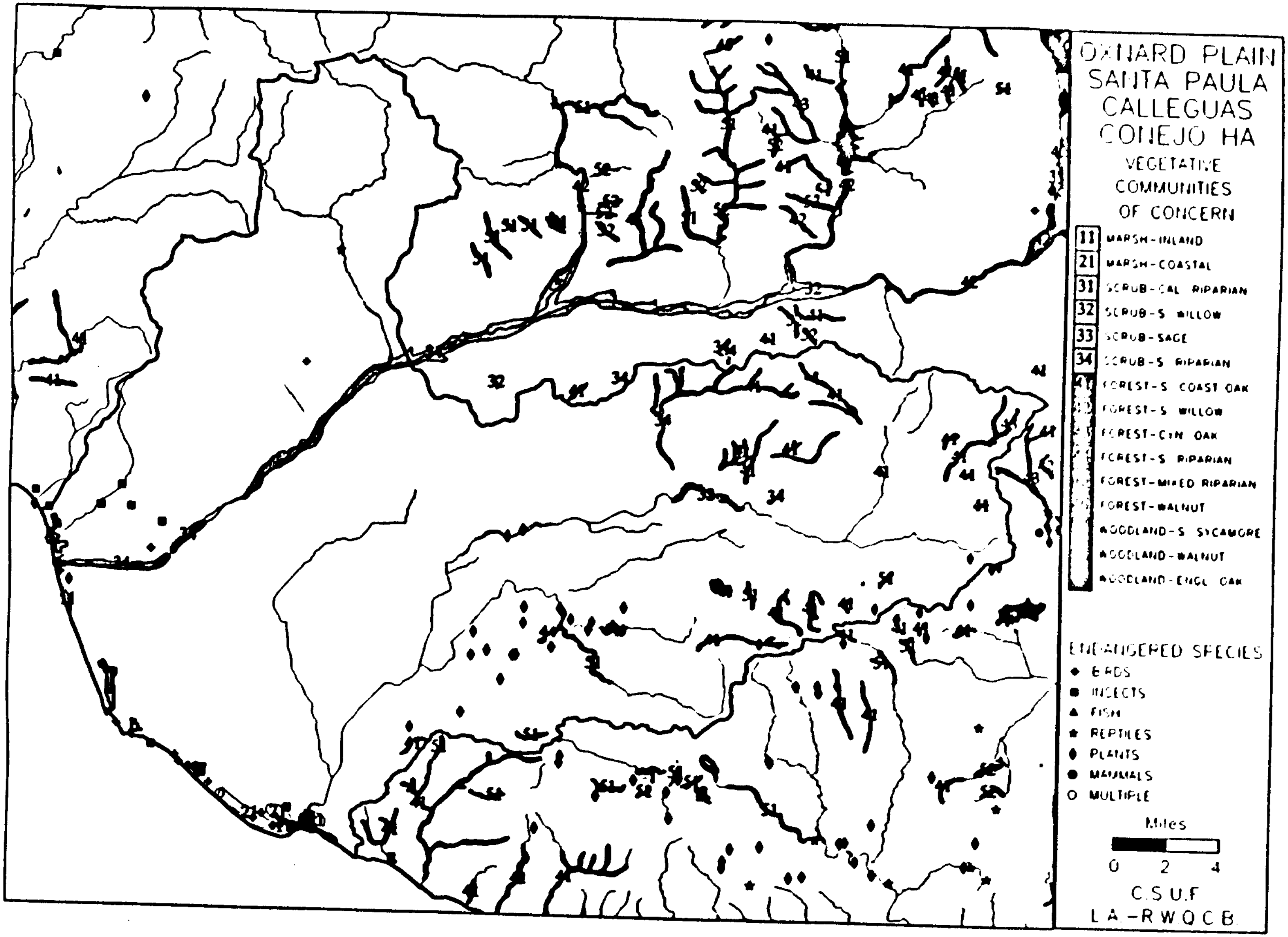
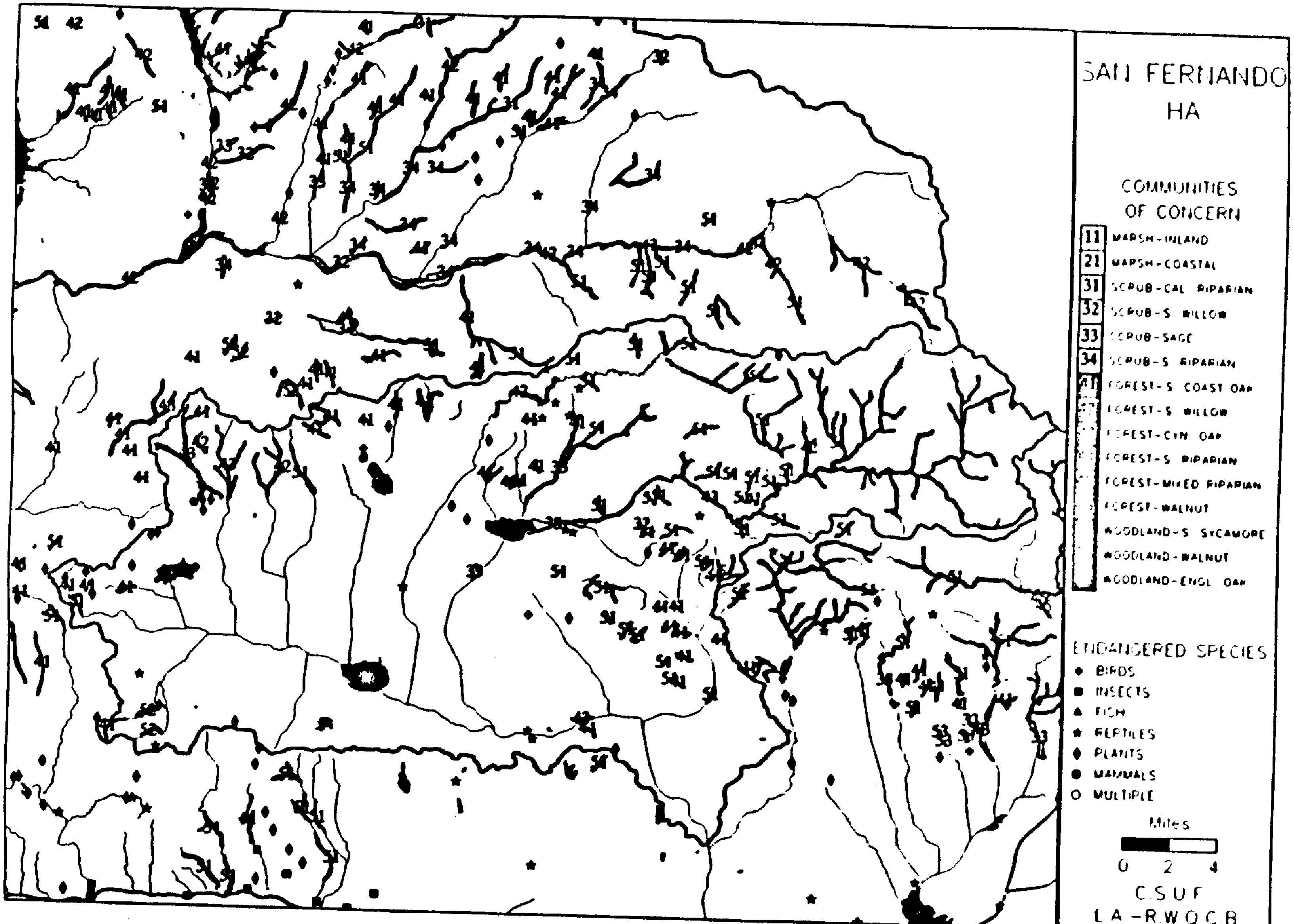

OXNARD PLAIN
SANTA PAULA
CALLEGUAS
CONEJO HA
VEGETATIVE
COMMUNITIES
OF CONCERN
11 MARSH-INLAND
21 MARSH-COASTAL
31 SCRUB-CAL RIPARIAN
32 SCRUB-S WILLOW
33 SCRUB-SAGE
34 SCRUB-S RIPARIAN
41 FOREST-S COAST OAK
FOREST-S WILLOW
FOREST-CYN OAK
FOREST-S RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S SYCAMORE
WOODLAND-WALNUT
WOODLAND-ENGL OAK
ENDANGERED SPECIES
BIRDS
INSECTS
FISH
REPTILES
PLANTS
MAMMALS
MULTIPLE
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.

FIG 6.5.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HA
COMMUNITIES
OF CONCERN
11 MARSH-INLAND
21 MARSH-COASTAL
31 SCRUB-CAL RIPARIAN
32 SCRUB-S WILLOW
33 SCRUB-SAGE
34 SCRUB-S RIPARIAN
41 FOREST-S COAST OAK
FOREST-S WILLOW
FOREST-CYN OAK
FOREST-S RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S SYCAMORE
WOODLAND-WALNUT
WOODLAND-ENGL OAK
ENDANGERED SPECIES
BIRDS
INSECTS
FISH
REPTILES
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MAMMALS
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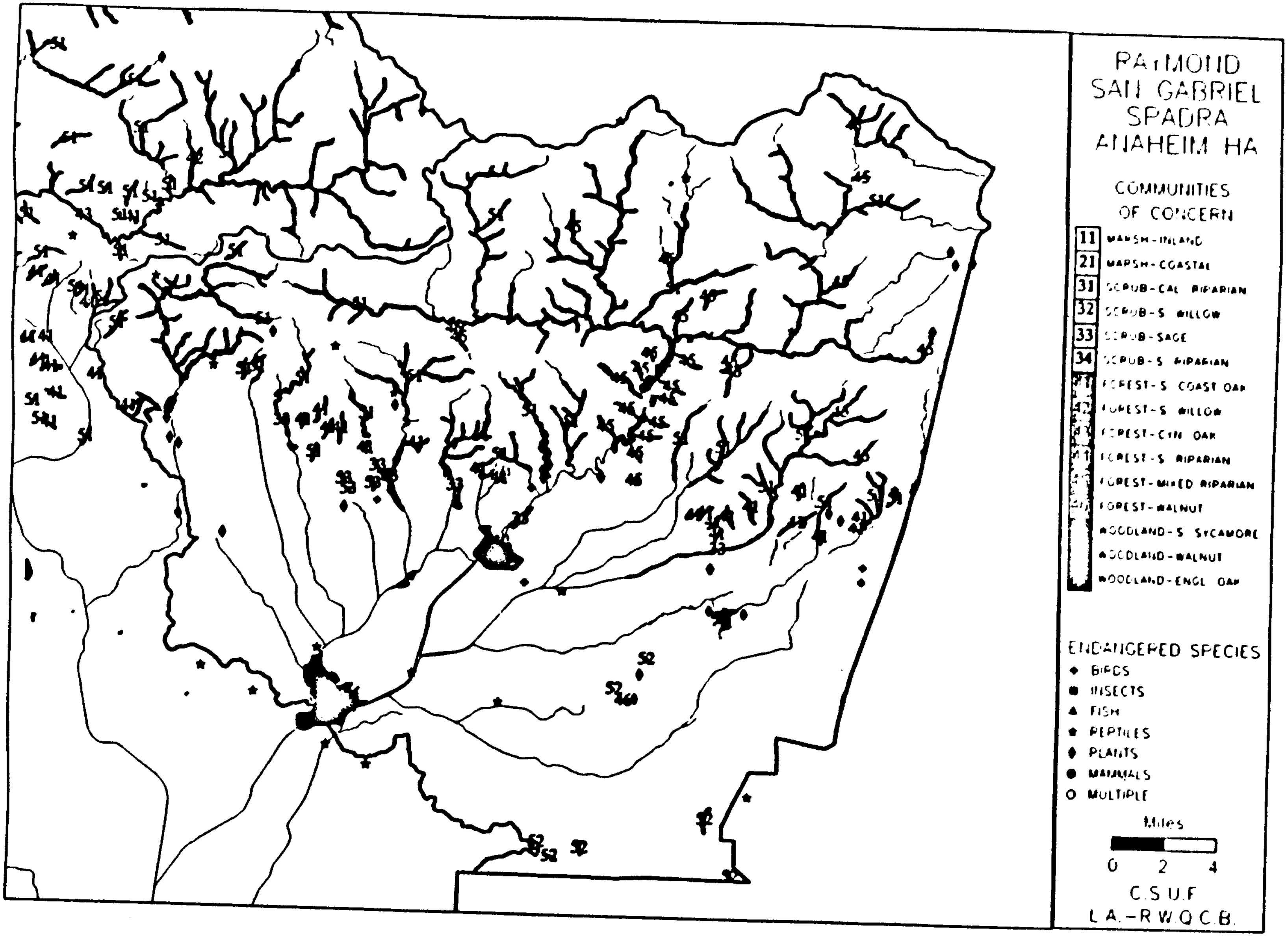
FIG 6.6.



RAYMOND
SAN GABRIEL
SPADRA
ANAHEIM HA
COMMUNITIES OF CONCERN
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21 MARSH-COASTAL
31 SCRUB-CAL RIPARIAN
32 SCRUB-S WILLOW
33 SCRUB-SAGE
34 SCRUB-S RIPARIAN
FOREST-S COAST OAK
FOREST-S WILLOW
FOREST-CYN OAK
FOREST-S RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S SYCAMORE
WOODLAND-WALNUT
WOODLAND-ENGL OAK
ENDANGERED SPECIES
BIRDS
INSECTS
FISH
REPTILES
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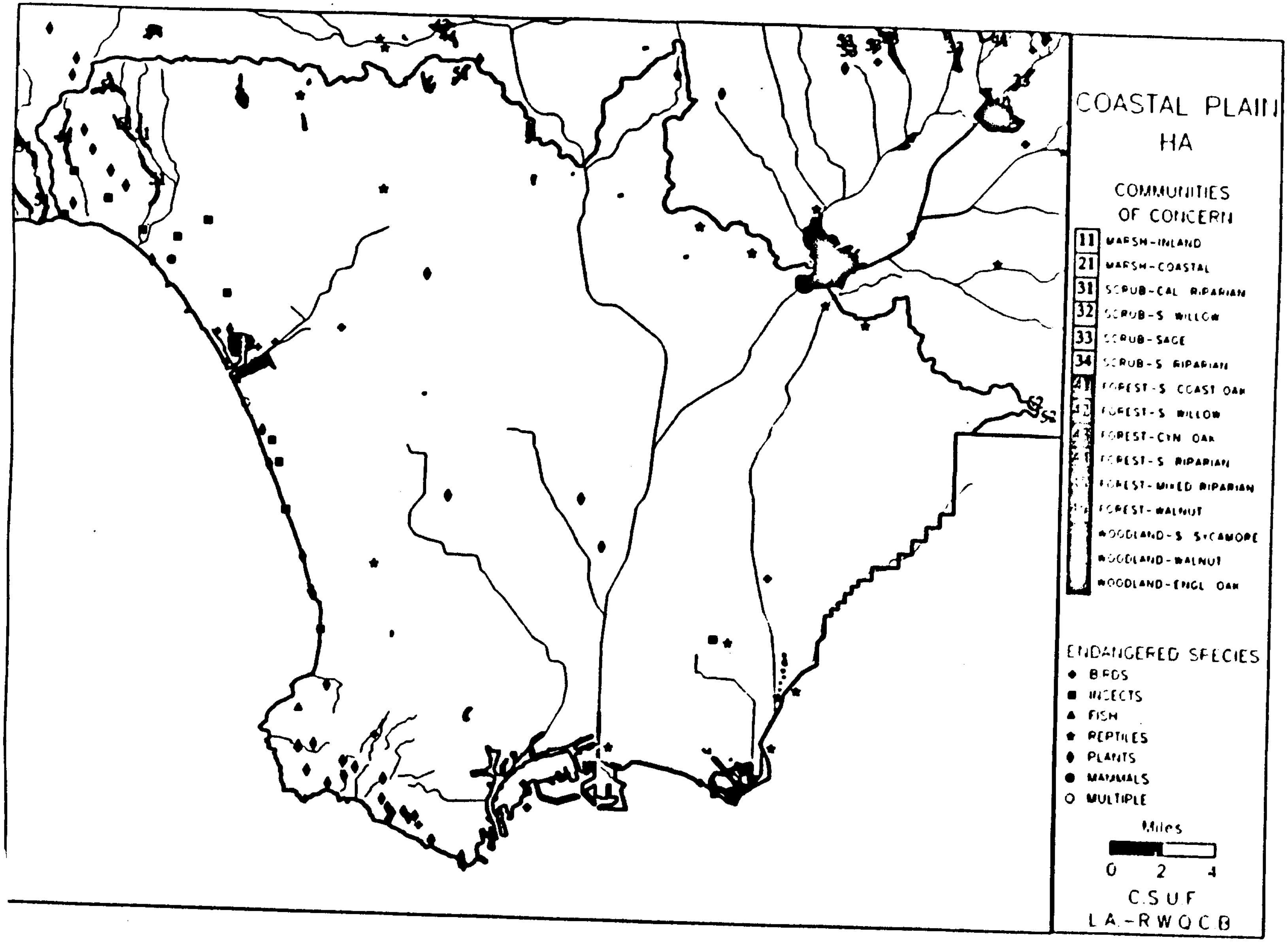
FIG 6.7.


COASTAL PLAIN
HA
COMMUNITIES
OF CONCERN
11 MARSH-INLAND
21 MARSH-COASTAL
31 SCRUB-CAL RIPARIAN
32 SCRUB-S WILLOW
33 SCRUB-SAGE
34 SCRUB-S RIPARIAN
41 FOREST-S COAST OAK
42 FOREST-S WILLOW
43 FOREST-CYN OAK
FOREST-S RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S SYCAMORE
WOODLAND-WALNUT
WOODLAND-ENGL OAK
ENDANGERED SPECIES
BIRDS
INSECTS
FISH
REPTILES
PLANTS
MAMMALS
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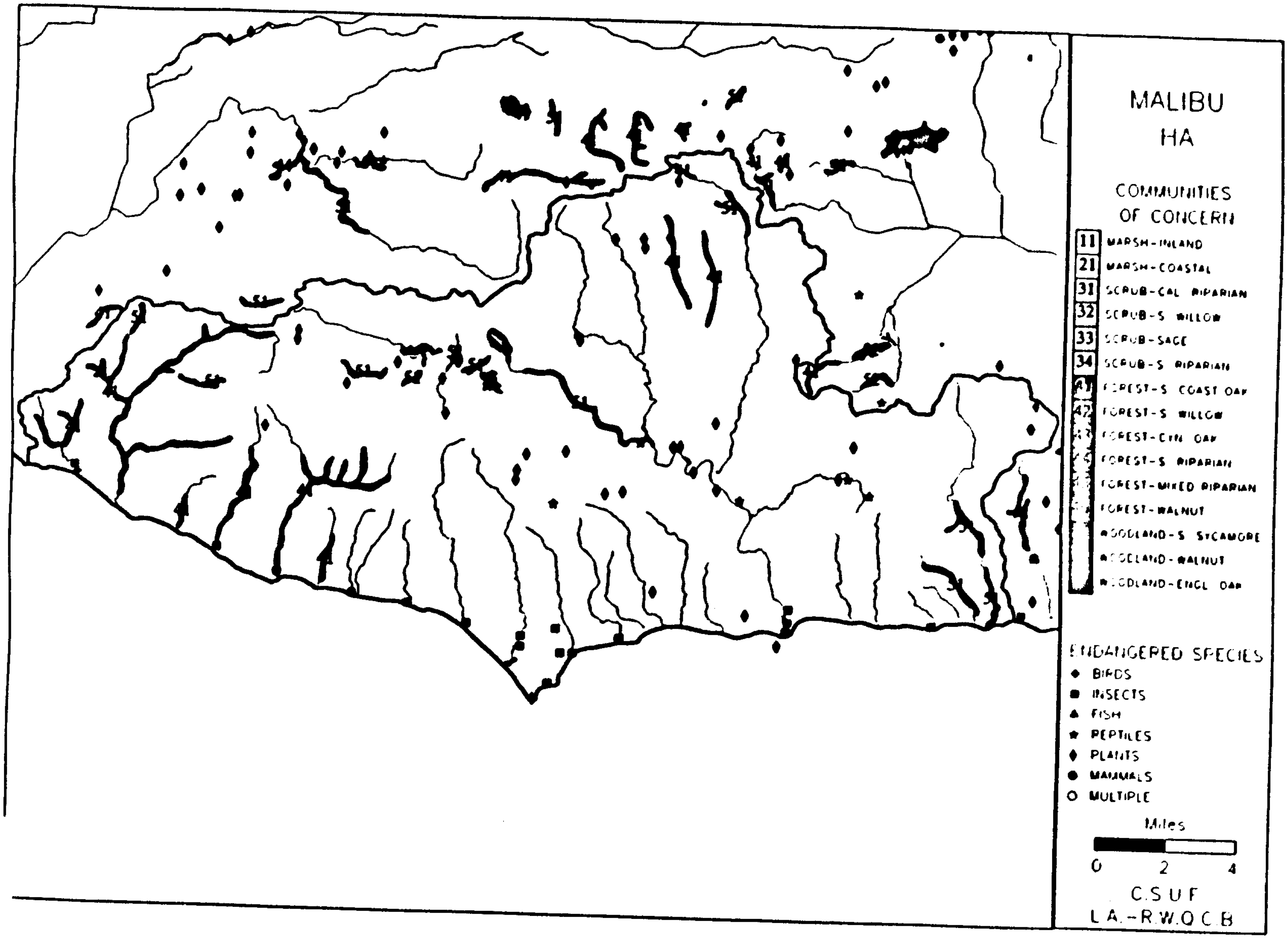
C.S.U.F
L.A.-RWQCB

FIG 6.8.



MALIBU
HA
COMMUNITIES
OF CONCERN
11 MARSH-INLAND
21 MARSH-COASTAL
31 SCRUB-CAL RIPARIAN
32 SCRUB-S WILLOW
33 SCRUB-SAGE
34 SCRUB-S RIPARIAN
41 FOREST-S COAST OAK
42 FOREST-S WILLOW
FOREST-CYN OAK
FOREST-S RIPARIAN
FOREST-MIXED RIPARIAN
FOREST-WALNUT
WOODLAND-S SYCAMORE
WOODLAND-WALNUT
WOODLAND-ENGL OAK
ENDANGERED SPECIES
BIRDS
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REPTILES
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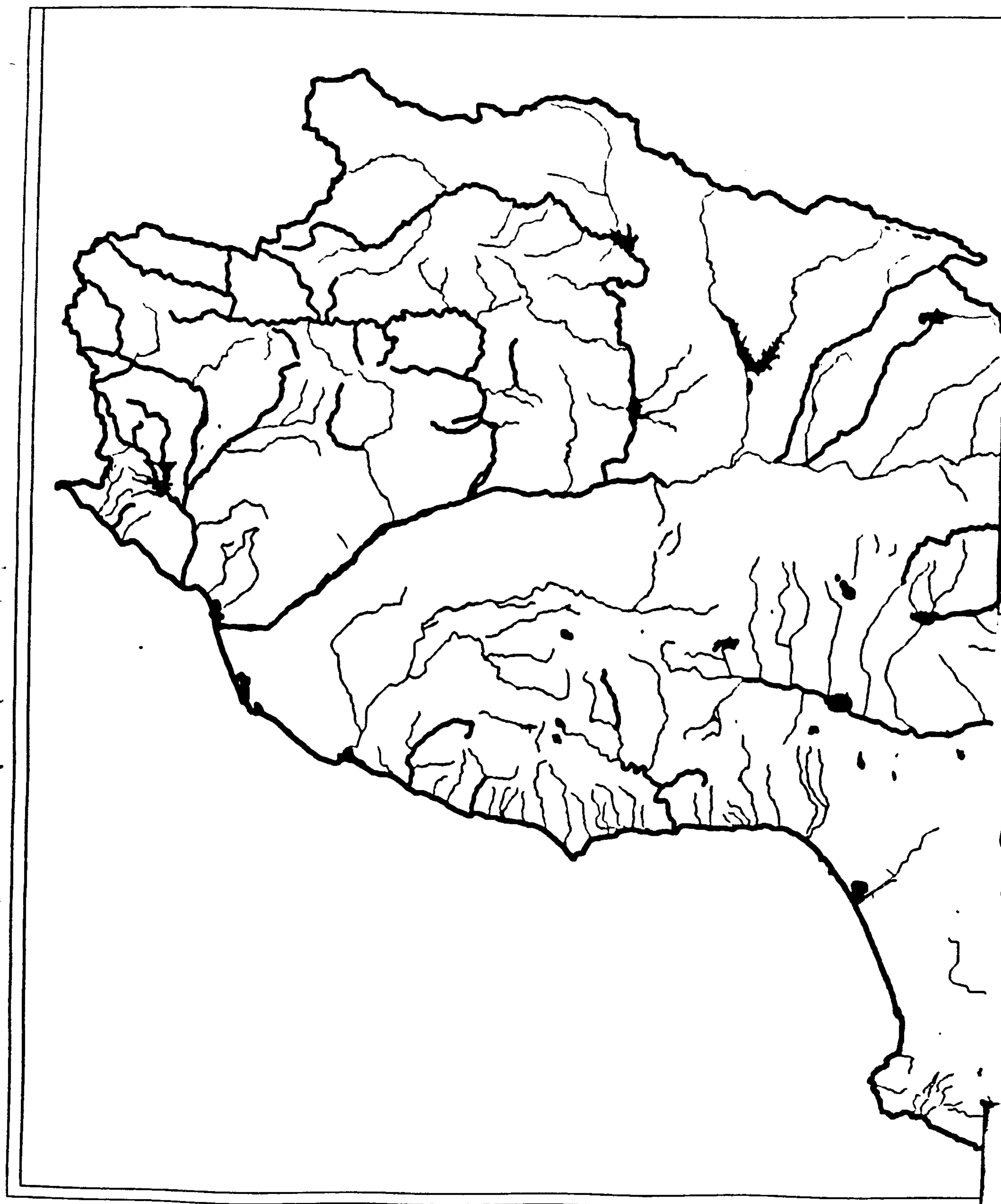
FIG 6.9.



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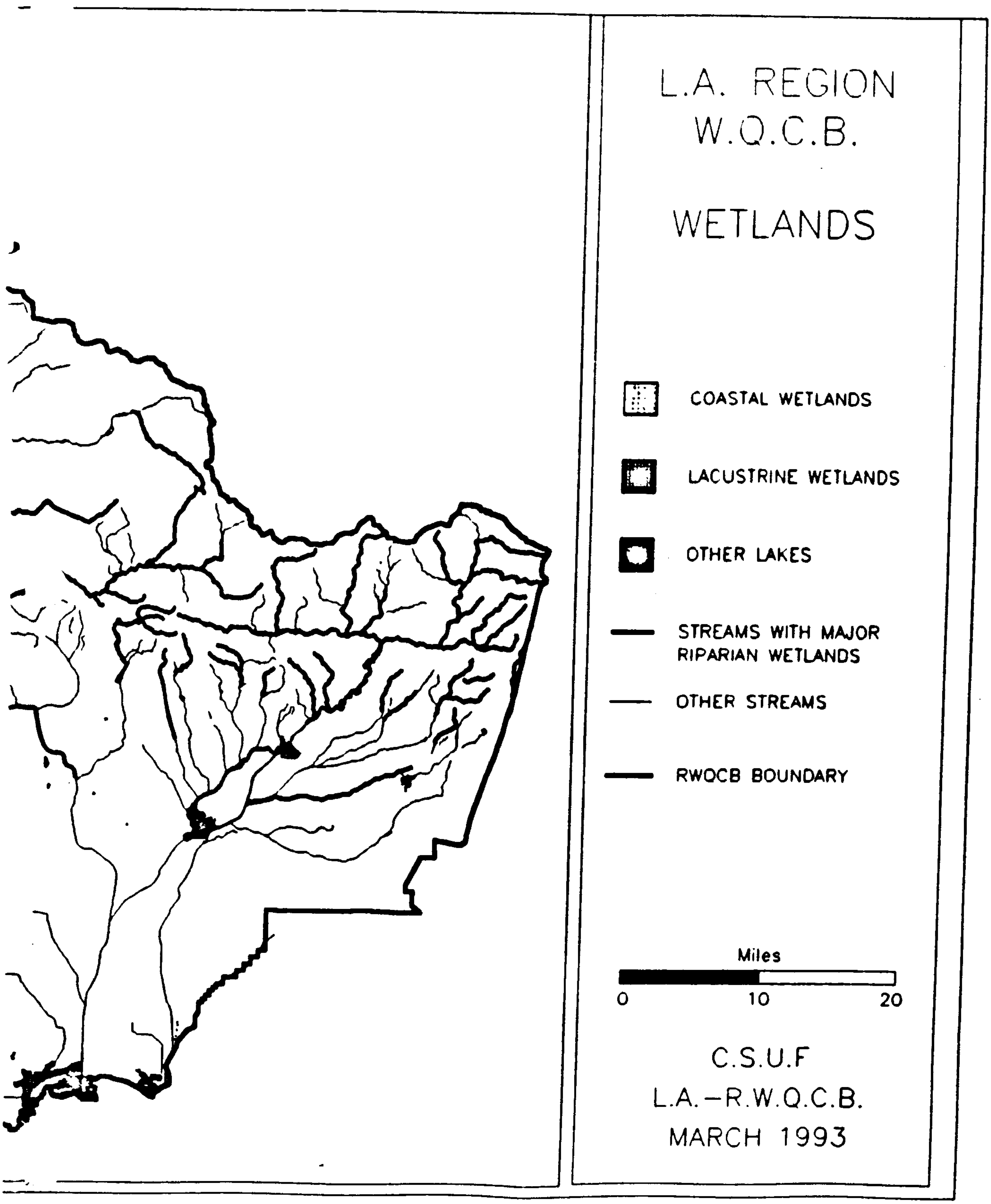

FIG 7.0.

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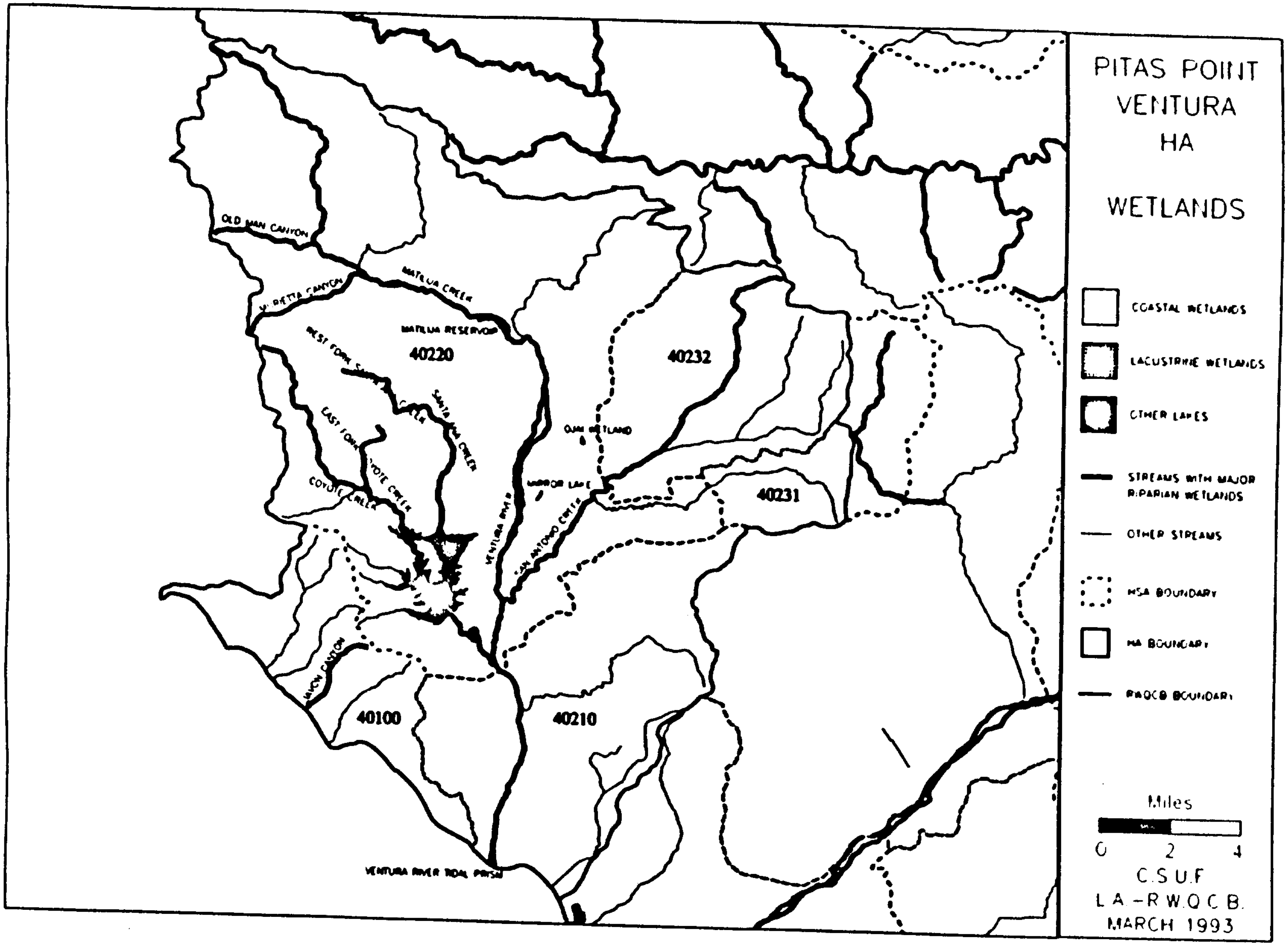
PITAS POINT
VENTURA
HA
WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
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C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
40220
40232
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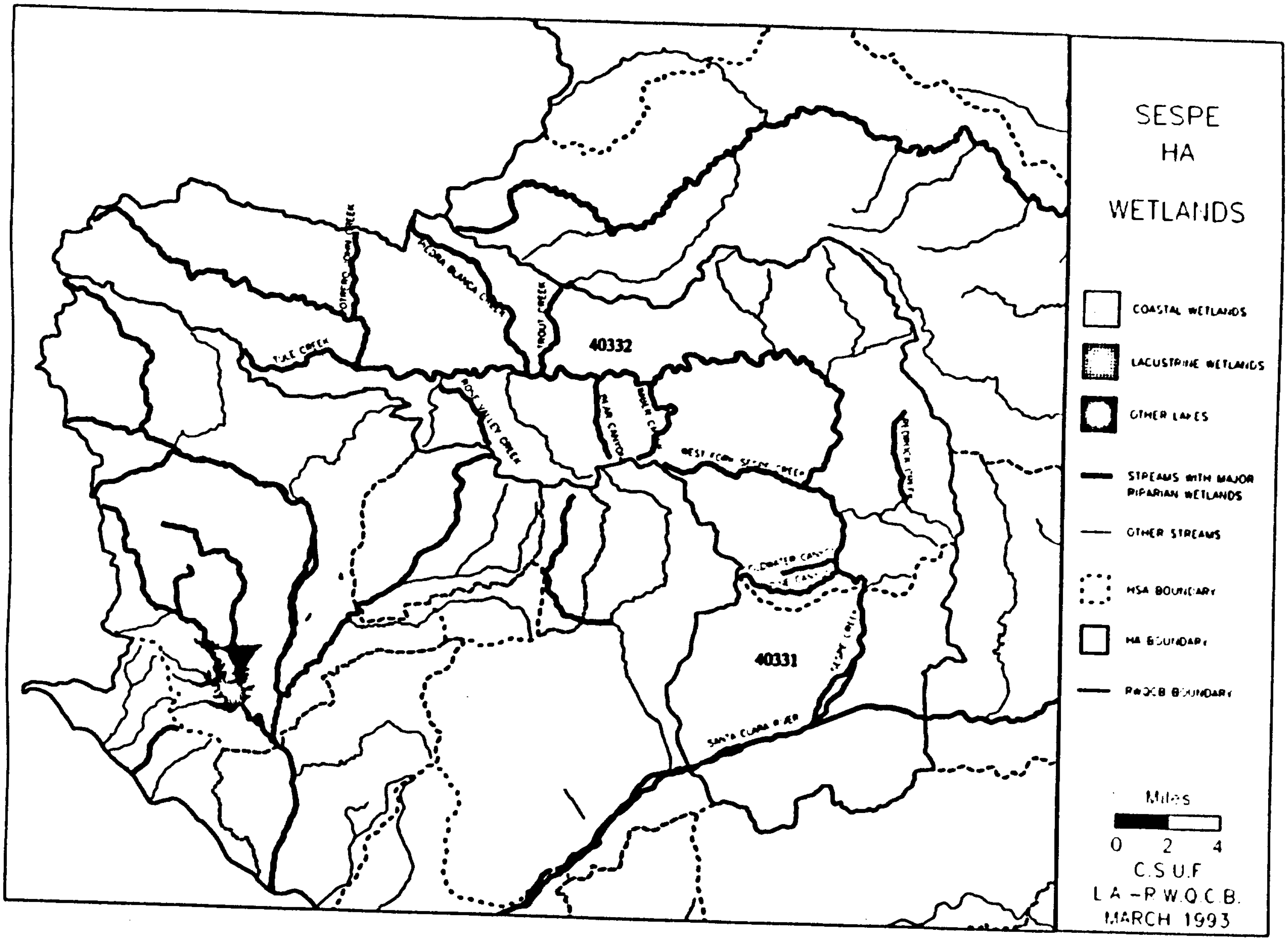
OLD MAN CANYON
MATILIJA CREEK
MATILIJA RESERVOIR
OJAI WETLAND
MIRROR LAKE
VENTURA RIVER
SAN ANTONIO CREEK
COYOTE CREEK
VENTURA RIVER TIDAL PRISM

FIG 7.1.


SESPE
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WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
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STREAMS WITH MAJOR RIPARIAN WETLANDS
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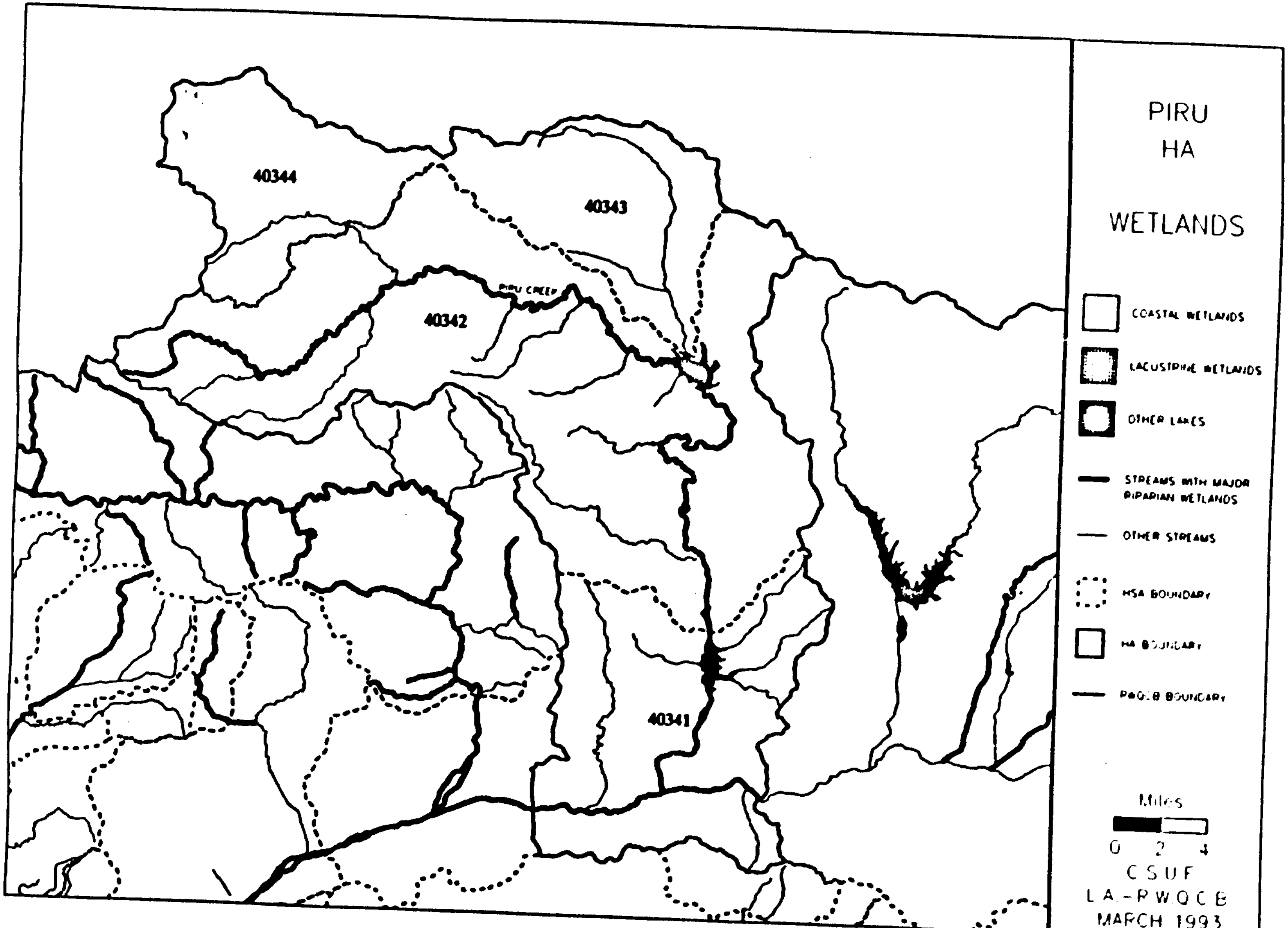
L.A.-R.W.Q.C.B.
MARCH 1993
40332
40331
TULE CREEK
TROUT CREEK
PIEDRA BLANCA CREEK
ROSE VALLEY CREEK
WEST FORK SESPE CREEK
SANTA CLARA RIVER

FIG 7.2.


PIRU
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WETLANDS
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PIRU CREEK
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
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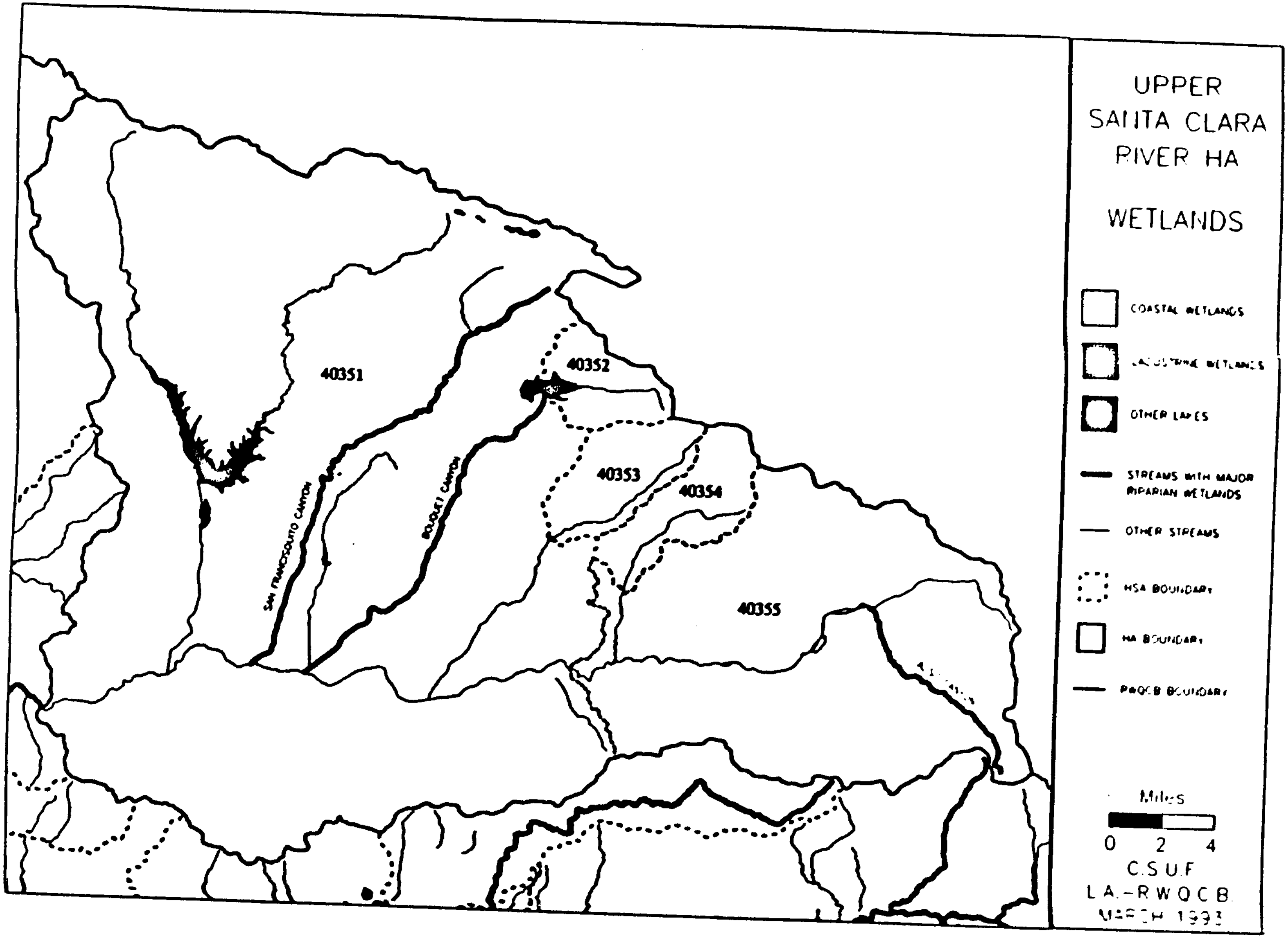
LA-RWQCB
MARCH 1993

FIG 7.3.


UPPER
SANTA CLARA
RIVER HA
WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
HSA BOUNDARY
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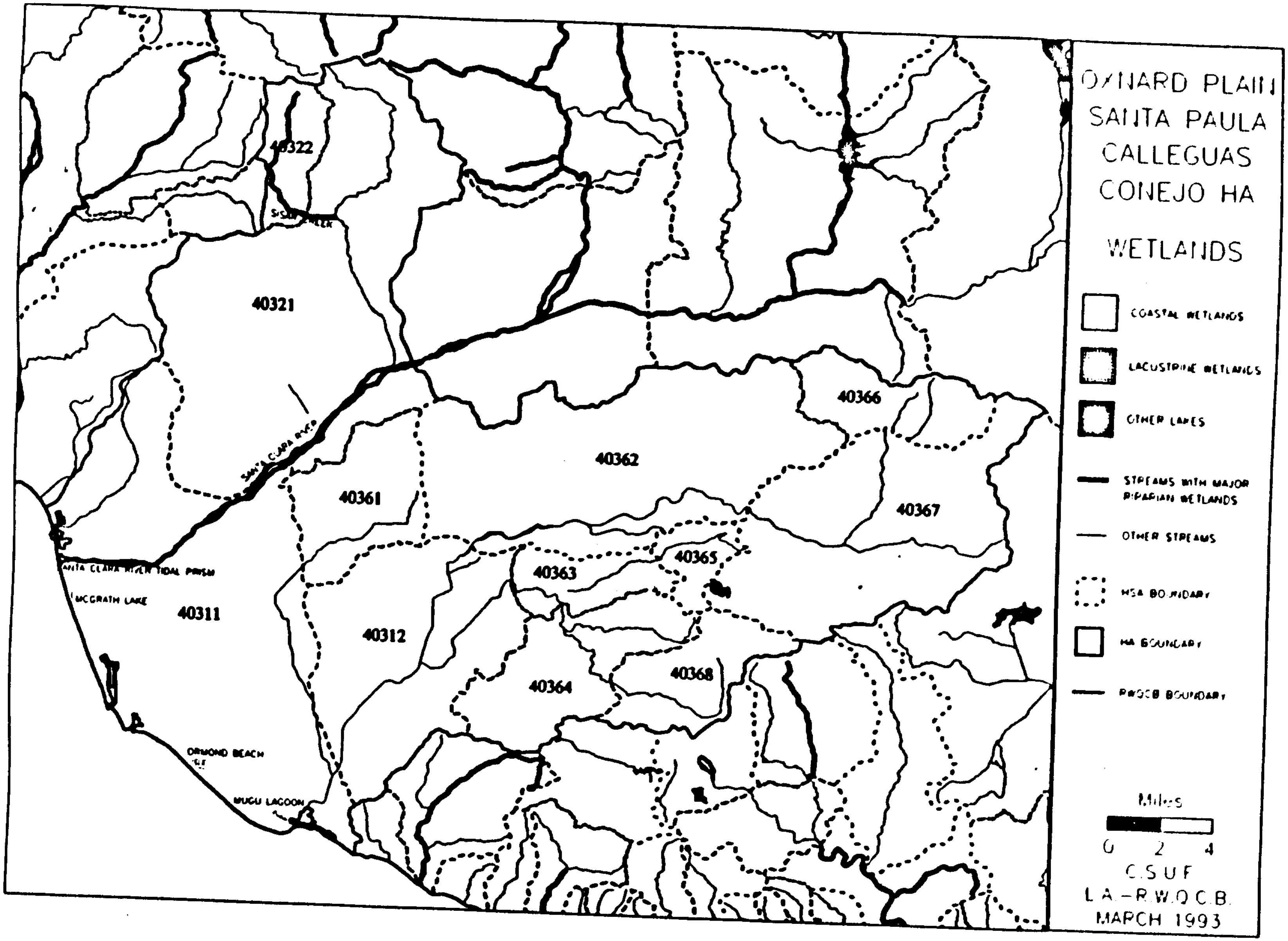
SAN FRANCISQUITO CANYON
BOUQUET CANYON

FIG 7.4.


OXNARD PLAIN
SANTA PAULA
CALLEGUAS
CONEJO HA
WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
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HA BOUNDARY
RWQCB BOUNDARY
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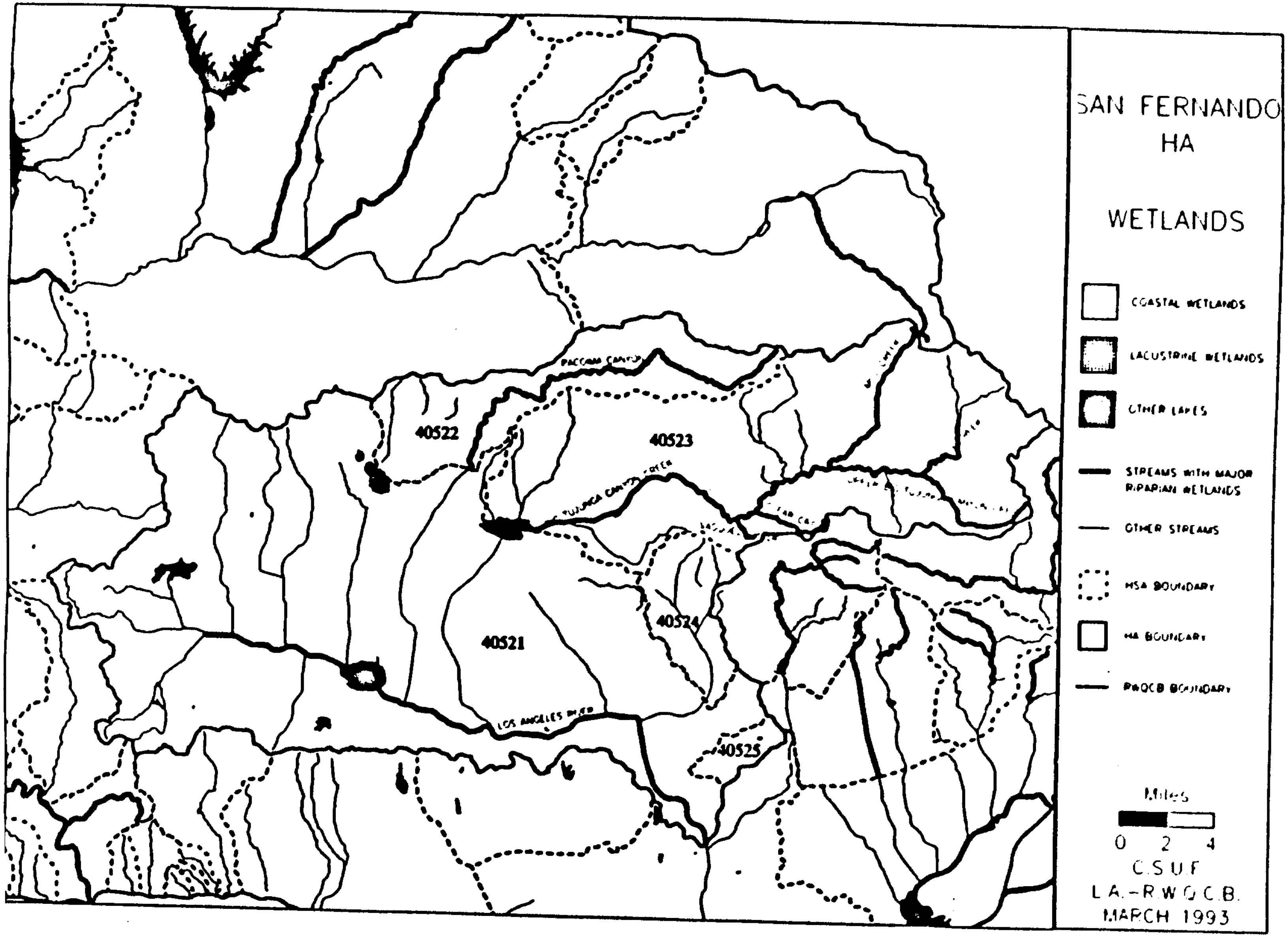
SANTA CLARA RIVER
SANTA CLARA RIVER TIDAL PRISM
MCGRATH LAKE
ORMOND BEACH
MUGU LAGOON

FIG 7.5.



SAN FERNANDO HA
WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
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HA BOUNDARY
RWQCB BOUNDARY
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MARCH 1993
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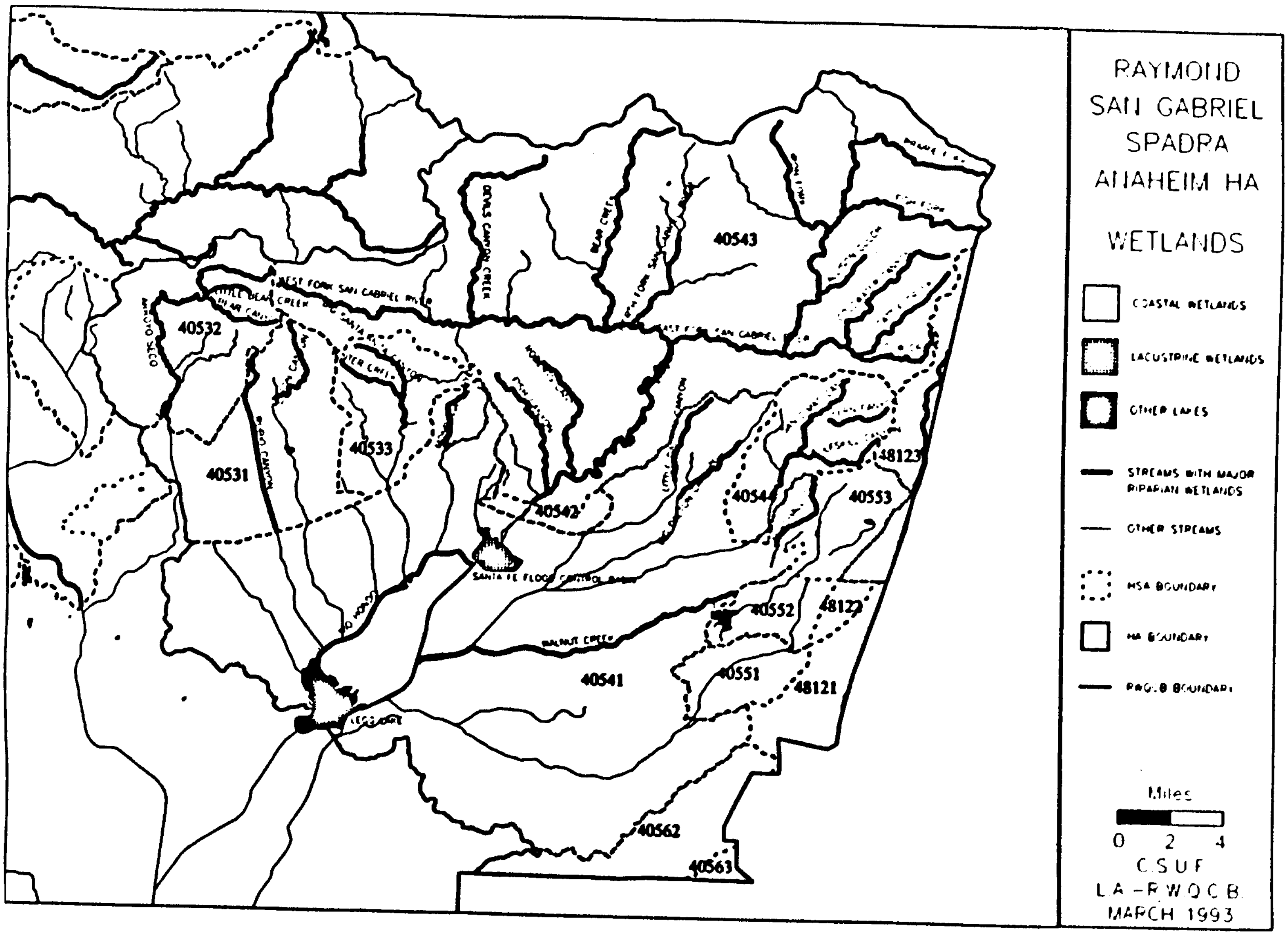
PACOIMA CANYON
TUJUNGA CANYON CREEK
LOS ANGELES RIVER

FIG 7.6.



RAYMOND
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STREAMS WITH MAJOR RIPARIAN WETLANDS
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MARCH 1993
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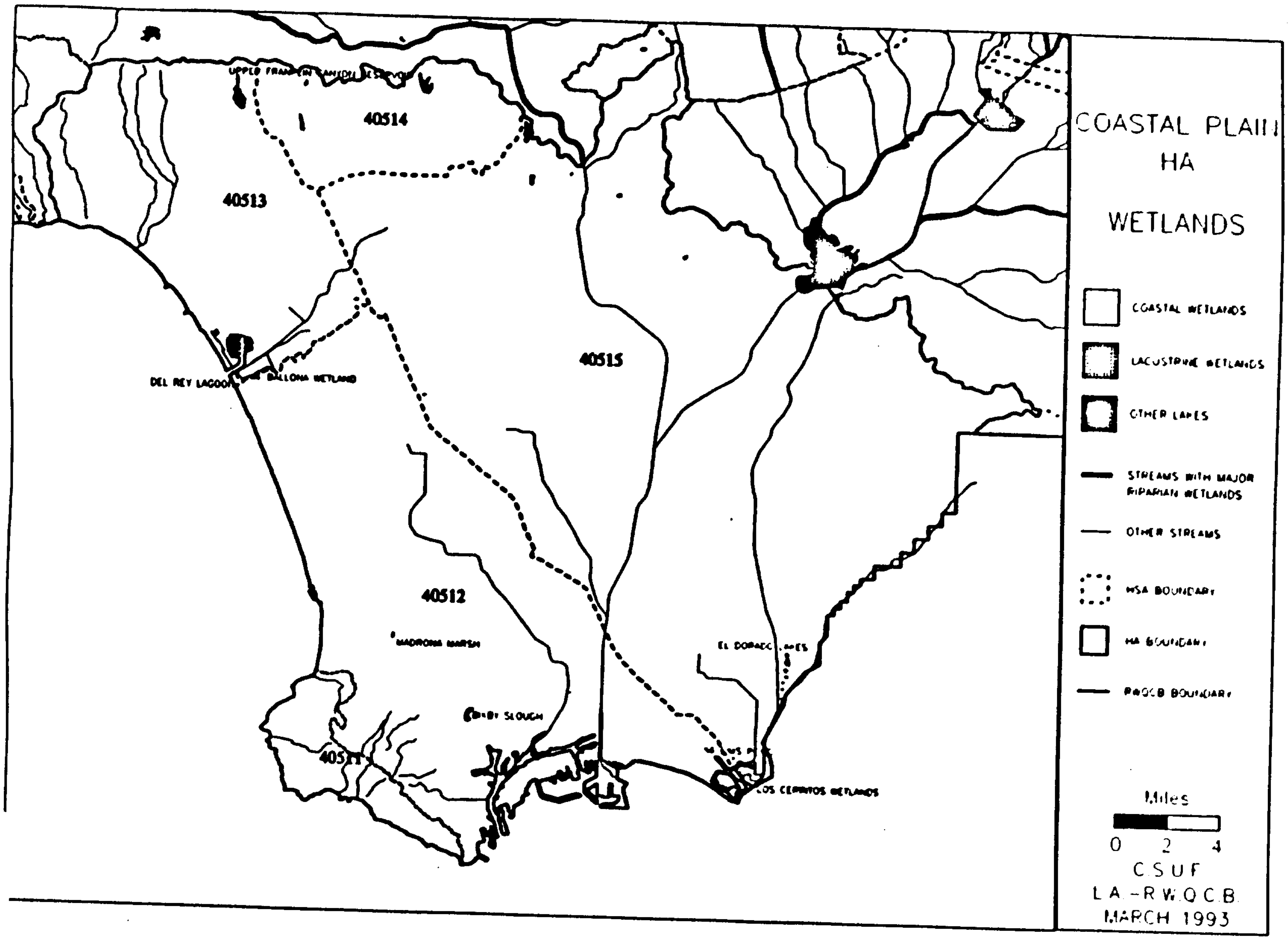
WEST FORK SAN GABRIEL RIVER
DEVILS CANYON CREEK
ARROYO SECO
WALNUT CREEK
SANTA FE FLOOD CONTROL BASIN

FIG 7.7.



COASTAL PLAIN
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DEL REY LAGOON
BALLONA WETLAND
MADRONA MARSH
LOS CERRITOS WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
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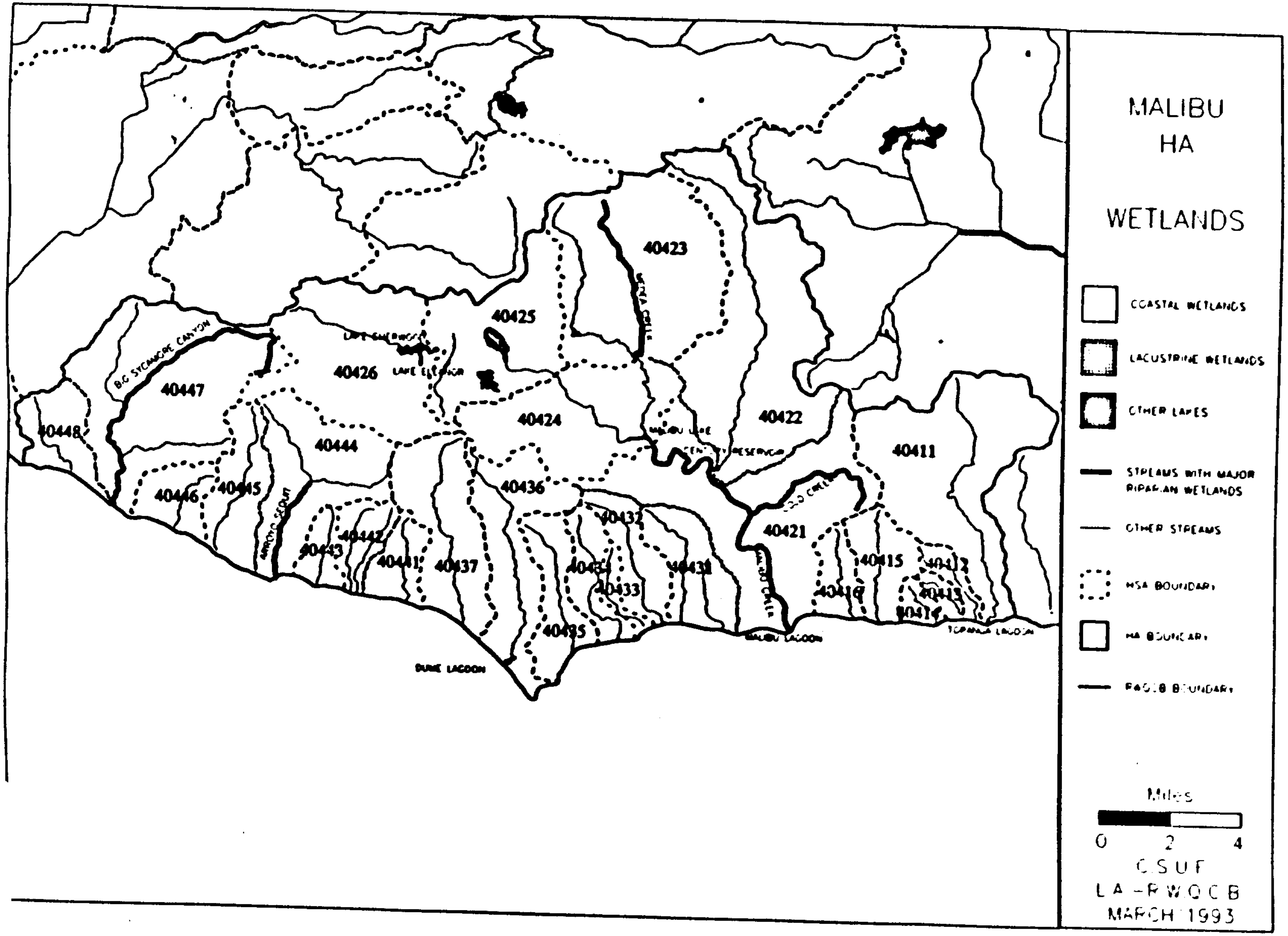
L.A.-R.W.Q.C.B.
MARCH 1993

FIG 7.8.


MALIBU
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WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
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RWQCB BOUNDARY
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MARCH 1993
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40435
BIG SYCAMORE CANYON
ARROYO SEQUIT
LAKE ELEANOR
MALIBU LAKE
MALIBU LAGOON
TOPANGA LAGOON
DUME LAGOON
COLD CREEK
MALIBU CREEK

FIG 7.9.

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CHAPTER 5: BENEFICIAL USES

Beneficial uses, simply put, are the many ways water can be used by the people and/or by the wildlife. In the Statewide Policy of Water Quality (1967), the State Water Resources Control Board defined beneficial uses of water as "that use of water that is in general productive of public benefit and which promotes peace, health, safety and welfare of the people of the State." Section 13020 et seq of the California Water Code identified uses of water as follows:

" 'Beneficial uses' of waters of the state may be protected against quality degradation include, but are not necessarily limited to, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife and other aquatic resources or preserves."

Section 303 of the Clean Water Act (PL 92-500, as amended) defines water quality standards as consisting of both the uses of the waters involved and the water quality criteria which are applied to protect those uses. Under the Porter Cologne Water Quality Control Act (California Water Code, Division 7), these concepts are separately considered as beneficial uses and water quality objectives.

For the Basin Planning effort, the State Board adopted, in 1972, a uniform list of description of beneficial uses to be applied to all waters. The complete list and definitions are contained in Table 4.0. To the original 21 beneficial uses three more were subsequently added and include Aquaculture (AQUA), Wetland Habitat (WET) and Estuarine (EST). For the purposes of this report the 24 beneficial uses are considered for allocation to the various waterbodies in the region.

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5.1. DECISION CRITERIA FOR BENEFICIAL USE DESIGNATION

The various elements in the decision process for the designation of beneficial uses is summarized in Figure 8.

Literature review consists of a survey of publications, regulations, consulting and research reports.

Regional Water Quality Control Board Basin Plans include those from the Los Angeles Basin as well as the Santa Ana Region(for comparison).

The Los Angeles Regional Water Quality Control Board 1975 Water Quality Control Plans 4A (Santa Clara Basin) and 4B (Los Angeles Basin) contain beneficial use tables 4, 5 and 6. According to our guidelines, beneficial use could only be added or upgraded (not removed), except in extremely rare instances where it can be documented that a gross error was made in assigning these uses in 1975. Beneficial uses could not be de-designated because of water quality impairment.

The Management Memorandum No. 20 (MM-20) lists four steps in the planning strategy for water quality management. These are:

1. Establishment of beneficial uses
2. Establishment of water quality objectives
3. Classification of waterbody segments for water quality and effluent limitation allocation
4. Development of alternative water quality management plans.

The MM-20 also includes tables for evaluating quality of water required for the following beneficial use categories:

Municipal (MUN)
Water contact recreation (REC-1)
Non contact recreation (REC-2)
Fresh water habitats (WARM, COLD, SPWN, MIGR, WILD)
Saltwater habitats (COMM, MAR, SAL, SHELL, SPWN, MIGR)
Agriculture (AGR), including irrigation and livestock

The Natural Diversity Database of the California Department of Fish and Game, covering the period of June 1991 to June 1992 was used to allocate RARE, WILD and BIO and WET categories of beneficial uses.

Landuse maps, including the maps of concrete and channelized river reaches (Figs 5.0- 5.9) were used to evaluate the compatibility of the various beneficial use designations to landuses.

Los Angeles Regional Water Quality Control Board Resolution No 89-03 was used to determine the MUN designation of all the waterbodies. According to this resolution all waterbodies not listed in the 1978 basin plan beneficial use tables 4, 5 and 6, were given a MUN designation. The State Water Resources Control Board Resolution No 88-63, which is the basis for the LA Regional resolution, further states that:

" All surface and ground waters of the State are considered to be suitable, or potentially suitable, for municipal and domestic water supply and should be so designated by Regional Boards". The exceptions are waters with total dissolved solids of more than 3000 mg/l, or untreatable contaminated waters or groundwaters which are not capable of producing 'an average, sustained yield of 200 gallons per day'.

Field surveys were conducted to document the existing conditions of habitats, erosion, diversions and usage of the existing and proposed waterbodies in the basin. The methodology is described in section 2.2 and the field survey forms are included in Appendix 2.

Public Agencies and Interest Group Surveys were conducted to seek the comments to our proposed designations of beneficial uses. The methodology is described in section 2.3 and the summary of comments is included in Appendix 3. The footnotes in the beneficial use tables (Table 4.1, 4.2) include the lists of agencies and interest groups whose comments were incorporated in our beneficial use recommendations.

5.2. BENEFICIAL USE RECOMMENDATIONS

Our recommended beneficial uses are presented as follows:

Table 4.1. Groundwater Resources

Table 4.2. Surface Water Resources

The groundwater resources include the groundwaters contained in designated groundwater basins (Fig 4.0-4.9) and 'other' groundwaters contained in the fractures and pore spaces of basin tributary valleys and bedrock. The occurrence and distribution of groundwater resources is described in section 4.7.

The surface water resources include rivers, lakes and reservoirs, coastal features and wetlands.The occurrence and distribution of the surface waters are described in sections 4.3 (rivers), 4.4 (lakes and reservoirs), 4.5 (coastal features), and 4.6 (wetlands).

5.2.1. Groundwater Resources (Table 4.1)

We recommend that the groundwater beneficial uses be designated according to the various basins as contained in Table 4.1. In the case of Oxnard and Pleasant Valley HSA's where enough information is available, beneficial use designation for the individual aquifers be included. This is consistent with the existing 1975 Basin Plans. An attempt was made to explore the feasibility of this scheme for the well defined aquifers in the West Coast Basin (HSA 405.12), and Central Basin (HSA 405.15). The multiple aquifer source of water in many wells in these basins makes the beneficial use designation by aquifers, quite impractical.

We recommend that 'all other groundwater' designation apply to all waters not included in the basins, to protect the groundwaters in the bedrock and tributary creeks. There are small supply wells in these areas which also form the recharge zones for the major basins.

5.2.2. Surface Water Resources (Table 4.2 and footnotes)

We recommend that the Municipal(MUN) designation be added to all the waterbodies that qualify for such designation, according to State Water Resources Control Board Resolution 88-63 and LA-RWQCB Resolution 89-03. The waterbodies are identified in Table 4.2.

We recommend that Groundwater Recharge (GWR) designation be added to all the rivers, lakes and reservoirs, located in the recharge zones of the various basins. In these areas, listed in Table 4.2, recharge occurs naturally through infiltration of precipitation, stream and lake waters through fractures and other pores.

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We recommend that the designation BIOL be expanded to include waterbodies other than those legally declared as Areas of Special Biological Significance (ASBS). Several waterbodies with rare and endangered species and those with wetlands, as identified in table 4.2, have unique ecological features to make them biologically significant. Some individual field observations and agency survey responses give further details.

We recommend that all the waterbodies included in the California Department of Fish and Game Rarefind and Natural Diversity Database, as shown in Table 4.2, be designated under RARE beneficial use category. The footnotes of the table 4.2. give details of the individual animal and plant listings.

We recommend that all the river mouths and tidal prisms, displaying estuarine conditions, and so identified in Table 4.2, be designated as EST.

We recommend that all the rivers, lakes and estuaries, displaying wetland hydrology, soil and vegetation conditions, and so identified in Table 4.2. be designated as WET category.

5.3. Comments on individual waterbodies and hydrological areas

The extensive footnotes for table 4.2. identify the sources of agency comments and the identity of the animals, rare plants and vegetation communities of interest, contained in the Rarefind Database. The following are excerpts from field observations, literature review and agency responses.

The Pitas Point HU consists of mountainous terrain, with many small canyons, with intermittent streams. Javon Creek, however, has several sections of perennial flow. According to the response from the Friends of Ventura River, this water provides existing wildlife habitats supporting regionally restricted plants, riparian wetland plants and spawning grounds for native Rainbow trout. The lower reaches provide habitat for cold water species such as native Rainbow trout and warm water species such as Threespined stickleback.

Lower Ventura River HA

The Ventura River Estuary, apart from providing wetland habitat, is an existing spawning habitat for cold water species of fish such as Prickly sculpin; habitat for federally classified or candidate rare and endangered species such as Tidewater Goby, Least Tern and Brown Pelican. **Lower Ventura River** provides existing and the **Canada Larga** provides intermittent migration and spawning habitat for native warm and cold water species including Steelhead, Threespined Stickleback and Prickly sculpin.

The Nearshore Zone provides existing spawning habitat for a variety of marine fish; the cobble tidepools provide habitat for shellfish, including Chione and Littleneck clams which are extensively harvested by sportfishers.

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Upper Ventura River HA
The mainstem of the Ventura River is an interrupted stream, with perennial flow below the confluence with San Antonio Creek, due to rising groundwater and discharge effluent from Ojai Valley Sanitation District. In the upper reaches, water from Ventura River is diverted to Lake Casitas.
Murietta Canyon, East Fork and West Fork Coyote Creek, Matilija Creek, West Fork Santa Ana Creek are existing spawning habitat for Steelhead rainbow trout. **Lake Casitas and Matilija Reservoirs**, operated by Casitas Municipal Water District (CMWD) control the flows of their tributary streams and have existing municipal, recreational and fisheries beneficial uses.
Horn Canyon, in the Ojai Valley, was found to be flowing in the upper mountainous reaches, after five years of drought. It is a source of municipal and irrigation water supply for the local Thatcher School, and hiking trails along the creek attest to its use for recreational and fisheries use. **Reeves Creek**, a tributary to the San Antonio Creek, provides migratory and spawning habitat for Steelhead rainbow trout.
Santa Clara-Calleguas HU
The Santa Clara River is the largest unurbanized river system, with extensive riparian habitat, in Southern California and includes significant tributaries like the Santa Paula, the Sespe and the Piru Creeks.
The Santa Clara River Estuary is an important wetland habitat for numerous bird species including the endangered Least Bell's vireo and California least tern, and for Tidewater goby, a Federal candidate species. Other coastal wetlands in this area include McGrath Lake, Ormond Beach Mugu Lagoon. **Mugu Lagoon** is the prime coastal wetland in Region 4, with rich vertebrate and invertebrate fauna. The most common fish found are arrow gobies, topsmelt, staghorn sculpin and shiner surfperch. Threatened and endangered species of birds using the Mugu Wetlands include light-footed clapper rail, Belding's savannah sparrow, brown pelican and least tern.
The Sespe and the Piru Creeks, in their upper reaches, flow through the Las Padres National Forest(LPNF), the newly created "Wilderness and Scenic Area", and the Condor Sanctuary. According to the response from the LPNF District Ranger, the beneficial uses in the National Forest are consistent with their Land Resources Management Plan. Sespe Creek provides habitat for spawning and migration of Steelhead rainbow trout, endangered birds including California condor and least Bell's vireo, and for candidate species including arroyo southwestern toad and southwestern pond turtle.
Pine Canyon, Coldwater Canyon and Redrock Canyon are in wilderness areas, within Condor Sanctuary and there is no public access. **West Fork Sespe Creek, Trout Creek, Piedra Blanca Creek and Potrero John Creek** are important wildlife habitat, with spawning areas for anadromous fish.
Pyramid Lake and Castaic Lakes are parts of the State Water Project, with significant existing municipal, recreational, fisheries and hydropower usage. **Lake Piru** also provides habitat for threatened and endangered species of southwestern pond turtle and Santa Ana sucker.

Pyramid Lake and Castaic Lakes are parts of the State Water Project, with significant existing municipal, recreational, fisheries and hydropower usage. Lake Piru also provides habitat for threatened and endangered species of southwestern pond turtle and Santa Ana sucker. The release of water from Drinkwater Reservoir, in San Francisquito Canyon provides habitat for Threespine stickleback.

MALIBU HYDROLOGICAL UNIT

The Malibu Region is drained by Malibu Creek and its tributaries, and a number of small creeks, all draining the Santa Monica Mountains, directly into the Pacific Ocean. It also has some reservoirs (Lake Sherwood, Westlake Lake, Lake Eleanor, Malibu Lake), and three coastal wetlands (Dume Lagoon, Malibu Lagoon and Topanga Lagoon). The beneficial uses are partially affected by the Santa Monica Mountain Recreation Area (SMMNRA). The WILD designation for the Cold Creek, Medea Creek, East Fork Arroyo Sequit, are due to their location within the SMMNRA.

According to the responses from L.A. County Natural History Museum (Camm Swift) and California Trout (Jim Edmondson), there are historical and potential anadromous migration, spawning and rearing habitats in Zuma Canyon Creek, Las Virgenes Creek, Solstice Canyon Creek, Medea Creek, Triunfo Canyon. There are existing such habitats in the Malibu Creek, Topanga Canyon Creek, Arroyo Sequit Creek and upper reaches of Big Sycamore Creek.

Malibu Lagoon is an important stopover and wintering area for migrating birds and a spawning and migratory route for Steelhead rainbow trout. It also provides habitat for California least tern, a state and federal listed endangered bird, and Tidewater Goby, a federal candidate for listing.

LOS ANGELES-SAN GABRIEL HYDROLOGIC UNIT

This includes the highly urbanized coastal plain, San Fernando Valley and San Gabriel Valley, where the rivers are largely channelized for flood control, and the headwaters of these streams in the rugged San Gabriel Mountains. The beneficial uses in the mountainous areas are affected by the Angeles National Forest Land Resources Mangement Plan and the SMMMNRA. The accessible rivers and lakes in the mountains have heavy recreational usage.

There are stretches of significant riparian wetlands in the soft bottomed channels of the Los Angeles and San Gabriel Rivers. Also, behind Whittier Narrows flood control dam there are lacustrine wetlands, with a high diversity of animal and plant life. These wetlands are also areas of heavy human usage, for recreational purposes. The wetlands in the urban coastal plain have undergone drastic reduction in size and distribution, as a result of flood control and agricultural practices. Overpumping of groundwater has lowered water table and diverted water supply from wetland areas. Should groundwater basins also have a WILD as a beneficial use?

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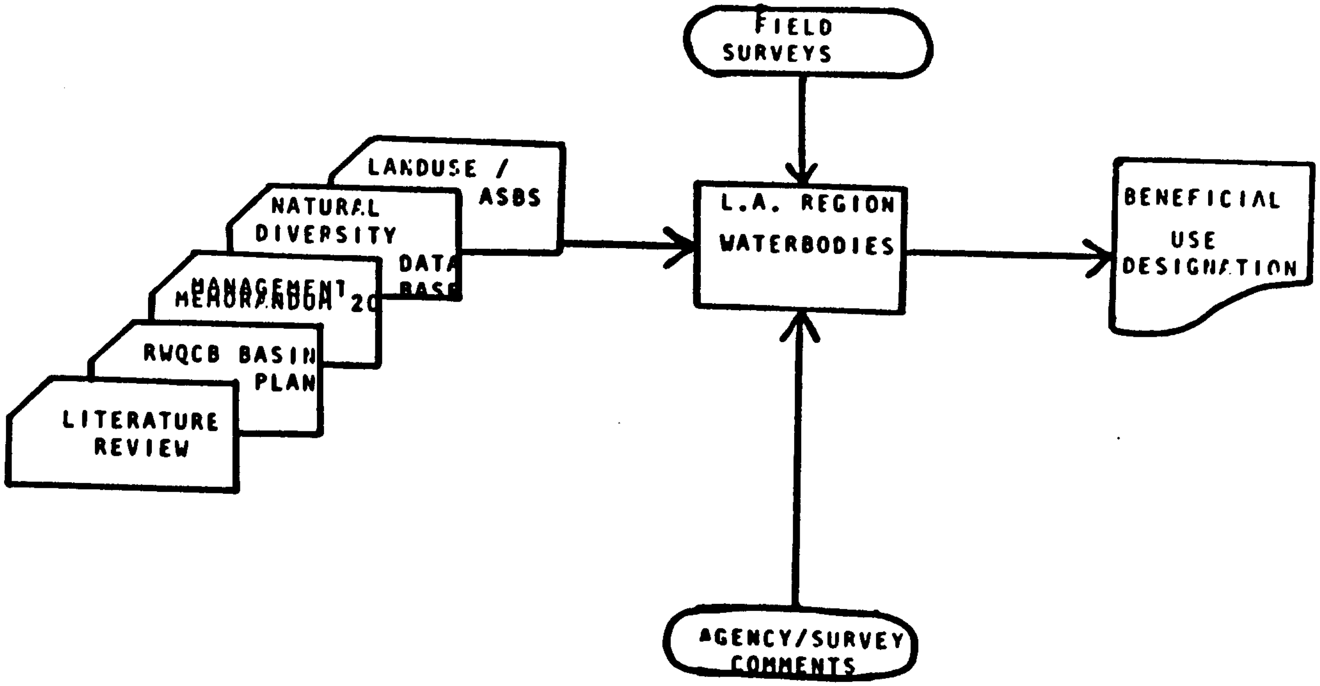

CSUF-LARWQCB WATERBODY I.D. & BENEFICIAL USE UPDATE	DECISION CRITERIA FOR BENEFICIAL USE DESIGNATION AND UPDATING OF WATERBODIES	FIG 8

TABLE 4.0

BENEFICIAL USE DEFINITIONS

Beneficial Use*	Abbreviation	Definition
Municipal and Domestic Supply	MUN	Usual uses in community or military water systems and domestic uses from individual water supply systems.
Agricultural Supply	AGR	Crop, orchard and pasture irrigation stockwatering; support of vegetation for range grazing and all uses in support of farming and ranching operations.
Industrial Service Supply	IND	Uses which do not depend primarily on water quality such as mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
Industrial Process Supply	PROC	Process water supply and all uses related to the manufacturing of products.
Ground Water Recharge	GWR	Natural or artificial recharge for future extraction for beneficial uses and to maintain salt balance or halt salt water intrusion into freshwater aquifers.
Freshwater Replenishment	FRSH	Provides a source of freshwater for replenishment of inland lakes and streams of varying salinities
Navigation	NAV	Commercial and naval shipping uses
Hydropower Generation	POW	Used for hydropower generation
Water Contact Recreation	REC-1	All recreational uses involving actual body contact with water, such as swimming, wading, waterskiing, skindiving surfing, sport fishing, uses in therapeutic spas and other uses where ingestion of water is reasonably possible.
Non-contact Water Recreation	REC-2	Recreational uses which involve the presence of water but do not require contact with water, such as picnicking sunbathing, hiking, beachcombing, camping, pleasure boating, tidepool and marine life study, hunting and aesthetic enjoyment in conjunction with the above activities, as well as sightseeing
Ocean Commercial and Sport Fishing	COMM	Commercial collection of various types of fish and shellfish, including those taken for bait purposes and sport fishing in ocean bays, estuaries, and similar non-freshwater areas
Warm Freshwater Habitat	WARM	Provides a warm-water habitat to sustain aquatic resources associated with a warm-water environment.
Cold Freshwater Habitat	COLD	Provides a cold-water habitat to sustain aquatic reasources associated with a cold-water environment.
Preservation of Areas of Special Biological Significance	BIOL	Preservation of Areas of Special Biolological Significance (ASBS) ASBS are those areas designated by the State Water Resources Control Board (SWRCB) as requiring protection of species or biological communities to the extent that alteration of natural water quality by even the slightest degree is undesirable.

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TABLE 4.0. (CONTINUED)

BENEFICIAL USE DEFINITIONS

Beneficial Use*	Abbreviation	Definition
Saline Water Habitat	SAL	Provides an inland saline water habitat for aquatic and wildlife resources
Wildlife Habitat	WILD	Provides a water supply and vegetative habitat for the maintenance
Preservation of Rare and Endangered Species	RARE	Provides an aquatic habitat necessary, at least, in part for the survival of certain species established as being rare and endangered species.
Marine Habitat	MAR	Provides for the preservation of the marine ecosystem including the propagation and sustenance of fish, shellfish, marine mammals, waterfowl, and vegetation such as kelp.
Fish Migration	MIGR	Provides a migration route and temporary aquatic environment for anadromous or other fish species
Fish Spawning	SPWN	Provides a high quality aquatic habitat especially suitable for fish spawning
Shellfish Harvesting	SHELL**	The collection of shellfish such as clams, oysters, abalone, shrimp, crab, and lobster for either commercial or sport purposes.

* The beneficial uses designated in Table 2 apply to the main watercourse named and to all tributaries thereto, unless specific tributaries are identified which may have different beneficial uses, in each hydrographic unit, area, or subarea. These waters are to be protected to insure that the designated beneficial uses are preserved.

** The definition of "SHELL" is different from that adopted by the State Health Department in that it does not include mussels but does include shrimp, crabs and lobsters.

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TABLE 4.0 Continued

Provisional Definitions for New Beneficial Use Categories

Aquaculture	AQUA	All beneficial uses associated with waters used for the propagation, cultivation, maintenance, and harvestin of aquatic plants and animals for huma consumption or bait purposes. These operations include fish hatcheries, an other aquaculture or mariculture operations.
Wetland Habitat	WET	All beneficial uses associated with waters or contiguous areas which provid wetland habitat in marine, estuarine and freshwater areas. These uses include, but are not limited to the preservation and enhancement of wetlan ecosystems (balanced communities of fish shellfish, vegetation, waterfowl, shor birds, and other wetland wildlife), flood and erosion control, filtratio and purification of naturally occurrin contaminants in water, stream-bank stabilization and control of siltation Examples of these communities includ tidal salt marshes, mudflats, brackish marshes, freshwater marshes swamps, wet meadows, bogs, bottomlan hardwoods, seasonal wetlands, and verna pools.
Estuarine	EST	All beneficial uses associated with waters used to provide an essential an unique habitat for estuarine organism that serves to acclimate anadromous fishes which migrate between fresh an marine waters and provides for the propagation and sustenance of a variet of fish and shellfish, vegetation, waterfowl, shore birds, and marine mammals.

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TABLE 4.1. BENEFICIAL USE DESIGNATION TABLES
GROUNDWATER RESOURCES

BASIN	MUN	IND	PROC	AGR
401.00 PITAS POINT HU				
p LOWER VENTURA GW BASIN		E	E	E
p ALL OTHER GROUNDWATER	P			E
402.10 LOWER VENTURA RIVER HA				
p LOWER VENTURA GW BASIN		E	E	E
p ALL OTHER GROUNDWATER	E	P	P	P
402.20 UPPER VENTURA RIVER HA				
p UPPER VENTURA GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	P
402.31 UPPER OJAI HSA				
p UPPER OJAI WEST GW BASIN	E	E	E	E
p UPPER OJAI EAST GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	P
402.32 OJAI VALLEY HSA				
p OJAI WEST GW BASIN	E	E	E	E
p OJAI EAST GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	P
403.11 OXNARD HSA				
OXNARD PLAIN GW BASIN				
SEMI-PERCHED AQUIFER	E	P		E
OXNARD AQUIFER	E	E	E	E
MUGU AQUIFER	E	E	E	E
HEUNEME AQUIFER	E	E	E	E
FOX CANYON AQUIFER	E	E	E	E
GRIMES CANYON AQUIFER	E	E	E	E
p MOUND GW BASIN	E	E	E	E
ALL OTHER GROUNDWATER	E	P	P	E

BASIN	MUN	IND	PROC	AGR
403.12 PLEASANT VALLEY HSA				
PLEASANT VALLEY G.W. BASIN				
p SEMI-PERCHED AQUIFER		E		E
p FOX CANYON AQUIFER	E	E	E	E
p GRIMES CANYON AQUIFER	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
403.21 SULPHUR SPRINGS HSA				
p SANTA PAULA GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
403.22 SISAR HSA				
p ALL GROUNDWATER	P			P
403.31 FILLMORE HSA				
p FILLMORE GW BASIN	E	E	E	E
ALL OTHER GROUNDWATER	E	P	P	E
403.32 TOPA TOPA HSA				
p ALL GROUNDWATER	P			P
403.41 SANTA FELICIA HSA				
p PIRU GW BASIN	E	E	E	E
ALL OTHER GROUNDWATER	E	P	P	E
403.42 UPPER PIRU HSA				
p ALL GROUNDWATER	P			P
403.43 HUNGRY VALLEY HSA				
HUNGRY VALLEY GW BASIN	E		E	E
p PEACE VALLEY GW BASIN	E		E	E
ALL OTHER GROUNDWATER	E	P	P	E

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BASIN	MUN	IND	PROC	AGR
403.44 STAUFFER HSA				
LOCKWOOD VALLEY GW BASIN	E	E		E
p ALL OTHER GROUNDWATER	E	P	P	E
403.51 EASTERN HSA				
p SANTA CLARA-CASTAIC GW BASIN	E	E	E	E
p SANTA CLARA EAST GW BASIN	E	E	E	E
p SANTA CLARA SOUTH FORK GW BASIN	E	E	E	E
p GREEN VALLEY GW BASIN	E	P	P	E
ALL OTHER GROUNDWATER	E	P	P	E
403.52 BOUQUET HSA				
BOUQUET CANYON GW BASIN	E	P	P	E
p ALL OTHER GROUNDWATER	P			P
403.53 MINT CANYON HSA				
p MINT CANYON GW BASIN	E			E
p ALL OTHER GROUNDWATER	P			P
403.54 SIERRA PELONA HSA				
p SIERRA PELONA GW BASIN	E	E		E
p ALL OTHER GROUNDWATER	P			P
403.55 ACTON HSA				
p ACTON VALLEY GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
403.61 WEST LAS POSAS HSA				
p NORTH LAS POSAS VALLEY GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
403.62 EAST LAS POSAS HSA				
p SOUTH LAS POSAS VALLLEY GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E

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BASIN	MUN	IND	PROC	AGR
403.63 ARROYO SANTA ROSA HSA				
p ARROYO SANTA ROSA GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
403.64 CONEJO VALLEY HSA				
p CONEJO VALLEY GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
403.65 TIERRA REJADA VALLEY HSA				
p TIERRA REJADA GW BASIN	E	P	P	E
p ALL OTHER GROUNDWATER	P			P
403.66 GILLIBRAND HSA				
p GILLIBRAND GW BASIN	E	E	P	E
p ALL OTHER GROUNDWATER	P			P
403.67 SIMI VALLEY HSA				
p SIMI VALLEY GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
403.68 THOUSAND OAKS HSA				
p THOUSAND OAKS GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
404.11 TOPANGA CANYON HSA				
p ALL GROUNDWATER	P			P
404.12 TUNA CANYON HSA				
p ALL GROUNDWATER	P			P
404.13 PENA CANYON HSA				
p ALL GROUNDWATER	P			P

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BASIN	MUN	IND	PROC	AGR[5]
404.14 PIERDO GORDA CANYON HSA				
p ALL GROUNDWATER	P			P
404.15 LAS FLORES CANYON HSA				
p ALL GROUNDWATER	P			P
404.16 CARBON CANYON HSA				
p ALL GROUNDWATER	P			P
404.21 MONTE NIDO HSA				
p MALIBU CREEK GW BASIN				E
p ALL OTHER GROUNDWATER				P
404.22 LAS VIRGENES CANYON HSA				
p ALL GROUNDWATER	P			P
404.23 LINDERO CANYON HSA				
p ALL GROUNDWATER	P			P
404.24 TRIUNFO CANYON HSA				
p ALL GROUNDWATER	P			P
404.25 RUSSELL VALLEY HSA				
p RUSSELL VALLEY GW BASIN	E			E
p ALL OTHER GROUNDWATER	P			P
404.26 SHERWOOD HSA				
p HIDDEN VALLEY GW BASIN	E			E
p ALL GROUNDWATER	P			P

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BASIN	MUN	IND	PROC	AGR
404.31 CORRAL CANYON HSA				
p ALL GROUNDWATER	P			P
404.32 SOLSTICE CANYON HSA				
p ALL GROUNDWATER	P			P
404.33 LATIGO CANYON HSA				
p ALL GROUNDWATER	P			P
404.34 ESCONDIDO CANYON HSA				
p ALL GROUNDWATER	P			P
404.35 RAMERA CANYON HSA				
p ALL GROUNDWATER	P			P
404.36 ZUMA CANYON HSA				
p ALL GROUNDWATER	P			P
404.37 TRANCAS CANYON HSA				
p ALL GROUNDWATER	P			P
404.41 ENCINAL CANYON HSA				
p ALL GROUNDWATER	P			P
404.42 LOS ALISOS CANYON HSA				
p ALL GROUNDWATER	P			P
404.43 NICHOLAS CANYON HSA				
p ALL GROUNDWATER	P			P

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BASIN	MUN	IND	PROC	AGR
404.44 ARROYO SEQUIT HSA				
p ALL GROUNDWATER	P			P
404.45 LITTLE SYCAMORE CANYON HSA				
p ALL GROUNDWATER	P			P
404.46 DEER CANYON HSA				
p ALL GROUNDWATER	P			P
404.47 BIG SYCAMORE CANYON HSA				
p ALL GROUNDWATER	P			P
404.48 LA JOLLA VALLEY HSA				
p ALL GROUNDWATER	P			P
405.11 PALOS VERDES HSA				
p ALL GROUNDWATER	P			P
405.12 WEST COAST HSA				
p WEST COAST GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	P	P	P	P
405.13 SANTA MONICA HSA				
p SANTA MONICA GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	P	P	P	P
405.14 HOLLYWOOD HSA				
p HOLLYWOOD GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	P	P	P	P

BASIN	MUN	IND	PROC	AGR
405.15 CENTRAL HSA				
CENTRAL GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	P	P	P	P
405.21 BULL CANYON HSA				
p SAN VERNANDO VALLEY GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
405.22 SYLMAR HSA				
p SYLMAR GW BASIN	E			E
p ALL OTHER GROUNDWATER	P			P
405.23 TUJUNGA HSA				
p ALL GROUNDWATER	P			P
405.24 VERDUGO HSA				
p VERDUGO GW BASIN	E			E
p ALL OTHER GROUNDWATER	P			P
405.25 EAGLE ROCK HSA				
p EAGLE ROCK GW BASIN	E			E
p ALL OTHER GROUNDWATER	P			P
405.31 PASADENA HSA				
p RAYMOND-PASADENA GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	P			P
405.32 MONK HILL HSA				
p RAYMOND-MONK HILL GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	P			P

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BASIN	MUN	IND	PROC	AGR
405.33 SANTA ANITA HSA				
p RAYMOND-SANTA ANITA GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	P			P
405.41 MAIN SAN GABRIEL HSA				
MAIN SAN GABRIEL GW BASIN	E	E	E	E
PUENTE GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
405.42 LOWER CANYON HSA				
p ALL GROUNDWATER	P			P
405.43 UPPER CANYON HSA				
p ALL GROUNDWATER	P			P
405.44 FOOTHILL HSA				
p ALL GROUNDWATER	P			P
405.51 SAN JOSE HSA				
SPADRA GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
405.52 POMONA HSA				
p POMONA GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
405.53 LIVE OAK HSA				
p LIVE OAK GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
406.10 ANACAPA ISLAND HA				
p ALL GROUNDWATER	P			P

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BASIN	MUN	IND	PROC	10 AGR
406.20 SAN NICOLAS ISLAND HA				
p ALL GROUNDWATER	P			P
406.30 SANTA BARBARA ISLAND HA				
p ALL GROUNDWATER	P			P
406.40 SANTA CATALINA ISLAND HA				
p ALL GROUNDWATER	P			P
406.50 SAN CLEMENTE ISLAND HA				
p ALL GROUNDWATER	P			P
481.21 CHINO HSA				
p CHINO GW BASIN	E	E	E	E
p ALL OTHER GROUNDWATER	E	P	P	E
481.23 CLAREMONT HEIGHTS HSA				
p CLAREMONT HEIGHTS GW BASIN	E	E	E	E
ALL OTHER GROUNDWATER	E	P	P	E

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Table 4.2. Surface Waters

BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
401.00 PITAS POINT HU																								
P JAVON CANYON	P				I				I	I		I	I			E			I	I				E
P LOS SAUCES CREEK	P				I				I	I		I	I			I			I	I				
P MADRANIO CANYON	P				I				I	I		I	I			I			I	I				
P PADRE JUAN CANYON	P				I				I	I		I	I			I			I	I				
P POVERTY CANYON	P				I				I	I		I	I			I			I	I				
NEARSHORE a							E		E	E	E							E			E			
P OTHER NEARSHORE ZONE							E		E	E	E							E			E			
P RINCON BEACH							E		E	E	E							E			E			
402.10 LOWER VENTURA RIVER HA																								
CANADA LARGA CREEK	P		I	I	I				I	I		I	I	E°		I			I°	I°				
VENTURA RIVER & TRIBUTARIES	P	E		E	E				E	E		E	E	E°		E	E°		E	E°				E
P EAST FORK HALL CANYON	P								I	I		I	I			I								
P HALL CANYON	P								I	I		I	I			I								
OTHER NEARSHORE ZONE							E		E	E	E						E	E		E°	E°			
VENTURA RIVER ESTUARY									E	E	E	E	E°			E	E°	E	E	E°	E	E		E
402.20 UPPER VENTURA RIVER HA																								
P SAN ANTONIO CREEK & TRIBUTARIES	E	E	E	E	E				E	E		E	E	E		E			E	E				E
VENTURA RIVER & TRIBUTARIES	E	E	E	E	E				E	E		E	E	E°		E	E°		E	E				E°
P AYERS CREEK	P				I°				I°	I°		I°				I°								
P CHISMAHOO CREEK	P				I°					I°						I°								
P COYOTE CREEK	P				E							E	E			E°			E°	E°				E°
P EAST FORK COYOTE CREEK	P				E°				E°	E°		E°	E°			E°			E°	E°				E°
P MATILIJA CREEK	P				E				E	E			E			E				E°				E°
P MURIETTA CANYON	P				E°				E°	E°			E°			E°			E°	E°				E°
P NORTH FORK MATILIJA CREEK	E°	E°	E°	E°	E°				E°	E°		E°	E°	E°		E°	E°							
P OLD MAN CANYON	P				E				E	E			E°			E°				E°				E°
P SANTA ANA CREEK	P			P	E°				E°	E°		E°	P°			E°	P°			E				E
P UPPER NORTH FORK MATILIJA CREEK	P				E				E	E			E			E	E°		E°	E°				E°
P WEST FORK COYOTE CREEK	E				E				E	E		E				E								
P WEST FORK SANTA ANA CREEK	P				I					I			E			E			E	E				E
P WILLOW CREEK	P				I					I		I				I				I				
LAKE CASITAS	E	E	E	E	P			P°	E°	E		E	E			E	E°							
MATILIJA RESERVOIR	E			E	E				E	E		E	E°			E			E	E				
P MIRROR LAKE					E					E														
P OJAI WETLAND										E				E		E								E
402.31 UPPER OJAI HSA																								
P LION CANYON	I	I	I	I					I	I		I	I			I								
402.32 OJAI VALLEY HSA																								
P HORN CANYON	E	P	P	E	E				E	E		E	E											
P REEVES CREEK	I	I	I	I	I				I	I		I												
403.11 OXNARD HSA																								
CALLEGUAS CREEK	P			E	E				E	E		E	E°			E	E°					E		E
REVOLON SLOUGH	P	P		E	E				E°	E		E				E								
SANTA CLARA RIVER	P	E	E	E	E				E	E		E	E°	E°		E	E°		E°	E°				E

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Table 4.2. Surface Waters

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BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
p SEXTON CANYON	P	I	I	I	I				I	I		I				I								
CHANNEL ISLANDS MARINA		E					E		E*	E	E													
MANDALAY BAY (MARINA)		E					E		E*	E								E						
PORT HUENEME (HARBOR)			E				E		E	E	E							E						
VENTURA KEYS (MARINA)							E		E	E	E							E						
VENTURA MARINA		E					E		E	E	E							E						
OTHER NEARSHORE							E		E	E	E							E			E			
p MANDALAY BEACH							E		E	E	E						E	E			E			
CALLEGUAS CREEK ESTUARY									E	E	E						E	E			E			
EDISON CANAL (TIDAL PRISM)		E							E*	E				E*		E	E*							
MCGRATH LAKE									E*	E								E						
MUGU LAGOON									E*	E*				E*		E								
SANTA CLARA RIVER ESTUARY									E*	E	P			E*		E	E*	E		E*	P	E*		E*
p ORMOND BEACH								E	E	E	E			E*		E	E*	E			E	E		E
403.12 PLEASANT VALLEY HSA																								
CALLEGUAS CREEK	P	E	E	E	E				E*	E		E				E								
CONEJO CREEK	P	E	E	E	E				E*	E		E				E								
p ARROYO LAS POSAS	P	P	P	P	E				E	E		E				E								
403.21 SULPHUR SPRINGS HSA																								
SANTA CLARA RIVER	P	E	E	E	E				E*	E		E		E*		E	E*		E					E
SANTA PAULA CREEK	P	E	E	E	E				E	E		E	E			E	E*			E				
SISAR CREEK	P	E	P	E	E				E	E		E	E	E		E	E*			E				E
403.22 SISAR HSA																								
SISAR CREEK	P	E	P	E	E				E	E		E	E	E		E	E*			E				E
403.31 FILLMORE HSA																								
SANTA CLARA RIVER	P	E	E	E	E				E*	E		E		E*		E	E*		E					E
SESPE CREEK	P	E	E	E	E				E*	E		E	E	E*		E	E*		E	E				E
403.32 TOPA TOPA HSA																								
SESPE CREEK	P	E	P	E	E				E	E		E	E	E		E	E*		E	E				E
p ALDER CREEK	P				E*				E*	E			E*			E	E*		E*					
p BEAR CANYON	P																							
p COLDWATER CANYON	P				E				E*	E		E	E*			E	E*		E*	E*				E*
p EAST FORK ALDER CREEK	P				E				P	E		E				E								
p HOT SPRINGS CANYON	P				E*				E*	I		I	E*			E*	E*		E*	E*				
p HOWARD CREEK	P				E*				E*	E*		P*				E	E*							E*
p LION CANYON	P				E*				E*	E*			E*	E*		E	E*		E*	E*				E*
p MAPLE CREEK	P				E				E*	E		E	E*			E			E*	E*				E*
p PIEDRA BLANCA CREEK	P																							
p PINE CANYON	P				E				E*	E			E*			E	E*		E*	E*				E*
p POPLAR CREEK	P				E								E*	E*		E	E*			E*				E*
p POTRERO JOHN CREEK	P				E*				I*	I			I*			E				E*				
p REDROCK CREEK	P				E				E*	E			E*			E	E*		E*	E*				E*
p ROSE VALLEY CREEK	P				E								E*	E*		E	E*			E*				E*
p TAR CREEK	P				E*				E*	E*		E*	E*			E				E*				E*
p TIMBER CREEK	P				E*				E*	E*			E*			E	E*		E*	E*				E*

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Table 4.2. Surface Waters

BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SWL	EST	AQU	WET
p TROUT CREEK	P				E				E*	E		E	E*			E	E*		E*	E*				E*
p TULE CREEK	P				E				P	E			E*	E*		E	E*		E*	E*				E*
p WEST FORK SESPE CREEK	P				E								E*	E		E	E*		E	E				
403.41 SANTA FELICIA HSA																								
HOPPER CREEK	P	E		E	E				E	E		E	E			E								
PIRU CREEK	P	E	E	E	E				E	E		E	E	E*		E	E*							
SANTA CLARA RIVER	P	E	E	E	E				E	E		E	E	E*		E	E*		E*	E				E
p DEVIL CANYON	P	E	E	E	E				E	E		E		E*		E	E*		E*					E
p DOMINGUEZ CANYON	P				I				I	I		I		E*		E								
p LECHLER CANYON	P				I							I	I*	E*		E								E*
p SANTA FELICIA CANYON	P				I				I	I		I				E								
p TAPO CANYON	P				I				I	I		I				E								
LAKE PIRU	P	E	E	E	E				E	E		E	E			E	E*			E				
403.42 UPPER PIRU HSA																								
PIRU CREEK	P	E	E	E	E				E	E		E	E			E								
p AGUA BLANCA CREEK	P				E				E	E		E	E	P*		E	E*			E				E
p BEARTRAP CANYON	P				E				E	E		E	E*	E*		E	E*			E				E*
p BUCK CREEK	P				E				E	E		E	E			E								
p FISH CREEK	P				E				E	E		E	E	E*		E	E*							
p FRAZIER CREEK	P				E				E	E		E	E	E*		E	E*							
p LOCKWOOD CREEK	P				E				E	E		E	E			E	E*							
p MUTAU CREEK	P				E				E	E		E	E			E								
p SNOWY CREEK	P				E				E	E		E	E			E								
p SOUTH FORK PIRU CREEK	P				E				E	E		E	E	E*		E	E*							
LAKE PIRU	P	E	E	E	E				E	E		E	E			E	E*							
PYRAMID LAKE	E	E	E	E	E*			E	E	E		E	E			E	E*			E				
403.43 HUNGRY VALLEY HSA																								
CANADA DE LOS ALAMOS & TRIBUTARIES	I			I	I				I	I		I	I	E*		I	E*							
p GORMAN CREEK	I	I	I	I	I				I	I		I	I	E*		E								
403.44 STAUFFER HSA																								
LOCKWOOD CREEK & TRIBUTARIES	I			I	I				I	I		I	I			I	E*							
403.51 EASTERN HSA																								
BOUQUET CANYON & TRIBUTARIES	I	I	I	I	I				I															
CASTAIC CREEK & TRIBUTARIES	I	I	I	I	I				I	E*				E*		E*								E
DRY CANYON	I	I	I	I	I				I	E*		I		E*		E*	E*							
ELIZABETH LAKE CANYON & TRIB.	I	I	I	I	I				I	I		I		E*		E*								
MINT CANYON & TRIBUTARIES	I	I	I	I	I				I	E*		I				E*								
SAN FRANCISQUITO CANYON & TRIB.	I	I	I	I	I				I	I		I		E*		E*								
SANTA CLARA RIVER & TRIBUTARIES	P	E	E	E	E			E*	I	E*		I				E*	E*							E
p SOUTH PORTAL CANYON					I				E	E		E		E*		E	E*							E
CASTAIC LAKE & ELDERBERRY FOREBAY	E	E	E	E	P				E	E		E				I								
DRY CANYON RESERVOIR	E	E	E	E	P				E	E		E				E								
LAKE ELIZABETH	P	P	P	P	P			E	E*	E		E				E								
LAKE HUGHES	P	P	P	P	P				E	E		E				E	E*							
p CASTAIC LAGOON	I	I	I	I	I				I	I		I		E*		E								

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Table 4.2. Surface Waters

BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SHL	EST	AQU	WET
p DRINKWATER RESERVOIR	P				E				E	E		P												
p MUNZ LAKES					E				E	E		P												
403.52 BOUQUET HSA																								
BOUQUET CREEK & TRIBUTARIES	P	P	P	E	E				E	E		E	E	E*		E	E*							E
BOUQUET RESERVOIR	E	E	E	E	E			P	E*	E		E				E								
403.53 MINT CANYON HSA																								
MINT CANYON & TRIBUTARIES	I			I	I				I	I		I		E*		I								
403.54 SIERRA PELONA HSA																								
AGUA DULCE CANYON & TRIBUTARIES	I			I	I				I	I		I		E*		E*								
403.55 ACTON HSA																								
AGUA DULCE CANYON & TRIBUTARIES				I	I				I	I		I		E*		E*								
SANTA CLARA RIVER & TRIBUTARIES	E	E	E	E	E				E	E		E		E*		E	E*							E
p ALISO CANYON				P	E				E	E		E		E*		E								
403.61 WEST LAS POSAS HSA																								
REVOLON SLOUGH (BEARDSLEY WASH)									E	E		E				E								
403.62 EAST LAS POSAS HSA																								
ARROYO SIMI	P	I			I				I	I		I		E*		I	E*							
CALLEGUAS CREEK & TRIB. (ARROYO LAS POSA					E				E	E		E				E								
403.63 ARROYO SANTA ROSA HSA																								
ARROYO SANTA ROSA	P				I				I	I		I				I								
CONEJO CREEK	P				I				I	I		I				I								
403.64 CONEJO VALLEY HSA																								
ARROYO CONEJO & TRIBUTARIES	P				I				I	I		I		E*		I	E*							
p NORTH FORK ARROYO CONEJO	P																							
403.65 TIERRA REJADA VALLEY HSA																								
ARROYO SANTA ROSA	P				I				I	I		I				I								
403.66 GILLIBRAND HSA																								
GILLIBRAND CANYON & TRIBUTARIES	P				I				I	I		I				I								
p TAPO CANYON	E				E				E	E		E				E								
403.67 SIMI VALLEY HSA																								
ARROYO SIMI & TRIBUTARIES	I	I			I				I	I		I				I								
p TAPO CANYON	I				I				I	I		I		E*		I								
LAKE BARD (WOOD RANCH RESERVOIR)	E	E	E	E	P				E*	E*		E		E		E								

Table 4.2. Surface Waters

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BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
p RUNKLE RESERVOIR	P															I								
403.68 THOUSAND OAKS HSA																								
ARROYO CONEJO & TRIBUTARIES	P				I				I	I		I				I								
p SKELETON CANYON	P				I				I	I		I				I								
404.11 TOPANGA CANYON HSA																								
TOPANGA CANYON CREEK	P								I	I		E	E*	E*		I			P*	E*				
p TOPANGA BEACH							E		E	E	E							E			E			
p TOPANGA LAGOON									E	E			E						P	E		E		E
404.12 TUNA CANYON HSA																								
TUNA CANYON CREEK	P								I	I		I		E*		I								
p LAS TUNAS BEACH							E		E	E	E							E			E			
404.13 PENA CANYON HSA																								
PENA CANYON CREEK	P								I	I		I	E			I								
404.14 PIERDO GORDA CANYON HSA																								
PIEDRA GORDA CANYON CREEK	P								I	I		I				I								
404.15 LAS FLORES CANYON HSA																								
LAS FLORES CANYON CREEK	P								I	I		I				I								
404.16 CARBON CANYON HSA																								
CARBON CANYON CREEK	P								I	I		I				I								
p CARBON BEACH							E		E	E	E							E			E			
p LA COSTA BEACH							E		E	E	E							E			E			
404.21 MONTE NIDO HSA																								
MALIBU CREEK	P*								E	E		E	E	E*		E	E*		E	E				E
p COLD CREEK	P			•				•	•		•			E		E	E*							E
p CENTURY RESERVOIR	P								E	E		E		E		E								E
p AMARILLO BEACH							E		E	E	E							E			E			
p MALIBU BEACH																								
MALIBU LAGOON		P							E	E				E*	E		E*	E	E	E		E		E
404.22 LAS VIRGENES CANYON HSA																								
LAS VIRGENES CREEK	P*								E*	E*		E*		E*		E*	E*		P*	P*				E
404.23 LINDERO CANYON HSA																								
LINDERO CREEK	P								I	I		I		E		I								
p MEDEA CREEK	P				I				I	I		I		E		I	E*							E
404.24 TRUINFO CANYON HSA																								
TRIUNFO CREEK	P								I	I		I		E*		I								

Table 4.2. Surface Waters

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BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SHL	EST	AQU	WET
p MEDEA CREEK	I				I				E	E		E		E		E								E
MALIBOU LAKE	P								E	E		E				E	E*							E
404.25 RUSSELL VALLEY HSA																								
p LAKE ELEANOR CREEK	P				I				I	I		I		E*		E								
p TRIUNFO CREEK	P				I				I	I		I		E*		E	E*							
LAS VIRGENES RESERVOIR (WEST LAKE RESERV	E*								E*	E*						E*								
WESTLAKE LAKE	P								E	E		E				E								
p LAKE ELEANOR	P				E				E	E		E		E		E	E*							E
404.26 SHERWOOD HSA																								
HIDDEN VALLEY CREEK	I				I				I	I		I		E*		I								
LAKE SHERWOOD	P				E				E	E		E				E	E*							E
404.31 CORRAL CANYON HSA																								
CORRAL CANYON CREEK	I								I	I		I		E		I								
PUERCO CANYON	I								I	I		I				I								
p ALL OTHER NEARSHORE							E		E	E	E							E			E			
p CORRAL BEACH							E		E	E	E							E			E			
p PUERCO BEACH							E		E	E	E							E			E			
404.32 SOLSTICE CANYON HSA																								
SOLSTICE CANYON CREEK	I								I	I		E	E	E		I			P*	P*				
404.33 LATIGO CANYON HSA																								
LATIGO CANYON CREEK	I								I	I		I		E		I	E*							
404.34 ESCONDIDO CANYON HSA																								
ESCONDIDO CANYON CREEK	I								I	I		I		E		I	E*							
p ESCONDIDO BEACH							E		E	E	E							E			E			
404.35 RAMERA CANYON																								
RAMIRA CANYON CREEK	I								I	I		I		E		I								
404.36 ZUMA CANYON HSA																								
DUME CREEK (ZUMA CANYON)	I								I	I		I		E		I	E*							
p POINT DUME BEACH																								
p WESTWARD BEACH							E		E	E	E							E			E			
p ZUMA COUNTY BEACH																								
p DUME LAGOON									E	E						E			P	P		E		E
404.37 TRANCAS CANYON HSA																								
TRANCAS CANYON CREEK	I								I	I		I		E		I	E*							
p TRANCAS BEACH							E		E	E	E							E			E			
404.41 ENCINAL CANYON HSA																								
ENCINAL CANYON CREEK									I	I		I		E		I	E*							

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BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SHL	EST	AQU	WET
404.42 LOS ALISOS CANYON HSA																								
LACHUSA CANYON CREEK	P								I	I		I		E		I								
LOS ALISOS CANYON CREEK	P								I	I		I				I	E*							
404.43 NICHOLAS CANYON HSA																								
SAN NICHOLAS CANYON CREEK	P								I	I		I		E*		I								
p NICHOLAS CANYON BEACH																								
404.44 ARROYO SEQUIT HSA																								
ARROYO SEQUIT	P				I				I	I		I	E	E*	E	I	E*		P*	E*				
p EAST FORK ARROYO SEQUIT	P				I				I	I		I	I	E*		E			I	I				
p WEST FORK ARROYO SEQUIT	P				I				I	I		I	I	E*		E			I	I				
404.45 LITTLE SYCAMORE CANYON HSA																								
LITTLE SYCAMORE CANYON CREEK	P								I	I		I		E*		I	E*							
404.46 DEER CANYON HSA																								
p DEER CANYON	P				I				I	I		I		E*		E								
404.47 BIG SYCAMORE CANYON HSA																								
BIG SYCAMORE CANYON CREEK	P				I				I	I		I	E*	E*		I			P*	P*				E
p SERRANO CANYON	P				I				I	I		I		E*		I								
p WOOD CANYON	P				I				I	I		I		E*		I								
404.48 LA JOLLA VALLEY HSA																								
p LA JOLLA CANYON	P				I				I	I		I		E*		I	E*							
405.11 PALOS VERDES HSA																								
p AGUA AMARGA CANYON	P				I					I						E*	E*							
p ALTAMIRA CANYON	P				I					I						I	E*							
p KLONDIKE CANYON	P																							
p MALAGA CANYON	P									I						P								
p PORTUGUESE CANYON	P				I					I						I	E*							
p ABALONE COVE																								
p POINT VICENTE BEACH																								
p ROYAL PALMS BEACH																								
p WHITES POINT BEACH																								
405.12 WEST COAST HSA																								
DOMINGUEZ CHANNEL TO TIDAL PRISM		P	P		P				P	E		P				P								
LOS ANGELES RIVER TO TIDAL PRISM									E	E		E*				E*	P*		P	P*				
p AGUA MAGNA CANYON									E	E*						E*								
p BENT SPRING CANYON	P									I						E								
p GEORGE CANYON	P									E						E								
p MIRALESTE CANYON	P									I						P								
p SAN PEDRO CANYON	P									I						E								

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BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SHL	EST	AQU	WET
p SEPULVEDA CANYON	P																							
BIXBY SLOUGH AND HARBOR LAKE										E						E								
p COLORADO LAGOON									E	E		E				E	E*							E
p MADRONA MARSH									E	E	E					E					E			
KING HARBOR-REDONDO BEACH										E				E		E								E
L.A./L.B. ALL OTHER INNER AREAS		E								E	E						E	E						
L.A./L.B. OUTER HARBOR		E					E			E							E	E			P			
L.A./L.B./HARBOR, MARINAS							E			E	E						E	E			P			
L.B. MARINA - ALL OTHER AREAS										E							E	E			P			
L.B. MARINA, STADIUM, & ALAMITOS BAY										E	E						E	E			P			
L.A./L.B. HARBOR/PUBLIC BEACH AREAS										E	E						E	E			E			
L.B. MARINA - PUBLIC BEACH AREAS									E	E	E						E	E			E			
p CABRILLO BEACH									E	E	E						E	E						
p DOCKWEILER BEACH																								
p HERMOSA BEACH																								
p LONG BEACH							E		E	E	E							E			E			
p MANHATTAN BEACH							E		E	E	E							E			E			
p OTHER NEARSHORE							E		E	E	E							E			E			
p REDONDO BEACH							E		E	E	E							E			E			
p TORRANCE BEACH									E	E								E						
DOMINGUEZ CHANNEL (TIDAL PRISM)																								
LOS ANGELES RIVER (TIDAL PRISM)										E					E		E	E						
p LOS CERRITOS CHANNEL (TIDAL PRISM)		E							E	E	E				E		E	E			P	E		
p ALAMITOS BAY		E								E	E				E		E	E			E	E		
									E	E				E*		E	P*					E		E
405.13 SANTA MONICA HSA																								
BALLONA CREEK ESTUARY																								
MANDEVILLE CANYON CREEK									E	E	E				E		E	E			E	E		
RUSTIC CANYON CREEK									I	I		I				I								
SANTA MONICA CANYON CHANNEL									I	I		I		E*		I								
SULLIVAN CANYON CREEK									P	I		P				P								
p CENTINELA CREEK CHANNEL									I	I		I		E*		I								
p SANTA YNEZ CANYON	P								P	P		P				P	E*							
p SEPULVEDA CHANNEL									I	E		I		E*		E	E*							
p SANTA YNEZ LAKE (LAKE SHRINE)	P																							
p STONE CANYON RESERVOIR										E		E												
p UPPER STONE CANYON RESERVOIR	E	E*	E*		E				E*	E*						E								
MARINA DEL REY - ALL OTHER AREAS																								
p MARINA DEL REY HARBOR										E	E						E	E			E			
MARINA DEL REY - PUBLIC BEACH AREAS							E		E	E	E							E			E			
p OTHER NEARSHORE ZONE									E	E							E	E						
p SANTA MONICA BEACH							E		E	E	E							E			E			
p VENICE BEACH							E		E	E	E							E			E			
p WILL ROGERS BEACH							E		E	E	E							E			E			
BALLONA CREEK TO TIDAL PRISM									E	E								E						
MARINA DEL REY - ENTRANCE CHANNEL									P	E		P				P								
VENICE CANALS - BALLONA CREEK (TIDAL PRI										E	E						E	E			E			
p BALLONA LAGOON	•								E	E	E				E		E	E			E			
p BALLONA WETLANDS										I*		I*	I*	E*	E	E	E*	E*		I*	E*	E*		E
p DEL REY LAGOON										E				E		E	E							E
									E	E						E								E
405.14 HOLLYWOOD HSA																								
p HOLLYWOOD RESERVOIR	E	E	E		P				E*	E*		E				E								

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BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
p LOWER FRANKLIN CANYON RESERVOIR	E*	E*	E*						E*	E*						E								
p UPPER FRANKLIN CANYON RESERVOIR	E*		E*						E	E		E				E								E
405.15 CENTRAL HSA																								
ARROYO SECO S. OF DEVIL'S GATE RES. (L)	P								I	I		P		E*		P								
COMPTON CREEK	P				E				P	E		E		P*		E								
COYOTE CREEK TO BEGINNING OF TIDAL PRISM		P	P						P	I		P				P	E*							
LOS ANGELES RIVER TO TIDAL PRISM		P*	P*		E				P	E		P		P*		P								
LOS CERRITOS CHANNEL TO TIDAL PRISM									P	I		I				I								
RIO HONDO BELOW SPREADING GROUNDS									P	I		P				P								
RIO HONDO TO SPREADING GROUNDS					I				I	I		P				P								
SAN GABRIEL RIVER-FIRESTONE BLVD. TO TID		P*	P						E	E		P				P								
p BALLONA CREEK									P	E		P		E		E								
p EL DORADO LAKES									E	E		E				E								E
p ELYSIAN RESERVOIR	E	E	E																					
p IVANHOE RESERVOIR	E*	E*	E*																					
p MORNINGSIDE PARK RESERVOIR	P									E						E								
p SILVER LAKE RESERVOIR	P									E						E								
p SIMS POND									E*	E*						E								
SAN GABRIEL RIVER (TIDAL PRISM)		E								E				E		E								E
p LOS CERRITOS LAGOON									E	E	E				E		E	E			P	E		
p LOS CERRITOS WETLANDS										E				E		E	E							E
405.21 BULL CANYON HSA																								
ALISO CREEK	P				I				I	I		I				I								
ARROYO CALABASAS	P								P	I		P		E*		P								
BELL CREEK	P				I				I	I		I				I								
BROWNS CREEK	P				I				I	I		I		E*		I								
BULL CREEK	P				I				I	I		I		E*		I								
BURBANK WESTERN CHANNEL										I		I				I								
CABALLERO CREEK	P				I				I	I		P				P								
DAYTON CANYON CREEK	P				I				I	I		I				I								
DRY CANYON CREEK	P				I				I	I		I		E*		I								
LA TUNA CANYON CREEK	P				I				I	I		I				I								
LIMEKILN CREEK	P				I				I	I		I		E*		I								
LOPEZ CANYON CREEK	P				I				I	I		I		E*		I								
LOS ANGELES RIVER		P*	P*	P*	I				I	I		I		E*		I								
MCCOY CANYON CREEK	P				E				E	E		E		E*		E	P*							
PACOIMA WASH	P				I				I	I		I		E*		I								
TUJUNGA WASH	P				E				P	E		E				E	E*							
p CHATSWORTH CREEK	P				I				P	I		P	P			P								
CHATSWORTH RESERVOIR	E	E	E		I					E		E				E								
LOS ANGELES RESERVOIR	E	E	E							E		E				E								
LOWER VAN NORMAN RESERVOIR										E						E								
SEPULVEDA FLOOD CONTROL RESERVOIR	P				I				I	E*		E*		E*		I								
p ENCINO RESERVOIR	E				P				E*	E*		E				E								
p GIRARD RESERVOIR	P*				P				I	I		I												
p LEES LAKE	P*				P				I	I		I												
p MONTERIA LAKE	P								E	E		E				E								
p SOLANO RESERVOIR	E	E	E							E		E				E								
p TOLUCA LAKE										E		E				E	E*							
405.22 SYLMAR HSA																								
HAY CANYON CREEK	P				I				I	E		I				I								

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BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
PACOIMA CANYON CREEK	P				E				E	E		E	E	E*		E	E*			E				E
STETSON CANYON CREEK	P				I				P	E		P				P								
WILSON CANYON CREEK	P				I				E	E		I		E*		I								
PACOIMA RESERVOIR	P				E				E	E		E				E								
405.23 TUJUNGA HSA																								
BIG TUJUNGA CANYON CREEK	P				E				E	E		E	E	E*		E	E*							E
HAINES CANYON CREEK	P				I				I	I		I		E*		I	E*							
KAGEL CANYON CREEK	P				I				I	I		I		E*		I								
LITTLE TUJUNGA CANYON CREEK	P				I				I	E*		I	I	E*		I	E*							
MILL CREEK	P				E				E	E		E	E	E*		E								
p ALDER CREEK	P				I				I	I		I		E*		E								E
p CLEAR CREEK	P				E				E	E		E	E	E*		E								E
p FALL CREEK	P				I				I	I		I		E*		E								
p FOX CREEK	P				I				I	I		I		E*		E								
p LOPEZ CANYON	P				I				I	I		I				I								
p UPPER BIG TUJUNGA CANYON CREEK	P				E				E	E		I		E*		E								
p VASQUEZ CREEK	P				E				E	E		P	P	E*		E								
p WEST FORK ALDER CREEK	P				I				I	I		I		E*		E								
p WEST FORK FOX CREEK	P				I				I	I		I		E*		E								
p WHITE OAK CANYON	P				I				I	I				E*		E								
p WICKIUP CANYON	P				I				I	I		I		E*		E								
BIG TUJUNGA RESERVOIR	P				E					E		E	P			E				E				
HANSEN FLOOD CONTROL RESERVOIR	P				E				E	E		E	E			E								
p HANSEN LAKE	P				E									E*		E								
p MIDDLE LAKE	P				E											E								
405.24 VERDUGO HSA																								
DUNSMORE CANYON CREEK	I	I	I		I				I	I		I				I								
PICKENS CANYON - BEFORE SHOVER CYN					I				I	I		I				I								
PICKENS CANYON CHANNEL BELOW FOOTHILL	I*				I				I	I		I		E*		I								
PICKENS CANYON-SHOVER CYN. TO FOOTHILL					I				I	I		I				I								
SHIELDS CANYON	I	I	I		I				I	I		I		E*		I								
VERDUGO WASH					I				P	I		P				P								
405.25 EAGLE ROCK HSA																								
p EAGLE ROCK RESERVOIR	E*	E*	E*		E											E								
405.31 PASADENA HSA																								
ARROYO SECO S. OF DEVIL'S GATE RES. (U)	P								I	I		P				P	E*							
EATON CANYON CREEK	P				I				E	E		E		E*		E	E*							E
EATON WASH (BELOW DAM)	P				I				I	I		I				P								
RUBIO CANYON	P				E				I	I		I		E*		E	E*							E
DEVILS GATE RESERVOIR (LOWER)	P				I				I	I		I				I								
EATON DAM AND RESERVOIR	P				I					I		I				E								
405.32 MONK HILL HSA																								
ARROYO SECO CANYON	E	E	E		E				E	E		E	E	E*		E								E
EL PRIETO CANYON CREEK	I	I	I		I				I	I		I		E*		I								
LITTLE BEAR CREEK	P				I				I	I		I	I	E*		I								

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BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
MILLARD CANYON CREEK	I	I	I		E				E	E		E		E*		E	E*							E
SNOVER CANYON	I	I	I		I				I	I		I		E*		I								
DEVIL'S GATE RESERVOIR (UPPER)	I				I				I	I		I				I								
405.33 SANTA ANITA HSA																								
ARCADIA WASH (UPPER)	P				I				P	I		P				P								
BIG SANTA ANITA CANYON CREEK	E				E				E	E		E	E	E*		E	E*			E				E
LITTLE SANTA ANITA CANYON CREEK	P				I				I	I		I		E*		E								
SANTA ANITA WASH (UPPER)					E				E	E*		E*		E*		E	E*							
WINTER CREEK	P				E				E	E		E		E*		E								
p EAST FORK SANTA ANITA CANYON	P				I				I	I		I	I	E*		E								E
BIG SANTA ANITA RESERVOIR	P				E					E		E	E			E								
405.41 MAIN SAN GABRIEL HSA																								
ALHAMBRA WASH	P				I				P	I		P				P								
ARCADIA WASH (LOWER)	P				I				P	I		P				P	E*							
BELL CANYON	P				I				I	I		I				E								
BIG DALTON CANYON CREEK	P				I				I	I		I		E		E								
BIG DALTON WASH	P				I				I	I		I		E*		E								E
BRADBURY CANYON CREEK	P				I				P	I		P				P								
LITTLE DALTON CANYON CREEK	P				I				I	I		I		E*		I								
LITTLE DALTON WASH	P				I				I	I		I		E*		I								E
MONROVIA CANYON CREEK	I				I				P	I		P				P								E
MYSTIC CANYON	P				I				I	I		I		E		E								E
PUDDINGSTONE WASH	P				I				I	I		I				I								
PUENTE CREEK					I				I	I		I				I								
RIO HONDO					I				P	I		P				P								
SAN DIMAS WASH (LOWER)	P				I				I	I		P				P	E*							
SANTA ANITA WASH (LOWER)	P				I				I	I		I		E*		I	E*							E
SAWPIT CANYON	P				I				P	E*		P		E*		P	E*							
SAWPIT WASH	I				I				I	I		I		E*		I	E*							
SPINKS CANYON CREEK	P				I				I	I		I				I								
WALNUT CREEK WASH	P				I				I	I		I		E*		I								
p EATON WASH	P				E				E	E		E				E								E
p MARSHALL CREEK	P				I				I	I		I				I								
p RUBIO WASH	P				E				E	E		E		E		E	E*							E
p SAN GABRIEL RIVER	P				I				I	I		I				I								
p SAN JOSE CREEK	P				I				P	I		I				I								
p SAN JOSE CREEK (OLD CHANNEL)	P				I				P	I		I				I								
p SOUTH SAN JOSE CREEK	P				I				P	I		I				I								
BIG DALTON DAM AND RESERVOIR	P				I					I		I				I								
LEGG LAKE	P				E					E		E				E								
SANTA FE FLOOD CONTROL BASIN	P				E				E	E		E	E			E								E
SAWPIT DAM AND RESERVOIR	P				I				P	I		I		E*		I								
WHITTIER NARROWS FLOOD CONTROL BASIN (RE	P				E				E	E		E				E								
405.42 LOWER CANYON HSA																								
SAN GABRIEL RIVER	E*	E	E	E	E				E	E		E	E	E*		E	E*							
405.43 UPPER CANYON HSA																								
CATTLE CREEK	P				E				E	E		E	E	E*		E	E*			E				E

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BENEFICIAL USE DESIGNATION TABLES

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BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
COLDWATER CANYON CREEK	P																							
COW CREEK	P				E				E	E		E	E	E*		E	E*			E				E
DEVILS CANYON CREEK	P				E				E	E		E	E	E*		E	E*			E				E
EAST FORK SAN GABRIEL RIVER	P				E				E	E		E	E	E*		E				E				E
FISH CANYON	P	I			E				E	E		E	E	E		E	E*			E				E
MADDOCK CANYON CREEK	P				E				E	E		E		E*		E	E*			E				E
NORTH FORK SAN GABRIEL RIVER	P				I				I	I		I				I								
ROBERTS CANYON	P				E				E	E		E	E	E*		E	E*			E*				E
SAN GABRIEL RIVER - MAIN STEM	P	P			I				I	I		I		E*		I	E*							E
VAN TASSEL CANYON	P				E				E	E		E		E		E								
WEST FORK SAN GABRIEL RIVER	P				I				I	I		I		E*		I	E*							
p ALLISON GULCH	P				E			P	E	E		E	E	E*		E	E*			E				E
p BEAR CREEK	P				I				I	I		I	I	E			E*							E
p BICHOTA CANYON	I				E				E	E		E	E	E*		E	E*			E*				E
p BOBCAT CANYON	P				I				I	I		I		E*		E								
p CEDAR CREEK	P				I				I	I		I	I											
p CHILENO CANYON	P				I				I	I		I				E								
p COLDBROOK CREEK	P				E				E	E		E	E	E*		E	E*							
p FISH FORK	P				I				I	I		I		E*		E								
p IRON FORK	P				E				E	E		E	E	E*		E				E*				E
p LOST CANYON	P				E				E	E		E	E	E*		E				E*				E
p PRAIRIE FORK	P				I				I	I		I		E*										
p SOLDIER CREEK	P				I				I	I		I	I	E*		E								E
p SOUTH FORK IRON FORK	P				I				I	I		I		E*		E								
p TUMBLER CANYON	P				E				E	E		E	E	E*		E				E*				E
p VINCENT GULCH	P				I				I	I		I	I	E*		E								
p WEST FORK BEAR CREEK	P				I				I	I		I	I	E*		E								
COGSWELL RESERVOIR	P				E				E	E		E	E	E*		E	E*			E				
CRYSTAL LAKE	P				E				E	E		E	E			E				E				
MORRIS RESERVOIR	E	E	E	E	E			E	P	E		E	E			E				E				
SAN GABRIEL RESERVOIR	E	E	E	E	E			E	E	E		E	E	E*		E				E				
405.44 FOOTHILL HSA																								
SAN DIMAS CANYON CREEK	E				E				E	E		E	E	E*		E								E
SAN DIMAS WASH (UPPER)	P				E				I	I		I		E*		I								
p FERN CANYON	P				E				E	E		E		E*		E								
p WEST FORK SAN DIMAS CANYON	P				I				I	I		I		E*		E								
p WOLFSKILL CANYON	P				E				E	E		E		E*		E	E*							
SAN DIMAS DAM AND RESERVOIR	P				E					E		E	E			E								
405.51 SAN JOSE HSA																								
SAN JOSE CREEK					I				P	I		I				I								
405.52 POMONA HSA																								
p LIVE OAK WASH	P				I				I	I		I				I								
p THOMPSON WASH	P				I				I	I		I				I								
PUDDINGSTONE DAM AND RESERVOIR	P			E	E				E	E		E	E			E	E*							
405.53 LIVE OAK HSA																								
EMERALD CREEK AND WASH	P				I	I			I	I		I				I								
LIVE OAK CREEK AND WASH	P				I	I			I	I		I		E*		I								

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BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
MARSHALL CREEK AND WASH					I				I	I		I		E*		I	E*							E
THOMPSON CREEK					I				I	I		I		E*		I	E*							
LIVE OAK DAM AND RESERVOIR					E				E	E		E				E								
THOMPSON CREEK DAM AND RESERVOIR					I					I		I				I	E*							
406.01 PACIFIC OCEAN HA																								
NEARSHORE ZONE		E					E		E	E	E		E	E*			E*	E	•	•	E			
OFFSHORE ZONE c		E					E		E	E	E						E	E	•	•	E			
406.10 ANACAPA ISLAND HA																								
NEARSHORE							E		E	E	E			E*				E	E*	E*	E			
ISLANDS																E	E							
406.20 SAN NICOLAS ISLAND HA																								
SURFACE WATERCOURSES																E	I*							
BEGG-ROCK NEARSHORE ZONE									E	E	E			E*			E	E			E			
NEARSHORE ZONE									E	E	E			E*			E	E	E*	E*	E			
406.30 SANTA BARBARA ISLAND HA																								
SANTA BARBARA ISLAND							E		E	E	E			E*		E	E	E*			E			
406.40 SANTA CATALINA ISLAND HA																								
p MIDDLE CANYON CREEK	P				I				I	I						I	I							
p BIG SPRINGS RESERVOIR	P				E				E	E						E	E							
p BUFFALO SPRINGS RESERVOIRS	E				E				P	E						E								
p CAPE CANYON RESERVOIR	P				I				I	I						I								
p DEEP TANK RESERVOIR	P				I				I	I						I								
p ECHO LAKE	P				I				I	I						I								
p HAYPRESS RESERVOIR	P				I				I	I						I								
p LOWER BUFFALO CORRAL RESERVOIR	P				I				I	I						I								
p PATRICK RESERVOIR	P				I				I	I						I								
p SUMMIT RESERVOIR	P				I				I	I						I								
p THOMPSON DAM	P				I				I	I						I								
p UPPER BUFFALO CORRAL RESERVOIR	P				I				I	I						I								
p WRIGLEY RESERVOIR	E				E				E	E						E								
p AVALON CANYON CREEK	P				I				I	I						I								
p BIG SPRINGS CANYON	P				I				I	I						I								
SANTA CATALINA ISLAND							E		E	E	E			E*			E	E			E			
406.50 SAN CLEMENTE ISLAND HA																								
SAN CLEMENTE ISLAND							E		E	E	E			E*			E	E*			E			
481.21 CHINO SPLIT																								
p SAN ANTONIO CREEK CHANNEL					I				P	I		I				I								
481.23 CLAREMONT HEIGHTS SPLIT																								
SAN ANTONIO CANYON CREEK	E			E	E			E	E	E		E	E	E*		E								E

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SHL	EST	AQU	WET
p SAN ANTONIO CREEK CHANNEL					I				P	I		I				I								
SAN ANTONIO DAM AND RESERVOIR					E				E	E		E				E								

Explanation:

Names preceded with a 'p' are newly proposed waterbodies not included in previous basin plan.

Beneficial use designations that are underlined are unchanged from the previous basin plan. All beneficial use designations which are not underlined represent newly proposed beneficial uses.

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Table 4.3 WETLANDS

BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
401.00 PITAS POINT HU																								
p JAVON CANYON	P				I				I	I		I	I			E			I	I				E
402.10 LOWER VENTURA RIVER HA																								
VENTURA RIVER & TRIBUTARIES	P	E		E	E				E	E		E	E	E*		E	E*		E	E*				E
VENTURA RIVER ESTUARY									E	E	E	E	E*			E	E*	E	E	E*	E	E		E
402.20 UPPER VENTURA RIVER HA																								
p SAN ANTONIO CREEK & TRIBUTARIES	E	E	E	E	E				E	E		E	E	E		E			E	E				E
VENTURA RIVER & TRIBUTARIES	E	E	E	E	E				E	E		E	E	E*		E	E*		E	E				E*
p COYOTE CREEK	P				E							E	E			E*			E*	E*				E*
p EAST FORK COYOTE CREEK	P				E*				E*	E*		E*	E*			E*			E*	E*				E*
p MATILIJA CREEK	P				E				E	E			E			E				E*				E*
p MURIETTA CANYON	P				E*				E*	E*			E*			E*			E*	E*				E*
p OLD MAN CANYON	P				E				E	E			E*			E*				E*				E*
p SANTA ANA CREEK	P			P	E*				E*	E*		E*	P*			E*	P*			E				E
p UPPER NORTH FORK MATILIJA CREEK	P				E				E	E			E			E	E*		E*	E*				E*
p WEST FORK SANTA ANA CREEK	P				I					I			E			E			E	E				E
p OJAI WETLAND										E				E		E								E
403.11 OXNARD HSA																								
CALLEGUAS CREEK	P			E	E				E	E		E	E*			E	E*					E		E
SANTA CLARA RIVER	P	E	E	E	E				E	E		E	E*	E*		E	E*		E*	E*				E
MUGU LAGOON									E*	E	P			E*		E	E*	E		E*	P	E*		E*
SANTA CLARA RIVER ESTUARY									E	E				E*		E	E*					E		E
p ORMOND BEACH								E	E	E	E					E	E	E			E			E
403.21 SULPHUR SPRINGS HSA																								
SANTA CLARA RIVER	P	E	E	E	E				E*	E		E		E*		E	E*		E					E
SISAR CREEK	P	E	P	E	E				E	E		E	E	E		E	E*			E				E
403.22 SISAR HSA																								
SISAR CREEK	P	E	P	E	E				E	E		E	E	E		E	E*			E				E
403.31 FILLMORE HSA																								
SANTA CLARA RIVER	P	E	E	E	E				E*	E		E		E*		E	E*		E					E
SESPE CREEK	P	E	E	E	E				E*	E		E	E	E*		E	E*		E	E				E
403.32 TOPA TOPA HSA																								
SESPE CREEK	P	E	P	E	E				E	E		E	E	E		E	E*		E	E				E
p BEAR CANYON	P				E				E*	E		E	E*			E	E*		E*	E*				E*
p HOT SPRINGS CANYON	P				E*				E*	E*		P*				E	E*							E*
p HOWARD CREEK	P				E*				E*	E*			E*	E*		E	E*		E*	E*				E*
p LION CANYON	P				E				E*	E		E	E*			E			E*	E*				E*
p PIEDRA BLANCA CREEK	P				E				E*	E			E*			E	E*		E*	E*				E*
p PINE CANYON	P				E								E*	E*		E	E*			E*				E*
p POTRERO JOHN CREEK	P				E				E*	E			E*			E	E*		E*	E*				E*
p REDROCK CREEK	P				E								E*	E*		E	E*			E*				E*
p ROSE VALLEY CREEK	P				E*				E*	E*		E*	E*			E				E*				E*
p TIMBER CREEK	P				E*				E*	E*			E*			E	E*		E*	E*				E*
p TROUT CREEK	P				E				E*	E		E	E*			E	E*		E*	E*				E*
p TULE CREEK	P				E				P	E			E*	E*		E	E*		E*	E*				E*

Table 4.3. WETLANDS

BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
403.41 SANTA FELICIA HSA																								
PIRU CREEK	P	E	E	E	E				E	E		E	E	E*		E	E*		E*	E				E
SANTA CLARA RIVER	P	E	E	E	E				E	E		E		E*		E	E*		E*					E
p DOMINGUEZ CANYON	P				I							I	I*	E*		E								E*
403.42 UPPER PIRU HSA																								
PIRU CREEK	P	E	E	E	E				E	E		E	E	P*		E	E*			E				E
p AGUA BLANCA CREEK	P				E				E	E		E	E*	E*		E	E*			E				E*
403.51 EASTERN HSA																								
BOUQUET CANYON & TRIBUTARIES	I	I	I	I	I				I	E*				E*		E*								E
SAN FRANCISQUITO CANYON & TRIB.	I	I	I	I	I			E*	I	E*		I				E*	E*							E
SANTA CLARA RIVER & TRIBUTARIES	P	E	E	E	E				E	E		E		E*		E	E*							E
403.52 BOUQUET HSA																								
BOUQUET CREEK & TRIBUTARIES	E	E	E	E	E				E	E		E	E	E*		E	E*							E
403.55 ACTON HSA																								
SANTA CLARA RIVER & TRIBUTARIES	E	E	E	E	E				E	E		E		E*		E	E*							E
404.11 TOPANGA CANYON HSA																								
p TOPANGA LAGOON									E	E			E						P	E		E		E
404.21 MONTE NIDO HSA																								
MALIBU CREEK	P*			•				•	E	E	•	E	E	E*		E	E*		E	E				E
p COLD CREEK	P													E		E	E*							E
p CENTURY RESERVOIR	P	P							E	E		E		E		E								E
MALIBU LAGOON									E	E				E*	E		E*	E	E	E		E		E
404.22 LAS VIRGENES CANYON HSA																								
LAS VIRGENES CREEK	P*								E*	E*		E*		E*		E*	E*		P*	P*				E
404.23 LINDERO CANYON HSA																								
p MEDEA CREEK	P				I				I	I		I		E		I	E*							E
404.24 TRIUNFO CANYON HSA																								
p MEDEA CREEK	I				I				E	E		E		E		E								E
MALIBOU LAKE	P								E	E		E				E	E*							E

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1 8830

R0052135

Table 4.3. WETL[illegible]S
BENEFICIAL USE DESIGNATION [illegible]ES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SHL	EST	AQU	WET
404.25 RUSSELL VALLEY HSA																								
p LAKE ELEANOR	P				E				E	E		E		E		E	E*							E
404.26 SHERWOOD HSA																								
LAKE SHERWOOD	P				E				E	E		E				E	E*							E
404.36 ZUMA CANYON HSA																								
p DUME LAGOON									E	E						E			P	P		E		E
404.47 BIG SYCAMORE CANYON HSA																								
BIG SYCAMORE CANYON CREEK	P				I				I	I		I	E*	E*		I			P*	P*				E
405.12 WEST COAST HSA																								
BIXBY SLOUGH AND HARBOR LAKE									E	E		E				E	E*							E
p MADRONA MARSH										E				E		E								E
p ALAMITOS BAY									E	E				E*		E	P*					E		E
405.13 SANTA MONICA HSA																								
p BALLONA LAGOON	•									I*		I*	I*	E*	E	E	E*	E*		I*	E*	E*		E
p BALLONA WETLANDS										E				E		E	E							E
p DEL REY LAGOON									E	E						E								E
405.14 HOLLYWOOD HSA																								
p UPPER FRANKLIN CANYON RESERVOIR	E*		E*						E	E		E				E								E
405.15 CENTRAL HSA																								
p EL DORADO LAKES									E	E		E				E								E
p SIMS POND										E				E		E								E
p LOS CERRITOS WETLANDS										E				E		E	E							E
405.22 SYLMAR HSA																								
PACOIMA CANYON CREEK	P				E				E	E		E	E	E*		E	E*			E				E
405.23 TUJUNGA HSA																								
BIG TUJUNGA CANYON CREEK	P				E				E	E		E	E	E*		E	E*							E
p ALDER CREEK	P				I				I	I		I		E*		E								E
p CLEAR CREEK	P				E				E	E		E	E	E*		E								E
405.31 PASADENA HSA																								
EATON CANYON CREEK	P				I				E	E		E		E*		E	E*							E
RUBIO CANYON	P				E				I	I		I		E*		E	E*							E
405.32 MONK HILL HSA																								
ARROYO SECO CANYON	E	E	E		E				E	E		E	E	E*		E								E
MILLARD CANYON CREEK	I	I	I		E				E	E		E		E*		E	E*							E
405.33 SANTA ANITA HSA																								
BIG SANTA ANITA CANYON CREEK	E				E				E	E		E	E	E*		E	E*			E				E
WINTER CREEK	P				E				E	E		E		E*		E								E
405.41 MAIN SAN GABRIEL HSA																								
BIG DALTON CANYON CREEK	P				I				I	I		I		E*		E								E
LITTLE DALTON CANYON CREEK	P				I				I	I		I		E*		I								E
LITTLE DALTON WASH	P				I				P	I		P				P								E
MONROVIA CANYON CREEK	I				I				I	I		I				E								E
SAN DIMAS WASH (LOWER)	P				I				I	I		I		E		I								E
WALNUT CREEK WASH	P				I				I	I		I		E*		I	E*							E
p MARSHALL CREEK	P				I				I	I		I				I								E
LEGG LAKE	P				E				E	E		E	E			E								E

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Table 4.3. WETLANDS

BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
405.43 UPPER CANYON HSA																								
CATTLE CREEK	P				E				E	E		E	E	E°		E	E°			E				E
COLDWATER CANYON CREEK	P				E				E	E		E	E	E°		E	E°			E				E
COW CREEK	P				E				E	E		E	E	E°		E	E°			E				E
DEVILS CANYON CREEK	P				E				E	E		E	E	E°		E				E				E
EAST FORK SAN GABRIEL RIVER	P				E				E	E		E	E	E		E	E°			E				E
FISH CANYON	P	I			E				E	E		E		E°		E	E°			E				E
NORTH FORK SAN GABRIEL RIVER	P				E				E	E		E	E	E°		E	E°			E°				E
ROBERTS CANYON	P				I				I	I		I		E°		I	E°							E
WEST FORK SAN GABRIEL RIVER	P				E			P	E	E		E	E	E°		E	E°			E				E
p ALLISON GULCH	P				I				I	I		I	I	E			E°							E
p BEAR CREEK	P				E				E	E		E	E	E°		E	E°			E°				E
p FISH FORK	P				E				E	E		E	E	E°		E				E°				E
p IRON FORK	P				E				E	E		E	E	E°		E				E°				E
p PRAIRIE FORK	P				I				I	I		I	I	E°		E								E
p SOUTH FORK IRON FORK	P				E				E	E		E	E	E°		E				E°				E
405.44 FOOTHILL HSA																								
SAN DIMAS CANYON CREEK	E				E				E	E		E	E	E°		E								E
405.53 LIVE OAK HSA																								
MARSHALL CREEK AND WASH					I				I	I		I		E°		I	E°							E
481.23 CLAREMONT HEIGHTS SPLIT																								
SAN ANTONIO CANYON CREEK	E			E	E			E	E	E		E	E	E°		E								E

Explanation:

Names preceded with a 'p' are newly proposed waterbodies not included in previous basin plan.

Beneficial use designations that are underlined are unchanged from the previous basin plan. All beneficial use designations which are not underlined represent newly proposed beneficial uses.

E : Existing I : Intermittent P : Potential Beneficial Uses

Los Angeles Regional Water Quality Control Board

TABLE 5 WATER QUALITY SAMPLING STATIONS

CODE	WATER BODY	LOCATION
401MV00500	LOS SAUCES CK	OLD HWY 101
401MV01000	DULAH-WEST CK	OLD HWY 101
402VE00500	VENTURA R MOUTH	SPRR BRIDGE
402VE01000	VENTURA R	N/O MAIN ST BR
402VE03000	VENTURA R	N/O STANLEY AV
402VE03500	CANADA LARGA	CANADA LARGA RD
402VE05000	COYOTE CK	SANTA ANA RD
402VE06000	SAN ANTONIO CK	OLD CREEK RD
402VE06500	LION CK	HWY 150
402VE07000	VENTURA R	CAMINO CIELO RD
402VE07500	MATILIJA CK	GAGE STN/BLW DM
402VE08000	MATILIJA CK	ABOVE DAM
402VE08500	MATILIJA CK NF	HWY 33 BRIDGE
403SC03000	SANTA CLARA R	SATICOY DIV
403SC05500	SISAR CK	HWY 150
403SC06000	SISAR CK	KOENIGSTEIN RD
403SC06500	SANTA PAULA CK	HWY 150
403SC08000	SESPE CK	HWY 126
403SC08500	SESPE CK	OLD TELEGRAPH RD
403SC09500	SESPE CK	LION CYN CMPGRT
403SC11000	HOPPER CK	HWY 126
403SC12500	PIRU CK	CENTER ST
403SC13000	PIRU CK	BLUEPOINT CMPGRD
403SC13500	PIRU CK	FRENCHMANS FLAT
403SC14000	GORMAN CK	PONDED AREA
403SC14500	CANADA D L ALAMOS	
403SC16500	PIRU CK	GOLD HILL RD
403SC17000	LOCKWOOD CK	CAMP BLW/SNEDDEN
403SC18000	TAPO CYN CK	NEWHALL RNC RD
403SC19000	SANTA CLARA R	NEWHALL RCH RD
403SC20500	SANTA CLARA R	CASTAIC CK
403SC21500	SANTA CLARA R	HWY 99
403SC22500	SAN FRANCISQTO	BRDG N/O PWRHSE
403SC24500	BOUQUET CYN CK	FALLS CAMP
403SC27500	SANTA CLARA R	BOOTLEGGERS
404CA00500	DUCK POND AG DRN	HEUNEME RD
404CA01000	CALLEGUAS CK	PAC CST HWY
404CA01500	REVOLON SLOUGH	WOOD RD
404CA02000	REVOLON SLOUGH	E 5TH STREET
404CA03000	BEARDSLEY WASH	CENTRAL AVCE
404CA04000	CALLEGUAS CK	HUENEME-LEWIS BR
404CA04500	CONEJO CK	CEMETARY RB
405MA00500	MALIBU CK	CROSS CK RD
405MA01000	MALIBU CK	SALVATION A CAMP
405MA01500	MADEA CK	KANAN RD
405MA02000	TRIUNFO CYN CK	KANAN RD
406BA01000	BALLONA CK	INGLEWOOD BLVD
406BA01500	SEPULVEDA CHNL	BALLONA CK
407ML01500	PICO-KENTER DRN	OCEAN FRONT

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CODE	WATER BODY	LOCATION
408DO01500	DOMINGUEZ CHNL	VERMONT AVE
409LA01000	COMPTON CK	LA RIVER
409LA02500	LOS ANGELES R	DEL ANO BRDG
409LA04000	RIO HONDO	RH SPREADING GRN
409LA08500	RIO HONDO	VALLEY BLVD BDG
409LA11500	SAWPIT WASH	PECK RD
409LA15000	LOS ANGELES R	DOWNEY RD
409LA19500	ARROYO SECO	SAN FERNANDO BR
409LA20500	LOS ANGELES R	PASADENA FWY
409LA21500	LOS ANGELES R	FLETCHER DR
409LA22000	LOS ANGELES R	LOS FELIZ BLVD
409LA23500	VERDUGO WASH CH	SAN FERNANDO RD
409LA25000	LOS ANGELES R	RIVERSIDE DR
409LA25500	BURBANK WESTERN	LOS ANGELES R
409LA29000	TUNJUNGA WASH	LAUREL CYN BLVD
409LA29500	PACOIMA WASH	WOODMAN
409LA34500	LOS ANGELES R	STANSBURY AVE
409LA35000	LOS ANGELES R	BURBANK BLVD
409LA35500	BULL CK	VICTORY BLVD
409LA38100	LOS ANGELES R	RESEDA
409LA38500	ALISO CYN CK	LOS ANGELES R
409LA40500	LOS ANGELES R	WINNETKA AVE
409LA41500	BROWNS CK	LOS ANGELES R
409LA43000	LOS ANGELES R	DE SOTO AVE
409LA44500	LOS ANGELES R	CANOGA AVE
410SG00500	SAN GABRIEL	TIDAL PRISM
410SG01000	SAN GABRIEL R CY SD	LW FLW-END CH
410SG01500	SAN GABRIEL R SG SD	LW FLW END CH
410SG02000	COYOTE CREEK	WILLOW STREET
410SG02001	SAN GABRIEL	WILLOW STREET
410SG09000	SAN GABRIEL	BEVERLY BLVD
410SG10000	SAN JOSE CREEK	WORKMAN MILL RD
410SG14000	WALNUT CREEK	BALDWIN PK BLD
410SG15000	BIG DALTON WASH	AZUSA CYN RD
410SG20000	SAN GABRIEL R	GOOTHILL BLVD
410SG21000	SAN GABRIEL	MORRIS DAM
410SG21500	SAN GABRIEL EF	CAMF OAK GROVE
410SG22000	CATTLE CYN CK	SAN GABRIEL R
410SG22500	SAN GABRIEL EF	CATTLE CYN CK
410SG23000	SAN GABRIEL NF	800' FROM W FORK
410SG23500	CEDAR CK	NR CRYSTAL LK
410SG24000	SAN GABRIEL WF	HWY 39 BRIDGE
412LK00500	BOUQUET RESVR	SE END OF DAM
412LK01000	CASTAIC LAKE	BOAT RAMP
412LK01500	ELIZABETH LK	WEST END
412LK02000	ELIZABETH LK	EAST END
412LK02500	LAKE HUGHES	SOUTH SHORE
412LK03000	MALIBU LAKE	NORTH END
412LK03500	MUNZ LAKE	CAMPGROUND
412LK04000	PIRU LAKE	WEST END DAM
412LK04500	PYRAMID LAKE	AT DAM

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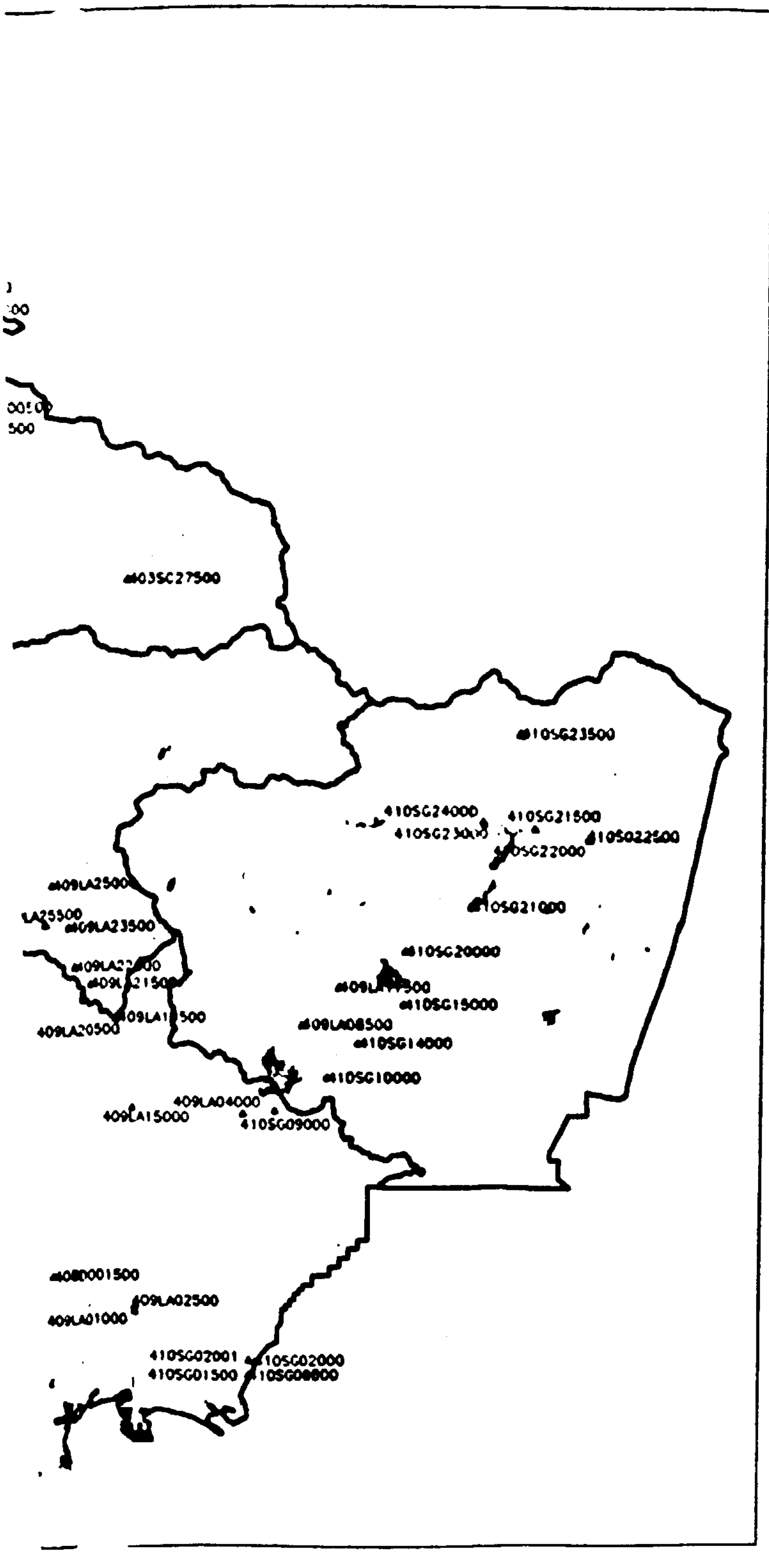

WATER QUALITY
SAMPLING
STATIONS

WATER QUALITY
CONTROL BOARD
REGION 4

LAKES

STREAMS

SUBREGIONS

Miles

0 10 20

FIG 9.0.

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1
8836


403SC17000
403SC16500
412LK04500
403SC09500
402VE08000
402VE07500
402VE07000
402VE06500
403SC06000
403SC06500
403SC08000
403SC18000
403SC12500
403SC20500
403SC21500
403SC19000
403SC22500
403SC24500
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401MV00800
401MV01000
403SC03000
404CA03000
404CA02000
404CA04500
404CA01500
404CA04000
404CA00500
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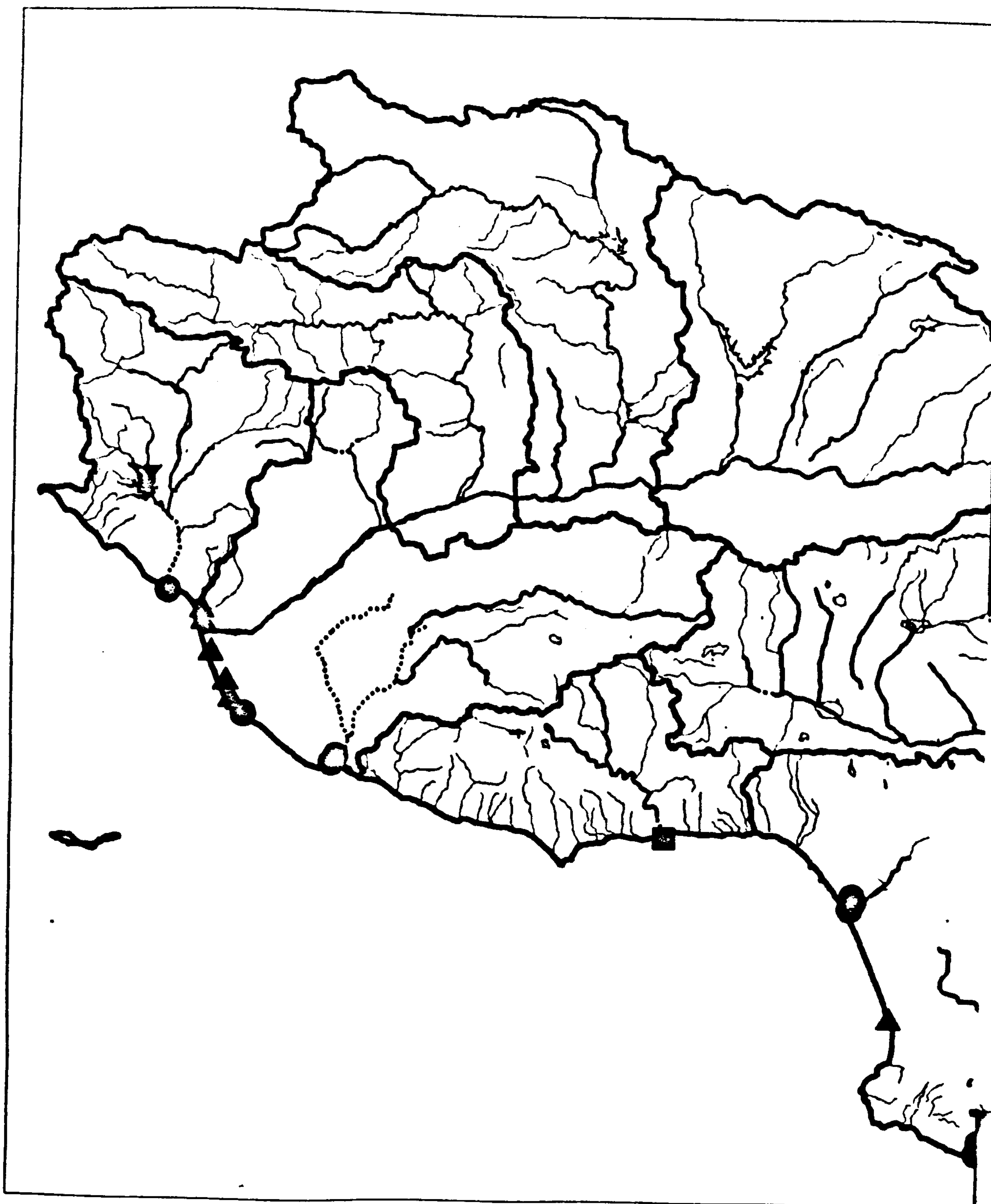
VOL 12 1 8835



VOL 12

18837

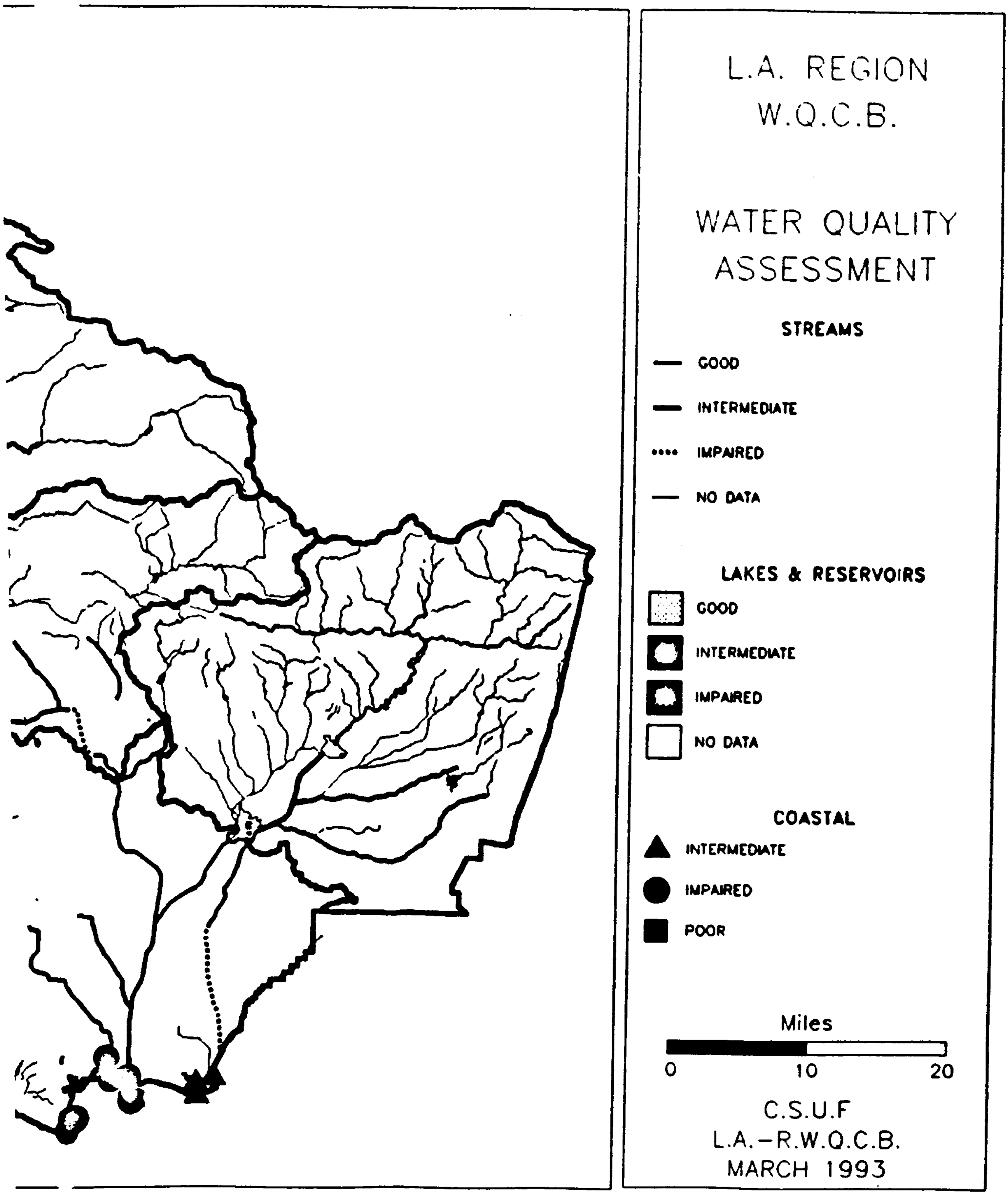


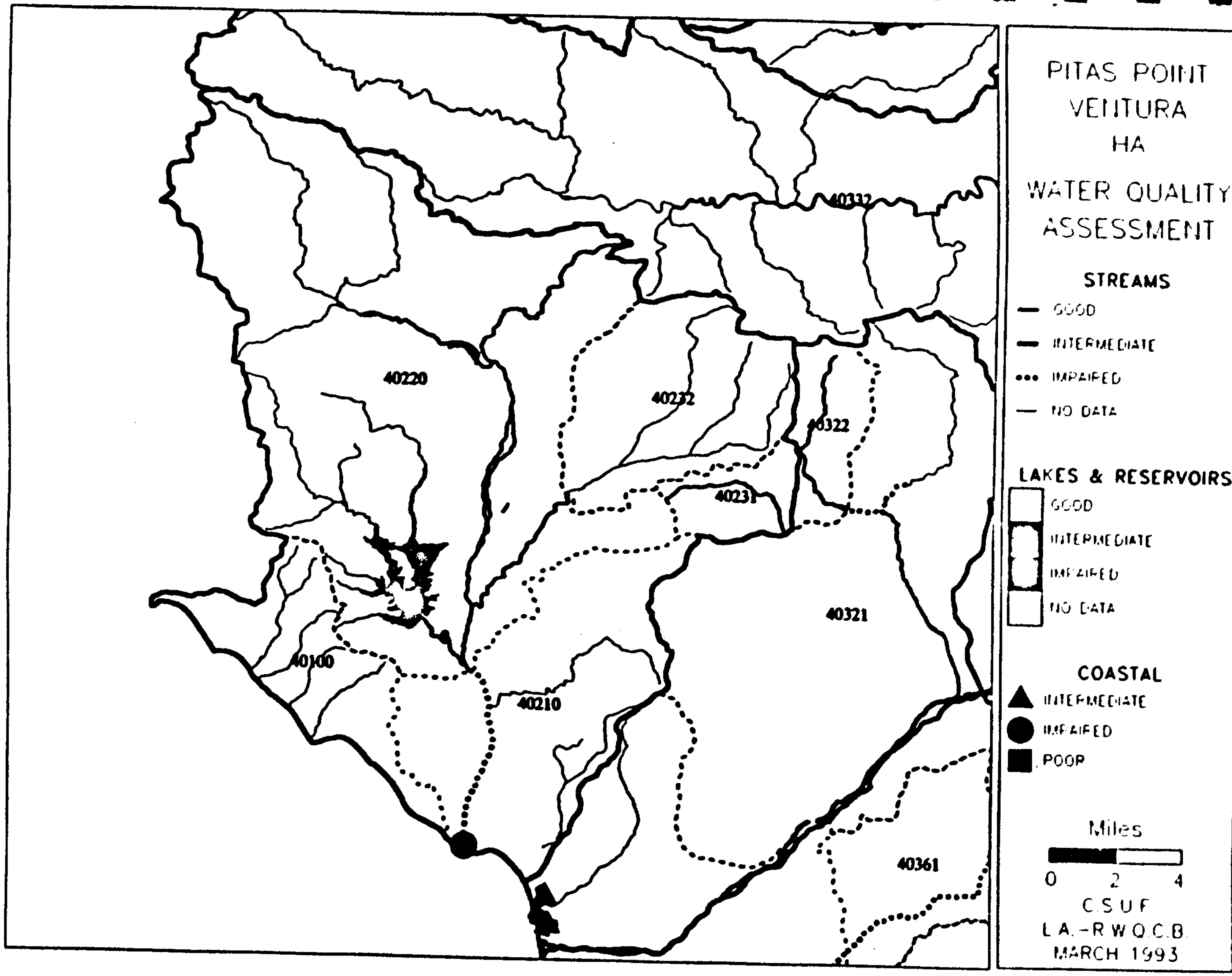
FIG 10.0

VOL 12

1

8838

R0052143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VENTURA
HA
WATER QUALITY
ASSESSMENT
STREAMS
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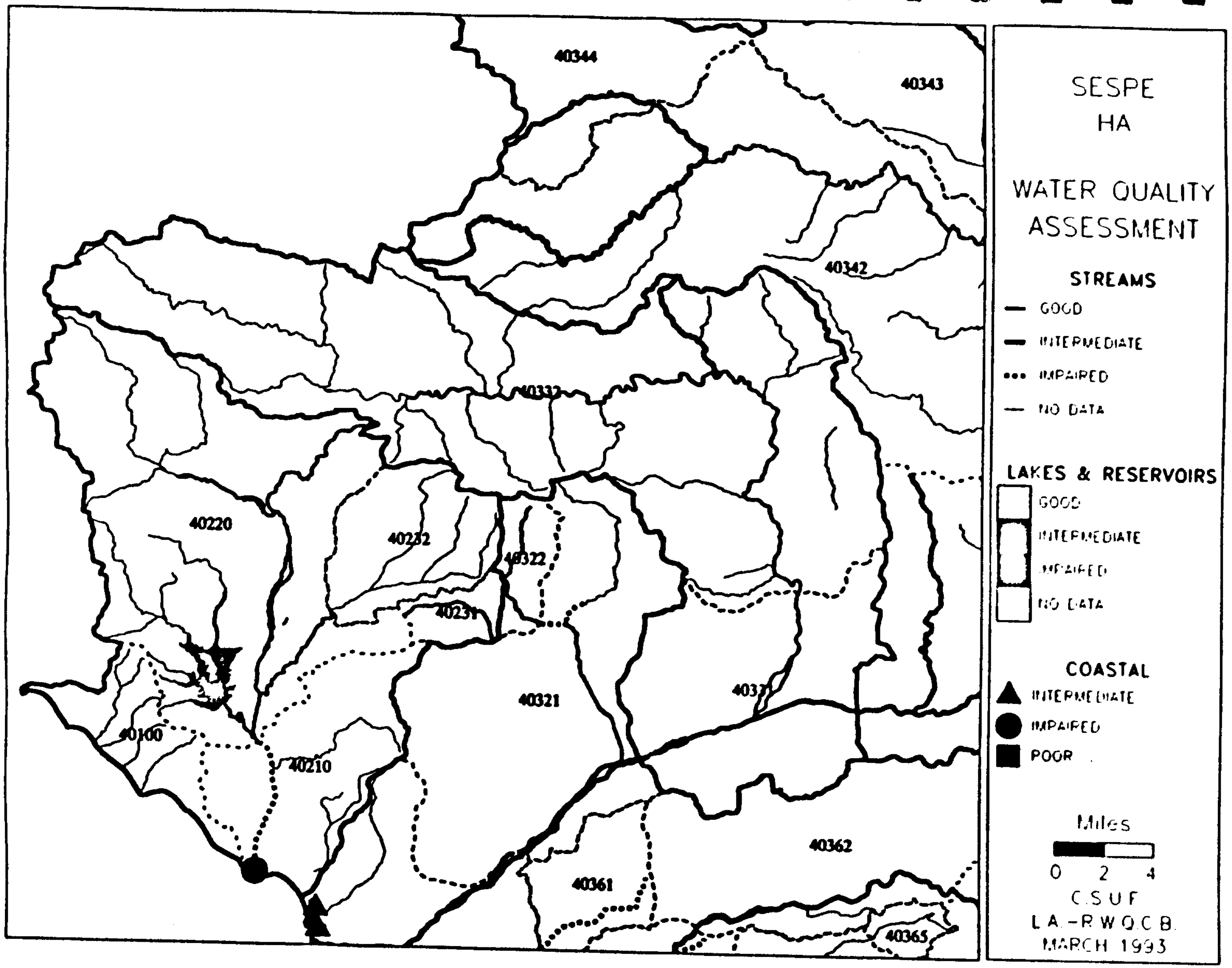
INTERMEDIATE
IMPAIRED
NO DATA
LAKES & RESERVOIRS
GOOD
INTERMEDIATE
IMPAIRED
NO DATA
COASTAL
INTERMEDIATE
IMPAIRED
POOR
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
40332
40220
40232
40322
40231
40321
40100
40210
40361

FIG 10.1


SESPE
HA
WATER QUALITY
ASSESSMENT
STREAMS
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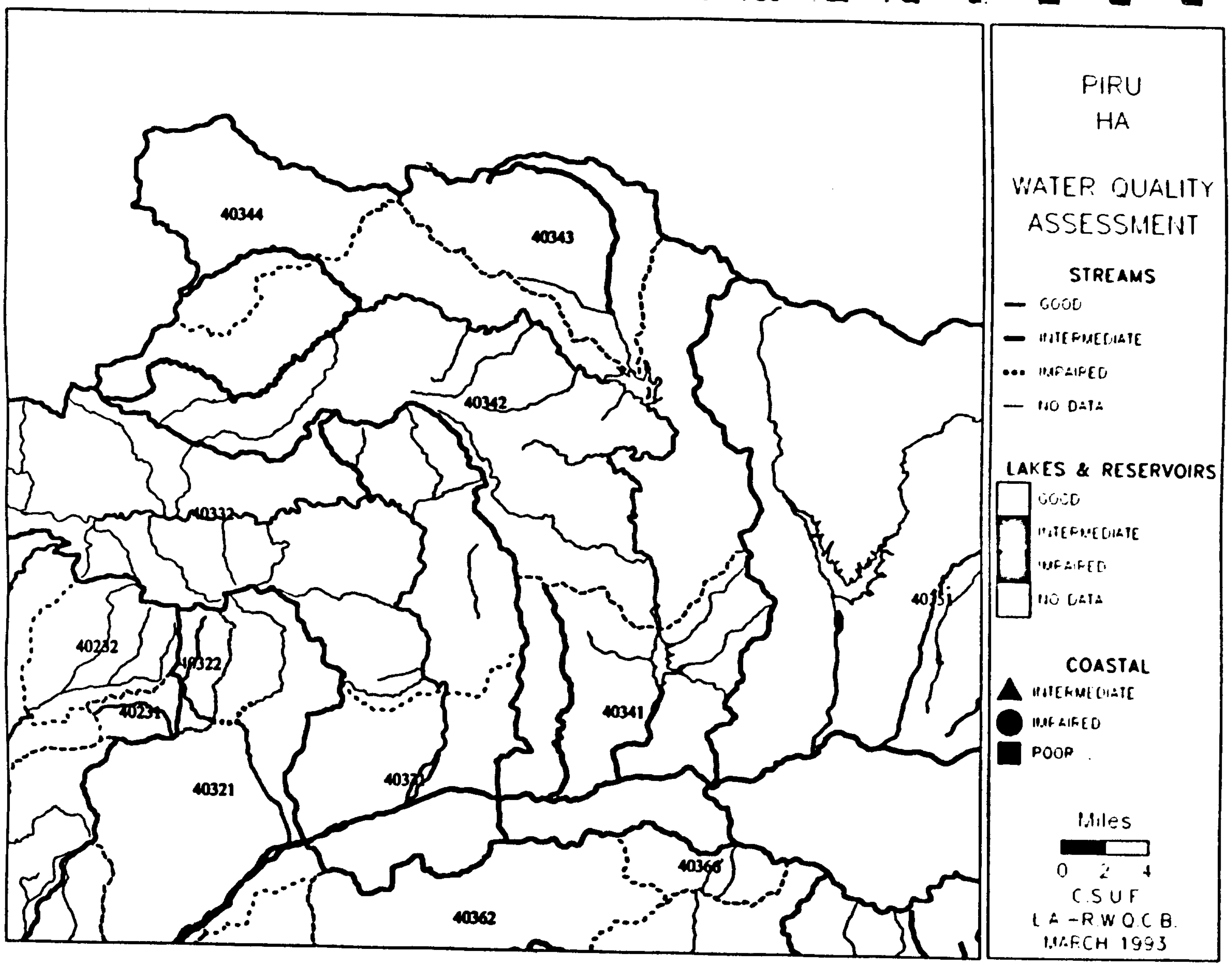
INTERMEDIATE
IMPAIRED
NO DATA
LAKES & RESERVOIRS
GOOD
INTERMEDIATE
IMPAIRED
NO DATA
COASTAL
INTERMEDIATE
IMPAIRED
POOR
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
40344
40343
40342
40332
40220
40232
40322
40231
40321
40100
40210
40362
40361
40365

FIG 10.2


PIRU
HA
WATER QUALITY
ASSESSMENT
STREAMS
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INTERMEDIATE
IMPAIRED
NO DATA
LAKES & RESERVOIRS
GOOD
INTERMEDIATE
IMPAIRED
NO DATA
COASTAL
INTERMEDIATE
IMPAIRED
POOR
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
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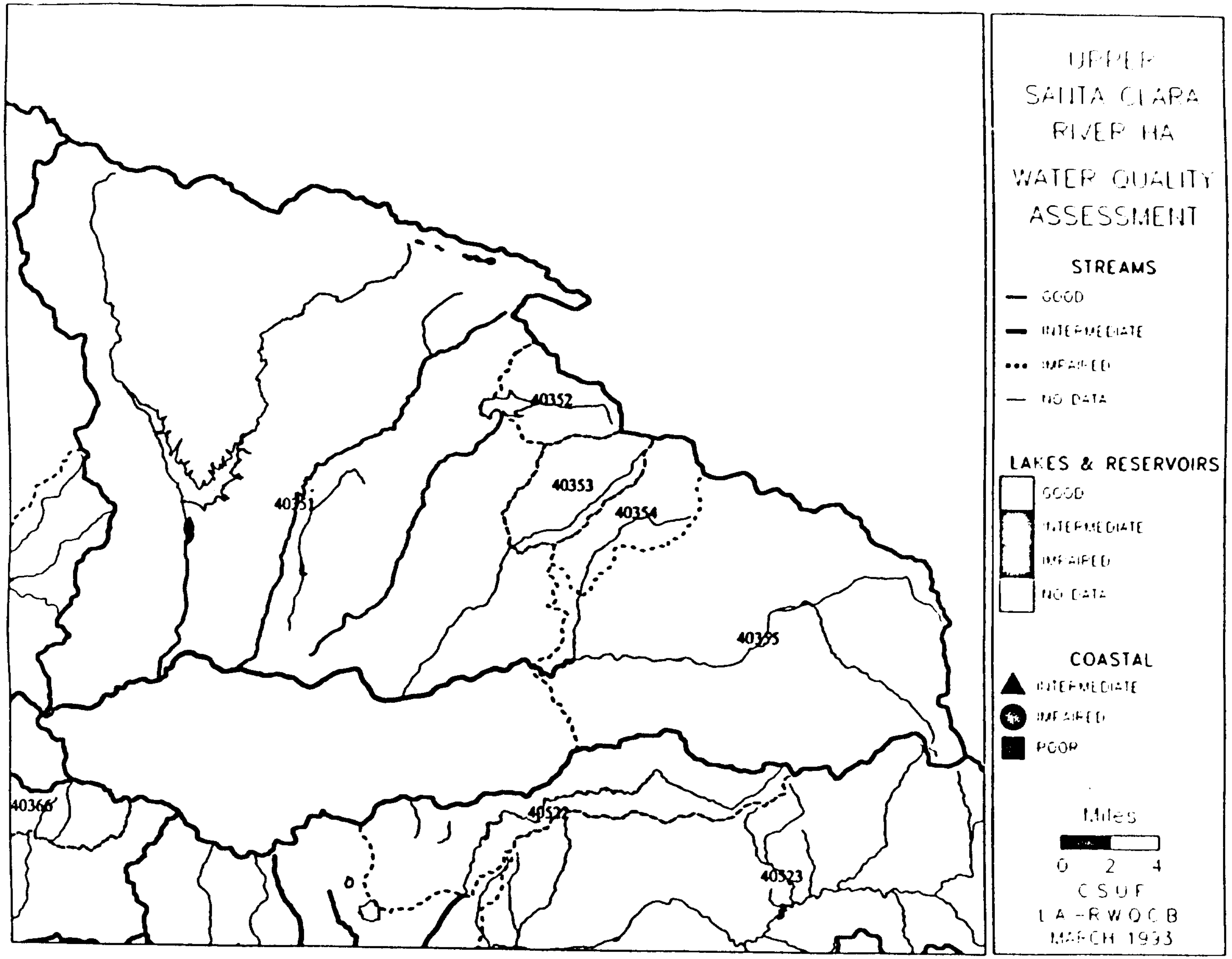
40341
40362
40366

FIG 10.3


UPPER
SANTA CLARA
RIVER HA
WATER QUALITY
ASSESSMENT
STREAMS
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INTERMEDIATE
IMPAIRED
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LAKES & RESERVOIRS
GOOD
INTERMEDIATE
IMPAIRED
NO DATA
COASTAL
INTERMEDIATE
IMPAIRED
POOR
Miles
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CSUF
LA-RWQCB
MARCH 1993
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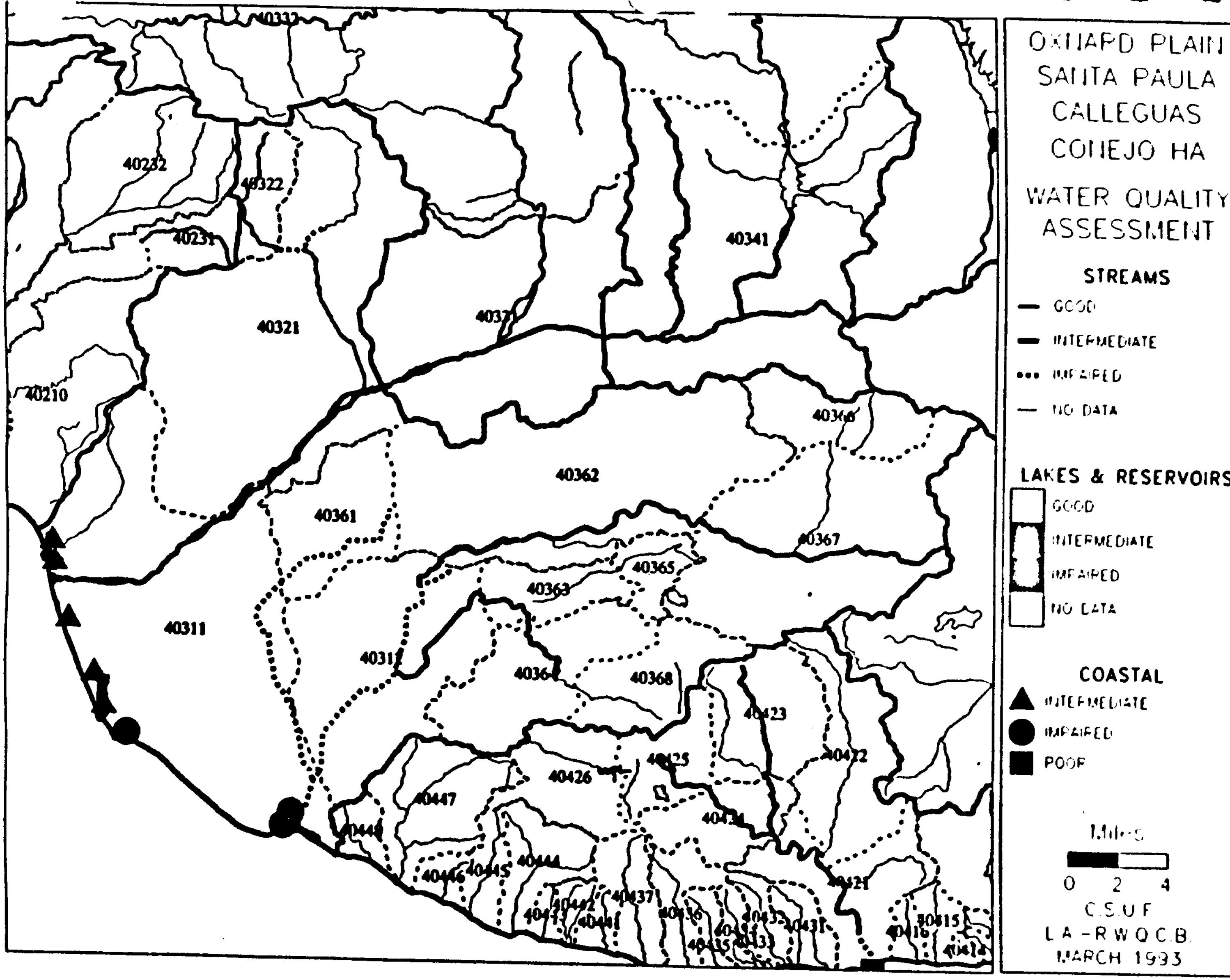
40354
40355
40366
40522
40523

FIG 10.4



OXNARD PLAIN
SANTA PAULA
CALLEGUAS
CONEJO HA
WATER QUALITY
ASSESSMENT
STREAMS
GOOD
INTERMEDIATE
IMPAIRED
NO DATA
LAKES & RESERVOIRS
GOOD
INTERMEDIATE
IMPAIRED
NO DATA
COASTAL
INTERMEDIATE
IMPAIRED
POOR
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
40332
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40321
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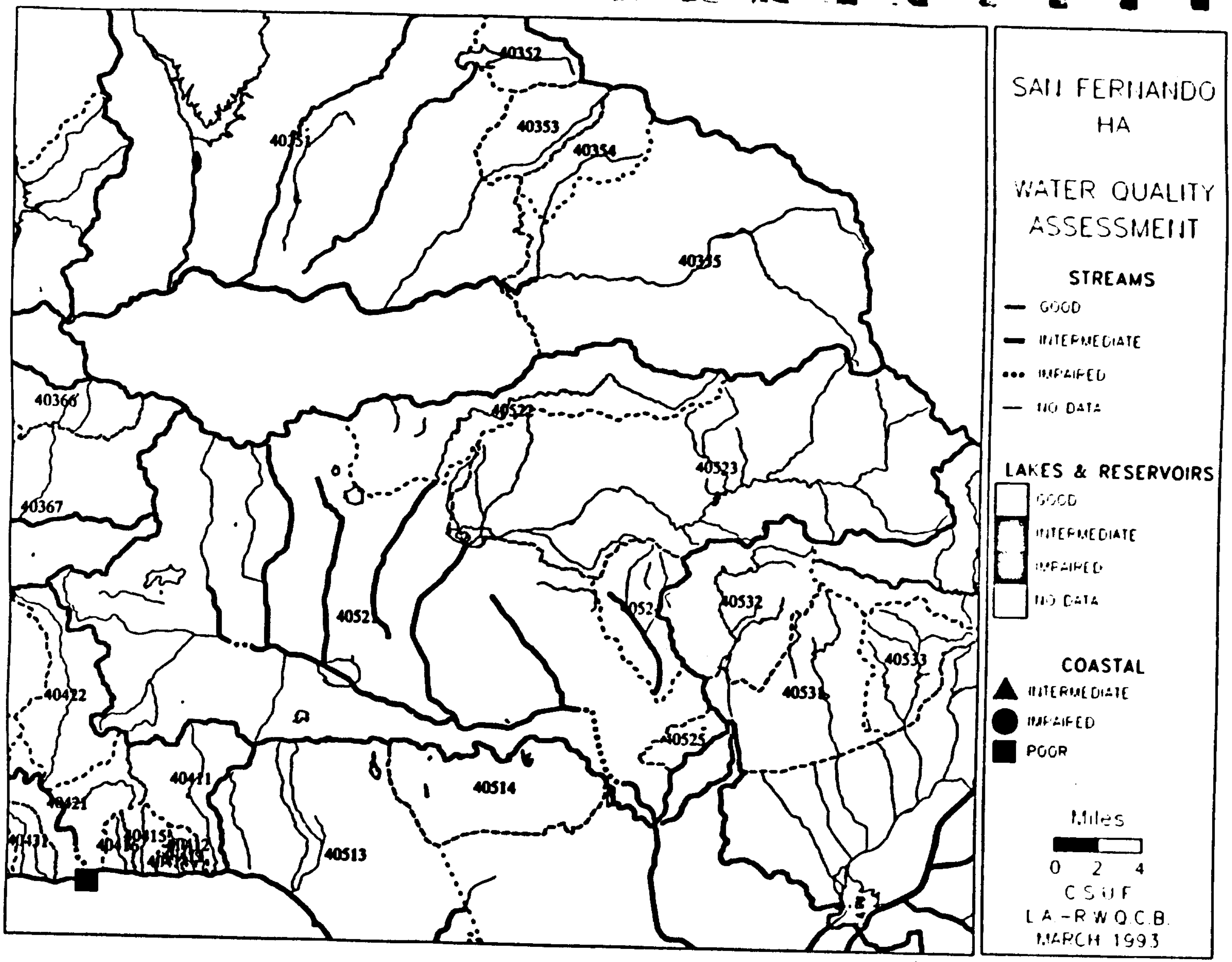
FIG 10.5



SAN FERNANDO HA
WATER QUALITY ASSESSMENT
STREAMS
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INTERMEDIATE
IMPAIRED
NO DATA
LAKES & RESERVOIRS
GOOD
INTERMEDIATE
IMPAIRED
NO DATA
COASTAL
INTERMEDIATE
IMPAIRED
POOR
Miles
0 2 4
C S U F
L.A.-R.W.Q.C.B.
MARCH 1993
40352
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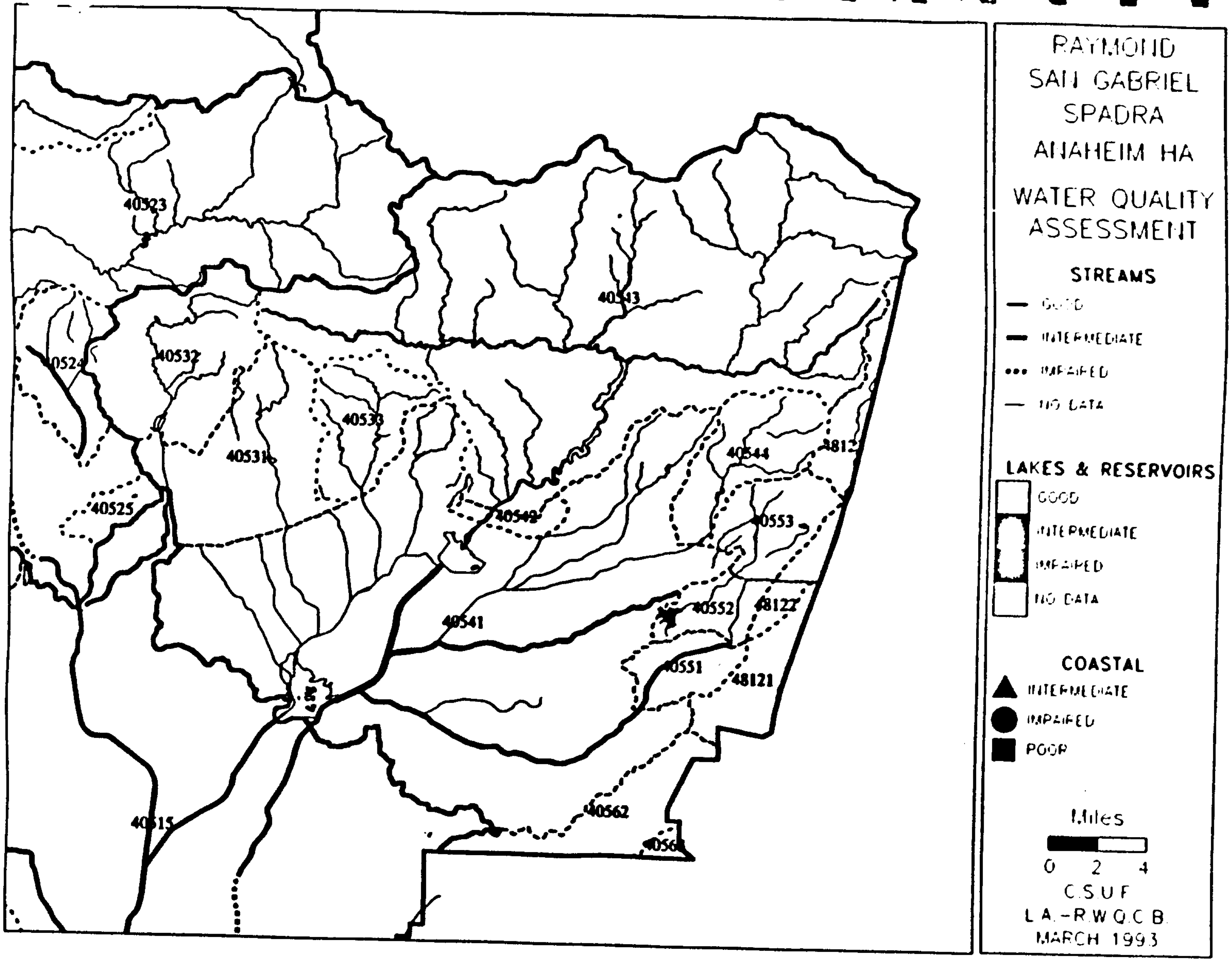
40431

FIG 10.6



RAYMOND
SAN GABRIEL
SPADRA
ANAHEIM HA
WATER QUALITY
ASSESSMENT
STREAMS
INTERMEDIATE
IMPAIRED
NO DATA
LAKES & RESERVOIRS
GOOD
INTERMEDIATE
IMPAIRED
NO DATA
COASTAL
INTERMEDIATE
IMPAIRED
POOR
Miles
0 2 4
C.S.U.F.
L.A.-R.W.Q.C.B.
MARCH 1993
40523
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FIG 10.7

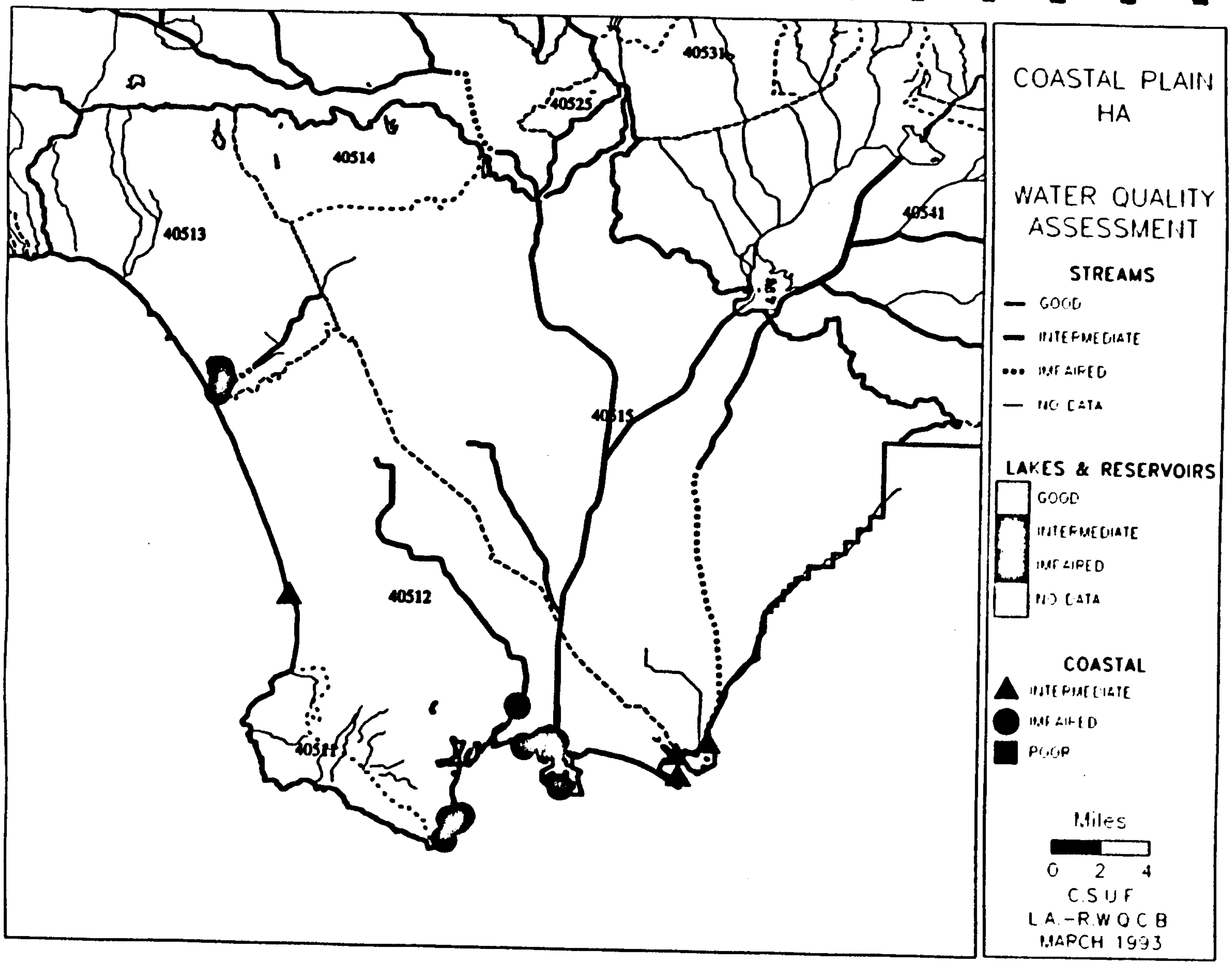

FIG 10.8

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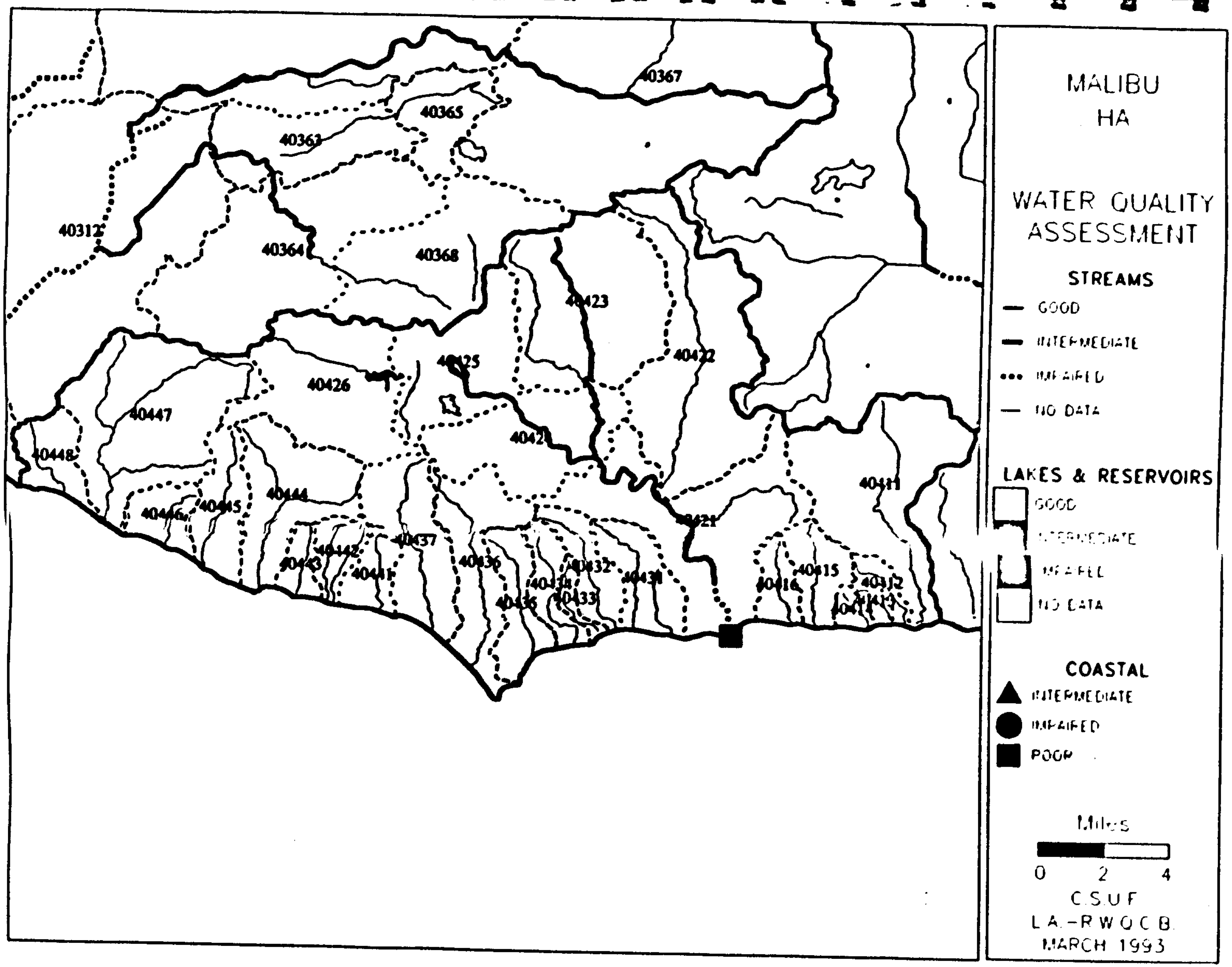
MALIBU
HA
WATER QUALITY
ASSESSMENT
STREAMS
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INTERMEDIATE
IMPAIRED
NO DATA
LAKES & RESERVOIRS
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INTERMEDIATE
IMPAIRED
NO DATA
COASTAL
INTERMEDIATE
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POOR
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FIG 10.9

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Appendix A: Examples of Field Survey Forms

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BENEFICIAL USES OF IDENTIFIED WATERBODIES

Site #_____

Waterbody Name____Date________________

Location Description____Evaluator_______

Associated Waterbodies (eg. spring/wetland: river/lake)__________________________

Waterbody Type (#) RIV LAKE BAY HARBOR EST WET OCEAN

Habitat Type(s) *

Description COW MRI VRI DRI FEW SEW RIV LAC EST AQ MAR ART PAL

____

Hydrologic Area & Subarea____

EPA River Reach No. (when available)_______________________________________

USGS Quad. Sheet Name (7 1/2')____

Township_____ Range_____ Section_____

County_________________________

Location Map: Thomas Guide page #____

Including nearest nearest cross streets and /oo accessif pertinent__________________

____

U.S. Fish and Wildlife Service Classification

MAR	EST	RIV	LAC	PAL = PALUTRINE
subtid	subtid	tidal	lemnetic	
intertid	intertid	low per	littoral	
		up per		
		interm		

* California Fish and Game
COW = COASTAL OAK WOODLAND, MRI = MONTANE RIPARIAN,
VRI = VALLEY FOOTHILL RIPARIAN, DRI = DESERT RIPARIAN,
FEW = FRESH EMERGENT WETLAND, SEW = SALINE EMERGENT WETLAND,
RIV = RIVERINE, LAC = LACUSTRINE, EST = ESTUARY,
AQ = AQUACULTURE, MAR = MARINE, ART = ARTIFICIAL

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WATERBODY FIELD SURVEY SITE FORM

Site #_____

Land Use (may be 1 or more)

Surrounding area Agri Commer Resid Grassl Scrub Chap U.S.For

Streams:

Channel base width_________ft.

Water present in stream: yes no

Approximate depth_________ft. width_________ ft.

Approximate flow _________cfs

Most probable source of flow_______________________________________

Standing Water

Water present: yes no

Approximate area_________ acres Approximate depth_________ ft.

Most probable source_______________________________________

Ecological Factors

Bottom substrate: mud sand gravel cobbles scoured

Bottom community: algae pond weed emergent

Bank erosion: none some considerable

Bank vegetation: none cattails/rushes/sedges scrub woodland forest

Bank substrate: earth rip-rap concrete

Riparian habitat: disturbed mft scr. wil scr. wil for. cwd wdl. oak for. syc wdl. ald for.

Has the vegetation, soils, and/or hydrology been significantly disturbed? yes no

Explain_______________________________________

Dominant Plant Species % Cover * Indicator Status Stratum

(Field use only) OBL FACW FAC OTHER // Bryo Herb Shrb Sapl Tree

1. _______________________________________
2. _______________________________________
3. _______________________________________
4. _______________________________________
5. _______________________________________
6. _______________________________________
7. _______________________________________

Percent of dominant species that are OBL, FACW, and/or FAC _____%

Wetland Vegetation present by Federal criteria: yes no

* A = 0-19 B = 20-39 C = 40-59 D = 60-100

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LARWQCB/CSUF BENEFICIAL USE UPDATE
FIELD SURVEY FORM

A. WATERBODY LOCATION
1. Waterbody Name________________ 2.Observer________ 3.Date______
4.Location Description ______________________________
5. Waterbody type RIV LAKE RESER WET EST BAY HARB BEACH
6. USGS 7.5 min Quad________________ 7 T____ 8R____ 9Sec__ 10.Qtr__
11.Hydrologic Area and Sub Area__________ 12. Photo Nos.________

B. HYDROLOGICAL FACTORS

21.Surrounding Area AGRI COMMERC RESID GRASS SCRUB CHAP FOR

STREAMS 22. Water Present YES NO
23. Approx. Depth______ft 24.Width_______ft 25. Velocity______ft/sec
26. Discharge_________cfs
STANDING WATER 27. Approximate Area________acres 28.Depth____ft.
29. Temp_________ 30.. EC_________ 31..pH______ 32.Other____________
32.. Most Probable source of water BASEFLOW STORM RUNOFF W.WTR
AG. RUNOFF INDUSTRIAL .EFFLUENT WELL
Others______________________________
General Conditions

C. ECOLOGICAL FACTORS

33. Bottom Substrate: mud sand gravel cobbles scoured

34. Bottom Community: algae pond weed emergent

35. Bank Erosion: none some considerable

36 Bank Vegetation: cattails/rushes/sedges scrub woodland forest

37. Riparian Habitat MULEFAT SCUB WILLOW SCRUB WILLOW FOR
OAK FOREST ALDER FOREST CWD WOODLAND
38. Dominant wetland plants: Indicator Status: OBL FAC FACW
39 Stratum: Bryo Herb Shrb Sapl Tree
(a)____________________ (b)____________________
(c)____________________ (d)____________________
(e)____________________ (f)____________________

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D. BENEFICIAL USES

USE	CURRENT DESIGNATION	RECOMMENDATION (E) (P) (I)	EVIDENCE/REFERENCE
51.	MUN		
52	AGR		
53	IND		
54	PROC		
55.	GWR		
56.	FRSH		
57.	POW		
58	REC-1		
59.	REC-2		
60.	WARM		
61	COLD		
62.	BIOL		
63.	WILD		
64.	RARE		
65.	MIGR		
66.	SPAWN		
67	SHELL		

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FIELD OBSERVATIONS AND LOCAL INTERVIEWS

68 Actual Uses HIKING BIKING WADING SWIMMING FISHING

Other Comments____________________________________

69. Evidence of Use TRASH FOOTPRINTS VEHICLE TRACKS ANIMAL TRACKS ANIMAL DROPPINGS FEATHERS BIRDS FISH MAMMALS

70 Access BRIDGE TRAILS HOLES-IN-THE-FENCE OPEN GATES

71. DIVERSIONS MODIFICATIONS DREDGINGS

72. Degree of Degradation HIGH MODERATE LOW

Explain____

SKETCHES OF FEATURES.

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BASIN & SITE I.D.____________

California State University, Fullerton
RWQCB WATERBODY & BENEFICIAL USE PROJECT
Photo Identification

Waterbody Name__________________________USGS 7.5 min Quad__________
T,R. Sec. No__________________
Location____

Photo Description(habitat type and condition, vegetation community, waterquality,streamflow,etc.)______________________________________

Source(s) of water____

Beneficial uses(Insert existing(E) intermittent(I) and Potential(P)____

Date________________________________Observer______________________

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Appendix B: Examples of Agency Surveys

Summary of Agency Responses

California State University, Fullerton
Fullerton, California 92634-9480

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(714) 773-3882

Hydrology Laboratory
(714) 773-3267

VOL 12

July 6, 1992

Request for Comments on Beneficial Use Designations for Waterbodies in Los Angeles and Ventura Counties

The California Regional Water Quality Control Board, Los Angeles Region, in conjunction with California State University, Fullerton, is conducting a survey of existing, potential and intermittent beneficial uses for all waterbodies in the Region (most of Los Angeles and Ventura counties). In order to obtain current information, we are surveying resource agencies and interest groups, and asking for assistance with this study. The results of this study will be used by the Regional Board to prepare their updates to the Basin Plans in 1993. Hopefully, your Agency will benefit from your participation in the Basin Planning process.

Enclosed you will find Tables 1, 2, and 3 which list all regional waterbodies and their designated uses, as published in the 1978 Basin Plans. We also have enclosed a regional map (Fig. 1) with the hydrological basins labeled for your reference. A list of beneficial uses and their definitions is also attached (Table 4). Please review the waterbodies in your geographic area and comment on the tables as necessary. Please keep in mind the following criteria when reviewing this information:

1. Existing beneficial uses have previously, or are presently in existence, and associated with the waterbody. If a beneficial use has been, or is presently in existence (E), it cannot be removed.

2. Intermittent uses (I) are designated under the assumption that they might only be present on a seasonal basis (based on presence of water).

3. Potential beneficial uses (P) are those which are desired on a waterbody, have a probability of occurrence, but may or may not exist.

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4. Beneficial uses can be added at any time, if they have been attained.

A survey form (Table 5) also has been included for your use in summarizing your comments. Please designate a contact person for your agency for further correspondence on these issues.

I would be grateful if you would send your comments to the above address by Monday, July 24, 1992. If you have any questions, please call me or Mr. Kwan Ihn at (714) 773-3267.

Thank you for your cooperation. We look forward to working with your agency or your group, and hope to make this study a valuable resource for all of us.

Prem K. Saint, Ph.D.
PROFESSOR & PRINCIPAL INVESTIGATOR
CSUF/LARWQCB Waterbody Project

Enclosures

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Hydrology Laboratory, MH-52
Department of Geological Sciences
California State University, Fullerton
Fullerton, California 92634-9480
Phone (714) 773-3267
Fax (714) 449-7266

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REEVALUATION OF BENEFICIAL USES IN THE 1978 BASIN PLANS

The objective of this survey is to review and update beneficial uses designated to waterbodies in the Regional Water Quality Control Board's (CRWQCB-LA) 1978 Basin Plans (most of Los Angeles and Ventura counties). The data from this survey will aid the CRWQCB in updating its Water Quality Control Plans (Basin Plans). As comments are received, we will make field verifications and review pertinent data to determine the validity and applicability of the recommendations. Please complete the following:

1. Review the beneficial uses listed in Tables 1, 2, and 3. Based on your best judgement, either add any additional beneficial use(s) and/or upgrade any existing beneficial use(s) (i.e., from potential to intermittent or intermittent to existing) for waterbodies under your jurisdiction or of interest to your group.* Do this directly on the tables, as shown in the example on the last page. Table 4 contains definitions for the 21 established beneficial uses. Figure 1 shows the locations of the hydrological areas listed in the left column of Tables 1, 2, and 3.

2. In Table 5, provide rationale for any recommended addition(s) or upgrade(s) made in Tables 1, 2, and 3. Moreover, if any gross errors are identified in these tables regarding beneficial use designation, indicate this and thoroughly explain why. Attach additional sheets as necessary.

3. If possible, provide references and/or enclose supplemental documents to support your recommendations.

4. If there are no comments, then indicate "no comments" in Table 5.

5. Please fill out the correspondence form on the following page and return it to the above address with the appropriate materials by July 24, 1992.

We appreciate your cooperation in our effort. If you have any questions, please contact me, Dr. Prem K. Saint, or Mr. Kwan Ihn at (714) 773-3267.

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* According to federal and state regulations, beneficial uses can only be added or upgraded (not removed), except in extremely rare instances where it can be documented that a gross error was made in assigning these uses in 1975. Beneficial uses cannot be de-designated because of water quality impairment.

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VOL 12

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March 1, 1993

REQUEST FOR COMMENTS ON BENEFICIAL USE DESIGNATIONS FOR GROUNDWATER BASINS IN LOS ANGELES AND VENTURA COUNTIES

The California Regional Water Quality Control Board, Los Angeles Region, in conjunction with California State University, Fullerton, is conducting a survey of existing, potential and intermittent beneficial uses for all waterbodies including groundwater basins in the Region (most of Los Angeles and Ventura counties). In order to obtain current information, we are surveying resource agencies and asking for assistance with this study. The results of this study will be used by the Regional Board to prepare their updates to the Basin Plans in 1993. Hopefully, your Agency will benefit from your participation in the Basin Planning process.

Enclosed you will find Table 1 which lists all regional groundwater basins and their designated uses. We also have enclosed a regional map (Fig. 1) with the groundwater basins labeled for your reference. A list of beneficial uses and their definitions is also attached (Table 2). A survey form (Table 3) also has been included for your use in summarizing your comments. Please designate a contact person for your agency for further correspondence on these issues.

Please review the groundwater basins in your geographic area and comment on the tables as necessary. Please keep in mind the following criteria when reviewing this information:

1. Existing (E) beneficial uses have previously, or are presently in existence, and associated with the waterbody. If a beneficial use has been, or is presently in existence, it cannot be removed.

2. Intermittent (I) uses are designated under the assumption that they might only be present on a seasonal basis (based on presence of water).

3. Potential (P) beneficial uses are those which are desired on a waterbody, have a probability of occurrence, but may or may not exist.

4. Beneficial uses can be added at any time, if they have been attained.

5. If, possible, provide references and/or enclose supplemental reports to support your recommendations.

6. If there are no comments, then indicate "no comments" in Table 3.

7. In some basins, various aquifers are identified. In those that are not identified, please specify the names of aquifers or aquifer systems (upper, lower, etc.) currently under your agency's jurisdiction. If possible, please allocate beneficial uses according to aquifers or aquifer systems.

I would be grateful if you would send your comments to the above address by Monday, March 15, 1993. In case of a delay in meeting this deadline, we will welcome a response anytime thereafter. If you have any questions, please call me, Dr. Prem K. Saint, or Mr. Kwan Ihn at (714) 773-3267.

Thank you for your cooperation. We look forward to working with your agency, and hope to make this study a valuable resource for all of us.

Prem K. Saint, Ph.D.
PROFESSOR & PRINCIPAL INVESTIGATOR
CSUF/LARWQCB Waterbody Project

Enclosures

PKS:kji

cc: Gerhardt Hubner, Contract Manager, LARWQCB

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Hydrology Laboratory
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March 3, 1993

REQUEST FOR COMMENTS ON BENEFICIAL USE DESIGNATIONS FOR COASTAL FEATURES (BAYS, BEACHES, HARBORS, LAGOONS, ETC.) IN LOS ANGELES AND VENTURA COUNTIES

The California Regional Water Quality Control Board, Los Angeles Region, in conjunction with California State University, Fullerton, is conducting a survey of existing, potential and intermittent beneficial uses for all waterbodies including coastal features in Region 4 (most of Los Angeles and Ventura counties). In order to obtain current information, we are surveying resource agencies and asking for assistance with this study. The results of this study will be used by the Regional Board to prepare their updates to the Basin Plans in 1993. Hopefully, your Agency will benefit from your participation in the Basin Planning process.

Enclosed you will find Table 1 which lists all coastal features and their designated uses. We also have enclosed a regional map (Fig. 1) delineating the hydrological areas and a coastal map (Fig. 2) with all coastal features proposed for inclusion in the Basin Plans. A list of beneficial uses and their definitions is also attached (Table 2). A survey form (Table 3) also has been included for your use in summarizing your comments. Please designate a contact person for your agency for further correspondence on these issues.

Please review the coastal features in your geographic area and comment on the tables as necessary. Please keep in mind the following criteria when reviewing this information:

1. Existing (E) beneficial uses have previously, or are presently in existence, and associated with the waterbody.

2. Intermittent (I) uses are designated under the assumption that they might only be present on a seasonal basis (based on presence of water).

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3. Potential (P) beneficial uses are those which are desired on a waterbody, have a probability of occurrence, but may or may not exist.

4. Beneficial uses can be added at any time, if they have been attained.

5. If, possible, provide references and/or enclose supplemental reports to support your recommendations.

6. If there are no comments, then indicate "no comments" in Table 3.

7. Please add other bays, beaches harbors, lagoons, etc. which are not listed and suggest appropriate beneficial uses for them. In addition, please label their locations directly on the coastal feature map (Fig. 2).

I would be grateful if you would send your comments to the above address by Wednesday, March 17, 1993. In case of a delay in meeting this deadline, we will welcome a response anytime thereafter. If you have any questions, please call me, Dr. Prem K. Saint, or Mr. Kwan Ihn at (714) 773-3267.

Thank you for your cooperation. We look forward to working with your agency, and hope to make this study a valuable resource for all of us.

Prem K. Saint, Ph.D.
PROFESSOR & PRINCIPAL INVESTIGATOR
CSUF/LARWQCB Waterbody Project

PKS:kji

Enclosures

cc: Gerhardt Hubner, Contract Manager, LARWQCB

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402.20 Upper Ventura River HA
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3.63 Arroyo Santa Rosa HSA
3.64 Conejo Valley HSA
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4.24 Triunfo Canyon HSA
4.25 Russell Valley HSA
4.26 Sherwood HSA
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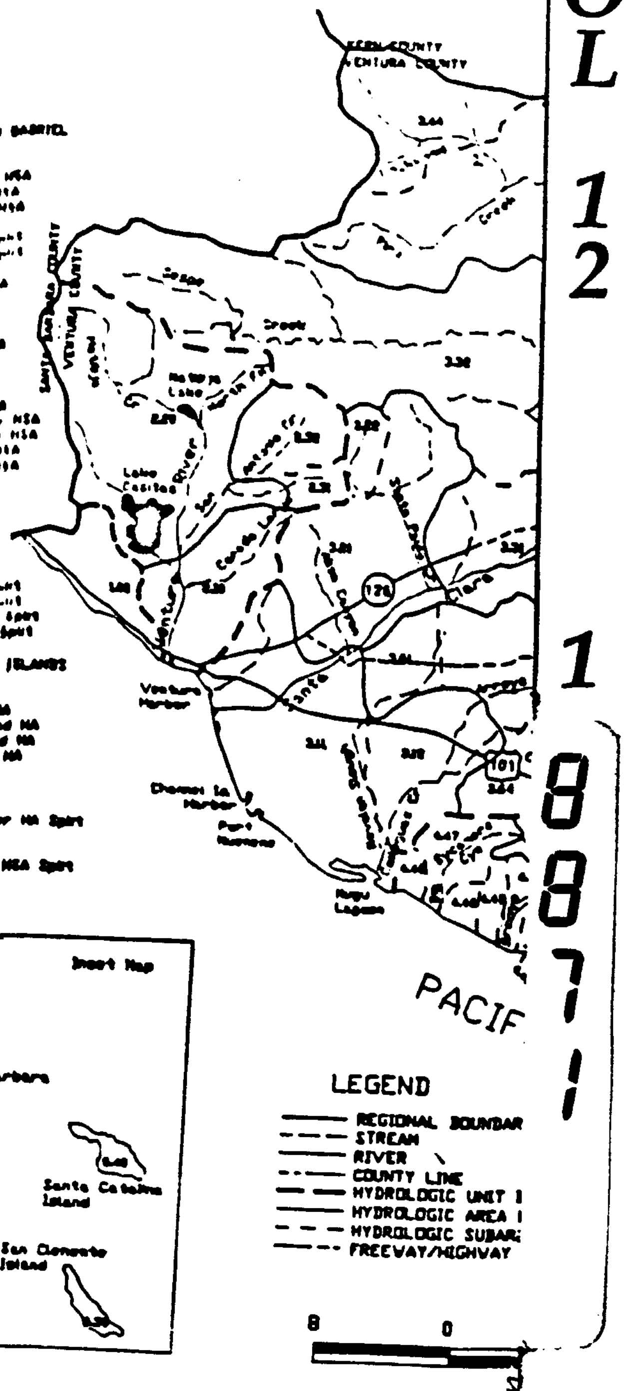
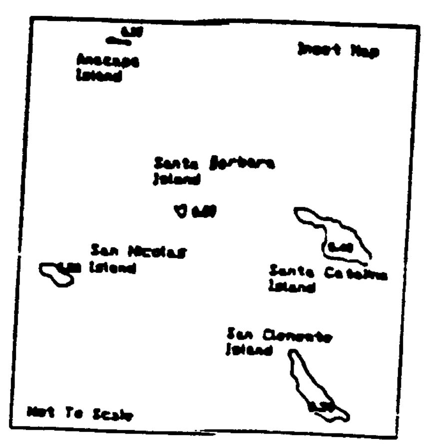
4.31 Corral Canyon HSA
4.32 Solstice Canyon HSA
4.33 Latigo Canyon HSA
4.34 Escondido Canyon HSA
4.35 Ramera Canyon HSA
4.36 Zuma Canyon HSA
4.37 Trancas Canyon HSA
404.40 Conardio HA
4.41 Encinal Canyon HSA
4.42 Los Alamos Canyon HSA
4.43 Nicholas Canyon HSA
4.44 Arroyo Sequit HSA
4.45 Little Sycamore Canyon HSA
4.46 Deer Canyon HSA
4.47 Big Sycamore Canyon HSA
4.48 La Jolla Valley HSA

405.00 LOS ANGELES-SAN GABRIEL HYDROLOGIC UNIT
405.10 Coastal Plain HA
5.11 Palos Verdes HSA
5.12 West Coast HSA
5.13 Santa Monica HSA
5.14 Hollywood HSA
405.15 Central HSA Split
845.15 Central HSA Split
405.20 San Fernando HA
5.21 Bull Canyon HSA
5.22 Sylmar HSA
5.23 Tujunga HSA
5.24 Verdugo HSA
5.25 Eagle Rock HSA
405.30 Raymond HA
5.31 Pasadena HSA
5.32 Monk Hill HSA
5.33 Santa Anita HSA
405.40 San Gabriel Valley HSA
5.41 Main San Gabriel HSA
5.42 Lower Canyon HSA
5.43 Upper Canyon HSA
5.44 Foothill HSA
405.50 Spadra HA
5.51 San Jose HSA
5.52 Pomona HSA
5.53 Live Oak HSA
405.60 Anaheim HA
845.61 Buena Park HSA
405.62 La Habra HSA Split
845.62 La Habra HSA Split
405.63 Yorba Linda HSA Split
845.63 Yorba Linda HSA Split

406.00 SAN PEDRO CHANNEL ISLANDS HYDROLOGIC UNIT
406.10 Anacapa Island HA
406.20 San Nicolas Island HA
406.30 Santa Barbara Island HA
406.40 Santa Catalina Island HA
406.50 San Clemente Island HA

801.00 SANTA ANA RIVER HYDROLOGIC UNIT
801.20 Middle Santa Ana River HA Split
481.21 Chino HSA Split
481.22 Harrison HSA
481.23 Claremont Heights HSA Split





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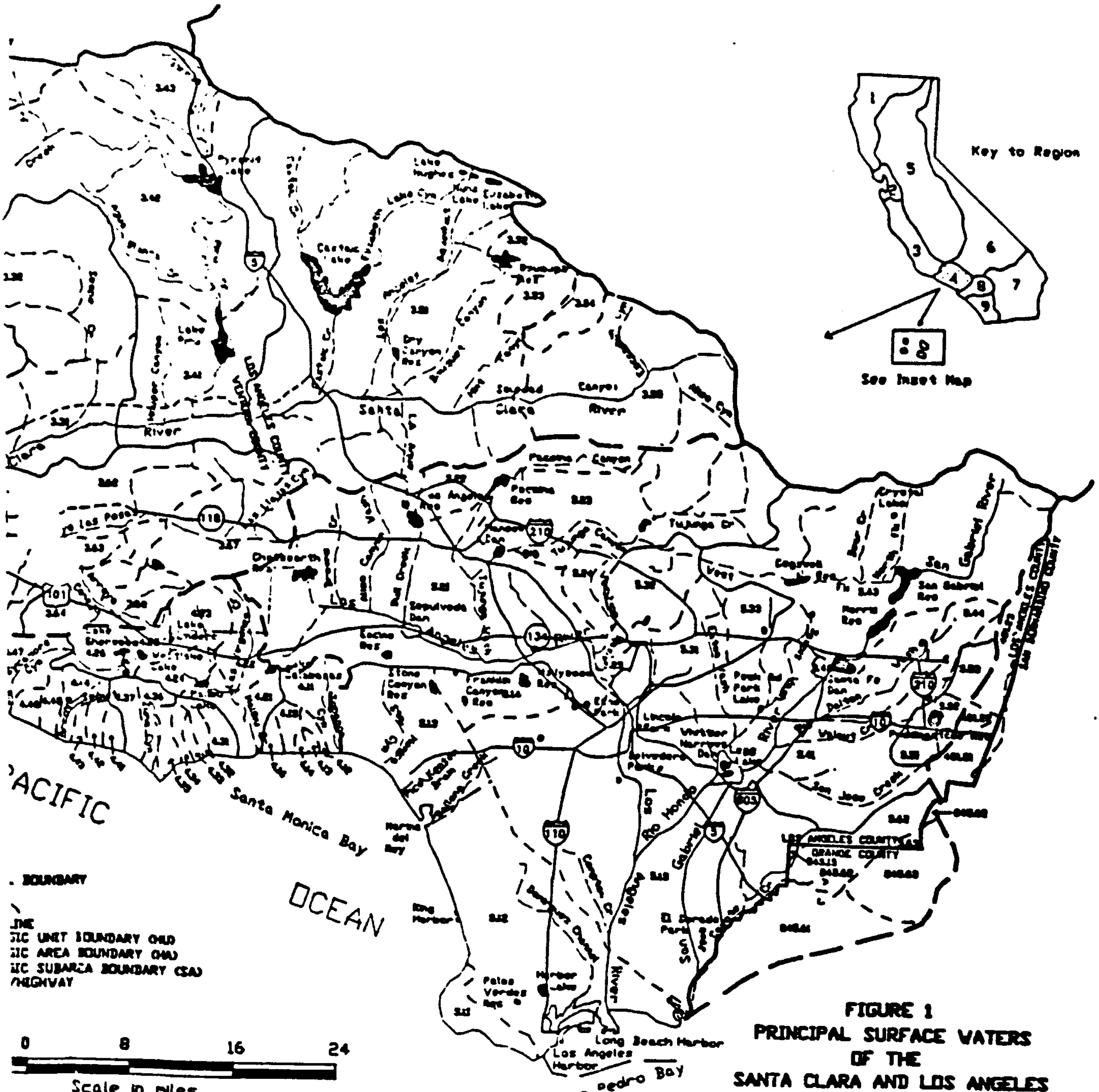

FIGURE 1
PRINCIPAL SURFACE WATERS
OF THE
SANTA CLARA AND LOS ANGELES
RIVER BASINS

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APPENDIX 3. SUMMARY OF RESPONSES AND COMMUNICATION WITH AGENCIES, INTEREST GROUPS, ETC.

1. California Coastal Conservancy,
1330 Broadway, Suite 1100,
Oakland, Ca 94612-2530 Tel (510) 286-1015
Reed Holderman, Manager, Resource Enhancement Program

1.1. Response on March 19, 1993

1.2. Suggested addition of Venice Canals to Ballona Lagoon and added beneficial uses;
Also added beneficial uses to:
402.10 Ventura River Estuary
403.11 Santa Clara River Estuary.

1.3. Informed us of the following studies and reports:
(a) Ballona Lagoon/ Venice Canals:
Resource Enhancement Plan, 1992.
Hydrology, Water Quality Report by Phil Williams;
Biology Report by Wetland Research;
(Contact Person: Iylene Weiss, Ballona Lagoon Marine Reserve).

(b) Josselyn, Michael, 1993. Wetland Inventory and Restoration Potential: Santa Monica Bay Restoration Project Report.
(Contact Person: Paul Michel- (213) 266-7516.

(c) Santa Clara River Estuary: DPR Report
(Contacts: Steve Trainer or Virginia Johnson (805) 654-4611)

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2. California Department of Boating and Waterways,
1629 South Street,
SACRAMENTO, Ca 95814-7291 Tel (916) 445-6281
Bill S. Satow, Interim Director.

2.1. Response to Waterbody and Beneficial Use Survey (dated July 15, 1992):
"No Comment"

3. California Department of Fish and Game,
1416 Ninth Street, P.O. Box 44209,
SACRAMENTO, CA 94244-2090 Tel (916) 653-7664
Boyd Gibbons, Director

3.1. Response to Existing Waterbody and Beneficial Use Survey. (Response dated August 12, 1992).

3.2. Suggested additions of BU's to:
405.12 Long Beach Marina,
Alamitos Bay,
403.11 Nearshore Zone

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3.3. Suggested further contact with Kris Lal, Richard Nitsos, Department Environmental Specialists, Long Beach

4. **California Trout,**
Region 5 Office, 9770 Sombra Terrace,
SHADOW HILLS, Ca 91040 Tel (818) 951-4015
Jim Edmondson, Regional Manager

4.1. Response to Existing Waterbody and Beneficial Use Survey. (Response dated July 27, 1992).
4.2. Suggested modifications to Beneficial Uses for:

404.36	Zuma Canyon Creek
403.11	Calleguas Creek
404.11	Topanga Canyon Creek
404.22	Las Virgenes Creek
404.44	Arroyo Sequit Creek
404.47	Big Sycamore Creek
404.32	Solstice Canyon Creek

4.3. Also provided references and copies of some reports.

5. **Crescenta Valley County Water District,**
2700 Foothill Boulevard,
LA CRESCENTA, Ca 91214. Tel (818) 248-1659
Michael Sovich, District Engineer

5.1. Response to Groundwater Basin Survey. (Response dated 4, 1993.

5.2. Suggested BU's for;
405.24 Verdugo Groundwater Basin

6. **Friends of Los Angeles River,**
Technical Advisory Board,
P.O. Box 292134,
LOS ANGELES, CA 90029 Tel (213) 223-0585
Jim Danza, Chair, Technical Advisory Board

6.1. Response to Beneficial Use Survey. (Response dated July 29, 1992.

6.2. Suggested changes and included justification for the following waterbodies:

405.12	Los Angeles River Tidal Prism
405.15	Arroyo Seco south of Devil's Gate Reservoir
405.15	Compton Creek
405.15	Los Angeles River to tidal prism
405.21	Los Angeles River
405.21	Sepulveda Flood Control Basin
405.20	San Fernando Valley Groundwater Basin

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6.3. Also provided documentation and photographs to support recommendations.
6.4. Follow-up discussions and a field trip with Jim Danza on FOLAR comments.

7. **Friends of Ventura River**
63 South Olive Street,
SAN BUENAVENTURA, CA 93001 Tel (305) 643-6074
Mark H. Capelli, Executive Director

7.1. Responses dated July 21, 1992, February 5, 1993 and June 9, 1993.
7.2. Suggested changes and provided justification for the following waterbodies:

401.00	Rincon Creek and other streams
	Javon Canyon
402.10	Lower Ventura River Tidal Prism
	Canada Larga
	Ventura River and tributaries
	Nearshore Zone
402.20	Murietta Canyon
	Matilija Reservoir
	East Fork Coyote Creek
	West Fork Coyote Creek
	Matilija Creek
	West Fork Matilija Creek
	Upper North Fork Matilija Creek
	West Fork Santa Ana Creek
	Mirror Lake
402.32	Reeves Creek
404.44	Arroyo Sequit

7.3. Also provided exhaustive documentation and copies of publications and reports.
7.4. Commented on June 9, 1993, in response to our coastal survey that "beneficial uses associated with Ventura River tidal prism appear to adequately cover existing uses". Cobble tide-pools in the Ventura River mouth are important shell-fish harvesting site.
7.5. Several follow-up phone conversations to get other information.

8.0. **Los Angeles County Department of Beaches and Harbors,**
13837 Fiji Way,
Marina Del Rey, Ca 90292 Tel (310) 305-9503
Gregory Woodell, Acting Chief, Planning

8.1. Response dated March 15, 1993, on coastal features.
8.2. Suggested changes to names of beaches.

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8.3. Provided a map giving the location and names of beaches, in use by the L.A. Department of Beaches and Harbors.

8.4. No beneficial use changes suggested.

9.0 **Los Angeles County Department of Health Services**
2525 Corporate Place, # 150,
Monterey Park, ca 91754-7631 Tel (213) 881-4011
Jack Petralia, Director of Environmental Protection.

9.1. Response dated July 23, 1992:
" No comments".

10.0 **Los Angeles County Museum of Natural History,**
900 Exposition Boulevard,
Los Angeles, Ca 90007
Camm Swift, Fisheries Biologist

9.1. Responses dated October 30, 1992 and January 15, 1993.

9.2. Suggested changes and provided justification for the following waterbodies:

402.10	Ventura River Tidal Prism
402.12	Arroyo Las Posas
402.20	Ventura River and tributaries
403.11	Calleguas Creek Tidal Prism
	Santa Clara River Estuary,
	Nearshore Zone
403.12	Calleguas Creek
	Conejo Creek
403.21	Santa Paula Creek
403.32	Pine, Coldwater, Bear, Portero John, Tule Creeks
403.41	Santa Felicia Canyon
403.43	Gorman Creek
403.51	Drinkwater Reservoir
	San Francisquito Canyon
	Santa Clara River
403.54	Agua Dulce Canyon
403.62	Arroyo Las Posas
404.11	Topanga Canyon Creek
404.21	Cold Creek
404.23	Medea Creek
404.25	Triunfo Canyon
404.44	Arroyo Sequit
	East Fork Arroyo Sequit
404.47	Wood Canyon
	Lebrand Canyon
	Big Sycamore Canyon Creek
405.12	Alamitos Bay
405.13	Ballona Wetland
405.15	Ballona Creek
405.22	Pacoima Canyon Creek

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405.23 Big Tujunga Canyon Creek
Upper Big Tujunga Canyon
Fox Creek
405.27 Hansen Lake
405.41 Whittier Narrows Flood Control Basin
405.43 Bichota Canyon
Cattle, Coldwater, Cow Creek
East and North Forks San Gabriel
River, Devil's Canyon Creek

10.3. Also included references

11. **Los Angeles County Department of Public Works**
P.O. Box 1460,
ALHAMBRA, Ca 91802-1460 Tel (818) 458-5948
Gary Hildebrand, Supervising Civil Engineer

11.1 Response dated January 13, 1993.
11.2 Suggested changes and gave justification for these waterbodies:

405.13 Cetinella Creek Channel
Sepulveda Channel

12. **Los Angeles Department of Water and Power,**
111 North Hope Street,
Los Angeles, Ca 90051-0100 Tel (213) 481-8701
Dennis C. Williams, Engineer in Charge, Aqueduct Division

12.1. Response dated November 30, 1992
12.2. Suggested changes for these waterbodies:

403.51 Dry Canyon Reservoir: out of service
403.52 Bouquet Reservoir
405.13 Stone Canyon Reservoir
405.14 Hollywood Reservoir
Upper Franklin Reservoir
Lower Franklin Reservoir
Ivanhoe Reservoir
Silverlakes Reservoir
Elysian Reservoir
Encino Reservoir
Los Angeles Reservoir
Solado Reservoir
405.20 San Fernando Valley Groundwater Basin
405.25 Eagle Rock Reservoir

13. **Las Virgenes Municipal Water District**
4232 Las Virgenes Road,
CALABASAS, Ca 91302 Tel (818) 880-4110
Ane D. Deister, Director of Resource Conservation

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13.1 Response dated July 23, 1992 and January 4, 1993
13.2 Gave status of beneficial uses for:
    404.21 Malibu Creek
    404.22 Las Virgenes Creek
13.3. Provided reports and documentation on water quality and groundwater.
13.4. Met with Ane Deister and other representatives, at the LVMWD offices to clarify locations and names of waterbodies in their district.

14. **NOAA National Marine Fisheries Service**
501 West Ocean Blvd., Suite 4200,
Long Beach, Ca 90802-4213 Tel (310) 980-4001
Gary Matlock, Acting Regional Director

14.1. Responses dated July 28, 1992 and January 21, 1993
14.2. Commented on general organization of BU tables; suggested addition of several additional BUs for groundwater basins, since groundwater withdrawal has eliminated several surface water habitats for fish. Also suggested addition of Estuaries and Wetlands to waterbodies, and expansion of definition of "nearshore zone," BIOL, WILD.
14..3. Specific suggestions on the following waterbodies:

403.11	Santa Clara River
405.12	Los Angeles River Tidal Prism
	Colorado Lagoon
	Alamitos Bay
	Las Cerritos Wetlands
405.13	Ballona Wetlands
406.00	Channel Islands

15. **Santa Clarita Water Company,**
P.O. Box 903,
SANTA CLARITA, Ca 91380 Tel (805) 259-2737
William J. Manetta

15.1. Response dated March 15, 1993
15.2 No Comments on the following groundwater basins:
    403.51 Eastern HSA Groundwater Basins
    403.52 Bouquet Canyon Groundwater Basin

16. **Southern California Coastal Water Research Project,**
646 West Pacific Coast Hwy.,
Long Beach, Ca 90806 Tel (310) 435-7071
Jeffrey Cross, Director

16.1. Response dated July 16, 1992
16.2. Comments and justification for the following waterbodies:

    405.12 King Harbor/Redondo Beach

	L.A./L.B. Outer Harbor
405.13	Marina del Rey Entrance Channel
406.01	Pacific Ocean Nearshore and Offshore Zone
406.10	Anacapa Islands Nearshore Zone
406.20	San Nicolas Island and Begg-Rock Nearshore Zone
406.30	Santa Barbara Island
406.50	San Clemente Island

16.3. Gave a reference of the following publication:
Dailey, Reish, Anderson, Editors
Ecology of Southern California Bight,
University of California Press, (UCLA Office)
IN PRESS (Dr. Cross is the author of the chapter on fishes).

17. **Santa Monica Mountain National Recreation Area,**
30401 Agoura Road, Suite 100,
Agoura Hills, Ca 91301 Tel (818) 597-1036
David Gackenbach, Superintendent

17.1. Response dated January 14, 1993.
17.2. Suggested modifications and justification for beneficial uses for these waterbodies:

404.21	Cold Creek
	Century Reservoir
404.24	Medea Creek
	Lake Enchanto
404.25	Lake Eleanor
	Las Virgenes Reservoir
404.44	East Fork, Arroyo Sequit
405.13	Santa Ynez Canyon
405.14	Franklin Canyon Reservoir
405.21	Encino Reservoir

17.3. Provided a map of the SMMNRA

18. **National Audubon Society,**
Education Division,
Los Angeles. Tel (213) 574-2797
Daniel Kahane, Environmental Education Specialist

18.1. Response dated January 15, 1993.
18.2. Comments on the following waterbodies:

405.13.	Ballona Wetlands
	Ballona Creek

19. **Three Valleys Municipal Water District,**
P.O. Box 1300,
CLAREMONT, Ca 91711
Rick Hansen, General Manager

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19.1. Response approximately March 4, 1993.
19.2. Comments on the following Groundwater Basins

405.41	Tributary basins to Main San Gabriel Basin
	Foothill GW Basin
	San Dimas GW Basin
	Way Hill GW Basin
	Glendora GW Basin
	Upper San Gabriel Canyon GW Basin
	Lower San Gabriel Canyon Groundwater Basin
405.52	Pomona GW Basin
405.53	Live Oak GW Basin
481.23	San Antonio Canyon Basin
	Upper Claremont Heights Basin
	Lower Claremont Heights Basin
	All other Groundwater

20. U.S. Forest Service,
Angeles National Forest,
701 North Santa Anita Ave.,
ARCADIA, Ca 91006-2799 Tel. (818) 574-1613
Joe Gonzales, Physical Science Technician

20.1. Response dated August 10, 1992

20.2. Suggested MUN, HYDRO, REC-1, REC-2, WILD, RARE, SPAWN, as beneficial uses for several waterbodies.

20.3. Provided a copy of the Angeles National Forest Area.
20.4. Follow-up telephone clarification with Mr. Gonzales.

21. U.S. Forest Service,
Las Padres National Forest,
1190 East Ojai Ave.,
OJAI, Ca 93023 Tel (805) 646-4348
Ron Bassett, District Ranger

21.1. Response dated January 20, 1993
21.3. Commented on the waterbodies lying within the boundaries of the Las Padres National Forest (LPNF), and the beneficial uses to be consistent with the LPNF Land and Resource Management Plan.
21.4. Suggested that since 402.20 West Fork Matilija does not exist on Forest Service maps, it should be depicted as Old Man Canyon.
21.5. Provided maps giving boundaries and explanation for Los Padres Condor Range and River Protection Act (PL 102-301: June 19, 1992),
21.6. Follow-up telephone conversations to clarify comments.

22. USDA Soil Conservation Service,

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P.O. Box 260,
SOMIS, Ca 93066   Tel (805) 386-4489
Sheri Klittich

22.1. Response dated July 23, 1992, with "No Comments".

23. United Water Conservation District,
725 East Main Street, Suite 301,
SANTA PAULA, Ca 93061   Tel (805) 525-4431
Jim Gross, Groundwater Resource Manager

23.1. Response dated July 24, 1992
23.2. Comments on the following Waterbodies:

403.42	Pyramid Lake
403.51	Castaic Lake and Forebay

23.3. Follow-up telephone comments on other groundwater basins.

24. U.S. Fish and Wildlife Service,
2140 Eastman Avenue, Suite 100,
VENTURA, Ca 9300   Tel (805) 644-1766
Cat Brown, Wildlife Biologist.

24.1. Response dated October 5, 1992
24.2. Provided information on the fisheries habitat and sensitive species in the following waterbodies:

402.10	Ventura River Tidal Prism
	Ventura River and Tributaries
403.11	Santa Clara River Tidal Prism
	Santa Clara River
403.31	Santa Clara River
	Sespe Creek
403.41	Piru Creek and Tributaries
	Santa Clara River
403.51	San Francisquito Canyon
	Santa Clara River and Tributaries
403.54	Agua Dulce Canyon

25. Ventura County Environmental Health Department,
800 South Victoria Ave.,
VENTURA, Ca 93009.
Robert Gallagher

25.1. Response with no date, probably after July 7, 1992
25.2. Comments on:

402.20	Lake Casitas

26. Ventura County Public Works Agency,
800 South Victoria Avenue,
VENTURA, Ca 93009   Tel (805) 654-2907
Lowell Preston, Manager, Water Resources Division

26.1. Response dated February 10, 1993
26.2. Provided comments on the following waterbodies:

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402.32 Horn Canyon
Reeves Canyon
403.62 Arroyo Las Posas
403.66 Tapo Canyon
403.67 Tapo Canyon
403.67 Wood Ranch (Bard) Reservoir
404.25 Lake Eleanor Creek

26.3. Follow-up telephone conversations with Mr. LaVern Hoffman, of their office, for information on groundwater basins.

27. **West Basin Municipal Water District,**
17140 S. Avalon Blvd., Suite 210,
CARSON, CA 90746-1218 Tel (310) 217-2411
Linda Palmquist, Water Resources Engineer

27.1. Response dated March 10, 1993
27.2. Provided information on:
405.12 West Coast Groundwater Basin
27.3. Enclosed James Montgomery Final Report.

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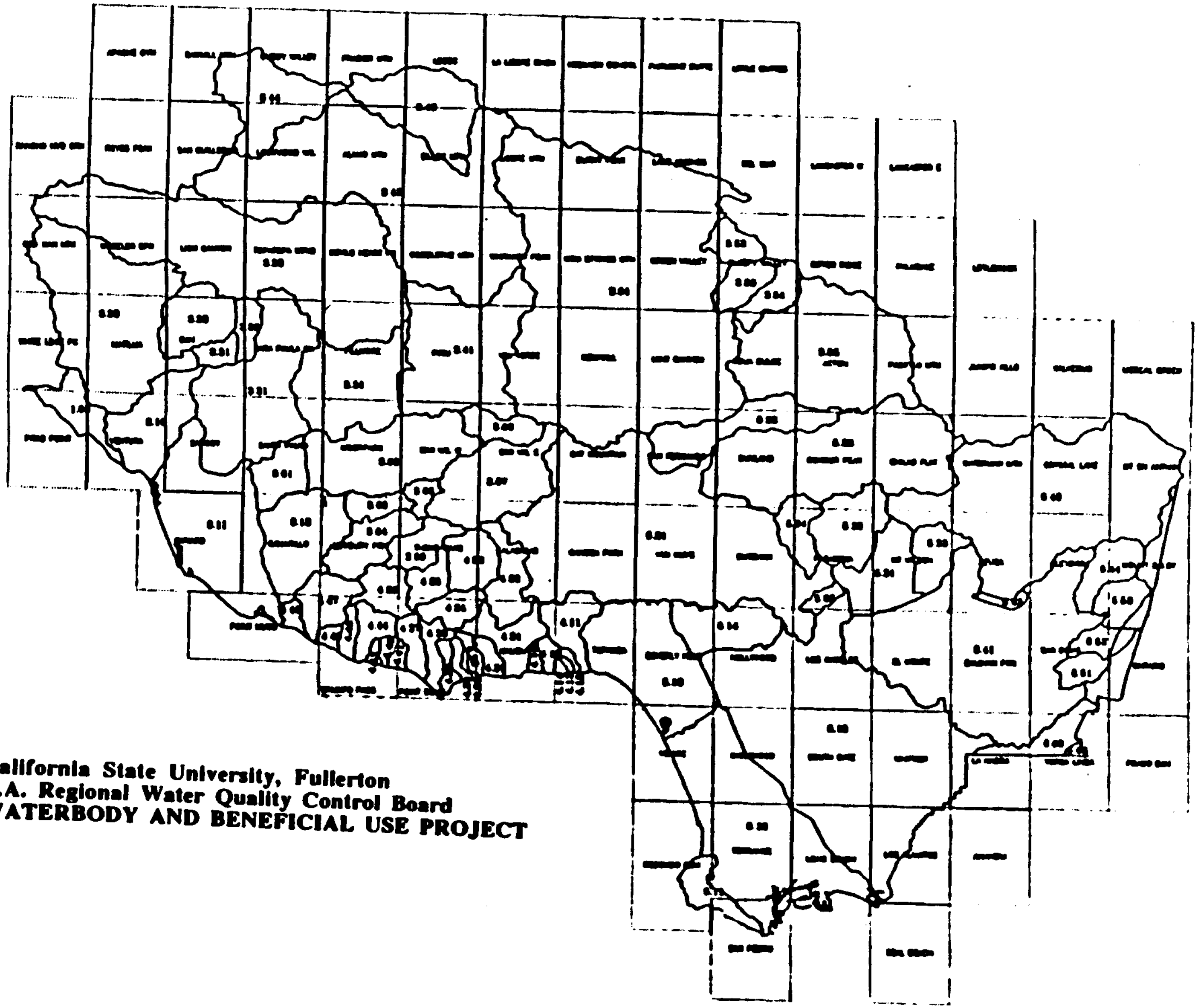

California State University, Fullerton
L.A. Regional Water Quality Control Board
WATERBODY AND BENEFICIAL USE PROJECT

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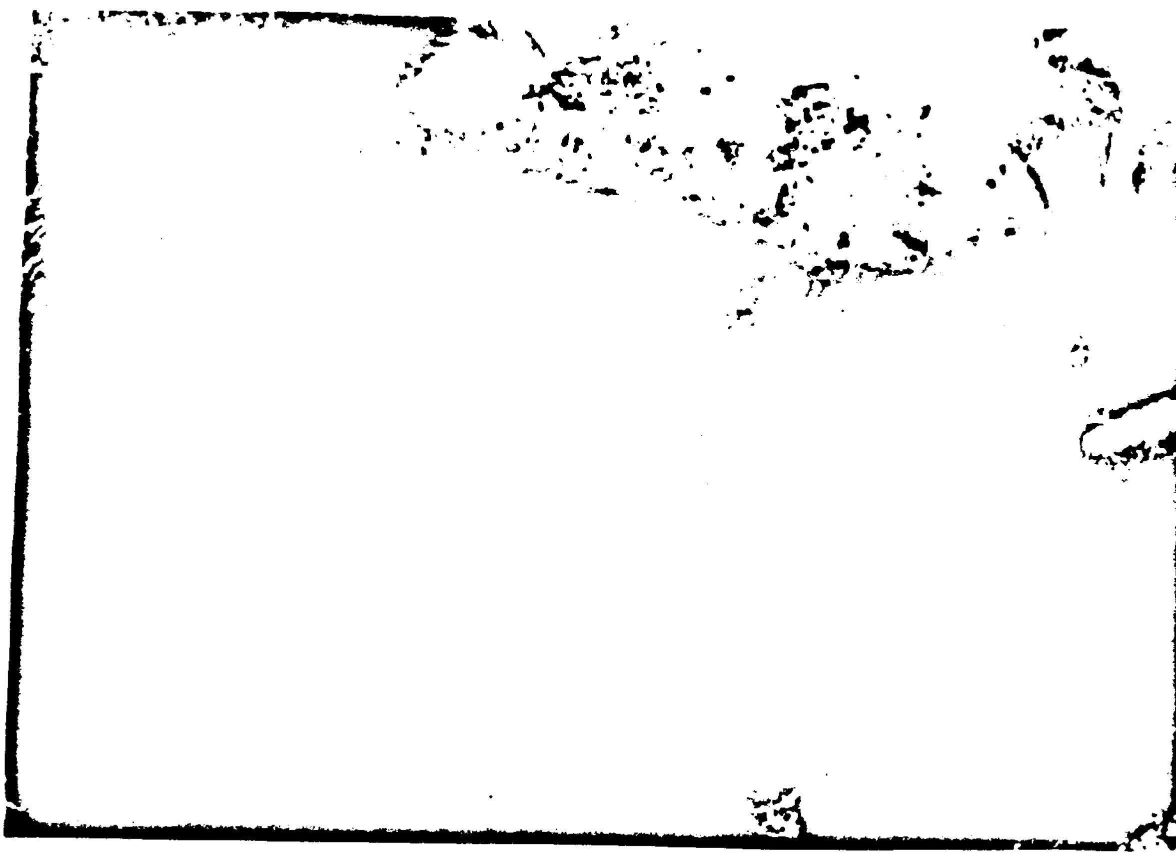
VOL 12

Waterbodies, Wetlands and their Beneficial Uses in the Los Angeles Region (4)

A Report Presented to
L A Regional Water Quality Control Board



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Prem K. Saint, Ted L. Hanes, William J. Lloyd
California State University, Fullerton

Volume 2. Wetlands and their Beneficial Uses
(Compiled by Tony Bomkamp)

July, 1993

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WATERBODIES, WETLANDS, AND THEIR BENEFICIAL USES IN THE LOS ANGELES REGION (4)

Principal Investigator: Dr. Prem K. Saint

Co-Principal Investigator: Dr. John H. Foster
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RWQCB Contract Manager: Gerhardt Hubner
CSUF Project Manager: Kwan J. Ihn

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EXECUTIVE SUMMARY

In order to prepare a wetland inventory for the Regional Water Quality Control Board, Region 4, a literature review and field surveys of rivers, lakes, reservoirs and estuaries of the coastal region of the Los Angeles and Ventura Counties were conducted from July, 1991 to January, 1993. Our study indicated the existence of at least 15 estuarine and coastal wetlands, 14 lacustrine wetlands and 79 rivers with stretches of riparian wetlands. The study period included the last two years of a six-year drought, and yet most of the rivers in the mountain reaches were flowing and supporting wetland vegetation. During the heavy rains of winter, 1993, several of the river mouth estuaries were breached by flood waters, allowing migration passage for anadromous fish like steelhead trout (*Oncorhynchus mykiss*).

Our study has concentrated on the estuarine, lacustrine, riverine and palustrine wetlands of the region, integrating these into estuarine, lacustrine and riparian categories. This is in agreement with the California Department of Fish and Game policy of placing riparian forests, woodlands and scrubs into riparian habitats.

In southern California, agricultural practices, followed by rapid urbanization had led to estimated losses of 90% of the coastal salt marsh. As a result of channelization and concrete lining of rivers, riparian habitats in the coastal floodplain has been reduced by 95 to 97%. Urbanization has not significantly affected the riparian wetlands in the mountainous regions, and has provided a net gain in lacustrine wetlands behind the flood control reservoirs. Many of the urban lakes, such as the Whittier Narrows Recreation Area, serve as "ecological islands" for many species of birds and fish. Several threatened and endangered species and species of special concern found in these artificial wetlands include: southwestern pond turtle (*Clemmys marmorata pallida*), at Lake Piru, Lake Sherwood, Lake Malibu, and Lake Casitas; Santa Ana sucker (*Catostomus santaanae*), at Lake Piru and San Gabriel Reservoir; and California least tern (*Sterna antillarum browni*), at Lake Machado and Harbor Lake.

The remaining riparian wetlands in the coastal region provide wildlife corridors. Malibu Creek, for example links various portions of the Santa Monica Mountains and the Santa Clara River provides a significant corridor for the rainbow and steelhead trout to migrate between the lower reaches of the river and spawning and rearing habitat in tributaries such as Sespe and Piru Creeks.

Our ranking system, using various wetland function criteria, has attempted to rank the coastal and riparian wetlands. We recommend a WETLAND designation for most of the waterbodies included in the Wetland report.

Waterbodies, Wetlands and Beneficial Uses of the Los Angeles Region

Volume 2: WETLANDS AND THEIR BENEFICIAL USES

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Acknowledgement

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INTRODUCTION

Wetlands have been important to people in California since prehistoric times. Archeological middens indicate that coastal wetlands were important sites for food-gathering among some aboriginal groups. Riverine habitats, which were the source of fish (salmon in particular), also provided acorns, the second most important dietary staple for these groups. Lakes were also exploited for fish, waterfowl, and other food sources along with bulrush or tule which provided fiber for clothing and housing (Beals and Hester 1971).

Reduction of wetland acreage began with European settlement. Salt marshes were reclaimed for salt ponds, agriculture, and urbanization (Macdonald 1988). The great riparian forests of the central valley were cleared for flood control and agriculture (Katibah 1984). Hydroelectric projects and stream channelization further contributed to the loss of wetlands throughout the state.

In southern California, agricultural practices during the late 1800s, followed by rapid urbanization after World War II, led to dramatic reduction of wetland. Regulatory agencies such as the California Coastal Commission have estimated losses of coastal salt marsh to be as high as 90% (Ferren 1990). Riparian habitat in southern California floodplain areas has been reduced by 95 to 97% (Faber et al. 1989).

Lands which were once thought to be worthless swamps, marshes, or mires are now being appreciated as areas which equal tropical rainforests for productivity (Williams 1990). These same biotic communities are also being recognized as areas important to numerous types of vegetation and wildlife. Southern California salt marshes are home to numerous threatened or endangered species including the light-footed clapper rail (*Rallus longirostris levipes*), Belding's savannah sparrow (*Passerculus sandwichensis beldingi*), California least tern (*Sterna antillarum browni*), salt marsh harvest mouse (*Reithrodontomys raviventris*), and salt marsh bird's-beak (*Cordylanthus maritimus ssp. maritimus*). Inland coastal freshwater wetlands provide habitat for other threatened or endangered species. These are the unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*), bank swallow (*Riparia riparia*), and the slender-horned spineflower (*Centrostegia leptoceras*). Many other plants and animals which depend on salt or fresh water wetlands are candidates for listing as endangered or threatened. The protection and enhancement of all types of wetland habitats in California requires an accurate inventory of the wetland resources within the state.

The purpose of this study was to provide the Los Angeles Water Quality Control Board, with an update of the surface water resources over which it has regulatory responsibilities and powers. A significant portion of the study involved the identification and ranking of the significant wetlands within Region 4. These wetland resources are areas of increasing importance to humans and wildlife as urban practices increasingly have negative impact on the surface water resources of the Region.

Description of Wetland Systems

Although wetlands traditionally have been thought of as areas of standing water, such as ponds, marshes, and swamps; drier wetlands are now included in the designation. The inclusion of the drier wetlands habitats is based on their unique and crucial ecological role. In these areas, the soil may only be saturated for a brief period during the growing season and water only flows occasionally on the surface.

Classification of the vegetation associated with the surface hydrologic features within Region 4 is based in part on criteria used to define wetlands. For wetlands, the definition by Cowardin et al. (1979) was used:

> "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purpose of this classification, wetlands have one or more of the following attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominately undrained hydric soil; (3) the substrate is nonsoil and is saturated with water or covered with shallow water at some time during the growing season of each year."

By means of aerial photo interpretation, the U.S. Fish and Wildlife Service (1976) has developed a detailed hierarchical system of classifying national wetlands and has created sets of U.S. Geological maps showing the five classifications and wetland habitats. These include numerous intertidal and nontidal types, and vegetated and nonvegetated types. Subtidal deepwater habitats occur in the nearshore waters adjacent to intertidal wetlands. The wetlands and deepwater habitats are grouped into five principal systems.

Marine System. This type occurs seaward of coastal dunes, dune swales, sandy beaches, and estuaries. It includes nearshore subtidal deepwater habitats and intertidal wetlands on the shallow continental shelf and coastline where salinities usually exceed 30 o/oo. Wetlands along the intertidal cobble and sand margin of river deltas and the adjacent nearshore subtidal deepwater habitats are dominated by marine algae and angiosperms. The distribution of plants and animals in the marine system primarily reflects the differences in four factors: (1) degree of exposure of the site to waves; (2) texture and physicochemical nature of the substrate; (3) amplitude of the tides; and (4) latitude, which

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governs water temperature, the intensity and duration of solar radiation, and the presence or absence of ice. Marine wetlands are common along the entire coastline of Region 4.

Estuarine System. This type includes habitats commonly referred to as coastal salt marshes, bays, tidal channels and lagoons, and consists of subtidal deepwater habitats and intertidal wetlands usually confined to coastal embayments or other physiographic features that are open to the ocean at some time during the year. They also receive freshwater runoff, and are flooded by water with an annual low-flow salinity greater than 0.5 o/oo from ocean derived salts. Wave action is minimal. Estuarine wetlands and associated subtidal deepwater habitats occur at the Ventura and Santa Clara Rivers, Point Mugu, Malibu and Ballona Creeks. Former estuarine wetlands habitats associated with the mouths of the Los Angeles and San Gabriel Rivers have been greatly reduced or eliminated by channelization and dredging.

Riverine System. This type occurs in river and stream channels. It includes deepwater habitats and wetlands (submerged by less than 2 m or 6.6 feet of water) that are characterized by non persistent annual plants, when vegetated, and are flooded by water with an average annual low-flow salinity of less than 0.5 o/oo from ocean derived salts. The exposed channel margins and permanently flooded channels of the Ventura, Santa Clara, Los Angeles and San Gabriel Rivers belong to this system and occur upriver from estuarine wetland habitats.

Palustrine System. This type includes wetlands that in California are called "riparian" or "floodplain" vegetation and are characterized by persistent plant types (perennial emergents, scrubs, shrubs, and trees) when vegetated and that are flooded by water with an average annual salinity of less than 0.5 o/oo from ocean derived salts. If non persistent (above-ground annual) vegetation occurs, the habitat is not a riverbed or streambed. Palustrine wetlands are the most common type in the inland portion of Region 4 and include dune swales, freshwater marsh, scrub/shrub, and wooded or forested wetlands.

Lacustrine System. This type includes wetlands and deepwater habitats such as permanently flooded lakes and reservoirs with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel, (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage, and (3) total area exceeds 8 ha (20 acres). Similar habitats totaling less than 8 ha are also included if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the deepest water exceeds 2 m at low water. This system is well represented in Region 4 by man-made lakes and reservoirs.

Region 4 contains all five wetland systems. This study, however has concentrated on only the Estuarine, Riverine, Palustrine and Lacustrine systems. Riverine, which is not well represented in Region 4 and Palustrine have been combined under the classification of Riparian. This is in agreement with Orme (1990) who places riparian forests, woodlands and scrubs and associated floodplains into the Riverine category. All wetlands in Region 4 therefore fall into one of three classifications: Estuarine wetlands, Lacustrine wetlands, and Riparian wetlands.

Methods and Approaches

For purposes of the study, wetland habitats were defined, delineated, and described by application of a modified version of the definition and classification of wetlands by the U.S. Fish and Wildlife Service (Cowardin et al. 1979). The major criteria of identification were plants and hydrology. Soils were not used in wetland delineation. Another departure from the U.S. Fish and Wildlife Service system was that three, instead of five, wetland categories were used. Our three categories are:

1. Coastal: including estuarine and coastal palustrine,
2. Lacustrine: including lacustrine and palustrine,
3. Riparian: including riverine and palustrine.

A multifaceted approach was employed in determining location, areal extent, and quality of coastal, lacustrine and riparian wetlands within Region 4.

Information from the following sources was used in a hierarchical schema which generally followed the order in which they are explained:

Literature Search. The initial step was to assemble literature on wetlands in southern California including scientific literature (journal articles, proceedings of symposia, etc.), environmental impact reports (EIRs), documents by public agencies, and pertinent field guides for both floral and faunal wetland components.

National Wetland Inventory Maps. U.S. Fish and Wildlife Service 7.5 min National Wetlands Inventory maps were used as a primary source for location and areal extent of wetlands. These maps were consulted throughout the study. Before visiting a site, the Wetlands Inventory maps were consulted so that field proofing could be accomplished.

Field Visits. Hydrological, floral, and faunal components of candidate sites were observed and recorded during field visits conducted between July 1991 and November 1992.

Hydrological. Presence of water, depth, width, velocity, and approximate discharge were recorded for each site. This information was augmented by data from stream gaging stations

Channel characteristics and degree of erosion was also recorded.

Floral. Vegetation was sampled using a modified form of the releve approach of Mueller-Dombois (1974). Sites were reconnoitered by driving or hiking a large enough portion to familiarize the field investigator with the community or communities present. Stands best representing each community were then chosen and sampled. Sampling was by quadrat or belt transect for species composition by percent cover. Determination of species composition is a key element in wetland determination. The indicator status of various plant species is given in the *National List of Plant Species That Occur in Wetlands: 1988 California (Region 0)*, (Reed 1988). The formula used in determining the presence of hydrophytic vegetation is provided in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (Federal Interagency Committee for Wetland Delineation 1989). Photographs were taken of representative stands along with other significant features such as waterfalls and wildlife. 7.5 min USGS maps were used in the field to record sampling sites.

Faunal. Animal observation consisted mostly of bird sightings, which were recorded by species. Many species of birds are obligately tied to wetland habitats such as Belted Kingfisher (*Ceryle alcyon*) observed at San Antonio Creek near Ojai and Osprey (*Pandion haliaetus*) diving for fish at Lake Eleanor in Thousand Oaks. Presence of fish and amphibians was also recorded.

Rare Find and Pacific Coast Ecological Inventory Maps. Rare Find is the name of a computer database and accompanying maps (1:100,000 scale) available from the California Department of Fish and Game, Natural Diversity Database. These were used to locate endangered, threatened, and rare plants; endangered and threatened animals; and vegetation communities considered by biologists to be of special concern. Rare Find is updated on an annual basis. The database for the period of June, 1991 to June, 1992 was used in this study. The U.S. Fish and Wildlife Service, 1:125,000 scale, Pacific Coast Ecological Inventory Map (1981) was used as a complement to Rare Find.

Color Infrared Aerial Photograph Interpretation. Infrared photos were used to confirm the accuracy of National Wetland Inventory maps in conjunction with field visits. They were also consulted to make determination of areal extent of riparian wetlands where access was not possible. Infrared photos were also used to determine extent of vegetation zones around lakes.

Questionnaire Responses. Questionnaires were sent to various agencies (U.S. Forest Service, California Fish and Game, etc.) and local interest groups. Information from questionnaires and letters received from such groups provided important

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"local" information on many wetlands and associated populations of plants and animals. Field checks were carried out to confirm comments, or comments were followed up by telephone conversations where clarification was needed.

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Wetland Selection and Ranking Process

Waterbodies which met the conditions for wetland designation, were also ranked based on a number of criteria. The ranking of wetlands provides the Board with information regarding the relative quality of wetlands over which they have jurisdiction. The criteria, nine in all, included six habitat related criteria and three related to function.

Habitat

(1) **Disturbance** - consists of two components: physical and biological. Physical disturbance includes such things as the dredging of channels (Santa Clara River), sand and gravel mining operations (lower Ventura River), presence of debris dams or basins (Santa Anita Canyon and Winter Creek), and off road vehicle use (North Fork, San Gabriel River). Biological disturbance is characterized by the invasion of alien plants or animals whose presence is deleterious to native species. For animals, a typical example is the introduction of Large-mouthed Bass (*Micropterus salmoides*) and Carp (*Cyprinus carpio*) in the lower Ventura River where they now compete with native species for resources. For plants, giant reed (*Arundo donax*) and Eupatory (*Ageratina adenophora*) represent the most invasive plant species. Often, physical disturbance, such as dredging significantly alters habitat such that invasion by exotic species becomes possible.

(2) **Discharge regime** - considers the year round hydrological conditions for a given wetland. Perennial waterbodies typically are more valuable as habitat and as wildlife corridors than those which have water only during the rainy season. Many streams within Region 4 are "interrupted" meaning that portions contain water year round while other sections do not. San Franciquito Canyon Creek, due to year round water below Drinkwater Reservoir, maintains a significant population of the Unarmored Threespine Stickleback (*Gasterosteus aculeatus williamsoni*).

(3) **Botanical Diversity** - considers the plant species richness for a particular wetland. The botanical diversity is usually the function of a number of interrelated features: size, diversity of habitat types, and lack of disturbance. Size is typically measured as coverage in acres for coastal and lacustrine wetlands and as length for riparian wetlands. Mugu Lagoon and its associated salt marsh supports a much larger diversity of plants than does the Ballona wetlands due to larger size, more diversity of habitat and less disturbance. In a similar way, Eaton Canyon Creek which includes canyon live oak ravine forest, white alder riparian forest, southern mixed riparian forest, southern arroyo willow riparian forest, southern sycamore alluvial woodland and alluvial scrub has higher diversity of plants than does Medea Creek which is composed almost entirely of southern arroyo willow riparian

forest.

(4) **Wildlife Habitat** - is an extension of the three previous criteria: botanical diversity, hydrological regime, and disturbance. High botanical diversity supports high wildlife diversity as does year round water supply. The presence of invasive exotic plants, such as *Arundo donax*, displaces native willows which are important habitat for numerous bird species including the endangered Least Bell's Vireo (*Vireo bellii pusillus*).

(5) **Uniqueness** - consists of two components. The first is the relative rarity of the vegetation type or community. Walnut riparian woodland is restricted to only a few sites in all of region 4 whereas mulefat scrub is very common. The second aspect considered when evaluating uniqueness concerns features which make a given wetland unique. Designation of certain reaches of streams in Region 4 as wild trout streams would be an example of this aspect.

(6) **Wildlife Corridors** - considers the value to wildlife in providing corridors for migration. This is particularly important in maintaining gene flow between disjunct populations, thereby increasing genetic diversity. These corridors are most important where urbanization is encroaching upon and fragmenting habitat.

<u>Functional</u>

(7) **Flood Control** - considers the value of wetland vegetation and associated riparian vegetation in attenuating floods. By holding back flood waters and slowly releasing it to the environment, wetlands decrease potential damage from major flood events.

(8) **Groundwater Recharge** - considers the role of wetlands in providing a zone for the replenishment of groundwater supplies. The mouth of San Dimas Canyon, for example, is a significant recharge zone.

(9) **Water Quality** - considers the role which wetlands play in removing pollutants, sediments, and biochemical oxygen demand from water which is to be used for various beneficial uses.

The information on the wetlands of the Los Angeles Region has been tabulated as follows:

Table W 1.1	Coastal Wetlands
Table W 1.2	Lacustrine Wetlands
Table W 1.3	Riparian Wetlands
Table W 2.0	Beneficial Uses of L.A. Wetlands
Table W 3.1	Coastal Wetland Ranking
Table W 3.2	Riparian Wetland Ranking

TABLE W1.1COASTAL WETLANDS OF REGION 4

H.U.	NAME	# INCLUDE/ PROPOSED	@ AREA ACRES	WETLND DESIGN
**	COASTAL WETLAND			
402.10	VENTURA RIVER TIDAL PRISM	INCLUDED	35.6	*
403.11	MCGRATH LAKE (TIDAL PRISM)	INCLUDED	19.5	*
403.11	MUGU LAGOON (TIDAL PRISM)	INCLUDED	323.3	*
403.11	ORMOND BEACH	PROPOSED	136.5	*
403.11	SANTA CLARA RIVER (TIDAL PRISM)	INCLUDED	55.7	*
404.11	TOPANGA LAGOON	PROPOSED	5.0	*
404.21	MALIBU LAGOON (TIDAL PRISM)	INCLUDED	20.9	*
404.36	DUME LAGOON	PROPOSED	17.4	*
405.12	ALAMITOS BAY	PROPOSED	320.0	*
405.13	BALLONA LAGOON	PROPOSED	13.2	*
405.13	BALLONA WETLANDS	PROPOSED	355.2	*
405.13	DEL REY LAGOON	PROPOSED	5.4	*
405.13	VENICE CANALS - BALLONA CREEK (TIDAL PRISM)	INCLUDED	17.7	*
405.15	LOS CERRITOS LAGOON	PROPOSED	22.2	*
405.15	LOS CERRITOS WETLANDS	PROPOSED	226.0	*

TABLE W1.2 LACUSTRINE WETLANDS OF REGION 4

H.U.	NAME	# INCLUDE/ PROPOSED	@ AREA ACRES	c INTERMIT/ PERMANENT	WETLND DESIGN
402.20	MATILIJA RESERVOIR	INCLUDED	126.9	PERM	*
402.20	MIRROR LAKE	PROPOSED	7.6	PERM	*
402.20	OJAI WETLAND	PROPOSED	7.5	I	*
404.21	CENTURY RESERVOIR	PROPOSED	6.0	PERM	*
404.24	MALIBU LAKE	INCLUDED	44.4	PERM	*
404.25	LAKE ELEANOR	PROPOSED	7.8	I	*
404.26	LAKE SHERWOOD	INCLUDED	136.6	PERM	*
405.12	BIXBY SLOUGH AND HARBOR LAKE	INCLUDED	44.7	PERM	*
405.12	MADRONA MARSH	PROPOSED	6.9	I	*
405.14	UPPER FRANKLIN CANYON RESERVOIR	PROPOSED	5.8	PERM	*
405.15	EL DORADO LAKES	PROPOSED	36.5	I	*
405.15	SIMS POND	PROPOSED	2.7	I	*
405.41	LEGG LAKE	INCLUDED	8.2	PERM	*
405.41	SANTA FE FLOOD CONTROL BASIN	INCLUDED	1020.9	I	*

Included means that the waterbody was included in the 1978 Basin Plan of the Los Angeles Regional Water Quality Control Board.

@ The area includes the areal extent of the whole lake, reservoir or estuary, not all of which has wetland vegetation.

c Intermittent means that the lake or reservoir has seasonal water supply.

TABLE W1.3 RIPARIAN WETLANDS OF REGION 4

H.U.	NAME	# INCLUDE/ PROPOSED	@ LENGTH MILES	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
401.00	JAVON CANYON	PROPOSED	2.8		I	•
402.10	VENTURA RIVER & TRIBUTARIES	INCLUDED	5.9		PERM	•
402.20	COYOTE CREEK	PROPOSED	14.1		PERM	•
402.20	EAST FORK COYOTE CREEK	PROPOSED	2.5		PERM	•
402.20	MATILIJA CREEK	PROPOSED	15.9		PERM	•
402.20	MURIETTA CANYON	PROPOSED	4.1		PERM	•
402.20	OLD MAN CANYON	PROPOSED	3.2		I	•
402.20	SAN ANTONIO CREEK & TRIBUTARIES	INCLUDED	5.4		PERM	•
402.20	SANTA ANA CREEK	PROPOSED	6.1		PERM	•
402.20	VENTURA RIVER & TRIBUTARIES	INCLUDED	10.4		PERM	•
402.20	WEST FORK SANTA ANA CREEK	PROPOSED	3.5		PERM	•
403.11	SANTA CLARA RIVER	INCLUDED	9.8		PERM	•
403.21	SANTA CLARA RIVER	INCLUDED	6.7		PERM	•
403.21	SISAR CREEK	INCLUDED	1.2		PERM	•
403.22	SISAR CREEK	INCLUDED	6.4		PERM	•
403.31	SANTA CLARA RIVER	INCLUDED	9.7		PERM	•
403.31	SESPE CREEK	INCLUDED	6.0		I	•
403.32	BEAR CANYON	PROPOSED	3.2		PERM	•
403.32	COLDWATER CANYON	PROPOSED	2.2		PERM	•
403.32	PIEDRA BLANCA CREEK	PROPOSED	9.0		PERM	•
403.32	PINE CANYON	PROPOSED	4.7		PERM	•
403.32	POTRERO JOHN CREEK	PROPOSED	3.6		PERM	•
403.32	REDROCK CREEK	PROPOSED	4.0		PERM	•
403.32	ROSE VALLEY CREEK	PROPOSED	3.5		PERM	•
403.32	SESPE CREEK & TRIBUTARIES	INCLUDED	52.9		PERM	•
403.32	TIMBER CREEK	PROPOSED	4.9		PERM	•
403.32	TROUT CREEK	PROPOSED	4.1		PERM	•
403.32	TULE CREEK	PROPOSED	5.3		PERM	•
403.32	WEST FORK SESPE CREEK	PROPOSED	6.3		PERM	•
403.41	PIRU CREEK & TRIBUTARIES	INCLUDED	8.5		PERM	•
403.41	SANTA CLARA RIVER	INCLUDED	11.2		PERM	•
403.42	PIRU CREEK & TRIBUTARIES	INCLUDED	60.0	0.6	PERM	•
403.51	BOUQUET CREEK & TRIBUTARIES	INCLUDED	14.3		PERM	•
403.51	SAN FRANCISQUITO CANYON & TRIB.	INCLUDED	21.7		PERM	•
403.55	ALISO CANYON	PROPOSED	9.4		PERM	•
404.21	COLD CREEK	PROPOSED	5.2		PERM	•
404.21	MALIBU CREEK	INCLUDED	9.7		PERM	•
404.23	MEDEA CREEK	PROPOSED	5.4		I	•
404.44	ARROYO SEQUIT	INCLUDED	3.2		PERM	•
404.47	BIG SYCAMORE CANYON CREEK	INCLUDED	9.8		I	•
405.21	LOS ANGELES RIVER	INCLUDED	26.8	26.8	PERM	•
405.22	PACOIMA CANYON CREEK	INCLUDED	23.3		I	•
405.23	ALDER CREEK	PROPOSED	3.6		PERM	•
405.23	BIG TUJUNGA CANYON CREEK	INCLUDED	24.1		PERM	•
405.23	CLEAR CREEK	PROPOSED	3.7		PERM	•
405.23	MILL CREEK	INCLUDED	8.3		PERM	•
405.23	UPPER BIG TUJUNGA CANYON CREEK	PROPOSED	6.4		PERM	•
405.23	VASQUEZ CREEK	PROPOSED	1.2		PERM	•
405.31	EATON CANYON CREEK	INCLUDED	4.5		PERM	•
405.31	RUBIO CANYON	INCLUDED	3.5		I	•
405.32	ARROYO SECO CANYON	INCLUDED	14.4		PERM	•
405.32	LITTLE BEAR CREEK	INCLUDED	1.9		PERM	•
405.33	BIG SANTA ANITA CANYON CREEK	INCLUDED	4.8		PERM	•
405.33	WINTER CREEK	INCLUDED	3.2		PERM	•

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TABLE W1.3 RIPARIAN WETLANDS OF REGION 4

H.U.	NAME	INCLUDE/ PROPOSED #	LENGTH MILES @	LENGTH CHNNLZD	INTERMIT/ PERMANENT	WETLND DESIGN
405.41	BIG DALTON CANYON CREEK	INCLUDED	3.8		I	*
405.41	LITTLE DALTON CANYON CREEK	INCLUDED	4.0		I	*
405.41	MONROVIA CANYON CREEK	INCLUDED	2.9		I	*
405.41	RIO HONDO	INCLUDED	12.1	12.1	I	*
405.41	WALNUT CREEK WASH	INCLUDED	13.9	8.9	I	*
405.43	ALLISON GULCH	PROPOSED	2.5		PERM	*
405.43	BEAR CREEK	PROPOSED	11.2		PERM	*
405.43	CATTLE CREEK	INCLUDED	9.0		PERM	*
405.43	COLDWATER CANYON CREEK	INCLUDED	7.4		PERM	*
405.43	COW CREEK	INCLUDED	5.0		I	*
405.43	DEVILS CANYON CREEK	INCLUDED	10.8		PERM	*
405.43	EAST FORK SAN GABRIEL RIVER	INCLUDED	16.5		I	*
405.43	FISH CANYON	INCLUDED	6.9		I	*
405.43	FISH FORK	PROPOSED	7.3		PERM	*
405.43	IRON FORK	PROPOSED	6.2		PERM	*
405.43	NORTH FORK SAN GABRIEL RIVER	INCLUDED	4.6		PERM	*
405.43	PRAIRIE FORK	PROPOSED	6.2		PERM	*
405.43	ROBERTS CANYON	INCLUDED	6.6		I	*
405.43	SAN GABRIEL RIVER - MAIN STEM	INCLUDED	11.6	0.3	PERM	*
405.43	WEST FORK SAN GABRIEL RIVER	INCLUDED	20.0		PERM	*
405.44	FERN CANYON	PROPOSED	2.8		I	*
405.44	SAN DIMAS CANYON CREEK	INCLUDED	6.7		I	*
405.44	WOLFSKILL CANYON	PROPOSED	4.1		I	*
405.53	MARSHALL CREEK AND WASH	INCLUDED	3.8		I	*
481.23	SAN ANTONIO CANYON CREEK	INCLUDED	6.4		I	*

Included means that the waterbody was included in the 1978 Basin Plan of the Los Angeles Water Quality Control Board.

@ The length includes the total length of the river. Wetland conditions exist in portions of the rivers.

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TABLE W2 WETLANDS
BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SHL	EST	AQU	WET
401.00 PITAS POINT HU																								
p JAVON CANYON	P				I				I	I		I	I			E			I	I				E
402.10 LOWER VENTURA RIVER HA																								
VENTURA RIVER & TRIBUTARIES	P	E		E	E				E	E		E	E	E*		E	E*		E	E*				E
VENTURA RIVER ESTUARY									E	E	E	E	E*			E	E*	E	E	E*	E	E		E
402.20 UPPER VENTURA RIVER HA																								
p SAN ANTONIO CREEK & TRIBUTARIES	E	E	E	E	E				E	E		E	E	E		E			E	E				E
VENTURA RIVER & TRIBUTARIES	E	E	E	E	E				E	E		E	E	E*		E	E*		E	E				E*
p COYOTE CREEK	P				E							E	E			E*			E*	E*				E*
p EAST FORK COYOTE CREEK	P				E*				E*	E*		E*	E*			E*			E*	E*				E*
p MATILIJA CREEK	P				E				E	E			E			E				E*				E*
p MURIETTA CANYON	P				E*				E*	E*			E*			E*			E*	E*				E*
p OLD MAN CANYON	P				E				E	E			E*			E*				E*				E*
p SANTA ANA CREEK	P			P	E*				E*	E*		E*	P*			E*	P*			E				E
p UPPER NORTH FORK MATILIJA CREEK	P				E				E	E			E			E	E*		E*	E*				E*
p WEST FORK SANTA ANA CREEK	P				I					I			E			E			E	E				E
p OJAI WETLAND										E				E		E								E
403.11 OXNARD HSA																								
CALLEGUAS CREEK	P			E	E				E	E		E	E*			E	E*					E		E
SANTA CLARA RIVER	P	E	E	E	E				E	E		E	E*	E*		E	E*		E*	E*				E
MUGU LAGOON									E*	E	P			E*		E	E*	E		E*	P	E*		E*
SANTA CLARA RIVER ESTUARY									E	E				E*		E	E*					E		E
p ORMOND BEACH								E	E	E	E						E	E			E			E
403.21 SULPHUR SPRINGS HSA																								
SANTA CLARA RIVER	P	E	E	E	E				E*	E		E		E*		E	E*		E					E
SISAR CREEK	P	E	P	E	E				E	E		E	E	E		E	E*			E				E
403.22 SISAR HSA																								
SISAR CREEK	P	E	P	E	E				E	E		E	E	E		E	E*			E				E
403.31 FILLMORE HSA																								
SANTA CLARA RIVER	P	E	E	E	E				E*	E		E		E*		E	E*		E					E
SESPE CREEK	P	E	E	E	E				E*	E		E	E	E*		E	E*		E	E				E
403.32 TOPA TOPA HSA																								
SESPE CREEK	P	E	P	E	E				E	E		E	E	E		E	E*		E	E				E
p BEAR CANYON	P				E				E*	E		E	E*			E	E*		E*	E*				E*
p HOT SPRINGS CANYON	P				E*				E*	E*		P*				E	E*							E*
p HOWARD CREEK	P				E*				E*	E*			E*	E*		E	E*		E*	E*				E*
p LION CANYON	P				E				E*	E		E	E*			E			E*	E*				E*
p PIEDRA BLANCA CREEK	P				E				E*	E			E*			E	E*		E*	E*				E*
p PINE CANYON	P				E								E*	E*		E	E*			E*				E*
p POTRERO JOHN CREEK	P				E				E*	E			E*			E	E*		E*	E*				E*
p REDROCK CREEK	P				E								E*	E*		E	E*			E*				E*
p ROSE VALLEY CREEK	P				E*				E*	E*		E*	E*			E				E*				E*
p TIMBER CREEK	P				E*				E*	E*			E*			E	E*		E*	E*				E*
p TROUT CREEK	P				E				E*	E		E	E*			E	E*		E*	E*				E*
p TULE CREEK	P				E				P	E			E*	E*		E	E*		E*	E*				E*

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BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SWL	EST	AQU	WET
403.41 SANTA FELICIA HSA																								
PIRU CREEK	P	E	E	E	E				E	E		E	E	E*		E	E*		E*	E				E
SANTA CLARA RIVER	P	E	E	E	E				E	E		E		E*		E	E*		E*					E
p DOMINGUEZ CANYON	P				I							I	I*	E*		E								E*
403.42 UPPER PIRU HSA																								
PIRU CREEK	P	E	E	E	E				E	E		E	E	P*		E	E*			E				E
p AGUA BLANCA CREEK	P				E				E	E		E	E*	E*		E	E*			E				E*
403.51 EASTERN HSA																								
BOUQUET CANYON & TRIBUTARIES	I	I	I	I	I				I	E*				E*		E*								E
SAN FRANCISQUITO CANYON & TRIB.	I	I	I	I	I			E*	I	E*		I				E*	E*							E
SANTA CLARA RIVER & TRIBUTARIES	P	E	E	E	E				E	E		E		E*		E	E*							E
403.52 BOUQUET HSA																								
BOUQUET CREEK & TRIBUTARIES	P	P	P	E	E				E	E		E	E	E*		E	E*							E
403.55 ACTON HSA																								
SANTA CLARA RIVER & TRIBUTARIES	E	E	E	E	E				E	E		E		E*		E	E*							E
404.11 TOPANGA CANYON HSA																								
p TOPANGA LAGOON									E	E			E						P	E		E		E
404.21 MONTE NIDO HSA																								
MALIBU CREEK	P*								E	E		E	E	E*		E	E*		E	E				E
p COLD CREEK	P			•				•	E•		•			E		E	E*							E
p CENTURY RESERVOIR	P								E	E		E		E		E								E
MALIBU LAGOON		P							E	E				E*	E		E*	E	E	E		E		E
404.22 LAS VIRGENES CANYON HSA																								
LAS VIRGENES CREEK	P*								E*	E*		E*		E*		E*	E*		P*	P*				E
404.23 LINDERO CANYON HSA																								
p MEDEA CREEK	P				I				I	I		I		E		I	E*							E
404.24 TRIUNFO CANYON HSA																								
p MEDEA CREEK	I				I				E	E		E		E		E								E
MALIBOU LAKE	P								E	E		E				E	E*							E

BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPW	SHL	EST	AQU	WET
404.25 RUSSELL VALLEY HSA																								
p LAKE ELEANOR	P				E				E	E		E		E		E	E*							E
404.26 SHERWOOD HSA																								
LAKE SHERWOOD	P				E				E	E		E				E	E*							E
404.36 ZUMA CANYON HSA																								
p DUME LAGOON									E	E						E			P	P		E		E
404.47 BIG SYCAMORE CANYON HSA																								
BIG SYCAMORE CANYON CREEK	P				I				I	I		I	E*	E*		I			P*	P*				E
405.12 WEST COAST HSA																								
BIXBY SLOUGH AND HARBOR LAKE									E	E		E				E	E*							E
p MADRONA MARSH										E				E		E								E
p ALAMITOS BAY									E	E				E*		E	P*					E		E
405.13 SANTA MONICA HSA																								
p BALLONA LAGOON	*									I*		I*	I*	E*	E	E	E*	E*		I*	E*	E*		E
p BALLONA WETLANDS										E				E		E	E							E
p DEL REY LAGOON									E	E						E								E
405.14 HOLLYWOOD HSA																								
p UPPER FRANKLIN CANYON RESERVOIR	E*		E*						E	E		E				E								E
405.15 CENTRAL HSA																								
p EL DORADO LAKES									E	E		E				E								E
p SIMS POND										E				E		E								E
p LOS CERRITOS WETLANDS										E				E		E	E							E
405.22 SYLMAR HSA																								
PACOIMA CANYON CREEK	P				E				E	E		E	E	E*		E	E*			E				E
405.23 TUJUNGA HSA																								
BIG TUJUNGA CANYON CREEK	P				E				E	E		E	E	E*		E	E*							E
p ALDER CREEK	P				I				I	I		I		E*		E								E
p CLEAR CREEK	P				E				E	E		E	E	E*		E								E
405.31 PASADENA HSA																								
EATON CANYON CREEK	P				I				E	E		E		E*		E	E*							E
RUBIO CANYON	P				E				I	I		I		E*		E	E*							E
405.32 MONK HILL HSA																								
ARROYO SECO CANYON	E	E	E		E				E	E		E	E	E*		E								E
MILLARD CANYON CREEK	I	I	I		E				E	E		E		E*		E	E*							E
405.33 SANTA ANITA HSA																								
BIG SANTA ANITA CANYON CREEK	E				E				E	E		E	E	E*		E	E*			E				E
WINTER CREEK	P				E				E	E		E		E*		E								E
405.41 MAIN SAN GABRIEL HSA																								
BIG DALTON CANYON CREEK	P				I				I	I		I		E*		E								E
LITTLE DALTON CANYON CREEK	P				I				I	I		I		E*		I								E
LITTLE DALTON WASH	P				I				P	I		P				P								E
MONROVIA CANYON CREEK	I				I				I	I		I		E		E								E
SAN DIMAS WASH (LOWER)	P				I				I	I		I		E*		I	E*							E
WALNUT CREEK WASH	P				I				I	I		I				I								E
p MARSHALL CREEK	P				I				I	I		I				I								E
LEGG LAKE	P				E				E	E		E	E			E								E

BENEFICIAL USE DESIGNATION TABLES

BASIN	MUN	IND	PRO	AGR	GWR	FRS	NAV	POW	RC1	RC2	COM	WRM	CLD	BIO	SAL	WLD	RAR	MAR	MGR	SPN	SHL	EST	AQU	WET
405.43 UPPER CANYON HSA																								
CATTLE CREEK	P				E				E	E		E	E	E*		E	E*			E				E
COLDWATER CANYON CREEK	P				E				E	E		E	E	E*		E	E*			E				E
COW CREEK	P				E				E	E		E	E	E*		E	E*			E				E
DEVILS CANYON CREEK	P				E				E	E		E	E	E*		E				E				E
EAST FORK SAN GABRIEL RIVER	P				E				E	E		E	E	E		E	E*			E				E
FISH CANYON	P	I			E				E	E		E		E*		E	E*			E				E
NORTH FORK SAN GABRIEL RIVER	P				E				E	E		E	E	E*		E	E*			E*				E
ROBERTS CANYON	P				I				I	I		I		E*		I	E*							E
WEST FORK SAN GABRIEL RIVER	P				E			P	E	E		E	E	E*		E	E*			E				E
p ALLISON GULCH	P				I				I	I		I	I	E			E*							E
p BEAR CREEK	P				E				E	E		E	E	E*		E	E*			E*				E
p FISH FORK	P				E				E	E		E	E	E*		E				E*				E
p IRON FORK	P				E				E	E		E	E	E*		E				E*				E
p PRAIRIE FORK	P				I				I	I		I	I	E*		E								E
p SOUTH FORK IRON FORK	P				E				E	E		E	E	E*		E				E*				E
405.44 FOOTHILL HSA																								
SAN DIMAS CANYON CREEK	E				E				E	E		E	E	E*		E								E
405.53 LIVE OAK HSA																								
MARSHALL CREEK AND WASH					I				I	I		I		E*		I	E*							E
481.23 CLAREMONT HEIGHTS SPLIT																								
SAN ANTONIO CANYON CREEK	E			E	E			E	E	E		E	E	E*		E								E

Explanation:

Names preceded with a 'p' are newly proposed waterbodies not included in previous basin plan.

Beneficial use designations that are underlined are unchanged from the previous basin plan. All beneficial use designations which are not underlined represent newly proposed beneficial uses.

E : Existing I : Intermittent P : Potential Beneficial Uses

TABLE W3.1. RANKING OF COASTAL WETLANDS

The criteria employed in the process of ranking the coastal wetlands of Region 4 is discussed in the section on "Methods and Approaches" in the general introduction to this wetlands report.

(A rank represents highest quality)

Coastal Wetland	Rank	Disturbance	Biotic Diversity	Habitat Quality	Uniqueness	Flood Control	Water Quality	Sediment Control
Mugu Lagoon	1	A	A	A	A	A	A	A
Ballona Wetland	2	B	A	A	A	A	A	A
Los Cerritos Wetlands	3	B	B	A	A	B	B	B
Malibu Lagoon	4	A	B	A	A	A	B	B
Ventura River Estuary	5	A	A	B	A	B	B	B
Santa Clara River Estuary	6	B	B	B	B	B	B	B
McGrath Lake	7	A	B	B	A	B	B	C
Ormond Beach	8	B	B	B	B	C	C	C
Dume Creek	9	B	B	B	B	C	B	C
Ballona Lagoon	10	C	C	C	C	A	C	C
Del Rey Lagoon	11	C	C	C	C	B	C	C
Topanga Lagoon	12	C	C	C	C	C	C	C

TABLE W 3.2

Ranking of Riparian Wetlands in the Los Angeles Region
(A represents highest quality)

Riparian Wetland	Rank	Disturbance	Biotic Diversity	Habitat Quality	Uniqueness	Flood Control	Wildlife Corridor
Rincon Creek	B	B	B	B	B	B	A
Javon Creek	C	C	B	C	B	C	C
Ventura River	B	B	B	B	B	B	B
Murietta Canyon Creek							
Coyote Creek							
East Fork Coyote Creek							
Matilija Creek	A	A	B	A	B	B	A
West Fork Matilija	A	A	B	A	B	B	A
Santa Ana Creek	B	B	B	B	B	B	B
West Fork Santa Ana	B	B	B	B	B	C	C
Ojai Wetland	C	C	C	C	C	C	C
San Antonio Creek	B	B	B	B	B	B	A
Santa Clara River	A	B	B	A	A	A	B
Sisar Creek	A	A	B	A	B	B	A
Sespe Creek	A	A	A	A	A	A	A
Sespe Tributaries	A	A	A	A	A	B	A
Piru Creek	A	A	A	A	A	B	A
San Francisquito Creek	A	B	A	A	A	B	A
Bouquet Canyon Creek	B	B	A	B	B	B	B
Aliso Creek	A	A	A	A	A	B	B
Malibu Creek	A	B	A	A	A	B	A
Cold Creek	A	A	A	A	B	B	A
Medea Creek	B	B	C	B	B	B	B
Arroyo Sequit	A	A	A	A	A	B	A
Big Sycamore Canyon	A	B	A	A	A	B	A
Los Angeles River	C	C	C	C	C	A	C
Pacoima Canyon Creek	B	B	B	B	B	B	B

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Table 3.2 (Continued)

Big Tujunga Canyon	B	B	A	B	B	B	A
Alder Creek	A	A	A	A	A	B	B
Mill Creek	B	B	A	A	B	B	B
Clear Creek	B	A	A	B	B	B	B
Vasquez Creek	B	A	B	B	A	B	B
Upper Big Tujunga	B	A	B	B	B	B	B
Eaton Canyon Creek	A	B	A	A	A	B	A
Rubio Canyon Creek	B	B	B	B	B	B	A
Arroyo Seco	B	C	B	B	B	B	A
Bear Canyon Creek	A	A	A	A	B	B	A
Little Bear Canyon	A	A	A	A	B	B	A
Santa Anita Canyon	B	C	B	B	B	B	B
Winter Creek	B	B	B	B	B	B	B
Rio Hondo	C	C	B	C	B	A	C
Big Dalton Canyon	C	C	B	B	B	B	B
Little Dalton	B	B	B	B	B	B	B
Walnut Creek	B	C	B	B	A	B	A
Monrovia Canyon Creek	A	B	B	A	A	B	A
Allison Gulch	A	A	B	A	B	B	B
Cattle Canyon	A	A	A	A	A	B	A
Cow Canyon	A	A	A	A	B	B	A
Devil's Canyon Creek	A	A	A	A	A	B	A
Bear Creek	A	A	A	A	A	B	A
Fish Creek	B	B	B	B	B	B	A
Robert's Canyon Creek	A	A	A	A	B	B	A
San Gabriel River, Main Stem	C	C	B	C	C	A	C
S.G.R., West Fork	B	B	A	A	B	A	A
S.G.R., East Fork	A	B	A	A	A	A	A
S.G.R., North Fork	A	B	A	A	A	A	A
S.G.R., Iron Fork	A	A	A	A	A	B	A
S.G.R., Fish Fork	A	A	A	A	A	B	A

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Table 3.2 (Continued)

S.G.R., Prairie Fork	A	A	A	A	A	A	A
San Dimas Canyon	B	B	B	B	B	B	B
Wolfskill Canyon	B	B	B	B	A	B	B
Fern Canyon	A	A	A	A	A	B	A
Marshall Canyon	B	C	B	B	B	C	B

Coastal Wetlands

Coastal wetlands are the most heavily impacted type of wetland in Region 4. Dennis (1984) reports that Los Angeles and Orange Counties have lost 90% of their coastal wetlands. Historically, there were seven major coastal wetlands totalling 17,300 acres. The coastline between Newport Beach and Long Beach was considered to be one of the best habitats for game birds in the world.

In Los Angeles County no major coastal wetland remains. Ballona Creek Marsh was originally 1,550 acres, today 182 acres remain. Los Cerritos Lagoon totalled 2,400 acres and has been reduced by piecemeal filling for residential uses to 188 acres. Wilmington Lagoon was situated between the mouths of the San Gabriel and Los Angeles Rivers and covered 3,450 acres. Today, 5-6 acres of wetland are left. Alamitos Bay, a coastal wetland of 2,400 acres has been reduced to 50 acres of degraded marsh along New River Slough.

In Ventura County, wetlands historically were located at the mouths of the Ventura and Santa Clara Rivers. The wetlands at the mouth of the Ventura river have been filled such that only 10 acres remain. During the late 1800s, Mugu Lagoon covered approximately 3,000 acres, paralleling the coast for 4 miles. The U.S. Navy gained control of the area in the 1940s and through dredging has reduced the total to about 1,400 acres some of which are degraded.

Coastal wetlands serve many important hydrological and biological functions:

Flood Protection - coastal wetlands serve as spreading basins which can accommodate both upland and tidal flooding.

Water Purification - coastal wetlands have the ability to "treat" municipal wastewater and storm runoff. The broad, flat surface in a saturated condition provides a substrate for physical, chemical, and biological transformations. Sediments carried into the marsh from storm drains will settle out, adhesive forces can bind heavy metals, hydrocarbons and other constituents to the sediments. Microorganisms in the sediment can then degrade and recycle various chemical (organic and inorganic) compounds. Marsh vegetation can remove pollutants directly by taking up nutrients (nitrogen, phosphorus etc.) and heavy metals.

Shoreline and Bank Protection - marsh vegetation interrupts and absorbs the energy of ocean waves. In doing so, bank and shoreline erosion is reduced, providing protection for shoreline structures.

Primary Productivity - the primary productivity of an ecosystem is measured by the amount of plant material and algae which grow over an area of ground in a given amount of time. Because of exposure to full sunlight for photosynthesis and a plentiful supply of water, salt marshes have levels of primary productivity equaling tropical rainforests (Williams 1990). This productivity supports complex food chains and webs. Much of this productivity is "exported" by shorebirds when they move into other ecosystems.

Wildlife Habitat - Numerous organisms are dependant upon the productivity and shelter provided by coastal salt marshes and associated subtidal habitats.

Dense communities of invertebrates inhabit the shallow depths of the tide flats, tidal creeks and brackish marshes. These include worms, clams, crabs, shrimp, amphipods and insects. Some invertebrates undergo larval stages in the sheltered habitat provided within the salt marsh.

Coastal wetlands containing tidal creeks or other types of open water support fish populations. Staghorn sculpin, three-spine stickleback, California killifish, and topsmelt are some of the more common components of tidal estuaries (Dennis 1984). The nutrient rich water of many lagoons and tidal creeks attracts many transient offshore species. Eight foot blue sharks have been recorded in Mugu Lagoon at high tide (Macdonald 1976). Anadromous fish such as steelhead trout and salmon spend up to several months in river estuaries before migrating upstream to spawn.

Birds are the most conspicuous form of wildlife in coastal wetlands in Region 4. Those remnant coastal wetlands which remain provide important links along the Pacific Flyway for species migrating between nesting grounds in Alaska and wintering grounds in California and Central and South America. At Mugu Lagoon it is common to have up to 10,000 mud hens present at one time during periods of migration (Macdonald 1976).

Salt marsh and river mouth habitats are important to various endangered and threatened species including California clapper rail (*Rallus longirostris obsoletus*), Light-footed clapper rail (*Rallus longirostris levipes*), California least tern (*Sterna antillarum browni*), Belding's savannah sparrow (*Passerculus sandwichensis beldingi*), Salt-marsh harvest mouse (*Reithrodontomys raviventris*), and Salt-marsh bird's-beak (*Cordylanthus maritimus* ssp. *maritimus*). Candidate species such as tidewater goby (*Eucyclogobius newberryi*) also depend on estuaries.

Aesthetic and Educational Values - Coastal wetlands provide a refuge to many people living in the crowded urban environment of Region 4. Hiking, birdwatching, and photography, are just a few of the activities afforded by these areas so rich in biological diversity. They also are excellent educational resourses because of their proximity to many urban centers.

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Classification of Coastal Wetlands in Region 4

Coastal wetlands can be classified in various ways: (1) according to vegetation type and zonation, (2) freshwater versus saline, and (3) according to their physical attributes. In many cases the distinctions between types is clear cut; however in many other cases there is a continuum of types that suggests an inter-relatedness among estuaries and their associated biota.

Vegetation - Salt marsh vegetation in California has been divided into three types: San Francisco Bay area marshes, northern California coastal marshes and southern California coastal marshes (Macdonald 1988).

In San Francisco Bay, Mahall and Park (1976) found *Spartina foliosa* as the primary colonist on broad tidal mudflats and nearly pure stands of *Spartina* dominate the low marsh. A dense cover of *Salicornia virginica* replaces the *Spartina* at about Mean High Water (MHW) and dominates the high marsh. The *Spartina-Salicornia* ecotone is abrupt with an elevation change of as little as 7 cm sufficient for pure stands of *Salicornia* to replace pure stands of *Spartina*.

Northern California coastal marshes also have *Spartina* as the primary colonist of the tidal mudflats. *Salicornia virginica* shares dominance with *Spartina* in the lower marsh and in some instances *Salicornia* may act as the primary colonist. In the high marsh, *Salicornia* shares dominance with *Distichlis spicata*, and *Jaumea carnosa*.

Southern California coastal marshes begin at Mugu Lagoon and are found southward into Baja California. *Spartina* remains the primary colonizer of tidal mudflats and dominates the low marsh environment. Instead of *Salicornia virginica* succeeding the *Spartina*, however, a narrow zone dominated by *Salicornia bigelovii* and *Batis maritima* exists. *Batis* becomes more prevalent in winter when *S. bigelovii* (an annual) dies down.

The Physical Characteristics of estuaries recently have been classified by Ferren (1990) into four types, reflecting their origin, type of watershed, and relation to the marine environment. These types are: (1) river mouth estuaries with brackish lagoons; (2) canyon mouth estuaries with brackish or euryhaline (fluctuating salinity) lagoons; (3) bay estuaries with extensive deepwater habitats and intertidal basins; and (4) structural basin estuaries with steep watersheds, much sedimentation, and hypersaline conditions.

River Mouth Estuaries typically have some or all of the following features: (1) year-round freshwater runoff (sometimes consisting of treated wastewater) and occasional catastrophic flooding and flushing due to winter and spring storms; (2) sand bars which separate the lagoon from the open ocean except during periods of flushing following storms; (3) brackish water conditions throughout the estuary when the mouth is open, but with a freshwater to slightly brackish layer on the lagoon surface when the mouth is closed. The Ventura River Estuary is the best example of this type of estuary in Region 4. Other river mouth estuaries include the Santa Clara River, McGrath Lake, and Ballona Wetland and related complex.

Canyon Mouth Estuaries are quite variable in nature. Portions of California coastline are characteristically deeply cut, parallel canyons and arroyos which drain watersheds of the coastal foothills and mountains. These canyons empty into the ocean through small estuaries that vary in size, frequency of tidal flushing, salinity regimes and associated biota. Malibu Lagoon is the best example of this type of estuary in Region 4. Dume Creek Lagoon and Topanga Lagoon are also canyon mouth estuaries.

Bay Estuaries have large areas of subtidal habitat (bays) and usually extensive, low elevation salt marsh on the bay margins. The subtidal habitats often support beds of eel grass (*Zostera marina*). Intertidal mudflats adjacent to subtidal areas support a high diversity of invertebrate species. The margins of the intertidal mudflats are dominated by cordgrass (*Spartina foliosa*) as is the lower marsh where *Salicornia virginica* becomes important. *Salicornia virginica* and numerous other species (see above under southern California coastal marsh) share the middle and upper marsh habitats. Alamitos Bay and Los Cerritos Wetlands were historically sites of extensive bay and salt marsh habitats (2,400 acres each).

Structural Basin Estuaries occur where considerable tectonic activity has caused down-faulting or down-folding along the coast. The basins formed support small estuaries. There are no structural basin estuaries in Region 4.

Intermediate Estuaries are estuaries which exhibit characteristics of more than one of the above categories. Mugu Lagoon is an intermediate estuary which historically had a small watershed and received little runoff from the surrounding Oxnard Plain. The tidal prism was sufficient to keep the mouth of the lagoon open to the ocean (Onuf 1987). In 1884, Mugu Lagoon became an estuary, when Calleguas Creek was channelized, and directed into the lagoon which effectively expanded the watershed of the lagoon by 250 times over what it had been.

The type of vegetation present in coastal wetlands is determined by the hydrological regime, substrate, and frequency of disturbance for a given site. Region 4 contains three types of coastal wetlands.

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Coastal Wetland Plant Communities

Southern Coastal Salt Marsh (Annual). Estuarine nonpersistent emergent wetlands generally lack aboveground persistent parts and are dominated by annual plants that regularly colonize seasonally exposed surfaces. Typically occurring in intertidal wetlands on exposed lagoonal bars and flats and also in the beds of shallow channels. These are not common in southern California most often associated with river mouth estuaries because of the presence of brackish or fresh water which is required for seed germination. Characteristic species include spear-leaved saltbush (*Atriplex patula*), coast goosefoot (*Chenopodium macrospermum*), salt marsh sand spurry (*Spergularia marina*), brass buttons (*Cotula coronopifolia*), and rabbitsfoot grass (*Polypogon monspeliensis*). The best example in Region 4 is at the Ventura River Estuary.

Southern Coastal Salt Marsh (Herbaceous Perennial). Is composed of persistent emergent, herbaceous vegetation which occurs on narrow to broad plains adjacent to bays or estuaries where tidal influences provide for typically saline or hypersaline conditions. Freshwater flushing occurs infrequently only following major winter or spring storms. The vegetation consists of succulent and suffrutescent perennials including pickleweed (*Salicornia virginica*), alkali heath (*Frankenia grandifolia*), fleshy jaumea (*Jaumea carnosa*), saltgrass (*Distichis spicata*), sea lavender (*Limonium californicum*), saltwort (*Batis maritima*) and arrowgrass (*Triglochin* spp.). Southern Coastal Salt Marsh also contains one annual species, *Salicornia bigelovii*. Mugu Lagoon is the best example of Southern Coastal Salt Marsh in Region 4 and in fact is the northernmost representative of this vegetation type. Other occurrances are at Anaheim Bay and at the Ballona Wetlands complex.

Coastal Brackish Marsh. Is dominated by perennial, emergent, herbaceous monocots to 2 m tall. Cover is often complete and dense. Similar to salt marshes and to freshwater marshes with some plants characteristic of both. Salinity varies considerably depending on interplay between tidal regimes and freshwater runoff. Most common along interior edges of coastal bays and estuaries where influx of freshwater is somewhat regular. In Region 4 characteristic species include narrowleaf cattail (*Typha domingensis*), broadleaf cattail (*T. latifolia*), california bulrush (*Scirpus californicus*), alkali bulrush (*S. maritimus*), and saltgrass (*Distichlis spicata*). This marsh type not widespread in Region 4. Localized occurrances are found at the Ventura River Estuary, Santa Clara River Estuary and Point Dume Creek.

Opposite Page Top: Coastal Salt Marsh at Mugu Lagoon, Ventura Co.

Opposite Page Bottom: Coastal Brackish Marsh, Point Dume, L.A. Co.

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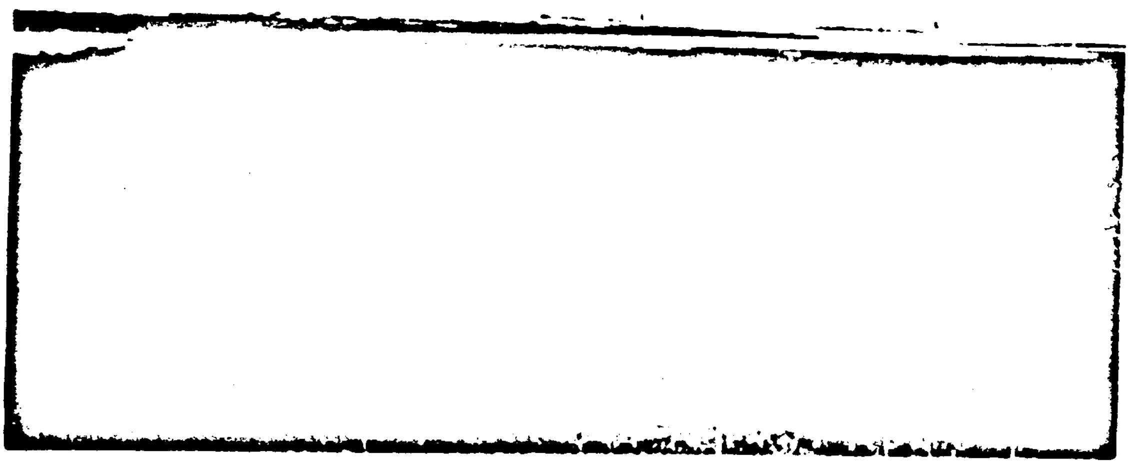

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Coastal Freshwater Marsh. Is dominated by perennial, emergent monocots to 4-5 m tall. Cover is dense to complete. This type is similar to coastal brackish marshes. *Scirpus* and *Typha* are typically dominant. The sites are quiet, lacking significant current and permanently flooded by fresh water (rather than brackish, alkaline or variable). Prolonged saturation allows accumulation of deep, peaty soils. Characteristic species are wooly sedge (*Carex lanuginosa*), rough carex (*C. senta*), chufa (*Cyperus esculentus*), umbrella sedge (*C. eragrostis*), spikerush (*Eleocharis spp.*), whorled penny-wort (*Hydrocotyl verticillata*), northern mudwort (*Limosella aquatica*), common reed (*Phragmites australis*), bulrushes (*Scirpus acutus, S. americanus, S. californicus*), and cattails (*Typha domingensis, T. angustifolium, T. latifolia*). Uncommon in Region 4, best example at McGrath Lake in Ventura Co.

Coastal Saltbush Scrub. This type of scrub is transitional between saline influenced wetland types and upland habitats. Cover varies from sparse to dense. Understory is composed of grasses and forbs. Soils are typically saline clay soils which drain slowly and accumulate high concentrations of salt due to evaporation. Characteristic species include four-wing saltbush (*Atriplex canescens*), Lenscale (*A. lentiformis ssp. breweri*), Australian saltbush (*A. semibaccata*), sandbar willow (*Salix hindsiana*), arroyo willow (*S. lasiolepis*). Understory consists of various annual grasses such as *Bromus rubens*, salt grass (*Distichlis spicata*), and brass buttons (*Cotula coronopifolia*).

Opposite Page Top: Coastal Freshwater Marsh, McGrath Lake, Ventura County.

Opposite Page Bottom: Coastal Saltbush Scrub, Ventura River Estuary - Emma Wood State Park, Ventura County. Dominant shrub is *Atriplex lentiformis ssp. breweri*. Grass in the foreground is saltgrass (*Distichlis spicata*).

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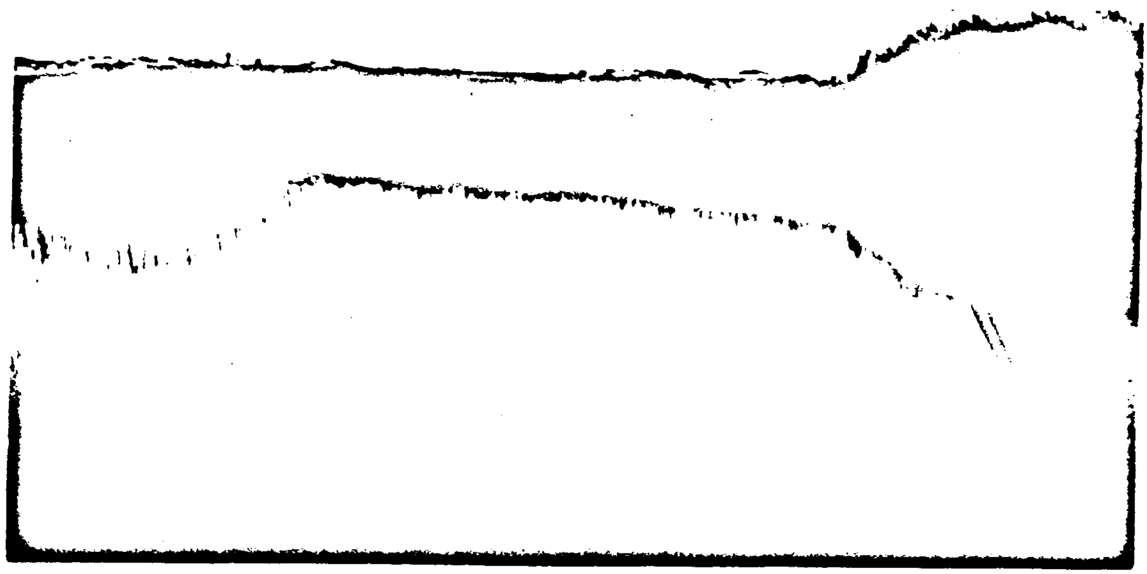

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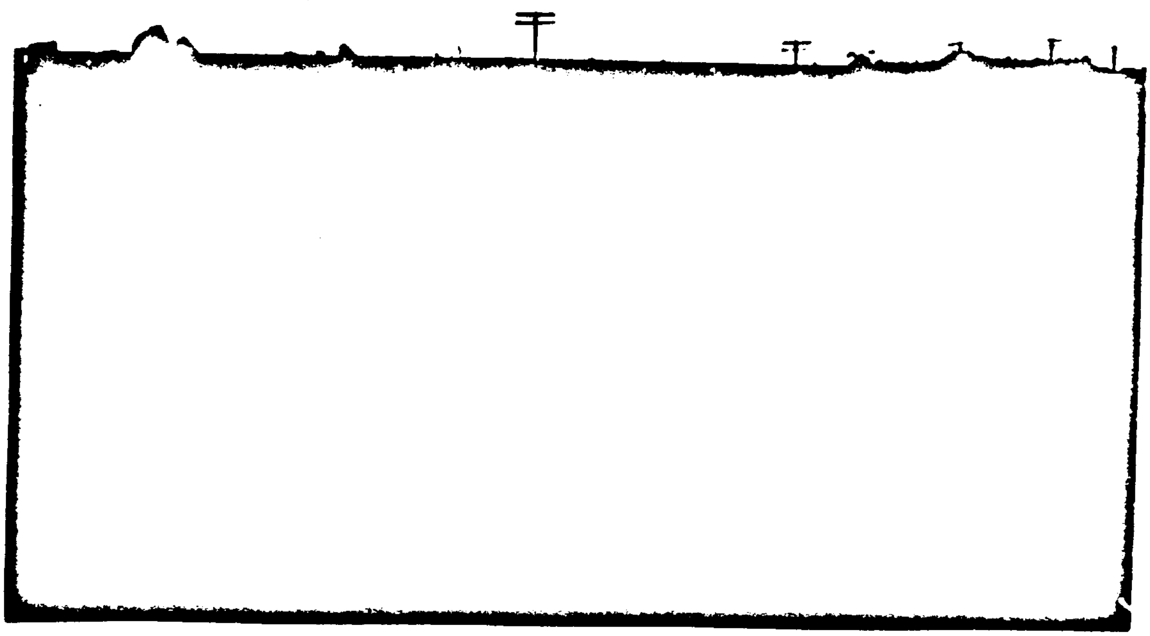
Coastal Wetlands: Ranking

The criteria employed in the process of ranking the coastal wetlands of Region 4 is discussed in the section on "Methods and Approaches" in the general introduction to this wetlands report.

Coastal Wetland	Rank	Disturbance	Biotic Diversity	Habitat Quality	Uniqueness	Flood Control	Water Quality	Sediment Control
Mugu Lagoon	1	A	A	A	A	A	A	A
Ballona Wetland	2	B	A	A	A	A	A	A
Los Cerritos Wetlands	3	B	B	A	A	B	B	B
Malibu Lagoon	4	A	B	A	A	A	B	B
Ventura River Estuary	5	A	A	B	A	B	B	B
Santa Clara River Estuary	6	B	B	B	B	B	B	B
McGrath Lake	7	A	B	B	A	B	B	C
Ormond Beach	8	B	B	B	B	C	C	C
Dume Creek	9	B	B	B	B	C	B	C
Ballona Lagoon	10	C	C	C	C	A	C	C
Del Rey Lagoon	11	C	C	C	C	B	C	C
Topanga Lagoon	12	C	C	C	C	C	C	C

L.A. Regional Water Quality Control Board
Coastal Wetlands — Ventura River Estuary

[illegible] River Estuary [illegible] the City of San Buenaventura [illegible] Seaside Wilderness [illegible] Park [illegible] vegetation type [illegible] of the estuary. [illegible] miles of watershed [illegible] a result [illegible] and [illegible] separates the [illegible] when the lagoon [illegible] when the [illegible] influence and freshwater [illegible] slightly hypersaline conditions when the lagoon is intact. These conditions in which freshwater predominates much of the time make this [illegible] different and more diverse than any other in Region 4.



Upper Salt Marsh, Ventura River Estuary. Salt grass (Distichlis spicata) [illegible] Saltbush [illegible] in background

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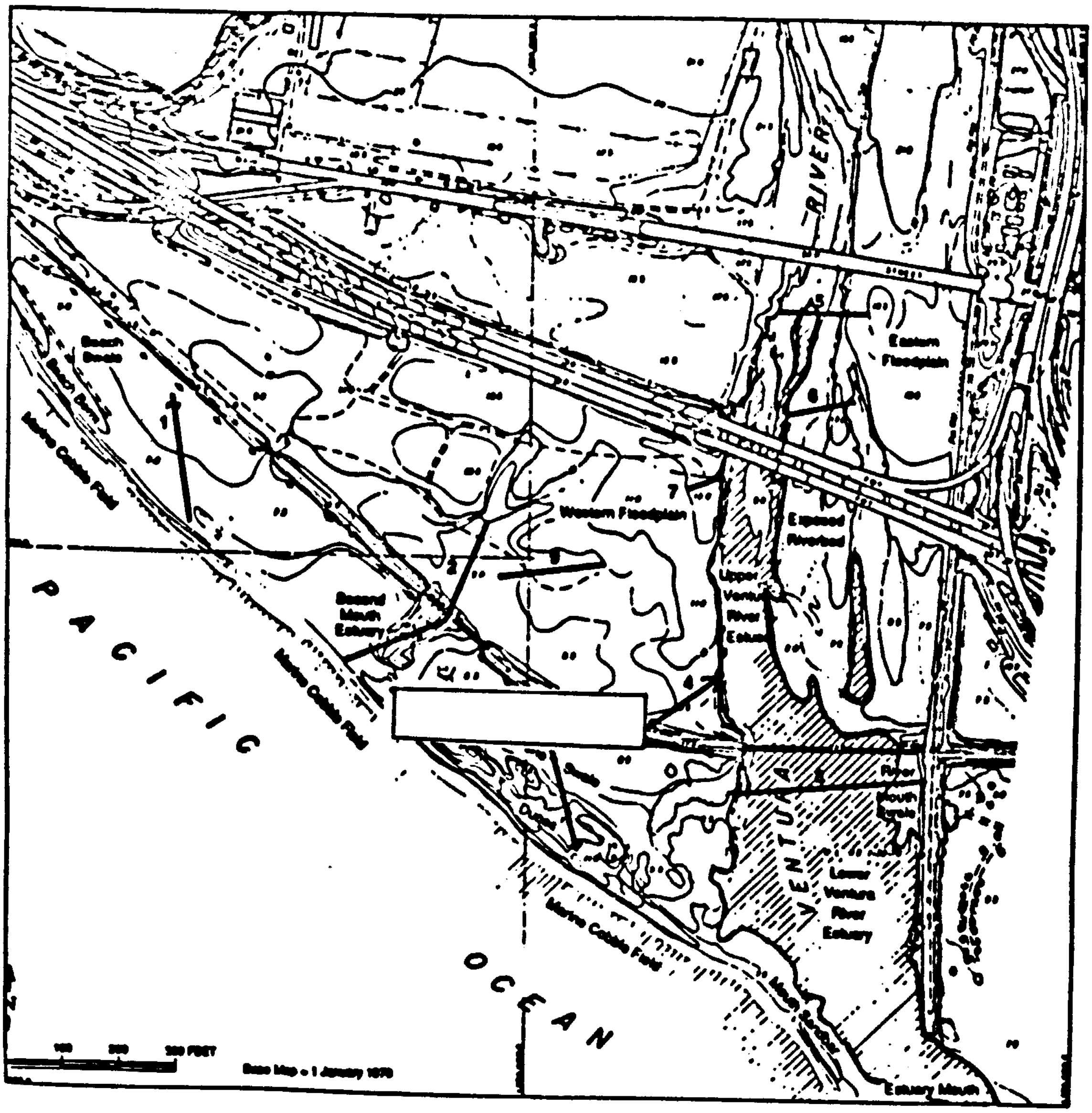
PACIFIC
OCEAN
RIVER
VENTURA
Western Floodplain
Eastern Floodplain
Exposed Riverbed
Second Mouth Estuary
Lower Ventura River Estuary
Marine Cobble Field
Estuary Mouth

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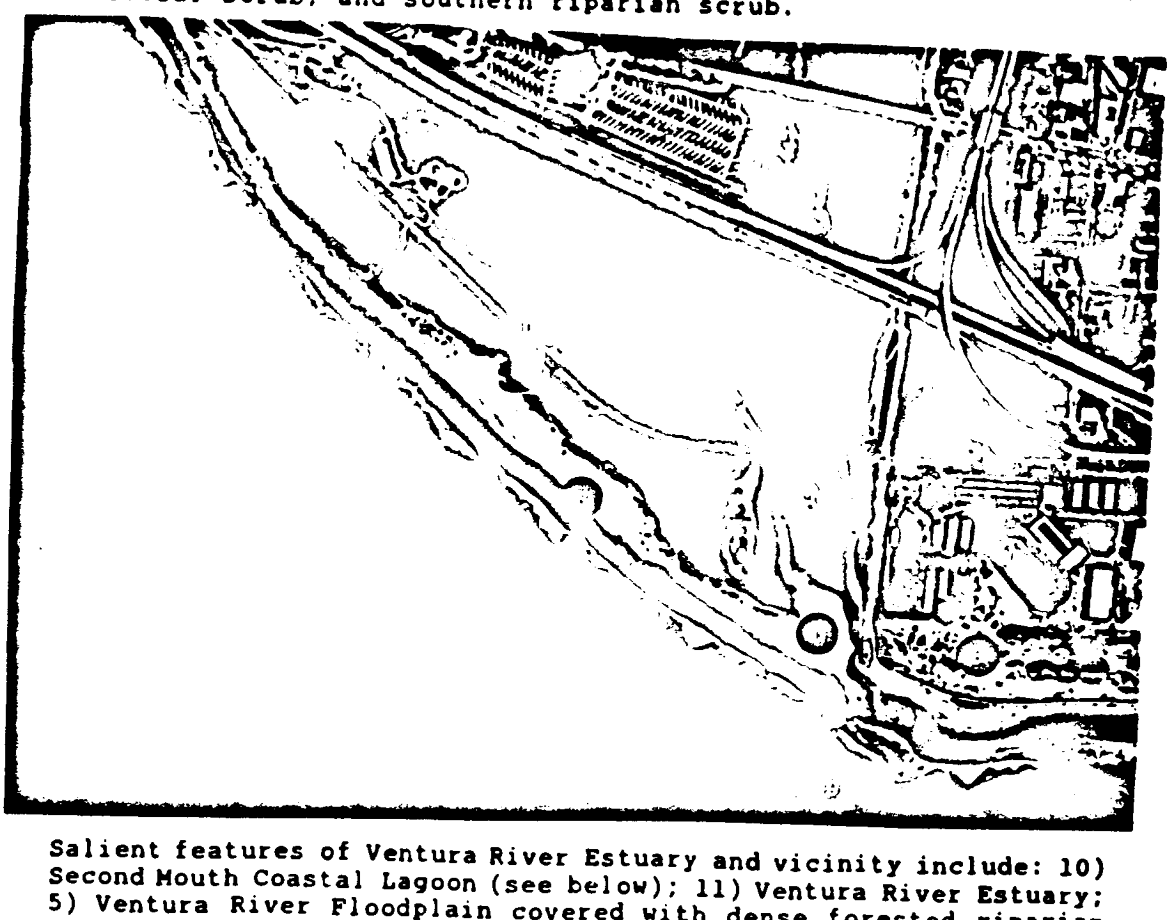
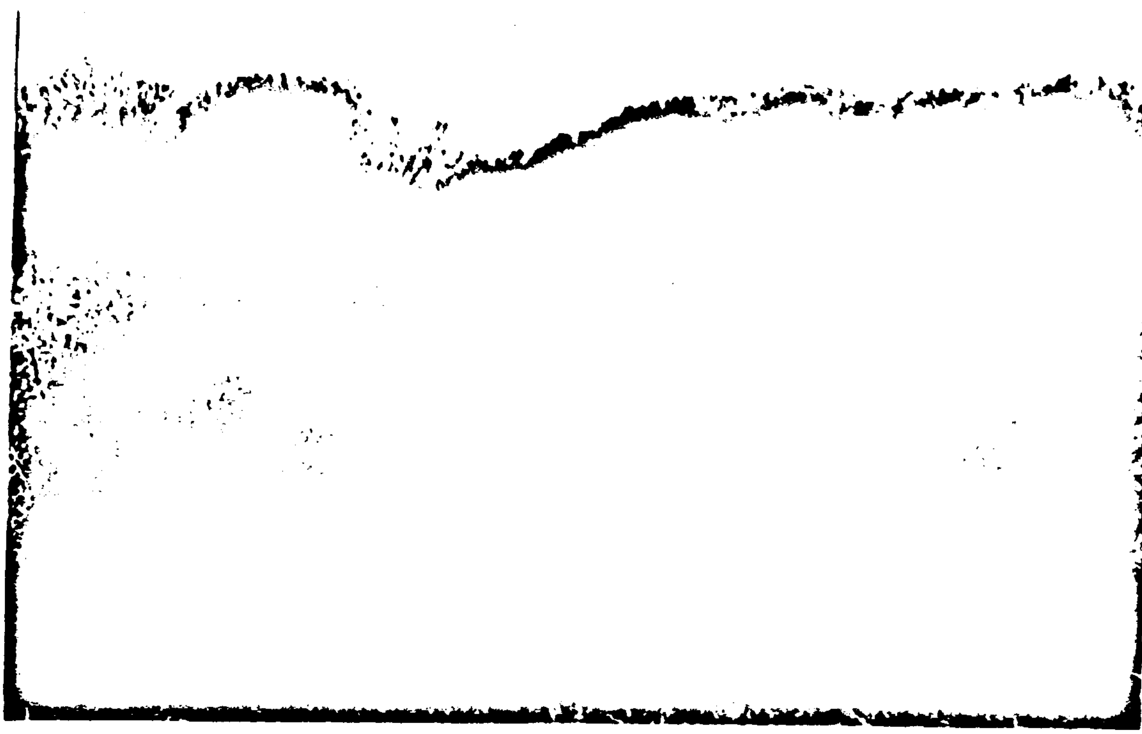
The Brackish lagoonal conditions along with a diversity of substrates and topography support a number of wetland community types which form a complex mosaic. The mosaic consists of southern coastal salt marsh dominated by pickleweed (*Salicornia virginica*) fleshy jaumea (*Jaumea carnosa*), and alkali heath (*Frankenia grandifolia*). At slightly higher elevations and intergrading with the salt marsh is a combination of dune swale wetland composed of *Salicornia virginica*, spiny rush (*Juncus acutus* var. *sphaerocarpus*), and bulrush (*Scirpus*); and scrub/shrub wetlands dominated by lenscale (*Atriplex lentiformis*), coastal goldenbush (*Isocoma veneta* ssp. *vernonoides*), and scrub willows (*Salix*). Along the west side of the estuary, between the railroad tracks and the beach is wetland dominated by nonpersistent emergent (annual) vegetation composed of coast goosefoot (*Chenopodium macrospermum* var. *farinosum*), spear-leaved saltbush (*Atriplex patula* ssp. *hastata*), and salt marsh sand spurrey (*Spergularia marina*). This is the only site for this vegetation type within Region 4. Other wetland types include southern arroyo willow riparian forest, alluvial scrub, and southern riparian scrub.



Salient features of Ventura River Estuary and vicinity include: 10) Second Mouth Coastal Lagoon (see below); 11) Ventura River Estuary; 5) Ventura River Floodplain covered with dense forested riparian vegetation.

W[illegible] the Ventura River estuary [illegible] which is only flooded during catastrophic [illegible] The area exhibits seasonal hydrological [illegible] high water [illegible] is at its highest when the main estuary [illegible] state. At [illegible] the salinity ranges from [illegible] the freshwater influence. When the [illegible] breached [illegible] are present, [illegible] estuary reach [illegible] The freshwater [illegible] water can be observed seeping [illegible] sand [illegible] along the shoreline. Salinities [illegible] before being [illegible] water [illegible] the [illegible] comes in.



Upper Salt Marsh with Salt Grass (*Distichlis spicata*) intergrading into upland vegetation with lenscale (*Atriplex lentiformis breweri*) being dominant. Willows (*Salix lasiolepis*) are behind the *Atriplex*.

L.A Regional Water Quality Control Board
Coastal Wetlands: Santa Clara River Estuary

[illegible] at the mouth of the [illegible] sandbar willow [illegible] [illegible] widespread [illegible]

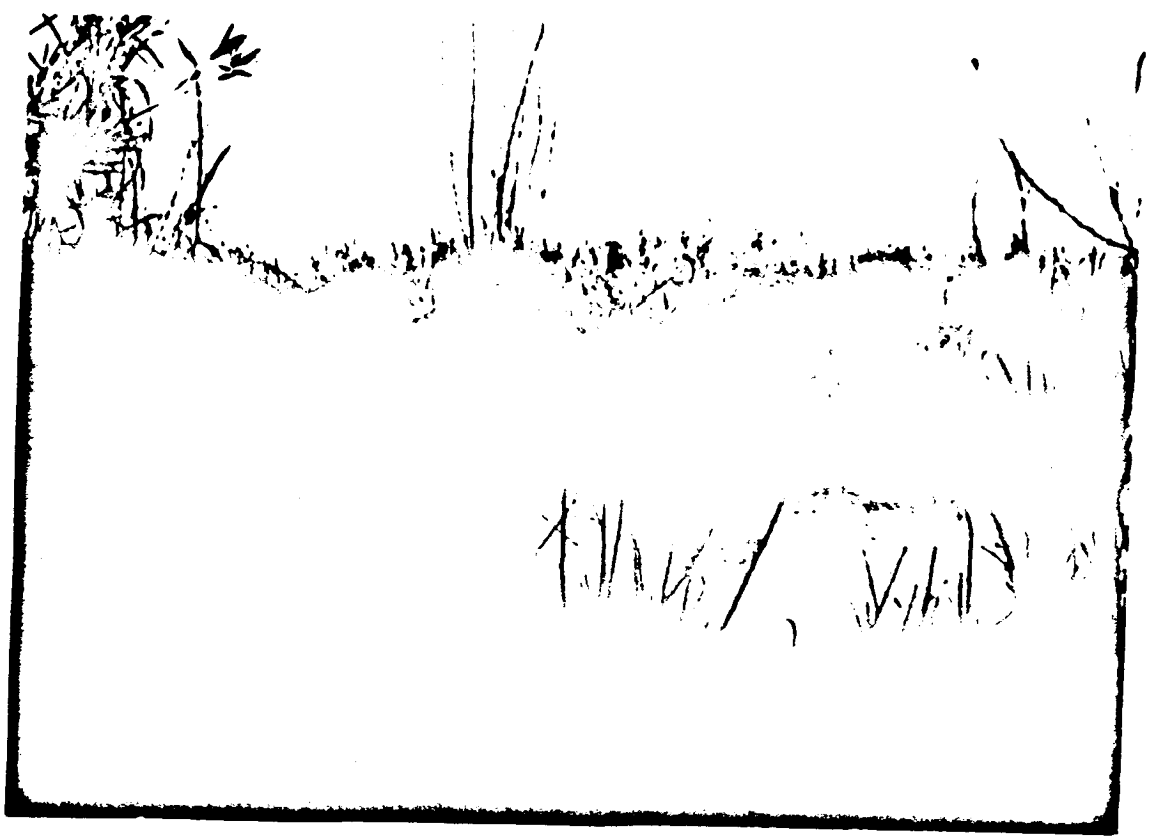


Photo: Santa Clara River Mouth, looking north at dense vegetation dominated by giant reed (Arundo donax)

The wetland covers approximately [illegible] acres and is in a significant state of disturbance due to the presence of giant reed. The giant reed displaces native vegetation, particularly the arroyo willow which is important habitat for numerous bird species including the endangered least Bell's vireo (Vireo bellii pusillus). California least tern (Sterna antillarum browni), which is a Federally listed endangered species, also nests at the river mouth. A habitat recovery plan for riparian vegetation also calls for the reintroduction of salt marsh bird's beak (Cordylanthus maritimus ssp. maritimus), a Federal candidate species, which had been extirpated from the area. Tidewater goby (Eucyclogobius newberryi), also a Federal candidate species, is found within the estuary.

Infrared Aerial Photograph: The Mouth of The Santa Clara River and surrounding vegetation. Sandbar is breached allowing tidal influence and therefore brackish conditions. The Ventura Marina can be seen to the west and adjacent to the [illegible] Mouth.

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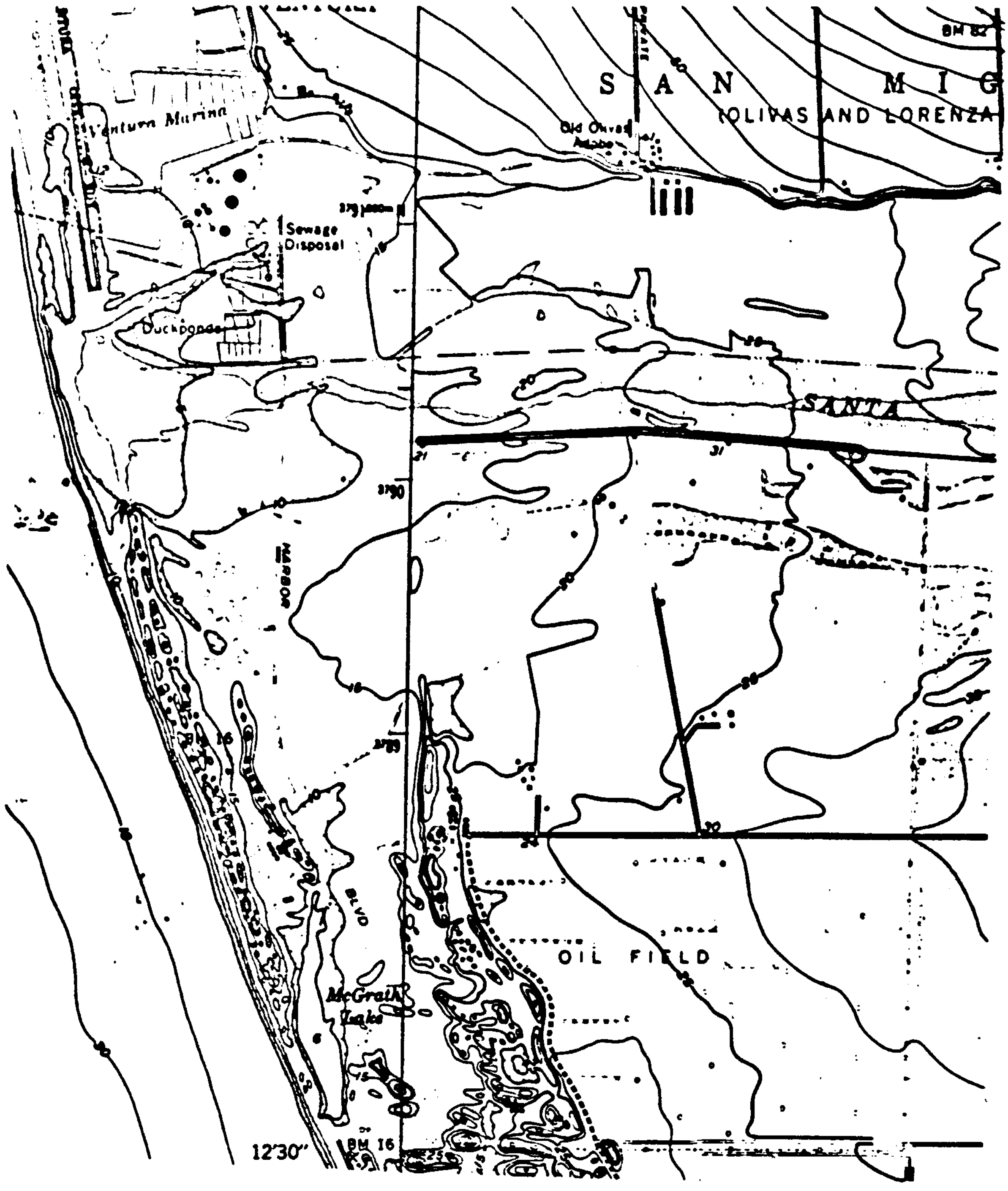
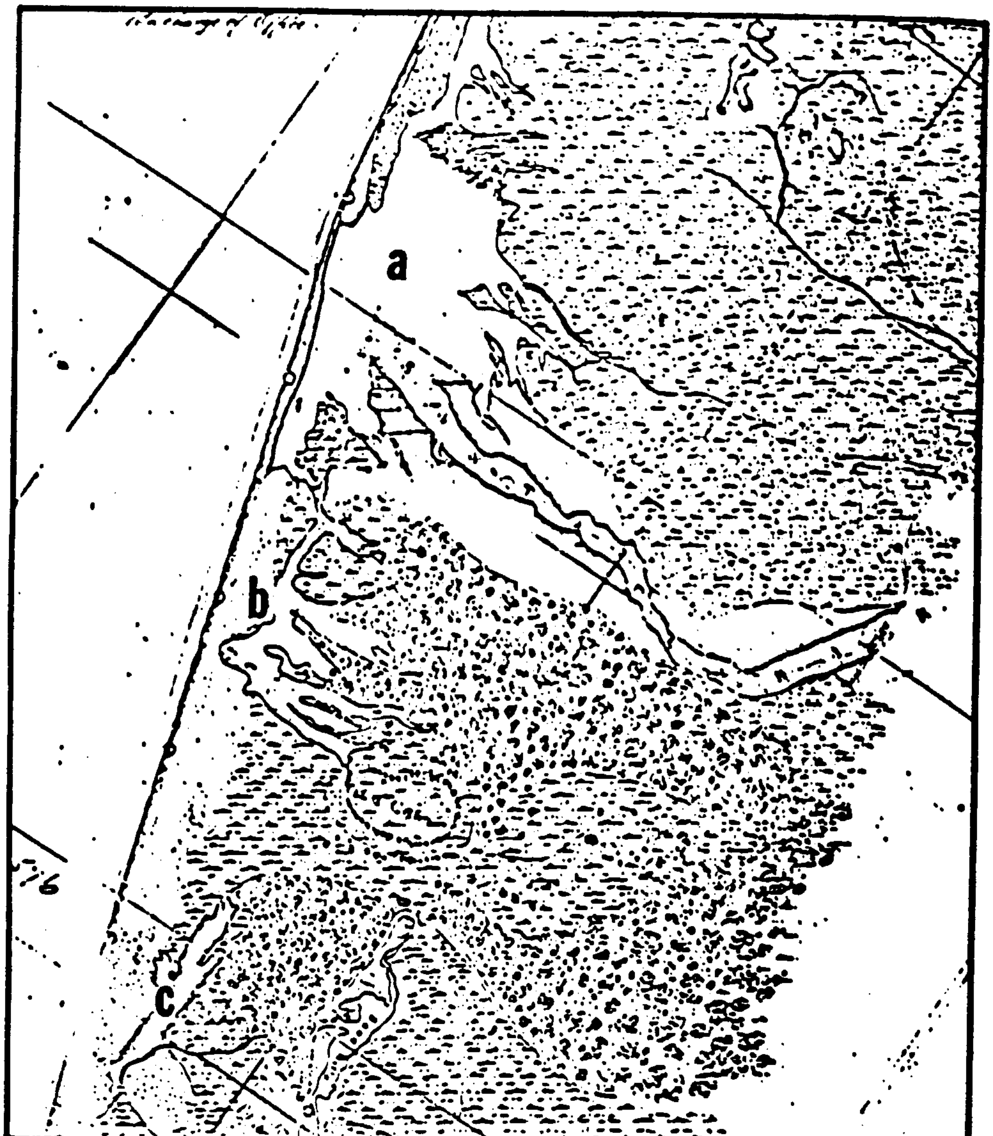


Santa Clara River Mouth from Oxnard USGS 7.5 min Quadrangle



Map: 1855 U.S. Coastal Survey Map. Significant points: a) Santa Clara River Mouth and approximate location of present Ventura Marina; b) approximate location of existing Santa Clara River mouth; c) estuary and present location of McGrath Lake.

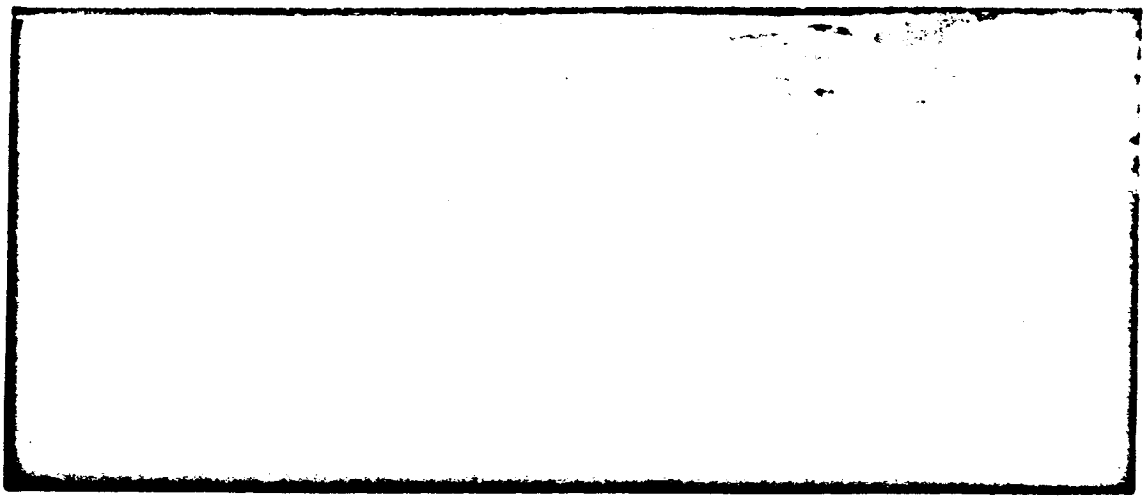


Photo: Santa Clara River Mouth, looking west at the sandbar at the mouth. Emergent vegetation in center of picture. Large monocultural stands of invasive exotic *Arundo donax* on both banks growing right to waters edge. Restoration of river mouth to native vegetation would entail eradication of *Arundo* which is an aggressive colonizer of disturbed riparian and wetland habitats. Flooding regimes favor *Arundo* over the native willows (*Salix*) because of extremely high growth rates and the ability to propagate vegetatively.

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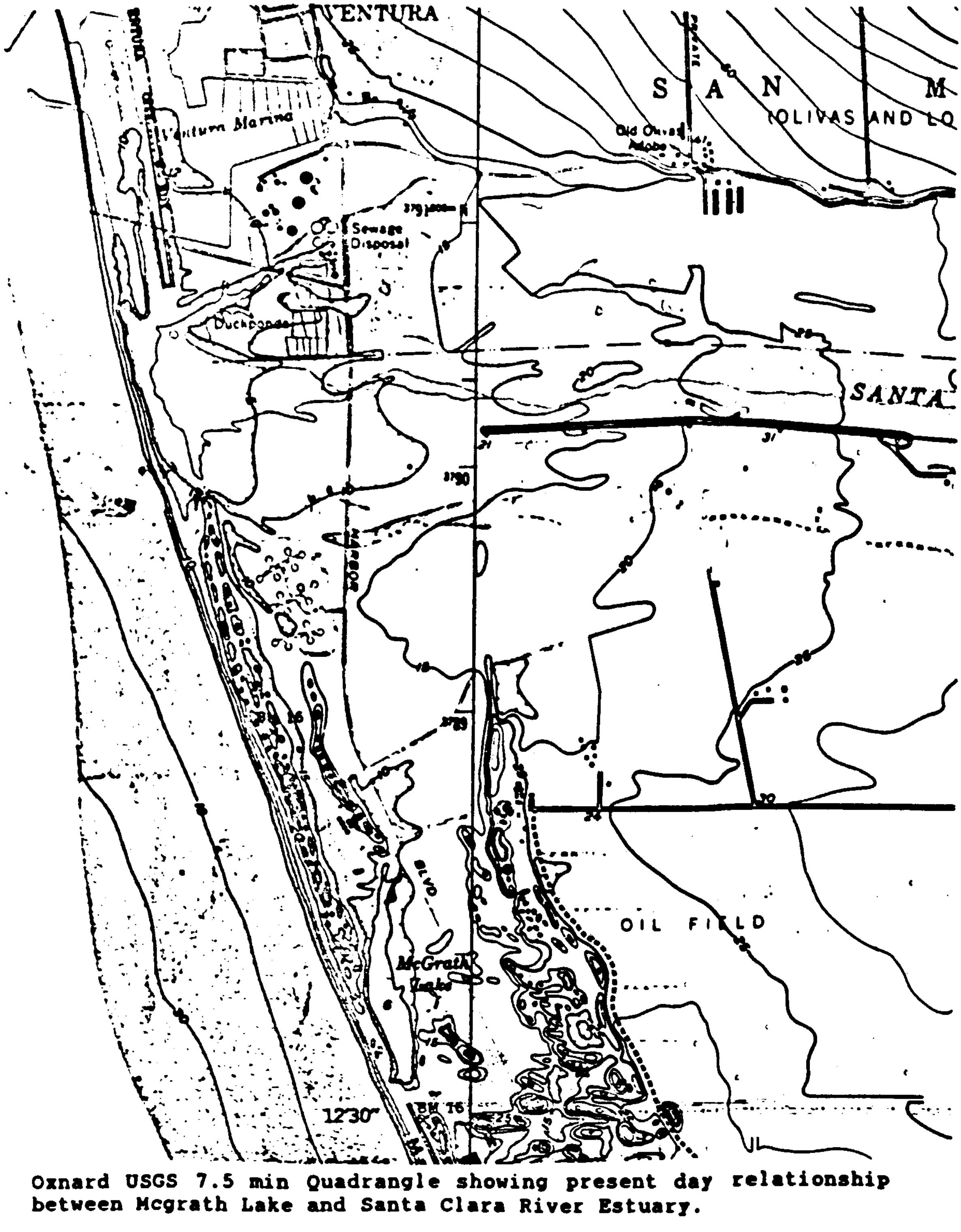
L.A.Regional Water Quality Control Board
Coastal Wetlands: McGrath Lake

McGrath Lake (403.11) a 10.3 acre lake with surrounding marsh is the best example of a coastal freshwater marsh in Region 4. The Santa Clara River has migrated during the last 200 years and the location of McGrath Lake is at a former site of the rivermouth estuary. The source of water for McGrath Lake is from groundwater derived from the persistent high water table. The vegetation is not highly diverse with stands of hard-stemmed bulrush (*Scirpus acutus*) common along the bank. Saltgrass (*Distichlis spicata*) is the dominant ground cover often forming dense mats. Willows (*Salix* sp.) are present and provide habitat for bird species. Invasive exotic giant reed (*Arundo donax*) has become established and poses a threat to other native vegetation. Coastal strand elements such as sea rockets (*Cakile maritima* and silver beachweed (*Ambrosia chamissonis*) are common on the coastal strand between McGrath Lake and the Pacific Ocean.



Oxnard USGS 7.5 min Quadrangle showing present day relationship between Mcgrath Lake and Santa Clara River Estuary.

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L.A. Regional Water Quality Control Board
Coastal Wetlands: Ormond Beach

Ormand Beach (403.11) is coastal strand-coastal salt marsh complex in the city of Oxnard which covers approximately 15 acres. The complex includes coastal dunes which form a barrier enclosing two lagoons and interconnecting channels. The low, central portion of the complex is subject to tidal inundation and is dominated by salt marsh vegetation with fleshy jaumea (*Jaumea carnosa*) and salt grass (*Distichlis spicata*) co-dominant. Pickleweed (*Salicornia virginica*) is present but not abundant. The margins of the marsh contain lenscale (*Atriplex lentiformis*) and *Atriplex patula*. The lagoon margins support small stands of bulrush (*Sripus*). The dune vegetation is highly diverse containing sea rockets (*Cakile maritima*), silver beachweed (*Ambrosia chamissonis*), dune evening primrose (*Camissonia chieranthifolia*), ice plant (*Mesembryanthemum crystalinum*), and sea fig (*Carpobrotus aequilaterus*) which covers the back side of the dunes along the inlet (back) channel. The overall habitat is somewhat disturbed with many weedy species common including ripgut grass (*Bromus diandrus*), red brome (*B. madritensis rubens*), yellow sweetclover (*Melilotus indicus*), ragweed (*Ambrosia psilostachya*), annual barley (*Hordeum glauca*), and two particularly invasive plants giant reed (*Arundo donax*) and kikuyu grass (*Pennisetum clandestinum*), a particularly troublesome invasive grass in the Morro Bay area and other coastal dune/marsh areas.

Map: Ormond beach in the City of Oxnard. From Oxnard USGS 7.5 min Quadrangle.

Photo: Upper (southern end) Lagoon at Ormond Beach showing bulrush, fleshy jaumea and saltgrass. Dune barrier in background and channel connecting upper and lower lagoons.

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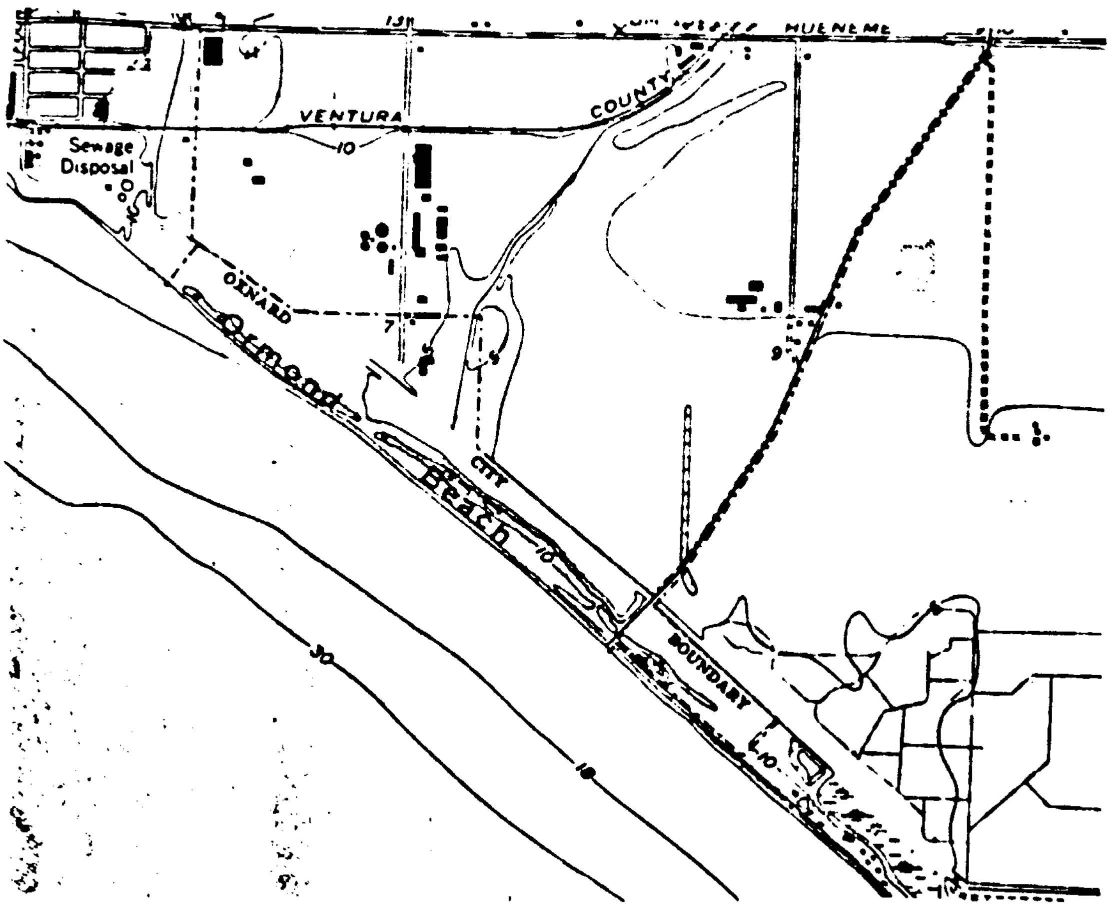

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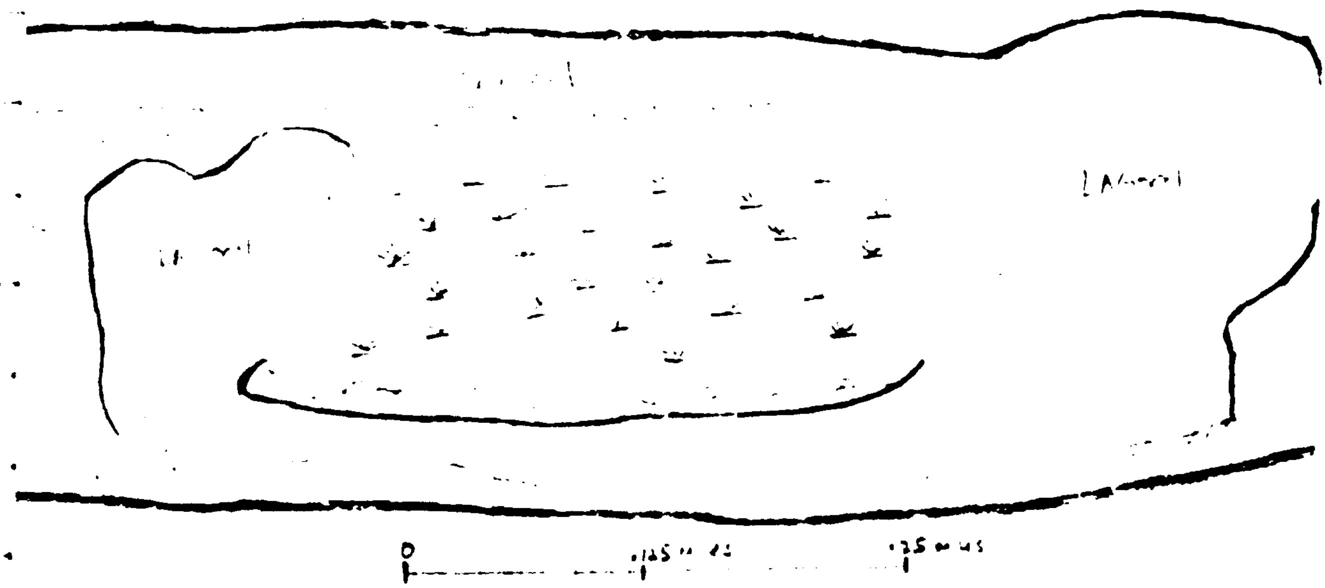
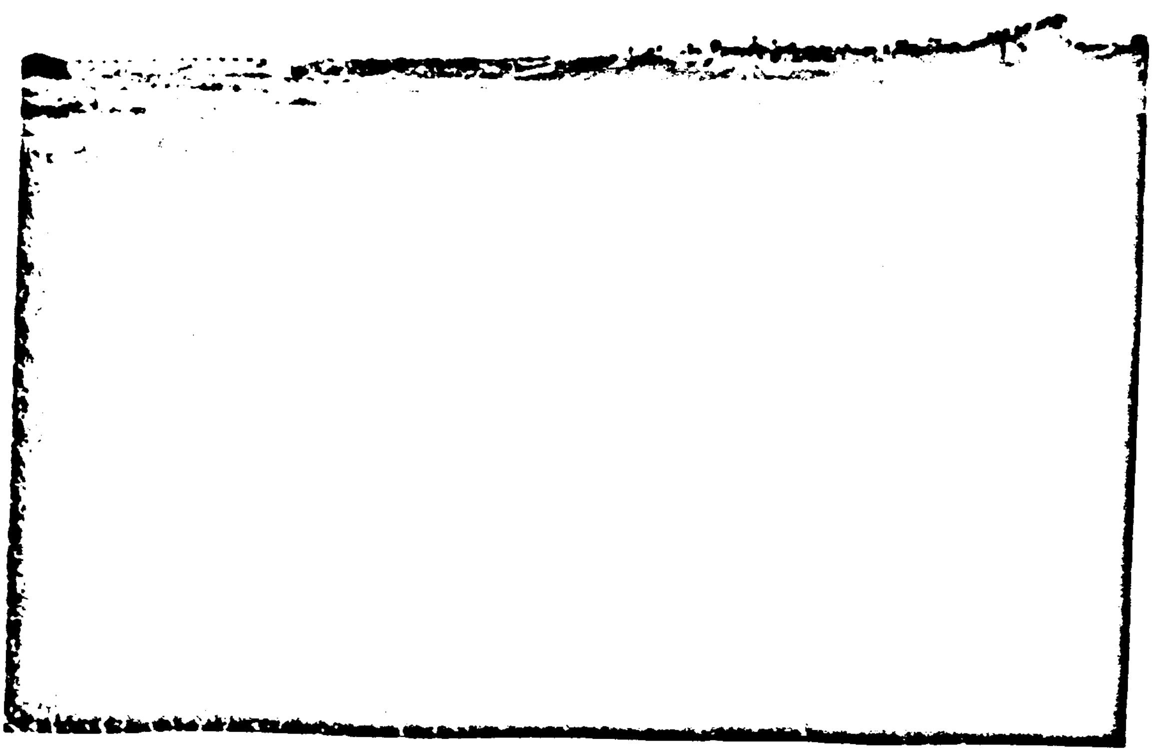


Above: Sketch Ormond Beach dune/wetland complex. Hatched area is coastal dunes containing healthy populations of coastal dune plants including *Cakile maritima*, *Ambrosia chamissonis*, and *Camissonia chieranthifolia*. The central portion of the complex is salt marsh dominated by *Jaumea carnosa* and *Distichlis spicata* with *Salicornia virginica* uncommon.

Below: *Jaumea carnosa* and *Distichlis spicata*.



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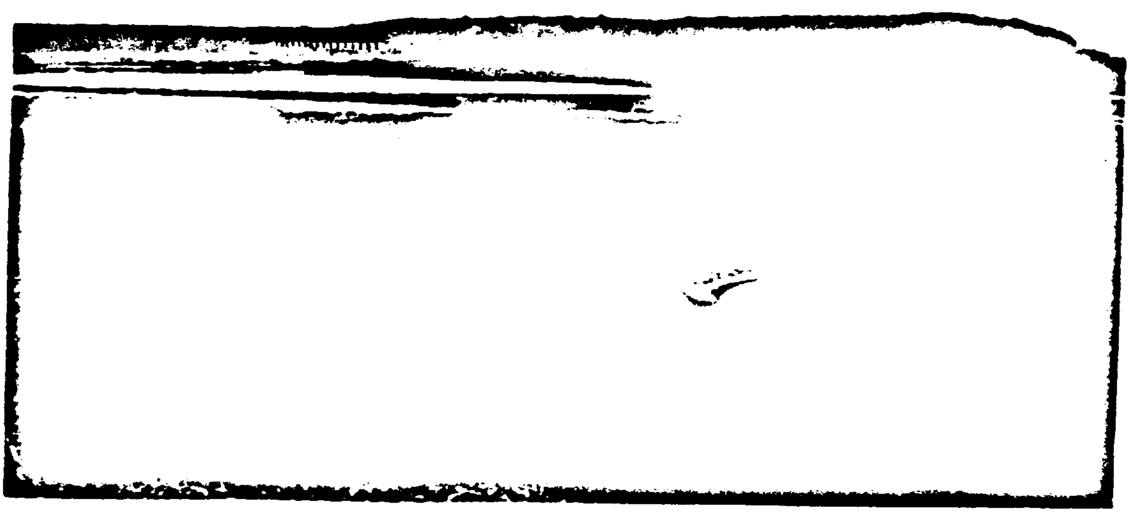
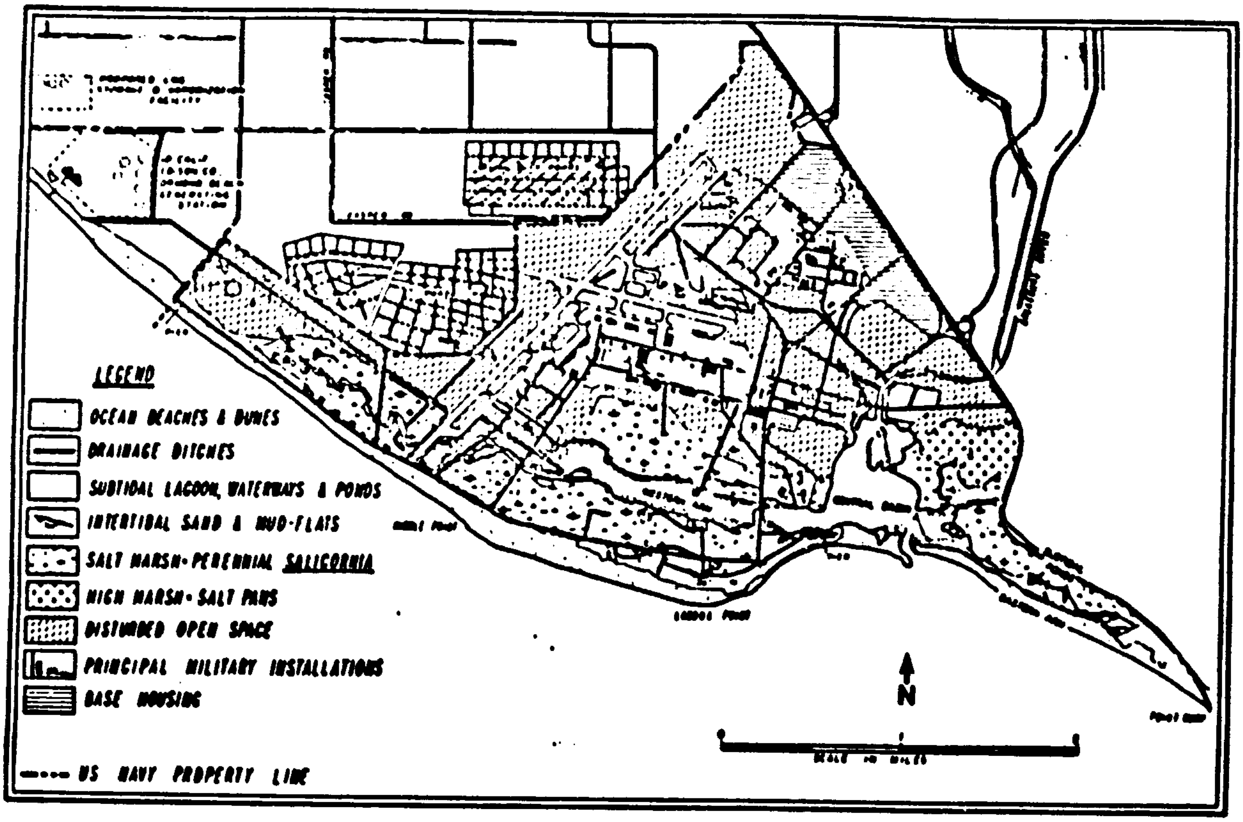
L.A. Regional Water Quality Control Board
Coastal Wetlands: Mugu Lagoon

Mugu Lagoon is located on the coastal margin of the Oxnard plain in Ventura County 5[illegible] miles northwest of Los Angeles. It is the largest coastal wetland system between Elkhorn Slough, in Monterey County, and Bolsa Bay in Orange County. It is far and away the largest coastal wetland complex of Region 4 (Dennis et al. 1984). Historically the Lagoon and surrounding wetlands paralleled the coast for nearly four miles and covered approximately 3,100 acres (Macdonald 197[illegible]). In the early 1940s the U.S Navy acquired the lagoon and surrounding wetlands. In 1946 a Naval Air Station was established and became the Pacific Missile Range in 1957. A large portion of the central lagoon, which was shallow tide flats was dredged to a depth of 30 feet to provide fill for construction on the base. The dredging and construction destroyed over half of the wetland so that today 1,400 acres remain. Because of the need for military security, the area was fenced, resulting in protection for remaining marsh areas.



Mugu Lagoon, from Highway 101, showing high marsh, salt pans, and some disturbed open spaces in the foreground. There is a shallow water table at the mouth of Calleguas Creek to the right, offsite.



MUGU LAGOON WETLAND: LANDUSE AND ECOLOGICAL ZONES

The Wetland System of Mugu lagoon is conveniently described by dividing the site into three sections: the shallow eastern arms of the lagoon, the deeper central lagoon section and the shallow western arm. The eastern Arm is 1.4 miles long and between 300 to 1,000 yards wide. There are 34 acres of low marsh habitat which intergrade into tideflats along the northern shore. The Central Lagoon, which originally consisted of tide flats and salt marsh, was dredged to a depth of 30 feet in the 1950s. This is slowly being filled by sediments from Calleguas Creek and is being colonized by salt marsh vegetation. The Western Arm is farther inland and the largest marsh areas are associated with this portion of the site. It is 1.5 miles long and 1,000 yards wide. Flood control ditches and a tidal creek extend two miles beyond the western end of the lagoon and carry tidal flows to another 300 acres of salt marsh. Some upper portions of the western arm have been cut off from tidal flows by construction of roads.

The Vegetation - studies suggest that at the Mugu complex there are four zones or types of vegetation (Macdonald and Barbour 1974). the lowest zone, dominated by cordgrass (*Spartina foliosa*), annual pickleweed, (*Salicornia bigelovii*) and perennial pickleweed (*S. virginica*). Most of this has been eliminated by dredging. The majority of the marsh is now occupied by lower and upper vegetation types that are usually separated abruptly by physiographic features (sharp change of slope, etc.) at Mean High Water (MHW). The species composition of the higher marsh changes with elevation as the marsh grades into barren salt flats interspersed with strips of sinuous vegetation. Observations concerning the floristics at Mugu are extrapolated from studies performed in the eastern arm of the wetland.

The Lower Marsh is dominated by *Salicornia virginica* forming large monocultural stands. Scattered occurrances of *S.bigelovii*, *Jaumea Carnosa*, alkali heath (*Frankenia grandifolia*) and *Monanthochloe littoralis* are found in this zone. Following major storms in 1978 and 1981 there was an increase in biomass of *S. virginica* within this zone. According to Onuf (1987) the increase is due to stimulation of growth by the lowering of soil salinities due to flushing and also due to increased nutrients made available by deposition of fine sediments from surrounding watershed, much of which is agricultural and therfore high in fertilisers.

The Upper Marsh is dominated by *Salicornia virginica*, but unlike the lower marsh, other species contribute significantly to the biomass of the upper marsh. Onuf (1987) found the following composition based on 10 samples: *S.virginica* accounted for 44% of the total biomass; sea lavender (*Limonium californicum*), 21%; alkali heath (*Frankenia grandifolia*), 15%; fleshy jaumea (*Jaumea carnosa*) 14%, saltwort (*Batis maritima*), 5%; and arrow grass (*Triglochin maritima*), 2%. Along the uppermost portion of this zone Atriplex spp., seablight (*Suaeda californica*) and *Salicornia subterminalis* become more prevalent.

The Subtidal Zone historically contained large beds of eelgrass (*Zostera marina*). The intense storm of February of 1978 buried the beds and suffocated the plants. The eelgrass beds have not recovered since, with only a few small patches remaining, these identified by means of aerial photographs (Onuf 1987).

The Fauna is extreemly rich for both invertebrates and vertebrates. The tidal mudflats contain nurmerous species at high densities. Densities of 30.000 organisms per square meter have been reported (Onuf 1987). Thirty-nine species of fish have been identified from Mugu Lagoon of which the most common are arrow gobies (*Clevelandia ios*), topsmelt (Atherinops afinis), staghorn sculpin (*Leptocottus armatus*), and shiner surfperch (*Cymatogaster aggregata*). Census data for birds at Mugu Lagoon has not been published; however a list compiled by the Natural Resources Management Office for the Naval Air Station shows 198 species. Threatened and Endangered species which use the wetland are the light-footed clapper rail, Belding's savannah sparrow, brown pelican, and least tern.

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Coastal Wetlands: Dume Creek Lagoon

Dume Creek Lagoon (404.36) is a small freshwater lagoon of approximately 17.4 acres adjacent to Dume Beach in Western Los Angeles County. The size of the lagoon varies yearly with the amount of freshwater input. The biological value of this area is enhanced by the unique geographic position of Point **Dume**. This headland extends into Santa Monica Bay more than a mile **beyond** the rest of the Malibu coast, and is located on the **Pacific Flyway**. As a result the lagoon serves as a resting area for migr**atory** birds and also provides habitat for year round natives. **The surrounding** area is slightly degraded due to development on the overlooking bluffs. Further degradation could threaten the wetland due to increased sedimentation and runoff from areas of housing. The coastal area generally exhibits low intensity recreational use.

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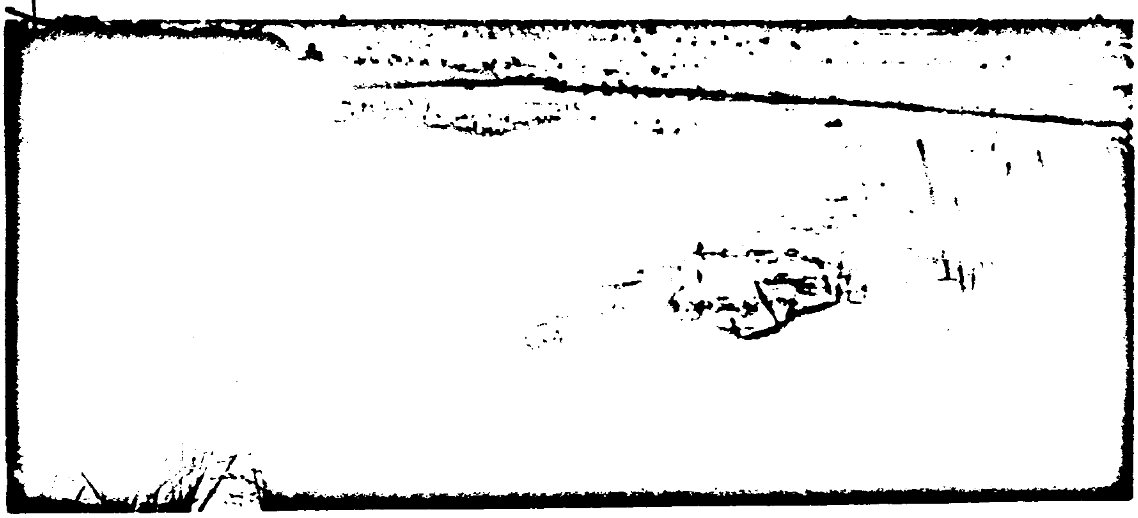
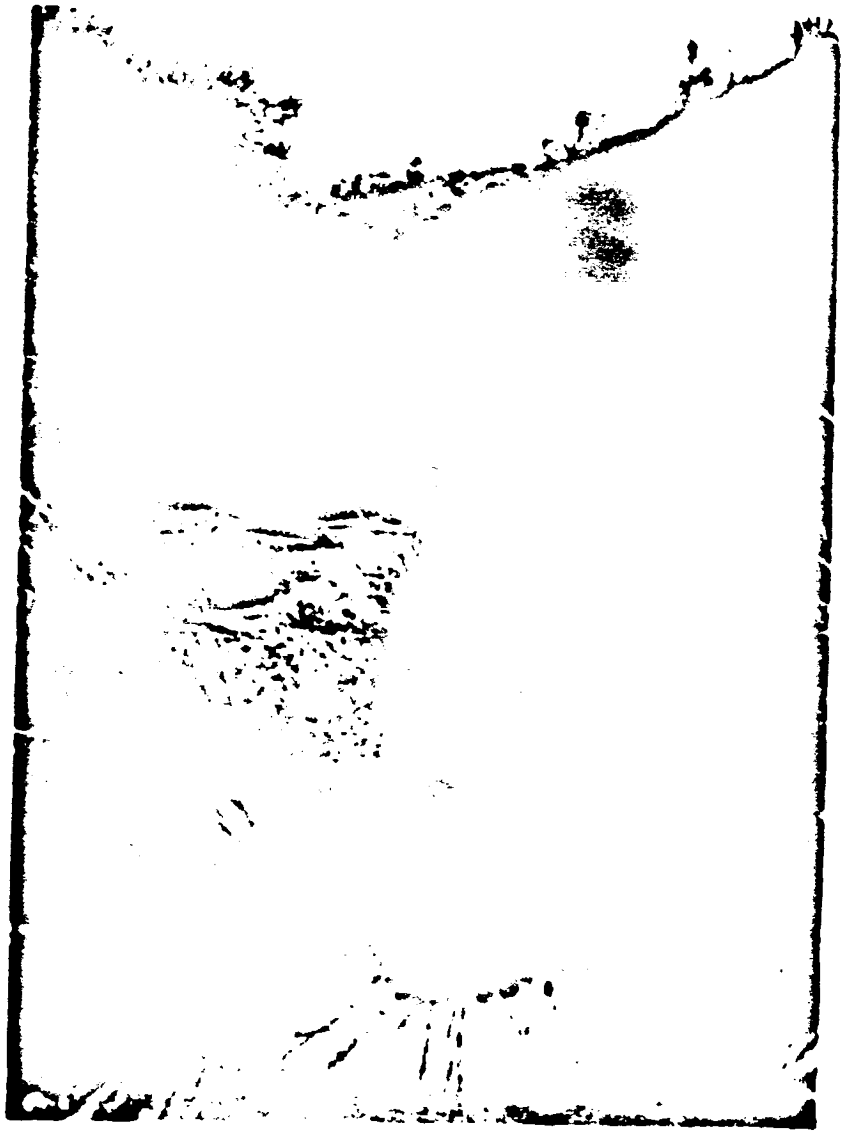


Photo: Dume Creek Lagoon, looking south toward sandbar which blocks connection with Pacific Ocean. Emergent cattails (*Typha sp.*) are in foreground with gulls and other shorebirds along the edge of the Lagoon.

The Habitat: [illegible] Dume Creek [illegible] runoff. The vegetation [illegible] wetland [illegible] determined by the amount of water present. Species present in the wetland at the mouth of Dume Creek include cattail (*Typha latifolia*), California bulrush (*Scirpus californicus*), saltgrass (*Distichlis spicata*), and pickleweed (*Salicornia virginica*). After above average rainfall in 1991, watercress (*Rorippa nasturtium-aquaticum*) appeared in dense mats in Dume Creek. This is an excellent indicator that this area supports wetland vegetation. The density of the watercress indicates a large seed bank present in the soil. The rainfall, which occurred after 6 years of drought also raise the water table which was low due to the drought conditions.



The Photo: Looking upstream at Dume Creek from the mouth where it enters the wetland. This photo was taken November 16, 1992 after significant rainfall in February and March, 1991. The Channel is lined with arroyo willow (*Salix lasiolepis*) and the emergent vegetation in the streambed is cattail (*Typha latifolia*) and watercress (*Rorippa nasturtium-aquaticum*).

Opposite Page Photo: Same view as above, taken November 17, 1991. Caster bean (*Ricinus communis*) is indicitave of disturbed habitat. After the rain it was no longer present due to the presence of inundated soil.

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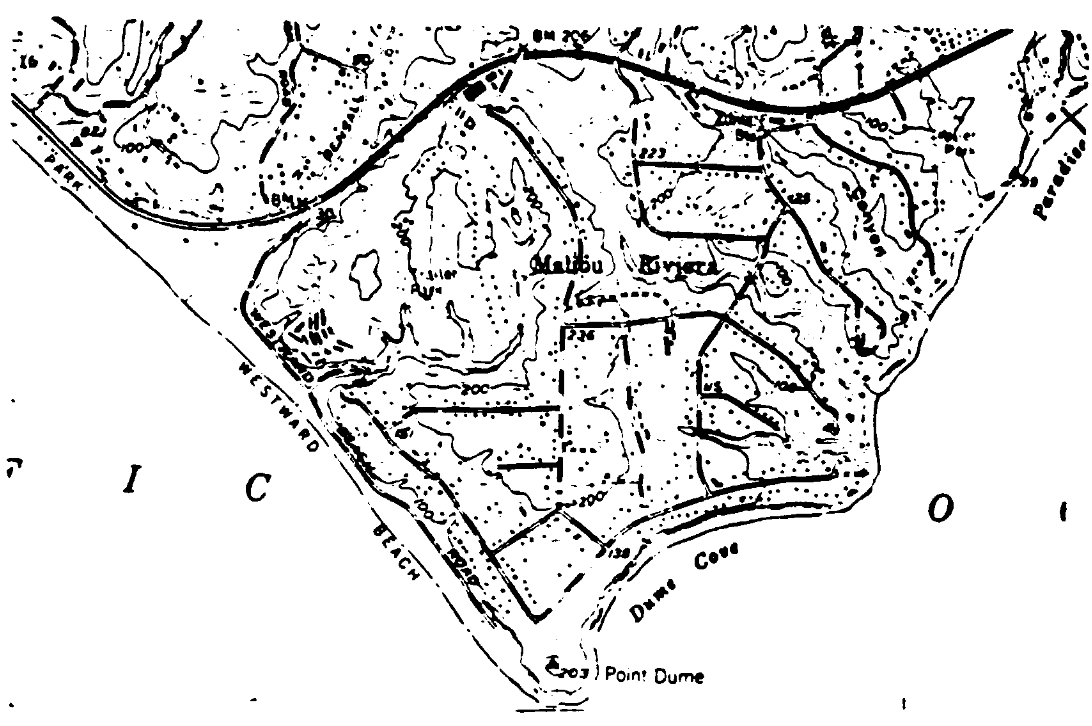
Topographic Map: USGS Point Dume 7.5 Min showing Point Dume



L.A. Regional Water Quality Control Board
Coastal Wetlands: Malibu Lagoon

Malibu Lagoon (404.21) is located in the town of Malibu, west of Malibu Pier, at the mouth of Malibu Creek. The lagoon covers 13 acres and contains roughly 2 acres of wetlands. It is one of the last remaining estuaries in Los Angeles County. Freshwater inflow through Malibu Creek is largely comprised of tertiary treated wastewater from the Tapia Water Reclamation Plant, five miles upstream. The lagoon is an important stopover and wintering area for migrating birds and is an essential nursery habitat for various fish species. Malibu Creek is presently the southernmost range extension of the anadromous steelhead trout (*Oncorhynchus mykiss*) which enters the lagoon to spawn upstream in Malibu Creek. The lagoon is readily accessible and receives heavy human use. A wetland restoration project, begun in 1983, has formed a permanent lagoon, a tidal marsh, and an upper marsh.

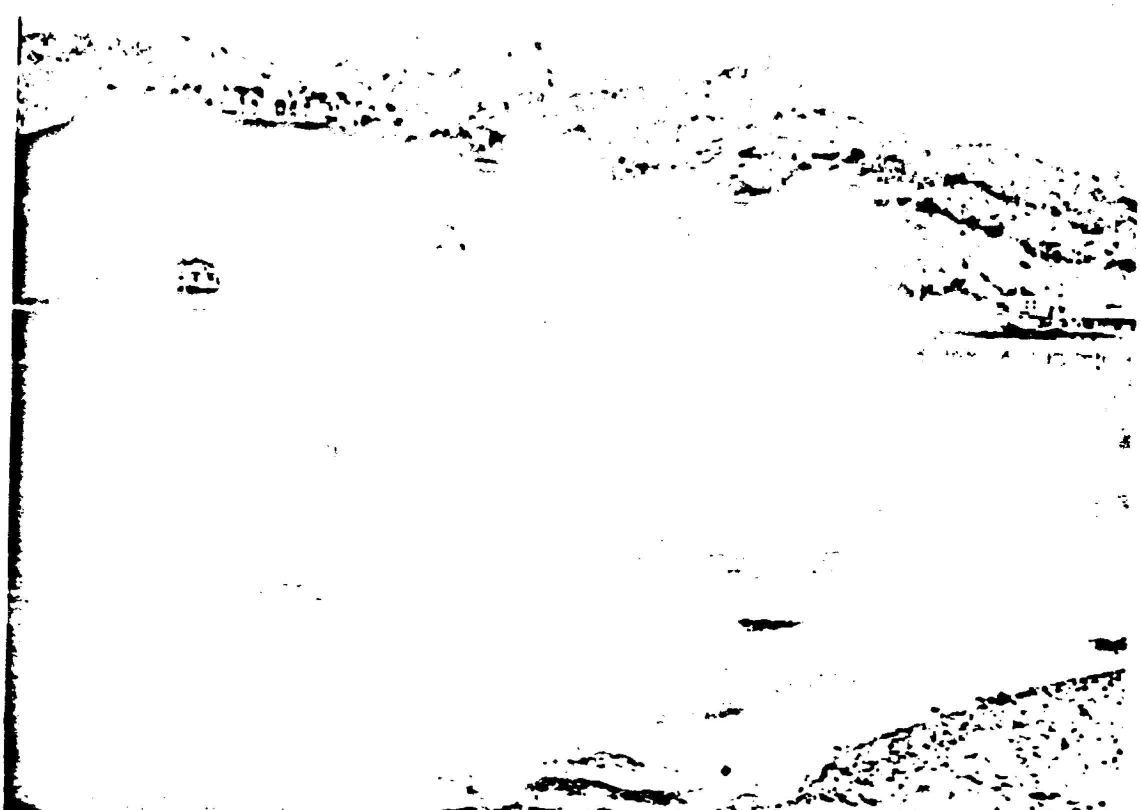
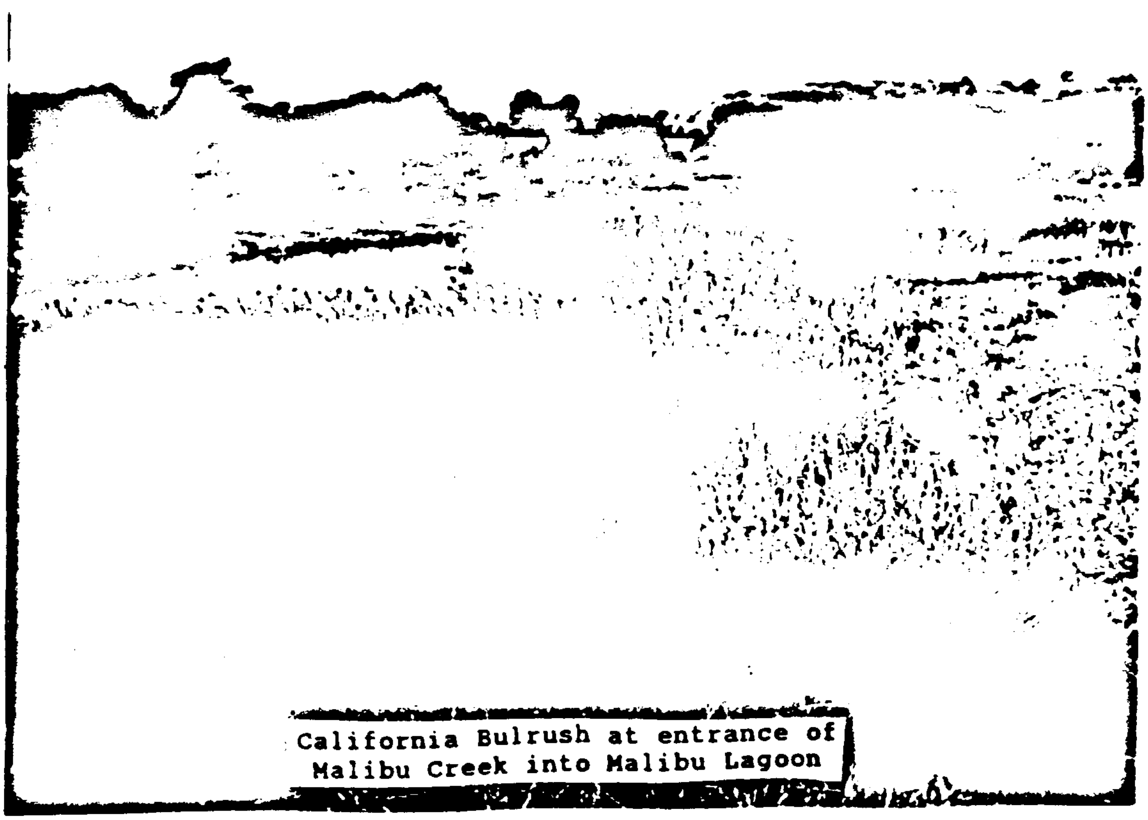


Photo: Malibu Lagoon facing north toward Pacific Coast Highway. Main lagoon, showing gulls, the most common of over 150 species which have been observed using the lagoon.

The Wetland Vegetation found at Malibu Lagoon is different from other tidal marshes in southern California. Typically, pickleweed (*Salicornia virginica*) is the first plant to establish dominance in salt marsh communities due to its ability to tolerate hypersaline soils. At Malibu Lagoon, fleshy jaumea (*Jaumea carnosa*) is the dominant low marsh plant and in some areas shares dominance with saltgrass (*Distichlis spicata*). This is probably due to two factors: (1) much of the substrate is sandy fill brought in during the restoration of the marsh. This soil drains quickly reducing the buildup of salt in the soils which favors pickleweed. (2) Pickleweed requires only a brief window of fresh water for germination, and when this is extended, germination rates fall. Jaumea germinates well in fresh water and has a competitive advantage over pickleweed in this estuarine environment which is subject to high amounts of freshwater influx. Other species found in the salt marsh include alkali heath (*Frankenia grandifolia*), *Limonium californicum*, dodder (*Cuscuta salina*), and arrow-grass (*Triglochin concinnum*). Bulrushes (*Scirpus californicus* and *S. robustus*) are found growing in the freshwater channel at the head of the lagoon. Past occurrances of *Astragalus Brauntonii*, a federal candidate 2 are recorded for the wetland area

The Animals which use Malibu Lagoon are numerous. There were recorded 151 different bird species between April of 1987 and March of 1988, including the California least tern (*Sterna antillarum browni*) which is listed as endangered (state and federal listings). Tidewater Goby (*Eucyclogobius newberryi*) a federal candidate for listing is also found in the lagoon.



California Bulrush at entrance of Malibu Creek into Malibu Lagoon

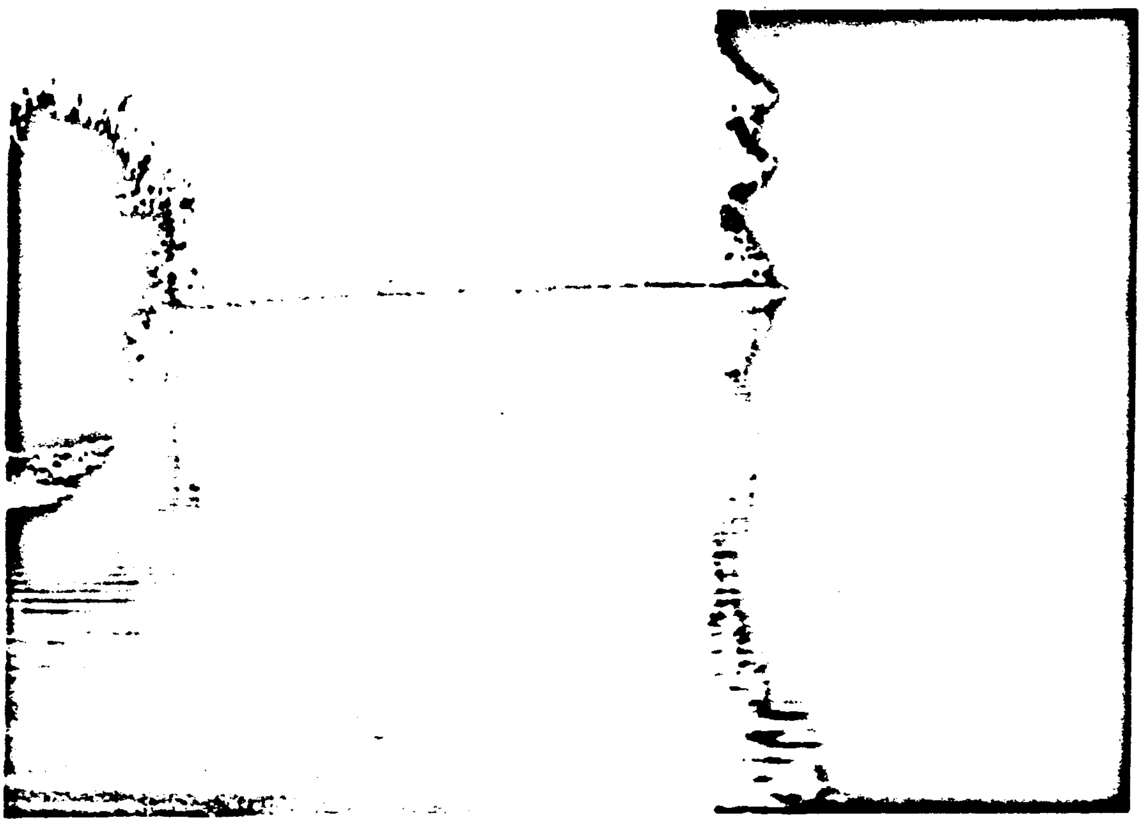
The Watershed drained by Malibu Creek is the largest in the Santa Monica Mountains comprising 67,000 acres. Malibu Lagoon forms at the terminus of Malibu Creek as a result of the fluvial processes of erosion, transportation and deposition of sediments. The winter and spring floods, typical of southern California, erode and carry the majority of yearly sediment load to the lagoon. The historic annual hydrologic cycles are currently disrupted by excessive non-seasonal domestic (tertiary treated) water most of which is from the Tapia Water Reclamation Facility of the Las Virgenes Municipal Water District. Tapia releases 8-10 million gallon per day into Malibu Creek.

The high influx of fresh water has a significant impact on the biota within the lagoon. Seawater salinity is typically 34-36 ppt. Measurements in the lagoon at various times and in various locations found salinities ranging from 2-35 ppt. There is often significant layering (saltwater lens formation) tied to the tidal cycles. As sediments flow into the lagoon, the mouth is closed, interrupting the influx of seawater. To mitigate the effects, Los Angeles County Department of Parks and Recreation periodically (once or twice a month) opens the mouth of the lagoon by bulldozing. During the rainy season, high flows associated with storms naturally breach the sediment at the mouth of the lagoon.

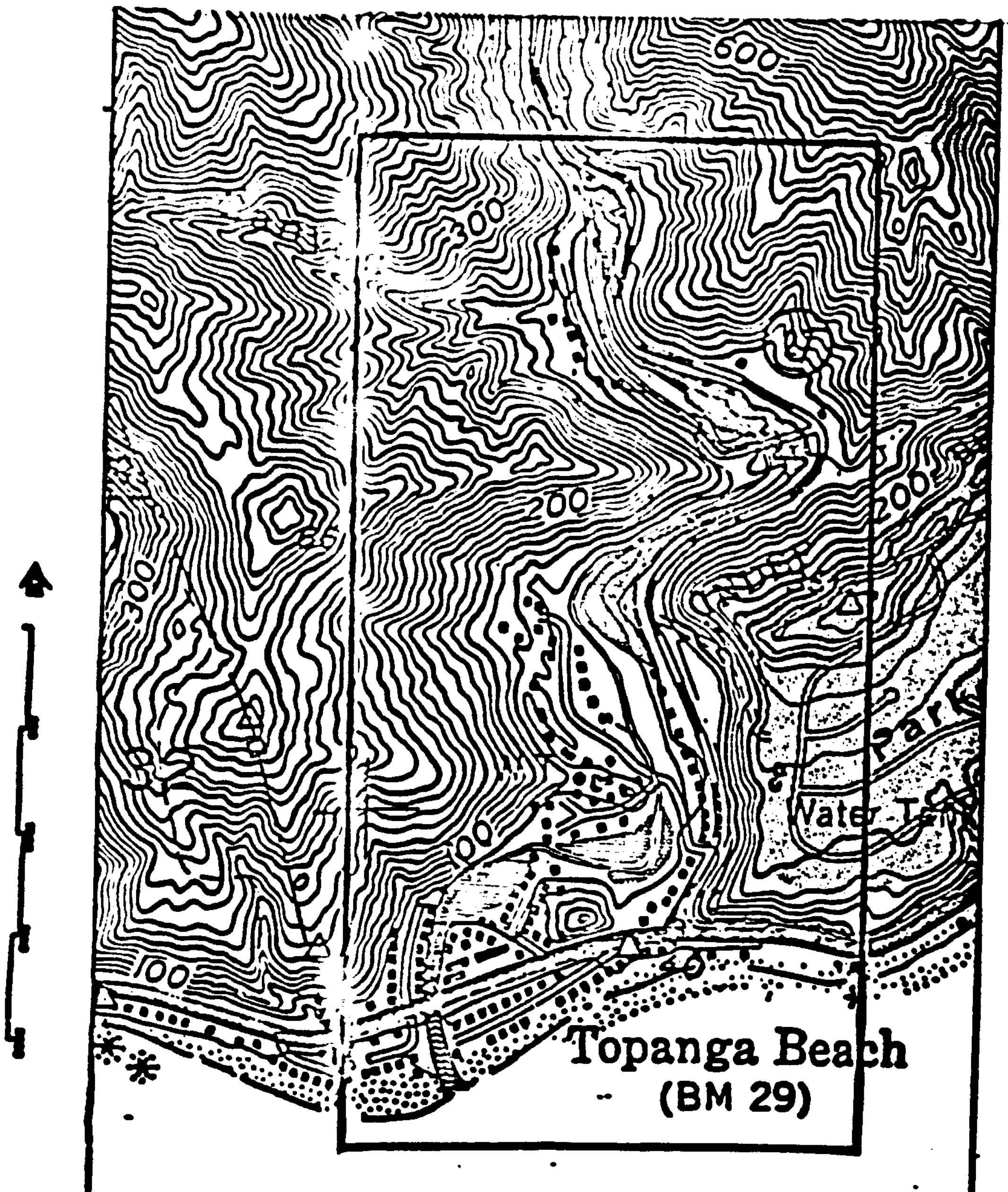
Infrared Aerial Photo: Malibu Lagoon and Adjacent watershed

L.A. Regional Water Quality Control Board
Coastal Wetlands: Topanga Lagoon

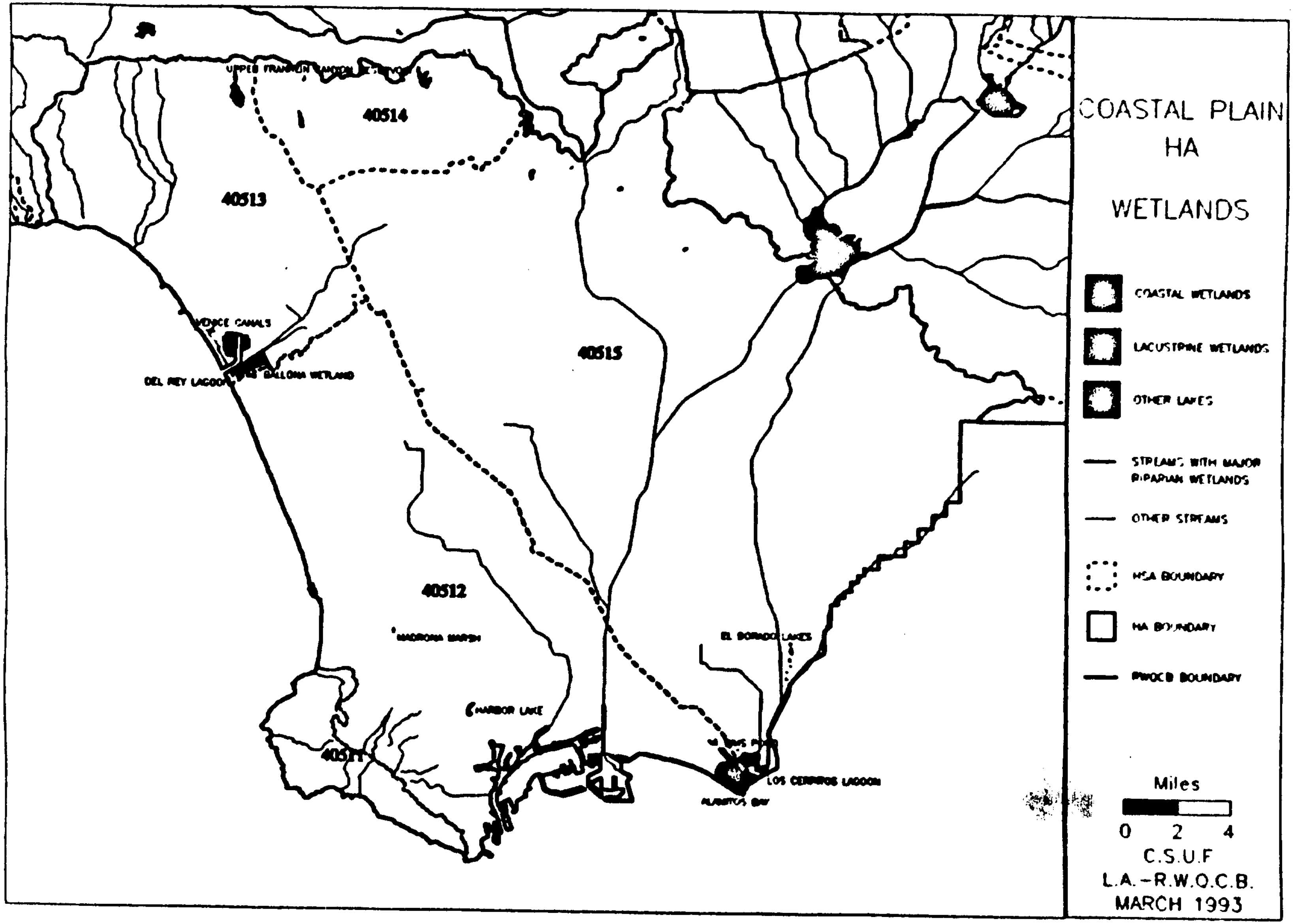
Topanga Lagoon (404.11) is a 5.0 acre estuarine waterbody at the terminus of Topanga Canyon Creek where it discharges into the Pacific Ocean. There is no significant salt marsh associated with Topanga Lagoon. Vegetation around the lagoon is **indicitave** of a disturbed habitat and consists of grand reed (**Arundo donax**), tree tobacco (*Nicotiana glauca*). Some isolated willows (***Salix***) are present. California Trout lists the lagoon as potential habitat for anadromous steelhead, and lists Topanga Canyon Creek as actual habitat for trout. Overall the area is degraded by large amounts of trash and broken concrete.



Topanga Lagoon, Los Angeles County



TOPANGA LAGOON WETLAND (from Josselyn and Chamberlain, 1993)


COASTAL PLAIN
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VENICE CANALS
BALLONA WETLAND
DEL REY LAGOON
MADRONA MARSH
HARBOR LAKE
EL DORADO LAKES
LOS CERRITOS LAGOON

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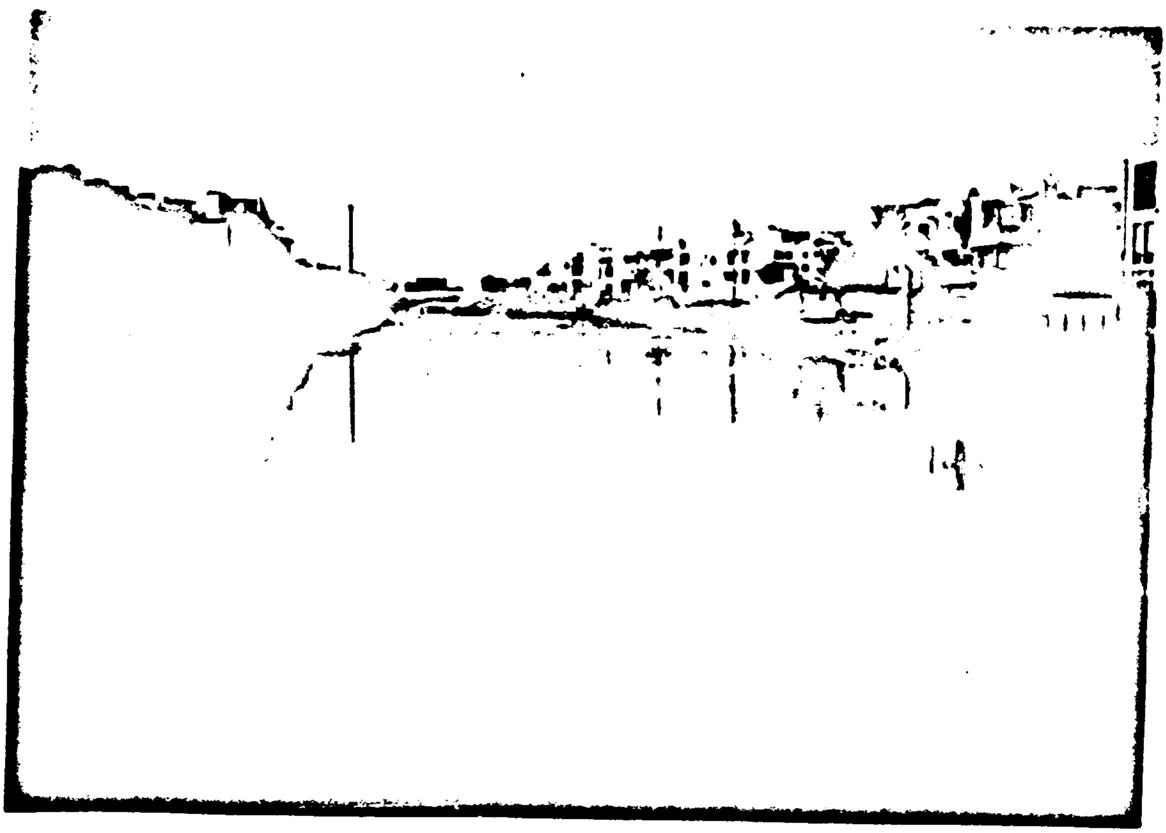
L.A. Regional Water Quality Control Board
Coastal Wetlands: Ballona and Del Rey Lagoons

Ballona and Del Rey Lagoons are part of the coastal wetland complex [illegible] to the north and south of the channelized Ballona Creek. The Ballona wetlands constitute the rest of the complex. Historically, nearly [illegible] acres of wetlands, the Ballona Creek Marsh, were situated at this site. In [illegible] the major lagoons were drained and [illegible] of the land was converted to agriculture. In the 1960s the remaining [illegible] acres of salt marsh were developed into the Marina Del Rey residential marina project.

The primary source of water is the marina and the mouth of the harbor which are connected to the lagoon through tidal gates. The lagoons are surrounded by houses and streets which contribute fresh water. The lagoons provide habitat for over [illegible] species of waterbirds with peak densities during winter.

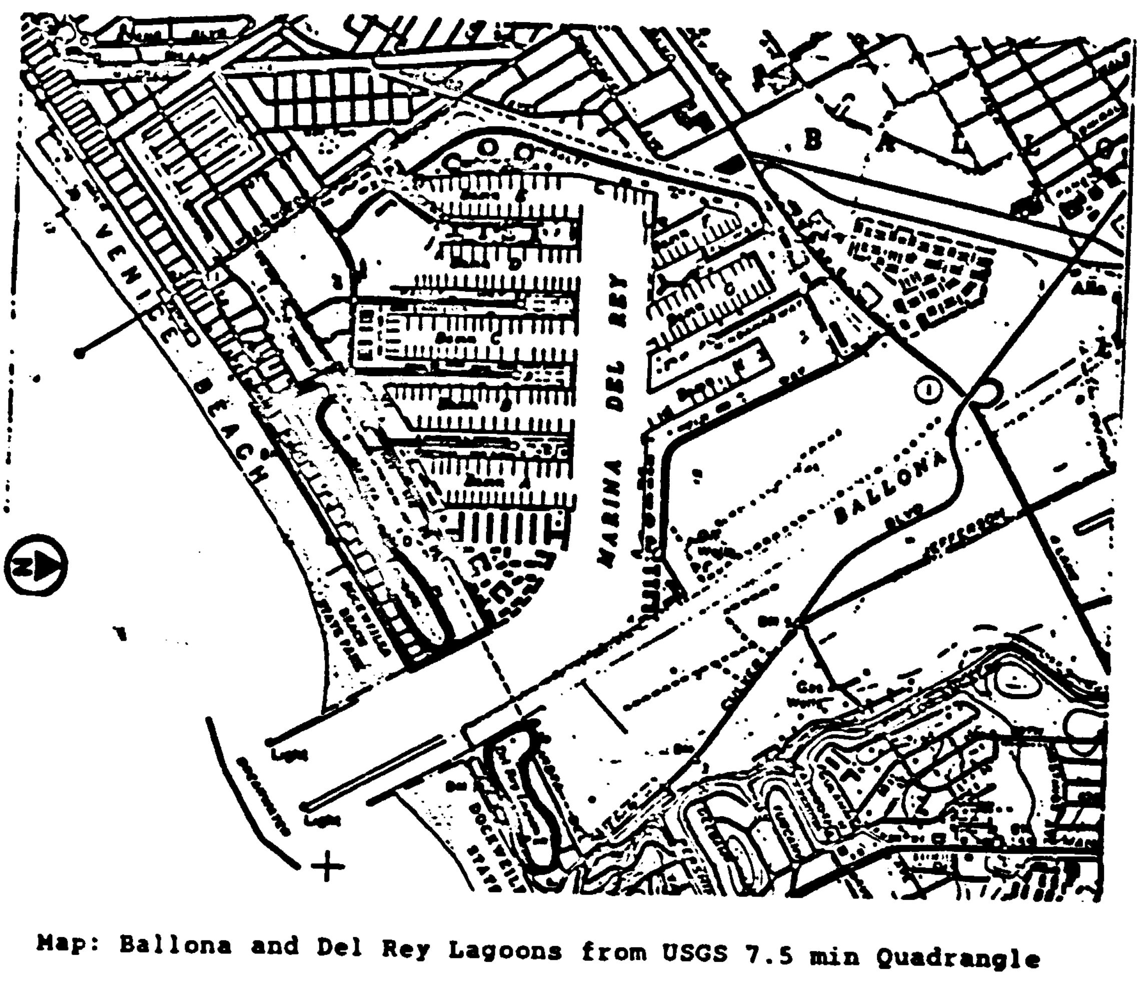


Ballona Lagoon, looking north from parking lot, near inlet from Marina Del Rey Harbor. The lagoon is surrounded by housing and slopes, some barren and some covered by iceplant (Carpobrotus sp.)

Ballona Lagoon (405.13) is located to the north and Del Rey Lagoon to the south of the channelized Ballona Creek. Ballona Lagoon covers 16 acres and has associated with it 1.5 acres of intertidal wetland vegetation mainly pickleweed (*Salicornia virginica*), and saltgrass (*Distichlis spicata*).

The Hydrology: The major source of water is marine water, derived from Marina Del Rey harbor entrance through the two tidal gates. There is also some fresh water derived from urban runoff, from a drainage are of about 290 acres which include the Venice Grand Canals to the north. At the site of seawater entrance from the south the water is saline.

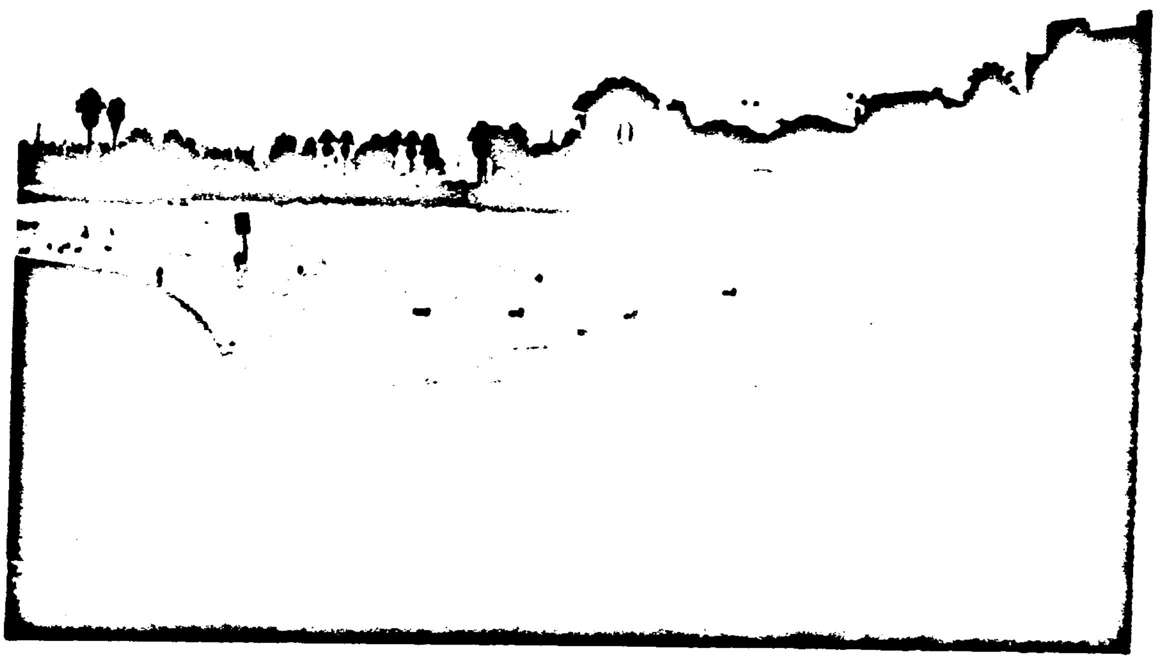
Occurrances of California least tern (*Sterna antillarum browni*), and the salt marsh skipper have been reported.



Map: Ballona and Del Rey Lagoons from USGS 7.5 min Quadrangle

Del Rey Lagoon is located to the south of Ballona Creek and to the west of the Ballona wetlands. There is no salt marsh vegetation, only iceplant (*Carpobrotus* sp.) which is used as a ground cover. Various waterbirds were observed during a field visit including a snowy egret (*Egretta thula*).

The Hydrology: The source of water is marine water which enters through the tidal gates located at the north of the lagoon. Some urban runoff from housing and streets to the east and west of the lagoon, and from irrigation waters for a park area in the south.



Del Rey Lagoon showing lack of vegetation.

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L.A. Regional Water Quality Control Board
Coastal Wetlands: Ballona Wetlands

Ballona Wetlands (405.13) is a [illegible] acre seasonal brackish and saline coastal wetland of which [illegible] acres are viable and are all that remains of an historical [illegible] acre salt marsh. It is located to the south of the channelized Ballona Creek and the harbor of Marina del Rey and is part of a larger complex which includes Ballona and Del Rey Lagoons. Shallow groundwater augmented by urban runoff is the main source of water. Tidal flows from Ballona Creek are blocked by tidal gates. The wetland presently is significantly degraded and restoration plans are proposed. These plans include creation of a freshwater marsh which will compensate for wetland losses. The marsh will be used for treatment of urban runoff and as wildlife habitat. Development of mid-tidal and full-tidal wetland systems is also proposed as a long-term goal.

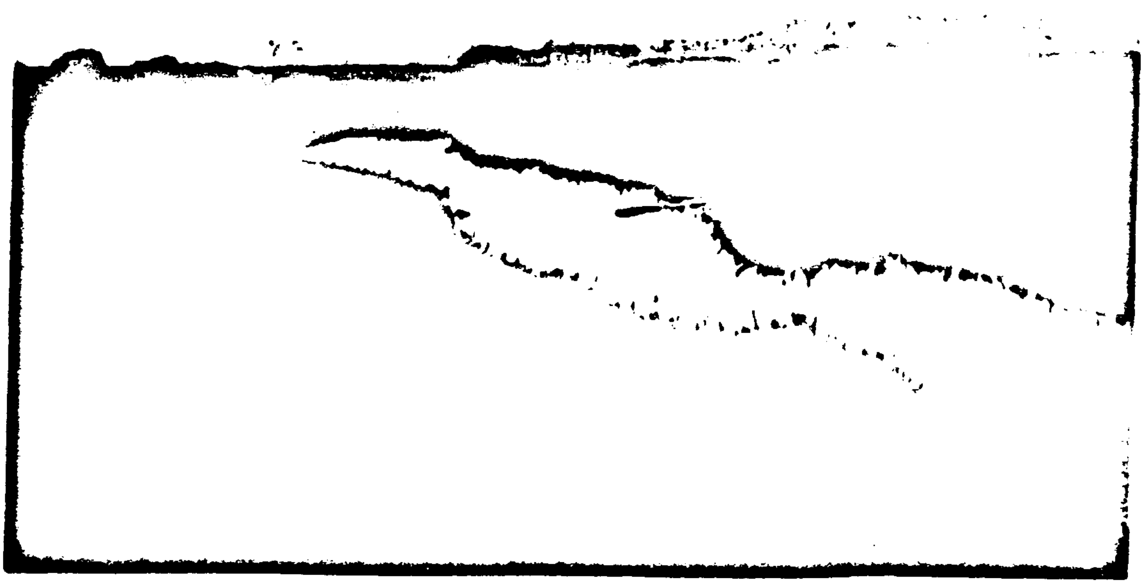

Photo: Ballona Wetland looking south from Ballona Creek. Pickleweed (*Salicornia virginica*) is the dominant herbaceous perennial. Willows (*Salix* sp.) can be seen in the background. Access to the site is limited by a fence.

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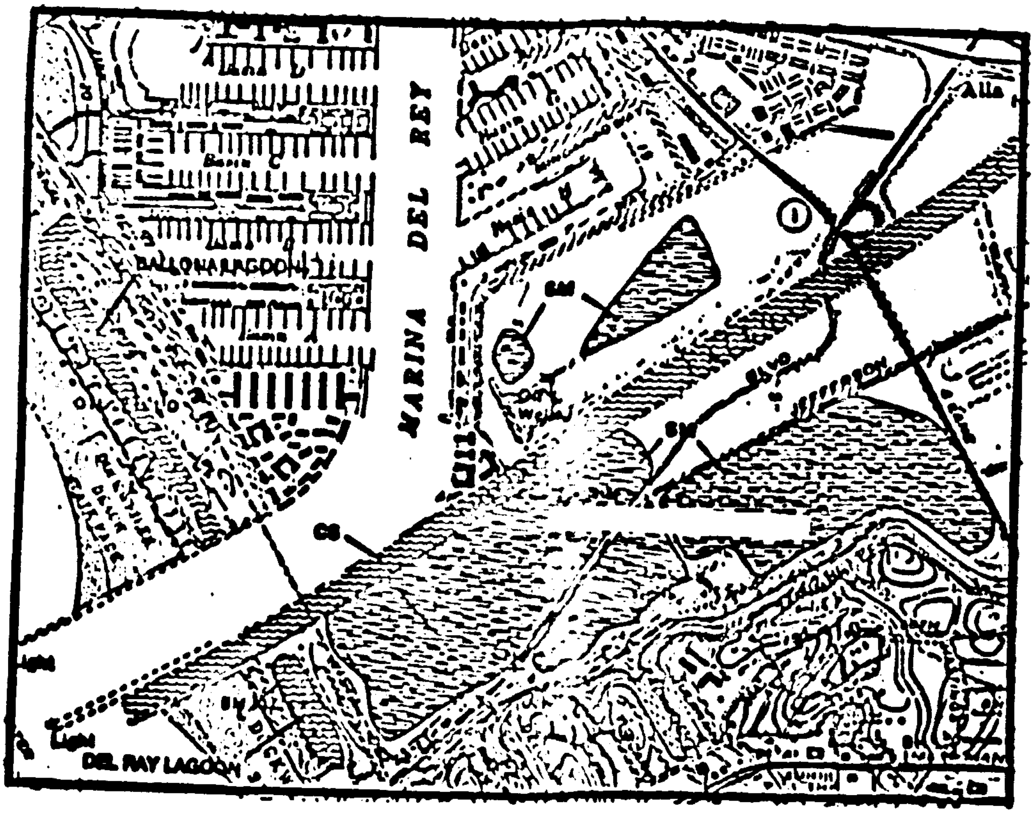
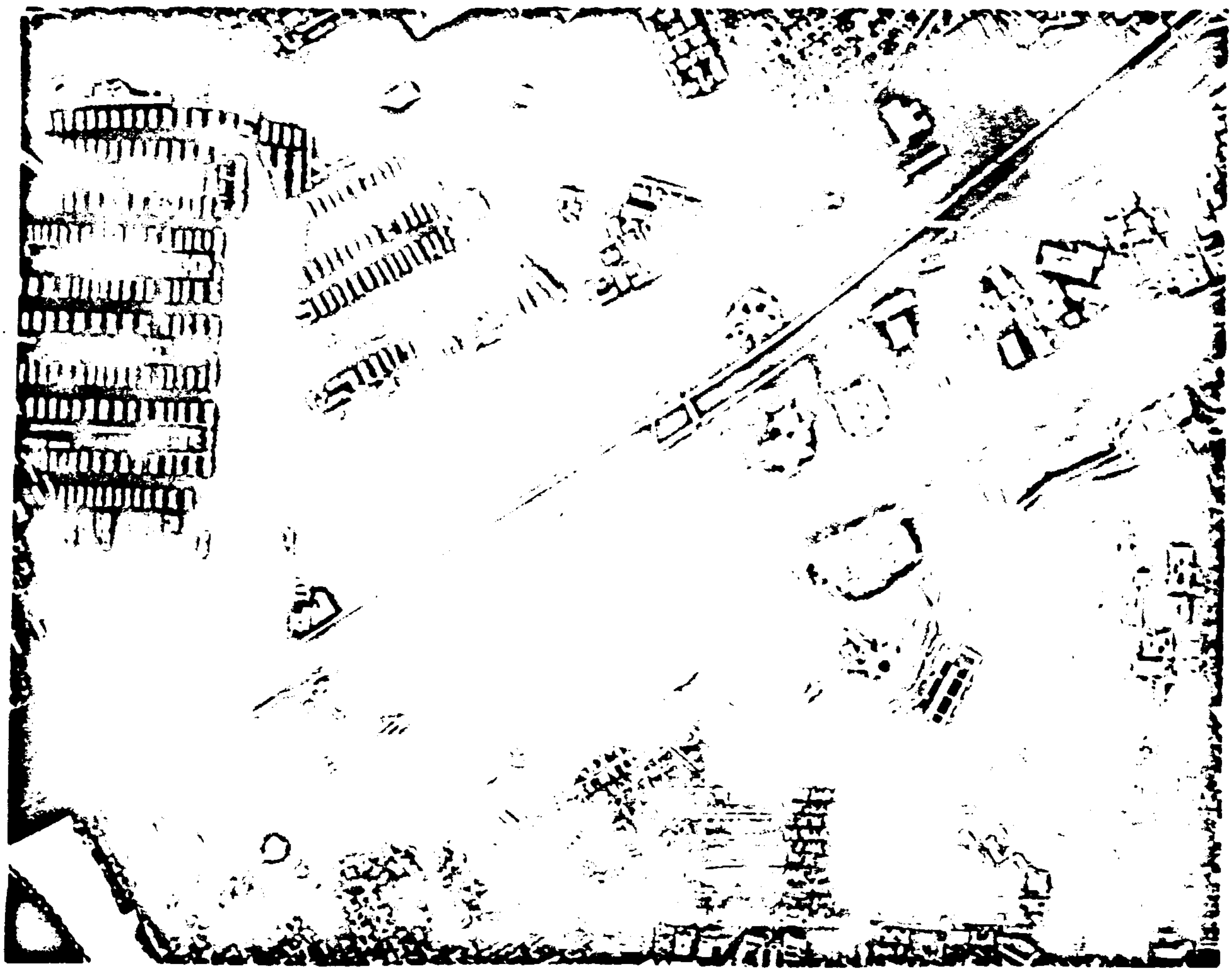


BALLONA LAGOON, DEL RAY LAGOON AND BALLONA WETLAND COMPLEX

(from Josselyn and Chamberlain, 1993)

The Site consists of 182 acres of non-tidal coastal wetland and 50 acres of flood control channel. The wetland atea lies below 10 feet Mean Sea Level with a 2 to 5 percent slope. The surrounding soils are in the Oceano association and the soils within the wetland are alluvial and tidal marsh soils with high clay content.

Considerations for the site are as follows: (1) The Ballona wetland is the single largest coastal wetland system remaining in Los Angeles County and therefore represents an important resource. (2) Although there are various proposals for enhancement or restoration to both fresh and tidal wetlands there are contraints such as the need for flood control, the presence of underground gas storage facilities within wetland area, and the presence of underground pipelines which would need rerouting should tidal action be restored. Despite these constraints, the current landowner Maguire Thomas Partners is working with the National Audubon Society in developing restoration plans which would restore some level of tidal action to the wetland.



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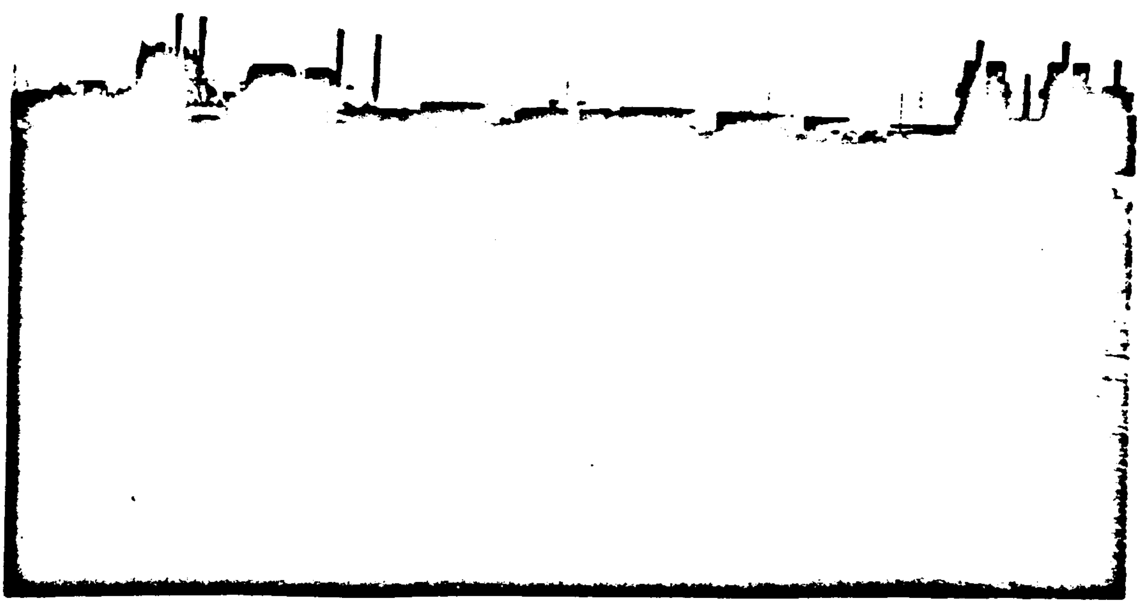
L.A. Regional Water Quality Control Board
Coastal Wetlands: Los Cerritos Wetlands

Los Cerritos Wetlands (405.12) is a complex consisting of coastal salt marsh, intertidal channels, freshwater input and a fresh water pond. The area covers approximately 244 acres near the intersection of Pacific Coast Highway and Westminster Boulevard in Long Beach. The area south of Westminster Boulevard and the western portion north of Westminster Boulevard is an oil fiel and is largely degraded. The remaining portion of the northern section is a high quality coastal salt marsh. Within the northern, high quality portion of the wetland the vegetation is composed of cordgrass (*Spartina foliosa*) which is dominant in the tidal flats where periods of inundation are longest and extending to the lower portions of the marsh. At higher elevations, *Spartina* gives way to pickleweed (*Salicornia virginica*) which is dominant in the higher elevations. Salt grass (*Distichlis spicata*) is common throughout the complex. Cattail (*Typha latifolia*) and California bulrush (*Scirpus californicus*) are also present.



Northern Portion Los Cerritos Wetlands: Photo taken from south side of channel, across from marina. View is to the east showing extensive stands of cordgrass (*Spartina foliosa*). Power plant in background is on Studebaker Road.

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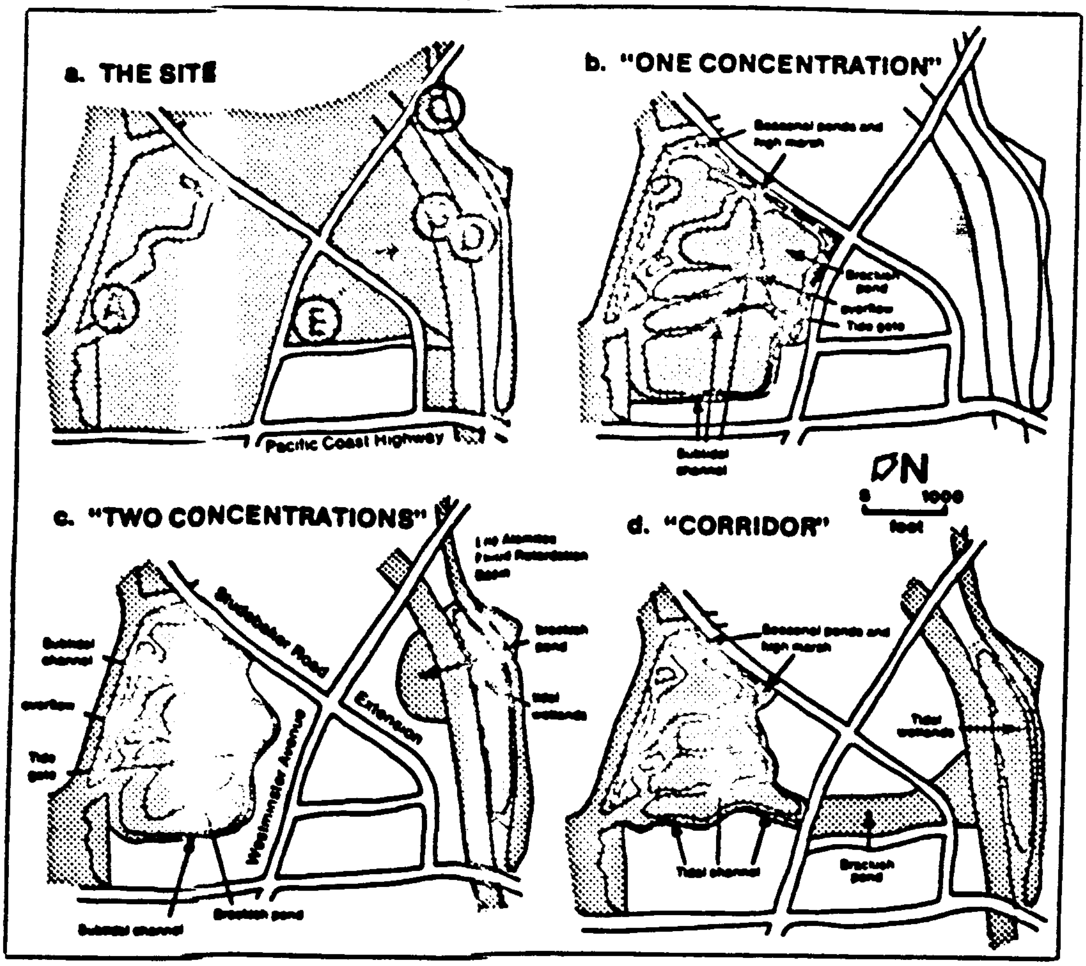
Los Cerritos Wetland Restoration Alternatives.
(proposed by Sorensen and Associates)



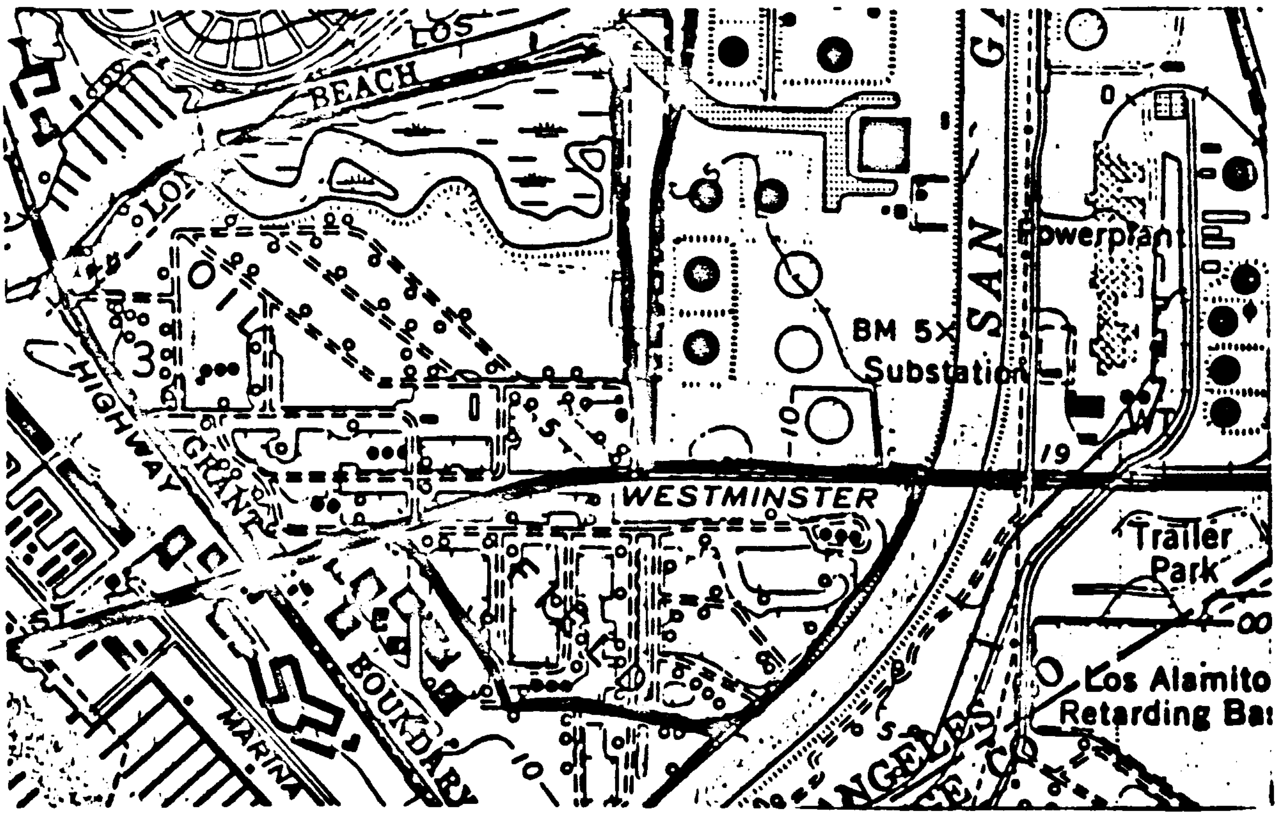
THE EXAMPLE OF LOS CERRITOS WETLAND RESTORATION

Alternative sketch plans for restoring Los Cerritos Wetlands (in Long Beach) were developed by Jens Sorensen and Associates. The restoration planning had the following features which were given at the onset:

- The site (Figure 7a) included 244 acres. Of this, 129.5 acres were to be restored as wetlands habitat; the remaining acreage would be developed.
- Studebaker Road was to be extended through the site.
- The site abutted another potential restoration project to the east.

Study of the area by the Department of Fish and Game and site inspection by scientists indicated that the following ecological assets already existed, although all were disturbed:

A. Intertidal channels, creeks, and marsh (functioning intertidal wetland)
B. San Gabriel River (aquatic habitat)
C. Power plant cooling-water intake (aquatic habitat)
D. Small intertidal channel and marsh connected to river by culvert
E. Artificially-built freshwater pond, heavily used by birds



Wetland Complex: High quality cordgrass/pickleweed salt marsh is separated from rest of complex by intertidal creek (in blue above and A below). Freshwater pond(s) (also in blue) support extensive stands of bulrush and cattail, and provide habitat for numerous birds.

Photo Opposite Top: Shows intermittent freshwater ponds on the southern portion of the complex which support large stands of California bulrush and cattail.

Photo Opposite Bottom: Intertidal Channel with stands of Pickleweed.

The complex is habitat for many bird species. Those observed during field visits were: great blue heron (*Ardea herodias*), green-backed heron (*Butorides striatus*), great egret (*Casmerodius albus*), willet (*Catoptrophorus semipalmatus*), kingfisher (*Ceryle alcyon*), and whimbrel (*Numenius phaeopus*). The complex is also potential habitat for Belding's savannah sparrow (*Passerculus sandwichensis beldingi*) and California least tern (*Sterna antillarum californicum*), both endangered species.

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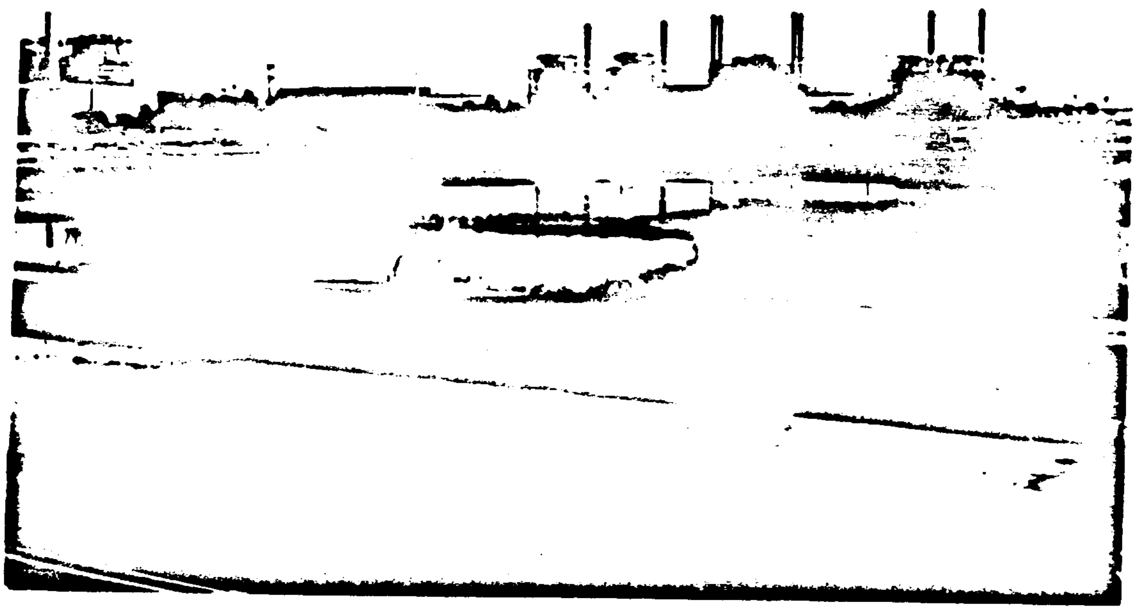


Lacustrine Wetlands

Lakes, and their associated lacustrine wetlands, typically occur in two physical situations: topographic lows and areas underlain by impermeable substrates. Topographic lows are created by a variety of erosional and depositional processes (Orme 1990). Southern California does not contain a large number of naturally occurring lakes. Another situation, namely the artificial impoundment of water behind dams, for purposes of flood control and water storage, provides for the formation of the majority of lakes in Region 4. Although artificial, many of the lakes and reservoirs have associated habitats which have the hydrology, soils, and vegetation which meet the criteria for wetland designation.

The rapid urban development in southern California since the 1930s has led to enormous losses, particularly of coastal wetlands and riparian wetlands of the coastal plain. During the same period, because of concerns regarding flood control and water storage, numerous reservoirs have been created, increasing the acreage of lacustrine wetlands. Many of these serve as "ecological islands" for many species of fish, birds and other vertebrates as well as many invertebrates. Large complexes, such as at the Whittier Narrows Recreation Area, provides habitat for numerous resident and migratory birds and waterfowl. Also significant is that many of these lacustrine wetlands occur along existing wildlife riparian corridors, enhancing the habitat and corridor value. Many threatened, endangered species and species of special concern utilize artificial lacustrine habitats. Examples include: southwestern pond turtle (*Clemmys marmorata pallida*), which is found at Lake Piru, Lake Sherwood, Lake Malibu, and Lake Casitas. Santa Ana sucker (*Catostomus santaanae*) is found at Lake Piru and at San Gabriel Reservoir. The threespine stickleback (*Gasterosteus aculeatus williamsoni*) is dependant on release of water from Drinkwater Reservoir in San Francisquito Canyon to provide flows required for maintenance of populations of this State and Federally listed fish. Bank swallows (*Riparia riparia*) utilize Lake Sherwood and occurrences of the California least tern (*Sterna antillarum browni*) have been recorded for Lake Machado and Harbor Lake.

As urbanization continues to exert pressure on the coastal and riparian wetland resources throughout the region, the importance of lacustrine wetlands can only become more significant. A thorough understanding of the hydrological and biological dynamics of lakes and reservoirs and their associated wetlands is necessary for the continued health of the habitat, for the maintenance of water quality (surface and groundwater), and the protection of the coastal areas from potential catastrophic flood events.

Description: Lacustrine Wetlands

Valley Freshwater Marsh is dominated by perennial, emergent monocots 4-5 meters tall often forming completely closed canopies. *Scirpus* and *Typha* are typically dominant. **Site factors** include quiet (lacking significant current), **permanent flooding** and freshwater. Prolonged saturation permits the **accumulation** of deep, peaty soils. Characteristic species include **chufa** (*Cyperus esculentus*), tall umbrella sedge (*Cyperus eragrostis*), ***Eleocharis*** spp., common reed (*Phragmites australis*), **black sedge** (*Scirpus acutus*), hard stem bulrush (*S. americanus*), California bulrush (*S. californicus*), narrow-leaf cattail (*Typha angustifolia*), southern cattail (*T. domingensis*) and broad-leaf cattail (*T. latifolia*). This type is found throughout Region 4. Good examples are found at Lake Eleanor, Century Reservoir, and Matilija Reservoir.

Stands of Cattail (*Typha*) and Bulrush (*Scirpus*) at Lake Eleanor.

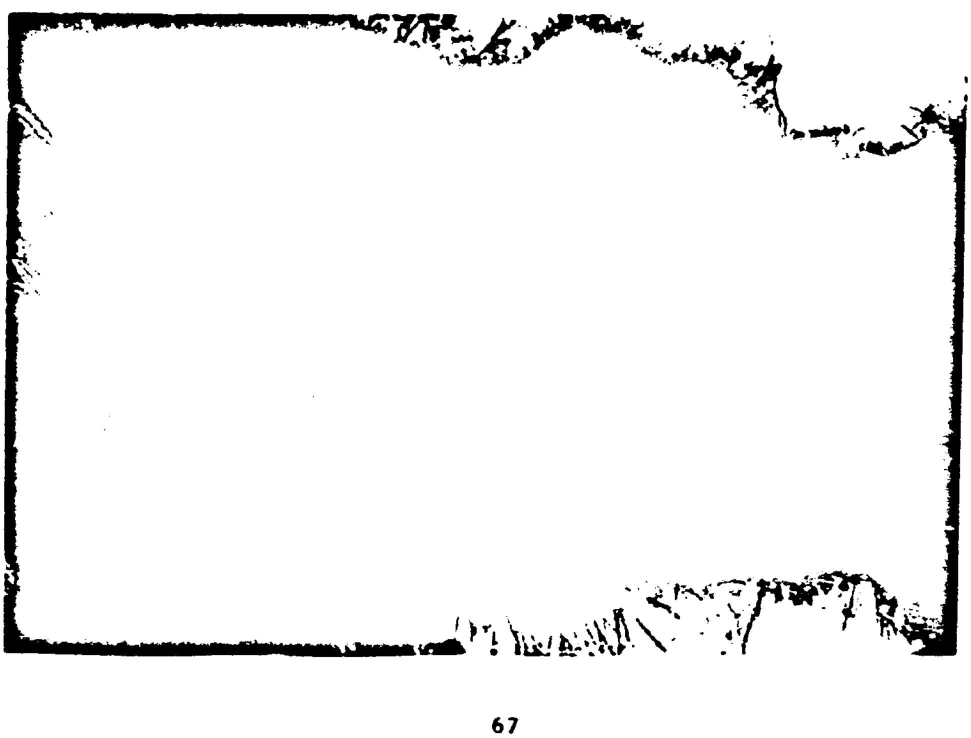
Functional Values

Wildlife Habitat is of primary importance in any consideration of lacustrine wetlands. The lakes and associated vegetated wetlands provide resources in the form of food and shelter for numerous species of invertebrates (primarily insects) which are in turn major food sources for fish and bird species. These, in turn, are utilized by raptorial birds and other animals at the top of the food chain. As discussed above, there are many endangered, threatened, candidate or sensitive species associated with and often obligately tied to lacustrine wetland habitats.

Water Storage in the arid southwest is a way of life. In Region 4, many of the large lakes were constructed to store water imported from the Owens Valley, Sacramento Delta or Colorado River. Presently, nearly all of the lakes in Region 4 serve as reservoirs.

Groundwater Recharge zones are often below major reservoirs so that water can be released at a rate which allows for minimal losses of the water resources. Water released from Morris Reservoir near the mouth of San Gabriel Canyon is directed to spreading ground in the large alluvial deposits along the San Gabriel River in Azusa and Irwindale.

Flood Control is also provided by many reservoirs. In the late 1930s disastrous floods occurred providing the impetus for the construction of numerous dams throughout the region. Many of these reservoirs now serve a dual purpose, providing flood control and storage capacity. The storage of a permanent water supply has created wetlands in the form of freshwater marshes.



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L.A. Regional Water Quality Control Board
Lacustrine Wetlands: Matilija Reservoir

Matilija Reservoir (402.20) is the most extensive and best example of a lacustrine wetland in Region 4. The wetland is located at the upper end of the reservoir where Matilija Creek discharges into the lake. The wetland is a mosaic of vegetation types including extensive monocultural stands of cattail (*Typha*) which provide approximately 80% of the vegetative cover. Bulrush (*Scirpus*) contributes about 15% of the total cover and also occurs in dense stands. Willow woodland is dominant along the margins of the wetland and is dominated by yellow willow (*Salix lasiandra*) and arroyo willow (*S. lasiolepis*). Individuals of sandbar willow (*S. hindsiana*) are found throughout the wetland. Other species include cocklebur (*Xanthium strumarium*), and invasive exotic giant reed (*Arundo donax*) which forms dense stands, displacing native plants.

The Mouth of Matilija Reservoir showing a mosaic of wetland vegetation dominated by cattail. Rounded plants are Bulrushes

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Above: Four common wetland plants: Sandbar Willow (*Salix hindsiana*) (far right), Cocklebur (*Xanthium strumarium*) (lower center), Bulrush (*Scirpus*) (center top), and Cattails (*Typha*) (left).
Below: Invasive Exotic *Arundo donax*

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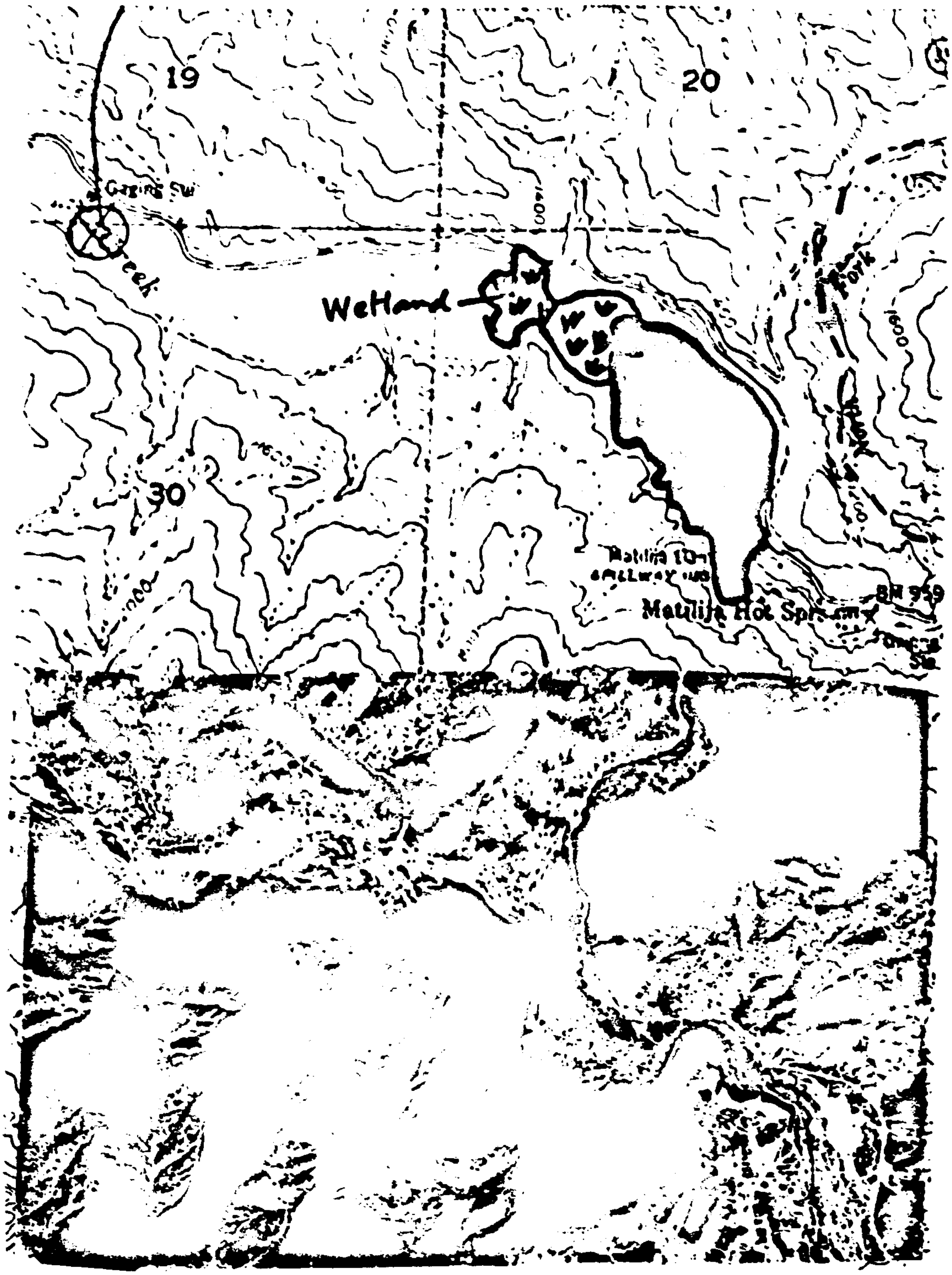

Extensive wetland (in green) at mouth of Matilija Reservoir is the largest freshwater marsh in Region 4. From Matilija 7.5 minute Quadrangle

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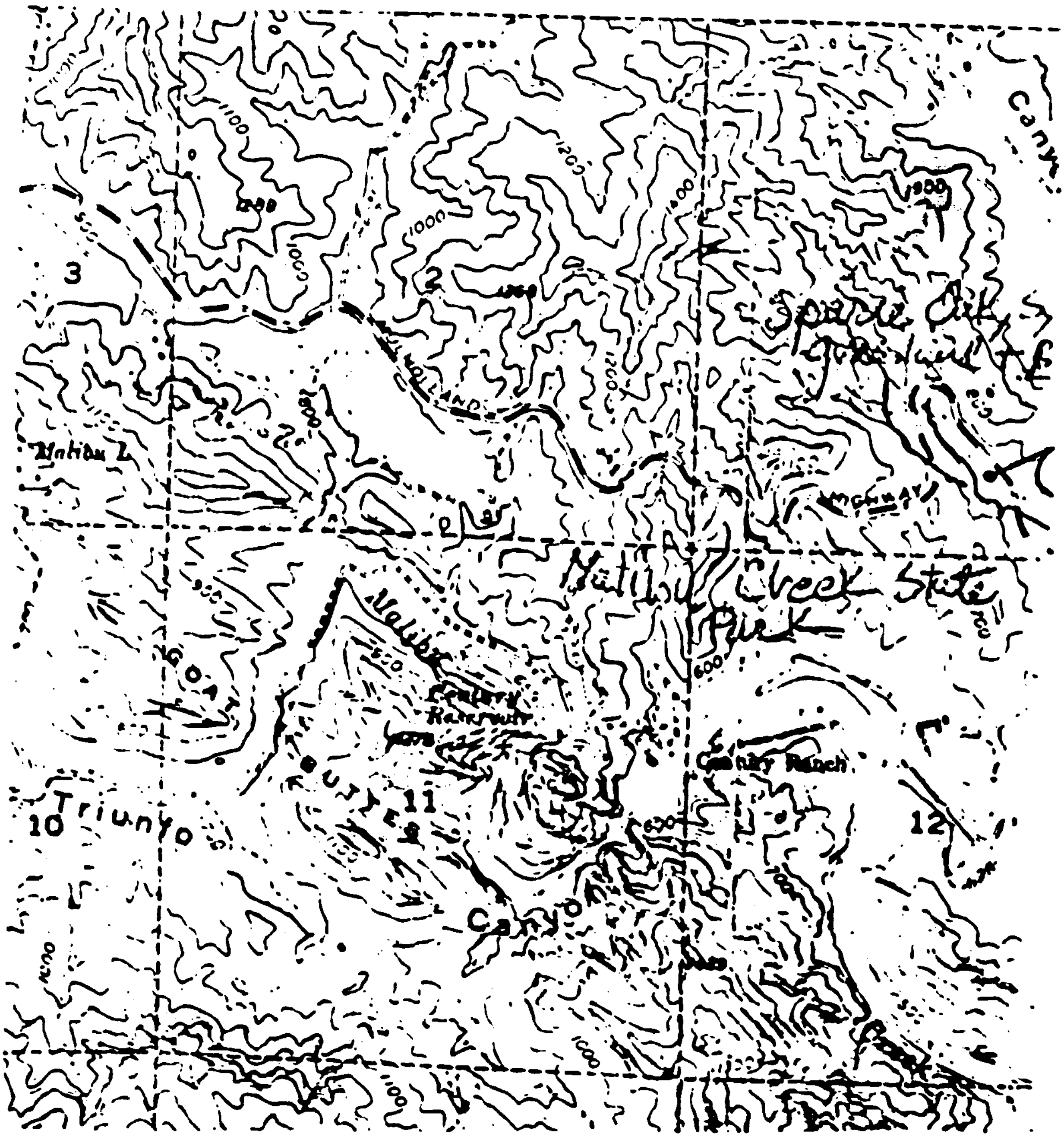
L.A. Regional Water Quality Control Board
Lacustrine Wetlands: Century Reservoir

Century Reservoir (404.21) is a 6.0 acre lake reservoir in Malibu State Park. There is a small wetland at the dammed end of the lake consisting of dense, monocultural stands southern cattail (*Typha domingensis*). The cattail wetland intergrades into southern arroyo willow riparian forest dominated by *Salix lasiolepis*. The cattails are emergent and dominant in a narrow zone along the entire shore of the lake. Other species include sycamore (*Platanus racemosa*), mule fat (*Baccharis salicifolia*), mugwort (*Artemisia douglasiana*), and California bay laurel (*Umbellularia californica*). The area is subject to various types of recreational uses including fishing, hiking, jogging.

Century Reservoir with dense stands of *Typha domingensis* flanked by Southern Arroyo Willow Riparian Forest dominated by *Salix lasiolepis*.



Century Reservoir: Malibu 7.5 minute Quadrangle

L.A. Regional Water Quality Control Board
Lacustrine Wetlands: Lake Eleanor

Lake Eleanor (404.25) is a [illegible] reservoir created by a dam on Eleanor Canyon Creek. At the southern end of the lake there is a high quality cattail (*Typha*) and bulrush (*Scirpus*) dominated wetland covering 3-4 acres which intergrades into southern arroyo willow riparian forest. The *Typha* and *Scirpus* form occassionally dense stands along the western shore of the lake while the eastern shore is dominated by mulefat (*Baccharis salicifolia*). Lake Eleanor demonstrates the importance of even small wetlands to certain species. During a field visit on 10 13 9[illegible] an osprey (*Pandion haliaetus*) was observered diving for fish in the lake. Also observed were coots (*Fulica americana*), pied billed grebes (*Podilymbus podiceps*), double crested cormorants (*Phalacrocorax auritus*), and a great blue heron (*Ardea herodias*). Though not large, this lake and associated wetland are significant habitat.

Mule Fat (*Baccharis salicifolia*) in foreground on eastern shore and Cattails (*Typha* sp.) on western shore of Lake Eleanor.

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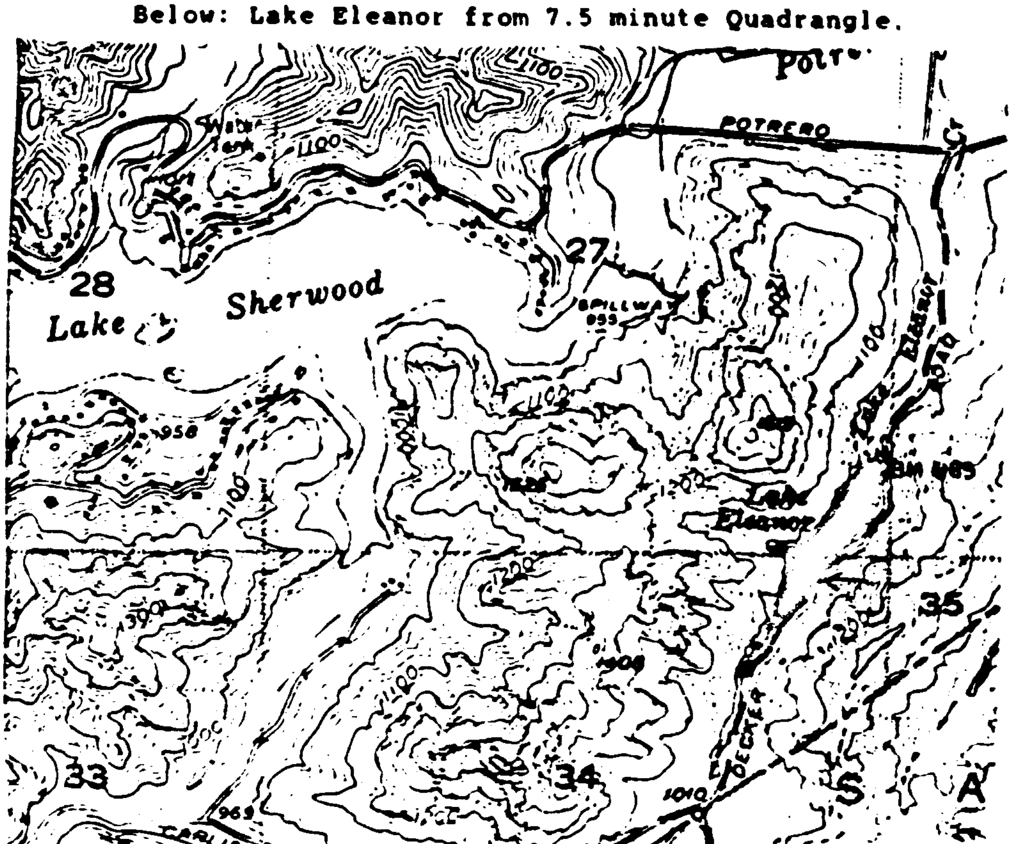
Above: Osprey (*Pandion haliatus*) at lake Eleanor.

Below: Lake Eleanor from 7.5 minute Quadrangle.



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L.A. Regional Water Quality Control Board
Lacustrine Wetlands: Harbor Lake

Harbor Lake (Machado Lake) (405.12) and its associated wetland is a 105 acre remnant of extensive freshwater wetlands which covered much of the southbay area of Los Angeles County. The lake is part of Harbor Lake Regional Park and is administered by Los Angeles County Parks Department. The area has been designated as Significant Ecological Area No. 35 for Los Angeles County. The wetland lies in the northern half of the park and also north of the park across Pacific Coast Highway. The entire area is surrounded by residential and commercial development. The wetland vegetation includes california bulrush (*Scirpus californicus*) southern cattail (*Typha domingensis*), mule fat (*Baccharis salicifolia*), arroyo willow (*Salix lasiolepis*) and yellow willow (*S. lasiandra*). The marsh supports numerous resident and migratory birds and waterfowl and the lakes supports various fish such as catfish, bass, and carp.

Harbor Lake with mulefat (*Baccharis salicifolia*) in foreground and large stands of southern cattail (*Typha domingensis*) and California bulrush (*Scirpus californica*) along far shore.

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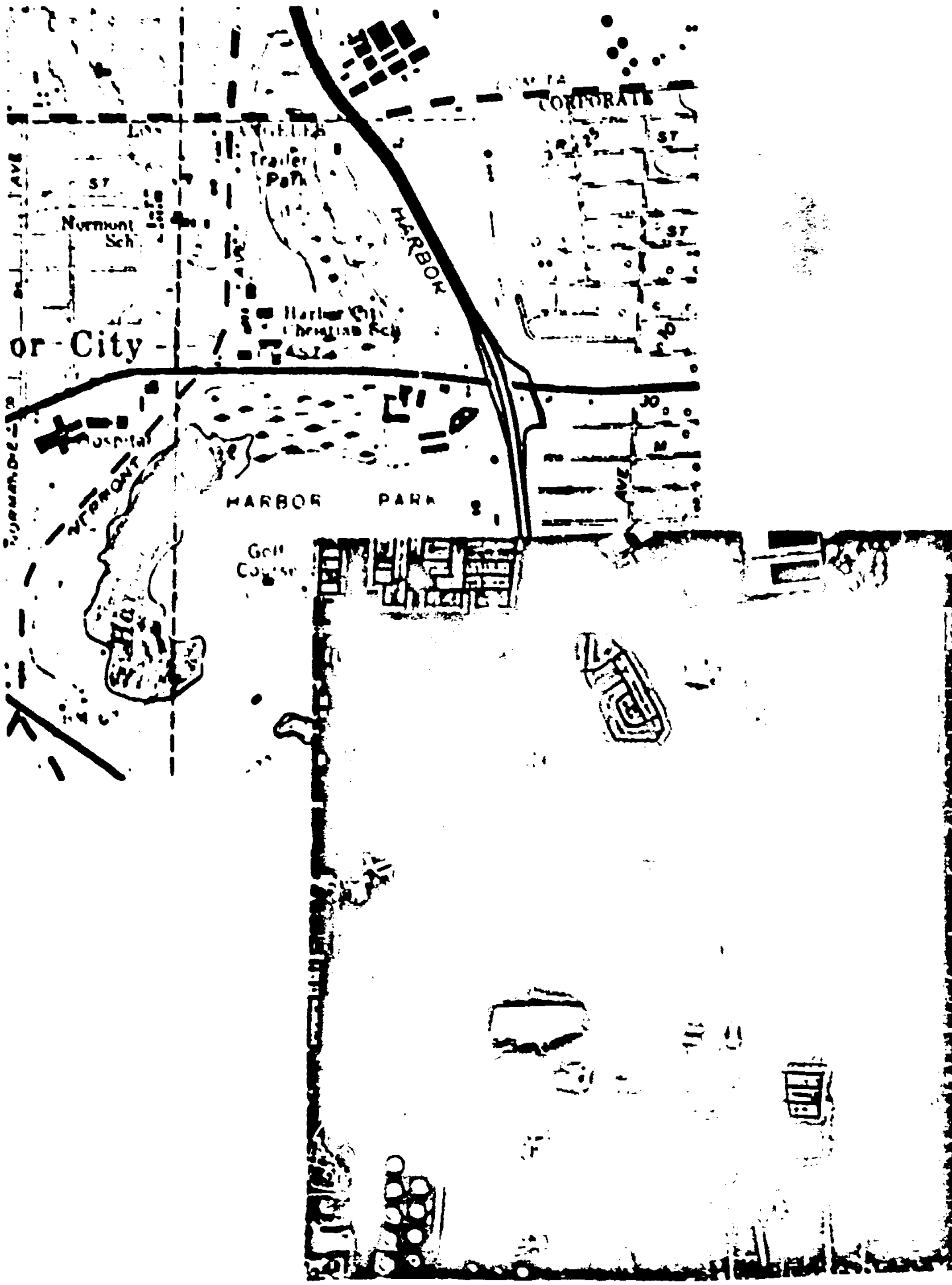

HARBOR LAKE WETLAND, USGS 7.5 minute Torrance Quad. and Color Infrared photo. Freshwater marsh (green on map), and(red on color IR photo), to the north of the lake, in extensive littoral zone.

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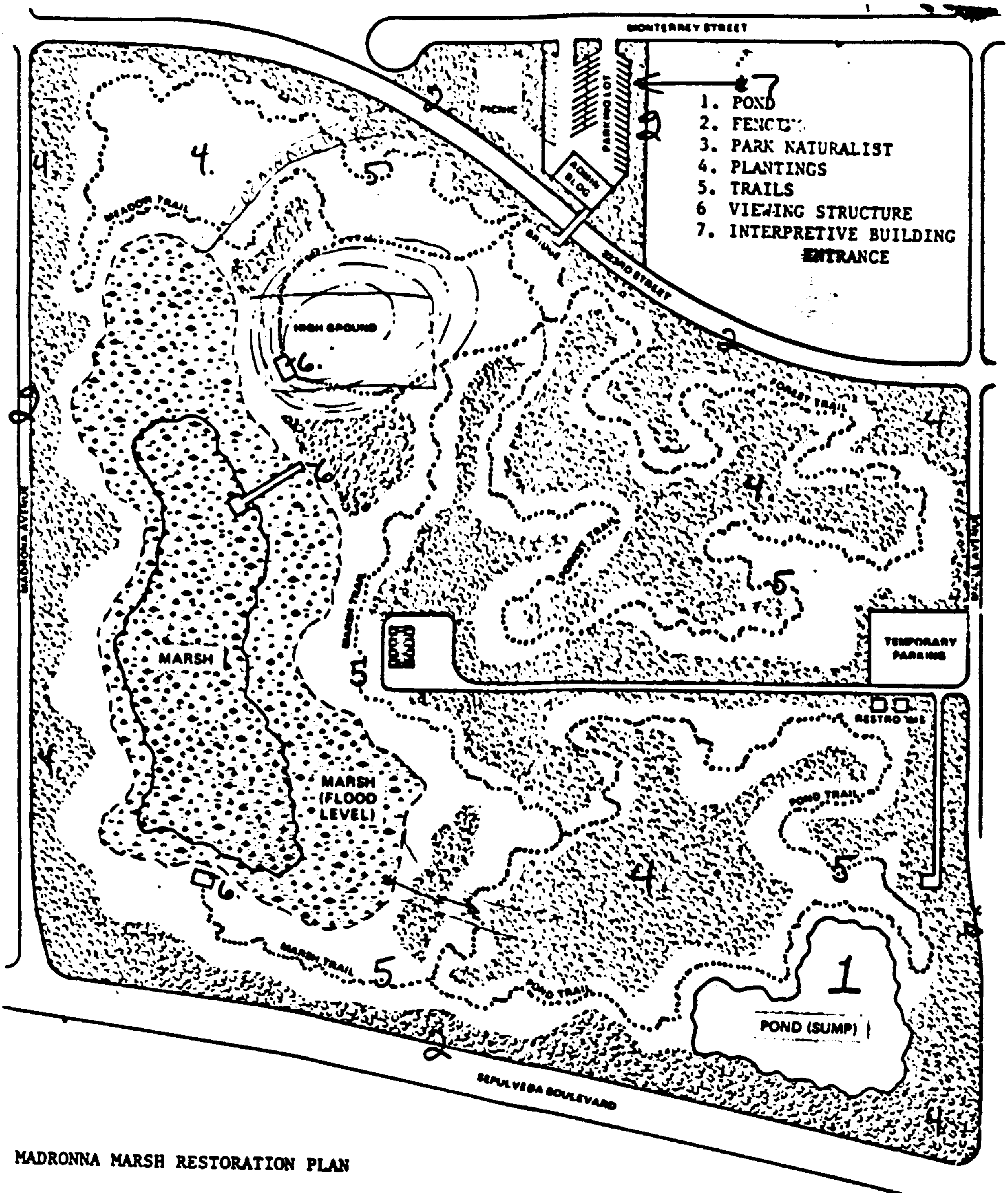
L.A. Regional Water Quality Control Board
Lacustrine Wetlands: Madrona Marsh

Madrona Marsh (405.12) is an 8 acre remnant of extensive freshwater wetlands which covered much of the coastal plain in the southbay area of Los Angeles County. Madrona Marsh is Significant Ecological Area No. 23 in Los Angeles County. The surrounding area consists of residential, commercial and industrial development. The area covered by the wetland is currently being used for gas and oil extraction. The remaining natural areas are in resonably good condition or make excellent candidates for restoration/revegetation projects. Wetland vegetation includes willow (*Salix* spp.), mule fat (*Baccharis salicifolia*), cocklebur (*Xanthiw strumarium*), bulrush (*Scirpus* spp.), cattail (*Typha* sp.), spikerush (*Eleocharis* sp.), umbrella sedge (*Cyperus eragrostis*), and mosquito fern (*azolla filiculoides*). This small wetland has as great a diversity among hydrophytes as any in the region.

Madrona Marsh showing bulrush (*Scirpus*) and cocklebur (*Xanthium strumarium*). Oil extraction is occurring in background.



MADRONNA MARSH RESTORATION PLAN

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Riparian Wetland Plant Communities

Vegetation ecologists have described various vegetation types or communities which are associated with riparian habitats. Some, such as white alder riparian forest or various willow forests are normally indicative of wetland conditions. Others, such as coast live oak riparian forest, are indicators of wetland conditions in some instances. Some riparian types, such as scalebroom scrub Magney 1992), do not meet the conditions required by the Army Corps of Engineers to be protected under 404 permitting requirements. The initial descriptions of these vegetation types was by Holland (1986). California Department of Fish and Game has utilized (and modified as more detailed information becomes available) the original descriptions which have been centralized in the California Natural Diversity Database (CNDDB). The CNDDB is a statewide manual and computerized inventory of information on the location of threatened,endangered, and rare plants; threatened and endangered animals; and biotic communities which are considered sensitive or endangered by the scientific community. Taxa which are not listed as threatened, endangered, or rare, but are considered sensitive or limited in their distribution are also included (Shevock and Hennessy 1987). Region 4 contains thirteen recognized riparian plant communities. Descriptions generally follow Holland (1986) with modifications where repeated field observations warrant. Additional sources include Bowler (1990) for white alder riparian forest; Mullally (1992) and Quinn (1990) for walnut riparian woodland; Pavlik et al. for coast live oak riparian forest and canyon live oak ravine forest; Magney (1992) for scalebroom scrub; and Raven et al. (1986) for intermittent streambed.

Riparian Scrub

Southern Riparian Scrub. Typically dense stands of riparian thickets found along streams or washes dominated by mule fat (*Baccharis salicifolia*), and or shrub willows (*Salix*); varies in height from 4 to 12 feet. Usually without understory. Substrate is loose, sandy or gravelly alluvium deposited near stream channels during floods. Some stands of mule fat may be sparse over broad alluvial surfaces as in the lower Santa Clara River, Ventura Co. and in drainages below 2,000 feet throughout Region 4.

Mule Fat Scrub. A depauperate to sometimes dense, tall, herbaceous riparian scrub dominated by *Baccharis salicifolia*. This early seral community is maintained by frequent flooding. When flooding is absent, sycamore or cottonwood woodland will become established. It is the most common scrub type within Region 4 below 2,000 feet. Found along and in most intermittent streambeds. Associated species include arroyo willow (*Salix lasiolepis*), sandbar willow (*S. hindsiana*), giant nettle (*Urtica holosericea*), and cudweed (*Gnaphalium*).

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Alluvial Scrub - Open stands of evergreen and drought-deciduous shrubs associated with alluvial fans or riverine terraces. Vegetation is adapted to frequent flooding and coarse alluvial soils. Scale-broom (*Lepidospartum squamatum*) is the indicator species. Associated species include California sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), laurel sumac (*Malosma laurina*), lemonadeberry (*Rhus integrifolia*), sugarbush (*R. ovata*) and holly-leaved cherry (*Prunus ilicifolia*). This type is poorly represented on the Santa Clara River in the Fillmore area, Ventura County. It is well represented in Big Tujunga Wash and the upper San Gabriel River, Los Angeles County.

Scalebroom Scrub - A sub-classification of alluvial scrub which has been proposed for addition to the California Natural Diversity Database Inventory of sensitive biotic communities (Magney 1992). Scalebroom scrub is an early seral stage of alluvial scrub which develops after flooding. *Lepidospartum squamatum* is the indicator species and associated species include burweed (*Ambrosia acanthicarpa*), western ragweed (*A. psilostachya*), *Bromus* sp., California bricklebush (*Brickellia californica*), Nevin's bricklebush (*B. nevinii*), hairy golden aster (*Heterotheca villosa*), wooly aster (*Corethrogyne filangifolia*), wooly star (*Eriastrum densifolium*), yerba santa (*Eriodictyon crassifolium* and *E. trichocalyx*), California buckwheat (*Eriogonum fasciculatum*), Cudweed (*Gnaphalium* sp.), and shrubby butterweed (*Senecio douglasii*). This somewhat herbaceous community is interspersed with California sycamore (*Platanus racemosa*), Fremont's cottonwood (*Populus fremontii*), and mule fat (*Baccharis salicifolia*). When flooding does not occur on a five to ten year cycle, woody upland species typical of alluvial scrub become established. Ventura County occurrences are along the Ventura River, Matilija Creek, upper and middle reaches of Sespe Creek and the lower half of Piru Creek. In Los Angeles County scalebroom scrub occurs at San Francisquito Wash, Big Tujunga Wash, Topanga Canyon (Raven et al. 1986), Eaton Canyon Wash, San Gabriel River, and San Antonio Creek. According to Magney (1992) this vegetation type does not fall within the U.S Army Corps of Engineers wetlands jurisdiction and is therefore often ignored as valuable habitat. More attention should be given to these and other similar habitats in environmental documents. Many areas of scalebroom scrub have already been lost to urbanization, recreational facilities, off road vehicle use, sand and gravel quarries, and flood control projects.

Previous Page Top: Southern Riparian Scrub, Las Virgenes Canyon, Los Angeles County.
Previous Page Bottom: Mule Fat Scrub, Lodi Cyn., L.A Co.

Opposite Page Top: Alluvial Scrub in the Santa Clara River, Soledad Canyon, Los Angeles County.
Opposite Page Bottom: Scalebroom Scrub in Eaton Wash, Los Angeles County.

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Riparian Woodlands and Forests

Southern Arroyo Willow Riparian Forest - Dense, low, closed canopy broadleafed winter deciduous forests dominated by *Salix lasiolepis*. This plant grows as a tree or as a large treelike shrub. The typically dense stands have little understory. Substrate is moist to saturated sandy or gravelly soil. Associated species include yellow willow (*S. lasiandra*), red willow (*S. laevigata*), mugwort (*Artemisia douglasiana*), giant nettle (*Urtica holosericea*), red top (*Agrostis alba*), smilo (*Piptatherum miliaceum*). This type is widespread in Region 4.

Southern Cottonwood-Willow Riparian Forest - Tall, opem, broadleafed winter deciduous riparian forests dominated by cottonwood (*Populus*) and several tree willows (*Salix*). Sub-irrigated and frequently overflowed lands along rivers and streams. This is provided after flood waters recede, leading to uniform-aged stands, but with vigorous vegetation reproduction from the roots, root-crowns, and fallen trunks. Characteristic species are mugwort (*Artemisia douglasiana*), mule fat (*Baccharis salicifolia*), wild cucumber (*Marah macrocarpus*), California sycamore (*Platanus racemosa*), Fremont's cottonwood (*Populus fremontii*), black cottonwood (*P. trichocarpa*), black willow (*Salix gooddingii*), arroyo willow (*S. lasiolepis*), and giant nettle (*Urtica holosericea*). Distributed along perennially wet streams and rivers of Region 4. A good example occurs on the Santa Clara River as viewed from Soledad Canyon Road, Los Angeles County.

Southern Mixed Riparian Forest - Tall, open, winter-deciduous and evergreen riparian forest composed of various combinations of tree willows (*Salix*), California sycamore (*Platanus racemosa*), coast live oak (*Quercus agrifolia*), and cottonwood (*Populus*). Understory of scattered shrubs or introduced grasses and forbs. Associated with low velocity flows, flood plains, and gentle topographywith deep alluvial soils and a high wate table. Best example on the Ventura River at Foster Park and Casitas Springs, Ventura County.

Opposite Page Top: Southern Arroyo Willow Riparian Forest, Big Tujunga Canyon, Los Angeles County.

Opposite Page Bottom: Southern Cottonwood-Willow Riparian Forest, Piru Creek, Ventura County.

Following Page Top: Southern Mixed Riparian Forest, Bichota Canyon, Los Angeles County.

Following Page Bottom: Southern Mixed Riparian Forest, Matilija Creek, Ventura County.

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Coast Live Oak Riparian Forest - Open to locally dense evergreen sclerophyllous (hard-leaved) riparian woodlands dominated by coast live oak (*Quercus agrifolia*). This type appears to be richer in herbs and poorer in understory shrubs than other riparian communities. Found in bottomlands and outer floodplains along larger streams, on fine-grained, rich alluvium. Characteristic species include big leaf maple (*Acer macrophyllum*), mugwort (*Artemisia douglasiana*), toyon (*Heteromeles arbutifolia*), honeysuckle (*Lonicera hispidula*), California rose (*Rosa californica*), blackberry (*Rubus ursinus*), elderberry (*Sambucus mexicana*), and poison oak (*Toxicodendron diversilobum*). Common in canyons and valleys throughout Region 4. Good examples are found in Marshall and Little Dalton Canyons above Glendora in Los Angeles County.

Canyon Live Oak Ravine Forest - Dense evergreen sclerophyllous riparian woodlands dominated by canyon live oak (*Quercus chrysolepis*). Understory is typically sparse. Found in narrow canyons and ravines between 2,500 and 9,000 feet (Pavlik et al. 1991). Trees often with multiple trunks, probably from crown-sprouting after fires. Characteristic species vary with altitude and include incense cedar (*Calocedrus decurrens*), California bay laurel (*Umbellularia californica*), bigcone douglas fir (also called bigcone spruce) (*Pseudotsuga macrocarpa*), coffeeberry (*Rhamnus californica*), deer brush (*Ceanothus integerrimus*), and bitter gooseberry (*Ribes amarum*). Important community at headwater settings due to the provision of coarse particulate organic matter which supports the predominately heterotrophic community in headwater reaches (Knight and Bottorf 1984). Common throughout the San Gabriel Mountains above 2,500 feet.

Walnut Riparian Woodland - Typically similar to and intergrading with coast live oak woodland but locally dominated by California black walnut (*Juglans californica*). Mullally (1992) reports that in the Santa Susana Mountains, density of walnut woodlands increases along intermittent streams and in canyons which channelize rainwater during rain storms. In many of the canyon bottoms walnut is dominant or sometimes shares dominance with elderberry (*Sambucus mexicana*). Most commonly, walnuts occurring in riparian settings are in easterly flowing drainages. Associated species are coast live oak (*Quercus agrifolia*), flowering ash (*Fraxinus dipetala*), and California bay laurel (*Umbellularia californica*). Because of the open canopy the understory is dominated by introduced annual grasses, The best examples occur throughout the Santa Susana Mountains and at Walnut Creek in San Dimas in Los Angeles County.

Following Page Top: Canyon Live Oak Ravine Forest, Eaton Canyon Los Angeles County.
Following Page Bottom: Coast Live Oak Riparian Forest, Marshall Canyon, Los Angeles County.

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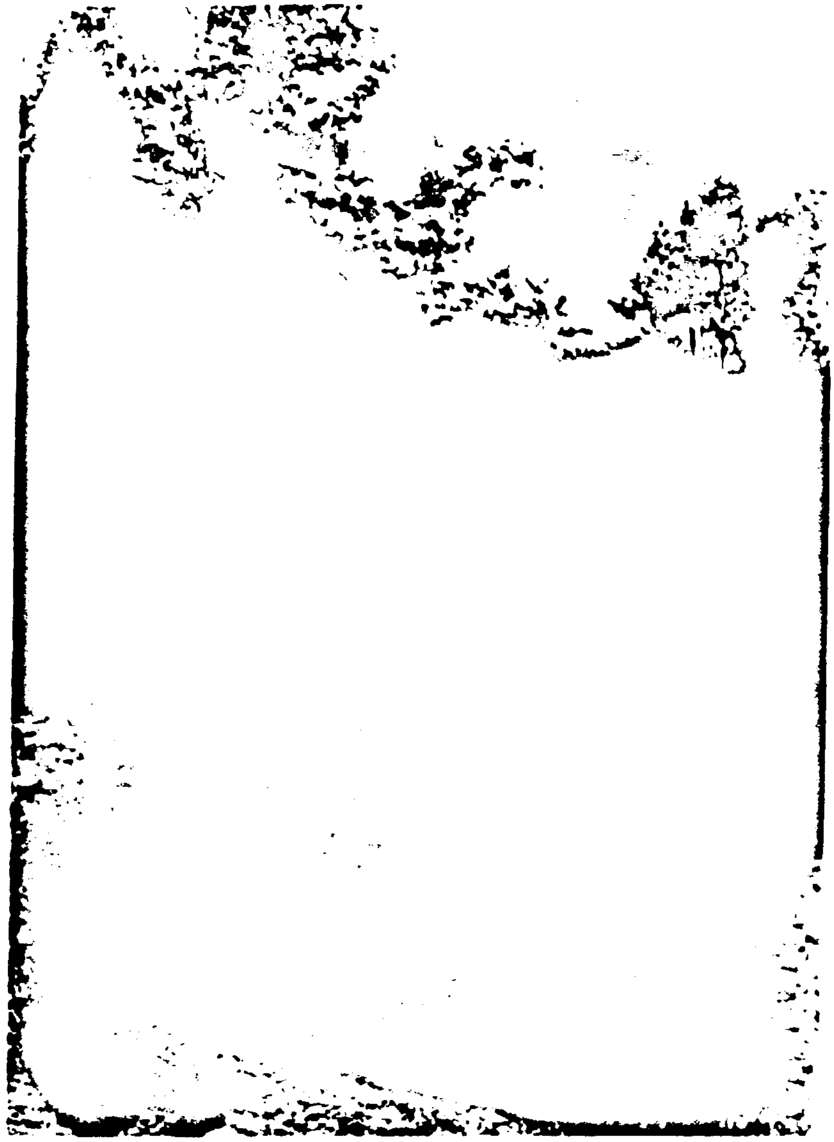
Intermittent Streambed - this designation refers to various communities composed of non-persistent herbaceous plants (annuals) within the banks of intermittent streams or channels. Perennials such as mule fat, scrub willow, etc., would be excluded. Many of the plants associated with this community share two common features: (1) adaptation to periodic flooding which often provides conditions required for the physical breakdown of the seedcoat (scarification) needed for germination, and (2) the deposition of nutrient rich sediments from upstream areas which enrich the typically nutrient poor sandy/gravelly soils commonly found in streambeds. Characteristic species include sprangletop (*Leptochloa uninervia*), sedges (*Carex* spp.), umbrella sedge (*Cyperus eragrostis*), mugwort (*Artemisia douglasiana*), dock (*Rumex* spp.), knotweed (*Polygonum* spp.), brooklime (*Veronica anagallis-aquatica*), rabbitsfoot grass (*Polypogon monspeliensis*), reed fescue (*Festuca arundinacea*), meadow fescue (*F. pratensis*), wild celery (*Apium graveolens*), water bent (*Agrostis semiverticillata*), and scarlet monkeyflower (*Mimulus cardinalis*).



Above: Southern Sycamore Alluvial Woodland in Mill Creek, Los Angeles County. Note the understory of Alluvial Scrub species.

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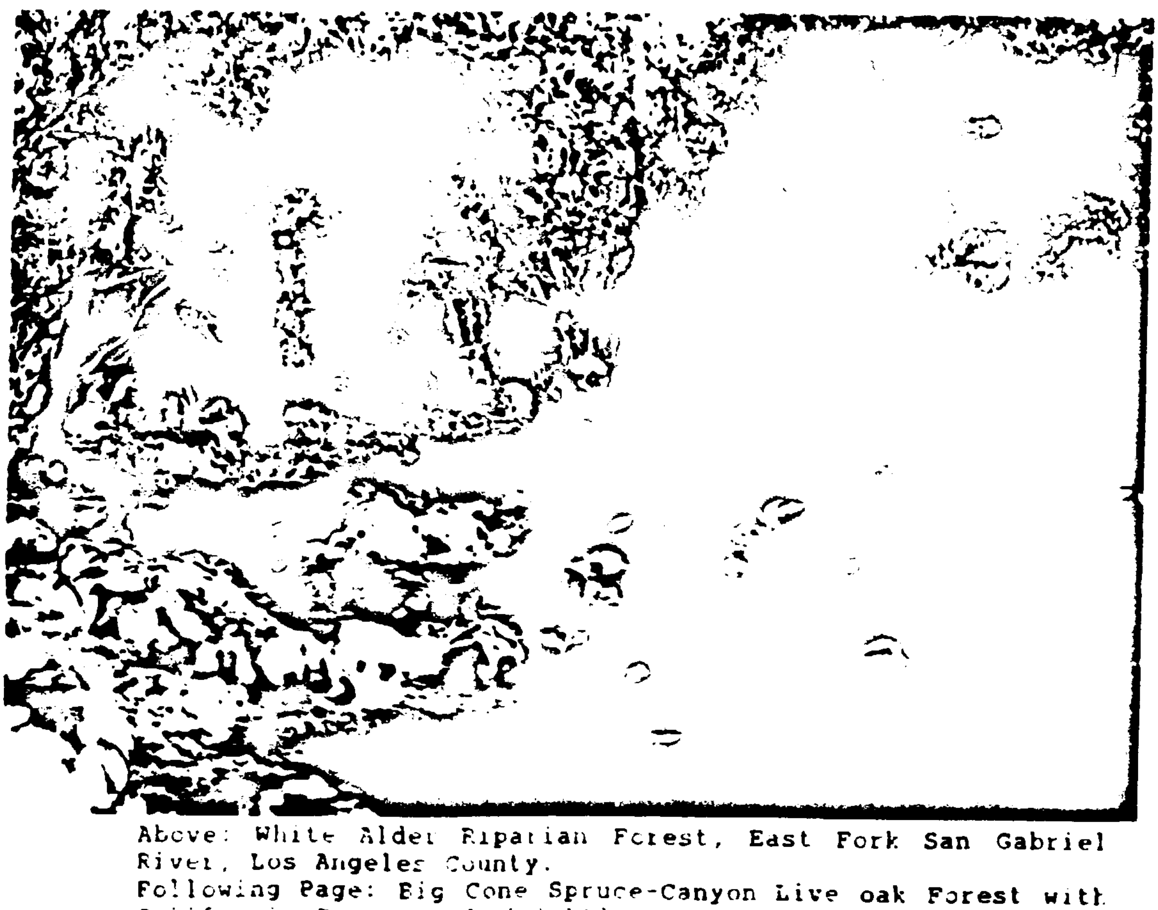
White Alder Riparian Forest Medium-tall broad-leafed deciduous streamside forest dominated by Alnus rhombifolia. Other trees present include big leaf maple (Acer macrophyllum), California bay laurel (Umbellularia californica), and arroyo willow (Salix lasiolepis). Understory can be poorly represented to dense and consists of semi-woody shrubs and various herbs including eupatory (Ageratina adenophora), nightshade (Solanum douglasii), knotweed (Polygonum punctatum) and hedgenettle (Stachys bullata). Best developed along rapidly flowing, well aerated perennial streams with coarse beds that reflect high stream power during spring runoff. Typical in bedrock constrained, steep-sided canyons making the riparian zone narrow. Common along all perennial in the San Gabriel Mountains up to 6,500 feet. Also found in the central portion of the Santa Monica Mountains along perennial streams up to 1,000 feet. On larger perennial rivers like the East Fork of the San Gabriel River this type is bordered by alluvial or scale-broom scrub.



Above: White Alder Riparian Forest, East Fork San Gabriel River, Los Angeles County.
Following Page: Big Cone Spruce-Canyon Live oak Forest with California Bay Laurel (right), Big Leaf Maple and Big Cone Spruce in Background. From East Fork San Gabriel River

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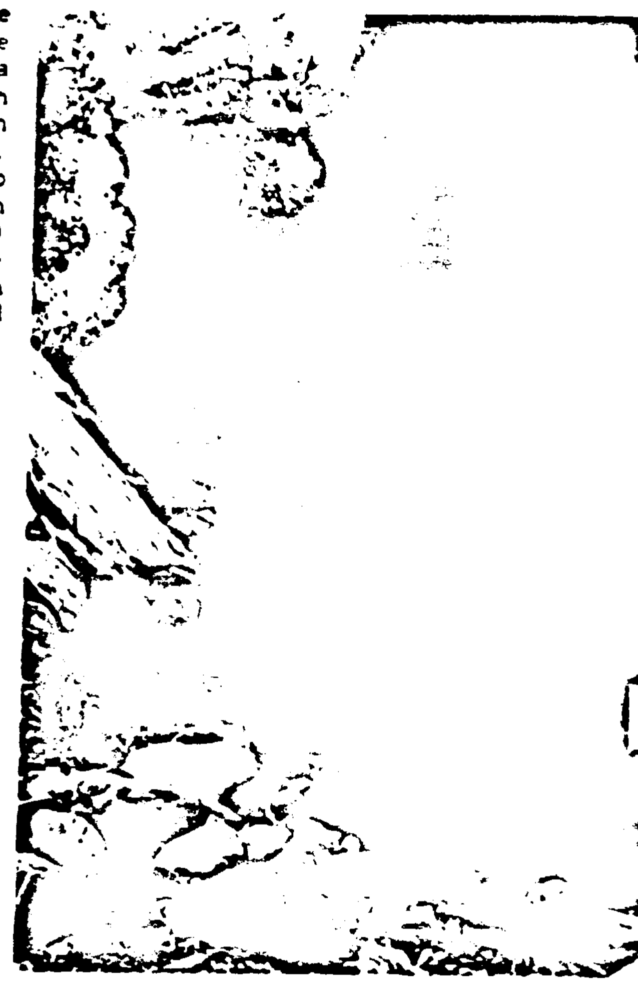
Bigcone Douglas Fir-Canyon Live Oak Forest - Open to dense forest dominated by *Pseudotsuga macrocarpa* 50-80 feet tall with a dense subcanopy of canyon live oak (*Quercus chrysolepis*). Herbaceous layer is sparse to nonexistent. Most common on (though not restricted to) canyon sides where it intergrades with various riparian forests. Not a wetland indicator as a community but often providing significant canopy for riparian vegetation. Ecological importance is in providing shade and nutrients to the headwaters portions of numerous streams throughout Region 4. Associated species include big leaf maple (*Acer macrophyllum*), incense cedar (*Calocedrus decurrens*), mountain mahogany (*Cercocarpus betuloides*), coast live oak (*Quercus agrifolia*), poison oak (*Toxicodendron diversililobum*), and California bay laurel (*Umbellularia californica*). Found along upper reaches and headwater areas of many streams in the San Gabriel Mountains and also at the head of various canyons in the Santa Susana Mountains.



Southern Sycamore Alluvial Woodland - Tall, open winter deciduous woodland of streamsides and alluvial fans dominated by *Platanus racemosa*. This type seldom forms closed canopy forests, and may even appear as scattered trees in a shrubby thicket of evergreen and deciduous species. Lianas (sprawling vines) of wild grape (*Vitis girdiana*), blackberry (*Rubus ursinus*), and poison oak (*Toxicodendron diversilobum*), are common. Found in rocky, boulder strewn streambeds subject to seasonal high-intensity flooding. The flooding is at times quite violent, damaging or uprooting trees. Sycamores have well developed vegetative reproduction, giving the woodland a clumped appearence. Common species include mugwort (*Artemisia douglasiana*), smilo (*Piptatherum miliaceum*), mule fat (*Baccharis salicifolia*), coast live oak (*Quercus agrifolia*), elderberry (*Sambucus mexicana*), and giant nettle (*Urtica holosericea*). This type intergrades into white alder riparian forest where canyons narrow or where there is permenant water. Best example is in Big Sycamore Canyon in Los Angeles County.

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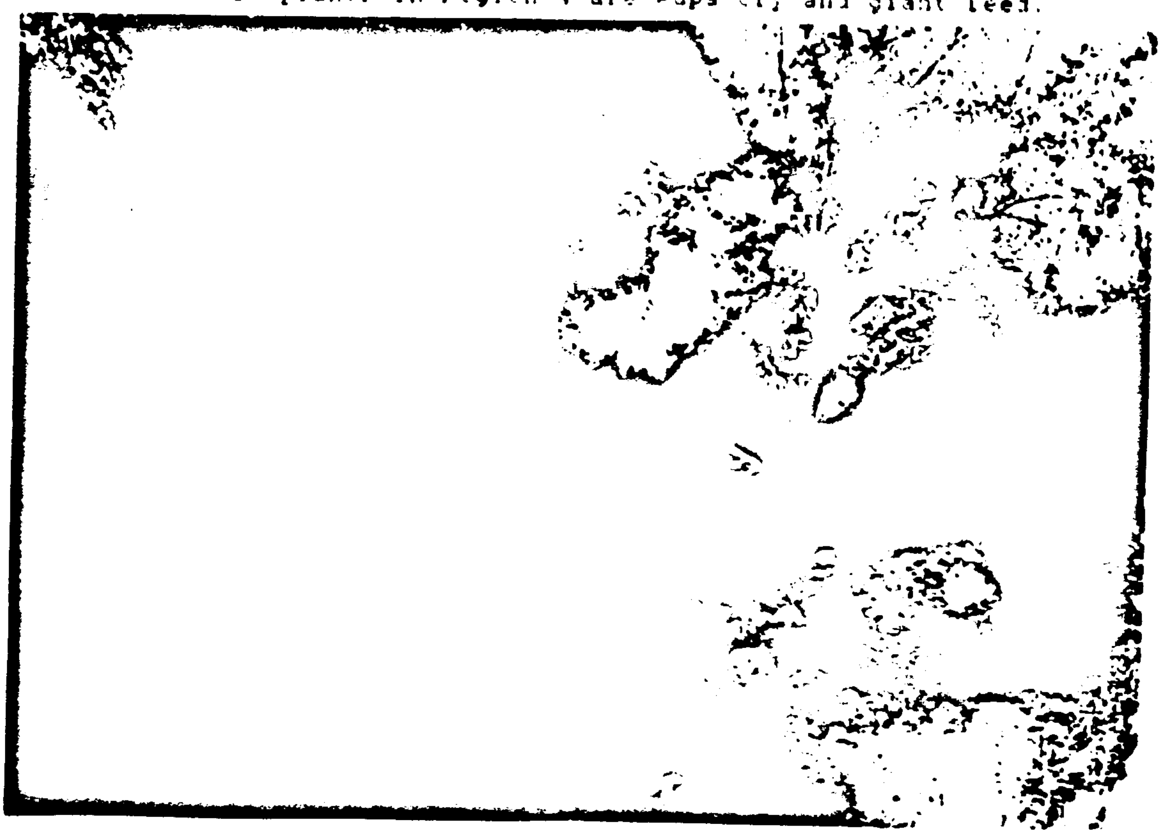
Invasive Exotic Plants: Impacts to Riparian Communities in Region 4

The impact of invasive exotic plants to plant communities throughout California has recently been given much attention. The formation of the California Exotic Pest Plant Council (CalEPPC) in October of 1992 was in response to numerous invading species statewide. At a symposium, held at Morro Bay in October of 1992, which marked the beginning of CalEPPC, some emphasis was given to exotics which are invading riparian habitats. Giant reed (Arundo donax) and salt cedar (Tamarix sp.) were two such plants. In CalEPPC News Winter [illegible], the newsletter of CalEPPC, Nerium oleander and Ficus carica were cited as invaders of riparian communities of the Central Valley.

The riparian communities of region 4 are subject to invasion by many such plants. Edible fig (Ficus carica) is established in many of the canyons of the San Gabriel Mountains. English Ivy (*Hedera helix*), and periwinkle (*Vinca major*) have been planted as ground cover around cabins in Big Santa Anita Canyon and San Dimas Canyon. These have become the dominant vegetation in some of these canyons, replacing native herbaceous and shrubby plants. Currently, the two most significant invasive exotic plants in Region 4 are eupatory and giant reed.



Eupatory dominating understory in Rubio Canyon Riparian Woodland

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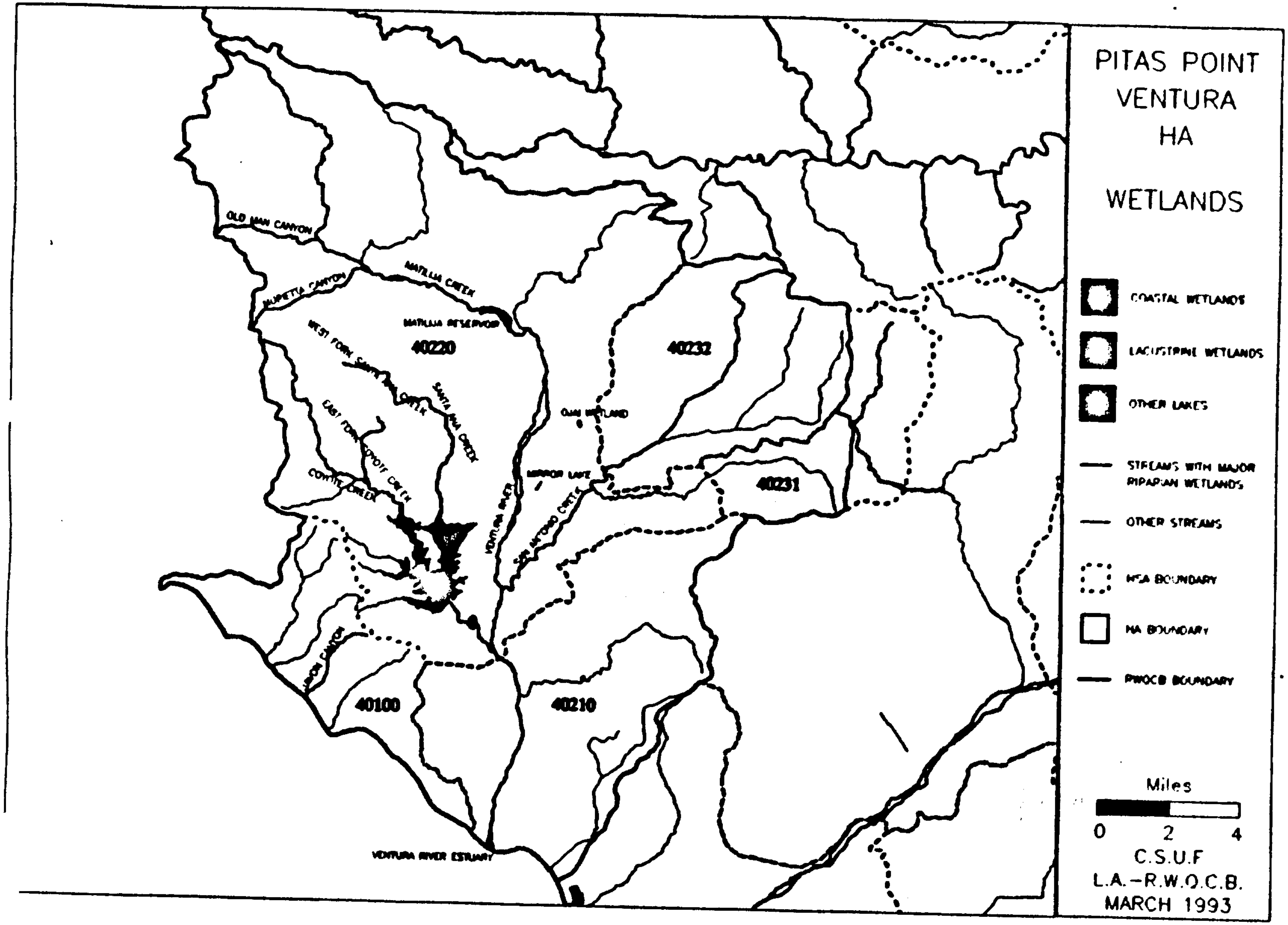
Eupatory (*Ageratina adenophora*) - is a native of mexico which escaped cultivation above Pasadena in the early 1900s (Abrams 1917). It has become a troublesome weed in other parts of the world including Australia, Hawaii, South Africa and the Philippines. It reproduces by seed and also vegetatively by means of stolons or runners. Because of the ability to propagate vegetatively, a single plant can become a dense mat or thicket within a few years. Eupatory is dominant, forming dense stands, in most front country canyons of the San Gabriel Mountains from Wolfskill Canyon on the east to Stough Canyon in the Verdugo Hills on the west. It appears to be limited by cold and does not extend above 2,700 feet in elevation. Eupatory is a federally listed noxious weed and is therefore subject to control efforts.

Giant Reed (*Arundo donax*) - is a native of the Mediterranean region and was originally imported for use as an ornamental plant. *Arundo* invades riparian habitats on the coastal plain and extends for a short distance into the mountain areas. *Arundo* typically becomes established after disturbance (natural or manmade) and outcompetes native vegetation due to extremely rapid growth rates (Rieger and Kreager 1999). Populations of native birds are often impacted because willow forests are often the most severely impacted by invasions of *Arundo*. Areas of significant infestation include the Santa Clara and Ventura Rivers, Big and Little Tujunga Canyons and the San Gabriel River.

Photo: Giant Reed (*Arundo donax*) along the upper Ventura River.



PITAS POINT
VENTURA
HA
WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
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MARCH 1993
OLD MAN CANYON
MATILIJA CREEK
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40220
40232
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OJAI WETLAND
MIRROR LAKE
VENTURA RIVER
COYOTE CREEK
VENTURA RIVER ESTUARY

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L.A. Regional Water Quality Control Board
Riparian Wetlands near Pitas Point:
Rincon Creek and Javon Canyon Creek

Rincon Creek and Javon Canyon Creek are the westernmost riparian wetlands in Region 4. They are located between Pitas Point and Carpenteria. Rincon Creek demarcates the boundary between Ventura and Santa Barbara Counties.

Topographic Map: 30 X 60 min, Santa Barbara Quadrangle

L.A. Regional Water Quality Control Board
Riparian Wetlands: Rincon Creek

Rincon Creek (401.0) - defines a portion of the boundary between Ventura and Santa Barbara Counties. The creek originates within the Santa Ynez Mountains of the Los Padres National Forest at an elevation of about 3,000 feet. The wetland begins at 2,400 feet and extends 7.5 miles to the Pacific Ocean. A number of riparian forest woodland types are found along the creek, including southern arroyo willow riparian forest, southern mixed riparian forest, coast live oak riparian forest, and southern sycamore-alder riparian forest. Often these types intergrade and are difficult to distinguish. Individuals of California black walnut (*Juglans californica*) are fairly common along sections of the stream. The extensive riparian forests provide habitat (existing or potential) for a number of endangered, candidate, or species of special concern. The endangered species are least Bell's vireo (*Vireo bellii pusillus*) and southwestern willow flycatcher (*Empidonax traillii extimus*). Candidate species are California red-legged frog (*Rana aurora draytonii*), and southwestern pond turtle (*Clemmys marmorata pallida*). Yellow warbler (*Dendroica petechia brewsteri*) is the species of special concern.

Willow Woodland along Rincon Creek with understory of Blackberry (*Rubus ursinus*), Mugwort (*Artemisia douglasiana*), and Ivy (*Hedera*).

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L.A. Regional Water Quality Control Board
Riparian Wetlands: Javon Canyon Creek

Javon Canyon Creek (401.0) - emerges from one of a series of north-south canyons between the Ventura River and Rincon Creek and runs in a deeply incised channel with vertical walls ranging from 6 to 15 feet. The creek is an interrupted stream which is fed in part by seeps at points along the steep gully walls (Holmgren 1989). The bottom of the creek channel supports *Enteramorpha* sp. (a freshwater green alga). Wetland indicator plants at the site include arroyo willow (*Salix lasiolepis*) mulefat (*Baccharis salicifolia*), Douglas baccharis (*Baccharis douglasii*), lenscale (*Atriplex lentiformis* ssp. *breweri*), salt heliotrope (*Heliotropum curassavicum*), halberd-leaf saltbush (*Atriplex patula*), salt grass (*Distichlis spicata*), and California figwort (*Scrophularia californica*). Plummer's baccharis (*Baccharis plummerae*), which is included on the California Native Plant Society list of plants of limited distribution, grows on the vertical sides of the canyon (Capelli and Gardiner 1990). The availability of water makes Javon Canyon important habitat. Holmgren (1989) in two field visits counted counted 28 bird species, 7 mammal species and 1 lizard.

The Mouth of Javon Canyon as viewed from Hwy 101 showing saltbush scrub.

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L.A. Regional Water Quality Control Board
Riparian Wetlands: Lower and Upper Ventura River

The Ventura River (402.10 and 402.20) is the northernmost major river in Region 4, extending 21 miles north from the Pacific Ocean and draining approximately 226 square miles. The main stem, which is about 15 miles long, originates at the confluence of Matilija and North Fork Matilija Creeks. Upland portions of the watershed, which reach 6,000 feet in elevation, consist of the narrow steep canyons while the main stem flows through a broad valley. Major tributaries are Matilija Creek, North Fork Matilija Creek, San Antonio Creek, and Coyote Creek. The river terminates in a small river mouth estuary which is closed to tidal action by a sandbar during times of low flow. During periods of storm runoff in winter and spring the sandbar is breached and the estuary is subject to tidal influence.

The main stem of the Ventura River is an interrupted stream, consisting of perennial reaches with intervening intermittent reaches (Hunt 1991). Water is diverted to the Casitas Reservoir for use by industrial, agricultural and municipal use (Ferren et al. 1990). Perennial flow from below the confluence with San Antonio Creek is due to high groundwater in the vicinity of Casitas Springs, base flow from San Antonio Creek, and discharged effluent from the Ojai Valley Sanitary District.

Upper and Lower Ventura River from
Santa Barbara 30 X 60 min Quadrangle.

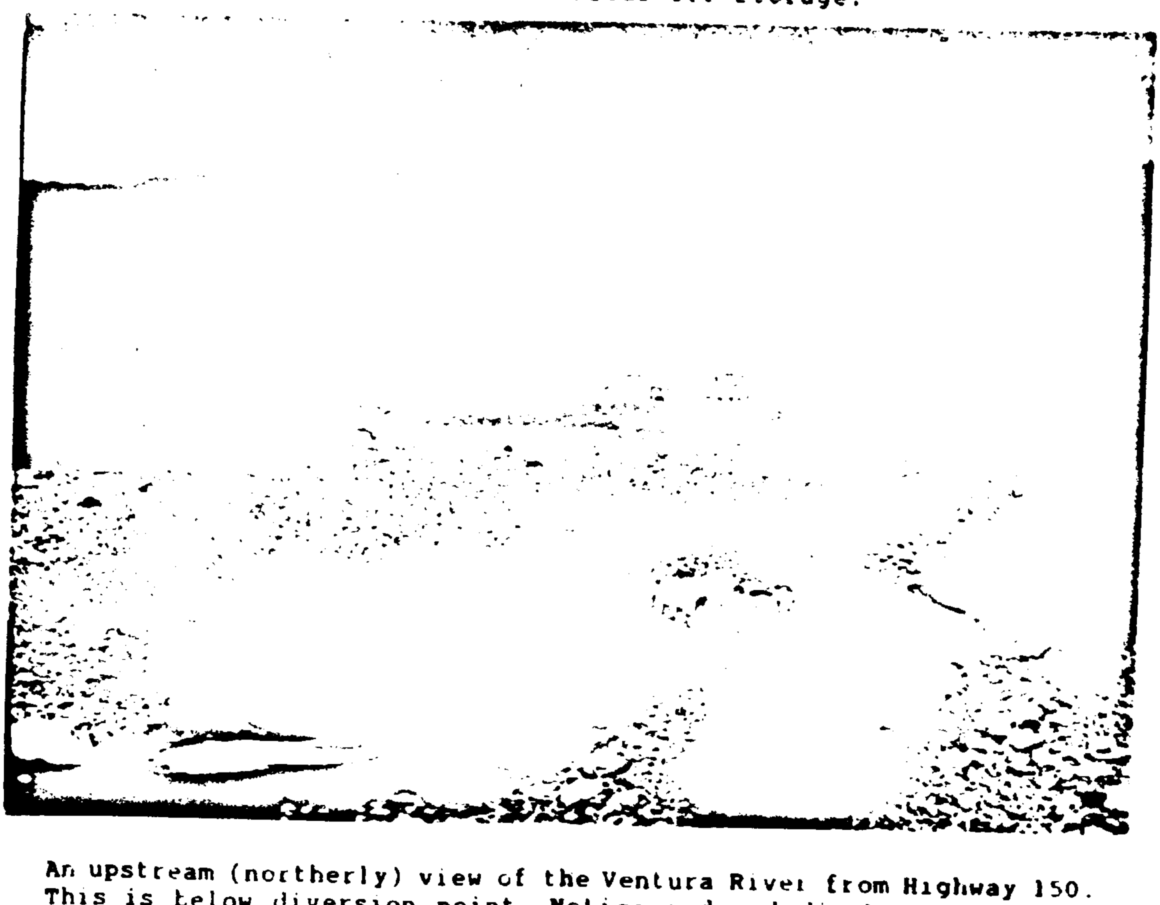
R0052292

Southern Pacific Milling Company currently maintains a sand and gravel mining operation near the junction of Highways 101 and 33. The site occupies 152.8 acres and stretches for about 1.6 miles along the floodplain. Hunt (1991) has determined that modifications to the habitat resulting from the operation have the following adverse impacts: 1) Reduction of wildlife habitat due to loss of vegetative cover; 2) Siltation of river bottom and estuary; 3) Increased water temperatures due to removal of riparian vegetation which provides shade and cover to river channel; 4) Reduction of aquatic and terrestrial insects due to removal of riparian and adjacent vegetation, thus diminishing and important food resource for fishes and other vertebrates; 5) Removal of spawning gravels utilized by anadromous fishes. Hunt (1991) has also found that the diversion of approximately 240,000 gallons of water per day for use in the mining process, which is accomplished by the use of a diversion dam and channel impacts the steelhead fishery resources by: 1) reducing the magnitude and duration of peak discharges; 2) reducing the duration and magnitude of between storm discharge; 3) increasing the duration and extent of desiccation of stream sections; 4) blocking or inhibiting the passage of adult steelhead to historically important spawning and rearing habitat in the major tributaries of the river; 5) reduction of freshwater inflows to the estuary and lagoon at the mouth of the river which may have negative impacts on the ability of the estuary to serve as fish nursery and spawning habitat, particularly for juvenile steelhead and adult tidewater goby.

The gravel mining operation has some indirect beneficial effects on wildlife resources. The constant disturbance of the habitat mimics the disturbance which is typical of flood events. This maintains the habitat in a number of successional stages which increases the diversity of small mammals (rodents) and therefore provides resources for predatory mammals and raptorial birds. These early successional stages tend to support higher numbers of browsing mammals such as rabbits and deer. The ponds which are used for sedimentation settling also provide habitat for some species of waterfowl.

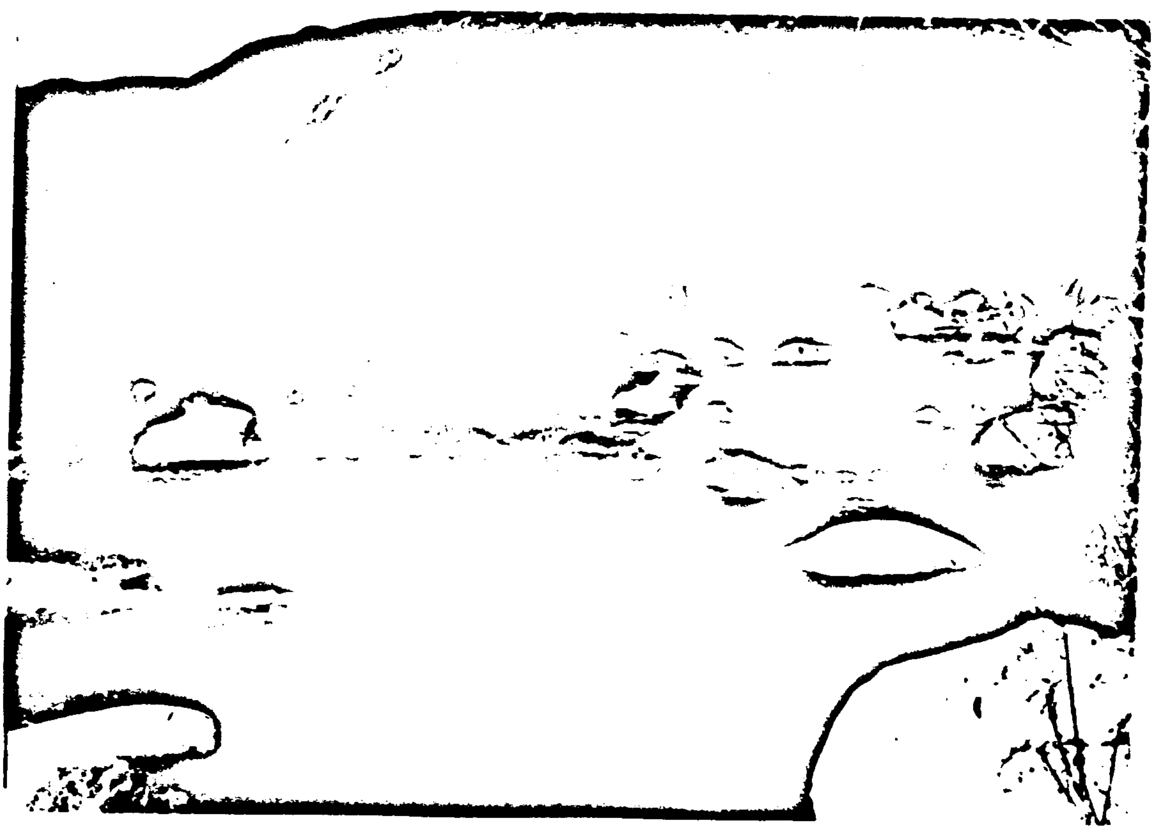
Despite the beneficial impacts, the overall influence of the gravel mining operations in the Ventura River Floodplain and the diversion and impoundment of water for the mining operations, is negative. The destruction of riparian vegetation, modification of the channel, and reduction of discharge rates severely impacts the vertebrate resources on the site and also downstream continuing to the estuary.

The Upper Ventura River begins at the confluence of Matilija Creek and North Fork Matilija Creek and extends to just below Casitas Springs. The entire reach, which is 7 miles long, is designated as wetland. The vegetation of the upper portion is southern mixed riparian forest and southern sycamore-alder riparian forest. Below this the canyon empties onto a broad alluvial plain. The vegetation changes to southern arroyo willow riparian forest along the streambank with alluvial scrub dominating the adjacent sand and cobble terraces. The willow forest gives way to a sand and cobble bottom with little vegetation at the point where a significant portion of the flow is diverted to Lake Casitas. From the point of diversion to Casitas Springs, flows are greatly reduced and during the dry season this reach of the stream often has no water. Since 1958, the Casitas Municipal Water District has by-passed the first 20 cfs of low flow at the Robles Diversion. This has helped to maintain the surface flow between Casitas Springs and the estuary (Ferren 1990). The Friends of the Ventura River won a law suit in 1988 preventing the Casitas Municipal Water District from diverting the remaining flow into Lake Casitas for storage.



An upstream (northerly) view of the Ventura River from Highway 150. This is below diversion point. Notice reduced discharge compared with photo taken above diversion point. Photos taken 2-6-93.

The Lower Ventura River. Because of the protected 20 cfs, along with discharge from San Antonio Creek and effluent from the Ojai Sanitation District, it remains a perennial stream. This reach of the stream, despite significant alterations, contains favorable habitat for various native fish such as pacific lamprey (*Entosphenus tridentata*), arroyo chub (*Gila orcutti*), three-spined stickleback (*Gasterosteus aculeatus microcephalus*), and sensitive species including the tidewater goby (*Eucyclogobius newberryi*) and summer steelhead trout (*Oncorhynchus mykiss gairdneri*) (Hunt 1991). Up to 27 steelhead trout have in recent years been observed about 30 meters upstream from the Southern Pacific Railroad bridge (Leidy 1991). The perennial flow on this reach of the river allows access by steelhead to Coyote Creek, below Lake Casitas, and also to San Antonio Creek which provide suitable spawning and rearing habitat (Hunt 1991). The vegetation primarily consists of southern arroyo willow riparian forest including arroyo willow (*Salix lasiolepis*), Red Willow (*S. laevigata*), yellow willow (*S. lasiandra*), and some individuals of white alder (*Alnus rhombifolia*). Invasive exotic *Ludwigia uruguayensis* is the dominant understory plant upstream from the estuary. *Arundo donax*, another invasive exotic is common, often displacing willow forest.



Looking north at Upper Ventura River above diversion point.

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L.A. Regional Water Quality Control Board
Riparian Wetlands: Ventura River Tributaries

**San Antonio Creek, Santa Ana Creek, Coyote Creek
West Fork Santa Ana Creek, Ojai Wetland**

The Ventura River is an interrupted stream. One of the reaches of which has a perennial flow is between Casitas Springs and the Estuary. This area is important to many vertebrate species (see Ventura River section). Discharge from San Antonio Creek and Coyote Creek provide a significant portion of water to this reach of the Ventura River. The Santa Ana Creek complex drains into Lake Casitas and is therefore also part of the Lower Ventura River system.

Tributaries of the Lower Ventura River:
Santa Barbara 30 X 60 min Quadrangle

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L.A. Regional Water Quality Control Board
Riparian Wetlands: Santa Ana Creek and West Fork Santa Ana Creek

The Santa Ana Creek drainage (402.2) includes the main stem which is 3.4 miles long the North Fork which is [illegible].7 miles long and the 3.5 mile long West Fork which joins the North Fork to form the main stem. The headwaters originate at above 3,000 feet in the Santa Ynez Mountains of the Los Padres National Forest. The riparian habitat consists primarily of coast live oak riparian forest, southern sycamore-alder riparian forest and southern riparian scrub dominated by arroyo willow (*Salix lasiolepis*). the understory is rich in hydrophytes including lance-leaved frog fruit (*Phyla lanceolata*), iris leaved rush (*Juncus xiphioides*), umbrella sedge (*Cyperus eragrostis*), scarlet monkey flower (*Mimulus cardinalis*), smilo (*Agrostis miliacea*), and horsetails (*Equisetum* sp.). Fish were observed swimming in large pools and frogs were also observed.
Santa Ana Creek is important spawning habitat for resident rainbow trout, and trout residing in Lake Casitas. Historically Santa Ana Creek was important spawning and rearing habitat for steelhead trout. Birds observered during field visits included black phoebe (*Sayornis nigricans*), Hutton's vireo (*Vireo huttoni*), warbling vireo (*Vireo gilvus*), and the red-shouldered hawk (*Buteo lineatus*).

Photo: Mixture of Oak and Sycamore along Santa Ana Creek

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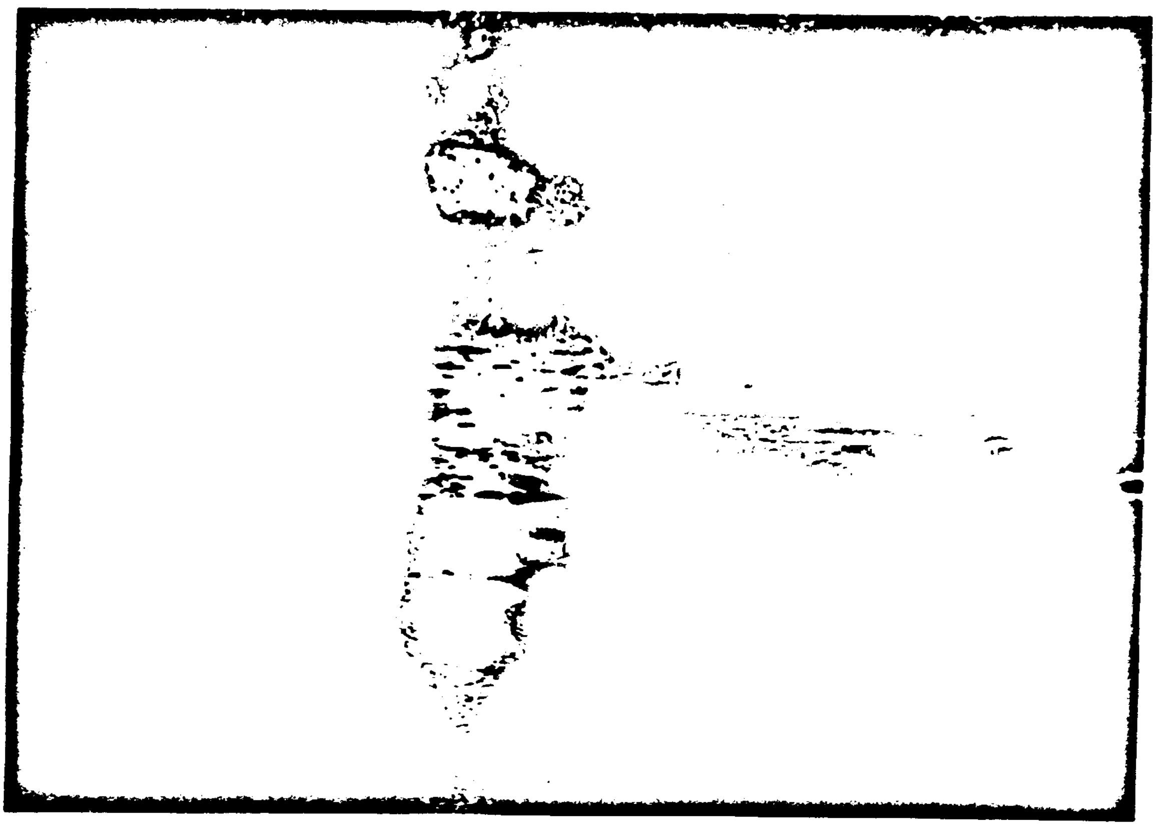
L.A. Regional Water Quality Control Board
Riparian Wetlands: San Antonio Canyon Creek

San Antonio Creek (402.2 and 402.3) is a major tributary of the Ventura River. The Wetland begins at the confluence with [illegible] Creek and extends nearly 5 miles to the Ventura River. A variety of habitat types are found along the creek including southern arroyo willow riparian forest, southern sycamore alder riparian forest and coast live oak riparian forest. The understory is rich in hydrophytes including watercress (*Rorippa nasturtium aquaticum*), lance-leaved frog fruit (*Phyla lanceolata*), duckweed (*Lemna sp.*), umbrella sedge (*Cyperus eragrostis*), cattail (*Typha domingensis*), and barnyard grass (*Echinochloa crusgalli*). Wetland associated bird species observed during field visits were the common yellow throat (*Geothlypis trichas*), black phoebe (*Sayornis nigricans*) and belted kingfisher (*Ceryle alcyon*). San Antonio Creek is important spawning and rearing habitat for remaining populations of steelhead trout and also native populations of rainbow trout.



Southern Arroyo Willow Riparian Forest along San Antonio Creek, Ventura County

18993

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L.A. Regional Water Quality Control Board
Riparian Wetlands: Coyote Creek

Coyote Creek (402.2) is a major tributary of the Ventura River which is interrupted by Lake Casitas. The headwaters originate below the Matilija Divide of the Santa Ynez Mountains within the Los Padres National Forest. The wetland extends from below the 3,000 foot elevation point to the Ventura River. The riparian wetland extends for 5.0 miles above Lake Casitas and for 3.1 miles below the lake. Tributaries to the main stem include the East and West Forks of Coyote Creek which are both 2.5 miles in length. The nearly 11 miles of riparian wetlands include southern sycamore-alder riparian forest, coast live oak riparian forest, and southern mixed riparian forest. Coyote Creek and its tributaries are important spawning and rearing habitat for resident rainbow trout and other trout residing in Lake Casitas. Historically, the Coyote Creek drainage was an important rearing and spawning area for steelhead trout. Presently the Coyote Creek system serves as an important wildlife corridor between the National Forest areas and the coast via the Ventura River.

Southern Mixed Riparian Forest typically found along Coyote Creek, Ventura County

18994

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L. A. Regional Water Quality Control Board Riparian Wetlands: Matilija Drainage

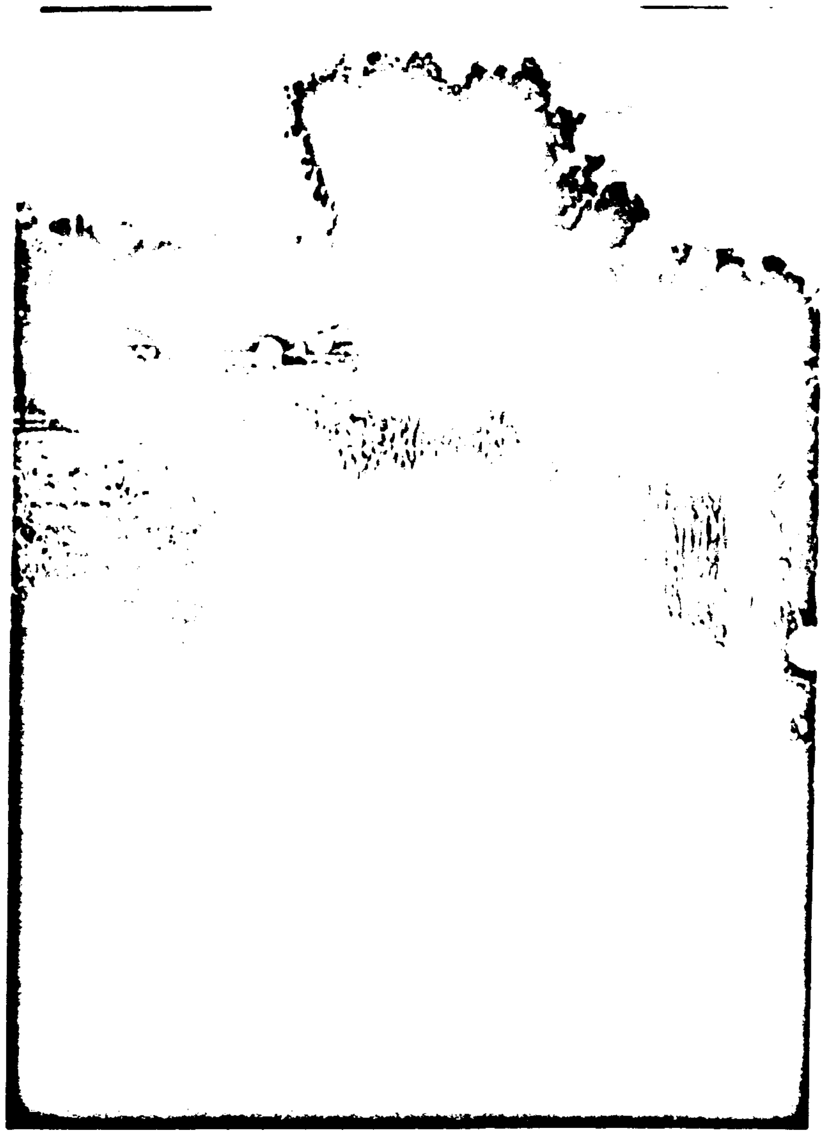
Matilija Creek (402.2?) and its associated tributaries which include Murietta Canyon Creek, Upper North Fork Matilija Creek, and Old Man Canyon Creek, are at the headwaters for the Ventura River. Murietta Canyon Creek is associated with approximately 3 miles of riparian wetland which begin at [illegible] feet and extend to the confluence with Matilija Creek. The wetland associated with the main stem of Matilija Creek extends approximately 7.0 miles from the [illegible] foot elevation level to the confluence with Upper North Fork Matilija Creek. The wetland associated with Old Man Creek begins at the [illegible] feet and extends [illegible] miles to the confluence with the Main Stem of Matilija Creek. The wetland associated with the Upper North Fork extends [illegible] miles beginning at [illegible] feet and ending at the confluence with the main stem. The vegetation is composed of various riparian woodlands including southern mixed riparian forest, southern sycamore-alder riparian forest, and coast live oak riparian forest. These riparian wetlands provide important spawning and rearing habitat and migration corridors for both steelhead trout and populations of native rainbow trout.

Southern Mixed Riparian Forest along North Fork Matilija Creek

1 8995

L.A. Regional Water Quality Control Board
Riparian Wetlands: Ojai Wetland

The Ojai wetland (402.2) is an area of freshwater marsh vegetation which originates at highway 33 between El Roblar and Nordoff High School and ends at the Happy Valley Drain. The total length is approximately one-quarter mile. The vegetation consists of 5 obligate wetland species including umbrella sedge (*Cyperus eragrostis*), wire grass (*Juncus sp.*), water cress (*Nasturtium officinale*), California bulrush (*Scirpus californica*), and narrowleaf cattail (*Typha domingensis*). The area adjacent to the the freshwater marsh is composed of naturalized annual grasses and a stand of eucalyptus trees. This wetland, while not significant at the regional level has been demonstrated by the California Department of Fish and Game to be important as a foraging area for various raptors including American kestrel (*Falco sparverius*), redtail hawk (*Buteo jamaicensis*) red shouldered hawk (*B. lineatus*), and black shouldered kite (*Elanus caeruleus*).



Ojai Wetland looking towards Highway 33. Narrowleaf Cattail (*Typha domingensis*) is the dominant vegetation.

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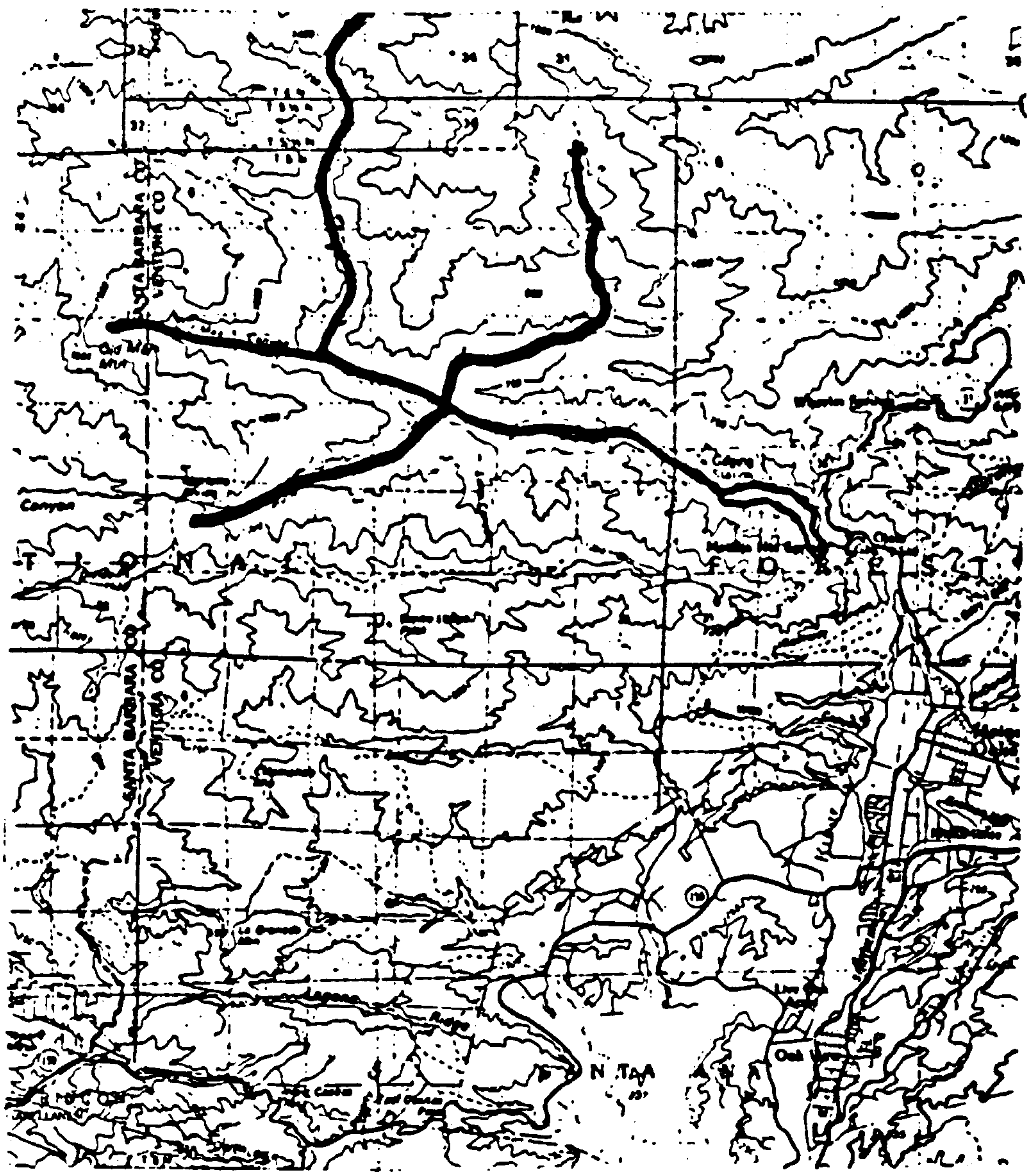
L.A. Regional Water Quality Control Board
Riparian Wetlands: Ventura River Tributaries

Murietta Canyon Creek, Matilija Creek, Upper North Fork Matilija Creek, and Old Man Canyon Creek



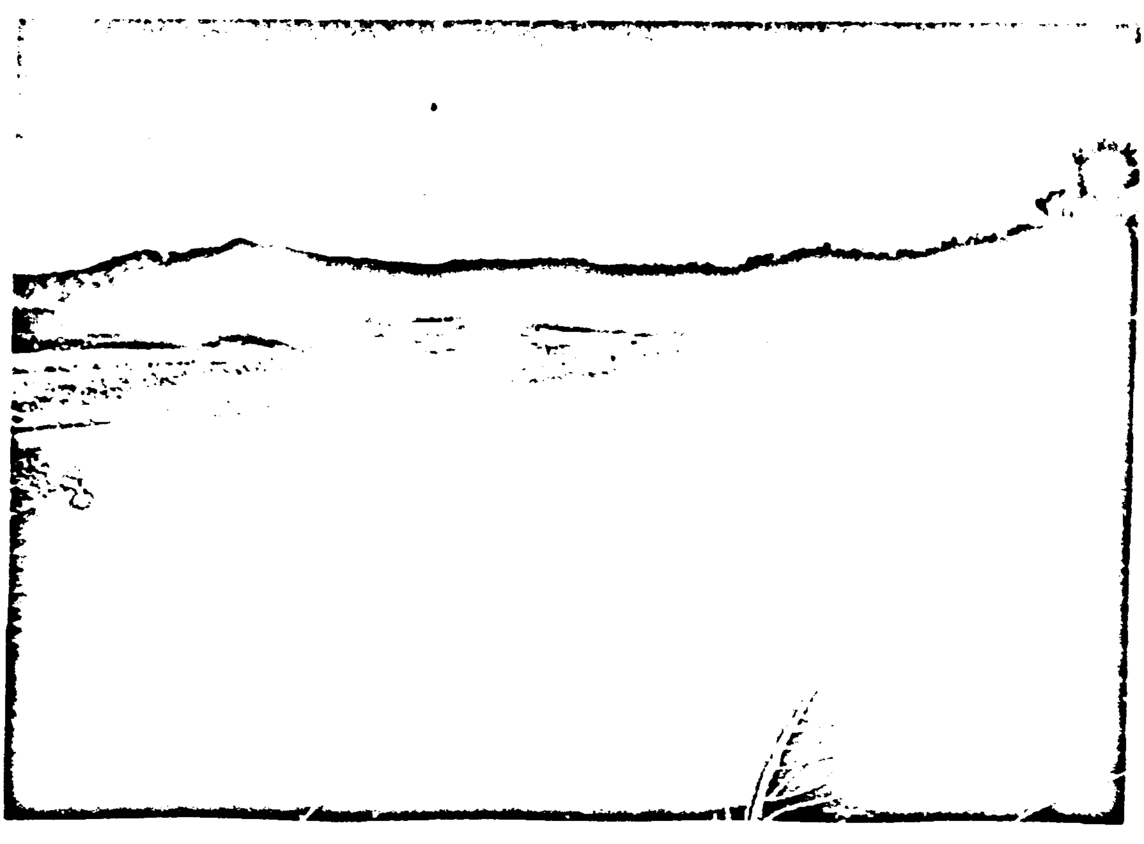
Upper tributaries of the Ventura River from Santa Barbara and Cuyama 30 X 60 min Quadrangles

1 8997

L.A. Regional Water Quality Control Board
Riparian Wetlands: Santa Clara River

The Santa Clara River is the largest river system in southern California and is one of the last which remains in a relatively natural state. The headwaters originate in the San Gabriel Mountains in Los Angeles County and below Mt. Pinos, the highest point of the watershed at 8,831 feet. The river traverses Ventura County and empties into the Pacific Ocean extending over 83 miles and draining a watershed of 1,600 square miles. All of the major tributaries originate in National Forest. Typical of southern California rivers, the stream flow is highly variable. Average daily discharge at Montalvo (about three miles from the coast) ranges from no flow (often for extended periods during the dry season) to winter flood peaks over 100,000 cubic feet per second.

Extensive, high quality riparian habitat is present along the length of the river. This habitat supports large populations of wildlife species, many of which are becoming rare as riparian habitats are destroyed, degraded or fragmented by development. Populations of many of these species are associated with the Santa Clara River system. The endangered California least tern (*Sterna antillarum browni*) nests at the mouth of the river and saltmarsh bird's-beak (*Cordylanthus maritimus maritimus*) which has been extirpated from the estuary is to be reintroduced to the site according to the species recovery plan. The recovery plan for least Bell's vireo cites the Santa Clara River as critical habitat.



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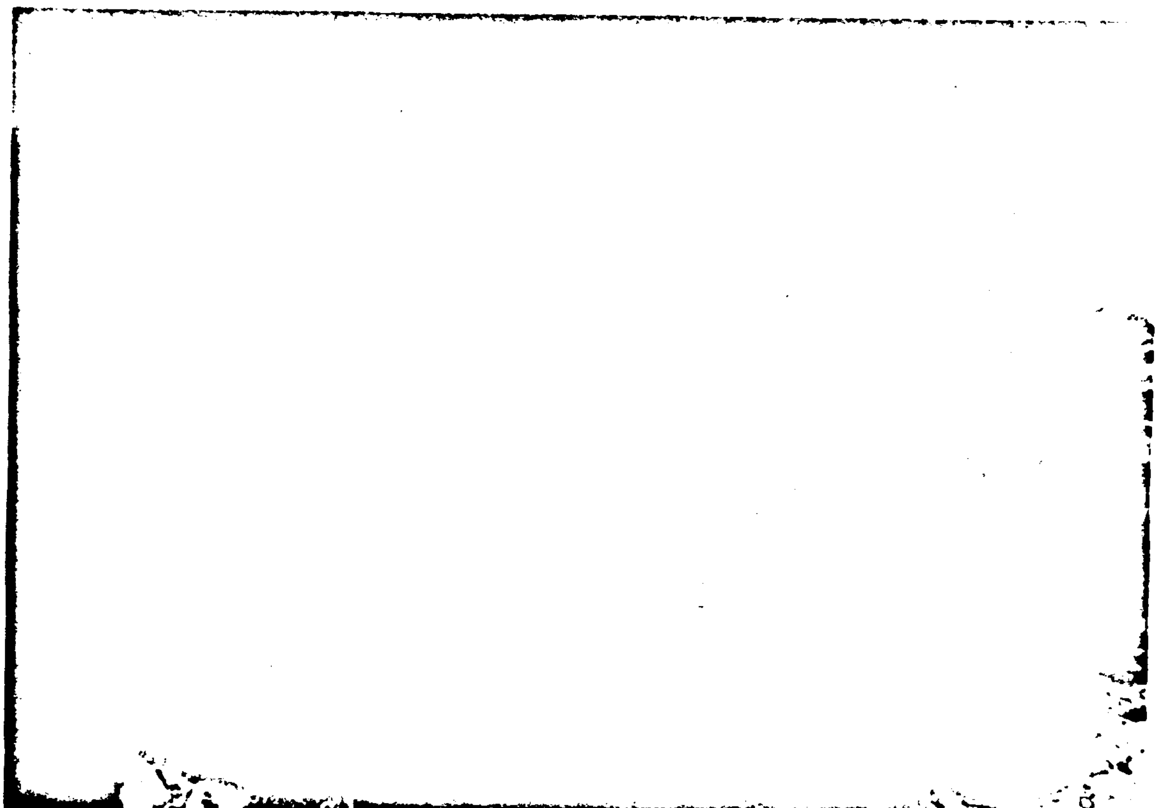
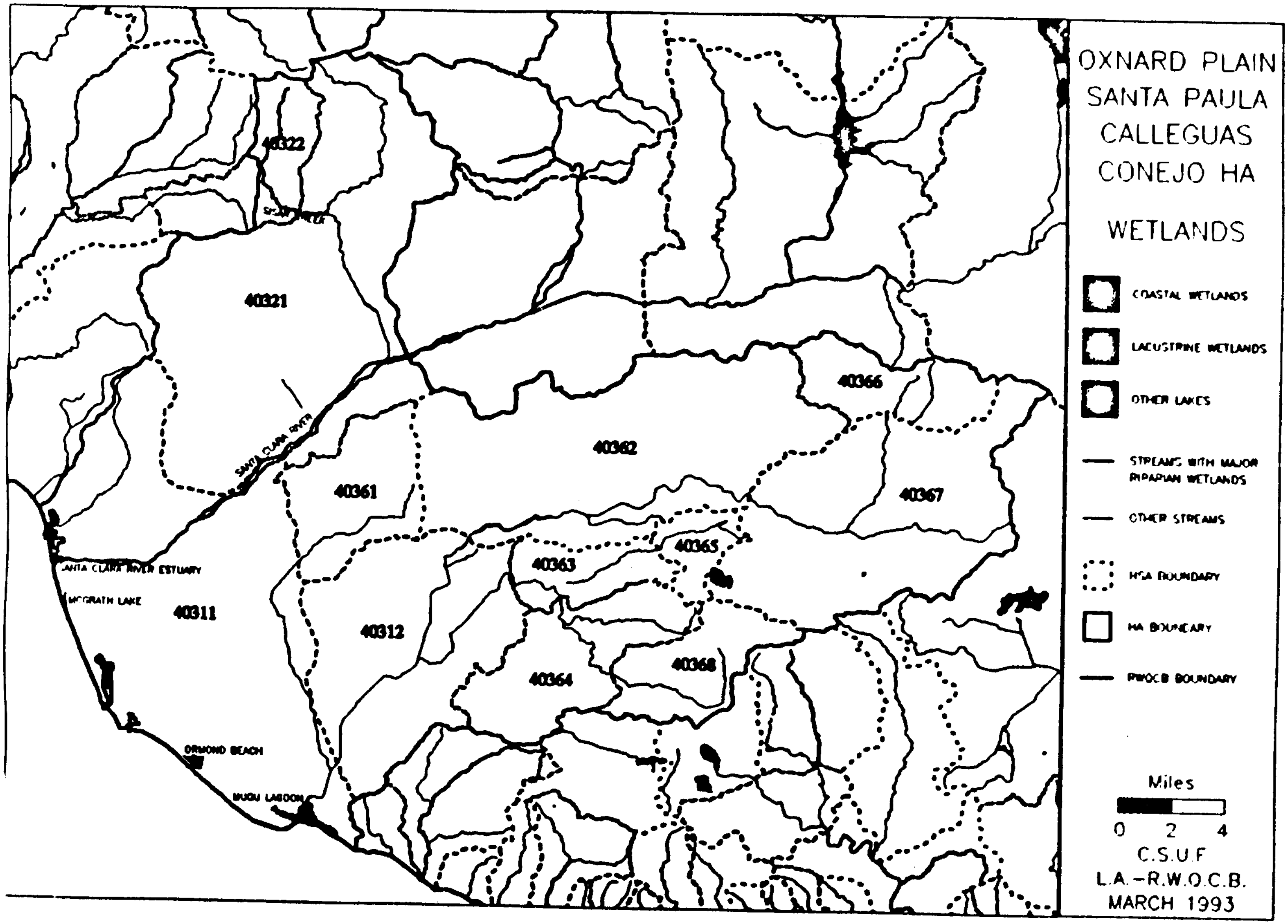


Above: Santa Clara River near L.A./Ventura county line. Southern Cottonwood-Willow Riparian Forest bordered by Alluvial Scrub.

Opposite page: Santa Clara River from Los Angeles 30 X 60 min Quad.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MCGRATH LAKE
ORMOND BEACH
MUGU LAGOON

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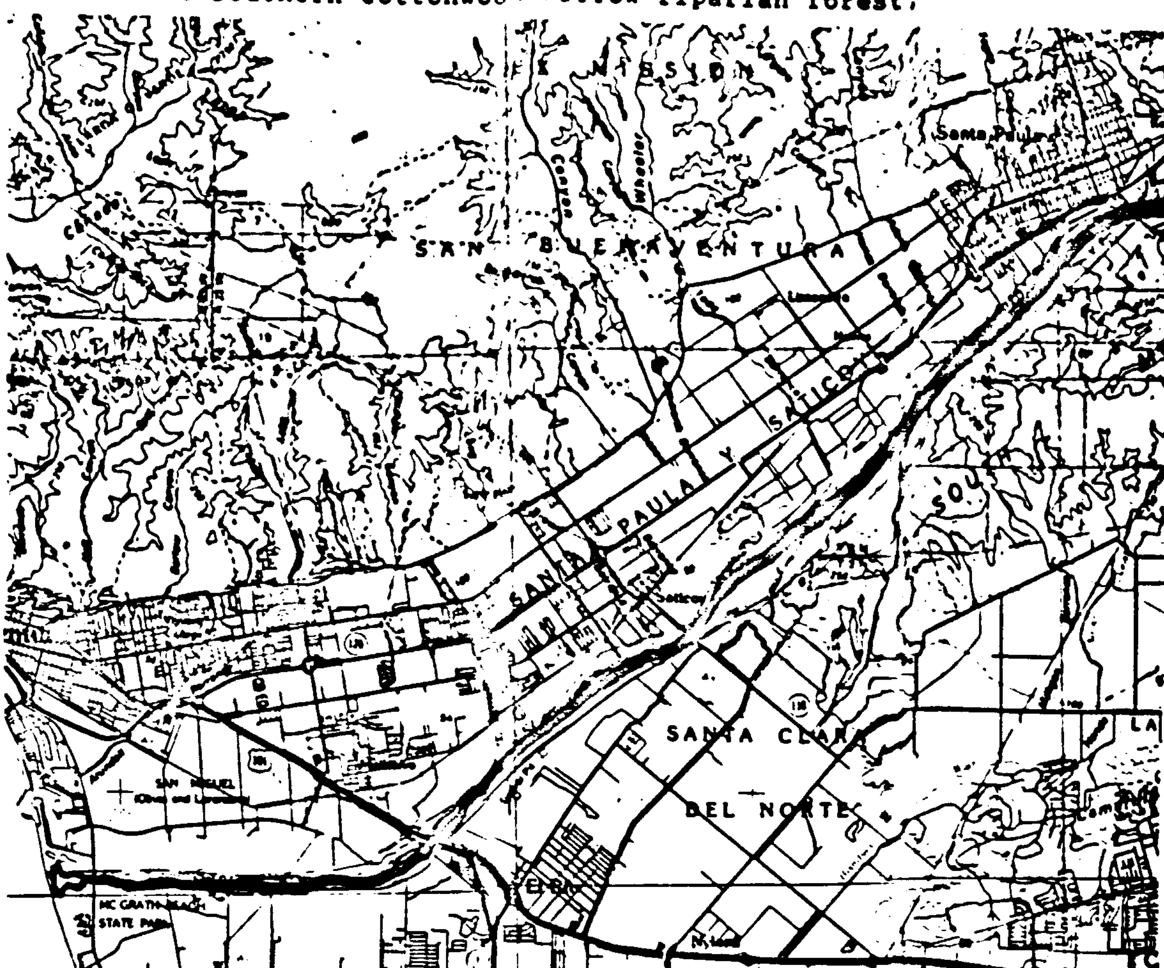
L.A. Regional Water Quality Board
Riparian Wetlands: Santa Clara River

The Lower Santa Clara River (403.11, 403.21) extends 16.5 miles from the coast to just above the confluence point with Santa Paula Creek. Near the coast the habitat is southern arroyo willow riparian forest. Much of the willow habitat which is important to species such as least Bell's vireo has been invaded by giant reed (Arundo donax) which has invaded large stretches of this section of the river. The Arundo becomes established after flood events and reproduces very rapidly by means of vegetative growth. The willows are outcompeted and valuable habitat is lost. Other vegetation types found along this portion of the river include mulefat scrub and some southern cottonwood-willow riparian forest.



Lower Santa Clara River: Santa Barbara 30 X 60 min Quadrangle
Opposite Page: Lower Santa Clara River near Hwy 101 showing extensive stands of giant reed (Arundo donax) as dominant.

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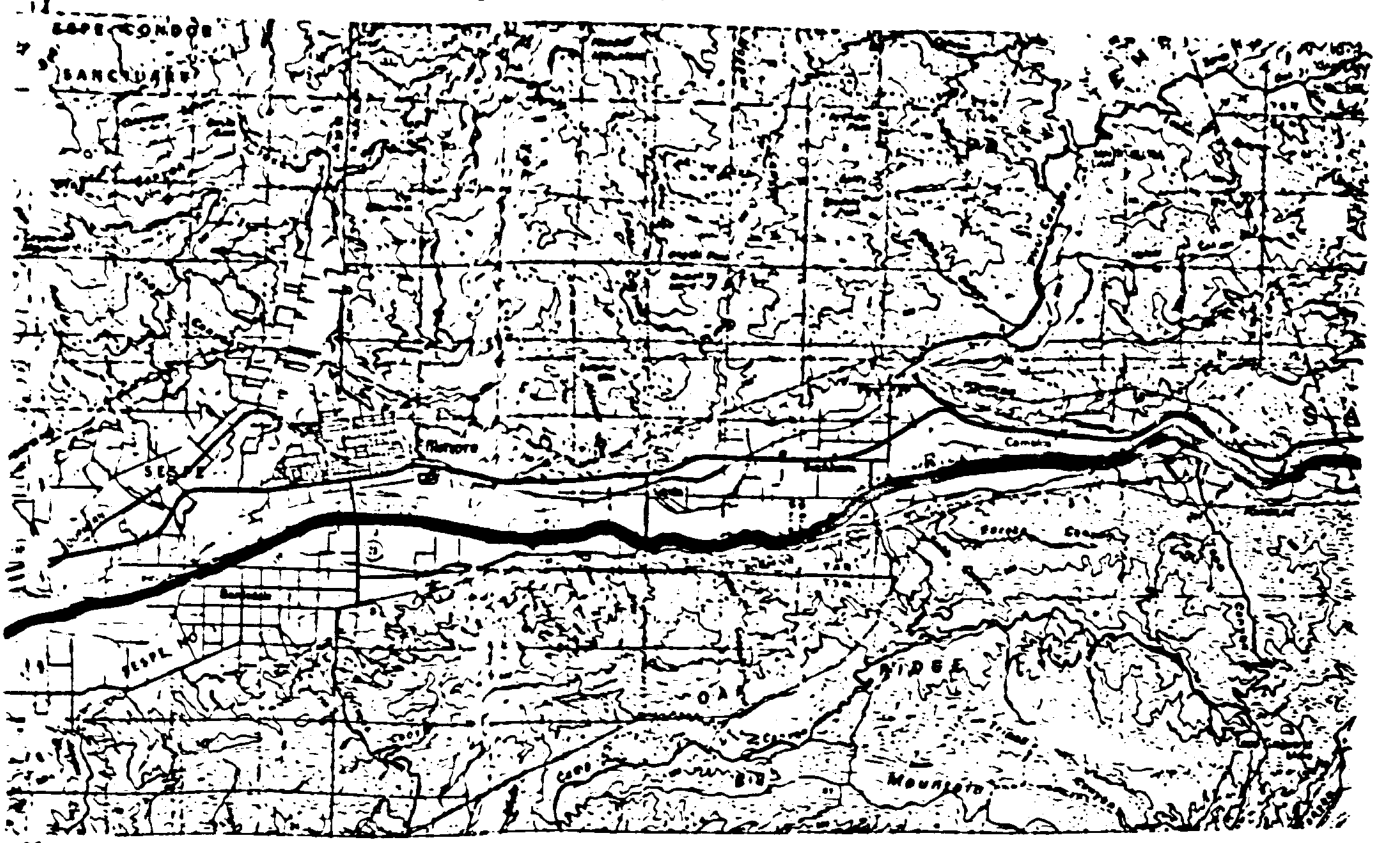
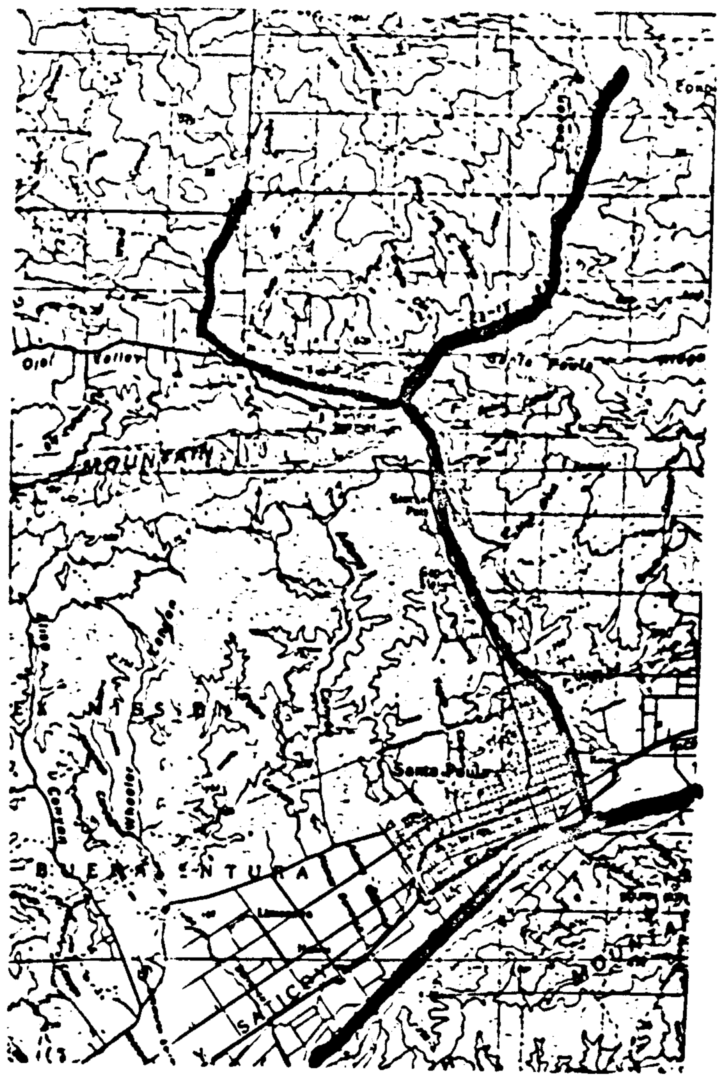
L.A. Regional Water Quality Control Board
Riparian Wetlands: Santa Clara River

The Santa Clara River (403.31, 403.41) extends 20.9 miles from Santa Paula to the Los Angeles/Ventura county line. Two of the river's major tributaries, Sespe and Piru Creeks empty into the river within about 4 miles of each other. The habitat consists primarily of southern cottonwood-willow riparian forest dominated by Fremont cottonwood (*Populus fremontii*), yellow willow (*Salix lasiandra*), and arroyo willow (*S. lasiolepis*). Alluvial scrub, dominated by scalebroom (*Lepidospartum squamatum*), borders the cottonwood-willow forest in most areas. This entire section of the river is wetland and provides a significant corridor for rainbow and steelhead trout to migrate between the lower reaches of the river and spawning and rearing habitat in tributaries such as Sespe and Piru Creeks. The threespine stickleback (*Gasterosteus aculeatus williamsonii*), an endangered fish, ranges from San Francisquito Canyon (which is upstream) to this section of the river. The fish requires clean, free-flowing perennial streams and ponds surrounded by native vegetation.



L.A. Regional Water Quality Control Board
Riparian Wetlands: Santa Paul and Sisar Creeks

Santa Paula Creek (403.21) is a major tributary of the Santa Clara River originating in the Los Padres National Forest at 5,000 feet. The topography of Santa Paula Canyon is quite severe and the canyon is generally narrow. The wetland begins at near the 4,000 foot level and extends nearly 15 miles to the Santa Clara River. The vegetation is a mixed riparian forest with the following species found during botanical surveys: red willow (*Salix laevigata*), mule fat (*Baccharis salicifolia*), Fremont cottonwood (*Populus fremontii*), white alder (*Alnus rhombifolia*), sycamore (*Platanus racemosa*), and coast live oak (*Quercus agrifolia*). Understory hydrophytes include watercress (*Rorippa nasturtium-aquaticum*), cattails (*Typha latifolia*), and willowherb (*Epilobium* spp.).



Sisar Creek (403.21 & 403.22) is a tributary of Santa Paula Creek which originates in the Los Padres National Forest at 4,500 feet. The wetland extends for 5.0 miles to the confluence with Santa Paula Creek. The vegetation is southern sycamore-alder riparian forest with white alder (*Alnus rhombifolia*) as dominant. Other species include coast live oak (*Quercus agrifolia*), sycamore (*Platanus racemosa*), California bay laurel (*Umbellularia californica*), and knotweed (*Polygonum spp.*) The habitat for both Santa Paula and Sisar Creeks is generally undisturbed.

Map: Santa Paula and Sisar riparian wetlands
from Santa Barbara 30 X 60 min Quadrangle

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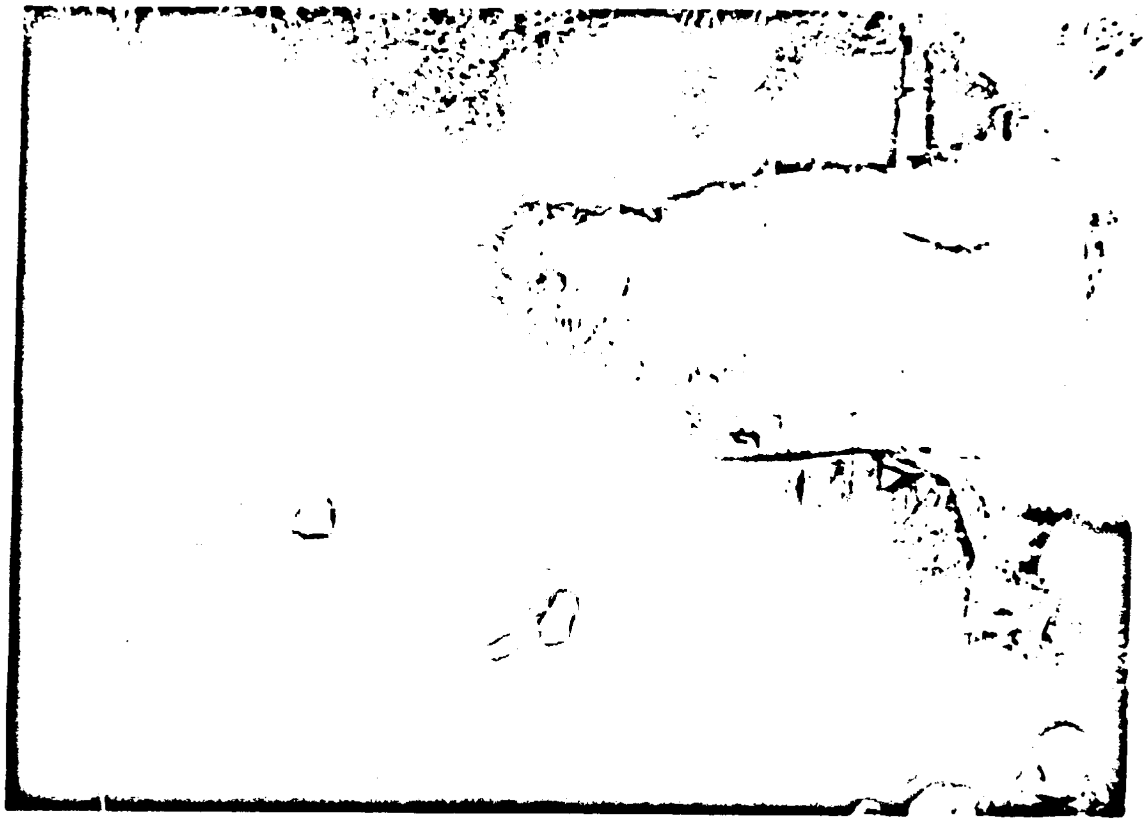
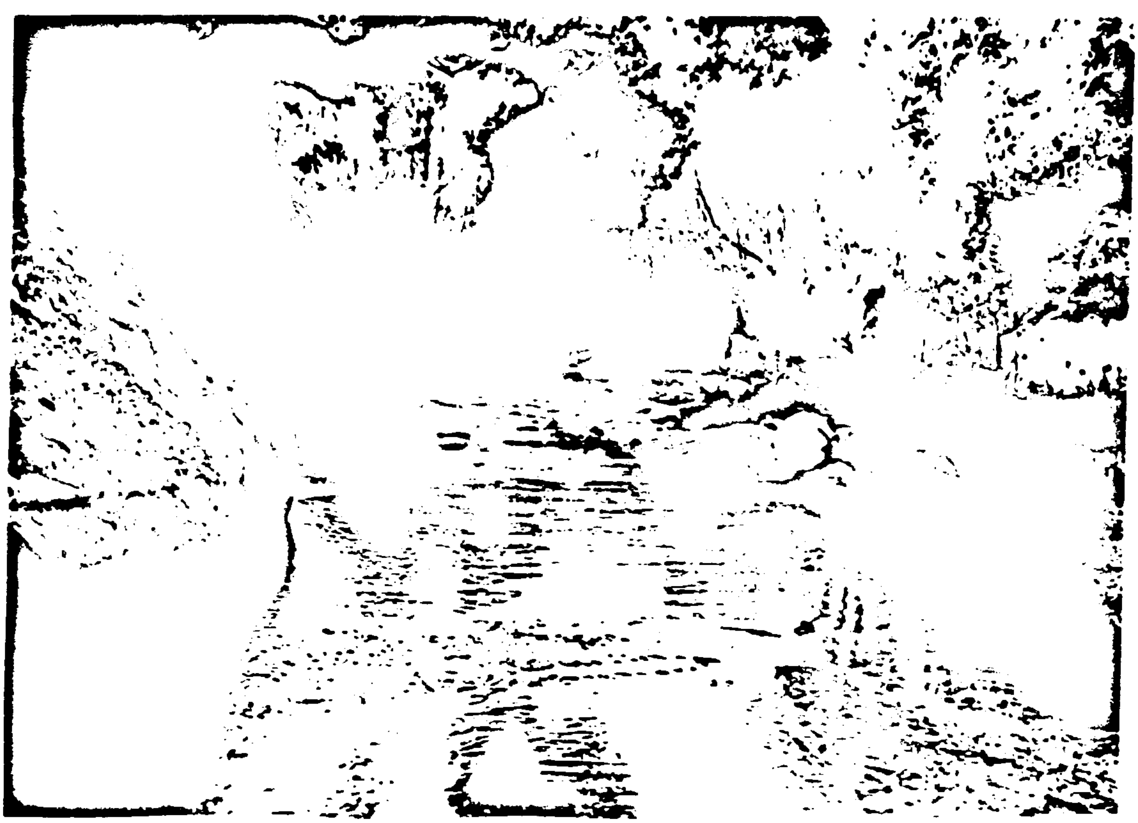


Above: Santa Paula Creek above confluence with Mud Creek
Below: Santa Paula Creek at confluence with Sisar Creek



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L.A. Regional Water Quality Control Board
Riparian Wetlands: Sespe Creek

Sespe Creek (403.31 & 403.32) is a major tributary of the Santa Clara River which extends for 58.9 miles mostly on National Forest Lands. On June 19, 1992 President Bush signed into law the "Los Padres Range and River Protection Act" (PL-102-301) establishing 400,450 acres of new wilderness and 84 miles of "Wild and Scenic Rivers" in Los Padres National Forest. A significant part of Sespe Creek and its adjoining watershed was included with the new "Wilderness" and "Scenic Rivers" area. The following paragraph was added to and amended the Wild and Scenic Rivers Act (16 U.S.C. 1274(a)):

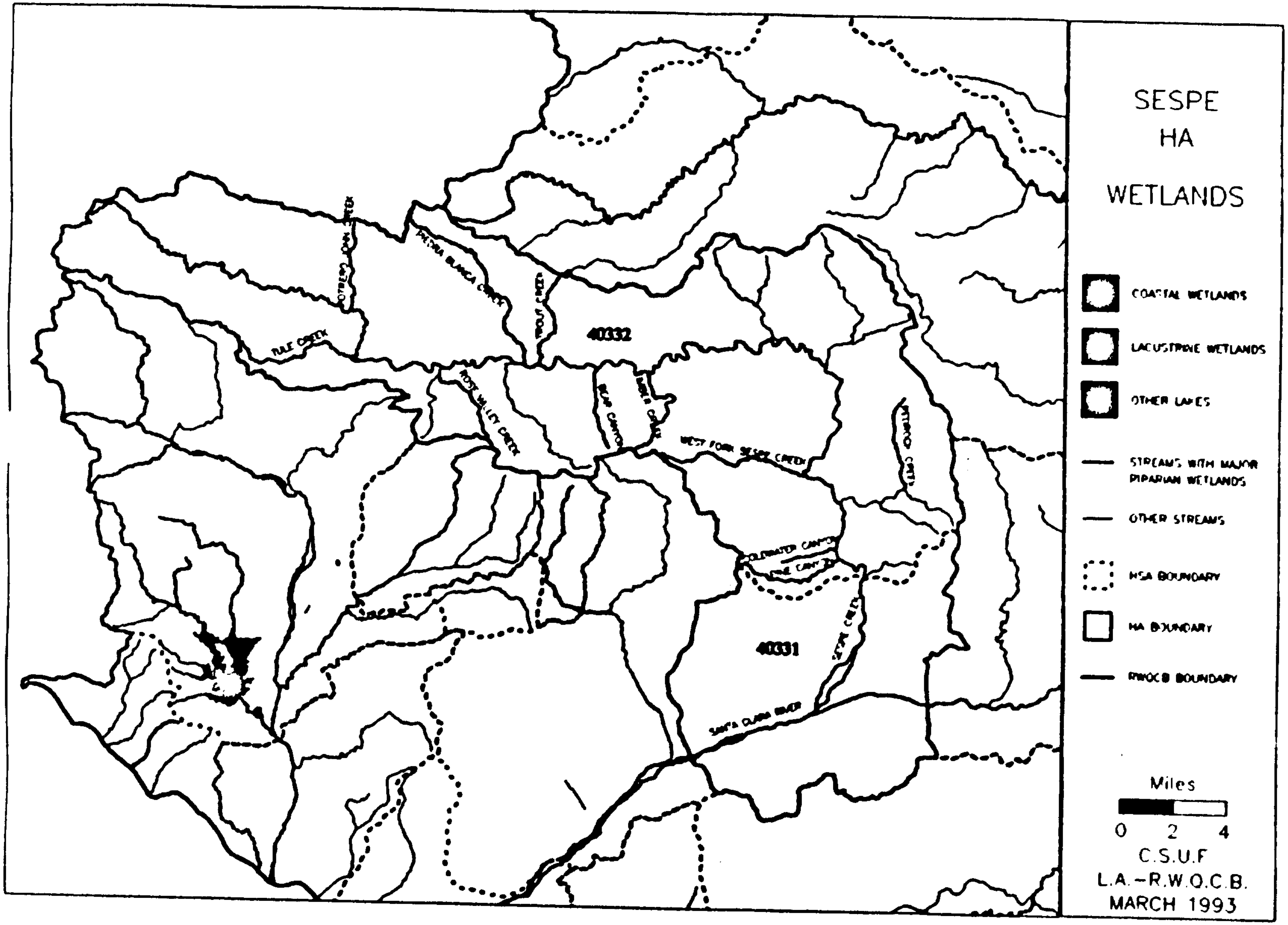
> "() SESPE CREEK, CALIFORNIA. --The 4-mile segment of the main stem of the creek from its confluence with Rock Creek and Howard Creek downstream to its confluence with Trout Creek, to be administered by the Secretary of Agriculture as a scenic river; and the 27.5 mile segment of the main stem of the creek extending from its confluence with Trout Creek downstream to where it leaves section 26, township 5 north, range 20 west, to be administered by the Secretary of Agriculture as a wild river"

Also added was part of Sespe Creek as a "Study River":

> "() SESPE CREEK, CALIFORNIA. --The segment from Chorro Grande Canyon downstream to its confluence with Rock Creek and Howard Creek, a distance of about 10.5 miles"

The wetland begins at Chorro Grande Canyon and extends the full length of the creek to the Santa Clara River. The vegetation is diverse along the length of the Sespe and includes most of the major riparian forest/woodland types found in Region 4. The area below Sespe Gorge is a mixed riparian forest with willows (*Salix lasiandra* and *S. lasiolepis*) being dominant. Also present is white alder (*Alnus rhombifolia*), and Fremont cottonwood (*Populus fremontii*). Hydrophytes *Typha* and *Scirpus* are also present. The area near the confluence with Piedra Blanca is cottonwood-willow riparian woodland dominated by *Populus fremontii*. The willows form a scrub understory to the cottonwoods. Lower Sespe Creek, north of Fillmore, is southern sycamore-alder riparian forest including white alder, sycamore (*Platanus racemosa*), willows and coast live oak (*Quercus agrifolia*). The broad alluvial floodplain below Little Sespe Creek is dominated by alluvial scrub vegetation including scalebroom (*Lepidospartum squamatum*), great basin sage (*Artemisia tridentata*), wild tarragon (*A. dracunculus*), yerba santa (*Eriodictyon crassifolium*), and California buckwheat (*Eriogonum fasciculatum*).

Sespe Creek provides unique habitat for anadromous fish including steelhead trout which historically used the Sespe and many of its tributaries as spawning and rearing grounds. Endangered animals include the California condor (*Gymnogyps californianus*) and least Bell's vireo (*Vireo bellii pusillus*). Candidate species include arroyo southwestern toad (*Bufo microscaphus californicus*), and southwestern pond turtle (*Clemmys marmorata pallida*).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ROSE VALLEY CREEK
WEST FORK SESPE CREEK
COLDWATER CANYON
SESPE CREEK
SANTA CLARA RIVER

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Above: [illegible] confluence with [illegible] Creek.
Below: Trout [illegible] near [illegible] Creek

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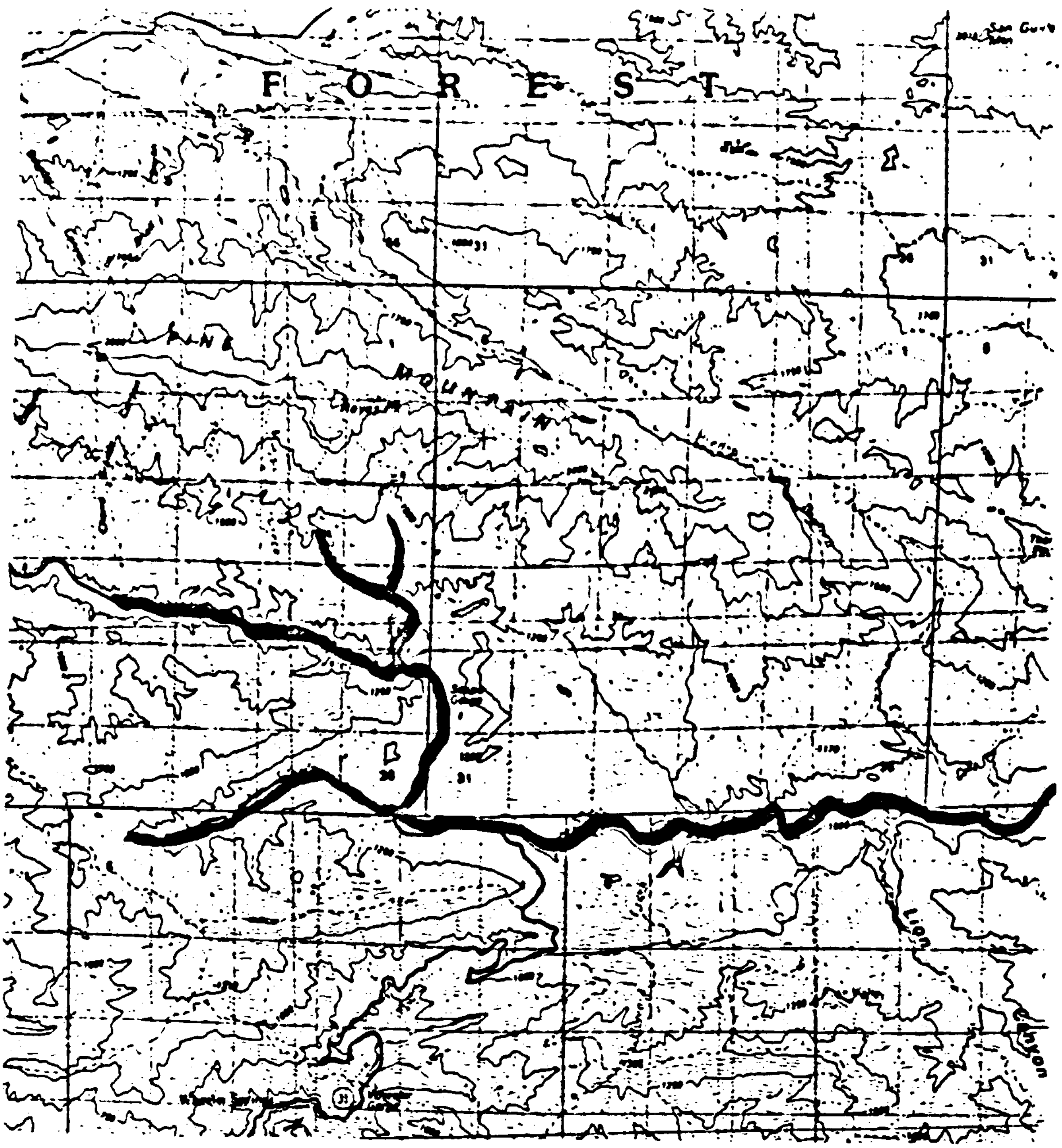

Upper Sespe Creek and tributaries Tule Creek and
Potrero John Creek. From Cuyama 30 X 60 min Quadrangle

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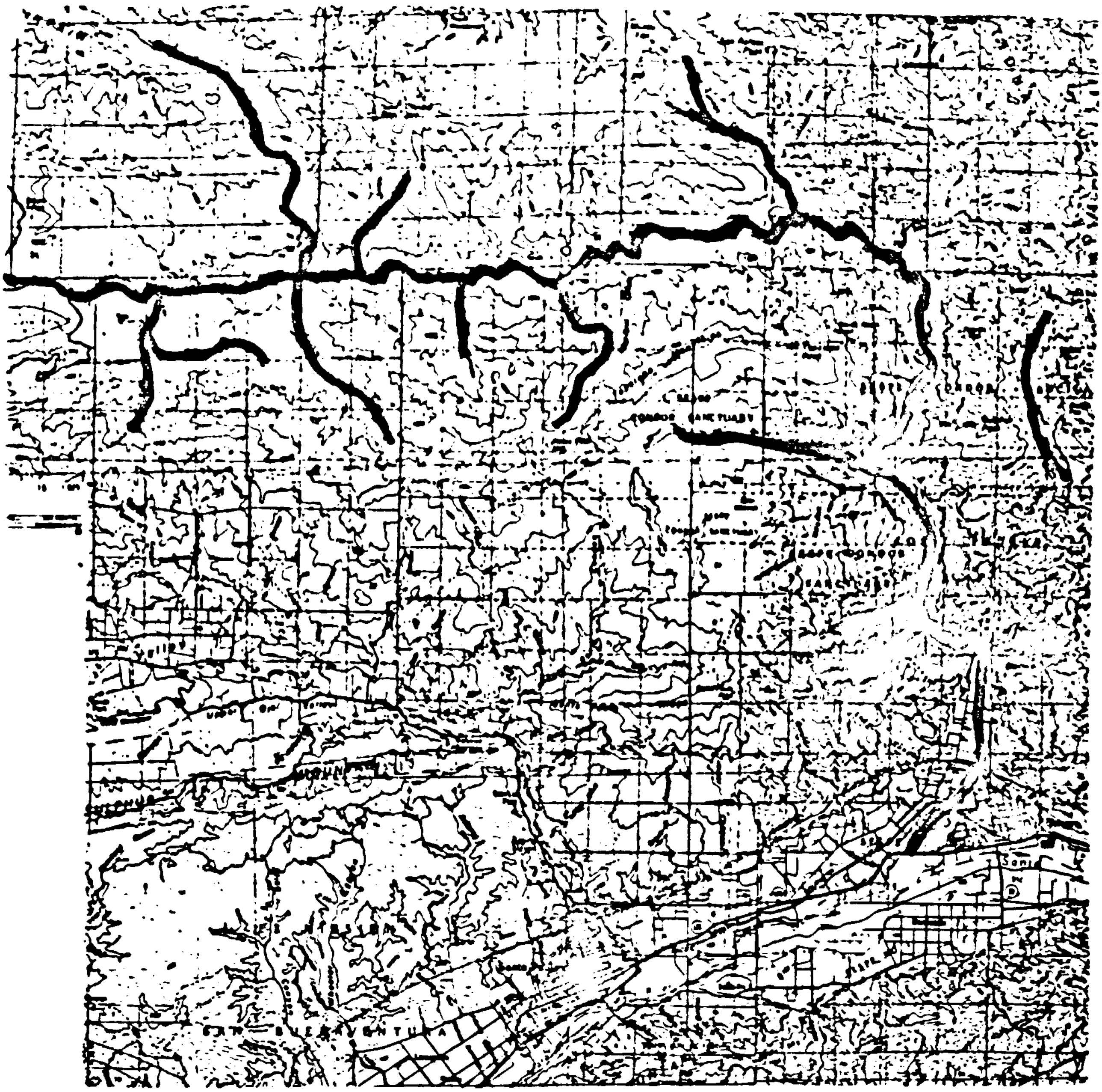

Sespe Creek and tributaries designated as riparian wetlands: Pine Canyon Creek, Coldwater Canyon Creek, Bear Creek, Redrock Creek, West Fork Sespe Creek, Rose Valley Creek, Timber Creek, Howard Creek, Trout Creek, and Piedra Blanca Creek. From Los Angeles, Santa Barbara, Lancaster and Cuyama 30 X 60 min Quadrangles.

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L.A. Regional Water Quality Control Board
Riparian Wetlands: Sespe Creek Tributaries

Sespe Creek (403.31 & 403.32) has numerous tributaries draining the newly designated Sespe Wilderness of the Los Padres National Forest. Based on comments by the District Ranger from the Ojai Ranger District of the Los Padres National Forest, the following waterbodies have been included as riparian wetlands:

Pine Canyon (403.32) Wilderness area within Condor Sanctuary, no public access.

Coldwater Canyon (403.32) Same as Pine Canyon.

Bear Canyon (403.32) Wilderness area with emphasis on recreation, fish and wildlife.

Redrock Canyon (403.32) Wilderness area and Condor habitat, no public access.

West Fork Sespe Creek (403.32) Wilderness area and Condor habitat. Also an important anadromous stream.

Rose Valley Creek (403.32) Management emphasis is on recreation and visual resources. Fish and wildlife habitat.

Timber Creek (403.32) Recreation emphasis. An important anadromous stream.

Lion Canyon (403.32) Management emphasis is wildlife, watershed, recreation, visual resources and wilderness. Importand anadromous spawning habitat.

Howard Creek (403.32) Management emphasis is recreation and visual resources. Includes important sensitive species habitat.

Trout Creek (403.32) Wilderness area with emphasis on wildlife. Anadromous spawning habitat.

Piedra Blanca (403.32) Same as Trout Creek.

Potrero John Creek (403.32) Same as Trout Creek.

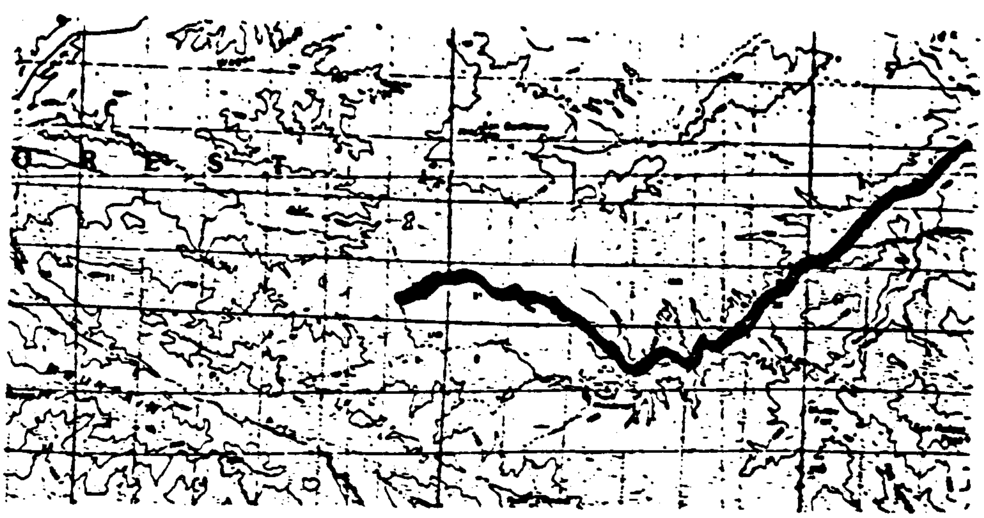
Tule Creek (403.32) Management emphasis is on Water Yield enhancement. Non-motorized recreation and wildlife. Includes sensitive species habitat.

L.A. Regional Water Quality Control Board
Riparian Wetlands: Piru Creek

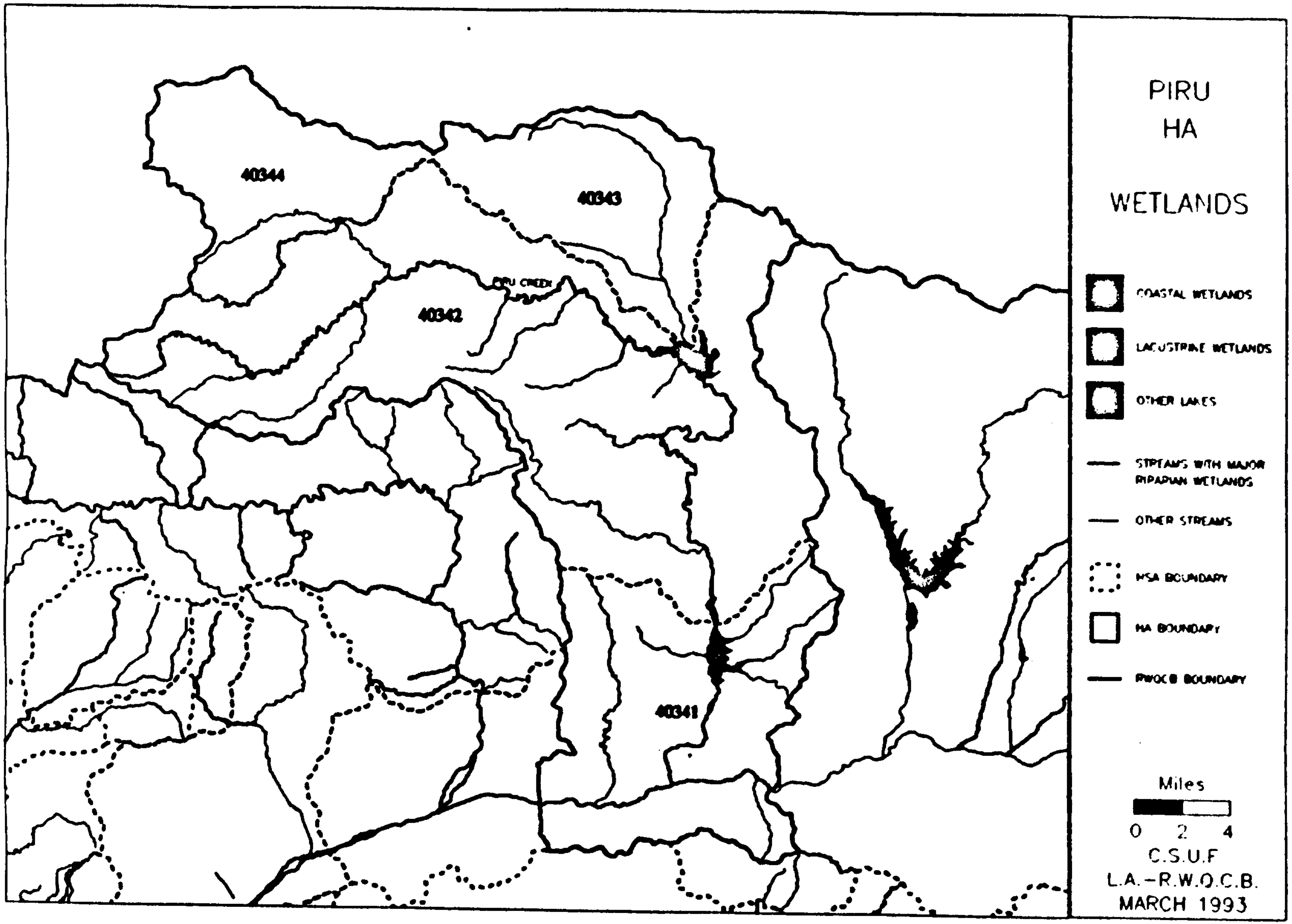
Piru Creek (403.41 & 403.42) is a major tributary of the Santa Clara River. The headwaters originate at over 5,000 feet in the Los Padres National Forest. The wetland begins near the headwater areas and extends nearly 60 miles to the Santa Clara River making it one of the longest riparian wetlands in Region 4. Because of its length there are a wide variety of riparian habitats associated with Piru Creek including southern coast live oak riparian forest, southern arroyo willow riparian forest, southern willow scrub, southern sycamore alder riparian woodland, and southern mixed riparian forest. Botanical surveys performed below Lake Piru found a mixed riparian habitat containing sycamore (*Platanus racemosa*), Fremont cottonwood (*Populus racemosa*), arroyo willow (*Salix lasiolepis*), with cattails (*Typha latifolia*), and mulefat (*Baccharis salicifolia*) in the understory. A large portion Piru Creek has been extended the status of "Study River" for purposes of inclusion in the "Wild and Scenic Rivers" legislation:

> "() PIRU CREEK, CALIFORNIA-- The segment of the main stem of the creek from its source downstream to the maximum pool of Pyramid Lake and the segment of the main stem of the creek beginning 300 feet below the dam at Pyramid Lake downstream to the maximum pool at Lake Piru, for a total distance of approximately 49 miles.

California Department of Fish and Game has designated 1.3 miles of Piru Creek as a "Wild Trout Stream" in California. Endangered or candidate species associated with Piru Creek include the California condor (*Gymnogyps californianus*), southwestern pond turtle (*Clemmys marmorata pallida*), and Santa Ana sucker (*Catostomus santaanae*).



Upper Piru Creek from Cuyama 30 X 60 min Quadrangle.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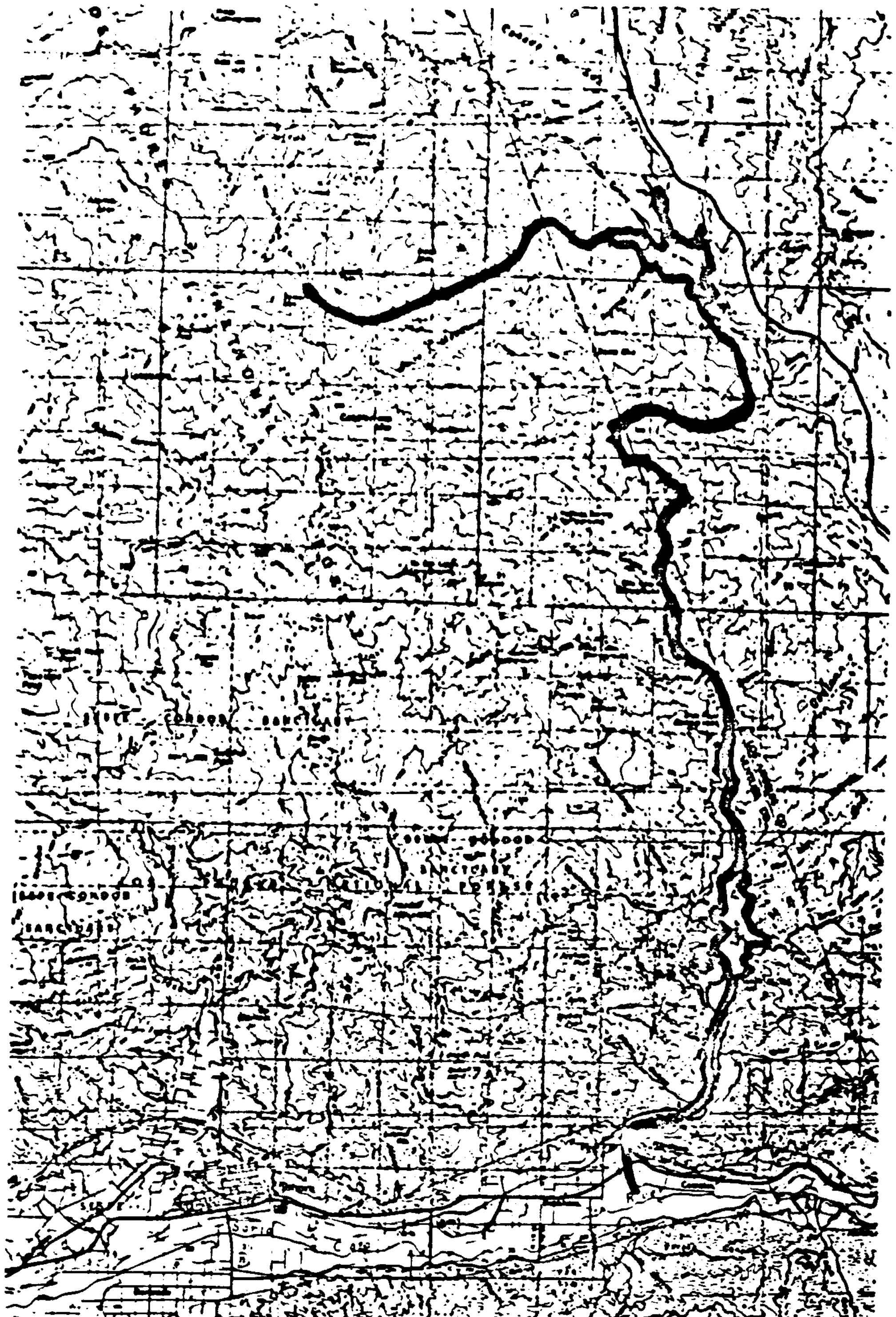
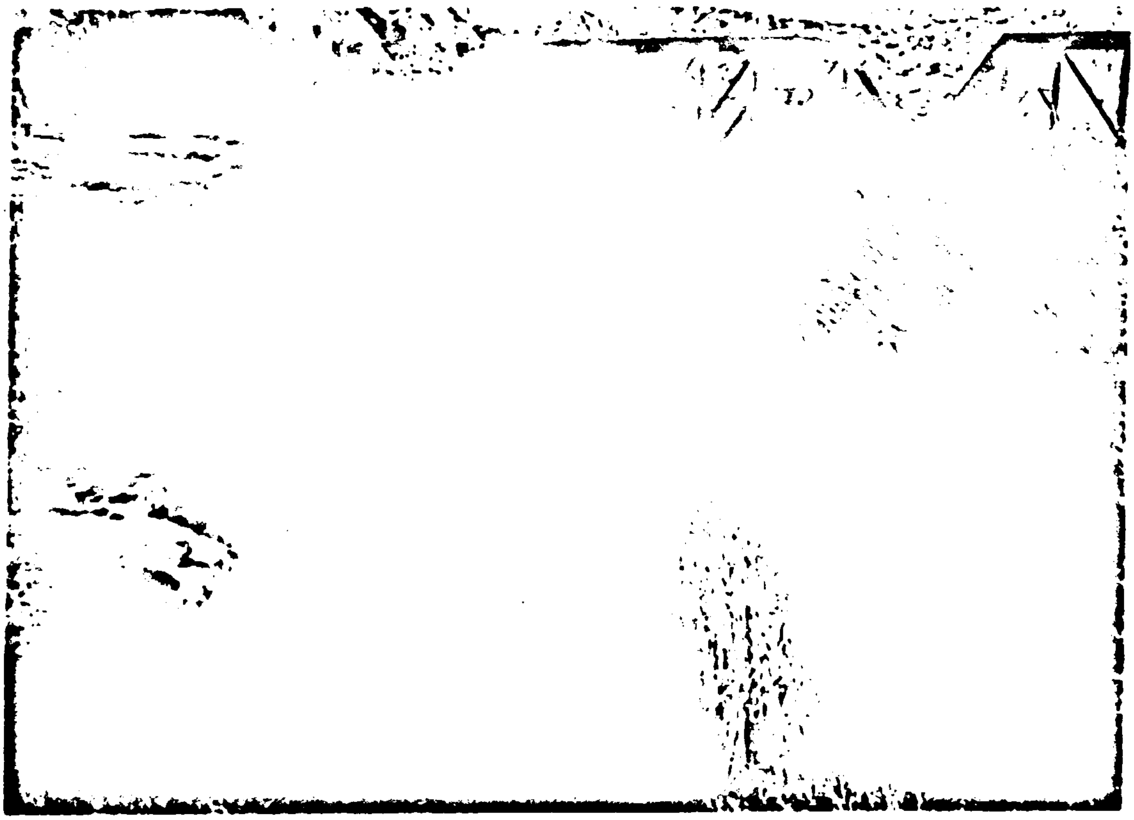


Piru Creek from Cuyama, Lancaster and Los Angeles 30 X 60 min Quads



Piru Creek below Lake Piru showing Mule Fat scrub dominated by *Baccharis salicifolia* and Arroyo Willow (*Salix lasiolepis*). Sycamores (*Platanus racemosa*) can be seen in upper left of photo.

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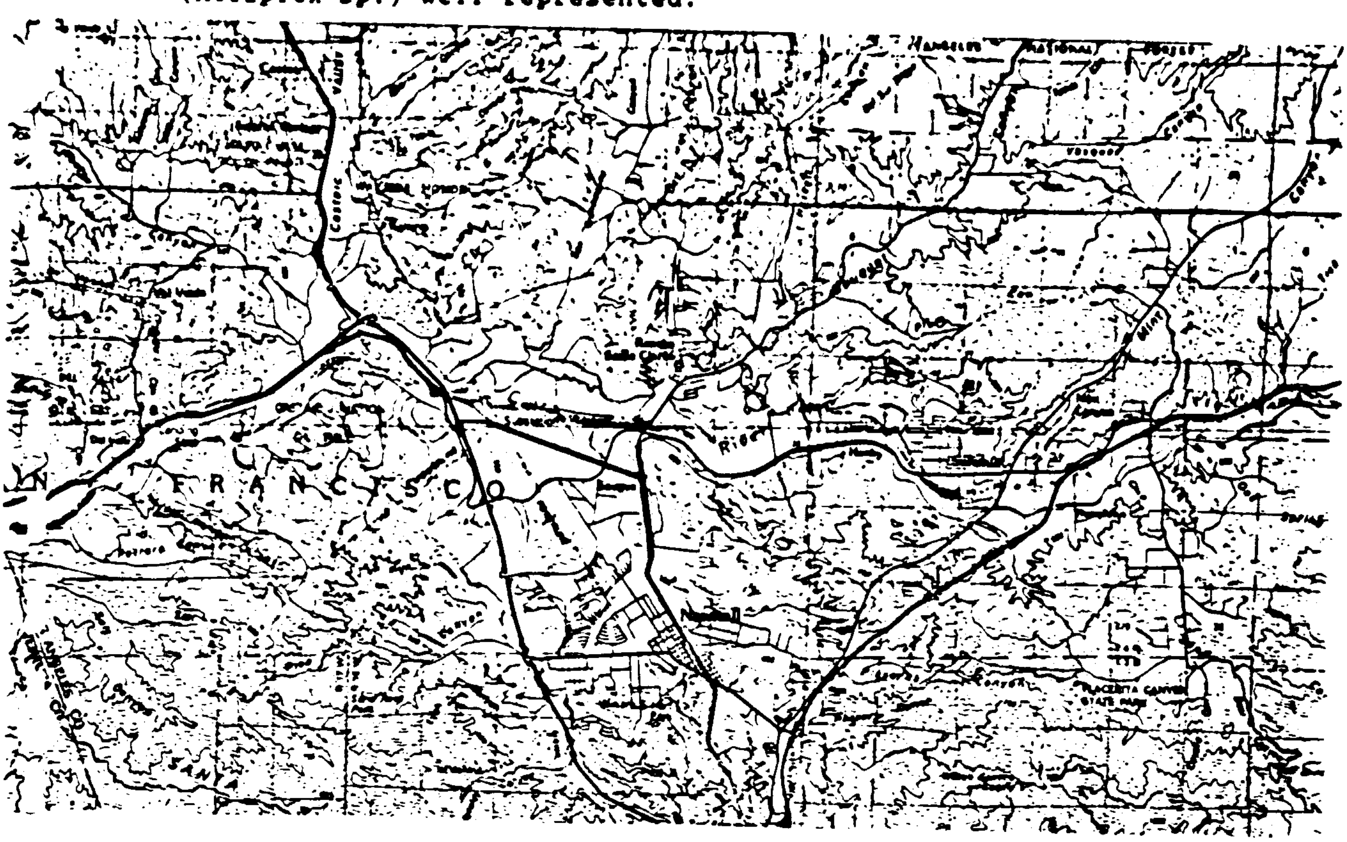
L.A. Regional Water Quality Control Board
Riparian Wetlands: Santa Clara River

The Santa Clara River (403.51) extends 23.8 miles from the Los Angeles/Ventura county line to Soledad Canyon. This section of the river is an interuppted stream with perennial water in portions only. Los Angeles county has designated the river, beginning at the county line and extending north to Arrastre Canyon, as Ecologically Significant Area No. 23 for Los Angeles County. This designation is primarily due to the presence of the threespine stickleback (*Gasterosteus aculeatus williamsoni*) which is an endangered species. The fish occurs only in this section of the Santa Clara river and in San Francisquito Canyon, a major tributary. The stickleback has survived due to a minimal amount of disturbance in these areas. The vegetation varies greatly depending on availability of water. Southern cottonwood-willow riparian forest is dominant where water is present or where the water table is high. Botanical surveys in the Valencia area found the following species in the cottonwood-willow forest: Fremont cottonwood (*Populus fremontii*), sycamore (*Platanus racemosa*), Mexican elderberry (*Sambucus mexicana*), yellow willow (*Salix lasiandra*), arroyo willow (*S. lasiolepis*), sandbar willow (*S. hindsiana*), mule fat (*Baccharis salicifolia*), and giant reed (*Arundo donax*). Other areas support little vegetation with only individuals of mule fat (*Baccharis salicifolia*) and salt bush (*Atriplex sp.*) well represented.



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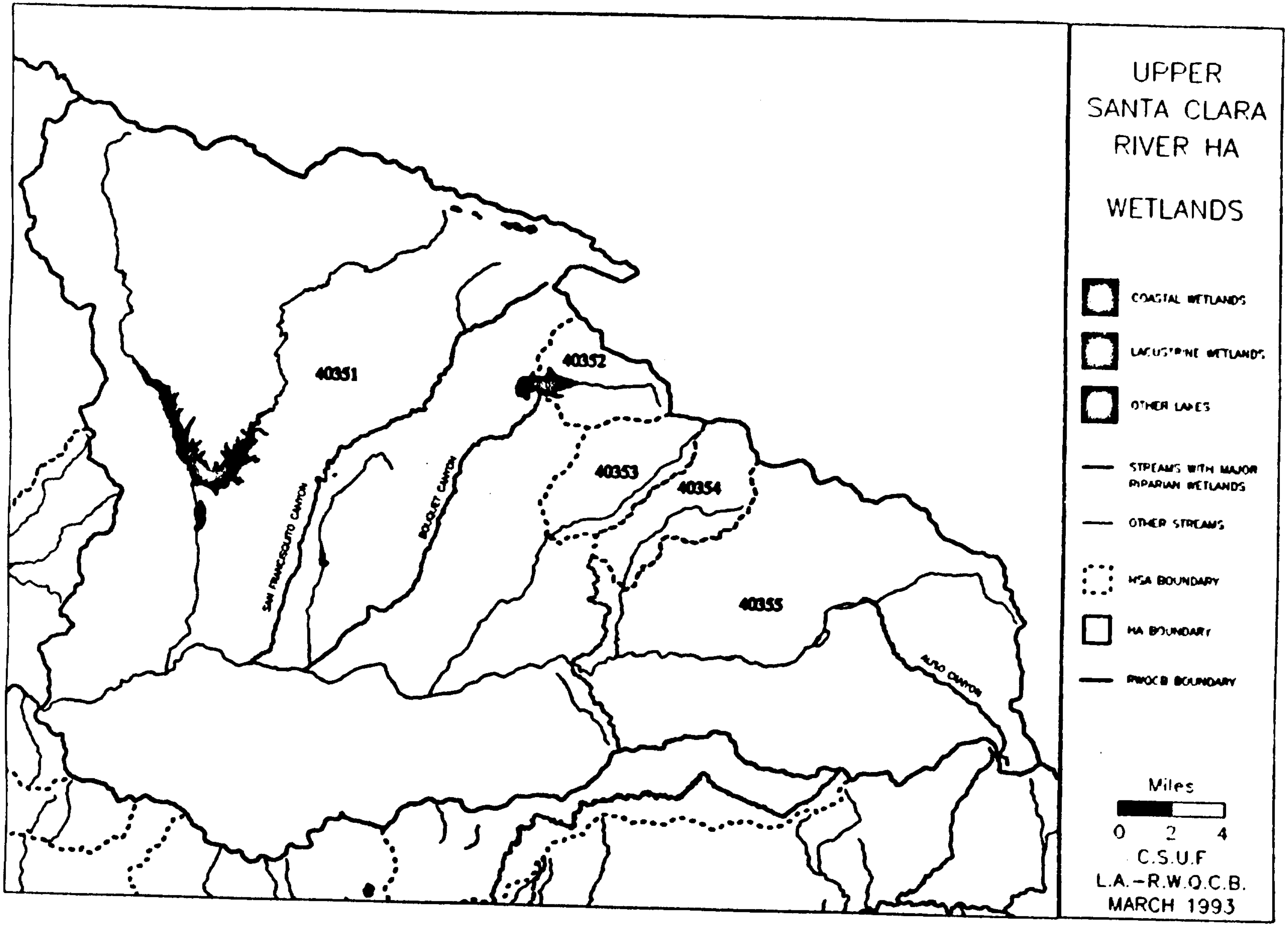
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SAN FRANCISQUITO CANYON
BOUQUET CANYON
ALISO CANYON

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L.A. Regional Water Quality Control Board
Riparian Wetlands: San Francisquito Canyon

San Francisquito Canyon (403 51[illegible]) is a riparian wetland which extends nearly 2[illegible] miles from the Santa Clara River to the confluence with [illegible] miles west of [illegible] Valley. The majority of San Francisquito Canyon lies within the Angeles National Forest and is designated as Ecologically Significant Area No. 1[illegible] for Los Angeles County. Two populations of the unarmored threespine stickleback [illegible] aculeatus williamsoni), which is now restricted to portions of the Santa Clara River and San Francisquito Canyon, [illegible] found [illegible] Reservoir and above Baird Canyon. This fish is on both State and Federal endangered species lists. San Francisquito Canyon is able to support these populations because the surrounding watershed is undisturbed, keeping sedimentation to a minimum and because of rich and healthy riparian forests. The habitat quality is also reflected in the designation of the stream as a an active trout fishing stream by USFS and CDFG. The riparian habitat consists of various types including white alder riparian forest, southern arroyo willow riparian forest, southern mixed riparian forest and coast live oak riparian forest. Currently, San Francisquito Canyon is the most favorable area for management of the endangered fish due to possibility of controlling development.

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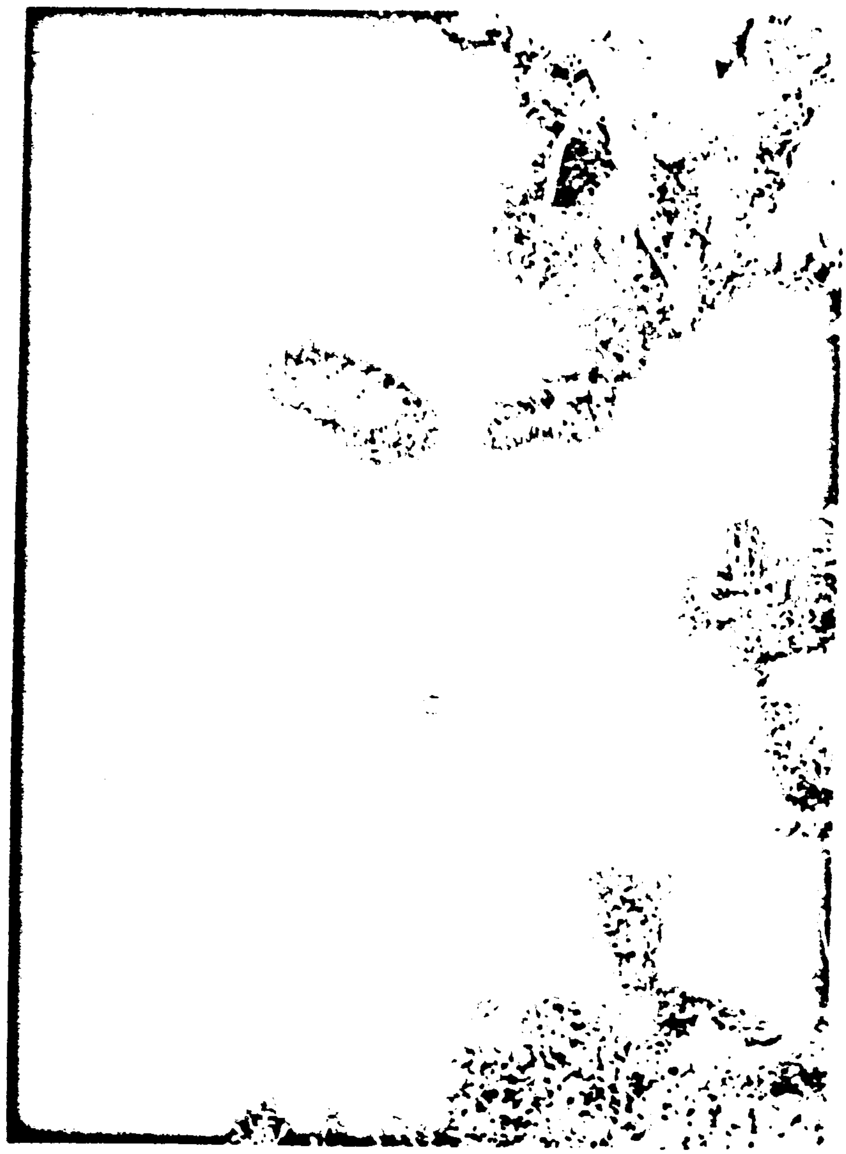
L. A. Regional Water Quality Control Board
Riparian Wetlands: Bouquet Canyon Creek

Bouquet Canyon Creek (403.51) [illegible] wetland [illegible] [illegible] the Bouquet Reservoir [illegible] Santa Clarita. The habitat [illegible] with a mixture of riparian wetland and [illegible] forest. The stream is perennial [illegible] regulated [illegible] the dam for the reservoir. The vegetation types include southern coast [illegible] riparian forest and southern mixed riparian forest. Common species include Fremont cotton-wood (*Populus fremontii*), coast live oak (*Quercus agrifolia*), and sycamore (*Platanus racemosa*). Understory components include hydrophytes: watercress (*Rorippa nasturtium-aquaticum*), sedges (*Carex* spp.), giant nettle (*Urtica holosericea*), and mint (*Mentha spicata*).

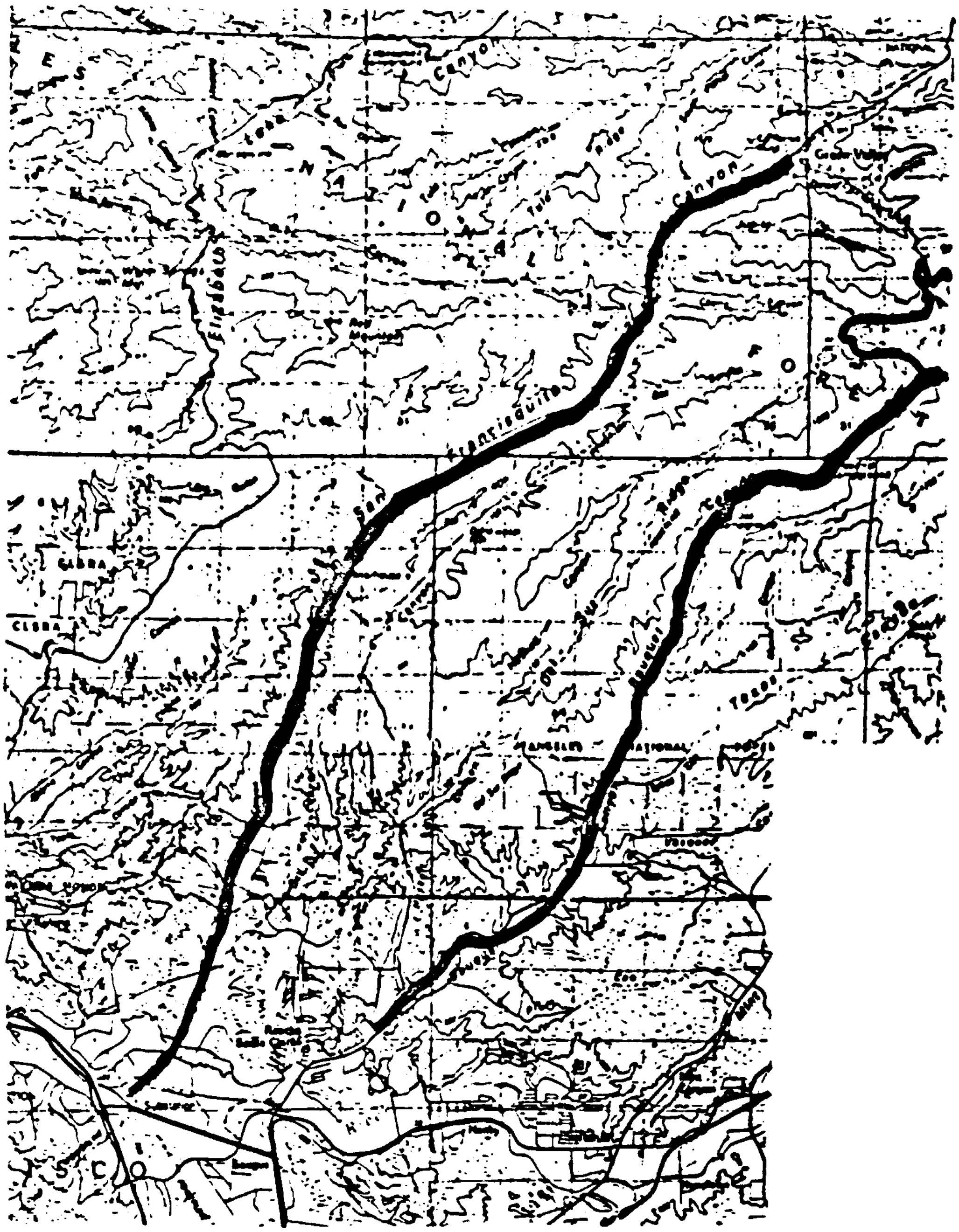
At a site near Texas Canyon, southern arroyo willow riparian forest was dominant with understory [illegible] hydrophytes (*Typha* sp.) and sedges (*Carex* sp.). Giant reed (*Arundo donax*) is become established in the lower portions of the canyon and represents the major source of disturbance.



Above: Bouquet Canyon Creek with rich understory within Southern Mixed Riparian Forest

Opposite Page: Freshwater Marsh along San Francisquito Canyon Creek. Hydrophytes include cattail (*Typha latifolia*), Tule (*Scirpus*), Sedges (*Carex*) and [illegible] (*Euthamia occidentalis*)

L.A. Regional Water Quality Control Board
Tributaries of the Santa Clara River



San Francisquito and Bouquet Canyons: L.A. 30 X 60 min Quadrangle.

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L.A. Regional Water Quality Control Board
Riparian Wetlands: Soledad Canyon

Soledad Canyon (405.55) - The uppermost part of the Santa Clara River beginning approximately where Soledad Canyon Rd. joins the river. Soledad Canyon extends 21.5 miles and is an interrupted stream. Soledad Canyon is contained within Los Angeles County Ecologically Significant Area No. [illegible] which extends into Aliso Canyon. Areas with permanent water are habitat for the threespine stickleback (*Gasterosteus aculeatus williamsoni*), an endangered fish. The lower portion of Soledad Canyon consists primarily of southern cottonwood-willow riparian forest interspersed with southern arroyo willow riparian forest. Upper portions above Acton Camp contain significant stands of the diminishing alluvial scrub vegetation which extends into the lower reaches of Aliso Canyon and Kentucky Springs Canyon. Botanical surveys found scalebroom (*Lepidospartum squamatum*), great basin sage (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), bush senecio (*Senecio douglasii*), mule fat (*Baccharis salicifolia*), California buckwheat (*Eriogonum fasciculatum*) and *Eriastrum densifolium* to be most common.

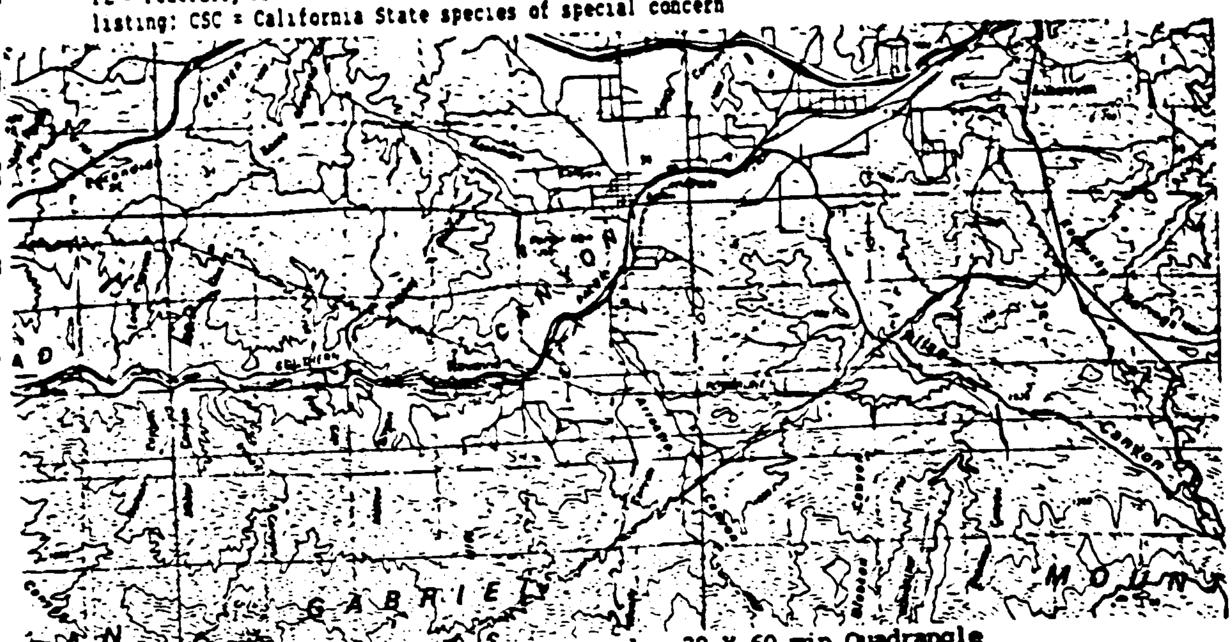
1 9020

Alluvial Scrub in Kentucky Springs Canyon near Soledad Canyon.
Opposite Page: Los Angeles 30 X 60 min Quadrangle.

Rare and Sensitive Species on the Santa Clara River and its Major Tributaries

BIRDS		
California least tern	*Sterna antillarum browni*	FE,SE
Western snowy plover	*Charadrius alexandrinus nivosus*	C1,CSC
California condor	*Gymnogyps californianus*	FE,SE
Black-shouldered kite	*Elanus caeruleus*	CSC
Cooper's hawk	*Accipter cooperii*	CSC
Spotted Owl	*Strix occidentalis*	C2
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	SE
Bank swallow	*Riparia riparia*	CSC
Least Bell's vireo	*Vireo bellii pusillus*	FE,SE
Yellow warbler	*Dendroica petechia brewsteri*	CSC
Yellow-breasted chat	*Icteria virens*	CSC
Southwestern willow flycatcher	*Empidonax traillii extimus*	C1
Belding's savannah sparrow	*Passerculus sandwichensis belbingi*	SE,C2
REPTILES AND AMPHIBIANS		
Arroyo southwestern toad	*Bufo microscaphus californicus*	C2,CSC
California red-legged frog	*Rana aurora draytoni*	C2,CSC
Southwestern pond turtle	*Clemmys marmorata pallida*	C1,CSC
San Diego horned lizard	*Phrynosoma coronatum blainvillei*	C2,CSC
Two-striped garter snake	*Thamnophis hamondii*	C2
FISH		
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*	FE,SE
Tidewater goby	*Eucyclogobius newberryi*	C1,CSC
Santa Ana sucker	*Catostomus santaanae*	C2,CSC
PLANTS		
Salt marsh bird's-beak	*Cordylanthus maritimus maritimus*	FE,SE

FE = Federally listed as endangered; SE = State listed as endangered; C1,C2 = Federal Candidate for listing; CSC = California State species of special concern



Soledad Canyon: Los Angeles 30 X 60 min Quadrangle

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Aliso Canyon Creek (403.55) is a riparian wetland which originates at Aliso Spring near Mill Creek Summit at the 4000 foot elevation. The wetland extends for nearly 5 miles to the Angelus National Forest boundary at 3,000 feet. The upper reaches of Aliso Canyon is southern riparian scrub dominated by narrowleaf willow (*Salix exigua*), arroyo willow (*S. lasiolepis*), *Rosa woodsii* var. *ultramontana* and deergrass (*Muhlenbergia rigens*. Where the streamcourse widens california sycamore (Platanus racemosa) is interspersed with the riparian scrub. The scrub/sycamore association intergrades into southern mixed riparian forest. Species present were Fremont's cottonwood (*Populus fremontii*), yellow willow (*Salix lasiandra*), and white alder (*Alnus rhombifolia*). under-story elements included various sedges (*Carex*), and western goldenrod (*Euthamia occidentalis*). Aliso Creek is a major headwater tributary of the Santa Clara River.

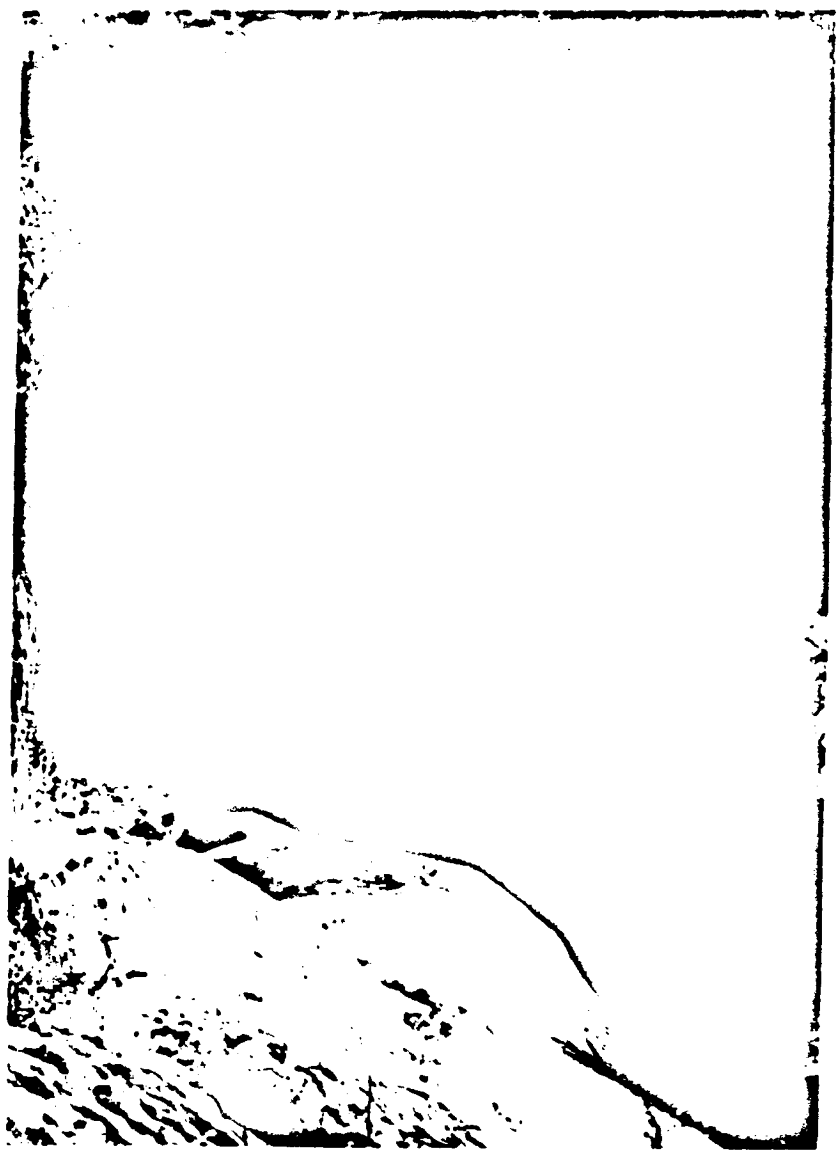

Photo: Narrowleaf Willow along Aliso Canyon Creek. Bunchgrass in lower right is Deergrass (*Muhlenbergia rigens*), which has the wetland indicator status of Facultative Wet.

Photo (Opposite Page): Southern Mixed Riparian Forest. Water present in November 1991.

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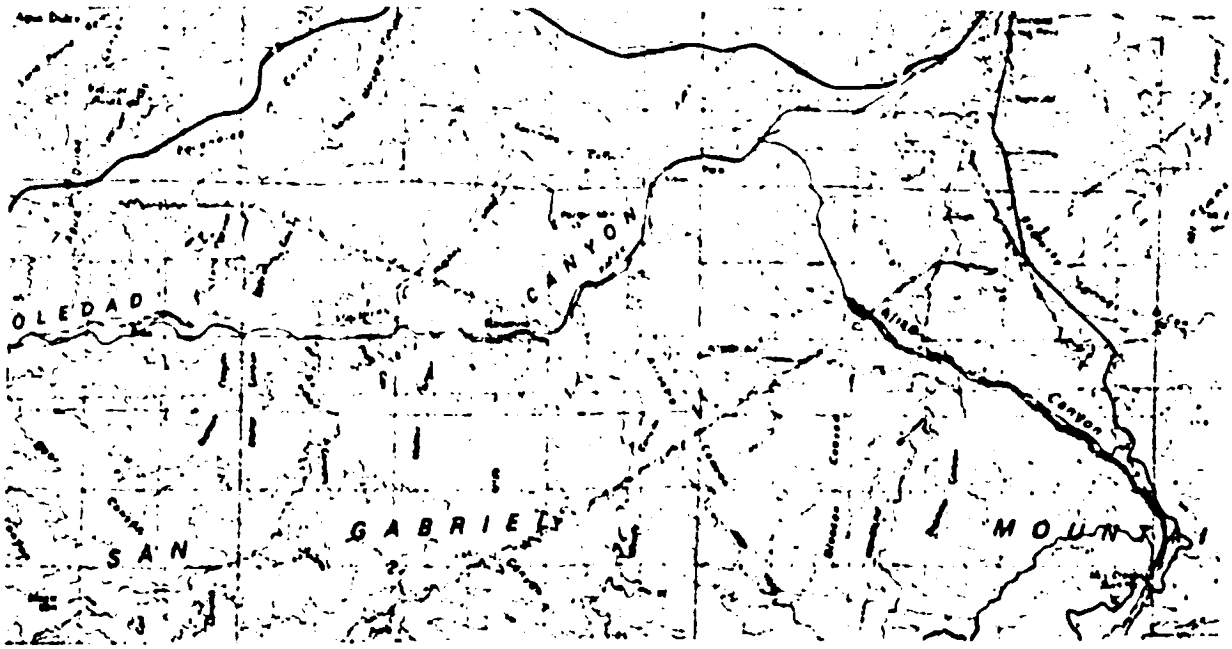


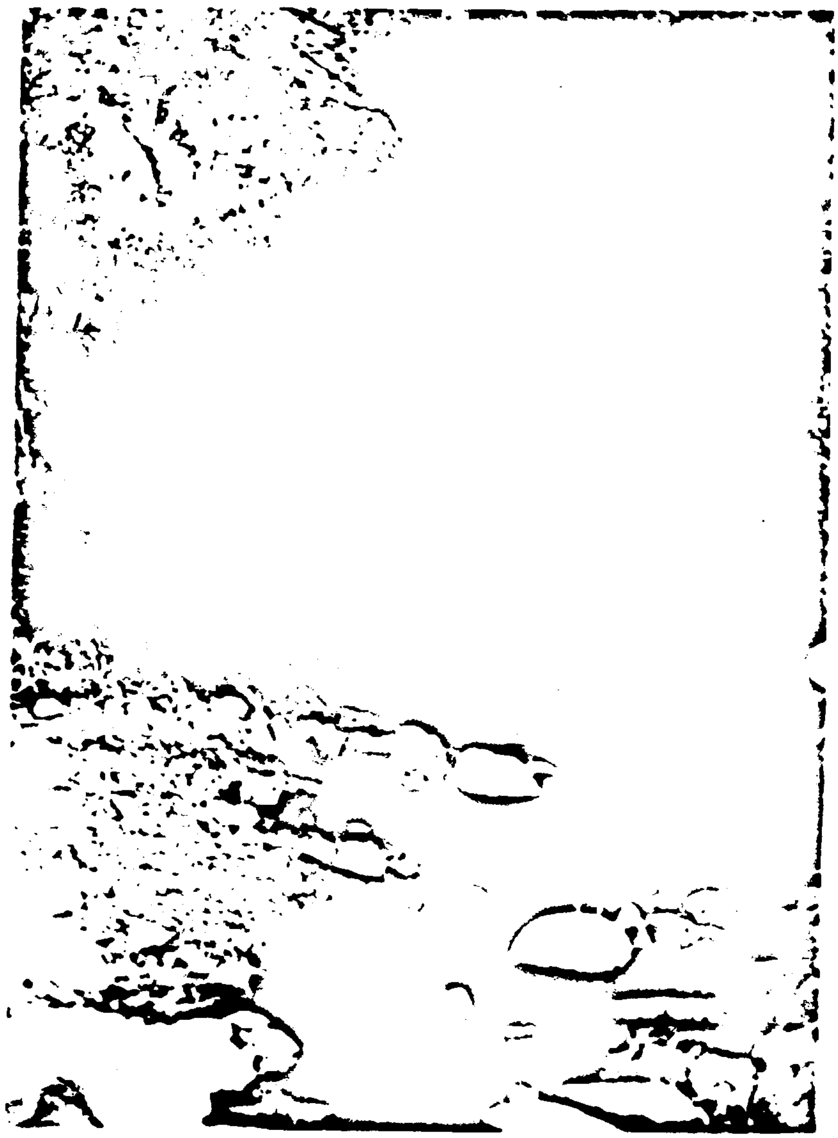
Aliso Canyon Creek from Los Angeles 30 X 60 min Quadrangle

1 9023

L.A. Regional Water Quality Control Board
Riparian Wetlands: Malibu Creek

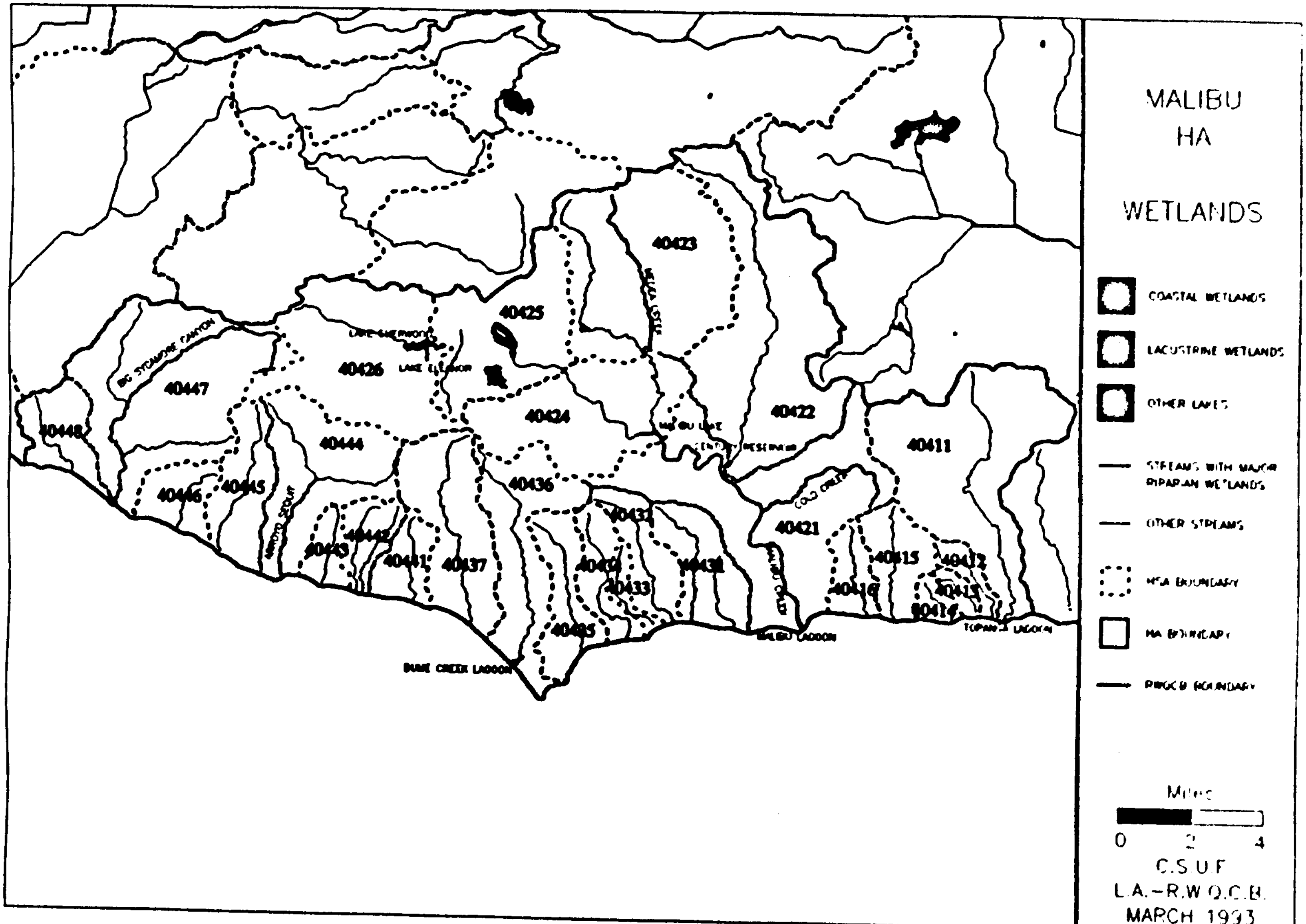
Malibu Creek (404.21) and its tributaries drain 105 square miles. Malibu Creek is fed by a complex of streams and lakes and it also receives treated wastewater. Regulation of the flow is controlled at Lake Sherwood Dam, Lake Eleanor Dam, Malibu Lake Dam, and Crag's Dam. Medea Creek and Triunfo Canyon Creek flow into Malibu Lake which is the headwaters for Malibu Creek. Las Virgenes and Cold Creeks flow directly into Malibu Creek. The headwaters of Las Virgenes and Medea Creeks originate in the Simi Hills. The wetland extends about [illegible] miles from Malibu Lake to the coast. Associated vegetation types include southern arroyo willow forest, coast live-oak riparian forest, southern sycamore alluvial woodland, and mulefat scrub. Malibu Creek is an important wildlife corridor linking various portions of the range. There is high species diversity including numerous hydrophytes, cattail (*Typha* spp.), umbrella sedge (*Cyperus eragrostis* and *C. odoratus*), and bulrush (*Scirpus* spp.). Giant reed (*Arundo donax*) is the most significant invasive exotic. *Dudleya cymosa* occurs on rocky cliffs along Malibu Creek and Tidewater Goby occurs in the estuary at the mouth of the creek. Both are candidates for federal listing.

Willow Riparian Forest along Malibu Creek, Los Angeles County.



Cold Creek (404.21) is a major tributary of Malibu Creek with the headwaters originating at the Arroyo Calabasas. The wetland extends [illegible] miles from Malibu Creek to Cold Creek Fire Road. Much of the wetland lies within the state owned Stunt's Ranch. The area receives heavy equestrian use. Two vegetation types characterize Cold Creek including coast live oak riparian forest (the most common type) and southern arroyo willow riparian forest. The oak forest has an unusually high level of diversity among the herbaceous understory and includes scarlet monkeyflower (*Mimulus cardinalis*), willow-herb (*Epilobium adenocaulon*), scouring rush (*Equisetum spp.*), goldenrod (*Solidago californica*), wild celery (*Apium graveolens*), and mugwort (*Artemisia douglasiana*). Lyons pentachaeta (*Pentachaeta lyonii*), which is listed as endangered, both federally and by the state, is found on Stunt Ranch as is the San Diego Horned Lizard which is a federal candidate species. The major source of disturbance is from giant reed (*Arundo donax*), and pampas grass (*Cortaderia atacamensis*).

Coast Live Oak Riparian Forest along Cold Creek, Los Angeles County. California Bay Laurel (*Umbellularia californica*): foreground, right.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BIG SYCAMORE CANYON
LAKE ELEANOR
MALIBU LAKE
COLD CREEK
MALIBU LAGOON
TOPANGA LAGOON

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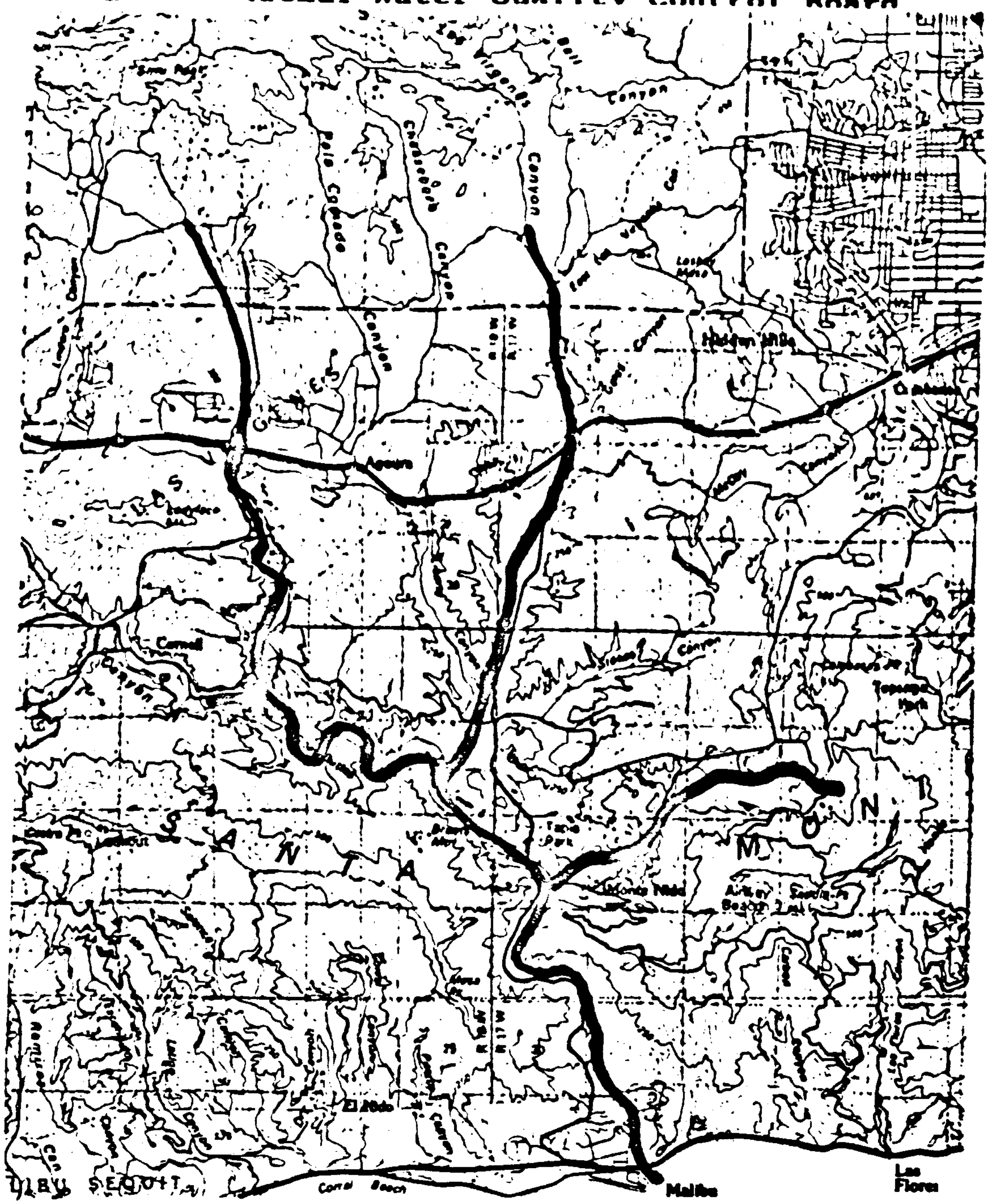

Riparian Wetland of the central Santa Monica Mountains
From Los Angeles 30 X 60 min Quadrangle

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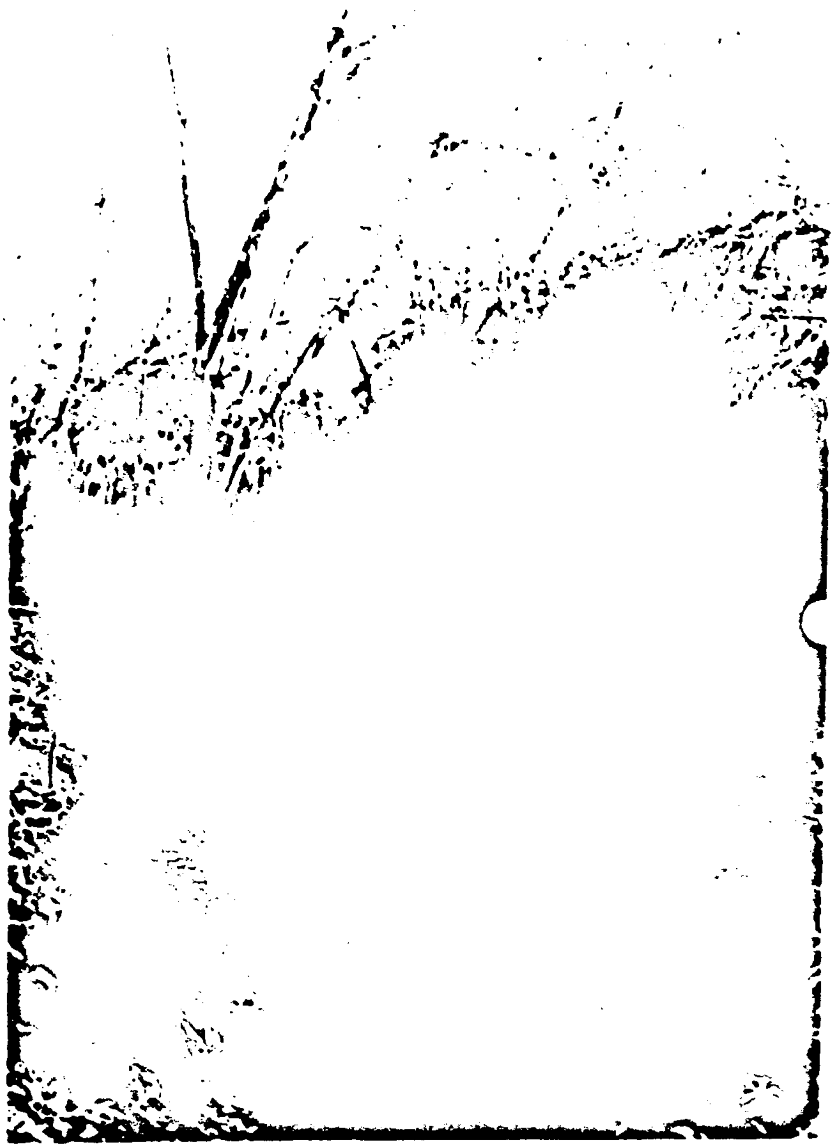
Medea Creek (404.23-404.24) begins in the Simi Hills and terminates in Malibu Lake which is the headwaters for Malibu Creek. The wetland extends from Malibu Lake to the confluence with Lindero Canyon Creek and Palo Comado Canyon Creek, just south of Highway 101. The wetland is 1.5 miles in length and consists of southern arroyo willow riparian forest. The understory is sparse containing mugwort (*Artemisia douglasiana*), giant nettle (*Urtica holosericea*), and blackberry (*Rubus ursinus*). Braunton,s milk vetch (*Astragalus brauntonii*), a candidate for federal listing, is found near the creek.

Las Virgenes Canyon Creek (404.22) - originates in the Simi Hills and empties into Malibu Creek. The wetland extends 7 miles from Malibu Creek to the confluence with East Las Virgenes Canyon Creek. North of Highway 101 is a mixture of coast live oak riparian forest, southern riparian scrub, and mulefat scrub. South of Highway 101 is southern arroyo willow riparian forest.



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Above: Dense Growth of Southern Arroyo Willow Riparian Forest, Medea Creek, Los Angeles County.

L.A Regional Water Quality Control Board
Riparian Wetlands: Arroyo Sequit

Arroyo Sequit (404.44) is one of the best preserved small coastal drainages in Region 4. It lies partly within each of Ventura and Los Angeles Counties. The headwaters originate at over 2,000 feet below Sandstone peak. The wetland begins at the confluence of the East and West Forks of Arroyo Sequit and extends 3.2 miles to the Pacific Ocean. The habitat is primarily sycamore alluvial woodland dominated by Sycamore (*Platanus racemosa*). Scattered individuals of California black walnut (*Juglans californica*) are found throughout the drainage. The flow is interrupted but still supports a wide variety of native aquatic animals, including resident and migratory populations of rainbow trout and steelhead trout.

Arroyo Sequit looking through *Platanus racemosa* which is beginning to leaf out in early Spring.

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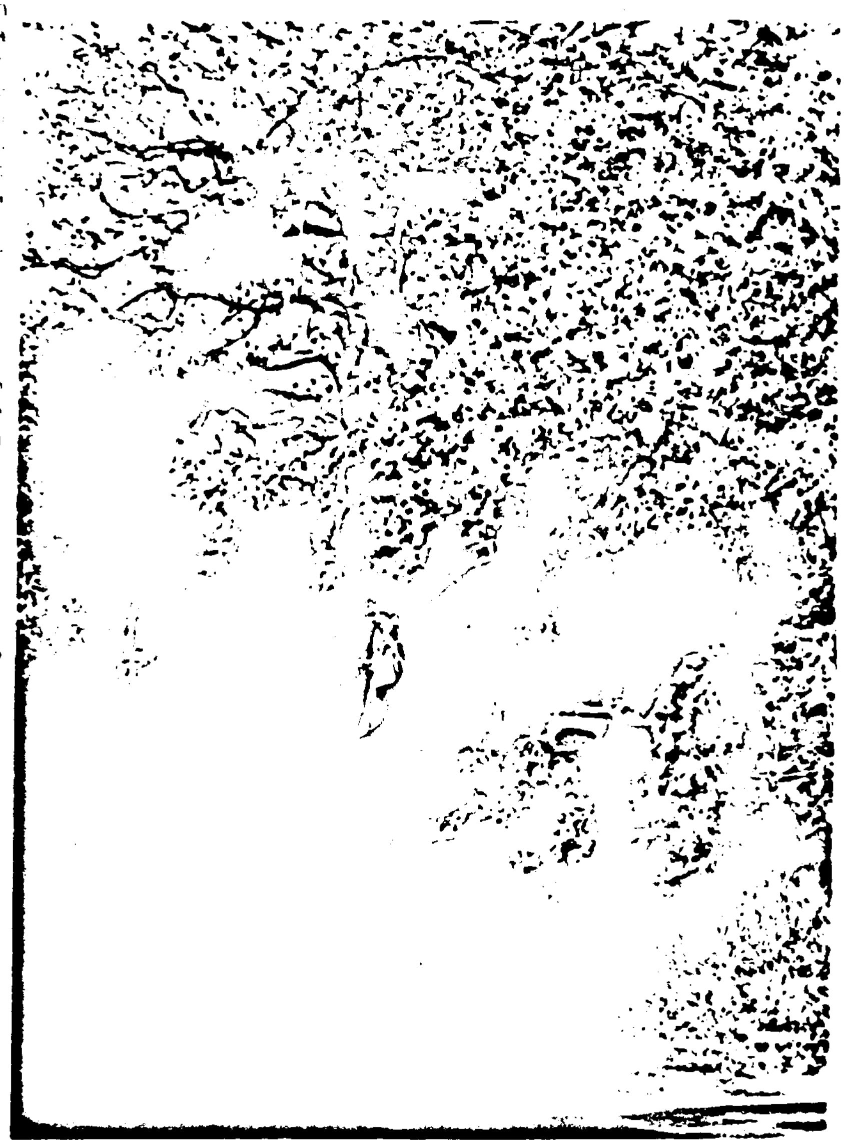
L.A. Regional Water Quality Control Board
Riparian Wetlands: Big Sycamore Canyon

Big Sycamore Canyon Creek (404.47) is a premiere example of southern sycamore alluvial woodland within Region 4. It lies within Point Mugu State Park and the Santa Monica Mountains National Recreation Area. The wetland originates at 2,200 feet below Boney Mountain. The wetland begins at about 900 feet and extends 6 miles to the Pacific Ocean. The sycamore woodland has a dense understory of herbs and shrubs including mulefat (*Baccharis salicifolia*), blackberry (*Rubus ursinus*), smilo grass (*Piptatherum miliaceum*), cocklebur (*Xanthium strumarium*), laurel sumac (*Malosma laurina*), mugwort (*Artemisia douglasiana*), and willow (*Salix lasiolepis*). The riparian corridor has a network of trails which receive heavy use by hikers and mountain bikers. The riparian habitat is an important corridor for wildlife species within the Santa Monica Mountains providing access between the coast and interior portions of the range.



Sycamore Woodland dominated by
Platanus racemosa in Mugu State Park.

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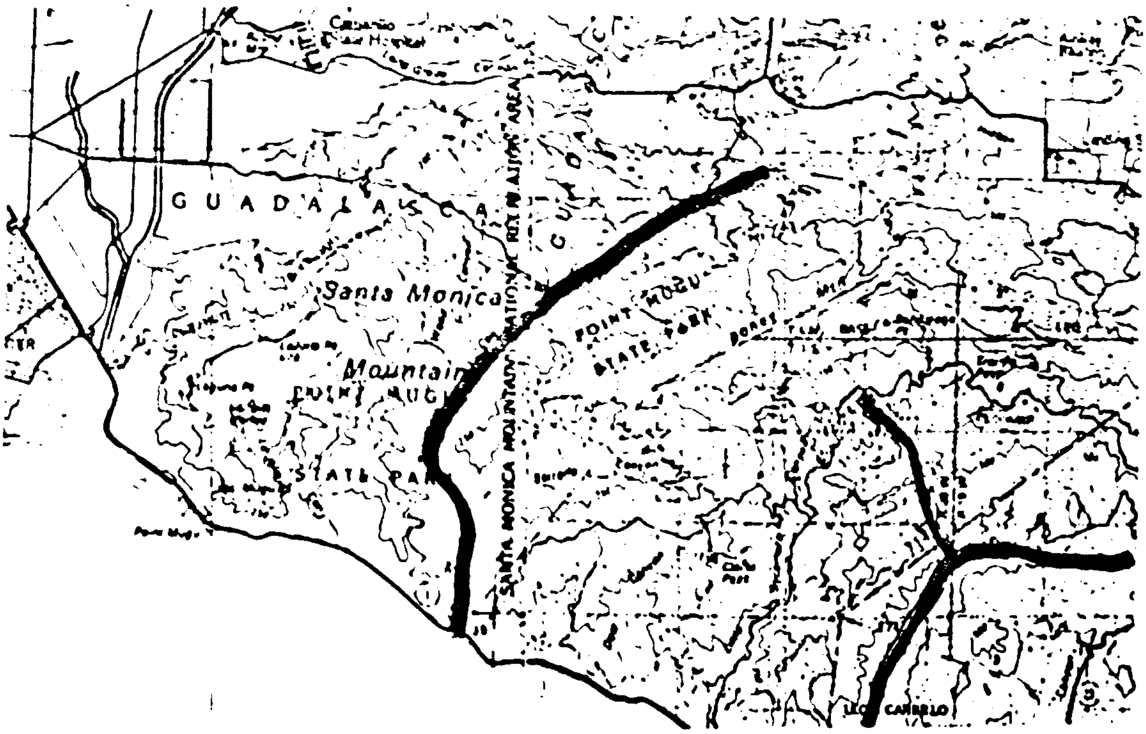

Above: Sycamore Canyon from Los Angeles and Santa Barbara 30 X 60 min Quadrangles
Below: Mulefat Scrub in Little Sycamore Canyon near discharge into Pacific Ocean

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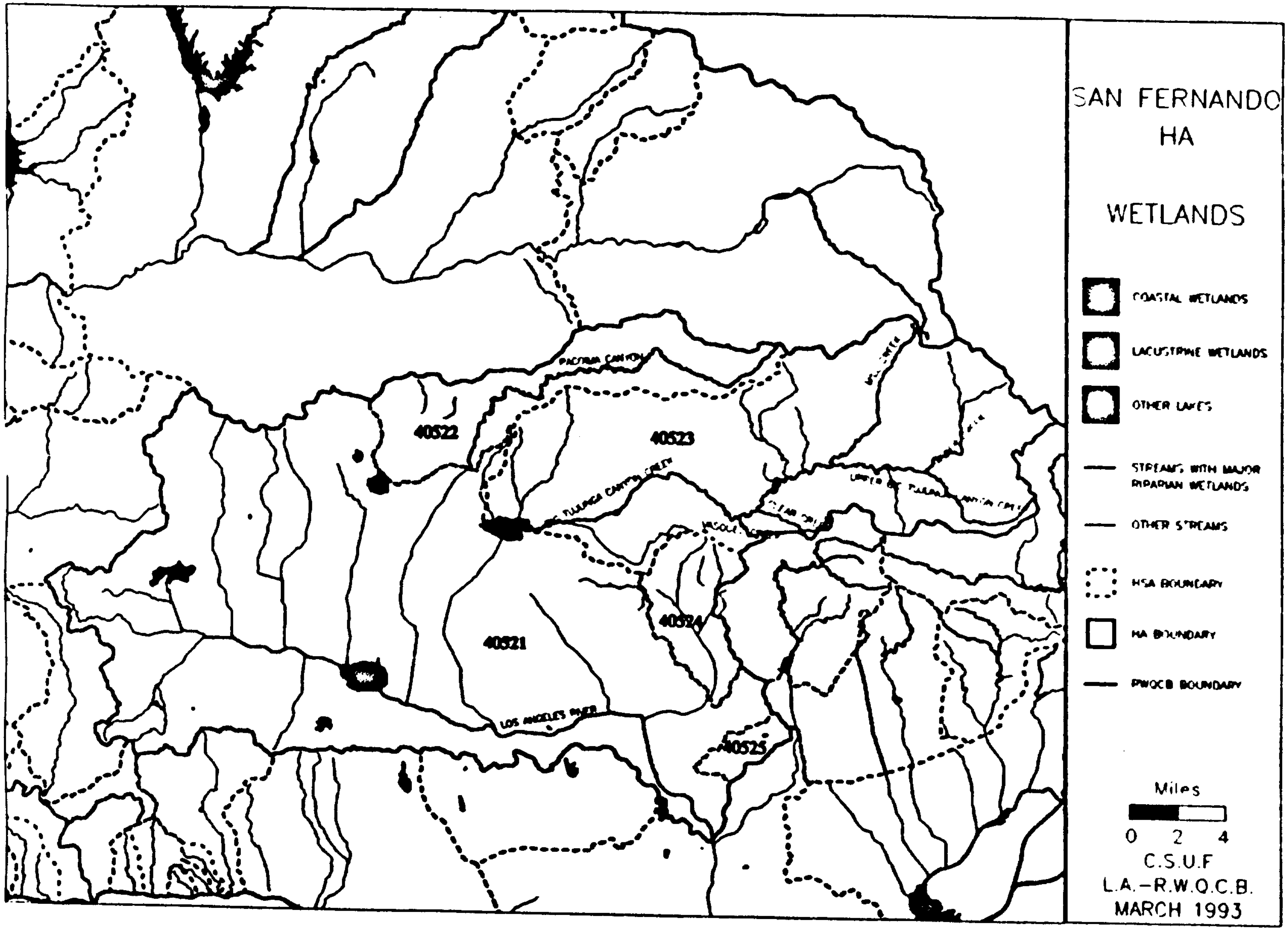
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PACOIMA CANYON
LOS ANGELES RIVER

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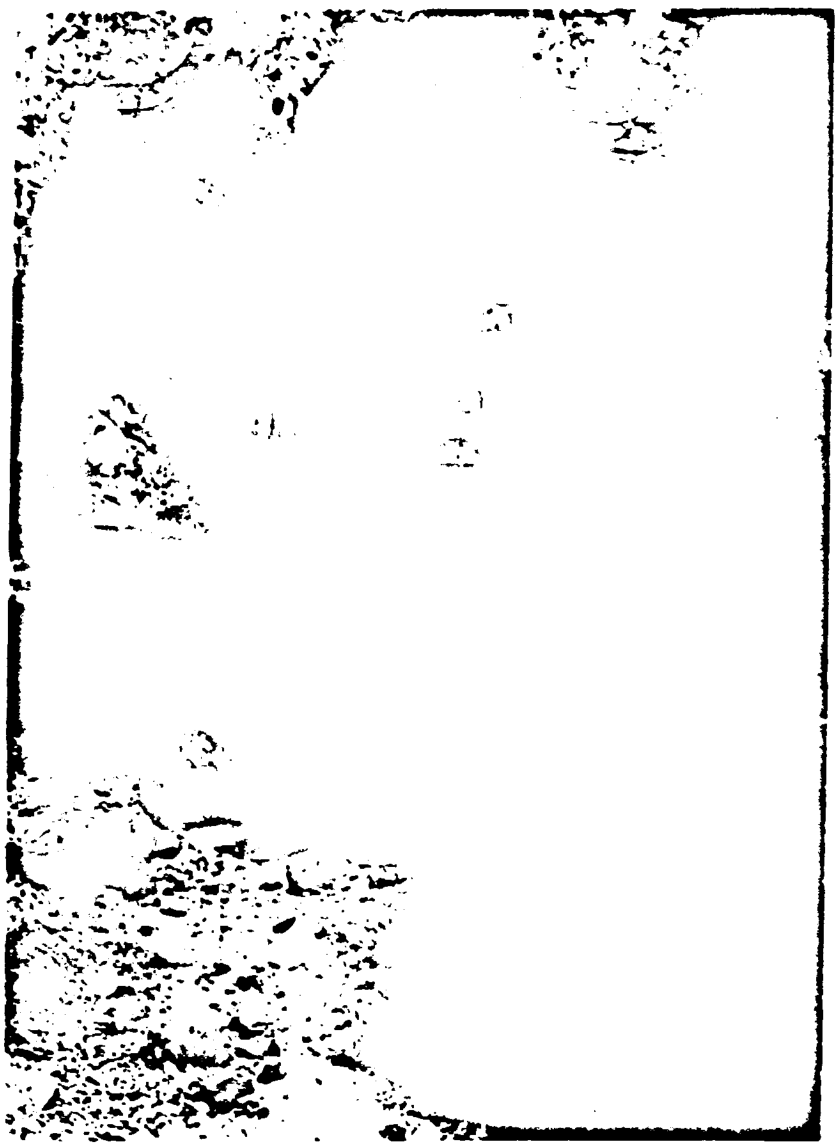
L.A. Regional Water Quality Control Board
Riparian Wetlands: Upper Big Tujunga Creek

Upper Big Tujunga Canyon Creek (405.23) [illegible] part [illegible] the headwaters [illegible] the [illegible] Tujunga drainage. It originate[illegible] [illegible] feet [illegible] the Angeles Forest Highway. The wetland [illegible] the highway [illegible] miles [illegible] the confluence with [illegible] Creek. The stream has perennial water [illegible] though [illegible] reduced to large pools with only [illegible] the rainy season begins in November. The vegetation is white alder riparian [illegible] interspersed with [illegible] riparian [illegible]. There is a high diversity in the understory including many hydrophytes: mugwort (*Artemisia douglasiana*), [illegible] monkey flower (*Mimulus guttatus*), scarlet monkey flower (*M. cardinalis*), willowherb (*Epilobium* sp.) and sedge (*Carex* sp.). The habitat is undisturbed, receiving light use by hikers. There are no significant invasive exotic plants in the area.

Upper Big Tujunga Canyon Creek showing pools at the end of the dry season in October. White Alder (*Alnus rhombifolia*) is in center.



[illegible] portion of Alder [illegible] is an [illegible] drainage with a [illegible] of riparian woodland bordered by alluvial scrub. Botanical surveys found high diversity. Trees include white alder (Alnus rhombifolia), sycamore (Platanus racemosa), [illegible] willow (Salix lasiolepis), red willow (S. [illegible]) and yellow willow (S. lasiandra). Alluvial scrub species include scalebroom (Lepidospartum squamatum), mulefat (Baccharis salicifolia), California brickelbush (Brickellia californica) and great basin sage (Artemisia tridentata). The wetland extends from the confluence of the West and Middle Forks of Alder [illegible] Upper Big Tujunga Canyon [illegible]. The [illegible] located [illegible].

Above: Mixed Conifer [illegible] M. [illegible] L.A. [illegible]

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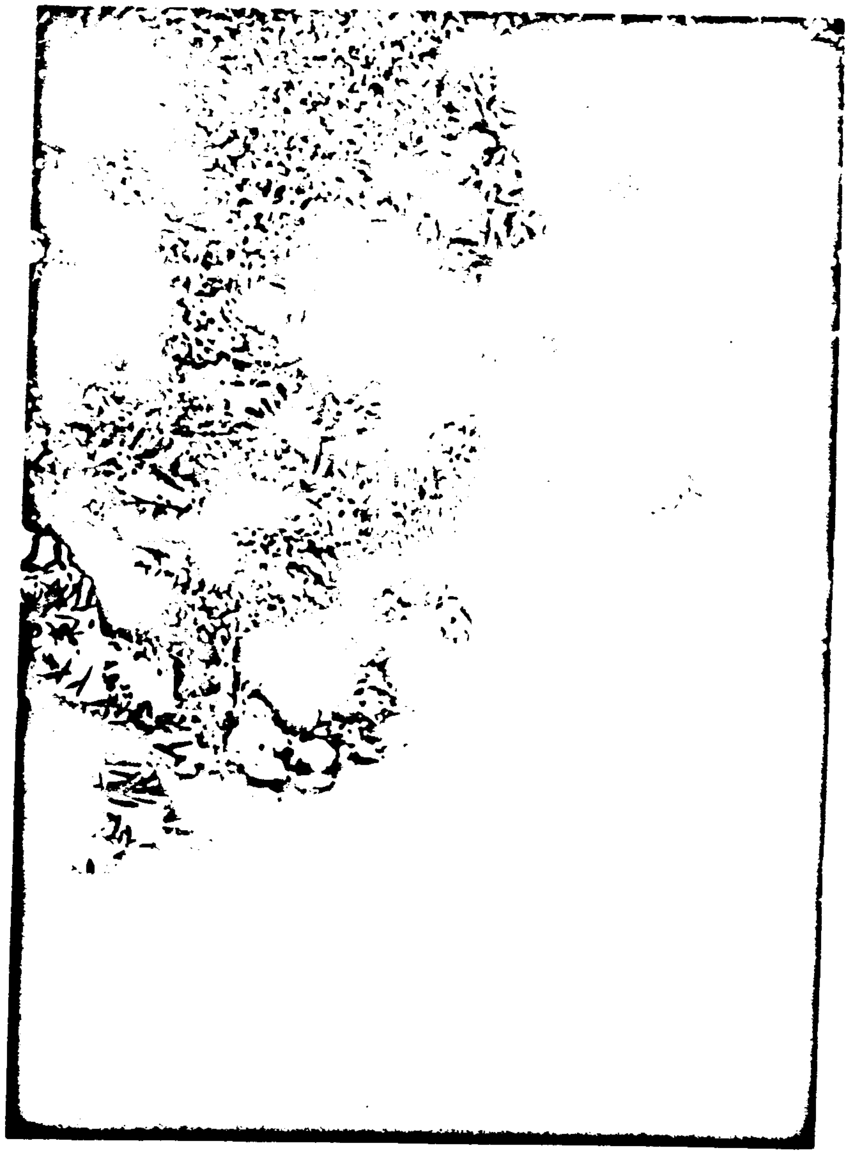

Mill Creek (40 [illegible] Baughman Spring and extends 5.0 miles to the Big Tujunga and Upper Big Tujunga confluence. This part of the creek is a mixture of white alder riparian forest and southern arroyo willow riparian forest. [illegible] surveys near Singing Springs found a mixed riparian forest of willows (Salix laevigata and S. lasiolepis) and alders with [illegible] hydrophytes in the understory: knotweed (Polygonum sp.), willow herb (Epilobium sp.), wiregrass (Juncus sp.) and [illegible]. Black cottonwood was also present. The habitat [illegible] [illegible] Highway.

Above: Mill Creek shaded by Willows and Alders

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L.A Regional Water Quality Control Board
Riparian Wetlands: Vasquez Creek

Vasquez Creek 405.23 is a tributary to Big Tujunga Canyon Creek which originates at [illegible] feet in the Angelus National Forest. The wetland extends [illegible] miles from the [illegible] foot elevation point to Big Tujunga Canyon Creek. The Canyon is steep and narrow with canyon live oak ravine forest dominant in the upper reaches. In the lower reaches the oak forest integrades in California bay (Umbellularia californica) and finally into white alder riparian forest with Alnus rhombifolia and big leaf maple (Acer macrophyllum). The understory is sparse containing mugwort (Artemisia douglasiana), boykinia (Boykinia rotundifolia), alum root (Heuchera sp.) and poison oak (Toxicodendron diversilobum). The habitat is undisturbed by invasive exotics. The area is used only lightly for hiking due to the narrowness of the canyon.

White Alder Riparian Forest in Vasquez Creek, Los Angeles County

Opposite Page Top: Upper Big Tujunga, Alder Creek and Mill Creek Los Angeles 30 X 60 min Quadrangle

Opposite Page Bottom: Riparian Woodland and Alluvial Scrub in Lower Alder Creek, Los Angeles Co.

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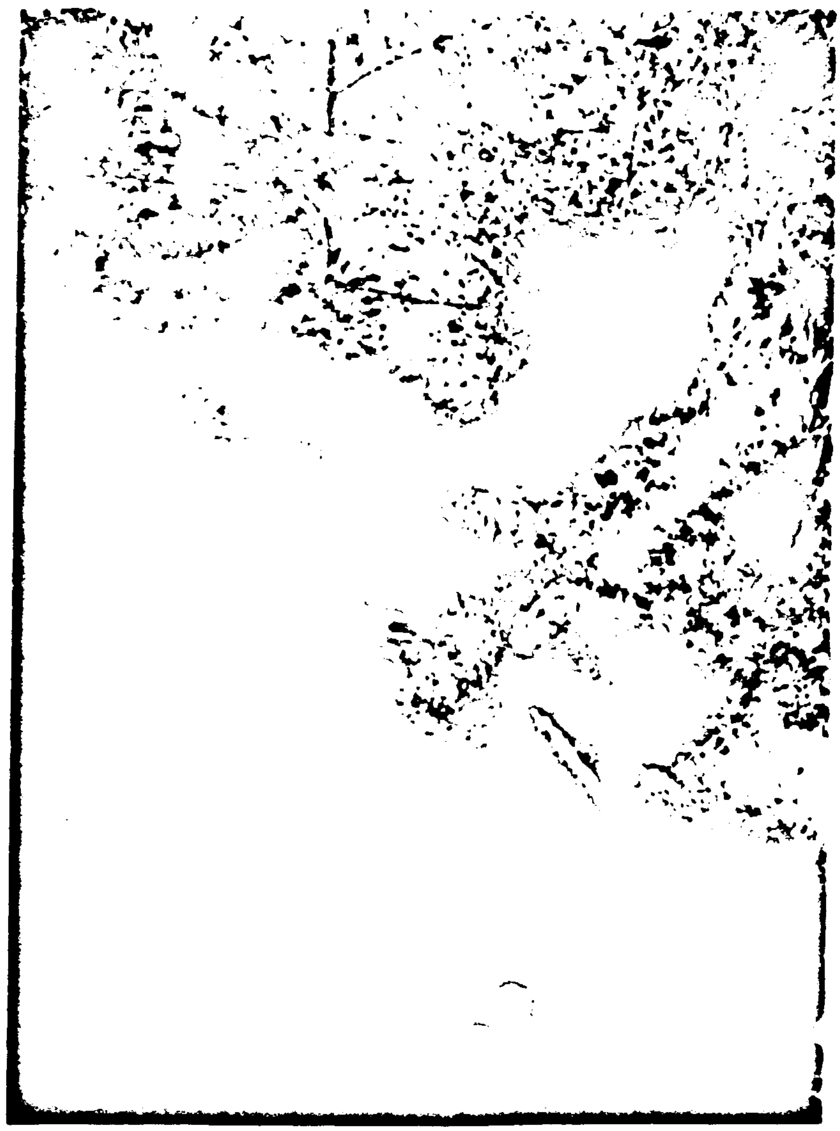
Clear Creek [illegible] tributary of Big Tujunga [illegible] confluence [illegible] west of Big Tujunga Dam. The wetland extends [illegible] Tujunga [illegible] three-quarters of a mile [illegible] Station. The elevation of the wetland [illegible] 2,150 feet [illegible] feet. Water [illegible] typically present [illegible] round though in the fall the flow is reduced to a trickle with large pools of up to two feet deep remaining. The vegetation is diverse. The canopy is white alder riparian forest including big leaf maple (*Acer macrophyllum*), California bay laurel (*Umbellularia californica*) and canyon live oak (*Quercus chrysolepis*). The understory is rich in herbaceous species including *Boykinia rotundifolia*, scarlet monkeyflower (*Mimulus cardinalis*), mugwort (*Artemisia douglasiana*), sedges (*Carex*) and willowherb (*Epilobium* sp.).



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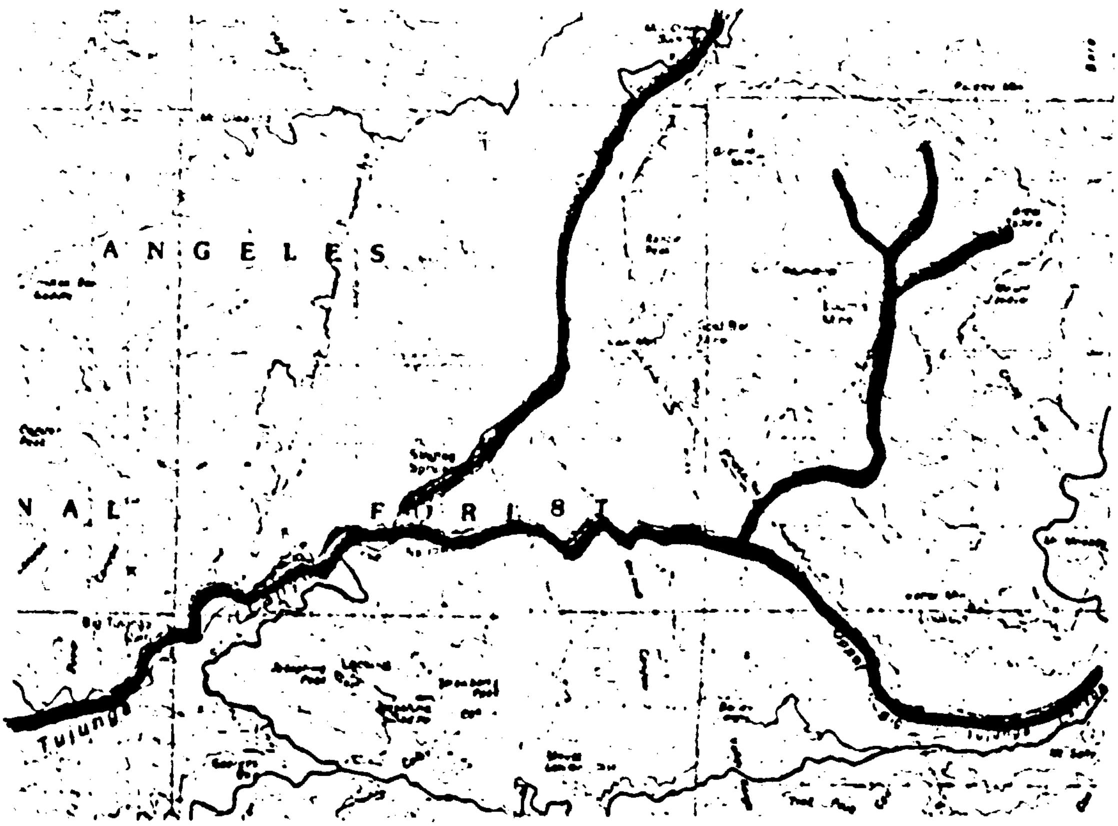
Above: Big Leaf Maple (*Acer macrophyllum*) with Scarlet Monkey Flower (*Mimulus cardinalis*) in the Understory.

Opposite Page: Big Tujunga Canyon with tributaries from Los Angeles 30 X 60 min Quadrangle.



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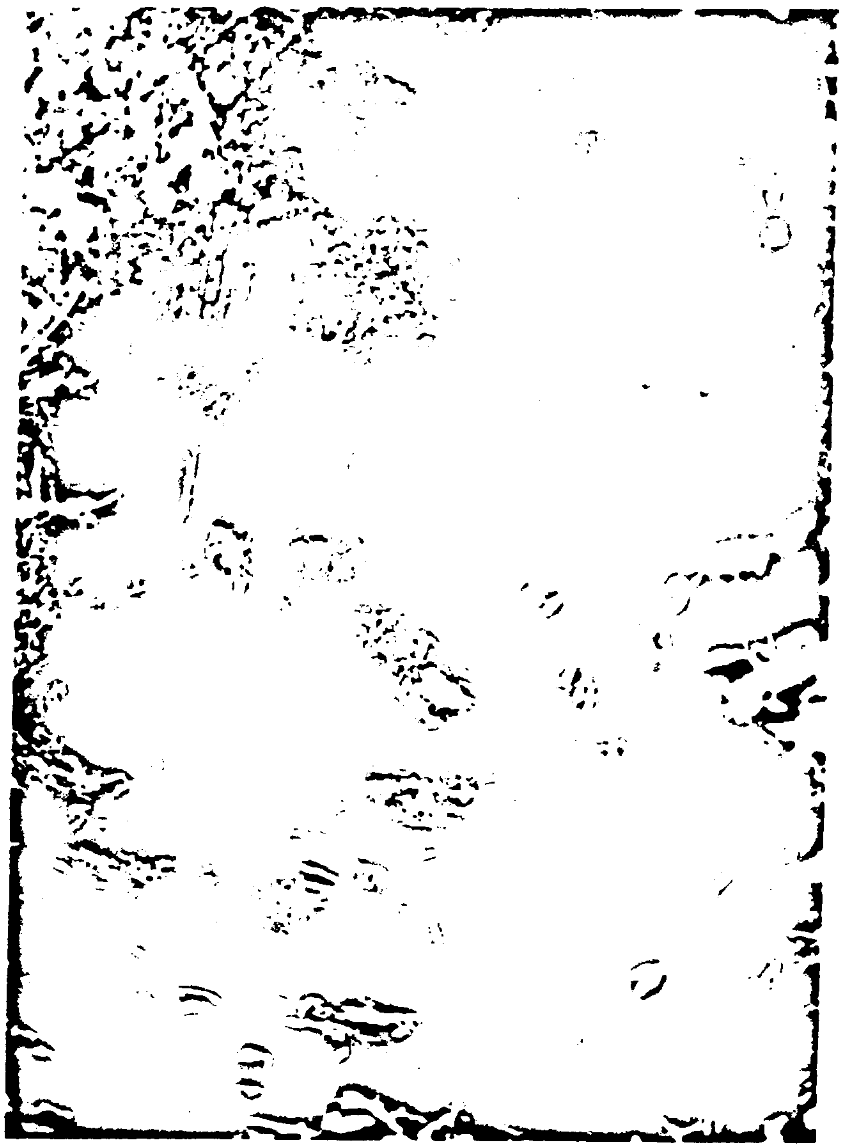
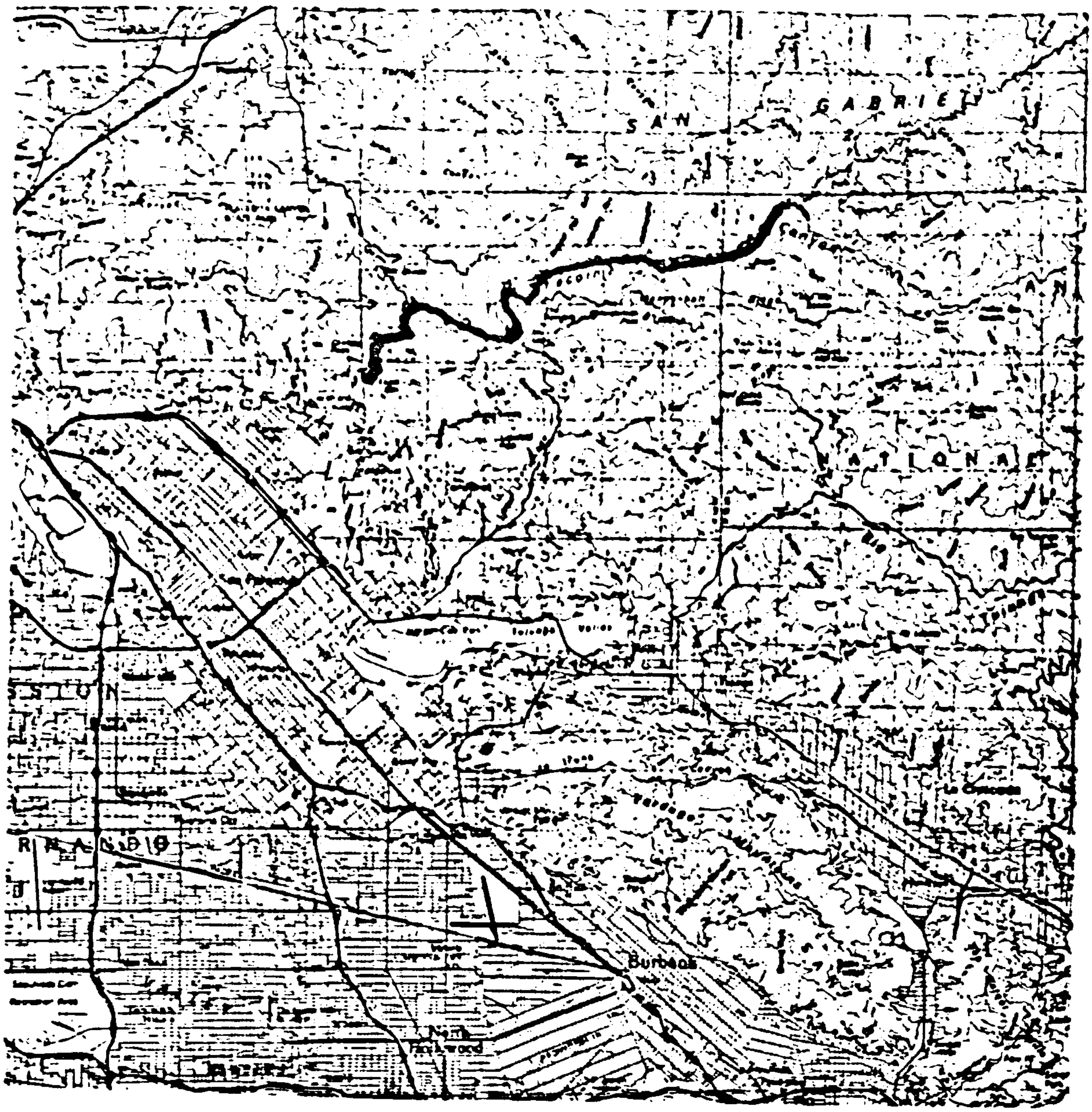
L.A. Regional Water Quality Control Board
Riparian Wetlands — Pacoima Canyon Creek

Pacoima Canyon Creek [illegible] ... [illegible] ... of Pacoima Canyon Creek and extends [illegible] miles to the [illegible]. [illegible] Botanical survey found a number of riparian communities based upon the hydrological regime. White alder riparian forest is an [illegible] indicator of perennial surface water such as west of the [illegible] Divide. Here white alder (Alnus rhombifolia) grows where there is surface water. Where the water is [illegible] the surface arroyo willow (Salix lasiolepis) is dominant. Understory plants include mugwort (Artemisia douglasiana), giant nettle (Urtica holosericea) and blackberry (Rubus ursinus). Other riparian communities include mule fat scrub dominated by Baccharis salicifolia and Southern coast live oak riparian forest with Quercus agrifolia as the indicator species.



Ecotone between White Alder Riparian Forest and Southern Arroyo Willow Riparian Forest in Pacoima Canyon Creek, Los Angeles [illegible]



Riparian wetland associated with Pacoima Canyon Creek from Los Angeles 30 X 60 min Quadrangle

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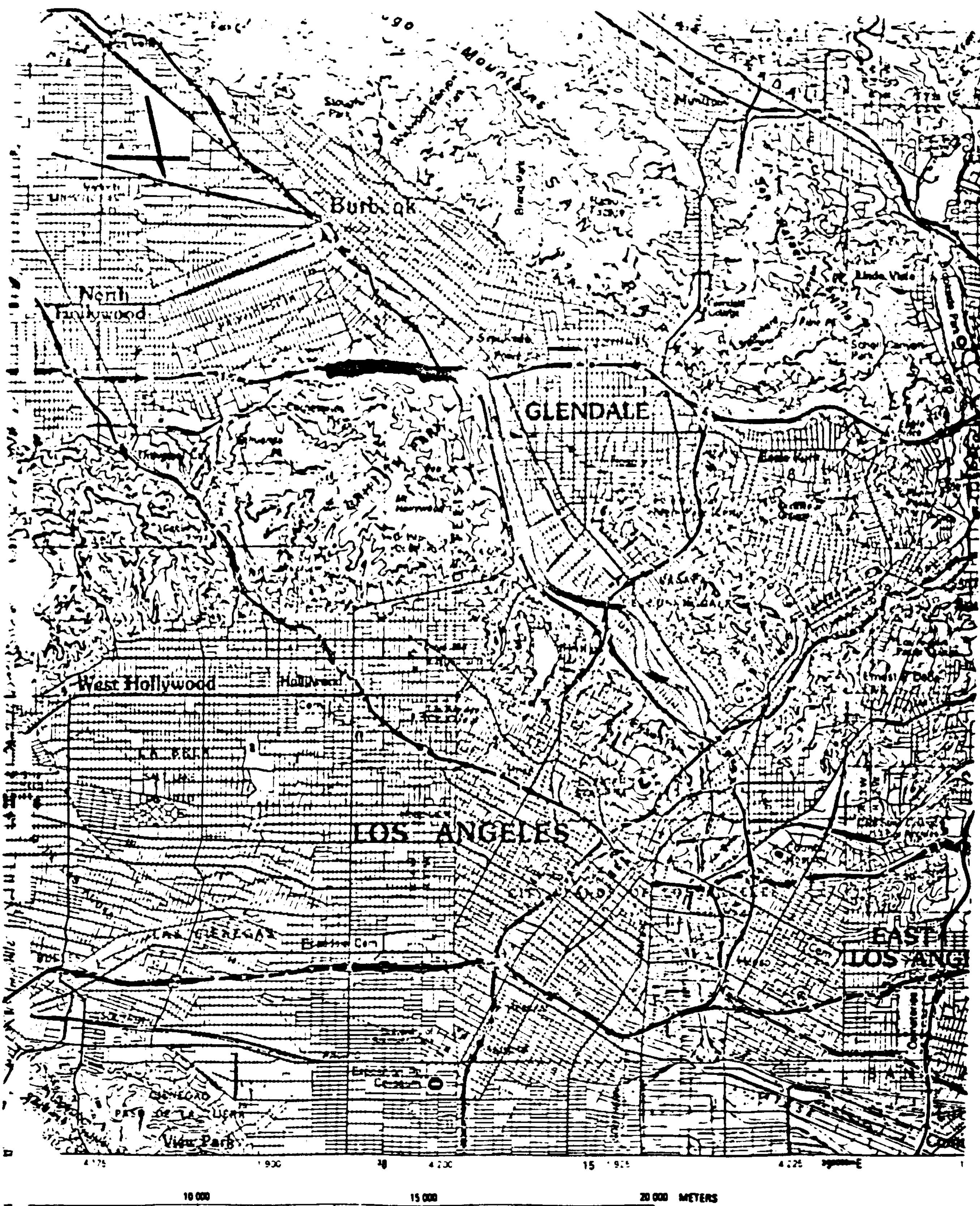
L.A. Regional Water Quality Control Board
Riparian Wetlands: Los Angeles River

The Los Angeles River (405.21) is concrete lined for most of its 4[illegible].1 miles. Two sections remain soft-bottomed and contain significant riparian and wetland habitat. The first section lies below the Sepulveda Dam Recreation Area extending 2.3 miles. The second and larger of the two reaches, covering 7.0 miles lies between Riverside Drive on the west and Figuroa St. on the east. The habitat is quite variable and diverse. Much of the channel contains significant stands of yellow willow (*Salix lasiandra*) which is the largest of the tree willows native to southern California. Giant reed (*Arundo donax*) an invasive exotic has become established in the channel, and although it is largely removed during flooding it quickly becomes reestablished from underground rhizomes. Botanical surveys found numerous hydrophytes including arroyo willow (*Salix lasiolepis*), sandbar willow (*S. hindsiana*), cattails (*Typha domingensis* and *T. latifolia*), bulrush (*Scirpus spp.*), knotweed (*Polygonum spp.*), cocklebur (*Xanthium strumarium*), barnyard grass (*Echinochloa crus-galli*), joint paspalum (*Paspalum distichium*), and umbrella sedges (*Cyperus eragrostis*, *C. alternifolius*). Other hydrophytes include various species of wiregrass (*Juncus*) and sedge (*Carex*). The riparian vegetation is habitat for numerous birds both resident and migratory. Many shorebirds such as snowy egrets (*Egretta thula*) can be found feeding along the shallows and on sandbars within the river. The river bottom has invertebrate species upon which many of the large migratory birds feed. This portion of the Los Angeles River is an ecological island for many species which depend on this habitat in a highly urbanized region.



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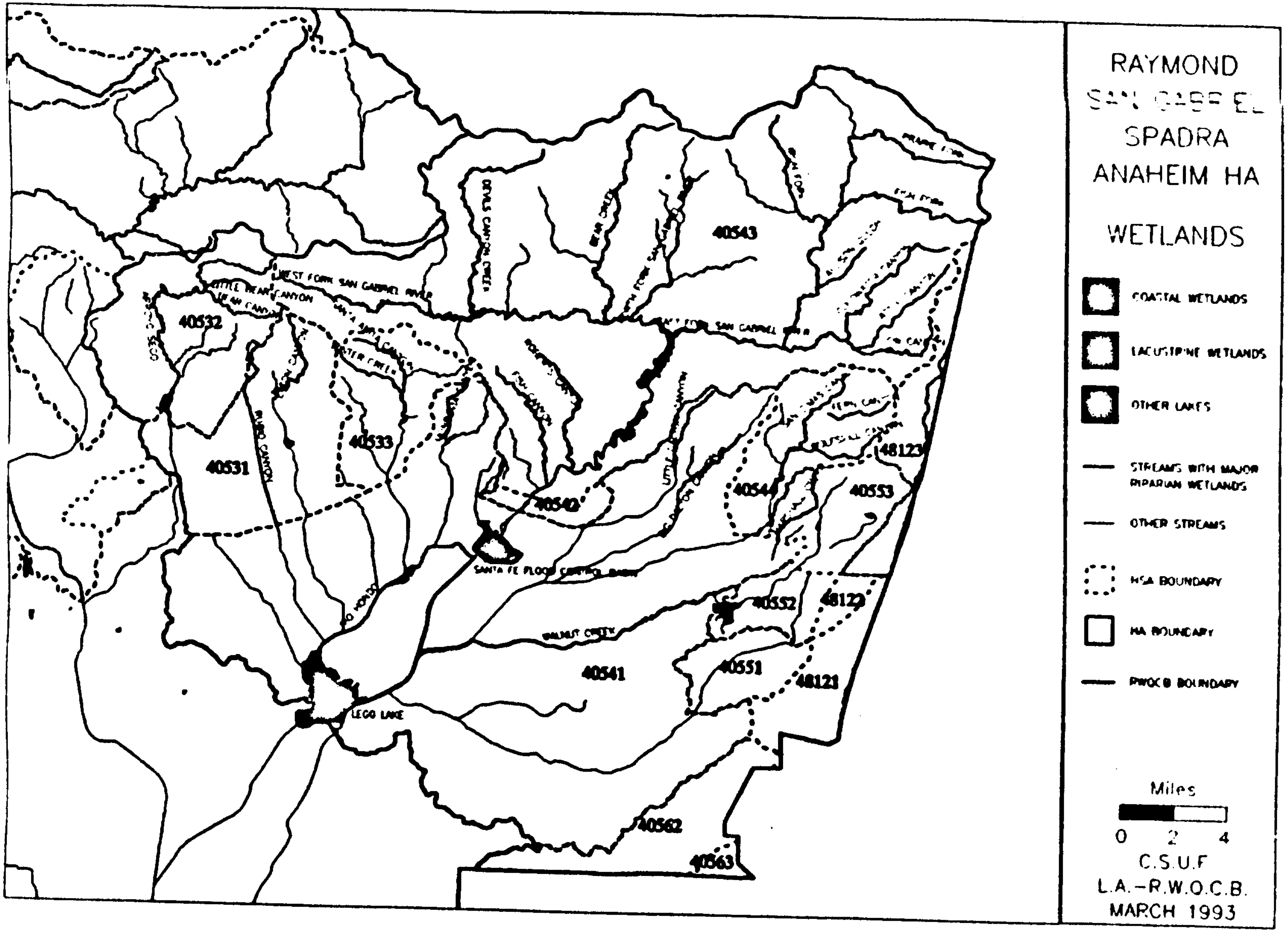

RAYMOND
SAN GABRIEL
SPADRA
ANAHEIM HA
WETLANDS
COASTAL WETLANDS
LACUSTRINE WETLANDS
OTHER LAKES
STREAMS WITH MAJOR RIPARIAN WETLANDS
OTHER STREAMS
HSA BOUNDARY
HA BOUNDARY
RWQCB BOUNDARY
Miles
0 2 4
C.S.U.F
L.A.-R.W.Q.C.B.
MARCH 1993
WEST FORK SAN GABRIEL RIVER
LITTLE BEAR CANYON
BEAR CANYON
EAST FORK SAN GABRIEL RIVER
SANTA FE FLOOD CONTROL BASIN
WALNUT CREEK
LEGG LAKE
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40532
40533
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L.A. Regional Water Quality Control Board
Riparian Wetlands: San Gabriel River System

The San Gabriel River, including all of the major forks, is the longest river system in Region 4 covering 108 linear miles. The watershed contains the highest point in Region 4 which is Mount San Antonio (= Mt. Baldy) at 10,080 feet and is highlighted by some of the most spectacular scenery and pristine habitat in the region. All of the upper watershed drains National Forest lands and includes two wilderness areas, the San Gabriel and Mountain Sheep Wilderness Areas which provide habitat for Nelson's bighorn sheep.

The perennial nature of the streams, that make up the headwaters of the San Gabriel River, is due to two major factors: 1) geological substrate and 2) precipitation regime. The watershed is underlain by igneous rock which has been extensively fractured by tectonic forces through geologic time. Unlike most metamorphic rock, this highly fractured rock can store large quantities of water. The water enters the hydrologic cycle as precipitation, most of which falls between November and April, when the moisture laden air from Pacific storms pushes across the mountain barrier and drops moisture due to adiabatic cooling. The water percolates quickly due to the porous nature of montane soils. The water flows underground until is forced to the surface forming the many springs found throughout the mountains. The area around Crystal Lake has many such springs.

Examples of all of the major biotic zones within Region 4 are represented along the San Gabriel River beginning at the headwater areas and flowing ultimately into the Pacific Ocean. The top of Mount San Antonio is a mixture of talus and stunted limber pine forest (*Pinus flexilis*). Much of the precipitation that falls on such areas percolates into the coarse soils and run downhill. Below this zone, often where the water emerges in the form of springs, is lodgepole pine forest dominated by *Pinus contorta*. Below this zone where streams are more developed is the white fir-sugar pine forest with *Abies concolor* and *Pinus lambertiana* as co-dominants. *Pinus ponderosa* and *P. Jeffreyi* are the major components of yellow pine forest which can be found at the upper reaches of the North, Iron and Prairie Forks. Mixed conifer forest with *Pseudotsuga macrocarpa*, *Pinus ponderosa*, *Calocedrus decurrens* and also *Quercus kellogii* and *Q. chrysolepis* are below the yellow pine forest and can be found at the headwaters of the West Fork. Below these zones the riparian corridor is most typically dominated by white alder (*Alnus rhombifolia*). This is dominant on the East, West and North Forks above San Gabriel Reservoir. Below Morris Reservoir, mule fat scrub and southern arroyo willow riparian forest are widespread. Upon entering the coastal plain, alluvial scrub is dominant to the Santa Fe Reservoir complex. Below this the river is a mixture of willows interspersed with giant reed (*Arundo donax*) and annual weedy vegetation. This annual vegetation is dominant to where channelization begins between Firestone Blvd and Florence Ave in Downey. Hydrophytes such as *Scirpus olneyi* and *Juncus acutus* are found in the soft-bottomed tidal prism.

L.A. Regional Water Quality Control Board
Riparian Wetlands, Main Stem, San Gabriel River

[illegible] San Gabriel River 405.31, 405.41, 405.42, 405.4[illegible] [illegible] San Gabriel [illegible] of the [illegible] alloy [illegible] Near the [illegible] San Gabriel Canyon the river [illegible] alluvial plain [illegible] The [illegible] contains [illegible] Salix lasiolepis [illegible] Baccharis salicifolia [illegible] The [illegible] giant reed (Arundo donax) forms dense stands [illegible] between the mouth of San Gabriel Canyon and near [illegible] where the river bottom becomes channelized. Portions of this part of the river contain only nonpersistent annual vegetation which includes cocklebur (Xanthium strumarium), various brome grasses (Bromus diandrus, B. madritensis rubens and B. hordeaceus), wild oats (Avena fatua and A. barbata), barnyard grass (Echinochloa crus-galli), Johnson grass (Sorghum halepense), Dallis grass (Paspalum dilatatum), sweet clover (Melilotus indicus) and [illegible] sunflower (Helianthus annuus). Castor bean (Ricinus communis), a perennial, is also common.

San Gabriel River [illegible]

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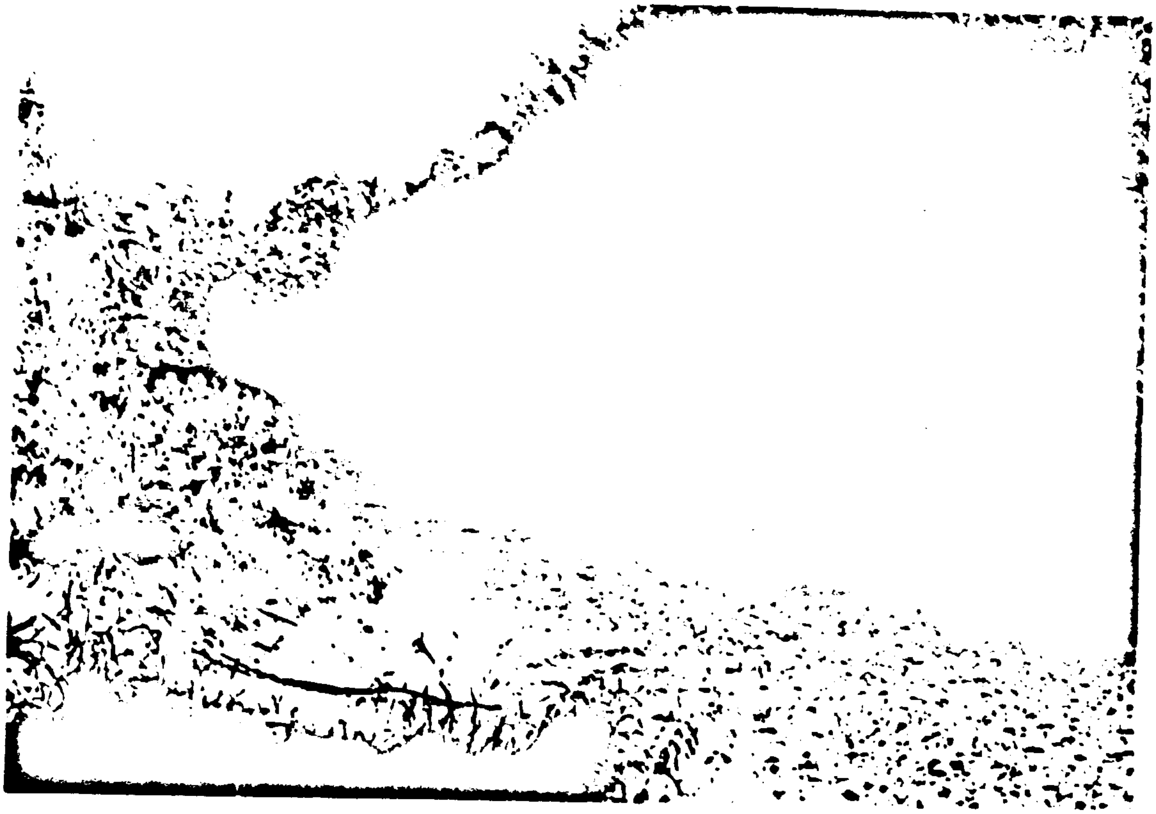
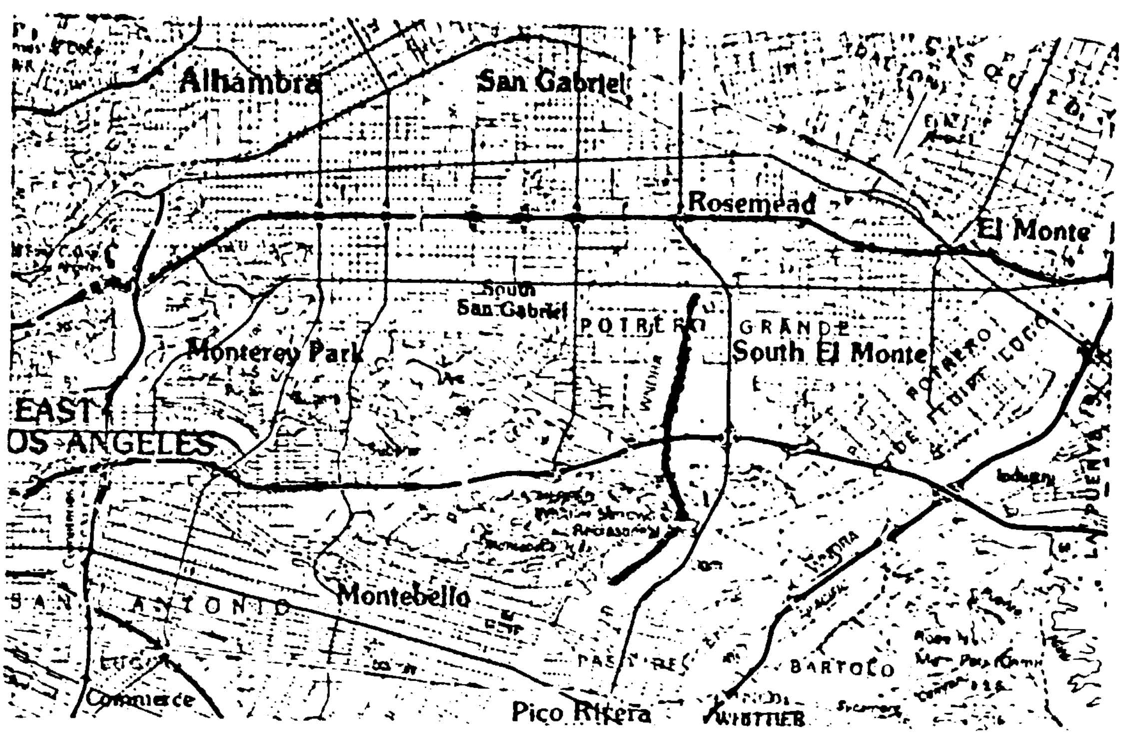
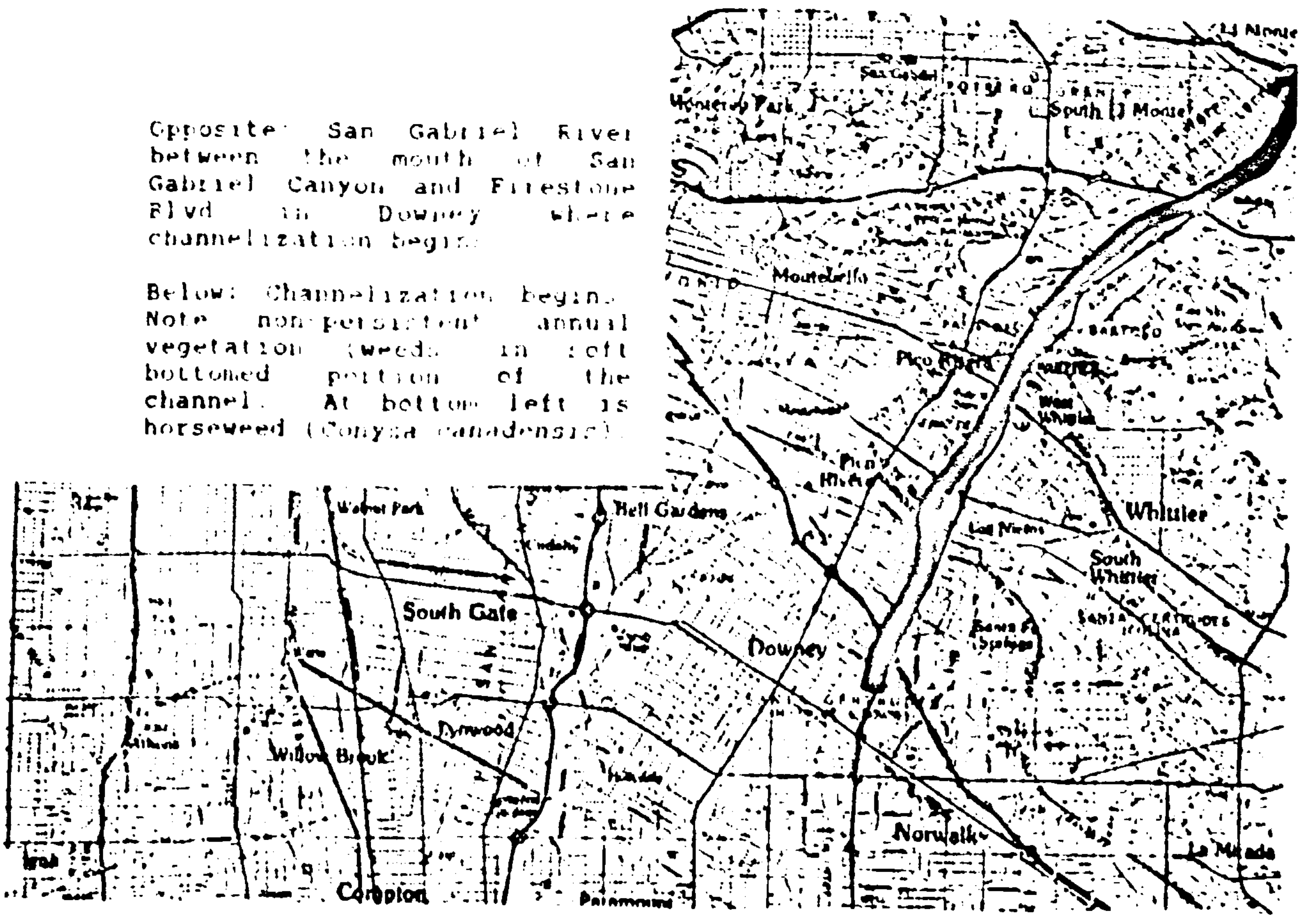



Alhambra
San Gabriel
Rosemead
El Monte
South San Gabriel
POTRERO GRANDE
South El Monte
Monterey Park
EAST LOS ANGELES
Montebello
SAN ANTONIO
BARTOLO
Commerce
Pico Rivera
WHITTIER

19046

Opposite: San Gabriel River between the mouth of San Gabriel Canyon and Firestone Blvd in Downey where channelization begins.

Below: Channelization begins. Note non-persistent annual vegetation (weeds) in soft bottomed portion of the channel. At bottom left is horseweed (Conyza canadensis).



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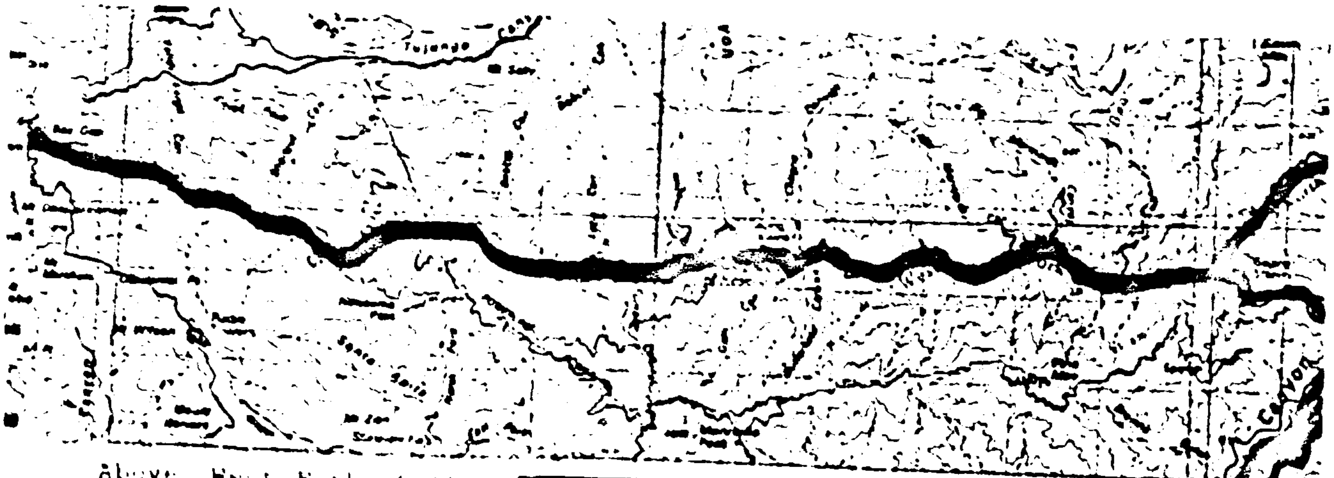
L. A. [illegible] Wetland [illegible] West Fork [illegible]

The West Fork of the San Gabriel River [illegible] feet. The [illegible] alder [illegible] Flats [illegible] Friendship [illegible] The [illegible] shrub species [illegible] The wetland [illegible] with the [illegible] in the middle portion [illegible] of [illegible] and the North Fork is white alder riparian forest and southern arroyo willow riparian forest. [illegible] to the [illegible] forests, by the alders and willows. The West Fork also defines the [illegible] boundary [illegible] the San Gabriel Wilderness [illegible] drained by Devil's Canyon Creek and Bear Creek. The area is subject to heavy use by picnickers who leave large quantities of trash, including dirty diapers in the stream. This could have a negative impact [illegible]. The West Fork is habitat to the Santa Ana sucker (Catostomus santaanae [illegible]

Alders in the Background and Willows at right along the West Fork

1 9048



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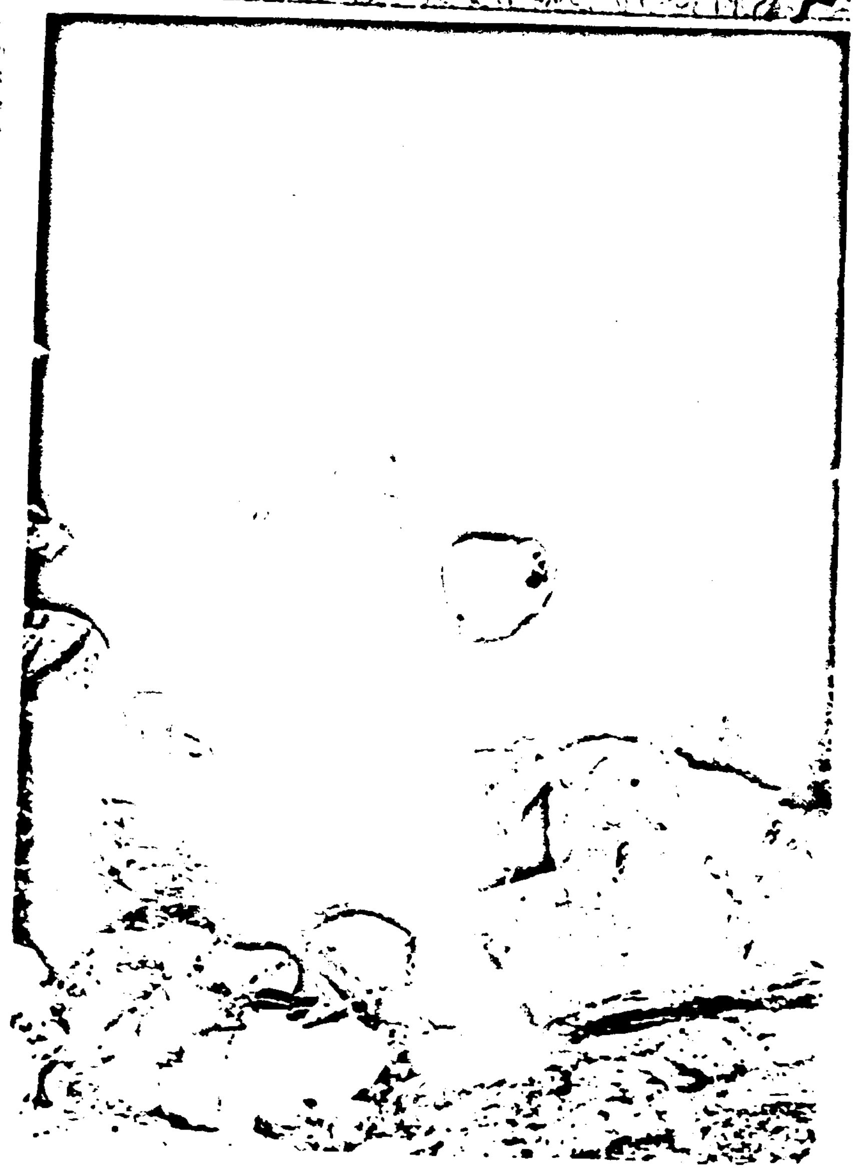
Above: West Fork of the San Gabriel River from headwaters near Red Box Gap to confluence with the North Fork of the San Gabriel River near entrance to Upper San Gabriel Reservoir.
From Los Angeles 30 X 60 min Quadrangle.

Photo: West Fork of the San Gabriel River near Red Box Gap. Canopy is Canyon Live Oak Big Cone Douglas Fir Forest with elements of alluvial scrub in the understory



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The San Gabriel Wilderness [illegible] [illegible] on the West Fork [illegible] [illegible] south. Three riparian wetlands [illegible] within the wilderness are: Bear Creek, West Fork Bear Creek, and Devil's Canyon. Headwaters for each [illegible] [illegible] 6,000 feet [illegible] Mount Waterman. Bear Creek flows into the West Fork of the San Gabriel River and Devil's Canyon empties into Cogswell Reservoir. There is little disturbance within the wilderness due to lack of access. Invasive exotic plants found in the front country canyons of the San Gabriels such as Ageratina adenophora are absent. [illegible] riparian forests in [illegible] canyon live oak-bigcone Douglas fir in the upper elevations giving way to white alder riparian forest in the lower elevations.

Devil's Canyon Creek (405.43) originates from numerous small streams draining Mount Waterman. The wetland extends 10.8 miles to Cogswell Reservoir. The trailhead providing access to the wilderness area is on Angeles Crest Highway near Chilao Creek. Canyon live oak ravine forest intergrades into white alder riparian forest. Hydrophytes include [illegible] [illegible] [illegible] cardinalis and [illegible]. Dominant trees include Pseudotsuga macrocarpa [illegible] [illegible]

Above: White Alder in Devil's Canyon, San Gabriel Wilderness

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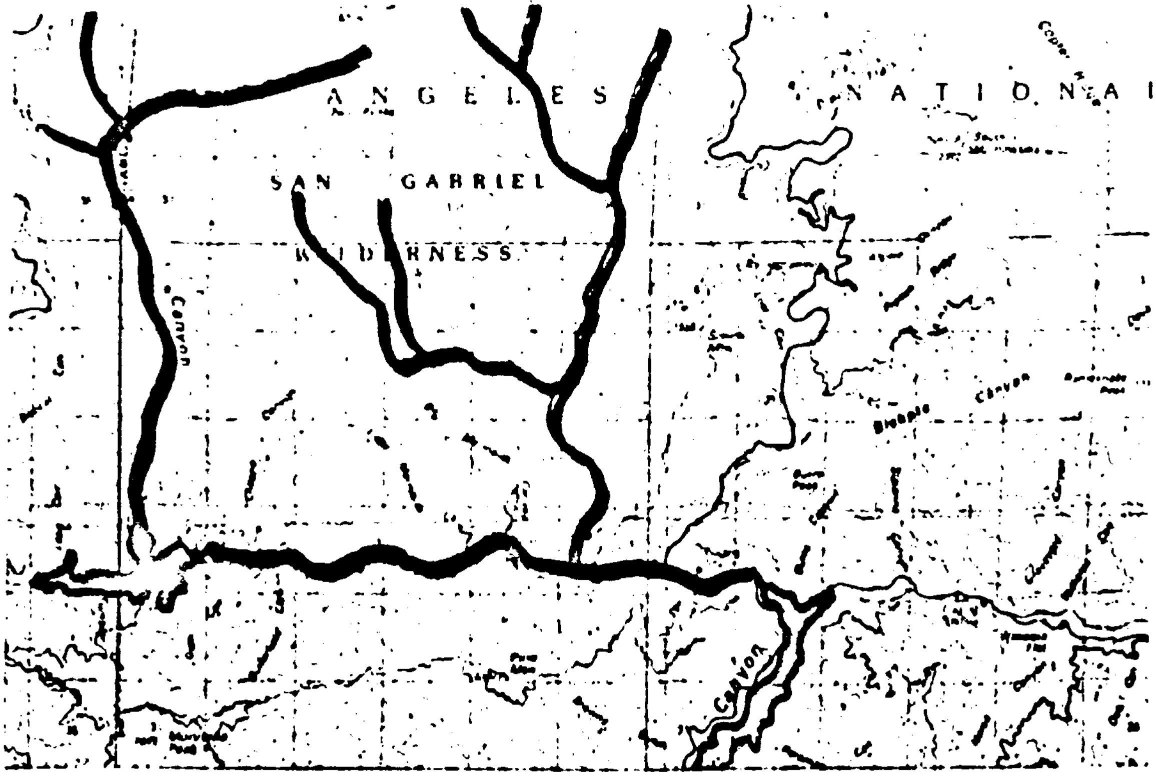
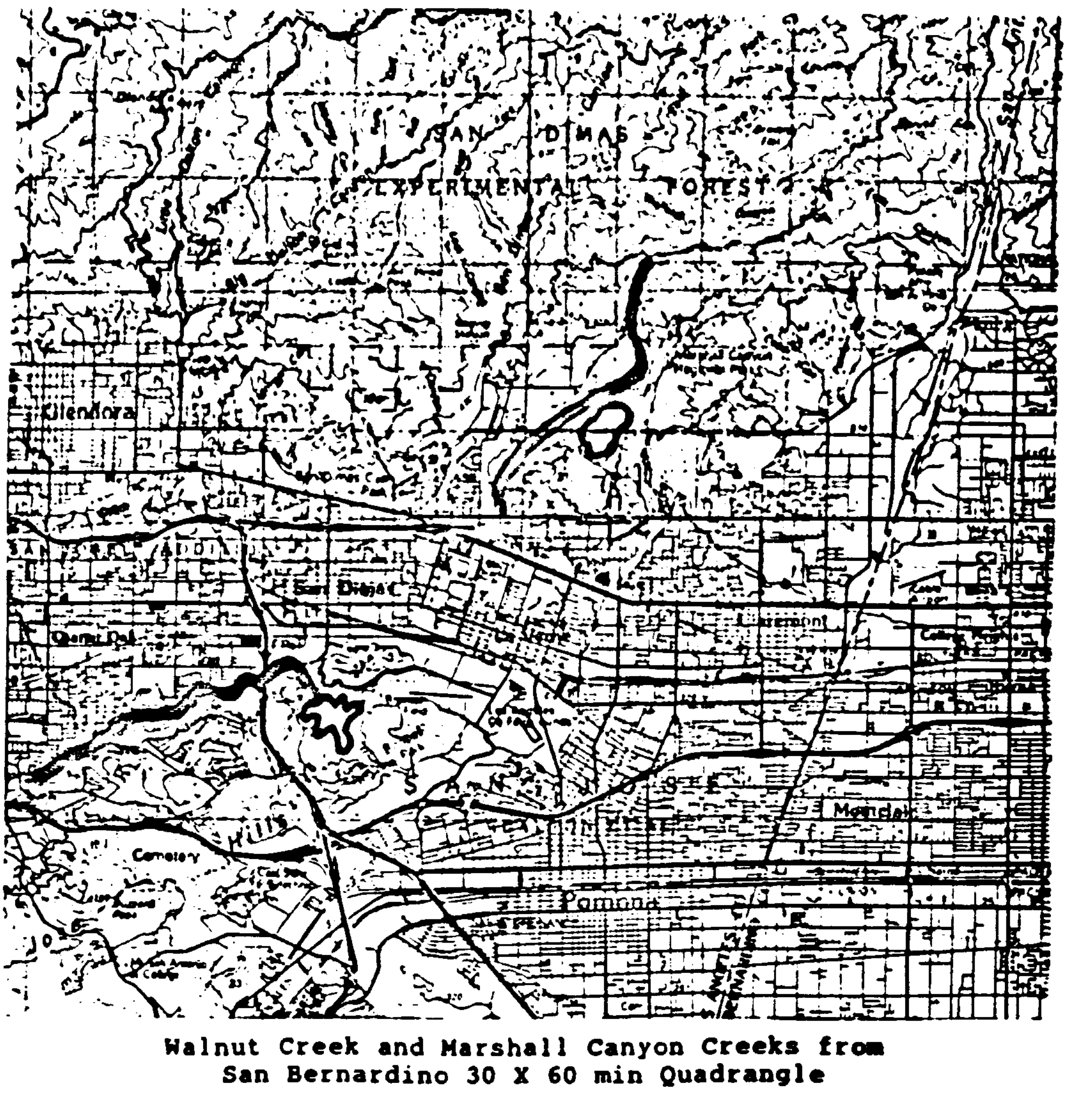


Above: West Fork, San Gabriel River and tributaries Devil's Canyon Creek and Bear Creek. From San Bernardino 30 X 60 min Quadrangle.
Below: Litter filled pool in Devil's Canyon Creek, Los Angeles Co.

L.A. Regional Water Quality Control Board
Riparian Wetlands: L.A. County Parks, San Dimas Vicinity

The Los Angeles County Park System has established numerous parks in natural areas for purposes of horseback riding, hiking, mountain bike riding, bird watching etc. Two such parks are located in the San Dimas vicinity and each is unique in its own way. Walnut Creek park begins at the 57 Freeway in San Dimas and extends into Covina. Marshall Canyon Regional Park is north of Baseline Avenue and includes an extensive trail system as well as a golf course. The streams associated with both parks have water year round.



Walnut Creek and Marshall Canyon Creeks from San Bernardino 30 X 60 min Quadrangle

Walnut Creek [illegible] The [illegible] at the [illegible] The [illegible] interrupted by the [illegible] The [illegible] east of the freeway is not accessible to human activity. The section west of the freeway [illegible] Los Angeles County park and receives [illegible] mountain bike and equestrian use. Walnut woodland is dominant at the eastern end of the park and intergrades into a mixture of willow and oak woodlands at the west end of the park. Numerous invasive exotic plants have become established in the riparian corridor including milk thistle (*Silybum marianum*), sweet fennel (*Foeniculum vulgare*), dwarf nettle (*Urtica urens*) and giant reed (*Arundo donax*). The park is an important wildlife corridor within the Puente Hills and also serves as habitat for numerous birds and mammals. Mountain lions have been seen in the park. There is high diversity of plant species including large stands of blackberry (*Rubus ursinus*), poison oak (*Toxicodendron diversilobum*), California sycamore (*Platanus racemosa*), California black walnut (*Juglans californica*), black cottonwood (*Populus trichocarpa*), big leaf maple (*Acer macrophyllum*) and willow [illegible].

Above: Walnut Woodland at Walnut Creek Park, Los Angeles County

L.A. Regional Water Quality Control Board
Riparian Wetlands: Robert's Canyon Creek

Robert's Canyon Creek [illegible] ... [illegible] ... [illegible] ... [illegible] ... [illegible] ... southern Sierra [illegible] ... water supply [illegible] ... become dominant. The [illegible] ... including [illegible] ... monkey flower, Mimulus guttatus, [illegible] ... Artemisia douglasiana. Federal candidate species Dudleya densiflora is found on rocky outcrops of Robert's Canyon. Invasive exotic [illegible] ... present but not well established.

[illegible] Robert's Canyon, L.A. County

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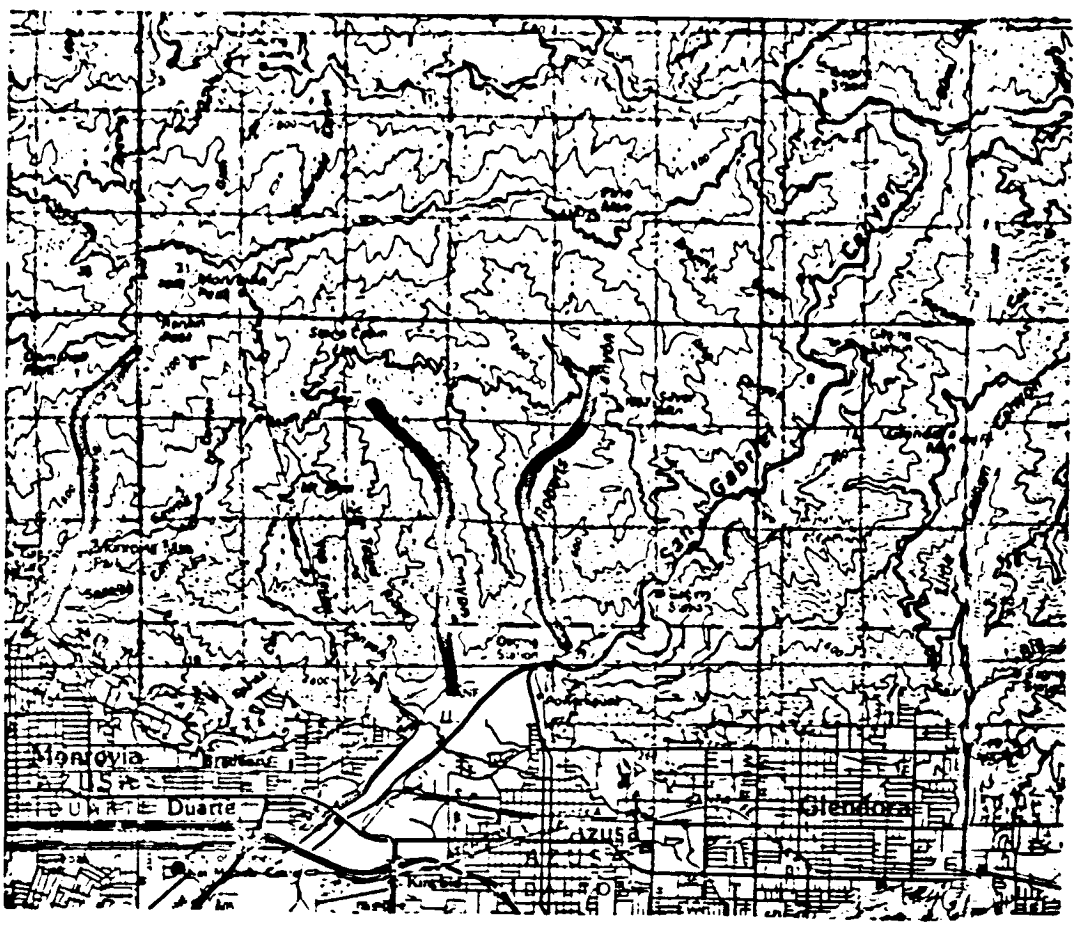
L.A. Regional Water Quality Control Board
Riparian Wetlands Above Monrovia:

Monrovia Canyon, Fish Canyon, and Roberts Canyon Creeks

West of the San Gabriel River drainage and east of the Big and Little Santa Anita Canyon complex of streams, a number of smaller streams drain the front country canyons of the San Gabriel Mountains. These canyons are steep V-shaped canyons characterized by highly fractured rock which stores large amounts of water during the rainy season which is typically from November to April. The headwater areas for these canyons receive between 30 and 40 inches of precipitation annually. This water is then released slowly to the environment, making it available to plants and animals through the dry summer and fall.



Monrovia Canyon Creek, Fish Canyon Creek and Roberts Canyon Creek From San Bernardino 30 X 60 Min Quadrangle

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Monrovia Canyon Creek (405.41) [illegible] steep canyon of the front country [illegible] the San [illegible] Mountains. The [illegible] waters originate in [illegible] separate [illegible] 4,000 feet [illegible] Clamshell and Rankin Peaks in the Angeles National Forest. The wetland begins at the 2,200 foot elevation level and extends [illegible] miles to the [illegible] basin below Sawpit Canyon Reservoir. The steep canyon is punctuated by a number of waterfalls. The lower portion of the canyon (approximately one mile is within Monrovia Mountain Park. The vegetation is white alder riparian forest with a dense canopy of California bay laurel (*Umbellularia californica*) growing on the margins of the stream and extending up the sides of the canyon. The understory is sparse due to the dense canopy. Escaped exotic eupatory (*Ageratina adenophora* has become well established in the canyon and forms dense stands in the bottom of the canyon. The flow regime in the lower portion of the canyon has been altered by the construction of sediment trapping debris dams. There is no trail system connecting this canyon with other areas of the San Gabriel Mountains, consequently this area receives use only by hikers.

Above: White Alder Riparian Forest in Monrovia Canyon with sediment trapping debris dam in background.

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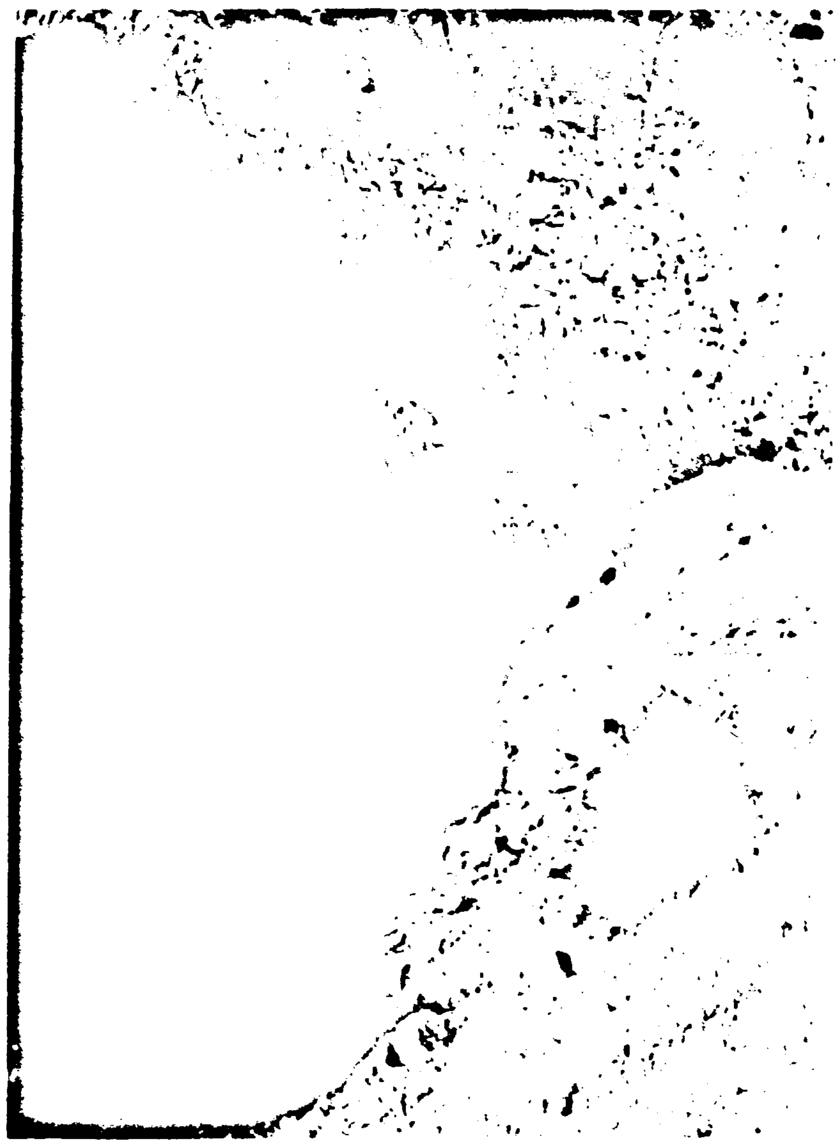
L.A Regional Water Quality Control Board
Riparian Wetlands: Fish Canyon

Fish Canyon Creek (405.43) [illegible] San Gabriel River [illegible] above Azusa. The headwaters [illegible] feet [illegible] the Angeles National Forest. The wetland begins [illegible] feet and extends nearly [illegible] miles to the San Gabriel River. The mouth of the canyon is the site of a sand and gravel mining operation which has significantly altered the mouth of the canyon as part of the mining process. From the National Forest boundary the habitat is relatively undisturbed except for the presence of invasive exotic *Ageratina adenophora*. The vegetation is primarily white alder riparian forest with limited areas of southern arroyo willow riparian forest. The sparse understory contains mugwort (*Artemisia douglasiana*), common monkey flower (*Mimulus guttatus*), and scarlet monkey flower (*M. cardinalis*). *Dudleya densiflora*, a federal candidate species is located on the rocky outcrops in the canyon and is threatened by continued mining operations.



The mouth of Fish Canyon which has been denuded of vegetation by the sand and gravel mining operation.

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L.A. Regional Water Quality Control Board
Riparian Wetlands - Wolfskill Canyon Creek

Wolfskill Canyon Creek (405.44) [illegible] Canyon Creek. [illegible] that of San [illegible] Creek. The [illegible] Wolfskill Canyon [illegible] Dimas Canyon. Wolfskill is less accessible than San Dimas Canyon having only [illegible] occurring at the area of confluence with the East Fork, San Dimas Canyon Creek. The canyon is very narrow in places and in such areas the white alder riparian forest is dominated by California bay laurel (*Umbellularia californica*). Field visits in September of 1991 and 1992 found water present with a discharge of less than 1.0 cfs which is similar to that found for East Fork, San Dimas Canyon Creek above the confluence point. Eupatory represents the only disturbance and it is not well established. No threatened, endangered, or rare species are currently listed for San Dimas Canyon or Wolfskill Canyon.

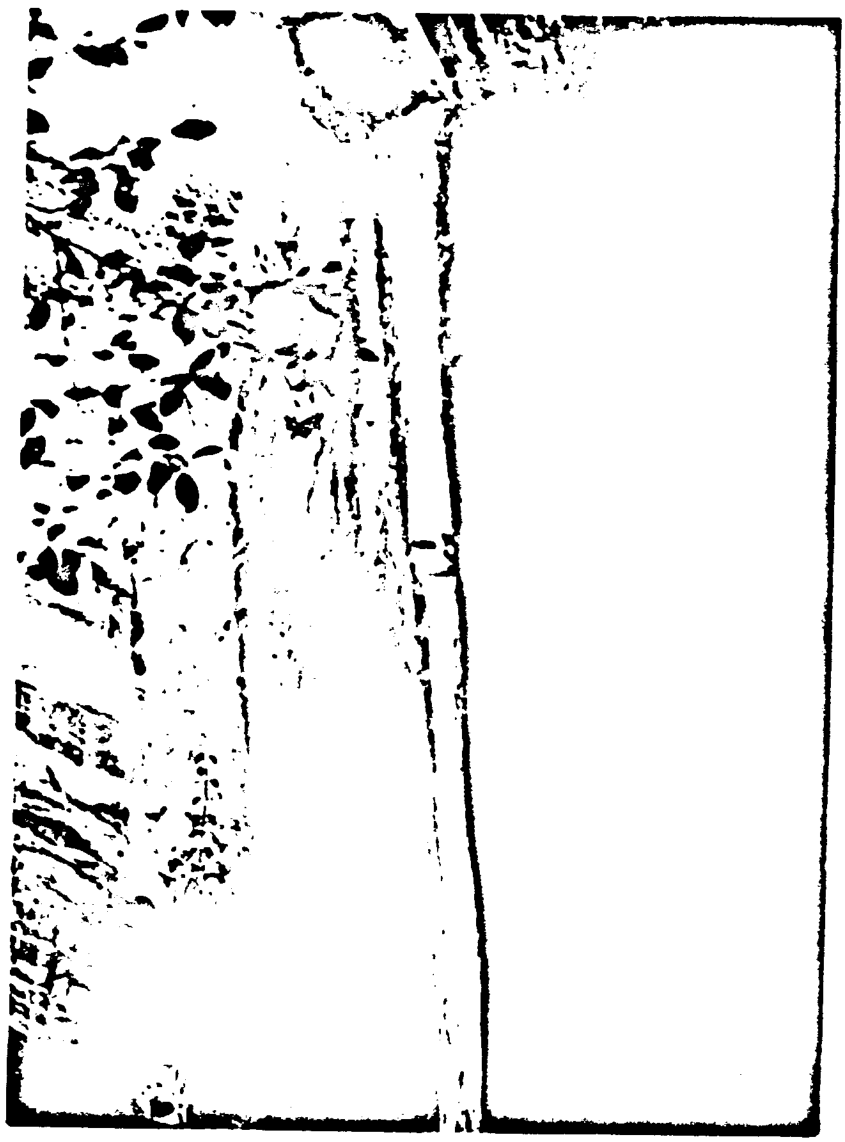

Photo: Wolfskill Falls. Taken in September of 1992, demonstrating the base-flow after six years of drought.

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L.A. Regional Water Quality Control Board
Riparian Wetlands: East Fork San Dimas Creek

East Fork San Dimas Canyon Creek (4[illegible]44 [illegible] a riparian wetland [illegible] the [illegible] mountains. The headwaters [illegible] at Fallen Leaf Spring [illegible] 2,800 feet and [illegible] Canyon [illegible] feet. The stream [illegible] the West Fork San Dimas Canyon just above the San Dimas Reservoir. The Wetland extends from the upper end of the Reservoir to Fallen Leaf Spring ([illegible] miles) and also into Fern Canyon (4.[illegible] miles). Fern Canyon is a Research Natural Area. This area is sub[illegible] significant amounts [illegible] vehicular traffic due to numerous (60) cabins. Residents have planted English ivy (*Helix hedera*) and periwinkle (*Vinca major*) as ground cover. In many area this has grown into the stream course displacing native vegetation. Invasive exotics giant reed (*Arundo donax*) and eupatory (*Ageratina adenophora*) are present. The entire San Dimas drainage culminates in an important groundwater basin which begins at the mouth of the canyon. The groundwater basin is divided by faults [illegible] the San Dimas Basin, the Foothill Basin, and the Way Basin. The vegetation of the East Fork and including Fern Canyon is relatively undisturbed beginning at the point of confluence with Wolfskill Canyon. The vegetation consists of white alder riparian forest and intergrades into [illegible] forest.

Photo: White Alder Riparian Forest at Confluence with Wolfskill Canyon

L.A. Regional Water Quality Control Board
Riparian Wetlands: Little Dalton Canyon Creek

Little Dalton Canyon Creek (405.41) lies just west of the San Dimas Experimental Forest boundary, paralleling the boundary at a distance of about three [illegible]. The headwaters originate at [illegible] feet near Horse Canyon Saddle. The vegetation at the headwater area is canyon live oak ravine forest mixed with California bay laurel (Umbellularia californica). The lower reaches are typically white alder riparian forest and to a lesser extent canyon live oak forest. A mixture of southern arroyo willow riparian forest and mulefat scrub is dominant near Glendora Mountain Road. The section between Glendora Mountain Road and the debris basin contains large stands of giant reed (*Arundo donax*). The wetland begins at 2,000 feet and extends 2.1 miles to the debris basin. Most of the wetland area is white alder riparian forest with a dense understory of herbaceous perennial hydrophytes including hedgenettle (*Stachys bullata*), clustered docks (*Rumex conglomeratus*), cattail (*Typha domingensis*), iris-leaved rush (*Juncus xiphioides*), barnyard grass (*Echinochloa crusgalli*), and invasive exotic *Ageratina adenophora*. Hydrophytic annuals include scarlet and common monkey flowers (*Mimulus cardinalis* and *M. guttatus*).

Above: Mule Fat Scrub near the mouth of Little Dalton Canyon, Los Angeles County

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Marshall Canyon [illegible] (1987) [illegible] of [illegible] riparian [illegible] in Region 4. The headwaters originate [illegible] which [illegible] Los Angeles County Park System. The wetland [illegible] portions of the drainage [illegible] riparian forest dominated by [illegible] riparian forest which [illegible] creek [illegible] and where there [illegible] permanent [illegible]. The [illegible] forests [illegible] woodland [illegible] understory species [illegible] berry [illegible] poison oak [illegible] elderberry (Sambucus [illegible]) southern honey[illegible] (Lonicera [illegible]) and fu[illegible] flowered gooseberry (Ribes [illegible]). The [illegible] to heavy equestrian use with numerous trails throughout the park. The only disturbance [illegible] which grows in large stands in various places in both the oak and white alder forests.

Dense Coast Live Oak Riparian Forest in Marshall Canyon, L.A. Co.

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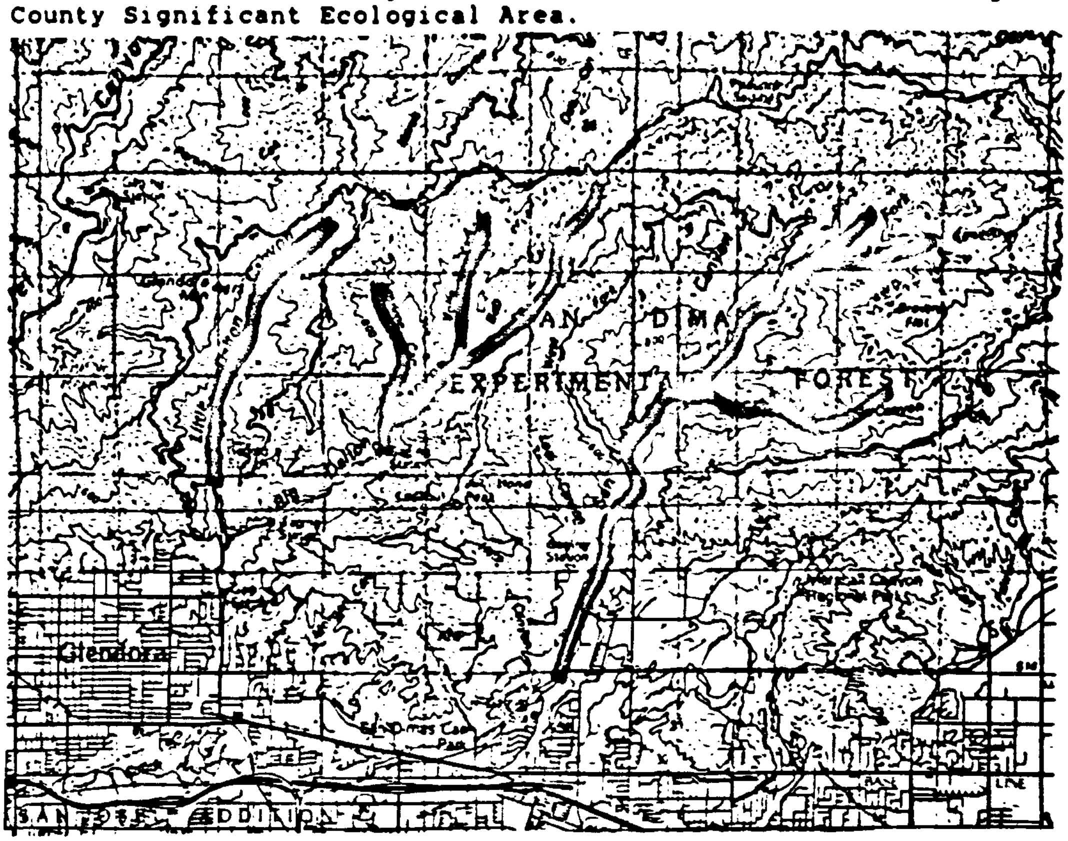
L.A. Regional Water Quality Control Board
Riparian Wetlands: San Dimas Experimental Forest

East Fork San Dimas Canyon Creek, Wolfskill Canyon Creek
Big Dalton Canyon Creek, Little Dalton Canyon Creek

The San Dimas Experimental Forest lies above San Dimas and Glendora in the Foothill HSA (405.44). The topography consists of steep V-shaped canyons typical of the front range of the San Gabriel Mountains. Rainfall at the headwater areas of the major drainages is between 34-38 inches annually with the greatest (38 inches) occurring at the headwaters of Wolfskill Canyon. The geological history of the San Gabriels has been one of continuous upheaval leaving much of the underlying rock highly fractured. This fracturing allows for infiltration of large amounts of water. This water is slowly released back into the stream courses where it is available for use by vegetation and animals.

All of the Experimental Forest lies within the Angelus National Forest. San Dimas Canyon has been designated as a Los Angeles County Significant Ecological Area.



Map: Riparian Wetlands of the San Dimas Experimental Forest
From San Bernardino 30 X 60 min Quadrangle

L.A. Regional Water Quality Control Board
Riparian Wetlands: Big Dalton Canyon

Big Dalton Canyon (405.41) lies west of the San Dimas Canyon Creek drainage system within the San Dimas Experimental Forest. The Headwaters originate in Monroe Canyon, Wolfe Canyon and Bell Canyon which flow into Big Dalton Reservoir. Big Dalton Canyon begins at the Reservoir and extends to Glendora Mountain Road. The wetland area begins at 2,200 feet in both Bell and Volfe Canyons and extends about one mile in each canyon until they join. From the confluence point to the reservoir is 0.9 miles and from the reservoir outfall to the debris basin at Glendora Mountain Road is 2.5 miles for a total of 5.4 miles of riparian wetlands. These streams are interrupted streams which carry perennial water only in portions where geological conditions cause ground water to be pushed to the surface. In such areas, white alder riparian forest is common. Where surface water is not available year round coast live oak riparian forest and southern arroyo willow riparian forest are most common. Hydrophytic vegetation includes lance-leaved frog fruit (*Phyla lanceolata*), common monkey flower (*Mimulus guttatus*), scarlet monkey flower (*Mimulus cardinalis*), watercress (*Rorippa nasturtium-aquaticum*), and invasive exotic *Ageratina adenophora*.

Alder Riparian Forest in Big Dalton Canyon, L.A. Co.

[illegible]

[illegible] wetland extends from the [illegible] of Eaton Wash [illegible] Eaton Canyon [illegible] the 4,[illegible] foot level and includes five different plant communities.

[illegible] Eaton Wash

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[illegible]

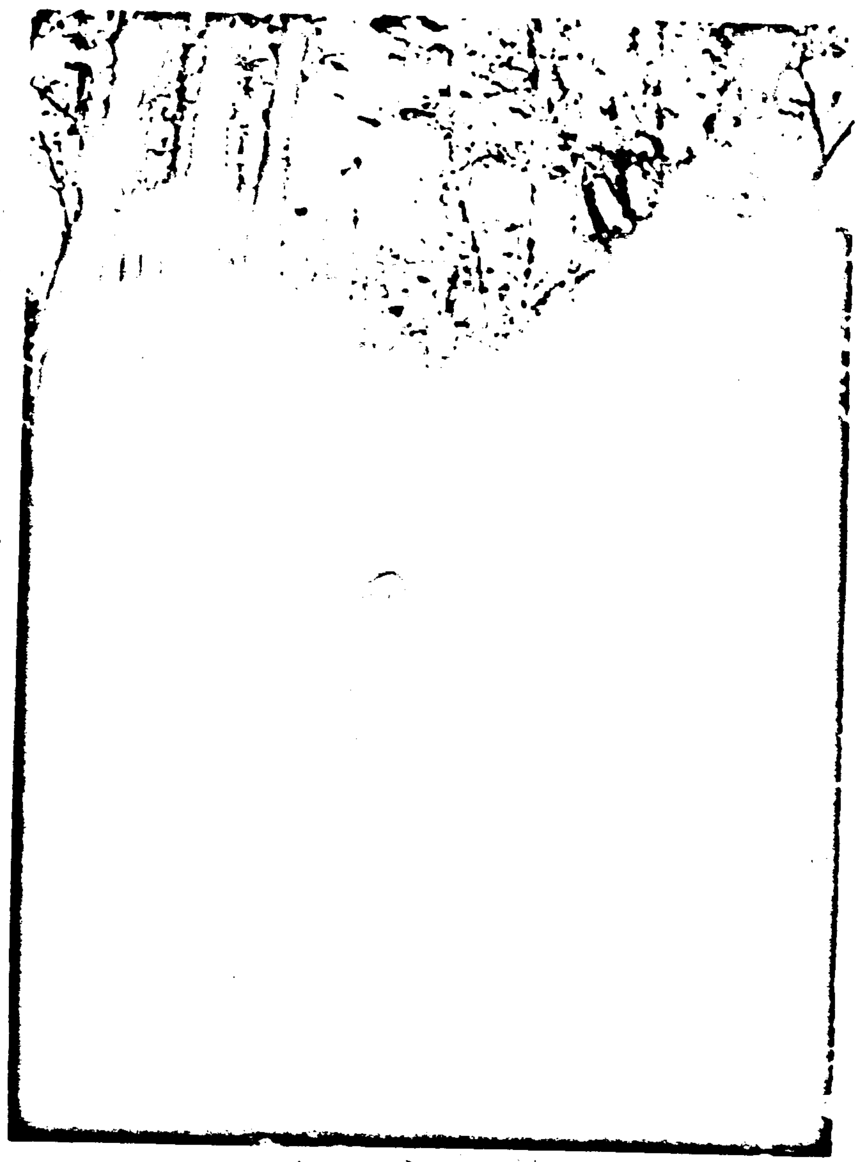

Photo: White Alder [illegible] Santa Anita Canyon, Los Angeles County

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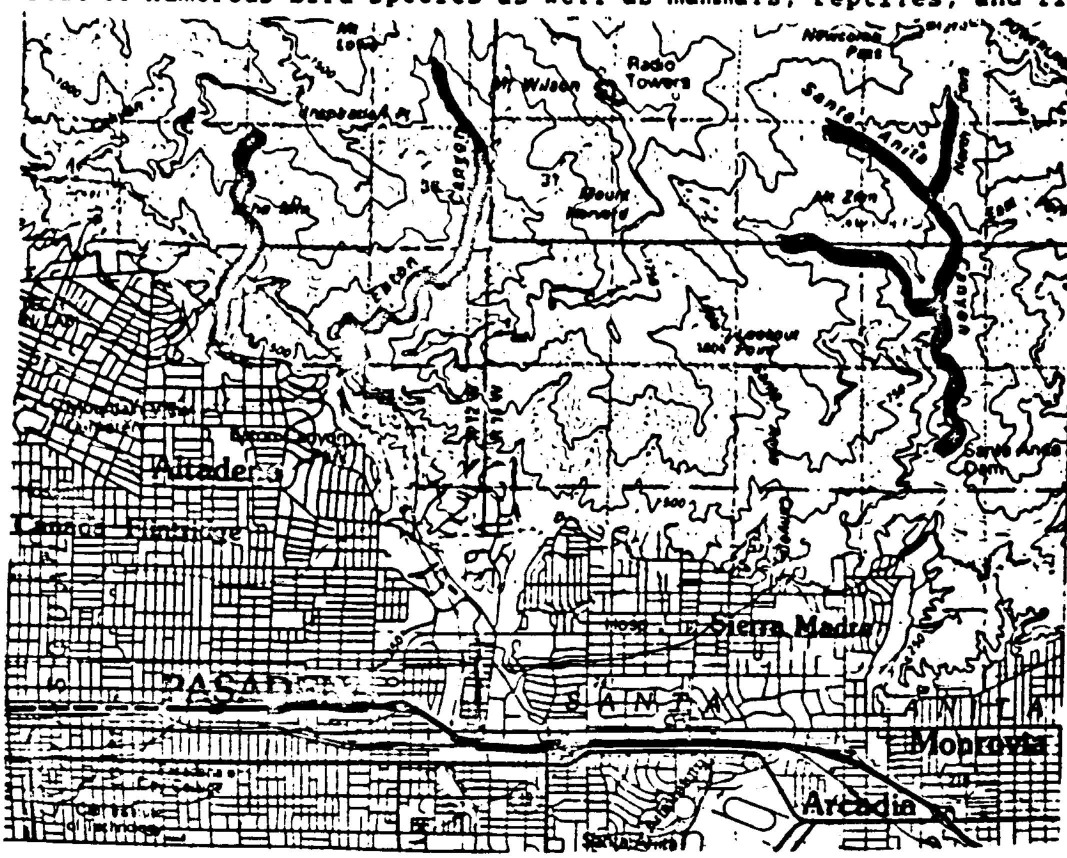
L.A Regional Water Quality Control Board
Riparian Wetlands above Pasadena:

Big Santa Anita Canyon Creek, Winter Creek
Eaton Canyon Creek and Rubio Canyon Creek

Steep V-shaped canyons are typical of the frontal range of the San Gabriel Mountains. The canyons above Pasadena offer some of the most severe topography in the entire range. Eaton and Rubio Canyons are the most severe. Historically, these areas have been subject to heavy human use. Today they are still heavily used by hikers, mountain bikers, and backpackers. During a field visit to Big Santa Anita Canyon a group baptism was observed in the pool below Sturtevant Falls!

The perennial source of water in these canyons is due to highly fractured rock which stores large quantities of water. This water is released slowly, thereby providing a constant supply even during drought. The constant supply of water insures rich vegetation, typically white alder riparian forest. The rich vegetation provides habitat to numerous bird species as well as mammals, reptiles, and fish.



Map: Riparian Wetlands of Big Santa Anita Canyon Creek, Winter Creek, Eaton Canyon Creek, and Rubio Canyon Creek.

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L.A Regional Water Quality Board
Riparian Wetland — Eaton Canyon and Wash

Eaton Canyon [illegible] ... canyon [illegible] Falls the [illegible] ... [illegible] leaf maple [illegible] ... with [illegible] at [illegible] feet level [illegible] also [illegible] The wetland extends for [illegible] The trail to the falls is subject to heavy [illegible] use for hiking. The only source of disturbance is from invasive exotic plants eupatory (Ageratina adenophora) and [illegible]

Southern Arroyo Willow Riparian Forest near Eaton Canyon Falls

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R0052372

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[illegible] The wetland area begins at the confluence with Big Santa Anita Canyon Creek and extends [illegible] 200 feet [illegible]. White alder riparian forest [illegible] above the [illegible] Campground where the live oak ravine forest begins. The area is used by hikers and campers. There are also 18 cabins in the canyon. English ivy (Hedera helix) is present around the cabins. Eupatory (Ageratina adenophora) is the major source of disturbance with some large stands which provide up to 100% cover in some areas. In area where eupatory has not become established there is high species diversity in the understory including Boykinia rotundifolia, Solanum douglasii, blackberry (Rubus ursinus), poison oak (Toxicodendron diversilobum), Mimulus guttatus and bracken fern (Pteridium aquilinum). The natural hydrological regime has been altered for both Winter Creek and Big Santa Anita Canyon Creek by debris dams.

Photo: A large stand of eupatory in white alder riparian forest along Winter Creek. Note debris dam in background.

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The Arroyo Seco ([illegible]) is one of the largest drainages of the [illegible] of the San Gabriel Mountains. The headwaters originate at about [illegible] feet near the Angeles Crest Highway above upper Switzer Camp. The wetland begins in the Angeles National Forest at [illegible] feet and extends over [illegible] miles to the Devil's Gate Reservoir. The habitat consists of white alder riparian forest, coast live oak riparian forest and southern arroyo willow riparian woodland. Hydrophytes include *Boykinia rotundifolia*, watercress (*Rorippa nasturtium-aquaticum*), common monkey flower (*Mimulus guttatus*), and invasive exotic *Ageratina adenophora*. Periwinkle (*Vinca major*) and English ivy (*Hedera helix*) have become dominate in some areas having been planted as groundcover around cabins many years ago.

White Alder Riparian Forest along the Arroyo Seco above Pasadena in Los Angeles County

19070

Bear Canyon (405.32) is the largest tributary of the Arroyo Seco and is possibly the most pristine canyon on the front range of the San Gabriel Mountains. The headwaters originate at [illegible],800 feet in the Angelus National Forest. The wetland is approximately 2 miles in length, ending at the confluence with the Arroyo Seco. The canyon is steep and narrow, containing a mixture of white alder riparian forest and big cone Douglas fir-canyon live oak ravine forest. The understory is sparse due to the dense canopy which in some areas consists of two layers. California bay laurel (*Umbellularia californica*), and big leaf maple (*Acer macrophyllum*) are also common.

Little Bear Canyon (405.32) empties into the Arroyo Seco about 600 feet below where Bear Canyon joins the Arroyo Seco. Little Bear Canyon is quite undisturbed due to a lack of access. The headwaters originate at about 4,000 feet and the wetland extends for one mile to the Arroyo Seco.

White Alder Riparian Forest in Bear Canyon, Los Angeles County.

R0052376

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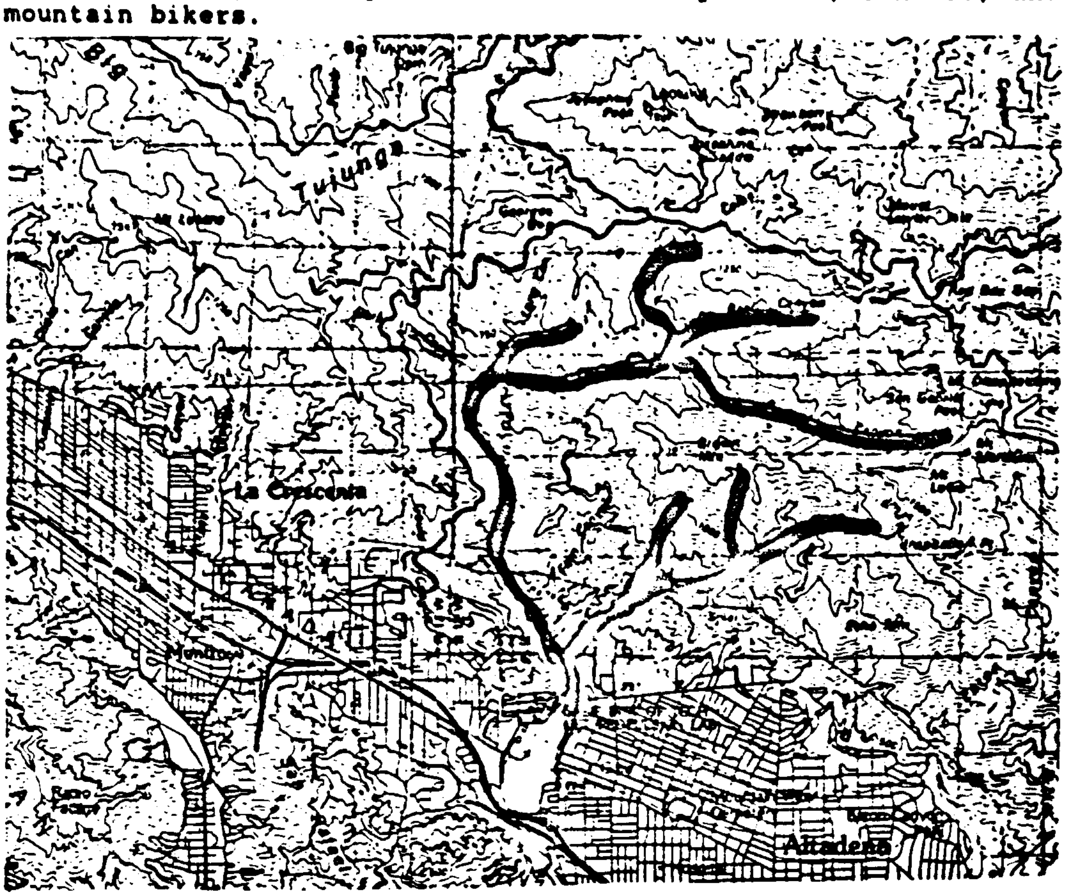
L.A. Regional Water Quality Control Board
Riparian Wetlands: Pasadena Area

Arroyo Seco and Millard Canyon Creek

The Arroyo Seco and Millard Canyon are typical of most canyons of the front country of the San Gabriel Mountains. The canyons are steep and V-shaped. The highly fractured granite of this portion of the range is able to store large quantities of water which falls as rain and snow between November and April. The water is released slowly to the environment so that even during the dry summer and fall, or after years of drought, there is still sufficient water to support diverse plant communities. These plant communities provide important habitat for numerous vertebrates. This part of the range has historically received heavy human use. Fifty years ago the Arroyo Seco was one of the favorite vacation spots in the range (Robinson 1990). Today the area is used by hikers, runners, and mountain bikers.



Arroyo Seco and Millard Canyon Creek
from Los Angeles 30 X 60 min Quadrangle

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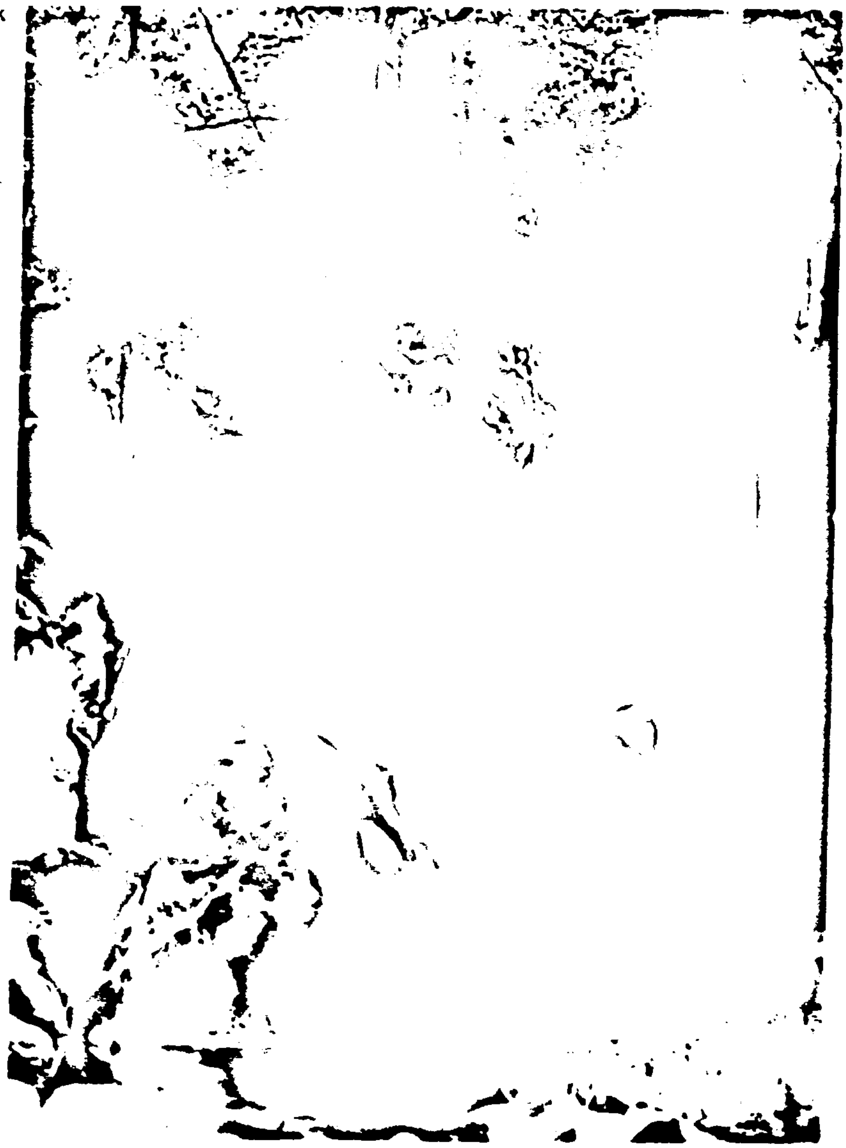
L.A. Regional Water Quality Control Board
Riparian Wetlands: Millard Canyon Creek

Millard Canyon Creek (405.32) is a tributary of the Arroyo Seco which joins it at the upper end of the Devil's Gate Reservoir. The headwaters originate in Saucer Branch at 4,000 feet and Grand Canyon at 3,600 feet. The wetland extends 3 miles to the confluence with the Arroyo Seco. The canyon is steep and narrow with white alder riparian forest as the dominant vegetation type. California bay laurel (*Umbellularia californica*) and canyon live oak (*Quercus chrysolepis*) form a dense canopy on the sides of the canyon and up the canyon walls. Big leaf maple (*Acer macrophyllum*) is also common. The understory is sparse due to the dense canopy and also the presence of invasive exotic *Ageratina adenophora* which forms dense stands in the canyon bottom. Hydrophytes include common monkey flower (*Mimulus guttatus*), scarlet monkey flower (*M. cardinalis*), and *Boykinia rotundifolia*. The canyon receives heavy use by hikers and picnickers.



White Alder Riparian Forest in
Millard Canyon Los Angeles County

R0052378

L.A. Regional Water Quality Control Board Riparian Wetlands: Fish and Iron Forks, San Gabriel River

The Fish Fork of the San Gabriel River (405.43) originates below Pine Mountain Ridge in the Sheep Mountain Wilderness and on the western slope of Mount San Antonio at [illegible] feet. The wetland extends [illegible] miles from below the 6,000 foot level to the confluence with the East Fork of the San Gabriel River. The canyons of the headwater areas contain canyon live oak-big cone Douglas fir forest. The coniferous forest intergrades into white alder riparian forest with California bay laurel (*Umbellularia californica*) and big leaf maple (*Acer macrophyllum*) often sharing dominance with *Alnus rhombifolia*. The area is pristine habitat, subject to little disturbance due to lack of accessibility. This area is important habitat for Nelson's bighorn sheep (*Ovis canadensis nelsoni*).

The Iron Fork of the San Gabriel River (405.43) consists of two branches, the main stem Iron Fork and South Fork Iron Fork. The main stem originates below Mount Baden-Powell at 7,500 feet. The wetland extends 2.1 from the 5,600 foot level to the confluence with the South Fork. The South Fork drains South Mount Hawkins with the wetland beginning at 5,200 and extending [illegible] miles to the main stem Iron Fork. The upper areas contain canyon live oak-big cone douglas fir forest. The wetland area below the confluence point is white alder riparian forest and extends about 2 miles to the East Fork, San Gabriel River.

White Alder Riparian Forest along the Iron Fork, San Gabriel River.

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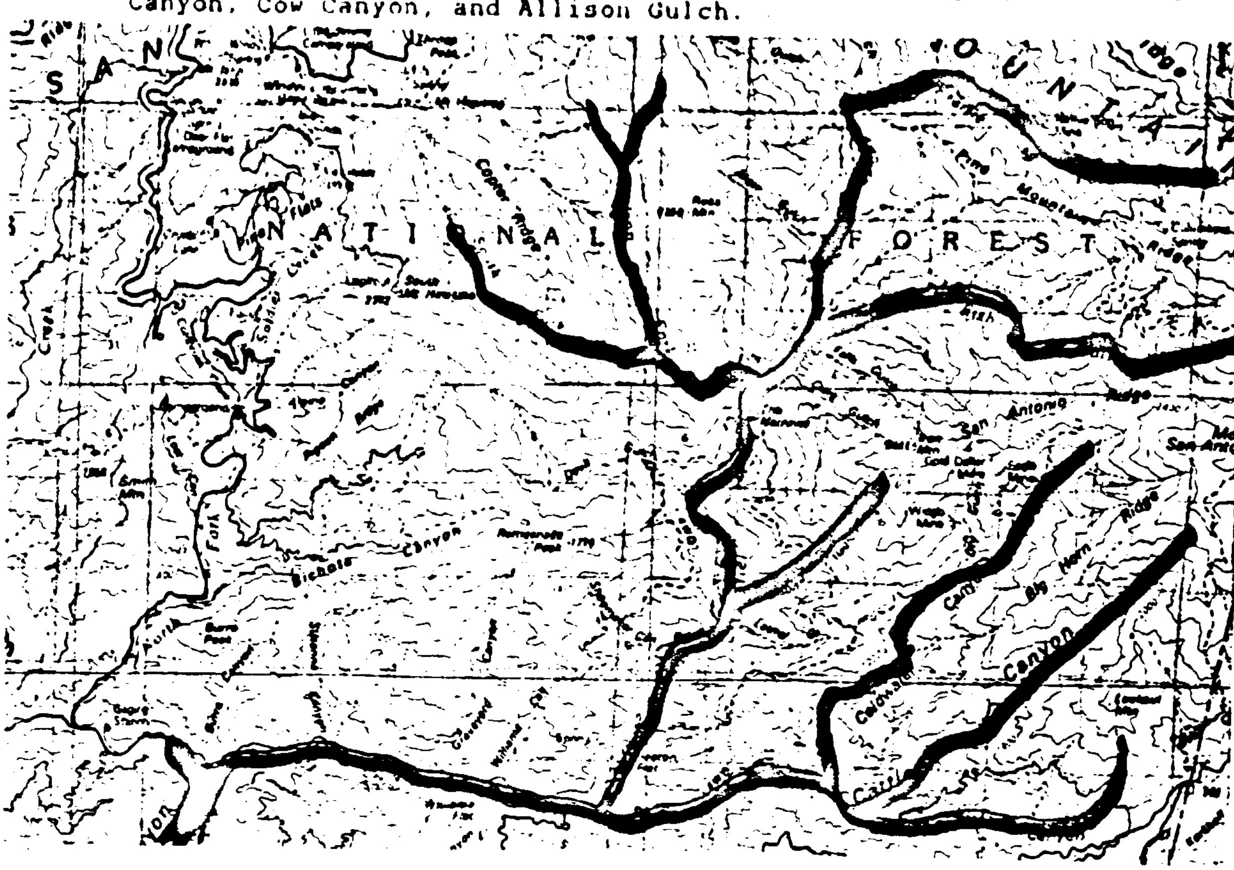
Above: White Alders, inundated near confluence of East Fork and Iron Forks of the San Gabriel River.

Below: Prairie Fork, Fish Fork, Iron Fork and the East Fork of the San Gabriel River and its tributaries Cattle Canyon, Coldwater Canyon, Cow Canyon, and Allison Gulch.



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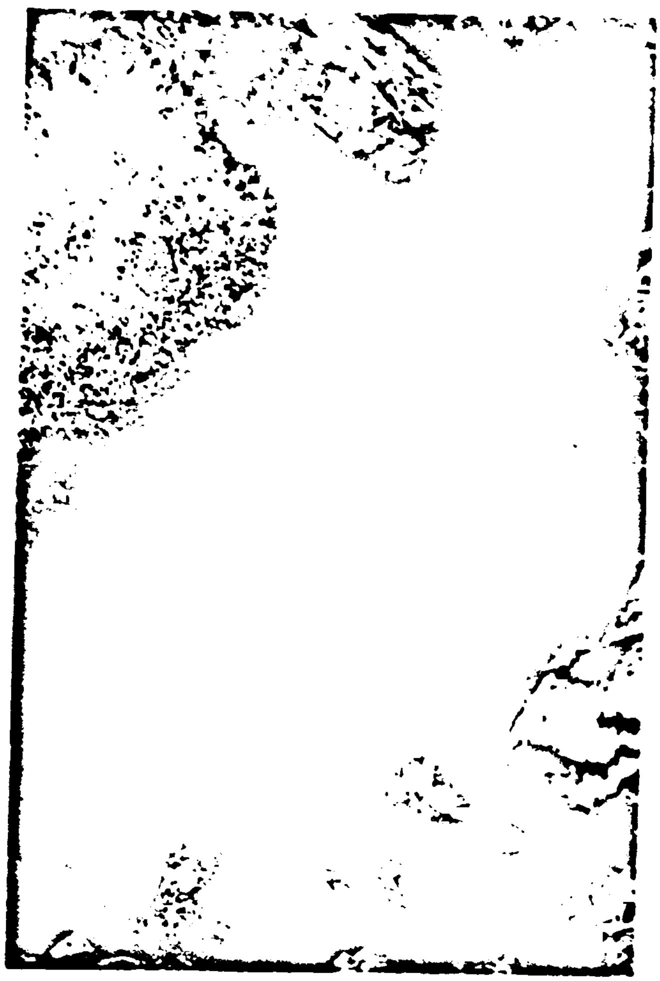
L.A. Regional Water Quality Control Board
Riparian Wetlands: East and Prairie Forks, San Gabriel River

The East Fork of the San Gabriel River (405.43) originates at the confluence of the Prairie Fork of the San Gabriel River and Vincent Gulch at an elevation of 4,[illegible] feet. The wetland extends approximately 1[illegible] miles to the San Gabriel Reservoir. The vegetation is white alder riparian forest which is found in and immediately adjacent to the streambed. Outside the active channel is a broad zone of alluvial scrub dominated by scalebroom (*Lepidospartum squamatum*), California buckwheat (*Eriogonum fasciculatum*) and Our Lord's candle (*Yucca whipplei*). The area receives heavy use by gold miners. The primary method employed by the miners is panning which causes large amonuts of sediments to be put back into the stream. The impact of panning for gold on the biotic resources is unknown and needs to be studied. The East Fork is habitat to the Santa Ana Sucker (*Catostomus santaanae*) and Nelson's big horn sheep (*Ovis canadensis nelsoni*).



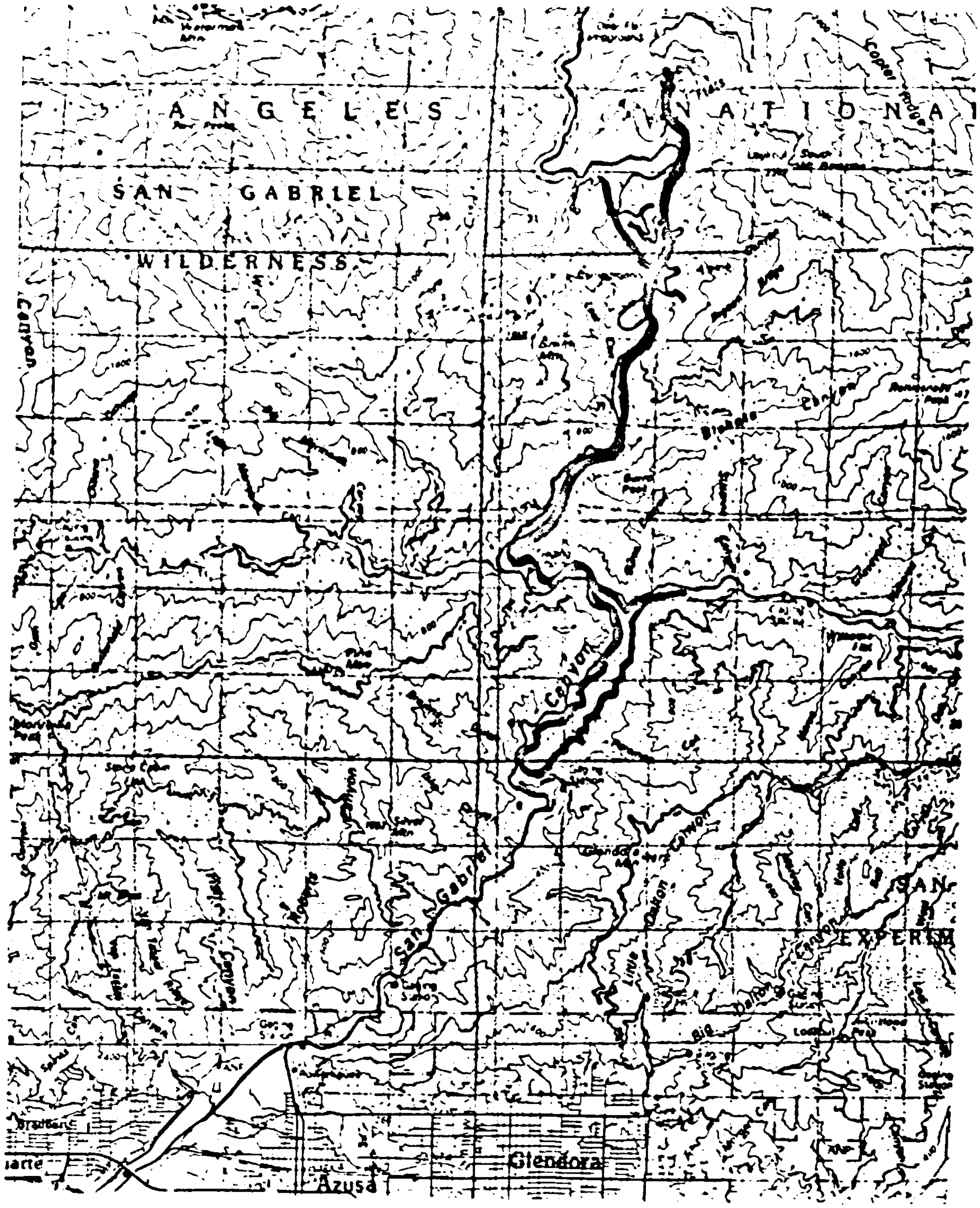
The Prairie Fork of the San Gabriel River (405.43) originates at 7,000 feet in the Sheep Mountain Wilderness. The wetland extends 6.2 miles to the beginning of the East Fork of the San Gabriel River. The vegetation at the headwaters is a mixture of white alder riparian forest dominated by *Alnus rhombifolia*. Occasional stands of big cone Douglas fir (*Pseudotsuga macrocarpa*) are found along the margins of the canyon and extending up the slopes. The canyon is a broad canyon and supports a number of plant communities including southern arroyo willow riparian forest which often takes on a stunted scrub-like appearence a[illegible] alluvial scrub.

Above: White Alder Riparian Forest in the Narrows Area of the East Fork, San Gabriel River.

L.A. Regional Water Quality Control Board
Riparian Wetlands: North Fork San Gabriel River

The North Fork of the San Gabriel River 405.43 originates in the Falling Springs area below the Crystal Lake Recreation Area in the Angeles National Forest. The wetland begins at 3,[illegible] feet at the confluence of Coldbrook and Soldier Creeks and extends 4.6 miles to the confluence with the West Fork of the San Gabriel River. The vegetation is primarily white alder riparian forest with occasional stands of big-cone Douglas fir. The lower areas are white alder riparian forest dominated by *Alnus rhombifolia* with occasional individuals of arroyo willow (*Salix lasiolepis*). The understory is sparse due to the dense understory with mugwort (*Artemisia douglasiana*) as the most common component. The white alder riparian forest is bordered by alluvial scrub including scalebroom (*Lepidospartum squamatum*), mulefat (*Baccharis salicifolia*), bush senecio (*Senecio douglasii*), California buckwheat (*Eriogonum fasciculatum*), California brickelbush (*Brickellia californica*) and *Heterotheca villosa* [illegible]. The area is subject to heavy use by picnickers who leave large amounts of trash including dirty diapers in the stream. This could have negative impact on water quality. The North Fork provides habitat for the Santa Ana sucker (*Catostomus santaanae*) and Nelson's big horn sheep (*Ovis canadensis nelsoni*).

White Alder Riparian Forest along The North Fork of the San Gabriel River, [illegible] County



North Fork, San Gabriel River and tributaries Soldier Creek and Coldbrook Creek. From San Bernardino 30 X 60 min Quadrangle.

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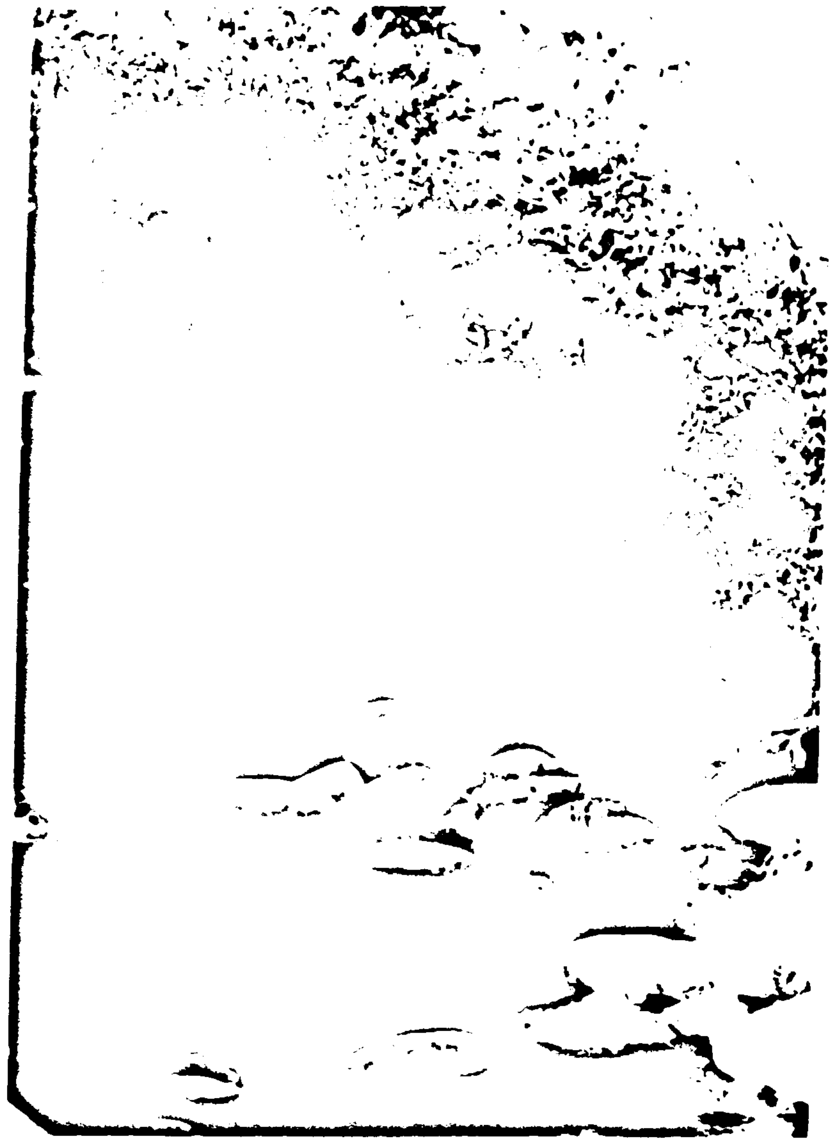

[illegible] Creek (4[illegible]) [illegible] the [illegible] River. The [illegible] in the lower [illegible] rich [illegible] hydrophytes [illegible] Stachys [illegible] Rorippa nasturtium-aquaticum, Mimulus guttatus, M. cardinalis, Cyperus eragrostis and Epilobium sp. The creek is habitat for Nelson's big horn sheep (Ovis canadensis nelsoni), Santa Ana sucker (Catostomus santaanae) and southwestern pond turtle (Clemmys marmorata).

West Fork Bear Creek (405.43) originates on the slopes of [illegible] peak at 6,000 feet. The wetland extends [illegible] miles to the main stem of Bear Creek. The canyon is steep and narrow [illegible] the canyon [illegible] oak ravine forest in the [illegible] reaches with California bay laurel (Umbellularia californica) [illegible] part of the white alder riparian forest in the lower reaches. The West Fork of Bear Creek is habitat for Nelson's big horn sheep (Ovis canadensis nelsoni), Santa Ana sucker (Catostomus santaanae) [illegible] pond turtle (Clemmys [illegible]).

[illegible] White Alder Riparian [illegible] Bear Creek [illegible] Wilderness [illegible]

R0052384

L.A. Regional Water Quality Control Board
Riparian Wetlands: Rio Hondo

Rio Hondo (405.41) is a river of the coastal plain of Los Angeles county. The headwaters originate high in the San Gabriel Mountains and the Rio Hondo begins at the confluence of two major drainages of the central portion of the range: Santa Anita and Eaton Washes. The river is concrete lined over most of its 11.1 miles. The notable exception to this is where the river flows through the Whittier Narrows Recreation Area. Here the river has remained in its natural state supporting a high diversity of native riparian vegetation along with a number of invasive exotic species as well as numerous weedy species. The wetland is 3.1 miles long, beginning south of Garvey Ave and extending to the Whittier Narrows Dam. The native riparian vegetation includes Sycamore (*Platanus racemosa*), Fremont cottonwood (*Populus fremontii*), black cottonwood (*P. trichocarpa*), arroyo willow (*Salix lasiolepis*), red willow (*S. laevigata*), yellow willow (*S. lasiandra*), California black walnut (*Juglans californica*), elderberry (*Sambucus mexicana*), and coast live oak (*Quercus agrifolia*). Understory species include mule fat (*Baccharis salicifolia*), cattails (*Typha* spp.), knotweed (*Polygonum* spp.), and cocklebur (*Xanthium strumarium*). Wild grape (*Vitis californica*) which is a vine , forms dense mats as it grows up into the canopy. Weedy species include various annual grasses (e.g. *Bromus* sp.), castor bean (*Ricinus communis*), tree tobacco (*Nicotiana glauca*), horehound (*Marrubium vulgare*), and most importantly giant reed (*Arundo donax*). *Arundo* has virtually taken over large portions of the Whittier Narrows Recreation Area. It forms dense monocultural stands, reproducing by underground rhizomes and excluding most native vegetation. This exclusion results in a loss of significant amounts of quality habitat upon which numerous native birds depend.

The area is used heavily for swimming and wading during those times when water is plentiful. The channel is heavily littered with various sorts of trash much of which is most probably washed from upstream areas which receive the same types of use.

The wetlands (both riparian and lacustrine) within the Whittier Narrows Recreation Area provide important habitat to numerous birds, both resident and migratory. It is an ecological island within a highly urbanized region and as such is indispensible in the maintainance of numerous bird and other vertebrate species throughout Region 4.

L.A. Regional Water Quality Control Board
Riparian Wetlands: Cattle Canyon and Tributaries

Cattle Canyon Creek (405.43) is a major tributary of the East Fork of the San Gabriel River. The headwaters originate at the 8,000 foot level of the south-west slope of Mount San Antonio and from Big Horn Ridge. The wetland extends 8.0 miles from about 5,400 feet to the East Fork of the San Gabriel River. The headwater areas consist of canyon live oak-big cone Douglas fir forest with willow scrub as understory. The lower portions are white alder riparian forest interspersed with southern arroyo willow riparian forest. Alluvial scrub occurs in those areas where the canyon broadens. Botanical surveys found a high diversity of trees in the riparian forests including *Alnus rhombifolia*, *Acer macrophyllum*, *Umbellularia californica*, *Fraxinus velutina*, *Quercus agrifolia* and various species of willow (*Salix* spp.). Cattle Canyon is habitat for the Santa Ana sucker (*Catostamos santaanae*), and Nelson's bighorn sheep (*Ovis canadensis nelsoni*).

Coldwater Creek (405.43) is a tributary of Cattle Canyon Creek originating from a number of branches draining the San Antonio Ridge. The wetland begins at 4,600 feet and extends nearly 6 miles to Cattle Canyon. Canyon live oak-big cone Douglas fir is dominant in the upper reaches and white alder riparian forest becomes dominant at lower elevations. Nelson's bighorn sheep (*Ovis canadensis nelsoni*) occurs here.

Cow Canyon Creek (405.43) is a tributary of Cattle Canyon Creek originating below Lookout Mountain at about 5,000 feet. The wetland extends 2.2 miles from the 3,600 foot level to Cattle Canyon. Big cone Douglas fir forest is overstory to willow scrub at the headwater areas and white alder riparian forest and southern arroyo willow riparian forest are dominant in the lower portions. Nelson's bighorn sheep (*Ovis canadensis nelsoni*) is present here.

Allison Gulch (405.43) is a tributary of the East Fork, San Gabriel River. The headwaters originate below Iron Mountain at 6,600 feet. The wetland extends 1.5 miles from above the Allison Trail to The East Fork, San Gabriel River. The canyon is steep and narrow and is dominated by bay laurel (*Umbellularia californica*), and big leaf maple (*Acer macrophyllum*). The upper part of the canyon is canyon live oak-big cone Douglas fir forest. Allison Gulch is within the Sheep Mountain Wilderness and is habitat for Nelson's bighorn sheep (*Ovis canadensis nelsoni*).

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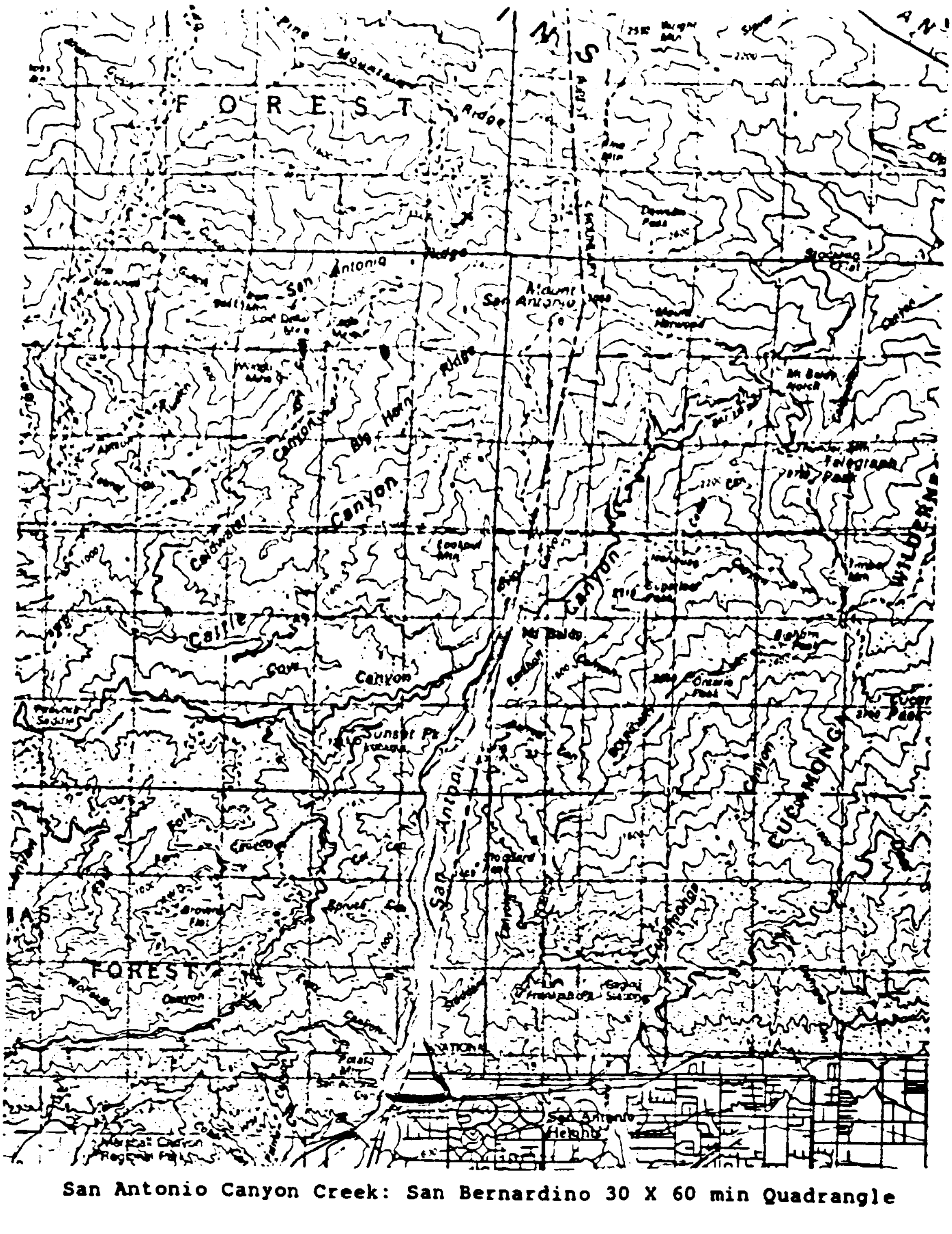

San Antonio Canyon Creek: San Bernardino 30 X 60 min Quadrangle

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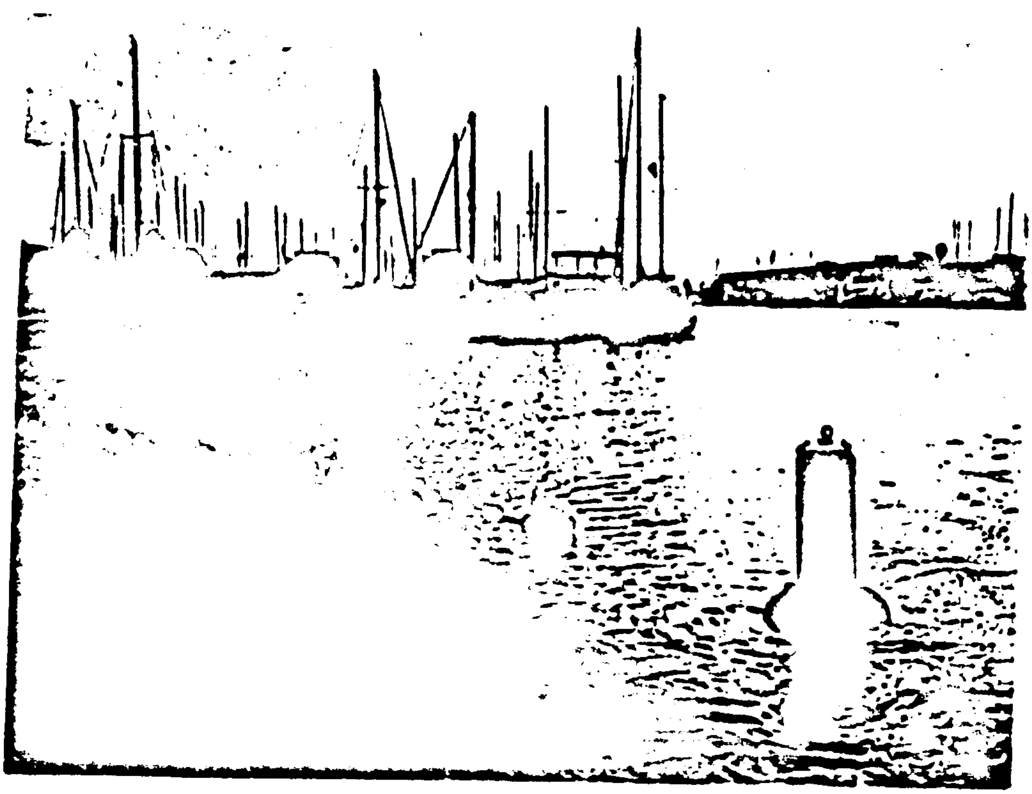
MARINE STUDIES OF SAN PEDRO BAY, CALIFORNIA, Part 20F

THE MARINE ENVIRONMENT OF MARINA DEL REY
October 1989 to September 1990

A Report to the Department of Beaches and Harbors
County of Los Angeles



by
Dorothy F. Soule, Mikihiko Oguri, and Burton H. Jones

Harbors Environmental Projects
University of Southern California
Los Angeles, California 90089-0371

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EXECUTIVE SUMMARY

Marina del Rey, is the largest manmade marina in the world, containing 5,800 boat slips, and a terrestrial resident population of almost 11,000 people. There are 28 restaurants many shops, four hotels and two motels which draw patrons to the dock area, in addition to the small boat operators who use the launching ramps.

The Marina is a surprisingly good habitat considering the impacts it receives, which largely originate in the urban area virtually surrounding it. Since about ninety percent of the natural wetlands of the Los Angeles area have been lost, protecting the modified wetlands such as bays and harbors, including the Marina, is critical to the health and productivity of adjacent shallow water coastal habitats. Continuing efforts are essential to maintain and improve conditions in the Marina in order for it to serve as a fish nursery and a productive benthic community.

WATER QUALITY

The water quality of Marina del Rey is influenced by a number of factors: these include potential impacts of recreational and residential usage such as oil seepage, illegal disposal of wastes, trash and caustic substances, use of bilfouling compounds, and boat scrapings. Impacts originating outside the Marina appear to have the larger effects; these include the meteorologic and oceanographic conditions affecting the Southern California Bight, and the impacts of urban runoff.

The period of October 1989 to September 1990 was strongly influenced by the lack of significant rainfall over the past several years. Small storms serve to transport refuse and sediments, to which trace metals and pesticides are attached, into the Marina via storm drains and flood control

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TEMPERATURE, RAINFALL AND DISSOLVED OXYGEN

Water temperatures during the monitoring period were subject to extremes; October and November were colder than usual, followed by a warmer period, then cold in February, and an unusually long, warm summer. The highest record during monitoring was 25.3°C.

The combination of low rainfall and high temperatures may have been responsible for the large number of low dissolved oxygen (DO) values recorded during the year. Regulatory agencies regard 5.0 ppm DO as the minimum level for the protection of fish species, although most can survive with less, and many invertebrate species require far less. No episodes of zero DO were recorded, which would cause production of toxic hydrogen sulfide. Pelagic fish tend to leave the warm waters for cooler coastal waters during the summer, but very warm temperatures and low DO could impact resident fish such as those in the shallow sea grass beds in Basin D. Low DOs also were widespread in the inner Marina in November and December 1989, in April 1990 following a rainstorm, at the Marina entrance in May, and at scattered inner stations in the summer of 1990.

NUTRIENTS

Nutrients support a high level of phytoplankton production, at times creating bloom conditions, but providing oxygen and food for some fish species. In general, concentrations of ammonia, nitrate and nitrite, phosphate and silicate follow a pattern of being low near the ocean and higher in the inner Marina. They also tend to be higher in winter when phytoplankton densities are reduced by cooler temperatures and lower light intensities. However, high levels of ammonia which persisted during the summer of 1990 were unusual and correlated with low dissolved oxygen channels but are insufficient to flush accumulated contaminated sediments into Santa Monica Bay.

Dry weather flow in Oxford Flood Control Basin carries a large burden of pollutants and bacteria for the volume of water involved. This may have been the source of polychlorinated biphenyls (PCBs) that entered the Marina in 1988-1989, perhaps due to excavations of highly contaminated sediments during construction on property near the Marina. Sediments may have drained into Oxford Basin and been flushed into the Marina.

Ballona Creek Flood Control Channel flow mixes with tidal waters upstream, and on a falling tide carries trash, particularly plastic refuse, to the mouth of the stream. On a rising tide, some of that material will be drawn into the Entrance Channel of the Marina where it may accumulate in an eddy. Figure *i* shows trash accumulating inside the breakwater, and Figure *ii* shows debris collected along the outer end of the south jetty after a 0.5 inch rainfall in April, 1990. While a boom has been installed upstream on Ballona Creek, it does not catch all of the trash and illegally dumped materials. Its efficiency depends in part on frequent cleaning. Neither can it solve the problem when higher tides sweep the jetty rocks of trash and organic material from fishermen who spend long hours there without sanitary or trash disposal facilities and organic wastes from dogs that are exercised there.

Wet weather flow of large volume tends to cleanse the sediments deposited in the Creek bed, but the trash barrier is opened during major storms so that it will not impede storm flows or be torn loose to cause damage.

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BACTERIAL CONTAMINATION

In Oxford Basin, there were a number of violations of Public Health standards for coliform and fecal coliform organisms, possibly of animal origin, and of enterococcus standards, which are indicative of human fecal contamination. Oxford Basin is not a body contact water area, but since it drains into Basin E where boaters or maintenance people might be in contact with the water, these episodes of violation are of concern. In December 1989, bacterial counts were also in violation in Ballona Creek at Stations 12 and 1.

RAINFALL EFFECTS

Impacts of a small rain storm were well illustrated when about 0.5 inches fell in the Los Angeles Basin on 4 April 1990, followed by monitoring on 5 April. Almost the entire Marina was in violation of bacterial standards from runoff. Ammonia levels were high in Oxford Basin and in Ballona Creek, as were nitrates and nitrites, and phosphates. Biochemical Oxygen Demand (BOD) was high, indicating the input of organic materials which would be broken down chemically or by bacteria in processes using up oxygen. Dissolved oxygen was low only in the inner Marina, probably because bacterial degradation had not yet been completed, and also because turbulence at the breakwater may have increased the level of dissolved oxygen.

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SEDIMENT CHARACTERISTICS AND CONTAMINANTS

Sediment grain size changed from the previous year, in particular at Station 2, at the entrance to the Marina, with a large increase in very fine sediments that have accumulated at the sandbar. These fine sediments carry a large proportion of the pollutant trace metals and pesticides adsorbed on or complexed to them.

Stations 9, 10 and 11 in the Marina, and 12 in Ballona Creek scored as the most contaminated by total trace metals. Based on criteria newly developed by the National Oceanographic and Atmospheric Administration (NOAA), sediments at most stations monitored are sufficiently contaminated with copper, lead, mercury and zinc to pose a low range level of effects (ER-L) on fish and/or invertebrates, especially larval or juvenile stages. Several stations are sufficiently contaminated to fall in the median range of effects (ER-M) from lead and zinc, and a few stations are in the range called the apparent effects threshold (AET). Falling in the AET for copper was Station 10 in Basin E, and for zinc, Stations 2, in the Entrance Channel and 9, 10 and 11 in the inner Marina; Station 12 was in the AET group for zinc, and Station 13 in Oxford Basin was in the AET for lead and zinc. Regulatory agency standards are not yet in place for sediment contaminants, except for dredge disposal permits issued on a case by case basis by the U.S. Army Corps of Engineers (COE) and the Environmental Protection Agency (EPA).

There is no direct correlation between any single trace metal or pesticide parameter for which analysis is conducted with the benthic or fish populations. The synergistic effects of contaminants are difficult to evaluate, and previous bioassays conducted have shown chronic inhibitory effects but not lethal effects of Marina sediments on selected indigenous organisms.

Tributyltin, the highly toxic antifouling agent that was banned in September 1987, has continued to decrease in Marina sediments, indicating good compliance with the ban. This may be related to the return of intertidal crustaceans and mussels which had almost disappeared from pilings and riprap.

The situation for pesticides and chlorinated hydrocarbons is of concern; levels of Chlordane were above the median effects range and the apparent effects threshold (AET) except at Stations 6 and 8, which have the lowest terrestrial drainage. The total DDTs were above the median effects range at all stations. Levels are sufficient to damage liver function or reproduction in sensitive species and inhibit the larval and juvenile stages of hardier species.

Polychlorinated biphenyls (PCBs), banned for years but formerly used in transformers, as lubricants in motors and pumps and in other industrial processes, had been absent from the Marina in 1985-1988. Highly toxic forms, the Aroclors 1254 and 1260, were found in October 1989, when Aroclor 1260 occurred at the Administration dock (Station 25) and in Ballona Creek. Aroclor 1254 was found in all other Marina Stations except Stations 1 and 3, with by far the highest level at Station 2 in the Entrance Channel where the finest sediments accumulate. This indicated that the introduction(s) had been long enough prior to the annual survey to become widely spread.

To verify the occurrence of Aroclor 1260, which is not common, a second survey was made in January 1990, at which time Aroclor 1260 was found to be more widely distributed, with peaks at the Administration dock and in Oxford Basin. This suggests separate introductions. Soils inland of Admiralty Way near the head of the Main Channel are known to be heavily contaminated with PCBs, including Aroclor 1260, at levels more than 1000 times higher than those in the Marina. Extensive grading and excavation inland of Marina del Rey appears to have been contaminating the Marina by runoff that is potentially highly toxic to fish and invertebrates.

FISH TISSUE BODY BURDENS

Concern for the levels of PCBs and DDTs in the Marina led to a special study to determine whether the fish caught in the Marina, especially at the fishing pier, might be hazardous to human health. Muscle tissues from 22 fish, representing 12 species, and 3 sets of liver/gonads were sampled and analyzed. Results indicated that the fish muscle tissues were well below Public Health limits for human consumption.

Concentrations varied greatly, with the high levels under 300 ppb of PCB in California halibut, California barracuda, white croaker and shiner surfperch. The same species tended to have the highest levels of DDTs and the effects are probably cumulative. Liver and gonads, which are gutted before human consumption, had much higher levels in some species, indicating possible impairment of liver and reproductive functions. The California lizardfish, which had very low levels in body tissue, had extremely high levels in the liver. Widely ranging fish may ingest these pollutants during feeding elsewhere in the Bight or in the Marina. Fish from off Whites Point and the south side of Palos Verdes Peninsula may contain much higher levels than those found in the Marina, and therefore white croaker are banned from commercial catch there. Content varies seasonally since chlorinated compounds are complexed to fats, which are transported from muscle and liver to eggs that are shed, lowering the body burden. These special studies are continuing in 1989-1990.

BENTHIC FAUNA

The benthic fauna consists primarily of polycheate annelid worms, which prefer the fine grained sediments and can tolerate contaminants. Molluscs, crustaceans and echinoderms that might be expected in the Marina environment are scarce, perhaps reduced or eliminated by the high levels of contaminants in the sediments which inhibit reproduction and impact larval and juvenile stages.

The long term mean number of benthic species in October surveys is 31, but the means have been below that in the last three years. Similarly the mean number of individuals has been lower in the last three years than in 1986. This may reflect the low rainfall and the lack of flushing which may be needed to stimulate populations or to remove inhibitory substances. There have been no major sewage or other spills of record during this year.

Of particular concern are benthic conditions at stations 9 and 11, which had by far their lowest populations ever, lower than would have been expected due to the change from open water to boat slips.

FISH FAUNA

In all over ninety species or taxa of fish have been recorded in the Marina during the monitoring surveys. Of these, 12 species have occurred in all spring surveys since 1984, one of which, the striped mullet, is uncommon in the southern California Bight, making the Marina an important habitat for that species. The mean number of species from all surveys since the 1970s is 40, with a range of variation from 33 to 47.

The Marina appeared to be relatively in stable condition in the October 1989 and May 1990 surveys, recognizing that the larger numbers of individuals are more likely to occur in May than in October. The larger numbers represent smelt, pelagic fish that move in and out of the Marina, and thus greatly influence the total numbers by their movements. The numbers of species caught by gill net has been reduced in surveys since May 1988 and the numbers of ichthyoplankton have been reduced following the October 1988 survey. These might be related to the PCBs spillage or drainage that occurred into the Marina sometime after the sediment chemistry survey of October 1988.

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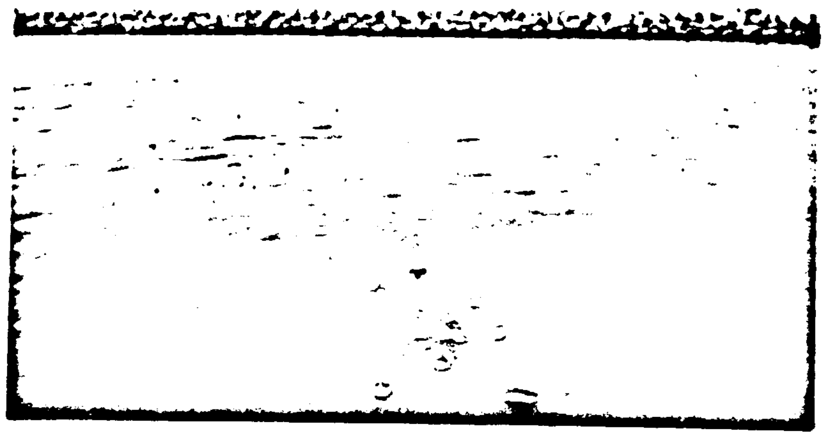

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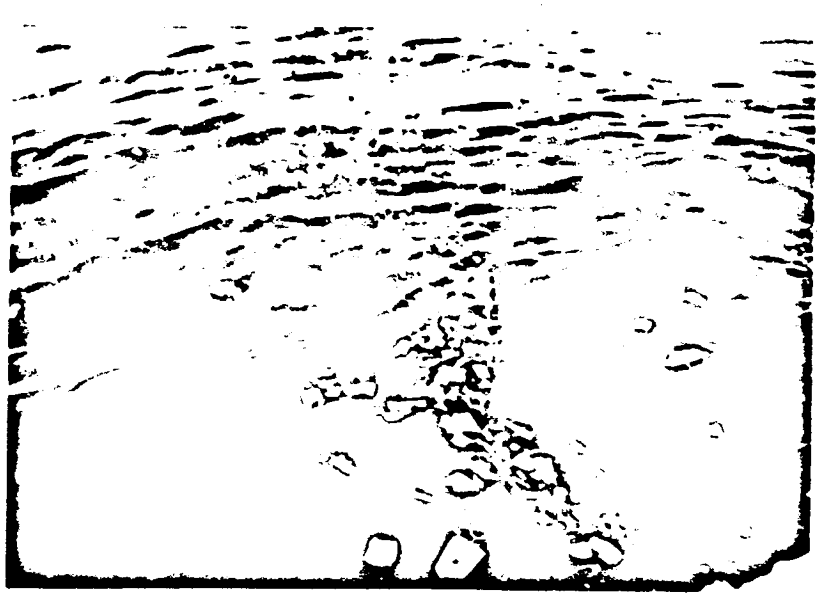

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Figure i. *Trash floating near breakwater*

Figure ii. *Trash accumulated beside south jetty at Marina entrance on falling tide.*

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APPENDICES

Photographs by Rita M. Bester

I. INTRODUCTION

HISTORICAL BACKGROUND

Marina del Rey, California is the largest manmade small craft harbor in the world, constructed on degraded wetlands of the former Ballona Creek Estuary in 1960-1962. Ballona wetlands historically extended inland through the Venice area to the north, to the San Diego Freeway area on the east, northeast toward downtown Los Angeles and southeast around Westchester bluffs and the Palos Verdes Peninsula, to join the wetlands of the Los Angeles River. At times when the Los Angeles River changed course, it exited at Ballona Lagoon (Bancroft, 1884; Beecher, 1915).

La Ballona area was several times seriously considered as the site for the Port Los Angeles but was finally rejected in favor of improving Los Angeles Harbor, in part because Ballona was poorly protected from prevailing wind and wave patterns.

In the 1920s and 1930s the rivers and creeks of the Los Angeles basin were channelized and lined with concrete in efforts to control the massive flooding and destruction that occurred during major winter storms. Thus Ballona Creek became part of the Los Angeles County Flood Control system.

When the Marina was constructed, large areas of the Ballona Creek wetlands had already been drained, cut off from tidal inundation, and filled to create farm lands, gas fields, salt pannes and informal trash disposal landfills (Figure 1). Public health control of mosquitoes and black flies was also an objective for draining "useless swamps".

Channeling Ballona Creek cut off access, except through tide gates, to Ballona Lagoon on the north, which had been the major drainage channel of the wetlands and source to the Venice Canals, as well as Del Rey Lagoon and the remaining wetlands on the south side. These lagoons lay inland of

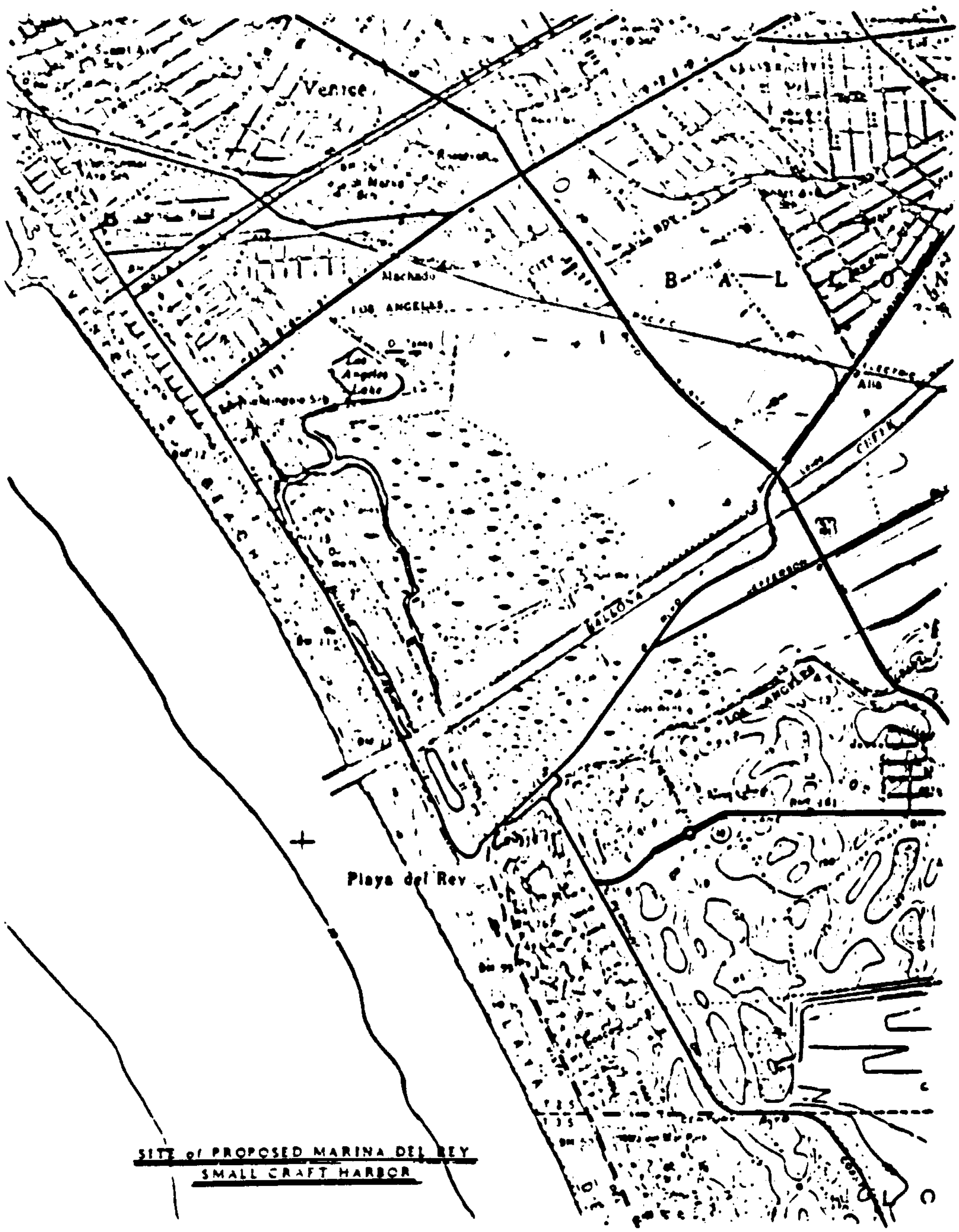

Figure 1. Ballona wetlands area prior to construction of Marina del Rey circa 1960.

the historic barrier beach. Design of the Marina placed the drainage pond known as Lake Los Angeles at the end of Basin D, now Marina Beach. The history of the wetlands and construction of the Marina were discussed and illustrated with photographs in detail in Soule and Oguri, 1990.

ENVIRONMENTAL STUDIES

No environmental inventories were undertaken before or after construction of the Marina and of the breakwater. In July 1976 through June 1979, baseline surveys were undertaken by the University of Southern California Harbors Environmental Projects under funding from the Sea Grant Program and the Los Angeles County Department of Small Craft Harbors (now the Department of Beaches and Harbors). An extensive program of physical, chemical and biological sampling at 13 stations (Soule and Oguri, 1980) provided a detailed picture of the Marina, not only as a recreational site but as a natural resource providing habitat in a region depleted of protected shallow water environments.

Limited surveys were resumed in 1984 in the spring and fall periods, with sampling that included monthly water quality measurements of water quality, biannual surveys of benthic organisms, fish and annually of sediment contaminants. Surveys were then reduced to one period a year, October, November and December (Soule and Oguri, 1985, 1986, 1987, 1988).

In 1988, year round monthly water quality surveys were resumed and four more stations were added (Soule and Oguri, 1990). Special studies have also been undertaken of the effects of tributyltin, bioassays of contaminated Marina bottom sediments, the incidence of coliform-enterococcus pollution, and the DDT and PCB body burdens of fish caught in the Marina as they might affect public health and fish reproduction. In 1989, one more station was added at the site for a potential entrance to a new marina basin. Figure 2 illustrates the western Los Angeles area where Marina del Rey is located, and Figure 3 gives the water quality station pattern in the Marina. Station descriptions are as follows:

STATION LOCATIONS AND DESCRIPTIONS

MDR-1. Located midway between the breakwater at the east entrance to the Marina and the beach, at the mouth of Ballona Creek Flood Control Channel. The area is subjected to discharges from the creek, to severe impacts from storm water flow and to deposition or erosion from storm wave action. Depth irregular, 2-6 meters.

MDR-2. At the entrance of the Marina, midway between the two Marina jetties. The area is protected from most storm waves but subject to weak coastal currents. Sands have been deposited from storms and blown from the adjacent beach resulting in severe, irregular deposition. Heavy flow in Ballona Creek flood control channel also carries sediment and debris into the mouth of the Marina. Dredging was undertaken in February 1987 to reestablish the channel. Depths 4-6 meters.

MDR-3. On the north (west) side of the entrance channel, in front of the tide gates to Ballona Lagoon and the Venice Canal system. Protected from all but severe storm waves, the site is subjected to discharge of waters from the canal system. Shell mounds present during the 1976-1979 surveys disappeared, replaced first with fine sediment and then sand. Depths 3-6 meters.

MDR-4. Seaward of the Administration/ Coast Guard dock on the south (east) side of the entrance channel at junction with main channel. Subject to heavy boat use. Protected from most surge, the area was heavily damaged by 1983 storms and docks were rebuilt in 1985. Depths 3-6 meters.

MDR-25 Between the Administration - Life Guard docks and the public fishing dock.

MDR-5. In the center of the Main Channel, subject to heavy boat traffic. Depth 3-6 meters.

MDR-6. At the innermost end of Basin B; protected from westerly winds by seawall, circulation reduced. Depth 3-5 meters.

MDR-7. At the end of Basin H near the work yard dock. Large storm drain present; exposed to afternoon westerly winds. Depth 3-4 meters.

MDR-8. Off the swimming beach in Basin D near first slips. Exposed to afternoon winds. Depth 3-4 meters.

MDR-9.	At the innermost end of Basin F. Large storm drain present; protected by slips and sea wall. Depth 2-4 meters.
MDR-10.	Innermost end of Basin E; subject to daily flushing from the Oxford Flood Control Basin through tide gates and to storm water runoff. Depth 3-4 meters.
MDR-11.	At end of Main Channel; subjected to storm drain flow and to influx from Station 10; impacted by reduced flushing due to increased slip capacity. Depth 3-5 meters.
MDR-12.	Ballona Creek, sampled from beneath the Pacific Avenue foot bridge. Subject to tidal flushing and continuing freshwater discharge into the flood control channel; also subjected to illegal dumping of trash upstream and to sewage overflow. Depths 1-4 meters.
MDR-13.	Inside tide gates of Oxford Flood Control Basin; subject to minimal daily tidal flushing, storm water runoff and drainage, surface only. Inaccessible at times.
MDR-18.	Twenty meters off wheelchair ramp in basin D perimeter of swimming area. Depths 1-3 meters
MDR-19.	At end of wheel chair ramp, surface only.
MDR-20.	At innermost end of Basin E where Oxford Basin flow enters Marina. Depths 1-4 meters; flow partially obstructed by large vessel docked there.
MDR-22.	Inner end of Oxford Basin at Washington Blvd. culvert, surface only.

Depths vary according to a number of factors including tidal stage, irregularities in the substrate due to storm deposition or erosion of sand, runoff, tide gate flow, and propeller wash.

SANTA MONICA BAY RESTORATION

Concern for water quality in Santa Monica Bay, and federal funding for restoration of the Bay, are focused heavily on controlling pollution from non-point sources, to which Ballona Creek contributes heavily. Documentation of conditions in the Marina, as they are influenced by the Ballona Creek and the Oxford Flood Control Basin, provides a major contribution to understanding the impacts of urban drainage on shallow coastal waters.

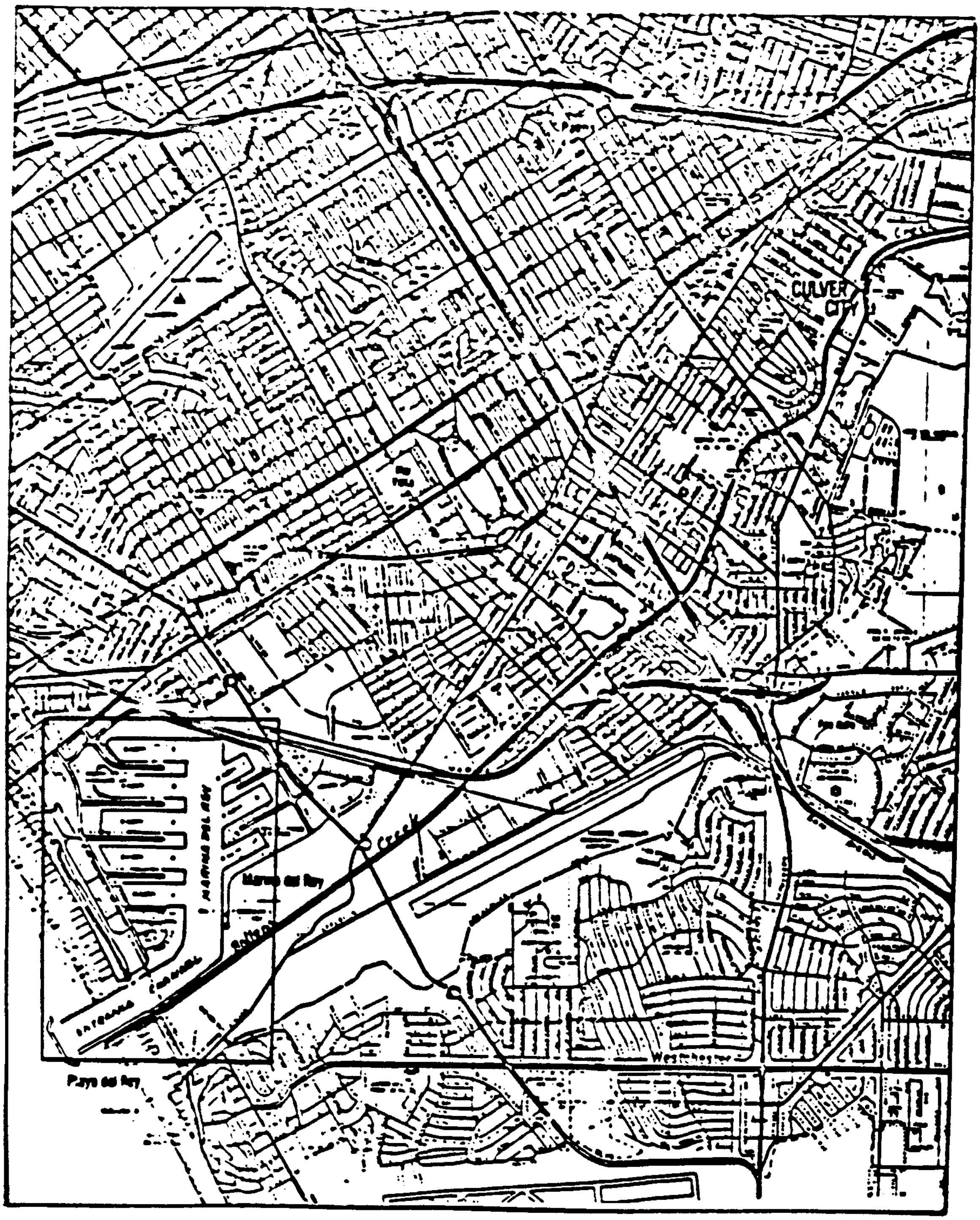

Figure 2. Western Los Angeles basin with Marina del Rey study site.

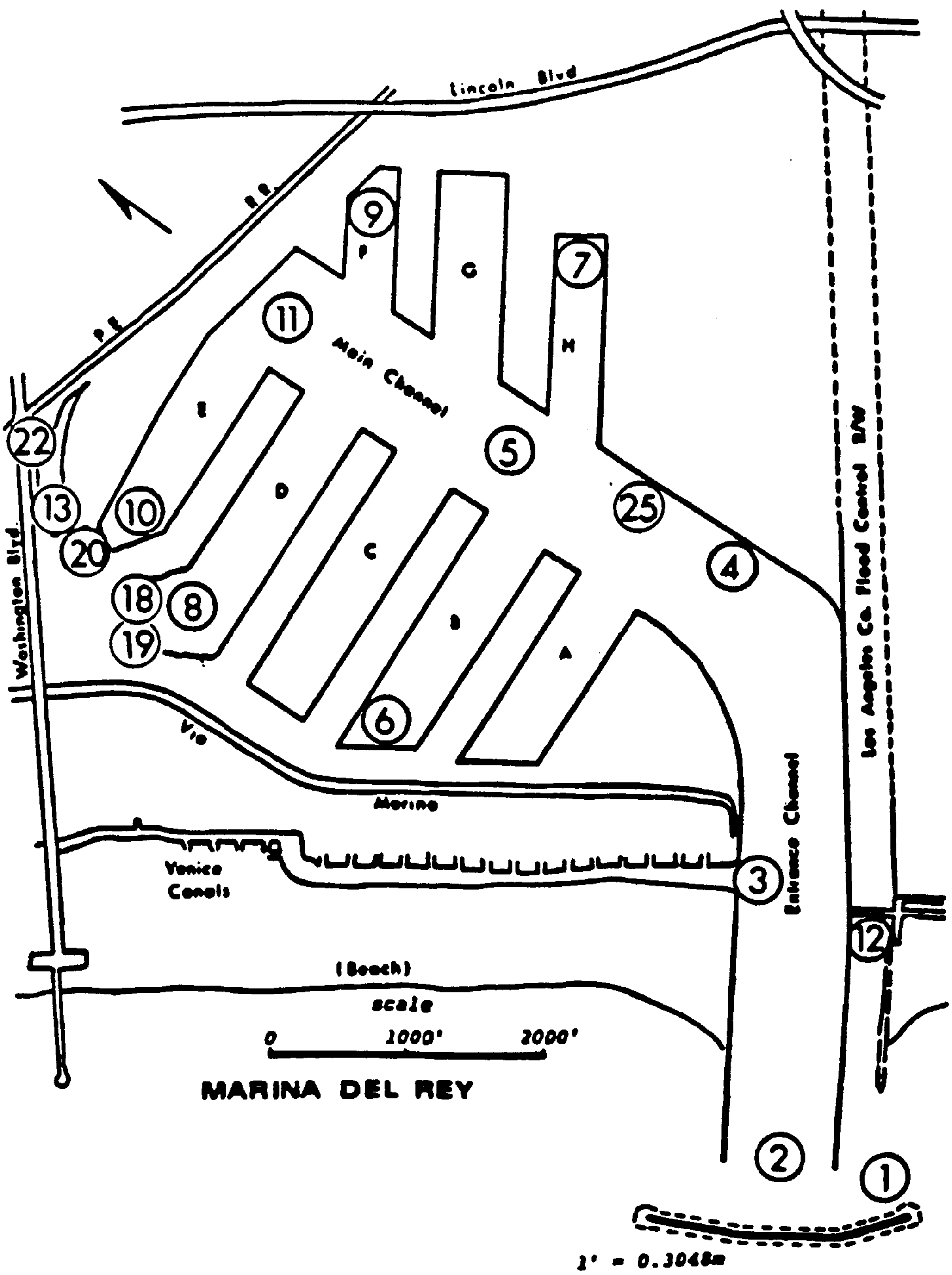

Figure 3. Water Quality Station Locations, Marina del Rey.

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II. PHYSICAL WATER QUALITY CHARACTERISTICS

INTRODUCTION

Physical factors affecting water quality and the biota of the Marina that are measured monthly include temperature, salinity, dissolved oxygen, hydrogen ion concentration (pH), and light transmittance; water turbidity and color, tide, wind and weather are also recorded. The 1989-1990 period was the second year since the 1970s studies by USC that the full year was monitored monthly rather than a seasonal segment.

Biochemical Oxygen Demand is determined from water samples taken along with nutrient and coliform samples. BOD_5 is an indicator of the presence of natural and manmade substances in the water column which are oxidized by microbial action when they are released into the water column, a process that removes dissolved oxygen from the water, potentially depriving the biota of adequate oxygen supplies.

METHODS

Monthly measurements of temperature, salinity, dissolved oxygen and pH are made using a Martek remote probe, and light transmittance is measured with a transmissometer having a self contained light path. Observations of light penetration are made with a Secchi disk and color is determined by the Forel-Ule (FU) scale. Biochemical Oxygen Demand is determined according to Standard Methods (APHA, 1985), modified for sea water, by dilution of samples and incubation in air tight bottles for five days at 20°C. Complete physical water quality data are recorded in Appendix B.

TEMPERATURE

The most extensive comparative temperature data base in the Marina is for the months of October, November and December. As shown in Figure 4, the 1989 October surface to 2 m temperatures were cooler at the Ballona

Creek and Entrance stations and at the inner Marina stations than in any year measured except 1986. The El Niño event of 1982-83 extended into October of 1984 in southern California, making temperatures higher than usual. The temperature range was wider in the 1980s than in the 1970s, from 18.1°C to 21.5°C, as shown in Figure 5.

The November 1989 surface to 2 m temperatures were lower than in the rest of the 1980s surveys (Figure 6) and also lower than in the 1970s surveys (Figure 7). Comparison shows that 1985 and 1976 were the warmest of the Novembers surveyed. In spite of the cool water in October and November 1989, the warmer water in the inner Marina in September 1989 (Soule and Oguri, 1990) gave the autumn 1989 period a wider range in temperatures, from 15.4 to 23.4°C, than in the previous year, with the warmest value 2.0°C higher (Table 1, below). September 1990 was even warmer.

Table 1. Temperature Ranges ($^{\circ}$C) by Season and Year in Marina del Rey*

	Spring Mar, Apr, May	Summer Jun, Jul, Aug	Autumn Sep, Oct, Nov	Winter Dec, Jan, Feb
1976		20.3-23.0	19.2-20.9	16.0-18.3
1977	15.7-18.3	19.8-22.0	16.1-19.7	15.0-15.9
1978	17.1-20.7	18.9-22.6	18.2-19.7	12.8-14.1
1979	16.4-18.4	19.3-20.9		
1984	17.7-20.2[1]	19.4-23.3[2]	16.8-25.5	
1985			18.0-21.8[2]	12.4-14.3[1]
1986			16.5-20.8[2]	14.5-16.5[1]
1987			17.2-21.4[2]	15.3-16.6[1]
1988			15.9-21.4[2]	11.2-14.3
1989	14.1-22.9	15.6-24.0	15.4-23.4	11.8-16.2
1990	14.0-20.8	17.4-25.3	16.6-23.6[1]	

[1] = one month only
[2] = two months only
* = excluding Station 22, inner Oxford Basin

December 1989 surface to 2 m temperatures were intermediate in comparison with other 1980s temperatures (Figure 8), being more similar to 1986 and 1987 than to the colder years of 1985 and 1988. Figure 9 illustrates temperature differences, with 1976 being much warmer than 1978 in December.

Temperature ranges in winter months (December 1989, January and February 1990) were warmer than in the comparable period the previous year (Table 1); the low was 0.6°C higher and the high was 1.9°C higher. While this was referred to as another El Niño in the press, it did not continue into the spring period, where the range was about 2.0°C lower. However, the summer months were also warmer in 1990 than 1989, with the highest temperature, 25.3°C, of those recorded in the USC monitoring studies. For comparative purposes, data from Station 22, at the innermost end of Oxford Basin is excluded, since it was not monitored before 1989 and is relatively isolated from the rest of the Marina.

The temperatures at 0-2 m and bottom for each monthly survey are illustrated in Figures 10 to 21. In general, waters are well mixed with little evidence of a thermocline through the winter months. Beginning in March, a small thermocline existed in the Entrance and Main Channel which became more pronounced during the summer months, culminating in the widest range in September.

There was evidence of upwelling in August, when Station 1 showed an unusually low temperature and high salinity at the bottom of 17.4°C (Figure 17).

The minimum, average and maximum temperatures without regard to depth are shown in Figure 22. This also illustrates the more uniform conditions

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in the winter and early spring and the wider ranges in July, August and September.

SALINITY

Salinity varies in the Marina according to the water masses entering Santa Monica Bay from the north or south, and according to the rainfall or dry weather flow into the flood control systems. Since measurements on a given day are taken over about three to four hours in the morning, tide phase also affects salinity by determining the influx of bay waters and mixing with Ballona Creek freshwater. The flow from Oxford Basin is of a lesser volume and thus may have less effect on salinity over a large area.

In 1990, most of the surveys were conducted during falling tides or near high tide followed by falling tide, in contrast to 1989 when most surveys were conducted on rising tides (Soule and Oguri, 1990). The exact time at which a station was occupied and the time of high tide are given in Appendix A, Cruise Logs, and Appendix B, Physical Water Quality Data.

Table 2 presents the low and high salinity values for each monitoring period and the stations showing the extremes, along with the tide phase. It can be seen that Stations 12 in Ballona Creek and Station 22 in Oxford Basin were generally the sources of low salinity water. There is apparently only a small surface intrusion of low salinity water into the Entrance Channel under dry weather flows in Ballona Creek, as is also evidenced by the floating trash that originates from the Creek and collects in the Entrance Channel. Bay waters mix with Creek waters at Station 1, with higher salinity water entering as a wedge on the bottom of Ballona Creek and the Marina. Complete salinity data are given in Appendix B.

The inner basins such as Stations 7 and 9 (Table 2) sometimes have the highest salinities, probably representing the residence time of water there and the evaporation due to insolation. Where the higher salinities occurred in the outer Entrance Channel they were in bottom waters but were generally mixed in the inner Entrance Channel and Main Channel, as is seen in January, February, April and June 1990. When highest salinities are in the Main Channel, coupled with the basins, it may represent mixing with basin waters or incursion of bay waters farther into the Marina, depending on tide stage and runoff.

Table 2. Salinity Ranges in Parts per Thousand (ppth) in Monthly Surveys, October 1989-September 1990

Month	Low	Station	High	Station	Tide Phase
October	24.7	12	32.1	3	rising
November	27.0	22	32.3	7	high, falling
December	16.4	12	32.0	7	falling
January	31.2	22	32.6	1,2,3,4,25	falling
February	30.7	12	32.6	1,2,3	falling
March	31.2	12	32.6	3,4,5,6,9	falling
April*	4.6	22	32.2	1,2	falling
	9.3	13			
	24.4	12			
May	29.6	12	31.5	2,3,5,7,9	low, rising
June	30.6	22	32.3	1,2	falling
July	28.1	12	32.0	7	rising
August	32.0	1	33.0	1,7,8	high, falling
September	31.9	22	32.5	2	high, falling

* one day after rainfall

Salinities in April at Station 12 in Ballona Creek and Stations 13 and 22 in Oxford Basin reflected runoff after about 0.5 inches of rain in the Los Angeles Basin the previous day, with a halocline at most stations. High tide had been about two hours prior to the start of monitoring at Station 12. Lowest Marina salinities were on the surface at Stations 1 through 5, probably reflecting the earlier incursion of Ballona Creek runoff waters during the rising tide, and at Stations 7, 9 and 11, where

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storm drains enter the Marina. At the same time, the highest salinities were at the bottom at Stations 1 and 2.

In August, on a falling tide, salinities at Station 12 were higher than at the surface of Station 1, but bottom water at Station 1 was unusually cold and of high salinity, which suggests upwelling in Santa Monica Bay.

Figure 23 illustrates the maximum, minimum, and average salinities for the entire Marina during each monthly survey. The maxima did not vary greatly, but the minima varied considerably. The minimum in December was most influenced by Station 12, and represented a large freshwater flow in Ballona Creek during dry weather from an unknown source. The April minimum was in Oxford Basin and followed the day after a 0.5 inch rainfall.

DISSOLVED OXYGEN

Dissolved oxygen (DO) along the open coast usually ranges from 6.0 ppm to 8.5 ppm, depending on whether waters have become supersaturated due to turbulence or to phytoplankton blooms. Regulatory agencies state that 5 pp. is the minimum level of DO for survival of fish species, although invertebrates may exist on very low levels of DO, and some species have alternative anaerobic metabolic pathways for survival (without oxygen).

Waters in the Marina in 1989-1990 had DO values ranging from 12 ppm down to 1.6 ppm. Saturation varies according to salinity and temperature, decreasing as temperature increases. The tendency of Marina waters to show a thermocline during the summer months, restricting mixing, and the elevated temperatures in the basins lead to depleted oxygen levels at times in bottom waters. Also, when phytoplankton (single celled plant) blooms are expanding, DO increases rapidly due to photosynthesis.

Depletion of DO can occur at night when a large bloom continues to take up oxygen during respiration while photosynthesis cannot continue in the absence of light. When the bloom dies off, bacterial degradation exerts a large oxygen demand. Organic detritus and inorganic chemicals, including ammonia, originating in the Marina or carried into it may also exert a significant oxygen demand, discussed under Biochemical Oxygen Demand.

Comparison of the October - December periods in the 1980s for which the largest data base exists indicate that at the 0-2 m depth DO was higher in October than in any year since 1984, except at Stations 12 and 1; bottom water DO averages were also high except at Station 12 (Figures 24 and 25). These profiles are more similar to those of the 1977 period than to other years monitored (Figures 26 and 27). The 1976 and 1978 DO profiles were lower in general in both surface and bottom waters.

There was a distinct shift in November 1989, with the DO at both the average 0-2 m and the bottom being distinctly lower than the other years in the 1980s, with few exceptions (Figures 28 and 29). The DO levels were more similar to the 1976 and 1978 levels (Figures 30 and 31), which were years with much more rainfall than in 1989.

In December 1989, DOs were high in the Entrance Channel and outer Main Channel, but were below 5.0 ppm in the inner Main Channel and the basins in both surface and bottom waters, making the averages at surface and bottom lower than those in other years in the 1980s (Figures 32 and 33). These values were not as low as those in December 1976 and 1978 (Figures 34 and 35). In the latter year there was more than 2.4 inches of rain in December, no doubt creating a high Biochemical Oxygen Demand on Marina waters.

In Figures 36 to 47, plots of surface and bottom DO at each station by month in 1989-1990 are shown. The highest DO values were usually at Stations 1, 2 or 3, decreasing toward the innermost stations. Disregarding the Oxford Basin Stations 13 and 22, outside the Marina, there were a number of low DO episodes during 1989-1990, primarily in the inner basins. These occurred in November and December 1989, and during May through September. The effect on the shallow area in Basin D during the summer may make the area unacceptable for the fish that commonly inhabit the sea grasses there, causing them to move out of the marina into deeper water, a normal phenomenon in shallow coastal waters. As the thermocline became more pronounced in July, lower DOs occurred in the outer Marina but values did not fall below 5 ppm.

RAINFALL EFFECTS

A modest rainstorm of about 0.5 inches in the Los Angeles Basin the day before monitoring in April 1990 illustrates the effects on DO values; Stations 1 had a DO maximum at the bottom of 10.5 ppm with high salinities, probably reflecting ocean storm turbulence. BODs were very high at Stations 1 through 5, reflecting Ballona Creek runoff. There were DO values between 4.0 and 5.0 ppm layered at the surface and/or on the bottom with higher values between at Stations 5, 25, 9, 10, and 11, and low values in the mid-water column at Stations 7 and 8. BODs at those stations were not high, mostly below 2.0 mg/l, indicating that the oxygen demand from runoff had already been exerted.

Waters in Oxford Basin had DOs below 2 ppm and very high BODs of 15 mg/l (= ppm) or above, at Stations 13 and 22. While Oxford Basin receives waters from a smaller drainage area than Ballona Creek, it empties into such a small area, which normally has low flushing, that it may exert a disproportionate influence on the Marina. Ballona Creek waters are mixed

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near the mouth and in the bay, but BODs ranged up to 12.0 ppm at Stations 1 through 4, without, however, depleting the DO because of the high levels due to ocean turbulence.

BIOCHEMICAL OXYGEN DEMAND

The interaction between dissolved oxygen (DO) and Biochemical Oxygen Demand during a rainfall runoff event was discussed above. The lowest BODs are usually below 1.0 ppm in the Marina, and these occur most often in areas of low runoff, such as Station 6, and Station 18. Station 11 also has low BODs at times, possibly for a different reason that may be related to toxicity of sediments and the very low benthic productivity there.

In general, BODs were below 2.0 ppm in the winter and above 2.0 ppm in summer, probably reflecting water temperature, and in the absence of the usual winter rainstorms in 1989-1990.

Maximum BODs ranged from 1.4 ppm in January to 15.5 ppm in April, and minimum values ranged from 0.3 ppm to 1.0 ppm. The monthly profiles are illustrated in Figures 48 to 59, and the data are presented in Appendix B.

In October 1989 through April 1990 there were few values above 2.0 ppm, at Stations 5, 7, and 9. In November, other than a maximum of 10.2 ppm in Oxford Basin, most stations were below 2.0 ppm. The December high of 2.4 ppm was in Ballona Creek, with most values below 1.0 ppm. The January high was also in Ballona Creek, at 1.4 ppm.

The February profile (Figure 52) showed a relatively large peak of 4.9 ppm at Station 3, the entrance to Ballona Lagoon, and may reflect activities associated with construction in the Lagoon. March (Figure 53) may have reflected earlier rainfall in mid-February or some other event in having a peak of 10.1 ppm in Ballona Creek and 9 ppm at Station 2, no doubt associated with Ballona Creek. The April rain event discussed above

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deviated strongly from the pattern of relatively low BODs.

May and June 1990 showed evidence of BOD originating in Ballona Creek or Oxford Basin, which may have been associated with earlier rainfall in April and May, or with dry weather flow. There were a number of stations with values above 2.0 ppm, but the maximum values were only 4.1 and 5.3 respectively. July's peak of 6.2 ppm was in Oxford Basin, as was the August peak of 4.9 ppm. The September peak of 5.1 ppm was at Station 19, at the wheel chair ramp, suggesting a human associated origin, as indicated by the high enterococcus value there at that time (see Microbiology section).

HYDROGEN ION (pH) CONCENTRATION

The pH of the open ocean generally ranges from 7.5 to 8.4 (Sverdrup et al., 1946). The range in the Marina in 1989-1990 was from 7.0 to 8.4, but all the low values occurred in Oxford Basin, except in July 1990 when the low of 7.9 occurred at the bottom in Station 10, concurrent with a low DO of 3.5 ppm. and a BOD of 4.8 ppm. A similar possible coupling of low pH, DO and elevated BOD occurred in June and September, both in Oxford Basin. This was not always the case, however.

Higher pH values can result from significant phytoplankton photosynthesis, resulting in uptake of carbon dioxide and a shift in the carbonata equilibrium. This activity may serve to buffer some of the lower pH potential due to chemicals introduced into Marina waters in runoff.

As illustrated in Figure 60, the maximum values and the average values for the entire Marina by month do not vary greatly but the minimum value do. In each case in this profile the lowest values in December and April reflect the effect of Stations 13 and 22 in Oxford Basin.

None of the pH levels were low enough to be harmful to organisms, but they could influence the very complex chemistry that determines the availability of toxic metals that are sorbed on particulates.

FOREL-UHL (FU) COLOR SCALE

Water color is an indicator of physical, chemical and biological factors such as depth, substrate, tide phase, turbulence, suspended particulates, bacteria and phytoplankton. Color is measured in the Forel-Uhl scale, which consists of a series of small, numbered glass vials filled with marine colors or shades which are compared to the seawater viewed above a white Secchi disk suspended at the surface. Numbers range from 1 to 3, deep sea blue; 4 to 5 are blue green, 5 to 11 are progressively darker greens; 12 to 15 are greenish browns, and 16 to 22 are progressively darker browns.

Colors of 3 to 5 rarely occur in the Marina; one 5 was observed at Station 1 in October 1989. The greens ranging from 6 to 9 usually occur in the Entrance Channel and the rest of the Marina stations usually range up to 14.

In 1989-1990, the minimum range was from about 5 to 10 (Figure 61), and the average was from about 9 to more than 13. The maxima were correspondingly higher, with a range from about 12 to 19, the latter value occurring after the rain in April 1990. Even excluding the April peak, the waters were more greenish to brown than in 1988-1989 when the peak was 15 at Station 9 in July 1989.

LIGHT TRANSMITTANCE

Water transparency is determined in two ways; one is by the self-contained light path in the transmissometer and the other is by visual observation of a white Secchi disk lowered in the water column, in the shade of the vessel if possible, to the depth in meters of disappearance.

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The latter method is traditional but can vary greatly according to the observer so that it is best if the same person always performs this.

The two methods produced somewhat different profiles of the maxima, minima and average values in the Marina in 1989-1990. While the lowest values obtained by transmissometer (Figure 62) and Secchi disk (Figure 63) were in April after the rain and in May, the curves for the minima and maxima were quite different, One might expect light transmittance to be inversely related to the color values, but that was the case only in a few instances. In October, the maximum Secchi disk value was related to the minimum FU color value of 5, and on 5 April 1990 the minimum transparency by both methods was related to the maximum color of 19 in Ballona Creek due to turbidity associated with rainfall runoff. Otherwise color and turbidity were not necessarily well related.

CONCLUSIONS

The wide range of temperatures in 1989-1990, with a cool fall, warm December and January and cold March, was followed by a very warm summer. This, coupled with very low seasonal rainfall which did not flush the Marina but served only to carry organic matter and trash into it, probably led to the more extensive low oxygen episodes (below 5.0 ppm) than seen in the recent past. There were no zero oxygen levels recorded, however; the lowest DO in the Marina proper was a 1.6 ppm at Station 8 in June. High temperatures and reduced oxygen levels probably cause fish to leave the inner Marina for deeper, cooler waters, but would probably not affect benthic fauna. Zero DOs would change the bottom sediment chemistry, and produce hydrogen sulfide, which is toxic.

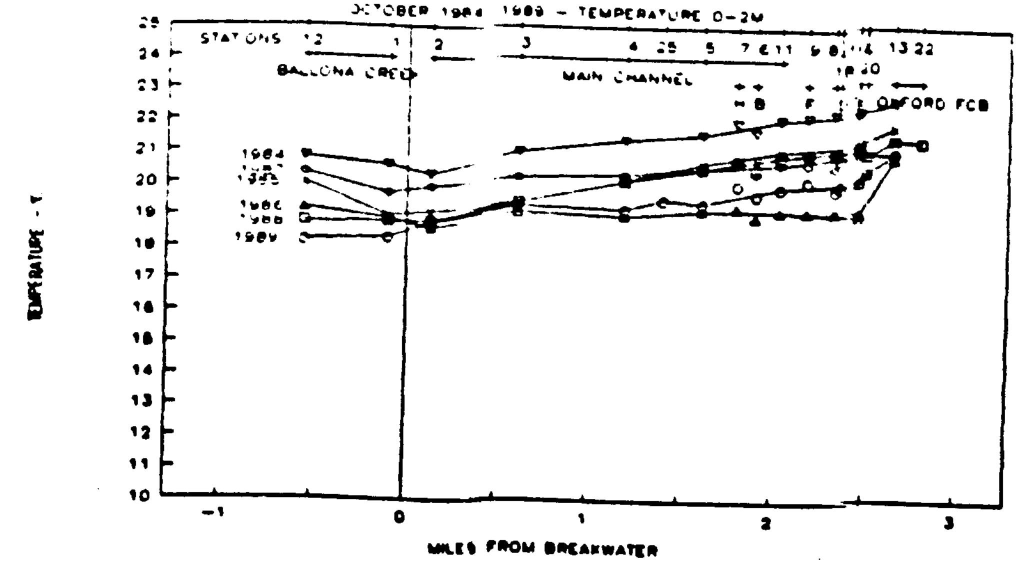

Figure 4. Average temperature (°C) surface to 2m, in October 1984-1989 surveys.

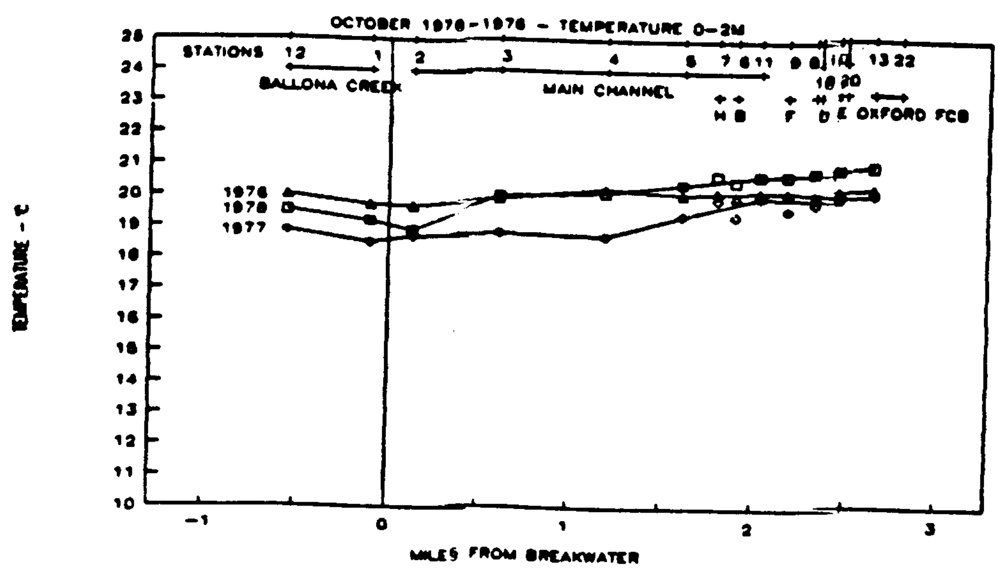

Figure 5. Average temperature (°C) surface to 2m, in October 1976-1978 surveys.

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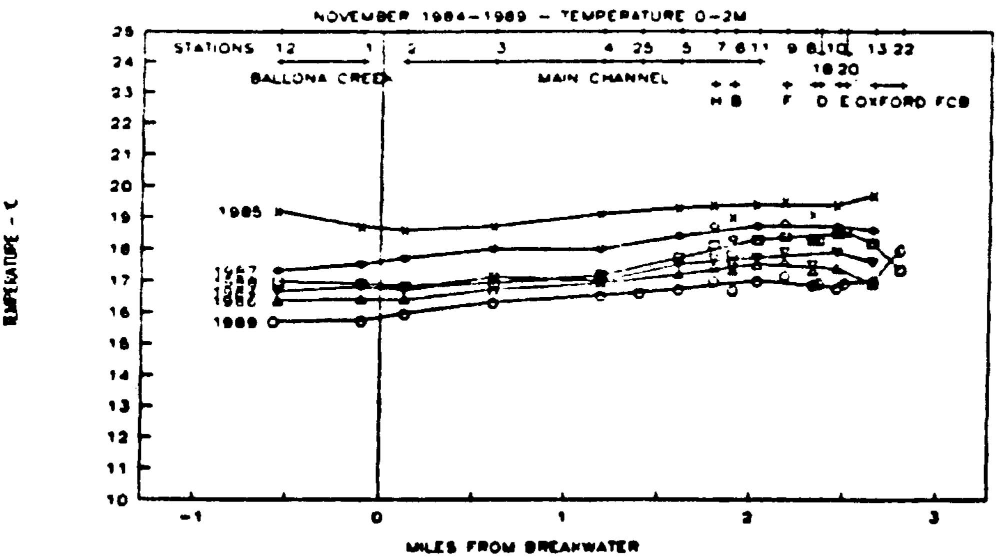

Figure 6. Average temperature (°C) surface to 2m, November 1984–1989 surveys.

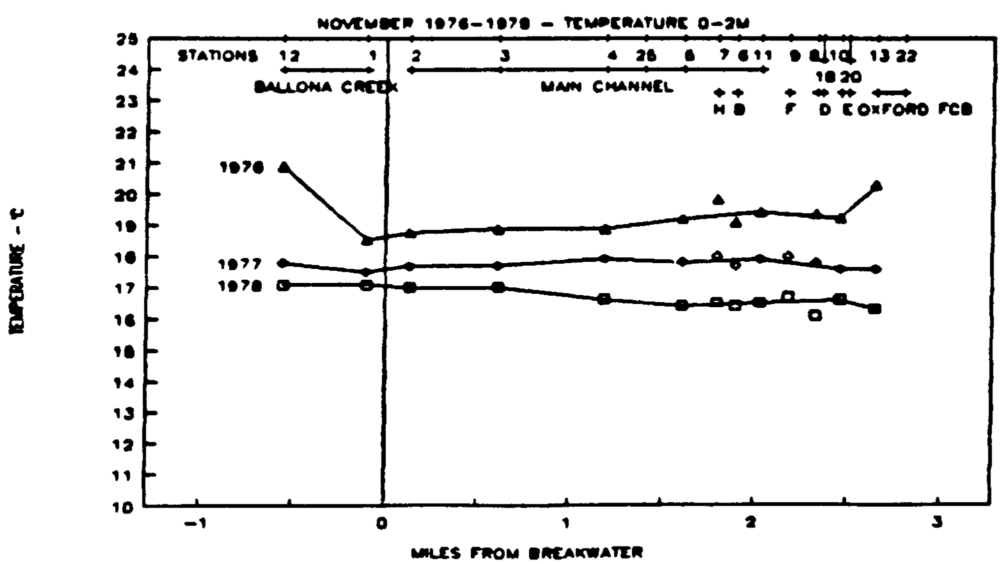

Figure 7. Average temperature (°C) surface to 2m, November 1976–1978 surveys.

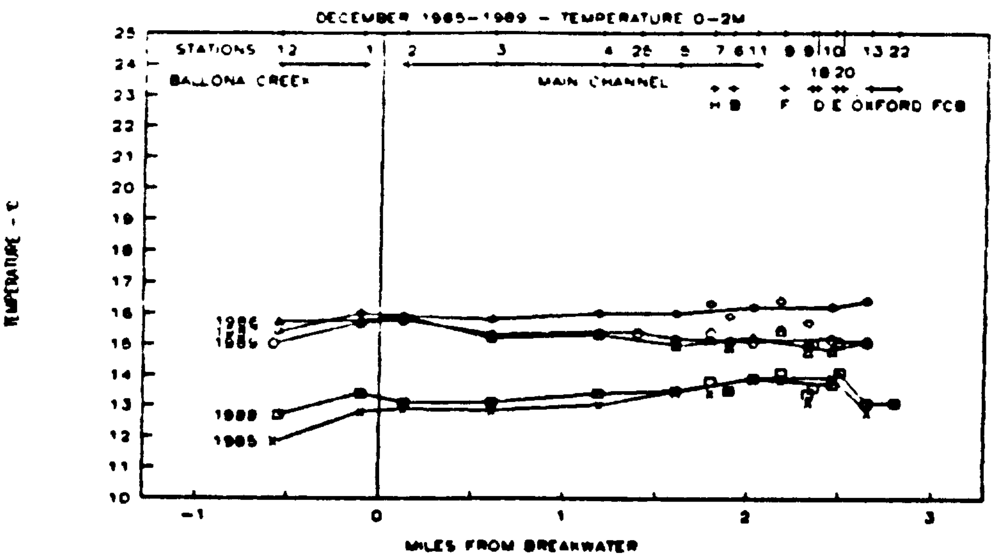

Figure 8. Average temperature (°C) surface to 2m, December 1985–1989.

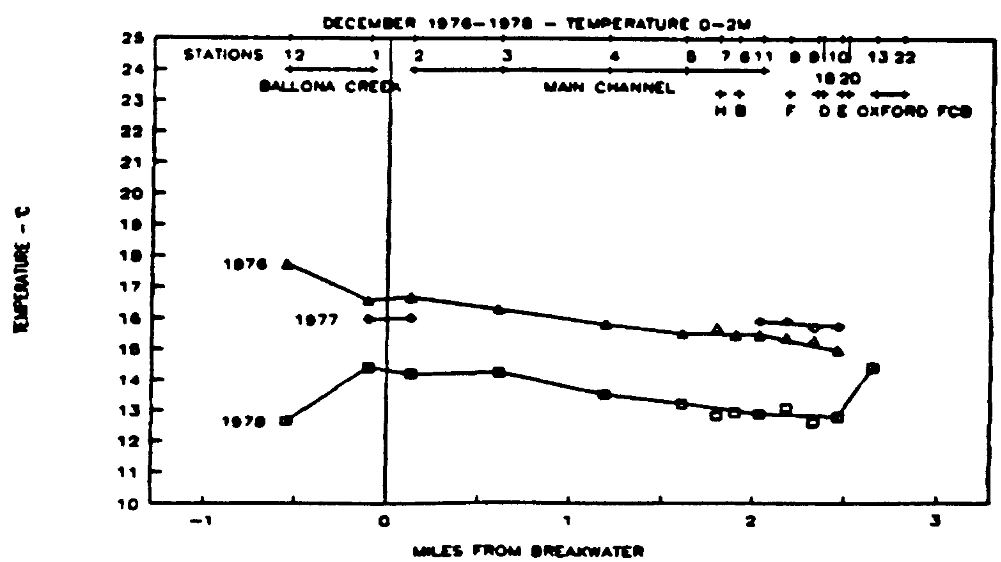

Figure 9. Average temperature (°C) surface to 2m, December 1976–1978. The 1977 data set is incomplete.

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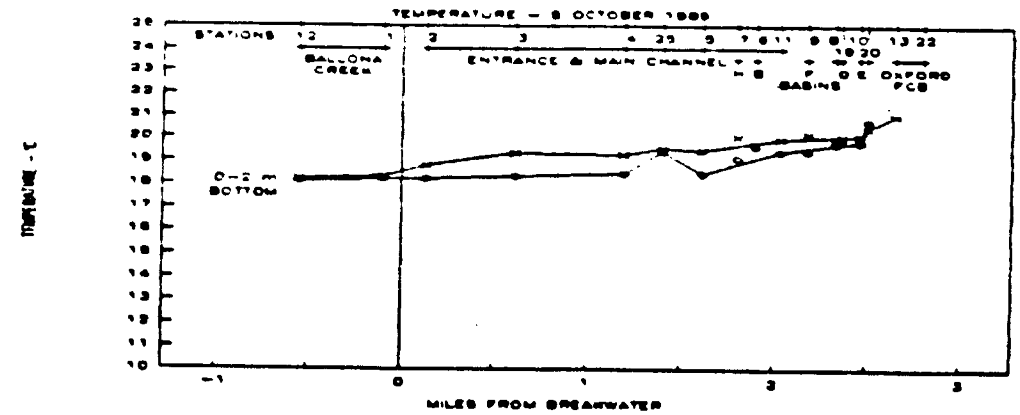

Figure 10. Average water temperature (°C), surface to 2m and bottom, 5 October 1989.

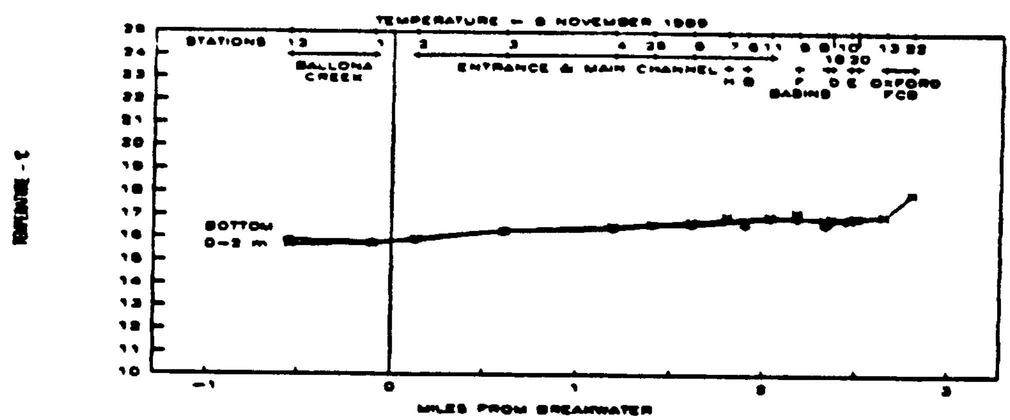

Figure 11. Average water temperature (°C), surface to 2m and bottom, 9 November 1989.

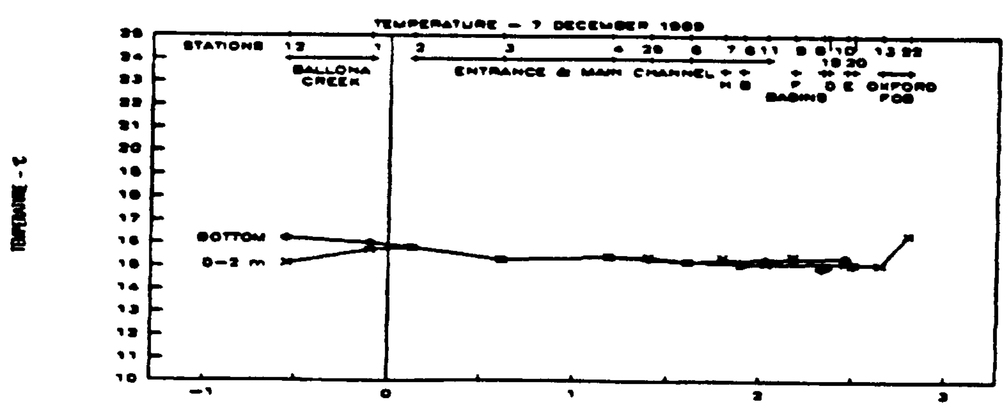

Figure 12. Average water temperature (°C), surface to 2m and bottom, 7 December 1989.

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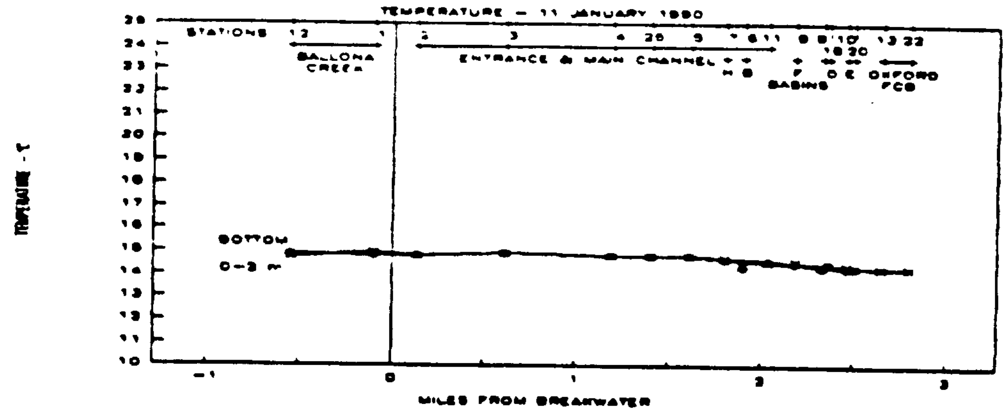

Figure 13. Average water temperature (°C), surface to 2m, and bottom, 11 January 1990.

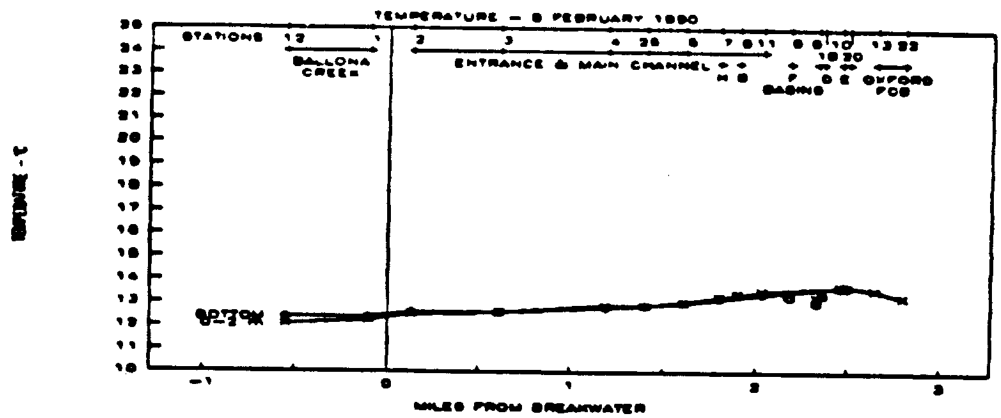

Figure 14. Average water temperature (°C), surface to 2m, and bottom, 8 February 1990.

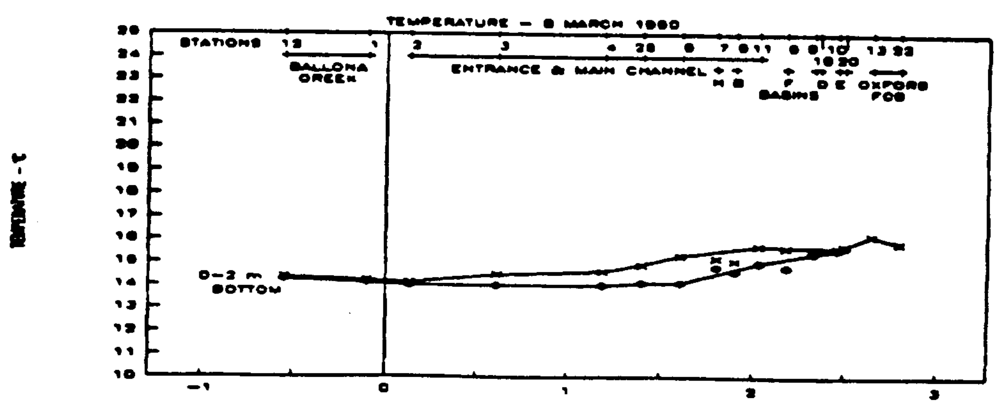

Figure 15. Average water temperature (°C), surface to 2m, and bottom, 8 March 1990.

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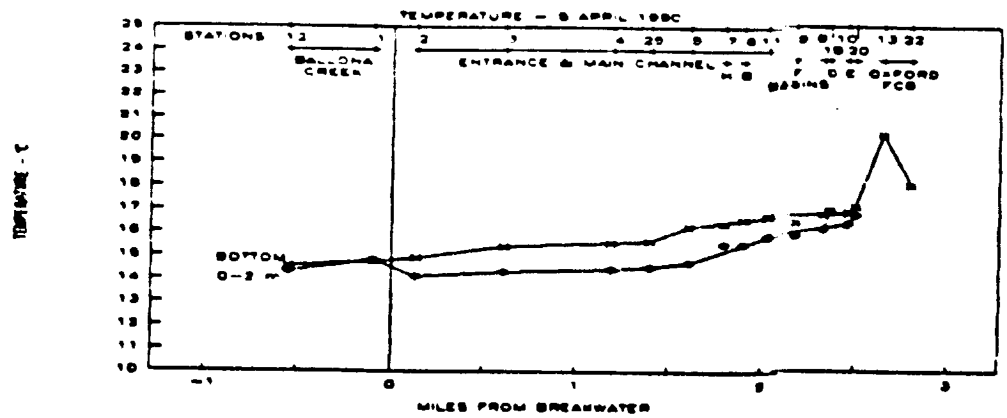

Figure 16. Average water temperature (°C), surface to 2m and bottom, 5 April 1990.

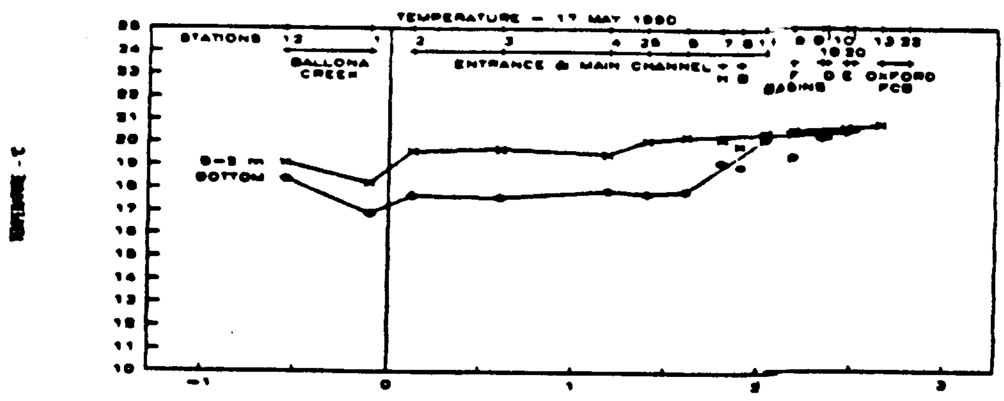

Figure 17. Average water temperature (°C), surface to 2m and bottom, 17 May 1990.

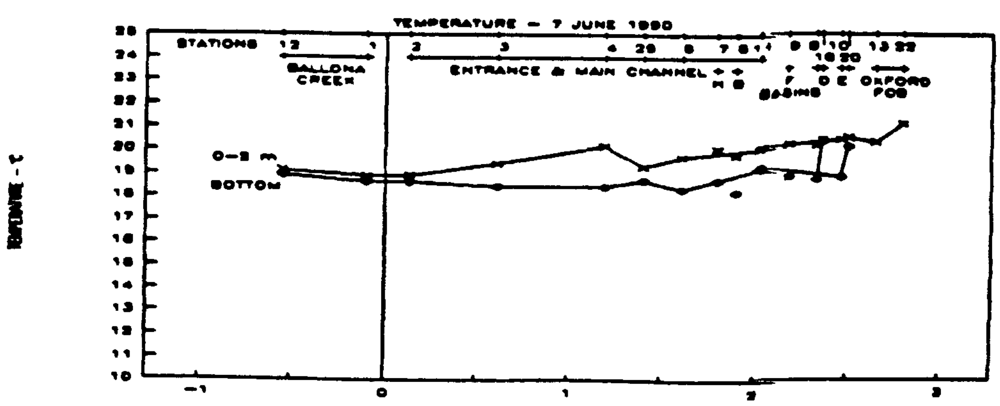

Figure 18. Average water temperature (°C), surface to 2m and bottom, 7 June 1990.

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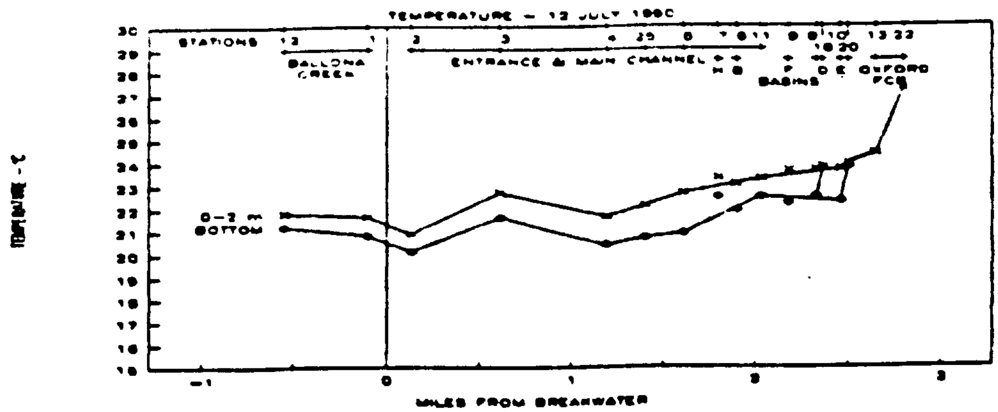

Figure 19. Average water temperature (°C), surface to 2m and bottom, 12 July 1990.

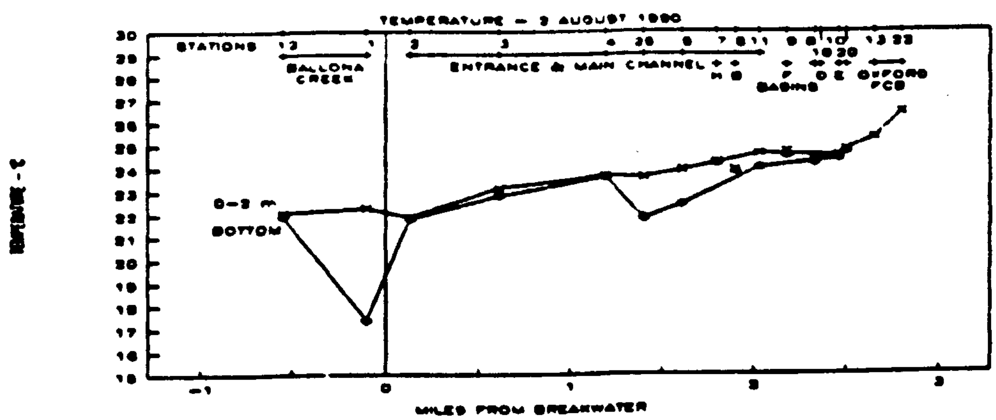

Figure 20. Average water temperature (°C), surface to 2m and bottom, 2 August 1990.

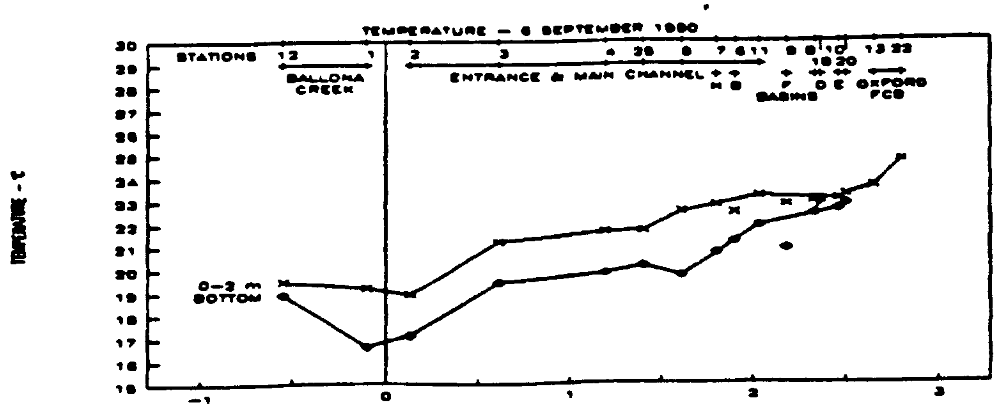

Figure 21. Average water temperature (°C), surface to 2m and bottom, 6 September 1990.

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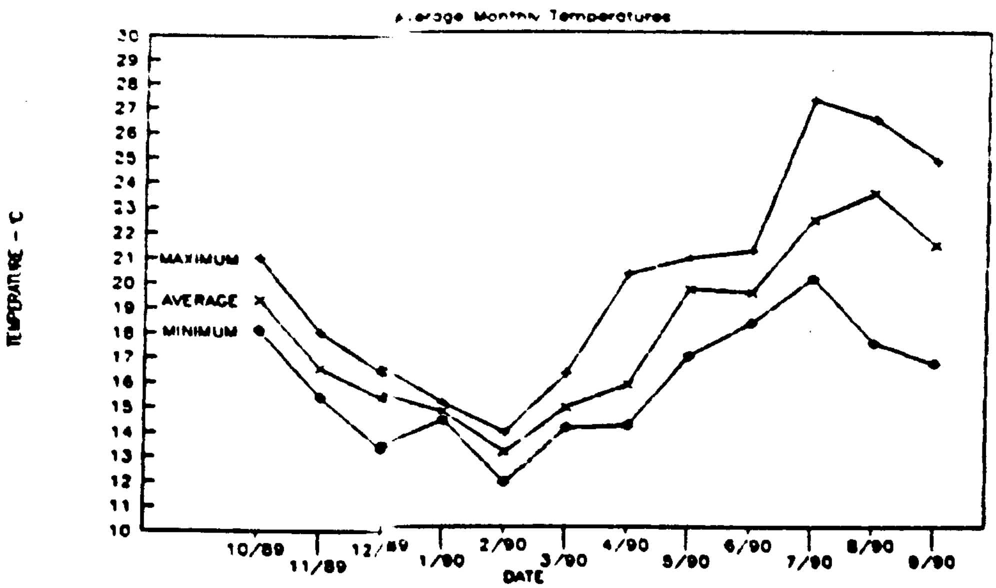

Figure 22. Minimum, maximum and average temperatures for all stations by month during October 1989 through September 1990.

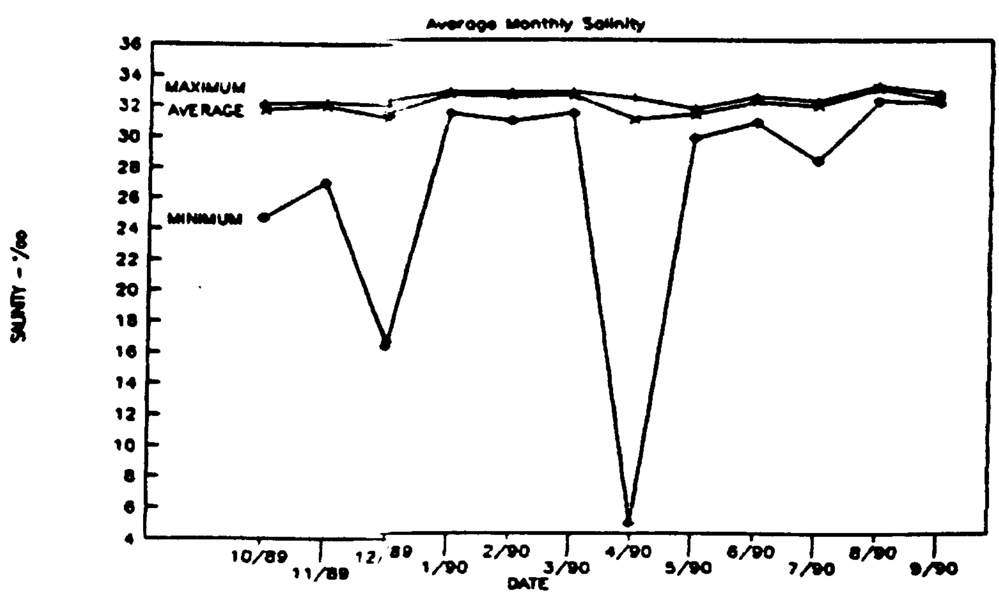

Figure 23. Minimum, maximum and average salinity (°/oo) for all stations and depths by month.

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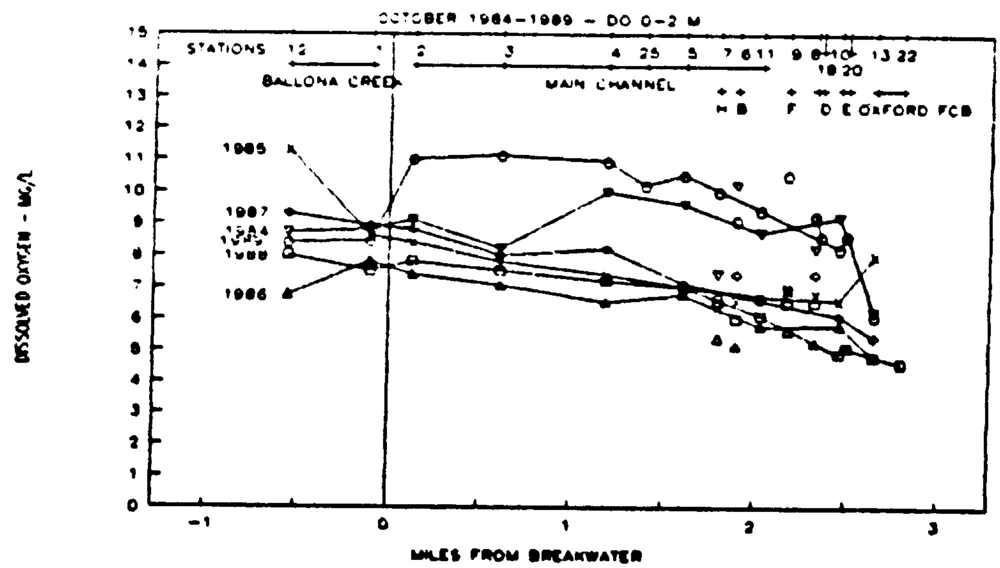

Figure 24. Average dissolved oxygen (ppm), surface–2m, October 1984–1989.

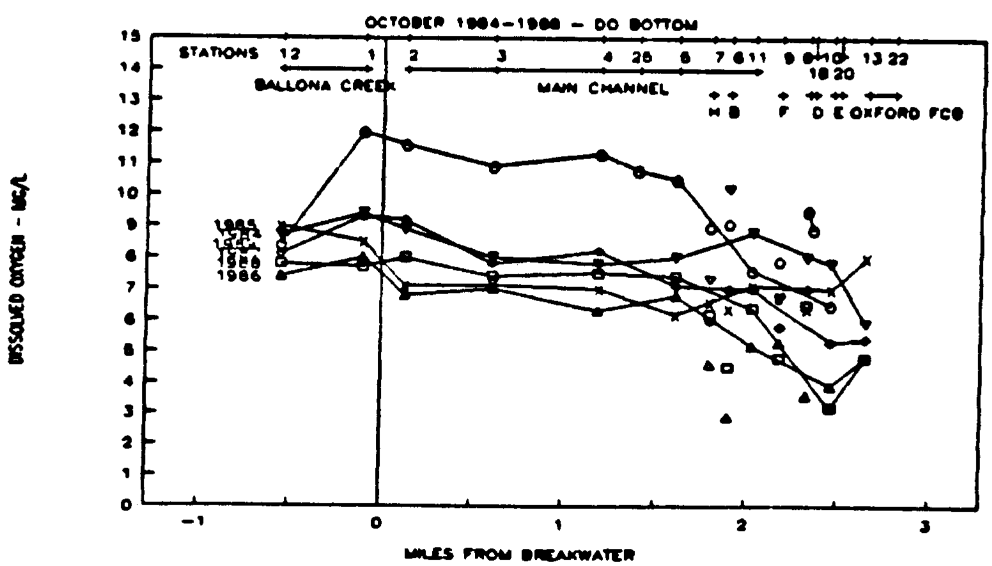

Figure 25. Average dissolved oxygen (ppm) in bottom water, October 1984–1989.

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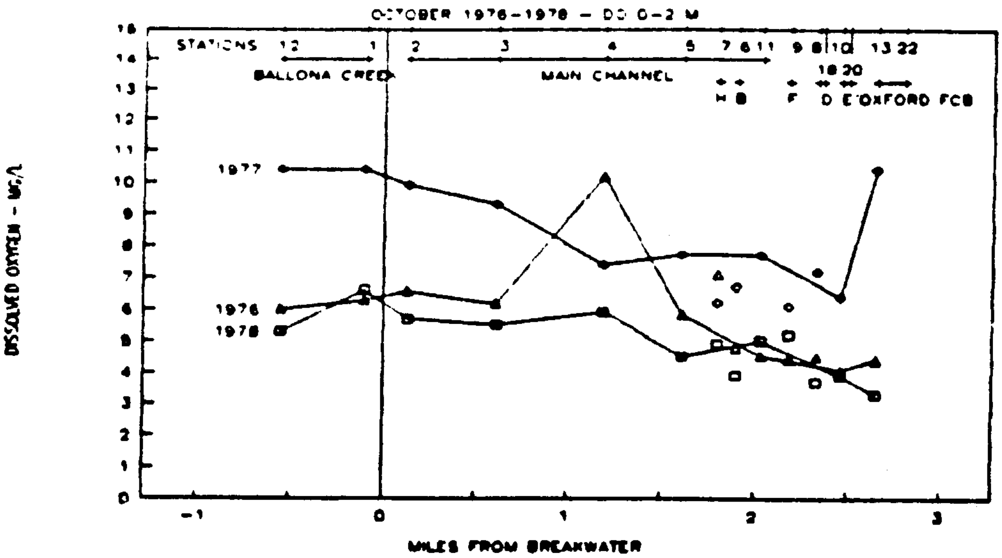

Figure 26. Average dissolved oxygen (ppm), surface–2m, October 1976–1978.

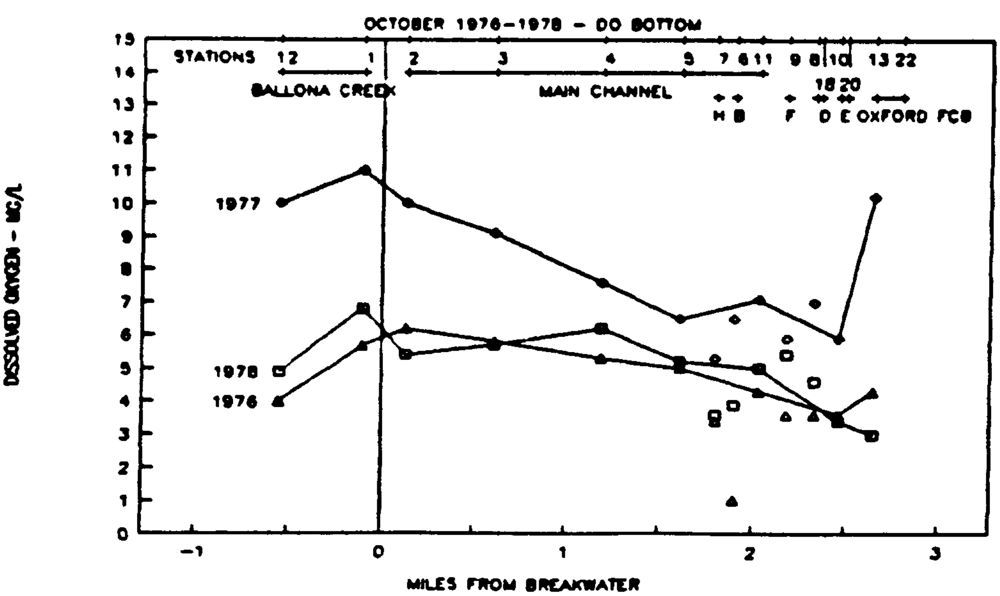

Figure 27. Average dissolved oxygen (ppm) in bottom water, October 1976–1978.

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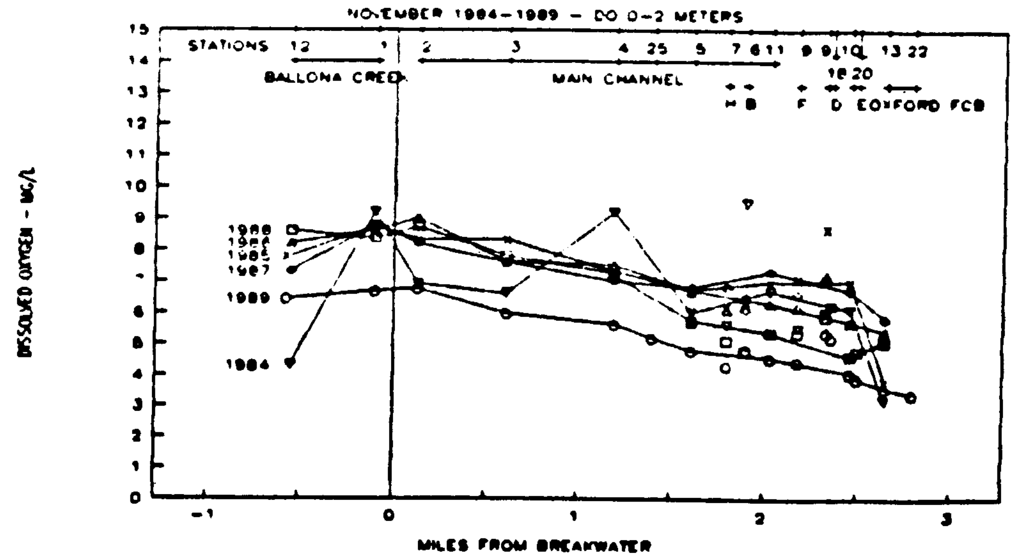

Figure 28. Average dissolved oxygen (ppm), surface to 2m, November 1984–1989.

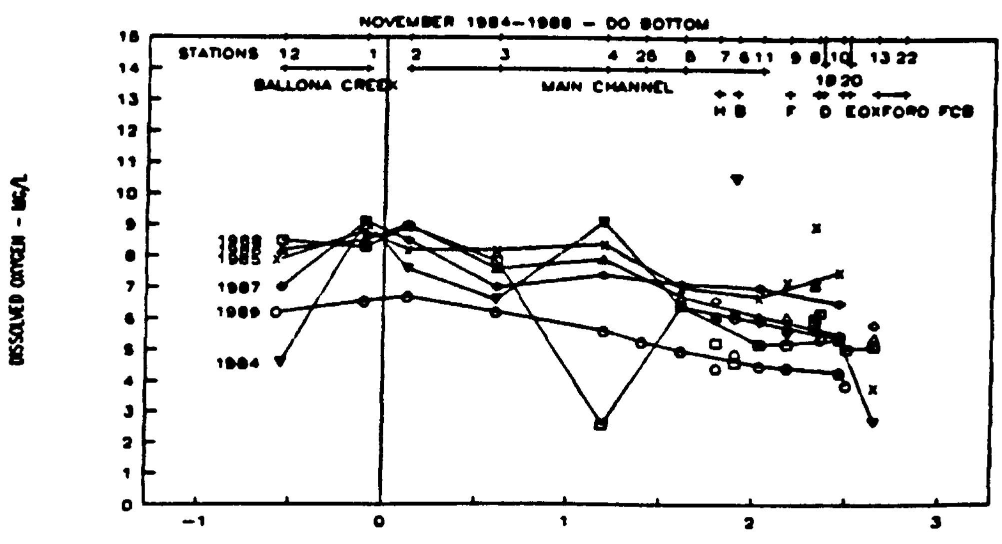

Figure 29. Dissolved oxygen (ppm) in bottom water, November 1984–1989.

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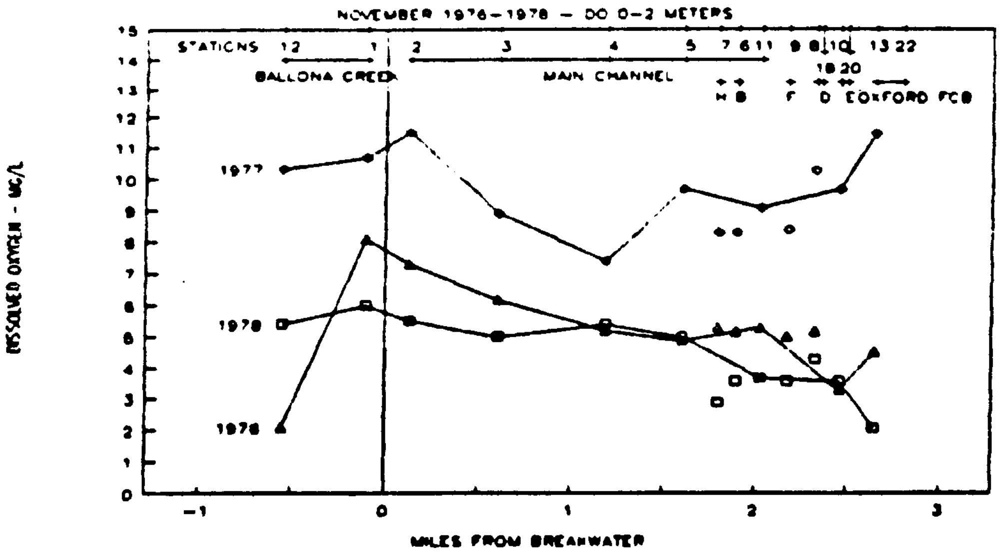

Figure 30. Average dissolved oxygen (ppm), surface to 2m, November 1976–1978.

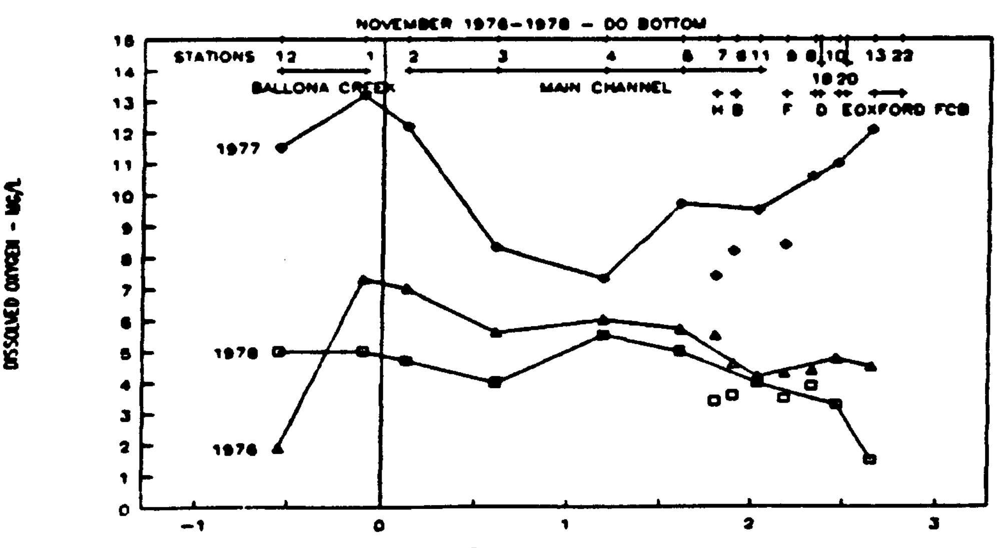

Figure 31. Dissolved oxygen (ppm) in bottom water, November 1976–1978.

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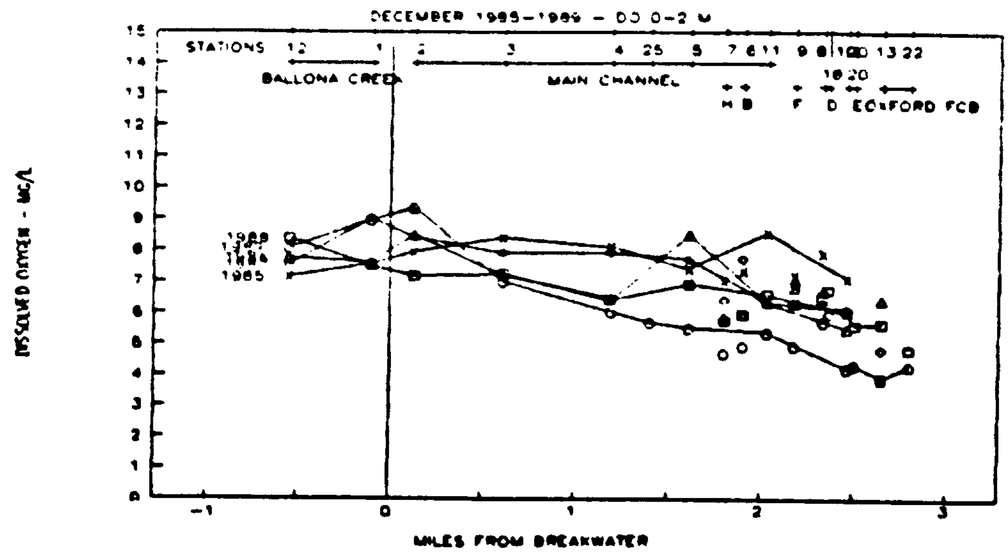

Figure 32. Average dissolved oxygen (ppm), surface to 2m, December 1985–1989.

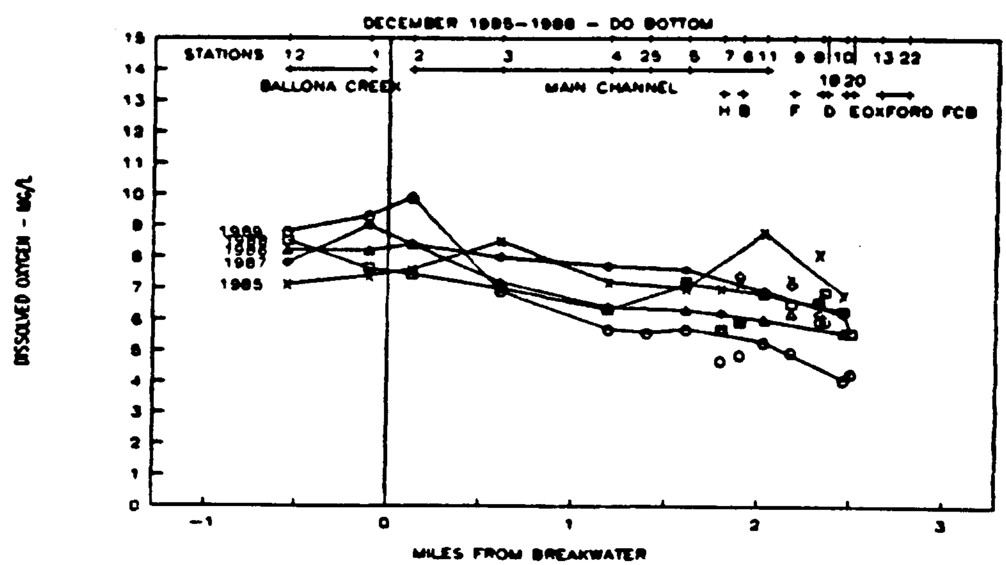

Figure 33. Dissolved oxygen (ppm) in bottom water, December 1985–1989.

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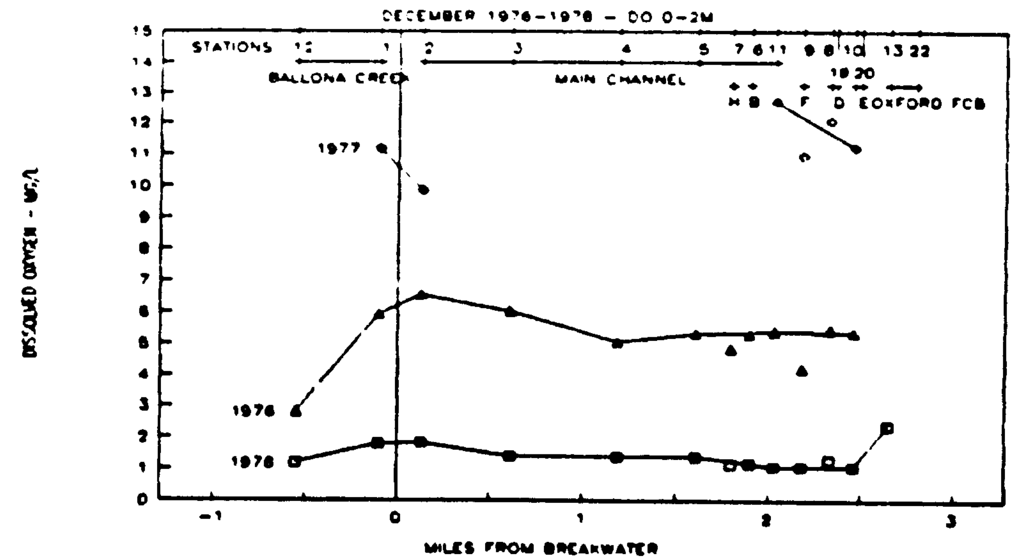

Figure 34. Average dissolved oxygen (ppm), surface to 2m, December 1976–1978.

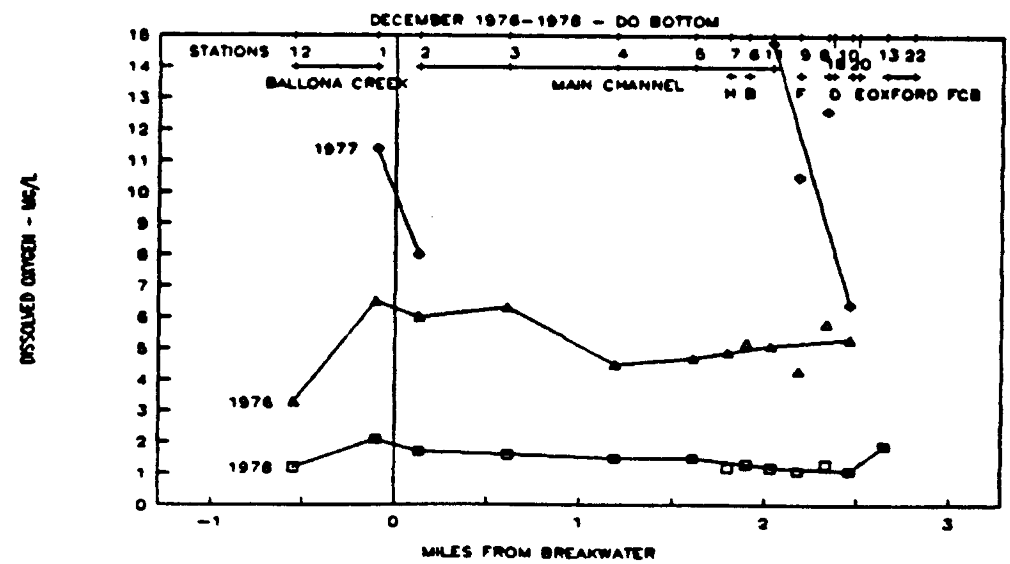

Figure 35. Dissolved oxygen (ppm) in bottom water, December 1976–1978.

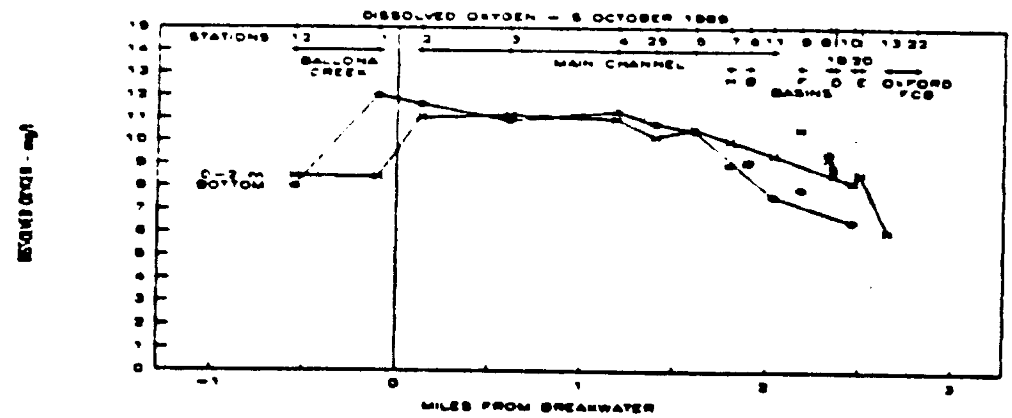

Figure 36. Average dissolved oxygen (ppm), surface to 2m and bottom, 5 October 1989.

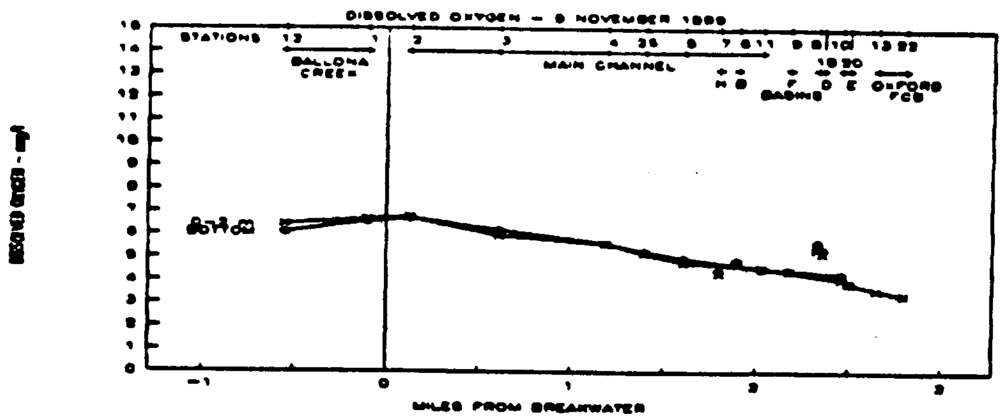

Figure 37. Average dissolved oxygen (ppm), surface to 2m and bottom, 9 November 1989

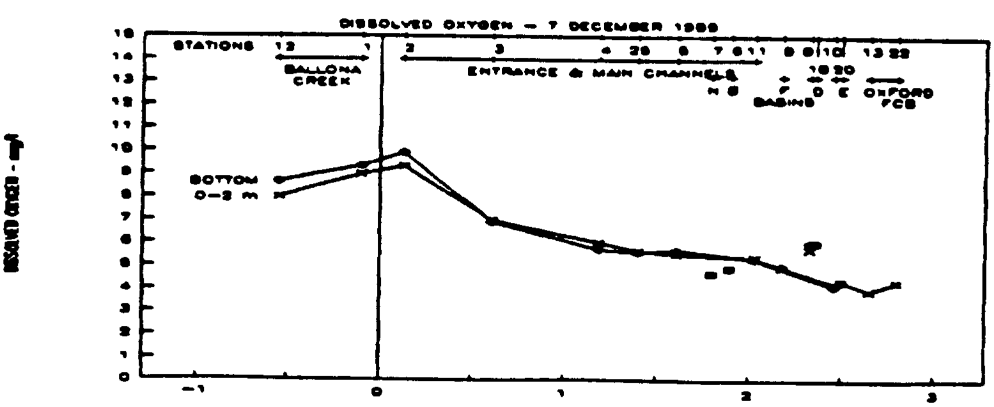

Figure 38. Average dissolved oxygen (ppm), surface to 2m and bottom, 7 December 1989.

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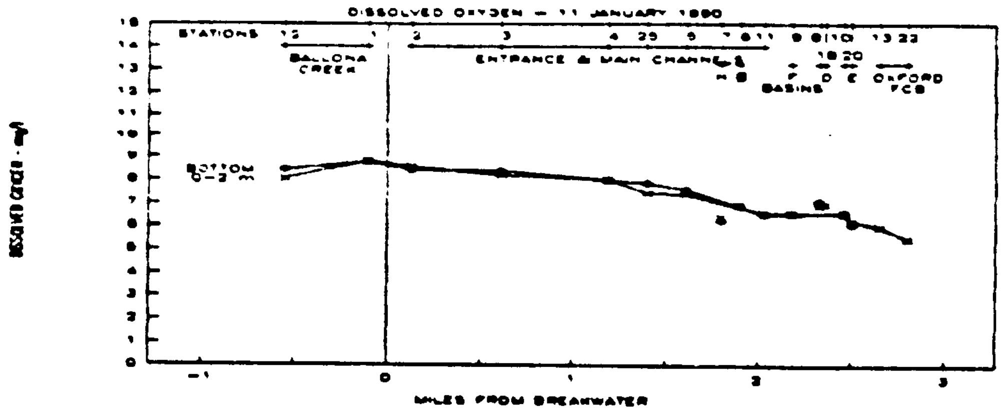

Figure 39. Average dissolved oxygen (ppm), surface to 2m and bottom, 11 January 1990.

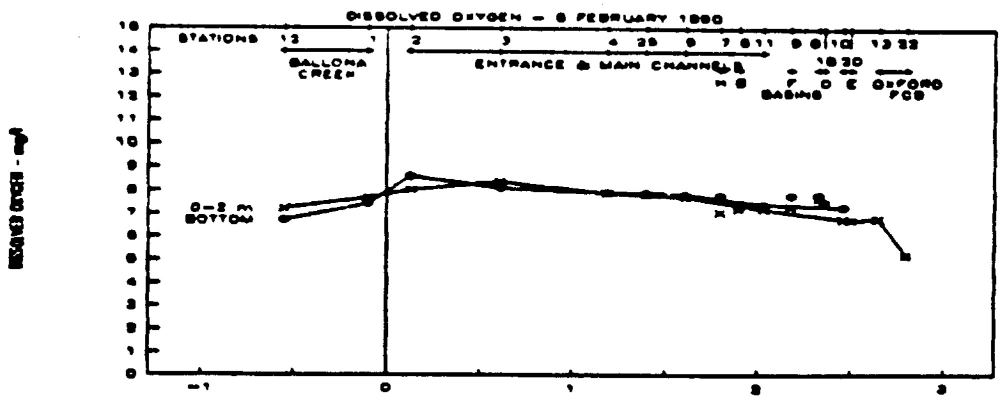

Figure 40. Average dissolved oxygen (ppm), surface to 2m and bottom, 8 February 1990.

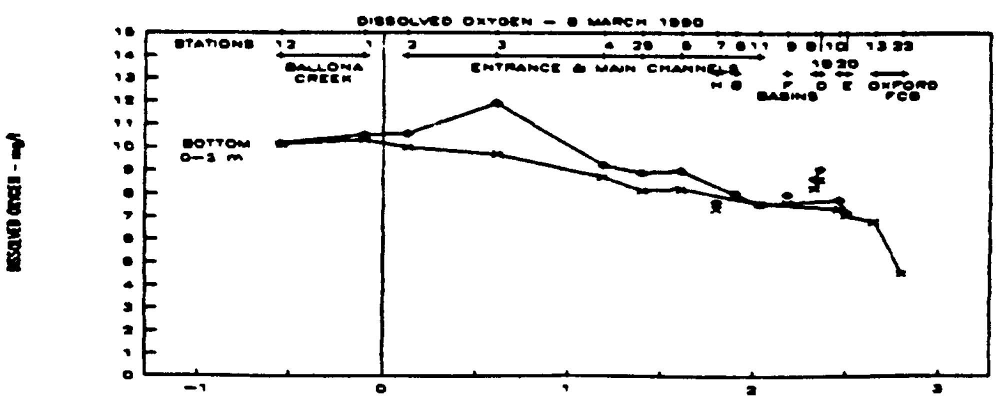

Figure 41. Average dissolved oxygen (ppm), surface to 2m and bottom, 8 March 1990.

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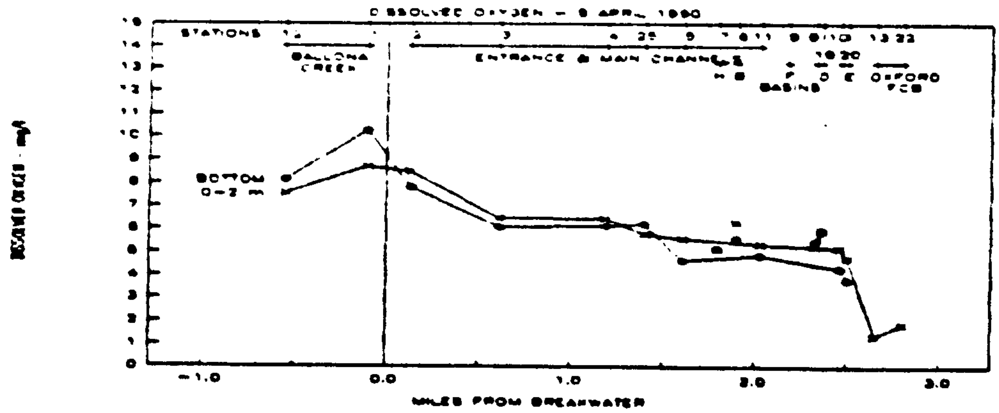

Figure 42. Average dissolved oxygen (ppm), surface to 2m and bottom, 5 April 1990.

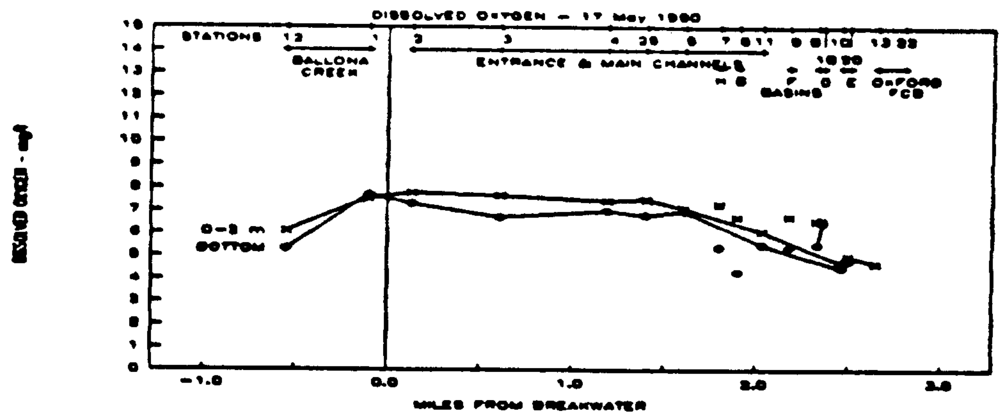

Figure 43. Average dissolved oxygen (ppm), surface to 2m and bottom, 17 May 1990.

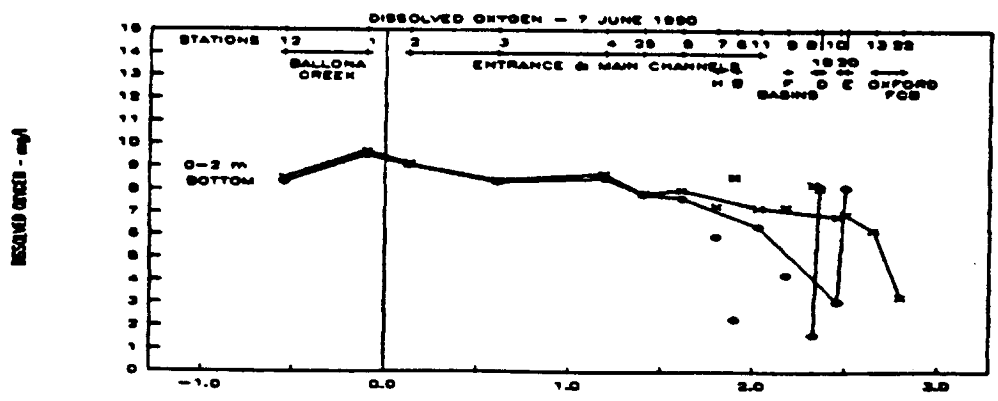

Figure 44. Average dissolved oxygen (ppm), surface to 2m and bottom, 7 June 1990.

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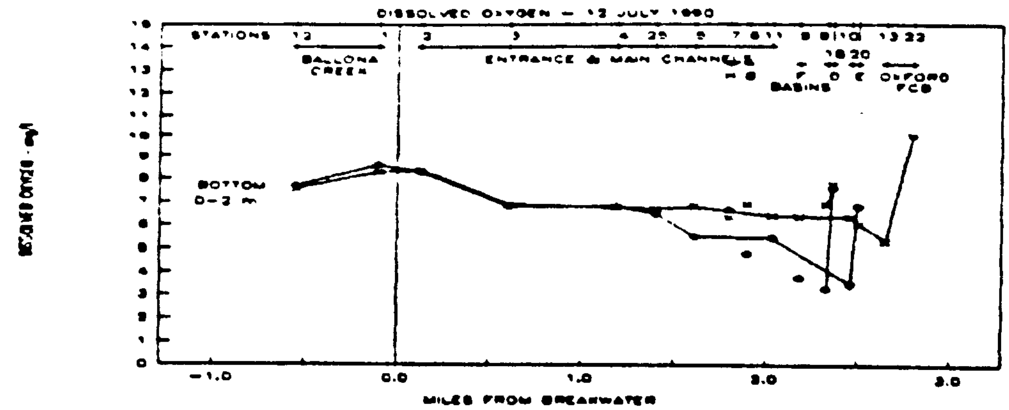

Figure 45. Average dissolved oxygen (ppm), surface to 2m and bottom, 12 July 1990.

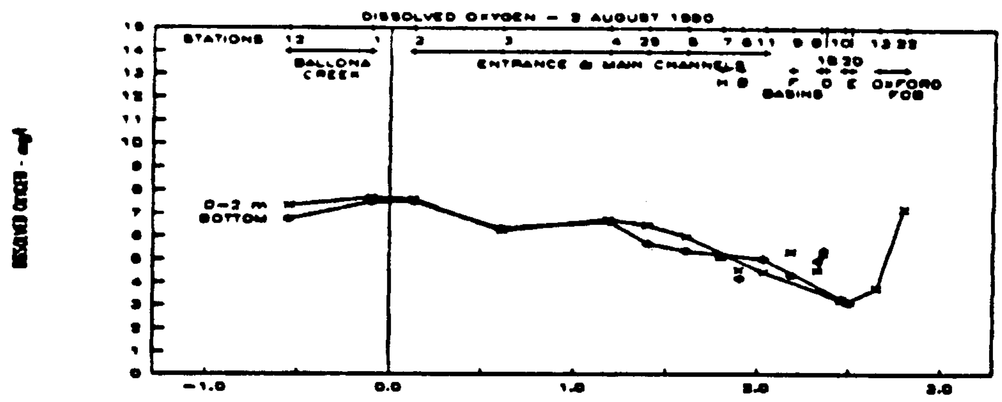

Figure 46. Average dissolved oxygen (ppm), surface to 2m and bottom, 2 August 1990.

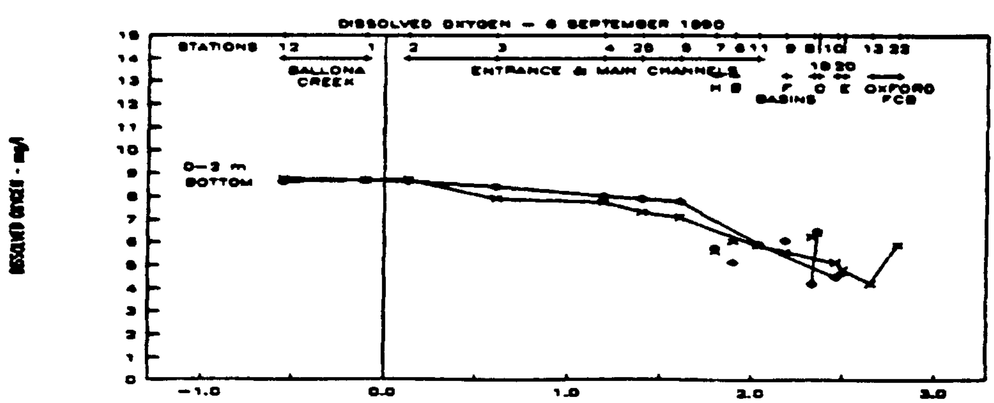

Figure 47. Average dissolved oxygen (ppm), surface to 2m and bottom, 6 September 1990.

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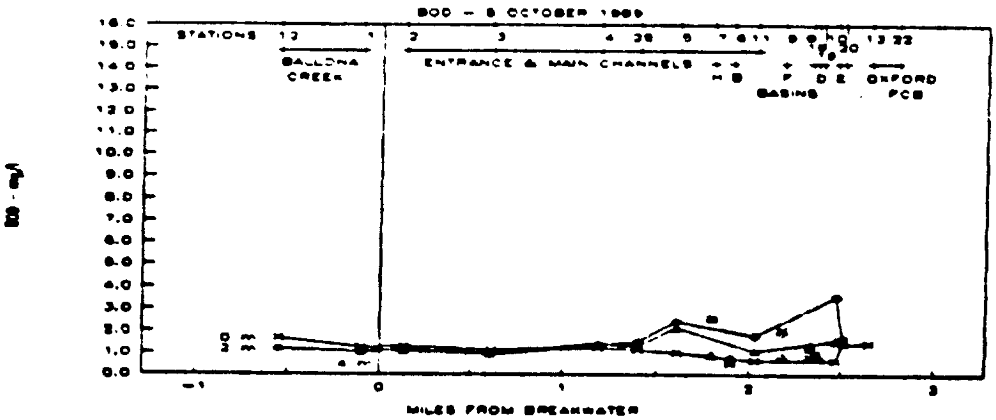

Figure 48. Five-day biochemical oxygen demand (mg/l), 5 October 1989.

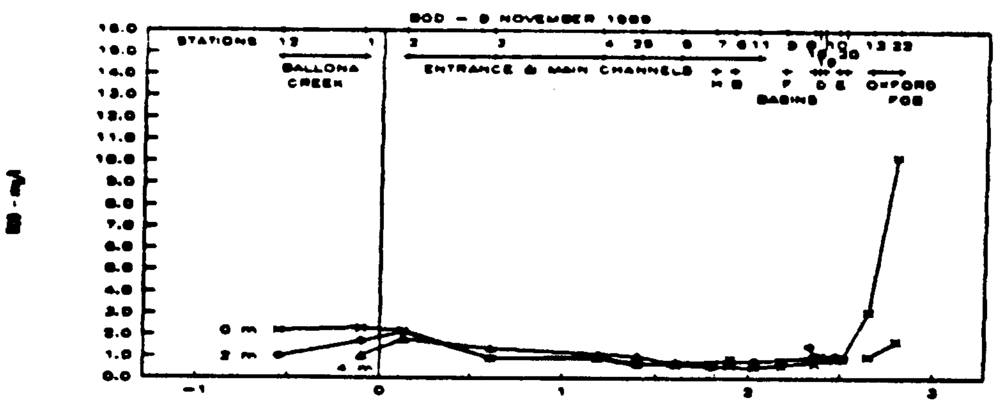

Figure 49. Five-day biochemical oxygen demand (mg/l), 9 November 1989.

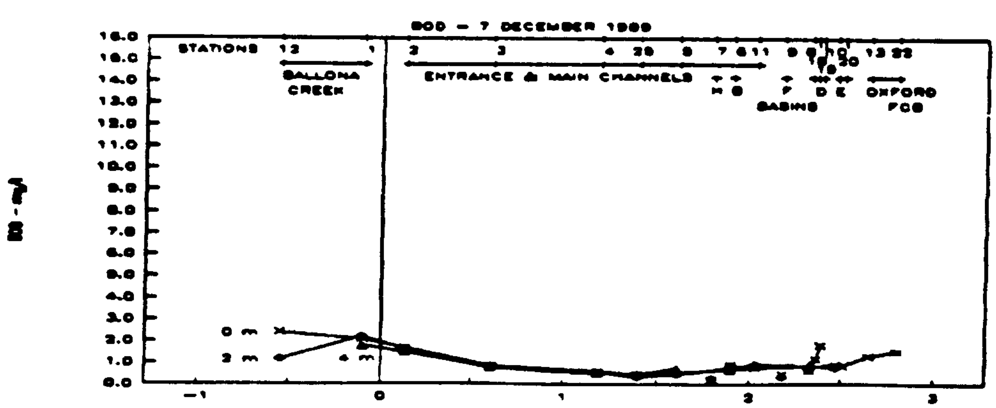

Figure 50. Five-day biochemical oxygen demand (mg/l), 7 December 1989.

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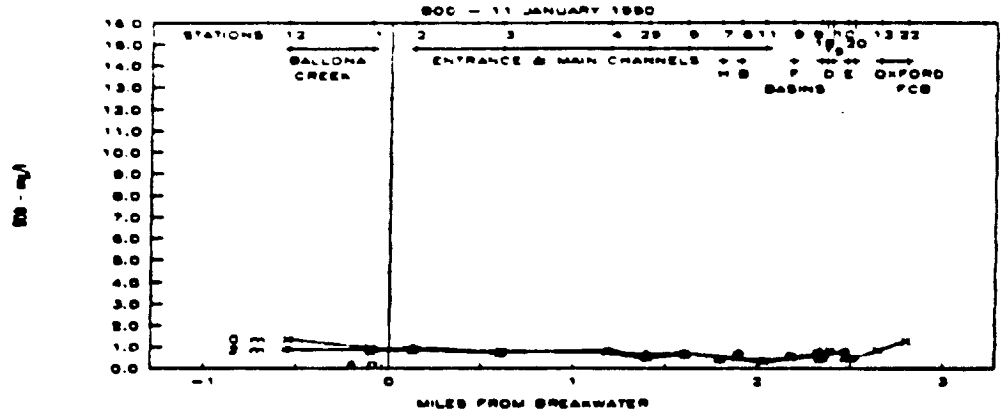

Figure 51. Five-day biochemical oxygen demand (mg/l), 11 January 1990.

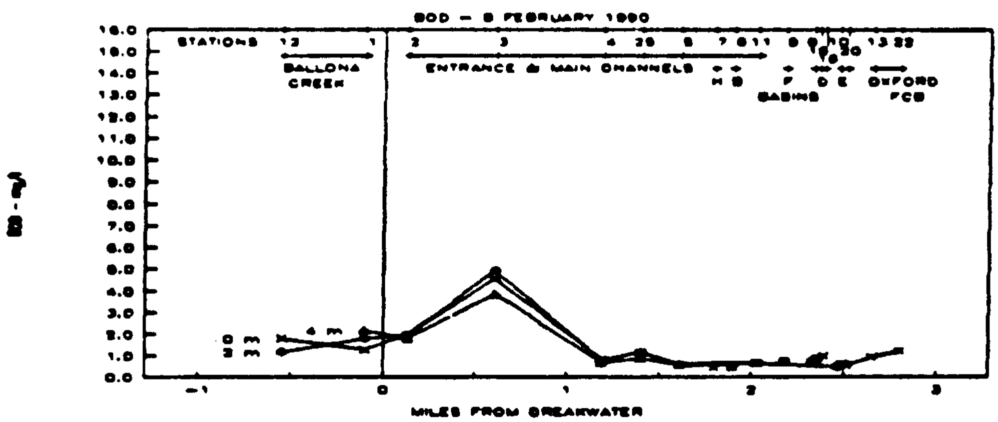

Figure 52. Five-day biochemical oxygen demand (mg/l), 8 February 1990.

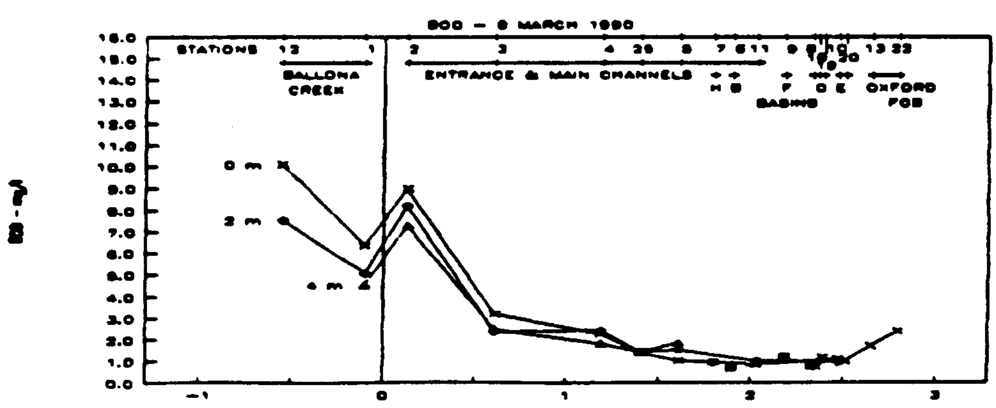

Figure 53. Five-day biochemical oxygen demand (mg/l), 8 March 1990.

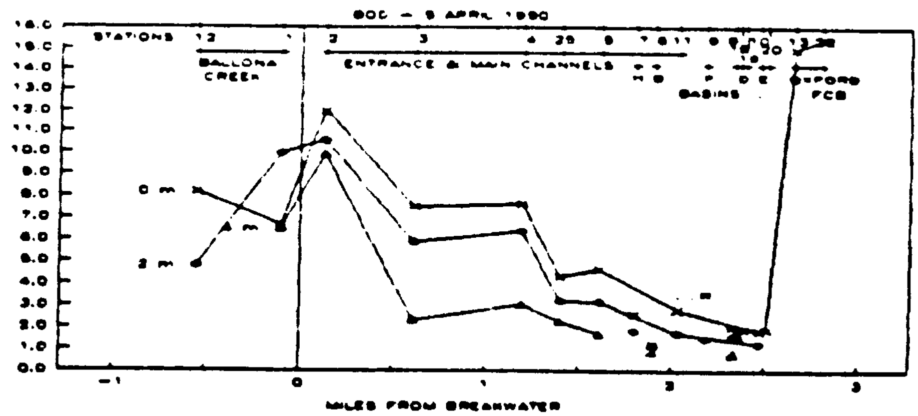

Figure 54. Five-day biochemical oxygen demand (mg/l), 5 April 1990.

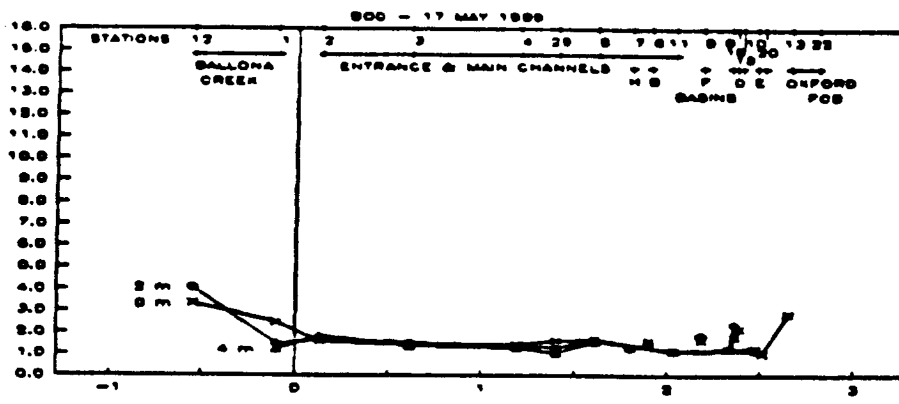

Figure 55. Five-day biochemical oxygen demand (mg/l), 17 May 1990.

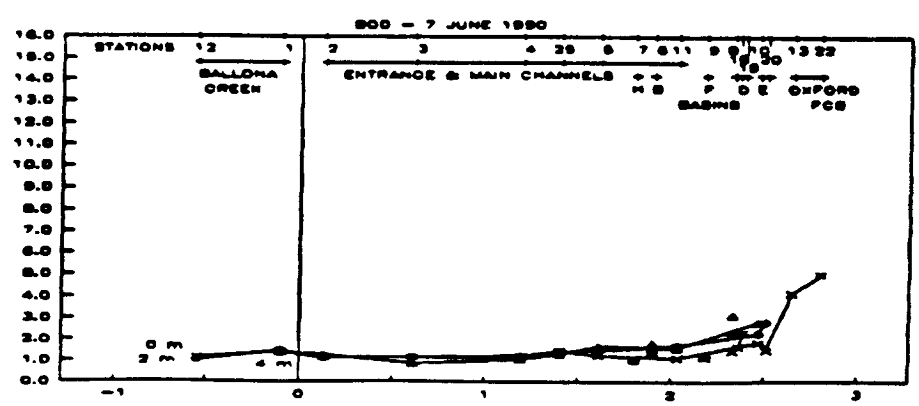

Figure 56. Five-day biochemical oxygen demand (mg/l), 7 June 1990.

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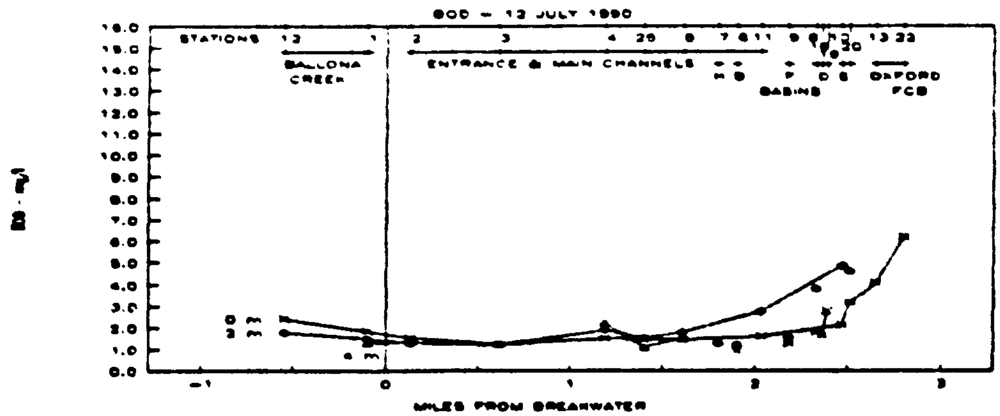

Figure 57. Five-day biochemical oxygen demand (mg/l), 12 July 1990.

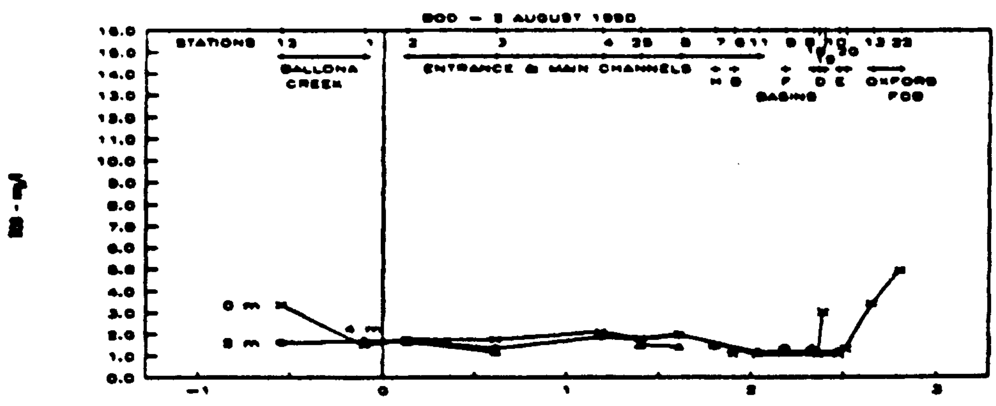

Figure 58. Five-day biochemical oxygen demand (mg/l), 2 August 1990.

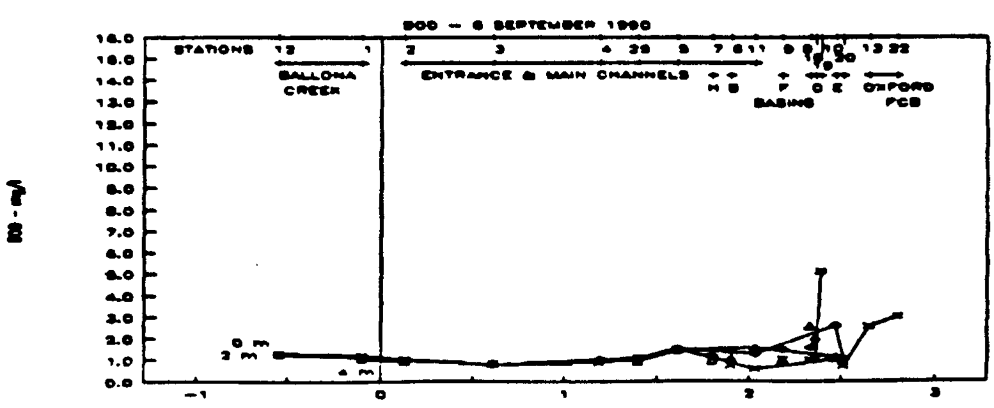

Figure 59. Five-day biochemical oxygen demand (mg/l), 6 September 1990.

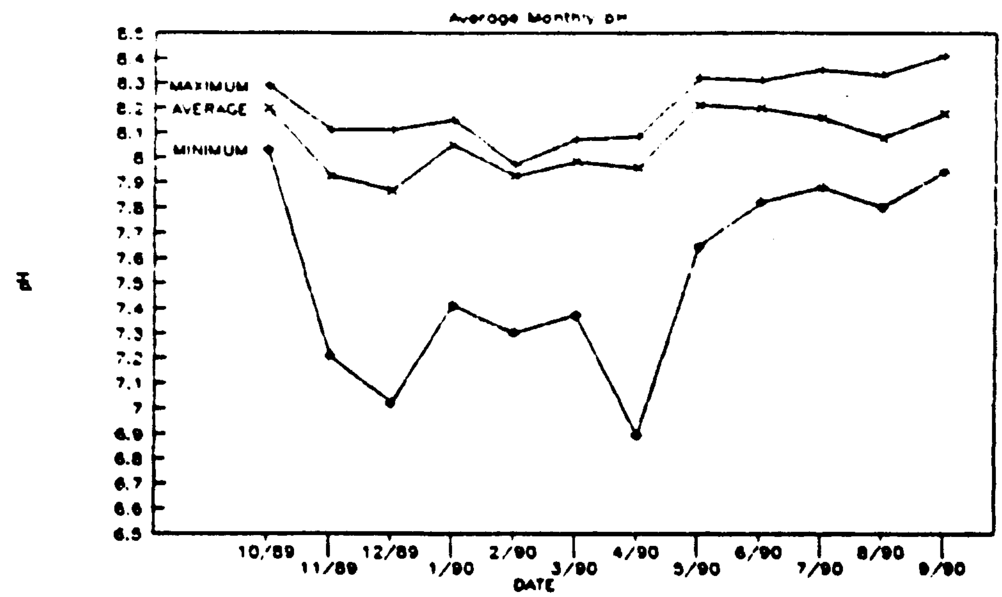

Figure 60. Maximum, minimum and average pH for all stations and depths by month.

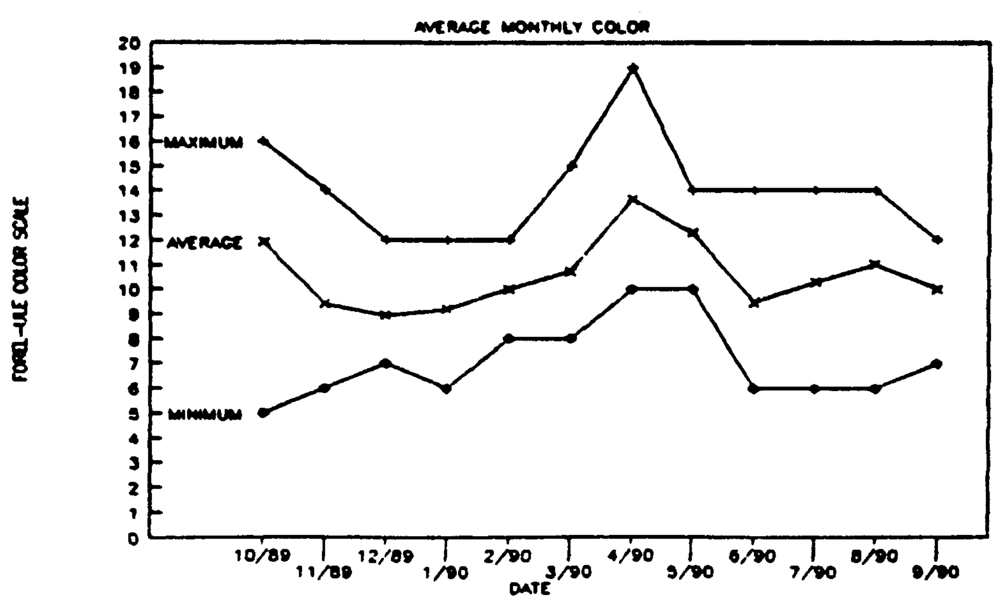

Figure 61. Maximum, minimum and average water color (Forel–Ule color scale) for all stations by month.

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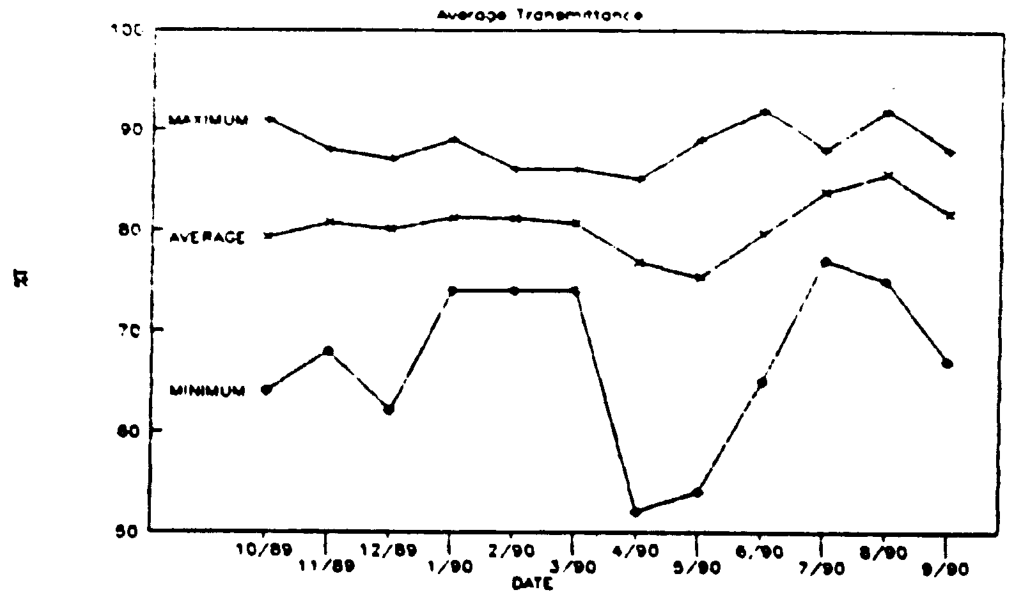

Figure 62. Maximum, minimum and average average water transparency (%T) for all stations and depths by month.

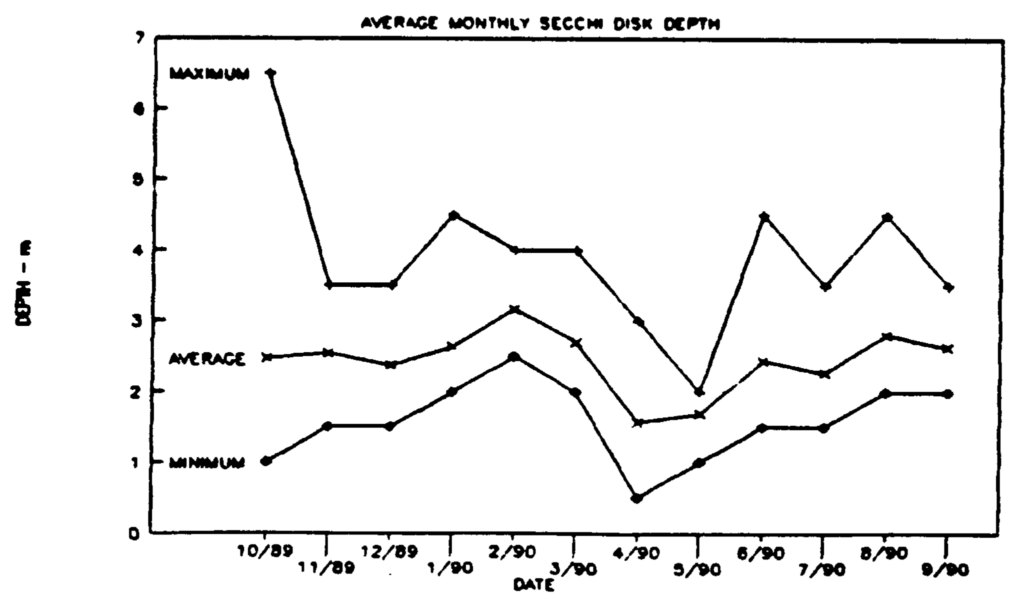

Figure 63. Maximum, minimum and average average Secchi disk depth (m) for all stations by month.

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III. NUTRIENTS

SOURCES AND FATES

Marine microscopic plants, the phytoplankton, are the most abundant form of plants in many aquatic systems. These planktonic plants depend on a supply of inorganic nutrients and energy from sunlight for growth. The major inorganic nutrients include nitrogen (usually in the form of nitrate, nitrite or ammonia), phosphate, silicate (for diatoms which have a silicon shell or frustule), and carbon from carbon dioxide. Trace metals are also necessary, but normally in much smaller quantities.

In the oceanic environment, nitrogen is often the nutrient that is in least supply and therefore most likely to regulate the growth of the phytoplankton, but in bays and estuaries the rate of supply of nutrients is less likely to limit phytoplankton growth due to input from terrestrial and/or anthropogenic sources. Often the phytoplankton in bays and estuaries are more likely to be limited by the light availability that is strongly affected by the turbidity in the water column (Kirk, 1983).

Within the ocean the nutrient supply primarily derives from natural processes of recycling. The organic nitrogen found in plants and animals is recycled by animals and microorganisms which break down the organic matter generated by the phytoplankton, releasing nitrogenous compounds. Ammonia nitrogen may be taken up directly by the plants to synthesize new organic matter or it may be oxidized first to nitrite, then to the more stable form of nitrate. Plants may take up nitrogen in any of these forms, but ammonia is often more readily taken up than the oxidized forms of nitrogen because it can be directly incorporated into amino acids.

Organic phosphate, which is used for energy transfer, for proteins, and for nucleic acids, is rapidly cycled within the water column since the form in which it occurs most frequently within organisms, ortho-phosphate, is also the form that is most abundant in seawater. Dissolved ortho-silicate comes from both recycling and river input.

METHODS

Water samples were obtained at all stations with a Naumann sampler, a PVC self-closing sampler, at two meter intervals beginning at the surface. One subsample was immediately acidified in the field with concentrated hydrochloric acid and held for later laboratory analysis with an Orion ammonia electrode. A second sample was immediately frozen in dry ice for later analysis in the laboratory. This sample was thawed and analyzed for silicate, phosphate, nitrate, and nitrite on an AlpKem RFA-300 automated analytical chemistry instrument using methods described by Whitledge et al. (1981). Complete nutrient data are presented in Appendix C.

AMMONIA-NITROGEN

Ammonia nitrogen is formed by the breakdown of organic material and recycled into inorganic nitrogen. In most ocean waters, it occurs at very low concentrations of less than 1 *ug-at/l* (1 *ug-at/l* = 17 *ug/l*). In southern California, higher concentrations (up to 25-30 *ug-at/l* may be observed. These high concentrations are usually due to anthropogenic sources such as ocean outfalls, (e.g. Eppley et al., 1979; Jones et al., 1990) and therefore are often indicative of sources of pollutants. When ammonia nitrogen is present, it is the most energetically effective form of nitrogen for the phytoplankton to use.

The ammonia-nitrogen concentrations within the Marina are generally higher than the concentrations observed in Santa Monica Bay and the adjacent ocean waters, except near the Hyperion and Whites Point sewage outfalls. Minimum concentrations within the Marina during October 1989 to September 1990 were 2-3 *ug-at/l* and occurred within the Main channel and at the breakwater (Station 2). The distribution patterns that are observed in ammonia concentration are similar to the patterns observed in the bacteriological samples (see Microbiology section).

The general spatial pattern is that the highest concentrations are observed within the Oxford Basin (Stations 13 and 22) and in Ballona Creek (Station 12). Ammonia concentrations were high within Oxford Basin in every sampling period, and had the highest ammonia concentrations except in October 1989 and August 1990. The ammonia concentrations within Ballona Creek were usually higher than within the Marina during the period of October through April, except in March 1990. The other areas that tended to have higher concentrations were the stations located at the end of the basins where tidal exchange is at a minimum (Stations 6, 7, 8, 9, 10, 11, 18, 19 and 20). There was not a clear relationship between the ammonia concentration at these stations and the concentrations within the Oxford Basin or Ballona Creek.

Ammonia concentrations were generally lowest within the Entrance Channel and the outer Main Channel (Stations 1, 2, 3, 4, 5, and 25). Presumably, these are regions where tidal flushing is most effective. It also suggests that there may not be a large exchange between the Ballona Creek outflow and the Marina inflow. However, this may be dependent on the tidal phase because Ballona Creek must be sampled near high tide due to the shallow water depth at Station 12. Observations suggest that material may be carried outside the breakwater on a falling tide and carried into the marina on the next rising tide.

Monthly profiles are shown in Figures 64 to 75, at the end of this section. During the October 1989 - September 1990 sampling period there were two periods when the average concentration of ammonia was relatively high within the Marina, excluding the samples from Oxford Basin and Ballona Creek (Table 3).

Table 3. Ammonia, Ranges in Concentration, October 1989-September 1990

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-89	2.1	5	13.0	12	3.7	3.4
Nov-89	5.1	8	45.0	13	9.9	8.1
Dec-89	2.6	2	19.4	22	9.8	9.3
Jan-90	2.4	1	26.0	22	6.5	5.7
Feb-90	2.9	11	16.3	22	4.7	4.1
Mar-90	2.7	5	22.0	22	4.4	3.9
Apr-90	2.9	6	99.3	22	9.1	4.3
May-90	2.7	3	16.5	13	4.4	4.1
Jun-90	3.8	4	17.3	13	6.3	5.9
Jul-90	3.3	7	74.3	13	7.0	5.1
Aug-90	2.7	1	59.0	11	8.3	8.2
Sep-90	2.6	25	20.0	13	5.2	4.6

* Excluding Oxford Basin and Ballona Creek: Sta 12, 13, 22.

The first period was during the late fall and winter of October 1989 through January 1990 (Figure 76). The second period of higher average ammonia concentrations occurred during the summer, June - August 1990. This contrasts with the observations from the previous twelve month period

(Soule and Oguri, 1990), when concentrations were relatively low during the summer period except after the 4 July 1990 weekend. The cause of the elevated concentrations during summer is unknown but might have resulted from increased recreational use of the Marina. Freshwater inflow resulting from rainfall, which would increase the concentrations, was at a minimum and high summer water temperatures would result in potentially higher phytoplankton growth rates and higher ammonia oxidation rates, which would normally minimize ammonia concentrations during the summer period.

Maximum concentrations occurred in November 1989, and in April, July and August 1990. The November, April and July maxima occurred in Oxford Basin. The August maximum was observed at Station 11 at the northern end of the main channel. Two of these maxima, in April (99.3 *ug-at/l*) and July (74.3 *ug-at/l*), exceeded the maximum of 61 *ug-at/l* observed in the previous year. These two maxima also exceed all other maximum concentrations within the USC data set from 1984-1990. The April maximum was probably due to a significant freshwater inflow resulting from approximately 0.5 inchs of rain on April 4, the day preceding the sampling. The seasonal rainfall was low and therefore a single rainfall event would carry high nutrient concentrations from the storm drains and runoff.

In comparison to previous years (1984-1988), the October 1989 ammonia concentrations were on average the lowest observed and also showed the least amount of variability between the sampling sites. The November observations were similar to those of previous years, except for much higher ammonia concentrations observed in Oxford Basin in 1989. For December the ammonia concentrations were comparable to those observed in December 1988 and higher than the concentrations observed during the three

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years preceding 1988.

NITRATE PLUS NITRITE-NITROGEN

Nitrate (NO_3) is usually the most abundant form of inorganic nitrogen in the ocean. Most of the NO_3 in the ocean is found below the upper layer, where it is present at concentrations up to more than 40 *ug-at/l*. In the San Pedro-Santa Monica Basin, NO_3 concentrations reach 35 *ug-at/l* at depths of 600 m (Williams, 1986). Surface concentrations are often much less than 1 *ug-at/l* due to the uptake by phytoplankton and a limited supply rate from below. However, surface concentrations may reach values of 5-30 *ug-at/l* in coastal upwelling regions such as occur along much of the California coast. Coastal upwelling is not a dominant process within Santa Monica Bay but occurs predictably off Point Dume and Point Fermin when winds are favorable for upwelling. Within Santa Monica Bay, concentrations may be 10-20 *ug-at/l* at 20 meters depth and can be brought to the surface either by wind induced mixing or by localized upwelling. The concentration of nitrate plus nitrite in sewage wastewater and sludge are two to three orders of magnitude less than the concentration of ammonia (Morel and Schiff, 1983). The impact of ocean outfall effluents on the coastal ocean nitrate plus nitrite concentrations is therefore much less than for ammonia (e.g. Jones et al., 1991, in press).

The measurement technique for nitrate requires that the nitrate first be converted to nitrite (NO_2) which is then measured colorimetrically (Whitledge et al., 1981). The NO_3 concentration is derived from this by correcting for the efficiency and of converting NO_3 to NO_2 and correcting for the ambient NO_2 concentration. Since NO_2 concentrations are generally much less than 1 *ug-at/l* the correction is generally not large. In the text that follows, nitrate will be used in place of nitrate plus nitrite for brevity.

The general spatial pattern is that the nitrate concentration is lowest at Station 2 at the breakwater and increases toward the inner Marina basin and into Ballona Creek (Figures 77-88). The low values at Station 2 (and sometimes Station 1) may reflect the influence of coastal Santa Monica Bay where the nitrate concentration is low except during mixing or coastal upwelling periods. When the average concentrations within the basin are less than 2 *ug-at/l*, as during May through September (Table 4), the nitrate

Table 4. Nitrate plus Nitrite Ranges in Concentration October 1989 to September 1990.

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-89	0.2	5	28.0	13	1.8	1.1
Nov-89	0.2	2	98.0	22	7.1	4.7
Dec-89	1.0	2	63.7	22	9.8	7.5
Jan-90	0.7	1	14.8	22	6.9	6.7
Feb-90	3.2	8	12.1	22	4.9	4.7
Mar-90	0.2	2	5.6	22	1.2	1.1
Apr-90	0.5	2	107.6	13	8.7	4.8
May-90	0.4	7	8.5	20	1.8	1.7
Jun-90	0.2	6	9.7	20	1.0	0.9
Jul-90	0.5	8	5.4	20	1.3	1.3
Aug-90	0.4	1	4.6	9	1.7	1.6
Sep-90	0.1	5	3.5	13	1.4	1.3

* Excluding Oxford Basin and Ballona Creek: Sta 12, 13, 22.

concentrations within the Entrance Channel and outer Main Channel (Stations 3, 4, 5, and 25) generally are less then 1 *ug-at/l*. Higher concentrations of nitrate are often observed at the end of the basins, similar to the patterns observed in ammonia.

The highest NO_3 concentrations usually occur in Oxford Basin and/or Ballona Creek. The highest concentrations in May, June and July 1990 occurred at Station 20 within the Marina next to Oxford Basin at the tide gate rather than in Oxford Basin or Ballona Creek. A large, live-aboard vessel is docked there, partially obstructing flow from Oxford Basin.

The highest seasonal average concentrations of nitrate occurred within the Marina during November, December, and January (Figure 89). A nitrate peak occurred again in April, as observed in the ammonia concentration. The April peak was probably due to the rainfall on April 4. The highest concentration observed during the year (exceeding 100 *ug-at/l*) occurred in Oxford Basin during the April sampling. This is far in excess of the natural concentrations observed outside of the Marina in Santa Monica Bay, or in most of the open ocean.

High winter concentrations could result from increased flow in the storm drains, washing down significant amounts of organic waste which are oxidized as they are transported. However, the winter rainfall during 1989-1990 was very low. The higher concentrations might also be affected by reduced phytoplankton growth and nutrient uptake rates resulting from lower temperatures and lower available light levels. The low NO_3 concentrations during May through September probably reflect the reduced inflow from storm drain sources and high phytoplankton productivity within the Marina resulting from increased light availability and possibly higher temperatures. The difference in uptake of NO_3 compared to that of ammonia,

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which is usually low in summer, may be due to the phytoplankton species that dominated during the unusually warm summer. During this period the concentrations in both Ballona Creek and the Oxford Basin also were much lower than they were during winter.

In comparison to the previous five years of observations, the concentrations during October 1989 were low, as they were in 1984 and 1987. The November 1989 observations are very similar to the observations from the preceding five years. Nitrate concentrations were generally low at Station 2 (<5*ug-at/l*) and increased toward 10 *ug-at/l* in the inner basins of the Marina. The Ballona Creek concentrations in November 1989 were very low (<2 *ug-at/l*) Creek during the previous five years when concentrations ranged from 5 to 24 *ug-at/l*. The December observations are very consistent with preceding five years of observations. Concentrations were high in Ballona Creek, low at Station 2 and increased toward the inner basins, and were high in Oxford Basin.

Nitrate concentrations were, on average, less than the ammonia concentrations observed for each sample period. The April observations are the notable exception to this when nitrate concentrations were mora than 10 *ug-at/l* within the main channel and ammonia concentrations were generally about 5 *ug-at/l*.

TOTAL DISSOLVED INORGANIC NITROGEN

Total dissolved inorganic nitrogen (DIN) is calculated as the sum of the measured concentrations of nitrate, nitrite and ammonium rather than measured directly. The concentration of DIN is important for water quality because it represents necessary nutrients for phytoplankton growth and productivity, and it is an indicator of the input into or regeneration of nitrogen in the Marina. The monthly profiles are shown in Figures 90-101.

The seasonal pattern of dissolved inorganic nitrogen is given in Table 5 and shown in Figure 102. Ammonium concentrations were high during the winter months of November through February, as were the concentrations of nitrate and ammonium. The DIN concentration also shows the April peak following the April 4 rainfall. During the summer period (May-September) the DIN concentrations were generally low, but reflected the increase from June to August observed in ammonia.

Table 5. Total Dissolved Inorganic Nitrogen, October 1989 to September 1990.

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-89	2.5	5	37.8	13	5.5	4.4
Nov-89	5.3	2	120.1	22	17.0	12.7
Dec-89	4.1	2	82.8	22	19.5	16.7
Jan-90	3.6	1	40.7	22	13.3	12.3
Feb-90	6.7	8	24.6	12	9.8	9.2
Mar-90	3.5	1	27.6	22	5.5	4.9
Apr-90	3.8	3	174.5	13	18.0	9.0
May-90	3.2	7	22.2	13	6.2	5.7
Jun-90	4.1	4	20.0	13	7.4	6.9
Jul-90	3.9	5	76.9	13	8.0	6.1
Aug-90	3.1	1	61.8	11	9.7	9.5
Sep-90	3.5	8	23.0	13	6.4	5.7

* Excluding Oxford Basin and Ballona Creek: Sta 12, 13, 22.

The range of DIN concentrations observed during October 1989 through September 1991 was similar to the concentration range observed during the previous year. The maximum concentration of DIN during this period was higher then the previous year, but not excessively so.

PHOSPHATE

Inorganic phosphate in the ocean of the Southern California Bight region ranges from more than 3.5 *ug-at/l* at depths of 800-900 meters in the basins to less than 0.5 *ug-at/l* in surface waters (Williams, 1986). As with the other nutrients local variations may be mediated by ocean outfalls, coastal upwelling and turbulent mixing processes. Unlike nitrate, phosphate is seldom depleted in the surface waters of the ocean and it is unlikely that phosphate limits the primary production of phytoplankton. Phosphates are readily used by the bacteria, as well as by phytoplankton. Phosphorous is important for proteins, nucleic acids and energy transfer within organisms.

The general pattern of phosphate distribution within Marina del Rey region (Figures 103-114) was similar to the patterns for nitrate and ammonium. High concentrations were always observed in Oxford Basin. Concentrations were relatively high at the surface at Station 12 in Ballona Creek during the fall and winter months (October-February, and again in April. The lowest concentrations within the study area usually occurred at Station 1 or 2, near the breakwater. Within the Marina phosphate concentrations were usually higher at the inner basin Stations (6, 7, 8, 9, 10, 18, 19, and 20) than in the Main Channel. The notable exception to this pattern occurred in April when, apart from Ballona Creek and Oxford Basin, the highest concentrations occurred in the Main Channel at Stations 3, 4, and 5.

Phosphate concentrations (Table 6) had the least amount of seasonal variability of the measured nutrients. The average concentrations within

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the basin (excluding Ballona Creek and Oxford Basin) ranged from 0.6 to 1.4 *ug-at/l* (Figure 115). This was much less than the relative range of the

Table 6. Phosphate-P, Ranges in Concentration October 1989 to September 1990.

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-89	0.2	1	2.2	12	0.7	0.7
Nov-89	0.4	2	4.7	22	1.1	1.0
Dec-89	0.6	2	6.1	12	1.7	1.4
Jan-90	0.4	1	2.2	22	1.1	1.0
Feb-90	0.8	2	2.0	12	1.1	1.0
Mar-90	0.3	7	3.3	22	0.7	0.6
Apr-90	0.6	6	11.9	13	1.6	1.0
May-90	0.4	1	1.7	10	0.9	0.8
Jun-90	0.3	1	3.3	22	0.8	0.8
Jul-90	0.3	1	1.9	22	0.9	0.8
Aug-90	0.3	1	2.6	13	1.1	1.0
Sep-90	0.3	1	1.8	13	0.8	0.8

* Excluding Oxford Basin and Ballona Creek, Stations 12, 13, 22.

average concentrations for either nitrate or silicate. Average phosphate concentrations were higher during winter (November 1989 - February 1990) than during summer (May - September 1990). The minimum average concentration occurred in March, and the maximum occurred in April, simultaneous with high average concentrations of nitrate and ammonia.

In comparison to the previous five years of observations, the October 1989 concentrations were lower than in any of the preceding years. The October 1989 observations were also the lowest overall concentrations observed within the October 1989 - September 1990 data set. The concentrations in November 1989 were comparable to the concentrations in previous years, and the December 1989 observations were low for the six year range.

SILICATE

Silicate concentrations in the ocean surrounding Los Angeles are often relatively low at the surface, ranging from nearly unmeasurable concentrations to several microgram-atoms per liter. In the deep basins, silicate concentrations may approach 100 *ug-at/l* at depths of 800-900 meters (Williams, 1986). Low silicate concentrations in the upper layer result primarily from uptake by diatoms when nitrate and phosphate are sufficient to promote their growth (e.g. Broecker and Peng, 1982). It is in the oceanic euphotic zone to find residual silicate concentrations of 2-5 *ug-at/l* after phytoplankton have reduced the available nitrogen to nanomolar (nanogram-atoms per liter) concentrations. Silicate concentrations are usually high in freshwater inflows into the coastal environment.

The spatial patterns for silicate (Figures 116-127) were similar to the general spatial patterns for the other nutrient variables. Concentrations were high in the Oxford Basin and at the surface at Station 12 in Ballona Creek. Silicate concentrations within the Marina were generally low at Station 2, near the breakwater, and increased toward the inner basins.

The average silicate concentrations within the Marina peaked in December 1989 and declined through April, despite the rainfall on April 4, the day preceding the April sampling (Table 7; Figure 128). The minimum

Table 7. Silicate, Ranges in Concentration October 1989 to September 1990.

Month	Min.	Sta.	Max.	Sta.	Average	Average*
Oct-89	4.0	1	48.2	13	13.8	12.2
Nov-89	5.4	2	57.9	22	16.6	14.2
Dec-89	8.5	2	71.3	12	23.8	20.9
Jan-90	1.1	1	27.1	22	13.6	12.7
Feb-90	7.0	2	39.2	12	10.4	9.6
Mar-90	5.9	7	24.8	22	9.6	8.8
Apr-90	0.3	18	31.9	13	6.3	4.4
May-90	6.8	1	33.1	1	16.5	16.0
Jun-90	0.9	1	23.9	20	4.7	4.1
Jul-90	6.0	1	29.3	12	17.6	17.0
Aug-90	3.1	1	42.8	12	12.9	11.4
Sep-90	4.5	1	19.7	13	12.6	12.5

* Excluding Oxford Basin and Ballona Creek, Stations 12, 13, 22.

average silicate concentration, excluding Ballona Creek and Oxford Basin was 4.1 *ug-at/l*, comparable to the minimum average concentrations for ammonia. However, the maximum average (20.9 *ug-at/l*) was more than twice the maximum average for ammonia. Summer concentrations averaged between 11 and 17 *ug-at/l*, except for June. These high summertime concentrations paralleled the high ammonia concentrations most of the summer, but contrasted with low phosphate and nitrate concentrations. This difference may result from the phytoplankton species that dominated the community during the summer. The warm, stratified conditions that characterized the Marina during the summer are conducive to dinoflagellate blooms. Dinoflagellates do not require silicon and therefore, if they dominate the phytoplankton community, could deplete the available dissolved inorganic nitrogen and phosphorus with little depletion of the available silicate.

Silicate concentrations and distributions during October-December 1989 compare with observations from previous years. Both the general spatial patterns and the magnitude of concentrations are similar. The primary difference appears to occur in the December 1989 data set, particularly at Stations 10, 19 and 20. At these stations the SiO_4 concentrations (30-40 *ug-at/l*) were significantly higher than in the rest of the Marina and exceed concentrations at these stations in previous years.

CORRELATIONS WITH OTHER VARIABLES

In the ocean, the relationships of one nutrient with another and of nutrients with physical variables such as temperature and salinity are usually predictable. For example, nitrate concentrations usually increase linearly with decreasing temperature below some threshold value, particularly below the euphotic zone (e.g. Zentara and Kamykowski, 1977; in the local coastal ocean the threshold temperature is ~13°C). An important question in understanding the processes within the Marina is whether or not the nutrients can be correlated with other variables in a predictable way that would provide a better understanding of their fluctuations.

The relationship between nutrients and temperature in the Marina is not as clear as it is for coastal and open ocean situations. During October 1989 through September 1990 the average nitrate concentration within the Marina was below 2 *ug-at/l* when temperatures were warmer than 18°C. At temperatures cooler than 18°C the average nitrate concentrations varied from 1 to 10 *ug-at/l*), but not in a predictable pattern. The phosphate temperature/relationship was similar to the nitrate/temperature

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relationship, except in August 1990 when an average phosphate concentration of more than 1 *ug-at/l* occurred at an average temperature above 23°C.

Ammonia and dissolved oxygen appear to be correlated. High average ammonia concentrations occurred at the lowest average oxygen concentrations and decreased as dissolved oxygen concentrations increased. Low oxygen/high ammonia conditions are consistent with water that has experienced significant breakdown of organic material. Bacterial oxidation of the organic matter would consume oxygen and release ammonia in the process of breaking down nitrogenous organic matter. Thus, in the months where the dissolved oxygen is low and the ammonia concentrations are high there has probably been a significant input of organic waste into the Marina or into the waters flowing into the Marina, such as in April when there was significant rainfall runoff and during normal winter months (November and December). A similar pattern is observed in the relationship between phosphate and dissolved oxygen, which is to be expected. However, the phosphate pattern was more scattered than the ammonia pattern. Correspondingly, the average phosphate concentrations are relatively well correlated with the average ammonia concentrations.

CONCLUSIONS

There are several generalizations that summarize the October 1989-September 1990 nutrient data in Marina del Rey. These conclusions are separated into the three categories of spatial patterns, seasonal patterns, and general relationships.

The spatial patterns of nutrient distribution within Marina del Rey tend to show similar patterns for each of the nutrients. The lowest concentrations are generally observed at Station 2 near the entrance of the

Marina. This probably reflects the mixing with Santa Monica Bay which often has low nutrient concentrations in the surface layer. Concentrations in the Main Channel may increase from the values observed at Station 2, but are usually lower than the concentrations observed within the inner basins. This gradient may result from the tidally induced mixing between the water of the inner basin stations and the low nutrient water from Santa Monica Bay. The inner basin stations generally have the highest nutrient concentrations within the Marina itself. However, the highest nutrient concentrations are nearly always observed in Oxford Basin and Ballona Creek.

The seasonal patterns show that the highest average concentrations occurred in the winter period of November 1989 to February 1990. These high concentrations may result from lower rates of phytoplankton growth due to cooler temperatures and lower integrated light available for photosynthesis. The rainfall event on April 4, one day prior to the April sampling, demonstrates the impact of rainfall on nutrient concentrations. Each of the measured nutrients showed a maximum on April 5. This maximum in nutrient concentrations no doubt resulted from the runoff from storm drains and the surrounding land. Summertime nutrient concentrations tended to be variable except for nitrate which was low throughout the summer.

Examination of the relationships between nutrient concentrations and other measured variables showed two distinct relationships. The monthly averages of ammonium and phosphate were negatively correlated with dissolved oxygen, consistent with the coupling of their variability with the oxidation of organic matter, and hence the input of organic matter into the Marina. This input can be from direct sources within the Marina, from runoff through Ballona Creek and Oxford Basin, and from rain-derived runoff as demonstrated in the April 1990 data set.

Nitrate variability appears to be coupled with temperature variability, which may simply be a seasonal phenomena. Nitrate concentrations are less than 2 *ug-at/l* during the summer months (May-September 1990) when Marina temperatures exceed $18^{\circ}C$.

Nutrient variability within the Marina is relatively uncoupled from nutrient variability within Santa Monica Bay. The concentrations of nutrients that are found within the Marina generally exceed the concentrations expected in the near-surface waters of the Bay. In addition, the nutrient/temperature (or nutrient/salinity) relationships that are observed within the Marina do not correspond with the typical patterns observed within Santa Monica Bay.

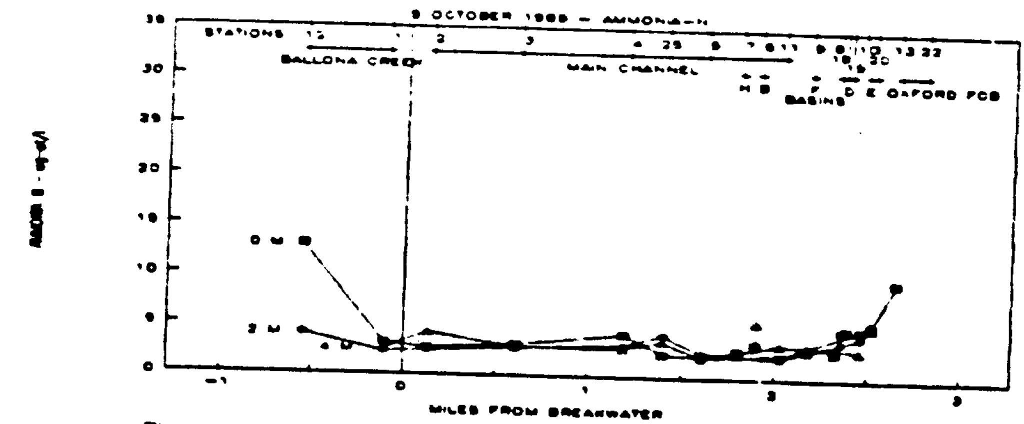

Figure 64. Ammonia-N (ug-at/l), 5 October 1969.

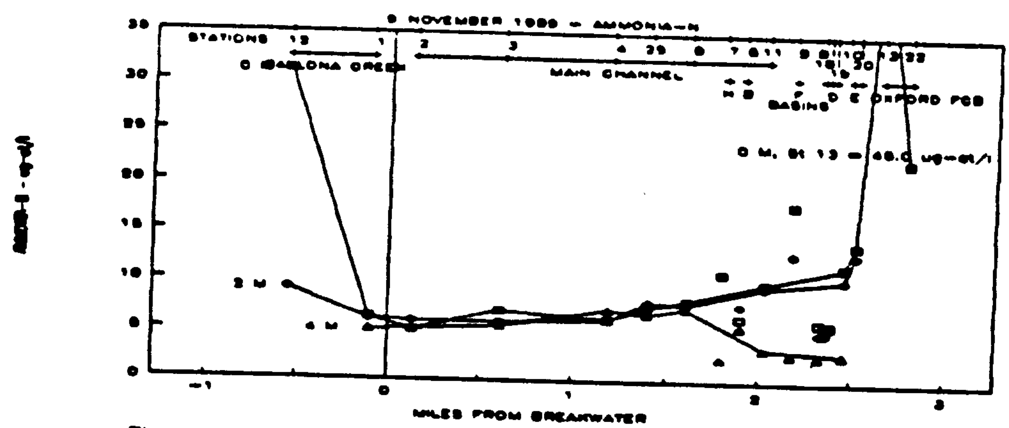

Figure 65. Ammonia-N (ug-at/l), 9 November 1969.

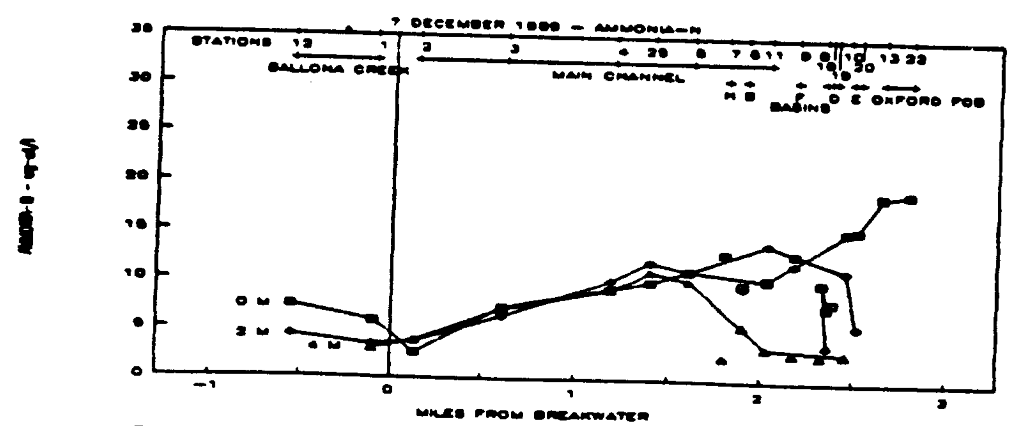

Figure 66. Ammonia-N (ug-at/l), 7 December 1969.

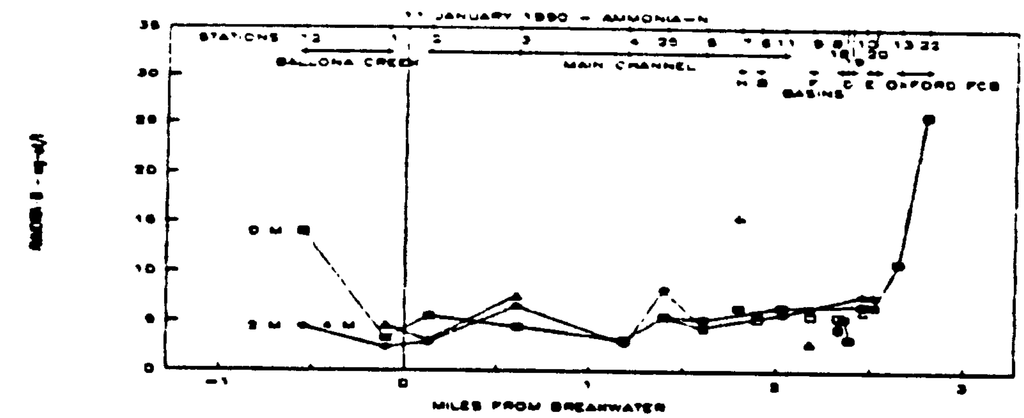

Figure 67. Ammonia-N (ug-at/l), 11 January 1990.

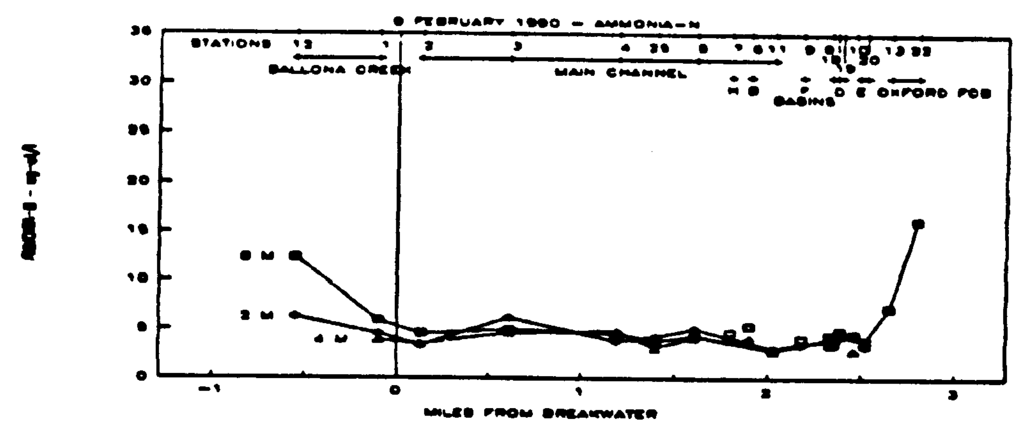

Figure 68. Ammonia-N (ug-at/l), 8 February 1990.

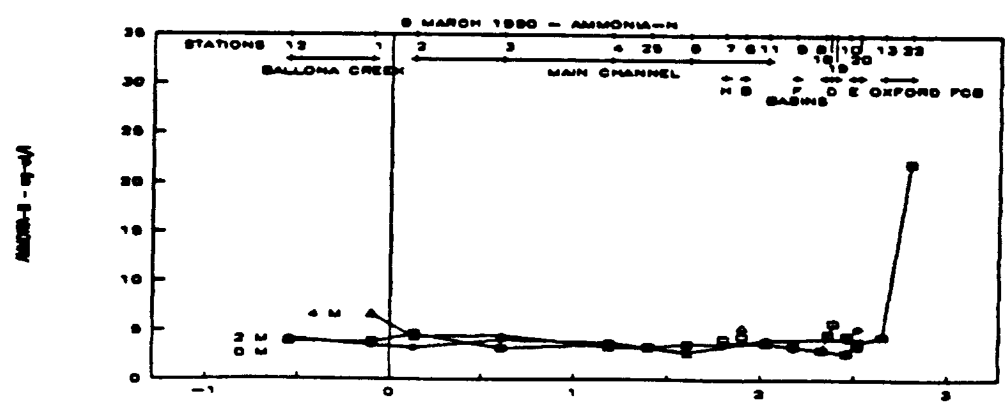

Figure 69. Ammonia-N (ug-at/l), 8 March 1990.

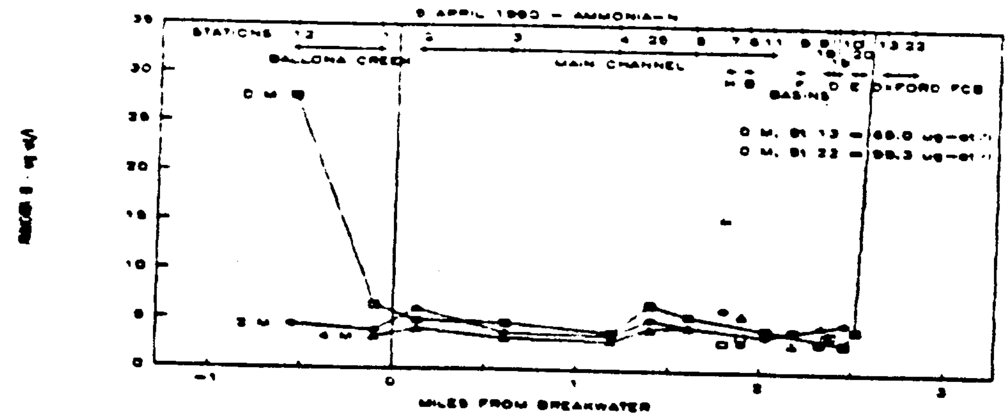

Figure 70. Ammonia-N (ug-at/l), 5 April 1990.

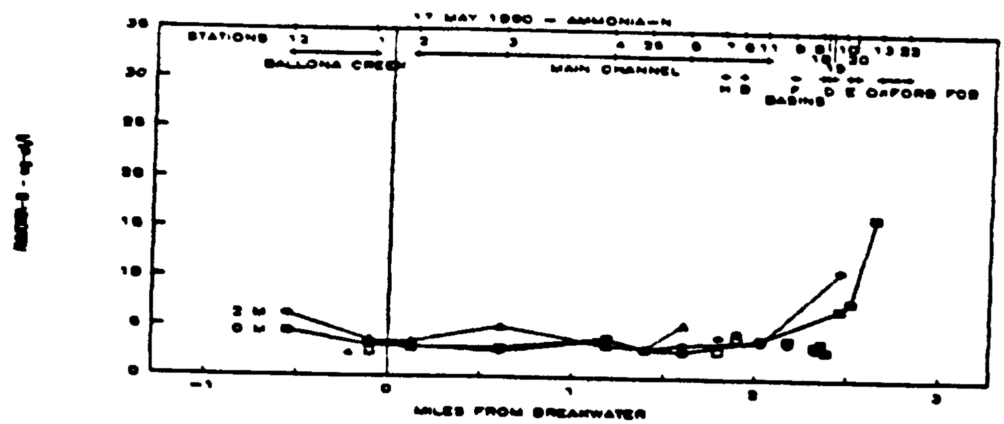

Figure 71. Ammonia-N (ug-at/l), 17 May 1990.

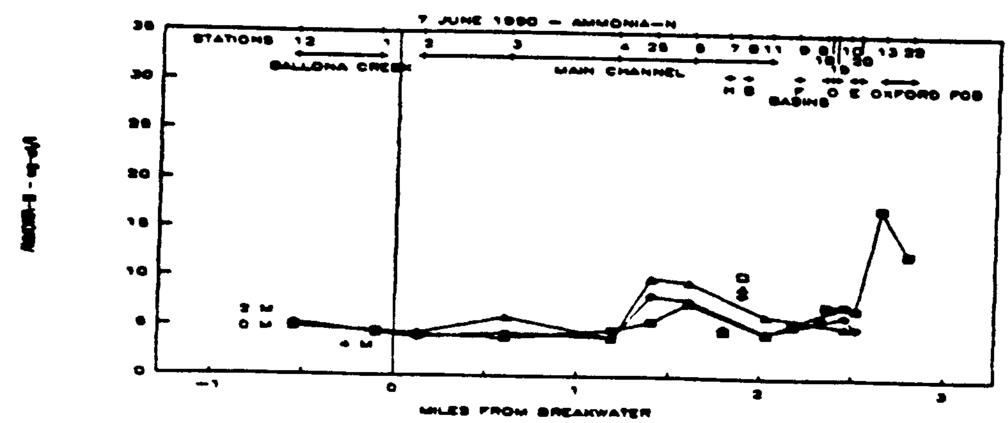

Figure 72. Ammonia-N (ug-at/l), 7 June 1990.

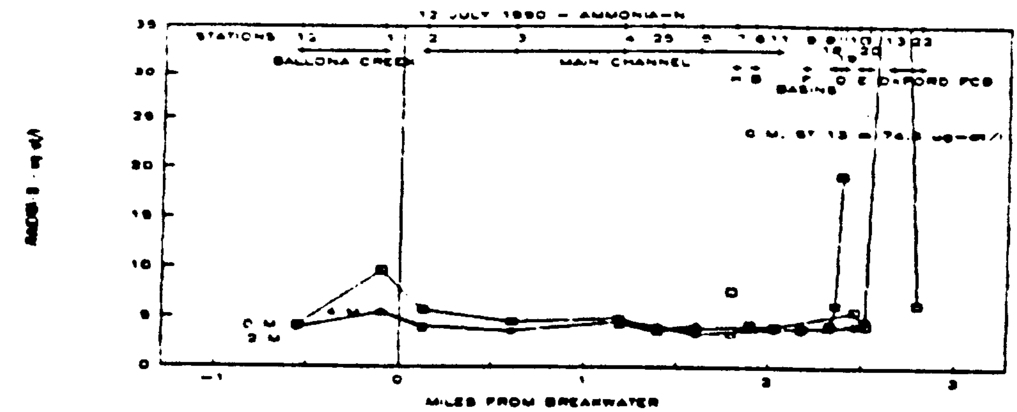

Figure 73. Ammonia-N (ug-at/l), 12 July 1990.

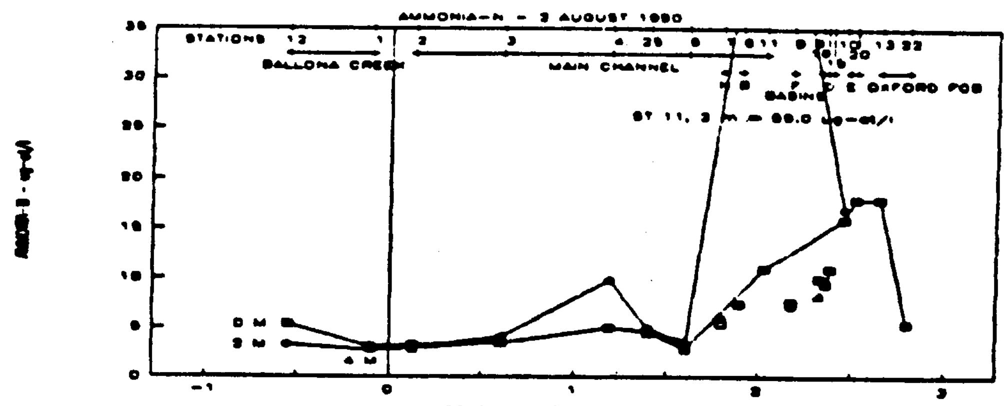

Figure 74. Ammonia-N (ug-at/l), 2 August 1990.

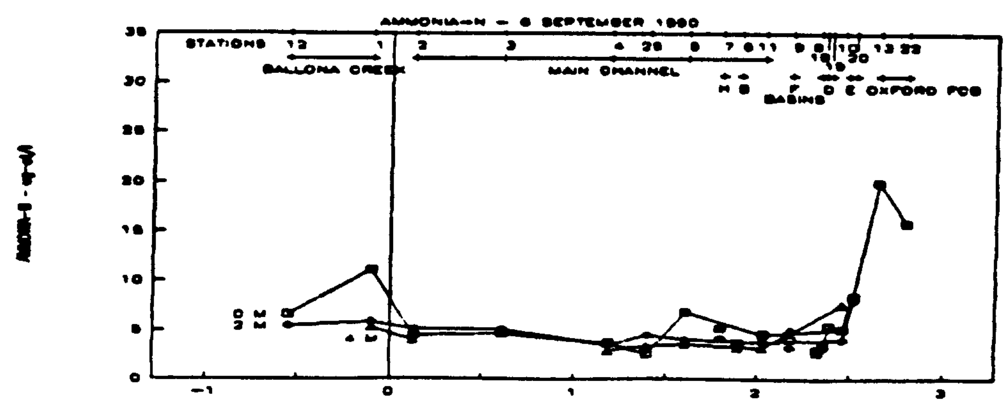

Figure 75. Ammonia-N (ug-at/l), 6 September 1990.

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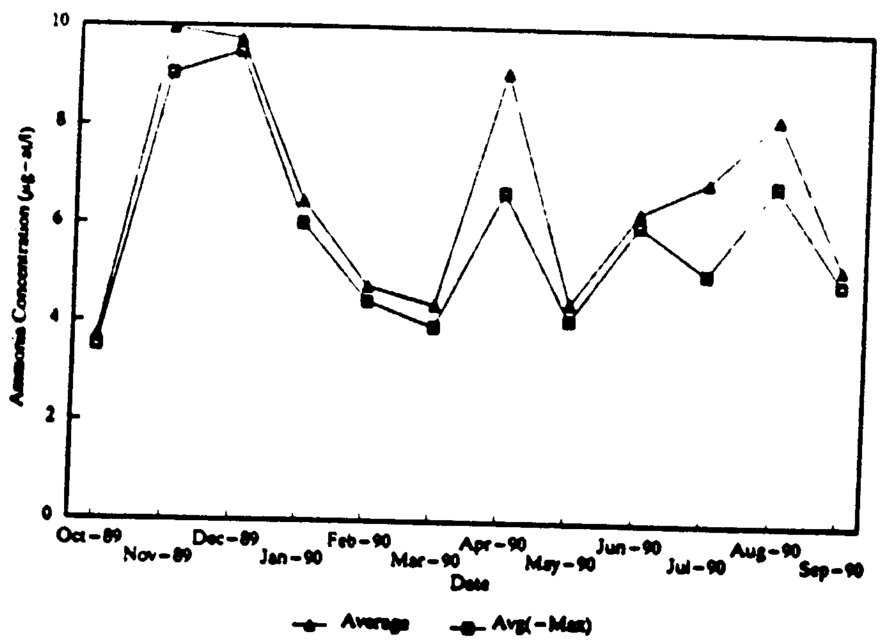

Figure 76. Average Ammonia values, and average values minus extremes, October 1989 - September 1990.

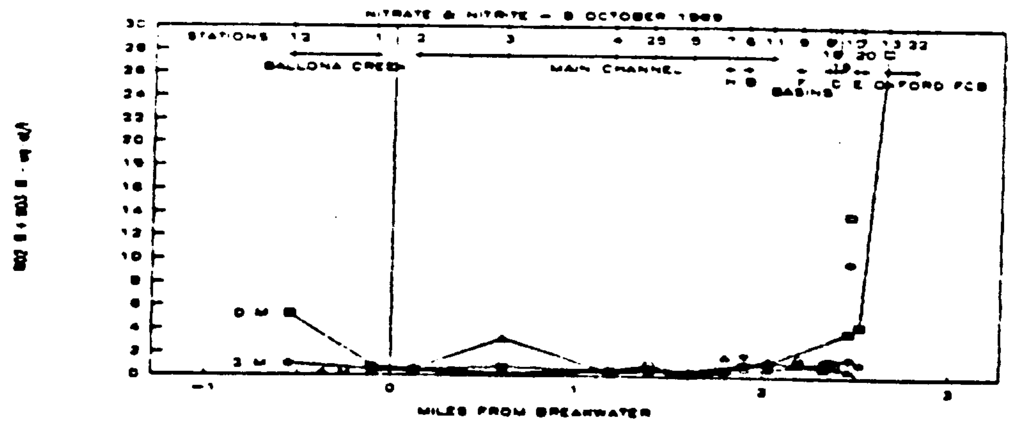

Figure 77. Nitrate–N and Nitrite–N (ug–at/l), 5 October 1969.

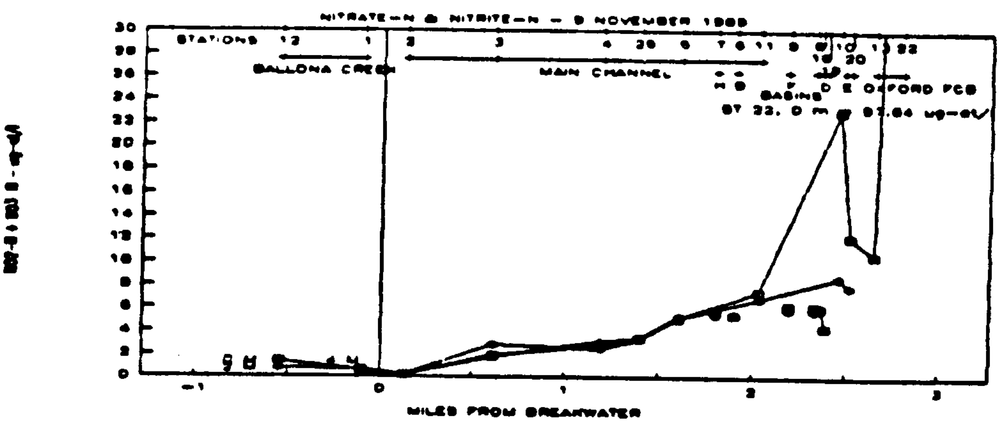

Figure 78. Nitrate–N and Nitrite–N (ug–at/l), 9 November 1969.

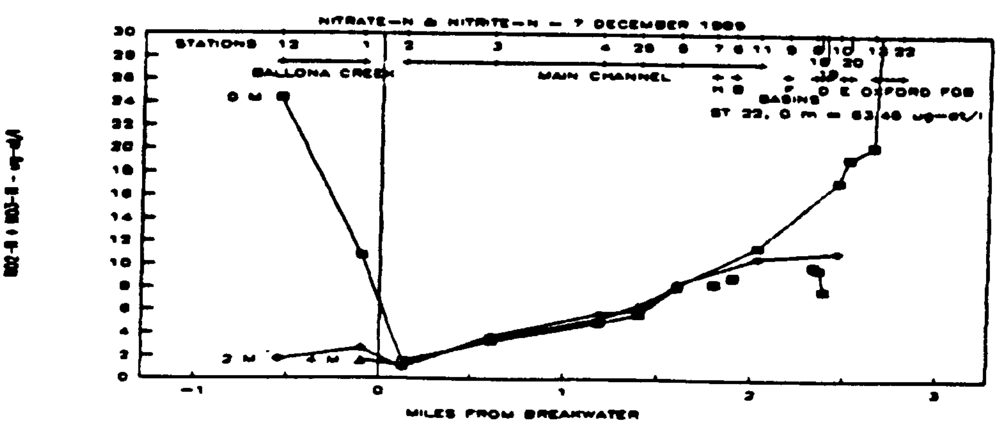

Figure 79. Nitrate–N and Nitrite–N (ug–at/l), 7 December 1969.

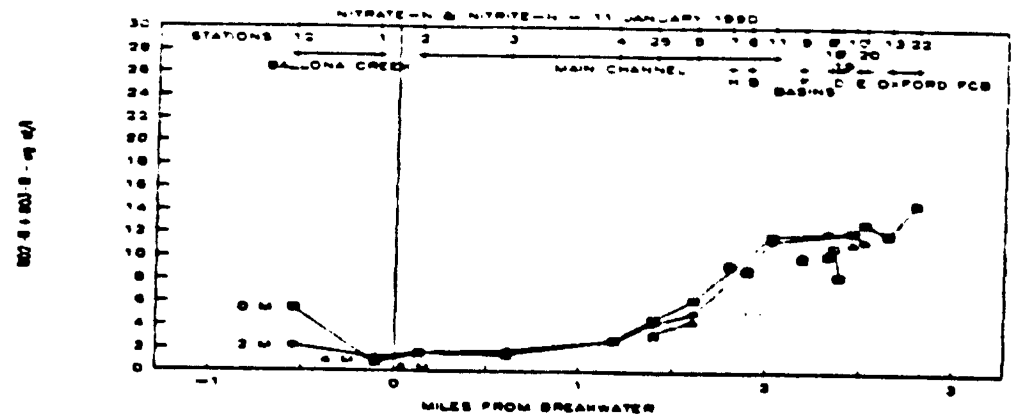

Figure 80. Nitrate-N and Nitrite-N (ug-at/l), 11 January 1990.

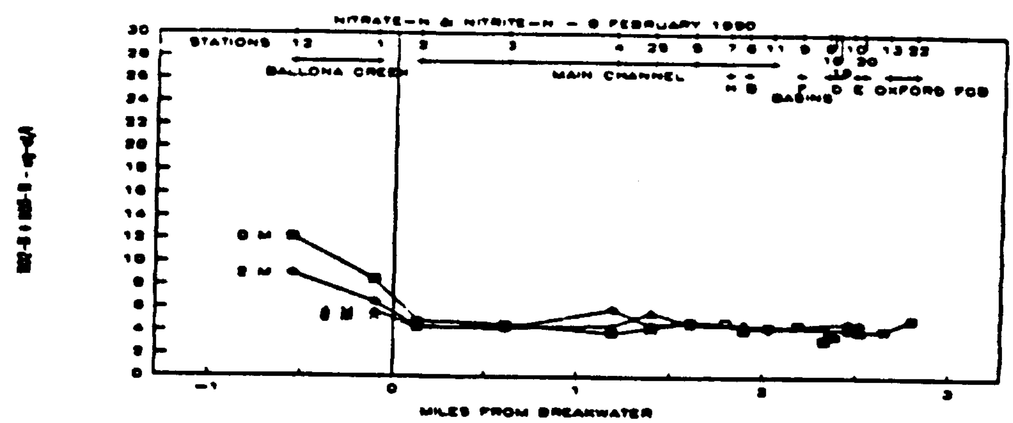

Figure 81. Nitrate-N and Nitrite-N (ug-at/l), 8 February 1990.

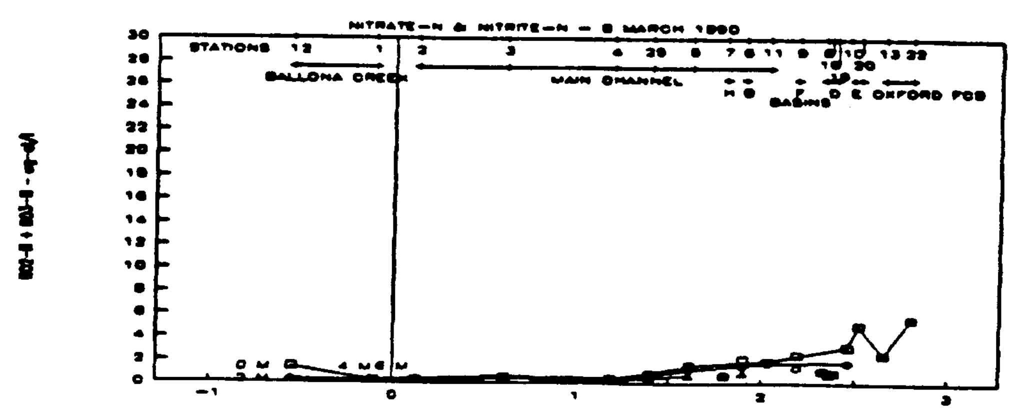

Figure 82. Nitrate-N and Nitrite-N (ug-at/l), 8 March 1990.

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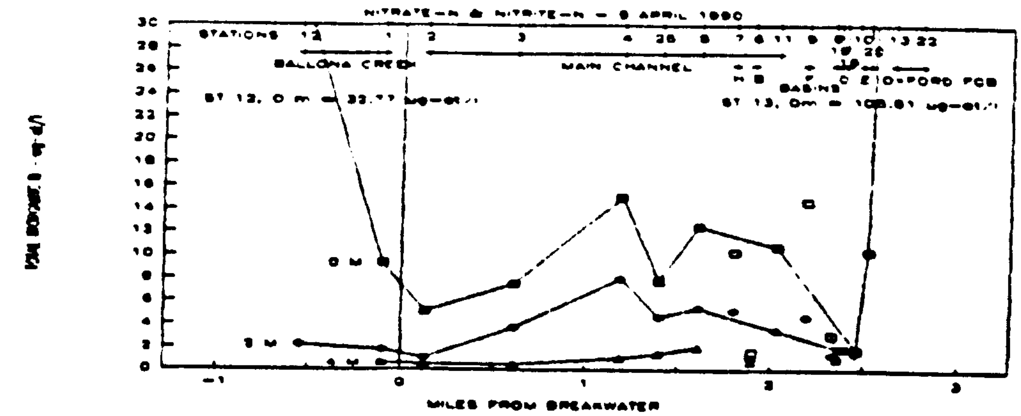

Figure 83. Nitrate-N and Nitrite-N (ug-at/l), 5 April 1990.

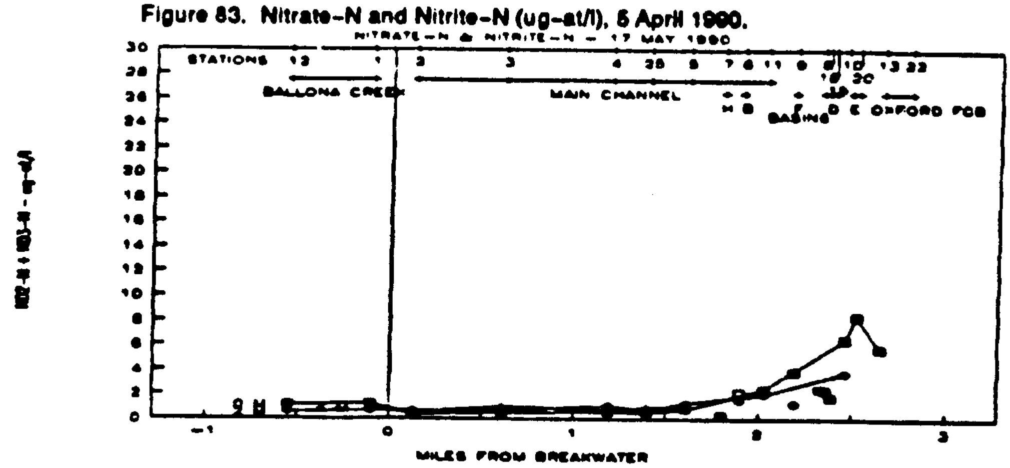

Figure 84. Nitrate-N and Nitrite-N (ug-at/l), 17 May 1990.

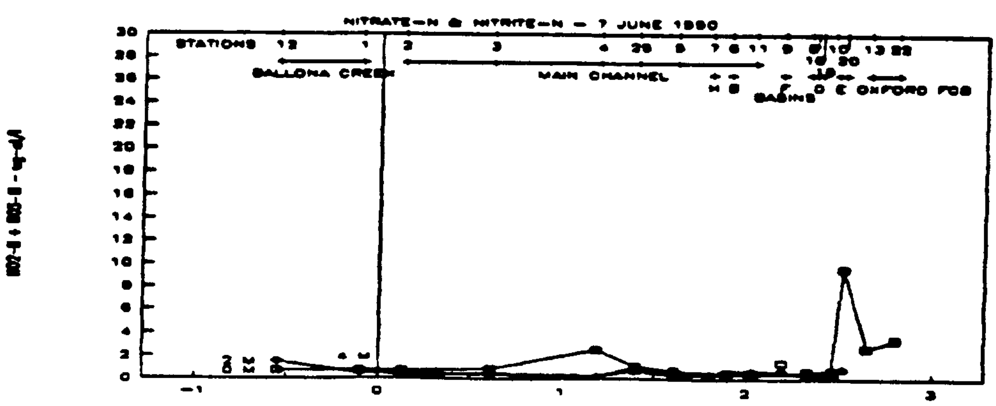

Figure 85. Nitrate-N and Nitrite-N (ug-at/l), 7 June 1990.

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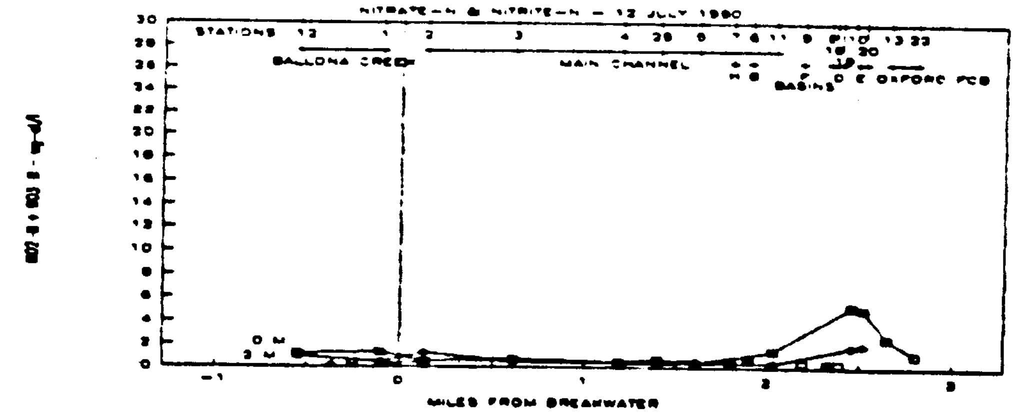

Figure 86. Nitrate-N and Nitrite-N (ug-at/l), 12 July 1990.

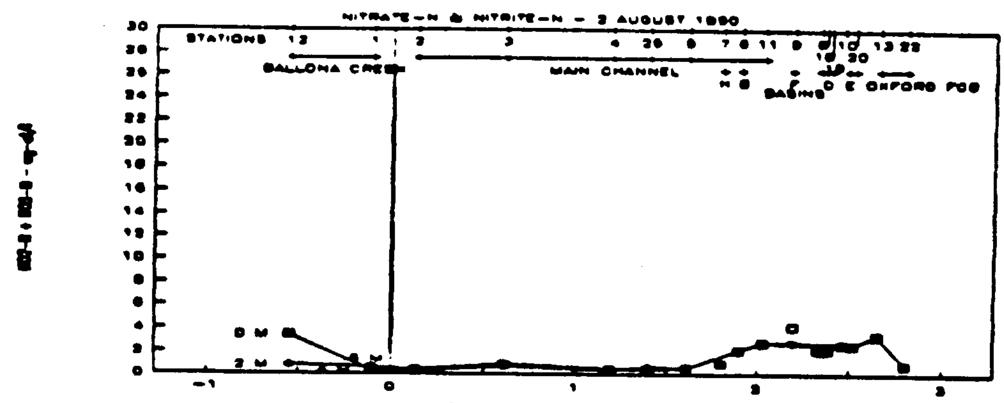

Figure 87. Nitrate-N and Nitrite-N (ug-at/l), 2 August 1990.

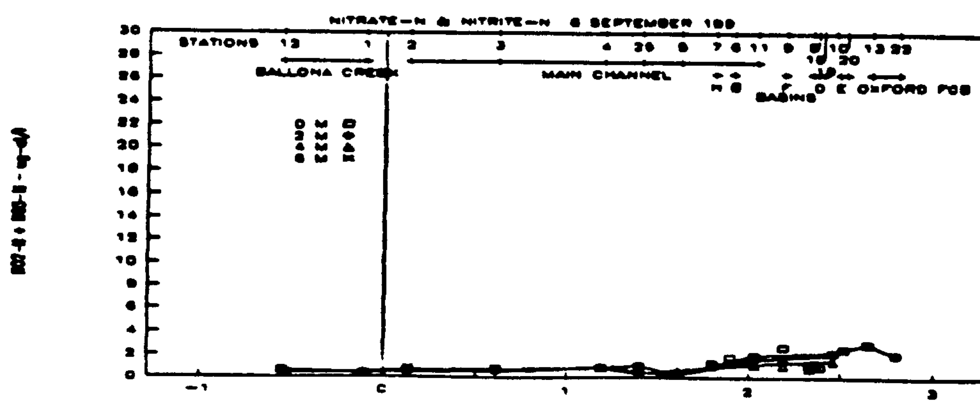

Figure 88. Nitrate-N and Nitrite-N (ug-at/l), 6 September 1990.

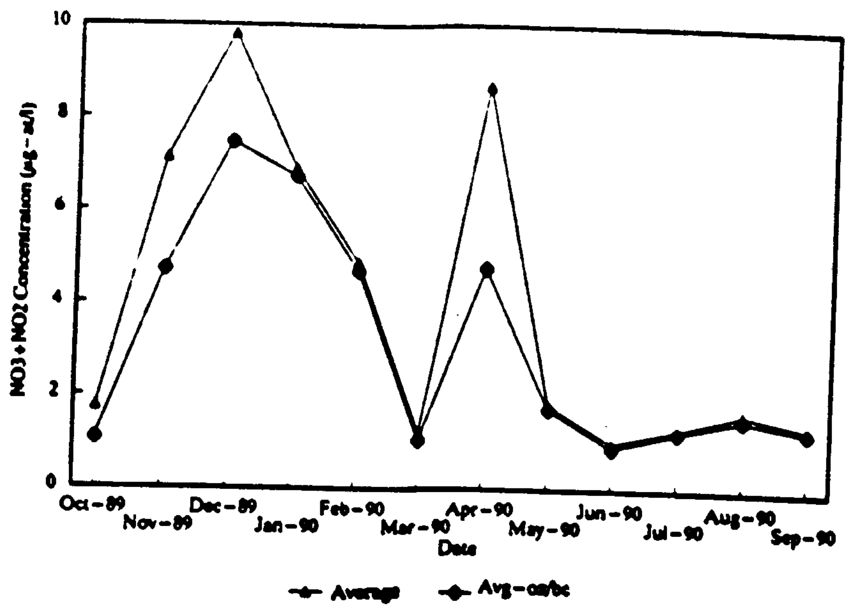

Figure 89. Average Nitrate plus nitrite, and averages minus Oxford Basin and Ballona Creek, October 1989 - September 1990.

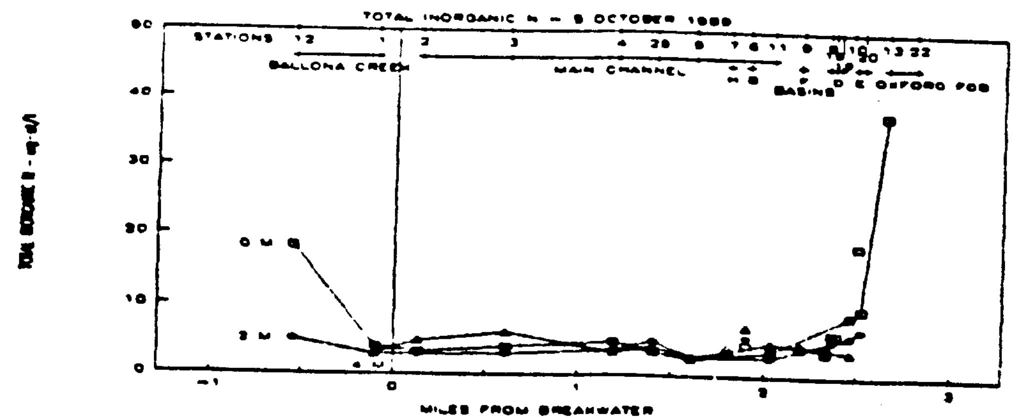

Figure 90. Dissolved inorganic nitrogen (ug-at/l), 5 October 1989.

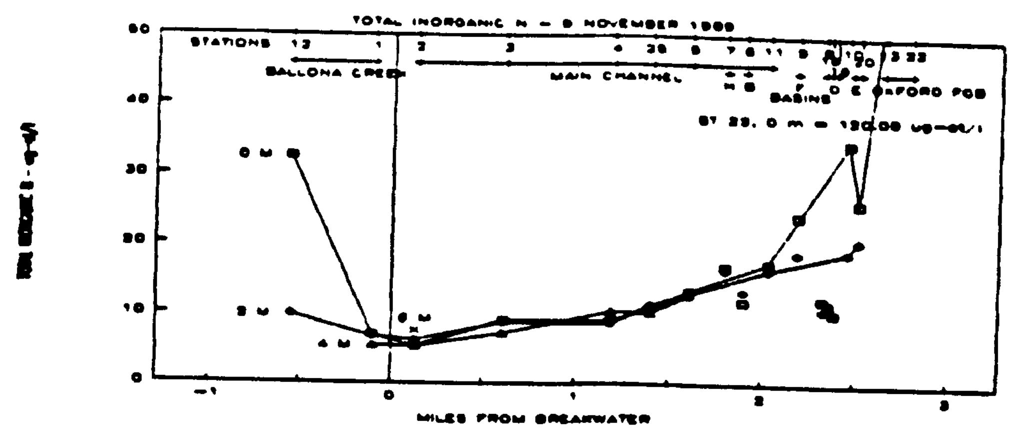

Figure 91. Dissolved inorganic nitrogen (ug-at/l), 9 November 1989.

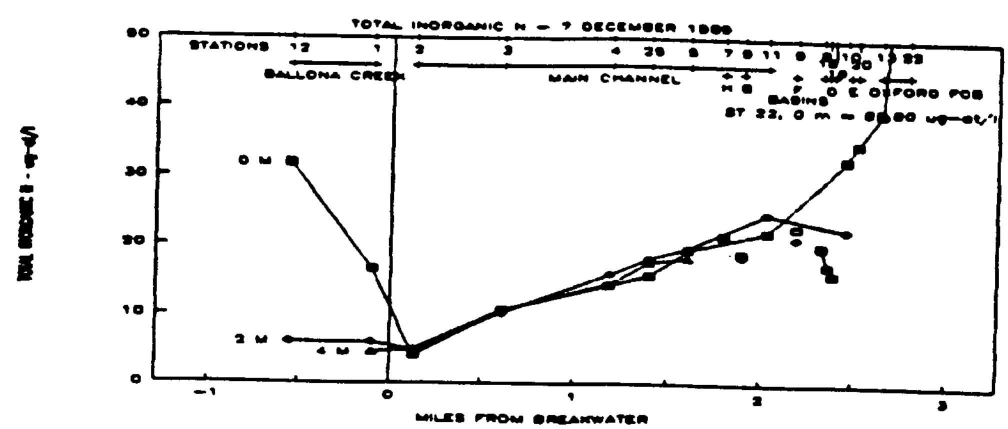

Figure 92. Dissolved inorganic nitrogen (ug-at/l), 7 December 1989.

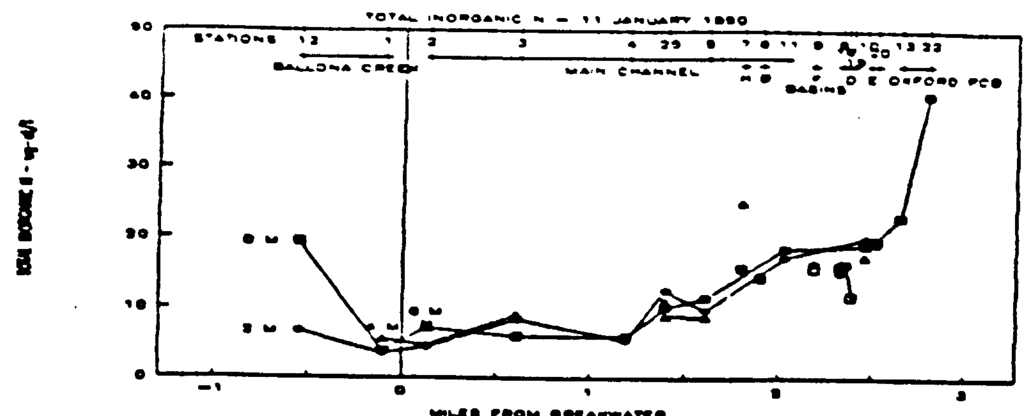

Figure 93. Dissolved inorganic nitrogen (ug-at/l), 11 January 1990.

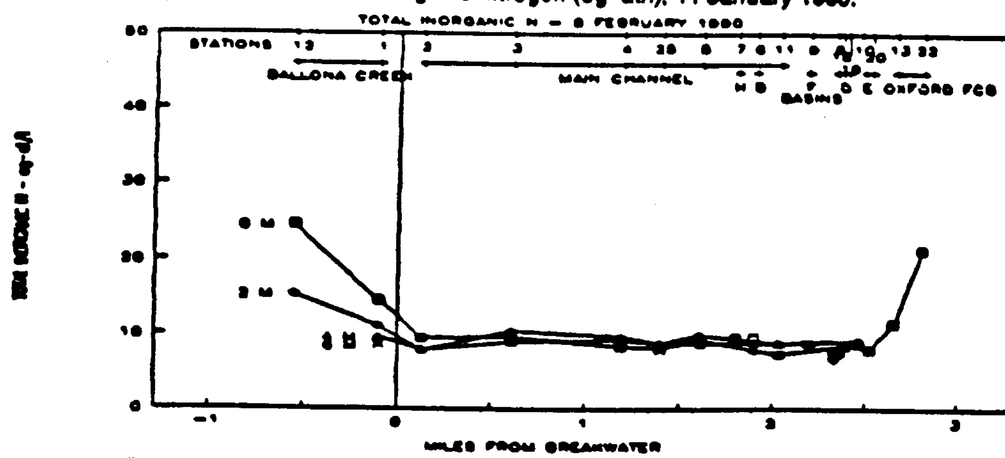

Figure 94. Dissolved inorganic nitrogen (ug-at/l), 8 February 1990.

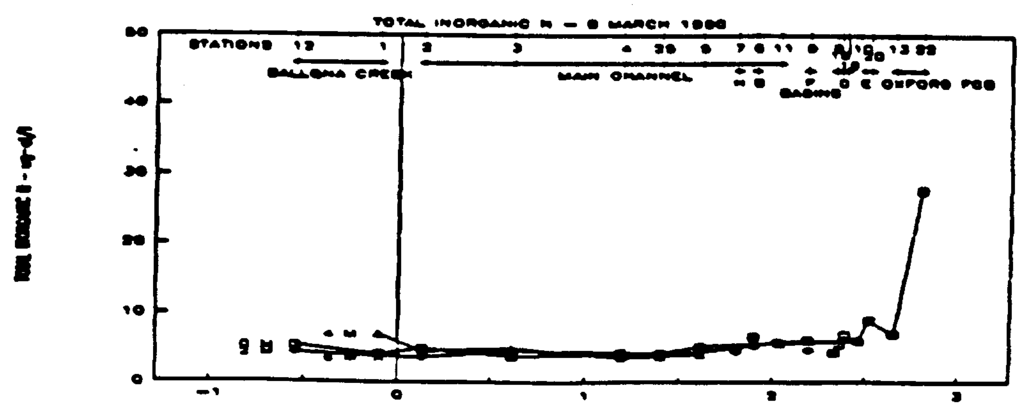

Figure 95. Dissolved inorganic nitrogen (ug-at/l), 8 March 1990.

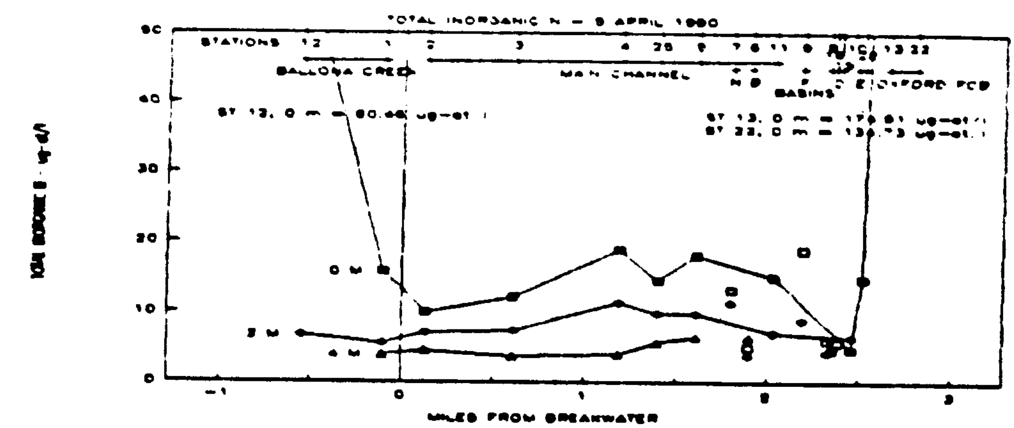

Figure 96. Dissolved inorganic nitrogen (ug–at/l), 6 April 1990.

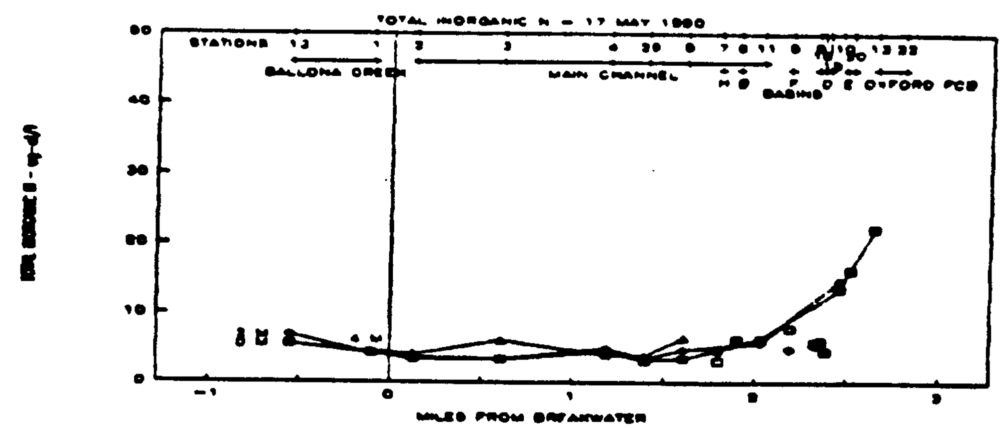

Figure 97. Dissolved inorganic nitrogen (ug–at/l), 17 May 1990.

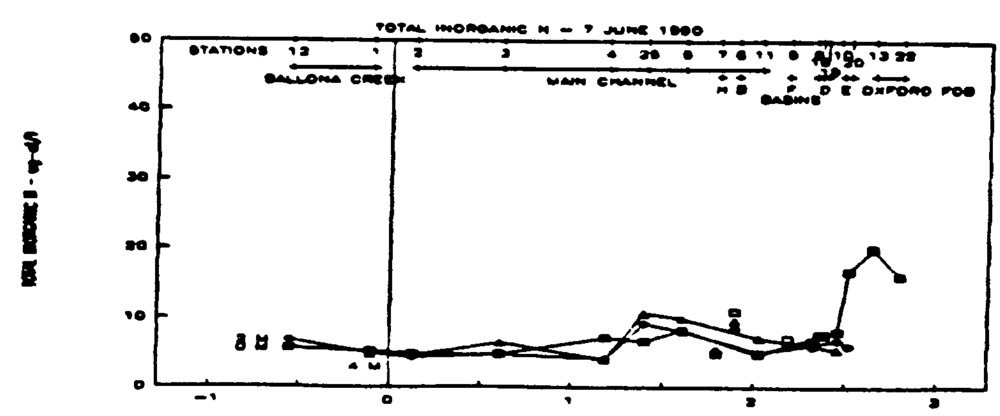

Figure 98. Dissolved inorganic nitrogen (ug–at/l), 7 June 1990.

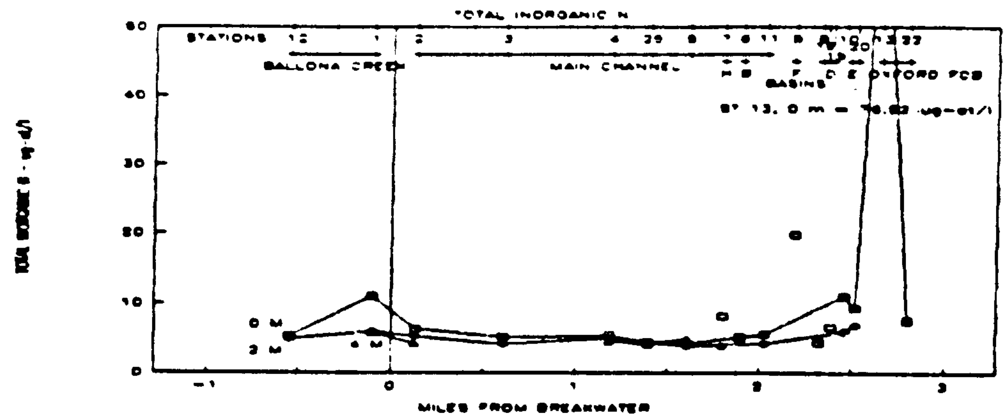

Figure 99. Dissolved inorganic nitrogen (ug–at/l), 12 July 1990.

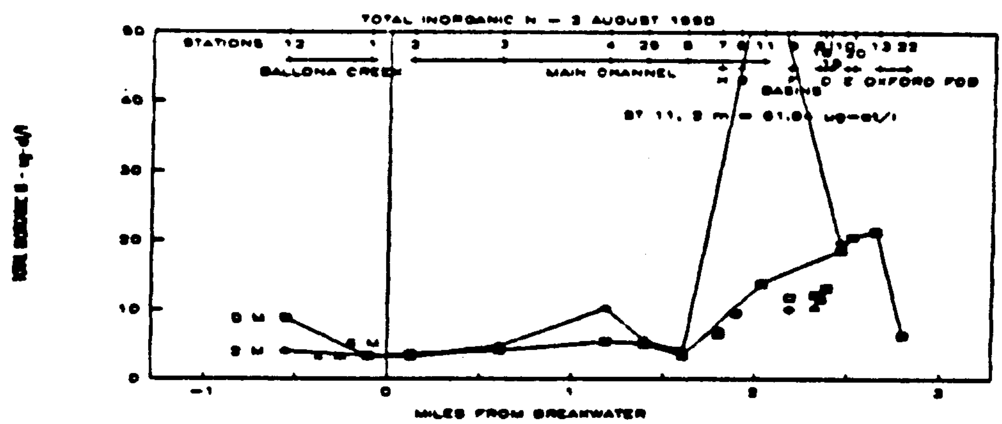

Figure 100. Dissolved inorganic nitrogen (ug–at/l), 2 August 1990.

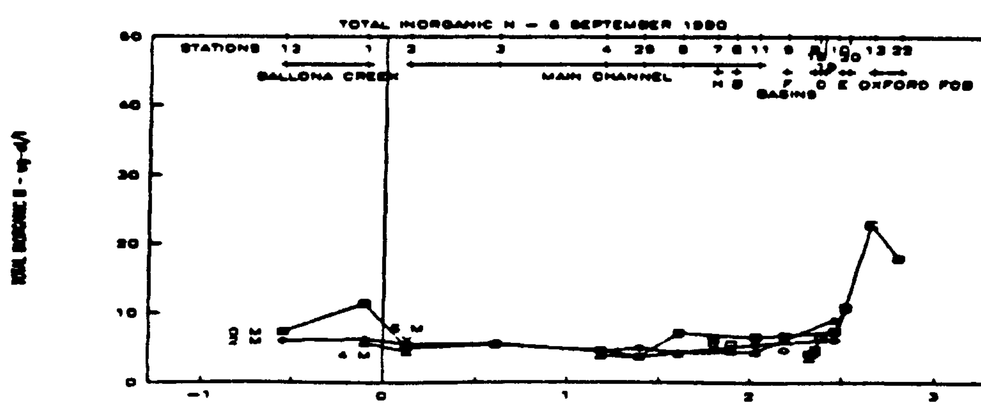

Figure 101. Dissolved inorganic nitrogen (ug–at/l), 6 September 1990.

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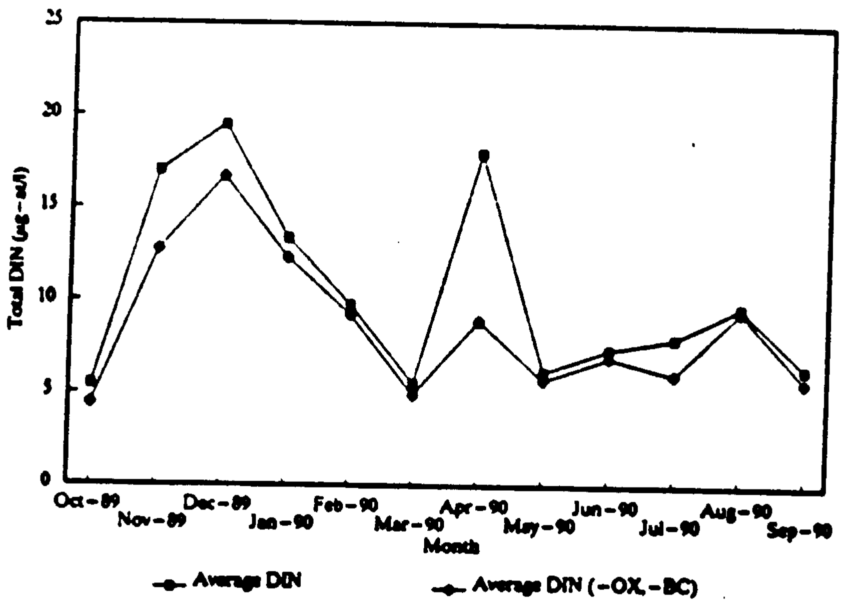

Figure 102. Average Dissolved Inorganic Nitrogen and average excluding Oxford Basin and Ballona Creek, October 1989 - September 1990.

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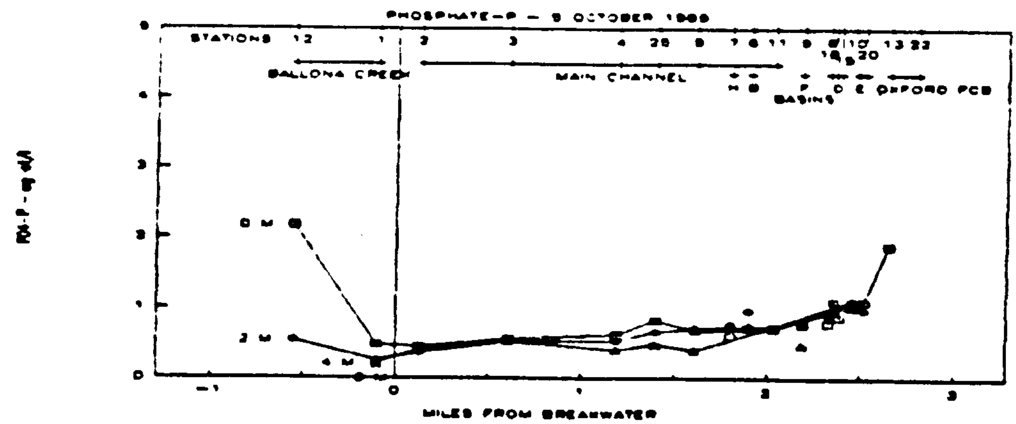

Figure 103. Phosphate-P (ug-at/l), 5 October 1989.

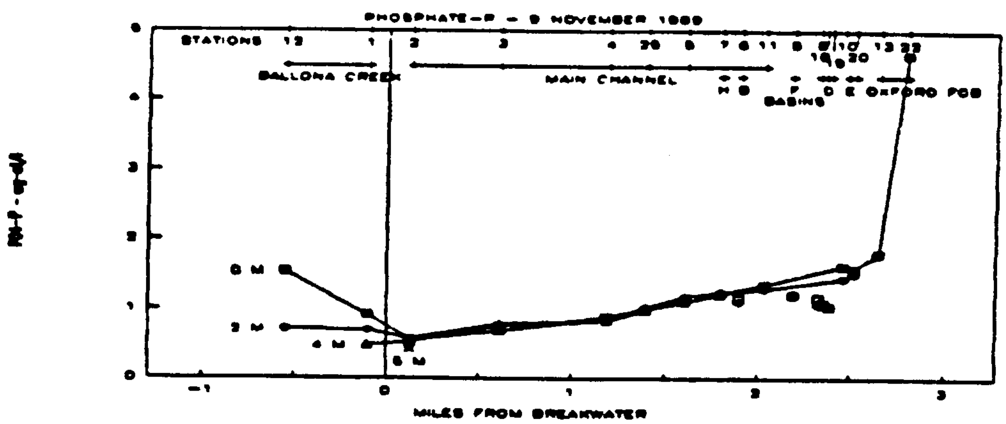

Figure 104. Phosphate-P (ug-at/l), 9 November 1989.

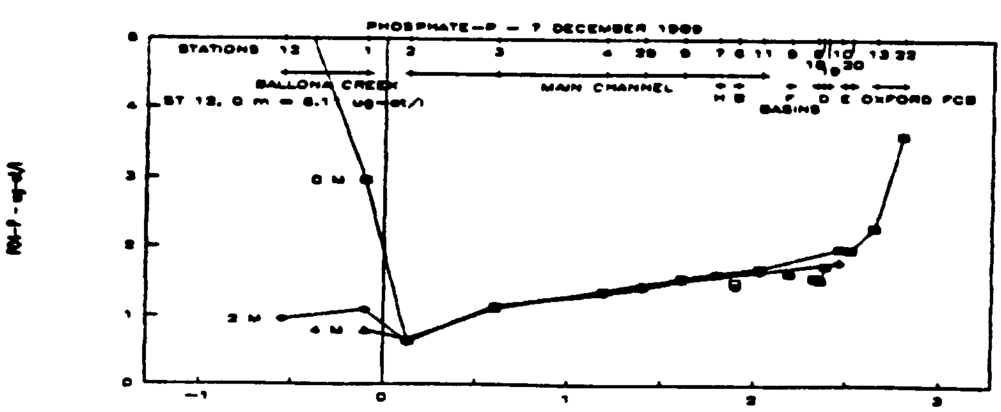

Figure 105. Phosphate-P (ug-at/l), 7 December 1989.

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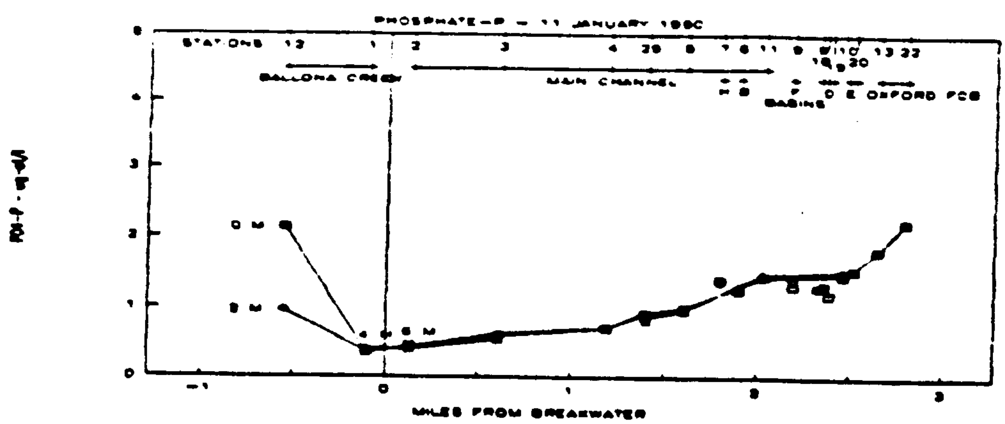

Figure 106. Phosphate-P (ug-at/l), 11 January 1990.

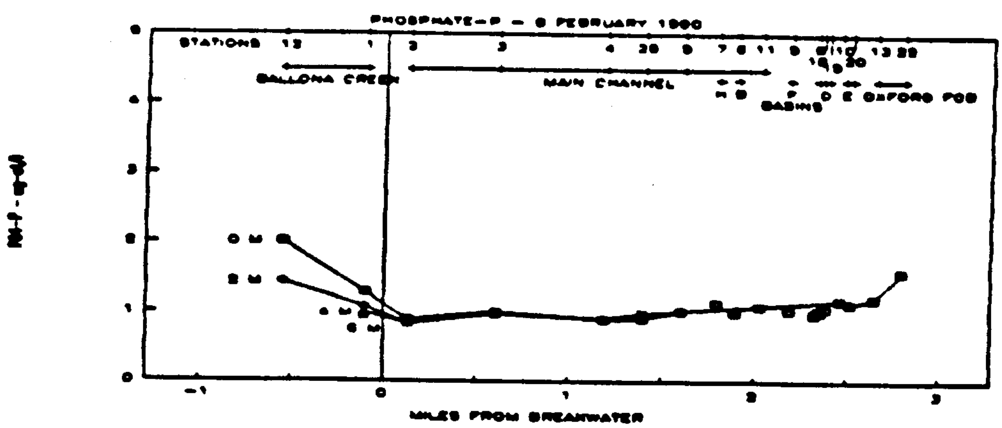

Figure 107. Phosphate-P (ug-at/l), 8 February 1990.

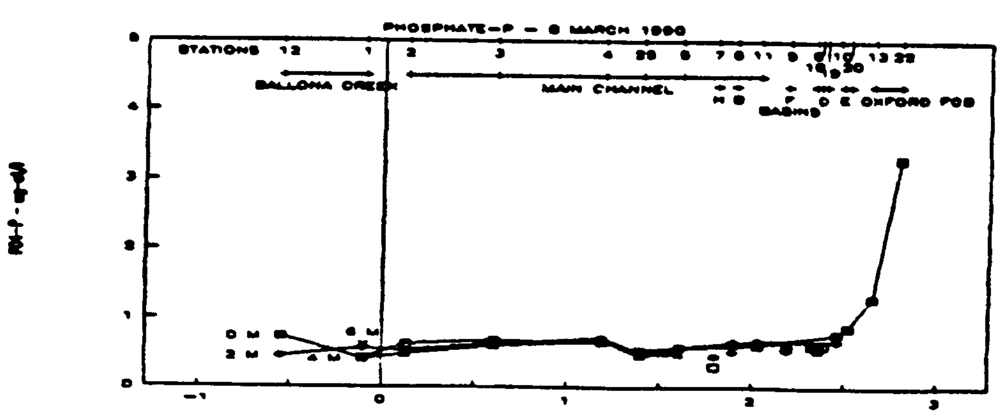

Figure 108. Phosphate-P (ug-at/l), 8 March 1990.

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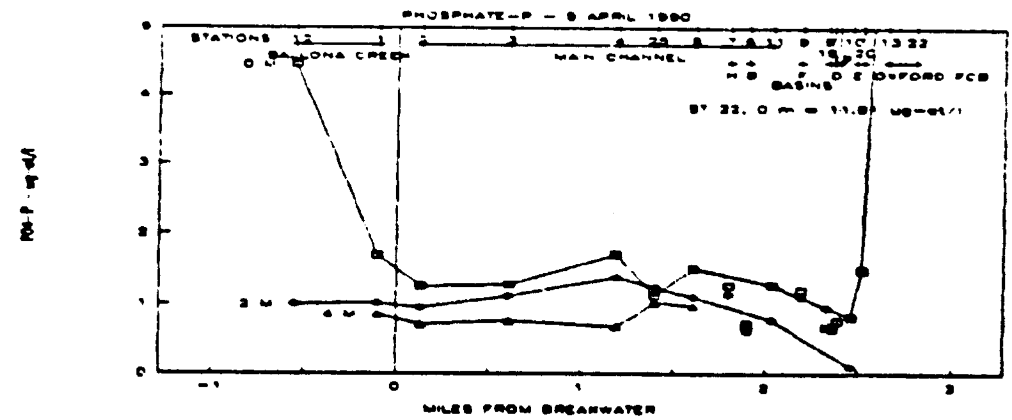

Figure 109. Phosphate-P (ug-at/l), 6 April 1990.

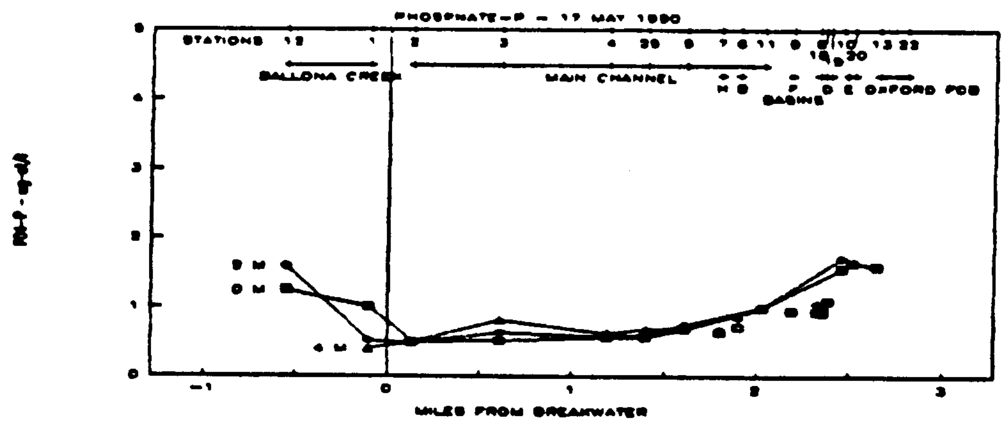

Figure 110 . Phosphate-P (ug-at/l), 17 May 1990.

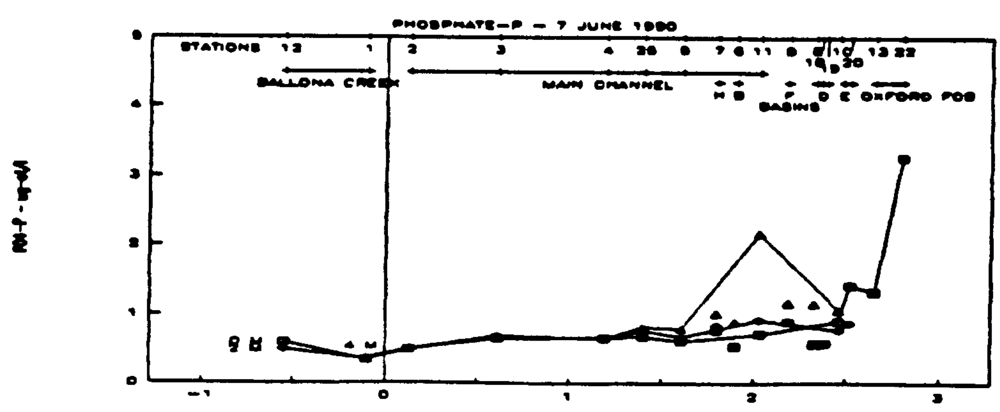

Figure 111. Phosphate-P (ug-at/l), 7 June 1990.

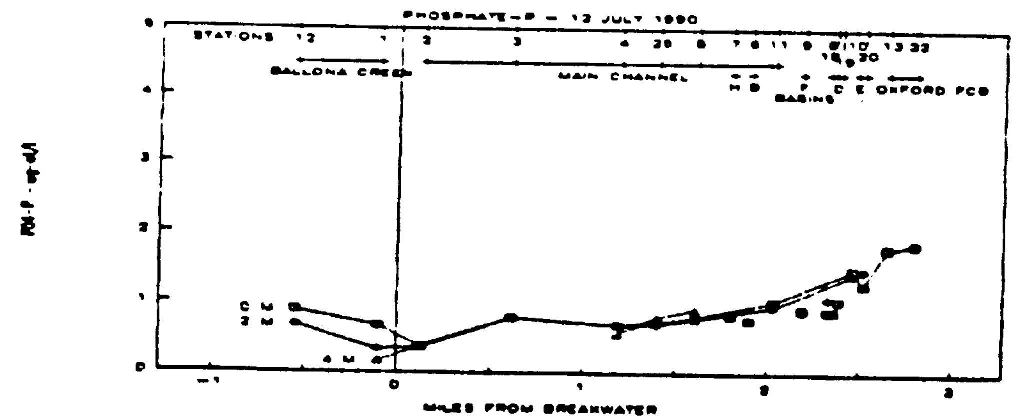

Figure 112. Phosphate-P (ug-at/l), 12 July 1990.

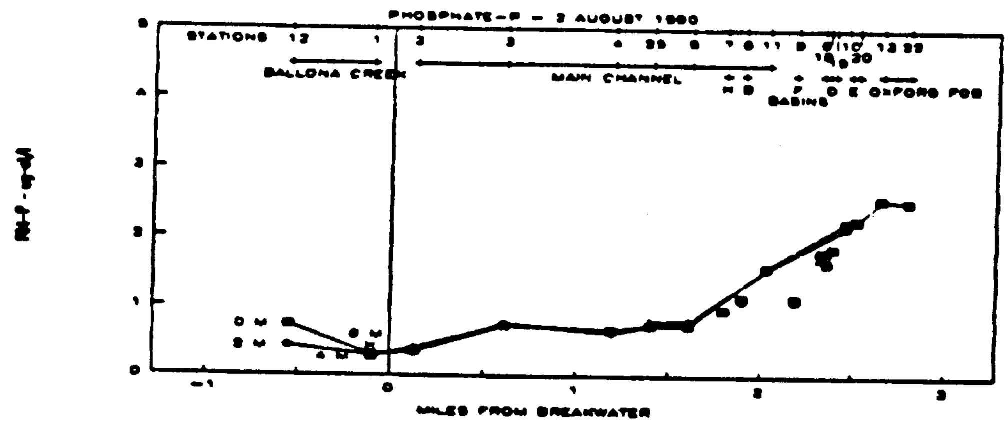

Figure 113. Phosphate-P (ug-at/l), 2 August 1990.

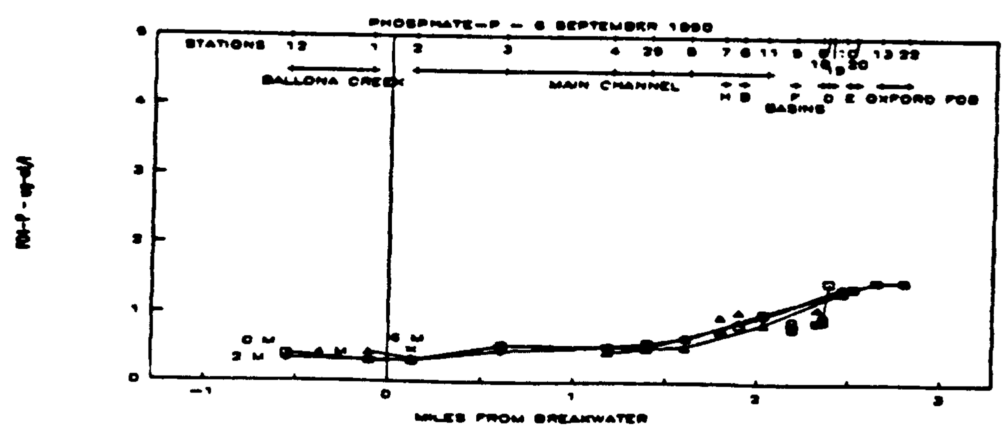

Figure 114. Phosphate-P (ug-at/l), 6 September 1990.

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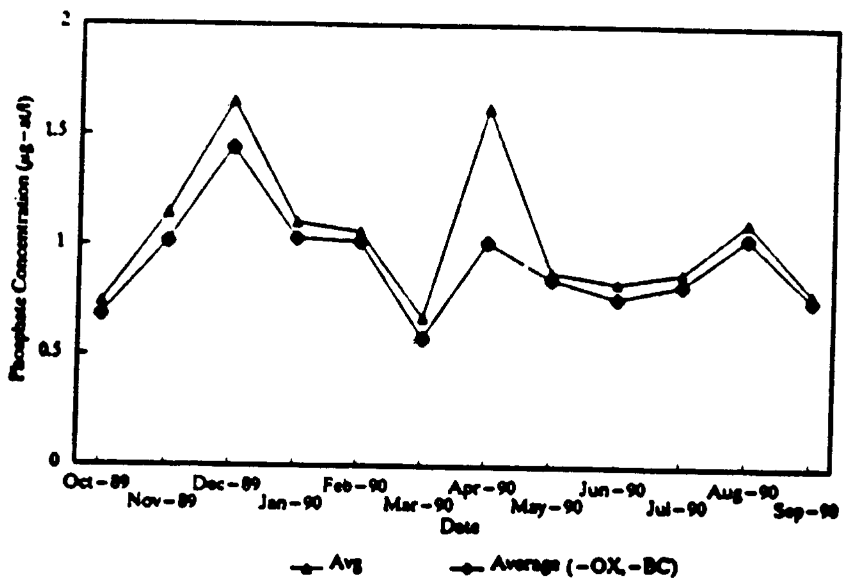

Figure 115. Average Phosphate excluding Oxford Basin and Ballona Creek, October 1989 - September 1990.

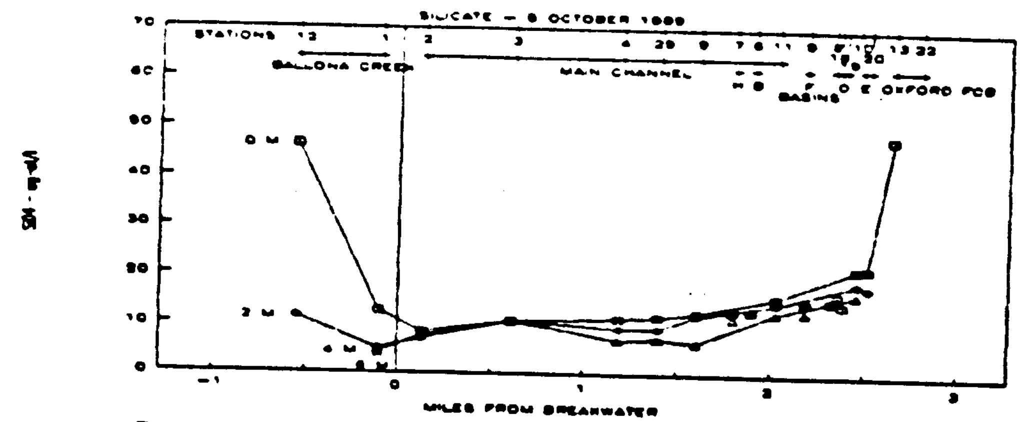

Figure 116. Silicate (ug–at/l), 5 October 1989.

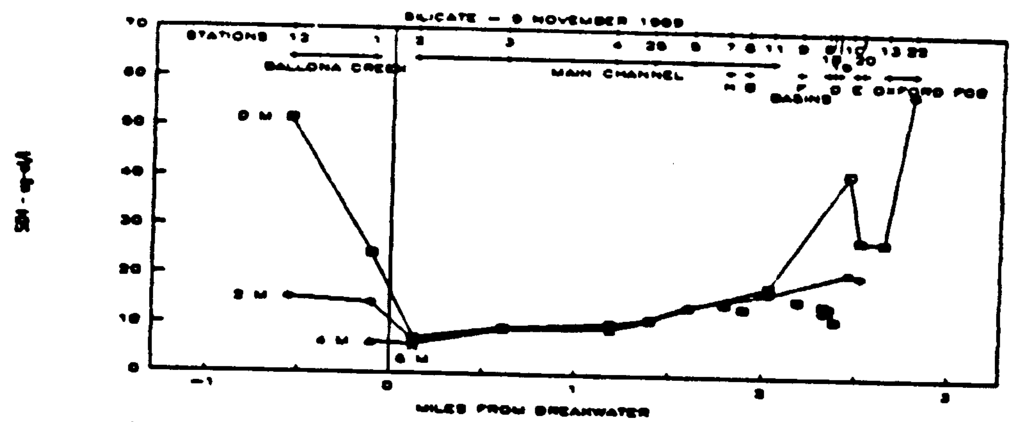

Figure 117. Silicate (ug–at/l), 9 November 1989.

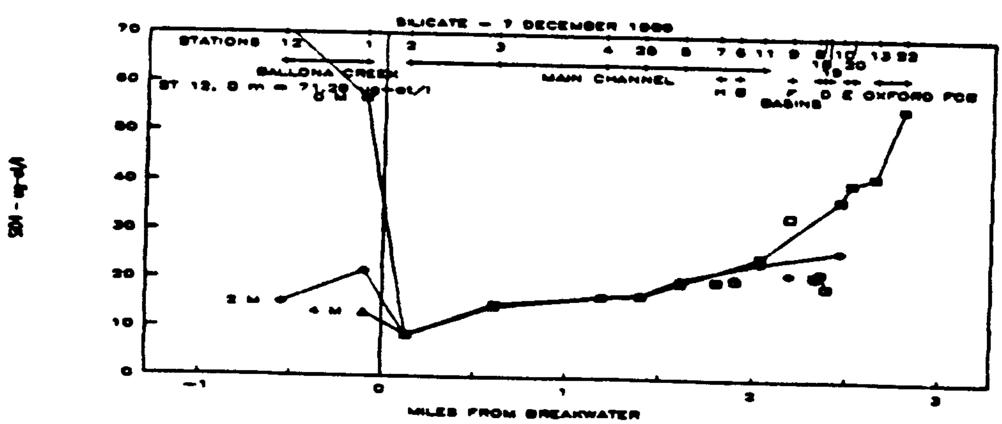

Figure 118. Silicate (ug–at/l), 7 December 1989.

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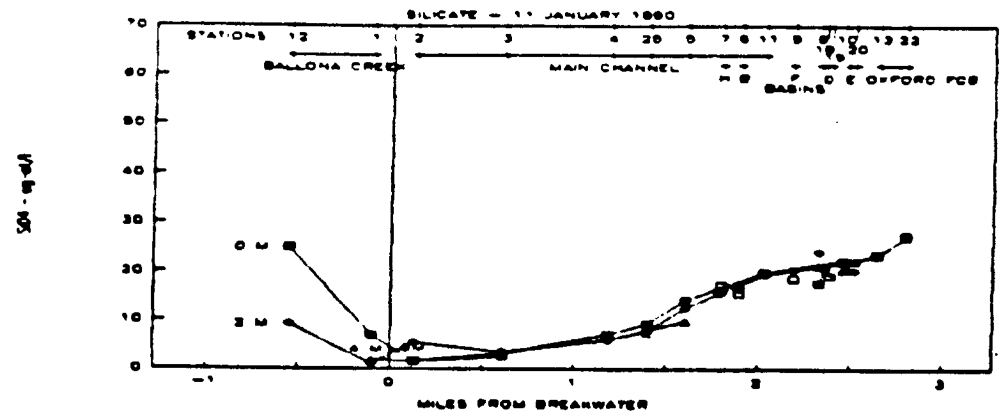

Figure 119. Silicate (ug–at/l), 11 January 1990.

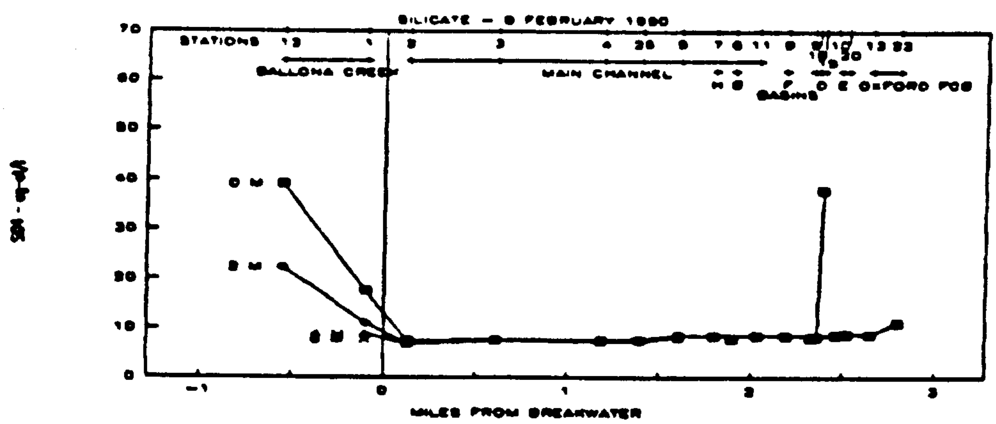

Figure 120. Silicate (ug–at/l), 8 February 1990.

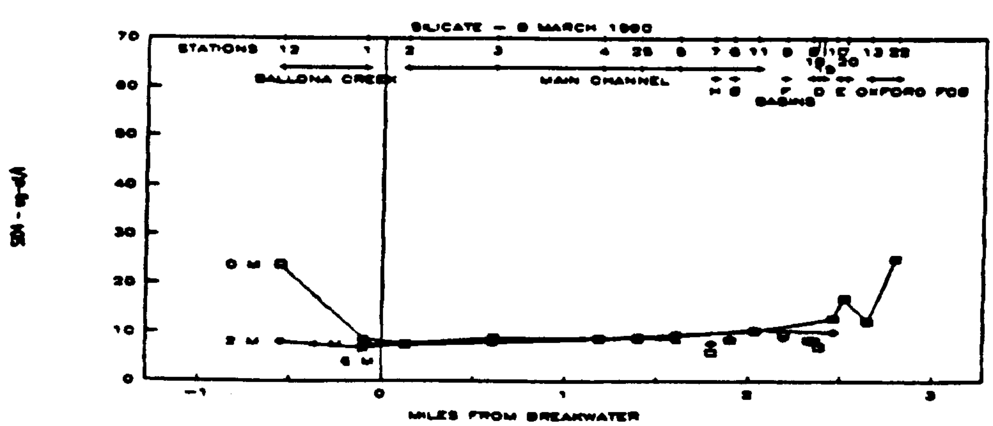

Figure 121. Silicate (ug–at/l), 8 March 1990.

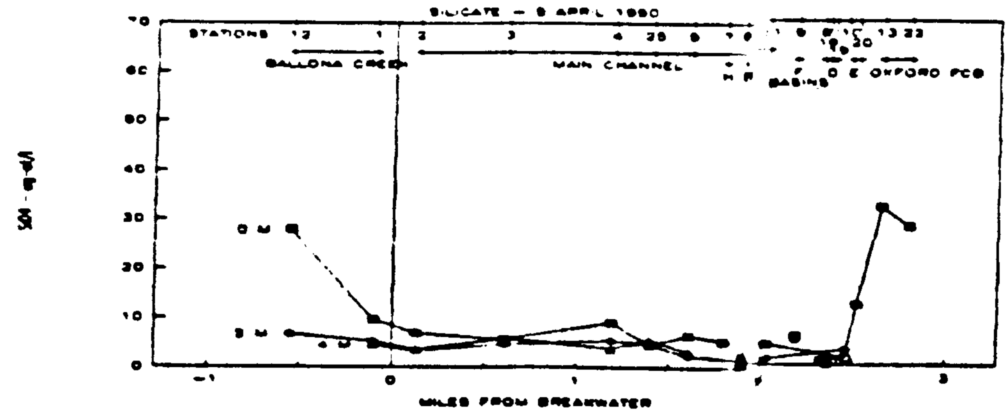

Figure 122. Silicate (ug-at/l), 5 April 1990.

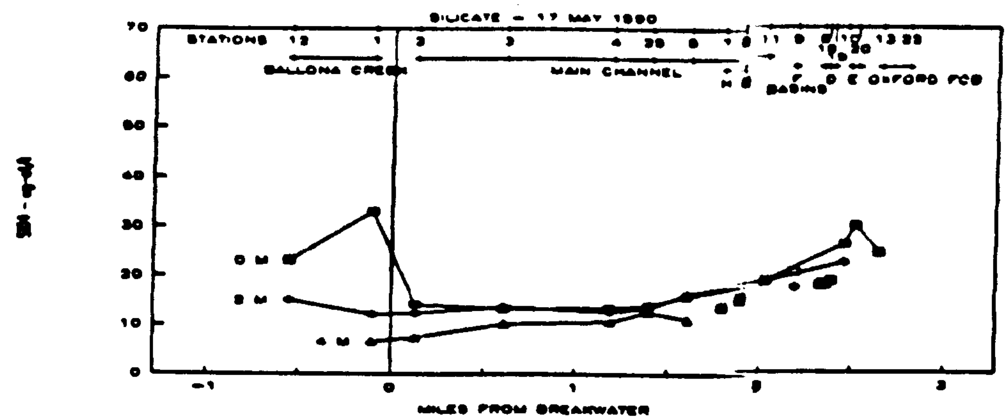

Figure 123. Silicate (ug-at/l), 17 May 1990.

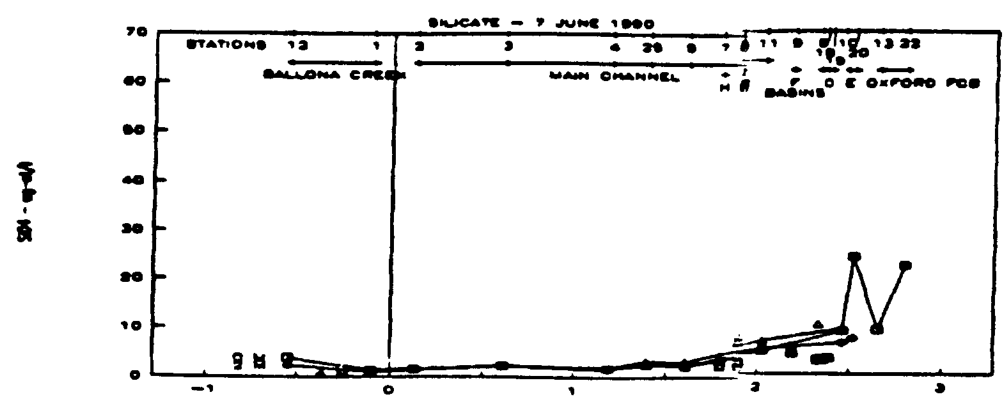

Figure 124. Silicate (ug-at/l), 7 June 1990.

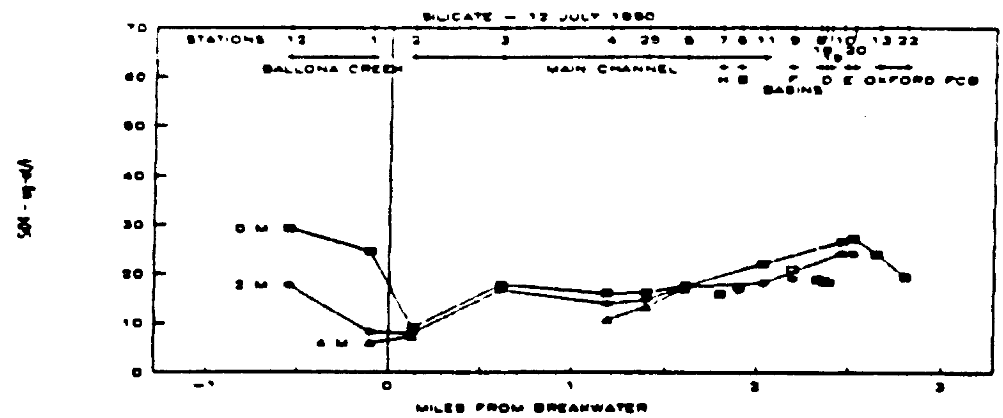

Figure 125. Silicate (ug-at/l), 12 July 1990.

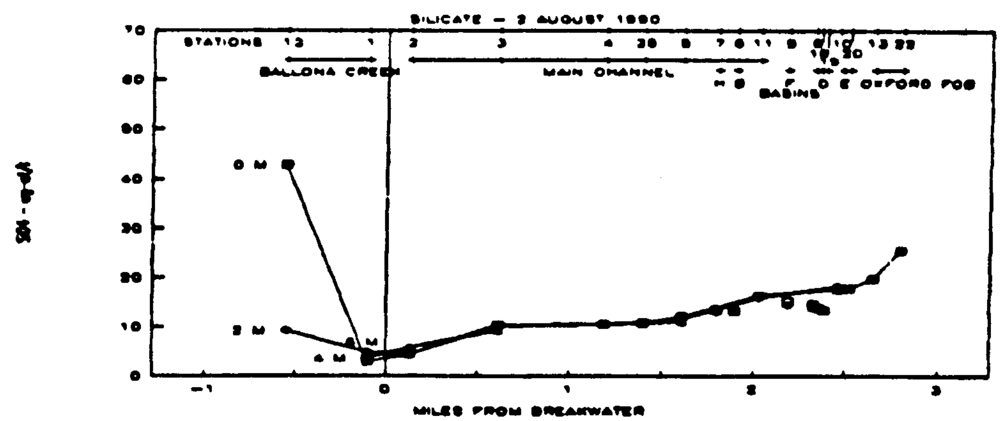

Figure 126. Silicate (ug-at/l), 2 August 1990.

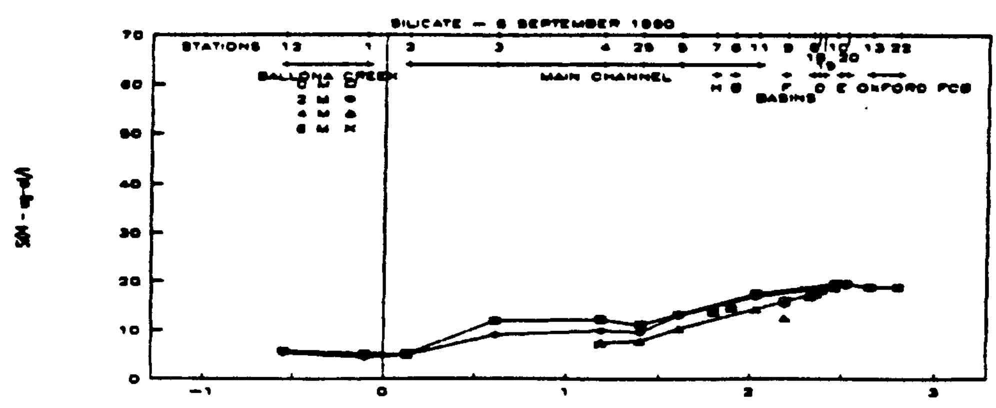

Figure 127. Silicate (ug-at/l), 6 September 1990.

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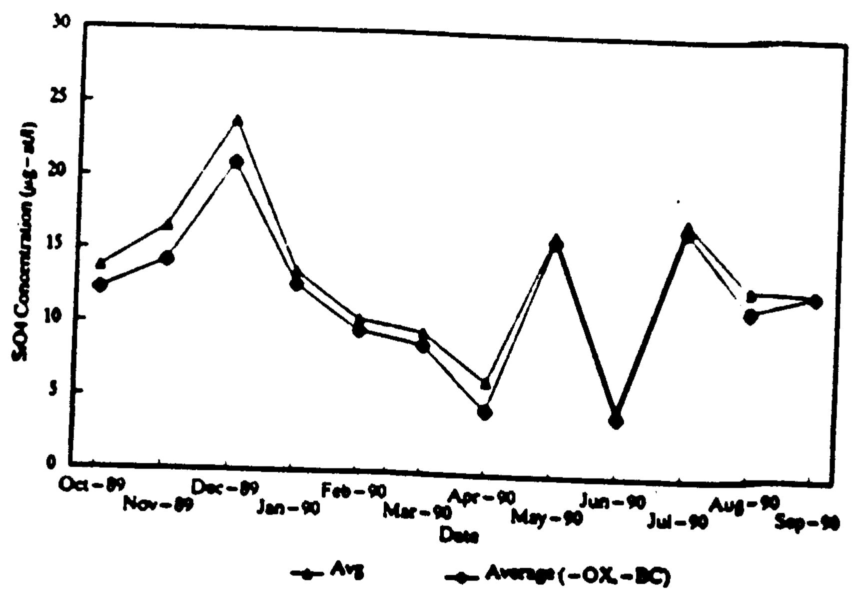

Figure 127. Average Silicate excluding Oxford Basin and Ballona Creek, October 1989 - September 1990.

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IV. SEDIMENT COMPOSITION AND CONTAMINATION

GRAIN SIZE

The sediment grain size of Marina del Rey was originally dictated by development of the Marina in a degraded wetlands, with the consequent perturbation of historic beach sands and the accumulation of eroded terrestrial sediments overlaying them. In low energy environments such as marinas, fine sediments are deposited as they drop out of the water column, whereas in high energy environments fines are carried out to sea to become suspended in turbidity currents and carried ultimately to other areas of low energy environment. Thus the Marina inner basins tend to be composed of much higher percentages of fine grained sediments than one would expect in the outer Marina, where flushing is greater.

There is an exception to this in the Marina, where the deposition of sand at Station 2, at the Entrance Channel, created a sand bar. This area was partially dredged in 1987, reducing the barrier but leaving sufficient deposition to cause the accumulation of contaminated, very fine grained sediments in the area, and greatly changing the character of the habitat.

The lack of heavy rainfall in the past few years has also reduced flushing; runoff from low rainfall or dry weather flow seems to have moved some of the finest sediments from the inner basins out as far as the Main Channel (e.g., Station 5) but has not carried them out of the Marina.

PROCEDURES

Grain size is a relative size determination made by sieving sediments through a series of screens with various mesh sizes. The greater the screen size number, the finer the sediments are that pass through it. Sediment samples for grain size determination were taken from Campbell grab samples that were used to determine benthic fauna and sediment chemistry.

Table 8. Percent Sediment Grain Size in Marina del Rey, 20 October 1988 (Particle size decreased with increasing mesh size)

Screen Size / Station	25	35	60	100	200	<200
1	3.46	5.37	29.44	28.62	22.09	11.02
2	1.17	1.23	5.21	10.88	42.81	38.70
3	3.01	13.32	61.94	9.40	1.24	11.09
4	0.18	0.31	0.64	2.95	15.96	79.96
5	0.04	0.30	0.65	0.66	1.52	96.83
6	0.15	0.86	3.93	20.04	21.01	54.01
7	0.28	0.28	0.34	1.51	1.74	95.85
8	0.31	0.93	2.21	6.84	14.83	74.88
9	0.70	0.48	0.78	1.94	4.58	91.52
10	0.35	0.45	0.66	1.55	5.79	91.20
11	0.00	0.12	0.10	0.13	0.40	99.25
12	Due to heavy bottom debris no sample collected					
13	9.42	5.24	12.67	10.28	8.86	33.53

Table 9. Percent Grain Size in Marina del Rey, 12 October 1989

Station	25	35	60	100	200	<200
1	12.82	11.88	35.66	19.45	12.64	7.55
2	2.31	0.85	2.17	4.02	19.79	70.86
3	14.32	29.05	46.30	2.75	0.12	7.46
4	0.14	0.26	1.34	12.18	53.78	32.30
5	0.02	0.10	0.20	0.58	1.45	97.65
6	0.40	0.26	1.15	10.74	37.11	50.34
7	0.20	0.24	0.37	1.49	10.42	87.27
8	0.06	0.50	2.75	4.55	10.03	82.11
9	0.05	0.15	0.20	0.47	0.40	98.73
10	0.16	0.29	0.87	1.90	4.96	91.82
11	0.05	0.05	0.12	0.24	0.28	99.26
12	7.24	1.96	4.48	11.29	25.13	49.54
13	33.93	6.54	15.64	8.75	7.25	27.89
25	0.50	0.37	1.63	4.60	23.04	69.86

RESULTS AND DISCUSSION

Results of grain size tests show that there have been a number of changes in the last year. Tables 8 and 9 show the grain size for October 1988 and October 1989 for comparison.

At Station 2, the buildup of the finest size particles (less than 200) has increased dramatically, rising from 38.7 percent to 70.86 percent in one year, while the medium sized particles (60) increased at adjacent Station 1 and fines decreased at Stations 1 and 3. This is, no doubt, the reason for the increase in contaminant burden at Station 2, because pollutants adsorb and complex more with finer particles, since they have a larger surface to volume ratio, than with large particles. The Station 2 area is due to be dredged in the fall of 1991.

At Station 4, which last year showed signs of having formed a depression which collected fines, the size has shifted to slightly larger particles from 79.96 percent particles of <200 to 32.3 percent 200 size.

There was little change at most of the inner stations; Station 6 sediments showed decreases in the larger particles (35 and 60 mesh) and in the finest size, with an increase in the 200 mesh size, as did sediments (25 and 35 mesh) at Station 7. At Stations 8 and 9, the already high percent of the finest sediments increased, and at Stations 10 and 11 there was little change from the already very high levels of the finest grained sediment.

Station 5 showed a slight shift downward in all sizes except for the finest, which increased slightly. That station seems to accumulate fine sediments and contaminants in the middle of the Main Channel when rainfall and dry weather flow is low into the inner basins.

Station 13, inside the Oxford Flood Control Basin, showed decreases in fine sediments and increases in the larger grain sizes. The reasons for

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this are not clear; the finest materials may have been tidally flushed away following erosion control efforts, but the water exchange is generally not of sufficient velocity to move the larger particles, resulting in sorting that was further influenced by low rainfall runoff.

SEDIMENT CONTAMINANTS

SOURCES

Contaminants attached to fine particulates enter the Marina from a number of sources: dry and wet weather drainage from parking lots and facilities in the Marina; the Ballona Creek Flood Control Channel; Ballona Lagoon, which enters the Marina at Station 3; and the Oxford Flood Control Basin, which drains an urban industrial and residential area into the end of Basin E. Ballona Lagoon is linked tidally to the Venice Canal system.

Ballona Creek drains much of the western and central Los Angeles area, bringing normal runoff but also carrying a burden of garden debris, trash, plastic food wrappings and grocery bags, all testifying to the amount of illegal dumping that occurs into the channel. A new screen boom in the channel, near Culver Blvd. traps trash during dry weather flow, but the boom is released prior to expected rainstorms, when the largest quantity of trash is brought downstream. In the past, overflows from Los Angeles City sewage processing sometimes overflowed into Ballona Creek, but measures to control that have apparently been successful. Oil and grease from streets, discarded motor oil and traffic accident spills are sometimes carried into the creek channel. High tides also sweep the jetties, carrying trash left by those who fish from the rocks, along with feces from humans and dogs, into the waters. Channel flow is partially reflected off the breakwater and is carried back into the Marina on incoming tides. Conversely, if Ballona Creek levels are low, it is possible for material originating in the Marina to move up the creek and be deposited as far inland as the sand bar near Culver Blvd, inland from Station 12.

STANDARDS

There are presently no Federal or State criteria or standards for sediment content of pollutants such as trace metals and pesticides but research has been directed toward developing them. Bulk analyses were not effective in determining impacts so bioassay determinations of sediment effects from a given site were substituted and compared with those from a so-called pristine site. Some factor was then applied such as 125 percent or two standard deviations, on a case by case basis, to determine whether sediments could be ocean dumped or had to be landfilled (EPA, 1988).

The problems of developing standards or criteria are complex, since data derived from different research laboratories, using differing protocols, organisms, exposure times and methods of dosing sediments have been difficult to integrate into a collation of reasonably predictive measurements. Recently the National Oceanic and Atmospheric Administration (NOAA) has issued a Technical Memorandum compiling nationwide information using several approaches: Comparison of background levels in pristine areas; sediment-water equilibrium partitioning; spiked-sediment bioassays (adding known amounts of chemicals to pristine sediment); and several methods of correlating field data for organisms with co-occurrences of contaminants in sediment (Long and Morgan, 1990). These data were then developed into: Ranges from threshold to the tenth percentile for Effects Range-Low (ER-L); an Effects Range-Median (ER-M); and an Apparent Effects Threshold (AET) to indicate sites with high potential of causing effects on biota. The National Research Council (NRC, 1989) also published a study on threshold values developed by EPA, the US Geological Survey and others.

According to Long and Morgan (1990), it has been assumed that water quality criteria were sufficient to protect infauna when applied to interstitial water of sediments. Physical/chemical principles are now used to predict chemical concentrations that would occur in interstitial water in equilibrium with concentrations sorbed on sediment particulates, recognizing that the distribution between the two phases is highly influenced by the amount of total organic carbon or acid volatile sulfides present. Past studies have indicated that the bulk analysis data for sediment concentrations are poor predictors of the bioavailability of those chemicals.

BIOAVAILABILITY

Most metals attached to marine sediments are not bioamplified by passage through the food chain to top consumers (Carpenter and Huggett, 1984; Jenkins and Brown, 1984; Peddicord, 1984). Bioaccumulation, the sequestering of metals and/or pesticides in certain body tissues, may or may not be detrimental to the organism itself. Of particular concern are those chemicals such as chlorinated hydrocarbons (pesticides and PCBs) that are sequestered as lipids (fats) in liver and reproductive organs or eggs, which can cause liver pathologies or reproductive failure in some species.

Synergism between certain metals species may suppress or enhance their toxicities. Marina sediment bioassay tests in 1987 (Soule and Oguri, 1988) indicated that there were no acute toxicities to representative test organisms, but there was evidence of long term stress from sediments at the most contaminated stations. At that time, Station 2 had been partially dredged, and hence it was not among the highly contaminated stations.

PROCEDURES

Sediment samples were taken for chemical analysis from benthic

Campbell grabs on 12 October 1989. Subsamples for metals were taken with plastic containers from an area of the sample that had not been in contact with the stainless steel grab, and pesticide subsamples were similarly taken with glass containers. These were frozen with dry ice in the field and kept frozen in the laboratory until analyzed by Associated Laboratories of Orange, California. Analytical techniques were those specified by the Environmental Protection Agency or Standard Methods (APHA, 1985).

RESULTS AND DISCUSSION

METALS

Based on the analytical data, the 14 stations sampled were ranked in order of the amount of each parameter from 1, the lowest, to 14, the highest. These scores were summed for each station and a relative ranking given to each station. This is only an approximation, since the actual toxicity of each parameter is not definitively known. As in the past (e.g., Soule and Oguri, 1989, 1988), Station 10, where the Oxford Flood Control Basin is flushed tidally into the Marina, was the most polluted (Table 10, below).

Table 10. Ranking of Stations by Sediment Contaminants and Trace Metals.

High Group		Medium High Group		Moderate Group		Low Group	
Station	Score	Station	Score	Station	Score	Station	Score
10	208	2	158	8	116	6	72
9	180	5	148	13	116	4	50
11	172	25	146			1	33
12	165	7	143			3	28

Table 11. Contaminants and Trace Metals Concentrations in Marina Del Rey, 12 October 1985

Station / Parameters*	1	2	3	4	5	6	7	8	9	10	11	12	13	25	Mean
Moisture %	25.61	61.10	23.03	33.67	49.71	42.44	50.96	52.04	59.95	62.15	57.97	59.69	33.01	45.92	46.95
Vol. Solid %	1.46	0.71	0.48	2.20	4.62	3.08	4.60	4.37	5.90	6.10	5.00	13.01	3.19	5.03	4.87
TOC %	0.85	5.05	0.20	1.32	2.60	1.79	2.67	2.42	3.47	3.54	2.90	8.07	1.85	3.44	40.33
IOD	12	32	12	50	60	94	98	94	92	235	131	461	157	61	113.50
COD	5446	160600	4250	2442	53090	25840	45280	40550	54553	83900	53700	215500	96230	61700	62436
Oil & Grease	976	10631	360	677	1712	404	4194	741	1377	2010	945	11090	1354	2060	2010
PO4	4270	9940	1900	8130	11400	4060	10900	8080	13363	10500	11400	9650	6760	10900	8728
Org-N	380	4370	479	894	1450	945	1830	1260	1640	2450	1800	4770	1900	1720	1846
Sulfide	<0.10	1.30	0.30	<0.10	<0.10	<0.10	0.20	<0.10	6.70	<0.10	<0.10	40.70	<0.10	<0.10	9.06
Arsenic	1.07	7.52	1.13	4.05	7.01	6.03	10.60	8.03	11.30	10.70	10.00	6.75	2.25	8.06	6.90
Cadmium	<0.27	1.70	<0.26	0.30	0.72	<0.35	0.59	0.05	0.62	1.60	0.64	1.09	2.12	1.00	0.96
Chromium	11.46	46.60	4.60	22.00	62.20	29.90	43.60	43.40	55.70	64.40	85.20	30.20	16.30	40.60	42.96
Copper	9.23	82.90	0.19	43.60	177	129	284	127	244	333	240	66.50	146	150	146.03
Iron	6610	28800	3219	11200	40200	21000	32200	37100	42760	47300	47100	17700	12800	28300	26200
Lead	83.60	270	17.00	60.40	136	55.90	133	90.10	132	256	108	205	305	154	143.06
Manganese	61.70	187	27.50	105	260	137	232	246	262	248	283	233	125	198	185.66
Mercury	<0.20	0.49	<0.15	<0.15	0.30	0.33	0.47	0.92	0.65	0.53	0.43	0.35	<0.12	0.17	0.46
Nickel	7.96	27.00	3.08	13.10	33.80	16.90	24.70	20.80	34.20	36.20	36.4	19.40	12.30	24.20	22.77
Tributyltin	<0.10	0.13	<0.10	0.11	0.31	0.12	0.33	<0.10	0.35	0.48	0.21	0.10	<0.10	0.16	0.22
Zinc	50	337	20.30	102	251	145	235	191	292	444	290	355	385	255	239.45

* in mg/kg dry wt. (ppm) unless otherwise indicated ND = none detected < = less than limits of detection

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Data from contaminants and heavy metals are presented in Table 11, and the distributions of the individual metals in the Marina on 12 October 1989 are illustrated in Figures 130 to 148, at the end of this section.

Station 12, in Ballona Creek, and Station 2, at the entrance of the Marina, tended with some exceptions to be the highest in the non-metal parameters such as oil and grease, volatile solids and organic nitrogen, whereas Stations 10, 9, and 11 tended to be highest in metals, but followed closely in rankings of non-metals.

Examination of the data of Long and Morgan (1990) gives some insight into the relative effects of trace metals, based on integration of results from a variety of field and laboratory tests. Table 12 gives the ranges

Table 12. Concentrations of Trace Metals Producing Biological Effects : Units are Effects Range-Low (ER-L)[1], Effects Range-Median (ER-M)[1], Apparent Effects Threshold (AET)[1], and EPA Threshold (NRC)[2]. Marina del Rey ranges and stations exceeding the ER-L, ER-M and AET are listed.

Parameter (ppm)	ER-L	ER-M	AET	NRC	MDR Range 1989-90	Stations Equal/Exceeding ER-L	Stations Equal/Exceeding ER-M	Stations Equal/Exceeding AET
Arsenic	33	85	50	33	1.13 - 10.8	----	----	----
Chromium	80	145	--	--	11.40 - 85.2	----	----	----
Copper	70	310	300	136	8.19 - 333	12,2,8,6,13, 25,5,7,11,9	10	10
Cadmium	5	9	5	31	<0.26 - 2.12	----	----	----
Lead	35	110	300	132	17.00 - 305	6,4,1,8,11	9,7,5,25, 12,10,2,13	13
Mercury	0.15	1	1	0.8	<0.15 - 0.65	25,5,6,12,11 7,2,10,9,8	----	----
Nickel	30	50	NSD	20	3.88 - 36.4	5,9,10,11	----	----
Zinc	120	270	260	760	20.3 - 444	6,8,7,5,25	11,9,2, 12,13,10	11,8,2, 12,13,10

NSD = Not sufficient data
[1] = Long and Morgan, 1990 (NOAA) [2] = National Research Council, 1989 (NAS)

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of low effects (ER-L), median range of effects (ER-M), apparent effects threshold (AET) (Long and Morgan, 1990), and threshold effects given in NRC (1989). These values are compared with ranges in concentrations found in the Marina, and stations that fall within and above the various ranges are listed in increasing order of concentration.

NOAA and NRC did not include tributyltin (TBT) in their studies of ER-L and ER-M values because of inconclusive data. Soule and Oguri (1988) reported extensively on the effects of TBT and on bioassays using Marina organisms and sediments.

In the Marina, TBT in sediment was down considerably from the October 1988 sampling; levels at that time were recalculated and ranged from below the limits of detection to 5.57 ppm (reported in Soule and Oguri, 1990, page 102 as being in ppt in sediment, whereas ppt levels occurred only in the water samples tested). In 1988, TBT was below the limits of detection at Stations 2 and 3; Station 12 was not sampled. Station 11 had the highest level, and the mean of 10 Stations where TBT occurred was 1.71 ppm.

In October 1989, TBT sediment levels were below the limits of detection at Stations 1, 3, 8 and 13, and the range was from 0.1 to a high of 0.4 ppm at Station 10. The mean of 10 stations where TBT was found was 0.22 ppm. This indicates that there has been an order of magnitude reduction at the highest stations in that highly toxic form of tin used in antifouling paints, indicating the success of the State ban in September 1987. Figures 148 and 149 compare the 1989 TBT concentrations with the 1988 concentrations, respectively.

Comparison of the rankings of stations by total contaminant levels in Table 10 with the stations that exceed the apparent affects threshold (AET) limits in Table 12 show that there is agreement on classification of Stations 9, 10, 11 and 12 as the highest contaminated group. However, based on the AET limits, Stations 2 and 13 should be added to that group because of their high levels of zinc and copper, respectively.

Table 13 compares the ranges of contaminants and trace metals for various years. The 1989 ranges were more similar to those in 1985, being higher than in the intervening years for most parameters. This may be due to the lack of significant rainfall, prior to the sampling. Exceptions were the peak sulfide at Station 12, a station not sampled in 1988.

METALS CONCLUSIONS

Since the data indicate that most stations would fall within the low effects range (ER-L) for some species, this may account for the absence of more sensitive species; hence the findings of low diversity in the Marina.

The median effects range (ER-M) indicates that populations are at risk from concentrations of copper, lead and zinc. Copper has been historically used in antifouling compounds, and all three metals occur in street runoff from industrial areas and from highways. Station 12, in Ballona Creek, and Station 13 in Oxford Basin indicate the major sources of the pollutants; Station 2 is at the sandbar near Ballona Creek that traps contaminants, and Station 10 is near Oxford Basin. Stations 9 and 11 also are near storm drains and, with Station 10, are poorly flushed. The data do not suggest why Stations 9 and 11 should have such poor benthic fauna as compared to that of Station 10. Station 2 had the lowest Shannon Wiener diversity index in the Marina, in keeping with the sediment quality there.

As in the past, there is no direct correlation between benthic numbers and trace metals, although the inner Marina stations are the most polluted, have the poorest flushing, and have the lowest benthic quality.

Table 13. Comparison of Contaminants and Trace Metal Levels in Sediments in Marina del Rey by years.

Parameter	March 1978 Range	Highest Stations	October 1985 Range	Highest Stations	February 1987 Range	Highest Stations	October 1987 Range	Highest Stations	October 1988 Range	Highest Stations	October 1989 Range	Highest Stations
TVS%	035-5,7	10	1.89-16.84	1,2	1.07-7.87	1,2	3.6-9.7	10,13	0.88-7.19	11,9	0.46-13.91	12,2,10
IOD	43-4500	8	75-850	10,11	<1-220	10,11	83-315	10,11	18-330	10,9	12-461	12,2,10
TOC%	0.10-48	10	1.01-10.10	1,2	0.8-4.7	1,2	2.1-5.8	10,13	0.51-4.17	11,9	0.28-8.07	12,2,10
COD (1000s)	7.3-33.9	10	3.4-194.8	1,2	3.75-131.5	1,2	25.3-98.8	2,10	8.3-87.6	10,9	2.4-215.6	12,2,10
Oil & Grease	708-4820	7	100-18700	1,2	1000-28700	1,2	800-280	2,3	500-3500	11,8,9	808-11090	12,2,7
PO4	542-1850	7	12400-47700	5,9	8200-45000	9,10	1900-5300	8,5	ND<1-3100	9,4	1900-11400	9,5,11
Org-N	110-827	5	850-5900	1,10	218-3900	1,10	1200-3000	10,13	135-1640	10,8	380-4770	12,2,10
Sulfide	66.88-351.21	10	0.09-16.9	1,9	6.3-8.9	1,9	0.5-4.7	3,1	0.2-12.1	2,13	0.2-40.7	12,3,2
Arsenic	2.78-13.7	7	ND		ND		3.3-9.8	4,10	1.88-12.0	10,9	1.13-10.8	11,10
Cadmium	0.158-0.788	7	ND <1.0	none	ND<1.8-5.8	11,1	<1.0-34	13	0.19-1.10	10,4	<0.28-2.12	13,12,2
Chromium	29.3-82.1	5	5.9-72	11,10	6.5-70.4	9,11	27.9-89.1	12,5	7.2-70.5	10,11	11.4-85.2	11,12,10
Copper	8.9-201	8	11.8-245.6	10,11	10.3-359	10,9	24.8-383.0	10.6	8.8-342	10,8	8.19-333	10,9
Iron (1000s)	13.4-43.8	11	15.15-45.8	11,10	4.8-49.5	11,9	12.5-40.9	11,10	4.2-50.1	10,11	3290-47100	11,10
Lead	11.3-68.5	1	18.1-376.6	10,9	11.0-37	1,12	8.0-583	13,10	25.4-208	10,9	17.0-305	13,2,10
Mercury	0.28-1.89	7	0.09-1.28	10,9	ND<0.1-1.47	9,10	<0.1-1.18	10,8	0.11-1.78	11,9	<0.15-0.85	8,9
Nickel	29.4-145	11	<1.0-39.3	10,9	4.4-41.6	11,9	14.8-59.6	12,10	4.0-37.4	10,11	3.88-36.4	11,10
TBT	ND		ND		ND		<80-1070	8,10	<.01-5.57	11,10	<0.1-0.40	10,7
Zinc	89.4-274	11	42-490.4	1,10	25-660	1,10	74-587	13,10	42.6-435	10.8	20.3-444	10,13,2

* in mg/k dry wt. unless otherwise indicated ND = no data

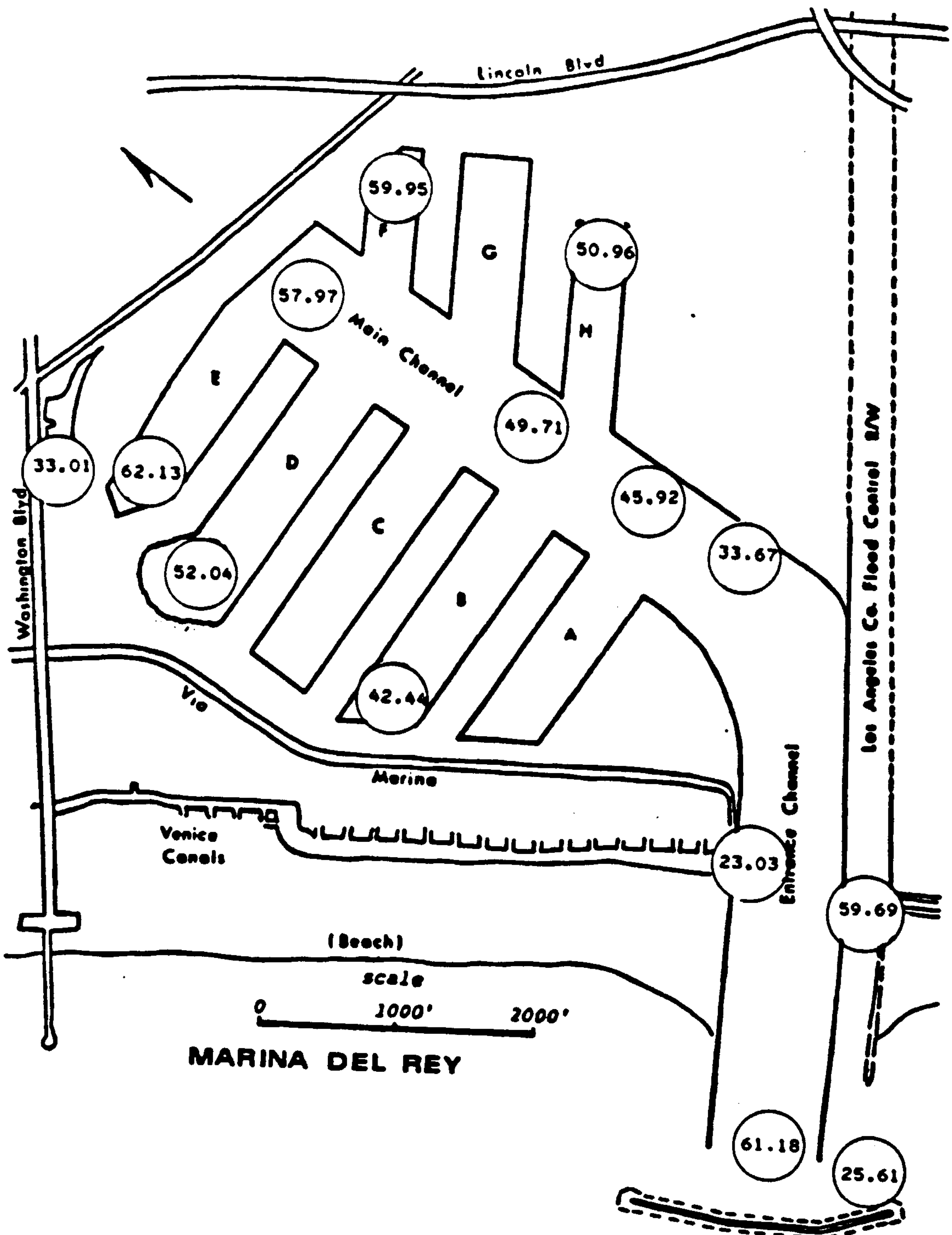

Figure 129. Percent Moisture in sediments.

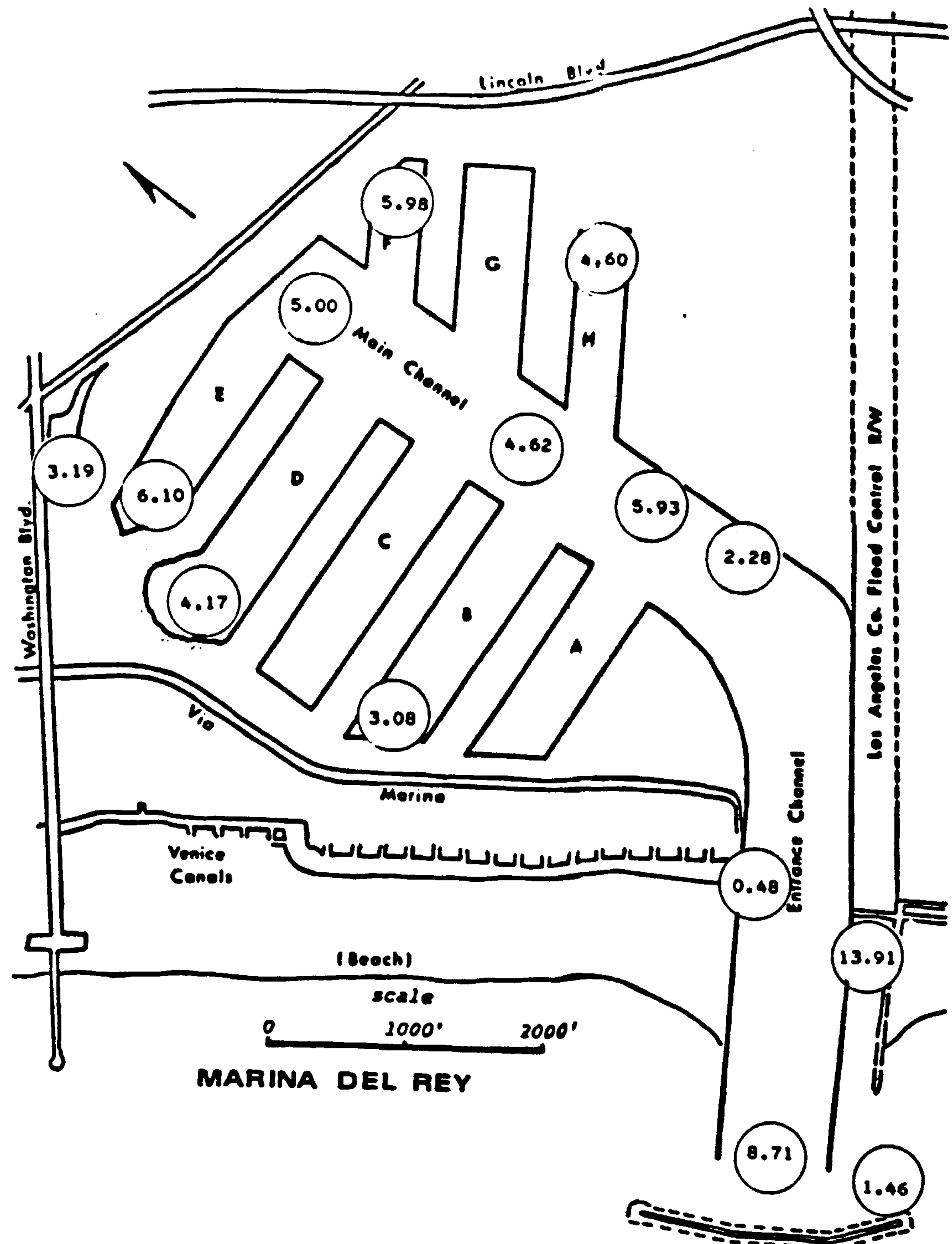

Figure 130. Percent Volatile Solids in sediments; 1' = 0.3048m

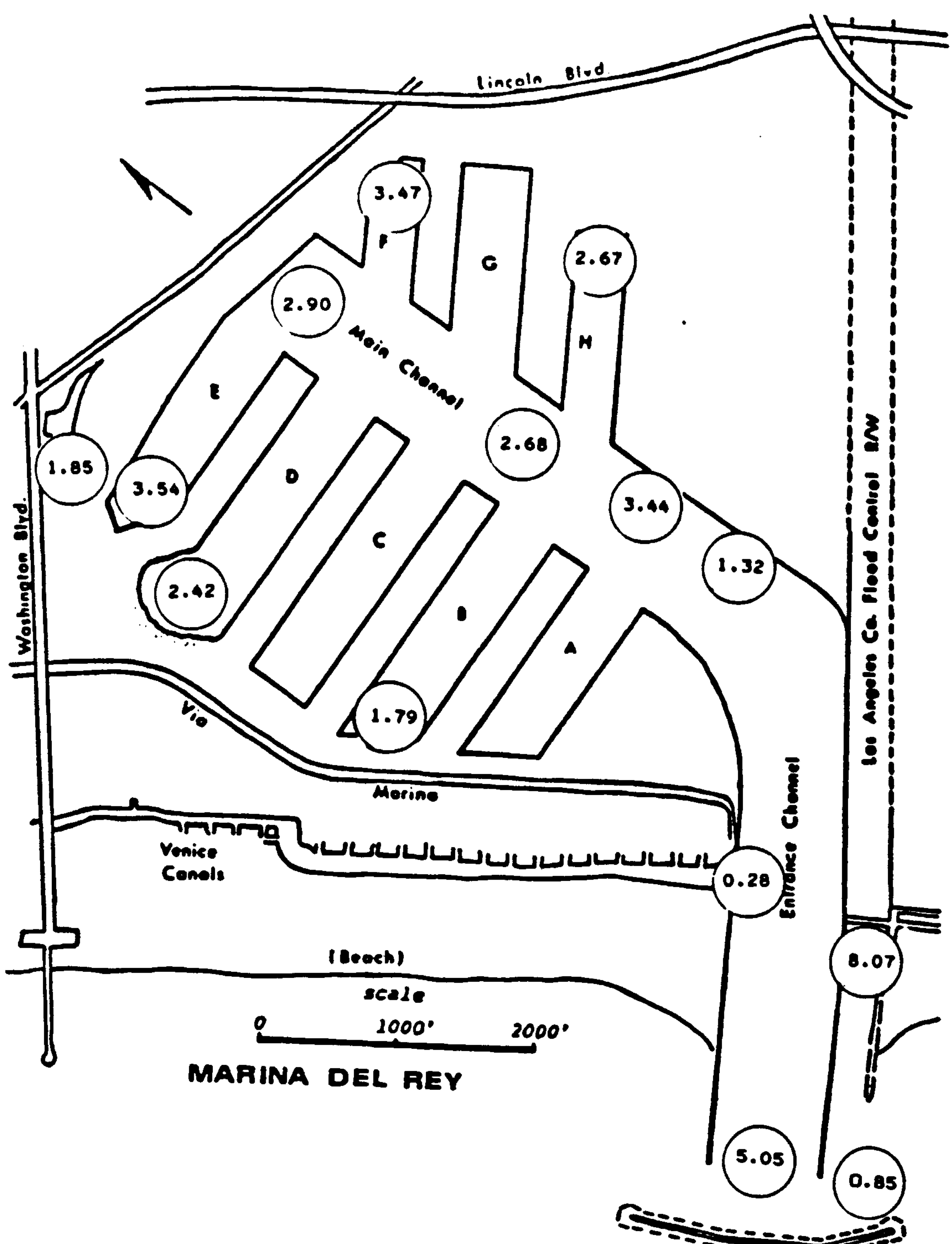

Figure 131. Immediate Oxygen Demand in mg/kg dry wt (ppm) in sediment.

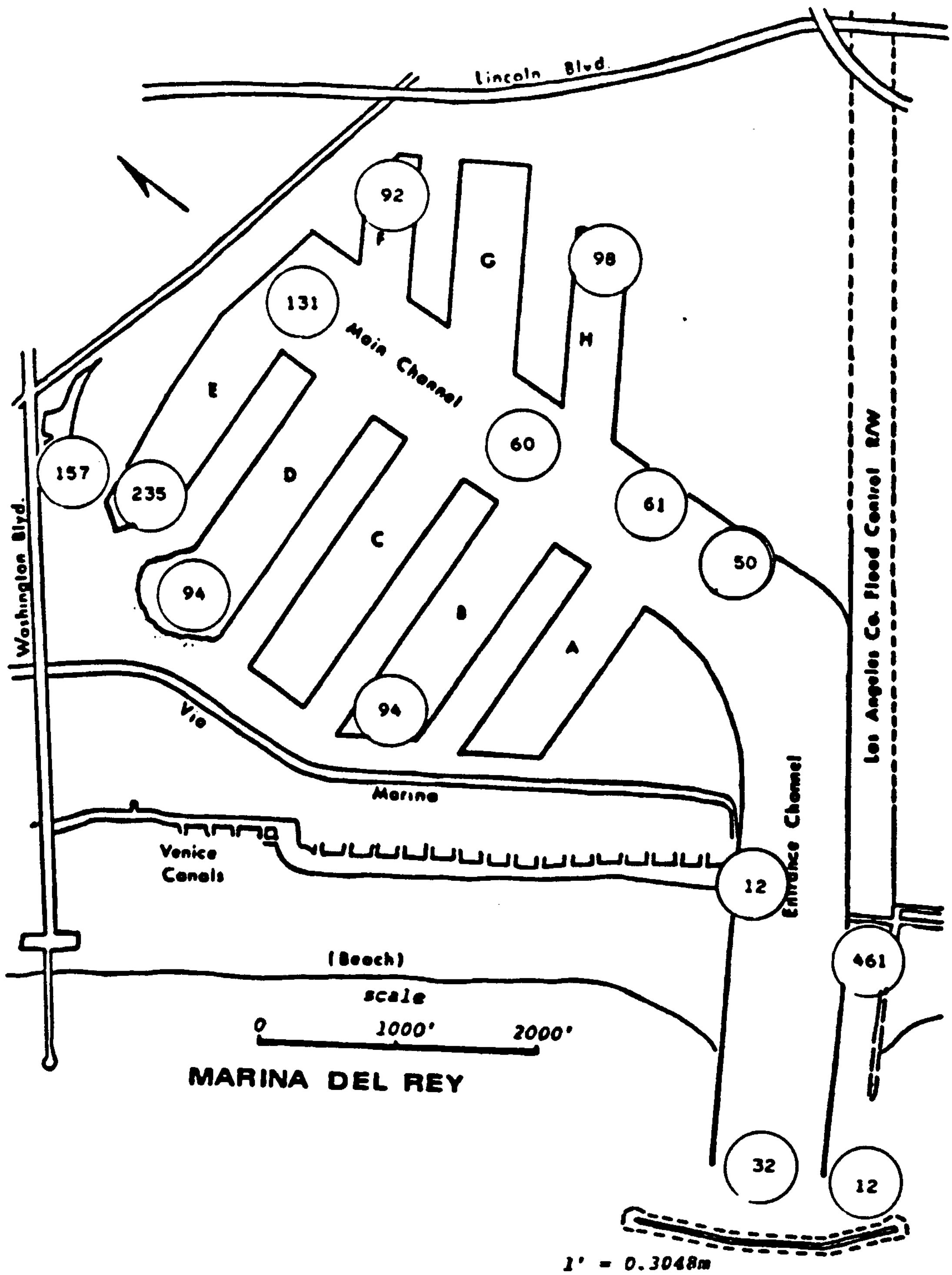

Figure 132. Percent Total Organic Carbon in sediments.

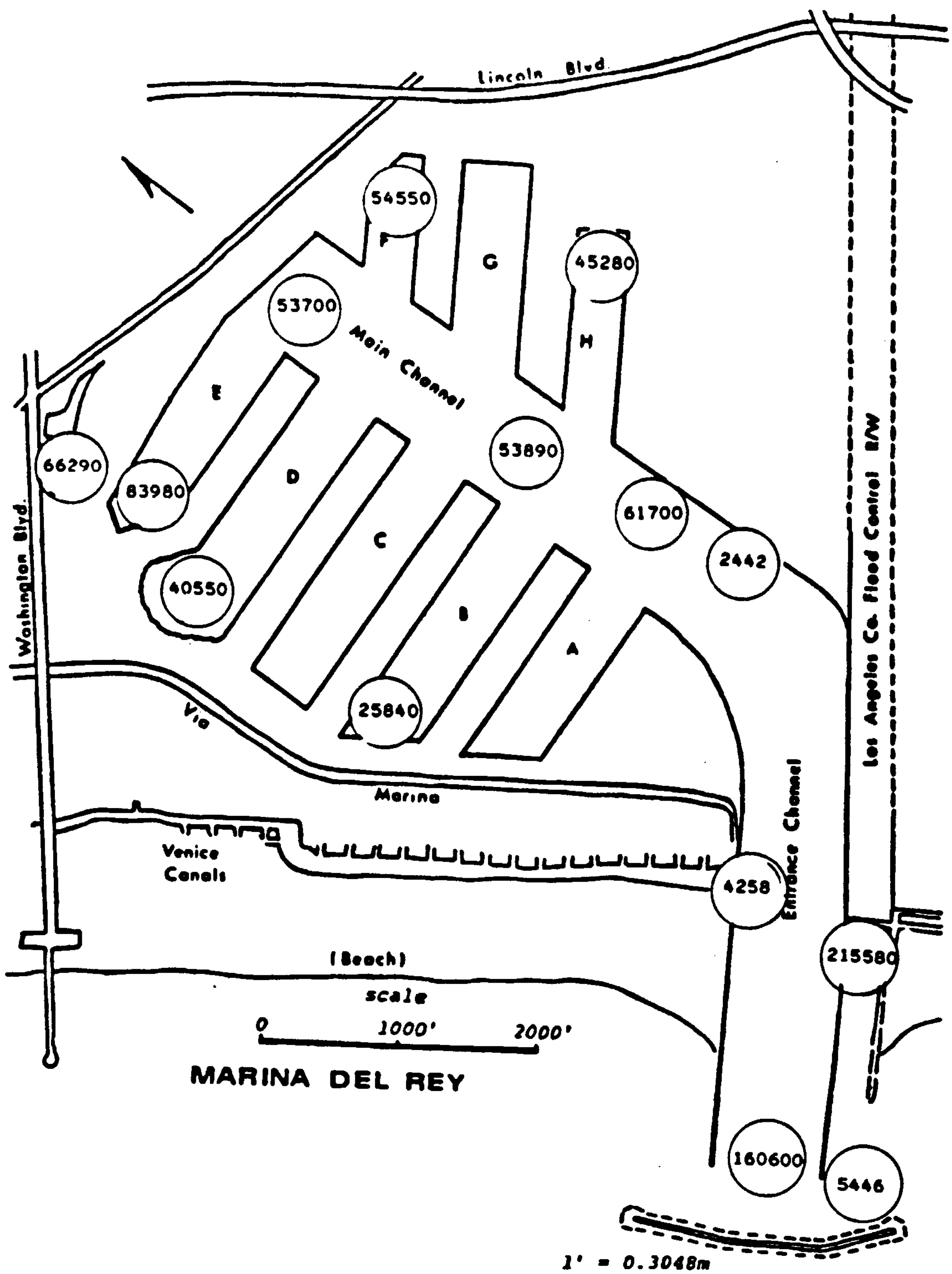

Figure 133. Chemical Oxygen Demand, in mg/kg dry wt (ppm) in sediment.

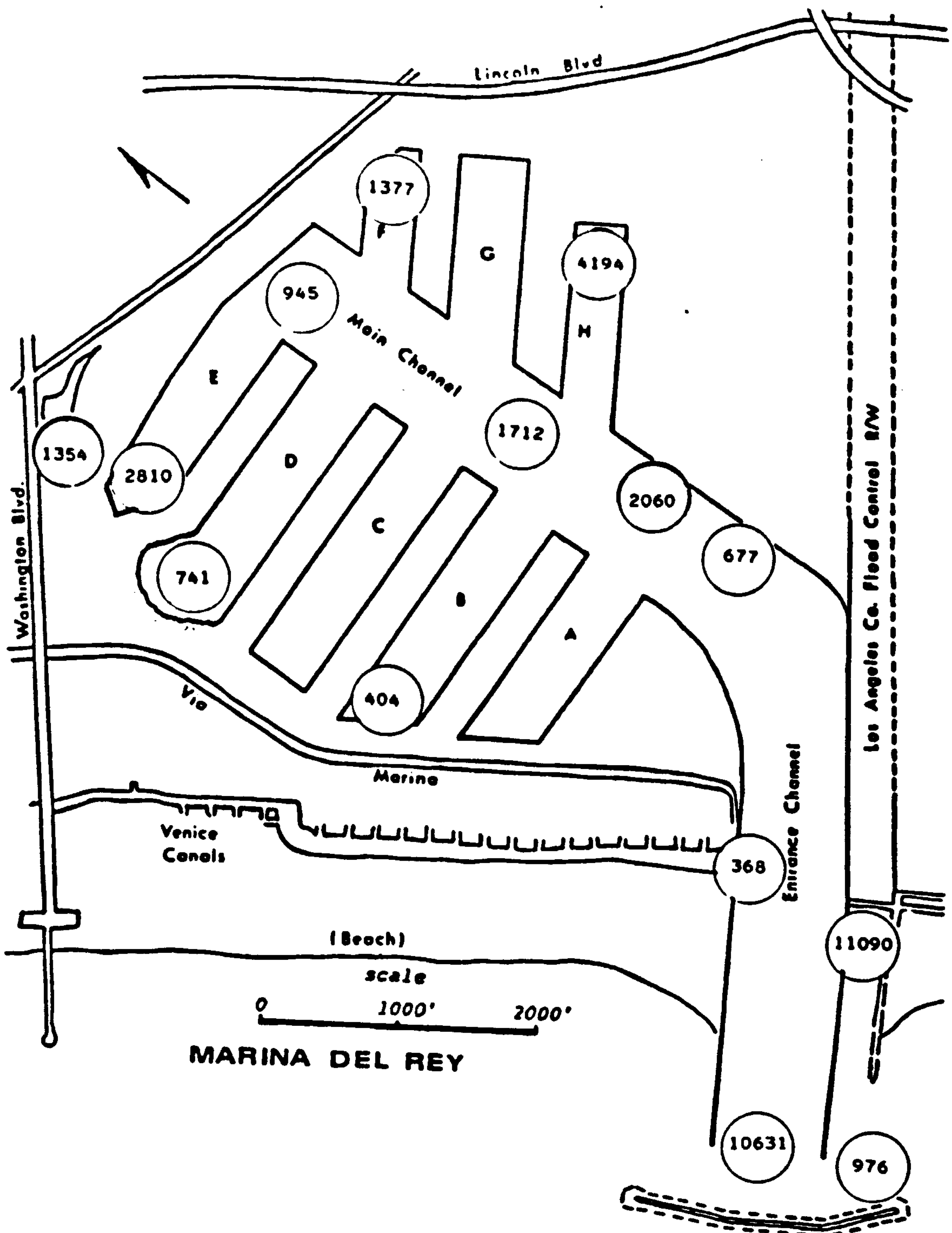

Figure 134. Oil and grease in mg/kg dry wt (ppm) in sediment.

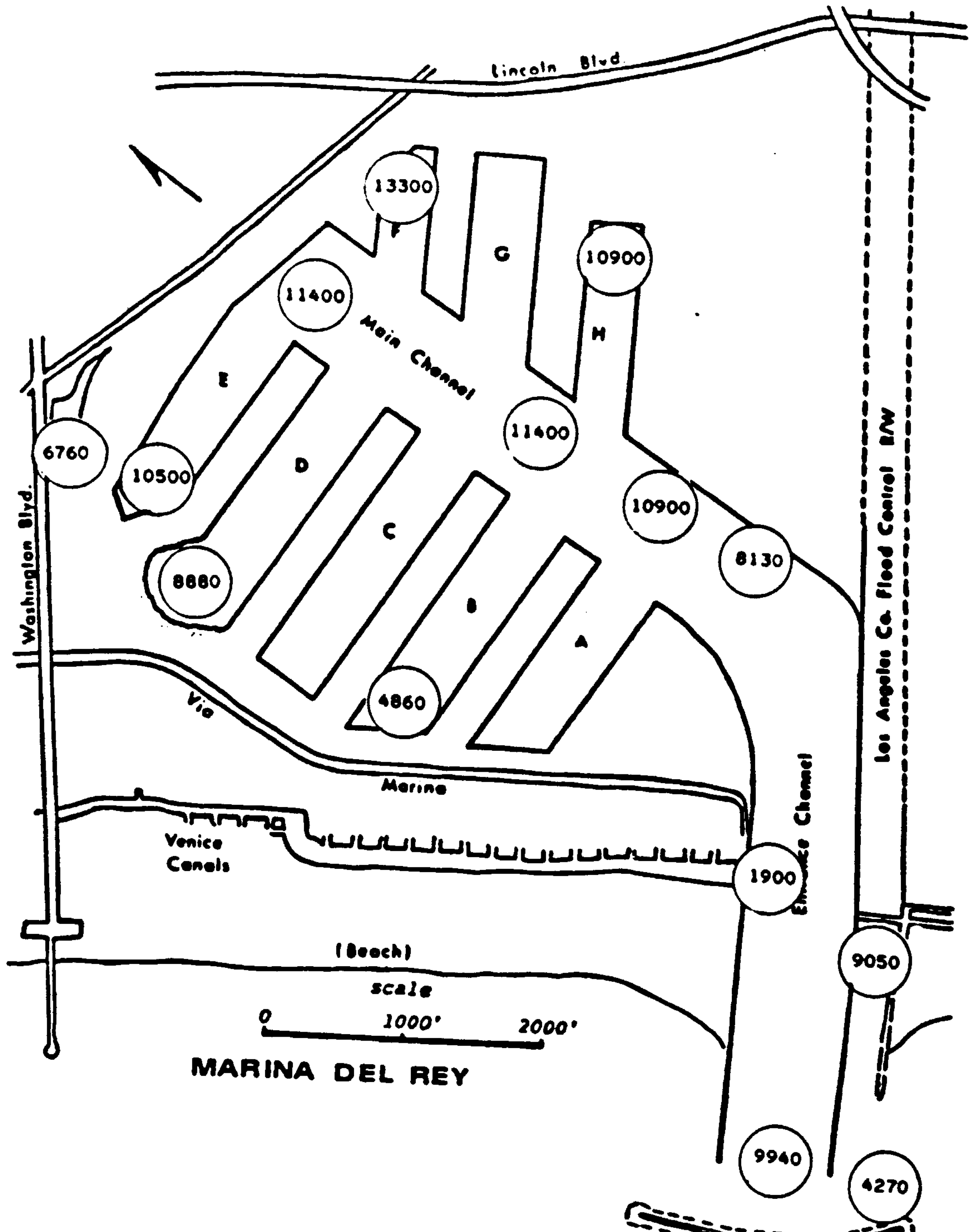

Figure 135. Total Phosphorus in mg/kg dry wt (ppm) in sediment.

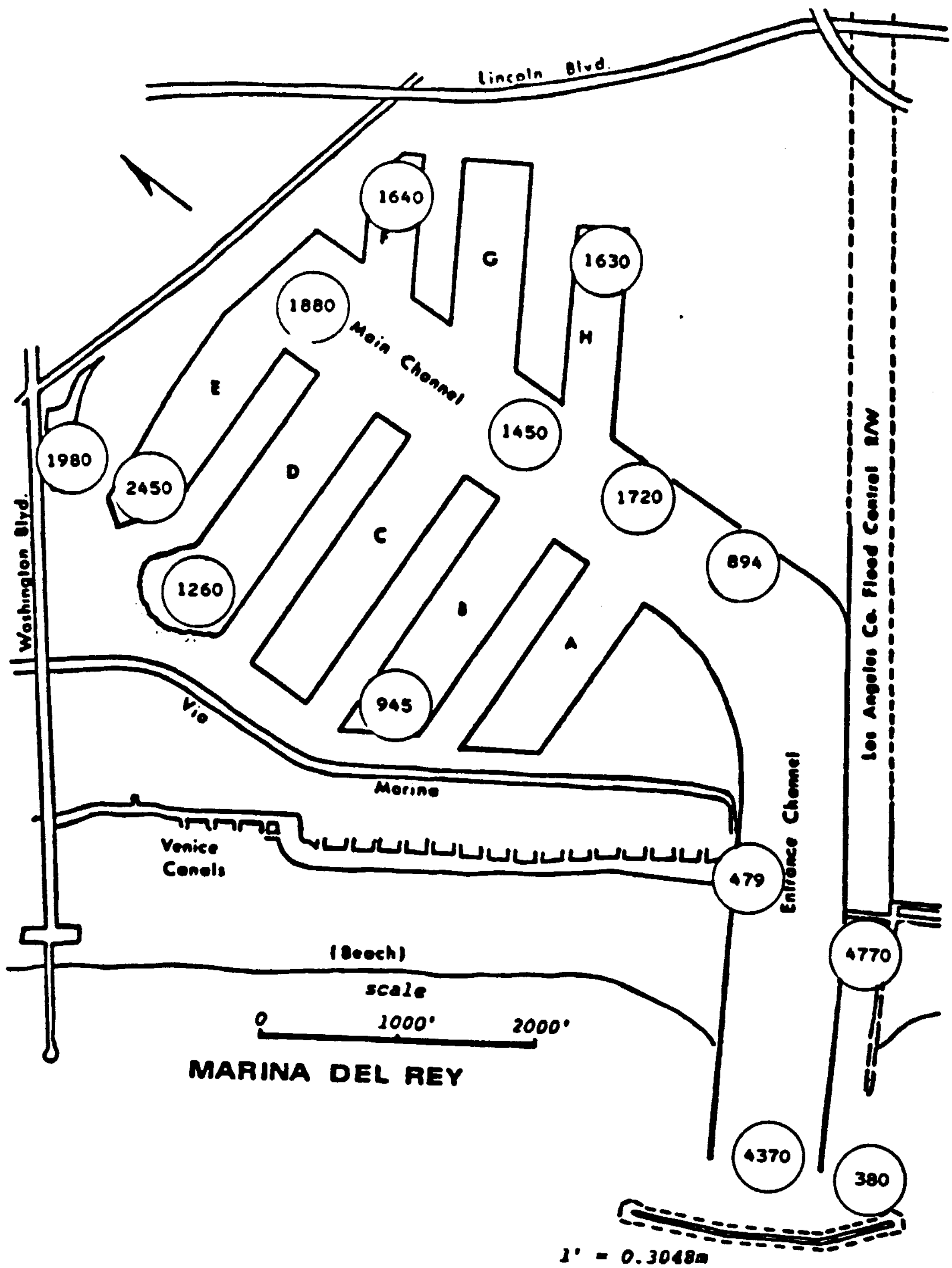

Figure 136. Organic Nitrogen in mg/kg dry wt (ppm) in sediment.

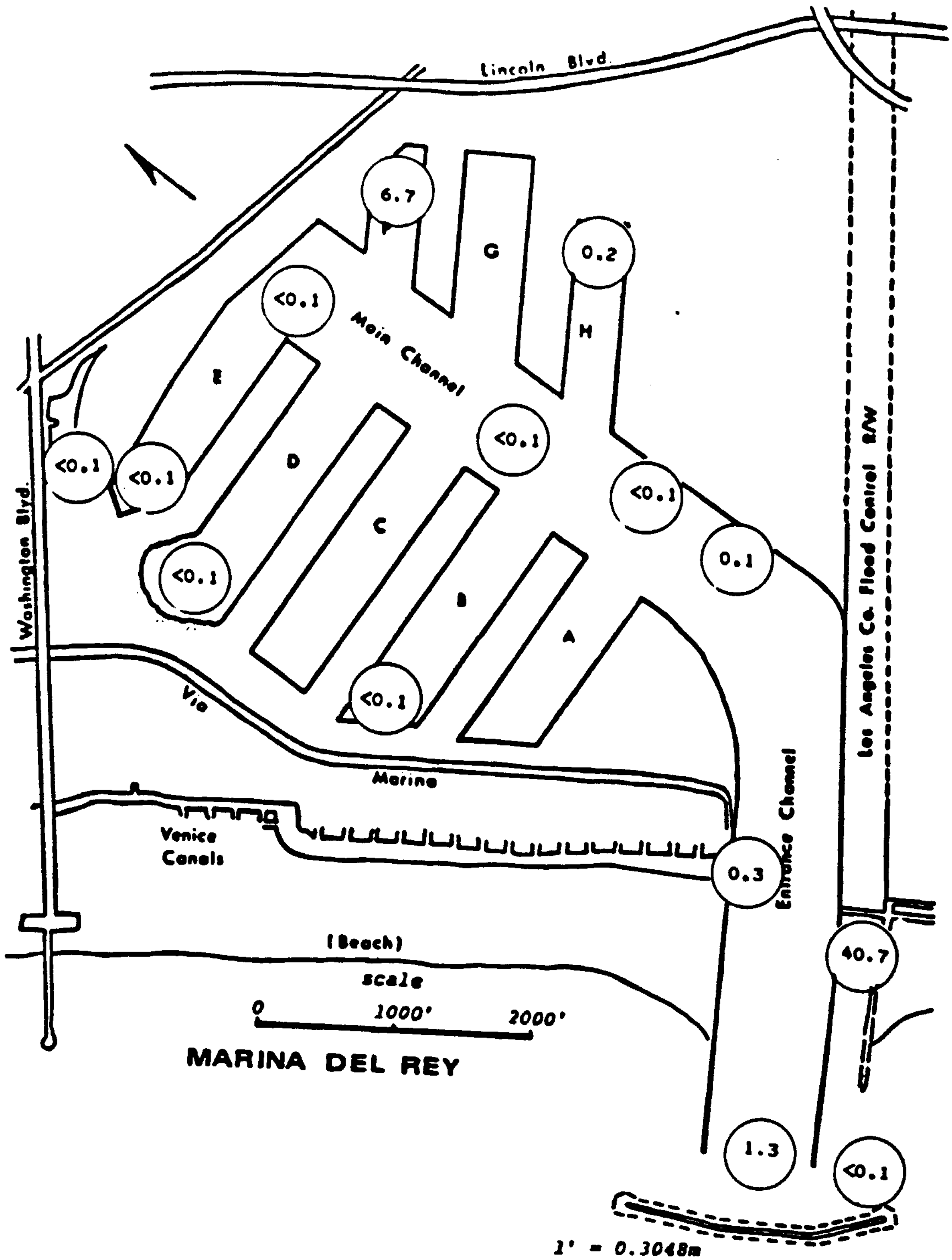

Figure 137. Sulfide in mg/kg dry wt (ppm) in sediment.

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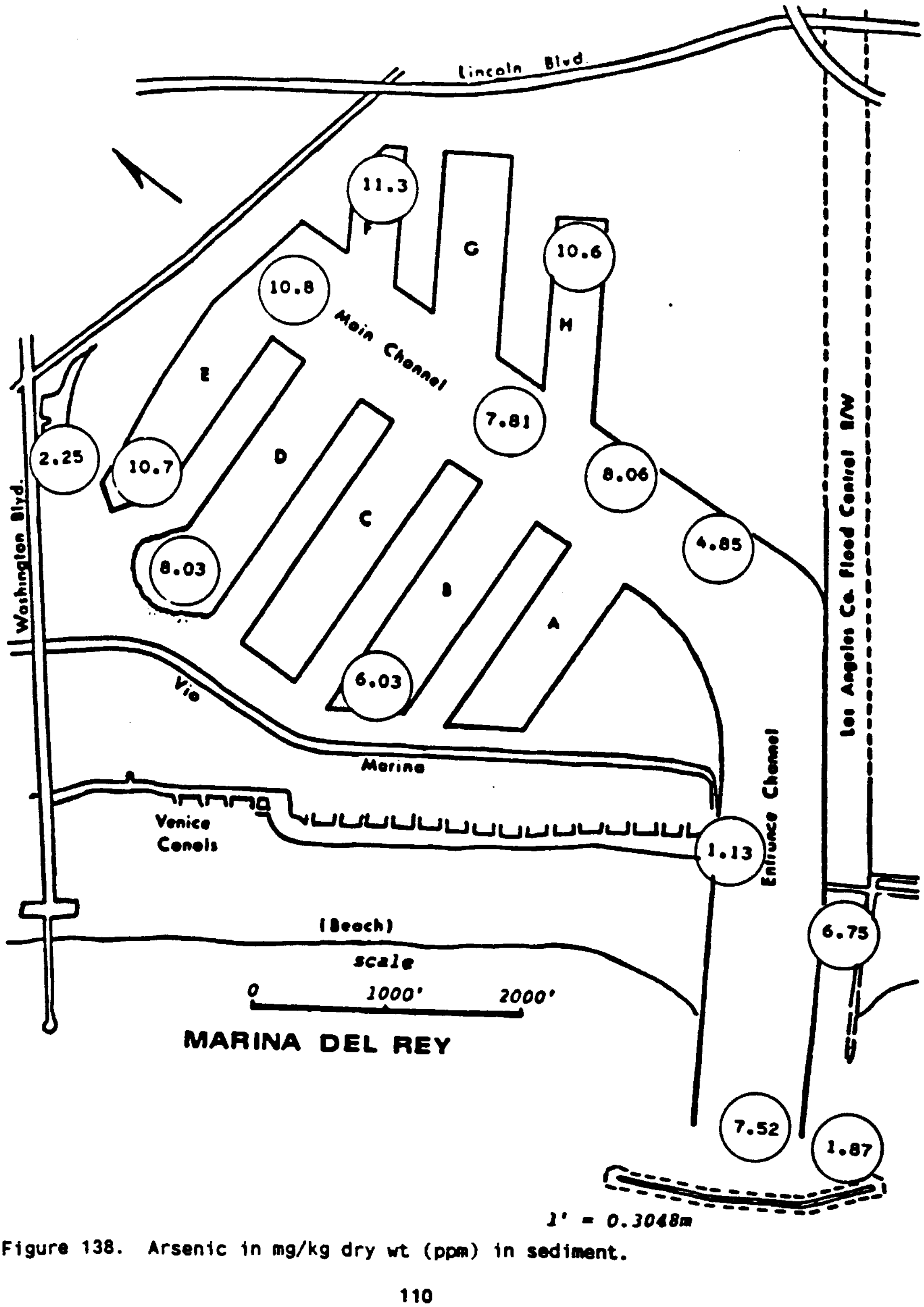

Figure 138. Arsenic in mg/kg dry wt (ppm) in sediment.

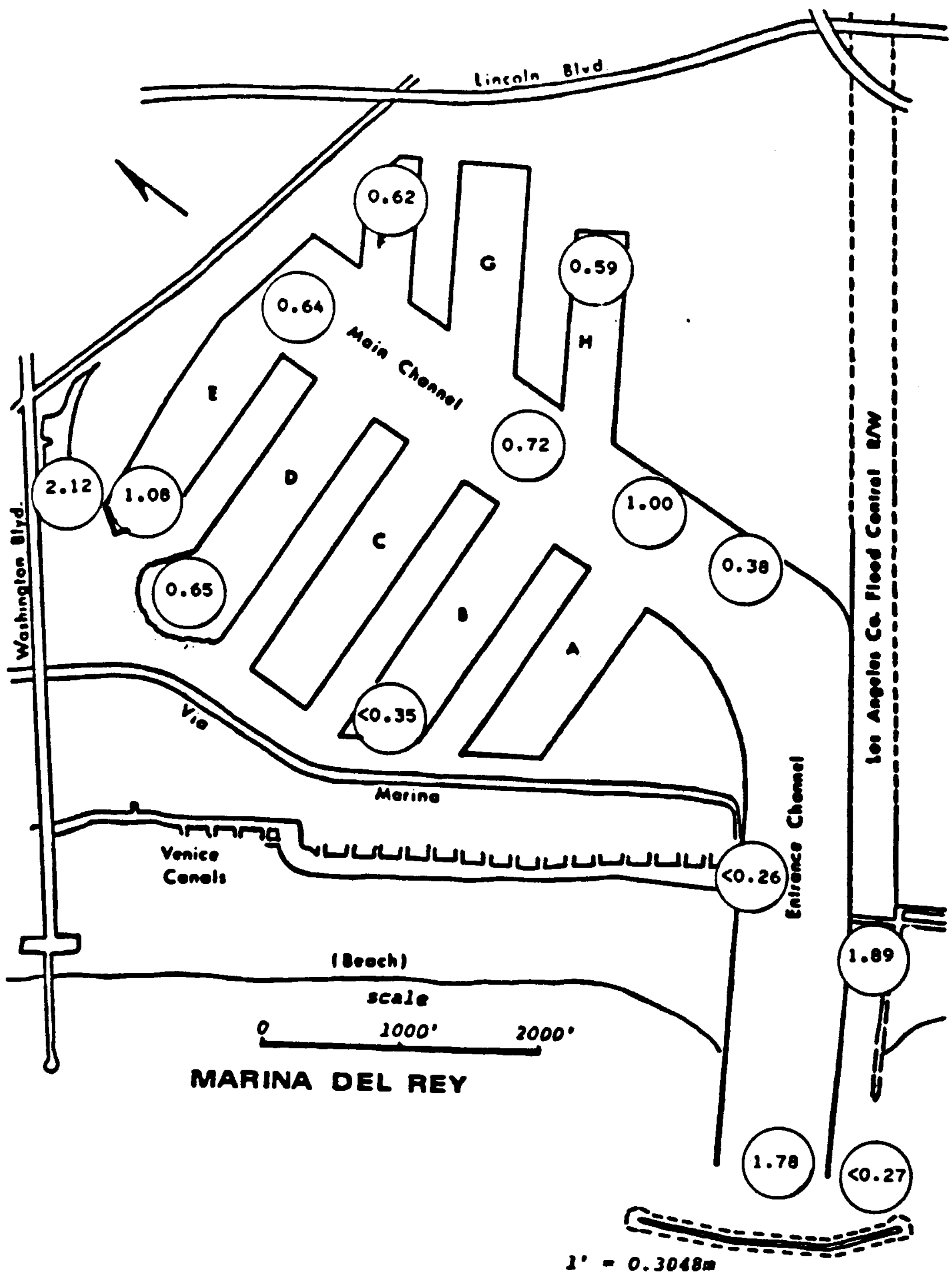

Figure 139. Cadmium in mg/kg dry wt (ppm) in sediment.

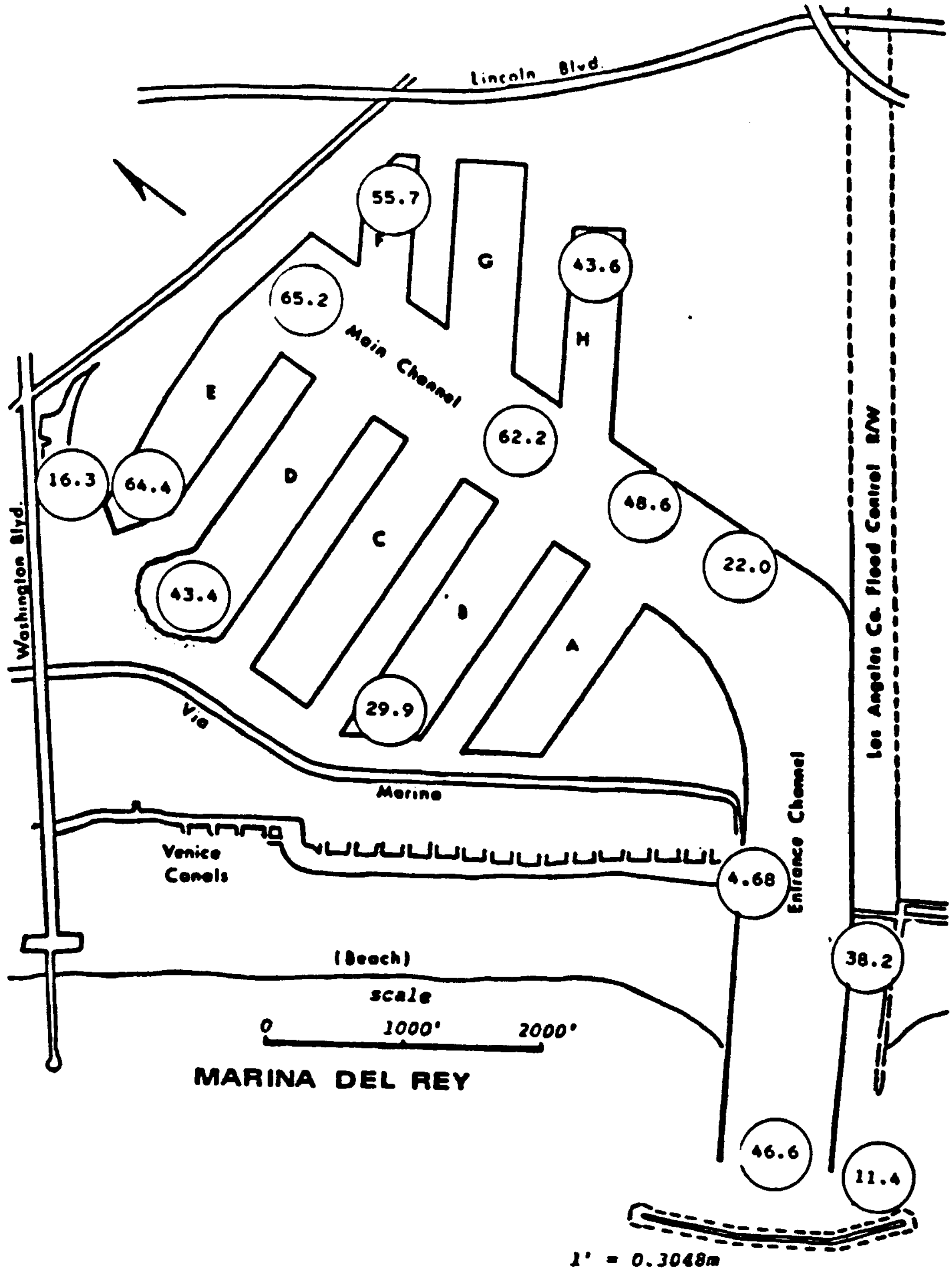

Figure 140. Chromium in mg/kg dry wt (ppm) in sediment.

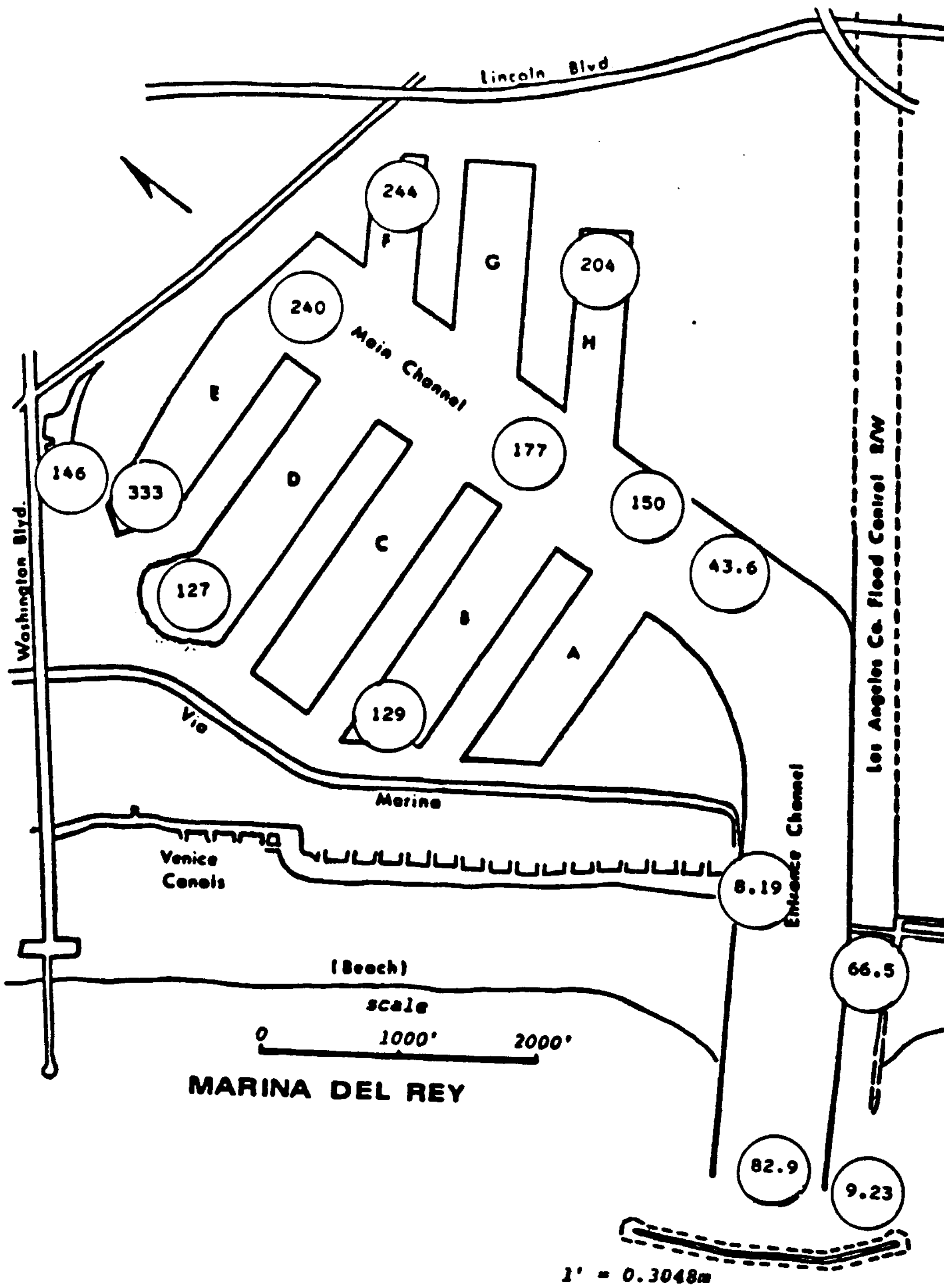

Figure 141. Copper in mg/kg dry wt (ppm) in sediment

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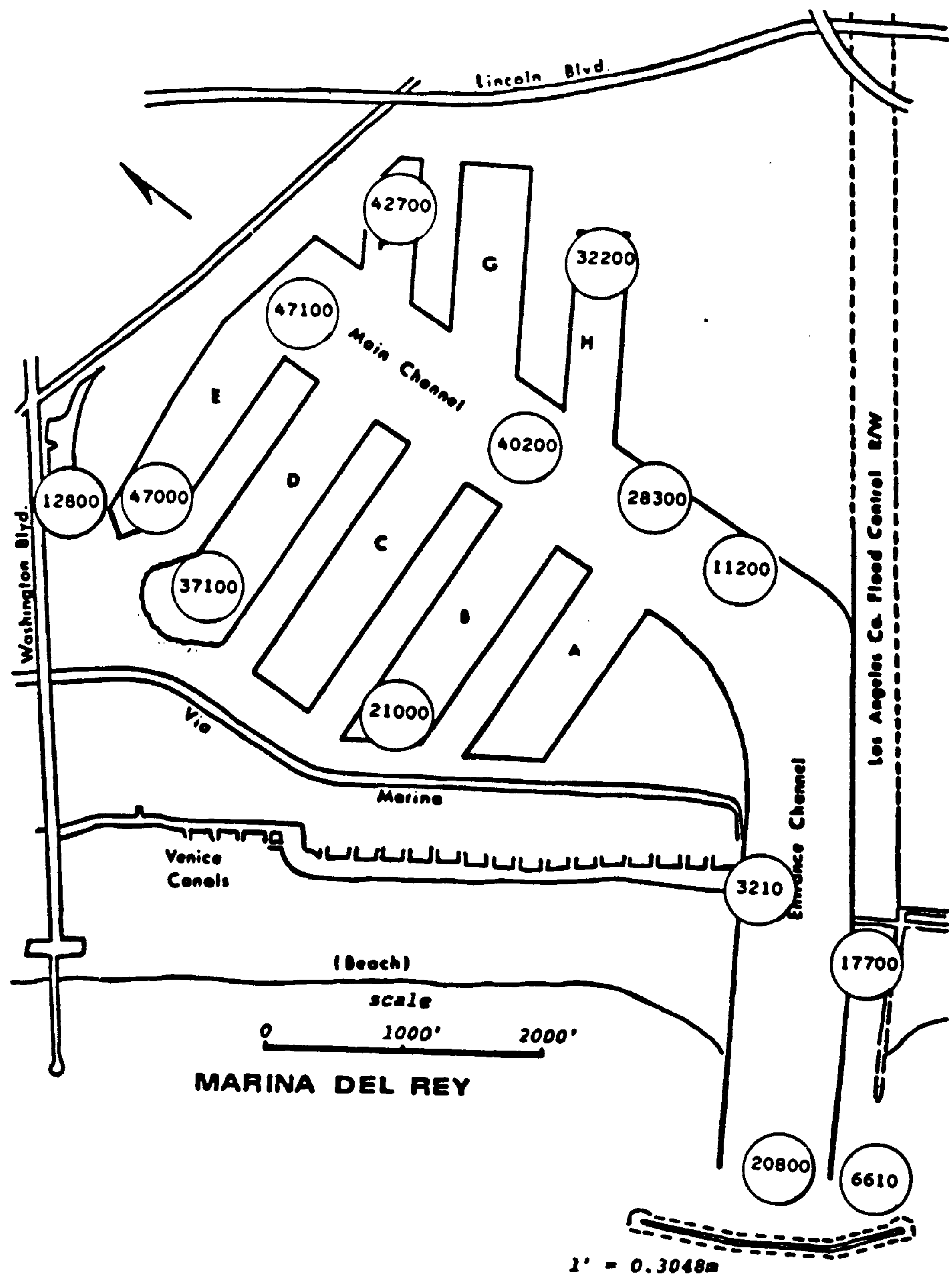

Figure 142. Iron in mg/kg dry wt (ppm) in sediment.

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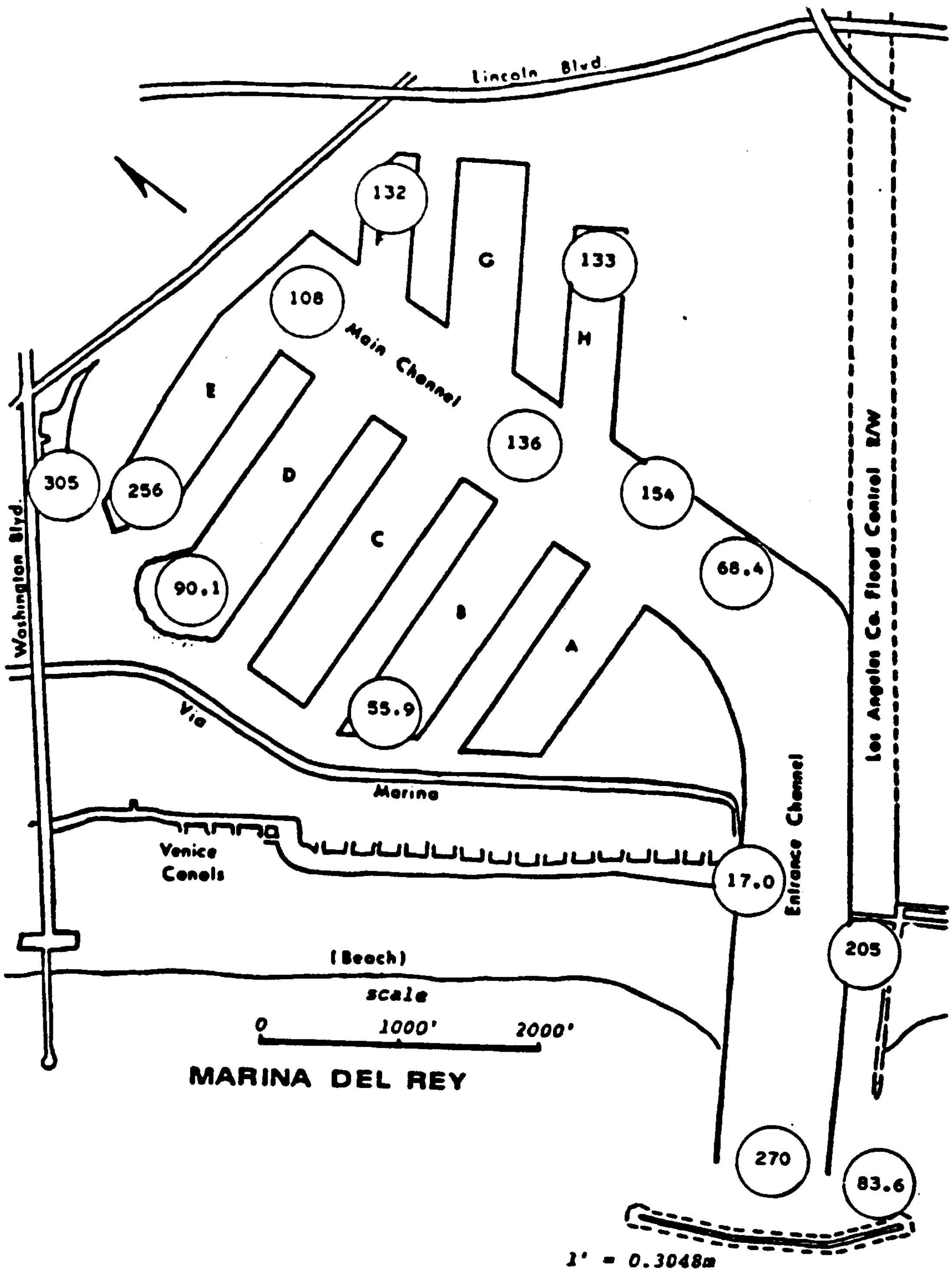

Figure 143. Lead in mg/kg dry wt (ppm) in sediment.

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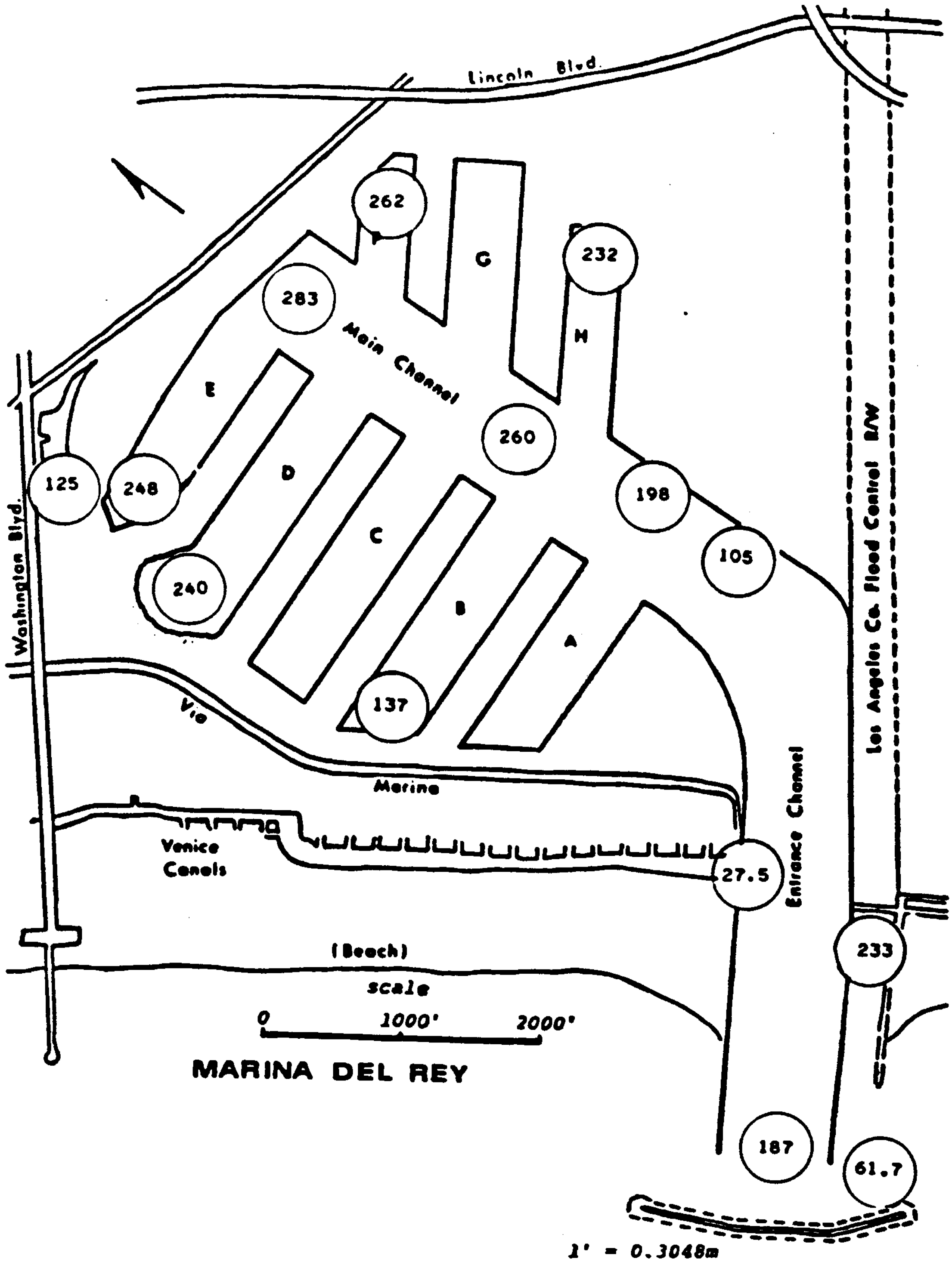

Figure 144. Manganese in mg/kg dry wt (ppm) in sediment.

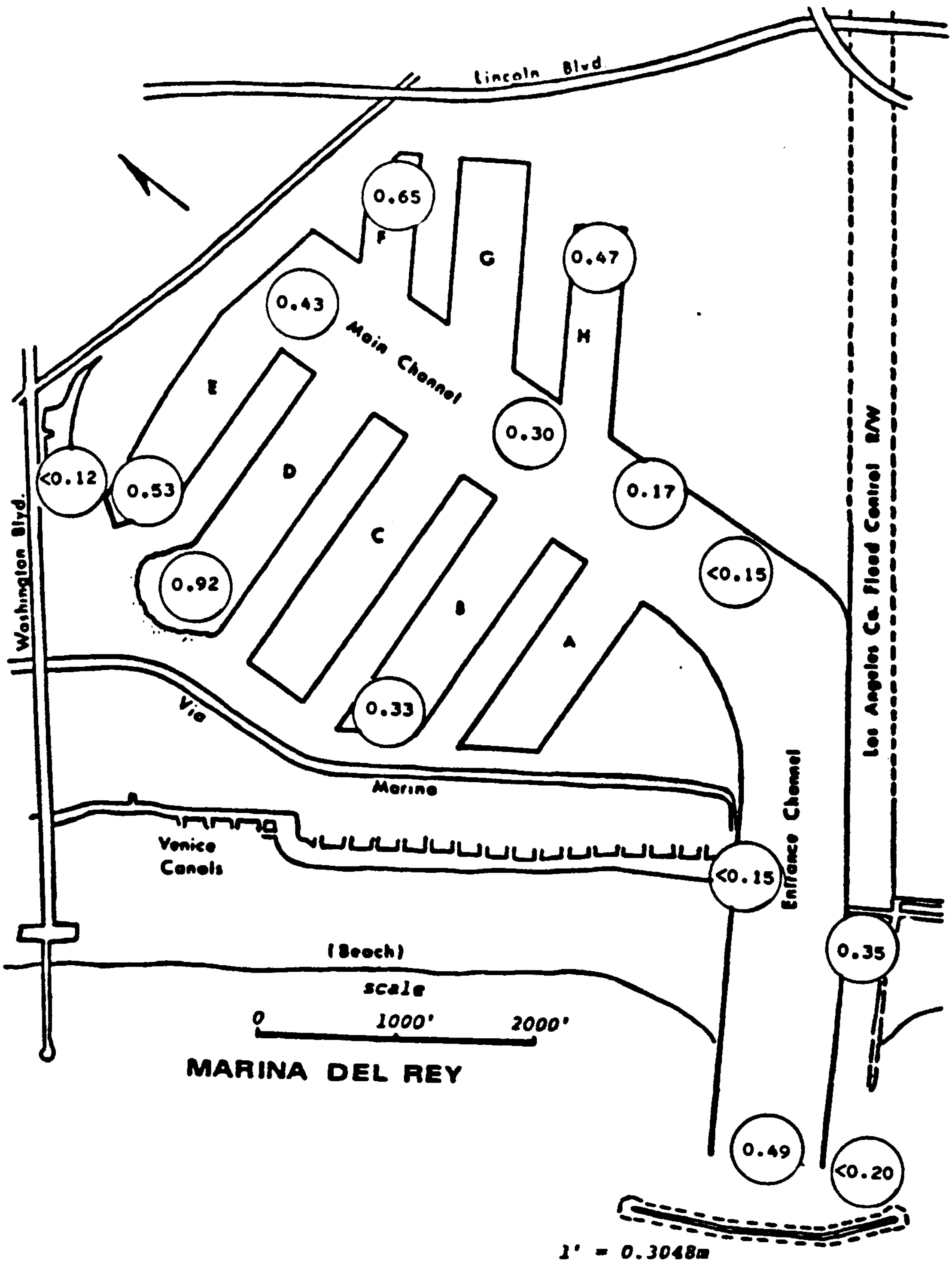

Figure 145. Mercury in mg/kg dry wt (ppm) in sediment.

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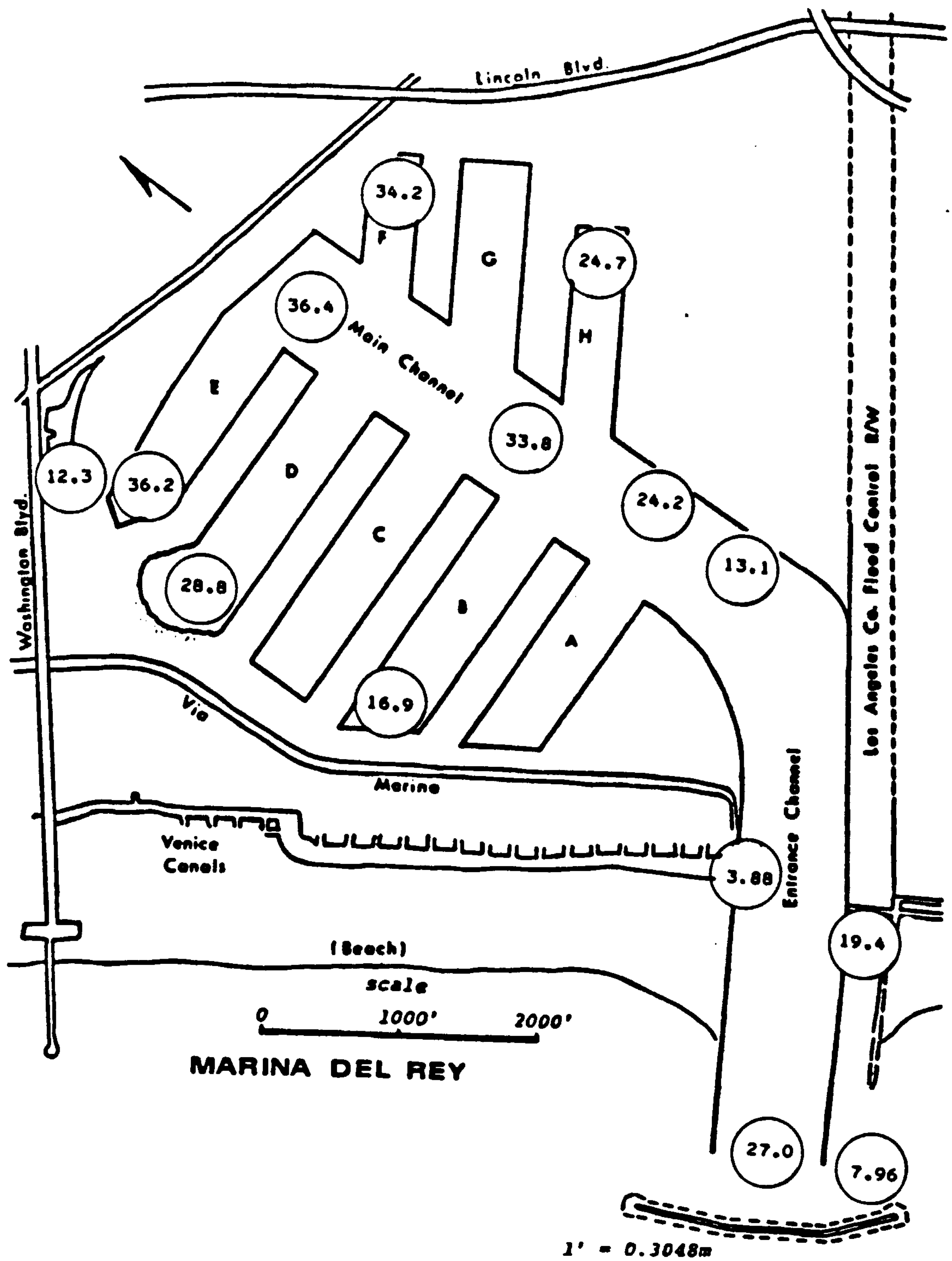

Figure 146. Nickel in mg/kg dry wt (ppm) in sediment.

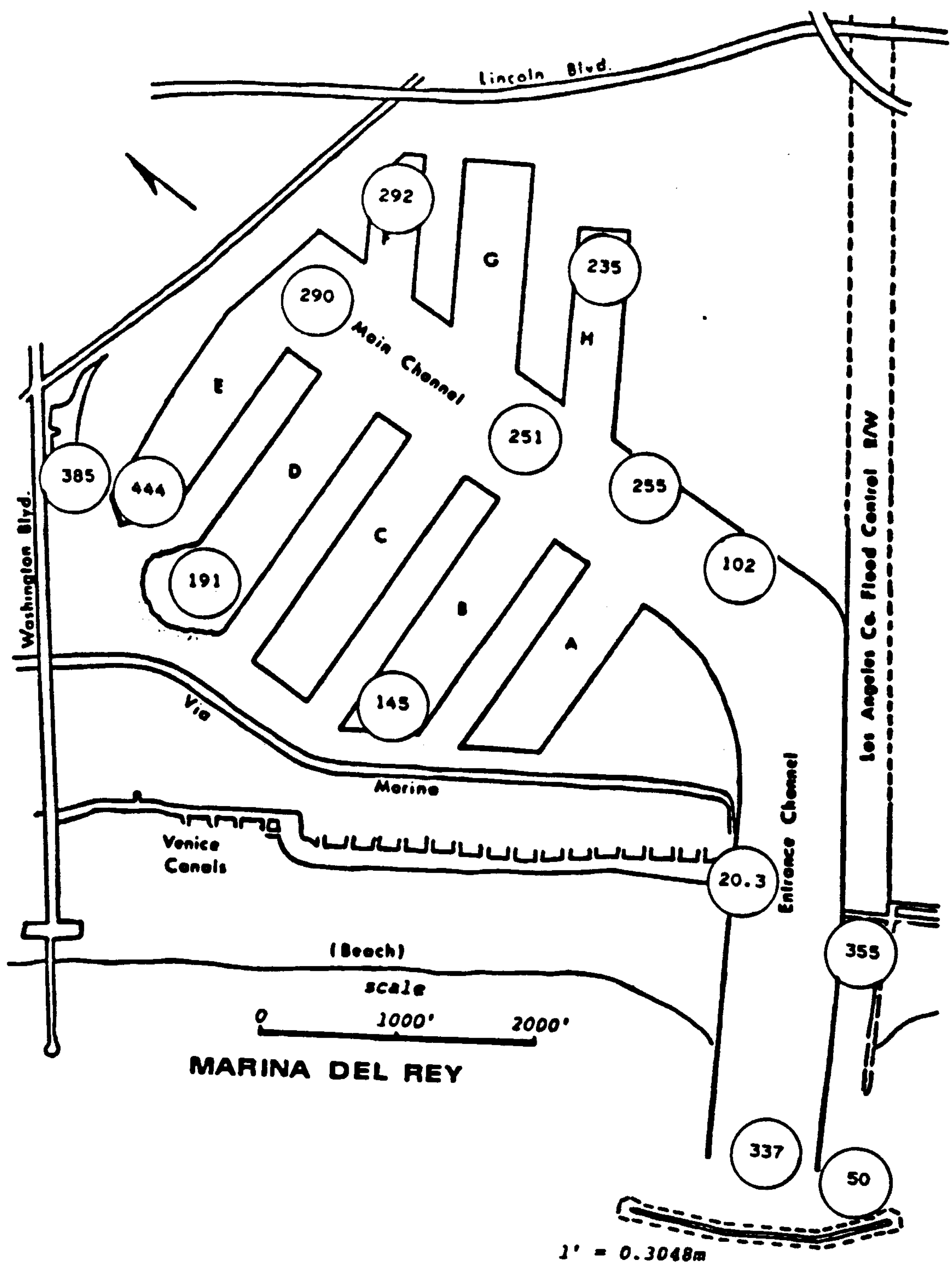

Figure 147. Zinc in mg/kg dry wt (ppm) in sediment.

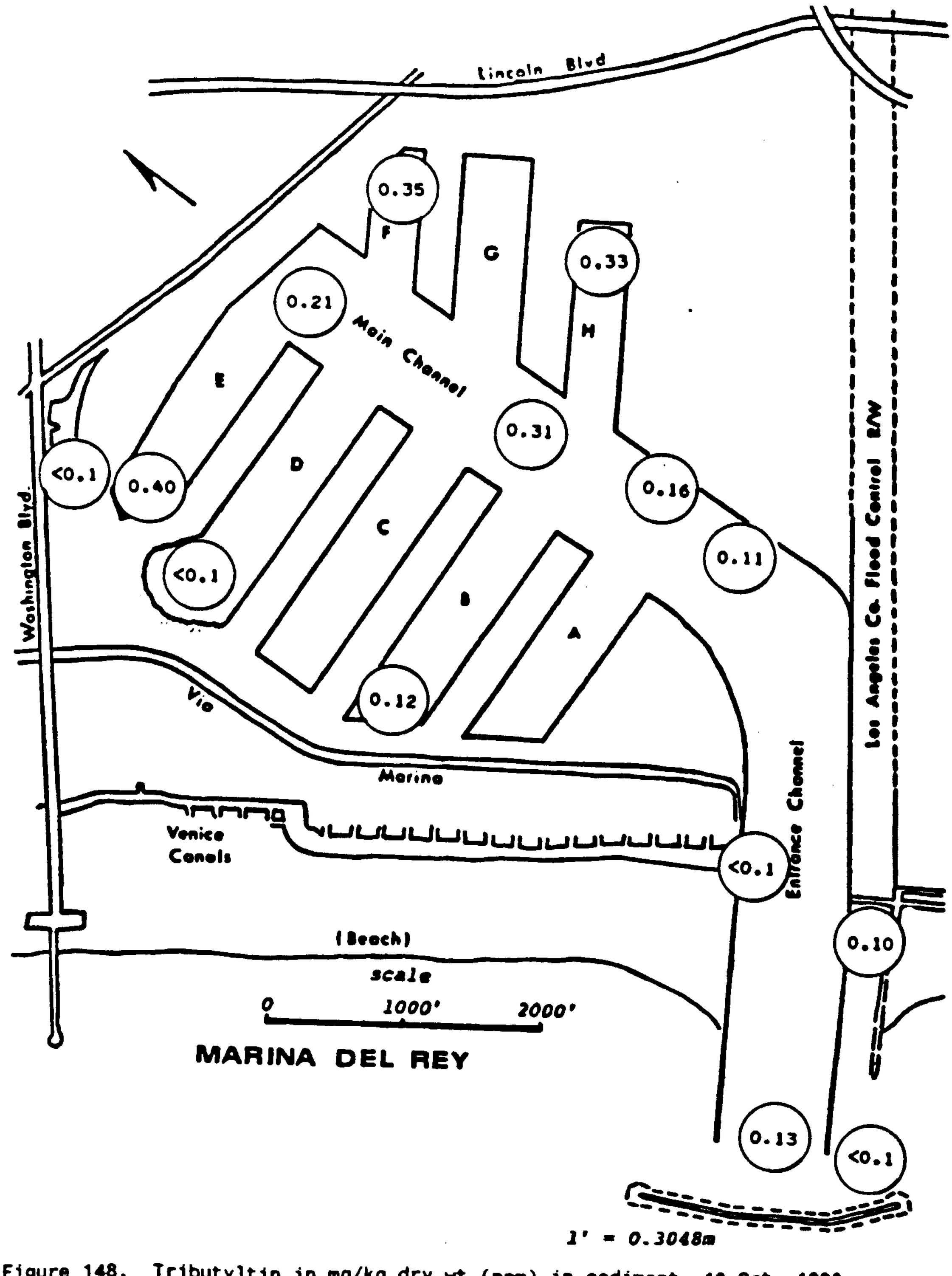

Figure 148. Tributyltin in mg/kg dry wt (ppm) in sediment, 12 Oct. 1989.

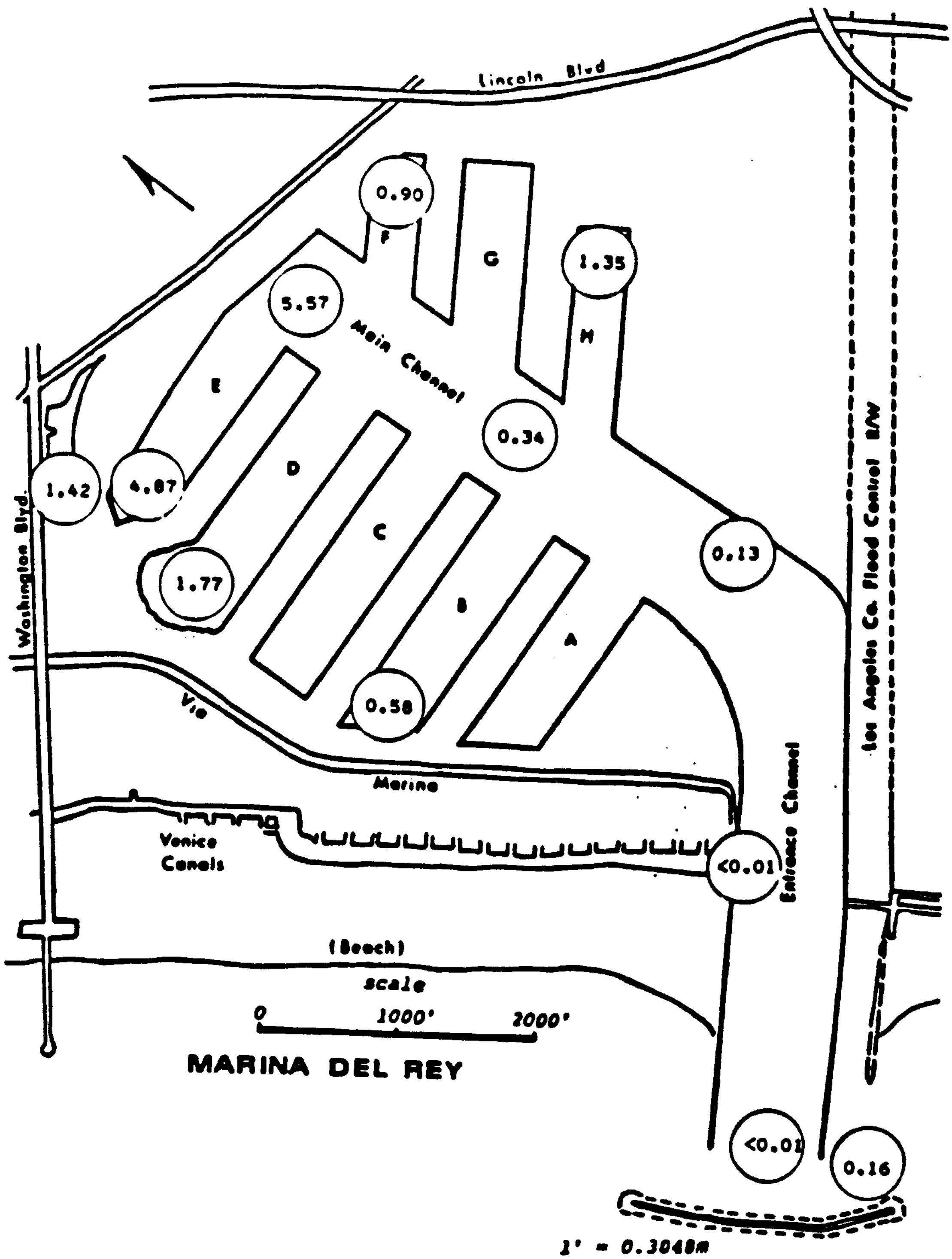

Figure 149. Tributyltin in mg/kg dry wt (ppm) in sediment, 20 Oct. 1988.

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Table 14. Sediment Pesticides and Chlorinated Hydrocarbons, 12 October 1985, Marina del Rey

Station / Parameters*	1	2	3	4	5	6	7	8	9	10	11	12	13	25	Mean
Aldrin	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND
Alpha BHC	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND
Beta BHC	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND
Lindane	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND
Chlordane	29.0	630.0	17.0	70.0	83.0	ND<2.0	85.0	ND<2.0	23.0	160.0	96.0	390.0	75.0	110.0	148.17
Dieldrin	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<0.1	ND<1.0	ND
Endrin	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND<2.0	ND
Toxaphene	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND<10.0	ND
Heptachlor	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND
Hepta. Epox.	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND
p,p'DDT	3.0	67.0	ND<4.0	27.0	88.0	30.0	86.0	7.0	120.0	14.0	85.0	200.0	13.0	24.0	58.15
p,p'DDD	2.0	26.0	ND<4.0	4.0	5.0	ND<4.0	13.0	ND<4.0	22.0	19.0	12.0	40.0	14.0	6.0	14.82
p,p'DDE	24.0	68.0	ND<4.0	22.0	60.0	26.0	52.0	16.0	65.0	76.0	77.0	49.0	48.0	14.0	43.21
Total Pest. Detected	58.0	791.0	17.0	123.0	246.0	56.0	236.0	23.0	230.0	269.0	270.0	679.0	150.0	154.0	235.86
Aroclor @ 1254	ND<1.0	330.0	ND<1.0	24.0	78.0	64.0	88.0	63.0	76.0	150.0	110.0	ND<1.0	86.0	ND<1.0	106.90
1260	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	ND<1.0	130.0	ND<1.0	200.0	165.00
Total Chem. Detected	58.0	1121.0	17.0	147.0	324.0	120.0	324.0	86.0	306.0	419.0	380.0	809.0	236.0	354.0	487.21

* in ug/kg dry wt (ppb) ND = none detected < = less than limits of detection

@ no Aroclor 1016, 1221, 1232, 1242, 1248 found no op DDT, DDD or DDE detected

PESTICIDES AND CHLORINATED HYDROCARBONS

Data for chlorinated hydrocarbons, including the polychlorinated biphenyls (PCBs) and pesticides, have been used to rank the stations, based on station scores as was done for metals. However, scores are lower since levels below the limits of detection were not counted. The following rankings of stations (Table 15) can be made:

Table 15. Ranking of Stations by Total Chlorinated Pesticides.

High Group		Medium High Group		Moderate Group		Low Group	
Station	Score	Station	Score	Station	Score	Station	Score
2	52	7	38	4	16	1	9
12	51	9	36	6	15	8	6
11	43	5	35			3	1
10	43	25	30				
		13	27				

The pesticide data (Table 14, opposite) indicate that the levels in sediment in the Marina are excessive and are cause for concern, according to the ER-L and ER-M values and the NRC values (Table 16, next page). It is not possible to correlate the excessive levels of pesticides at Station 2 with the high benthic faunal diversity and numbers found there. It is quite possible, however, that Station 2 would have a completely different fauna if it did not contain the burden of contaminants it presently has. If it returns to a primarily sandy substrate after dredging, there may be a return of some molluscs, echinoderms and crustaceans.

CHLORDANE

Chlordane, which is at least as toxic as DDTs, increased markedly at Station 2, from 238 ppb in 1988 to 630 ppb in 1989; also the mean for the entire Marina rose from 78.33 ppb to 148.17 ppb. Since this substance is banned for most uses, its sources are of concern. Station 12 (Figure 150) the next highest level, suggesting that it is being transported into the Marina from Ballona Creek and deposited at Station 2. Lesser peaks occurred at Station 25 where parking lots of the Administration Building and a restaurant drain into the Marina, and at Station 10, which probably represents deposition from Oxford Basin.

Table 16. Concentrations of Chlorinated Hydrocarbons Producing Biological Effects Range-Low (ER-L)[1] and Effects Range-Median (ER-M)[1], with Apparent Effects Thresholds (AET)[1], and EPA Thresholds (NRC)[2] as compared with ranges and stations exceeding the ER-L, ER-M and AET.

Parameter (ppb)	ER-L	ER-M	AET	NRC	MDR Range 1989-90	Stations Equal/Exceeding ER-L	Stations Equal/Exceeding ER-M	Stations Equal/Exceeding AET
Chlordane	0.5	6	2 ?	20	17.0 - 630	all (Sta 6,8 -LD)	all others	all but Sta 6,8
p.p'DDT	1	7	6 ?	6	3.0 - 200	all (Sta 3 -LD)	all but Sta 1,3	all but Sta 1,3
p.p'DDD	2	20	?	13000	2.0 - 40	all (Sta 3,6,8 -LD)	4,5,25,11 7,13,10,6	2,12
p.p'DDE	2	15	2 ?	28000	14.0 - 77	all (Sta 3 -LD)	all others but Sta 25	all but Sta 3
Aroclor 1254**	50	400	3 ?	0.26	<1.0 - 330	4 (Sta 1,3 12,25-LD)	———	all but Sta 1,3,12,25
Aroclor 1260**	50	400	3 ?	0.28	<1.0 - 200	25,12 (all others -LD)	-------	25,12

[1] = Long and Morgan, 1990 (NOAA)
[2] = National Research Council 1989 (NAS)
** = ER-L, ER-M and AET calculated for total Aroclors;
-LD = less than limits of detection

Chlordane concentrations at all stations exceed the ER-L and ER-M values except at Stations 6 and 9, where it was below the limits of detection. Only Station 3, with 17 ppb, was slightly below the NRC value for threshold effects.

<u>DDTs</u>

Ranges in most of the chlorinated hydrocarbons increased in 1989 after decreasing over the years of monitoring; Dieldrin, however, had disappeared by 1987 (Table 17). Total DDTs measured in 1978 ranged from none detected to 589 ppb. Total DDTs were considerably lower in 1985 and 1987, with total peak values of 146.7 and 197 ppb, respectively, but in 1988 tests the peak had increased to 284.8 ppb (Soule and Oguri, 1990) and 317 ppb in 1989. The peak 1989 p.p'DDT value was 200 ppb at Station 12.

Table 17. Chlorinated Hydrocarbon Ranges in Sediment in 1985, 1987 - 1989.

Parameter ug/l-ppb	Oct 1985	Highest Stations	Oct. 1987	Highest Stations	Oct. 1988	Highest Stations*	Oct. 1989	Highest Stations
Chlordane	<LD-335	2,1	<LD-290	2,1	13.5-283	2,4	<2.0-830	2,12
Dieldrin	<LD-11	1	<LD		<LD		<LD	
p.p'DDT	<LD-93.4	10,5	8-57	2,10	<4.0-29.1	8,11	3.0-200	12,9
p.p'DDD	<LD-14.1	9,7	2-34	9,2	<4.0-66.7	9,4	2.0-40	12,2
p.p'DDE	<LD-39.2	10,5	10-106	9,10	<4.0-189	9,10	<4.0-77	11,10
Aroclor								
1254	<LD		<1.0		<1.0		<1.0-330	2,10
1260	<LD		<1.0		<1.0		<1.0-200	25,12

* Station 12 not sampled in 1988 <LD See Soule and Oguri (1986) for Limits of Detection

in Ballona Creek, suggesting a terrestrial origin, but a significant increase over the 1985-1988 range. Figures 151 to 153, at the end of this section, show distributions of the DDTs.

TERRESTRIAL DDT

Some terrestrial soil analyses in February 1990 from the hotel site on Admiralty Way and from building sites on Ballona Lagoon showed peak values for total DDTs of 488 and 220 ppbs respectively. It is disturbing to see an increased influx of total DDTs; since DDT has been banned for about two decades, but it is either still being obtained or has been buried in filled land, to be eroded after excavation at a later time.

Although well below the ER-L given by NOAA, the acute toxicity of DDT in seawater listed in the California Ocean Plan (SWRCB, 1989) is 0.011 ppb. DDT is bioconcentrated and 3 to 4 mg/g in fish ovarian tissue is known to inhibit reproduction (Cross and Hose, 1988).

According to Pollock et al. (1990) of the California Department of Health Services, who quoted EPA, currently available epidemiological data on the carcinogenicity of DDTs is inadequate for complete evaluation. A human carcinogenic potency factor of 0.34 mg/kg per day (340 ppb) was calculated based on rodent studies.

POLYCHLORINATED BIPHENYLS (PCBs)

In general, the higher the last two digits of ARoclor, the higher percent chlorine it has (from 16 to 60), and the greater the toxicity, although there is some question about Aroclor 1260, according to the American Conference of Governmental Industrial Hygienists (ACGIH, 1986).

PCBs, as Aroclors, were produced from 1920s until 1977 for use in electrical systems, pumps and compressors, in hydraulic fluids and plasticizers. They are stable, with the appearance of light oil.

According to the Agency for Toxic Substances and Disease Registry of the US Public Health Services (USPHS, 1987) few tests have been performed on Aroclor 1260, as 1242 and 1254 were more commonly used. These tests indicate carcinogenicity in humans at an intake of mg/kg body weight per day, considerably above any normal oral intake. Acute toxicity in rats was in the 1.3 to 10 g/kg range, a level reached only under test conditions. Pollock et al. (1990) indicate that the EPA (1990) gave 7.7 mg/kg/day as the carcinogenic level based on rat diets of 100 ppm/day for 16 mo, 50 ppm/day for 8 mo and 10 ppm/day for 5 mo. Female rats surviving for 18 months had a 91 percent incidence of hepatic carcinoma. The USPHS gives carcinogenicity in humans, based on rat studies, at 1.3 to 10 mg/kg/day, far above normal human consumption levels.

Although Long and Morgan (1990) indicate a moderate level of confidence in the ER-L and ER-M data for PCBs, which are not discriminated by chlorine numbers, there are very large differences in the field toxicity data by several orders of magnitude. They state that PCBs in field-collected sediments may be highly particle bound and not bioavailable and/or they may have a relatively minor role in causing biological effects such as acute mortality relative to other co-occurring contaminants.

The occurrence of PCBs in the Marina was thought to have ceased between the 1970s surveys and the 1980s surveys, although the detection limits were greatly improved by 1986; in 1978 the peak value of Total PCBs was 1,247 ppb. None was detected again until October 1989, when they were found at all stations except Stations 1 and 3, both of which are cleaned by tidal action (Figure 154).

Aroclor 1260 occurred in October 1989 at Station 25 at 200 ppb and at Station 12 at 130 ppb; this suggested either an origin near Station 25 or simply deposition in a low spot on the Main Channel. None was detected at

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the other stations (LD=<1.0) Aroclor 1254, which may have been a degradation product of Aroclor 1260 or a separate introduction, occurred at most stations, making it difficult to propose a source point. The highest level of Aroclor 1254 was 330 ppb at Station 2, followed by 150 ppb at Station 10 and 110 ppb at Station 11. It was not detected at Stations 1, 3, 12 and 25. No other Aroclors were detected. Selected replicate samples were sent to State laboratories for verification.

The reappearance of PCBs was so unexpected that a second benthic sediment sampling survey PCBs was undertaken in January 1990. This indicated that a new pulse of Aroclor 1260 had spread through the Marina, for it was found at all but Stations 3, 4, and 10 (Figure 155). By October 1990, both Aroclors were widely distributed, but distributions of Aroclor 1260 and 1254 did not coincide (Figure 156). This will be discussed further in the 1990-1991 report.

POTENTIAL TERRESTRIAL SOURCES OF PCBs

Some terrestrial soil near the Marina is known to have an extremely high level of Aroclor 1260, up to 22,200 ppb, inland from the Oxford Basin at the head of the Main Channel near Admiralty Way. A grassy area inland of Oxford Basin might have received sediments in runoff that drained into the Marina via parking lot drains near Station 11, or via Oxford Basin and into the Marina. There has been extensive grading and excavation inland of the Marina periphery which may have exposed contaminatied soils. Other storm drains are potential pathways, and it is also possible that runoff carrying contaminated soils has drained into Ballona Creek and moved into the Marina from that direction.

There were no PCBs in sediment samples taken at the hotel site under construction near Station 1 nor at Ballona Lagoon where construction was also underway. It is, of course, possible that some sort of leaking transformer or pump was dumped or sank in the Marina at an unidentified time and place, but the PCBs were so widespread as to be puzzling.

PCBs AND CHLORINATED HYDROCARBON CONCLUSIONS

Pesticides and other chlorinated hydrocarbons, including PCBs, are a continuing problem in the Marina, if not an increasing one, based on the limited sampling data obtained. Levels are not hazardous to human health but are potentially sufficient to inhibit some infaunal species and to reduce reproductive capacity in some fish species. The Marina provides sheltered, warm waters for larval and juvenile fish, with turbidity to protect them from predators and an ample food supply, but the environmental function if inhibited by the presence of pollutants.

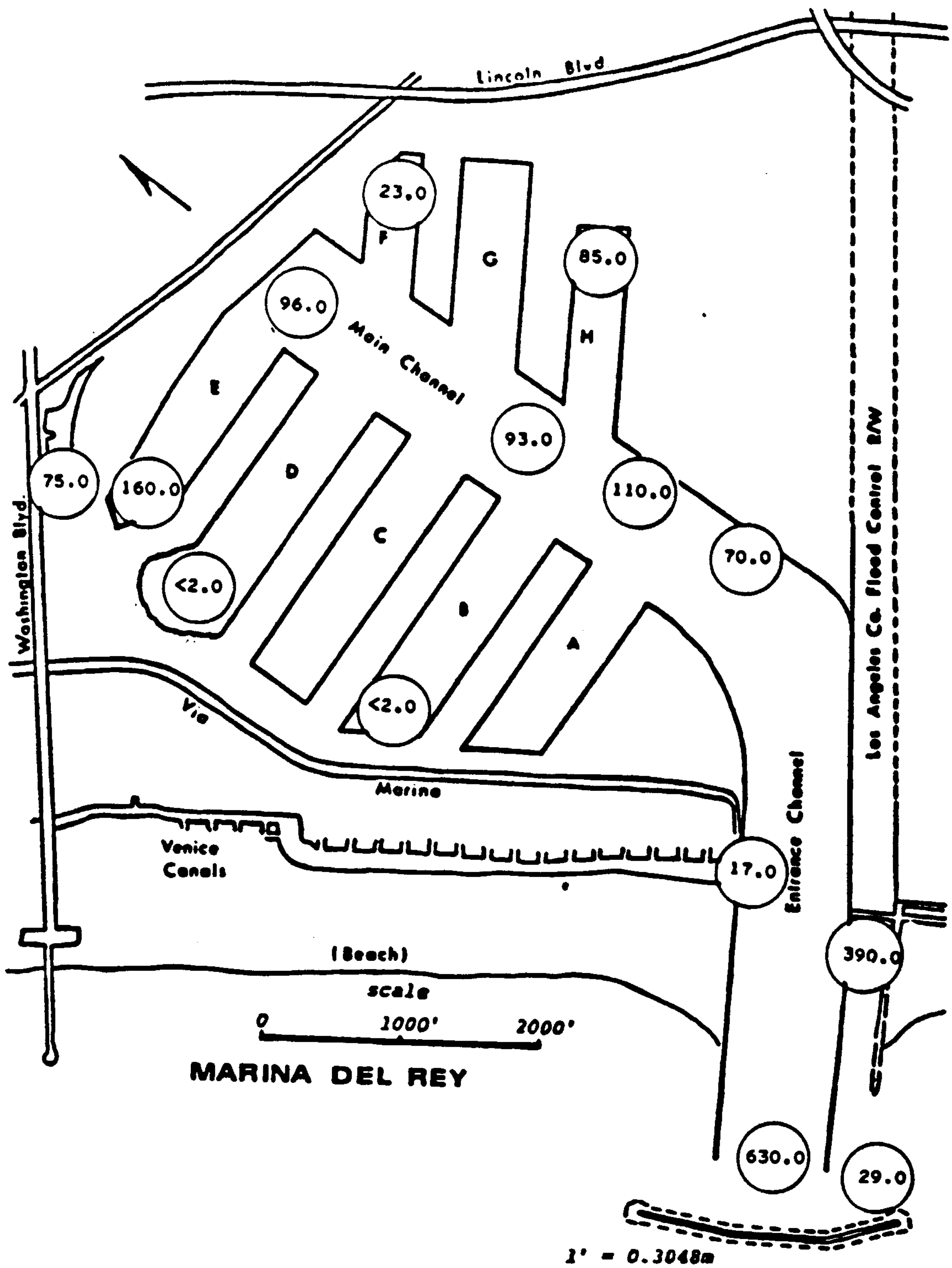

Figure 150. Chlordane in mg/kg dry wt (ppb) in sediment

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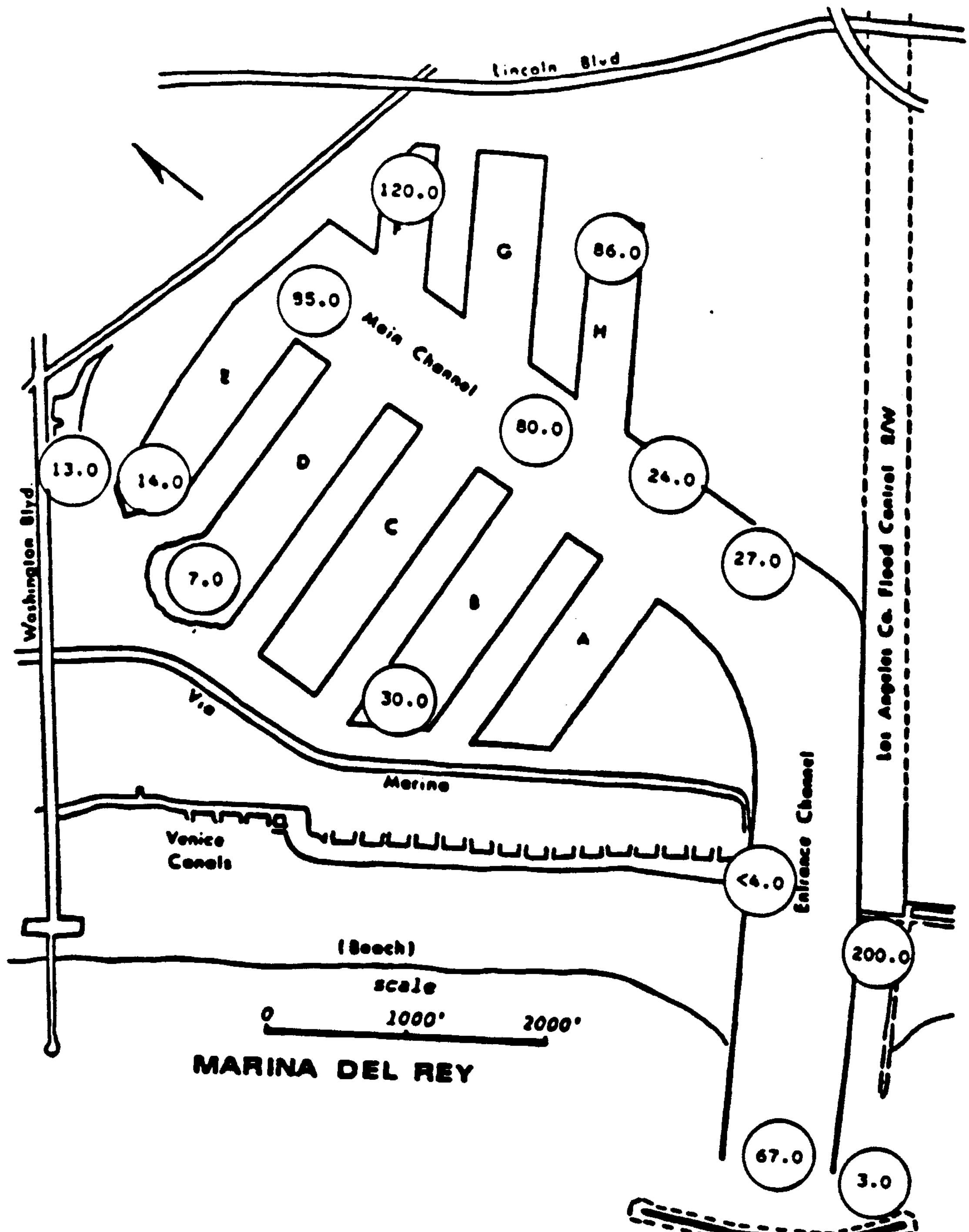

Figure 151. p.p'DDT in sediment, ug/kg (ppb).
(< = below limits of detection)

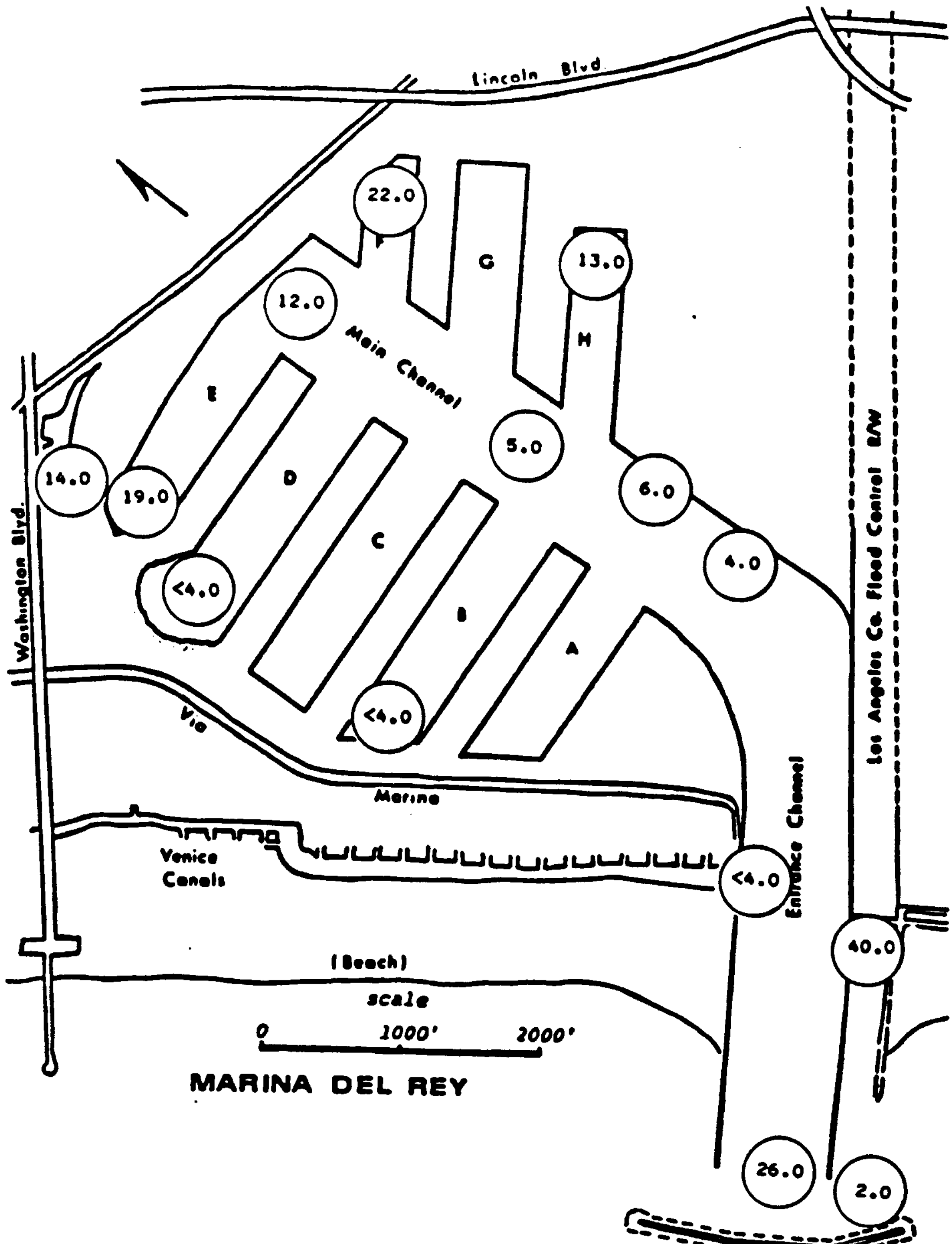

Figure 152. p.p'DDD in sediment, ug/kg (ppb).
(< = below limits of detection)

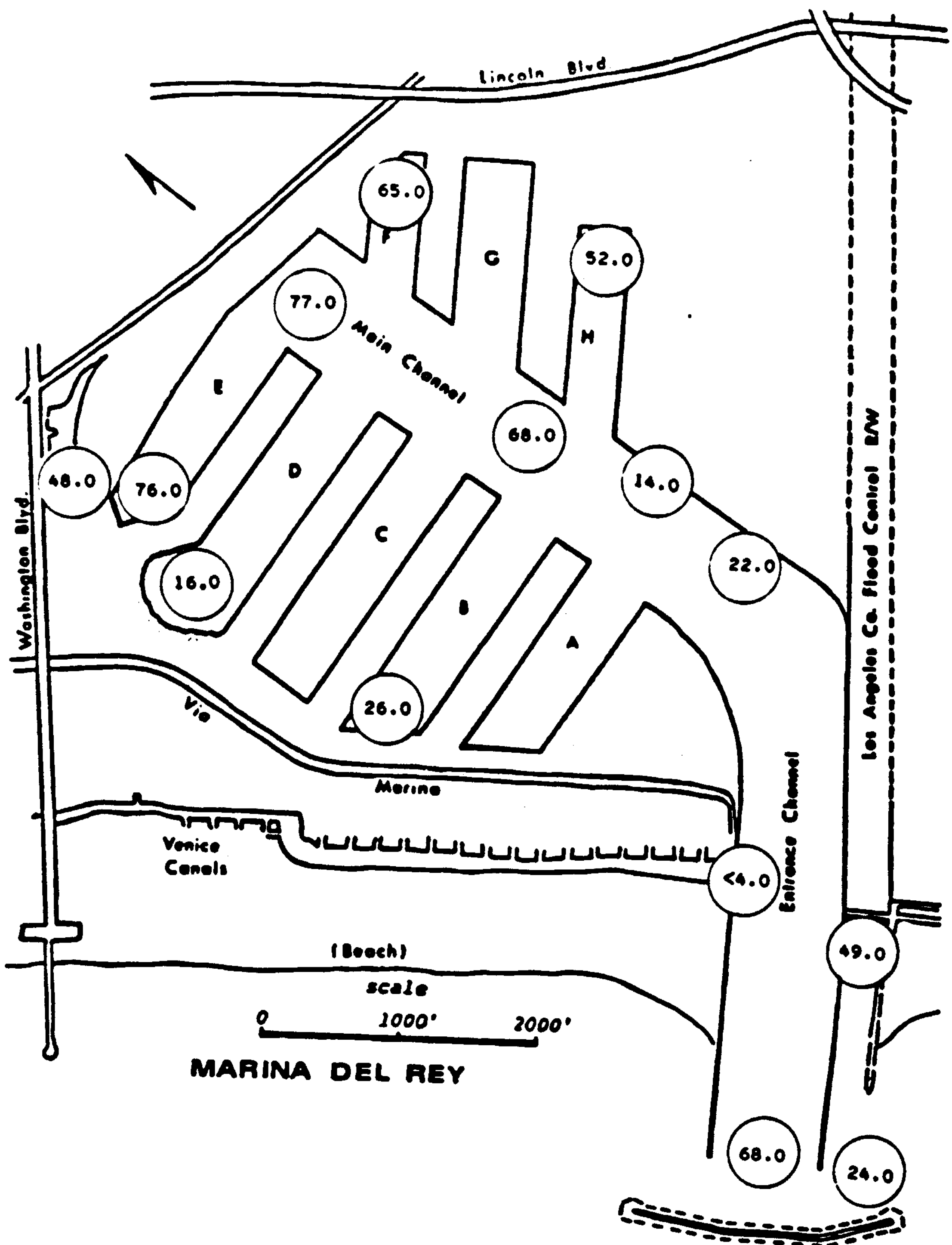

Figure 153. p.p'DDE in sediment, ug/kg (ppb).
(< = below limits of detection)

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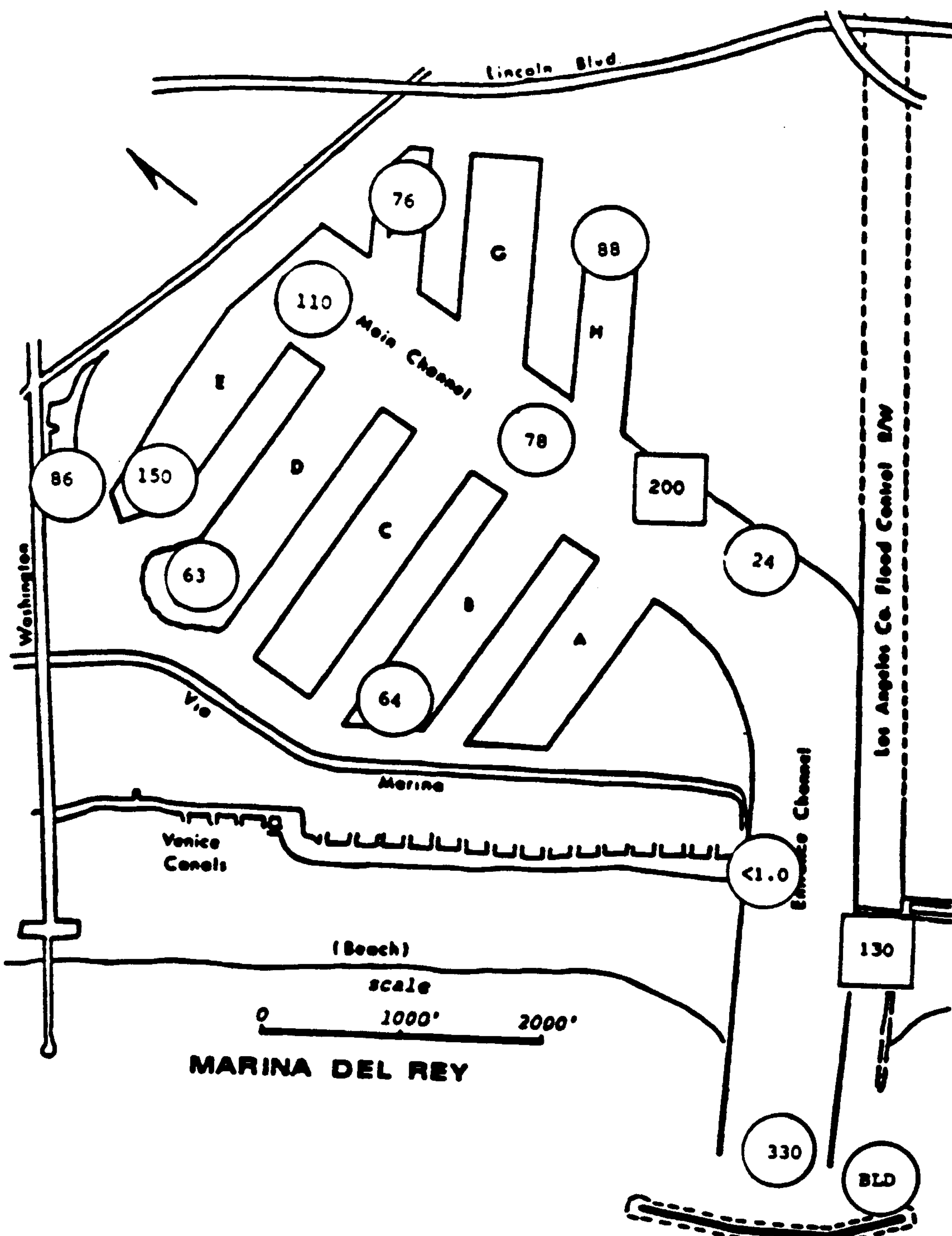

Figure 154. Aroclor 1254 (circle) and 1260 (box), October 1989 *ug*/kg dry wt (ppb). (< = below limits of detection)

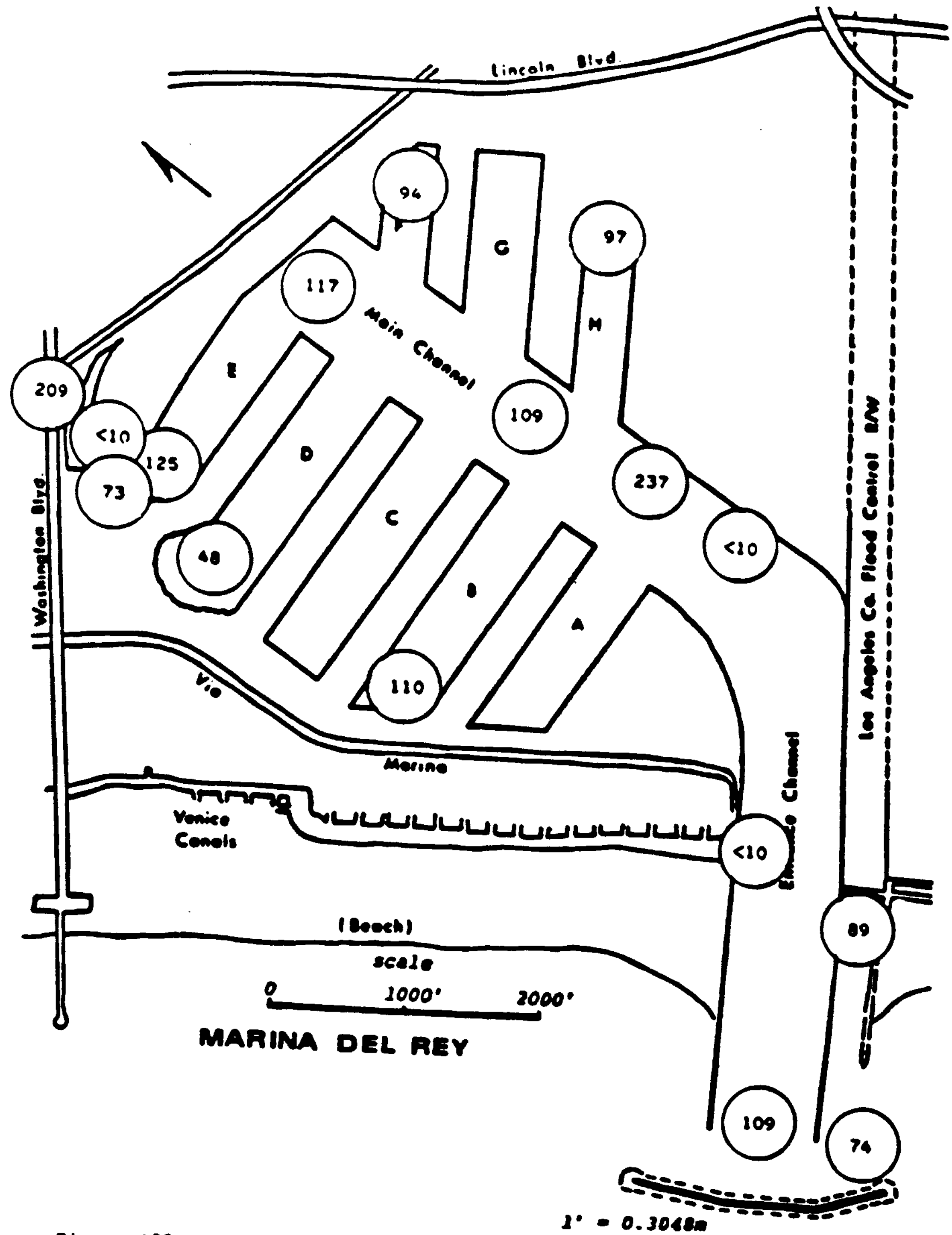

Figure 155. Aroclor 1260, January 1990, in sediment, ug/kg dry wt (ppb). (< = below limits of detection)

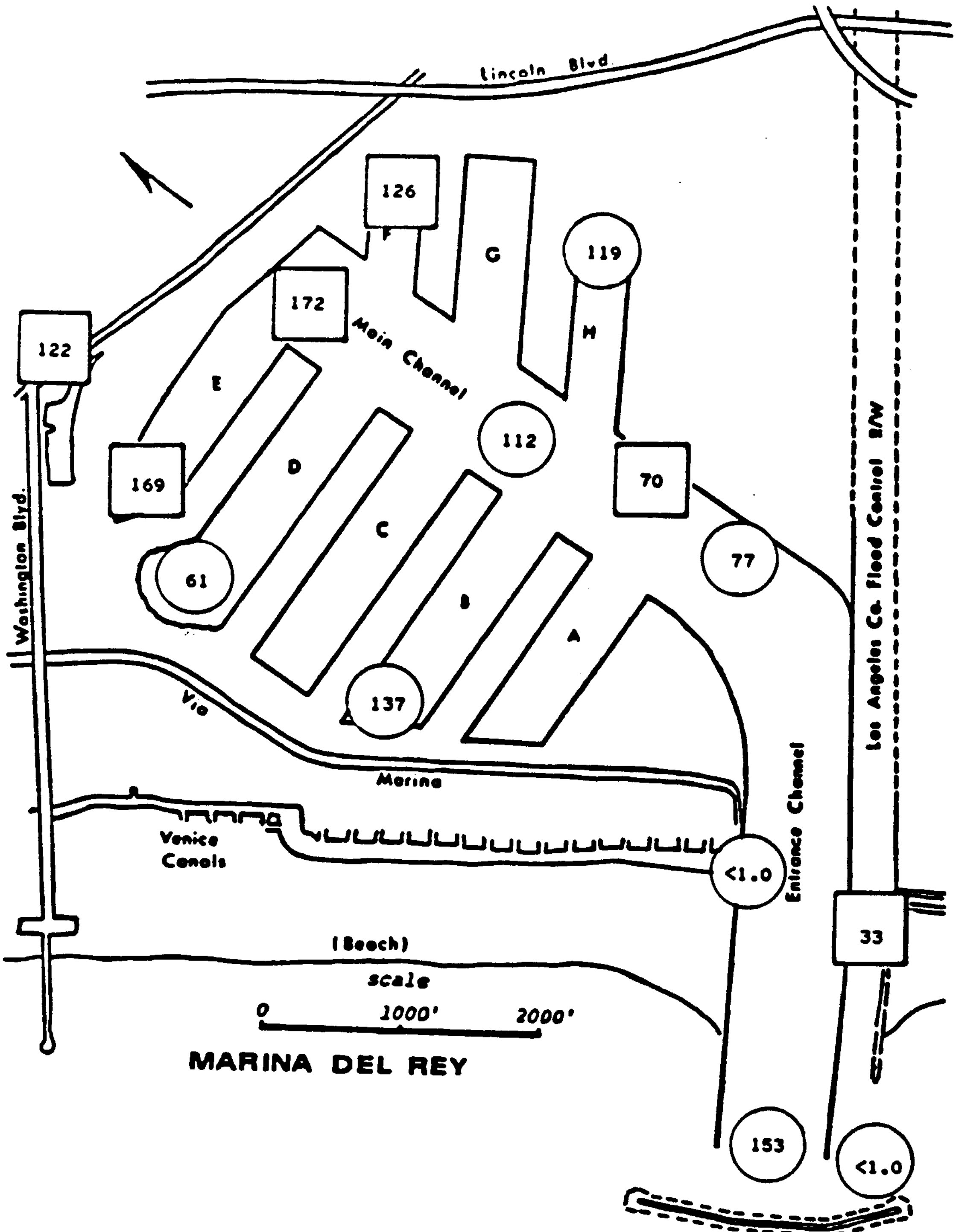

Figure 156. Aroclor 1254 (circle) and 1260 (box) 18 October 1990 in sediment (ppb).

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V. FISH-TISSUE ANALYSES FOR PCBs AND DDTs

POTENTIAL CONTAMINATION

Because fishing dock and jetties are used to catch fish for human consumption, the Los Angles County Department of Beaches and Harbors was concerned about potential public health exposure to the PCBs identified as present in sediments for the first time in recent years.

To determine body burdens of PCB 1260, fish were obtained on 25 January - 2 February 1990 by trawl and by purchase or donation of fish from recreational anglers on the public dock. Samples were frozen with dry ice in the field and muscle tissue was dissected in the laboratory in preparation for chemical analysis by Associated Laboratories, Orange, California.

Because DDT body burden had not previously been examined, tissues were also analyzed for DDT, DDD and DDE. Liver and gonads of several specimens were analyzed separately.

RESULTS AND DISCUSSION

Muscle tissue from 12 species, represented by 32 specimens of fish, were analyzed and 3 liver/gonad tissues were analyzed separately. Table 18 presents the results of the analyses.

Body burdens varied considerably among individuals of the same species or between species, indicating variation in exposure and bioaccumulation. Lee (1984) noted the great differences between species, with some able to metabolize DDTs and others storing it. The fish used for analysis herein were all small, young specimens.

Since liver and gonads are discarded when fish are cleaned for consumption, levels in those tissues are not usually relevant to human health. They are important however, relevant to the health of the local fish population if they impair the liver and reproductive capacity.

The range in muscle tissue for Aroclor 1260 were 15 to 298 ppb while liver/gonad samples showed a range of 548 to 4,270 ppb. The PCB in edible muscle portions did not approach the 2 ppm level for action under public health regulations.

There is a seasonal variation in the chlorinated hydrocarbons in muscle tissue and in liver and gonads. Cross (1986) demonstrated that DDT and PCBs are concentrated in the lipids in liver and gonads of white croaker in the months prior to spawning, and after spawning the body burdens are much lower (Figure 157).

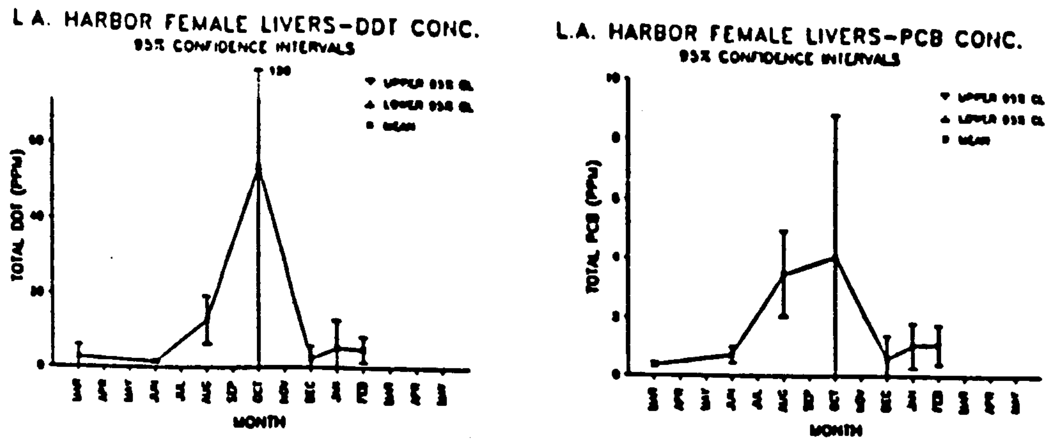

Figure 157. Mean total DDT and total PCB concentration (mg/kg wet weight =ppm and 95% confidence interval in the liver of female white croaker collected in outer Los Angeles Harbor from March 1985 through May 1986. N=5 per sampling period (Cross, 1986).

Because Marina fish sampling was performed in January - February 1990, at a period of theoretically low level of body burden, it was considered important to repeat the survey in October, which may be the peak body burden period, and in May 1991, a presumed low period.

Comparison of body burden with fish from off Whites Point and Santa

Monica Bay can be made with Table 19, from NRC (1989). Concentrations of DDT in ppm, were much higher from off Whites Point than from Santa Monica Bay, but PCB levels are less distinct.

CONCLUSIONS

It is clear that levels of metals, especially copper, lead and zinc, are excessive and capable of causing chronic damage to marine organisms. Since reproduction is most often compromised, this reduces the secondary productivity of the Marina. The more sensitive organisms such as echinoderms, crustaceans and molluscs are inhibited by chronic toxicity and species diversity is thus reduced.

Chlorinated hydrocarbon levels are excessive and the sources are not known. DDTs are very persistent in the environment, but non-degraded p,p'DDT should not be appearing, unless fresh inputs or excavation of previously unexposed contaminated sediments are the cause. Chlordane has been banned for most uses, and DDTs and PCBs have not been manufactured for many years. Natural flushing would have removed residual deposits by now if new material were not being introduced.

The January - February 1990 tests of fish tissues indicated that fish are not harmful to anglers under normal levels of consumption. The levels are, however, inhibitory to fish reproduction. To follow the levels of PCBs and pesticides, additional sampling was to be performed in October 1990 and May 1991. Chlordane will also be analyzed, since it probably is cumulative in effects with the DDTs. Muscle tissue may have a lower burden in October due to movement of lipids, in which chlorinated hydrocarbons are complexed to liver, reproductive organs and eggs prior to spawning.

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Table 18. Polychlorinated Biphenyls (PCBS) and DDTs in Fish Tissues

Sample/ Numbers	Sample Identification	ug/kg wet weight (ppb) PCB 1260	DDE	DDD	DDT
001	*Atherinopsis californiensis* (Jacksmelt)	103	189	40	30
002	*Atherinopsis californiensis* (jacksmelt)	74	160	32	25
003	*Hyperprosopon argenteum* (walleye surfperch)	217	UD	50	35
004	*Hyperprosopon argenteum* (walleye surfperch)	107	220	39	29
005	*Cymatogaster aggregata* (shiner surfperch)	266	1,142	102	51
006	*Cymatogaster aggregata* (shiner surfperch)	107	108	37	30
007	*Cymatogaster aggregata* (shiner surfperch)	246	371	69	52
008	*Synodus lucioceps* (California lizardfish)	78	120	33	24
009	*Synodus lucioceps* (California lizardfish)	142	303	47	34
010	*Sphyraena argentea* (California barracuda)	291	1,665	86	60
011	*Sphyraena argentea* (California barracuda)	92	262	33	26
012	*Sphyraena argentea* (California barracuda)	27	197	28	25
013	*Myliobatis californica* (bat ray)	221	133	57	44
014	*Seriphus politus* (queenfish)	187	411	69	39
015	*Paralichthys californicus* (California halibut)	91	228	33	25
017	*Genyonemus lineatus* (Tom cod/white croaker)	277	239	73	48
018	*Genyonemus lineatus* (Tom cod/white croaker)	154	UD	UD	UD
020	*Myliobatis californica* (bat ray)	15	28	22	UD
021	*Paralichthys californicus* (California halibut)	265	119	54	44
022	*Paralichthys californicus* (California halibut)	184	114	42	36
023	*Pleuronichthys ritteri* (spotted turbot)	223	119	49	42
024-025	*Myliobatis californica* (bat ray liver and gonad)	548	525	127	79

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Table 18, cont.

Sample/ Numbers	Sample Identification	ug/kg wet weight (ppb) PCB 1260	DDE	DDD	DDT
026-027	*Pleuronichthys ritteri* (spotted turbot liver and gonad)	1,100	1,268	167	140
028	*Paralichthys californicus* (California halibut)	117	84	33	30
029	*Paralichthys californicus* (California halibut)	127	84	33	32
030	*Citharichthys stigmaeus* (speckled sanddab)	59	52	27	20
031	*Synodus leucoceps* (California lizardfish)	32	41	25	20
032	*Paralichthys californicus* (California halibut)	195	132	45	42
033	*Paralichthys californicus* (California halibut)	298	317	66	57
034	*Paralabrax nebulifer* (sand bass)	178	333	23	20
035	*Synodus leucoceps* (California lizardfish liver of specimen 031)	4,270	6,806	311	179

UD = Undeterminable

Group 1. Fish tissue samples were collected by purchase of fish from anglers at public fish dock at Fishermen's Village.
01/25/90: Numbers 001 - 015
02/02/90: Numbers 017 - 018

Group 2. Fish collected by otter trawl in Entrance Channel
01/25/90: Numbers 020, 024+025 (liver and gonad of 020), 028 - 030, 034

Group 3. Fish collected by otter trawl near public fish dock
01/25/90: Numbers 021, 022, 023, 026+027 (liver and gonad of 023), 031 - 033, 035 (liver and gonad of 031)

Table 19. Contaminant Concentration and Risk Assessment for Consumption of Southern California Fish at Average U.S. Consumption Rate[a]

		Concentration mg/kg wet wt	Risk
White Point White Croakers	DDTs	7.6	3.4/10,000
	PCBs	0.38	2.2/20,000
	Total	8.0	5.6/10,000
Rockfish	DDTs	0.44	2.0/100,000
	PCBs	0.057	3.3/100,000
	Total	0.50	5.3/100,000
P. Mackerel	DDTs	0.051	2.3/1,000,000
	PBCs	0.014	8.0/1,000,000
	Total	0.065	2.0/1000,000
Santa Monica Bay White Croakers	DDTs	0.57	2.6/1000,000
	PCBs	0.20	1.1/10,000
	Total	0.77	1.4/10,000
Rockfish	DDTs	0.22	9.9/1,000,000
	PCBs	0.12	6.9/1,000,000
	Total	0.34	7.9/100,000
P. Mackerel	DDTs	0.057	2.6/1,000,000
	PCBs	0.015	8.6/2,000,000
	Total	0.072	1.1/100,000

NOTE: [a]9.3 b/day consumption of domestic estuarine and marine fish.
SOURCE; Brown, 1985 in NRC, 1989.

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VI. MICROBIOLOGY

PUBLIC HEALTH CONCERNS

Marina del Rey is not primarily a body contact water area, but does contain one beach, variously known as Marina Beach, Baby Beach and Mothers' Beach, located in Basin D. Following major sewage spills into adjacent waters in 1987, extensive monitoring of bacterial counts was undertaken by the Los Angeles Department of Health Services to determine when beaches could be reopened. However, counts did not recede as expected and an extensive study was undertaken by the Department of Beaches and Harbors to determine the sources. The beach was closed from October 1987 for more than a year. During this time a number of possible sources such as sewer or storm drain leaks were ruled out.

The major contributor to coliform contamination was identified as the seagull population that rested on the beach, especially during the cool weather months when there are few beach visitors to disturb them. The solution was similar to that used locally in some of the sanitary landfills to fend off hordes of gulls. Monofilament line, and later polypropylene line, was strung between a few poles at strategic locations. This seems to interfere with their flight pattern and keeps the gulls away but does not interfere with the smaller numbers of wading birds (Soule and Oguri, 1989; Charness and Smith, 1990).

Another significant source of coliforms is rainfall, which carries fecal material from transients, discarded diapers, dogs runs, and in some localities, drainage from horses, into the storm drains and flood control channels. Rainfall carries these materials into embayments and coastal waters, where the fecal bacteria persist for several days. Swimming after a rain should therefore be avoided for two to three days.

STANDARDS

Total coliform bacteria counts have for many years been used to measure the presence offecal material in water supplies. They were believed to be harmless, and are easier to culture in the laboratory than more dangerous pathogenic bacteria. Fecal coliform counts were added later, as being a more accurate measure of enteric contamination, and finally enterococcus counts were determined to be still more effective. The problem of identifying human contamination from illegal waste disposal, leaking sewers, vessel holding tanks and the like is that coliform bacteria also occur naturally in soil, and fecal coliforms occur in warm blooded animal feces, thereby confusing the results.

Enterococcus are really part of a group of *Streptococcus* species that occur in warm blooded animals. The enterococcus test eliminates those *Streptococcus* strains from cattle, horses and fowl, especially chickens, but it is not exclusive to humans. Because enterococcus do not generally survive long outside their hosts, they are supposed to be indicators of very recent contamination. None of the methods are truly accurate but can provide indicators of risk to public health; coliform tests have been in use for so many years that they represent the best historical data base for comparative evaluations. Research for better indicators is a continuing objective of public health agencies.

Federal (EPA), State and Los Angeles County standards for total coliforms in recreational waters stipulate that no single sample, when verified by a sample repeated within 48 hours, shall exceed 10,000 MPN (most probable number) per 100 ml (SWRCB, 1989). If daily monitoring were

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done, not more than 20 percent of samples taken in a 30 day period could exceed 1,000 MPN per 100 ml, but sampling is not normally done with that frequency.

Federal and State standards for fecal coliforms provide that not more than 10 percent of samples within a 60 day period may exceed 400 MPN per 100 ml. Since the USC surveys were done monthly, and the County Department of Health Services (DHS) monitoring is irregular, the 400 MPN per 100 ml standard is applied.

The EPA and DHS standard for enterococcus has been a geometric mean of 35 colonies (C) per 100 ml, or that no single sample may exceed 100 C per 100 ml. The State has proposed a standard of 24 C per 100 ml (SWRCB, 1989).

The County Department of Health Services in 1988 began to post beaches immediately after rains as being unsafe for swimming, based on results of monitoring in past years. Bacterial tests require incubation for several days before fecal contamination can be determined, and thus the waters could not be posted until after the risks had diminished if the County waited until the presence of contamination was confirmed.

METHODS

Surface water samples were taken in conjunction with sampling for nutrients and BOD_5 with the Naumann self-closing sampler. Samples were chilled and transported to Associated Laboratories of Orange, California for culture and counting according to Standard Methods and/or EPA approved protocols.

RESULTS AND DISCUSSION

Results of the monthly surveys are documented in Tables 20 to 25 and illustrated in Figures 158 to 169. The figures are plotted linearly in distance from the breakwater along the main channels, so that stations in the basins are positioned off the principal line. Station 12 is in Ballona Creek and Station 1 is at the mouth. Stations 8, 18 and 19 are relatively closely spaced in Basin D, where body contact is most likely to occur near the bathing beach and the wheel chair ramp; kayaking also occurs there. Station 13 is in Oxford Basin at the tide gate to Basin E and Station 22 is at the shore in inner Oxford Basin, where values are affected by runoff. Public Health standards are shown on the figures as solid transverse lines to indicate when contamination levels exceed the standards mentioned above.

BALLONA CREEK

Violations of standards have often occurred at Station 12 in the past (Soule and Oguri, 1990). There were none in October and November, but on 7 December 1989 there were fecal coliform and enterococcus violations at Stations 12 and 1 although it had not rained for two weeks (Figure 160). The tide had been +5.2 feet at 0431 hours on 7 December, which may have brought material down the channel and off the jetties. However, there were no violations there in January 1990, when tides were even higher (+6.3 ft).

There were no further violations observed in Ballona Creek during monthly monitoring until 5 April 1990, the day after about 0.5 inches of rain inland. All three parameters were in violation, but enterococcus was especially high, 3,100/100 ml, at Station 12. Total coliforms were in violation throughout the Marina, and fecal coliforms were in violation from Station 12 to Station 3. No violations occurred on subsequent monthly monitoring during the year. The June 1990 survey occurred ten days after heavy rains, but no bacterial effects could be noted in Ballona Creek.

BASIN D

Station 8, located at the innermost boat slip off the beach basin is the oldest of the survey stations in Basin D. Stations 18 and 19 were added in 1987 at the perimeter rope for the swimming area and at the end of the wheelchair ramp respectively. The only violations at Station 8 occurred for total and fecal coliforms after rainfall in April 1990. There were no violations at Station 18 throughout the year, while at Station 19 there was a very high enterococcus value on 10 May 1990. This may represent a human episode, perhaps of diaper contamination. A high fecal coliform in September may have been from birds.

OXFORD BASIN

Station 13, inside the basin at the tide gate, is frequently in violation of coliform standards; this is not a body contact area and thus is not a threat in itself, but waters from Oxford Basin, tidally flushed, can affect Station 20, on the Marina side of the tide gate, and/or Station 10, at the end of the first boat slip. Station 22 is at the inland end of Oxford Basin and receives drainage from a low grassy area which is used for recreation such as soccer but does not have sanitary facilities.

At Station 13, violations of fecal coliform standards occurred on 5 October 1989, 11 January 1990, 8 February, 8 March, 10 May, 2 August, and 6 September; total and fecal coliforms were in violation on 9 November 1989, 5 April, and 7 June 1990. The only enterococcus violation was after the rain, on 5 April 1990. The total and fecal coliform contamination may represent the neighborhood dog, wild rabbit and bird populations but the enterococcus violation may well represent human wastes.

At Station 22, violations of total and fecal coliform standards

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occurred on 9 November 1989; violations in fecal coliforms only occurred on 7 December 1989, 2 August 1990 and 6 September 1990. Enterococcus violations occurred on 7 December, 8 March, 5 April, and 7 June. Water was too low to be accessible for sampling on 5 October 1989 and 10 May 1990.

Station 20, where a large vessel is docked near the tide gate, has been a problem area in the past for bacteria and also ammonia levels. It was in violation of fecal coliform and enterococcus standards in October and December 1989, with both parameters exceeding those at Station 13 by an order of magnitude. All three standards were violated in April 1990, but this also occurred in most of the Marina following the rainfall. Total and fecal coliforms were in violation in May and June, when Station 13 levels were also high. The problem of probable human waste contamination at the dock was not evident as frequently as in previous years.

CONCLUSIONS

The only stations in the Marina proper not affected greatly by rainfall runoff are Station 6, in Basin B, and the Basin D beach stations, Stations 18 and 19. If further evidence were needed of the effects of rainfall on bacterial contamination from runoff, the profile (Figure 164) and data (Table 23) for 5 April 1990, the day after a 0.5 inch rain, would be illustrative.

Causes of other episodes of standards violations are not clear, as for example on 7 December 1989, when there were violations in Ballona Creek and Oxford Basin. Rainfall had occurred about two weeks earlier, and enterococcus should not have been able to persist for that long an exposure. Violations in Oxford Basin in May and June were also two weeks or more after rainfall. Recreational use of the area may be contributory

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to the problem. Violations from vessels does not seem to be a problem, other than the possible contamination at Station 20 in October 1989.

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Table 20. Coliform and Enterococcus Bacteria in Surface Waters, October, November 1989

Station	5 October 1989 Coliform Total (MPN/100ml)	5 October 1989 Coliform Fecal (MPN/100ml)	5 October 1989 Enterococcus (Colonies/100ml)	Station	9 November 1989 Coliform Total (MPN/100ml)	9 November 1989 Coliform Fecal (MPN/100ml)	9 November 1989 Enterococcus (Colonies/100ml)
1	40	40	4	1	900	900	19
2	<20	<20	1	2	<20	<1	1
3	<20	<20	4	3	<20	<1	2
4	70	70	<1	4	80	80	8
5	80	20	3	5	20	20	1
6	80	40	3	6	170	20	4
7	40	40	2	7	20	20	<1
8	20	<20	25	8	900	40	<1
9	<20	<20	3	9	<20	<20	<1
10	20	<20	<1	10	8,000	900	28
11	<20	<20	1	11	80	<20	<1
12	2,400	40	19	12	1,100	220	12
13	3,000	800	21	13	30,000	1,700	18
18	20	20	8	18	20	20	<1
19	70	20	1	19	70	20	1
20	5,000	5,000	163	20	1,400	500	30
22	Gate locked, no access			22	17,000	3,000	80
25	40	20	<1	25	80	80	9
Avg	684	388	18	Avg	3,117	378	11
Num	18	18	18	Num	18	18	18
Std Dev	1,421	1,205	39	Std Dev	7,611	750	19
Max	5,000	5,000	163	Max	30,000	3,000	80
Min	20	20	1	Min	20	20	1

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Table 21. Coliform and Enterococcus Bacteria in Surface Waters, December 1989, January 1990

7 December 1989

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	3,000	1,700	156
2	20	20	4
3	70	40	24
4	80	80	3
5	40	20	15
6	170	60	2
7	70	20	1
8	170	20	3
9	40	20	3
10	2,100	500	9
11	130	40	96
12	1,300	800	346
13	7,000	300	43
18	170	130	1
19	1,700	60	21
20	3,000	2,200	76
22	8,000	1,300	352
25	90	20	4
Avg	1,525	407	67
Num	18	18	18
Std Dev	2,352	644	108
Max	8,000	2,200	352
Min	20	20	1

11 January 1990

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	40	20	1
2	500	220	5
3	70	<20	2
4	90	60	1
5	40	20	2
6	40	<20	6
7	230	20	1
8	70	40	<1
9	<20	<20	<1
10	40	40	9
11	300	300	<1
12	1,300	230	65
13	2,400	800	28
18	130	20	1
19	70	<20	13
20	700	80	2
22	7,000	80	14
25	130	20	4
Avg	743	113	9
Num	18	18	18
Std Dev	1,627	186	15
Max	7,000	800	65
Min	20	20	1

Table 22. Coliform and Enterococcus Bacteria in Surface Waters, February, March 1990

8 February 1990

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	900	20	8
2	80	20	1
3	110	<20	<1
4	130	40	<1
5	20	20	1
6	80	20	3
7	40	<20	<1
8	80	<20	<1
9	70	70	1
10	1,700	90	5
11	40	<20	1
12	5.000	270	41
13	500	500	31
18	<20	<20	<1
19	115	110	1
20	110	20	2
22	3,000	230	91
25	20	<20	<1
Avg	645	81	5
Num	17	17	17
Std Dev	1,328	75	22
Max	5,000	270	91
Min	20	20	1

8 March 1990

Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	140	110	4
2	40	<20	3
3	40	<20	<2
4	80	40	4
5	40	<20	<1
6	230	<20	<1
7	<20	<20	<1
8	40	20	<1
9	<20	<20	<1
10	340	140	8
11	20	<20	<1
12	800	40	3
13	2,400	1,300	27
18	20	20	<1
19	80	80	<1
20	1,100	300	11
22	90,000	110	140
25	900	20	2
Avg	5,351	129	12
Num	18	18	18
Std Dev	20,539	292	32
Max	90,000	1,300	140
Min	20	20	1

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Table 23. Coliform and Enterococcus Bacteria in Surface Waters, April, May 1990

5 April 1990*				10 May 1990			
Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)	Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	160,000	160,000	135	1	70	20	26
2	160,000	9,000	54	2	20	<20	3
3	80,000	14,000	135	3	40	20	5
4	160,000	7,000	279	4	20	<20	7
5	28,000	3,000	181	5	<20	<20	1
6	2,800	60	8	6	40	<20	4
7	22,000	700	49	7	<20	<20	1
8	18,000	800	38	8	130	<20	<1
9	30,000	2,200	70	9	20	<20	<2
10	7,000	800	90	10	3,300	500	70
11	50,000	800	74	11	220	220	<1
12	160,000	50,000	3,100	12	40	<20	8
13	160,000	160,000	4,808	13	8,000	1,100	12
18	800	80	12	18	20	<20	3
19	500	220	28	19	60	90	215
20	90,000	9,000	244	20	30,000	2,100	86
22	160,000	160,000	6,510	22	Water too low to sample		
25	160,000	1,700	186	25	<20	<20	4

* 0.5 inch rainfall on 4 April 1990

	5 April Total	5 April Fecal	5 April Enterococcus		10 May Total	10 May Fecal	10 May Enterococcus
Avg	78,728	32,186	888	Avg	2,298	248	24
Num	18	18	18	Num	17	17	17
Std Dev	67,994	58,251	1,643	Std Dev	7,056	536	52
Max	160,000	160,000	6,510	Max	30,000	2,100	215
Min	500	60	8	Min	20	20	1

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Table 24. Coliform and Enterococcus Bacteria in Surface Waters, June, July 1990

7 June 1990				12 July 1990			
	Coliform				Coliform		
Station	Total	Fecal	Enterococcus	Station	Total	Fecal	Enterococcus
	(MPN/100ml)		(Colonies/100ml)		(MPN/100ml)		(Colonies/100ml
1	<20	<20	3	1	80	80	1
2	<20	<20	3	2	40	<20	1
3	<20	<20	3	3	90	<20	<1
4	20	20	<1	4	20	<20	<1
5	20	20	<1	5	20	<20	<1
6	230	130	15	6	<20	<20	<1
7	20	<20	1	7	20	20	1
8	40	<20	<1	8	20	<20	<1
9	20	20	1	9	80	20	1
10	700	500	10	10	1,300	300	14
11	170	20	2	11	110	20	<1
12	130	20	10	12	70	20	4
13	24,000	3,000	20	13	220	80	9
18	1,700	1,700	5	18	20	<20	<1
19	80	<20	3	19	20	20	1
20	90,000	24,000	7	20	5,000	220	18
22	<160,000	<160,000	169	22	3,000	230	28
25	40	<20	<1	25	20	<20	1
Avg	15,402	10,532	24	Avg	563	64	5
Num	18	18	18	Num	18	18	18
Std Dev	40,831	38 660	52	Sta Dev	1,292	86	7
Max	160,000	160,000	169	Max	5,000	300	28
Min	20	20	1		20	20	1

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Table 25. Coliform and Enterococcus Bacteria in Surface Waters, August, September 1990

2 August 1990				9 September 1990			
Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)	Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	<20	<20	<1	1	<20	<20	<1
2	<20	<20	<1	2	20	20	<1
3	40	<20	<1	3	110	40	2
4	<20	<20	<1	4	40	<20	<1
5	100	40	<1	5	20	<20	5
6	20	<20	<1	6	40	20	<1
7	<20	<20	<1	7	40	40	<1
8	20	<20	<1	8	20	<20	<1
9	230	230	<1	9	1,700	500	<1
10	40	20	<1	10	70	20	2
11	20	20	<1	11	80	20	2
12	220	130	1	12	80	20	2
13	2,400	800	66	13	1,700	1,700	82
18	<20	<20	<1	18	<20	<20	<1
19	20	20	1	19	500	500	35
20	<20	<20	<1	20	170	80	<1
22	7,000	1,300	11	22	2,400	1,300	5
25	<20	<20	<1	25	20	<20	<1
Avg	560	153	5	Avg	392	243	8
Num	19	18	18	Num	18	18	19
Std Dev	1,651	332	15	Std Dev	711	473	20
Max	7,000	1,300	66	Max	2,400	1,700	82
Min	20	20	1	Min	20	20	1

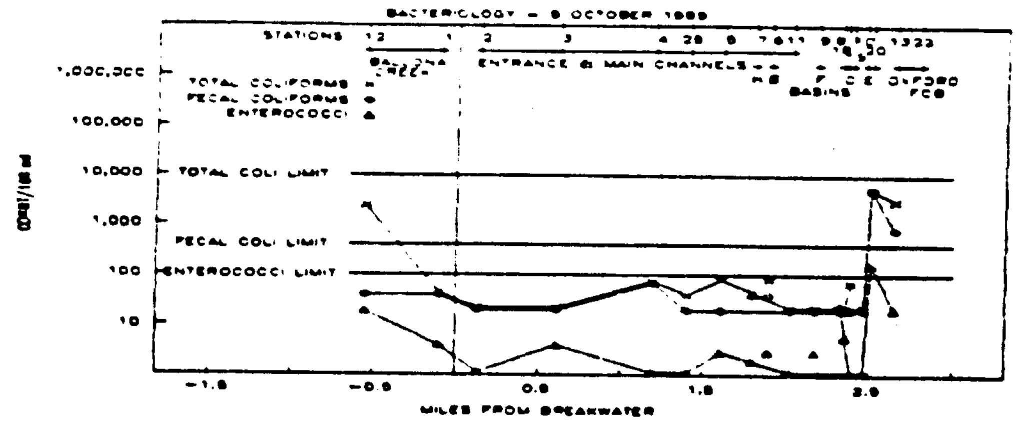

Figure 158. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 5 October 1989. Public health limits are indicated by transverse lines.

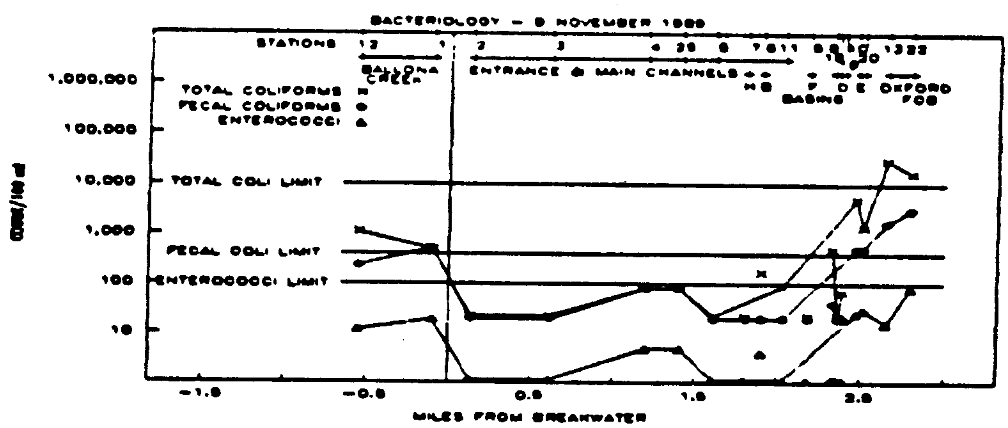

Figure 159. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 9 November 1989. Public health limits are indicated by transverse lines.

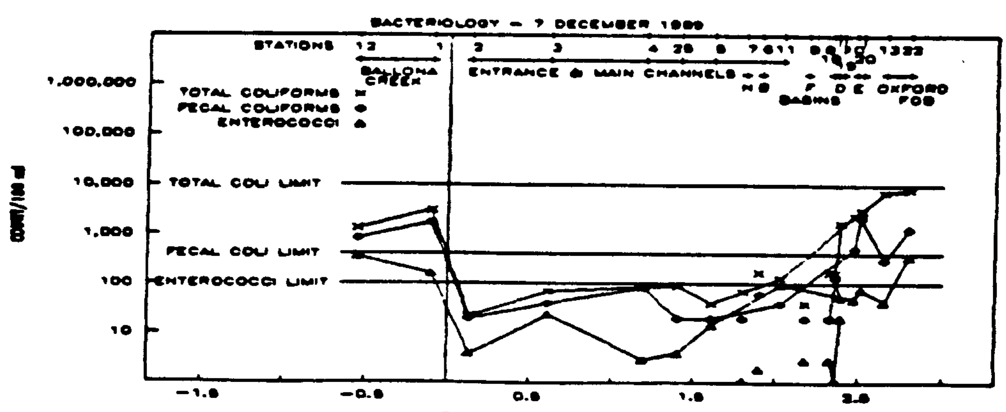

Figure 160. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 7 December 1989. Public health limits are indicated by transverse lines.

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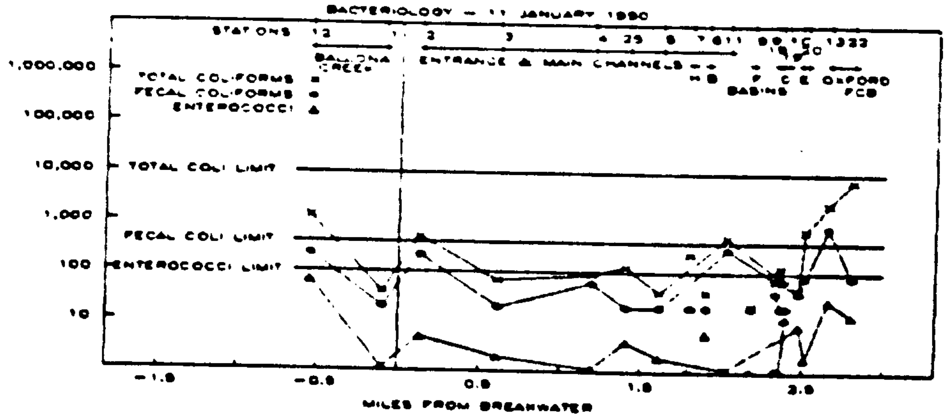

Figure 161. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 11 January 1990. Public health limits are indicated by transverse lines.

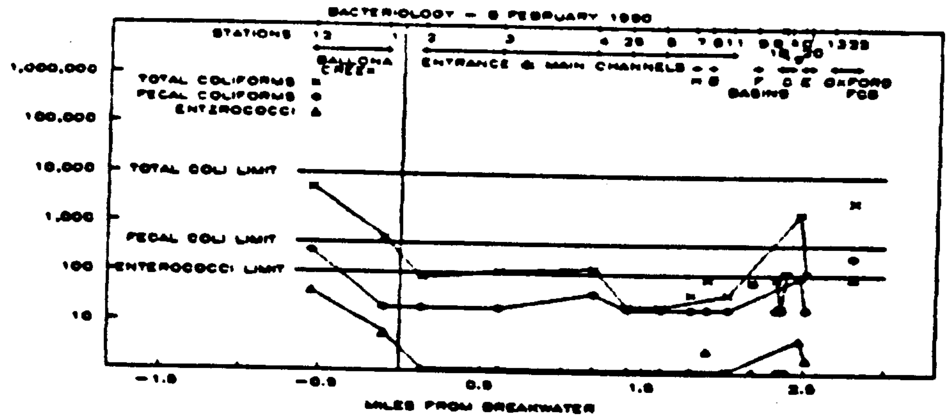

Figure 162. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 8 February 1990. Public health limits are indicated by transverse lines.

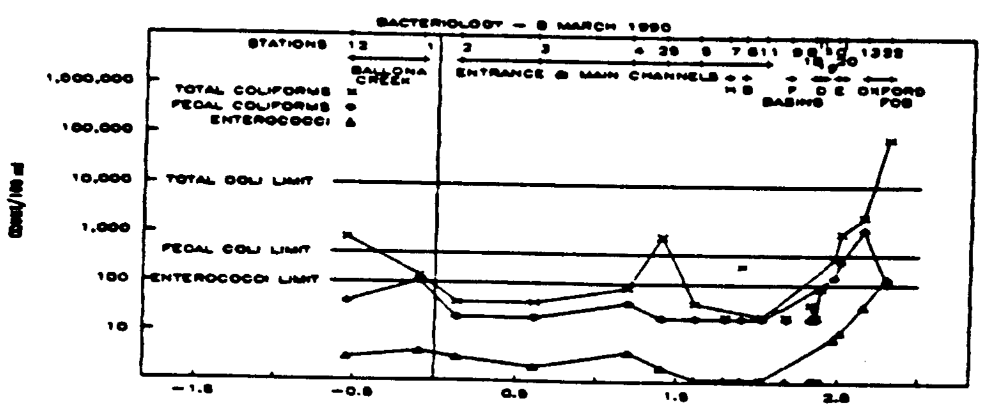

Figure 163. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 8 March 1990. Public health limits are indicated by transverse lines.

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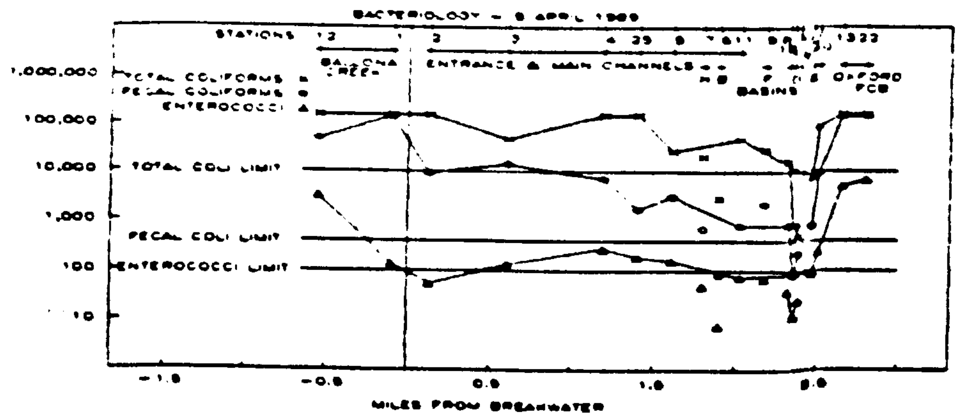

Figure 164. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 5 April 1990. Public health limits are indicated by transverse lines.

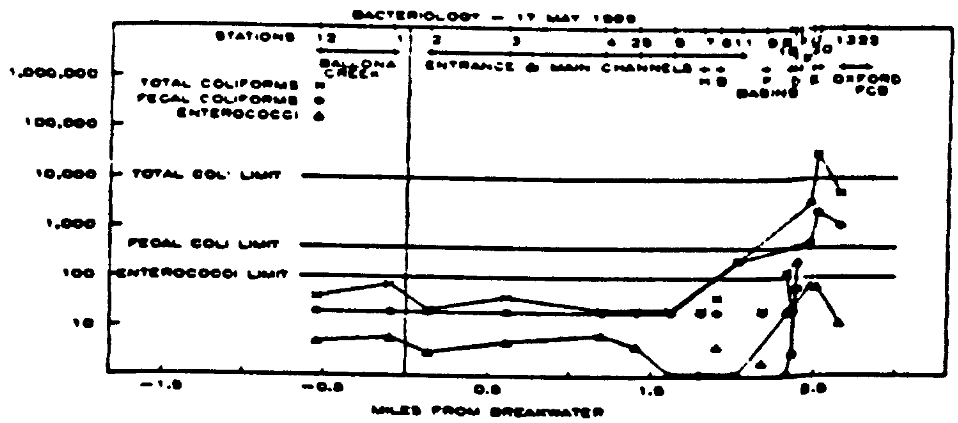

Figure 165. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 17 May 1990. Public health limits are indicated by transverse lines.

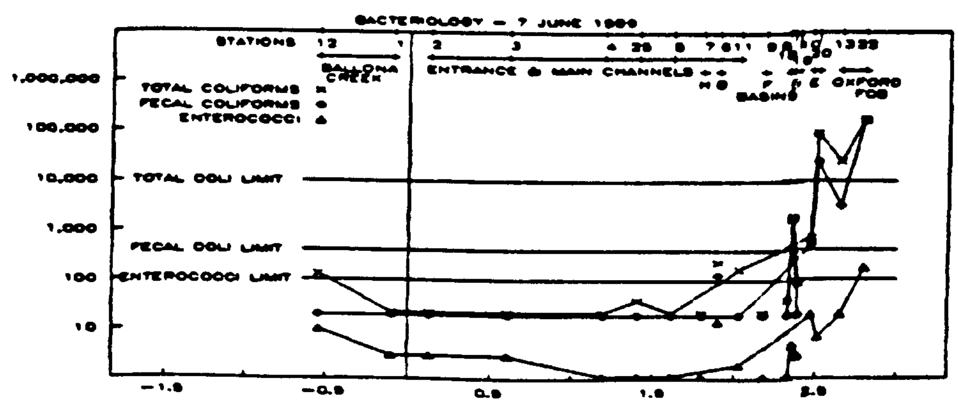

Figure 166. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 7 June 1990. Public health limits are indicated by transverse lines.

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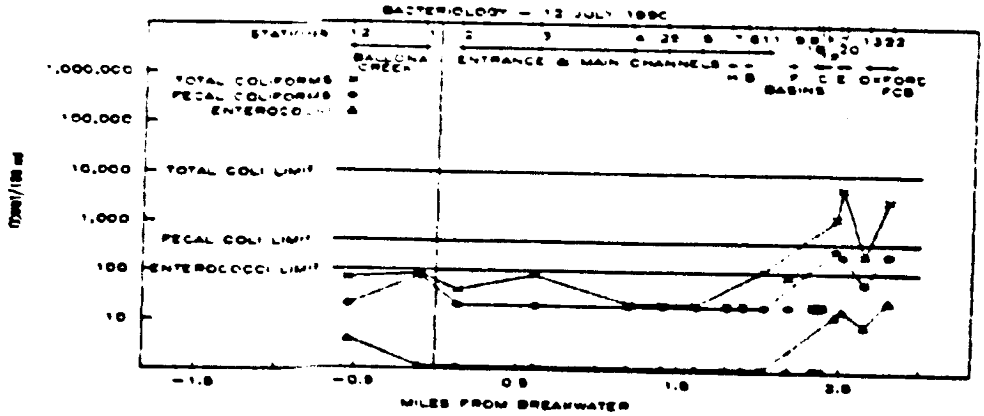

Figure 167. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 12 July 1990. Public health limits are indicated by transverse lines.

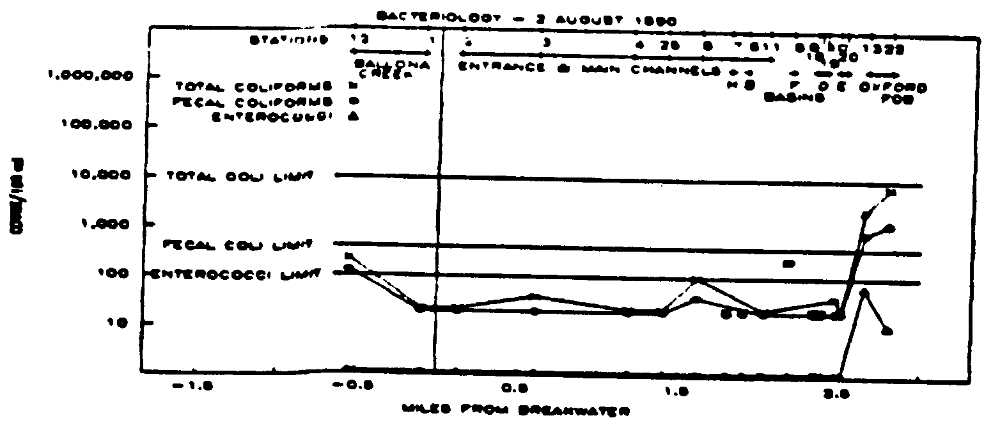

Figure 168. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 2 August 1990. Public health limits are indicated by transverse lines.

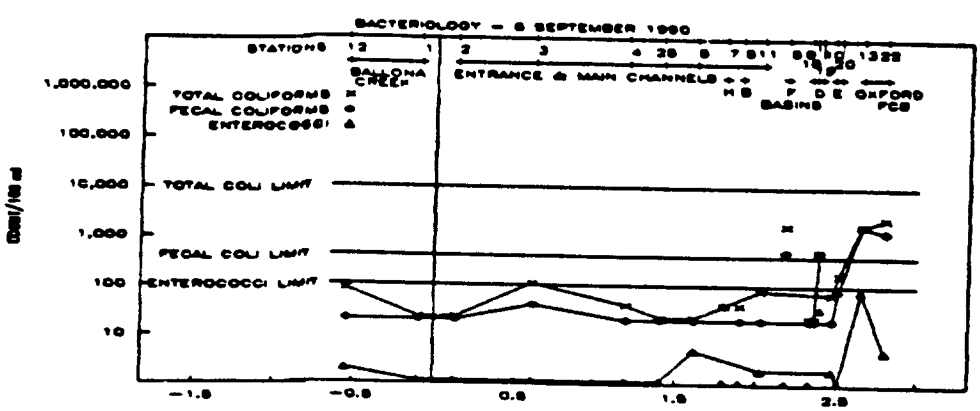

Figure 169. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 6 September 1990. Public health limits are indicated by transverse lines.

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VII. BENTHIC ORGANISMS

INTRODUCTION

Benthic organisms, those living in or on the bottom (benthos), are very important components of the fauna of soft bottomed estuaries and marinas. The fauna usually consists largely of polychaete annelid worms, molluscs and crustaceans, although in polluted or disturbed areas the diversity in major groups may be reduced to polychaetes and other worms such as nematodes and oligochaetes.

Benthic organisms are good indicators of environmental stress, since they are predominantly sedentary, sessile or attached, and thus subjected to any environmental insults. Larvae of some species are planktonic, moving about with water exchange, which provides a mechanism for recolonization following impacts.

PROCEDURES

Field sampling was conducted on 12 October 1989 from the University of Southern California research vessel *Golden West*. A Campbell grab (modified Van Veen) which samples 0.1 m^2 of surface was used at 12 stations. While the Reineke box corer is a more accurate sampling device, it is not possible to operate a large enough vessel to accommodate it within the narrow confines of the innermost areas of the basins where many water quality stations are located.

Samples were washed through a 0.5 mm screen and preserved with 10 percent buffered formalin in the field. They were rough sorted to major taxa from debris and transferred to 70 percent ethanol in the laboratory prior to identification and enumeration by taxonomists. Numbers of individuals are multiplied by 10 for calculation of the numbers per m^2 of bottom sampled.

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Species were ranked according to the most numerous taxa for each station, so that results can be compared with previous years (Soule and Oguri, 1977, 1980, 1985, 1986, 1987, 1988, and 1990). The species diversity index (SDI), a measure of how varied the fauna is, was calculated by two methods, the Shannon-Wiener SDI and Gleason's SDI. Gleason's SDI was used during the 1970s and Shannon-Weiner SDI was addeo in 1984. Gleason's Index is more influenced by large numbers of individuals of a given species than is the Shannon-Weiner Index.

RESULTS AND DISCUSSION

Complete benthic data are presented in Appendix D. The following discussions summarize the results.

POPULATION DENSITY

The mean number of individuals per m^2 in 1989 was about the same as that in 1988, although the numbers do not approach those found in 1986 or earlier, in 1977 (Table 26). Numbers were increased in 1989 at Station 2, but the increase consisted primarily of Nematoda (roundworms), indicating a disturbed environment. Numbers decreased by about 50 percent at Station 6, by 57 percent at Station 11, and by about 68 percent at Stations 7 and 9. The total number of individuals was 151,190, up from 124,480 in 1988 due to the large number of nematodes and also to the addition of two stations.

The station, Station 25, located between the Administration building docks and the fishing pier, showed a surprisingly good benthic population even though it is located where it might be affected by the daily operations of the Life Guard's and Sheriff's Department vessels. There is far greater activity at that location than there would be at a recreational dock in terms of possible oil and gas contamination, and also there are many birds resting and feeding at the adjacent fishing pier, while washdown

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Table 26. Numbers of Benthic Taxa or Species/Individuals Per Square Meter

Station	16 Sept 1977	25 Oct 1984	18 Oct 1985	23 Oct 1986	22 Oct 1987	20 Oct 1988	12 Oct 1989
1	31/29,210	60/ 6,800	38/ 5,490	55/225,520	39/ 6,530	31/11,550	25/ 1,640
2	41/75,060	48/12,260	43/ 6,190	ND	39/ 3,840	74/56,510	34/76,100
3	25/23,920	52/12,270	51/ 9,690	79/36,830	50/42,160	56/ 9,195	72/24,230
4	67/28,700	43/ 9,750	32/ 5,820	37/ 4,820	44/ 5,980	33/ 3,040	37/ 2,760
5	31/15,740	37/ 7,800	21/ 1,960	30/ 2,750	22/ 2,840	19/ 1,200	16/ 2,350
6	25/ 8,480	23/ 9,290	25/ 4,710	33/11,060	29/11,510	24/12,940	25/ 6,380
7	32/32,740	31/12,700	27/ 6,130	39/18,870	20/ 4,700	16/14,740	26/ 4,590
8	9/ 5,390	19/ 4,090	29/ 7,240	35/14,950	21/ 3,040	16/ 1,990	13/ 2,740
9	24/ 8,220	21/ 2,420	22/ 7,220	18/11,150	12/ 1,890	15/ 2,460	12/ 780
10	11/ 2,540	21/ 6,870	36/15,280	33/14,280	24/ 4,150	30/ 9,610	17/ 2,410
11	28/20,060	20/ 3,450	20/ 5,180	22/ 6,120	16/ 2,650	11/ 630	10/ 360
$\bar{X}$ (11)	29/22,733	34/ 7,972	31/ 6,811	38/34,635	29/ 8,117	30/11,260	26/11,304
12							21/18,320
25							43/ 8,530
$\bar{X}$ (13)							27/11,630
Mean without Nematodes				37/20,480	28/ 5,241		

Table 27. Shannon-Weiner (SWI) and Gleason (GI) Species Diversity Indices

Station	25 Oct '84 SWI	25 Oct '84 GI	18 Oct '85 SWI	18 Oct '85 GI	23 Oct '86 SWI	23 Oct '86 GI	22 Oct '87 SWI	22 Oct '87 GI	20 Oct '88 SWI	20 Oct '88 GI	12 Oct '89 SWI	12 Oct '89 GI
1	3.09	5.30	1.71	4.30	1.49	4.38	2.41	4.33	0.88	3.21	1.76	3.24
2	2.25	4.02	2.19	4.81	ND		2.40	4.60	2.02	6.67	0.58	2.94
3	2.44	4.35	2.78	5.45	1.86	7.42	1.46	4.60	2.95	6.03	2.84	7.03
4	2.20	3.66	2.10	3.58	2.48	4.25	2.76	4.94	2.55	3.99	2.99	4.54
5	2.25	3.20	2.13	2.64	1.90	3.66	2.04	2.64	2.23	2.54	1.42	1.93
6	1.96	1.92	2.29	2.84	2.27	3.44	1.22	2.99	1.43	2.43	1.60	2.74
7	1.87	2.55	1.67	2.98	2.12	3.86	1.96	2.25	0.76	1.56	2.18	2.97
8	1.81	1.70	1.89	3.15	2.30	3.54	1.76	2.49	1.61	1.97	1.10	1.52
9	1.83	1.98	1.06	2.36	1.50	1.82	1.19	1.46	1.70	1.79	1.88	1.65
10	1.82	1.80	2.19	3.36	2.24	3.34	2.10	2.76	2.22	3.16	1.58	2.06
11	2.04	1.82	1.39	2.22	1.91	2.41	1.39	1.90	1.90	1.56	1.99	1.53
$\bar{X}$ (11)	2.14	2.93	1.94	3.42	2.00	3.81	1.88	2.90	1.88	3.17	1.81	2.92
12											0.55	2.04
25											2.37	4.64
$\bar{X}$ (13)											1.76	2.99

water from parking lots drains into the area. However, it is not located in a deadend basin, and therefore water circulation is better.

Station 12, in Ballona Creek, has been sampled in some years but in other years it has not been possible to sample due to debris accumulation or to low tides which make the station inaccessible for benthic sampling. Station 12 had the highest levels of volatile solids, total organic carbon, chemical oxygen demand, oil and grease and organic nitrogen of all stations sampled.

NUMBERS OF SPECIES

The mean number of species for the eleven stations previously surveyed dropped slightly, from 30 per m^2 in October 1988 to 26 in 1989 (Table 26). If the new station, Station 25, and the Ballona Creek station, Station 12, are added, the mean number increases to $27/m^2$. The decrease is due in part to a decrease from 74 species to 34 species/m^2 at Station 2, and to decreases in the inner basins, particularly in Basin E at Station 10. There were substantial increases at Station 3 and 7.

Reasons for the declines at Stations 2, 9 and 10 are not readily apparent, but may be linked to the lack of heavy enough rainfall runoff in recent years to leanse the Marina and Ballona Creek by carrying the finest sediments, to which pollutants complex or adhere, seaward.

Sand deposition and uneven dredging at Station 2 has led to a buildup of polluted sediments at the entrance to the Marina. Station 10 has had a history of high metals contamination and Stations 2 and 10 have had high pesticide levels (Soule and Oguri, 1988; 1990). Populations at Station 11 had already decreased greatly between the 1987 and 1988 surveys, following construction of new docks in a formerly open area there. Stations 10, 9, 11, and 2 are the most polluted in descending order, within the Marina. In all, there were declines at 7 of 11 stations.

The total number of species or taxa in October 1989 was 164, up from 148 in the 1988 sampling and 117 in 1987. More than 40 of the 164 were single occurrences (count of 10/m^2), however. The species, or higher taxa if not identifiable to species level, are listed in Appendix D according to station occurrence and numbers of individuals calculated per square meter.

Figure 170 illustrates the general pattern of species numbers for all surveys in the 1980s, indicating the lower numbers of species per station in the inner basins, with several stations in 1989 having lower numbers than in prior years. Variation has generally been greatest at Stations 1 through 3. Figure 171 shows similar patterns and ranges for autumn surveys during 1976-1979, but with a large drop in numbers at Station 3 in 1977, suggesting some perturbation from Ballona Lagoon.

SPECIES DIVERSITY

The species diversity index (SDI) decreased slightly under both the Shannon-Weiner (S-W) and Gleason's methods. Although the Marina soft bottom habitat environment probably leads to a lower SDI than some other habitats might, the Marina SDIs remain low. The hypothetical S-W SDI would range from 2.4 to 4.3, and some Entrance Channel stations (3, 4) achieve the lower level, but the inner basins do not, and thus the means are lower.

One would expect the Marina to maintain a mean S-W SDI of at least 2.00, as it did in 1984 and 1986, but it has not, dropping gradually from 2.14 in 1984 to 1.88 in 1988 to 1.81 in 1989 for the 11 Marina stations or 1.76 for 13 stations. There were increases in the S-W SDI at six stations and decreases at the rest (Table 27).

Figure 172 illustrates the wide range of variation that has occurred over the 1980s monitoring periods in S-W SDI at Stations 1 through 3, as well as the decrease at Station 8 in 1989. In Figure 173, the S-W SDI

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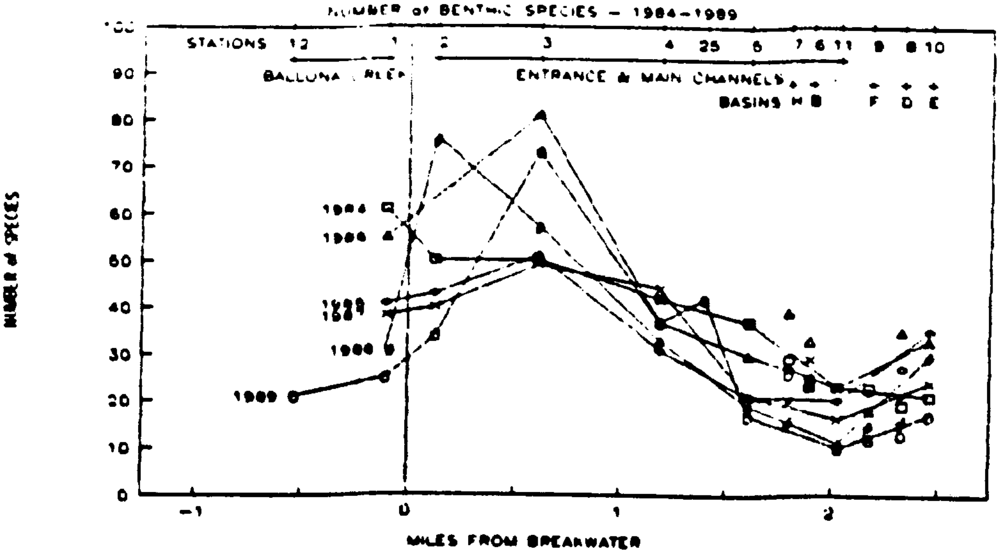

Figure 170. Numbers of benthic species per station, 1984–1989.

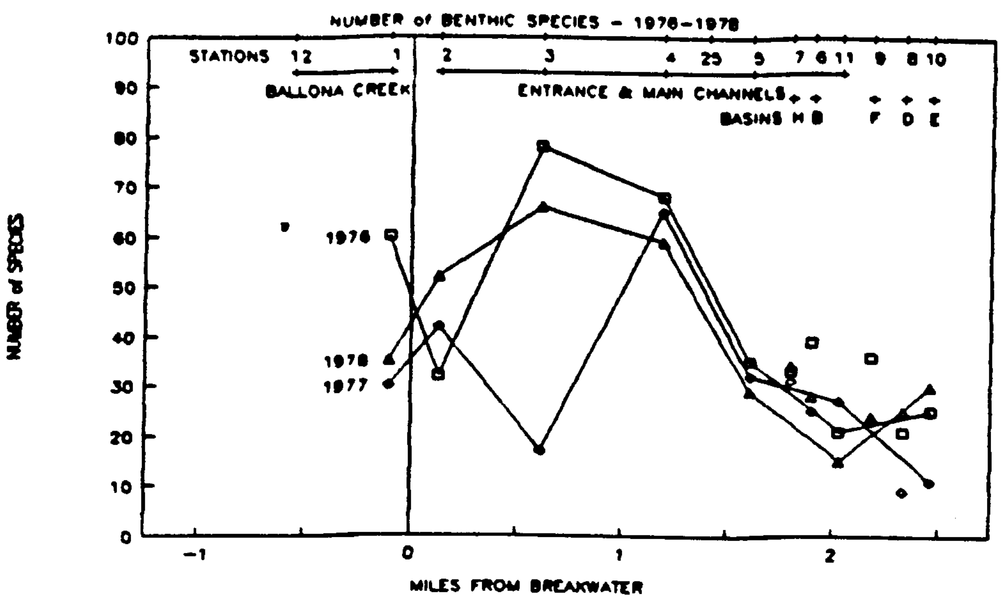

Figure 171. Numbers of benthic species per station, 1976–1979.

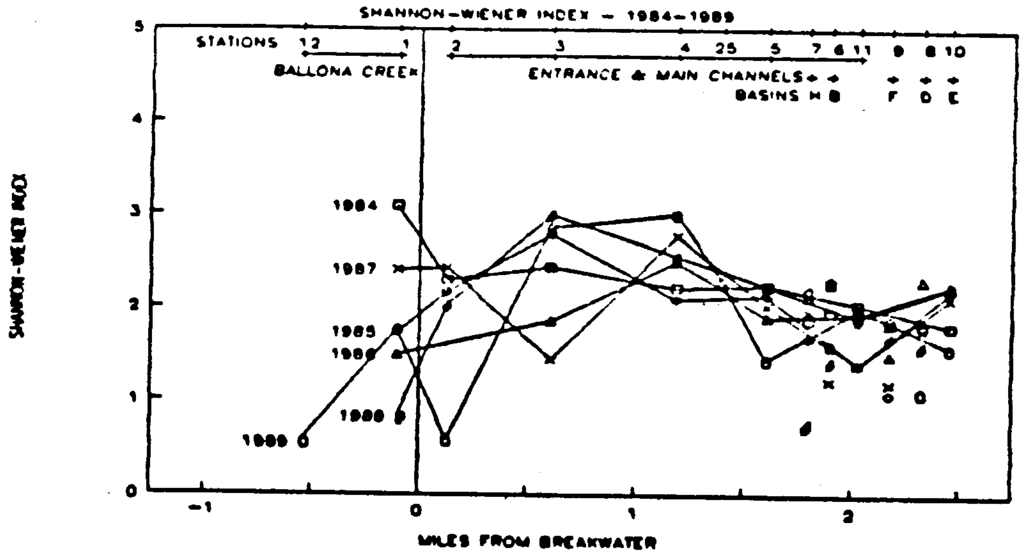

Figure 172. Shannon-Wiener Species Diversity Index, 1984-1989.

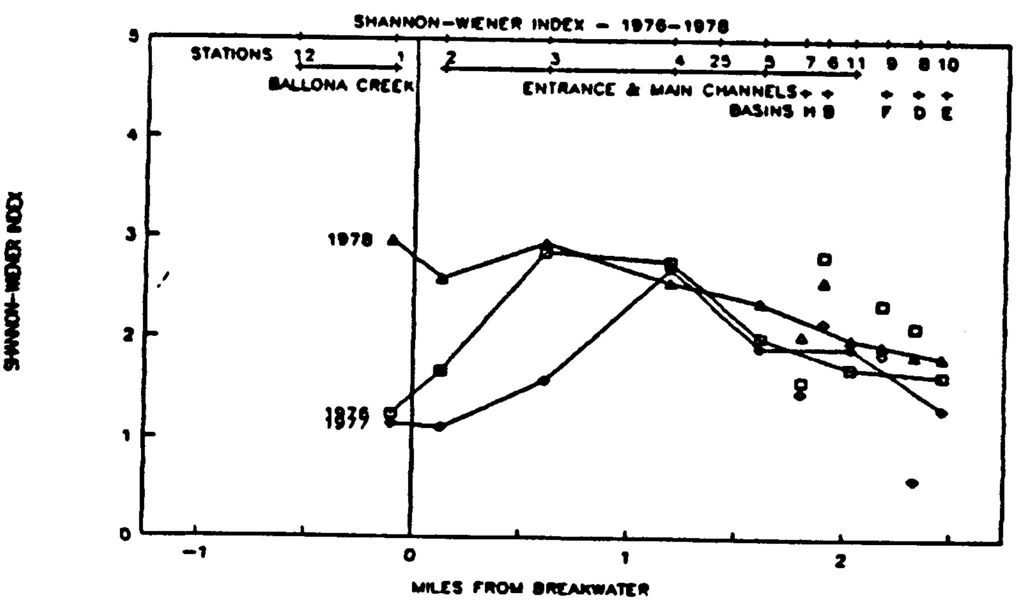

Figure 173. Shannon-Wiener Species Diversity Index, 1976-1979.

showed lower values in 1976 and 1977 in the Entrance Channel and higher values in Basin B, Station 6.

The Gleason's SDI has ranged from 2.90 in 1987 to 3.81 in 1986, with an October 1989 value of 2.92 for 11 stations and 2.99 for 13 stations. There were increases at five stations, but this was masked by large decreases at Stations 2 and 5.

Increases in the SDI agreed under both methods at Stations 1, 4, 6, and 7. Decreases agreed under both methods at Stations 2, 5, 8, and 10. The Gleason's SDI has in the past appeared to follow the pattern of higher values in the Entrance Channel, followed by the Main Channel and inner Basins more consistently than did the S-W SDI, but the deterioration at Station 2 in 1988 and 1989 has altered the channel pattern. Station 10, which has had a higher SDI than expected since 1985, given the runoff from the Oxford Flood Control Basin, has declined since then and now has an SDI little different from that in the other inner basins.

SPATIAL DISTRIBUTION AND DOMINANT SPECIES

The numerically dominant species for October 1989 are listed in Table 28. The large numbers of nematodes and oligochaete worms at Station 2 dominated the counts in the entire Marina. Surface sediments at Station 2 have become much less sandy and more organic in the last few years as the sand deposited there formed a trap for fine sediments and pollutants following dredging, and lack of heavy rainfall runoff has not carried material seaward. The highest Volatile Solids, Total Organic Carbon, Chemical Oxygen Demand and Oil and Grease values occurred at Stations 12 and 2, suggesting a spill during the year in Ballona Creek. High Chlordane and Aroclor 1254 levels probably originated through drainage or dumping directly into the Marina rather than from the creek (See Sediment

Contamination section.

Nebalia pugettensis, a shrimplike crustacean that is common in shallow coastal waters, occurred in large numbers at Station 12, in the creek bed. Most of the numbers are otherwise dominated by polychaete worms, with a few crustacean and molluscan species.

If the species are listed in order of the number of occurrences in the Marina, the nematodes and *Nebalia* drop far down the list into the 90 species that occurred only at one station in October 1989. Forty of these were collected as single specimens (counted as 10 individuals when calculated to the square meter). Table 29 shows species ranked by number of station occurrences (righthand column), with *Mediomastus ambiseta* occurring at all stations except Stations 12 and 1, and *Psuedopolydora paucibranchiata* occurring at all except at Stations 12, 1 and 2. Most species in the higher ranks are again polychaetes, with a few crustaceans and molluscs in the groups with three or more station occurrences. Interestingly, the arrow goby (fish) *Clevelandia ios* was taken in the grab sampler at three stations.

Station 1

Station 1 is located at the mouth of Ballona Creek where it mingles with waters from the Marina inside the breakwater and the ocean. The Creek is a flood control channel for a large urban area of the western and central Los Angeles area, receiving urban runoff, accidental spills of various sorts, and illegally dumped trash or waste. Tidal flow carries waters up the creek and tidal exchange flushes the Marina into Santa Monica Bay, all of which influence conditions at Station 1.

The number of species decreased by 20 percent at Station 1 in October 1989, and the number of individuals decreased by 86 percent, but the cause is unknown, and the pollutant loading is relatively low. A vessel has been

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anchored nearby for a number of months. The fauna was again dominated by *Armandia bioculata*, although it had decreased from 84 percent of the fauna to 50 percent. Nematoda, which represented 5 percent of the fauna in 1988 sampling, were not found at the site. For the first time, two crustaceans, the cumacean *Leptocuma forsmani* and the amphipod *Synchelidium shoemakeri* appeared in the most numerous taxa at this location. The dominant taxa are as follows:

Species	Percent
Armandia bioculata	50.00
Apoprionospio pygmaea	24.39
Leptocuma forsmani	6.10
Synchelidium shoemakeri	2.44
Microspio maculata	1.83

Station 2

Located at the entrance of the Marina between the north and south jetties, this station has deteriorated faunally in recent years due to a buildup of organic matter at the sandbar inside the entrance and along the south jetty. Lack of significant rainfall has kept the fines from being carried out into the ocean, as would normally occur during storm periods. The grain size has shifted to >70 percent fine silt, approaching conditions in the inner basins, and these have high levels of Total Volatile Solids, Total Organic Carbon, Immediate Oxygen Demand, Chemical Oxygen Demand, Oil and Grease, Lead, and Organic Nitrogen.

The dominant species are as follows:

Species	Percent
Nematoda, unid.	85.41
Oligochaeta, unid.	11.17
Schistomeringos longicornis	0.99
Neanthes acuminata	0.57
Armandia bioculata	0.39
Capitella capitata	0.25

In October 1988, the fauna was dominated by 35.53 percent Oligochaeta

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but few Nematoda. In October 1989, nematodes had increased to form 96.56 percent of the population, and the three clam species found in 1988 (Soule and Oguri, 1989) had virtually disappeared.

Station 3

Located at the tide gate buoy marking the entrance to Ballona Lagoon, Station 3 has a comparatively large grain size and is the cleanest station based on trace metal and pesticide concentrations. Flushing through the tide gate no doubt helps to reduce buildup of fine materials and organics.

In 1987 nematodes dominated this station during excavation in Ballona Lagoon for construction, forming 63.3 percent of the fauna, but in 1988 a more diverse fauna was found. The number of species increased in 1989 and the population more than doubled from the previous year, but the total number has not risen to those found in 1986 and 1987. Two crustaceans, the corophiid *Rudilemboides stenopropodus* and the amphipod *Mayerella banksia* were found. The dominant species are as follows:

Species	Percent
Pseudopolydora paucibranchiata	33.31
Rudilemboides stenopropodus	7.06
Exogone sp. *A*	6.97
Saccocirrus sp.	6.36
Oligochaeta, unid.	4.37
Mayerella banksia	4.00
Prionospio heterobranchia	3.92

Station 4

Located off the embankment riprap in front of apartment houses and west of the Coast Guard dock, this station continued to show lower numbers than it did in the 1977, when it had 67 species and 28,700 individuals/m^2, or in 1984, when it had 43 species and 9,750 individuals/m^2. In October 1988, this station had the highest Chlordane and DDT levels in the Marina. By 1989, the sediment carrying this burden had moved down to Station 2, and

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a mixture of DDT, DDD and DDE were present there, with the result that Station 4 was among the cleaner stations.

There was little change in the faunal numbers, with a slight increase in the number of species and a slight decrease in number of individuals. The crustacean *Hemigrapsus oregonensis*, found in 1988, had disappeared by October 1989, leaving a dominant fauna of polychaetes, as follows:

Species	Percent
Minuspio cirrefera	12.68
Mediomastus ambiseta	10.87
Lumbrineris ? tetraura	9.78
Cossura candida	8.33
Euchone limnicola	7.61
Pseudopolydora paucibranchiata	6.88

Station 25

Station 25 is a new station, added between the Life Guard and Sheriff's patrol docks at the County Administration Building and the public fishing dock at Fisherman's Village. It is the site of the entrance to the proposed new Playa Vista Marina. It receives drainage from restaurant and Administration parking lots, and is subjected to potential oil and grease seepage from frequently operated vessels. However, those levels were low, but the Chlordane level was among the highest, suggesting terrestrial input from adjacent wood buildings or ornamental plantings.

Benthic fauna was moderately good, with 43 species and 8,530 individuals/m^2. The number of species was higher than at the seaward Station 4 and at Station 5. Dominant fauna were polychaetes and oligochaetes, as follows:

Species	Percent
Mediomastus ambiseta	28.37
Pseudopolydora paucibranchiata	23.09
Lumbrineris lagunae	11.25
Minuspio cirrifera	6.45
Euchone limnicola	4.57
Oligochaeta, unid.	4.57

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Station 5

Station 5 is located in the middle of the Main Channel between the entrance of Basins B and H at a buoy. When storm rainfall is low, sediments that are flushed from the basins may be carried only as far as midchannel and not move farther down channel. Station 5 is a depositional area, ranked third in the amount of the finest grained sediments, with 97.65 percent. The 1989 levels of Chlordane dropped from 151 ppb to 93 ppb but DDT increased from 17.8 ppb to 80 ppb. In theory, DDT in the Marina should have long ago been degraded to DDD or DDE following the ban on its use in the USA, but either fresh applications have been made on land or deposits that have not been degraded are being uncovered and washed into the Marina. However, it is puzzling that populations were better in the 1970s when these chemicals were in widespread use.

The fauna in 1989 was typical of the polychaete species found elsewhere in the Marina, but *Pseudopolydora paucibranchiata* increased from 33.33 percent in 1988 to 61.7 percent in 1989, decreasing the species diversity indices substantially (Table 27). The dominant species were as follows:

Species	Percent
Pseudopolydora paucibranchiata	61.70
Cirriformia spirabrancha	17.45
Lumbrineris lagunae	5.11
Leitoscoloplos elongatus	2.55
Leptosynapta sp.	2.55
Mediomastus ambiseta	2.13

Station 6

Station 6 is located in the inner end of Basin B and is less polluted than most of the basins sampled, probably because it has a lower percentage of the finest grain size sediments or receives less contaminated runoff.

The polychaete *Tharyx* continued to dominate this station, the only location in the Marina where it does. In 1987 *Tharyx* provided 73.6 percent of the fauna; in 1988 it decreased to 55.55 percent and in 1989 it provided 58.9 percent. The crustacean Caprellidea, unidentifiable, dropped from the species list there, and the mollusc *Cylichnella inculta* decreased from 640 to 80 individuals. The dominant species were as follows:

Species	Percent
Tharyx sp.	58.93
Pseudopolydora paucibranchiata	15.05
Euchone limnicola	4.86
Mediomastus ambiseta	3.92
Schistomeringos longicornis	3.45
Leitoscoloplos elongatus	2.98

Station 7

Station 7 is located at the inner end of Basin H at the buoy off the launch ramp. It receives runoff from a large parking lot and a large storm drain as well as contamination which may be flushed from maintenance and boat yards.

The number of species rose at Station 7 from 16 in 1988 to 26 in 1989, but the number of individuals dropped from 14,700 to 4,590. While *Hydroides elegans* is often found in the Marina, it seldom occurs in such large numbers as it did in 1989. The dominant species were as follows:

Species	Percent
Hydroides elegans	36.82
Pseudopolydora paucibranchiata	15.25
Euchone limnicola	7.84
Lumbrineris lagunae	7.63
Tharyx sp.	6.97

Station 8

Located off Marina beach, otherwise known as Mother's Beach or Baby's Beach, this station lies outside of the sandy swimming area and seaward of the seagrass beds that border it near the innermost boat slips. The bottom is fine grained sediment with moderate levels of trace metals, including

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the highest value for mercury.

The number of species dropped from $35/m^2$ in 1986 to 21 in 1987, 16 in 1988 and 13 in 1989. The peak population was in 1986, 14,950 individuals $/m^2$, while the low was in 1988, 1,990, and there was an increase to 2,740 in 1989. The population was dominated by *Cirriformia spirabrancha*, with 71.53 percent, giving the station a low species diversity. That species formed only 6.53 percent of the population in October 1988. The dominant species are as follows:

Species	Percent
Cirriformia spirabrancha	71.53
Phoronis sp.	13.14
Pseudopolydora paucibranchiata	5.11
Euchone limnicola	2.92
Lumbrineris lagunae	2.19

Station 9

Located at the inner end of Basin F, Station 9 receives runoff from storm drains and has poor circulation, resulting in the second highest level of very fine sediment in the Marina, 98.73 percent. It had the highest DDT level within the Marina and the second highest pollution score in October 1989. The benthic fauna at this station has deteriorated, along with that at Station 11, since the new docks were constructed at the latter, creating a depositional area, although there may be no cause and effect relationship. Lack of heavy rainfall in recent years also has meant that pollutants are carried into the Basin F by stormdrain runoff but not out of it.

Station 9 has had low production of benthic fauna subsequent to 1986, when it had 18 species and 11,150 individuals$/m^2$. The population reached a new low of 780 individuals with 12 species$/m^2$ in October 1989. Dominant species were the usual polychaetes, except for the echinoderm holothurian *Leptosynapta*; holothurians are present in highly organic sediments, including places receiving human waste. Station 9 had the highest sulfide values, which increased in 1989. Dominant organisms were as follows:

Species	Percent
Pseudopolydora paucibranchiata	33.33
Lumbrineris lagunae	25.64
Cirriformia spirabrancha	14.10
Leptosynapta sp.	6.41
Mediomastus ambiseta	5.13
Leitoscoloplos elongatus	5.13

Station 10

Station 10 is the most polluted station in the Marina based on total levels of all contaminants. Located at the inner end of Basin E, near the tide gate from the Oxford St. Flood Control Basin, the area receives runoff from a large urban area. The tide gate is open to the Oxford Basin at all times except when a storm is expected, and it is cleaned of debris and reopened after a rain. Station 10 had high levels of Chlordane, DDE, tributyltin (TBT) and the PCB Aroclor 1254. PCBs had not been found in the Marina since the 1976-79 survey until 1989, when alarmingly high levels were found to have entered, perhaps through the Flood Control Basin from excavation of contaminated sediments for development on adjacent property in Los Angeles City or from Ballona Creek, or an unknown spill into the Marina. PCBs have since been carried throughout the Marina and deposited in areas of low flushing and fine sediment.

In October 1989, the number of species had declined by 44 percent and the population declined by 75 percent from October 1988. The dominant fauna were as follows:

Species	Percent
Cirriformia spirabrancha	51.87
Phoronis sp.	23.24
Pseudopolydora paucibranchiata	7.05
Euchone limnicola	4.98
Lumbrineris lagunae	2.49

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<u>Station 11</u>

Station 11 has the highest percentage, 99.26, of the finest sediments in the Marina. Located at the inner end of the Main Channel, this area was open water until the installation of new floating docks in 1987. It is high in DDT, DDE, TBT and most metals.

Since 1986, benthic fauna has decreased at Station 11 from 22 species and 6,120 individuals/m^2 to 10 species and 360 individuals/m^2. The dominant species are as follows:

Species	Percent
Euchone limnicola	27.78
Cirriformia spirabranchia	16.67
Lumbrineris lagunae	16.67
Mediomastus ambiseta	13.89
Cylichnella inculta	8.33
Tharyx sp.	5.56

<u>Station 12</u>

Station 12 does not lie in the Marina, but is located in Ballona Creek at the footbridge. In some years it has not been possible to sample due to debris in the creek bed or to insufficient water level to gain access with a large enough vessel to operate the grab sampler. The grain size at the time of sampling in October 1989 had 49.54 percent very fine sediment, lower than most Marina stations except Stations 1, 3 and 4.

The number of species was fairly high, and the number of individuals exceeded those at Marina stations except at Stations 2 and 3. This would have been decreased substantially had there been a heavy rainfall prior to sampling. A shrimplike crustacean common to shallow coastal waters and mudflats, *Nebalia pugettensis*, dominated the fauna, which indicates that the freshwater flow is not sufficient to dominate the bottom fauna. It provided 89.3 percent of the fauna, giving a low S-W SDI value of 0.55; the

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other dominant species were polychaetes, as shown as follows:

Species	Percent
Nebalia pugettensis	89.30
Neanthes acuminata	3.44
Schistomeringos longicornis	3.06
Microphthalmus sp.	1.36
Ophiodromus pugettensis	0.87

LONG TERM TRENDS

Previous monitoring records were examined to determine long term trends. In the current studies, benthic species were ranked according to the total number of individuals per square meter throughout the entire Marina (Table 28), and in Table 29 they were ranked according to the number of stations at which they appeared in October 1989. Records of monitoring in October 1976 and in September 1977 and 1978 were then sorted and compared with those in October of 1984-1988 to note the most numerous species for each year for the nine years of fall sampling. The number following the total count in Table 29 is the number of years surveyed in which the species has occurred.

There were 17 species or other taxa that appeared in all nine autumn surveys, of which two are fine sediment molluscs; the others were Nematoda, Oligochaeta and other polychaete worms. Eight other species were present eight out of nine years, of which two were molluscs, two crustaceans and the rest worms. This indicates that there is a resident core of species characteristic of the soft bottom marina environment. There were an additional 143 species present in at least 50 percent of the time periods sampled.

The taxonomy of nematodes and oligochaetes has not been adequately enough advanced in the literature to permit more precise identification of those groups and each is listed as a single entity, which may result in other dominant species were polychaetes, as shown as follows:

Species	Percent
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Neanthes acuminata	3.44
Schistomeringos longicornis	3.06
Microphthalmus sp.	1.36
Ophiodromus pugettensis	0.87

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The taxonomy of nematodes and oligochaetes has not been adequately enough advanced in the literature to permit more precise identification of those groups and each is listed as a single entity, which may result in underestimation of species diversity. Nematodes appear in large numbers intermittently, as noted in Table 30, being significant in 1977, 1986 and 1989 at a single station each time.

In 1976-1978, 96 species appeared one or more of the three autumn surveys which were not recorded in the 1980s; 62 of these occurrences were in one period only. There were 364 species present in one or more of the six autumn surveys in 1984-1989, 126 of which were not identified as present in the 1970s; 125 taxa were recorded only in one period.

Of the total of 460 taxa reported in all autumn surveys, 187 species, or about 41 percent of the taxa, were recorded only one time; some of these were unusual for the area, some were juveniles unidentifiable to species, or otherwise unrecognized taxa. A few represented bottom fish not usually caught or freshly deposited fauna from boat scrapings. Some of these records also may be artifacts of identifying more recently described species, whereas each revision of a taxon is included under a single name to avoid duplication.

The benthic fauna is thus about 50 percent a stable group of species or taxa and about 50 percent incidental. The numbers of individuals varies greatly in response to a number of factors including localized impacts and natural succession. The opportunistic species, those that reproduce year around, can usually outcompete others with seasonal reproductive periods, and may dominate the fauna for short or long periods.

There was a decrease in the so-called pollution indicator species *Capitella capitata* in the 1980s, but other species of similar habitat preferences, though perhaps not as pollution tolerant, dominate the present benthos. The highest mean number of species in the 1970s autumn sampling occurred in 1978, when 37 species/m^2 were found, but only 9,040 individuals/m^2 were counted (Soule and Oguri, 1980). In contrast, in

1986, when 38 species were found, counts were 34,635/m^2.

CONCLUSIONS

The benthic fauna are influenced by many factors, including normal water temperature changes, the timing and magnitude of rain events, pollutant burden, accidental spills, localized disturbances such as propeller wash excavations, dumping of household cleaning products and holding tank chemicals.

There is a large natural variation in the presence and population numbers of the dominant species, and a greater variation in the presence/absence of non-dominant species.

No single parameter of pollutant measured correlates directly with the low incidence of species and populations in the innermost basins.

The areas of poorest fauna are in those areas with poor flushing; however, the large and continuing decreases at Stations 9, 10 and 11 suggest that impacts are due to other factors as well. The degradation associated with construction of new slips at Station 11 might be due to reduction in flushing alone, or to chemicals present such as those used in construction and/or vessel antifouling. It is clear, however, that Station 11 has been heavily impacted by that change.

The trend toward increased moorings and decreased open water suggests that benthic fauna will continue to decline, especially in years with little heavy rainfall or oceanic storms.

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Table 28. Dominant benthic species in Marina Del Rey, 12 October 1989. Species are rank ordered by total count per square centimeter in the entire Marina, with counts of individuals given for each station. Stations are listed in order of distance from the breakwater, with Station 12 located in Ballona Creek and Station 1 off the mounth of Ballona Creek.

Taxa\Station	12	1	2	3	4	25	5	7	6	11	9	8	10	TOTAL
Nematoda, unid.			65,000											65,000
Neballa pugettensis	16,360													16,360
Pseudopolydora paucibranchiata				8,070	190	1,970	1,460	700	960	10	260	140	170	13,920
Oligochaeta, unid.			8,500	1,060		390			10					9,960
Tharyx sp.					90	30		320	3,760	20	10	10		4,240
Cirriformia spirabrancha				340			410	20	20	60	110	1,960	1,250	4,170
Mediomastus ambiseta			140	530	300	2,420	50	250	250	50	40	30	40	4,100
Lumbrineris lagunae					80	960	120	350	90	60	200	60	60	1,980
Schistomeringos longicornis	560		750	220		140			220				10	1,900
Exogone sp. *A*				1,690		20			10				10	1,730
Rudilemboides stenopropodus				1,710										1,710
Hydroides elegans								1,690						1,690
Euchone limnicola					210	390	40	360	310	100	20	80	120	1,630
Saccocirrus sp.				1,540										1,540
Prionospio heterobranchia			130	950	70	290			60				10	1,510
Armandia bioculata	10	820	360	240										1,430
Phoronis sp.				50			40	40	150		10	360	560	1,210
Neanthes acuminata	630		430			10						10	30	1,110
Mayerella banksia			40	970		50								1,060
Minuspio cirrifera	30				350	550			10					940
Tagelus subteres			50	540	20	150	20							780
Hesionura coineaui difficilis				750										750
Caecum californicum				750										750
Leitoscoloplos elongatus					180	160	60	30	190		40	30	40	720
Protodorvillea gracilis				670										670
Total species in survey	28	30	34	77	42	48	21	31	30	15	17	18	22	164
Total individuals in survey	18,320	1,640	76,100	24,230	2,760	8,530	2,350	4,590	6,380	360	780	2,740	2,410	151,190

Table 29. Benthic Species Ranked by Total Number of Station Occurrences, 12 October 1989. Station order is based on distance of the station from the breakwater, with Station 12 located in Ballona Creek. Not included are species with counts of less than 100 at one station

Taxa \ Station	12	1	2	3	4	25	5	7	6	11	9	8	10	Total	Station Occur.
Mediomastus ambiseta			140	530	300	2,420	50	250	250	50	40	30	40	4,100	11
Pseudopolydora paucibranchiata				8,070	190	1,970	1,450	700	960	10	260	140	170	13,920	10
Lumbrineris lagunae					80	960	120	350	90	60	200	60	60	1,980	9
Euchone limnicola					210	380	40	380	310	100	20	80	120	1,630	9
Cirriformia spirabrancha				340			410	20	20	60	110	1,960	1,250	4,170	8
Leitoscoloplos elongatus					180	150	60	30	190		40	30	40	720	8
Leptosynapta sp.				30		30	60	10	10		50	30	10	230	8
Tharyx sp.					90	30		320	3,760	20	10	10		4,240	7
Phoronis sp.				50			40	40	150		10	360	560	1,210	7
Schistomeringos longicornis	560		750	220		140			220				10	1,900	6
Prionospio heterobranchia			130	950	70	280			80				10	1,510	6
Spirorbidae, unid.				10				250						510	6
Cylichnella inculta						10	30	50	80	30			40	240	6
Chaetozone corona					40	40	20			10	20		20	150	6
Neanthes acuminata	630		430			10						10	30	1,110	5
Tagelus subteres			50	540	20	150	20							780	5
Paranemertes sp. A	10	10		90	10	10								130	5
Laevicardium substriatum	10			40	40	20						10		120	5
Oligochaeta, unid.			8,500	1,060		390			10					9,960	4
Exogone sp. A				1,690		20			10				10	1,730	4
Armandia bioculata	10	820	300	240										1,370	4
Minuspio cirrifera	30				350	550			10					940	4
Capitella capitata	10		190			190				10				400	4
Lumbrineris sp.	10		50	210	80									350	4
Notomastus tenuis			20	260				20			10			310	4
Sphaerosyllis californiensis	10		20	210				10						250	4
Protothaca staminea	10			110		40	10							170	4
Mayerella banksia			40	970		50								1,060	3
Apoprionospio pygmaea		400	70		10									480	3
Polyophthalmus pictus	50	20		380										450	3

Table 29. Benthic Species Ranked by Total Number of Station Occurrences, 12 October 1989. (cont.)

Taxa \ Station	12	1	2	3	4	25	5	7	6	11	9	8	10	Total	Station Occur.
Scoloplos acmeceps				390	10				10					410	3
Microphthalmus sp.	250		10	20										280	3
Mysidacea, unid.						30		70	50					150	3
Pontogeneia intermedia	10							20	90					120	3
Tubulanus polymorphus				30	40							10		80	3
Melanochlamys diomedea			10	40		20								70	3
Clevelandia ios			10			30				10				50	3
Nephtys caecoides		20		20					10					50	3
Pagurus sp.			10	340										350	2
Mediomastus acutus				160	130									290	2
Coseura candida					230			10						240	2
Oxyurostylus pacifica		20	150											170	2
Caulleriella sp., juv.				160		10								170	2
Lophopanopeus diegensis				30	80									110	2
Goniada littorea			10		90									100	2
Polycladida, unid.		10		60										70	2
Polydora ligni					10	50								60	2
Nereididae, unid. juv.				40					20					60	2
Pitar newcombianus				50		10								60	2
Lumbrineris erecta								30	20					50	2
Corophium acherusicum	20			30										50	2
Scolelepis acuta					20	30								50	2
Heteromysis odontops					40	10								50	2
Macoma nasuta			10			30								40	2
Cerebratulus californiensis			20	20										40	2
Harpacticoida, unid.			10	30										40	2
Porifera, unid.		10						30						40	2
Nemertea, unid.				20			10							30	2
Cirriformia luxuriosa									20				10	30	2
Coseura pygodactylata					20				10					30	2
Carinoma mutabilis				20			10							30	2
Cancer jordani	10		20											30	2
Cyclopoidea, unid.			10	20										30	2

Table 29. Benthic Species Ranked by Total Number of Station Occurrences, 12 October 1989. (cont.)

Taxa \ Station	12	1	2	3	4	25	5	7	6	11	9	8	10	Total	Station Occur.
Phyllodoce sp.			10	20										30	2
Hydrozoa, unid.				10	10									20	2
Chaetozone nr. *setosa*		10			10									20	2
Caprellidea, unid.			10	10										20	2
Owenia collaris		10		10										20	2
Diastylopsis tenuis		10	10											20	2
Callianassa affinis			10		10									20	2
Pyromaia tuberculata								10	10					20	2
Lineus sp.				10	10									20	2
Cooperella subdiaphana		10					10							20	2
Nematoda, unid.			65,000											65,000	1
Nebalia pugettensis	16,360													16,360	1
Streblospio benedicti						2,700								2,700	1
Rudilemboides stenopropodus				1,710										1,710	1
Hydroides elegans								1,690						1,690	1
Saccocirrus sp.				1,540										1,540	1
Caecum californicum				750										750	1
Hesionura coineaui difficilis				750										750	1
Protodorvillea gracilis				670										670	1
Demonax medius								290						290	1
Hemipodus borealis				270										270	1
Lumbrineris tetraura					270									270	1
Ophiodromus pugettensis	160													160	1
Lumbrineris limicola				150										150	1
Leptosuma foremani		100												100	1

Table 30. Dominant Benthic Species by Year, with Total Number of Individuals Each Year and Number of Years Appearing as Dominant Species.

Species	Count/ Year	No. of Years	Species	Count/ Year	No. of Years
28 October 1976			**25 October 1984**		
Streblospio benedicti	16600	6	*Euchone incolor*	13960	6
Nematoda, unid.	12400	9	*Mediomastus ambiseta*	12170	9
Mediomastus ambiseta	11340	9	*Pseudopolydora paucibranchiata*	10810	9
Capitella capitata	9820	9	Nematoda, unid.	4270	9
Cossura pygodactylata	6820	9	*Tharyx* sp.	4260	9
Lumbrineris sp.	4970	4	*Prionospio heterobranchia*	4000	9
Crepidula onyx	4730	7	*Cirriformia spirabrancha*	3650	6
Hydroides elegans	3640	7	Oligochaeta, unid.	3140	9
Pseudopolydora paucibranchiata	3350	7	*Leitoscoloplos elongatus*	3040	9
Prionospio heterobranchia	2330	7	*Capitella capitata*	2630	9
16 September 1977			**18 October 1985**		
Nematoda, unid.	65930	9	*Cirriformia spirabrancha*	14490	6
Capitella capitata	27730	9	Nematoda, unid.	6380	9
Pseudopolydora paucibranchiata	27530	9	*Caprella equilibra*	6220	4
Cossura pygodactylata	25950	4	*Pseudopolydora paucibranchiata*	5810	9
Hydroides elegans	14990	9	*Euchone incolor*	5900	6
Streblospio benedicti	13900	6	*Mediomastus ambiseta*	4710	9
Janua brasiliensis	10000	3	*Tharyx* sp.	4010	9
Mediomastus ambiseta	6900	9	*Capitella capitata*	2940	9
Gammaridae, unid.	7380	5	*Prionospio heterobranchia*	2610	9
Oligochaeta, unid.	6700	9	*Polydora ligni*	2380	9
21 September 1978			**23 October 1986**		
Pseudopolydora paucibranchiata	14380	9	Nematoda, unid.	104860	9
Mediomastus ambiseta	13760	9	*Capitella capitata*	83170	9
Cylichnella inculta	13050	9	*Pseudopolydora paucibranchiata*	40530	9
Prionospio heterobranchia	6290	9	*Cirriformia spirabrancha*	19550	6
Cossura pygodactylata	6230	4	*Prionospio heterobranchia*	13970	9
Streblospio benedicti	5480	6	*Caprella equilibra*	10870	4
Tharyx sp.	4820	9	*Euchone incolor*	9520	6
Lumbrineris sp.	3910	7	*Tharyx* sp.	7330	9
Capitellidae, unid.	3770	2	*Mediomastus ambiseta*	7080	9
Leitoscoloplos elongatus	2470	9	*Schistomeringos longicornis*	4730	9

Table 30. cont.

Species	Count/ Year	No. of Years	Species	Count/ Year	No. of Years
22 October 1987					
Nematoda, unid.	28530	9			
Tharyx sp.	10440	9			
Mediomastus ambiseta	9020	9			
Prionospio heterobranchia	5960	9			
Cirriformia spirabrancha	4880	6			
Pseudopolydora paucibranchiata	4840	9			
Euchone limnicola	1740	6			
20 October 1988					
Armandia bioculata	22940	9			
Tharyx sp.	20870	9			
Oligochaeta, unid.	20800	9			
Prionospio heterobranchia	14380	9			
Pseudopolydora paucibranchiata	7480	9			
Phoronida, unid.	3800	3			
Mediomastus ambiseta	2590	9			
Capitella capitata	2190	9			
Euchone limnicola	2140	6			
Cirriformia spirabrancha	1880	6			
12 October 1989					
Nematoda, unid.	69000	9			
Nebalia pugettensis	16300	1			
Pseudopolydora paucibranchiata	13920	9			
Oligochaeta, unid.	9960	9			
Tharyx sp.	4240	9			
Cirriformia spirabrancha	4170	6			
Mediomastus ambiseta	4100	9			
Lumbrineris lagunae	1960	9			
Schistomeringos longicornis	1900	9			
Exogone sp. A	1730	8			

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VIII. FISH FAUNA

INTRODUCTION

The fish fauna of Marina del Rey were surveyed by Harbors Environmental Projects of the University of Southern California five times during 1977-1979 (Soule and Oguri, 1980), providing the first baseline studies of the area. Various techniques were tested to determine the most effective methods of sampling. Surveys were resumed, mostly on a semiannual basis, in 1984 with the *Vantuna* Research Group of Occidental College under the direction of Dr. John S. Stephens, Jr. and his staff.

During the 15 periods surveyed, a total of 95 species or taxa of fish has been identified from fish trawls, ichthyoplankton trawls, gill netting, beach seines and diver surveys, with an average of about 40 species present at any one time.

The importance of the Marina as a local shallow water habitat cannot be overlooked (Soule and Oguri, 1990), since about 90 percent of the wetlands in Los Angeles County have been lost (U.S. Fish and Wildlife Service, 1972). The Marina has hosted 15 important backbay wetlands species, most of which are rare in the open coast shallow water. Some species have been present only as young-of-the-year (YOY) and not as adults, and some were found only as eggs or larvae. Larvae of a deep water Mictophidae were found once in 1984.

PROCEDURES

Fish surveys reported herein were performed on 11 October 1989 and 17-18 May 1990. The techniques and equipment were the same as those used since 1984. The otter trawl is a 15 ft semiballoon trawl which is towed for ten minutes at three locations (Figure 174). A 100 ft multimesh gill net is deployed at three locations for 45 minutes each, and a 100 ft beach

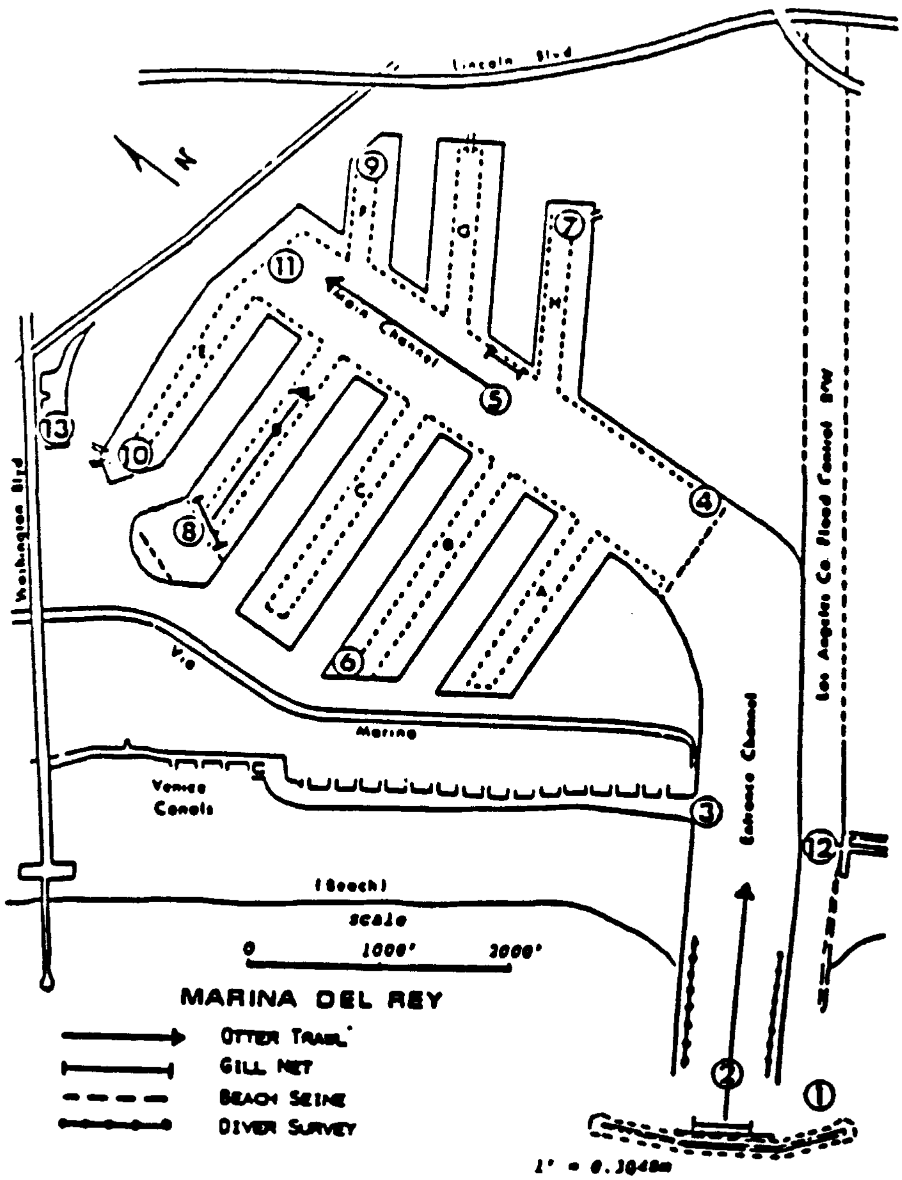

Figure 174. Fish Sampling Stations for Marina del Rey

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seine is deployed in 8 ft of water about 30 yds from the beach in Basin D near Station 8 and fished to the beach. Diver surveys are performed at the entrance breakwater and along the entrance jetties. Ichthyoplankton (eggs and larvae) are collected by towing a 333um mesh plankton net at 1 m depth for two minutes and on the bottom for three minutes.

RESULTS AND DISCUSSION

11 October 1989

A total of 35 species were identified in the October 1989 survey: 22 from diver observations, 7 from beach seines, 8 from otter trawls, 2 from gill nets and 3 from ichthyoplankton samples of eggs and larvae. This is five less than the total of 39 species in the October 1988 collection, and the lowest total for an autumn collection (Table 31); there were only 33 species in the May 1988 survey, the lowest total of all surveys.

Diver surveys in October 1989 identified the most species of all the sampling techniques, as has been usual in past surveys. The number of species in both the gill nets and ichthyoplankton collections were low, as they were in May 1989. Similarly the yield of these two techniques were at the lowest levels of all autumn collections.

Once again the total numbers of fish collected were predominantly due to the *Atherinops affinis* collected in the beach seine (Table 32). October ichthyoplankton results are presented in Table 33. Numbers of ichthyoplankton were very low, totaling 151, which was similar to the low in 1986.

The gobies *Clevelandia ios* and *Quietula y-cauda* returned to the beach seine station, but not in large numbers (Table 34). Those species were absent in October surveys in 1978 and 1988, and *Quietula* was also missing in May 1989. Both were missing in October of 1984 and 1985 as well, and

Table 31. Number of Fish Species by Month and Year per Each Sampling Technique

	1977-1979*	1980*	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 88	Oct 89	May 90
Diver Transects	14	-	20	24	19	22	20	18	24	15	24	22	22	13
Beach Seine	2	-	7	5	5	10	17	10	8	8	5	5	7	8
Gill Net	3	-	6	4	4	9	8	6	8	8	2	1	2	2
Otter Trawl	16	7	14	4	3	8	4	7	8	8	10	10	8	12
Ichthyoplankton (larvae only)	-	30+	10	7	8	11	7	9	10	8	4	4	3	14
Drop Net	-	8	-	-	-	-	-	-	-	-	-	-	-	-
Cryptic Fish	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Creel Census or visual sighting	4	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL NO. SPECIES:	35	44	47	37	38	40	41	39	40	33	39	43	35	36

*Quarterly sampling for Jan 1977 through June 1978 and 1979

*Quarterly sampling for 1980: Aug 1980, Sept 1980, Jan 1981 and April 1981

Table 32. Number of Individuals by Month and year per Each Sampling Technique.

	Jun 77	Oct 77	Jun 78	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 88	Oct 88	May 90
Beach Seine	---	---	---	186	303	241	476	400	791	70	14135	486	1253	554	3550
Gill Net	---	---	---	80	19	17	42	13	56	27	65	49	20	5	263
Otter Trawl	816	212	238	136	14	8	17	13	26	18	95	251	34	59	33
TOTAL FISH				402	336	284	535	426	873	115	14295	788	1307	618	3846
TOTAL ICHTHYOPLANKTON				42086	1853	204	134	163	859	14148	6894	6470	1327	151	1711

Table 33. Ichthyoplankton Survey, October 1989 (Larvae Only)

Species	Stations 2 S	2 B	5 S	5 B	8 S	8 B	
Gobiidae A/C	13	10	1	1	0	1	
Hypsoblennius sp.	13	12	58	23	10	7	
Oligocottus/ Clinocottus type A	2						
SUBTOTALS	28	22	59	24	10	8	TOTAL 151

S = surface B = bottom

these were all periods of warmer waters (See Physical Water Quality).

The October 1989 reduction in total number of species, especially those from gill net and ichthyoplankton samples, suggests a decline in conditions within inner Marina del Rey. This might be linked to the PCB Aroclor 1260 drainage into the inner end of the Marina, possibly from land development to the north in the City of Los Angeles, sometime between October 1988 and October 1989.

Conversely, the diver surveys showed a healthy fish population at the mouth of the harbor with many juvenile fish present. Also, the top smelt population from the inner harbor contained many young of the year.

17-18 May 1990

In the spring survey conducted on 17-18 May, 1990, 38 species were identified: 13 from diver observations, 8 from beach seines, 12 from otter trawls, 2 from gill nets and 14 from ichthyoplankton samples of eggs and larvae. The total is 5 less than in the spring of 1989 (Table 31) and it is below the 41.6 mean (Standard Deviation = 5.73) for previous spring surveys. The mean of 41.6 is below the projected equilibrium number of 46 species calculated for an embayment of Marina size by Horn and Allen (1976).

The only method of sampling that produced a drop in species numbers in the 1990 spring survey was the diver transects, which dropped by 9 species, to 13 from 22 in May 1989. This may have been the result of a low tide (-0.4) which was ebbing, causing a strong current along the north and south points at the Marina mouth, very poor visibility, and reduced substrate availability.

Based upon diver observations at the entrance, the Marina would have been considered in very poor condition, but it was, at least in part, the result of poor sampling conditions rather than environmental deterioration. With respect to the rest of the survey, species numbers per sampling technique were relatively good, but gill netting has been poor since 1988. This could possibly be related to the PCB spillage or drainage into the Marina sometime between October 1988 and October 1989.

The total fish abundance, 3,846 individuals, was almost three times the numbers of last spring (1,327) but a little more than a quarter of the May 1988 total of 14,295 (Table 32). However, these numbers are not necessarily related to the abundance within Marina del Rey, but are almost directly proportional to the amount of smelt, *Atherinops affinis* and *Atherinopsis californiensis*, caught each year. Excluding the smelt, abundance of other species has remained relatively stable.

Importantly, the gobies *Ilypnus gilberti* and *Quietula y-cauda* have returned to the beach seine station at the end of Basin D. Their absence in May 1989 may have been a reflection of the collapse of the biota in this area of Marina del Rey due to disruption of the sea grass habitat when a bubbler was used in an attempt to reduce swim beach coliform counts. *Ilypnus* and *Quietula* were absent in October surveys in 1985, 1987 and 1988. *Typhlogobius californiensis* reappeared in the Station 2 ichthyoplankton sample after being absent since May 1986.

The May 1990 fish abundance data are summarized in Table 35 for beach seine, gill net and otter trawl while ichthyoplankton abundance data are presented in Table 36. Gill net results were considerably better than in any previous year, indicating recovery of the beach area. A survey of the sea grass bed of *Ruppia maritima* in Basin D in March 1990 was made by Domenic Gregorio which showed a very patchy bed below mean lower low water outside the swimming beach safety line from the south end to beyond the handicapped ramp. This is good habitat for small forage fish and juveniles.

LONG TERM RECORDS

In all, 95 species or taxa have been reported in the total surveys conducted since 1977, as is illustrated in Table 37 by sampling period. There were three additions to the list in May 1990, all larvae: Clinidae A, *Oxylebius pictus*, and Sciaenidae complex 2. *Oxylebius pictus* is a cold water species and its temperature preference is below that generally found in Marina del Rey. The one *Oxylebius pictus* was collected at Station 8, although it is possible that it was spawned elsewhere.

Twelve species have occurred in all of the spring surveys since 1984. Of these, *Mugil cephalus* (striped mullet) remains uncommon in the Southern California Bight. This makes it an important resident of the marina. Only one fish, *Halichoeres semicinctus* (rock wrasse) which has appeared in all of the surveys since 1984 was not found this year, and *Sardinops sagax* (Pacific sardine) which had been present since 1984 has not appeared since May 1989. *Halichoeres semicinctus* adults have been observed on the diver transects. If their larvae were to be found, then it would be during the fall survey. *Sardinops sagax* is a pelagic fish and its absence from the Marina may be significant to the Bight, but not necessarily related to the health of the Marina.

CONCLUSIONS

The mean number of species for all surveys since 1976 is 40, with a range of variation between 33 and 47. The mean in 1989-90 was 36.5. The Marina appeared to be in stable condition in October 1989 and May 1990, recognizing that the larger numbers are most likely to appear in May than in October. Very large numbers of individuals reflect the presence of smelt, which move in and out of the Marina and serve as forage fish for the numerous birds and larger fish in coastal waters.

The mouth of the Marina appeared to be in poor condition in May 1990, but this may have been the result of a strong ebbing minus tide, resulting in a lower total number of species. However, the beach seine station appeared to be healthier, with the reappearance of the gobies. This is encouraging, since a PCB Araclor 1260 spillage or drainage into the inner end of the Marina sometime between October 1988 and October 1990 created cause for alarm and may have inhibited those fish normally caught in the gill net. More frequent sampling would have been needed to determine whether there was a true trend. Aroclors are known to be toxic to larvae, but since the fish populations are so linked to smelt, no conclusion can be made on numbers of individuals. PCBs sometimes create an oily sheen on the water, which may keep pelagic fish away from an area.

Although otter trawl catch since 1984 has not approached the numbers caught in the 1970s, it peaked in the 1988 surveys and has since shown moderately stable levels. Marina del Rey does not appear to have deteriorated since 1984, recognizing the cyclic nature of the population, which is influenced by natural and non-natural factors

Table 34. Fish Species and Numbers Collected, by Technique, 11 October 1989

SPECIES	DIVER TRANSECTS Breakwater Terminal	South	North	BEACH SEINE	GILL NET STATIONS 2	5	8	OTTER TRAWL STATIONS 2	5	8
Anisotremus davidsonii	6J									
Atherinops affinis	120S		50S	388			1			
	30J									
Cheilotrema saturnum	50J	6J	5J							
Chromis punctipinnis	2A,70J	2A,10S	4A,10S							
	10J	7J	30J							
Citharichthys stigmaeus								2		
Clevelandia ios				6						
Cymatogaster aggregata	1A,2J	10S								
Embiotoca jacksoni	3A,7S	10A,2S	5A,1S					1		
Engraulis mordax										24
Fundulus parvipinnis				114						
Gibbonsia elegans			1A							
Girella nigricans	13A,85S	34A,70S	8A,22S							
			50J							
Halichoeres semicinctus	7A,2S	1J								
Heterostichus rostratus		2A,1S								
Hypsopsetta guttulata								2	1	
Leptocottus armatus				3						
Micrometrus minimus	1A	8A	6A							
Mugil cephalus				1			4			
Myliobatis californica	1A									
Oxyjulis californica		2A	1A							
Paralabrax clathratus	15A,10S	3A,7S								
	4J									
P. maculatofasciatus		1A								
Paralabrax nebulifer	1A,3S	2A,2S	1A,6S					4	1	
		2J	3J							
Paralichthys californicus			1A					5	3	3
Pleuronichthys ritteri								11	1	
Quietula y-cauda				14						
Rhacochilus vacca	1A,1S		1A							
	1J									
Scorpaenichthys marmoratus	1A									
Sebastes serranoides	1A		1J							
Seriphus politus	1J								1	
Strongylura exilis				90						
Xenistius californiensis	10S		150J							
Species/Station	17	12	13	7	0	0	2	8	5	2
No. Individuals/Station	408	182	389	554	0	0	5	25	7	27
Species/Technique		22		7		2			8	

A = Adult, J = Juvenile, S = Subadult

Table 35. Fish Species and Numbers Collected, by Technique, 17-18 May 1990

SPECIES	DIVER TRANSECTS Breakwater Terminal	South	North	BEACH SEINE	GILL NET STATIONS 2	5	8	OTTER TRAWL STATIONS 2	5	8
Atherinops affinis				3502	25		233			
Cymatogaster aggregata			4J							
Embiotoca jacksoni	1A,8J	2J	1J					1		
Engraulis mordax									2	
Fundulus parvipinnis				15						
Genyonemus lineatus									18	
Girella nigricans	3S	18J								
Heterodontus francisci								1		
Heterostichus rostratus	1J								1	
Hypsopsetta guttulata				3						
Hypsypops rubicundus	2A									
Ilypnus gilberti				3					3	
Leptocottus armatus				6						
Micrometrus minimus			2J							
Mugil cephalus				1						
Myliobatus californica										2
Paralabrax clathratus	15A	4A						5		
P. maculatofasciatus		1S								
P. nebulifer	4A	1A,3S								1
Paralichthys californicus		1A	2A,1J							2
Phanerodon furcatus								1		
Quietula y-cauda				4					1	
Rhacochilus toxotes	2J									
Rhacochilus vacca	12J		1J							
Sphyraena argentea					5					
Strongylura exilis				16						
Syngnathus sp.			1A							
Species/Station	8	8	6	8	2	0	1	4	5	3
No. Individuals/Station	48	30	12	3550	30	0	233	8	21	5
Species/Technique		13		8	2				12	

A = Adult, J = Juvenile, S = Subadult

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Table 36. Ichthyoplankton Survey, May 1990

Species		Stations 2 S	2 B	5 S	5 B	8 S	8 B
Atherinops affinis	E	0	0	0	0	0	0
	L	1	0	0	0	0	0
Cheilotrema saturnum	E	0	0	0	0	0	0
	L	0	1	0	1	0	0
Clinidae type A	E	0	0	0	0	0	0
	L	1	0	0	0	0	0
Engraulis mordax	E	0	1	1	2	0	0
	L	0	0	0	0	0	0
Gobiesox rhessodon	E	0	0	0	0	0	0
	L	0	15	0	4	0	0
Gobiidae type A/C	E	0	0	0	0	0	0
	L	7	175	2	458	209	39
Hypsoblennius sp	E	0	0	0	0	0	0
	L	65	161	13	165	17	22
Hypsypops rubicundus	E	0	0	0	0	0	0
	L	0	1	0	0	0	0
Oxylebius pictus	E	0	0	0	0	0	0
	L	0	0	0	0	0	1
Paraclinus integripinnis	E	0	0	0	0	0	0
	L	0	3	0	0	0	0
Pleuronichthys verticalis	E	0	0	0	0	0	0
	L	0	1	0	0	0	0
Sciaenidae complex 2	E	0	0	0	0	0	0
	L	0	3	0	0	0	0
Seriphus politus	E	0	0	0	0	0	0
	L	0	2	0	0	0	0
Typhlogobius californiensis	E	0	0	0	0	0	0
	L	0	1	0	0	0	0
Unknown	E	141	170	8	0	0	0
	L	0	1	0	0	0	0
SUBTOTALS		215	554	24	630	226	62

TOTAL 1711

E = egg L = larvae S = surface B = bottom

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Table 37. Incidence of Fish Species in Marina del Rey, 1977-1990

Species	1977-79	1980	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90
Acanthogobius flavimanus		X					X		X	X	X	X		
Albula vulpes			X							X				
Anchoa compressa			X		X	X		X			X			
Anchoa delicatissima									X					
Anisotremus davidsoni			X	X	X	X	X	X				X	X	
Atherinops affinis	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Atherinopsis californiensis	X					X	X	X	X	X		X		
Atractoscion nobilis			X			X	X	X						
Cheilotrema saturnum		X		X	X	X	X	X	X	X	X	X	X	X
Chitonotus pugetensis											X			
Chromis punctipinnis				X	X	X	X	X	X	X	X		X	
Citharichthys stigmaeus		X	X	X					X		X		X	
Clevelandia ios	X	X	X			X	X	X		X			X	
Clinidae Type A												X		X
Clinocottus analis	X	X	X		X		X			X	X	X		
Clupeiformes			X							X				
Coryphopterus nicholsii			X					X				X		
Cottidae		X												
Cymatogaster aggregata	X					X		X				X	X	X
Embiotoca jacksoni	X		X	X	X	X	X	X	X	X	X	X	X	X
Engraulis mordax	X	X		X		X	X			X	X		X	X
Engraulididae			X			X								
Fundulus parvipinnis	X		X	X	X		X	X		X	X		X	X
Genyonemus lineatus	X	X	X		X	X		X				X		X
Gibbonsia elegans	X		X		X		X		X		X	X	X	
Gillichthys mirabilis		X					X							
Girella nigricans	X		X	X	X	X	X	X	X	X	X	X	X	X
Gobiesox rhessodon		X			X	X						X		X
Gobiidae A/C			X			X		X		X		X		X
Gobiidae D			X											
Goby A/C		X	X	X	X	X	X			X	X	X	X	X
Goby D			X	X	X	X					X			
Halichoeres semicinctus			X	X	X	X	X	X	X	X	X	X	X	
Hermosilla azurea				X	X		X				X	X		

Table 37. cont.

Species	1977-79	1980	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90
Heterodontus francisci			x	x								x		x
Heterostichus rostratus		x	x		x	x	x		x	x	x	x	x	x
Hippoglossina stomata		x				x								
Hyperprosopon argenteum				x		x								
Hypsoblennius sp.	x		x	x	x	x				x	x	x	x	x
Hypsoblennius gilberti		x					x							
H. gentilis			x		x	x	x		x					
H. jenkinsi			x	x	x			x		x		x		
Hypsopsetta guttulata	x	x	x	x			x	x			x	x	x	x
Hypsypops rubicundus	x		x	x	x		x		x	x	x	x		x
Ilypnus gilberti			x	x		x	x	x		x				x
Lepidogobius lapidus						x								
Leptocottus armatus	x					x	x	x		x		x	x	x
Lythrypnus dalli		x												
Medialuna californiensis									x					
Menticirrhus undulatus						x	x		x	x	x	x		
Micrometrus minimus			x	x	x	x	x	x	x	x	x	x	x	x
Mugil cephalus			x	x	x	x	x	x	x	x	x	x	x	x
Mustelus henlei	x								x					
Myctophidae			x											
Myliobatis californica	x					x	x	x	x		x	x	x	x
Neoclinus stephensae		x												
Oligo/Clinocottus type A													x	
Oxyjulis californica	x		x	x	x	x		x	x		x	x	x	
Oxylebius pictus														x
Paraclinus integripinnis		x			x		x					x		x
Paralabrax clathratus	x		x	x	x	x	x	x	x	x	x	x	x	x
P. maculatofasciatus	x		x	x	x	x	x	x	x			x	x	x
P. nebulifer	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Paralichthys californicus	x	x	x	x	x	x	x		x	x	x	x	x	x
Phanerodon furcatus	x					x					x	x		x
Pleuronichthys coenosus					x									
P. ritteri			x		x		x	x	x	x	x	x	x	
P. verticalis		x				x								x

Table 37. cont.

Species	1977-79	1980	May 84	Oct 84	Oct 85	May 86	Oct 86	May 87	Oct 87	May 88	Oct 88	May 89	Oct 89	May 90
Quietula y-cauda			X			X	X	X		X		X	X	X
Rhacochilus toxotes		X			X				X		X			X
R. vacca			X	X	X	X	X	X	X	X	X	X	X	X
Rhinobatis productus			X											
Rimicola muscarum	X		X	X										
Sarda chiliensis	X		X	X			X		X					
Sardinops sagax		X	X	X	X	X	X	X	X	X	X	X		
Sciaenidae complx 2											X			X
Scorpaena guttata						X						X		
Scorpaenichthys marmoratus			X									X	X	
Sebastes auriculatus			X											
S. serranoides	X		X		X	X			X	X	X		X	
Semicossyphus pulcher = *Pimelometopon pulchrum*									X		X			
Seriphus politus	X	X	X	X	X	X		X	X	X	X	X	X	X
Sphyraena argentea	X			X	X	X			X	X				X
Squatina californica					X									
Stenobrachius leucopsarus		X				X								
Strongylura exilis				X		X		X			X	X	X	X
Symphurus atricauda	X	X		X										
Synodus lucioceps		X									X			
Syngnathus sp.	X	X	X		X									X
Syngnathus leptorhynchus								X	X			X		
Typhlogobius californiensis		X	X			X								X
Umbrina roncador			X	X	X		X	X	X		X			
Urolophus halleri	X	X	X				X	X		X		X		
Xenistius californiensis				X					X				X	
Xystreurys liolepis		X	X								X			

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APPENDIX A

FIELD LOGS

1989-1990

1993/3

R0052618

CRUISE: MDR89-90 Date: 5 October 1989 Type: Water Quality

VESSEL & PERSONNEL:

D. Soule, P.I.
M. Oguri, USC
R. Bester, USC
T. Grothues USC

Bay Watch

T. Estlow
T. Bond

TIDE:
Low 0441 2.8 ft
High 1156 5.1 ft

SAMPLING STATIONS:

Left Dock 0840

WEATHER : WIND

Clear, Warm, Smoggy
E-SW - 0-7k

Martek, NH_3, Nutrients
Transmissometer, TBT, Sal.
Secchi Disk, DO, pH, FU,
Coliform

Station	Time	Observations	Comments
12	0850		Calm
1	0900		Mild Santa Ana, smoggy
2	0910		
3	0921		
4	0931		
25	0940		New Station off Shanghai Reds
5	0951		
6	1003		
18	1025		
19	1025		Hand sampled from beach
8	1035	Water very calm, dark green	
10	1052	Water cloudy, dark green	
20	1059	White scum floating	
11	1113	Water soapy, completely calm	
9	1124		
7	1139		
13	1200	Water still	Hand sampled from shore
22			Area locked - no sample

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R0052619

CRUISE: MDR 89-90 Date: 12 October 1989 Type: Benthic org., Water Coliform, Bottom Coliform, metals, pesticides

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VESSEL & PERSONNEL:

D. Soule, PI, USC
M. Oguri, USC
R. Bester, USC
R. Webber, Assoc. Lab.
D. Reynoso, USC

Golden West

K. Kevett, Operator
T. Grotheus, Tech.

TIDE:
Low 0149 0.1 ft
High 0807 5.6 ft

SAMPLING STATIONS: WEATHER:

Left Dock 0810 Overcast Campbell Grab

Station	Time	Depth	Procedure	Comments
12	0837		Bottom sediment coliform, metals, pesticides. Benthic org.	1st grab smells of sulfide, lots of small creatures. 2nd grab very heavy, too large to put through sieve
1	0906		Bottom sediment coliform, metals, pesticides. Benthic org.	Poor sample, sandy
2	0925		Bottom sediment coliform, metals, pesticides. Benthic org.	Lot of debris, strong sulfide odor, oily
3	0948		Bottom sediment coliform, metals, pesticides. Benthic org.	Very sandy, trouble sieving, large number of shells. Took 4 grabs to obtain sample
4	1020		Bottom sediment coliform, metals, pesticides. Benthic org.	Silty, lots of small crustacean and tubes
25	1040		Bottom sediment coliform, metals, pesticides. Benthic org.	Silty, very oily. Many pieces of plastic wrap
5	1115		Bottom sediment coliform, metals, pesticides. Benthic org.	Black, silty mud

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CRUISE: 12 October 1989 cont.

Station	Time	Depth	Procedure	Comments
6	1135		Bottom sediment coliform, metals, pesticides. Benthic org.	Black, silty - lots of worms
8	1205		Bottom sediment coliform, metals, pesticides. Benthic org.	Strong sulfide smell Black, silty mud
10	1250		Bottom sediment coliform, metals, pesticides. Benthic org.	Black, silty mud
11	1328		Bottom sediment coliform, metals, pesticides. Benthic org.	Black, silty mud
9	1343		Bottom sediment coliform, metals, pesticides. Benthic org.	Black, silty mud
7	1417		Bottom sediment coliform, metals, pesticides. Benthic org.	Black, silty mud
13	1424		East end Oxford Flood Control	Chemistry only Hand sampled from shore

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1
9
3
1
6

CRUISE MDR 89-90 Date: 9 November 1989 Type: Water Quality

VESSEL & PERSONNEL

D. Soule, P.I.
M. Oguri, USC
R. Bester, USC
D. Reynoso, USC

Bay Watch

S. Butler
M. Frazer

TIDE:
Low 1219 0.8 ft
High 0554 5.5 ft

SAMPLING STATIONS:

Left Dock 0808

WEATHER : WIND

Sunny,warm, slight Santa Ana. NE,W,SW

Martek, NH_3, Nutrients Transmissometer, TBT, Sal. Secchi Disk, DO, pH, FU, Coliform

Station	Time	Observations	Comments
12	0825		Water temp. has dropped this week 16 degrees
1	0834		
2	0842	Water sudsy	
3	0855	Water gushing out of Ballona Lagoon on falling tide	
4	0905		
25	0916		
5	0925	Water green, may be dying bloom. Oxygen lower than it has been previously	
6	0936		
18	0956		
19	0956		Hand sampled from beach
8	1004		
10	1018		
11	1037		
9	1046		
7	1058		
13	1133		Hand sampled from shore
22	1140		Hand sampled from shore

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CRUISE: MDR 89-90 Date: 7 December 1989 Type: Water Quality

VESSEL & PERSONNEL:

D. Soule, PI,
M. Oguri, USC
R. Bester, USC
D. Reynoso, USC

Bay Watch

S. Butler
M. Frazer

TIDE:

Low	0431	5.2 ft
High	1114	1.2 ft

SAMPLING STATIONS:

Left Dock 0808

WEATHER : WIND

Crisp, sunny, clear
E-W - 0-13k

Martek, NH_3, Nutrients
Transmissometer, TBT, Sal.
Secchi Disk, DO, pH, FU,
Coliform

Station	Time	Observations	Comments
12	0825		
1	0830		Santa Ana condition
2	0838		Wind getting stronger
3	0848	Tide gate up, heavy flow of water emptying out	
4	0858	Water very green	
25	0906	Plug inserted in drain from Shanghai Red Restaurant	
5	0916		
6	0926	Water lighter green	
18	0947		
19	0947		Hand sampled from beach
8	0958	Water glassy and soapy	
10	1009		
20	1015		
11	1026		
9	1035		
7	1050		
13	1123	Water still	Hand sampled from shore
22	1137		Hand sampled from shore

1
9
3
1
8

CRUISE: MDR 88-89 Date: 11 January 1990 Type: Water Quality

VESSEL & PERSONNEL:

D. Soule, PI
M. Oguri, USC
R. Bester, USC
T. Grothues, USC

Baywatch

S. Butler
T. Estlow

TIDE:
Low 1551 -1.5 ft
High 0836 6.8 ft

SAMPLING STATIONS:

Left Dock 0846

WEATHER : WIND

Clear and warm
E-SE, S-SW - 2-8k

Martek, NH_3, Nutrients
Transmissometer, TBT, Sal.
Secchi Disk, DO, pH, FU,
Coliform

Station	Time	Observations	Comments
12	0900	Debris very thick	Extra high tide
1	0910		
2	0918	Kelp appearing	
3	0930	Heavy oil film, may be from rocks, kelp & sewage, Gobs of oil, plastic bags & cups	
4	0940		
25	0949	Water very calm	
5	0959		
6	1014		
18	1035		
19	1035		Hand sampled from beach
8	1040		
10	1058		
20	1105		
11	1115		
9	1125		
7	1140		
13	1214		Hand sampled from shore
22	1226		Hand sampled from shore

8RUISE: MDR 89-90   Date: 8 February 1990   Type: Water Quality

VESSEL & PERSONNEL:

D. Soule, PI
M. Oguri, USC
R. Bester, USC
T. Grothues, USC

Bay Watch

T. Estlow
J Meckman

TIDE:
Low 1452 1.3 ft
High 0749 6.4 ft

SAMPLING STATIONS:

Left Dock 0810

WEATHER : WIND

Cold and windy
N-NE - 2-10k

Martek, NH_3, Nutrients
Transmissometer, TBT, Sal.
Secchi Disk, DO, pH, FU,
Coliform

Station	Time	Observations	Comments
12	0825	Debris floating on water	
1	0837	Water choppy	
2	0845		
3	0857	Water sudsy	
4	0908		
25	0915	Many birds around fishing dock	
5	0927		
6	0935	Abundant numbers of larval fish in water	
18	1001		
19	1001		Hand sampled from beach
8	1008	Lots more larval fish	
10	1028		
20	1038		
11	1051		
9	1100	Filamentous Algae	
7	1115		
13	1145		Hand sampled from shore
22	1158		Hand sampled from shore

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1930

R0052625

CRUISE: MDR 89-90 Date: 8 March 1990 Type: Water Quality

VESSEL & PERSONNEL: Baywatch

D. Soule, PI
M. Oguri, USC
R. Bester, USC
B. Jones, USC
D. Reynoso, USC

S. Butler

TIDE:
Low 1352 0.8 ft
High 0702 5.7 ft

SAMPLING STATIONS:

Left Dock 0805

WEATHER : WIND
Overcast and cool
NE, S-SW - 3-7k

Martek, NH_3, Nutrients
Transmissometer, TBT, Sal.
Secchi Disk, DO, μH, FU,
Coliform

Station	Time	Observations	Comments
12	0818		
1	0828	Gross amount of debris floating on water	Pictures taken for documentation
2	0840		Pictures taken
3	0902		
4	0914		
25	0924	Great amount of debris	
5	0934	Sun coming out	
6	0947	Wind coming up	
18	1010		
19	1010		Hand sampled from beach
8	1016		
10	1032		
20	1038	Docked boat is occupied	
11	1049		
9	1059		
7	1112		
13	1145		Hand sampled from shore
22	1158		Hand sampled from shore

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19321

CRUISE: MDR 89-90 Date: 5 April 1990 Type: Water Quality

VESSEL & PERSONNEL: Baywatch

D. Soule, USC
M. Oguri, USC
R. Bester, USC
B. Jones, USC
T. Grothues

S. Butler
T. Estlow

TIDE:
Low 1243 0.3 ft
High 0601 4.9 ft
Rain measuring ± 1/2"
Wed. April 4, 1990

SAMPLING STATIONS: WEATHER : WIND

Left Dock 0800

Very clear, sunny
NE-NW, 2-7k - W-SW, 5-8k.

Martek, NH_3, Nutrients
Transmissometer, TBT, Sal.
Secchi Disk, DO, pH, FU,
Coliform

Station	Time	Observations	Comments
12	0815	Water very calm, and very green	Picture taken at entrance near jetty.
1	0824	Large number of baby pelicans on breakwater	
2	0833		
3	0845		
4	0856	Oil slick on water	
25	0905	Soapy flow coming from drain at Shanghai reds. Fish jumping	
5	0915		
6	0927		
18	0948		
19	0948	Fish jumping	Hand sampled from beach
8	0957		
10	1015		
20	1022	Anchored boat occupied	
11	1032		
9	1042		
7	1055		
13	1129	Water flowing into MDR	Hand sampled from shore
22	1140		Hand sampled from shore

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19322

CRUISE: MDR 89-90 | Date: 17 May 1990 | Type: Water Quality

VESSEL & PERSONNEL:

Baywatch

D. Soule, USC PI
M. Oguri, USC
R. Bester, USC
B. Jones, USC
P. Hentschke, USC

S. Butler
J. White

TIDE:

High	0233	4.0 ft
Low	1007	0.4 ft
High	1726	3.5 ft

SAMPLING STATIONS: | WEATHER : WIND | Martek, NH_3, Nutrients Transmissometer, TBT, Sal. Secchi Disk, DO, pH, FU, Coliform

Left Dock 0803 | Very calm, overcast

Station	Time	Observations	Comments
1	0817		Water very warm
2	0826		
3	0830	Gate from Ballona Lagoon opened. Organic substance floating on water	
4	0847		
25	0855		
5	0904		
6	0916		
18	0937		
19	0937		Hand sampled from beach
8	0944		
10	0959		
20	1008	Anchored boat occupied	
11	1018		
9	1029	Sun making appearance	
7	1043	Sun out full	
12	1201		Hand sampled from bridge, tide too low for boat

CRUISE: 17 May 1990, cont.

Station	Time	Observations	Comments
13	1238		Hand sampled from shore
22	1246		Too shallow to sample

CRUISE: MDR 89-90 Date: 7 June 1990 Type: Water Quality

VESSEL & PERSONNEL:

	Baywatch	TIDE: Low 1441 2.4 ft High 1033 3.4 ft
M. Oguri, USC	S. Butler	Late start. Lifeguards called out on emergency. Water rough. Started by doing Oxford flood control area.
R. Bester, USC	J. White	
B. Jones, USC		
P. Hentschke, USC		
A. Brierton, USC		

SAMPLING STATIONS: | WEATHER : WIND | Martek, NH_3, Nutrients Transmissometer, TBT, Sal. Secchi Disk, DO, pH, FU, Coliform

Left Dock 0853 | Sunny and warm SW 3-7

Station	Time	Observations	Comments
13	0815		Hand sampled from shore, while waiting for boat
22	0830		Hand sampled from shore
25	0854	Vast amounts of plastic bags, cups and other debris floating in water	
5	0906		
6	0919		
18	0939		
19	0939		Hand sampled from beach,
8	0943	Sea grass floating on water	
10	1002		
20	1009	Anchored boat occupied	
11	1020		
9	1030		
7	1047		
12	1112		
1	1120		
2	1128	Many pelicans on breakwater	

CRUISE; 7 June 1990, cont.

Station	Time	Observations	Comments
3	1140		
4	1151		

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19326

CRUISE: MDR 89-90 Date: 12 July 1990 Type: Water Quality

VESSEL & PERSONNEL:

D. Soule, USC PI
M. Oguri, USC
B. Jones, USC
A. Brierton, USC
P. Hentschke, USC

Baywatch

T. Estlow
F. Boyteus

TIDE:
Low 0647 0.1 ft
High 1332 4.5 ft

SAMPLING STATIONS:

Left Dock 0809

WEATHER : WIND

Hot, sultry, partly overcast. Tropical storm to south. 90° in town at 8am.
<2-W,SW 9

Martek, NH_3, Nutrients Transmissometer, TBT, Sal. Secchi Disk, DO, pH, FU, Coliform

Station	Time	Observations	Comments
12	0827		
1	0838	Water clean of debris, very dark green	
2	0845		
3	0855		
4	0903		
25	0912		
5	0921		
6	0935		Sun out, very hot
18	0956		
19	0956	Water very low	Hand sampled from beach
8	1002		
20	1020	Whitish grease line 2" wide at high water line on surrounding wall by Edies diner	
10	1026		
11	1039		

CRUISE: 12 July 1990 cont.

Station	Time	Observations	Comments
9	1049		
7	1107		
13	1138		Hand sampled from shore
22	1148		Algal mat on water

CRUISE: MDR 89-90 Date: August 1990 Type: Water Quality

VESSEL & PERSONNEL:

M. Oguri, USC
R. Bester, USC
A. Brierton, USC
P. Hentschke, USC

Baywatch

E. Atkison
F. Boyteus

TIDE:
Low 0219 0.2 ft
High 0912 3.6 ft
Low 1306 2.9 ft

SAMPLING STATIONS:

Left Dock 0940

WEATHER : WIND

Overcast, cool
W - 7-13k

Martek, NH_3, Nutrients
Transmissometer, TBT, Sal.
Secchi Disk, DO, pH, FU,
Coliform

Station	Time	Observations	Comments
12	0955	Sun coming out	
1	1005		Tide going out, hard to keep on station
2	1015		
3	1025	Tide gate open, water soapy	
4	1036		
25	1045		Swift current, hard to stay on station
5	1058		
6	1110		
18	1131		
19	1131		Hand sampled from beach
8	1135		
10	1154		
20	1201		
11	1208		
9	1222		
7	1235		
13	1310		Hand sampled from shore
22	1322		Hand sampled from shore

CRUISE: MDR 89-90 Date: 6 September 1990 Type: Water Quality

VESSEL & PERSONNEL:

D. Soule, PI
M. Oguri, USC
R. Bester, USC
B. Jones, USC
A. Zellers, USC

Baywatch

T. Estlow
F. Boyteus

TIDE:
Low 0325 0.4 ft
High 0940 5.6 ft
Low 1549 0.6 ft

SAMPLING STATIONS:

Left Dock 0812

WEATHER : WIND

Sunny, hot, calm
<2k to W 4-7k, NW
2-4k, SW 4-6k

Martek, NH_3, Nutrients
Transmissometer, TBT, Sal.
Secchi Disk, DO, pH, FU,
Coliform

Station	Time	Observations	Comments
12	0830	Heavy swells, much debris, water foamy from high tide hitting breakwater	
1	0842	Thermocline shallow	
2	0851		
3	0904		
4	0916		
25	0927		
5	0939		
6	0953		
18	1015	Fish jumping	
19	1015	Water foamy	Hand sampled from shore
8	1023		
10	1042		
20	1051		
11	1102		
9	1112		
7	1128		

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CRUISE: 6 September 1990, cont.

Station	Time	Observations	Comments
13	1206		Hand sampled from shore
22	1214		Hand sampled from shore

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APPENDIX B

PHYSICAL WATER QUALITY DATA

October 1989 - September 1990

VOL

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B2

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Table B1. Physical Water Quality Data. 5 October 1989

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, very calm

TIDE	TIME	HEIGHT (ft)
Low	0441	2.8
High	1156	5.1

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0850	12	0	18.4	24.7	8.2	8.2	88	8	3.0	1.7
0		1	18.1	31.4	8.6	8.2	90			
		2	18.1	31.7	8.6	8.2	90			1.2
0900	1	0	18.3	31.5	8.4	8.3	90	5	6.5	1.3
E4		1	18.3	31.8	8.4	8.3	91			
		2	18.3	31.8	8.4	8.3	91			1.1
		3	18.3	31.8	8.4	8.3	91			
		4	18.3	31.8	8.9	8.3	88			1.0
		5	18.3	31.8	12.0	8.3	90			
		6	18.2	31.9	12.0	8.3	90			0.9
0910	2	0	18.8	31.7	10.9	8.3	86	10	4.0	1.3
E4-5		1	18.8	31.7	11.0	8.3	86			
		2	18.7	31.8	11.2	8.3	86			1.1
		3	18.3	31.8	11.2	8.3	89			
		4	18.2	31.8	11.5	8.3	89			1.1
		5	18.2	31.9	11.6	8.3	90			
0921	3	0	19.3	32.1	10.8	8.3	82	10	2.5	1.1
E5		1	19.3	31.8	11.3	8.3	82			
		2	19.3	31.8	11.3	8.3	82			0.9
		3	19.3	31.8	11.5	8.3	82			
		4	19.3	31.9	11.2	8.3	82			1.0
		5	18.3	32.0	10.9	8.3	81			
0931	4	0	19.5	31.9	11.2	8.2	81	12	2.5	1.2
		1	19.4	31.8	10.7	8.3	81			
		2	18.8	31.9	11.0	8.3	83			1.4
		3	18.7	31.8	11.2	8.3	84			
		4	18.5	31.8	11.3	8.3	85			1.4
		5	18.4	31.8	11.3	8.3	85			
0940	25	0	19.6	31.7	10.4	8.2	81	12	2.5	1.2
0		1	19.6	31.7	10.2	8.2	81			
		2	19.4	31.8	10.0	8.2	82			1.5
		3	18.9	32.0	10.6	8.2	80			
		4	18.6	31.9	11.0	8.3	83			1.3
		5	18.5	31.9	11.0	8.3	82			
		6	18.4	31.9	11.8	8.2	78			1.3

Table B1. 5 October 1989 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, very calm

TIDE	TIME	HEIGHT (ft)
Low	0441	2.8
High	1156	5.1

Time/ Wind k	Station m	Depth C	Temp. o/oo	Sal. mg/l	DO	pH	%T	FU	Secchi	BOD mg/l
0951 E7	5	0	19.8	31.8	10.1	8.2	79	12	2.5	1.0
		1	19.8	31.8	10.7	8.2	81			
		2	19.7	31.8	10.8	8.2	79			2.4
		3	19.4	31.9	10.6	8.2	73			
		4	18.6	31.8	10.4	8.2	77			2.2
		5	18.4	31.9	10.5	8.2	75			
1003 S5	6	0	19.7	31.8	9.2	8.2	80	12	2.5	0.5
		1	19.7	31.8	9.2	8.2	80			
		2	19.7	31.8	9.0	8.2	81			0.8
		3	19.6	31.8	9.1	8.2	81			
		4	19.6	31.8	9.1	8.2	80			0.6
1025 SW5	18	0	20.2	31.8	8.0	8.1	79	12	2.0	1.0
		1	20.0	31.8	8.9	8.2	79			
		2	19.9	31.8	8.9	8.2	79			1.0
1025 SW5	19	0	Beach Station							0.8
1035 SW5	8	0	20.0	31.8	9.1	8.2	76	12	2.0	0.8
		1	19.9	31.8	9.3	8.2	77			
		2	19.8	31.8	9.4	8.2	76			1.4
		3	19.8	31.8	9.4	8.2	76			
		4	19.7	31.9	9.5	8.2	78			1.3
1052 0	10	0	20.2	31.7	9.0	8.1	75	15	1.0	0.7
		1	20.1	31.8	8.3	8.1	68			
		2	20.0	31.8	7.4	8.1	69			3.6
		3	19.9	31.8	6.6	8.1	71			
		4	19.8	31.9	6.5	8.1	68			1.6
1059 0	20	0	20.7	31.5	7.8	8.1	79	15	1.5	1.4
		1	20.3	31.6	10.5	8.1	82			
		2	20.2	31.7	7.6	8.1	65			1.73
		3	19.9	31.9	5.8	8.1	72			

Table B1. 5 October 1989 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, very calm

TIDE	TIME	HEIGHT (ft)
Low	0441	2.8
High	1156	5.1

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1113	11	0	20.0	31.8	9.4	8.1	78	12	2.0	0.7
0		1	20.0	31.8	9.4	8.1	78			
		2	19.8	31.8	9.4	8.1	75			1.8
		3	19.6	31.9	8.4	8.1	73			
		4	19.4	32.0	7.6	8.1	68			1.1
1124	9	0	20.4	31.6	11.4	8.2	72	16	1.0	2.1
		1	20.2	31.5	11.5	8.2	72			
		2	19.9	31.7	8.5	8.1	73			1.9
		3	19.6	31.7	7.5	8.1	65			
		4	19.4	31.8	7.9	8.1	64			0.9
1139	7	0	20.3	31.8	10.6	8.2	71	16	1.5	2.6
SW6		1	20.1	31.9	10.7	8.2	69			
		2	19.7	31.9	8.8	8.1	69			2.6
		3	19.4	32.0	9.0	8.1	69			
		4	19.1	32.1	9.0	8.1	68			1.0
1210	13	0	21.0	30.4	6.1	8.0	81			1.6
	22	0	Gate locked - not accessible							
	Average		19.3	31.7	9.7	8.2	79.3	11.9	2.5	1.3
	Sta. Dev.		0.7	0.8	1.5	0.1	7.0	3.0	1.3	0.6
	Maximum		21.0	32.1	12.0	8.3	91.0	16.0	6.5	3.6
	Minimum		18.1	24.7	5.8	8.0	64.0	5.0	1.0	0.5

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Table B2. Physical Water Quality Data. 9 November 1989

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny and warm, slight Santa Ana

TIDE	TIME	HEIGHT (ft)
High	0554	5.5
Low	1219	0.8

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0825	12	0	15.4	28.2	6.7	8.0	85	14	3.0	2.2
NE2		1	15.8	31.3	6.4	8.0	87			
		2	15.9	31.9	6.2	8.0	88			1.0
0834	1	0	15.6	31.0	6.6	8.1	70	10	3.5	2.3
NE6		1	15.7	31.8	6.7	8.1	87			
		2	15.9	32.0	6.7	8.1	87			1.7
		3	15.9	32.1	6.6	8.1	87			
		4	15.9	32.2	6.6	8.1	87			1.0
		5	15.8	32.2	6.6	8.1	86			
0842	2	0	16.0	32.0	6.7	8.1	86	7	3.5	2.2
NE6		1	16.0	32.0	6.8	8.1	86			
		2	15.9	32.0	6.8	8.1	86			2.1
		3	15.9	32.0	7.0	8.1	86			
		4	15.9	32.0	6.9	8.1	86			1.8
		5	15.9	32.1	6.8	8.1	87			
		6	15.9	32.1	6.7	8.1	85			1.5
0855	3	0	16.3	32.0	5.9	8.0	85	6	3.0	0.9
NE2		1	16.3	32.1	5.9	8.0	85			
		2	16.3	32.1	6.0	8.0	84			0.9
		3	16.3	32.1	6.1	8.0	84			
		4	16.3	32.0	6.2	8.0	84			1.4
0905	4	0	16.6	32.1	5.5	8.0	75	10	2.5	1.0
0		1	16.5	32.1	5.6	8.0	79			
		2	16.5	32.1	5.6	8.0	79			0.9
		3	16.5	32.1	5.7	8.0	80			
		4	16.4	32.1	5.7	8.0	81			1.1
		5	16.4	32.1	5.6	8.0	82			
0916	25	0	16.6	32.1	5.2	8.0	68	10	2.0	0.7
0		1	16.7	32.1	5.2	8.0	78			
		2	16.6	32.1	5.2	8.0	78			0.6
		3	16.6	32.1	5.2	8.0	78			
		4	16.6	32.1	5.3	8.0	78			1.0
		5	16.6	32.1	5.3	8.0	76			

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Table B2. 9 November 1989 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny and warm, slight Santa Ana

TIDE	TIME	HEIGHT (ft)
High	0554	5.5
Low	1219	0.8

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0925	5	0	16.8	32.0	4.8	7.9	83	7	2.5	0.7
0		1	16.7	32.1	4.8	7.9	82			
		2	16.7	32.1	4.8	7.9	82			0.8
		3	16.7	32.1	4.8	7.9	82			
		4	16.7	32.1	4.9	7.9	80			0.7
		5	16.6	32.1	5.1	7.9	77			
0936	6	0	16.8	32.2	4.8	7.9	78	10	2.0	0.6
SW3		1	16.7	32.2	4.8	7.9	79			
		3	16.6	32.2	4.9	7.9	80			
0956	18	0	17.0	32.2	5.1	7.9	83	10	2.5	0.7
		1	17.0	32.2	5.2	7.9	83			
		2	16.8	32.2	5.4	8.0	83			1.0
0958	19	0	Beach Station							1.1
SW4										
1004	8	0	17.0	32.2	5.1	7.9	79	10	2.5	0.8
W6		1	16.7	32.2	5.5	7.9	81			
		2	16.9	32.2	5.6	7.9	81			1.5
		3	16.6	32.2	5.7	7.9	80			
1018	10	0	16.9	31.8	4.0	7.8	81	10	3.0	0.9
0		1	16.8	31.7	4.0	7.9	82			
		2	16.7	31.8	4.2	7.9	82			1.0
		3	16.9	32.0	4.3	7.9	79			
1024	20	0	17.1	31.7	3.9	7.8	76	10	1.5	0.9
0		1	16.8	31.8	3.9	7.8	77			
		2	16.9	32.0	3.9	7.8	80			0.9
1024	11	0	17.1	32.2	4.5	7.8	80	7	2.0	0.5
W3		1	17.0	32.2	4.7	7.8	79			
		2	16.9	32.2	4.5	7.8	77			0.8
		3	16.9	32.2	4.5	7.8	76			
1046	9	0	17.3	32.2	4.4	7.8	69	10	2.0	0.6
WSW6		1	17.2	32.2	4.5	7.8	72			
		2	17.0	32.1	4.4	7.8	74			0.7
		3	16.9	32.2	4.5	7.8	74			

Table B2. 9 November 1989 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny and warm, slight Santa Ana

TIDE	TIME	HEIGHT (ft)
High	0554	5.5
Low	1219	0.8

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1058	7	0	17.1	32.2	4.2	7.8	76	10	2.5	0.6
SW4		1	17.0	32.3	4.3	7.8	81			
		2	16.9	32.2	4.4	7.8	81			0.6
		3	16.9	32.2	4.5	7.8	79			
1133	13	0	17.0	31.7	3.6	7.2				3.1
1140	22	0	18.0	27.0	3.4	7.2				10.2
	Average		16.6	31.9	5.3	7.9	80.7	9.4	2.5	1.4
	Sta. Dev.		0.5	0.8	1.0	0.2	4.5	1.9	0.6	1.5
	Maximum		18.0	32.3	7.0	8.1	88.0	14.0	3.5	10.2
	Minimum		15.4	27.0	3.4	7.2	68.0	6.0	1.5	0.5

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Table B3. Physical Water Quality Data. 7 December 1989

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Clear and sunny

TIDE	TIME	HEIGHT (ft)
High	0431	5.2
Low	1114	1.2

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0825 E7	12	0	13.3	16.4	7.3	8.0	79	12	2.5	2.4
		1	15.9	28.6	8.0	7.9	85			
		2	16.2	30.7	8.6	8.0	87			1.2
0830 E13	1	0	15.7	29.9	8.5	8.0	87	7	3.5	2.1
		1	15.7	30.4	9.0	8.0	87			
		2	15.7	30.9	9.4	8.0	87			2.2
		3	16.0	31.2	9.4	8.1	87			
		4	16.0	31.3	9.3	8.1	87			1.8
0838 E7	2	0	15.8	31.5	9.4	8.0	85	8	3.0	1.7
		1	15.8	31.5	9.4	8.1	85			
		2	15.8	31.5	9.2	8.1	85			1.6
		3	15.8	31.5	9.9	8.1	85			
		4	15.8	31.5	9.9	8.1	85			1.5
		5	15.8	31.5	9.9	8.1	84			
0848 E6	3	0	15.3	31.5	6.9	8.0	82	10	2.5	0.8
		1	15.2	31.5	7.1	8.0	82			
		2	15.4	31.5	7.0	8.0	82			0.9
		3	15.4	31.6	6.9	8.0	82			
		4	15.3	31.5	6.9	8.0	80			0.8
0858 0	4	0	15.4	31.6	6.1	7.9	81	10	2.5	0.6
		1	15.4	31.6	6.0	7.9	81			
		2	15.4	31.6	5.9	7.9	80			0.6
		3	15.4	31.6	5.9	7.9	80			
		4	15.4	31.6	5.7	7.9	80			0.5
		5	15.4	31.7	5.7	7.9	78			
0906 0	25	0	15.4	31.7	5.7	7.9	80	10	1.5	0.5
		1	15.4	31.7	5.7	7.9	80			
		2	15.4	31.7	5.6	7.9	79			0.3
		3	15.3	31.7	5.7	7.9	78			
		4	15.3	31.7	5.7	7.9	77			0.5
		5	15.3	31.7	5.6	7.9	77			

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Table B3. 7 December 1989 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Clear and sunny

TIDE	TIME	HEIGHT (ft)
High	0431	5.2
Low	1114	1.2

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0915 E5	5	0	15.2	31.7	5.6	7.9	78	7	2.5	0.5
		1	15.2	31.7	5.4	7.9	78			
		2	15.2	31.7	5.5	7.9	80			0.5
		3	15.2	31.7	5.6	7.9	79			
		4	15.2	31.7	5.7	7.9	79			0.8
0926 E3	6	0	15.1	31.7	5.0	7.9	72	12	1.5	0.9
		1	15.1	31.7	4.9	7.9	77			
		2	15.1	31.7	4.8	7.9	76			0.9
		3	15.1	31.7	4.9	7.9	73			
0947 0	18	0	15.1	31.7	5.9	7.9	84	7	2.0	1.2
		1	15.0	31.7	6.0	7.9	84			
0947 0	19	0	Beach Station							1.8
0954 0	8	0	15.1	31.70	5.7	7.9	81	8	2.5	0.7
		1	15.0	31.80	5.6	7.9	81			
		2	14.9	31.80	5.9	7.9	82			0.7
		3	14.9	31.80	6.0	7.9	81			
1009 0	10	0	15.1	30.8	4.3	7.8	82	7	2.5	0.9
		1	15.0	31.2	4.3	7.8	82			
		2	15.4	31.5	4.1	7.8	82			0.8
		3	15.4	31.7	4.1	7.8	70			
1015 0	20	0	15.1	30.6	4.4	7.8	79	10	2.0	0.9
		1	15.1	31.3	4.3	7.8	82			
1026 0	11	0	15.2	31.6	5.4	7.8	75	8	2.5	0.8
		1	15.1	31.7	5.4	7.8	80			
		2	15.1	31.7	5.4	7.8	79			0.9
		3	15.3	31.7	5.3	7.8	75			
1035 0	9	0	15.6	31.7	5.0	7.8	72	10	1.5	0.5
		1	15.4	31.9	4.9	7.8	75			
		2	15.4	31.9	4.9	7.8	75			0.4
		3	15.3	31.9	5.0	7.8	76			

Table B3. 7 December 1989 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Clear and sunny

TIDE	TIME	HEIGHT (ft)
High	0431	5.2
Low	1114	1.2

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1050 W4	7	0	15.4	31.9	4.7	7.8	62	8	2.5	0.3
		1	15.4	32.0	4.7	7.8	79			
		2	15.4	32.0	4.7	7.8	79			0.3
		3	15.3	32.0	4.7	7.8	79			
1123	13	0	15.1	30.4	3.9	7.0	84			1.3
1134	22	0	16.4	27.0	4.3	7.2				1.6
	Average		15.4	31.2	6.2	7.9	80.1	8.9	2.4	1.0
	Sta. Dev.		0.4	2.0	1.7	0.2	4.5	1.7	0.5	0.6
	Maximum		16.4	32.0	9.9	8.1	87.0	12.0	3.5	2.4
	Minimum		13.3	16.4	3.9	7.0	62.0	7.0	1.5	0.3

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Table B4. Physical Water Quality Data. 11 January 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Clear and sunny

TIDE	TIME	HEIGHT (ft)
High	0836	6.8
Low	1551	1.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0900 E2	12	0	14.7	31.2	7.6	7.9	86	10	3.0	1.4
		1	14.8	31.8		8.0	87			
		2	14.8	32.3	8.4	8.0	89			0.9
		3	14.8	32.5		8.1	89			
0910 SE3	1	0	14.9	32.5	8.9	8.1	87	6	4.5	1.0
		1	15.0	32.5		8.1	88			
		2	15.0	32.5	8.8	8.1	88			0.9
		3	14.9	32.6		8.1	88			
		4	14.9	32.6	8.8	8.1	88			0.8
		5	14.8	32.6		8.1	88			
0918 SE3	2	0	14.8	32.4	8.5	8.1	84	6	3.5	0.8
		1	14.8	32.6		8.1	86			
		2	14.8	32.6	8.6	8.1	86			1.0
		3	14.8	32.6		8.1	86			
		4	14.8	32.6	8.6	8.2	86			0.9
		5	14.8	32.6		8.2	85			
		6	14.8	32.6	8.4	8.2	86			0.7
0930 S4	3	0	14.9	32.6	8.3	8.1	85	7	3.5	0.8
		1	14.9	32.6		8.1	85			
		2	14.9	32.6	8.2	8.1	85			0.8
		3	14.9	32.6		8.1	85			
		4	14.9	32.6	8.4	8.1	85			0.7
0940 0	4	0	14.9	32.5	8.0	8.1	82	10	2.0	0.8
		1	14.9	32.6		8.1	82			
		2	14.9	32.6	8.0	8.1	82			0.9
		3	14.9	32.6		8.1	81			
		4	14.9	32.6		8.1	81			
		5	14.9	32.6		8.1	81			
0949 E2	25	0	14.8	32.5	7.4	8.1	81	10	2.0	0.4
		1	14.8	32.5		8.1	80			
		2	14.8	32.6	7.5	8.1	80			0.6
		3	14.8	32.6		8.1	80			
		4	14.8	32.6	7.6	8.1	80			0.7
		5	14.8	32.6		8.1	79			
		6	14.8	32.6	7.9	8.1	79			0.8

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Table B4. 11 January 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Clear and sunny

TIDE	TIME	HEIGHT (ft)
High	0836	6.8
Low	1551	1.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0959 SW3.5	5	0	14.8	32.5	7.4	8.1	81	7	2.5	0.7
		1	14.8	32.5		8.1	81			
		2	14.8	32.5	7.5	8.1	80			0.7
		3	14.8	32.5		8.1	80			
		4	14.8	32.5	7.6	8.1	79			0.6
		5	14.8	32.5		8.1	79			
1014 SW7	6	0	14.5	32.5	7.0	8.1	80	10	2.5	0.5
		1	14.4	32.5		8.1	80			
		2	14.4	32.5	6.9	8.1	80			0.7
		3	14.4	32.5		8.1	79			
		4	14.3	32.5	6.9	8.1	79			0.8
1035 SW8	18	0	14.5	32.3	7.0	8.1	81	10	2.0	0.4
		1	14.5	32.4		8.1	81			
1035 SW8	19	0	Beach Station							0.8
1040 SW8	8	0	14.5	32.3	6.9	8.1	76	10	2.5	0.4
		1	14.3	32.4		8.0	77			
		2	14.3	32.4	7.0	8.0	77			0.8
		3	14.3	32.4		8.0	78			
		4	14.3	32.4	7.1	8.0	79			0.7
1058 SW6	10	0	14.4	32.3	6.6	8.0	79	10	2.5	0.7
		1	14.4	32.3		8.0	79			
		2	14.4	32.3	6.6	8.0	77			0.8
		3	14.3	32.3		8.0	77			
		4	14.3	32.3	6.6	8.0	77			0.5
		5	14.3	32.3		8.0	74			
1105 SW5	20	0	14.4	32.2	6.4	8.0	84	10	2.0	0.5
		1	14.3	32.3		8.0	84			
		2	14.3	32.3	6.1	8.0	79			0.5
		3	14.3	32.3		8.0	76			
1115 SW4	11	0	14.6	32.3	6.7	8.0	79	10	2.5	0.3
		1	14.5	32.3		8.0	80			
		2	14.5	32.3	6.5	8.0	76			0.4
		3	14.5	32.4		8.0	74			

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Table B4. 11 January 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Clear and sunny

TIDE	TIME	HEIGHT (ft)
High	0836	6.8
Low	1551	1.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1125 SW5	9	0	14.7	32.4	6.6	8.0	75	12	2.0	0.5
		1	14.6	32.4		8.0	74			
		2	14.5	32.5	6.6	8.0	77			0.6
		3	14.5	32.5		8.01	77			
		4	14.5	32.6		8.01	77			
1140	7	0	14.8	32.4	6.5	8.0	82	10	2.5	0.5
		1	14.7	32.4		8.0	81			
		2	14.7	32.6	6.3	8.0	80			0.4
		3	14.7	32.6		8.0	79			
		4	14.6	32.5	6.29	8.0	77			0.5
1214	13	0	14.3	31.8	6.0	7.4	83			0.8
1226	22	0	14.3	31.2	5.5	7.4				1.3
	Average		14.7	32.4	7.3	8.0	81.2	9.2	2.6	7.1
	Sta. Dev.		0.2	0.3	0.9	0.1	3.9	1.7	0.7	2.2
	Maximum		15.0	32.6	8.9	8.2	89.0	12.0	4.5	1.4
	Minimum		14.3	31.2	5.5	7.4	74.0	6.0	2.0	0.3

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Table B5. Physical Water Quality Date. 8 February 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, warm, very clear
Santa Ana condition

TIDE	TIME	HEIGHT (ft)
High	0749	6.4
Low	1452	-1.3

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0825	12	0	11.8	30.7	7.2	7.9	81	10	2.5	1.8
NE6		1	12.1	32.2	7.1	7.9	81			
		2	12.3	32.6	7.0	7.9	81			1.2
		3	12.4	32.6	6.8	8.0	79			
0837	1	0	12.0	31.7	7.3	7.9	80	10	2.5	1.3
NE8		1	12.3	32.4	7.7	7.9	80			
		2	12.4	32.6	8.1	7.9	80			1.8
		3	12.5	32.6	8.1	7.9	80			
		4	12.5	32.6	8.1	7.9	80			2.2
		5	12.5	32.6	8.3	7.9	80			
		6	12.4	32.6	7.4	7.9	80			
0845	2	0	12.5	32.6	8.1	7.9	79	10	2.5	2.0
NE8		1	12.5	32.6	8.0	8.0	80			
		2	12.5	32.6	8.1	8.0	79			2.0
		3	12.6	32.6	8.3	8.0	79			
		4	12.6	32.6	8.3	8.0	79			1.8
		5	12.6	32.6	8.6	8.0	79			
0857	3	0	12.6	32.6	8.5	8.0	80	12	2.5	4.6
NE7		1	12.6	32.4	8.3	8.0	79			
		2	12.6	32.4	8.4	8.0	79			4.9
		3	12.6	32.5	8.3	8.0	79			
		4	12.6	32.5	8.2	8.0	81			3.9
		5	12.6	32.5	8.1	8.0	82			
0908	4	0	12.9	32.4	8.0	7.9	83	8	3.0	0.8
N9		1	12.9	32.5	7.8	7.9	82			
		2	12.9	32.5	7.9	8.0	82			0.8
		3	12.8	32.5	8.0	8.0	82			
		4	12.8	32.5	7.8	8.0	81			0.7
		5	12.8	32.5	7.9	8.0	82			
0915	25	0	12.9	32.5	7.9	8.0	83	10	2.5	1.2
		1	12.9	32.4	7.8	8.0	83			
		2	12.9	32.4	7.8	8.0	84			1.2
		3	12.9	32.4	7.8	8.0	84			
		4	12.9	32.4	7.8	8.0	84			0.9
		5	12.9	32.4	7.8	8.0	81			
		6	12.9	32.5	8.0	8.0	80			

Table B5. 8 February 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, warm, very clear
Santa Ana condition

TIDE	TIME	HEIGHT (ft)
High	0749	6.4
Low	1452	1.3

Time/ Wind	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0927 N7	5	0	13.1	32.2	7.7	7.9	86	10	4.0	0.6
		1	13.0	32.3	7.7	7.9	85			
		2	13.1	32.3	7.8	8.0	84			0.6
		3	13.0	32.3	7.8	8.0	84			
		4	13.0	32.3	7.9	8.0	84			0.6
		5	13.0	32.3	7.8	8.0	84			
0935 NE2	6	0	13.5	32.3	7.4	7.9	83	10	3.5	0.5
		1	13.4	32.3	7.2	8.0	83			
		2	13.4	32.3	7.1	8.0	83			0.6
		3	13.4	32.3	7.2	8.0	83			
		4	13.4	32.3	7.3	8.0	83			0.5
1001	18	0	13.4	32.2	7.4	7.9	80	10	3.0	0.9
		1	13.4	32.2	7.4	7.9	82			
		2	13.4	32.2	7.5	8.0	83			0.9
1001	19	0	Beach Station							1.0
1007	8	0	13.3	32.1	7.6	8.0	85	10	3.0	0.7
		1	13.3	32.1	7.7	8.0	85			
		2	13.3	32.1	7.7	8.0	84			0.7
		3	13.3	32.1	7.7	8.0	85			
		4	13.0	32.2	7.8	8.0	84			0.8
1028	10	0	13.8	32.2	6.7	7.9	79	10	4.0	0.5
		1	13.7	32.2	6.8	7.9	80			
		2	13.7	32.2	6.8	7.9	80			0.5
		3	13.7	32.2	7.0	7.9	81			
		4	13.7	32.2	7.3	7.9	79			0.6
1038	20	0	13.8	32.1	6.8	7.9	78	10	3.0	0.6
		1	13.8	32.2	6.7	7.9	80			
		2	13.7	32.1	6.7	7.9	80			0.6
		3	13.7	32.1	6.6	7.9	79			
1051	11	0	13.6	32.3	7.2	7.9	74	10	3.5	0.7
		1	13.5	32.2	7.2	7.9	79			
		2	13.5	32.2	7.2	7.9	80			0.7
		3	13.4	32.3	7.4	7.9	80			

Table B5. 8 February 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, warm, very clear
Santa Ana condition

TIDE	TIME	HEIGHT (ft)
High	0749	6.4
Low	1452	1.3

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1100 N6	9	0	13.6	32.3	7.3	7.9	80	10	4.0	0.8
		1	13.5	32.2	7.2	7.9	80			
		2	13.3	32.3	7.4	7.9	79			0.8
		3	13.3	32.3	7.8	7.9	79			
1115 N10	7	0	13.4	32.3	6.8	7.9	81	10	4.0	0.5
		1	13.3	32.3	6.9	7.9	81			
		2	13.3	32.3	7.6	7.9	80			0.6
		3	13.2	32.3	7.8	7.9	79			
1145	13	0	13.6	32.0	6.8	7.3	81			0.9
1158	22	0	13.3	31.6	5.2	7.4				1.2
	Average		13.0	32.3	7.6	7.9	81.1	10.0	3.2	1.2
	Sta. Dev.		0.5	0.3	0.6	0.1	2.1	0.7	0.6	1.0
	Maximum		13.8	32.6	8.6	8.0	86.0	12.0	4.0	4.9
	Minimum		11.8	30.7	5.2	7.3	74.0	8.0	2.5	0.5

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Table B6. Physical Water Quality Data. 8 March 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, chilly and windy

TIDE	TIME	HEIGHT (ft)
High	0702	5.7
Low	1352	-0.8

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0818	12	0	14.3	31.2	10.1	7.9	76	15	2.0	10.1
		1	14.3	31.5	10.1	7.9	77			
		2	14.3	32.2	10.1	7.9	81			7.5
		3	14.3	32.3	10.1	7.9	83			
0828	1	0	14.3	32.0	10.4	8.0	80	12	2.0	6.3
		1	14.2	32.3	10.2	8.0	80			
		2	14.1	32.3	10.2	8.0	80			5.0
		3	14.1	32.3	10.2	8.0	80			
		4	14.1	32.4	10.4	8.0	80			4.5
		5	14.1	32.4	10.5	8.0	80			
		6	14.1	32.4	10.5	8.0	80			4.4
0840	2	0	14.1	32.5	9.8	8.1	80	14	2.5	9.0
		1	14.1	32.5	10.1	8.1	78			
		2	14.1	32.5	10.1	8.1	78			8.2
		3	14.1	32.5	10.4	8.1	78			
		4	14.1	32.5	10.6	8.1	78			7.3
		5	14.1	32.5	10.4	8.1	79			
		6	14.0	32.5	10.5	8.1	80			
0902	3	0	14.5	32.5	9.3	8.0	74	10	2.0	3.2
		1	14.5	32.4	9.5	8.0	77			
		2	14.4	32.5	10.2	8.0	77			2.3
		3	14.2	32.5	10.9	8.0	77			
		4	14.0	32.5	11.3	8.0	77			2.5
		5	14.0	32.6	11.9	8.0	77			
0914	4	0	14.8	32.4	8.3	8.0	80	10	2.0	2.3
		1	14.6	32.5	8.8	8.0	81			
		2	14.4	32.5	8.9	8.0	80			2.4
		3	14.3	32.5	8.8	8.0	80			
		4	14.2	32.5	9.0	8.0	78			1.8
		5	14.1	32.6	9.0	8.0	76			
		6	14.0	32.6	9.2	8.0	76			1.8
0934	5	0	15.4	32.3	8.0	8.0	75	10	3.0	1.0
		1	15.4	32.3	8.3	8.0	80			
		2	15.1	32.4	8.3	8.0	82			1.5
		3	14.6	32.4	8.5	8.0	81			
		4	14.2	32.5	8.7	8.0	81			1.8
		5	14.1	32.6	9.0	8.0	81			

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Table B6. 8 March 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, chilly and windy

TIDE	TIME	HEIGHT (ft)
High	0702	5.7
Low	1352	-0.8

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0924	25	0	15.0	32.4	7.9	8.0	81	12	2.5	1.4
		1	15.0	32.4	8.1	8.0	82			
		2	14.7	32.4	8.3	8.0	82			1.4
		3	14.7	32.4	8.2	8.0	82			
		4	14.4	32.5	8.6	8.0	80			1.4
		5	14.2	32.5	8.4	8.0	76			
		6	14.1	32.6	8.9	8.0	75			
0947	6	0	15.1	32.4	7.7	8.0	80	10	3.0	0.7
		1	15.1	32.4	7.9	8.0	85			
		2	15.0	32.4	7.9	8.0	85			0.7
		3	14.8	32.5	8.1	8.0	81			
		4	14.6	32.6	8.0	8.0	81			0.8
1010	18	0	15.6	32.5	8.1	8.0	86	10	3.0	0.7
		1	15.6	32.4	9.1	8.0	86			
1010	19	0	Beach Station							1.2
1016	8	0	15.6	32.3	8.0	8.0	85	8	4.0	0.8
		1	15.5	32.3	8.2	8.0	85			
		2	15.5	32.4	8.4	8.0	85			0.9
		3	15.4	32.4	8.6	8.6	84			
1032	10	0	15.7	31.9	7.1	8.0	74	10	3.0	1.1
		1	15.7	32.1	7.3	8.0	84			
		2	15.6	32.3	7.5	8.0	82			1.0
		3	15.6	32.4	7.7	8.0	82			
1038	20	0	15.8	31.5	6.9	8.0	83	10	3.0	1.0
		1	15.7	32.0	7.0	8.0	83			
		2	15.7	32.2	7.1	8.0	84			
1049	11	0	15.8	32.3	7.3	8.0	86	10	3.5	0.8
		1	15.8	32.3	7.6	8.0	86			
		2	15.6	32.3	7.7	8.0	85			1.0
		3	15.0	32.6	7.5	8.0	82			
1059	9	0	16.0	32.4	7.5	8.0	78	10	2.0	1.2
		1	15.9	32.4	7.7	8.0	80			
		2	15.1	32.6	7.6	8.0	81			1.2
		3	14.8	32.6	7.9	8.0	82			

Table B6. 8 March 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, chilly and windy

TIDE	TIME	HEIGHT (ft)
High	0702	5.7
Low	1352	-0.8

Time/ Wind	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1112	7	0	15.5	32.4	7.1	8.0	83	10	3.0	1.0
		1	15.3	32.4	7.3	8.0	84			
		2	14.8	32.5	7.6	8.0	84			0.9
1145	13	0	16.2	32.0	6.8	7.4	85			1.7
1158	22	0	15.9	31.2	4.5	7.4				2.4
	Average		14.8	32.4	8.7	8.0	80.6	10.7	2.7	2.7
	Sta. Dev.		0.7	0.3	1.3	0.1	3.1	1.7	0.6	2.6
	Maximum		16.2	32.6	11.9	8.1	86.0	15.0	4.0	10.1
	Minimum		14.0	31.2	4.5	7.4	74.0	8.0	2.0	0.7

Table B7. Physical Water Quality Data.

5 April 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, chilly and windy

TIDE	TIME	HEIGHT (ft)
High	0601	4.9
Low	1243	-0.3

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0815 NE3	12	0	15.0	24.4	6.1	7.8	52	19	0.5	8.2
		1	14.3	31.2	8.4	7.8	78			
		2	14.3	31.7	8.1	7.8	80			4.8
0824 NW3	1	0	14.8	30.9	8.2	8.0	75	16	1.0	6.7
		1	14.7	31.4	8.6	8.0	76			
		2	14.7	31.9	9.3	8.0	76			9.9
		3	14.7	32.0	10.0	8.0	77			
		4	14.8	32.2	10.5	8.1	81			6.5
		5	14.8	32.2	10.2	8.1	85			
0833 NW7	2	0	15.0	31.0	7.9	8.1	73	16	1.0	12.0
		1	14.8	31.5	9.1	8.1	65			
		2	14.8	31.8	8.4	8.0	65			10.5
		3	14.7	32.0	8.4	8.0	74			
		4	14.3	32.0	8.3	8.0	76			9.9
		5	14.1	32.2	7.8	8.0	81			
0845 NW5	3	0	15.6	30.4	6.4	8.0	73	14	1.5	7.5
		1	15.5	31.4	6.5	8.0	73			
		2	15.0	31.8	6.5	8.0	74			5.9
		3	14.6	32.0	6.5	8.0	74			
		4	14.4	32.1	6.8	8.0	76			2.4
		5	14.3	32.1	6.1	8.0	74			
0856 NW5	4	0	15.4	30.3	6.3	8.0	73	16	1.0	7.6
		1	15.6	30.6	6.2	8.0	71			
		2	15.6	31.6	6.8	8.0	75			6.4
		3	14.9	32.0	6.9	8.0	78			
		4	14.7	32.0	6.9	8.0	80			3.0
		5	14.4	32.0	6.1	8.0	79			
0905 NW2	25	0	15.7	30.7	4.5	8.0	75	14	1.5	4.3
		1	15.7	30.8	6.4	8.0	75			
		2	15.5	31.6	6.5	8.0	77			3.2
		3	15.0	31.9	6.9	8.0	77			
		4	14.7	32.0	6.8	8.0	77			2.3
		5	14.5	32.1	6.2	8.0	76			

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Table B7. 5 April 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, chilly and windy

TIDE	TIME	HEIGHT (ft)
High	0601	4.9
Low	1243	-0.3

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0915 W5	5	0	16.0	30.6	4.3	8.0	73	14	1.5	4.7
		1	16.5	31.4	6.4	8.0	75			
		2	16.2	31.8	6.2	8.0	78			3.2
		3	15.5	32.1	6.1	8.0	78			
		4	15.0	32.1	6.2	8.0	79			1.7
		5	14.7	32.1	4.6	8.0	79			
0927 SW5	6	0	16.5	31.6	6.0	8.0	82	10	3.0	1.2
		1	16.6	31.7	6.4	8.0	84			
		2	16.6	31.7	6.6	8.0	82			1.2
		3	15.7	32.1	6.3	8.0	82			
		4	15.5	32.0	5.6	8.0	79			0.9
0948 W7	18	0	16.9	31.6	5.9	8.0	82	10	2.0	1.6
		1	16.9	31.7	6.0	8.0	82			
0948	19	0	Beach Station							1.9
0958 W6	8	0	16.8	31.4	5.7	8.0	79	12	2.0	2.0
		1	16.6	31.5	4.9	8.0	80			
		2	16.7	31.5	5.2	8.0	81			1.6
		3	16.1	32.0	5.5	7.9	78			
1015 W8	10	0	16.9	31.4	5.4	8.0	80	12	2.0	1.9
		1	16.9	31.5	5.4	8.0	80			
		2	16.6	31.7	4.8	8.0	80			1.3
		3	16.3	32.0	4.3	8.0	76			
1022	20	0	17.4	30.5	5.1	8.0	75	12	2.0	1.9
		1	17.1	31.0	5.4	8.0	79			
		2	16.7	31.7	3.8	8.0	79			
1032 W6	11	0	16.7	30.8	5.3	8.0	74	12	1.5	2.8
		1	16.7	31.1	5.4	8.0	75			
		2	16.6	31.6	5.2	8.0	77			1.8
		3	15.8	31.8	4.9	8.0	77			
1042 SW6	9	0	16.5	30.9	5.6	8.0	76	14	1.5	3.5
		1	16.6	31.2	5.8	8.0	76			
		2	16.0	31.8	4.8	7.9	79			1.5
		3	15.8	31.9	4.7	7.9	78			

Table B7. 5 April 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, chilly and windy

TIDE	TIME	HEIGHT (ft)
High	0601	4.9
Low	1243	-0.3

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1055 W8	7	0	16.8	30.7	5.2	8.0	80	14	1.5	2.6
		1	16.4	31.2	5.5	8.0	79			
		2	15.9	31.7	4.8	7.9	78			1.8
		3	15.5	31.9	5.2	8.0	76			
1129	13	0	20.2	9.3	1.4	6.9				15.0
1140	22	0	18.0	4.6	1.9	6.9				15.5
	Average		15.7	30.8	6.2	8.0	76.8	13.7	1.6	4.8
	Stamdard		1.1	4.2	1.6	0.2	4.7	23.6	0.6	3.7
	Maximum		20.2	32.2	10.5	8.1	85.0	19.0	3.0	15.5
	Minimum		14.1	4.6	1.4	6.9	52.0	10.0	0.5	0.9

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Table B8. Physical Water Quality Data. 17 May 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, clear and windy

TIDE	TIME	HEIGHT (ft)
Low	1007	0.4
High	1726	2.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0817	1	0	19.0	29.8	7.5	8.1	81	12	2.0	2.5
		1	18.0	30.5	7.4	8.1	83			
		2	17.7	30.9	7.6	8.1	85			1.5
		3	17.4	31.0	7.7	8.2	88			
		4	17.2	31.1	7.8	8.2	89			1.2
		5	16.9	31.1	7.7	8.2	89			
0826	2	0	19.6	30.8	7.8	8.2	79	10	2.0	1.6
		1	19.8	30.9	7.9	8.3	78			
		2	19.5	31.0	7.5	8.3	77			1.7
		3	19.0	31.1	7.4	8.3	77			
		4	17.7	31.5	7.3	8.3	79			1.8
0836	3	0	19.8	31.0	7.9	8.3	78	14	1.5	1.4
		1	19.7	31.1	7.5	8.3	76			
		2	19.7	31.1	7.6	8.3	76			1.5
		3	19.5	31.1	7.2	8.3	75			
		4	17.6	31.6	6.7	8.3	71			1.4
0847 NW5	4	0	20.0	31.1	7.5	8.3	78	12	2.0	1.4
		1	19.8	31.1	7.4	8.3	78			
		2	18.8	31.1	7.2	8.3	78			1.4
		3	18.3	31.2	7.1	8.3	77			
		4	17.9	31.2	7.0	8.3	74			1.3
0855 NW3	25	0	20.2	30.9	7.7	8.3	77	10	1.0	1.6
		1	20.1	31.1	7.5	8.3	78			
		2	20.1	31.1	7.3	8.3	79			1.3
		3	19.8	31.1	6.8	8.3	80			
		4	18.1	31.2	6.7	8.3	69			1.1
		5	17.8	31.2	6.8	8.3	54			
0904 SW5	5	0	20.4	31.2	7.3	8.3	71	12	1.5	1.7
		1	20.4	31.1	7.1	8.3	74			
		2	20.1	31.1	6.9	8.3	74			1.6
		3	19.1	31.5	6.8	8.3	74			
		4	17.9	31.5	7.0	8.3	65			1.6

Table B8. 17 May 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, clear and windy

TIDE	TIME	HEIGHT (ft)
Low	1007	0.4
High	1726	2.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0916 NW6	6	0	20.0	31.2	6.8	8.3	82	10	2.0	1.6
		1	20.0	31.2	6.7	8.3	82			
		2	19.8	31.2	6.6	8.3	81			1.5
		3	19.0	31.3	4.3	8.2	74			
0937 SW6	18	0	20.3	31.3	6.7	8.2	77	14	1.5	1.8
		1	20.3	31.3	6.6	8.2	77			
		2	20.3	31.3	6.5	8.2	74			2.4
0937	19	0	Beach Station							2.2
0944	8	0	20.3	31.3	6.5	8.2	78	14	2.0	1.2
		1	20.4	31.3	6.5	8.2	78			
		2	20.4	31.3	6.6	8.2	77			1.3
		3	20.2	31.3	5.5	8.2	72			
0959	10	0	20.7	30.8	5.3	8.2	81	12	2.0	1.3
		1	20.6	31.2	4.6	8.2	77			
		2	20.6	31.2	4.3	8.1	72			1.3
		3	20.6	31.2	4.5	8.1	65			
1008 SW5	20	0	20.6	30.6	5.2	8.2	76	14	1.0	1.0
		1	20.7	30.9	4.8	8.2	76			
1018 W5	11	0	20.5	31.3	6.4	8.2	64	12	1.5	1.1
		1	20.6	31.3	6.3	8.2	74			
		2	20.2	31.4	5.5	8.2	66			1.2
1029 W5	9	0	20.6	31.2	7.3	8.2	68	14	1.5	1.7
		1	20.6	31.2	6.8	8.2	71			
		2	20.4	31.3	6.2	8.2	68			1.9
		3	19.4	31.5	5.4	8.2	66			
1043	7	0	20.3	31.4	7.7	8.3	61	12	2.0	1.3
		1	20.3	31.4	7.6	8.3	77			
		2	20.0	31.5	6.5	8.2	74			1.3
		3	19.2	31.5	5.4	8.2	69			
1138	13	0	20.8	31.1	4.7	7.6				2.9
1146	22	Water too shallow to measure								

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Table B8. 17 May 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, clear and windy

TIDE	TIME	HEIGHT (ft)
Low	1007	0.4
High	1726	2.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1201	12	0	19.8	29.6	6.8	7.9	79			3.3
		1	19.2	30.9	6.2	7.9	73			
		2	18.4	31.3	5.3	7.9	73			4.1
	Average		19.6	31.1	6.7	8.2	75.3	12.3	1.7	1.7
	Sta. Dev.		1.0	0.3	1.0	0.1	6.3	1.5	0.4	0.6
	Maximum		20.8	31.5	7.9	8.3	89.0	14.0	2.0	4.1
	Minimum		16.9	29.6	4.3	7.6	54.0	10.0	1.0	1.0

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Table B9. Physical Water Quality Data. 7 June 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, clear and windy

TIDE	TIME	HEIGHT (ft)
High	0933	2.4
Low	1341	2.4

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0815	13	0	20.3	31.7	6.3	8.1				4.1
0830	22	0	21.1	30.6	3.3	7.8				5.3
0854 W5	25	0	19.6	32.2	8.1	8.3	83	10	2.0	1.5
		1	19.3	32.3	7.7	8.3	82			
		2	18.9	32.3	7.7	8.3	81			1.4
		3	18.9	32.3	7.7	8.3	79			
		4	18.8	32.3	7.8	8.3	77			1.3
		5	18.7	32.3	7.9	8.3	73			
0906 W5.5	5	0	19.8	32.0	7.9	8.3	92	10	2.0	1.2
		1	19.8	32.0	8.1	8.3	83			
		2	19.5	32.0	8.0	8.3	81			1.5
		3	19.2	32.0	7.9	8.3	78			
		4	18.8	32.0	7.9	8.3	77			1.7
		5	18.3	32.2	7.6	8.3	76			
0919 SW6	6	0	19.8	31.9	8.6	8.3	85	10	3.0	1.4
		1	19.8	31.9	8.5	8.3	86			
		2	19.7	31.9	8.6	8.3	85			1.4
		3	19.1	31.9	7.0	8.2	84			
		4	18.2	31.9	2.3	7.9	72			1.8
0939	18	0	20.5	31.9	8.1	8.2	85	10	2.0	1.6
		1	20.3	31.8	8.2	8.2	85			
0939	19	0	Beach Station							2.3
0943 SW6	8	0	20.2	31.8	8.3	8.2	81	8	2.5	1.4
		1	20.0	31.8	8.3	8.2	82			
		2	20.0	31.8	8.2	8.2	80			2.2
		3	19.5	31.9	4.6	8.1	77			
		4	18.7	31.8	1.6	7.8	68			3.1
1002	10	0	20.7	31.7	7.3	8.2	84	12	2.5	1.8
		1	20.5	31.7	7.6	8.2	84			
		2	20.0	31.8	5.6	8.3	83			2.3
		3	19.2	32.0	4.8	8.1	73			
		4	18.8	31.9	3.1	7.9	71			2.8

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Table B9. 7 June 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, clear and windy

TIDE	TIME	HEIGHT (ft)
High	0933	2.4
Low	1341	2.4

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1009	20	0	20.9	31.2	5.8	8.0	79	14	1.5	1.6
		1	20.5	31.5	8.1	8.2	85			
		2	20.1	31.7	8.4	8.2	74			2.8
1020	11	0	20.4	31.2	7.2	8.2	82	10	2.0	1.1
SW5		1	20.0	31.5	7.2	8.2	83			
		2	19.8	31.6	7.2	8.2	78			1.7
		3	19.2	31.8	6.4	8.1	74			
1030	9	0	20.6	31.7	7.3	8.1	80	10	2.0	1.1
SW5		1	20.5	31.7	7.3	8.1	79			
		2	19.5	31.7	7.2	8.1	75			1.2
		3	19.1	31.9	5.8	8.1	74			
		4	18.8	32.0	4.3	8.0	65			1.2
1048	7	0	20.4	31.9	7.3	8.2	81	10	2.0	1.1
		1	20.2	31.9	7.4	8.2	80			
		2	19.6	31.8	7.2	8.2	73			1.0
		3	19.2	31.8	7.5	8.2	71			
		4	18.7	32.1	6.0	8.1	67			1.0
1112	12	0	19.1	32.0	8.3	8.3	85	6	3.0	1.1
SW8		1	19.0	32.2	8.4	8.3	86			
		2	18.9	32.2	8.4	8.3	86			1.0
1120	1	0	18.9	32.3	9.5	8.3	89	6	4.5	1.4
SW7		1	18.9	32.3	9.9	8.3	89			
		2	18.8	32.3	9.7	8.3	86			1.4
		3	18.6	32.3	9.4	8.3	85			
		4	18.6	32.3	9.5	8.3	83			1.4
1128	2	0	19.0	32.2	9.2	8.3	82	7	2.5	1.2
		1	18.9	32.2	9.0	8.3	84			
		2	18.8	32.2	9.3	8.3	83			1.2
		3	18.8	32.2	9.2	8.3	82			
		4	18.7	32.3	9.1	8.3	83			1.3
		5	18.6	32.3	9.1	8.3	82			

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Table B9. 7 June 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, clear and windy

TIDE	TIME	HEIGHT (ft)
High	0933	2.4
Low	1341	2.4

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1140 SW7	3	0	19.8	32.0	8.5	8.2	80	7	2.5	1.1
		1	19.7	32.0	8.4	8.2	79			
		2	18.7	32.2	8.4	8.2	76			1.1
		3	18.5	32.3	8.5	8.2	75			
		4	18.5	32.2	8.7	8.2	75			0.9
		5	18.4	32.2	8.4	8.2	71			
1151	4	0	20.2	32.0	8.9	8.2	77	12	2.5	1.2
		1	20.2	31.9	8.5	8.2	80			
		2	20.1	31.9	8.7	8.2	80			1.2
		3	18.8	32.1	8.6	8.2	79			
		4	18.5	32.2	8.8	8.2	81			1.1
		5	18.4	32.2	8.5	8.2	70			
	Average		19.4	32.0	7.6	8.2	79.7	9.5	2.4	1.6
	Sta. Dev.		0.7	0.3	1.7	0.1	5.4	2.2	0.7	0.9
	Maximum		21.1	32.3	9.9	8.3	92.0	14.0	1.5	5.3
	Minimum		18.2	30.6	1.6	7.8	65.0	6.0	1.5	0.9

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Table B10. Physical Water Quality Data. 12 July 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Hot, sultry, partly cloudy

TIDE	TIME	HEIGHT (ft)
Low	0647	0.1
High	1332	4.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0829	12	0	22.7	28.1	7.4	8.4	78	12	2.0	2.4
		1	21.5	30.1	7.9	8.3				
		2	21.2	31.4	7.7	8.3				1.8
0838	1	0	21.2	31.6	8.0	8.3	86	6	3.5	1.9
		1	21.1	31.6	8.3	8.3	87			
		2	21.0	31.7	8.6	8.3	88			1.5
		3	20.9	31.7	8.5	8.3	88			
		4	20.8	31.7	8.6	8.3	87			1.3
0846 SW4	2	0	21.1	31.4	8.6	8.3	85	6	3.0	1.6
		1	20.9	31.6	8.3	8.3	*			
		2	20.7	31.7	8.3	8.3				1.3
		3	20.3	31.7	8.3	8.3				
		4	20.1	31.8	8.3	8.3				1.3
0855 SW2	3	0	22.8	31.7	7.0	8.2	82	10	2.0	1.2
		1	22.8	31.7	7.1	8.2				
		2	22.5	31.7	6.7	8.2	80			1.2
		3	21.6	31.7	6.8	8.2	77			
0904 SW5	4	0	22.5	31.7	7.0	8.2		10	2.5	1.5
		1	21.4	31.8	6.5	8.2				
		2	21.0	31.7	6.9	8.2				1.9
		3	20.9	31.8	7.6	8.3				
		4	20.8	31.8	7.9	8.3				2.2
		5	20.6	31.8	7.3	8.2				
		6	20.4	31.8	6.8	8.2				
0913 SW<2	25	0	22.8	31.7	7.0	8.2		8	2.0	1.4
		1	22.4	31.8	6.6	8.2				
		2	21.1	31.8	6.5	8.2				1.5
		3	21.0	31.8	6.6	8.2				
		4	20.7	31.8	6.5	8.2				1.1
0921 SE5	5	0	23.1	31.8	7.0	8.2		12	2.0	1.5
		1	22.8	31.8	7.0	8.2				
		2	22.0	31.8	6.5	8.2				1.8
		3	21.1	31.8	5.9	8.1				
		4	20.9	31.8	5.6	8.1				1.5

* Transmissometer malfunction

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Table B10. 12 July 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Hot, sultry, partly cloudy

TIDE	TIME	HEIGHT (ft)
Low	0647	0.1
High	1332	4.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0935	6	0	23.1	31.8	7.3	8.1		8	3.5	1.0
SW7		1	23.1	31.8	6.6	8.1				
		2	22.9	31.7	7.0	8.2				1.2
		3	21.9	31.7	4.8	8.1				
0954	18	0	23.9	32.0	7.9	8.2		12	2.0	1.7
		1	23.7	31.9	8.7	8.2				
0956	19	0	Beach Station							2.8
SW6										
1002	8	0	23.8	31.9	7.1	8.1		12	1.5	1.8
SW4		1	23.6	31.9	7.2	8.1				
		2	23.6	31.9	6.7	8.1				3.8
		3	22.5	31.9	3.3	7.9				
1020	20	0	24.1	31.2	5.3	8.0		14	1.5	3.2
SW3		1	23.8	31.7	6.9	8.1				
1025	10	0	24.0	31.6	6.7	8.0		14	1.5	2.1
W4		1	23.6	31.7	6.8	8.1				
		2	23.5	31.7	5.8	8.0				4.8
		3	22.3	31.7	3.5	7.9				
1039	11	0	23.6	31.9	6.4	8.1		10	2.5	1.6
SW6		1	23.2	31.8	6.5	8.1				
		2	23.0	31.8	6.4	8.1				2.7
		3	22.5	32.0	5.5	8.1				
1049	9	0	23.8	31.8	6.7	8.1		10	2.5	1.3
W7		1	23.7	31.8	6.9	8.1				
		2	23.4	31.8	5.6	8.1				1.5
		3	22.2	31.8	3.8	7.9				
1106	7	0	23.6	31.9	6.4	8.1		10	2.0	1.4
W9		1	23.5	32.0	6.5	8.1				
		2	22.8	32.0	6.2	8.1				1.3
		3	22.5	32.0	6.7	8.1				
1138	13	0	24.4	31.7	5.3	8.0				4.1

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1 9362

Table B10. 12 July 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch

WEATHER: Hot, sultry, partly cloudy

TIDE	TIME	HEIGHT (ft)
Low	0647	0.1
High	1332	4.5

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1148	22	0	27.2	31.4	10.1	8.2				6.2
	Average		22.4	31.7	6.9	8.2	83.8	10.3	2.3	2.1
	Sta. Dev.		1.4	0.5	1.2	0.1	4.0	2.4	0.6	1.2
	Maximum		27.2	32.0	10.1	8.4	88.0	14.0	3.5	6.2
	Minimum		20.0	28.1	3.3	7.9	77.0	6.0	1.5	1.0

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19353

Table B11. Physical Water Quality Data. 2 August 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, cool and windy

TIDE	TIME	HEIGHT (ft)
Low	0219	0.2
High	0912	3.6

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0955 W4	12	0	22.2	32.2	7.6	8.3	86	8	3.0	3.4
		1	22.1	32.2	7.6	8.3	86			
		2	21.9	32.4	6.8	8.3	89			1.6
1005 W9	1	0	22.3	32.0	7.3	8.3	91	6	4.5	1.5
		1	22.3	32.6	7.7	8.3	91			
		2	22.2	32.8	8.1	8.3	89			1.7
		3	22.0	32.8	7.9	8.3	89			
		4	21.5	32.9	8.1	8.3	89			1.7
		5	20.0	32.9	7.8	8.3	90			
		6	17.4	33.0	7.5	8.2	86			2.8
1015 W7	2	0	21.9	32.8	7.4	8.3	87	7	3.5	1.7
		1	21.9	32.8	7.8	8.3	87			
		2	21.8	32.8	7.7	8.3	87			1.7
		3	21.8	32.8	7.6	8.3	87			
		4	21.8	32.8	7.7	8.3	87			1.7
		5	21.8	32.8	7.5	8.3	87			
1025 W8.5	3	0	23.2	32.8	6.1	8.1	88	8	3.5	1.7
		1	23.1	32.8	6.2	8.1	86			
		2	23.1	32.8	6.5	8.1	85			1.4
		3	23.0	32.8	6.5	8.1	86			
		4	22.8	32.8	6.4	8.1	84			1.2
1036 W7	4	0	23.7	32.8	6.7	8.1	86	12	2.5	2.1
		1	23.7	32.8	6.9	8.1	85			
		2	23.6	32.8	6.7	8.2	84			1.9
		3	23.6	32.8	6.7	8.2	84			
1045 W8.5	25	0	23.6	32.7	6.6	8.1	86	12	3.0	1.8
		1	23.6	32.8	6.5	8.1	86			
		2	23.6	32.8	6.5	8.1	86			1.8
		3	23.2	32.9	6.0	8.1	86			
		4	22.4	32.8	6.2	8.1	82			1.5
		5	21.8	32.9	5.7	8.1	77			

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Table B11. 2 August 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, cool and windy

TIDE	TIME	HEIGHT (ft)
Low	0219	0.2
High	0912	3.6

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1058	5	0	24.0	32.8	6.3	8.1	88	12	2.0	2.0
W10		1	23.9	32.8	5.9	8.1	85			
		2	23.8	32.8	5.9	8.1	84			2.0
		3	23.7	32.8	6.3	8.1	84			
		4	22.8	32.9	5.8	8.1	81			1.4
		5	22.4	32.8	5.4	8.1	78			
1110	6	0	23.9	32.8	4.5	8.0	86	10	3.5	1.1
W7.5		1	23.9	32.8	4.6	8.0	87			
		2	23.9	32.8	4.5	8.0	87			1.1
		3	23.8	32.8	4.2	8.0	87			
1131	18	0	24.4	33.0	5.2	8.0	86	12	2.0	1.0
10		1	24.4	33.0	5.4	8.0	86			
1010	19	0	Beach Station							3.0
1135	8	0	24.5	33.0	4.9	8.0	90	12	3.5	1.2
7		1	24.3	32.9	4.4	7.9	90			
		2	24.3	32.9	4.3	7.9	87			1.2
		3	24.2	33.0	4.3	8.0	87			
		4	24.2	33.0	5.0	8.0	87			1.4
1154	10	0	24.7	32.9	3.1	7.9	92	12	2.5	1.1
7		1	24.5	32.9	3.4	7.9	84			
		2	24.4	32.9	3.4	7.9	80			1.2
		3	24.4	32.9	3.3	7.9	76			
1201	20	0	24.9	33.0	3.3	7.9	92	14	2.0	1.3
8.5		1	24.7	32.9	3.1	7.9	88			
1208	11	0	24.7	33.0	4.6	7.9	90	14	2.0	1.0
8		1	24.6	32.9	4.4	7.9	87			
		2	24.6	32.9	4.4	7.9	84			1.2
		3	24.0	33.0	5.1	8.0	82			
1222	9	0	24.9	32.9	5.3	8.0	88	12	2.5	1.2
5		1	24.8	32.9	5.3	8.0	88			
		2	24.5	32.9	5.3	8.0	87			1.4
		3	24.5	32.9	4.3	8.0	82			

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Table B11. 2 August 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Overcast, cool and windy

TIDE	TIME	HEIGHT (ft)
Low	0219	0.2
High	0912	3.6

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1235	7	0	24.3	33.0	5.1	8.0	78	14	2.0	1.4
5		1	24.2	33.0	5.2	8.0	80			
		2	24.2	33.0	5.1	8.0	77			1.4
		3	24.2	33.0	5.1	8.0	75			
1310	13	0	25.3	33.0	3.8	7.8				3.4
1322	22	0	26.4	32.8	7.2	8.1				4.9
	Average		23.4	32.8	5.8	8.1	85.6	11.0	2.8	1.7
	Sta. Dev.		1.4	0.2	1.4	0.1	3.8	2.5	0.8	0.8
	Maximum		26.4	33.0	8.1	8.3	92.0	14.0	4.5	4.9
	Minimum		17.4	32.0	3.1	7.8	75.0	6.0	2.0	1.0

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Table B12. Physical Water Quality Data. 6 September 1990

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, hot and calm

TIDE	TIME	HEIGHT (ft)
Low	0325	0.4
High	0940	5.4
Low	1549	0.6

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0830 <2	12	0	19.8	32.3	8.8	8.4	84	10	2.5	1.3
		1	19.7	32.1	8.4	8.4	84			
		2	18.9	32.0	9.1	8.4	83			1.3
		3	18.9	32.2	8.7	8.4	82			
0842 NW2	1	0	20.2	32.1	8.4	8.4	82	7	2.0	1.2
		1	19.6	32.1	8.7	8.4	83			
		2	17.8	32.3	8.9	8.4	85			1.1
		3	17.4	32.3	9.0	8.4	86			
		4	17.0	32.3	8.9	8.3	82			1.0
		5	16.6	32.3	8.7	8.3	77			
0851 NW4	2	0	19.4	32.5	8.6	8.4	82	10	2.5	1.0
		1	19.0	32.2	8.8	8.4	84			
		2	18.3	32.3	8.9	8.4	83			0.1
		3	17.9	32.2	9.0	8.4	83			
		4	18.0	32.2	8.9	8.3	83			0.9
		5	17.7	32.2	8.9	8.3	82			
		6	17.1	32.3	8.7	8.3	82			0.9
0904 W5	3	0	22.0	32.0	7.6	8.3	84	10	2.5	0.8
		1	21.6	32.0	7.9	8.3	84			
		2	20.0	32.0	8.2	8.3	83			0.8
		3	19.4	32.3	8.4	8.3	82			
0916 W7	4	0	22.0	32.0	7.6	8.3	85	10	3.0	0.9
		1	22.0	32.0	7.7	8.3	85			
		2	20.9	32.1	7.9	8.3	85			1.0
		3	20.7	32.0	8.0	8.3	81			
		4	20.2	32.0	8.2	8.3	81			1.1
		5	20.0	32.1	8.2	8.3	79			
		6	19.8	32.1	8.0	8.3	79			1.1
0927 W6	25	0	21.9	32.0	6.7	8.2	84	10	3.0	1.0
		1	21.9	32.0	7.6	8.2	85			
		2	21.2	32.0	7.6	8.2	84			1.1
		3	20.6	32.0	8.0	8.3	83			
		4	20.2	32.0	7.6	8.3	81			0.9
		5	20.1	32.0	7.9	8.3	79			

Table B12. 6 September 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, hot and calm

TIDE	TIME	HEIGHT (ft)
Low	0325	0.4
High	0940	5.4
Low	1549	0.6

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
0939 W6	5	0	22.6	32.1	6.5	8.2	82	10	3.0	1.5
		1	22.5	32.0	7.3	8.2	83			
		2	22.4	32.0	7.5	8.2	83			1.5
		3	22.1	32.0	7.3	8.2	82			
		4	21.2	31.9	8.1	8.3	82			1.4
		5	20.0	32.1	8.2	8.3	81			
		6	19.7	32.1	7.8	8.3	79			
0953 W6	6	0	22.5	32.1	5.4	8.1	85	7	3.5	0.7
		1	22.5	32.1	6.1	8.1	87			
		2	22.4	32.0	6.5	8.1	88			1.4
		3	22.2	32.1	5.7	8.1	88			
		4	21.2	32.1	5.1	8.1	74			1.0
1015 SW6	18	0	23.1	32.1	5.9	8.1	85	10	3.0	1.0
		1	23.0	32.1	6.9	8.1	85			
		2	22.9	32.1	6.5	8.1	81			1.9
1015	19	0	Beach Station							5.1
1023 SW4	8	0	23.1	32.1	5.8	8.1	83	12	2.0	1.0
		1	23.0	32.1	6.5	8.1	84			
		2	22.9	32.0	6.3	8.1	82			1.6
		3	22.8	32.1	6.0	8.1	80			
		4	22.5	32.0	4.9	8.0	76			2.6
		5	22.4	32.0	4.2	8.0	67			
1042 SW4	10	0	23.1	32.0	4.7	8.0	86	12	2.0	1.0
		1	23.1	32.0	5.4	8.0	81			
		2	23.0	32.0	5.2	8.0	79			2.6
		3	22.8	32.0	4.9	8.0	78			
		4	22.6	32.0	4.5	8.0	78			1.1
1051	20	0	23.5	32.0	4.5	8.0	85	10	3.0	0.7
		1	23.2	32.0	4.9	8.0	87			
		2	23.0	32.0	4.9	8.0	85			1.0
		3	22.8	32.0	4.6	8.0	80			

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Table B12. 6 September 1990 cont.

CRUISE: MDR 89-90 Vessel: Bay Watch
WEATHER: Sunny, hot and calm

TIDE	TIME	HEIGHT (ft)
Low	0325	0.4
High	0940	5.4
Low	1549	0.6

Time/ Wind k	Station	Depth m	Temp. C	Sal. o/oo	DO mg/l	pH	%T	FU	Secchi	BOD mg/l
1102	11	0	23.2	32.0	5.5	8.0	85	10	2.5	0.6
		1	23.3	32.0	6.0	8.0	85			
		2	23.1	32.0	6.0	8.1	84			1.3
		3	22.6	32.0	5.9	8.1	80			
		4	21.9	32.0	5.9	8.1	76			1.5
1112	9	0	23.2	32.0	5.5	8.1	79	12	2.5	1.0
		1	22.8	32.0	5.9	8.1	77			
		2	22.5	32.0	5.2	8.0	75			1.6
		3	21.6	32.0	5.4	8.0	72			
		4	20.9	32.0	6.0	8.1	72			1.0
1128	7	0	22.9	32.0	5.3	8.0	84	10	2.5	1.1
W6		1	22.9	32.0	5.8	8.0	85			
		2	22.6	32.0	5.6	8.0	85			1.2
		3	22.3	32.0	5.9	8.1	80			
		4	21.3	32.0	5.2	8.0	75			0.9
		5	20.7	32.0	5.7	8.1	71			
1206	13	0	23.6	32.2	4.2	7.9				2.5
1214	22	0	24.7	31.9	5.9	8.1				3.0
	Average		21.3	32.1	6.8	8.2	81.6	10.0	2.6	1.3
	Sta. Dev.		1.9	0.1	1.5	0.1	4.0	1.4	0.4	0.8
	Maximum		24.7	32.5	9.1	8.4	88.0	12.0	3.5	5.1
	Minimum		16.6	31.9	4.2	7.9	67.0	7.0	2.0	0.6

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APPENDIX C

NUTRIENT CHEMISTRY DATA

October 1989 - September 1990

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C2

Table C1. MDR Nutrient Chemistry Data (in ug-at/L) 5 October 1989

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	2.18	46.38	5.33	0.91	4.41	13.00
	2	0.55	11.47	1.01	0.20	0.81	4.13
1	0	0.48	12.69	0.84	0.20	0.64	3.19
	2	0.25	5.04	0.58	0.08	0.49	2.30
	4	0.22	4.01	0.37	0.08	0.29	2.59
	6	0.22	3.98	0.42	0.08	0.34	2.78
2	0	0.45	8.39	0.53	0.10	0.43	2.73
	2	0.37	7.05	0.43	0.08	0.35	2.44
	4	0.40	7.46	0.59	0.15	0.45	4.30
3	0	0.56	10.65	0.79	0.18	0.61	3.20
	2	0.54	10.69	0.26	0.14	0.13	2.80
	4	0.54	10.73	3.22	0.13	3.09	2.90
4	0	0.62	11.23	0.49	0.14	0.35	4.30
	2	0.54	9.27	0.46	0.12	0.34	3.20
	4	0.41	6.91	0.38	0.16	0.22	2.90
25	0	0.83	11.66	1.01	0.27	0.73	2.40
	2	0.66	9.34	0.65	0.15	0.50	4.30
	4	0.50	7.40	0.53	0.19	0.34	3.70
	6	0.48	7.31	0.60	0.22	0.38	3.10
5	0	0.69	12.55	0.26	0.12	0.14	2.20
	2	0.72	12.06	0.19	0.10	0.09	2.60
	4	0.41	6.54	0.48	0.05	0.43	2.10
6	0	0.73	13.11	1.07	0.21	0.86	3.50
	2	0.97	13.41	1.93	0.22	1.70	3.70
	4	0.76	13.28	1.41	0.21	1.19	5.70
18	0	1.10	16.49	1.33	0.26	1.06	4.90
	2	0.96	15.45	1.47	0.20	1.26	3.80
19	0	0.88	14.60	1.15	0.20	0.95	5.10
8	0	0.80	15.27	0.80	0.16	0.65	2.80
	2	0.92	15.27	1.43	0.20	1.22	2.90
	4	0.88	15.25	0.89	0.17	0.72	2.80
10	0	1.09	21.59	3.84	0.28	3.56	5.00
	2	1.11	18.81	1.60	0.20	1.40	4.30
	4	1.03	16.54	0.66	0.22	0.43	3.00

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Table A1. cont. MDR Nutrient Chemistry Data (in ug-at/L) 5 October 1989

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
20	0	1.10	21.81	4.49	0.27	4.21	5.30
	2	0.99	17.93	1.22	0.22	0.99	5.70
11	0	0.72	15.84	1.18	0.19	0.99	2.40
	2	0.74	14.64	0.67	0.16	0.51	2.10
	4	0.74	12.79	1.40	0.15	1.25	3.50
9	0	0.78	14.99	1.21	0.20	1.01	3.00
	2	0.78	14.53	1.17	0.17	1.00	3.30
	4	0.50	12.97	1.78	0.16	1.62	3.00
7	0	0.61	13.04	0.55	0.14	0.41	2.80
	2	0.78	13.10	0.44	0.35	0.09	2.70
	4	0.77	11.62	1.73	0.90	0.83	2.50
13	0	1.89	48.17	28.01	0.94	27.06	9.80
22	0	Area unaccessible due to locked gate					
	Average	0.74	13.77	1.76	0.22	1.53	3.71
	Number	46	46	46	46	46	46
	Standard	0.36	8.22	4.06	0.19	3.93	1.92
	Maximum	2.18	48.17	28.01	0.94	27.06	13
	Minimum	0.22	3.98	0.19	0.05	0.09	2.10

Table C2. MDR Nutrient Chemistry Data (in ug-at/L) 9 November 1989

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	1.54	51.54	1.45	0.31	1.07	31.20
	2	0.71	15.34	0.78	0.33	0.38	9.22
1	0	0.92	24.47	0.64	0.15	0.46	6.37
	2	0.70	14.33	0.68	0.17	0.48	6.16
	4	0.49	6.40	0.37	0.07	0.28	5.16
2	0	0.56	7.26	0.22	0.07	0.12	5.13
	2	0.57	6.88	0.24	0.13	0.08	6.00
	4	0.53	6.07	0.18	0.10	0.06	5.23
	6	0.42	5.38	0.32	0.14	0.15	7.28
3	0	0.69	9.53	1.97	0.27	1.64	7.12
	2	0.79	9.60	2.88	0.31	2.50	6.03
	4	0.76	9.19	1.79	0.24	1.50	5.55
4	0	0.89	10.60	2.82	0.33	2.43	6.31
	2	0.84	10.06	2.48	0.24	2.19	6.24
	4	0.84	9.42	3.19	0.29	2.84	7.30
25	0	1.00	11.43	3.45	0.35	3.02	7.54
	2	1.03	11.59	3.35	0.33	2.95	8.09
	4	0.99	11.33	3.48	0.32	3.09	6.81
5	0	1.12	13.97	5.23	0.44	4.69	8.18
	2	1.19	14.44	5.25	0.43	4.72	7.82
	4	1.16	14.38	5.44	0.51	4.83	7.46
6	0	1.17	14.05	5.51	0.50	4.91	6.55
	2	1.12	13.96	5.62	0.47	5.06	7.80
18	0	1.10	14.36	6.19	0.59	5.48	5.52
	2	1.06	14.20	5.95	0.51	5.34	5.07
19	0	1.05	11.90	4.49	0.53	3.86	5.97
8	0	1.17	14.85	6.27	0.70	5.43	6.17
	2	1.08	13.37	5.89	0.58	5.20	5.07
10	0	1.63	41.44	23.13	0.79	22.19	11.75
	2	1.45	21.27	8.79	0.64	8.02	10.48
20	0	1.59	28.00	12.32	0.74	11.44	14.00
	2	1.51	20.75	8.01	0.64	7.23	13.00

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Table C2. cont. MDR Nutrient Chemistry Data (in ug-at/L) 9 November 1989

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
11	0	1.35	18.28	7.56	0.66	6.78	10.00
	2	1.30	16.95	6.90	0.60	6.19	9.60
9	0	1.22	15.84	6.35	0.58	5.66	18.00
	2	1.23	15.51	5.95	0.51	5.35	13.00
7	0	1.22	14.79	6.02	0.67	5.21	11.00
	2	1.25	14.84	5.50	0.55	4.84	11.00
13	0	1.81	27.65	10.76	0.80	9.79	45.00
22	0	4.67	57.90	97.97	1.54	96.10	22.44
	Average	1.14	16.58	7.13	3.69	3.35	9.94
	Number	40	40	40	40	40	40
	Standard	0.65	11.04	15.12	14.97	3.95	7.56
	Maximum	4.67	57.90	97.97	96.10	22.19	45.00
	Minimum	0.42	5.38	0.18	0.07	0.06	5.07

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Table C3. MDR Nutrient Chemistry Data (in ug-at/L) 7 December 1989

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	6.11	71.28	24.93	2.93	21.44	7.36
	2	0.95	14.96	1.76	0.24	1.47	4.33
1	0	2.96	56.75	11.00	1.31	9.44	6.80
	2	1.09	21.51	2.73	0.45	2.19	3.39
	4	0.79	13.04	1.62	0.32	1.23	3.00
2	0	0.64	8.48	1.51	0.20	1.28	2.60
	2	0.62	8.45	1.02	0.23	0.74	3.80
	4	0.66	8.53	1.18	0.16	1.00	3.82
3	0	1.14	14.87	3.39	0.40	2.92	7.28
	2	1.15	14.47	3.85	0.43	3.34	6.41
	4	1.12	14.47	3.65	0.41	3.16	7.06
4	0	1.36	16.52	5.11	0.48	4.55	9.26
	2	1.32	16.65	5.78	0.49	5.20	10.14
	4	1.37	16.75	5.31	0.52	4.70	9.15
25	0	1.42	16.99	5.76	0.48	5.19	10.00
	2	1.40	17.06	6.15	0.61	5.43	12.05
	4	1.46	17.17	6.57	0.57	5.90	11.09
5	0	1.55	19.69	8.37	0.64	7.62	11.14
	2	1.52	20.50	8.53	0.70	7.73	11.19
	4	1.53	20.11	8.12	0.69	7.34	10.21
6	0	1.50	20.36	9.02	0.72	8.21	9.95
	2	1.43	21.06	8.95	0.70	8.16	9.58
18	0	1.53	22.23	9.83	0.91	8.80	7.64
19	0	1.73	19.19	7.95	0.97	6.86	8.20
8	0	1.56	21.65	10.12	0.95	9.06	10.11
	2	1.53	20.89	9.82	0.88	8.63	10.17
10	0	1.98	36.97	17.43	1.03	16.27	15.34
	2	1.79	26.54	11.24	0.82	10.32	11.31
20	0	1.97	40.48	19.46	1.08	18.25	15.51
11	0	1.69	25.15	11.67	0.82	10.75	10.40
	2	1.64	23.98	10.75	0.94	9.70	14.00

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Table C3. cont. MDR Nutrient Chemistry Data (in ug-at/L) 7 December 1989

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
9	0	1.62	33.46	9.80	0.73	8.98	13.00
	2	1.63	21.81	9.30	0.77	8.44	12.00
7	0	1.60	20.08	8.49	0.80	7.59	13.00
	2	1.62	20.21	8.38	0.79	7.50	13.00
13	0	2.29	41.94	20.57	1.01	19.37	19.00
22	0	3.62	55.69	63.68	1.20	62.25	19.35
	Average	1.65	23.78	9.81	1.45	8.24	9.75
	Number	37	37	37	37	37	37
	Standard	0.93	13.57	10.45	3.29	10.14	4.03
	Maximum	6.11	71.28	63.68	19.37	62.25	19.35
	Minimum	0.62	8.45	1.02	0.16	0.74	2.60

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Table C4. MDR Nutrient Chemistry Data (in ug-at/L) 11 January 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	2.15	24.83	5.59	0.88	4.59	14.00
	2	0.96	9.30	2.27	0.46	1.75	4.50
1	0	0.40	6.99	0.70	0.14	0.54	3.30
	2	0.39	1.12	1.22	0.14	1.06	2.40
	4	0.41	1.87	1.03	0.16	0.84	4.60
2	0	0.47	1.69	1.65	0.23	1.38	5.60
	2	0.44	5.46	1.63	0.31	1.28	2.90
	4	0.47	1.88	1.61	0.32	1.25	3.10
	6	0.48	1.92	1.53	0.31	1.17	6.20
3	0	0.60	3.11	1.58	0.31	1.23	4.50
	2	0.62	3.58	1.87	0.37	1.45	6.61
	4	0.55	2.69	1.50	0.24	1.22	7.62
4	0	0.71	7.14	2.80	0.25	2.25	3.21
	2	0.72	5.98	2.68	0.24	2.24	2.82
25	0	0.92	9.32	4.62	0.35	4.22	5.54
	2	0.93	7.84	4.30	0.31	3.95	8.27
	4	0.86	8.01	3.43	0.32	3.07	5.56
	6	0.80	7.27	3.13	0.19	2.91	8.10
5	0	1.00	14.22	6.34	0.47	5.80	5.30
	2	0.97	12.51	5.17	0.41	4.70	4.60
	4	0.96	9.84	4.51	0.41	4.04	4.40
6	0	1.25	15.50	8.98	0.54	8.37	5.30
	2	1.29	16.47	8.89	0.52	8.30	5.90
	4	1.28	17.16	8.86	0.51	8.28	5.80
18	0	1.33	20.86	10.94	0.70	10.14	5.50
19	0	1.19	19.08	8.43	0.64	7.70	3.40
8	0	1.30	17.84	10.15	0.60	9.47	5.61
	2	1.31	23.97	12.24	0.71	11.44	4.21
	4	1.30	21.12	10.54	0.62	9.84	4.82
10	0	1.47	22.09	12.29	0.65	11.55	6.74
	2	1.53	21.84	12.29	0.74	11.45	7.76
	4	1.49	20.45	11.33	0.59	10.66	6.15

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Table C4. cont. MDR Nutrient Chemistry Data (in ug-at/L) 11 January 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
20	0	1.54	22.02	13.09	0.85	12.12	6.67
	2	1.54	20.20	11.50	0.70	10.71	7.70
11	0	1.44	19.75	11.95	0.62	11.24	6.54
	2	1.48	19.50	11.45	0.64	10.72	5.87
9	0	1.31	18.66	9.97	0.65	9.24	5.70
	2	1.40	20.40	10.21	0.59	9.54	6.34
7	0	1.40	17.18	10.38	0.74	9.54	6.48
	2	1.36	15.67	9.08	0.61	8.39	6.41
	4	1.42	16.41	9.54	0.66	8.79	15.60
13	0	1.82	23.36	12.10	0.83	11.16	11.00
22	0	2.24	27.13	14.82	1.09	13.58	26.00
	Average	1.10	13.56	6.90	0.80	6.05	6.48
	Number	43	43	43	43	43	43
	Standard	0.46	7.73	4.30	1.98	4.01	3.95
	Maximum	2.24	27.13	14.82	13.58	12.12	26.00
	Minimum	0.39	1.12	0.70	0.14	0.54	2.40

Table C5. MDR Nutrient Chemistry Data (in ug-at/L) 8 February 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	2.02	39.15	12.12	1.09	11.08	12.38
	2	1.44	22.41	8.93	0.67	8.30	6.28
1	0	1.28	17.59	8.46	0.71	7.77	5.95
	2	1.07	11.13	6.49	0.65	5.87	4.53
	4	0.98	8.86	5.59	0.54	5.08	3.94
	6	0.92	7.86	5.32	0.47	4.87	3.22
2	0	0.90	7.58	4.83	0.44	4.40	4.60
	2	0.83	6.99	4.36	0.44	3.94	3.44
	4	0.84	6.95	4.33	0.44	3.90	3.59
3	0	1.00	7.77	4.56	0.61	3.98	4.99
	2	0.99	7.80	4.19	0.59	3.63	6.20
	4	0.97	7.74	4.30	0.72	3.62	4.68
4	0	0.90	7.58	3.84	0.47	3.39	4.52
	2	0.91	7.66	5.87	0.68	5.22	3.82
	4	0.91	7.58	4.42	0.71	3.75	4.80
5	0	1.02	8.50	4.82	0.66	4.19	4.35
	2	1.01	8.34	4.74	0.56	4.21	5.11
	4	1.01	8.23	4.57	0.61	3.99	4.20
25	0	0.91	7.74	4.33	0.60	3.75	3.83
	2	0.92	7.68	4.52	0.55	3.99	4.26
	4	0.98	7.80	5.60	0.71	4.92	3.17
	6	1.00	7.73	4.26	0.53	3.76	3.60
6	0	1.01	7.96	4.10	0.55	3.57	5.40
	2	1.03	7.99	4.09	0.50	3.61	3.70
	4	1.00	7.95	4.72	0.61	4.13	4.20
18	0	1.01	8.32	3.88	0.65	3.25	4.10
	2	1.07	8.26	3.78	0.64	3.17	3.50
19	0	1.07	37.97	3.58	0.59	3.01	4.90
8	0	0.97	8.20	3.27	0.39	2.90	4.50
	2	1.03	8.10	3.23	0.44	2.81	3.40
	4	1.02	8.08	3.25	0.38	2.89	4.10
10	0	1.18	8.69	4.18	0.43	3.77	4.53
	2	1.17	8.73	4.41	0.40	4.03	4.35

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Table C5. cont. MDR Nutrient Chemistry Data (in ug-at/L) 8 February 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
20	0	1.13	8.88	4.00	0.38	3.64	3.89
	2	1.15	8.88	4.71	0.46	4.26	3.39
11	0	1.09	8.52	4.39	0.40	4.01	2.90
	2	Data missing					3.12
9	0	1.04	8.46	4.62	0.43	4.21	4.10
	2	Data missing					3.51
7	0	1.14	8.48	4.80	0.45	4.37	4.73
	2	Data missing					4.14
13	0	1.20	8.81	4.15	0.52	3.65	7.30
22	0	1.59	11.24	5.02	0.79	4.27	16.25
	Average	1.06	10.39	4.88	0.56	4.35	4.74
	Number	39	39	39	39	39	44
	Standard	0.21	7.11	1.64	0.14	1.55	2.32
	Maximum	2.02	39.15	12.12	1.09	11.08	16.25
	Minimum	0.83	6.95	3.23	0.38	2.81	2.90

Table C6. MDR Nutrient Chemistry Data (in ug-at/L) 8 March 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	0.73	23.72	1.39	0.24	1.15	3.90
	2	0.44	8.11	0.30	0.11	0.19	4.00
1	0	0.42	8.64	0.30	0.10	0.20	3.80
	2	0.56	6.73	0.25	0.08	0.17	3.50
	4	0.41	7.03	0.25	0.09	0.16	6.60
	6	0.61	6.80	0.37	0.14	0.23	3.10
2	0	0.62	7.69	0.35	0.13	0.21	4.60
	2	0.53	7.44	0.41	0.21	0.20	3.20
	4	0.48	7.36	0.24	0.17	0.07	4.30
3	0	0.68	8.84	0.54	0.14	0.40	3.20
	2	0.63	8.53	0.54	0.14	0.40	4.00
	4	0.60	7.94	0.43	0.16	0.26	4.50
4	0	0.65	8.74	0.41	0.12	0.29	3.60
	2	0.71	8.71	0.46	0.20	0.26	3.80
	4	0.68	8.64	0.25	0.09	0.16	3.30
	6	0.69	8.58	0.49	0.13	0.36	3.93
25	0	0.53	8.98	0.88	0.25	0.62	3.35
	2	0.50	8.88	0.72	0.21	0.50	3.27
	4	0.47	8.72	0.48	0.18	0.29	3.29
5	0	0.57	9.53	1.54	0.28	1.26	3.63
	2	0.58	9.08	1.17	0.27	0.89	2.82
	4	0.50	8.62	0.75	0.24	0.51	2.73
6	0	0.63	8.40	2.11	0.33	1.77	4.50
	2	0.52	8.55	1.41	0.18	1.23	3.84
	4	0.67	8.84	0.96	0.16	0.80	5.44
18	0	0.56	8.30	0.84	0.14	0.70	4.71
19	0	0.62	7.06	0.98	0.20	0.78	5.84
8	0	0.62	8.34	1.14	0.17	0.97	3.16
	2	0.60	8.24	1.26	0.09	1.10	3.20
10	0	0.78	12.80	3.20	0.27	2.92	2.79
	2	0.68	10.06	1.78	0.28	1.50	4.20
20	0	0.87	16.96	5.07	0.26	4.81	3.83

Table C6. cont. MDR Nutrient Chemistry Data (in ug-at/L) 8 March 1990

STA	DEPTH (m)	PO4	S1O4	NO3+NO2	NO2	NO3	NH3+NH4
11	0	0.62	10.20	1.92	0.20	1.71	3.78
	2	0.67	10.59	1.78	0.27	1.50	4.11
9	0	0.59	9.58	2.49	0.22	2.28	3.62
	2	0.56	8.91	1.40	0.22	1.18	3.34
7	0	0.31	5.92	0.65	0.13	0.51	4.20
	2	0.46	7.69	0.84	0.16	0.68	3.60
13	0	1.30	12.27	2.51	0.22	2.29	4.60
22	0	3.30	24.83	5.63	0.54	5.08	22.00
	Average	0.67	9.62	1.21	0.26	0.95	4.37
	Number	40	40	40	40	40	41
	Standard	0.45	3.83	1.19	0.32	1.13	2.89
	Maximum	3.30	24.83	5.63	1.71	5.08	22.00
	Minimum	0.31	5.92	0.24	0.08	0.07	2.79

Table C7. MDR Nutrient Chemistry Data (in ug-at/L) 5 April 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	4.46	27.00	34.05	4.90	27.87	27.69
	2	1.00	6.72	1.91	2.25	0.00	4.47
1	0	1.69	9.65	9.70	1.40	7.88	6.52
	2	1.01	5.33	1.88	0.51	1.21	3.94
	4	0.86	4.69	0.68	0.10	0.55	3.34
2	0	1.25	6.99	5.53	1.22	3.88	4.91
	2	0.95	3.47	1.22	0.42	0.64	6.10
	4	0.71	3.55	0.53	0.08	0.42	4.11
3	0	1.27	5.62	7.66	0.42	7.07	4.71
	2	1.11	4.58	3.75	0.17	3.51	3.72
	4	0.76	5.93	0.53	0.00	0.53	3.22
4	0	1.70	9.09	15.37	0.79	14.23	3.83
	2	1.37	5.54	8.15	0.45	7.49	3.53
	4	0.68	3.80	1.15	0.21	0.84	3.03
25	0	1.12	4.67	7.87	0.19	7.59	6.70
	2	1.23	4.86	4.62	0.01	4.61	5.23
	4	1.02	5.71	1.72	0.53	0.93	4.25
5	0	1.50	6.58	12.58	0.17	12.33	5.59
	2	1.10	2.52	5.43	0.07	5.33	4.60
	4	0.97	3.33	1.99	0.06	1.90	4.53
6	0	0.72	0.42	1.55	0.00	1.55	3.62
	2	0.61	0.41	1.03	0.05	0.96	2.91
		0.69	2.82	0.79	0.04	0.72	5.80
18	0	0.65	0.32	1.03	0.08	0.91	3.70
19	0	0.76	0.74	1.92	0.06	1.83	3.90
8	0	0.68	0.96	3.09	0.10	2.94	3.10
	2	0.95	0.93	1.40	0.09	1.28	3.00
10	0	0.82	1.44	1.89	0.15	1.67	3.00
	2	1.11	3.16	1.44	0.00	1.44	5.00
20	0	1.48	12.27	10.34	0.03	10.30	4.40

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1 9384

Table C7. cont. MDR Nutrient Chemistry Data (in ug-at/L) 5 April 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
11	0	1.27	4.19	10.72	0.02	10.69	4.30
	2	0.78	1.39	3.45	0.00	3.45	3.65
9	0	1.19	5.76	14.62	0.00	14.62	4.18
	2	1.11	5.09	5.22	1.12	3.51	4.31
7	0	1.26	5.39	10.68	0.87	9.35	3.02
	2	1.14	5.15	5.42	0.46	4.71	6.31
13	0	9.82	31.91	107.58	8.92	96.59	69.00
22	0	11.81	27.85	21.44	17.27	18.20	99.26
	Average	1.62	6.33	8.68	1.43	7.43	9.12
	Number	38	38	38	38	38	38
	Standard	2.27	7.20	17.59	3.54	15.78	18.43
	Maximum	11.81	31.91	107.58	18.20	96.59	99.26
	Minimum	0.11	0.32	0.53	0.00	0.00	2.91

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1 9385

Table C8. MDR Nutrient Chemistry Data (in ug-at/L) 17 May 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
1	0	1.01	33.10	1.23	0.39	0.77	3.24
	2	0.52	12.18	0.69	0.30	0.33	3.70
	4	0.40	6.79	0.99	0.51	0.38	3.60
2	0	0.51	14.22	0.43	0.29	0.08	3.00
	2	0.49	12.39	0.69	0.39	0.23	3.10
	4	0.50	7.47	0.54	0.26	0.23	3.60
3	0	0.52	13.30	0.54	0.44	0.02	3.00
	2	0.64	13.73	0.75	0.42	0.26	2.70
	4	0.82	10.30	1.05	0.38	0.60	5.10
4	0	0.57	13.39	0.62	0.35	0.21	4.00
	2	0.57	12.76	1.17	0.36	0.74	3.91
	4	0.63	10.81	0.82	0.54	0.18	3.32
25	0	0.58	14.00	0.55	0.36	0.13	2.92
	2	0.60	13.54	0.69	0.34	0.28	2.93
	4	0.69	12.83	0.99	0.45	0.47	3.04
5	0	0.69	16.02	0.88	0.36	0.46	2.75
	2	0.75	16.34	1.40	0.48	0.84	3.47
	4	0.70	11.22	1.04	0.47	0.49	5.50
6	0	0.73	15.19	2.30	0.51	1.70	4.11
	2	0.86	15.14	1.57	0.40	1.10	4.71
18	0	0.94	17.94	2.46	0.68	1.66	3.72
	2	1.00	17.63	2.29	0.56	1.64	3.12
19	0	1.10	18.67	1.81	0.43	1.30	2.92
8	0	0.95	17.60	2.55	0.53	1.93	3.43
	2	1.06	18.43	2.48	0.59	1.79	3.13
10	0	1.57	26.18	6.55	0.59	5.87	7.10
	2	1.72	22.45	3.84	0.62	3.11	11.00
20	0	1.66	30.00	8.49	0.77	7.59	7.90
11	0	1.00	18.62	2.48	0.39	2.03	4.00
	2	1.00	18.50	2.06	0.37	1.64	3.80
9	0	0.96	20.45	3.94	0.38	3.49	4.00
	2	0.97	17.21	1.31	0.33	0.94	3.70

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1 9386

Table C8. cont. MDR Nutrient Chemistry Data (in ug-at/L) 17 May 1990

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NH3+NH4
7	0	0.65	13.63	0.36	0.18	0.15	2.90
	2	0.67	13.92	0.47	0.26	0.17	4.20
13	0	1.61	24.43	5.85	0.57	5.18	16.46
22		Water too shallow to measure					
12	0	1.25	23.16	1.17	0.36	0.75	4.55
	2	1.59	15.06	0.59	0.31	0.24	6.32
	Average	0.88	16.45	1.83	0.43	1.32	4.43
	Number	37	37	37	37	37	37
	Standard	0.36	5.55	1.79	0.12	1.69	2.59
	Maximum	1.72	33.10	8.49	0.77	7.59	16.46
	Minimum	0.40	6.79	0.36	0.18	0.02	2.70

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1 9 3 8 7

Table C9. MDR Nutrient Chemistry Data (in ug-at/L) 7 June 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
13	0	1.33	9.06	2.70	0.18	2.48	17.30
22	0	3.27	22.20	3.58	1.08	2.33	12.67
25	0	0.68	2.57	1.13	0.21	2.89	5.54
	2	0.76	2.93	1.06	0.22	0.80	8.23
	4	0.82	3.36	0.77	0.22	0.51	9.97
5	0	0.61	2.35	0.80	0.23	0.54	7.48
	2	0.68	2.60	0.34	0.17	0.14	7.82
	4	0.79	3.25	0.38	0.17	0.19	9.61
6	0	0.54	2.20	0.62	0.23	0.35	10.40
	2	0.54	2.19	0.21	0.11	0.08	8.36
	4	0.90	7.46	0.51	0.28	0.18	9.19
18	0	0.57	3.08	0.32	0.15	0.14	7.32
19	0	0.59	3.31	0.46	0.19	0.24	7.19
8	0	0.58	2.89	0.74	0.22	0.49	5.97
	2	0.60	3.40	0.26	0.14	0.09	9.70
	4	1.16	10.16	0.54	0.22	0.29	5.97
10	0	0.91	8.81	0.74	0.21	0.49	7.34
	2	0.78	6.33	0.59	0.19	0.37	6.26
	4	1.07	9.20	0.32	0.22	0.07	5.22
20	0	1.42	23.92	9.70	0.52	9.11	7.04
	2	0.88	7.34	0.95	0.24	0.68	5.07
11	0	0.72	4.62	0.47	0.24	0.20	4.45
	2	0.92	5.22	0.54	0.20	0.31	4.60
	4	2.17	6.71	0.87	0.38	0.44	6.29
9	0	0.89	4.12	1.44	0.24	1.18	5.65
	2	0.91	4.26	0.84	0.22	0.60	5.27
	4	1.17	5.63	0.86	0.29	0.53	5.28
7	0	0.77	2.38	0.30	0.15	0.14	4.65
	2	0.84	2.46	0.27	0.18	0.07	5.01
	4	1.02	3.85	0.53	0.24	0.27	5.08
12	0	0.60	3.98	0.77	0.23	0.51	4.82
	2	0.50	2.53	1.49	0.21	1.27	5.26

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1 9 3 8 8

Table C9. cont. MDR Nutrient Chemistry Data (in ug-at/L) 7 June 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
1	0	0.34	1.30	0.80	0.27	0.50	4.44
	2	0.36	0.91	0.49	0.02	0.48	4.27
	4	0.37	1.03	0.77	0.08	0.66	4.25
2	0	0.50	1.66	0.80	0.13	0.61	4.08
	2	0.49	1.59	0.54	0.15	0.33	3.86
	4	0.50	1.49	0.31	0.09	0.17	4.33
3	0	1.65	2.31	0.94	0.13	0.75	3.88
	2	0.69	3.49	0.48	0.14	0.28	4.25
	4	0.67	2.32	0.53	0.15	0.32	5.91
4	0	0.66	1.91	2.60	0.15	2.38	4.63
	2	0.65	1.64	0.22	0.05	0.14	3.93
	4	0.65	1.98	0.30	0.10	0.16	3.81
	Average	0.83	4.66	1.01	0.21	0.74	6.31
	Number	44	44	44	44	44	44
	Standard	0.49	4.66	1.48	0.16	1.40	2.61
	Maximum	3.27	23.92	9.70	1.08	9.11	17.30
	Minimum	0.34	0.91	0.21	0.02	0.07	3.81

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1939

Table C10. MDR Nutrient Chemistry Data (in ug-at/L) 12 July 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	0.90	29.25	1.39	0.26	0.90	4.21
	2	0.69	17.73	1.21	0.27	0.71	3.96
1	0	0.68	24.53	1.67	0.41	0.91	9.68
	2	0.34	8.25	0.62	0.16	0.31	5.53
	4	0.31	6.04	0.47	0.16	0.17	5.58
2	0	0.38	9.08	0.68	0.14	0.41	5.78
	2	0.37	8.04	2.07	0.87	0.41	4.14
	4	0.37	7.42	0.58	0.16	0.27	3.95
3	0	0.79	17.86	0.97	0.29	0.41	4.54
	2	0.79	16.82	0.63	0.16	0.32	3.69
4	0	0.69	16.12	0.63	0.14	0.35	4.91
	2	0.69	13.96	0.72	0.24	0.25	4.55
	4	0.57	10.77	0.61	0.29	0.03	4.34
25	0	0.73	16.24	1.00	0.31	0.39	3.76
	2	0.70	14.70	0.87	0.43	0.02	4.10
	4	0.80	13.25	0.87	0.28	0.30	3.64
5	0	0.80	17.63	0.67	0.23	0.21	3.89
	2	0.79	17.57	0.79	0.31	0.17	3.41
	4	0.92	17.02	0.89	0.22	0.45	4.32
6	0	0.77	17.25	1.17	0.35	0.46	4.32
	2	0.78	16.78	0.92	0.22	0.47	4.11
18	0	0.90	18.68	0.59	0.19	0.21	6.25
19	0	1.05	18.32	0.65	0.18	0.28	19.30
8	0	0.89	18.98	0.45	0.12	0.21	4.10
	2	1.07	19.20	0.67	0.20	0.27	4.54
10	0	1.48	26.51	4.94	0.43	4.10	5.68
	2	1.41	24.18	2.03	0.25	1.54	4.18
20	0	1.27	27.19	5.37	0.26	4.86	4.24
	2	1.47	24.21	2.24	0.26	1.71	4.86
11	0	1.02	21.94	1.62	0.20	1.24	4.12
	2	0.95	18.25	0.61	0.16	0.30	3.81

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1990

Table C10. cont. MDR Nutrient Chemistry Data (in ug-at/L) 12 July 1990

STA	DEPTH (m)	PO4	SIO4	NO3+NO2	NO2	NO3	NH3+NH4
9	0	0.92	20.90	2.79	0.17	2.47	3.97
	2	0.90	19.12	1.26	0.18	0.90	3.79
7	0	0.83	16.07	0.66	0.20	0.27	7.70
	2	0.87	16.02	0.76	0.15	0.49	3.34
13	0	1.79	24.06	3.01	0.47	2.15	74.30
22	0	1.85	19.41	1.42	0.31	0.85	6.43
	Average	0.88	17.55	1.09	0.26	0.83	6.96
	Number	37	37	37	37	37	37
	Standard	0.37	5.48	1.14	0.13	1.11	11.54
	Maximum	1.85	29.25	5.29	0.87	4.86	74.30
	Minimum	0.17	6.04	0.32	0.12	0.02	3.34

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1993

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Table C11. MDR Nutrient Chemistry Data (in ug-at/L) 2 August 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	0.74	42.80	3.94	1.06	2.42	5.39
	2	0.43	9.33	0.88	0.21	0.57	3.27
1	0	0.30	4.97	0.74	0.20	0.44	3.01
	2	0.31	3.07	0.37	0.10	0.23	2.73
	4	0.31	3.65	0.41	0.09	0.27	3.00
	6	0.43	4.50	0.37	0.07	0.27	3.16
2	0	0.36	4.52	0.50	0.12	0.31	3.20
	2	0.35	4.43	0.44	0.13	0.25	2.95
	4	0.40	5.90	0.41	0.10	0.25	2.90
3	0	0.74	10.38	0.99	0.25	0.60	3.38
	2	0.76	10.22	0.84	0.18	0.55	4.08
	4	0.74	9.38	0.95	0.20	0.62	3.61
4	0	0.68	10.60	0.62	0.21	0.28	5.00
	2	0.64	10.51	0.48	0.10	0.31	9.83
25	0	0.74	10.85	0.58	0.13	0.35	4.70
	2	0.74	10.96	0.80	0.25	0.38	5.01
	4	0.80	10.97	0.72	0.15	0.48	4.51
5	0	0.74	12.10	0.73	0.24	0.32	2.91
	2	0.79	11.77	0.76	0.22	0.38	3.32
	4	0.82	11.11	0.70	0.18	0.39	3.73
6	0	1.15	13.40	2.37	0.31	1.82	7.46
	2	1.11	13.28	2.18	0.29	1.68	7.37
18	0	1.66	13.94	2.30	0.27	1.81	9.50
19	0	1.86	13.53	2.45	0.41	1.73	11.00
8	0	1.81	14.69	2.39	0.30	1.85	10.00
	2	1.77	14.67	2.56	0.44	1.76	10.00
	4	1.74	14.28	2.47	0.42	1.71	8.40
10	0	2.24	17.75	3.02	0.52	2.08	16.00
	2	2.16	18.30	3.17	0.53	2.19	17.00
20	0	2.27	17.77	2.95	0.46	2.11	18.00
11	0	1.58	16.41	3.18	0.46	2.34	11.00
	2	1.55	16.11	3.29	0.54	2.30	59.00

1993 2

Table C11. cont. MDR Nutrient Chemistry Data (in ug-at/L) 2 August 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
9	0	1.14	15.41	4.55	0.43	3.76	7.60
	2	1.10	14.60	3.22	0.44	2.42	7.20
7	0	0.97	13.11	1.22	0.31	0.66	5.50
	2	0.99	13.59	1.26	0.29	0.72	6.10
13	0	2.57	19.76	3.73	0.76	2.66	18.00
22	0	2.53	25.57	1.01	0.34	0.52	5.50
	Average	1.11	12.85	1.46	0.31	1.15	8.27
	Number	38	38	38	38	38	38
	Standard	0.66	6.87	1.09	0.20	0.93	9.40
	Maximum	2.57	42.80	4.19	1.06	3.76	59.00
	Minimum	0.30	3.07	0.33	0.07	0.23	2.73

Table C12. MDR Nutrient Chemistry Data (in ug-at/L) 6 September 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
12	0	0.39	5.61	0.85	0.22	0.43	6.60
	2	0.36	5.45	0.58	0.13	0.32	5.52
1	0	0.30	5.18	0.47	0.18	0.13	11.09
	2	0.31	4.51	0.62	0.21	0.21	5.87
	4	0.43	4.83	0.73	0.25	0.25	5.29
2	0	0.31	5.02	0.81	0.21	0.41	4.49
	2	0.32	4.85	0.70	0.17	0.36	5.13
	4	0.34	4.85	0.79	0.21	0.38	3.91
	6	0.47	5.01	1.06	0.18	0.70	5.30
3	0	0.54	11.78	0.97	0.21	0.56	4.70
	2	0.45	9.02	0.68	0.14	0.40	5.10
4	0	0.52	12.09	1.17	0.28	0.61	3.70
	2	0.52	9.79	1.12	0.23	0.66	3.50
	4	0.44	7.39	1.13	0.25	0.63	2.90
	6	0.46	7.03	0.93	0.16	0.62	3.20
25	0	0.58	11.03	1.34	0.32	0.71	2.60
	2	0.51	9.44	0.25	0.09	0.42	4.50
	4	0.50	7.62	0.14	0.12	0.24	3.35
5	0	0.65	13.18	0.09	0.12	0.17	6.81
	2	0.67	12.94	0.06	0.07	0.21	3.98
	4	0.53	10.18	0.54	0.17	0.49	3.61
6	0	0.85	14.44	2.01	0.46	1.38	3.78
	2	0.90	14.66	1.51	0.35	1.07	3.61
	4	1.05	15.30	1.57	0.45	0.93	3.22
18	0	0.93	17.24	1.35	0.31	0.93	3.62
	2	1.00	17.21	1.02	0.32	0.57	3.23
19	0	1.47	18.11	1.05	0.30	0.66	5.50
8	0	0.90	16.70	1.28	0.28	0.89	3.04
	2	0.91	16.69	1.11	0.28	0.64	3.05
	4	1.10	17.71	1.05	0.37	0.41	2.76
10	0	1.33	19.39	2.56	0.42	1.80	5.13
	2	1.40	19.01	2.53	0.57	1.50	4.02
		1.33	18.58	1.85	0.44	1.03	7.60

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1 9394

Table C12. cont. MDR Nutrient Chemistry Data (in ug-at/L) 6 September 1990

STA	DEPTH (m)	PO4	SiO4	NO3+NO2	NO2	NO3	NH3+NH4
20	0	1.39	19.52	3.01	0.52	2.02	8.38
	2	1.39	19.17	2.93	0.46	2.05	7.97
11	0	1.02	17.35	2.32	0.37	1.58	4.59
	2	0.97	16.76	2.13	0.53	1.10	3.87
	4	0.87	14.25	1.62	0.44	0.72	3.25
9	0	0.86	15.95	3.08	0.32	2.37	4.11
	2	0.93	15.37	1.97	0.52	0.90	3.33
	4	0.81	12.41	1.57	0.42	0.67	5.10
7	0	0.75	13.53	1.68	0.32	0.92	5.20
	2	0.77	14.28	1.88	0.54	0.74	4.20
	4	0.97	13.52	1.54	0.38	0.66	5.20
13	0	1.76	19.70	3.45	0.49	2.50	19.98
22	0	1.49	18.72	2.51	0.47	1.61	15.90
	Average	0.79	12.64	1.15	0.31	0.84	5.23
	Number	46	46	46	46	46	46
	Standard	0.36	4.98	0.68	0.14	0.58	3.20
	Maximum	1.49	19.52	2.99	0.57	2.50	19.98
	Minimum	0.30	4.51	0.28	0.07	0.13	2.60

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1

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APPENDIX D

BENTHIC DATA

OCTOBER 1989

VOL 12

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D2

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations 12	1	2	3	4	25	5	7	6	11	9	8	10
<u>ANNELIDA</u>													
OLIGOCHAETA													
Oligochaeta, unid.			8500	1060		390			10				
Tubificidae													
Peloscolex gabriellae													
POLYCHAETA													
Ampharetidae													
Ampharete labrops													
Amphicteis scaphobranchiata													
Melinna oculata				10									
Amphinomidae													
Amphinomidae, unid., juv.				10									
Arabellidae													
Arabellidae, unid. juv.													
Capitellidae													
Capitellidae, unid., juv.													
Anotomastus gardiodes					10								
Capitella capitata	10		190			190				10			
Decamastus gracilis													
Dodecaceria oraria				90									
Heteromastus sp.													
Mediomastus acutus				190	130								
Mediomastus ambiseta (= *M. californiensis*, = *Capitita ambiseta*)			140	530	300	2420	80	280	250	50	40	30	40
Mediomastus sp.													
Notomastus nr hemipodus							10						
Notomastus magnus						P							
Notomastus tenuis			20	280				20			10		
Notomastus sp.													
Chaetopteridae													
Chaetopterus sp.				60									
Mesochaetopterus sp., juv.				10									
Spiochaetopterus costarum													
Chrysopetalidae													
Chrysopetalum occidentale													
Paleanotus bellis													
Cirratulidae													
Cirratulidae unid.													
Caulleriella alata													
Caulleriella bioculata													
Caulleriella hamata													
Caulleriella sp., juv.				160		10							
Chaetozone corona					40	40	20			10	20		20
Chaetozone nr. *setosa* (= *Chaetozone setosa*)		10			10								
Chaetozone sp.													

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Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
POLYCHAETA, cont.														
Cirratulus cirratus														
Cirriformia luxuriosa										20				10
Cirriformia spirabranchia					340			410	20	20	60	110	1960	1140
Cirriformia sp., juv.										10				
Tharyx nr. *tesselata*														
Tharyx sp.						90	30		320	3760	20	10	10	
Cossuridae														
Cossura candida						230	30		10					
Cossura pygodactylata						20				10				
Ctenodrilidae														
Ctenodrilus serratus														
Dorvilleidae														
Dorvilleidae, unid.														
Ophryotrocha puerilis														
Protodorvillea gracilis					870									
Schistomeringos longicornis		960		750	220		140			220				10
Eunicidae														
Marphysa disjuncta														
Flabelligeridae														
Flabelligeridae unid.														
Pherusa capulata														
Pherusa sp., juv														
Glyceridae														
Glycera americana									P					
Glycera capitata														
Glycera convoluta														
Gylcera rouxii														
Glycera sp., juv.							10							
Hemipodus borealis					270									
Goniadidae														
Goniadidae, unid. juv.														
Glycinde armigera						10								
Goniada brunnea														
Goniada littorea				10		90								
Goniada sp., juv.				10										
Hesionidae														
Hesionidae unid.														
Gyptis brunnea														
Heteropodarke heteromorpha														
Microphthalmus sp.		250		10	20									
Micropodarke dubia					20									
Ophiodromus pugettensis		180												
Podarkeopsis glabra (= *Gyptis brevipalpa*)						10								
Lumbrineridae														

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
POLYCHAETA, cont.														
Lumbrineridae, unid.														
Lumbrineris ? crassidentata														
Lumbrineris cruzensis														
Lumbrineris erecta									30	20				
Lumbrineris lagunae						80	980	120	350	90	80	200	80	80
Lumbrineris limicola					150									
Lumbrineris tetraura						270								
Lumbrineris sp.		10		50	210	80								
Magelonidae														
Magelona sacculata														
Maldanidae														
Maldanidae, unid.														
Asychis disparidentata														
Asychis sp.														
Axiothella sp.					20									
Praxillella pacifica (= P. affinis pacifica)														
Praxillella sp.														
Praxillura maculata														
Nephtyidae														
Nephtyidae, unid. juv.														
Nephtys caecoides			20		20					10				
Nephtys californiensis														
Nephtys cornuta franciscana														
Nephtys ferruginea														
Nereididae (= Nereidae)														
Nereididae, unid. juv.					40					20				
Neanthes acuminata (= Neanthes arenaceodentata)		830		430			10						10	30
Nereis latescens		40												
Nereis procera														
Nereis sp., juv.														
Perinereis monterea														
Platynereis bicanaliculata														
Onuphidae														
Onuphidae, unid. juv.														
Diopatra ornata														
Diopatra splendidissima														
Diopatra sp., juv.														
Onuphis elegans (= Nothria elegans)														
Opheliidae														
Opheliidae, unid.														

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Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations 12	1	2	3	4	25	5	7	6	11	9	8	10
POLYCHAETA, cont.													
Armandia bioculata	10	620	380	240									
Ophelina acuminata													
Polyophthalmus pictus	50	20		380									
Orbiniidae													
Leitoscoloplos elongatus (= *Haploscoloplos elongatus*)					180	150	60	30	190		40	30	40
Naineris dentritica													
Scoloplos acmeceps				390	10				10				
Scoloplos nr. *armiger*													
Scoloplos sp.													
Oweniidae													
Myriochele nr. *pygidialis* (= nr. *heeri*)													
Owenia collaris		10		10									
Paraonidae													
Acmira catherinae (= *Acesta catherinae*)					10								
Acmira horikoshii (= *Acesta horikoshii*)													
Paraonella platybranchia (= *Paraonides platybranchia*)													
Pectinariidae													
Pectinaria californiensis (= *P. f. newportensis*)						20							
Phyllodocidae													
Phyllodocidae, unid.													
Eteone alba													
Eteone californica													
Eteone dilatae													
Eteone sp.				10									
Eulalia ? myriacyclum													
Eulalia quadrioculata (= *Eulalia aviculiseta*)													
Eulalia sp., juv.													
Eumida bifoliata													
Eumida sanguinea													
Genetyllis ? castanea													
Hesionura coineaui difficilis				750									
Phyllodoce groenlandica								10					
Phyllodoce hartmanae													
Phyllodoce (Anaitides) papillosa													
Phyllodoce sp.			10	20									

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
POLYCHAETA, cont.													
Phyllodoce (Anaitides) sp., juv.													
Pterocirrus sp.													
Pilargiidae													
Ancistrosyllis hamata													
Sigambra tentaculata													
Poecilochaetidae													
Poecilochaetus johnsoni													
Polynoidae													
Polynoidae, unid.													
Halosydna johnsoni													
Halosydna sp.													
Harmothoe ? crassicirrata													
Harmothoe hirsuta													
Harmothoe imbricata													
Harmothoe scriptoria													
Harmothoe sp.													
Lepidonotus ? squamatus													
Tenonia priops (= *Harmothoe priops*)													
Questidae													
Questidae, unid													
Sabellariidae													
Sabellaria cementarium													
Sabellidae													
Sabellidae, unid.							10						
Chone albocincta													
Chone ecaudata													
Chone minuta													
Chone mollis													
Chone sp.													
Demonax medius								290					
Euchone lianicola					210	390	40	380	310	100	20	80	120
Megalomma pigmentum													
Myxicola ? infundibulum													
? *Potamilla* sp.													
Sabella crassicornis													
Saccocirridae													
Saccocirrus sp.				1540									
Scalibregmatidae													
Scalibregma inflatum													
Serpulidae													
Serpulidae, unid.													
Hydroides elegans (= *Hydroides pacifica*)								1690					
Hydroides gracilis (= *Eupomatus gracilis*)													

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Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
POLYCHAETA, cont.														
Sigalionidae														
Pholoe glabra														
Sthenelais verruculosa														
Sthenelanella uniformis														
Spionidae														
Spionidae, unid.														
Spionidae sp. A														
Aonides sp.														
Apoprionospio pygmaea														
(= *Prionospio pygmaeus*)			400	70		10								
Boccardia sp.														
Boccardia basilaria														
Boccardiella hamata														
(= *Boccardia hamata*)														
Dispio uncinata														
Laonice cirrata														
Microspio maculata														
(= *Spio maculata*;														
= *Nerinides maculata*)			30											
Microspio microcera														
Microspio pigmentata														
Microspio sp. A														
Minuspio cirrifera														
(= *Prionospio cirrifera*)		30				350	550			10				
Paraprionospio pinnata														
Polydora bioccipitalis														
Polydora caulleryi														
(= *P. brachycephala*)														
Polydora ligni						10	30							
Polydora neocardalia														
Polydora nuchalis														
Polydora socialis														
Polydora sp.														
Prionospio heterobranchia														
(= *P. h. newportensis*)				130	950	70	290			80				10
Prionospio sp. A														
(= *Prionospio*														
"*steenstrupi*";														
= *P.* nr. *malmgreni*)														
Prionospio sp.														
Pseudopolydora kempi														
Pseudopolydora														
paucibranchiata					8070	190	1970	1450	700	960	10	280	140	170
Rhynchospio arenicola							10							
Rhynchospio sp.														
Scolelepis acuta														
(= *Nerinides acuta*)						20	30							

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
POLYCHAETA, cont.													
Scolelepis foliosa occidentalis													
Scolelepis sp. A													
*Spio * filicornis*													
Spiophanes berkeleyorum													
Spiophanes bombyx													
Spiophanes missionensis				50									
Spiophanes sp.													
Streblospio benedicti						2700							
Spirorbidae													
Spirorbidae, unid.				10				250					
Janua brasiliensis													
Pileolaria pseudomilitaris													
Syllidae													
Syllidae, unid.													
Autolytus sp.								10					
Brania sp.													
Eusyllis sp.													
Exogone gemmifera													
Exogone lourei													
Exogone verugera													
Exogone sp. A				1690		20			10				10
Exogone sp.													
Odontosyllis phosphorea				10									
Pionosyllis uraga													
Sphaerosyllis californiensis	10		20	210				10					
Sphaerosyllis sp.													
Streptosyllis sp.													
Syllides japonica	70												
Syllides reishi													
Typosyllis alternata													
Typosyllis ? hyalina													
Typosyllis sp.													
Terebellidae													
Terebellidae, unid. juv.				10									
Amaeana occidentalis						10							
Pista disjuncta (= Pista fasciata)													
Pista nr. *disjuncta*													
Pista sp. B													
Pista sp., juv.													
Polycirrus sp.				10									
Streblosoma crassibranchia													

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations 12	1	2	3	4	25	5	7	6	11	9	8	10
<u>ARTHROPODA</u>													
CRUSTACEA													
CEPHALOCARIDA													
COPEPODA													
CALANOIDA													
Calanoida, unid.													
Calanus sp.													
CYCLOPOIDEA													
Cyclopoidea, unid.			10	20									
Clausidium vancouverense													
HARPACTICOIDEA													
Harpacticoida, unid.			10	30									
OSTRACODA													
Ostracoda, unid.													
Bathyleberis sp.													
Cylindroleberis sp.													
Philomedes sp.													
Rutiderma rostrata													
CIRRIPEDIA													
Cyprid, larvae													
Balanus (Balanus) pacificus													
Balanus trigonus													
Balanus sp.													
Megabalanus tintinnabulum californicus (= Balanus t. californicus)													
DECAPODA													
Decapoda--larval													
MALACOSTRACA													
Anomura													
Anomura, unid. juv.													
Albuneidae													
Blephripoda occidentalis													
Callianassidae													
Callianassa affinis			10		10								
Callianassa californiesis											10		
Callianassa sp.													
Upogebia sp.													
Paguridae													
Pagurus sp.			10	340									
Brachyura													
Brachyura, unid. juv.													

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations 12	1	2	3	4	25	5	7	6	11	9	8	10
MALACOSTRACA, cont.													
Canceridae													
Cancer anthonyi													
Cancer gracilis													
Cancer jordani	10		20										
Cancer sp., juv.													
Goneplacidae													
Malacoplax californiensis					50								
Grapsidae													
Hemigrapsus nudus													
Hemigrapsus oregonensis	30												
Hemigrapsus sp., juv.													
Majidae													
Loxorhyncus crispatus													
Podochela sp.													
Pyromaia tuberculata								10	10				
Pinnotheridae													
Pinnotheridae, unid.													
Opisthopus transversus													
Pinnixa franciscana													
Pinnixa sp.													
Scleroplax granulata													
Xanthidae													
Lophopanopeus diegensis				30	80								
Caridea													
Alpheidae, unid.													
Alpheus californiensis								10					
Alpheopsis equidactylus (= *Alpheus equidactylus*)						10							
Betaeus sp.													
Palaemonidae													
Palaemonella holmesi													
LEPTOSTRACA													
Epinebalia sp.													
Nebalia pugettensis	16360												
PERACARIDA													
AMPHIPODA													
Aeginellidae													
Mayerella banksia			40	370		50							
CAPRELLIDEA													
Caprellidea, unid.			10	10									
Caprellidae, unid. B													
Caprella californica													
Caprella equilibra													
GAMMARIDEA													
Gammaridea, unid.													

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
GAMMARIDEA, cont.														
Ampeliscidae														
Ampelisca sp.														
Aoroidae														
Aoroides columbiae														
Grandidierella japonica					90									
Aoroides sp., juv.														
Aoroides sp.														
Corophiidae														
Amphideutopus oculatus						20								
Cerapus tubularis														
Corophium acherusicum		20			30									
Corophium volutator														
Corophium sp.														
Gammaropsis thompsoni			10											
Megamphopus mamolus														
Microdeutopus schmitti														
Photis sp.														
Rudilemboides stenopropodus					1710									
Gammaridae														
Elasmopus rapax														
Elasmopus sp.														
Ischyroceridae														
Ericthonius brasiliensis							10							
Liljeborgiidae														
Listriella melanica														
Oedicerotidae														
Monoculoides hartmanae						10								
Monoculoides sp.														
Synchelidium shoemakeri			40											
Synchelidium sp., juv.														
Westwoodilla caecula														
Phoxocephalidae														
Rhepoxynius daboius			10											
Pleustidae														
Parapleustes pugettensis														
Pleusymtes subglaber (= *Sympleustes subglaber*)														
Podoceridae														
Podocerus cristatus														
Podocerus sp.														
Pontogeneiidae														
Pontogeneia intermedia		10							20	90				
CUMACEA														
Cumacea, unid.														

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations 12	1	2	3	4	25	5	7	6	11	9	8	10
CUMACEA, cont.													
Campylaspis rubromaculata													
Campylaspis sp.													
Campylaspis sp. C		20											
Cyclaspis nubilla													
Cyclaspis sp. A													
Diastylis pelucida													
Diastylis sp.													
Diastylopsis tenuis		10	10										
Leptocuma forsmani		100											
Leucon subnasica													
Oxyurostylus pacifica		20	150										
ISOPODA													
Isopoda, unid.													
Cyathura sp.													
Edotea sublittoralis		10											
Edotea sp.													
Limnoria sp.													
Munna sp.													
Paracercels caudata													
Paracercels sculpta													
Paranthura elegans				40									
Serolis carinata													
Silophasma geminatum													
Synidotea magnifica													
EUPHAUSIACEA													
Euphausiacea, unid.													
MYSIDACEA													
Mysidacea, unid.						30		70	80				
Acanthomysis sp.		10											
Heteromysis odontops					40	10							
TANAIDACEA													
Tanaidacea, unid.													
Anatanais normani (= *Zeuxo normani*)													
Leptochelia dubia				80									
Leptochelia sp.													
INSECTA													
Chironomidae, larvae													
Paraclunio alaskensis, larvae													
CHELICERATA													
PYCNOGONIDA													
Pycnogonida, unid.													
Anoplodactylus erectus													

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon / Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
<u>CHELICERATA</u>, cont.													
Callipallene californiensis													
Pallenidae, unid.													
Tantystylum intermedium													
<u>ASCHELMINTHES</u>													
Nematoda, unid.			65000										
<u>BRACHIOPODA</u>													
Glottidia albida													
<u>BRYOZOA (= ECTOPROCTA)</u>													
(No. of colonies)													
Bowerbankia gracilis													
Bugula neritina						1	1						
Bugula stolonifera (= *Bugula californica*)													
Cryptosula pallasiana													
Ctenostomata, unid.													
Holoporella (Celleporaria) brunnea			1	1									
Membranipora tuberculata													
Rynchozoon rostratum				1									
Schizoporella errata				1									
Schizoporella unicornis													
Scrupocellaria diegensis													
Tubulipora tuba													
Watersipora arcuata				1		1		1					
Watersipora subtorquata				1		1							
Zoobotryon verticillatum													
<u>CHORDATA</u>													
UROCHORDATA													
ASCIDIACEA													
Ascidacea, unid.													
Botryllus sp.													
Ciona intestinalis													
Molgula pugetiensis													
Molgula sp.								40					
Styela clava													
Styela plicata													
Styela sp.													
CEPHALOCHORDATA													
Branchiostoma californiense													

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Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations 12	1	2	3	4	25	5	7	6	11	9	8	10
VERTEBRATA													
OSTEICHTHYS													
Osteichthys, unid. juv.													
Gobiesocidae													
Gobiesox rhessodon													
Gobiidae													
Gobiidae, unid.													
Gobiidae, larvae													
Clevelandia ios			10			30				10			
Ilypnus gilberti													
Lepidogobius lepidus													
CNIDARIA (= COELENTERATA)													
ANTHOZOA													
Anthozoa, unid.				20									
ACTINARIA													
Actinaria, unid.													
Diadumenidae													
Diadumene sp.													
Edwardsiidae													
Edwardsiidae, unid.													
Edwardsia californica													
Edwardsia sp.				20									
Edwardsia sp., juv.													
Isoedwardsia sp. A													
Halcliviidae													
Mesacmaea sp. A													
CERIANTHARIA													
Ceriantharia, unid.													
HYDROZOA													
HYDROIDA													
Hydrozoa, unid.				P	P								
Aglaophenia, diversidentata													
Aglaophenia sp.			P										
Corymorpha aurata (= Euphysa sp. A)					10								
Obelia sp.													
ECHINODERMATA													
ECHINOIDEA													
Echinoidea, unid. juv.													
Dendraster excentricus													
Strongylocentrotus purpuratus													
HOLOTHUROIDEA													
Holothuroidea, unid.		10											
Havelockia benti													

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Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
HOLOTHUROIDEA, cont.													
Leptosynapta sp.				30		30	60	10	10		50	30	10
Pentamera populifera													
OPHIUROIDEA													
Ophiuroidea, unid. juv.		20											
Amphiodia digitata													
Amphiodia urtica													
ECHIURA													
Listriolobus sp.													
Urechis caupo													
HEMICHORDATA													
Enteropneusta, unid.													
MOLLUSCA													
GASTROPODA													
Gastropoda, unid. juv.													
PROSOBRANCHIA													
ARCHAEOGASTROPODA													
Phasianellidae													
Epitonium sp.		10											
MESOGASTROPODA													
Caecidae													
Caecum californicum				750									
Caecum crebricinctum													
Caecum sp.													
Fartulum sp.													
Micranellium sp.													
Calyptraeidae													
Crepidula dorsata (= *Crepipatella lingulata*)													
Crepidula onyx				90									
Crepidula perforans													
Crepidula sp., juv.													
Lamellariidae													
Marseniopsis sharonae (= *Lamellaria sharonae*)													
Naticidae													
Neverita recluziana													
Sinum sp.													
Vitrinellidae													
Vitrinella oldroydi													
NEOGASTROPODA													
Columbellidae													
Alia carinata (= *Mitrella carinata*)			50										

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
NEOGASTROPODA, cont.													
Nitrella aurantiaca			10										
Nitrella sp., juv.													
Conidae													
Conus californica				20									
Muricidae													
Pteropurpura festiva													
Nassariidae													
Nassarius mendicus													
Nassarius perpinguis													
Nassarius tegula													
Nassarius sp.													
Olividae													
Olivella baetica		10											
Turridae													
Kurtziella beta													
Kurtziella plumbea													
OPHISTHOBRANCHIA													
CEPHALASPIDEA													
Cephalaspidea, unid.													
..cteonidae													
Rictaxis punctocaelatus													
..glajidae													
Melanochlamys diomedea			10	40		20							
Aglaja sp.													
Bullidae													
Bulla gouldiana													
Haminoeidae (= Atyidae)													
Haminoea sp., juv.													
Philinidae													
Woodbridgea sp.													
Retusidae													
Sulcoretusa sp.													
Scaphandridae													
Cylichnella culcitella (= *Acteocina culcitella*)													
Cylichnella harpa (= *Acteocina harpa*)													
Cylichnella inculta (= *Acteocina inculta*)						10	30	50	80	30			40
Cylichnella sp.													10
PTEROPODA													
Pteropoda, unid.													
NUDIBRANCHIA													
Nudibranchia, unid.													
Acanthodoris sp.													

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Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations	12	1	2	3	4	25	5	7	8	11	9	6	10
NUDIBRANCHIA, cont.														
Cuthona sp. (= *Trinchesia* sp.)														
PYRAMIDELLIDA														
Pyramidellidae														
Odostomia sp.														
Turbonilla sp.														
PELECYPODA														
Pelecypoda, unid. juv.				20										
Veneroida, unid. juv.														
Cardiidae														
Laevicardium substriatum		10			40	40	20						10	
Cooperellidae														
Cooperella subdiaphana			10					10						
Corbulidae														
Corbula sp.														
Donacidae														
Donax gouldii														
Erycinidae														
Lasaea subviridis														
Hiatellidae														
Hiatella arctica														
Kelliidae														
Kellia laperousi														
Leptonidae														
Platomysia moroeum (= *Lepton moroeum*)														
Limidae														
Limidae, unid.														
Lucinidae														
Parvilucina approximata														
Parvilucina tenuisculpta (= *Parvilucina* sp.)														
Lyonsiidae														
Lyonsia californica														
Mactridae														
Mactridae, juv.														
Mactra californica							20							
Mactra sp.														
Spisula catilliformis														
Spisula sp.														
Tresus nuttallii														
Montacutidae														
Mysella pedroana														
Mysella sp.														

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations 12	1	2	3	4	25	5	7	6	11	9	8	10
PELECYPODA, cont.													
Mysella sp. A						10							
Neaeromya sp.													
(= *Orobitella* sp.)													
Myidae													
Cryptomya californica													
Mytilidae													
Mytilidae, juv.													
Amygdalum sp.													
Modiolus sp.													
Musculus senhousei													
Mytilus edulis													
Ostreidae													
Ostrea lurida													
Pectinidae													
Leptopecten latiauratus													
Petricolidae													
Petricola tellimyalis													
Petricola sp.													
Semelidae													
Cumingia californica													
Theora lubrica													20
Semele sp.				90									
Solecurtidae													
Tagelus californianus													
Tagelus subteres			50	540	20	150	20						
Tagelus sp., juv.													
Solenidae													
Siliqua lucida													
Solen rosaceus													
Solen sicarius													
Solen sp., juv.													
Tellinidae													
Leporimetis obesa													
Macoma acolasta													
Macoma carlottensis													
Macoma nasuta			10			30							
Macoma secta		10											
Macoma yoldiformis													
Macoma sp., juv.												10	
Tellina carpenteri						20							
Tellina modesta													
Tellina sp., juv.													
Thraciidae													
Asthenothaerus villosior													
Thyasiridae													
Axinopsida serricata													
Thyasira flexuosa													

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations	12	1	2	3	4	25	5	7	6	11	9	8	10
PELECYPODA, cont.														
Ungulinidae														
Diplodonta orbella					90									
Veneridae														
Veneridae sp., juv.														
Chione californiensis					40									
Chione ? undatella														
Chione sp., juv.														
Pitar newcombianus					50		10							
Protothaca staminea		10			110		40	10						
Protothaca sp., juv.														
Saxidomus nuttalli														
Saxidomus sp., juv.														
POLYPLACOPHORA														
Polyplacophora, unid.														
Mopalia sp.														
NEMERTEA														
Lineidae, unid.														
Nemertea, unid.					20			10						
Amphiporus cruentatus														
Amphiporus sp.							20							
Carinoma mutabilis					20			10						
Carinomella lactea														
Cerebratulus californiensis				20	20									
Cerebratulus sp.														
Emplectonema gracile		30												
Euplectonema burgeri														
Lineus sp.					10	10								
Micrura alaskensis														
Monostylifera sp.														
Paranemertes sp. A		10	10		90	10	10							
Tubulinidae, unid														
Tubulanus nothus														
Tubulanus pellucidus														
Tubulanus polymorphus					30	40							10	
Tubulanus sp.														
PHORONIDA														
Phoronida, unid.														
Phoronis pallida														
Phoronis sp.					50			40	40	150		10	380	560
Phoronopsis sp.														

Benthic Data in Order of Distance from Breakwater, 12 October 1989.

Taxon	Stations 12	1	2	3	4	25	5	7	6	11	9	8	10
<u>PLATHYHELMINTHES</u>													
Polycladida, unid.		10		80									
Turbellaria, unid.													
<u>PORIFERA</u>													
Porifera, unid.		F						30					
<u>SIPUNCULIDA</u>													
Sipunculida, unid.													
Thysanocardia nigra				70									

F = fragment - P = piece

AMERICAN OCEANS CAMPAIGN

CHEMICAL CONTAMINANT RELEASES INTO SANTA MONICA BAY

Executive Summary

Based on a Pilot Study

by

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CHEMICAL CONTAMINANT RELEASES INTO SANTA MONICA BAY

I. THE NEED FOR AN ADVOCACY MODEL BASED UPON EMPIRICAL SCIENTIFIC RESEARCH

Modern lifestyles are replete with and have been dependent upon the use of toxic chemicals harmful to both the environment and human life. In the United States alone, petroleum products, synthetic food additives, pesticides, plastics and other chemicals are marketed at a rate currently estimated at a thousand new chemical compounds a year.[1] Indeed, between 1950 and 1985 the annual production of synthetic, organic chemicals in the United States increased ninefold from 24 billion to 225 billion pounds.[2] Toxicants are ubiquitous and have been integrated into our society's economy and environment.

American Oceans Campaign believes that toxic contamination of the marine environment poses a serious threat to both the ecosystem and to human health. It is estimated that approximately 25 million gallons of untreated runoff flows into Santa Monica Bay every day. The flow of runoff increases to ten billion gallons a day during a rainstorm.[3] However, there has been relatively little empirical data and modeling done to develop applicable standards to assess the risk which these compounds pose to both human health and the ecosystem.

This pilot study, funded by Environment Now, the City of Santa Monica, the Santa Monica Bay Restoration Project, and American Oceans Campaign, and carried out by preeminent research scientists from the UCLA School of Public Health,[4] represents not only a unique public/private partnership but a model for the future, particularly relevant to solving environmental problems. All too often, environmental laws and policies are promulgated in a political vacuum either without science or without using scientific data specifically developed in relationship to the policy in question. Such an ad hoc approach routinely avoids setting adequate environmental policies, regulations and guidelines based upon empirical scientific evidence.

This study focuses on the chemical composition of hazardous effluent to Santa Monica Bay through the storm drain system in Los Angeles County. A parallel study which addressed the aquatic toxicity study of dry weather flow was performed at the same time with funding from the Santa Monica Bay Restoration Project. Their report will soon be available. By releasing the results of this study, American Oceans Campaign hopes to create a decision making process capable of responding to environmental threats by giving policymakers empirical scientific evidence that defines the nature of the environmental threat and creates a basis for formulating practical solutions.

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II. TOXIC CHEMICALS ROUTINELY ENTER SANTA MONICA BAY THROUGH STORM DRAIN RUNOFF, WHICH IS CAUSE FOR CONCERN.

There are approximately sixty storm drains which flow into Santa Monica Bay. The vast majority of these storm drains are artificially created, with the exception of Malibu and Topanga Creeks which are naturally flowing discharge channels into the Bay. These natural creeks, act like rivers flowing into estuaries or other receiving waters.

A wide variety of chemical substances, as well as heavy metals[5] and pathogens (bacteria and viruses),[6] enter the Bay through the storm drain system. Limited studies have begun to identify those toxic chemicals which routinely enter Santa Monica Bay through storm drain runoff.[7]

This study, designed to become a part of existing literature identifying pollutants entering the Bay sampled effluent from the following five storm drains: Pico-Kenter, Ashland, Sepulveda Channel, Ballona Creek, and Centinela. These storm drains were specifically chosen because they were examples of highest flow areas, previously studied areas with existing background data and good comparisons of small and large drains. Water samples from all five drains were collected over a six month period. An analysis of these samples identified a soup of approximately 160 toxic chemicals entering the Bay through the storm drains. Some of these chemicals bioaccumulate (build up in the bodies of living organisms). Some of these chemicals are carcinogens, some are reproductive toxicants, and others are known or suspected to have acute or chronic toxicity. While this is obviously cause for concern, and while these findings unequivocally suggest that swimmers, waders, and people fishing in the Bay stay out of the storm drains themselves and away from the mouth of drains which discharge into the Bay, it was beyond the scope of this study to actually quantify the risks to either human health or the ecology of the Bay. Additional studies therefore will be needed to assess these risks.

To date, the bulk of pollution control efforts throughout the Santa Monica Bay region have focused on point source reduction from industrial and sewage wastewater treatment plants. Efforts to control storm drain runoff have not been given adequate attention both due to the diffuse nature of the problem and the expense associated with toxic testing. Yet, as this study shows, there are very real stormwater risks to both users of the Bay and the ecology itself which must be evaluated and quantified if we are to properly inform our citizens and protect Santa Monica Bay.

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III. TOXICANTS IDENTIFIED BY THE STUDY

Because of the limited scope of this study, a protocol was designed to evaluate some of the most serious chemical compounds--carcinogens, reproductive toxicants, and other acute toxicants. The study demonstrated that many of the compounds identified are in fact carcinogens, probable carcinogens, possible carcinogens, reproductive toxicants and compounds having chronic and acute toxicity that are capable of absorption through dermal contact as well as by inhalation or ingestion. Chemical contamination was found in samples from all five storm drains in this study.

A minimum of 50 trace organic compounds were identified in each storm drain tested (with over 120 compounds found at the Ashland storm drain). Compounds found with toxicologic significance were polycyclic aromatic hydrocarbons (PAHs), phthalates, polychlorinated biphenyls (PCBs), chlorinated pesticides, chlorinated hydrocarbons, phenols, and other carcinogenic organic compounds and organophosphate pesticides. In addition, 33 volatile organic compounds were found in the effluent from all five storm drains.

In this study references are made to the California Ocean Plan and to Drinking Water Standards promulgated by the U. S. Environmental Protection Agency (EPA). These references are used for comparison's sake as indicators of potential problem pollutants. The study found significant levels of toxicants in excess of California Ocean Plan Standards in all five storm drains sampled. The study also found levels of methylene chloride, bis(2-ethylhexyl)phthalate and benzo(a)pyrene in excess of EPA Drinking Water Standards.

The chemicals identified by this study enter the body through two pathways: dermal absorption (through the skin) and bioaccumulation (through the food chain, i.e. eating fish and shellfish).

The California Ocean Plan was designed to provide water quality standards to protect human health and enjoyment and preserve aquatic ecosystems in ocean waters. Because many of our storm drains discharge directly across our beaches and people swim or wade in this runoff, the California Ocean Plan should be applied to storm drain effluent as well as point source discharges.

A. POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

Seventeen PAHs in excess of California Ocean Plan standards[8] were identified in all five storm drains studied. Seven of the PAHs, five of which were found in all five storm drains,[9] are identified as carcinogens under California's Proposition 65[10] and are listed as possible carcinogens by EPA.

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PAHs are not derived from point sources. They represent products of an urban society which emphasizes the use of petroleum-based transport. They are often products of incomplete combustion and are found throughout the environment. They may emanate from exhaust, tires, used motor oil, or other transport-related processes, as well as from industrial sources, and outdoor barbecues, all of which create products of incomplete combustion.

The greatest concentration of PAHs found at Sepulveda were the benzo(a)pyrene, chrysene, and pyrene concentrations (all 3 of which are carcinogenic), which were 1,803 ng/l, 2,016 ng/l and 956 ng/l, respectively. These numbers can be compared to California Ocean Plan standards which seek to limit PAH concentrations to 8.8 ng/L

The primary health risk associated with PAHs in the water would probably derive from dermal contact. The carcinogenicity of this class of compounds was originally recognized as a result of studies which focused on dermal contact. Although the scope of PAHs sampled in this study was limited, it is reasonable to believe that other more potent PAHs (6-nitrochrysene an order of magnitude more potent than benzo(a)pyrene, dibenzopyrenes approximately 10 times more potent carcinogens than benzo(a)pyrene) may also be present in Santa Monica Bay storm drains. Because PAHs are potent toxicants, their presence in all five storm drains is cause for significant concern.

B. POLYCHLORINATED BIPHENYLS (PCBs)

PCBs were identified in all the storm drains studied, although the highest concentrations were found at the Ashland site. PCBs are found in aerosols and the ambient air. They are used for insulation purposes (in transformers) and they are virtually indestructible in the environment. They also bioaccumulate in living systems. The California Ocean Plan standard for PCBs is 0.019 ng/l. Many of the PCBs identified in this study exceed that value by a factor greater than 1000. (The total PCBs found in the Ashland drain were 451 ng/l; assuming a background of approximately 125 ng/l, the concentration of identified PCBs is approximately 325 ng/l, which is 17,000 times the California Ocean Plan limit.)

PCBs are listed as chemicals known to cause cancer and reproductive toxicity under Proposition 65. PCBs are considered probable carcinogens by EPA[11] and the International Agency for Research on Cancer (IARC). PCBs can enter the body through dermal contact. PCBs also bioaccumulate in the environment. Bioaccumulation through the food chain may represent the most important route of exposure to humans of PCBs. PCBs will concentrate in fish and other sea life and the risk associated with ingestion will increase as bioaccumulation occurs. The existence of PCBs in the studied storm drains is one of the <u>most</u> important discoveries of the study and is a serious concern to both humans and the ecology of Santa Monica Bay.

C. PESTICIDES

The finding of pesticides in the storm drains represents an important element of the study. Chlorinated pesticides, like PCBs, are very toxic, persistent and bioaccumulate in the environment.

The organophosphate pesticide diazinon was identified in water from Centinela, Ashland, and Pico-Kenter, while dimethoate was found at Ballona. (These are commonly used pesticides, and it is not surprising that they were identified.) Their persistence in the environment is a matter of concern and an area for further study.

The finding of alpha-chlordane, (at all five sites) and dieldrin (Pico-Kenter) represents an important finding in this study. These substances are of particular significance because of their potential toxicity, persistence, and potential for bioaccumulation in the environment. Chlordane is considered a possible carcinogen by IARC.[12] Chlordane and dieldrin are listed as carcinogens under Proposition 65 in California.

D. OTHER TOXICANTS IDENTIFIED BY THE STUDY

1. Phthalates

Six Phthalates[13] were present in the storm drain effluent from all five sites. Phthalates are widely used in industrial applications . They exist wherever plastics are found. They are generally considered ubiquitous contaminants, and are recognized to be laboratory contaminants as well. The phthalates present as laboratory contaminants were accounted for by analyzing appropriate controls.[14]

The most important compound identified was bis(2-ethylhexyl)phthalate (DEHP). DEHP is classified as a carcinogen and reproductive toxicant under California Proposition 65. It is also classified as a probable human carcinogen by the U.S. EPA and IARC. It is considered a chemical teratogen and may damage the testes. Repeated exposure may also result in neurological consequences. It has acute toxicity and produces irritation of the eyes, nose and throat. Exposure to DEHP can occur through inhalation, ingestion or dermal contact. The maximum contaminate level (MCL) established for DEHP in drinking water by EPA is 4 parts per billion (ppb). The California Ocean Plan limit is 3.5 ppb. The average concentration found for DEHP in this study was 6.6 ppb. The greatest concentration, 14.8 ppb, was found at Ashland, and the lowest concentration was found at Sepulveda. Because of their toxicity and potential impact to humans through dermal absorption, the presence of phthalates found in all five storm drains is significant.

2. Phenols

Seven phenols were identified as being present in the storm drain effluent in this study. Phenols are benzene derivatives which possess acute toxicity and there is evidence of some having chronic effects. Phenol and 2-nitrophenol were found at all five sites, 4-methyl phenyl was found at three sites. 4-chloro-3-methyl phenol, 2-methyl phenol, 4-nitrophenol, and 2,4-dimethyl phenol were found at one site.

2-methyl phenol is classified as a possible human carcinogen by EPA. There is evidence from animal studies of reproductive toxicity associated with exposure to phenols, and phenol is classified as a reproductive toxicant under Proposition 65. The presence of these compounds in Santa Monica Bay storm drains is a matter requiring further evaluation to assess the impact on both the ecology of the Bay and human health.

3. Other Carcinogens Identified

Two probable human carcinogens, azobenene, and 1,4-dichlorobenzene were identified at all five sites. N-nitrosodiphenylamine and N-nitrosodin-propylamine were present at three sites. These compounds are considered to be carcinogens under Proposition 65 and are classified by EPA as probable human carcinogens They were found in trace quantities and further study will be required to evaluate their continued presence.

4. Volatile Organic Compounds (VOCs)

Thirty-three volatile organic compounds were found in the effluent from the five sampled storm drains.[15] VOCs are low molecular weight hydrocarbons, aromatics and chlorinated hydrocarbons. VOCs were included in the study because they are found in solvents routinely used in dry cleaning and common household functions. A number of VOCs recognized as being potential human carcinogens or reproductive toxicants were identified in all five storm drains. All these are capable of absorption through dermal contact, as well as by inhalation or ingestion. The identified compounds; benzene, bromochloromethane, bromodichloromethane, bromoform, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, methylene chloride[16] , trichloroethylene, and perchloroethylene are classified as chemicals known to cause cancer under Proposition 65. The concentration of VOCs, however, was low in relation to the other identified toxic contaminants, thereby failing to indicate evidence of illicit dumping.

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5. The Chemical Soup

A myriad of other, yet to be analyzed, chemicals were present in the water samples studied.[17] Preliminary research indicates that some of the compounds in this chemical soup may be traceable to illegal dumping.[18] These chemicals need to be quantified and evaluated for toxicity before the risk to human health and the ecology can be properly assessed.

IV. RECOMMENDATIONS

A. THE NEED FOR FOLLOW UP STUDIES

This study evaluated dry weather flow of organic toxicants. In order to provide a basis to assess the potential health and ecologic risks associated with urban runoff into the Santa Monica Bay several other studies must be conducted.

1. Expanding the Scope of this Study to Include Wet Weather and Dry Weather Flows

This research only studied dry weather flows. Wet weather flows are essential to broaden the scope of the data to the point where risk assessment models and standards can be developed. A study of the aquatic toxicity of wet weather flows will begin later this year conducted by the Santa Monica Bay Restoration Project. Additional studies during wet weather flows must also be conducted to assess the human health risk from exposure to toxicants present in storm drain effluent. To date, data on flow rates, current dilution, and dilution speed into the Bay are lacking for both dry and wet weather flows. Such studies, when combined with the results of this study, will allow evaluation of the importance of the compounds present and their mass loading[19] to the Bay.

2. Development of a Quantitative Risk Assessment for Human Health and the Ecology of the Bay

A quantitative risk assessment methodology combining the health risks from the chlorinated pesticides, PCBs, PAHs, volatile organic compounds, phthalates, and other identified carcinogens and toxicants, should be developed to investigate the risk to swimmers, surfers, and waders, as well as to address the consequences of the bioaccumulation of toxicants in fish and other sea life. To date, there are limited models or standards by which we can assess the risk to health, through dermal absorption and bioaccumulation. More sophisticated models can and should be developed, thereby allowing us to create standards capable of assessing the risks to human health posed by chemicals entering the Bay through stormwater effluent. In addition, toxicity studies that examine the impact of the releases of toxicants on sea life and the ecology of the Bay are clearly desirable.

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3. Polychlorinated Biphenyls (PCBs)

The finding of alpha-chlordane, dieldrin, and PCBs--the latter especially in the Ashland drain--represents a major finding in this study. These substances are of particular significance because of their potential toxicity, persistence and potential for bioaccumulation in the environment. Follow-up studies to identify the sources of these compounds are clearly indicated.

4. Assess Whether PAHs Attached To Sediment Desorb Into the Ocean

PAHs, one of the most potent chemicals identified in the study, are associated with sediment in the storm drain effluent (i.e., they are attached to particulates). Whether these PAHs are desorbed from the sediment when the storm drain reaches the Bay, thereby exposing living organisms, including humans, to acute toxicity, is an essential question which must be addressed in order to properly determine risk assessment. A series of studies is therefore required to determine the desorption of contaminants from the suspended sediment.

5. Heavy Metals

The scope of this study did not provide for an analysis and identification of heavy metals entering the Bay. However, preliminary work on metals indicates that heavy metals from stormwater runoff rivals, and in some cases surpasses, sewage plant discharges as a source of Santa Monica Bay pollution.[20] This preliminary evidence, when combined with the fact that heavy metals bioaccumulate, and thereby threaten both the ecology of the Bay and humans who eat food from the Bay, makes a study identifying the kinds and quantities of metals entering the Bay essential.

6. Compilation and Analysis of All Existing Literature on Stormwater Effluent Entering Santa Monica Bay

Much of the research done on stormwater effluent entering the Bay is unpublished or unreleased by state and local agencies and therefore known as "grey" literature. If researchers are to avoid duplicating efforts already undertaken, it is essential that this "grey" literature be compiled and analyzed.

B. NEEDED GOVERNMENT ACTION

1. Keep Swimmers, Waders, Surfers and People Fishing Out of, and Away from, the Storm Drains

Based upon the significant results of this study, coupled with existing evidence of pathogens and heavy metals discharged into Santa Monica Bay through the storm drain system the California State Department of Health Services should immediately take the necessary action to post bilingual warnings telling people not to swim or wade in storm drains, or around the mouth of storm drains which enter receiving waters. Surfers, swimmers, and waders should be explicitly warned that there is a chemical contaminant risk to being in the water, or around the mouth of storm drains, especially after rainfalls. This is particularly true for the season's first rainfall, which flushes a toxic cocktail of compounds through the storm drains and into the Bay.

This warning should not be limited to Santa Monica Bay. It is reasonable to believe that similar compounds to those found in this study are entering other bays and estuaries throughout the State, thereby requiring the warning on a statewide basis.

2. The California Ocean Plan Should be Applied to Storm Drain Effluent and Discharge

Stricter standards should be adopted if the present three year review of the Plan does not protect public health and preservation of the marine ecosystem from both storm drain effluent and point source discharge into ocean waters. The Ocean Plan should be amended to clarify its applicability to stormwater discharges.

3. The State of California Must Develop a Coherent Management Strategy for Storm Drains

California urban stormwater regulations are similar to Federal EPA regulations outlined in Section 319 of the Federal Clean Water Act. Section 319 emphasizes a weak, voluntary approach to controlling stormwater runoff (non-point source pollution). Because toxicants represent a serious threat to both the vitality of coastal ecosystems and human health, the State should establish mandatory stringent controls for stormwater pollution. While several non-point source programs are seeking to assess the environmental impacts of polluted runoff contamination, including the Los Angeles County Public Works Department in its proposed NPDES monitoring program, few cities have adequately brought about the implementation of pollution control measures.

Such a management strategy must be concerned with both treatment measures as applied to storm drains and source reduction, and recycling of toxicants which enter the Bay through storm drain effluent.

The problem of chemical contamination of the Bay is, of course, ultimately a question of huge economic and social proportions which, to date, society has been

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reluctant to address. While there are technical "remedial" techniques which can and should be used like filter strips and infiltration devices, as well as careful land use planning, the issue of toxic contamination can only be solved by a commitment to source reduction and recycling.

Source reduction, recycling, and the creation of non-toxic alternatives are issues which can, in the current economic climate, be used to argue against the establishment of mandatory controls for storm drain toxic pollution. Such arguments, however, must be weighed against the ultimate cost to health, the ecology, and that part of the economy (tourism, fishing, coastal real estate) dependent on a healthy coastal ecosystem. Policymakers must address the fact that the creation of non-toxic alternatives would create an entire new economic base for the State of California. In addition, fees[21] can be charged to those "impervious properties" which generate stormwater runoff, and which in turn can be used to subsidize the recycling of toxins, the reduction of toxins at the source, and the creation of non-toxic alternatives.

C. The Role of Local Governments

Local governments can use the state non-point source management plan to help identify the degraded local waters and stormwater pollution sources. Thereafter local governments can impose initial "remedial" solutions through implementing land use ordinances which may contain some of the following:

1. Catch basins--boxes placed underneath gutters which catch solids and allow liquid to flow over the edge--used at the mouth of storm drain openings can act as the first point of sediment settling, thereby reducing the flow of toxicants into the Bay.

2. The placement of vegetation on the sides of storm drain channels has been demonstrated to significantly reduce the amount of pollutants in stormwater. This is accomplished by slowing the velocity of the water, thereby allowing toxicants to attach to the vegetation.

3. Placing gravel and small stones in storm drain channels. This will attract the PAHs, chlorinated hydrocarbons, and heavy metals in the flow of effluent, thereby further reducing the entry of toxicants into the Bay.

A more sophisticated yet still palliative technology involves placing mini-chemical pre-treatment facilities in storm drains. Mini pre-treatment filtration plants, while effective at decreasing the amount of toxics which flow into the Bay, alone cannot solve the problem.

D. The Role of Individual Citizens

Individual citizens represent an army of people who can successfully wage war against toxic pollution in stormwater runoff. There are a number of actions individuals can take to help.

1. Recycle Used Motor Oil.

Yearly, the equivalent of 35 Exxon Valdez oil spills enter coastal waters through storm drain runoff, most of which comes from dumping by people who change their own motor oil. Used motor oil should be recycled, or taken to a toxic waste facility. The cessation of this kind of illegal dumping by individuals can aid immeasurably in keeping toxicants out of the storm drain system.

2. Purchase Non-toxic Household Products.

An array of non-toxic household cleaners and products are available in today's market place. Toxic household cleaners and products often find their way into storm drains. These products should be replaced with non-toxic alternatives.

3. Proper Storage and Clean-up of Household Chemicals.

Individuals can insure that substances such as pesticides, fertilizers, paints, preservatives, strippers and solvents are stored in dry places away from water sources. Once used, these substances should not be disposed of in the local storm drain. They should be either recycled or brought to local toxic or hazardous metals disposal sites.

4. Increase Vegetation Around the Home.

By increasing the amount of vegetated area around a home, a homeowner increases the porosity of the soil and reduces soil erosion, which lessens the amount of stormwater runoff. (The vegetated areas act as a natural filter, slowing the movement of stormwater runoff which allows many contaminants to settle out.)

5. Educate Politicians to Enact Laws and Policies Which Will Stop Chemical Contamination of the Bay.

Ultimately removing chemical contaminants from storm drains and the Bay is a question of political will. We have the technology and the alternatives to solve the problem. We do not at the present time have the will to do so. Politicians respond to constituent pressure. Concerned individuals should, therefore, educate their elected representatives to the importance of removing toxic chemicals from the storm drain system.

CONCLUSION

Santa Monica Bay represents a natural resource of untold beauty and benefit to the citizens of Southern California. Its economic value in terms of coastal tourism and real estate is in the 40 billion dollar range. Its sport and commercial fishing value is in the 2.2 billion dollar range. It is a focal point for the region and a recreational and esthetic treasure. For many it is also a source of food.

It is clear from this study that chemical contamination is a threat to both the vitality of the Bay and to those humans who use the Bay. Given that our life styles are dependent upon toxic chemicals, it is a certainty that toxicants will continue to enter Santa Monica Bay through the storm drain system. Each of us therefore must make a choice either to phase out toxics from our lifestyles and pressure elected officials to enact laws and policies which will remove toxins from the environment, or to pass on to our children and their children a Santa Monica Bay polluted by toxic chemicals.

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[1] Ehrlich and Ehrlich: Healing the Planet (1991), pp.140-42.

[2] Ibid.

[3] Dr. Michael Stenstrom and Eric W. Strecker, UCLA Department of Civil and Environmental Engineering, Assessment of Storm Drain Sources of Contaminants to Santa Monica Bay, Vol. 1, 1993.

[4] Principal researchers for the study were: Dr. I.H. (Mel) Suffet and Dr. John Froines; in collaboration with Dr. Michael K. Stenstrom.

[5] Clean Water: Natural Resources Defense Council (1991) ["From January through December 1989, NRDC estimates that roughly twice as much zinc and cadmium were discharged via storm drains runoff into Santa Monica Bay, as were discharged by the Hyperion Plant and the joint Water Pollution Control Plant for the year 1988, p.1]; also see The U. S. EPA Annual Toxics Release Inventory (initiated 1987) ["...1989 poison runoff from the greater Los Angeles area contributed one and one-half times as much lead, one-half as much copper, and one-third as much chromium as did the two sewage plants in 1988." p.1]

[6] Gold, M., et. al. (1990) An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses From Two Santa Monica Bay Storm Drains. A document prepared for the Santa Monica Bay Restoration Project.

[7] Studies conducted under the auspices of the City of Santa Monica have identified a number of chemical agents in the effluent from the Pico-Kenter storm drain. Chlorinated hydrocarbon solvents and suspected carcinogens were detected during 1985 and 1986. Between 1989-90 bromoform, chloroform, toluene, xylene, perchloroethylene, polycyclic aromatic hydrocarbons, nitroaromatics, bromodichloromethane and others in the Pico-Kenter storm drain. A study by Schager and Gossett (June 1988) identified DDT, PCBs, PAHs, and alkalines in Ballona Creek. In addition, Heal the Bay, in conjunction with the City of Los Angeles, the Los Angeles County Sanitation Districts, and the Santa Monica Bay Restoration Project has studied the problem of human fecal matter discharged from storm drains. Engineering Science under

contract with the City of Los Angeles, has monitored runoff from different land use types in Los Angeles. Dr. Michael K. Stenstrom (Department of Civil and Environmental Engineering, UCLA), also in conjunction with the Santa Monica Bay Restoration Project, is monitoring toxicity in marine organisms in the Bay. More recently, Fisher et. al. (1993), in a paper being prepared for publication, have reported the presence of dioxins, furans, and polychlorinated naphthalenes in storm drain effluent entering the Bay.

[8] Acenaphthene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pypene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3,4-c,d)pyrene, 2-methyl apthalene, naphthalene, phenanthrene, and pyrene.

[9] Benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3,4-c,d)pyrene.

[10] California's Proposition 65 classifies chemicals as carcinogens when they are known to cause cancer in animals. This classification is not used by U.S. EPA.

[12] Ibid.

[13] The six phthalates that were found in the storm drain effluent are bis(2-ethylhexyl)phthalate (DEHP), butyl benzyl phthalate, dimethyl phthalate, diethyl phthalate, di-n-butyl phthalate, di-n-octyl phthalate.

[14] "Appropriate control" in this context means an extensive quality assurance/quality control program.

[15] The 33 volatile organic compounds found were dichlorodifluoromethane, chloromethane, carbon disulfide, methlyene chloride (1), trans-1,2-dichloroethene, 2-butanone, bromochloromethane, chloroform, 1,1,1-trichloroethane, benzene, trichloroethene, dibromomethane, bromodichloromethane, 4-methyl-2-pentanone, toluene, tetrachloroethene, 2-henanone, dibromochloromethane, styrene, bromoform, 1,2,4-trimethylbenzene, napthalene, 1,1-dichloropropene, p-isopropyltoluene, (m+p)-xylene, o-xylene, 1,1-dichloroethane, 1,2-dichlorobenzene. Five compounds, bromoform, chloroform, dibromochloromethane, dichloromethane(methylene chloride), and 4-methyl-2-pentanone, had over all averages in the ppb range. The largest number of compounds and the greatest concentrations of the trihalomethanes, bromoform, chloroform, and dibromochloromethane, and 9 methylene chloride, were 10.6, 4.1, 4.9, 6.3 ppb at this site.

[16] The carcinogen methylene chloride after analyzing appropriate controls was found in excess of EPA Drinking Water Standards.

[17] The actual chemicals identified can be found in the Report on Tables 14 (page 63), and 22 (page 110-11).

[18] Styrene is associated with point discharges, thereby indicating that it may have been illegally dumped.

[19] Mass loading is defined as the amount of chemicals released into the receiving water from a storm drain over a specified time period.

[20] Supra nt. 1.

[21] Innovative tools for funding storm water management exist and should be investigated by those in State and local governments who wish to free storm drains from toxic runoff. One innovative financing tool now being implemented by the City of Los Angeles, is commonly known as "storm water utility." These are local government entities that fund storm water management services through "user Charges" which pass on storm water management costs to the "generators" of the runoff.

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LOS ANGELES COUNTY

DEPARTMENT OF PUBLIC WORKS

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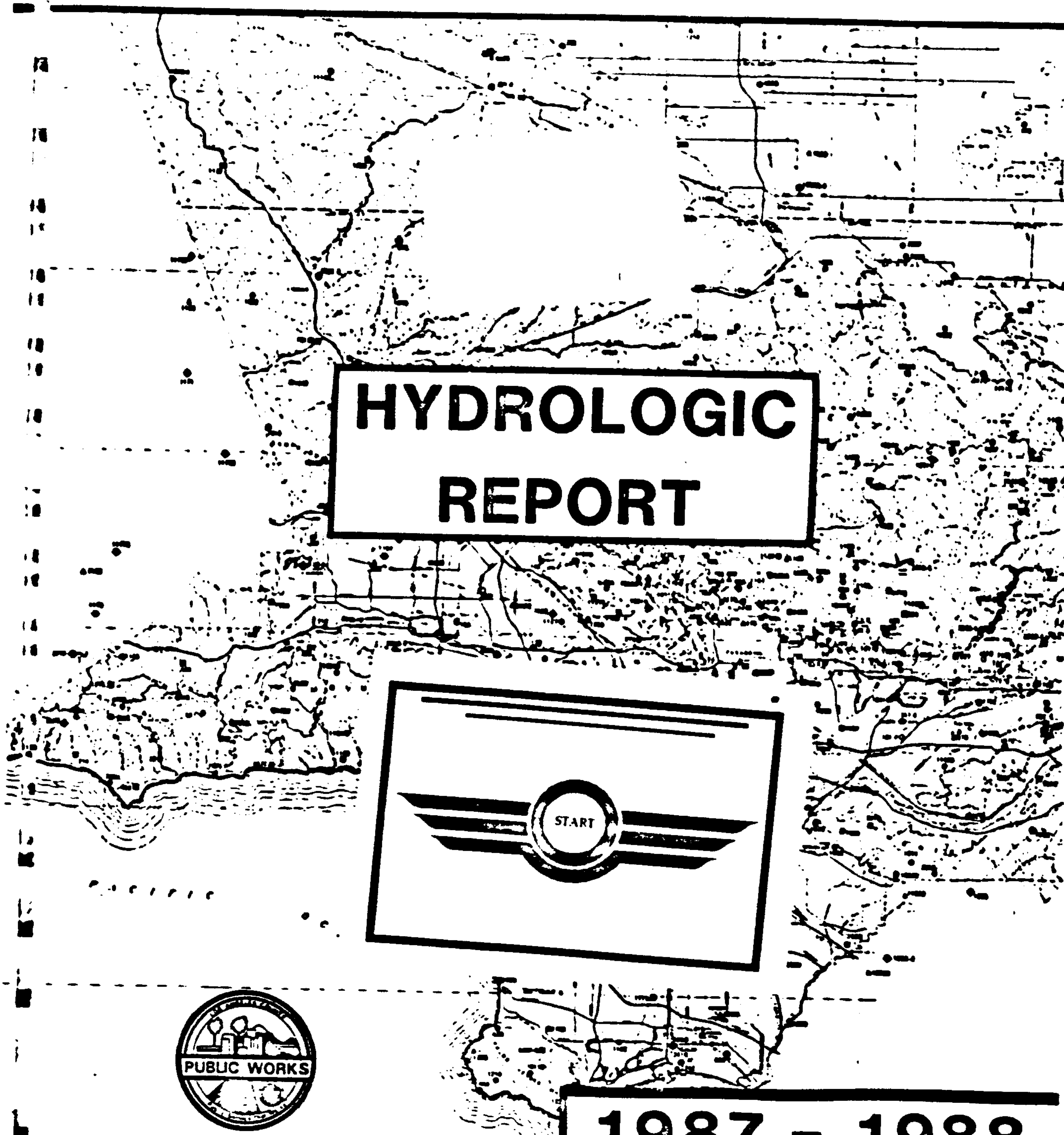
HYDROLOGIC REPORT



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PUBLIC WORKS

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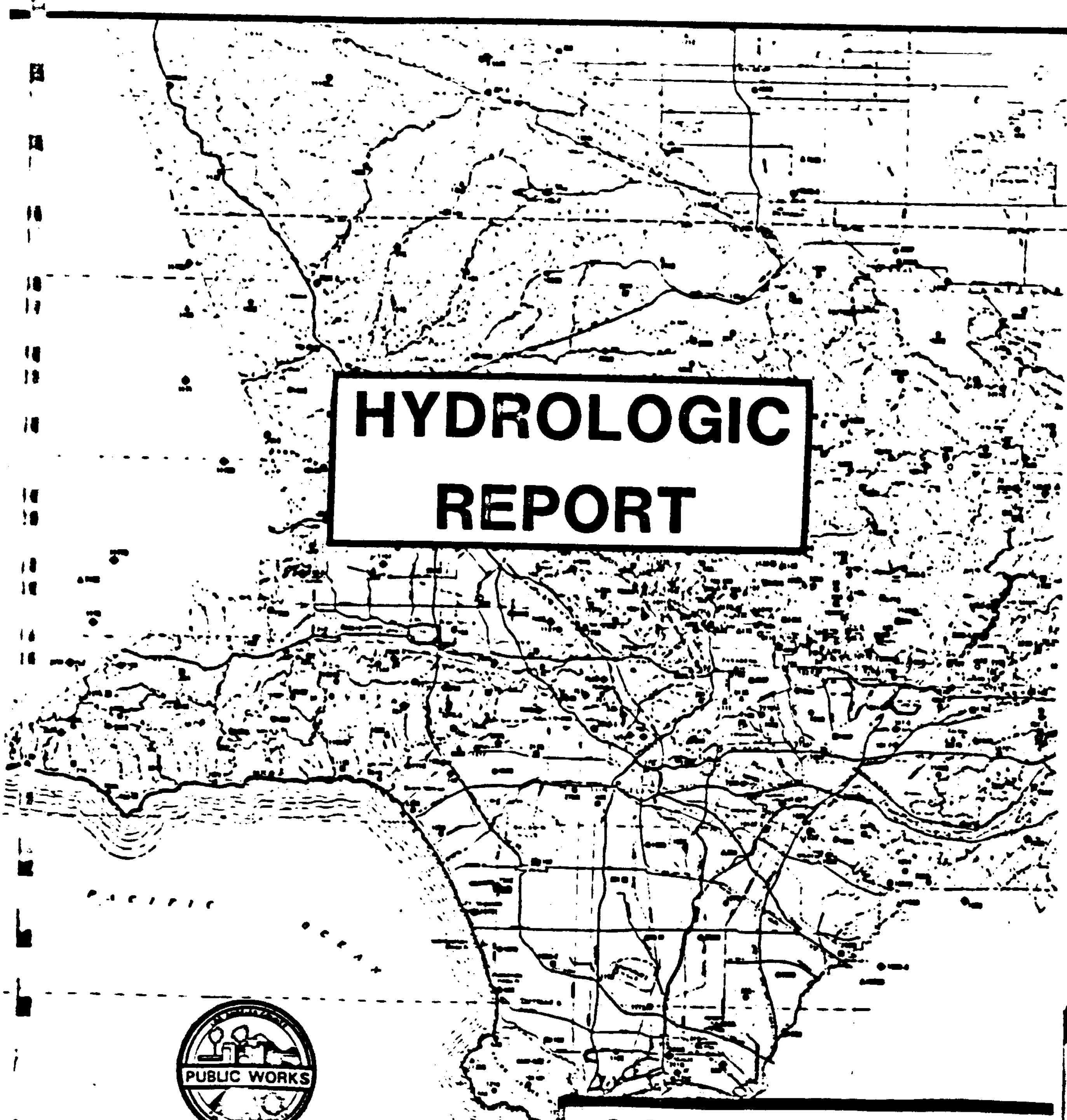

HYDROLOGIC REPORT

1 9433

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DEPARTMENT OF PUBLIC WORKS

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PREPARED BY THE
HYDRAULIC/WATER CONSERVATION DIVISION

NOVEMBER 1988

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This report was prepared in the Hydraulic/Water Conservation Division under the direction of Donald F. Nichols, Assistant Deputy Director. The following people contributed to the completion of this report:

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NOTE ON CONSOLIDATION

This report contains hydrologic data for the 1987-88 water year. On January 1, 1985, the Los Angeles County Flood Control District consolidated with the Los Angeles County Road Department and portions of the Los Angeles County Engineer to become the Los Angeles County Department of Public Works. The hydrologic data processing and reporting functions formerly carried out by the Flood Control District have now been assumed by the Department of Public Works.

ABOUT THIS REPORT

The 1987-88 Hydrologic Report represents a significant departure in terms of data content and format from reports published previously by the Department of Public Works and its predecessor, the Los Angeles County Flood Control District. The changes primarily entail the reporting of less detailed hydrologic data than were previously published, such as monthly and annual summaries instead of daily data. We apologize for any inconvenience this may cause our users, but it was felt necessary to make these changes to be current in our data publishing.

With the rapid development of computing technology, there appears to be less demand for hydrologic data in written form, and it is our intention at some future time to phase out the published book reports and make the data available on computer diskettes. In the meantime, any user who desires more detailed information about any of the types of hydrologic data which we manage can write the Custodian of Hydrologic Records at:

Los Angeles County Department
of Public Works
Hydraulic/Water Conservation Division
P.O. Box 1460
Alhambra, CA 91802-1460

or telephone: (818) 458-6112

INTRODUCTION

This report contains hydrologic data within Los Angeles County for the period beginning October 1, 1987 and ending September 30, 1988. The data are presented in seven sections.

1. Precipitation - lists 385 active rainfall stations and presents corresponding seasonal rainfall amounts.

2. Evaporation - lists all locations for which evaporation data is on file and provides monthly evaporation amounts at 14 locations.

3. Runoff - presents the maximum, minimum, and mean of the daily flow rates for each month and the monthly volumes for 53 streamflow stations and three Metropolitan Water District outlets.

4. Dam Operation - presents the maximum and minimum of the daily inflow and outflow rates for each month, the instantaneous peak inflow and outflow rates and storage volumes for 14 dams and reservoirs.

5. Erosion Control - list debris basins and debris production amounts and displays maps of major watershed burns.

6. Water Quality Monitoring - presents maps of surface and groundwater sampling locations, and data at selected locations.

7. Conservation and Groundwater - presents records of water conserved at various facilities, water injected at seawater barrier projects, well hydrographs, and groundwater basins.

Where practical, data which would satisfy immediate needs and serve as useful reference are published in these reports. Several tables appear listing locations where unpublished data are available. Additional information may be obtained by writing to:

Los Angeles County Department
of Public Works
Hydraulic/Water Conservation Division
P.O. Box 1460
Alhambra, CA 91802-1460

or telephone: (818) 458-6112

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THE LOS ANGELES COUNTY

TOPOGRAPHY

The County of Los Angeles covers an area of 4,083 square miles and measures approximately 66 miles in the east - west and 73 miles in the north - south directions.

The terrain within the County can be classified in broad terms as being 26 percent mountainous, 12 percent coastal plain; and 62 percent hills, valleys, or deserts. Relief of the terrain ranges from sea level to a maximum elevation of 10,000 feet. The coastal plain is generally of mild slope and contains relatively few depressions or natural ponding areas. The slopes of main river systems crossing the coastal plain, such as the San Gabriel River, Los Angeles River, and Ballona Creek, range from 4 to 14 feet per mile.

Topography in the mountainous area is generally rugged with deep, V-shaped canyons separated by sharp dividing ridges. Steepwalled canyons with side slopes of 70 percent or more are common. The gradient of principal canyons in the San Gabriel Mountains ranges from 150 to 850 feet per mile. Mountain ranges are aligned in a general east-west direction, the major range being the San Gabriel Mountains. The majority of mountain ridges lie below Elevation 5,000, the total area above this level being approximately 210 square miles.

GEOLOGY - SOILS

Igneous, sedimentary, and metamorphic rock groups are all represented within the County. The San Gabriel Mountains and Verdugo Hills are composed primarily of highly fractured igneous rock, with large areas of granitic rock formation being exposed above soils which are coarse and porous. Faulting and deep weathering have produced porous zones in the rock formation; however, rock masses have produced a comparatively shallow soil mantle due to the steepness of slopes which accelerates erosion of the fine material.

LAND USE

The principal vegetative cover of upper mountain areas consists of various species of brush and shrubs known as chaparral. Most trees found on mountain slopes are oak, with alder, willow, and sycamore found along streambeds at lower elevations. Pine, cedar, and juniper are found in ravines at higher elevations and along high mountain summits.

The chaparral is extremely flammable, and extensive burns of the mountain vegetation frequently occur during dry, low-humidity weather accompanied by high winds. Chaparral has the ability to sprout following fires and grows rapidly to re-establish the watershed cover within a period of 5 to 10 years.

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Grasses are the principal natural vegetation on the hills. Much of the hill land and nearly all of the valley land in the densely populated portion of the County south of the San Gabriel Mountains has been converted to urban and suburban use. Development of the Santa Clarita Valley and desert areas to the north of the San Gabriel Mountains is sparse at present but is proceeding at an accelerated rate.

Other mountains and hilly reaches within the Department are composed primarily of folded and faulted sedimentary rocks, including shale, sandstone, and conglomerate. Residual soils in these areas are shallow and are generally less pervious than those of the San Gabriel Mountain range.

Valley and desert soils are alluvial and vary from coarse sand and gravel near canyon mouths to silty clay and gravel or clay in lower valleys and the coastal plain. The alluvial fill has been built up by repeated deposition of debris to depths as great as 2,000 feet in places. This fill is quite porous in areas of relatively low clay content. Impervious layers and irregularities in the underlying bedrock divide the alluvium into several County groundwater basins. Valley soils are generally well drained and relatively few perched water or artesian areas are present.

CLIMATE

The climate within the County varies between subtropical on the Pacific Ocean side of the San Gabriel mountain range to arid in the Mojave Desert. Nearly all precipitation occurs during the months of December through March. Precipitation during summer months is infrequent, and rainless periods of several months are common. Snowfall at elevations above 5,000 feet is frequently experienced during the winter storms, but the snow melts rapidly except on higher peaks and the northern slopes. Snow is rarely experienced on the coastal plain.

January and July are the coldest and warmest months of the year, respectively. At Los Angeles, the 30-year average daily minimum temperature for January is 48 degrees above zero. The average daily maximum temperature for July is 84 degrees. At Mount Wilson (Elevation 5,850 feet), the 30-year average daily minimum temperature for January is 36 degrees above zero and the average daily maximum temperature for July is 81 degrees.

HYDROMETEOROLOGIC CHARACTERISTICS

Coastal and Mountain Areas

Precipitation in the Los Angeles area occurs primarily in the form of winter orographic rainfall associated with extratropical cyclones of North Pacific origin. Major storms consists of one or more frontal systems and occasionally last four days or longer. Air masses and frontal systems associated with major storms commonly extend for 500 to 1,000 miles in length and produce rainfall simultaneously throughout the County. Major storms approach Southern California from the west or southwest with southerly winds which continue until frontal passage. The mountain ranges lie directly across the path of the inflow of warm, moist air, and orographic effects cause precipitation to be greatly intensified.

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The effect of snowmelt upon flood runoff is of significance in the few cases when warm spring rains from southerly storms fall on a snowpack. During major storms, temperatures throughout the County may remain above freezing.

Average individual storm rainfall amounts and intensities conform to a fairly definite aerial pattern which reflects general effects of topographic differences.

Desert Areas

Summer convective rainfall is principally experienced in the upper San Gabriel Mountains and the Mojave Desert regions. In many desert areas, the most serious flooding occurs as a result of summer convective storms.

RUNOFF CHARACTERISTICS

Mountain Areas

In mountain areas, the steep canyon slopes and channel gradients are conducive to rapid concentration of storm runoff quantities. Depression storage and detention storage effects are minor in the rugged terrain. Soil moisture during a storm has a pronounced effect on runoff from the porous soils supporting a good growth of deeprooted vegetation such as chaparral. Soil moisture deficiency is greatest at the beginning of a rainy season, having been depleted by evapotranspiration process during the dry summer months. Precipitation during periods of soil moisture deficiency is nearly entirely absorbed by soils, and except for periods of extremely intense rainfall, significant runoff does not occur until soils are wetted to field moisture capacity. Due to high infiltration rates and porosity of mountain soils, runoff occurs primarily as subsurface flow or interflow rather than as direct runoff. Spring or base flow is essentially limited to portions of the San Gabriel mountain range, most streams in the Department being intermittent.

Runoff from a mountain watershed recently denuded by fire exceeds that for the unburned state due to greatly increased quantities of inorganic debris present in the flow and lowflows from a denuded watershed. Debris production from a major storm has amounted to as much as 120,000 cubic yards per square mile of watershed. Boulders up to eight feet in diameter have been deposited in a valley area a considerable distance from their source.

Debris quantities equal in volume to storm runoff, or in other words 100 percent bulking of runoff from a major storm, have been recorded. Where debris-laden flow traverses an alluvial fill unconfined by flood control works, flood discharges follow an unpredictable path across the debris cone formed at the canyon mouth.

Hill and Valley Areas

In hill areas, runoff concentrates rapidly from the generally steep slopes; however, runoff rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size. In those hill areas which have been developed for residential use, concentration times become considerably decreased due to drainage improvements, and runoff volumes and rates become increased due to increased imperviousness. On the other hand, erosion is controlled and debris content of storm flow is practically eliminated. Debris production rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size.

In highly developed valley areas, local runoff volumes have increased as the soil surface has become covered by impervious materials. Peak runoff rates for valley areas have also increased due to elimination of natural ponding areas and improved hydraulic efficiency of water carriers such as streets and storm drain systems.

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FLOOD CONTROL AND WATER CONSERVATION

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FLOODS. . .AN OLD STORY

Floods in Los Angeles County have been recorded as far back as the days of the Mission Padres. For centuries waters have swept out of the San Gabriel Mountains causing extensive property damage and taking a great toll of lives.

Such a flood occurred in 1914 causing over $10 million in property damage and taking many lives. As a result, the State legislature passed an act creating the Los Angeles County Flood Control District.

The Department was assigned two tasks. . .control the floods and conserve the water.

CONTROLLING THE WATERS

Successful early bond issues financed construction of the 14 dams which the Department built high in the San Gabriel Mountains to impound storm waters until they could be released in an orderly fashion. Debris basins were constructed to trap eroded materials which had caused terrible damage in the past. Flood channel improvements were undertaken to confine the waters.

Department engineers prepared a Comprehensive Plan in the early 1930's which provided for the control of flooding and the saving of as much of the water as practicable. With minor modifications, it is still the plan today.

Federal legislation in 1936 brought the United States Army Corps of Engineers into the local flood control picture. Since that time, the two agencies have been jointly persuing construction of the Comprehensive Plan. The Department also cooperates with the United States Soil Conservation Service and Forestry Service in erosion control and debris reduction programs.

CONSERVING THE WATERS

In addition to its flood control program, the Department has the equally important task of conserving as much of the storm and other waste waters as practicable. The use of water conservation facilities adjacent to river channels and their tributaries permits water to be percolated into ground reservoirs for later pumping by consumers. These water conservation facilities are located in areas where the underlying soils are composed of porous sands and gravel formations. Some resemble rice paddies, while others are deep basins which were once gravel pits.

The importance of this activity is apparent when it is realized that about 35 to 40 percent of the water used in the County is pumped from ground supplies. The growth of the County, combined with periodic droughts, seriously depleted these supplies on numerous occasions down through the years.

Other major conservation efforts by the Department include combatting the serious intrusion by salt water to underground fresh well supplies along the Pacific Ocean and the utilization of reclaimed sewage waters in spreading operations.

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ORGANIZED TO DO THE JOB

Day-to-day administration of Department affairs is vested in the Director of Public Works who is appointed by and responsible to the Los Angeles County Board of Supervisors. A part of the Department's activities involve the construction of flood control and water conservation facilities, and the operation and maintenance of dams, debris basins, spreading grounds, channels, and storm drains.

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PRECIPITATION

PRECIPITATION

This section contains annual precipitation data collected by the Department for the period beginning October 1, 1987 and ending September 30, 1988. Although the Department operates and maintains 385 rainfall stations, including standard and automatic gages which record amounts for durations ranging from 15 minutes to 24 hours, only annual amounts for the report period are listed herein. Additional data can be obtained by contacting the custodian of hydrologic records at the location shown in the front of the report.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorological conditions in the County and Southern California in real time, i.e., as they occur. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels, and which forecast peak flows in the Los Angeles River and the Rio Hondo.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The cooperation of observers in furnishing rainfall data to the Department as a public service is appreciated. The effort of the many agencies and individuals who have so freely cooperated with us in the collection of this data have resulted in the large number of complete records for the period covered by this report.

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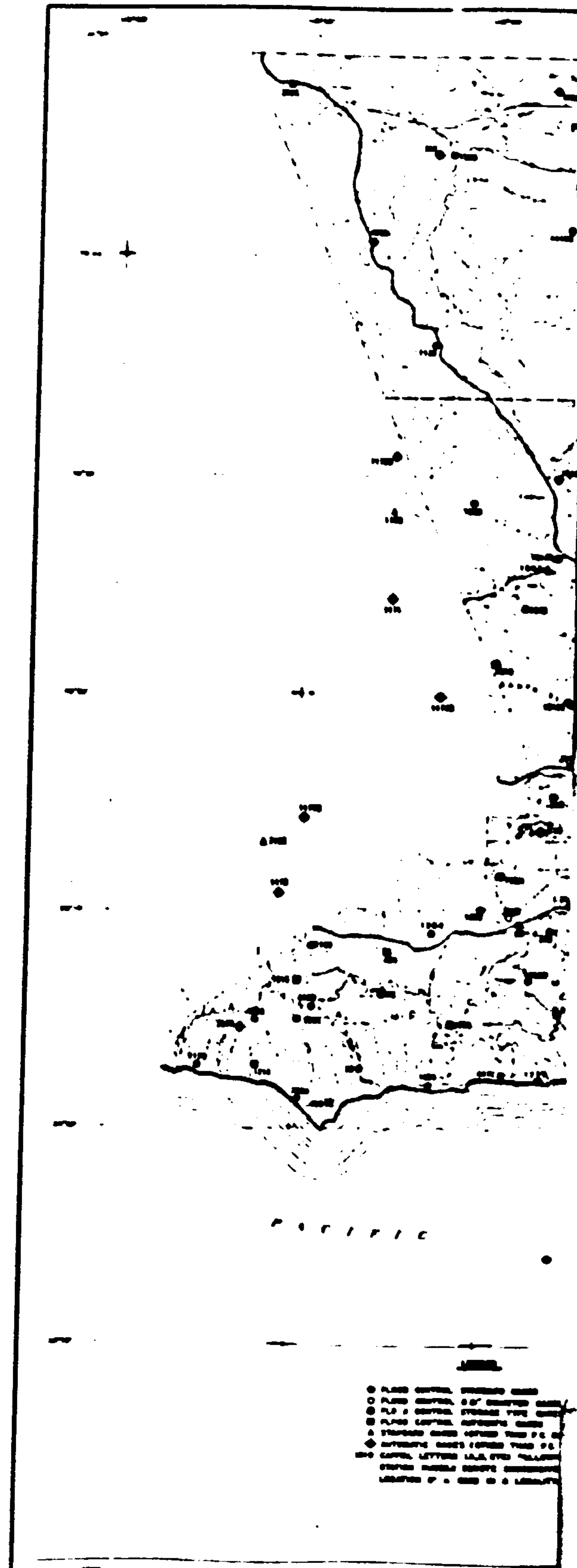

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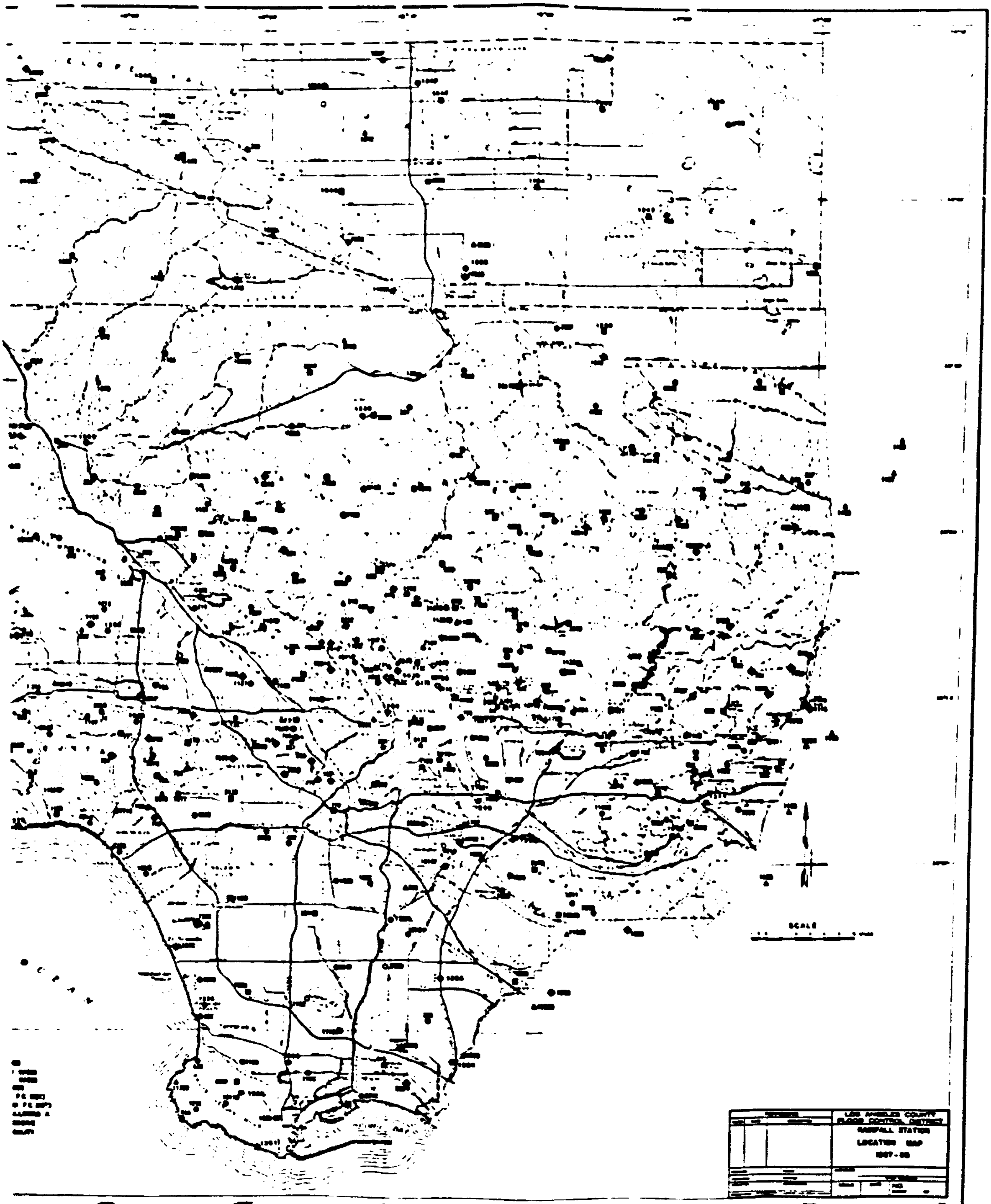
SCALE
LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT
RAINFALL STATION
LOCATION MAP

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ACTIVE RAINFALL STATIONS 1987 - 1988

STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (in inches)
2 B	ESCONDIDO CANYON	S	112 E3	34-02-55	118-46-25	1050	13.8*
5 B	CALABASAS	S	100 F3	34-09-24	118-38-14	924	19.5
6	TOPANGA PATROL STATION	A	109 C5	34-05-03	118-35-57	745	21.6
9 B	SEPULVEDA AND RAYEN	S	8 C6	34-13-52	118-28-04	828	20.1
10 A	BEL AIR HOTEL	A	22 E5	34-05-11	118-26-45	540	18.5*
11 D	UPPER FRANKLIN CANYON RESERVOIR	SP A	33 B1	34-07-10	118-24-35	867	17.7
13 C	NORTH HOLLYWOOD-LAKESIDE	S	23 F4	34-08-46	118-21-13	550	20.3
14 C	ROSCOE-MERRILL	S	9 F5	34-14-19	118-21-32	1050	20.2*
15 A	VAN NUYS	S	15 D6	34-10-48	118-27-03	695	14.4
17	SEPULVEDA CANYON @ MULHOLLAND HWY	A	22 A5	34-07-51	118-29-28	1425	25.4
20 B	GIRARD RESERVOIR	S	13 B3	34-09-07	118-36-36	986	19.0*
21 B	WOODLAND HILLS	S	13 C1	34-10-14	118-35-33	875	18.0
23 B	CHATSWORTH RESERVOIR	SP AP	6 A6	34-13-44	118-37-18	900	18.3*
24 A	CHATSWORTH	S	8 C3	34-15-25	118-36-20	980	18.1*
25 C	NORTHRIDGE-L.A.D.W.P.	SP	7 B6	34-13-52	118-32-28	810	18.1*
29 F	GRANADA HILLS	S 8.81	7 D2	34-15-03	118-31-08	1035	18.1
30 B	SYLMAR	SP	2 B3	34-18-37	118-28-15	1250	17.7*
32 C	NEWHALL-SOLEDAD DIV HDQTRS	S AP	127 C3	34-23-07	118-31-54	1243	19.0*
33 A	PACOIMA DAM	S A	128 F9	34-19-48	118-23-50	1500	21.8
39 B	SUNSET DEBRIS BASIN	8.81	18 A3	34-12-18	118-17-05	1610	21.0*
42 C	REDONDO BEACH-CITY HALL	S	67 D3	33-50-43	118-23-20	70	12.7
43 D	PALOS VERDES ESTATES	S	72 C2	33-47-58	118-23-29	216	12.7
44 A	POINT VINCENTE LIGHTHOUSE	A	77 B3	33-44-30	118-24-38	125	10.6
46 D	BIG TUJUNGA DAM	S A	M C2	34-17-40	118-11-14	2315	28.5
47 D	CLEAR CREEK-CITY SCHOOL	A	M D3	34-16-38	118-10-12	3150	27.8*
50 B	LA CANADA-ARROYO SECO	S	19 C4	34-11-52	118-11-05	1155	23.8*
53 D	COLBY'S	A	M F2	34-18-05	118-06-39	3620	28.3
54 C	LOOMIS RANCH-ALDER CREEK	S A	(197)	34-20-55	118-02-54	4325	17.6
57 B	CAMP HI HILL (OPIDS)	A	M F3	34-15-18	118-05-41	4250	31.0*
60 A	HOEGEE'S	A	20A D1	34-12-32	118-02-02	2412	24.5*
63 C	SANTA ANITA DAM	S A	20A F2	34-11-03	118-01-12	1400	27.8
67 G	MONROVIA-MOUNTAIN AVENUE	S	29 C4	34-08-46	117-59-05	602	17.4
68 C	SAWPIT DAM	S A	20B C6	34-10-30	117-59-07	1375	28.4
73	GLENDORA-ENGLEWILD RANCH	A	87 C3	34-09-22	117-50-57	1165	20.2*
78 B	COLDBROOK RANGER STATION	A	P A2	34-17-28	117-50-28	3280	32.4
80 B	PRAIRIE FORKS	ST	P F1	34-20-20	117-41-30	5640	17.0*
81 B	VINCENT GAP	ST	(200)	34-22-28	117-45-05	6590	21.0*
82 F	TABLE MOUNTAIN	S	(201)	34-22-56	117-40-39	7420	17.0
83 B	BIG PINES RECREATION PARK	A	(201)	34-22-44	117-41-20	6860	17.5*
89 B	SAN DIMAS DAM	S A	95A C3	34-09-10	117-46-17	1350	23.2
91	INDIAN HILL-CLAREMONT	S	91 B1	34-07-22	117-43-11	1403	22.3
92	CLAREMONT-POMONA COLLEGE	SP A	91 C4	34-05-48	117-42-33	1185	17.8

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ACTIVE RAINFALL STATIONS 1987 - 1988

STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (in inches)
1209	SAN JOSE CHANNEL @ WORKMAN MILL RD	8.81	47 F4	34-01-55	118-06-39	275	12.7
1210	NEENACH	ST	148 H4	34-46-42	118-15-48	2413	6.0*
1211	HACIENDA GOLF CLUB	S	98A A1	33-57-40	117-56-57	750	11.0*
1212	LANCASTER FSS/FAA	SP	147 C9	34-44-00	118-13-00	2340	6.0*
1213	NORTHRIDGE-DAVIS	S	7 D3	34-15-15	118-30-58	950	18.0*
1214	ENCINAL CANYON-FIRE STATION	A	111 B4	34-02-52	118-52-07	175	18.2
1215	SANTA MONICA MTS-CAMP KILPATRICK	A	105 F4	34-06-45	118-49-52	1775	23.0*
1216	PALOS VERDES-MONACO	S	77 C1	33-45-10	118-23-32	780	13.3
1217	LOS ANGELES COUNTRY CLUB	S	42 A1	34-04-10	118-25-17	380	16.1
1222	NORTHRIDGE-GARLAND	8.81	7 E3	34-14-	118-30-		18.3
1223	WOODLAND HILLS-SHERMAN	8.81	100 E1	34-05-29	118-38-53	1035	17.3
1225	REDONDO BEACH-LACFCD YARD	S	67 D1	33-51-	118-23-		10.4
1238	ACTON-MEARNS	S	189 G2	34-27-05	118-12-50		15.0*
1239	MALIBU-BIG ROCK MESA	A	115 A4	34-02-34	118-37-16	725	13.5*
1240	PEARBLOSSOM-CAL.D.W.R. BOOSTER STA.	SP AP	185 B7	34-30-32	117-55-15	3050	9.6
1242	ROCKY BUTTES	A	(182)	34-39-00	117-51-48	2540	7.0*
1243	REDMAN	A	(150)	34-45-52	117-55-30	2380	6.7
1244	LANCASTER-ROPER	A	161 C8	34-40-27	118-00-37	2450	6.0*
1245	QUARTZ HILL-HALL	A	159 B7	34-40-28	118-14-40	2395	5.0*
1246	SCOTT RANCH	A	(145)	34-46-59	118-28-10	2710	14.0*
1247	NORTH LANCASTER	A	148 D8	34-45-41	118-07-30	2310	6.0*
1248	MESCAL-SMITH	A	(194)	34-28-03	117-42-40	3810	9.2*
1249	RELAY	A	(150)	34-45-43	117-47-55	3140	7.0*
1250	AVEK	A	185 B5	34-32-21	117-55-23	2825	8.4
1251	PALOS VERDES-WHITES POINT	S	78 D8	33-42-50	118-19-02	100	12.1
1252	PALOS VERDES LANDFILL	S	73 A4	33-45-40	118-20-03	400	13.7
1253	CARSON-COUNTY SANITATION	S	74 A2	33-48-07	118-16-58	40	12.0
1254	LONG BEACH RECLAMATION PLANT	S	78 F1	33-48-11	118-05-20	20	8.0
1255	LOS COYOTES RECLAMATION PLANT	S	66 E4	33-53-05	118-06-24	70	8.9
1256	SOUTH GATE TRANSFER STATION	S	59 E3	33-56-40	118-09-56	100	9.7
1257	SAN JOSE CREEK RECLAMATION PLANT	S	47 F4	34-01-55	118-01-16	275	13.3
1258	PUENTE HILLS LANDFILL	S	47 E5	34-01-35	118-01-49	300	14.3
1259	WHITTIER NARROWS RECLAMATION PLANT	S	47 B1	34-03-59	118-03-54	225	11.2
1260	SPADRA LANDFILL	S	93 E4	34-02-36	117-49-50	700	13.7
1261	LA CANADA RECLAMATION PLANT	S	19 D2	34-13-00	118-11-14	1800	19.1
1262	SAUGUS RECLAMATION PLANT	S	124 B9	34-24-48	118-32-23	1150	17.0
1263	VALENCIA RECLAMATION PLANT	S	123 D7	34-25-55	118-37-13	1000	16.7
1264	CALABASAS LANDFILL	S	100A E3	34-08-25	118-42-35	800	19.3
1265	SCHOLL CANYON LANDFILL	S	26 C4	34-08-38	118-11-07	1000	18.7
1266	MISSION CANYON LANDFILL	S	22 B6	34-03-40	118-28-45	1150	18.9
1267	LANCASTER RECLAMATION PLANT	S	147 H4	34-46-38	118-09-11	2302	7.5

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STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (in inches)
1132	OAK FLAT GUARD STATION	S	(166)	34-35-56	118-43-15	2800	18.0*
1133	FISH CANYON	ST	N D5	34-12-23	117-56-43	2600	32.0*
1135 B	LUNADA BAY	SP	72 A4	33-46-37	118-25-01	250	13.0*
1138	MOUNT DISAPPOINTMENT	A	M F4	34-14-42	118-08-07	5725	28.0*
1140	ROSEMEAD	8.81	38 B5	34-04-53	118-03-55	305	13.4
1145	UPLAND	SP	S.B.CO.	34-07-57	117-38-38	1605	22.0*
1146	SANTA ANITA CANYON-HELIPORT	S	20A F1	34-12-52	118-01-05	2575	38.0*
1147	EL CABALLERO COUNTRY CLUB	S	21 C4	34-08-52	118-31-53	1000	25.1
1148 B	SAN JOSE HILLS	S	92 C3	34-03-00	117-54-53	440	12.4*
1152	CLEAR CREEK RANGER STATION	S	M D3	34-16-15	118-09-11	3625	25.7
1157	CAL STATE UNIVERSITY-NORTHRIDGE	SP AP	7 C5	34-14-17	118-31-48	890	18.0*
1158	TORRANCE MUNICIPAL AIRPORT	S	73 B2	33-47-59	118-20-08	102	14.3
1159	SHORTCUT CANYON-WEST FORK	A	N A3	34-15-55	118-04-08	4425	28.0*
1160	SAN GABRIEL CYN-WEST FORK HELIPORT	A	N B4	34-15-02	118-01-30	3200	39.0*
1162	IRON MOUNTAIN	ST	(198)	34-21-08	118-13-46	5320	29.0*
1166	MILE HIGH RANCH	S	(193)	34-24-40	117-46-15	5280	17.8
1167	FENNER CANYON	S	(200)	34-23-25	117-46-27	5380	21.0*
1169 B	PIRU-TEMESCAL GUARD STATION	SP	V.CO.	34-28-22	118-45-21	1150	19.7
1170 B	THOUSAND OAKS WEATHER STATION	AP	V.CO.	34-10-44	118-51-01	805	17.8
1171 B	CAMULOS RANCH	SP AP	V.CO.	34-24-22	118-45-21	725	18.7
1172 B	PIRU CANYON ABOVE PIRU LAKE	AP	(177)	34-30-48	118-45-24	1150	17.0
1173 B	TAPO CANYON	AP	V.CO.	34-19-54	118-42-39	1525	18.8
1177 B	BARD RESERVOIR	AP	V.CO.	34-14-32	118-49-41	1010	15.5
1183 B	LA HABRA FIRE STATION	3" P	84 F4	33-55-53	117-57-17	315	10.0*
1187	MILLARD-CAMP SIERRA	SP	20 B2	34-13-04	118-07-58	2760	28.0*
1188	EATON-MARKHAM SADDLE	SP	M F4	34-14-31	118-05-38	5400	28.8*
1190	PACOIMA CYN-NORTH FORK RANGER STA.	A	(195)	34-23-17	118-15-08	4180	29.0*
1191	BEAR DIVIDE	S	128 F8	34-21-35	118-23-37	2700	27.0
1192	CARSON FIRE STATION	8.81	64 C6	33-52-04	118-15-45	92	11.0*
1193	WESTLAKE VILLAGE	S	102 A5	34-08-19	118-49-05	885	20.0*
1194	SANTA YNEZ RESERVOIR	S	109 F6	34-04-23	118-33-59	735	18.0*
1195	CHINO FIRE STATION NO.2	SP	S.B.CO.	33-59-00	117-43-20	655	11.0*
1196	MONTCLAIR FIRE DEPARTMENT	SP	95 E2	34-03-41	117-41-16	985	18.0*
1197	CAJON WEST SUMMIT	SP	S.B.CO.	34-23-30	117-34-35	4838	13.0*
1198	PHELAN FIRE CONTROL	SP	S.B.CO.	34-25-30	117-34-00	4160	10.0*
1199	CLOUDCROFT DEBRIS BASIN	A	115 F3	34-02-58	118-34-12	350	15.0
1202	CAMP CISQUITO	S	157A D4	34-10-04	118-40-03	1135	18.0*
1203	LITTLE TUJUNGA-ALDER CREEK	ST	(195)	34-20-03	118-18-50	2825	24.0*
1205	MOODY SPRING	ST	(176)	34-36-04	117-40-23	2915	7.0*
1206	MUROC	ST	(138)	34-48-26	117-55-03	2310	7.0*
1207	ROSAMOND-WEST	ST	147 F1	34-48-14	118-11-35	2340	7.0*
1208	LA CRESCENTA-VIRGITH	S	11 C5	34-14-30	118-15-25	1707	22.0*

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STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (in inches)
1048 B	LA CRESCENTA-L.A.CO.ROAD DEPT.	S	18 C1	34-13-27	118-15-23	1410	21.8*
1050 F	OLD TOPANGA CANYON	S	108 F3	34-06-24	118-37-43	1000	24.0*
1051 B	CANOGA PARK-PIERCE COLLEGE	SP	12 E5	34-10-51	118-34-23	800	21.0*
1052	CAMP JOSEPHO	S	30 D5	34-04-51	118-31-10	860	20.0*
1058 B	PALMDALE	SP AP	172 E7	34-35-17	118-05-31	2595	7.8
1059 B	SOUTH MT. HAWKINS	ST	P B1	34-18-46	117-48-32	7700	28.0*
1060 B	LITTLE ROCK-SYCAMORE CAMP	A	(191)	34-25-02	117-58-13	4000	17.0*
1062	BUCKHORN FLAT	A	(199)	34-20-44	117-55-08	6760	25.0*
1063	SOLEDAD PASS	S	189 E9	34-29-35	118-05-28	3520	12.2
1068	RATTLESNAKE CANYON-CAMP NO.13	S	105 C5	34-05-00	118-51-56	1290	20.0*
1070	MANHATTAN BEACH	S	62 D4	33-53-00	118-23-19	182	10.0*
1071 B	DESCANSO GARDENS	S	19 B2	34-12-07	118-12-46	1325	22.0
1072 B	LITTLE TUJUNGA RANGER STATION	SP A	3 F5	34-17-37	118-21-38	1275	22.8
1074	LITTLE GLEASON	A	(197)	34-22-43	118-08-57	5600	23.8*
1075	UPPER WOLFSKILL	AP	98 B2	34-10-13	117-43-18	3625	27.0*
1076	MONTE CRISTO RANGER STATION	SP	M E1	34-19-42	118-07-20	3360	23.1
1077 B	MONROVIA-FIVE POINTS	S	29 B1	34-09-58	117-59-37	982	22.9
1078	COVINA-GRIFFITH	A	93 C1	34-04-10	117-50-47	975	18.2
1079	RUBIO DEBRIS BASIN	8.81	20 C4	34-11-57	118-07-22	1653	26.5*
1080 B	BRADBURY DEBRIS BASIN	A	29 E3	34-09-23	117-57-58	935	23.0*
1081 B	GLENDALE-GREGG	SP AP	18 D4	34-11-45	118-14-30	1350	20.8
1087	GREEN-VERDUGO PUMPING PLANT	S	10 B3	34-15-25	118-20-11	1340	18.0*
1088 B	LA HABRA HEIGHTS-MUTUAL WATER CO.	S A	84 E2	33-56-55	117-57-51	445	10.8
1090	LOS ALAMITOS	SP	81 B6	33-48-35	118-04-35	25	8.5
1092 B	BUENA PARK	3"P	OC10 C1	33-51-28	117-59-29	80	9.0
1093 E	FULLERTON AIRPORT	SP AP	83 D5	33-52-23	117-58-24	100	9.0
1095	ORANGE COUNTY RESERVOIR	SP AP	OC 2 F4	33-56-07	117-52-58	880	10.9
1099	WHITTIER-CATE	S	55 C2	34-00-20	118-03-30	280	13.4*
1104	BOUQUET CANYON AT TEXAS CANYON	S	(180)	34-30-35	118-27-00	1760	15.2
1105 B	FAIRMONT	S	(145)	34-44-23	118-27-15	2855	14.4*
1107 D	LA TUNA DEBRIS BASIN	A	10 C5	34-14-13	118-19-37	1160	20.0*
1111 C	DEVILS PUNCHBOWL	S	(192A)	34-24-48	117-51-25	4760	21.1
1113	DOMINGUEZ WATER CO.	A	69 F4	33-49-54	118-13-30	30	12.0*
1114 B	WHITTIER NARROWS DAM	AP	47 A6	34-01-29	118-05-02	239	8.1
1115	SAN ANTONIO DAM	AP	98 F3	34-09-24	117-40-20	2120	22.1
1119 B	ATMORE MEADOW	ST	(155)	34-41-18	118-36-16	4325	26.5*
1120	DAWSON SADDLE	ST	(200)	34-22-08	117-48-10	7900	23.7*
1121 C	BARLEY FLAT	S	N A3	34-16-40	118-04-40	5525	26.0*
1126	L.A. WATER DEPT.-EAST VALLEY	8.81	16 A2	34-12-30	118-24-35	780	21.0*
1127	WEST BURBANK	S	17 B6	34-10-47	118-20-07	815	15.9
1128	WRIGHTWOOD FIRE DEPARTMENT	SP	S.B.CO.	34-21-34	117-37-57	5960	18.0*
1129 B	NICHOLAS CANYON	S	110 D3	34-02-52	118-54-57	340	14.8

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STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (in inches)
735 H	BELL CANYON	A	5 D4	34-11-40	118-39-23	895	19.0*
740 B	SAN DIMAS CANYON-FERN NO.2	AP	P F8	34-11-48	117-41-45	5200	27.9*
741	SAN DIMAS CYN-UPPER EAST FORK	AP	P E6	34-11-41	117-44-28	2675	28.0*
742 C	SAN GABRIEL-FIRE DEPARTMENT	SP	37 E3	34-06-11	118-05-56	445	28.0*
747	SANDBERG-AIRWAYS STATION	SP AP	(142)	34-44-47	118-43-29	4517	18.5*
749 B	BURBANK VALLEY PUMP PLANT	SP AP	17 A5	34-11-11	118-20-54	655	16.0*
750 B	PALMDALE-F.A.A. AIRPORT	SP	172 F8	34-37-20	118-05-00	2528	8.5
755	GRIFFITH PARK-LITTLE CANYON	AP	25 A8	34-07-32	118-16-58	900	15.0*
757	GRIFFITH PARK-FERN DELL	AP	34 E1	34-07-12	118-18-20	750	17.0*
759 B	NICHOLS DEBRIS BASIN	AP	33 F2	34-08-10	118-21-23	440	18.0*
762	UPPER STONE CANYON	AP	22 D8	34-07-27	118-27-15	943	20.0*
767	MANDEVILLE CANYON ROAD	SP AP	30 F2	34-08-24	118-30-10	1160	23.0*
771 B	PACIFIC PALISADES-RIVIERA C. C.	S	40 F3	34-03-03	118-29-58	315	17.0*
772	LOS ANGELES-ECHO PARK & LUCRETIA	AP	35 C5	34-05-02	118-15-11	475	15.0*
794 E	LOWER FRANKLIN RESERVOIR	SP	33 B4	34-05-43	118-24-40	585	16.0*
795	PASADENA-JOURDAN	SP	27 F4	34-08-52	118-05-14		18.8
796	ELYSIAN PARK-FIRE DEPARTMENT	AP	35 E5	34-04-55	118-14-22	757	15.0*
797	DE SOTO RESERVOIR	SP	6 D1	34-16-17	118-35-12	1127	19.0*
801 B	MAGIC MOUNTAIN	AP	(195)	34-23-18	118-19-27	4720	27.7*
802 C	EAGLE ROCK RESERVOIR	SP	26 C4	34-08-47	118-11-20	970	17.0*
807	ASCOT RESERVOIR	SP A	36 C5	34-04-46	118-11-14	620	14.0*
1005 B	MINT CANYON FIRE STATION	S	(180)	34-30-35	118-21-40	2300	18.8
1006	SAN PEDRO-CITY RESERVOIR	A	78 F2	33-44-37	118-17-47	150	12.0*
1008 E	LA FRESA-S.C.E.CO. SUBSTATION	A	63 C8	33-52-07	118-19-55	65	14.0*
1011 B	PALOS VERDES FIRE STATION	S	78 A1	33-45-25	118-21-11	1275	14.2
1012 B	CASTAIC JUNCTION	A	123 E8	34-26-18	118-36-43	1005	17.0*
1014 F	RIO HONDO SPREADING GROUNDS	S A	54 E3	33-59-57	118-06-04	170	10.0*
1017 B	LITTLE ROCK CREEK ABOVE DAM	A	(191)	34-28-41	118-01-24	3260	11.0*
1019	SANTA SUSANA MOUNTAINS-SALT CYN	ST	126 A6	34-21-24	118-39-42	2850	17.0*
1020 B	PADUA HILLS PATROL STATION	S	96 D4	34-08-52	117-41-55	1800	20.1
1022	HASLEY CANYON	S	(122)	34-28-44	118-41-04	1725	17.5*
1023 B	SANTA MARIA CREEK-SPEER	S	13 E8	34-07-44	118-34-42	1415	23.0*
1025	MALIBU BEACH-DUNNE	S	113 E5	34-02-00	118-42-42	160	12.4
1029 C	TUJUNGA-MILL CK SUMMIT RANGER STA	AP	(197)	34-23-22	118-04-49	4990	21.0
1030	MOUNT ISLIP-LITTLE JIMMY CAMP	ST	(200)	34-20-50	117-49-57	7520	28.5*
1031 B	MOUNT WATERMAN	ST	(199)	34-20-23	117-56-21	7980	24.4*
1037	ARCADIA-ARBORETUM	S	28 C4	34-08-48	118-02-59	565	16.9
1038 B	PACIFICO MT.	ST	(198)	34-22-40	118-01-44	6880	17.5*
1040	POTRERO CANYON-SUNRAY DX OIL CO.	S	126 C2	34-23-50	118-38-18	1150	17.0*
1041 B	SANTA FE DAM	AP	39 D1	34-07-04	117-58-24	427	15.2
1046 B	SANTA ANITA CANYON-CHANTRY FLAT	S	20A F1	34-11-46	118-01-20	2175	34.3

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458	ZUMA CANYON PATROL STATION	A	112 C6	34-01-10	118-47-46	115	14.0*
460 C	PLEASANT VIEW MESA	S	192 A4	34-27-40	117-55-51	3960	14.0*
462 B	LOS ANGELES-HILLCREST C. C.	S	42 B3	34-02-54	118-24-06	185	14.9
465 C	SEPULVEDA DAM	AP	22 B1	34-10-06	118-28-11	683	19.0
466 B	PACOIMA CANYON-DUTCH LOUIE	A	(195)	34-21-07	118-20-38	3220	28.0*
471	LITTLE TUJUNGA-GOLD CREEK	AP	M D5	34-18-57	118-18-02	2750	23.2*
477 D	SANTA ANITA-SPRING CAMP	A	208 C2	34-12-52	117-58-56	4655	38.0*
480 B	TEMPLE CITY FIRE STATION	S	38 C2	34-06-31	118-03-25	404	16.0*
482	LOS ANGELES - U.S.C.	S	43 F8	34-01-14	118-17-15	208	12.4
488 B	KAGEL CANYON PATROL STATION	S	3 E4	34-17-45	118-22-30	1450	21.2
491 D	PACIFIC PALISADES	S	40 C4	34-02-22	118-31-43	293	14.0*
492 A	CHILAO-STATE HWY MAINTENANCE STA	A	N C1	34-19-02	118-00-30	5280	23.5*
493 D	SAND CANYON-MACMILLAN RANCH	A	128 D3	34-23-17	118-24-50	1805	25.7*
497	CLAREMONT-SLAUGHTER	B.81	91 A1	34-07-35	117-43-56	1350	20.0*
498	DARK CYN TRAIL-ANGELES CREST HWY	A	M C3	34-15-21	118-11-45	2800	27.0*
517 B	LEWIS RANCH	A	(192A)	34-25-12	117-53-11	4815	21.7*
542 E	FAIRMONT	SP	(145)	34-42-15	118-25-40	3050	14.0*
580 A	LA VERNE HEIGHTS	S	90 E2	34-06-48	117-45-02	1210	19.2
584 C	LLANO	S	185 J8	34-29-13	117-50-02	3390	10.6
588 D	MT. LOWE	ST	20 D1	34-13-37	118-08-33	4435	28.0*
591 B	SANTA ANITA RESERVOIR	SP	20 E5	34-11-08	118-08-16	1205	28.4
598 C	NEENACH-ERSTAD	S	(143)	34-46-28	118-35-55	3062	19.0*
598 D	NEENACH-CHECK 43-CALIFORNIA D.W.R.	SP AP	(143)	34-47-40	118-37-15	2985	18.0*
610 B	PASADENA-CITY HALL	SP	27 A4	34-08-54	118-08-38	864	17.4
611 C	ALTADENA GOLF COURSE-DEBRIS BASIN	B.81	20 C6	34-10-48	118-07-01	1186	22.0*
612 B	PASADENA-CHLORINE PLANT	SP	19 E3	34-12-04	118-09-49	1160	22.9
613 C	PASADENA-HURLBUT FIRE STATION	SP	27 B5	34-07-15	118-08-05	779	16.7
619	SAN ANTONIO CYN-SIERRA POWER HOUSE	A	P F5	34-12-29	117-40-26	3110	27.8
627	SAN GABRIEL CANYON-POWER HOUSE	SP A	86 D3	34-09-20	117-54-28	744	21.2
634 C	SANTA MONICA	S	49 A1	34-00-43	118-29-27	94	13.0*
662 D	LONG BEACH AIRPORT-W.S.O.	AP	71 A6	33-49-	118-09-	34	8.0*
680 B	WESTWOOD - U.C.L.A.	SP	41 E1	34-04-10	118-26-30	430	16.5*
683 B	SUNSET RIDGE	S AP	19 E4	34-12-53	118-08-47	2110	20.0
694 G	BIG TUJUNGA CANYON-CAMP 15	A	M D6	34-17-22	118-17-17	1525	22.0*
695 B	TUJUNGA CANYON-VOGEL FLAT	S	M B2	34-17-12	118-13-32	1850	29.3
716	LOS ANGELES-DUCOMMUN ST.	SP A	44 E3	34-03-09	118-14-13	308	13.4
718 C	THOUSAND OAKS WEATHER STATION		V.CO.	34-13-06	118-51-56	800	19.0*
722 C	BELLEVIEW	S	171 B3	34-37-23	118-13-55	2880	5.0*
726 C	ANGELES CREST GUARD STATION	S	M D4	34-14-01	118-11-04	2300	31.42
727 B	NEWCOMB PASS	S	N B4	34-14-17	118-01-04	4025	39.0*
731	OAK GROVE HDQTRS	SP	19 D4	34-11-47	118-10-29	1080	21.0*
734 C	LOS ANGELES INTL AIRPORT	SP AP	56 C3	33-56-25	118-23-44	105	9.0*

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ACTIVE RAINFALL STATIONS 1987 - 1988

STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (IN INCHES)
321 E	PINE CANYON PATROL STATION	A	157 D7	34-40-24	118-25-45	3288	14.5*
322	MUNZ VALLEY RANCH	S	158 A2	34-42-50	118-21-15	2800	11.8
334 B	COGSWELL DAM	S A	N D4	34-14-37	117-57-35	2300	38.1
336	SILVER LAKE RESERVOIR	SP AP	35 B3	34-06-08	118-15-54	445	15.0*
338 C	MT. WILSON-OBSERVATORY	SP	20A C1	34-13-	118-03-		32.0*
341	ALISO CANYON-BLUM RANCH	S	189 J4	34-27-33	118-09-20	2900	13.0*
348 D	EAST FORK RANGER STATION	ST	P D4	34-14-20	117-46-09	2075	21.5*
352 B	LECHUZA PATROL STATION	S AP	105 B6	34-04-38	118-52-47	1620	18.5
355 B	LOS ANGELES-CITY COLLEGE	S AP	34 F4	34-05-14	118-17-28	310	16.0*
356 C	SPADRA PACIFIC COLONY	S A	93 F4	34-02-31	117-48-35	690	13.8
363	WILSON CANYON	ST	128 A7	34-21-17	118-27-00	3175	21.0*
372	SAN FRANCISQUITO CANYON #2	SP A	(179)	34-32-02	118-31-27	1580	19.7
373 C	BRIGGS TERRACE	S A	11 F5	34-14-17	118-13-27	2200	25.1
379 B	SAN GABRIEL-EAST FORK	A	P C4	34-14-09	117-48-18	1600	27.0*
386 C	ZUMA CANYON-OAKLEY	S	105 F5	34-04-58	118-49-38	1500	24.8
387 B	COVINA CITY YARD	SP	88 E5	34-05-02	117-53-57	508	12.0*
388 D	PARAMOUNT-COUNTY FIRE DEPT	8.81	65 E3	33-53-50	118-10-02	80	9.0*
390 B	MORRIS DAM	SP	P A6	34-10-53	117-52-43	1210	24.4
391 C	MONTEBELLO-FIRE DEPARTMENT	8.81	54 E1	34-01-08	118-08-15	250	10.0*
394	HIGHLAND PARK-LINDSAY	S	36 D1	34-07-08	118-10-39	620	18.5
395 B	OLIVE VIEW SANITARIUM	S	2 D1	34-19-29	118-26-56	1425	17.0*
402 F	CEDAR SPRINGS	A	(199)	34-21-21	117-52-34	6780	25.7*
405 B	SOLEDAD CANYON	S	188 F6	34-26-23	118-17-33	2150	18.9
408 C	WEST AZUSA	S	88 C2	34-08-53	117-54-58	505	18.8
409 B	PYRAMID RESERVOIR	SP AP	(154)	34-40-34	118-46-47	2505	19.0*
415	SIGNAL HILL-CITY HALL	S A	75 E2	33-47-49	118-10-03	140	8.8
419 B	SANTA CLARA RIDGE-MT. GLEASON	ST	(196)	34-22-38	118-12-23	5420	28.0*
423 C	ANGELES FOREST-ALISO CYN	S	(190A)	34-24-57	118-05-28	3920	18.7
425 B	SAN GABRIEL DAM	S A	P A5	34-12-19	117-51-38	1481	30.1
433 C	FAIR OAKS DEBRIS BASIN	A	20 B3	34-12-15	118-08-18	1585	24.0*
434	AGOURA	A	100A A5	34-08-08	118-45-08	800	20.3
435	MONTE NIDO	A	108 A6	34-04-41	118-41-35	600	19.9
436 C	HANSEN DAM	AP	9 C2	34-16-08	118-23-59	1110	21.7
440 D	CHILAO-U.S.F.S. CAMP	S	N B1	34-20-00	118-01-23	5220	20.0*
442 C	MESCAL CREEK	S	(194)	34-29-05	117-44-10	3570	8.9
443 B	LATIGO CANYON-BEACH RANCH	S	106 B4	34-05-35	118-48-52	1700	24.4*
444 F	ROLLING HILLS-SO.COAST GARDENS	A	73 B4	33-47-00	118-20-35	400	11.7
446	ALISO CANYON-OAT MOUNTAIN	A	1 A2	34-18-53	118-33-25	2367	20.0*
447 C	CARBON CANYON	S	114 E4	34-02-18	118-38-58	50	18.0*
449 B	EATON WASH DAM	A	27 E1	34-10-06	118-05-33	880	22.0*
453 C	DEVILS GATE DAM	S A	19 D6	34-11-08	118-10-19	1090	21.0*
455 B	LANCASTER STATE HWY MAINTENANCE STAS		160 B6	34-40-57	118-08-02	2395	9.1

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ACTIVE RAINFALL STATIONS 1987 - 1988

STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (in inches)
201 D	HACIENDA HEIGHTS	A	85 C3	33-59-40	117-59-28	875	15.9
210 B	BRAND PARK	A	18 B5	34-11-18	118-16-20	1250	20.5*
213 G	LOS ANGELES-HANCOCK PARK	A	42 F1	34-03-52	118-21-17	200	17.0*
216 B	GLENDALE-ANDREE	S	25 D2	34-09-54	118-15-01	815	18.8
222 C	NORTH HOLLYWOOD PUMPING PLANT	SP	16 C4	34-11-39	118-23-17	717	21.0*
223 C	BIG DALTON DAM	S A	87 F2	34-10-08	117-48-38	1587	28.8
224 C	LONG BEACH-ALAMITOS LAND CO	S	75 C5	33-48-01	118-11-48	220	7.5
225	MONTANA RANCH	S	71 C3	33-50-35	118-07-08	47	8.7
226 B	BURBANK-FIRE STATION	S	17 E8	34-10-58	118-18-23	680	17.7
227 D	SAN GABRIEL-BRUINGTON-ORTON	S	37 D2	34-06-18	118-06-32	472	15.7
228 C	BEVERLY HILLS CITY HALL	S AP	33 C8	34-08-	118-23-		15.8
235 C	HENNIGER FLATS	A 8.81	20 F4	34-11-38	118-05-17	2550	28.0*
237 C	STONE CANYON RESERVOIR	SP	32 D2	34-06-21	118-27-13	865	21.0*
238	HOLLYWOOD DAM	SP	34 C1	34-07-04	118-19-55	750	18.0*
250 D	ACTON CAMP	A	189 E5	34-27-02	118-11-55	2625	15.2*
251 C	LA CRESCENTA	S	18 D1	34-13-20	118-14-40	1440	21.8
252 C	CASTAIC DAM	SP AP	(178)	34-29-53	118-36-53	1150	14.0*
255 F	MT. SAN ANTONIO COLLEGE	S	93 C4	34-02-41	117-50-18	720	14.0
256 C	POMONA-FIRE STATION	S	94 E3	34-03-18	117-45-10	844	15.5*
257	GRIFFITH PARK NURSERY	S	35 A1	34-07-18	118-17-04	850	13.0*
259 D	CHATSWORTH-TWIN LAKES	S A	1A D6	34-16-43	118-35-41	1275	19.5*
261 F	ACTON-ESCONDIDO CANYON	A	181 H9	34-29-42	118-16-22	2980	12.2
269 D	DIAMOND BAR FIRE STATION	SP AP	97 F2	33-59-	117-48-	870	11.8*
272 F	GENE AUTRY MUSEUM	AP	25 A4	34-08-	118-16-		17.0*
274 B	ACTON-HUBBARD	SP	182 B5	34-31-31	118-13-58	3490	11.0*
277	SAWMILL MOUNTAIN	S	(155)	34-43-15	118-35-00	3700	28.5
278 B	LOS ANGELES-CLARK MEMORIAL LIB	S	43 D5	34-02-00	118-18-48	203	13.8*
280 C	FLINTRIDGE-SACRED HEART	A	19 D8	34-10-54	118-11-08	1600	23.8
283 C	CRYSTAL LAKE-EAST PINE FLAT	A	P B1	34-19-02	117-50-28	5370	39.8
287 B	GLENDORA-CITY HALL	8.81	87 B5	34-08-09	117-51-52	785	22.2
289	LAGUNA-BELL-S.C.E. CO. SUBSTATION	SP	54 A5	33-58-37	118-08-48	140	10.9
290 B	MONTEREY PARK-FIRE STATION	S	48 B4	34-02-27	118-07-42	305	14.0*
291	LOS ANGELES-98th AND CENTRAL	A	58 C3	33-56-56	118-15-17	121	11.0
292 D	ENCINO RESERVOIR	A	21 D3	34-08-56	118-30-57	1075	21.8
293 B	LAKE LOS ANGELES	SP	2 A4	34-17-18	118-28-54	1150	19.0
294 B	SIERRA MADRE-MIRA MONTE P. P.	SP	28 C1	34-10-11	118-02-51	985	24.8
298 C	GORMAN-SHERIFF	A	(141)	34-47-47	118-51-27	3835	17.0*
299 F	LITTLE ROCK-SCHWAB	S	184 F5	34-32-12	117-58-43	2800	9.5*
303 F	PASADENA-CAL TECH	A	27 C5	34-08-14	118-07-25	800	18.0*
304	SAWPIT CANYON-DEER PARK	A	208 E4	34-11-38	117-57-52	2690	31.0*
306 H	ZUMA BEACH	S	111 F6	34-01-15	118-49-42	15	15.1

ACTIVE RAINFALL STATIONS 1987 - 1988

STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (in inches)
93 C	CLAREMONT-POLICE STATION	8.81	91 B4	34-05-45	117-43-18	1170	17.5
95	SAN DIMAS-FIRE WARDEN	S	89 F3	34-06-26	117-48-19	955	16.7
96 C	PUDDINGSTONE DAM	S A	89 F4	34-05-31	117-48-24	1030	16.8
102 D	WALNUT-W.I.	S	97 B2	34-00-11	117-52-10	500	11.8
106 F	WHITTIER CITY YARD	S	55 D4	33-58-	118-01-	300	11.8
107 D	DOWNEY-FIRE DEPARTMENT	S	60 A5	33-55-48	118-08-47	110	11.5
108 D	EL MONTE FIRE STATION	S	38 D6	34-04-30	118-02-30	275	13.3
109 D	WEST ARCADIA	S	28 A6	34-07-42	118-04-22	547	16.8
110 B	ALHAMBRA	S	37 C4	34-05-40	118-07-41	533	15.2
116 G	INGLEWOOD COURTHOUSE	A	57 A1	33-57-53	118-21-22	153	12.0*
117 F	COMPTON FIRE STATION	S	64 F3	33-53-42	118-13-34	78	10.5*
118 C	WILMINGTON	S	74 C3	33-47-27	118-15-30	40	12.0*
119 G	SAWTELLE-SOLDIERS' HOME	S	32 D2	34-03-21	118-27-20	345	16.0*
120	VINCENT PATROL STATION	S	183 A9	34-29-17	118-08-27	3135	11.8*
122 G	LEONA VALLEY-RACKETT RANCH	S	171 G3	34-37-52	118-19-22	3300	8.0*
124 B	BOUQUET CANYON RESERVOIR	AP	(169)	34-35-14	118-21-45	3050	11.0*
125 B	SAN FRANCISQUITO CANYON #1	SP	(169)	34-35-25	118-27-15	2105	18.4
126 C	BOONE OLIVE PUMP PLANT	A	49 D4	33-58-58	118-27-33	30	11.8*
127 B	DRY CANYON RESERVOIR	SP	124 D1	34-28-55	118-31-32	1511	17.5*
128 B	ELIZABETH LAKE-WARM SPRINGS CAMP	A	(168)	34-36-28	118-33-40	2075	21.0*
130 B	SANDBERG-QUAIL LAKE PATROL STA	S	(142)	34-44-37	118-42-43	4025	DISC.
134 C	PUDDINGSTONE DIVERSION	8.81	95A C5	34-07-52	117-48-55	1160	18.2
140 C	SAWTELLE - W. L.A. MUNICIPAL BLDG	AP	41 D3	34-02-43	118-28-56	250	14.0*
143 B	AZUSA-CITY PARK	S	86 D5	34-08-03	117-54-17	610	19.8
144	SIERRA MADRE DAM	S	20A D3	34-10-34	118-02-32	1100	25.9
156 B	LA MIRADA-STANDARD OIL COMPANY	A	83 A4	33-52-58	118-01-00	75	10.0*
157 C	EL SEGUNDO-STANDARD OIL COMPANY	S AP	56 A6	33-54-57	118-25-05	150	9.5
158	TANBARK FLATS	SP A	P D5	34-12-20	117-45-40	2750	27.0*
167 C	ARCADIA PUMPING PLANT #1	S	28 E2	34-09-31	118-02-02	611	21.1
169	SIERRA MADRE PUMPING PLANT	SP	28 D2	34-09-47	118-02-21	700	21.9
170 F	POTRERO HEIGHTS	S	47 A4	34-02-32	118-04-44	285	11.9
172 B	DUARTE	S	29 E4	34-08-28	117-58-02	548	14.9
174 B	GLENDORA-WARREN	S	87 E6	34-07-43	117-49-08	930	16.5
175 B	LA CANADA IRRIGATION DISTRICT	S	19 A1	34-13-39	118-12-40	2020	24.2
178	ALTADENA-RUBIO CANYON	SP	20 B6	34-10-55	118-08-15	1125	18.7
178 C	AZUSA VALLEY WATER CO.	A	88 F2	34-08-38	117-52-50	620	17.0
191 C	ALCAZAR - PUBLIC WORKS WAREHOUSE	A	45 B1	34-03-	118-11-		13.0*
192 C	BELL-FIRE STATION	8.81	53 C5	33-58-45	118-11-16	145	10.5*
193 B	COVINA-TEMPLE	S	88 F5	34-04-57	117-52-29	580	18.6
196 C	LA VERNE-FIRE STATION	S	90 D3	34-06-06	117-46-20	1050	17.7
199 D	HUNTINGTON PARK	S	52 E5	33-59-00	118-13-47	175	11.2*
200	SAUGUS-S.C.E. CO. SUBSTATION	S	123 H8	34-25-21	118-34-26	1096	18.0*

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ACTIVE RAINFALL STATIONS 1987 - 1988

STA.NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	ELEV OF GAGE	1987-88 SEASONAL TOTAL (in inches)
1268	PALMDALE RECLAMATION PLANT	S	172 G6	34-35-30	118-05-10	2565	6.3
1271	POMONA WASTE RECLAMATION PLANT	S	94 B3	34-03-18	117-47-34		14.4
X 15 D	HI VISTA	S	(151)	34-44-31	117-46-43	3087	7.0*
X 22	ISLIP SADDLE	ST	(199)	34-21-27	117-51-05	6680	25.5*
X 23	DORR CANYON	ST	(200)	34-22-18	117-46-51	7280	22.7*
X 24	GRASSY HOLLOW	ST	(201)	34-22-30	117-43-05	7360	19.0*
X 25	BEAR GULCH	ST	(201)	34-21-58	117-41-27	7880	17.8*
X 26	BLUE RIDGE CAMP	ST	(201)	34-20-57	117-40-23	8450	18.8*
X 27	GUFFY'S CAMP	ST	(201)	34-20-20	117-38-55	8080	17.0*
X 28 B	HOLIDAY HILL	A	(201)	34-21-29	117-40-54	8130	17.0*

LEGEND REGARDING GAGE TYPE, OWNERSHIP, AND W.Y. 1987-88 SEASONAL TOTAL

S	STANDARD 8" DIAMETER NON RECORDING GAGE OWNED BY THE DEPARTMENT OF PUBLIC WORKS
A	AUTOMATIC RECORDING GAGE OWNED BY THE DEPARTMENT OF PUBLIC WORKS
ST	STORAGE TYPE GAGE OWNED BY THE DEPARTMENT OF PUBLIC WORKS
8.81	8.81" DIAMETER NON RECORDING GAGE OWNED BY THE DEPARTMENT OF PUBLIC WORKS
3"P	3"DIAMETER NON RECORDING GAGE OWNED BY OUTSIDE INTERESTS
SP	STANDARD 8" DIAMETER NON RECORDING GAGE OWNED BY OUTSIDE INTERESTS
AP	AUTOMATIC RECORDING GAGE OWNED BY OUTSIDE INTERESTS
SUFFIX B OR C	DENOTES SECOND OR THIRD LOCATION OF STATION IN SAME AREA
( )	THOMAS GUIDE FUTURE PAGE ASSIGNMENT
O.CO.	ORANGE COUNTY THOMAS GUIDE PAGE
V.CO.	VENTURA COUNTY THOMAS GUIDE PAGE
S.B.CO.	SAN BERNARDENO COUNTY THOMAS GUIDE PAGE
*	ESTIMATED SEASONAL TOTAL
DISC.	DISCONTINUED

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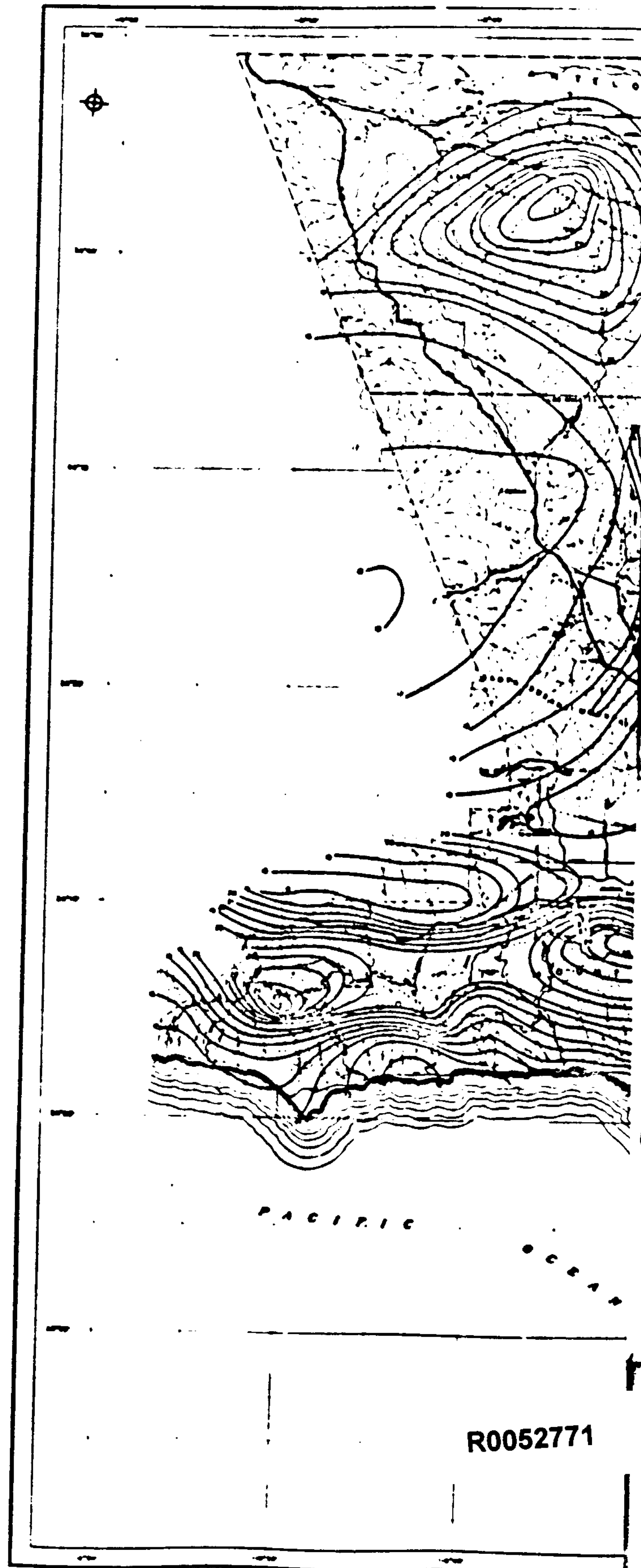

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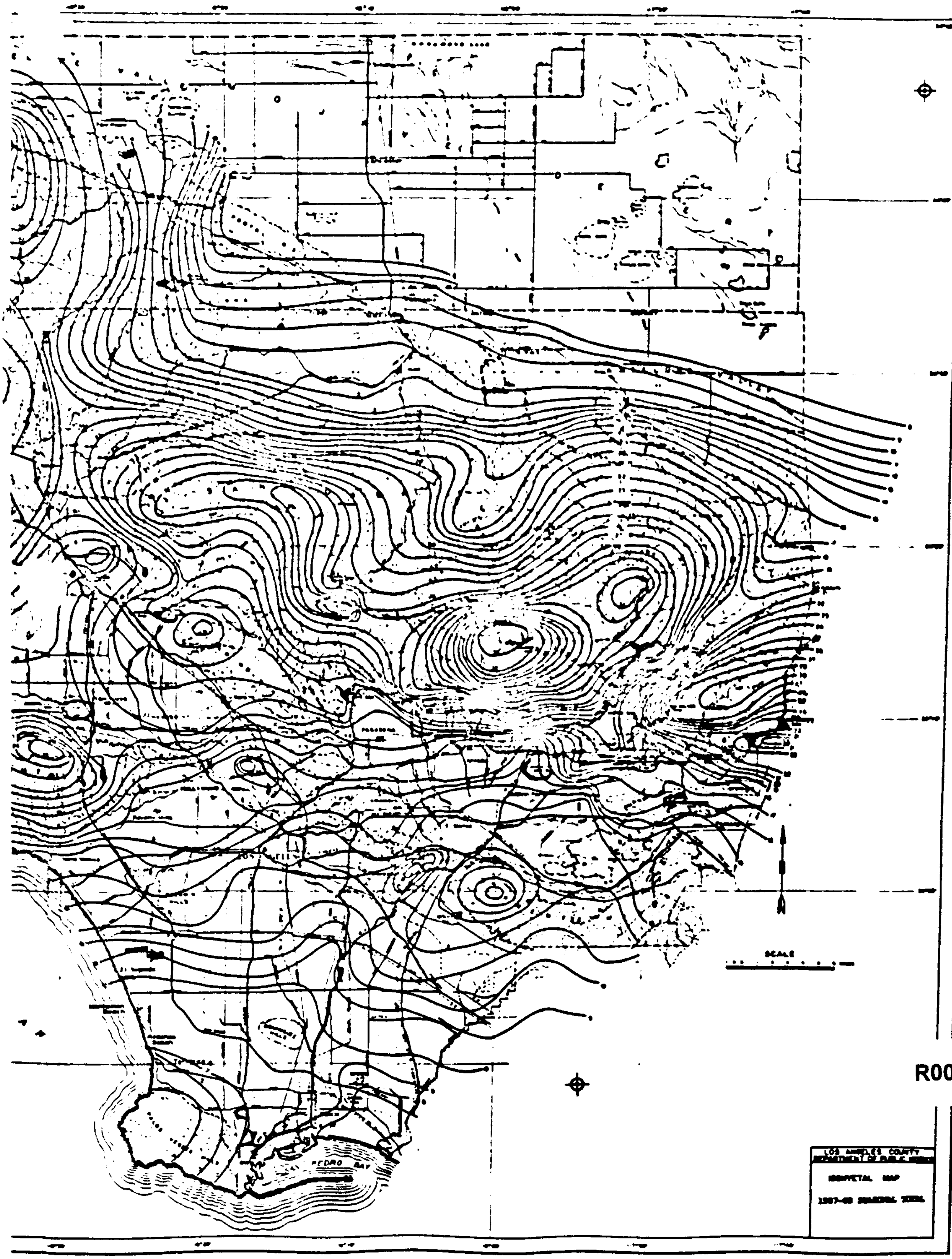

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PA2

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EVAPORATION

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EVAPORATION

Data for 14 active evaporation stations were reported to the Department during the 1987-88 water year. Daily records of active and inactive Department stations, as well as some stations of other agencies, are available in the Department's files. Monthly and seasonal evaporation has been published in the Department's Annual or Biennial Reports on Hydrologic Data since the 1931-32 season.

COOPERATION

The Department receives evaporation data from the Los Angeles City Department of Water and Power, The Metropolitan Water District, Southern California Edison Company, United States Forest Service, County Departments, California Department of Water Resources, and various individuals.

LENGTH OF RECORD

The first land pan installed by this Department was at Santa Anita Dam in March of 1929. There are 30 evaporation stations which have records of 15 seasons or more in the Department's files.

1969

EVAPORATION STATION LIST 1987 - 88

STA.NO.	STATION NAME	EQUIPMENT	ELEVATION OF PAN	THOMAS GUIDE	NORTH LATITUDE	WEST LONGITUDE
33 A	Pacoima Dam	24X36 S	1500	145 F9	34-19-48	118-23-58
46 D	Big Tujunga Dam	24X36 S	2315	F C2	34-17-40	118-11-14
63 D	Santa Anita Dam	24X36 S	1400	99 F2	34-11-03	118-01-12
89 B	San Dimas Dam	24X36 S	1350	95A C3	34-09-10	117-46-17
98 C	Puddingstone Dam	24X36 S	1030	88 F4	34-05-31	117-48-24
223 B	Big Dalton Dam	24X36 S	1587	87 F1	34-10-08	117-48-38
252 C	Castaic Reservoir	48X10 S	1150	(178)	34-29-53	118-38-53
334 B	Cogswell Dam	24X36 S	2300	6 D4	34-14-37	117-57-35
390 B	Morris Dam	72X36 US	1210	86 F1	34-10-53	117-52-43
409	Pyramid Reservoir	48X10 S	2505	(154)	34-40-34	118-46-47
425 B	San Gabriel Dam	24X36 S	1481	H A5	34-12-19	117-51-38
1014 F	Rio Hondo S. G.	24X36 S	170	54 D3	33-58-57	118-08-04
1058 B	Palmdale	24X36 S	2595	172 F7	34-35-17	118-05-31
1071 B	Descanso Gardens	24X36 S	1325	19 B3	34-12-07	118-12-48

LEGEND

24X36 S = Screened land pan, 24 inches in diameter by 36 inches deep.
48X10 S = Screened land pan, 48 inches in diameter by 10 inches deep.
72X36 US = Unscreened land pan, 72 inches in diameter by 36 inches deep.
( ) = Thomas Guide future page assignment.

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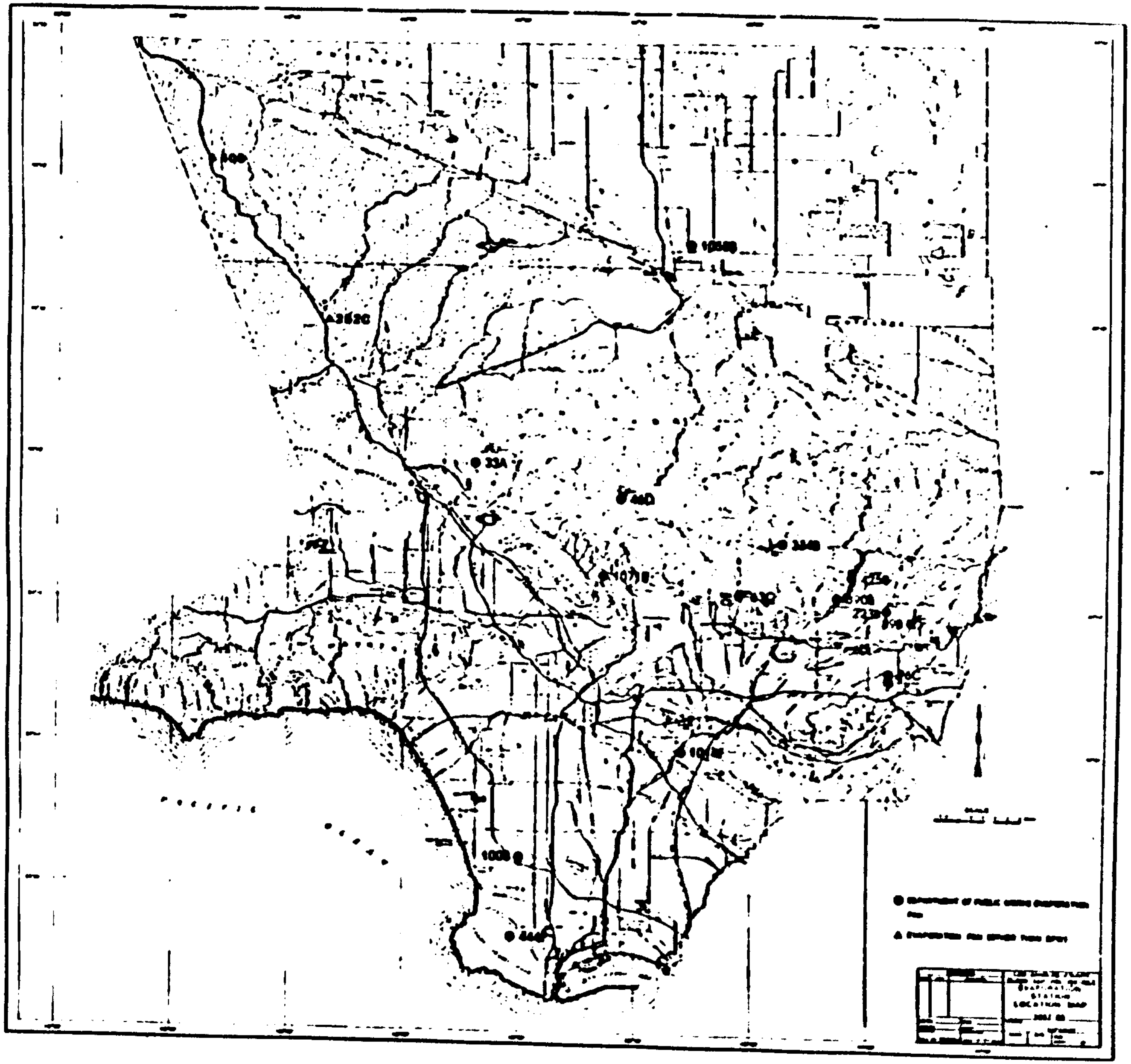
EVAPORATION MONTHLY SUMMARY 1987 - 88 (in inches)

STA.NO.	STATION NAME	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
33 A	Pacoima Dam	7.66	5.83	4.68	6.21	8.12	9.10	6.89	8.62	7.26	8.51	7.94	8.12	88.93
46 D	Big Tujunga Dam	5.72	3.16	3.16	3.60	4.69	5.82	4.87	7.56	7.30	10.34	9.40	8.48	74.10
63 D	Santa Anita Dam	4.06	2.94	2.35	2.52	3.58	4.21	3.44	4.80	4.63	5.94	5.34	5.37	49.18
89 B	San Dimas Dam	4.13	1.87	1.96	1.33	2.52	3.62	4.05	5.91	6.40	7.59	6.75	5.89	52.02
96 C	Puddingstone Dam	4.68	2.86	2.43	2.17	3.54	5.23	5.19	7.88	8.44	9.23	8.62	7.34	67.60
223 B	Big Dalton Dam	4.09	2.26	2.08	1.80	2.72	3.94	3.76	5.98	6.74	7.47	6.64	5.89	53.37
252 C	Castaic Reservoir	7.25	5.12	6.64	6.29	3.37	3.85	5.21	6.56	7.99	9.00	8.17	7.75	77.20
334 B	Cogswell Dam	3.87	1.52	1.22	1.32	2.10	3.48	3.38	5.93	7.02	8.90	8.03	6.39	53.16
390 B	Morris Dam	6.02	3.25	5.70	3.95	6.02	6.95	6.82	8.82	9.24	10.80	9.66	8.42	85.65
409	Pyramid Reservoir	6.07	6.58	4.67	2.93	2.54	4.43	4.45	6.40	8.61	8.73	8.14	7.99	71.54
425 B	San Gabriel Dam	5.52	3.43	2.87	2.70	4.20	5.61	4.70	7.36	7.38	8.70	8.16	7.44	68.07
1014 F	Rio Hondo S. G.	4.41	3.87	2.54	2.22	3.95	5.11	4.74	6.96	6.90	7.23	7.31	5.56	60.80
1058 B	Palmdale	3.48	1.54	1.47	1.92	1.84	4.52	4.48	7.57	8.71	9.83	7.82	5.65	58.83
1071 B	Descanso Gardens	4.00	2.33	1.85	1.52	2.79	3.60	3.54	5.26	5.65	8.77	6.06	5.22	48.39



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PB1

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RUNOFF

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R U N O F F

The Department operated or received data from 88 water-stage recording stations during the 1987-88 water year. Data from 56 of those stations are summarized and published in this volume.

RECORDS OF STREAMFLOW

Records published give the following information:

1. Station description which presents location, drainage area, type of channel, control, regulations, diversions, and available records.

2. Discharge tabulation which summarizes the maximum, minimum, and mean of the daily flow rates in second-feet for each month and the total monthly volumes in acre-feet.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorlogical conditions in the County and Southern California in real time, i.e., as they occur. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels, and which forecast peak flows in the Los Angeles River and the Rio Hondo.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The Department receives streamflow data from other agencies and publishes, or has access to, the records for local stations. Department hydrographers also make periodic streamflow measurements and observations at installations belonging to these organizations. Data from 25 of the Department's stations are reviewed and published in the Geological Survey's annual water supply papers.

Agencies with which the Department exchanges data are:

United States Geological Survey, Water Resources Division

United States Corps of Engineers

State Department of Water Resources

The Metropolitan Water District

San Gabriel River Water Committee

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LEGEND

Stations are designated by letters and numbers which indicate ownership, operation agency, and type of station. The letters used have the following connotations:

Prefix F - Indicates a station owned and operated by the Los Angeles County Department of Public Works.

Prefix E - Indicates a station owned and operated by the Corps of Engineers, Department of the Army but operated and maintained by the United States Geological Survey.

Prefix U - Indicates a station originally constructed and operated by the United States Geological Survey, Water Resources Division, now operated by the Department.

Prefix P - Indicates a station owned and operated by the Department formerly, operated by the Pasadena Water Department.

Prefix L - Indicates a station owned and operated by the Department formerly, operated in cooperation with the Little Rock - Palmdale Irrigation District.

Suffix R - Indicates a recorder station.

Suffix B - Indicates that the station has been moved. B represents second location, C a third location, etc.

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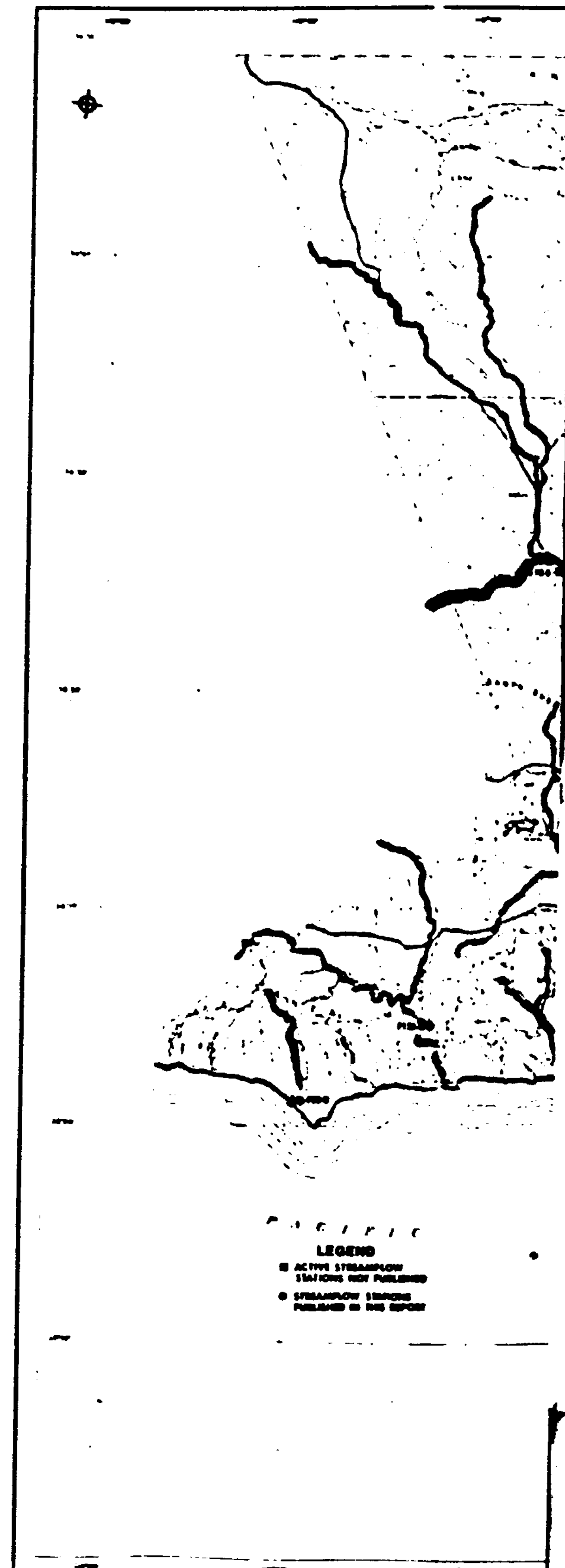
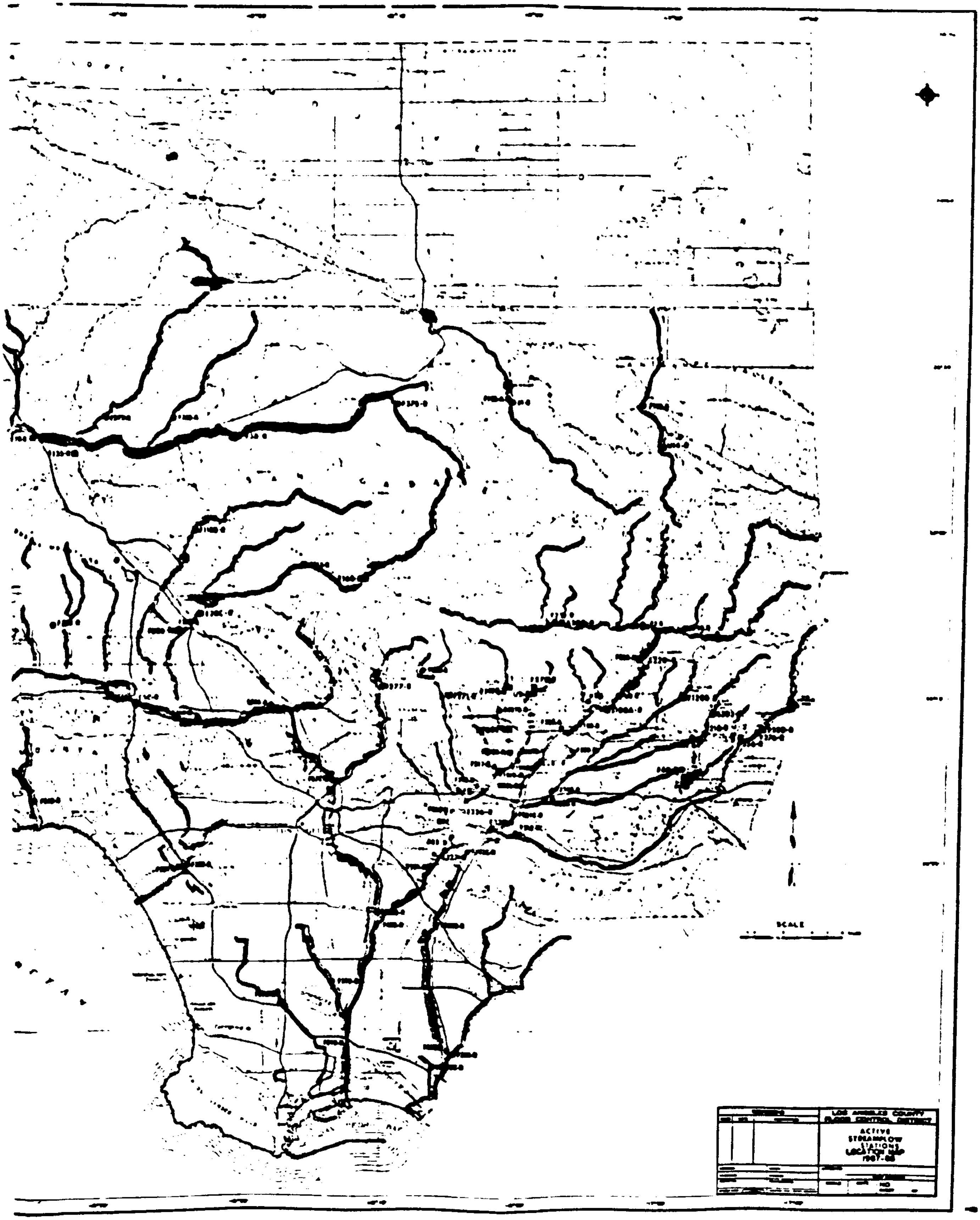
1945





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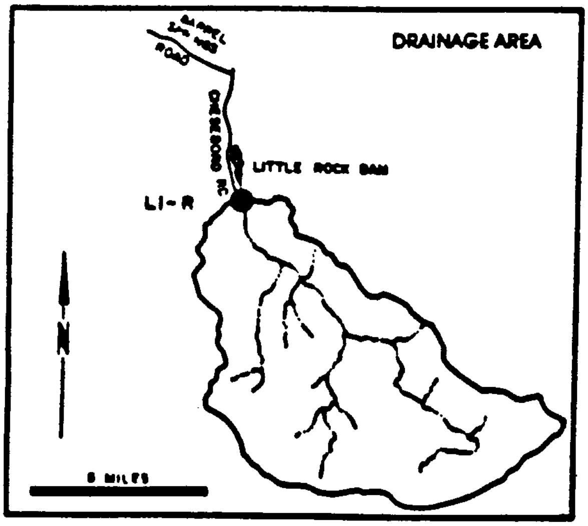
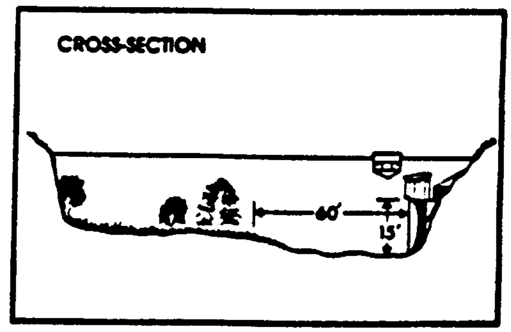
1 9476

R0052781

LITTLE ROCK CREEK
above Little Rock Dam
STATION NO. L1-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 49.2 square miles.
LOCATION- 2.0 miles above Little Rock Dam, 5.0 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel, and boulders, natural in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1930 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : L1-R DRAINAGE AREA : 49.20 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	6.6	19.6	9.3	19.4	33.8	43.4	67.0	76.9	24.0	1.5	0.35	0.0
YEAR	MAX.	95.2	140.0	17.2	38.0	181.0	178.0	205.0	88.3	59.0	2.5	2.3	0.0
87-88	MIN.	0.0	6.1	5.9	8.8	20.1	24.4	32.7	59.5	2.6	0.0	0.0	0.0
	TOTAL AF	408.0	1170.0	573.0	1190.0	1940.0	2670.0	3990.0	4730.0	1430.0	89.0	21.0	0.0

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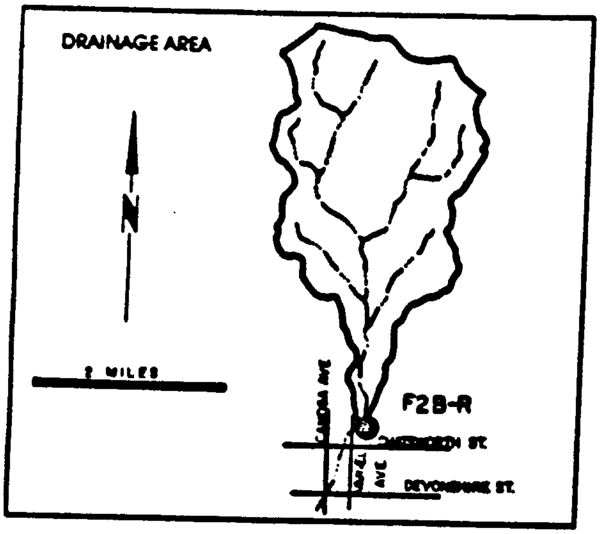
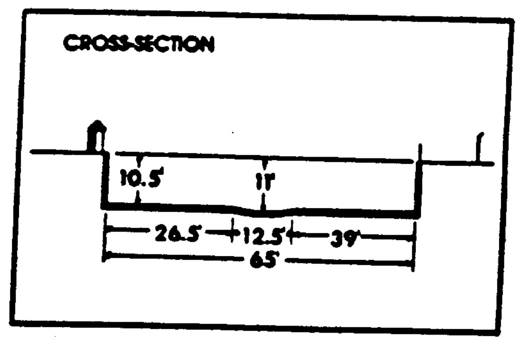
BROWNS CREEK
at Variel Avenue
STATION NO. F2B-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 13.5 square miles.
LOCATION- 100.0 feet upstream from Variel Avenue, 1.0 mile northeast of Chatsworth.
REGULATION- none.
CHANNEL- sand and gravel with pipe and wire revetments, temporarily improved section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F2-R, December 11, 1928, to August 27, 1932 and October 2, 1935, to October 31, 1939. at Station F2B-R, October 12, 1961, to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F2B-R

DRAINAGE AREA : 13.50 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	0.22	0.51	0.87	0.67	0.84	1.4	0.66	0.17	0.01	0.0	0.0	0.0
	MAX.	5.3	4.6	5.0	1.0	7.4	11.8	4.8	0.3	0.10	0.0	0.0	0.0
	MIN.	0.0	0.10	0.30	0.30	0.40	0.10	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	13.0	30.0	54.0	41.0	49.0	84.0	39.0	10.0	0.40	0.0	0.0	0.0

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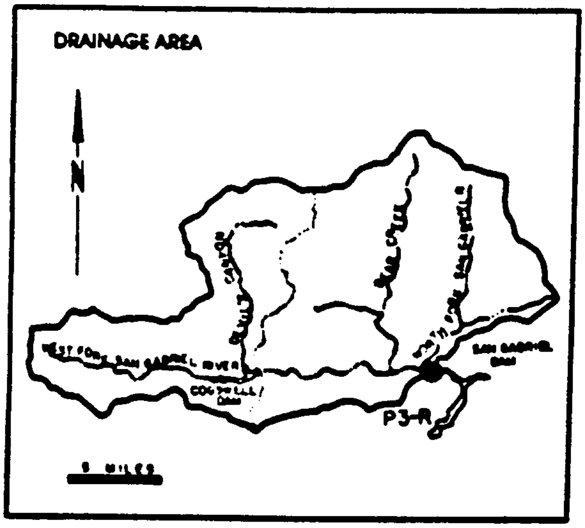
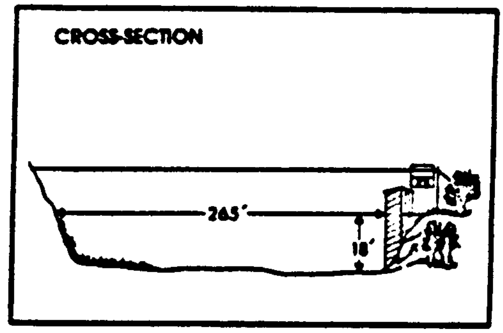
1978

SAN GABRIEL RIVER
West Fork above Forks
STATION NO. P3-R





RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 102.0 square miles.

LOCATION- 1.5 miles above confluence with East Fork.

REGULATION- partially regulated by Cogswell Dam.

CHANNEL- natural, sand, gravel, and boulders.

CONTROL- subject to shifts in natural bottom.

LENGTH OF RECORD- at Station P3-R, December 3, 1930 to July 12, 1938 and September 27, 1938 to date. at Station P3B-R, July 12, 1938, to September 27, 1938.

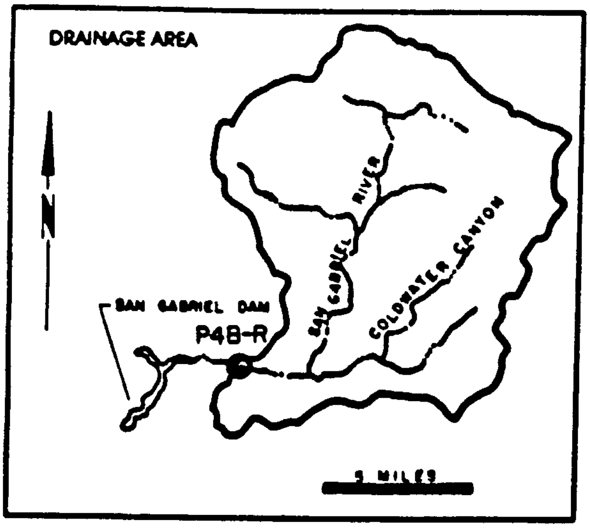
REMARKS- for records prior to December 3, 1930 refer to Station P1-R.

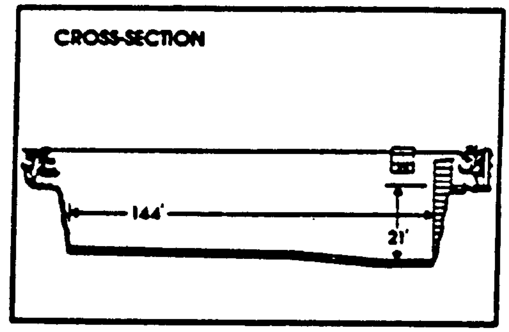
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : P3-R DRAINAGE AREA : 102.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	14.9	46.6	63.8	78.7	44.7	107.0	62.7	48.6	33.9	27.8	20.4	19.1
YEAR	MAX.	123.0	165.0	128.0	168.0	102.0	375.0	202.0	83.0	40.8	194.0	29.2	28.6
87-88	MIN.	5.1	28.6	37.1	20.7	24.9	36.2	23.4	32.8	26.7	18.9	16.4	12.0
	TOTAL AF	914.0	2770.0	3920.0	4840.0	2570.0	6590.0	3730.0	2990.0	2020.0	1710.0	1260.0	1140.0

SAN GABRIEL RIVER
East Fork above Forks
STATION NO. P4B-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 88.2 square miles.
LOCATION- 2.5 miles above the West Fork, 12.0 miles north of Azusa.
REGULATION- none.
CHANNEL- sand, gravel, and boulders, natural section.
CONTROL- concrete, stabilizer with a 20-foot-wide low flow notch (constructed in November 1947).
LENTH OF RECORD- at Station P4-R, November 30, 1932 to December 10, 1938. at Station P4B-R, December 10, 1938 to date.
REMARKS- the control height was increased 2.0 feet in September, 1965.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : P4B-R　　　　DRAINAGE AREA : 88.20 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	16.7	57.9	31.0	50.6	39.4	59.8	84.6	64.3	28.9	9.3	20.4	4.4
YEAR	MAX.	182.0	244.0	81.8	207.0	92.3	211.0	294.0	117.0	40.1	15.9	29.2	17.8
87-88	MIN.	1.1	20.4	3.0	24.0	27.3	28.5	28.6	40.6	17.7	4.6	16.4	0.50
	TOTAL AF	1030.0	3440.0	1900.0	3110.0	2270.0	3680.0	5030.0	3950.0	1720.0	573.0	1280.0	262.0

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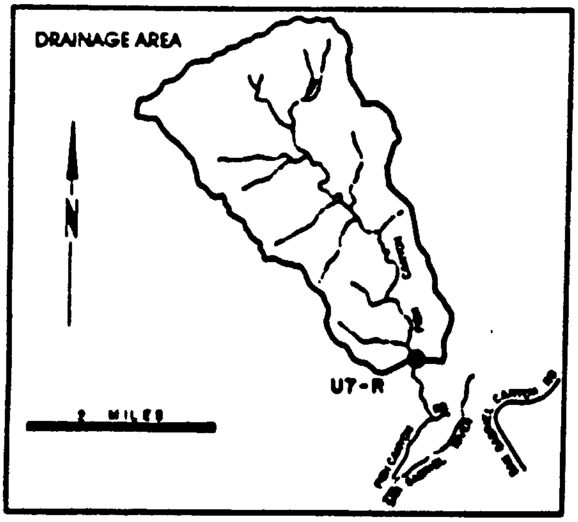
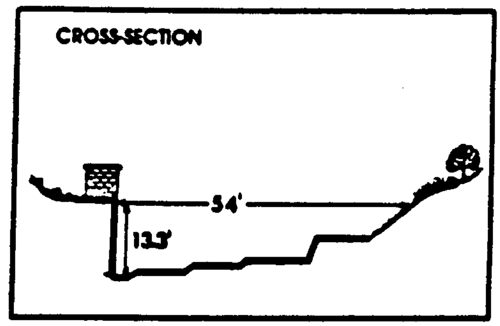
FISH CREEK
above Mouth of Canyon
STATION NO. U7-R





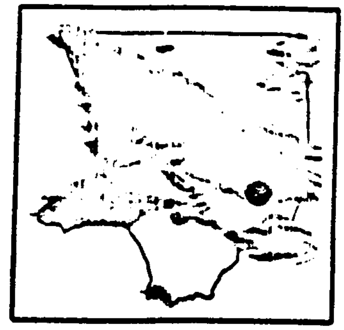
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 6.36 square miles.
LOCATION - 0.8 miles upstream of mouth of canyon and 3.0 miles northeast of Duarte.
REGULATION- none.
CHANNEL- natural, rock and gravel.
CONTROL- concrete control.
LENGTH OF RECORD- July to September 1916. July 1917 to date.
REMARKS- operated and maintained by USGS until October 1, 1971.

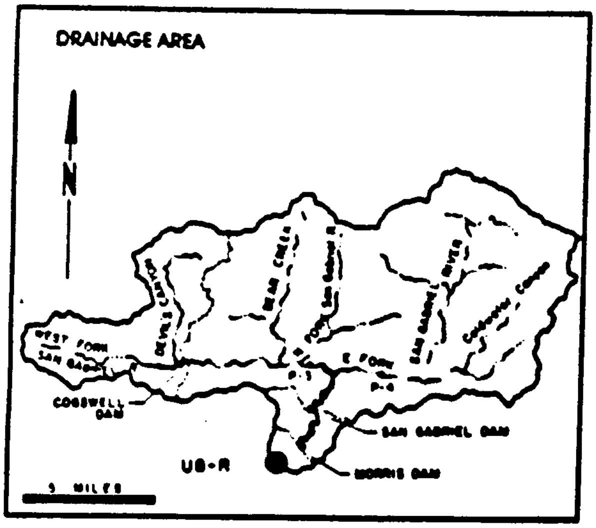
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

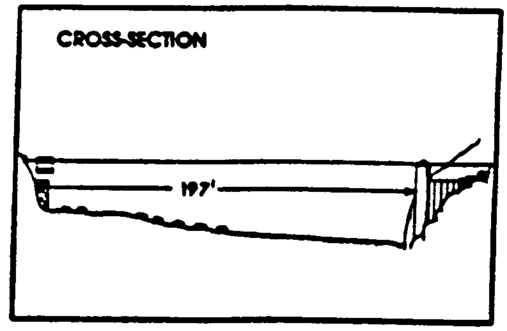
STATION NO. : U7-R — DRAINAGE AREA : 6.36 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	1.5	2.5	0.78	3.69	1.3	1.6	3.6	1.8	0.38	0.0	0.15	0.59
YEAR	MAX.	17.9	14.2	4.0	48.9	5.4	6.4	24.7	2.8	1.2	0.0	0.30	0.90
87-88	MIN.	0.0	0.80	0.50	0.50	0.80	0.70	0.60	1.1	0.0	0.0	0.10	0.30
	TOTAL AF	93.0	150.0	48.0	227.0	76.0	96.0	216.0	108.0	23.0	0.0	9.5	35.0

SAN GABRIEL RIVER
below Morris Dam
STATION NO.U8-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 212.4 square miles.
LOCATION- 1.1 miles downstream of Morris Dam, 2.7 miles northeast of Azusa.
REGULATION- all flows regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- gravel and boulders, natural section.
CONTROL- concrete control.
LENGTH OF RECORD- May 1894 to date.
REMARKS- flows up to 90 cfs are at times diverted past the station through the Azusa Conduit; flows at station may include imported water from the MWD outlet below Morris Dam.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : U8-R

DRAINAGE AREA : 212.40 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	22.4	137.0	119.0	228.0	200.0	53.4	48.4	38.0	239.0	0.01	0.0	48.6
YEAR	MAX.	28.0	228.0	250.0	253.0	242.0	81.0	50.8	49.7	600.0	0.40	0.0	242.0
87-88	MIN.	21.4	24.0	0.0	195.0	48.8	49.7	45.2	19.5	21.0	0.0	0.0	0.0
	TOTAL AF	1380.0	8150.0	7310.0	13910.0	11490.0	3280.0	2880.0	2220.0	14200.0	0.80	0.0	2950.0

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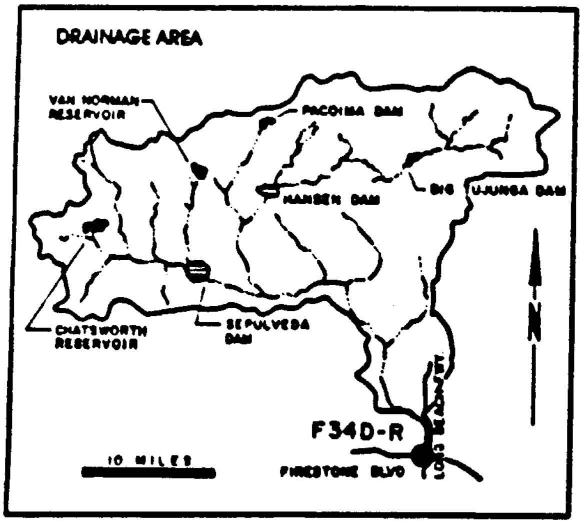
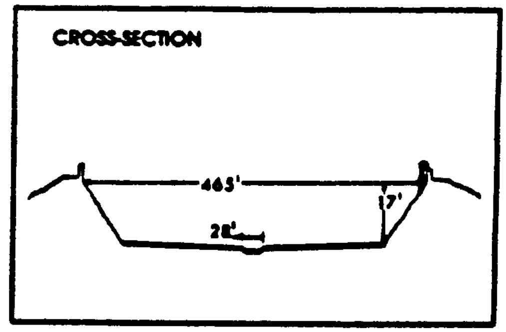
1982

LOS ANGELES RIVER
below Firestone Boulevard
STATION NO. F34D-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 896.0 square miles.
LOCATION- 472.0 feet downstream of Firestone Boulevard 3.0 miles west of Downey.
REGULATION- partially regulated by Sepulveda, Pacoima, Big Tujunga, Hansen, and Devil's Gate Dam; and by several spreading grounds, reservoirs, and debris basins.
CHANNEL- concrete, with rip-rap side slopes, trapezoidal in section, with trapezoidal low- flow channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F34-R March 1, 1928 to April 11, 1938. at Station F34B-R, April 11, 1938 to November 3, 1949. at Station F34C-R November 4, 1949, to December 11, 1986. at Station F34D-R December 11, 1986 to date.
REMARKS- subject to diversions from Big Tujunga Creek, Arroyo Seco, and other domestic and irrigation diversions.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : DRAINAGE AREA :

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN MAX. MIN.	NO DATA AVAILABLE AT TIME OF PRINTING											
	TOTAL AF												

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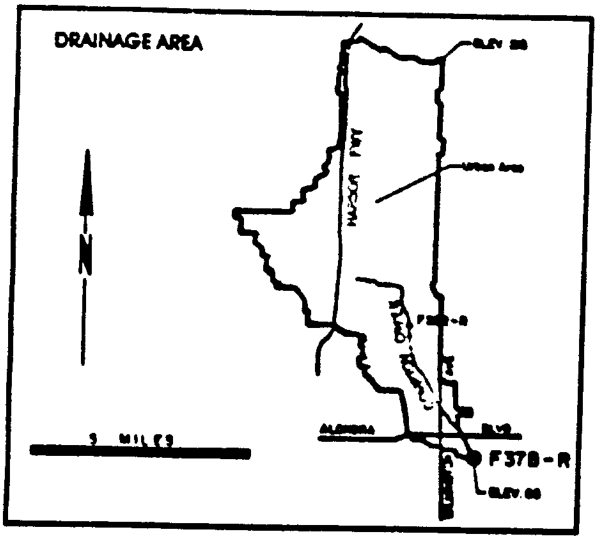
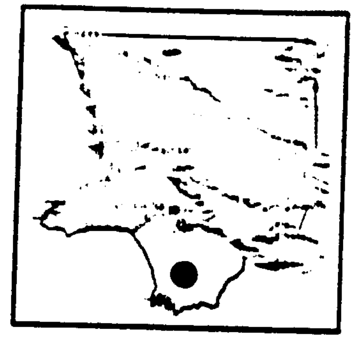
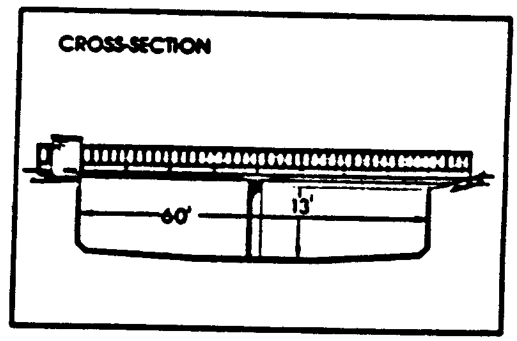
1 9483

COMPTON CREEK
near Greenleaf Drive
STATION NO. F37B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 22.6 square miles.
LOCATION- 120.0 feet above Greenleaf Boulevard, 1.5 miles south west of Compton.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 60 feet wide by 13 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F37-R January 22, 1928 to June 9, 1938. at Station F37B-R October 3, 1938 to date

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F37B-R

DRAINAGE AREA : 22.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	16.7	7.4	15.3	18.2	14.7	2.9	13.3	0.53	.78	1.1	3.9	1.6
	MAX.	276.0	64.6	192.0	443.0	167.0	28.9	134.0	0.70	1.2	1.6	79.0	10.1
	MIN.	0.60	0.70	0.40	0.40	0.40	0.30	0.40	0.40	0.60	0.90	0.70	0.30
	TOTAL AF	1030.0	439.0	940.0	1120.0	846.0	180.0	790.0	33.0	45.0	69.0	237.0	97.0

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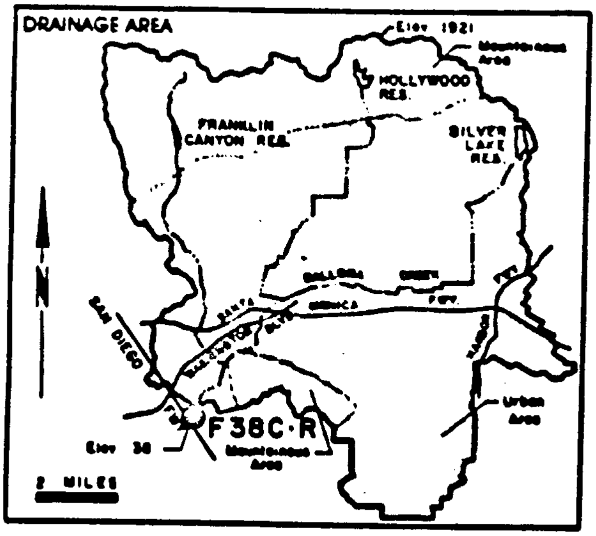
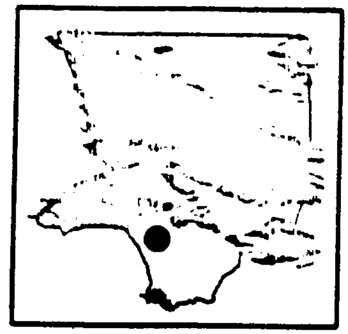
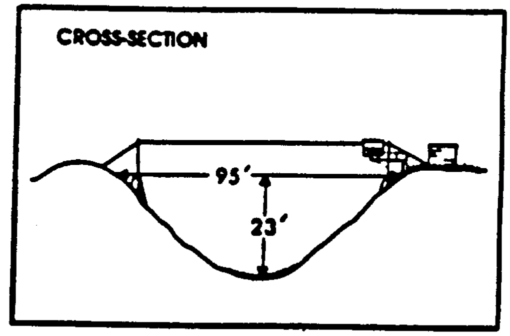
1 9 8 4

R0052789

BALLONA CREEK
above Sawtelle Boulevard
STATION NO. F38C-R







RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 88.6 square miles.

LOCATION- 530.0 feet above Sawtelle Boulevard, 1.5 miles southwest of Culver City.

REGULATION- Stone Canyon Reservoir prior to January, 1951. Upper and Lower Franklin Canyon Reservoir, Hollywood Reservoir, and Silverlake Reservoir.

CHANNEL- concrete rubble, trapezoidal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F38-R February 27,1928 to April 27, 1936. at Station F38B-R, May 14, 1936 to August 10, 1967. at Station F38C-R August 10, 1967, to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F38C-R

DRAINAGE AREA : 88.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	179.0	58.0	50.6	111.0	120.0	66.0	93.0	12.4	10.6	10.3	16.8	9.9
	MAX.	2320.0	840.0	925.0	2920.0	1320.0	1530.0	838.0	17.0	13.0	11.8	217.0	12.4
	MIN.	10.0	5.0	9.4	10.0	11.2	12.4	7.6	8.8	8.8	9.4	8.2	8.8
	TOTAL AF	10980.0	3450.0	3110.0	6820.0	6890.0	4060.0	5540.0	760.0	632.0	636.0	1030.0	588.0

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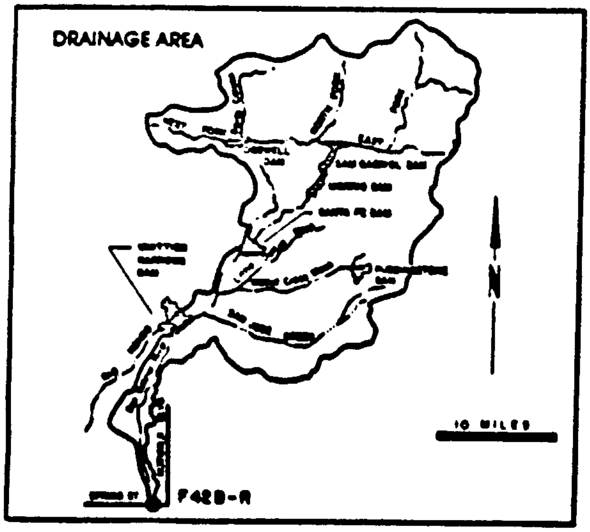
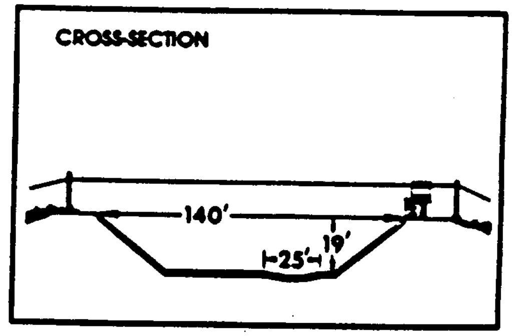
1 1948 5

SAN GABRIEL RIVER
above Spring Street
STATION NO. F42B-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 231.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 455.0 feet north of Spring Street, 4.0 miles east of Signal Hill, Long Beach.
REGULATION- partially regulated by Cogswell, San Grabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek, and Whittier Narrows Dams, several debris basins, MWD outlet, and several spreading grounds.
CHANNEL- concrete, trapezoidal section with a low-flow channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F42-R February 6, 1928 to May 26, 1964. at Station F42B-R, November 16, 1964 to date.
REMARKS- high flows into Whittier Narrows Reservoir are partially diverted to the Rio Hondo.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F42B-R

DRAINAGE AREA : 231.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	115.0	121.0	116.0	138.0	152.0	125.0	101.0	44.5	97.6	92.5	114.0	85.4
YEAR	MAX.	359.0	201.0	222.0	575.0	556.0	727.0	320.0	133.0	137.0	142.0	148.0	141.0
87-88	MIN.	46.0	44.4	42.8	44.0	54.0	43.2	36.8	26.0	36.3	40.6	42.2	42.3
	TOTAL AF	7070.0	7170.0	7110.0	8500.0	8760.0	7710.0	6030.0	2740.0	5810.0	5690.0	7000.0	5080.0

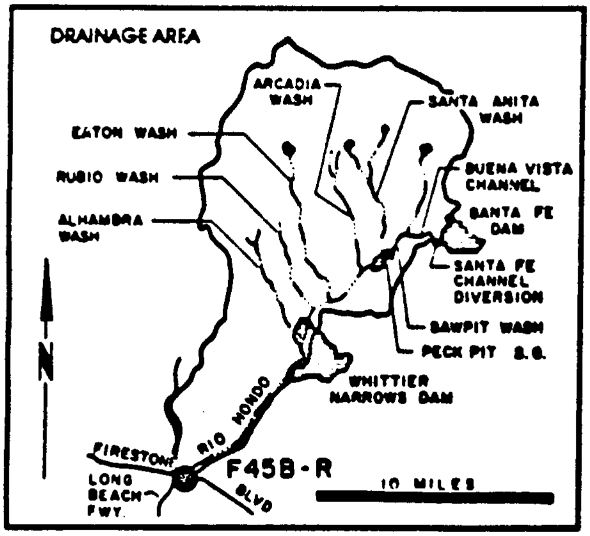
VOL 12
1 9486

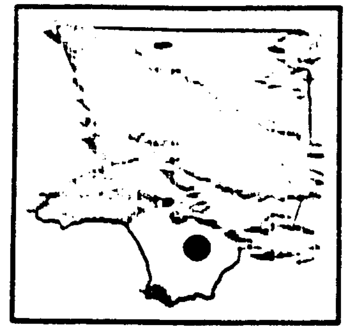
R0052791

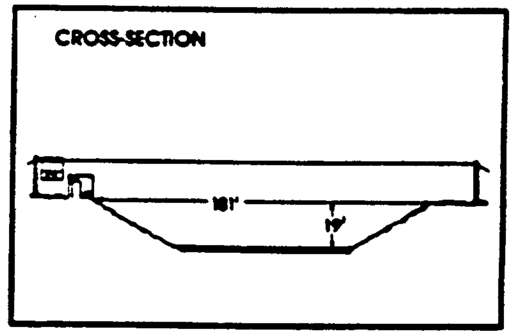
RIO HONDO
above Stewart and Gray Road
STATION NO. F45B-R

VOL 12

1987







RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 140 square miles (excludes area above Santa Fe Dam).

LOCATION- 0.6 mile upstream of the confluence of Rio Hondo and Los Angeles River, 1.5 miles west of Downey.

REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, Santa Fe, and Whittier Narrows Dams, several debris basins, and spreading grounds.

CHANNEL- concrete with rip-rap side slopes. trapizodal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F45-R March 1, 1928 to April 18, 1951. at Station F45B-R October 31, 1951 to date.

REMARKS- subject to diversions from Eaton Creek, Monrovia Creek, Sawpit Creek, Little Santa Anita Canyon and other locations for irrigation and spreading. High flows from San Gabriel River may flow into Rio Hondo above Whittier Narrows Dam.

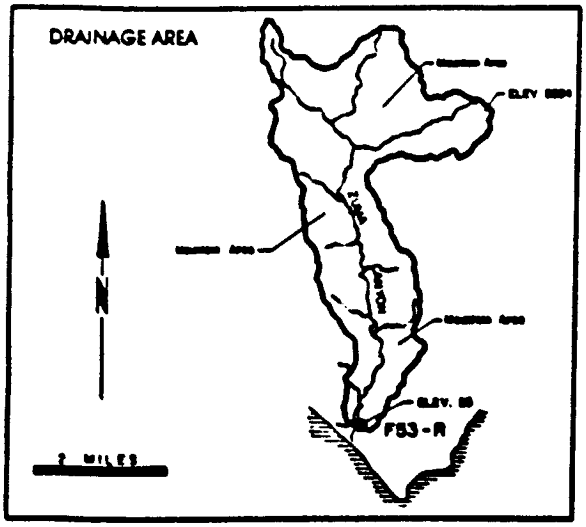
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

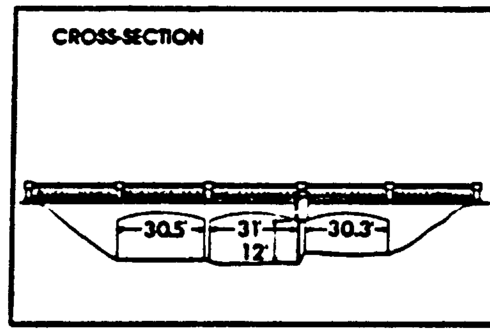
STATION NO. : F45B-R

DRAINAGE AREA : 140.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	36.3	9.2	34.9	88.7	6.7	5.4	13.1	1.1	0.42	0.31	0.30	1.9
YEAR	MAX.	592.0	154.0	913.0	2660.0	86.4	93.1	163.0	13.1	1.0	0.70	0.70	21.7
87-88	MIN.	0.10	0.30	0.0	0.10	0.90	0.7	0.90	0.10	0.10	0.10	0.10	0.10
	TOTAL AF	2230.0	546.0	2150.0	5460.0	383.0	331.0	779.0	65.0	25.0	19.0	18.0	111.0

DUME CREEK
at Pacific Coast Highway
STATION NO. F53-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from highway bridge.
DRAINAGE AREA- 8.8 square miles.
LOCATION- on the downstream side of Pacific Coast Highway bridge near Dume Point about 0.2 miles from Pacific Ocean.
REGULATION- none.
CHANNEL- sand and gravel.
CONTROL- channel forms control.
LENGTH OF RECORD- January 15, 1930 to November 26, 1937 and November 3, 1938 to date.

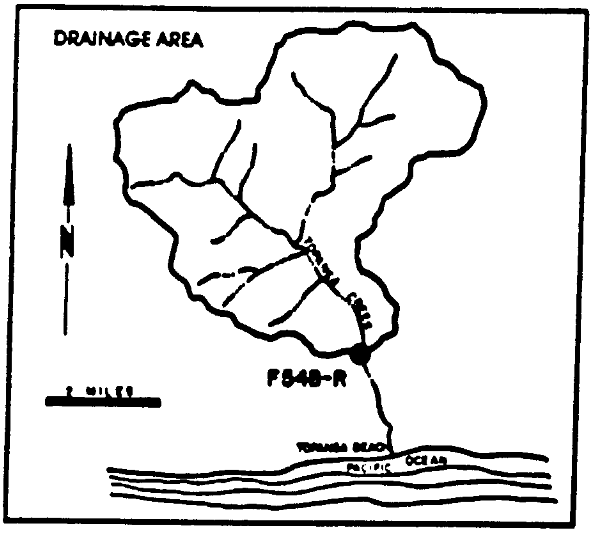
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

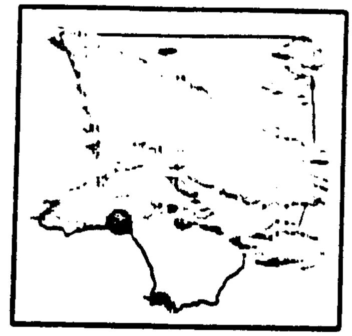
STATION NO. : F53-R DRAINAGE AREA : 8.80 SQ. MI.

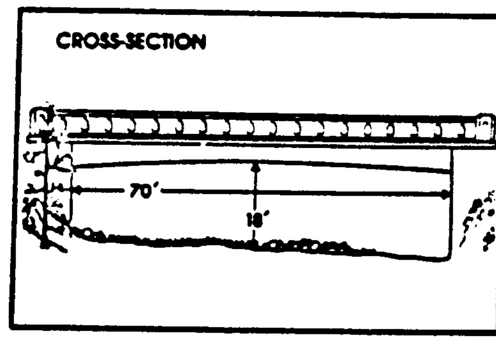
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	1.6	0.12	0.03	0.09	0.05	0.0	0.02	0.0	0.01	0.0	0.0	0.0
YEAR	MAX.	7.9	1.2	0.80	2.8	1.5	0.0	0.70	0.0	0.10	0.0	0.0	0.0
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	95.0	7.3	1.6	5.8	3.0	0.0	1.4	0.0	0.60	0.0	0.0	0.0

VOL 12
1988

TOPANGA CREEK
above Mouth of Canyon
STATION NO. F54B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 18.0 square miles.
LOCATION- downstream side of Topanga Canyon Road bridge, 2.0 miles north of Topanga Beach.
REGULATION- none.
CHANNEL- rock and gravel, natural section.
CONTROL- none.
LENGTH OF RECORD- at Station F54-R January 1, 1930 to June 4, 1940. at Station F54B-R, June 5, 1940 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. :

DRAINAGE AREA :

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN MAX. MIN.	NO DATA AVAILABLE AT TIME OF PRINTING											
	TOTAL AF												

VOL 12

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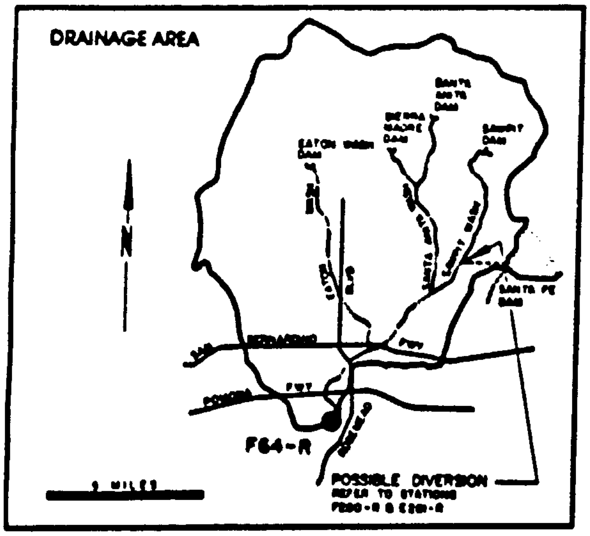
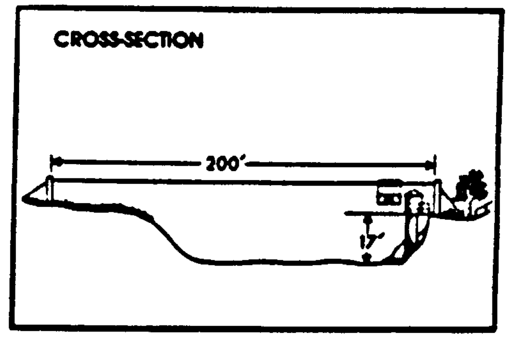
R0052794

RIO HONDO
above Mission Bridge
STATION NO. F64-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 115 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,000 feet above San Gabriel Boulevard, west of Rosemead Boulevard, 2.0 miles northeast of Montebello.
REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, and Santa Fe Dams and several debris basins.
CHANNEL- sand and silt, natural in section.
CONTROL- none.
LENGTH OF RECORD- July 1, 1928 to date.
REMARKS- subject to diversions; water purchased from the MWD passes this station for spreading in the coastal basin.

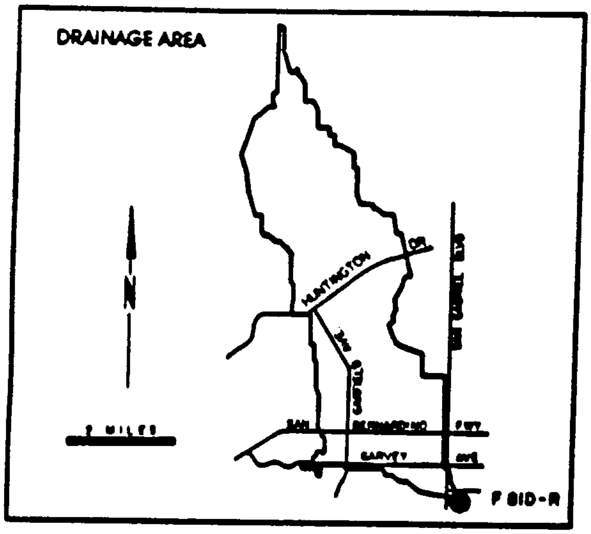
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

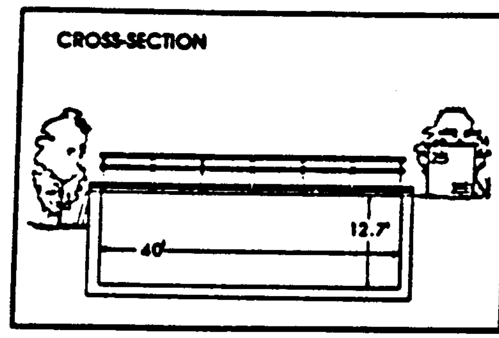
STATION NO. : F64-R DRAINAGE AREA : 115.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	59.5	34.8	40.2	46.5	26.6	7.1	36.7	2.8	88.5	2.0	0.34	3.4
YEAR	MAX.	963.0	558.0	671.0	1260.0	311.0	98.7	355.0	3.9	258.0	4.8	2.5	71.0
87-88	MIN.	1.0	0.80	1.2	1.2	3.4	3.0	1.7	2.3	1.6	0.0	0.0	0.0
	TOTAL AF	3660.0	2070.0	2470.0	2860.0	1530.0	436.0	2180.0	173.0	5260.0	121.0	21.0	199.0

VOL 12
1990

ALHAMBRA WASH
near Klingerman Street
STATION NO. F81D-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 15.2 square miles.
LOCATION- 250± feet above Klingerman Street and 2,680.0 feet below Garvey Avenue, South San Gabriel.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 40.0 feet wide by 12.7 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F81-R January 14, 1930 to September 30, 1934. at Station F81B-R October 1, 1934 to February 25, 1935. at Station F81C-R February 25, 1935 to April 27, 1936. at Station F81B-R April 27, 1936 to May 22, 1936. at Station F81D-R September 2, 1936 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F81D-R

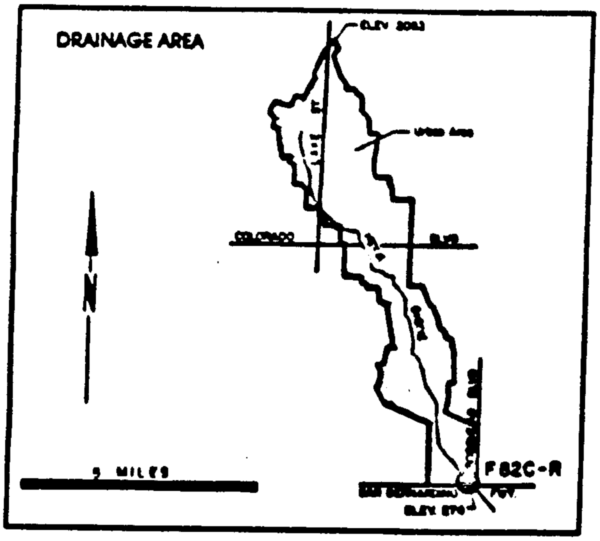
DRAINAGE AREA : 15.20 SQ. MI.

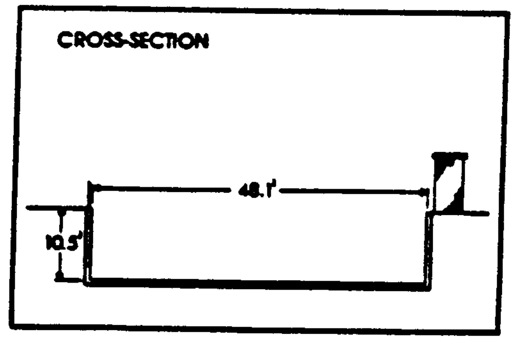
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	23.2	9.8	10.8	13.6	8.0	2.1	9.9	1.1	1.2	1.2	1.2	1.5
	MAX.	382.0	130.0	220.0	386.0	117.0	19.0	90.7	1.4	1.8	1.8	1.8	8.9
	MIN.	0.90	0.90	0.60	0.60	0.60	0.60	0.60	0.60	0.90	0.90	0.90	0.90
	TOTAL AF	1430.0	580.0	664.0	836.0	458.0	127.0	588.0	68.0	70.0	71.0	72.0	87.0

R0052796

VOL 12 1991

RUBIO WASH
at Glendon Wash
STATION NO. F82C-R





RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge at station.
DRAINAGE AREA- 10.9 square miles.
LOCATION- on the east side of channel, 10 feet south of the westerly extension of Glendon Way, Rosemead.
REGULATION- flow partly regulated by Las Flores and Rubio debris basins.
CHANNEL- rectangular concrete.
CONTROL- channel forms control.
LENGTH OF RECORD- see station summary.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

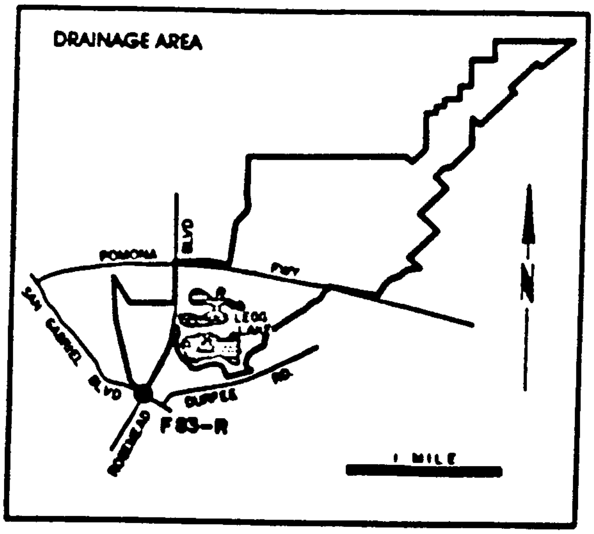
STATION NO. : F82C-R DRAINAGE AREA : 10.90 SQ. MI.

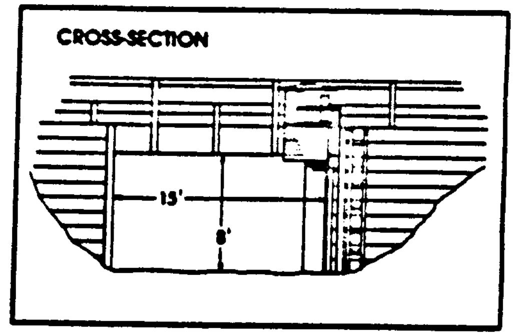
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	11.3	7.1	6.5	8.3	6.2	2.0	7.7	0.45	0.39	0.38	0.48	0.74
	MAX.	165.0	96.9	145.0	246.0	102.0	30.0	78.2	1.0	0.60	0.60	1.0	10.5
	MIN.	0.10	0.10	0.10	0.0	0.0	0.20	0.20	0.10	0.20	0.20	0.20	0.20
	TOTAL AF	696.0	421.0	399.0	512.0	357.0	122.0	459.0	28.0	23.0	23.0	28.0	44.0

R0052797

MISSION CREEK
at San Gabriel Boulevard
STATION NO. F83-R

VOL 12





1993

RECORDER- continuous water stage.
METHOD MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 4.2 square miles.
LOCATION- upstream of San Gabriel Boulevard, 0.2 miles northeast of Montebello.
REGULATION- partially regulated by outflow from Legg Lake.
CHANNEL- sand with brush and fences, natural in section.
CONTROL- channel forms control.
LENGTH OF RECORD- June 14, 1930 to date.
REMARKS- nearly all flows originate in rising water.

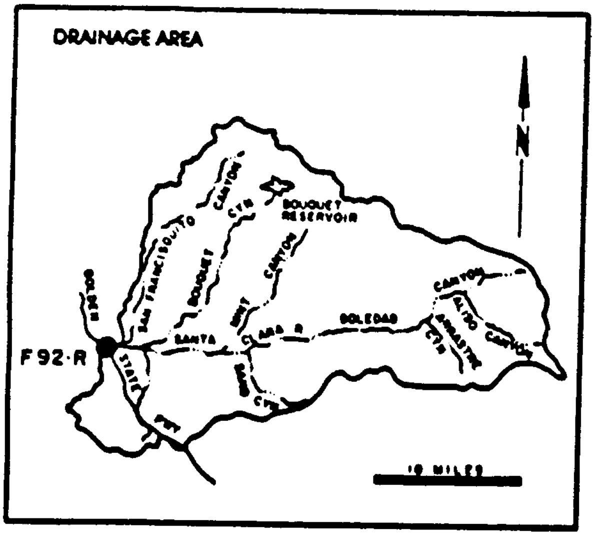
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

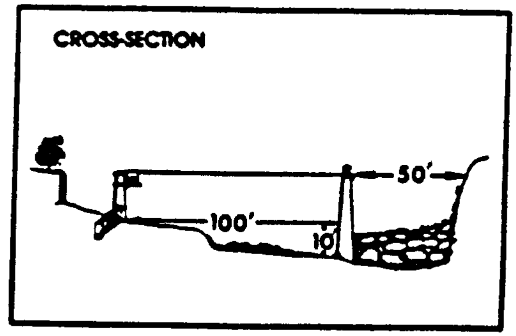
STATION NO. :

DRAINAGE AREA :

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN												
	MAX.			NO DATA AVAILABLE AT TIME OF PRINTING									
	MIN.												
	TOTAL AF												

SANTA CLARA RIVER
below Highway 5
STATION NO. F92-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 410.4 square miles.
LOCATION- downstream side of Old Highway bridge, 3.0 miles west of Saugus.
REGULATION- partially regulated by Bouquet Canyon and Dry Canyon Reservoirs.
CHANNEL- sand and gravel with brush, natural section.
CONTROL- none.
LENGTH OF RECORD- at Station F92-R January 18, 1930 to March 28, 1938, and September 24, 1956 to date. at Station F92B-R, October 1, 1938 to September 24, 1956.
REMARKS- subject to diversions for irrigation.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

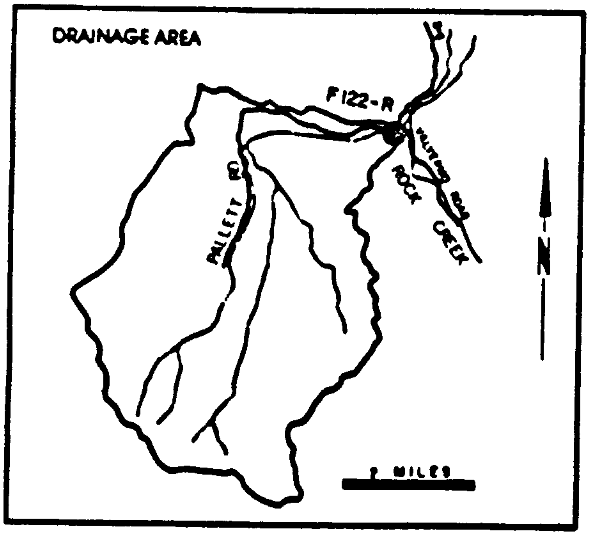
STATION NO. : F92C-R DRAINAGE AREA : 410.40 SQ. MI.

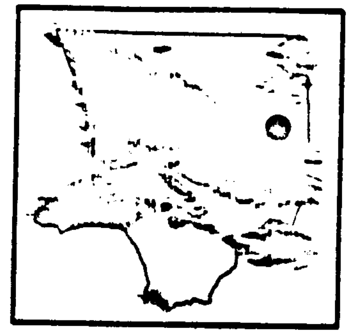
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	18.9	21.7	33.1	26.2	19.6	12.5	10.2	11.3	14.9	11.2	9.0	9.3
YEAR	MAX.	485.0	198.0	447.0	281.0	128.0	17.0	17.0	15.3	15.3	14.0	9.3	9.3
87-88	MIN.	0.0	14.6	10.6	11.5	7.6	12.0	3.9	8.8	14.0	8.4	8.8	9.3
	TOTAL AF	1160.0	1290.0	2030.0	1610.0	1130.0	768.0	607.0	698.0	887.0	690.0	556.0	553.0

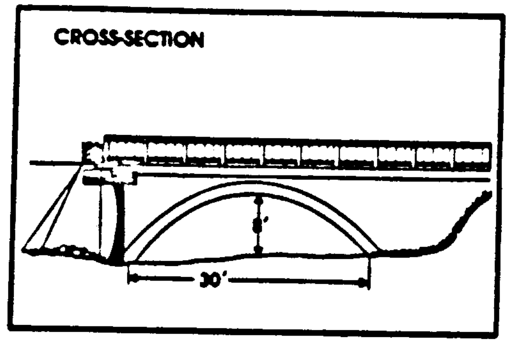
R0052799

VOL 12
1994

PALLETT CREEK
at Valyermo Highway
STATION NO. F122-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 15.8 square miles.
LOCATION- upstream side of Valyermo Highway bridge, 5.0 miles southeast of Pearblossom.
REGULATION- none.
CHANNEL- sand and gravel, natural section.
CONTROL- channel forms control for low flows; bridge culvert forms control for high flows.
LENGTH OF RECORD- at Station F122-S December 29, 1930 to October 31, 1961. at Station F122-R, October 31, 1961 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F122-R

DRAINAGE AREA : 15.80 SQ. MI.

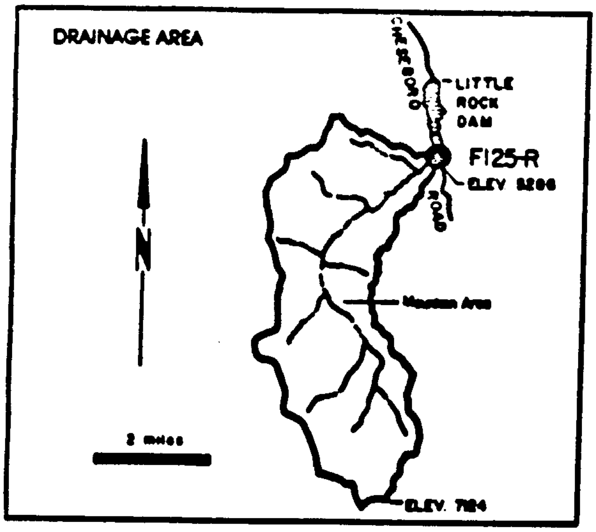
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	0.61	0.73	0.0	0.56	0.09	0.20	0.21	0.23	0.45	0.48	0.19	0.30
	MAX.	18.9	21.9	0.0	16.0	0.10	0.20	0.50	0.60	0.50	0.50	0.50	0.50
	MIN.	0.0	0.0	0.0	0.0	0.0	0.20	0.0	0.10	0.30	0.40	0.0	0.20
	TOTAL AF	37.0	43.0	0.0	35.0	5.2	12.0	13.0	14.0	27.0	29.0	12.0	18.0

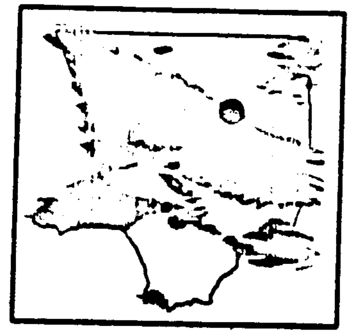
VOL 12

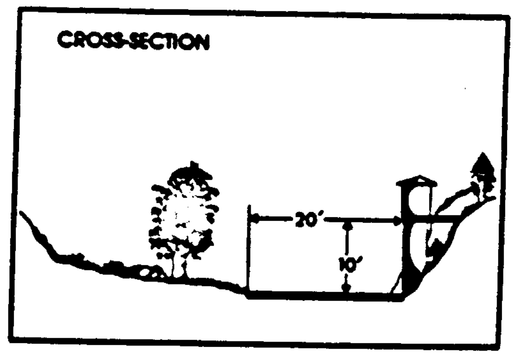
1995

R0052800

SANTIAGO CREEK
above Little Rock Creek
STATION NO. F125-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 11.2 square miles.
LOCATION- 1,000 feet above Little Creek and 4.6 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel and boulders.
CONTROL- concrete and rubble wall.
LENGTH OF RECORD- September 29, 1983 to date.
REMARKS- no high flow measurements.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F125-R

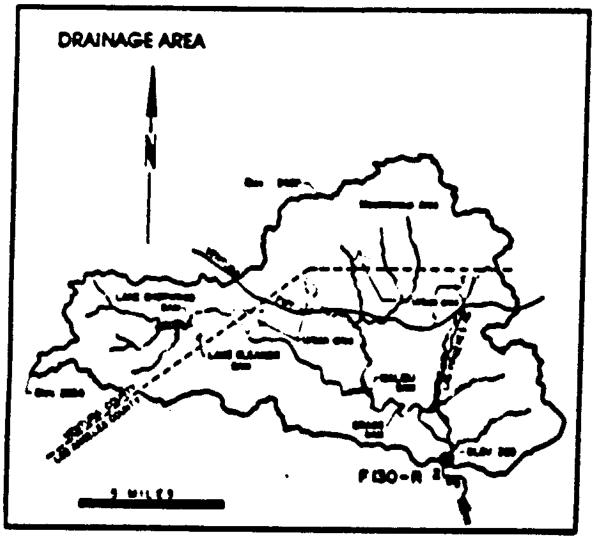
DRAINAGE AREA : 11.20 SQ. MI.

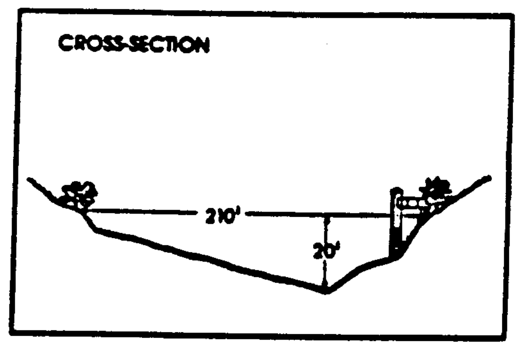
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.0	0.0	0.0	0.44	0.93	1.7	0.32	0.003	0.0	0.0	0.0	0.0
YEAR	MAX.	0.0	0.0	0.0	1.9	10.0	17.0	3.5	0.10	0.0	0.0	0.0	0.0
87-88	MIN.	0.0	0.0	0.0	0.0	0.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	27.0	54.0	104.0	19.0	0.20	0.0	0.0	0.0	0.0

VOL 12 - 1996

VOL 12

MALIBU CREEK
below Cold Creek
STATION NO. F130-R





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9
4
9
7

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 104.98 square miles
LOCATION- 0.2± mile downstream of Cold Creek, 6.0 miles southwest of Calabasas.
REGULATION- Lake Sherwood Dam, Lake Eleanor Dam, Malibu Lake Dam, and Crag's Dam. Other small recreational dams affect low summer flows.
CHANNEL- coarse sand and gravel, lined with trees and brush, natural in section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- January 17, 1931 to date.
REMARKS- cableway washed out on January 25, 1969; no high flow measurements since that date.

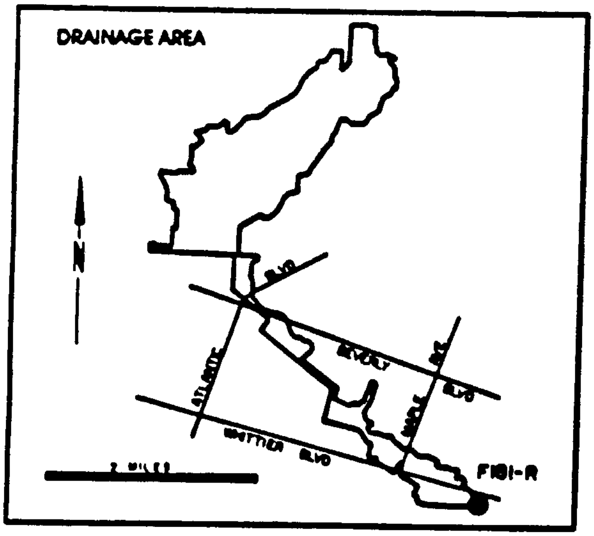
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

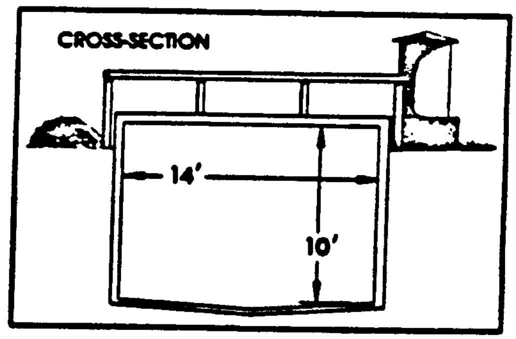
STATION NO. : F130-R

DRAINAGE AREA : 104.98 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	15.2	28.4	52.2	53.9	51.4	28.0	34.5	7.5	4.8	2.7	2.1	INC.
YEAR	MAX.	143.0	295.0	368.0	559.0	471.0	226.0	299.0	14.8	7.1	6.9	4.4	INC.
87-88	MIN.	1.4	13.1	13.1	16.8	12.7	6.6	6.3	4.4	3.5	0.6	0.9	INC.
	TOTAL AF	934.0	1690.0	3210.0	3320.0	2960.0	1720.0	2050.0	462.0	283.0	167.0	128.0	INC.

MONTEBELLO STORM DRAIN
above Rio Hondo
STATION NO. F181-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 9.6 square miles.
LOCATION- 150.0 feet east of Mines Avenue and 800.0 feet west of Rio Hondo.
REGULATION- none.
CHANNEL- 14.0-foot by 10.0-foot concrete, box section.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1932 to date.
REMARKS- may be affected by backwater during flood flows.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F181-R — DRAINAGE AREA : 9.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	2.5	0.98	1.7	2.9	1.1	0.35	1.8	0.22	0.28	0.37	0.33	0.28
YEAR	MAX.	38.2	10.1	28.9	81.2	14.2	3.2	20.6	0.40	0.40	0.40	0.60	0.80
87-88	MIN.	0.10	0.0	0.0	0.0	0.10	0.10	0.10	0.10	0.20	0.30	0.20	0.10
	TOTAL AF	156.0	59.0	107.0	178.0	61.0	21.0	104.0	13.0	16.0	23.0	20.0	17.0

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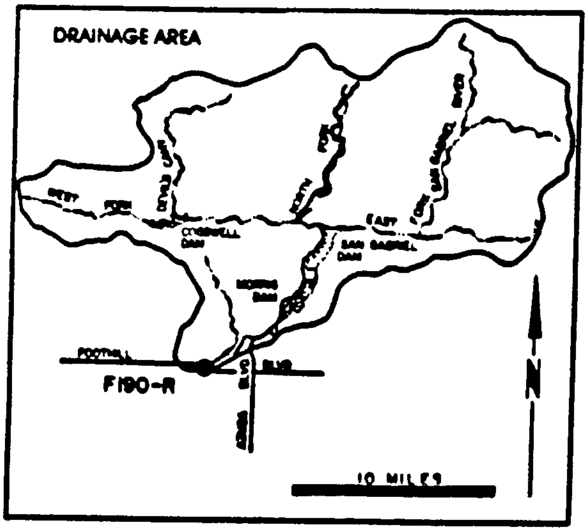
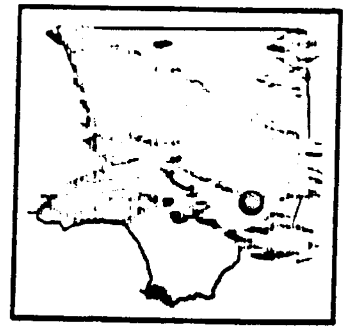
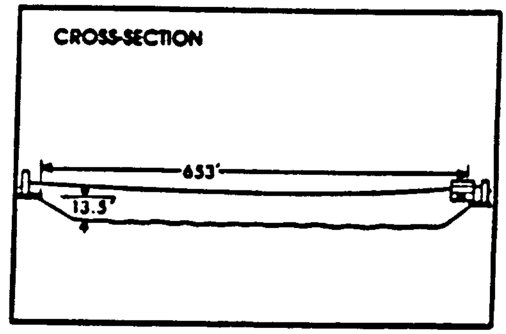
SAN GABRIEL RIVER
at Foothill Boulevard
STATION NO. F190-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 230.0 square miles.
LOCATION- downstream side of Foothill Boulevard bridge, 2.0 miles west of Azusa.
REGULATION- partially regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- sand, gravel and rock,trapezoidal section with soft bottom.
CONTROL- gunited rock stabilizers.
LENGTH OF RECORD- February 22, 1932 to date.
REMARKS- flows may include imported water originating at the Metropolitan Water District outlet below Morris Dam.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F190-R

DRAINAGE AREA : 230.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	4.9	42.6	107.0	230.0	172.0	0.0	0.0	0.0	172.0	0.0	5.7	13.2
	MAX.	7.6	100.0	151.0	387.0	296.0	0.0	0.0	0.0	544.0	0.0	18.8	100.0
	MIN.	3.6	0.0	8.2	179.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	299.0	2540.0	6570.0	14160.0	9920.0	0.0	0.0	0.0	10260.0	0.0	348.0	783.0

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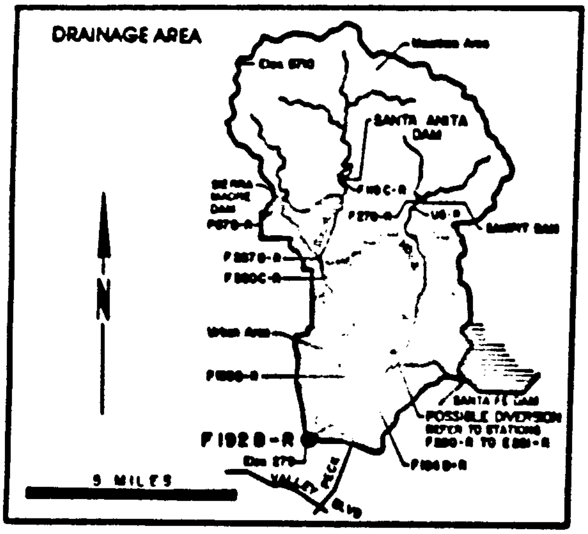
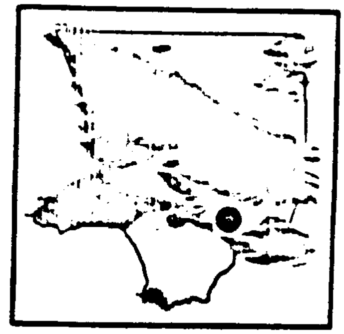
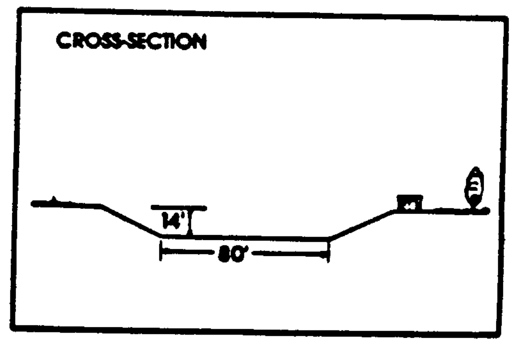
R0052804

RIO HONDO
below Lower Azusa Road
STATION NO. F192B-R







RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading.

DRAINAGE AREA- 40.9 square miles (excludes area above Santa Fe Dam).

LOCATION- 300.0 feet downstream from Lower Azusa Road, 1.5 miles north of El Monte.

REGULATION- partially regulated by Sierra Madre Dam, Santa Anita Dam, Sawpit Dam, Santa Fe Dam, Peck Pit, Buena Vista Pit, and several debris basins.

CHANNEL- concrete, trapezoidal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F192-R February 22, 1932 to May 7, 1968. at Station F192B-R May 7, 1968 to date.

REMARKS- subject to diversions from Monrovia, Sawpit, and Little Santa Anita Creeks. Also from the San Gabriel River below Santa Fe Dam; and for irrigation and spreading.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F192B-R

DRAINAGE AREA : 40.90 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.75	0.29	0.55	0.83	0.34	0.03	0.49	0.04	68.6	0.04	0.03	0.06
YEAR	MAX.	16.1	6.4	12.0	25.4	3.7	0.60	6.6	0.10	223.0	0.10	0.10	0.50
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	46.0	17.0	34.0	51.0	20.0	1.6	29.0	2.6	4080.0	2.2	2.0	3.8

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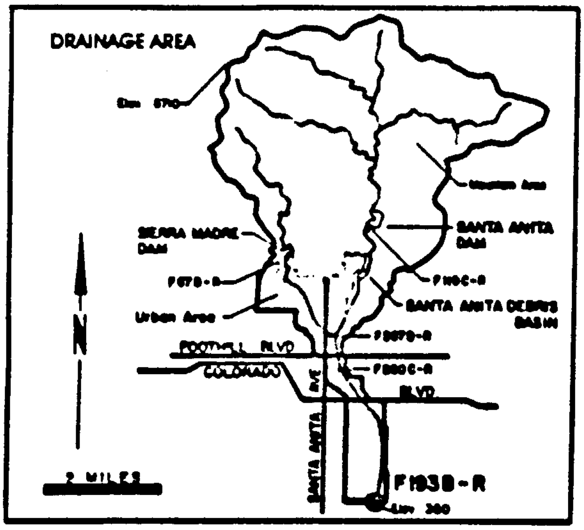
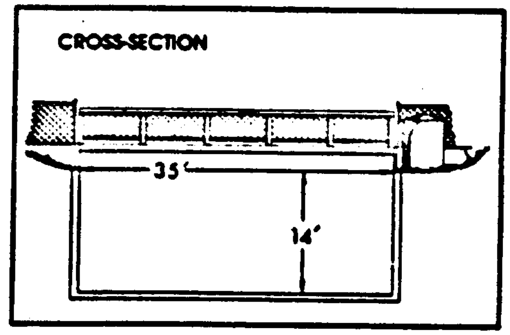
SANTA ANITA WASH
at Longden Avenue
STATION NO. F193B-R





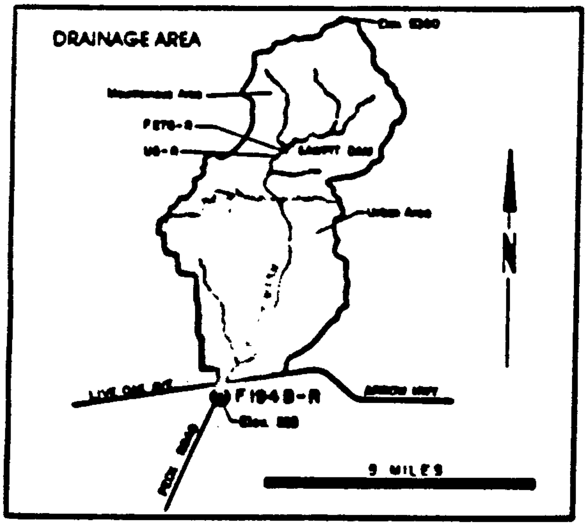
RECORDER - continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 18.8 square miles.
LOCATION - 30.0 feet above Longden Avenue, 1.5 miles south of Arcadia.
REGULATION - regulated by Santa Anita and Sierra Madre Dams, and Santa Anita Debris Basin.
CHANNEL - concrete rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F193-R, April 28, 1932 to March 1, 1938. at Station F193B-R, January 8, 1960 to date.

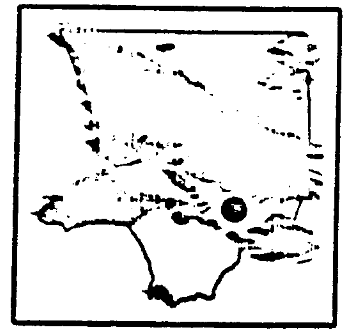
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

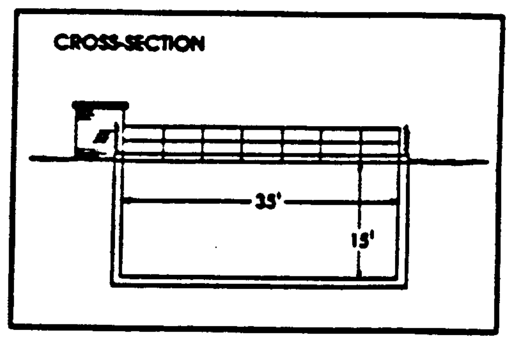
STATION NO. : F193B-R — DRAINAGE AREA : 18.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	3.1	2.0	1.8	3.0	3.8	1.7	2.1	0.11	0.48	0.51	0.25	0.33
YEAR	MAX.	48.1	31.9	30.4	82.0	74.3	42.3	27.3	0.30	1.0	1.0	0.70	3.6
87-88	MIN.	0.20	0.10	0.0	0.0	0.0	0.10	0.0	0.0	0.10	0.20	0.0	0.0
	TOTAL AF	191.0	121.0	112.0	182.0	217.0	106.0	125.0	6.5	29.0	32.0	15.0	20.0

SAWPIT WASH
below Live Oak Avenue
STATION NO. F194B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 16.1 square miles.
LOCATION- 1,500 feet below Arrow Highway, 3.0 miles south of Monrovia.
REGULATION- partially regulated by Sawpit and Santa Fe Dams, and by several debris basins.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F194-R February 22, 1932 to September 1, 1936. at Station F194B-R December 6, 1960 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F194B-R DRAINAGE AREA : 16.10 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	6.0	3.4	3.3	4.8	2.7	0.83	4.6	0.45	130.0	0.13	0.18	0.41
YEAR	MAX.	111.0	59.1	61.4	137.0	26.2	17.1	47.8	0.90	385.0	0.20	0.40	6.9
87-88	MIN.	0.10	0.10	0.0	0.10	0.10	0.10	0.10	0.30	0.10	0.10	0.10	0.10
	TOTAL AF	368.0	202.0	205.0	294.0	153.0	51.0	273.0	28.0	7730.0	8.1	11.0	24.0

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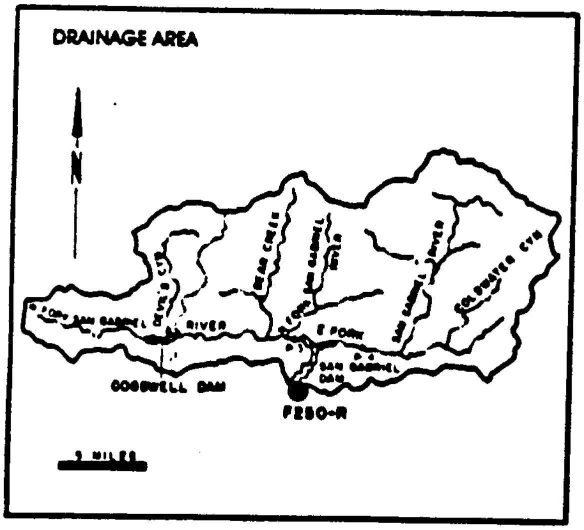
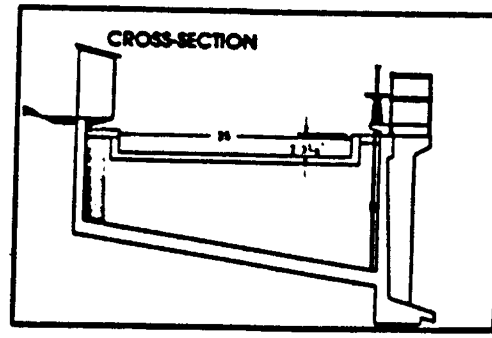
SAN GABRIEL-AZUSA CONDUIT
at 25 ft. Weir below San Gabriel Dam
STATION NO. F250-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- weir formula with gage height observation.
DRAINAGE AREA- none.
LOCATION- on the concrete conduit which diverts from San Gabriel Dam, 160 feet below the Dam.
REGULATION- regulated in section.
CONTROL- 25-foot concrete weir.
LENGTH OF RECORD- February 26, 1933, to date.
REMARKS- approximate capacity 96 second-feet.

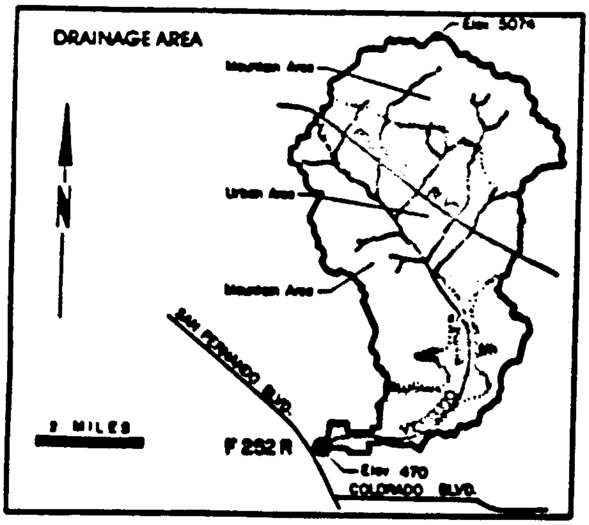
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

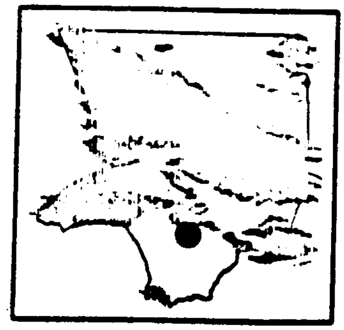
STATION NO. : F250-R

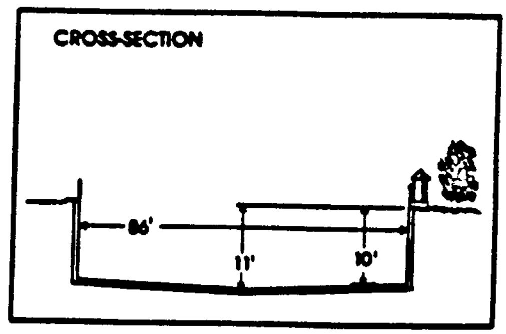
DRAINAGE AREA : NONE

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	5.6	43.9	20.7	16.6	22.1	37.5	22.4	61.6	46.2	50.1	49.2	51.8
YEAR	MAX.	29.8	79.4	44.9	45.9	60.1	53.4	53.4	70.7	69.5	50.2	50.2	54.1
87-88	MIN.	0.0	24.6	0.20	0.20	0.20	0.20	0.20	0.20	0.20	49.1	23.4	48.0
	TOTAL AF	346.0	2610.0	1270.0	1020.0	1270.0	2310.0	1330.0	3790.0	2750.0	3080.0	3030.0	3080.0

VERDUGO WASH
at Estelle Avenue
STATION NO. F252-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from Concord Street Bridge.
DRAINAGE AREA- 26.8 square miles.
LOCATION- 800.0 feet east of San Fernando Road, 2.0 miles northwest of Glendale.
REGULATION- partially regulated by several debris basins.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- December 2, 1936 to date.

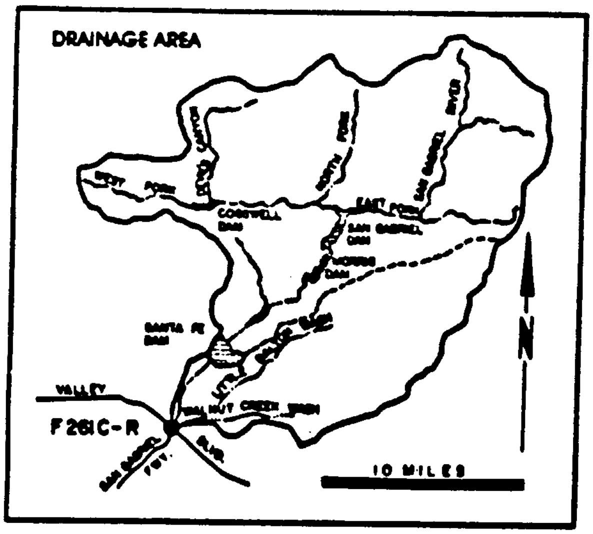
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

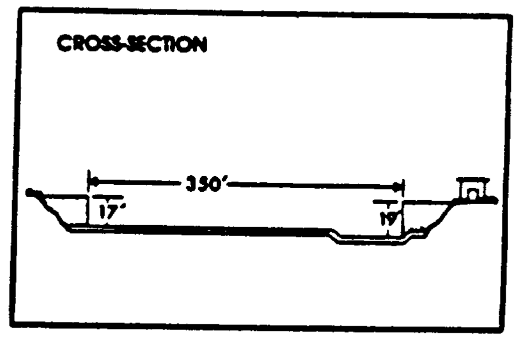
STATION NO. : F252-R

DRAINAGE AREA : 26.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	38.1	32.8	54.1	25.7	31.9	5.9	14.8	5.1	7.8	4.9	6.8	4.6
	MAX.	294.0	272.0	688.0	478.0	423.0	74.0	183.0	14.8	10.6	8.4	80.6	30.2
	MIN.	2.8	3.9	5.0	5.0	2.8	2.8	2.5	2.5	5.0	2.8	2.3	2.3
	TOTAL AF	2340.0	1950.0	3330.0	1580.0	1830.0	364.0	878.0	313.0	462.0	301.0	418.0	275.0

SAN GABRIEL RIVER
below Valley Boulevard
STATION NO. F261C-R





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RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 118.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,150.0 feet below Valley Boulevard, 2.5 miles east of El Monte.
REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, and Puddingstone Dams.
CHANNEL- sand and gravel bottom with rip-rap side slopes; trapezoidal section.
CONTROL- concrete stabilizer with low-flow notch.
LENGTH OF RECORD- at Station F261-R March 11, 1937 to September 30, 1941. at Station F261B-R October 1, 1941 to April 23, 1946. at Station F261C-R November 29, 1960 to date.
REMARKS- flows may include imported water originating at Metropolitan Water District outlets at San Dimas Canyon and below San Bernardino Road.

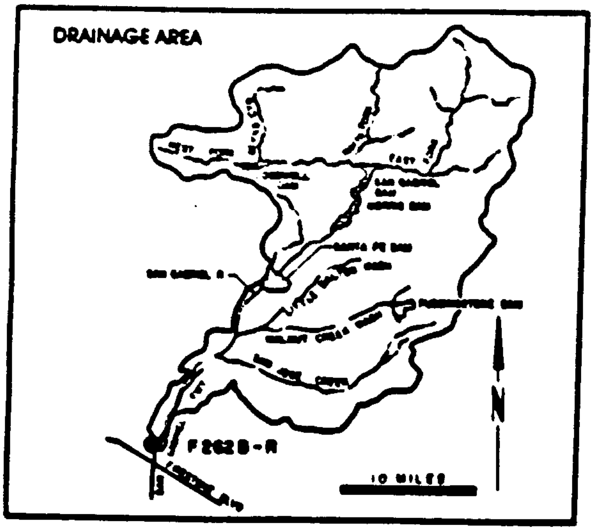
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

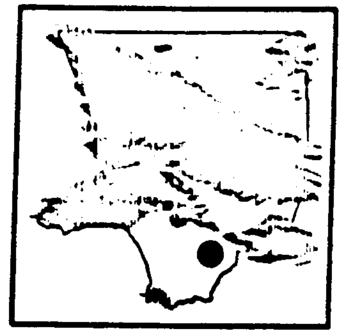
STATION NO. : F261C-R

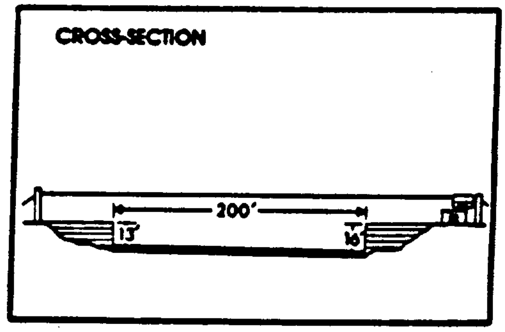
DRAINAGE AREA : 118.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	36.4	97.3	30.9	46.7	68.8	103.0	53.8	142.0	63.5	2.5	5.1	7.0
	MAX.	738.0	315.0	448.0	1000.0	234.0	160.0	571.0	219.0	157.0	11.0	27.0	16.6
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	2.6
	TOTAL AF	2240.0	5790.0	1900.0	2870.0	3940.0	6340.0	3200.0	8700.0	3780.0	153.0	316.0	415.0

SAN GABRIEL RIVER
above Florence Avenue
STATION NO. F262B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 215.8 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,400 feet above Florence Avenue, 2.0 miles east of Downey.
REGULATION- partially regulated by Cogswell, San Gabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek and Whittier Narrows Dams, several debris basins, MWD outlets, and several spreading grounds.
CHANNEL- sand bottom with rip-rap slopes, trapezoidal section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F267-R February 27, 1937 to September 30, 1967. at Station F262B-R August 6, 1968 to date.
REMARKS- no record during 1967-1968 season due to channel construction.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F262B-R

DRAINAGE AREA : 215.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.0	0.0	0.07	5.8	0.0	0.04	1.8	0.0	0.0	0.0	0.0	0.0
YEAR	MAX.	0.0	0.0	2.1	75.9	0.0	0.80	34.4	0.0	0.0	0.0	0.0	0.0
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	4.6	354.0	0.0	2.2	105.0	0.0	0.0	0.0	0.0	0.0

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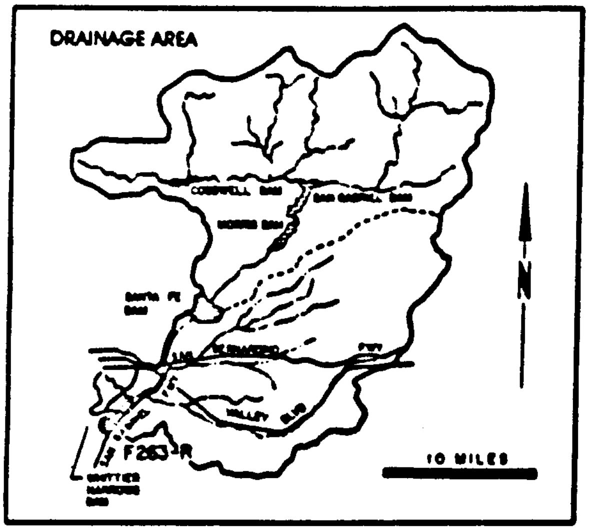
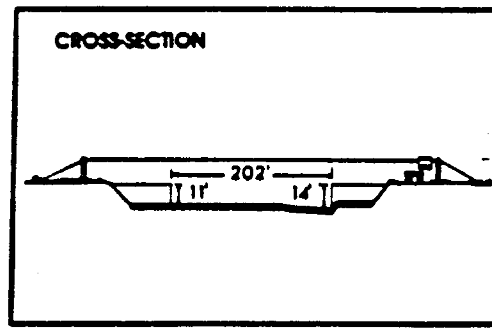
SAN GABRIEL RIVER
below San Gabriel River Parkway
STATION NO. F263C-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 206.3 square miles (excludes area above Santa Fe Dam).
LOCATION- 462.0 feet below San Gabriel River Parkway, 1.4 miles northeast of Pico Rivera.
REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, Puddingstone, and Thompson Creek Dams. Flows may include imported water from several Metropolitan Water District outlets. Water is at times diverted to the Zone I ditch upstream of Whittier Narrows Dam.
CHANNEL- rip-rap slopes with sand bottom trapezoidal section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD - at Station F263-R February 4, 1937 to March 6, 1952. at Station F263B-R March 6, 1952 to August 9, 1968. at Station F263C-R August 9, 1968 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F263C-R　　　DRAINAGE AREA : 206.30 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	21.1	49.6	55.7	39.3	54.1	63.6	52.4	7.9	34.7	4.4	10.1	0.0
YEAR	MAX.	189.0	124.0	168.0	395.0	262.0	141.0	559.0	24.4	90.0	45.6	26.8	0.0
87-88	MIN.	0.0	1.4	3.8	2.6	7.8	22.5	1.2	0.80	0.0	0.0	0.0	0.0
	TOTAL AF	1300.0	2950.0	3420.0	2420.0	3110.0	3910.0	3120.0	487.0	2070.0	271.0	619.0	0.0

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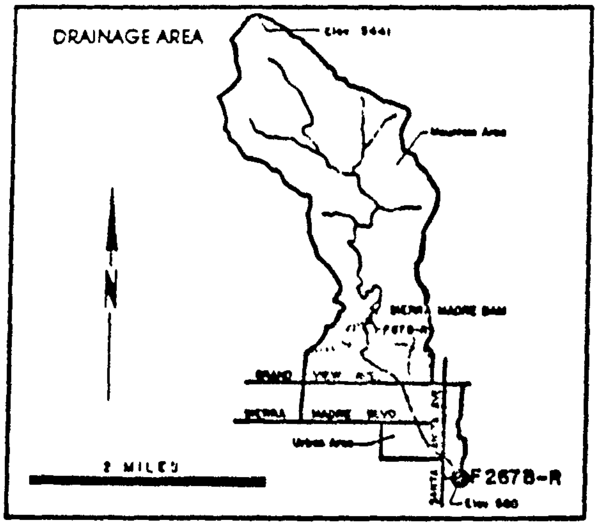
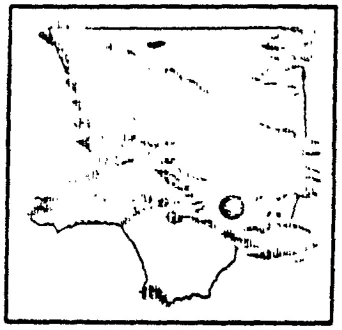
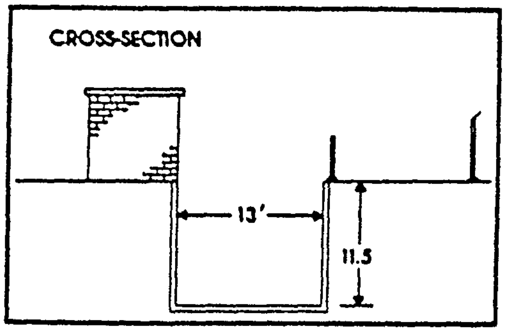
SIERRA MADRE WASH
at Highland Oaks Avenue
STATION NO. F267B-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream end of conduit 50 feet below station.
DRAINAGE AREA- 3.8 square miles.
LOCATION- on the south bank of the channel 50 feet above Highland Oaks Avenue, one and one-half miles southeast of Sierra Madre.
REGULATION- partially regulated by Sierra Madre Dam. Usual regulation affects high flows only.
DIVERSIONS- underground and surface flows developed and diverted by Sierra Madre Water Department. Flow also diverted about one mile above station for spreading in Sierra Madre Spreading Grounds.
CHANNEL-rectangular concrete 13 feet wide and 11.5 feet deep.
LENGTH OF RECORD- see station summary.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F267B-R

DRAINAGE AREA : 3.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.75	0.43	1.7	0.64	0.43	0.33	0.38	0.01	0.05	0.08	0.05	0.10
YEAR	MAX.	12.0	5.9	11.9	18.6	7.6	6.7	4.5	0.10	0.10	0.20	0.10	2.4
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	46.0	28.0	102.0	39.0	25.0	20.0	23.0	0.40	2.8	5.0	2.2	6.0

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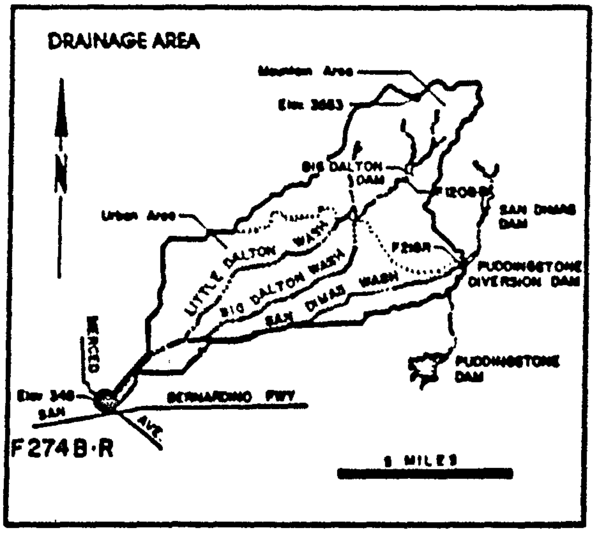
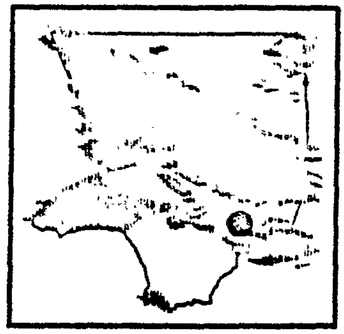
R0052813

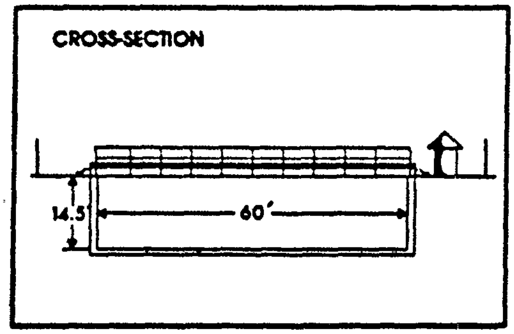
VOL 12

19509

DALTON WASH
at Merced Avenue
STATION NO. F274B-R







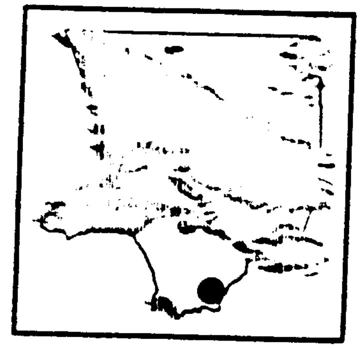
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge 100 feet upstream from station.
DRAINAGE AREA- 36.0 square miles, not including the area above Puddingstone Diversion Dam.
LOCATION- on the west bank and upstream of Merced Avenue about 150 feet, about one-half mile above the junction with Walnut Wash and about one mile south of Baldwin Park.
REGULATION- partly regulated by Big Dalton Dam, San Dimas Dam, Puddingstone Diversion Dam, Big Dalton Spreading Grounds, Little Dalton Spreading Grounds, Big Dalton Debris Basin, Little Dalton Debris Basin, and Irwindale Spreading Grounds.
REMARKS- flow may include imported water originating at San Dimas.

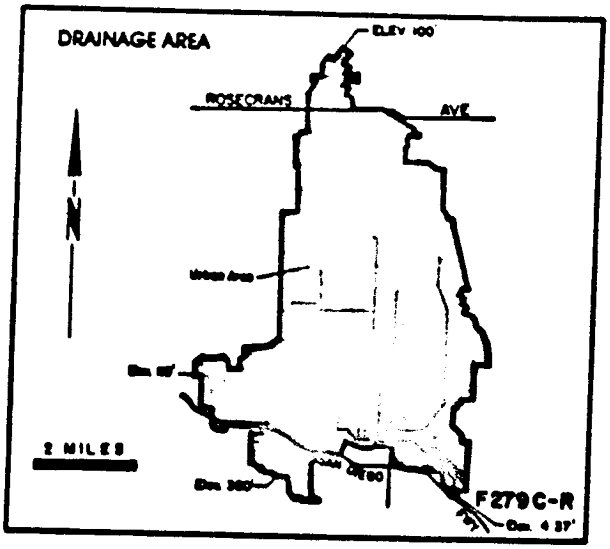
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

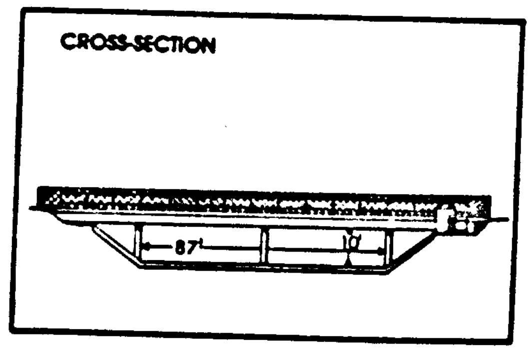
STATION NO. : F274B-R DRAINAGE AREA : 35.95 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	21.3	90.8	29.3	19.2	44.8	102.0	36.5	152.0	69.2	2.5	3.8	4.0
	MAX.	418.0	214.0	311.0	421.0	128.0	207.0	263.0	273.0	184.0	9.1	16.3	10.4
	MIN.	1.0	1.9	1.6	2.7	2.3	0.10	0.40	0.40	1.3	0.10	1.9	1.6
	TOTAL AF	1310.0	5400.0	1800.0	1180.0	2580.0	6290.0	2170.0	9320.0	4120.0	154.0	236.0	238.0

LOS CERRITOS CHANNEL
at Stearns Street
STATION NO. F279C-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 25.6 square miles.
LOCATION- upstream of Stearns Street, Long Beach.
REGULATION- none.
CHANNEL- concrete, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F279-R November 23, 1942 to January 1, 1949. at Station F279B-R January 1, 1949 to May 26, 1955. at Station F279C-R October 26, 1955 to date.
REMARKS- station not in service May 26, 1955 to October 26, 1955 due to channel construction.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F279C-R

DRAINAGE AREA : 25.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	15.4	6.0	13.1	16.1	8.8	2.2	11.6	1.0	1.2	1.3	2.4	2.1
	MAX.	267.0	50.3	168.0	412.0	167.0	10.6	153.0	1.5	1.7	1.5	7.6	4.4
	MIN.	1.0	0.60	0.10	0.20	0.40	0.60	0.80	0.40	0.80	1.1	1.5	1.3
	TOTAL AF	946.0	357.0	805.0	989.0	508.0	135.0	688.0	64.0	72.0	79.0	146.0	122.0

R0052815

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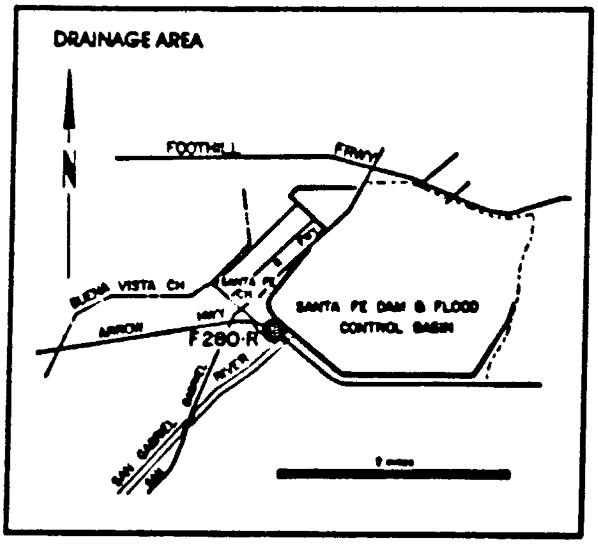
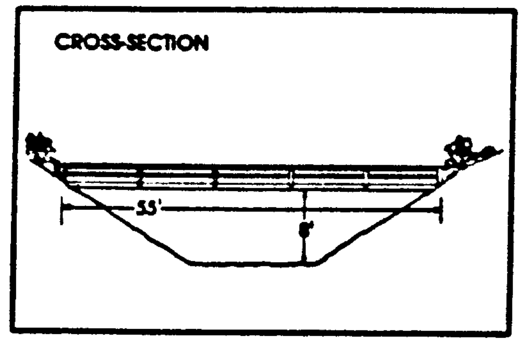
SANTA FE CHANNEL
below Santa Fe Dam
STATION NO. F280-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- controlled.
LOCATION- 400.0 feet downstream of Santa Fe Dam outlet and 1.5 miles north of Baldwin Park.
REGULATION- flow regulated by five gates of stilling basin outlet of Santa Fe Dam.
CHANNEL- sand and gravel, natural section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F280-S October 1, 1942 to May 12, 1944. at Station F280-R May 12, 1944 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F280-R

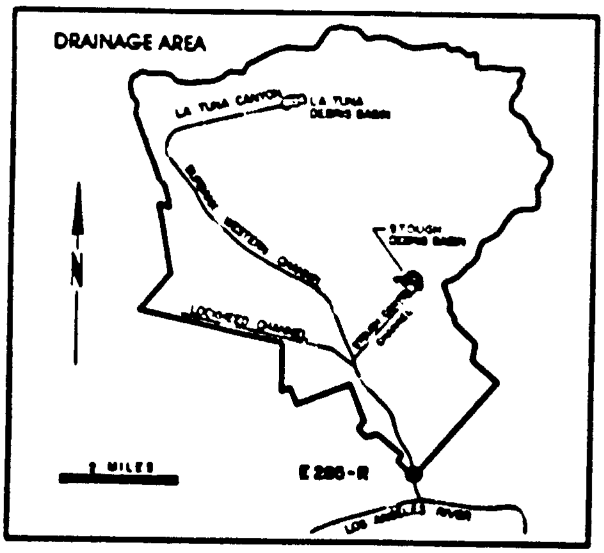
DRAINAGE AREA : CONTROLLED

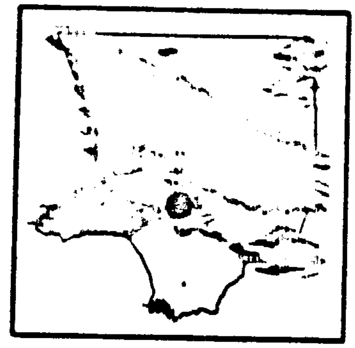
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.0	0.0	0.0	0.003	0.0	0.0	0.0	0.0	145.0	0.0	0.0	0.01
YEAR	MAX.	0.0	0.0	0.0	0.10	0.0	0.0	0.0	0.0	424.0	0.0	0.0	0.10
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	0.20	0.0	0.0	0.0	0.0	8360.0	0.0	0.0	0.60

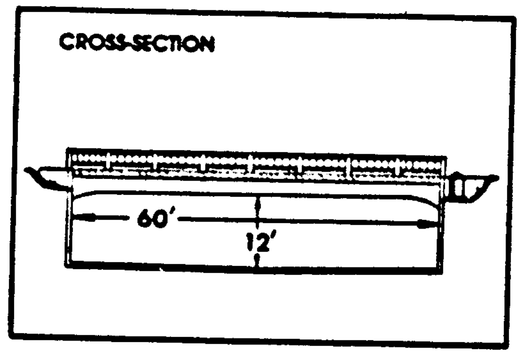
VOL 12
1951

R0052816

BURBANK-WESTERN ST. DR.
at Riverside Drive
STATION NO. E 285-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading and from bridge.
DRAINAGE AREA- 25.0 square miles.
LOCATION- 20.0 feet upstream from Riverside Drive bridge, Glendale.
REGULATION- Several debris basins on tributaries.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1949 to date.
REMARKS- operated in cooperation with the USGS.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

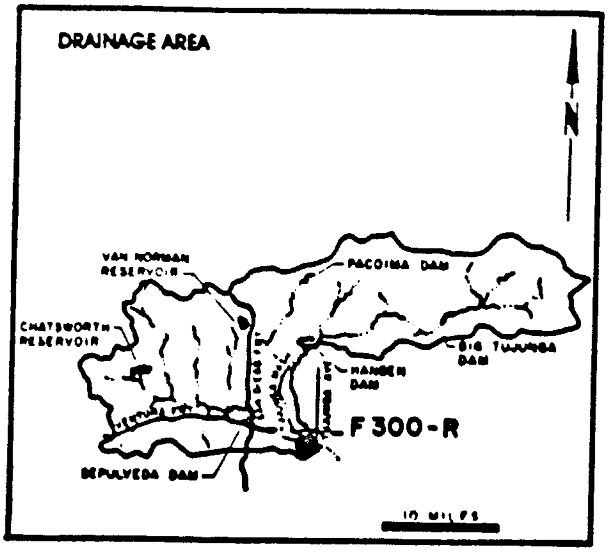
STATION NO. : E285-R

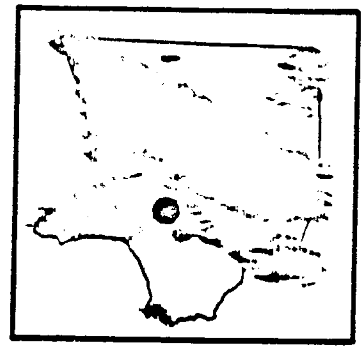
DRAINAGE AREA : 25.00 SQ. MI.

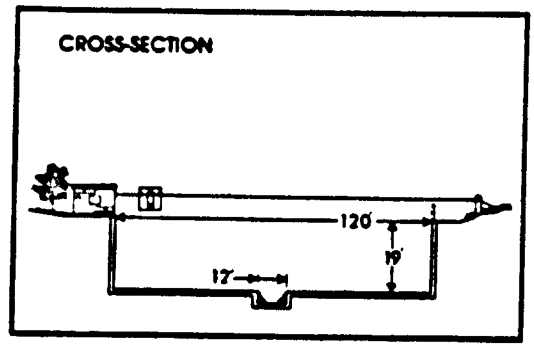
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	44.1	22.4	19.2	24.4	27.1	12.4	25.5	10.7	9.3	12.4	11.7	13.5
YEAR	MAX.	601.0	166.0	179.0	363.0	228.0	18.5	146.0	11.9	10.6	13.1	13.1	21.2
87-88	MIN.	10.6	7.9	7.9	10.6	10.6	9.1	10.6	9.1	9.1	10.6	9.1	10.6
	TOTAL AF	2710.0	1330.0	1180.0	1500.0	1560.0	765.0	1520.0	655.0	553.0	761.0	716.0	804.0

LOS ANGELES RIVER
at Tujunga Avenue
STATION NO. F300-R

VOL 12







19513

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 401.0 square miles.
LOCATION- 200.0 feet above Tujunga Avenue bridge, Studio City.
REGULATION- flow regulated by Sepulveda, Big Tujunga, Hansen, and Pacoima Dams, Lopez Debris Dam, and Project No. 88 Diversion.
CHANNEL- concrete, rectangular section, 120 feet wide by 19 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- May 8, 1960, to date.
REMARKS- subject to diversions at mouth of Big Tujunga and Pacoima Canyons for irrigation, at Big Tujunga, Branford, Hansen, and Pacoima Spreading Grounds.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

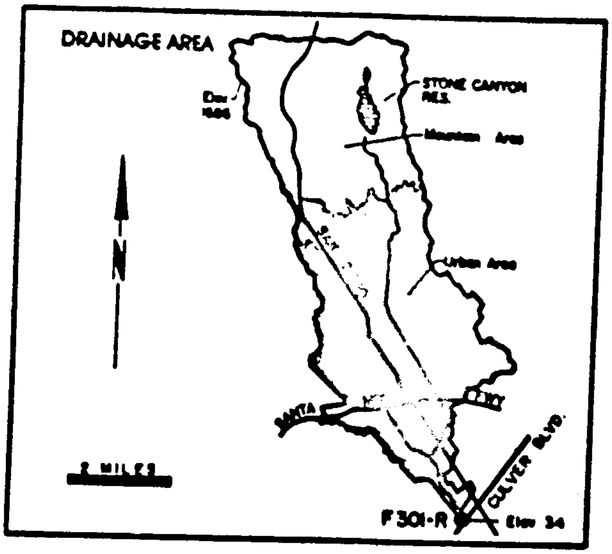
STATION NO. :

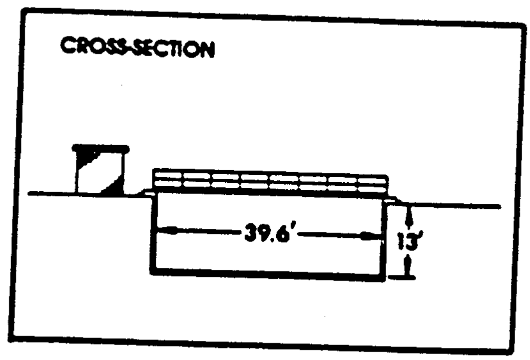
DRAINAGE AREA :

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN MAX. MIN.			NO DATA AVAILABLE AT TIME OF PRINTING									
	TOTAL AF												

R0052818

SAWTELLE-WESTWOOD CHANNEL
above Culver Boulevard
STATION NO. F301-R





RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge at station.
DRAINAGE AREA- 22.96 square miles.
LOCATION- on the south channel wall, 141 feet above Culver Boulevard bridge about one and one half miles southwest of Culver City.
REGULATION- Stone Canyon Reservoir, Southern California Water Company spills flow up to 5.0 second-feet into Sawtelle-Westwood Channel above Charnock Road for short periods nearly every day.
CHANNEL- rectangular concrete channel 40 feet wide and 13 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- see station summary.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F301-R

DRAINAGE AREA : 22.96 SQ. MI.

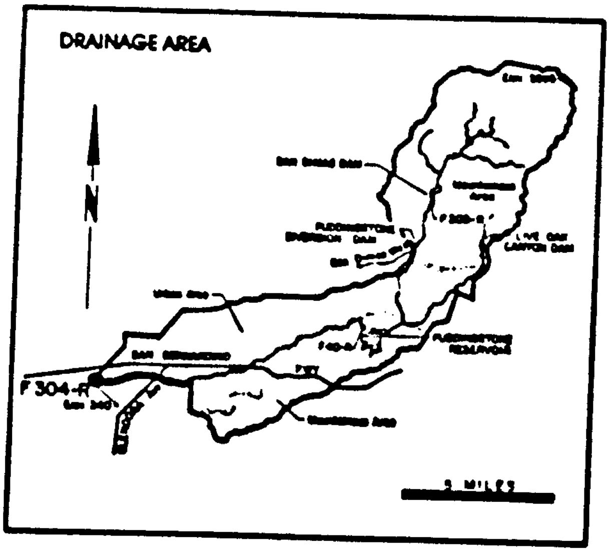
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN MAX. MIN.			NO DATA AVAILABLE AT TIME OF PRINTING									
	TOTAL AF												

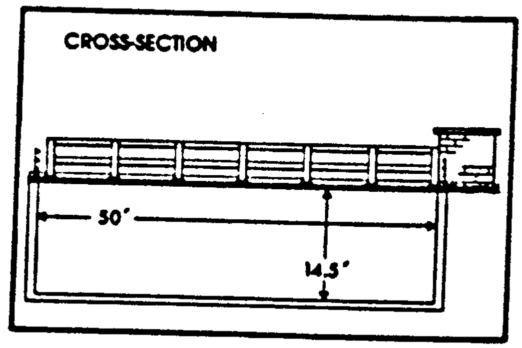
R0052819

VOL 12

1954

WALNUT CREEK
above Puente Avenue
STATION NO. F304-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 57.6 square miles.
LOCATION- 845.0 feet upstream of Puente Avenue bridge, Baldwin Park.
REGULATION- partially regulated by San Dimas, Puddingstone Diversion, Puddingstone, and Live Oak Dams.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 14, 1952 to April 11, 1961, January 3, 1962 to date.
REMARKS- no record during April 11, 1961 to January 3, 1962 due to channel construction.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F304-R

DRAINAGE AREA : 57.60 SQ. MI.

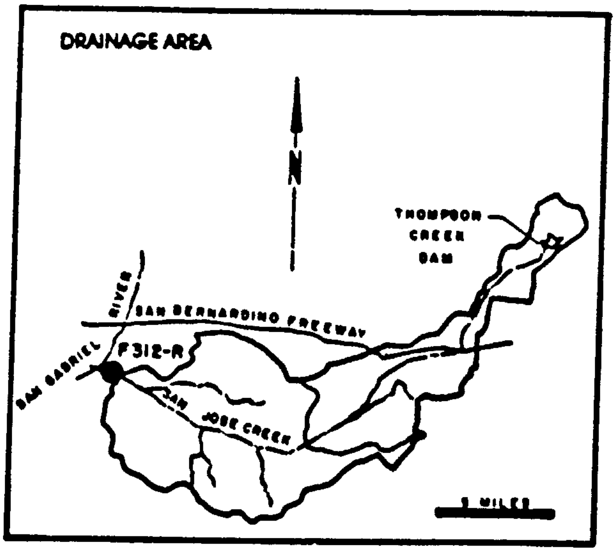
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	15.3	12.6	11.0	24.4	6.5	1.4	17.2	0.16	0.0	0.0	0.0	0.0
YEAR	MAX.	340.0	127.0	211.0	454.0	81.5	20.0	264.0	1.6	0.0	0.0	0.0	0.0
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	938.0	747.0	676.0	1500.0	372.0	85.0	1020.0	9.9	0.0	0.0	0.0	0.0

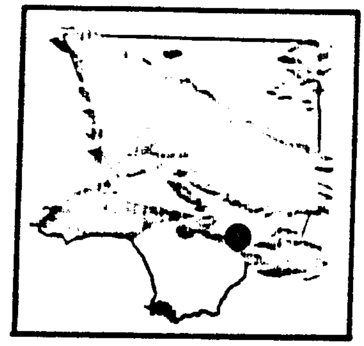
R0052820

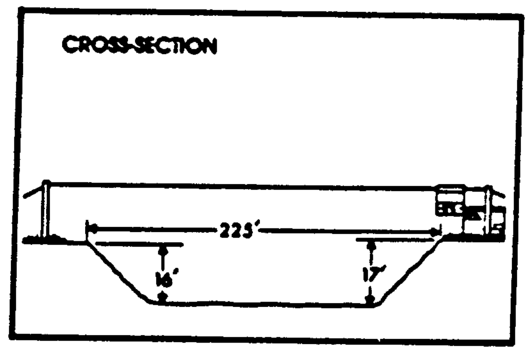
VOL 12

1955

SAN JOSE CHANNEL
above Workman Mill Road
STATION NO. F312-R







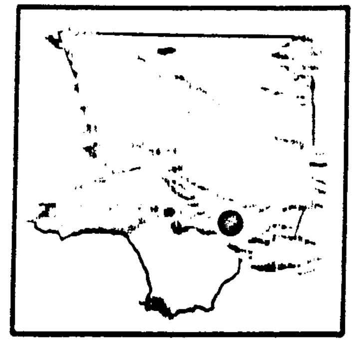
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 83.4 square miles.
LOCATION- 1,650 feet above Workman Mill Road, 3.0 miles southeast of El Monte.
REGULATION- partially regulated by Thompson Creek Dam and Pomona Sewage Treatment Plant.
CHANNEL- grouted rip-rap side slopes with natural bottom, trapezoidal section.
CONTROL- rock stabilizer.
LENGTH OF RECORD- September 13, 1956 to date.

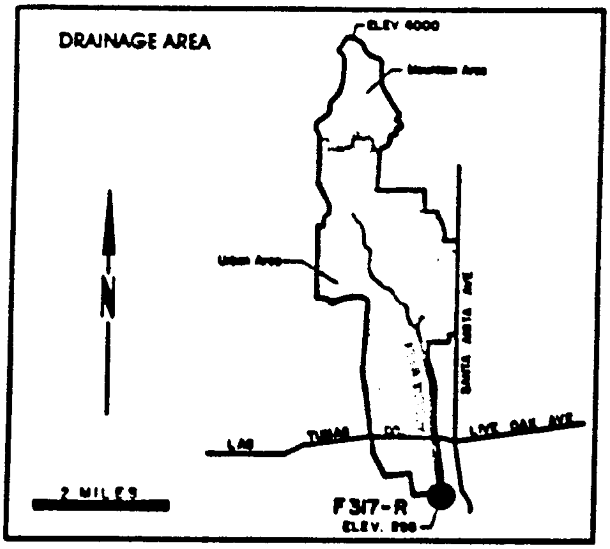
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

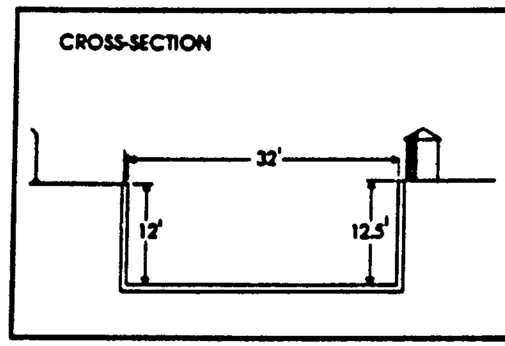
STATION NO. : F312-R　　　DRAINAGE AREA : 83.40 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	104.0	30.6	52.4	71.8	26.9	14.8	63.0	9.6	9.0	9.1	21.3	9.5
YEAR	MAX.	804.0	377.0	609.0	1700.0	275.0	134.0	780.0	12.6	10.2	10.2	86.0	18.6
87-88	MIN.	15.0	11.8	10.2	9.4	6.3	7.8	8.6	7.8	7.0	7.8	7.0	7.8
	TOTAL AF	6410.0	1820.0	3220.0	4410.0	1550.0	909.0	3750.0	591.0	537.0	562.0	1310.0	565.0

ARCADIA WASH
below Grand Avenue
STATION NO. F317-R







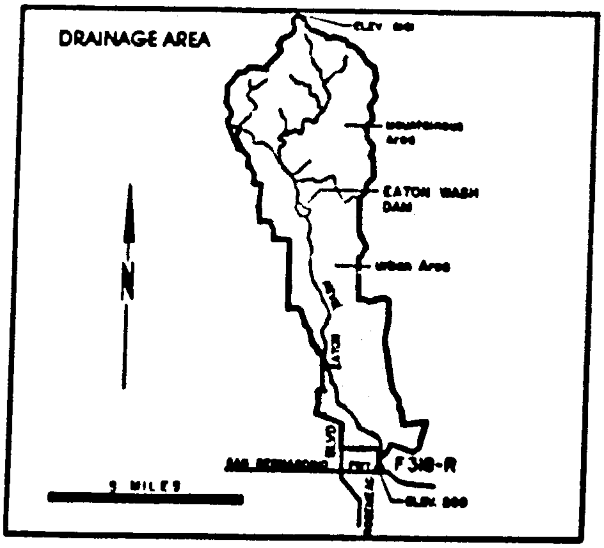
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of Grand Avenue bridge.
DRAINAGE AREA- 8.5 square miles.
LOCATION- on the west wall of Arcadia Wash about 75 feet downstream from centerline of Grand Avenue.
REGULATION- several debris basins located upstream.
CHANNEL- rectangular concrete.
LENGTH OF RECORD- December 12, 1966 to date.

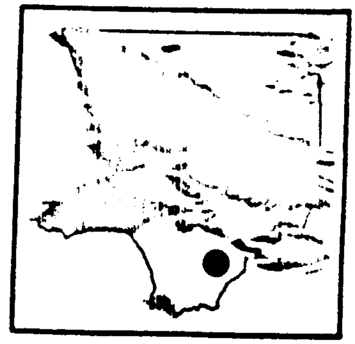
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

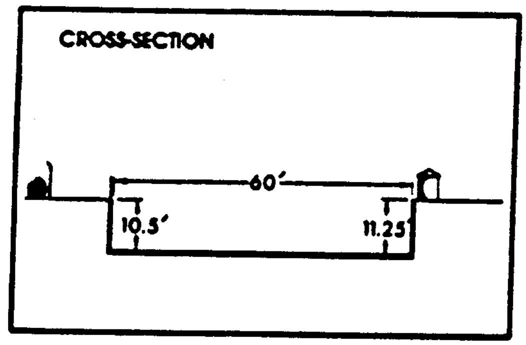
STATION NO. : F317-R DRAINAGE AREA : 8.50 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	12.3	7.8	9.8	10.5	8.9	2.4	10.0	0.54	0.51	0.35	0.46	1.3
YEAR	MAX.	171.0	117.0	139.0	284.0	97.6	48.3	112.0	0.90	0.90	0.50	4.3	29.4
87-88	MIN.	0.40	0.20	0.20	0.30	0.10	0.20	0.30	0.20	0.40	0.20	0.20	0.20
	TOTAL AF	757.0	461.0	604.0	644.0	513.0	149.0	597.0	33.0	30.0	22.0	28.0	78.0

EATON WASH
at Loftus Drive
STATION NO. F318-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of East Loftus Drive bridge.
DRAINAGE- 22.8 square miles.
LOCATION- on the west wall of the channel 52 feet above the centerline of East Loftus Drive bridge, 1.3 miles west of El Monte.
REGULATION- partly regulated by Eaton Dam.
DIVERSIONS- the Pasadena Water Department diverts some water just above the mouth of Eaton Canyon. The Flood Control District diverts water to spreading grounds below Eaton Dam and below Huntington Drive.
CHANNEL- rectangular concrete, 60 feet wide, 11.3 feet.
CONTROL- channel forms control.
LENGTH OF RECORD- 1956 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

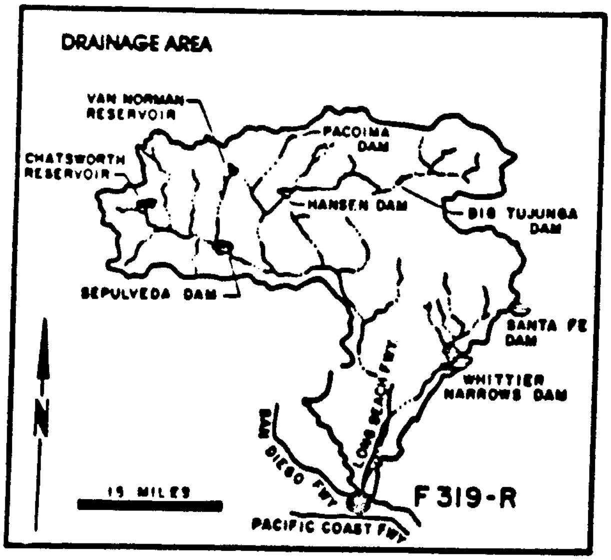
STATION NO. : F318-R DRAINAGE AREA : 22.80 SQ. MI.

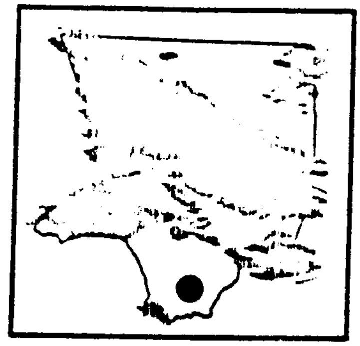
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	11.3	5.7	8.0	10.5	4.7	1.3	7.2	0.13	0.12	0.21	0.16	1.1
YEAR	MAX.	229.0	108.0	155.0	317.0	64.0	26.1	79.6	0.20	0.20	0.50	0.20	25.8
87-88	MIN.	0.10	0.10	0.0	0.0	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	TOTAL AF	695.0	336.0	490.0	648.0	272.0	77.0	431.0	8.1	7.1	13.0	9.9	62.0

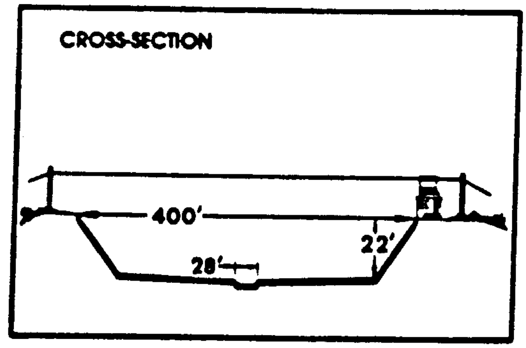
VOL 12

1958

LOS ANGELES RIVER
below Wardlow Road
STATION NO. F319-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 815.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 900.0 feet below Wardlow Road, Long Beach.
REGULATION- flow is subject to the same regulation as Stations F34D-R and F45B-R.
DIVERSIONS- flows diverted to Dominguez Gap Spreading Grounds.
CHANNEL- trapezoidal, concrete, 302.0 feet wide at bottom with 2.25:1 side slopes. Low flow channel 28.0 feet wide by 1.0 foot deep in center of channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F180-R October 31, 1931 to January 13, 1966. at Station F319-R January 13, 1966 to date.
REMARKS- prior to 1931, see Station F36-R.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F319-R

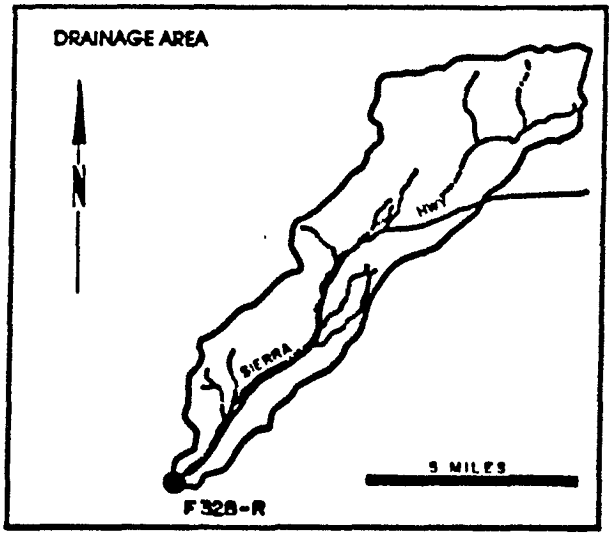
DRAINAGE AREA : 815.00 SQ. MI.

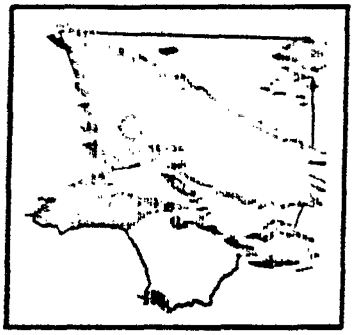
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN MAX. MIN.			NO DATA AVAILABLE AT TIME OF PRINTING									
	TOTAL AF												

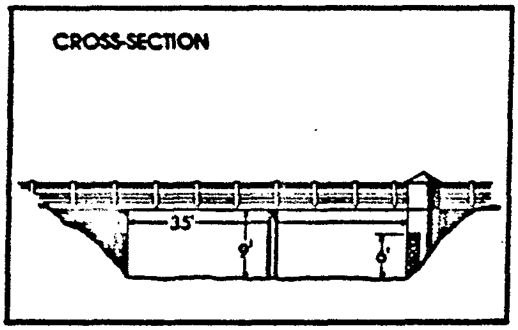
VOL 12

19519

MINT CANYON CREEK
at Finch Avenue
STATION NO. F328-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 26.9 square miles.
LOCATION- 8.5 miles northeast of Saugus on west end of Finch Avenue bridge.
REGULATION- none.
CHANNEL- natural, sand and gravel.
CONTROL- concrete control at downstream end of bridge.
LENGTH OF RECORD- October 26, 1956 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F328-R

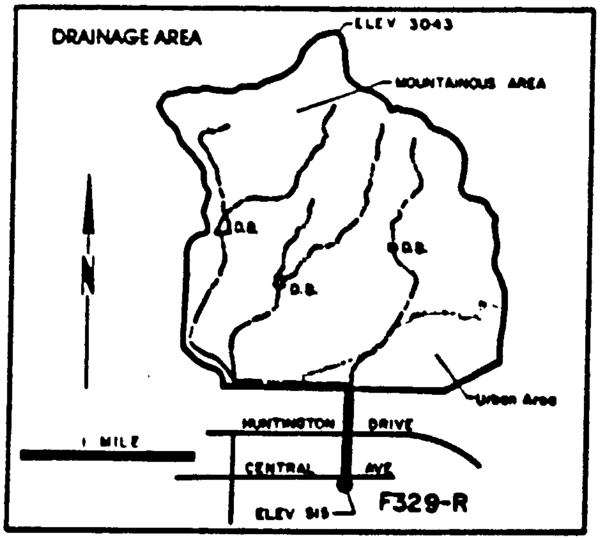
DRAINAGE AREA : 26.90 SQ. MI.

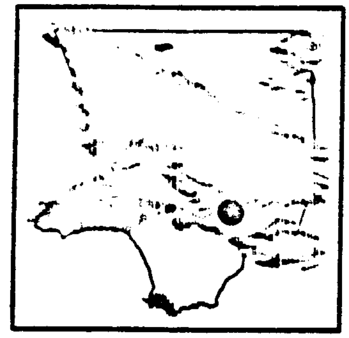
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.0	0.0	0.01	0.29	0.29	0.06	0.72	0.0	0.0	0.0	0.0	0.0
YEAR	MAX.	0.0	0.0	0.30	8.8	4.4	1.2	2.5	0.0	0.0	0.0	0.0	0.0
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.60	18.0	17.0	3.6	43.0	0.0	0.0	0.0	0.0	0.0

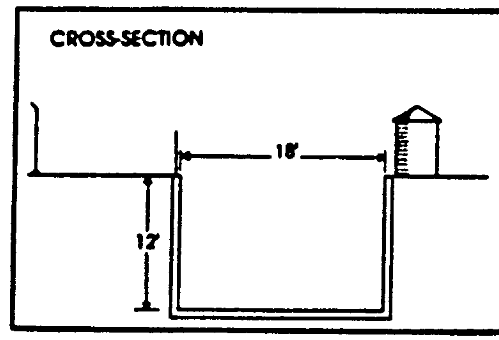
VOL 12

19520

BRADBURY CHANNEL
below Central Avenue
STATION NO. F329-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENT- low flows measured by wading. High flows measured from footbridge four feet downstream from recorder.
DRAINAGE AREA- 3.3 square miles.
LOCATION- on the east wall of Bradbury Channel, 200 feet downstream from the centerline of Central Avenue, one mile east of Duarte.
REGULATION- two debris basins located upstream.
CHANNEL- rectangular concrete, 18 feet wide, 12 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- June 14, 1967 to present.

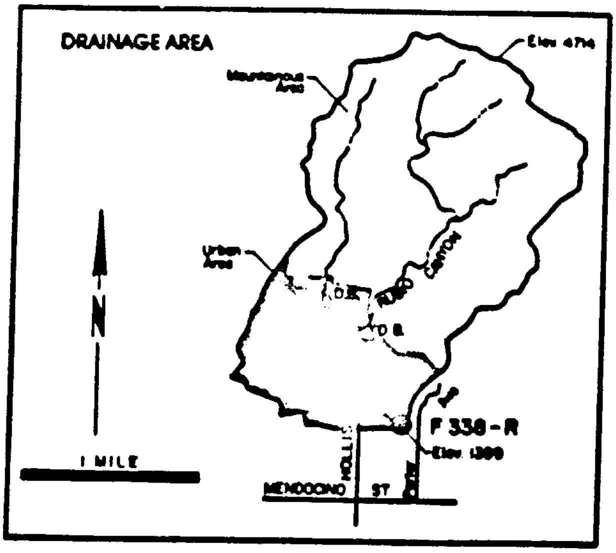
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

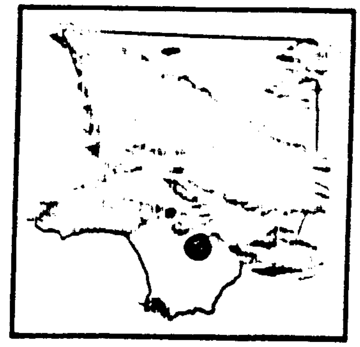
STATION NO. : F329-R DRAINAGE AREA : 3.30 SQ. MI.

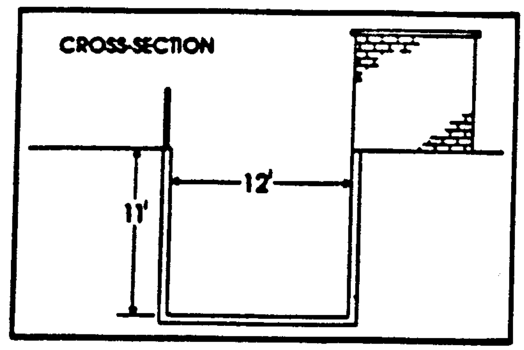
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	1.5	0.54	24.5	1.2	0.31	0.19	1.4	0.64	1.7	0.54	0.19	0.16
YEAR	MAX.	20.0	7.9	166.0	35.3	3.1	2.4	11.5	1.6	2.8	1.5	0.3	1.2
87-88	MIN.	0.0	0.0	0.0	0.0	0.1	0.10	0.10	0.10	0.60	0.10	0.0	0.0
	TOTAL AF	94.0	32.0	1510.0	75.0	18.0	12.0	82.0	39.0	99.0	33.0	12.0	9.3

R0052826

RUBIO DIVERSION CHANNEL
below Goosebury Inlet
STATION NO. F338-R







RECORDER - 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from steel footbridge 27 feet above station.
DRAINAGE AREA- 2.1 square miles.
LOCATION- on the north bank, 375 feet upstream of Crest Drive, three and one-half miles northeast of Pasadena.
REGULATION- flow partially regulated by Rubio and Gooseberry Debris Basins.
DIVERSIONS- Rubio Canyon Land and Water Association diverts low flows in Rubio Canyon.
CHANNEL- rectangular concrete, 12 feet wide and 11 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- December 16, 1959 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F338-R DRAINAGE AREA : 2.10 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.38	0.91	1.1	0.81	0.86	0.59	1.2	1.5	0.61	0.38	0.21	0.26
YEAR	MAX.	3.1	5.4	7.5	9.0	7.5	5.1	5.6	3.6	1.0	0.80	0.60	1.5
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.20	0.20	0.0	0.20	0.20
	TOTAL AF	23.0	54.0	70.0	38.0	49.0	36.0	74.0	93.0	36.0	23.0	13.0	15.0

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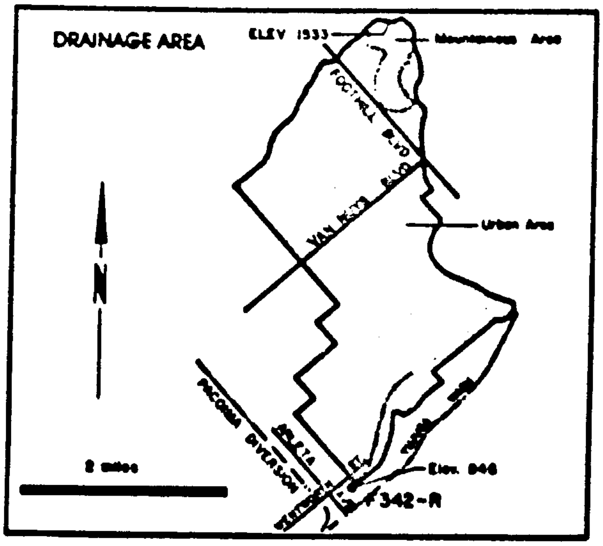
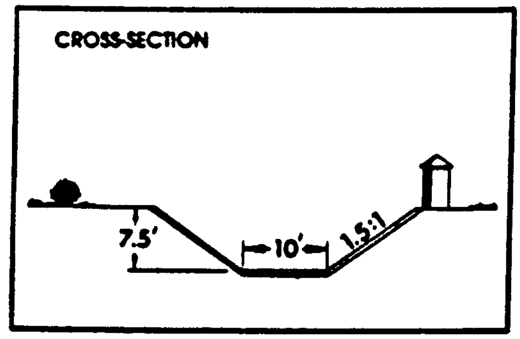
1952-2

BRANFORD STREET CHANNEL
below Sharp Avenue
STATION NO. F342-R





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19523

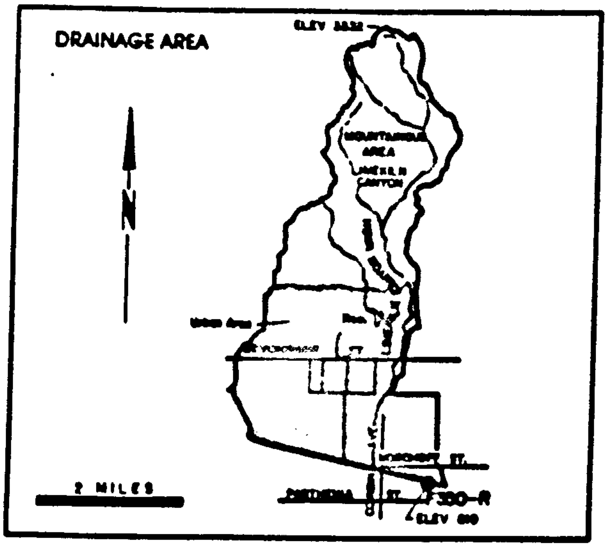
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured by floats.
DRAINAGE AREA- 5.01 square miles.
LOCATION- on the south bank of channel, 125 feet downstream from Sharp Avenue, about 3.6 miles south of San Fernando.
REGULATION- flow from Lopez Creek is diverted to Hansen Dam at the mouth of Lopez Canyon.
CHANNEL- trapezoidal, 10 feet wide at bottom and 7.5 feet deep with 1.5 to 1 side slopes.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1962 to date.

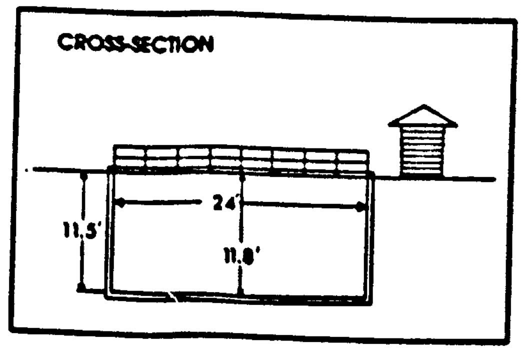
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F342-R DRAINAGE AREA : 5.01 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	6.3	1.1	1.6	1.5	3.8	1.3	1.9	0.0	0.0	0.0	0.0	0.0
YEAR	MAX.	123.0	12.1	30.2	34.6	55.1	3.2	18.9	0.0	0.0	0.0	0.0	0.0
87-88	MIN.	0.0	0.30	0.30	0.30	0.30	0.90	0.10	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	387.0	66.0	101.0	91.0	219.0	79.0	114.0	0.0	0.0	0.0	0.0	0.0

LIMEKILN CREEK
above Aliso Creek
STATION NO. F350-R





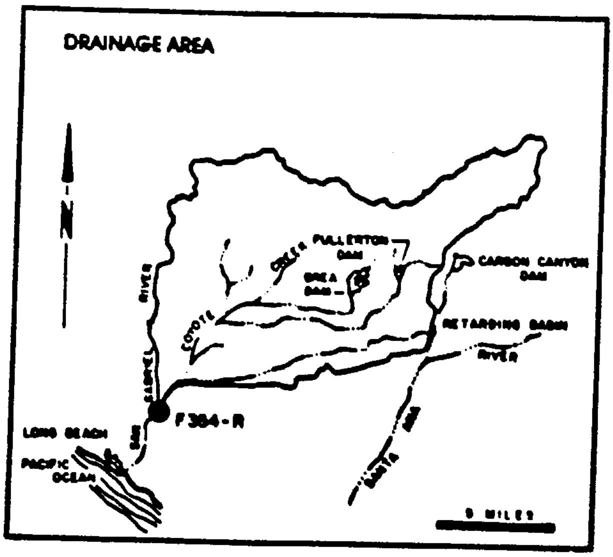
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from a steel footbridge 10 feet above the gage.
DRAINAGE AREA- 10.3 square miles.
LOCATION- on the south bank, 1,600 feet above Aliso Creek and one mile west of Northridge.
REGULATION- flow partly regulated by Limekiln Debris Basin.
CHANNEL- rectangular concrete.
LENGTH OF RECORD- see station summary.

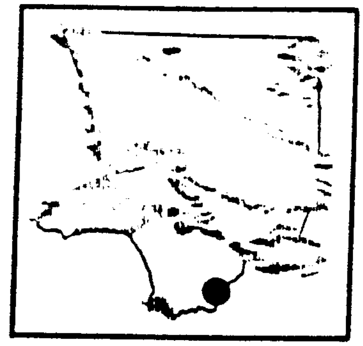
WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

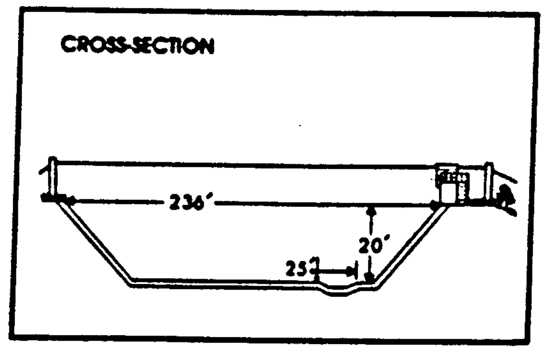
STATION NO. : F350-R — DRAINAGE AREA : 10.30 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	12.3	9.5	5.5	5.3	4.0	0.4	5.8	0.5	0.2	0.2	0.3	0.4
YEAR	MAX.	193.0	210.0	85.8	143.0	45.5	1.7	45.9	0.8	0.5	0.5	0.8	5.8
87-88	MIN.	0.2	0.1	+	+	+	+	0.3	0.4	0.1	0.1	0.2	0.1
	TOTAL AF	757.0	567.0	340.0	325.0	228.0	26.8	343.0	30.3	14.9	13.9	16.5	24.0

COYOTE CREEK
below Spring Street
STATION NO. F354-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 185.0 square miles.
LOCATION- 241.0 feet below Spring Street, 7.6 miles northeast of Long Beach.
REGULATION- partially regulated by Fullerton Dam, Brea Dam, and Carbon Canyon Dam.
CHANNEL- concrete, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD - December 17, 1963 to date.
REMARKS - previous gaging stations for record correlation: Station F41 - S December 1, 1928 to January 14, 1930. Station F41 - R January 14, 1930 to October 30, 1936. Station F41B - R October 30, 1936 to February 17, 1937. Station F41C - R February 18, 1937 to February 8, 1956. Station F320 - R February 9, 1956 to July 2, 1966.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F354-R

DRAINAGE AREA : 185.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 87-88	MEAN	80.7	26.9	72.8	156.0	46.1	14.5	102.0	10.0	9.6	11.3	9.0	21.3
	MAX.	1180.0	259.0	756.0	2940.0	644.0	123.0	945.0	10.0	13.3	16.0	33.8	73.0
	MIN.	6.8	5.2	5.5	6.1	6.1	5.5	3.1	10.0	6.1	9.4	3.7	6.1
	TOTAL AF	4960.0	1600.0	4470.0	9610.0	2650.0	891.0	6050.0	615.0	572.0	697.0	552.0	1270.0

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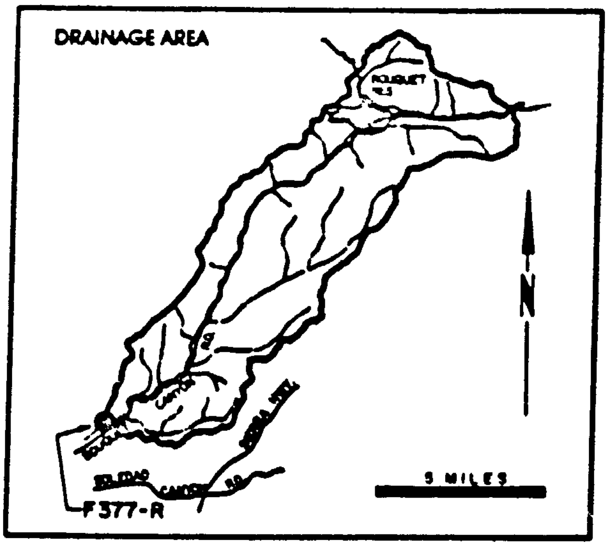
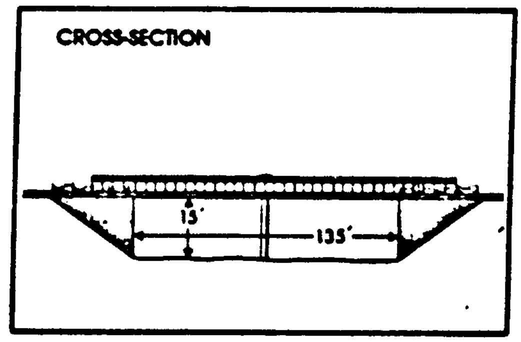
1955

BOUQUET CANYON CREEK
at Urbandale Avenue
STATION NO. F377-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 51.9 square miles.
LOCATION- Bouquet Canyon Creek at Urbandale Avenue, 3.8 miles northeast of Saugus.
REGULATION- Bouquet Reservoir.
CHANNEL- concrete sides with natural bottom, trapezoidal in section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- October 11, 1967 to date.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F377-R DRAINAGE AREA : 51.9 SQ. MI.

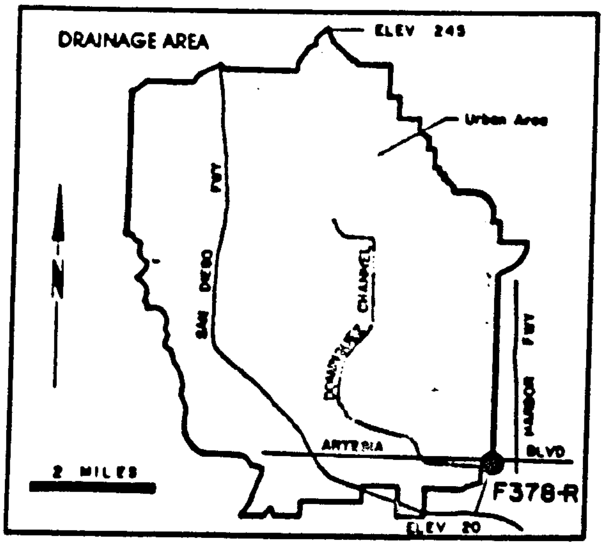
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.78	0.14	1.3	0.05	0.02	0.0	4.7	0.0	0.09	0.10	0.10	0.09
YEAR	MAX.	14.8	1.5	27.8	1.6	0.50	0.0	52.6	0.0	1.0	0.10	0.20	0.10
87-88	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.10	0.0
	TOTAL AF	48.0	8.1	77.0	3.2	1.4	0.0	279.0	0.0	5.4	6.1	6.3	5.2

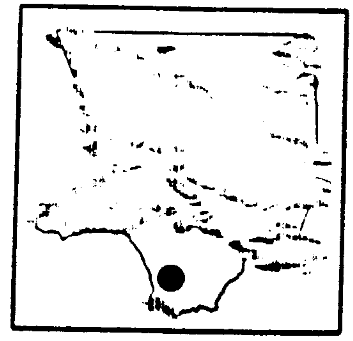
R0052831

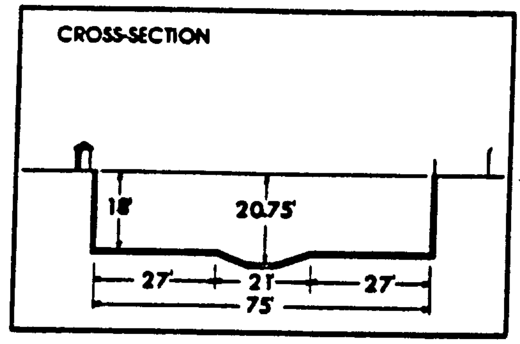
VOL 12

19526

DOMINGUEZ CHANNEL
at Vermont Avenue
STATION NO. F378-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from Vermont Avenue bridge.
DRAINAGE AREA- 37.1 square miles.
LOCATION- on the south bank, 93 feet above Vermont Avenue, about one mile south of Gardena.
REGULATION- none
CHANNEL- rectangular concrete with trapezoidal low flow channel at center.
LENGTH OF RECORD- November 23, 1966 to date.
REMARKS- gage is affected by tides greater than 4.0 feet above mean lower low water.

WATER YEAR : 1987-88
(DISCHARGE IN SEC-FT)

STATION NO. : F378-R   DRAINAGE AREA : 22.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	16.7	7.4	15.3	18.2	14.7	2.9	13.3	0.53	.76	1.1	3.9	1.8
YEAR	MAX.	276.0	64.6	192.0	443.0	167.0	28.9	134.0	0.70	1.2	1.8	79.0	10.1
87-88	MIN.	0.60	0.70	0.40	0.40	0.40	0.30	0.40	0.40	0.60	0.90	0.70	0.30
	TOTAL AF	1030.0	439.0	940.0	1120.0	846.0	180.0	790.0	33.0	45.0	69.0	237.0	97.0

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19527

VOL 12

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VOL 12

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9529

RESERVOIRS

VOL 12

19530

RESERVOIRS

Following the damaging flood of 1914 and creation of the Los Angeles County Flood Control District in 1915, it initiated a program of flood control and water conservation including the construction of 14 dams. These dams were operated by the Department during the period covered by this report. In addition, five Corps of Engineers' dams and Morris Dam owned by The Metropolitan Water District were utilized to achieve flood control and water conservation. The Corps of Engineers' dams are: Hansen Dam on Tujunga Wash, Sepulveda Dam on the Los Angeles River, Santa Fe Dam on the San Gabriel River, Whittier Narrows Dam serving both the Rio Hondo and San Gabriel River, and San Antonio Dam on San Antonio Creek.

OPERATION

The reservoirs are operated to control flood waters during storm periods. Post storm releases are made, when feasible, in amounts which can be conserved in downstream spreading grounds and by channel percolation.

SAN GABRIEL DAM HYDROELECTRIC PLANT

In December 1987, construction of two hydroelectric generator units at San Gabriel Dam was completed by San Gabriel Hydroelectric Partnership, a joint venture between private investors and the County of Los Angeles. The generator units are operated by Department personnel and the power generated is purchased by Southern California Edison Company. During December 1987 to July 1988, over two million kilowatt-hours of energy have been generated resulting in revenues of over $150,000.00. Recently an optimization computer was installed on Unit 1 to schedule power production during hours of peak energy demand.

RECORDS

The storage and flow records at the 14 Department reservoirs are summarized on the Dam Operation Record Sheets. The sheets show:

1. Reservoir water surface elevations based on the spillway datum. Elevations are obtained from water stage recorder graphs or interpolation from staff gage readings and recorded as of midnight of each day. Only maximum and minimum water surface elevations for each year are shown.

2. Storage in acre-feet based on the most recent topographic surveys. Annual storage volumes are shown.

3. Inflow in cubic feet per second. This is usually calculated from storage change and known outflow. When outflow is not known, the inflow may be determined from gaging station records or interpolated between measurements. Only the maximum and minimum of the daily flow rates for the year and the instantaneous peak flow rate are shown.

4. Outflow in cubic feet per second. These values are determined from gaging station records, known valve openings and rating curves, or from storage change and known inflow. Only the maximum and minimum of the daily outflow rates for the year and the instantaneous peak outflow rate are shown.

5. Discrepancies between outflow and storage losses at certain dams are attributable to percolation and/or evaporation losses. Total monthly evaporation losses are determined from the measurements made on floating or land evaporation pans. In those cases where no allowances were made for evaporation, the amounts are necessarily included in the flow values. Accuracy of the flow records computed from storage records is dependent on the frequency with which storage data are revised to keep in step with the physical change in reservoirs.

VOL 12

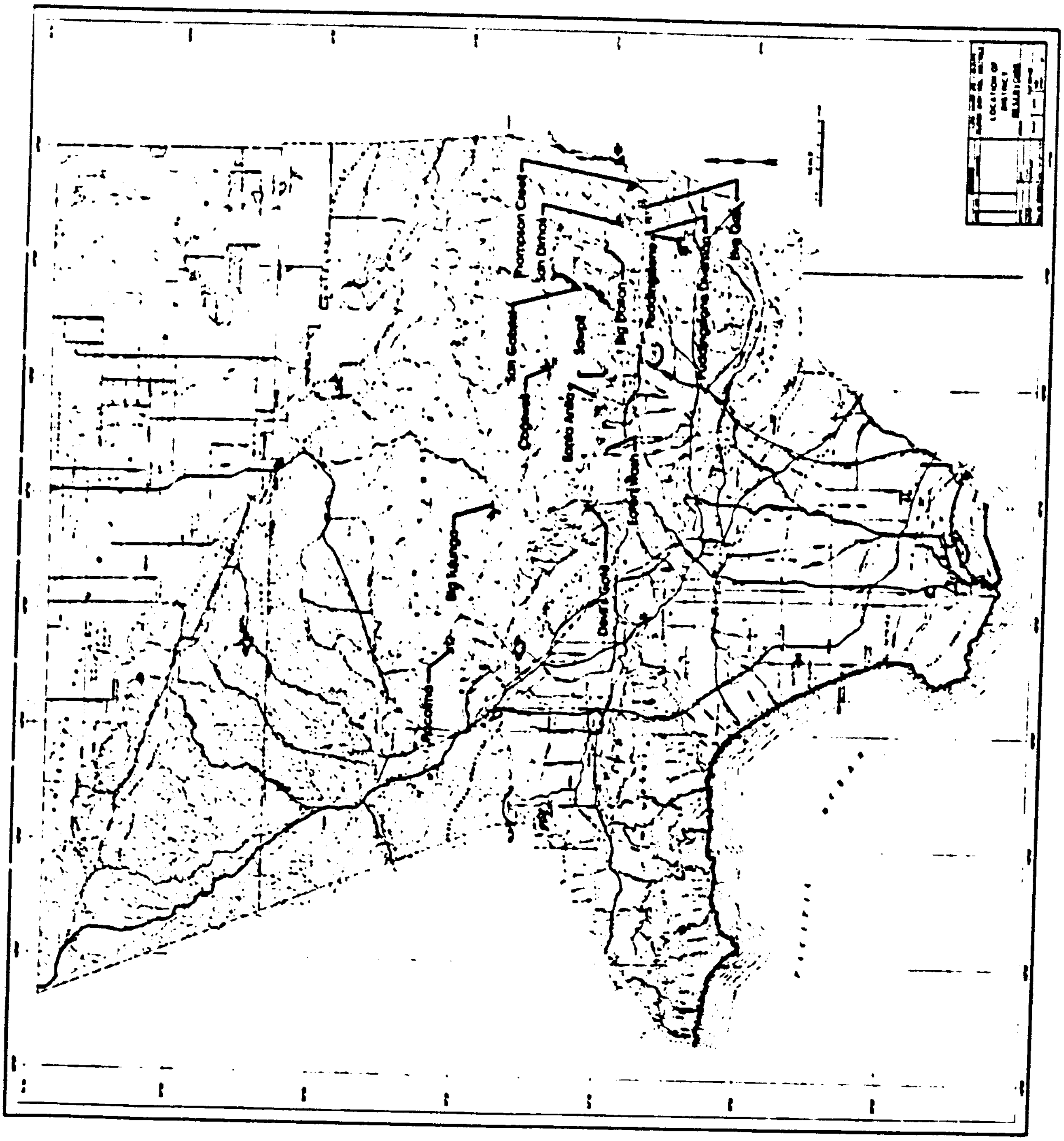
1953 1

VOL 12

PD1

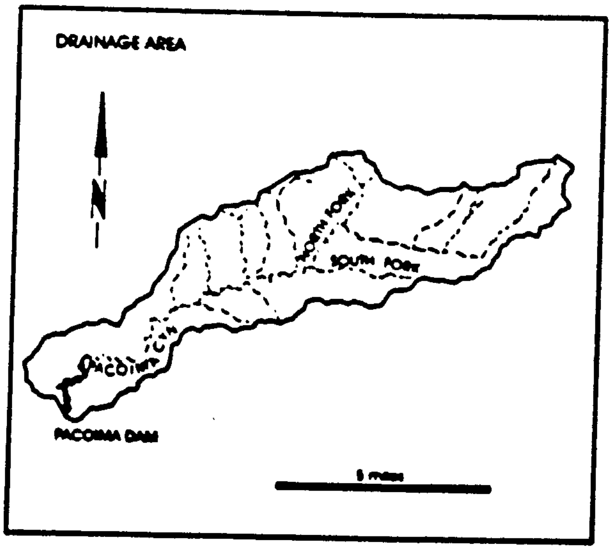
1

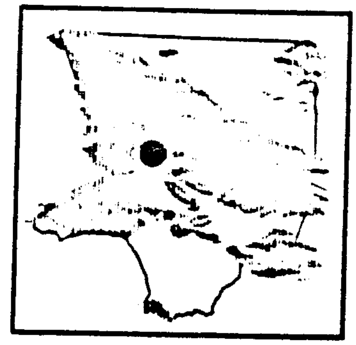
9532

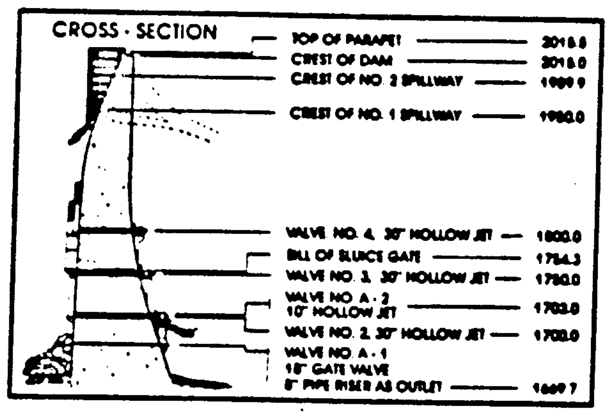


R0052837

PACOIMA DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1925. Completed February 1929.
LOCATION - Pacoima Canyon, 4.0 miles northeast of San Fernando.
DRAINAGE AREA - 28.2 square miles.
CAPACITY - 3,929 acre - feet.
SPILLWAY ELEVATION - 1,950.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	92.49	CFS	from	0400	on	10-23-87	to	0500	on	10-23-87
MAX. PEAK OUTFLOW	86.50	CFS	from	0300	on	01-20-88	to	0400	on	01-20-88
MAX. W.S. ELEVATION	1915.18	feet		on	12-30-87	STORAGE	2131.20	ACRE-FEET		
MIN. W.S. ELEVATION	1881.35	feet		on	01-27-88	STORAGE	1122.40	ACRE-FEET		

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PACOIMA DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	252.50	287.10	237.30	582.80
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	119.40	1415.00
MAX. MEAN DAILY INFLOW (CFS)	49.70	28.80	12.90	37.10
TOTAL MONTHLY LOSSES (AF)	17.80	16.10	13.90	13.70
MIN. MEAN DAILY INFLOW (CFS)	0.10	1.50	1.40	1.40
MONTHLY STORAGE CHANGE (AF)	234.70	271.00	104.40	-845.90

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	371.90	704.50	631.30	294.80
TOTAL MONTHLY OUTFLOW (AF)	0.00	1094.10	0.00	808.30
MAX. MEAN DAILY INFLOW (CFS)	47.70	52.10	48.80	9.90
TOTAL MONTHLY LOSSES (AF)	17.40	22.10	13.40	18.60
MIN. MEAN DAILY INFLOW (CFS)	2.10	1.10	1.90	2.30
MONTHLY STORAGE CHANGE (AF)	354.50	-411.70	617.90	-532.00

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	73.60	37.90	27.20	20.80
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.40	3.40
MAX. MEAN DAILY INFLOW (CFS)	2.30	0.90	0.80	0.70
TOTAL MONTHLY LOSSES (AF)	14.40	17.80	16.60	17.20
MIN. MEAN DAILY INFLOW (CFS)	0.70	0.30	0.30	0.20
MONTHLY STORAGE CHANGE (AF)	59.20	20.10	10.20	0.20

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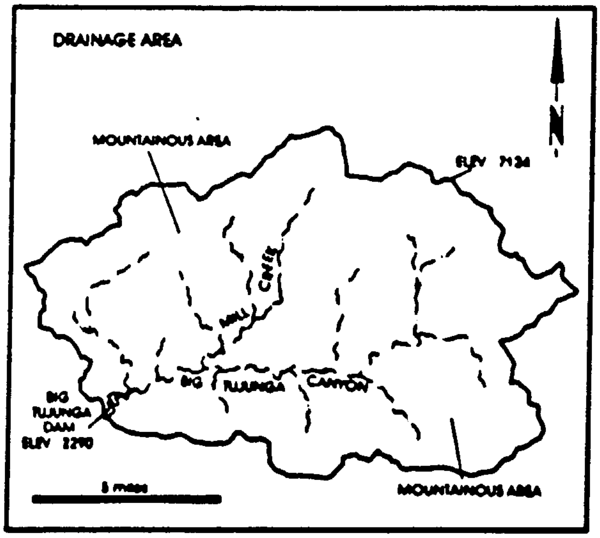
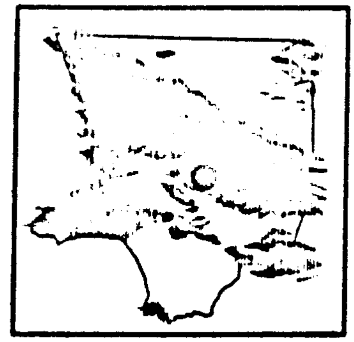
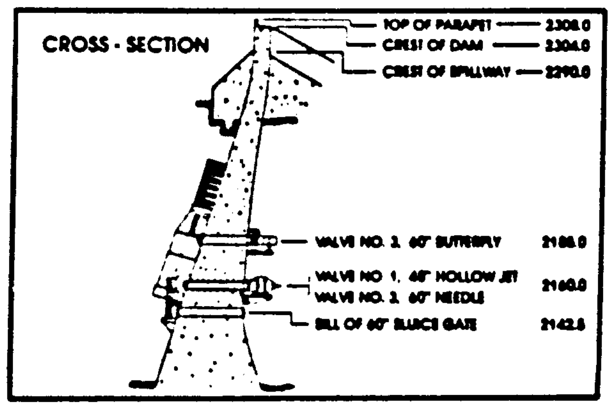
1954-34

BIG TUJUNGA DAM
AND RESERVOIR







PURPOSE - Flood Control Conservation.
DATE CONSTRUCTED - Started January 1930. Completed July 1931.
LOCATION - Big Tujunga Canyon, 10.0 miles northeast of Sunland.
DRAINAGE AREA - 82.3 square miles.
CAPACITY - 6,027 acre - feet.
SPILLWAY ELEVATION - 2,290.0 feet.

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1 9535

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	884.70	CFS	from	2100	on	02-29-88	to	2200	on	02-29-88
MAX. PEAK OUTFLOW	290.00	CFS	from	1100	on	03-01-88	to	1115	on	03-01-88
MAX. W.S. ELEVATION	2219.45	feet		on	03-01-88	STORAGE	1479.20	ACRE-FEET		
MIN. W.S. ELEVATION	2204.85	feet		on	11-10-87	STORAGE	1043.90	ACRE-FEET		

R0052840

BIG TUJUNGA DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	362.00	658.70	438.80	1168.90
TOTAL MONTHLY OUTFLOW (AF)	169.00	656.50	623.70	1158.10
MAX. MEAN DAILY INFLOW (CFS)	55.00	68.20	32.70	142.50
TOTAL MONTHLY LOSSES (AF)	12.90	7.20	7.20	7.90
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.50	0.30	5.40
MONTHLY STORAGE CHANGE (AF)	180.20	-5.00	-192.10	0.80

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	888.70	1426.90	1389.30	505.20
TOTAL MONTHLY OUTFLOW (AF)	617.30	1665.50	1217.70	614.10
MAX. MEAN DAILY INFLOW (CFS)	153.50	189.50	153.50	12.20
TOTAL MONTHLY LOSSES (AF)	10.20	11.70	10.80	16.00
MIN. MEAN DAILY INFLOW (CFS)	4.30	5.20	6.30	4.40
MONTHLY STORAGE CHANGE (AF)	261.20	-250.40	160.80	-124.80

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	170.90	42.10	31.80	39.40
TOTAL MONTHLY OUTFLOW (AF)	29.40	30.70	19.80	100.20
MAX. MEAN DAILY INFLOW (CFS)	5.50	1.60	1.30	1.70
TOTAL MONTHLY LOSSES (AF)	17.00	22.20	18.30	20.00
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.10	0.00	0.10
MONTHLY STORAGE CHANGE (AF)	124.50	-10.80	-6.30	-80.70

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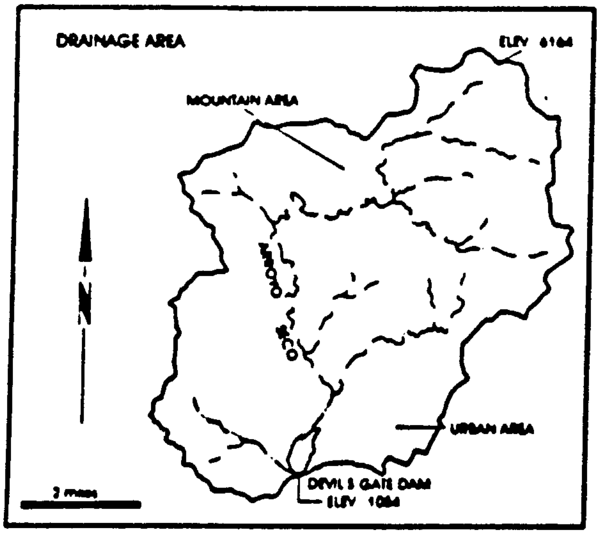
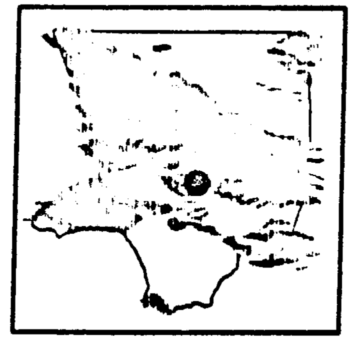
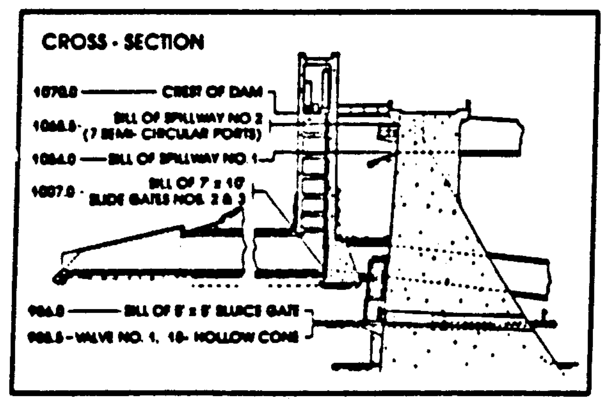
DEVIL'S GATE DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started May 1919. Completed June 1920.
LOCATION - On Arroyo Seco, northwest of Pasadena.
DRAINAGE AREA - 31.9 square miles.
CAPACITY - 1,928 acre - feet.
SPILLWAY ELEVATION - 1,064.0 feet.



DAM OPERATION RECORD SUMMARY *

MAX. PEAK INFLOW	225.80	CFS	from	1300	on	10-31-87	to	1315	on	10-31-87
MAX. PEAK OUTFLOW	671.00	CFS	from	0745	on	11-06-87	to	0800	on	11-06-87
MAX. W.S. ELEVATION	1016.85	feet	on	11-05-87	STORAGE	94.50	ACRE-FEET			
MIN. W.S. ELEVATION	992.00	feet	on	VARIES	STORAGE	0.00	ACRE-FEET			

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DEVIL'S GATE DAM OPERATION RECORD SUMMARY *

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	184.50	482.20	393.50	221.20
TOTAL MONTHLY OUTFLOW (AF)	181.10	485.60	393.50	221.20
MAX. MEAN DAILY INFLOW (CFS)	16.70	98.30	91.30	23.20
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.20	1.60	1.60	0.90
MONTHLY STORAGE CHANGE (AF)	3.40	-3.40	0.00	0.00

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	316.00	239.80	509.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	316.00	239.80	509.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	80.90	30.30	88.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.70	1.70	1.70	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

* = VALUES ESTIMATED DUE TO INCOMPLETE RECORDS

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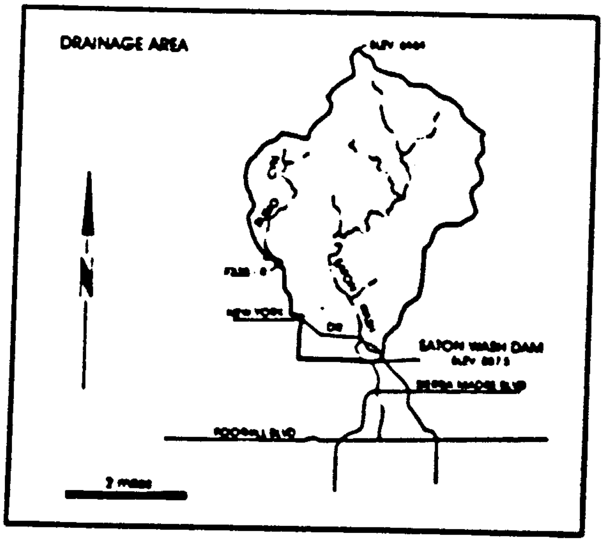
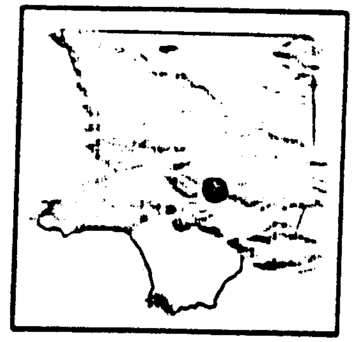
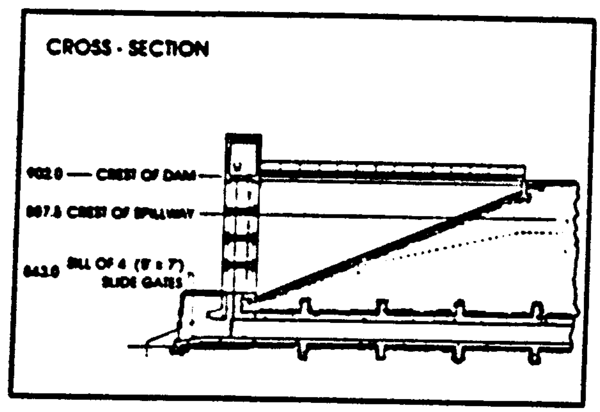
1 9538

EATON WASH DAM
AND RESERVOIR







PURPOSE - Debris Storage and Conservation.
DATE CONSTRUCTED - Started January 1936 . Completed February 1937.
LOCATION - Eaton Wash, northeast of Pasadena.
DRAINAGE AREA - 12.4 square miles.
CAPACITY - 879 acre - feet.
SPILLWAY ELEVATION - 887.5 feet.

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1 9539

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	227.50	CFS	from	1700	on	02-29-88	to	1800	on	02-29-88
MAX. PEAK OUTFLOW	28.80	CFS	from	1400	on	04-25-88	to	1415	on	04-25-88
MAX. W.S. ELEVATION	869.10	feet	on	04-25-88	STORAGE	204.20	ACRE-FEET			
MIN. W.S. ELEVATION	845.00	feet	on	VARIES	STORAGE	0.00	ACRE-FEET			

EATON WASH DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	101.80	53.40	67.10	128.80
TOTAL MONTHLY OUTFLOW (AF)	0.00	128.50	41.10	97.60
MAX. MEAN DAILY INFLOW (CFS)	19.90	10.90	3.90	22.00
TOTAL MONTHLY LOSSES (AF)	5.40	2.00	13.10	13.50
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	96.30	-77.10	13.00	17.70

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	148.80	124.00	214.20	8.90
TOTAL MONTHLY OUTFLOW (AF)	22.00	199.50	152.70	6.10
MAX. MEAN DAILY INFLOW (CFS)	55.00	18.90	31.40	1.70
TOTAL MONTHLY LOSSES (AF)	23.80	35.80	23.20	54.40
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	102.80	-111.30	38.30	-51.60

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	1.20	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	1.20	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.20	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

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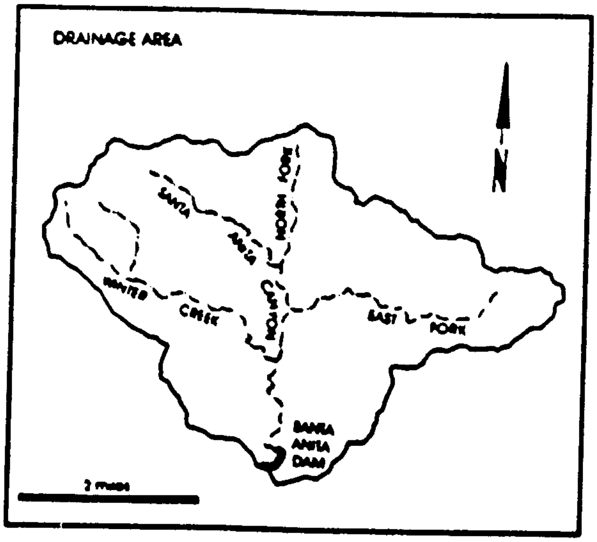
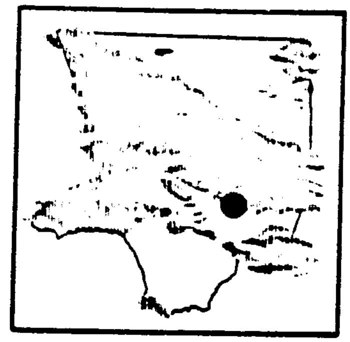
1

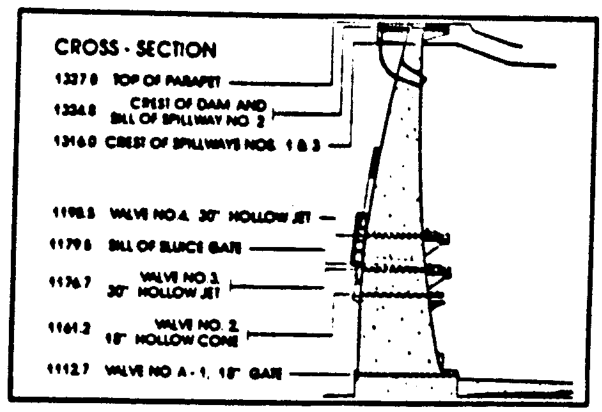
9540

SANTA ANITA DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started October 1924. Completed March 1927.
LOCATION - 2.5 miles north of Arcadia
DRAINAGE AREA - 10.8 square miles.
CAPACITY - 836 acre - feet.
SPILLWAY ELEVATION - 1,316.0 feet.



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DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	87.20	CFS	from	1900	on	01-17-88	to	2000	on	01-17-88	
MAX. PEAK OUTFLOW	37.50	CFS	from	0900	on	03-02-88	to	1000	on	03-02-88	
MAX. W.S. ELEVATION	1272.23	feet	on	01-19-88	STORAGE	373.30	ACRE-FEET				
MIN. W.S. ELEVATION	1236.00	feet	on	12-10-87	STORAGE	144.30	ACRE-FEET				

SANTA ANITA DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	123.20	253.10	191.10	397.00
TOTAL MONTHLY OUTFLOW (AF)	85.90	222.20	158.70	497.10
MAX. MEAN DAILY INFLOW (CFS)	18.10	15.70	10.90	37.00
TOTAL MONTHLY LOSSES (AF)	1.70	2.80	1.00	1.20
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.30	0.30	0.80
MONTHLY STORAGE CHANGE (AF)	35.80	28.30	31.40	-101.30

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	251.20	429.50	381.50	223.70
TOTAL MONTHLY OUTFLOW (AF)	129.90	453.40	434.00	171.40
MAX. MEAN DAILY INFLOW (CFS)	34.40	34.80	23.50	7.00
TOTAL MONTHLY LOSSES (AF)	1.80	2.10	1.70	2.30
MIN. MEAN DAILY INFLOW (CFS)	2.20	2.80	2.00	1.70
MONTHLY STORAGE CHANGE (AF)	119.50	-26.00	-54.20	50.10

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	113.30	56.30	34.00	35.80
TOTAL MONTHLY OUTFLOW (AF)	168.80	78.70	0.00	87.90
MAX. MEAN DAILY INFLOW (CFS)	3.80	1.80	0.70	1.90
TOTAL MONTHLY LOSSES (AF)	2.30	2.40	2.40	2.80
MIN. MEAN DAILY INFLOW (CFS)	0.70	0.10	0.40	0.20
MONTHLY STORAGE CHANGE (AF)	-57.80	-24.80	31.80	-54.70

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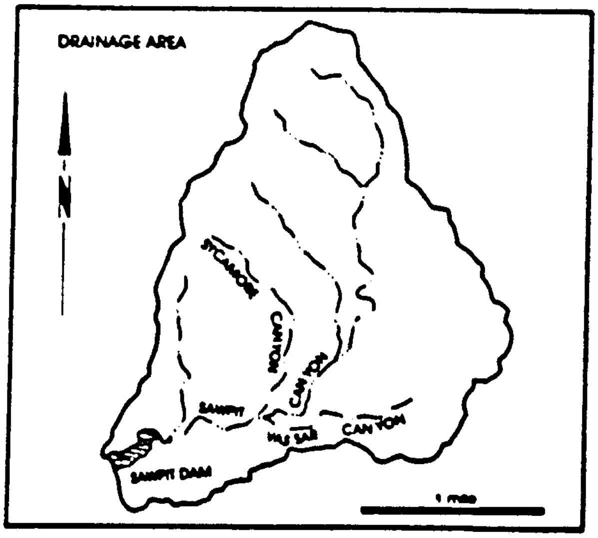
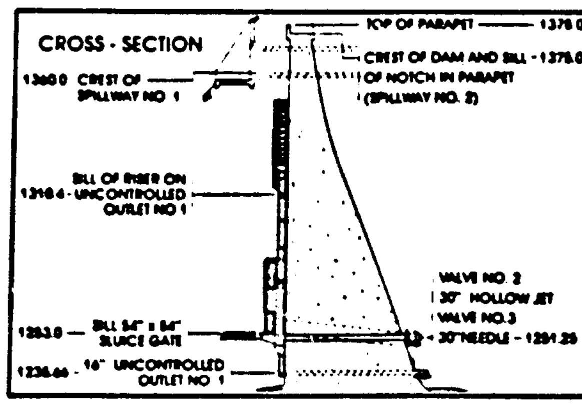
SAWPIT DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1926. Completed June 1927.
LOCATION - 2.0 miles north of Monrovia.
DRAINAGE AREA - 3.2 square miles.
CAPACITY - 391 acre - feet.
SPILLWAY ELEVATION - 1,360.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	5.00	CFS	from	2100	on	03-01-88	to	2200	on	03-01-88
MAX. PEAK OUTFLOW	17.00	CFS	from	1845	on	10-22-87	to	2000	on	10-22-87
MAX. W.S. ELEVATION	1310.63	feet	on	04-20-88	STORAGE	97.10	ACRE-FEET			
MIN. W.S. ELEVATION	1310.11	feet	on	09-14-88	STORAGE	95.20	ACRE-FEET			

R0052848

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SAWPIT DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	57.20	113.60	103.30	148.70
TOTAL MONTHLY OUTFLOW (AF)	56.90	113.90	103.30	148.80
MAX. MEAN DAILY INFLOW (CFS)	5.00	4.90	2.40	7.30
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.30	1.00	0.90	1.00
MONTHLY STORAGE CHANGE (AF)	0.20	-0.20	0.00	0.00

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	114.40	115.40	120.20	24.80
TOTAL MONTHLY OUTFLOW (AF)	114.40	115.40	120.20	24.80
MAX. MEAN DAILY INFLOW (CFS)	3.00	3.90	7.20	1.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.90	0.80	0.90	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	46.80	46.00	46.00	38.90
TOTAL MONTHLY OUTFLOW (AF)	46.80	46.00	46.00	38.90
MAX. MEAN DAILY INFLOW (CFS)	0.80	0.80	0.80	0.80
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.50	0.00	0.10	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

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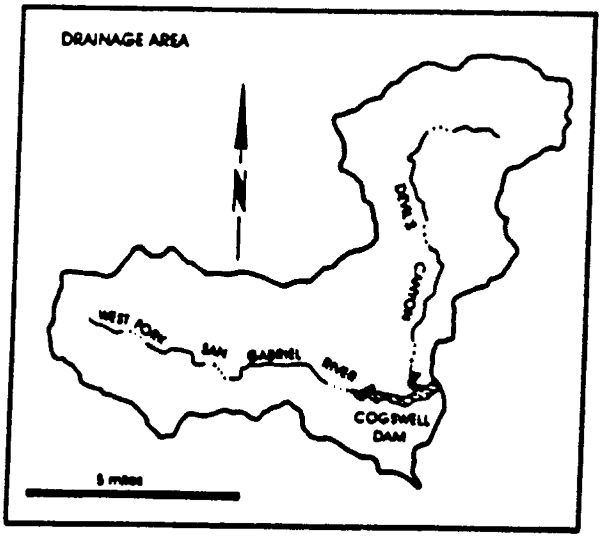
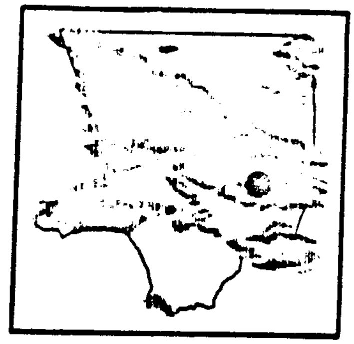
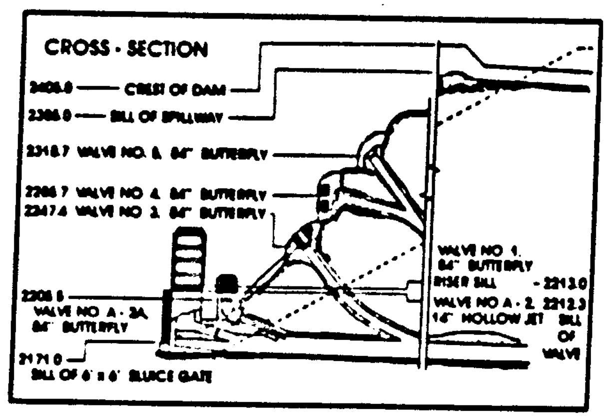
1954 4

COGSWELL DAM
AND RESERVOIR







PURPOSE - Flood Control, Conservation, and Recreation.
DATE CONSTRUCTED - Started March 1932. Completed April 1934.
LOCATION - 22.0 miles north of Azusa.
DRAINAGE AREA - 39.2 square miles.
CAPACITY - 9,339 acre - feet.
SPILLWAY ELEVATION - 2,385.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	527.90	CFS	from	0600	on	03-01-88	to	0700	on	03-01-88
MAX. PEAK OUTFLOW	756.00	CFS	from	1100	on	01-27-88	to	1115	on	01-27-88
MAX. W.S. ELEVATION	2329.39	feet	on	06-03-88	STORAGE	3012.30	ACRE-FEET			
MIN. W.S. ELEVATION	2261.02	feet	on	10-22-87	STORAGE	442.70	ACRE-FEET			

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1 9545

R0052850

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COGSWELL DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	344.50	1008.90	1096.60	1957.60
TOTAL MONTHLY OUTFLOW (AF)	168.60	306.20	1692.90	1987.60
MAX. MEAN DAILY INFLOW (CFS)	107.00	102.40	39.00	198.60
TOTAL MONTHLY LOSSES (AF)	5.90	4.60	2.50	3.20
MIN. MEAN DAILY INFLOW (CFS)	0.40	4.60	7.50	10.50
MONTHLY STORAGE CHANGE (AF)	170.00	698.00	-598.70	-33.30

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1433.40	2605.50	1779.30	844.00
TOTAL MONTHLY OUTFLOW (AF)	817.40	3020.20	248.90	287.40
MAX. MEAN DAILY INFLOW (CFS)	203.80	282.20	159.20	24.20
TOTAL MONTHLY LOSSES (AF)	4.10	7.30	9.90	33.50
MIN. MEAN DAILY INFLOW (CFS)	9.70	11.50	7.20	7.40
MONTHLY STORAGE CHANGE (AF)	611.90	-421.90	1520.50	523.10

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	332.60	105.20	56.50	56.80
TOTAL MONTHLY OUTFLOW (AF)	575.00	608.90	613.90	591.70
MAX. MEAN DAILY INFLOW (CFS)	6.60	3.90	4.20	2.20
TOTAL MONTHLY LOSSES (AF)	39.80	44.50	34.70	25.30
MIN. MEAN DAILY INFLOW (CFS)	1.30	0.10	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	-282.20	-548.20	-592.10	-560.20

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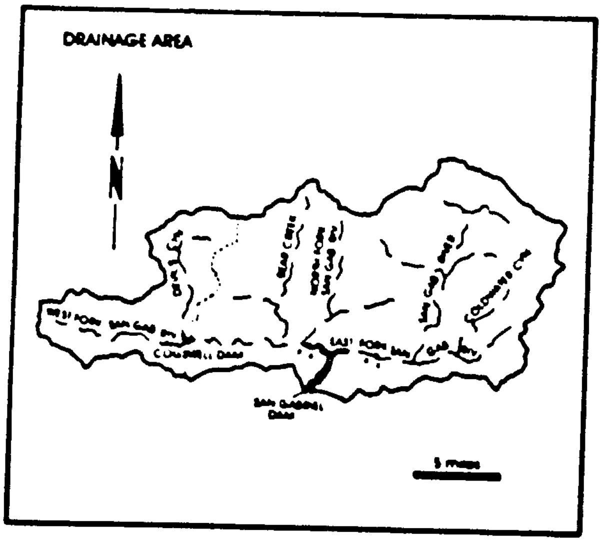
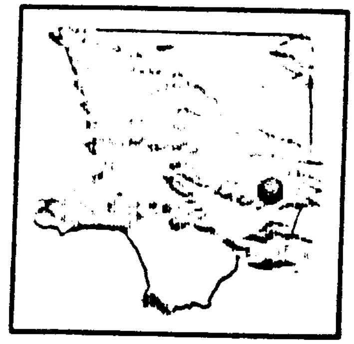
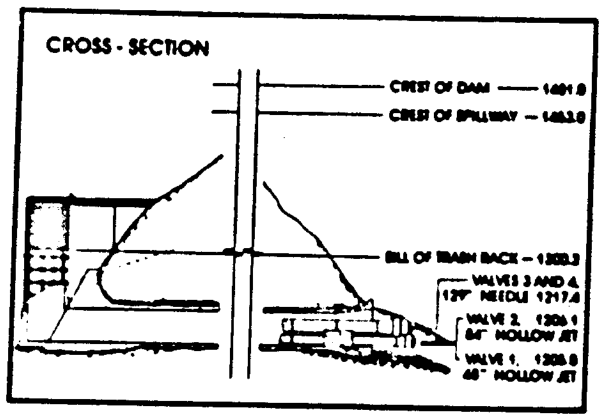
SAN GABRIEL DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1932. Completed July 1939.
LOCATION - San Gabriel Canyon, 7.5 miles north of Azusa.
DRAINAGE AREA - 163.5 square miles (uncontrolled)
39.2 square miles (controlled)
Total 202.7 square miles
(Includes Cogswell drainage)
CAPACITY - 41,549 acre - feet.
SPILLWAY ELEVATION - 1,453 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	814.00	CFS	from	2200	on	02-29-88	to	2300	on	02-29-88
MAX. PEAK OUTFLOW	476.00	CFS	from	0000	on	01-19-88	to	0015	on	01-19-88
MAX. W.S. ELEVATION	1404.13	feet	on	06-21-88	STORAGE	22543.00	ACRE-FEET			
MIN. W.S. ELEVATION	1329.93	feet	on	10-01-87	STORAGE	2979.90	ACRE-FEET			

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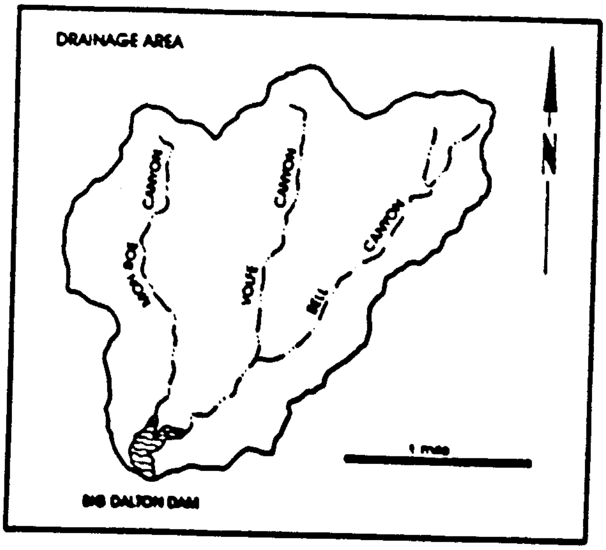
SAN GABRIEL DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	2631.00	6330.20	6268.80	8870.70
TOTAL MONTHLY OUTFLOW (AF)	473.70	7346.80	6150.70	9234.40
MAX. MEAN DAILY INFLOW (CFS)	265.40	359.50	184.60	473.80
TOTAL MONTHLY LOSSES (AF)	61.70	57.70	37.70	34.10
MIN. MEAN DAILY INFLOW (CFS)	3.80	65.10	46.20	49.10
MONTHLY STORAGE CHANGE (AF)	2095.70	-1074.30	80.30	-397.90

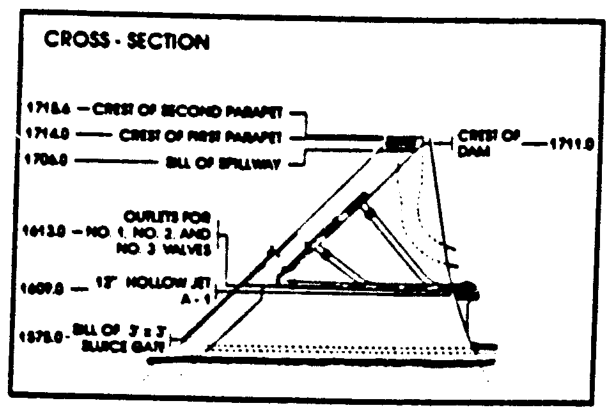
WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	5480.80	10231.10	9118.60	7318.30
TOTAL MONTHLY OUTFLOW (AF)	3449.90	3052.00	1683.40	4629.80
MAX. MEAN DAILY INFLOW (CFS)	376.10	574.00	504.70	190.70
TOTAL MONTHLY LOSSES (AF)	60.90	124.70	122.50	210.60
MIN. MEAN DAILY INFLOW (CFS)	59.00	83.40	57.70	73.10
MONTHLY STORAGE CHANGE (AF)	1970.10	7054.40	7312.70	2477.90

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	4096.90	2285.10	1869.70	1599.90
TOTAL MONTHLY OUTFLOW (AF)	4150.60	3091.40	3086.70	2987.10
MAX. MEAN DAILY INFLOW (CFS)	90.20	46.60	49.20	39.70
TOTAL MONTHLY LOSSES (AF)	223.40	257.80	236.10	209.80
MIN. MEAN DAILY INFLOW (CFS)	56.80	29.40	23.70	20.10
MONTHLY STORAGE CHANGE (AF)	-277.20	-1084.10	-1453.10	-1597.00

BIG DALTON DAM
AND RESERVOIR



PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1927. Completed August 1929.
LOCATION - Big Dalton Canyon, 4.0 miles northeast of Glendora.
DRAINAGE AREA - 4.5 square miles.
CAPACITY - 963 acre - feet.
SPILLWAY ELEVATION - 1,706.0 feet.



DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	17.40	CFS	from	1000	on	01-17-88	to	1100	on	01-17-88
MAX. PEAK OUTFLOW	8.80	CFS	from	1015	on	09-12-88	to	1030	on	09-12-88
MAX. W.S. ELEVATION	1640.90	feet	on	04-25-88	STORAGE	89.10	ACRE-FEET			
MIN. W.S. ELEVATION	1630.20	feet	on	04-29-88	STORAGE	53.20	ACRE-FEET			

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BIG DALTON DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	5.40	9.90	25.40	63.80
TOTAL MONTHLY OUTFLOW (AF)	1.00	0.00	27.80	57.90
MAX. MEAN DAILY INFLOW (CFS)	0.90	0.40	0.80	6.90
TOTAL MONTHLY LOSSES (AF)	1.20	0.80	0.80	0.50
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.30
MONTHLY STORAGE CHANGE (AF)	3.20	9.10	-3.20	5.20

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	41.90	62.40	59.40	36.50
TOTAL MONTHLY OUTFLOW (AF)	39.50	59.70	83.70	30.90
MAX. MEAN DAILY INFLOW (CFS)	2.80	3.20	3.10	1.30
TOTAL MONTHLY LOSSES (AF)	0.80	1.10	2.20	2.80
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.30	0.10	0.00
MONTHLY STORAGE CHANGE (AF)	1.70	1.60	-28.50	2.90

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	14.60	9.50	9.20	4.50
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	15.90	7.10
MAX. MEAN DAILY INFLOW (CFS)	0.30	0.30	0.40	0.20
TOTAL MONTHLY LOSSES (AF)	2.30	2.20	3.80	1.40
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	12.30	7.20	-10.50	-4.00

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SAN DIMAS DAM
AND RESERVOIR

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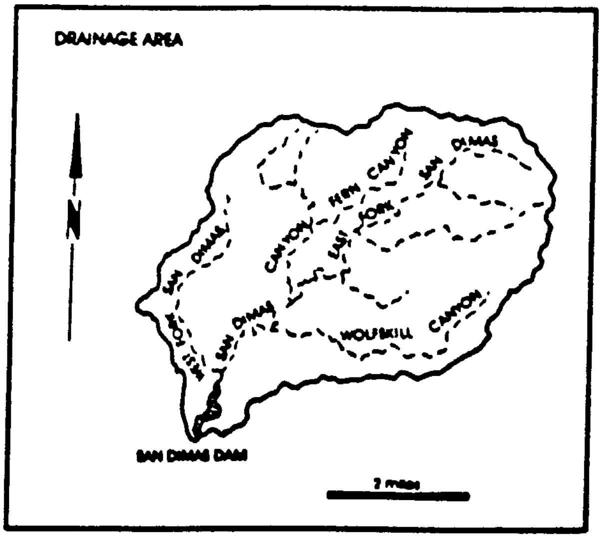

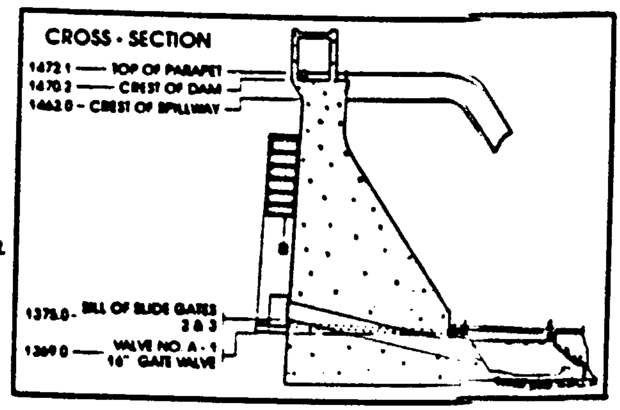

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PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started November 1920. Completed September 1922.
LOCATION - 3.0 miles northeast of San Dimas.
DRAINAGE AREA - 16.2 square miles.
CAPACITY - 1,515 acre - feet.
SPILLWAY ELEVATION - 1,462.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	156.80	CFS	from	1200	on	01-17-88	to	1300	on	01-17-88
MAX. PEAK OUTFLOW	309.00	CFS	from	1315	on	06-28-88	to	1330	on	06-28-88
MAX. W.S. ELEVATION	1450.38	feet	on	05-03-88	STORAGE	1160.80	ACRE-FEET			
MIN. W.S. ELEVATION	1397.80	feet	on	VARIES	STORAGE	54.40	ACRE-FEET			

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SAN DIMAS DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	92.50	166.80	205.30	359.40
TOTAL MONTHLY OUTFLOW (AF)	24.80	24.00	38.30	31.10
MAX. MEAN DAILY INFLOW (CFS)	12.70	10.00	11.50	54.10
TOTAL MONTHLY LOSSES (AF)	2.50	2.70	3.30	2.70
MIN. MEAN DAILY INFLOW (CFS)	0.10	1.20	1.40	0.20
MONTHLY STORAGE CHANGE (AF)	65.30	140.00	165.70	325.60

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	179.00	270.20	238.80	193.40
TOTAL MONTHLY OUTFLOW (AF)	47.40	153.10	40.10	487.10
MAX. MEAN DAILY INFLOW (CFS)	10.30	19.00	25.80	9.60
TOTAL MONTHLY LOSSES (AF)	5.50	7.90	9.40	14.30
MIN. MEAN DAILY INFLOW (CFS)	1.10	0.50	0.30	0.50
MONTHLY STORAGE CHANGE (AF)	126.10	109.10	187.30	-308.10

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	46.20	41.80	15.60	14.50
TOTAL MONTHLY OUTFLOW (AF)	159.50	99.00	49.60	64.30
MAX. MEAN DAILY INFLOW (CFS)	1.20	1.70	1.40	0.70
TOTAL MONTHLY LOSSES (AF)	14.70	15.80	25.50	13.90
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.00	0.00	0.10
MONTHLY STORAGE CHANGE (AF)	-128.00	-73.00	-59.50	-63.70

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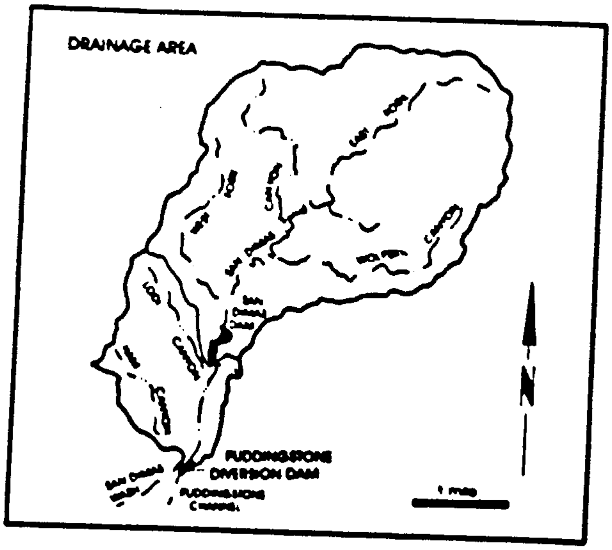
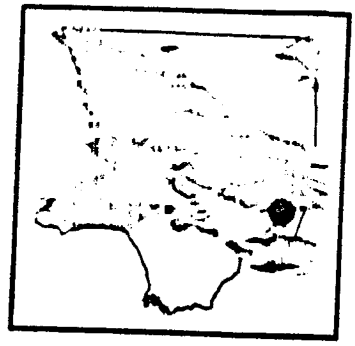
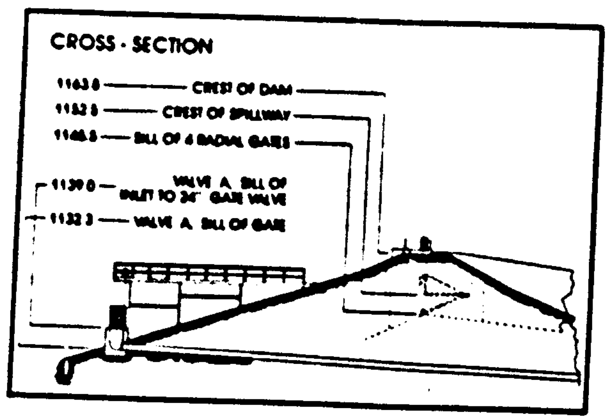
PUDDINGSTONE DIVERSION DAM
AND RESERVOIR







PURPOSE - Flood Control and Diversion of flow and Conservation.
DATE CONSTRUCTED - Started September 1927. Completed July 1928
LOCATION - 2.0 miles northeast of San Dimas.
DRAINAGE AREA - 3.7 square miles (uncontrolled)
16.2 square miles (controlled)
Total 19.9 square miles
CAPACITY - 148 acre feet.
SPILLWAY ELEVATION - 1,152.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	214.20	CFS	from	0900	on	01-17-88	to	1000	on	01-17-88	
MAX. PEAK OUTFLOW	16.00	CFS	from	0645	on	07-05-88	to	0700	on	07-05-88	
MAX. W.S. ELEVATION	1148.92	feet		on	07-01-88	STORAGE	139.50	ACRE-FEET			
MIN. W.S. ELEVATION	1133.00	feet		on	VARIES	STORAGE	0.00	ACRE-FEET			

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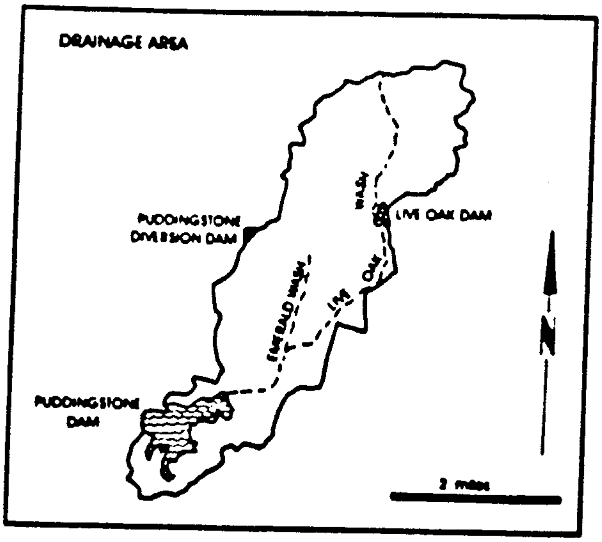
PUDDINGSTONE DIVERSION DAM OPERATION RECORD SUMMARY

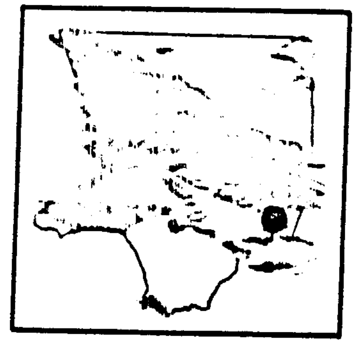
WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	40.00	44.50	64.90	70.80
TOTAL MONTHLY OUTFLOW (AF)	15.30	56.70	55.90	51.80
MAX. MEAN DAILY INFLOW (CFS)	7.80	5.00	9.00	27.60
TOTAL MONTHLY LOSSES (AF)	0.00	0.80	0.00	4.80
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	24.80	-13.00	8.90	14.30

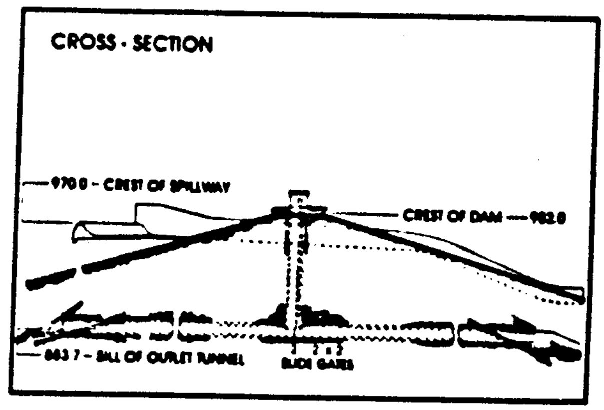
WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	23.90	124.90	41.10	364.60
TOTAL MONTHLY OUTFLOW (AF)	5.80	109.90	31.50	388.00
MAX. MEAN DAILY INFLOW (CFS)	5.70	6.80	3.90	9.20
TOTAL MONTHLY LOSSES (AF)	5.80	3.00	7.80	1.80
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	12.30	12.00	1.70	-25.10

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	122.30	13.30	0.00	16.70
TOTAL MONTHLY OUTFLOW (AF)	10.80	96.80	0.00	0.60
MAX. MEAN DAILY INFLOW (CFS)	37.60	6.60	0.00	3.80
TOTAL MONTHLY LOSSES (AF)	22.80	33.50	0.00	3.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	88.60	-117.00	0.00	13.10

PUDDINGSTONE DAM
AND RESERVOIR







PURPOSE - Flood Control and Recreation.
DATE CONSTRUCTED - Started February 1925. Completed January 1928
LOCATION - 1.0 mile south of San Dimas.
DRAINAGE AREA - 11.0 square miles (uncontrolled)
22.1 square miles (controlled)
Total 33.1 square miles
CAPACITY - 16,856 acre - feet.
SPILLWAY ELEVATION - 970.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	421.60	CFS	from	1400	on	01-17-88	to	1500	on	01-17-88	
MAX. PEAK OUTFLOW	107.00	CFS	from	1700	on	11-06-87	to	1715	on	11-06-87	
MAX. W.S. ELEVATION	942.16	feet		on	01-25-88	STORAGE	6608.20	ACRE-FEET			
MIN. W.S. ELEVATION	938.00	feet		on	10-15-87	STORAGE	5583.00	ACRE-FEET			

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PUDDINGSTONE DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	507.80	428.80	429.50	802.00
TOTAL MONTHLY OUTFLOW (AF)	15.30	749.60	15.30	1068.30
MAX. MEAN DAILY INFLOW (CFS)	76.10	63.50	19.90	143.00
TOTAL MONTHLY LOSSES (AF)	97.50	65.60	49.70	42.60
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.20
MONTHLY STORAGE CHANGE (AF)	395.00	-386.40	364.60	-308.90

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	332.80	324.30	585.40	411.70
TOTAL MONTHLY OUTFLOW (AF)	141.60	110.70	107.10	89.40
MAX. MEAN DAILY INFLOW (CFS)	47.30	52.50	44.60	119.90
TOTAL MONTHLY LOSSES (AF)	75.40	104.20	106.20	162.30
MIN. MEAN DAILY INFLOW (CFS)	1.60	0.60	1.20	0.00
MONTHLY STORAGE CHANGE (AF)	115.80	109.40	372.20	160.00

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	1.30	74.50	73.10	38.40
TOTAL MONTHLY OUTFLOW (AF)	37.30	21.70	17.30	18.90
MAX. MEAN DAILY INFLOW (CFS)	0.00	2.60	3.10	3.90
TOTAL MONTHLY LOSSES (AF)	175.00	179.30	175.90	158.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.10	0.00
MONTHLY STORAGE CHANGE (AF)	-211.50	-126.50	-120.10	-138.60

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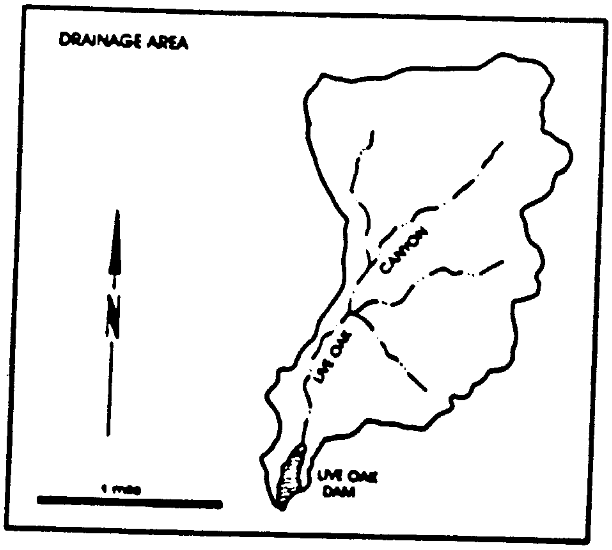
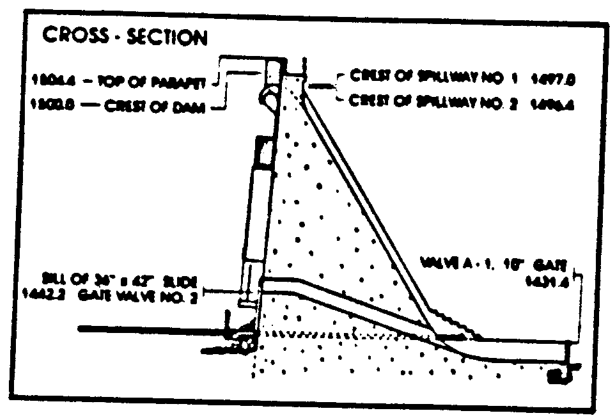
LIVE OAK DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started August 1921. Completed November 1922.
LOCATION - 2.5 miles northeast of La Verne.
DRAINAGE AREA - 2.3 square miles.
CAPACITY - 240 acre-feet.
SPILLWAY ELEVATION - 1,496.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	3.90	CFS	from	1600	on	01-17-88	to	1700	on	01-17-88
MAX. PEAK OUTFLOW	2.60	CFS	from	0930	on	05-17-88	to	0945	on	05-17-88
MAX. W.S. ELEVATION	1456.74	feet		on	05-16-88	STORAGE	9.80	ACRE-FEET		
MIN. W.S. ELEVATION	1440.00	feet		on	VARIES	STORAGE	0.00	ACRE-FEET		

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LIVE OAK DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	2.40	8.30	20.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	2.40	8.10	20.40
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.90	0.90	2.70
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.10
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.20	-0.20

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	5.20	8.10	14.80	7.70
TOTAL MONTHLY OUTFLOW (AF)	5.20	8.80	8.50	15.50
MAX. MEAN DAILY INFLOW (CFS)	0.40	1.40	0.70	0.20
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.10	0.10
MONTHLY STORAGE CHANGE (AF)	0.00	0.20	8.00	-7.70

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	2.40	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	2.40	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.10	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

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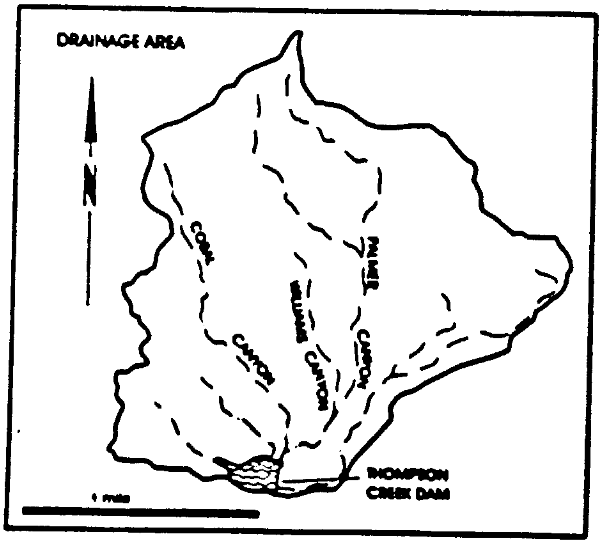
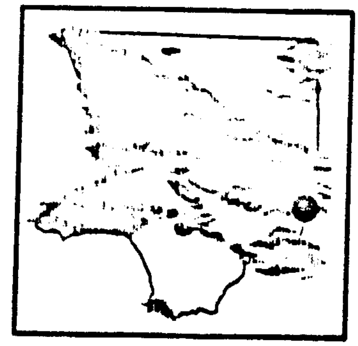
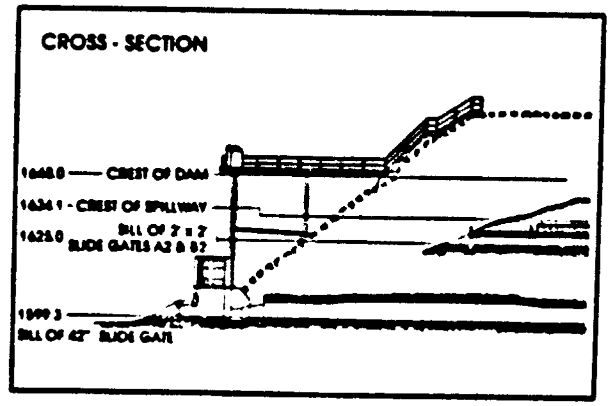
THOMPSON CREEK DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started September 1925. Completed March 1928.
LOCATION - 3.0 miles north of Claremont.
DRAINAGE AREA - 3.5 square miles.
CAPACITY - 447.5 acre - feet.
SPILLWAY ELEVATION - 1,634 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	0.90	CFS	from	0800	on	01-17-88	to	0900	on	01-17-88
MAX. PEAK OUTFLOW	1.30	CFS	from	0830	on	01-17-88	to	0845	on	01-17-88
MAX. W.S. ELEVATION	1600.04	feet		on	01-17-88	STORAGE	0.00	ACRE-FEET		
MIN. W.S. ELEVATION	1600.00	feet		on	VARIES	STORAGE	0.00	ACRE-FEET		

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THOMPSON CREEK DAM OPERATION RECORD SUMMARY

WATER YEAR 1987-88	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.80	1.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.80	1.20
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.30	0.30
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1987-88	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1987-88	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

EROSION CONTROL

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EROSION CONTROL

Each year eroded material in various forms (trees, rock, sand, etc.) flows out of the mountain watersheds of Los Angeles County. In an effort to control this potentially disruptive force, the Department maintains a series of debris basins in canyon mouths and upstream stabilization structures in selected watersheds.

PURPOSE

The purpose of a debris basin is to entrap the debris flows emanating from the canyon and let the relatively desilted water pass into flood control channels.

From 1987 to 1988, the number of debris basins increased from 129 to 131 yielding a total maximum capacity of 7,648,700 cubic yards.

Records of sediment inflow at individual debris basins and amounts excavated and removed are available in the Hydraulic/Water Conservation Division.

STABILIZATION STRUCTURES

Stabilization structures are constructed to control erosion in natural canyons. They serve to prevent downcutting by stabilizing alluvium deposits. In addition, they store debris generated by the watershed and serve to stabilize side banks, reducing side slope sloughing and bank erosion.

The Department maintains 225 stabilization structures in 47 major watersheds. No structures have been constructed since the 1973-74 water year.

EMERGENCY STRUCTURES

Emergency structures (rail and timber, and crib type) have been constructed to entrap the debris inflow from burned watersheds. They serve to protect the existing structures (road, channel, residence, etc.) located immediately downstream of the watersheds. Currently, 38 emergency structures exist with a total maximum capacity of 341,600 cubic yards.

SEDIMENT REMOVAL FROM RESERVOIRS

Sediment deposition in reservoirs reduces the storage capacities and adversely affects flood control and water conservation efforts. Sediment removal is periodically necessary and is generally an expensive effort due to large quantities, the need to deal with water inflows, and in several cases, remote locations and limited accessibility for equipment.

Where practical, the Department encourages sediment removal by permittees at no cost to the Department such as at Eaton Wash and Devil's Gate Dams.

The Department presently is studying the feasibility of various methods for the removal and long-term management of sediment in the three reservoirs in San Gabriel Canyon. These three currently contain about 36 million cubic yards - about three-quarters of the cumulative volume of sediment currently behind all dams under the Department's control.

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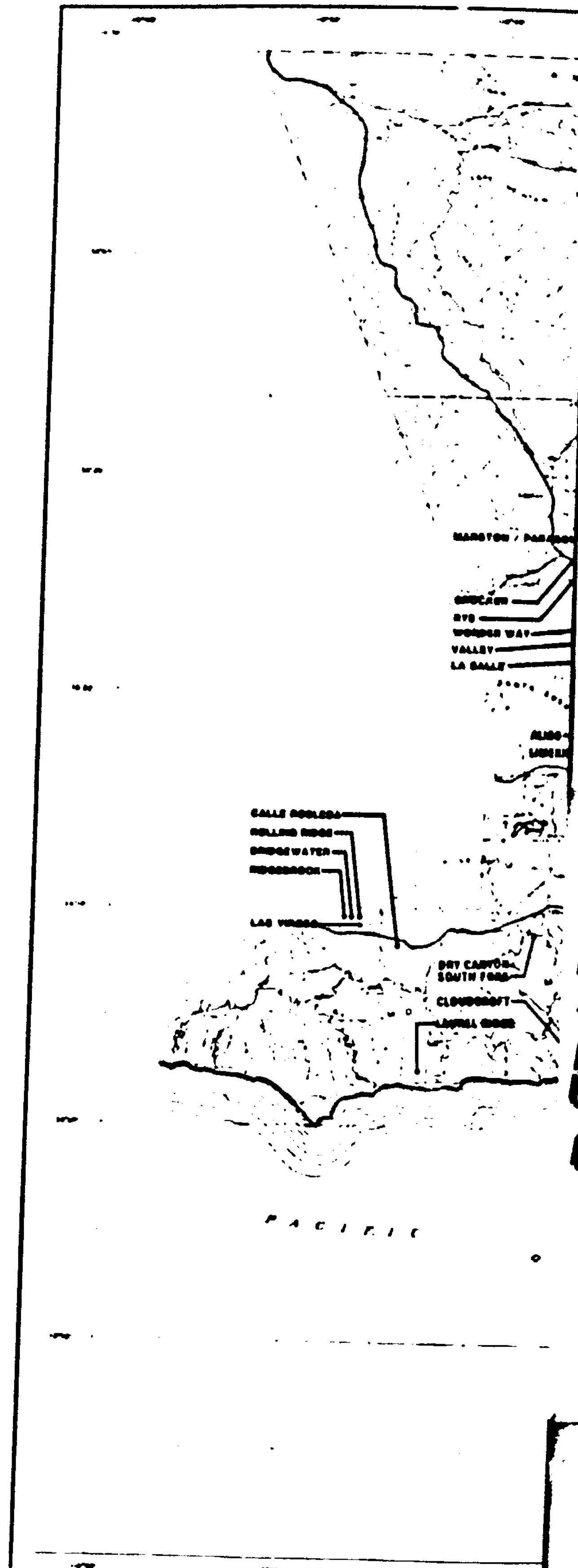

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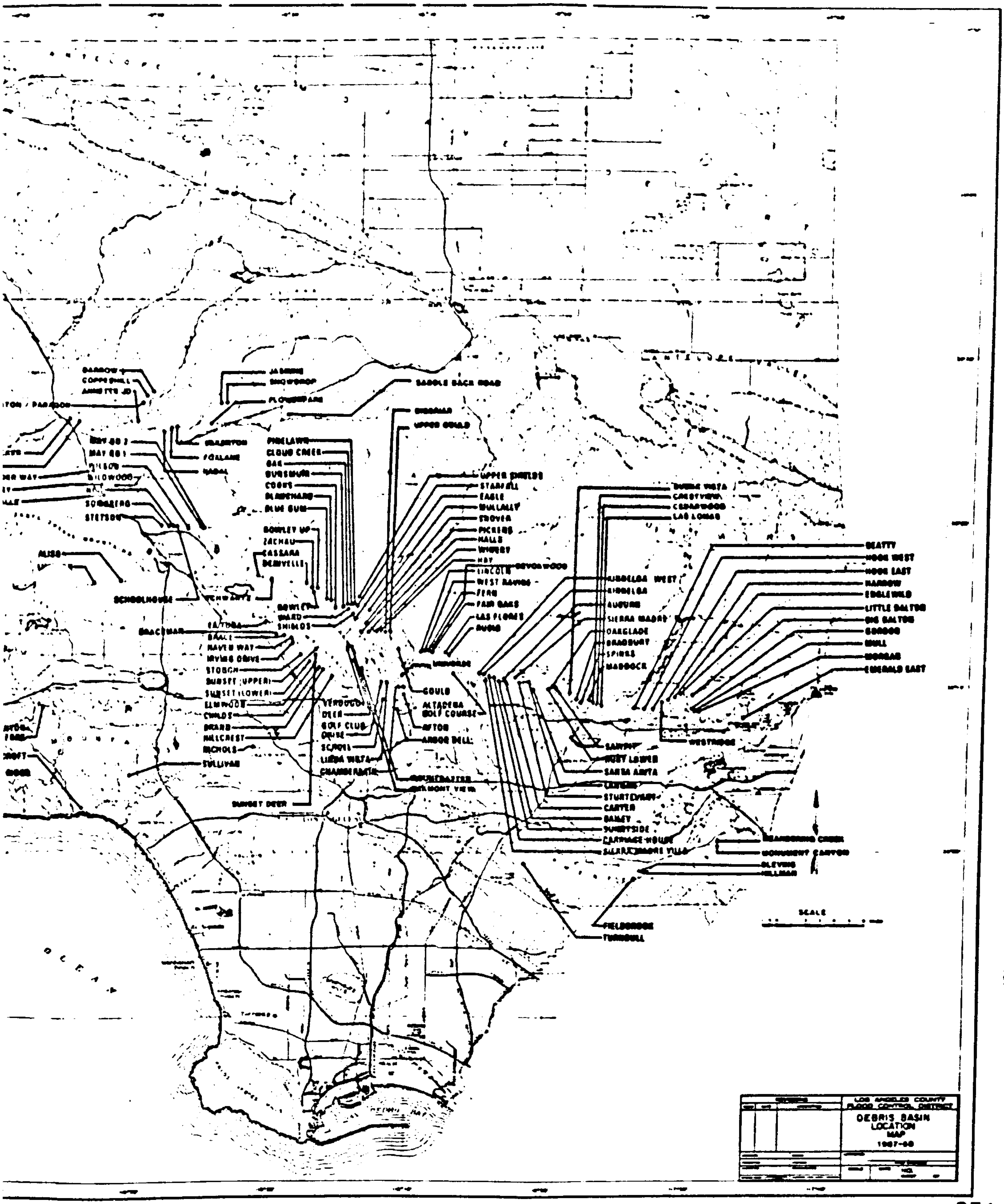

R0052870

VOL 12

1 9566

DEBRIS BASIN - DESIGN DATA

Including 1987-1988 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1988

DATA SHEET A

DEBRIS BASIN	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.	ESTIMATED DEBRIS CAPACITY BEGINNING SEASON CU. YD.	PER CENT
Elmwood	912.0	911.5	938.0	22.0	952.0	61,900	59,431	96
Emerald-East	1185.1	1181.1	1192.0	30.0	1204.0	13,200	11,400	86
Englewild	1274.7	1544.0	1292.0	50.0	1300.0	50,400	49,879	99
Fair Oaks	1542.8	1275.0	1581.9	(8)	1588.5	25,200	26,263	104
Fern	1438.7	1462.4	1470.2	25.0	1480.5	30,600	28,660	94
Fieldbrook	712.7	713.0	718.0	28.0	722.3	2,800	2,293	82
Flowerpark	1694.5	1694.4	1700.9	16.0	1703.0	1,300	1,535	118
Foxlane	1518.8	1518.8	1525.5	(10)	1528.0	13,900	13,900	100
Golf Club Drive	880.7	880.7	902.0	38.7	915.0	14,700	14,377	98
Gordon	1075.7	1075.0	1088.0	22.0	1098.0	16,800	16,981	101
Gould	1528.0	1528.2	1548.0	55.0	1548.0	49,600	47,328	95
Gould (Upper)	1864.0	1863.9	1897.7	32.0	1901.0	52,000	48,023	92
Halls	1641.6	1641.8	1654.3	131.0	1664.0	89,400	88,227	99
Harrow	1254.8	1255.0	1269.0	40.0	1277.8	68,000	72,791	107
Hart, W. S.	1284.0	1280.0	1290.0	19.0	1293.0	2,800	2,102	75
Hay	1875.4	1901.0	1905.0	38.0	1915.0	34,400	33,862	98
Hillcrest	863.6	863.5	885.0	18.0	901.0	54,400	51,785	95
Hog	1520.3	1520.0	1535.0	32.0	1547.0	39,600	39,544	100
Hook East	1197.5	1198.0	1210.9	37.0	1215.0	30,700	30,732	100
Hook West	1144.8	1145.0	1158.9	40.0	1167.0	39,600	35,488	90
Inverness	1252.7	1252.9	1257.0	20.0	1261.0	3,200	2,935	92
Irving Drive	905.8	905.0	915.3	12.0	920.0	2,100	2,145	102
Jasmine	1915.8	1916.2	1920.0	20.0	1924.0	5,500	5,354	97
Kinneloa	1370.0	1370.0	1388.0	40.0	1395.0	17,200	17,738	103
Kinneloa-west	1384.9	1385.0	1400.0	22.0	1408.5	23,600	22,974	97
Lannan	1016.0	1015.0	1035.8	14.0	1043.0	44,600	51,299	115
La Salle	1371.0	1370.0	1380.0	32.0	1388.5	14,900	13,448	90
La Tuna	1109.0	1110.0	1140.0	75.0	1157.0	482,300	492,745	102
Las Flores	1685.1	(9)	1715.6	50.0	1728.4	57,600	56,927	99
Las Lomas	895.4	898.0	908.6	24.0	911.0	9,300	9,265	100
Las Virgenes	(10)	(10)	(10)	(10)	(10)	4,000	(10)	(10)
Laurel Ridge	411.3	411.3	417.0	15.0	420.0	1,700	1,597	94
Limekiln	990.2	992.0	1003.0	77.0	1019.0	171,300	162,355	95
Lincoln	1275.8	1278.0	1304.0	56.0	1322.5	38,400	37,377	97
Linda Vista	979.5	979.5	989.8	40.0	995.7	3,200	3,178	99
Little Dalton	1140.0	1139.5	1186.0	84.0	1200.2	656,500	643,606	98
Maddock	888.6	891.8	901.0	38.0	904.0	45,900	43,690	95
May No. 1	1665.9	1668.0	1684.0	60.0	1692.5	64,000	64,505	101
May No. 2	1663.5	1663.5 (2)	1669.5	20.0	1674.0	10,000	9,997	100

R0052871

VOL 12

DEBRIS BASIN - DESIGN DATA

Including 1987-1988 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1, 1988

DATA SHEET A

DEBRIS BASIN	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.	ESTIMATED DEBRIS CAPACITY BEGINNING SEASON CU. YD.	PER CENT
Meandering Creek	973.5	973.8	978.3	20.0	980.0	2,500	2,532	101
Monument Canyon	942.3	942.3	950.0	12.0	954.0	6,700	6,662	99
Morgan	1135.0	1135.0	1158.0	45.0	1167.0	51,100	50,021	98
Mountbatten	1136.2	1135.5	1140.9	20.0	1141.0	1,400	1,427	102
Mull	1146.9	1147.0	1154.0	20.0	1165.0	16,000	15,938	100
Mullally	2420.0	2420.0	2435.4	42.0	2439.8	12,000	11,518	96
Nadal	1387.0	1387.0	1391.3	9.0	1394.0	1,100	1,105	100
Nichols	481.0	481.0	485.1	50.0	495.0	13,100	11,080	85
Oak	2145.7	2145.7	2151.8	50.0	2156.2	8,700	7,981	92
Oakglade	1274.8	1280.0	1290.0	20.0	1298.0	12,300	11,751	96
Oakmont	1315.5	1315.5	1327.5	20.0	1327.5	3,400	3,400	100
Pickens	1546.0	1587.3	1600.0	123.0	1613.0	131,400	127,413	97
Pinelawn	2431.0	2430.5	2443.0	(7)	2448.5	5,800	5,475	94
Ridgebrook	1086.8	1083.3	(10)	(10)	1099.0	530.0	530.0	100
Rolling Ridge	1087.0	(10)	(10)	(10)	1095.0	280.0	280.0	100
Rowley	1701.6	1703.8	1714.0	60.0	1722.0	37,700	39,240	104
Rowley (Upper)	1926.0	1926.0	1946.0	42.0	1951.3	28,800	28,418	99
Rubio	1582.1	1582.1	1608.3	59.0	1625.5	127,200	125,041	98
Ruby (Lower)	810.8	809.6	828.0	45.0	833.0	28,600	23,852	83
Rye	1073.9	1073.8	1077.7	58.2	1081.5	19,100	19,078	100
Santa Anita	748.5	748.5 (3)	774.7	160.0	798.0	393,900	393,648	100
Sawpit	928.5	933.4	981.8	110.0	1000.0	644,500	644,098	100
Scholl	950.0	950.0 (2)	958.0	76.0	966.0	11,100	10,432	94
Schoolhouse	1459.6	1460.0	1478.5	20.0	1491.0	66,700	63,405	95
Schwartz	1298.0	1294.7	1313.2	35.0	1319.0	45,400	38,040	84
Shields	2030.0	2050.0	2058.1	30.0	2070.2	34,600	33,083	96
Sierra Madre	1119.6	1119.5	1172.5	82.5	1175.0	133,600	134,778	101
Sierra Madre Villa	1069.2	1069.2	1088.9	48.0	1102.5	402,700	441,373	110
Snover	1858.0	1874.4	1879.0	40.0	1893.7	23,400	22,439	96
Snow Drop	1891.6	1892.2	1898.0	20.0	1900.0	4,100	4,205	103
Sombrero	1539.6	1540.0	1564.8	45.0	1580.0	87,900	87,732	100
Spinks	749.2	750.0	761.5	40.0	765.9	82,900	81,327	97
Starfall	2428.0	2428.0	2441.5	30.0	2446.5	18,400	19,216	104
Stetson	1556.0	1555.0	1570.0	32.0	1570.0	39,000	39,000	100
Stough	1006.0	1005.8	1031.5 (4)	100.0	1043.5	181,200	171,512	95
Sturtevant	975.0	971.0	983.6	8.0	990.0	2,300	2,194	95
Sullivan	569.9	569.9	587.0	50.0	599.3	51,000	51,000	100
Sunnyside	1290.0	1290.0	1299.5	15.0	1303.8	4,300	4,325	101
Sunset Canyon-Deer	1382.4	1380.5	1401.8	24.0	1409.1	6,400	6,380	99

VOL 12

DEBRIS BASIN - DESIGN DATA

Including 1987-1988 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1988

DATA SHEET A

DEBRIS BASIN	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.	ESTIMATED DEBRIS CAPACITY BEGINNING SEASON	
							CU. YD.	PER CENT
Afton	1032.2	1030.0	1041.4	20.0	1046.6	7,200	7,314	102
Aliso	1108.0	1108.4	1120.0	70.0	1134.0	41,700 (8)	38,756	93
Annette Jo	1353.6	1353.6	1356.8	12.0	1358.8	200	225	113
Arbor Dell	899.3	898.4	913.0	22.9	919.8	12,800	11,963	93
Auburn	1263.9	1263.0	1275.0	30.0	1283.0	33,700	33,687	100
Bailey	1122.5	1123.1	1155.0	30.0	1166.0	135,000	127,537	94
Bakerton	1519.9	1518.8	1524.8	20.0	1530.0	2,700	2,617	97
Beatty	800.0	800.0	807.0	32.0	815.5	43,000	39,764	92
Bigbriar	1898.3	1898.0	1910.0	14.0	1910.8	3,100	2,658	86
Big Dalton	1102.0	1101.9 (3)	1131.5	116.0	1146.7	534,400	512,622	96
Blanchard	2028.0	2028.0	2053.5	40.0	2065.0	75,300	74,374	99
Blue Gum	2020.0	2020.0	2042.0	25.0	2053.0	39,600	38,188	96
Brace	1189.7	1189.7	1194.5	20.0	1203.3	27,500	27,680	101
Bracemare	1140.0	1140.0	1145.5	8.0	1148.0	660 (11)	888	135 (11)
Bradbury	912.5	913.1	920.0	58.0	928.0	90,500	88,534	98
Brand	859.0	860.0	890.0	60.0	903.0	170,700	149,080	87
Bridgewater	1078.4	(10)	(10)	(10)	1086.0	270	270	100
Buena Vista	978.7	978.7	992.0	39.0	997.7	25,500	25,482	100
Calle Robleda	931.8	931.8	944.0	7.5	947.0	7,100	7,135	100
Carriage House	1350.0	1350.0	1362.9	15.0	1366.8	10,400	10,741	103
Carter	1222.0	1223.2	1238.2	30.0	1245.0	18,700	18,487	99
Cassara	1271.5	1275.8	1291.7	66.0	1295.4	35,100	33,618	96
Cedarwood	866.8	867.5	872.3	10.0	876.0	900	857	95
Chamberlain	1084.6	1084.0	1097.5	20.0	1101.3	6,600	6,706	102
Childs	1030.0	1022.0	1058.0	23.0	1071.0	49,500	46,200	93
Cloud Creek	2347.3	2350.5	2380.0	(5)	2382.0	14,800	14,150	96
Cloudcroft	313.9	315.0	329.5	36.0	329.5	31,800	33,073	104
Cooks	2080.0	2058.0	2082.9	48.0	2092.0	46,900	48,898	104
Copper Hill	1417.0	1418.2	1423.0	35.0	1428.0	7,900	6,725	85
Crestview	884.4	884.0	886.2	20.0	891.7	5,900	5,945	101
Crocker	1059.9	1064.2	1069.8	36.0	1077.0	39,200	39,196	100
Darrow	1415.0	1414.3	1418.0	35.0	1422.0	9,200	8,923	97
Deer	1185.4	1185.0	1201.0	56.0	1209.6	56,600	49,727	88
Denivelle	1471.0	1471.0	1479.3	46.0	1483.3	8,200	7,641	93
Devonwood	1899.0	1899.0	1915.8	22.0	1921.5	6,400	6,698	105
Dry Canyon-South Fork	1062.8	1062.5	1074.8	32.0	1079.3	7,900	7,769	98
Dunsmuir	2228.0	2227.7	2257.2	80.0	2272.2	110,900	108,224	98
Eagle	1853.7	1870.2	1880.2	60.0	1895.2	55,800	49,727	89
El Selinda	(10)	(10)	(10)	(10)	(10)	1,500	(10)	(10)

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D E B R I S   B A S I N - D E S I G N   D A T A

Including 1987-1988 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1988

DATA SHEET A

DEBRIS BASIN	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.	ESTIMATED DEBRIS CAPACITY BEGINNING SEASON CU. YD.	PER CENT
Sunset (Lower)	1003.8	994.5	1040.0	40.0	1056.0	160,800	144,075	90
Sunset (Upper)	1574.2	1574.0	1603.7	75.0	1610.1	15,900	17,044	107
Turnbull	480.0	478.0	492.0	40.0	503.0	20,300	19,905	98
Upper Shields	2502.0	2502.0	2518.9	29.5	2524.0	5,700	5,758	101
Valley	1351.0	(10)	(10)	31.0	1365.0	4,000	(10)	(10)
Verdugo	1109.5	1110.0 (2)	1119.7	145.0	1131.0	131,000	123,848	95
Ward	2021.1	2022.0	2033.0	58.0	2035.3	12,400	12,170	98
West Ravine	1468.8	1498.8	1501.9	20.0	1505.5	46,800	37,288	80
Westridge	894.0	894.0	901.0	10.7	908.0	1,400	1,200	86
Wildwood	1340.3	(9)	1354.0	50.0	1360.0	22,500	21,108	94
Wilson	1517.3	1493.0	1528.0	80.0	1543.0	316,900	295,329	93
Winery	1920.0	1920.0	1935.0	20.0	1945.0	29,200	27,285	93
Wonderway	1272.9	1272.0	1276.8	10.0	1281.4	1,700	1,665	98
Zacheu	1803.1	1803.1	1817.0	44.0	1823.0	38,600	38,552	100

131 DEBRIS BASINS ______ 7,850,040 ____ 7,473,678

(1) LOWEST CLEAR WATER OUTLET, NOT SPILLWAY.
(2) ELEVATION OF SPILLWAY NOTCH.
(3) FLOW LINE OF SLUICEWAY.
(4) ELEVATION OF SPILLWAY INTO OUTLET CHANNEL. ELEVATION OF OVERFLOW SPILLWAY 1038.9 FEET.
(5) ONE 30-INCH REINFORCED CONCRETE PIPE.
(6) FOUR 36-INCH CORRUGATED METAL PIPES.
(7) ONE 36-INCH REINFORCED CONCRETE PIPE.
(8) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(9) PIT-TYPE BASIN.
(10) INFORMATION UNAVAILABLE.
(11) MAXIMUM CAPACITY MAY BE LESS THAN SHOWN AND IS BEING REVIEWED. FIELD INSPECTION SUGGESTS BASIN IS NEAR ITS FULLEST POSSIBLE CAPACITY.

VOL 12

1 9570

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

DATA SHEET 8

Including 1987-1988 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1988
File: DPH1.WK1

DEBRIS BASIN	FIRST DEBRIS SEASON	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	MAX.DEB. CAP. CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	CU. YDS. PER SQ. MI.	SEASON
Afton	1974 - 75	14	1,030	0.08	7,200	800	13,800	1974-75
Aliso	1970 - 71	18	131,723	2.77	41,700 (5)	30,700	11,100	1982-83
Annette Jo	1977 - 78	11	255	0.09	200	100	1,800	1977-78
Arbor Dell	1971 - 72	17	1,397	0.11	12,800	800	7,600	1979-80
Auburn	1954 - 55	34	87,388	0.19	33,700	20,100	105,900	1981-82
Bailey	1945 - 46	43	238,794	0.60	135,000	91,000	151,700	1979-80
Bakerton	1970 - 71	18	759	0.25	2,700	700	2,700	1979-80
Beatty	1970 - 71	18	13,297	0.27	43,000	7,600	28,300	1979-80
Bigbriar	1971 - 72	17	2,004	0.02	3,100	623	38,100	1987-88
Big Dalton	1959 - 60	29	833,003	2.62	534,400	296,700	113,200	1968-69
Blanchard	1968 - 69	20	68,196	0.50	75,300	36,600	73,200	1977-78
Blue Gum	1968 - 69	20	37,572	0.19	39,600	19,100	100,600	1977-78
Brace	1971 - 72	17	35,621	0.29	27,500	12,000	41,300	1977-78
Bracemare	1971 - 72	17	680 (7)	0.01	700	(6)	(6)	(6)
Bradbury	1954 - 55	34	287,430	0.68	90,500	70,200	103,300	1968-69
Brand	1935 - 36	53	248,895	1.04	170,700	53,100	51,600	1977-78
Bridgewater	(8)	(8)	(8)	0.04	(8)	(6)	(6)	(6)
Buena Vista	1985 - 86	3	38	0.10	25,500	38	(6)	1987-88
Calle Robleda	1982 - 83	6	2,082	0.11	7,100	2,000	18,400	1982-83
Carriage House	1970 - 71	18	4,742	0.03	10,400	3,400	114,700	1979-80
Carter	1954 - 55	34	36,890	0.12	18,700	12,600	104,700	1979-80
Cassara	1976 - 77	12	25,583	0.21	35,100	16,800	80,000	1977-78
Cedarwood	1983 - 84	5	0	0.0075	900	(6)	(6)	(6)
Chamberlain	1974 - 75	14	556	0.04	6,600	300	7,900	1974-75
Childs	1963 - 64	25	45,220	0.31	49,500	10,700	34,500	1980-81
Cloud Creek	1972 - 73	16	3,282	0.02	14,800	1,800	91,600	1977-78
Cloudcroft	1973 - 74	15	12,290	0.21	31,800	6,100	28,900	1973-74
Cooks	1951 - 52	37	166,539 (3)	0.01	46,900	61,200	105,600	1977-78
Copper Hill	1979 - 80	9	1,148	0.27	7,900	1,100	4,300	1981-82
Crestview	1983 - 84	5	0	0.03	5,900	(6)	(6)	(6)
Crocker	1983 - 84	5	0	0.67	39,200	(6)	(6)	(6)
Darrow	1979 - 80	9	412	0.13	9,200	400	3,200	1982-83
Deer	1954 - 55	34	156,948	0.59	56,600	44,200	74,900	1968-69
Denivelle	1976 - 77	12	8,680	0.18	6,200	5,500	30,400	1977-78
Devonwood	1981 - 82	7	132	0.05	6,400	100	2,600	1982-83
Dry Canyon-South Fork	1978 - 79	10	6,003	1.05	7,900	5,300	5,100	1979-80
Dunsmuir	1935 - 36	53	349,183	0.84	110,900	86,200	102,600	1977-78
Eagle	1936 - 37	52	199,315	0.48	55,800	41,700	68,300	1937-38

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DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1987-1988 Season

DATA SHEET B

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1988
File: DPH1.WK1

DEBRIS BASIN	FIRST DEBRIS SEASON	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	MAX.DEB. CAP. CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	CU. YDS. PER SQ. MI.	SEASON
El Selinda	(8)	(8)	(8)	0.03	1,500	(8)	(8)	(8)
Elmwood	1964 - 65	24	52,781	0.31	61,900	16,100	51,900	1980-81
Emerald-East	1964 - 65	24	8,959	0.16	13,200	1,800	11,300	1985-86
Englewild	1961 - 62	27	85,119 (2)	0.40	50,400	60,200	150,500 (2)	1968-69
Fair Oaks	1935 - 36	53	109,020	0.21	25,200	15,700	74,800	1935-36
Fern	1935 - 36	53	159,554	0.31	30,600	23,900	79,600	1968-69
Fieldbrook	1974 - 75	14	1,354	0.35	2,800	500	1,400	1977-78
Flowerpark	1972 - 73	16	1,305	0.08	1,300	800	10,800	1982-83
Foxlane	1979 - 80	9	719	0.19	13,900	700	3,800	1979-80
Golf Club Drive	1970 - 71	18	30,157	0.32	14,700	11,600	36,300	1979-80
Gordon	1973 - 74	15	4,485	0.18	16,800	3,800	21,200	1977-78
Gould	1947 - 48	41	115,091	0.29	49,800	18,000	38,300	1985-86
Gould (Upper)	1976 - 77	12	21,628	0.18	52,000	10,100	55,900	1977-78
Halls	1935 - 36	53	569,156	0.86	89,400	102,100	98,300	1937-38
Harrow	1958 - 59	30	78,297 (2)	0.43	68,000	63,400	147,400 (2)	1968-69
Hart, W. S.	1983 - 84	5	1,329	0.09	2,800	1,000	11,200	1983-84
Hay	1936 - 37	52	67,952	0.20	34,400	18,200	63,000	1937-38
Hillcrest	1962 - 63	26	48,589	0.35	54,400	11,700	33,300	1984-85
Hog	1969 - 70	19	6,500	0.30	39,600	3,900	13,000	1977-78
Hook East	1968 - 69	20	45,709 (2)	0.18	30,700	40,200	223,100 (2)	1968-69
Hook West	1970 - 71	18	6,537	0.17	39,600	3,600	21,200	1979-80
Inverness	1982 - 83	6	285	0.03	3,200	300	10,000	1982-83
Irving Drive	1974 - 75	14	1,244	0.03	2,100	600	18,500	1980-81
Jasmine	1976 - 77	12	2,841	0.10	5,500	1,100	10,700	1982-83
Kinneloa	1964 - 65	24	48,929 (2)	0.20	17,200	17,600	88,100 (2)	1968-69
Kinneloa-west	1966 - 67	22	59,055 (2)	0.16	23,600	22,200	138,500 (2)	1968-69
Lannan	1954 - 55	34	84,087	0.25	44,600	18,200	73,000	1969-70
La Salle	1979 - 80	9	1,454	0.22	14,900	1,200	5,500	1982-83
La Tuna	1955 - 56	33	595,914	5.34	482,300	172,100	32,200	1977-78
Las Flores	1935 - 36	53	214,754	0.45	57,600	36,000	80,000	1937-38
Las Lomas	1983 - 84	5	35	0.07	9,300	(6)	(6)	(6)
Las Virgenes	(8)	(8)	(8)	0.14	4,000	(8)	(8)	(8)
Laurel Ridge	1977 - 78	11	997	0.03	1,700	400	14,800	1985-86
Limekiln	1963 - 64	25	270,549	3.69	171,300	42,300	11,500	1985-86
Lincoln	1935 - 36	53	128,104	0.50	38,400	28,400	56,800	1968-69
Linda Vista	1970 - 71	18	11,051	0.37	3,200	3,400	9,200	1977-78
Little Dalton	1959 - 60	29	905,170	3.31	656,500	337,800	102,100	1968-69
Maddock	1954 - 55	34	56,454	0.25	45,900	16,200	64,700	1980-81

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DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

DATA SHEET 8

Including 1987-1988 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1988
File: DPH1.WK1

DEBRIS BASIN	FIRST DEBRIS SEASON	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	MAX.DEB. CAP. CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION		
						CU. YDS.	CU. YDS. PER SQ. MI.	SEASON
May No. 1	1953 - 54	35	203,322	0.70	64,000	45,800	65,400	1968-69
May No. 2	1953 - 54	35	27,314	0.09	10,000	6,200	68,600	1966-67
Meandering Creek	1973 - 74	15	1,654	0.09	2,500	900	9,800	1973-74
Monument Canyon	1981 - 82	7	2,855	0.11	6,700	2,600	24,000	1981-82
Morgan	1964 - 65	24	30,292	0.60	51,100	12,900	21,500	1968-69
Mountbatten	1983 - 84	5	0	0.01	1,400	(6)	(6)	(6)
Mull	1973 - 74	15	1,970	0.15	16,000	1,100	7,000	1979-80
Mullally	1974 - 75	14	51,721 (4)	0.34	12,000	24,400	71,900 (4)	1977-78
Nadal	1969 - 70	19	478	0.08	1,100	400	5,600	1979-80
Nichols	1937 - 38	51	126,652	0.35	13,100	21,800	62,300	1951-52
Oak	1975 - 76	13	13,258	0.05	8,700	6,900	138,200	1977-78
Oakglade	1974 - 75	14	1,455	0.08	12,300	1,200	20,700	1977-78
Oakmount	1984 - 85	4	0	0.02	3,400	(6)	(6)	(6)
Pickens	1935 - 36	53	716,116	1.50	131,400	140,600	93,700	1977-78
Pinelawn	1973 - 74	15	5,113	0.02	5,800	1,200	60,000	1976-77
Ridgebrook	(8)	(8)	(8)	0.08	(8)	(6)	(6)	(6)
Rolling Ridge	(8)	(6)	(8)	0.04	(8)	(6)	(6)	(6)
Rowley	1953 - 54	35	76,207 (4)	0.27	37,700	16,700	61,700 (4)	1977-78
Rowley (Upper)	1976 - 77	12	49,019 (4)	0.31	28,800	31,900	102,800 (4)	1977-78
Rubio	1943 - 44	45	271,322	1.28	127,200	133,000	105,600	1979-80
Ruby (Lower)	1955 - 56	33	20,448	0.28	28,600	8,300	29,700	1968-69
Rye	1981 - 82	7	10,419	1.11	19,100	10,000	9,100	1981-82
Santa Anita	1959 - 60	29	689,384 (2,3)	1.70	393,900	132,000	77,600 (2,3)	1981-82
Sampit	1954 - 55	34	678,599 (2,3)	2.78	644,500	233,800	82,300 (2,3)	1968-69
Scholl	1945 - 46	43	16,794	0.88	11,100	3,500	5,200	1968-69
Schoolhouse	1962 - 63	26	33,550	0.28	68,700	21,600	77,200	1962-63
Schwartz	1976 - 77	12	45,183	0.27	45,400	23,400	86,500	1977-78
Shields	1937 - 38	51	173,202 (3)	0.03	34,800	35,100	130,200	1937-38
Sierra Madre	1927 - 28	61	383,695 (2)	2.39	133,600	95,200	39,800 (2)	1968-69
Sierra Madre Villa	1957 - 58	31	508,701	1.46	402,700	116,600	81,200	1981-82
Snover	1936 - 37	52	104,397	0.23	23,400	21,100	91,700	1938-39
Snow Drop	1976 - 77	12	1,700	0.14	4,100	1,000	7,400	1979-80
Sombrero	1969 - 70	19	6,030	1.08	87,900	3,300	3,100	1977-78
Spinks	1958 - 59	30	67,086	0.44	62,900	16,400	37,200	1968-69
Starfall	1973 - 74	15	27,128	0.13	18,400	14,200	109,200	1977-78
Statson	1969 - 70	19	5,035	0.29	39,000	1,500	5,300	1977-78
Stough	1940 - 41	48	181,148	1.65	181,200	44,100	26,700	1984-85
Sturtevant	1967 - 68	21	1,296	0.03	2,300	500	16,900	1977-78

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

DATA SHEET B

Including 1987-1988 Season

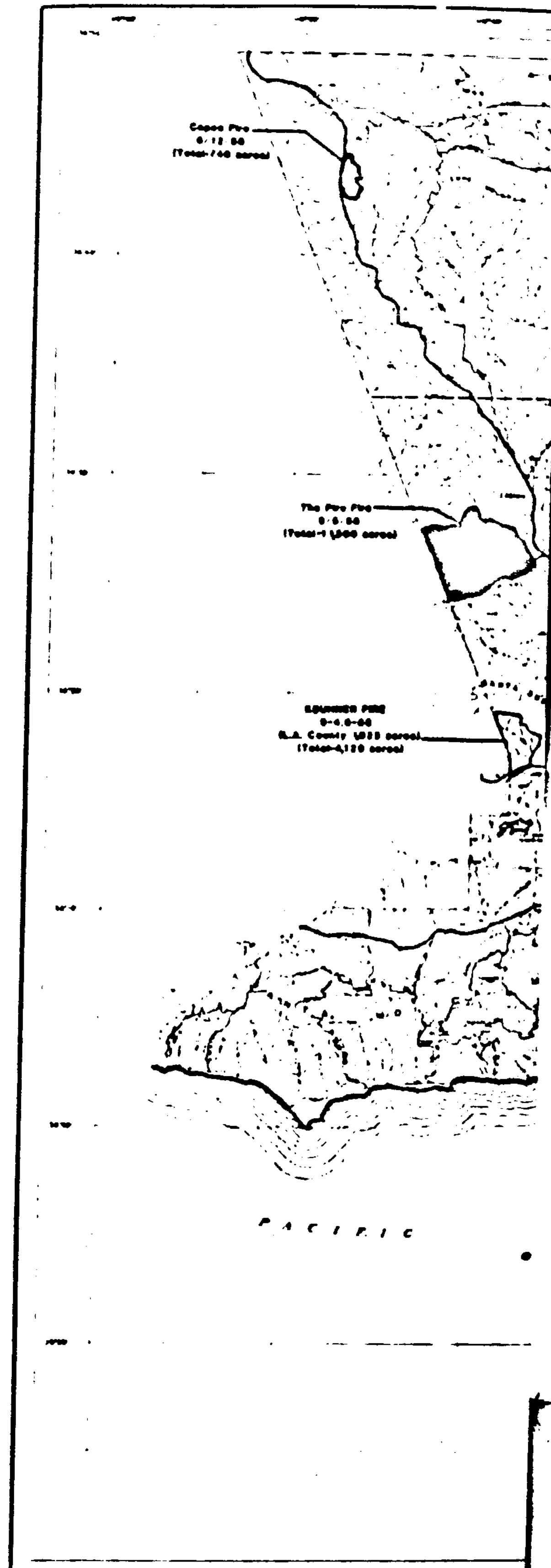
Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1, 1988
File: DPH1.WK1

DEBRIS BASIN	FIRST DEBRIS SEASON	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	MAX.DEB. CAP. CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	CU. YDS. PER SQ. MI.	SEASON
Sullivan	1970 - 71	18	89,957	2.38	51,000	35,300	14,800	1979-80
Sunnyside	1970 - 71	18	1,749	0.02	4,300	800	41,000	1978-79
Sunset Canyon-Deer	1982 - 83	6	3,678	0.20	6,400	3,200	16,000	1982-83
Sunset (Lower)	1963 - 64	25	142,169	0.65	160,600	29,200	44,900	1980-81
Sunset (Upper)	1928 - 29	60	142,392	0.44	15,900	27,000	61,400	1984-85
Turnbull	1952 - 53	36	50,390 (2)	0.99	20,300	15,900	16,000 (2)	1968-69
Upper Shields	1976 - 77	12	50,514 (4)	0.20	5,700	16,900	84,500	1977-78
Valley	1986 - 87	(8)	(8)	0.22	4,000	(6)	(6)	(6)
Verdugo	1935 - 36	53	806,212	3.09	131,000	105,400	11,200	1937-38
Ward	1956 - 57	32	51,668	0.12	12,400	17,800	148,100	1977-78
West Ravine	1935 - 36	53	148,333	0.25	48,800	29,900	119,500	1937-38
Westridge	1974 - 75	14	200	0.02	1,400	(6)	(6)	(6)
Wildwood	1967 - 68	21	67,450	0.65	22,500	16,700	25,700	1977-78
Wilson	1962 - 63	28	217,988	2.58	318,900	55,500	21,500	1968-69
Winery	1968 - 69	20	23,137	0.18	29,200	9,400	52,200	1968-69
Wonder Way	1975 - 76	13	35	0.07	1,700	NEGL.	300	1975-76
Zachau	1956 - 57	32	108,174 (4)	0.36	38,600	48,100	137,300 (4)	1977-78

131 DEBRIS BASINS——— 88.37 ———7,849,000

AVE. SEDIMENT INFLOW = 3,288 CUBIC YARDS PER YEAR
(119 Debris Basins)

(1) VOLUME OF DEBRIS DEPOSITED IN BASINS DOES NOT INCLUDE DEBRIS SLUICED THROUGH OPEN PORTS OR NOTCH.
(2) VOLUME OF DEBRIS DEPOSITED DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1968-69 SEASON.
(3) INCLUDING DEBRIS FROM UPSTREAM BASIN OR DAM.
(4) VOLUME OF DEBRIS DEPOSITED DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1977-78 SEASON.
(5) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(6) NO SIGNIFICANT MAXIMUM DEBRIS INFLOWS RECORDED.
(7) NO RECORDS OF DEBRIS DEPOSITION EXIST FOR THE FIRST 9 SEASONS.
(8) INFORMATION UNAVAILABLE.



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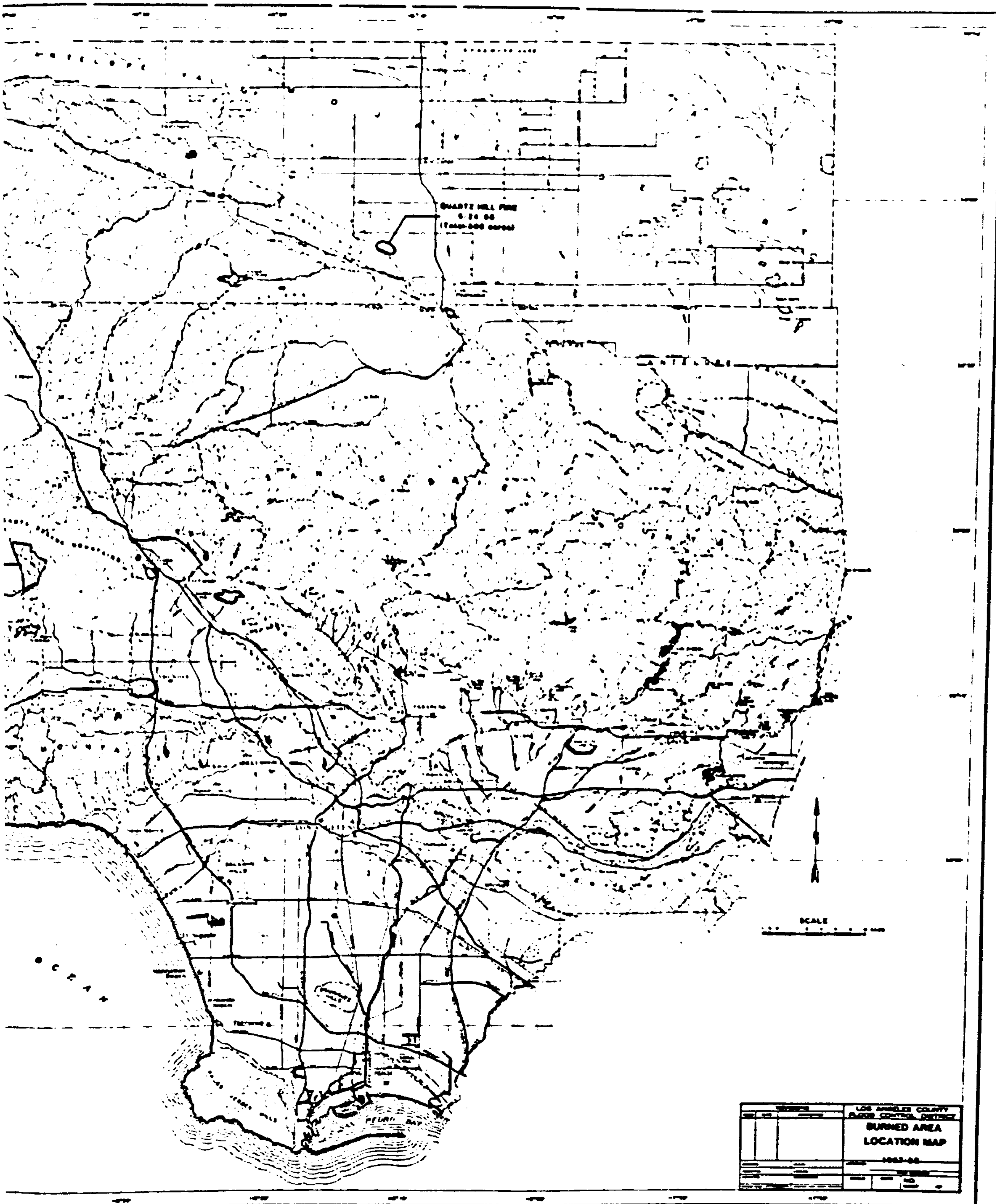

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WATER QUALITY

WATER QUALITY

Since its conception, the Flood Control District (now Department of Public Works) has actively engaged in operations which have proven indispensable in preserving the integrity of our water resources, both quantity and quality, and has aided in the establishment of regulations or controlling criteria by those agencies so empowered.

Prior to March 1986, monitoring activities in the field of water quality control were conducted by the Water Quality Section of Hydraulic/Water Conservation Division. In March 1986, the responsibilities of conducting such activities were transferred to Waste Management Division as a result of the consolidation. These activities include, among others, the collection of water quality samples, their analyses, and the interpretation and reporting of the resulting data.

Areas of involvement include the monitoring of all groundwater basins through the sampling of numerous wells, the monitoring of storm and low water flows at various strategic locations on the major streams or channels, and an assumed or obligated responsibility to monitor the quality effects and subsurface travel of recharge areas, specifically the Whittier Narrows Spreading Grounds area.

The Water Quality Section, together with personnel of other Departmental divisions, also conducts investigations into pollutional problems relative to our facilities, particularly those from industrial discharges, vehicle accidents, ruptured pipelines, or the indiscriminate dumping of various waste products.

The principal objectives of these investigations are to determine the degree and apparent source or origin of the pollution and to take the necessary action that will immediately abate the existing problem and possibly provide a means to prevent or limit recurrence.

SURFACE WATER QUALITY

The Surface Water Quality Monitoring Program involves the sampling of dry weather flows of a number of the principal water conveyance systems within the County prior to July 1984, samples were collected at 31 stations located on the Los Angeles River, San Gabriel River, Santa Clara River, Rio Hondo Channel, Coyote Creek, Dominguez Channel, Ballona Creek, Centinela Creek, San Jose Creek, Topanga Canyon Channel, Malibu Creek, and Kenter Avenue Drain. Samples were collected monthly at each station and analyzed by the Department's Water Quality Laboratory for major minerals, total dissolved solids (TDS), total hardness, specific conductance, pH, dissolved oxygen demand, coliform, fecal coliform, and enterococci. In addition to these constituents, residual chlorine, total organic carbon (TOC), and chlorinated pesticides were also determined at selective locations as well as an annual analysis for trace metals such as barium, copper, chronium, lead, mercury, nickel, selenium, silver, zinc, iron, and manganese.

In July 1984, the monitoring program was reduced in terms of sampling location and monitoring frequency as well as number of constituents analyzed. The modified program involves collection of monthly/quarterly samples from

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21 monitoring stations for ph, total dissolved solids, specific conductance, and dissolved oxygen analyses. In addition, an annual sample is collected from each of the 21 stations for more extensive analyses. Since July 1984, this Department closed its laboratory and has utilized a contract laboratory to perform all the above analyses.

A selective list of total dissolved solids is shown for some of the sampling locations on the streams and channels monitored under the Surface Water Quality Program. For a conception of the analysis performed on surface flows, a yearly compilation of constituent determination is shown for one (Los Angeles River at Wardlow) of the sampling stations in the program.

This program has been expanded, effective January 1, 1988, to approximate the pre-1984 monthly program with the addition of various organic constituents. Implementation of the modified program started May 1, 1988.

STORM WATER QUALITY

The annual Storm Water Quality Program is a comprehensive sampling of major storm flows at many locations throughout the County. The samples are analyzed for major minerals, specific conductance, suspended solids, pH, dissolved oxygen, biochemical oxygen demand, total coliform, fecal coliform, enterococci, total organic carbon, and nutrients level.

In 1984, the number of sampling stations for this program was reduced to 15 including San Gabriel River and Rio Hondo Spreading Grounds where samples were collected up to four times annually for extensive analyses including purgeable and non-purgeable organics.

In addition, storm samples are taken at various gaging stations and spreading grounds. The flow data is recorded at the time each sample is taken and these samples are analyzed for specific conductance.

GROUNDWATER QUALITY

The annual sampling of water wells, under a selected scheduling, in five major basins in Los Angeles County comprise the Groundwater Quality Program. The program, initiated in 1970, is coordinated with the State of California Department of Water Resources and the City of Los Angeles Department of Water and Power.

These agencies participate in the obtainment and analysis of samples. All the water wells samples are active production wells used either for municipal supply irrigation, or for industrial purposes and are selected to represent a general portrayal of basin water quality conditions. The samples taken under this program are analyzed for major mineral, total dissolved solids, electrical conductivity, ph and, in specific cases, phosphate, iron, manganese, fluoride, or boron.

WATER QUALITY DATA ACCESSIBILITY

Data acquired from the various programs are on file in the Water Quality Section. In addition, all data is accessible to any user through STORET, an

Environmental Protection Agency computer system that stores, retrieves, and manipulates data using agency code 21CALAFD.

Surface Water Quality Monitoring Selected Surface Station

Table 1 Total Dissolved Solids - mg/l
1987-88 Season (Dry Weather Flow)

Sampling Location	Oct. '87	Nov. '87	Dec. '87	Jan. '88	Feb. '88	Mar. '88	Apr. '88	May '88	Jun. '88	Jul. '88	Aug. '88	Sep. '88	Average Value
Ballona Creek at Sawtelle Boulevard	-	-	-	-	-	-	-	802	810	812	727	860	802
Coyote Creek at Orangethorpe Ave.	-	-	1000	-	-	-	-	886	941	799	882	983	915
Willow Street	-	-	-	-	-	-	-	1390	1110	686	648	786	924
Dominquez Channel Above Vermont Ave.	-	-	-	-	-	-	-	801	778	610	628	613	686
L.A. River at Warlow Road	640	670	620	-	-	-	-	768	814	708	980	745	794
Firestone Boulevard	-	-	650	-	-	-	-	424	554	-	539	573	516
Los Cerritos Ch. at Stearns Street	670	730	700	-	-	-	-	651	656	664	622	666	670
Rio Hondo River at Southern Ave.	-	-	750	-	-	-	-	768	814	708	980	745	794
Spreading Grounds	650	280	590	-	-	-	-	424	554	-	539	573	516
Santa Monica Cyn. Ch. at Short St.	820	850	840	-	-	-	-	1072	562	959	972	903	872
San Gabriel River at Spreading Grounds	-	430	620	-	-	-	-	698	545	-	534	-	565
Willow Street	-	-	-	-	-	-	-	858	765	658	710	725	743
San Jose Creek at Workman Mill Road	-	800	-	-	-	-	-	1013	923	909	591	950	864

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Water Quality Analysis

Monthly Monitoring 1986-87 Season (Dry Weather)

Los Angeles River @ Wardlow Road

Constituent mg/l	Oct. '87	Nov. '87	Dec. '87	Jan. '88	Feb. '88	Mar. '88	Apr. '88	May '88	Jun. '88	Jul. '88	Aug. '88	Sep. '88	Average
Hardness	-	-	-	-	-	-	-	295	324	265	257	311	290
Calcium	-	-	-	-	-	-	-	72	80.5	65.4	62.0	69.3	69.8
Magnesium	-	-	-	-	-	-	-	28	29.8	24.6	24.7	33.6	28.1
Sodium	-	-	-	-	-	-	-	110	115	104	96	122	109
Potassium	-	-	-	-	-	-	-	13.2	17.3	14.6	16.8	13.2	15.0
Ammonium-N	-	-	-	-	-	-	-	1.4	1.6	0.8	3.8	2.2	2.0
Alkalinity	-	-	-	-	-	-	-	182	163	164	196	182	177
Sulfate	-	-	-	-	-	-	-	171	200	154	149	179	171
Chloride	-	-	-	-	-	-	-	113	121	115	103	134	117
Nitrate-N	-	-	-	-	-	-	-	1.74	6.03	1.59	1.40	2.28	2.61
Phosphate-P	-	-	-	-	-	-	-	3.6	6.3	0.8	9.8	0.4	4.2
Total Dissolved Solids	640	670	620	-	-	-	-	684	691	590	616	732	655
DO	10.4	8.2	11.2	-	-	-	-	-	-	-	-	-	9.9
BOD	-	-	-	-	-	-	-	<1	<1	3.1	60.5	46.5	22.0
Total Organic Carbon	-	-	-	-	-	-	-	5.16	<1.0	3.00	4.00	4.00	3.2
Per 100ml													
Fecal Coliform	-	-	-	-	-	-	-	11K	-	2.7K	400	3.4K	7,040
Total Coliform	-	-	-	-	-	-	-	620K	-	170K	250K	630K	1,078
Fecal Streptococcus	-	-	-	-	-	-	-	9.8K	-	4.4K	900K	2.7K	80
pH	9.4	8.8	9.5	-	-	-	-	9.0	8.7	8.5	8.6	8.6	8.9
Temperature (F)	78	74	66	-	-	-	-	69	69	84	73	68	73

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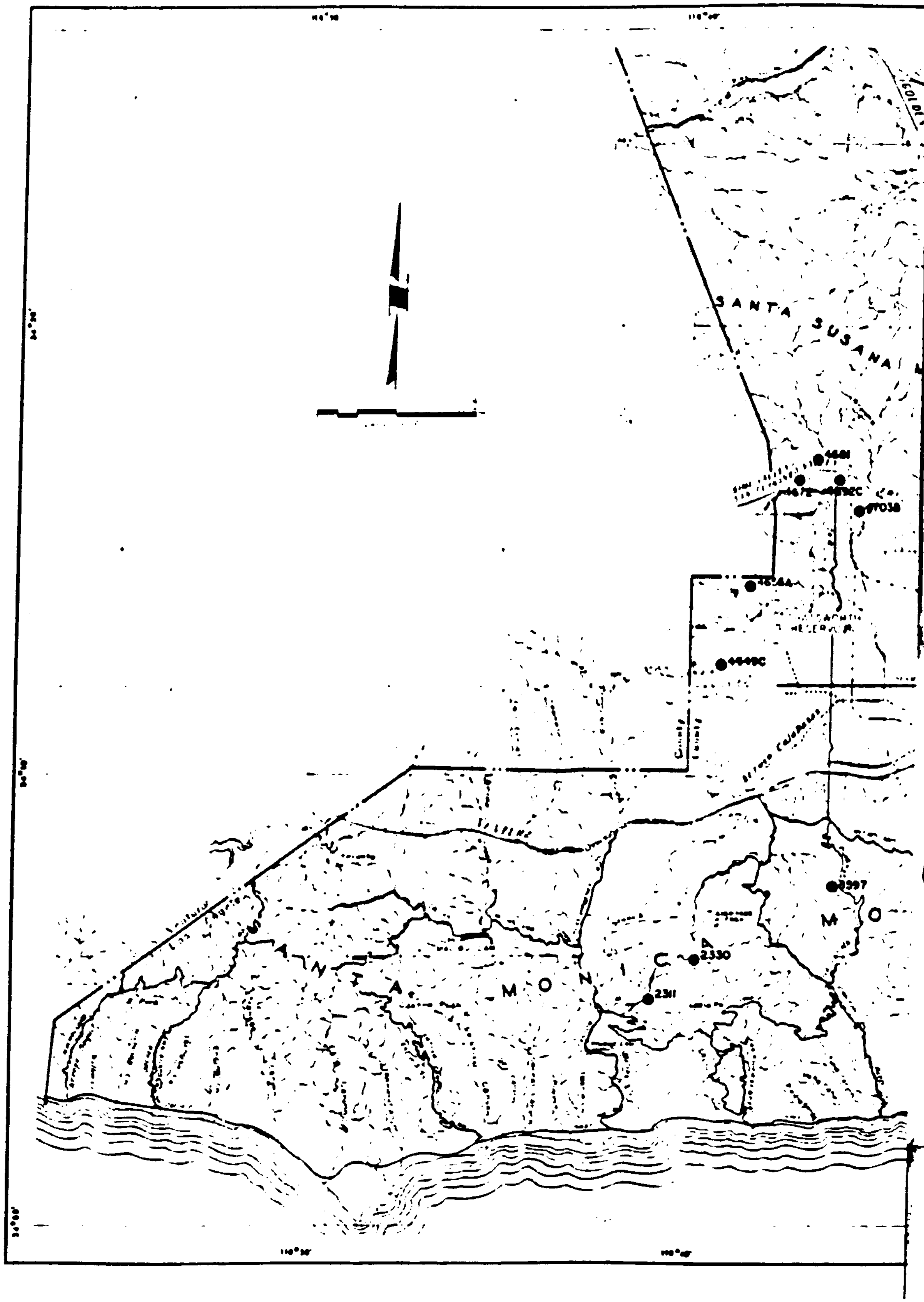

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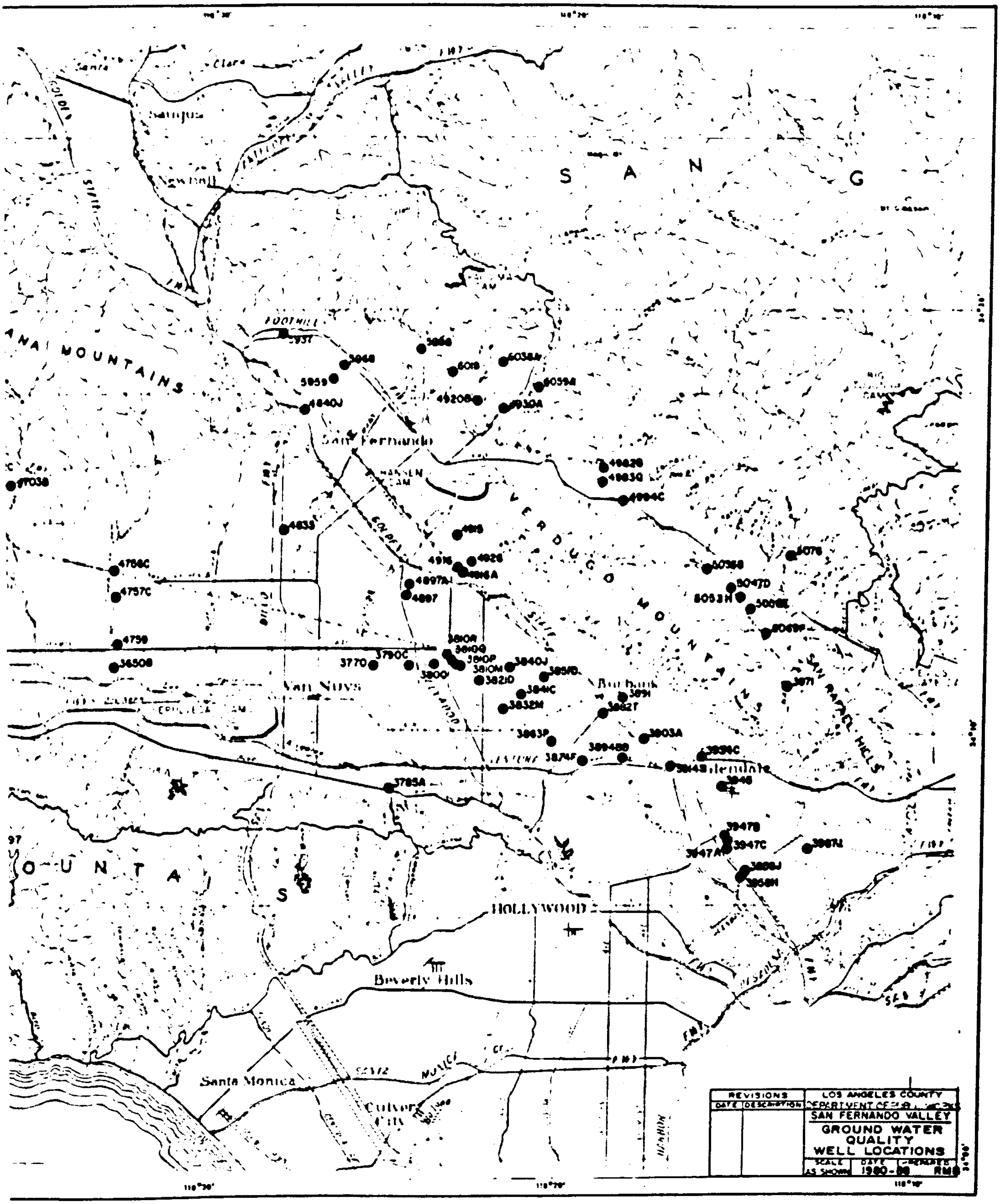

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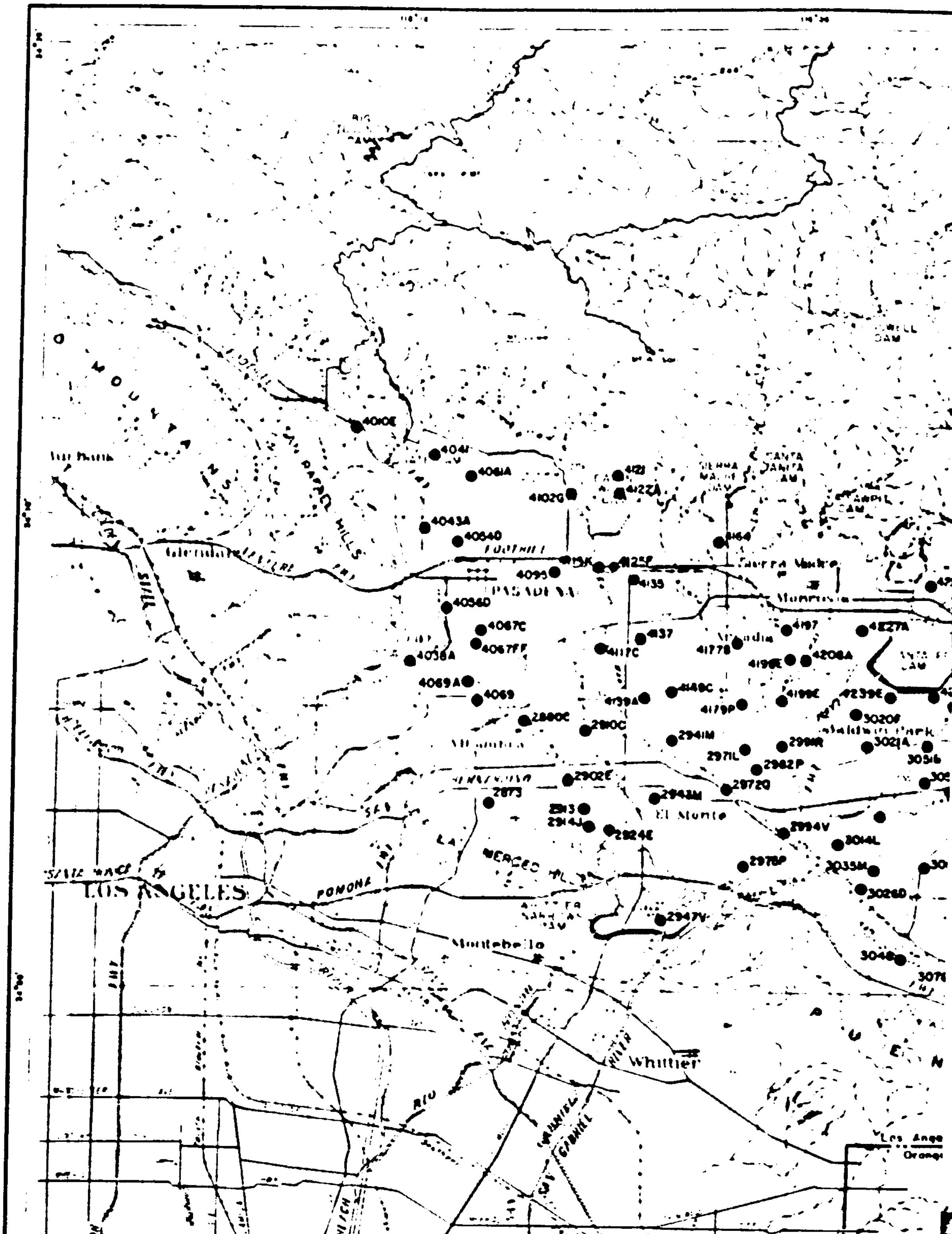

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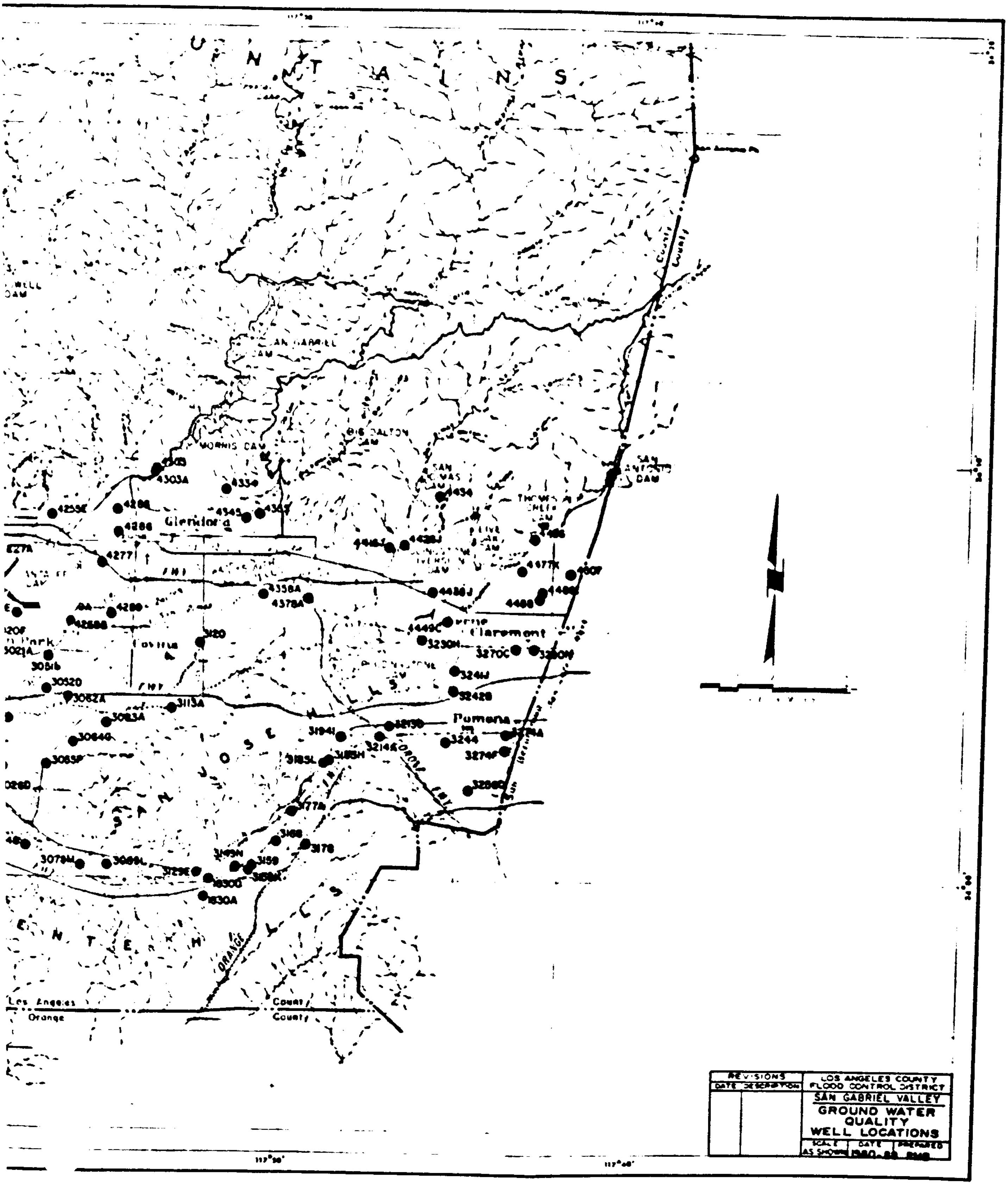

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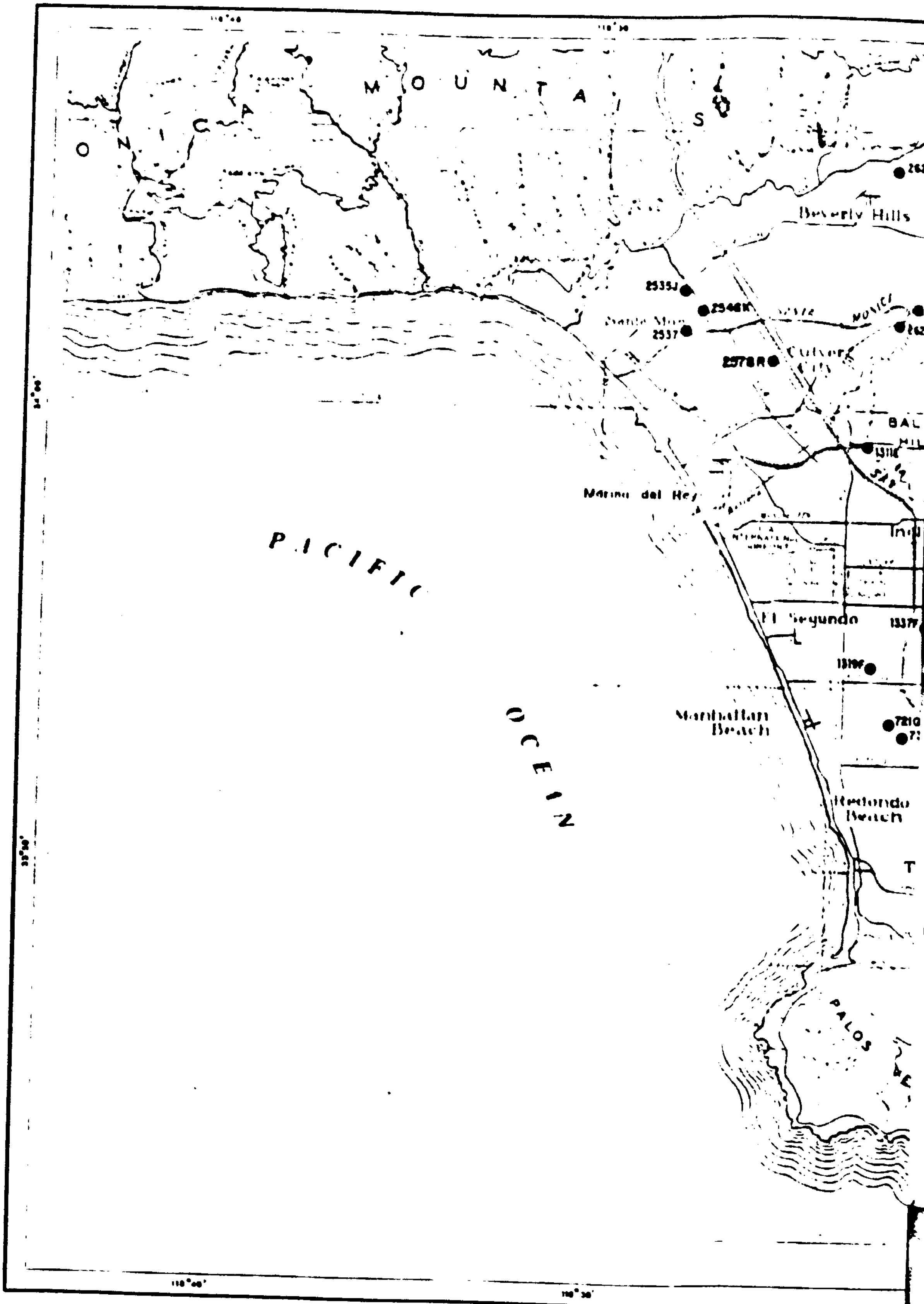

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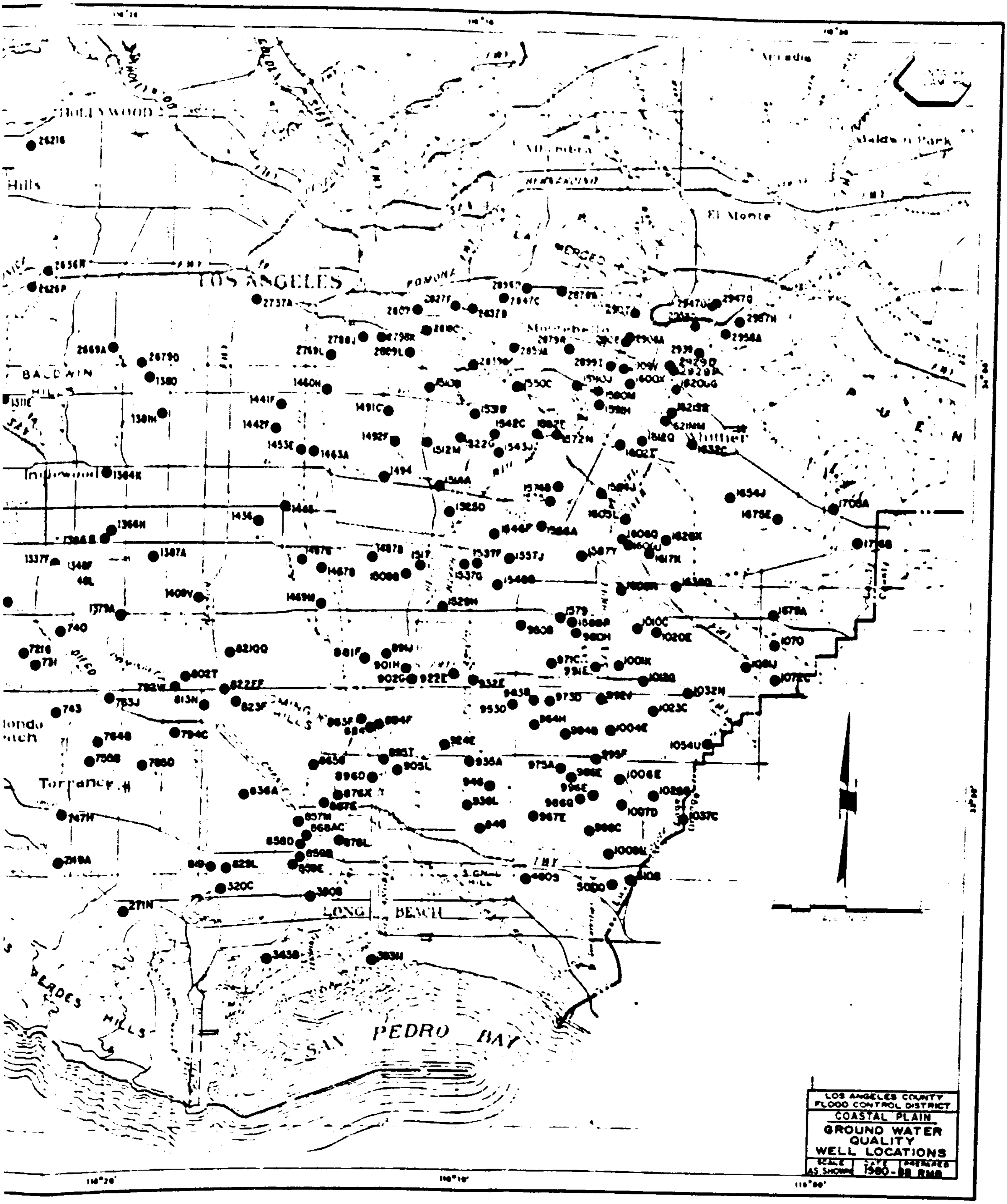

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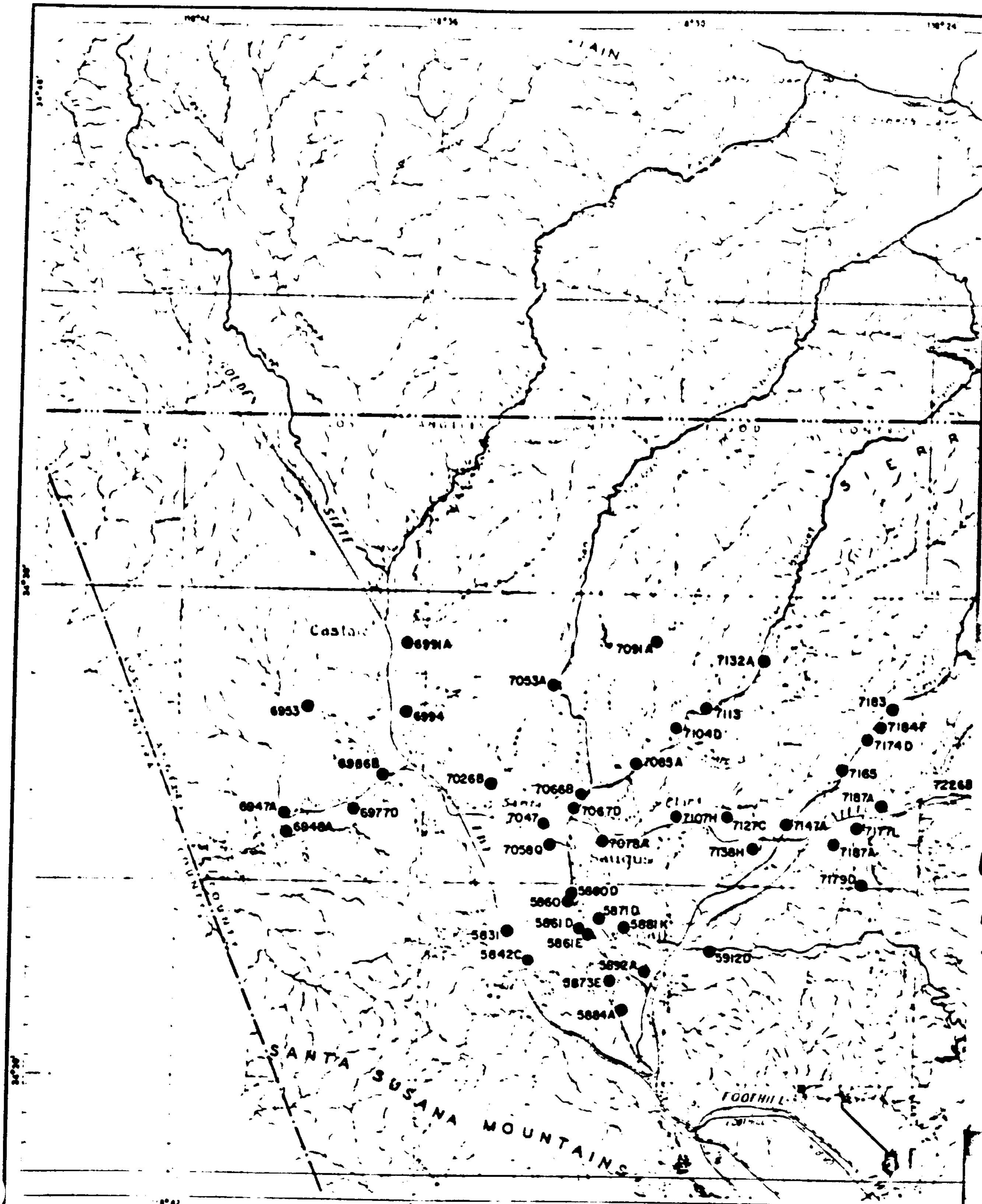

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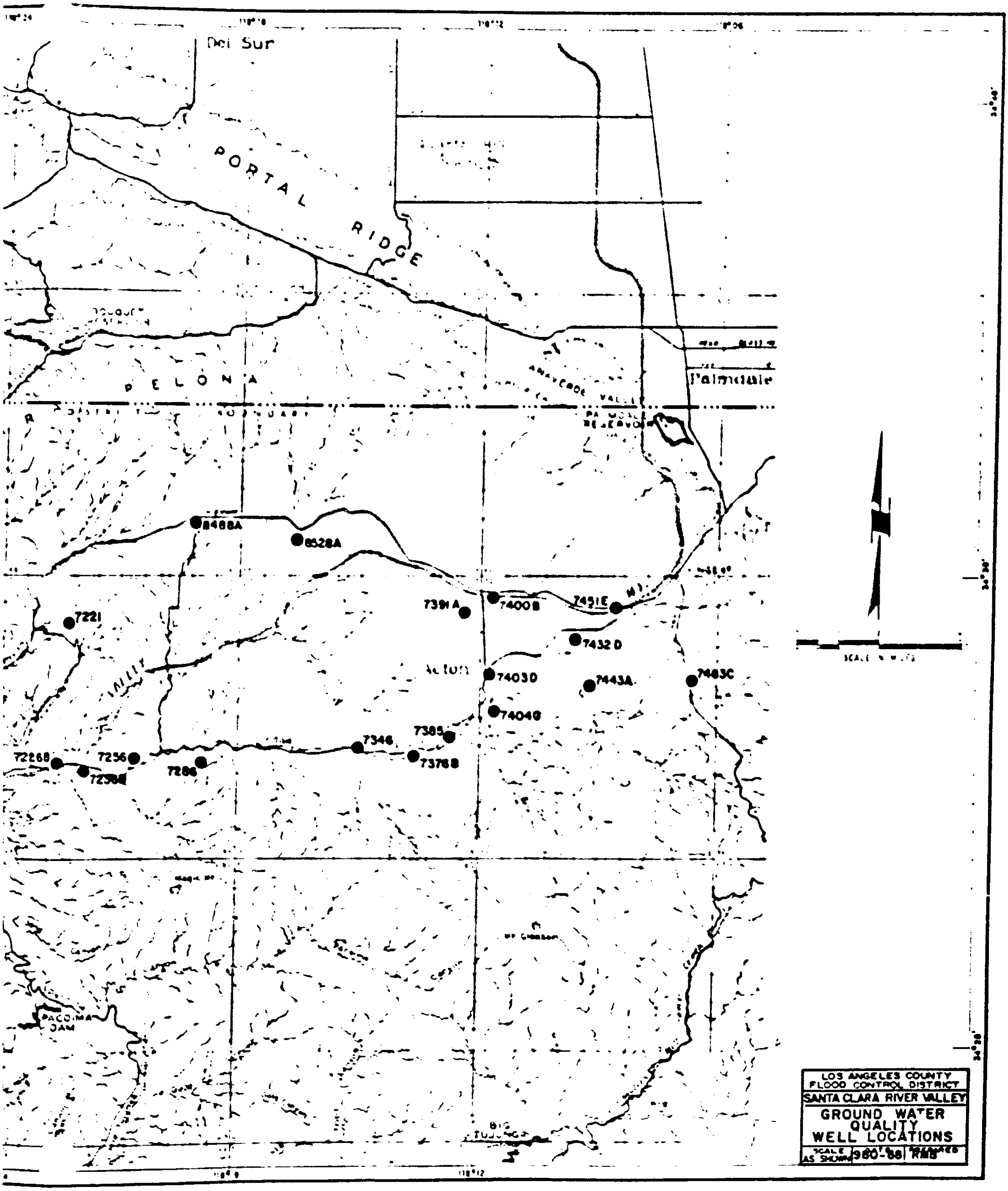

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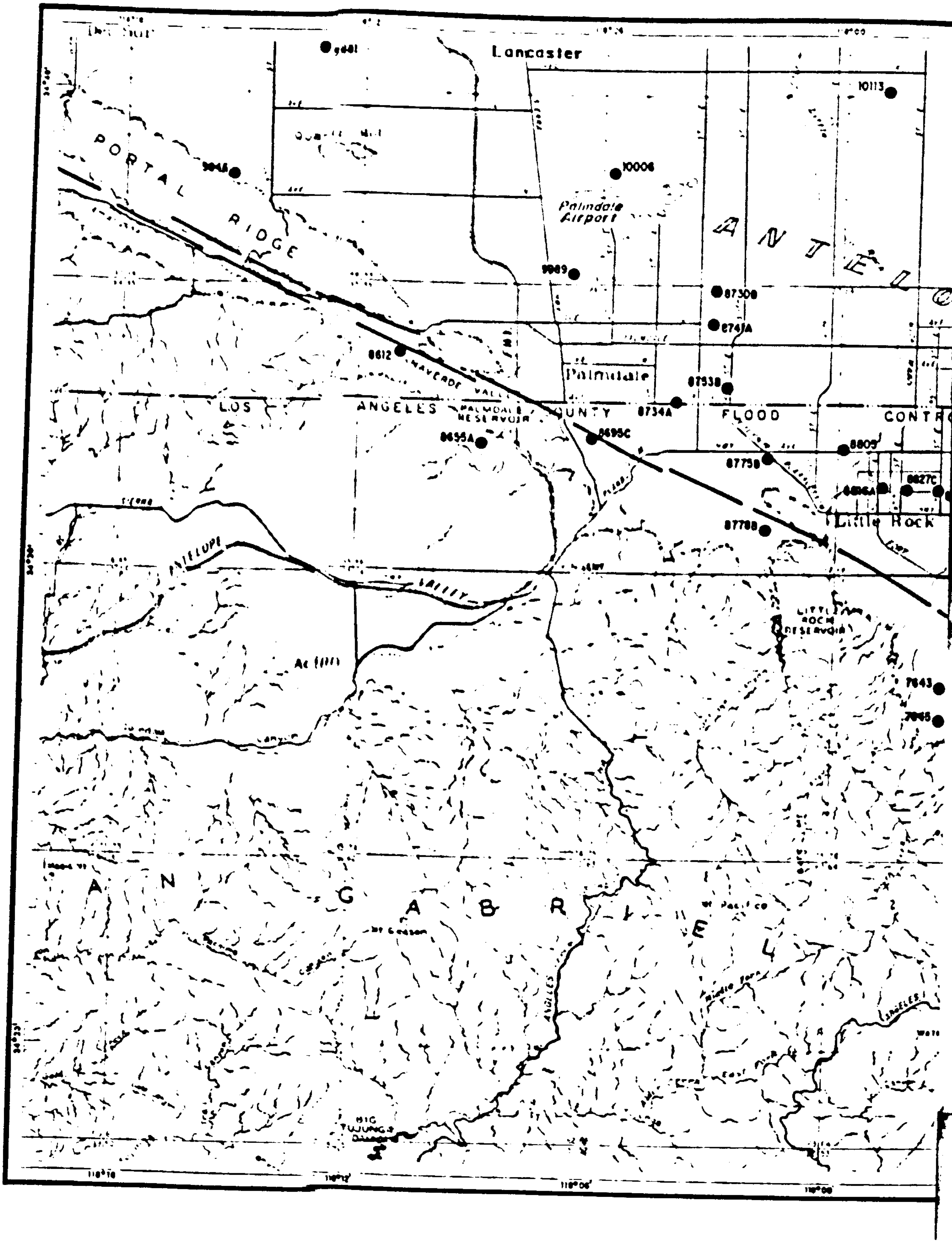
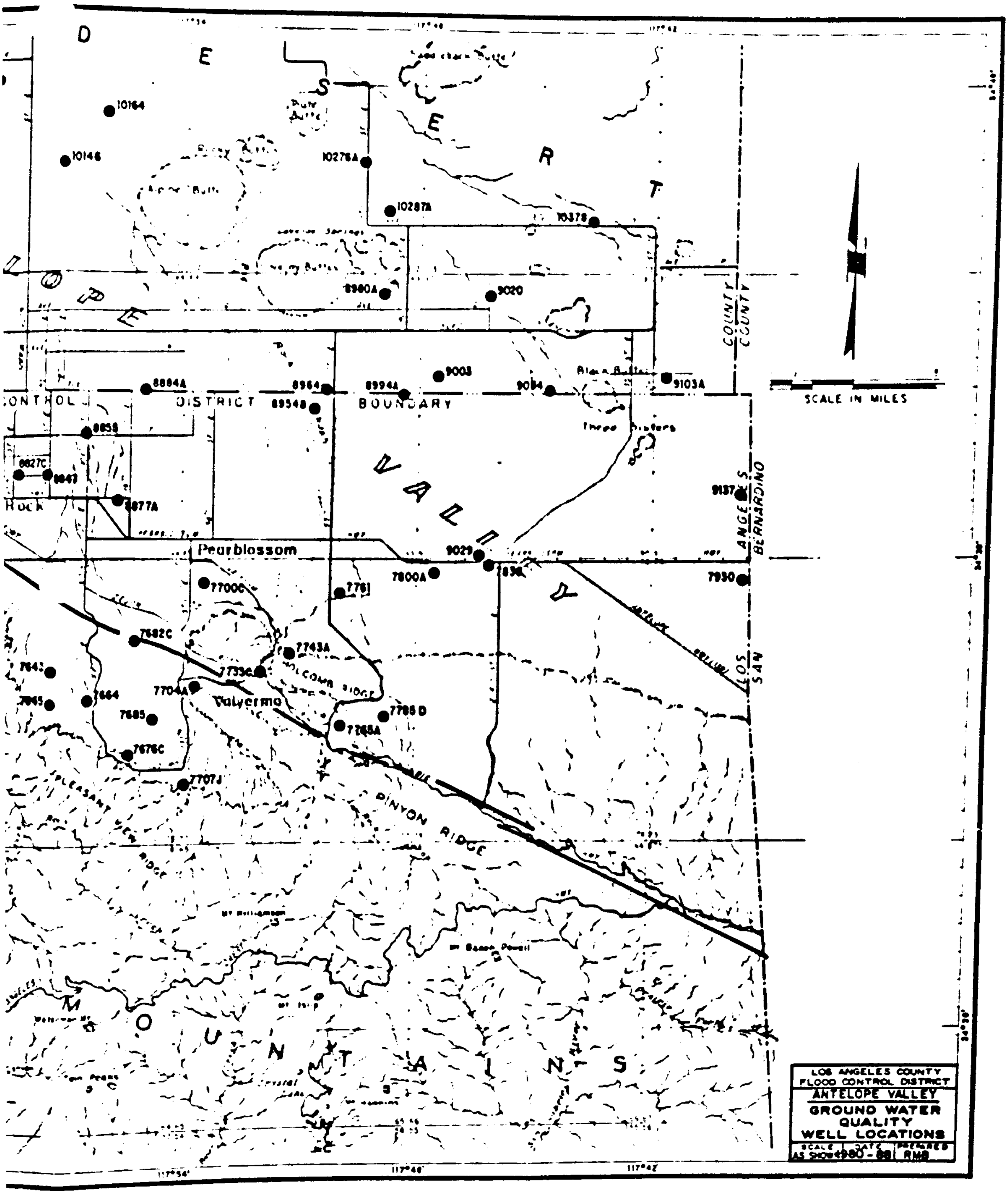

Lancaster
PORTAL RIDGE
Palmdale Airport
Palmdale
LOS ANGELES COUNTY FLOOD CONTRO
PALMDALE RESERVOIR
Little Rock
LITTLE ROCK RESERVOIR
ANTELOPE VALLEY
A N G A B R I E L
BIG TUJUNGA DAM
10113
9045
10006
9089
8730B
8741A
8612
8753B
8734A
8655A
8695C
8805
8775B
8806A
8827C
8778B
7643
7665

VOL 12 1959 1



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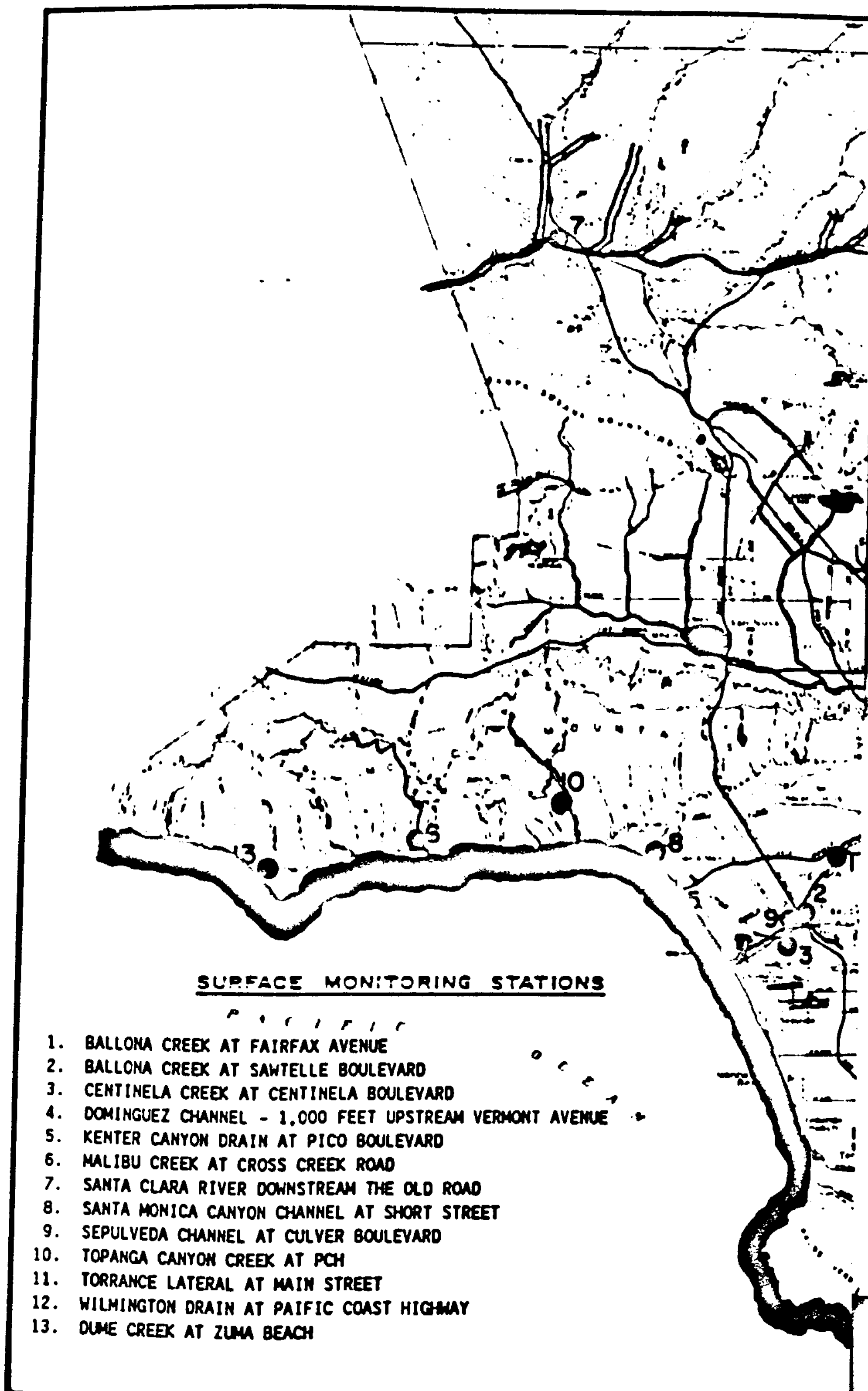
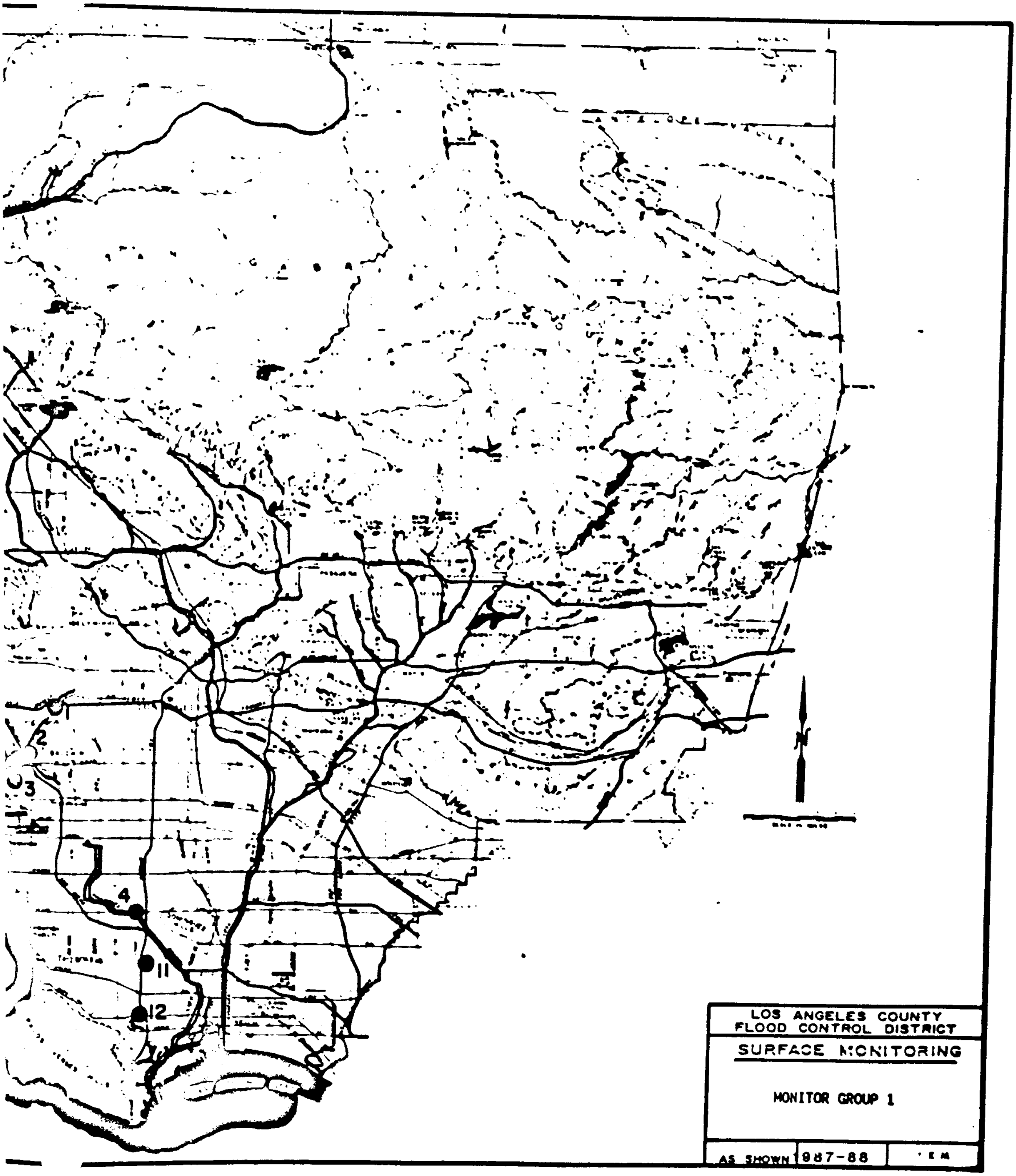

SURFACE MONITORING STATIONS
PACIFIC OCEAN
1. BALLONA CREEK AT FAIRFAX AVENUE
2. BALLONA CREEK AT SAWTELLE BOULEVARD
3. CENTINELA CREEK AT CENTINELA BOULEVARD
4. DOMINGUEZ CHANNEL - 1,000 FEET UPSTREAM VERMONT AVENUE
5. KENTER CANYON DRAIN AT PICO BOULEVARD
6. MALIBU CREEK AT CROSS CREEK ROAD
7. SANTA CLARA RIVER DOWNSTREAM THE OLD ROAD
8. SANTA MONICA CANYON CHANNEL AT SHORT STREET
9. SEPULVEDA CHANNEL AT CULVER BOULEVARD
10. TOPANGA CANYON CREEK AT PCH
11. TORRANCE LATERAL AT MAIN STREET
12. WILMINGTON DRAIN AT PAIFIC COAST HIGHWAY
13. DUME CREEK AT ZUMA BEACH



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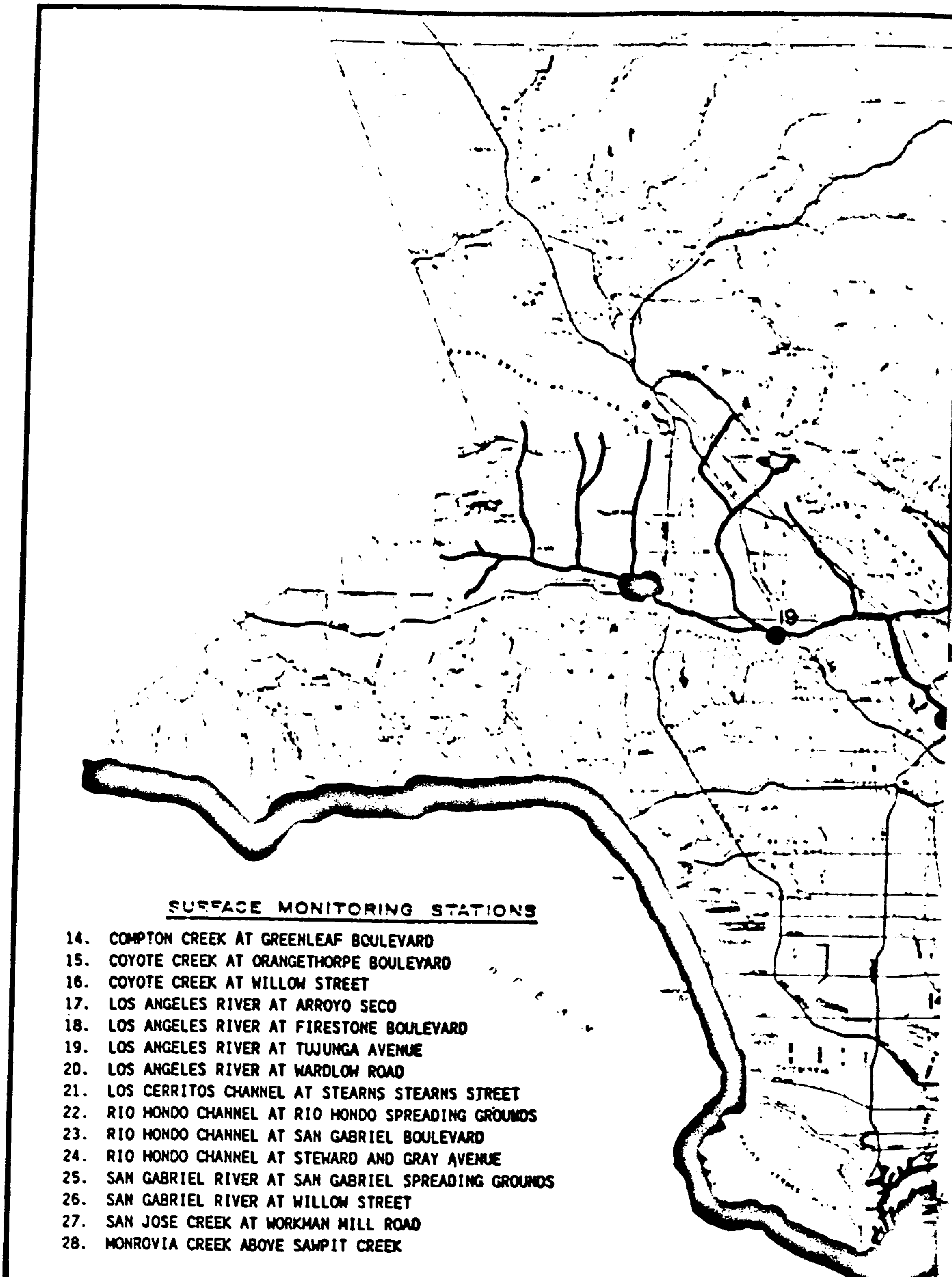
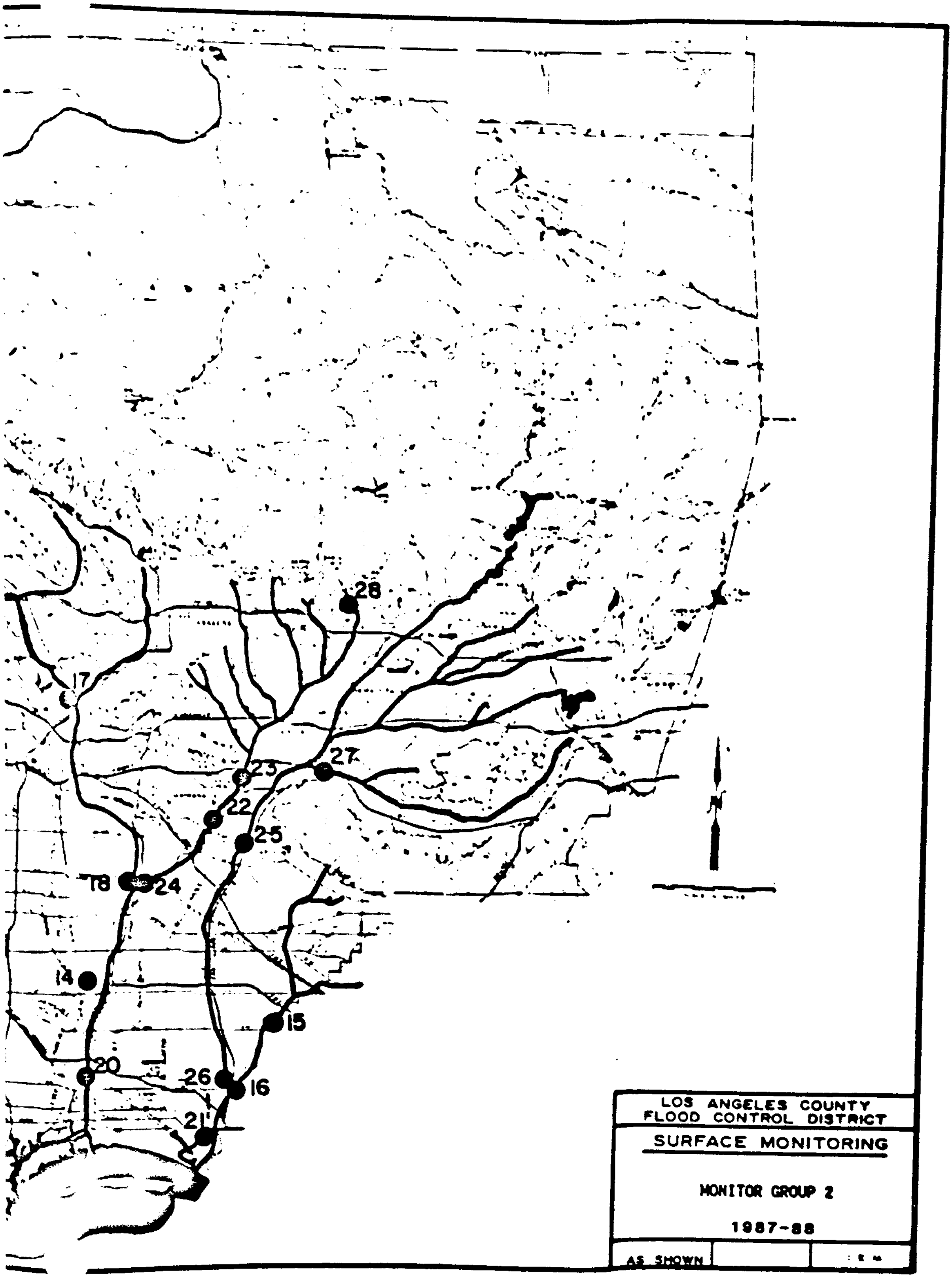

19
SURFACE MONITORING STATIONS
14. COMPTON CREEK AT GREENLEAF BOULEVARD
15. COYOTE CREEK AT ORANGETHORPE BOULEVARD
16. COYOTE CREEK AT WILLOW STREET
17. LOS ANGELES RIVER AT ARROYO SECO
18. LOS ANGELES RIVER AT FIRESTONE BOULEVARD
19. LOS ANGELES RIVER AT TUJUNGA AVENUE
20. LOS ANGELES RIVER AT WARDLOW ROAD
21. LOS CERRITOS CHANNEL AT STEARNS STEARNS STREET
22. RIO HONDO CHANNEL AT RIO HONDO SPREADING GROUNDS
23. RIO HONDO CHANNEL AT SAN GABRIEL BOULEVARD
24. RIO HONDO CHANNEL AT STEWARD AND GRAY AVENUE
25. SAN GABRIEL RIVER AT SAN GABRIEL SPREADING GROUNDS
26. SAN GABRIEL RIVER AT WILLOW STREET
27. SAN JOSE CREEK AT WORKMAN HILL ROAD
28. MONROVIA CREEK ABOVE SAWPIT CREEK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LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT
SURFACE MONITORING
MONITOR GROUP 2
1987-88
AS SHOWN

G-2

WATER CONSERVATION

R0052902

VOL 12

1997

WATER CONSERVATION

Information presented in this section includes amounts of local, imported, and reclaimed water conserved in spreading areas, and information on the seawater barrier projects which prevent salt water intrusion to groundwater zones in the coastal areas. Pertinent data are presented regarding the locations and descriptions of Department conservation facilities, as well as facilities owned by others. Also included are groundwater maps delineating elevations recorded during the report period and hydrographs of selected key wells.

CONSERVING THE WATERS

In addition to its flood control program, the Department has the equally important task of conserving as much of the storm and other waste waters as practicable. The use of water spreading facilities adjacent to river channels and in soft-bottom channels permits water to percolate into underground reservoirs for later pumping. These water spreading facilities are located in areas where the underlying soils are composed of sand and gravel formations and some are deep basins which were once gravel pits.

The various types of water conserved, local, imported, and reclaimed, are construed to have the following meanings in this section: Local water is primarily runoff due to rainfall on the mountain and valley watersheds within the County. Imported water is water originating outside the County which is transported to and delivered within the County. Reclaimed water is the effluent produced by the Whittier Narrows Water Reclamation Plant, the San Jose Creek Water Renovation Plant, and the Pomona Reclamation Plant, all operated by the Los Angeles County Sanitation Districts.

The importance of this activity is apparent when it is realized that about 35 to 40 percent of the water used in the County is pumped from ground supplies. The growth of the County combined with periodic droughts seriously depleted these supplies on numerous occasions down through the years.

The Department's policy is to conserve the maximum amount of storm water possible consistent with considering runoff quantity and quality, capacities of the spreading facilities, and groundwater conditions.

SPREADING GROUNDS

The total gross area of spreading areas owned and operated by the Department during this report amounted to 2,369 acres. The Department also assisted in the operation and maintenance of 679 acres of spreading grounds owned by others. An additional 246 acres of spreading grounds are controlled, maintained, and operated by other agencies. The total gross acreage of spreading grounds in the County is 3,294 acres.

IMPORTED WATER

During this period, imported Colorado River water and State Project water for spreading was obtained from The Metropolitan Water District. Also imported State Project Water for spreading was obtained from the San Gabriel Valley Municipal Water District.

Imported water for groundwater recharge in the Coastal Plain was spread in the Department's facilities in the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds and San Gabriel River systems south of Whittier Narrows Dam on behalf of the Central and West Basin Water Replenishment District.

Imported water for groundwater recharge in the San Gabriel Valley was spread in Santa Fe Spreading Grounds, in the San Gabriel River between Morris Dam and the spreading grounds, in Irwindale Spreading Basin and in Forbes Spreading Grounds on behalf of MWD, the Main San Gabriel Basin Watermaster, and the San Gabriel Valley Municipal Water District.

RECLAIMED WATER

The County Sanitation Districts' Whittier Narrows Water Reclamation Plant effluent, purchased by the Central and West Basin Water Replenishment District, was transported to the Rio Hondo and San Gabriel Spreading Grounds and San Gabriel River System for groundwater replenishment.

The County Sanitation Districts' San Jose Creek Water Reclamation Plant, activated in May 1972, made its first delivery of effluent in November 1972. The portion of the effluent that is spread is also purchased by the Central and West Basin Water Replenishment District.

The maximum amount of reclaimed water allowed includes Pomona Plant Water for spreading annually in the Montebello Forebay was increased from 32,700 acre-feet to 37,700 acre-feet in the 1986-87 water year, and to 42,700 acre-feet effective July 1988.

SEAWATER BARRIER PROJECTS

The Department operates three barrier projects to protect the groundwater in the West Coast and Central Basins against seawater intrusion by creating freshwater pressure ridges along the coastline. The pressure ridges are created by injecting fresh water through a series of injection wells. During the report period, 24,300 acre-feet of water were injected at the West Coast Basin Barrier Project, 7,050 acre-feet at the Dominguez Gap Barrier Project, and 4,000 acre-feet at the Los Angeles part of the Alamitos Barrier Project. On behalf of the Orange County Water District, 2,170 acre-feet of water were injected at the Orange County portion of the Alamitos Barrier Project.

SEASONAL DATA AND MAPS

During this report period, monthly and semiannual measurements of groundwater levels in observation wells located throughout the groundwater basins in Los Angeles County were made and processed.

Hydrographs of selected key wells are included in this report.

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GROUNDWATER BASINS AND GROUNDWATER RECHARGE

Groundwater in Los Angeles County is stored in basins underlying five major geographic areas. These groundwater basins are separated by geologic features which impede groundwater movement or sometimes by arbitrary political boundaries. Following is a background and summary of the Department's groundwater recharge activities within each of these areas.

The Department operates 2,369 acres of spreading grounds and basins and soft-bottom channel spreading areas for replenishment of local aquifers to increase water supplies. During the report period, the Department conserved more than 124,000 acre-feet of storm runoff.

The conservation of local runoff is supplemented by spreading imported water and reclaimed water purchased by water agencies. During the period, 72,150 acre-feet of imported water and 40,200 acre-feet of reclaimed water were spread.

SAN GABRIEL VALLEY

The Department operates 20 spreading grounds in the San Gabriel Valley to receive direct valley runoff and flows from the San Gabriel Mountains, some can also receive imported water. During the report period, the Department added approximately 47,900 acre-feet of local water and 47,200 acre-feet of imported water to the groundwater stored in the basins underlying the San Gabriel Valley.

Main San Gabriel Basin

This is the largest basin underlying the San Gabriel Valley with an estimated storage capacity of 9.5 million acre-feet. It reacts quickly to artificial spreading in Santa Fe Reservoir Spreading Grounds and to percolation in the San Gabriel River downstream of Santa Fe Dam. Citrus Spreading Grounds which was dormant for 17 years, was reactivated in early 1985. The basins were reconfigured by permittee and contract work to increase the surface storage capacity from 25 acre-feet to 85 acre-feet and a 35-50 cfs intake from Big Dalton Wash was constructed. During this period, construction of a new intake structure with a capacity of 200 cfs was started.

During the report period, the Department replenished the Main San Gabriel Basin with 18,700 acre-feet of local water and 23,400 acre-feet of imported water.

Upper San Gabriel Canyon Basin

Approximately 16,500 acre-feet of local water and approximately 22,800 acre-feet of imported water were recharged by the Department through its San Gabriel Canyon Spreading Grounds and by percolation in the adjacent San Gabriel River. Also, 6,000 acre-feet of water were routed to Fish Canyon Spreading Grounds which is operated by the Committee of Nine. A contract for an intake system with a capacity of 200 cfs for San Gabriel Canyon Spreading Grounds was under way during the report period.

1 9500

Lower Canyon Basin

The basin is located south of the Upper San Gabriel Canyon Basin and is separated from it by the underground Lohmon Dike. Groundwater cascades over the Lohmon Dike from the Upper San Gabriel Canyon Basin and recharges the Lower San Gabriel Canyon Basin. The Department spread 610 acre-feet of local water in Sawpit Spreading Grounds which is within the Lower Canyon Basin.

Wayhill Basin

A contract was awarded to improve the storage capacity and construct a new intake at Forbes Spreading Grounds.

The Department spread 370 acre-feet of local water and 1,000 acre-feet of imported water in the Wayhill basin.

Foothill Basin

The Department spread 770 acre-feet of local water at its San Dimas Canyon Spreading Grounds facility in the Foothill Basin.

Glendora Basin

The Department spread 470 acre-feet of local water in its Dalton facilities within the Glendora Basin.

Claremont Heights Basin

Ten acre-feet of local water were diverted to the Pomona Valley Protective Associaton's Thompson Creek Spreading Grounds which benefits the groundwater in the Claremont Heights Basin.

Live Oak Basin

The Department has no spreading facilities in the Live Oak basin.

Chino Basin

The basin is located in the most eastern part of the County. No Department recharge facilities are located within the Chino Basin.

San Dimas Basin

The basin is north of the San Jose Hills, east of the Main Basin, and south of the Wayhill Basin. The Department spread 70 acre-feet of local water in its Live Oak Spreading Grounds to recharge the basin.

Pomona Basin

The basin is located south of Claremont, Live Oak, and San Dimas Basins, and north of the Chino Basin and northeast of the San Jose Hills. The Department has no water spreading facilities within this basin.

Puente, Spadra, and Walnut Basins

No spreading occurs in this area.

Raymond Basin

The basin covering approximately 40 square miles is located in the northwest corner of the San Gabriel Valley and is separated from the Main San Gabriel Basin by the Raymond Fault. The Raymond Basin contains the Monk Hill Basin and the Pasadena and Santa Anita subareas. The Department recharged 2,810 acre-feet of local water by its spreading facilities in the Raymond Basin and diverted 1,590 acre-feet to the City of Sierra Madre's spreading facility during the report period.

COASTAL PLAIN

The groundwater basins underlying the Coastal Plain are divided by geological features into the Central (includes the Montebello and Los Angeles Forebays), West Coast, Santa Monica, and Hollywood Basins. During the period October 1, 1987 to September 30, 1988, the Department recharged 50,100 acre-feet of local water, 25,000 acre-feet of imported water, and 40,200 acre-feet of reclaimed water to the basins underlying the Coastal Plain. Most of the water was spread in the Montebello Forebay.

The Department is continuing with improvements in the Montebello Forebay to maximize water conserved and to simplify the spreading operations.

Central Basin

The Central Basin has the most storage capacity of the basins in the Coastal Plain. In addition to the waters recharged in the Department's spreading facilities, water injected in the Alamitos Barrier Project also contributes to the replenishment of the groundwater stored in the Central Basin. The Montebello Forebay is the groundwater recharge intake for the pressure aquifers underlying the Central Basin.

Rio Hondo Coastal Basin Spreading Grounds

On the east side of the Rio Hondo Spreading Grounds, 31 basins have been deepened and combined into 10 basins, increasing conservation storage capacity from 1,600 acre-feet to 4,500 acre-feet. Also, a 1,000 cfs gravity-flow-type intake structure has been constructed to provide a larger inflow to the new basins. A Phase I contract for construction of interbasin structures to handle higher flows for that part of the Rio Hondo Spreading Grounds east side spreading facilities below Washington Boulevard has been completed. A Phase II contract for construction of interbasin structures in the Rio Hondo Spreading Grounds east side upstream of Washington Boulevard started on June 18, 1988.

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San Gabriel River

Air-inflatable rubber dams have been installed on stabilizers in the soft-bottom river at Washington Boulevard and upstream of Telegraph Road to provide additional surface storage for water conservation and to eliminate the need to use sand levees which wash out with high river flows.

A contract was begun on June 6, 1988 for the installation of three additional rubber dams in the San Gabriel River: upstream of Slauson Avenue, upstream of Florence Avenue, and upstream of Firestone Boulevard.

West Coast Basin

The West Coast Basin is the second largest basin underlying the Coastal Plain and is separated from the Central Basin by the Newport-Inglewood Fault zone. Groundwater is primarily recharged by Central Basin subsurface flows and by water injected by the Department in the West Coast Basin and Dominguez Gap Barrier Projects. Groundwater elevations in the West Coast Basin are below sea level except in the area of the West Coast Basin Barrier injection mound.

SAN FERNANDO VALLEY

The San Feranando Valley is also called the Upper Los Angeles River Area (ULARA). Most of the runoff from the surrounding mountains flows to the Valley.

San Fernando Main Basin

The basin is the largest basin underlying the San Fernando Valley. During the report period, 23,200 acre-feet of local water spread by the Department recharged this basin. Pacoima Spreading Grounds were improved beginning in 1985 and continuing into this period by combining and excavating 36 basins into 12 basins and replacing the flashboard structures with spillway type structures. Improvements to the intake were also made.

Sylmar Basin

A much smaller basin underlying the San Fernando Valley is the Sylmar Basin; the Department has no spreading facility within this basin.

Verdugo and Eagle Rock Basins

The small Verdugo and Eagle Rock Basins comprise the remaining basins underlying the San Fernando Valley. The Department has no spreading facilities within either basin.

SANTA CLARITA VALLEY

The Department has no spreading facilities in the area. Most of the Valley area is farmland, permitting substantial natural percolation.

The Upper Santa Clarita subunit comprises five basins. The groundwater in storage in this subunit increased considerably after the heavy rains in 1969.

1 9603

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ANTELOPE VALLEY

There are several groundwater basins underlying the Antelope Valley, five of them are located within Los Angeles County.

During this report period, the Department recharged over 2,900 acre-feet of local water in its spreading facility in the Big Rock area to groundwater in the Pearland Basin.

The groundwater level in the Lancaster Basin, has declined steadily since 1925 and reached a new historic low during the report period.

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19605

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
WATER CONSERVATION DIVISION

SUMMARY OF DATA ON SPREADING FACILITIES
OWNED AND OPERATED BY THE DISTRICT
UPDATED THROUGH SEPTEMBER [illegible]

SPREADING FACILITY	TYPE	PLACED FIRST USE	AREA IN ACRES: GROSS	AREA IN ACRES: WETTED	CAPACITIES: CHANNEL** CFS	CAPACITIES: INTAKE CFS	CAPACITIES: STORAGE A.F.	CAPACITIES: PERCOLATION* CFS	LOCATION	SOURCE OF WATER	REMARKS
PACOIMA	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	17,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PECK ROAD	DEEP BASIN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CONFLUENCE OF SAWPIT AND SANTA ANITA WASHES.	ALL FLOWS IN SAWPIT AND SANTA ANITA WASHES.	
RIO HONDO COASTAL	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SAN DIMAS CANYON	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
SAN GABRIEL CANYON	DEEP BASINS	[illegible]	[illegible]	-	-	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]
SAN GABRIEL COASTAL	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
SAN GABRIEL RIVER LOWER	TEMPORARY CHECK LEVEES	[illegible]	[illegible]	[illegible]	-	-	[illegible]	[illegible]	[illegible]	SEE SAN GABRIEL COASTAL REMARKS	
SAN GABRIEL RIVER UPPER	TEMPORARY CHECK LEVEES	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]
SANTA ANITA	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SANTA FE	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SAWPIT	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
WALNUT	DEEP BASIN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
TOTAL:			[illegible] AC.	[illegible] AC.	-	-	[illegible] A.F.	[illegible] CFS			

* THE CAPACITIES LISTED ARE BASED ON INFILTRATION RATES WHICH MAY BE EXPECTED TO PERSIST FOR AT LEAST FIVE DAYS BUT ARE NOT VALID FOR SUSTAINED SPREADING OPERATIONS.

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
WATER CONSERVATION DIVISION

SUMMARY OF DATA ON SPREADING FACILITIES
NOT OWNED BY THE DISTRICT
UPDATED THROUGH SEPTEMBER [illegible]

GROUNDS	TYPE	SEASON FIRST USED	AREA IN ACRES: GROSS	AREA IN ACRES: WETTED	CAPACITIES*: CHANNEL** (CFS)	CAPACITIES*: INTAKE (CFS)	CAPACITIES*: STORAGE (A.F.)	CAPACITIES*: PERCOLATION (CFS)	LOCATION	SOURCE OF WATER	REMARKS
GROUNDS IN WHICH DISTRICT DOES CONSTRUCTION MAINTENANCE AND DOES OPERATIONS:											
SIERRA MADRE	SHALLOW BASINS	ABOUT [illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	CITY OF SIERRA MADRE. NORTH SIDE OF [illegible] AVENUE, ONE HALF MILE WEST OF SANTA ANITA AVENUE.	LITTLE SANTA ANITA CREEK AND STREET RUNOFF ONLY PRIOR TO 1951-52. STARTING IN 1951-52 ALSO CONTROLLED FLOWS FROM SANTA ANITA DAM.	NO RECORDS OF WATER SPREAD PRIOR TO 1951-52. [illegible] ULTIMATE CAPACITY ESTIMATED [illegible]. THREE BASINS ADDED IN [illegible]
FISH CREEK	SHALLOW BASINS	ABOUT [illegible]	[illegible]	[illegible]	-	-	-	[illegible]	WESTERLY SIDE OF SAN GABRIEL RIVER BELOW MOUTH OF FISH CANYON AND NORTH OF THE CITY OF AZUSA.	THE "COMMITTEE OF NINE" DIVERTS WATER TO CAL AMERICAN PIPELINE [illegible] DIVERTS FLOW TO FISH CREEK [illegible]	OWNED AND OPERATED BY CAL-AMERICAN WATER COMPANY.
THOMPSON CREEK	DITCHES CHECKS AND DEEP BASINS	ABOUT [illegible]	[illegible]	[illegible]	-	[illegible]	-	[illegible]	[illegible] AND ADJACENT TO THOMPSON CREEK DAM. EAST SIDE OF CREEK.	[illegible], WILLIAMS, PALMER, AND [illegible] CREEKS. ALSO THOMPSON CREEK. [illegible] ELEVATION [illegible].	OPERATED BY POMONA VALLEY PROTECTIVE ASSOCIATION. IN ADDITION TO THE [illegible] ACRES, SOME AREA WITHIN THOMPSON CREEK RESERVOIR IS USED TO SPREAD [illegible]. WATER SPREAD IN AREA SINCE ABOUT [illegible].
SAN ANTONIO	DITCHES CHECKS AND SHALLOW BASINS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	BOTH SIDES OF SAN ANTONIO CREEK FROM TWO AND ONE HALF MILES ABOVE BASE LINE NORTH-WESTERLY TO BASE LINE.	CONTROLLED RELEASES FROM THE SAN ANTONIO FLOOD CONTROL DAM.	OPERATED BY POMONA VALLEY PROTECTIVE ASSOCIATION. WEST SIDE OF CHANNEL [illegible] ACRES. EAST SIDE OF CHANNEL [illegible]. IN ADDITION THERE ARE [illegible] ACRES EAST OF CHANNEL IN SAN BERNARDINO COUNTY. WATER SPREAD IN VICINITY ON AND OFF AS EARLY AS ABOUT [illegible].
TOTALS:			[illegible]	-	-	-	-	[illegible]			
GROUNDS CONTROLLED BY OTHERS. THE DISTRICT COOPERATING:											
[illegible] (CITY OF LOS ANGELES)	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	SAN FERNANDO VALLEY, NORTH OF LOS ANGELES RIVER, ABOVE [illegible] STREET.	LOS ANGELES RIVER. PARTIALLY CONTROLLED BY VARIOUS DAMS. RELEASE OF [illegible] VALLEY WATER FROM CHATSWORTH RESERVOIR. GROUNDWATER FROM WELLS IN THE WEST END OF SAN FERNANDO VALLEY.	
L.A.CITY DEPT. OF WATER AND POWER TUJUNGA	SHALLOW BASINS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	SAN FERNANDO VALLEY, EAST SIDE OF TUJUNGA WASH AT [illegible] BOULEVARD.	LOS ANGELES CITY'S OWENS VALLEY AQUEDUCT AND CONTROLLED RELEASES FROM HANSEN DAM.	PRIOR TO [illegible] FLOOD, USED [illegible] ACRES [illegible]. TUJUNGA CHANNEL ON [illegible] SIDE OF GROUNDS PAVED IN [illegible].
CITY OF POMONA	DITCHES CHECKS AND SHALLOW BASINS	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	NORTH OF CLAREMONT, ONE HALF MILE NORTH OF FOOTHILL BOULEVARD AND ONE-EIGHTH MILE WEST OF MILLS AVENUE.	SAN ANTONIO CREEK WATER DELIVERED THROUGH LOOP [illegible] CANYON WATER COMPANY'S PIPE LINE. ALSO SOME LOCAL RUNOFF.	WATER SPREAD IN VICINITY ON AND OFF SINCE ABOUT [illegible]. GROUNDS ACQUIRED BY CITY OF POMONA, OCTOBER [illegible]. NO RECORDS OF WATER SPREAD PRIOR TO [illegible]. DEEP BASIN COMPLETED IN [illegible].
TOTALS:			[illegible]	[illegible]	-	-	-				

* THE CAPACITIES LISTED ARE BASED ON INFILTRATION RATES WHICH MAY BE EXPECTED TO PERSIST FOR AT LEAST FIVE DAYS BUT ARE NOT VALID FOR SUSTAINED SPREADING OPERATIONS.

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

1 9607

WATER CONSERVED IN ALL DEPARTMENT FACILITIES
WATER YEAR : 1987-1988
(in acre-feet)

	SPREADING FACILITY	MONTHS: OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	ACCUMULATIVE TOTALS
SAN FERNANDO VALLEY	BRANFORD	118.0	0.0	91.3	23.0	36.0	67.0	16.6	0.0	0.0	0.0	0.0	0.0	384.9
	HANSEN	327.0	1,446.0	1,407.0	2,312.0	1,792.0	3,363.0	2,727.0	1,364.0	760.0	664.0	87.9	272.0	17,226.9
	LOPEZ	1.0	0.0	1.2	773.0	0.0	438.0	15.1	318.0	0.0	0.0	0.0	0.0	1,037.1
	PACOIMA	606.0	342.0	386.0	1,318.0	323.0	366.0	323.0	316.0	0.0	0.0	0.0	0.0	4,538.0
	SUBTOTAL	1,252.0	1,776.0	1,886.5	4,128.0	2,309.8	4,434.0	2,289.7	2,172.0	760.0	664.0	87.9	272.0	23,168.9
SAN GABRIEL VALLEY	ARROYO SECO	102.0	242.0	172.0	138.0	78.0	279.0	306.0	2.0	60.0	2.2	0.0	0.0	1,371.0
	BEN LOMOND	0.7	73.0	204.0	276.0	311.0	160.0	260.0	919.0	643.0	360.0	280.0	38.7	3,338.0
	BIG DALTON	0.0	2.0	33.1	69.0	26.2	66.0	81.3	64.0	0.0	0.0	2.0	0.6	308.2
	BUENA VISTA	147.0	243.0	128.0	164.3	121.7	136.2	198.2	118.3	33.6	42.0	98.0	88.0	1,539.2
	CITRUS	46.6	79.3	43.0	61.1	32.2	38.7	110.0	21.1	13.7	0.0	0.0	7.7	688.7
	EATON BASIN	273.0	148.0	163.0	217.0	139.0	37.3	307.0	17.9	23.0	17.3	39.0	38.9	1,238.0
	EATON WASH	0.0	134.0	68.2	98.2	23.0	198.0	139.0	23.0	0.0	0.0	0.0	0.0	784.2
	FORBES	12.9	77.0	42.6	28.2	66.0	87.1	141.0	428.0	66.0	400.0	26.2	7.3	1,363.0
	IRWINDALE	302.0	38.3	292.0	860.0	291.0	1.0	397.0	409.0	104.0	339.0	122.0	388.0	2,688.2
	LITTLE DALTON	1.2	60.7	14.5	22.0	11.7	29.0	28.2	3.6	0.0	0.0	0.0	0.0	136.9
	LIVE OAK	0.0	1.4	12.3	78.6	10.3	18.0	1.6	4.2	0.0	0.0	0.0	0.0	72.0
	MORRIS TO STA. F190	1,800.0	4,100.0	2,200.0	2,700.0	3,666.0	238.0	1,300.0	1,400.0	5,421.0	73.0	380.0	1,100.0	28,962.0
	STA. F190 TO SANTA FE S.G.	111.0	77.0	107.0	228.0	102.0	0.0	0.0	0.0	100.0	0.0	0.0	488.0	1,130.0
	PECK ROAD	312.0	308.7	282.9	425.2	238.0	138.2	300.0	31.7	3,670.0	37.0	26.0	48.0	6,213.3
	SAN DIMAS CANYON	13.3	61.2	29.0	38.0	3.6	116.0	31.9	308.0	10.9	73.2	0.0	0.0	772.0
	SAN GABRIEL CANYON	72.0	1,208.0	710.0	1,904.0	1,398.0	276.0	1,770.0	1,673.0	1,301.0	1,168.0	300.0	900.0	13,338.0
	SANTA ANITA	0.3	39.3	148.0	98.0	0.0	165.0	66.0	23.2	0.0	0.0	0.0	0.0	322.6
	SANTA FE	108.0	2,463.0	3,033.0	6,422.0	6,698.0	19.0	1.0	0.0	91.0	0.0	0.0	0.0	19,119.0
	SANTA FE RESERVOIR	110.0	77.0	107.0	360.0	0.0	0.0	0.0	0.0	228.0	0.0	320.0	228.0	1,004.0
	SANTA FE TO STA. F264	0.0	0.0	0.0	137.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	408.0	388.1
	SANTA FE DIVERSION	0.0	0.0	0.0	0.2	0.0	0.0	4.0	0.0	1,000.0	0.0	0.0	0.6	1,088.0
	SAWPIT	79.7	79.3	96.6	139.0	65.3	138.0	2.6	0.0	0.0	0.0	0.0	19.2	642.1
	WALNUT	173.0	143.0	166.0	162.0	108.0	98.2	164.0	128.0	121.0	176.0	118.0	138.0	1,691.2
	SUBTOTAL	4,088.3	9,439.3	7,971.6	13,223.2	14,744.0	2,336.6	3,784.2	3,448.1	13,281.7	2,829.7	1,988.2	3,958.2	87,460.3
COASTAL PLAIN	DOMINGUEZ GAP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RIO HONDO	EAST FLUME	3,440.0	3,266.0	2,026.0	1,148.0	1,093.0	1,706.0	4,993.0	3,033.0	4,777.0	0.0	0.0	0.0	29,888.0
	WEST FLUME	800.0	1,993.0	738.0	953.0	1,286.0	1,373.0	801.0	0.0	342.0	646.0	0.0	0.0	9,389.0
	R/D FLUME	427.0	608.0	328.0	707.0	481.0	393.0	1,200.0	0.0	304.0	887.0	138.0	388.0	3,484.2
	102" INTAKE	43.1	0.0	0.0	0.0	0.0	0.0	326.0	1,431.0	958.0	294.0	0.2	0.0	6,782.1
SAN GABRIEL	INTAKE	2,438.0	3,546.0	3,364.0	3,388.0	2,980.0	3,718.0	2,246.0	2,764.0	1,017.0	312.0	738.0	307.0	29,738.0
	RIVER	631.0	73.0	31.0	0.0	138.0	376.0	879.0	2,382.0	1,203.0	0.0	1,172.0	2,308.0	7,138.0
	S.G. RESERVOIR	3,415.0	2,291.0	1,304.0	1,411.0	2,666.0	2,871.0	1,457.0	3,890.0	3,446.0	1,312.0	1,064.0	1,458.0	27,176.0
	SUBTOTAL	13,818.1	12,771.0	9,001.4	7,407.0	8,586.0	9,433.0	12,132.0	13,828.0	12,366.0	4,042.0	4,443.2	4,998.0	115,317.7
ANTELOPE VALLEY	BIG ROCK	0.0	23.2	132.0	146.0	323.0	388.0	391.0	687.0	312.0	132.0	64.9	109.0	2,927.1
	GRAND TOTAL	19,138.6	24,299.3	18,950.5	26,986.2	23,932.6	17,004.1	21,616.9	20,330.1	26,927.7	7,684.7	6,346.2	9,292.2	228,766.2

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1 9608

LOCAL WATER DIVERTED TO OTHER THAN DEPARTMENT FACILITIES
WATER YEAR : 1987-1988
(in acre-feet)

	SPREADING FACILITY	MONTHS: OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	ACCUMULATIVE TOTALS
OTHER FACILITIES	SIERRA MADRE	75.0	132.0	0.0	253.0	118.0	303.0	272.0	179.0	166.0	75.0	0.0	88.1	1,594.0
	THOMPSON CREEK	0.0	0.0	0.0	7.1	0.6	1.0	0.1	0.0	0.0	0.0	0.0	0.0	10.1
	FISH CANYON	127.0	252.0	464.0	520.0	619.0	459.0	604.0	752.0	632.0	520.0	533.0	518.0	5,900.0
	GRAND TOTAL	202.0	384.1	464.0	780.1	737.6	763.0	876.2	932.0	798.0	595.0	533.0	598.1	7,503.0

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R0052915

WATER DELIVERED IN ACRE-FEET
WATER YEAR : 1987-1988
(in acre-feet)

	IMPORTED WATER OUTLETS										RECLAIMED WATER SPREAD AND WASTED										
	SAN DIMAS	THOMPSON CREEK	SAN GAB. RIVER	ALHAMBRA	OLDEN ST.	USG 3	BEATTY CANYON	SAN DIMAS SD	IMPORTED WATER		WHITTIER NARROWS PLANT				SAN JOSE PLANT				POMONA PLANT	RECLAIMED WATER SPREAD	
											SPREAD		WASTED	MONTHLY		SPREAD		MONTHLY			
MONTH	CB-40	CB-20	CB-17	CB-36	S.G. 699	ROCKWD	SCVWD	SDVWD	MONTHLY A.F.	WTR YEAR A.F.	R.HONDO	S.GABRIEL	AF	TOTAL	RELEASE	R.HONDO	S.GABRIEL	TOTAL		MONTHLY A.F.	WATER YEAR AF
OCTOBER	0.0	3,860.6	0.0	0.0	0.0	0.0	2,902.5	0.0	6,763.1	6,763.1	1,319.2	126.0	7.4	1,316.7	2,109.5	134.1	1,966.6	2,102.7	129.0	3,576.4	3,576.4
NOVEMBER	4,135.9	0.0	0.0	0.0	0.0	6,682.8	500.5	0.0	11,319.2	18,082.3	1,324.6	0.0	0.0	1,324.6	1,951.7	385.7	1,566.0	1,950.7	155.0	3,431.3	7,007.7
DECEMBER	715.9	0.0	0.0	0.0	0.0	5,521.9	0.0	0.0	6,237.8	24,320.1	769.9	592.2	6.6	1,356.5	1,881.0	307.0	1,573.6	1,880.6	244.0	3,481.1	10,488.8
JANUARY	0.0	0.0	0.0	0.0	0.0	11,960.7	0.0	0.0	11,960.7	36,280.8	203.6	877.4	17.6	1,063.4	1,648.4	0.0	1,647.4	1,647.4	159.0	2,869.8	13,430.8
FEBRUARY	3,491.7	0.0	0.0	0.0	0.0	10,078.9	0.0	0.0	13,570.6	49,851.4	90.8	1,010.8	0.0	1,109.6	695.2	0.0	695.2	695.2	4.0	1,808.8	15,067.4
MARCH	5,902.3	0.0	2.6	0.0	0.0	0.0	0.0	0.0	5,904.8	55,756.2	0.0	1,250.3	0.0	1,250.3	874.0	481.4	357.3	838.7	36.0	2,132.2	17,180.3
APRIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,560.2	1,560.2	57,324.4	1,250.7	5.6	3.7	1,258.0	2,790.7	1,390.7	643.0	2,034.5	81.0	3,972.1	21,152.4
MAY	8,128.2	0.0	0.0	0.0	0.0	0.0	0.0	1,049.6	9,177.8	66,502.2	845.7	310.0	0.0	1,156.5	5,022.7	162.0	4,859.3	5,021.3	40.0	6,217.8	27,400.2
JUNE	3,765.0	0.0	0.0	0.0	0.0	0.0	1,228.3	158.0	5,152.1	68,654.3	325.0	813.0	0.0	1,138.0	1,783.1	1,233.5	549.6	1,783.1	8.0	2,929.1	30,329.3
JULY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	961.1	961.1	69,615.4	852.4	160.6	0.0	1,013.0	2,156.3	2,155.2	0.0	2,155.2	0.0	3,206.2	33,535.5
AUGUST	0.0	1,028.1	0.0	0.0	0.0	0.0	673.2	200.4	1,901.7	71,607.0	499.4	811.7	0.0	1,311.1	1,433.3	116.0	1,317.0	1,433.0	0.0	2,744.1	36,279.6
SEPTEMBER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	530.0	530.0	72,145.0	1,181.2	0.0	2.1	1,179.1	2,720.5	0.0	2,720.6	2,720.6	0.0	3,909.7	40,189.3
TOTALS	25,949.7	3,888.7	2.6	0.0	0.0	36,152.3	6,494.5	4,947.3	72,145.0	\\\\\\\\\\\\	8,581.5	6,036.2	42.4	14,575.2	24,785.0	6,973.6	17,707.4	24,681.0	933.0	40,189.3	\\\\\\\\\\\\

NOTES: - 11960.7 A.F. OF USG-3 DURING JANUARY INCLUDES 4975.0 A.F. FOR U.O.D. CYCLIC STORAGE.
- 1174.9 A.F. OF SDVWD SAN DIMAS OUTLET SPREAD IN MONTEBELLO FOREBAY DURING APRIL 1988.

WELL HYDROGRAPHS INCLUDED IN THIS REPORT

GROUNDWATER BASIN	WELL NO.	APPROXIMATE LOCATION	PAGE NO.
WEST COAST	1346D 760C	11305 TRURO AVE., 250 FT. N. OF IMPERIAL HWY., COMPTON 99 FT. S.W. OF INTERSECTION OF COMPTON BLVD. & DOTY AVE., LAWNDALE	G16
CENTRAL BASIN	460K 1601T 906D	2,600 FT. N.E. OF THE INTERSECTION OF LAKEWOOD BLVD. & PACIFIC COAST HWY., LONG BEACH 1,000 FT. S. OF THE INTERSECTION OF WASHINGTON BLVD. & ROSEMEAD BLVD., MONTEBELLO 1,300 FT. N.W. OF THE INTERSECTION OF LONG BEACH & SAN ANTONIO DR., LONG BEACH	G16 G17 G17
MAIN SAN GABRIEL	3030F 2955X	600 FT. N.W. OF THE INTERSECTION OF LOS ANGELES ST. & MAINE AVE., BALDWIN PARK TYLER AVE. & CENTRAL AVE., S. EL MONTE	G18 G19
SAN GABRIEL CANYON	4284A 4285	5,600 FT. N.W. OF THE INTERSECTION OF SIERRA MADRE AVE & SAN GABRIEL CYN. RD., AZUSA 2,700 FT. N.W. OF SAN GABRIEL CANYON RD. & SIERRA MADRE AVE.	G19
POMONA	3251E 3241J	2,200 FT. N. OF THE INTERSECTION OF SAN BERNARDINO FWY. & TOWNE AVE., POMONA 725 FT. S.W. OF LA VERNE AVE., 400 FT. S.E. OF N. GAREY AVE.	G20
CLAREMONT HEIGHTS	4508B 4508A	800 FT. S.E. OF THE INTERSECTION OF BASELINE RD. & PADUA AVE., CLAREMONT 270 FT. N.W. OF WELL 4508B	G20
RAYMOND	4057H	LOS ROBLES & GLENARM STREETS, PASADENA	G21
SANTA CLARA	7048A	S.E. OF THE INTERSECTION OF NEWHALL AVE. & MAGIC MOUNTAIN PKWY, SAUGUS	G21
ANTELOPE VALLEY	9974 8825	8,976 FT. S. OF AVE K & 200 FT. W. OF SIERRA HWY., LANCASTER 25 FT. N. OF AVE T & 45 FT. E. OF 90TH ST., LITTLE ROCK	G22
MAIN SAN FERNANDO	3872H 4709	CLARK AVE & GRIFFITH PARK DR., BURBANK SHERMAN WAY & DEERING AVE., CANOGA PARK	G23 G23

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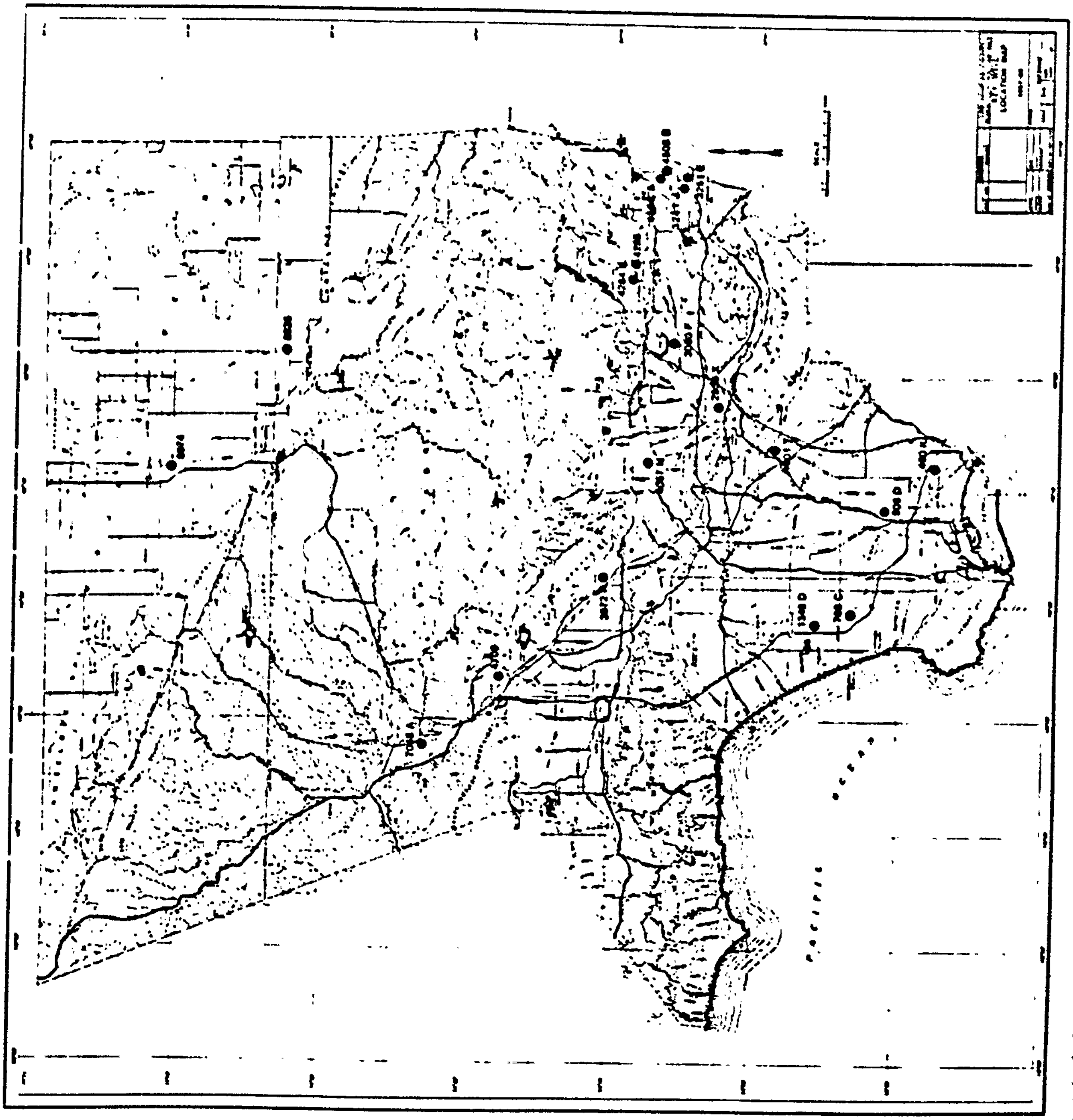
1961



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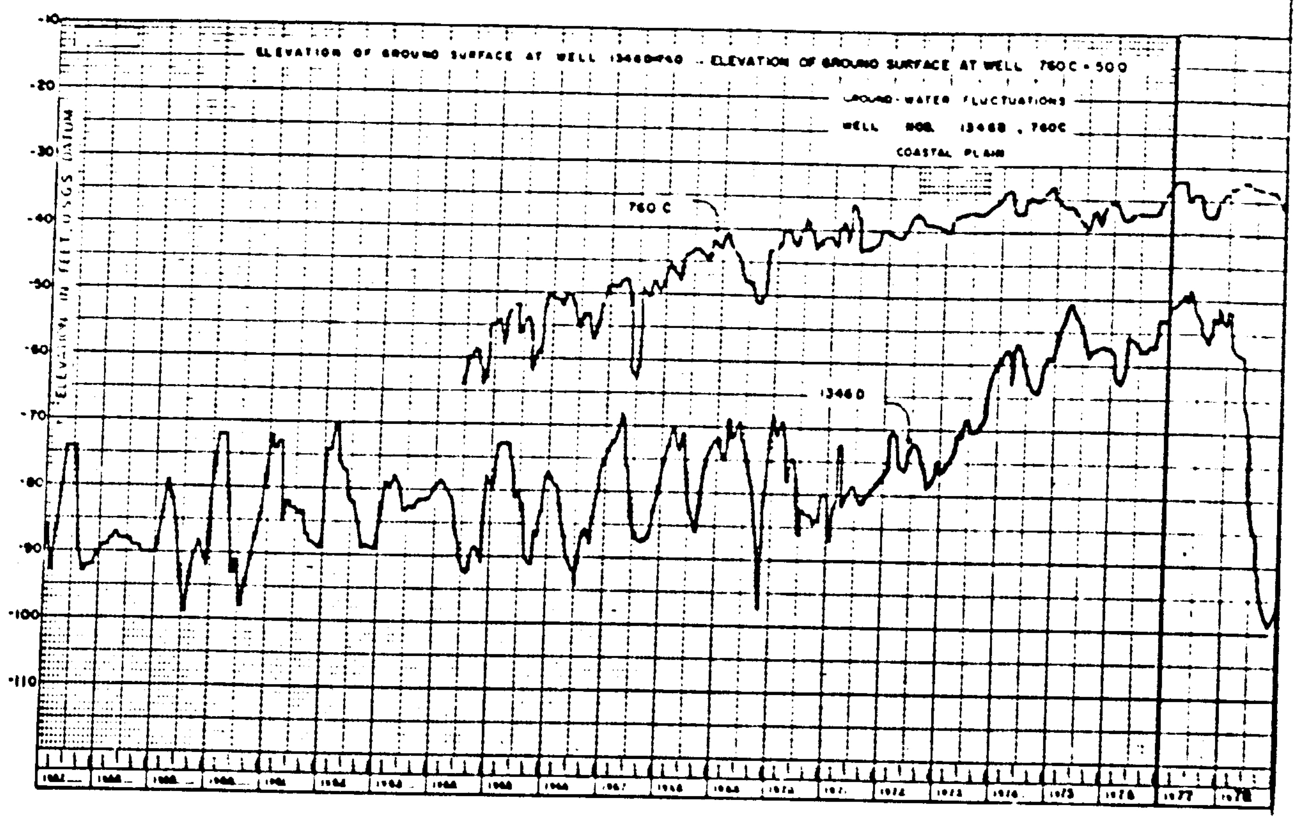
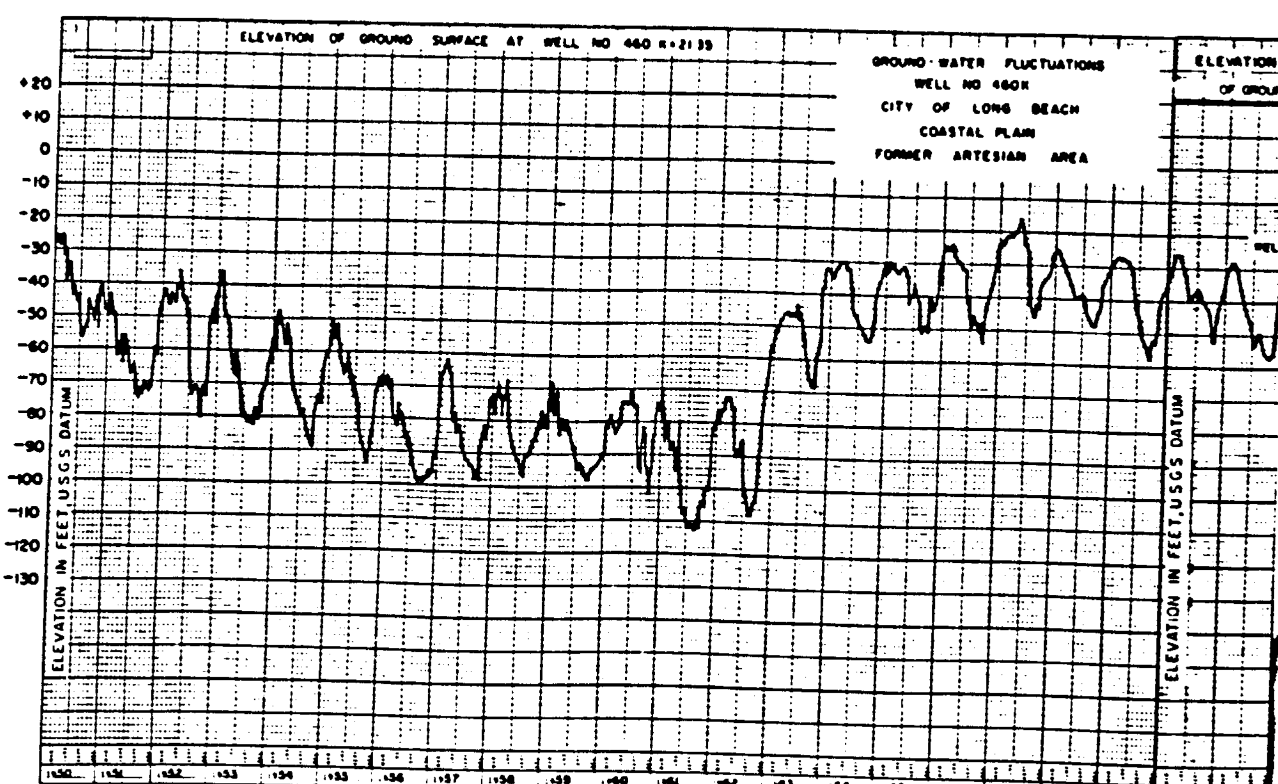
VOL 12 1963





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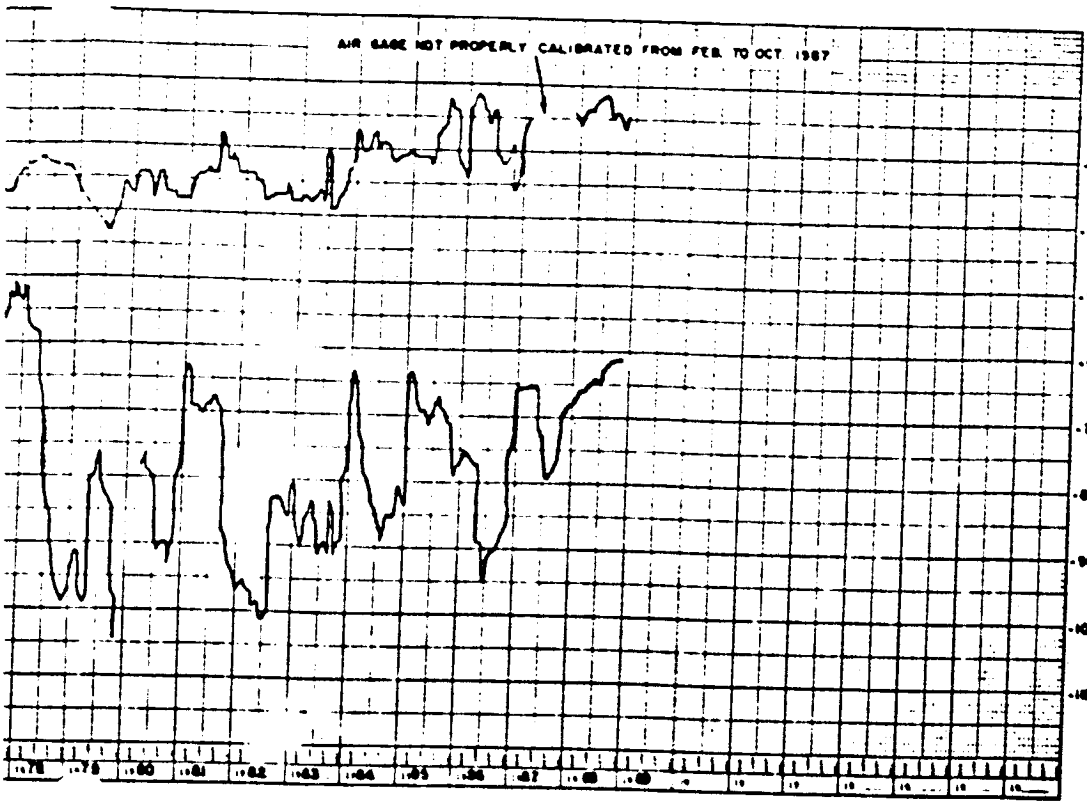
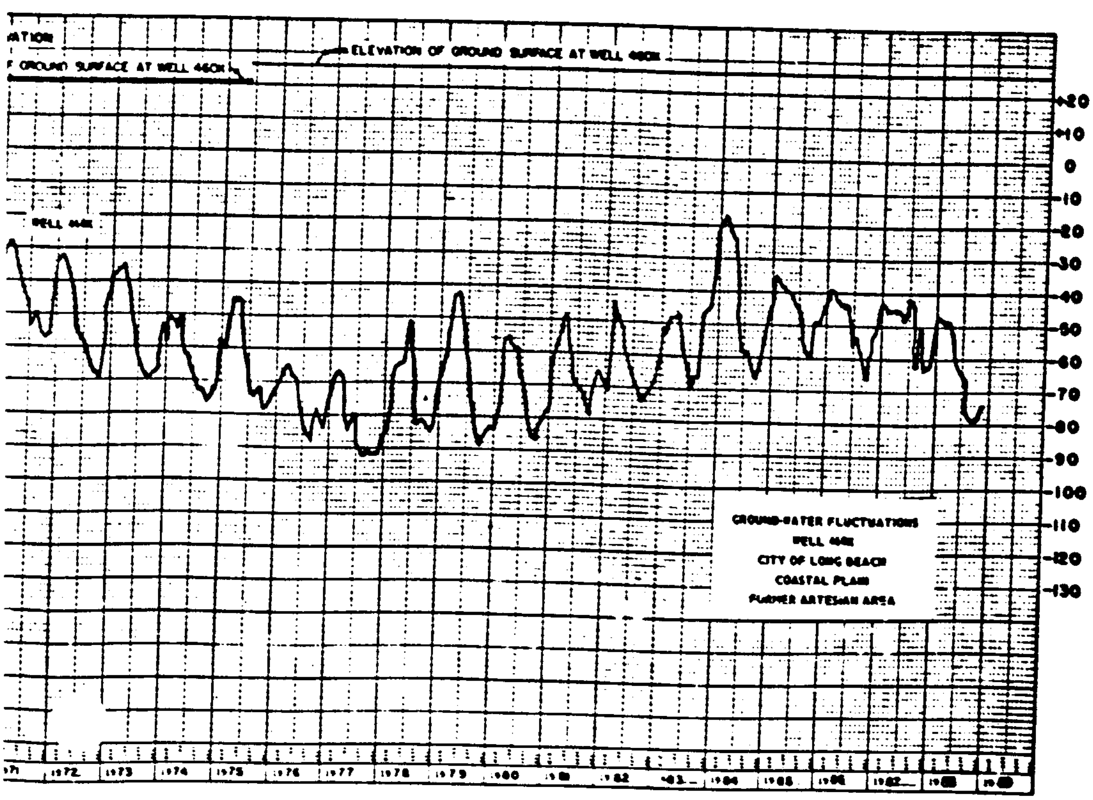
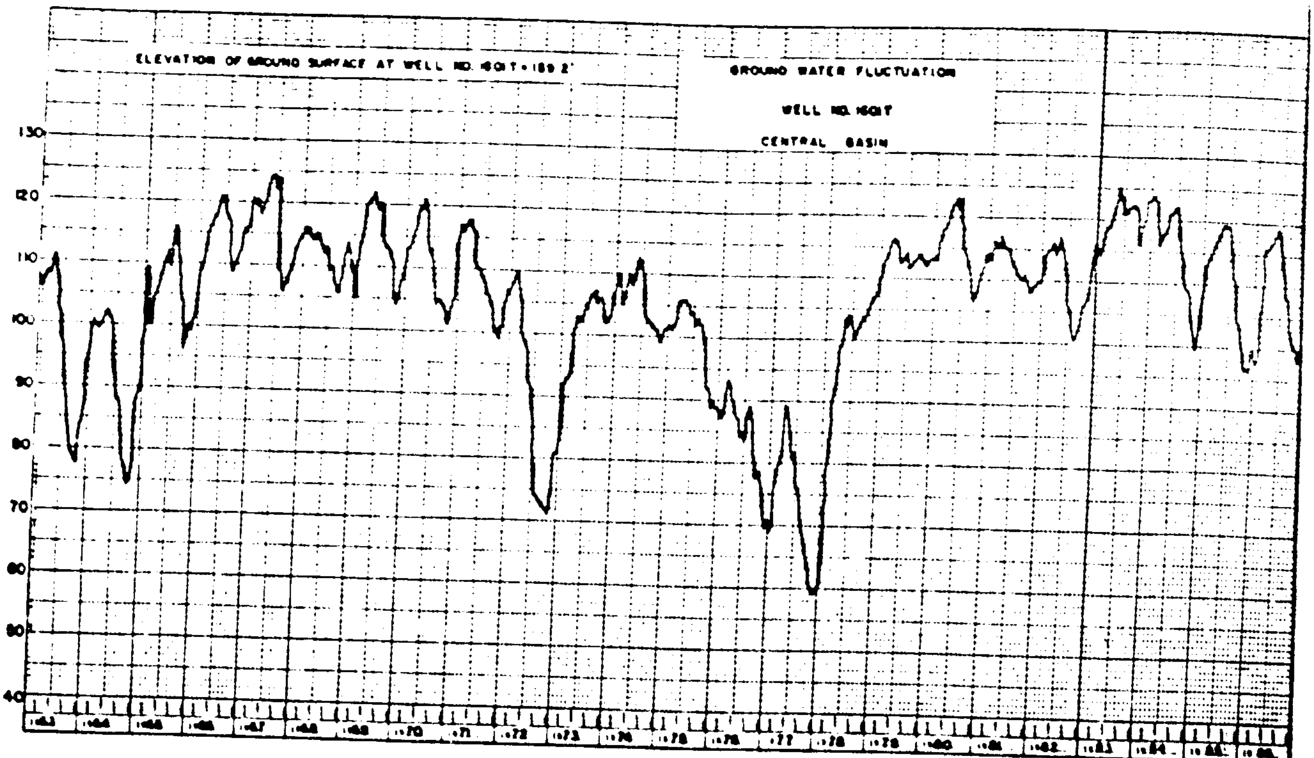

AIR GAGE NOT PROPERLY CALIBRATED FROM FEB. TO OCT. 1987

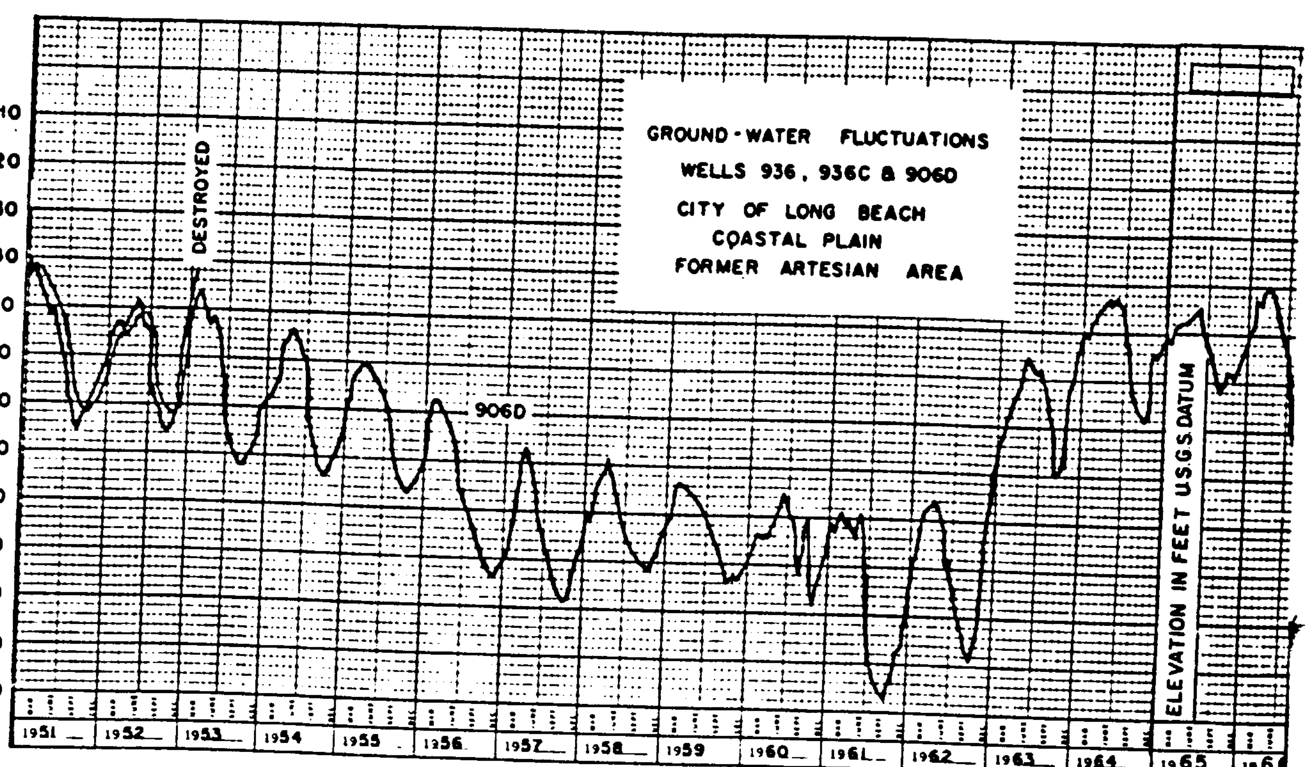

ELEVATION OF GROUND SURFACE AT WELL
GROUND-WATER FLUCTUATIONS
CITY OF LONG BEACH
COASTAL PLAIN
FORMER ARTESIAN AREA

VOL 12

1 9614



ELEVATION OF GROUND SURFACE AT WELL NO. 1601T = 189.2'
GROUND WATER FLUCTUATION
WELL NO. 1601T
CENTRAL BASIN
130
120
110
100
90
80
70
60
50
40



GROUND-WATER FLUCTUATIONS
WELLS 936, 936C & 906D
CITY OF LONG BEACH
COASTAL PLAIN
FORMER ARTESIAN AREA
DESTROYED
906D
ELEVATION IN FEET U.S.G.S. DATUM
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
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1951
1952
1953
1954
1955
1956
1957
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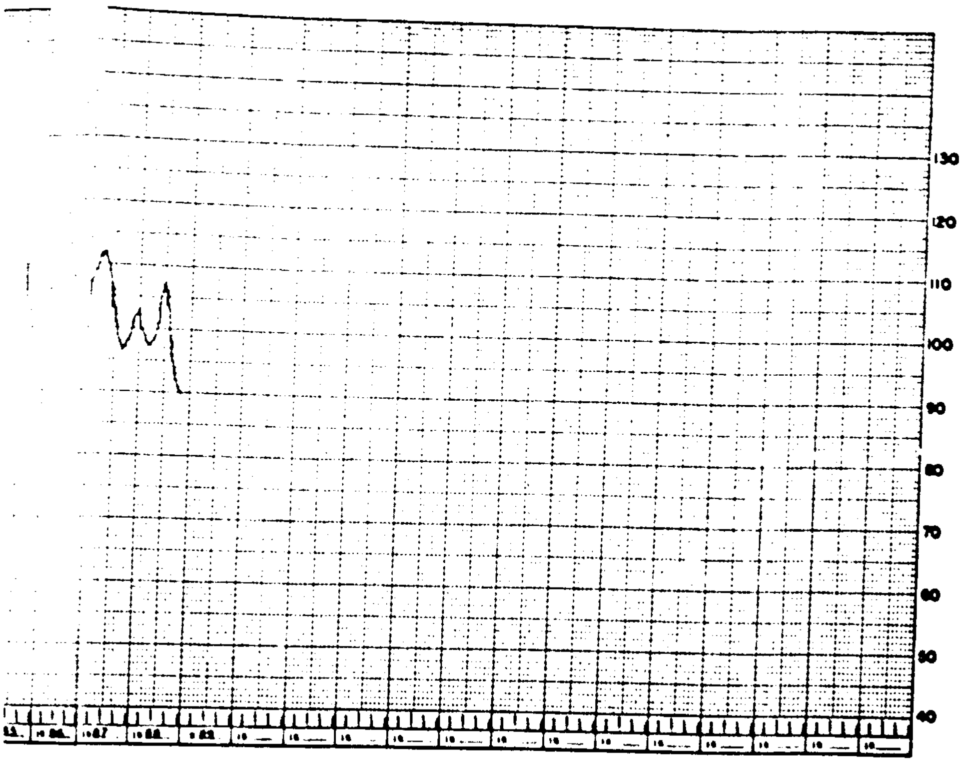
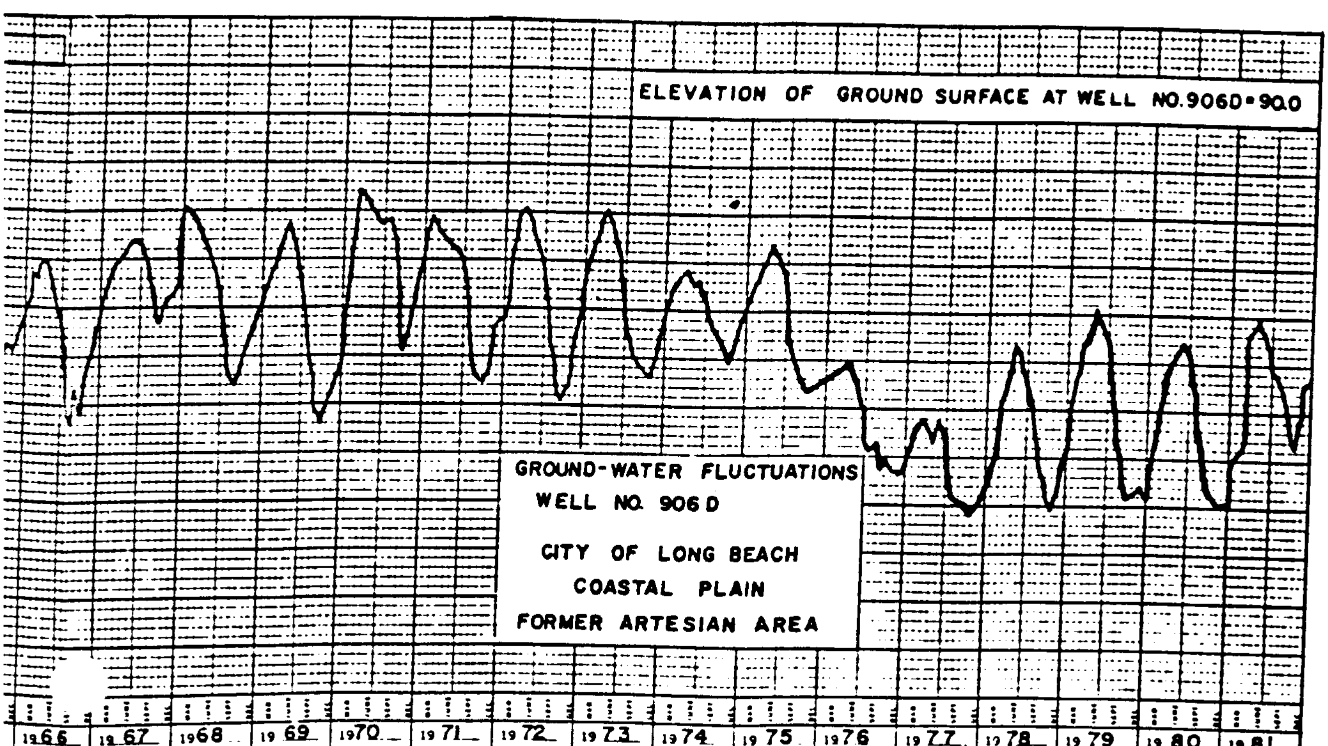
1959
1960
1961
1962
1963
1964
1965
1966





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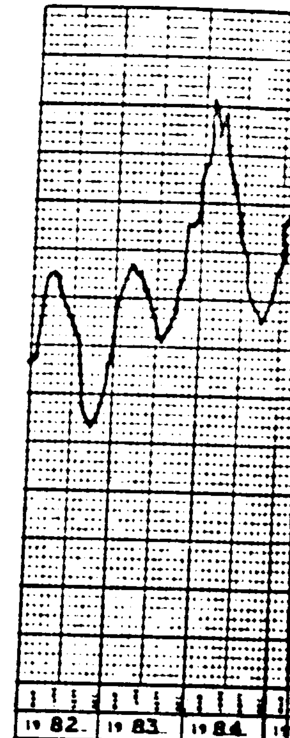
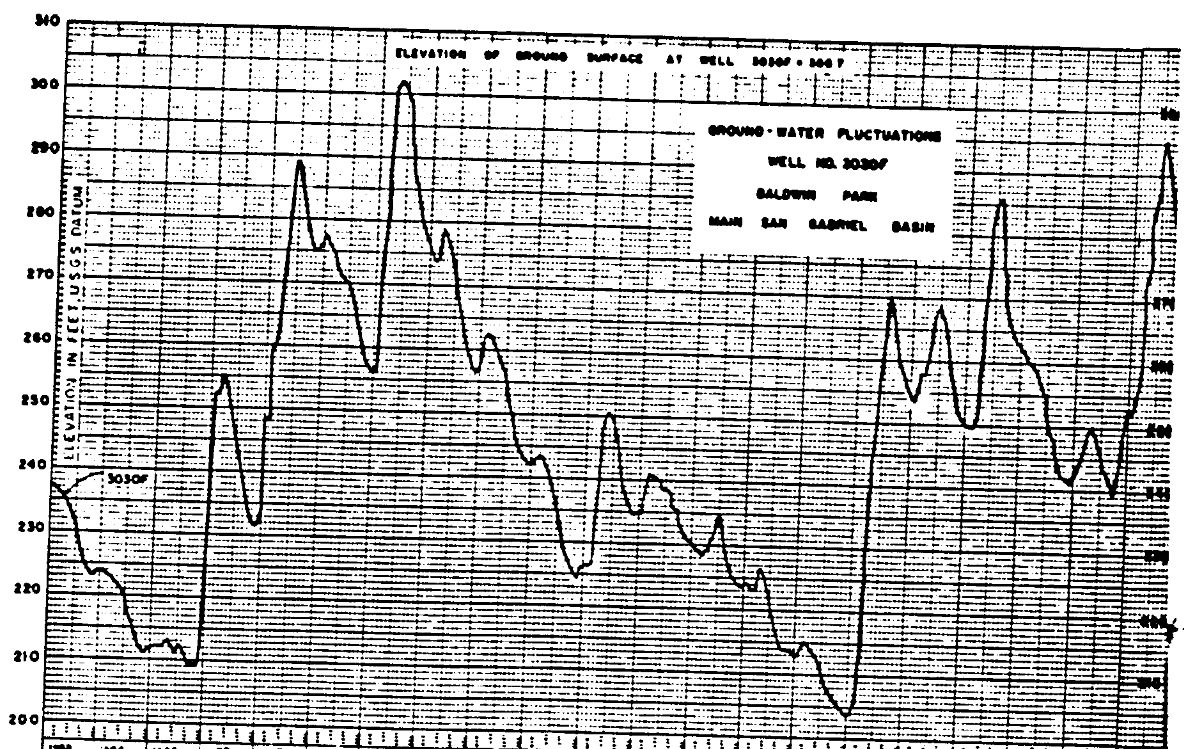
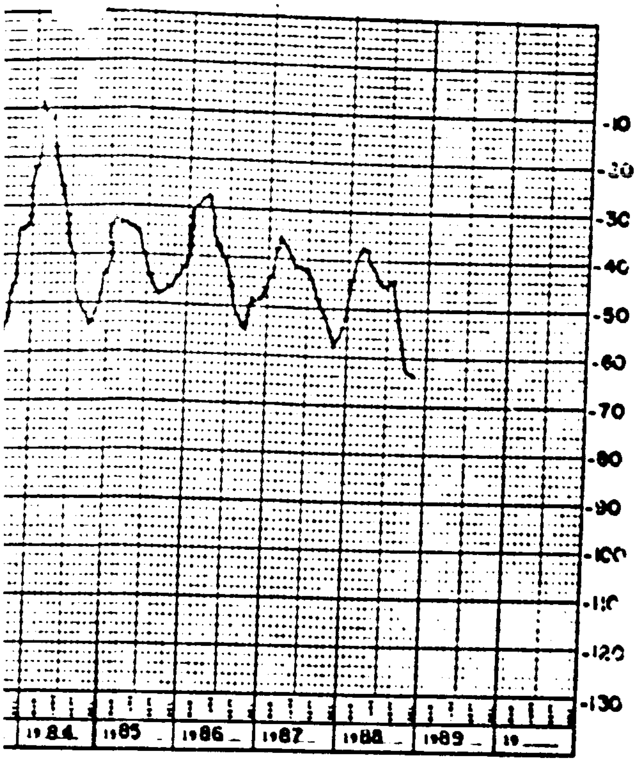


VOL 12 1967



R0052922


-10
-20
-30
-40
-50
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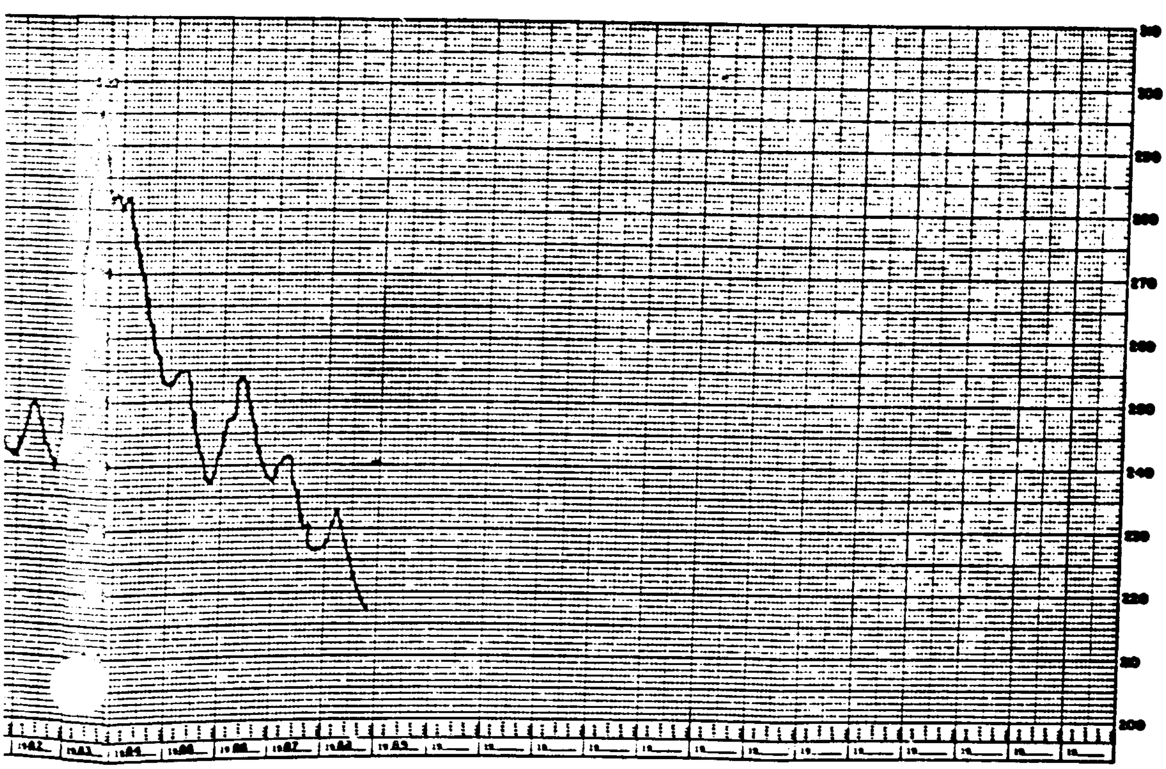
-70
-80
-90
-100
-110
-120
-130
1984
1985
1986
1987
1988
1989
19



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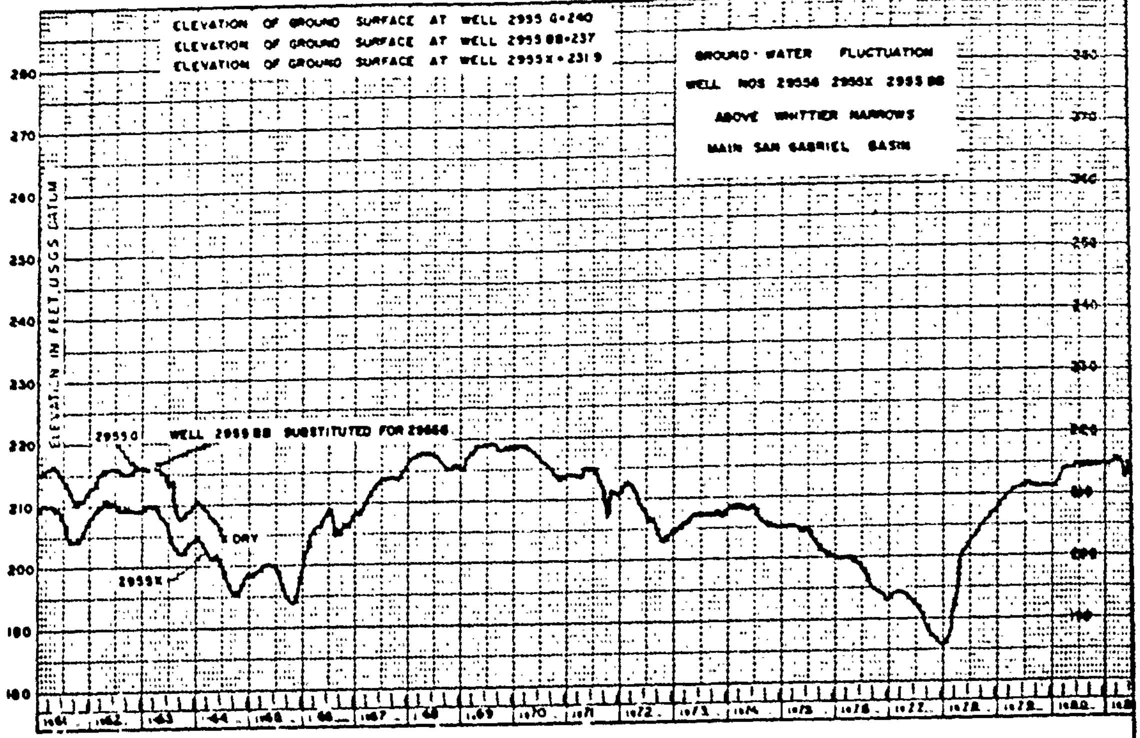
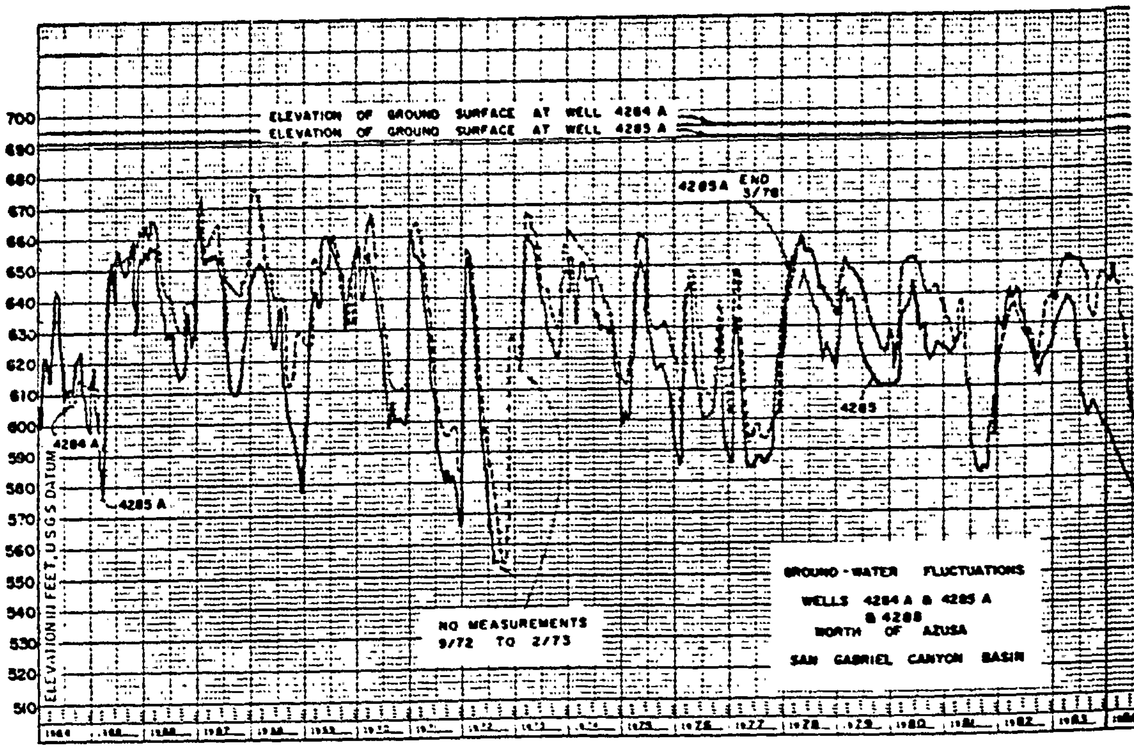


1969



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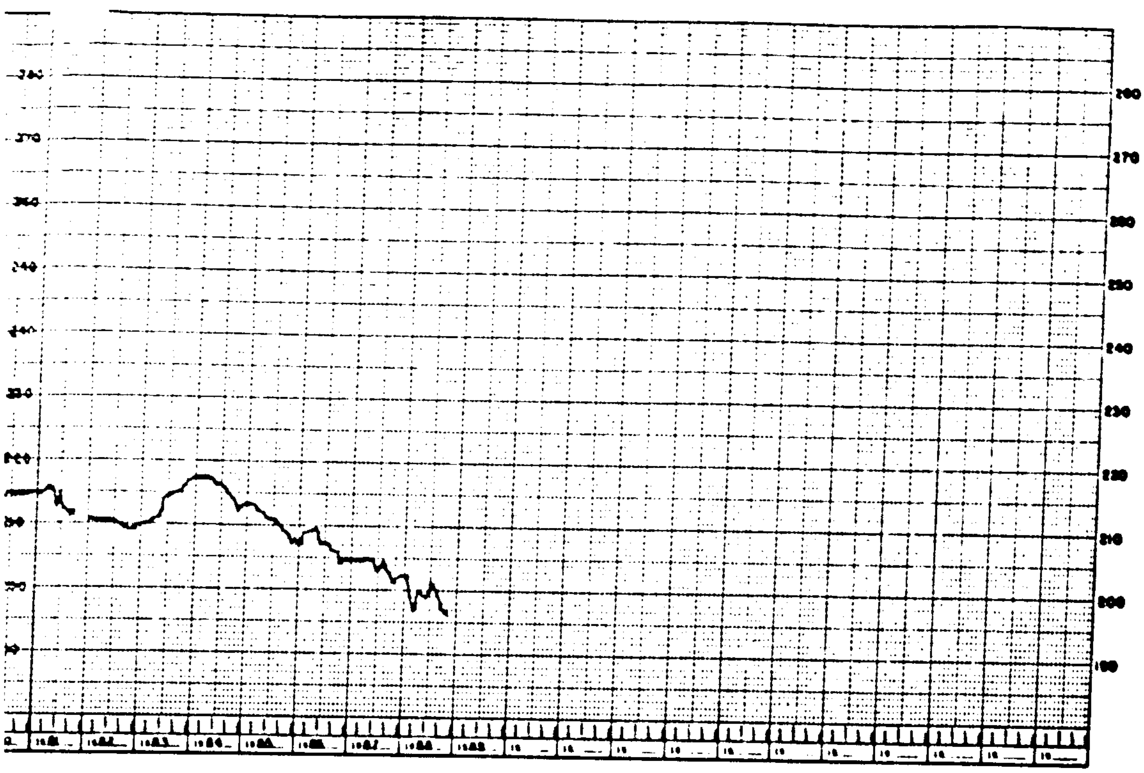

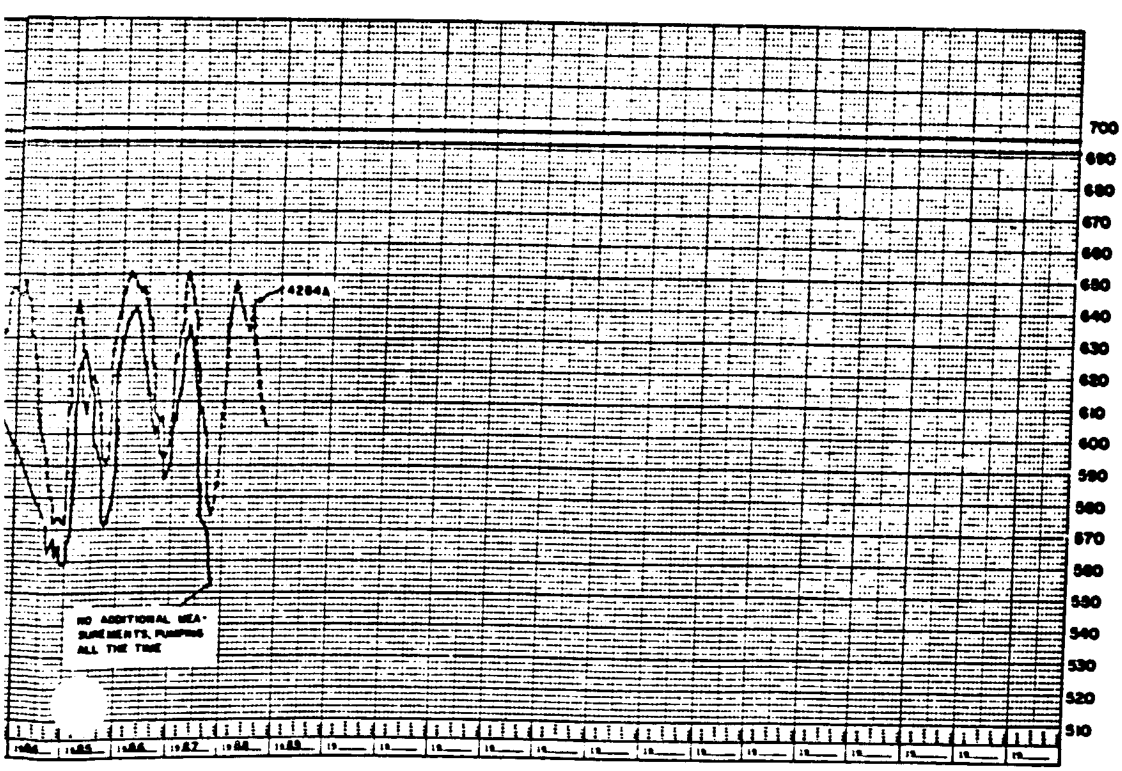

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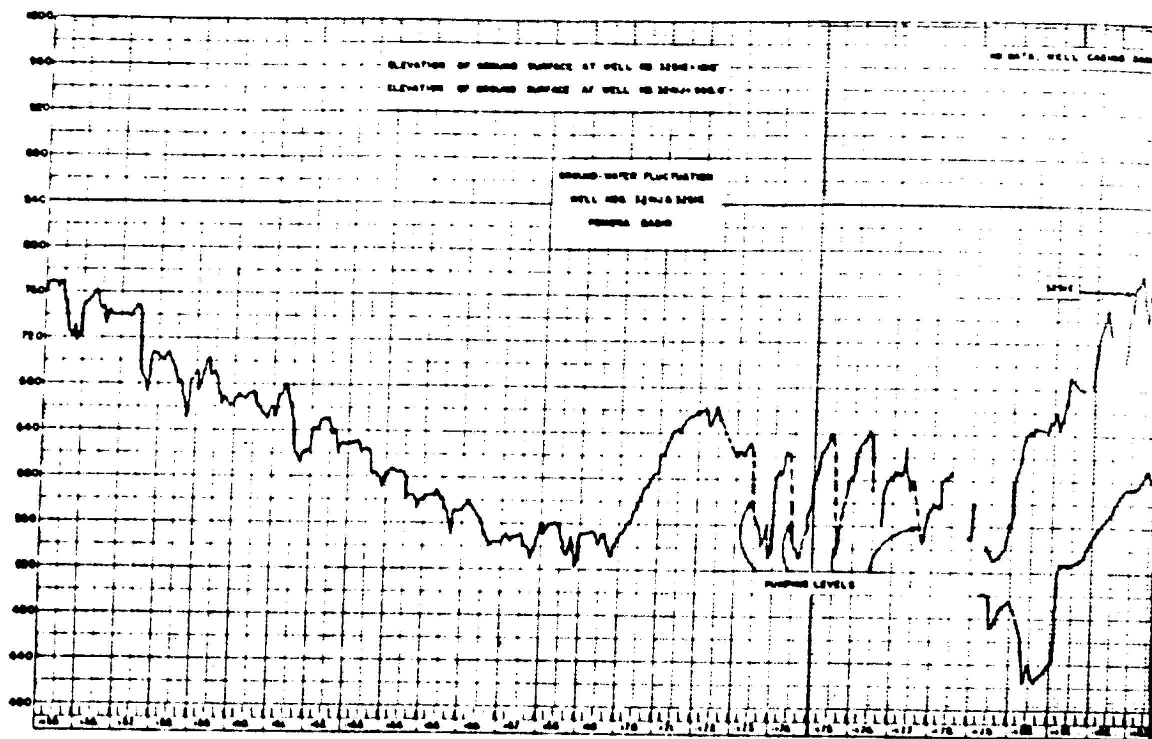
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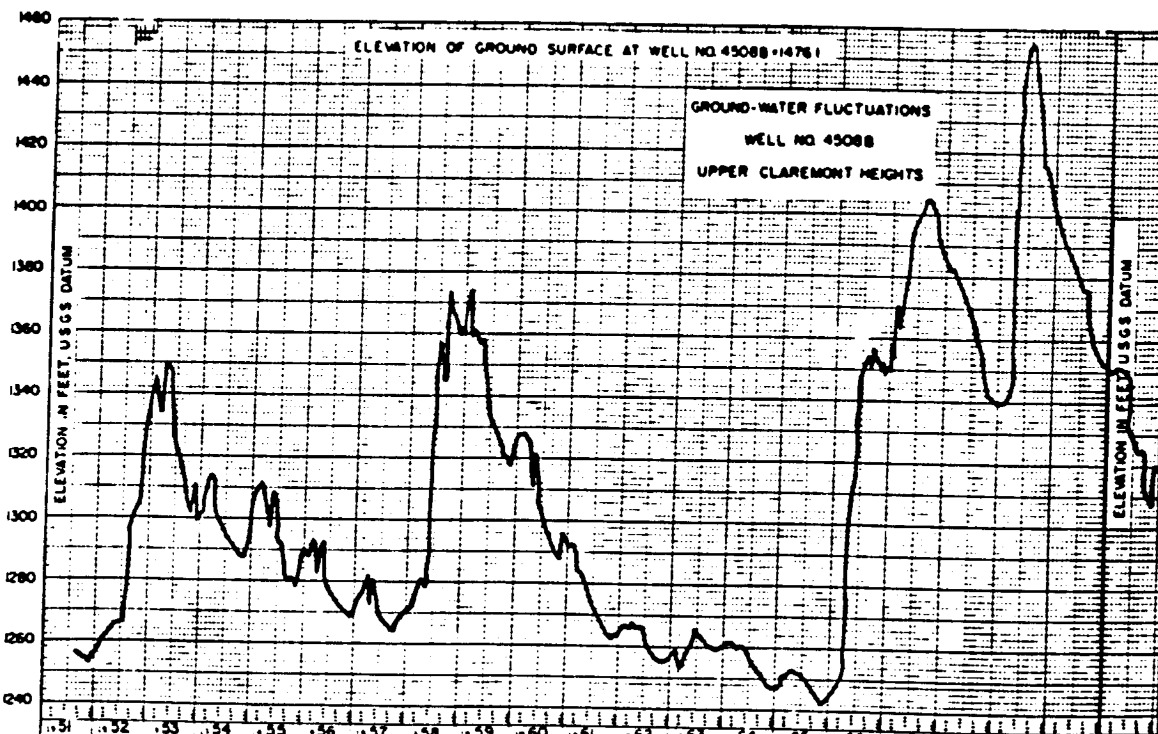
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UPPER CLAREMONT HEIGHTS
ELEVATION IN FEET, USGS DATUM
1460
1440
1420
1400
1380
1360
1340
1320
1300
1280
1260
1240
51
52
53
54
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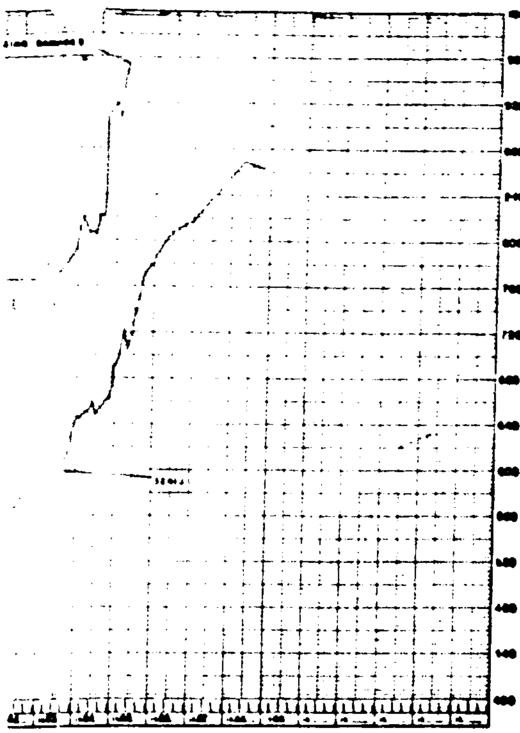
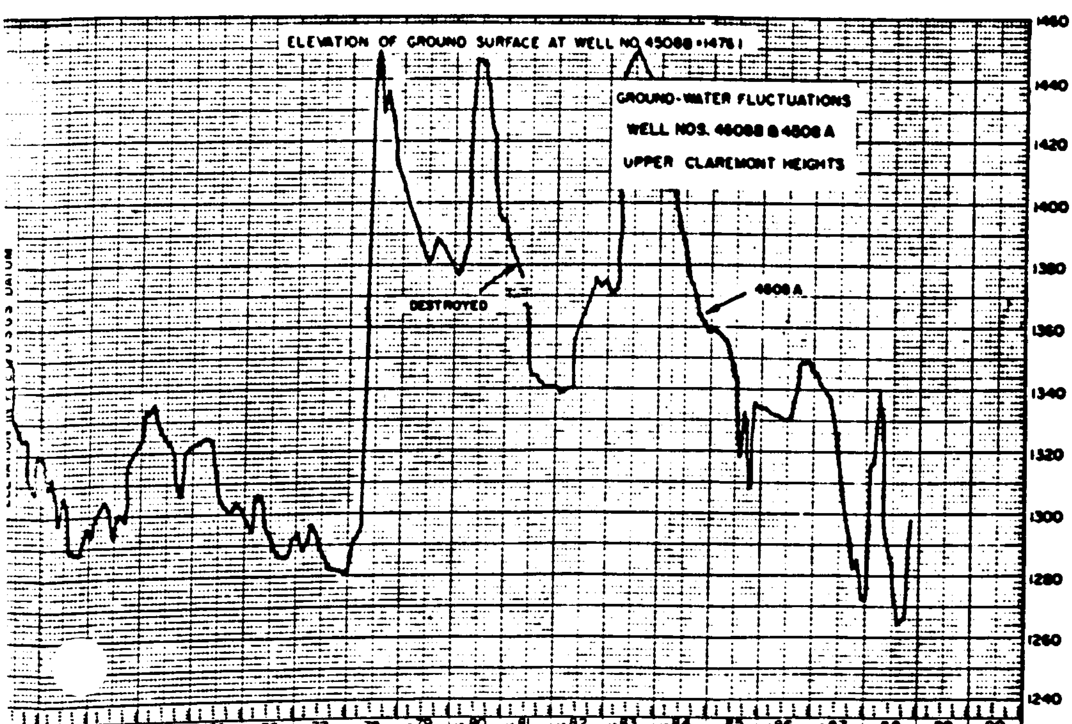
71





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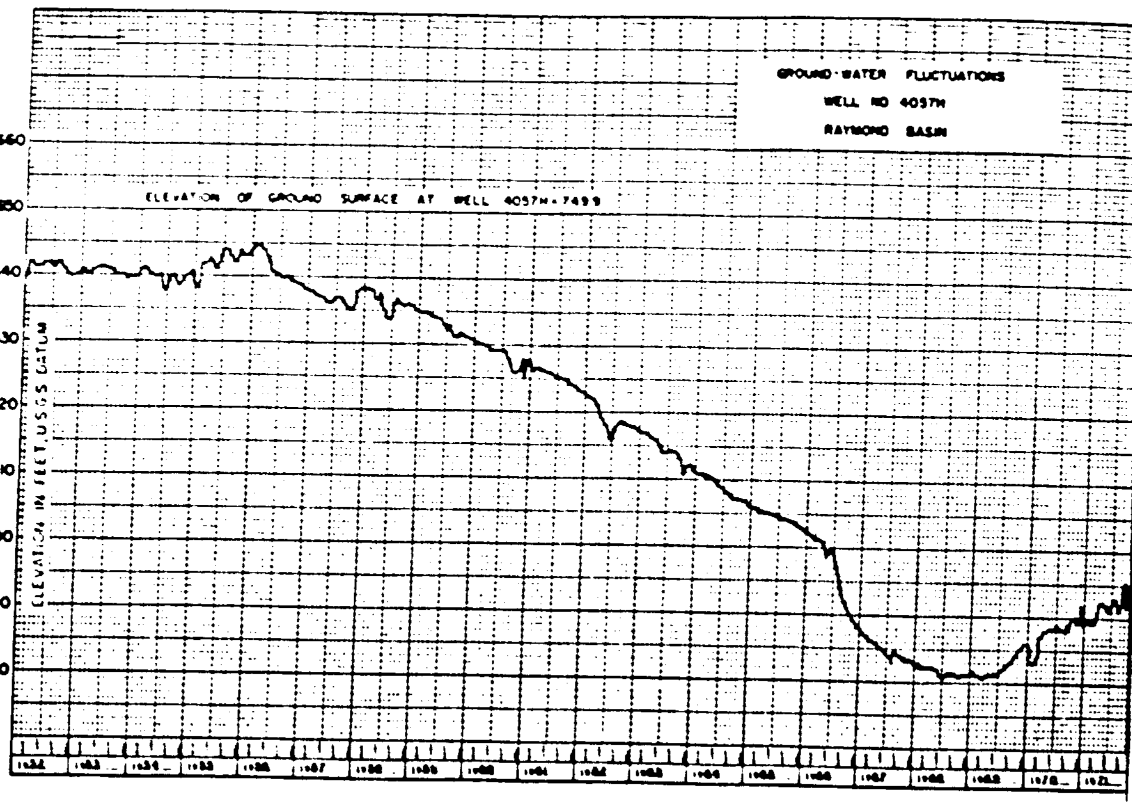

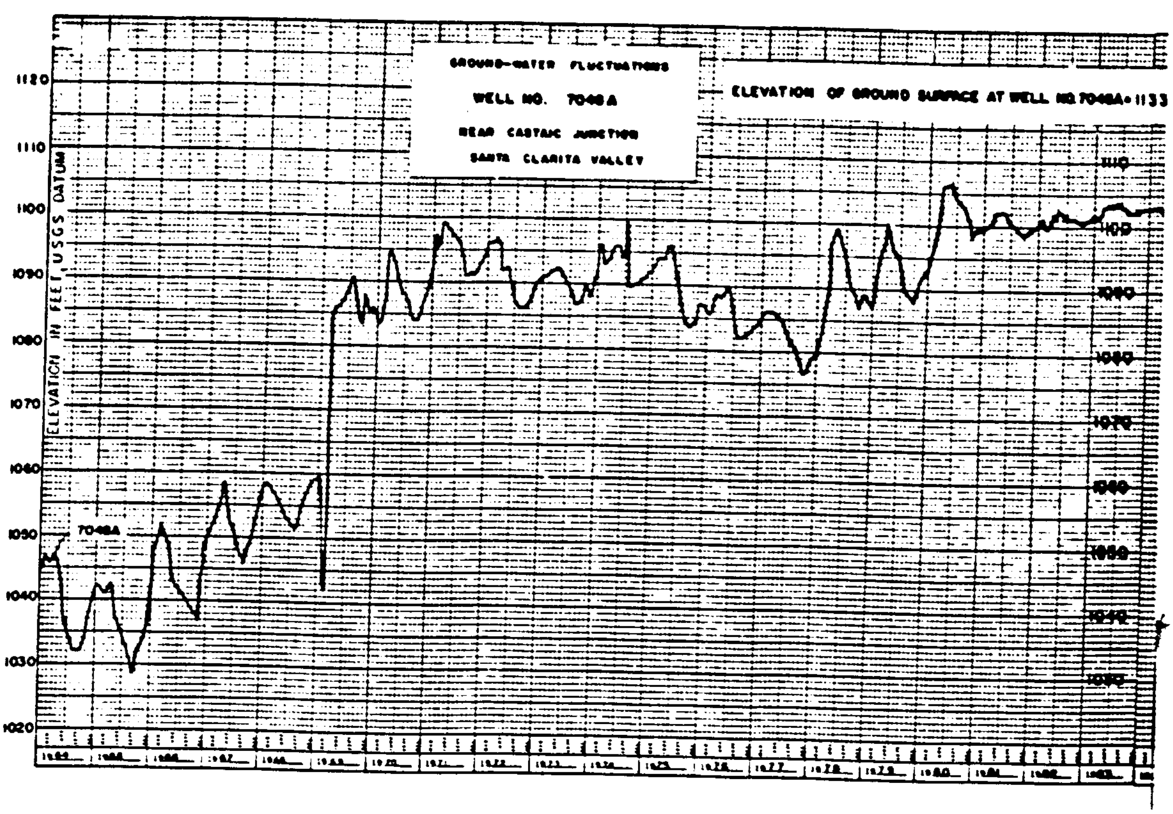

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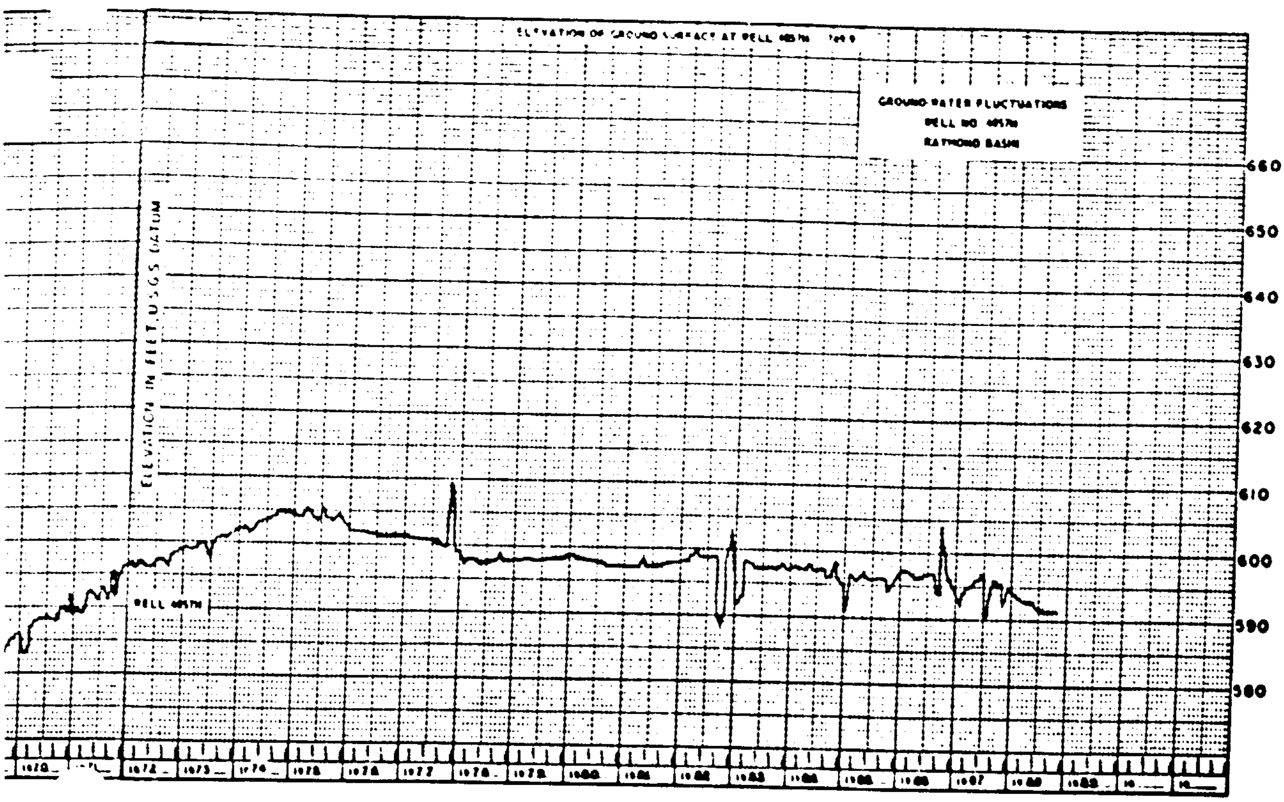
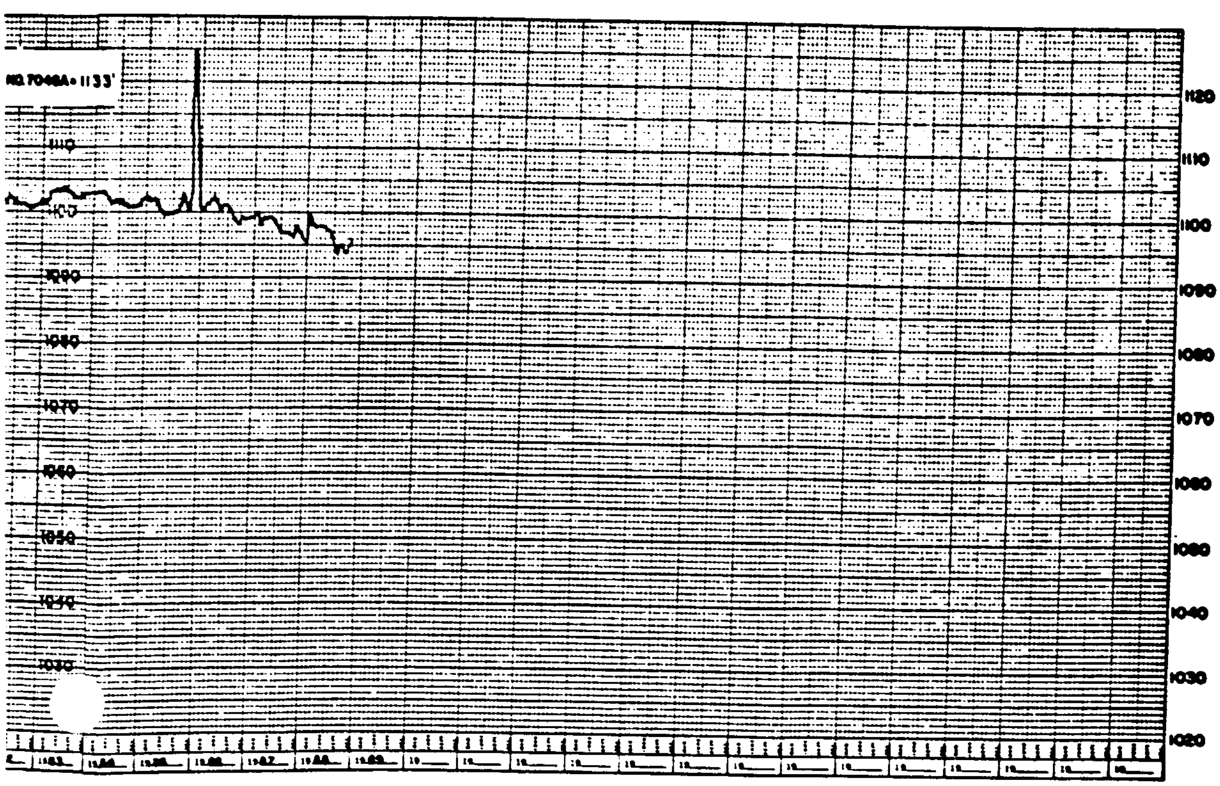

GROUND-WATER FLUCTUATIONS
RAYMOND BASIN
ELEVATION IN FEET, U.S.G.S. DATUM
660
650
640
630
620
610
600
590
580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1100
1090
1080
1070
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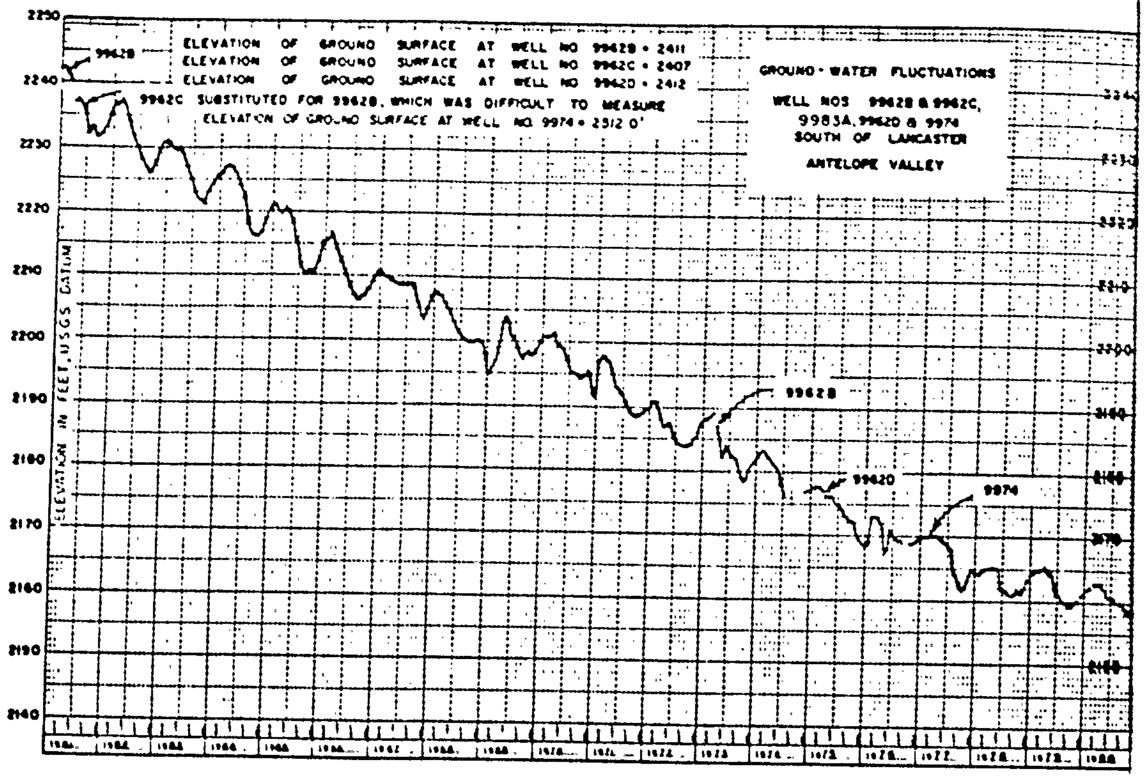
1040
1030
1020



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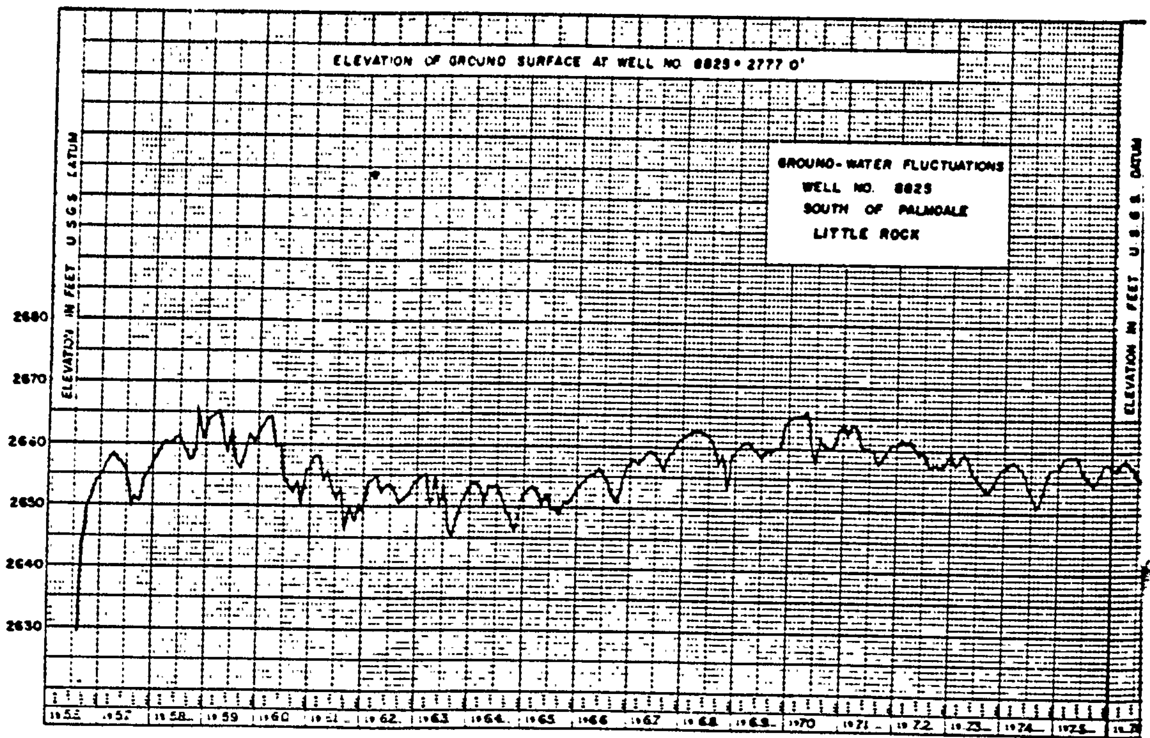

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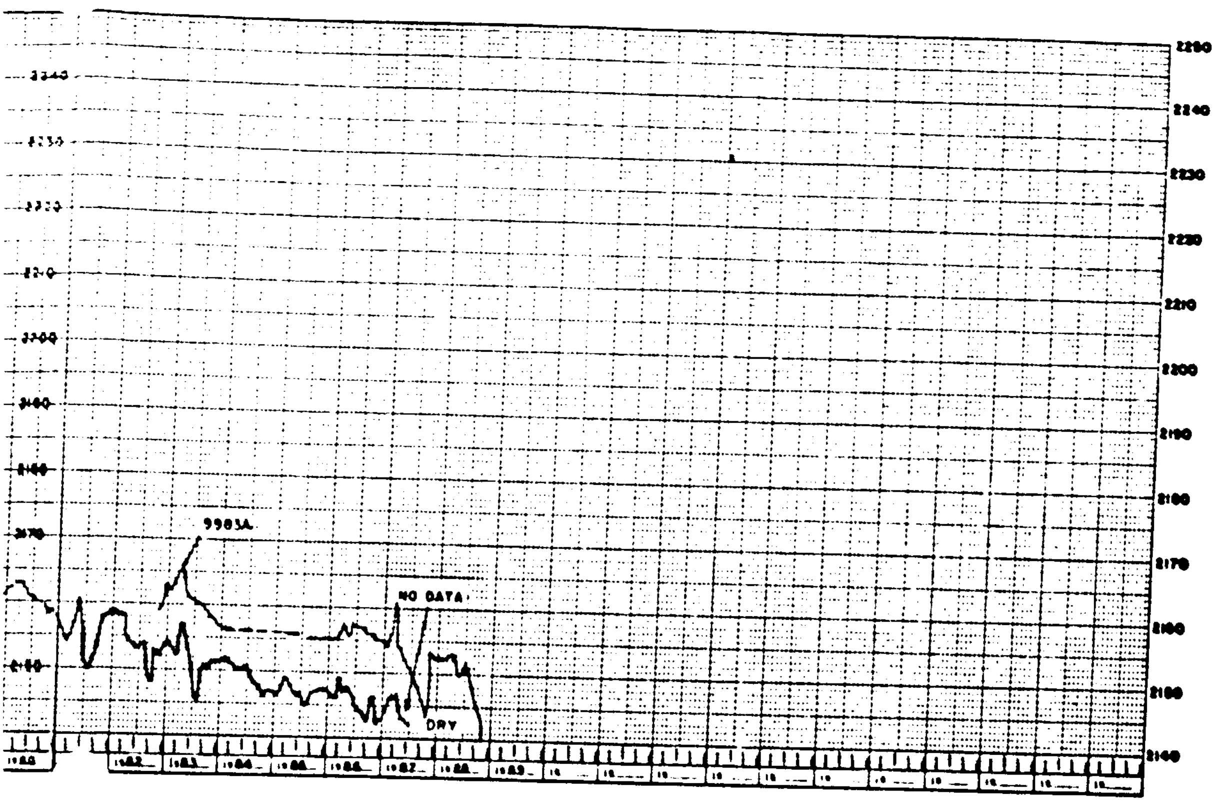

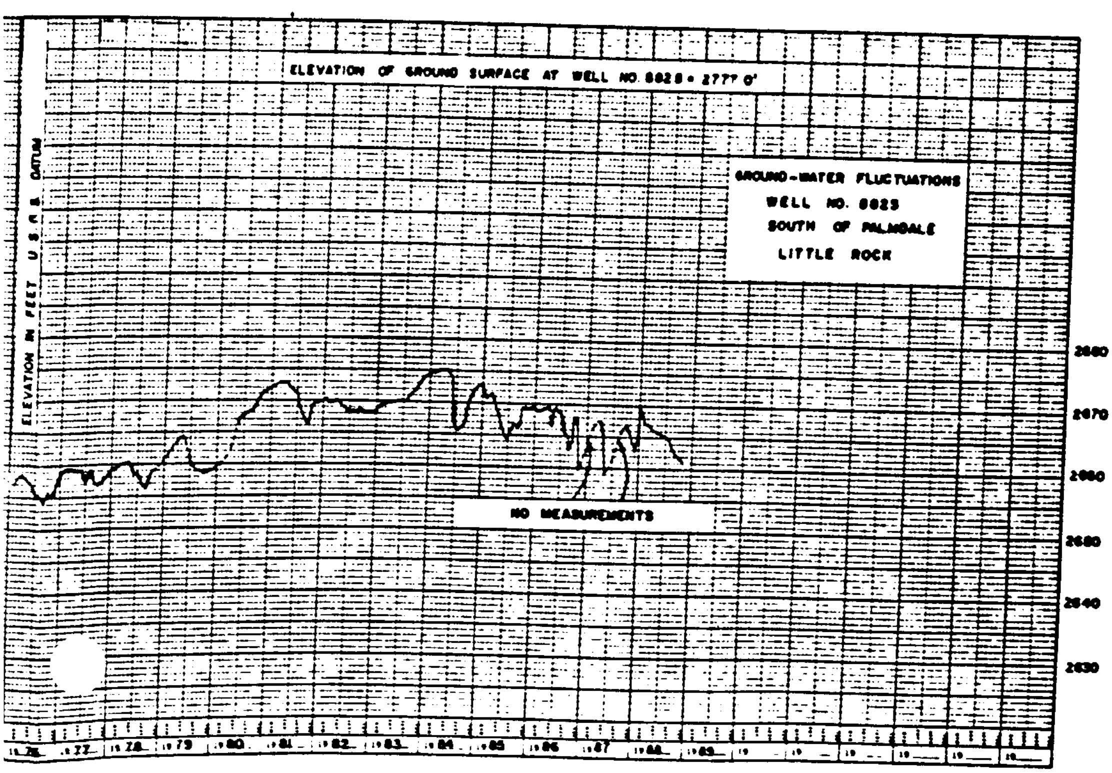

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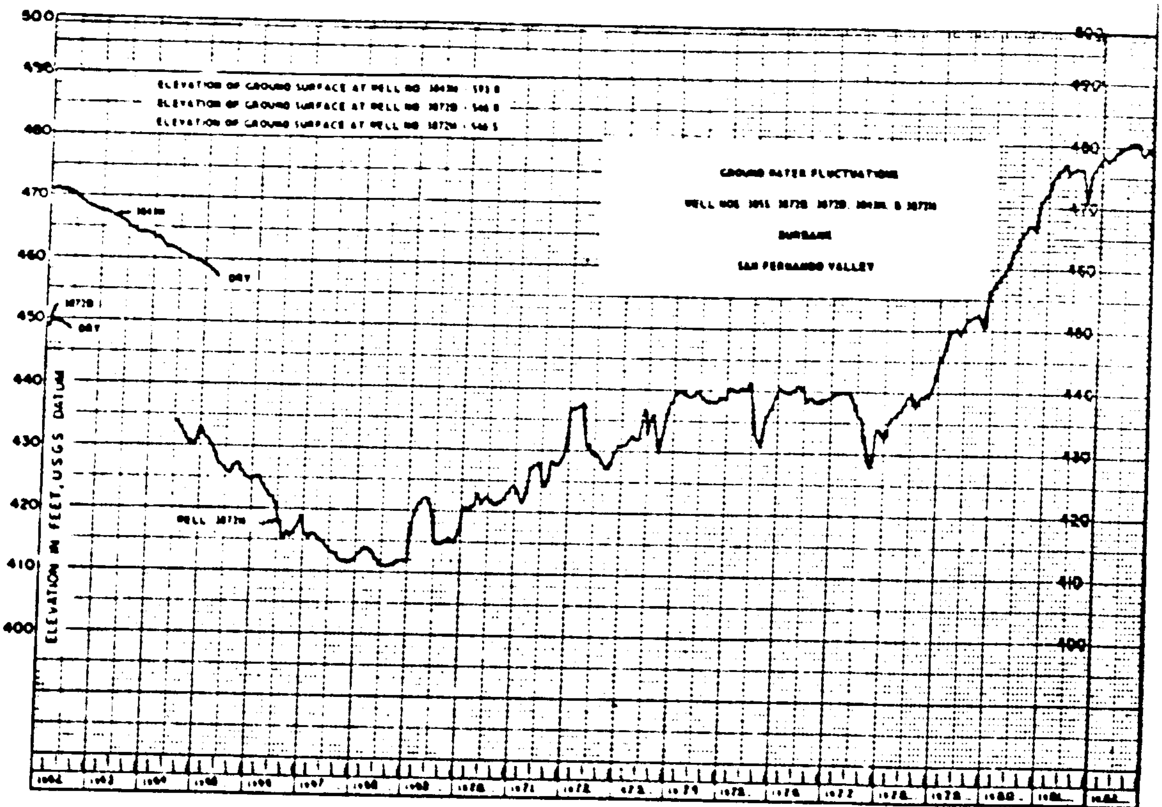
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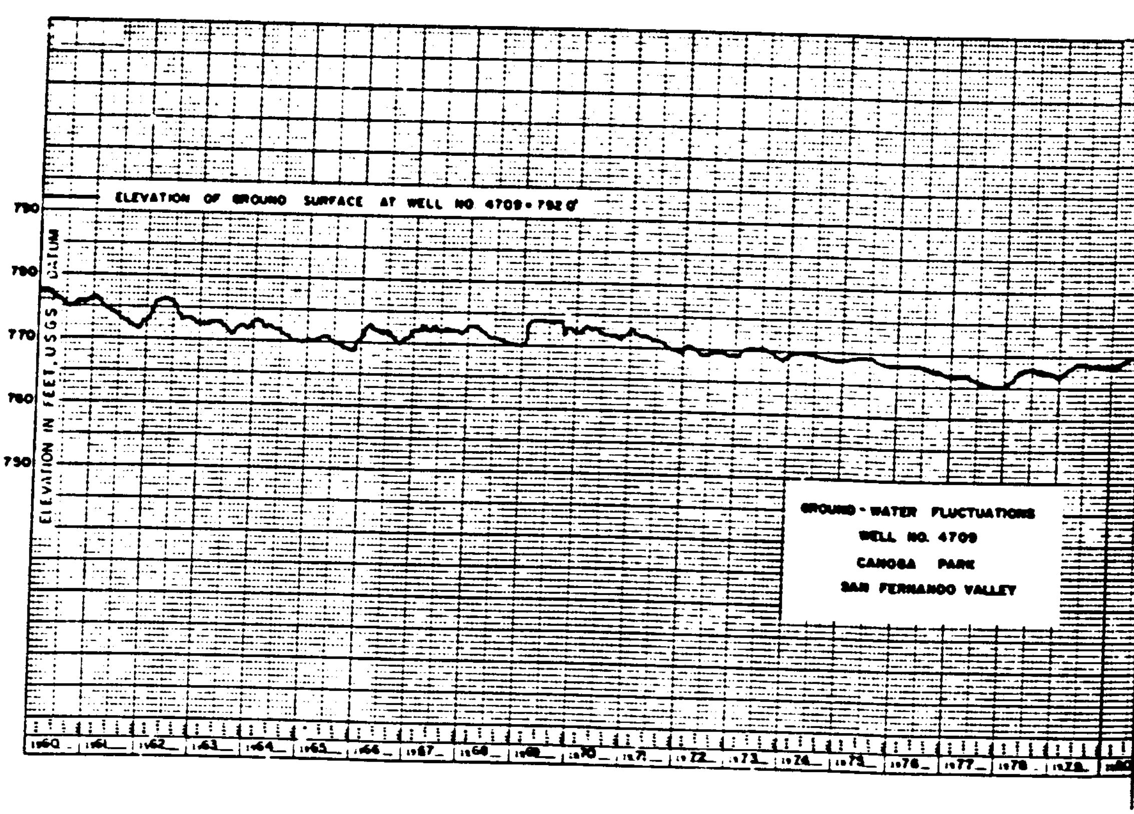
ELEVATION IN FEET, USGS DATUM
WELL 3072H
DRY
500
490
480
470
460
450
440
430
420
410
400

1 9527


ELEVATION OF GROUND SURFACE AT WELL NO 4709 = 792.0'
GROUND - WATER FLUCTUATIONS
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CANOGA PARK
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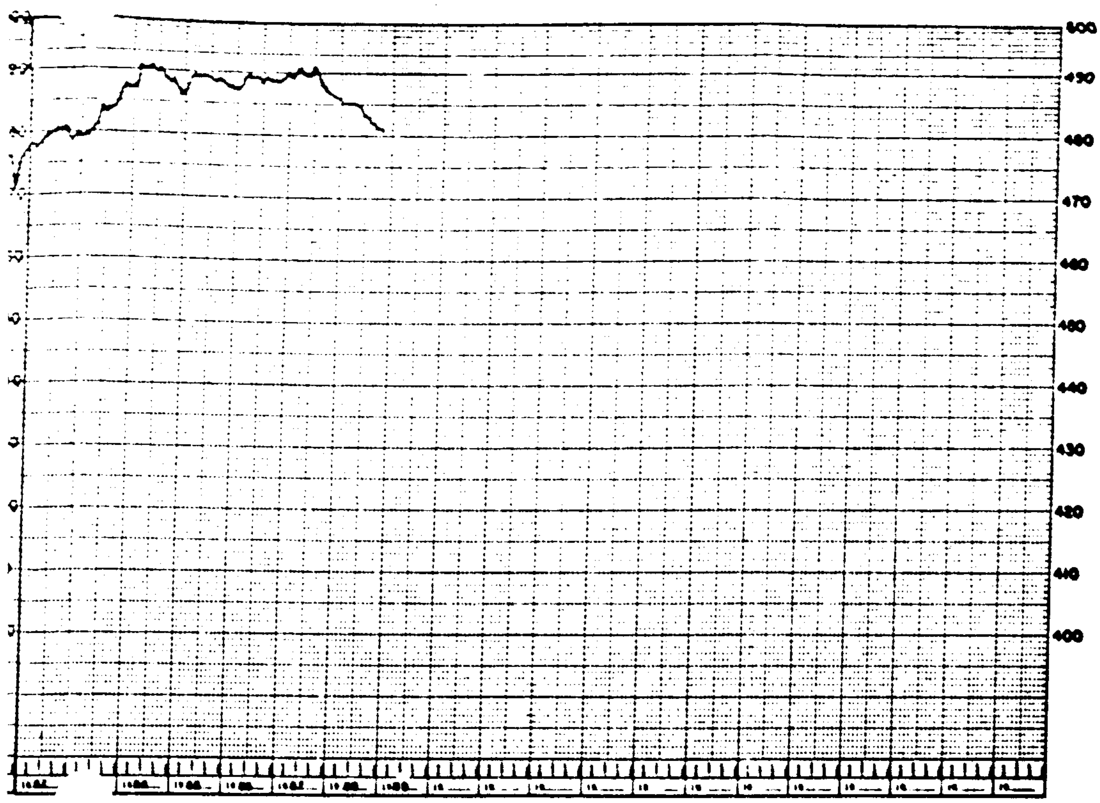
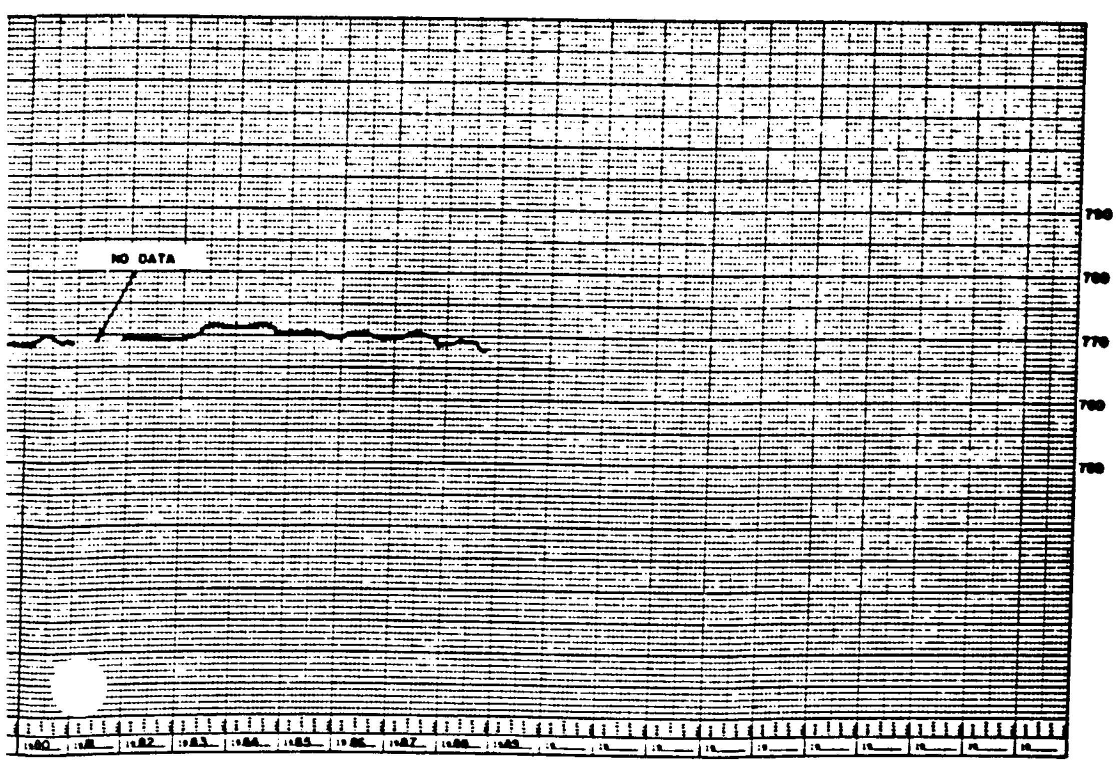
790
780
770
760
750





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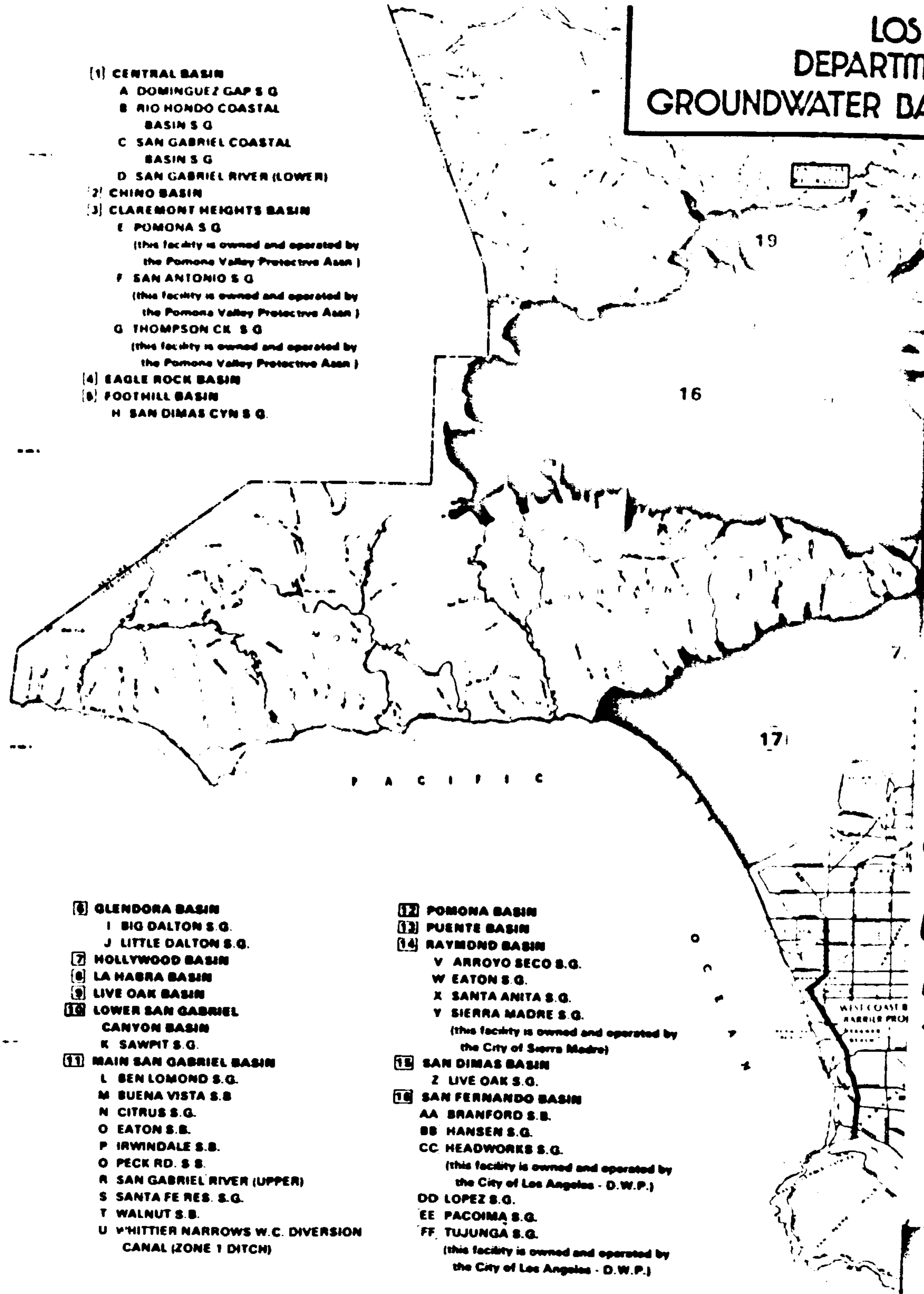

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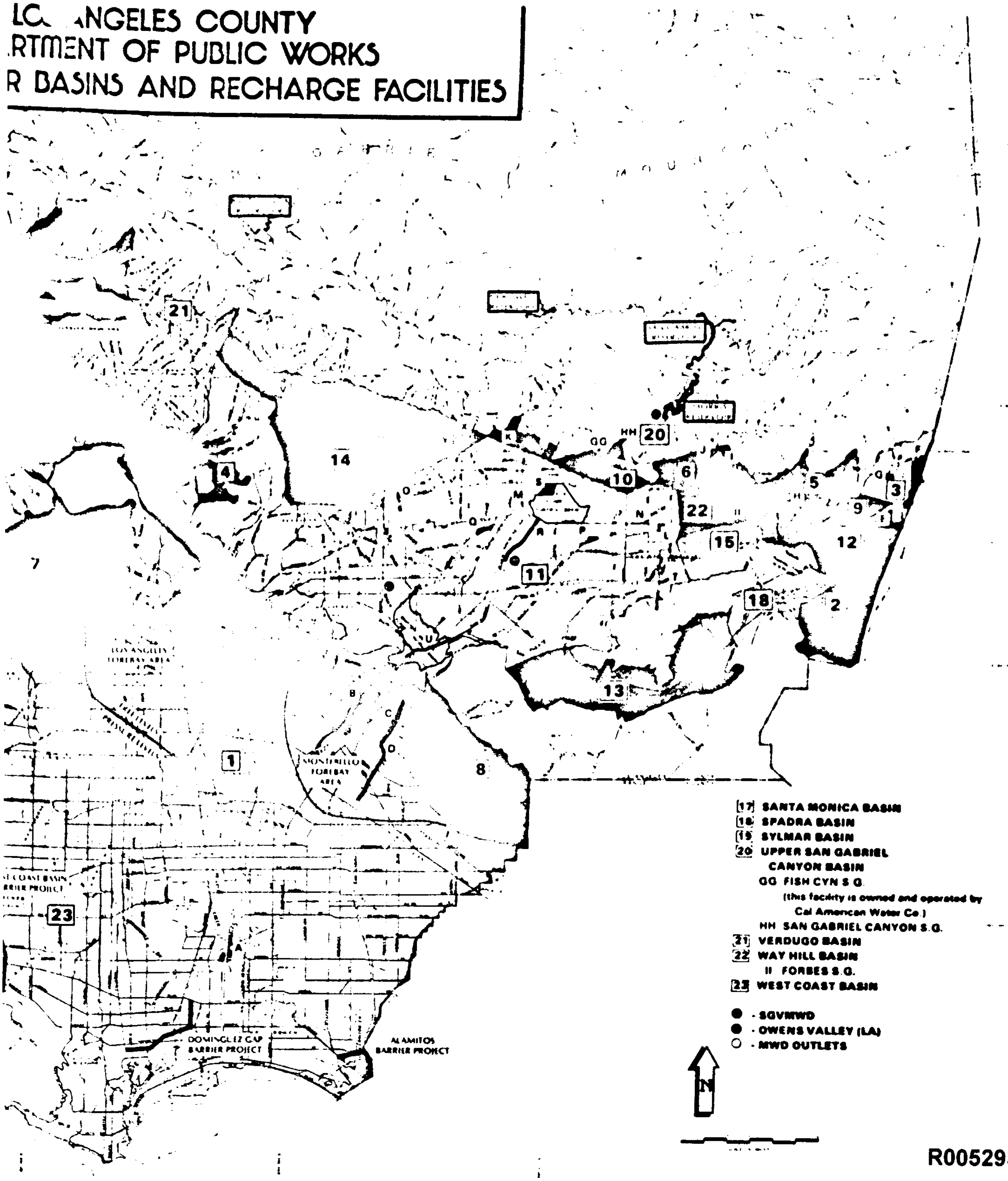

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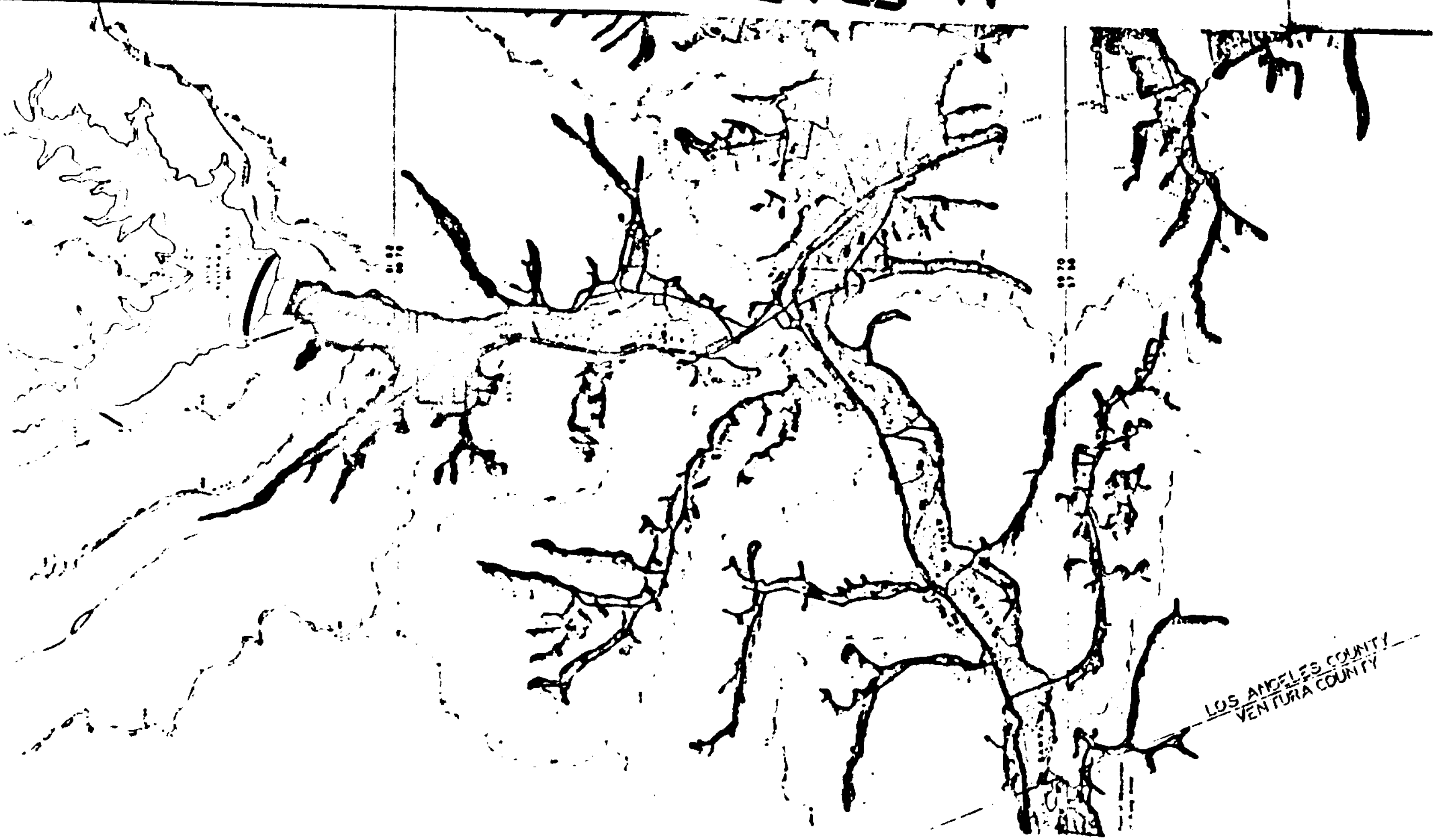

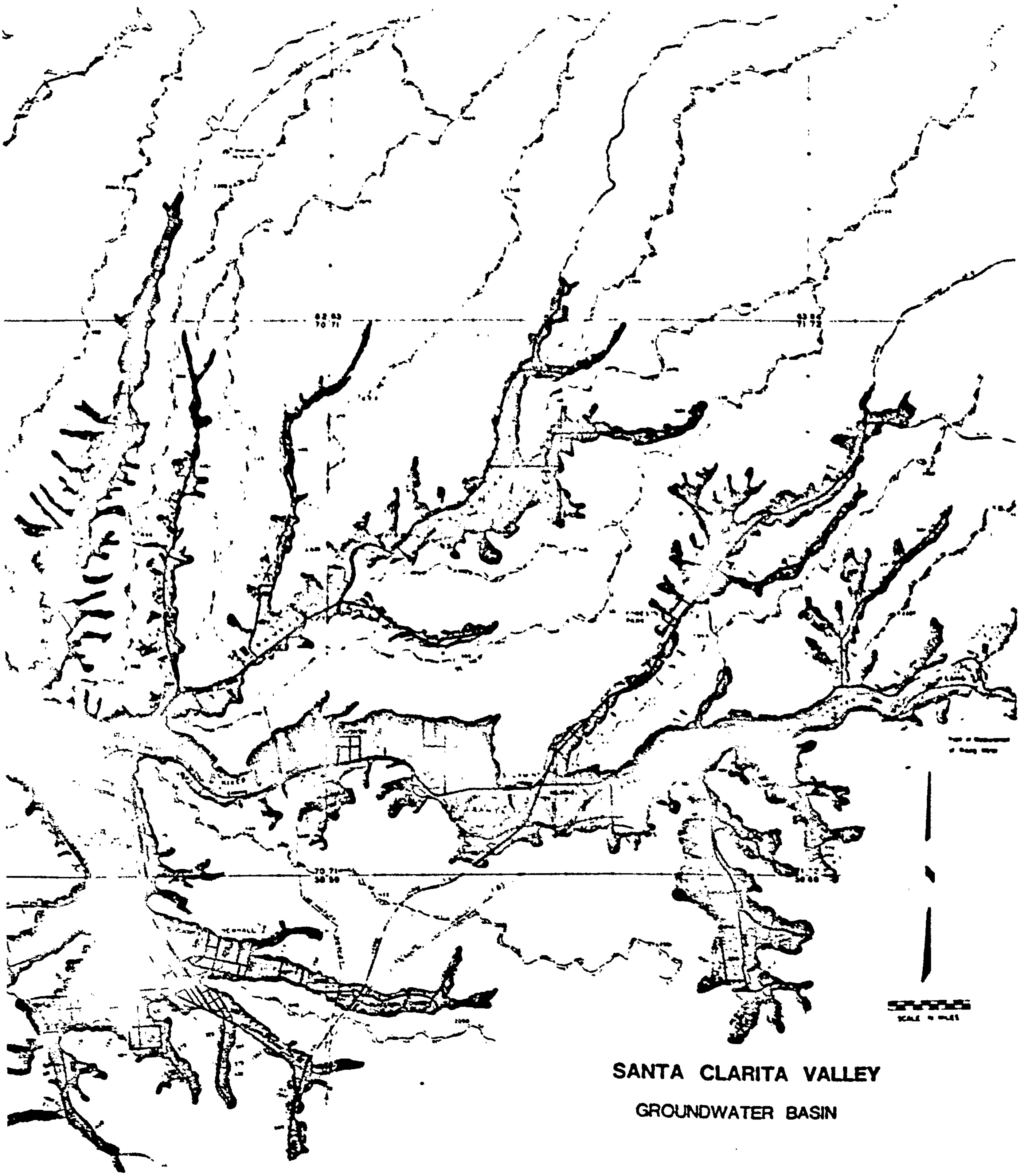

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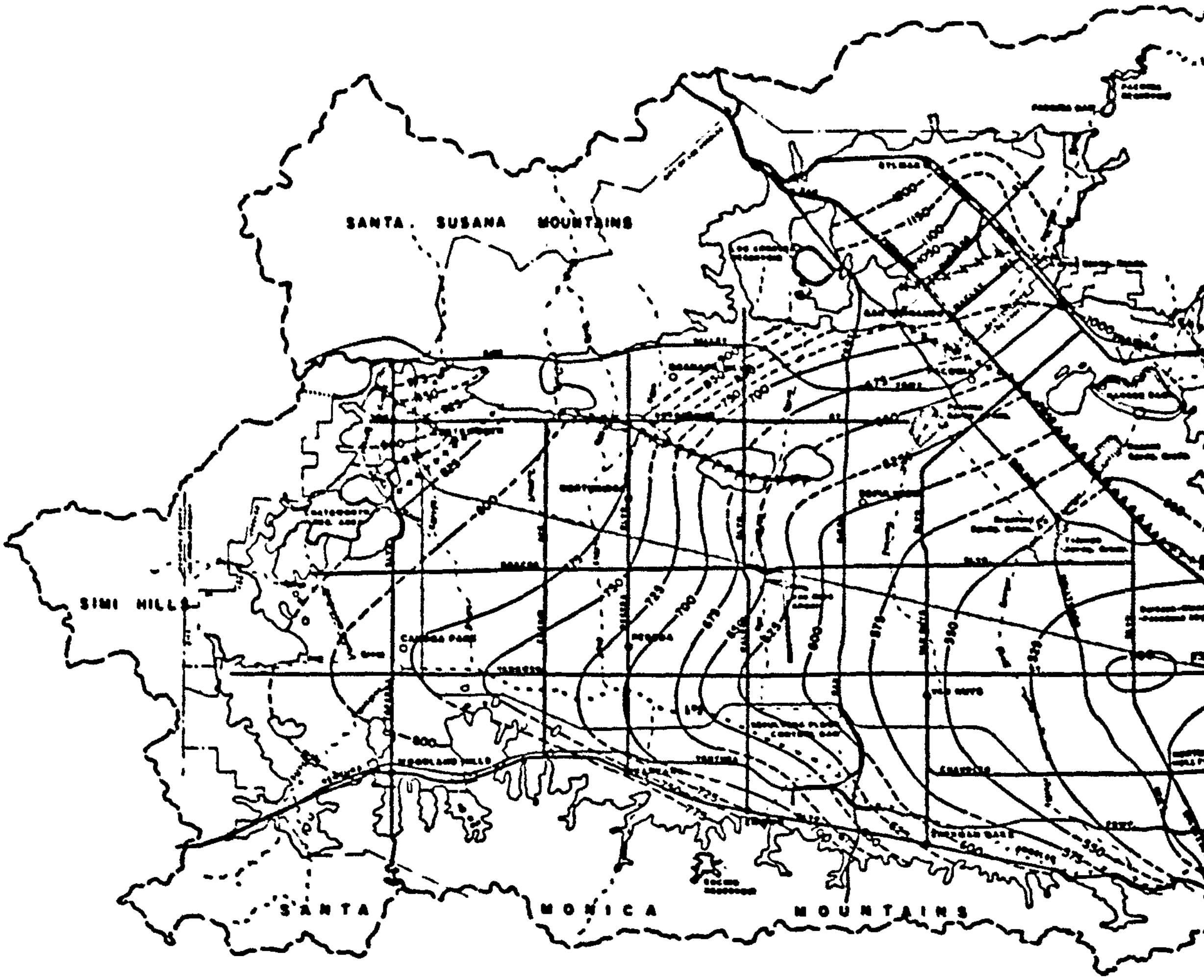
GROUNDWATER BASIN



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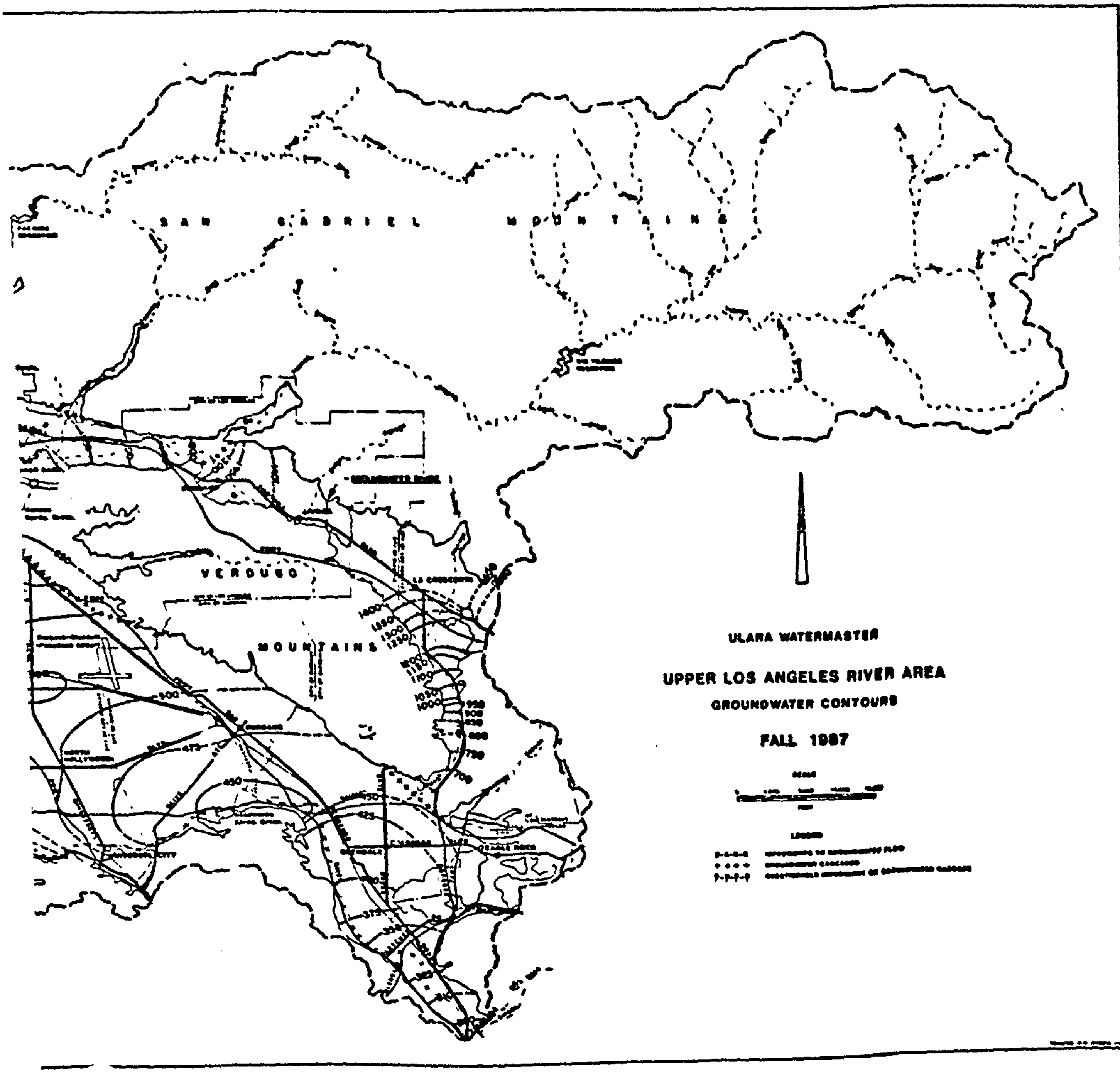

PG3

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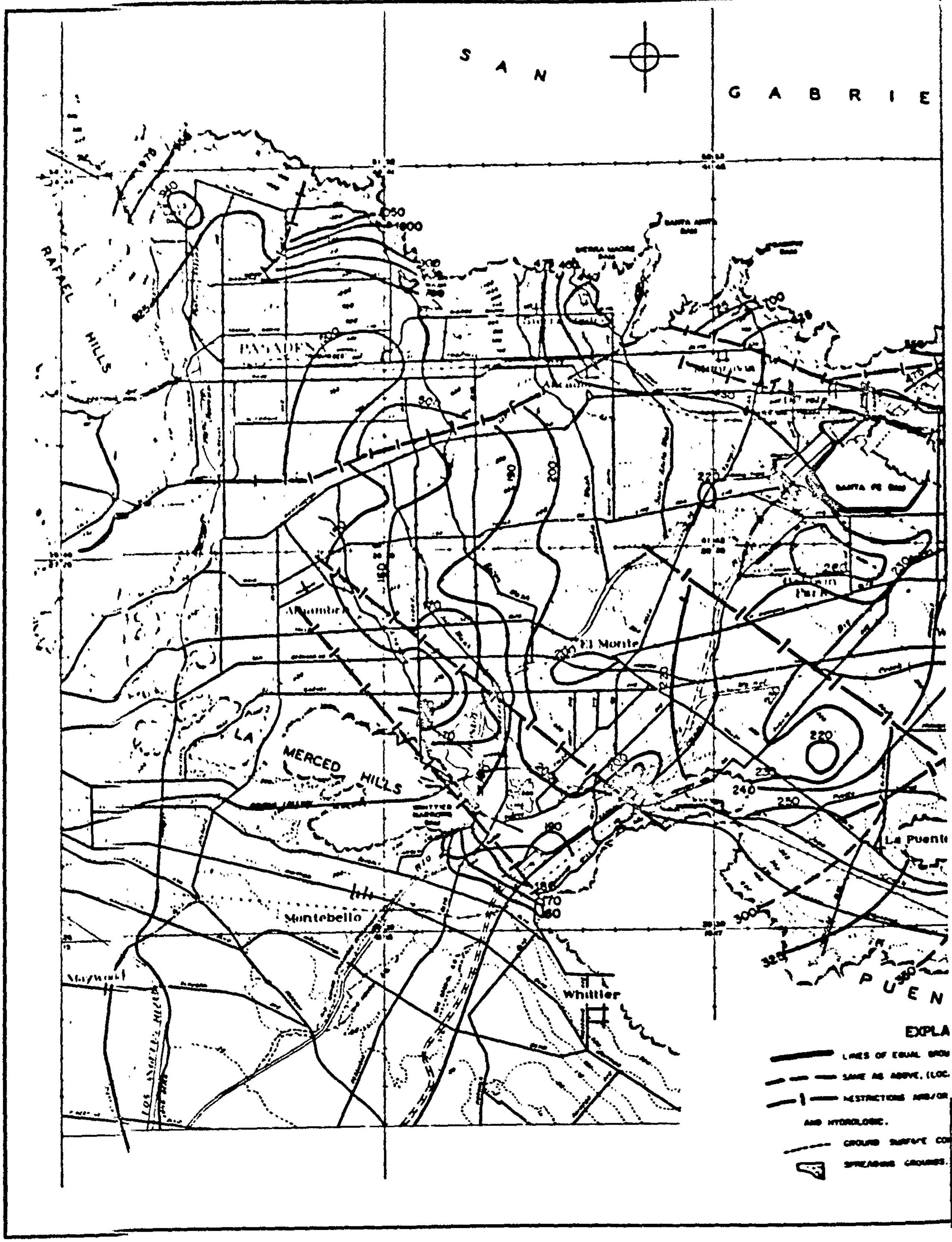

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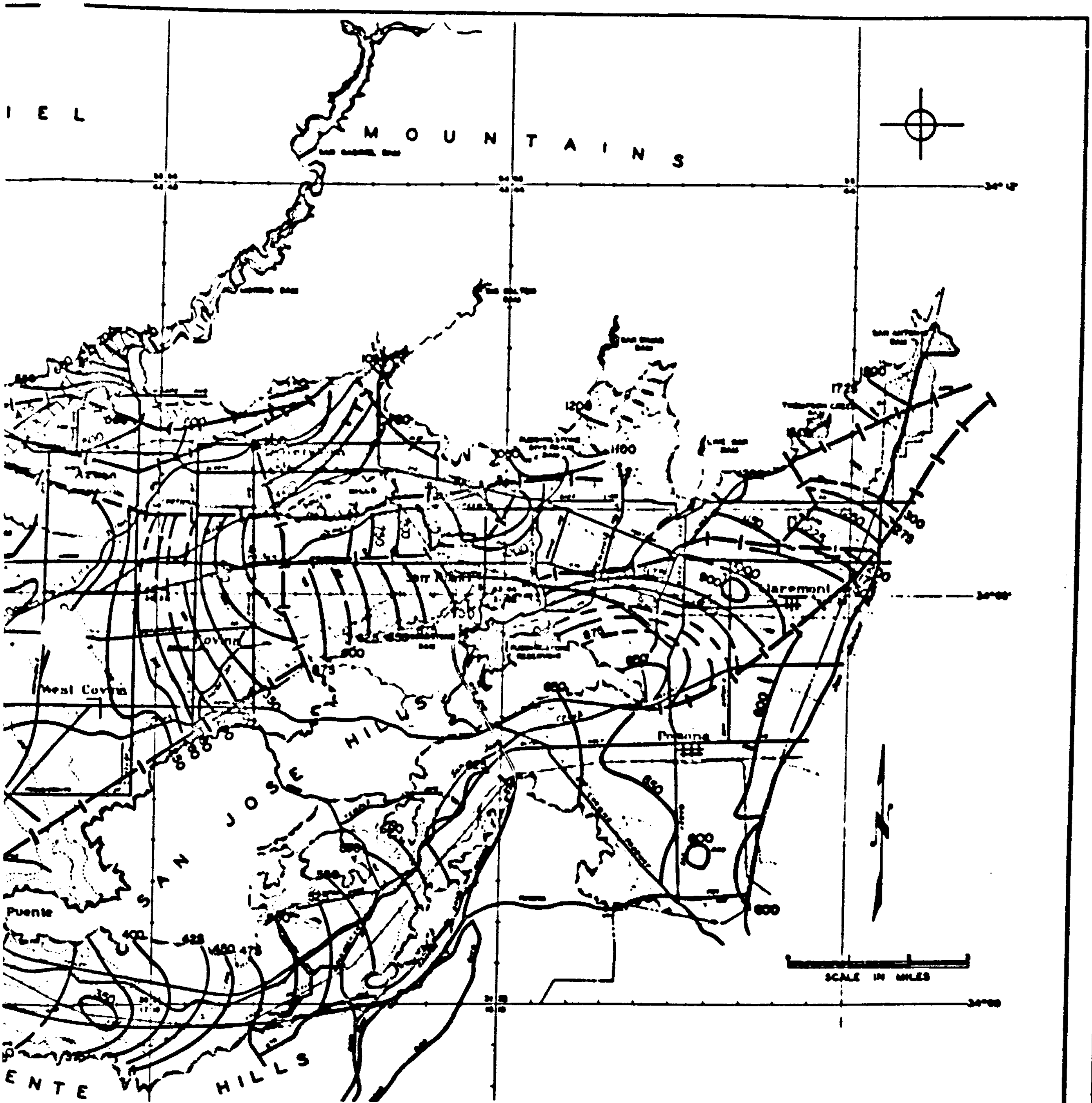

EXPLANATION

...AL GROUNDWATER LEVELS, (INTERPOLATED BETWEEN WELLS.)

...NE, (LOCATION APPROXIMATE.)

... AND/OR BARRIERS TO GROUNDWATER MOVEMENT, GEOLOGIC

REVISIONS			COUNTY OF LOS ANGELES DEPARTMENT OF PUBLIC WORKS
NO.	DATE	DESCRIPTION	SAN GABRIEL VALLEY GROUNDWATER CONTOURS FOR FALL 1987

DESIGNED BY | CHECKED BY | DRAWN BY | PROJECT ENGINEER | RECOMMENDED BY | DATE | SCALE | NO. | SHEET OF

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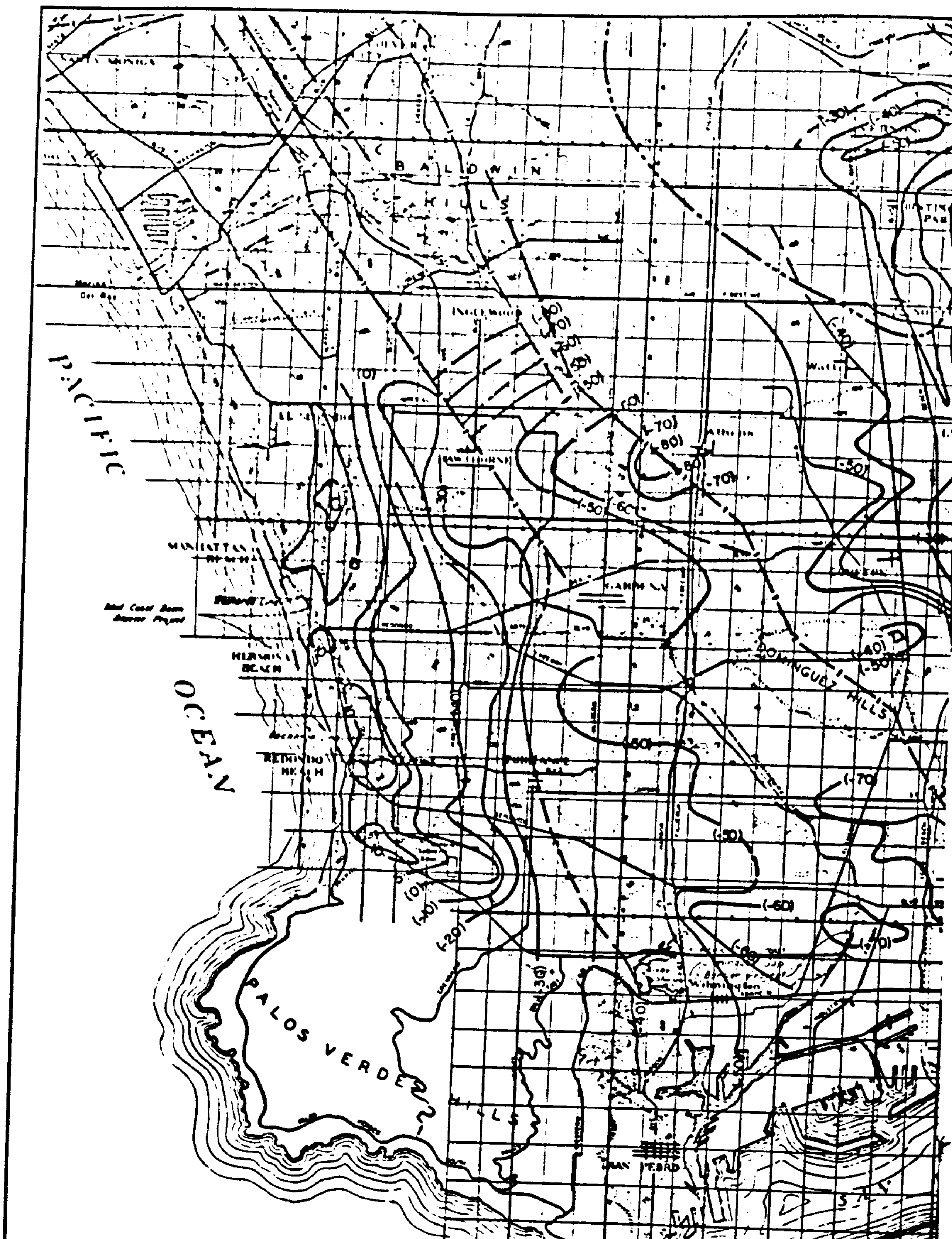
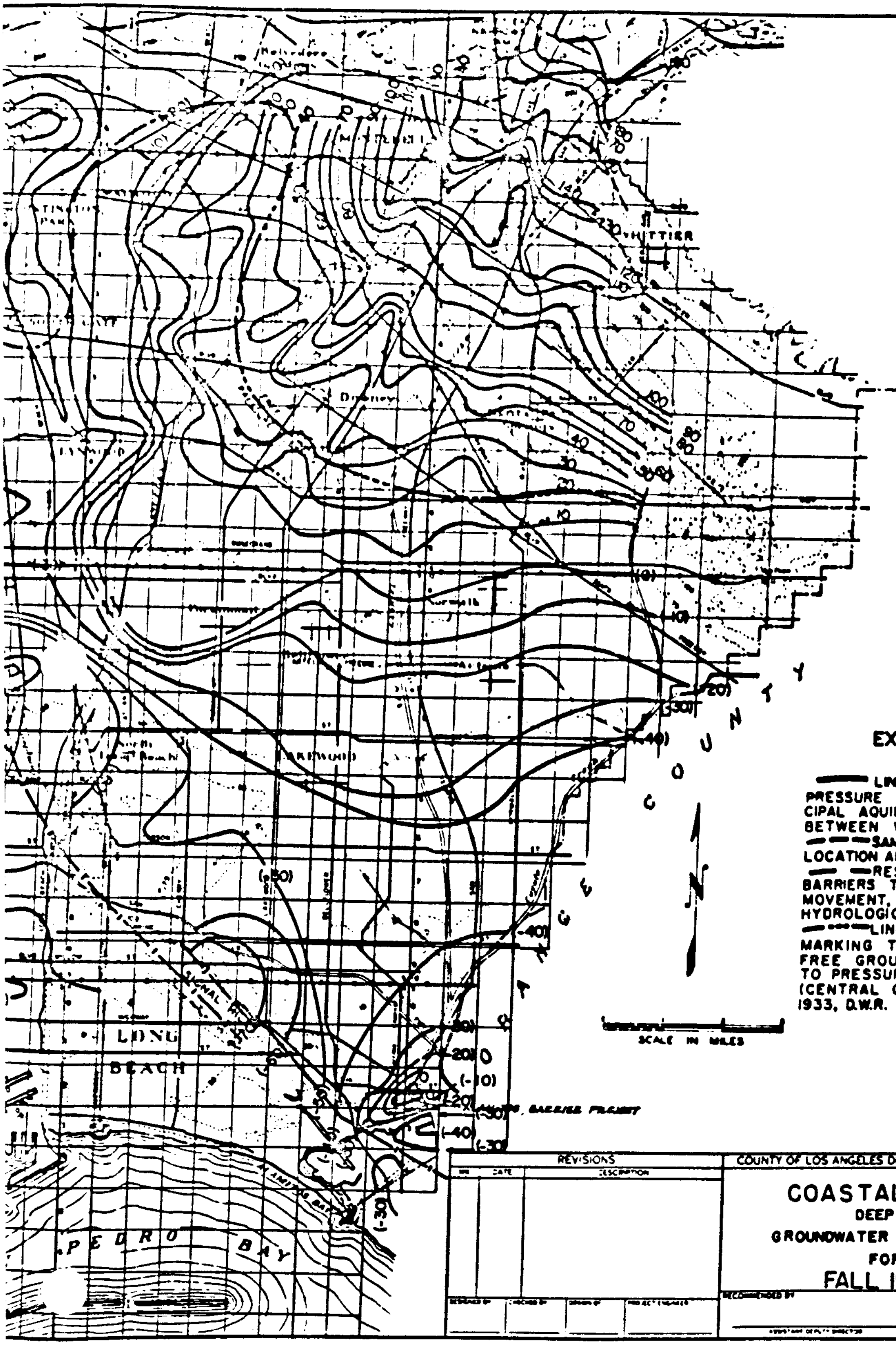


PACIFIC
OCEAN
PALOS VERDES
HILLS
BALDWIN
HILLS
DOMINGUEZ HILLS
MANHATTAN BEACH
HERMOSA BEACH
REDONDO BEACH
SAN PEDRO
(-70)
(-80)
(-50)
(-60)
(-40)
(-20)
(-10)
(0)

VOL
12
1
9637



EXPLANATION

LINES OF EQUAL PRESSURE ELEVATIONS- PRINCIPAL AQUIFER (INTERPOLATED BETWEEN WELLS)
SAME AS ABOVE, LOCATION APPROXIMATE.
RESTRICTIONS OR BARRIERS TO GROUNDWATER MOVEMENT. (GEOLOGIC AND/OR HYDROLOGIC)
LINE APPROXIMATELY MARKING TRANSITION FROM FREE GROUNDWATER LEVELS TO PRESSURE LEVELS. (CENTRAL COASTAL PLAIN 1933, D.W.R. BULL. NO. 45.)

SCALE IN MILES

REVISIONS

COUNTY OF LOS ANGELES DEPARTMENT OF PUBLIC WORKS

COASTAL PLAIN
DEEP AQUIFER
GROUNDWATER CONTOUR MAP
FOR
FALL 1987

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Plat. Deep Aquifer wells

PG5

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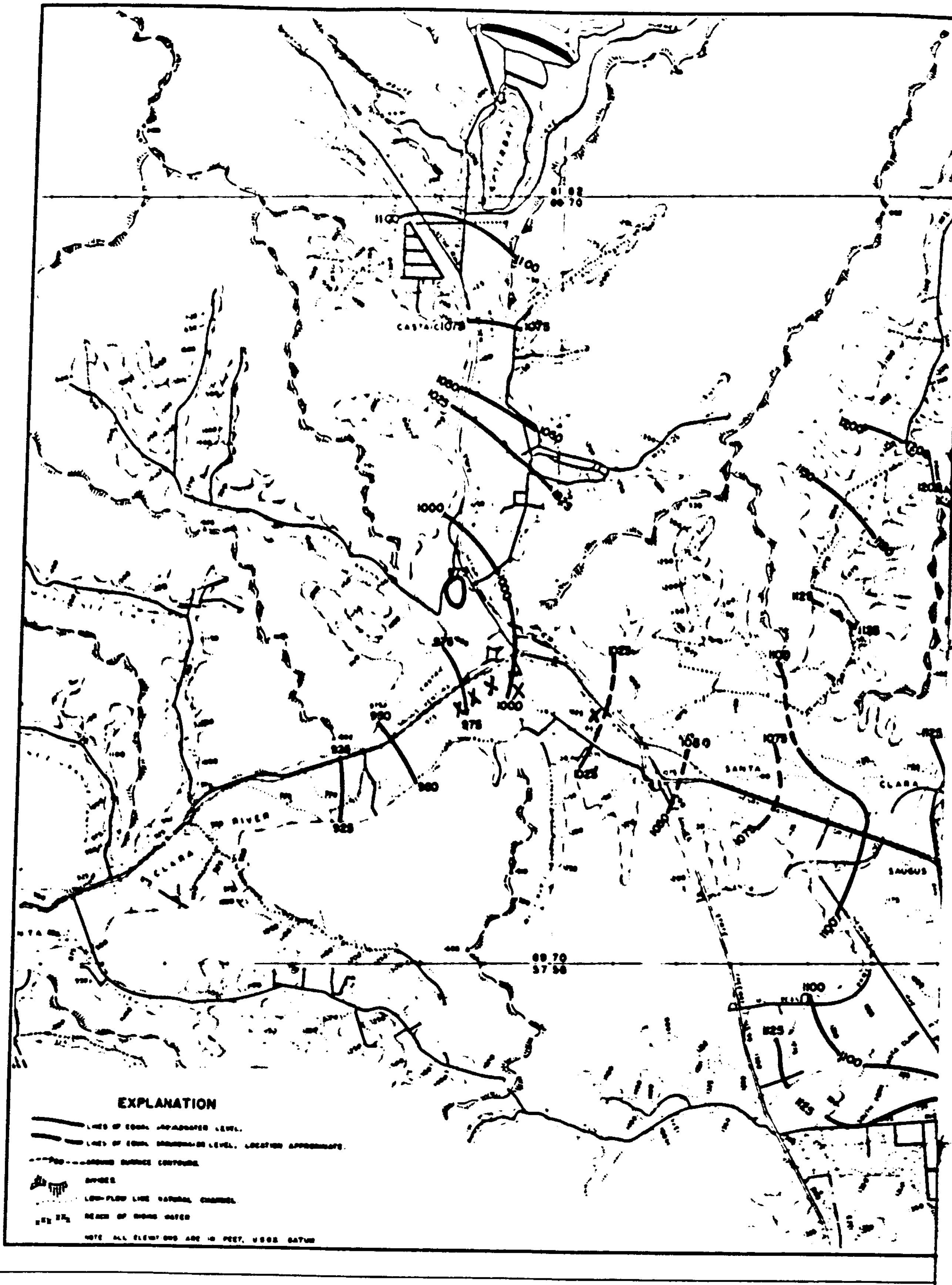
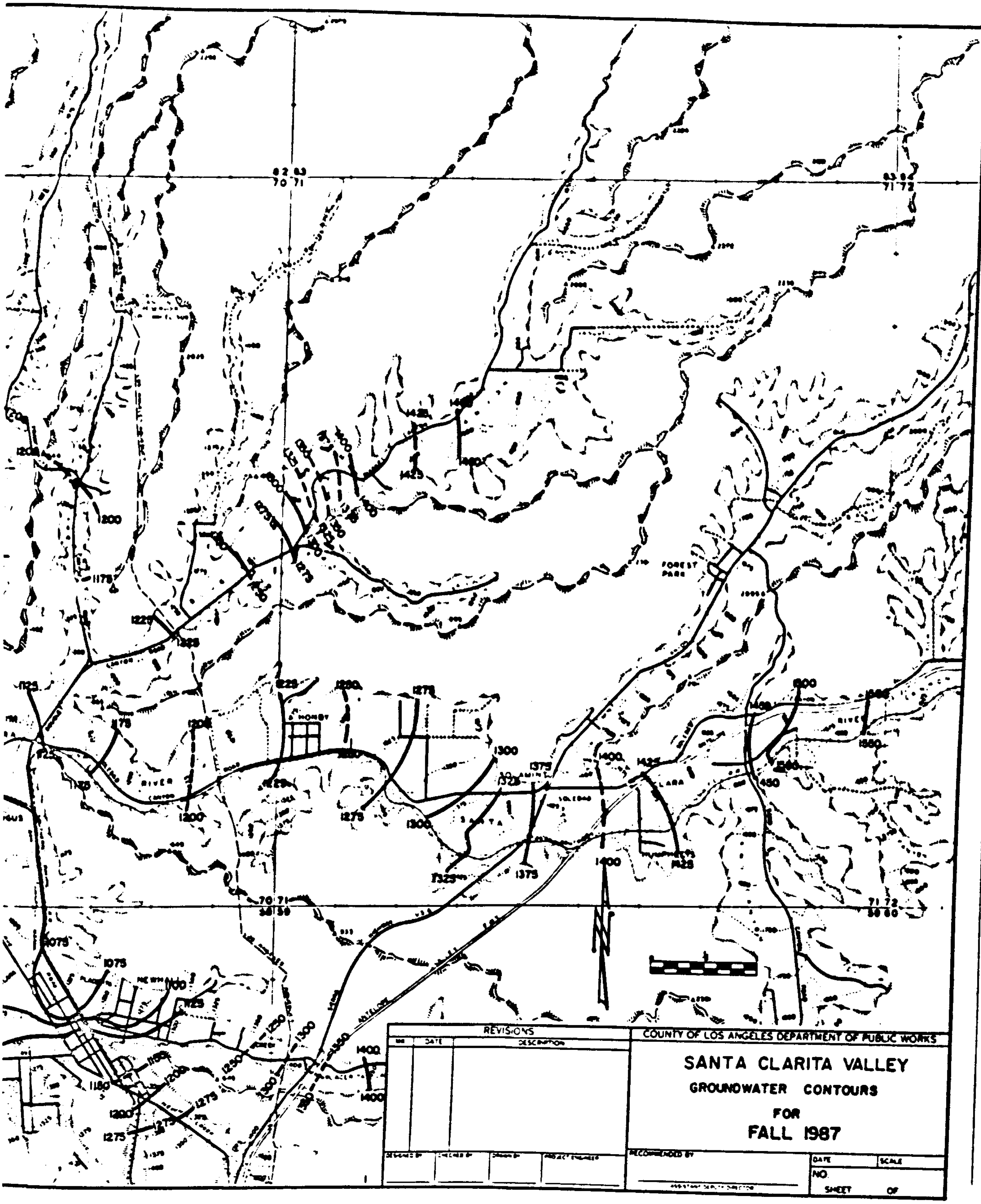

EXPLANATION



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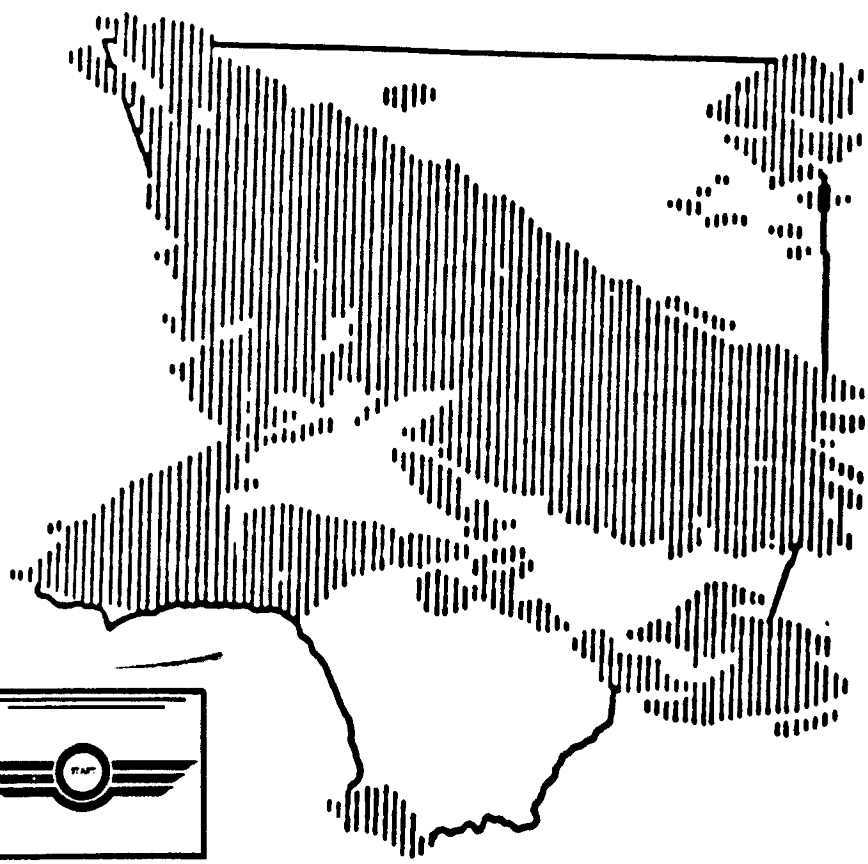
Los Angeles County Department of Public Works

HYDROLOGIC REPORT



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PUBLIC WORKS

LOS ANGELES COUNTY

Public Service That Works

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LOS ANGELES COUNTY
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PREPARED BY THE
HYDRAULIC/WATER CONSERVATION DIVISION
APRIL 1990

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This report was prepared in the Hydraulic/Water Conservation Division under the direction of Donald F. Nichols, Assistant Deputy Director. The following people contributed to the completion of this report:

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ABOUT THIS REPORT

The 1988-89 Hydrologic Report represents a significant departure in terms of data content and format from reports published previously by the Department of Public Works and its predecessor, the Los Angeles County Flood Control District. The changes primarily entail the reporting of less detailed hydrologic data than were previously published, such as monthly and annual summaries instead of daily data. We apologize for any inconvenience this may cause our users.

With the rapid development of computing technology, there appears to be less demand for hydrologic data in written form, and it is our intention at some future time to phase out the published book reports and make the data available on computer diskettes. In the meantime, any user who desires more detailed information about any of the types of hydrologic data which we manage can write the Custodian of Hydrologic Records at:

Los Angeles County Department of Public Works
Hydraulic/Water Conservation Division
P.O. Box 1460
Alhambra, CA 91802-1460

or telephone: **(818) 458-6112**

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INTRODUCTION

This report contains hydrologic data within Los Angeles County for the period beginning October 1, 1988 and ending September 30, 1989. The data are presented in seven sections.

Precipitation - lists 383 active rainfall stations and presents corresponding seasonal rainfall amounts.

Evaporation - lists all locations for which evaporation data is on file and provides monthly evaporation amounts at 14 locations.

Runoff - presents the maximum, minimum, and mean of the daily flow rates for each month and the monthly volumes for 50 streamflow stations and three Metropolitan Water District outlets.

Dam Operation - presents the maximum and minimum of the daily inflow and outflow rates for each month, the instantaneous peak inflow and outflow rates and storage volumes for 14 dams and reservoirs.

Erosion Control - list debris basins and debris production amounts and displays maps of major watershed burns.

Water Quality Monitoring - presents maps of surface and groundwater sampling locations, and data at selected locations.

Conservation and Groundwater - presents records of water conserved at various facilities, water injected at seawater barrier projects, well hydrographs, and groundwater basins.

Where practical, data which would satisfy immediate needs and serve as useful reference are published in these reports. Several tables appear listing locations where unpublished data are available. Additional information may be obtained by writing to:

Los Angeles County Department of Public Works
Hydraulic/Water Conservation Division
P.O. Box 1460
Alhambra, CA 91802-1460

or telephone: **(818) 458-6112**

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LOS ANGELES COUNTY

TOPOGRAPHY

The County of Los Angeles covers an area of 4,083 square miles and measure approximately 66 miles in the east - west and 73 miles in the north - south directions.

The terrain within the County can be classified in broad terms as being 26 percent mountainous, 12 percent coastal plain; and 62 percent hills, valleys, or deserts. Relief of the terrain ranges from sea level to a maximum elevation of 10,000 feet. The coastal plain is generally of mild slope and contains relatively few depressions or natural ponding areas. The slopes of main river systems crossing the coastal plain, such as the San Gabriel River, Los Angeles River, and Ballona Creek, range from 4 to 14 feet per mile.

Topography in the mountainous area is generally rugged with deep, V-shaped canyons separated by sharp dividing ridges. Steepwalled canyons with side slopes of 70 percent or more are common. The gradient of principal canyons in the San Gabriel Mountains ranges from 150 to 850 feet per mile. Mountain ranges are aligned in a general east-west direction, the major range being the San Gabriel Mountains. The majority of mountain ridges lie below Elevation 5,000, the total area above this level being approximately 210 square miles.

GEOLOGY - SOILS

Igneous, sedimentary, and metamorphic rock groups are all represented within the County. The San Gabriel Mountains and Verdugo Hills are composed primarily of highly fractured igneous rock, with large areas of granitic rock formation being exposed above soils which are coarse and porous. Faulting and deep weathering have produced porous zones in the rock formation; however, rock masses have produced a comparatively shallow soil mantle due to the steepness of slopes which accelerates erosion of the fine material.

LAND USE

The principal vegetative cover of upper mountain areas consists of various species of brush and shrubs known as chaparral. Most trees found on mountain slopes are oak, with alder, willow, and sycamore found along streambeds at lower elevations. Pine, cedar, and juniper are found in ravines at higher elevations and along high mountain summits.

The chaparral is extremely flammable, and extensive burns of the mountain vegetation frequently occur during dry, low-humidity weather accompanied by high winds. Chaparral has the ability to sprout following fire and grows rapidly to re-establish the watershed cover within a period of 5 to 10 years.

Grasses are the principal natural vegetation on the hills. Much of the hill land and nearly all of the valley land in the densely populated portion of the County south of the San Gabriel Mountains has been converted to urban and suburban use. Development of the Santa

1953

Clarita Valley and desert areas to the north of the San Gabriel Mountains is sparse at present but is proceeding at an accelerated rate.

Other mountains and hilly reaches within the Department are composed primarily of folded and faulted sedimentary rocks, including shale, sandstone, and conglomerate. Residual soils in these areas are shallow and are generally less pervious than those of the San Gabriel Mountain range.

Valley and desert soils are alluvial and vary from coarse sand and gravel near canyon mouths to silty clay and gravel or clay in lower valleys and the coastal plain. The alluvial fill has been built up by repeated deposition of debris to depths as great as 2,000 feet in places. This fill is quite porous in areas of relatively low clay content. Impervious layers and irregularities in the underlying bedrock divide the alluvium into several County groundwater basins. Valley soils are generally well drained and relatively few perched water or artesian areas are present.

CLIMATE

The climate within the County varies between subtropical on the Pacific Ocean side of the San Gabriel mountain range to arid in the Mojave Desert. Nearly all precipitation occurs during the months of December through March. Precipitation during summer months is infrequent, and rainless periods of several months are common. Snowfall at elevations above 5,000 feet is frequently experienced during the winter storms, but the snow melts rapidly except on higher peaks and the northern slopes. Snow is rarely experienced on the coastal plain.

January and July are the coldest and warmest months of the year, respectively. At Los Angeles, the 30-year average daily minimum temperature for January is 47 degrees above zero. The average daily maximum temperature for July is 83 degree. At Mount Wilson (Elevation 5,850 feet), the 30-year average daily minimum temperature for January is 35 degrees above zero and the average daily maximum temperature for July is 80 degrees.

HYDROMETEOROLOGIC CHARACTERISTICS

Coastal and Mountain Areas

Precipitation in the Los Angeles area occurs primarily in the form of winter orographic rainfall associated with extratropical cyclones of North Pacific origin. Major storms consists of one or more frontal systems and occasionally last four days or longer. Air masses and frontal systems associated with major storms commonly extend for 500 to 1,000 miles in length and produce rainfall simultaneously throughout the County. Major storms approach Southern California from the west or southwest with southerly winds which continue until frontal passage. The mountain ranges lie directly across the path of the inflow of warm, moist air, and orographic effects cause precipitation to be greatly intensified.

The effect of snowmelt upon flood runoff is of significance in the few cases when warm spring rains from southerly storms fall on a snowpack. During major storms, temperatures throughout the County may remain above freezing.

Average individual storm rainfall amounts and intensities conform to a fairly definite aerial pattern which reflects general effects of topographic differences.

Desert Areas

Summer convective rainfall is principally experienced in the upper San Gabriel Mountains and the Mojave Desert regions. In many desert areas, the most serious flooding occurs as a result of summer convective storms.

RUNOFF CHARACTERISTICS

Mountain Areas

In mountain areas, the steep canyon slopes and channel gradients are conducive to rapid concentration of storm runoff quantities. Depression storage and detention storage effects are minor in the rugged terrain. Soil moisture during a storm has a pronounced effect on runoff from the porous soils supporting a good growth of deeprooted vegetation such as chaparral. Soil moisture deficiency is greatest at the beginning of a rainy season, having been depleted by evapotranspiration process during the dry summer months. Precipitation during periods of soil moisture deficiency is nearly entirely absorbed by soils, and except for periods of extremely intense rainfall, significant runoff does not occur until soils are wetted to field moisture capacity. Due to high infiltration rates and porosity of mountain soils, runoff occurs primarily as subsurface flow or interflow rather than as direct runoff. Spring or base flow is essentially limited to portions of the San Gabriel mountain range, most streams in the Department being intermittent.

Runoff from a mountain watershed recently denuded by fire exceeds that for the unburned state due to greatly increased quantities of inorganic debris present in the flow and lowflows from a denuded watershed. Debris production from a major storm has amounted to as much as 223,000 cubic yards per square mile of watershed. Boulders up to eight feet in diameter have been deposited in a valley area a considerable distance from their source.

Debris quantities equal in volume to storm runoff, or in other words 100 percent bulking of runoff from a major storm, have been recorded. Where debris-laden flow traverses an alluvial fill unconfined by flood control works, flood discharges follow an unpredictable path across the debris cone formed at the canyon mouth.

Hill and Valley Areas

In hill areas, runoff concentrates rapidly from the generally steep slopes; however, runoff rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size. In those hill areas which have been developed for residential use,

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concentration times become considerably decreased due to drainage improvements, and runoff volumes and rates become increased due to increased imperviousness. On the other hand, erosion is controlled and debris content of storm flow is practically eliminated. Debris production rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size.

In highly developed valley areas, local runoff volumes have increased as the soil surface has become covered by impervious materials. Peak runoff rates for valley areas have also increased due to elimination of natural ponding areas and improved hydraulic efficiency of water carriers such as streets and storm drain systems.

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FLOOD CONTROL AND WATER CONSERVATION

FLOODS. . AN OLD STORY

Floods in Los Angeles County have been recorded as far back as the days of the Mission Padres. For centuries waters have swept out of the San Gabriel Mountains causing extensive property damage and taking a great toll of lives.

Such a flood occurred in 1914 causing over $10 million in property damage and taking many lives. As a result, the State legislature passed an act creating the Los Angeles County Flood Control District.

The Department was assigned two tasks. . .control the floods and conserve the water.

CONTROLLING THE WATERS

Successful early bond issues financed construction of the 14 dams which the Department built in the San Gabriel Mountains and foothills to impound storm waters until they could be released in an orderly fashion. Debris basins were constructed to trap eroded materials which had caused terrible damage in the past. Flood channel improvements were undertaken to confine the waters.

Department engineers prepared a Comprehensive Plan in the early 1930's which provided for the control of flooding and the saving of as much of the water as practicable.

Federal legislation in 1936 brought the United States Army Corps of Engineers into the local flood control picture. Since that time, the two agencies have been jointly persuing construction of the Comprehensive Plan. The Department also cooperates with the United States Soil Conservation Service and Forestry Service in erosion control.

CONSERVING THE WATERS

In addition to its flood control program, the Department has the equally important task of conserving as much of the storm and other waste waters as practicable. The use of water conservation facilities in or adjacent to river channels and their tributaries permits water to be percolated into ground reservoirs for later pumping and supply to consumers. These water conservation facilities are located in areas where the underlying soils are composed of porous sands and gravel formations. Some resemble rice paddies, while others are deep basins which were once gravel pits.

The importance of this activity is apparent when it is realized that about 35 to 40 percent of the water used in the County is pumped from ground supplies. The growth of the County, combined with periodic droughts, seriously depleted these supplies on numerous occasions down through the years.

Other major conservation efforts by the Department include combatting the serious intrusion by salt water to underground fresh well supplies inland from the Pacific Ocean and the utilization of imported water and reclaimed sewage waters in spreading operations.

ORGANIZED TO DO THE JOB

Day-to-day administration of Department affairs is vested in the Director of Public Works who is appointed by and responsible to the Los Angeles County Board of Supervisors. A part of the Department's activities involve the construction of flood control and water conservation facilities, and the operation and maintenance of dams, debris basins, spreading grounds, channels, and storm drains.

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PRECIPITATION

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PRECIPITATION

This section contains annual precipitation data collected by the Department for the period beginning October 1, 1988 and ending September 30, 1989. Although the Department operates and maintains 358 rainfall stations, including standard and automatic gages which record amounts for durations ranging from 15 minutes to 24 hours, only annual amounts for the report period are listed herein. Additional data can be obtained by contacting the custodian of hydrologic records at the location shown in the front of the report.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meterological conditions in the County and Southern California in real time, i.e., as they occur. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels. The system can forecast peak flows in the Los Angeles, Rio Hondo, and San Gabriel Rivers.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The cooperation of observers in furnishing rainfall data to the Department as a public service is appreciated. The effort of the many agencies and indi viduals who have so freely cooperated with us in the collection of this data have resulted in the large number of complete records for the period covered by this report.

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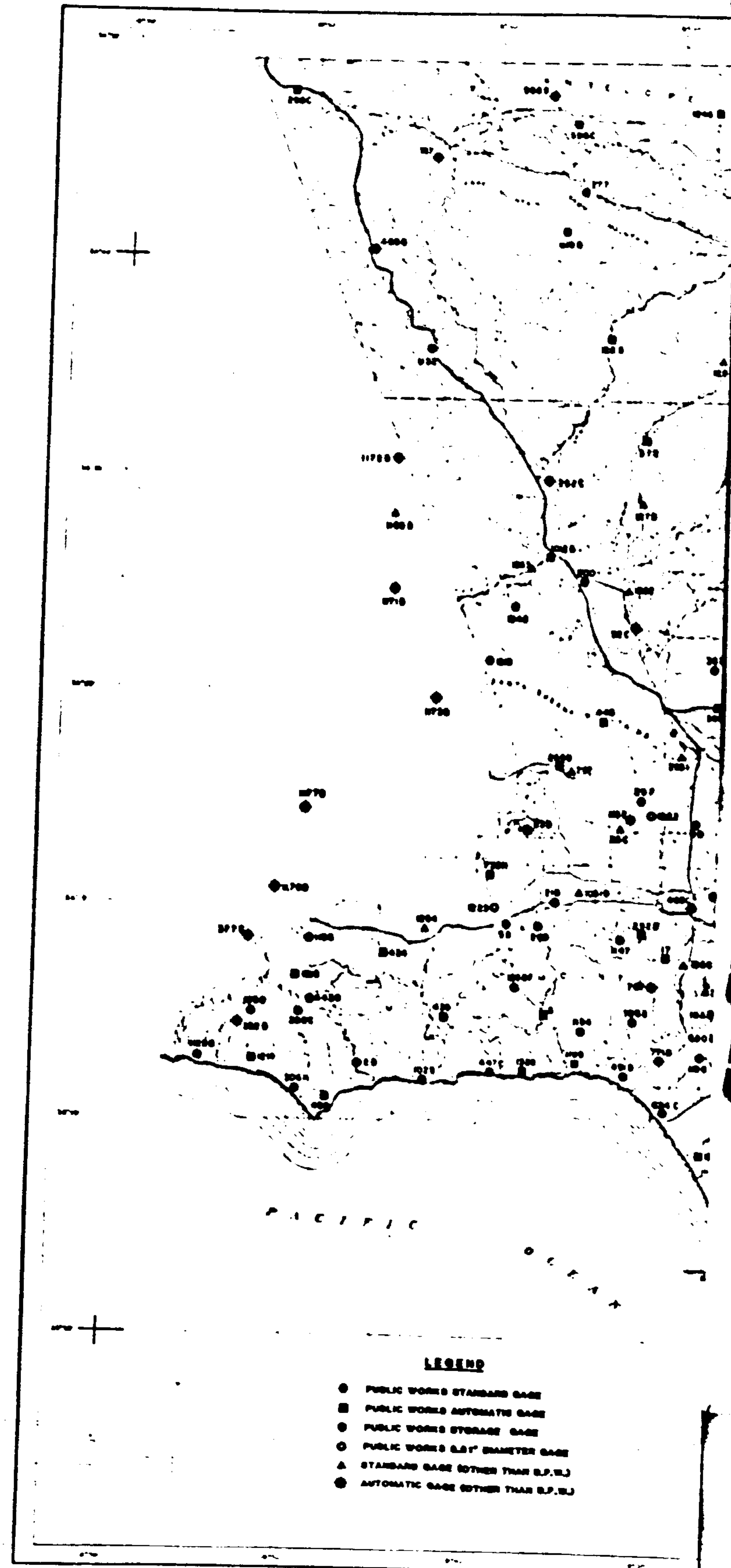

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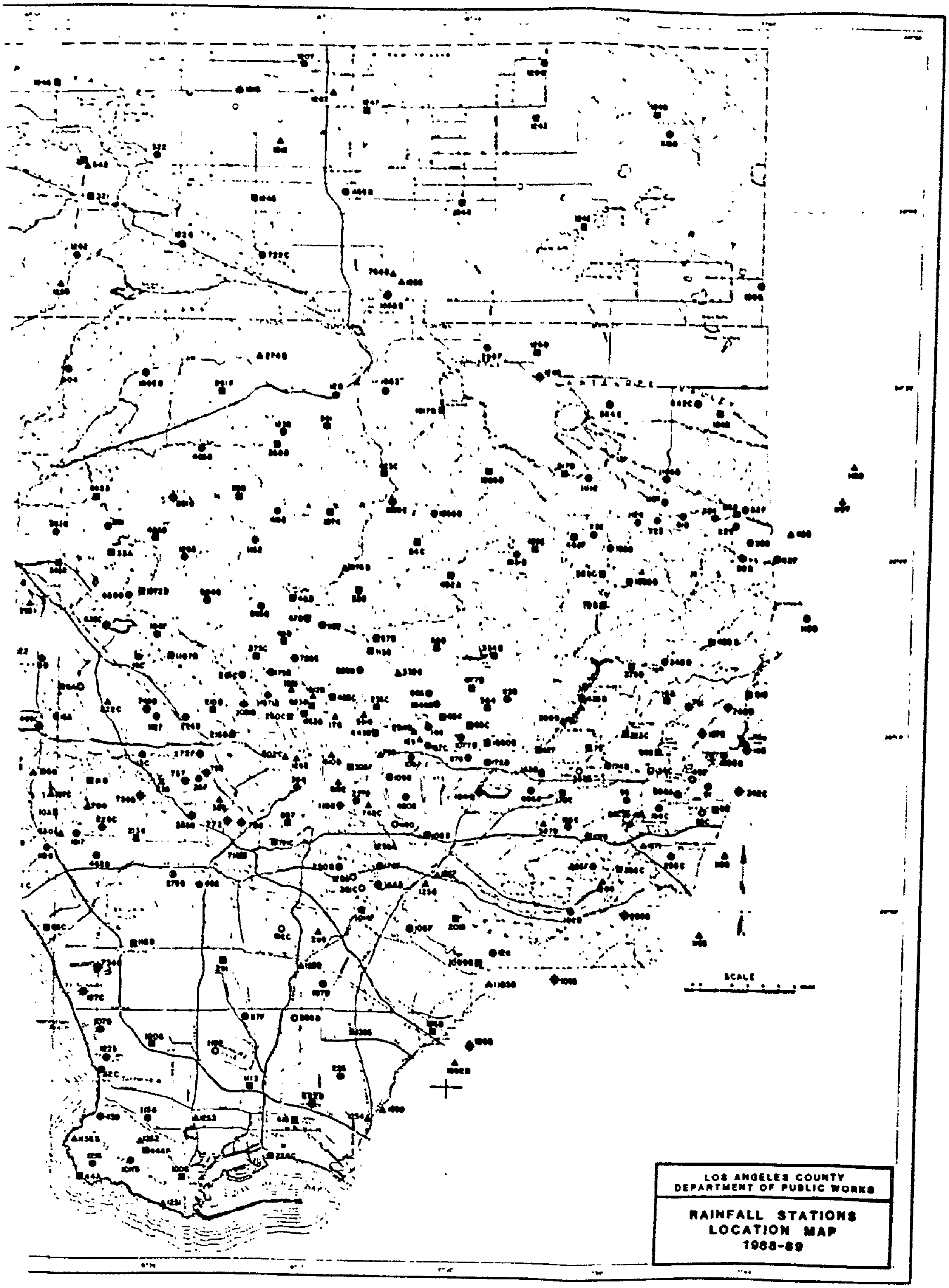

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ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
2B	ESCONDIDO CANYON	S	112 E3	34-02-55	118-40-25	1050	11.50
5B	CALABASAS	S	100 F3	34-08-24	118-38-14	924	7.0
6	TOPANGA PATROL STATION	A	109 C5	34-05-03	118-35-57	745	12.0
9B	SEPULVEDA AND RAYEN	S	8 C6	34-13-52	118-28-04	828	5.7
10A	BEL AIR HOTEL	A	32 E5	34-05-11	118-26-45	540	11.4
11D	UPPER FRANKLIN CYN RESERVOIR	SP A	33 B1	34-07-10	118-24-55	887	10.4
13C	NORTH HOLLYWOOD-LAKESIDE	S	23 F4	34-08-40	118-21-13	550	9.1
14C	ROSCOE-MERRILL	S	9 F5	34-14-15	118-21-32	1050	9.50
15A	VAN NUYS	S	15 D6	34-10-48	118-27-03	685	7.4
17	SEPULVEDA CYN AT MULHOLLAND	A	22 A5	34-07-51	118-29-20	1425	11.6
20B	GIRARD RESERVOIR	S	13 B3	34-09-07	118-36-36	960	9.8
21B	WOODLAND HILLS	S	13 C1	34-10-14	118-35-33	875	8.8
23B	CHATSWORTH RESERVOIR	SP AP	6 A6	34-13-44	118-37-18	900	7.4
25C	NORTHRIDGE-L.A.D.W.P.	SP	7 B6	34-13-52	118-32-28	810	8.9
29F	GRANADA HILLS	S	7 D2	34-15-03	118-31-06	1035	11.3
32C	NEWHALL-SOLEDAD DIV.HDQTRS	S AP	127 C3	34-23-07	118-31-54	1243	10.3
33A	PACOIMA DAM	S A	120 F8	34-19-40	118-23-58	1500	13.2
42C	REDONDO BEACH-CITY HALL	S	67 D3	33-50-43	118-23-20	70	7.5
43D	PALOS VERDES ESTATES	S	72 C2	33-47-58	118-23-25	216	8.4
44A	POINT VICENTE LIGHTHOUSE	A	77 B3	33-44-30	118-24-38	125	6.8
46D	BIG TUJUNGA DAM	S A	M C2	34-17-40	118-11-14	2315	17.5
47D	CLEAR CREEK-CITY SCHOOL	A	M D3	34-16-38	118-10-12	3150	23.0
53D	COLBY'S	A	M F2	34-18-05	118-06-35	3620	16.5
54C	LOOMIS RANCH-ALDER CREEK	S A	(197)	34-20-55	118-02-54	4325	12.4
57B	CAMP HI HILL (OPIDS)	A	M F3	34-15-18	118-05-41	4250	26.2
60A	HOEGEE'S	A	20A D1	34-12-32	118-02-02	2412	23.00
63C	SANTA ANITA DAM	S A	20A F2	34-11-03	118-01-12	1400	18.8
67G	MONROVIA-MOUNTAIN AVENUE	S	29 C4	34-09-40	117-59-05	602	14.4
68C	SAWPIT DAM	S A	20B C8	34-10-30	117-59-07	1375	20.3
73	GLENDORA-ENGLEWILD RANCH	A	87 C3	34-09-22	117-50-57	1165	17.3
78B	COLDBROOK RANGER STATION	A	P A2	34-17-28	117-50-28	3280	18.0
80B	PRAIRIE FORKS	ST	P F1	34-20-20	117-41-30	5640	13.50
81B	VINCENT GAP	ST	(200)	34-22-28	117-45-05	6590	8.00
82F	TABLE MOUNTAIN	S	(201)	34-22-56	117-40-39	7420	8.9
83B	BIG PINES RECREATION PARK	A	(201)	34-22-44	117-41-20	6860	13.4
89B	SAN DIMAS DAM	S A	95A C3	34-09-10	117-46-17	1350	18.7
91	CLAREMONT-INDIAN HILL	S	91 B1	34-07-22	117-43-11	1403	14.9
92	CLAREMONT-POMONA COLLEGE	S A	91 C4	34-05-48	117-42-33	1185	13.40
93C	CLAREMONT-POLICE STATION	S.01	91 B4	34-05-45	117-43-18	1170	13.4
95	SAN DIMAS-FIRE WARDEN	S	89 F3	34-06-28	117-48-18	955	13.8

ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
96C	PUDDINGSTONE DAM	S A	89 F4	34-05-31	117-48-24	1030	14.0
102D	WALNUT-H.I. INDUSTRIES	S	87 B2	34-00-11	117-52-10	500	8.1
106F	WHITTIER CITY YARD	S	55 D4	33-58-	118-01-	300	8.8
107D	DOWNEY-FIRE DEPARTMENT	S	60 A5	33-55-46	118-08-47	110	7.6
108D	EL MONTE FIRE STATION	S	38 D6	34-04-30	118-02-30	275	10.2
109D	WEST ARCADIA	S	28 A6	34-07-42	118-04-22	547	11.1
110B	ALHAMBRA	S	37 B3	34-05-40	118-07-41	533	12.0
116G	INGLEWOOD COURTHOUSE	A	57 A1	33-57-05	118-21-13		8.8
117F	COMPTON FIRE STATION	S	64 F3	33-53-42	118-13-34	78	N.A.
118G	SAWTELLE-SOLDIERS HOME	S	32 D2	34-03-21	118-27-20	345	8.90
120	VINCENT PATROL STATION	S	183 A9	34-28-17	118-06-27	3135	5.3
122G	LEONA VALLEY-RACKETT RANCH	S	171 G3	34-37-52	118-18-22	3300	5.10
125B	SAN FRANCISQUITO CYN P.H.#1	SP	(188)	34-35-28	118-27-18	2105	11.4
126C	BOONE OLIVE PUMP PLANT	A	48 D4	33-58-56	118-27-33	30	8.5
127B	DRY CANYON RESERVOIR	SP	124 D1	34-28-55	118-31-32	1511	INC.
128B	ELIZABETH LAKE-WARM SPRINGS	A	(188)	34-36-28	118-33-40	2075	INC.
134C	PUDDINGSTONE DIVERSION	S.01	88A C5	34-07-52	117-48-58	1100	15.1
140C	SAWTELLE	AP	41 D3	34-02-43	118-28-55	280	DSC.
143B	AZUSA-CITY PARK	S	86 D5	34-08-03	117-54-17	610	13.00
144	SIERRA MADRE DAM	S	20A D3	34-10-34	118-02-32	1100	15.0
155B	LA MIRADA-STANDARD OIL CO.	A	83 A4	33-52-58	118-01-00	75	INC.
157C	EL SEGUNDO-CHEVRON OIL COMPA	S AP	56 A6	33-54-57	118-25-05	150	7.0
158	TANBARK FLATS	A AP	P D5	34-12-20	117-45-40	2750	23.20
167C	ARCADIA PUMPING PLANT #1	S	28 E2	34-09-31	118-02-02	611	13.7
168	SIERRA MADRE PUMPING PLANT	SP	28 D2	34-09-47	118-02-21	700	13.9
170F	POTRERO HEIGHTS	S	47 A4	34-02-32	118-04-44	288	10.4
172B	DUARTE	S	29 E4	34-08-26	117-58-02	548	INC.
174B	GLENDORA	S	87 E8	34-07-43	117-49-06	830	15.8
175B	LA CANADA IRRIGATION DIS.	S	19 A1	34-13-38	118-12-40	2020	18.8
178	ALTADENA-RUBIO CANYON	SP	20 B6	34-10-55	118-08-15	1125	14.3
179C	AZUSA VALLEY WATER CO.	A	88 F2	34-06-38	117-52-50	820	13.2
191C	LOS ANGELES-DPW WAREHOUSE	A	45 B1	34-03-	118-11-		10.90
192C	BELL-FIRE STATION	S.01	53 C5	33-58-45	118-11-18	145	8.10
193C	COVINA-HIGG	S	89 A5	34-04-	117-52-	575	12.0
196C	LA VERNE-FIRE STATION	S	90 D3	34-06-06	117-46-20	1050	13.3
200	SAUGUS-S.C.E. CO.	S	123 H8	34-25-21	118-34-28	1066	8.9
201D	HACIENDA HEIGHTS	A	85 C3	33-59-40	117-59-28	875	11.4
210B	BRAND PARK	A	18 B5	34-11-18	118-16-20	1250	10.8
213G	LOS ANGELES-HANCOCK PARK	A	42 F1	34-03-52	118-21-17	200	10.2
216B	GLENDALE-ANDREE	S	25 D2	34-09-54	118-15-01	815	11.3

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ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
222C	NORTH HOLLYWOOD P. P.	SP	16 C4	34-11-38	118-23-17	717	8.8
223C	BIG DALTON DAM	S A	87 F2	34-10-06	117-48-38	1587	22.8
224C	LONG BEACH-ALAMITOS LAND CO.	S	75 C5	33-46-01	118-11-48	220	8.3
225	MONTANA RANCH	S	71 C3	33-50-35	118-07-08	47	8.7
226B	BURBANK-FIRE STATION	S	17 E8	34-10-58	118-18-23	660	7.5
227D	SAN GABRIEL-BRUINGTON-ORTON	S	37 D2	34-06-18	118-06-32	472	11.7
228C	BEVERLY HILLS CITY HALL	S AP	33 C6	34-06-	118-23-		10.50
235C	HENNIGER FLATS	A S.81	20 F4	34-11-38	118-05-17	2550	18.7
237C	STONE CANYON RESERVOIR	SP	32 D2	34-08-21	118-27-13	865	INC.
238	HOLLYWOOD DAM	SP	34 C1	34-07-04	118-19-55	750	10.1
250D	ACTON CAMP	A	188 E5	34-27-02	118-11-55	2825	12.50
251C	LA CRESCENTA	S	18 D1	34-13-20	118-14-40	1440	15.4
252C	CASTAIC DAM	SP AP	(178)	34-28-53	118-36-53	1150	8.7
255F	MT. SAN ANTONIO COLLEGE	S	83 D4	34-02-41	117-50-10	720	12.2
256C	POMONA-FIRE STATION	S	94 E3	34-03-18	117-45-10	844	7.5
257	GRIFFITH PARK NURSERY	S	35 A1	34-07-18	118-17-04	850	10.00
259D	CHATSWORTH-TWIN LAKES	S A	1A D6	34-16-43	118-35-41	1275	7.8
261F	ACTON-ESCONDIDO CANYON	A	181 H9	34-29-42	118-16-22	2900	8.00
269D	DIAMOND BAR FIRE STATION	SP AP	87 F2	33-59-	117-48-	870	11.8
272F	GENE AUTRY MUSEUM	AP	25 A4	34-09-	118-16-		DSC.
274G	ACTON-LEE	SP	182 B5	34-31-31	118-13-58	3490	N.A.
277	SAWMILL MOUNTAIN	S	(153)	34-43-15	118-35-00	3700	12.3
278B	L.A.-CLARK MEMORIAL LIBRARY	S	43 D6	34-02-00	118-18-46	203	N.A.
280C	FLINTRIDGE-SACRED HEART	A	18 D6	34-10-54	118-11-08	1800	15.1
283C	CRYSTAL LAKE-EAST PINE FLAT	A	P B1	34-19-02	117-50-20	5370	21.7
287B	GLENDORA-CITY HALL	S.81	87 B5	34-08-09	117-51-52	785	18.8
289	LAGUNA-BELL-S.C.E.	SP	54 A5	33-58-37	118-08-48	140	10.3
290B	MONTEREY PARK-FIRE STATION	S	48 B4	34-02-27	118-07-42	305	11.1
291	LOS ANGELES-96th AND CENTRAL	A	58 C3	33-56-56	118-15-17	121	7.4
292D	ENCINO RESERVOIR	S A	21 D3	34-09-56	118-30-57	1070	7.8
293B	LAKE LOS ANGELES	SP	2 A4	34-17-18	118-28-54	1190	12.2
294B	SIERRA MADRE-MIRA MONTE P.P.	SP	28 C1	34-10-11	118-02-51	985	18.1
296C	GORMAN - SHERIFF	A	(141)	34-47-47	118-51-27	3838	8.5
299F	LITTLE ROCK - SCHWAB	S	184 F8	34-32-12	117-58-43	2900	4.0
303F	PASADENA - CAL TECH	A	27 C5	34-08-14	118-07-25	800	12.4
304	SAWPIT CANYON-DEER PARK	A	208 E4	34-11-36	117-57-52	2690	22.00
306H	ZUMA BEACH	S	111 F8	34-01-18	118-49-42	15	8.7
321	PINE CANYON PATROL STATION	A	187 D7	34-40-24	118-25-45	3288	8.00
322	MUNZ VALLEY RANCH	S	158 A2	34-42-50	118-21-15	2800	5.3
334B	COGSWELL DAM	S A	N D4	34-14-37	117-57-35	2300	24.2

ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
336	SILVER LAKE RESERVOIR	SP	35 B3	34-06-06	118-15-54	445	10.2
338C	MT. WILSON-OBSERVATORY	SP	20A C1	34-14	118-04	5709	30.8
341	ALISO CANYON-BLUM RANCH	S	189 J4	34-27-33	118-09-20	2900	8.8
342C	UPLAND-EUCLID PUMP PLANT	AP	96 E6	34-07-33	117-40-52	1810	12.5
348D	EAST FORK RANGER STATION	ST	P D4	34-14-20	117-46-09	2075	23.0*
352B	LECHUZA PATROL STATION	S AP	105 B6	34-04-38	118-52-47	1820	12.4
355B	LOS ANGELES CITY COLLEGE	S AP	34 F4	34-05-14	118-17-26	310	10.0*
356C	SPADRA-LANTERMAN HOSPITAL	S A	93 F4	34-02-31	117-48-35	680	11.8
363C	WILSON CANYON	ST	128 A7	34-21-17	118-27-00	3175	18.3*
372	SAN FRANCISQUITO P.H. #2	SP A	(176)	34-32-02	118-31-27	1580	11.8
373C	BRIGGS TERRACE	S A	11 F5	34-14-17	118-13-27	2200	INC.
377F	LAKE SHERWOOD ESTATES	SP AP	102A C4	34-08-26	118-52-31	960	12.0
379B	SAN GABRIEL-EAST FORK	A	P C4	34-14-09	117-48-18	1800	22.8*
386C	ZUMA CANYON	S	105 F5	34-04-58	118-49-38	1500	18.8
387B	COVINA CITY YARD	SP	86 E5	34-05-02	117-53-57	560	11.7
388D	PARAMOUNT-COUNTY FIRE DEPT.	S.81	65 E3	33-53-50	118-10-02	80	N.A.
390B	MORRIS DAM	SP	P A8	34-10-53	117-52-43	1210	20.0
391C	MONTEBELLO-FIRE DEPARTMENT	S.81	54 E1	34-01-06	118-06-15	250	7.8
394	HIGHLAND PARK	S	36 D1	34-07-06	118-10-38	620	12.3
395B	OLIVE VIEW SANITARIUM	A	2 D1	34-19-28	118-26-55	1425	15.8
402F	CEDAR SPRINGS	A	(189)	34-21-21	117-52-34	6780	20.7
405B	SOLEDAD CANYON	S	188 F8	34-26-23	118-17-33	2150	8.8
406C	WEST AZUSA	S	89 C2	34-06-53	117-54-56	606	12.3
409B	PYRAMID RESERVOIR	SP AP	(184)	34-40-34	118-46-47	2606	5.8
415	SIGNAL HILL-CITY HALL	S A	75 E2	33-47-49	118-10-03	140	8.5
418B	SANTA CLARA RIDGE-MT GLEASON	ST	(196)	34-22-36	118-12-23	6420	18.1*
423C	ANGELES FOREST-ALISO CYN.	A	(190A)	34-24-57	118-05-26	3920	13.7
425B	SAN GABRIEL DAM	S A	P A5	34-12-19	117-51-38	1481	20.8
433C	FAIR OAKS DEBRIS BASIN	A	20 B3	34-12-15	118-08-10	1585	14.8
434	AGOURA	A	100A A5	34-08-06	118-45-06	800	8.2
435	MONTE NIDO	A	108 A6	34-04-41	118-41-35	600	13.8*
438C	HANSEN DAM	AP	8 C2	34-16-06	118-23-58	1110	10.8
442C	MESCAL CREEK	S	(194)	34-29-05	117-44-10	3570	3.8
443B	LATIGO CANYON-BEACH RANCH	S	108 B4	34-05-35	118-46-52	1700	18.0
444F	ROLLING HILLS-BOTANICAL	A	73 B4	33-47-00	118-20-35	400	7.4
446	ALISO CANYON-OAT MOUNTAIN	A	1 A2	34-19-53	118-33-29	2367	12.3*
447C	CARBON CANYON	S	114 E4	34-02-19	118-38-56	50	7.8
449B	EATON WASH DAM	S A	27 E1	34-10-06	118-05-33	860	12.1
453D	DEVILS GATE DAM	A	19 D6	34-10-53	118-10-27	860	16.0*
455B	LANCASTER-STATE HWY STA.	S	160 B6	34-40-57	118-08-02	2385	4.4

ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
458	ZUMA CANYON PATROL STATION	A	112 C8	34-01-10	118-47-46	115	8.4
462B	LOS ANGELES-HILLCREST C.C.	S	42 B3	34-02-54	118-24-06	185	10.0
465C	SEPULVEDA DAM	AP	22 B1	34-10-06	118-28-11	663	7.2
466B	PACOIMA CANYON-DUTCH LOUIE	A	(185)	34-21-07	118-20-38	3220	20.5
477D	SANTA ANITA-SPRING CAMP	A	208 C2	34-12-52	117-58-56	4055	24.40
480B	TEMPLE CITY FIRE STATION	S	36 C2	34-06-31	118-03-28	404	10.70
482	LOS ANGELES-U.S.C.	S	43 F6	34-01-14	118-17-18	208	8.10
488C	WALKER RANCH	A	P E3	34-15-30	117-42-57	3720	22.50
488B	KAGEL CANYON PATROL STATION	S	3 E4	34-17-48	118-22-30	1450	9.0
491D	PACIFIC PALISADES	S	40 C4	34-02-22	118-31-43	293	8.20
492A	CHILAO - STATE HWY STA.	A	N C1	34-19-05	118-00-30	5275	15.4
493D	SAND CANYON-MACMILLAN RANCH	A	128 D3	34-23-17	118-24-50	1806	18.2
497	CLAREMONT-SLAUGHTER	S,S1	81 A1	34-07-35	117-43-55	1350	14.8
498	DARK CANYON TRAIL	A	N C3	34-18-21	118-11-45	2800	23.8
517B	LEWIS RANCH	A	(192A)	34-25-12	117-53-11	4815	8.50
542	FAIRMONT	SP	(148)	34-42-15	118-25-40	3050	8.2
560A	LA VERNE HEIGHTS	S	90 E2	34-06-48	117-45-02	1210	14.4
564C	LLANO	S	188 J8	34-29-13	117-50-02	3380	4.1
568D	MT. LOWE	ST	20 D1	34-13-37	118-06-33	4435	22.80
591B	SANTA ANITA RESERVOIR	SP	20 E5	34-11-06	118-06-18	1205	12.7
596C	NEENACH-ERSTAD	S	(143)	34-46-28	118-35-55	3082	4.8
598D	NEENACH-CHECK 43	SP	(143)	34-47-40	118-37-15	2968	4.5
610B	PASADENA-CITY HALL	SP	27 A4	34-08-54	118-08-36	864	12.8
612B	PASADENA-CHLORINE PLANT	SP	18 E3	34-12-04	118-09-45	1160	18.0
613C	PASADENA FIRE STATION	SP	27 B5	34-07-15	118-08-06	778	12.4
616	SAN ANTONIO CANYON	A	P F5	34-12-28	117-40-28	3110	21.3
627	SAN GABRIEL CYN-POWER HOUSE	SP A	86 D3	34-09-20	117-54-28	744	17.8
634C	SANTA MONICA	S	49 A1	34-00-43	118-28-27	84	INC.
662D	LONG BEACH AIRPORT	SP	71 A6	33-49-	118-09-	34	6.4
680B	WESTWOOD (U.C.L.A.)	SP	41 E1	34-04-10	118-26-30	430	10.2
683B	SUNSET RIDGE	S A	19 E4	34-12-53	118-08-47	2110	17.1
694G	BIG TUJUNGA CANYON-CAMP 15	A	N D6	34-17-22	118-17-17	1525	11.7
695B	TUJUNGA CANYON-VOGEL FLAT	S	N B2	34-17-12	118-13-32	1850	14.8
716	LOS ANGELES-DUCOMMUN ST.	SP A AP	44 E3	34-03-09	118-14-13	306	8.5
722C	BELLEVIEW	S	171 B3	34-37-23	118-13-55	2880	N.A.
726C	ANGELES CREST GUARD STATION	S	N D4	34-14-01	118-11-04	2300	22.5
734C	L.A. INTERNATIONAL AIRPORT	SP AP	56 C3	33-56-25	118-23-44	105	8.7
735H	BELL CANYON	A	5 D4	34-11-40	118-39-23	885	8.9
740B	SAN DIMAS CANYON-FERN NO.2	AP	P F6	34-11-48	117-41-45	5200	21.20
741	SAN DIMAS CYN-EAST FORK	AP	P E6	34-11-41	117-44-28	2675	23.00

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ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
742C	SAN GABRIEL FIRE DEPARTMENT	SP	37 E3	34-06-11	118-05-56	445	12.1
747	SANDBERG-AIRWAYS STATION	SP AP	(142)	34-44-47	118-43-29	4517	8.2*
749B	BURBANK VALLEY PUMP PLANT	SP AP	17 A5	34-11-11	118-20-54	655	INC.
750B	PALMDALE-F.A.A. AIRPORT	S	172 F8	34-37-20	118-05-00	2528	4.2
755	GRIFFITH PARK-LITTLE CANYON	AP	25 A8	34-07-32	118-16-58	900	DSC.,
757	GRIFFITH PARK-FERN DELL	AP	34 E1	34-07-12	118-18-20	750	DSC.
759B	NICHOLS DEBRIS BASIN	AP	33 F2	34-08-10	118-21-23	440	DSC.
762	UPPER STONE CANYON	AP	22 D8	34-07-27	118-27-18	843	DSC.
767	MANDEVILLE CANYON ROAD	AP	30 F2	34-06-24	118-30-10	1100	DSC.
771B	PACIFIC PALISADES	S	40 F3	34-03-03	118-29-58	315	8.5*
772	LOS ANGELES-ECHO PARK	AP	35 C5	34-05-02	118-15-11	475	DSC.
784	LOWER FRANKLIN RESERVOIR	SP	33 B4	34-05-43	118-24-40	585	10.3
785	PASADENA	SP	27 F4	34-08-52	118-08-14		12.1
786	ELYSIAN PARK	AP	35 E5	34-04-55	118-14-22	787	DSC.
787	DE SOTO RESERVOIR	SP	8 D1	34-16-17	118-35-12	1127	11.8
801B	MAGIC MOUNTAIN	AP	(185)	34-23-18	118-18-27	4720	18.1
802C	EAGLE ROCK RESERVOIR	SP	26 C4	34-08-47	118-11-20	970	13.6
807	ASCOT RESERVOIR	SP AP	38 C5	34-04-48	118-11-14	820	10.6
1005B	MINT CANYON FIRE STATION	S	(180)	34-30-35	118-21-40	2300	5.8
1006	SAN PEDRO-CITY RESERVOIR	SP A	78 F2	33-44-37	118-17-47	180	7.7
1008	LA FRESA-S.C.E. SUBSTATION	S A	63 C6	33-52-07	118-19-55	85	8.8
1011B	PALOS VERDES FIRE STATION	S	78 A1	33-45-25	118-21-11	1275	8.8
1012B	CASTAIC JUNCTION	S A	123 E8	34-26-18	118-36-43	1005	10.4
1014F	RIO HONDO SPREADING GROUNDS	A	54 E3	33-58-57	118-08-04	170	8.1
1017B	LITTLE ROCK CREEK ABOVE DAM	A	(181)	34-28-41	118-01-24	3280	7.0*
1018	SANTA SUSANA MTS-SALT CYN	ST	128 A8	34-21-24	118-38-42	2850	N.A.
1020B	PADUA HILLS PATROL STATION	S	96 D4	34-08-52	117-41-55	1800	14.8
1025	MALIBU BEACH-DUNNE	S	113 E5	34-02-00	118-42-42	180	8.1
1029C	TUJUNGA-MILL CREEK SUMMIT	S AP	(187)	34-23-22	118-04-48	4980	14.8
1030	MT ISLIP-LITTLE JIMMY CAMP	ST	(200)	34-20-50	117-49-57	7520	17.5*
1031B	MOUNT WATERMAN	ST	(198)	34-20-23	117-56-21	7980	18.0*
1037	ARCADIA-ARBORETUM	S	28 C4	34-08-48	118-02-58	565	10.8
1038S	PACIFICO MOUNTAIN	ST	(186)	34-22-40	118-01-44	6880	15.5*
1040	POTRERO CYN-SUNRAY DX OIL CO	S	126 C2	34-23-50	118-38-18	1150	8.2
1041B	SANTA FE DAM	S.S1 AP	39 D1	34-07-04	117-58-24	427	10.4
1046B	SANTA ANITA CYN-CHANTRY FLAT	S	20A F1	34-11-48	118-01-20	2175	25.4
1050F	OLD TOPANGA CANYON	S	108 F3	34-06-24	118-37-43	1000	13.5*
1051B	CANOGA PARK-PIERCE COLLEGE	SP	12 E5	34-10-51	118-34-23	800	7.2*
1052	CAMP JOSEPHO	S	30 D5	34-04-51	118-31-10	880	11.0*
1058B	PALMDALE	SP AP	172 E7	34-35-17	118-05-31	2585	4.1

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ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
1059B	SOUTH MT. HAWKINS	ST	P B1	34-18-46	117-48-32	7700	18.5*
1060B	LITTLE ROCK-SYCAMORE CAMP	A	(191)	34-25-02	117-58-13	4000	8.0*
1062	BUCKHORN FLAT	A	(199)	34-20-44	117-55-06	6760	18.0*
1063	SOLEDAD PASS	S	199 E9	34-29-35	118-05-28	3520	7.0
1068	RATTLESNAKE CYN-CAMP NO.13	S	105 C5	34-05-00	118-51-55	1260	13.0*
1070	MANHATTAN BEACH	S	82 D4	33-53-00	118-23-18	182	INC.
1071B	DESCANSO GARDENS	S	19 B2	34-12-07	118-12-48	1325	13.8
1072B	LITTLE TUJUNGA RANGER STA	SP A	3 F5	34-17-37	118-21-38	1278	13.5
1074	LITTLE GLEASON	A	(187)	34-22-43	118-08-57	5600	12.0*
1075	UPPER WOLFSKILL	AP	96 B2	34-10-13	117-43-18	3825	18.5*
1076B	MONTE CRISTO RANGER STATION	SP	M E1	34-18-42	118-07-20	3360	12.2
1077B	MONROVIA-FIVE POINTS	S	28 B1	34-09-58	117-58-37	862	18.0
1078	COVINA	A	83 C1	34-04-10	117-50-47	575	14.3
1080B	BRADBURY DEBRIS BASIN	A	29 E3	34-09-23	117-57-58	835	17.4
1081B	GLENDALE-GREGG	SP AP	18 D4	34-11-48	118-14-30	1350	14.0
1087	GREEN-VERDUGO PUMPING PLANT	S	10 B3	34-15-25	118-20-11	1340	8.8
1088B	LA HABRA HEIGHTS	S A	84 E2	33-58-58	117-57-51	445	8.8
1090	LOS ALAMITOS	SP	81 B6	33-48-35	118-04-38	25	4.8
1092B	BUENA PARK	S*P	OC10 C1	33-51-28	117-58-29	80	8.0
1093	FULLERTON AIRPORT	SP AP	83 D5	33-52-23	117-58-24	100	N.A.
1095	ORANGE COUNTY RESERVOIR	SP AP	OC 2 F4	33-56-07	117-52-58	600	10.8
1104	BOUQUET CANYON AT TEXAS CYN	S	(180)	34-30-35	118-27-00	1700	8.2*
1107D	LA TUNA DEBRIS BASIN	A	10 C5	34-14-13	118-18-37	1100	12.3
1109	MT. BALDY	ST	S.B.CO.	34-18-53	117-37-00	8650	N.A.
1111C	DEVILS PUNCHBOWL	S	(182A)	34-24-48	117-51-28	4700	8.0*
1113	DOMINGUEZ WATER CO.	A	69 F4	33-48-54	118-13-30	30	7.1
1114B	WHITTIER NARROWS DAM	AP	47 A6	34-01-29	118-05-02	238	8.8
1115	SAN ANTONIO DAM	AP SP	86 F3	34-09-24	117-40-20	2120	18.3
1119B	ATMORE MEADOW	ST	(155)	34-41-18	118-36-18	4325	13.0*
1120	DAWSON SADDLE	ST	(200)	34-22-06	117-48-10	7900	12.8*
1126A	LOS ANGELES-EAST VALLEY	S.S1	16 B3	34-12-30	118-24-35	780	8.2
1127	WEST BURBANK	S	17 B6	34-10-47	118-20-07	818	8.4
1128	WRIGHTWOOD FIRE DEPARTMENT	SP	S.B.CO.	34-21-34	117-37-57	5980	8.5
1129B	NICHOLAS CANYON	S	110 D3	34-02-52	118-54-57	340	8.1
1132	OAK FLAT GUARD STATION	S	(188)	34-35-58	118-43-15	2800	10.3
1133	FISH CANYON	ST	N D5	34-12-23	117-56-43	2600	22.2*
1135B	LUNADA BAY	SP	72 A4	33-46-37	118-25-01	250	INC.
1138	MOUNT DISAPPOINTMENT	A	M F4	34-14-42	118-06-07	5725	20.8
1140	ROSEMEAD	S.S1	38 B5	34-04-53	118-03-55	305	10.2
1147	EL CABALLERO COUNTRY CLUB	S	21 C4	34-08-52	118-31-53	1000	10.0*

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ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
1152	CLEAR CREEK RANGER STATION	S	N D3	34-16-15	118-09-11	3625	18.0
1157	NORTHRIDGE - C.S.U.	SP AP	7 C5	34-14-17	118-31-48	890	10.3*
1158	TORRANCE MUNICIPAL AIRPORT	S	73 B2	33-47-59	118-20-08	102	7.8
1160	SAN GABRIEL CANYON-WEST FORK	A	N B4	34-15-02	118-01-30	3200	24.2*
1162	IRON MOUNTAIN	ST	(198)	34-21-06	118-13-48	5320	18.5*
1166B	MILE HIGH RANCH	S	(193)	34-24-40	117-48-15	5200	8.8
1167	FENNER CANYON	S	(200)	34-23-25	117-48-27	5380	8.5*
1169B	PIRU-TEMESCAL GUARD STATION	SP	V.CO.	34-28-22	118-45-21	1150	12.1
1170B	THOUSAND OAKS WEATHER STA	AP	V.CO.	34-10-44	118-51-01	805	8.1
1171B	CAMULOS RANCH	SP AP	V.CO.	34-24-22	118-45-21	725	10.8
1172B	PIRU CANYON ABOVE PIRU LAKE	AP	(177)	34-30-48	118-48-24	1120	8.1
1173B	TAPO CANYON	AP	V.CO.	34-19-54	118-42-39	1825	13.0
1177B	SARD RESERVOIR	AP	V.CO.	34-14-32	118-40-41	1010	8.9
1183B	LA HABRA FIRE STATION	S P	84 F4	33-55-53	117-57-17	315	7.8
1190	PACOIMA CANYON-NORTH FORK	S A	(185)	34-23-17	118-15-08	4180	13.8
1191	BEAR DIVIDE	S	128 F6	34-21-38	118-23-37	2700	22.2
1192	CARSON FIRE STATION	S.S1	64 C6	33-52-04	118-15-48	52	10.8
1193	WESTLAKE VILLAGE	S	102 A5	34-08-19	118-48-05	865	8.1
1194	SANTA YNEZ RESERVOIR	S	109 F8	34-04-23	118-33-58	735	14.3
1195	CHINO FIRE STATION NO.2	SP	S.B.CO.	33-59-00	117-43-20	655	INC.
1196	MONTCLAIR FIRE DEPARTMENT	SP	65 E2	34-03-41	117-41-18	908	11.4
1197	CAJON WEST SUMMIT	SP	S.B.CO.	34-23-30	117-34-35	4630	7.8
1198	PHELAN FIRE CONTROL	SP	S.B.CO.	34-25-30	117-34-00	4180	1.8
1199	CLOUDCROFT DEBRIS BASIN	A	115 F3	34-02-58	118-34-12	350	8.8
1202	CAMP CISQUITO	S	157A D4	34- -	118-40-03	1135	N.A.
1203	LITTLE TUJUNGA-ALDER CREEK	ST	(185)	34-20-03	118-18-50	2825	18.5*
1205	MOODY SPRING	ST	(178)	34-38-04	117-40-23	2915	2.9*
1206	MUROC	ST	(136)	34-48-26	117-55-03	2310	2.0*
1207	ROSAMOND	ST	147 F1	34-48-14	118-11-35	2340	2.0*
1209	SAN JOSE CHANNEL	S.S1	47 F4	34-01-55	118-08-39	278	INC.
1210	NEENACH	ST	146 H4	34-48-42	118-15-48	2413	3.3*
1211	HACIENDA GOLF CLUB	S	98A A1	33-57-40	117-56-57	750	10.7
1212	LANCASTER FSS/FAA	SP	147 C9	34-44-00	118-13-00	2340	4.1
1214	ENCINAL CANYON-FIRE STATION	A	111 B4	34-02-52	118-52-07	175	8.1
1215	SANTA MONICA MTS-KILPATRICK	A	105 F4	34-06-45	118-49-52	1775	14.9*
1216	RANCHO PALOS VERDES	S	77 C1	33-45-10	118-23-32	780	7.3
1217	LOS ANGELES COUNTRY CLUB	S	42 A1	34-04-10	118-25-17	300	10.4
1222	NORTHRIDGE-GARLAND	S.S1	7 E3	34-14-	118-30-		10.8
1223	WOODLAND HILLS-SHERMAN	S.S1	100 E1	34-10-06	118-38-57	1035	7.8
1225	REDONDO BEACH-LACDPW YARD	S	67 D1	33-51-	118-23-		INC.

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ACTIVE RAINFALL STATIONS 1988 - 1989

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
1238	ACTON-MEARNS	S	189 G2	34-27-05	118-12-50		11.0*
1239	MALIBU-BIG ROCK MESA	A	115 A4	34-02-34	118-37-18	725	8.4
1240	PEARBLOSSOM-CALIF.D.W.R.	SP AP	185 B7	34-30-32	117-55-15	3050	4.5
1242	ROCKY BUTTES	A	(182)	34-39-00	117-51-48	2540	2.1
1243	REDMAN	A	(150)	34-45-52	117-55-30	2380	2.6
1244	LANCASTER-ROPER	A	161 C6	34-40-27	118-00-37	2450	3.0*
1245	QUARTZ HILL-HALL	A	159 B7	34-40-28	118-14-40	2385	3.9
1246	SCOTT RANCH	A	(149)	34-46-59	118-28-10	2710	3.4
1247	NORTH LANCASTER	A	146 D6	34-45-41	118-07-30	2310	2.4
1248	MESCAL-SMITH	A	(194)	34-29-03	117-42-40	3810	3.9*
1249	RELAY	A	(150)	34-45-43	117-47-55	3140	2.5
1250	AVEK	A	185 B5	34-32-21	117-56-23	2825	3.9*
1251	PALOS VERDES-WHITES POINT	SP	78 D6	33-42-50	118-18-02	100	8.9
1252	PALOS VERDES LANDFILL	SP	73 A4	33-45-40	118-20-03	400	5.4
1253	CARSON-COUNTY SANITATION	SP	74 A2	33-48-07	118-18-58	40	6.5
1254	LONG BEACH RECLAMATION PLANT	SP	78 F1	33-48-11	118-05-20	20	5.1
1255	LOS COYOTES REC. PLANT	SP	66 E4	33-53-05	118-06-24	70	6.5
1256	SOUTH GATE TRANSFER STATION	SP	59 E3	33-58-40	118-09-56	100	5.2
1257	SAN JOSE CRK REC. PLANT	SP	47 F4	34-01-55	118-01-19	275	6.9
1258	PUENTE HILLS LANDFILL	SP	47 E5	34-01-35	118-01-48	300	6.5
1259	WHITTIER NARROWS REC. PLANT	SP	47 B1	34-03-59	118-03-54	225	6.0
1260	SPADRA LANDFILL	SP	83 E4	34-02-38	117-49-50	700	6.7
1261	LA CANADA RECLAMATION PLANT	SP	19 D2	34-13-00	118-11-14	1800	13.3
1262	SAUGUS RECLAMATION PLANT	SP	124 B8	34-24-48	118-32-23	1180	8.2
1263	VALENCIA RECLAMATION PLANT	SP	123 D7	34-25-55	118-37-13	1000	8.0
1264	CALABASAS LANDFILL	SP	100A E3	34-08-25	118-42-35	800	4.2
1265	SCHOLL CANYON LANDFILL	SP	20 C4	34-08-38	118-11-07	1000	7.1
1266	MISSION CANYON LANDFILL	SP	22 B6	34-08-40	118-28-45	1150	5.6
1267	LANCASTER RECLAMATION PLANT	SP	147 H4	34-40-38	118-09-11	2302	1.7
1268	PALMDALE RECLAMATION PLANT	SP	172 G6	34-35-30	118-05-10	2585	3.1
1271	POMONA WASTE REC. PLANT	SP	94 B3	34-03-18	117-47-34		10.1
X150	HI VISTA	S	(151)	34-44-31	117-48-43	3087	INC.
X22	ISLIP SADDLE	ST	(199)	34-21-27	117-51-08	6680	N.A.
X23	DORR CANYON	ST	(200)	34-22-18	117-48-51	7280	10.9*
X24	GRASSY HOLLOW	ST	(201)	34-22-30	117-43-05	7380	9.0*
X25	BEAR GULCH	ST	(201)	34-21-58	117-41-27	7880	10.0*
X26	BLUE RIDGE CAMP	ST	(201)	34-20-57	117-40-23	6450	N.A.
X27	GUFFY'S CAMP	ST	(201)	34-20-20	117-38-55	8080	15.0*

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ACTIVE RAINFALL STATIONS 1988 - 1989

LEGEND REGARDING GAGE TYPE, OWNERSHIP, AND SEASONAL TOTAL:

S	STANDARD 8 INCH DIAMETER NON RECORDING GAGE OWNED BY THE DEPARTMENT OF PUBLIC WORKS
8.81	8.81 INCH DIAMETER NON RECORDING GAGE OWNED BY THE DEPARTMENT OF PUBLIC WORKS
A	AUTOMATIC RECORDING GAGE OWNED BY THE DEPARTMENT OF PUBLIC WORKS
ST	STORAGE TYPE GAGE OWNED BY THE DEPARTMENT OF PUBLIC WORKS
SP	STANDARD 8 INCH DIAMETER NON RECORDING GAGE OWNED BY OUTSIDE INTEREST
AP	AUTOMATIC RECORDING GAGE OWNED BY OUTSIDE INTEREST
3 P	3 INCH DIAMETER NON RECORDING GAGE OWNED BY OUTSIDE INTEREST
( )	THOMAS GUIDE FUTURE PAGE
O.CO.	ORANGE COUNTY THOMAS GUIDE PAGE
V.CO.	VENTURA COUNTY THOMAS GUIDE PAGE
S.B.CO.	SAN BERNARDENO COUNTY THOMAS GUIDE PAGE
DSC.	DISCONTINUED
INC.	INCOMPLETE TOTAL
*	ESTIMATED SEASONAL TOTAL

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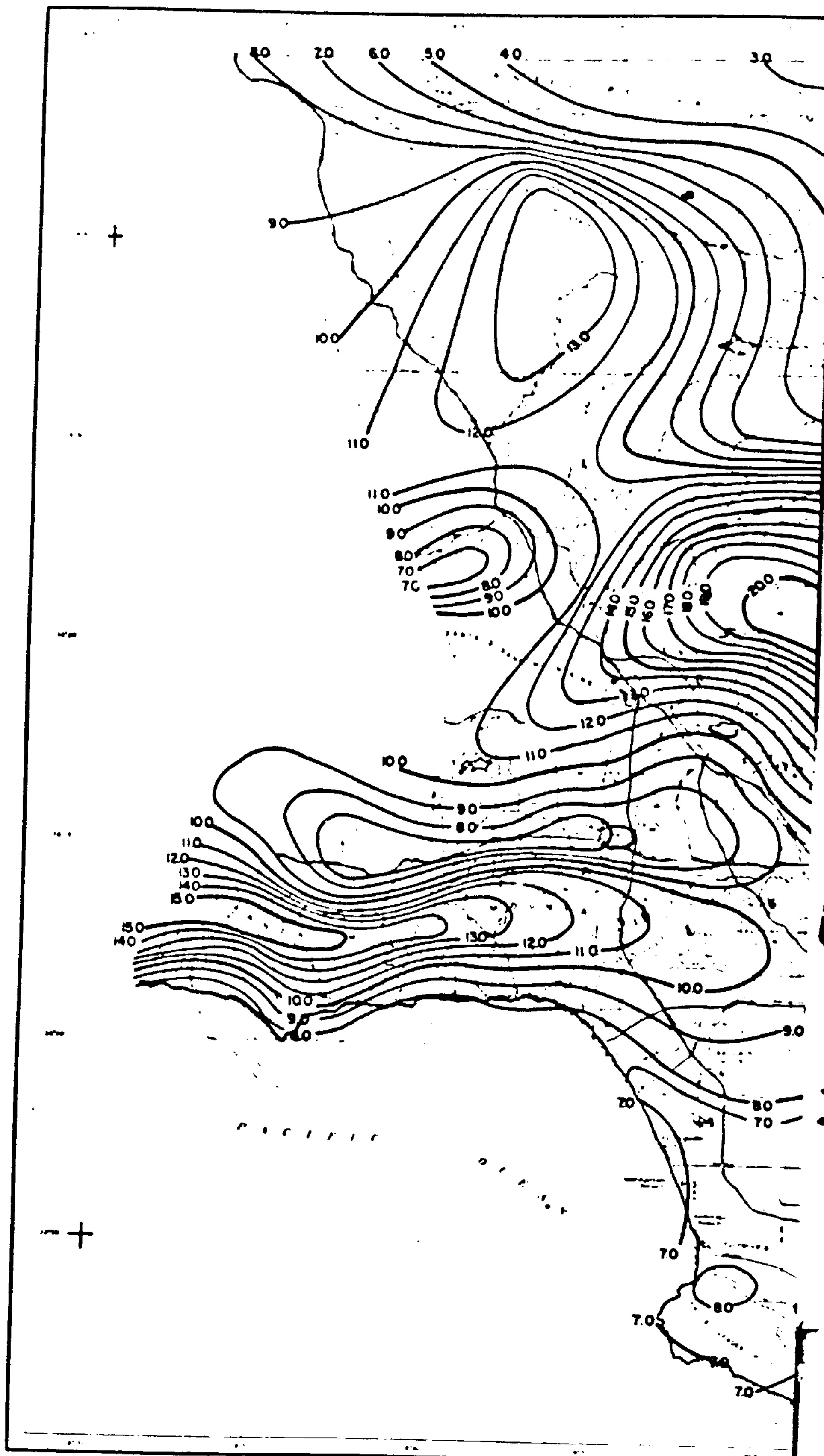

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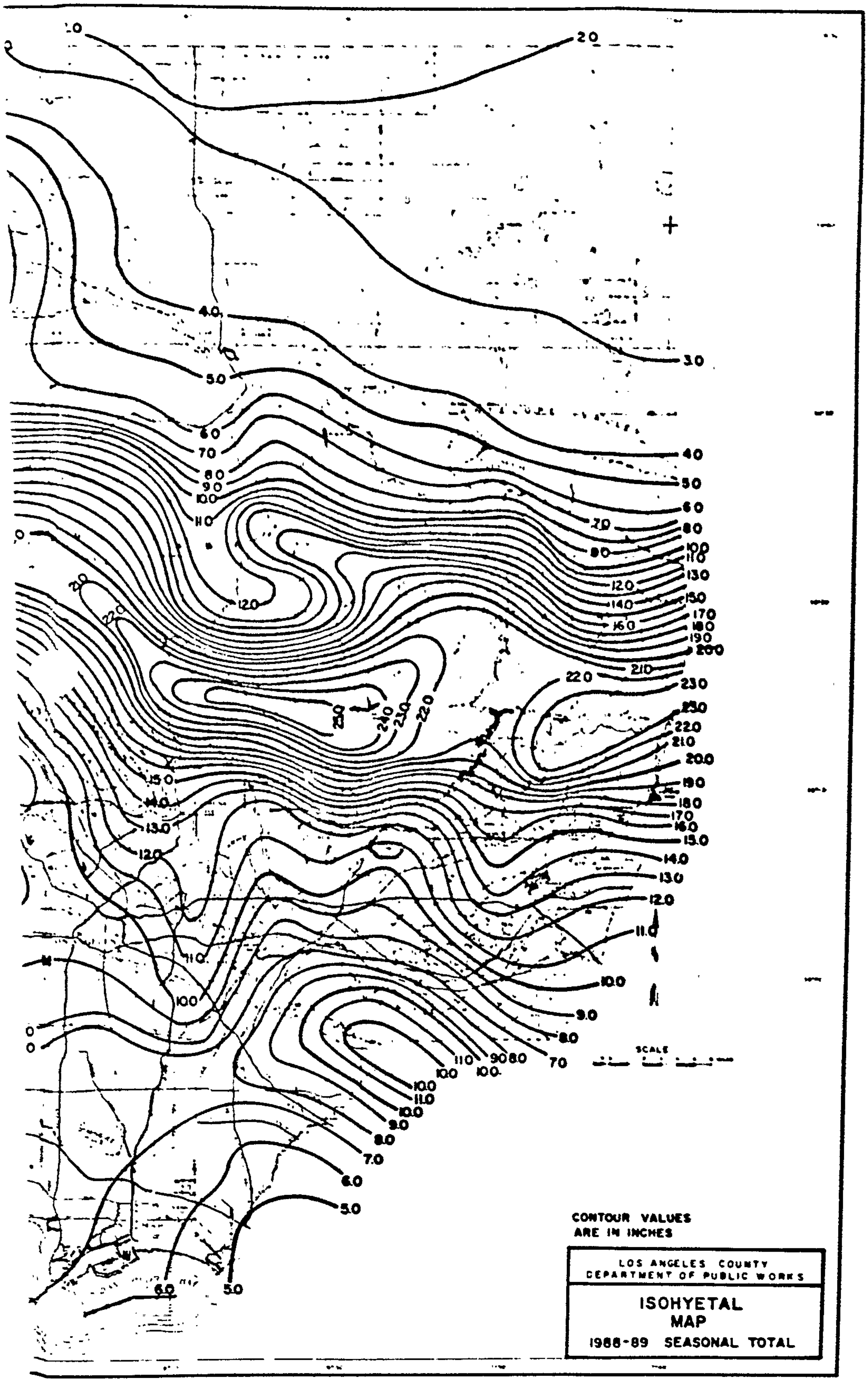

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EVAPORATION

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EVAPORATION

Data for 14 active evaporation stations were reported to the Department during the 1988-89 water year. Daily records of active and inactive Department stations, as well as some stations of other agencies, are available in the Department's files. Monthly and seasonal evaporation has been published in the Department's Annual or Biennial Reports on Hydrologic Data since the 1931-32 season.

COOPERATION

The Department receives evaporation data from The Metropolitan Water District, Palmdale Water District, California Department of Water Resources, and Descanso Gardens.

LENGTH OF RECORD

The first land pan installed by this Department was at Santa Anita Dam in March of 1929. There are 30 evaporation stations which have records of 15 seasons or more in the Department's files.

EVAPORATION STATION LIST 1988 - 89

STA. NO.	STATION NAME	EQUIPMENT	ELEVATION OF PAN	THOMAS GUIDE	NORTH LATITUDE	WEST LONGITUDE
33 A	Pacoima Dam	24X36 S	1500 ft.	145 F9	34-19-48	118-23-59
46 D	Big Tujunga Dam	24X36 S	2315 ft.	F C2	34-17-40	118-11-14
63 C3	Santa Anita Dam	24X36 S	1400 ft.	99 F2	34-11-03	118-01-12
89 B	San Dimas Dam	24X36 S	1350 ft.	95A C3	34-09-10	117-46-17
96 C	Puddingstone Dam	24X36 S	1030 ft.	89 F4	34-05-31	117-48-24
223 B	Big Dalton Dam	24X36 S	1587 ft.	87 F1	34-10-06	117-48-36
252 C	Castaic Reservoir	48X10 S	1150 ft.	(178)	34-29-53	118-36-53
334 B	Cogswell Dam	24X36 S	2300 ft.	G D4	34-14-37	117-57-35
390 B	Morris Dam	72X36 US	1210 ft.	86 F1	34-10-53	117-52-43
409 B	Pyramid Reservoir	48X10 S	2505 ft.	(154)	34-40-34	118-46-47
425 B	San Gabriel Dam	24X36 S	1481 ft.	H A5	34-12-19	117-51-38
1014 F	Rio Hondo S. G.	24X36 S	170 ft.	54 D3	33-59-57	118-06-04
1058 B	Palmdale	24X36 S	2595 ft.	172 F7	34-35-17	118-05-31
1071 B	Descanso Gardens	24X36 S	1325 ft.	19 B3	34-12-07	118-12-46

LEGEND

24X36 S = Screened land pan, 24 inches in diameter by 36 inches deep.
48X10 S = Screened land pan, 48 inches in diameter by 10 inches deep.
72X36 US = Unscreened land pan, 72 inches in diameter by 36 inches deep.
( ) = Thomas Guide future page assignment.

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MONTHLY EVAPORATION SUMMARY FOR WATER YEAR 1988 - 89 (inches)

STA. NO.	STATION NAME	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL
33 A	Pacoima Dam	6.60	5.81	6.21	6.20	4.21	5.84	7.71	6.25	6.98	9.59	8.61	10.17	84.18
46 D	Big Tujunga Dam	7.10	4.10	4.20	3.69	3.78	5.36	8.22	7.92	9.76	12.57	11.62	9.70	88.02
63 D	Santa Anita Dam	4.22	2.74	3.91	2.83	1.90	2.89	4.07	3.37	4.55	6.04	5.97	5.98	48.47
89 B	San Dimas Dam	3.81	2.22	2.54	2.00	1.96	2.88	4.81	5.23	6.13	8.53	7.42	6.59	54.12
96 C	Puddingstone Dam	5.13	2.97	3.00	2.53	3.00	3.97	6.55	7.08	8.04	10.79	9.06	7.93	70.05
223 B	Big Dalton Dam	3.71	2.18	3.18	1.62	1.43	2.63	4.55	5.24	6.65	8.72	7.44	7.41	54.76
252 C	Castaic Reservoir	6.68	4.58	N/A	N/A	2.10	3.38	5.59	5.98	6.07	8.77	7.72	7.66	N/A
334 B	Cogswell Dam	4.79	2.41	1.76	1.72	1.41	2.75	4.59	5.27	7.40	9.73	8.48	6.25	56.56
390 B	Morris Dam	6.44	3.70	7.96	5.32	3.12	5.65	7.46	7.70	8.81	11.42	10.16	9.77	87.51
409 B	Pyramid Reservoir	6.86	5.54	6.29	1.35	1.16	5.97	5.27	6.51	9.00	9.88	8.51	7.62	73.96
425 H	San Gabriel Dam	6.14	3.73	3.97	3.04	2.73	4.26	5.93	6.08	7.17	9.72	8.78	8.62	70.17
1014 F	Rio Hondo S. G.	3.90	2.93	2.13	2.50	1.88	3.42	4.58	5.33	5.85	7.14	6.59	4.68	50.93
1058 H	Palmdale	3.88	2.06	1.80	1.56	1.77	5.59	6.15	7.69	9.03	10.25	8.05	5.60	63.43
1071 B	Descanso Gardens	3.66	2.97	2.45	1.68	1.39	2.91	3.91	4.62	5.24	7.01	6.79	5.61	48.34

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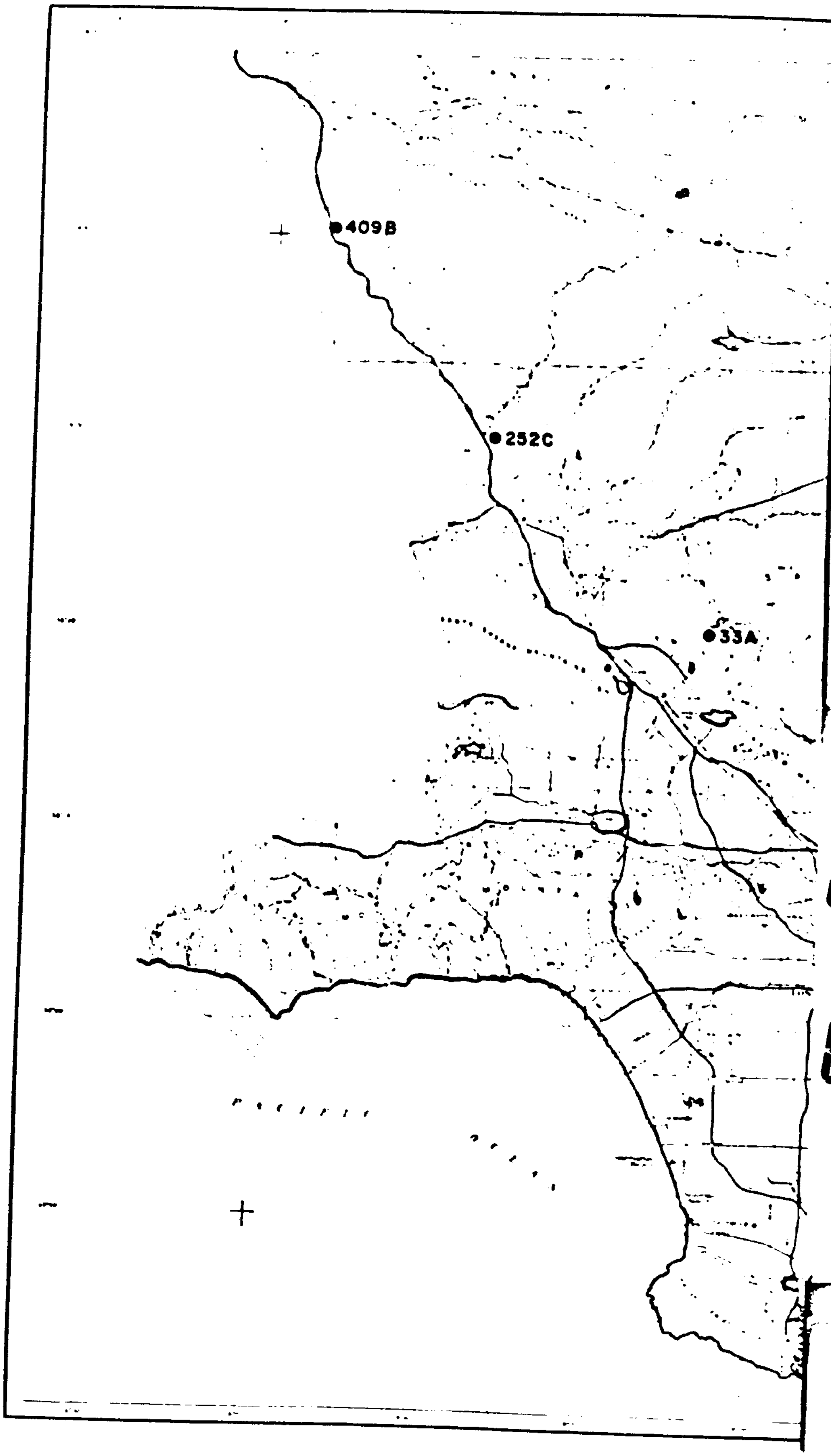

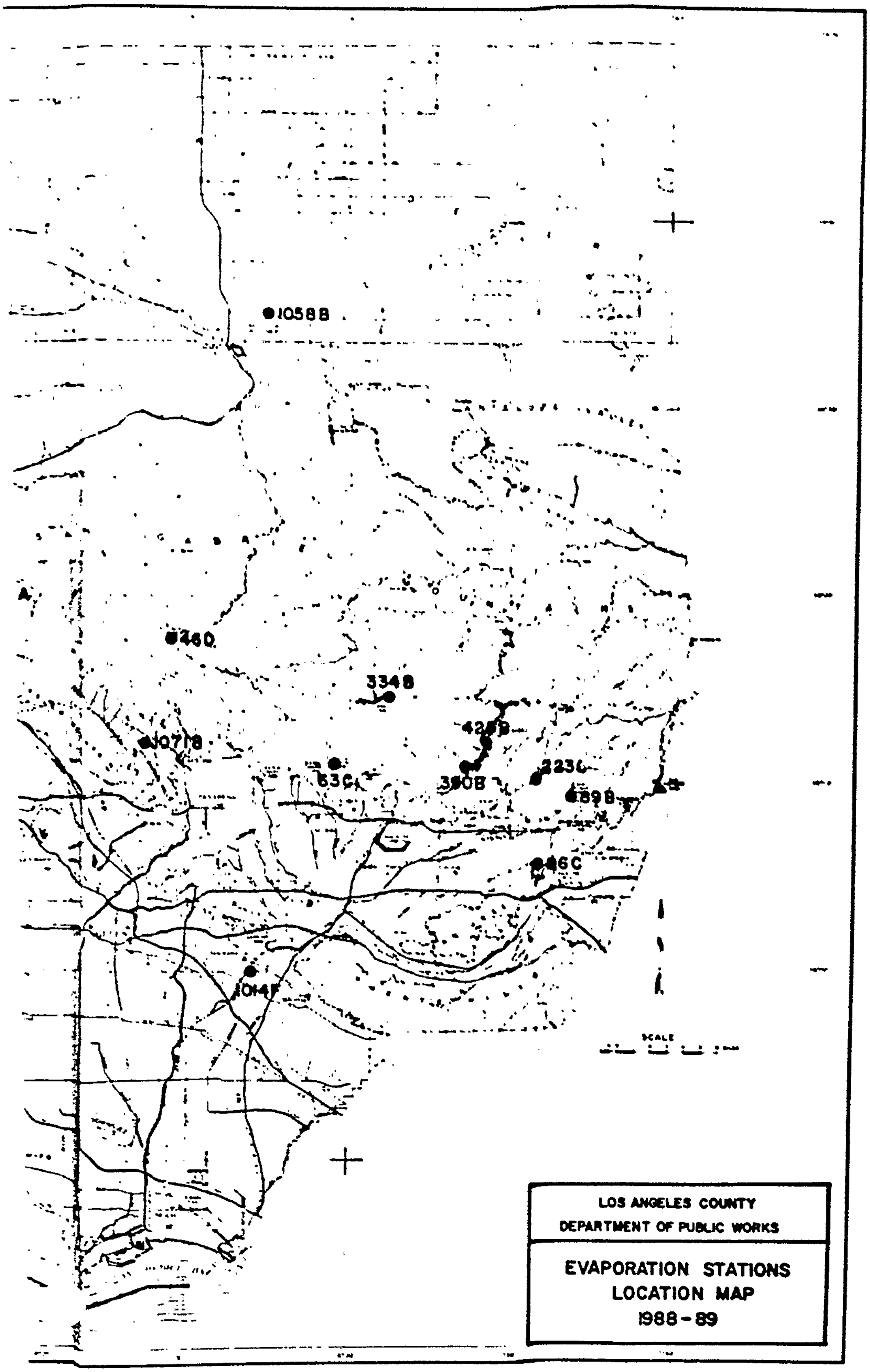

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VOL 12

1 9680

RUNOFF

R0052985

RUNOFF

The Department operated or received data from 81 water-stage recording stations during the 1988-89 water year. Data from 51 of those stations are summarized and published in this volume.

RECORDS OF STREAMFLOW

Records published give the following information:

1. Station description which presents location, drainage area, type of channel, control, regulations, diversions, and available records.

2. Discharge tabulation which summarizes the maximum, minimum, and mean of the daily flow rates in second-feet for each month and the total monthly volumes in acre-feet.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorological conditions at 27 locations in the County. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels, and which forecast peak flows in the Los Angeles and San Gabriel Rivers and the Rio Hondo Channel.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The Department receives streamflow data from other agencies, or has access to the records for local stations. Department hydrographers also make periodic streamflow measurements and observations at installations belonging to these organizations. Data from 25 of the Department's stations are reviewed and published in the Geological Survey's annual water supply papers.

Agencies with which the Department exchanges data are:

United States Geological Survey, Water Resources Division
United States Corps of Engineers
State Department of Water Resources
The Metropolitan Water District
San Gabriel River Water Committee

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LEGEND

Stations are designated by letters and numbers which indicate ownership, operation agency, and type of station. The letters used have the following connotations:

Prefix F - Indicates a station owned and operated by the Los Angeles County Department of Public Works.

Prefix E - Indicates a station owned and operated by the Corps of Engineers, Department of the Army but operated and maintained by the United States Geological Survey.

Prefix U - Indicates a station originally constructed and operated by the United States Geological Survey, Water Resources Division, now operated by the Department.

Prefix P - Indicates a station owned and operated by the Department formerly, operated by the Pasadena Water Department.

Prefix L - Indicates a station owned and operated by the Department formerly, operated in cooperation with the Little Rock - Palmdale Irrigation District.

Suffix R - Indicates a recorder station.

Suffix B - Indicates that the station has been moved. B represents second location, C a third location, etc.

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INDEX OF STREAM GAGING STATIONS

STATION	NAME	THOMAS GUIDE PG.	ALERT NO.	REGU-LATED	DRAINAGE AREA •
L1-R	LITTLE ROCK CREEK ABOVE LITTLE ROCK DAM	J		NO	49.20
F2B-R	BROWNS CREEK AT VARIEL AVENUE	6 / D - 2		NO	13.50
P3-R	SAN GABRIEL RIVER - WEST FORKS ABOVE FORKS	P / A - 4		YES	102.00
P4B-R	SAN GABRIEL - EAST FORK	P / D - 4		NO	88.20
U5-R	SAWPIT CREEK BELOW MONROVIA CREEK	29 / C - 1		YES	5.30
U7-R	FISH CREEK ABOVE MOUTH OF CANYON	86 / B - 2		NO	6.36
U8-R	SAN GABRIEL RIVER BELOW MORRIS DAM	86 / F - 1	415	YES	212.40
U14-R	BIG ROCK CREEK ABOVE MOUTH OF CANYON	J		NO	23.00
AAS(015)	VALYERMO S. G., BIG ROCK CK. D/S VALYERMO RD	192 / H - 5			
F32B-R	THOMPSON CREEK BELOW THOMPSON CREEK DAM	96 / C - 5	433	YES	3.70
F34D-R	LOS ANGELES RIVER BELOW FIRESTONE BLVD.	59 / E - 3	315	YES	596.00
F37B-R	COMPTON CREEK NEAR GREENLEAF DRIVE	64 / F - 4		NO	22.60
F38C-R	BALLONA CREEK ABOVE SAWTELLE BLVD.	50 / B - 3	369	YES	88.60
F40-R	PUDDINGSTONE CREEK BELOW PUDDINGSTONE DAM	89 / F - 4	427	YES	33.20
F42B-R	SAN GABRIEL RIVER ABOVE SPRING STREET	76 / F - 1	435	YES	231.00
F45B-R	RIO HONDO ABOVE STUART AND GRAY ROAD	59 / E - 3	307	YES	140.00
F53-R	DUME CREEK AT PACIFIC COAST HIGHWAY	110 / B - 4		NO	8.80
F54B-R	TOPANGA CREEK ABOVE MOUTH OF CANYON	109 / C - 4		NO	18.00
F64-R	RIO HONDO ABOVE MISSION BRIDGE	47 / B - 5		YES	115.00
F81D-R	ALHAMBRA WASH NEAR KLINGERMAN STREET	46 / F - 2	347	NO	15.20
F82C-R	RUBIO WASH AT GLENDON WAY	38 / A - 6	353	YES	10.90
F92C-R	SANTA CLARA RIVER AT OLD ROAD BRIDGE	123 / G - 7		YES	410.40
F93B-R	SANTA CLARA RIVER AT LANG RAILROAD BRIDGE	125 / J - 7		NO	157.30
F118B-R	PACOIMA CREEK FLUME BELOW PACOIMA DAM	3 / C - 1	330	YES	28.20
F119C-R	SANTA ANITA CREEK BELOW SANTA ANITA DAM	20A / F - 2	345	YES	10.80
F120B-R	BIG DALTON CREEK BELOW BIG DALTON DAM	87 / F - 2	418	YES	4.80
F122-R	PALLETT CREEK AT VALYERMO HIGHWAY	199 / G - 4		NO	15.80
F125-R	SANTIAGO CREEK ABOVE LITTLE ROCK CREEK	J		NO	11.20
F130B-R	MALIBU CREEK BELOW COLD CREEK	107 / F - 6		YES	104.96
F168-R	BIG TUJUNGA CREEK BELOW BIG TUJUNGA DAM	M / C - 2	333	YES	82.30
F181-R	MONTEBELLO STORM DRAIN OUTLET TO RIO HONDO	54 / E - 3		NO	9.60
F190-R	SAN GABRIEL RIVER AT FOOTHILL BLVD.	86 / A - 5		YES	230.00
F192B-R	RIO HONDO BELOW LOWER AZUSA ROAD	38 / E - 4		YES	40.90
F193B-R	SANTA ANITA WASH AT LONGEN AVENUE	38 / F - 1		YES	18.80
F194B-R	SAWPIT WASH BELOW LIVE OAK AVENUE	39 / A - 2		YES	16.10 •
F202-R	BIG DALTON CREEK AT SIERRA MADRE AVENUE	87 / D - 4		YES	11.00
F209-R	SAN GABRIEL RIVER - W. FORK BELOW COGSWELL DAM	N / D - 4	410	YES	41.00
F218-R	SAN DIMAS WASH BELOW PUDD DIVERSION DAM	95A / C - 5	424	YES	19.90
F220B-R	SAN GABRIEL - AZUSA CONDUIT 10FT WEIR BELOW DAM	P / A - 5		YES	0.00
F250-R	SAN GABRIEL - AZUSA CONDUIT 25FT WEIR BELOW DAM	P / A - 5		YES	202.70
F251-R	SAN GABRIEL W. FORK AT TOE OF COGSWELL DAM	N / D - 4		YES	39.20
F252-R	VERDUGO WASH AT ESTELLE AVENUE	25 / B - 3		YES	26.80
F260C-R	SANTA ANITA WASH BELOW FOOTHILL BLVD.	28 / E - 3		YES	17.20
F261C-R	SAN GABRIEL RIVER BELOW VALLEY BLVD.	48 / A - 2	351	YES	118.00
F262B-R	SAN GABRIEL RIVER ABOVE FLORENCE AVENUE	60 / E - 4		YES	215.80
F263C-R	SAN GABRIEL RIVER BELOW S. G. RIVER PKWY	55 / C - 1		YES	206.30
F267B-R	SIERRA MADRE WASH AT HIGHLAND OAKS AVENUE	28 / E - 3		YES	3.80
F271-R	EATON WASH BELOW EATON WASH DAM	27 / F - 1	342	YES	12.40
F274B-R	DALTON WASH AT MERCED AVENUE	48 / F - 1		YES	35.95
F276-R	THOMPSON CREEK S. G. INTAKE AT TSN CREEK	96 / C - 5		YES	3.70

INDEX OF STREAM GAGING STATIONS

STATION	NAME	THOMAS GUIDE PG.	ALERT NO.	REGU- LATED	DRAINAGE AREA *
F277-R	ARROYO SECO BELOW DEVILS GATE DAM	19 / D - 5	336	YES	32.50
F278-R	SAWPIT CREEK BELOW SAWPIT DAM	29 / C - 1	339	YES	3.30
F279C-R	LOS CERRITOS CHANNEL AT STEARNS STREET	76 / E - 3		NO	25.60
F280-R	SANTA FE DIVERSION CHANNEL BELOW SANTA FE DAM	39 / D - 2		YES	CONTROLLED
F285-R	BURBANK WESTERN STORM DRAIN AT RIVERSIDE DR.	24 / E - 2		YES	25.00
F299-R	LOS ANGELES RIVER AT RADFORD	23 / C - 4			
F300-R	LOS ANGELES RIVER AT TUJUNGA AVE.	23 / D - 4		YES	401.00
F301-R	SAWTELLE-WESTWOOD CHANNEL ABOVE CULVER BLVD	50 / A - 3		YES	22.96
F303-R	SAN DIMAS CREEK BELOW SAN DIMAS DAM	95A / C - 3	421	YES	16.20
F304-R	WALNUT CREEK ABOVE PUENTE AVENUE	48 / D - 1		YES	57.60
F305-R	PACOIMA DIVERSION AT BRANFORD STREET	9 / A - 5		YES	48.80
F312-R	SAN JOSE CHANNEL ABOVE WORKMAN MILL ROAD	47 / F - 5	324	YES	83.40
F313B-R	RIO HONDO BYPASS CHANNEL ABOVE WHITTIER NAR.	47 / B - 5		YES	CONTROLLED
F317-R	ARCADIA WASH BELOW GRAND AVENUE	38 / E - 3	355	YES	8.50
F318-R	EATON WASH AT LOFTUS DRIVE	34 / C - 6		YES	22.80
F319-R	LOS ANGELES RIVER BELOW WARDLOW RIVER RD.	70 / B - 5	313	YES	815.00
E326-R	RIO HONDO BELOW GARVEY AVENUE	47 / B - 2		YES	91.20
F328-R	MINT CANYON CREEK AT FITCH AVENUE	125 / C - 5		NO	26.90
F329-R	BRADBURY CHANNEL BELOW CENTRAL AVENUE	29 / F - 5		YES	3.30
F338-R	RUBIO DIV. CHANNEL BEL. GOOSEBERRY CYN INLET	20 / C - 4		YES	2.10
F342-R	BRANFORD STREET CHANNEL BELOW SHARP AVE.	9 / B - 5		YES	5.01
F350-R	LIMEKILN CREEK ABOVE ALISO CREEK	7 / B - 6		YES	10.30
F354-R	COYOTE CREEK BELOW SPRING STREET	76 / F - 1	437	YES	185.00
F356-R	LIVE OAK CREEK BELOW LIVE OAK DAM	95A / F - 6	430	YES	2.28
F375-R	ALISO CREEK ON BLUM RANCH	109 / H - 6		NO	23.70
F377-R	BOUQUET CANYON CREEK AT URBANDALE AVENUE	124 / F - 5		YES	51.90
F378D-R	DOMINGUEZ CHANNEL AT VERMONT AVENUE	63 / F - 5		NO	37.10
F393-R	LITTLE ROCK AT HIGHWAY 138	184 D - 6		YES	70.00
F394-R	BIG ROCK CREEK UPSTREAM FROM PALLETT CREEK	192 /J - 4		NO	34.30
F395-R	MESCAL CREEK AT MOUTH	J		NO	5.71
G44B-R	SAN GABRIEL RIVER ABOVE WHITTIER NAR. DAM	47 /C - 6		NO	

* NOTE: All drainage areas in square miles.

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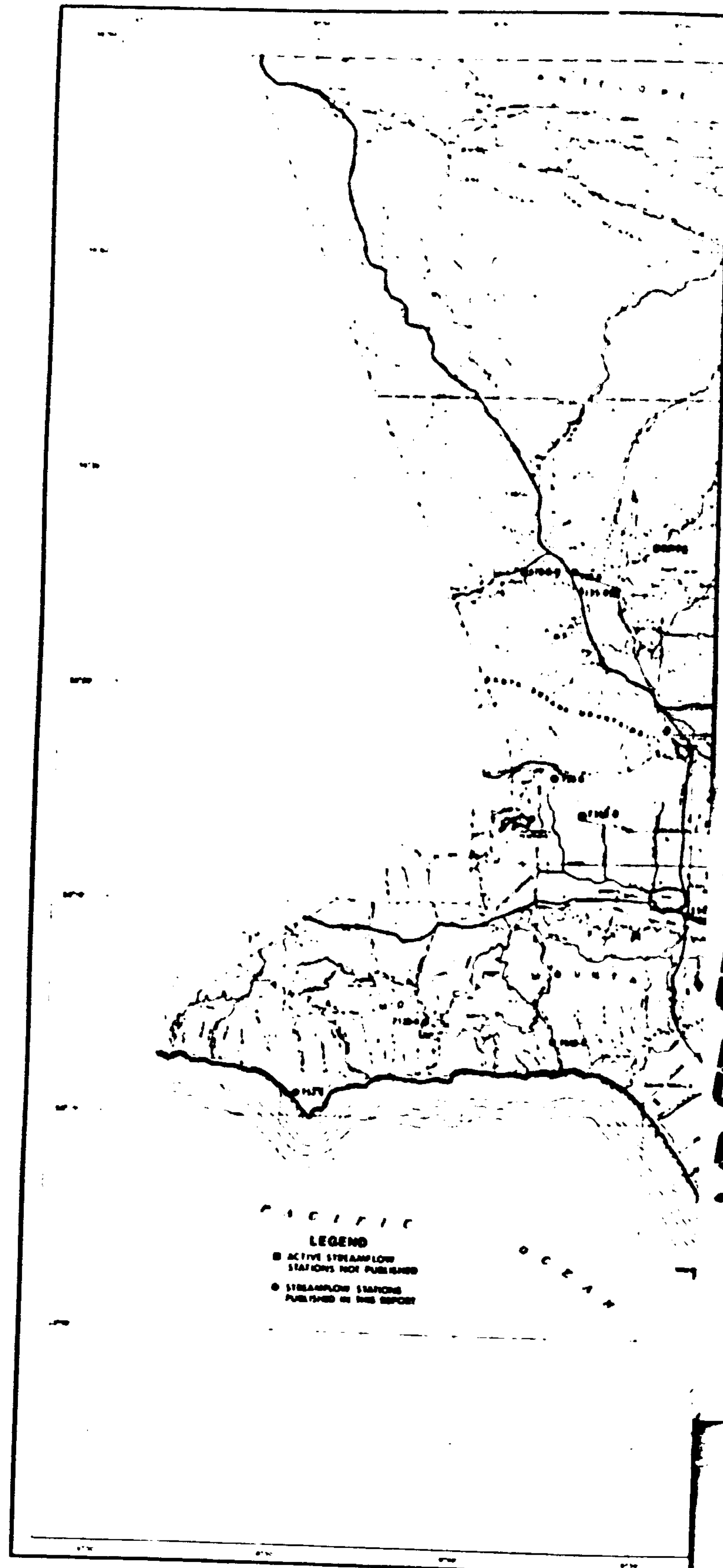
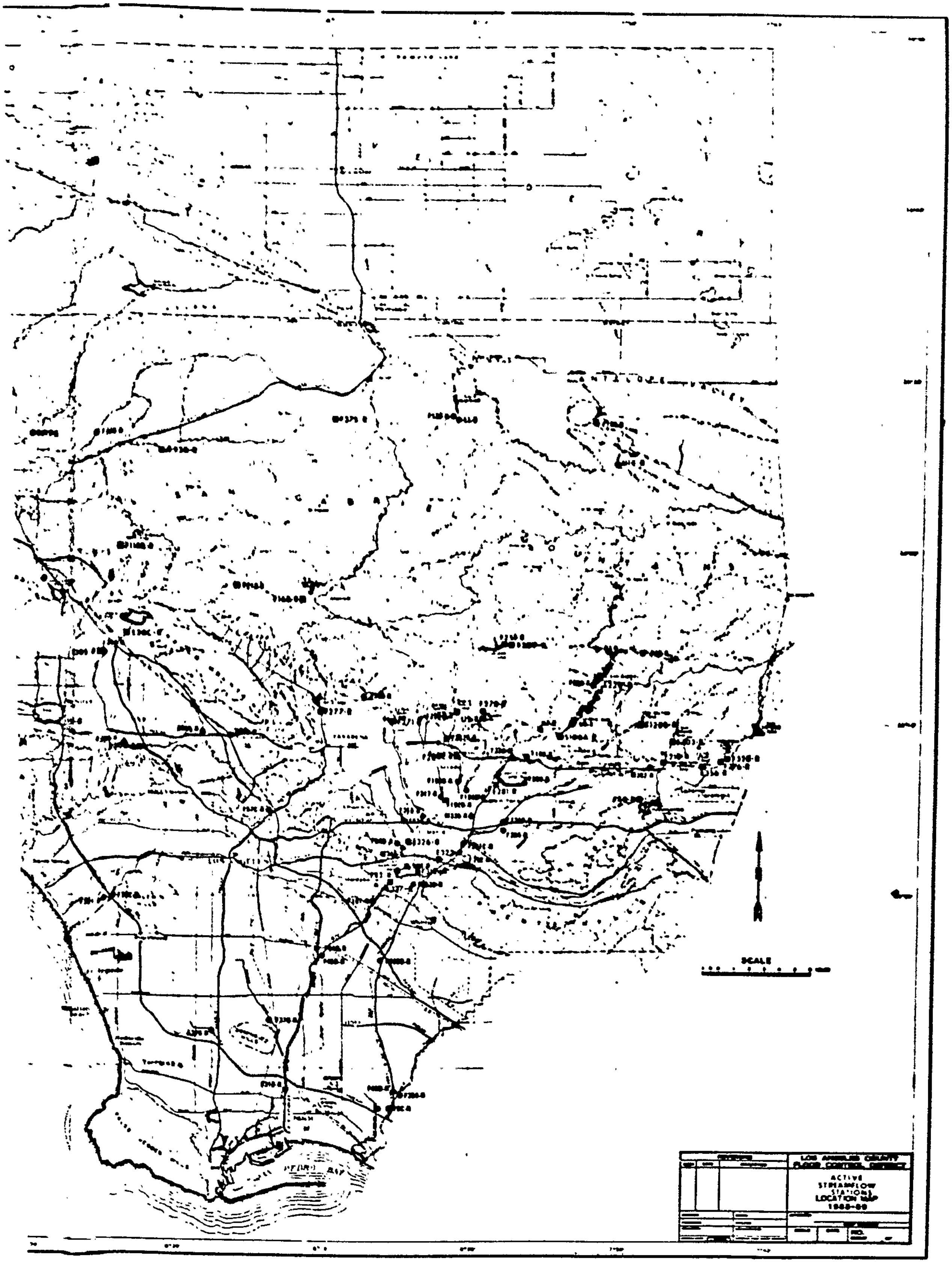
15685


PACIFIC
OCEAN
LEGEND
ACTIVE STREAMFLOW STATIONS NOT PUBLISHED
STREAMFLOW STATIONS PUBLISHED IN THIS REPORT



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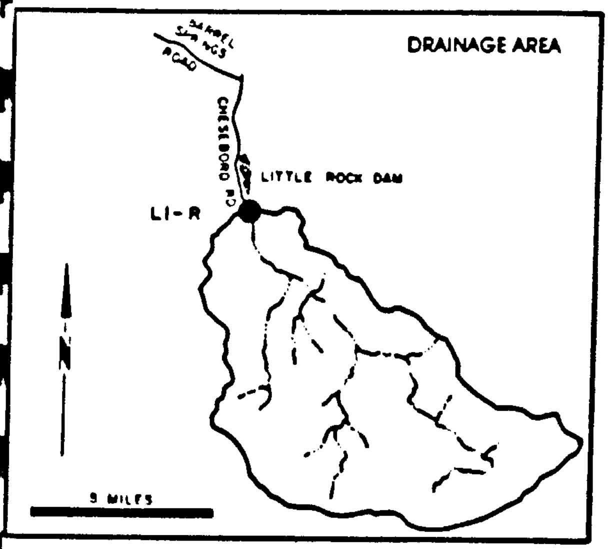
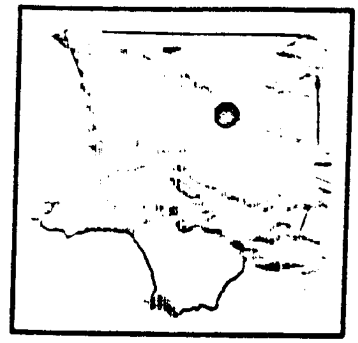
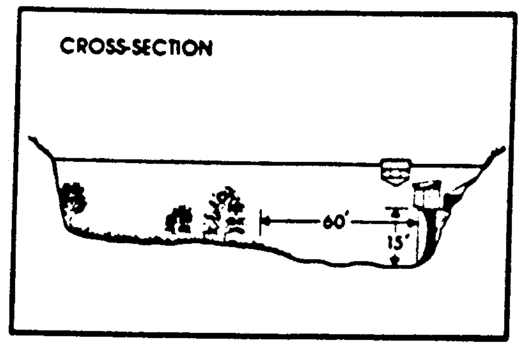
R0052991

LITTLE ROCK CREEK
above Little Rock Dam
STATION NO. L1-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 49.2 square miles.
LOCATION- 2.0 miles above Little Rock Dam, 5.0 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel, and boulders, natural in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1930 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : L1-R — DRAINAGE AREA : 49.20 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	0.0	6.2	12.6	24.6	23.9	7.9	2.9	1.1	0.0	0.0	0.0
	MAX.	0.0	0.0	17.9	15.4	47.8	39.1	16.2	4.2	2.1	0.0	0.0	0.0
	MIN.	0.0	0.0	1.1	10.6	13.5	16.2	3.8	1.9	0.9	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	385.0	773.0	[illegible]	1467.0	471.0	177.0	65.4	0.0	0.0	0.0

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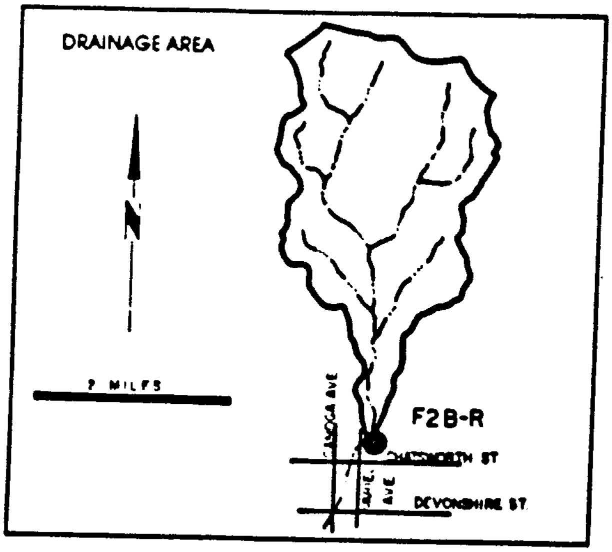
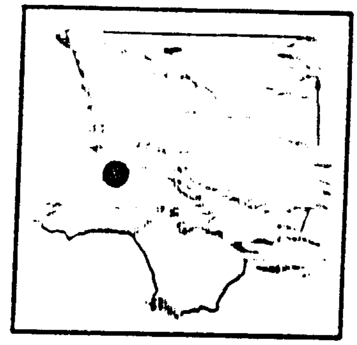
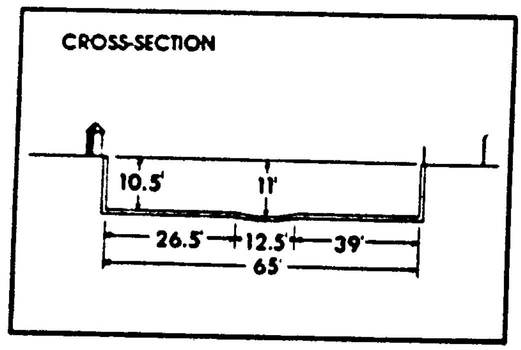
19687

BROWNS CREEK
at Variel Avenue
STATION NO. F2B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 13.5 square miles.
LOCATION- 100.0 feet upstream from Variel Avenue, 1.0 mile northeast of Chatsworth.
REGULATION- none.
CHANNEL- sand and gravel with pipe and wire revetments, temporarily improved section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F2-R, December 11, 1928, to August 27, 1932 and October 2, 1935, to October 31, 1939. at Station F2B-R, October 12, 1961, to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F2B-R

DRAINAGE AREA : 13.50 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.3	0.3	1.4	0.8	1.9	0.9	0.2	0.1	0.0	0.0	0.0	.01
	MAX.	.03	.09	10.5	1.84	7.1	1.8	0.8	0.3	0.0	0.0	0.0	0.2
	MIN.	.03	.03	0.0	.43	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	1.6	1.9	88.7	49.3	105.0	56.5	14.1	5.8	0.0	0.0	0.0	0.8

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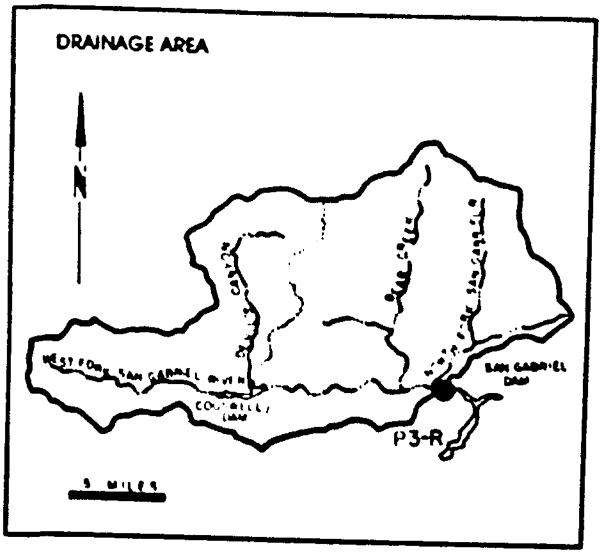
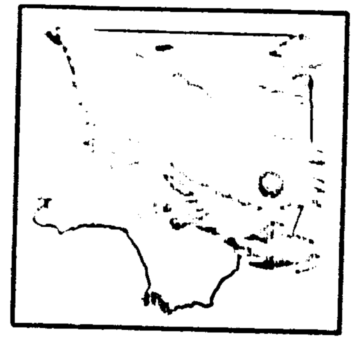
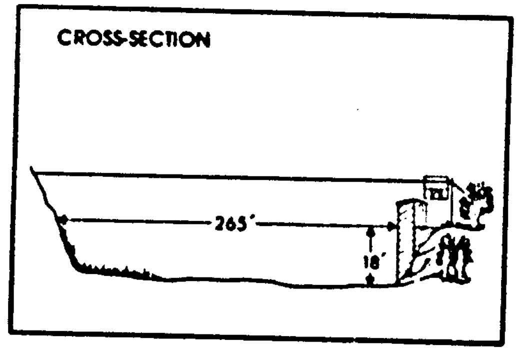
19588

R0052993

SAN GABRIEL RIVER
West Fork above Forks
STATION NO. P3-R







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9689

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 102.0 square miles.
LOCATION- 1.5 miles above confluence with East Fork.
REGULATION- partially regulated by Cogswell Dam.
CHANNEL- natural, sand, gravel, and boulders.
CONTROL- subject to shifts in natural bottom.
LENGTH OF RECORD- at Station P3-R, December 3, 1930 to July 12, 1938 and September 27, 1938 to date. at Station P38-R, July 12, 1938, to September 27, 1938.
REMARKS- for records prior to December 3, 1930 refer to Station P1-R.

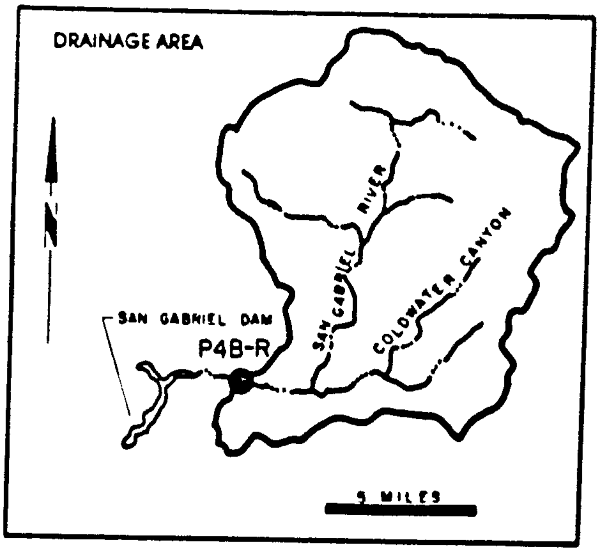
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

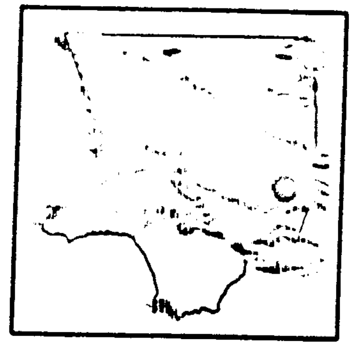
STATION NO. : P3-R

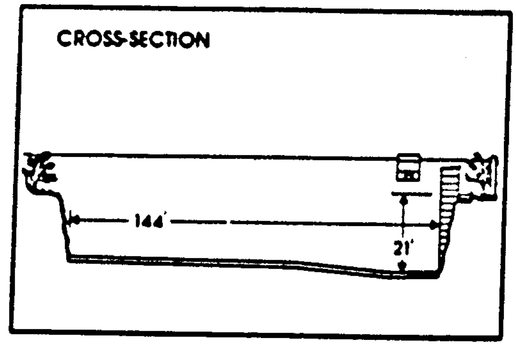
DRAINAGE AREA : 102.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	8.06	10.2	39.5	42.7	86.9	31.4	17.9	14.8	8.0	2.9	4.0	3.3
	MAX.	12.5	21.7	215.0	92.0	187.0	54.6	22.4	22.4	12.6	5.6	6.1	5.4
	MIN.	6.77	7.89	9.3	22.6	19.8	21.9	14.0	11.1	5.8	1.4	2.1	2.3
	TOTAL AF	495.0	605.0	2430.0	2620.0	4830.0	1928.0	1068.0	912.0	475.0	181.0	244.0	198.0

SAN GABRIEL RIVER
East Fork above Forks
STATION NO. P4B-R







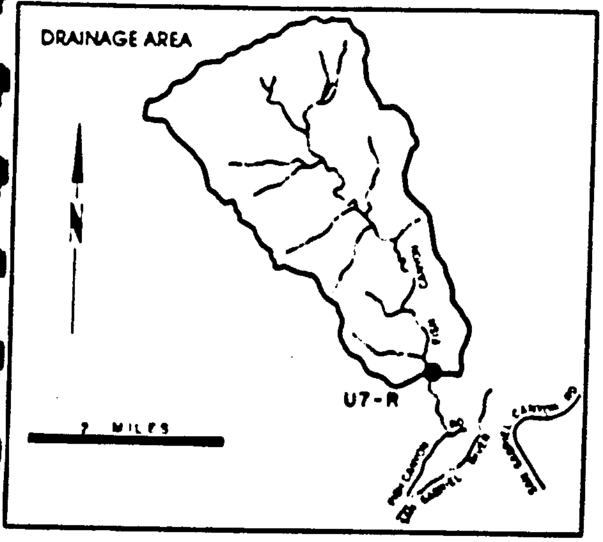
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 88.2 square miles.
LOCATION- 2.5 miles above the West Fork, 12.0 miles north of Azusa.
REGULATION- none.
CHANNEL- sand, gravel, and boulders, natural section.
CONTROL- concrete, stabilizer with a 20-foot-wide low flow notch (constructed in November 1947).
LENTH OF RECORD- at Station P4-R, November 30, 1932 to December 10, 1938. at Station P4B-R, December 10, 1938 to date.
REMARKS- the control height was increased 2.0 feet in September, 1955.

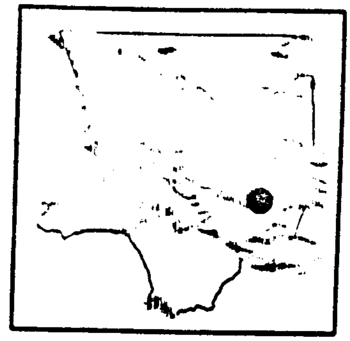
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

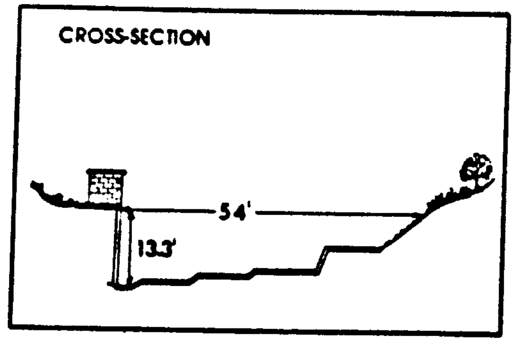
STATION NO. : P4B-R DRAINAGE AREA : 88.20 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	13.7	12.9	29.4	29.5	75.2	53.3	26.0	21.6	13.5	8.5	6.3	4.7
	MAX.	15.4	61.9	94.5	59.6	277.0	76.4	32.3	30.0	25.6	11.2	11.2	18.2
	MIN.	11.9	5.94	12.8	23.5	23.5	30.7	15.0	10.0	4.5	5.4	3.2	0.1
	TOTAL AF	844.0	770.0	1810.0	1814.0	4176.0	3275.0	1549.5	1331.0	802.0	522.0	387.0	280.0

FISH CREEK
above Mouth of Canyon
STATION NO. U7-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 6.36 square miles.
LOCATION - 0.8 miles upstream of mouth of canyon and 3.0 miles northeast of Duarte.
REGULATION- none.
CHANNEL- natural, rock and gravel.
CONTROL- concrete control.
LENGTH OF RECORD- July to September 1916. July 1917 to date.
REMARKS- operated and maintained by USGS until October 1, 1971.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : U7-R DRAINAGE AREA : 6.36 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	.63	1.08	2.4	2.56	9.39	2.5	0.92	0.8	0.5	0.3	0.0	0.0
	MAX.	1.38	6.83	20.5	4.18	80.7	4.3	2.0	1.7	1.0	0.2	0.0	0.3
	MIN.	.25	.5	0.0	1.74	2.0	1.9	0.5	0.4	0.2	0.1	0.0	0.0
	TOTAL AF	39.0	64.0	148.0	157.0	522.0	153.0	54.7	49.6	27.6	2.0	0.0	1.2

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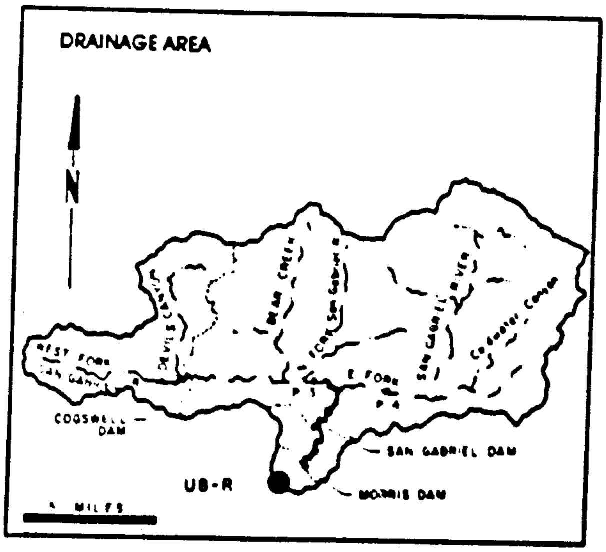
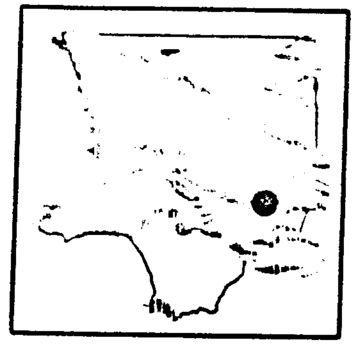
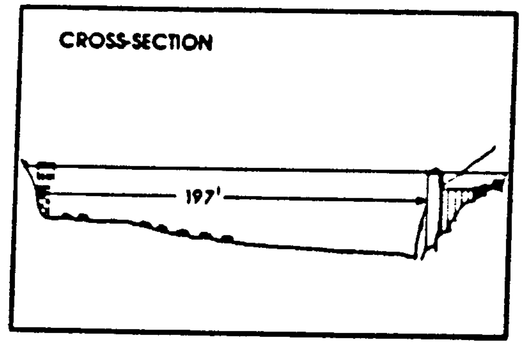
1991

SAN GABRIEL RIVER
below Morris Dam
STATION NO.U8-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 212.4 square miles.
LOCATION- 1.1 miles downstream of Morris Dam, 2.7 miles northeast of Azusa.
REGULATION- all flows regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- gravel and boulders, natural section.
CONTROL- concrete control.
LENGTH OF RECORD- May 1894 to date.
REMARKS- flows up to 9J cfs are at times diverted past the station through the Azusa Conduit; flows at station may include imported water from the MWD outlet below Morris Dam.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : U8-R

DRAINAGE AREA : 212.40 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	31.3	10.1	186.0	211.0	168.0	85.6	106.0	3.6	3.0	2.0	1.7	10.0
	MAX.	166.0	94.8	384.0	434.0	192.0	158.0	110.0	39.8	26.9	2.2	2.4	48.9
	MIN.	0.7	0.4	3.16	2.5	157.0	3.0	104.0	1.8	1.9	1.9	0.9	1.8
	TOTAL AF	1927.0	601.0	11460.0	12958.0	9330.0	5261.0	6290.0	219.0	177.0	126.0	102.0	593.0

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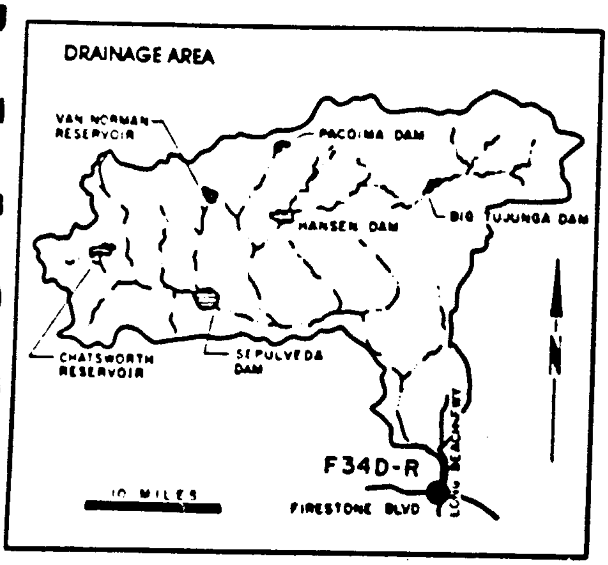
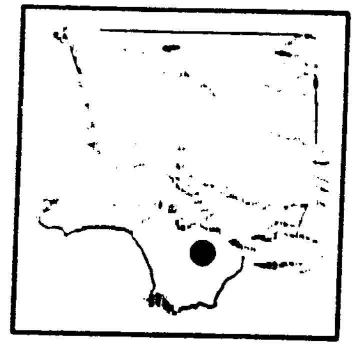
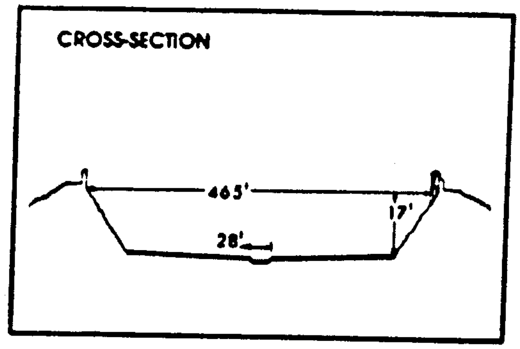
R0052997

LOS ANGELES RIVER
below Firestone Boulevard
STATION NO. F34D-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 596.0 square miles.
LOCATION- 472.0 feet downstream of Firestone Boulevard 3.0 miles west of Downey.
REGULATION- partially regulated by Sepulveda, Pacoima, Big Tujunga, Hansen, and Devil's Gate Dam; and by several spreading grounds, reservoirs, and debris basins.
CHANNEL- concrete, with rip-rap side slopes, trapezoidal in section, with trapezoidal low- flow channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F34-R March 1, 1928 to April 11, 1938. at Station F34B-R, April 11, 1938 to November 3, 1949. at Station F34C-R November 4, 1949, to December 11, 1956. at Station F34D-R December 11, 1956 to date.
REMARKS- subject to diversions from Big Tujunga Creek, Arroyo Seco, and other domestic and irrigation diversions.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

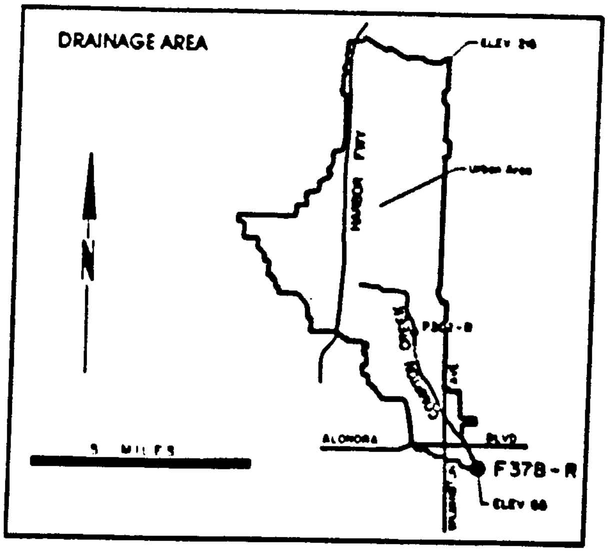
STATION NO. : F34D-R

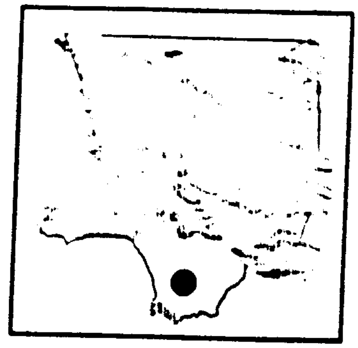
DRAINAGE AREA : 596.00 SQ. MI.

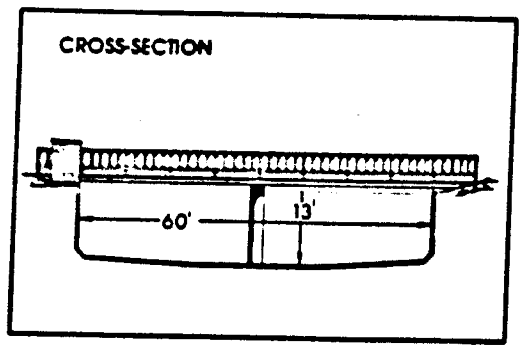
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN							126.0	122.0	121.0	126.0	133.0	137.0
	MAX.	NO DATA	AVAILABLE		FOR	THESE	MONTHS	158.0	131.0	130.0	135.0	137.0	800.0
	MIN.							97.8	111.0	112.0	·114.0	122.0	96.0
	TOTAL AF							7499.7	7477.7	7214.0	7720.0	8148.0	8195.7

VCL 12 1993

COMPTON CREEK
near Greenleaf Drive
STATION NO. F37B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 22.6 square miles.
LOCATION- 120.0 feet above Greenleaf Boulevard, 1.5 miles south west of Compton.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 60 feet wide by 13 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F37-R January 22, 1928 to June 9, 1938. at Station F37B-R October 3, 1938 to date

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F37B-R DRAINAGE AREA : 22.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.7	7.1	26.4	4.2	14.8	7.4	0.9	1.1	1.3	2.2	1.6	3.3
	MAX.	0.9	86.5	258.0	56.9	133.0	117.0	1.5	2.8	2.4	2.9	1.9	30.9
	MIN.	0.6	0.9	0.8	0.9	0.8	0.9	0.6	0.8	0.8	1.2	0.9	0.8
	TOTAL AF	46.0	422.0	1622.0	260.0	823.0	456.0	52.4	67.0	79.1	133.0	95.6	198.0

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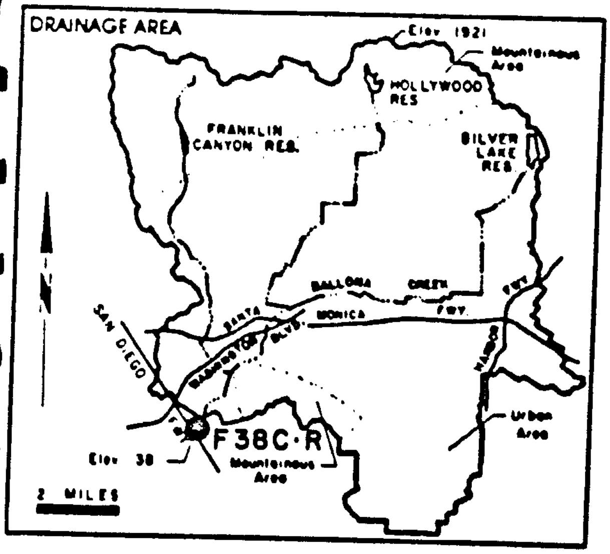
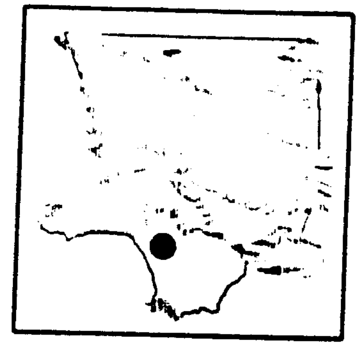
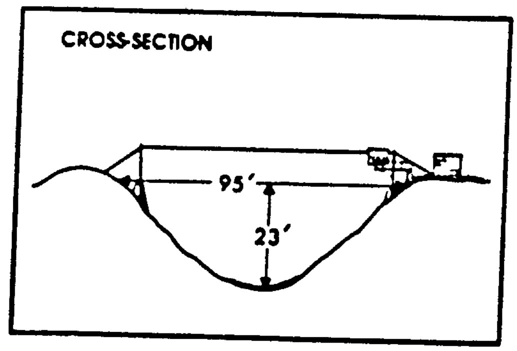
1 9694

R0052999

BALLONA CREEK
above Sawtelle Boulevard
STATION NO. F38C-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 88.6 square miles.
LOCATION- 530.0 feet above Sawtelle Boulevard, 1.5 miles southwest of Culver City.
REGULATION- Stone Canyon Reservoir prior to January, 1951. Upper and Lower Franklin Canyon Reservoir, Hollywood Reservoir, and Silverlake Reservoir.
CHANNEL- concrete rubble, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F38-R February 27,1928 to April 27, 1936. at Station F38B-R, May 14, 1936 to August 10, 1967. at Station F38C-R August 10, 1967, to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F38C-R

DRAINAGE AREA : 88.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	12.6	43.0	186.5	19.3	82.5	37.1	13.2	10.9	12.4	11.5	14.0	19.4
	MAX.	13.0	460.0	1660.0	205.0	941.0	446.0	17.1	22.9	26.2	13.3	18.3	177.0
	MIN.	10.4	9.3	8.9	8.2	7.6	10.5	10.9	9.9	9.3	10.5	8.7	9.3
	TOTAL AF	777.0	2558.0	11466.0	1185.0	4552.0	2281.0	785.0	656.0	739.0	706.0	858.0	1154.0

R0053000

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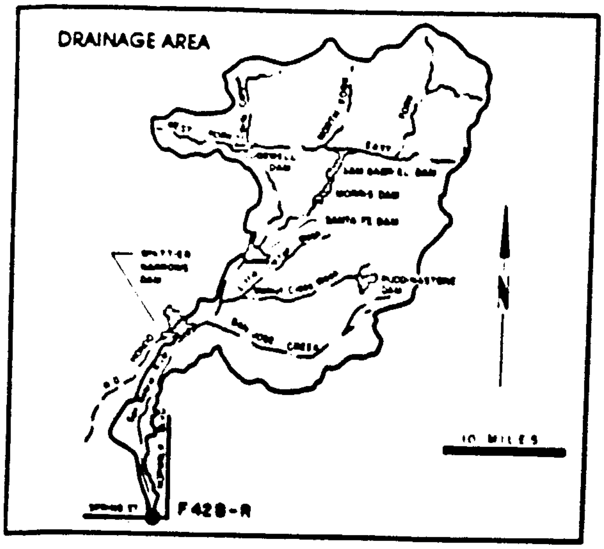
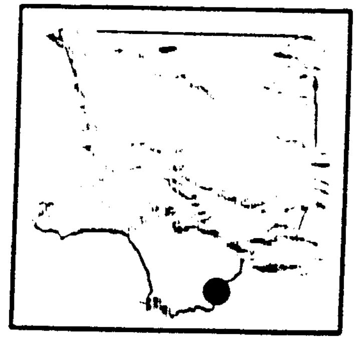
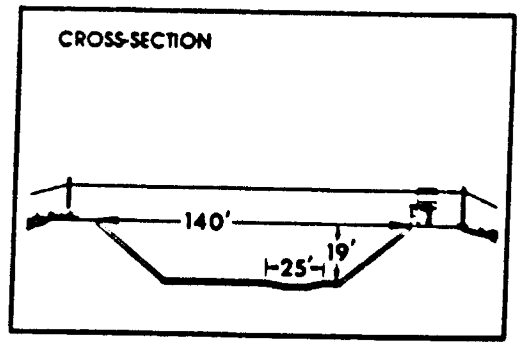
19695

SAN GABRIEL RIVER
above Spring Street
STATION NO. F42B-R







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1996

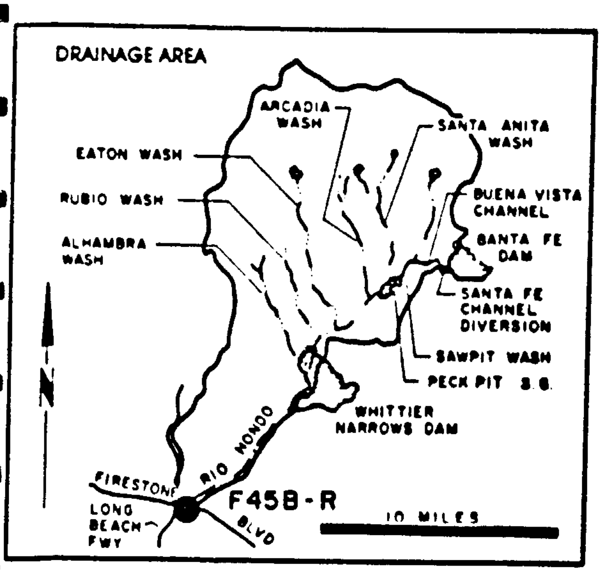
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 231.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 455.0 feet north of Spring Street, 4.0 miles east of Signal Hill, Long Beach.
REGULATION- partially regulated by Cogswell, San Grabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek, and Whittier Narrows Dams, several debris basins, MWD outlet, and several spreading grounds.
CHANNEL- concrete, trapizoidal section with a low-flow channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F42-R February 6, 1928 to May 26, 1964 at Station F42B-R, November 16, 1964 to date.
REMARKS- high flows into Whittier Narrows Reservoir are partially diverted to the Rio Hondo.

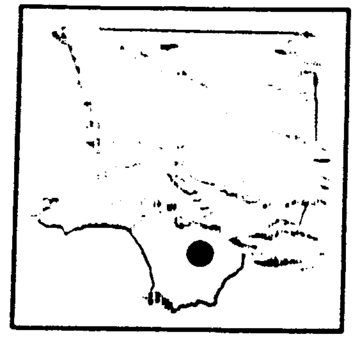
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

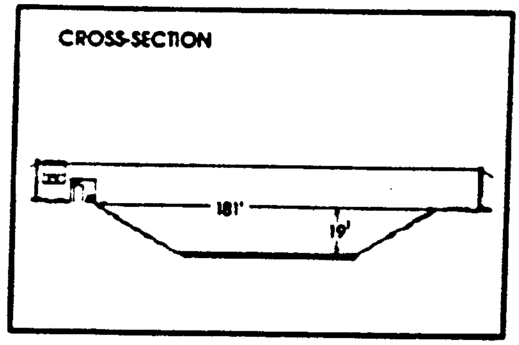
STATION NO. : F42B-R DRAINAGE AREA : 231.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	57.5	74.6	153.0	81.7	140.0	88.7	57.1	47.7	97.4	127.0	92.1	78.2
	MAX.	136.0	150.0	406.0	151.0	231.0	196.0	137.0	108.0	143.0	136.0	143.0	146.0
	MIN.	37.9	40.3	41.4	36.3	42.5	43.2	33.3	33.9	35.3	-105.0	37.8	38.7
	TOTAL AF	3530.0	4440.0	9437.0	5021.0	7751.0	5456.0	3398.0	2932.0	5794.0	7821.0	5662.0	4652.0

RIO HONDO
above Stewart and Gray Road
STATION NO. F45B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 140 square miles (excludes area above Santa Fe Dam).
LOCATION- 0.6 mile upstream of the confluence of Rio Hondo and Los Angeles River, 1.5 miles west of Downey.
REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, Santa Fe, and Whittier Narrows Dams, several debris basins, and spreading grounds.
CHANNEL- concrete with rip-rap side slopes. trapizodal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F45-R March 1, 1928 to April 18, 1951 at Station F45B-R October 31, 1951 to date.
REMARKS- subject to diversions from Eaton Creek, Monrovia Creek, Sawpit Creek, Little Santa Anita Canyon and other locations for irrigation and spreading. High flows from San Gabriel River may flow into Rio Hondo above Whittier Narrows Dam.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F45B-R

DRAINAGE AREA : 140.0 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.8	10.0	105.6	3.8	12.2	6.1	0.4	0.3	0.3	0.5	0.8	6.8
	MAX.	1.4	220.0	1280.0	47.7	155.0	105.0	1.1	1.3	0.5	0.7	1.3	144.0
	MIN.	0.4	0.2	0.6	0.1	0.1	0.2	0.1	0.1	0.1	- 0.2	0.4	0.6
	TOTAL AF	50.0	592.0	6490.0	235.0	678.0	373.0	22.2	20.2	17.9	29.0	50.0	405.0

R0053002

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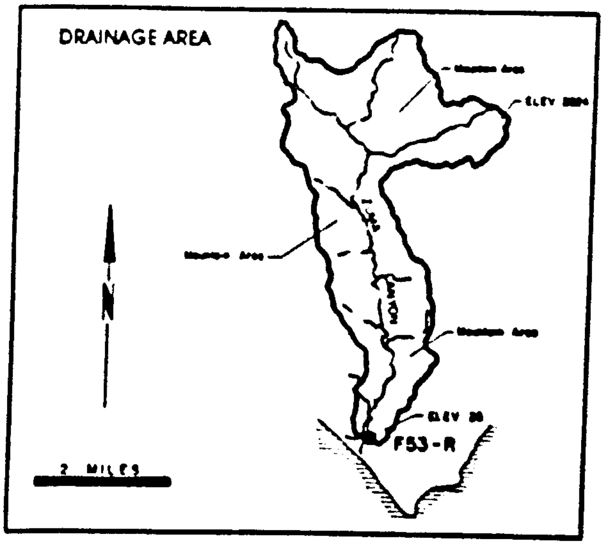
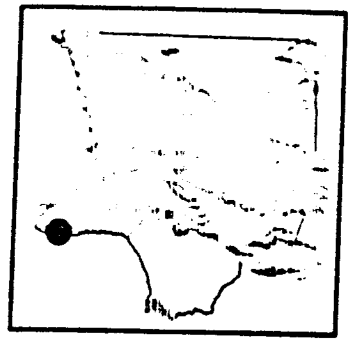
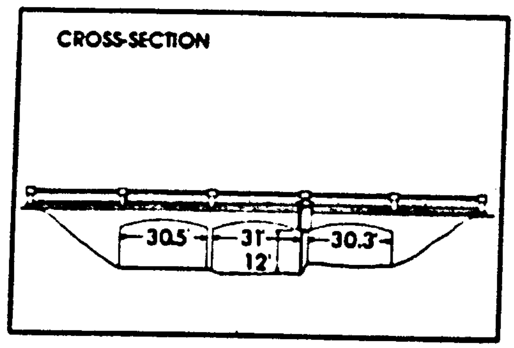
1997

DUME CREEK
at Pacific Coast Highway
STATION NO. F53-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from highway bridge.
DRAINAGE AREA- 8.8 square miles.
LOCATION- on the downstream side of Pacific Coast Highway bridge near Dume Point about 0.2 miles from Pacific Ocean.
REGULATION- none.
CHANNEL- sand and gravel.
CONTROL- channel forms control.
LENGTH OF RECORD- January 15, 1930 to November 26, 1937 and November 3, 1938 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F53-R — DRAINAGE AREA : 8.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	0.1	1.7	0.0	1.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0
	MAX.	0.0	2.8	18.0	0.6	21.9	3.6	0.0	0.0	0.0	0.0	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	6.5	107.0	2.0	100.0	25.2	0.0	0.0	0.0	0.0	0.0	0.0

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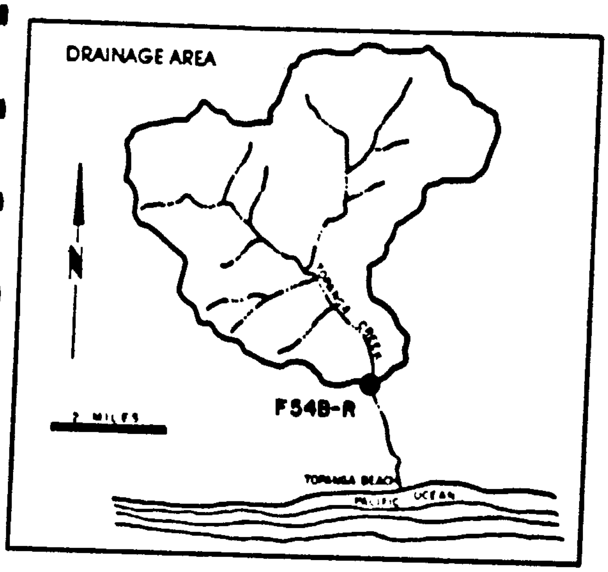
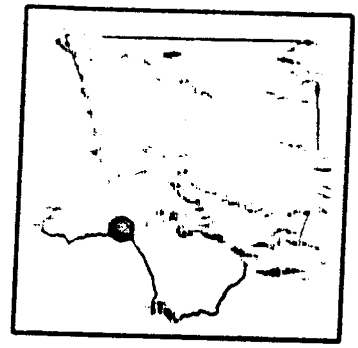
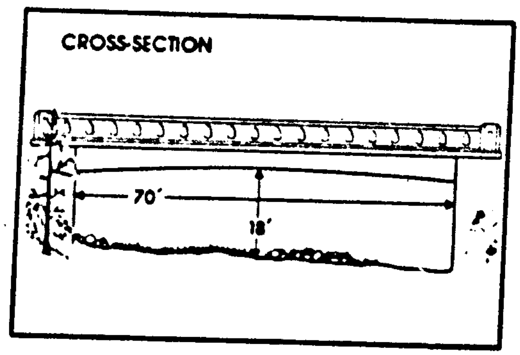
1998

R0053003

TOPANGA CREEK
above Mouth of Canyon
STATION NO. F54B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 18.0 square miles.
LOCATION- downstream side of Topanga Canyon Road bridge, 2.0 miles north of Topanga Beach.
REGULATION- none.
CHANNEL- rock and gravel, natural section.
CONTROL- none.
LENGTH OF RECORD- at Station F54-R January 1, 1930 to June 4, 1940. at Station F54B-R, June 5, 1940 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F54B-R

DRAINAGE AREA : 18.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.2	0.3	1.0	0.4	1.1	0.9	0.2	0.2	0.1	0.1	0.2	0.1
	MAX.	0.3	0.4	9.7	1.7	8.8	2.9	0.3	0.3	0.2	0.2	0.2	0.3
	MIN.	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	TOTAL AF	10.3	20.2	64.3	22.0	59.5	52.8	12.7	10.1	6.1	8.3	9.5	8.9

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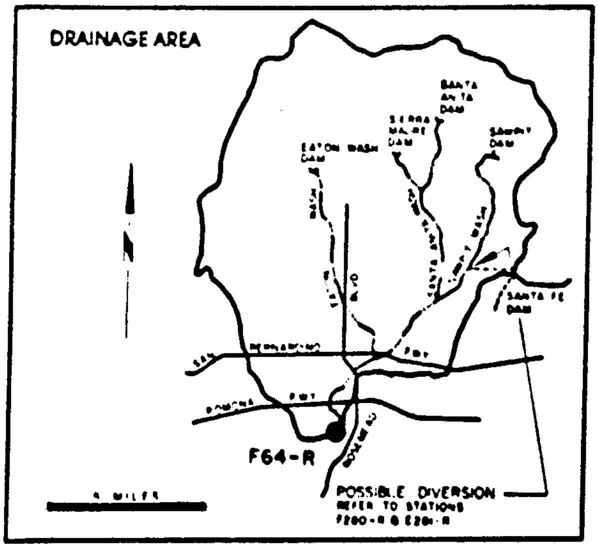
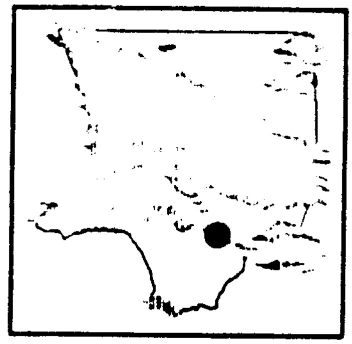
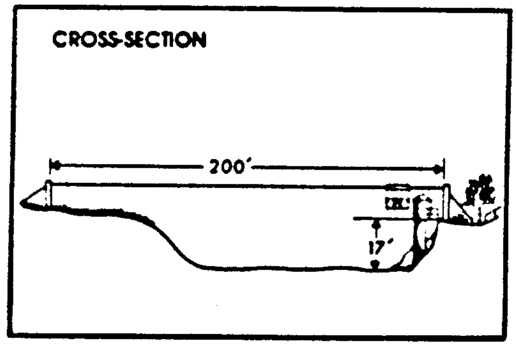
R0053004

RIO HONDO
above Mission Bridge
STATION NO. F64-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 115 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,000 feet above San Gabriel Boulevard, west of Rosemead Boulevard, 2.0 miles northeast of Montebello.
REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, and Santa Fe Dams and several debris basins.
CHANNEL- sand and silt, natural in section.
CONTROL- none.
LENGTH OF RECORD- July 1, 1928 to date.
REMARKS- subject to diversions; water purchased from the MWD passes this station for spreading in the coastal basin.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

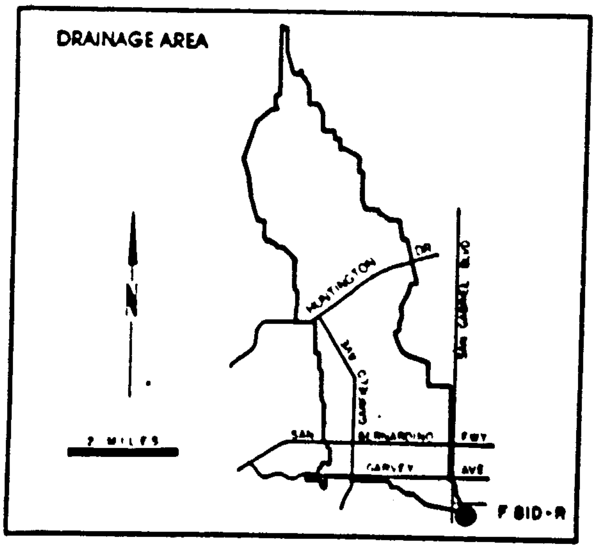
STATION NO. : F64-R DRAINAGE AREA : 115.00 SQ. MI.

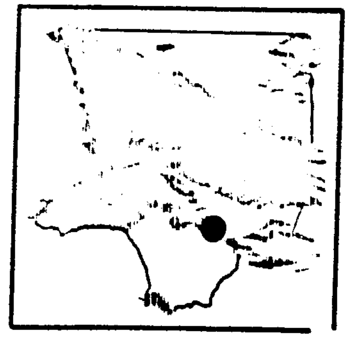
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	2.2	21.6	64.6	15.8	33.2	16.5	2.2	2.4	1.1	1.1	1.0	13.2
	MAX.	3.1	420.0	646.0	272.0	338.0	281.0	3.3	19.7	2.8	3.4	2.3	273.0
	MIN.	1.1	0.0	1.1	1.7	2.3	2.3	0.9	1.0	0.5	• 0.2	0.0	0.7
	TOTAL AF	133.0	1283.0	3971.0	974.0	1843.0	1013.0	131.0	150.0	66.6	65.3	61.1	785.0

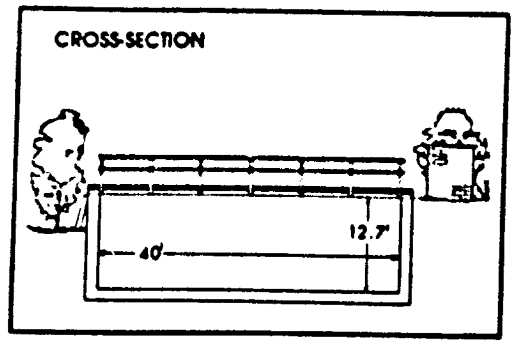
ALHAMBRA WASH
near Klingerman Street
STATION NO. F81D-R

VOL 12

19701







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 15.2 square miles.
LOCATION- 250± feet above Klingerman Street and 2,650.0 feet below Garvey Avenue, South San Gabriel.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 40.0 feet wide by 12.7 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F81-R January 14, 1930 to September 30, 1934. at Station F81B-R October 1, 1934 to February 25, 1935. at Station F81C-R February 25, 1935 to April 27, 1936. at Station F81B-R April 27, 1936 to May 22, 1936. at Station F81D-R September 2, 1936 to date.

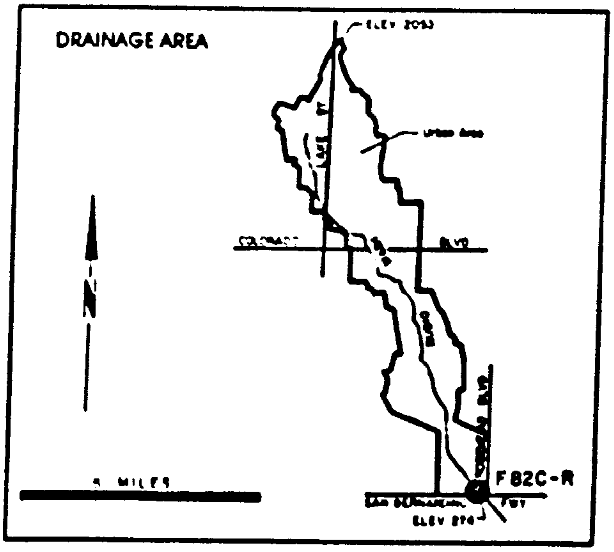
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

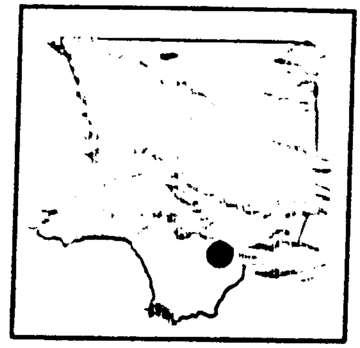
STATION NO. : F81D-R DRAINAGE AREA : 15.20 SQ. MI.

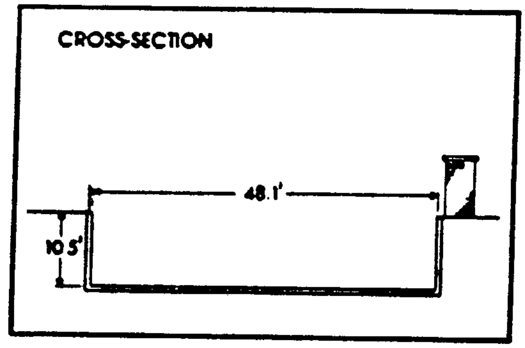
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	1.3	6.0	23.4	4.0	9.7	4.3	1.4	1.5	1.3	1.4	1.5	3.6
	MAX.	1.4	85.4	226.0	75.3	115.0	56.8	1.6	7.8	1.5	1.7	1.9	56.2
	MIN.	1.1	0.8	1.0	0.9	0.9	1.1	1.2	1.1	1.2	1.1	1.3	1.3
	TOTAL AF	81.0	355.0	1422.0	248.0	540.0	264.0	84.1	91.6	78.5	86.5	89.3	212.0

R0053006

RUBIO WASH
at Glendon Wash
STATION NO. F82C-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge at station.
DRAINAGE AREA- 10.9 square miles.
LOCATION- on the east side of channel, 10 feet south of the westerly extension of Glendon Way, Rosemead.
REGULATION- flow partly regulated by Las Flores and Rubio debris basins.
CHANNEL- rectangular concrete.
CONTROL- channel forms control.
LENGTH OF RECORD- see station summary.

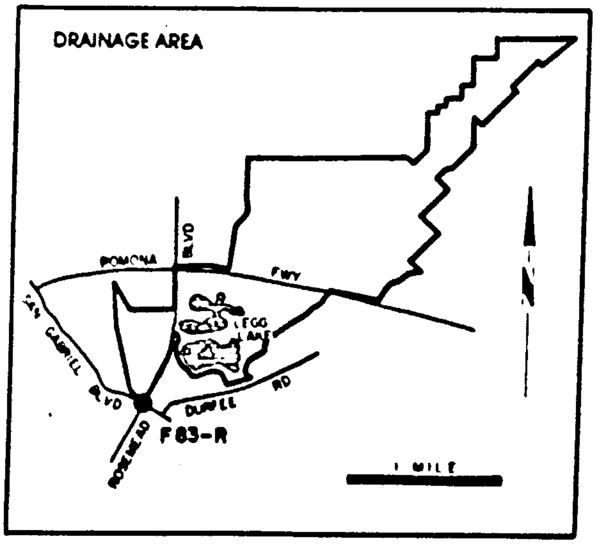
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

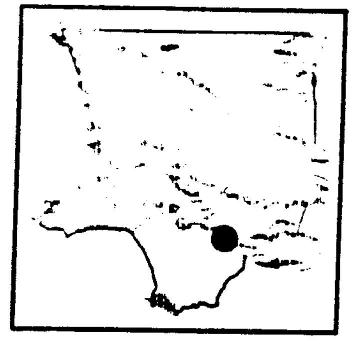
STATION NO. : F82C-R **DRAINAGE AREA :** 10.90 SQ. MI.

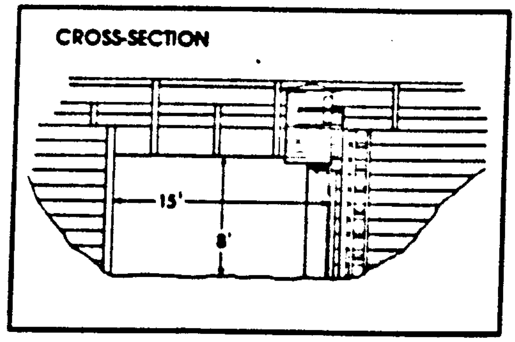
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.3	3.6	12.1	1.9	6.1	3.2	0.4	0.9	0.7	0.7	1.8	3.6
	MAX.	0.6	60.0	123.0	40.1	72.6	42.3	0.6	11.7	1.4	1.4	2.5	37.0
	MIN.	0.2	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	1.0
	TOTAL AF	19.8	214.0	742.0	118.0	341.0	196.0	28.0	55.9	41.1	45.2	108.0	212.0

VOL 12
19702

MISSION CREEK
at San Gabriel Boulevard
STATION NO. F83-R







RECORDER- continuous water stage.
METHOD MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 4.2 square miles.
LOCATION- upstream of San Gabriel Boulevard, 0.2 miles northeast of Montebello.
REGULATION- partially regulated by outflow from Legg Lake.
CHANNEL- sand with brush and fences, natural in section.
CONTROL- channel forms control.
LENGTH OF RECORD- June 14, 1930 to date.
REMARKS- nearly all flows originate in rising water.

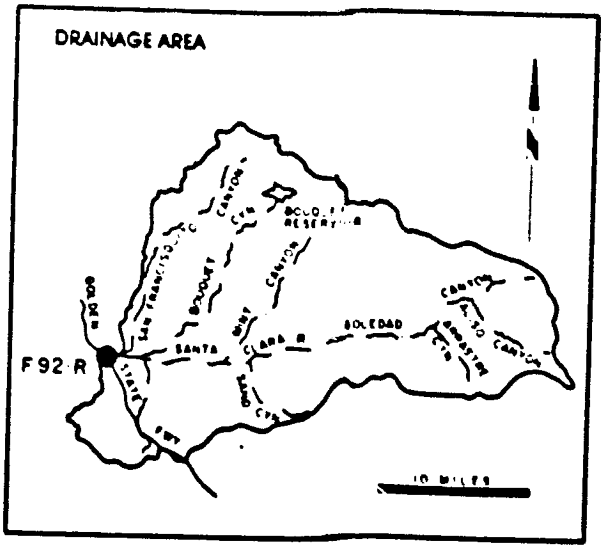
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

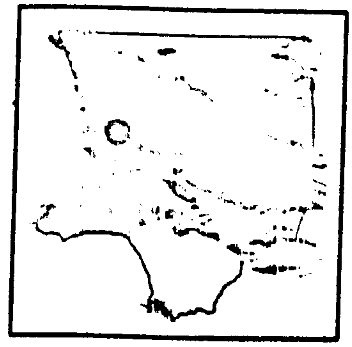
STATION NO. : F83-R DRAINAGE AREA : 4.20 SQ. MI.

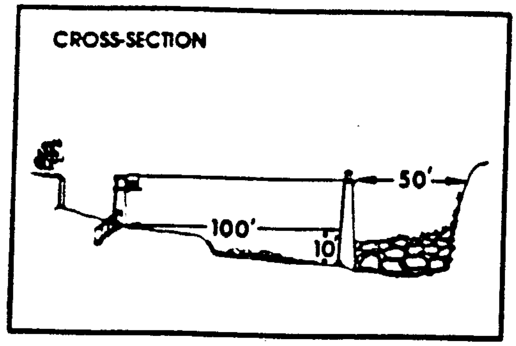
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	MAX.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

VOL 12
1970-3

SANTA CLARA RIVER
below Highway 5
STATION NO. F92C–R







VOL 12

19704

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 410.4 square miles.
LOCATION- downstream side of Old Highway bridge, 3.0 miles west of Saugus.
REGULATION- partially regulated by Bouquet Canyon and Dry Canyon Reservoirs.
CHANNEL- sand and gravel with brush, natural section.
CONTROL- none.
LENGTH OF RECORD- at Station F92-R January 18, 1930 to March 28, 1938, and September 24, 1956 to date. at Station F92B-R, October 1, 1938 to September 24, 1956.
REMARKS- subject to diversions for irrigation.

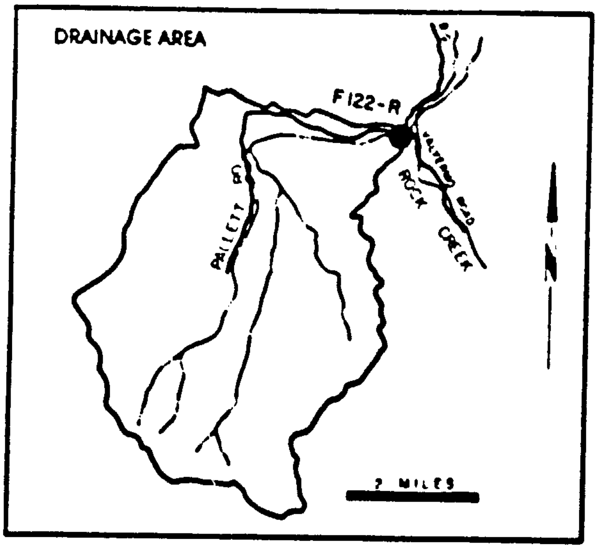
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

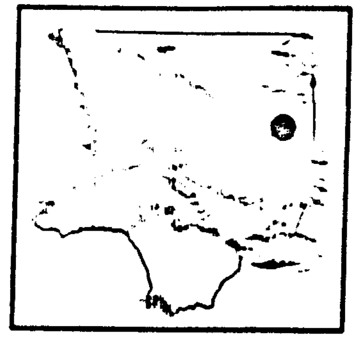
STATION NO. : F92C-R **DRAINAGE AREA :** 410.40 SQ. MI.

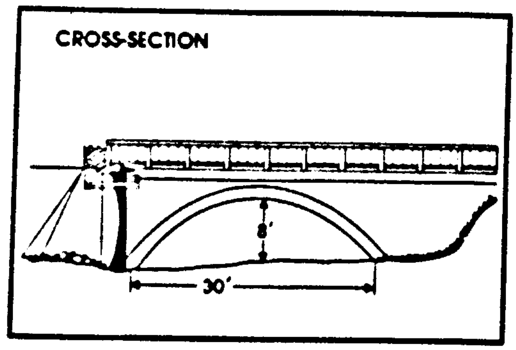
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	9.4	10.2	27.1	12.2	14.5	10.9	8.7	8.1	8.5	9.6	11.0	11.1
	MAX.	9.8	31.8	145.0	24.3	62.5	14.0	8.8	8.8	10.1	9.6	15.0	14.6
	MIN.	9.1	6.4	7.2	11.5	6.3	3.7	8.3	7.3	6.7	9.6	7.2	9.2
	TOTAL AF	579.0	613.0	1669.0	753.0	805.0	671.0	515.0	497.0	509.0	590.0	675.0	660.0

R0053009

PALLETT CREEK
at Valyermo Highway
STATION NO. F122-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 15.8 square miles.
LOCATION- upstream side of Valyermo Highway bridge, 5.0 miles southeast of Pearblossom.
REGULATION- none.
CHANNEL- sand and gravel, natural section.
CONTROL- channel forms control for low flows; bridge culvert forms control for high flows.
LENGTH OF RECORD- at Station F122-S December 29, 1930 to October 31, 1961. at Station F122-R, October 31, 1961 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F122-R

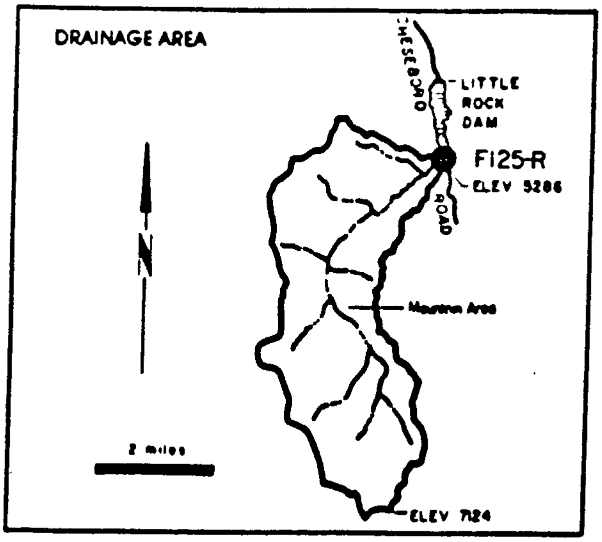
DRAINAGE AREA : 15.80 SQ. MI.

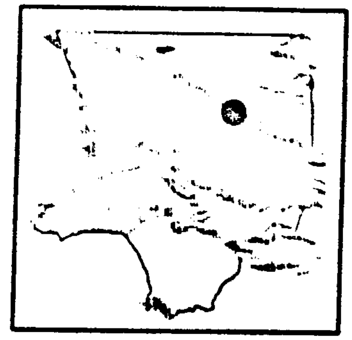
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.3	.18	0.3	0.2	0.3	0.2	0.2	0.2	0.0	0.0	0.0	0.0
	MAX.	0.3	.21	0.5	0.2	0.4	0.3	0.3	0.2	0.0	0.0	0.0	0.0
	MIN.	0.2	.16	0.2	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0
	TOTAL AF	15.5	11.0	16.0	9.8	10.0	13.0	11.0	12.0	0.0	0.0	0.0	0.0

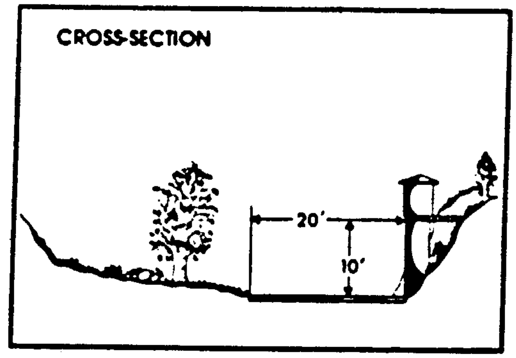
VOL 12

1 9705

SANTIAGO CREEK
above Little Rock Creek
STATION NO. F125-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 11.2 square miles.
LOCATION- 1,000 feet above Little Creek and 4.5 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel and boulders.
CONTROL- concrete and rubble wall.
LENGTH OF RECORD- September 29, 1953 to date.
REMARKS- no high flow measurements.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

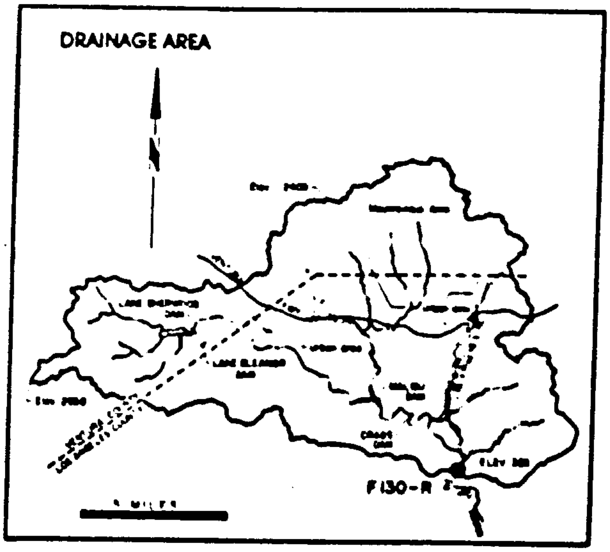
STATION NO. : F125-R DRAINAGE AREA : 11.20 SQ. MI.

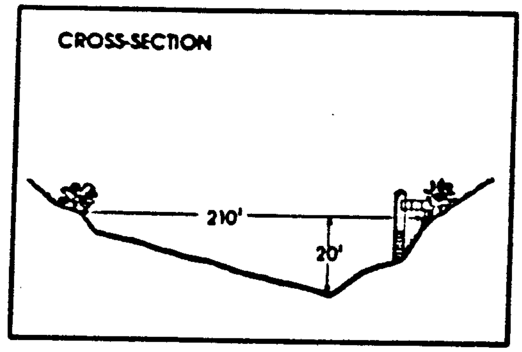
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	0.0	0.0	0.0	2.0	0.8	0.1	0.0	0.0	0.0	0.0	0.0
	MAX.	0.0	0.0	0.0	0.0	10.9	3.7	0.4	0.0	0.0	0.0	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	0.0	110.0	47.6	6.4	0.0	0.0	0.0	0.0	0.0

VOL 12

1970-6

MALIBU CREEK
below Cold Creek
STATION NO. F130-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 104.96 square miles
LOCATION- 0.2± mile downstream of Cold Creek, 6.0 miles southwest of Calabasas.
REGULATION- Lake Sherwood Dam, Lake Eleanor Dam, Malibu Lake Dam, and Crag's Dam. Other small recreational dams affect low summer flows.
CHANNEL- coarse sand and gravel, lined with trees and brush, natural in section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- January 17, 1931 to date.
REMARKS- cableway washed out on January 25, 1969; no high flow measurements since that date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F130-R DRAINAGE AREA : 104.96 SQ. MI.

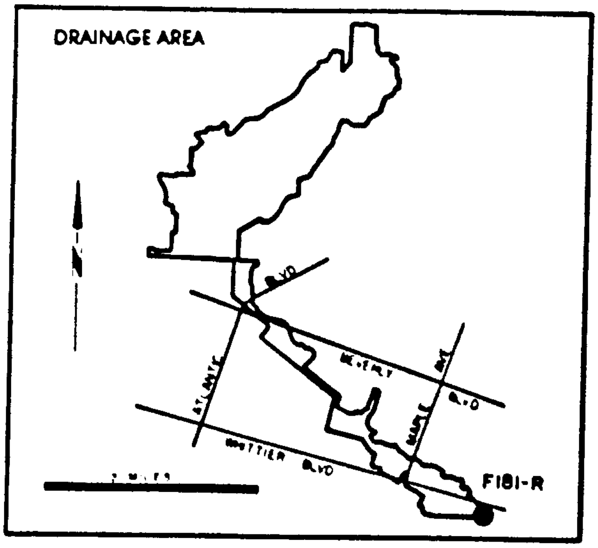
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	10.0	13.7	28.5	24.4	31.7	17.6	7.4	4.8	2.7	2.4	2.1	3.1
	MAX.	12.6	19.1	183.0	41.3	257.0	31.5	9.9	6.6	6.2	3.3	3.0	4.6
	MIN.	7.2	9.1	9.3	10.4	10.0	8.9	4.9	3.8	1.7	1.8	1.6	2.0
	TOTAL AF	611.7	816.0	1751.0	1500.0	1758.0	1062.0	436.0	297.0	162.0	149.0	128.0	184.0

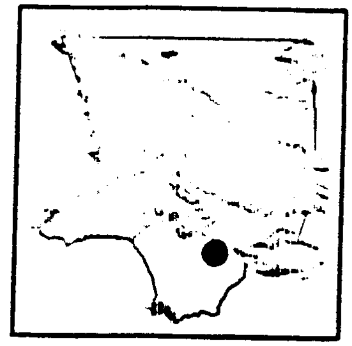
VOL 12

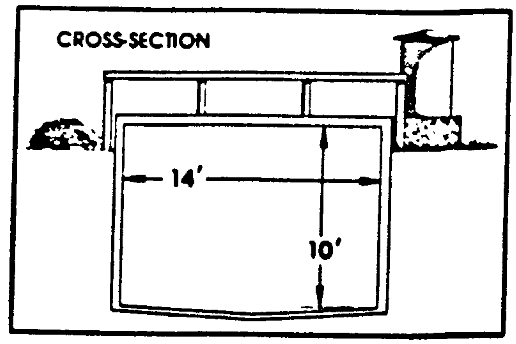
1 9707

MONTEBELLO STORM DRAIN
above Rio Hondo
STATION NO. F181-R

VOL 12







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 9.6 square miles.
LOCATION- 150.0 feet east of Mines Avenue and 500.0 feet west of Rio Hondo.
REGULATION- none.
CHANNEL- 14.0-foot by 10.0-foot concrete, box section.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1932 to date.
REMARKS- may be affected by backwater during flood flows.

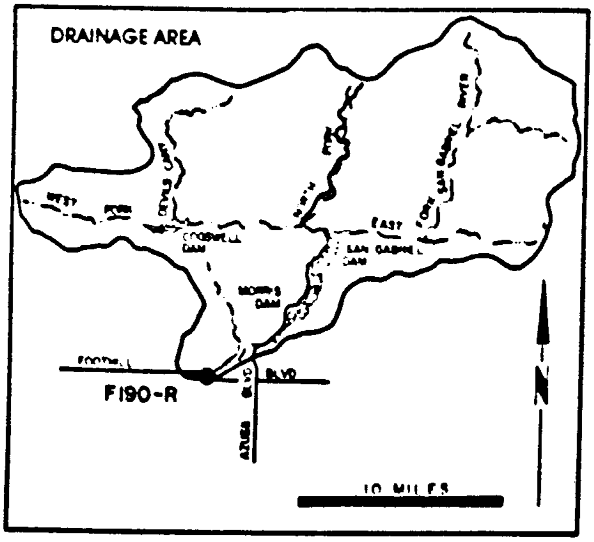
1 9708

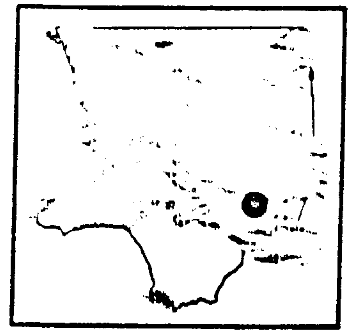
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

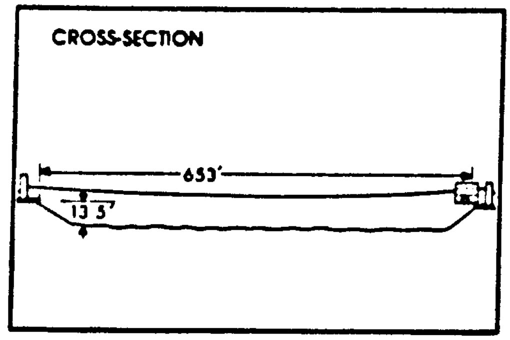
STATION NO. : F181-R DRAINAGE AREA : 9.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.3	0.9	4.2	0.7	2.2	1.0	0.3	0.4	0.5	0.4	0.5	0.8
	MAX.	0.5	11.1	30.3	12.0	21.3	11.2	0.4	0.8	1.0	0.5	0.6	7.3
	MIN.	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.4	0.4	0.5	0.3
	TOTAL AF	17.3	53.8	255.0	41.7	121.0	59.3	16.5	21.8	30.1	27.2	32.5	44.8

SAN GABRIEL RIVER
at Foothill Boulevard
STATION NO. F190-R







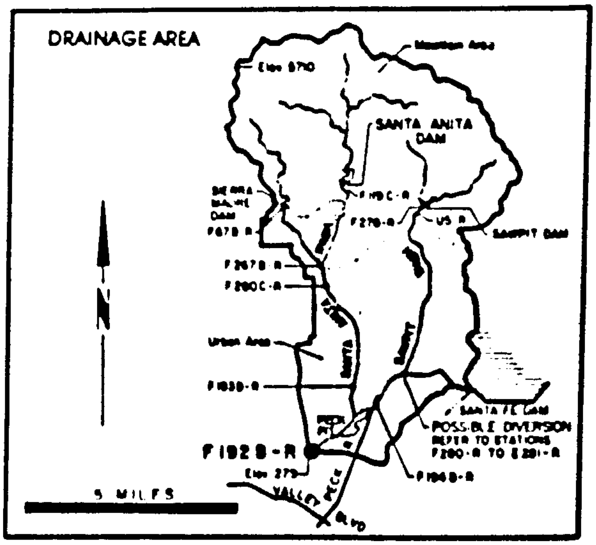
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 230.0 square miles.
LOCATION- downstream side of Foothill Boulevard bridge, 2.0 miles west of Azusa.
REGULATION- partially regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- sand, gravel and rock,trapezoidal section with soft bottom.
CONTROL- gunited rock stabilizers.
LENGTH OF RECORD- February 22, 1932 to date.
REMARKS- flows may include imported water originating at the Metropolitan Water District outlet below Morris Dam.

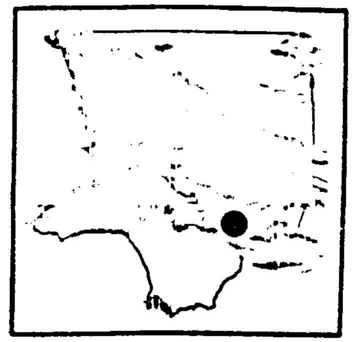
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

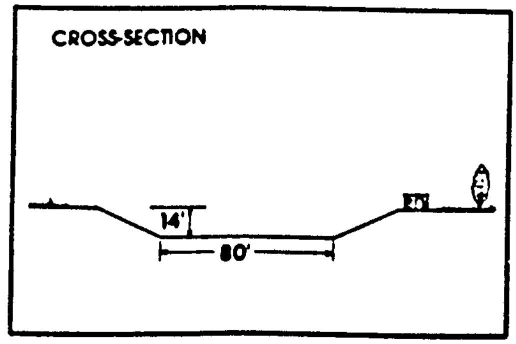
STATION NO. : F190-R — DRAINAGE AREA : 230.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	9.3	6.3	113.0	156.0	155.0	59.8	49.9	22.4	5.9	5.6	9.3	8.7
	MAX.	53.4	22.6	358.0	417.0	464.0	144.0	67.2	35.9	248.0	17.3	22.4	25.8
	MIN.	0.0	0.0	0.0	0.0	84.1	4.2	38.8	1.2	0.0	0.0	0.0	0.0
	TOTAL AF	573.0	376.0	6960.0	9572.0	8600.0	3677.0	2968.0	1381.0	352.0	347.0	570.0	520.0

RIO HONDO
below Lower Azusa Road
STATION NO. F192B-R







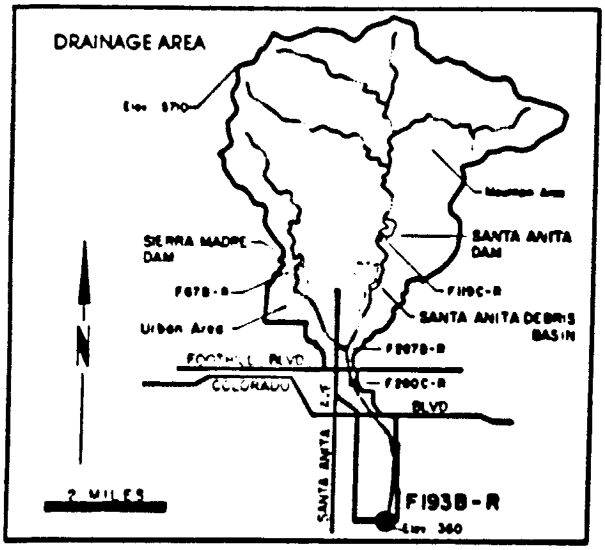
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 40.9 square miles (excludes area above Santa Fe Dam).
LOCATION- 300.0 feet downstream from Lower Azusa Road, 1.5 miles north of El Monte.
REGULATION- partially regulated by Sierra Madre Dam, Santa Anita Dam, Sawpit Dam, Santa Fe Dam, Peck Pit, Buena Vista Pit, and several debris basins.
CHANNEL- concrete, trapizoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F192-R February 22, 1932 to May 7, 1958 at Station F192B-R May 7, 1958 to date.
REMARKS- subject to diversions from Monrovia, Sawpit, and Little Santa Anita Creeks. Also from the San Gabriel River below Santa Fe Dam; and for irrigation and spreading.

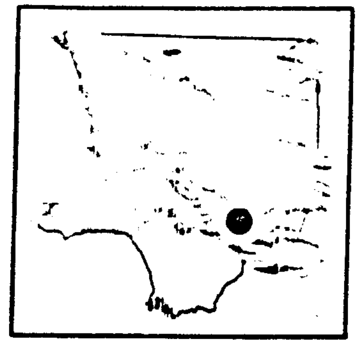
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

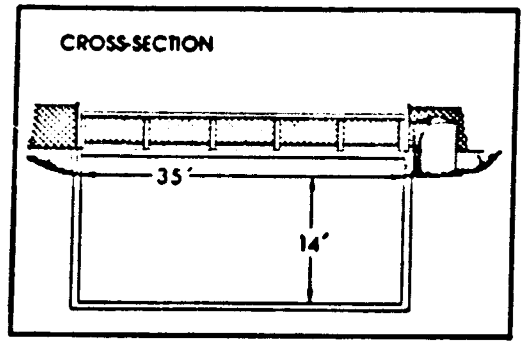
STATION NO. : F192B-R DRAINAGE AREA : 40.90 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	0.3	1.3	0.2	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.1
	MAX.	0.1	3.8	12.7	4.0	7.9	4.6	0.2	0.3	0.1	0.1	0.1	2.5
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.4	15.4	79.9	13.5	35.3	16.7	1.0	2.0	0.2	0.8	1.0	6.1

SANTA ANITA WASH
at Longden Avenue
STATION NO. F193B-R







RECORDER - continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 18.8 square miles.
LOCATION- 30.0 feet above Longden Avenue, 1.8 miles south of Arcadia.
REGULATION - regulated by Santa Anita and Sierra Madre Dams, and Santa Anita Debris Basin.
CHANNEL - concrete rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F193-R, April 25, 1932 to March 1, 1938. at Station F193B-R, January 5, 1960 to date.

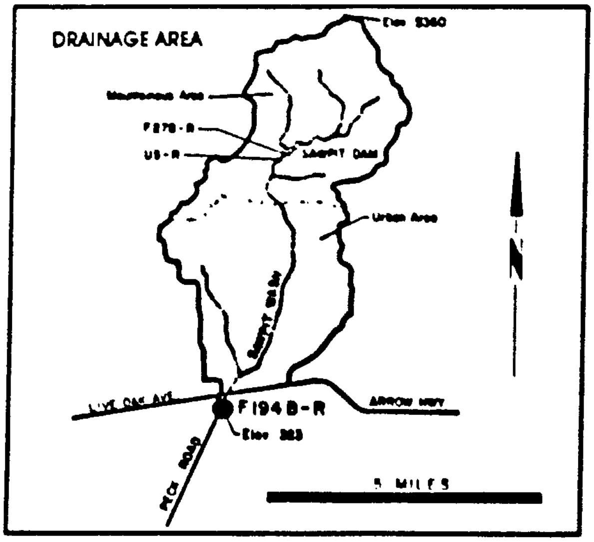
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

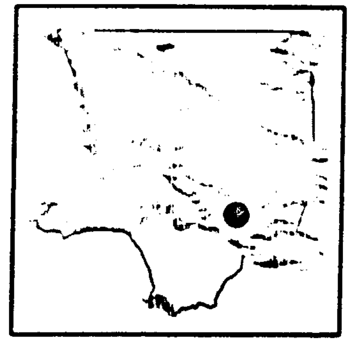
STATION NO. : F193B-R **DRAINAGE AREA :** 18.80 SQ. MI.

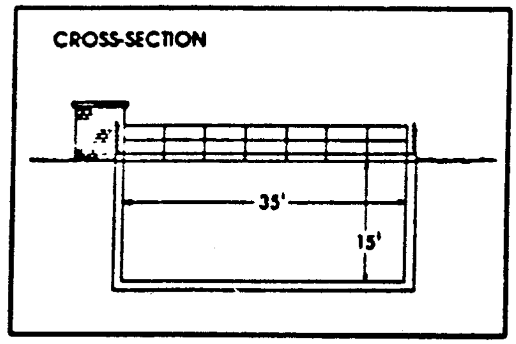
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	1.3	2.3	2.7	0.7	2.7	0.8	0.0	0.3	0.2	0.2	0.2	0.6
	MAX.	4.7	22.1	23.0	3.2	42.2	11.5	0.1	3.2	0.3	0.3	0.6	8.0
	MIN.	0.4	0.3	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	TOTAL AF	[illegible]	[illegible]	[illegible]	42.2	151.0	48.2	2.2	20.4	12.1	10.7	9.7	32.7

VOL 12
1971

SAWPIT WASH
below Live Oak Avenue
STATION NO. F194B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 16.1 square miles.
LOCATION- 1,500 feet below Arrow Highway, 3.0 miles south of Monrovia.
REGULATION- partially regulated by Sawpit and Santa Fe Dams, and by several debris basins.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F194-R February 22, 1932 to September 1, 1935. at Station F194B-R December 5, 1960 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

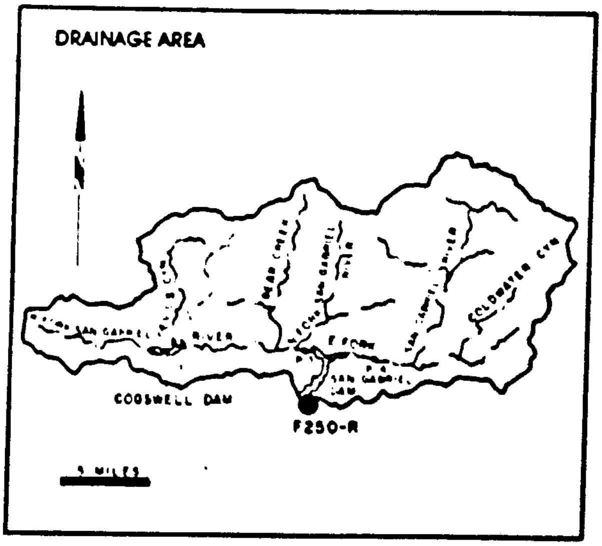
STATION NO. : F194B-R **DRAINAGE AREA :** 16.10 SQ. MI.

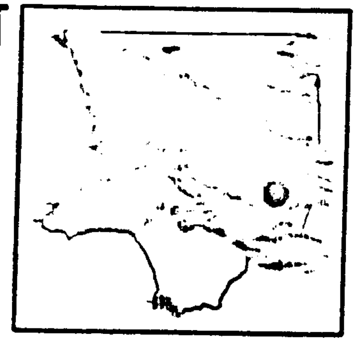
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.1	2.1	7.7	1.2	4.9	1.4	0.1	0.8	0.7	0.1	0.1	0.5
	MAX.	0.2	34.0	75.8	20.4	73.0	20.6	0.7	5.6	2.9	0.2	0.2	10.2
	MIN.	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
	TOTAL AF	5.0	125.0	472.0	68.6	270.0	83.1	8.1	50.6	39.7	8.5	6.3	30.1

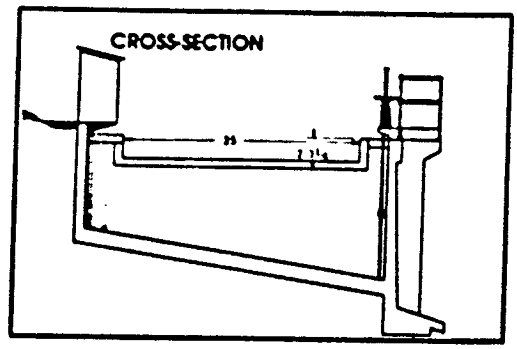
VOL 12

1972

SAN GABRIEL-AZUSA CONDUIT
at 25 ft. Weir below San Gabriel Dam
STATION NO. F250-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- weir formula with gage height observation.
DRAINAGE AREA- none.
LOCATION- on the concrete conduit which diverts from San Gabriel Dam, 160 feet below the Dam.
REGULATION- regulated in section.
CONTROL- 25-foot concrete weir.
LENGTH OF RECORD- February 26, 1933, to date.
REMARKS- approximate capacity 95 second- feet.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F250-R DRAINAGE AREA : NONE

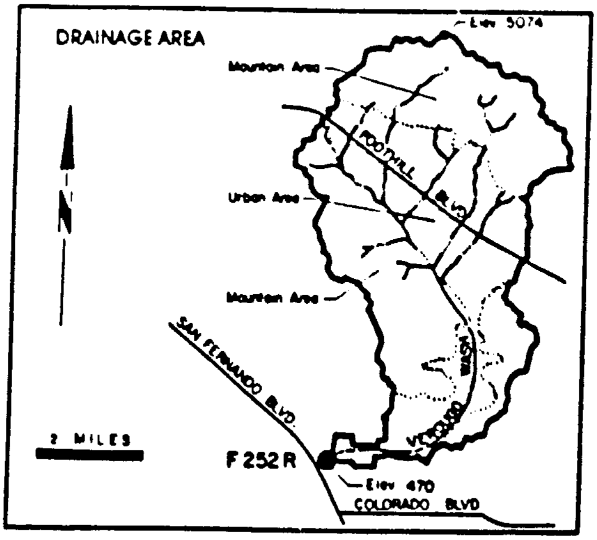
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	61.3	67.1	60.5	43.4	40.9	41.2	42.4	38.9	39.3	46.4	43.2	33.9
	MAX.	79.1	84.5	85.2	62.1	43.5	46.0	48.0	39.4	40.3	49.8	51.2	41.8
	MIN.	48.6	29.0	34.1	31.3	39.5	35.8	31.1	38.7	38.8	38.8	39.2	0.0
	TOTAL AF	3770.0	3991.0	3718.0	2672.0	2271.0	2531.0	2524.0	2392.4	2338.0	2855.0	2655.0	2018.0

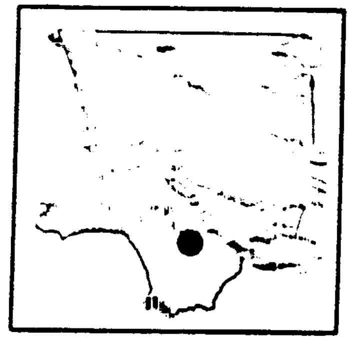
VOL 12

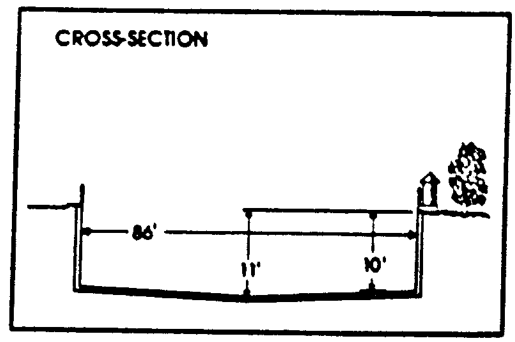
1973

R0053018

VERDUGO WASH
at Estelle Avenue
STATION NO. F252-R







RECORDL?- continuous water stage.
METHOD O.' MEASUREMENTS- wading or from Concord Street Bridge.
DRAINAGE A. 'SA- 26.8 square miles.
LOCATION- 800 0 feet east of San Fernando Road, 2.0 miles northwest of Glendale.
REGULATION- partially regulated by several debris basins.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- December 2, 1935 to date.

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1971-4

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F252-R

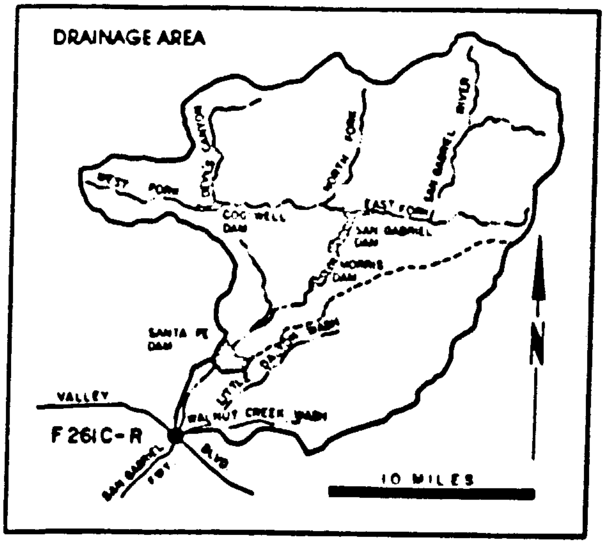
DRAINAGE AREA : 26.80 SQ. MI.

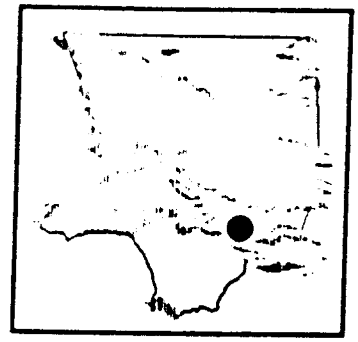
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	3.1	13.2	34.0	5.0	26.7	8.3	3.0	3.2	1.4	1.7	2.0	6.5
	MAX.	6.2	201.0	301.0	43.4	301.0	78.5	5.0	8.5	2.7	2.3	3.6	133.0
	MIN.	1.9	1.9	2.0	1.7	1.5	1.9	1.8	1.5	0.9	0.3	1.2	1.2
	TOTAL AF	189.0	786.0	2092.0	307.0	1484.0	512.0	179.0	200.0	85.1	102.0	124.0	388.0

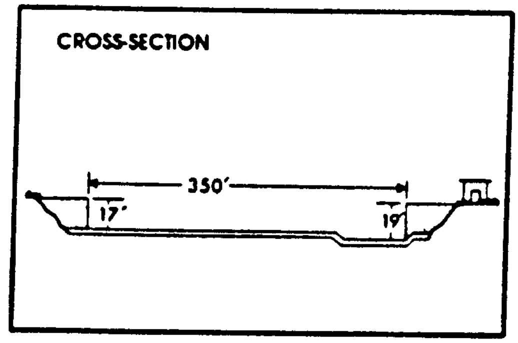
R0053019

SAN GABRIEL RIVER
below Valley Boulevard
STATION NO. F261C-R

VOL 12







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 118.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,150.0 feet below Valley Boulevard, 2.5 miles east of El Monte.
REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, and Puddingstone Dams.
CHANNEL- sand and gravel bottom with rip-rap side slopes; trapezoidal section.
CONTROL- concrete stabilizer with low-flow notch.
LENGTH OF RECORD- at Station F261-R March 11, 1937 to September 30, 1941. at Station F261B-R October 1, 1941 to April 23, 1946. at Station F261C-R November 29, 1960 to date.
REMARKS- flows may include imported water originating at Metropolitan Water District outlets at San Dimas Canyon and below San Bernardino Road.

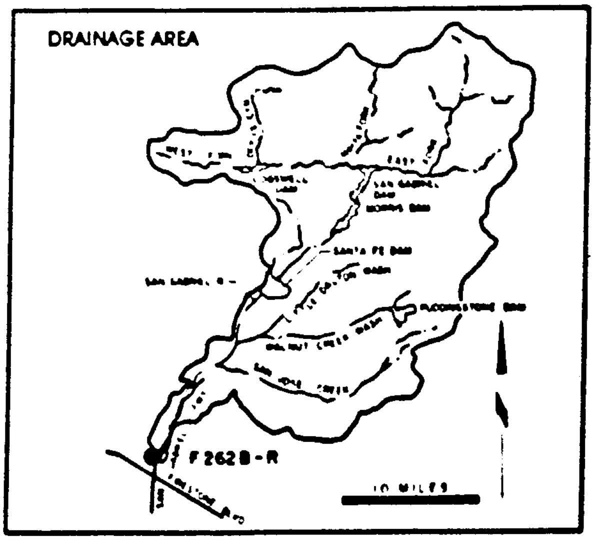
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

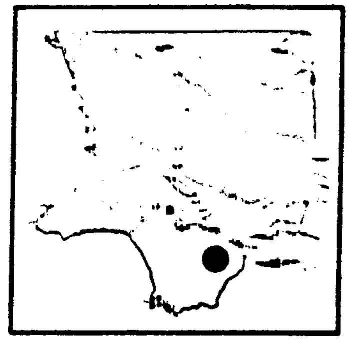
STATION NO. : F261C-R **DRAINAGE AREA :** 118.00 SQ. MI.

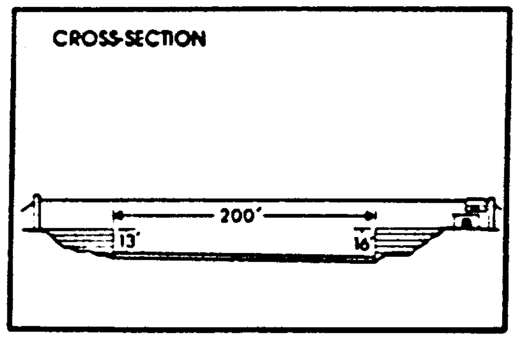
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	1.5	18.3	136.0	111.0	167.0	105.0	110.0	34.4	93.8	1.3	2.7	7.8
	MAX.	8.2	209.0	704.0	264.0	569.0	355.0	124.0	122.0	196.0	10.6	11.7	81.7
	MIN.	0.0	0.2	1.7	0.6	7.5	0.0	68.5	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	94.8	1089.0	8352.0	6827.0	9249.0	6446.0	6530.0	2112.0	5768.0	82.5	167.0	466.0

R0053020

SAN GABRIEL RIVER
above Florence Avenue
STATION NO. F262B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 215.8 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,400 feet above Florence Avenue, 2.0 miles east of Downey.
REGULATION- partially regulated by Cogswell, San Gabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek and Whittier Narrows Dams, several debris basins, MWD outlets, and several spreading grounds.
CHANNEL- sand bottom with rip-rap slopes, trapezoidal section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F267-R February 27, 1937 to September 30, 1967 at Station F262B-R August 6, 1968 to date.
REMARKS- no record during 1967-1968 season due to channel construction.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F262B-R DRAINAGE AREA : 215.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	0.0	6.9	4.8	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	MAX.	0.0	0.0	148.0	75.0	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	424.0	294.0	107.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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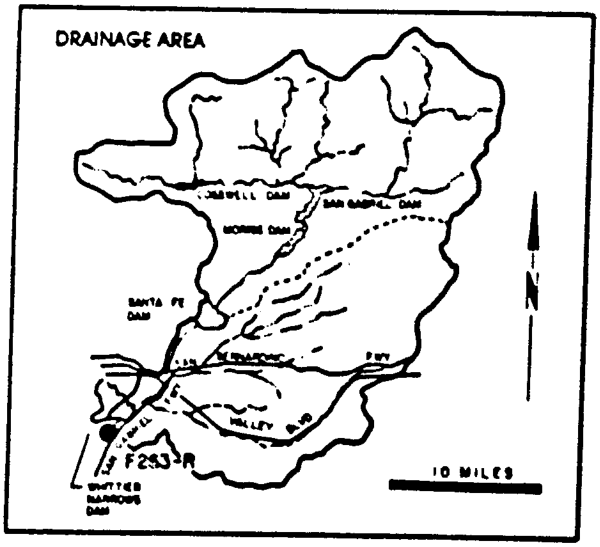
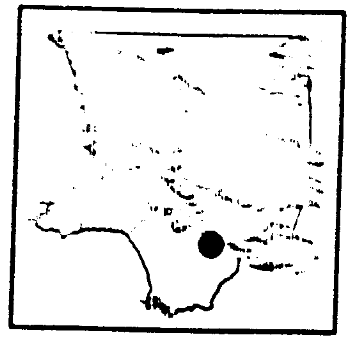
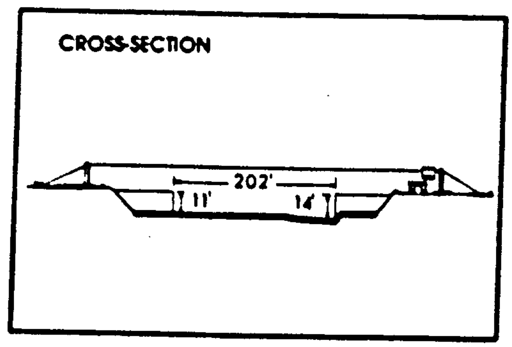
1976

R0053021

SAN GABRIEL RIVER
below San Gabriel River Parkway
STATION NO. F263C-R







VOL 12

1977

RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 206.3 square miles (excludes area above Santa Fe Dam).

LOCATION- 462.0 feet below San Gabriel River Parkway, 1.4 miles northeast of Pico Rivera.

REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, Puddingstone, and Thompson Creek Dams. Flows may include imported water from several Metropolitan Water District outlets. Water is at times diverted to the Zone I ditch upstream of Whittier Narrows Dam.

CHANNEL- rip-rap slopes with sand bottom trapezoidal section.

CONTROL- concrete stabilizer.

LENGTH OF RECORD - at Station F263-R February 4, 1937 to March 6, 1952. at Station F263B-R March 6, 1952 to August 9, 1968. at Station F263C-R August 9, 1968 to date.

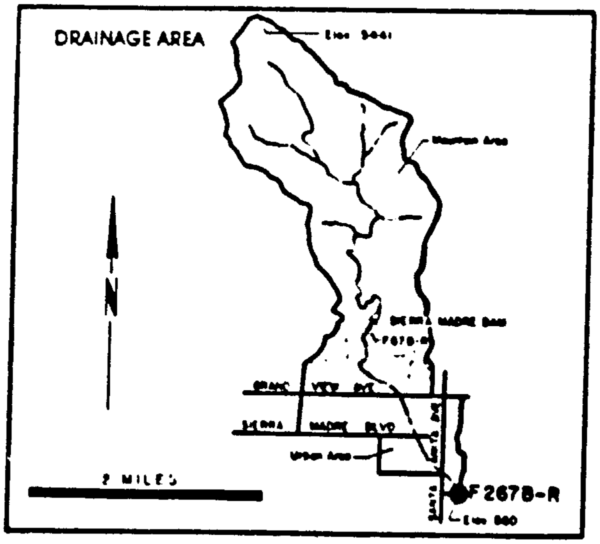
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

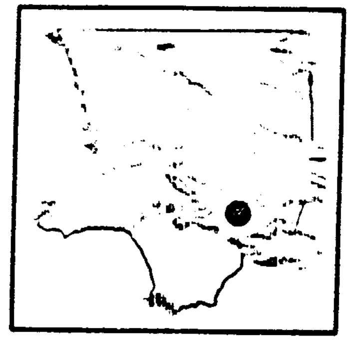
STATION NO. : F263C-R — DRAINAGE AREA : 206.30 SQ. MI.

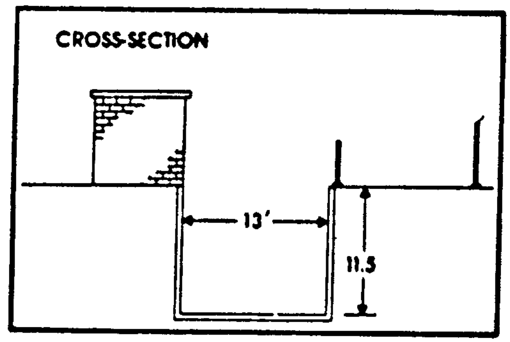
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	1.8	19.7	100.0	52.8	96.1	56.2	9.5	2.1	0.0	0.0	0.7	11.2
	MAX.	28.2	199.0	570.0	151.0	546.0	288.0	79.9	22.1	0.0	0.0	5.3	144.0
	MIN.	0.0	0.0	7.5	1.1	1.5	1.4	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	109.0	1170.0	6169.0	3249.0	5340.0	3457.0	567.0	131.0	0.0	0.0	42.4	664.0

R0053022

SIERRA MADRE WASH
at Highland Oaks Avenue
STATION NO. F267B-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream end of conduit 50 feet below station.
DRAINAGE AREA- 3.8 square miles.
LOCATION- on the south bank of the channel 50 feet above Highland Oaks Avenue, one and one-half miles southeast of Sierra Madre.
REGULATION- partially regulated by Sierra Madre Dam. Usual regulation affects high flows only.
DIVERSIONS- underground and surface flows developed and diverted by Sierra Madre Water Department. Flow also diverted about one mile above station for spreading in Sierra Madre Spreading Grounds.
CHANNEL-rectangular concrete 13 feet wide and 11.5 feet deep.
LENGTH OF RECORD- see station summary.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F267B-R DRAINAGE AREA : 3.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.1	0.2	0.4	0.1	0.7	0.2	0.3	0.3	0.3	0.4	0.4	0.5
	MAX.	0.7	2.7	4.8	0.9	11.1	1.1	0.6	1.0	0.5	0.6	0.7	1.4
	MIN.	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	TOTAL AF	7.1	12.3	25.8	6.5	36.9	10.7	15.1	19.8	17.1	22.4	22.4	30.7

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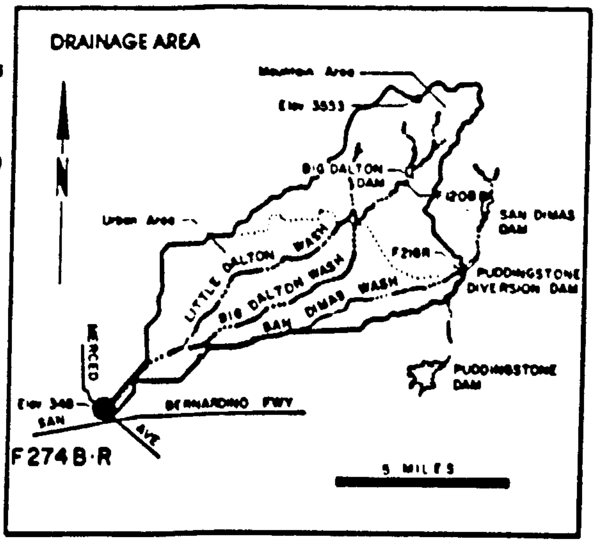
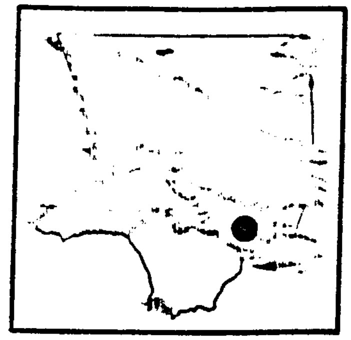
1978

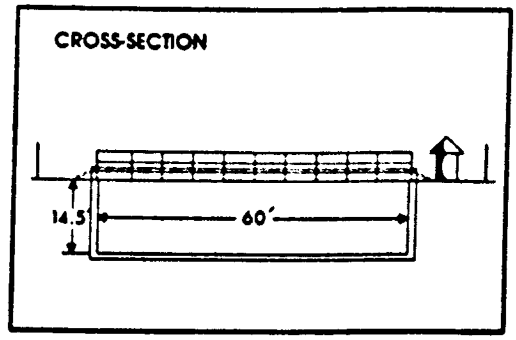
VOL 12

1979

DALTON WASH
at Merced Avenue
STATION NO. F274B-R







RECORDER- 15 minute punched tape.

METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge 100 feet upstream from station.

DRAINAGE AREA- 36.0 square miles, not including the area above Puddingstone Diversion Dam.

LOCATION- on the west bank and upstream of Merced Avenue about 150 feet, about one-half mile above the junction with Walnut Wash and about one mile south of Baldwin Park.

REGULATION- partly regulated by Big Dalton Dam, San Dimas Dam, Puddingstone Diversion Dam, Big Dalton Spreading Grounds, Little Dalton Spreading Grounds, Big Dalton Debris Basin, Little Dalton Debris Basin, and Irwindale Spreading Grounds.

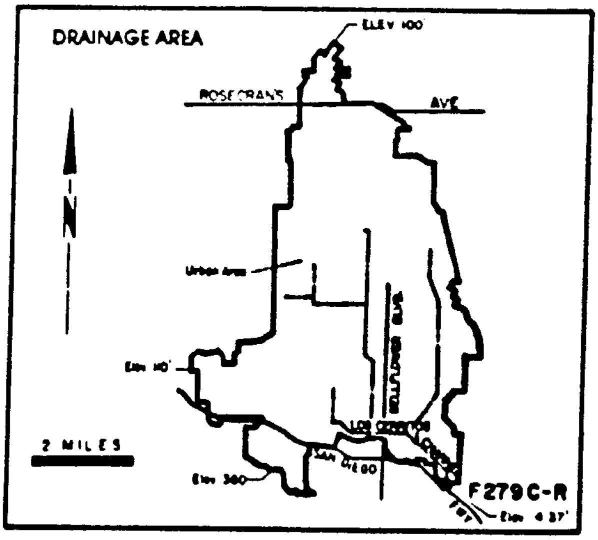
REMARKS- flow may include imported water originating at San Dimas.

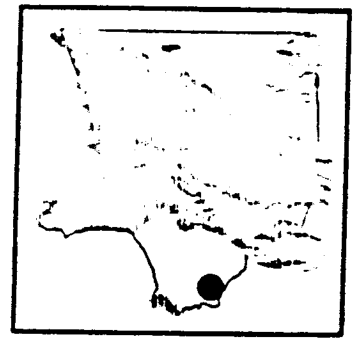
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

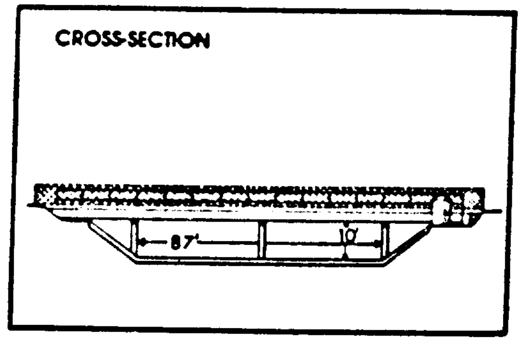
STATION NO. : F274B-R DRAINAGE AREA : 35.95 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	2.9	11.6	84.0	88.1	127.0	102.0	141.0	135.0	121.0	2.0	3.6	7.4
	MAX.	6.9	104.0	286.0	156.0	296.0	246.0	192.0	121.0	275.0	7.1	11.7	38.8
	MIN.	1.6	1.5	3.8	3.7	4.0	4.3	85.7	1.7	1.8	1.3	1.3	1.4
	TOTAL AF	175.0	689.0	5160.0	5419.0	6820.0	6260.0	8392.0	2122.0	7203.0	129.0	222.0	442.0

LOS CERRITOS CHANNEL
at Stearns Street
STATION NO. F279C-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 25.6 square miles.
LOCATION- upstream of Stearns street, Long Beach.
REGULATION- none.
CHANNEL- concrete, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F279-R November 23, 1942 to January 1, 1949. at Station F279B-R January 1, 1949 to May 26, 1955. at Station F279C-R October 26, 1955 to date.
REMARKS- station not in service May 26, 1955 to October 26, 1955 due to channel construction.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F279C-R **DRAINAGE AREA :** 25.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	2.1	5.8	27.2	2.8	9.6	8.9	1.8	1.5	1.0	1.2	1.6	4.3
	MAX.	3.6	55.0	331.0	30.0	90.0	113.0	2.9	2.1	1.8	1.7	2.0	82.9
	MIN.	1.0	0.5	0.2	0.5	0.6	1.2	1.3	0.9	0.4	0.9	1.3	1.3
	TOTAL AF	132.0	343.0	1672.0	169.0	533.0	546.0	109.0	90.8	56.9	71.8	95.2	256.0

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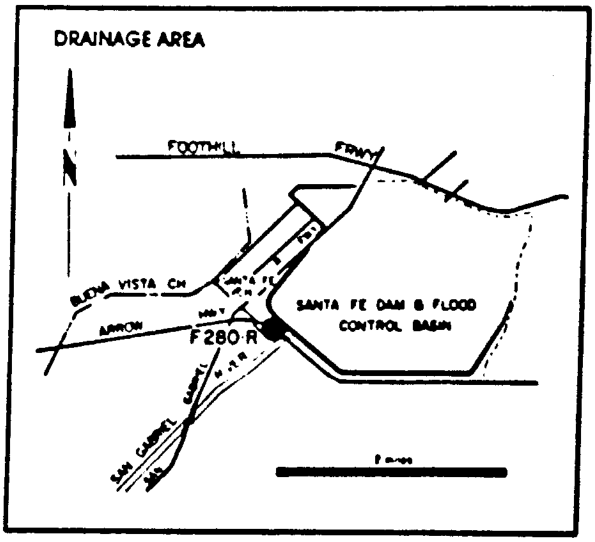
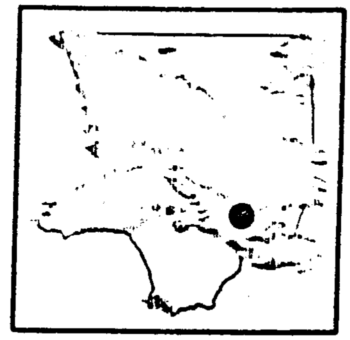
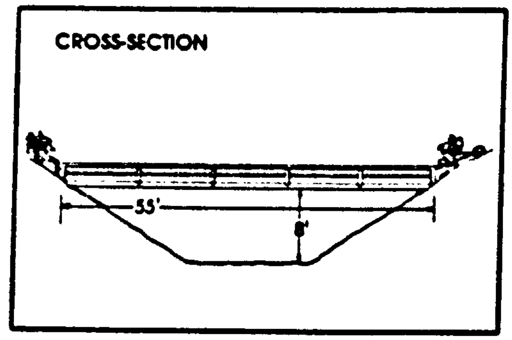
R0053025

SANTA FE CHANNEL
below Santa Fe Dam
STATION NO. F280-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- controlled.
LOCATION- 400.0 feet downstream of Santa Fe Dam outlet and 1.5 miles north of Baldwin Park.
REGULATION- flow regulated by five gates of stilling basin outlet of Santa Fe Dam.
CHANNEL- sand and gravel, natural section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F280-S October 1, 1942 to May 12, 1944. at Station F280-R May 12, 1944 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F280-R | DRAINAGE AREA : CONTROLLED

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	1.7	0.0	0.0	0.0
	MAX.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	7.0	0.0	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	198.0	103.0	0.0	0.0	0.0

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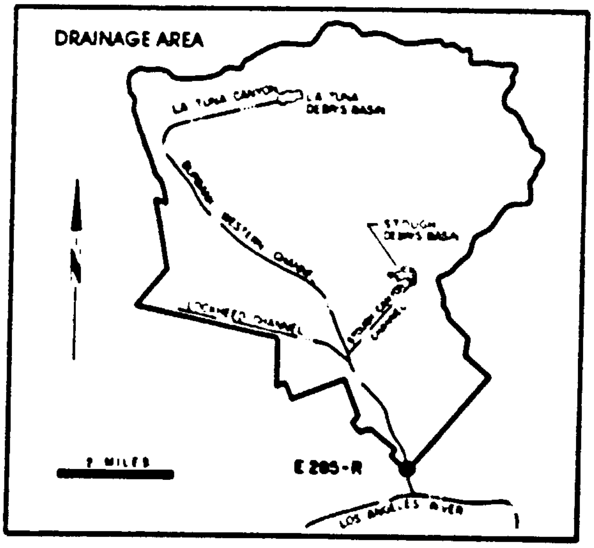
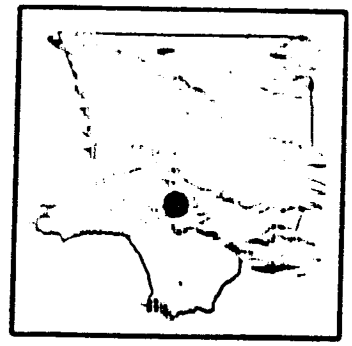
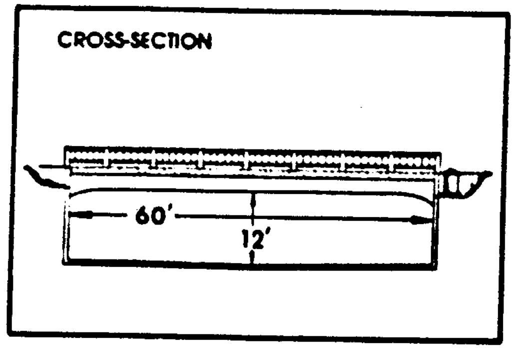
BURBANK-WESTERN ST. DR.
at Riverside Drive
STATION NO. E 285-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading and from bridge.
DRAINAGE AREA- 25.0 square miles.
LOCATION- 20.0 feet upstream from Riverside Drive bridge, Glendale.
REGULATION- Several debris basins on tributaries.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1949 to date.
REMARKS- operated in cooperation with the USCE.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : E285-R　　　　DRAINAGE AREA : 25.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	11.6	16.3	25.9	11.6	21.9	15.3	9.1	7.9	8.4	6.2	8.4	8.3
	MAX.	15.1	54.7	143.0	22.9	194.0	83.2	11.5	10.5	9.4	7.1	11.7	25.2
	MIN.	10.2	11.1	11.3	8.1	10.0	9.0	6.0	5.9	6.7	5.3	6.5	4.4
	TOTAL AF	714.0	969.0	1590.0	713.0	1218.0	942.0	542.0	486.0	502.0	383.0	515.0	494.0

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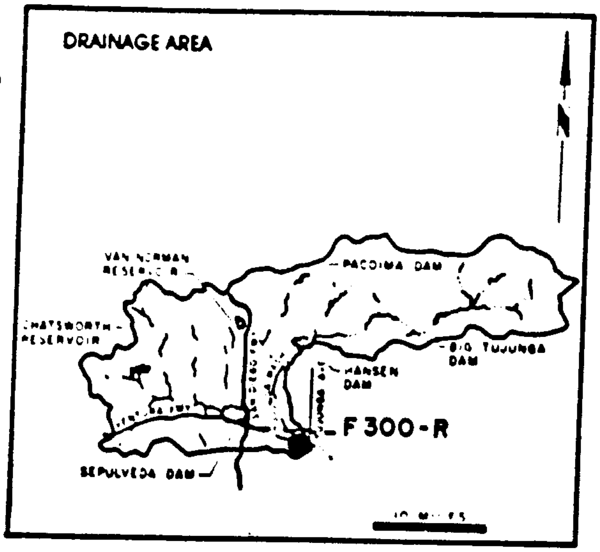
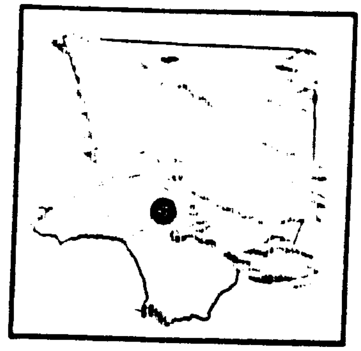
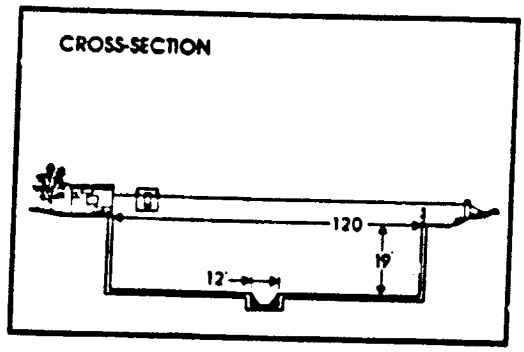
LOS ANGELES RIVER
at Tujunga Avenue
STATION NO. F300-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 401.0 square miles.
LOCATION- 200.0 feet above Tujunga Avenue bridge, Studio City.
REGULATION- flow regulated by Sepulveda, Big Tujunga, Hansen, and Pacoima Dams, Lopez Debris Dam, and Project No. 85 Diversion.
CHANNEL- concrete, rectangular section, 120 feet wide by 19 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- May 8, 1960, to date.
REMARKS- subject to diversions at mouth of Big Tujunga and Pacoima Canyons for irrigation, at Big Tujunga, Branford, Hansen, and Pacoima Spreading Grounds.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F300-R

DRAINAGE AREA : 401.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	79.6	91.5	254.0	94.1	178.0	107.0	73.6	69.8	72.9	74.7	71.7	78.0
	MAX.	83.7	322.0	1460.0	404.0	1260.0	542.0	93.4	74.7	77.4	81.1	76.4	336.0
	MIN.	61.7	62.6	66.6	68.7	75.6	67.3	63.1	65.0	59.8	64.6	66.0	62.8
	TOTAL AF	4896.0	5444.0	15635.0	5805.0	9884.0	6542.0	4380.0	4292.0	4338.0	4590.0	4411.0	4642.0

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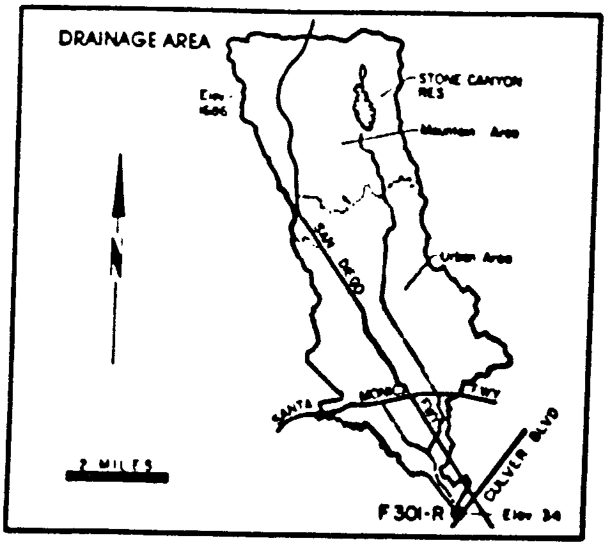
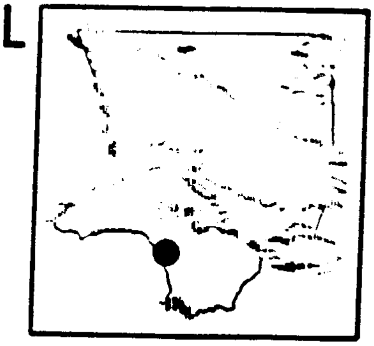
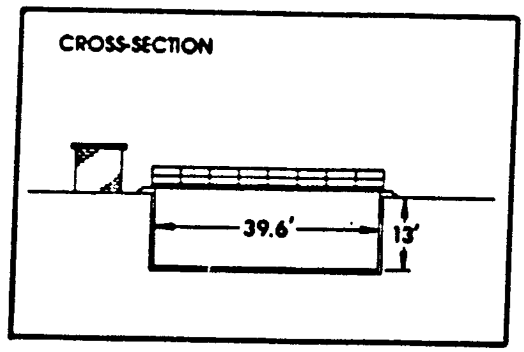
SAWTELLE-WESTWOOD CHANNEL
above Culver Boulevard
STATION NO. F301-R







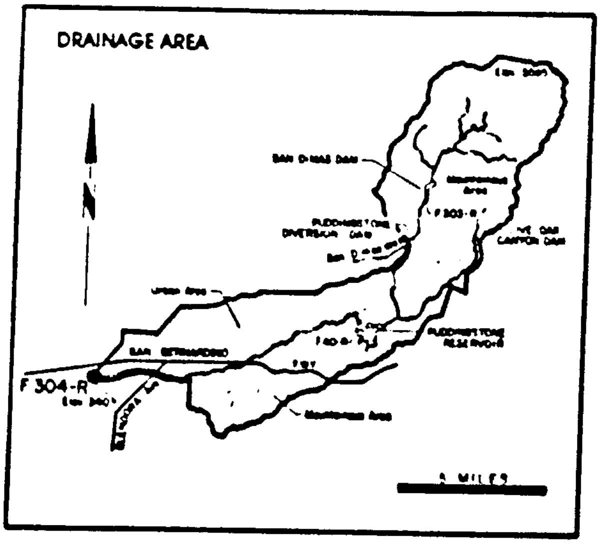
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge at station.
DRAINAGE AREA- 22.96 square miles.
LOCATION- on the south channel wall, 141 feet above Culver Boulevard bridge about one and one half miles southwest of Culver City.
REGULATION- Stone Canyon Reservoir, Southern California Water Company spills flow up to 5.0 second-feet into Sawtelle-Westwood Channel above Charnock Road for short periods nearly every day.
CHANNEL- rectangular concrete channel 40 feet wide and 13 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- see station summary.

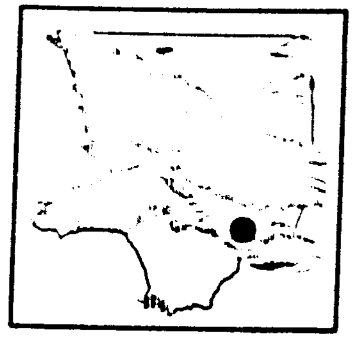
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

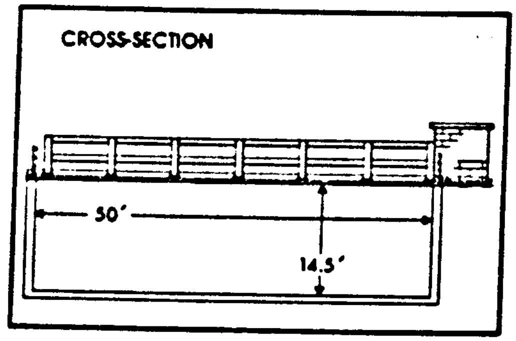
STATION NO. : F301-R — DRAINAGE AREA : 22.96 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	11.0	11.5	34.0	5.9	14.6	10.0	4.7	3.4	4.9	4.8	4.0	5.2
	MAX.	17.0	64.1	206.0	60.3	178.0	118.0	8.9	7.3	7.4	6.5	7.4	20.2
	MIN.	4.7	5.2	4.5	2.6	3.1	2.9	3.6	1.5	3.3	3.3	2.7	2.9
	TOTAL AF	682.3	683.0	2096.0	362.0	812.0	616.0	281.0	208.0	290.0	294.0	247.0	309.0

WALNUT CREEK
above Puente Avenue
STATION NO. F304-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 57.6 square miles.
LOCATION- 845.0 feet upstream of Puente Avenue bridge, Baldwin Park.
REGULATION- partially regulated by San Dimas, Puddingstone Diversion, Puddingstone, and Live Oak Dams.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 14, 1952 to April 11, 1961, January 3, 1962 to date.
REMARKS- no record during April 11, 1961 to January 3, 1962 due to channel construction.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F304-R

DRAINAGE AREA : 57.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	1.8	0.0	0.1	18.4	5.9	0.3	0.1	.04	.04	0.0	1.7
	MAX.	.01	24.9	0.0	0.4	157.0	115.0	0.9	0.8	0.4	0.7	0.1	33.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	.02	108.0	0.0	3.6	1020.0	363.0	15.1	5.0	2.4	2.4	0.6	102.0

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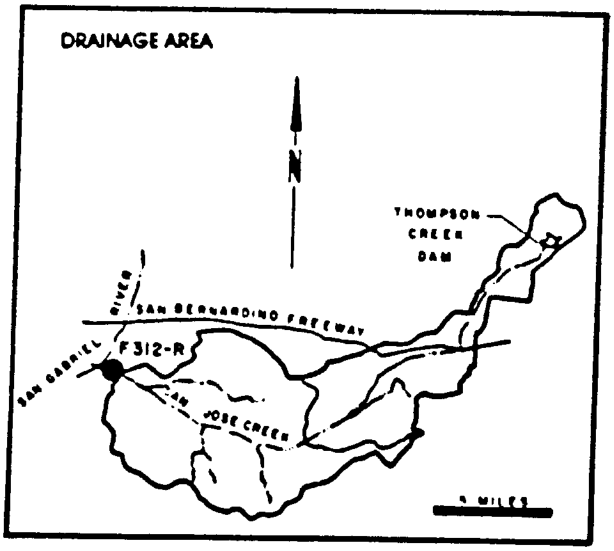
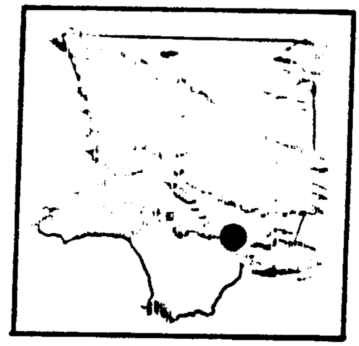
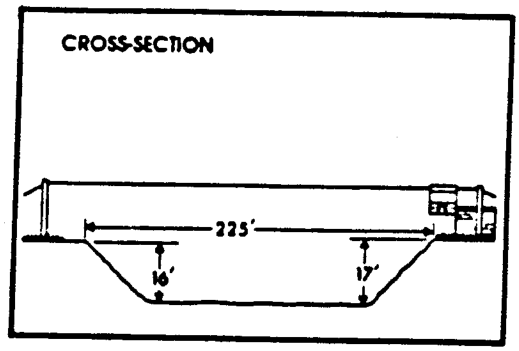
R0053030

SAN JOSE CHANNEL
above Workman Mill Road
STATION NO. F312-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 83.4 square miles.
LOCATION- 1,650 feet above Workman Mill Road, 3.0 miles southeast of El Monte.
REGULATION- partially regulated by Thompson Creek Dam and Pomona Sewage Treatment Plant.
CHANNEL- grouted rip-rap side slopes with natural bottom, trapezoidal section.
CONTROL- rock stabilizer.
LENGTH OF RECORD- September 13, 1965 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F312-R — DRAINAGE AREA : 83.40 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	9.8	30.0	190.0	89.6	113.0	33.7	12.8	10.5	31.5	141.0	19.7	19.1
	MAX.	13.7	321.0	1100.0	179.0	714.0	398.0	27.7	14.2	125.0	160.0	153.0	181.0
	MIN.	7.7	8.9	15.7	13.4	15.6	11.3	7.4	8.6	8.7	-122.0	8.9	8.7
	TOTAL AF	[illegible]	1787.0	11685.0	5506.0	6296.0	2071.0	764.0	649.0	1874.0	8666.0	1214.0	1139.0

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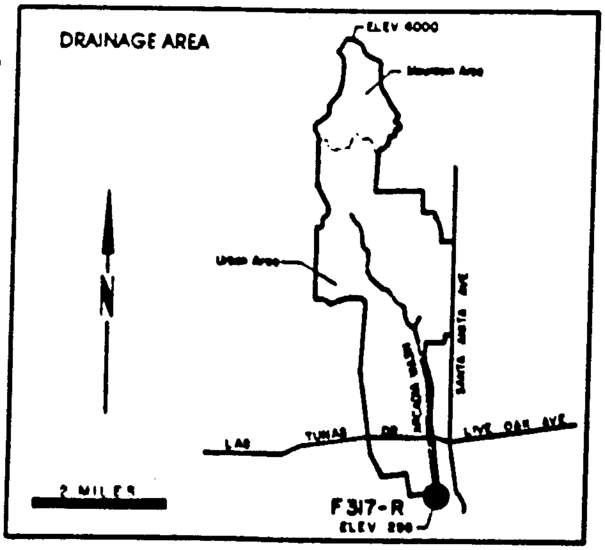
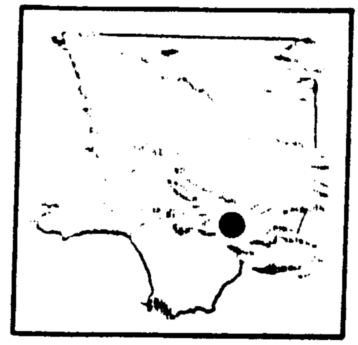
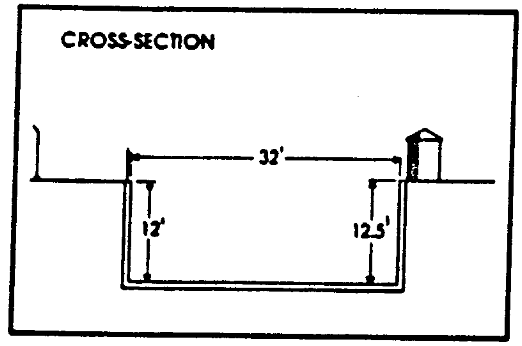
1 9726

R0053031

ARCADIA WASH
below Grand Avenue
STATION NO. F317-R







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RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of Grand Avenue bridge.
DRAINAGE AREA- 8.5 square miles.
LOCATION- on the west wall of Arcadia Wash about 75 feet downstream from centerline of Grand Avenue.
REGULATION- several debris basins located upstream.
CHANNEL- rectangular concrete.
LENGTH OF RECORD- December 12, 1955 to date.

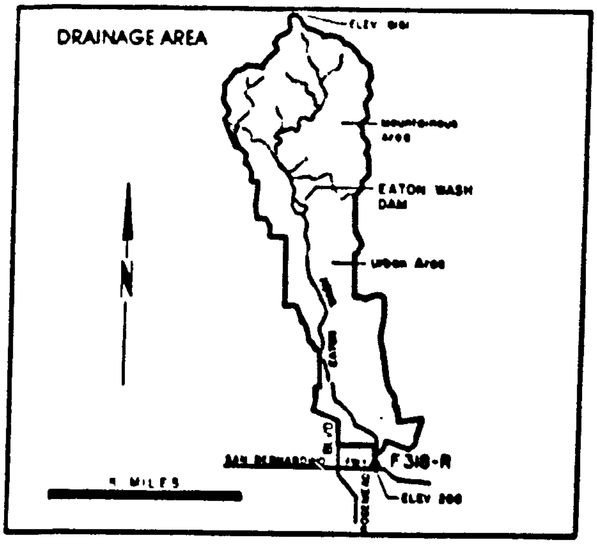
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

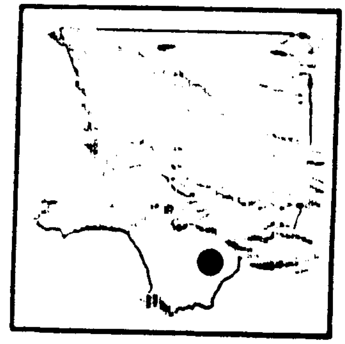
STATION NO. : F317-R

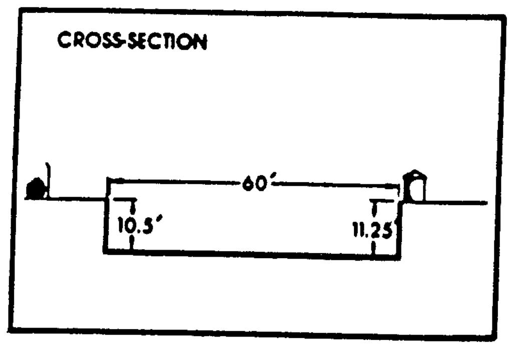
DRAINAGE AREA : 8.50 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.7	5.2	12.5	2.6	10.5	3.9	0.7	0.9	0.5	2.4	0.4	2.1
	MAX.	1.4	58.8	112.0	60.9	114.0	54.6	1.5	8.0	0.7	11.8	0.7	28.8
	MIN.	0.1	0.2	0.1	0.2	0.2	0.2	0.4	0.2	0.2	0.4	0.2	0.2
	TOTAL AF	41.3	307.0	768.0	157.0	551.0	235.6	41.9	55.7	31.9	149.0	22.8	125.8

EATON WASH
at Loftus Drive
STATION NO. F318-R







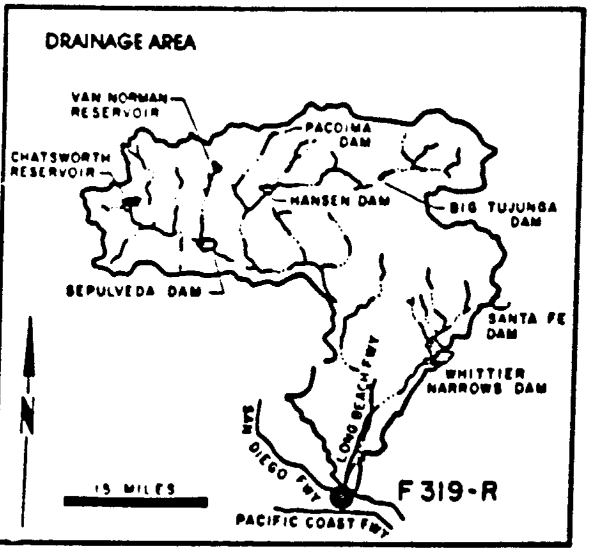
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of East Loftus Drive bridge.
DRAINAGE- 22.8 square miles.
LOCATION- on the west wall of the channel 52 feet above the centerline of East Loftus Drive bridge, 1.3 miles west of El Monte.
REGULATION- partly regulated by Eaton Dam.
DIVERSIONS- the Pasadena Water Department diverts some water just above the mouth of Eaton Canyon. The Flood Control District diverts water to spreading grounds below Eaton Dam and below Huntington Drive.
CHANNEL- rectangular concrete, 60 feet wide, 11.3 feet.
CONTROL- channel forms control.
LENGTH OF RECORD- 1956 to date.

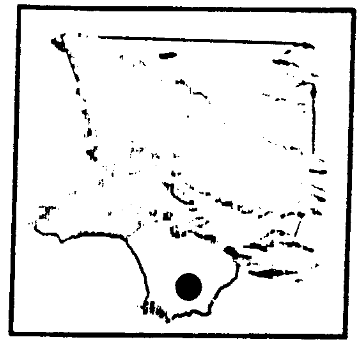
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

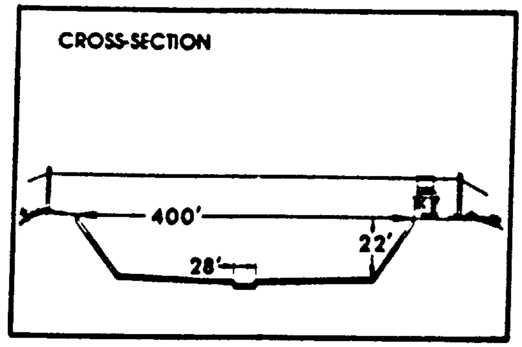
STATION NO. : F318-R DRAINAGE AREA : 22.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.2	4.8	15.4	2.0	6.6	2.7	0.2	0.4	0.2	0.2	0.2	2.6
	MAX.	0.2	93.5	172.0	46.1	88.7	47.0	1.5	6.6	0.3	0.5	0.3	53.2
	MIN.	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2
	TOTAL AF	12.3	285.0	946.0	126.0	367.0	153.0	13.5	22.8	11.1	13.3	12.3	154.0

LOS ANGELES RIVER
below Wardlow Road
STATION NO. F319-R







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RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 815.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 900.0 feet below Wardlow Road, Long Beach.
REGULATION- flow is subject to the same regulation as Stations F34D-R and P458-R.
DIVERSIONS- flows diverted to Dominguez Gap Spreading Grounds.
CHANNEL- trapezoidal, concrete, 302.0 feet wide at bottom with 2.25:1 side slopes. Low flow channel 28.0 feet wide by 1.0 foot deep in center of channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F180-R October 31, 1931 to January 13, 1956. at Station F319-R January 13, 1956 to date.
REMARKS- prior to 1931, see Station F36-R.

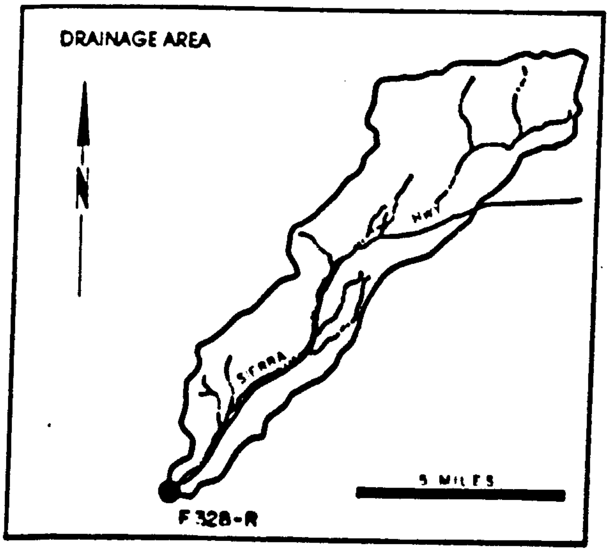
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

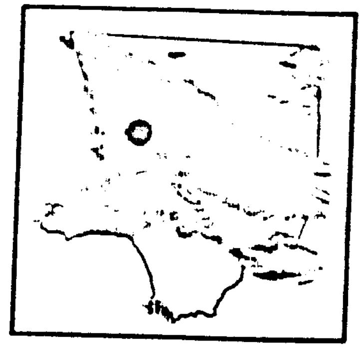
STATION NO. : F319-R   DRAINAGE AREA : 815.00 SQ. MI.

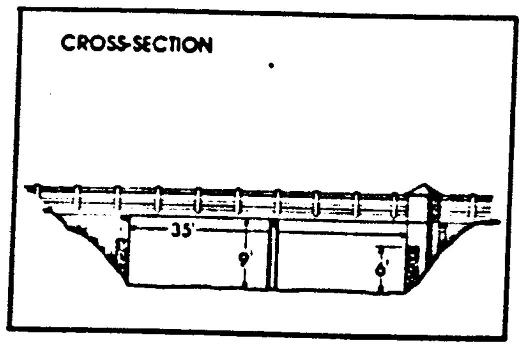
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	109.0	164.0	551.0	178.0	337.0	198.0	137.0	127.0	128.0	130.0	136.0	152.0
	MAX.	119.0	1120.0	3740.0	889.0	2440.0	1110.0	177.0	178.0	137.0	137.0	139.0	821.0
	MIN.	101.0	107.0	112.0	119.0	116.0	118.0	116.0	114.0	120.0	-120.0	126.0	124.0
	TOTAL AF	6732.0	9784.0	33858.0	10957.0	18720.0	12186.0	8168.0	7815.0	7591.0	7978.0	8384.0	9072.0

R0053034

MINT CANYON CREEK
at Finch Avenue
STATION NO. F328-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 26.9 square miles.
LOCATION- 8.5 miles northeast of Saugus on west end of Finch Avenue bridge.
REGULATION- none.
CHANNEL- natural, sand and gravel.
CONTROL- concrete control at downstream end of bridge.
LENGTH OF RECORD- October 26, 1956 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F328-R DRAINAGE AREA : 26.90 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.0	0.8	0.7	0.1	0.8	0.1	.03	0.0	0.1	0.1	.02	0.4
	MAX.	0.0	1.4	12.3	1.3	19.0	1.3	0.1	0.0	0.8	1.5	0.4	6.4
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	1.6	44.4	3.2	42.1	3.6	2.0	0.0	3.0	4.0	1.0	22.8

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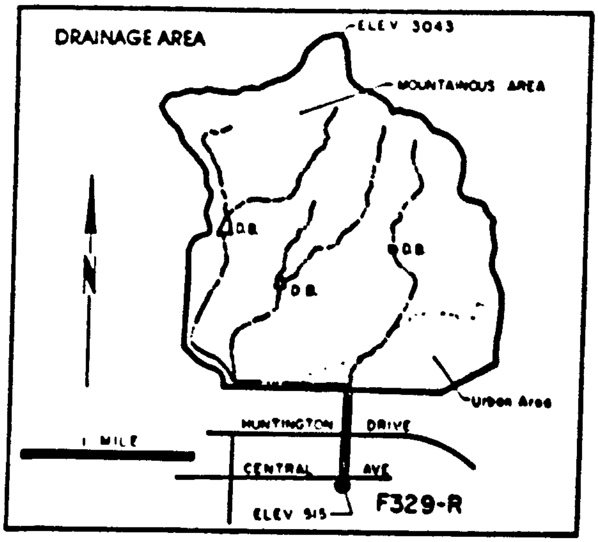
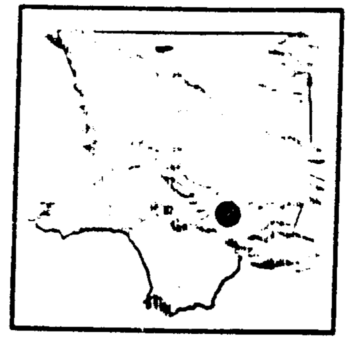
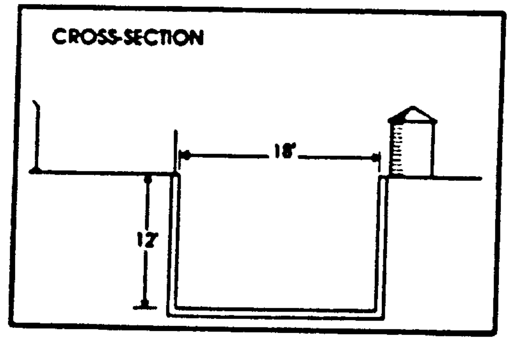
BRADBURY CHANNEL
below Central Avenue
STATION NO. F329-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENT- low flows measured by wading. High flows measured from footbridge four feet downstream from recorder.
DRAINAGE AREA- 3.3 square miles.
LOCATION- on the east wall of Bradbury Channel, 200 feet downstream from the centerline of Central Avenue, one mile east of Duarte.
REGULATION- two debris basins located upstream.
CHANNEL- rectangular concrete, 18 feet wide, 12 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- June 14, 1957 to present.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F329-R

DRAINAGE AREA : 3.30 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.6	1.7	1.9	.03	1.4	0.9	1.6	1.7	0.5	0.4	0.4	1.7
	MAX.	1.5	7.9	16.3	.03	25.3	4.8	2.8	5.8	1.3	1.7	1.4	6.8
	MIN.	.06	.03	.03	.03	0.1	0.3	0.4	0.5	0.1	0.1	0.1	0.1
	TOTAL AF	35.2	96.0	117.0	1.8	78.0	54.5	92.4	103.0	30.1	22.4	22.6	99.8

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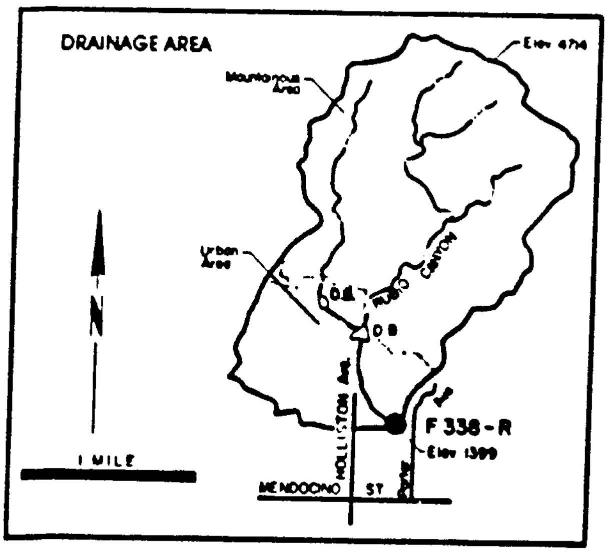
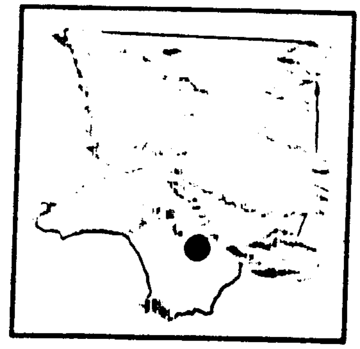
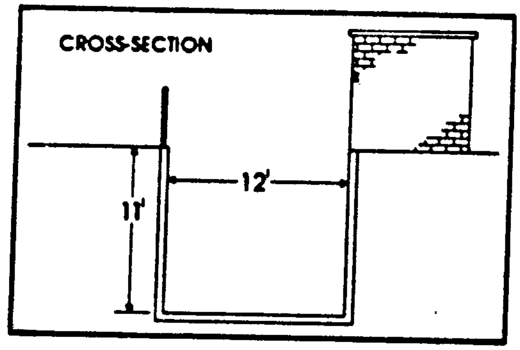
R0053036

RUBIO DIVERSION CHANNEL
below Goosebury Inlet
STATION NO. F338-R







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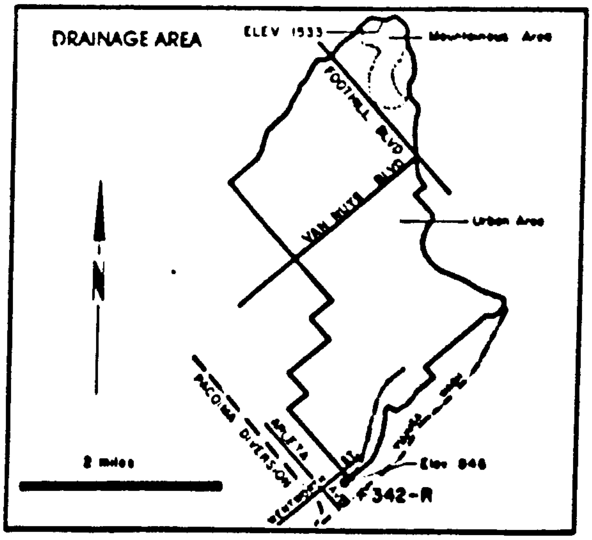
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from steel footbridge 27 feet above station.
DRAINAGE AREA- 2.1 square miles.
LOCATION- on the north bank, 375 feet upstream of Crest Drive, three and one-half miles northeast of Pasadena.
REGULATION- flow partially regulated by Rubio and Gooseberry Debris Basins.
DIVERSIONS- Rubio Canyon Land and Water Association diverts low flows in Rubio Canyon.
CHANNEL- rectangular concrete, 12 feet wide and 11 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- December 16, 1959 to date.

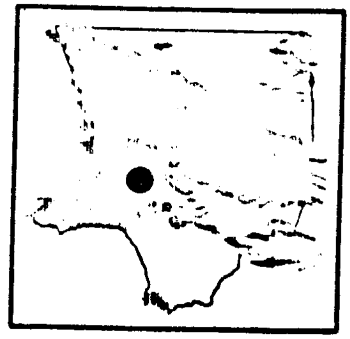
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

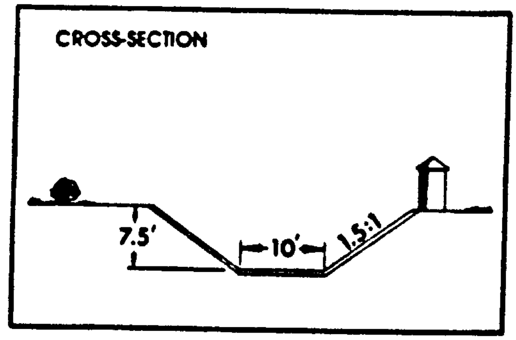
STATION NO. : F338-R DRAINAGE AREA : 2.10 SQ. MI

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.2	0.3	0.9	0.5	1.1	0.9	1.8	1.9	2.1	0.5	0.1	0.2
	MAX.	0.4	2.7	3.6	2.6	6.0	5.5	2.3	2.5	2.8	2.4	0.1	2.0
	MIN.	0.0	0.0	0.0	0.0	0.1	0.1	1.6	1.6	2.0	0.0	0.0	0.0
	TOTAL AF	12.1	18.4	54.5	33.1	60.7	54.5	108.0	116.0	126.0	33.3	3.2	11.9

BRANFORD STREET CHANNEL
below Sharp Avenue
STATION NO. F342-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured by floats.
DRAINAGE AREA- 5.01 square miles.
LOCATION- on the south bank of channel, 125 feet downstream from Sharp Avenue, about 3.6 miles south of San Fernando.
REGULATION- flow from Lopez Creek is diverted to Hansen Dam at the mouth of Lopez Canyon.
CHANNEL- trapezoidal, 10 feet wide at bottom and 7.5 feet deep with 1.5 to 1 side slopes.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1962 to date.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F342-R

DRAINAGE AREA : 5.01 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	.06	0.7	3.4	0.3	2.5	0.6	.06	.05	.01	0.0	.01	0.3
	MAX.	0.2	8.5	30.2	7.8	27.6	12.5	1.0	0.6	0.2	0.1	0.2	8.6
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	3.5	42.2	206.0	18.2	141.0	35.6	4.0	3.4	0.6	0.2	0.6	19.6

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LIMEKILN CREEK
above Aliso Creek
STATION NO. F350-R

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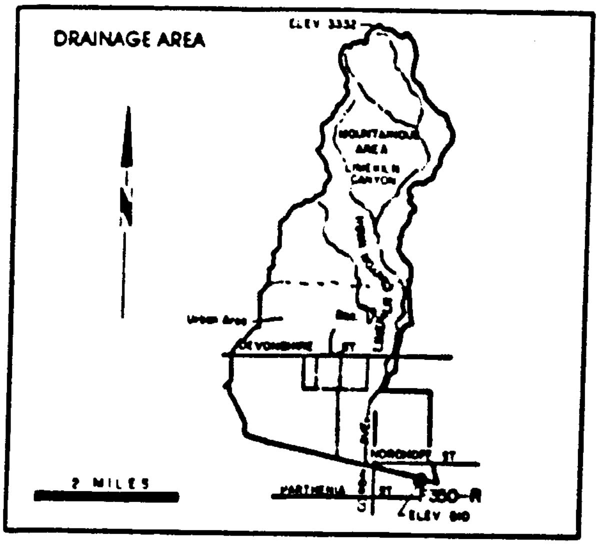

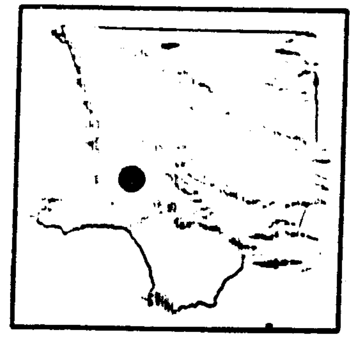

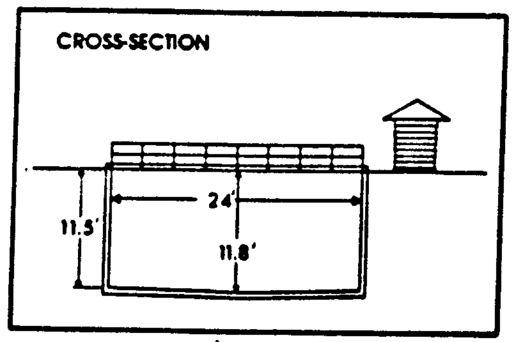

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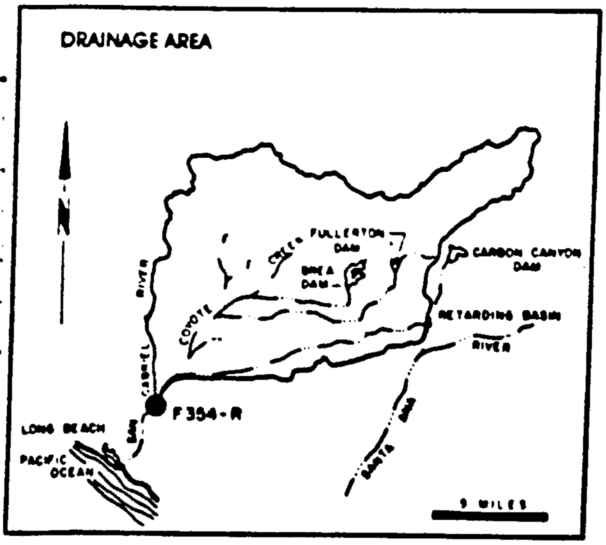
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from a steel footbridge 10 feet above the gage.
DRAINAGE AREA- 10.3 square miles.
LOCATION- on the south bank, 1,600 feet above Aliso Creek and one mile west of Northridge.
REGULATION- flow partly regulated by Limekiln Debris Basin.
CHANNEL- rectangular concrete.
LENGTH OF RECORD- see station summary.

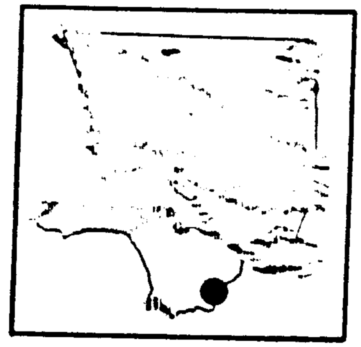
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

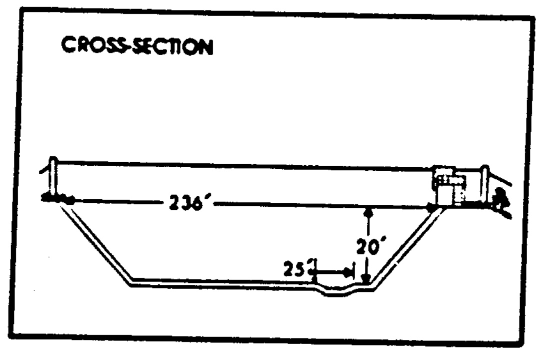
STATION NO. : F350-R DRAINAGE AREA : 10.30 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.3	1.4	9.5	1.5	5.0	2.3	0.6	0.3	0.5	0.6	0.6	1.1
	MAX.	0.4	13.7	84.3	31.1	48.7	36.5	3.4	0.9	1.1	1.5	1.0	13.7
	MIN.	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.3
	TOTAL AF	15.0	81.7	581.0	93.6	278.0	141.0	33.3	18.6	30.3	36.9	39.1	67.2

COYOTE CREEK
.. below Spring Street
STATION NO. F354-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 185.0 square miles.
LOCATION- 241.0 feet below Spring Street, 7.5 miles northeast of Long Beach.
REGULATION- partially regulated by Fullerton Dam, Brea Dam, and Carbon Canyon Dam.
CHANNEL- concrete, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD - December 17, 1963 to date.
REMARKS - previous gaging stations for record correlation: Station F41 - S December 1, 1928 to January 14, 1930. Station F41 - R January 14, 1930 to October 30, 1936. Station F41B - R October 30, 1936 to February 17, 1937. Station F41C - R February 18, 1937 to February 8, 1956. Station F320 - R February 9, 1956 to July 2, 1965.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F354-R DRAINAGE AREA : 185.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	13.5	32.0	195.0	31.5	112.0	72.8	12.1	9.1	13.2	9.4	7.6	35.4
	MAX.	26.2	450.0	1350.0	208.0	796.0	1360.0	120.0	16.8	33.3	16.5	8.5	796.0
	MIN.	3.1	3.0	5.2	7.3	5.7	3.1	6.0	5.8	5.4	5.9	6.6	4.0
	TOTAL AF	829.0	1900.0	11970.0	1939.0	6246.0	4476.0	723.0	560.0	783.0	575.0	468.0	2106.0

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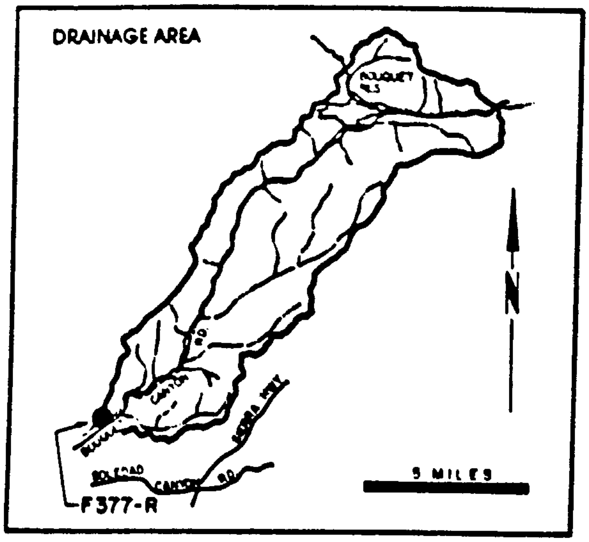
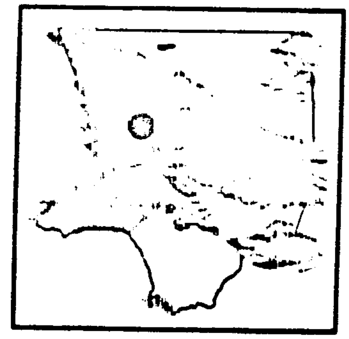
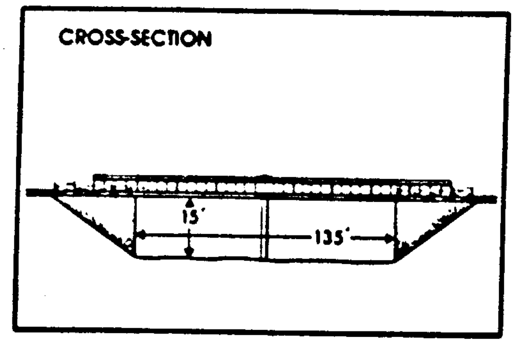
BOUQUET CANYON CREEK
at Urbandale Avenue
STATION NO. F377-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 51.9 square miles.
LOCATION- Bouquet Canyon Creek at Urbandale Avenue, 3.5 miles northeast of Saugus.
REGULATION- Bouquet Reservoir.
CHANNEL- concrete sides with natural bottom, trapezoidal in section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- October 11, 1967 to date.

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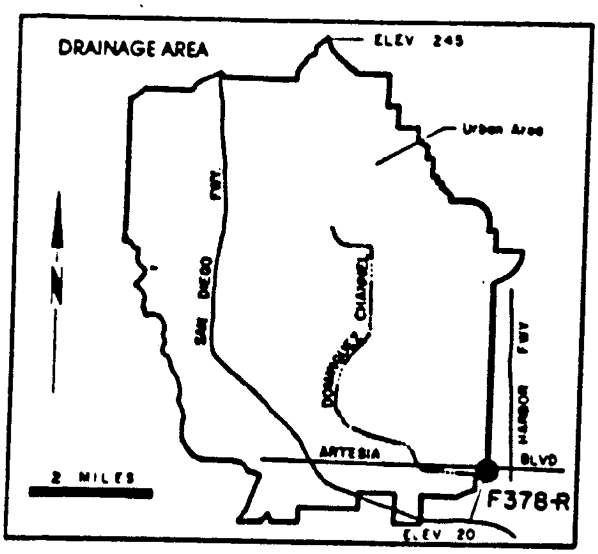
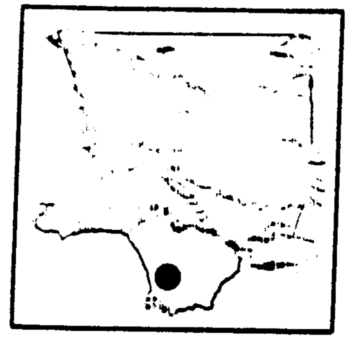
WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

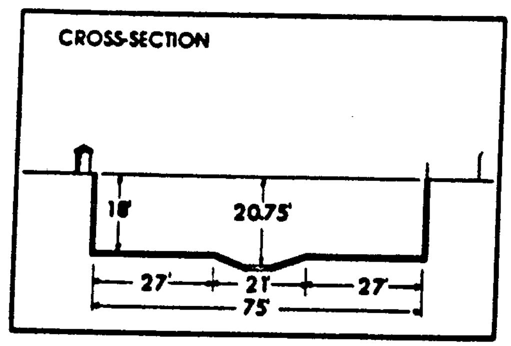
STATION NO. : F377-R   DRAINAGE AREA : 51.90 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN	0.1	0.0	7.3	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1
	MAX.	0.1	0.1	137.0	0.0	1.4	2.4	0.0	0.1	0.0	0.4	0.0	1.7
	MIN.	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	6.2	1.8	447.0	0.0	9.7	5.2	0.0	0.2	0.0	1.6	0.0	3.4

DOMINGUEZ CHANNEL
at Vermont Avenue
STATION NO. F378-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS-low flows measured by wading. High flows measured from Vermont Avenue bridge.
DRAINAGE AREA- 37.1 square miles.
LOCATION- on the south bank, 93 feet above Vermont Avenue, about one mile south of Gardena.
REGULATION- none
CHANNEL- rectangular concrete with trapezoidal low flow channel at center.
LENGTH OF RECORD- November 23, 1966 to date.
REMARKS- gage is affected by tides greater than 4.0 feet above mean lower low water.

WATER YEAR : 1988 - 89
(DISCHARGE IN SEC-FT)

STATION NO. : F378-R

DRAINAGE AREA : 22.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 88-89	MEAN MAX. MIN.	NO	DATA	AVAILABLE		24.0 350.0 1.7	16.4 215.0 2.2	2.5 11.7 1.3	1.9 2.6 1.3	1.6 2.1 1.3	2.2 3.7 1.6	1.9 2.5 1.6	3.8 42.0 1.2
	TOTAL AF					1335.0	1010.0	150.0	117.0	97.0	138.0	113.0	228.0

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RESERVOIRS

RESERVOIRS

Following the damaging flood of 1914 and creation of the Los Angeles County Flood Control District in 1915, it initiated a program of flood control and water conservation including the construction of 14 dams. These dams were operated by the Department during the period covered by this report. In addition, five Corps of Engineers' dams and Morris Dam owned by The Metropolitan Water District were utilized to achieve flood control and water conservation. The Corps of Engineers' dams are: Hansen Dam on Tujunga Wash, Sepulveda Dam on the Los Angeles River, Santa Fe Dam on the San Gabriel River, Whittier Narrows Dam serving both the Rio Hondo and San Gabriel River, and San Antonio Dam on San Antonio Creek.

OPERATION

The reservoirs are operated to control flood waters during storm periods. Post storm releases are made, when feasible, in amounts which can be conserved in downstream spreading grounds and by channel percolation.

SAN GABRIEL DAM HYDROELECTRIC PLANT

In December 1987, construction of two hydroelectric generator units at San Gabriel Dam was completed by San Gabriel Hydroelectric Partnership, a joint venture between private investors and the County of Los Angeles. The generator units are operated by Department personnel and the power generated is purchased by Southern California Edison Company. During the report period, over four and one-half million kilowatt-hours of energy have been generated resulting in revenues of over $330,000. Recently an optimization computer was installed on Unit 1 to schedule power production during hours of peak energy demand.

RECORDS

The storage and flow records at the 14 Department reservoirs are summarized on the Dam Operation Record Sheets. The sheets show:

1. Reservoir water surface elevations based on the spillway datum. Elevations are obtained from water stage recorder graphs or interpolation from staff gage readings and recorded as of midnight of each day. Only maximum and minimum water surface elevations for each year are shown.

2. Storage in acre-feet based on the most recent topographic surveys. Annual storage volumes are shown.

3. Inflow in cubic feet per second. This is usually calculated from storage change and known outflow. When outflow is not known, the inflow may be determined from gaging station records or interpolated between measurements. Only the maximum and minimum of the daily flow rates for the year and the instantaneous peak flow rate are shown.

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4. Outflow in cubic feet per second. These values are determined from gaging station records, known valve openings and rating curves, or from storage change and known inflow. Only the maximum and minimum of the daily outflow rates for the year and the instantaneous peak outflow rate are shown.

5. Discrepancies between outflow and storage losses at certain dams are attributable to percolation and/or evaporation losses. Total monthly evaporation losses are determined from the measurements made on floating or land evaporation pans. In those cases where no allowances were made for evaporation, the amounts are necessarily included in the flow values. Accuracy of the flow records computed from storage records is dependent on the frequency with which storage data are revised to keep in step with the physical change in reservoirs.

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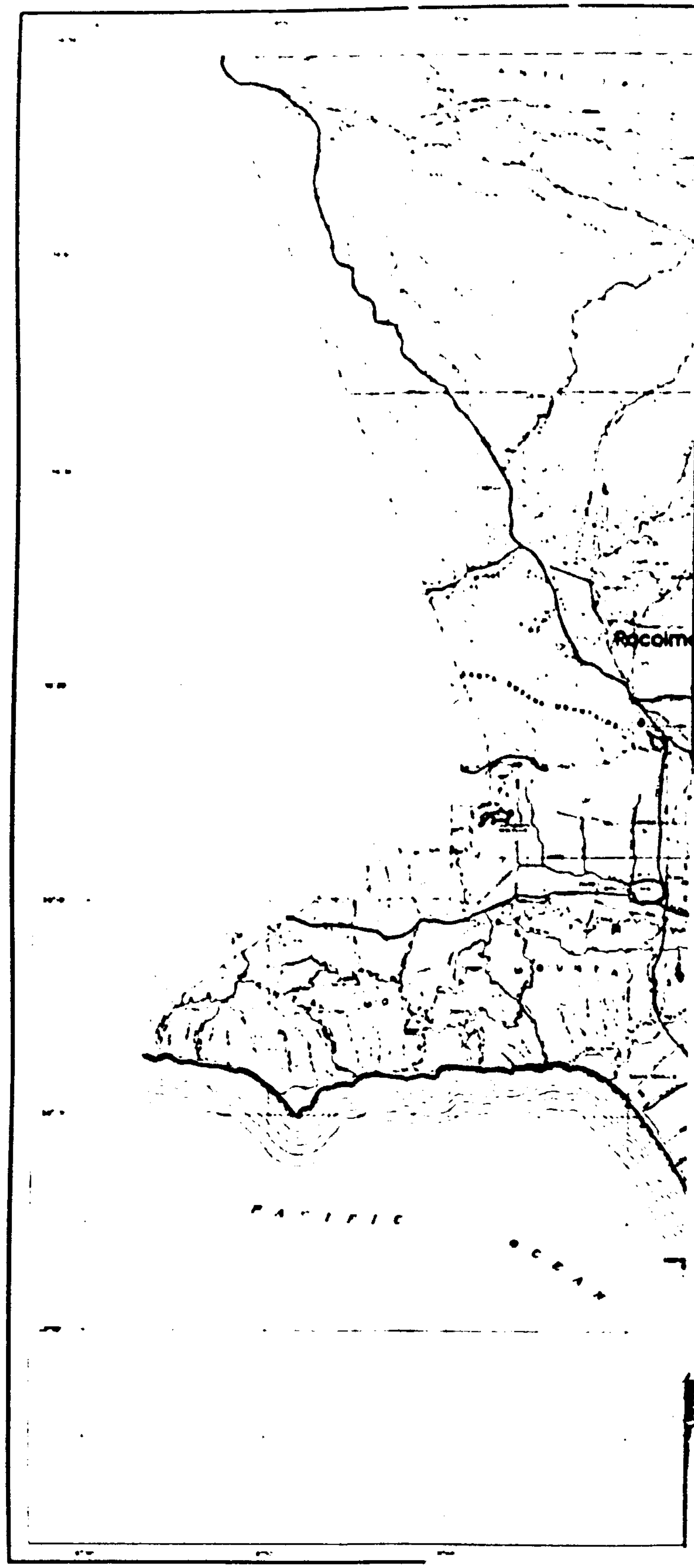

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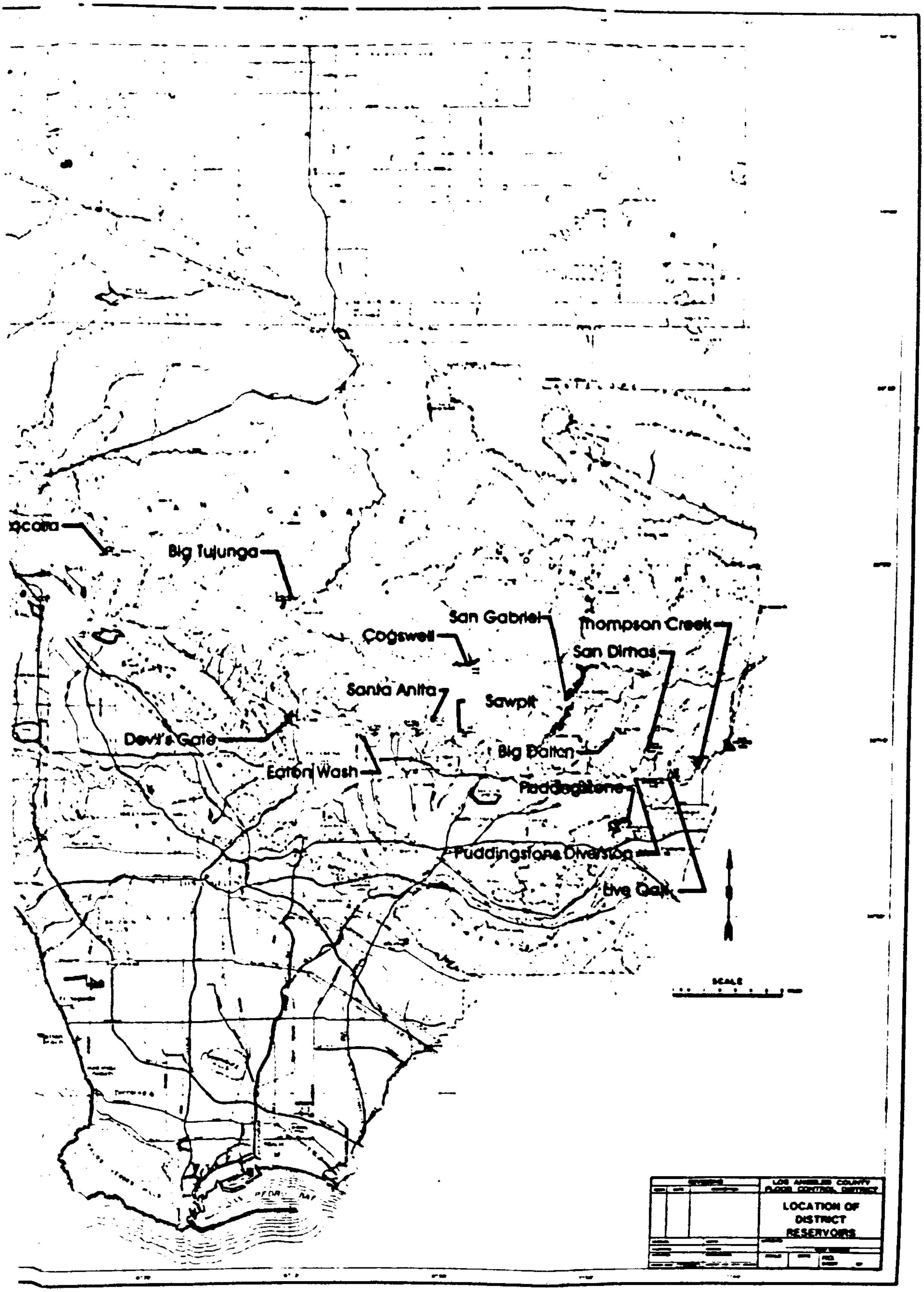

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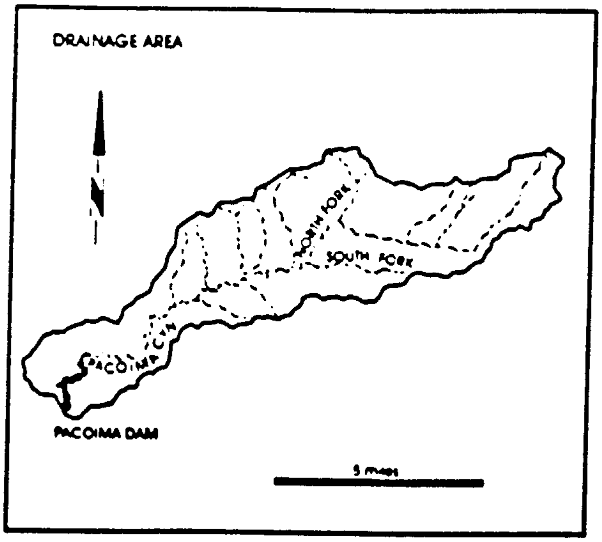
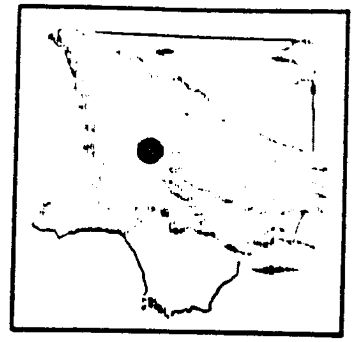
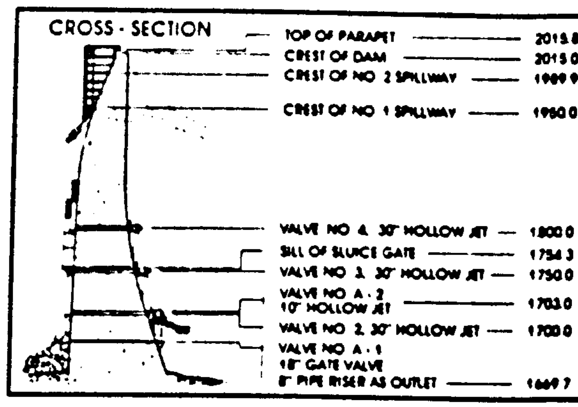
PACOIMA DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1925. Completed February 1929
LOCATION - Pacoima Canyon, 4.0 miles northeast of San Fernando
DRAINAGE AREA - 28.2 square miles.
CAPACITY - 3,929 acre - feet.
SPILLWAY ELEVATION - 1,950.0 feet.

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1 9743

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	72.12	CFS	from	2000	on	02-04-89	to	2100	on	02-04-89
MAX. PEAK OUTFLOW	312.00	CFS	from	0700	on	12-21-88	to	0755	on	12-21-88
MAX. W.S. ELEVATION	1920.32	feet	on	02-13-89	STORAGE	2334.00	ACRE-FEET			
MIN. W.S. ELEVATION	1888.80	feet	on	varies	STORAGE	1299.20	ACRE-FEET			

PACOIMA DAM OPERATION RECORD SUMMARY

WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	19.30	28.20	421.10	272.60
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	36.10	183.10
MAX. MEAN DAILY INFLOW (CFS)	0.60	3.30	27.60	17.30
TOTAL MONTHLY LOSSES (AF)	14.00	12.60	13.90	16.40
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.10	0.30	2.10
MONTHLY STORAGE CHANGE (AF)	5.30	15.60	371.10	73.10

WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1001.70	355.50	140.70	50.40
TOTAL MONTHLY OUTFLOW (AF)	1062.50	575.00	208.40	0.00
MAX. MEAN DAILY INFLOW (CFS)	40.20	12.50	13.60	1.30
TOTAL MONTHLY LOSSES (AF)	12.20	15.50	16.80	13.50
MIN. MEAN DAILY INFLOW (CFS)	2.80	0.50	0.50	0.40
MONTHLY STORAGE CHANGE (AF)	-73.10	-235.10	-84.50	36.90

WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	37.70	31.10	13.00	27.60
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	1.10	0.60	0.50	1.40
TOTAL MONTHLY LOSSES (AF)	15.30	21.70	11.60	23.20
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.40	0.00	0.20
MONTHLY STORAGE CHANGE (AF)	22.40	9.30	1.40	4.40

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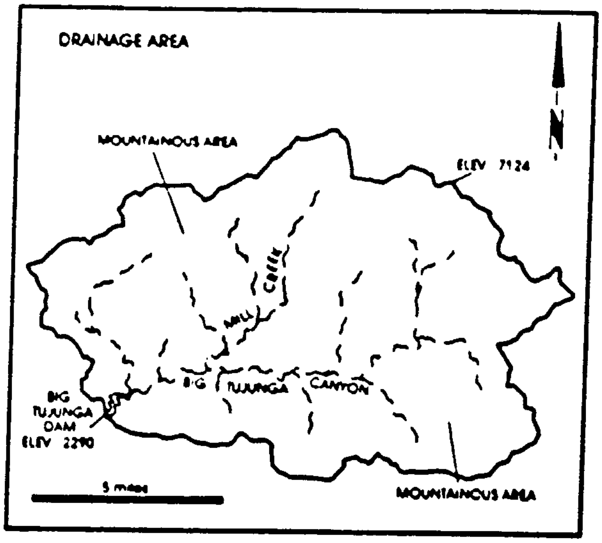
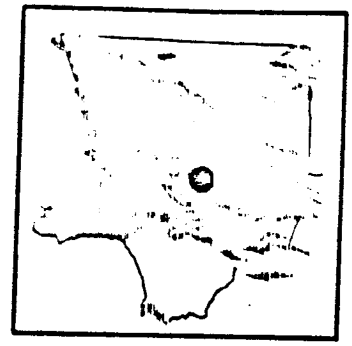
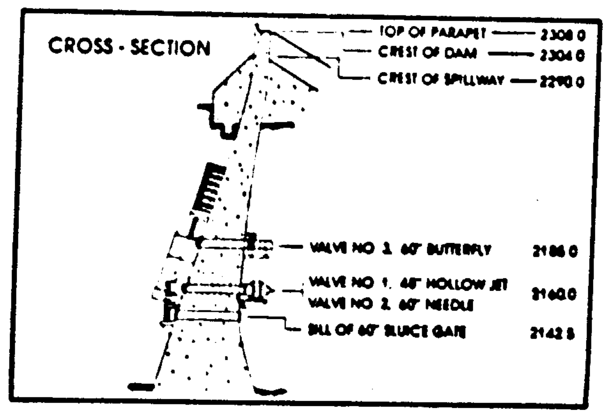
BIG TUJUNGA DAM
AND RESERVOIR







PURPOSE - Flood Control Conservation.
DATE CONSTRUCTED - Started January 1930. Completed July 1931.
LOCATION - Big Tujunga Canyon, 10.0 miles northeast of Sunland.
DRAINAGE AREA - 82.3 square miles.
CAPACITY - 6,027 acre - feet.
SPILLWAY ELEVATION - 2,290.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	131.16	CFS	from	0600	on	02-10-89	to	0700	on	02-10-89
MAX. PEAK OUTFLOW	240.00	CFS	from	1045	on	03-06-89	to	1100	on	03-06-89
MAX. W.S. ELEVATION	2260.00	feet	on	02-28-89	STORAGE	3483.60	ACRE-FEET			
MIN. W.S. ELEVATION	2204.75	feet	on	varies	STORAGE	1046.20	ACRE-FEET			

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BIG TUJUNGA DAM OPERATION RECORD SUMMARY

WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	192.00	210.60	743.80	597.70
TOTAL MONTHLY OUTFLOW (AF)	206.20	116.70	155.20	157.40
MAX. MEAN DAILY INFLOW (CFS)	6.20	6.70	49.00	15.60
TOTAL MONTHLY LOSSES (AF)	15.70	9.30	12.40	12.60
MIN. MEAN DAILY INFLOW (CFS)	1.70	0.90	3.20	4.40
MONTHLY STORAGE CHANGE (AF)	-29.90	84.70	576.20	427.70

WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1458.50	381.80	268.00	229.80
TOTAL MONTHLY OUTFLOW (AF)	248.70	2340.90	414.00	336.60
MAX. MEAN DAILY INFLOW (CFS)	91.10	25.70	7.30	6.40
TOTAL MONTHLY LOSSES (AF)	17.00	18.00	19.40	18.20
MIN. MEAN DAILY INFLOW (CFS)	5.20	0.00	0.70	0.50
MONTHLY STORAGE CHANGE (AF)	1192.80	-1977.10	-165.40	-154.90

WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	110.30	67.40	34.00	6.50
TOTAL MONTHLY OUTFLOW (AF)	51.40	116.60	34.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	4.10	4.80	2.80	0.30
TOTAL MONTHLY LOSSES (AF)	21.80	27.70	1.40	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.20	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	37.10	-76.80	-1.30	6.50

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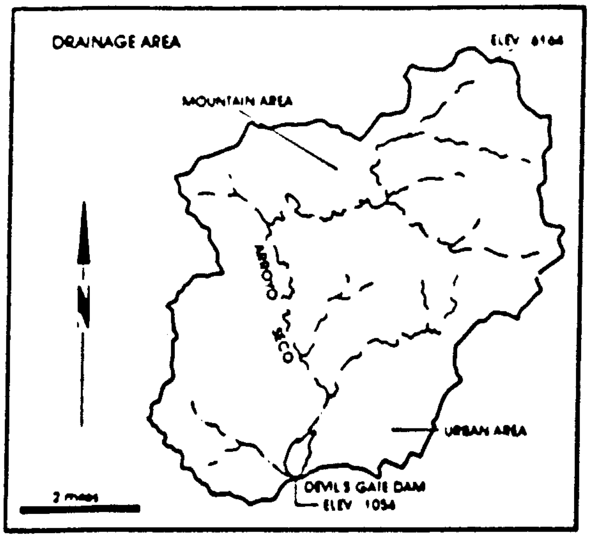
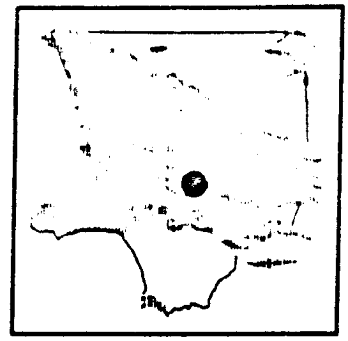
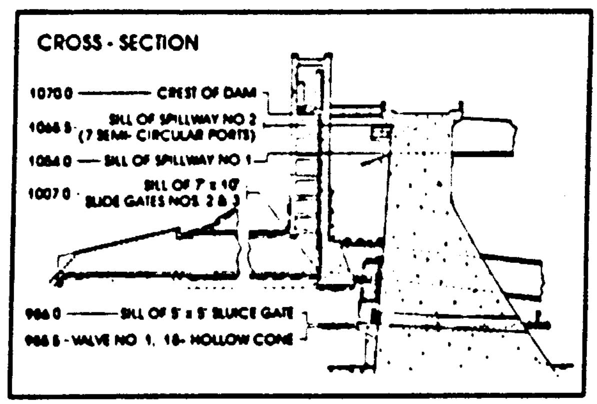
DEVIL'S GATE DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started May 1919 Completed June 1920.
LOCATION - On Arroyo Seco, northwest of Pasadena.
DRAINAGE AREA - 31.9 square miles.
CAPACITY - 1,928 acre - feet.
SPILLWAY ELEVATION - 1,054.0 feet.



DAM OPERATION RECORD SUMMARY *

MAX. PEAK INFLOW	54.40	CFS	from	0300	on	12-16-88	to	0500	on	12-16-88
MAX. PEAK OUTFLOW	52.30	CFS	from	1200	on	02-09-89	to	1215	on	02-09-89
MAX. W.S. ELEVATION	1012.70	feet	on	12-16-88	STORAGE	51.10	ACRE-FEET			
MIN. W.S. ELEVATION	998.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

DEVIL'S GATE DAM OPERATION RECORD SUMMARY *

WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	73.80	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	73.80	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	17.60	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	38.70	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	38.70	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	10.10	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

* = VALUES ESTIMATED DUE TO INCOMPLETE RECORDS

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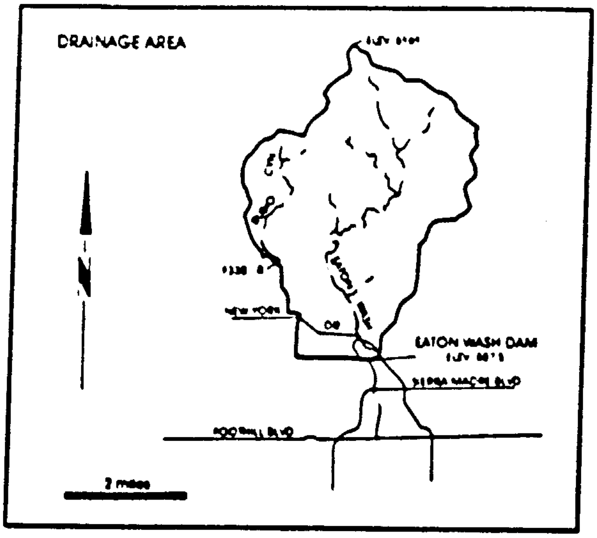
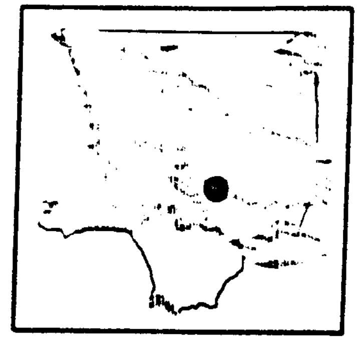
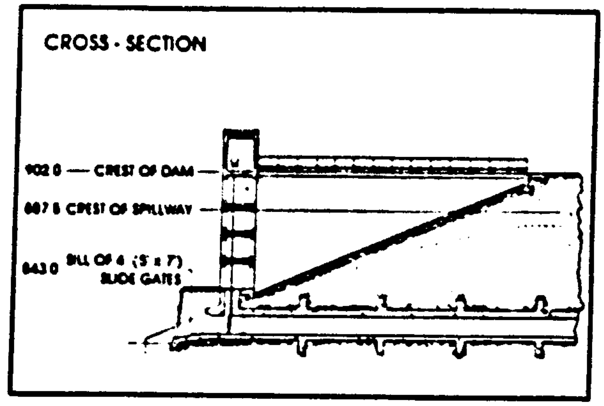
EATON WASH DAM
AND RESERVOIR





PURPOSE - Debris Storage and Conservation.
DATE CONSTRUCTED - Started January 1936 Completed February 1937
LOCATION - Eaton Wash, northeast of Pasadena.
DRAINAGE AREA - 12.4 square miles.
CAPACITY - 879 acre - feet.
SPILLWAY ELEVATION - 887.5 feet.



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DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	74.11 CPS from 0700 on 12-16-88 to 0800 on 12-16-88
MAX. PEAK OUTFLOW	34.40 CPS from 0000 on 02-15-89 to 0015 on 02-15-89
MAX. W.S. ELEVATION	866.90 feet on 02-14-89 STORAGE 154.00 ACRE-FEET
MIN. W.S. ELEVATION	846.00 feet on varies STORAGE 0.00 ACRE-FEET

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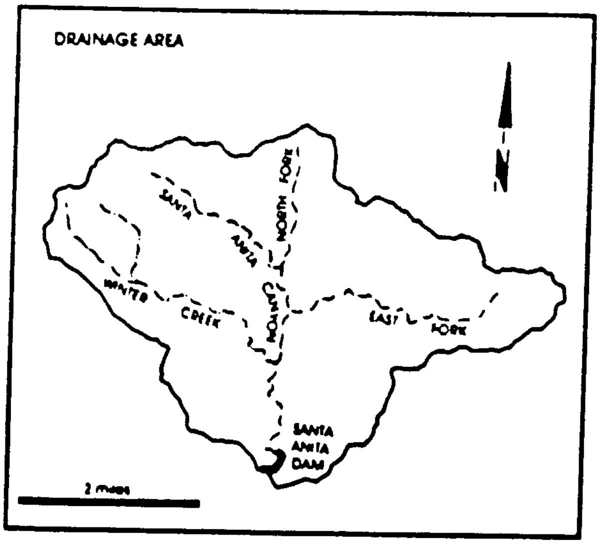
EATON WASH DAM OPERATION RECORD SUMMARY

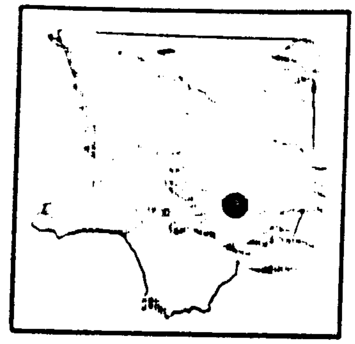
WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	98.40	35.30
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	69.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	20.80	12.30
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.10	35.20
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	29.30	0.10

WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	172.00	15.80	0.30	0.00
TOTAL MONTHLY OUTFLOW (AF)	113.10	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	25.80	3.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	46.20	23.20	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	12.70	-7.30	-0.60	0.00

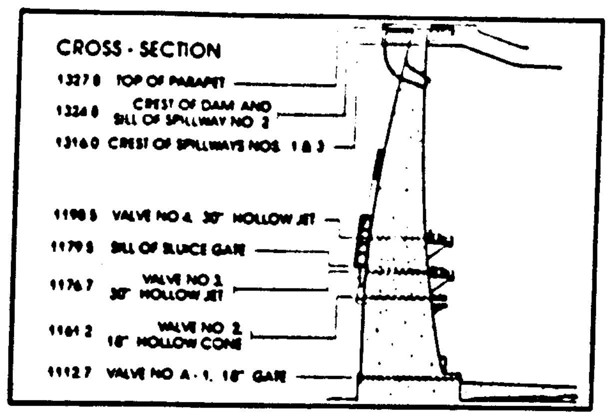
WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

SANTA ANITA DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started October 1924 Completed March 1927
LOCATION - 2.5 miles north of Arcadia
DRAINAGE AREA - 10.8 square miles.
CAPACITY - 836 acre - feet.
SPILLWAY ELEVATION - 1,316.0 feet.



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DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	119.45	CFS	from	1400	on	02-04-89	to	1500	on	02-04-89
MAX. PEAK OUTFLOW	32.10	CFS	from	2340	on	12-20-88	to	2355	on	12-20-88
MAX. W.S. ELEVATION	1268.80	feet	on	02-05-89	STORAGE	345.40	ACRE-FEET			
MIN. W.S. ELEVATION	1237.30	feet	on	01-13-89	STORAGE	150.60	ACRE-FEET			

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1 9752

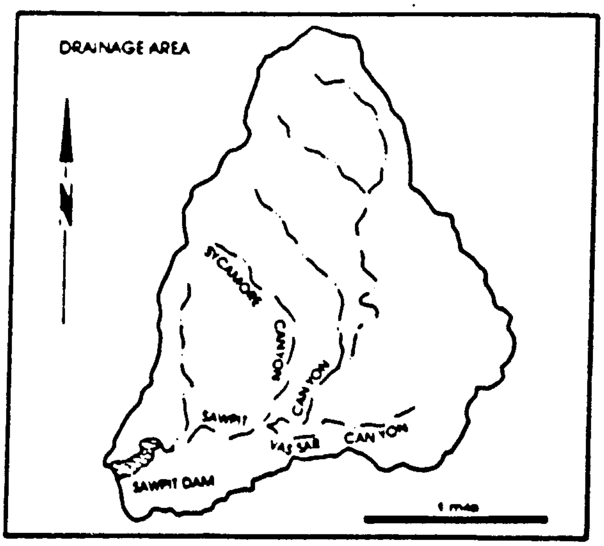
SANTA ANITA DAM OPERATION RECORD SUMMARY

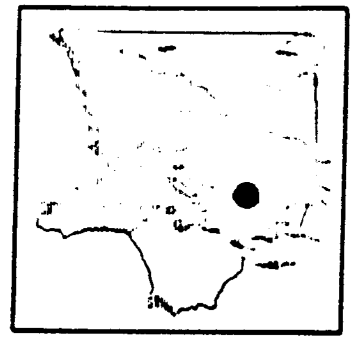
WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	32.00	83.70	328.30	195.50
TOTAL MONTHLY OUTFLOW (AF)	0.00	69.40	353.30	137.10
MAX. MEAN DAILY INFLOW (CFS)	0.70	5.40	18.60	6.50
TOTAL MONTHLY LOSSES (AF)	1.80	1.30	1.90	1.30
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.50	0.60	1.00
MONTHLY STORAGE CHANGE (AF)	30.20	12.90	-25.90	58.10

WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	582.30	202.20	130.60	79.50
TOTAL MONTHLY OUTFLOW (AF)	575.60	142.00	121.00	101.20
MAX. MEAN DAILY INFLOW (CFS)	51.60	5.70	5.20	1.90
TOTAL MONTHLY LOSSES (AF)	0.90	1.40	2.20	1.80
MIN. MEAN DAILY INFLOW (CFS)	2.00	0.00	0.60	0.00
MONTHLY STORAGE CHANGE (AF)	5.80	58.70	7.50	-23.40

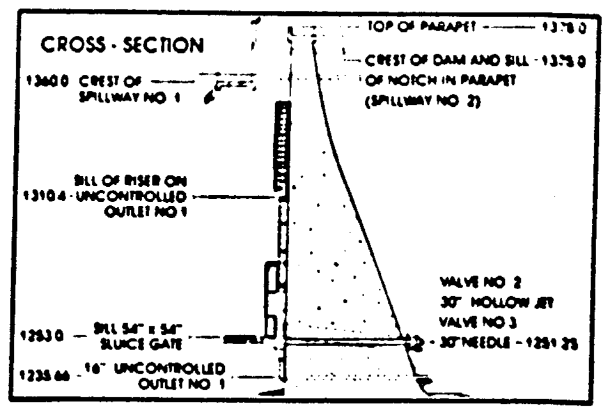
WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	52.50	22.40	18.80	8.50
TOTAL MONTHLY OUTFLOW (AF)	99.20	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	1.80	1.00	0.30	0.30
TOTAL MONTHLY LOSSES (AF)	2.40	2.60	2.90	2.80
MIN. MEAN DAILY INFLOW (CFS)	0.40	0.00	0.10	0.00
MONTHLY STORAGE CHANGE (AF)	-49.10	19.80	7.90	5.80

SAWPIT DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1926. Completed June 1927
LOCATION - 2.0 miles north of Monrovia.
DRAINAGE AREA - 3.2 square miles.
CAPACITY - 391 acre - feet.
SPILLWAY ELEVATION - 1,360.0 feet.



DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	11.14	CFS	from	0600	on	12-16-88	to	0700	on 12-16-88
MAX. PEAK OUTFLOW	28.80	CFS	from	0915	on	12-21-88	to	0930	on 12-21-88
MAX. W.S. ELEVATION	1310.70	feet	on	12-16-88	STORAGE	97.30	ACRE-FEET		
MIN. W.S. ELEVATION	1310.10	feet	on	varies	STORAGE	95.20	ACRE-FEET		

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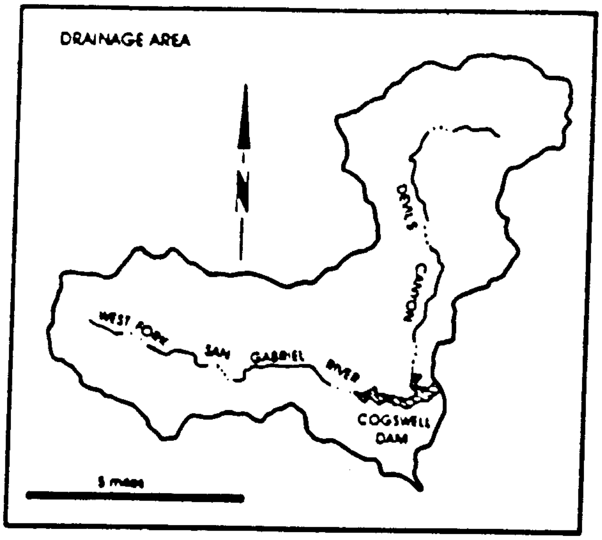
SAWPIT DAM OPERATION RECORD SUMMARY

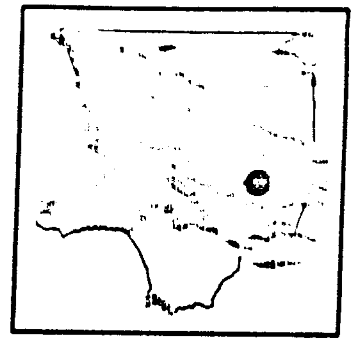
WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	13.50	51.40	117.60	99.70
TOTAL MONTHLY OUTFLOW (AF)	13.50	51.60	117.60	99.80
MAX. MEAN DAILY INFLOW (CFS)	0.30	1.70	6.70	2.30
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.20	1.00	1.20
MONTHLY STORAGE CHANGE (AF)	0.00	-0.20	0.00	0.00

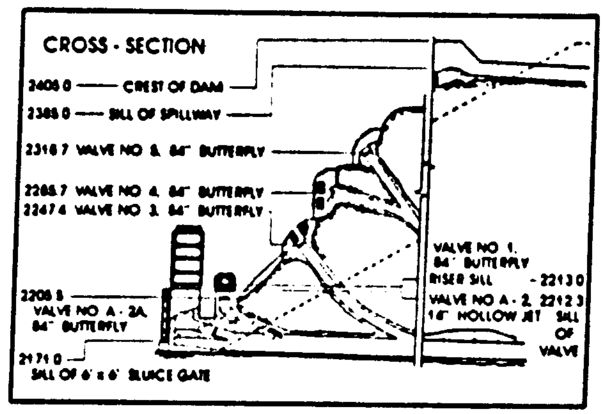
WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	153.30	103.30	58.90	62.50
TOTAL MONTHLY OUTFLOW (AF)	153.30	103.30	58.90	62.50
MAX. MEAN DAILY INFLOW (CFS)	8.30	2.30	1.20	1.70
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.20	1.10	0.80	0.70
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	31.30	30.70	16.90	11.90
TOTAL MONTHLY OUTFLOW (AF)	31.30	30.70	16.90	11.90
MAX. MEAN DAILY INFLOW (CFS)	0.60	0.60	0.50	0.40
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.40	0.40	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

COGSWELL DAM
AND RESERVOIR







PURPOSE - Flood Control, Conservation, and Recreation.
DATE CONSTRUCTED - Started March 1932. Completed April 1934.
LOCATION - 22.0 miles north of Azusa.
DRAINAGE AREA - 39.2 square miles.
CAPACITY - 9,339 acre - feet.
SPILLWAY ELEVATION - 2,385.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	175.36 CFS from 1500 on 02-04-89 to 1600 on 02-04-89
MAX. PEAK OUTFLOW	45.10 CFS from 0645 on 02-09-89 to 0745 on 02-09-89
MAX. W.S. ELEVATION	2298.40 feet on 02-13-89 STORAGE 1290.00 ACRE-FEET
MIN. W.S. ELEVATION	2269.60 feet on 12-15-88 STORAGE 602.80 ACRE-FEET

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COGSWELL DAM OPERATION RECORD SUMMARY

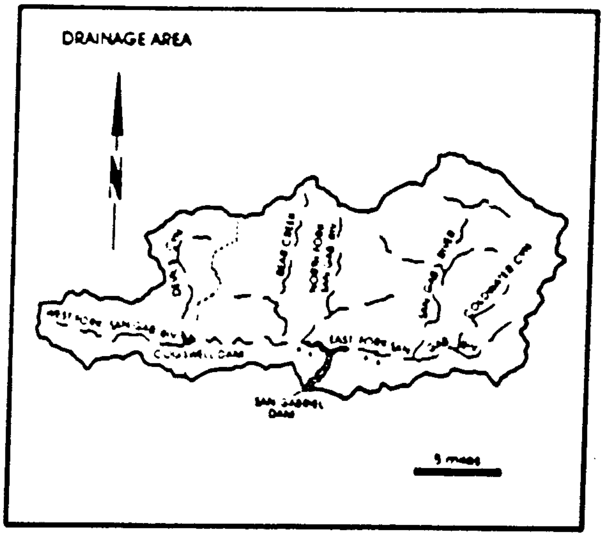
WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY **
TOTAL MONTHLY INFLOW (AF)	37.00	35.10	1192.40	849.40
TOTAL MONTHLY OUTFLOW (AF)	213.60	191.20	869.60	929.10
MAX. MEAN DAILY INFLOW (CFS)	1.70	2.10	96.60	35.10
TOTAL MONTHLY LOSSES (AF)	10.10	5.60	3.10	3.40
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.20	0.00	7.50
MONTHLY STORAGE CHANGE (AF)	-186.70	-161.70	319.70	-83.10

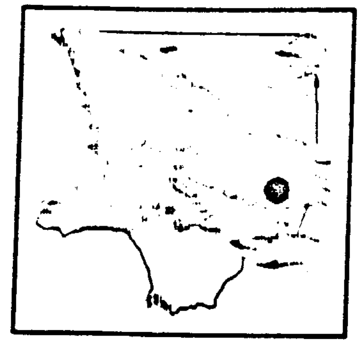
WATER YEAR 1988-89	FEBRUARY **	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1544.40	653.90	287.40	141.80
TOTAL MONTHLY OUTFLOW (AF)	1621.90	312.40	178.10	147.40
MAX. MEAN DAILY INFLOW (CFS)	98.80	18.20	7.50	3.60
TOTAL MONTHLY LOSSES (AF)	3.20	6.10	12.60	14.80
MIN. MEAN DAILY INFLOW (CFS)	0.00	7.00	3.20	1.20
MONTHLY STORAGE CHANGE (AF)	-80.60	335.40	96.70	-20.40

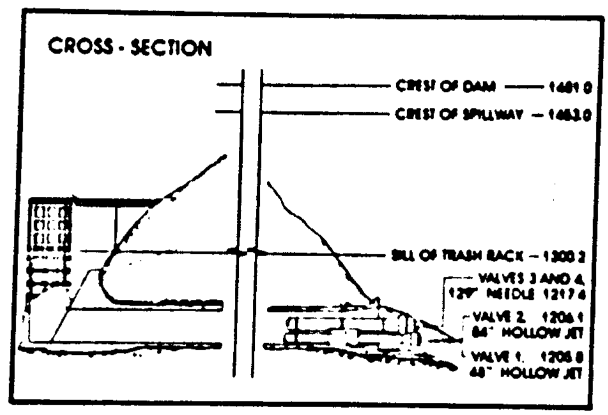
WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	85.10	57.10	33.60	35.60
TOTAL MONTHLY OUTFLOW (AF)	159.90	164.80	153.90	162.80
MAX. MEAN DAILY INFLOW (CFS)	2.50	1.40	1.60	1.00
TOTAL MONTHLY LOSSES (AF)	19.00	23.00	20.30	12.10
MIN. MEAN DAILY INFLOW (CFS)	0.40	0.40	0.10	0.20
MONTHLY STORAGE CHANGE (AF)	-93.80	-130.80	-140.60	-139.30

** = VALUES ESTIMATED

SAN GABRIEL DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1932. Completed July 1939.
LOCATION - San Gabriel Canyon, 7.5 miles north of Azusa.
DRAINAGE AREA - 163.5 square miles (uncontrolled)
39.2 square miles (controlled)
Total 202.7 square miles
(includes Cogswell drainage)
CAPACITY - 41,549 acre - feet.
SPILLWAY ELEVATION - 1,453 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	495.89 CFS from 0900 on 12-16-88 to 1000 on 12-16-88
MAX. PEAK OUTFLOW	288.80 CFS from 0900 on 01-03-89 to 1500 on 01-05-89
MAX. W.S. ELEVATION	1391.27 feet on 10-01-88 STORAGE 18080.00 ACRE-FEET
MIN. W.S. ELEVATION	1325.15 feet on 09-26-89 STORAGE 2391.00 ACRE-FEET

VCL 12
19757

R0053062

SAN GABRIEL DAM OPERATION RECORD SUMMARY

WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER **	JANUARY
TOTAL MONTHLY INFLOW (AF)	1133.60	1604.20	4890.60	4728.80
TOTAL MONTHLY OUTFLOW (AF)	3966.00	4219.80	11149.30	6152.90
MAX. MEAN DAILY INFLOW (CFS)	22.20	53.20	269.50	192.60
TOTAL MONTHLY LOSSES (AF)	168.30	91.60	81.30	46.70
MIN. MEAN DAILY INFLOW (CFS)	12.10	9.40	4.00	46.20
MONTHLY STORAGE CHANGE (AF)	-3000.70	-2707.30	-6340.00	-1470.90

WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	7648.50	4870.00	2894.70	2139.50
TOTAL MONTHLY OUTFLOW (AF)	2510.50	2382.60	2801.30	2852.00
MAX. MEAN DAILY INFLOW (CFS)	272.80	120.80	59.80	55.90
TOTAL MONTHLY LOSSES (AF)	52.80	95.60	134.30	135.90
MIN. MEAN DAILY INFLOW (CFS)	45.60	49.10	37.70	26.50
MONTHLY STORAGE CHANGE (AF)	5085.10	1891.80	-40.80	-848.40

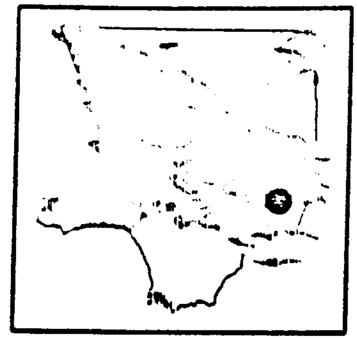
WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	1350.30	904.00	731.50	538.80
TOTAL MONTHLY OUTFLOW (AF)	2699.70	3257.10	3001.20	2190.70
MAX. MEAN DAILY INFLOW (CFS)	34.30	19.70	18.60	15.90
TOTAL MONTHLY LOSSES (AF)	152.30	192.30	146.40	101.10
MIN. MEAN DAILY INFLOW (CFS)	16.30	9.90	6.70	4.20
MONTHLY STORAGE CHANGE (AF)	-1501.70	-2545.40	-2416.10	-1753.00

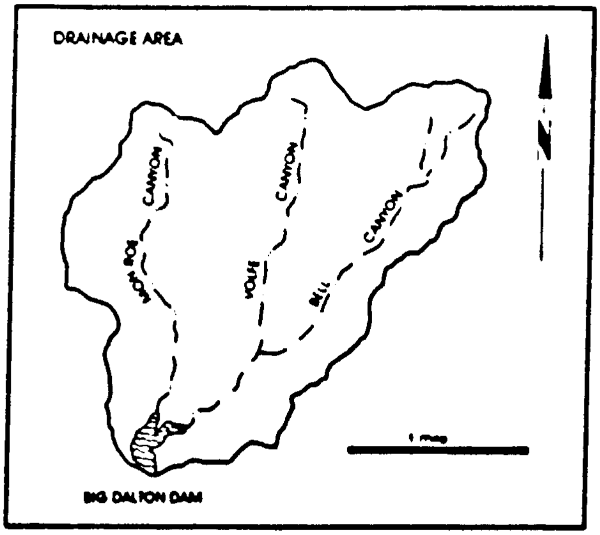
** = VALUES ESTIMATED

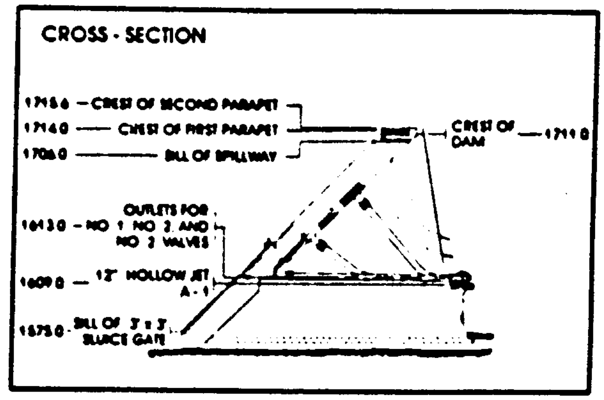
VOL 12 1 9758

BIG DALTON DAM
AND RESERVOIR

VOL 12







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1927 Completed August 1929
LOCATION - Big Dalton Canyon, 4.0 miles northeast of Glendora.
DRAINAGE AREA - 4.5 square miles.
CAPACITY - 963 acre - feet.
SPILLWAY ELEVATION - 1,706.0 feet.

19759

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	31.20	CFS	from	1400	on	02-04-89	to	1500	on	02-04-89
MAX. PEAK OUTFLOW	16.40	CFS	from	1300	on	02-15-89	to	1315	on	02-15-89
MAX. W.S. ELEVATION	1641.90	feet	on	02-04-89	STORAGE	93.30	ACRE-FEET			
MIN. W.S. ELEVATION	1632.00	feet	on	02-17-89	STORAGE	58.20	ACRE-FEET			

BIG DALTON DAM OPERATION RECORD SUMMARY

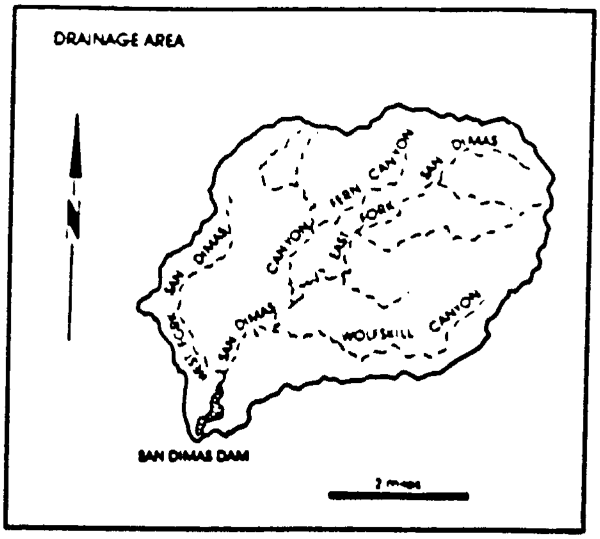
WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	3.30	2.50	33.10	55.60
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	36.40	44.20
MAX. MEAN DAILY INFLOW (CFS)	0.10	0.20	2.50	1.80
TOTAL MONTHLY LOSSES (AF)	1.00	0.60	0.90	0.40
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.30
MONTHLY STORAGE CHANGE (AF)	2.30	1.90	-4.20	11.00

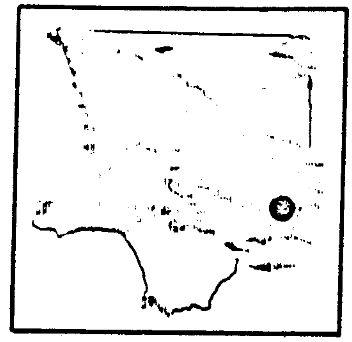
WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	145.50	73.30	27.30	18.30
TOTAL MONTHLY OUTFLOW (AF)	138.00	95.00	4.40	22.00
MAX. MEAN DAILY INFLOW (CFS)	13.00	2.10	0.90	0.60
TOTAL MONTHLY LOSSES (AF)	0.40	0.80	1.20	1.60
MIN. MEAN DAILY INFLOW (CFS)	0.50	0.70	0.20	0.20
MONTHLY STORAGE CHANGE (AF)	7.00	-22.50	21.70	-5.30

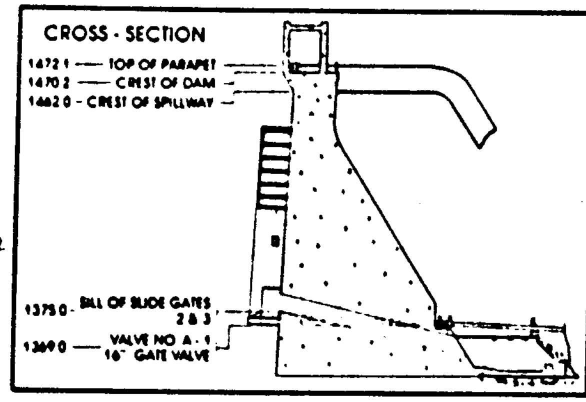
WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	9.30	5.90	4.50	3.50
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.60	0.30	0.10	0.10
TOTAL MONTHLY LOSSES (AF)	2.10	19.30	2.10	2.20
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	7.20	-13.40	2.40	1.30

VOL 12 1 9760

SAN DIMAS DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started November 1920. Completed September 1922.
LOCATION - 3.0 miles northeast of San Dimas.
DRAINAGE AREA - 16.2 square miles.
CAPACITY - 1,515 acre - feet.
SPILLWAY ELEVATION - 1,462.0 feet.

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1976 1

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	96.19	CFS	from	1300	on	02-04-89	to	1400	on	02-04-89
MAX. PEAK OUTFLOW	248.00	CFS	from	1300	on	05-10-89	to	1315	on	05-10-89
MAX. W.S. ELEVATION	1439.81	feet	on	02-10-89	STORAGE	850.10	ACRE-FEET			
MIN. W.S. ELEVATION	1416.44	feet	on	09-30-89	STORAGE	290.10	ACRE-FEET			

VCL 12

SAN DIMAS DAM OPERATION RECORD SUMMARY

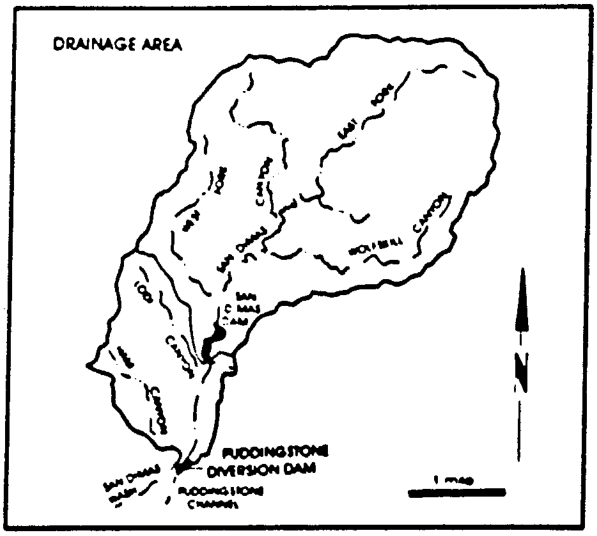
WATER YEAR 1983-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	29.60	56.30	229.20	158.60
TOTAL MONTHLY OUTFLOW (AF)	58.20	18.60	68.80	100.20
MAX. MEAN DAILY INFLOW (CFS)	1.30	4.30	19.20	6.90
TOTAL MONTHLY LOSSES (AF)	8.30	4.30	5.20	6.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.30	0.40	1.30
MONTHLY STORAGE CHANGE (AF)	-37.30	33.30	155.20	52.40

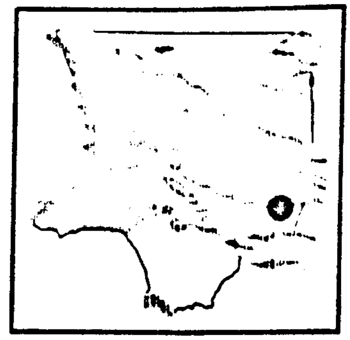
WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	383.90	121.80	51.60	42.10
TOTAL MONTHLY OUTFLOW (AF)	484.20	81.80	31.30	331.20
MAX. MEAN DAILY INFLOW (CFS)	34.50	5.60	1.30	1.70
TOTAL MONTHLY LOSSES (AF)	4.00	5.90	10.20	6.50
MIN. MEAN DAILY INFLOW (CFS)	1.50	0.20	0.50	0.00
MONTHLY STORAGE CHANGE (AF)	-104.20	34.00	10.10	-295.60

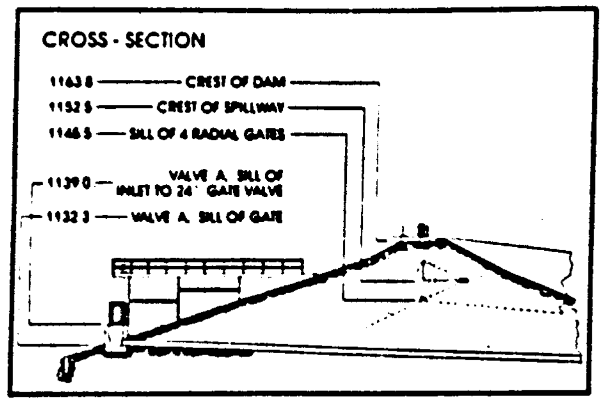
WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	18.30	10.20	15.90	5.70
TOTAL MONTHLY OUTFLOW (AF)	21.10	13.00	9.10	7.00
MAX. MEAN DAILY INFLOW (CFS)	0.70	0.00	1.00	0.40
TOTAL MONTHLY LOSSES (AF)	10.40	14.10	23.30	12.20
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	-0.10	0.00
MONTHLY STORAGE CHANGE (AF)	-13.20	-16.90	-16.50	-13.40

19762

PUDDINGSTONE DIVERSION DAM
AND RESERVOIR







PURPOSE - Flood Control and Diversion of flow and Conservation.
DATE CONSTRUCTED - Started September 1927. Completed July 1928.
LOCATION - 2.0 miles northeast of San Dimas.
DRAINAGE AREA - 3.7 square miles (uncontrolled)
16.2 square miles (controlled)
Total 19.9 square miles
CAPACITY - 148 acre feet.
SPILLWAY ELEVATION - 1,152.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	111.49	CFS	from	1300	on	02-04-89	to	1400	on	02-04-89
MAX. PEAK OUTFLOW	104.00	CFS	from	1450	on	05-10-89	to	0730	on	05-11-89
MAX. W.S. ELEVATION	1146.20	feet	on	05-11-89	STORAGE	107.40	ACRE-FEET			
MIN. W.S. ELEVATION	1133.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

R0053068

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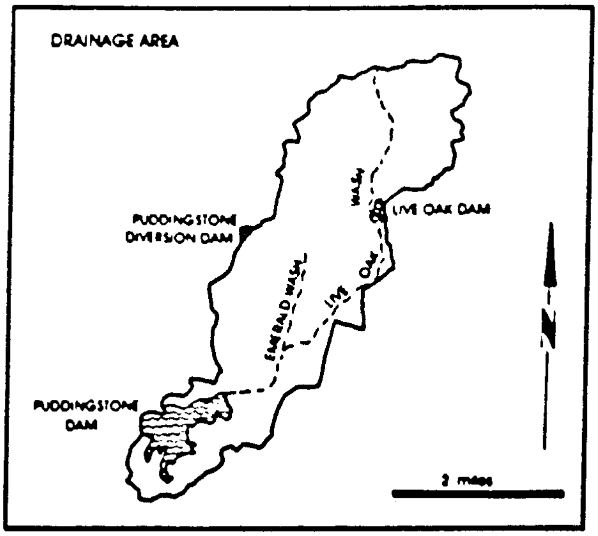
PUDDINGSTONE DIVERSION DAM OPERATION RECORD SUMMARY

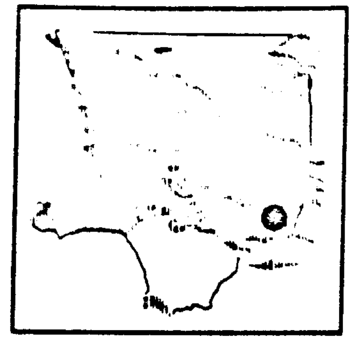
WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	17.90	112.80	92.10
TOTAL MONTHLY OUTFLOW (AF)	0.00	17.90	55.70	127.50
MAX. MEAN DAILY INFLOW (CFS)	0.00	6.10	13.20	12.20
TOTAL MONTHLY LOSSES (AF)	12.00	0.00	16.80	4.60
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	-12.00	0.00	40.40	-40.00

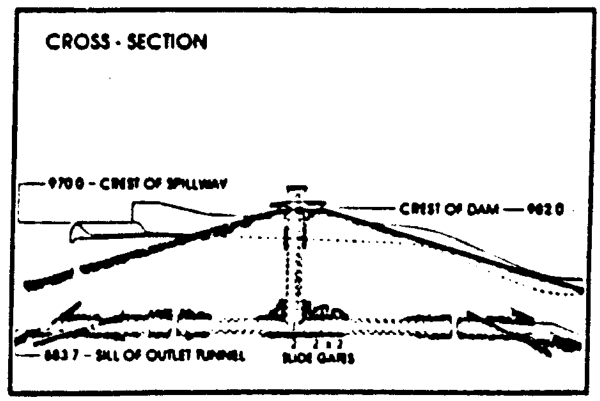
WATER YEA 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	483.40	89.90	13.10	248.20
TOTAL MONTHLY OUTFLOW (AF)	425.30	79.90	14.70	206.10
MAX. MEAN DAILY INFLOW (CFS)	28.30	7.30	5.20	76.30
TOTAL MONTHLY LOSSES (AF)	16.10	29.00	16.50	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	42.10	-19.00	-18.00	-16.50

WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00*	0.00	0.00	3.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.50
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	3.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

PUDDINGSTONE DAM
AND RESERVOIR







PURPOSE - Flood Control and Recreation.
DATE CONSTRUCTED - Started February 1925. Completed January 1928.
LOCATION - 1.0 mile south of San Dimas.
DRAINAGE AREA - 11.0 square miles (uncontrolled)
22.1 square miles (controlled)
Total 33.1 square miles
CAPACITY - 16,856 acre - feet.
SPILLWAY ELEVATION - 970.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	211.16	CFS	from	1500	on	02-04-89	to	1600	on	02-04-89
MAX. PEAK OUTFLOW	47.70	CFS	from	1100	on	02-10-89	to	1145	on	02-10-89
MAX. W.S. ELEVATION	942.70	feet	on	12-21-88	STORAGE	6746.00	ACRE-FEET			
MIN. W.S. ELEVATION	938.35	feet	on	05-10-89	STORAGE	5667.00	ACRE-FEET			

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1 9765

R0053070

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PUDDINGSTONE DAM OPERATION RECORD SUMMARY

WATER YEAR 1988-89	OCTOBER **	NOVEMBER **	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	114.70	145.60	1085.20	145.20
TOTAL MONTHLY OUTFLOW (AF)	15.50	20.30	880.10	306.70
MAX. MEAN DAILY INFLOW (CFS)	6.00	15.20	94.70	31.60
TOTAL MONTHLY LOSSES (AF)	107.50	121.20	61.40	81.30
MIN. MEAN DAILY INFLOW (CFS)	0.50	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	-8.30	4.20	143.80	-242.90

WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	561.90	167.80	0.10	197.70
TOTAL MONTHLY OUTFLOW (AF)	668.00	30.50	31.30	21.80
MAX. MEAN DAILY INFLOW (CFS)	117.20	33.60	0.00	44.00
TOTAL MONTHLY LOSSES (AF)	65.70	79.70	131.00	143.10
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	-169.80	57.60	-162.20	32.80

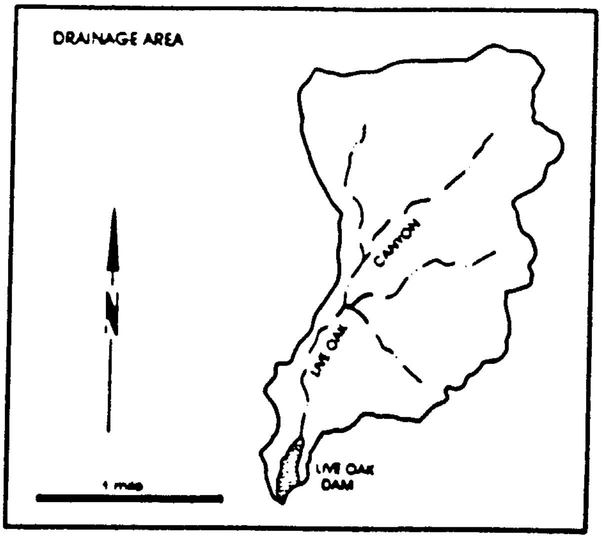
WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	765.30	124.30	80.80	150.20
TOTAL MONTHLY OUTFLOW (AF)	17.70	18.40	18.40	17.90
MAX. MEAN DAILY INFLOW (CFS)	63.70	5.50	3.70	15.20
TOTAL MONTHLY LOSSES (AF)	165.70	223.80	185.00	172.10
MIN. MEAN DAILY INFLOW (CFS)	0.40	0.00	0.00	0.40
MONTHLY STORAGE CHANGE (AF)	581.90	-118.00	-122.70	-39.70

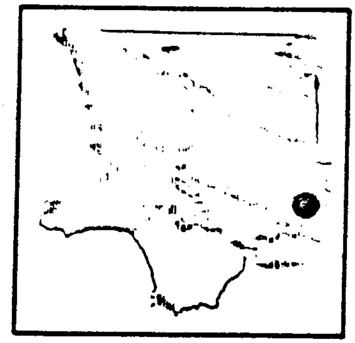
** = VALUES ESTIMATED

19766

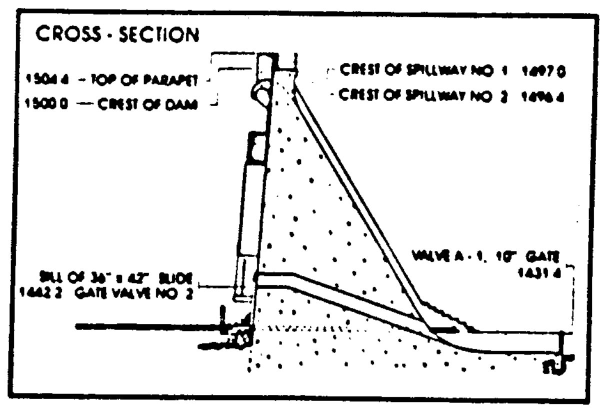
LIVE OAK DAM
AND RESERVOIR

VOL 12





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started August 1921. Completed November 1922.
LOCATION - 2.5 miles northeast of La Verne.
DRAINAGE AREA - 2.3 square miles.
CAPACITY - 240 acre-feet.
SPILLWAY ELEVATION - 1,496.0 feet.



19767

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	10.89	CFS	from	1300	on	02-04-89	to	1400	on	02-04-89
MAX. PEAK OUTFLOW	0.00	CFS	from	1115	on	02-14-89	to	2300	on	02-14-89
MAX. W.S. ELEVATION	1469.00	feet	on	02-14-89	STORAGE	44.50	ACRE-FEET			
MIN. W.S. ELEVATION	1440.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

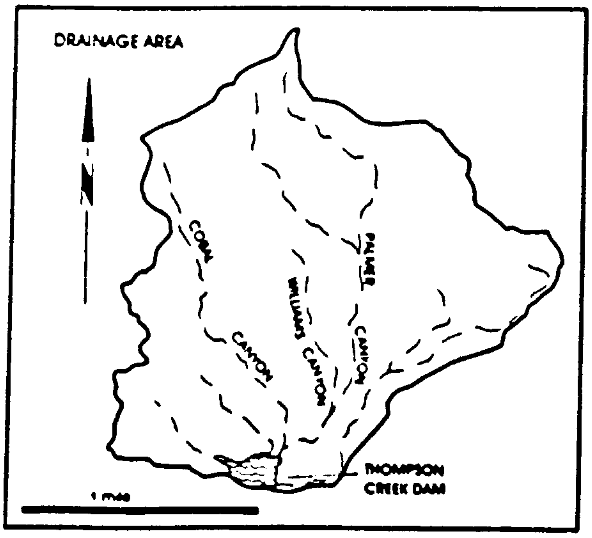
LIVE OAK DAM OPERATION RECORD SUMMARY

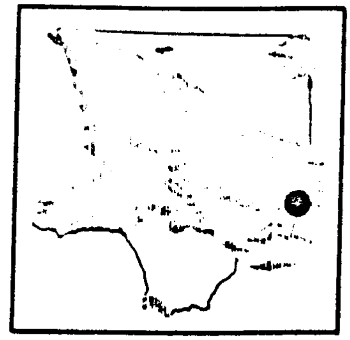
WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	11.20	11.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	7.10	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	2.50	2.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	4.10	11.20

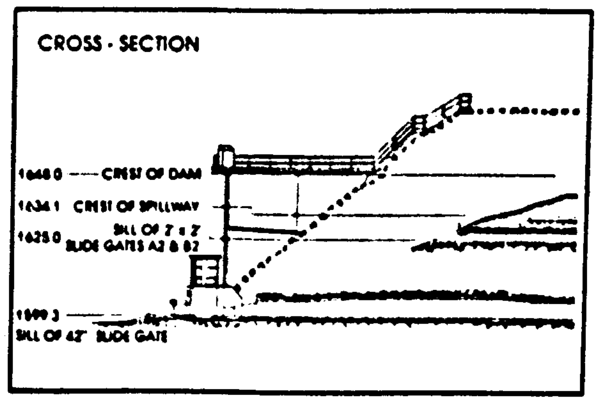
WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	41.10	8.70	11.10	6.10
TOTAL MONTHLY OUTFLOW (AF)	53.30	8.70	11.10	6.10
MAX. MEAN DAILY INFLOW (CFS)	6.00	0.50	0.30	0.10
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.10	0.10	0.10
MONTHLY STORAGE CHANGE (AF)	-12.20	0.00	0.00	0.00

WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	6.00	0.20	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	6.00	0.20	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.10	0.10	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

THOMPSON CREEK DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started September 1925. Completed March 1928
LOCATION - 3.0 miles north of Claremont.
DRAINAGE AREA - 3.5 square miles.
CAPACITY - 447.5 acre - feet.
SPILLWAY ELEVATION - 1,634 feet.

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1979 – 1969

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	0.50	CFS	from	1100	on	02-04-89	to	1500	on	02-04-89
MAX. PEAK OUTFLOW	0.50	CFS	from	1030	on	02-04-89	to	1100	on	02-04-89
MAX. W.S. ELEVATION	1600.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			
MIN. W.S. ELEVATION	1600.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

R0053074

THOMPSON CREEK DAM OPERATION RECORD SUMMARY

WATER YEAR 1988-89	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.90	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.90	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.30	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1988-89	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1.20	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	1.20	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.30	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1988-89	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

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EROSION CONTROL

EROSION CONTROL

Each year eroded material in various forms (trees, rock, sand, etc.) flows out of the mountain watersheds of Los Angeles County. In an effort to control this potentially disruptive force, the Department maintains a series of debris basins in canyon mouths and upstream stabilization structures in selected watersheds.

PURPOSE

The purpose of a debris basin is to entrap the debris flows emanating from the canyon and let the relatively desilted water pass into flood control channels.

From 1988 to 1989, the number of debris basins was changed from 131 to 114 by downgrading 20 to inlets, then adding 3 new basins. This gives a total capacity of 7,561,600 cubic yards.

Records of sediment inflow at individual debris basins and amounts excavated and removed are available in the Hydraulic/Water Conservation Division.

STABILIZATION STRUCTURES

Stabilization structures are constructed to control erosion in natural canyons. They serve to prevent downcutting by stabilizing alluvium deposits. In addition, they store debris generated by the watershed and serve to stabilize side banks, reducing side slope sloughing and bank erosion.

The Department maintains 225 stabilization structures in 47 major watersheds. No structures have been constructed since the 1973-74 water year.

EMERGENCY STRUCTURES

Emergency structures (rail and timber, and crib type) have been constructed to entrap the debris inflow from burned watersheds. They serve to protect improvements (road, channel, residence, etc.) located immediately downstream of the watersheds. Currently, 39 emergency structures exist with a total maximum capacity of 349,500 cubic yards. Five major fires, (those over 500 acres), burned 11,380 acres in this water year and are shown on page PE2. Emergency structures were built below one of these fires.

SEDIMENT REMOVAL FROM RESERVOIRS

Sediment deposition in reservoirs reduces the storage capacities and adversely affects flood control and water conservation efforts. Sediment removal is periodically necessary and is generally an expensive effort due to large quantities, the need to deal with water inflows, and in several cases, remote locations and limited accessibility for equipment.

Where practical, the Department encourages sediment removal by permittees at no cost to the Department such as at Eaton Wash and Devil's Gate Dams.

The Department presently is studying the feasibility of various methods for the removal and long-term management of sediment in the three reservoirs in San Gabriel Canyon. These three currently contain about 36 million cubic yards - about three-quarters of the cumulative volume of sediment currently behind all dams under the Department's control.

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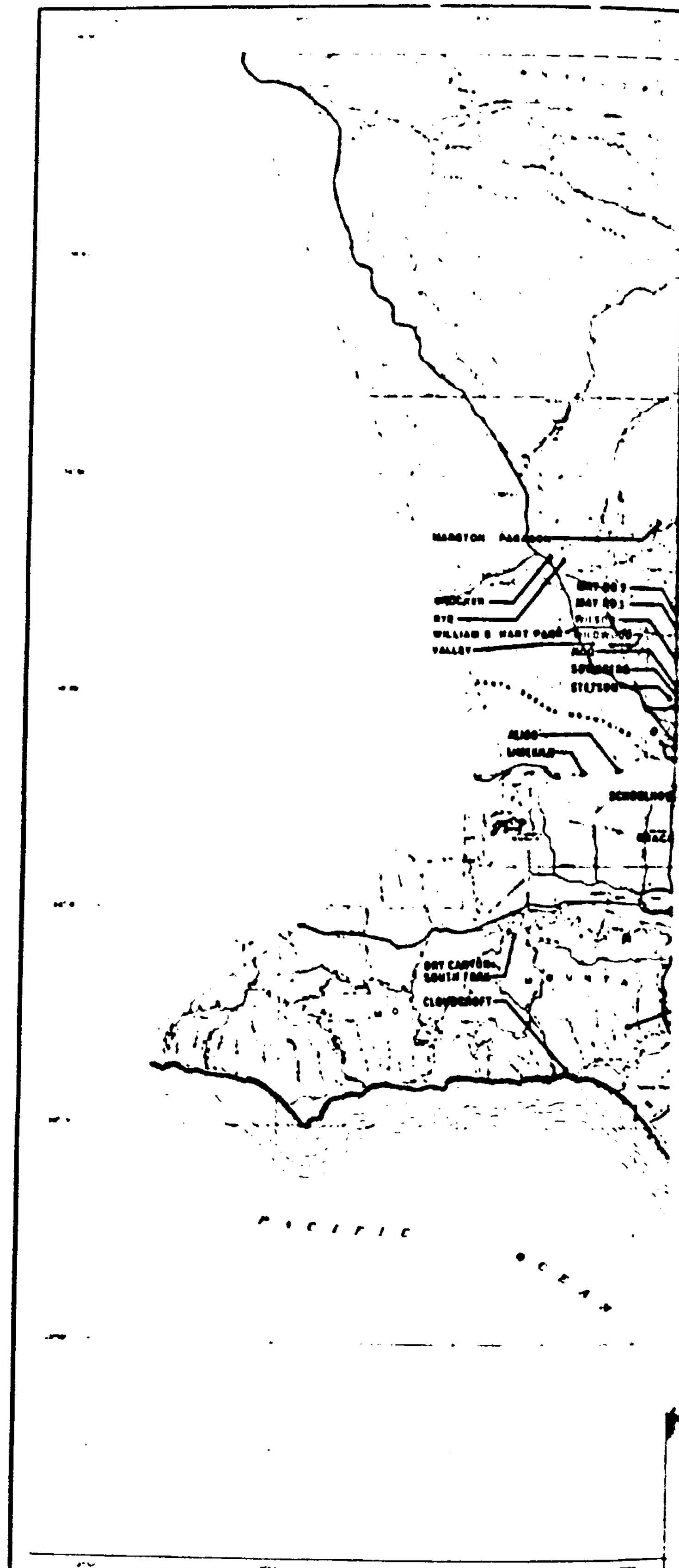
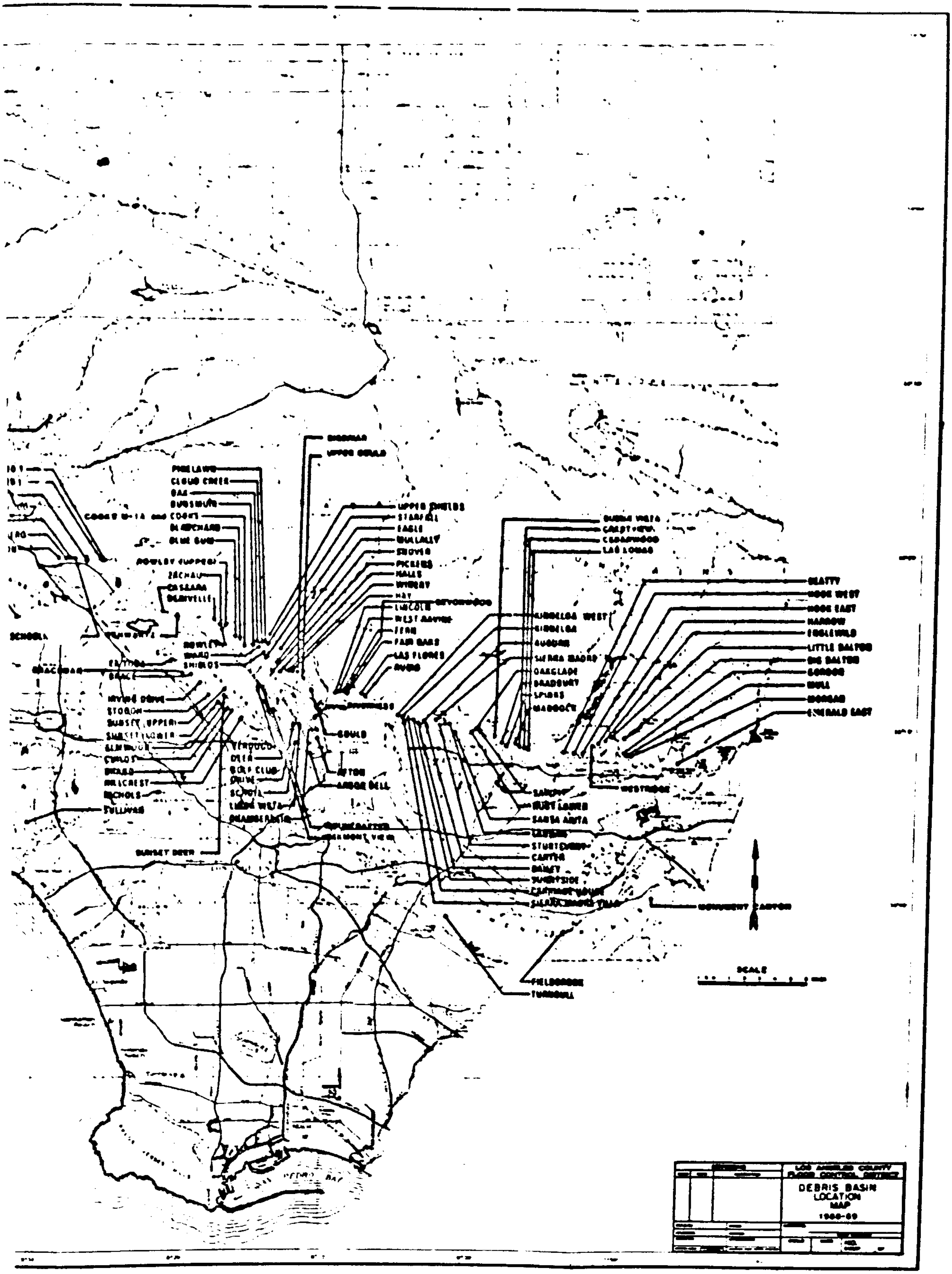


MARSTON
RYE
WILLIAM S HART PARK
VALLEY
ALISO
DRY CANYON SOUTH FORK
CLOUDCROFT
PACIFIC
OCEAN

VCL 12

1975


LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT
DEBRIS BASIN
LOCATION
MAP
1968-69
SCALE
DIGHTON
UPPER GOULD
PINELAWN
CLOUD CREST
BAS
BUGSMUTH
BLANCHARD
BLUE GUM
ROWLEY (UPPER)
ZACHAU
CASSARA
DEBIVILLE
UPPER SHIELDS
STARFALL
EAGLE
WHITTLEY
HAY
LINCOLN
WEST RAVINE
FERN
FAIR OAKS
LAS FLORES
RUBIO
DEVONWOOD
BUENA VISTA
CREST HAVEN
CEDARWOOD
LAS LOMAS
SIERRA MADRE
OAKGLADE
BRADBURY
SPINKS
MADDOCK
BEATTY
HOOK WEST
HOOK EAST
HARROW
ENGLEWILD
LITTLE DALTON
BIG DALTON
GORDON
MULL
MORGAN
EMERALD EAST
WESTRIDGE
SANTA ANITA
CARTER
BAILEY
SIERRA MADRE VILLA
MONUMENT CANYON
FIELDBROOK
TURNBULL
GOULD
ARROYO BELL
SCHOOL
SULLIVAN
NICHOLS
HILLCREST
SUNSET DEER
SAN PEDRO BAY
PE1
R0053080

VOL 12

1976

DEBRIS BASIN - DESIGN DATA

Including 1988-1989 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section

Date: October 1, 1989

FILE: DSA89.WK1

DATA SHEET A

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.
Afton	1974 - 75	0.06	1032.2	1030.0	1041.4	20.0	1046.6	7,200
Aliso	1970 - 71	2.77	1108.0	1108.4	1120.0	70.0	1134.0	41,700 (8)
Arbor Dell	1971 - 72	0.11	899.3	898.4	913.0	22.9	919.6	12,800
Auburn	1954 - 55	0.19	1263.9	1263.0	1275.0	30.0	1282.0	33,700
Bailey	1945 - 46	0.60	1122.5	1123.1	1155.0	30.0	1166.0	128,800 (16)
Beatty	1970 - 71	0.27	800.0	800.0	807.0	32.0	815.5	43,000
Bigbriar	1971 - 72	0.02	1898.3	1896.0	1910.0	14.0	1910.8	3,100
Big Dalton	1959 - 60	2.94	1102.0	1101.9 (3)	1131.5	116.0	1148.7	517,300 (16)
Blanchard	1968 - 69	0.47	2026.0	2026.0	2053.5	40.0	2065.0	74,500 (16)
Blue Gum	1968 - 69	0.19	2020.0	2020.0	2042.0	25.0	2053.0	39,600
Brace	1971 - 72	0.29	1189.7	1189.7	1194.5	20.0	1203.3	27,500
Braemar	1971 - 72	0.01	1140.0	1140.0	1145.5	8.0	1148.0	700 (11)
Bradbury	1954 - 55	0.68	912.5	913.1	920.8	58.0	928.0	90,500
Brand	1935 - 36	1.06	859.0	860.0	890.0	60.0	903.0	170,700
Buena Vista	1985 - 86	0.10	978.7	978.7	992.2	39.0	997.7	25,500
Carriage House	1970 - 71	0.03	1350.3	1350.0	1362.9	15.0	1366.8	10,400
Carter	1954 - 55	0.12	1222.0	1223.2	1238.2	30.0	1245.8	18,700
Cassara	1976 - 77	0.21	1271.5	1275.8	1291.7	66.0	1295.4	37,000
Cedarwood	1983 - 84	0.0075	866.8	867.5	872.3	10.0	876.0	900
Chamberlain	1974 - 75	0.04	1084.6	1084.0	1097.5	20.0	1101.3	6,800
Childs	1963 - 64	0.30	1022.0	1022.8	1058.6	23.0	1071.0	50,400 (16)
Cloud Creek	1972 - 73	0.02	2347.2	2350.5	2360.0	(5)	2362.0	14,800
Cloudcroft	1973 - 74	0.21	313.9	315.0	329.5	36.0	329.5	34,700 (16)
/Cooks	1951 - 52	0.58	2058.0	2058.0	2082.9	48.0	2092.0	78,400 (16)
\Cooks N-1A	1975 - 76	(15)	(15)	(15)	(15)	(15)	(15)	(15)
Crestview	1983 - 84	0.03	864.4	864.0	886.2	20.0	891.7	5,900
Crocker	1983 - 84	0.67	1059.9	1064.2	1069.8	36.0	1077.0	39,200
Deer	1954 - 55	0.59	1185.4	1185.0	1201.0	56.0	1209.6	56,600
Denivelle	1976 - 77	0.18	1471.0	1471.0	1479.3	46.0	1483.3	8,200
Devonwood	1981 - 82	0.05	1899.0	1899.0	1915.8	22.0	1921.5	6,400
Dry Canyon-South Fork	1978 - 79	1.05	1062.8	1062.5	1074.8	32.0	1079.3	7,900
Dunsmuir	1935 - 36	0.84	2228.0	2227.7	2257.2	60.0	2272.2	110,900
Eagle	1936 - 37	0.48	1848.3	1844.3	1880.2	60.0	1895.2	62,400 (16)
Elmwood	1964 - 65	0.31	912.0	911.5	938.0	22.0	952.0	63,200 (16)
Emerald-East	1964 - 65	0.16	1185.1	1181.1	1192.0	30.0	1204.0	13,200
Englewild	1961 - 62	0.40	1274.9	1275.0	1297.0	50.0	1300.0	50,400
Fair Oaks	1935 - 36	0.21	1544.0	1544.0	1561.9	(6)	1566.5	23,800 (16)
Fern	1935 - 36	0.31	1438.7	1462.4	1470.2	25.0	1480.5	20,600
Fieldbrook	1974 - 75	0.35	712.7	713.0	718.0	28.0	722.3	2,800
Golf Club Drive	1970 - 71	0.32	880.7	880.7	902.0	36.7	915.0	14,700
Gordon	1973 - 74	0.18	1075.7	1075.0	1088.0	22.0	1096.0	16,800
Gould	1947 - 48	0.29	1529.5	1528.2	1548.0	55.0	1548.0	49,600
Gould (Upper)	1976 - 77	0.18	1863.9	1863.9	1897.7	32.0	1901.0	52,000
Halls	1935 - 36	0.86	1641.8	1641.8	1661.3	131.0	1664.0	89,400

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D E B R I S   B A S I N - D E S I G N   D A T A

Including 1988-1989 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1989
FILE: DSA89.WK1

DATA SHEET A

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.
Harrow	1958 - 59	0.43	1254.8	1255.0	1269.0	40.0	1277.8	68,000
Hay	1936 - 37	0.20	1875.4	1901.0	1905.0	36.0	1915.0	34,400
Hillcrest	1962 - 63	0.35	863.5	863.5	885.0	18.0	901.0	57,800 (16)
Hog	1969 - 70	0.30	1520.3	1520.0	1535.0	32.0	1547.0	39,600
Hook East	1968 - 69	0.18	1197.5	1198.0	1210.9	37.0	1215.0	30,700
Hook West	1970 - 71	0.17	1144.8	1145.0	1158.9	40.0	1167.0	39,600
Inverness	1982 - 83	0.03	1253.0	1252.9	1256.7	20.0	1261.0	3,300 (16)
Irving Drive	1974 - 75	0.03	905.8	905.0	915.3	12.0	920.0	2,100
Kinneloa	1964 - 65	0.20	1370.0	1370.0	1388.0	40.0	1395.0	17,200
Kinneloa West Branch	1966 - 67	0.16	1384.9	1385.0	1400.0	22.0	1408.5	23,600
Lannan	1954 - 55	0.25	1016.0	1015.0	1035.8	14.0	1043.0	44,600
La Tuna	1955 - 56	5.34	1109.0	1110.0	1140.0	75.0	1157.0	495,300 (16)
Las Flores	1935 - 36	0.45	1685.1	(9)	1715.6	50.0	1726.4	57,600
Las Lomas	1983 - 84	0.07	895.4	896.0	906.6	24.0	911.0	9,300
Limekiln	1963 - 64	3.72	992.0	992.0	1003.0	77.0	1019.0	171,600 (16)
Lincoln	1935 - 36	0.50	1275.8	1276.0	1304.0	56.0	1322.5	38,400
Linda Vista	1970 - 71	0.37	979.5	979.5	989.8	40.0	995.7	3,200
Little Dalton	1959 - 60	3.31	1140.0	1139.5	1186.0	84.0	1200.2	656,500
Maddock	1954 - 55	0.25	888.6	891.8	901.0	36.0	904.0	45,900
Marston/Paragon	1988 - 89	0.20	(10)	(10)	(10)	(10)	(10)	(10)
May No. 1	1953 - 54	0.70	1665.9	1666.0	1684.0	60.0	1692.5	64,000
May No. 2	1953 - 54	0.09	1663.4	1663.5 (2)	1669.5	20.0	1674.0	10,000
Monument	1981 - 82	0.11	943.8	942.3	950.0	12.0	954.0	8,800 (16)
Morgan	1964 - 65	0.60	1135.0	1135.0	1158.0	45.0	1167.0	51,100
Mountbatten	1983 - 84	0.01	1136.2	1135.5	1140.9	20.0	1141.0	1,400
Mull	1973 - 74	0.15	1146.9	1147.0	1154.0	20.0	1165.0	16,000
Mullally (12)	1974 - 75	0.34	2420.0	2420.0	2435.4	42.0	2439.6	12,000
Nichols	1937 - 38	0.35	481.0	481.0	485.1	50.0	495.0	13,100
Oak	1975 - 76	0.05	2145.7	2145.7	2151.8	50.0	2156.2	8,700
Oakglade	1974 - 75	0.06	1274.6	1280.0	1290.0	20.0	1296.0	12,300
Oakmont View Drive	1984 - 85	0.02	1315.5	1315.5	1327.5	20.0	1327.5	3,400
Pickens	1935 - 36	1.50	1546.0	1587.3	1600.0	123.0	1613.0	131,400
Pinelawn	1973 - 74	0.02	2431.0	2430.5	2443.0	(7)	2448.5	5,800
Rowley	1953 - 54	0.27	1701.6	1703.6	1714.0	60.0	1722.0	37,700
Rowley (Upper)	1976 - 77	0.31	1926.0	1926.0	1946.0	42.0	1951.3	28,800
Rubio	1943 - 44	1.26	1582.1	1582.1	1608.3	59.0	1625.5	127,200
Ruby (Lower)	1955 - 56	0.28	810.8	809.6	828.0	45.0	833.0	28,600
Rye	1981 - 82	1.11	1073.9	1073.8	1077.7	58.2	1081.5	19,100
Santa Anita	1959 - 60	1.70	748.5	748.5 (3)	774.7	160.0	796.0	393,900
Sawpit	1954 - 55	2.78	928.5	933.4	982.0	110.0	1000.0	644,500
Scholl	1945 - 46	0.66	950.0	950.0 (2)	956.0	76.0	966.0	11,100
Schoolhouse	1962 - 63	0.28	1459.6	1450.0	1478.5	20.0	1491.0	67,700 (16)
Schwartz	1976 - 77	0.25	1296.0	1294.7	1312.2	35.0	1319.0	45,400
Shields	1937 - 38	0.03	2030.0	2050.0	2058.1	30.0	2070.2	34,800

1977

DEBRIS BASIN - DESIGN DATA

Including 1988-1989 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1989
FILE: DSA89.WK1

DATA SHEET A

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.
Sierra Madre Dam (14)	1927 - 28	2.39	1119.5	1119.5	1172.5	62.5	1175.0	133,600
Sierra Madre Villa	1957 - 58	1.46	1069.2	1069.2	1098.9	48.0	1102.5	402,700
Snover	1926 - 27	0.23	1858.0	1874.4	1879.0	40.0	1893.7	23,400
Sombrero	1969 - 70	1.06	1539.6	1540.0	1564.8	45.0	1580.0	87,900
Spinks	1958 - 59	0.42	750.0	750.0	761.5	49.0	765.9	56,000 (16)
Starfall	1973 - 74	0.12	2428.0	2428.0	2441.5	30.0	2446.5	18,400
Stetson	1969 - 70	0.29	1556.0	1555.0	1570.0	32.0	1570.0	39,000
Stough	1940 - 41	1.65	1006.0	1005.8	1031.5 (4)	100.0	1043.5	181,200
Sturtevant	1967 - 68	0.03	975.0	971.0	983.6	8.0	990.0	2,300
Sullivan	1970 - 71	2.28	570.0	570.0	587.0	50.0	599.3	51,000
Sunnyside	1970 - 71	0.02	1290.0	1290.0	1299.5	15.0	1303.8	4,300
Sunset Canyon-Deer	1982 - 83	0.20	1382.4	1380.5	1401.8	24.0	1409.1	6,400
Sunset (Lower)	1953 - 64	0.65	1003.8	994.5	1040.0	40.0	1056.0	160,600
Sunset (Upper)	1928 - 29	0.44	1574.2	1574.0	1603.7	75.0	1610.1	15,900
Turnbull	1952 - 53	0.99	480.0	476.0	492.0	40.0	503.0	20,300
Upper Shields (12)	1976 - 77	0.20	2505.0	2502.0	2518.8	29.5	2524.0	5,600
Valley	1987 - 88	0.22	1351.0	(10)	(10)	31.0	1365.0	4,000
Verdugo	1935 - 36	3.09	1109.5	1110.0	1119.7	145.0	1131.0	131,000
Ward	1956 - 57	0.12	2021.1	2022.0	2033.0	58.0	2035.3	12,400
West Ravine	1935 - 36	0.25	1468.8	1496.6	1501.9	20.0	1505.5	46,800
Westridge	1974 - 75	0.02	894.0	894.0	901.0	10.7	906.0	1,400
Wildwood	1967 - 68	0.65	1340.3	(9)	1354.0	50.0	1360.0	22,500
William S. Hart Park	1983 - 84	0.09	1284.0	1280.0	1290.0	19.0	1293.0	2,400
Wilson	1962 - 63	2.58	1517.3	1493.0	1526.0	60.0	1543.0	316,900
Winery	1968 - 69	0.18	1920.0	1920.0	1935.0	20.0	1945.0	29,200
Zachau	1956 - 57	0.35	1803.1	1803.1	1817.0	44.0	1823.0	38,600

114 DEBRIS BASIN ____________________ 7,561,600

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R0053083

DEBRIS BASIN - DESIGN DATA

Including 1988-1989 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1989

DATA SHEET A

(1) LOWEST CLEAR WATER OUTLET, NOT SPILLWAY.
(2) ELEVATION OF SPILLWAY NOTCH.
(3) FLOW LINE OF SLUICEWAY.
(4) ELEVATION OF SPILLWAY INTO OUTLET CHANNEL. ELEVATION OF OVERFLOW SPILLWAY 1030.0 FEET.
(5) ONE 30-INCH REINFORCED CONCRETE PIPE.
(6) FOUR 36-INCH CORRUGATED METAL PIPES.
(7) ONE 36-INCH REINFORCED CONCRETE PIPE.
(8) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(9) PIT-TYPE BASIN.
(10) INFORMATION UNAVAILABLE.
(11) MAXIMUM CAPACITY MAY BE LESS THAN SHOWN AND IS BEING REVIEWED. FIELD INSPECTION SUGGESTS BASIN IS NEAR ITS FULLEST POSSIBLE CAPACITY.
(12) SPECIAL CLEANOUT REQUIRED DUE TO LIMITED STORAGE.
(13) TRANSFERRED FOR MAINTENANCE AFTER THE 87-88 STORM SEASON. FIRST DEBRIS SEASON WILL BE 88-89.
(14) CLEANOUT WHEN DEBRIS REACHES OR EXCEEDS ELEV. 1128.9 AGAINST FACE OF DAM.
(15) VALUES ARE COMBINED WITH COOKS DEBRIS BASIN.
(16) VALUES ARE BASED ON RECENTLY APPROVED CUTPLANS.

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1 9779

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1988-1989

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1989
FILE: DSB89.WK1

DATA SHEET B

DEBRIS BASIN	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS DEBRIS STORED CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE PER CENT
Afton	15	1,022	800	1974-75	-114	7,314	102
Aliso	19	134,730	30,700	1982-83	-1439	43,139	103 (5)
Arbor Dell	18	1,297	800	1979-80	368	12,432	97
Auburn	35	87,386	20,100	1961-62	13	33,687	100
Bailey	44	238,794	91,000	1979-80	1240	127,537	99
Beatty	19	13,297	7,600	1979-80	3236	39,764	92
Bigbriar	18	2,004	623	1987-88	-193	3,293	106
Big Dalton	30	833,003	296,700	1968-69	5184	512,622	99
Blanchard	21	68,196	36,600	1977-78	159	74,374	100
Blue Gum	21	37,572	19,100	1977-78	1473	38,127	96
Brace	18	35,621	12,000	1977-78	-18	27,518	100
Braemar	18	664 (7)	283	1980-81	-228	888	135 (9)
Bradbury	35	267,430	70,200	1968-69	1966	88,534	98
Brand	54	248,895	53,100	1977-78	21640	149,060	87
Buena Vista	4	38	38	1987-88	38	25,462	100
Carriage House	19	4,742	3,400	1979-80	-341	10,741	103
Carter	35	36,890	12,600	1979-80	213	18,487	99
Cassara	13	25,583	16,800	1977-78	3384	33,616	91
Cedarwood	6	(6)	(6)	(6)	3	857	100
Chamberlain	15	556	300	1974-75	-105	6,705	102
Childs	26	45,220	10,700	1980-81	4227	46,200	92
Cloud Creek	17	3,262	1,800	1977-78	650	14,150	96
Cloudcroft	16	12,290	6,100	1973-74	1627	33,073	95
Cooks	38	166,864 (3)	61,200	1977-78	-4466	82,866	106
Cooks N-1A	14	(13)	(13)	(13)	(13)	(13)	(13)
Crestview	6	(6)	(6)	(6)	-45	5,945	101
Crocker	6	(6)	(6)	(6)	4	23,198	100
Deer	35	156,948	44,200	1968-69	6873	49,727	88
Denivelle	13	8,660	5,500	1977-78	559	7,641	93
Devonwood	8	132	100	1982-83	-296	6,696	105
Dry Canyon-South Fork	11	6,003	5,300	1979-80	111	7,789	99
Dunsmuir	54	349,183	86,200	1977-78	2676	108,224	98
Eagle	53	200,286	41,700	1937-38	7072	55,328	89
Elmwood	25	52,781	16,100	1980-81	3643	59,557	94 (14)
Emerald-East	25	8,959	1,800	1985-86	53	13,147	100
Englewild	28	85,119 (2)	60,200 (2)	1968-69	521	49,879	99
Fair Oaks	54	109,020	15,700	1935-36	-2463	26,263	110
Fern	54	159,554	23,900	1968-69	1940	28,660	94
Fieldbrook	15	1,354	500	1977-78	507	2,293	82
Golf Club Drive	19	30,157	11,600	1979-80	323	14,377	98
Gordon	16	4,485	3,800	1977-78	-181	16,987	101
Gould	42	115,091	18,000	1965-66	2272	47,328	95
Gould (Upper)	13	25,444	10,100	1977-78	-161	52,161	100
Halls	54	553,156	102,100	1937-38	1173	88,227	99

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1988-1989

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1989
FILE: DS889.WK1

DATA SHEET 8

DEBRIS BASIN	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS DEBRIS STORED CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE PER CENT
Harrow	31	78,237 (2)	62,400 (2)	1958-69	-4791	72,791	107
Hay	53	67,952	18,200	1937-38	738	33,662	98
Hillcrest	27	48,589	11,700	1964-65	6005	51,785	90
Hog	20	5,500	3,900	1977-78	56	39,544	100
Hook East	21	45,709 (2)	40,200 (2)	1968-69	-32	30,732	100
Hook West	19	6,537	3,600	1979-80	5012	34,588	87
Inverness	7	265	300	1982-83	365	2,935	89
Irving Drive	15	1,244	600	1980-81	90	2,010	96
Kinneloa	25	48,929 (2)	17,600 (2)	1968-69	-536	17,736	103
Kinneloa West Branch	23	59,055 (2)	22,200 (2)	1968-69	626	22,974	97
Lannan	25	84,067	18,200	1969-70	-6530	51,130	115
La Tuna	34	595,914	172,100	1977-78	2515	492,745	99
Las Flores	54	214,754	36,000	1937-38	673	56,927	99
Las Lomas	6	(6)	(6)	(6)	35	9,265	100
Limekiln	26	270,549	42,300	1965-66	9245	162,355	95
Lincoln	54	126,104	28,400	1968-69	1023	37,377	97
Linda Vista	19	11,407	3,400	1977-78	-242	3,442	108
Little Dalton	30	905,170	327,800	1968-69	12037	644,463	98
Maddock	35	56,454	16,200	1980-81	2420	43,480	95
Marston/Paragon	1	(8)	(8)	(8)	0	(8)	(8)
May No. 1	36	203,322	45,800	1968-69	-505	64,505	101
May No. 2	36	27,314	6,200	1966-67	3	9,997	100
Monument	8	2,855	2,600	1981-82	138	6,662	98
Morgan	25	30,292	12,900	1968-69	1079	50,021	98
Mountbatten	6	55	(6)	(6)	55	1,345	96
Mull	16	1,970	1,100	1979-80	62	15,938	100
Mullally (10)	15	51,849 (4)	24,400 (4)	1977-78	596	11,404	95 (14)
Nichols	52	125,652	21,800	1951-52	2020	11,080	85
Oak	14	13,258	6,900	1977-78	739	7,961	92
Oakglade	15	1,455	1,200	1977-78	549	11,751	96
Oakmont View Drive	5	(6)	(6)	(6)	0	3,400	100
Pickens	54	716,116	140,600	1977-78	6285	125,115	95
Pinelawn	16	5,113	1,200	1976-77	325	5,475	94
Rowley	36	76,207 (4)	16,700 (4)	1977-78	-1540	39,240	104
Rowley (Upper)	13	49,019 (4)	31,300 (4)	1977-78	384	28,416	99
Rubio	46	271,322	133,000	1979-80	2159	125,041	98
Ruby (Lower)	24	20,448	8,300	1968-69	4696	23,904	84
Rye	8	10,419	10,000	1981-82	22	19,078	100
Santa Anita	30	689,384 (2,3)	132,000 (2,3)	1961-62	252	393,648	100
Sawpit	35	680,058 (2,3)	223,800 (2,3)	1968-69	402	644,098	100
Schell	44	16,794	3,500	1958-69	888	10,432	94
Schoolhouse	27	33,550	21,600	1962-63	4295	63,405	94
Schwartz	13	45,183	23,400	1977-78	7360	38,040	84
Shields	52	173,202 (3)	35,100	1937-38	1717	33,083	95

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DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1935-1989

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1,1989
FILE: DSB89.WK1

DATA SHEET B

DEBRIS BASIN	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS DEBRIS STORED CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE PER CENT
Sierra Madre Dam (12)	62	363,695 (2)	95,200 (2)	1968-69	-1178	134,778	101
Sierra Madre Villa	32	509,701	118,600	1961-62	-38674	441,374	110
Snover	52	104,397	21,100	1938-39	961	22,439	96
Sombrero	20	6,030	3,300	1977-78	168	87,732	100
Spinks	31	67,086	16,400	1968-69	-5374	61,327	110
Starfall	16	27,128	14,290	1977-78	-818	19,218	104
Stetson	20	5,035	1,500	1977-78	0	39,000	100
Stough	49	161,148	44,100	1964-65	9688	171,512	95
Sturtevant	22	1,321	500	1977-78	106	2,194	95
Sullivan	19	89,957	25,300	1979-80	1183	49,817	98
Sunnyside	19	1,749	800	1978-79	-25	4,325	101
Sunset Canyon-Deer	7	3,678	3,200	1982-83	40	6,360	99
Sunset (Lower)	26	142,169	29,200	1980-81	16525	144,075	90
Sunset (Upper)	61	142,392	27,000	1964-65	-1144	17,044	107
Turnbull	37	50,514 (2)	15,900 (2)	1968-69	-1252	21,552	106
Upper Shields (10)	13	39,692 (4)	16,900	1977-78	-228	5,828	104
Valley	2	200	(6)	(6)	200	3800	95
Verdugo	54	807,740	105,400	1937-38	8680	122,320	93
Ward	33	51,668	17,800	1977-78	230	12,170	98
West Ravine	54	148,333	29,900	1937-38	9538	37,262	80
Westridge	15	200	(6)	(6)	187	1,213	87
Wildwood	22	67,450	16,700	1977-78	1392	21,108	94
William S. Hart Park	6	1,329	1,000	1983-84	298	2,102	88
Wilson	27	257,968	55,500	1968-69	21571	295,329	93
Winery	21	23,137	9,400	1968-69	1935	27,265	93
Zachau	33	107,185 (4)	48,100 (4)	1977-78	1059	37,541	97

114 DEBRIS BASINS

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DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1988-1989

DATA SHEET D

Compiled by: Hydraulic and Water Conservat
Division - Sedimentation Sect
Date: October 1,1989

(1) VOLUME OF DEBRIS DEPOSITED IN BASINS DOES NOT INCLUDE DEBRIS SLUICED THROUGH OPEN PORTS OR NOTCH.
(2) VOLUME OF DEBRIS DEPOSITED DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1968-69 SEASON.
(3) INCLUDING DEBRIS FROM UPSTREAM BASIN OR DAM.
(4) VOLUME OF DEBRIS DEPOSITED DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1977-78 SEASON.
(5) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(6) NO SIGNIFICANT DEBRIS INFLOWS RECORDED.
(7) NO RECORDS OF DEBRIS DEPOSITION EXIST FOR THE FIRST 9 SEASONS.
(8) INFORMATION UNAVAILABLE.
(9) MAXIMUM CAPACITY MAY BE MORE THAN SHOWN AND IS BEING REVIEWED.
(10) SPECIAL CLEANOUT REQUIRED DUE TO LIMITED STORAGE.
(11) TRANSFERRED FOR MAINTENANCE AFTER 87-88 STORM SEASON. FIRST DEBRIS SEASON WILL BE 88-89.
(12) CLEANOUT WHEN DEBRIS REACHES OR EXCEEDS ELEV. 1128.9 AGAINST FACE OF DAM.
(13) VALUES ARE COMBINED WITH COOKS DEBRIS BASIN.
(14) TO BE CLEANED.

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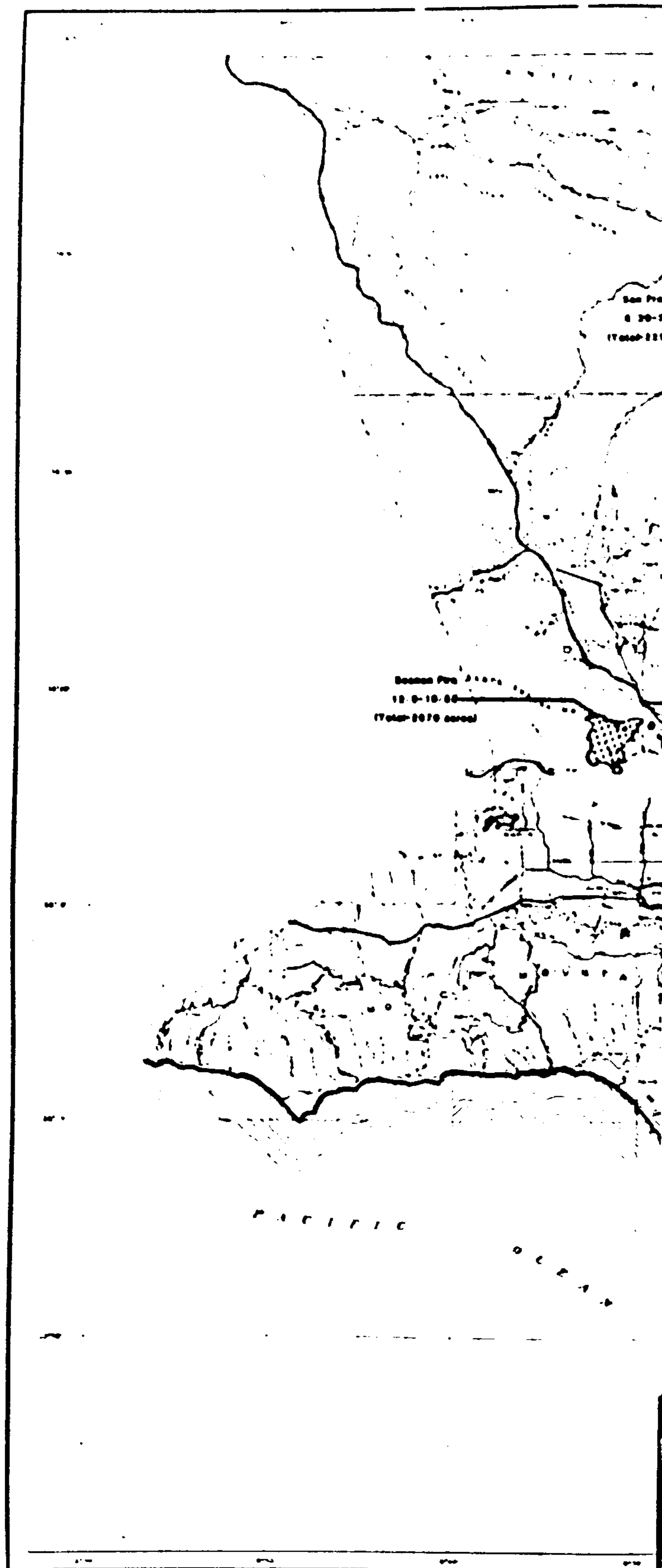

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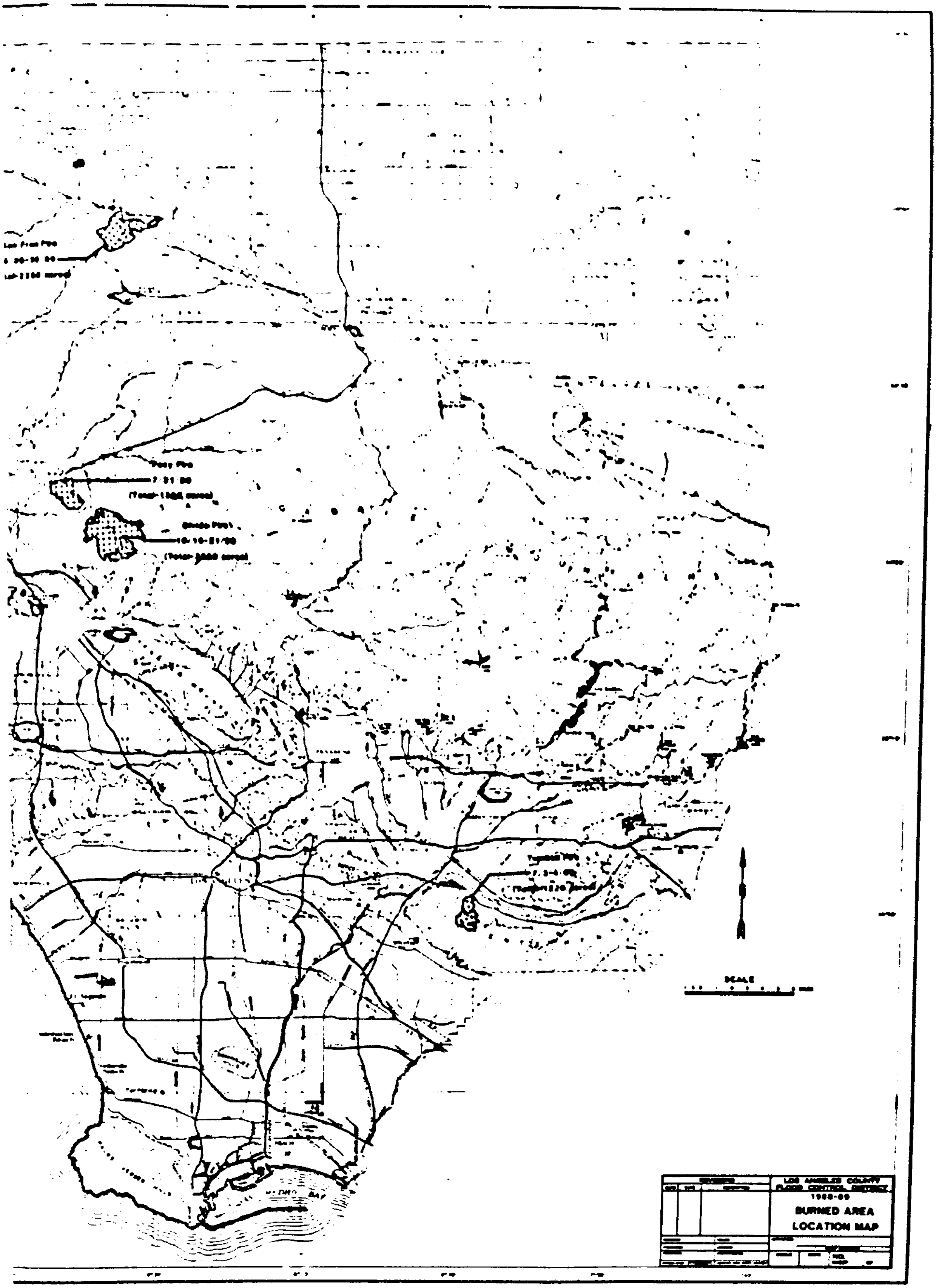

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WATER QUALITY

VOL 12

1987

WATER QUALITY

Since its conception, the Flood Control District (now Department of Public Works) has actively engaged in operations which have proven indispensable in preserving the integrity of our water resources, both quantity and quality, and has aided in the establishment of regulations or controlling criteria by those agencies so empowered.

Prior to March 1986, monitoring activities in the field of water quality control were conducted by the Water Quality Section of Hydraulic/Water Conservation Division. In March 1986, the responsibilities of conducting such activities were transferred to Waste Management Division as a result of the consolidation. These activities include, among others, the collection of water quality samples, their analyses, and the interpretation and reporting of the resulting data.

Areas of involvement include the monitoring of all groundwater basins through the sampling of numerous wells, the monitoring of storm and low water flows at various strategic locations on the major streams or channels, and an assumed or obligated responsibility to monitor the quality effects and subsurface travel of recharge areas, specifically the Whittier Narrows Spreading Grounds area.

The Water Quality Section, together with personnel of other Departmental divisions, also conducts investigations into pollution problems relative to our facilities, particularly those from industrial discharges, vehicle accidents, ruptured pipelines, or the indiscriminate dumping of various waste products.

The principal objectives of these investigations are to determine the degree and apparent source or origin of the pollution and to take the necessary action that will immediately abate the existing problem and possibly provide a means to prevent or limit recurrence.

The above-mentioned activities of the Water Quality Section have recently been intensified, particularly in the areas of interfacing with other counties, cities, environmental organizations, as well as Federal and State agencies, in response to and in voicing the Department's concerns over the proposed require ments of the 1987 Amendments to the Federal Clean Water Act. It is anticipated that the Act will be implemented by the United States Environmental Protection Agency (EPA) with final regulations during the second half of 1990. The said Amendments require National Pollutant Discharge Elimination System (NPDES) permits on discharges of municipal storm sewers into the waters of the United States. Although the NPDES permit requirements are still being developed by the EPA, the final requirements are expected to require a more thorough water quality monitoring within the storm drain system; adoption by municipalities/cities of ordinances prohibiting illegal storm drain hook-ups; and responding to and containing spills of hazardous materials in the storm drains. These Amendments recognize that land drainage flows are the last major discharges currently unregulated.

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SURFACE WATER QUALITY

Prior to 1984, dry weather samples were collected from 30 sampling stations on a monthly basis for analysis such as general minerals, bacteria, pesticides, and heavy metals. In addition, storm samples were also collected and analyzed at least three times annually from the same 30 stations during storm season.

From 1984 to 1987, as a result of reorganization, the number of surface water monitoring stations was reduced to 21, while the parameters analyzed were reduced to include only total dissolved solids, pH, and dissolved oxygen. Storm sampling activities were also significantly curtailed.

In 1988, recognizing the inadequacy of the then existing monitoring program to meet the Department's need in dealing with all the important issues in the areas of water quality, the Department Administration approved and implemented an expanded monitoring program effective May 1, 1988.

There are 28 monitoring stations in the Department's current Surface Water Quality Monitoring Program, from which dry weather samples are collected and analyzed on a monthly basis. These sampling stations are strategically located throughout the Department's major storm drains and water conservation facilities where the flows are representative of typical land uses as well as areas of significant water quality concerns. Of the 28 monitoring stations in the program, six are located at the outlets to Santa Monica Bay, while on is located in the mountain area where the flow is considered to be natural and uncontaminated with the various pollutants associated with urbanization and developed land uses.

Monthly dry weather samples, thus collected, are analyzed for general minerals, (pH, specific conductance, total dissolved solids, total hardness, potassium sulfate, calcium, magnesium, chloride, fluoride, nitrate-nitrogen, nitrite- nitrogen, ammonium-nitrogen, phosphate-P, boron, iron, and manganese) bacteria, pesticides, heavy metals (silver arsenic, barium, cadmium, chromium, mercury, lead, selenium, copper, nickel, zinc, and chromium [VI]), oil and grease, total organic carbon, total petroleum hydrocarbons, PCB's, biochemical oxygen demand, and volatile organic compounds (TCE, carbon tetrachloride, vinyl chloride, 1,2 dichlorethene, benzene, 1,1 dichloroethylene, 1,1,1 trichloroethane, p-dichlo robenzene). In addition, storm samples are collected for three to four storms annually from 21 stations, including San Gabriel Coastal and Rio Hondo Spreading Grounds for extensive analysis similar to those for dry weather samples, with additional testing of total suspended solids and volatile suspended solids to be included. For storm samples collected at San Gabriel Coastal and Rio Hondo Spreading Grounds, priority pollutant constituents are also analyzed under an agreement with the Central and West Basin Water Replenishment District.

1988

A selective list of total dissolved solids is shown for some of the sampling locations on the streams and channels monitored under the Surface Water Quality Program. For a conception of the analysis performed on surface flows, a yearly compilation of constituent determination is shown for one (Los Angeles River at Wardlow) of the sampling stations in the program.

GROUNDWATER QUALITY

The annual sampling of water wells, under a selected scheduling, in five major basins in Los Angeles County comprise the Groundwater Quality Program. The program, initiated in 1970, is coordinated with the State of California Department of Water Resources and the City of Los Angeles Department of Water and Power. These agencies participate in the obtainment and analysis of samples.

All the water wells samples are active production wells used either for municipal supply, irrigation, or for industrial purposes and are selected to represent a general portrayal of basin water quality conditions. The samples taken under this program are analyzed for major mineral, total dissolved solids, electrical conductivity, pH, and in specific cases, phosphate, iron, manganese, fluoride, or boron.

WATER QUALITY DATA ACCESSIBILITY

Data acquired from the various programs are on file in the Water Quality Section. In addition, all data is accessible to any user through STORET, an Environmental Protection Agency computer system that stores, retrieves, and manipulates data using agency code 21CALAFD.

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R0053095

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Surface Water Quality Monitoring Selected Surface Station

Table 1 Total Dissolved Solids - mg/l
1988-89 Season (Dry Weather Flow)

Sampling Location	Oct. 1988	Nov. 1988	Dec. 1988	Jan. 1989	Feb. 1989	Mar. 1989
Ballona Creek at						
Sawtelle Blvd.	754	722	587	760	878	772
Coyote Creek at						
Orangethorpe Avenue	1077	897	1045	630	665	870
Willow Street	687	928	729	630	674	1429
Dominguez Channel						
Above Vermont Avenue	791	7470 *	591	1216	6899 *	652
Los Angeles River at						
Wardlow Road	719	645	725	594	770	684
Firestone Boulevard	741	687	695	674	659	673
Los Cerritos Channel at						
Stearns Street	587	564	694	604	387	521
Rio Hondo River at						
Southern Avenue	720	613	707	464	523	516
Spreading Grounds	533	493	529	498	546	485
Santa Monica Cyn. Ch. at						
Short Street	889	880	923	955	991	921
San Gabriel River at						
Spreading Grounds	705	712	537	538	546	589
Willow Street	849	859	723	578	671	910
San Jose Creek at						
Workman Mill Road	1113	864	620	594	601	907

* Influenced by tidal water; not included in average
** No samples collected due to dry conditions

R0053096

Mar. 1989	Apr. 1989	May 1989	Jun. 1989	Jul. 1989	Aug. 1989	Sep. 1989	Average Value
772	556	723	762	724	700	839	734
871 1420	1031 657	830 644	935 863	884 732	968 681	891 811	894 789
652	584	701	715	695	683	728	736
684 673	760 716	559 620	630 655	640 617	652 656	684 688	672 673
5.	535	532	810	627	642	492	583
516 485	857 468	545 610	835 389	855 574	1075 **	645 523	696 513
921	942	949	904	862	876	887	915
588 910	577 886	** 809	** 668	** 557	** 642	760 789	621 745
907	919	903	900	632	855	955	822

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1 9792

R0053097

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VOL 12

1993

Water Quality Analysis (Partial Data)

<u>Monthly Monitoring 1988-89 Season (Dry Weather)</u>

Los Angeles River @ Wardlow Road

Constituent mg/l	Oct. 1987	Nov. 1987	Dec. 1987	Jan. 1988	Feb. 1988
Hardness as $CaCO_3$	300	235	288	250	274
Calcium	71	60	73	65	70
Magnesium	30	21	25	22	24
Sodium	122	119	115	109	151
Potassium	14.4	16.6	16.3	14.2	15.0
Ammonium-N	3.3	8.3	6.3	5.8	7.8
Alkalinity as $CaCO_3$	161	170	205	180	198
Sulfate	181	160	191	184	185
Chloride	150	136	122	90.9	161
Nitrate-N	2.60	3.07	3.48	2.01	2.21
Phosphate-P	1.48	1.70	2.58	1.50	2.10
Total Dissolved Solids	719	645	725	594	770
BOD	7.3	6.0	1.5	5.0	2.0
Total Organic Carbon	<1	<1	<1	<1	<1
MPN/100ml					
Fecal Coliform	93,000	430	4,300	13	1,100
Total Coliform	230,000	4,300	4,300	940	33,000
Fecal Streptococcus	400	<100	200	<100	7,000
pH	7.5	8.3	8.5	8.6	8.1
Temperature (F)	66	66	56	54	52

Mar. 1988	Apr. 1988	May 1988	Jun. 1988	Jul. 1988	Aug. 1988	Sep. 1988	Average
277	329	239	234	305	300	238	272
68	79	56	64	75	70	61	68
26	32	24	18	29	30	21	25
121	132	108	130	104	117	97	119
14.0	6.6	17.0	10.6	11.4	13.8	13.5	13.6
4.7	3.2	2.6	0.3	0.4	1.0	0.1	3.6
[illegible]	208	168	175	178	228	145	185
	183	115	116	154	154	136	160
[illegible]	158	124	149	120	130	111	130
2.28	7.01	1.51	0.77	0.72	0.61	0.99	2.27
0.45	0.51	0.62	0.26	0.28	0.56	2.05	1.17
684	760	559	630	640	652	684	672
6.0	5.0	4.0	5.0	6.0	5.0	<1	5
8.6	10.0	7.0	7.7	<1	4.6	16.5	5
49	230	790	23,000	23	490	2,800	11,000
700	7,900	7,000	170,000	230	17,000	17,000	41,000
<100	<100	400	14,000	100	200	46	1,900
9.0	9.2	8.9	8.3	8.2	7.8	8.1	8.4
70	68	72	70	79	80	72	67

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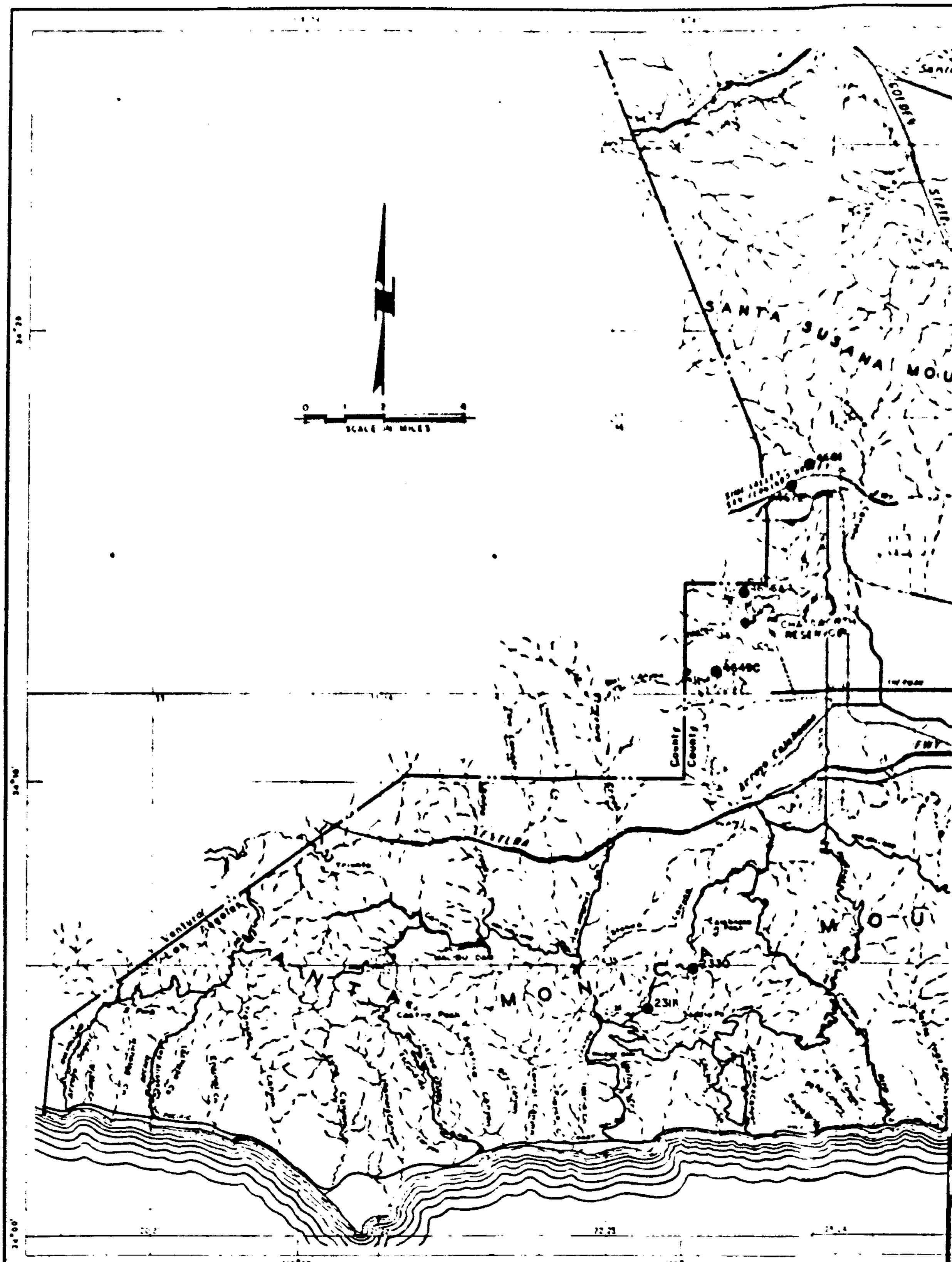
1 9794



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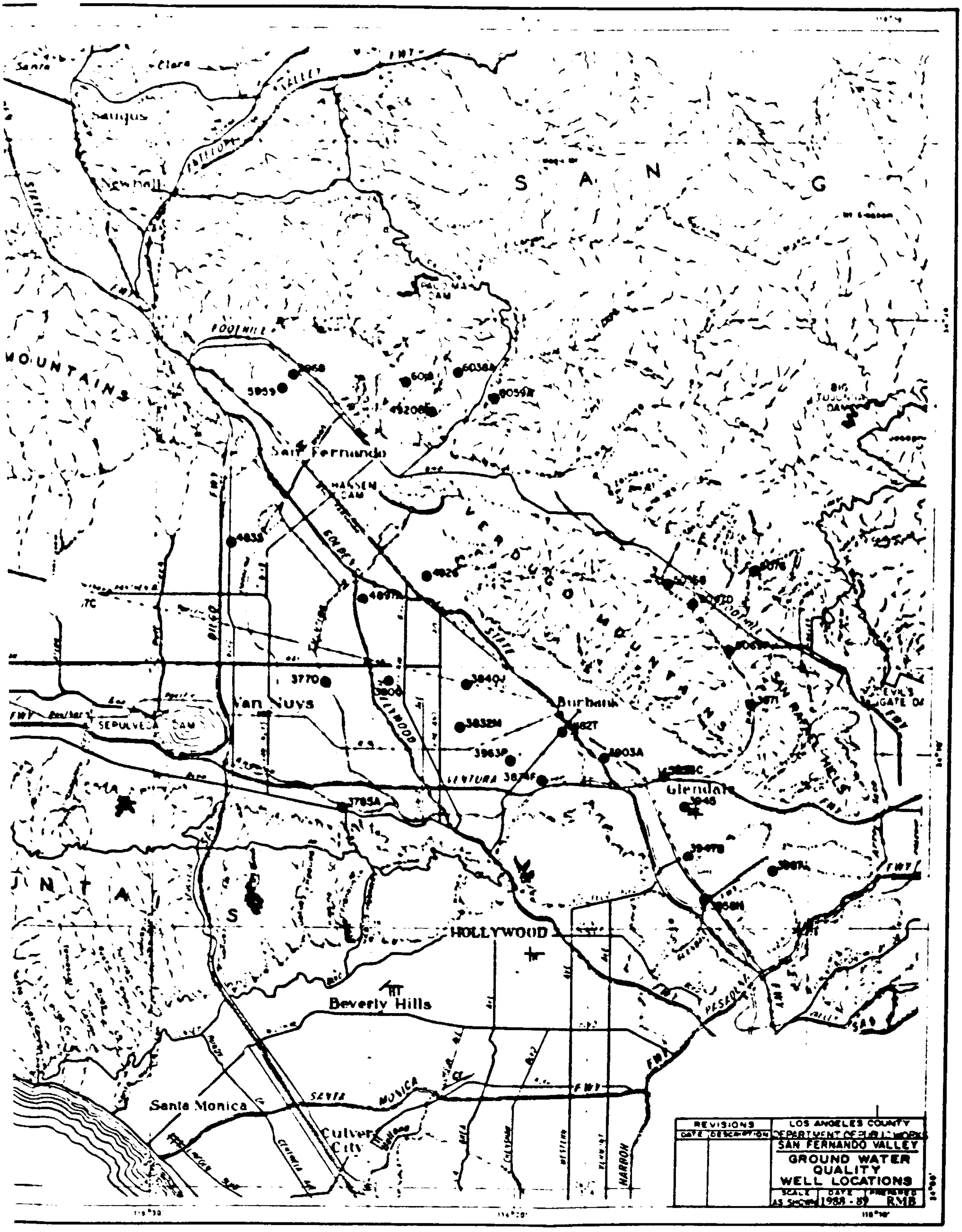
1995

R0053100

VOL 12

1996



LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS
SAN FERNANDO VALLEY
GROUND WATER
QUALITY
WELL LOCATIONS
REVISIONS
DATE
DESCRIPTION
SCALE
AS SHOWN
DATE
1988 - 89
PREPARED
RMB
Saugus
Newhall
S A N G
MOUNTAINS
San Fernando
HANSEN DAM
BIG TUJUNGA DAM
VERDUGO MOUNTAINS
SAN RAFAEL HILLS
DEVIL'S GATE DAM
Van Nuys
SEPULVEDA DAM
Burbank
Glendale
HOLLYWOOD
Beverly Hills
Santa Monica
Culver City
N T A
S
FOOTHILL
GOLDEN STATE
VENTURA
HOLLYWOOD
PASADENA
SANTA MONICA
FWY
HARBOR
3959
3958
6018
6038A
6059R
4920B
4835
4926
4897B
3770
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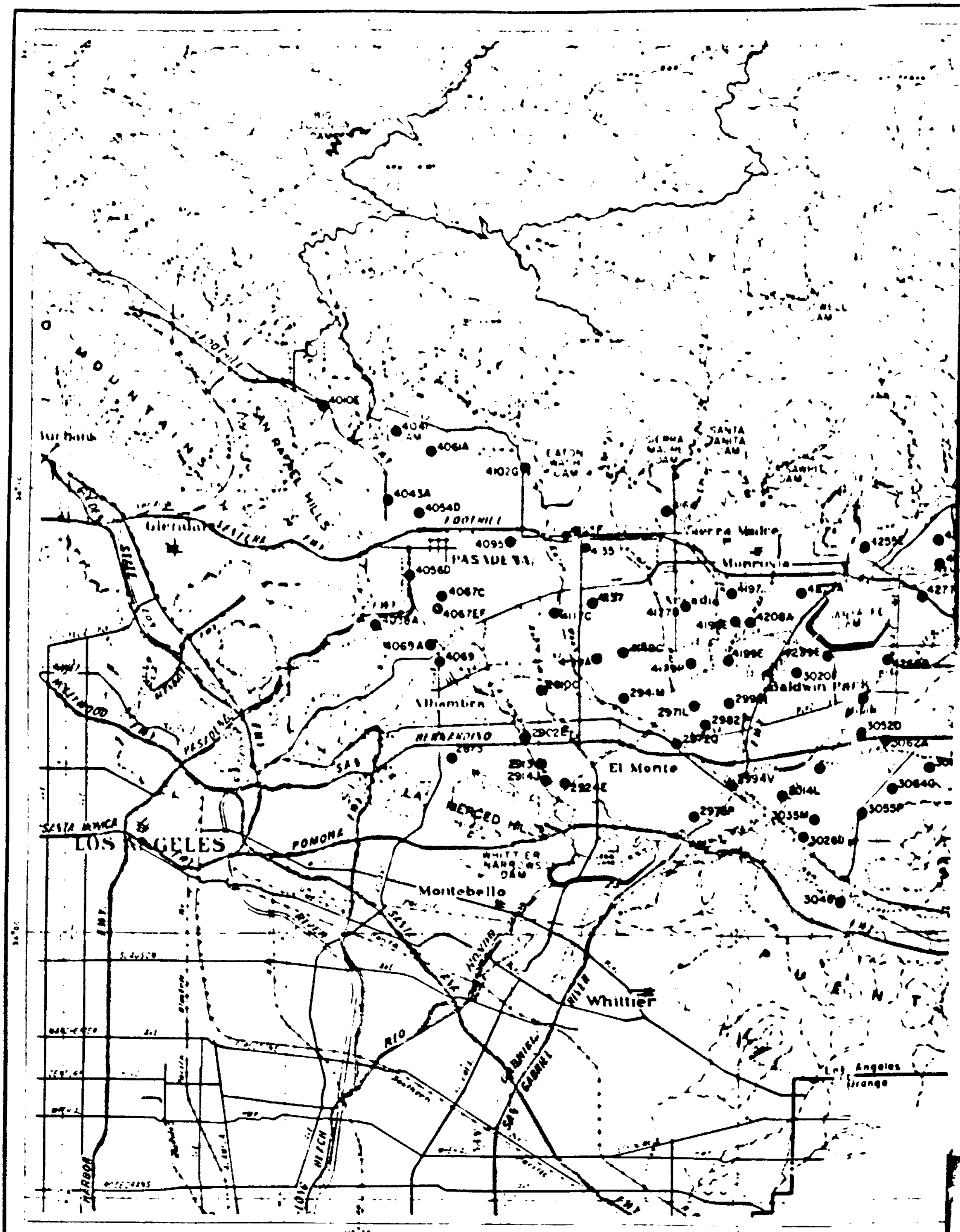

Glendale
PASADENA
Sierra Madre
Monrovia
Arcadia
Alhambra
Baldwin Park
El Monte
LOS ANGELES
Montebello
Whittier
SANTA MONICA
POMONA
SAN BERNARDINO
EATON WASH DAM
SANTA ANITA DAM
SANTA FE DAM
WHITTIER NARROWS DAM
Los Angeles
Orange
4010E
4061A
4102G
4043A
4054D
4095
4056D
4067C
4067EF
4058A
4069A
4069
2873
3052D
3062A
3055P
3026D
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2982
2971L
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4277

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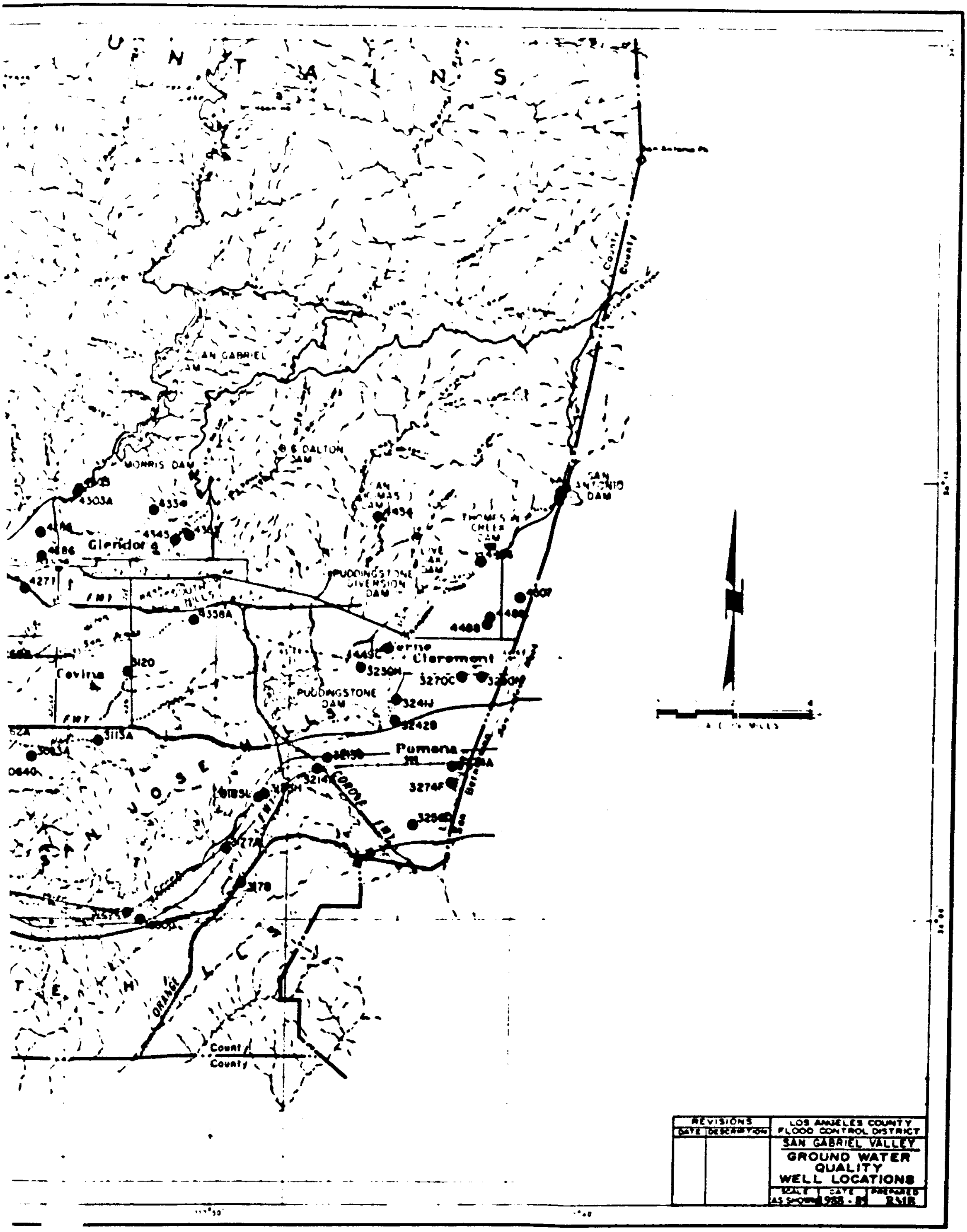
1997



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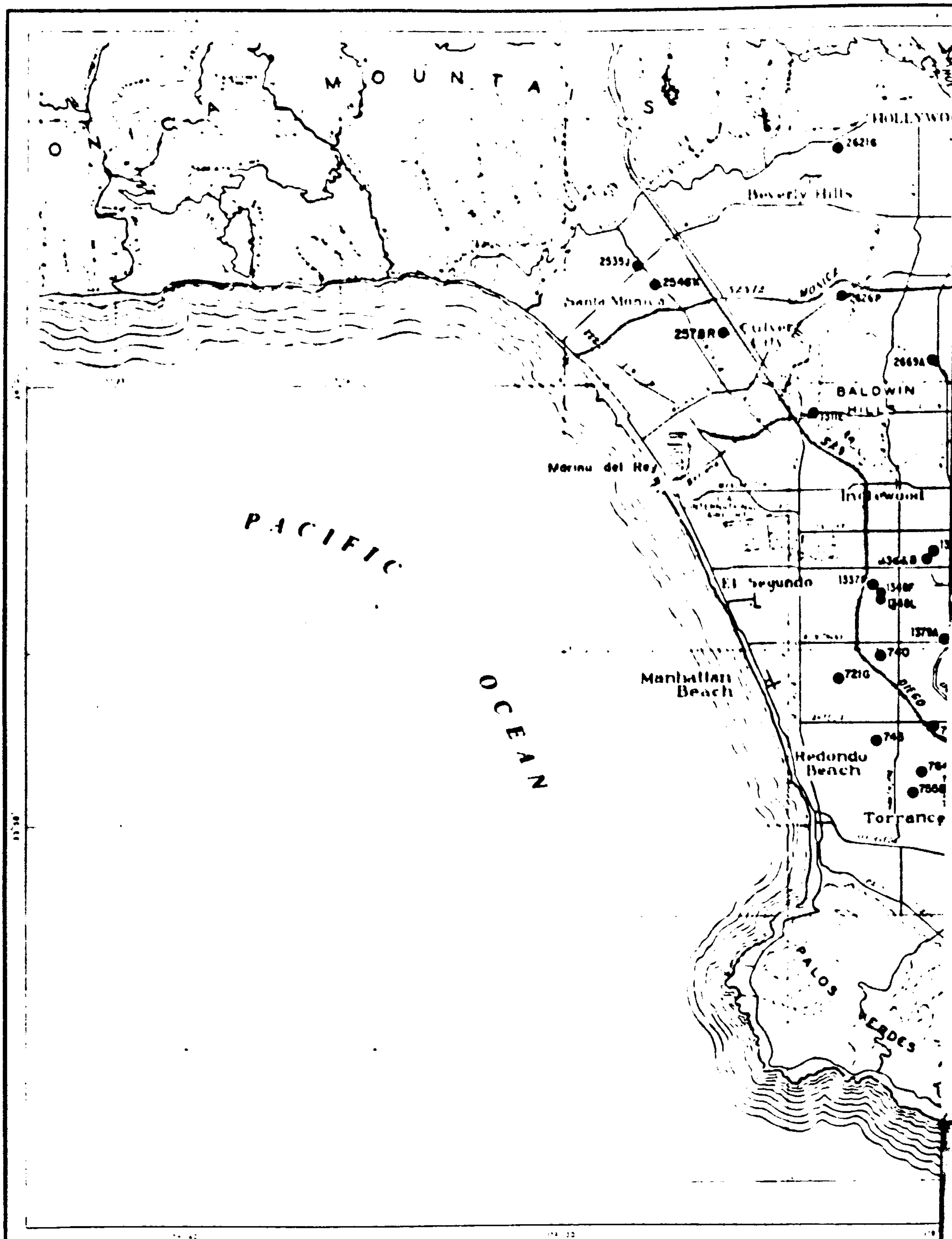
MOUNTAINS
Beverly Hills
Santa Monica
2539J
2546K
2578R
Culver City
BALDWIN HILLS
Marina del Rey
Inglewood
PACIFIC
OCEAN
El Segundo
Manhattan Beach
Redondo Beach
Torrance
PALOS VERDES

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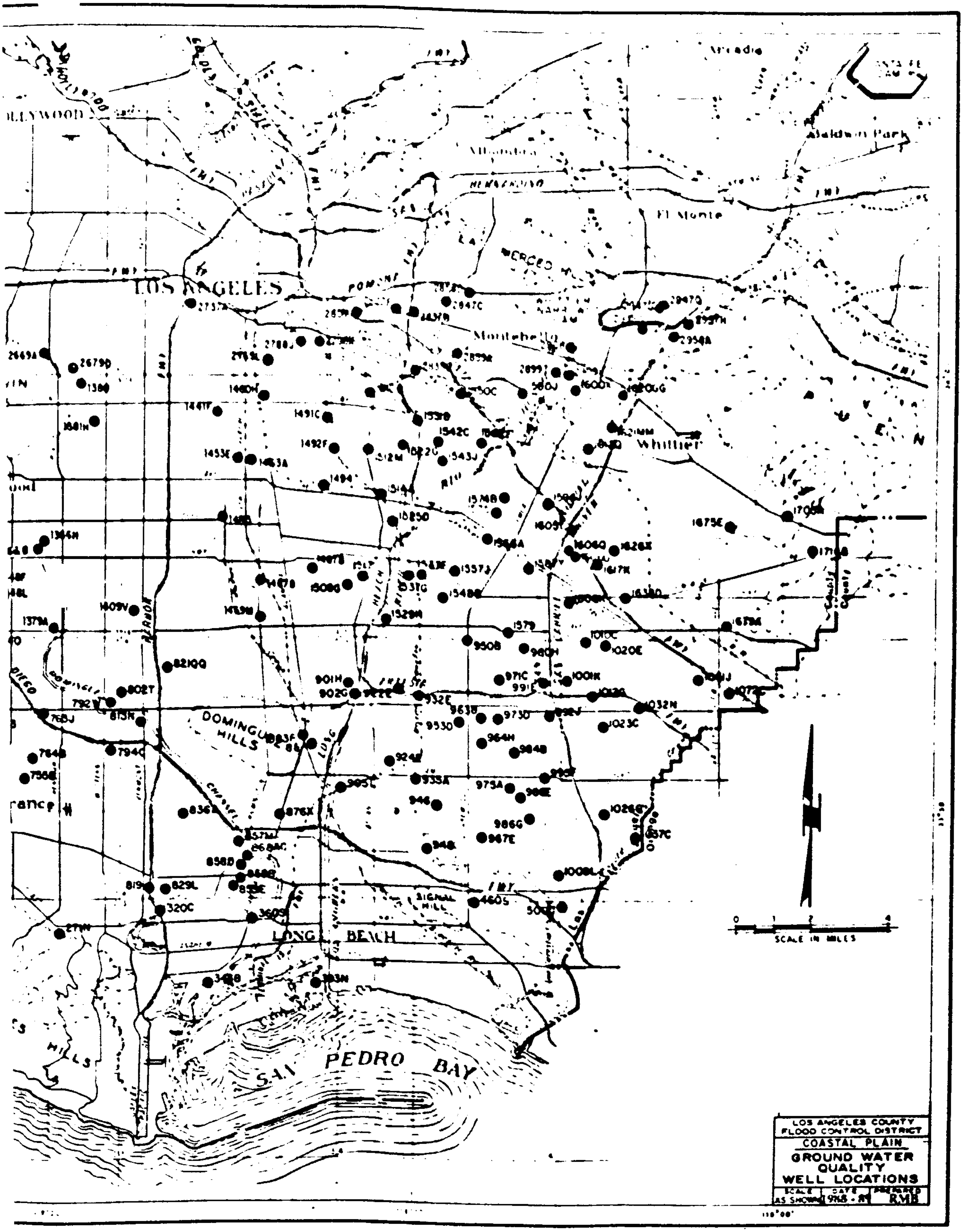
1979



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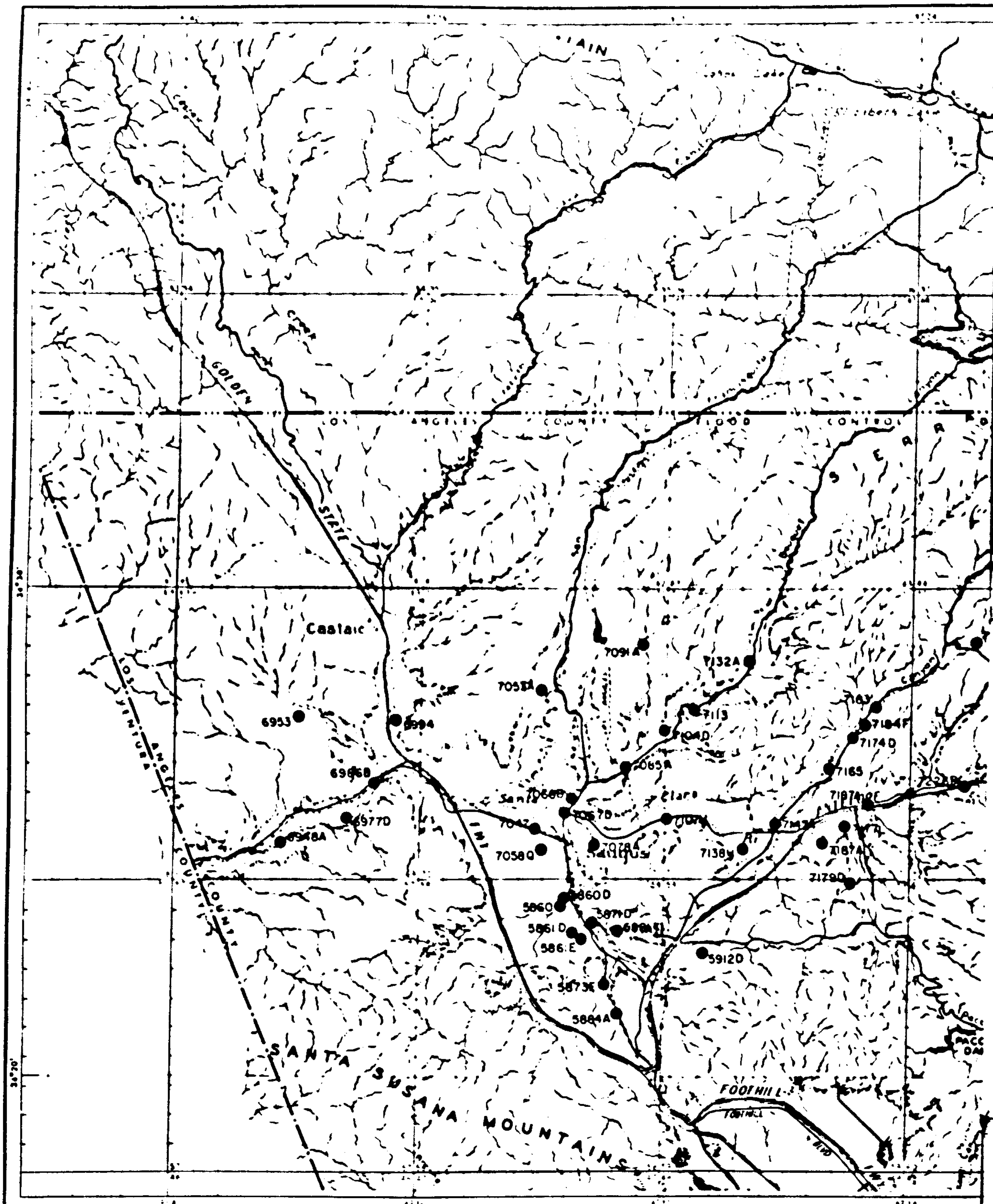

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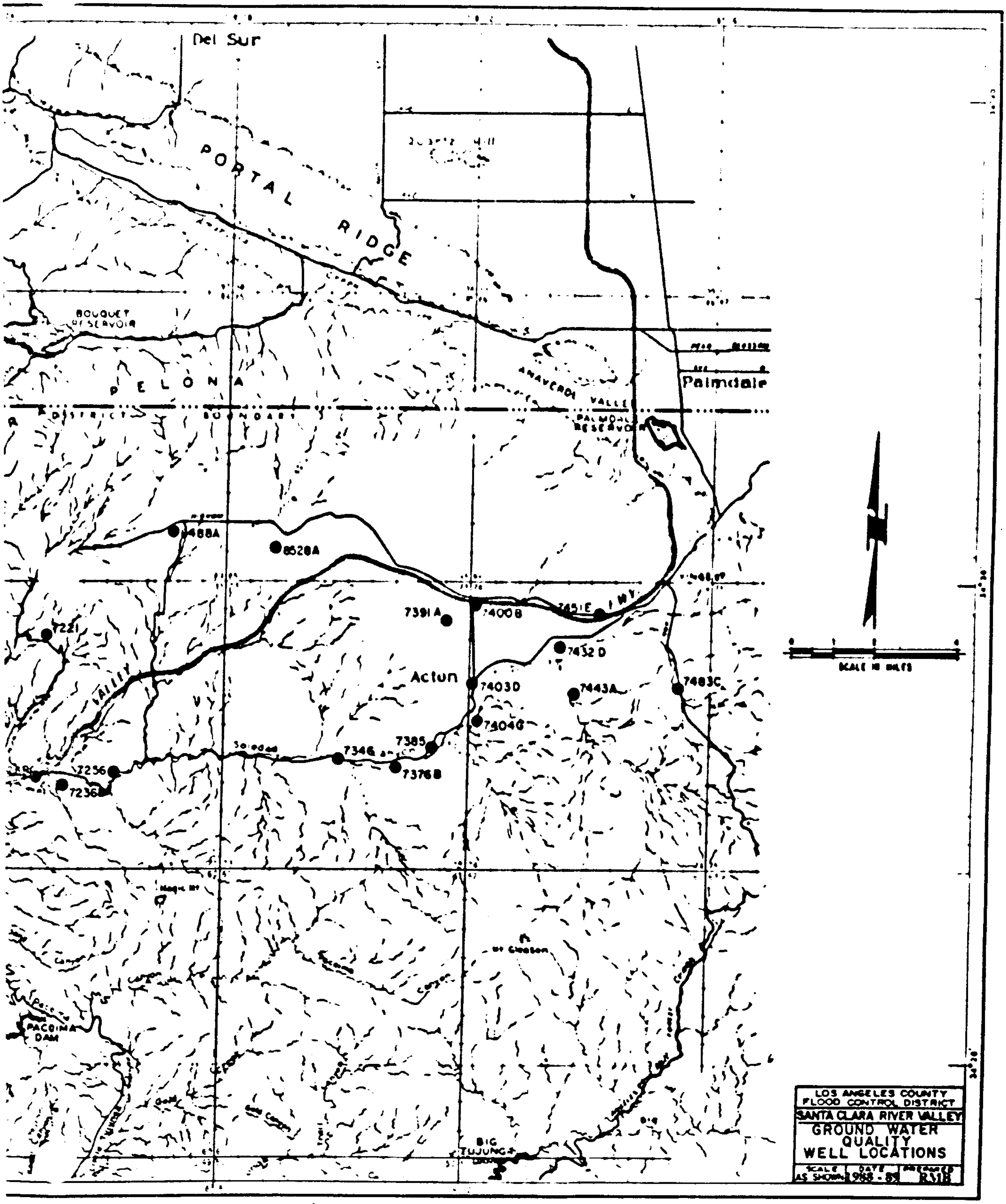

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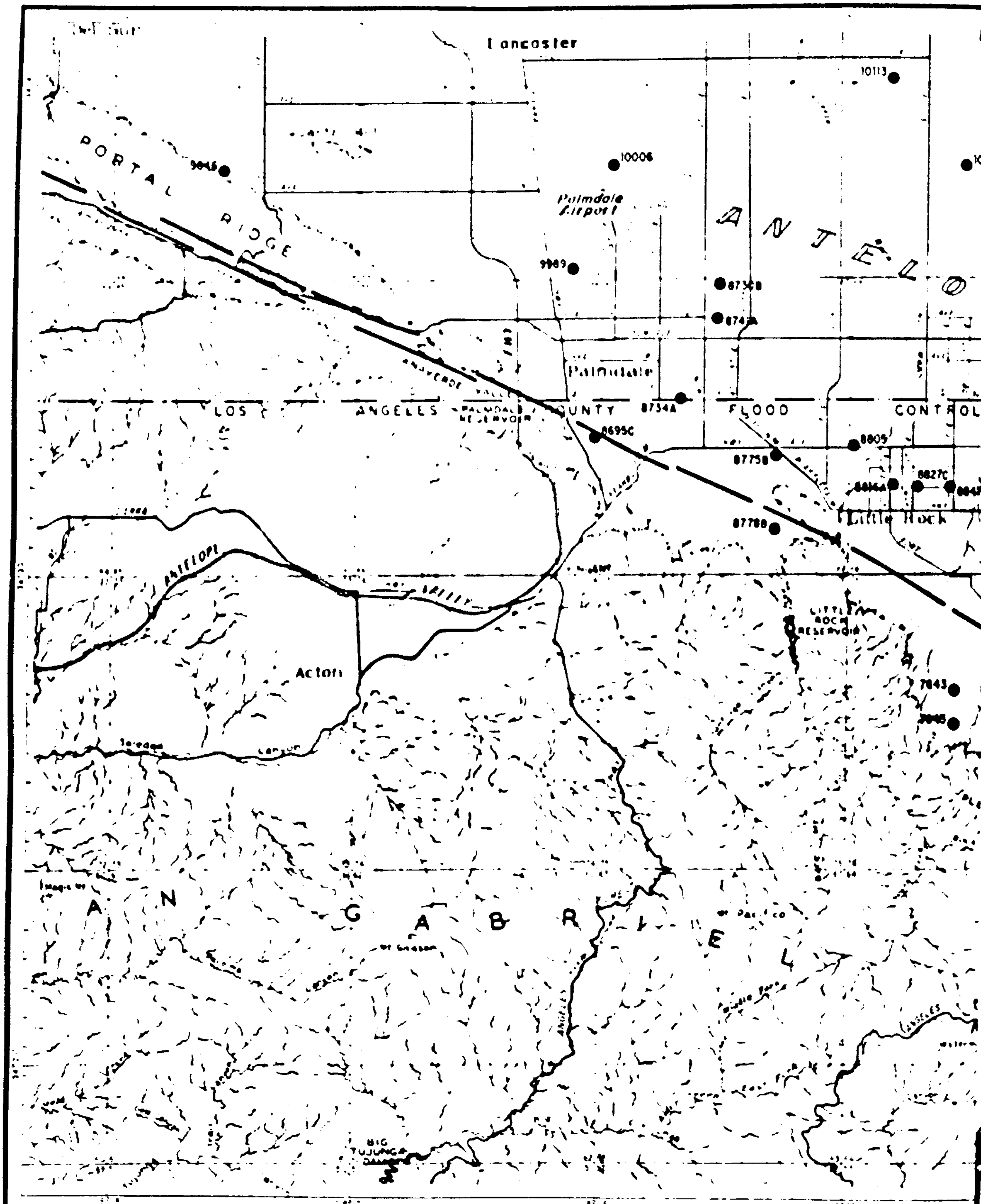

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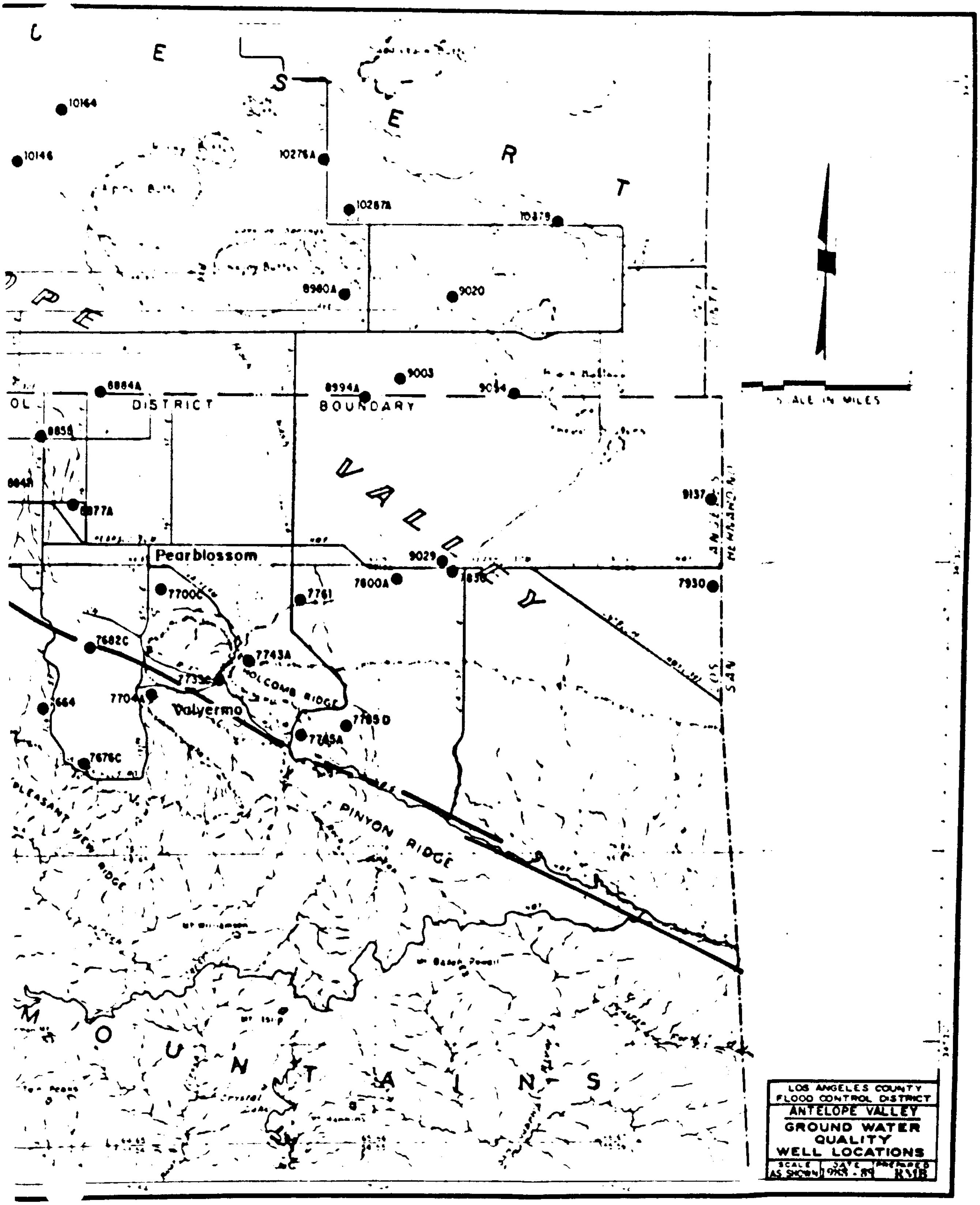

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VOL 12

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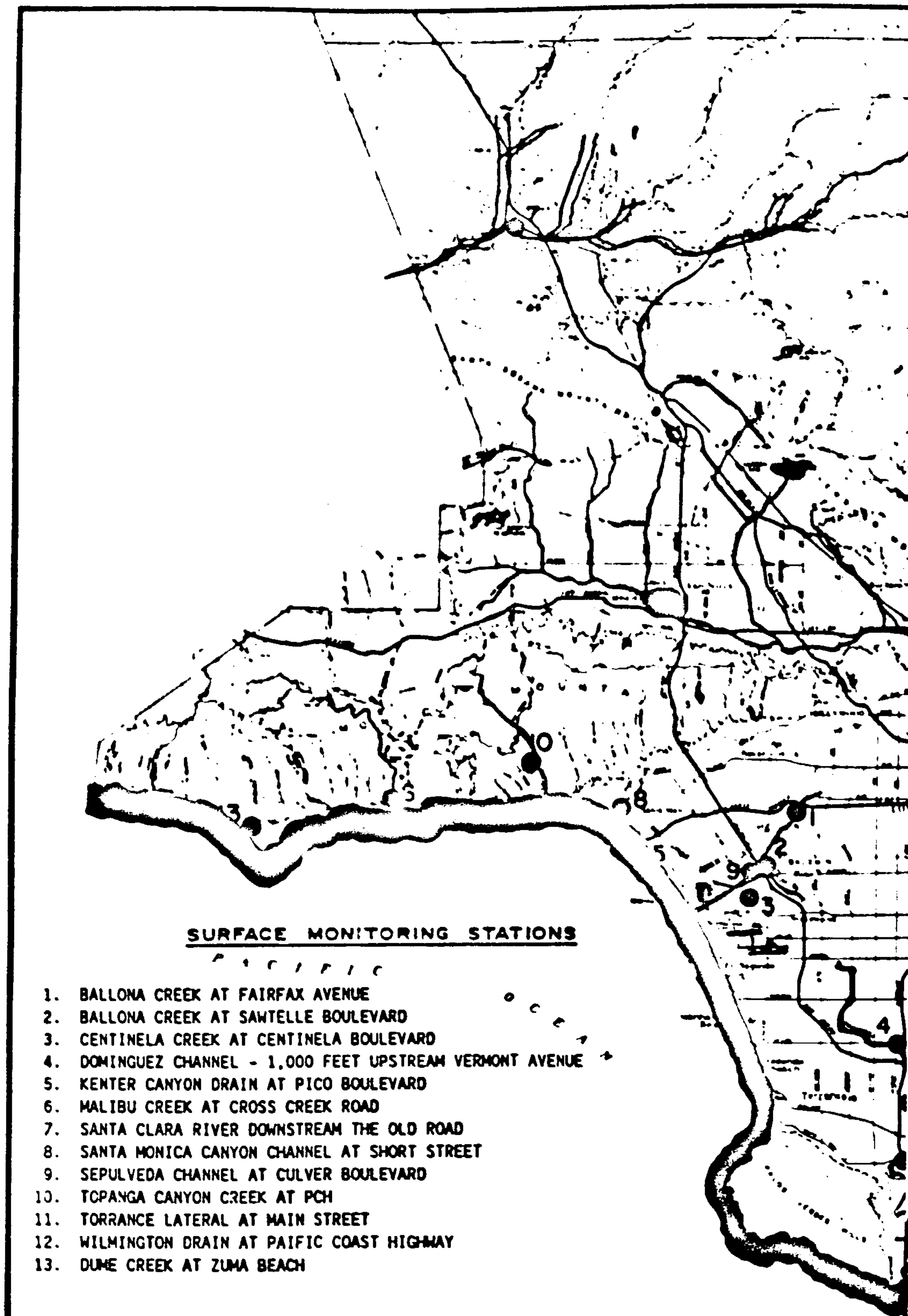

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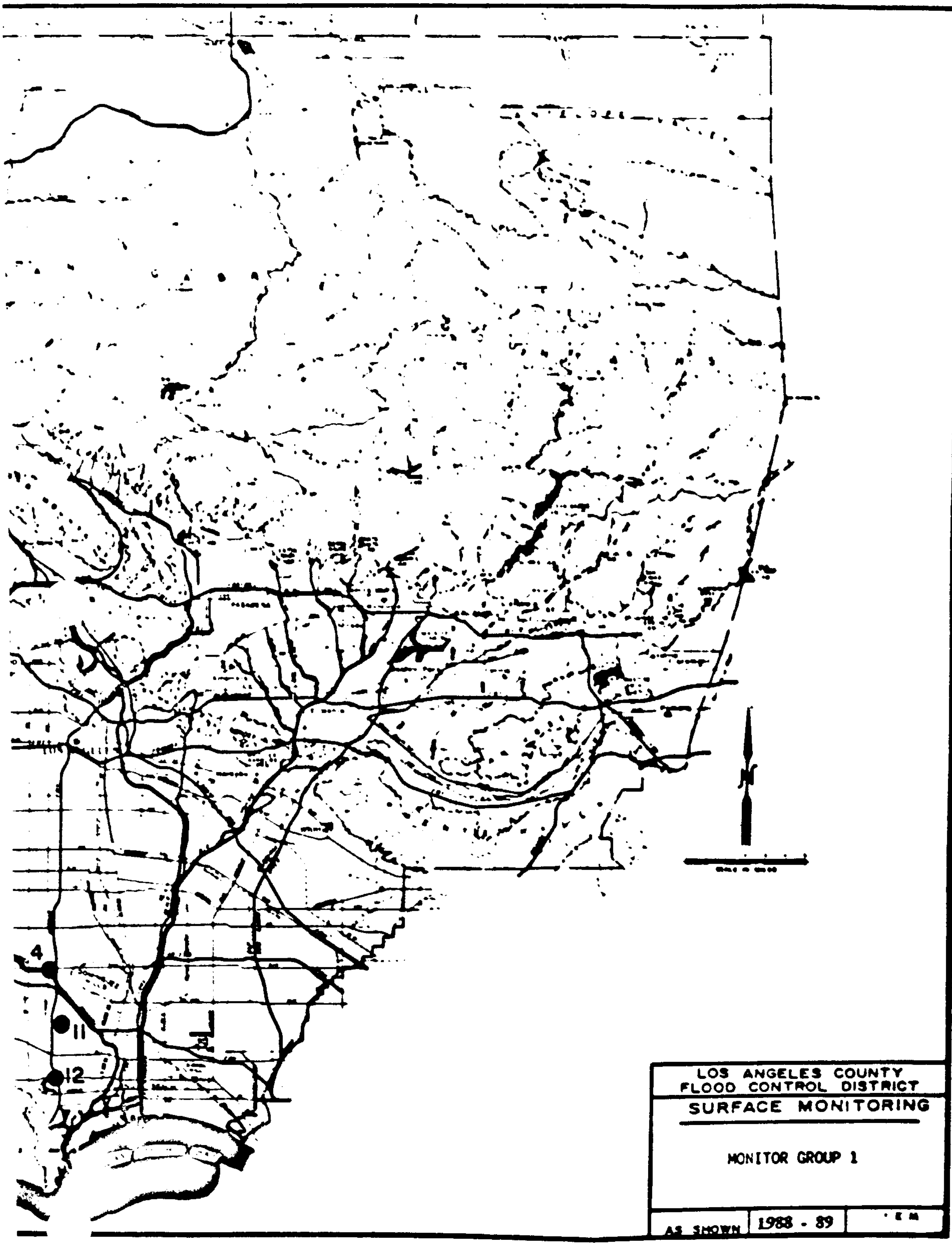

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

SURFACE MONITORING

MONITOR GROUP 1

AS SHOWN	1988 - 89	E M

VOL 12

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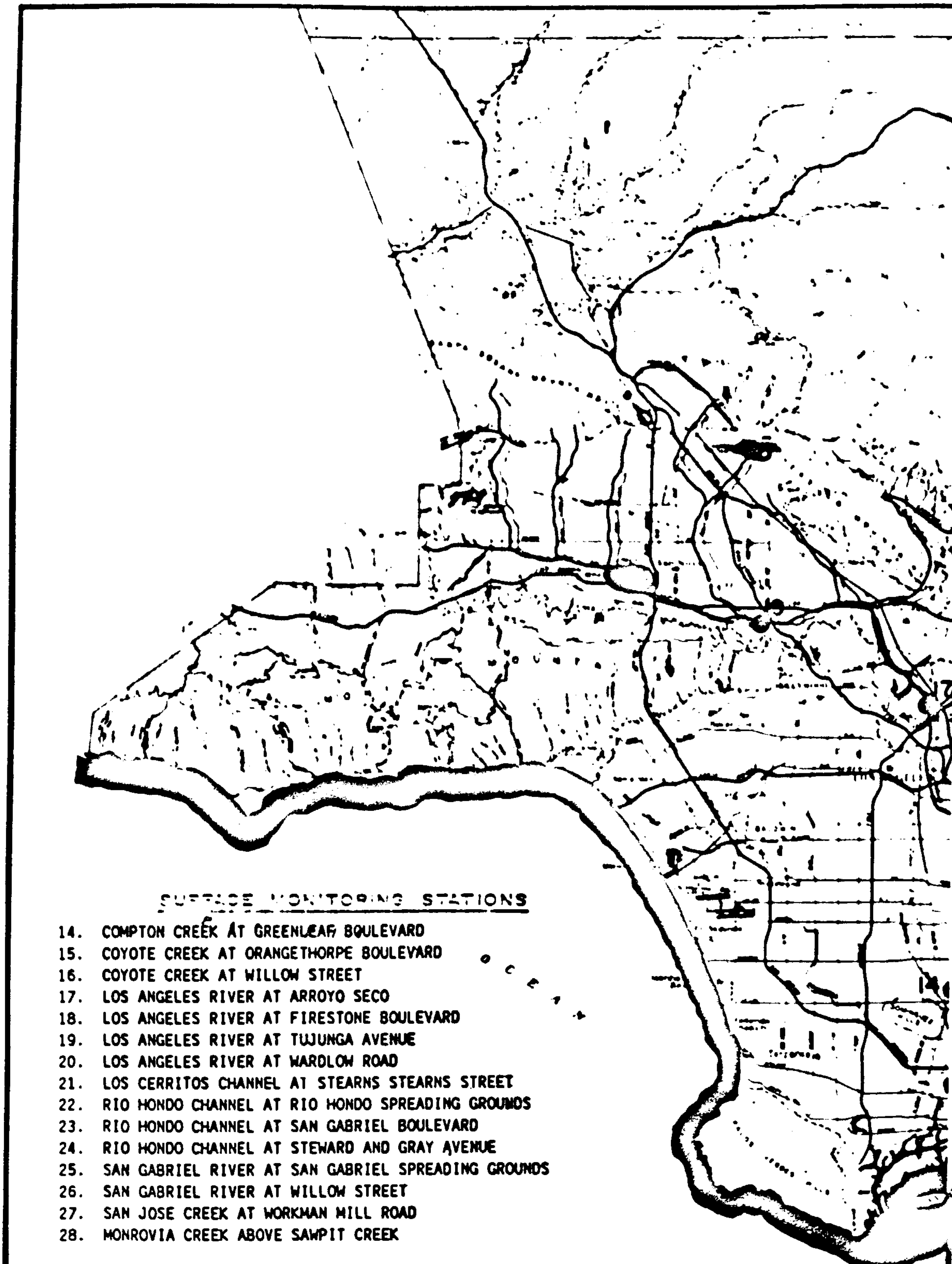
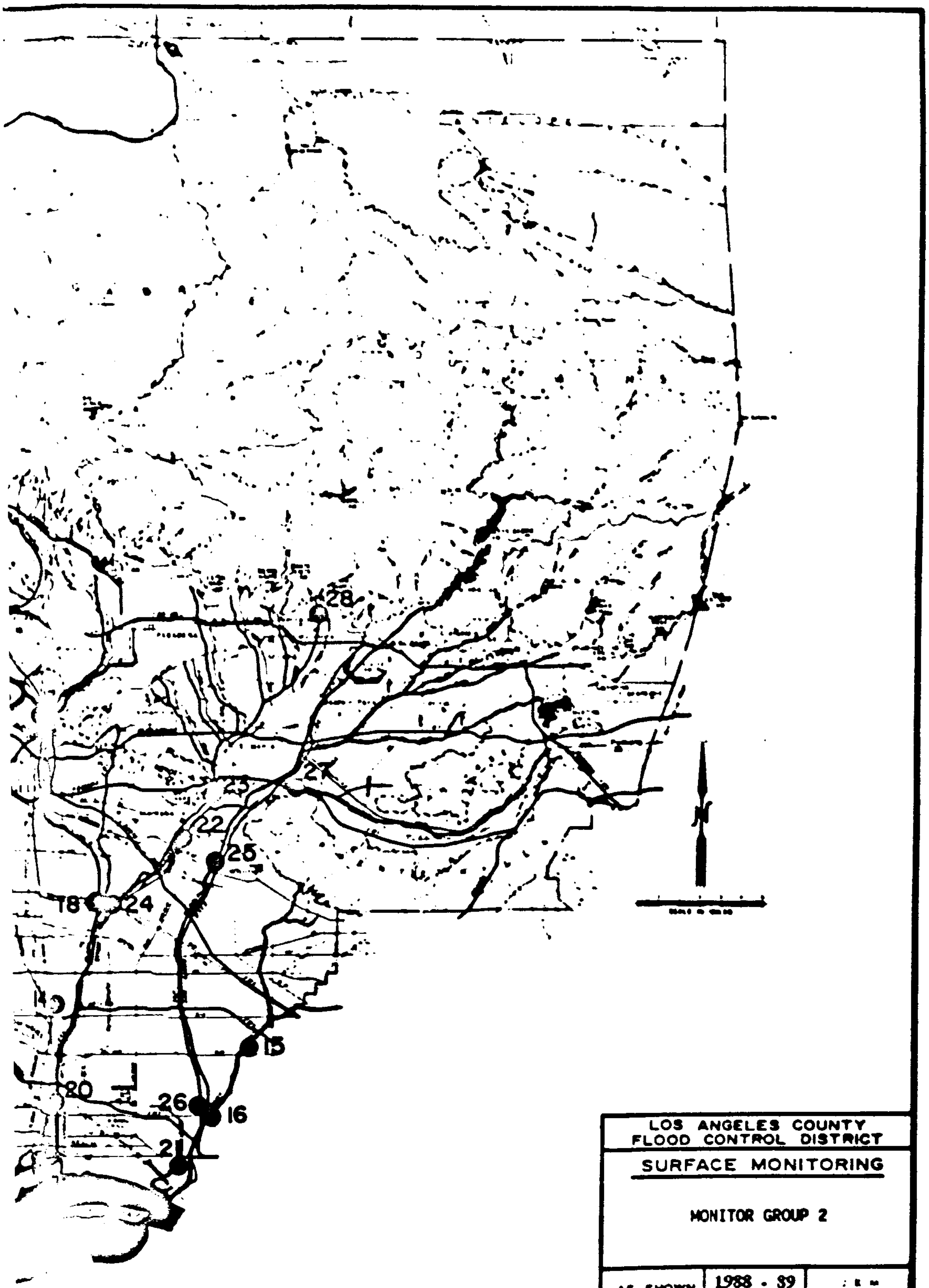

SURFACE MONITORING STATIONS
14. COMPTON CREEK AT GREENLEAF BOULEVARD
15. COYOTE CREEK AT ORANGETHORPE BOULEVARD
16. COYOTE CREEK AT WILLOW STREET
17. LOS ANGELES RIVER AT ARROYO SECO
18. LOS ANGELES RIVER AT FIRESTONE BOULEVARD
19. LOS ANGELES RIVER AT TUJUNGA AVENUE
20. LOS ANGELES RIVER AT WARDLOW ROAD
21. LOS CERRITOS CHANNEL AT STEARNS STEARNS STREET
22. RIO HONDO CHANNEL AT RIO HONDO SPREADING GROUNDS
23. RIO HONDO CHANNEL AT SAN GABRIEL BOULEVARD
24. RIO HONDO CHANNEL AT STEWARD AND GRAY AVENUE
25. SAN GABRIEL RIVER AT SAN GABRIEL SPREADING GROUNDS
26. SAN GABRIEL RIVER AT WILLOW STREET
27. SAN JOSE CREEK AT WORKMAN MILL ROAD
28. MONROVIA CREEK ABOVE SAWPIT CREEK



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WATER CONSERVATION

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WATER CONSERVATION

Information presented in this section includes amounts of local, imported, and reclaimed water conserved in spreading areas, information on the seawater barrier projects which prevent saltwater intrusion to groundwater zones in the coastal areas. Pertinent data are presented regarding the locations and descriptions of Department water conservation facilities, as well as facilities owned by others. Also included are groundwater maps delineating static groundwater elevations recorded during the report period and hydrographs of selected key wells.

CONSERVING THE WATERS

In addition to its flood control program, the Department has the equally important task of conserving as much of the storm and other waste waters as practicable. The use of water conservation facilities adjacent to river channels, and in soft-bottom channels permits water to percolate into groundwater reservoirs for later pumping. These water spreading facilities are located in areas where the underlying soils are composed of pervious formations.

The various types of water conserved, local, imported, and reclaimed, are construed to have the following meanings in this section: Local water is primarily runoff due to rainfall on the mountain and valley watersheds, dam releases, and rising water within the County. Imported water is water originating outside the County either from Northern California or from the Colorado River, commonly blended from both sources which is transported to and delivered within the County. Reclaimed water is the effluent produced by the Whittier Narrows Water Reclamation Plant, the San Jose Creek Water Reclamation Plant, and the Pomona Reclamation Plant, all operated by the Los Angeles County Sanitation Districts.

The importance of this activity is apparent when it is realized that about 35 to 45 percent of the water used in the County is pumped from ground supplies. The growth of the County, combined with periodic droughts, seriously depleted these supplies on numerous occasions down through the years.

The Department's policy is to conserve the maximum amount of storm water possible consistent with considering runoff quantity and quality, capacities of the spreading facilities, and groundwater conditions.

SPREADING GROUNDS

The total gross area of spreading grounds owned and operated by the Department during this report period amounted to 2,369 acres. The Department also assisted in the operation and maintenance of 679 acres of spreading grounds owned by others. An additional 246 acres of spreading grounds are controlled, maintained, and operated by other agencies. The total gross acreage of spreading grounds in the County is 3,294 acres.

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IMPORTED WATER

During this report period, imported Colorado River and State Project water for spreading was obtained from the Metropolitan Water District. Also imported State Project Water for spreading was obtained from the San Gabriel Valley Municipal Water District. Imported water for groundwater recharge in the Coastal Plain was spread in the Department's facilities in the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds and San Gabriel River systems south of Whittier Narrows Dam on behalf of the Central and West Basin Water Replenishment District. Imported water for groundwater recharge in the San Gabriel Valley was spread in Santa Fe Spreading Grounds, in the San Gabriel River between Morris Dam and the spreading grounds, in Irwindale Spreading Basin and in Forbes Spreading Grounds on behalf of MWD, the Main San Gabriel Basin Watermaster, and the San Gabriel Valley Municipal Water District.

RECLAIMED WATER

The County Sanitation Districts' Whittier Narrows Water Reclamation Plant effluent, purchased by the Central and West Basin Water Replenishment District, was transported to the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds and San Gabriel River System for groundwater replenishment.

The County Sanitation Districts' San Jose Creek Water Reclamation Plant, activated in May 1972, made its first delivery of effluent in November 1972. The portion of the effluent that is spread is also purchased by the Central and West Basin Water Replenishment District.

The maximum amount of reclaimed water allowed for spreading annually in the Montebello Forebay was increased from 32,700 acre-feet to 37,700 acre-feet in the 1986-87 water year, to 42,700 acre-feet in July 1988, and to 50,000 acre-feet effective July 1989.

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SEAWATER BARRIER PROJECTS

The Department operates three barrier projects to protect the groundwater in the West Coast and Central Basins against seawater intrusion by creating freshwater pressure ridges along the coastline. The pressure ridges are created by injecting fresh water through a series of injection wells. During the report period, 22,735 acre-feet of water were injected at the West Coast Basin Barrier Project, 5,223 acre-feet at the Dominguez Gap Barrier Project, and 3,901 acre-feet at the Los Angeles part of the Alamitos Barrier Project. On behalf of the Orange County Water District, 1,675 acre-feet of water were injected at the Orange County portion of the Alamitos Barrier Project.

SEASONAL DATA AND MAPS

During this report period, monthly and semi-annual measurements of groundwater levels in observation wells located throughout the groundwater basins in Los Angeles County were made and processed.

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Hydrographs of selected key wells are included in this report.

GROUNDWATER BASINS AND GROUNDWATER RECHARGE

Groundwater in Los Angeles County is stored in basins underlying five major geographic areas. These groundwater basins are separated by geologic features which impede groundwater movement or sometimes by arbitrary political boundaries. Following is a background and summary of the Department's groundwater recharge activities within each of these areas.

The Department operates 2,369 acres of spreading grounds and basins and soft-bottom channel spreading areas for replenishment of local aquifers to increase water supplies. During the report period, the Department conserved more than 59,900 acre-feet of storm runoff.

The conservation of local runoff is supplemented by spreading imported water and reclaimed water purchased by water agencies. During the period, 107,442 acre-feet of imported water and 52,374 acre-feet of reclaimed water were spread.

The Department is continuing its efforts to improve its water spreading facilities in order to maximize the amounts of water conserved and to simplify the spreading operations.

SAN GABRIEL VALLEY

The Department operates 20 spreading grounds in the San Gabriel Valley to receive direct valley runoff and flows from the San Gabriel Mountains, some can also receive imported water. During the report period, the Department added approximately 29,870 acre-feet of local water and 61,440 acre-feet of imported water to the groundwater stored in the basins underlying the San Gabriel Valley.

The following construction projects were performed in San Gabriel Valley during the report period:

1. Forbes Spreading Grounds:

The existing basins were deepened and the flashboard structures were replaced with concrete spillways. A new intake was constructed to deliver 100 cfs.

2. Citrus Spreading Grounds:

The existing basins were combined into two basins. A new intake system was constructed to deliver 200 cfs and the existing intake capacity was increased from 25 to 85 cfs.

A contract was awarded to construct the "Granado Drain" to direct excess Covina Irrigation Company water to Big Dalton Wash for spreading in Citrus Spreading Grounds.

1982

3. Santa Fe Spreading Grounds:

The existing 23 west basins were combined into four basins averaging 7.5 feet deep. Six flashboard structures and 14,500 linear feet of levee were eliminated resulting in the removal of 800,000 cubic yards of soil. The storage capacity was increased by 577 acre-feet.

4. San Gabriel Canyon Spreading Grounds:

The Department constructed a 250 cfs intake from the river to basin 2.

5. Irwindale Spreading Basin:

The Department acquired the adjacent Manning Pit and is evaluating its long-term filling and an overflow connection from Irwindale Basin.

6. Eaton Wash Spreading Grounds and Eaton Basin:

A contract was awarded to install motor operators on the intake gates at Eaton Wash Spreading Grounds (Raymond Basin) and to install new gates with electric motor operators at Eaton Basin (Main San Gabriel Basin).

Main San Gabriel Basin

This is the largest basin underlying the San Gabriel Valley with an estimated storage capacity of 9.5 million acre-feet. It reacts quickly to artificial spreading in Santa Fe Reservoir Spreading Grounds and to infiltration in the San Gabriel River downstream of Santa Fe Dam.

During the report period, the Department replenished the Main San Gabriel Basin with 16,610 acre-feet of local water and 38,700 acre-feet of imported water.

Upper San Gabriel Canyon Basin

Approximately 6,175 acre-feet of local water and approximately 21,440 acre-feet of imported water were recharged by the Department through its San Gabriel Canyon Spreading Grounds and by percolation in the adjacent San Gabriel River. Also, 5,375 acre-feet of water were routed to Fish Canyon Spreading Grounds which is operated by the Committee of Nine.

Lower Canyon Basin

The basin is located south of the Upper San Gabriel Canyon Basin and is separated from it by the underground Lohmon Dike. Groundwater cascades over the Lohmon Dike from the Upper San Gabriel Canyon Basin and recharges the Lower San Gabriel Canyon Basin. The Department spread 605 acre-feet of local water in Sawpit Spreading Grounds which is within the Lower Canyon Basin.

VOL 12 1984

Wayhill Basin

The Department spread 30 acre-feet of local water and 1,300 acre-feet of imported water in the wayhill basin.

Foothill Basin

The Department spread 690 acre-feet of local water at its San Dimas Canyon Spreading Grounds facility in the Foothill Basin.

Glendora Basin

The Department spread 345 acre-feet of local water in its Dalton facilities within the Glendora Basin.

Claremont Heights Basin

Approximately 10 acre-feet of local water were diverted to the Pomona Valley Protective Association's Thompson Creek Spreading Grounds which benefits the groundwater in the Claremont Heights Basin.

Live Oak Basin

The Department has no spreading facilities in the Live Oak Basin.

Chino Basin

The basin is located in the most eastern part of the County. No Department recharge facilities are located within the Chino Basin.

San Dimas Basin

The basin is north of the San Jose Hills, east of the Main Basin, and south of the Wayhill Basin. The Department spread 30 acre-feet of local water in its Live Oak Spreading Grounds to recharge the basin.

Pomona Basin

The basin is located south of claremont, Live Oak, and San Dimas Basins, and north of the Chino Basin and northeast of the San Jose Hills. The Department has no water spreading facilities within this basin.

Puente, Sapdra, and Walnut Basins

No spreading occurs in this area.

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Raymond Basin

The basin covering approximately 40 square miles is located in the northwest corner of the San Gabriel Valley and is separated from the Main San Gabriel Basin by the Raymond Fault. The Raymond Basin contains the Monk Hill Basin and the Pasadena and Santa Anita Subareas. The Department recharged 1,060 acre-feet of local water by its spreading facilities in the Raymond Basin and diverted 1,200 acre-feet to the City of Sierra Madre's spreading facility during the report period.

COASTAL PLAIN

The groundwater basins underlying the Coastal Plain are divided by geological features into the Central (includes the Montebello and Los Angeles Forebays), West Coast, Santa Monica, and Hollywood Basins. During the period October 1, 1988 to September 30, 1989, the Department recharged 15,500 acre-feet of local water, 46,000 acre-feet of imported water, 52,375 acre-feet of reclaimed water to the groundwater basins underlying the Coastal Plain. Most of the water was spread in the Montebello Forebay.

During the report period, the first phase of the Groundwater Recharge Telemetry System (GRTS I) was being installed. GRTS I will provide computerized remote monitoring of flows in Montebello Forebay tributary to our Rio Hondo and San Gabriel Coastal Basin Spreading Grounds, and remote monitoring and control of San Gabriel Coastal Basin Spreading Grounds operations. Central computer stations will be located at the Rio Hondo Headworks and our Fremont headquarters Operation Center. The system will be used in conjunction with our ALERT (Automatic Local Evaluation in Real Time) System.

The next phase for GRTS II will provide remote control for the Rio Hondo Spreading Grounds and the five rubber dams in the San Gabriel River.

Central Basin

The Central Basin has the most storage capacity of the basins in the Coastal Plain. In addition to the water recharged in the Department's spreading facilities, water injected in the Alamitos Barrier Project also contributes to the replenishment of the pressure aquifers underlying the Central Basin.

Rio Hondo System

A. Rio Hondo Coastal Basin Spreading Grounds

1. Extensive modification of the east side grounds combined 31 basins into 10 large basins, added 2,900 acre-feet of storage capacity making the total storage 4,500 acre-feet.

2. A 1,000 cfs gravity flow type intake structure was installed.

1985

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3. Approximately 4.5 miles of levees were removed and 350,000 square feet of roadways were paved.

4. One thousand eight hundred flashboards were eliminated.

B. Whittier Narrows Dam - Rio Hondo Side

A concept plan was devised to increase the conservation pool from 2,500 acre-feet to 3,700 acre-feet. This enlargement plan is presently under negotiation with the U.S. Army Corps of Engineers.

San Gabriel System

A. San Gabriel Coastal Basin Spreading Grounds

1. The existing basins were combined into four large basins adding 300 acre-feet of storage.

2. A structure was installed in the intake canal to divert flows into basin 1, in order to increase the intake capacity.

B. San Gabriel River

1. The Department has completed the installation of five air inflated rubber dams each 200 feet long, six to seven feet high on the stabilizers in the soft bottom river from Washington Boulevard to Florence Avenue, adding 500 acre-feet of storage.

2. The Department had a contract to extend the storm drain (Choiser Drain) outlet to downstream of the rubber dam in the San Gabriel River in Washington Boulevard to prevent backflow in the drain due to the potential for water levels in back of the dam.

West Coast Basin

The West Coast Basin is the second largest basin underlying the Coastal Plain and is separated from the Central Basin by the Newport-Inglewood Fault zone. Groundwater is primarily recharged by Central Basin subsurface flows and by water injected by the Department in the West Coast Basin and Dominguez Gap Barrier Projects. Groundwater elevations in the West Coast Basin are below sea level except in the area of the West Coast Basin Barrier injection mound.

Dominguez Spreading Grounds

Approximately 25,000 cubic yard of silt were removed from the west side basin of Dominguez Spreading Grounds.

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1987

SAN FERNANDO VALLEY

The San Fernando Valley is also called the Upper Los Angeles River Area (ULARA). Most of the runoff from the surrounding mountains flows to the Valley.

Pacoima Spreading Grounds

The 36 existing basins were combined and excavated into 12 basins and a portion of the interbasin hydraulic system was constructed. This modification added 200 acre-feet of storage capacity.

San Fernando Main Basin

The basin is the largest basin underlying the San Fernando Valley. During the report period, 11,100 acre-feet of local water spread by the Department recharged this basin.

Sylmar Basin

A much smaller basin underlying the San Fernando Valley is the Sylmar Basin; the Department has no spreading facility within this basin.

Verdugo and Eagle Rock Basins

The small Verdugo and Eagle Rock Basins comprise the remaining basins underlying the San Fernando Valley. The Department has no spreading facilities within either basin.

SANTA CLARITA VALLEY

The Department has no spreading facilities in the area. Most of the Valley are is farmland, permitting substantial natural percolation.

The Upper Santa Clarita subunit comprises five basins.

ANTELOPE VALLEY

There are several groundwater basins underlying the Antelope Valley, five of them are located within Los Angeles County.

During this report period, the Department recharged over 1,100 acre-feet of local water in its spreading facility in the Big Rock area to groundwater in the Pearland Basin.

The groundwater level in the Lancaster Basin, has declined steadily since 1925 and reached a new historic low during the report period.

LOS ANGELES COUNTY DEPA[...]
WATER CONSERV[...]

SUMMARY OF DATA ON [...]
OWNED AND OPERATED [...]
UPDATED THROUGH [...]

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1981-8

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES CHANNEL**	CAPACITIES INTAKE	CAPACITIES STORAGE	CAPACITIES PERCOLATI[...]
					CFS	CFS	A.F.	CFS
ARROYO SECO	SHALLOW BASINS	1948-49	24	13	-	75	30	18
BEN LOMOND	SHALLOW BASINS	1959-59	24	17	-	25	25	18
BIG DALTON	SHALLOW BASINS	1930-31	24	13	-	45	25	15
BRANFORD	DEEP BASIN	1956-57	12	8	1,540	1,540	137	1
BUENA VISTA	DEEP BASIN	1954-55	10	6	2,900	2,900	177	6
CITRUS	MEDIUM DEPTH BASINS	1960-61	19	14.4	-	200	80	28
DOMINGUEZ GAP	DEEP BASINS	1957-58	54	31	-	20	140	3

* THE CAPACITIES LISTED ARE BASED ON INFILTRATION RATES WHICH MAY BE EXPECTED TO PERSIST FOR AT LEAST FIVE DAYS BUT ARE NOT VALID FOR SUSTAINED SPREADING OPERATIONS.

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

DEPARTMENT OF PUBLIC WORKS
NSERVATION DIVISION

A ON SPREADING FACILITIES
ATED BY THE DEPARTMENT
ROUGH SEPTEMBER 1989

PERCOLATION	LOCATION	SOURCE OF WATER	REMARKS
CFS			
18	EASTERLY SIDE OF ARROYO SECO, 0.5 MILES ABOVE DEVIL'S GATE DAM.	UNCONTROLLED FLOW FROM ARROYO SECO AND THE ALTADENA STORM DRAIN. CONTROLLED FLOW FROM CITY OF PASADENA.	SPREADING GROUNDS ARE HELD UNDER EASEMENT FROM THE CITY OF PASADENA.
18	BOTH NORTH AND SOUTH SIDES OF SAN DIMAS WASH CHANNEL AT SOUTHWESTERLY CORNER OF INTERSECTION OF ARROW HIGHWAY AND BARRANCA AVENUE.	COVINA IRRIGATING COMPANY.	SPREADING GROUNDS UTILIZED TO CONSERVE EXCESS COVINA IRRIGATION COMPANY WATER RELEASED FROM THE COMMITTEE OF NINE.
15	WESTERLY SIDE OF BIG DALTON WASH, ONE HALF MILE ABOVE SIERRA MADRE AVENUE.	CONTROLLED FLOWS FROM BIG DALTON DAM AND BIG DALTON DEBRIS BASIN.	
1	SOUTHWESTERLY OF ARLETA AVENUE ABOVE CONFLUENCE OF TUJUNGA WASH AND PACOIMA DIVERSION CHANNEL.	UNCONTROLLED FLOWS FROM BRANFORD STREET DRAIN.	OUTLET CAPACITY 1,540 CFS TO PACOIMA DIVERSION CHANNEL.
6	1.0 MILE EASTERLY OF SAWPIT WASH. 0.5 MILE NORTHERLY OF ARROW HIGHWAY, BETWEEN MERIDIAN STREET AND BUENA VISTA CHANNEL.	CONTROLLED FLOW FROM SANTA FE DAM AND UNCONTROLLED FLOW FROM BUENA VISTA CHANNEL.	AN ADDITIONAL OUTLET CONSTRUCTED TO PROVIDE TOTAL OUTLET CAPACITY OF 270 CFS.
29	SOUTH SIDE OF BIG DALTON WASH BETWEEN CITRUS AND CERRITOS AVENUES.	CONTROLLED FLOW FROM BIG DALTON WASH.	THERE ARE 2 INTAKES, ONE IS A DROP INLET, THE OTHER A AIR INFLUTED RUBBER DAM.
3	SOUTH OF DEL AMO BOULEVARD. AND BORDERS THE EASTERN AND WESTERN SIDES OF THE LOS ANGELES RIVER.	CONTROLLED FLOW FROM LOS ANGELES RIVER LOW FLOW CHANNEL AND UNCONTROLLED FLOWS FROM STORM DRAINS.	EAST SIDE BASIN USED FOR FLOOD REGULATION WITH SOME CONSERVATION STORAGE. INTAKE CAPACITY IS 20 CFS FOR LOW FLOW DIVERSION FROM THE LOS ANGELES RIVER. THE WEST SIDE BASIN IS FED BY A 42-INCH CONCRETE PIPE FROM THE EAST SIDE BASIN.

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1989

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LOS ANGELES
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SUMMAR
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SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES		CAPA	
			GROSS	WETTED	CHANNEL**	INTAKE
					CFS	CFS
EATON BASIN	DEEP BASIN	1956-57	16	11	9,600	400
EATON WASH	DEEP & SHALLOW BASINS	1947-48	29	24	8,800	100
FORBES	MEDIUM DEPTH BASINS	1964-65	21	8.8	-	100
HANSEN	SHALLOW BASINS	1944-45	156	110	22,000	400
IRWINDALE	DEEP BASIN	1958-59	17	14	20,000	450
LITTLE DALTON	SHALLOW BASINS	1931-32	14	5	-	20
LIVE OAK	SHALLOW BASINS	1961-62	5	2	-	15
LOPEZ	SHALLOW BASINS	1956-57	18	12	-	25

* THE CAPACITIES LISTED ARE BASED ON INFILTRATION RATES WHICH MAY BE E
PERSIST FOR AT LEAST FIVE DAYS BUT ARE NOT VALID FOR SUSTAINED SPREA

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

IGELES COUNTY DEPARTMENT OF PUBLIC WORKS
TER CONSERVATION DIVISION

MMARY OF DATA ON SPREADING FACILITIES
VNED AND OPERATED BY THE DEPARTMENT
UPDATED THROUGH SEPTEMBER 1989

CAPACITIES			LOCATION	SOURCE OF WATER	REMARKS
INTAKE	STORAGE	PERCOLATION*			
CFS	A.F.	CFS			
400	284	10	EAST SIDE OF EATON WASH, NORTH OF DUARTE ROAD, 0.6 MILE SOUTH OF HUNTINGTON DRIVE.	CONTROLLED FLOW FROM EATON WASH DAM AND UNCONTROLLED FLOWS BETWEEN DAM AND SPREADING BASIN.	
100	525	17	EASTERLY SIDE OF EATON WASH FROM BELOW EATON DAM TO FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM EATON WASH DAM.	THREE DEEP BASINS COMPRISING 15 ACRES. THE SHALLOW STRIP BASINS TOTAL 13 ACRES.
100	87	7	SOUTH SIDE OF SAN DIMAS WASH BETWEEN LONE HILL AVENUE AND VALLEY CENTER AVENUE.	CONTROLLED RELEASES FROM PUDDINGSTONE DIVERSION DAM, AND LOCAL STORM RUNOFF FROM SAN DIMAS WASH.	
[illegible]00	[illegible]20	250	NORTHWESTERLY SIDE OF TUJUNGA WASH FROM ABOVE GLENOAKS BOULEVARD SOUTHWESTERLY TO SAN FERNANDO ROAD.	CONTROLLED FLOWS FROM HANSEN DAM AND BIG TUJUNGA DAM.	
50	428	15	NORTHEASTERLY OF INTER-SECTION OF BIG DALTON CHANNEL AND IRWINDALE AVENUE; CONTINUES 1,300 FEET EAST OF IRWINDALE AVENUE.	BIG DALTON CHANNEL CONTROLLED FLOWS FROM BIG AND LITTLE DALTON DEBRIS DAMS AND PUDDINGSTONE DIVERSION DAM; UNCONTROLLED FLOWS.	
[illegible]0	5	15	WESTERLY OF GLENDORA MT. ROAD, FROM LITTLE DALTON DEBRIS BASIN SOUTH TO EAST PALM DRIVE.	CONTROLLED FLOW FROM LITTLE DALTON DEBRIS BASIN.	
5	2	13	WESTERLY SIDE OF LIVE OAK WASH. NORTH OF BASE LINE ROAD (PROJECTED).	CONTROLLED FLOW FROM LIVE OAK DAM AND LIVE OAK DEBRIS BASIN.	
[illegible]	23.6	15	SOUTHEASTERLY SIDE OF PACOIMA WASH, NORTHEASTERLY OF FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM PACOIMA DAM AND LOPEZ FLOOD CONTROL BASIN.	THE FLOW IS DIVERTED FROM LOPEZ FLOOD CONTROL BASIN VIA CANAL TO THE SPREADING GROUNDS. BASIN NOT REMOVED

BE EXPECTED TO
SPREA[illegible] [illegible]ERATIONS.

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LOS ANGELES COUNTY DE
WATER CONSE

SUMMARY OF DATA C
OWNED AND OPERAT
UPDATED THROU

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2

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES CHANNEL**	CAPACITIES INTAKE	CAPACITIES STORAGE	PE
					CFS	CFS	A.F.	
PACOIMA	MEDIUM DEPTH BASINS	1932-33	169	107	17,000	600	432	
PECK ROAD	DEEP BASIN	1959-60	157	85	30,100	30,100	3,347	
RIO HONDO COASTAL	MEDIUM DEPTH BASINS	1937-38	570	400	40,000	1950	3,894	
SAN DIMAS CANYON	SHALLOW BASINS	1965-66	22	11	-	25	22	
SAN GABRIEL CANYON	DEEP BASINS	1917	185	-	-	250	-	
SAN GABRIEL COASTAL	MEDIUM DEPTH BASINS	1938-39	128	90	-	350	575	

* THE CAPACITIES LISTED ARE BASED ON INFILTRATION RA
PERSIST FOR AT LEAST FIVE DAYS BUT ARE NOT VALID

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

TY DEPARTMENT OF PUBLIC WORKS
CONS ATION DIVISION

ATA ON SPREADING FACILITIES
ERATED BY THE DEPARTMENT
THROUGH SEPTEMBER 1989

PERCOLATION*	LOCATION	SOURCE OF WATER	REMARKS
CFS			
50	BOTH SIDES OF OLD PACOIMA WASH CHANNEL FROM ARLETA AVENUE SOUTHWESTERLY TO WOODMAN AVENUE.	CONTROLLED FLOW FROM PACOIMA DAM. PARTIALLY CONTROLLED FLOW FROM LOPEZ FLOOD CONTROL BASIN, UNCONTROLLED FLOW FROM EAST CANYON AND PACOIMA WASH.	IN JULY 1930 LOS ANGELES CITY BEGAN DELIVERING OWENS VALLEY WATER THROUGH OLDEN STREET OUTLET ON STETSON CANYON CHANNEL.
25	CONFLUENCE OF SAWPIT AND SANTA ANITA WASHES.	ALL FLOWS IN SAWPIT AND SANTA ANITA WASHES.	
400	EASTERLY SIDE OF RIO HONDO SOUTHERLY FROM U.P.R.R. (SOUTH OF WHITTIER BLVD.) TO SLAUSON AVENUE; WEST SIDE OF RIO HONDO CHANNEL FROM 0.2 MILE ABOVE WHITTIER BOULEVARD SOUTH TO FOSTER BRIDGE BOULEVARD.	CONTROLLED RELEASES FROM SAN GABRIEL CANYON DAMS AND SANTA FE DAM, AND CONTROLLED RELEASES OUT OF WHITTIER NARROWS DAM FROM VALLEY RUNOFF VIA RIO HONDO; ALSO IMPORTED AND RECLAIMED WATER.	IN COOPERATION WITH THE CORPS OF ENGINEERS. THE DISTRICT OPERATES 2,500 ACRE-FOOT POOL AT WHITTIER NARROWS DAM FOR RETENTION OF STORM WATERS.
12	SOUTHEAST SIDE OF SAN DIMAS WASH BETWEEN PUDDINGSTONE DIVERSION AND SAN DIMAS CANYON ROAD.	CONTROLLED RELEASES FROM PUDDINGSTONE DIVERSION DAM; UNCONTROLLED FLOW FROM SAN DIMAS WASH.	
35	EASTERLY SIDE OF SAN GABRIEL RIVER. BELOW MOUTH OF SAN GABRIEL CANYON. NORTH OF THE CITY OF AZUSA.	SAN GABRIEL RIVER CONTROLLED RELEASES FROM COGSWELL DAM, SAN GABRIEL DAM, AND MORRIS DAM.	THE DISTRICT TOOK OVER OPERATION OF THIS FACILITY IN NOVEMBER 1969. RECEIVES SURPLUS WATER FROM THE COMMITTEE OF NINE. TWO DEEP BASINS ARE CURRENTLY BEING EXCAVATED REPLACING DITCHES AND CHECK LEVEES.
75	WESTERLY SIDE OF SAN GABRIEL RIVER, SOUTHERLY FROM WHITTIER BOULEVARD TO WASHINGTON BOULEVARD.	CONTROLLED FLOW FROM DAMS IN SAN GABRIEL CANYON AND SANTA FE DAM, CONTROLLED RELEASES FROM WHITTIER NARROWS DAM, UNCONTROLLED VALLEY RUNOFF BELOW WHITTIER NARROWS DAM VIA SAN GABRIEL RIVER; ALSO IMPORTED AND RECLAIMED WATER.	

TION RATES WHICH MAY BE EXPECTED TO
VALID FOR SUSTAINED SPREADING OPERATIONS.

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LOS ANGELES COUNTY DEPARTME
WATER CONSERVATION

SUMMARY OF DATA ON SPRE
OWNED AND OPERATED BY T
UPDATED THROUGH SEPT

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES		CAPACITIES			
			GROSS	WETTED	CHANNEL**	INTAKE	STORAGE	PERCOLATION*
					CFS	CFS	A.F.	CFS
SAN GABRIEL RIVER LOWER*	MEDIUM DEPTH BASINS	1954-55	133	156	-	550	702	100
SAN GABRIEL RIVER UPPER*	TEMPORARY CHECK LEVEES	1955-56	136	196	-	-	-	180
SANTA ANITA	SHALLOW BASINS	1944-45	20	8.5	-	20	25	5
SANTA FE	SHALLOW AND MEDIUM DEPTH BASINS	1953-54	338	111	-	400	200	400
SAWPIT	SHALLOW BASINS	1946-47	12	3.8	-	30	13	12
WALNUT	DEEP BASIN	1962-63	16	7.3	8,000	90	199	5
TOTAL:			2,356 AC.	1,455 AC.	-	-	11,612 A.F.	1,728 CFS

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* THE CAPACITIES LISTED ARE BASED ON INFILTRATION RATES WHICH MAY BE EXPECTED TO PERSIST FOR AT LEAST FIVE DAYS BUT ARE NOT VALID FOR SUSTAINED SPREADING OPER

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

PARTMENT OF PUBLIC WORKS
RVATION DIVISION

ON SPREADING FACILITIES
ED BY THE DEPARTMENT
GH SEPTEMBER 1989

PERCOLATION	LOCATION	SOURCE OF WATER	REMARKS
CFS			
100	SAN GABRIEL RIVER FROM WHITTIER NARROWS DAM TO ABOVE FIRESTONE BLVD.	SAME AS UPPER PORTION. ALSO RECLAIMED WATER.	SAME AS UPPER PORTION. SEE SAN GABRIEL COASTAL REMARKS. RUBBER DAMS INSTALLED ON DROP STRUCTURES.
180	SAN GABRIEL RIVER FROM SANTA FE DAM.	CONTROLLED FLOW FROM DAMS IN SAN GABRIEL CANYON, SANTA FE DAM AND UNCONTROLLED VALLEY RUNOFF BELOW SANTA FE DAM; ALSO IMPORTED WATER.	CHECK LEVEES DEVELOPED IN RIVER TO SPREAD WATER.
5	WESTERLY SIDE OF SANTA ANITA WASH 1.25 MILES ABOVE FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM SANTA ANITA DAM AND SANTA ANITA DEBRIS BASIN.	THE HEADWORKS LOCATED UPSTREAM OF THE DEBRIS BASIN DIVERTS WATER TO SANTA ANITA SPREADING GROUNDS AND CITY OF SIERRA MADRE SPREADING GROUNDS.
400	WITHIN SANTA FE DAM RESERVOIR AND SPILLWAY AREAS.	CONTROLLED FLOWS FROM SAN GABRIEL CANYON AND UNCONTROLLED FLOWS FROM BRADBURY CHANNEL AND SAN GABRIEL RIVER BELOW MORRIS RESEVOIR.	RIGHT OF WAY, HELD UNDER LICENSE FROM THE FEDERAL GOVERNMENT INCLUDES 30 ACRE IN SAN GABRIEL RIVER BED FOR EARTH DIVERSION LEVEE. CONSTRUCTION OF THE 605 FREEWAY REDUCED THE SPREADING AREA IN THE RESERVOIR AND A SUBSTITUTE AREA WAS PROVIDED DOWNSTREAM OF THE SPILLWAY FLOCCULANT FACILITY ADDED IN 1978.
12	WESTERLY SIDE OF SAWPIT WASH BELOW MOUTH OF CANYON NEAR OF NORUMBEGA DRIVE, MONROVIA.	CONTROLLED FLOWS FROM SAWPIT DAM AND SAWPIT DEBRIS BASIN.	
5	WEST SIDE OF WALNUT WASH, NORTH OF SAN BERNARDINO FREEWAY.	CONTROLLED FLOW FROM PUDDINGSTONE DAM AND UNCONTROLLED FLOW FROM WALNUT WASH CHANNEL; EXCESS WATER FROM COVINA IRRIGATING COMPANY.	
8 CFS			

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ING OPERATIONS.

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LOS ANGELES COUN
WATER

SUMMARY OF D
NOT OWN
UPDATED

GROUNDS	TYPE	SEASON FIRST USED	AREA IN ACRES		CAPACITIES			
			GROSS	WETTED	CHANNEL**	INTAKE	STORAGE	PERCO
					CFS	CFS	A.F.	C
GROUNDS IN WHICH DEPARTMENT DOES CONSTRUCTION MAINTENANCE AND SOME OPERATIONS:								
SIERRA MADRE	SHALLOW BASINS	ABOUT 1933	22	9	-	25	47	
FISH CANYON	SHALLOW BASINS	ABOUT 1917	6	4	-	-	-	
THOMPSON CREEK	DITCHES CHECKS AND DEEP BASIN	ABOUT 1928	53	37	-	70	-	3
SAN ANTONIO	DITCHES CHECKS AND SHALLOW BASINS	1921-22	598	300	8,000	900	-	30
TOTALS:			679	-	-	-	-	38

* THE CAPACITIES LISTED ARE BASED ON INFILTRATION RATES WHICH MAY BE EXPECTED TO PERSIST FOR AT LEAST FIVE DAYS BUT ARE NOT VALID FOR SUSTAINED SPREADING OPERATIO

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

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COUNTY DEPARTMENT OF PUBLIC WORKS
'ATER CONSERVATION DIVISION

Y OF DATA ON SPREADING FACILITIES
T OWNED BY THE DEPARTMENT
ATED THROUGH SEPTEMBER 1989

E PERCOLATION	LOCATION	SOURCE OF WATER	REMARKS
CFS			
'5	CITY OF SIERRA MADRE, SOUTH SIDE OF GRANDVIEW AVENUE, ONE HALF MILE WEST OF SANTA ANITA AVENUE.	LITTLE SANTA ANITA CREEK AND STREET RUNOFF ONLY PRIOR TO 1951-52. STARTING IN 1951-52 ALSO CONTROLLED FLOWS FROM SANTA ANITA DAM.	NO RECORDS OF WATER SPREAD PRIOR TO 1951-52. GROUNDS REBUILT IN 1951. ULTIMATE CAPACITY ESTIMATED 25 CFS. THREE BASINS ADDED IN SUMMER OF 1959.
7	WESTERLY SIDE OF SAN GABRIEL RIVER BELOW MOUTH OF FISH CANYON AND NORTH OF THE CITY OF AZUSA.	THE "COMMITTEE OF NINE" DIVERTS WATER TO CAL-AMERICAN PIPELINE, WHO INTERN DIVERTS FLOW TO FISH CREEK S.G.	OWNED AND OPERATED BY CAL-AMERICAN WATER COMPANY.
37	SOUTHERLY FROM, AND ADJACENT TO THOMPSON CREEK DAM, EAST SIDE OF CREEK.	COBAL, WILLIAMS, PALMER, AND PADLA CREEKS, ALSO THOMPSON CREEK, WHEN RESERVOIR ABOVE ELEVATION 1,625.	OPERATED BY POMONA VALLEY PROTECTIVE ASSOCIATION. IN ADDITION TO THE 53 ACRES, SOME AREA WITHIN THOMPSON CREEK RESERVOIR IS USED TO SPREAD STORM FLOWS. WATER SPREAD IN AREA SINCE ABOUT 1918.
300	BOTH SIDES OF SAN ANTONIO CREEK FROM TWO AND ONE HALF MILES ABOVE BASE LINE SOUTH-WESTERLY TO BASE LINE.	CONTROLLED RELEASES FROM THE SAN ANTONIO FLOOD CONTROL DAM.	OPERATED BY POMONA VALLEY PROTECTIVE ASSOCIATION WEST SIDE OF CHANNEL 500 ACRES. EAST SIDE OF CHANNEL 98 ACRES. IN ADDITION THERE ARE 207 ACRES EAST OF CHANNEL IN SAN BERNARDINO COUNTY; WATER SPREAD IN VICINITY ON AND OFF AS EARLY AS ABOUT 1896.
382			

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PERATIONS.

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LOS ANGELES COUN
WATER

SUMMARY OF D
NOT OWN
UPDATED T

GROUNDS	TYPE	SEASON FIRST USED	AREA IN ACRES		CAPACITIES			
			GROSS	WETTED	CHANNEL**	INTAKE	STORAGE	PERCO
					CFS	CFS	A.F.	C
GROUNDS CONTROLLED BY OTHERS. THE DEPARTMENT COOPERATING:								
HEADWORKS (CITY OF LOS ANGELES)	SHALLOW BASINS	1938-39	48	28	57,000	-	40	[illegible]
L.A.CITY DEPT. OF WATER AND POWER TUJUNGA	SHALLOW BASINS	1931-32	138	130	22,000	400	-	[illegible]
CITY OF POMONA	DITCHES CHECKS AND SHALLOW BASINS	(SEE REMARKS)	10	8	-	-	-	
TOTALS:			246	166	-	-	-	

* THE CAPACITIES LISTED ARE BASED ON INFILTRATION RATES WHICH MAY BE EXPECTED TO PERSIST FOR AT LEAST FIVE DAYS BUT ARE NOT VALID FOR SUSTAINED SPREADING OPERATIO

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

COUNTY DEPARTMENT OF PUBLIC WORKS
ATER CONSERVATION DIVISION

OF DATA ON SPREADING FACILITIES
OWNED BY THE DEPARTMENT
TED THROUGH SEPTEMBER 1989

PERCOLATION	LOCATION	SOURCE OF WATER	REMARKS
CFS			
40	SAN FERNANDO VALLEY, SOUTH OF LOS ANGELES RIVER, ABOVE MARIPOSA STREET.	LOS ANGELES RIVER. PARTIALLY CONTROLLED BY VARIOUS DAMS. RELEASE OF OWENS VALLEY WATER FROM CHATSWORTH RESERVOIR. GROUNDWATER FROM WELLS IN THE WEST END OF SAN FERNANDO VALLEY.	
390	SAN FERNANDO VALLEY, EAST SIDE OF TUJUNGA WASH AT ROSCOE BOULEVARD.	LOS ANGELES CITY'S OWENS VALLEY ACQUEDUCT AND CONTROLLED RELEASES FROM HANSEN DAM.	PRIOR TO 1933 FLOOD, USED 80 ACRES NET. TUJUNGA CHANNEL ON WESTERLY SIDE OF GROUNDS PAVED IN 1950.
-	NORTH OF CLAREMONT, ONE HALF MILE NORTH OF FOOTHILL BOULEVARD AND ONE-EIGHTH MILE WEST OF MILLS AVENUE.	SAN ANTONIO CREEK WATER DELIVERED THROUGH LOOP MESERVE CANYON WATER COMPANY'S PIPE LINE. ALSO SOME LOCAL RUNOFF.	WATER SPREAD IN VICINITY ON AND OFF SINCE ABOUT 1897. GROUND ACQUIRED BY CITY OF POMONA, OCTOBER 1928. NO RECORD OF WATER SPREAD PRIOR TO 1949-50. DEEP BASIN COMPLETED IN 1957.

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PERATIONS.

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SPREADING FACILITY		MONTHS: OCTOBER	NOVEMBER	DECEMBER
SAN FERNANDO VALLEY	BRANFORD	3.5	45.2	67.0
	HANSEN	255.0	248.0	1,098.0
	LOPEZ	0.0	0.2	1.8
	PACOIMA	0.0	72.0	948.0
	SUBTOTAL	258.5	365.4	2,024.8
SAN GABRIEL VALLEY	ARROYO SECO	2.4	38.5	250.0
	BEN LOMOND	33.1	1.0	91.3
	BIG DALTON	0.0	0.0	2.6
	BUENA VISTA	10.1	12.0	22.7
	CITRUS	13.2	34.3	109.0
	EATON BASIN	1.8	42.3	324.0
	EATON GROUNDS	0.0	0.0	55.5
	FORBES	0.0	0.0	0.0
	IRWINDALE	211.0	263.0	255.0
	LITTLE DALTON	0.0	0.0	0.0
	LIVE OAK	0.0	0.0	2.6
	MORRIS TO STA. F190	639.0	512.0	3,453.0
	STA. F190 TO SANTA FE S.G	5.0	95.0	160.0
	STA. F190 TO SANTA FE DAM	317.6	98.0	12.0
	SANTA FE RESERVOIR	317.6	98.0	12.0
	PECK ROAD	85.3	245.6	561.1
	SAN DIMAS CANYON	0.0	0.5	51.0
	SAN GABRIEL CANYON	790.0	459.0	2,191.0
	SANTA ANITA	0.0	0.0	47.6
	SANTA FE SPR. GRDS.	48.4	183.0	6,748.0
	SANTA FE TO STA. F251	202.0	0.0	40.0
	SANTA FE DIVERSION	0.0	0.0	0.0
	SAWPIT	0.0	41.3	112.0
	WALNUT	124.0	68.6	633.0
	SUBTOTAL	2,805.5	2,182.7	15,139.9
COASTAL PLAIN	DOMINGUEZ GAP	0.0	0.0	0.0
	RIO HONDO EAST FLUME	0.0	0.0	0.0
	WEST FLUME	1,289.0	941.0	1,385.0
	R/W FLUME	10.3	400.0	496.0
	102" INTAKE	267.0	923.0	8,890.0
	SAN GABRIEL	2,974.5	3,415.2	6,232.5
	SUBTOTAL	4,540.8	5,679.2	17,003.5
ANTELOPE VALLEY	BIG ROCK	96.0	82.0	161.0
OTHER FACILITIES	SIERRA MADRE	0.0	46.0	232.0
	THOMPSON CREEK	0.0	0.0	2.7
	FISH CREEK	523.0	437.0	458.0
	SUBTOTAL	523.0	483.0	692.7
GRAND TOTAL WATER SPREAD & OR DIVERTED		8,224.8	8,792.3	35,001.9

W'TER CONSERVED ALL FACILITIES
WATER YEAR : 1988 - 1989
(in acre-feet)

CMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	ACCUMULATIVE TOTALS
67.0	18.0	55.0	35.5	4.0	3.4	0.6	0.2	0.6	19.5	254.0
399.0	755.0	1,388.0	2,530.0	745.0	487.0	6.0	0.0	0.0	0.0	7,524.3
1.3	30.2	173.0	225.0	121.0	0.0	0.0	0.0	0.0	0.0	511.2
48.0	110.0	1,103.0	454.0	0.0	0.0	0.0	0.0	0.0	0.0	2,533.0
34.3	391.2	2,720.0	3,244.6	870.0	490.4	7.5	0.2	0.6	19.6	11,033.1
50.0	20.2	325.0	4.2	0.0	11.1	2.0	3.4	1.4	5.4	554.7
91.3	74.0	22.2	45.5	36.1	0.0	0.0	0.0	0.0	7.1	251.9
2.6	20.2	162.0	30.5	13.4	9.7	0.0	5.3	0.0	0.0	249.7
22.7	17.5	4.5	11.0	2.2	15.5	0.5	4.6	8.7	3.1	112.4
39.0	59.7	51.5	20.0	21.3	10.7	0.0	0.0	2.8	19.2	247.3
24.0	63.7	223.0	72.0	4.6	10.0	15.7	18.5	51.0	22.4	355.5
55.5	0.0	106.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	161.5
0.0	0.0	249.0	1.0	334.0	78.5	100.0	153.0	204.0	153.0	1,328.5
35.0	70.4	312.0	72.2	250.0	94.0	43.4	202.0	131.0	132.0	2,140.0
0.0	11.5	54.5	21.2	5.2	0.0	0.0	0.0	0.0	0.0	95.4
2.6	0.0	23.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.0
3.0	3,216.0	2,511.0	2,407.0	3,154.0 *	631.0 *	352.0 *	538.0 *	818.0 *	837.0 *	19,068.0
0.0	230.0	202.0	91.0	220.0 *	28.0 *	0.0 *	0.0	0.0	0.0	1,031.6
2.0	720.0	1,121.0	624.0	522.0	1,094.0	249.0	317.0	570.0	520.0	6,225.5
2.0	228.0	240.0	0.0	0.0	216.0	34.0	0.0	0.0	0.0	1,145.6
1.1	97.3	385.7	114.6	9.3	69.0	51.6	18.4	15.0	56.7	1,709.5
1.0	88.1	415.0	87.0	6.9	42.0	0.0	0.0	0.0	0.0	690.5
1.0	1,136.0	861.0	440.0	734.0	328.0	373.0	434.0	343.0	292.0	8,441.0
7.6	19.2	156.0	13.3	0.0	0.0	0.0	0.0	0.0	0.0	226.1
8.0	8,622.0	5,540.0	2,952.0	2,226.0	59.5	0.0	0.0	0.0	0.0	27,378.9
0.0	0.0	727.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	369.0
0.0	0.0	0.0	0.0	0.0	198.0	103.0	0.0	0.0	0.0	301.0
8.0	42.2	202.0	87.5	50.5	36.5	31.9	0.0	0.0	0.0	604.0
1.0	78.5	173.0	56.9	88.7	149.0	90.0	108.0	116.0	81.7	1,773.4
.9	14,877.5	15,083.9	7,161.0	7,786.3	3,082.9	1,446.1	1,940.3	2,310.9	2,179.6	75,897.1
.0	0.0	0.0	0.0	30.0	60.0	50.0	45.0	45.0	40.0	270.0
.0	0.0	4,566.0	5,772.0	4,170.0	3,272.0	5,572.0	4,305.0	2,083.0	1,831.0	32,271.0
.0	1,076.0	418.0	78.7	189.0	839.0	1,242.0	17.5	15.1	0.0	7,490.3
.0	836.0	682.0	6.1	813.0	432.0	1,076.0	0.0	0.0	0.0	4,751.4
.0	6,319.0	3,712.0	1,561.0	771.0	1,109.0	0.0	2,548.0	435.0	179.0	26,714.0
.5	6,801.3	6,119.0	4,867.6	4,566.3	1,406.2	1,208.1	21.8	225.8	2,234.9	40,173.7
.5	15,032.3	15,497.0	12,285.4	10,539.8	7,118.2	9,248.1	7,537.3	2,803.9	4,284.9	111,670.4
.0	145.0	232.0	322.0	99.8	27.8	0.2	0.0	0.0	0.0	1,165.8
.0	123.0	384.0	128.0	97.8	94.2	95.6	0.0	0.0	0.0	1,200.6
.7	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5
.0	458.2	420.5	473.5	439.9	428.6	404.3	495.6	424.6	413.0	5,376.3
.7	581.2	812.3	601.5	537.7	522.8	499.9	495.6	424.6	413.0	6,587.4
.9	.0.2	34,251.5	23,714.6	19,934.1	11,242.1	11,201.8	9,373.4	5,540.0	5,397.1	206,403.8

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IMPORTED WATER OUTLETS								
MONTH	SAN DIMAS CB - 48	THOMPSON CREEK CB - 28	SAN GAB. RIVER CB - 37	ALHAMBRA CB - 35	OLDEN ST. L.A. 693	USG 3 USGMWD	BEATTY CANYON SGVMWD	SAN DIMA WE SGVMWD
OCTOBER	0.0	0.0	0.0	0.0	0.0	0.0	334.2	691.6
NOVEMBER	0.0	0.0	0.0	0.0	0.0	0.0	337.3	416.5
DECEMBER	3,866.3	3,557.6	0.0	0.0	0.0	5,345.0	0.0	0.0
JANUARY	5,309.9	3,667.7	0.0	0.0	0.0	9,321.7	0.0	0.0
FEBRUARY	6,272.3	2,818.8	0.0	0.0	0.0	9,410.9	0.0	658.4
MARCH	5,996.2	204.0	0.0	0.0	0.0	5,646.5	0.0	0.0
APRIL	5,902.9	0.0	0.0	0.0	0.0	6,078.1	0.0	1,807.1
MAY	2,013.0	0.0	0.0	0.0	0.0	250.8	1,531.9	547.5
JUNE	6,785.4	1,229.8	0.0	0.0	0.0	1,436.1	606.1	1,007.2
JULY	0.0	7,418.7	0.0	0.0	0.0	0.0	831.9	621.8
AUGUST	0.0	529.8	0.0	0.0	0.0	0.0	1,286.6	323.4
SEPTEMBER	0.0	0.0	0.0	0.0	0.0	0.0	1,049.1	560.3
TOTALS	36,545.5	19,426.4	0.0	0.0	0.0	37,539.1	5,537.1	7,243.8

NOTES :
- 5051 A.F. MAKE-UP WATER FROM CB-48 DURING MARCH 1989 INCLUDED.
- ALL BEATTY CANYON RELEASE ON MAY 1989 FOR M.W.D. CYCLIC WATER STORAG
- 1,431.4 A.F. OF USG3 DURING JUNE 1989 DELIVERED THROUGH SAN GABRIEL
- 825.3 A.F. OF CB-48 DURING JUNE 1989 DELIVERED THROUGH SAN GABRIEL F
- 2,501 A.F. FROM SAN JOSE WATER,DURING OCTOBER 1988,WAS CREDITED TO F

1983 2

OTAL WATER DELIVERED IN ACRE - FEET
WATER YEAR : 1988 - 1989

			RECLAIMED WATER SPREAD AND WASTED										
...N DIMAS ...ES ...GWND	IMPORTED WATER MONTHLY A.F.	IMPORTED WATER WTR YEAR A.F.	WHITTIER NARROWS PLANT SPREAD R.HONDO	WHITTIER NARROWS PLANT SPREAD S.GABRIEL	WHITTIER NARROWS PLANT WASTED AF	WHITTIER NARROWS PLANT MONTHLY TOTAL	SAN JOSE PLANT RELEASE	SAN JOSE PLANT SPREAD R.HONDO	SAN JOSE PLANT SPREAD S.GABRIEL	SAN JOSE PLANT MONTHLY TOTAL	POMONA PLANT	RECLAIMED WATER SPREAD MONTHLY A.F.	RECLAIMED WATER SPREAD WATER YEAR AF
631.6	1,085.8	1,085.8	1,242.2	0.0	0.0	1,242.2	4,705.0	1,315.5	[illegible]	4,707.0	38.0	5,033.1	5,088.1
415.5	1,403.8	2,489.6	1,101.6	0.0	8.9	1,092.7	3,567.8	381.2	2,755.3	3,566.5	70.0	4,829.2	10,917.3
0.0	12,768.9	15,258.5	792.3	496.2	96.2	1,182.3	868.8	392.2	487.5	879.7	220.0	2,282.5	13,099.8
0.0	18,798.3	34,056.8	581.9	783.8	4.0	1,361.7	4,242.8	0.0	3,846.3	3,846.3	323.0	5,531.0	18,630.8
668.4	1,170.0	53,227.7	350.2	0.0	5.4	942.8	1,030.1	101.2	855.0	957.2	309.0	2,240.0	20,870.8
0.0	11,746.7	64,974.4	920.0	0.0	1.6	918.4	3,544.4	2,102.3	1,410.6	3,512.9	315.0	4,746.3	25,617.1
807.1	13,788.1	78,762.5	1,199.6	142.2	0.0	1,341.8	5,005.2	893.8	4,259.8	4,993.6	196.0	6,531.4	32,148.5
547.5	4,343.2	83,105.7	1,020.8	364.9	0.0	1,385.7	5,247.7	3,981.3	1,275.2	5,256.5	76.0	6,718.2	38,866.7
307.2	11,114.6	94,220.3	1,199.2	17.6	0.0	1,216.8	2,055.2	845.7	1,225.1	2,052.8	42.0	3,312.6	42,179.3
521.8	8,872.4	103,092.7	1,121.1	0.0	0.0	1,121.1	21.3	0.0	21.8	21.8	36.0	1,178.9	43,358.2
123.4	2,639.8	105,732.5	961.5	152.2	0.0	1,113.7	2,818.3	2,634.6	183.4	2,818.0	34.0	3,965.7	47,323.9
760.3	1,709.4	107,441.3	522.1	559.5	57.1	1,124.5	2,396.4	1,816.6	1,570.9	3,387.7	43.0	4,555.2	51,879.1
42.8	107,441.3	\\\\\\\\\\\\	11,503.0	2,616.4	174.2	14,045.2	36,503.5	14,954.5	[illegible]	35,131.9	1,702.0	51,879.1	\\\\\\\\\\\\

TORAGE.
RIEL PIPELINE.
IEL PIPELINE.
TO PREVIOUS YEAR.

VOL 12

1

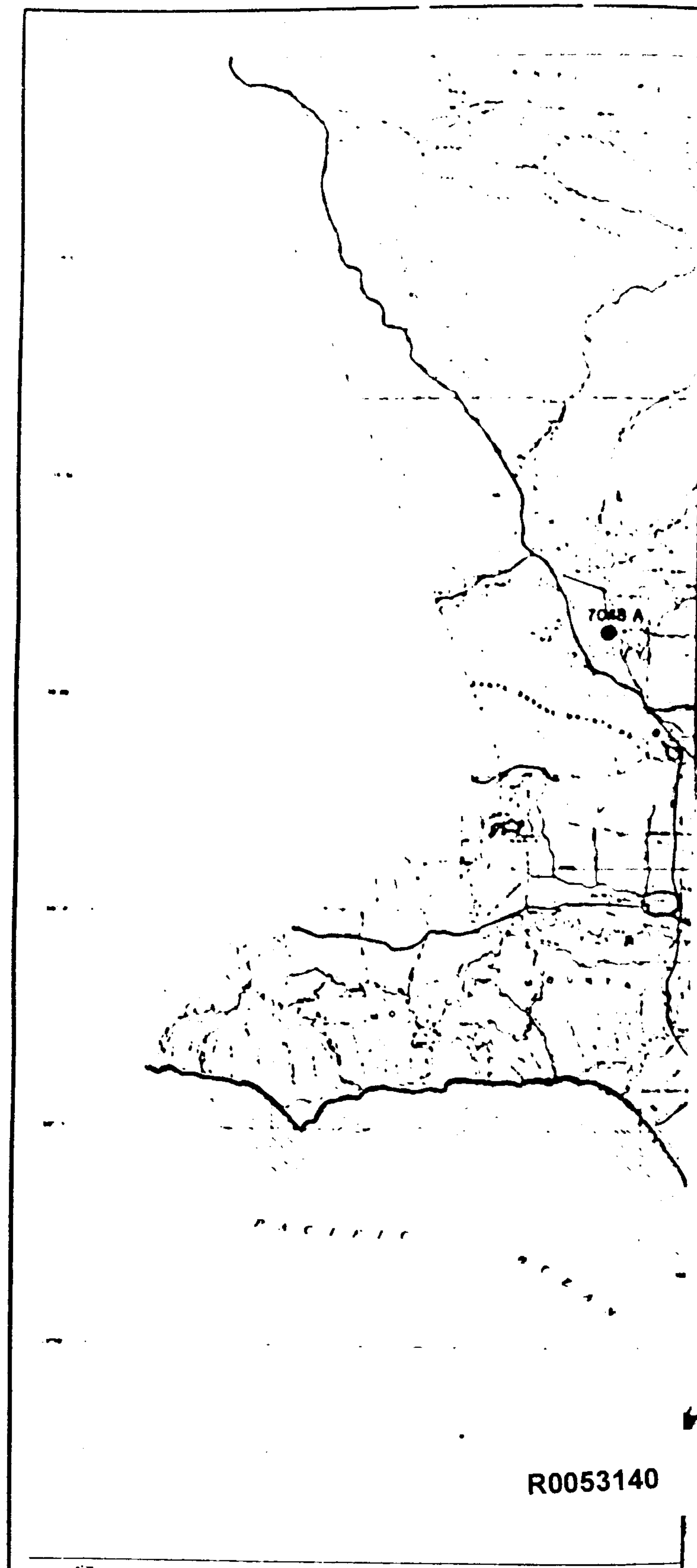
9833

R0053138

VOL 12 19834

WELL HYDROGRAPHS INCLUDED IN THIS REPORT

GROUNDWATER BASIN	WELL NO.	APPROXIMATE LOCATION	PAGE NO.
WEST COAST	1346D	11305 TRURO AVE., 250 FT. N. OF IMPERIAL HWY., COMPTON	G19
	760C	90 FT. S.W. OF INTERSECTION OF COMPTON BLVD. & DOTY AVE., LAWNDALE	
CENTRAL BASIN	460K	2,600 FT. N.E. OF THE INTERSECTION OF LAKEWOOD BLVD. & PACIFIC COAST HWY., LONG BEACH	G19
	1601T	1,000 FT. S. OF THE INTERSECTION OF WASHINGTON BLVD. & ROSEMEAD BLVD., MONTEBELLO	G20
	906D	1,300 FT. N.W. OF THE INTERSECTION OF LONG BEACH & SAN ANTONIO DR., LONG BEACH	G20
MAIN SAN GABRIEL	3030F	600 FT. N.W. OF THE INTERSECTION OF LOS ANGELES ST. & MAINE AVE., BALDWIN PARK	G21
	2955X	TYLER AVE. & CENTRAL AVE., S. EL MONTE	G22
SAN GABRIEL CANYON	4284A	5,600 FT. N.W. OF THE INTERSECTION OF SIERRA MADRE AVE & SAN GABRIEL CYN. RD., AZUSA	G22
	4285	2,700 FT. N.W. OF SAN GABRIEL CANYON RD. & SIERRA MADRE AVE	
POMONA	3251E	2,200 FT. N. OF THE INTERSECTION OF SAN BERNARDINO FWY. & TOWNE AVE., POMONA	G23
	3241J	425 FT. S.W. OF LA VERNE AVE., 400 FT. S.E. OF N. GAREY AVE.	
CLAREMONT HEIGHTS	4508B	800 FT. S.E. OF THE INTERSECTION OF BASELINE RD. & PADUA AVE., CLAREMONT	G23
	4508A	270 FT. N.W. OF WELL 4508B	
RAYMOND	4057H	LOS ROBLES & GLENARM STREETS, PASADENA	G24
SANTA CLARA	7048A	S.E. OF THE INTERSECTION OF NEWHALL AVE. & MAGIC MOUNTAIN PKWY, SAUGUS	G24
ANTELOPE VALLEY	9974	8,976 FT. S. OF AVE K & 200 FT W. OF SIERRA HWY., LANCASTER	G25
	8825	25 FT. N. OF AVE T & 45 FT. E. OF 90TH ST., LITTLE ROCK	
MAIN SAN FERNANDO	3872H	CLARK AVE & GRIFFITH PARK DR., BURBANK	G26
	4709	SHERMAN WAY & DEERING AVE., CANOGA PARK	G26



VOL 12

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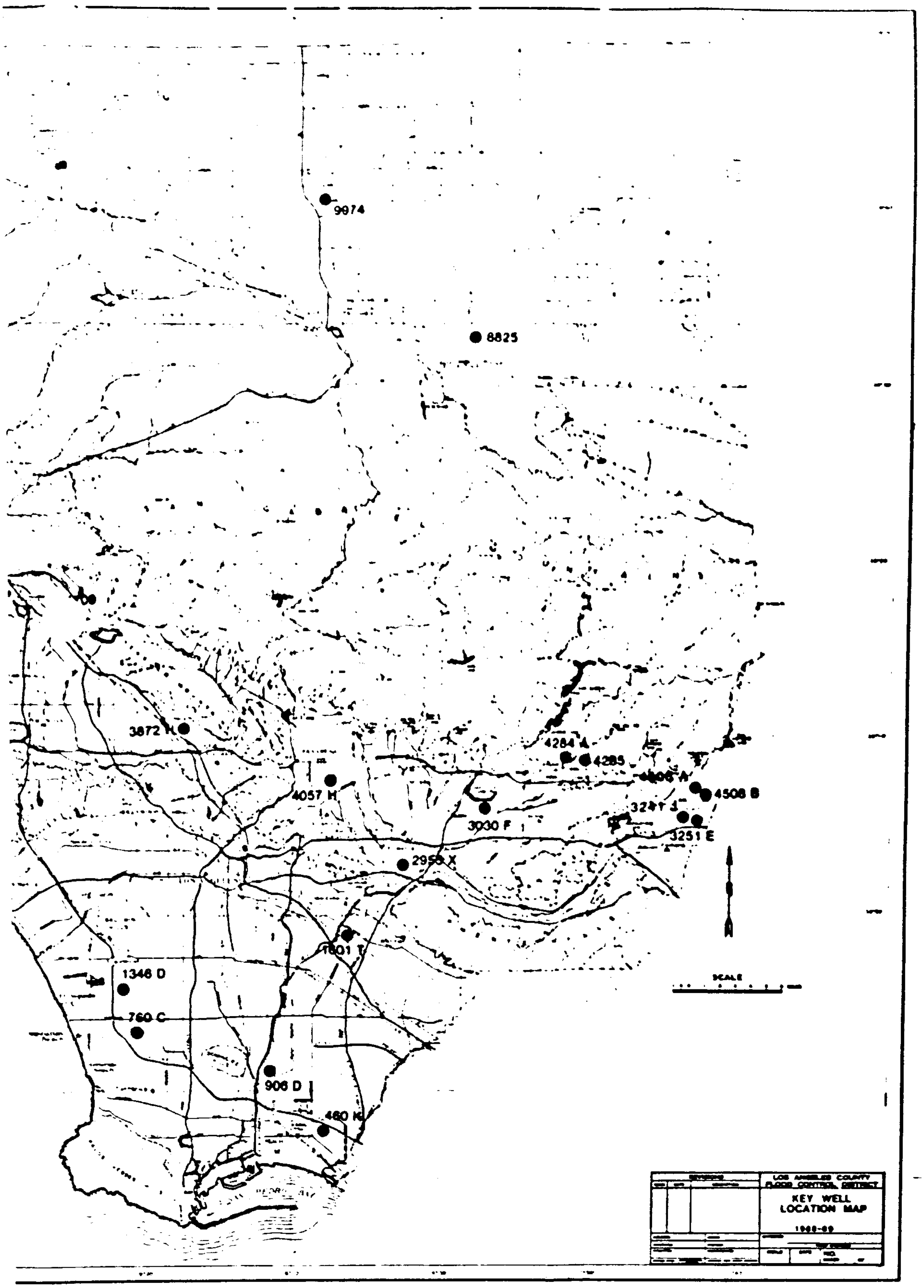
5835

R0053140

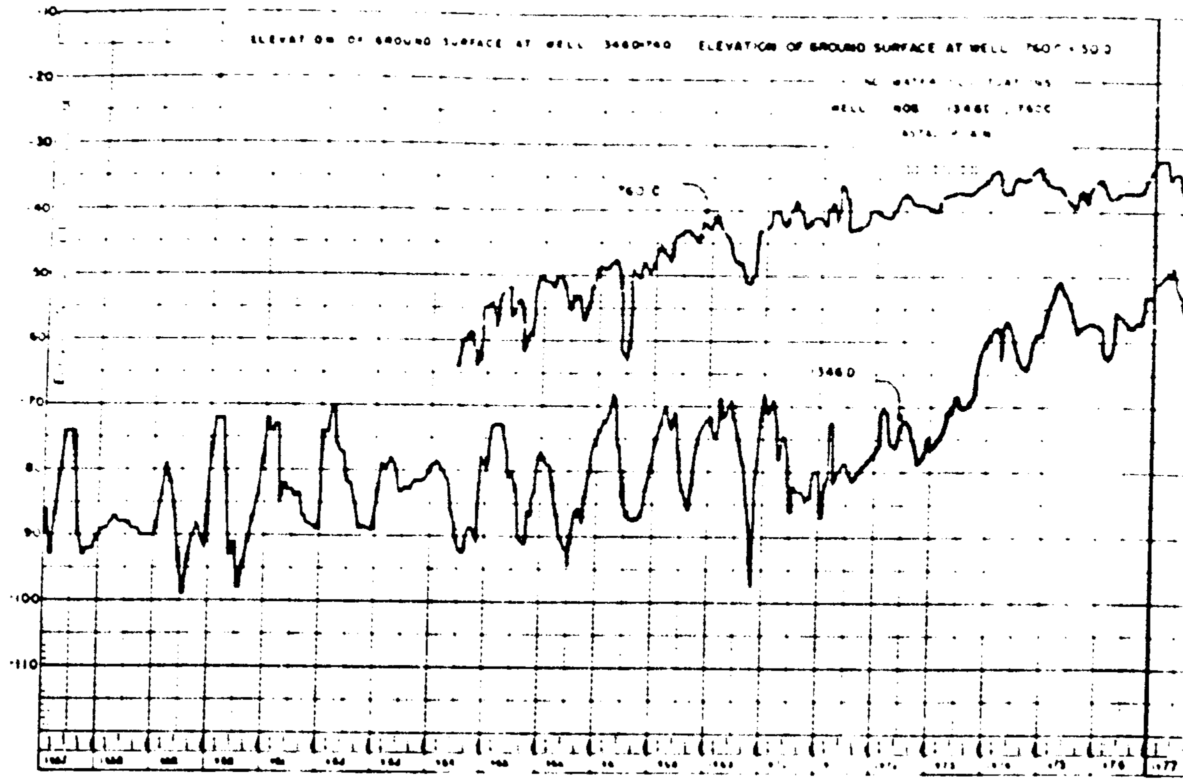


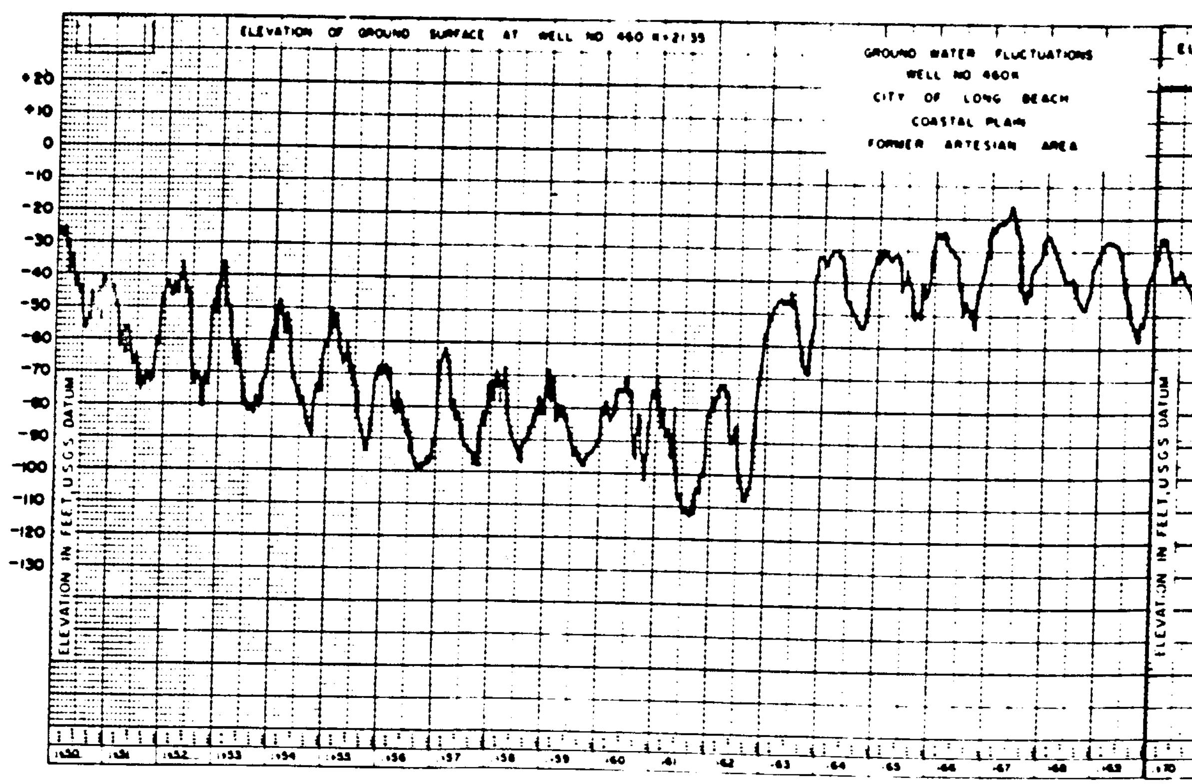
VOL 12

1 9836

G18

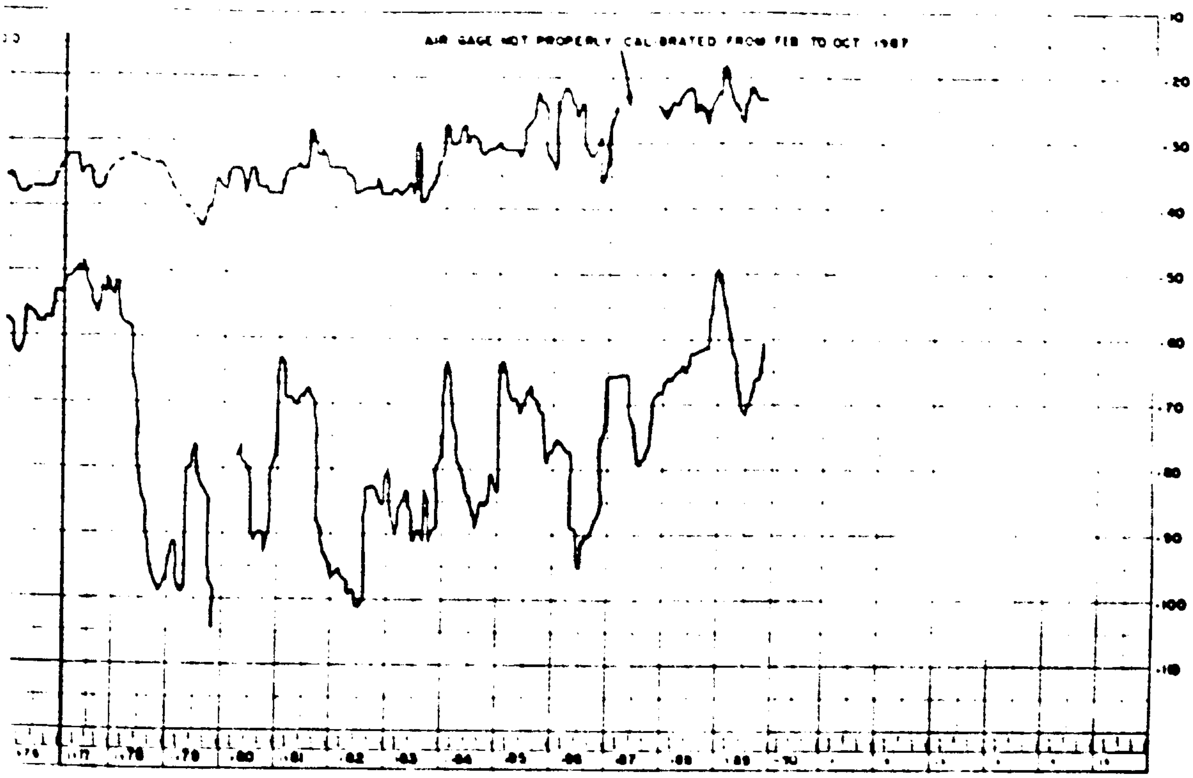
R0053141

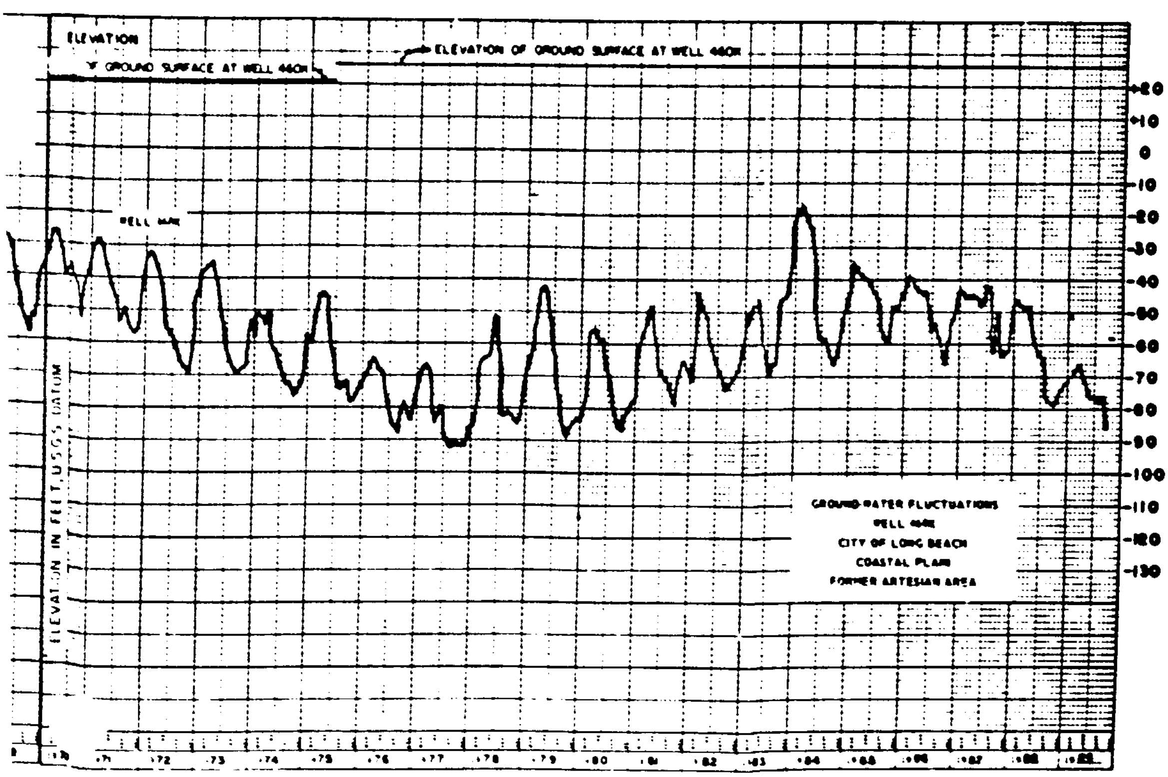




VOL 12 1987

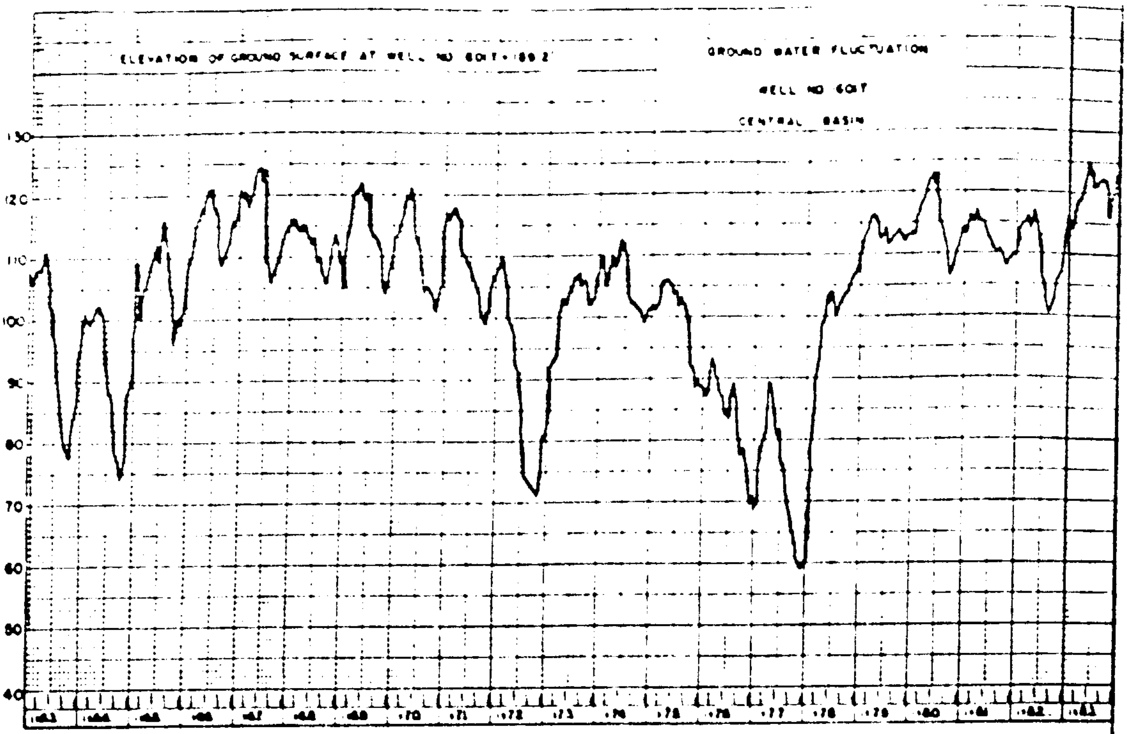
R0053142

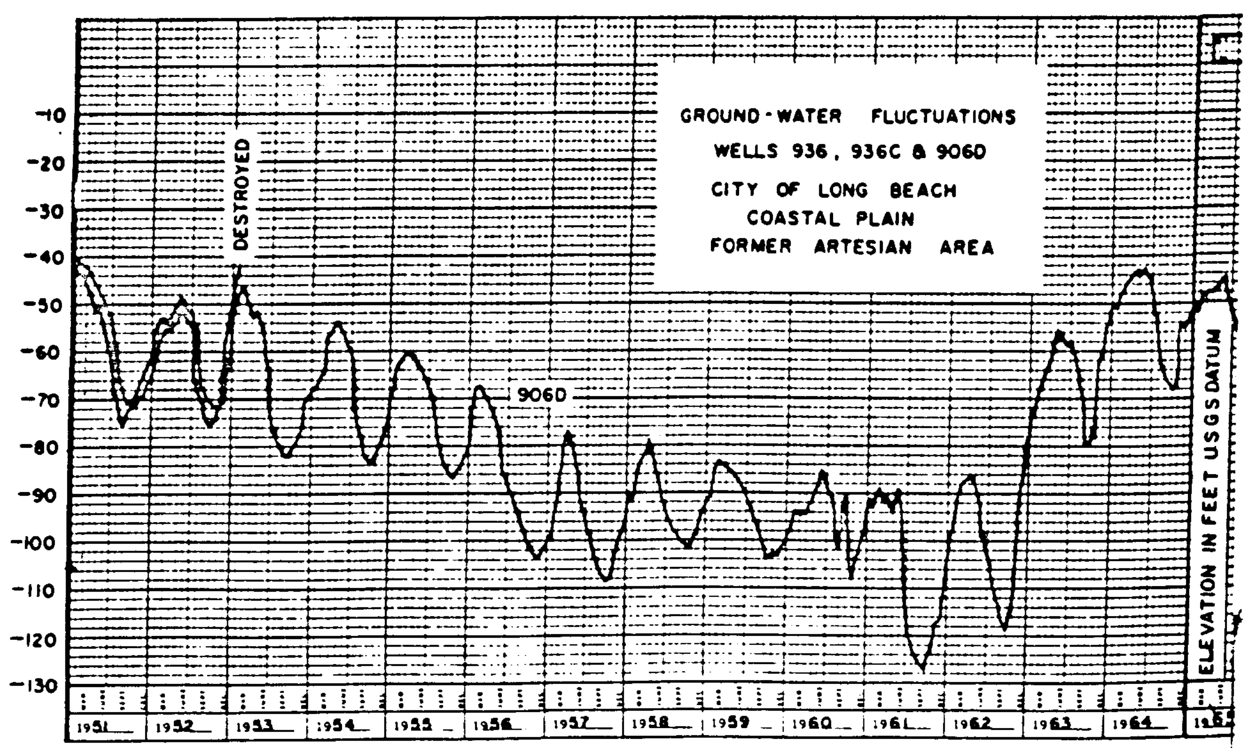




VOL 12

1 98938





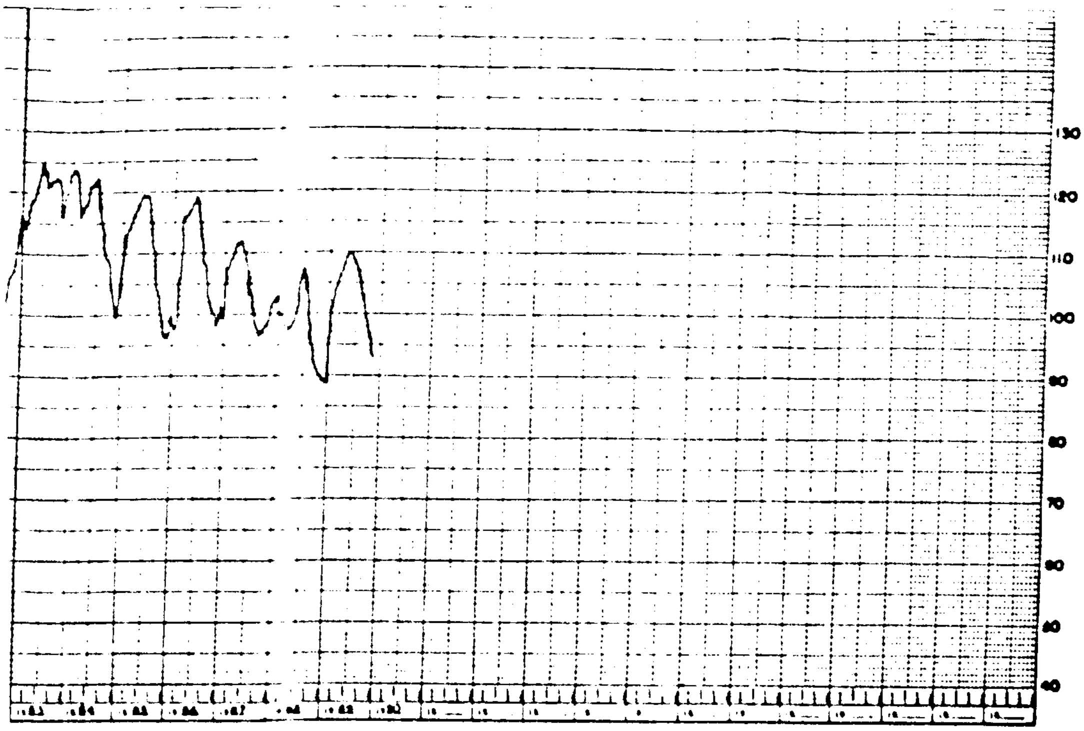
VOL 12

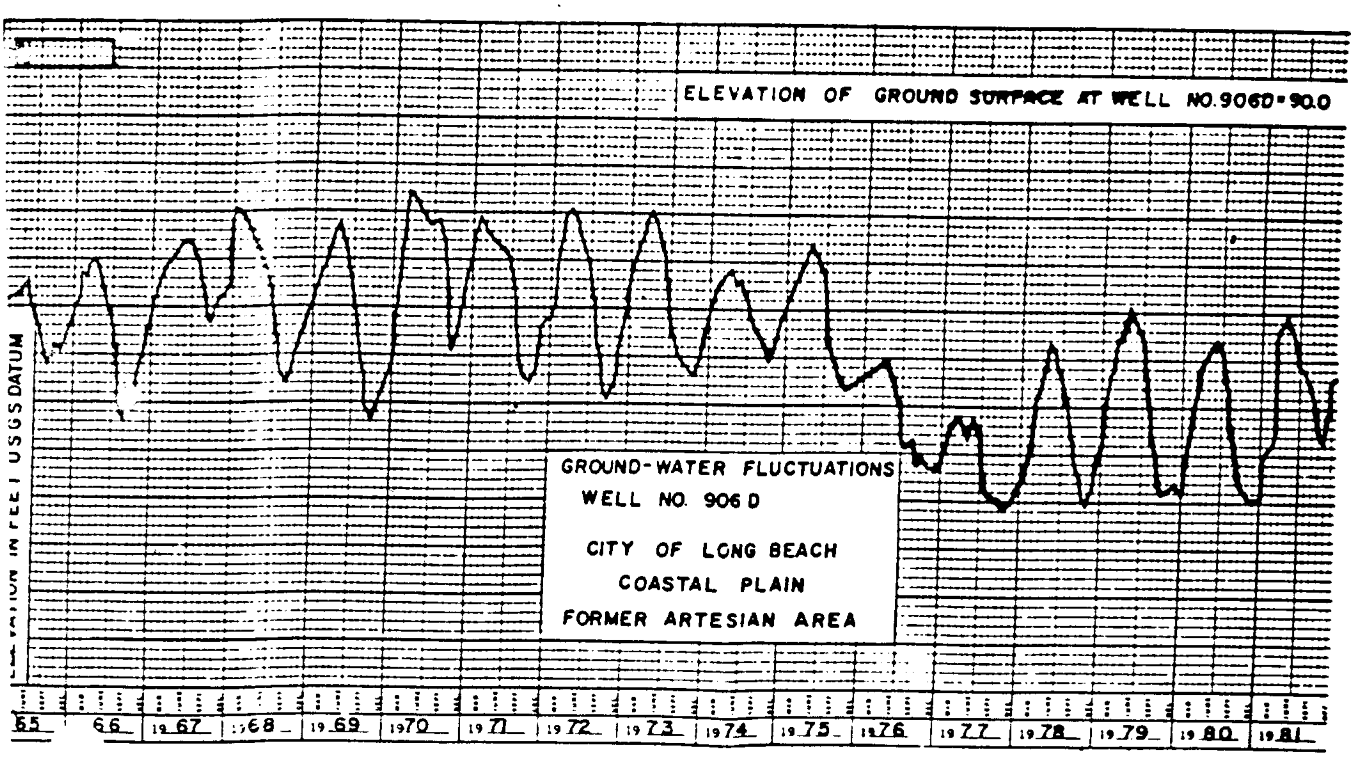
1989

R0053144

VOL 12

1 9840



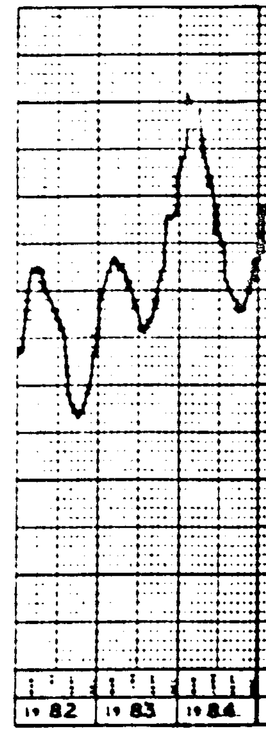


CONTINUED ON PAGE (G21)

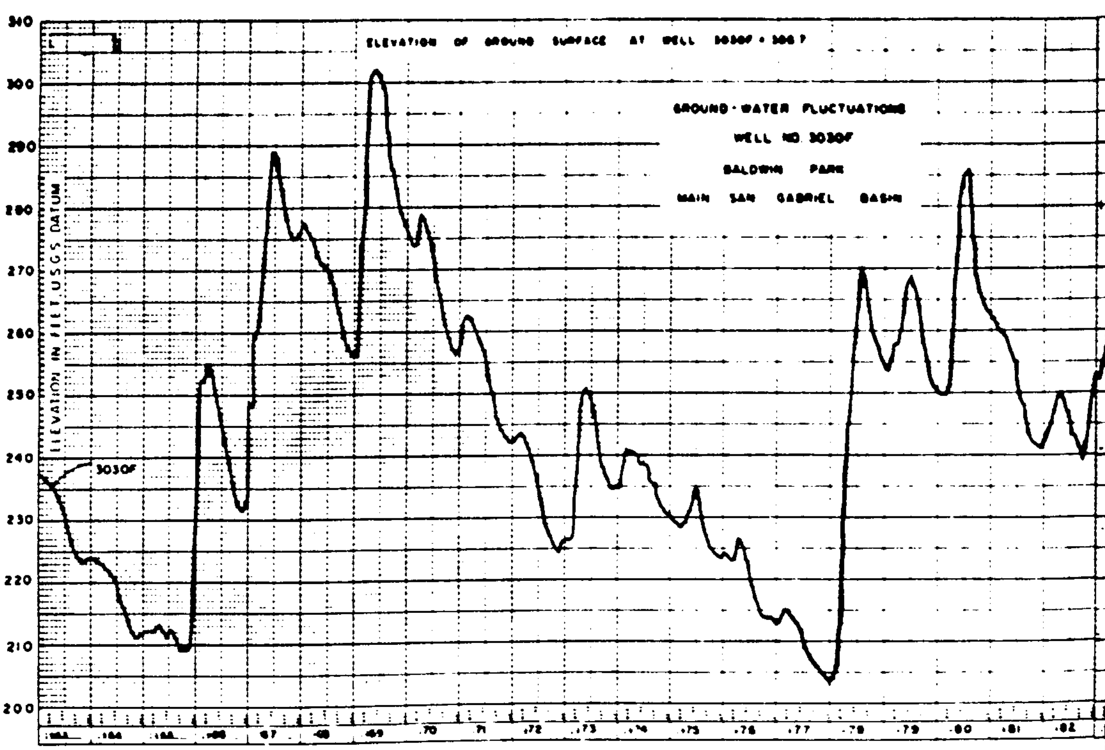
R0053145

VOL 12

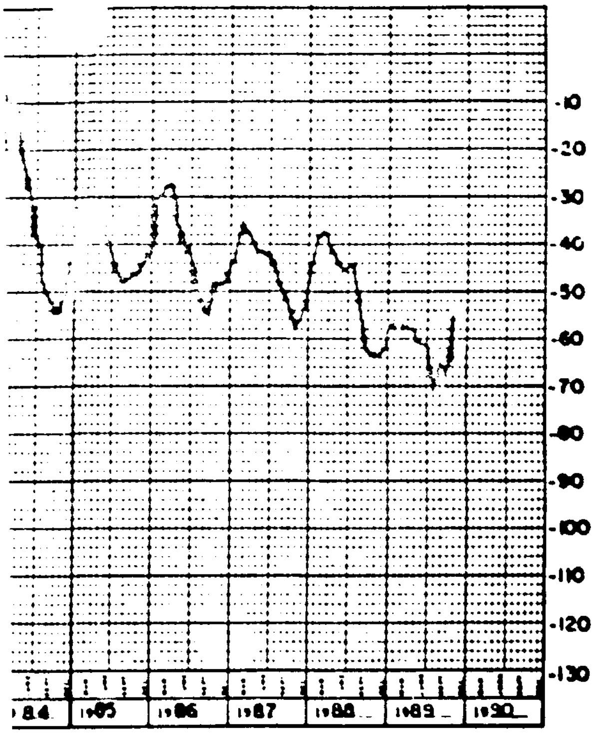
CONTINUED FROM PAGE (G20)

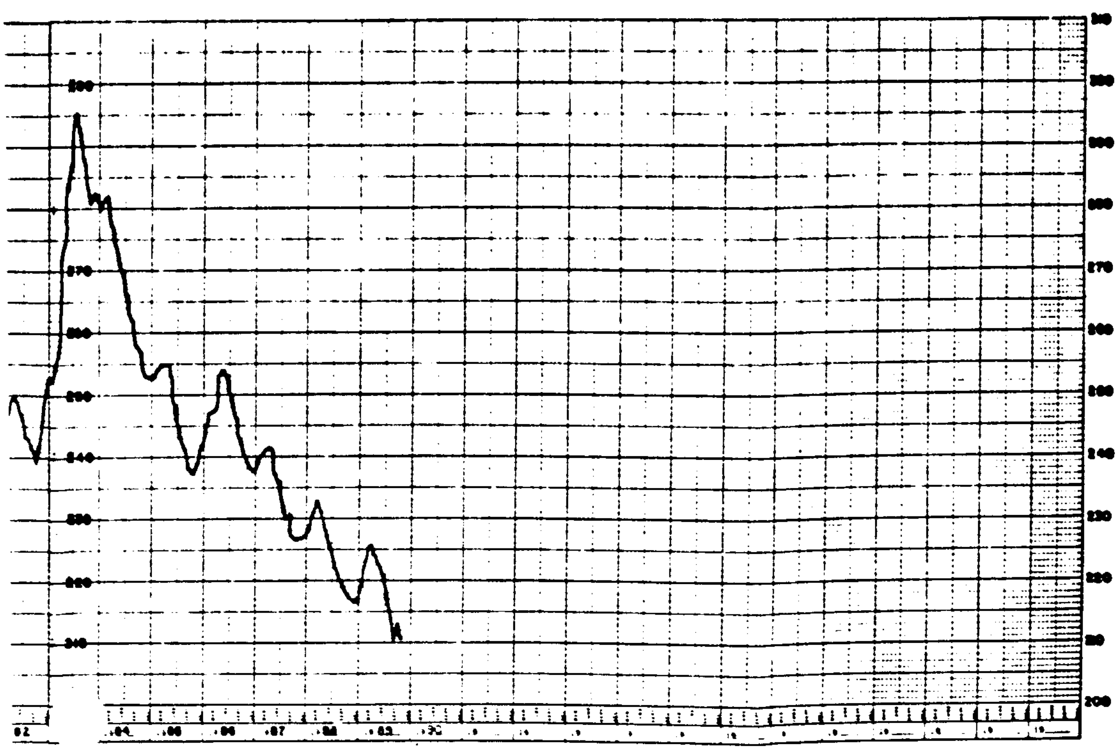


1984



R0053146





VOL 12

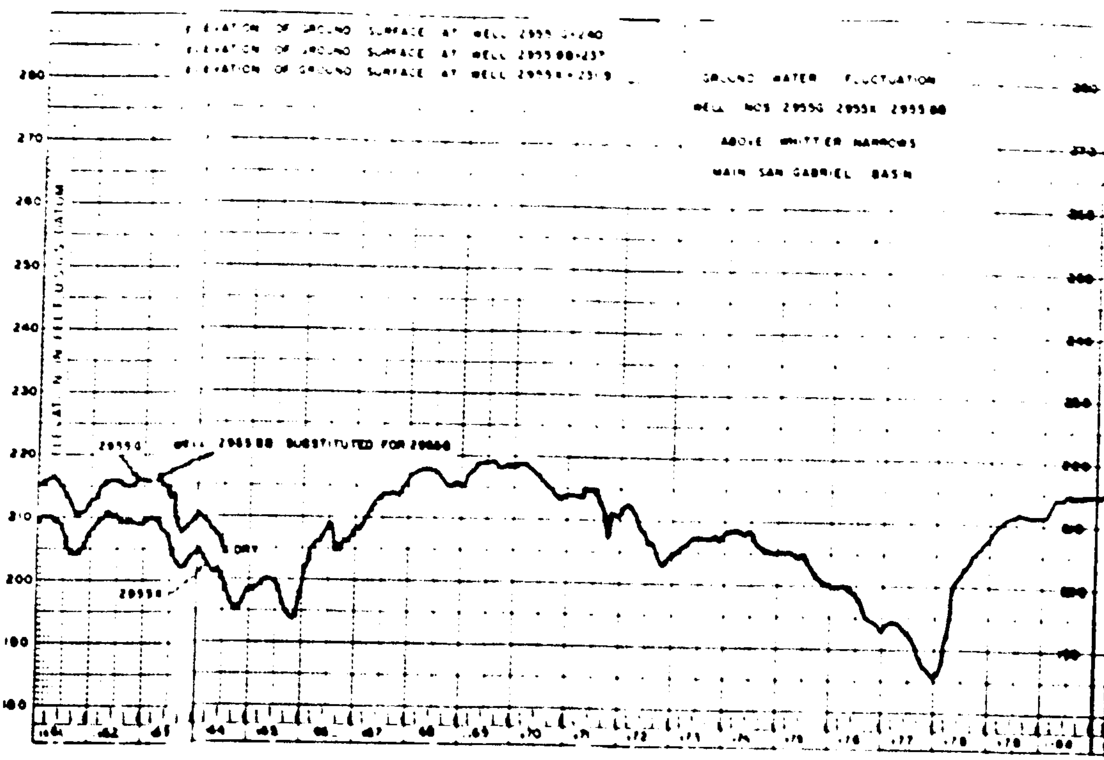
1

9842

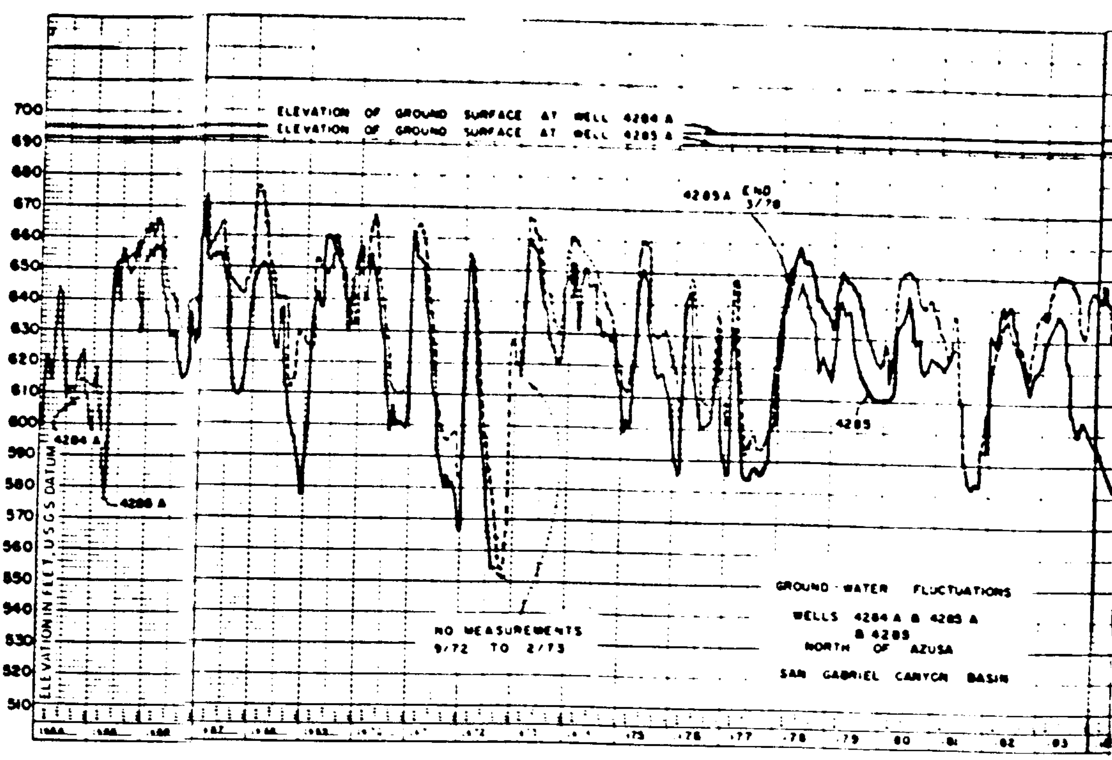
G21

R0053147

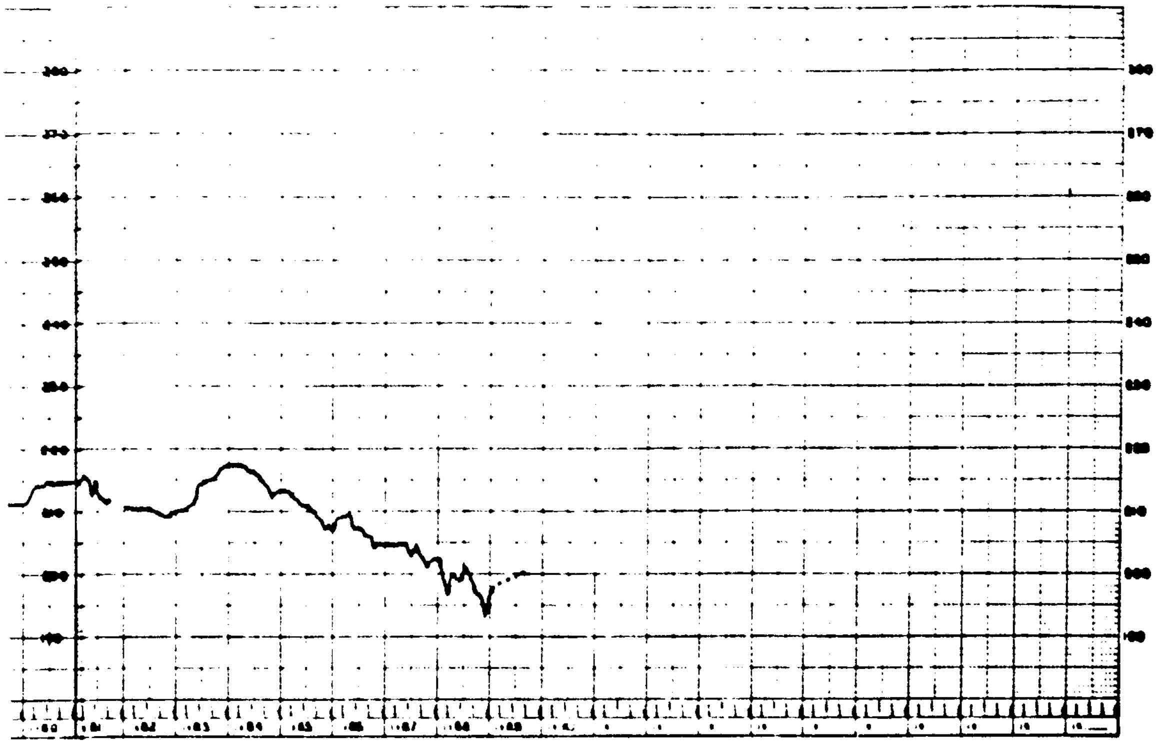
VOL 12

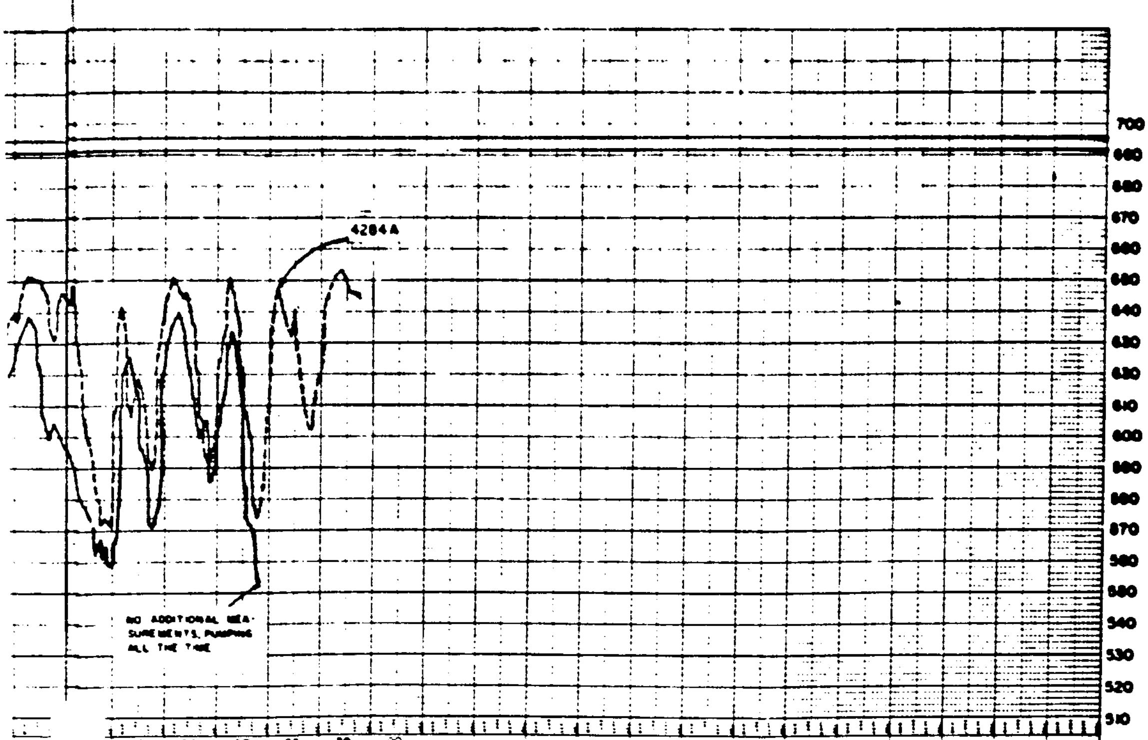


1983



R0053148



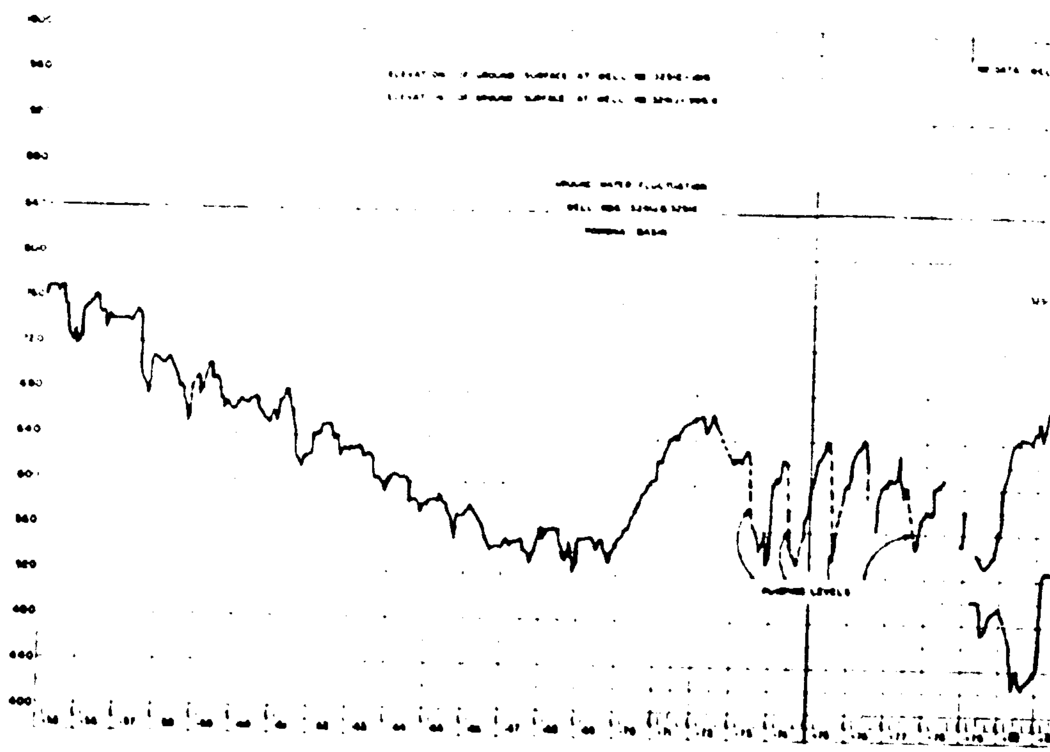


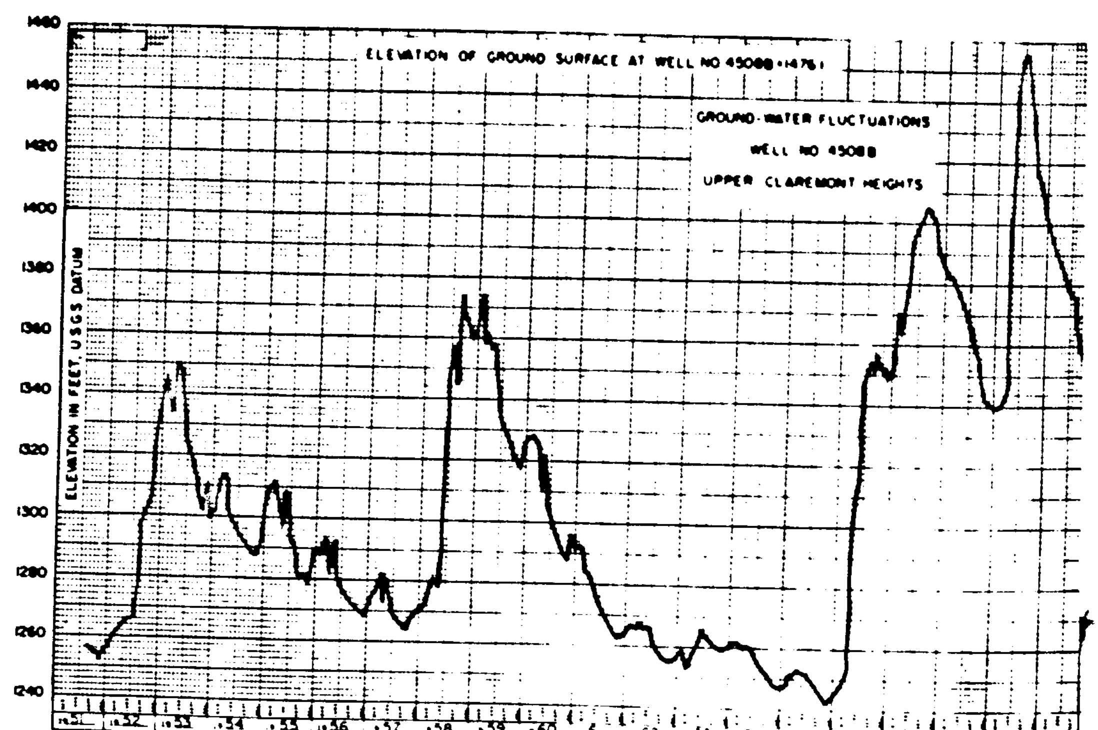
VCL 12

1984

G22

R0053149

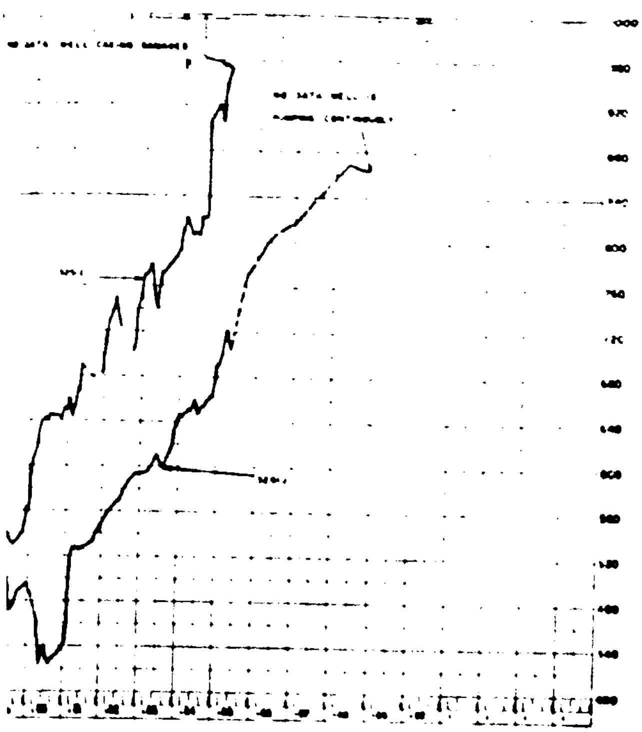


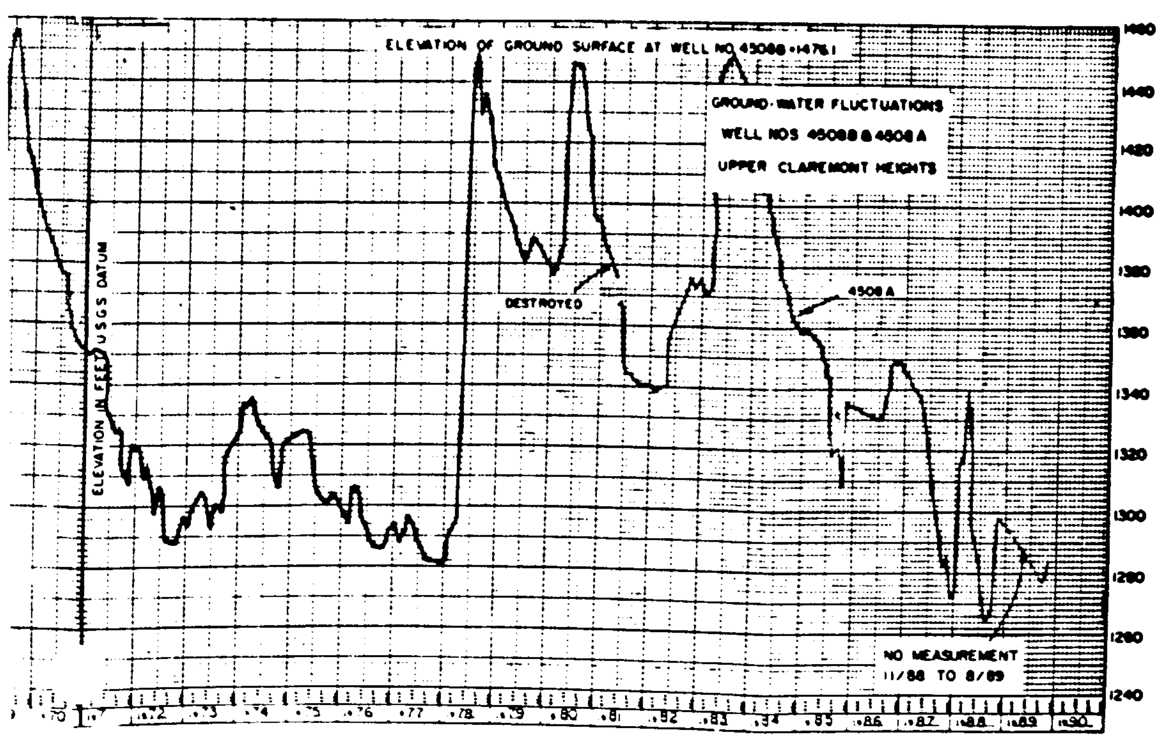


VOL 12

1 9845

R0053150



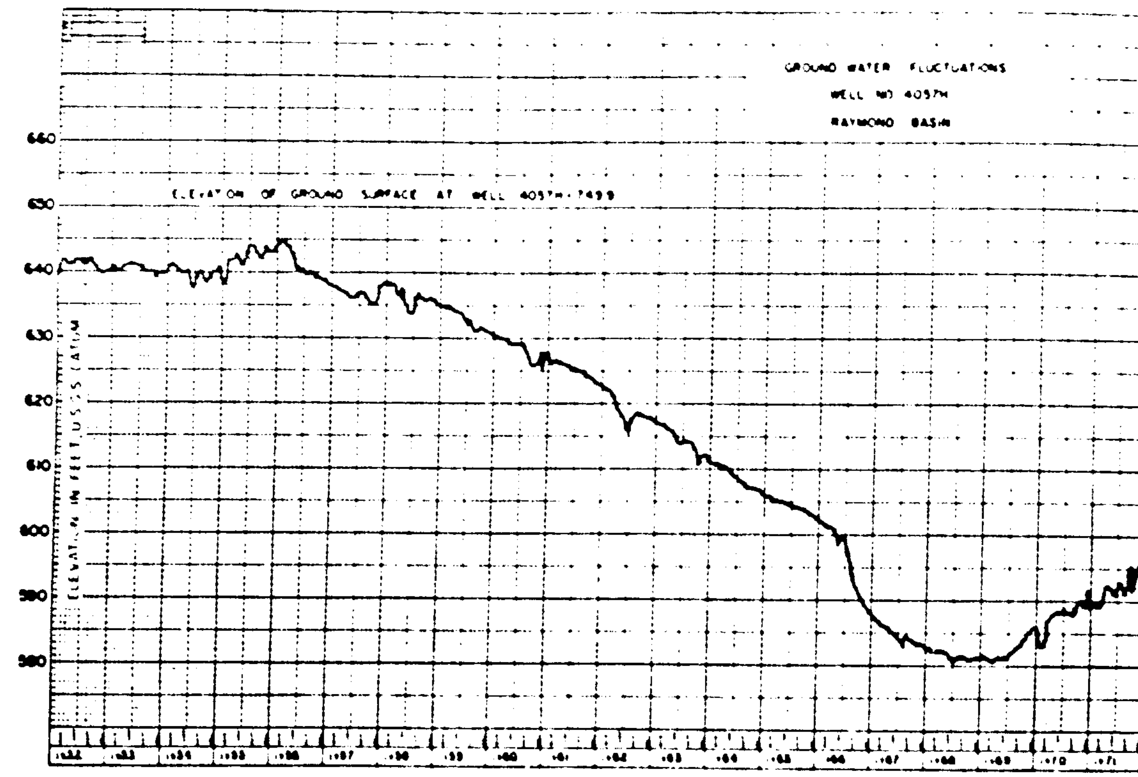


VCL 12

1 9846

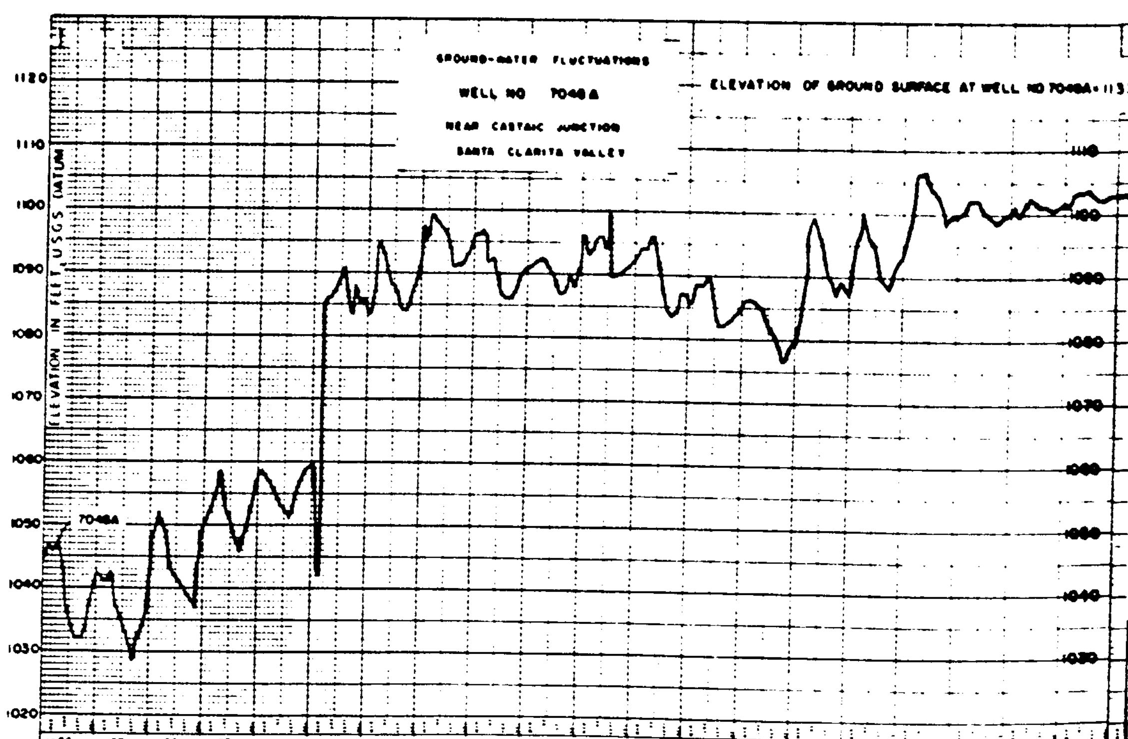
G23

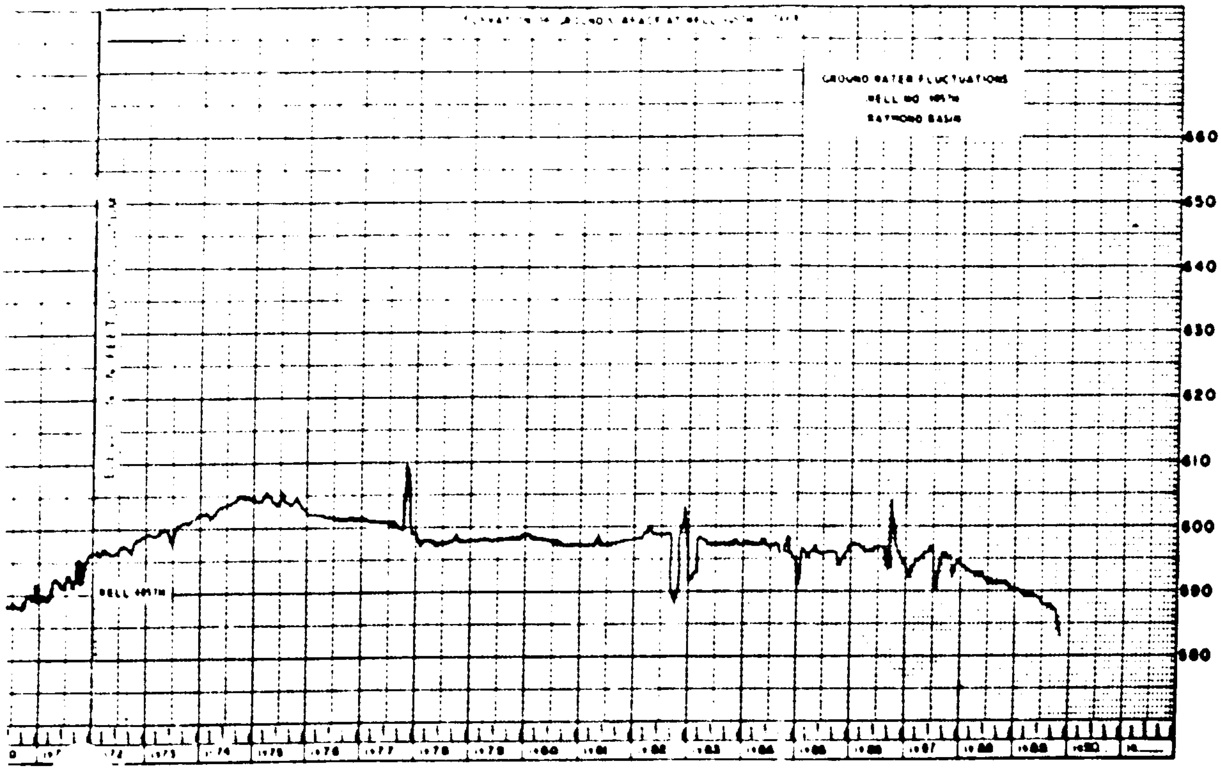
R0053151

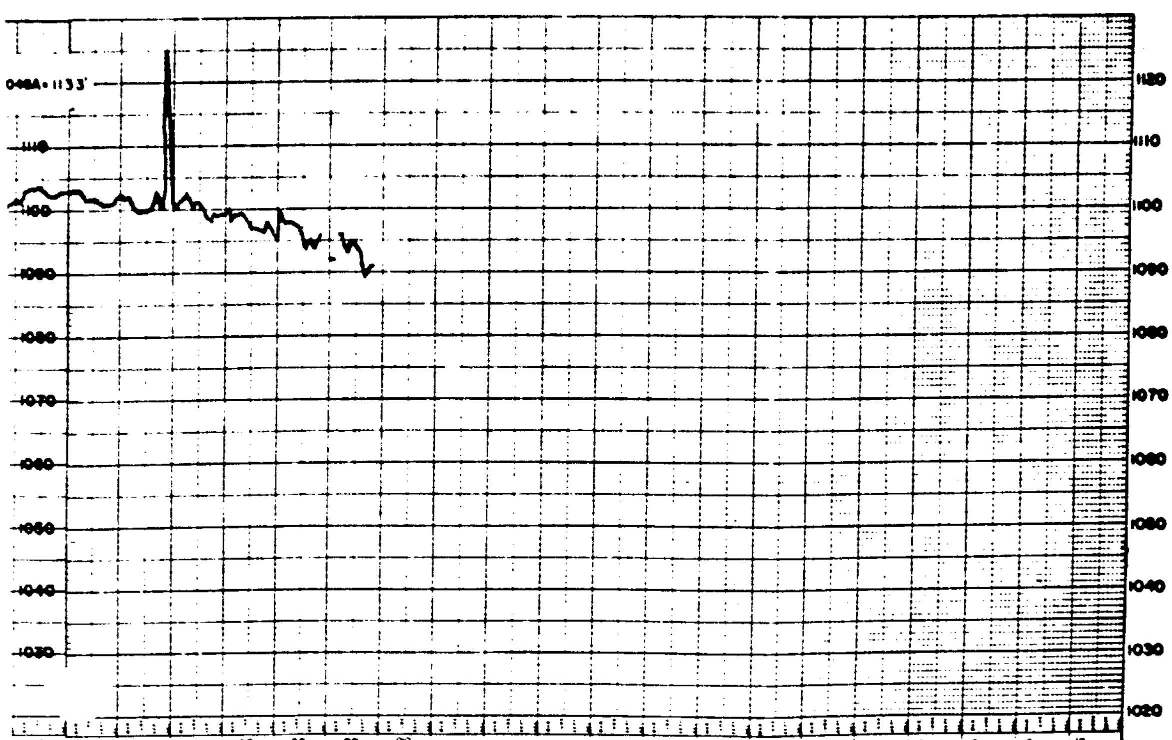

GROUND WATER FLUCTUATIONS
WELL NO 4057H
RAYMOND BASIN
ELEVATION IN FEET, USGS DATUM

VOL 12

1 9847

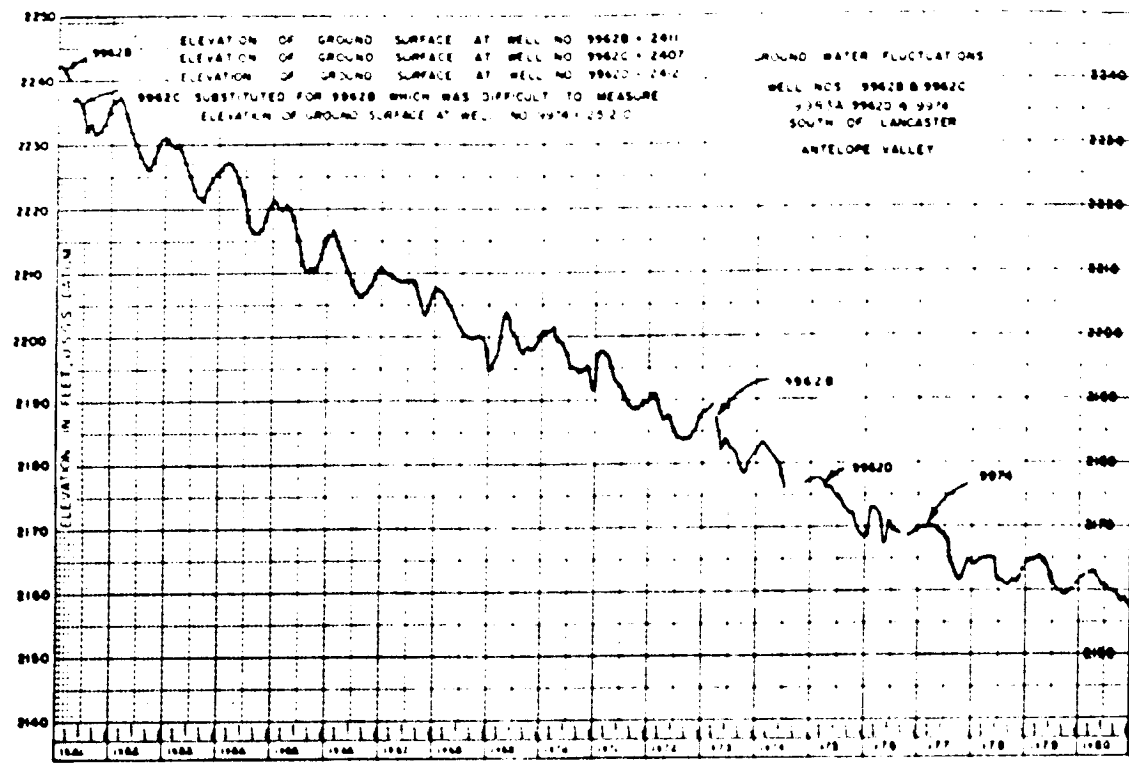

GROUND-WATER FLUCTUATIONS
WELL NO 7046A
NEAR CASTAIC JUNCTION
SANTA CLARITA VALLEY
ELEVATION OF GROUND SURFACE AT WELL NO 7046A=1133
ELEVATION IN FEET, USGS DATUM
7046A

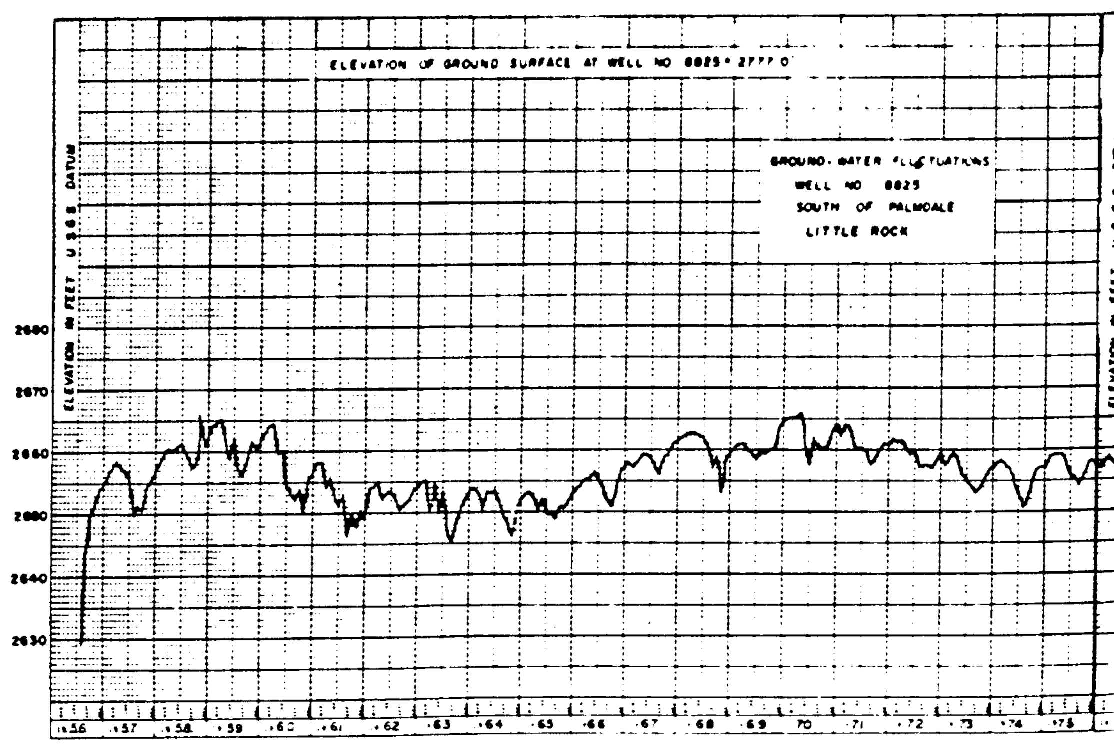

GROUND WATER FLUCTUATIONS
RAYMOND BASIN
660
650
640
630
620
610
600
590
580


1120
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020

VCL 12

1 9848

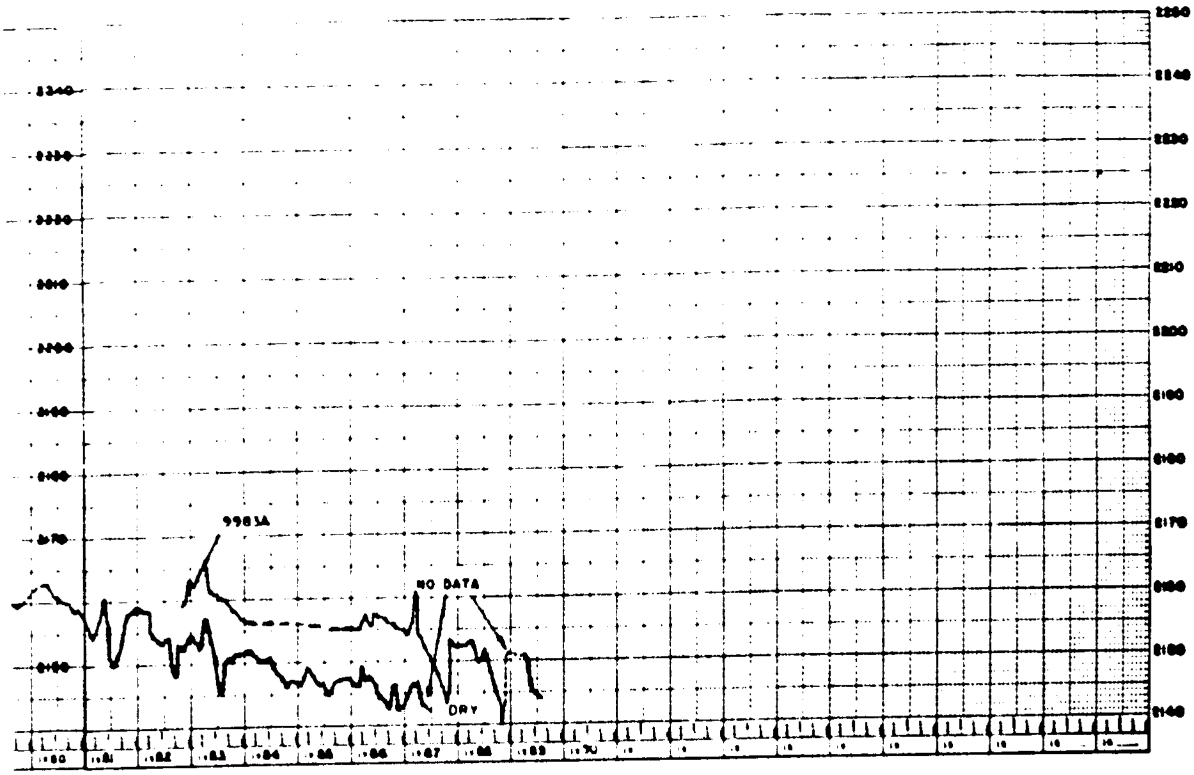

ELEVATION OF GROUND SURFACE AT WELL NO 9962B = 2411
ELEVATION OF GROUND SURFACE AT WELL NO 9962C = 2407
ELEVATION OF GROUND SURFACE AT WELL NO 9962D = 2412
9962C SUBSTITUTED FOR 9962B WHICH WAS DIFFICULT TO MEASURE
GROUND WATER FLUCTUATIONS
WELL NOS 9962B & 9962C
SOUTH OF LANCASTER
ANTELOPE VALLEY
ELEVATION IN FEET, U.S.G.S. DATUM
9962B
9962D
9974

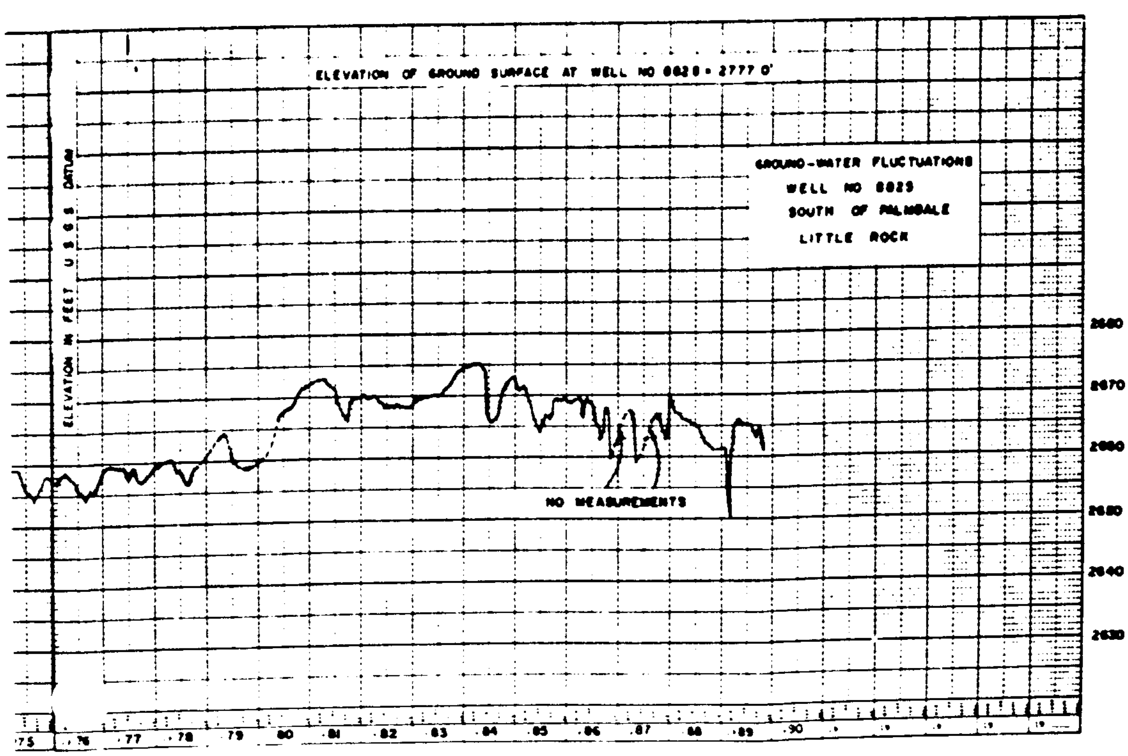

ELEVATION OF GROUND SURFACE AT WELL NO 8825 = 2777.0
GROUND-WATER FLUCTUATIONS
WELL NO 8825
SOUTH OF PALMDALE
LITTLE ROCK
ELEVATION IN FEET U S G S DATUM

R0053154

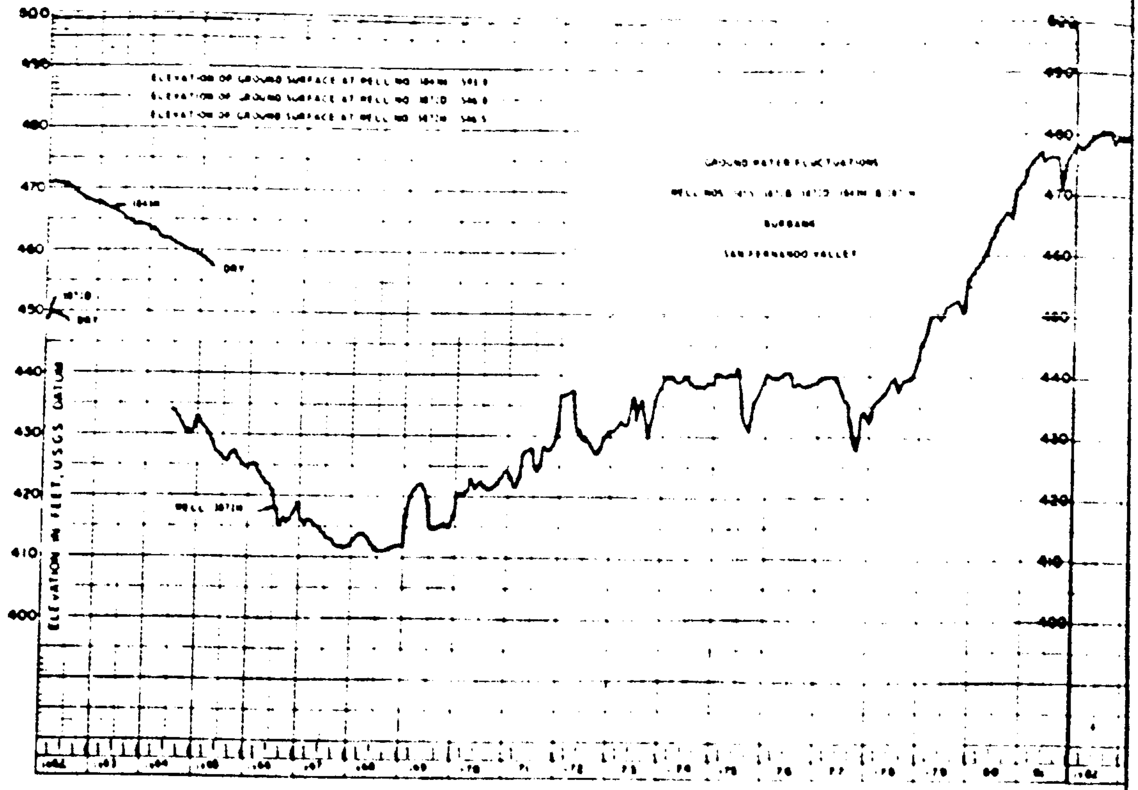
VCL 12

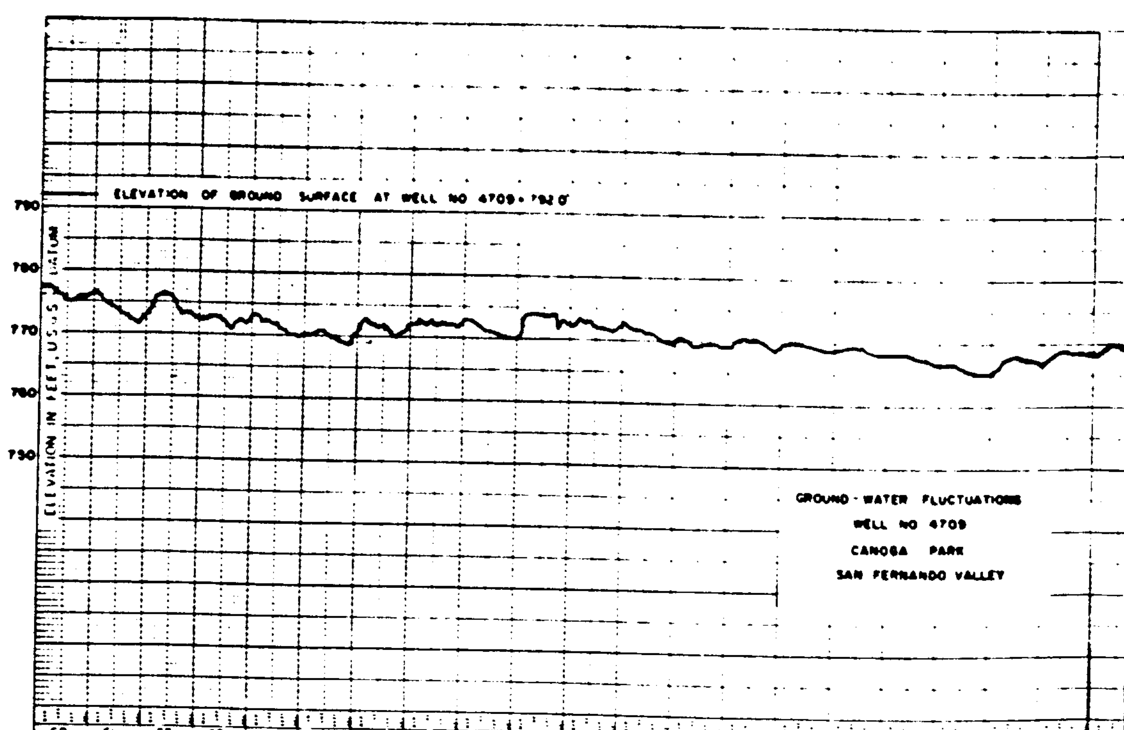
19850





R0053155

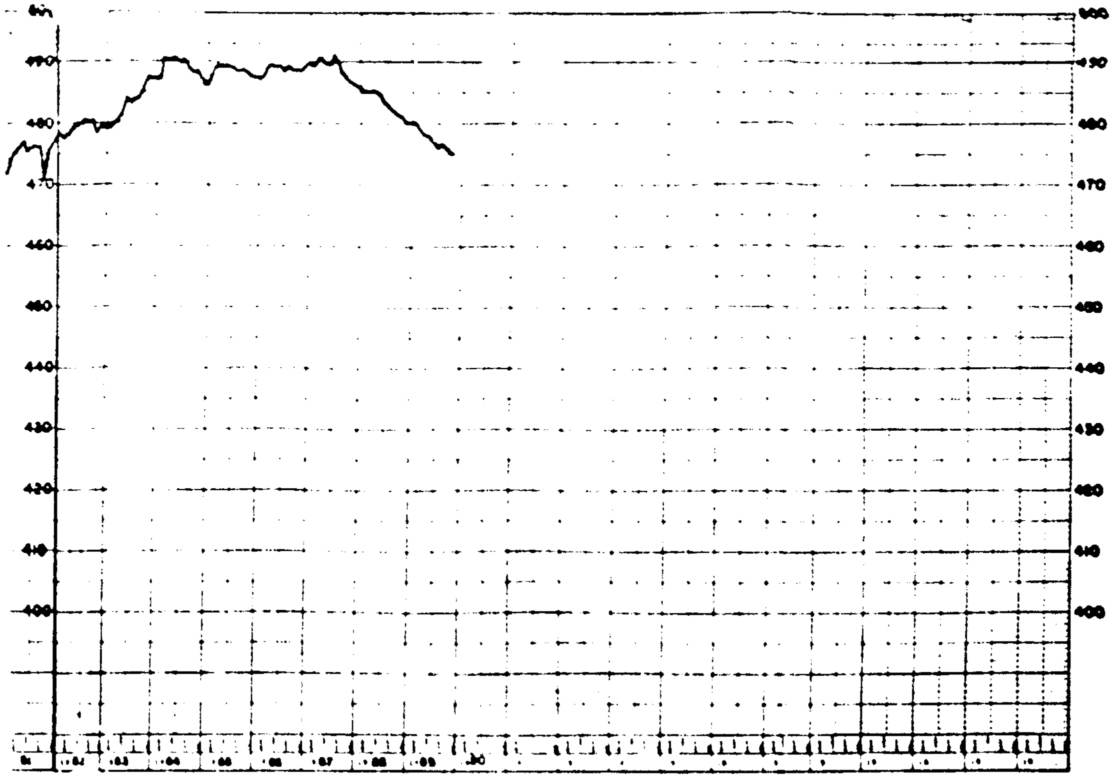


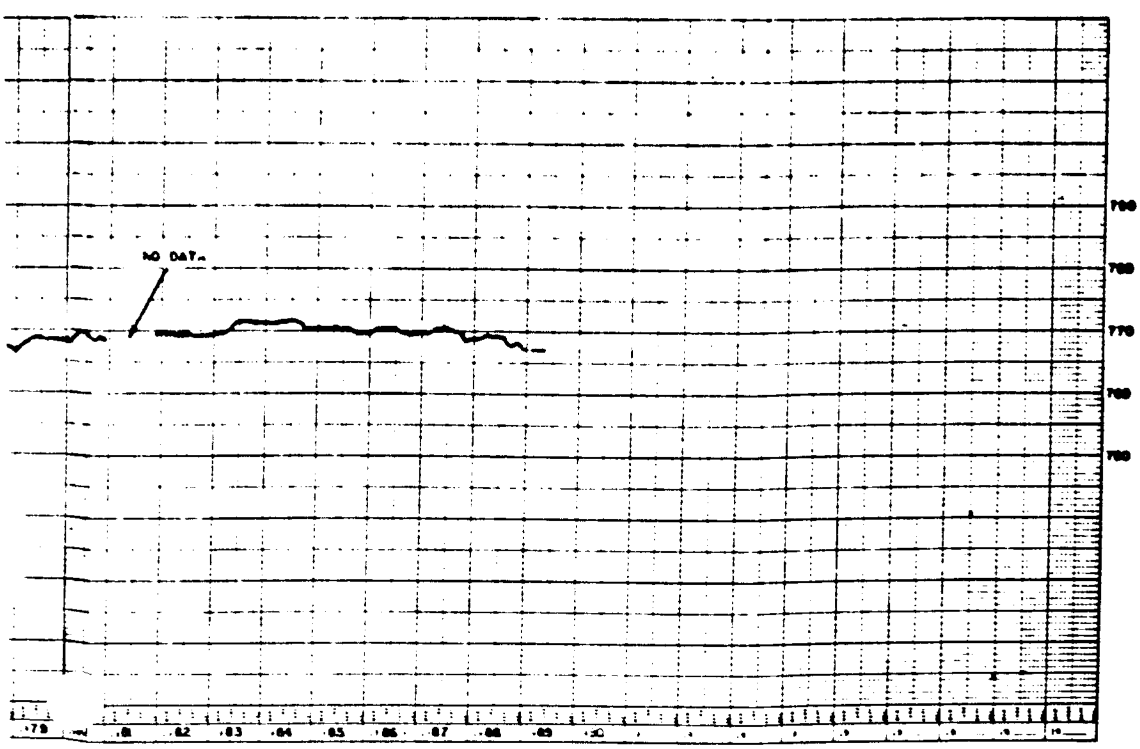


VCL 12

1985 1

R0053156



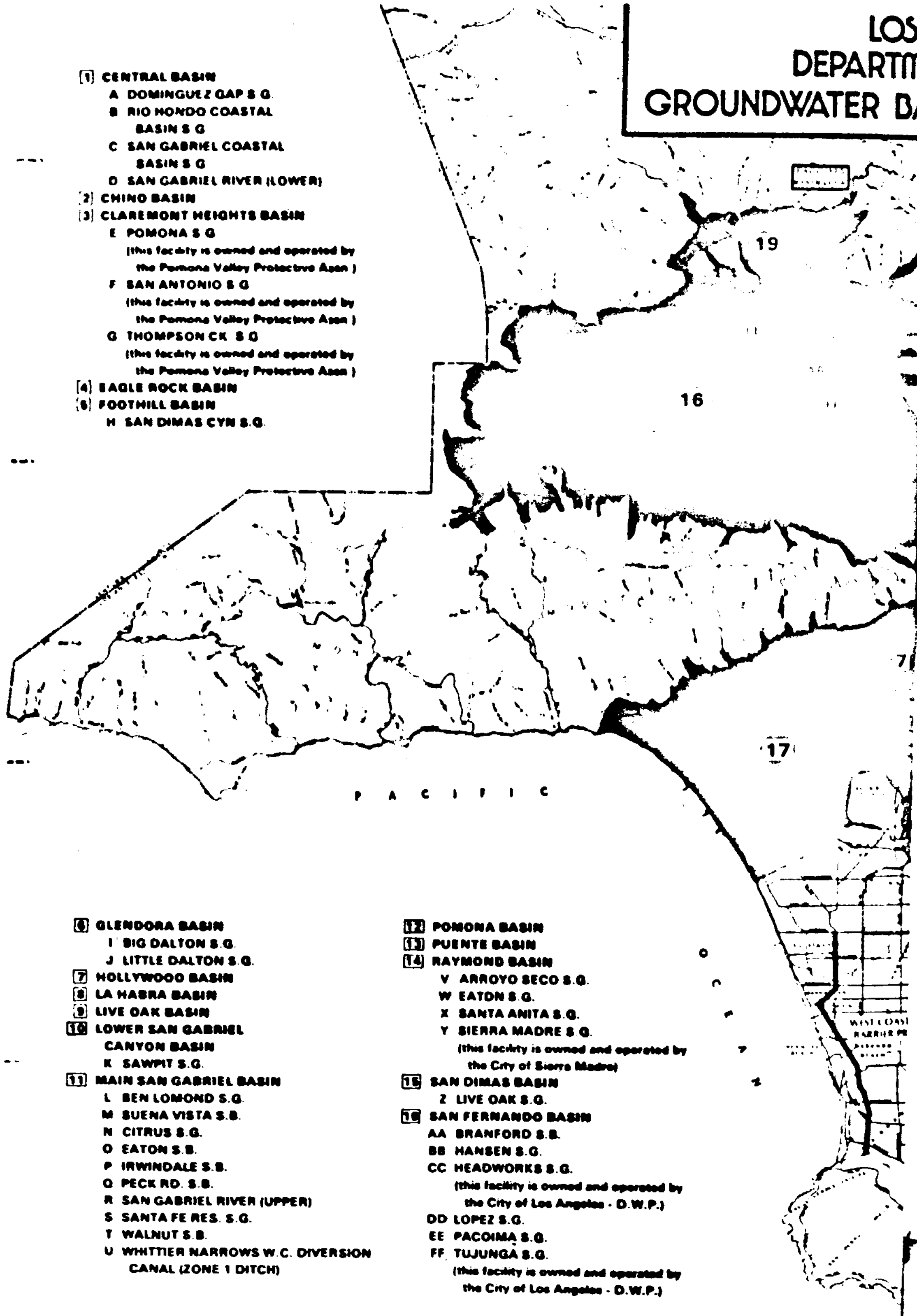


VOL 12

1 9852

G26

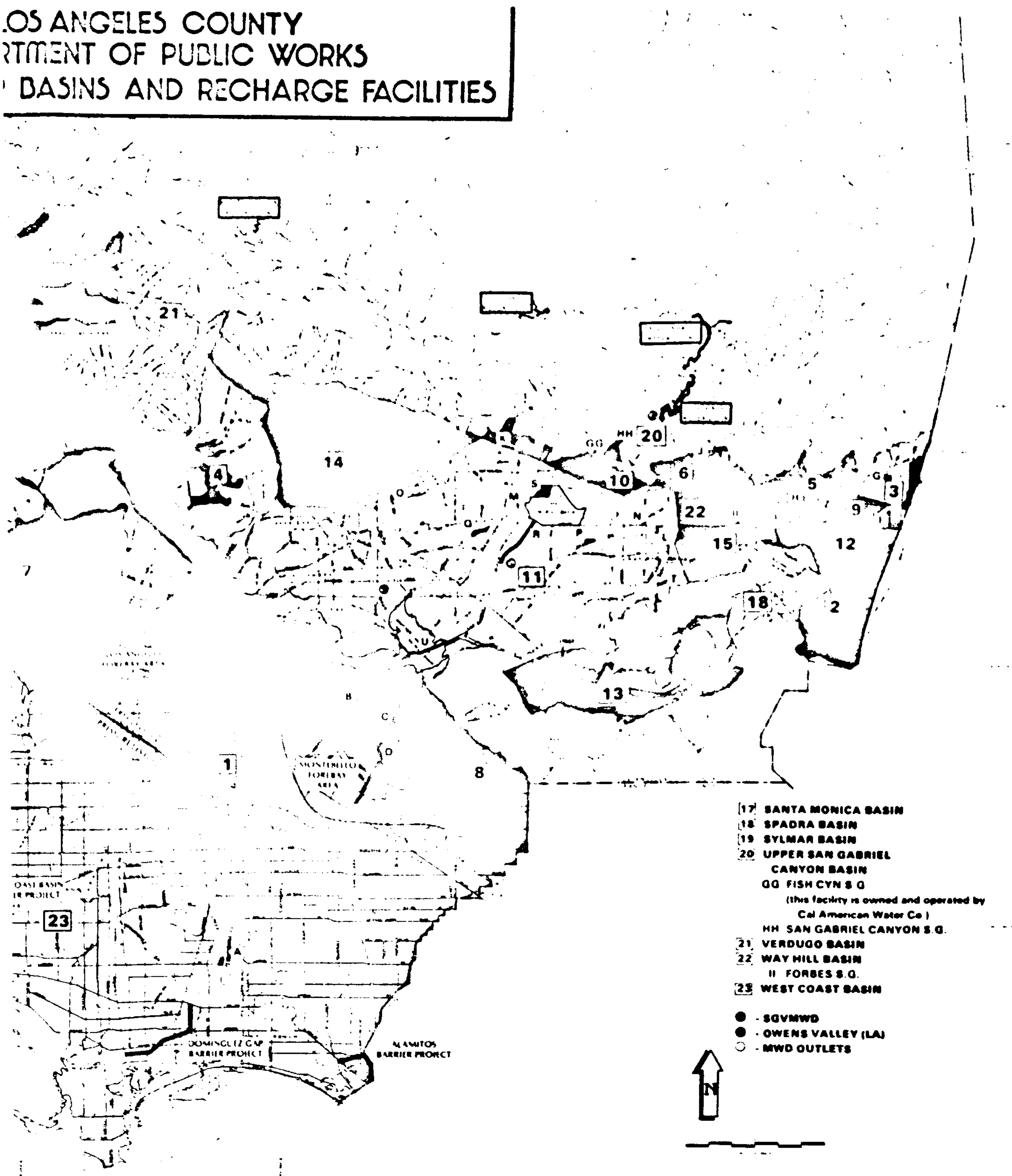
R0053157


LOS
DEPARTM
GROUNDWATER BA
[1] CENTRAL BASIN
A DOMINGUEZ GAP S.G.
B RIO HONDO COASTAL BASIN S.G.
C SAN GABRIEL COASTAL BASIN S.G.
D SAN GABRIEL RIVER (LOWER)
[2] CHINO BASIN
[3] CLAREMONT HEIGHTS BASIN
E POMONA S.G.
(this facility is owned and operated by the Pomona Valley Protective Assn.)
F SAN ANTONIO S.G.
(this facility is owned and operated by the Pomona Valley Protective Assn.)
G THOMPSON CK. S.G.
(this facility is owned and operated by the Pomona Valley Protective Assn.)
[4] EAGLE ROCK BASIN
[5] FOOTHILL BASIN
H SAN DIMAS CYN S.G.
19
16
17
PACIFIC
[6] GLENDORA BASIN
I BIG DALTON S.G.
J LITTLE DALTON S.G.
[7] HOLLYWOOD BASIN
[8] LA HABRA BASIN
[9] LIVE OAK BASIN
[10] LOWER SAN GABRIEL CANYON BASIN
K SAWPIT S.G.
[11] MAIN SAN GABRIEL BASIN
L BEN LOMOND S.G.
M BUENA VISTA S.B.
N CITRUS S.G.
O EATON S.B.
P IRWINDALE S.B.
Q PECK RD. S.B.
R SAN GABRIEL RIVER (UPPER)
S SANTA FE RES. S.G.
T WALNUT S.B.
U WHITTIER NARROWS W.C. DIVERSION CANAL (ZONE 1 DITCH)
[12] POMONA BASIN
[13] PUENTE BASIN
[14] RAYMOND BASIN
V ARROYO SECO S.G.
W EATON S.G.
X SANTA ANITA S.G.
Y SIERRA MADRE S.G.
(this facility is owned and operated by the City of Sierra Madre)
[15] SAN DIMAS BASIN
Z LIVE OAK S.G.
[16] SAN FERNANDO BASIN
AA BRANFORD S.B.
BB HANSEN S.G.
CC HEADWORKS S.G.
(this facility is owned and operated by the City of Los Angeles - D.W.P.)
DD LOPEZ S.G.
EE PACOIMA S.G.
FF TUJUNGA S.G.
(this facility is owned and operated by the City of Los Angeles - D.W.P.)

VOL
12
1
9853

VOL 12

1 9854



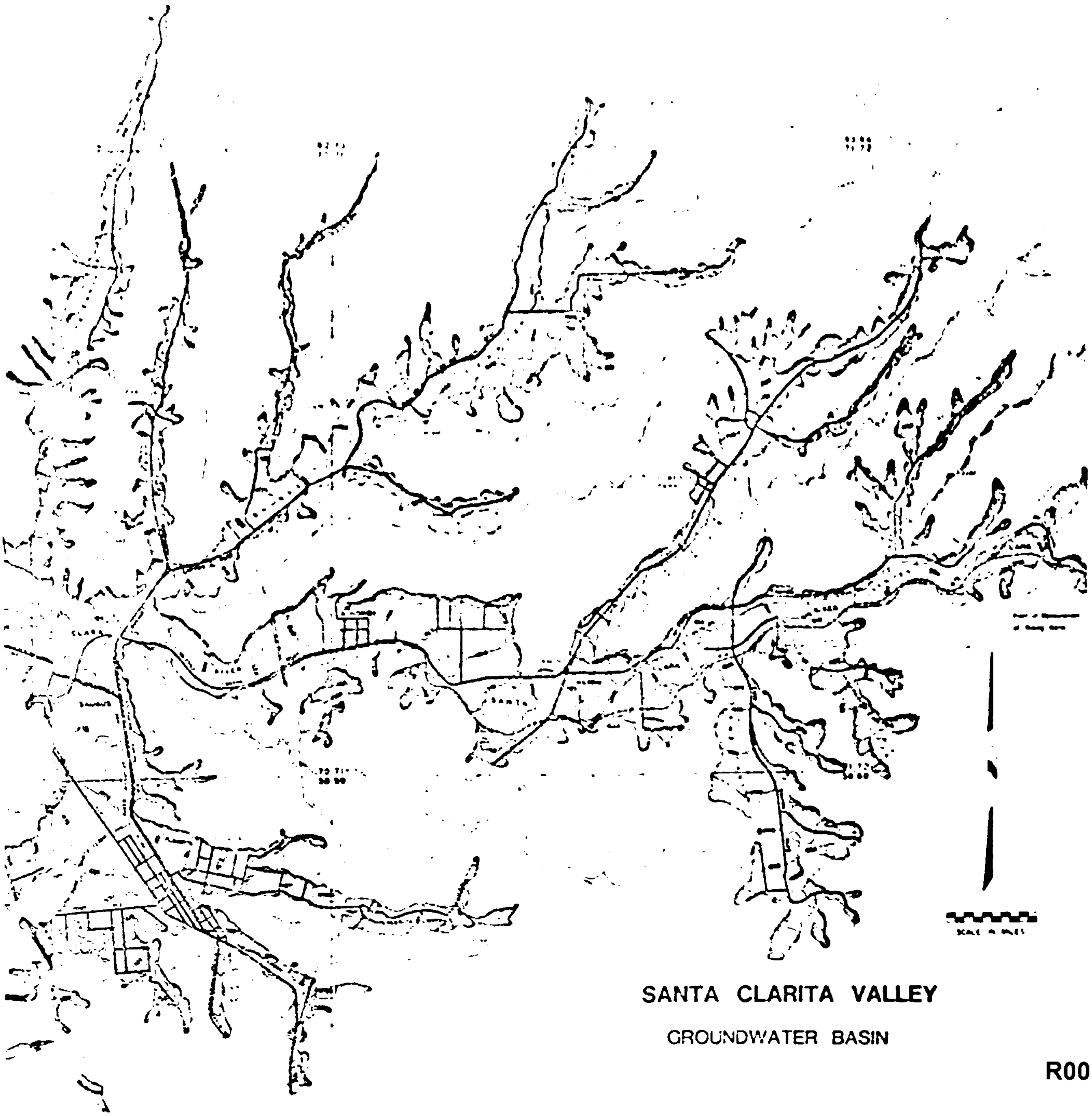
R0053159

VOL 12

1 9855

VOL 12

19856

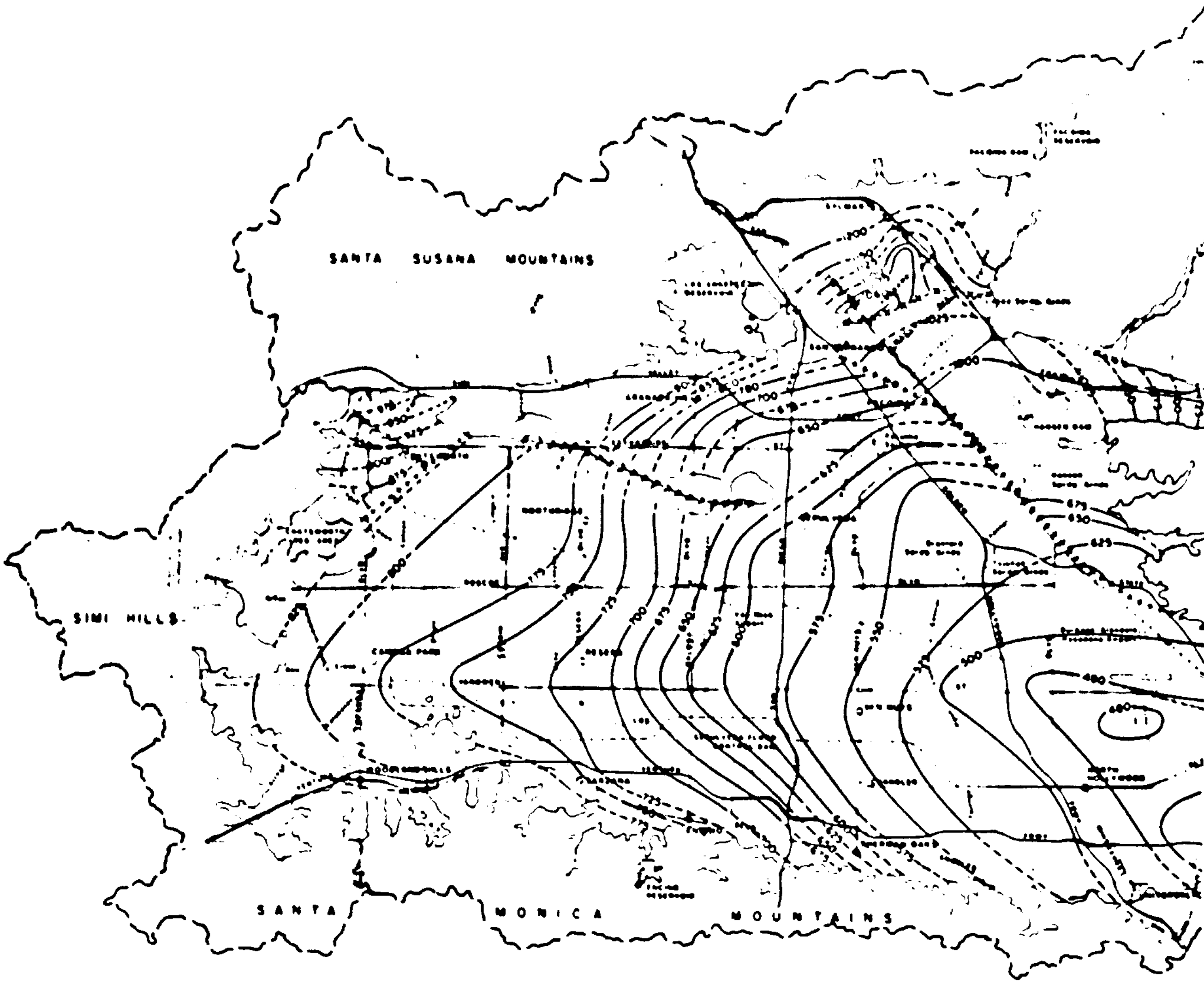


SANTA CLARITA VALLEY

GROUNDWATER BASIN

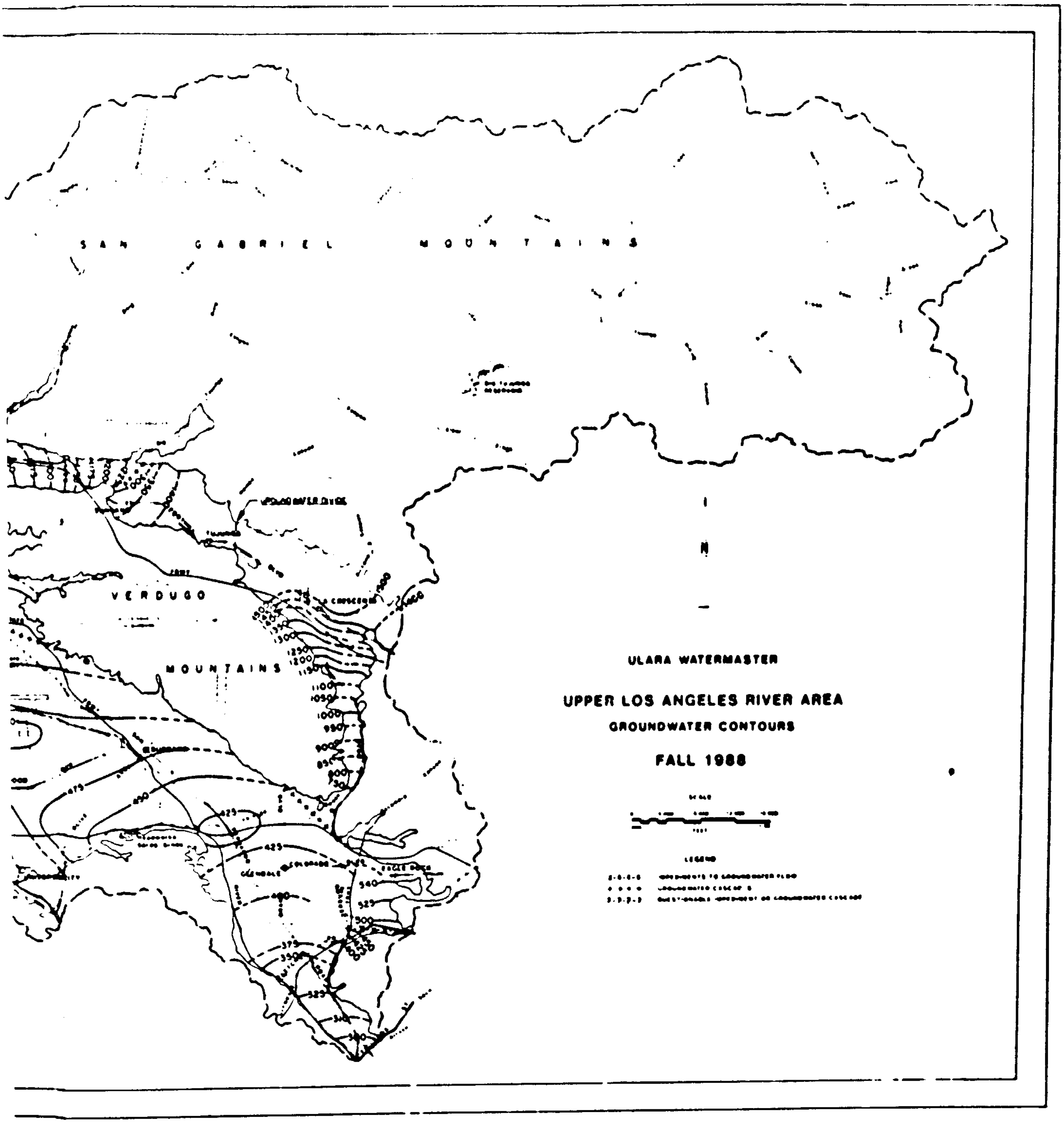
R0053161

PG2



VOL 12 1 5857

R0053162

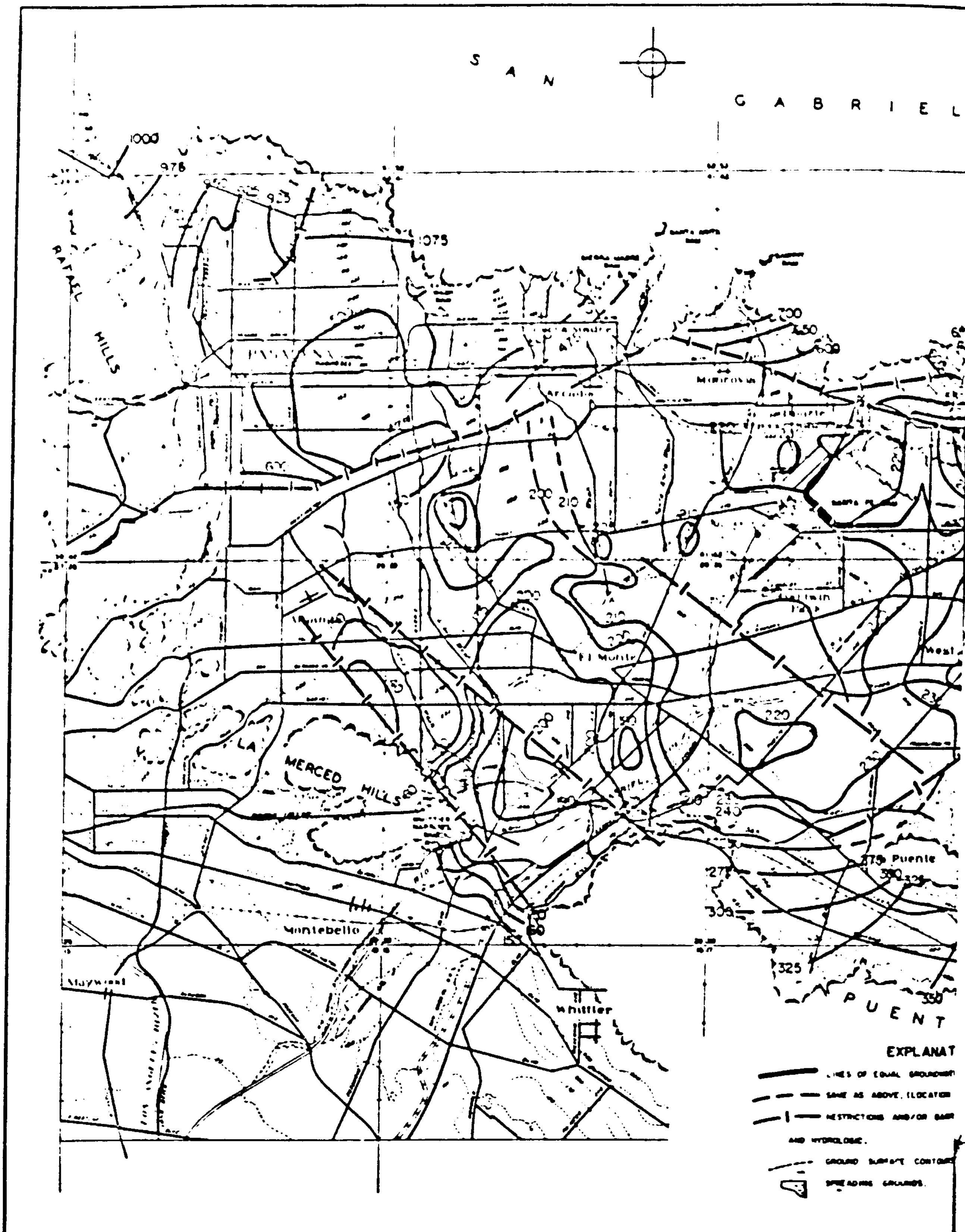


VOL 12

1 9858

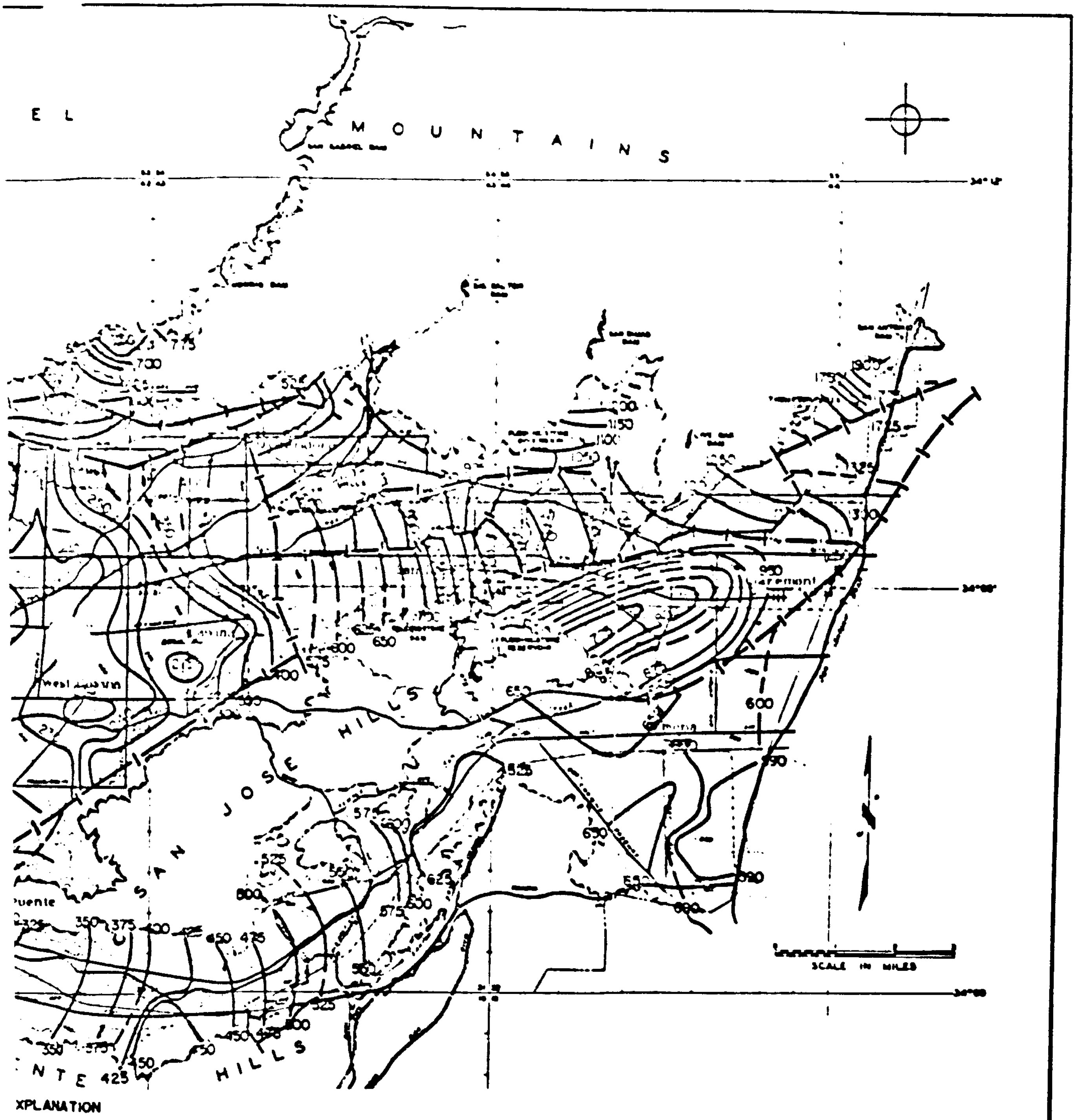
PG3

R0053163


S A N
G A B R I E L
RAFAEL
HILLS
LA
MERCED
HILLS
El Monte
Montebello
Whittier
Maywood
Arcadia
Monrovia
Puente
P U E N T
EXPLANAT
SPREADING GROUNDS.

VOL 12

1 9 8 5 9



XPLANATION

L GROUNDWATER LEVELS, INTERPOLATED BETWEEN WELLS.

(LOCATION APPROXIMATE.)

AND/OR BARRIERS TO GROUNDWATER MOVEMENT, GEOLOGIC

E CONTOURS.

OURS.

REVISIONS		
NO	DATE	DESCRIPTION

COUNTY OF LOS ANGELES DEPARTMENT OF PUBLIC WORKS

SAN GABRIEL VALLEY
GROUNDWATER CONTOURS
FOR
FALL 1988

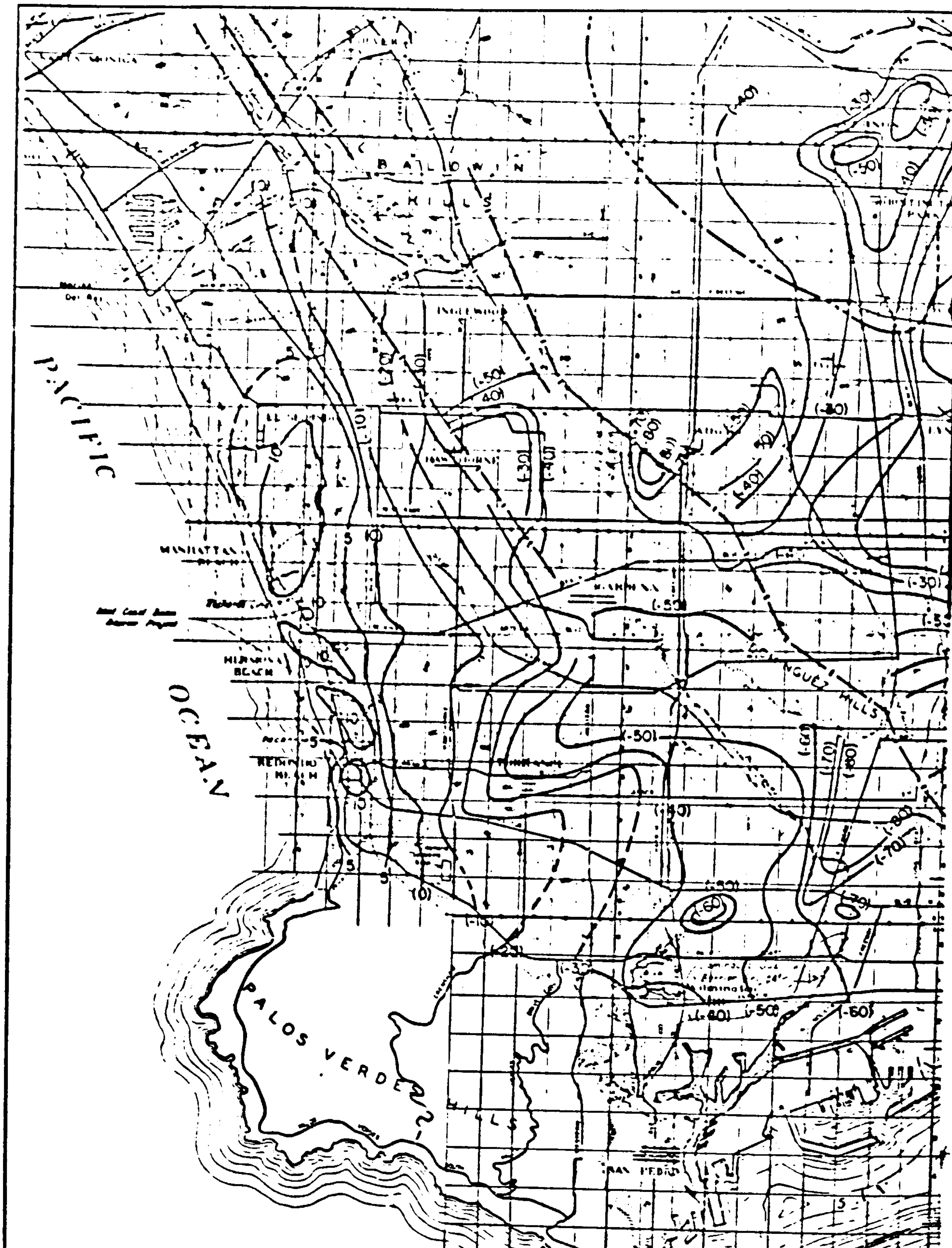
RECOMMENDED BY | DATE | SCALE | NO | SHEET | OF

VOL 12

1 9850

PG4

R0053165



VOL 12

1986 1

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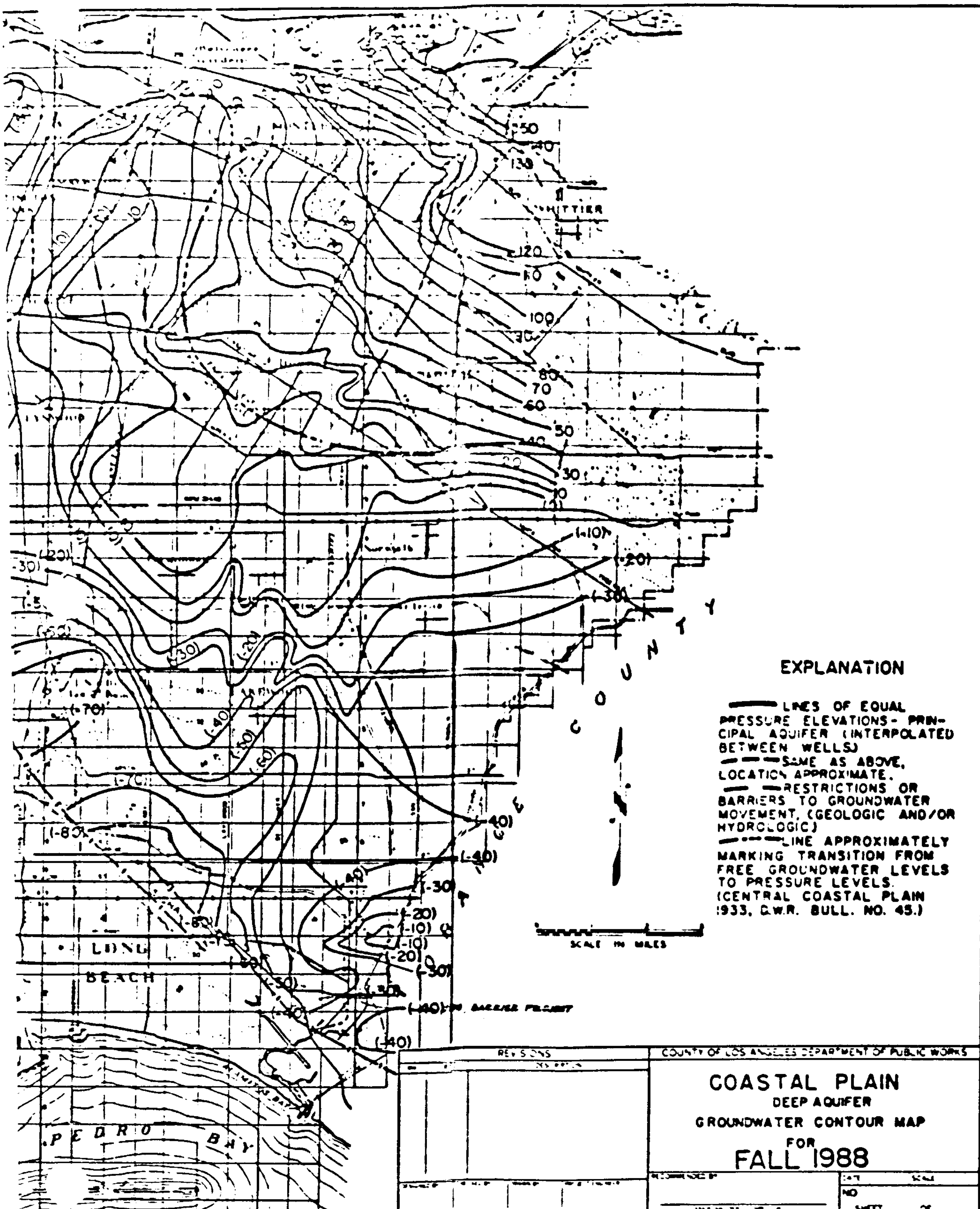

EXPLANATION

LINES OF EQUAL PRESSURE ELEVATIONS - PRINCIPAL AQUIFER (INTERPOLATED BETWEEN WELLS)

SAME AS ABOVE, LOCATION APPROXIMATE.

RESTRICTIONS OR BARRIERS TO GROUNDWATER MOVEMENT. (GEOLOGIC AND/OR HYDROLOGIC)

LINE APPROXIMATELY MARKING TRANSITION FROM FREE GROUNDWATER LEVELS TO PRESSURE LEVELS. (CENTRAL COASTAL PLAIN 1933, D.W.R. BULL. NO. 45.)

REVISIONS

COUNTY OF LOS ANGELES DEPARTMENT OF PUBLIC WORKS

COASTAL PLAIN
DEEP AQUIFER
GROUNDWATER CONTOUR MAP
FOR
FALL 1988

Flat Deep Aquifer wells

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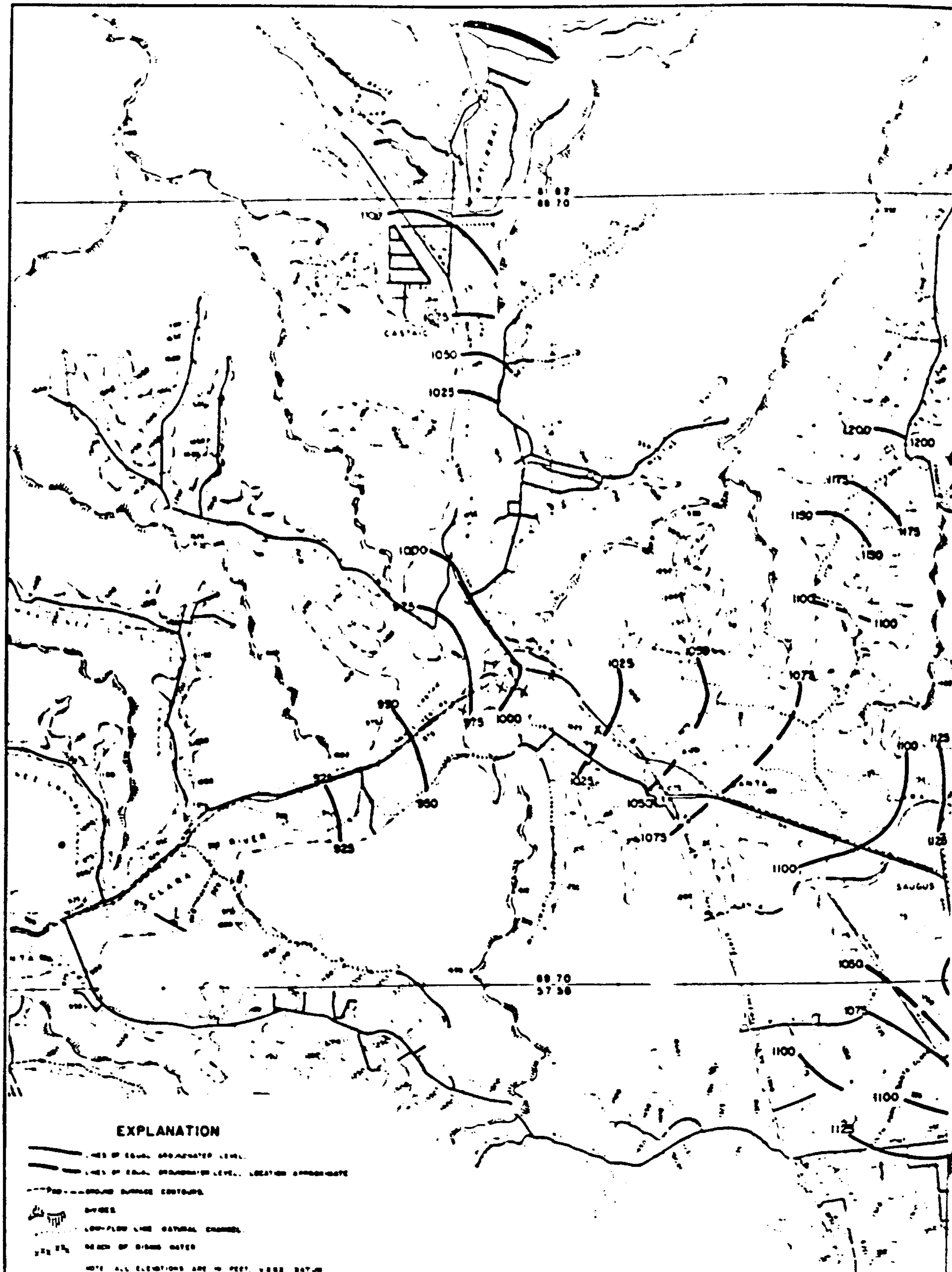

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EXPLANATION

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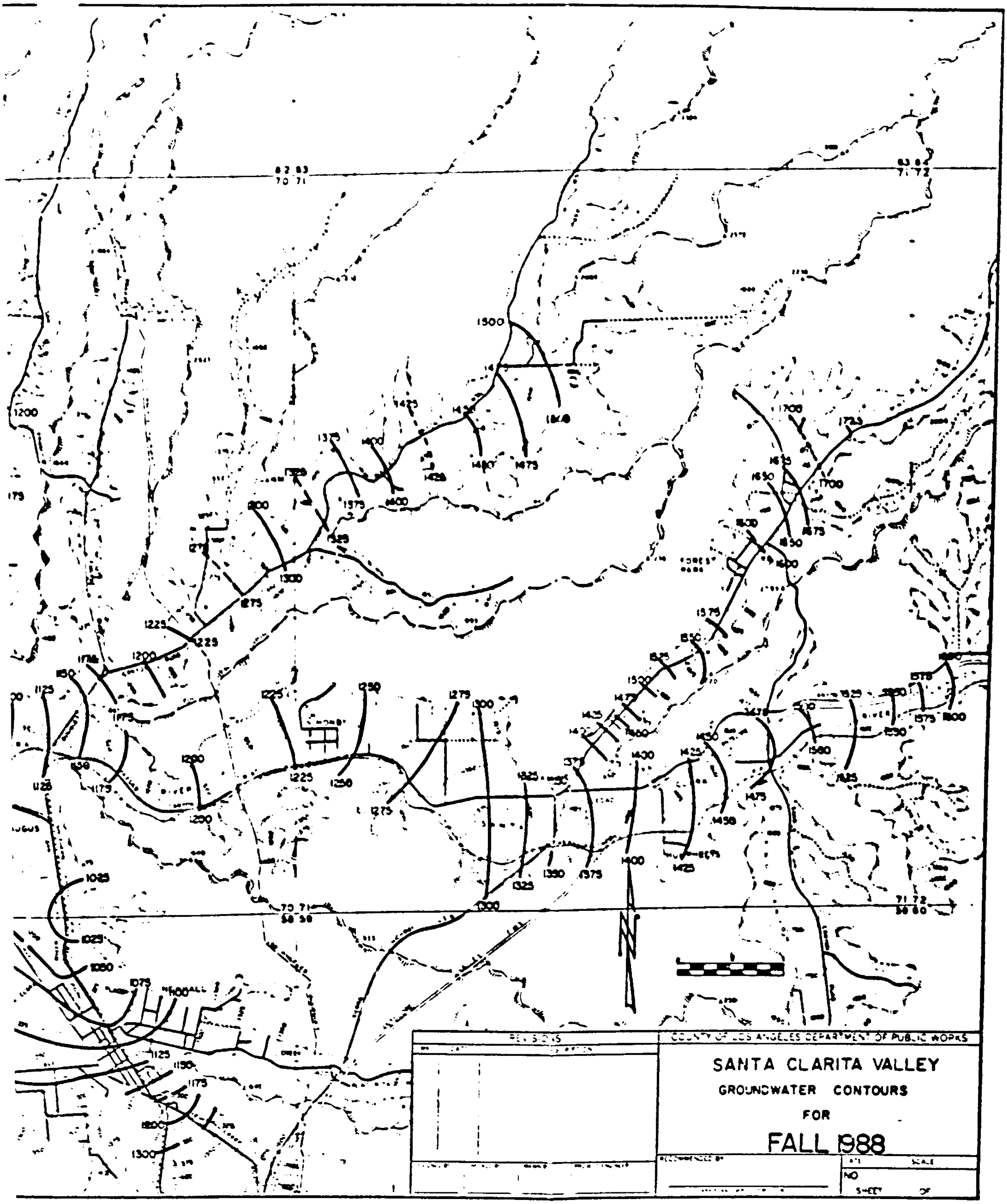

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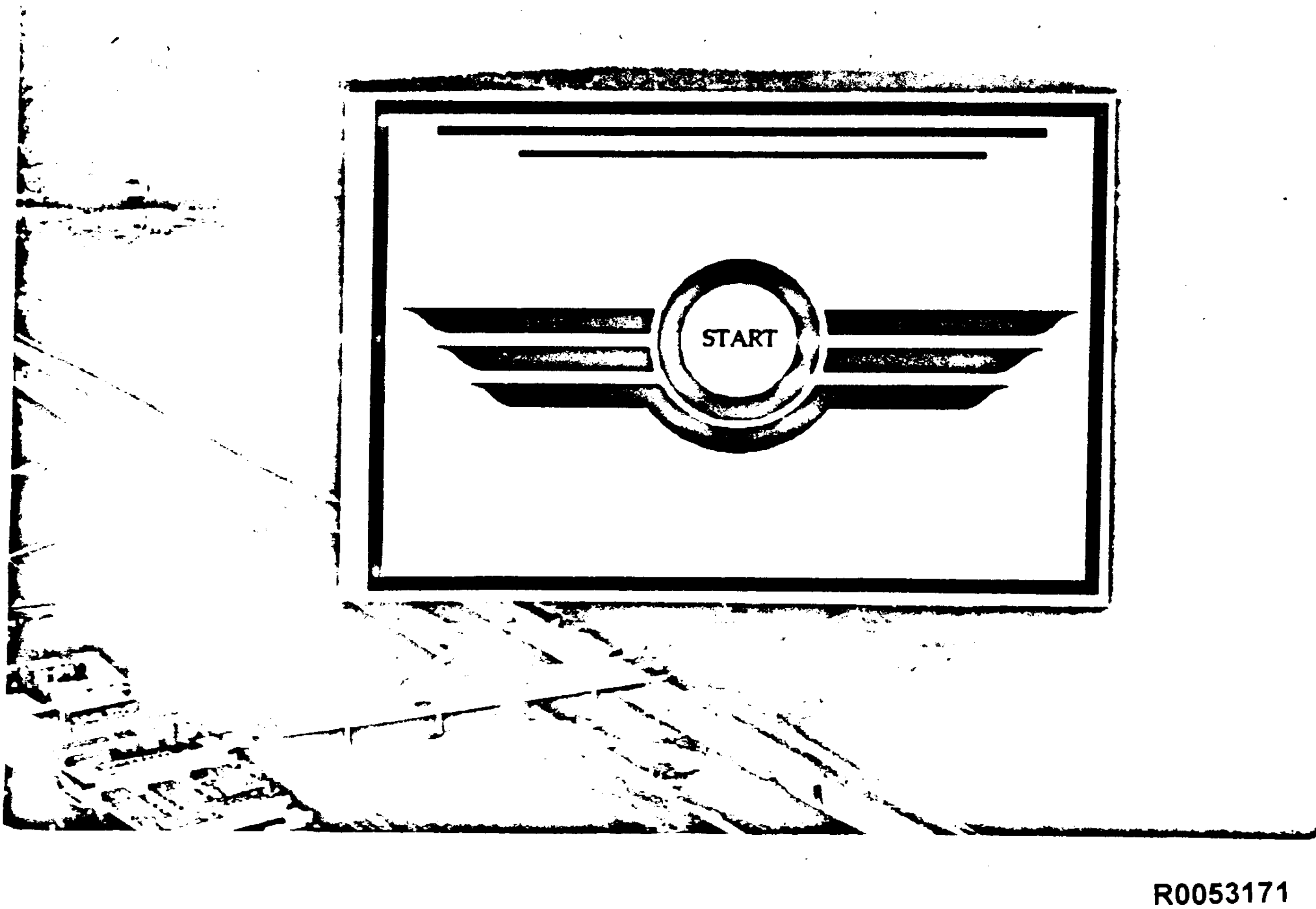

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Los Angeles County Department of Public Works

HYDROLOGIC REPORT
1990 - 91

LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS

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PREPARED BY THE
HYDRAULIC/WATER CONSERVATION DIVISION
JULY 1992

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This report was prepared in the Hydraulic/Water Conservation Division under the direction of Donald F. Nichols, Assistant Deputy Director. The following people contributed to the completion of this report:

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INTRODUCTION

This report contains hydrologic data relative to Los Angeles County for the period beginning October 1, 1990 and ending September 30, 1991. The data are presented in seven sections.

Precipitation - lists 294 active rainfall stations and presents corresponding seasonal rainfall amounts.

Evaporation - lists all locations for which evaporation data is on file and provides monthly evaporation amounts at 14 locations.

Runoff - presents the maximum, minimum, and mean of the daily flow rates for each month and the monthly volumes for 48 streamflow stations.

Dam Operation - presents the maximum and minimum of the daily inflow and outflow rates for each month, the instantaneous peak inflow and outflow rates and storage volumes for 14 dams and reservoirs.

Erosion Control - lists debris basins and debris production amounts.

Water Quality Monitoring - presents maps of surface and groundwater sampling locations, and data at selected locations.

Conservation and Groundwater - presents records of water conserved at various facilities, water injected at seawater barrier projects, well hydrographs, and static groundwater contour maps.

Where practical, data which would satisfy immediate needs and serve as useful reference are published in these reports. Several tables appear listing locations for which unpublished data are available. Additional information may be obtained by writing to:

Los Angeles County Department of Public Works
Hydraulic/Water Conservation Division
P.O. Box 1460
Alhambra, CA 91802-1460

or telephone: **(818) 458-6112**

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LOS ANGELES COUNTY

TOPOGRAPHY

The County of Los Angeles covers an area of 4,083 square miles and measures approximately 66 miles in the east - west and 73 miles in the north - south directions.

The terrain within the County can be classified in broad terms as being 25 percent mountainous; 10 percent coastal plain; and 65 percent hills, valleys, or deserts. Relief of the terrain ranges from sea level to a maximum elevation of 10,000 feet. The coastal plain is generally of mild slope and contains relatively few depressions or natural ponding areas. The slopes of main river systems crossing the coastal plain, such as the San Gabriel River, Los Angeles River, and Ballona Creek, range from 4 to 14 feet per mile.

Topography in the mountainous area is generally rugged with deep, V-shaped canyons separated by sharp dividing ridges. Steepwalled canyons with side slopes of 70 percent or more are common. The gradient of principal canyons in the San Gabriel Mountains ranges from 150 to 850 feet per mile. Mountain ranges are aligned in a general east-west direction with the major range being the San Gabriel Mountains. The majority of mountain ridges lie below Elevation 5,000 feet. The total area above this level is approximately 210 square miles.

GEOLOGY - SOILS

Igneous, sedimentary, and metamorphic rock groups are all represented within the County. The San Gabriel Mountains and Verdugo Hills are composed primarily of highly fractured igneous rock, with large areas of granitic rock formation being exposed above soils that are coarse and porous. Faulting and deep weathering have produced porous zones in the rock formation; however, rock masses have produced a comparatively shallow soil mantle due to the steepness of slopes which accelerates erosion of the fine material.

LAND USE

The principal vegetative cover of upper mountain areas consists of various species of brush and shrubs known as chaparral. Most trees found on mountain slopes are oak, with alder, willow, and sycamore found along streambeds at lower elevations. Pine, cedar, and juniper are found in ravines at higher elevations and along high mountain summits.

The chaparral is extremely flammable, and extensive burns of the mountain vegetation frequently occur during dry, low-humidity weather accompanied by high winds. Chaparral has the ability to sprout following fire and grows rapidly to re-establish the watershed cover within a period of 5 to 10 years.

Grasses are the principal natural vegetation on the hills. Much of the hill land and nearly all of the valley land in the densely populated portion of the County south of the San Gabriel Mountains has been converted to urban and suburban use. Development of the

Santa Clarita Valley and desert areas to the north of the San Gabriel Mountains is sparse at present but is proceeding rapidly.

Other mountains and hilly reaches are composed primarily of folded and faulted sedimentary rock, including shale, sandstone, and conglomerate. Residual soils in these areas are shallow and are generally less pervious than those of the San Gabriel Mountain range.

Valley and desert soils are alluvial and vary from coarse sand and gravel near canyon mouths to silty clay and gravel or clay in lower valleys and the coastal plain. The alluvial fill has been built up by repeated deposition of debris to depths as great as 2,000 feet in places. This fill is quite porous in areas of relatively low clay content. Impervious layers and irregularities in the underlying bedrock divide the alluvium into several County groundwater basins. Valley soils are generally well drained but there are a few areas having perched water.

CLIMATE

The climate within the County varies between subtropical on the Pacific Ocean side of the San Gabriel Mountain range to arid in the Mojave Desert. Nearly all precipitation occurs during the months of December through March. Precipitation during summer months is infrequent, and rainless periods of several months are common. Snowfall at elevations above 5,000 feet is frequently experienced during the winter storms, but the snow melts rapidly except on higher peaks and the northern slopes. Snow is rarely experienced on the coastal plain.

January and July are the coldest and warmest months of the year, respectively. At Los Angeles, the 30-year average daily minimum temperature for January is 48 degrees above zero. The average daily maximum temperature for July is 84 degrees. At Mount Wilson (Elevation 5,850 feet), the 30-year average daily minimum temperature for January is 35 degrees above zero and the average daily maximum temperature for July is 80 degrees.

HYDROMETEOROLOGIC CHARACTERISTICS

Coastal and Mountain Areas

Precipitation in the Los Angeles area occurs primarily in the form of winter orographic rainfall associated with extratropical cyclones of North Pacific origin. Major storms consist of one or more frontal systems and occasionally last four days or longer. Air masses and frontal systems associated with major storms commonly extend for 500 to 1,000 miles in length and produce rainfall simultaneously throughout the County. Major storms approach Southern California from the west or southwest with southerly winds which continue until frontal passage. The mountain ranges lie directly across the path of the inflow of warm, moist air, and orographic effects greatly intensify precipitation.

The effects of snowmelt upon flood runoff is of significance in the few cases when warm spring rains from southerly storms fall on a snowpack. During major storms, temperatures throughout the County may remain above freezing. Average individual storm rainfall amounts and intensities conform to a fairly definite aerial pattern which reflects general effects of topographic differences.

Desert Areas

Summer convective rainfall is principally experienced in the upper San Gabriel Mountains and the Mojave Desert regions. In many desert areas, the most serious flooding occurs as a result of summer convective storms.

RUNOFF CHARACTERISTICS

Mountain Areas

In mountain areas, the steep canyon slopes and channel gradients promote a rapid concentration of storm runoff quantities. Depression storage and detention storage effects are minor in the rugged terrain. Soil moisture during a storm has a pronounced effect on runoff from the porous soils supporting a good growth of deeprooted vegetation such as chaparral. Soil moisture deficiency is greatest at the beginning of a rainy season, having been depleted by the evapotranspiration process during the dry summer months. Precipitation during periods of soil moisture deficiency is nearly entirely absorbed by soils, and except for periods of extremely intense rainfall, significant runoff does not occur until soils are wetted to field moisture capacity. Due to high infiltration rates and porosity of mountain soils, runoff occurs primarily as subsurface flow or interflow rather than as direct runoff. Spring or base flow is essentially limited to portions of the San Gabriel Mountain range. Consequently, most streams in the County are intermittent.

Runoff from a mountain watershed recently denuded by fire exceeds that for the unburned state due to greatly increased quantities of inorganic debris present in the flow and increased direct runoff resulting from lowered infiltration rates. Debris production from a major storm has amounted to as much as 223,000 cubic yards per square mile of watershed. Boulders up to eight feet in diameter have been deposited in valley areas a considerable distance from their source.

Debris quantities equal in volume to storm runoff, or in other words 100 percent bulking of runoff from a major storm, have been recorded. Where debris-laden flow traverses an alluvial fill unconfined by flood control works, flood discharges follow an unpredictable path across the debris cone formed at the canyon mouth.

Hill and Valley Areas

In hill areas, runoff concentrates rapidly from the generally steep slopes; however, runoff rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size. In those hill areas which have been developed for residential use, concentration times become considerably decreased due to drainage improvement, and runoff volumes and rates become increased due to increased imperviousness. On the other hand, erosion is controlled and debris is practically eliminated from storm flows. Debris production rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size.

In highly developed valley areas, local runoff volumes have increased as the soil surface has become covered by impervious materials. Peak runoff rates for valley areas have also increased due to elimination of natural ponding areas and improved hydraulic efficiency of water carriers such as streets and storm drain systems.

FLOOD CONTROL AND WATER CONSERVATION

FLOODS. . AN OLD STORY

Floods in Los Angeles County have been recorded as far back as the days of the Mission Padres. For centuries waters have swept out of the San Gabriel Mountains causing extensive property damage and taking a great toll of lives.

Such a flood occurred in 1914 causing over $10 million in property damage and taking many lives. As a result, the State legislature enacted the statute creating the Los Angeles County Flood Control District. The responsibilities and authority vested in the Flood Control District are now part of the Los Angeles County Department of Public Works.

The Department has two tasks. . .control the floods and conserve the water.

CONTROLLING THE WATERS

Successful early bond issues financed construction of the 14 dams which the Department built in the San Gabriel Mountains and foothills to impound storm waters until they could be safely released. Debris basins were constructed to trap eroded materials which had caused terrible damage in the past. Flood channel improvements were undertaken to confine the waters.

Department engineers prepared a Comprehensive Plan in the early 1930's which would control flooding and save as much of the water as practicable when fully implemented.

Federal legislation in 1936 brought the United States Army Corps of Engineers into the local flood control picture. Since that time, the two agencies have been jointly pursuing implementation of the Comprehensive Plan. The Department also cooperates with the United States Soil Conservation Service and Forestry Service in erosion control.

CONSERVING THE WATERS

In addition to its flood control program, the Department has the equally important task of conserving as much of the storm and other waste waters as practicable. The use of water conservation facilities in or adjacent to river channels and their tributaries permits water to be percolated into underground reservoirs for later pumping and supply to consumers. These water conservation facilities are located in areas where the underlying soils are composed of porous sands and gravel formations. Some resemble rice paddies, while others are deep basins which were once gravel pits.

The importance of this activity is apparent when it is realized that about 35 to 40 percent of the water used in the County is pumped from ground supplies. The growth of the County, combined with periodic droughts, seriously depleted these supplies on numerous occasions throughout the history of the County.

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Other major conservation efforts by the Department include combatting the serious salt water intrusion into underground fresh water supplies inland from the Pacific Ocean and utilizing imported water and reclaimed sewage waters in spreading operations.

ORGANIZED TO DO THE JOB

Day-to-day administration of Department affairs is vested in the Director of Public Works who is appointed by and responsible to the Los Angeles County Board of Supervisors. A part of the Department's activities involve the planning, design and construction of flood control and water conservation facilities, and the operation and maintenance of dams, debris basins, spreading grounds, channels, and storm drains.

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PRECIPITATION

PRECIPITATION

This section contains annual precipitation data collected by the Department for the period beginning October 1, 1990 and ending September 30, 1991. Although the Department operates and maintains 294 rainfall stations, including standard and automatic gages which record amounts for durations ranging from 5 minutes to 24 hours, only annual amounts for the report period are listed herein. Additional data can be obtained by contacting the custodian of hydrologic records at the location shown in the front of the report.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorological conditions in the County and Southern California in real time, i.e., as they occur. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The cooperation of observers in furnishing rainfall data to the Department as a public service is appreciated. The effort of the many agencies and individuals who have so freely cooperated with us in the collection of this data have resulted in the large number of complete records for the period covered by this report.

ACTIVE RAINFALL STATIONS 1990-1991

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
2B	ESCONDIDO CANYON	S	112 E3	34-02-55	118-46-25	1050	13.2*
5B	CALABASAS	S	100 F3	34-09-24	118-38-14	924	14.2
6	TOPANGA PATROL STATION	A	109 C5	34-05-03	118-35-57	745	17.2
9B	SEPULVEDA AND RAYEN	S	8 C6	34-13-52	118-28-04	828	12.3
10A	BEL AIR HOTEL	A	32 E5	34-05-11	118-26-45	540	10.6
11D	UPPER FRANKLIN CYN RES.	SP	33 B1	34-07-10	118-24-35	867	12.4
13C	NORTH HOLLYWOOD-LAKESIDE	S	23 F4	34-08-46	118-21-13	550	16.2
14C	ROSCOE-MERRILL	S	9 F5	34-14-19	118-21-32	1050	10.4
15A	VAN NUYS	S	15 D6	34-10-48	118-27-03	695	12.2
17	SEPULVEDA CYN AT MULHOLLAND	A	22 A5	34-07-51	118-29-26	1425	19.1
20B	GIRARD RESERVOIR	S	13 B3	34-09-07	118-36-36	986	15.8
21B	WOODLAND HILLS	S	13 C1	34-10-14	118-35-33	875	14.8
23B	CHATSWORTH RESERVOIR	SP AP	6 A6	34-13-44	118-37-18	900	11.6
25C	NORTHRIDGE-L.A.D.W.P.	SP	7 B6	34-13-52	118-32-28	810	11.9
32C	NEWHALL-SOLEDAD DIV. HDQTRS	AP S	127 C3	34-23-07	118-31-54	1243	12.8
33A	PACOIMA DAM	S A	128 F9	34-19-48	118-23-59	1500	14.2
42C	REDONDO BEACH-CITY HALL	S	67 D3	33-50-43	118-23-20	70	10.3
43D	PALOS VERDES ESTATES	S	72 C2	33-47-58	118-23-29	216	13.1
44A	POINT VICENTE LIGHTHOUSE	A	77 B3	33-44-30	118-24-38	125	9.9
46D	BIG TUJUNGA DAM	S A	N C2	34-17-40	118-11-14	2315	25.3
47D	CLEAR CREEK-CITY SCHOOL	A	N D3	34-16-38	118-10-12	3150	31.4
53D	COLBY'S	A	N F2	34-18-05	118-06-39	3620	24.0
54C	LOOMIS RANCH-ALDER CREEK	S A	(197)	34-20-55	118-02-54	4325	18.9
57B	CAMP HI HILL (OPIDS)	A	N F3	34-15-18	118-05-41	4250	29.0*
63C	SANTA ANITA DAM	S A	20A F2	34-11-03	118-01-12	1400	23.7
67G	MONROVIA-MOUNTAIN AVENUE	S	29 C4	34-08-46	117-59-05	602	18.7
68C	SAWPIT DAM	S A	20B C6	34-10-30	117-59-07	1375	22.5
82F	TABLE MOUNTAIN	S	(201)	34-22-56	117-40-39	7420	13.2
83B	BIG PINES RECREATION PARK	A	(201)	34-22-44	117-41-20	6860	20.0
89B	SAN DIMAS DAM	S A	95A C3	34-09-10	117-46-17	1350	21.6
91	CLAREMONT-INDIAN HILL	S	91 B1	34-07-22	117-43-11	1403	19.4
92	CLAREMONT-POMONA COLLEGE	S	91 C4	34-05-48	117-42-33	1185	17.5*
93C	CLAREMONT-POLICE STATION	8.81	91 B4	34-05-45	117-43-18	1170	17.4
95	SAN DIMAS-FIRE WARDEN	S	89 F3	34-06-26	117-48-19	955	17.0
96C	PUDDINGSTONE DAM	S A	89 F4	34-05-31	117-48-24	1030	18.3
102D	WALNUT-W.I. INDUSTRIES	S	97 B2	34-00-11	117-52-10	500	11.2
106F	WHITTIER CITY YARD	S	55 D4	33-58-57	118-02-50	300	12.9
107D	DOWNEY-FIRE DEPARTMENT	S	60 A5	33-55-48	118-08-47	110	12.2
108D	EL MONTE FIRE STATION	S	38 D6	34-04-30	118-02-30	275	13.6
109D	WEST ARCADIA	S	28 A6	34-07-42	118-04-22	547	18.5
110B	ALHAMBRA	S	37 B3	34-05-40	118-07-41	533	16.7
117F	COMPTON FIRE STATION	S	64 F3	33-53-42	118-13-34	78	10.8*
119G	SAWTELLE-SOLDIERS HOME	S	41 D2	34-03-21	118-27-20	345	10.2
120	VINCENT PATROL STATION	S	183 A9	34-29-17	118-08-27	3135	8.4

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ACTIVE RAINFALL STATIONS 1990-1991

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
122G	LEONA VALLEY-RACKETT RANCH	S	171 G3	34-37-52	118-19-22	3300	16.6
125B	SAN FRANCISQUITO CYN P.H. 1	SP	(169)	34-35-25	118-27-15	2105	17.1
128B	ELIZABETH LAKE	A	(168)	34-36-28	118-33-40	2075	23.0*
134C	PUDDINGSTONE DIVERSION	8.81	95A C5	34-07-52	117-46-55	1160	19.2
143B	AZUSA-CITY PARK	S	86 D5	34-08-03	117-54-17	610	17.8
144	SIERRA MADRE DAM	S	20A D3	34-10-34	118-02-32	1100	22.6
156B	LA MIRADA-STANDARD OIL CO.	A	83 A4	33-52-59	118-01-00	75	12.4
157C	EL SEGUNDO-CHEVRON OIL CO.	AP S	56 A6	33-54-57	118-25-05	150	8.5*
158	TANBARK FLATS	AP A	P D5	34-12-20	117-45-40	2750	25.9
167C	ARCADIA PUMPING PLANT #1	S	28 E2	34-09-31	118-02-02	611	19.9
169	SIERRA MADRE PUMPING PLANT	SP	28 D2	34-09-47	118-02-21	700	20.9
170F	POTRERO HEIGHTS	S	47 A4	34-02-32	118-04-44	285	12.7
172B	DUARTE	S	29 E4	34-08-26	117-58-02	548	17.7
174B	GLENDORA	S	87 E6	34-07-43	117-49-08	930	17.1
175B	LA CANADA IRRIGATION DIS.	S	19 A1	34-13-39	118-12-40	2020	21.5
176	ALTADENA-RUBIO CANYON	SP	20 B6	34-10-55	118-08-15	1125	21.1
191C	L.A.C.D.P.W. WAREHOUSE	A	45 B1	34-03-48	118-11-58	400	14.4
192C	BELL-FIRE STATION	8.81	53 C5	33-58-45	118-11-16	145	12.2*
193C	COVINA-NIGG	S	89 A5	34-04-55	117-52-25	575	16.0
196C	LA VERNE-FIRE STATION	S	90 D3	34-06-06	117-46-20	1050	16.8
200	SAUGUS-S. C. EDISON CO.	S	123 H8	34-25-21	118-34-26	1096	12.4
201D	HACIENDA HEIGHTS	A	85 C3	33-59-40	117-59-28	875	16.4
210B	BRAND PARK	A	18 B5	34-11-18	118-16-20	1250	16.8*
216B	GLENDALE-ANDREE	S	25 D2	34-09-54	118-15-01	615	16.8
222C	NORTH HOLLYWOOD P. P.	SP	16 C4	34-11-39	118-23-17	717	12.7*
223C	BIG DALTON DAM	S A	87 F2	34-10-06	117-48-36	1587	23.4
224D	LONG BEACH-ALAMITOS LAND CO.	S	76 B3	34-47-	118-08-	45	10.3
225	MONTANA RANCH	S	71 C3	33-50-35	118-07-09	47	11.8
226B	BURBANK-FIRE STATION	S	17 E6	34-10-58	118-18-23	680	13.3
227D	SAN GABRIEL-BRUINGTON-ORTON	S	37 D2	34-06-18	118-06-32	472	16.5
228C	BEVERLY HILLS CITY HALL	AP S	33 C6	34-06-00	118-23-40	245	11.3
235C	HENNIGER FLATS	A 8.81	20 F4	34-11-38	118-05-17	2550	25.5
237C	STONE CANYON RESERVOIR	SP	32 D2	34-06-21	118-27-13	865	16.2
238	HOLLYWOOD DAM	SP	34 C1	34-07-04	118-19-55	750	10.7
250D	ACTON CAMP	A	189 E5	34-27-02	118-11-55	2625	10.5
251C	LA CRESCENTA	S	18 D1	34-13-20	118-14-40	1440	21.3
252C	CASTAIC DAM	SP AP	(178)	34-29-53	118-36-53	1150	15.1
255F	MT. SAN ANTONIO COLLEGE	S	93 D4	34-02-41	117-50-19	720	15.7
256C	POMONA-FIRE STATION	S	94 E3	34-03-16	117-45-10	844	15.7*
257	GRIFFITH PARK NURSERY	S	35 A1	34-07-18	118-17-04	850	12.6*
261F	ACTON-ESCONDIDO CANYON	A	181 H9	34-29-42	118-16-22	2960	10.4
269D	DIAMOND BAR FIRE STATION	SP AP	97 F2	33-59-50	117-48-55	870	12.2
277	SAWMILL MOUNTAIN	S	(155)	34-43-15	118-35-00	3700	21.6
278B	L.A. CLARK MEMORIAL LIBRARY	S	43 D5	34-02-00	118-18-46	203	11.4*

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ACTIVE RAINFALL STATIONS 1990-1991

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
280C	FLINTRIDGE-SACRED HEART	A	19 D6	34-10-54	118-11-08	1600	21.0
283C	CRYSTAL LAKE-EAST PINE FLAT	A	P B1	34-19-02	117-50-28	5370	29.8
287B	GLENDORA-CITY HALL	8.81	87 B5	34-08-09	117-51-52	785	20.3
289	LAGUNA-BELL-S.C.E. CO.	SP	54 A5	33-58-37	118-08-48	140	12.5
290B	MONTEREY PARK-FIRE STATION	S	46 B4	34-02-27	118-07-42	305	12.4
291	LOS ANGELES-96th AND CENTRAL	A	58 C3	33-56-56	118-15-17	121	11.7
292D	ENCINO RESERVOIR	S A	21 D3	34-08-56	118-30-57	1075	15.9
293B	LAKE LOS ANGELES	SP	2 A4	34-17-18	118-28-54	1150	14.1
294B	SIERRA MADRE-MIRA MONTE P.P.	SP	28 C1	34-10-11	118-02-51	985	22.9
298C	GORMAN - SHERIFF	A	(141)	34-47-47	118-51-27	3835	11.0*
299F	LITTLE ROCK - SCHWAB	S	184 F5	34-32-12	117-58-43	2800	6.5
303F	PASADENA - CALTECH	A	27 C5	34-08-14	118-07-25	800	18.4
306H	ZUMA BEACH	S	111 F6	34-01-15	118-49-42	15	10.6
321	PINE CANYON PATROL STATION	A	157 D7	34-40-24	118-25-45	3286	21.5*
322	MUNZ VALLEY RANCH	S	158 A2	34-42-50	118-21-15	2600	11.1
334B	COGSWELL DAM	S A	N D4	34-14-37	117-57-35	2300	26.9
336	SILVER LAKE RESERVOIR	SP	35 B3	34-06-08	118-15-54	445	12.4
338C	MT. WILSON-OBSERVATORY	SP	20A C1	34-14-07	118-04-28	5709	35.8
341	ALISO CANYON-BLUM RANCH	S	189 J4	34-27-33	118-09-20	2900	10.5*
342C	UPLAND-EUCLID PUMP PLANT	AP	96 E6	34-07-33	117-40-52	1610	17.7
352B	LECHUZA PATROL STATION	AP S	105 B6	34-04-38	118-52-47	1620	15.4
355B	LOS ANGELES CITY COLLEGE	AP S	34 F4	34-05-14	118-17-28	310	13.0
356C	SPADRA-LANTERMAN HOSPITAL	S A	93 F4	34-02-31	117-48-35	690	14.0
372	SAN FRANCISQUITO P. H. NO.2	SP A	(179)	34-32-02	118-31-27	1580	20.1
373C	BRIGGS TERRACE	S A	11 F5	34-14-17	118-13-27	2200	23.2
377F	LAKE SHERWOOD ESTATES	SP AP	102A C4	34-08-26	118-52-31	960	16.8
379B	SAN GABRIEL-EAST FORK	A	P C4	34-14-09	117-48-18	1600	24.0*
387B	COVINA CITY YARD	SP	88 E5	34-05-02	117-53-57	508	14.8
388D	PARAMOUNT-COUNTY FIRE DEPT.	8.81	65 E3	33-53-50	118-10-02	80	11.3*
390B	MORRIS DAM	SP	P A6	34-10-53	117-52-43	1210	20.3
391C	MONTEBELLO-FIRE DEPARTMENT	8.81	54 E1	34-01-08	118-06-15	250	10.1
394	HIGHLAND PARK	S	36 D1	34-07-06	118-10-39	620	17.0
395B	OLIVE VIEW SANITARIUM	A	2 D1	34-19-29	118-26-55	1425	15.1
402F	CEDAR SPRINGS	A	(199)	34-21-21	117-52-34	6780	26.9*
405B	SOLEDAD CANYON	S	188 F6	34-26-23	118-17-33	2150	14.8
406C	WEST AZUSA	S	88 C2	34-06-53	117-54-56	505	17.2
409B	PYRAMID RESERVOIR	SP AP	(154)	34-40-34	118-46-47	2505	14.8
415	SIGNAL HILL-CITY HALL	S A	75 E2	33-47-49	118-10-03	140	10.6
423C	ANGELES FOREST-ALISO CYN	A	(190A)	34-24-57	118-05-26	3920	19.6*
425B	SAN GABRIEL DAM	S A	P A5	34-12-19	117-51-38	1481	22.0
434	AGOURA	A	100A A5	34-08-08	118-45-08	800	17.0*
435	MONTE NIDO	A	108 A6	34-04-41	118-41-35	600	17.2*
436C	HANSEN DAM	AP	9 C2	34-16-08	118-23-59	1110	13.4
442C	MESCAL CREEK	S	(194)	34-29-05	117-44-10	3570	6.6

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443B	LATIGO CANYON-BEACH RANCH	S	106 B4	34-05-35	118-48-52	1700	19.2
446	ALISO CANYON-OAT MOUNTAIN	A	1 A2	34-18-53	118-33-25	2367	14.2*
447C	CARBON CANYON	S	114 E4	34-02-18	118-38-56	50	11.0
449B	EATON WASH DAM	S A	27 E1	34-10-06	118-05-33	880	18.4
453D	DEVILS GATE DAM	A	19 D6	34-10-53	118-10-27	980	14.2
455B	LANCASTER-HWY MAINTENANCE	S	160 B6	34-40-57	118-08-02	2395	8.7
462B	HILLCREST COUNTRY CLUB	S	42 B3	34-02-54	118-24-06	185	10.9
465C	SEPULVEDA DAM	AP	22 B1	34-10-06	118-28-11	683	13.3
478	VALYERMO-U.S.F.S.	SP	192 H5	34-26-44	117-51-10	3710	9.5
480B	TEMPLE CITY FIRE STATION	S	38 C2	34-06-31	118-03-25	404	12.4
482	LOS ANGELES-U.S.C.	S	43 F6	34-01-14	118-17-15	208	11.5
488B	KAGEL CANYON PATROL STATION	S	3 E4	34-17-45	118-22-30	1450	14.6
491D	PACIFIC PALISADES	S	40 C4	34-02-22	118-31-43	293	10.1
492A	CHILAO-HWY MAINTENANCE STA.	A	N C1	34-19-05	118-00-30	5275	18.5*
493D	SAND CANYON-MACMILLAN RANCH	A	128 D3	34-23-17	118-24-50	1605	17.2*
497	CLAREMONT-SLAUGHTER	8.81	91 A1	34-07-35	117-43-55	1350	18.5
517B	LEWIS RANCH	A	(192A)	34-25-12	117-53-11	4615	13.0*
542	FAIRMONT	SP	(145)	34-42-15	118-25-40	3050	14.4
560A	LA VERNE HEIGHTS	S	90 E2	34-06-48	117-45-02	1210	18.1
564C	LLANO	S	185 J9	34-29-13	117-50-02	3390	6.6
591B	SANTA ANITA RESERVOIR	SP	20 E5	34-11-08	118-06-16	1205	17.6
598C	NEENACH-ERSTAD	S	(143)	34-46-28	118-35-55	3062	9.5
598D	NEENACH-CHECK 43-D.W.R.	SP	(143)	34-47-40	118-37-15	2965	10.6
610B	PASADENA-CITY HALL	SP	27 A4	34-08-54	118-08-36	864	18.7
612B	PASADENA-CHLORINE PLANT	SP	19 E3	34-12-04	118-09-49	1160	20.9
613C	PASADENA FIRE STATION	SP	27 B5	34-07-15	118-08-05	779	17.6
619	SAN ANTONIO CYN-SIERRA P. H.	A	P F5	34-12-29	117-40-26	3110	30.0
627	SAN GABRIEL CANYON-P. H.	SP A	86 D3	34-09-20	117-54-28	744	21.1
634C	SANTA MONICA	S	49 A1	34-00-43	118-29-27	94	9.0
662D	LONG BEACH AIRPORT	SP	71 A6	33-49-	118-09-	34	10.1
680B	WESTWOOD (U.C.L.A.)	SP	41 E1	34-04-10	118-26-30	430	12.3
683B	SUNSET RIDGE	S A	19 E4	34-12-53	118-08-47	2110	21.5
694G	BIG TUJUNGA CANYON-CAMP 15	A	M D6	34-17-22	118-17-17	1525	17.6
695B	TUJUNGA CANYON-VOGEL FLAT	S	M B2	34-17-12	118-13-32	1850	25.8
716	LOS ANGELES-DUCOMMUN ST.	SP A AP	44 E3	34-03-09	118-14-13	306	12.6
722C	BELLEVIEW	S	171 B3	34-37-23	118-13-55	2880	13.0*
726C	ANGELES CREST GUARD STATION	S	M D4	34-14-01	118-11-04	2300	26.6
734C	L. A. INTERNATIONAL AIRPORT	SP AP	56 C3	33-56-25	118-23-44	105	8.3
735H	BELL CANYON	A	5 D4	34-11-40	118-39-23	895	13.9
740B	SAN DIMAS CANYON-FERN NO.2	AP	P F6	34-11-48	117-41-45	5200	28.8
741	SAN DIMAS CYN	AP	P E6	34-11-41	117-44-26	2675	24.6
742C	SAN GABRIEL FIRE DEPARTMENT	SP	37 E3	34-06-11	118-05-56	445	15.3
747	SANDBERG-AIRWAYS STATION	SP AP	(142)	34-44-47	118-43-29	4517	14.4
749B	BURBANK VALLEY PUMP PLANT	SP AP	17 A5	34-11-11	118-20-54	655	12.5

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750B	PALMDALE REGIONAL AIRPORT	S	172 F6	34-37-20	118-05-00	2528	7.1
771B	PACIFIC PALISADES-RIVIERA	S	40 F3	34-03-03	118-29-58	315	11.2
794	LOWER FRANKLIN RESERVOIR	SP	33 B4	34-05-43	118-24-40	585	11.2
795	PASADENA	SP	27 F4	34-08-52	118-05-14	***	17.1
797	DE SOTO RESERVOIR	SP	6 D1	34-16-17	118-35-12	1127	12.9
801B	MAGIC MOUNTAIN	AP	(195)	34-23-18	118-19-27	4720	20.0
802C	EAGLE ROCK RESERVOIR	SP	26 C4	34-08-47	118-11-20	970	16.4
807	ASCOT RESERVOIR	SP AP	36 C5	34-04-46	118-11-14	620	14.2
1005B	MINT CANYON FIRE STATION	S	(180)	34-30-35	118-21-40	2300	12.8
1006	SAN PEDRO-CITY RESERVOIR	SP A	78 F2	33-44-37	118-17-47	150	9.5
1008	LA FRESA-S.C.E.CO.	S	63 C6	33-52-07	118-19-55	65	11.0
1011B	PALOS VERDES FIRE STATION	S	78 A1	33-45-25	118-21-11	1275	9.7
1012B	CASTAIC JUNCTION	S A	123 E6	34-26-18	118-36-43	1005	12.9
1017B	LITTLE ROCK CREEK ABOVE DAM	A	(191)	34-28-41	118-01-24	3280	9.5
1020B	PADUA HILLS PATROL STATION	S	96 D4	34-08-52	117-41-55	1800	22.7
1025	MALIBU BEACH-DUNNE	S	113 E5	34-02-00	118-42-42	160	10.0
1029C	TUJUNGA-MILL CREEK SUMMIT	AP S	(197)	34-23-22	118-04-49	4990	17.4
1037	ARCADIA-ARBORETUM	S	28 C4	34-08-48	118-02-59	565	18.1
1040	POTRERO CYN-SUNRAY OIL CO.	S	126 C2	34-23-50	118-38-18	1150	12.2
1041B	SANTA FE DAM	AP	39 D1	34-07-04	117-58-24	427	16.9
1046B	SANTA ANITA CYN-CHANTRY FLAT	S	20A F1	34-11-46	118-01-20	2175	26.7
1050F	OLD TOPANGA CANYON	S	108 F3	34-06-24	118-37-43	1000	21.2
1051B	CANOGA PARK-PIERCE COLLEGE	SP	12 E5	34-10-51	118-34-23	800	13.9
1052	CAMP JOSEPHO	S	30 D5	34-04-51	118-31-10	660	15.2
1058B	PALMDALE	SP AP	172 E7	34-35-17	118-05-31	2595	7.0
1060B	LITTLE ROCK-SYCAMORE CAMP	A	(191)	34-25-02	117-58-13	4000	12.6*
1062	BUCKHORN FLAT	A	(199)	34-20-44	117-55-08	6760	27.0*
1063	SOLEDAD PASS	S	183 E9	34-29-35	118-05-28	3520	10.3
1068	RATTLESNAKE CANYON	S	105 C5	34-05-00	118-51-55	1290	16.5
1070	MANHATTAN BEACH	S	62 D4	33-53-00	118-23-19	182	8.6
1071B	DESCANSO GARDENS	S	19 B2	34-12-07	118-12-46	1325	16.8
1072B	LITTLE TUJUNGA RANGER STA.	SP A	3 F5	34-17-37	118-21-38	1275	15.6
1074	LITTLE GLEASON	A	(197)	34-22-43	118-08-57	5600	20.0*
1075	UPPER WOLFSKILL	AP	96 B2	34-10-13	117-43-16	3625	24.4
1076B	MONTE CRISTO RANGER STATION	SP	M E1	34-19-42	118-07-20	3360	20.0
1077B	MONROVIA-FIVE POINTS	S	29 B1	34-09-58	117-59-37	962	22.1
1081B	GLENDALE-GREGG	SP	18 D4	34-11-45	118-14-30	1350	19.1
1087	GREEN-VERDUGO PUMPING PLANT	S	10 B3	34-15-25	118-20-11	1340	13.9
1088B	LA HABRA HEIGHTS	S A	84 E2	33-56-55	117-57-51	445	14.6
1090	LOS ALAMITOS	SP	81 B6	33-48-35	118-04-35	25	8.3
1092B	BUENA PARK	3*P	OC10 C1	33-51-28	117-59-29	80	11.6*
1093	FULLERTON AIRPORT	SP,AP	83 D5	33-52-23	117-58-24	100	10.8*
1095	ORANGE COUNTY RESERVOIR	SP AP	OC 2 F4	33-56-07	117-52-58	660	12.9
1104	BOUQUET CANYON AT TEXAS CYN	S	(180)	34-30-35	118-27-00	1760	13.9*

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STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
1107D	LA TUNA DEBRIS BASIN	A	10 C5	34-14-13	118-19-37	1160	13.6
1111C	DEVILS PUNCHBOWL	S	(192A)	34-24-48	117-51-25	4760	14.9
1113	DOMINGUEZ WATER CO.	A	69 F4	33-49-54	118-13-30	30	10.5
1114B	WHITTIER NARROWS DAM	AP	47 A6	34-01-29	118-05-02	239	13.1
1115	SAN ANTONIO DAM	AP SP	96 F3	34-09-24	117-40-20	2120	24.5
1126A	LOS ANGELES-EAST VALLEY	8.81	16 B3	34-12-30	118-24-35	780	12.0
1127	WEST BURBANK	S	17 B6	34-10-47	118-20-07	615	13.0*
1128	WRIGHTWOOD FIRE DEPARTMENT	SP	S.B.CO.	34-21-34	117-37-57	5960	16.1
1129B	NICHOLAS CANYON	S	110 D3	34-02-52	118-54-57	340	11.9
1132	OAK FLAT GUARD STATION	S	(166)	34-35-56	118-43-15	2800	21.7
1135B	LUNADA BAY	SP	72 A4	33-46-37	118-25-01	250	10.0*
1140	ROSEMEAD	8.81	38 B5	34-04-53	118-03-55	305	12.8
1147	EL CABALLERO COUNTRY CLUB	S	21 C4	34-08-52	118-31-53	1000	14.7
1152	CLEAR CREEK RANGER STATION	S	H D3	34-16-15	118-09-11	3625	27.4
1157	CAL STATE UNIV. NORTHRIDGE	SP AP	7 C5	34-14-17	118-31-48	890	12.0*
1158	TORRANCE MUNICIPAL AIRPORT	S	73 B2	33-47-59	118-20-08	102	11.6
1166B	MILE HIGH RANCH	S	(193)	34-24-40	117-46-15	5280	12.1
1167	FENNER CANYON	S	(200)	34-23-25	117-46-27	5380	21.0*
1169B	PIRU-TEMESCAL GUARD STATION	SP	V.CO.	34-28-22	118-45-21	1150	18.2*
1170B	THOUSAND OAKS WEATHER STA.	AP	V.CO.	34-10-44	118-51-01	805	14.6
1171B	CAMULOS RANCH	SP AP	V.CO.	34-24-22	118-45-21	725	17.6
1172B	PIRU CANYON ABOVE PIRU LAKE	AP	(177)	34-30-48	118-45-24	1120	18.3
1173B	TAPO CANYON	AP	V.CO.	34-19-54	118-42-39	1525	13.7
1177B	BARD RESERVOIR	AP	V.CO.	34-14-32	118-49-41	1010	13.8
1183B	LA HABRA FIRE STATION	3"P	84 F6	33-55-53	117-57-17	315	12.9*
1190	PACOIMA CYN-NORTH FORK	S	(195)	34-23-17	118-15-06	4180	20.2
1191	BEAR DIVIDE	S	128 F6	34-21-35	118-23-37	2700	18.4
1192	CARSON FIRE STATION	8.81	64 C6	33-52-04	118-15-45	92	9.2
1193	WESTLAKE VILLAGE	S	102 A5	34-08-19	118-49-05	885	15.7
1194	SANTA YNEZ RESERVOIR	S	109 F6	34-04-23	118-33-59	735	15.0*
1195	CHINO FIRE STATION NO. 2	SP	S.B.CO.	33-59-00	117-43-20	655	13.4
1196	MONTCLAIR FIRE DEPARTMENT	SP	95 E2	34-03-41	117-41-16	965	8.2
1197	CAJON WEST SUMMIT	SP	S.B.CO.	34-23-30	117-34-35	4838	9.8
1198	PHELAN FIRE CONTROL	SP	S.B.CO.	34-25-30	117-34-00	4160	9.0*
1211	HACIENDA GOLF CLUB	S	98A A1	33-57-40	117-56-57	750	15.0*
1212	LANCASTER FSS/FAA	SP	147 C9	34-44-00	118-13-00	2340	6.9
1216	RANCHO PALOS VERDES	S	77 C1	33-45-10	118-23-32	780	8.8
1217	LOS ANGELES COUNTRY CLUB	S	42 A1	34-04-10	118-25-17	380	11.7
1222	NORTHRIDGE-GARLAND	8.81	7 E3	34-14-17	118-30-59	911	12.9
1223	WOODLAND HILLS-SHERMAN	8.81	100 E1	34-10-06	118-38-57	1035	12.8
1238	ACTON-MEARNS	S	189 G2	34-27-05	118-12-50	2775	10.5*
1239	MALIBU-BIG ROCK MESA	A	115 A4	34-02-34	118-37-16	725	10.5
1240	PEARBLOSSOM-CALIF.D.W.R.	SP AP	185 B7	34-30-32	117-55-15	3050	6.2
1242	ROCKY BUTTES	A	(162)	34-39-00	117-51-48	2540	5.6*

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1243	REDMAN	A	(150)	34-45-52	117-55-30	2360	5.5*
1244	LANCASTER-ROPER	A	161 C6	34-40-27	118-00-37	2450	5.7*
1245	QUARTZ HILL-HALL	A	159 B7	34-40-28	118-14-40	2395	11.0*
1246	SCOTT RANCH	A	(145)	34-46-59	118-28-10	2710	11.5*
1247	NORTH LANCASTER	A	148 D6	34-45-41	118-07-30	2310	6.5*
1248	MESCAL-SMITH	A	(194)	34-28-03	117-42-40	3810	7.0*
1249	RELAY	A	(150)	34-45-43	117-47-55	3140	5.1*
1250	AVEK	A	185 B5	34-32-21	117-55-23	2825	6.3*
1251	PALOS VERDES-WHITES POINT	SP	78 D6	33-42-50	118-19-02	100	7.0
1252	PALOS VERDES LANDFILL	SP	73 A4	33-45-40	118-20-03	400	10.8
1253	CARSON-COUNTY SANITATION	SP	74 A2	33-48-07	118-16-58	40	10.7
1254	LONG BEACH RECLAMATION PLANT	SP	76 F1	33-48-11	118-05-20	20	10.4
1255	LOS COYOTES RECLAMATION	SP	66 E4	33-53-05	118-06-24	70	10.7
1256	SOUTH GATE TRANSFER STATION	SP	59 E3	33-56-40	118-09-56	100	9.2
1257	SAN JOSE CREEK RECLAMATION	SP	47 F4	34-01-55	118-01-16	275	14.0
1258	PUENTE HILLS LANDFILL	SP	47 E5	34-01-35	118-01-49	300	14.6
1259	WHITTIER NARROWS RECLAMATION	SP	47 B1	34-03-59	118-03-54	225	12.9
1260	SPADRA LANDFILL	SP	93 E4	34-02-36	117-49-50	700	15.9
1261	LA CANADA RECLAMATION PLANT	SP	19 D2	34-13-00	118-11-14	1800	20.9
1262	SAUGUS RECLAMATION PLANT	SP	124 B9	34-24-48	118-32-23	1150	14.8
1263	VALENCIA RECLAMATION PLANT	SP	123 D7	34-25-55	118-37-13	1000	12.9
1264	CALABASAS LANDFILL	SP	100A E3	34-08-25	118-42-35	800	14.1
1265	SCHOLL CANYON LANDFILL	SP	26 C4	34-08-38	118-11-07	1000	17.2
1266	MISSION CANYON LANDFILL	SP	22 B6	34-08-40	118-28-45	1150	12.8
1267	LANCASTER RECLAMATION PLANT	SP	147 H4	34-46-38	118-09-11	2302	6.1
1268	PALMDALE RECLAMATION PLANT	SP	172 G6	34-35-30	118-05-10	2565	5.6
1271	POMONA WASTE RECLAMATION	SP	94 B3	34-03-18	117-47-34	786	15.4

LEGEND:

- S — Standard 8 inch diameter non-recording gage owned by the Department of Public Works
- 8.81 — 8.81 inch diameter non-recording gage owned by the Department of Public Works
- A — Automatic recording gage owned by the Department of Public Works
- ST — Storage type gage owned by the Department of Public Works
- SP — Standard 8 inch diameter non-recording gage owned by outside interest
- AP — Automatic recording gage owned by outside interest
- ( ) — Thomas Guide future page
- O.CO. — Orange County Thomas Guide page
- V.CO. — Ventura County Thomas Guide page
- S.B.CO. — San Bernardeno County Thomas Guide page
- DSC. — Discontinued
- INC. — Incomplete records
- * — Estimated Seasonal Total
- N.R — No Record(Data Not Available)

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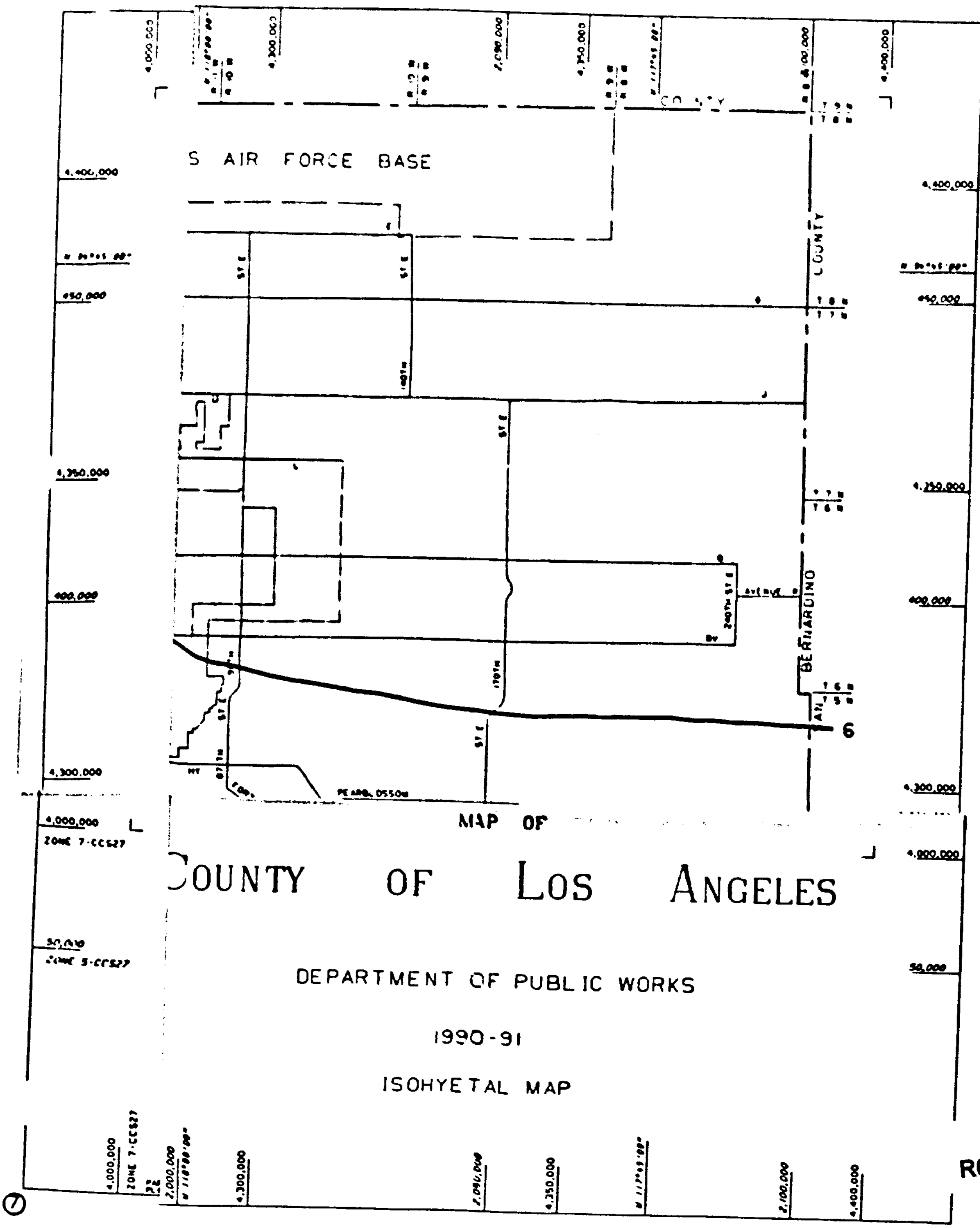

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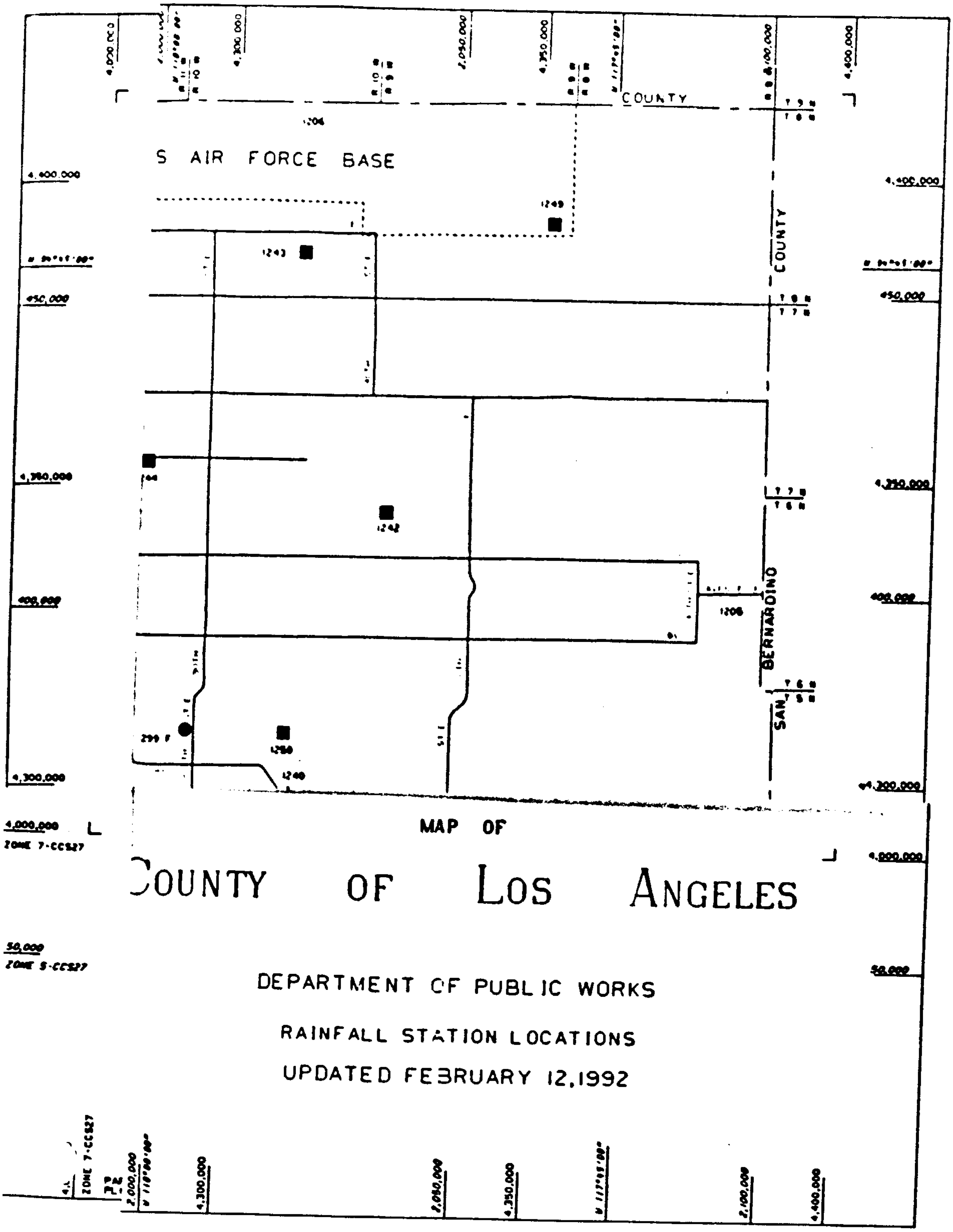

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PA1

EVAPORATION

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1 9895

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1996

EVAPORATION

Data for 14 active evaporation stations were reported to the Department during the 1990-91 water year. Daily records of active and inactive Department stations, as well as some stations of other agencies, are available in the Department's files. Monthly and seasonal evaporation has been published in the Department's Annual or Biennial Reports on Hydrologic Data since the 1931-32 season.

COOPERATION

The Department receives evaporation data from The Metropolitan Water District, Palmdale Water District, California Department of Water Resources, and Descanso Gardens.

LENGTH OF RECORD

The first land pan installed by this Department was at Santa Anita Dam in March 1929. There are 30 evaporation stations which have records of 15 seasons or more in the Department's files.

EVAPORATION STATION LIST 1990 - 91

STA. NO.	STATION NAME	EQUIPMENT	ELEVATION OF PAN	THOMAS GUIDE	NORTH LATITUDE	WEST LONGITUDE
33 A	Pacoima Dam	24X36 S	1500 ft.	145 F9	34-19-48	118-23-59
46 D	Big Tujunga Dam	24X36 S	2315 ft.	F C2	34-17-40	118-11-14
63 C3	Santa Anita Dam	24X36 S	1400 ft.	99 F2	34-11-03	118-01-12
89 B	San Dimas Dam	24X36 S	1350 ft.	95A C3	34-09-10	117-46-17
96 C	Puddingstone Dam	24X36 S	1030 ft.	89 F4	34-05-31	117-48-24
223 B	Big Dalton Dam	24X36 S	1587 ft.	87 F1	34-10-06	117-48-36
252 C	Castaic Reservoir	48X10 S	1150 ft.	(178)	34-29-53	118-36-53
334 B	Cogswell Dam	24X36 S	2300 ft.	G D4	34-14-37	117-57-35
390 B	Morris Dam	72X36 US	1210 ft.	86 F1	34-10-53	117-52-43
409 B	Pyramid Reservoir	48X10 S	2505 ft.	(154)	34-40-34	118-46-47
425 B	San Gabriel Dam	24X36 S	1481 ft.	H A5	34-12-19	117-51-38
1014 F	Rio Hondo S. G.	24X36 S	170 ft.	54 D3	33-59-57	118-06-04
1058 B	Palmdale	24X36 S	2595 ft.	172 F7	34-35-17	118-05-31
1071 B	Descanso Gardens	24X36 S	1325 ft.	19 B3	34-12-07	118-12-46

LEGEND

24X36 S = Screened land pan, 24 inches in diameter by 36 inches deep.
48X10 S = Screened land pan, 48 inches in diameter by 10 inches deep.
72X36 US = Unscreened land pan, 72 inches in diameter by 36 inches deep.
( ) = Thomas Guide future page assignment.

MONTHLY EVAPORATION SUMMARY FOR WATER YEAR 1990-91 (inches)

STA. NO		STATION NAME	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
33	A	Pacoima Dam	10.21	8.84	7.10	5.56	6.84	4.50	7.13	6.67	5.49	6.83	7.96	8.16	85.29
46	D	Big Tujunga Dam	9.65	7.34	4.58	4.11	5.70	4.25	6.59	8.64	9.83	10.79	9.69	9.33	90.50
63	D	Santa Anita Dam	6.01	5.42	4.49	2.93	3.59	2.42	3.90	4.58	4.21	5.45	5.85	6.03	54.88
89	B	San Dimas Dam	4.41	3.25	2.08	1.95	2.38	3.00	4.20	5.45	5.39	6.59	6.54	5.33	50.57
96	C	Puddingstone Dam	6.44	4.82	3.75	2.54	3.53	3.24	5.89	7.30	7.41	8.91	9.00	7.51	70.34
223	B	Big Dalton Dam	5.32	3.23	2.06	1.58	2.48	2.34	4.37	5.45	5.04	6.58	7.01	5.84	51.30
252	C	Castaic Reservoir	7.14	5.70	3.42	3.00	4.50	8.92	4.12	5.65	6.41	7.28	8.00	7.94	72.08
334	B	Cogswell Dam	4.73	3.18	1.76	1.53	2.18	2.16	4.10	5.88	6.77	8.15	7.75	6.28	54.47
390	B	Morris Dam	8.22	7.45	4.42	5.32	5.21	3.43	7.08	7.82	7.80	9.58	9.67	8.40	84.40
409	B	Pyramid Reservoir	7.92	4.69	3.58	2.35	1.93	6.68	4.36	6.45	8.22	9.24	10.13	7.28	72.83
425	B	San Gabriel Dam	7.92	5.88	4.31	3.72	4.79	3.59	6.44	7.22	6.86	8.08	9.05	8.16	76.02
1014	F	Rio Hondo S.G.	4.84	3.63	3.24	2.06	3.08	3.46	5.01	6.04	7.27	6.28	6.21	5.30	56.42
1058	B	Palmdale	4.38	3.19	1.11	1.52	3.81	3.25	5.95	7.70	10.18	10.46	8.24	6.51	66.30
1071	B	Descanso Gardens	4.37	3.30	1.77	2.10	2.29	2.38	4.03	5.26	5.00	5.81	5.50	4.67	46.48

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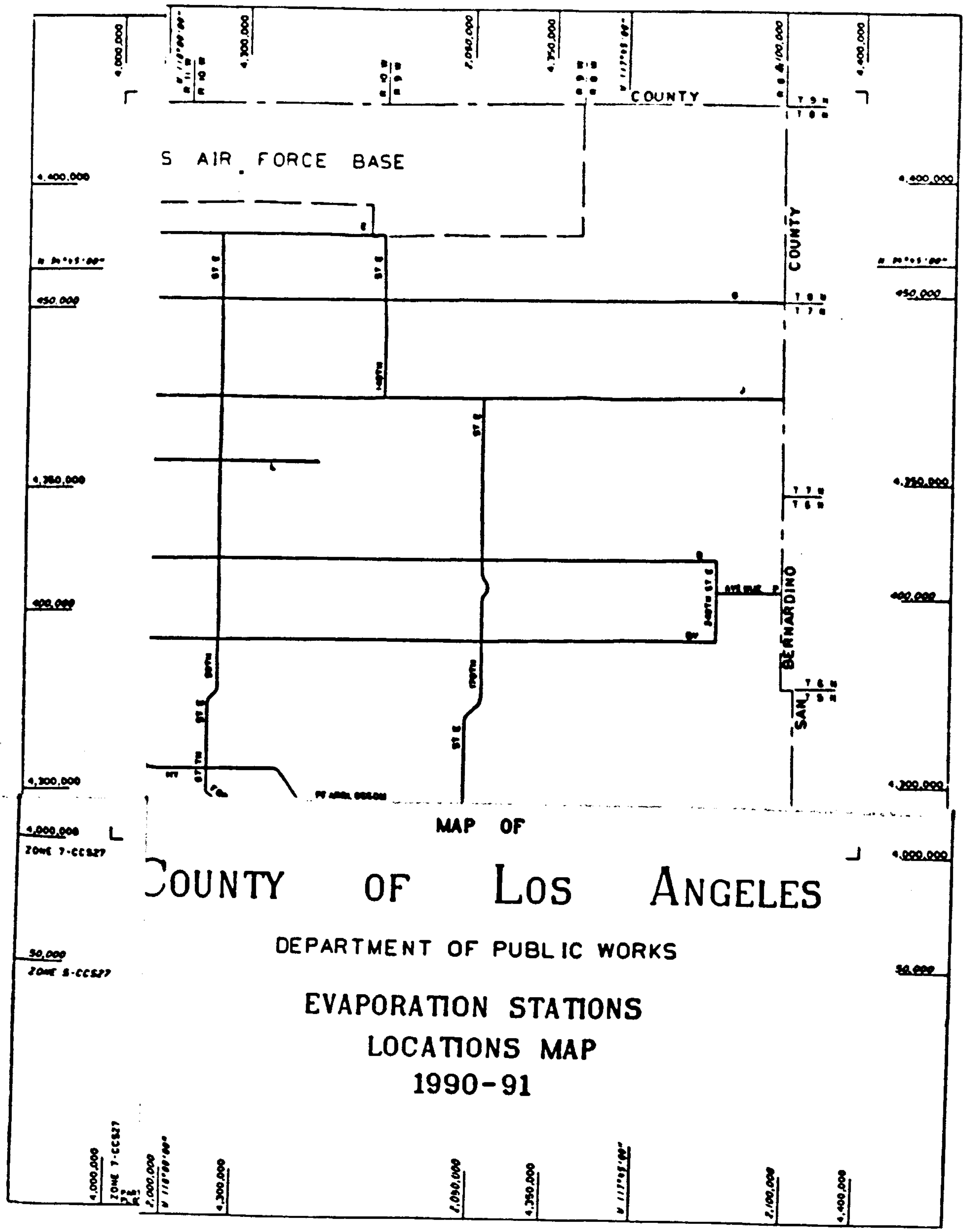

PB1

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RUNOFF

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1990

RUNOFF

The Department operated or received data from 81 water-stage recording stations during the 1990-91 water year. Data from 48 of those stations are summarized and published in this volume.

RECORDS OF STREAMFLOW

Records published give the following information:

1. Station description which presents location, drainage area, type of channel, control, regulations, diversions, and available records.

2. Discharge tabulation which summarizes the maximum, minimum, and mean of the daily flow rates in second-feet for each month and the total monthly volumes in acre-feet.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorological conditions at 27 locations in the County. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels.

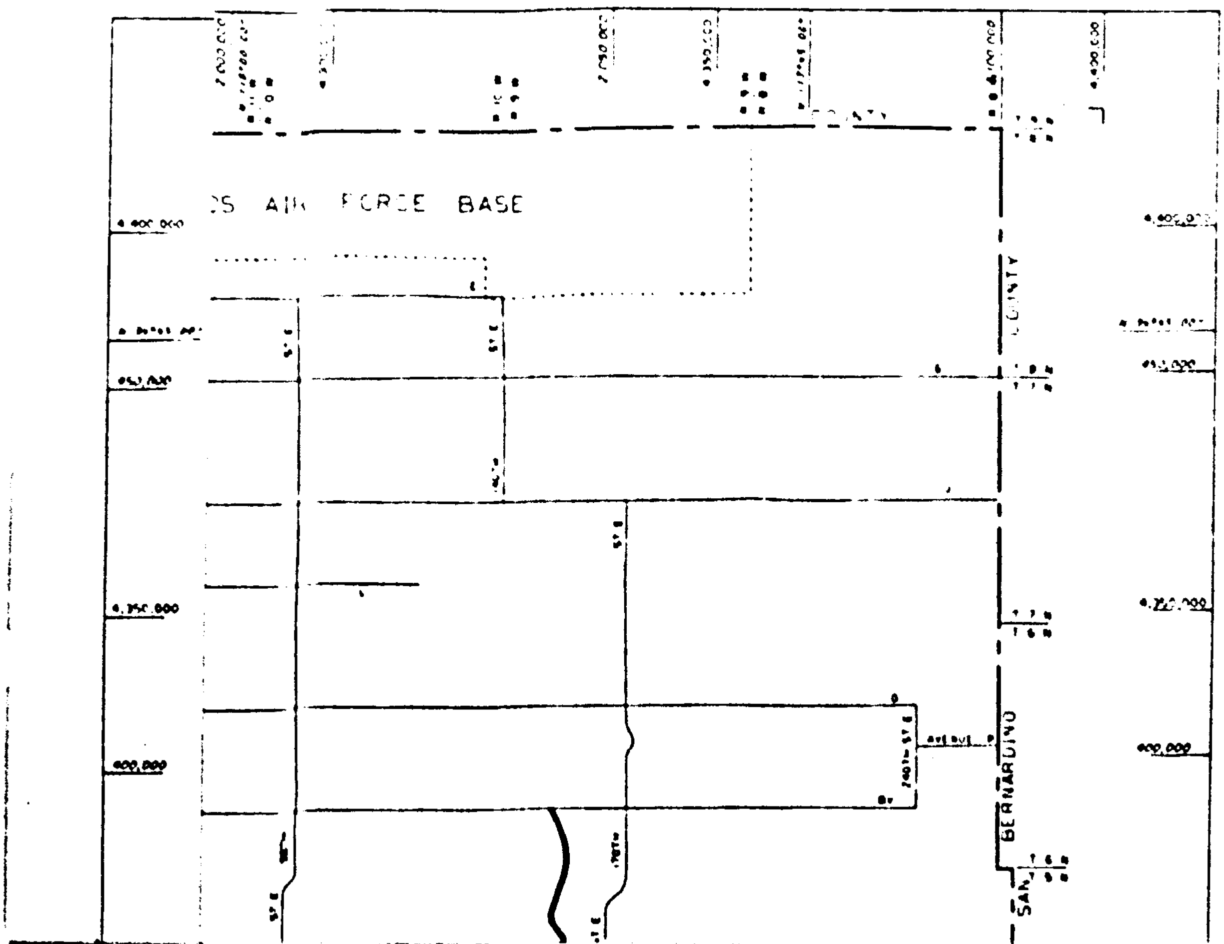
During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The Department receives streamflow data from other agencies, or has access to the records for local stations. Data from 7 of the Department's stations are published in the United States Geological Survey's annual water supply papers.

Agencies with which the Department exchanges data are:

United States Geological Survey, Water Resource Division
United States Corps of Engineers
State Department of Water Resources
The Metropolitan Water District
San Gabriel River Water Committee



MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

STREAMFLOW GAGING STATION LOCATIONS

UPDATED MARCH 18.1992

PC1

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INDEX OF STREAM GAGING STATIONS

STATION	NAME	THOMAS GUIDE PG.	ALERT NO.	REGU-LATED	DRAINAGE AREA *
L1-R	LITTLE ROCK CREEK ABOVE LITTLE ROCK DAM	J		NO	49.20
F2B-R	BROWNS CREEK AT VARIEL AVENUE	6 / D - 2		NO	13.50
F3-R	SAN GABRIEL RIVER - WEST FORKS ABOVE FORKS	P / A - 4		YES	102.00
F4B-R	SAN GABRIEL - EAST FORK	P / D - 4		NO	88.20
U5-R	SAWPIT CREEK BELOW MONROVIA CREEK	29 / C - 1		YES	5.30
U7-R	FISH CREEK ABOVE MOUTH OF CANYON	86 / B - 2		NO	6.36
U8-R	SAN GABRIEL RIVER BELOW MORRIS DAM	86 / F - 1	415	YES	212.40
U14-R	BIG ROCK CREEK ABOVE MOUTH OF CANYON	J		NO	23.00
AAN(015)	VALYERMO S. G. BIG ROCK CK. D/S VALYERMO RD.	192 / H - 5			
F32B-R	THOMPSON CREEK BELOW THOMPSON CREEK DAM	96 / C - 5	433	YES	3.70
F34D-R	LOS ANGELES RIVER BELOW FIRESTONE BLVD.	59 / E - 3	315	YES	596.00
F37B-R	COMPTON CREEK NEAR GREENLEAF DRIVE	64 / F - 4		NO	22.60
F38C-R	BALLONA CREEK ABOVE SAWTELLE BLVD.	50 / B - 3	369	YES	88.60
F40-R	PUDDINGSTONE CREEK BELOW PUDDINGSTONE DAM	89 / F - 4	427	YES	33.20
F42B-R	SAN GABRIEL RIVER ABOVE SPRING STREET	76 / F - 1	435	YES	231.00
F45B-R	RIO HONDO ABOVE STEWART AND GRAY ROAD	59 / E - 3	307	YES	140.00
F53-R	DUME CREEK AT PACIFIC COAST HIGHWAY	110 / B - 4		NO	8.80
F54B-R	TOPANGA CREEK ABOVE MOUTH OF CANYON	109 / C - 4		NO	18.00
F64-R	RIO HONDO ABOVE MISSION BRIDGE	47 / B - 5		YES	115.00
F81D-R	ALHAMBRA WASH NEAR KLINGERMAN STREET	46 / F - 2	347	NO	15.20
F82C-R	RUBIO WASH AT GLENDON WAY	38 / A - 6	353	YES	10.90
F92C-R	SANTA CLARA RIVER AT OLD ROAD BRIDGE	123 / G - 7		YES	410.40
F93B-R	SANTA CLARA RIVER AT LANG RAILROAD BRIDGE	125 / J - 7		NO	157.30
F118B-R	PACOIMA CREEK FLUME BELOW PACOIMA DAM	3 / C - 1	330	YES	28.20
F119C-R	SANTA ANITA CREEK BELOW SANTA ANITA DAM	20A / F - 2	345	YES	10.80
F120B-R	BIG DALTON CREEK BELOW BIG DALTON DAM	87 / F - 2	418	YES	4.80
F122-R	PALLETT CREEK AT VALYERMO HIGHWAY	199 / G - 4		NO	15.80
F125-R	SANTIAGO CREEK ABOVE LITTLE ROCK CREEK	J		NO	11.20
F130B-R	MALIBU CREEK BELOW COLD CREEK	107 / F - 6		YES	104.96
F168-R	BIG TUJUNGA CREEK BELOW BIG TUJUNGA DAM	M / C - 2	333	YES	82.30
F181-R	MONTEBELLO STORM DRAIN OUTLET TO RIO HONDO	54 / E - 3		NO	9.60
F190-R	SAN GABRIEL RIVER AT FOOTHILL BLVD.	86 / A - 5		YES	230.00
F192B-R	RIO HONDO BELOW LOWER AZUSA ROAD	38 / E - 4		YES	40.90
F193B-R	SANTA ANITA WASH AT LONGDEN AVENUE	38 / F - 1		YES	18.80
F194B-R	SAWPIT WASH BELOW LIVE OAK AVENUE	39 / A - 2		YES	16.10
F202-R	BIG DALTON CREEK AT SIERRA MADRE AVENUE	87 / D - 4		YES	11.00
F209-R	SAN GABRIEL RIVER - W. FORK BELOW COGSWELL DAM	N / D - 4	410	YES	41.00
F218-R	SAN DIMAS WASH BELOW PUDD. DIVERSION DAM	95A / C - 5	424	YES	19.90
F220B-R	SAN GABRIEL - AZUSA CONDUIT 10FT WEIR BELOW DAM	P / A - 5		YES	0.00
F250-R	SAN GABRIEL - AZUSA CONDUIT 25FT WEIR BELOW DAM	P / A - 5		YES	202.70
F251-R	SAN GABRIEL W. FORK AT TOE OF COGSWELL DAM	N / D - 4		YES	39.20
F252-R	VERDUGO WASH AT ESTELLE AVENUE	25 / B - 3		YES	26.80
F260C-R	SANTA ANITA WASH BELOW FOOTHILL BLVD.	28 / E - 3		YES	17.20
F261C-R	SAN GABRIEL RIVER BELOW VALLEY BLVD.	48 / A - 2	351	YES	118.00
F262B-R	SAN GABRIEL RIVER ABOVE FLORENCE AVENUE	60 / E - 4		YES	215.80
F263C-R	SAN GABRIEL RIVER BELOW S. G. RIVER PKWY	55 / C - 1		YES	206.30
F267B-R	SIERRA MADRE WASH AT HIGHLAND OAKS AVENUE	28 / E - 3		YES	3.80
F271-R	EATON WASH BELOW EATON WASH DAM	27 / F - 1	342	YES	12.40
F274B-R	DALTON WASH AT MERCED AVENUE	48 / F - 1		YES	35.95
F276-R	THOMPSON CREEK S. G. INTAKE AT TSN CREEK	96 / C - 5		YES	3.70

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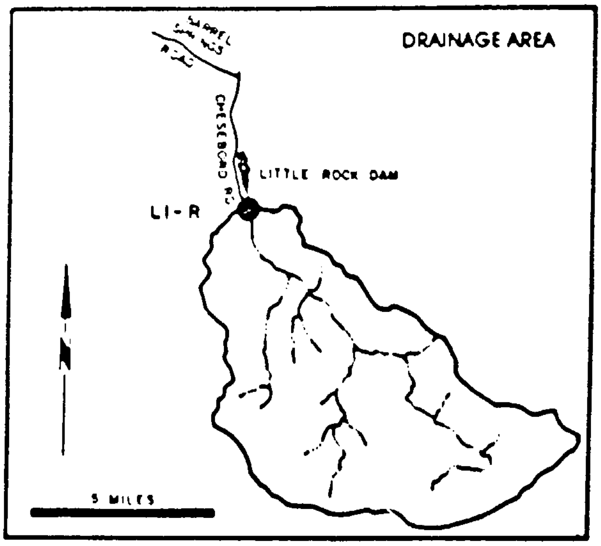
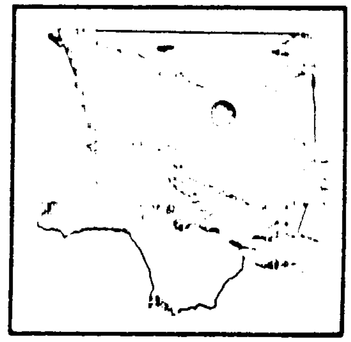
INDEX OF STREAM GAGING STATIONS

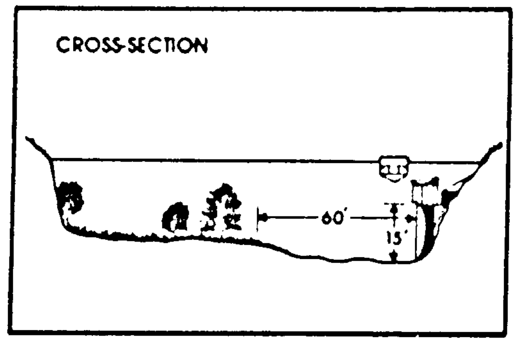
STATION	NAME	THOMAS GUIDE PG.	ALERT NO.	REGU-LATED	DRAINAGE AREA *
F277-R	ARROYO SECO BELOW DEVILS GATE DAM	19/D-5	336	YES	32.50
F278-R	SAWPIT CREEK BELOW SAWPIT DAM	29/C-1	339	YES	3.30
F279C-R	LOS CERRITOS CHANNEL AT STEARNS STREET	76/E-3		NO	25.60
F280-R	SANTA FE DIVERSION CHANNEL BELOW SANTA FE DAM	39/D-2		YES	CONTROLLED
F285-R	BURBANK WESTERN STORM DRAIN AT RIVERSIDE DR	24/E-2		YES	25.00
F299-R	LOS ANGELES RIVER AT RADFORD	23/C-4			
F300-R	LOS ANGELES RIVER AT TUJUNGA AVE.	23/D-4		YES	401.00
F301-R	SAWTELLE-WESTWOOD CHANNEL ABOVE CULVER BLVD	50/A-3		YES	22.96
F303-R	SAN DIMAS CREEK BELOW SAN DIMAS DAM	95A/C-3	421	YES	16.20
F304-R	WALNUT CREEK ABOVE PUENTE AVENUE	48/D-1		YES	57.60
F305-R	PACOIMA DIVERSION AT BRANFORD STREET	9/A-5		YES	48.80
F312-R	SAN JOSE CHANNEL ABOVE WORKMAN MILL ROAD	47/F-5	324	YES	83.40
F313B-R	RIO HONDO BYPASS CHANNEL ABOVE WHITTIER NAR.	47/B-5		YES	CONTROLLED
F317-R	ARCADIA WASH BELOW GRAND AVENUE	38/E-3	355	YES	8.50
F318-R	EATON WASH AT LOFTUS DRIVE	34/C-6		YES	22.80
F319-R	LOS ANGELES RIVER BELOW WARDLOW RIVER RD.	70/B-5	313	YES	815.00
F326-R	RIO HONDO BELOW GARVEY AVENUE	47/B-2		YES	91.20
F328-R	MINT CANYON CREEK AT FITCH AVENUE	125/C-5		NO	26.90
F329-R	BRADBURY CHANNEL BELOW CENTRAL AVENUE	29/F-5		YES	3.30
F338-R	RUBIO DIV. CHANNEL BEL. GOOSEBERRY CYN INLET	20/C-4		YES	2.10
F342-R	BRANFORD STREET CHANNEL BELOW SHARP AVE.	9/B-5		YES	5.01
F350-R	LIME KILN CREEK ABOVE ALISO CREEK	7/B-6		YES	10.30
F354-R	COYOTE CREEK BELOW SPRING STREET	76/F-1	437	YES	185.00
F356-R	LIVE OAK CREEK BELOW LIVE OAK DAM	95A/F-6	430	YES	2.28
F377-R	BOUQUET CANYON CREEK AT URBANDALE AVENUE	124/F-5		YES	51.90
F378D-R	DOMINGUEZ CHANNEL AT VERMONT AVENUE	63/F-5		NO	37.10
F393-R	LITTLE ROCK AT HIGHWAY 138	184/D-6		YES	70.00
F394-R	BIG ROCK CREEK UPSTREAM FROM PALLETT CREEK	192/J-4		NO	34.30
F395-R	MESCAL CREEK AT MOUTH	J		NO	5.71
G44B-R	SAN GABRIEL RIVER ABOVE WHITTIER NAR. DAM	47/C-6		NO	

* NOTE: All drainage areas in square miles.

LITTLE ROCK CREEK
above Little Rock Dam
STATION NO. L1-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 49.2 square miles.
LOCATION- 2.0 miles above Little Rock Dam, 5.0 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel, and boulders, natural in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1930 to date.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: L1-R   DRAINAGE AREA: 49.20 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.0	0.6	4.6	53.9	61.4	7.5	4.7	1.6	0.0	0.0
	MAX.	0.0	0.0	0.0	0.9	105.0	369.0	148.0	14.2	8.0	3.3	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.6	17.2	9.2	3.6	2.3	0.2	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	35.7	256.7	3315.0	3651.0	462.0	277.0	96.6	0.0	0.0

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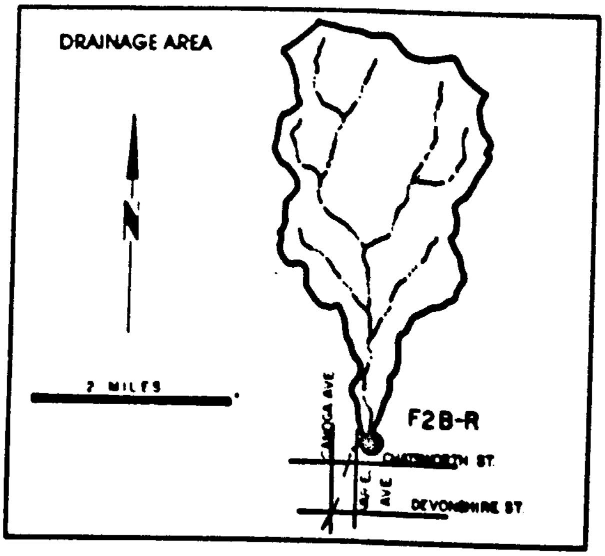
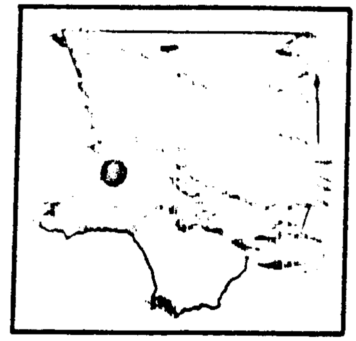
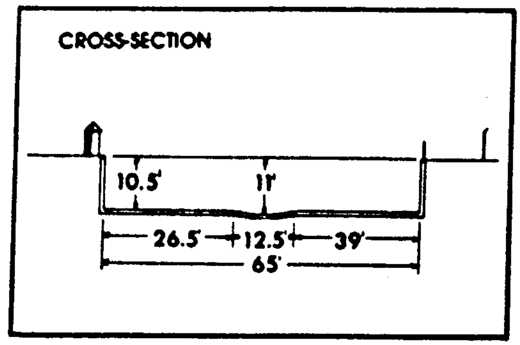
BROWNS CREEK
at Variel Avenue
STATION NO. F2B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 13.5 square miles.
LOCATION- 100.0 feet upstream from Variel Avenue, 1.0 mile northeast of Chatsworth.
REGULATION- none.
CHANNEL- sand and gravel with pipe and wire revetments, temporarily improved section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F2-R, December 11, 1928, to August 27, 1932 and October 2, 1935, to October 31, 1939. at Station F2B-R, October 12, 1961, to date.

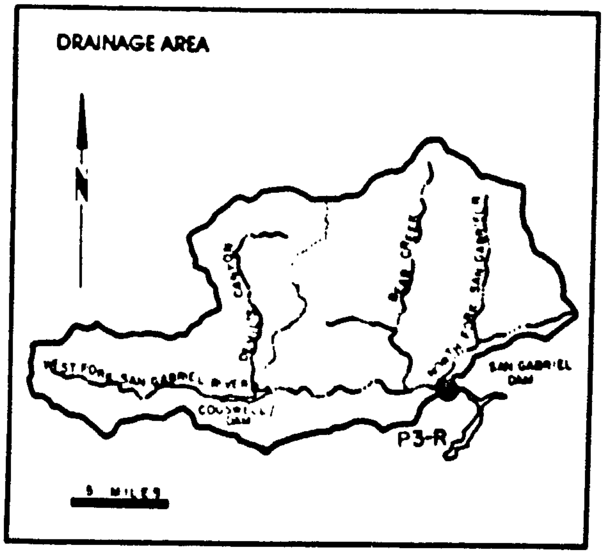
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

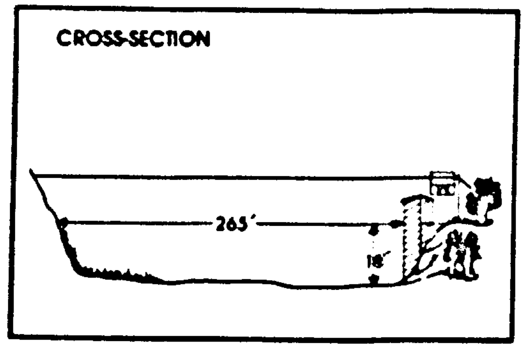
STATION NO.: F2B-R

DRAINAGE AREA: 13.50 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.0	0.2								
	MAX.	0.0	0.4	0.0	2.8			DEACTIVATED					
	MIN.	0.0	0.0	0.0	0.0								
	TOTAL AF	0.0	2.6	0.0	9.7								

SAN GABRIEL RIVER
West Fork above Forks
STATION NO. P3-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 102.0 square miles.
LOCATION- 1.5 miles above confluence with East Fork.
REGULATION- partially regulated by Cogswell Dam.
CHANNEL- natural, sand, gravel, and boulders.
CONTROL- subject to shifts in natural bottom.
LENGTH OF RECORD- at Station P3-R, December 3, 1930 to July 12, 1938 and September 27, 1938 to date. at Station P3B-R, July 12, 1938, to September 27, 1938.
REMARKS- for records prior to December 3, 1930 refer to Station P1-R.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: P3-R DRAINAGE AREA: 102.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	3.8	4.8	5.7									
YEAR	MAX.	4.3	7.6	8.8					DEACTIVATED				
90-91	MIN.	3.4	3.4	3.9									
	TOTAL AF	233.0	288.0	350.0									

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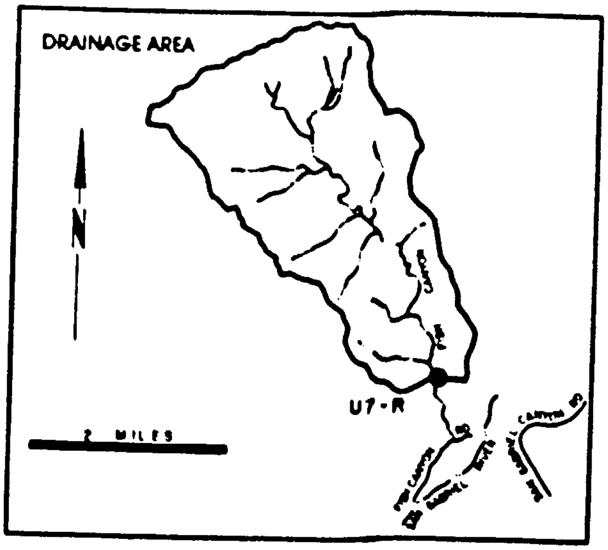
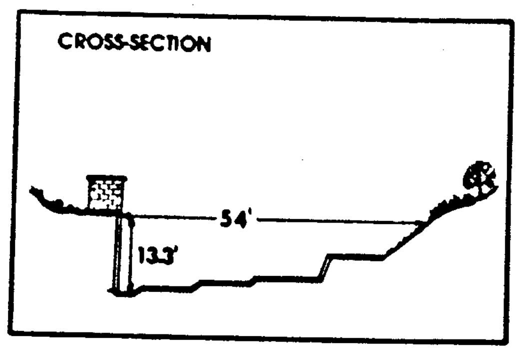
FISH CREEK
above Mouth of Canyon
STATION NO. U7-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 6.36 square miles.
LOCATION - 0.8 miles upstream of mouth of canyon and 3.0 miles northeast of Duarte.
REGULATION- none.
CHANNEL- natural, rock and gravel.
CONTROL- concrete control.
LENGTH OF RECORD- July to September 1916. July 1917 to date.
REMARKS- operated and maintained by USGS until October 1, 1971.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: U7-R

DRAINAGE AREA: 6.36 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.3	1.3	5.4	12.0	8.3	1.9	0.9	0.4	0.1	0.1
	MAX.	0.0	0.0	0.7	3.7	70.9	87.4	9.6	6.3	1.1	1.1	0.3	0.2
	MIN.	0.0	0.0	0.0	0.6	1.5	1.8	6.9	0.8	0.7	0.2	0.1	0.0
	TOTAL AF	0.0	0.0	15.7	81.1	298.0	739.0	492.0	117.0	55.3	26.0	9.1	5.0

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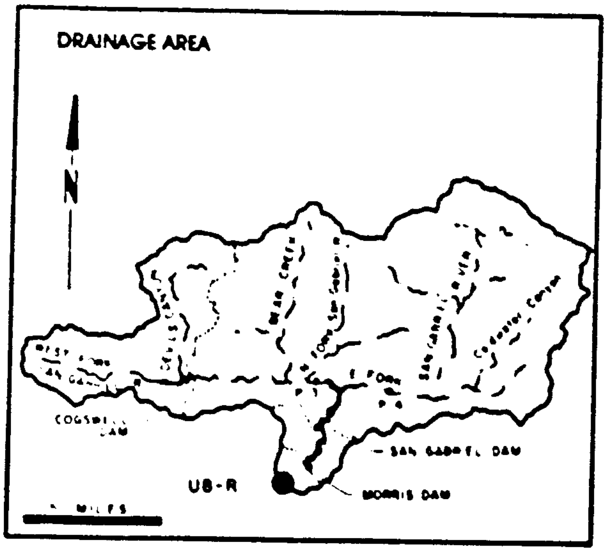
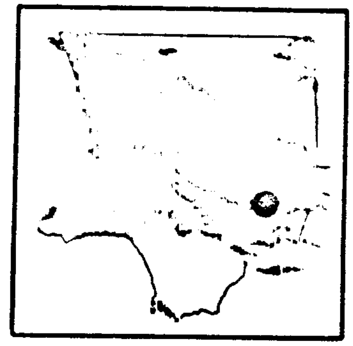
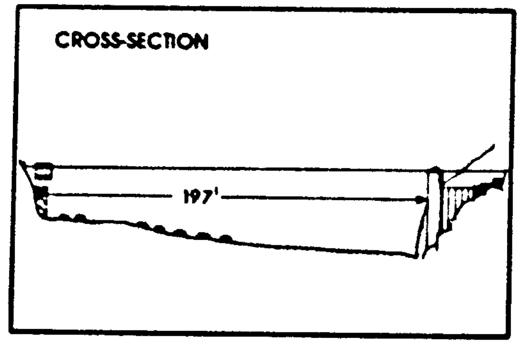
R0053212

SAN GABRIEL RIVER
below Morris Dam
STATION NO.U8-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 212.4 square miles.
LOCATION- 1.1 miles downstream of Morris Dam, 2.7 miles northeast of Azusa.
REGULATION- all flows regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- gravel and boulders, natural section.
CONTROL- concrete control.
LENGTH OF RECORD- May 1894 to date.
REMARKS- flows up to 90 cfs are at times diverted past the station through the Azusa Conduit; flows at station may include imported water from the MWD outlet below Morris Dam.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO. : U8-R　　　　DRAINAGE AREA : 212.40 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	112.6	0.0	0.0	55.8	0.2	187.0	65.9	5.3	34.9	186.0	423.0	258.0
	MAX.	149.0	0.0	0.0	149.0	6.0	206.0	202.0	43.9	292.0	785.0	679.0	327.0
	MIN.	0.1	0.0	0.0	0.0	0.0	71.2	1.6	2.1	0.6	0.1	227.0	134.0
	TOTAL AF	6926.0	0.0	0.0	3430.0	12.9	11485.0	3922.0	326.0	2079.0	11449.0	26011.0	15358.0

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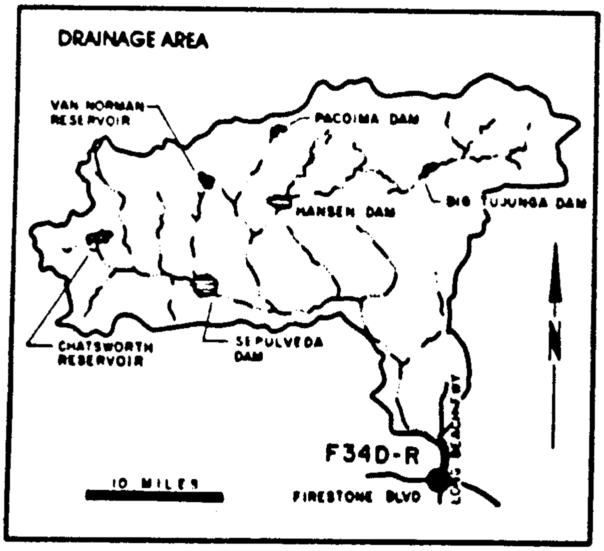
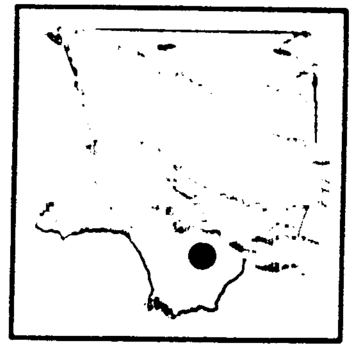
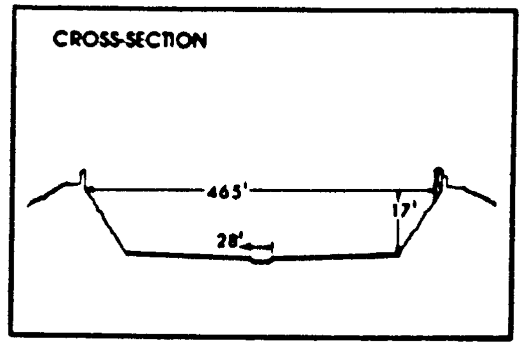
19908

LOS ANGELES RIVER
below Firestone Boulevard
STATION NO. F34D-R







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RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from bridge.

DRAINAGE AREA- 596.0 square miles.

LOCATION- 472.0 feet downstream of Firestone Boulevard 3.0 miles west of Downey.

REGULATION- partially regulated by Sepulveda, Pacoima, Big Tujunga, Hansen, and Devil's Gate Dam; and by several spreading grounds, reservoirs, and debris basins.

CHANNEL- concrete, with rip-rap side slopes, trapezoidal in section, with trapezoidal low- flow channel.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F34-R March 1, 1928 to April 11, 1938 at Station F34B-R, April 11, 1938 to November 3, 1949. at Station F34C-R November 4, 1949, to December 11, 1956. at Station F34D-R December 11, 1956 to date.

REMARKS- subject to diversions from Big Tujunga Creek, Arroyo Seco, and other domestic and irrigation diversions.

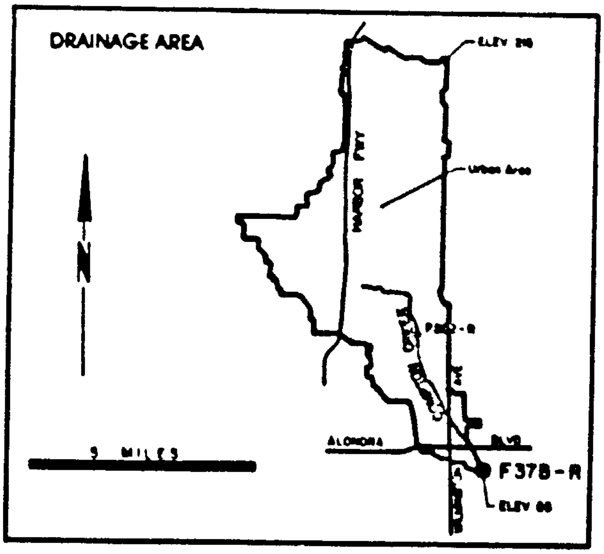
19909

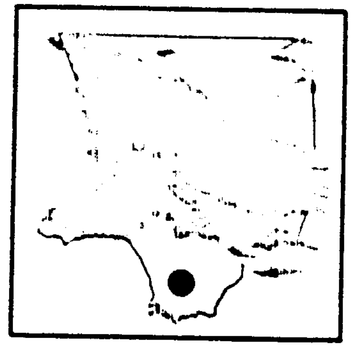
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

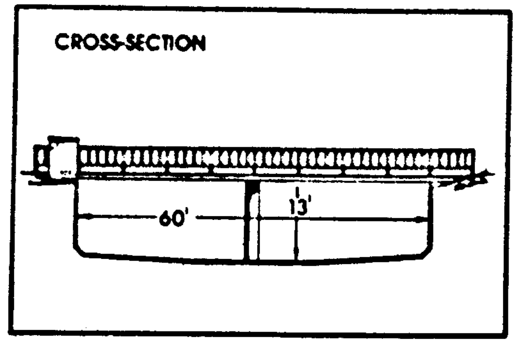
STATION NO.: F34D-R DRAINAGE AREA: 596.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	114.0	195.0	113.0	214.0	655.0	998.0	133.0	118.0	113.0	117.0	114.0	106.0
	MAX.	115.0	1700.0	114.0	1340.0	7850.0	6190.0	292.0	124.0	116.0	123.0	118.0	111.0
	MIN.	114.0	112.0	112.0	113.0	103.0	129.0	119.0	113.0	108.0	108.0	111.0	99.0
	TOTAL AF	7020.0	11580.0	6920.0	13170.0	36400.0	61360.0	7900.0	7260.0	6690.0	7210.0	7030.0	6290.0

COMPTON CREEK
near Greenleaf Drive
STATION NO. F37B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 22.6 square miles.
LOCATION- 120.0 feet above Greenleaf Boulevard, 1.8 miles south west of Compton.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 60 feet wide by 13 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F37-R January 22, 1928 to June 9, 1938. at Station F37B-R October 3, 1938 to date

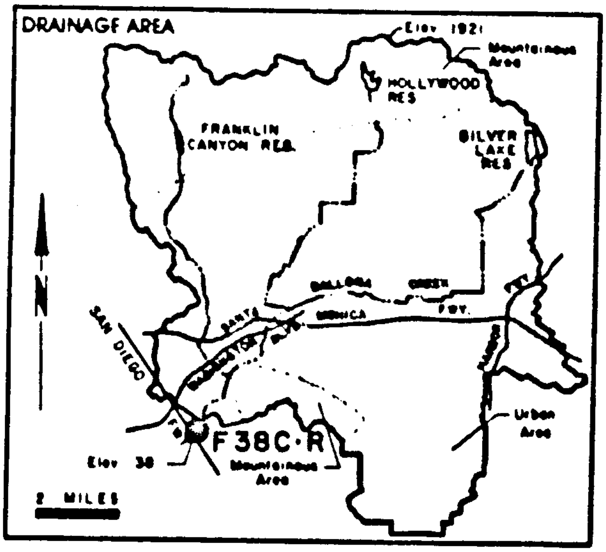
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

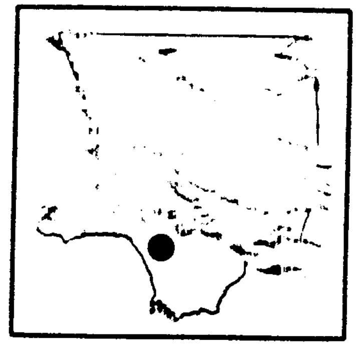
STATION NO.: F37B-R

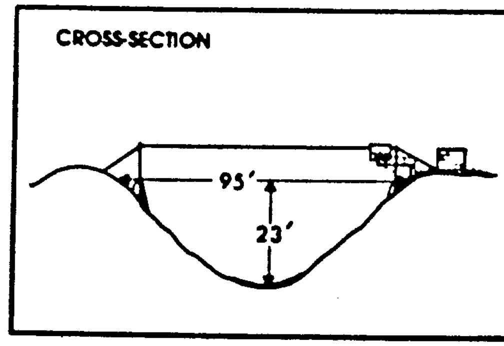
DRAINAGE AREA: 22.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.9	3.4	0.7	14.2	34.4	48.8	1.5	0.7	0.8	2.3	1.0	1.8
	MAX.	0.9	61.0	1.9	133.0	527.0	365.0	5.2	0.8	1.1	16.8	1.4	12.8
	MIN.	0.8	0.6	0.5	0.8	0.7	3.4	0.6	0.6	0.8	0.8	0.9	0.8
	TOTAL AF	54.9	205.0	44.6	874.0	1909.0	3000.0	91.0	43.4	49.8	144.0	61.9	109.0

BALLONA CREEK
above Sawtelle Boulevard
STATION NO. F38C-R







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RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 88.6 square miles.

LOCATION- 530.0 feet above Sawtelle Boulevard, 1.5 miles southwest of Culver City.

REGULATION- Stone Canyon Reservoir prior to January, 1951. Upper and Lower Franklin Canyon Reservoir, Hollywood Reservoir, and Silverlake Reservoir.

CHANNEL- concrete rubble, trapezoidal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F38-R February 27,1928 to April 27, 1936. at Station F38B-R, May 14, 1936 to August 10, 1967. at Station F38C-R August 10, 1967, to date.

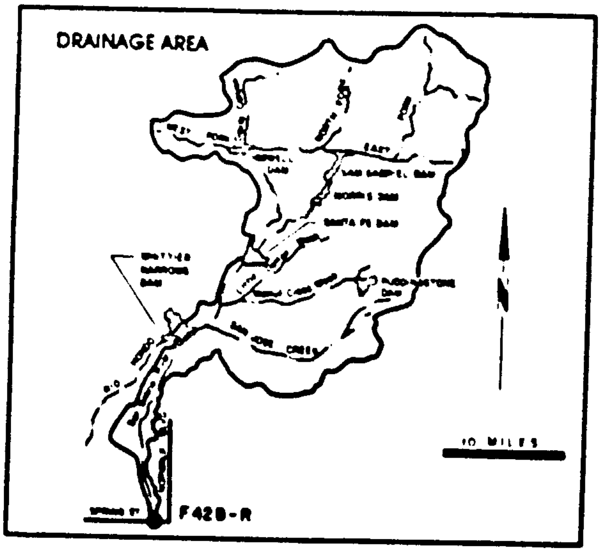
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

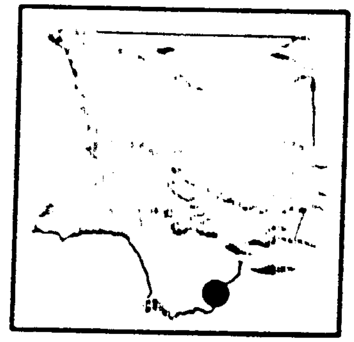
STATION NO.: F38C-R

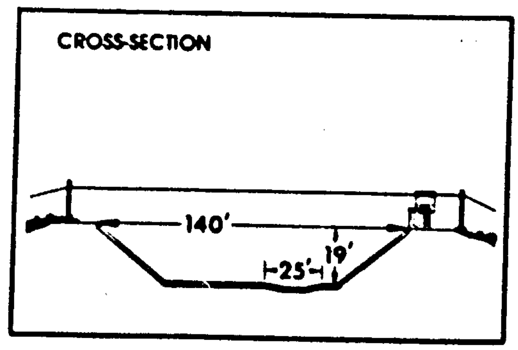
DRAINAGE AREA: 88.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	10.4	28.4	8.7	47.4	115.0	187.0	10.1	9.9	8.3	10.5	9.7	8.1
	MAX.	14.0	491.0	14.3	443.0	2150.0	1150.0	14.7	11.7	10.4	51.5	11.8	31.8
	MIN.	8.7	7.0	6.6	9.9	7.6	8.7	8.7	8.2	8.2	7.0	8.2	3.0
	TOTAL AF	640.0	1692.0	533.0	2917.0	6407.0	11522.0	598.0	607.0	492.0	644.0	596.0	485.0

SAN GABRIEL RIVER
above Spring Street
STATION NO. F42B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 231.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 455.0 feet north of Spring Street, 4.0 miles east of Signal Hill, Long Beach.
REGULATION- partially regulated by Cogswell, San Gabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek, and Whittier Narrows Dams, several debris basins, MWD outlet, and several spreading grounds.
CHANNEL- concrete, trapizoidal section with a low-flow channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F42-R February 6, 1928 to May 26, 1964. at Station F42B-R, November 16, 1964 to date.
REMARKS- high flows into Whittier Narrows Reservoir are partially diverted to the Rio Hondo.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F42B-R

DRAINAGE AREA: 231.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	79.1	64.1	42.1	80.5	91.9	194.0	101.0	34.1	38.8	48.1	83.3	81.5
YEAR	MAX.	144.0	134.0	89.1	213.0	642.0	813.0	120.0	70.4	73.4	119.0	146.0	171.0
90-91	MIN.	35.7	35.9	32.9	34.2	33.4	66.8	31.3	25.7	31.6	37.7	33.8	44.5
	TOTAL AF	4865.0	3813.0	2589.0	4947.0	5104.0	11946.0	5988.0	2094.0	2306.0	2959.0	5124.0	4847.0

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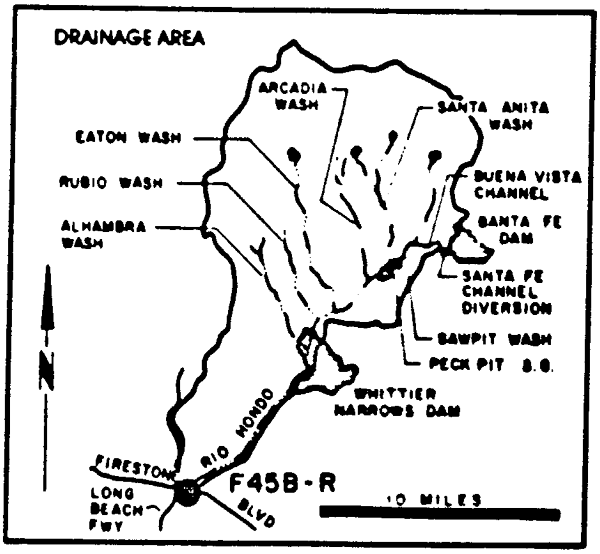
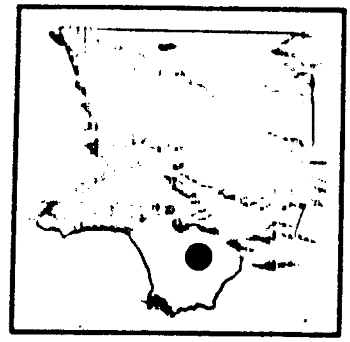
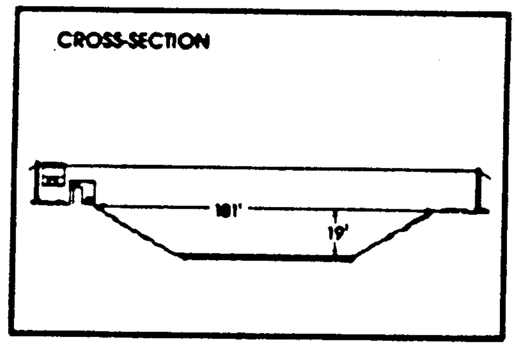
RIO HONDO
above Stewart and Gray Road
STATION NO. F45B-R







RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 140 square miles (excludes area above Santa Fe Dam).

LOCATION- 0.6 mile upstream of the confluence of Rio Hondo and Los Angeles River, 1.5 miles west of Downey.

REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, Santa Fe, and Whittier Narrows Dams, several debris basins, and spreading grounds.

CHANNEL- concrete with rip-rap side slopes. trapezoidal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F45-R March 1, 1928 to April 18, 1951. at Station F45B-R October 31, 1951 to date.

REMARKS- subject to diversions from Eaton Creek, Monrovia Creek, Sawpit Creek, Little Santa Anita Canyon and other locations for irrigation and spreading. High flows from San Gabriel River may flow into Rio Hondo above Whittier Narrows Dam.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F45B-R

DRAINAGE AREA: 140.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.4	4.3	0.3	10.2	175.0	226.0	0.6	0.2	0.2	0.6	0.3	0.7
	MAX.	1.0	114.0	1.1	164.0	3880.0	2880.0	5.7	0.7	0.5	16.1	1.4	10.9
	MIN.	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1
	TOTAL AF	25.8	257.0	15.5	626.0	9728.0	13916.0	33.5	9.9	9.3	38.7	20.4	39.7

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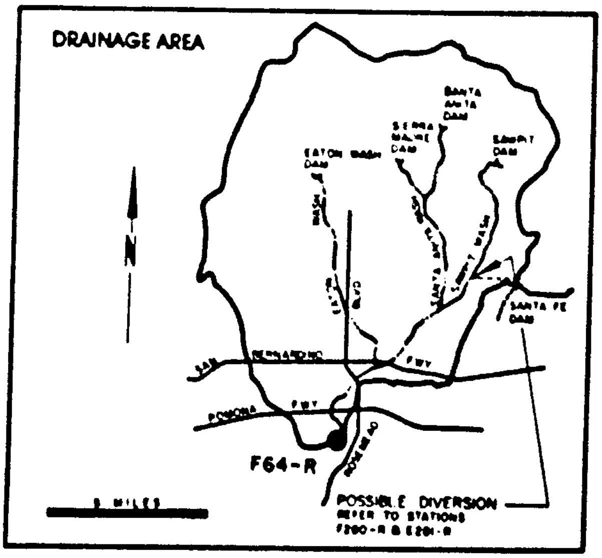
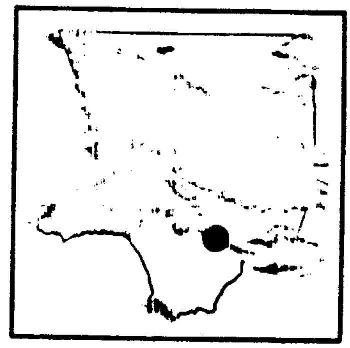
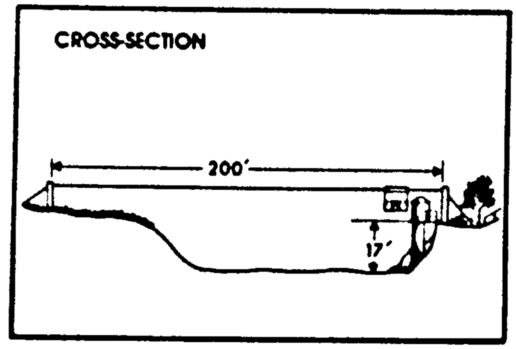
1991 3

R0053218

RIO HONDO
above Mission Bridge
STATION NO. F64-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 115 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,000 feet above San Gabriel Boulevard, west of Rosemead Boulevard, 2.0 miles northeast of Montebello.
REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, and Santa Fe Dams and several debris basins.
CHANNEL- sand and silt, natural in section.
CONTROL- none.
LENGTH OF RECORD- July 1, 1928 to date.
REMARKS- subject to diversions; water purchased from the MWD passes this station for spreading in the coastal basin.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F64-R

DRAINAGE AREA: 115.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	47.7	41.6	36.3	92.5	62.5	290.0	30.6	24.0	63.5	86.0	167.0	85.4
	MAX.	74.5	347.0	74.0	1180.0	500.0	600.0	34.4	33.4	153.0	505.0	423.0	132.0
	MIN.	23.9	1.1	25.5	22.6	20.0	2.1	18.5	13.2	10.2	40.1	32.6	11.9
	TOTAL AF	2933.0	2476.0	2232.0	5689.0	3471.0	17848.0	1822.0	1473.0	3778.0	5290.0	10249.0	5084.0

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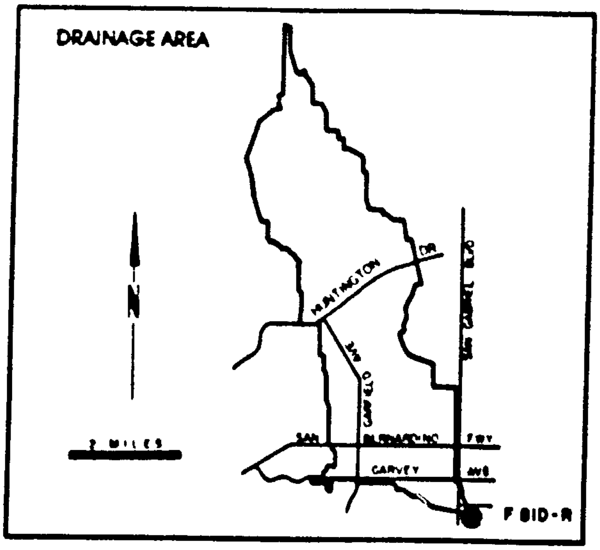
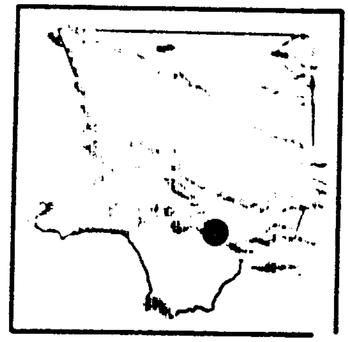
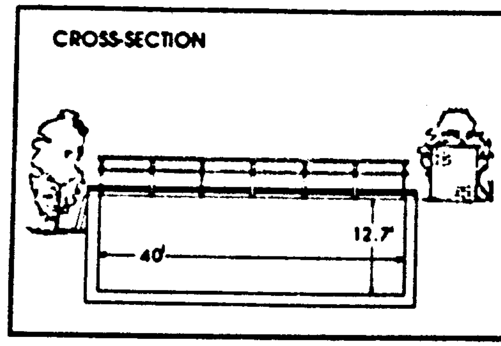
19914

R0053219

ALHAMBRA WASH
near Klingerman Street
STATION NO. F81D-R







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1995

RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from footbridge.

DRAINAGE AREA- 15.2 square miles.

LOCATION- 250± feet above Klingerman Street and 2,650.0 feet below Garvey Avenue, South San Gabriel.

REGULATION- none.

CHANNEL- concrete, rectangular in section, 40.0 feet wide by 12.7 feet deep.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F81-R January 14, 1930 to September 30, 1934. at Station F81B-R October 1, 1934 to February 25, 1935. at Station F81C-R February 25, 1935 to April 27, 1936. at Station F81B-R April 27, 1936 to May 22, 1936. at Station F81D-R September 2, 1936 to date.

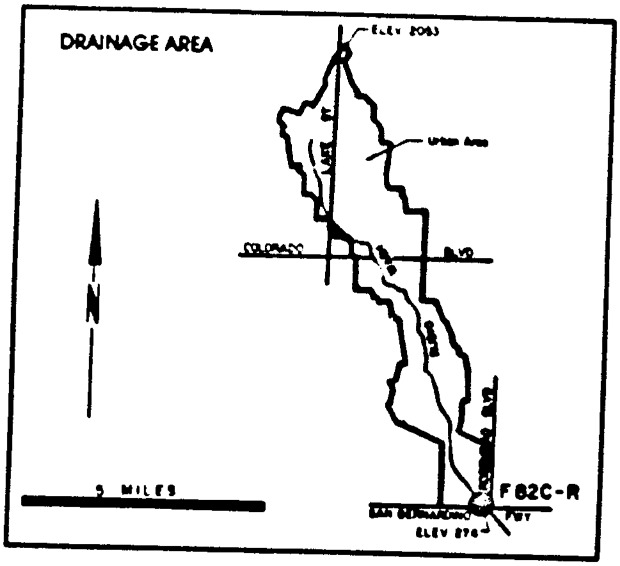
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

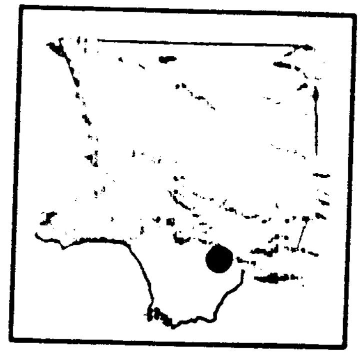
STATION NO.: F81D-R

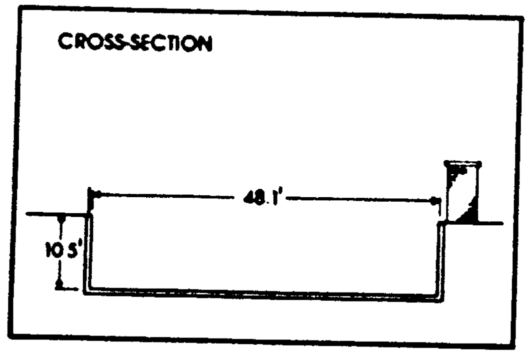
DRAINAGE AREA: 15.20 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	1.1	2.5	1.1	9.2	30.9	38.1	1.1	1.2	2.4	1.7	1.1	1.1
	MAX.	1.3	30.6	2.6	136.0	452.0	243.0	3.4	1.5	4.6	10.2	1.3	6.0
	MIN.	1.0	0.9	0.9	0.9	1.1	0.6	0.8	0.9	1.1	1.0	1.0	0.6
	TOTAL AF	70.6	149.0	65.5	568.0	1714.0	2345.0	68.2	73.4	143.0	107.0	70.6	68.0

RUBIO WASH
at Glendon Wash
STATION NO. F82C-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge at station.
DRAINAGE AREA- 10.9 square miles.
LOCATION- on the east side of channel, 10 feet south of the westerly extension of Glendon Way, Rosemead.
REGULATION- flow partly regulated by Las Flores and Rubio debris basins.
CHANNEL- rectangular concrete.
CONTROL- channel forms control.
LENGTH OF RECORD- see station summary.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F82C-R

DRAINAGE AREA: 10.90 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.5	1.5	0.8	5.6	23.0	26.5	0.2	0.1	0.3	0.4	0.3	0.1
	MAX.	0.7	26.5	3.9	80.9	355.0	180.0	0.9	0.1	0.6	3.9	0.7	1.8
	MIN.	0.4	0.2	0.4	0.3	0.3	0.0	0.1	0.0	0.3	0.2	0.3	0.0
	TOTAL AF	28.2	91.6	48.6	343.0	1277.0	1631.0	13.5	5.8	20.6	27.4	20.6	6.1

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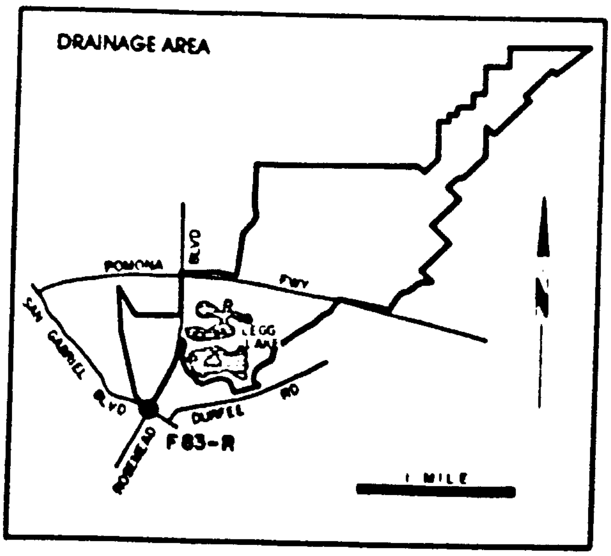
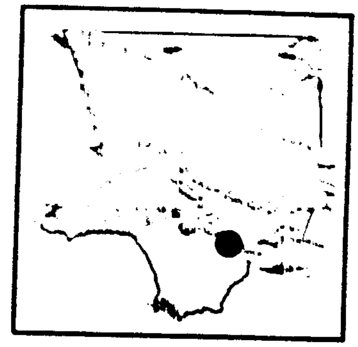
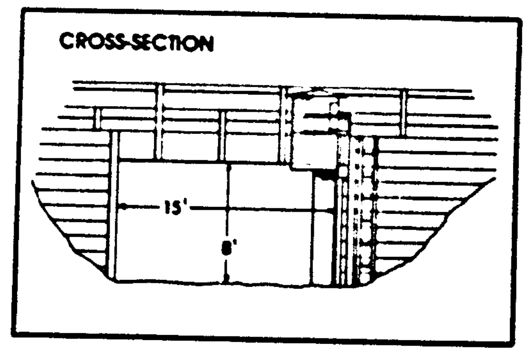
MISSION CREEK
at San Gabriel Boulevard
STATION NO. F83-R







VOL 12

1991-7

RECORDER- continuous water stage.
METHOD MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 4.2 square miles.
LOCATION- upstream of San Gabriel Boulevard, 0.2 miles northeast of Montebello.
REGULATION- partially regulated by outflow from Legg Lake.
CHANNEL- sand with brush and fences, natural in section.
CONTROL- channel forms control.
LENGTH OF RECORD- June 14, 1930 to date.
REMARKS- nearly all flows originate in rising water.

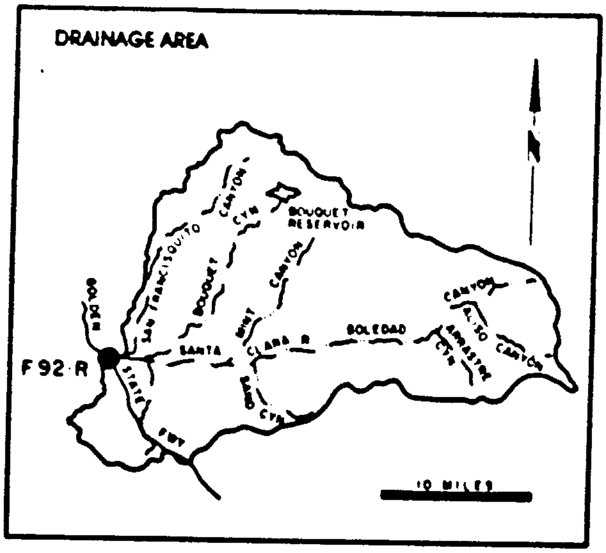
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

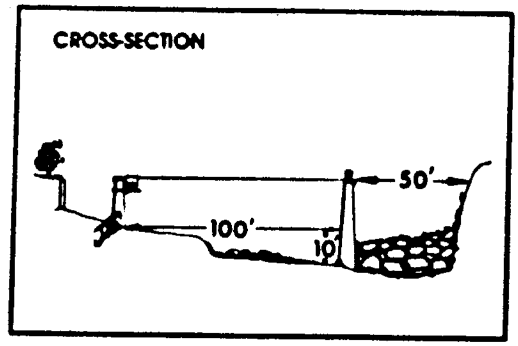
STATION NO. : F83-R

DRAINAGE AREA : 4.20 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.0	0.0								
	MAX.	0.0	0.0	0.0	0.0			DATA		NOT		AVAILABLE	
	MIN.	0.0	0.0	0.0	0.0								
	TOTAL AF	0.0	0.0	0.0	0.0								

SANTA CLARA RIVER
below Highway 5
STATION NO. F92C-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 410.4 square miles.
LOCATION- downstream side of Old Highway bridge, 3.0 miles west of Saugus.
REGULATION- partially regulated by Bouquet Canyon and Dry Canyon Reservoirs.
CHANNEL- sand and gravel with brush, natural section.
CONTROL- none
LENGTH OF RECORD- at Station F92-R January 18, 1930 to March 28, 1938, and September 24, 1956 to date. at Station F92B-R, October 1, 1938 to September 24, 1956.
REMARKS- subject to diversions for irrigation.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F92C-R

DRAINAGE AREA: 410.40 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	16.1	14.4	8.0	7.9	21.4	59.7	7.6	9.1	8.4	6.1	5.0	3.0
	MAX.	16.9	17.5	9.6	9.2	241.0	604.0	8.3	10.6	9.8	6.7	5.9	3.9
	MIN.	13.1	10.1	7.9	6.7	6.1	7.5	7.4	7.5	6.7	5.7	3.9	2.4
	TOTAL AF	992.0	858.0	494.0	483.0	1187.0	3670.0	454.0	562.0	497.0	377.0	305.0	179.0

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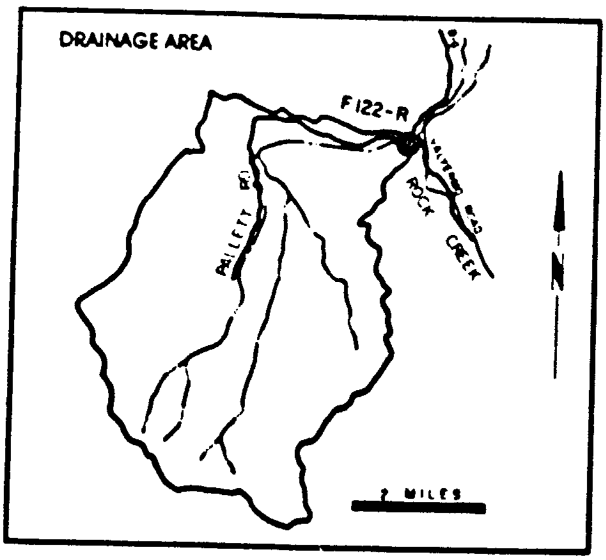
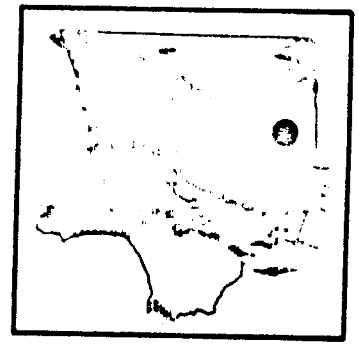
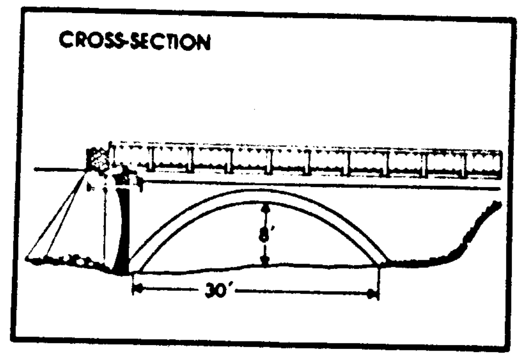
1991-8

PALLETT CREEK
at Valyermo Highway
STATION NO. F122-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 15.8 square miles.
LOCATION- upstream side of Valyermo Highway bridge, 5.0 miles southeast of Pearblossom.
REGULATION- none.
CHANNEL- sand and gravel, natural section.
CONTROL- channel forms control for low flows; bridge culvert forms control for high flows.
LENGTH OF RECORD- at Station F122-S December 29, 1930 to October 31, 1961. at Station F122-R, October 31, 1961 to date.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

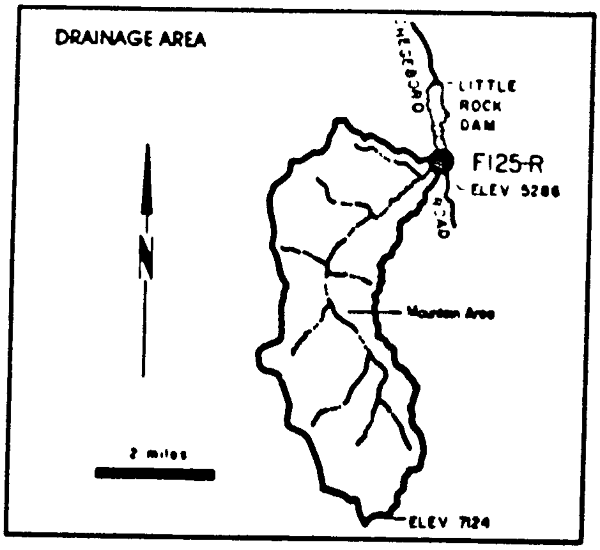
STATION NO.: F122-R

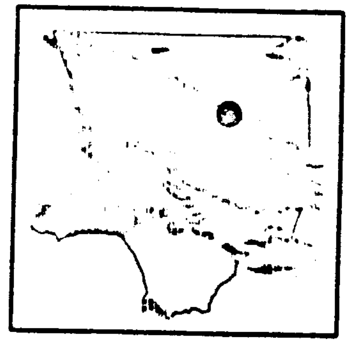
DRAINAGE AREA: 15.80 SQ. MI.

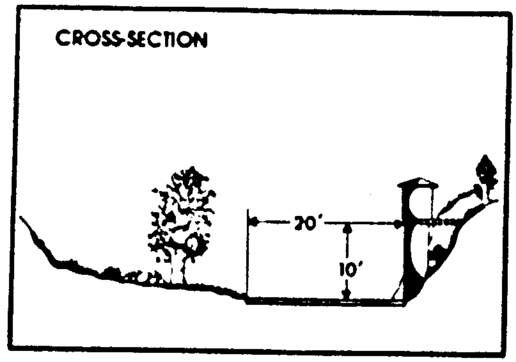
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	MAX.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

VOL 12
1991

SANTIAGO CREEK
above Little Rock Creek
STATION NO. F125-R







VOL 12

19920

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 11.2 square miles.
LOCATION- 1,000 feet above Little Creek and 4.5 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel and boulders.
CONTROL- concrete and rubble wall.
LENGTH OF RECORD- September 29, 1953 to date.
REMARKS- no high flow measurements.

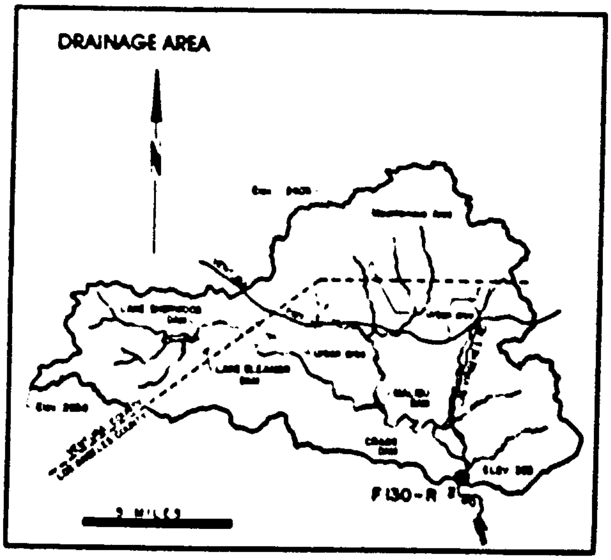
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

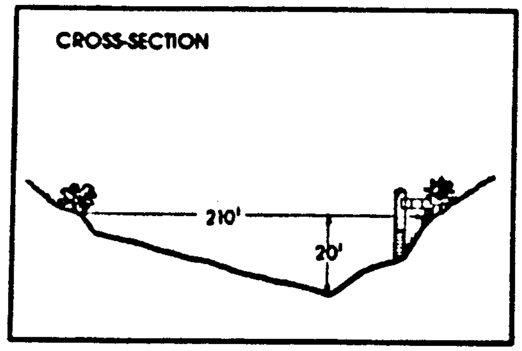
STATION NO. : F125-R

DRAINAGE AREA : 11.20 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.0	0.0	0.0	0.8	1.0	0.0	0.0	0.0	0.0	0.0
	MAX.	0.0	0.0	0.0	0.0	0.0	19.7	1.2	0.0	0.0	0.0	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	0.0	0.0	48.8	60.1	0.0	0.0	0.0	0.0	0.0

MALIBU CREEK
below Cold Creek
STATION NO. F130-R





VOL 12

1992

RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 104.96 square miles

LOCATION- 0.2± mile downstream of Cold Creek, 6.0 miles southwest of Calabasas.

REGULATION- Lake Sherwood Dam, Lake Eleanor Dam, Malibu Lake Dam, and Crag's Dam. Other small recreational dams affect low summer flows.

CHANNEL- coarse sand and gravel, lined with trees and brush, natural in section.

CONTROL- concrete stabilizer.

LENGTH OF RECORD- January 17, 1931 to date.

REMARKS- cableway washed out on January 26, 1969; no high flow measurements since that date.

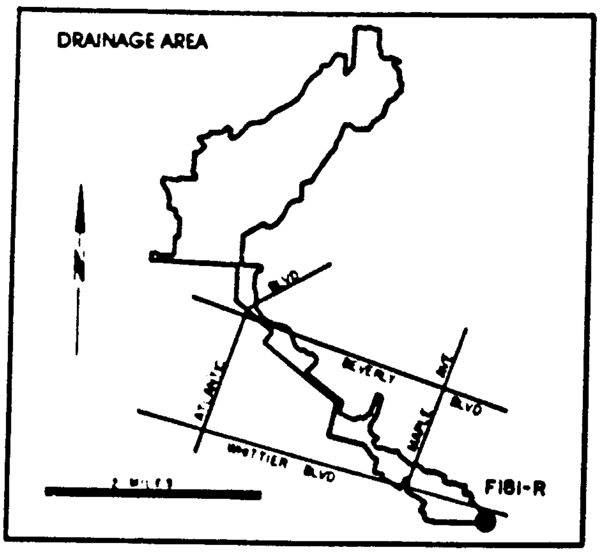
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

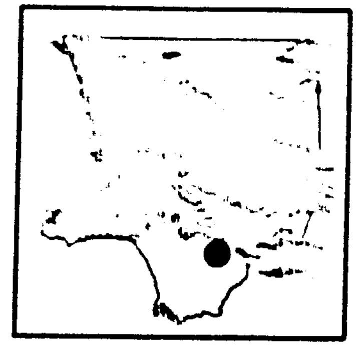
STATION NO.: F130-R

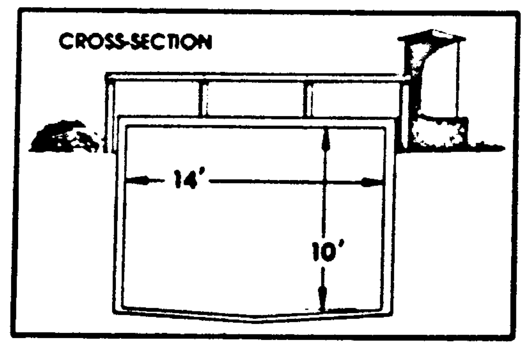
DRAINAGE AREA: 104.96 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	1.4	3.6	6.2	11.6	30.1	153.0	19.4	9.0	4.1	2.8	2.2	1.9
	MAX.	2.1	11.8	8.4	30.8	526.0	982.0	58.4	13.3	4.4	3.8	2.5	2.1
	MIN.	0.8	1.2	4.1	3.9	3.2	11.7	9.9	4.4	3.8	2.5	1.9	1.7
	TOTAL AF	86.5	212.0	384.0	713.0	1674.0	9424.0	1152.0	554.0	246.0	175.0	137.0	114.0

MONTEBELLO STORM DRAIN
above Rio Hondo
STATION NO. F181-R







VOL 12

1992

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 9.6 square miles.
LOCATION- 150.0 feet east of Mines Avenue and 500.0 feet west of Rio Hondo.
REGULATION- none.
CHANNEL- 14.0-foot by 10.0-foot concrete, box section.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1932 to date.
REMARKS- may be affected by backwater during flood flows.

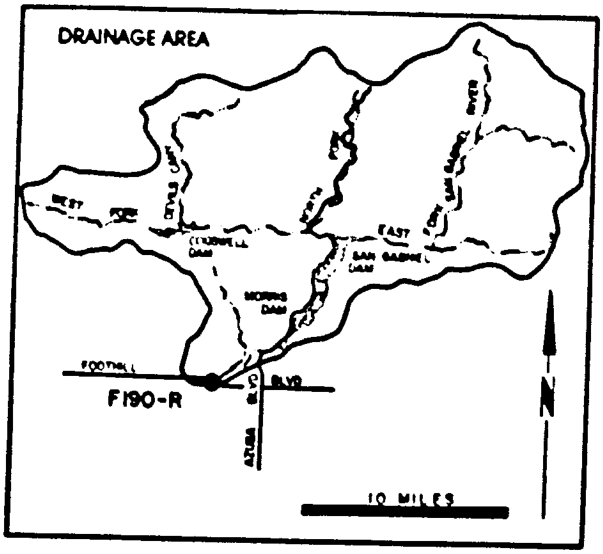
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

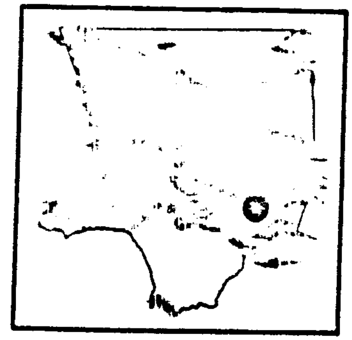
STATION NO.: F181-R　　　DRAINAGE AREA: 9.60 SQ. MI.

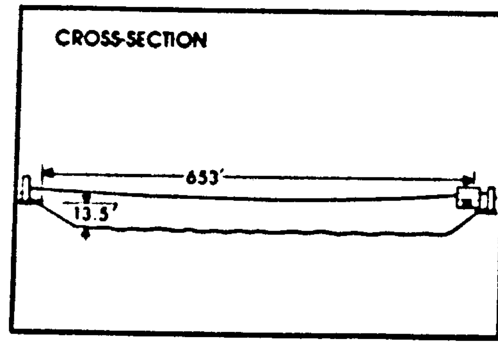
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.2	0.2	0.2	2.0	4.9	6.6	0.2	0.1	0.1	0.2	0.1	0.3
	MAX.	0.3	2.2	0.3	32.2	74.8	56.5	0.9	0.4	0.2	3.3	0.3	4.6
	MIN.	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
	TOTAL AF	9.3	14.5	9.5	123.0	273.0	406.0	11.1	8.3	7.9	15.1	7.9	20.2

R0053227

SAN GABRIEL RIVER
at Foothill Boulevard
STATION NO. F190-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 230.0 square miles.
LOCATION- downstream side of Foothill Boulevard bridge, 2.0 miles west of Azusa.
REGULATION- partially regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- sand, gravel and rock, trapezoidal section with soft bottom.
CONTROL- gunited rock stabilizers.
LENGTH OF RECORD- February 22, 1932 to date.
REMARKS- flows may include imported water originating at the Metropolitan Water District outlet below Morris Dam.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F190-R

DRAINAGE AREA: 230.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	44.1	0.0	0.0	3.3	1.1	133.0	56.1	0.0	17.3	129.0	296.0	190.0
	MAX.	65.8	0.0	0.0	30.2	28.8	459.0	184.0	0.0	185.0	567.0	520.0	291.0
	MIN.	0.0	0.0	0.0	0.0	0.0	77.4	0.0	0.0	0.0	0.0	46.6	18.6
	TOTAL AF	2709.0	0.0	0.0	204.0	60.9	8184.0	3341.0	0.0	1032.0	7928.0	18173.0	11276.0

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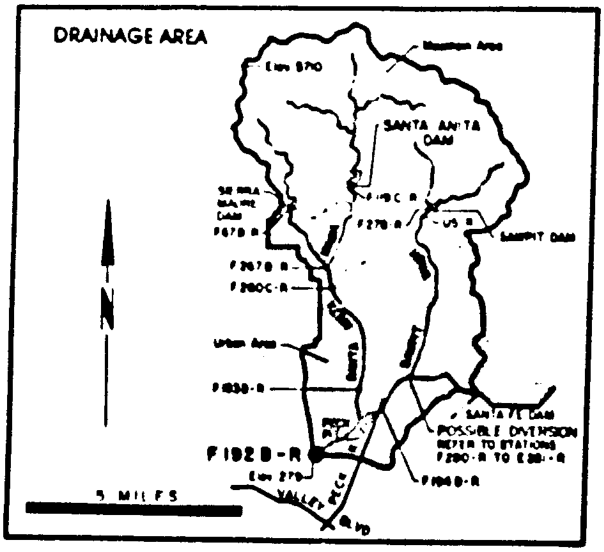
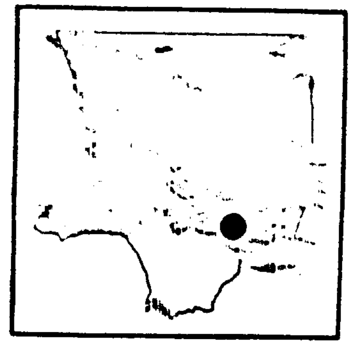
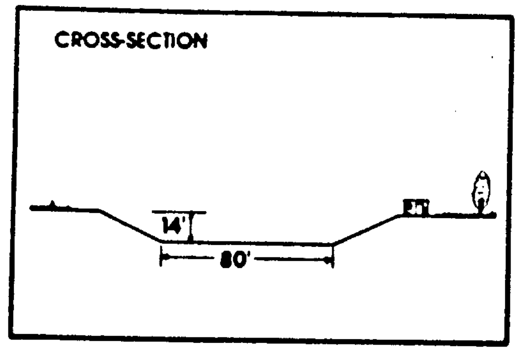
1992 3

RIO HONDO
below Lower Azusa Road
STATION NO. F192B-R

VOL 12







1 9 9 2 4

RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading.

DRAINAGE AREA- 40.9 square miles (excludes area above Santa Fe Dam).

LOCATION- 300.0 feet downstream from Lower Azusa Road, 1.5 miles north of El Monte.

REGULATION- partially regulated by Sierra Madre Dam, Santa Anita Dam, Sawpit Dam, Santa Fe Dam, Peck Pit, Buena Vista Pit, and several debris basins.

CHANNEL- concrete, trapizoidal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F192-R February 22, 1932 to May 7, 1958 at Station F192B-R May 7, 1958 to date.

REMARKS- subject to diversions from Monrovia, Sawpit, and Little Santa Anita Creeks. Also from the San Gabriel River below Santa Fe Dam; and for irrigation and spreading.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

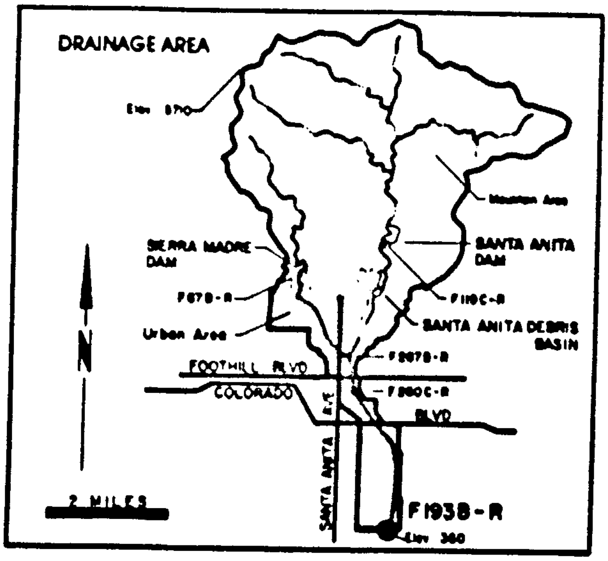
STATION NO.: F192B-R

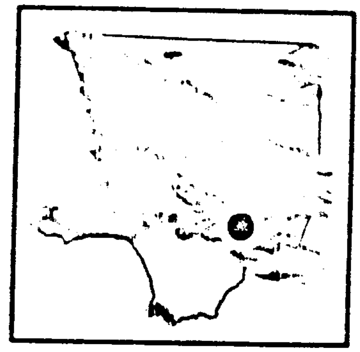
DRAINAGE AREA: 40.90 SQ. MI.

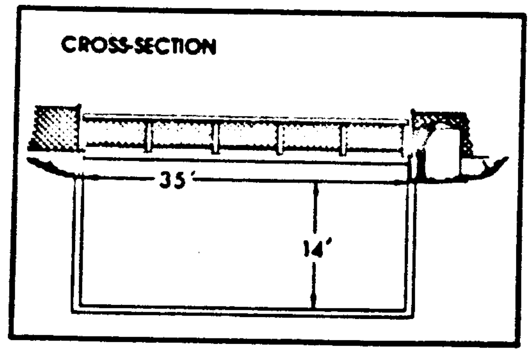
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.1	0.1	1.0	2.2	3.2	0.0	0.4	0.0	20.6	100.0	0.0
	MAX.	0.8	1.7	0.9	13.7	37.6	23.7	0.2	12.1	0.2	388.0	352.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	3.0	7.9	6.3	59.5	121.0	194.0	0.6	24.2	1.0	1267.0	6160.0	0.0

SANTA ANITA WASH
at Longden Avenue
STATION NO. F193B-R

VOL 12







RECORDER - continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 18.8 square miles.
LOCATION - 30.0 feet above Longden Avenue, 1.5 miles south of Arcadia.
REGULATION - regulated by Santa Anita and Sierra Madre Dams, and Santa Anita Debris Basin.
CHANNEL - concrete rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F193-R, April 25, 1932 to March 1, 1938. at Station F193B-R, January 8, 1960 to date.

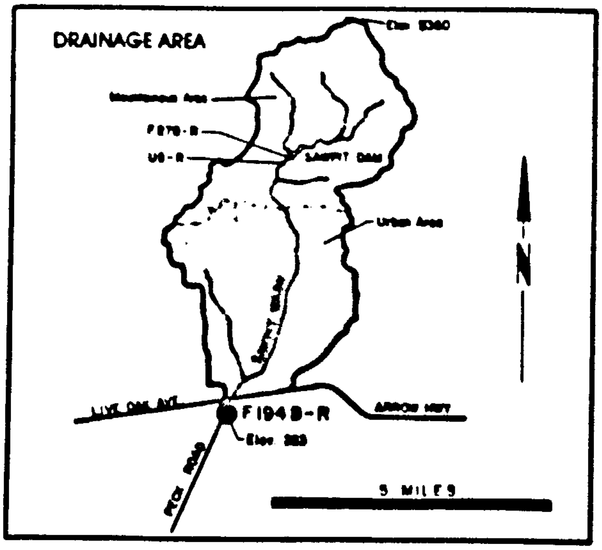
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

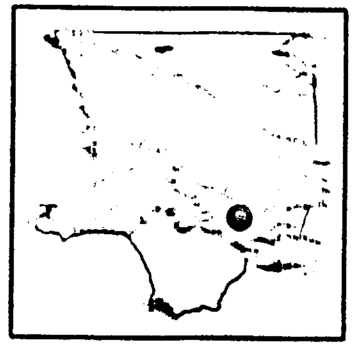
STATION NO.: F193B-R

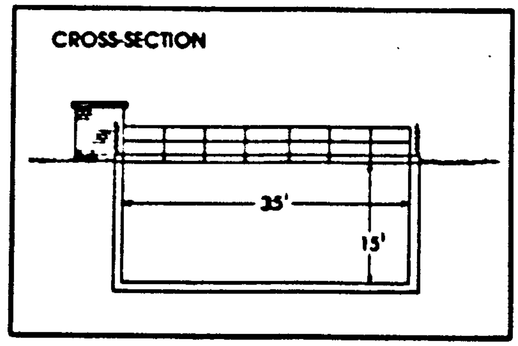
DRAINAGE AREA: 18.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.4	0.1	2.0	4.9	17.0	1.9	0.1	0.0	0.1	0.0	0.2
	MAX.	0.4	4.4	1.2	32.2	76.1	104.0	10.3	0.7	0.5	0.5	0.0	1.5
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.8	24.0	3.4	122.0	272.0	1047.0	113.0	4.0	1.4	3.8	0.0	10.3

SAWPIT WASH
below Live Oak Avenue
STATION NO. F194B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 16.1 square miles.
LOCATION- 1,500 feet below Arrow Highway, 3.0 miles south of Monrovia.
REGULATION- partially regulated by Sawpit and Santa Fe Dams, and by several debris basins.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F194-R February 22, 1932 to September 1, 1935. at Station F194B-R December 5, 1960 to date.

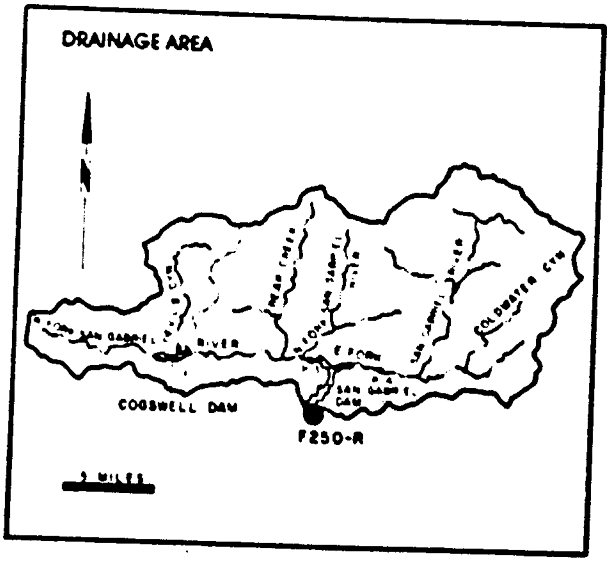
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

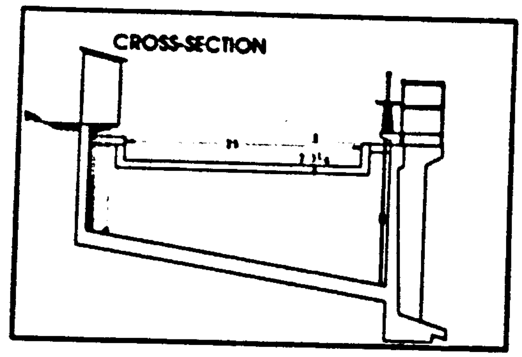
STATION NO.: F194B-R DRAINAGE AREA: 16.10 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.1	0.4	0.0	1.3	10.3	16.1	0.5	0.7	0.7	55.8	87.1	35.2
	MAX.	0.2	7.0	0.5	27.4	147.0	150.0	2.0	1.5	1.3	331.0	306.0	58.9
	MIN.	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.4	0.3	0.1	0.1
	TOTAL AF	6.3	20.8	1.2	79.7	572.0	990.0	29.4	41.5	40.9	3432.0	5358.0	2095.0

VOL 12
1 9926

SAN GABRIEL-AZUSA CONDUIT
at 25 ft. Weir below San Gabriel Dam
STATION NO. F250-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- weir formula with gage height observation.
DRAINAGE AREA- none.
LOCATION- on the concrete conduit which diverts from San Gabriel Dam, 160 feet below the Dam.
REGULATION- regulated in section.
CONTROL- 25-foot concrete weir.
LENGTH OF RECORD- February 26, 1933, to date.
REMARKS- approximate capacity 95 second-feet.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F250-R

DRAINAGE AREA NONE

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	14.7	4.9	7.1	9.3	7.3	13.4	28.9	42.7	41.6	44.9	49.2	71.2
	MAX.	17.4	10.1	7.9	10.8	7.3	73.2	42.2	44.9	44.9	46.7	70.8	79.4
	MIN.	7.9	3.7	3.7	6.9	7.3	3.0	9.6	39.9	29.3	42.6	44.9	66.5
	TOTAL AF	903.0	289.0	439.0	574.0	405.0	824.0	1721.0	2627.0	2477.0	2759.0	3027.0	4235.0

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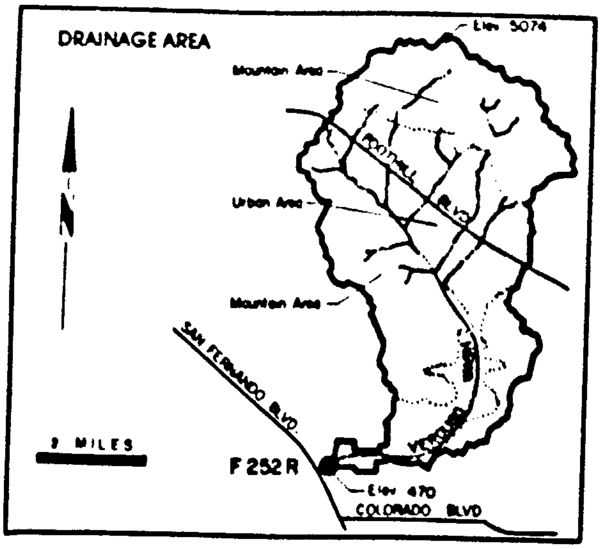
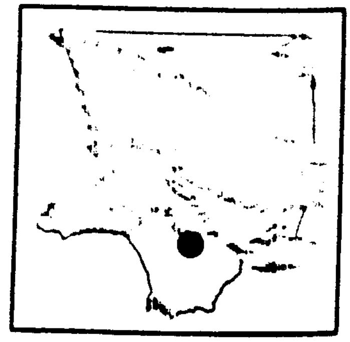
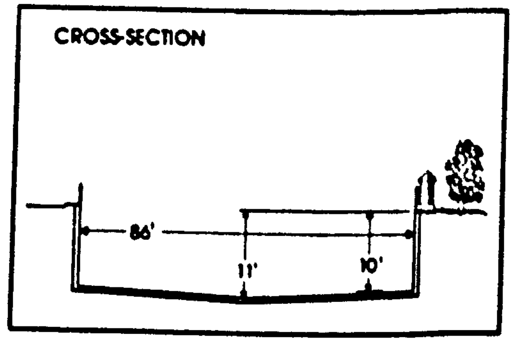
VERDUGO WASH
at Estelle Avenue
STATION NO. F252-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from Concord Street Bridge.
DRAINAGE AREA- 26.8 square miles.
LOCATION- 800.0 feet east of San Fernando Road, 2.0 miles northwest of Glendale.
REGULATION- partially regulated by several debris basins.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- December 2, 1936 to date.

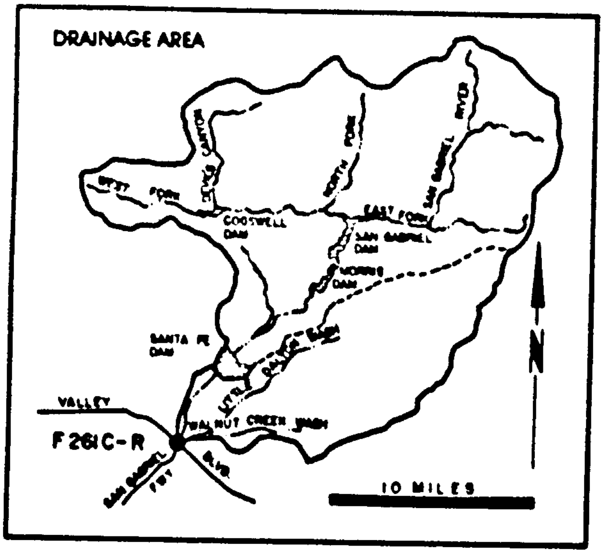
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

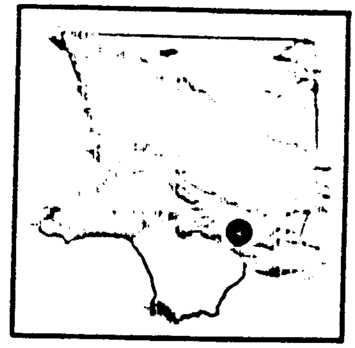
STATION NO.: F252-R

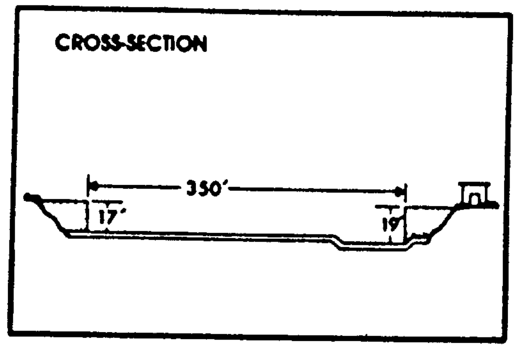
DRAINAGE AREA: 26.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	1.3	8.5	1.5	8.1	38.0	70.1	2.3	1.4	1.1	1.0	0.6	1.2
	MAX.	2.0	140.0	2.5	114.0	511.0	544.0	6.8	2.0	1.5	2.8	1.0	2.3
	MIN.	0.7	1.1	0.8	1.2	1.4	2.3	1.0	0.7	0.8	0.5	0.2	0.2
	TOTAL AF	81.5	503.0	89.7	497.0	2109.0	4311.0	136.0	87.1	64.7	64.1	38.7	69.2

SAN GABRIEL RIVER
below Valley Boulevard
STATION NO. F261C-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 118.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,150.0 feet below Valley Boulevard, 2.8 miles east of El Monte.
REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, and Puddingstone Dams.
CHANNEL- sand and gravel bottom with rip-rap side slopes; trapezoidal section.
CONTROL- concrete stabilizer with low-flow notch.
LENGTH OF RECORD- at Station F261-R March 11, 1937 to September 30, 1941. at Station F261B-R October 1, 1941 to April 23, 1946. at Station F261C-R November 29, 1960 to date.
REMARKS- flows may include imported water originating at Metropolitan Water District outlets at San Dimas Canyon and below San Bernardino Road.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F261C-R

DRAINAGE AREA: 118.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	6.3	8.1	0.1	83.1	79.9	143.0	30.6	0.0	0.0	0.2	0.0	0.0
	MAX.	7.8	49.7	3.7	568.0	1470.0	1280.0	140.0	0.2	0.0	0.7	0.0	0.0
	MIN.	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	387.0	482.0	7.3	5109.0	4437.0	8770.0	1820.0	0.6	0.0	10.1	0.0	0.0

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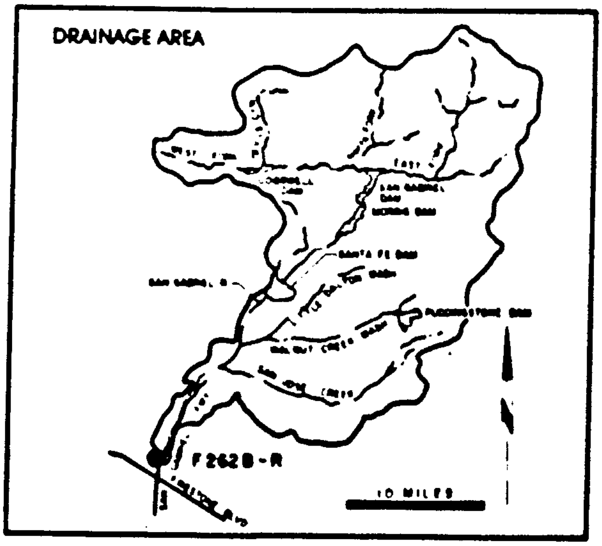
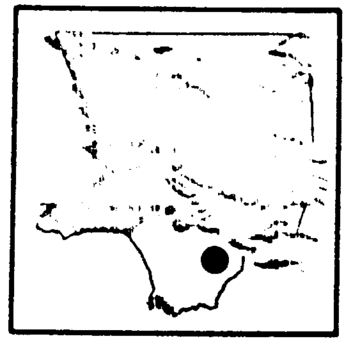
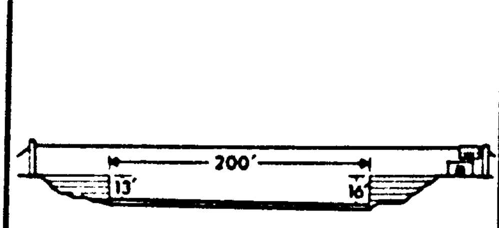
SAN GABRIEL RIVER
above Florence Avenue
STATION NO. F262B-R

DRAINAGE AREA





CROSS-SECTION



RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 215.8 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,400 feet above Florence Avenue, 2.0 miles east of Downey.
REGULATION- partially regulated by Cogswell, San Gabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek and Whittier Narrows Dams, several debris basins, MWD outlets, and several spreading grounds.
CHANNEL- sand bottom with rip-rap slopes, trapezoidal section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F267-R February 27, 1937 to September 30, 1967. at Station F262B-R August 6, 1968 to date.
REMARKS- no record during 1967-1968 season due to channel construction.

WATER YEAR 1990 - 91 *
(DISCHARGE IN SEC-FT.)

STATION NO.: F262B-R | DRAINAGE AREA: 215.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	0.0	0.0	0.0	0.0	1.4	10.0	0.0	0.0	0.0	0.0	0.0	0.0
YEAR	MAX.	0.0	0.0	0.0	0.0	39.0	169.0	0.3	0.0	0.0	0.0	0.0	0.0
90-91	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	0.0	77.0	616.0	0.9	0.0	0.0	0.0	0.0	0.0

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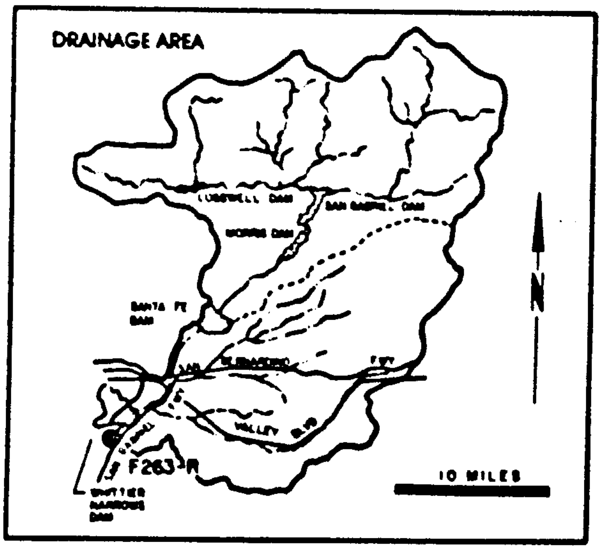
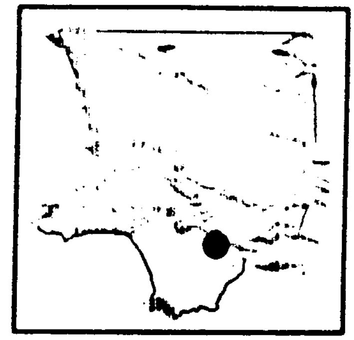
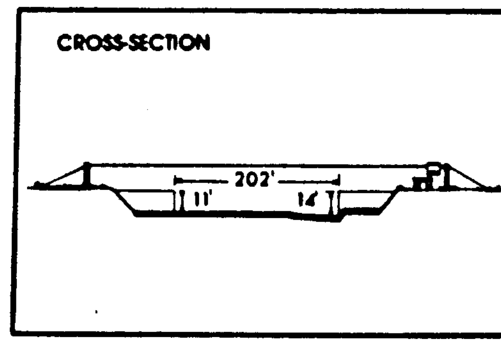
1990

SAN GABRIEL RIVER
below San Gabriel River Parkway
STATION NO. F263C-R







RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 206.3 square miles (excludes area above Santa Fe Dam).

LOCATION- 462.0 feet below San Gabriel River Parkway, 1.4 miles northeast of Pico Rivera.

REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, Puddingstone, and Thompson Creek Dams. Flows may include imported water from several Metropolitan Water District outlets. Water is at times diverted to the Zone I ditch upstream of Whittier Narrows Dam.

CHANNEL- rip-rap slopes with sand bottom trapezoidal section.

CONTROL- concrete stabilizer.

LENGTH OF RECORD- at Station F263-R February 4, 1937 to March 6, 1952. at Station F263B-R March 6, 1952 to August 9, 1968. at Station F263C-R August 9, 1968 to date.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO. : F263C-R DRAINAGE AREA : 206.30 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER	MEAN	57.6	45.8	33.8	39.2	71.8	126.0	25.1	8.2	2.6	0.8	4.8	0.0
YEAR	MAX.	148.0	113.0	78.5	450.0	787.0	607.0	134.0	46.3	14.1	11.9	12.0	0.0
90-91	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	3540.0	2727.0	2014.0	2407.0	3990.0	7728.0	1493.0	502.0	156.0	51.6	295.0	0.0

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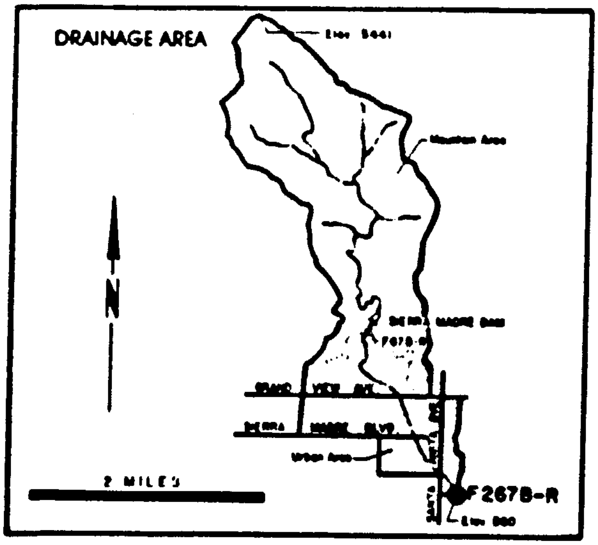
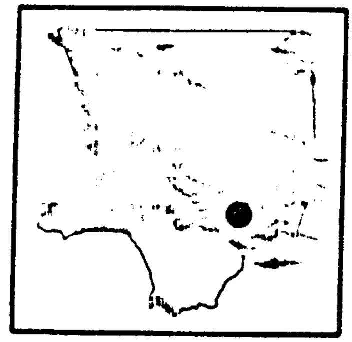
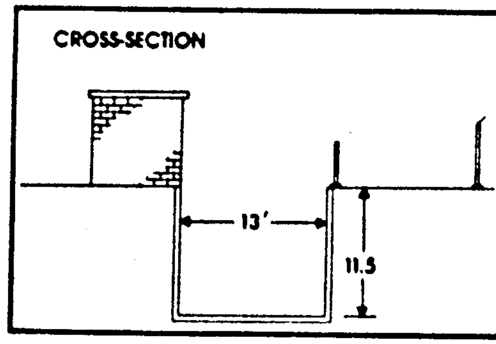
SIERRA MADRE WASH
at Highland Oaks Avenue
STATION NO. F267B-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream end of conduit 50 feet below station.
DRAINAGE AREA- 3.8 square miles.
LOCATION- on the south bank of the channel 50 feet above Highland Oaks Avenue, one and one-half miles southeast of Sierra Madre.
REGULATION- partially regulated by Sierra Madre Dam. Usual regulation affects high flows only.
DIVERSIONS- underground and surface flows developed and diverted by Sierra Madre Water Department. Flow also diverted about one mile above station for spreading in Sierra Madre Spreading Grounds.
CHANNEL-rectangular concrete 13 feet wide and 11.5 feet deep.
LENGTH OF RECORD- see station summary.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F267B-R DRAINAGE AREA: 3.80 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.0	0.2	1.2							
	MAX.	0.0	0.4	0.1	2.9	17.9				DEACTIVATED			
	MIN.	0.0	0.0	0.0	0.0	0.0							
	TOTAL AF	0.0	1.8	0.2	13.3	65.1							

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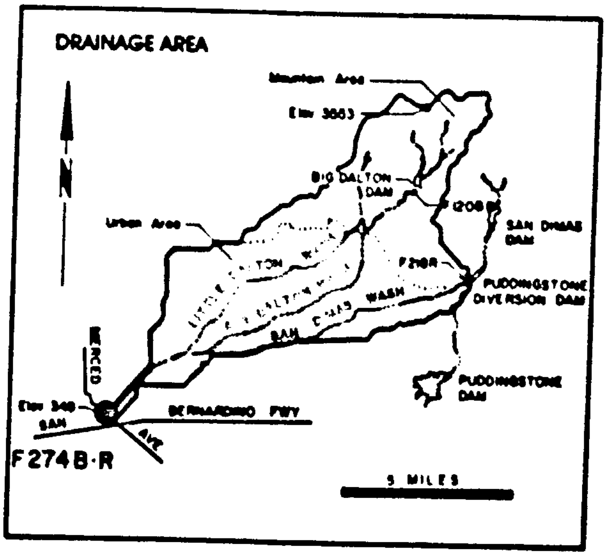
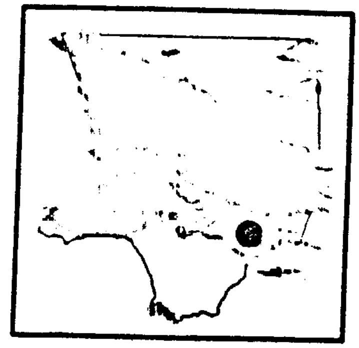
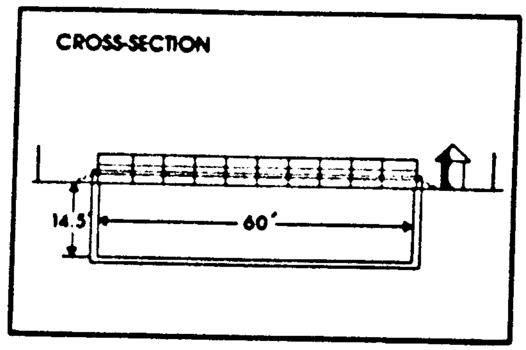
DALTON WASH
at Merced Avenue
STATION NO. F274B-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge 100 feet upstream from station.
DRAINAGE AREA- 36.0 square miles, not including the area above Puddingstone Diversion Dam.
LOCATION- on the west bank and upstream of Merced Avenue about 150 feet, about one-half mile above the junction with Walnut Wash and about one mile south of Baldwin Park.
REGULATION- partly regulated by Big Dalton Dam, San Dimas Dam, Puddingstone Diversion Dam, Big Dalton Spreading Grounds, Little Dalton Spreading Grounds, Big Dalton Debris Basin, Little Dalton Debris Basin, and Irwindale Spreading Grounds.
REMARKS- flow may include imported water originating at San Dimas.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F274B-R

DRAINAGE AREA: 36.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	33.8	30.5	0.4	56.5	37.2	58.5	8.5	0.8	0.2	0.2	0.5	0.6
	MAX.	39.0	46.6	4.3	311.0	593.0	468.0	42.6	3.0	0.8	0.8	1.1	2.5
	MIN.	29.9	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.3	0.1
	TOTAL AF	2078.0	1812.0	21.8	3475.0	2066.0	3599.0	507.0	49.8	11.5	10.1	33.3	36.3

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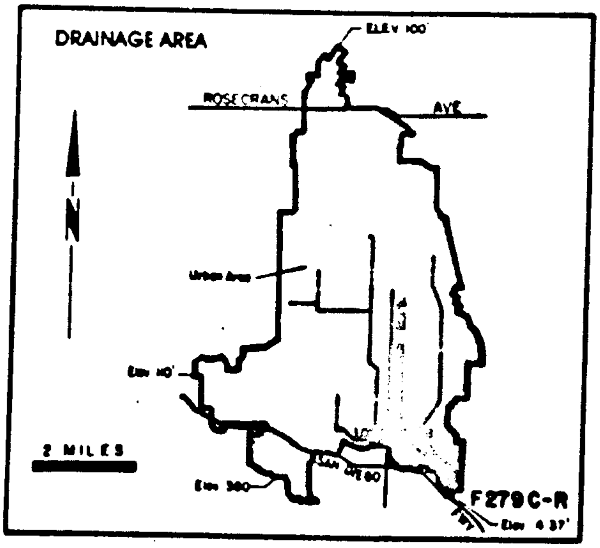
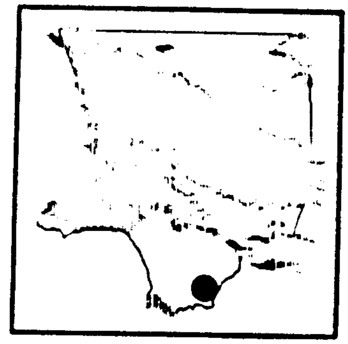
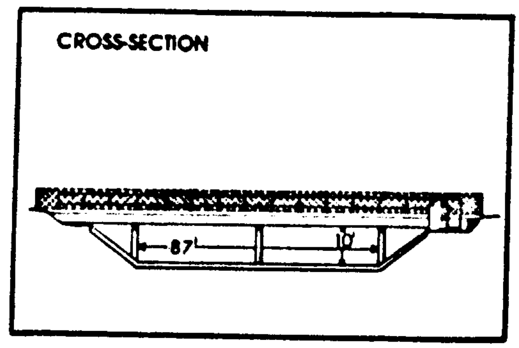
R0053238

LOS CERRITOS CHANNEL
at Stearns Street
STATION NO. F279C-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 25.6 square miles.
LOCATION- upstream of Stearns Street, Long Beach.
REGULATION- none.
CHANNEL- concrete, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F279-R November 23, 1942 to January 1, 1949. at Station F279B-R January 1, 1949 to May 26, 1955. at Station F279C-R October 26, 1955 to date.
REMARKS- station not in service May 26, 1955 to October 26, 1955 due to channel construction.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

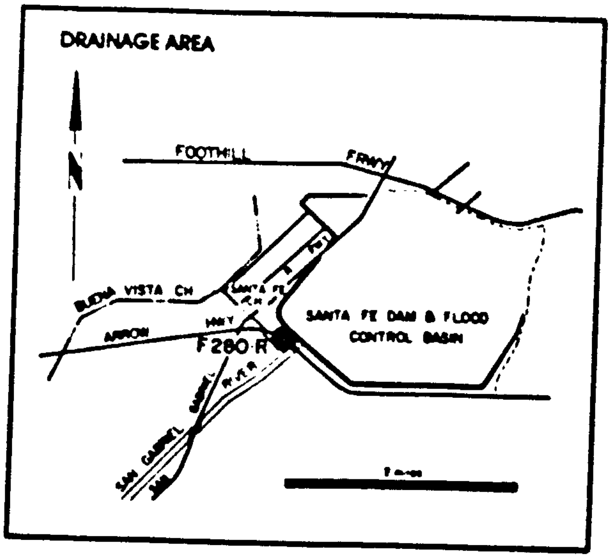
STATION NO.: F279C-R

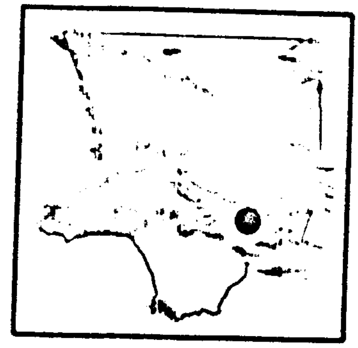
DRAINAGE AREA: 25.60 SQ. MI.

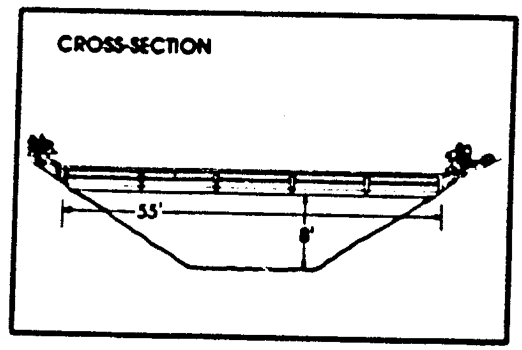
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.9	1.3	1.7	16.4	30.2	45.0	0.5					
	MAX.	1.5	20.2	4.5	160.0	489.0	262.0	1.4			DEACTIVATED		
	MIN.	0.3	0.2	0.1	0.2	0.1	0.2	0.2					
	TOTAL AF	58.3	78.5	103.0	1008.0	1679.0	2766.0	31.1					

R0053239

SANTA FE CHANNEL
below Santa Fe Dam
STATION NO. F280-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- controlled.
LOCATION- 400.0 feet downstream of Santa Fe Dam outlet and 1.5 miles north of Baldwin Park.
REGULATION- flow regulated by five gates of stilling basin outlet of Santa Fe Dam.
CHANNEL- sand and gravel, natural section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F280-S October 1, 1942 to May 12, 1944. at Station F280-R May 12, 1944 to date.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F280-R

DRAINAGE AREA: CONTROLLED

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.5	152.0	28.1
	MAX.	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	547.0	531.0	53.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0
	TOTAL AF	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0.0	5746.0	9366.0	1669.0

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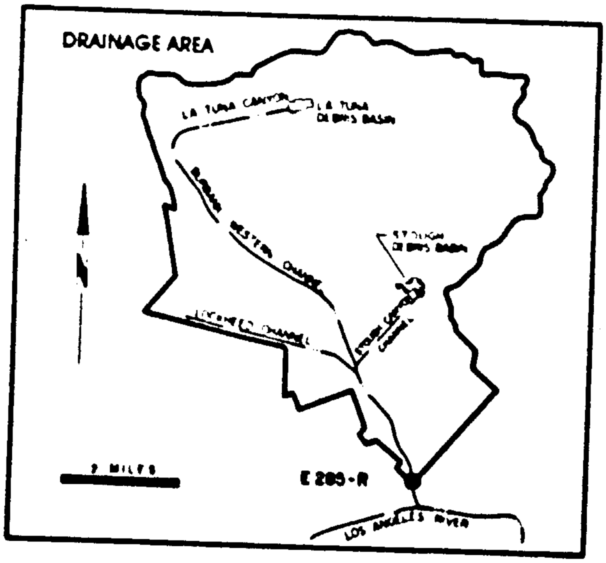
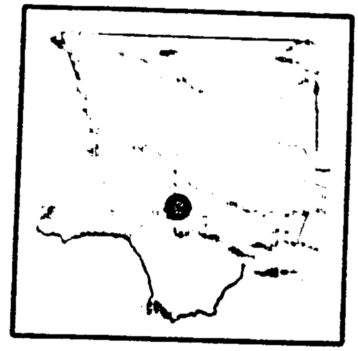
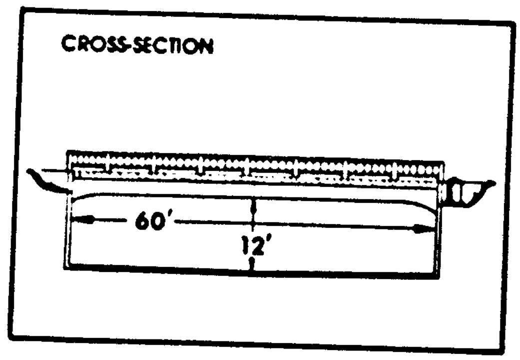
BURBANK-WESTERN ST. DR.
at Riverside Drive
STATION NO. E 285-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading and from bridge.
DRAINAGE AREA- 25.0 square miles.
LOCATION- 20.0 feet upstream from Riverside Drive bridge, Glendale.
REGULATION- Several debris basins on tributaries.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1949 to date.
REMARKS- operated in cooperation with the USCE.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: E285-R

DRAINAGE AREA: 25.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	6.6	19.5	7.4	18.5	27.3	11.4	2.2	2.3	7.0	6.9	7.9	10.4
	MAX.	7.9	147.0	10.2	60.1	376.0	113.0	2.2	2.8	15.9	7.9	7.9	22.9
	MIN.	5.0	6.2	3.4	2.2	4.6	2.0	1.7	1.2	4.6	1.5	7.9	9.0
	TOTAL AF	405.0	1158.0	456.0	1136.0	1515.0	699.0	129.0	139.0	418.0	423.0	486.0	617.0

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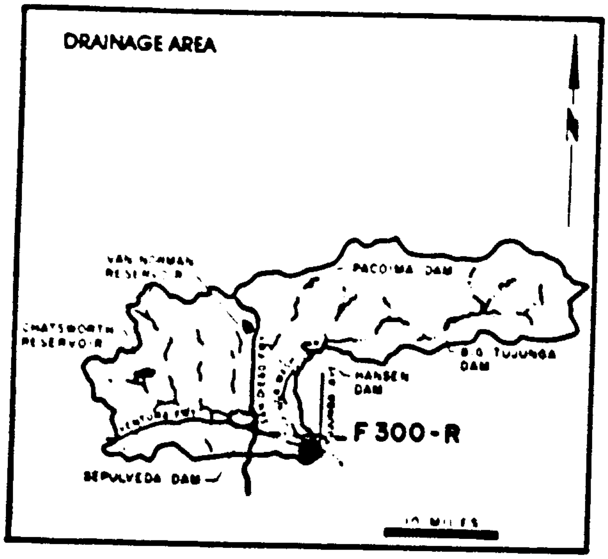
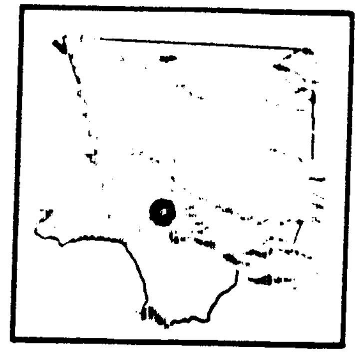
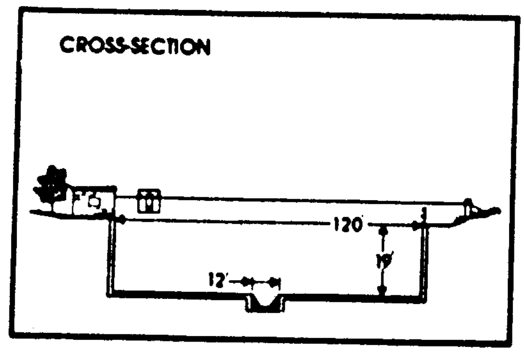
1 9936

R0053241

LOS ANGELES RIVER
at Tujunga Avenue
STATION NO. F300-R







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RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 401.0 square miles.
LOCATION- 200.0 feet above Tujunga Avenue bridge, Studio City.
REGULATION- flow regulated by Sepulveda, Big Tujunga, Hansen, and Pacoima Dams, Lopez Debris Dam, and Project No. 86 Diversion.
CHANNEL- concrete, rectangular section, 120 feet wide by 19 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- May 8, 1950, to date.
REMARKS- subject to diversions at mouth of Big Tujunga and Pacoima Canyons for irrigation, at Big Tujunga, Branford, Hansen, and Pacoima Spreading Grounds.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

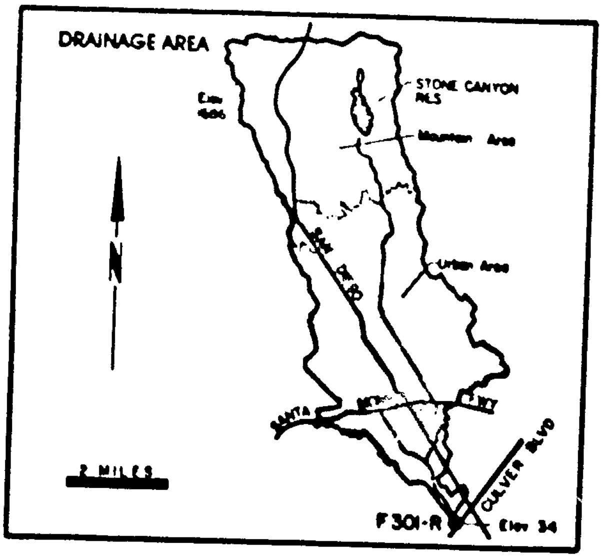
ft³/sec

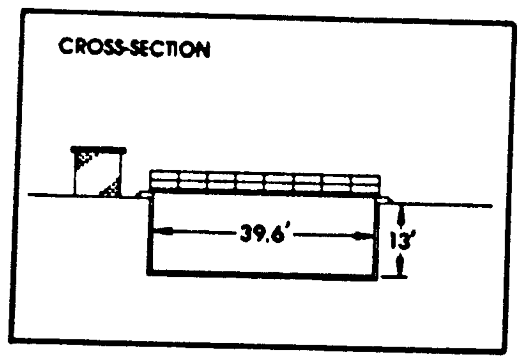
STATION NO.: F300-R

DRAINAGE AREA: 401.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	62.3	75.2	60.0	119.0	255.0	481.0	69.0	66.0	64.5	51.7	27.1	40.4
	MAX.	67.2	385.0	68.3	950.0	3130.0	2540.0	80.2	72.2	70.0	79.7	44.0	66.0
	MIN.	50.1	48.4	43.5	47.4	45.5	61.7	53.9	58.1	43.5	36.8	14.4	23.4
	TOTAL AF	3829.0	4473.0	3736.0	7306.0	14170.0	29549.0	4103.0	4105.0	3837.0	3182.0	1667.0	2404.0

SAWTELLE-WESTWOOD CHANNEL
above Culver Boulevard
STATION NO. F301-R





RECORDER- 15 minute punched tape.

METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge at station.

DRAINAGE AREA- 22.96 square miles.

LOCATION- on the south channel wall, 141 feet above Culver Boulevard bridge about one and one half miles southwest of Culver City.

REGULATION- Stone Canyon Reservoir, Southern California Water Company spills flow up to 5.0 second-feet into Sawtelle-Westwood Channel above Charnock Road for short periods nearly every day.

CHANNEL- rectangular concrete channel 40 feet wide and 13 feet deep.

CONTROL- channel forms control.

LENGTH OF RECORD- see station summary.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.) cfs

STATION NO.: F301-R

DRAINAGE AREA: 22.96 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	4.5	8.6	3.1	9.6	30.1	36.6			DEACTIVATED			
	MAX.	5.0	78.0	9.0	102.0	599.0	302.0						
	MIN.	4.2	4.0	1.6	2.1	2.6	3.8						
	TOTAL AF	275.0	512.0	188.0	593.0	1673.0	2253.0						

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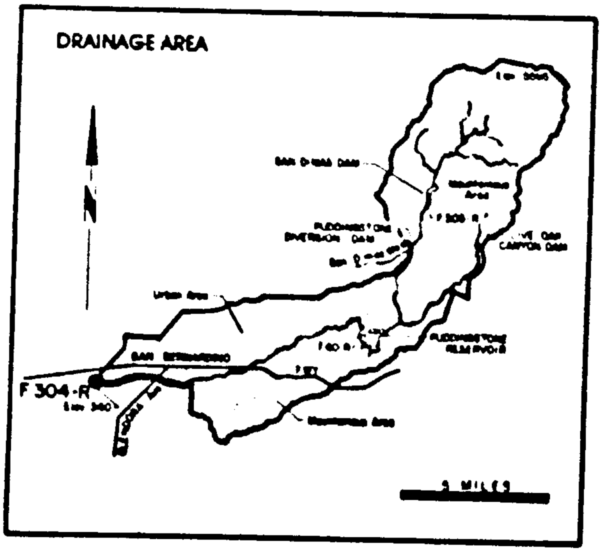
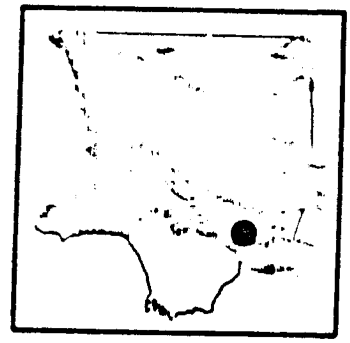
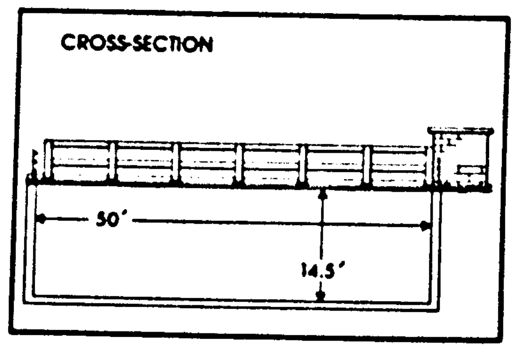
WALNUT CREEK
above Puente Avenue
STATION NO. F304-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 57.6 square miles.
LOCATION- 845.0 feet upstream of Puente Avenue bridge, Baldwin Park.
REGULATION- partially regulated by San Dimas, Puddingstone Diversion, Puddingstone, and Live Oak Dams.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 14, 1952 to April 11, 1961, January 3, 1962 to date.
REMARKS- no record during April 11, 1961 to January 3, 1962 due to channel construction.

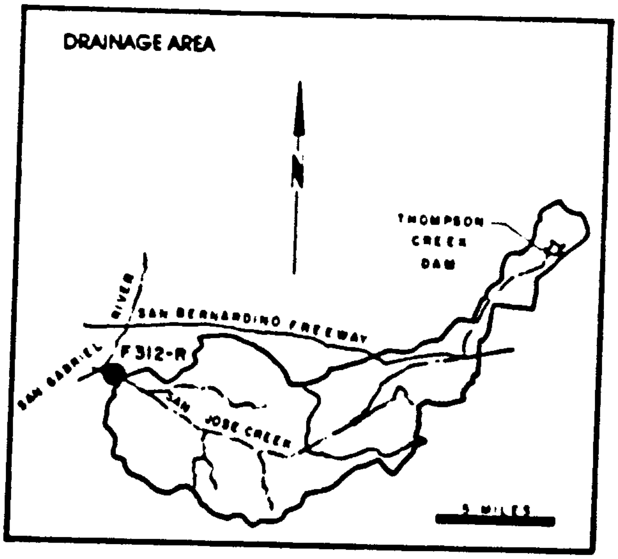
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

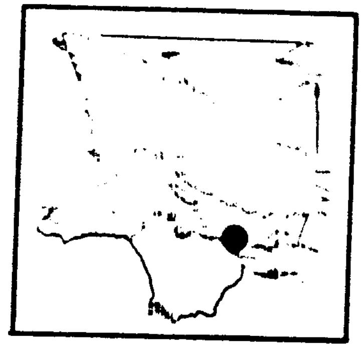
STATION NO.: F304-R

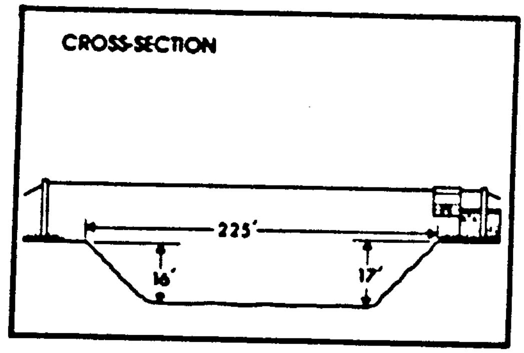
DRAINAGE AREA: 57.60 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	1.5	0.2	10.9	40.2	77.7	2.2	0.0	0.0	0.0	0.1	0.0
	MAX.	0.1	17.6	2.6	203.0	724.0	721.0	23.6	0.4	0.0	0.2	0.6	0.9
	MIN.	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.2	89.7	14.5	671.0	2232.0	4780.0	130.0	1.0	0.0	0.4	3.4	2.2

SAN JOSE CHANNEL
above Workman Mill Road
STATION NO. F312-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 83.4 square miles.
LOCATION- 1,650 feet above Workman Mill Road, 3.0 miles southeast of El Monte.
REGULATION- partially regulated by Thompson Creek Dam and Pomona Sewage Treatment Plant.
CHANNEL- grouted rip-rap side slopes with natural bottom, trapezoidal section.
CONTROL- rock stabilizer.
LENGTH OF RECORD- September 13, 1955 to date.

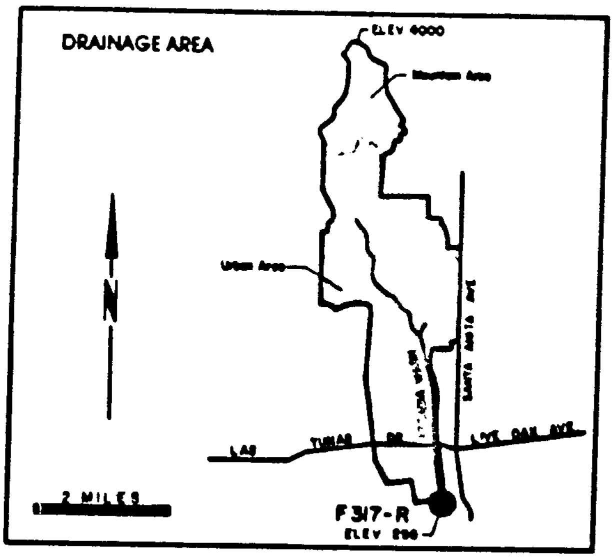
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

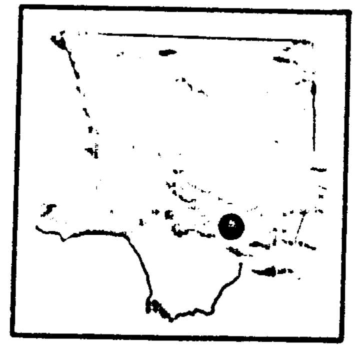
STATION NO. : F312-R

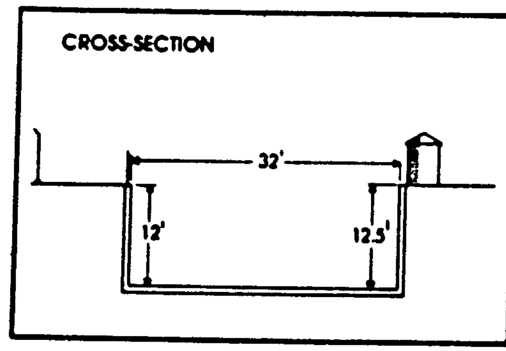
DRAINAGE AREA : 83.40 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	112.0	41.3	11.8	69.5	141.0	221.0	16.8	12.2	10.0	10.5	23.8	146.0
	MAX.	141.0	135.0	29.1	863.0	1960.0	1960.0	25.7	25.7	14.1	15.5	137.0	154.0
	MIN.	13.2	7.5	7.8	10.8	9.6	12.0	13.7	9.1	7.1	8.6	9.5	136.0
	TOTAL AF	6916.0	2457.0	724.0	4271.0	7804.0	13613.0	1002.0	750.0	595.0	645.0	1465.0	8713.0

ARCADIA WASH
below Grand Avenue
STATION NO. F317-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of Grand Avenue bridge.
DRAINAGE AREA- 8.5 square miles.
LOCATION- on the west wall of Arcadia Wash about 75 feet downstream from centerline of Grand Avenue.
REGULATION- several debris basins located upstream.
CHANNEL- rectangular concrete.
LENGTH OF RECORD- December 12, 1956 to date.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F317-R

DRAINAGE AREA: 8.50 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.6	2.1	0.5	8.7	16.5	27.2	0.3	0.7	0.7	0.4	0.8	1.9
	MAX.	3.1	25.6	4.7	125.0	220.0	173.0	0.9	12.4	3.4	1.3	1.3	20.2
	MIN.	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.7
	TOTAL AF	33.9	124.0	30.1	535.0	918.0	1671.0	15.7	40.5	43.6	23.8	50.2	113.0

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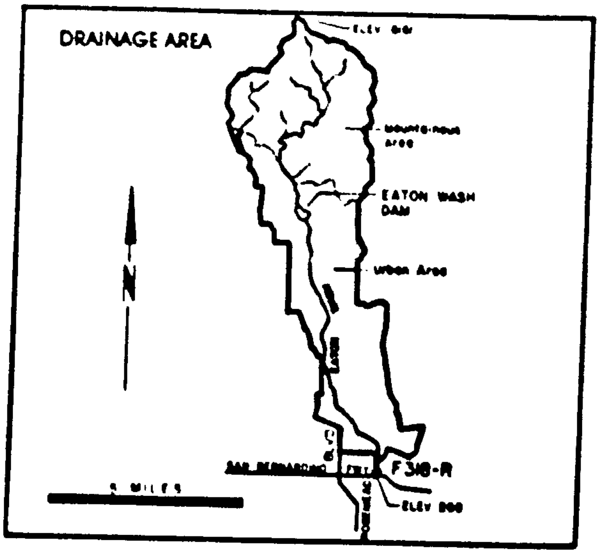
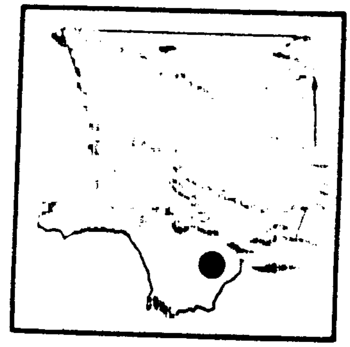
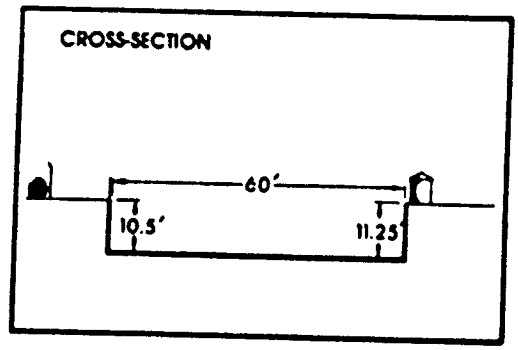
EATON WASH
at Loftus Drive
STATION NO. F318-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of East Loftus Drive bridge.
DRAINAGE- 22.8 square miles.
LOCATION- on the west wall of the channel 52 feet above the centerline of East Loftus Drive bridge, 1.3 miles west of El Monte.
REGULATION- partly regulated by Eaton Dam.
DIVERSIONS- the Pasadena Water Department diverts some water just above the mouth of Eaton Canyon. The Flood Control District diverts water to spreading grounds below Eaton Dam and below Huntington Drive.
CHANNEL- rectangular concrete, 60 feet wide, 11.3 feet.
CONTROL- channel forms control.
LENGTH OF RECORD- 1956 to date.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F318-R

DRAINAGE AREA: 22.80 SQ. MI.

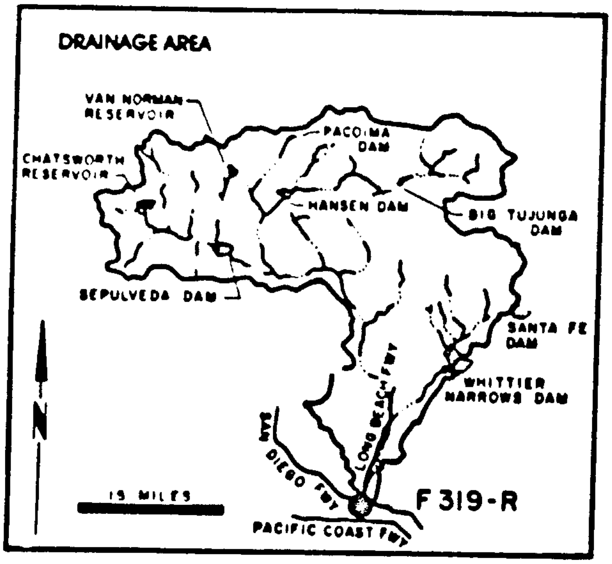
		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.1	1.8	0.2	6.5	20.6	36.3	0.1	0.0	0.1	0.2	0.1	0.2
	MAX.	0.2	31.4	4.0	110.0	331.0	278.0	3.0	0.3	0.2	1.6	0.5	2.3
	MIN.	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0
	TOTAL AF	7.5	110.0	15.1	399.0	1143.0	2230.0	7.3	2.2	6.9	12.7	8.9	10.7

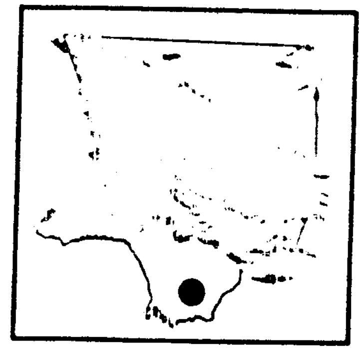
R0053247

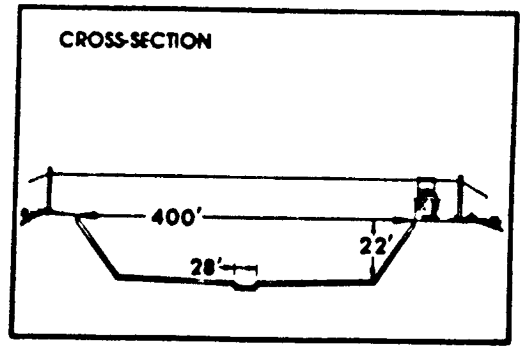
VOL 12

19942

LOS ANGELES RIVER
below Wardlow Road
STATION NO. F319-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 815.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 900.0 feet below Wardlow Road, Long Beach.
REGULATION- flow is subject to the same regulation as Stations F34D-R and F45B-R.
DIVERSIONS- flows diverted to Dominguez Gap Spreading Grounds.
CHANNEL- trapezoidal, concrete, 302.0 feet wide at bottom with 2.25:1 side slopes. Low flow channel 28.0 feet wide by 1.0 foot deep in center of channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F180-R October 31, 1931 to January 13, 1956. at Station F319-R January 13, 1956 to date.
REMARKS- prior to 1931, see Station F36-R.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO. : F319-R

DRAINAGE AREA : 815.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	125.0	271.0	129.0	344.0	732.0	1340.0	148.0	128.0	127.0	138.0	125.0	133.0
	MAX.	129.0	2790.0	173.0	2220.0	10700.0	8290.0	187.0	142.0	156.0	257.0	149.0	250.0
	MIN.	120.0	120.0	120.0	128.0	130.0	287.0	136.0	120.0	116.0	116.0	114.0	108.0
	TOTAL AF	7694.0	16122.0	7914.0	21138.0	40647.0	82556.0	8785.0	7896.0	7557.0	8489.0	7670.0	7942.0

VOL 12

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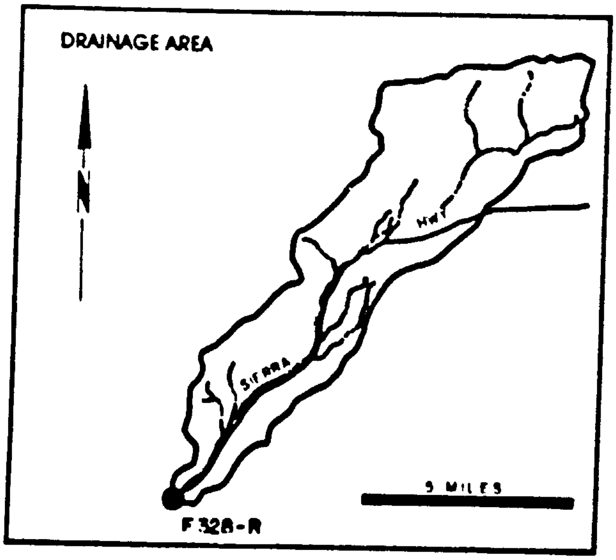
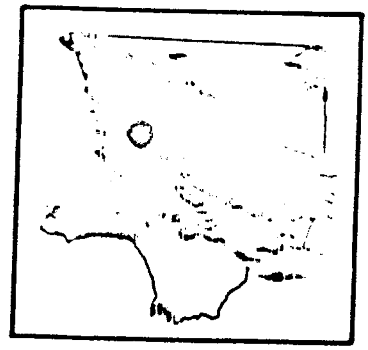
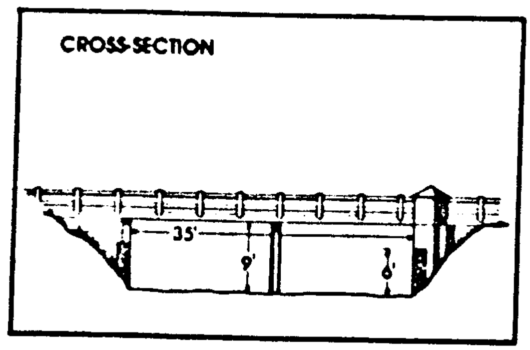
R0053248

MINT CANYON CREEK
at Finch Avenue
STATION NO. F328-R

VOL 12







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RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 26.9 square miles.
LOCATION- 8.5 miles northeast of Saugus on west end of Fitch Avenue bridge.
REGULATION- none.
CHANNEL- natural, sand and gravel.
CONTROL- concrete control at downstream end of bridge.
LENGTH OF RECORD- October 26, 1956 to date.

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4

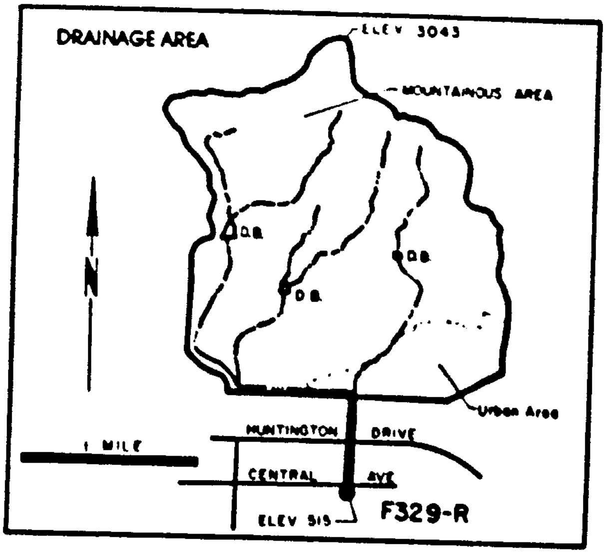
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

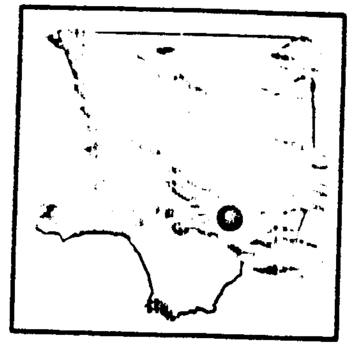
STATION NO.: F328-R

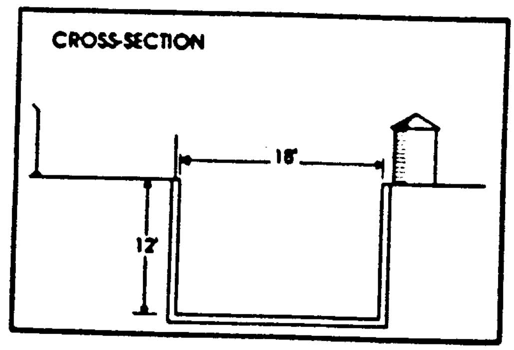
DRAINAGE AREA: 26.90 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN								0.0	0.0	0.0	0.0	0.0
	MAX.	RECORDER	INOPERATIVE						0.0	0.0	0.0	0.0	0.0
	MIN.								0.0	0.0	0.0	0.0	0.0
	TOTAL AF								0.0	0.0	0.0	0.0	0.0

BRADBURY CHANNEL
below Central Avenue
STATION NO. F329-R







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RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENT- low flows measured by wading. High flows measured from footbridge four feet downstream from recorder.
DRAINAGE AREA- 3.3 square miles.
LOCATION- on the east wall of Bradbury Channel, 200 feet downstream from the centerline of Central Avenue, one mile east of Duarte.
REGULATION- two debris basins located upstream.
CHANNEL- rectangular concrete, 18 feet wide, 12 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- June 14, 1957 to present.

1995

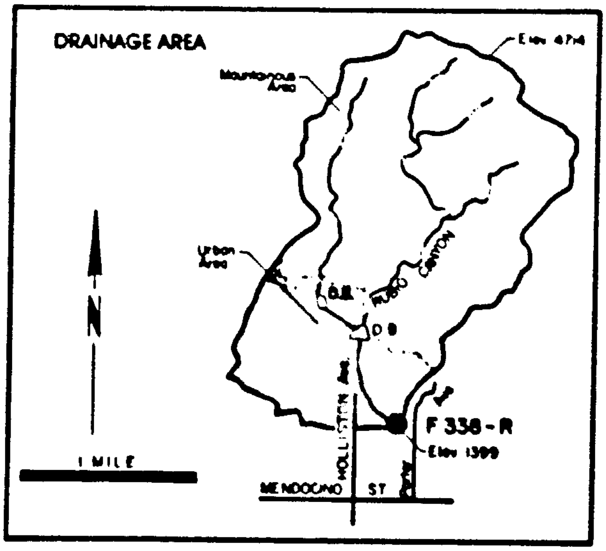
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

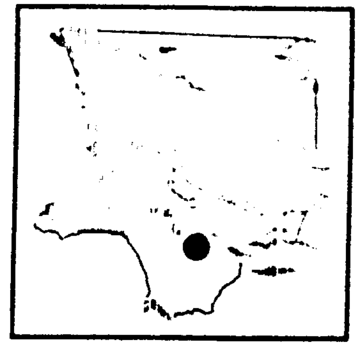
STATION NO.: F329-R

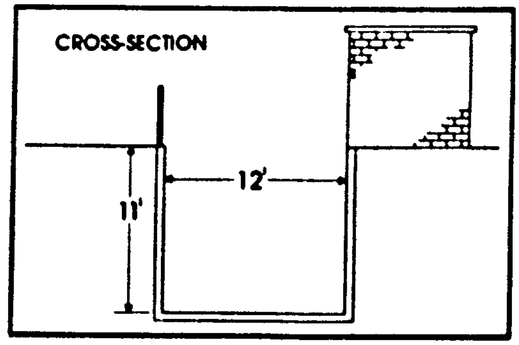
DRAINAGE AREA: 3.30 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.7	0.1	0.2	2.1	4.4	5.7	1.1	1.2	1.0	1.9	1.7	1.2
	MAX.	1.5	0.6	0.6	23.5	44.6	44.6	1.7	2.8	3.1	2.4	3.0	3.2
	MIN.	0.3	0.0	0.1	0.1	0.6	0.3	0.8	0.6	0.3	1.1	0.6	0.1
	TOTAL AF	43.6	6.1	9.7	131.0	244.0	351.0	62.7	73.8	58.3	115.0	105.0	66.4

RUBIO DIVERSION CHANNEL
below Goosebury Inlet
STATION NO. F338-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from steel footbridge 27 feet above station.
DRAINAGE AREA- 2.1 square miles.
LOCATION- on the north bank, 375 feet upstream of Crest Drive, three and one-half miles northeast of Pasadena.
REGULATION- flow partially regulated by Rubio and Gooseberry Debris Basins.
DIVERSIONS- Rubio Canyon Land and Water Association diverts low flows in Rubio Canyon.
CHANNEL- rectangular concrete, 12 feet wide and 11 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- December 16, 1969 to date.

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F338-R DRAINAGE AREA: 2.10 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.1	0.0	0.3	0.7	2.4	0.3	0.0	0.1	0.1	0.0	0.1
	MAX.	0.1	0.8	0.2	4.0	11.8	16.3	1.7	0.0	0.4	1.0	0.2	0.3
	MIN.	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.2	5.0	2.0	19.0	40.9	149.0	16.1	0.0	6.5	3.8	2.0	4.0

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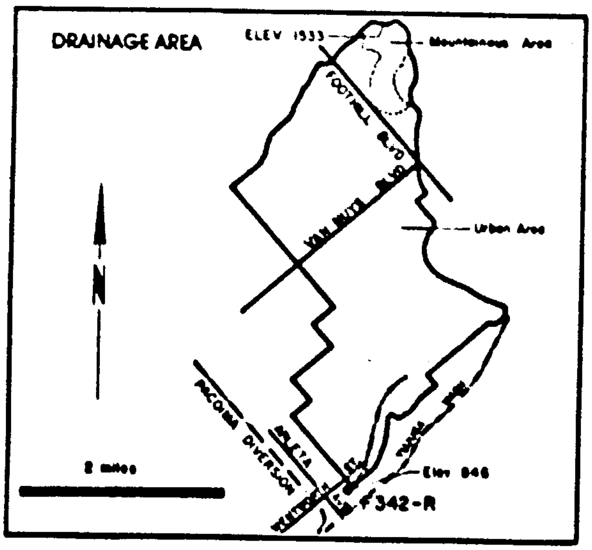
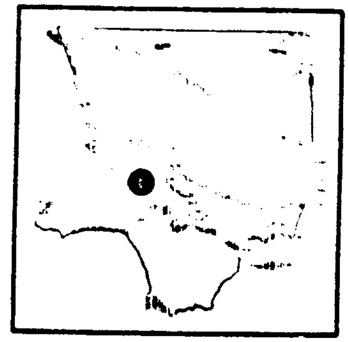
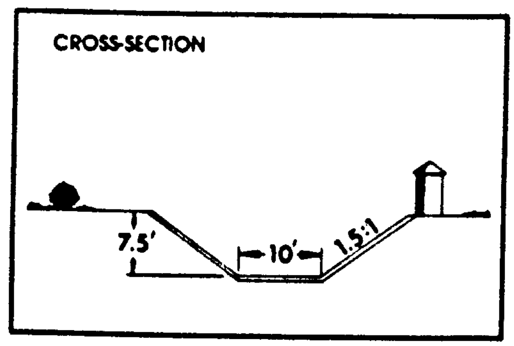
BRANFORD STREET CHANNEL
below Sharp Avenue
STATION NO. F342-R

VOL 12







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured by floats.
DRAINAGE AREA- 5.01 square miles.
LOCATION- on the south bank of channel, 125 feet downstream from Sharp Avenue, about 3.6 miles south of San Fernando.
REGULATION- flow from Lopez Creek is diverted to Hansen Dam at the mouth of Lopez Canyon.
CHANNEL- trapezoidal, 10 feet wide at bottom and 7.5 feet deep with 1. 5 to 1 side slopes.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1962 to date.

1 9947

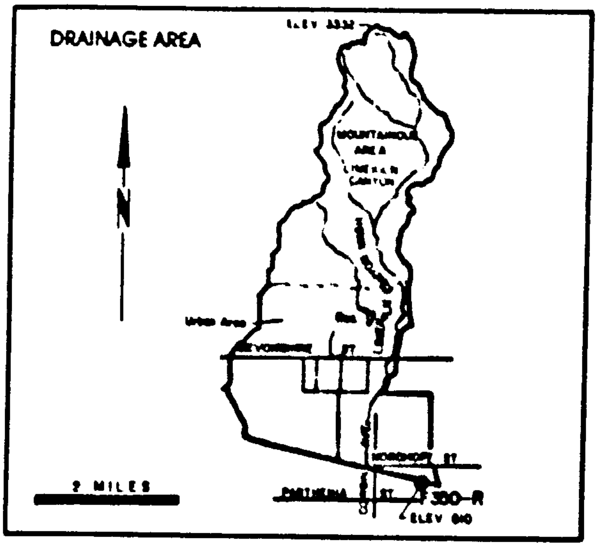
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

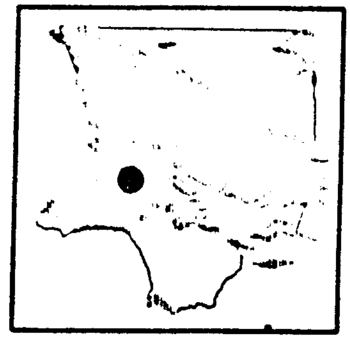
STATION NO.: F342-R

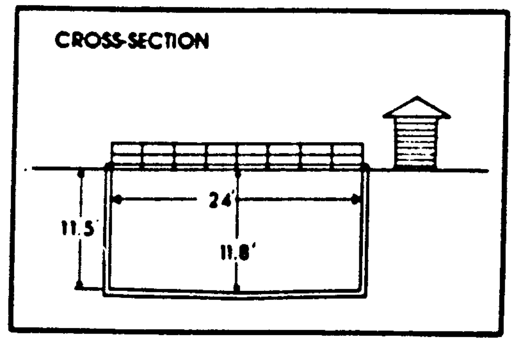
DRAINAGE AREA: 5.01 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.5	0.0	1.4	3.4	6.7	0.0	0.0	0.0	0.0	0.0	0.0
	MAX.	0.2	7.1	0.6	24.0	64.6	49.6	0.2	0.2	0.0	0.8	0.3	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.4	26.8	2.2	88.1	190.0	415.0	1.0	0.4	0.0	1.6	0.8	0.0

LIMEKILN CREEK
above Aliso Creek
STATION NO. F350-R







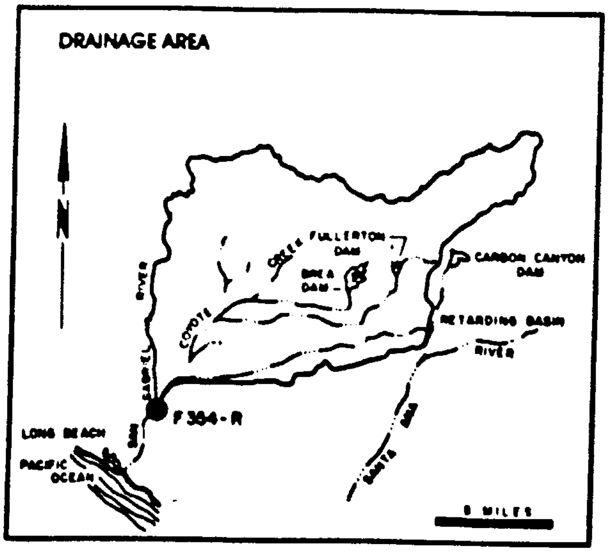
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from a steel footbridge 10 feet above the gage.
DRAINAGE AREA- 10.3 square miles.
LOCATION- on the south bank, 1,600 feet above Aliso Creek and one mile west of Northridge.
REGULATION- flow partly regulated by Limekiln Debris Basin.
CHANNEL- rectangular concrete.
LENGTH OF RECORD- see station summary.

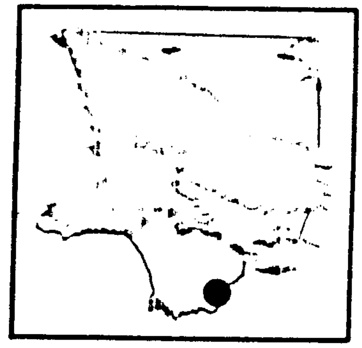
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

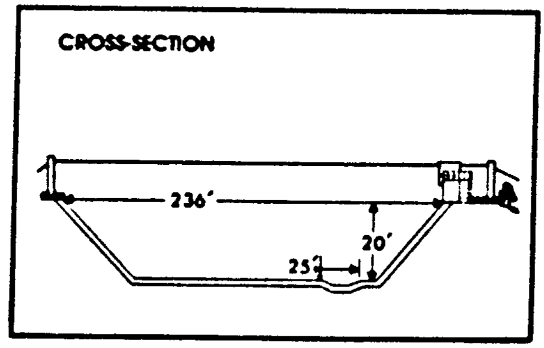
STATION NO. : F350-R DRAINAGE AREA : 10.30 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.9	1.6	0.5	0.6	12.2	16.0	0.3	0.4				
	MAX.	4.1	10.4	1.0	10.4	201.0	100.0	1.0	0.7		DEACTIVATED		
	MIN.	0.4	0.1	0.1	0.0	0.4	0.2	0.2	0.2				
	TOTAL AF	56.3	92.2	30.3	36.3	678.0	984.0	19.6	22.0				

COYOTE CREEK
below Spring Street
STATION NO. F354-R







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RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 185.0 square miles.

LOCATION- 241.0 feet below Spring Street, 7.5 miles northeast of Long Beach.

REGULATION- partially regulated by Fullerton Dam, Brea Dam, and Carbon Canyon Dam.

CHANNEL- concrete, trapezoidal in section.

CONTROL- channel forms control.

LENGTH OF RECORD - December 17, 1963 to date.

REMARKS - previous gaging stations for record corelation: Station F41 - S December 1, 1928 to January 14, 1930. Station F41 - R January 14, 1930 to October 30, 1936. Station F41B - R October 30, 1936 to February 17, 1937 Station F41C - R February 18, 1937 to February 8, 1956. Station F320 - R February 9, 1956 to July 2, 1965.

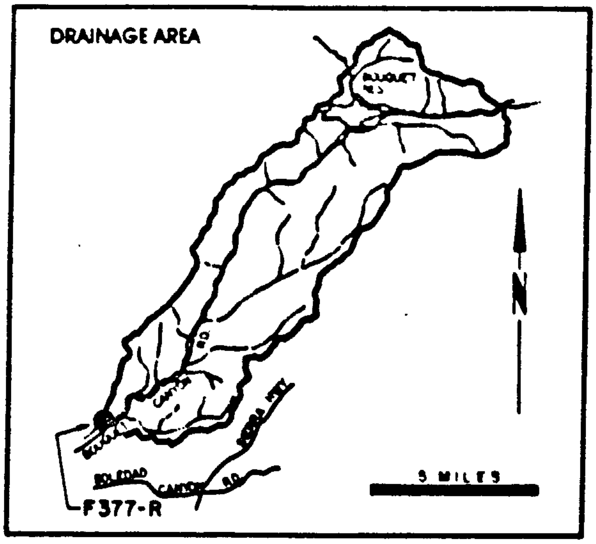
WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

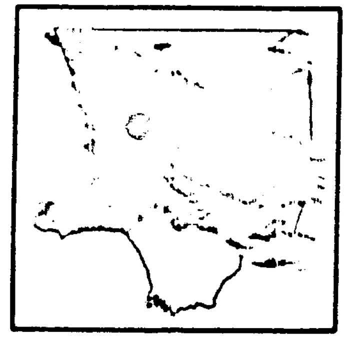
STATION NO.: F354-R

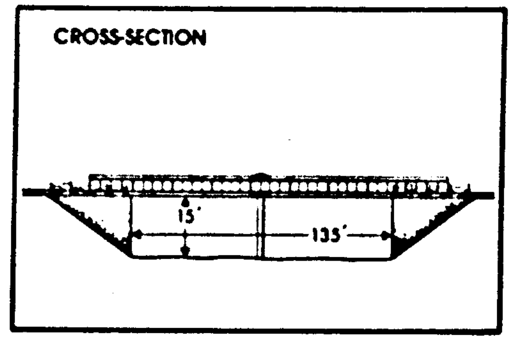
DRAINAGE AREA: 185.00 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	5.5	18.3	7.3	61.8	160.0	294.0	16.2	6.5	8.5	7.0	5.8	5.5
	MAX.	6.8	286.0	33.9	613.0	2250.0	1840.0	39.4	9.0	31.3	23.1	17.1	11.8
	MIN.	3.9	3.7	4.8	3.5	3.7	4.1	9.0	4.5	5.5	5.5	4.5	3.4
	TOTAL AF	337.0	1088.0	450.0	3798.0	8876.0	18097.0	964.0	398.0	506.0	430.0	358.0	329.0

BOUQUET CANYON CREEK
at Urbandale Avenue
STATION NO. F377-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 51.9 square miles.
LOCATION- Bouquet Canyon Creek at Urbandale Avenue, 3.5 miles northeast of Saugus.
REGULATION- Bouquet Reservoir.
CHANNEL- concrete sides with natural bottom, trapezoidal in section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- October 11, 1967 to date.

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WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F377-R

DRAINAGE AREA: 51.90 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	MAX.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
	MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL AF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0	0.0

DOMINGUEZ CHANNEL
at Vermont Avenue
STATION NO. F378-R

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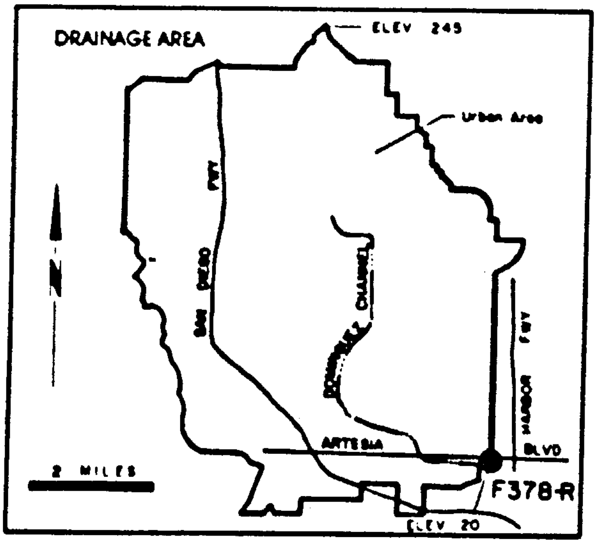

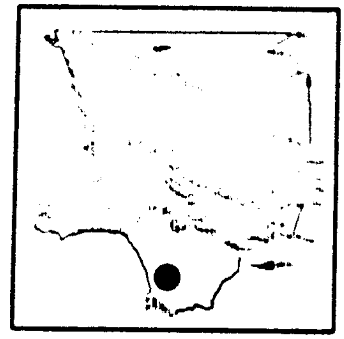

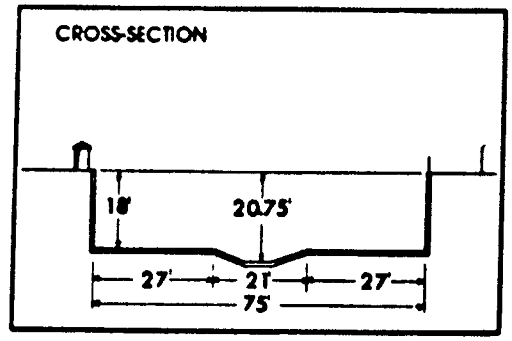

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RECORDER- continuous water stage.
METHOD OF MEASUREMENTS-low flows measured by wading. High flows measured from Vermont Avenue bridge.
DRAINAGE AREA- 37.1 square miles.
LOCATION- on the south bank, 93 feet above Vermont Avenue, about one mile south of Gardena.
REGULATION- none
CHANNEL- rectangular concrete with trapezoidal low flow channel at center.
LENGTH OF RECORD- November 23, 1966 to date.
REMARKS- gage is affected by tides greater than 4.0 feet above mean lower low water.

9951

WATER YEAR 1990 - 91
(DISCHARGE IN SEC-FT.)

STATION NO.: F378-R

DRAINAGE AREA: 37.10 SQ. MI.

		OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
WATER YEAR 90-91	MEAN	1.7	2.5	2.1	7.3	7.8	15.1	1.9	1.3	1.3	2.4	1.0	1.8
	MAX.	2.7	15.0	3.8	76.2	102.0	111.0	3.1	1.8	1.9	20.2	2.4	10.4
	MIN.	1.2	1.0	1.4	1.1	1.1	1.7	1.3	0.8	0.8	1.0	0.3	0.9
	TOTAL AF	105.0	146.0	127.0	449.0	432.0	928.0	115.0	81.9	74.2	146.0	59.9	106.0

RESERVOIRS

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RESERVOIRS

Following the damaging flood of 1914 and creation of the Los Angeles County Flood Control District in 1915, a program of flood control and water conservation was initiated. Part of this program included the construction of 14 dams. These dams were operated by the Department during the period covered by this report. In addition, two Corps of Engineers' dams, Santa Fe Dam and Whittier Narrows Dam, and Morris Dam owned by The Metropolitan Water District were operated in conjunction with the Department dams to achieve flood control and/or water conservation.

OPERATION

The reservoirs are operated to control flood waters during storm periods. Post storm releases are made, when feasible, in amounts which can be conserved in downstream spreading grounds and by channel percolation. Cleanouts are done to regain storage capacity in reservoirs (see Erosion Control for cleanout data). Cogswell Reservoir had valve cylinders replaced this water year during a dry cleanout.

RECORDS

The storage and flow records at the 14 Department reservoirs are summarized on the Dam Operation Record Sheets. The sheets show:

1. Reservoir water surface elevations. Elevations are obtained from water stage recorder graphs or interpolation from staff gage readings and recorded as of midnight of each day. Only maximum and minimum water surface elevations for each year are shown.

2. Storage in acre-feet based on the most recent topographic surveys. Annual storage volumes are shown.

3. Inflow in cubic feet per second. This is usually calculated from storage change and known outflow. Only the maximum and minimum of the daily flow rates for the year and the instantaneous peak flow rate are shown.

4. Outflow in cubic feet per second. These values are determined from gaging station records, or when these are not available, from valve and spillway rating curves. Only the maximum and minimum of the daily outflow rates for the year and the instantaneous peak outflow rate are shown.

5. Discrepancies between outflow and storage losses at certain dams are attributable to evaporation and/or percolation losses. Total monthly evaporation losses are determined from the measurements made on land evaporation pans. In those cases where no allowances were made for evaporation, the amounts are necessarily included in the flow values. Accuracy of flow records computed from storage records is dependent on the frequency with which storage data are revised to keep in step with the physical change in reservoirs.

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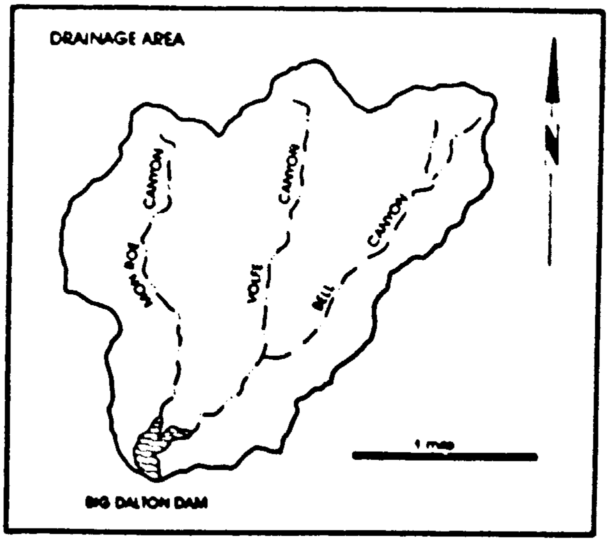
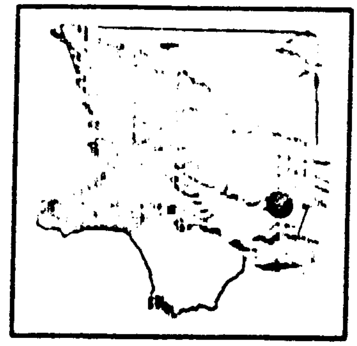
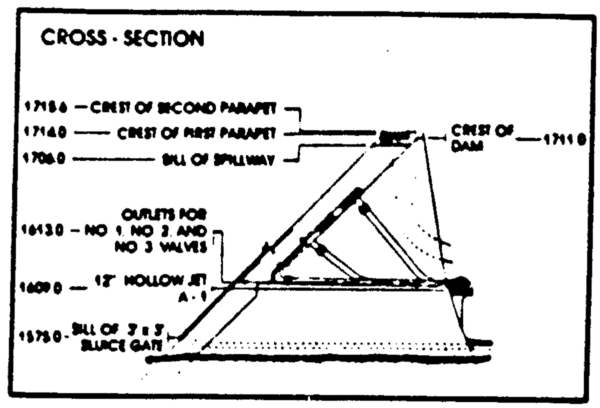
BIG DALTON DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1927. Completed August 1929.
LOCATION - Big Dalton Canyon, 4.0 miles northeast of Glendora.
DRAINAGE AREA - 4.5 square miles.
CAPACITY - 963 acre - feet.
SPILLWAY ELEVATION - 1,706.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	62.01	CFS	from	0000	on	03-27-91	to	0100	on	03-27-91
MAX. PEAK OUTFLOW	10.90	CFS	from	0930	on	03-27-91	to	2330	on	03-28-91
MAX. W.S. ELEVATION	1648.60	feet	on	03-29-91	STORAGE	125.60	ACRE-FEET			
MIN. W.S. ELEVATION	1632.00	feet	on	04-11-91	STORAGE	58.20	ACRE-FEET			

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BIG DALTON DAM OPERATION RECORD SUMMARY

WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	1.60	2.70	1.30	3.60
TOTAL MONTHLY OUTFLOW (AF)	0.00	13.70	0.00	1.20
MAX. MEAN DAILY INFLOW (CFS)	0.10	0.20	0.10	0.70
TOTAL MONTHLY LOSSES (AF)	1.70	1.00	0.60	0.40
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	-11.90	0.70	2.00

WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	14.60	290.50	96.40	24.90
TOTAL MONTHLY OUTFLOW (AF)	0.00	262.20	124.80	0.00
MAX. MEAN DAILY INFLOW (CFS)	6.30	25.90	5.00	0.70
TOTAL MONTHLY LOSSES (AF)	0.70	0.70	1.30	1.90
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.50	0.50	0.10
MONTHLY STORAGE CHANGE (AF)	13.90	27.70	-29.60	22.90

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	14.20	10.20	6.40	4.00
TOTAL MONTHLY OUTFLOW (AF)	50.80	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.40	0.30	0.10	0.10
TOTAL MONTHLY LOSSES (AF)	1.40	1.90	2.10	1.80
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.10	0.00
MONTHLY STORAGE CHANGE (AF)	-38.00	8.30	4.30	2.30

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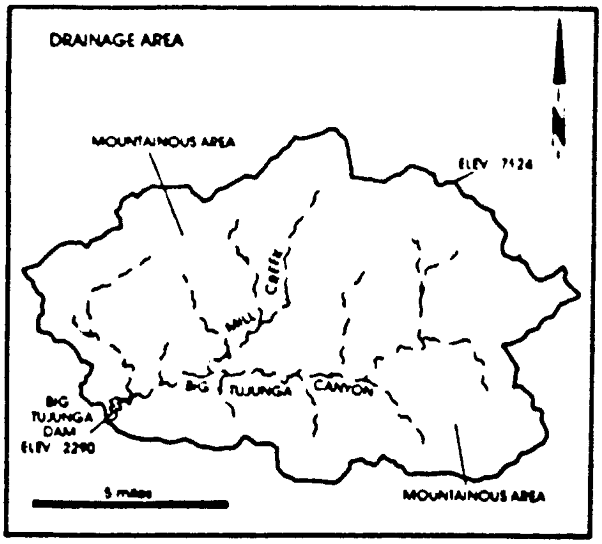
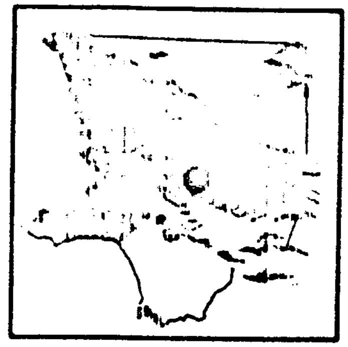
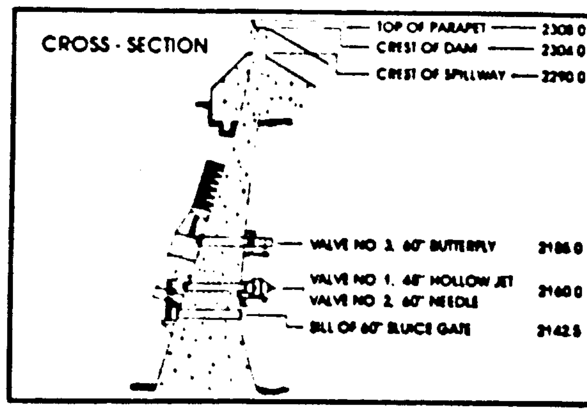
BIG TUJUNGA DAM
AND RESERVOIR





PURPOSE - Flood Control Conservation.
DATE CONSTRUCTED - Started January 1930 Completed July 1931.
LOCATION - Big Tujunga Canyon, 10.0 miles northeast of Sunland.
DRAINAGE AREA - 82.3 square miles.
CAPACITY - 6,027 acre - feet.
SPILLWAY ELEVATION - 2,290.0 feet.



DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	1871.16	CFS	from	0700	on	03-01-91	to	0800	on	03-01-91
MAX. PEAK OUTFLOW	470.00	CFS	from	1000	on	03-01-91	to	1015	on	03-01-91
MAX. W.S. ELEVATION	2229.70	feet	on	03-01-91	STORAGE	1871.30	ACRE-FEET			
MIN. W.S. ELEVATION	2204.35	feet	on	varies	STORAGE	1036.10	ACRE-FEET			

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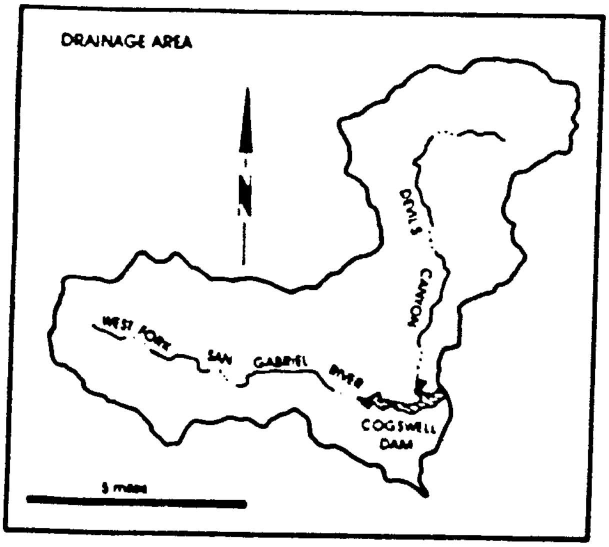
BIG TUJUNGA DAM OPERATION RECORD SUMMARY

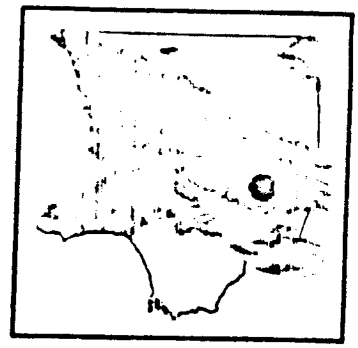
WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	9.80	69.50	66.80	137.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	193.30	0.00	100.80
MAX. MEAN DAILY INFLOW (CFS)	0.40	5.00	2.60	5.90
TOTAL MONTHLY LOSSES (AF)	21.00	16.90	9.70	8.40
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.10	0.00
MONTHLY STORAGE CHANGE (AF)	-11.20	-140.70	57.10	28.10

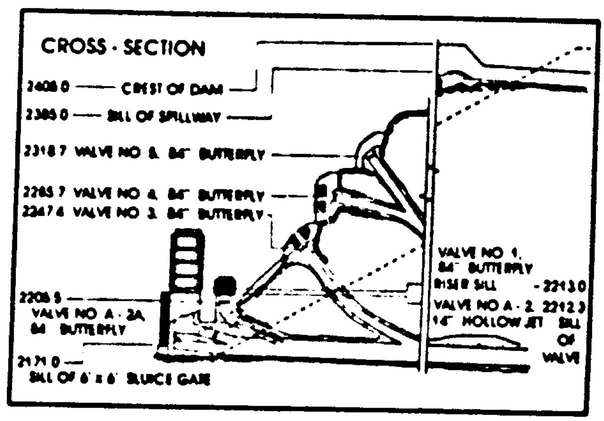
WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	541.40	4123.80	1895.10	588.00
TOTAL MONTHLY OUTFLOW (AF)	305.50	3894.00	2319.60	553.70
MAX. MEAN DAILY INFLOW (CFS)	196.40	529.50	85.60	13.00
TOTAL MONTHLY LOSSES (AF)	12.60	9.00	15.20	18.30
MIN. MEAN DAILY INFLOW (CFS)	0.50	6.10	13.10	6.30
MONTHLY STORAGE CHANGE (AF)	223.30	130.90	-439.60	16.00

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	301.60	249.00	52.30	39.70
TOTAL MONTHLY OUTFLOW (AF)	288.40	242.80	3.40	0.00
MAX. MEAN DAILY INFLOW (CFS)	8.30	5.60	2.30	1.00
TOTAL MONTHLY LOSSES (AF)	21.60	23.60	17.00	20.60
MIN. MEAN DAILY INFLOW (CFS)	3.70	2.80	0.00	0.30
MONTHLY STORAGE CHANGE (AF)	-8.40	-17.40	31.90	19.10

COGSWELL DAM
AND RESERVOIR







PURPOSE - Flood Control, Conservation, and Recreation.
DATE CONSTRUCTED - Started March 1932. Completed April 1934.
LOCATION - 22.0 miles north of Azusa.
DRAINAGE AREA - 39.2 square miles.
CAPACITY - 9,339 acre-feet.
SPILLWAY ELEVATION - 2,385.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	1063.09	CFS	from	0500	on	03-01-91	to	0600	on	03-01-91
MAX. PEAK OUTFLOW	417.00	CFS	from	1530	on	04-03-91	to	1700	on	04-03-91
MAX. W.S. ELEVATION	2325.60	feet	on	03-05-91	STORAGE	2752.00	ACRE-FEET			
MIN. W.S. ELEVATION	2190.12	feet	on	varies	STORAGE	2.80	ACRE-FEET			

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R0053264

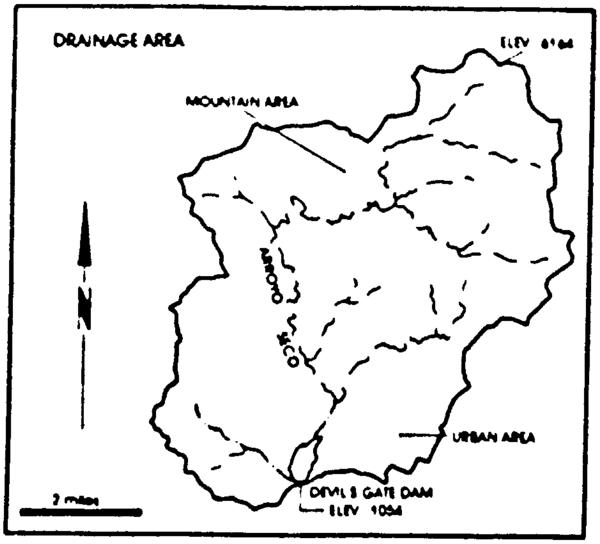
COGSWELL DAM OPERATION RECORD SUMMARY

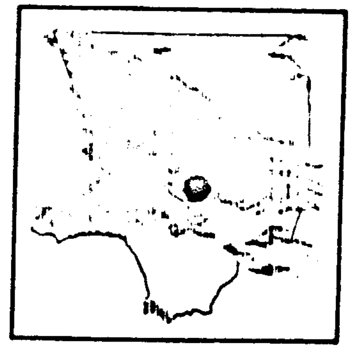
WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	10.00	17.10	25.50	42.30
TOTAL MONTHLY OUTFLOW (AF)	118.00	122.80	102.30	90.20
MAX. MEAN DAILY INFLOW (CFS)	0.70	3.20	0.70	1.60
TOTAL MONTHLY LOSSES (AF)	8.20	5.10	2.60	2.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.10	0.10	0.40
MONTHLY STORAGE CHANGE (AF)	-116.20	-110.80	-79.50	-50.00

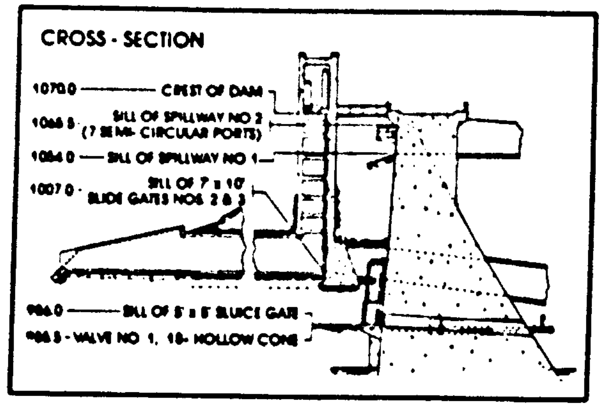
WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	868.70	5402.40	2618.00	640.50
TOTAL MONTHLY OUTFLOW (AF)	98.60	3967.30	5120.70	633.90
MAX. MEAN DAILY INFLOW (CFS)	357.00	605.00	113.60	18.00
TOTAL MONTHLY LOSSES (AF)	2.70	8.20	4.20	2.20
MIN. MEAN DAILY INFLOW (CFS)	0.60	8.20	16.80	6.60
MONTHLY STORAGE CHANGE (AF)	767.40	1426.80	-2507.00	4.40

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	257.70	160.30	107.80	78.80
TOTAL MONTHLY OUTFLOW (AF)	285.80	179.30	110.50	91.80
MAX. MEAN DAILY INFLOW (CFS)	6.70	4.20	2.60	3.10
TOTAL MONTHLY LOSSES (AF)	1.70	1.40	0.90	0.50
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.70	1.00	0.10
MONTHLY STORAGE CHANGE (AF)	-29.90	-20.40	-3.50	-13.50

DEVIL'S GATE DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started May 1919 Completed June 1920.
LOCATION - On Arroyo Seco, northwest of Pasadena.
DRAINAGE AREA - 31.9 square miles.
CAPACITY - 1,928 acre - feet.
SPILLWAY ELEVATION - 1,054.0 feet.

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1996

DAM OPERATION RECORD SUMMARY *

MAX. PEAK INFLOW	923.97	CFS	from	0200	on	03-01-91	to	0300	on	03-01-91
MAX. PEAK OUTFLOW	800.00	CFS	from	1300	on	03-01-91	to	1600	on	03-01-91
MAX. W.S. ELEVATION	1032.63	feet	on	03-01-91	STORAGE	701.38	ACRE-FEET			
MIN. W.S. ELEVATION	993.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

R0053266

DEVIL'S GATE DAM OPERATION RECORD SUMMARY *

WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	4.20	0.00	20.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	4.20	0.00	20.20
MAX. MEAN DAILY INFLOW (CFS)	0.00	1.60	0.00	8.60
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	681.10	3976.70	218.20	28.80
TOTAL MONTHLY OUTFLOW (AF)	533.40	4124.20	218.40	28.80
MAX. MEAN DAILY INFLOW (CFS)	238.30	522.80	22.10	0.80
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	1.00	0.00	0.30
MONTHLY STORAGE CHANGE (AF)	147.70	-147.50	-0.20	0.00

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	22.60	45.40	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	22.60	45.40	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.80	3.40	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.20	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

* = VALUES ESTIMATED DUE TO INCOMPLETE RECORDS

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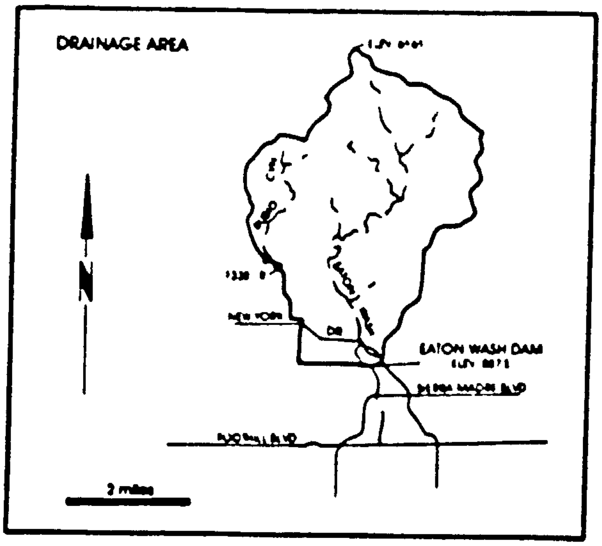
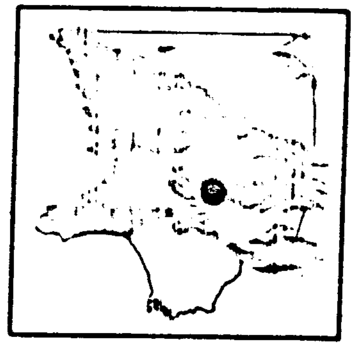
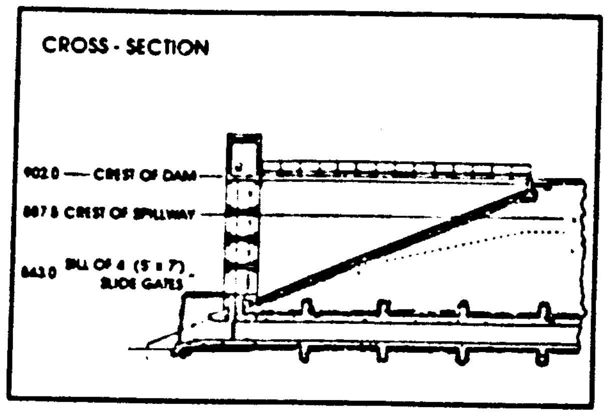
EATON WASH DAM
AND RESERVOIR







PURPOSE - Debris Storage and Conservation.
DATE CONSTRUCTED - Started January 1936 Completed February 1937
LOCATION - Eaton Wash, northeast of Pasadena.
DRAINAGE AREA - 12.4 square miles.
CAPACITY - 879 acre - feet.
SPILLWAY ELEVATION - 887.5 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	239.10	CFS	from	0300	on	03-01-91	to	0400	on	03-01-91
MAX. PEAK OUTFLOW	150.00	CFS	from	1600	on	03-01-91	to	1800	on	03-01-91
MAX. W.S. ELEVATION	880.77	feet	on	03-01-91	STORAGE	478.82	ACRE-FEET			
MIN. W.S. ELEVATION	846.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

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R0053268

EATON WASH DAM OPERATION RECORD SUMMARY

WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	9.90
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	2.10
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	9.90
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	264.90	1152.30	172.90	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	1168.50	400.30	0.00
MAX. MEAN DAILY INFLOW (CFS)	95.40	126.70	14.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	12.50	0.00	6.50
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	264.90	-28.60	-227.40	-7.60

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	2.10	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	20.20	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.10	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	4.60	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	-22.70	0.00	0.00	0.00

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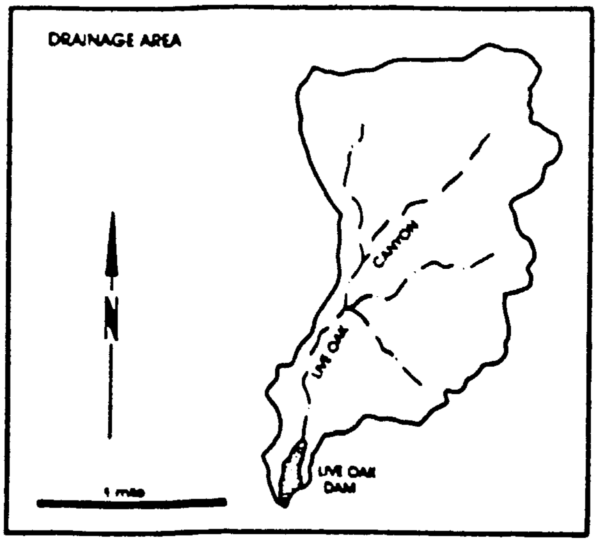
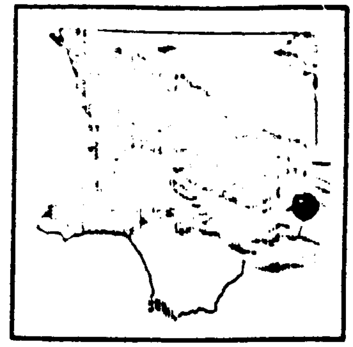
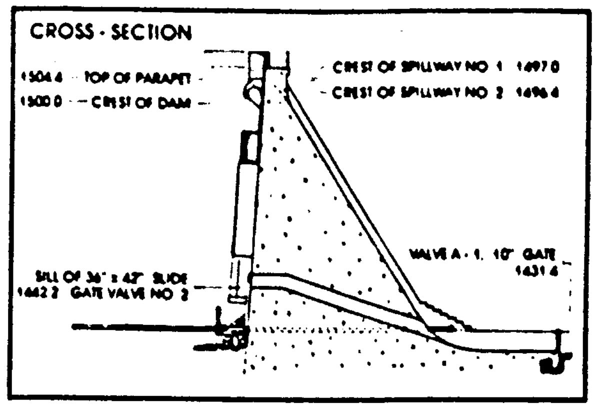
LIVE OAK DAM
AND RESERVOIR







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PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started August 1921. Completed November 1922.
LOCATION - 2.5 miles northeast of La Verne.
DRAINAGE AREA - 2.3 square miles.
CAPACITY - 240 acre feet.
SPILLWAY ELEVATION - 1,496.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	44.45	CFS	from	0900	on	03-01-91	to	1000	on	03-01-91
MAX. PEAK OUTFLOW	4.80	CFS	from	20.15	on	03-04-91	to	2030	on	03-04-91
MAX. W.S. ELEVATION	1473.00	feet	on	03-02-91	STORAGE	62.60	ACRE-FEET			
MIN. W.S. ELEVATION	1440.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

LIVE OAK DAM OPERATION RECORD SUMMARY

WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	27.90	154.30	10.40	7.70
TOTAL MONTHLY OUTFLOW (AF)	5.40	148.20	37.50	7.70
MAX. MEAN DAILY INFLOW (CFS)	13.00	21.60	1.70	0.30
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	1.60	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	22.60	6.10	-28.70	0.00

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	5.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	5.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.30	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

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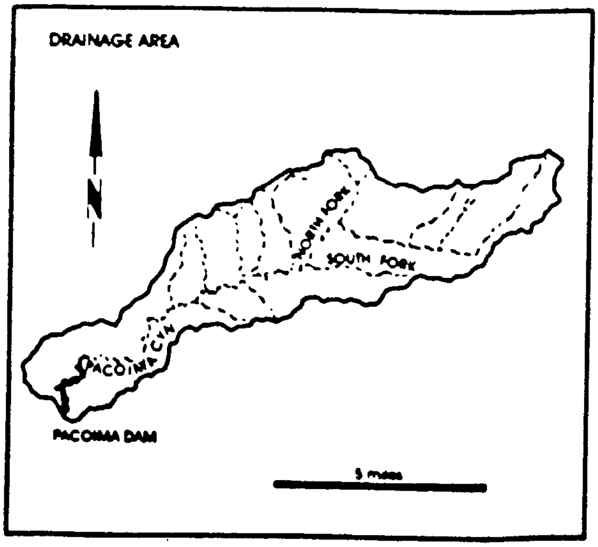
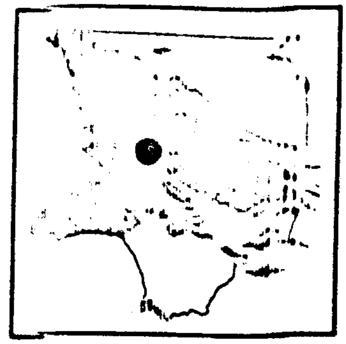
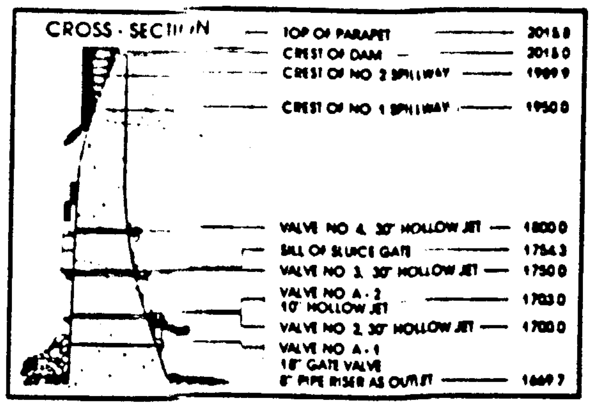
PACOIMA DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1925. Completed February 1929.
LOCATION - Pacoima Canyon, 4.0 miles northeast of San Fernando.
DRAINAGE AREA - 28.2 square miles.
CAPACITY - 3,929 acre-feet.
SPILLWAY ELEVATION - 1,950.0 feet.



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DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	139.36	CFS	from	0600	on	03-27-91	to	0700	on	03-27-91
MAX. PEAK OUTFLOW	100.00	CFS	from	1500	on	04-03-91	to	0800	on	04-04-91
MAX. W.S. ELEVATION	1941.60	feet	on	04-03-91	STORAGE	3210.60	ACRE-FEET			
MIN. W.S. ELEVATION	1882.35	feet	on	05-16-91	STORAGE	1108.30	ACRE-FEET			

PACOIMA DAM OPERATION RECORD SUMMARY

WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	19.40	18.40	15.20	21.50
TOTAL MONTHLY OUTFLOW (AF)	2.40	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.70	0.70	0.40	1.70
TOTAL MONTHLY LOSSES (AF)	19.70	17.10	13.70	10.60
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.10	0.10	0.10
MONTHLY STORAGE CHANGE (AF)	-2.70	1.30	1.40	11.00

WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	63.70	1852.00	1287.90	78.40
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	2272.50	942.10
MAX. MEAN DAILY INFLOW (CFS)	19.00	126.90	51.30	3.50
TOTAL MONTHLY LOSSES (AF)	13.30	11.90	26.20	15.00
MIN. MEAN DAILY INFLOW (CFS)	0.10	1.70	0.20	0.00
MONTHLY STORAGE CHANGE (AF)	50.40	1840.10	-1010.80	-878.80

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	60.10	43.90	33.10	26.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	4.40	0.20	0.00
MAX. MEAN DAILY INFLOW (CFS)	1.90	0.90	1.10	0.70
TOTAL MONTHLY LOSSES (AF)	10.80	13.70	16.10	16.30
MIN. MEAN DAILY INFLOW (CFS)	0.70	0.50	0.30	0.10
MONTHLY STORAGE CHANGE (AF)	49.20	25.80	16.80	9.80

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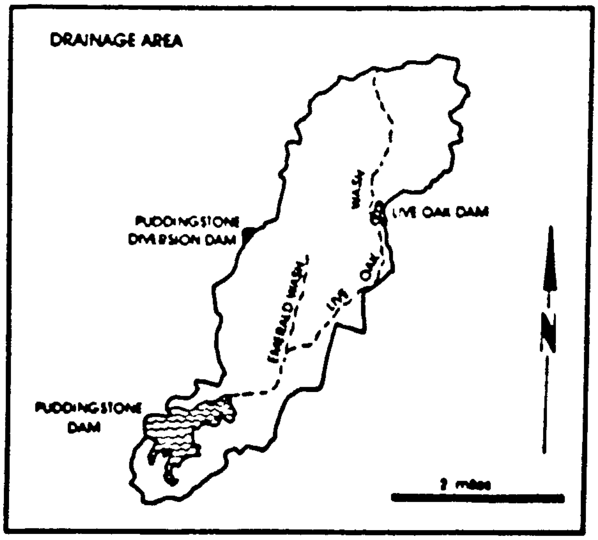
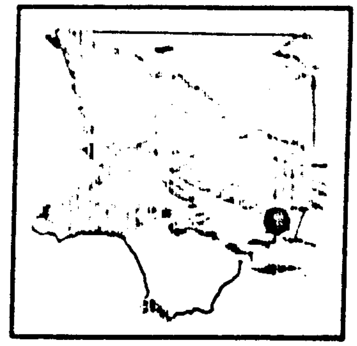
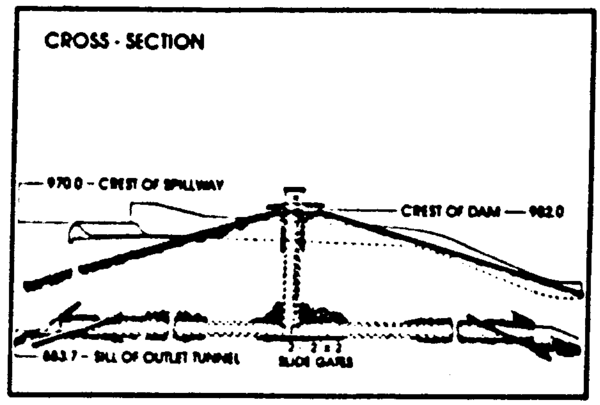
PUDDINGSTONE DAM
AND RESERVOIR







PURPOSE - Flood Control and Recreation.
DATE CONSTRUCTED - Started February 1925. Completed January 1928.
LOCATION - 1.0 mile south of San Dimas.
DRAINAGE AREA - 11.0 square miles (uncontrolled)
22.1 square miles (controlled)
Total 33.1 square miles
CAPACITY - 16,856 acre - feet.
SPILLWAY ELEVATION - 970.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	1269.53	CFS	from	0400	on	03-01-91	to	0500	on	03-01-91
MAX. PEAK OUTFLOW	697.00	CFS	from	0215	on	03-27-91	to	0245	on	03-27-91
MAX. W.S. ELEVATION	946.01	feet	on	03-01-91	STORAGE	7611.72	ACRE-FEET			
MIN. W.S. ELEVATION	939.82	feet	on	varies	STORAGE	6024.80	ACRE-FEET			

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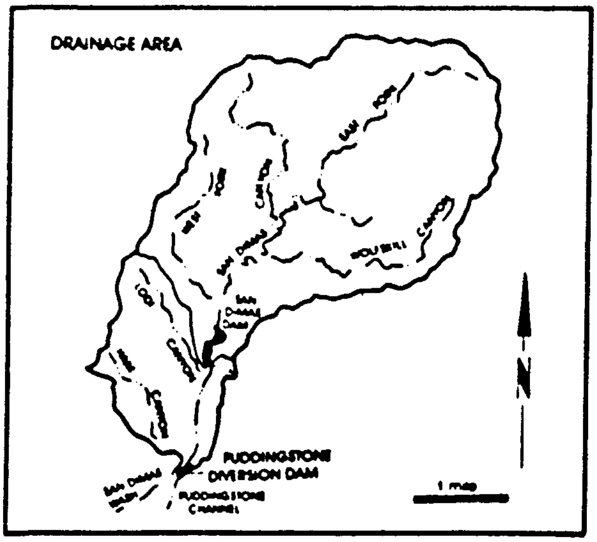
PUDDINGSTONE DAM OPERATION RECORD SUMMARY

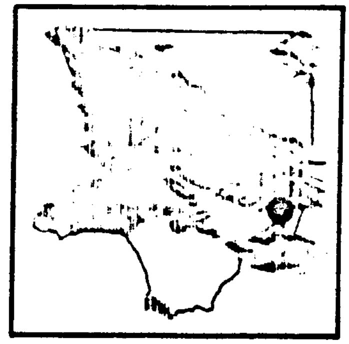
WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	76.70	99.20	38.90	460.40
TOTAL MONTHLY OUTFLOW (AF)	13.70	11.50	6.10	12.30
MAX. MEAN DAILY INFLOW (CFS)	3.00	5.80	1.90	101.80
TOTAL MONTHLY LOSSES (AF)	135.00	102.60	91.70	52.80
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.10	0.10	0.30
MONTHLY STORAGE CHANGE (AF)	-72.00	-14.80	-59.00	395.30

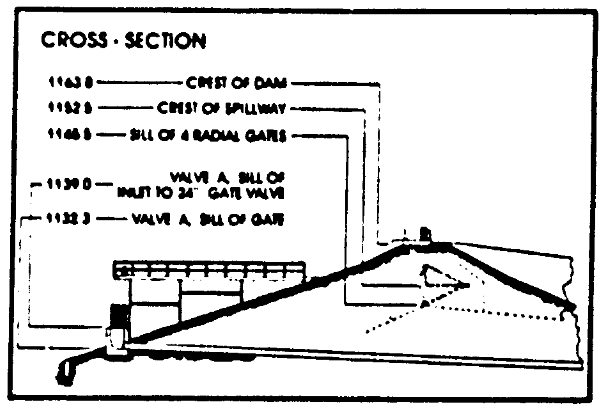
WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1252.20	1968.50	252.50	61.30
TOTAL MONTHLY OUTFLOW (AF)	201.70	2237.20	275.90	89.50
MAX. MEAN DAILY INFLOW (CFS)	371.20	278.60	14.80	3.30
TOTAL MONTHLY LOSSES (AF)	77.50	70.00	126.30	156.00
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.20	0.30	0.10
MONTHLY STORAGE CHANGE (AF)	973.00	-338.60	-149.70	-184.20

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	65.10	67.10	68.60	50.10
TOTAL MONTHLY OUTFLOW (AF)	45.60	13.50	15.70	9.50
MAX. MEAN DAILY INFLOW (CFS)	3.50	2.70	3.30	1.80
TOTAL MONTHLY LOSSES (AF)	156.80	186.40	188.40	154.70
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.00	0.20	0.10
MONTHLY STORAGE CHANGE (AF)	-137.10	-132.80	-135.50	-114.10

PUDDINGSTONE DIVERSION DAM
AND RESERVOIR







PURPOSE - Flood Control and Diversion of flow and Conservation.

DATE CONSTRUCTED - Started September 1927. Completed July 1928.

LOCATION - 2.0 miles northeast of San Dimas.

DRAINAGE AREA - 3.7 square miles (uncontrolled)
16.2 square miles (controlled)
Total 19.9 square miles

CAPACITY - 148 acre feet.

SPILLWAY ELEVATION - 1,152.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	195.43	CFS	from	1100	on	02-28-91	to	1200	on	02-28-91
MAX. PEAK OUTFLOW	20.50	CFS	from	1600	on	03-06-91	to	1615	on	03-06-91
MAX. W.S. ELEVATION	1148.70	feet	on	03-01-91	STORAGE	136.80	ACRE-FEET			
MIN. W.S. ELEVATION	1133.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

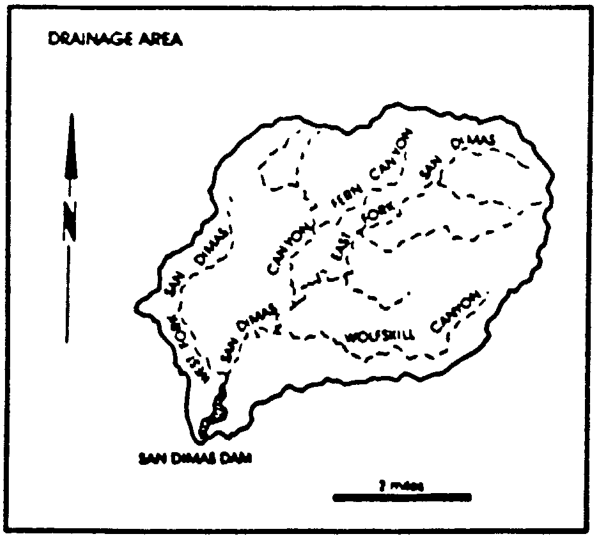
PUDDINGSTONE DIVERSION DAM OPERATION RECORD SUMMARY

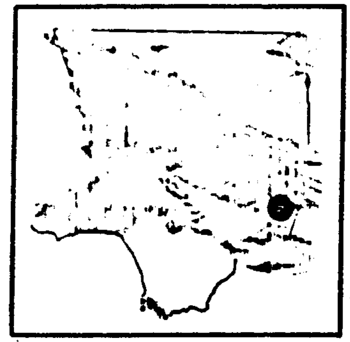
WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	6.40
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.20
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	2.90
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	6.30
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

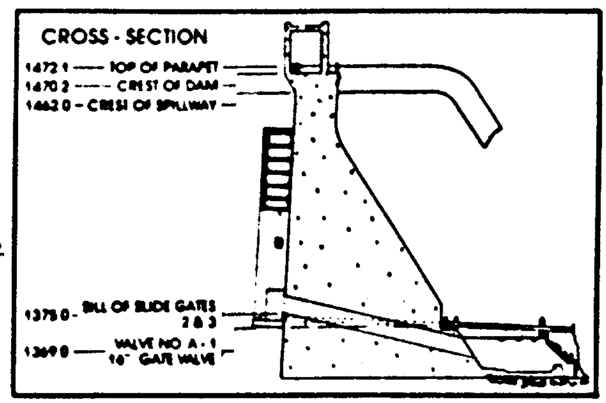
WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	113.40	645.30	594.90	336.30
TOTAL MONTHLY OUTFLOW (AF)	13.30	660.50	587.30	375.90
MAX. MEAN DAILY INFLOW (CFS)	53.90	33.70	12.10	7.80
TOTAL MONTHLY LOSSES (AF)	0.10	0.00	4.90	10.10
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	6.30	0.00
MONTHLY STORAGE CHANGE (AF)	100.00	-15.20	2.70	-49.70

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	355.90	27.10	0.10	0.00
TOTAL MONTHLY OUTFLOW (AF)	361.00	16.10	9.30	0.00
MAX. MEAN DAILY INFLOW (CFS)	12.60	2.90	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	11.90	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	-5.10	-0.80	-9.20	0.00

SAN DIMAS DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started November 1920. Completed September 1922.
LOCATION - 3.0 miles northeast of San Dimas.
DRAINAGE AREA - 16.2 square miles.
CAPACITY - 1,515 acre - feet.
SPILLWAY ELEVATION - 1,462.0 feet.

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DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	236.29	CFS	from	0000	on	03-27-91	to	0100	on	03-27-91
MAX. PEAK OUTFLOW	229.40	CFS	from	0815	on	10-23-90	to	0830	on	10-23-90
MAX. W.S. ELEVATION	1451.90	feet	on	03-31-91	STORAGE	1209.40	ACRE-FEET			
MIN. W.S. ELEVATION	1374.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

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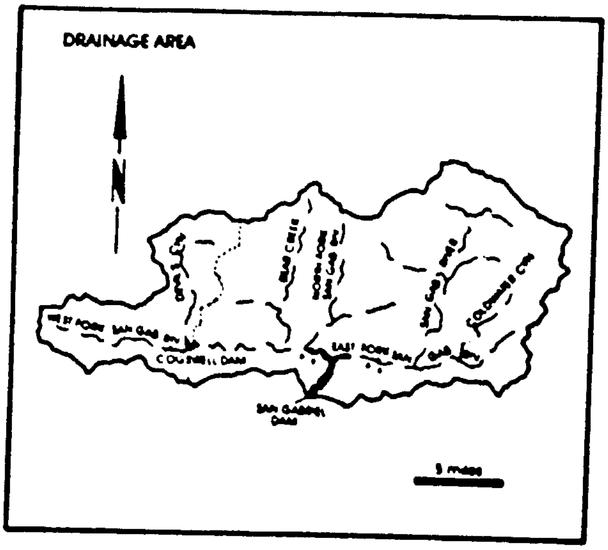
SAN DIMAS DAM OPERATION RECORD SUMMARY

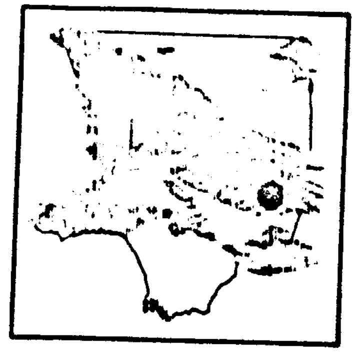
WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	6.00	13.10	36.10	88.40
TOTAL MONTHLY OUTFLOW (AF)	18.40	11.50	10.30	14.90
MAX. MEAN DAILY INFLOW (CFS)	1.10	1.20	0.90	7.30
TOTAL MONTHLY LOSSES (AF)	8.40	6.10	3.80	3.90
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.20	0.30
MONTHLY STORAGE CHANGE (AF)	-20.90	-4.60	22.00	69.70

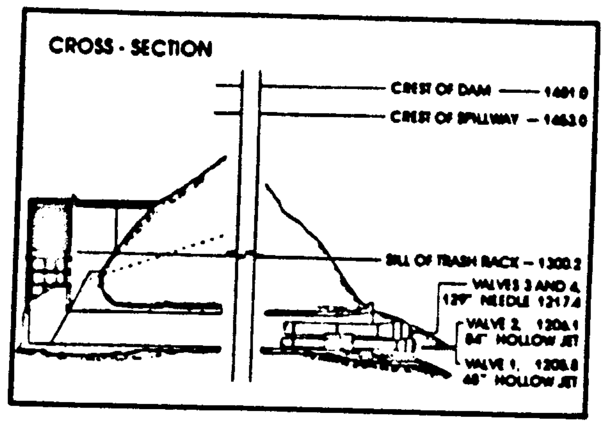
WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	265.60	1034.10	268.60	131.60
TOTAL MONTHLY OUTFLOW (AF)	12.30	591.50	653.40	475.30
MAX. MEAN DAILY INFLOW (CFS)	107.90	111.90	11.70	3.10
TOTAL MONTHLY LOSSES (AF)	4.70	7.00	10.40	11.50
MIN. MEAN DAILY INFLOW (CFS)	0.20	2.50	2.00	1.40
MONTHLY STORAGE CHANGE (AF)	248.60	435.60	-395.10	-355.10

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	52.50	37.70	20.00	13.30
TOTAL MONTHLY OUTFLOW (AF)	400.10	139.50	20.00	13.30
MAX. MEAN DAILY INFLOW (CFS)	2.60	1.50	0.40	0.30
TOTAL MONTHLY LOSSES (AF)	7.30	2.50	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.10	0.20	0.20
MONTHLY STORAGE CHANGE (AF)	-354.90	-104.30	0.00	0.00

SAN GABRIEL DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1932. Completed July 1939.
LOCATION - San Gabriel Canyon, 7.5 miles north of Azusa.
DRAINAGE AREA - 163.5 square miles (uncontrolled)
39.2 square miles (controlled)
Total 202.7 square miles
(Includes Cogswell drainage)
CAPACITY - 41,549 acre - feet.
SPILLWAY ELEVATION - 1,453 feet.

VOL 12

1975

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	4294.32 CFS from 0700 on 03-01-91 to 0800 on 03-01-91
MAX. PEAK OUTFLOW	2702.16 CFS from 1100 on 04-23-91 to 1115 on 04-23-91
MAX. W.S. ELEVATION	1438.49 feet on 06-26-91 STORAGE 36892.46 ACRE-FEET
MIN. W.S. ELEVATION	1324.80 feet on 11-08-90 STORAGE 2350.00 ACRE-FEET

VOL 12

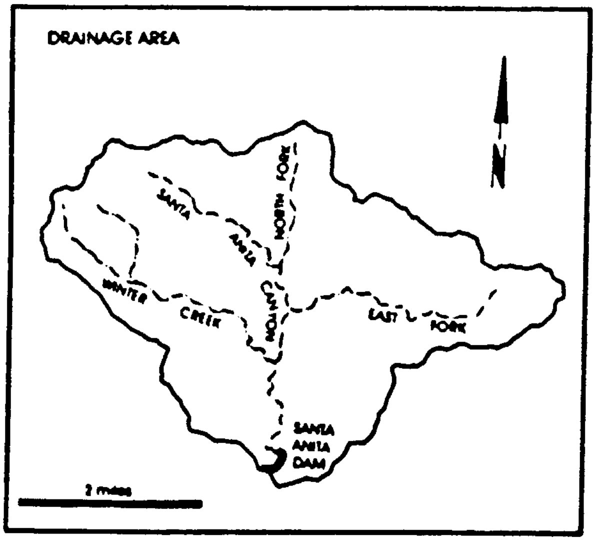
SAN GABRIEL DAM OPERATION RECORD SUMMARY

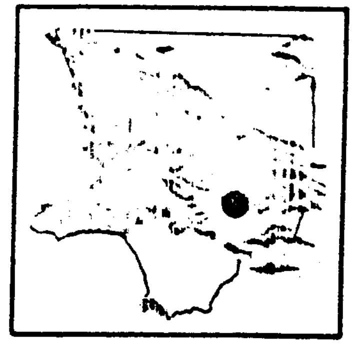
WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	401.50	545.40	744.90	1183.20
TOTAL MONTHLY OUTFLOW (AF)	1186.70	392.90	570.00	721.60
MAX. MEAN DAILY INFLOW (CFS)	10.30	13.10	15.20	40.60
TOTAL MONTHLY LOSSES (AF)	83.80	55.70	43.40	40.00
MIN. MEAN DAILY INFLOW (CFS)	3.30	6.50	10.10	13.20
MONTHLY STORAGE CHANGE (AF)	-869.10	96.80	131.50	421.70

WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	2537.00	20489.50	19410.80	7515.50
TOTAL MONTHLY OUTFLOW (AF)	509.80	542.30	12109.30	2917.30
MAX. MEAN DAILY INFLOW (CFS)	777.60	1574.90	707.90	161.50
TOTAL MONTHLY LOSSES (AF)	55.80	90.90	223.50	274.30
MIN. MEAN DAILY INFLOW (CFS)	12.70	71.60	156.00	81.00
MONTHLY STORAGE CHANGE (AF)	1971.40	19856.40	7078.10	4323.90

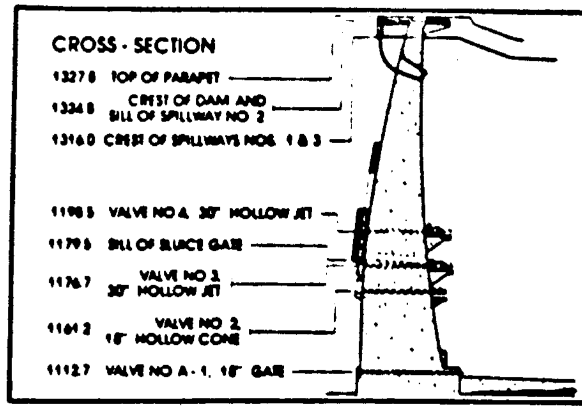
WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	3617.00	2288.10	1510.20	1235.90
TOTAL MONTHLY OUTFLOW (AF)	2987.30	7404.70	4136.50	5975.50
MAX. MEAN DAILY INFLOW (CFS)	85.80	57.80	39.50	35.80
TOTAL MONTHLY LOSSES (AF)	259.20	287.60	297.70	255.00
MIN. MEAN DAILY INFLOW (CFS)	35.20	16.10	15.10	12.60
MONTHLY STORAGE CHANGE (AF)	370.50	-5404.20	-2924.00	-4994.60

SANTA ANITA DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started October 1924. Completed March 1927
LOCATION - 2.5 miles north of Arcadia
DRAINAGE AREA - 10.8 square miles.
CAPACITY - 836 acre - feet.
SPILLWAY ELEVATION - 1,316.0 feet.



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1997

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	416.70	CFS	from	0500	on	03-01-91	to	0600	on	03-01-91
MAX. PEAK OUTFLOW	163.00	CFS	from	0125	on	03-01-91	to	0225	on	03-01-91
MAX. W.S. ELEVATION	1282.01	feet	on	03-01-91	STORAGE	444.80	ACRE-FEET			
MIN. W.S. ELEVATION	1240.23	feet	on	01-16-91	STORAGE	151.84	ACRE-FEET			

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1997 8

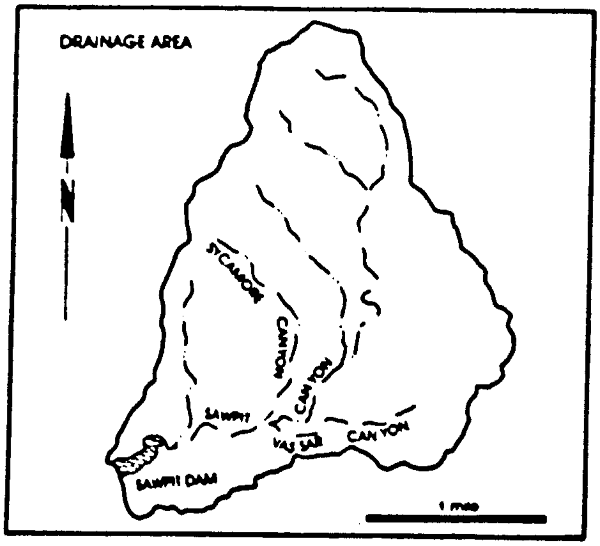
SANTA ANITA DAM OPERATION RECORD SUMMARY

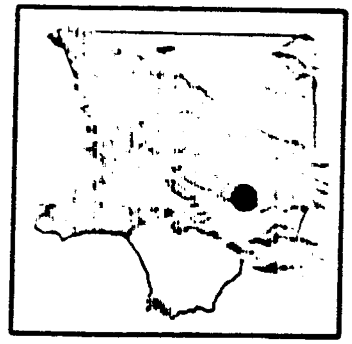
WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	5.40	7.00	17.30	62.00
TOTAL MONTHLY OUTFLOW (AF)	2.00	0.00	0.00	87.90
MAX. MEAN DAILY INFLOW (CFS)	0.10	0.20	0.50	3.80
TOTAL MONTHLY LOSSES (AF)	2.60	2.50	2.10	1.20
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.10	0.10	0.40
MONTHLY STORAGE CHANGE (AF)	0.80	4.60	15.30	-27.10

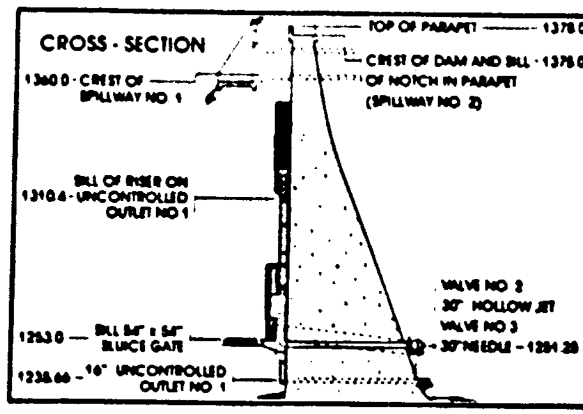
WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	188.40	1148.50	537.10	155.20
TOTAL MONTHLY OUTFLOW (AF)	29.40	1145.90	661.50	134.10
MAX. MEAN DAILY INFLOW (CFS)	64.30	92.20	19.20	7.50
TOTAL MONTHLY LOSSES (AF)	1.70	1.50	2.10	2.20
MIN. MEAN DAILY INFLOW (CFS)	0.40	2.40	3.30	0.90
MONTHLY STORAGE CHANGE (AF)	157.40	1.20	-126.40	18.90

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	105.10	76.30	61.00	29.80
TOTAL MONTHLY OUTFLOW (AF)	132.10	0.00	130.50	0.00
MAX. MEAN DAILY INFLOW (CFS)	5.70	1.60	2.80	0.60
TOTAL MONTHLY LOSSES (AF)	2.30	2.90	3.00	2.70
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.70	0.60	0.30
MONTHLY STORAGE CHANGE (AF)	-29.30	73.40	-72.40	27.00

SAWPIT DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1926. Completed June 1927.
LOCATION - 2.0 miles north of Monrovia.
DRAINAGE AREA - 3.2 square miles.
CAPACITY - 391 acre - feet.
SPILLWAY ELEVATION - 1,360.0 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	77.49	CFS	from	0500	on	03-01-91	to	0600	on	03-01-91
MAX. PEAK OUTFLOW	57.50	CFS	from	0900	on	03-01-91	to	0915	on	03-01-91
MAX. W.S. ELEVATION	1312.20	feet	on	03-01-91	STORAGE	102.80	ACRE-FEET			
MIN. W.S. ELEVATION	1309.80	feet	on	09-17-91	STORAGE	94.20	ACRE-FEET			

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1997

SAWPIT DAM OPERATION RECORD SUMMARY

WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	13.00	23.80	37.40	64.50
TOTAL MONTHLY OUTFLOW (AF)	13.10	23.80	37.30	64.50
MAX. MEAN DAILY INFLOW (CFS)	0.30	0.70	0.80	1.80
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.20	0.60	0.60
MONTHLY STORAGE CHANGE (AF)	-0.10	0.00	0.10	0.00

WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	90.40	334.50	128.80	102.70
TOTAL MONTHLY OUTFLOW (AF)	88.50	336.00	129.30	102.70
MAX. MEAN DAILY INFLOW (CFS)	17.70	33.90	3.50	1.90
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.90	1.30	1.40	1.50
MONTHLY STORAGE CHANGE (AF)	2.00	-1.50	-0.50	0.00

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	96.20	111.30	63.00	47.60
TOTAL MONTHLY OUTFLOW (AF)	96.20	111.30	63.10	47.60
MAX. MEAN DAILY INFLOW (CFS)	2.20	2.20	1.20	1.10
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.40	1.00	0.50	0.40
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	-0.10	0.00

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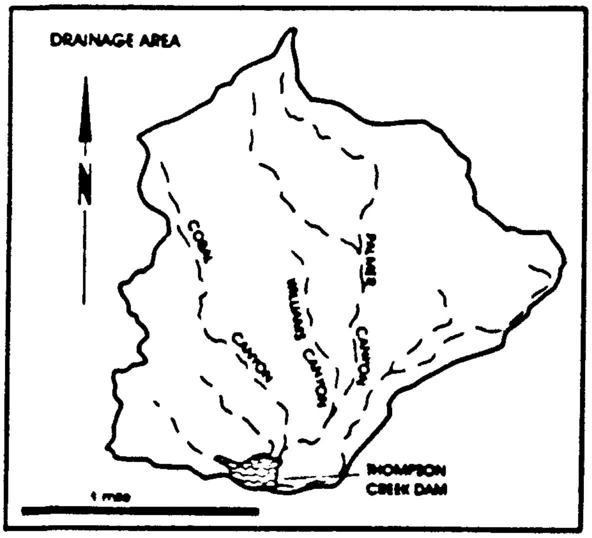
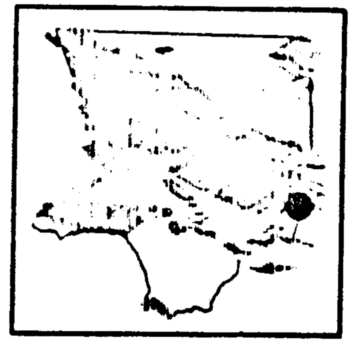
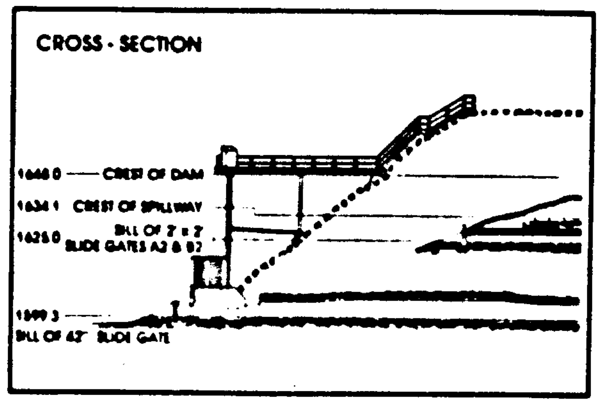
THOMPSON CREEK DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started September 1925 Completed March 1928
LOCATION - 3.0 miles north of Claremont
DRAINAGE AREA - 3.5 square miles.
CAPACITY - 447.5 acre - feet.
SPILLWAY ELEVATION - 1,634 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	19.78	CFS	from	0600	on	03-27-91	to	0700	on	03-27-91
MAX. PEAK OUTFLOW	2.73	CFS	from	0915	on	03-02-91	to	1100	on	03-02-91
MAX. W.S. ELEVATION	1605.90	feet	on	03-27-91	STORAGE	33.30	ACRE-FEET			
MIN. W.S. ELEVATION	1600.00	feet	on	varies	STORAGE	0.00	ACRE-FEET			

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1998 1

THOMPSON CREEK DAM OPERATION RECORD SUMMARY

WATER YEAR 1990-91	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1990-91	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	0.00	76.30	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	33.70	0.60	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	17.20	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	21.20	20.60	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	21.30	-21.30	0.00

WATER YEAR 1990-91	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

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1 9982

EROSION CONTROL

VOL 12

1983

R0053288

VOL 12

1 1984

EROSION CONTROL

Each year eroded material in various forms (trees, rock, sand, etc.) flows out of the mountain watersheds of Los Angeles County. In an effort to control this potentially disruptive force, the Department maintains a series of debris basins in canyon mouths and upstream stabilization structures in selected watersheds.

DEBRIS BASINS

The purpose of a debris basin is to entrap the debris flows emanating from the canyon and let the relatively desilted water pass into flood control channels.

From 1990 to 1991, the number of debris basins was changed from 115 to 114 by declassifying an existing debris basin to a drain inlet. This gives a total capacity of approximately 7,603,725 cubic yards.

Records of sediment inflow at individual debris basins and amounts excavated and removed are available in the Hydraulic/Water Conservation Division.

STABILIZATION STRUCTURES

Stabilization structures are constructed to control erosion in natural canyons. They serve to prevent downcutting by stabilizing alluvial deposits. In addition, they store debris generated by the watershed and serve to stabilize side banks, reducing side slope sloughing and bank erosion.

The Department maintains 225 stabilization structures in 47 major watersheds. No structures have been constructed since the 1973-74 water year.

EMERGENCY STRUCTURES

Emergency structures (rail and timber) have been constructed to entrap the debris inflow from burned watersheds. They serve to protect improvements (road, channel, residence, etc.) located immediately downstream of the watersheds. Currently 36 emergency structures exist with a total maximum capacity of 272,215 cubic yards. No major fires (those over 500 acres) occurred in this water year.

SEDIMENT REMOVAL FROM RESERVOIRS

Sediment deposition in reservoirs reduces the storage capacities and adversely affects flood control and water conservation efforts. Sediment removal is periodically necessary and is generally an expensive effort due to large quantities, the need to deal with water inflows, and in several cases, remote locations and limited accessibility for equipment.

Where practical, the Department encourages sediment removal by permittees at no cost to the Department such as at Eaton Wash and Devil's Gate Dams.

During the 1990-91 water year the Department initiated cleanouts in Cogswell Reservoir and Morris Reservoir. These are two of three reservoirs in San Gabriel Canyon which collectively contain 36 million cubic yards (cy), about three-quarters of the cumulative volume of sediment currently behind all dams under the Department's control.

Cogswell Reservoir was cleaned out mechanically and the removed material was placed in a canyon sediment placement site (SPS) upstream of the dam. (The location of the SPS was mandated by the US Forest Service because of accessibility, aesthetics and safety reasons.) About 450,000 cy of material was removed with this year's cleanout.

Morris reservoir's cleanout consisted of a Pilot Sluicing Project. This is the first debris removed from Morris Reservoir in its 57 year history. About 435,000 cy of material was removed with this year's cleanout.

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1985

VOL 12

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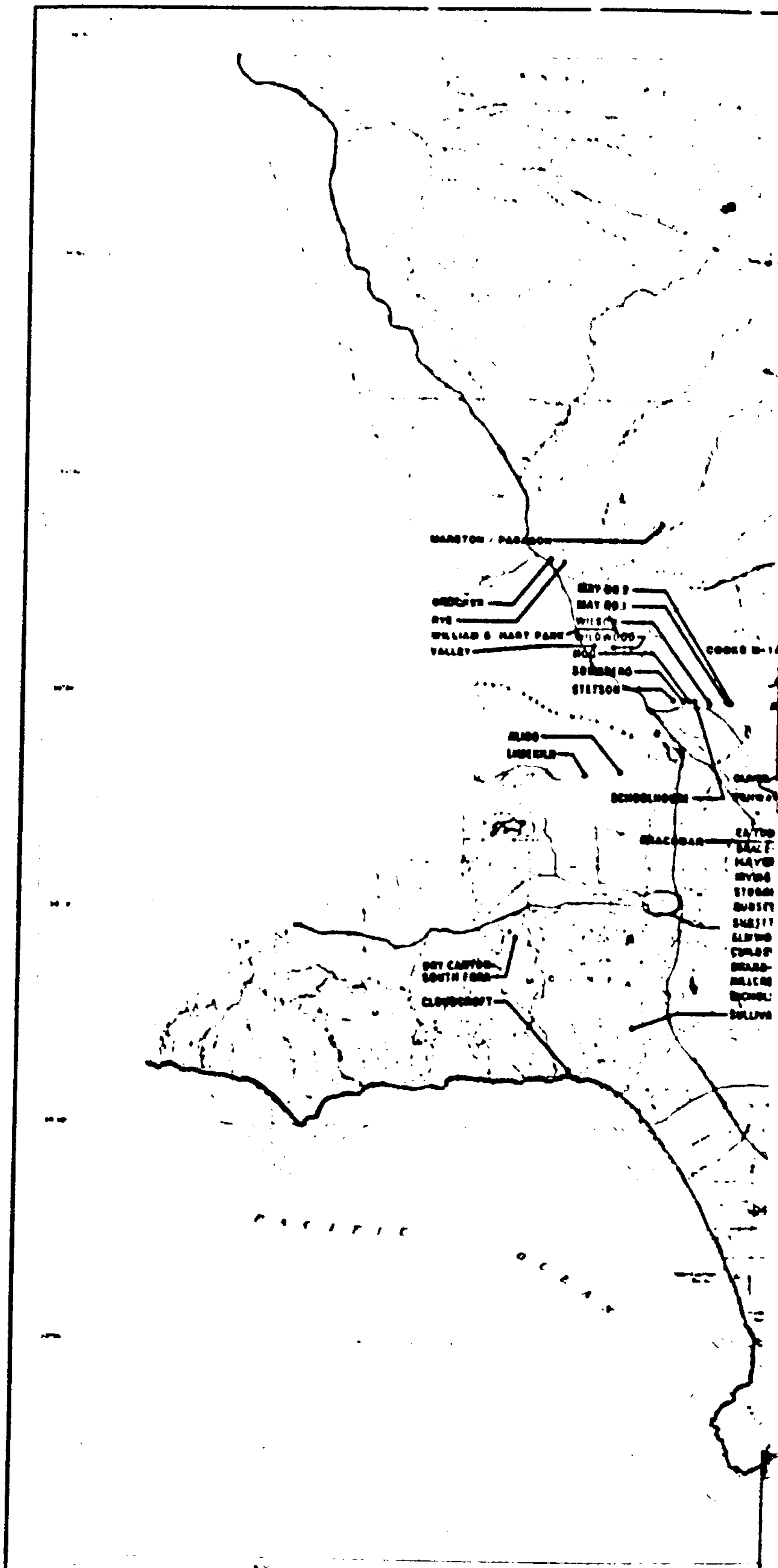

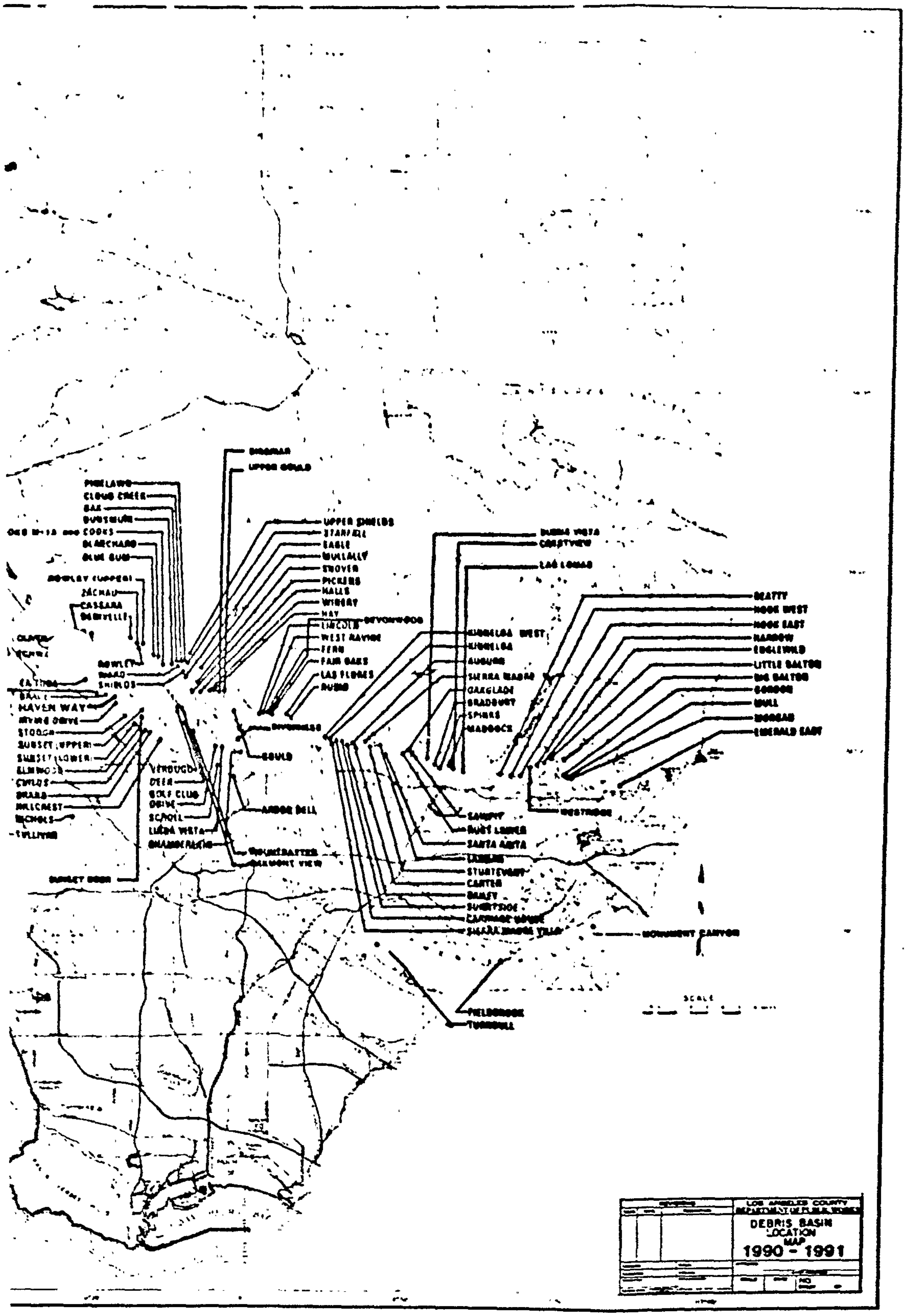

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R0053292

D E B R I S   B A S I N - D E S I G N   D A T A

Including 1990-1991 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1, 1991
FILE: AADP91.WK1

DATA SHEET A

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.
Aliso	1970 - 71	2.77	1108.0	1108.4	1120.0	70.0	1134.0	41,700 (8)
Arbor Dell	1971 - 72	0.11	899.3	898.4	913.0	22.9	919.6	12,400
Auburn	1954 - 55	0.19	1263.9	1263.0	1275.0	30.0	1283.0	31,100 (15,18)
Bailey	1945 - 46	0.60	1122.5	1123.1	1155.0	30.0	1166.0	128,800 (15)
Beatty	1970 - 71	0.27	800.0	800.0	807.0	32.0	815.5	43,000
Bigbriar	1971 - 72	0.02	1898.3	1896.0	1910.0	14.0	1910.8	2,600 (15,18)
Big Dalton	1959 - 60	2.94	1102.0	1101.9 (3)	1131.5	116.0	1148.7	317,800 (15)
Blanchard	1968 - 69	0.47	2026.0	2026.0	2053.5	40.0	2065.0	74,500 (15)
Blue Gum	1968 - 69	0.19	2020.0	2020.0	2042.0	25.0	2053.0	39,600
Brace	1971 - 72	0.29	1189.7	1189.7	1194.5	20.0	1203.3	27,500
Bracemar	1971 - 72	0.01	1140.0	1140.0	1145.5	8.0	1148.0	700 (11)
Bradbury	1954 - 55	0.88	912.5	913.1	920.0	58.0	928.0	89,800
Brand	1935 - 36	1.04	859.0	860.0	890.0	60.0	903.0	166,000 (15)
Buena Vista	1985 - 86	0.10	978.7	978.7	992.2	39.0	997.7	21,400 (15,18)
Carriage House	1970 - 71	0.03	1350.3	1350.0	1362.9	15.0	1366.8	6,100 (15,18)
Carter	1954 - 55	0.12	1222.0	1223.2	1238.2	30.0	1245.0	14,600 (15,18)
Cassara	1976 - 77	0.21	1271.5	1271.5	1291.7	66.0	1295.4	36,700 (15)
Chamberlain	1974 - 75	0.04	1084.6	1084.0	1097.5	20.0	1101.3	4,700 (15)
Childs	1963 - 64	0.30	1022.0	1022.0	1058.8	23.0	1071.0	50,400 (15)
Cloud Creek	1972 - 73	0.01	2347.2	2350.5	2360.0	(5)	2362.0	6,200 (15,19)
Cloudcroft	1973 - 74	0.21	313.9	315.0	329.5	36.0	329.5	34,700 (15)
Cooks	1951 - 52	0.58	2058.0	2058.0	2082.9	48.0	2092.0	85,600 (15)
Cooks M-1A (14)	1975 - 76	(14)	(14)	(14)	(14)	(14)	(14)	0 (14)
Crestview	1983 - 84	0.03	864.4	864.0	886.2	20.0	891.7	5,900
Crocker	1983 - 84	0.67	1064.8	1064.2	1069.8	36.0	1077.0	19,300 (15)
Deer	1954 - 55	0.59	1185.4	1185.0	1201.0	56.0	1209.6	56,600
Denivelle	1976 - 77	0.18	1471.0	1471.0	1479.3	46.0	1483.3	8,200
Devonwood	1981 - 82	0.03	1899.0	1899.0	1915.8	22.0	1921.5	5,700 (15,18,19
Dry Canyon-South Fork	1978 - 79	0.49	1062.8	1062.5	1074.8	32.0	1079.3	7,900 (19)
Dunsmuir	1935 - 36	0.84	2228.0	2227.7	2257.2	60.0	2272.2	101,900 (15,18)
Eagle	1936 - 37	0.48	1848.3	1844.3	1880.2	60.0	1895.2	62,400 (15)
Elmwood	1964 - 65	0.31	912.0	911.5	938.0	22.0	952.0	66,400 (15)
Emerald-East	1964 - 65	0.32	1185.1	1181.1	1192.0	30.0	1204.0	13,200
Englewild	1961 - 62	0.44	1274.9	1275.0	1297.0	50.0	1300.0	40,600 (15,18,19
Fair Oaks	1935 - 36	0.21	1544.0	1544.0	1561.9	(6)	1566.5	23,800 (15)
Fern	1935 - 36	0.31	1438.7	1462.4	1470.2	25.0	1480.5	30,600
Fieldbrook	1974 - 75	0.35	712.7	713.0	718.0	28.0	722.3	2,800
Golf Club Drive	1970 - 71	0.97	880.7	880.7	902.0	36.7	915.0	14,700 (19)
Gordon	1973 - 74	0.18	1075.7	1075.0	1088.0	22.0	1096.0	16,800
Gould	1947 - 48	0.36	1529.5	1528.2	1548.0	55.0	1548.0	49,600 (19)

1991

D E B R I S   B A S I N - D E S I G N   D A T A

Including 1990-1991 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1, 1991
FILE: AADP91.WK1

DATA SHEET A

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.
Gould (Upper)	1976 - 77	0.18	1863.9	1863.9	1887.7	32.0 (16)	1901.0	52,300
Halls	1935 - 36	0.86	1641.6	1641.8	1661.3	131.0	1664.0	89,400
Harrow	1958 - 59	0.43	1254.8	1255.0	1269.0	40.0	1277.8	68,000
Hay	1936 - 37	0.20	1875.4	1901.0	1905.0	36.0	1915.0	36,000
Hillcrest	1962 - 63	0.35	863.5	863.5	885.0	18.0	901.0	57,800 (15)
Hog	1969 - 70	0.33	1520.3	1520.0	1535.0	32.0	1547.0	39,600 (19)
Hook East	1968 - 69	0.18	1197.5	1198.0	1210.9	37.0	1215.0	22,300 (15,18)
Hook West	1970 - 71	0.17	1144.8	1145.0	1158.9	40.0	1167.0	21,600 (15,18)
Inverness	1982 - 83	0.03	1253.0	1252.9	1256.7	20.0	1261.0	3,200 (15,18)
Irving Drive	1974 - 75	0.03	905.8	905.0	915.3	12.0	920.0	1,200 (15,18)
Kinneloa	1964 - 65	0.20	1370.0	1370.0	1388.0	40.0	1395.0	14,100 (15,18)
Kinneloa West Branch	1966 - 67	0.19	1384.9	1385.0	1400.0	22.0	1408.5	23,600 (15,18)
Lannan	1954 - 55	0.25	1016.0	1015.0	1035.8	14.0	1043.0	36,700 (15)
La Tuna	1955 - 56	5.34	1109.0	1110.0	1140.0	75.0	1157.0	495,300 (15)
Las Flores	1935 - 36	0.45	1685.1	(8)	1715.8	50.0	1726.4	57,600 (15,18)
Las Lomas	1983 - 84	0.07	895.4	896.0	906.6	24.0	911.0	9,300 (15,18)
Limekiln	1963 - 64	3.72	990.0	992.0	1003.0	77.0	1019.0	171,600 (15)
Lincoln	1935 - 36	0.50	1275.8	1276.0	1304.0	56.0	1322.5	38,400
Linda Vista	1970 - 71	0.37	979.5	979.5	989.8	40.0	995.7	3,200
Little Dalton	1959 - 60	3.31	1140.0	1139.5	1196.0	84.0	1200.2	660,500 (15)
Maddock	1954 - 55	0.25	888.8	891.8	901.0	36.0	904.0	45,000 (15)
Marston/Paragon	1988 - 89	0.20	1455.5	1455.5	1468.0	(10)	1466.0	13,000
May No. 1	1953 - 54	0.70	1665.9	1666.0	1684.0	60.0	1692.5	64,000
May No. 2	1953 - 54	0.09	1663.4	1663.5 (2)	1669.5	20.0	1674.0	10,000
Monument	1981 - 82	0.11	943.8	942.3	950.0	12.0	954.0	6,800 (15)
Morgan	1964 - 65	0.60	1135.0	1135.0	1158.0	45.0	1167.0	47,700 (15,18)
Mountbatten	1983 - 84	0.01	1136.2	1135.5	1140.9	20.0	1141.0	1,400
Mull	1973 - 74	0.15	1146.9	1147.0	1154.0	20.0	1165.0	12,500 (15,18)
Mullally (12)	1974 - 75	0.34	2420.0	2420.0	2435.4	42.0	2439.6	9,400 (15,18)
Nichols	1937 - 38	0.94	481.0	481.0	485.1	50.0	495.0	13,100 (19)
Oak	1975 - 76	0.05	2145.7	2145.7	2151.8	50.0	2156.2	6,200 (18)
Oakglade	1974 - 75	0.06	1274.6	1280.0	1290.0	20.0	1298.0	7,200 (15,18)
Oakmont View Drive	1984 - 85	0.02	1315.5	1315.5	1327.5	20.0	1327.5	3,400
Oliver	1989 - 90	0.18	1253.4	1253.4	1278.0	41.0	1283.3	32,100
Pickens	1935 - 36	1.50	1564.0	1564.0	1600.0	123.0	1613.0	125,115
Pinelawn	1973 - 74	0.02	2431.0	2430.5	2443.0	(7)	2448.5	3,200 (15,18)
Rowley	1953 - 54	0.21	1701.6	1703.6	1714.0	60.0	1722.0	43,100 (19)
Rowley (Upper)	1976 - 77	0.31	1926.0	1926.0	1946.0	42.0	1951.3	28,800
Rubio	1943 - 44	1.26	1582.1	1582.1	1608.3	59.0	1625.5	127,200
Ruby (Lower)	1955 - 56	0.28	810.8	809.6	828.0	45.0	833.0	26,600

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1 1989

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D E B R I S   B A S I N - D E S I G N   D A T A

Including 1990-1991 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1, 1991
FILE: AADP91.WK1

DATA SHEET A

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN SQ. MI.	BOTTOM ELEV. AT MAX CAP. FT.	ELEV PORT INVERT FT. (1)	ELEV. SPILLWAY CREST	WIDTH SPILLWAY FT.	ELEV. CREST. OF DAM FT.	MAX. DEB. CAP. CU. YDS.
Rye	1981 - 82	1.11	1073.9	1073.8	1077.7	58.2	1081.5	19,100
Saddleback	1988 89	0.04	1779.0	1779.3	1790.0	(10)	1796.0	27,000
Santa Anita	1959 - 60	1.70	748.5	748.5 (3)	774.7	160.0	796.0	394,600
Sawpit	1954 - 55	2.82	928.5	933.4	982.0	110.0	1000.0	635,700 (15,19)
Scholl	1945 - 46	0.16	950.0	950.0 (2)	956.0	76.0	966.0	9,300 (19)
Schoolhouse	1962 - 63	0.28	1459.6	1460.0	1478.5	20.0	1491.0	87,700 (15)
Schwartz	1976 - 77	0.25	1296.0	1294.7	1313.2	35.0	1319.0	45,400
Shields	1937 - 38	0.06	2030.0	2050.0	2058.1	30.0	2070.2	34,800 (19)
Sierra Madre Dam (13)	1927 - 28	2.39	1119.5	1119.5	1172.5	82.5	1175.0	138,400
Sierra Madre Villa	1957 - 58	1.46	1069.2	1069.2	1080.9	48.8	1102.5	402,700
Snover	1938 - 37	0.21	1858.0	1874.4	1879.0	40.0	1893.7	23,400 (19)
Sombrero	1969 - 70	1.06	1539.6	1540.0	1564.8	45.0	1580.0	87,900
Spinks	1958 - 59	0.42	750.0	750.0	781.5	40.0	765.9	56,000 (15)
Starfall	1973 - 74	0.13	2428.0	2428.0	2441.5	30.0	2446.5	14,900 (15,18)
Stetson	1969 - 70	0.29	1556.0	1555.0	1570.0	32.0	1570.0	41,300 (15)
Stough	1940 - 41	1.85	1006.0	1005.8	1031.5 (4)	100.0	1043.5	181,200
Sturtevant	1967 - 68	0.03	975.0	971.0	983.6	8.0	990.0	1,400 (15,18)
Sullivan	1970 - 71	2.38	570.0	570.0	587.0	50.0	599.3	51,000
Sunnyside	1970 - 71	0.02	1290.0	1290.0	1299.5	15.0	1303.8	3,400 (15,18)
Sunset Canyon-Deer	1982 - 83	0.21	1382.4	1380.5	1401.8	24.0	1409.1	5,000 (15,18)
Sunset (Lower)	1983 - 84	0.45	1003.8	994.5	1040.0	60.0	1056.0	160,600 (19)
Sunset (Upper)	1928 - 29	0.44	1574.2	1574.0	1603.7	75.0	1610.1	15,900
Turnbull	1952 - 53	0.99	480.0	475.6	492.0	40.0	503.0	20,300 (8)
Upper Shields (12)	1976 - 77	0.20	2505.0	2502.0	2518.8	29.5	2524.0	5,600
Valley	1987 - 88	0.22	1351.0	(10)	(10)	31.0	1365.0	4,000
Verdugo	1935 - 36	3.09	1109.5	1110.0	1119.7	145.0	1131.0	131,000
Ward	1956 - 57	0.12	2021.6	2022.0	2043.0	58.0	2035.3	26,400
West Ravine	1935 - 36	0.25	1470.0	(9)	1501.9	20.0	1505.5	44,900 (15)
Westridge	1974 - 75	0.02	894.0	894.0	901.0	10.7	906.0	1,400
Wildwood	1967 - 68	0.85	1342.9	1342.9	1354.0	50.0	1360.0	20,700
William S. Hart Park	1983 - 84	0.09	1284.0	1280.0	1290.0	19.0	1293.0	2,400
Wilson	1962 - 63	2.58	1517.3	1493.0	1526.0	60.0	1543.0	313,100 (15)
Winery	1968 - 69	0.16	1920.0	1920.0	1935.0	20.0	1945.0	29,200
Zachau	1956 - 57	0.35	1803.4	1803.1	1820.5	44.0	1823.0	48,100

113 DEBRIS BASINS ________________________________ 7,553,615

1990

R0053295

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D E B R I S   B A S I N - D E S I G N   D A T A

Including 1990-1991 Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1, 1991

DATA SHEET A

(1) LOWEST CLEAR WATER OUTLET, NOT SPILLWAY.
(2) ELEVATION OF SPILLWAY NOTCH.
(3) FLOW LINE OF SLUICEWAY.
(4) ELEVATION OF SPILLWAY INTO OUTLET CHANNEL. ELEVATION OF OVERFLOW SPILLWAY 1036.9 FEET.
(5) ONE 30-INCH REINFORCED CONCRETE PIPE.
(6) FOUR 36-INCH CORRUGATED METAL PIPES.
(7) ONE 36-INCH REINFORCED CONCRETE PIPE. (ELEVATED INLET)
(8) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(9) PIT-TYPE BASIN.
(10) INFORMATION UNAVAILABLE.
(11) MAXIMUM CAPACITY MAY BE LESS THAN SHOWN AND IS BEING REVIEWED. FIELD INSPECTION SUGGESTS BASIN IS NEAR ITS FULLEST POSSIBLE CAPACITY.
(12) SPECIAL CLEANOUT REQUIRED DUE TO LIMITED STORAGE.
(13) CLEANOUT WHEN DEBRIS REACHES OR EXCEEDS ELEV. 1120.9 AGAINST FACE OF DAM.
(14) VALUES ARE COMBINED WITH COOKS DEBRIS BASIN
(15) VALUES ARE BASED ON RECENTLY APPROVED CUTPLANS
(16) SPILLWAY IS STREET
(17) CLEANED FALL OF 1991
(18) CAPACITY REDUCED FOR 5% MAX CONE SLOPE
(19) DRAINAGE AREA CORRECTED JUNE 1991

AFTON REMOVED FROM D/B LIST JULY 1991
CEDARWOOD REMOVED FROM D.B LIST AUGUST 1991

D E B R I S   B A S I N - D E B R I S   P R O D U C T I O N   H I S T O R Y

Including 1990 - 1991

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1, 1991
FILE: AADP91.WK1

DATA SHEET B

DEBRIS BASIN	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS DEBRIS STORED CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE PER CENT
Aliso (11)	21	134,730	30,700	1982-83	2400	39,300	94 (5)
Arbor Dell (11)	20	1,397	800	1979-80	390	12,010	97
Auburn	37	87,386	20,100	1961-62	350	30,750	99
Bailey	46	238,794	91,000	1979-80	1700	127,100	99
Beatty	21	13,297	7,600	1979-80	3250	39,750	92
Bigbriar	20	2,004	623	1987-88	50	2,550	98
Big Dalton	32	833,003	296,700	1968-69	5200	512,600	99
Blanchard	23	68,196	36,600	1977-78	200	74,300	100
Blue Gum	23	37,572	19,100	1977-78	1500	38,100	96
Brace	20	35,621	12,000	1977-78	25	27,475	100
Braemar	20	664 (7)	283	1980-81	-200	900	129 (9)
Bradbury	37	267,430	70,200	1968-69	2500	87,300	97
Brand	56	248,095	53,100	1977-78	22000	144,000	87
Buena Vista	6	38	38	1987-88	40	21,360	100
Carriage House	21	4,742	3,400	1979-80	60	6,040	99
Carter	37	36,890	12,600	1979-80	550	14,050	96
Cassara	15	25,503	16,800	1977-78	3800	32,900	90
Chamberlain	17	556	300	1974-75	-100	4,800	102
Childs	28	45,220	10,700	1980-81	4250	46,150	92
Cloud Creek	19	3,262	1,800	1977-78	650	5,550	90
Cloudcroft	16	12,290	6,100	1973-74	800	34,100	98
Cooks	40	186,864 (3)	61,200	1977-78	7014	78,586	92
Cooks M-1A	16	(13)	(13)	(13)	(13)	(13)	0 (13)
Crestview	8	(6)	(6)	(6)	5	5,895	100
Crocker	8	(6)	(6)	(6)	1500	17,800	92
Deer	37	156,948	44,200	1968-69	6900	49,700	88
Denivelle	15	8,660	5,500	1977-78	575	7,625	93
Devonwood	10	132	100	1982-83	30	5,670	99
Dry Canyon-South Fork	13	6,003	5,300	1979-80	2075	(8)	0 (14)
Dunsmuir	56	349,183	86,200	1977-78	2900	99,000	97
Eagle	55	200,286	41,700	1937-38	7200	55,200	88
Elmwood	27	52,781	16,100	1980-81	670	65,730	99
Emerald-East	27	8,959	1,800	1985-86	39	13,161	100
Englewild	30	85,119 (2)	60,200 (2)	1968-69	570	40,030	99
Fair Oaks	56	109,020	15,700	1935-36	200	23,800	99
Fern	56	159,554	23,900	1968-69	2000	28,800	93
Fieldbrook	17	1,354	500	1977-78	520	2,280	81
Golf Club Drive	21	30,157	11,600	1979-80	555	14,145	96
Gordon	18	4,485	3,800	1977-78	0	16,800	100
Gould	44	115,091	18,000	1965-66	4400	45,200	91
Gould (Upper)	15	25,444	10,100	1977-78	1750	50,550	97

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DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1990 - 1991

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section

Date: October 1, 1991

FILE: AADP91.WK1

DATA SHEET B

DEBRIS BASIN	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS DEBRIS STORED CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE PER CENT
Halls	56	569,156	102,100	1937-38	6500	82,900	93
Harrow	33	78,297 (2)	63,400 (2)	1968-69	-470	68,470	101
Hay	55	67,952	18,200	1937-38	0	36,000	100
Hillcrest	29	48,589	11,700	1964-65	6060	51,740	90
Hog	22	6,500	3,900	1977-78	65	39,535	100
Hook East	23	45,709 (2)	40,200 (2)	1968-69	-20	22,320	100
Hook West	21	8,537	3,600	1979-80	5675	(8)	0 (14)
Inverness	9	265	300	1982-83	370	2,830	88
Irving Drive	17	1,244	600	1980-81	100	1,100	92
Kinneloa	27	48,929 (2)	17,600 (2)	1968-69	500	13,600	96
Kinneloa West Branch	25	59,055 (2)	22,200 (2)	1968-69	3400	20,200	86
Lannan	37	84,067	18,200	1969-70	600	36,100	98
La Tuna	36	595,914	172,100	1977-78	3000	492,300	99
Las Flores	56	214,754	36,000	1937-38	2000	55,600	97
Las Lomas	8	(6)	(8)	(6)	35	9,265	100
Limekiln	28	270,549	42,300	1965-66	12000	159,800	93
Lincoln	56	126,104	28,400	1968-69	2000	36,400	95
Linda Vista	21	11,407	3,400	1977-78	-173	3,373	105 (14)
Little Dalton	32	905,170	337,800	1968-69	12100	848,400	96
Maddock	37	56,454	18,200	1980-81	3320	42,580	93
Marston/Paragon	3	(8)	(8)	(8)	200	12,800	98
May No. 1	38	203,322	45,800	1968-69	1300	62,700	98
May No. 2	38	27,314	6,200	1966-67	10	9,990	100
Monument	10	2,655	2,600	1981-82	140	6,860	98
Morgan	27	30,292	12,900	1968-69	1080	46,620	98
Mountbatten	8	55	(8)	(6)	80	1,320	94
Mull	18	1,970	1,100	1979-80	62	12,438	100
Mullally (10)	17	51,849 (4)	24,400 (4)	1977-78	259	9,141	97 (14)
Nichols	54	126,652	21,800	1951-52	2050	11,050	84
Oak	16	13,258	6,900	1977-78	785	5,415	87
Oakglade	17	1,455	1,200	1977-78	550	6,650	92
Oakmont View Drive	7	(6)	(6)	(6)	30	3,370	99
Oliver	2	30380 (15)	16255	1977-78	50	32,050	100
Pickens	56	716,116	140,600	1977-78	250	124,865	100
Pinelawn	18	5,113	1,200	1976-77	425	2,775	87
Rowley	38	76,207 (4)	16,700 (4)	1977-78	500	42,600	99
Rowley (Upper)	15	49,019 (4)	31,900 (4)	1977-78	400	28,400	99
Rubio	48	271,322	133,000	1979-80	7000	120,200	94
Ruby (Lower)	36	20,448	8,300	1968-69	1016	27,584	96
Rye	10	10,419	10,000	1981-82	25	19,075	100
Saddleback	3	(6)	(6)	(8)	500	26,500	98

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DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1990 - 1991

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section
Date: October 1, 1991
FILE: AADP91.WK1

DATA SHEET B

DEBRIS BASIN	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED CU. YDS. (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS DEBRIS STORED CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE CU. YD.	ESTIMATED CONDITIONS CAPACITY AVAILABLE PER CENT
Santa Anita	32	689,384 (2,3)	132,000 (2,3)	1961-62	6000	388,600	98
Sawpit	37	680,058 (2,3)	233,800 (2,3)	1968-69	500	635,200	100
Scholl	46	16,794	3,500	1968-69	670	8,630	93
Schoolhouse	29	33,550	21,600	1962-63	4500	63,200	93
Schwartz	15	45,183	23,400	1977-78	7410	37,990	84
Shields	54	173,202 (3)	35,100	1937-38	1800	33,000	95
Sierra Madre Dam (12)	64	363,695 (2)	95,200 (2)	1968-69	1052	135,368	99
Sierra Madre Villa	34	506,701	118,600	1961-62	1300	401,400	100
Snover	55	104,397	21,100	1938-39	0	0	0 (16)
Sombrero	22	6,030	3,300	1977-78	175	87,725	100
Spinks	33	67,086	16,600	1968-69	700	55,300	99
Starfall	18	27,128	14,200	1977-78	-600	15,500	104
Stetson	22	5,035	1,500	1977-78	2300	39,000	94
Stough	51	161,148	44,100	1964-65	9700	171,500	95
Sturtevant	24	1,321	500	1977-78	120	1,280	91
Sullivan	21	89,957	35,300	1979-80	1200	49,800	98
Sunnyside	21	1,749	800	1978-79	35	3,365	99
Sunset Canyon-Deer	9	3,678	3,200	1982-83	50	4,550	91
Sunset (Lower)	28	142,169	29,200	1980-81	16550	144,050	90
Sunset (Upper)	63	142,392	27,000	1964-65	550	15,350	97
Turnbull	39	50,514 (2)	15,900 (2)	1968-69	0	20,200	100 (5)
Upper Shields (10)	15	39,692 (4)	16,900	1977-78	335	5,265	94
Valley	4	200	(6)	(6)	125	3,875	97
Verdugo	56	807,740	105,400	1937-38	9000	122,000	93
Ward	35	51,668	17,800	1977-78	230	26,170	99
West Ravine	56	248,333	29,900	1937-38	10000	34,900	78
Westridge	17	200	(6)	(6)	187	1,213	87
Wildwood	24	67,450	16,700	1977-78	1800	19,100	92
William S. Hart Park	8	1,329	1,000	1983-84	295	2,105	88
Wilson	29	217,968	55,500	1968-69	3993	309,100	99
Winery	23	23,137	9,400	1968-69	1950	27,250	93
Zachau	35	107,185 (4)	48,100 (4)	1977-78	1100	47,000	98
114 DEBRIS BASINS					244,719		

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

DATA SHEET B

Including 1990-1991

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Section

Date: October 1, 1991

(1) VOLUME OF DEBRIS DEPOSITED IN BASINS DOES NOT INCLUDE DEBRIS SLUICED THROUGH OPEN PORTS OR NOTCH.
(2) VOLUME OF DEBRIS DEPOSITED DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1968-69 SEASON.
(3) INCLUDING DEBRIS FROM UPSTREAM BASIN OR DAM.
(4) VOLUME OF DEBRIS DEPOSITED DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1977-78 SEASON.
(5) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(6) NO SIGNIFICANT DEBRIS INFLOWS RECORDED.
(7) NO RECORDS OF DEBRIS DEPOSITION EXIST FOR THE FIRST 9 SEASONS.
(8) INFORMATION UNAVAILABLE.
(9) MAXIMUM CAPACITY MAY BE MORE THAN SHOWN AND IS BEING REVIEWED.
(10) SPECIAL CLEANOUT REQUIRED DUE TO LIMITED STORAGE.
(11) SPECIAL CLEANOUT REQUIRED DUE TO BURNED WATERSHED
(12) CLEANOUT WHEN DEBRIS REACHES OR EXCEEDS ELEV. 1128.9 AGAINST FACE OF DAM.
(13) VALUES ARE COMBINED WITH COOKS DEBRIS BASIN.
(14) TO BE CLEANED.
(15) DATA FROM PREVIOUS BASIN.
(16) BASIN UNDER RECONSTRUCTION

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WATER QUALITY

Since its conception, the Flood Control District (now Department of Public Works) has actively engaged in operations which have proven indispensable in preserving the integrity of our water resources, both quantity and quality, and has aided in the establishment of regulations or controlling criteria by those agencies so empowered.

Prior to March 1986, monitoring activities in the field of water quality control were conducted by the Water Quality Section of Hydraulic/Water Conservation Division. In March 1986, the responsibilities of conducting such activities were transferred to Waste Management Division as a result of the consolidation. These activities include, among others, the collection of water quality samples, their analyses, and the interpretation and reporting of the resulting data.

Areas of involvement include the monitoring of all groundwater basins through the sampling of numerous wells, the monitoring of storm and low water flows at various strategic locations on the major streams or channels, and an assumed or obligated responsibility to monitor the quality effects and subsurface travel of recharge areas, specifically the Whittier Narrows Spreading Grounds area.

The Water Quality Section, together with personnel of other Departmental divisions, also conducts investigations into pollution problems relative to our facilities, particularly those from industrial discharges, vehicle accidents, ruptured pipelines, or the indiscriminate dumping of various waste products.

The principal objectives of these investigations are to determine the degree and apparent source or origin of the pollution and to take the necessary action that will immediately abate the existing problem and possibly provide a means to prevent or limit recurrence.

Since 1986, the Water Quality Section also has been conducting the screening of proposed connections to County storm drains, and developments over County right-of-ways, for the purpose of minimizing/eliminating potential of pollutants to the storm drain waters and, thereby, to the environment.

The above-mentioned activities of the Water Quality Section have recently been intensified, particularly in the areas of interfacing and coordinating with other municipalities/cities, environmental organizations, as well as Federal and State agencies, in an effort to comply with the regulations and requirements mandated under the 1987 Clean Water Act, whereby the Department's storm drain system is under the National Pollutant Discharge Elimination System (NPDES) permitting regulations of the California Regional Water Quality Control Board (CRWQCB).

The NPDES Permit (CA0061654) issued for the storm drain system in Los Angeles County requires the development of programs to improve the quality of stormwater/urban runoff discharges into the storm drain system. Los Angeles County, represented by the Department of Public Works, is the Principal Permittee and the cities within the County are

Co-Permittees. The drainage area covered by the Permit will become active in three phases, with Phase 1, the Santa Monica Bay Drainage Basin, having begun July 1, 1990.

The Permit requires the County, together with the cities in the County, to (a.) develop and implement a stormwater/urban runoff monitoring program to gather data on the type and source of pollutants within the drainage basin, and (b.) develop and implement Best Management Practices (BMPs) to reduce the amount of pollutants that find their way into the storm drain system.

SURFACE WATER QUALITY

Prior to 1984, dry weather samples were collected from 30 sampling stations on a monthly basis for analysis such as general minerals, bacteria, pesticides, and heavy metals. In addition, storm samples were also collected and analyzed at least three times annually from the same 30 stations during storms season.

From 1984 to 1987, as a result of reorganization, the number of surface water monitoring stations was reduced to 21, while the parameters analyzed were reduced to include only total dissolved solids, pH, and dissolved oxygen. Storm sampling activities were also significantly curtailed.

In 1988, recognizing the inadequacy of the then existing monitoring program to meet the Department's need in dealing with the important issues in the areas of water quality, the Department Administration approved and implemented an expanded monitoring program effective May 1, 1988.

There are 28 monitoring stations in the Department's current Surface Water Quality Monitoring Program, from which dry weather samples are collected and analyzed on a monthly basis. These sampling stations are strategically located throughout the Department's major storm drains and water conservation facilities where the flows are representative of typical land uses as well as areas of significant water quality concerns. Of the 28 monitoring stations in the program, six are located at the outlets to Santa Monica Bay, while one is located in the mountain area where flow is considered to be natural and uncontaminated with the various pollutants associated with urbanization and developed land uses.

Monthly dry weather samples, thus collected, are analyzed for general minerals (pH, specific conductance, total dissolved solids, total hardness, potassium sulfate, calcium, magnesium, chloride, fluoride, nitrate-nitrogen, nitrite-nitrogen, ammonium-nitrogen, phosphate-P, boron, iron, and manganese), bacteria, pesticides, heavy metals (silver arsenic, barium, cadmium, chromium, mercury, lead, selenium, copper, nickel, zinc, and chromium [VI]), oil and grease, total organic carbon, total petroleum hydrocarbons, PCB's, biochemical oxygen demand, and volatile organic compounds (TCE, carbon tetrachloride, vinyl chloride, 1,2 dichlorethene, benzene, 1,1 dichloroethylene, 1,1,1 trichloroethane, p-dichlorobenzene). In addition, storm samples are collected for three to four storms annually from 21 stations, including San Gabriel Coastal and Rio Hondo Spreading Grounds for extensive analysis similar to those for dry weather samples, with additional testing of total suspended solids and volatile suspended solids to be included. For storm samples collected at San Gabriel Coastal and Rio Hondo Spreading Grounds, priority pollutant constituents are also analyzed under an agreement with the Central and West Basin Water Replenishment District.

A selective list of total dissolved solids is shown for some of the sampling locations on the streams and channels monitored under the Surface Water Quality Program. For a conception of the analysis performed on the surface flows, a yearly compilation of constituent determination is shown for one (Los Angeles River at Wardlow) of the sampling stations in the program.

GROUNDWATER QUALITY

The annual sampling of water wells, under a selected scheduling, in five major basins in Los Angeles County comprise the Groundwater Quality Program. The program, initiated in 1970, is coordinated with the State of California Department of Water Resources and the City of Los Angeles Department of Water and Power. These agencies participate in the obtainment and analysis of samples.

All the water well samples are from active production wells used either for municipal supply, irrigation, or for industrial purposes and are selected to represent a general portrayal of basin water quality conditions. The samples taken under this program are analyzed for major minerals, total dissolved solids, electrical conductivity, pH, and in specific cases, phosphate, iron, manganese, fluoride, or boron.

WATER QUALITY DATA ACCESSIBILITY

Data acquired from the various programs are on file in the Water Quality Section. In addition, all data is accessible to any user through STORET, an Environmental Protection Agency computer system that stores, retrieves, and manipulates data using agency code 21CALAFD.

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Surface Water Quality Monitoring Selected Surface Station
Table 1 Total Dissolved Solids - mg/l
1990-91 Season (Dry Weather Flow)

Sampling Location	Oct. 1990	Nov. 1990	Dec. 1990	Jan. 1991	Feb. 1991	Mar. 1991	Apr. 1991	May 1991	Jun. 1991	Jul. 1991	Aug. 1991	Sep. 1991	Average Value
Ballona Creek at Sawtelle Blvd.	753	845	735	848	738	1027	976	1020	**	**	**	**	868
Coyote Creek at Orangethorpe Avenue Willow Street	574 627	974 888	853 706	1014 734	990 1532	1128 683	1026 829	1043 745	** **	** **	** **	** **	950 843
Dominguez Channel Above Vermont Avenue	599	627	597	686	622	742	668	753	**	**	**	**	662
Los Angeles River at Wardlow Road Firestone Boulevard	716 647	694 646	652 637	705 588	624 555	582 598	683 708	763 685	** **	** **	** **	** **	677 633
Los Cerritos Channel at Stearns Street	770	719	681	684	795	589	826	597	**	**	**	**	708
Rio Hondo River at Southern Avenue Spreading Grounds	937 530	725 594	648 613	581 620	902 563	* 615	878 568	* 593	** **	** **	** **	** **	779 587
Santa Monica Cyn. Ch. at Short Street	901	983	969	908	920	1061	1254	1059	**	**	**	**	1007
San Gabriel River at Spreading Grounds Willow Street	* 660	* 860	* 830	* 764	639 811	647 628	* 759	567 840	** **	** **	** **	** **	618 769
San Jose Creek at Workman Mill Road	681	959	772	863	954	930	878	933	**	**	**	**	871

* No Samples collected due to dry conditions
** Contract laboratory services were not available from June to September

Surface Water Quality Analysis (Partial Data)
Monthly Monitoring 1990-91 Season (Dry Weather)
Los Angeles River at Wardlow Road

Constituent mg/l	Oct. 1990	Nov. 1990	Dec. 1990	Jan. 1991	Feb. 1991	Mar. 1991	Apr. 1991	May 1991	Jun. 1991	Jul. 1991	Aug. 1991	Sep. 1991	Average
Hardness as CaCO3	266	276	224	198	153	238	251	301	*	*	*	*	238
Calcium	58	60	54	73	42	63	69	72	*	*	*	*	61
Manesium	30	30	22	28	12	20	19	29	*	*	*	*	24
Sodium	135	105	121	121	128	118	132	124	*	*	*	*	123
Potassium	13.2	12.7	10.3	11.1	11.6	10.7	10.8	15.7	*	*	*	*	12.0
Ammonium	2.1	3.2	3.9	5.5	4.2	0.6	3.0	7.2	*	*	*	*	3.7
Alkalinity as CaCO3	185	138	104	179	92	173	149	182	*	*	*	*	150
Sulfate	145	153	159	178	150	163	217	213	*	*	*	*	172
Chloride	140	137	142	135	142	103	121	135	*	*	*	*	132
Nitrate-N	6.85	5.70	5.76	2.96	2.78	1.97	1.23	0.45	*	*	*	*	3.46
Phosphate	3.40	4.21	2.30	3.10	0.50	1.20	6.30	0.42	*	*	*	*	2.68
Total Dissolved Solids	716	694	652	705	624	582	683	763	*	*	*	*	677
BOD	3.9	6.0	7.7	3.4	9.3	2.0	2.0	20.4	*	*	*	*	6.8
Total Organic Carbon	11.1	14.9	14.3	10.8	13.4	11.8	14.7	20.0	*	*	*	*	13.9
MPN/100ml													
Fecal Coliform	5,000	8,000	1,100	7,000	<2	22	8	<2	*	*	*	*	2,600
Total Coliform	50,000	17,000	2,200	130,000	<2	90	23	6	*	*	*	*	25,000
Fecal Streptococcus	3,000	1,700	1,100	3,000	230	130	70	500	*	*	*	*	1,200
Enterococcus	1,700	1,700	1,100	3,000	230	80	70	500	*	*	*	*	1,100
pH	8.0	8.7	7.0	8.3	9.0	9.3	9.1	9.0	*	*	*	*	8.6
Temperature	70	55	60	50	64	64	68	77	*	*	*	*	64

* Contract laboratory services were not available from June to September

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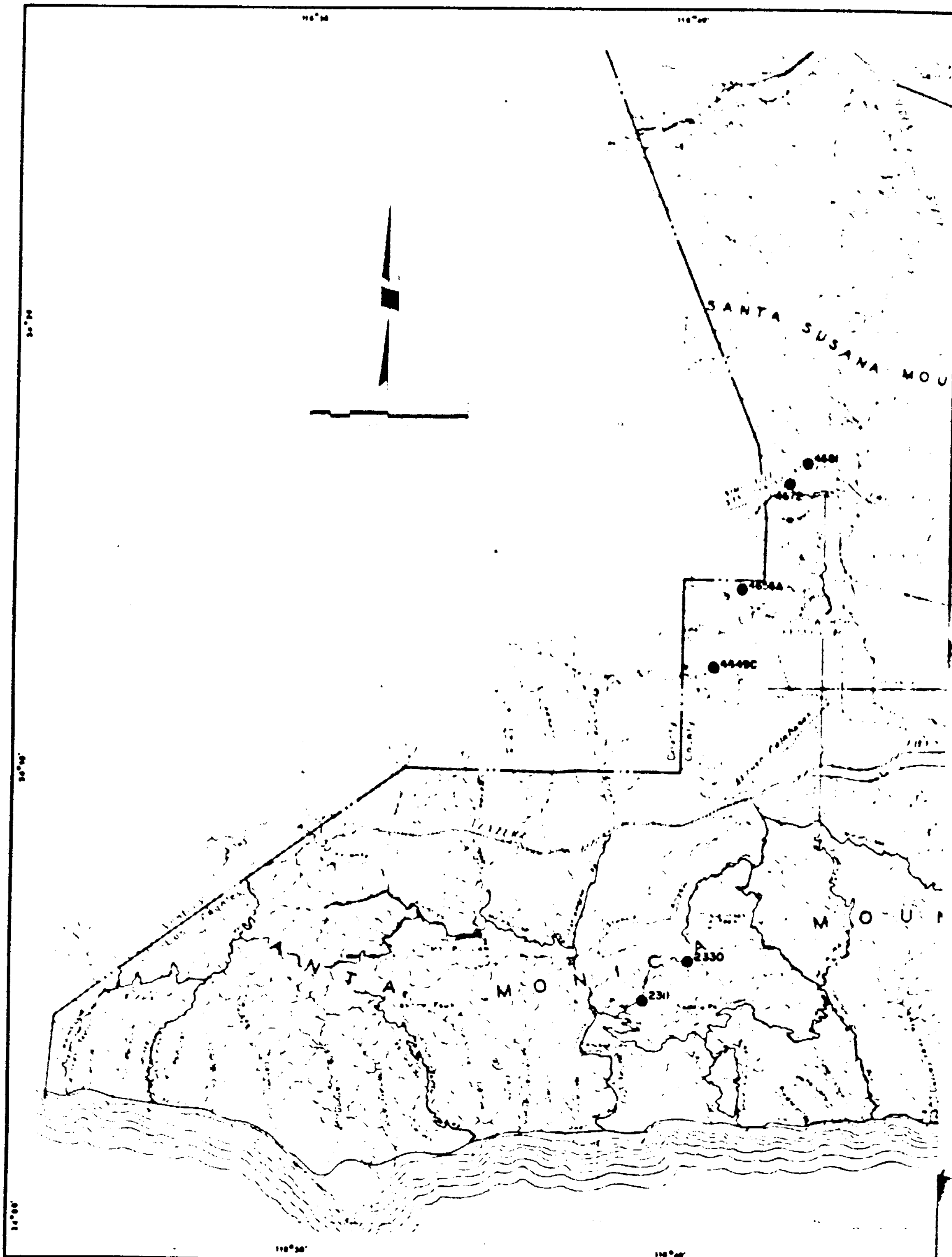

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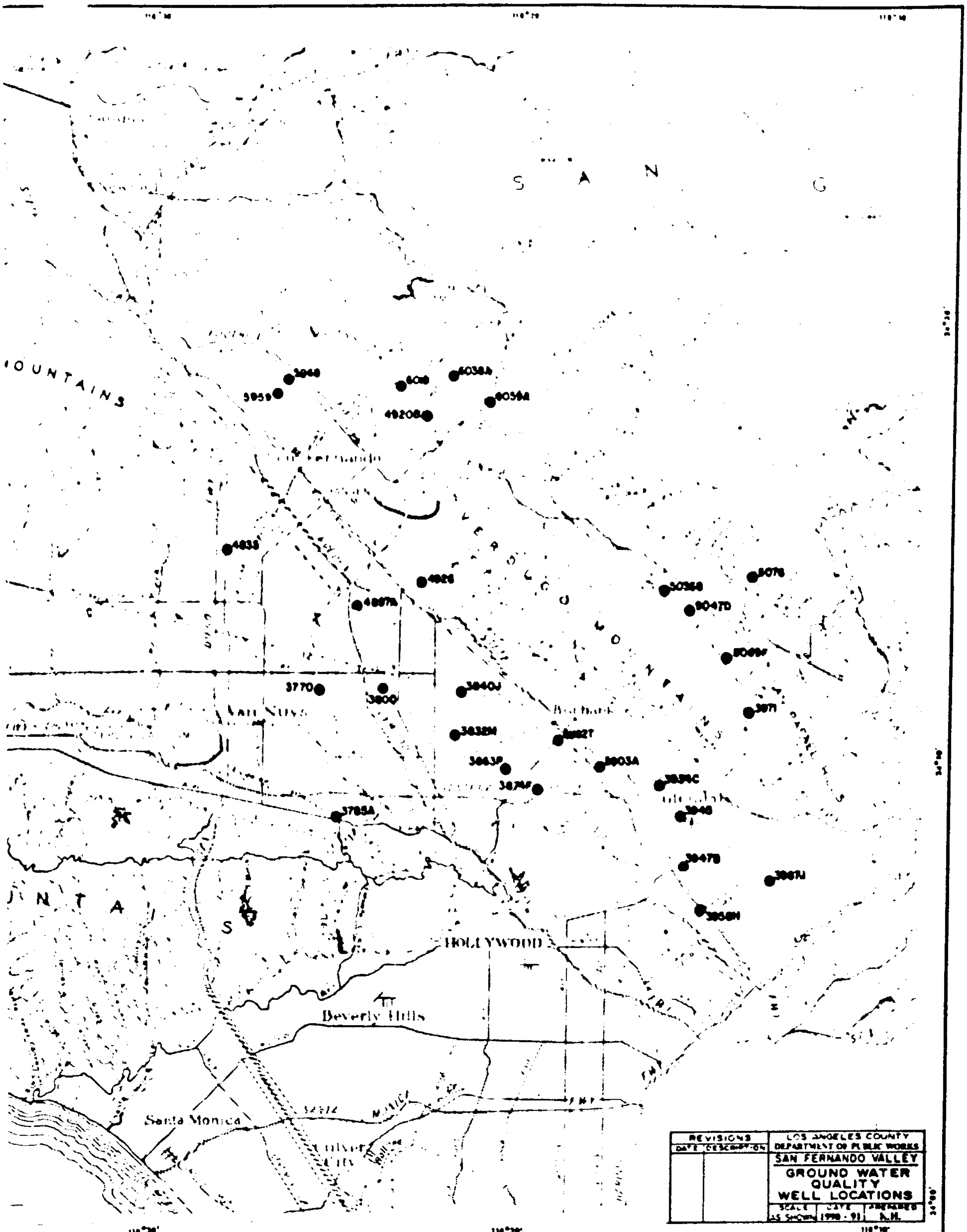

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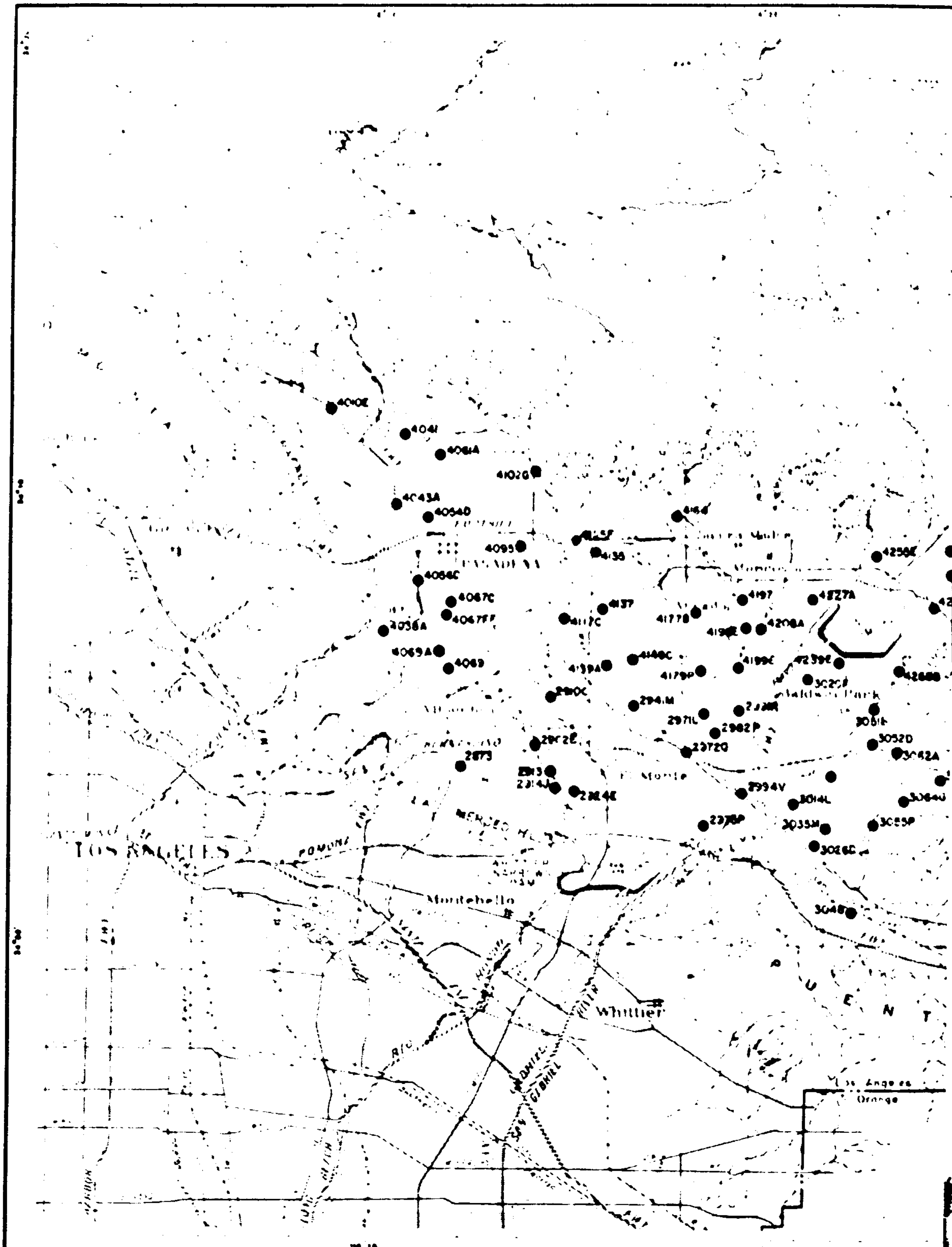

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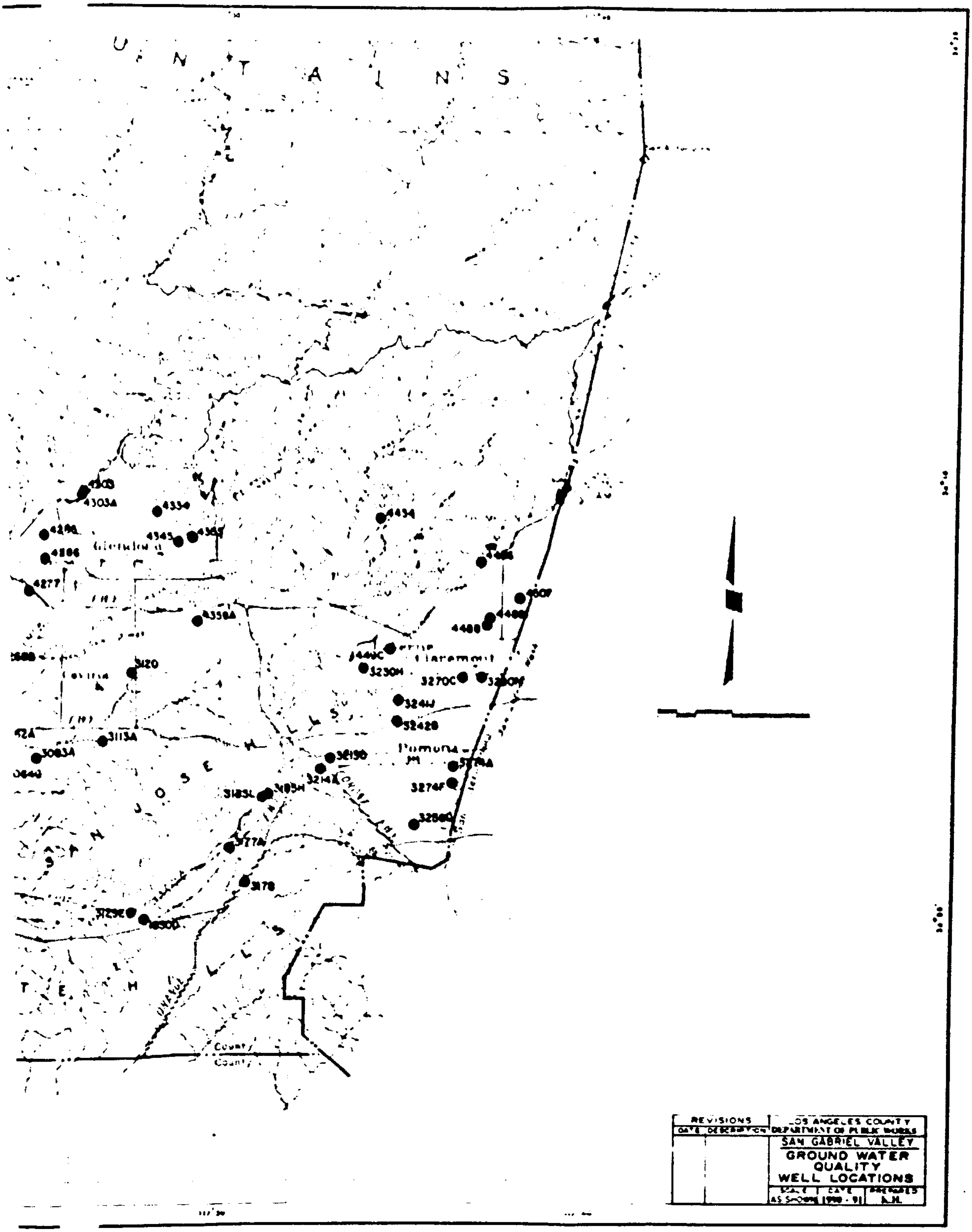

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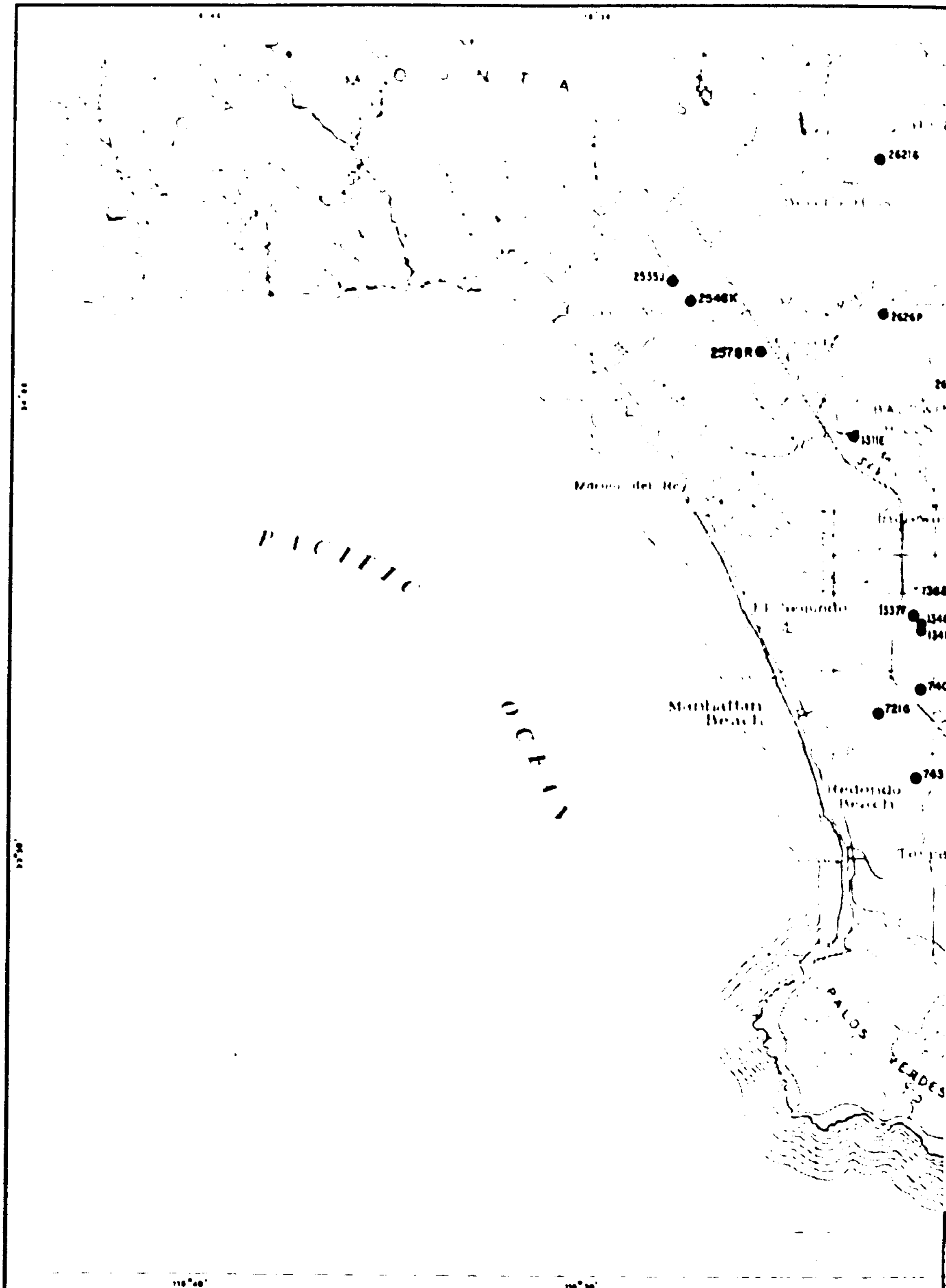

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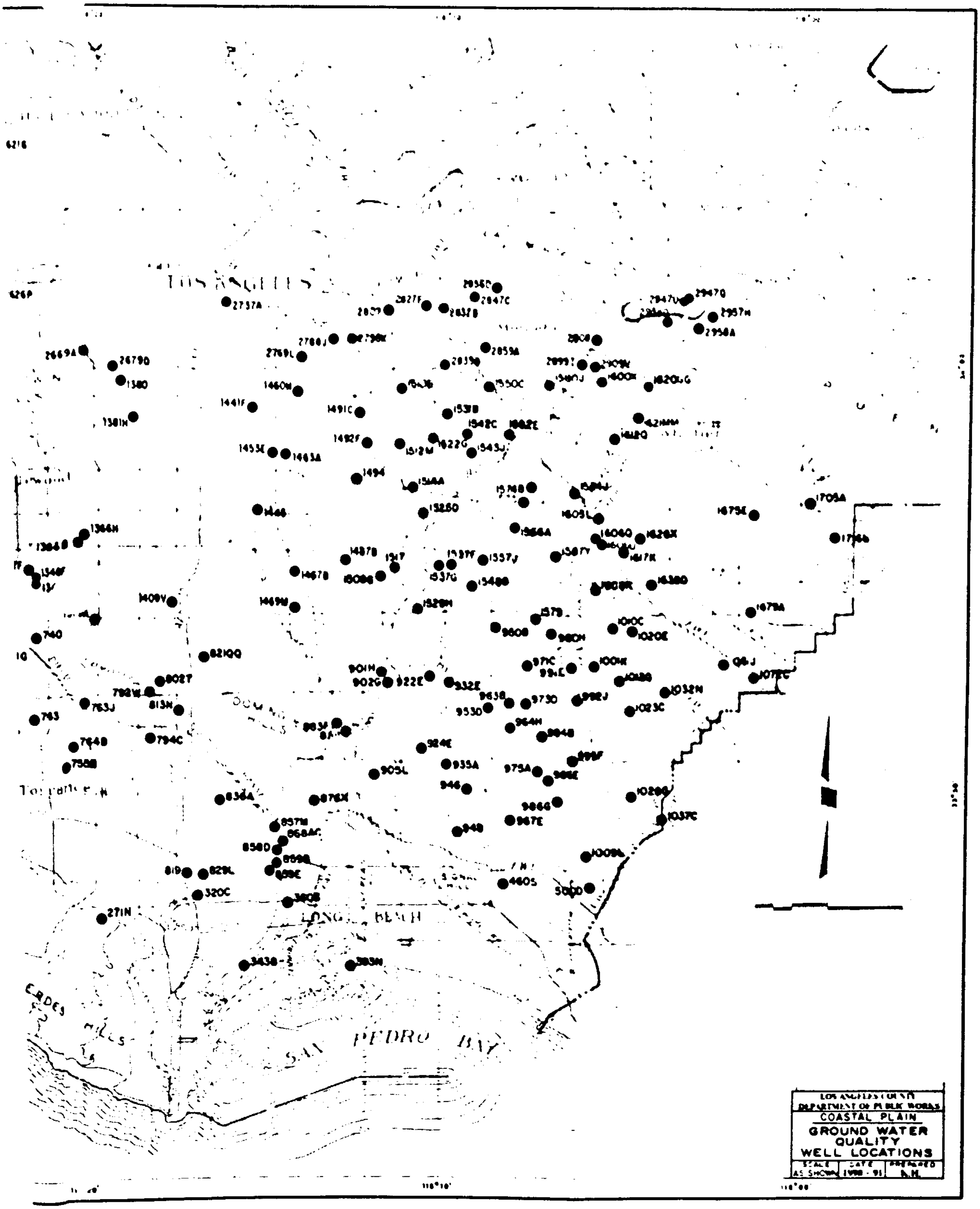

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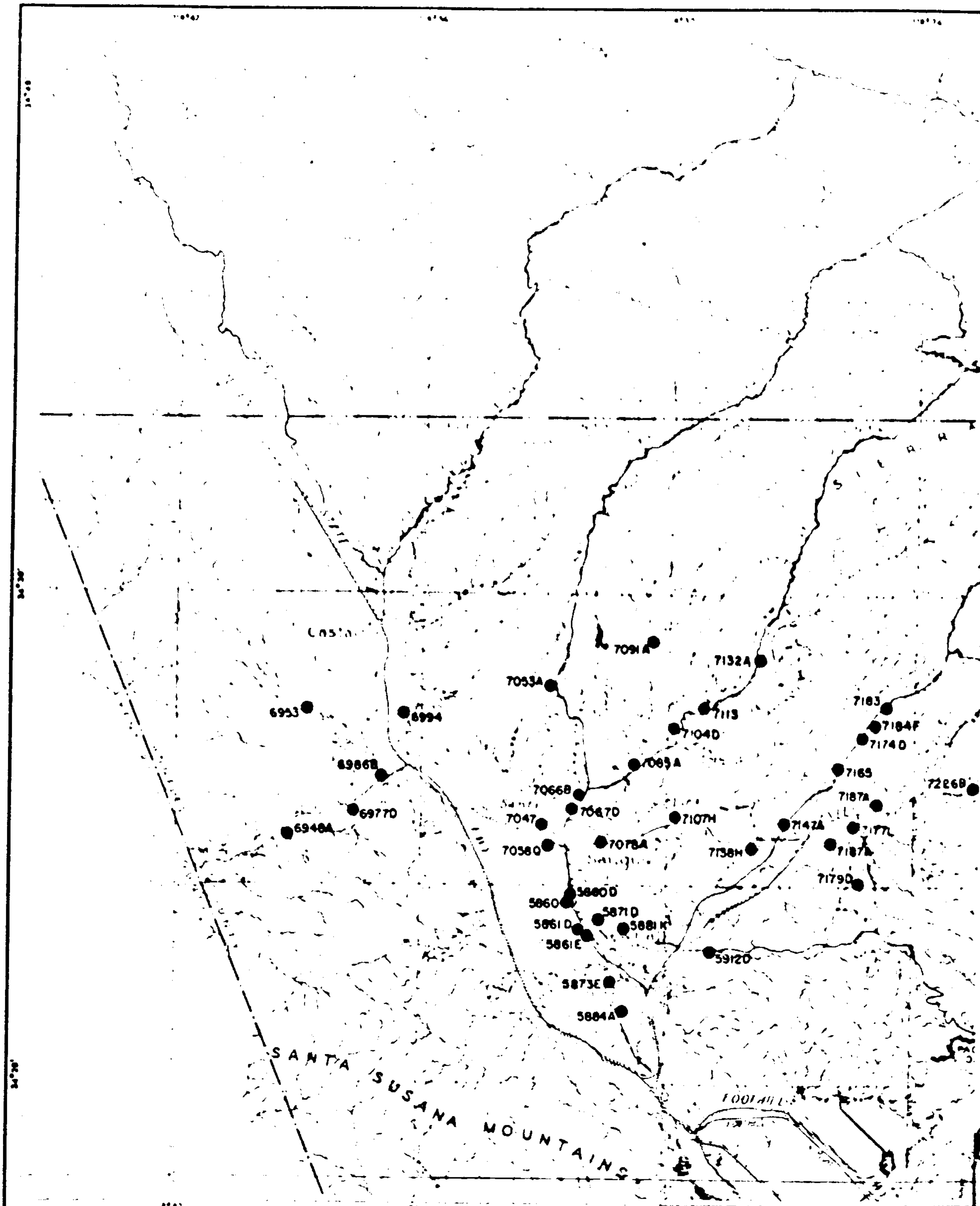

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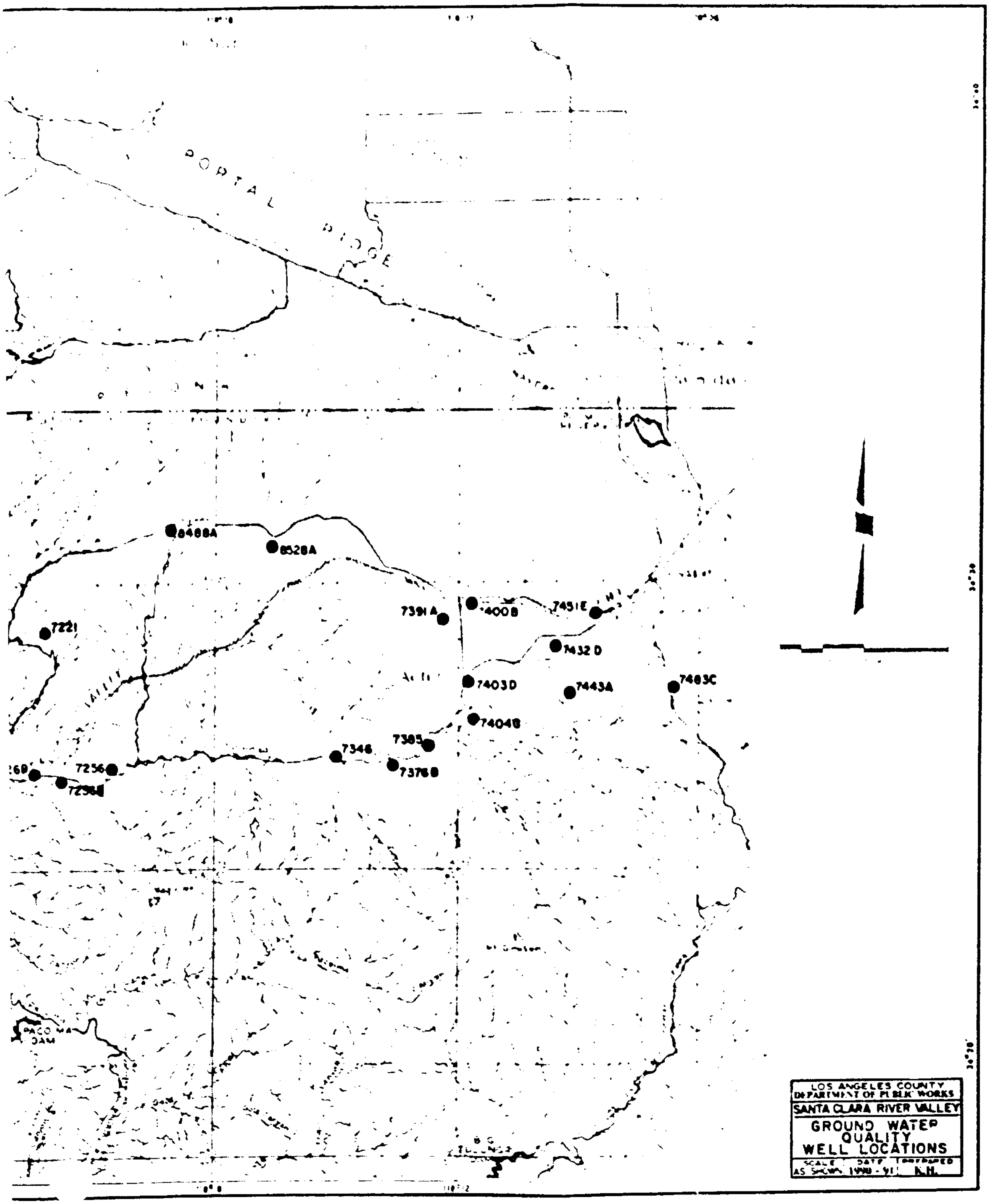

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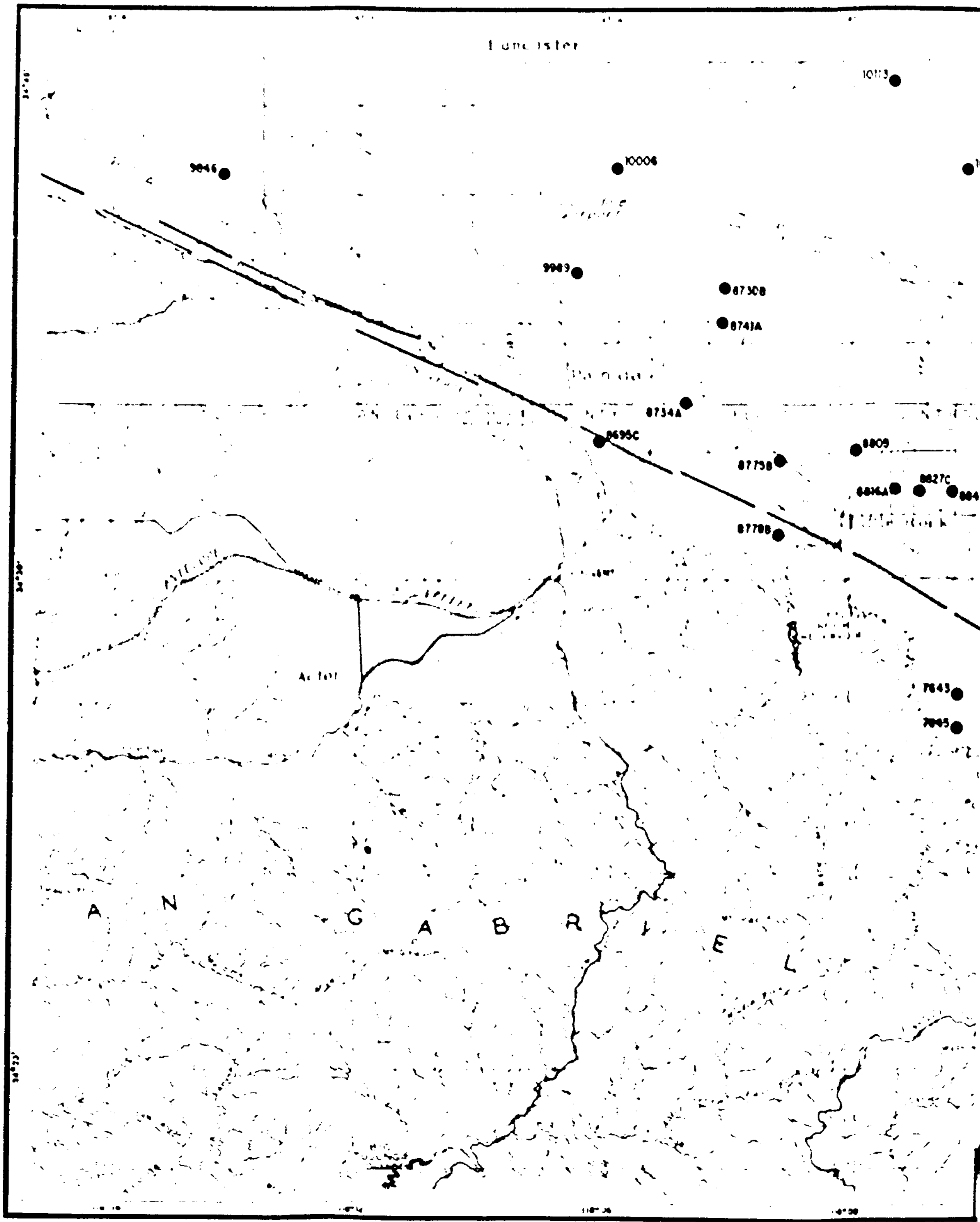

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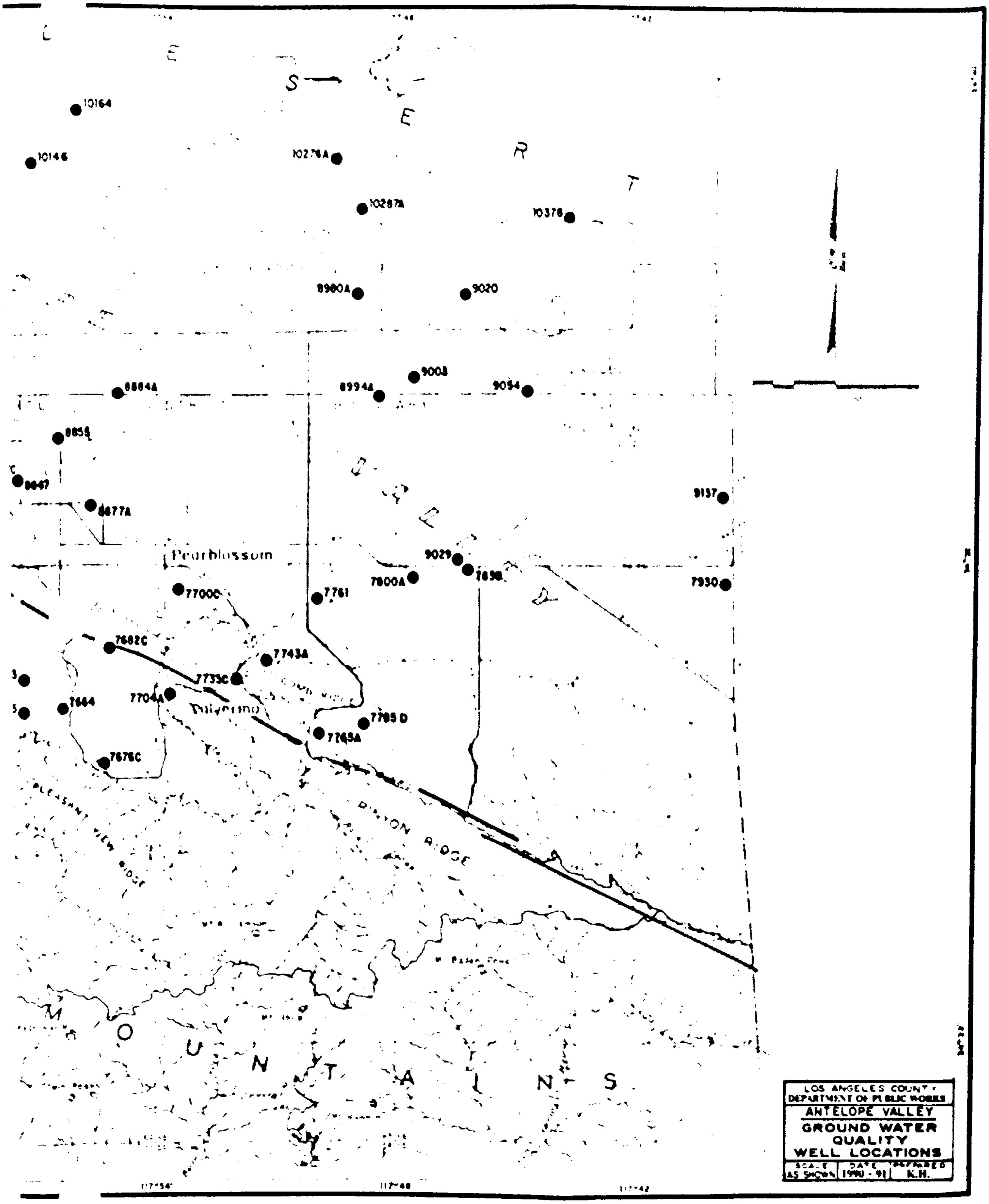

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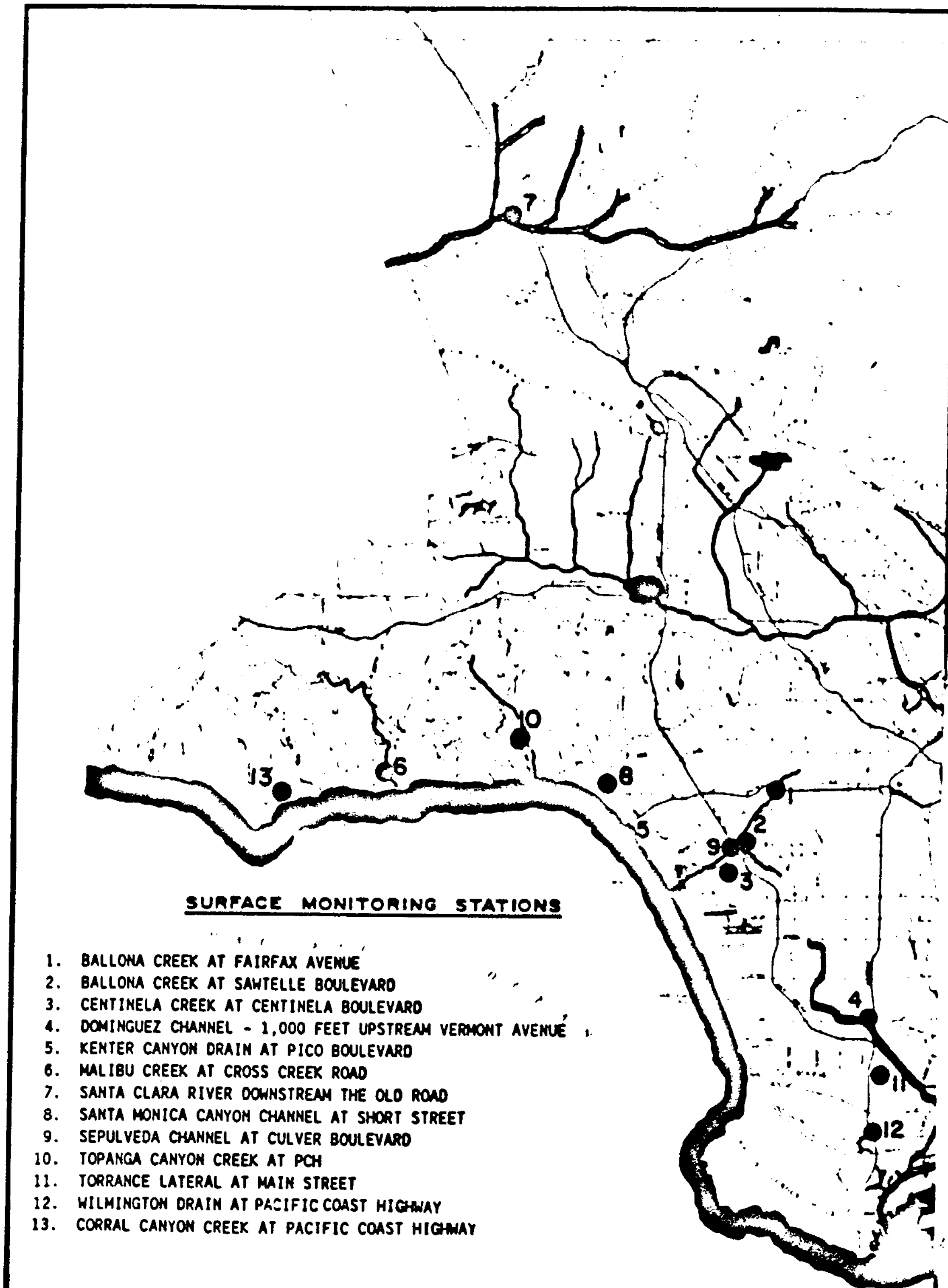

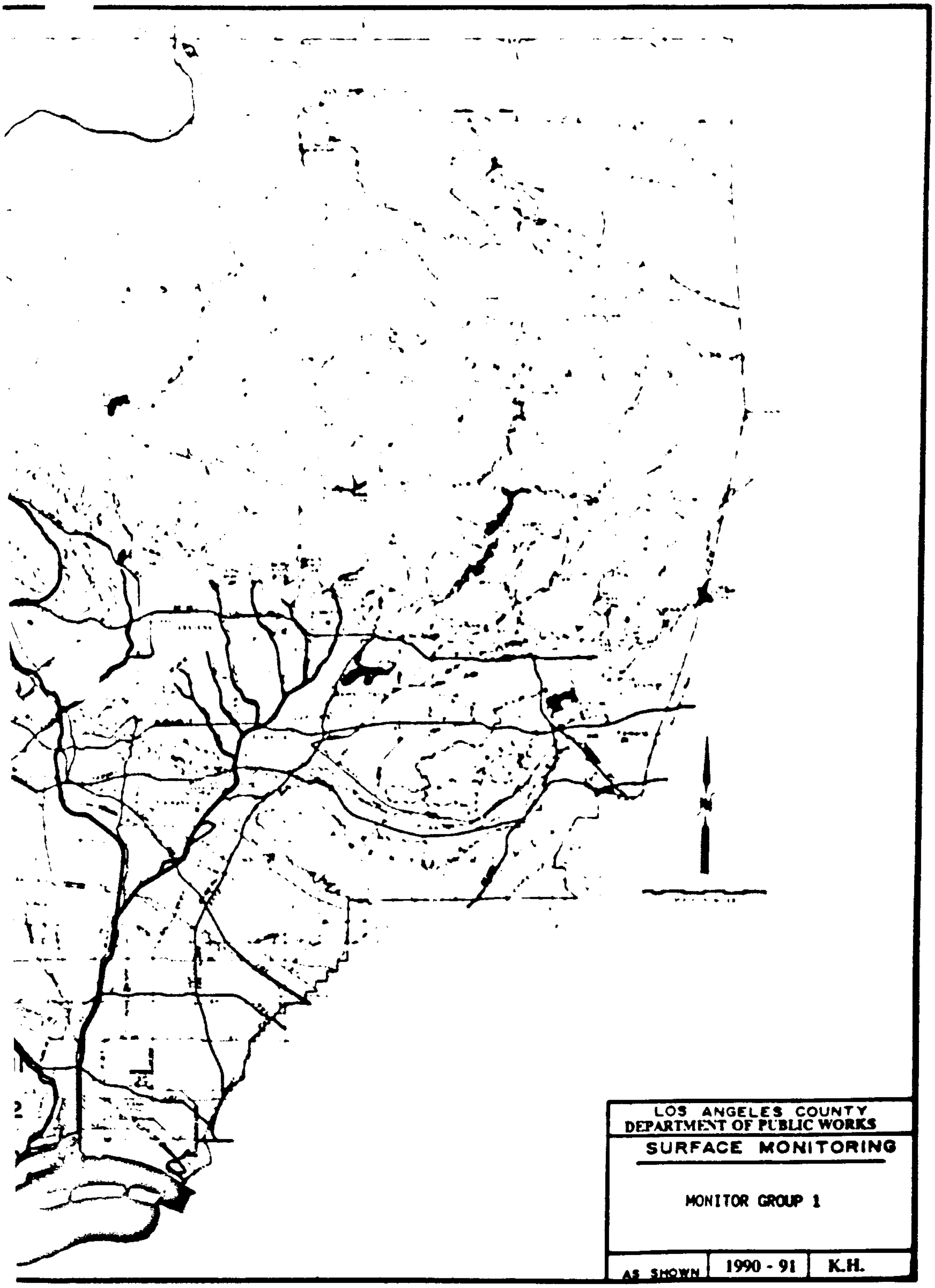

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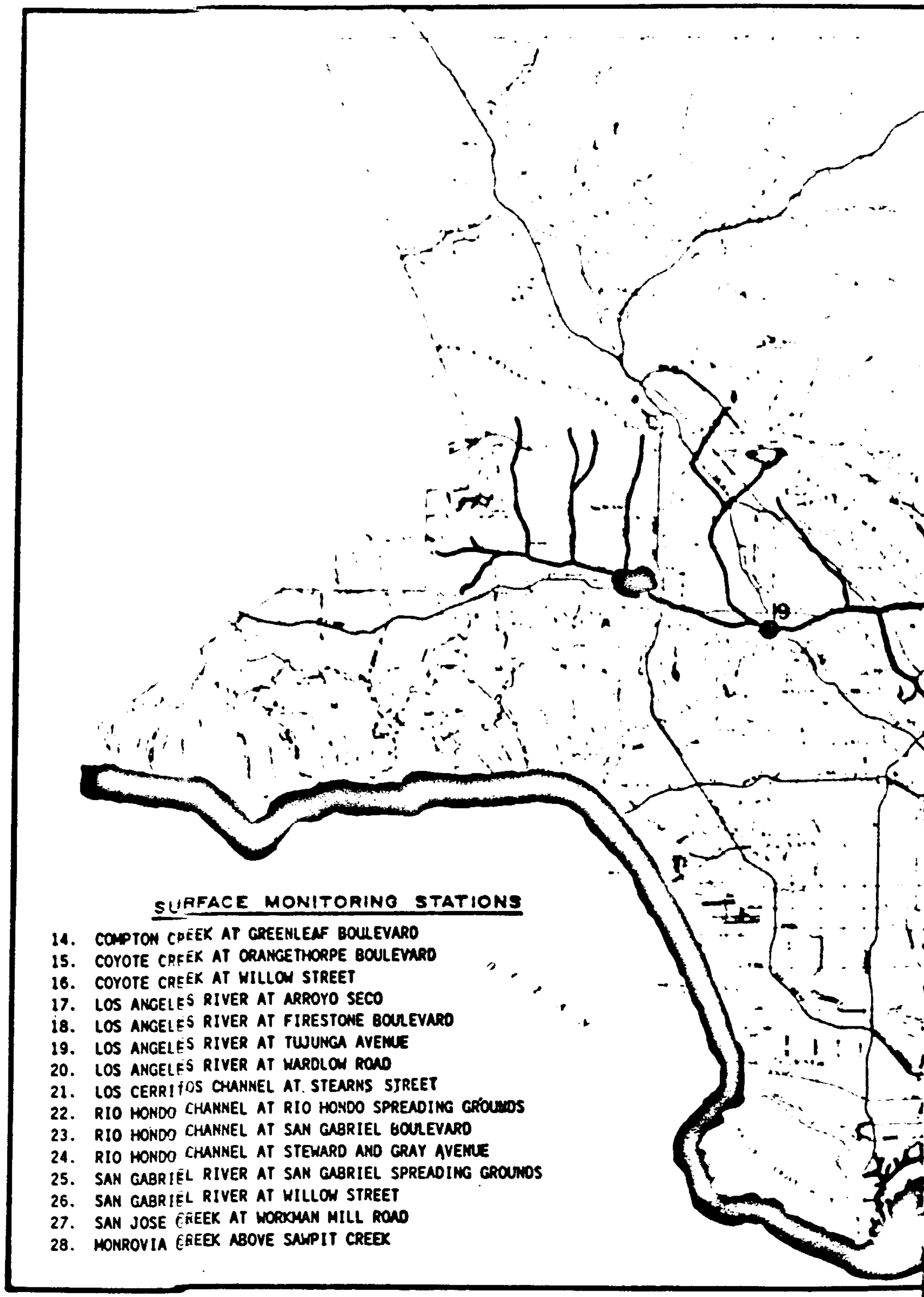
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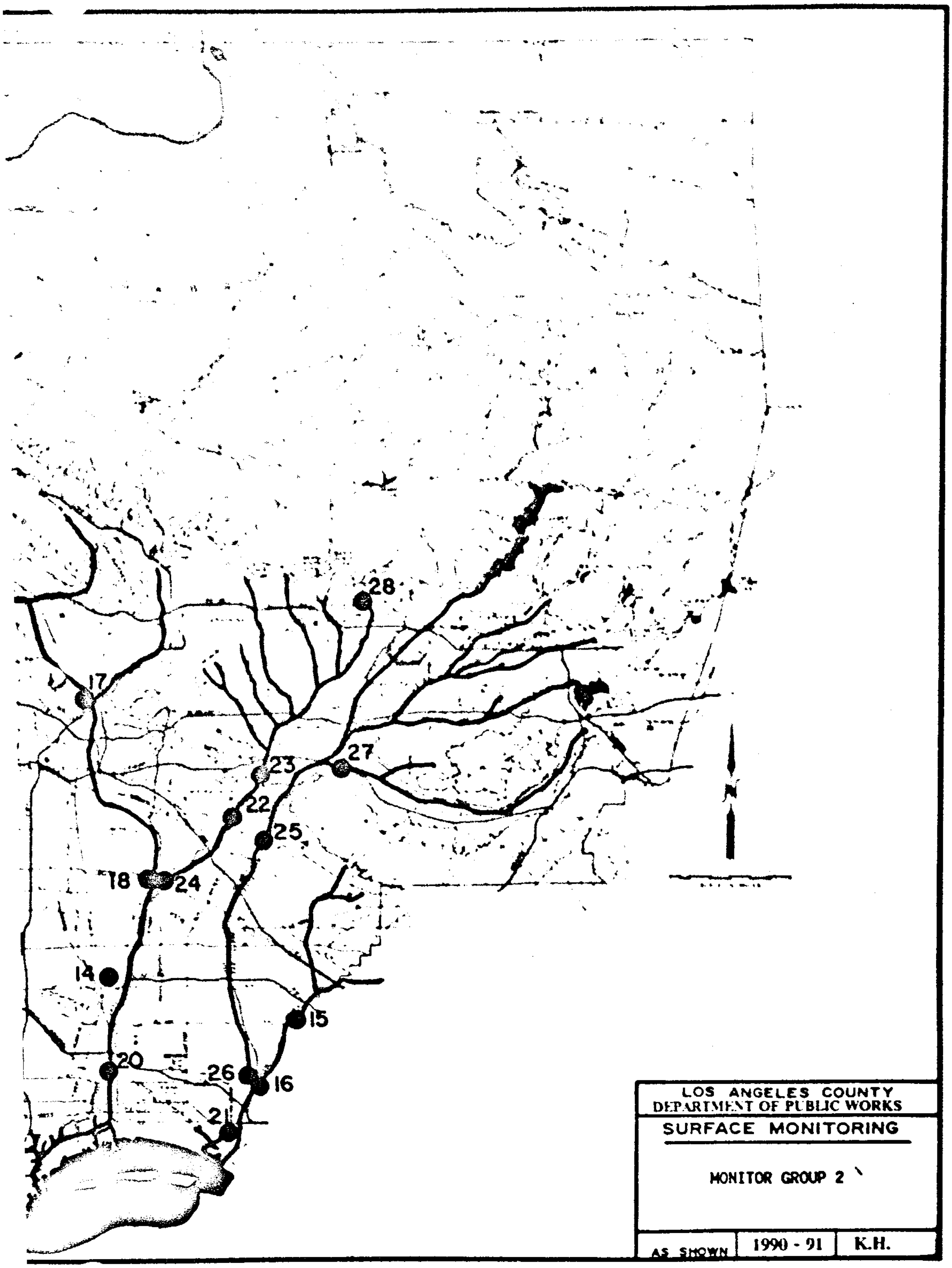
SURFACE MONITORING STATIONS
14. COMPTON CREEK AT GREENLEAF BOULEVARD
15. COYOTE CREEK AT ORANGETHORPE BOULEVARD
16. COYOTE CREEK AT WILLOW STREET
17. LOS ANGELES RIVER AT ARROYO SECO
18. LOS ANGELES RIVER AT FIRESTONE BOULEVARD
19. LOS ANGELES RIVER AT TUJUNGA AVENUE
20. LOS ANGELES RIVER AT WARDLOW ROAD
21. LOS CERRITOS CHANNEL AT STEARNS STREET
22. RIO HONDO CHANNEL AT RIO HONDO SPREADING GROUNDS
23. RIO HONDO CHANNEL AT SAN GABRIEL BOULEVARD
24. RIO HONDO CHANNEL AT STEWARD AND GRAY AVENUE
25. SAN GABRIEL RIVER AT SAN GABRIEL SPREADING GROUNDS
26. SAN GABRIEL RIVER AT WILLOW STREET
27. SAN JOSE CREEK AT WORKMAN MILL ROAD
28. MONROVIA CREEK ABOVE SAWPIT CREEK



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WATER CONSERVATION

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WATER CONSERVATION

Information presented in this section includes amounts of local, imported, and reclaimed water conserved in spreading areas and information on the seawater barrier projects which prevent saltwater intrusion to groundwater zones in the coastal areas. Pertinent data is presented regarding the locations and descriptions of Department water conservation facilities, a well as facilities owned by others. Also included are groundwater maps delineating static groundwater elevations recorded during the report period and hydrographs of selected key wells.

CONSERVING THE WATERS

In addition to its flood control program, the Department has the equally important task of conserving as much of the storm and other waters as practicable. The use of water conservation facilities adjacent to river channels, and in soft-bottom channels permits water to percolate into groundwater basins for later pumping. These water spreading facilities are located in areas where the underlying soils are composed of pervious formations.

The various types of water conserved, local, imported, and reclaimed, are construed to have the following meanings in this section: Local water is primarily runoff due to rainfall on the mountain and valley watersheds, dam releases, and rising water within the County. Imported water is water originating outside the County either from Northern California or from the Colorado River. Reclaimed water is the effluent produced by the Whittier Narrows Water Reclamation Plant, the San Jose Creek Water Reclamation Plant, and the Pomona Reclamation Plant, all operated by the Los Angeles County Sanitation District.

The importance of this activity is apparent when it is realized that about 30 to 40 percent of the water used in the County is pumped from ground supplies. The growth of the County, combined with periodic droughts, has seriously depleted these supplies on numerous occasions.

The Department's policy is to conserve the maximum amount of storm water possible consistent with considering runoff quantity and quality, capacities of the spreading facilities, and groundwater conditions.

IMPORTED WATER

During this report period, imported Colorado River and State Project water for spreading was received from the Metropolitan Water District. Imported water for groundwater recharge in the Coastal Plain was spread at the Department's facilities in the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds on behalf of the Central and West Basin Water Replenishment District. Imported water for groundwater recharge in the San Gabriel Valley was spread in Santa Fe Spreading Grounds, in the San Gabriel River between Morris and Santa Fe Dams, in Irwindale Spreading Basin and in Citrus and Forbes Spreading Grounds on behalf of MWD, the Main San Gabriel Basin Watermaster, Three Valleys Municipal Water District, and the San Gabriel Valley Municipal Water District.

RECLAIMED WATER

The County Sanitation District's Whittier Narrows Water Reclamation Plant effluent, purchased by the Central and West Basin Water Replenishment District, was transported to the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds for groundwater replenishment.

The County Sanitation District's San Jose Creek Water Reclamation Plant, activated in May 1972, made its first delivery of effluent in November 1972. The portion of the effluent that is spread is also purchased by the Central and West Basin Water Replenishment District.

Water from the Pomona Reclamation Plant is released down the San Jose Creek - San Gabriel River System to the Department's recharge facilities in the Rio Hondo and San Gabriel Coastal Basin spreading grounds.

The maximum amount of reclaimed water allowed for spreading in the Montebello Forebay, effective July 1991, is 60,000 acre-feet per year, but not to exceed 150,000 acre-feet over a three year period.

SEAWATER BARRIER PROJECTS

The Department operates three barrier projects to protect the groundwater in the West Coast and Central Basins against seawater intrusion by creating freshwater pressure ridges along the coastline. The pressure ridges are created by injecting fresh water through a series of injection wells. During the report period, 16,037 acre-feet of water was injected at the West Coast Basin Barrier Project, 7,757 acre-feet at the Dominguez Gap Barrier Project, and 4,096 acre-feet at the Los Angeles part of the Alamitos Barrier Project. On behalf of the Orange County Water District, 1,818 acre-feet of water was injected at the Orange County portion of the Alamitos Barrier Project.

The following seawater barrier improvements were completed during the 1990-91 water year:

1. Alamitos Barrier Project:

    Four multi-zone injection wells were constructed along the southeasterly reach of the barrier. This construction project was managed by the Orange County Water District and our Department shared in the capital construction cost.

2. Dominguez Gap Barrier Project

    A geologic investigation was begun to determine the cause of surface leakage along the barrier alignment. This included the construction of 17 shallow piezometers. The data collected from this project will be used to evaluate the liquefaction potential and the integrity of the confining cap. We will also use this data to determine the maximum water surface elevations and the injection pressures for the optimum operations of the barrier.

3. West Coast Basin Barrier Project

Five single zone injection wells were constructed in the northerly portion of Lower San Pedro Aquifer in the barrier.

SEASONAL DATA AND MAPS

During this report period, weekly, monthly, and semi-annual measurements of groundwater levels in observations wells located throughout the groundwater basins in Los Angeles County were made and processed.

Hydrographs of selected key wells are included in this report.

GROUNDWATER BASINS AND GROUNDWATER RECHARGE

Groundwater in Los Angeles County is stored in basins underlying five major geographic areas. These groundwater basins are separated by geologic features which impede groundwater movement or sometimes by arbitrary political boundaries. The following is a background summary of the Department's groundwater recharge activities within each of these areas:

The Department operates 2,436 acres of spreading grounds and soft-bottom channel spreading areas for replenishment of local aquifers to increase water supplies. The Department also assisted in the operation and maintenance of 269 acres of spreading grounds owned by others. An additional 656 acres of spreading grounds are controlled, maintained, and operated by other agencies. The total gross acreage of spreading grounds in the county is 3,361 acres. During the report period, the Department conserved approximately 167,564 acre-feet of storm runoff.

The conservation of local runoff is supplemented by spreading imported water and reclaimed water purchased by water agencies. During the period, 113,301 acre-feet of imported water and 53,864 acre-feet of reclaimed water were spread.

The Department is continuing its efforts to improve its water spreading facilities in order to maximize the amounts of water conserved and to simplify the spreading operations.

<u>SAN GABRIEL VALLEY</u>

The Department operates 20 spreading grounds in the San Gabriel Valley that receive direct valley runoff and flows from the San Gabriel Mountains. Some of these spreading grounds can also receive imported water. During the report period, the Department added approximately 92,725 acre-feet of local water and 62,697 acre-feet of imported water to the groundwater stored in the basins underlying the San Gabriel Valley and diverted 4,104 acre-feet of local water to grounds owned by others.

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The following projects were constructed in the San Gabriel Valley during the report period:

1. Irwindale Spreading Basin:

   Construction of the inlet structure to Manning Pit was completed.

2. Eaton Wash Spreading Grounds:

   Modification and earthwork in basins, construction of a drainage system and construction of intake weir structures with motorized gates were completed.

Main San Gabriel Basin

This is the largest basin underlying the San Gabriel Valley with an estimated storage capacity of 9.5 million acre-feet. It reacts quickly to artificial spreading in Santa Fe Reservoir Spreading Grounds and to infiltration in the San Gabriel River Downstream of Santa Fe Dam.

During the report period, the Department replenished the Main San Gabriel Basin with 72,780 acre-feet of local water and 34,597 acre-feet of imported water. Also, a new historic low for the groundwater elevation in the San Gabriel Main Basin was recorded. Well 3030F in Baldwin Park recorded a new historic low groundwater elevation of 196.7 ft on March 2, 1991.

Upper San Gabriel Canyon Basin

Approximately 13,667 acre-feet of local water and approximately 27,200 acre-feet of imported water were recharged by the Department through its San Gabriel Canyon Spreading Grounds and by percolation in the adjacent San Gabriel River. Also, 2,648 acre-feet of local water was routed to Fish Canyon Spreading Grounds which is operated by the Committee of Nine.

Lower San Gabriel Canyon Basin

The basin is located south of the Upper San Gabriel Canyon Basin and is separated from it by the underground Lohmon Dike. Groundwater cascades over the Lohmon Dike from the Upper San Gabriel Canyon Basin and recharges the Lower San Gabriel Canyon Basin. The Department spread 462 acre-feet of local water in Sawpit Spreading Grounds which is within the Lower Canyon Basin.

Wayhill Basin

The Department spread 281 acre-feet of local water and 900 acre-feet of imported water at Forbes spreading facility in the Wayhill Basin.

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Foothill Basin

The Department spread 2,008 acre-feet of local water at its San Dimas Canyon Spreading Grounds facility in the Foothill Basin.

Glendora Basin

The Department spread 467 acre-feet of local water in its Dalton facilities within the Glendora Basin.

Claremont Heights Basin

Approximately 87 acre-feet of local water were diverted to the Pomona Valley Protective Association's Thompson Creek Spreading Grounds which benefits the groundwater in the Claremont Heights Basin.

Live Oak Basin

The Department has no spreading facilities in the Live Oak Basin.

Chino Basin

The basin is located in the most eastern part of the County. No Department recharge facilities are located within the Chino Basin.

San Dimas Basin

The basin is north of the San Jose Hills, east of the Main Basin, and south of the Wayhill Basin. The Department spread 186 acre-feet of local water in its Live Oak Spreading Grounds to recharge the basin.

Pomona Basin

The basin is located south of Claremont, Live Oak, and San Dimas Basins, and north of the Chino Basin and northeast of the San Jose Hills. The Department has no water spreading facilities within this basin.

Puente and Spadra Basins

No spreading occurs in this area.

Raymond Basin

The basin covering approximately 40 square miles is located in the northwest corner of the San Gabriel Valley and is separated from the Main San Gabriel Basin by the Raymond Fault. The Raymond Basin contains the Monk Hill Basin and the Pasadena and Santa

Anita Subareas. The Department recharged 2,874 acre-feet of local water by its spreading facilities in the Raymond Basin and diverted 1,369 acre-feet to the City of Sierra Madre's spreading facility during the report period.

COASTAL PLAIN

The groundwater basins underlying the Coastal Plain are divided by geological features into the Central (includes the Montebello and Los Angeles Forebays), West Coast, Santa Monica, and Hollywood Basins. During the period of October 1, 1990 to September 30, 1991, the Department recharged 41,998 acre-feet of local water, 52,937 acre-feet of imported water, and 50,100 acre-feet of reclaimed water to the groundwater basins underlying the Coastal Plain. Most of the water was spread in the Montebello Forebay.

The following projects were constructed in the Coastal Plain during the report period:

1. Rio Hondo Coastal Basin Spreading Ground West Side:

   Construction of about 5 miles of chain link fence with electric roller gates operated by loop sensors were completed along with construction of a bike trail under the AT and SF Rail Road.

2. West Coast Basin Saline Water Plume Mitigation Study:

   James M. Montgomery Consulting Engineers and Camp, Dresser and McKee, Inc., continue the development of the groundwater model for this study.

   These consultants have completed Task 4, which describes selected alternatives for plume mitigation. Also completed is Task 5 of the study, which evaluates and ranks the plume mitigation and basin management alternatives.

Central Basin

The Central Basin has the most storage capacity of the basins in the Coastal Plain. In addition to the water recharged in the Department's spreading facilities, water injected in the Alamitos Barrier Project also contributes to the replenishment of the pressure aquifers underlying the Central Basin.

West Coast Basin

The West Coast Basin is the second largest basin underlying the Coastal Plain and is separated from the Central Basin by the Newport-Inglewood Fault zone. Groundwater is primarily recharged by Central Basin subsurface flows and by water injected by the Department in the West Coast Basin and Dominguez Gap Barrier Projects. Groundwater elevations in the West Coast Basin are below sea level except in the area of the West Coast Basin Barrier injection mound.

The Department spread 96 acre-feet of water in the Dominguez Spreading Grounds.

Santa Monica and Hollywood Basins

The Department has no spreading facilities in either the Santa Monica or Hollywood groundwater basins.

SAN FERNANDO VALLEY

The San Fernando Valley is also called the Upper Los Angeles River Area (ULARA). Most of the runoff from the surrounding mountains flows to the Valley.

San Fernando Main Basin

The basin is the largest basin underlying the San Fernando Valley. During the report period, 18,162 acre-feet of local water and 504 acre-feet of imported water were spread by the Department. The County entered into an agreement with the City of Los Angeles to spread water at the newly renovated Tujunga Wash Spreading Grounds which is located approximately two miles downstream of Hansen Spreading Grounds. The City installed a rubber dam diversion and appurtenant facilities for County Spreading operations which started in March 1990.

Sylmar Basin

A much smaller basin underlying the San Fernando Valley is the Sylmar Basin; the Department has no spreading facility within this basin.

Verdugo and Eagle Rock Basins

The small Verdugo and Eagle Rock Basins comprise the remaining basins underlying the San Fernando Valley. The Department has no spreading facilities within either basin.

SANTA CLARITA VALLEY

The Department has no spreading facilities in the area. Most of the Valley is farmland, permitting substantial natural percolation.

The Upper Santa Clarita subunit comprises five basins.

ANTELOPE VALLEY

There are several groundwater basins underlying the Antelope Valley, five of them are located within Los Angeles County.

During this report period a private water company under contract with the Department recharged over 489 acre-feet of local water in its spreading facility in the Big Rock area to groundwater in the Pearland Basin.

The groundwater level in the Lancaster Basin has declined steadily since 1925 and reached a new historic low during the report period.

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LOS ANGELES COUNTY DEP
HYDRAULIC/WATER CO

SUMMARY OF DATA ON
OWNED AND OPERATE
UPDATED THROUG

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES* CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCO (C
ARROYO SECO	SHALLOW BASINS	1948-49	24	15.1	-	75	30	
BEN LOMOND	SHALLOW BASINS	1958-59	24	14.1	-	25	25	
BIG DALTON	SHALLOW BASINS	1930-31	24	7.7	-	45	12	
BRANFORD	DEEP BASIN	1956-57	12	7	1,540	1,540	137	
BUENA VISTA	DEEP BASIN	1954-55	10	5	2,900	2,900	177	
CITRUS	MEDIUM DEPTH BASINS	1960-61	19	14.6	-	200	80	
DOMINGUEZ GAP	DEEP BASINS	1957-58	54	23.8	-	20	234	
EATON BASIN	DEEP BASIN	1956-57	16	10.5	9,600	400	284	
EATON WASH	DEEP & SHALLOW BASINS	1947-48	28	25.4	6,600	200	525	

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION
DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS DO N

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

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VOL 12

2 0026

Y DE TMENT OF PUBLIC WORKS
ER CONSERVATION DIVISION

A ON SPREADING FACILITIES
RATED BY THE DEPARTMENT
ROUGH SEPTEMBER 1991

PERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
18	EASTERLY SIDE OF ARROYO SECO, 0.5 MILES ABOVE DEVIL'S GATE DAM.	CONTROLLED FLOW FROM CITY OF PASADENA. UNCONTROLLED FROM ARROYO SECO AND THE ALTADENA STORM DRAIN.	SPREADING GROUNDS ARE HELD UNDER EASEMENT FROM THE CITY OF PASADENA.
18	BOTH NORTH AND SOUTH SIDES OF SAN DIMAS WASH CHANNEL AT SOUTHWESTERLY CORNER OF INTERSECTION OF ARROW HIGHWAY AND BARRANCA AVENUE.	COVINA IRRIGATING COMPANY.	SPREADING GROUNDS UTILIZED TO CONSERVE EXCESS COVINA IRRIGATION COMPANY WATER RELEASED FROM THE COMMITTEE OF NINE.
15	WESTERLY SIDE OF BIG DALTON WASH, ONE HALF MILE ABOVE SIERRA MADRE AVENUE.	CONTROLLED FLOWS FROM BIG DALTON DAM AND BIG DALTON DEBRIS BASIN.	
1	SOUTHWESTERLY OF ARLETA AVENUE ABOVE CONFLUENCE OF TUJUNGA WASH AND PACOIMA DIVERSION CHANNEL.	UNCONTROLLED FLOWS FROM BRANFORD STREET DRAIN.	INSTREAM SPREADING FACILITY. OUTLET CAPACITY 1,540 CFS TO PACOIMA DIVERSION CHANNEL.
	1.0 MILE EASTERLY OF SAWPIT WASH. 0.5 MILE NORTHERLY OF ARROW HIGHWAY, BETWEEN MERIDIAN STREET AND BUENA VISTA CHANNEL.	CONTROLLED FLOW FROM SANTA FE DAM AND UNCONTROLLED FLOW FROM BUENA VISTA CHANNEL.	INSTREAM SPREADING FACILITY. AN ADDITIONAL OUTLET CONSTRUCTED TO PROVIDE TOTAL OUTLET CAPACITY OF 270 CFS.
28	SOUTH SIDE OF BIG DALTON WASH BETWEEN CITRUS AND CERRITOS AVENUES.	CONTROLLED FLOWS FROM BIG DALTON DAM AND BIG DALTON, LITTLE DALTON DEBRIS BASINS. UNCONTROLLED FLOWS FROM BIG DALTON WASH.	THERE ARE 2 INTAKES, ONE IS A DROP INLET, THE OTHER AN AIR INFLATED RUBBER DAM.
1	SOUTH OF DEL AMO BOULEVARD AND BORDERS THE EASTERN AND WESTERN SIDES OF THE LOS ANGELES RIVER	CONTROLLED FLOW FROM LOS ANGELES RIVER LOW FLOW CHANNEL AND UNCONTROLLED FLOWS FROM STORM DRAINS.	EAST SIDE BASIN USED FOR FLOOD REGULATION WITH SOME CONSERVATION STORAGE. INTAKE CAPACITY IS 20 CFS FOR LOW FLOW DIVERSION FROM THE LOS ANGELES RIVER. THE WEST SIDE BASIN IS FED BY A 24-INCH CONCRETE PIPE FROM THE EAST SIDE BASIN.
10	EAST SIDE OF EATON WASH, NORTH OF DUARTE ROAD, 0.6 MILES SOUTH OF HUNTINGTON DRIVE.	CONTROLLED FLOW FROM EATON WASH DAM AND UNCONTROLLED FLOWS BETWEEN DAM AND SPREADING BASIN.	
17	EASTERLY SIDE OF EATON WASH FROM BELOW EATON DAM TO FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM EATON WASH DAM.	GROUND MODIFICATIONS COMPLETED IN DECEMBER 1991.

* RATES WHICH MAY BE EXPECTED TO OCCUR
O NOT REFLECT LONG TERM SPREADING OPERATIONS.

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LOS ANGELES COUNTY DEP
HYDRAULIC/WATER CO

SUMMARY OF DATA ON
OWNED AND OPERATE
UPDATED THROUG

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES		CAPACITIES			
			GROSS	WETTED	CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCO (CF
FORBES	MEDIUM DEPTH BASINS	1964-65	21	10	-	100	87	
HANSEN	SHALLOW BASINS	1944-45	156	105.3	22,000	400	320	2
IRWINDALE/MANNING PIT	DEEP BASINS	1958-59	62	30	20,000	400	1134	
LITTLE DALTON	SHALLOW BASINS	1931-32	14	4.7	-	20	5	
LIVE OAK	SHALLOW BASINS	1961-62	5	1.2	-	15	2	
LOPEZ	SHALLOW BASINS	1956-57	18	11.9	-	25	23.6	
PACOIMA	MEDIUM DEPTH BASINS	1932-33	169	107.3	17,000	600	440	
PECK ROAD	DEEP BASIN	1959-60	157	105	30,100	30,100	3,347	

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION R
DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS DO NO

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

VOL 12

2 0028

Y DE TMENT OF PUBLIC WORKS
ER C..SERVATION DIVISION

A ON SPREADING FACILITIES
RATED BY THE DEPARTMENT
ROUGH SEPTEMBER 1991

PERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
5	SOUTH SIDE OF SAN DIMAS WASH BETWEEN LONE HILL AVENUE AND VALLEY CENTER AVENUE.	CONTROLLED RELEASES FROM PUDDINGSTONE DIVERSION DAM, AND UNCONTROLLED FLOWS FROM SAN DIMAS WASH; ALSO IMPORTED FROM SGVMWD AND CB48.	RECONSTRUCTION OF BASINS, FROM SHALLOW TO MEDIUM DEPTHS, WAS COMPLETED IN APRIL 1989.
250	NORTHWESTERLY SIDE OF TUJUNGA WASH FROM ABOVE GLENOAKS BOULEVARD SOUTHWESTERLY TO SAN FERNANDO ROAD.	CONTROLLED FLOWS FROM HANSEN DAM AND BIG TUJUNGA DAM.	
70	NORTHEASTERLY OF INTER-SECTION OF BIG DALTON CHANNEL AND IRWINDALE AVENUE; CONTINUES 1,300 FEET EAST OF IRWINDALE AVENUE	BIG DALTON CHANNEL CONTROLLED FLOWS FROM BIG AND LITTLE DALTON DEBRIS DAMS AND PUDDINGSTONE DIVERSION DAM; UNCONTROLLED FLOWS; ALSO IMPORTED WATER FROM CB48 AND SGVMWD.	MANNING PIT INTAKE COMPLETED MARCH 1991.
	WESTERLY OF GLENDORA MT. ROAD, FROM LITTLE DALTON DEBRIS BASIN SOUTH TO EAST PALM DRIVE.	CONTROLLED FLOW FROM LITTLE DALTON DEBRIS BASIN.	
13	WESTERLY SIDE OF LIVE OAK WASH. NORTH OF BASE LINE ROAD (PROJECTED).	CONTROLLED FLOW FROM LIVE OAK DAM AND LIVE OAK DEBRIS BASIN.	
15	SOUTHEASTERLY SIDE OF PACOIMA WASH, NORTHEASTERLY OF FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM PACOIMA DAM AND LOPEZ FLOOD CONTROL BASIN.	
50	BOTH SIDES OF OLD PACOIMA WASH CHANNEL FROM ARLETA AVENUE SOUTHWESTERLY TO WOODMAN AVENUE.	CONTROLLED FLOW FROM PACOIMA DAM. PARTIALLY CONTROLLED FLOW FROM LOPEZ FLOOD CONTROL BASIN, UNCONTROLLED FLOW FROM EAST CANYON AND PACOIMA WASH. IMPORTED WATER FROM OWENS VALLEY DELIVERED BY CITY OF LOS ANGELES.	
25	CONFLUENCE OF SAWPIT AND SANTA ANITA WASHES.	CONTROLLED RELEASES FROM SANTA ANITA AND SAWPIT DEBRIS BASINS AND UNCONTROLLED FLOWS FROM LOCAL RUNOFF VIA SAWPIT AND SANTA ANITA WASHES.	INSTREAM SPREADING FACILITY.

ON RATES WHICH MAY BE EXPECTED TO OCCUR
DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

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LOS ANGELES COUNTY DEP
HYDRAULIC/WATER CO

SUMMARY OF DATA ON
OWNED AND OPERATE
UPDATED THROUG

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SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES		CAPACITIES			
			GROSS	WETTED	CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCO (C
RIO HONDO COASTAL	MEDIUM DEPTH BASINS	1937-38	570	430.1	40,000	1,950	3,694	
SAN DIMAS CANYON	SHALLOW BASINS	1965-66	22	10.8	-	25	22	
SAN GABRIEL CANYON	DEEP BASINS	1917	165	-	-	60	-	
SAN GABRIEL COASTAL	MEDIUM DEPTH BASINS	1938-39	128	95.0	-	350	575	
SAN GABRIEL RIVER (MONTEBELLO FOREBAY)	MEDIUM DEPTH BASINS	1954-55	156	156	20,000	550	1,462***	
SAN GABRIEL RIVER (SAN GABRIEL VALLEY)	TEMPORARY CHECK LEVEES	1965-66	196	196	-	-	-	
SANTA ANITA	SHALLOW BASINS	1944-45	20	8.5	-	20	25	

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS DO N

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

Y DE TMENT OF PUBLIC WORKS
ER CONSERVATION DIVISION

A ON SPREADING FACILITIES
RATED BY THE DEPARTMENT
ROUGH SEPTEMBER 1991

PERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
400	EASTERLY SIDE OF RIO HONDO SOUTHERLY FROM S.P.R.R. (SOUTH OF WHITTIER BLVD.) TO SLAUSON AVENUE; WEST SIDE OF RIO HONDO CHANNEL FROM 0.2 MILE ABOVE WHITTIER BOULEVARD SOUTH TO FOSTER BRIDGE BOULEVARD.	CONTROLLED RELEASES FORM SAN GABRIEL CANYON DAMS, SANTA FE AND WHITTIER NARROWS DAMS. UNCONTROLLED RUNOFF VIA SAN GABRIEL RIVER, RIO HONDO CHANNEL AND THEIR TRIBUTARIES; ALSO IMPORTED AND RECLAIMED WATER.	IN COOPERATION WITH THE CORPS OF ENGINEERS. THE DISTRICT OPERATES 2,500 ACRE-FOOT POOL AT WHITTIER NARROWS DAM FOR RETENTION OF STORM WATER.
12	SOUTHEAST SIDE OF SAN DIMAS WASH BETWEEN PUDDINGSTONE DIVERSION AND SAN DIMAS CANYON ROAD.	CONTROLLED RELEASES FROM PUDDINGSTONE DIVERSION DAM; UNCONTROLLED FLOW FROM LOCAL STORM RUNOFF.	
35	EASTERLY SIDE OF SAN GABRIEL RIVER. BELOW MOUTH OF SAN GABRIEL CANYON. NORTH OF THE CITY OF AZUSA.	SAN GABRIEL RIVER CONTROLLED RELEASES FROM COGSWELL DAM, SAN GABRIEL DAM, AND MORRIS DAM. COMMITTEE OF NINE SURPLUS FLOWS.	
	WESTERLY SIDE OF SAN GABRIEL RIVER, SOUTHERLY FROM WHITTIER BOULEVARD TO WASHINGTON BOULEVARD.	CONTROLLED RELEASES FROM SAN GABRIEL CANYON DAMS, SANTA FE AND WHITTIER NARROWS DAMS. ALSO IMPORTED AND RECLAIMED WATER.	IN COOPERATION WITH THE CORPS OF ENGINEERS. THE DISTRICT OPERATES 2,500 ACRE-FOOT POOL AT WHITTIER NARROWS DAM FOR RETENTION OF STORM WATERS.
75	HEADWORKS TO FIRESTONE AVE ONLY. STORAGE BEHIND THE RUBBER DAMS.	SAME AS UPPER PORTION. ALSO RECLAIMED WATER.	FIVE RUBBER DAMS INSTALLED ON DROP STRUCTURES. WHEN INFLATED, CONVERTS RIVER BED TO SPREADING AREAS.
180	SAN GABRIEL RIVER FROM SANTA FE DAM.	CONTROLLED FLOW FROM DAMS IN SAN GABRIEL CANYON, SANTA FE DAM AND UNCONTROLLED VALLEY RUNOFF BELOW SANTA FE DAM; ALSO IMPORTED WATER.	CHECK LEVEES DEVELOPED IN RIVER TO SPREAD WATER.
5	WESTERLY SIDE OF SANTA ANITA WASH 1.25 MILES ABOVE FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM SANTA ANITA DAM AND SANTA ANITA DEBRIS BASIN.	THE HEADWORKS LOCATED UPSTREAM OF THE DEBRIS BASIN DIVERTS WATER TO SANTA ANITA SPREADING GROUNDS AND CITY OF SIERRA MADRE SPREADING GROUNDS.

ION RATES WHICH MAY BE EXPECTED TO OCCUR
DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

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2 0031

LOS ANGELES COUNTY DEP
HYDRAULIC/WATER CO

SUMMARY OF DATA ON
OWNED AND OPERATE
UPDATED THROUG

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES CHANNEL** (CFS)	CAPACITIES INTAKE (CFS)	CAPACITIES STORAGE (A.F.)	CAPACITIES PERCO (C
SANTA FE	SHALLOW AND MEDIUM DEPTH BASINS	1953-54	338	168	-	400	540	4
SAWPIT	SHALLOW BASINS	1946-47	12	3.8	-	30	13	
WALNUT	DEEP BASIN	1962-63	16	8.4	8,000	150	166	
	TOTAL:		2,636	1,576	-	-	13,368	1,

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION R
DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS DO NO

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

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DEP' "MENT OF PUBLIC WORKS
: CO 'VATION DIVISION

ON SPREADING FACILITIES
ATED BY THE DEPARTMENT
JUGH SEPTEMBER 1991

ERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
400	WITHIN SANTA FE DAM RESERVOIR AND SPILLWAY AREAS.	CONTROLLED FLOWS FROM SAN GABRIEL CANYON RESERVOIRS. UNCONTROLLED FLOWS FROM SAN GABRIEL RIVER BELOW MORRIS RESERVOIR; ALSO IMPORTED WATER FROM SGVMWD AND USG-3.	RIGHT OF WAY, HELD UNDER LICENSE FROM THE FEDERAL GOVERNMENT INCLUDES 30 ACRES IN SAN GABRIEL RIVER BED FOR EARTH DIVERSION LEVEE.
12	WESTERLY SIDE OF SAWPIT WASH BELOW MOUTH OF CANYON NEAR NORUMBEGA DRIVE, MONROVIA.	CONTROLLED FLOWS FROM SAWPIT DAM AND SAWPIT DEBRIS BASIN.	
5	WEST SIDE OF WALNUT WASH, NORTH OF SAN BERNARDINO FREEWAY.	CONTROLLED FLOW FROM PUDDINGSTONE DAM AND UNCONTROLLED FLOWS FROM WALNUT WASH CHANNEL.	
1,756			

RATE' "HICH MAY BE EXPECTED TO OCCUR
NOT 'T LONG TERM SPREADING OPERATIONS.

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LOS ANGELES COUNTY DEPA
HYDRAULIC/WATER CON

SUMMARY OF DATA ON S
NOT OWNED BY T
UPDATED THROUGH

GROUNDS	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES CHANNEL** (CFS)	CAPACITIES INTAKE (CFS)	CAPACITIES STORAGE (A.F.)	CAPACITIES PERCOLA (CFS
SIERRA MADRE**** (CITY OF SIERRA MADRE)	SHALLOW BASINS	ABOUT 1933	22	9	-	25	47	
FISH CANYON (COMMITTEE OF NINE)	SHALLOW BASINS	ABOUT 1917	6	4	-	-	-	
THOMPSON CREEK **** POMONA VALLEY PROTECTIVE ASSOCIATION	DITCHES CHECKS AND DEEP BASIN	ABOUT 1928	53	37	-	35	-	
TUJUNGA (L.A. CITY DEPT. OF WATER AND POWER) ***	SHALLOW BASINS	1931-32	180	83.2	22,000	400	-	3
	TOTALS:		260	133	-	-	-	42

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRA
DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

*** THE DEPARTMENT ENTERED INTO AN AGREEMENT WITH T
THIS FACILITY.

**** THE DEPARTMENT DIVERTS WATER TO THESE FACILITIE

DEP   MENT OF PUBLIC WORKS
‹ CONSERVATION DIVISION

ON SPREADING FACILITIES
BY THE DEPARTMENT
ↃUGH SEPTEMBER 1991

RCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
15	CITY OF SIERRA MADRE, SOUTH SIDE OF GRANDVIEW AVENUE, ONE HALF MILE WEST OF SANTA ANITA AVENUE.	LITTLE SANTA ANITA CREEK AND STREET RUNOFF ALSO CONTROLLED FLOWS FROM SANTA ANITA DAM.	
7	WESTERLY SIDE OF SAN GABRIEL RIVER BELOW MOUTH OF FISH CANYON AND NORTH OF THE CITY OF AZUSA.	THE 'COMMITTEE OF NINE'.	OWNED AND OPERATED BY CAL-AMERICAN WATER COMPANY.
15	SOUTHERLY FROM, AND ADJACENT TO THOMPSON CREEK DAM, EAST SIDE OF CREEK. ELEVATION 1,625.	COBAL, WILLIAMS, PALMER, AND PADUA CREEKS, ALSO THOMPSON CREEK, WHEN RESERVOIR ABOVE	OPERATED BY POMONA VALLEY PROTECTIVE ASSOCIATION.
390	SAN FERNANDO VALLEY, EAST SIDE OF TUJUNGA WASH AT ROSCOE BOULEVARD.	LOS ANGELES CITY'S OWENS VALLEY AQUEDUCT AND CONTROLLED RELEASES FROM HANSEN DAM.	PRIOR TO 1938 FLOOD, USED 80 ACRES NET. TUJUNGA CHANNEL ON WESTERLY SIDE OF GROUNDS PAVED IN 1950.
427			

LTRATION RATES WHICH MAY BE EXPECTED TO OCCUR
MBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

TH THE CITY OF LOS ANGELES TO OPERATE

ITIES.

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VOL 12

WATER CONSERVED
WATER YEAR

BASINS	SPREADING FACILITIES	MONTHS: OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
SAN FERNANDO VALLEY	BRANFORD	0.4	26.8	2.2	82.3	89.0
	HANSEN	44.0	166.0	90.0	141.0	439.0
	LOPEZ	0.0	0.0	0.0	0.0	0.0
	PACOIMA	0.0	0.0	0.0	764.0	175.0
	TUJUNGA	0.0	0.0	0.0	0.0	321.1
	SUBTOTAL	44.4	192.8	92.2	987.3	1,024.1
SAN GABRIEL VALLEY	ARROYO SECO	0.0	0.0	0.0	1.2	60.0
	BEN LOMOND	12.0	44.0	11.0	5.6	24.0
	BIG DALTON	0.0	0.0	0.0	0.0	0.0
	BUENA VISTA	46.4	40.9	35.5	98.9	110.7
	CITRUS	6.5	4.2	6.6	26.0	17.0
	EATON BASIN	25.0	15.0	39.0	212.0	320.0
	EATON GROUNDS	0.0	0.0	0.0	227.0	0.0
	FORBES	136.0	166.0	0.0	251.0	73.0
	IRWINDALE	0.0	2.9	3.8	4.6	0.0
	LITTLE DALTON	0.0	0.0	0.0	0.0	0.0
	LIVE OAK	0.0	0.0	0.0	1.8	3.8
	MORRIS TO STA. F190	4,582.7	88.6	86.8	3,510.1	352.3
	STA. F190 TO SANTA FE DAM	69.0	0.0	0.0	80.0	37.0
	PECK ROAD	4.3	36.5	2.3	142.2	722.0
	SAN DIMAS CANYON	0.0	0.0	0.0	0.0	9.8
	SAN GABRIEL CANYON	0.0	0.0	0.0	494.0	0.0
	SANTA ANITA	0.0	0.0	0.0	0.0	0.5
	SANTA FE SPRD. GROUNDS	2,640.0	0.0	0.0	122.0	24.0
	SANTA FE TO STA. F261	0.0	0.0	0.0	2.1	134.0
	SANTA FE DIVERSION	0.0	0.0	0.0	0.0	0.0
	SAWPIT	0.0	0.0	0.0	44.0	38.0
	WALNUT	113.0	4.3	1.4	192.0	110.0
	F261 TO WHITTIER NARROWS DAM	4,555.5	3,808.0	2,174.3	3,592.2	10,864.0
	SUBTOTAL	12,190.4	4,208.4	2,360.7	9,006.7	12,900.1
COASTAL PLAIN	RIO HONDO S.G.	6,464.0	2,664.0	4,113.2	9,248.0	3,871.0
	W.N. RESERVOIR (R.HONDO)	1,187.0	2,571.0	1,137.8	909.0	4,965.0
	SAN GABRIEL S.G.*	3,583.2	2,727.0	2,031.2	4,710.4	5,105.6
	DOMINGUEZ GAP	4.5	12.5	17.3	12.7	14.0
	SUBTOTAL	11,258.7	7,974.5	7,299.5	14,880.1	13,955.6
ANTELOPE VALLEY	BIG ROCK	0.0	4.6	6.1	6.1	1.0
OTHER FACILITIES	SIERRA MADRE	0.0	0.0	0.0	70.0	11.0
	THOMPSON CREEK	0.0	0.0	0.0	0.4	19.0
	FISH CREEK	114.6	43.6	54.3	94.2	17.4
	SUBTOTAL	114.6	43.6	54.3	164.6	47.4
GRAND TOTAL ALL WATER SPREAD & OR DIVERTED		23,608.1	12,423.9	9,812.8	25,044.8	27,928.2

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'ED ALL FACILITIES
AR : 1990-1991

UARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	ACCUMULATIVE TOTALS
89.0	302.0	1.4	0.8	0.2	2.2	1.6	0.0	508.9
439.0	4,920.0	3,680.0	1,010.0	181.0	289.0	253.0	276.0	11,489.0
0.0	1.0	223.0	17.0	0.0	0.0	0.0	0.0	241.0
175.0	974.0	1,120.0	907.0	0.0	0.0	0.0	0.0	3,940.0
321.1	1,390.6	0.0	0.0	760.0	15.0	0.0	0.0	2,486.7
324.1	7,587.6	5,024.4	1,934.8	941.2	306.2	254.6	274.0	18,665.6
60.0	553.0	303.0	0.0	0.0	25.0	0.3	0.0	942.5
24.0	136.0	180.0	169.0	124.0	131.0	129.0	170.0	1,135.8
0.0	138.0	156.0	0.0	2.7	0.0	0.0	0.0	296.7
110.7	142.8	42.4	32.7	29.5	67.3	62.4	71.9	781.4
17.0	140.0	46.0	25.0	0.0	1.4	4.3	0.3	277.3
120.0	336.0	28.0	17.0	23.0	29.0	23.0	17.0	1,084.0
0.0	900.0	400.0	0.0	0.0	0.0	0.0	0.0	1,527.0
73.0	40.0	0.0	0.0	292.0	99.0	0.0	128.0	1,181.0
0.0	573.0	105.0	0.0	1,160.0	1,280.0	9.9	3,350.0	8,489.2
0.0	130.0	40.0	0.0	0.0	0.0	0.0	0.0	170.0
3.8	141.0	39.0	0.2	0.0	0.0	0.0	0.0	185.8
52.3	4,376.6	1,329.3	651.3	1,184.5	3,850.0	8,200.0	4,463.0	32,675.2
37.0	907.0	362.0	0.0	92.0	286.0	1,776.0	1,365.0	4,954.0
22.0	843.0	141.8	21.3	41.5	2,163.0	0.0	2,101.4	7,219.3
9.8	653.0	587.0	373.0	361.0	14.9	9.3	0.0	2,008.0
0.0	2,480.0	936.0	634.0	577.0	708.0	1,860.0	503.0	6,192.0
0.5	229.0	94.0	39.0	16.0	0.5	25.0	0.0	404.0
24.0	2,070.0	2,300.0	0.0	770.0	963.0	5,530.0	0.0	14,419.0
34.0	3,840.0	294.0	0.0	0.0	120.0	1,500.0	9,600.0	15,490.1
0.0	0.0	0.0	0.0	0.0	2,252.7	3,954.6	0.0	6,207.3
38.0	241.0	104.0	0.0	0.0	0.8	34.0	0.0	461.8
10.0	128.0	95.0	176.0	124.0	125.0	71.0	83.0	1,222.7
64.0	14,648.0	235.7	1,523.1	769.9	1,410.7	1,398.6	3,118.2	48,098.2
00.1	34,645.4	7,818.2	3,661.6	5,567.1	13,527.3	24,587.4	24,948.8	155,422.2
71.0	15,651.0	2,123.0	2,248.0	2,643.0	6,429.2	8,184.0	7,888.0	71,546.4
55.0	7,737.0	769.0	1,012.0	1,932.0	1,331.8	3,276.1	4,159.8	30,997.5
05.6	7,112.7	1,698.4	2,960.3	4,652.5	2,833.0	2,537.2	3,371.0	43,322.5
14.0	4.5	2.6	10.3	13.8	0.4	2.1	1.3	95.9
55.6	30,505.2	4,593.0	6,230.6	9,241.3	10,594.4	13,999.4	15,430.1	145,962.3
1.0	160.7	310.9	0.0	0.0	0.0	0.0	0.0	489.4
1.0	534.0	459.0	119.0	83.0	0.0	93.0	0.0	1,369.0
9.0	67.8	0.2	0.0	0.0	0.0	0.0	0.0	87.4
7.4	37.9	23.6	539.7	511.5	516.6	197.3	497.2	2,647.9
7.4	639.7	482.8	658.7	594.5	516.6	290.3	497.2	4,104.3
8.2	8.6	18,229.3	12,485.7	16,344.1	24,944.5	39,131.7	41,152.1	324,643.8

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G14

R0053342

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TOTAL WATER DELIV
WATER YEAR

MONTH	IMPORTED WATER OUTLET RELEASES								
	SAN DIMAS CB - 48	THOMPSON CREEK CB - 28	SAN GAB. RIVER CB - 37	ALHAMBRA CB - 36	OLDEN ST. L.A. 699	USG 3 USGMWD	BEATTY CANYON SGVMWD	SAN DIMAS WH SGVMWD	MONTHLY TOTAL IMPORTED WATER SPREAD
OCTOBER	0.0	6,246.0	0.0	2,601.7	0.0	7,166.2	0.0	2,204.0	18,217.9
NOVEMBER	0.0	1,705.3	0.0	1,563.2	0.0	0.0	0.0	1,686.0	4,954.5
DECEMBER	0.0	0.0	0.0	2,066.3	0.0	0.0	0.0	0.0	2,066.3
JANUARY	3,610.8	0.0	0.0	1,637.1	503.9	3,675.0	0.0	0.0	9,626.8
FEBRUARY	0.0	0.0	0.0	1,790.1	0.0	0.0	0.0	0.0	1,790.1
MARCH	1,858.4	0.0	0.0	3,979.3	0.0	8,821.4	0.0	0.0	14,659.1
APRIL	1,999.7	0.0	0.0	1,012.4	0.0	4,391.3	0.0	0.0	7,403.4
MAY	0.0	0.0	0.0	993.1	0.0	144.4	0.0	0.0	1,137.5
JUNE	0.0	0.0	0.0	2,980.7	0.0	28.9	0.0	1,758.4	4,768.0
JULY	0.0	0.0	0.0	5,059.1	0.0	0.0	0.0	1,839.0	6,898.1
AUGUST	0.0	635.8	0.0	4,744.8	0.0	8,967.2	0.0	0.0	14,347.8
SEPTEMBER	3,648.2	7,023.6	0.0	4,892.5	0.0	12,067.4	0.0	0.0	27,631.7
TOTALS	11,117.1	15,610.7	0.0	33,320.3	503.9	45,261.8	0.0	7,487.4	113,301.2

NOTES : -THE AMOUNTS OF RECLAIMED WATER FROM POMONA PLANT ARE ESTIMATED.
-THE AMOUNT OF WATER FROM USG3 DURING MARCH 1991 INCLUDES 2793.7 A.F. OF CYCLIC STORAGE.
-THE AMOUNT OF WATER RELEASED FROM CB-48 DURING SEPTEMBER 91 WAS SPREAD IN THE MAIN S.G. B

2 0038

LIVERED IN ACRE-FEET
EAR : 1990-1991

	RECLAIMED WATER DELIVERED										
L R	WHITTIER NARROWS PLANT				SAN JOSE PLANT				POMONA PLANT	MONTHLY TOTAL RECLAIMED WATER SPREAD
	SPREAD		WASTED	MONTHLY SPREAD	SPREAD		WASTED	MONTHLY SPREAD		
	R.HONDO	S.GABRIEL			R.HONDO	S.GABRIEL				
.9	741.5	301.0	0.0	1,042.5	2,293.7	544.8	0.0	2,838.5	30.0	3,911.0
.5	1,220.9	0.0	7.5	1,213.4	1,995.2	1,967.1	33.0	3,929.3	40.0	5,182.7
.3	992.5	279.8	0.0	1,272.3	2,063.4	3,128.8	0.0	5,192.2	80.0	6,544.5
.8	881.6	250.0	0.0	1,131.6	381.1	2,841.5	0.0	3,222.6	134.0	4,488.2
.1	513.8	538.6	38.9	1,013.5	175.2	3,410.1	0.0	3,585.3	105.0	4,703.7
.1		398.1	29.0	1,081.6	0.0	0.7	0.0	0.7	161.0	1,243.3
4	798.0	361.7	0.0	1,159.7	0.0	206.3	0.0	206.3	175.0	1,541.0
5	1,084.8	0.0	0.0	1,084.8	917.2	3,467.2	0.0	4,384.4	143.0	5,612.2
0	797.4	275.5	0.0	1,072.9	0.0	4,541.4	0.0	4,541.4	142.0	5,756.3
1	1,011.4	125.3	0.0	1,136.7	2,141.5	2,781.4	0.0	4,922.9	147.0	6,206.6
8	665.0	592.0	0.0	1,257.0	165.7	2,242.9	0.0	2,408.6	111.0	3,776.6
7	1,374.4	0.0	0.0	1,374.4	0.0	3,371.0	0.0	3,371.0	152.0	4,897.4
2	10,793.7	3,122.0	75.4	13,840.3	10,132.9	28,503.2	33.0	38,603.1	1,420.0	53,863.4

E.
G. BASIN.

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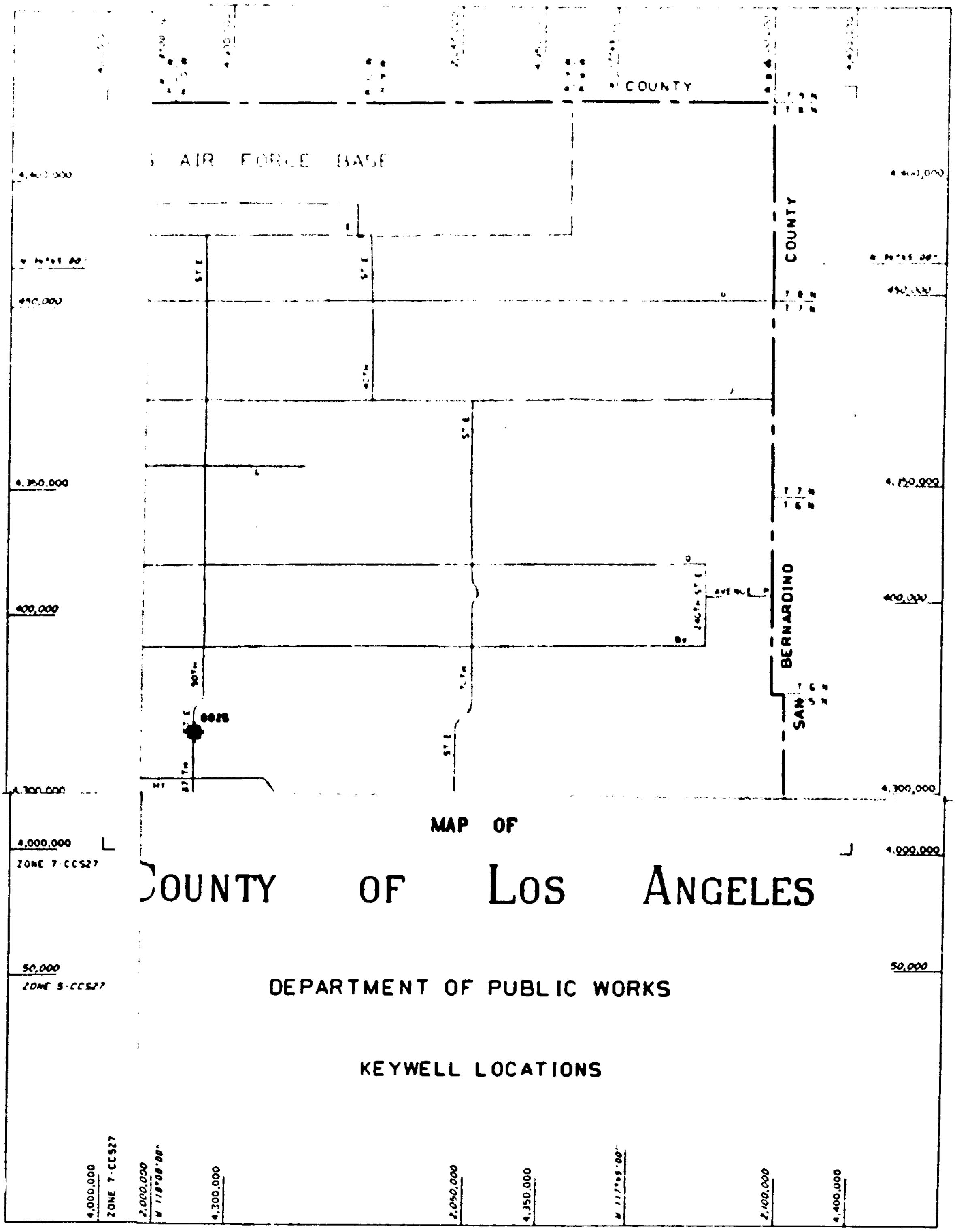
WELL HYDROGRAPHS INCLUDED IN THIS REPORT

GROUND WATER BASIN	WELL NO.	APPROXIMATE LOCATION	PAGE NO.
WEST COAST	1346D	11305 TRURO AVE., 250 FT. N. OF IMPERIAL HWY., COMPTON	G18
	760C	90 FT. S.W. OF INTERSECTION OF COMPTON BLVD. & DOTY AVE., LAWNDALE	
CENTRAL BASIN	400K	2,600 FT. N.E. OF THE INTERSECTION OF LAKEWOOD BLVD. & PACIFIC COAST HWY., LONG BEACH	G18
	1601T	1,000 FT. S. OF THE INTERSECTION OF WASHINGTON BLVD. & ROSEMEAD BLVD., MONTEBELLO	G19
	906D	1,300 FT. N.W. OF THE INTERSECTION OF LONG BEACH & SAN ANTONIO DR., LONG BEACH	G19
MAIN SAN GABRIEL	3030F	600 FT. N.W. OF THE INTERSECTION OF LOS ANGELES ST. & MAINE AVE., BALDWIN PARK	G20
	2955X	TYLER AVE. & CENTRAL AVE., S. EL MONTE	G21
SAN GABRIEL CANYON	4284A	5,600 FT. N.W. OF THE INTERSECTION OF SIERRA MADRE AVE. & SAN GABRIEL CANYON RD., AZUSA	G21
	4285	2,700 FT. N.W. OF SAN GABRIEL CANYON RD. & SIERRA MADRE AVE.	
POMONA	3251E	2,200 FT. N. OF THE INTERSECTION OF SAN BERNADINO FWY. & TOWNE AVE., POMONA	G22
	3241J	425 FT. S.W. OF LA VERNE AVE., 400FT. S.E. OF N. GAREY AVE.	
	4469A	739 FT. W. OF MOUNTAIN AVE., 1,025 FT. N. OF HARRISON AVE.	
CLAREMONT HEIGHTS	4508B	800 FT. S.E. OF THE INTERSECTION OF BASELINE RD. & PADUA AVE., CLAREMONT	G22
	4508A	270 FT. N.W. OF WELL 4508B	
RAYMOND	4057H	LOS ROBLES & GLENARM STREETS, PASADENA	G23
SANTA CLARA	7048A	S.E. OF THE INTERSECTION OF NEWHALL AVE. & MAGIC MOUNTAIN PARKWAY, SAUGUS	G23
	7048C	544 FT. W. OF W. CURB OF VALENCIA BLVD., 56 FT. S. OF MAGIC MOUNTAIN PARKWAY, VALENCIA	
ANTELOPE VALLEY	9974	8.976 FT. S. OF AVE. K & 200 FT. W. OF SIERRA HWY., LANCASTER	G24
	8825	25 FT. N. OF AVE. T & 45 FT. E. OF 90TH ST., LITTLE ROCK	G24
MAIN SAN FERNANDO	3872H	CLARK AVE. & GRIFFITH PARK DR., BURBANK	G25
	4709	SHERMAN WAY & DEERING AVE., CANOGA PARK	G25

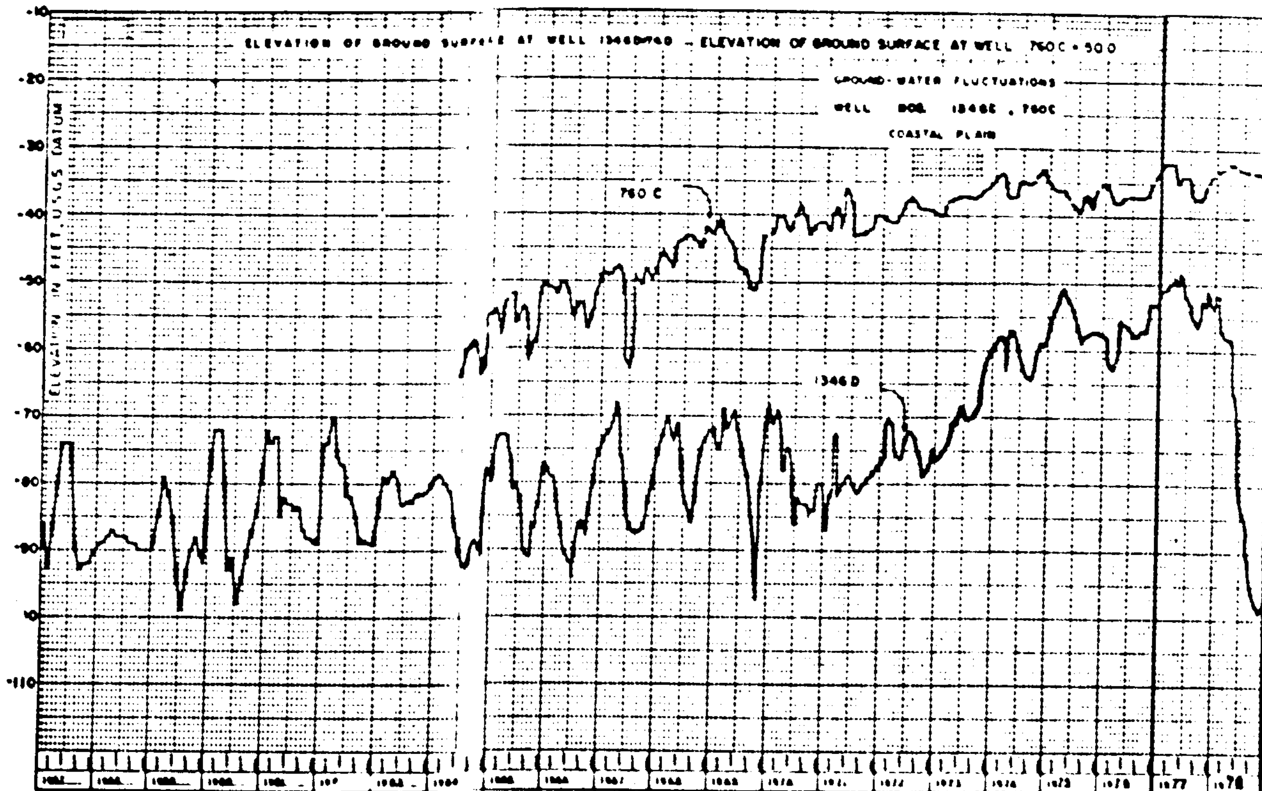


VOL 12

2 0041

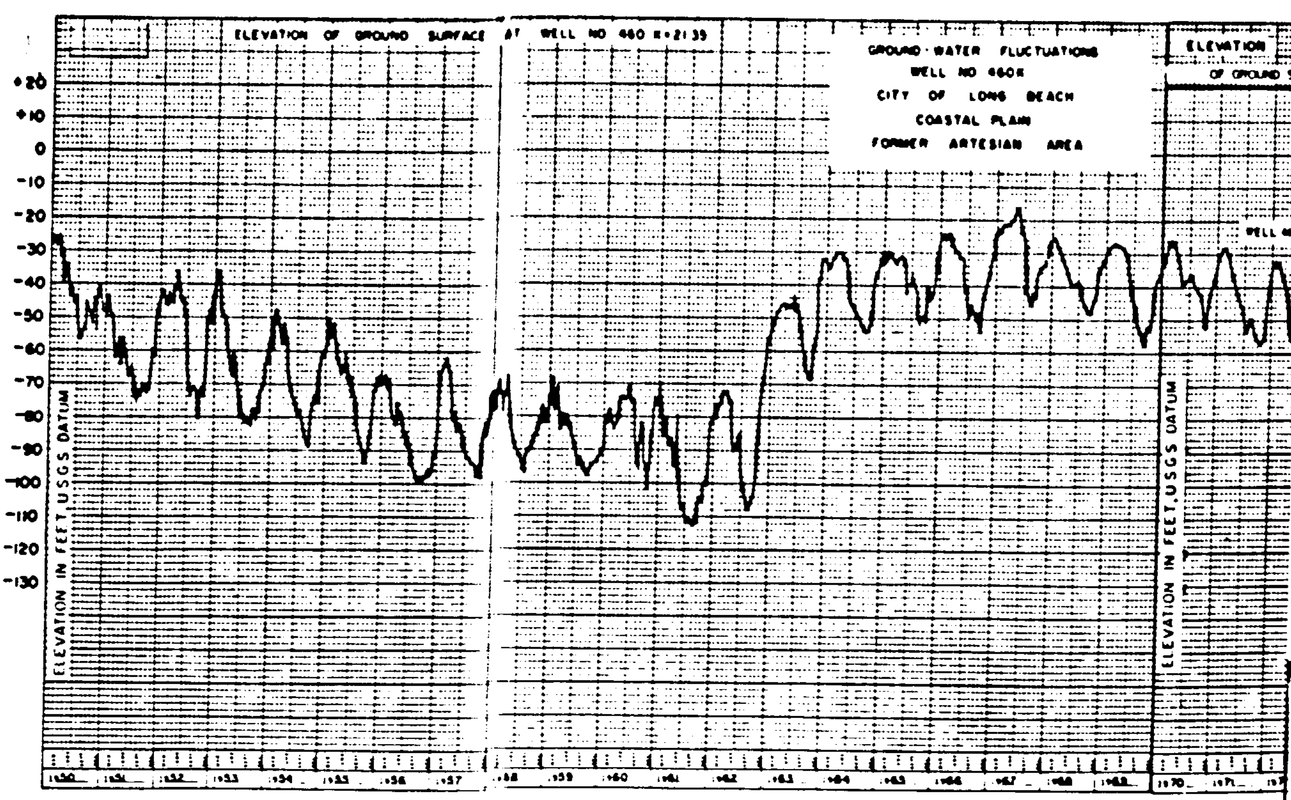
G17

R0053346



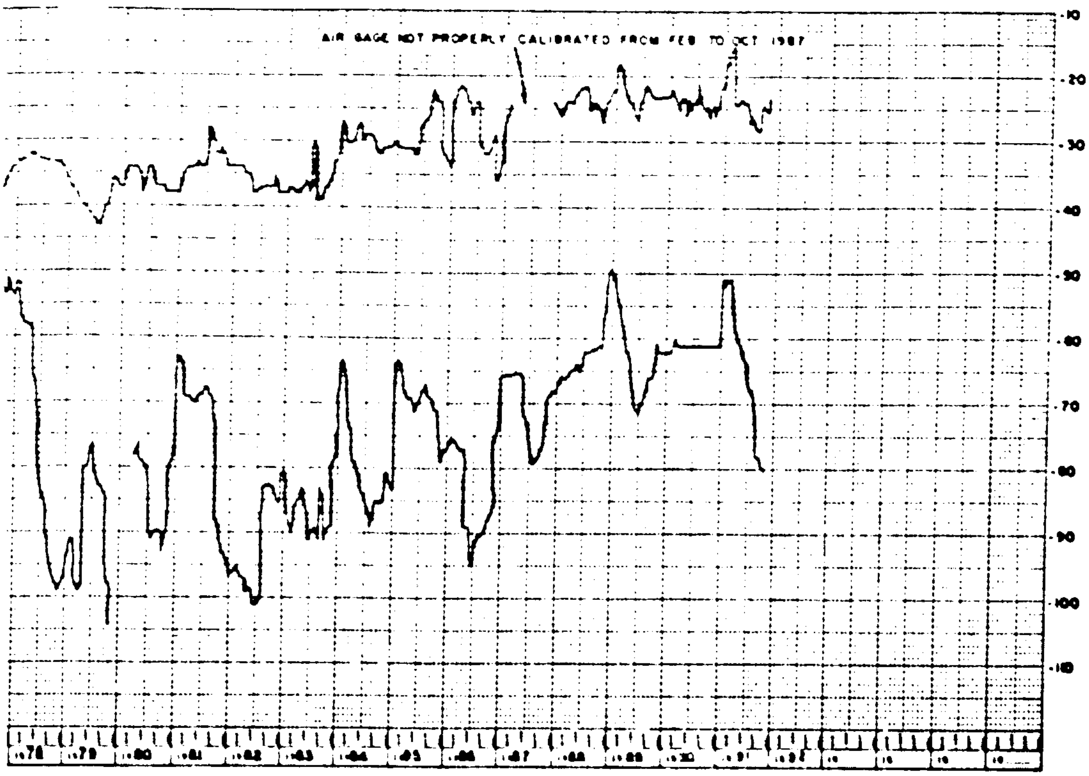
VOL 12

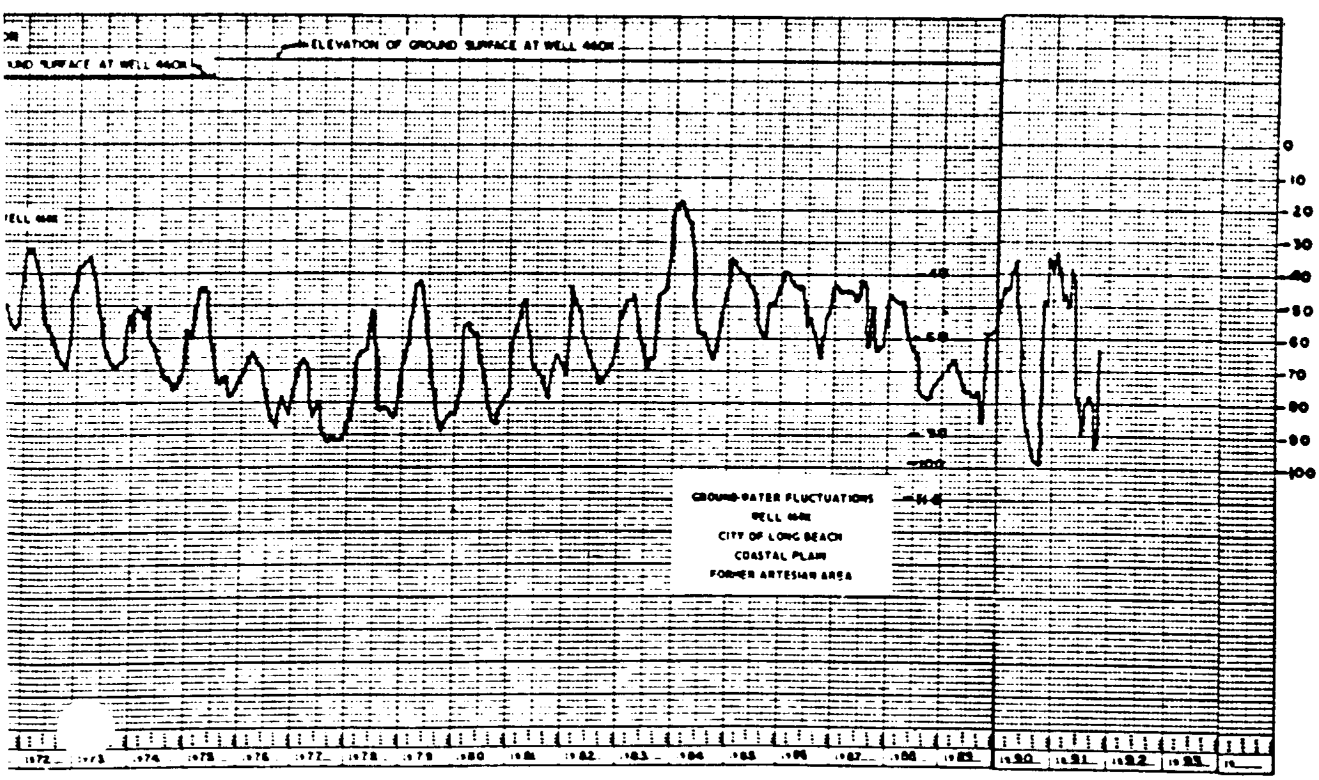
2



00042

R0053347

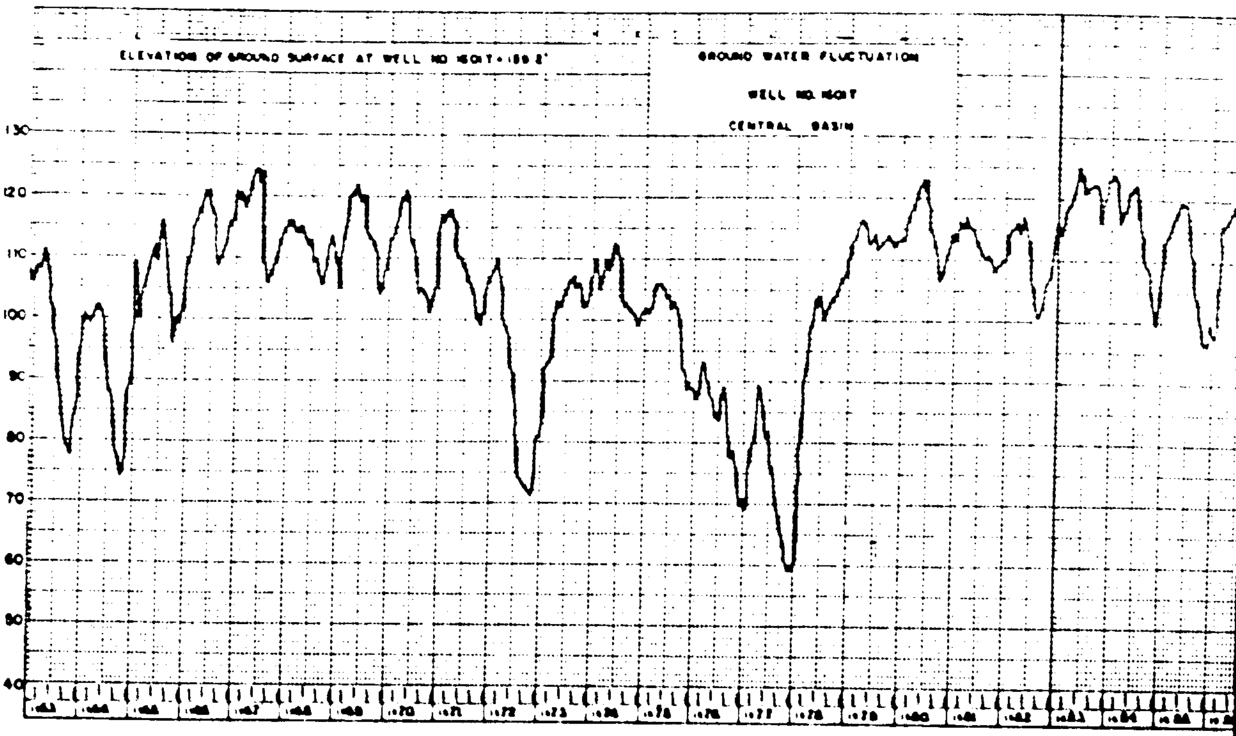




VOL 12

2 00043

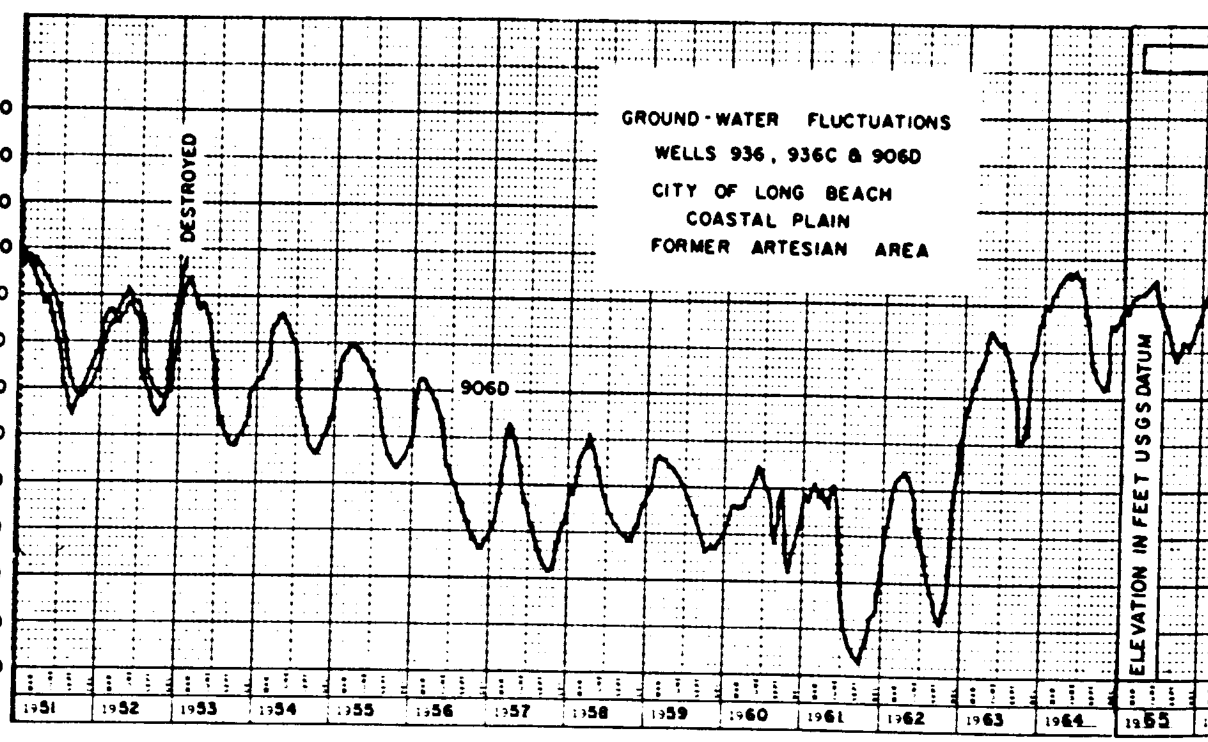
VOL 12



GROUND WATER FLUCTUATION
CENTRAL BASIN

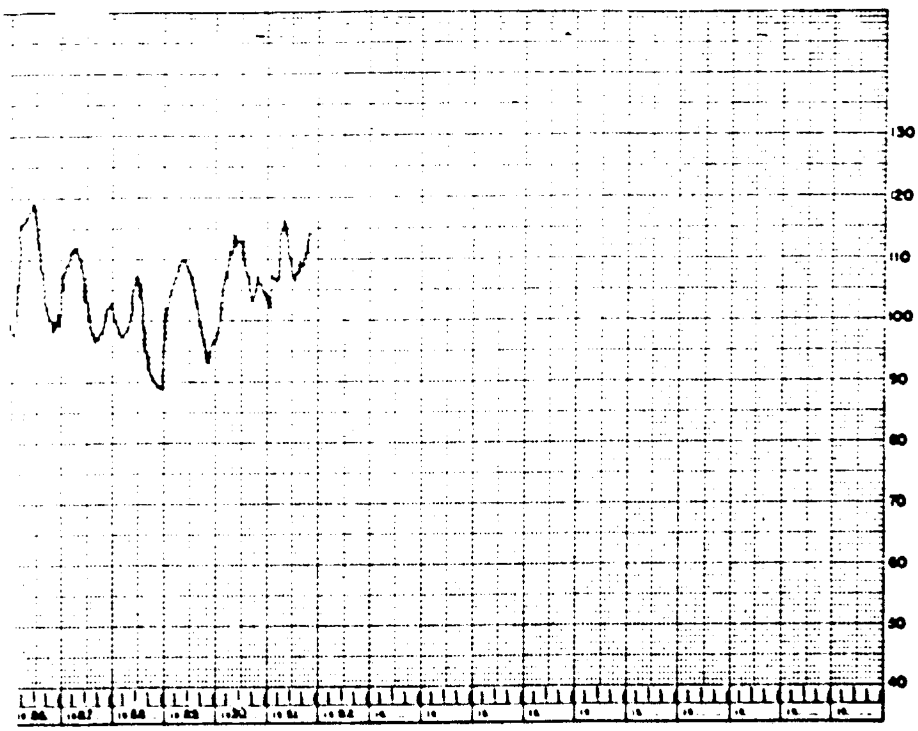
2

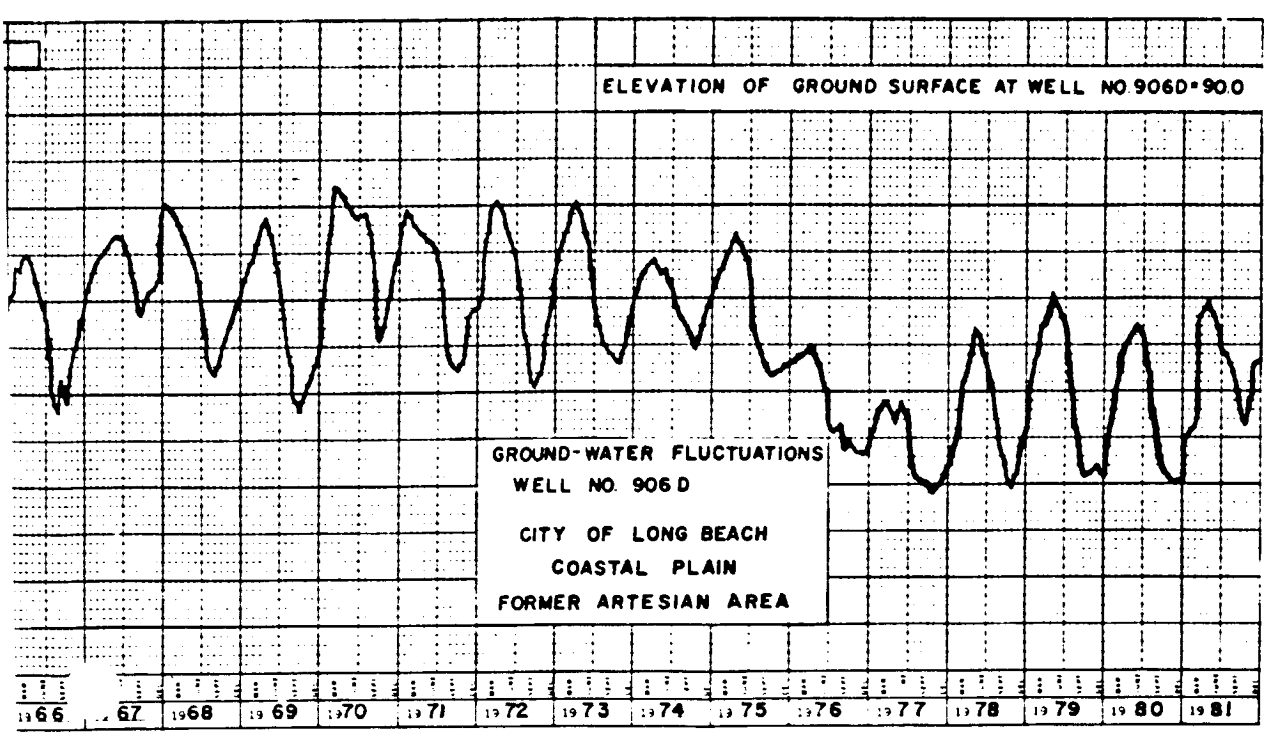
0044



GROUND-WATER FLUCTUATIONS
WELLS 936, 936C & 906D
CITY OF LONG BEACH
COASTAL PLAIN
FORMER ARTESIAN AREA
DESTROYED
906D
ELEVATION IN FEET USGS DATUM
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965

VOL 12



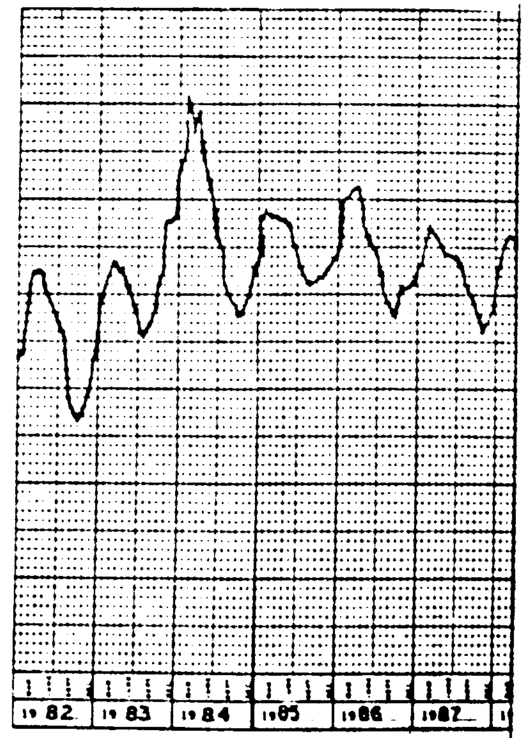


CONTINUED ON PAGE G20

2 0045

R0053350

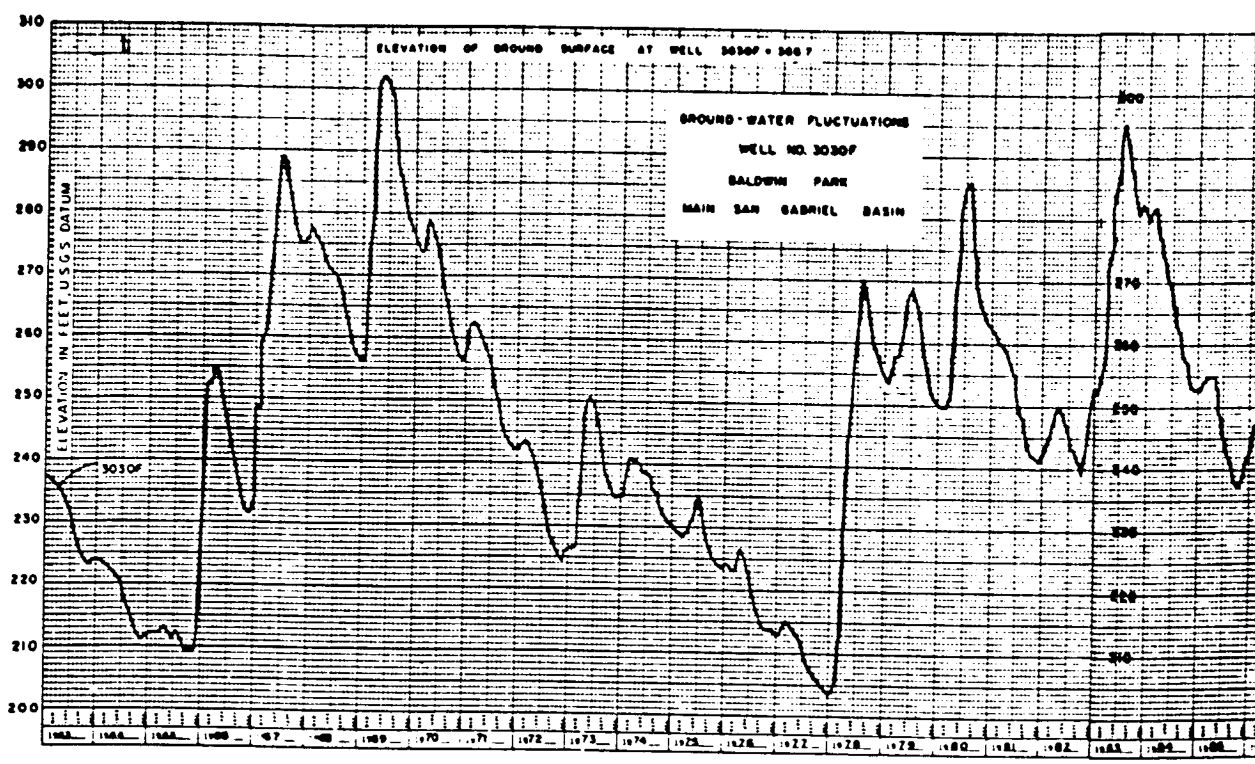
WELL NO. 906D
CONTINUED FROM PAGE G19

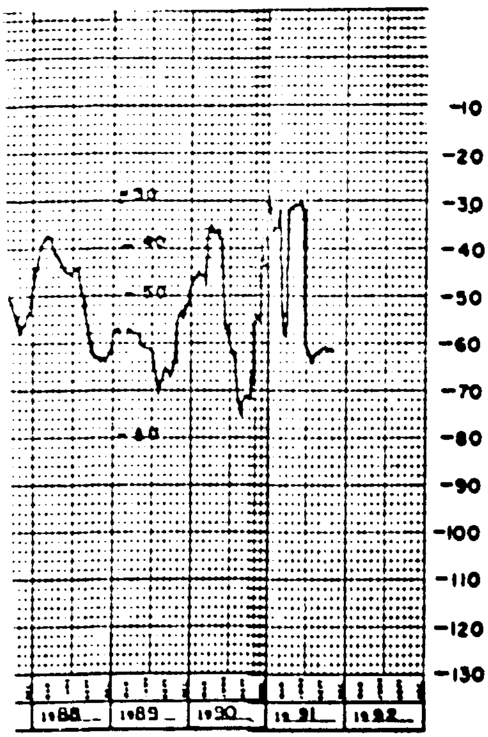


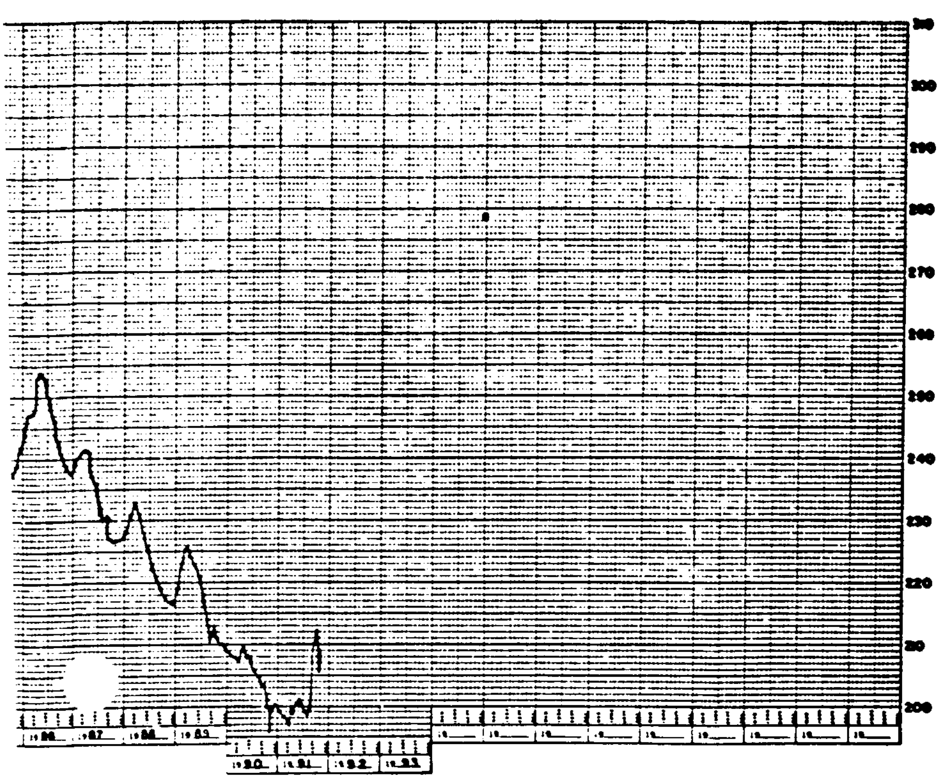
VOL 12

2

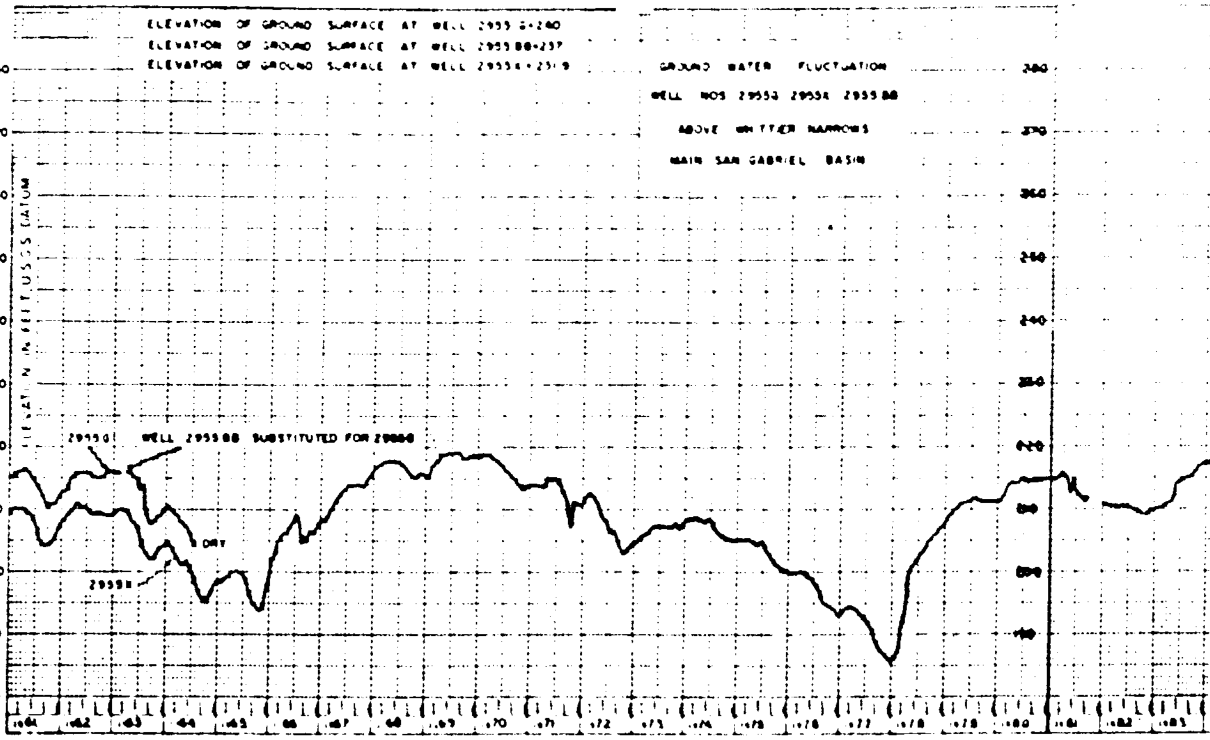
0046



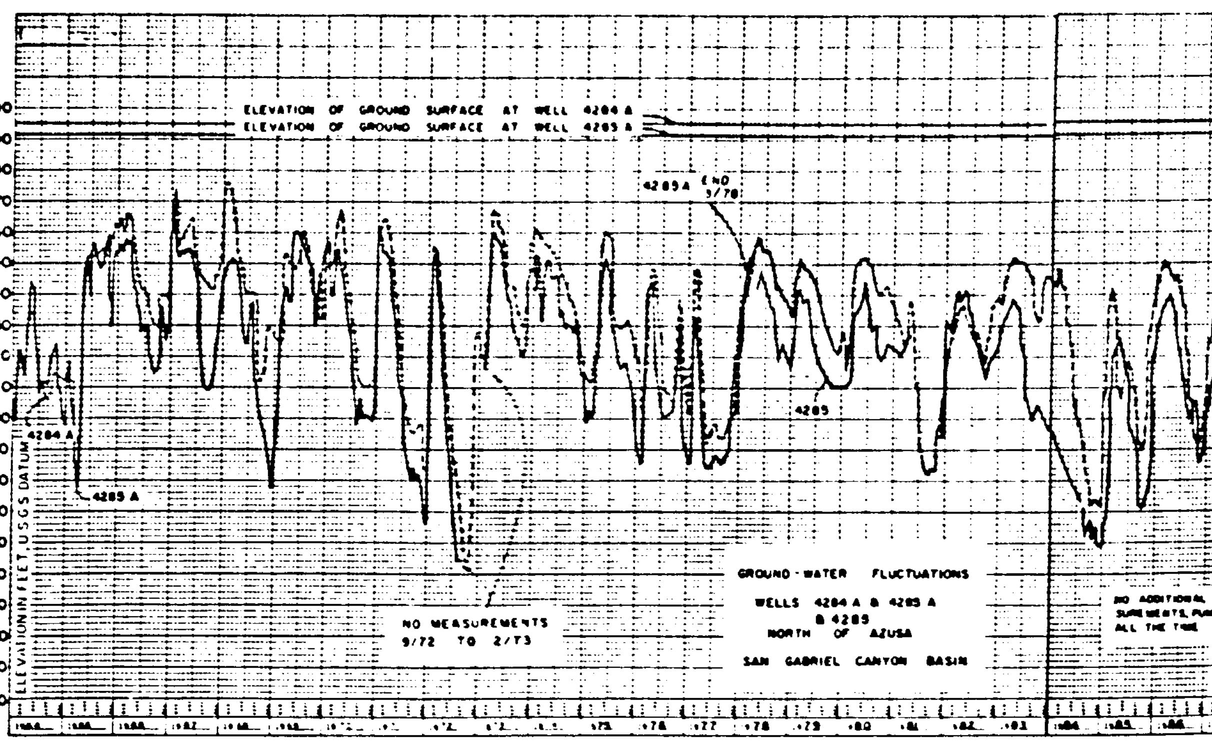

-30
-40
-50
-80
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
1888
1889
1890
1891
1892


200
210
220
230
240
250
260
270
280
290
300
310

VOL 12

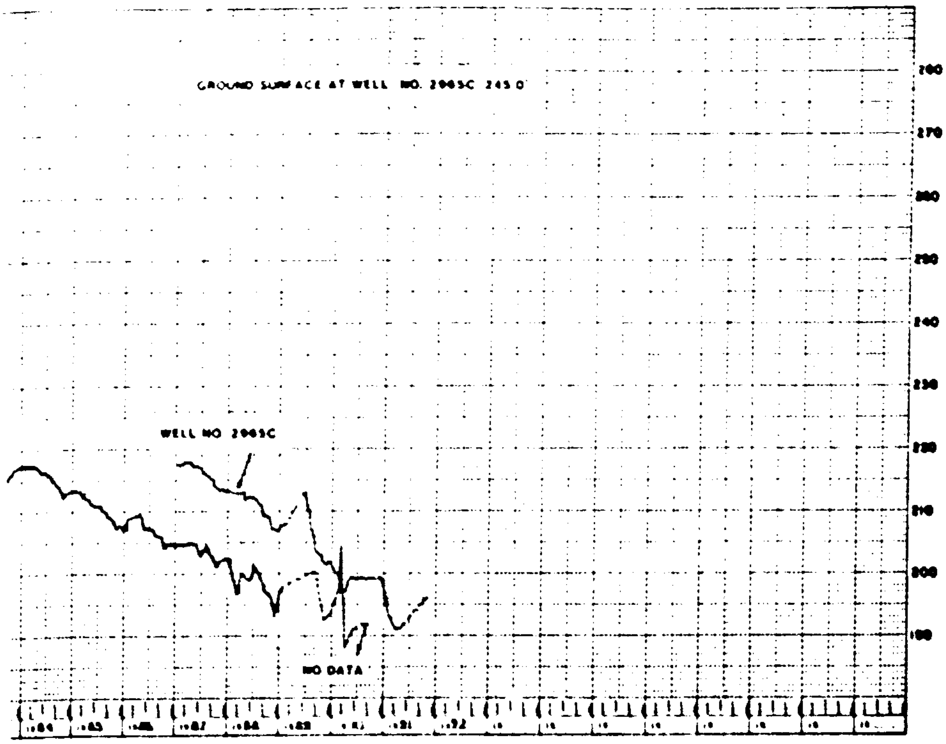


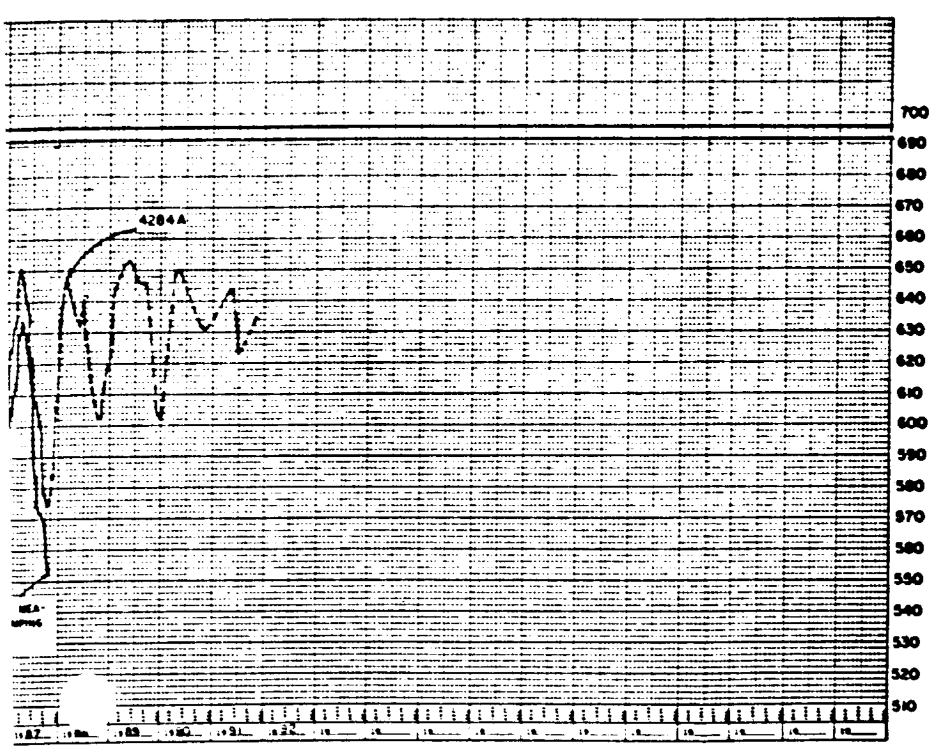
2



0048

R0053353



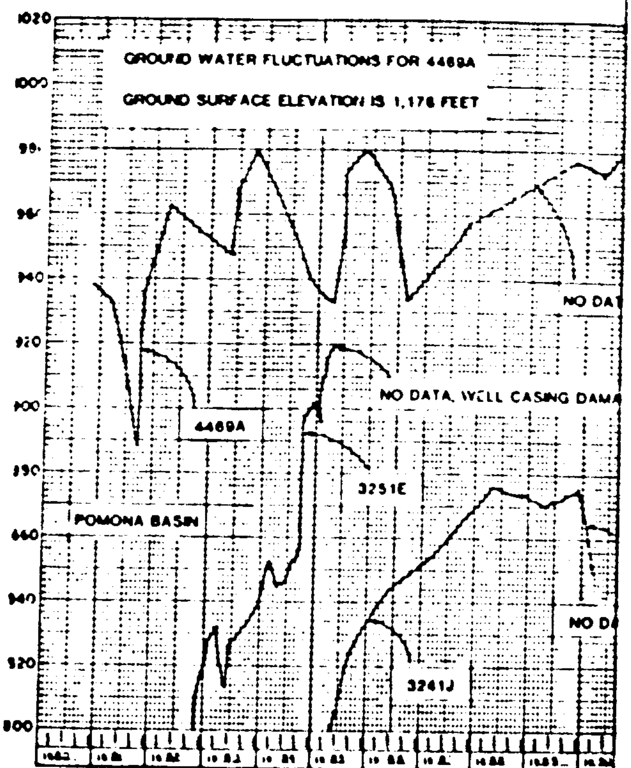


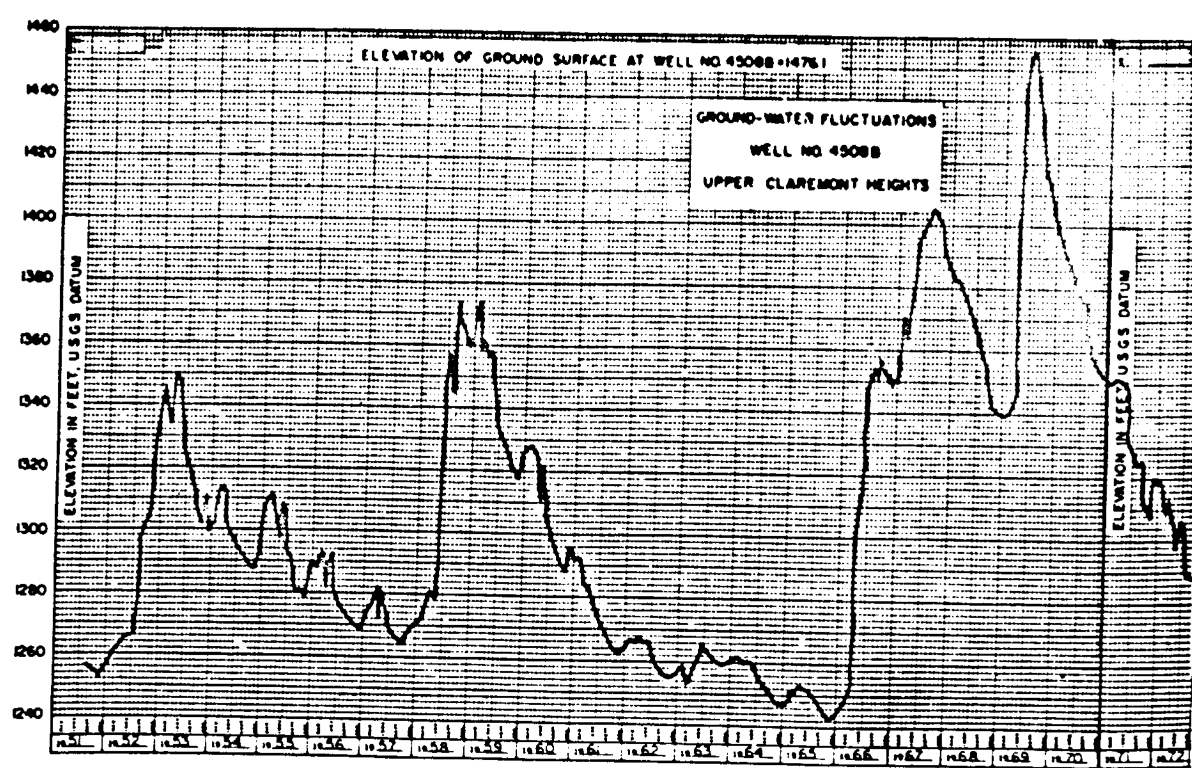
VOL 12

20049

G21

R0053354



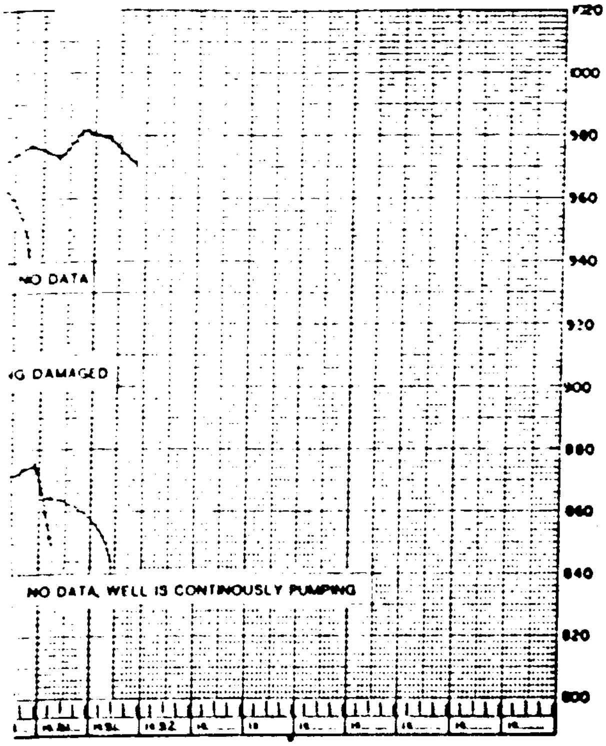


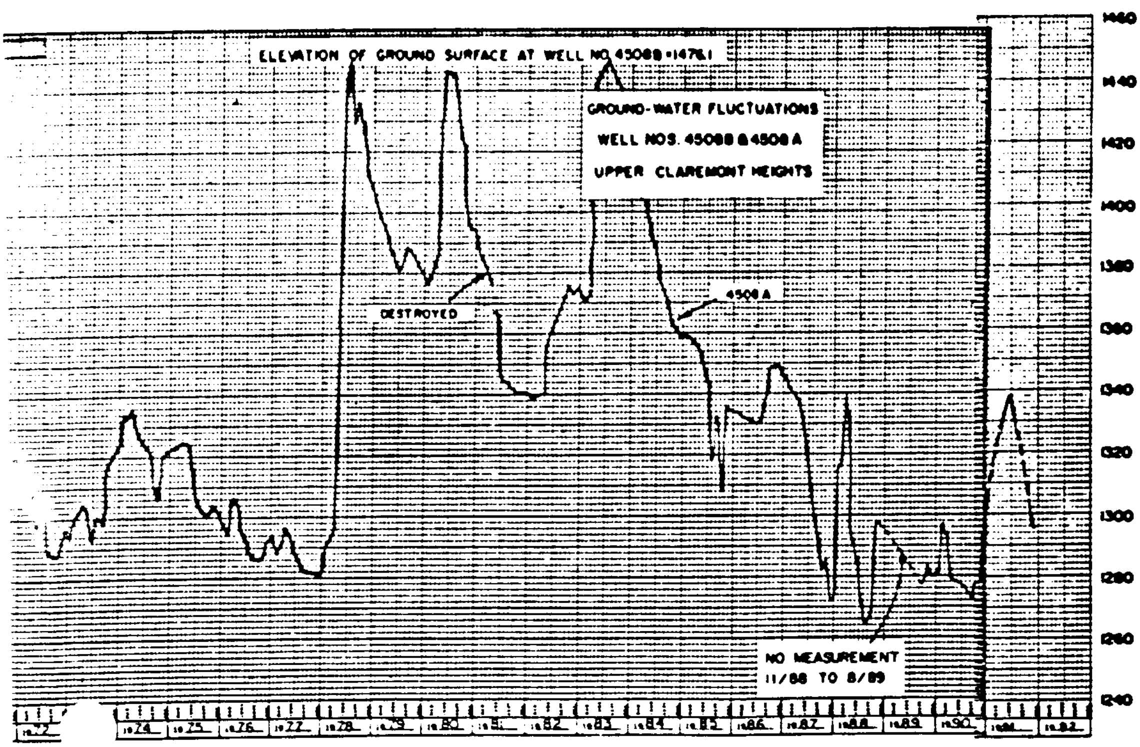
VOL 12

2

00050

R0053355



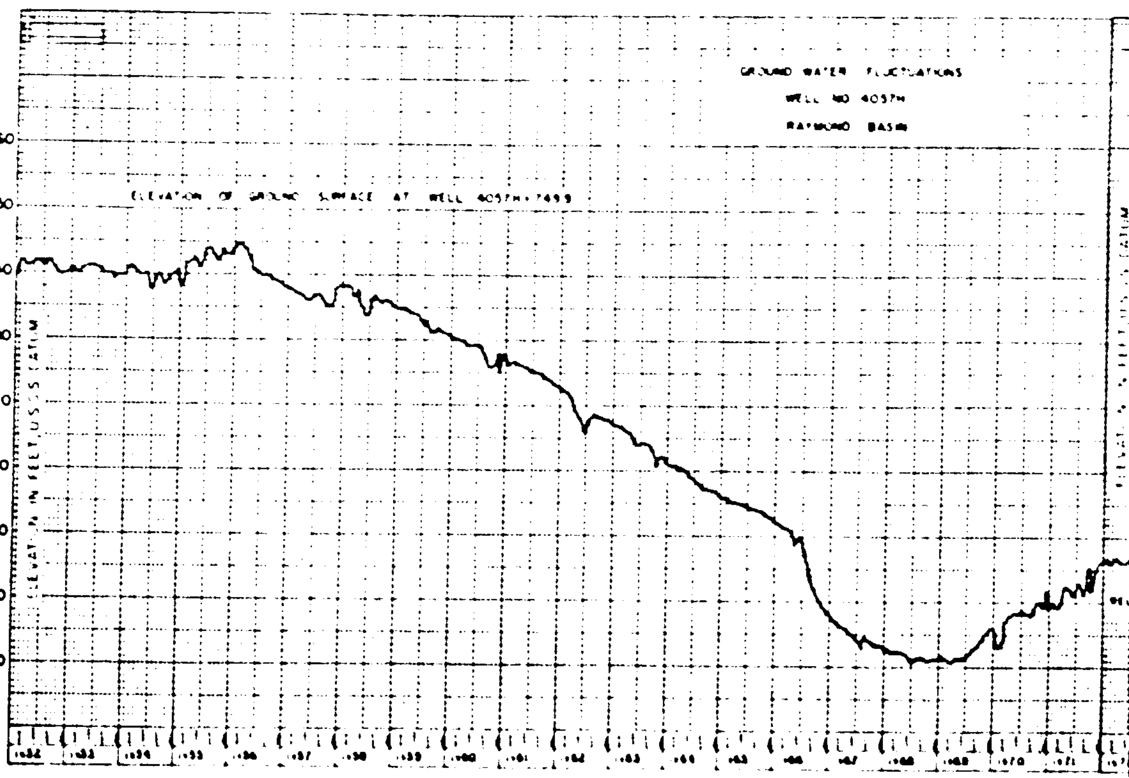


VOL 12

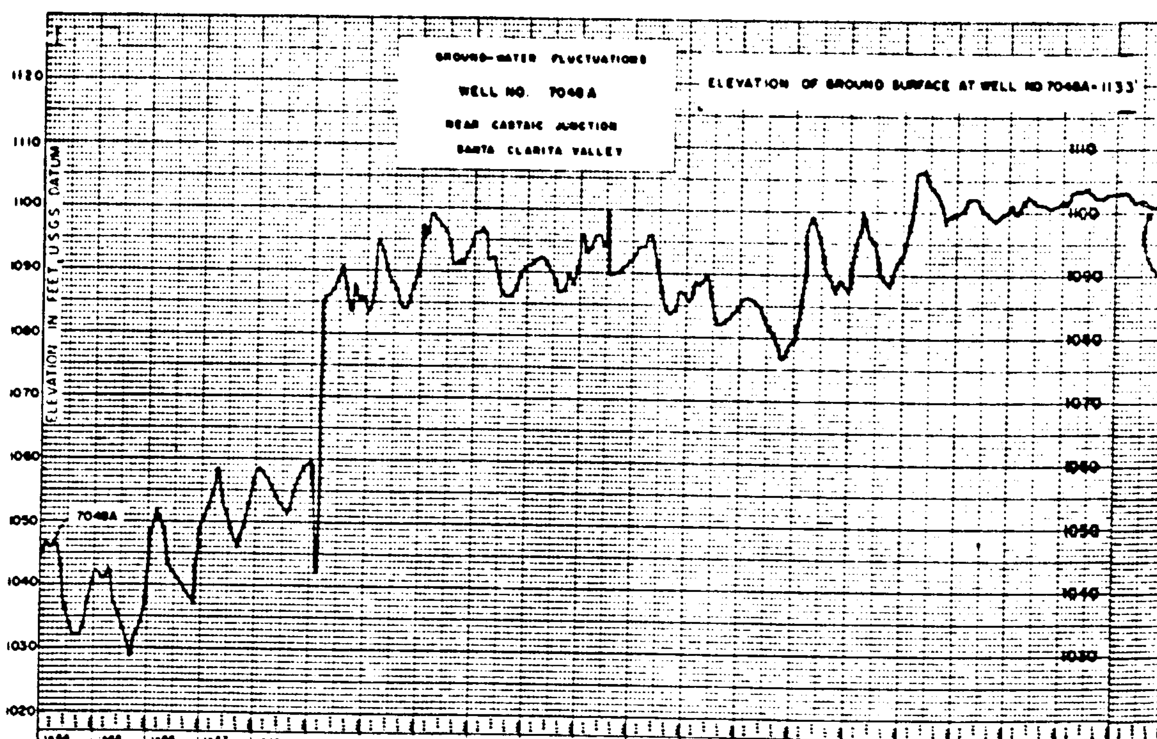
2 00051

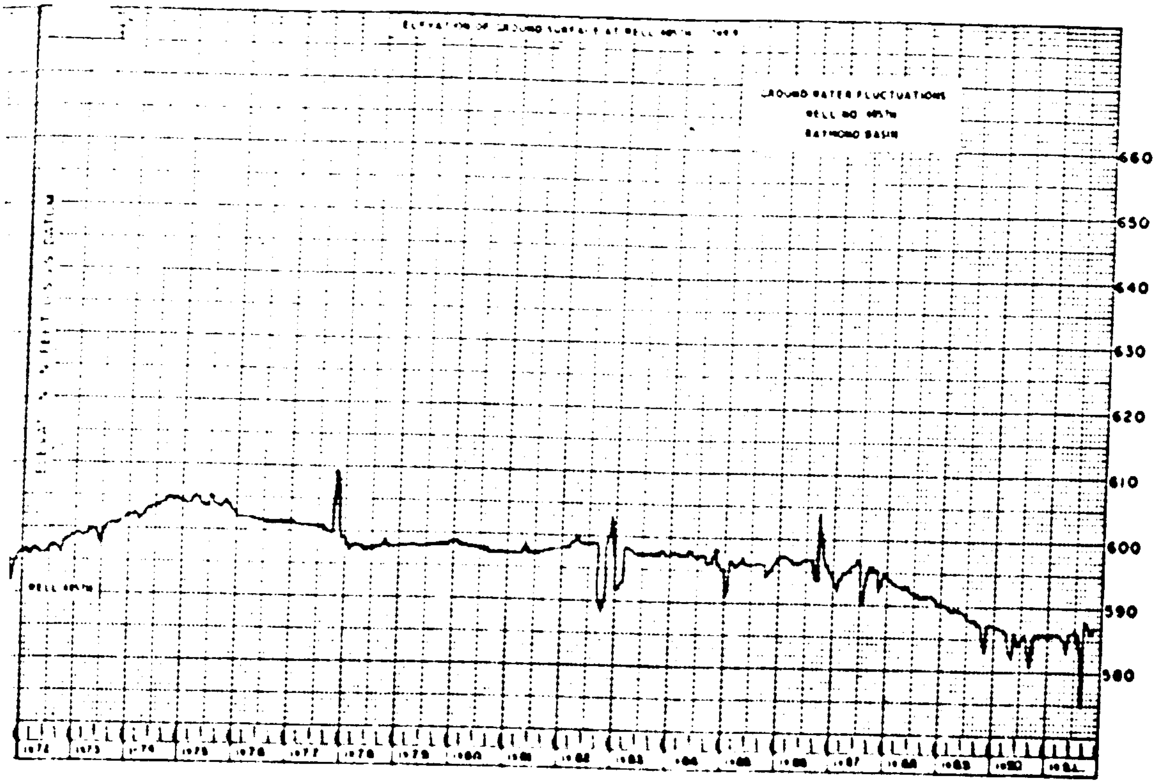
R0053356

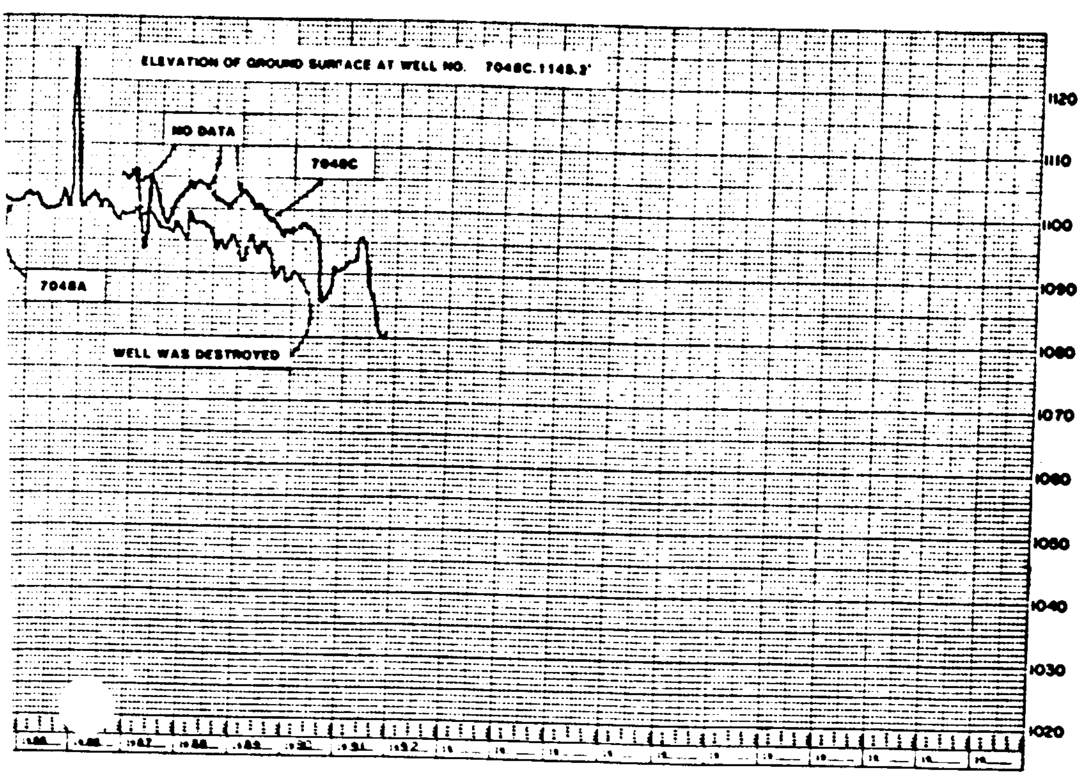
VOL 12


GROUND WATER FLUCTUATIONS
WELL NO 4057H
RAYMOND BASIN
ELEVATION OF GROUND SURFACE AT WELL 4057H
ELEVATION IN FEET, U.S.G.S. DATUM
660
650
640
630
620
610
600
590
580

2 0052


GROUND-WATER FLUCTUATIONS
WELL NO. 7048A
NEAR CASTAIC JUNCTION
SANTA CLARITA VALLEY
ELEVATION OF GROUND SURFACE AT WELL NO 7048A=1133'
ELEVATION IN FEET USGS DATUM
7048A
1120
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020





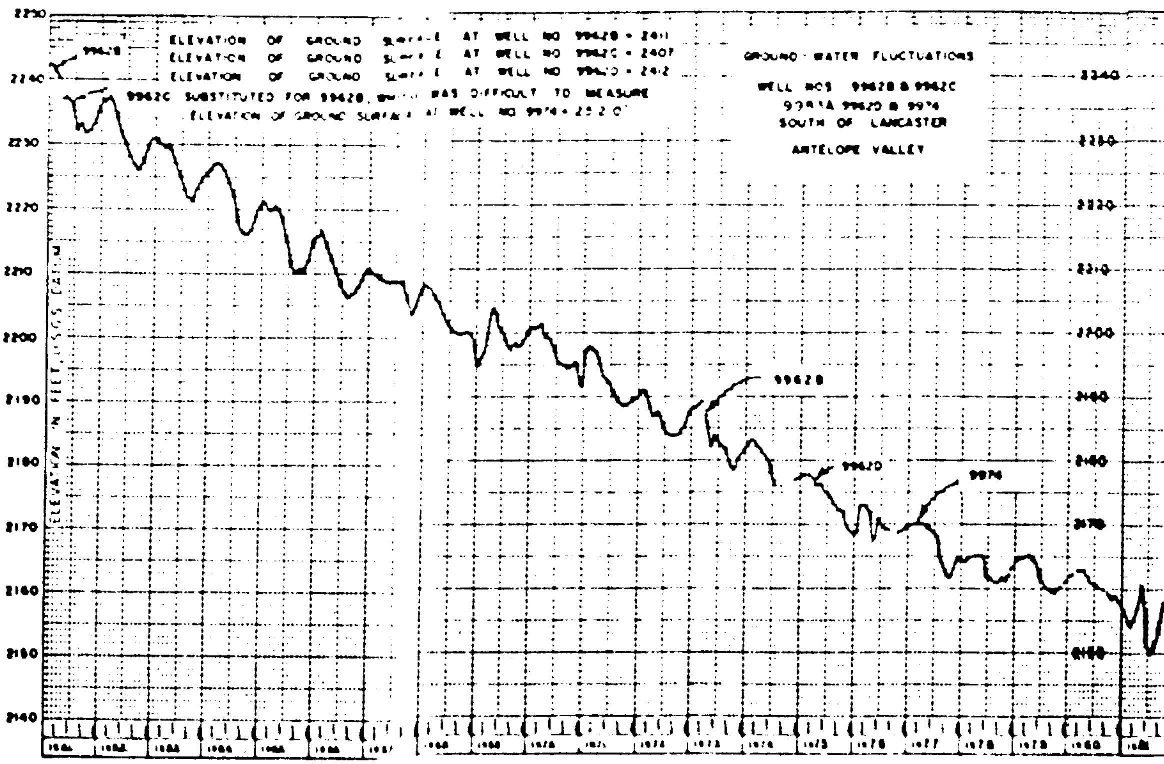
VOL 12

2 00053

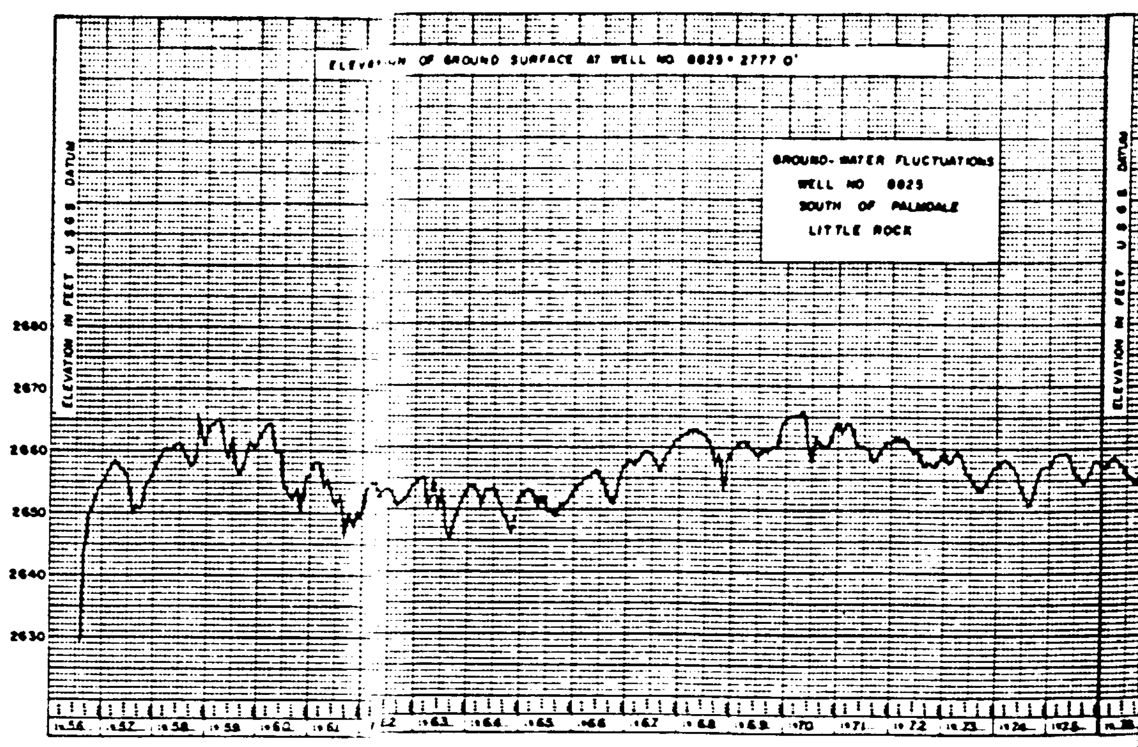
G23

R0053358

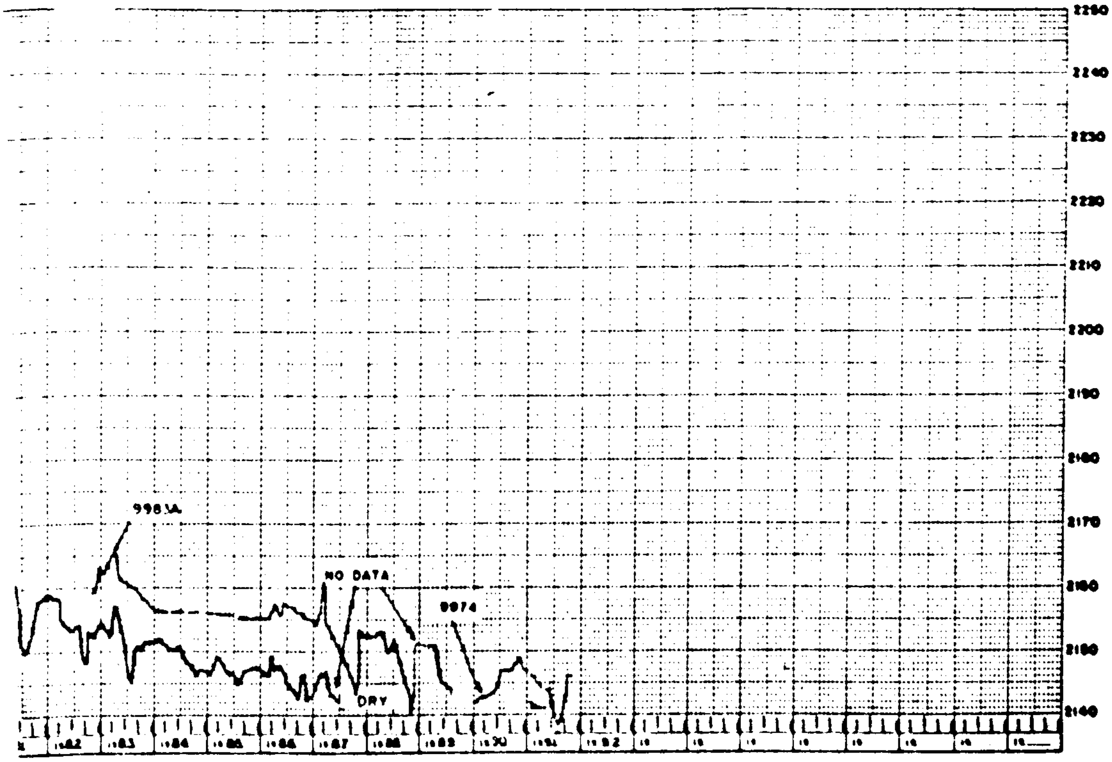
VOL 12

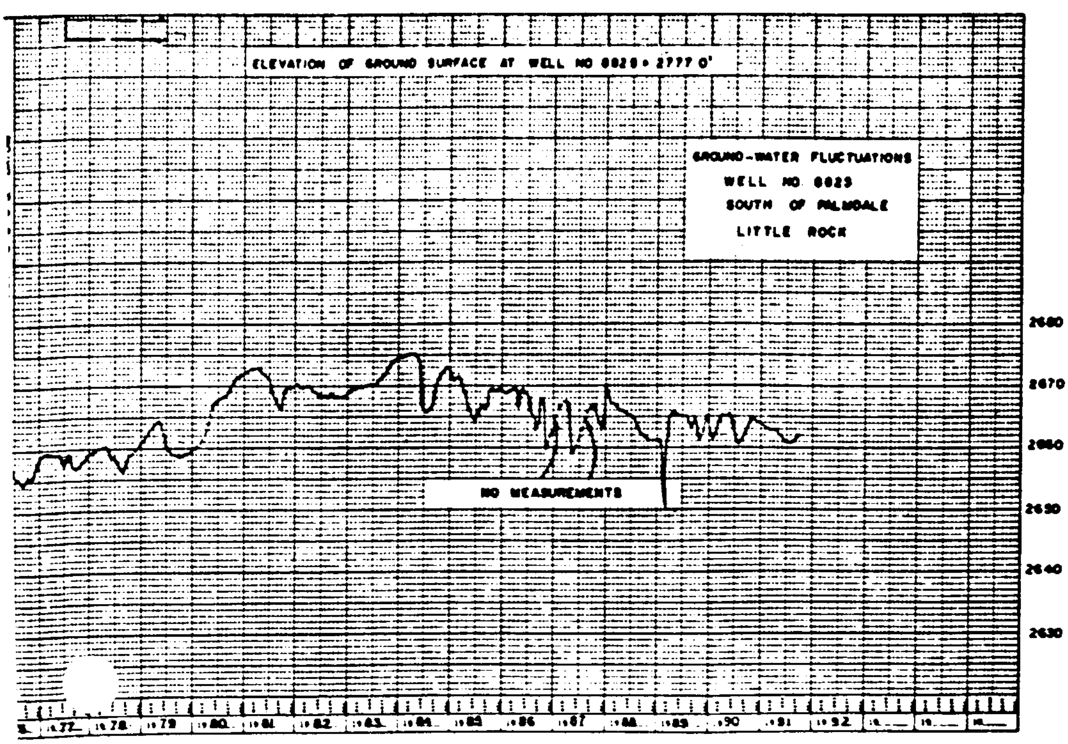


2 00054



R0053359



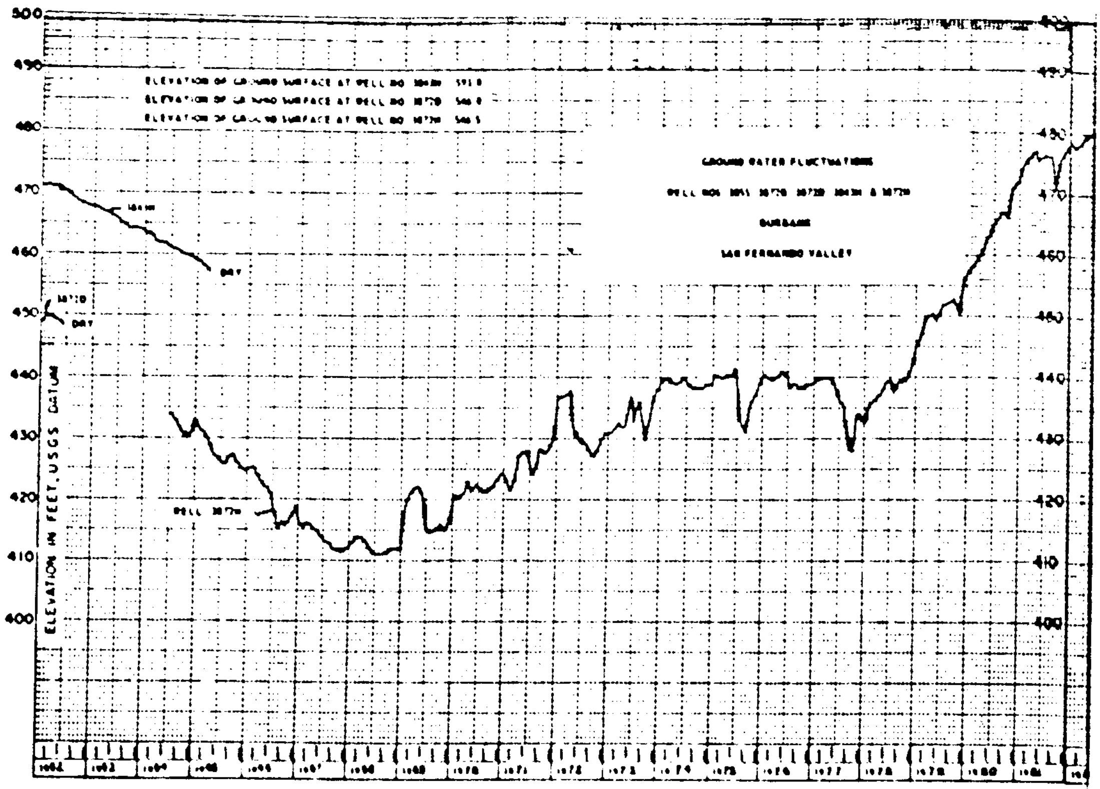


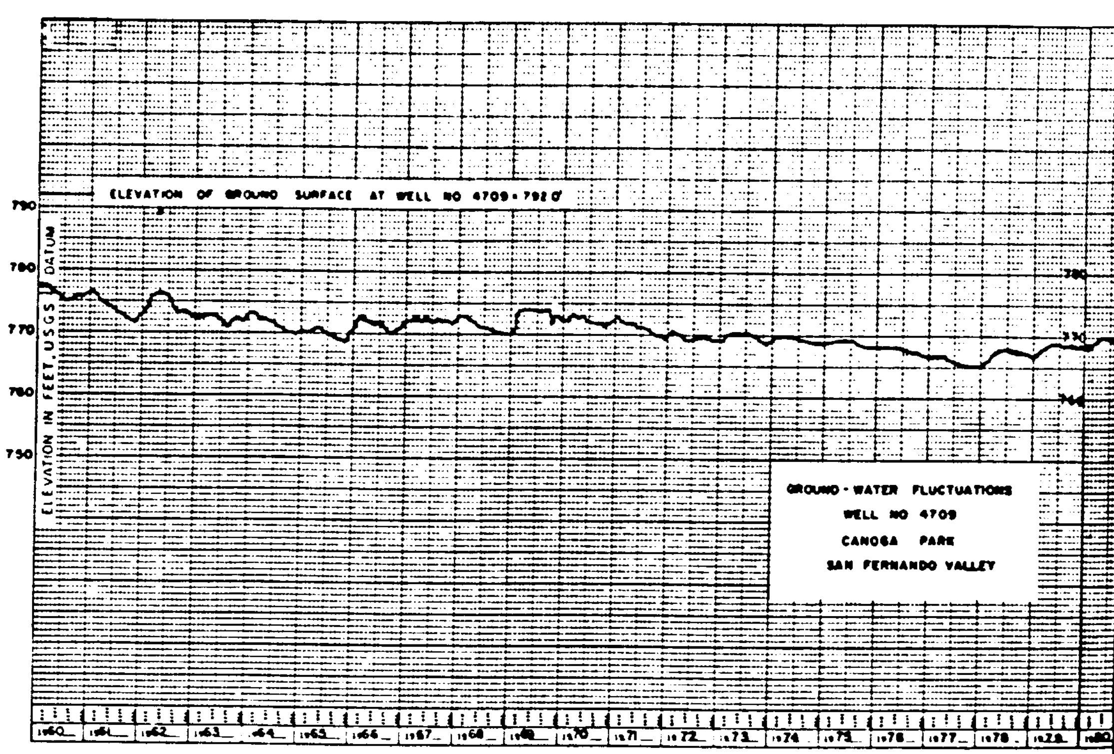
VOL 12

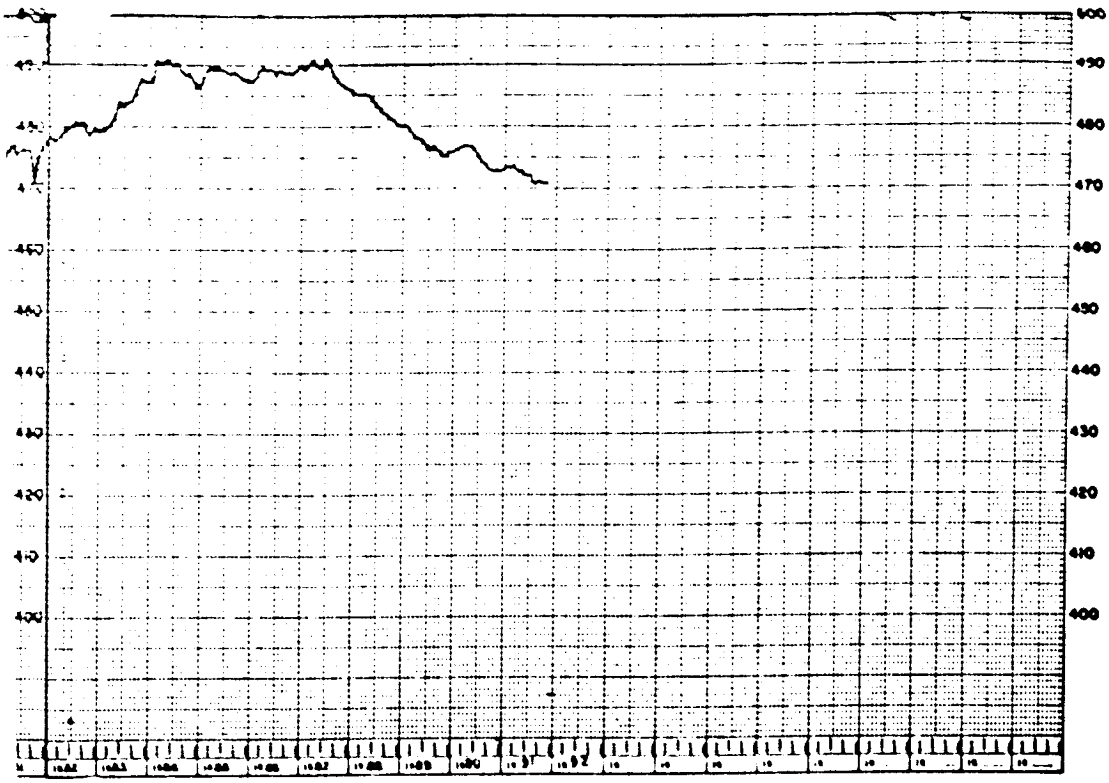
2 0055

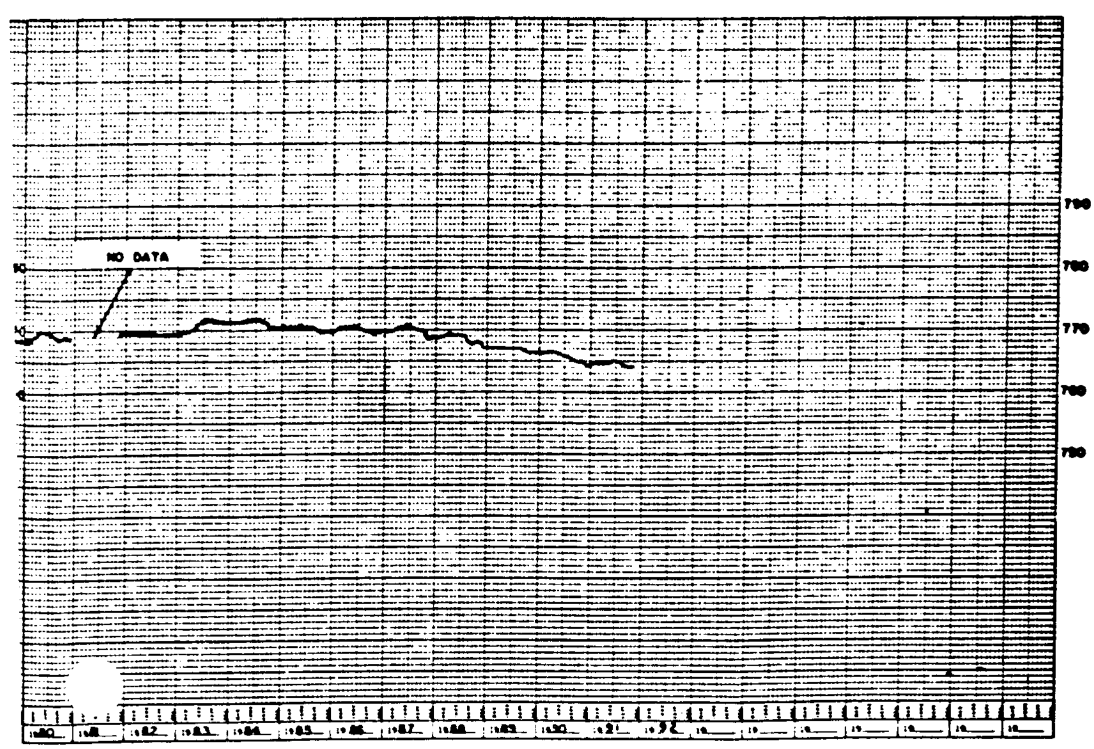
G24

R0053360


GROUND WATER FLUCTUATIONS
BURBANK
SAN FERNANDO VALLEY
ELEVATION IN FEET, U.S.G.S. DATUM
DRY
DRY
WELL 3872H
500
490
480
470
460
450
440
430
420
410
400


ELEVATION OF GROUND SURFACE AT WELL NO 4709 = 792.0'
ELEVATION IN FEET, U.S.G.S. DATUM
790
780
770
760
750
GROUND - WATER FLUCTUATIONS
WELL NO 4709
CANOGA PARK
SAN FERNANDO VALLEY
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980

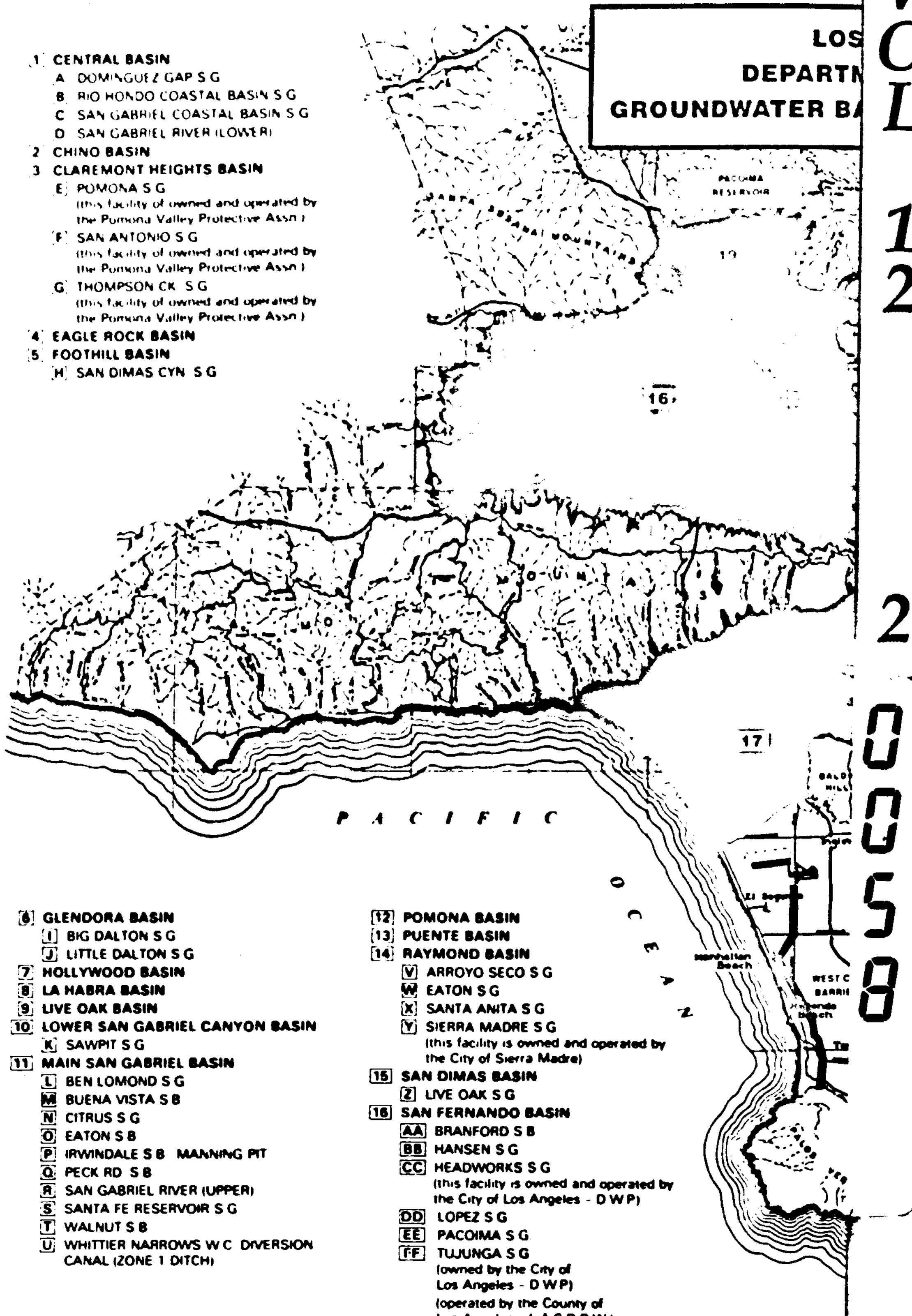




VOL 12 2 0057

G25

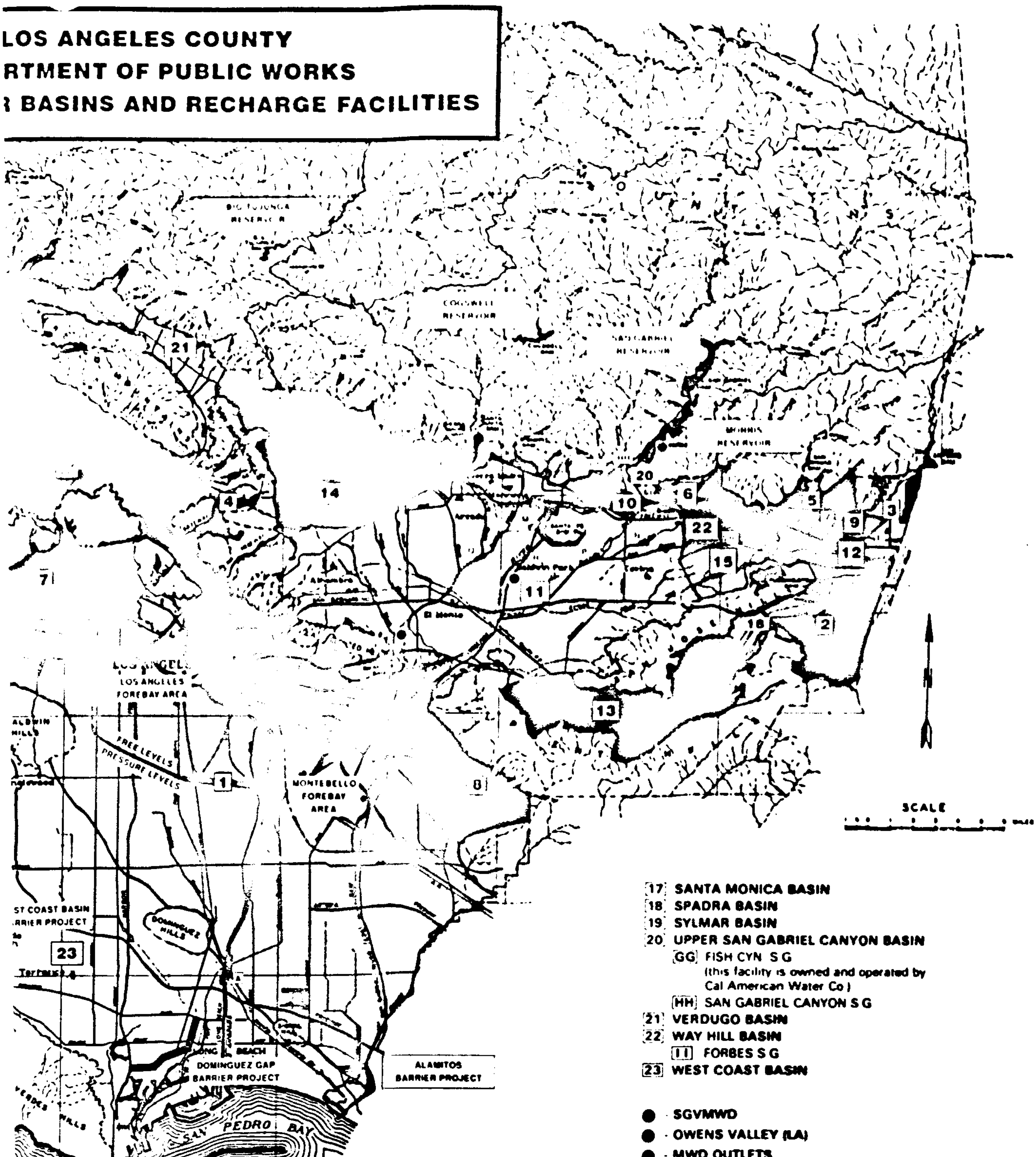
R0053362



VOL 12

2 00058

R0053363



VOL 12

2 0059

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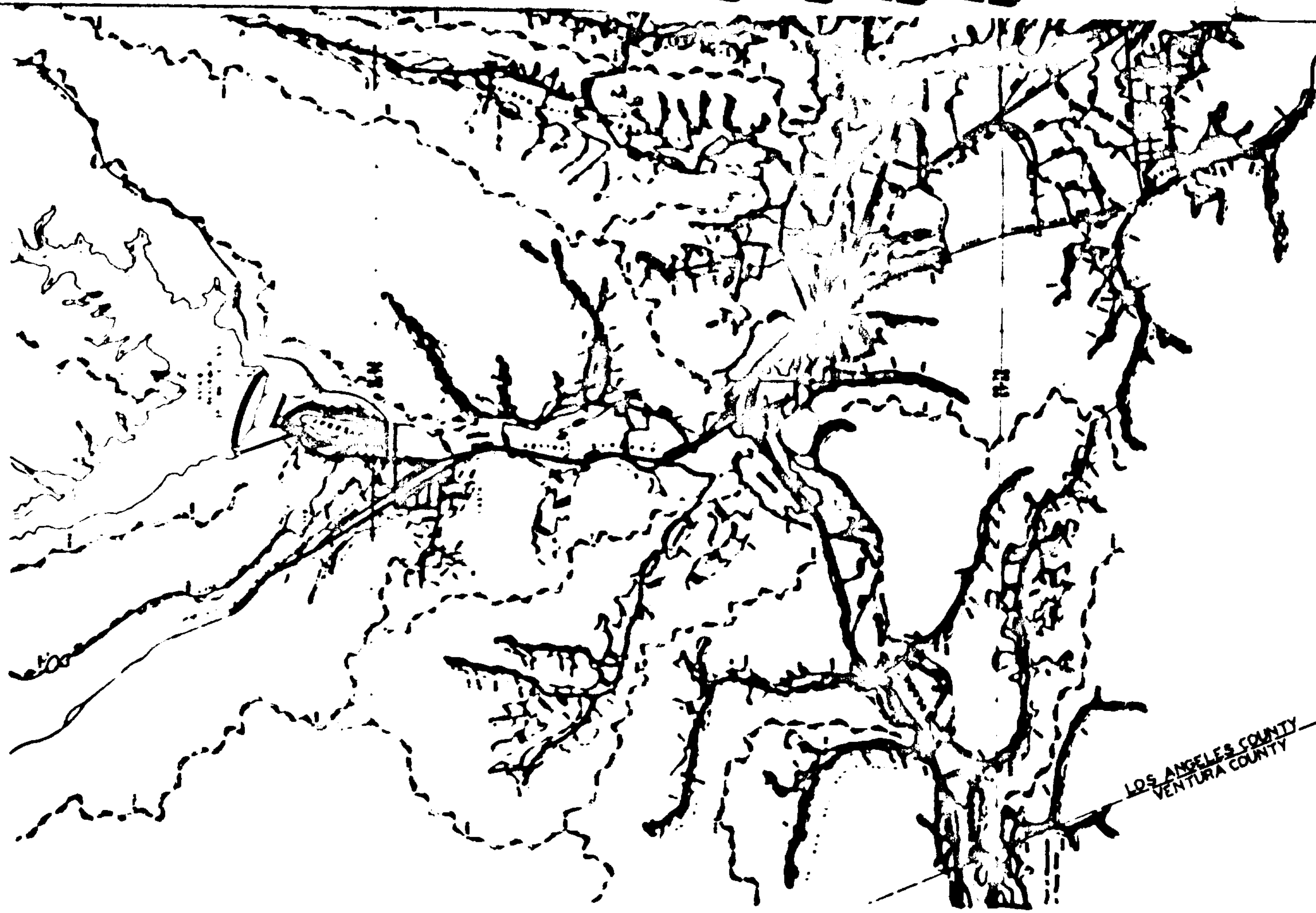

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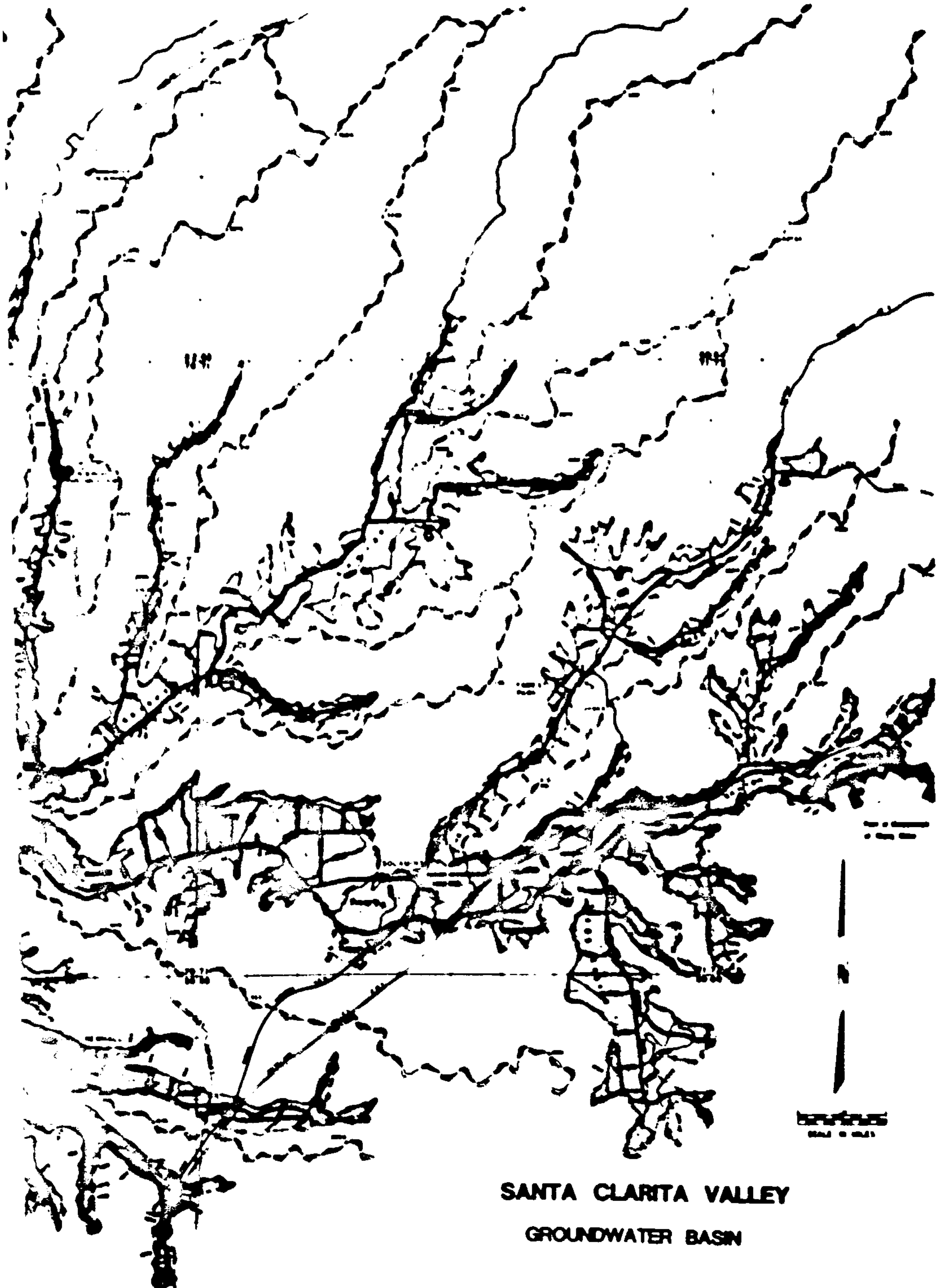

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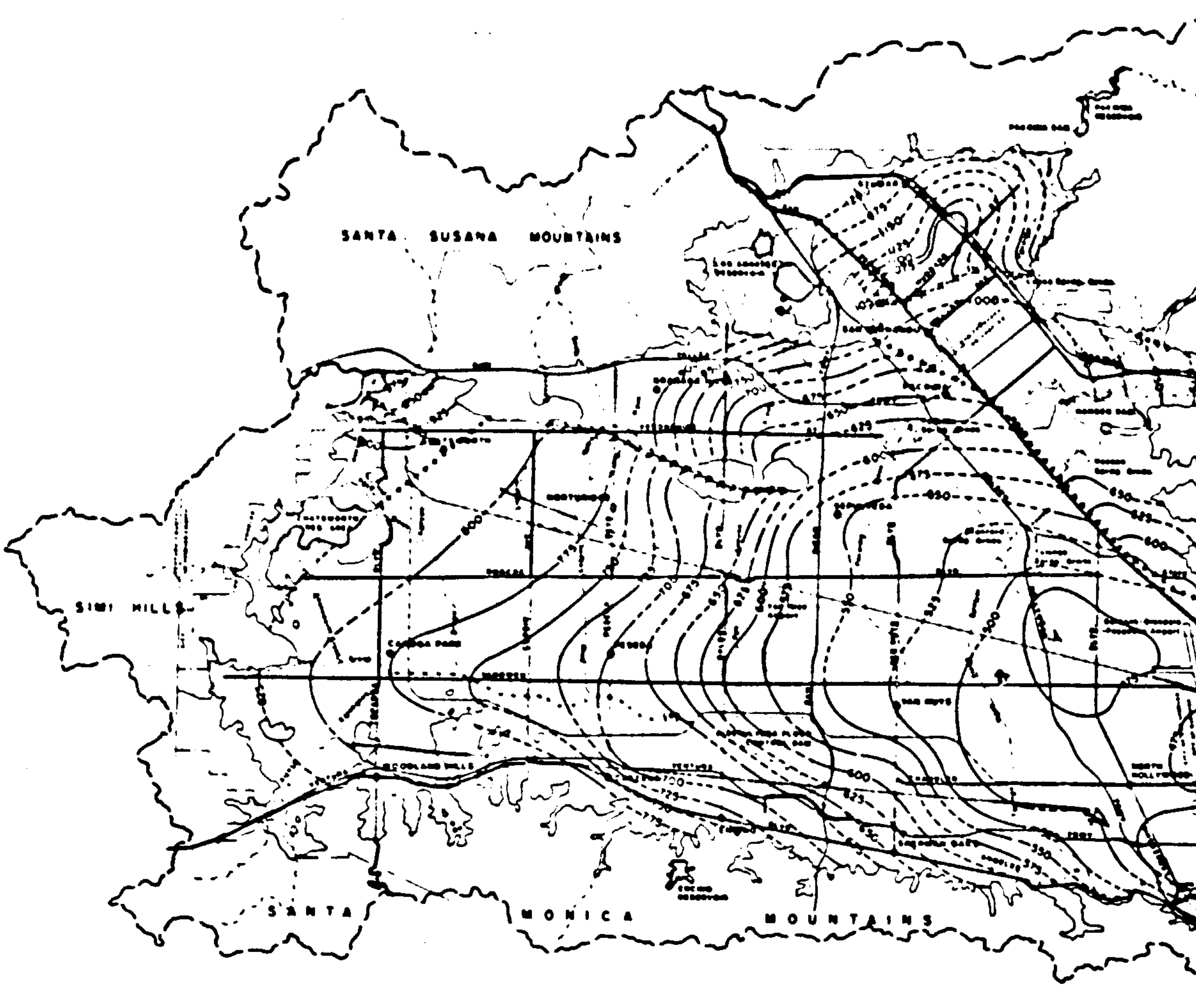

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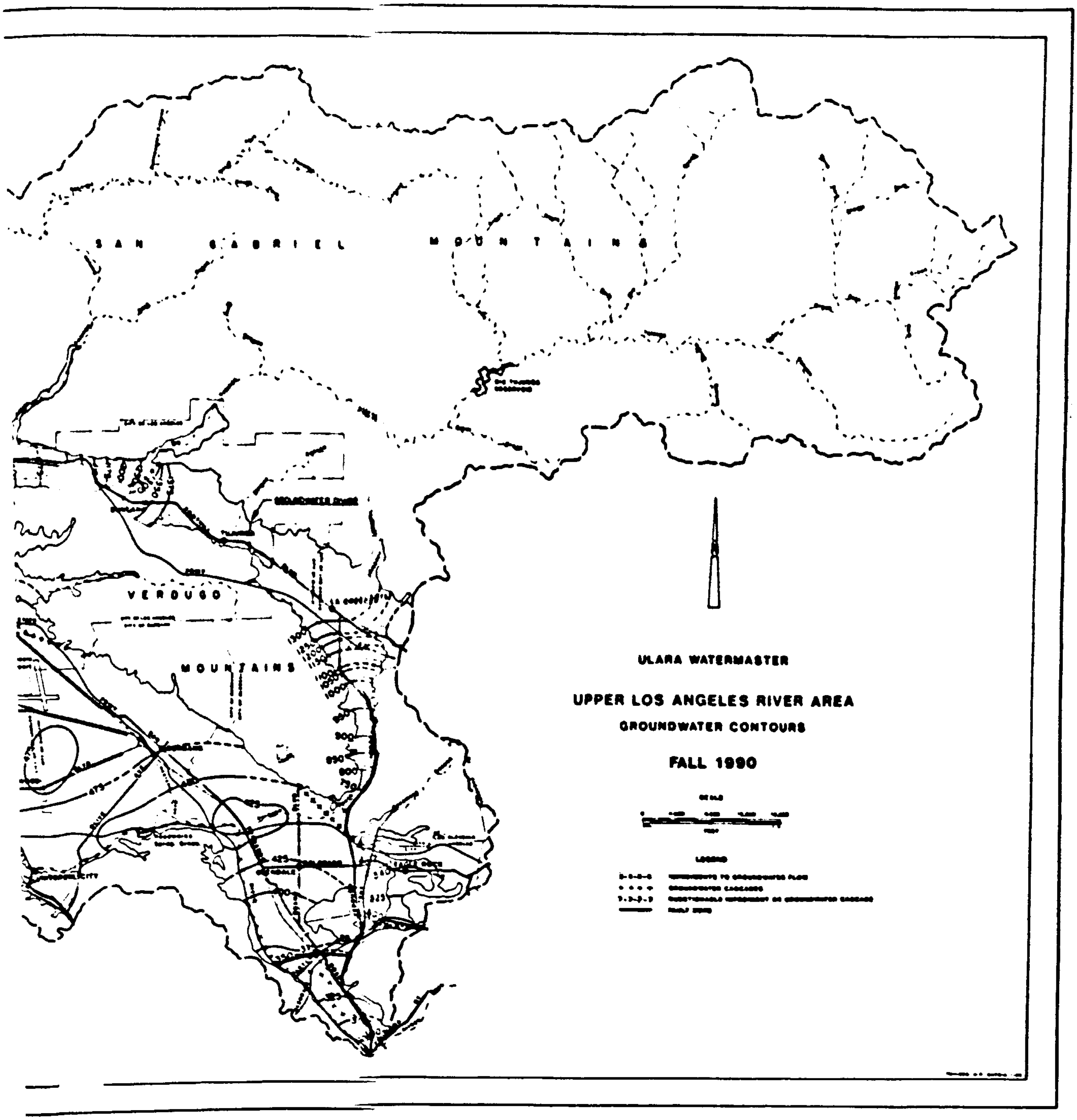
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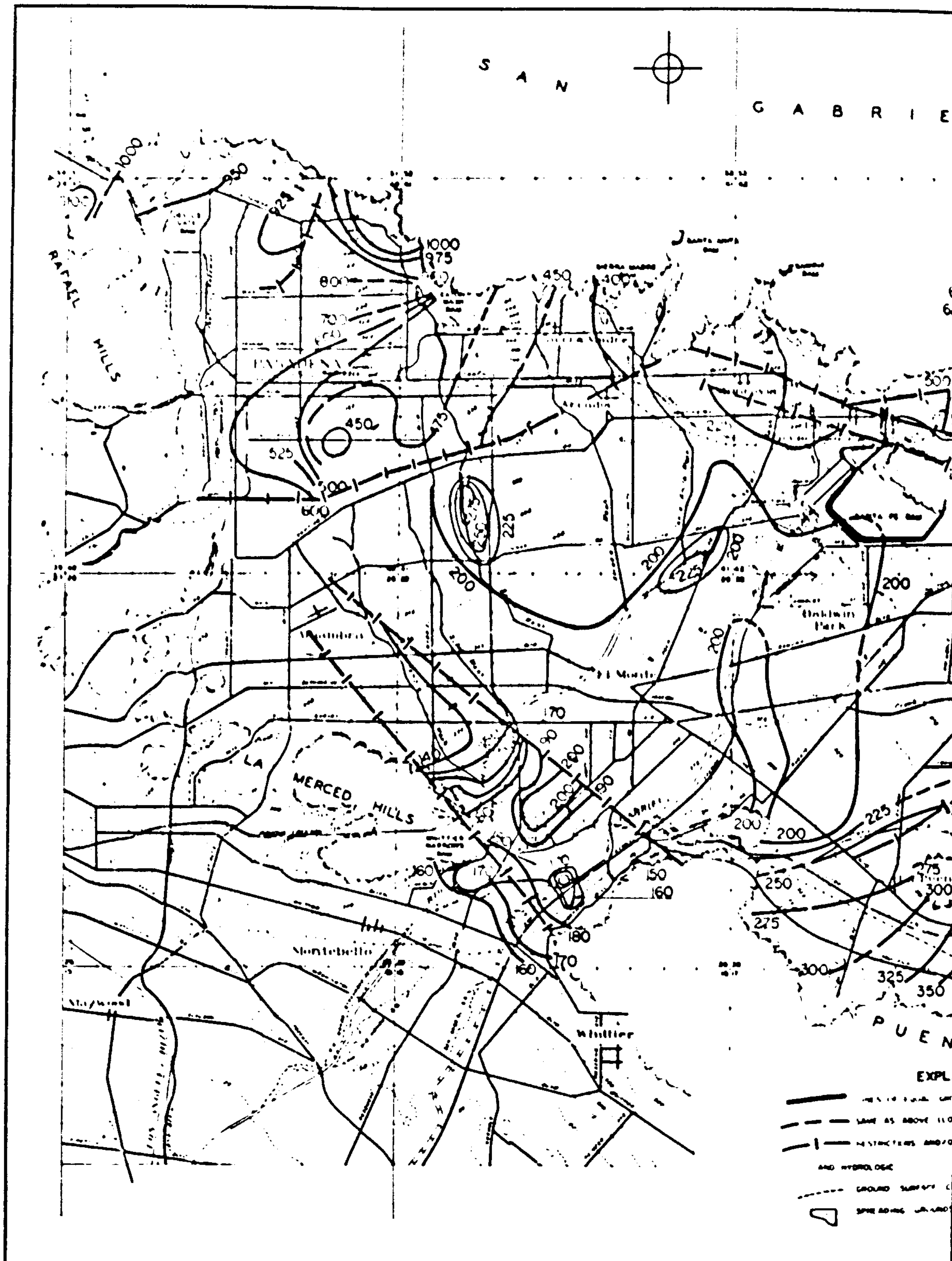
MOUNTAINS
ULARA WATERMASTER
UPPER LOS ANGELES RIVER AREA
GROUNDWATER CONTOURS
FALL 1990



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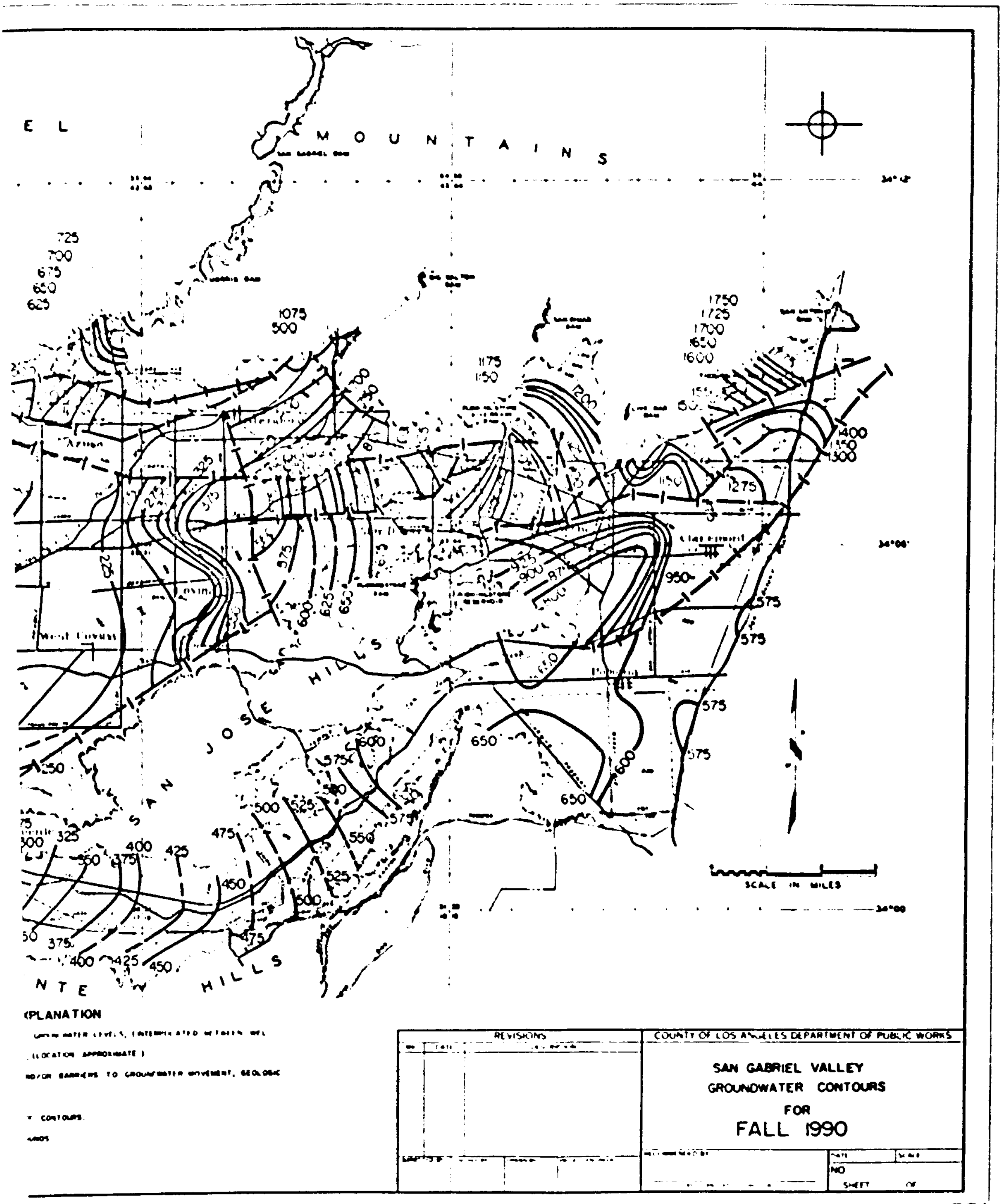

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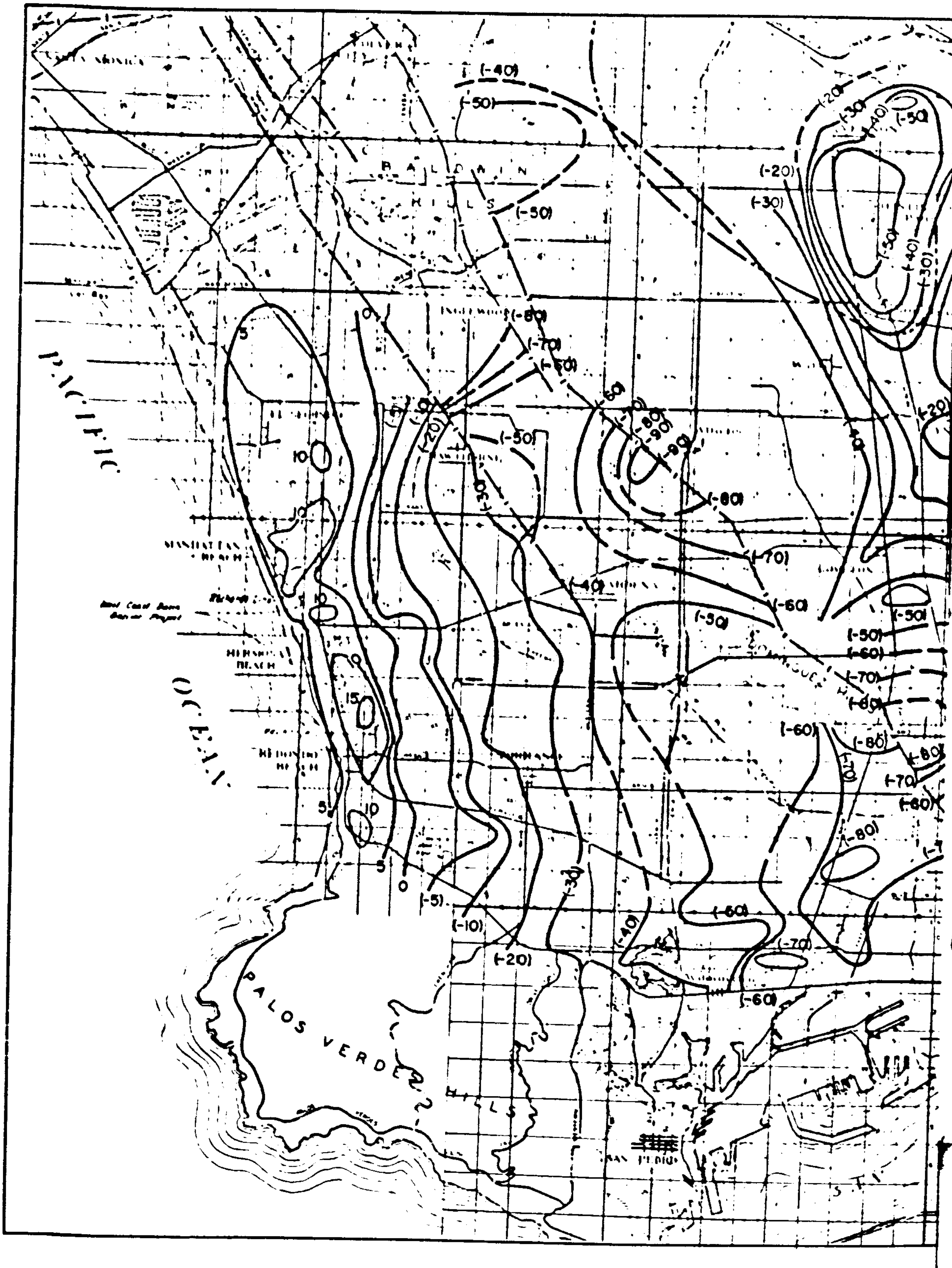

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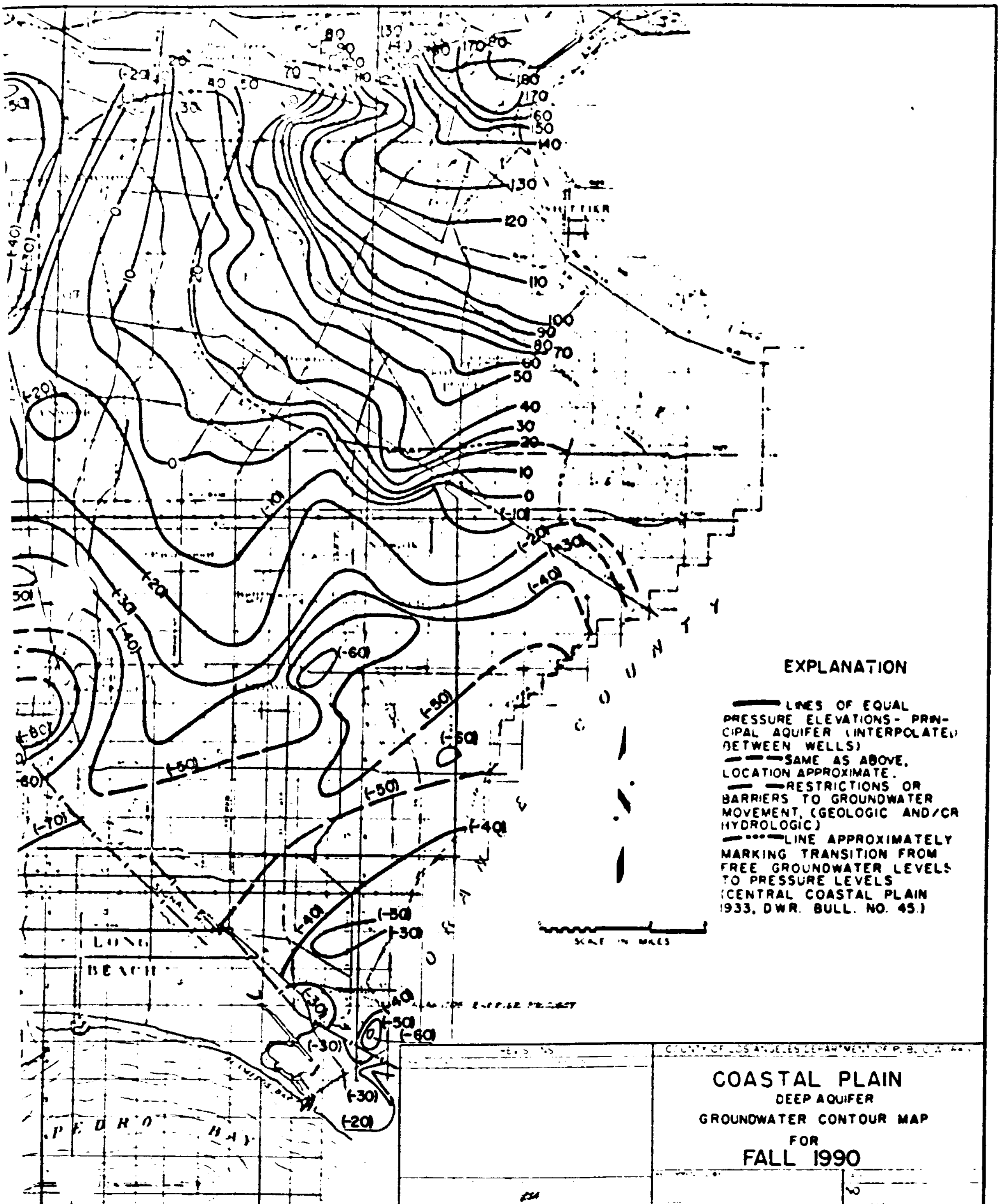

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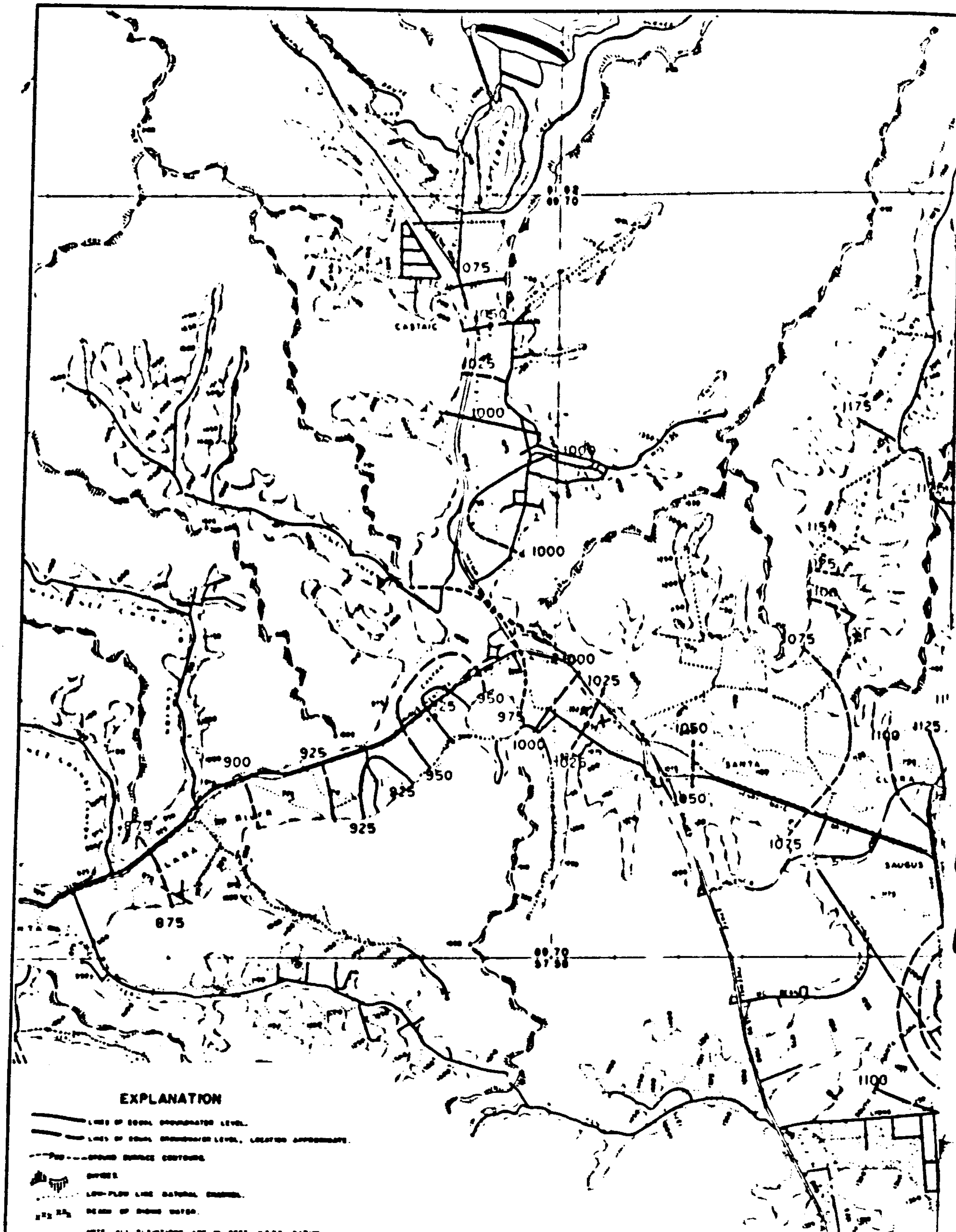

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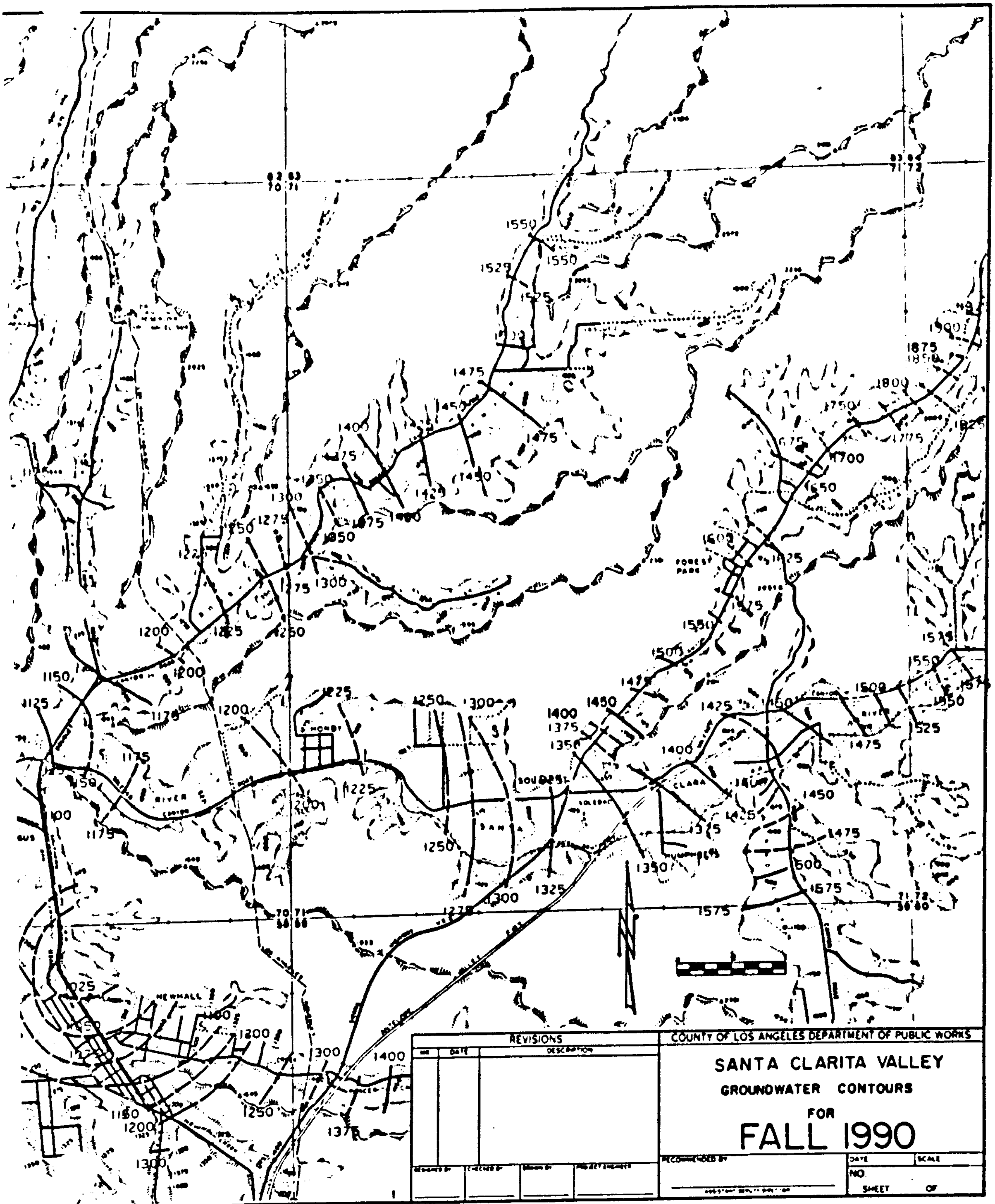

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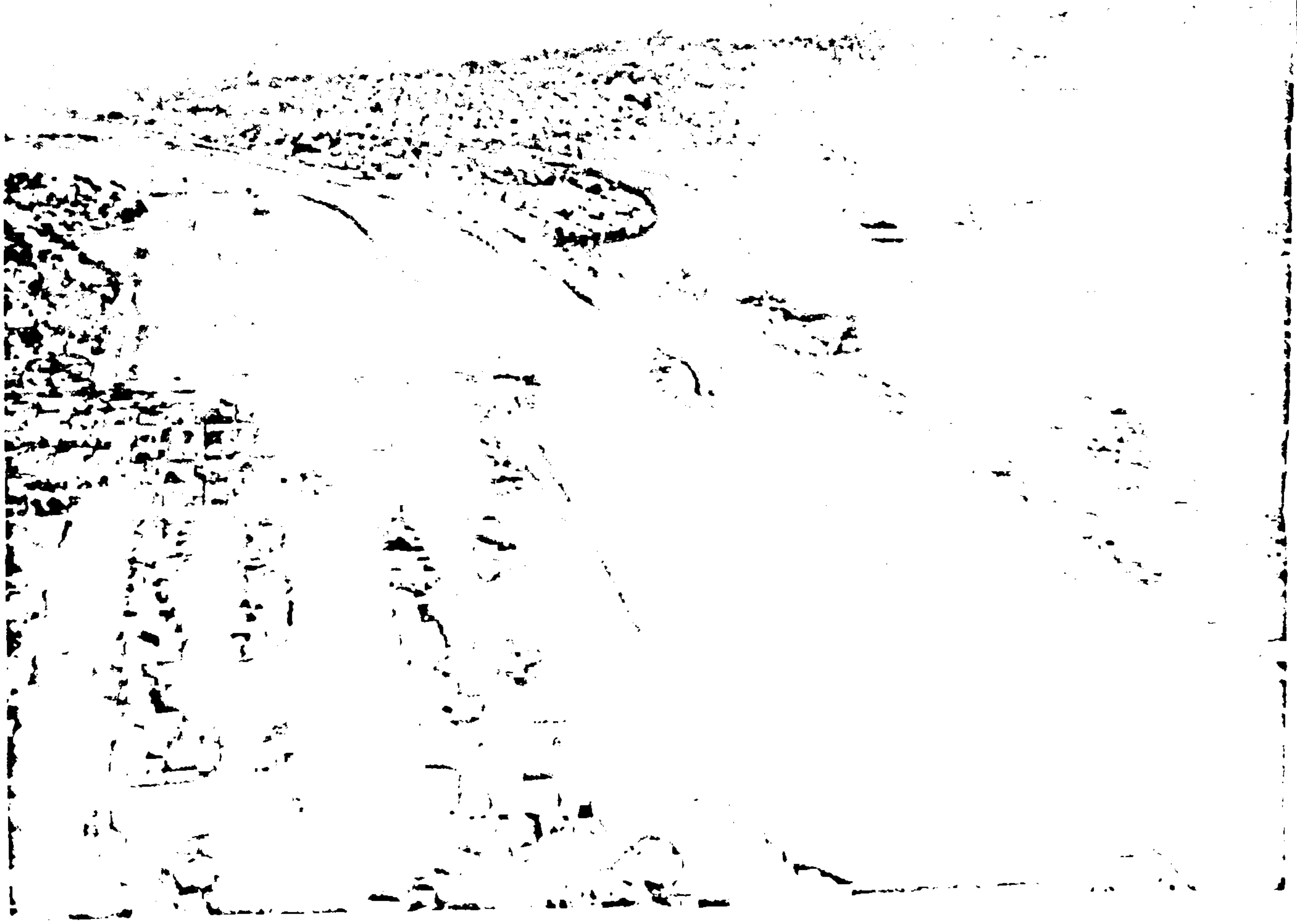
Los Angeles County Department of Public Works

HYDROLOGIC REPORT
1991 - 92



VOL 12

LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS

HYDROLOGIC REPORT

1991 - 92

PREPARED BY THE
HYDRAULIC/WATER CONSERVATION DIVISION
JULY 1993

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This report was prepared in the Hydraulic/Water Conservation Division under the direction of Donald F. Nichols, Assistant Deputy Director. The following people contributed to the completion of this report:

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Graphic Design, Layout, Art Production	K. Hu R. Brown D. Sackley	

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INTRODUCTION

This report contains hydrologic data relative to Los Angeles County for the period beginning October 1, 1991 and ending September 30, 1992. The data are presented in seven sections.

Precipitation - lists 294 active rainfall stations and presents corresponding seasonal rainfall amounts.

Evaporation - lists all locations for which evaporation data is on file and provides monthly evaporation amounts at 14 locations.

Runoff - presents the maximum, minimum, and mean of the daily flow rates for each month and the monthly volumes for 40 streamflow stations.

Dam Operation - presents the maximum and minimum of the daily inflow and outflow rates for each month, the instantaneous peak inflow and outflow rates and storage volumes for 14 dams and reservoirs.

Erosion Control - lists debris basins and debris production amounts.

Water Quality Monitoring - presents maps of surface and groundwater sampling locations, and data at selected locations.

Conservation and Groundwater - presents records of water conserved at various facilities, water injected at seawater barrier projects, well hydrographs, and static groundwater contour maps.

Where practical, data which would satisfy immediate needs and serve as useful reference are published in these reports. Several tables appear listing locations for which unpublished data are available. Additional information may be obtained by writing to:

Los Angeles County Department of Public Works
Hydraulic/Water Conservation Division
P.O. Box 1460
Alhambra, CA 91802-1460

or telephone: **(818) 458-6112**

LOS ANGELES COUNTY

TOPOGRAPHY

The County of Los Angeles covers an area of 4,083 square miles and measures approximately 66 miles in the east - west and 73 miles in the north - south directions.

The terrain within the County can be classified in broad terms as being 25 percent mountainous; 10 percent coastal plain; and 65 percent hills, valleys, or deserts. Relief of the terrain ranges from sea level to a maximum elevation of 10,000 feet. The coastal plain is generally of mild slope and contains relatively few depressions or natural ponding areas. The slopes of main river systems crossing the coastal plain, such as the San Gabriel River, Los Angeles River, and Ballona Creek, range from 4 to 14 feet per mile.

Topography in the mountainous area is generally rugged with deep, V-shaped canyons separated by sharp dividing ridges. Steepwalled canyons with side slopes of 70 percent or more are common. The gradient of principal canyons in the San Gabriel Mountains ranges from 150 to 850 feet per mile. Mountain ranges are aligned in a general east-west direction with the major range being the San Gabriel Mountains. The majority of mountain ridges lie below Elevation 5,000 feet. The total area above this level is approximately 210 square miles.

GEOLOGY - SOILS

Igneous, sedimentary, and metamorphic rock groups are all represented within the County. The San Gabriel Mountains and Verdugo Hills are composed primarily of highly fractured igneous rock, with large areas of granitic rock formation being exposed above soils that are coarse and porous. Faulting and deep weathering have produced porous zones in the rock formation; however, rock masses have produced a comparatively shallow soil mantle due to the steepness of slopes which accelerates erosion of the fine material.

LAND USE

The principal vegetative cover of upper mountain areas consists of various species of brush and shrubs known as chaparral. Most trees found on mountain slopes are oak, with alder, willow, and sycamore found along streambeds at lower elevations. Pine, cedar, and juniper are found in ravines at higher elevations and along high mountain summits.

The chaparral is extremely flammable, and extensive burns of the mountain vegetation frequently occur during dry, low-humidity weather accompanied by high winds. Chaparral has the ability to sprout following fire and grows rapidly to re-establish the watershed cover within a period of 5 to 10 years.

Grasses are the principal natural vegetation on the hills. Much of the hill land and nearly all of the valley land in the densely populated portion of the County south of the San Gabriel Mountains has been converted to urban and suburban use. Development of the

Santa Clarita Valley and desert areas to the north of the San Gabriel Mountains is sparse at present but is proceeding rapidly.

Other mountains and hilly reaches are composed primarily of folded and faulted sedimentary rock, including shale, sandstone, and conglomerate. Residual soils in these areas are shallow and are generally less pervious than those of the San Gabriel Mountain range.

Valley and desert soils are alluvial and vary from coarse sand and gravel near canyon mouths to silty clay and gravel or clay in lower valleys and the coastal plain. The alluvial fill has been built up by repeated deposition of debris to depths as great as 2,000 feet in places. This fill is quite porous in areas of relatively low clay content. Impervious layers and irregularities in the underlying bedrock divide the alluvium into several County groundwater basins. Valley soils are generally well drained but there are a few areas having perched water.

CLIMATE

The climate within the County varies between subtropical on the Pacific Ocean side of the San Gabriel Mountain range to arid in the Mojave Desert. Nearly all precipitation occurs during the months of December through March. Precipitation during summer months is infrequent, and rainless periods of several months are common. Snowfall at elevations above 5,000 feet is frequently experienced during the winter storms, but the snow melts rapidly except on higher peaks and the northern slopes. Snow is rarely experienced on the coastal plain.

January and July are the coldest and warmest months of the year, respectively. At Los Angeles, the 30-year average daily minimum temperature for January is 48 degrees above zero. The average daily maximum temperature for July is 84 degrees. At Mount Wilson (Elevation 5,850 feet), the 30-year average daily minimum temperature for January is 35 degrees above zero and the average daily maximum temperature for July is 80 degrees.

HYDROMETEOROLOGIC CHARACTERISTICS

Coastal and Mountain Areas

Precipitation in the Los Angeles area occurs primarily in the form of winter orographic rainfall associated with extratropical cyclones of North Pacific origin. Major storms consist of one or more frontal systems and occasionally last four days or longer. Air masses and frontal systems associated with major storms commonly extend for 500 to 1,000 miles in length and produce rainfall simultaneously throughout the County. Major storms approach Southern California from the west or southwest with southerly winds which continue until frontal passage. The mountain ranges lie directly across the path of the inflow of warm, moist air, and orographic effects greatly intensify precipitation.

The effects of snowmelt upon flood runoff is of significance in the few cases when warm spring rains from southerly storms fall on a snowpack. During major storms, temperatures throughout the County may remain above freezing. Average individual storm rainfall amounts and intensities conform to a fairly definite aerial pattern which reflects general effects of topographic differences.

Desert Areas

Summer convective rainfall is principally experienced in the upper San Gabriel Mountains and the Mojave Desert regions. In many desert areas, the most serious flooding occurs as a result of summer convective storms.

RUNOFF CHARACTERISTICS

Mountain Areas

In mountain areas, the steep canyon slopes and channel gradients promote a rapid concentration of storm runoff quantities. Depression storage and detention storage effects are minor in the rugged terrain. Soil moisture during a storm has a pronounced effect on runoff from the porous soils supporting a good growth of deeprooted vegetation such as chaparral. Soil moisture deficiency is greatest at the beginning of a rainy season, having been depleted by the evapotranspiration process during the dry summer months. Precipitation during periods of soil moisture deficiency is nearly entirely absorbed by soils, and except for periods of extremely intense rainfall, significant runoff does not occur until soils are wetted to field moisture capacity. Due to high infiltration rates and porosity of mountain soils, runoff occurs primarily as subsurface flow or interflow rather than as direct runoff. Spring or base flow is essentially limited to portions of the San Gabriel Mountain range. Consequently, most streams in the County are intermittent.

Runoff from a mountain watershed recently denuded by fire exceeds that for the unburned state due to greatly increased quantities of inorganic debris present in the flow and increased direct runoff resulting from lowered infiltration rates. Debris production from a major storm has amounted to as much as 223,000 cubic yards per square mile of watershed. Boulders up to eight feet in diameter have been deposited in valley areas a considerable distance from their source.

Debris quantities equal in volume to storm runoff, or in other words 100 percent bulking of runoff from a major storm, have been recorded. Where debris-laden flow traverses an alluvial fill unconfined by flood control works, flood discharges follow an unpredictable path across the debris cone formed at the canyon mouth.

Hill and Valley Areas

In hill areas, runoff concentrates rapidly from the generally steep slopes; however, runoff rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size. In those hill areas which have been developed for residential use, concentration times become considerably decreased due to drainage improvement, and runoff volumes and rates become increased due to increased imperviousness. On the other hand, erosion is controlled and debris is practically eliminated from storm flows. Debris production rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size.

In highly developed valley areas, local runoff volumes have increased as the soil surface has become covered by impervious materials. Peak runoff rates for valley areas have also increased due to elimination of natural ponding areas and improved hydraulic efficiency of water carriers such as streets and storm drain systems.

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FLOOD CONTROL AND WATER CONSERVATION

FLOODS. . AN OLD STORY

Floods in Los Angeles County have been recorded as far back as the days of the Mission Padres. For centuries waters have swept out of the San Gabriel Mountains causing extensive property damage and taking a great toll of lives.

Such a flood occurred in 1914 causing over $10 million in property damage and taking many lives. As a result, the State legislature enacted the statute creating the Los Angeles County Flood Control District. The responsibilities and authority vested in the Flood Control District are now part of the Los Angeles County Department of Public Works.

The Department has two tasks. . .control the floods and conserve the water.

CONTROLLING THE WATERS

Successful early bond issues financed construction of the 14 dams which the Department built in the San Gabriel Mountains and foothills to impound storm waters until they could be safely released. Debris basins were constructed to trap eroded materials which had caused terrible damage in the past. Flood channel improvements were undertaken to confine the waters.

Department engineers prepared a Comprehensive Plan in the early 1930's which would control flooding and save as much of the water as practicable when fully implemented.

Federal legislation in 1936 brought the United States Army Corps of Engineers into the local flood control picture. Since that time, the two agencies have been jointly pursuing implementation of the Comprehensive Plan. The Department also cooperates with the United States Soil Conservation Service and Forestry Service in erosion control.

CONSERVING THE WATERS

In addition to its flood control program, the Department has the equally important task of conserving as much of the storm and other waste waters as practicable. The use of water conservation facilities in or adjacent to river channels and their tributaries permits water to be percolated into underground reservoirs for later pumping and supply to consumers. These water conservation facilities are located in areas where the underlying soils are composed of porous sands and gravel formations. Some resemble rice paddies, while others are deep basins which were once gravel pits.

The importance of this activity is apparent when it is realized that about 30 to 40 percent of the water used in the County is pumped from ground supplies. The growth of the County, combined with periodic droughts, seriously depleted these supplies on numerous occasions throughout the history of the County.

Other major conservation efforts by the Department include combatting the serious salt water intrusion into underground fresh water supplies inland from the Pacific Ocean and utilizing imported water and reclaimed sewage waters in spreading operations.

ORGANIZED TO DO THE JOB

Day-to-day administration of Department affairs is vested in the Director of Public Works who is appointed by and responsible to the Los Angeles County Board of Supervisors. A part of the Department's activities involve the planning, design and construction of flood control and water conservation facilities, and the operation and maintenance of dams, debris basins, spreading grounds, channels, and storm drains.

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PRECIPITATION

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PRECIPITATION

This section contains annual precipitation data collected by the Department for the period beginning October 1, 1991 and ending September 30, 1992. Although the Department operates and maintains 293 rainfall stations, including standard and automatic gages which record amounts for durations ranging from 5 minutes to 24 hours, only annual amounts for the report period are listed herein. Additional data can be obtained by contacting the custodian of hydrologic records at the location shown in the front of the report.

RAINFALL AMOUNTS

For the year, rainfall recorded at the downtown Los Angeles station (No. 716) reached 23.26 inches, or 150 percent of the long-term average of 15.51 inches. The Cogswell Dam station (No. 334B) recorded 52.35 inches for the year which is 159 percent of the long-term average of 32.88 inches. The County received the greatest amount of rainfall during the month of February, with the San Fernando Valley in the vicinity of the Sepulveda Basin being among the hardest-hit areas. The above two stations recorded rainfall of 9.02 inches and 23.22 inches, respectively, during that month.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorological conditions in the County and Southern California in real time, i.e., as they occur. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The cooperation of observers in furnishing rainfall data to the Department as a public service is appreciated. The effort of the many agencies and individuals who have so freely cooperated with us in the collection of this data have resulted in the large number of complete records for the period covered by this report.

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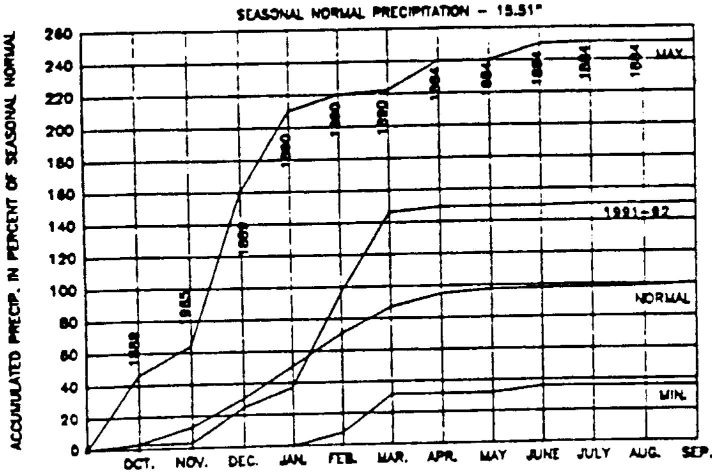
LOS ANGELES COUNTY RAINFALL INDICES USING SELECTED STATIONS FOR THE PERIOD OCTOBER 1, 1991 THROUGH SEPTEMBER 30, 1992

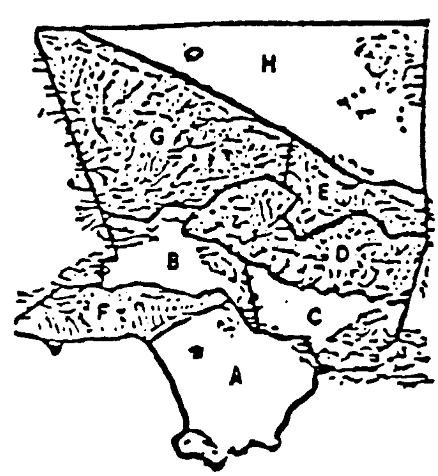
	PERCENT OF AREA	SEASONAL NORMAL PRECIP. (inches)	TOTAL PRECIP. (inches)	PERCENT OF SEASONAL NORMAL	TOTAL PRECIP. LAST YR. (inches)
A. COASTAL PLAIN	14.1	13.71	17.80	130	11.57
B. SAN FERNANDO VALLEY	7.9	17.62	30.56	173	15.21
C. SAN GABRIEL VALLEY	7.5	17.64	20.40	116	14.91
D. SAN GABRIEL MTS.	13.4	27.50	37.67	137	23.81
E. LITTLE ROCK, BIG ROCK	4.5	18.61	24.94	134	16.13
F. SANTA MONICA MTS.	5.7	19.96	31.56	158	14.80
G. SANTA CLARA	18.9	16.64	27.56	166	14.92
H. DESERT	28.0	7.83	14.79	189	8.61
COUNTY	100	15.65	23.77	152	13.94
LOS ANGELES (STATION #716)		15.51	23.26	150	12.60
COGSWELL DAM (STATION #334B)		32.88	52.35	159	26.88

MAX., MIN. & NORMAL CURVES

LOS ANGELES (STATION #716)

SEASONAL NORMAL PRECIPITATION - 15.51"





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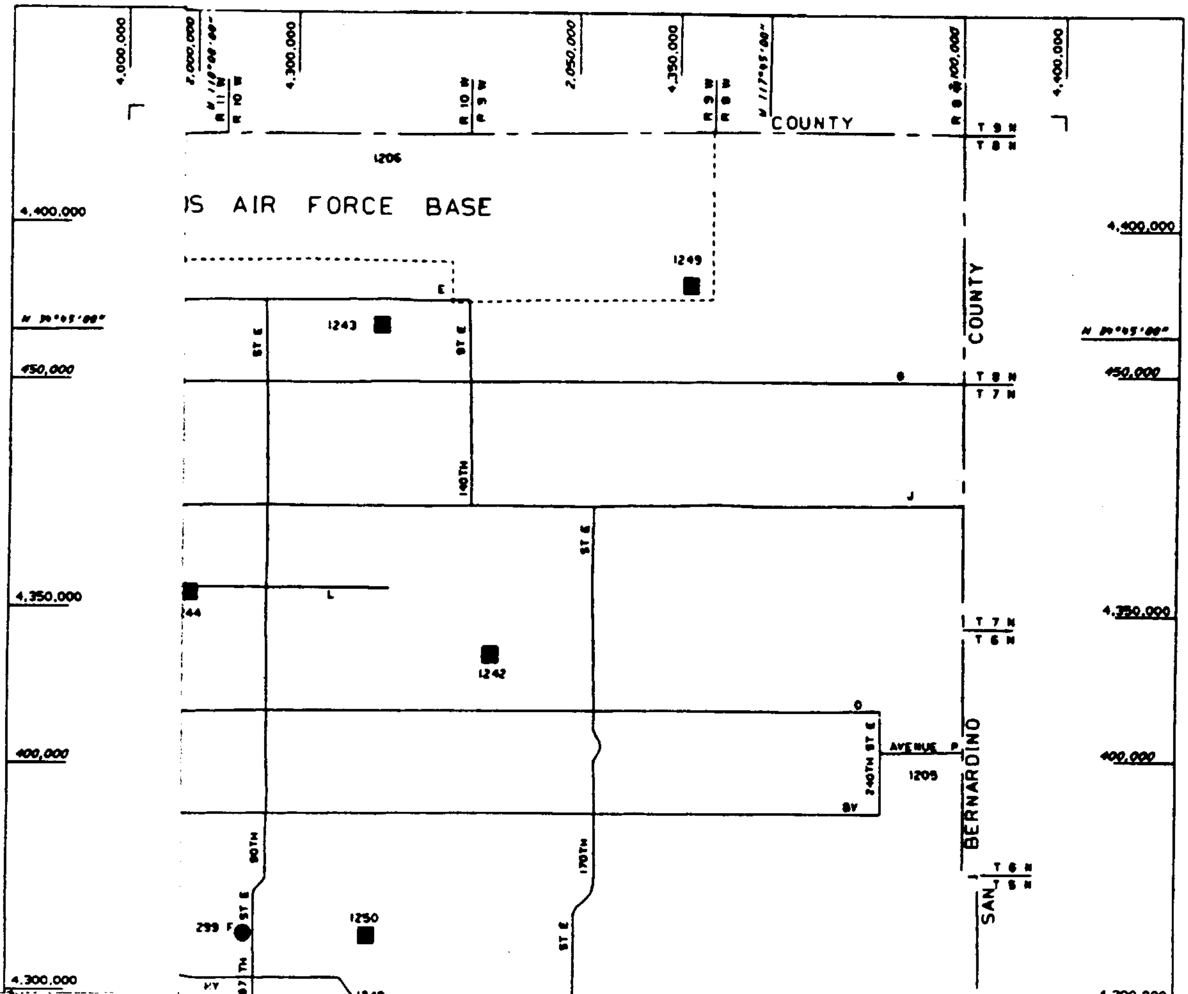

MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

RAINFALL STATION LOCATIONS

UPDATED FEBRUARY 12.1992

R0053394

ACTIVE RAINFALL STATIONS 1991-1992

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
2B	ESCONDIDO CANYON	S	112 E3	34-02-55	118-46-25	1050	19.00*
5B	CALABASAS	S	100 F3	34-09-24	118-38-14	924	33.47
6	TOPANGA PATROL STATION	A	109 C5	34-05-03	118-35-57	745	33.00
9B	SEPULVEDA AND RAYEN	S	8 C6	34-13-52	118-28-04	828	32.93
10A	BEL AIR HOTEL	A	32 E5	34-05-11	118-26-45	540	26.07
11D	UPPER FRANKLIN CYN RES.	SP	33 B1	34-07-10	118-24-35	867	25.72
13C	NORTH HOLLYWOOD-LAKESIDE	S	23 F4	34-08-46	118-21-13	550	31.51
14C	ROSCOE-MERRILL	S	9 F5	34-14-19	118-21-32	1050	29.00*
15A	VAN NUYS	S	15 D6	34-10-48	118-27-03	695	28.27
17	SEPULVEDA CYN AT MULHOLLAND	A	22 A5	34-07-51	118-29-26	1425	37.10
20B	GIRARD RESERVOIR	S	13 B3	34-09-07	118-36-36	986	36.55
21B	WOODLAND HILLS	S	13 C1	34-10-14	118-35-33	875	28.11
23B	CHATSWORTH RESERVOIR	SP AP	6 A6	34-13-44	118-37-18	900	26.35
25C	NORTHRIDGE-L.A.D.W.P.	SP	7 B6	34-13-52	118-32-28	810	27.97
32C	NEWHALL-SOLEDAD DIV. HDQTRS	AP S	127 C3	34-23-07	118-31-54	1243	31.61
33A	PACOIMA DAM	S A	128 F9	34-19-48	118-23-59	1500	31.66
42C	REDONDO BEACH-CITY HALL	S	67 D3	33-50-43	118-23-20	70	15.48
43D	PALOS VERDES ESTATES	S	72 C2	33-47-58	118-23-29	216	19.05
44A	POINT VICENTE LIGHTHOUSE	A	77 B3	33-44-30	118-24-38	125	14.30
46D	BIG TUJUNGA DAM	S A	M C2	34-17-40	118-11-14	2315	41.09
47D	CLEAR CREEK-CITY SCHOOL	A	M D3	34-16-38	118-10-12	3150	41.90
53D	COLBY'S	A	M F2	34-18-05	118-06-39	3620	38.20
54C	LOOMIS RANCH-ALDER CREEK	S A	(197)	34-20-55	118-02-54	4325	24.62
57B	CAMP HI HILL (OPIDS)	A	M F3	34-15-18	118-05-41	4250	62.93
63C	SANTA ANITA DAM	S A	20A F2	34-11-03	118-01-12	1400	36.04
67G	MONROVIA-MOUNTAIN AVENUE	S	29 C4	34-08-46	117-59-05	602	23.91
68C	SAWPIT DAM	S A	20B C6	34-10-30	117-59-07	1375	34.30
82F	TABLE MOUNTAIN	S	(201)	34-22-56	117-40-39	7420	32.60
83B	BIG PINES RECREATION PARK	A	(201)	34-22-44	117-41-20	6860	30.00
89B	SAN DIMAS DAM	S A	95A C3	34-09-10	117-46-17	1350	28.21
91	CLAREMONT-INDIAN HILL	S	91 B1	34-07-22	117-43-11	1403	23.44
92	CLAREMONT-POMONA COLLEGE	S	91 C4	34-05-48	117-42-33	1185	23.50*
93C	CLAREMONT-POLICE STATION	8.81	91 B4	34-05-45	117-43-18	1170	23.28
95	SAN DIMAS-FIRE WARDEN	S	89 F3	34-06-26	117-48-19	955	20.02
96C	PUDDINGSTONE DAM	S A	89 F4	34-05-31	117-48-24	1030	24.27
102D	WALNUT-W.I. INDUSTRIES	S	97 B2	34-00-11	117-52-10	500	17.91
106F	WHITTIER CITY YARD	S	55 D4	33-58-57	118-02-50	300	17.14
107D	DOWNEY-FIRE DEPARTMENT	S	60 A5	33-55-48	118-08-47	110	16.07
108D	EL MONTE FIRE STATION	S	38 D6	34-04-30	118-02-30	275	18.02
109D	WEST ARCADIA	S	28 A6	34-07-42	118-04-22	547	24.19

ACTIVE RAINFALL STATIONS 1991-1992

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
110B	ALHAMBRA	S	37 B3	34-05-40	118-07-41	533	25.52
117F	COMPTON FIRE STATION	S	64 F3	33-53-42	118-13-34	78	18.00*
119G	SAWTELLE-SOLDIERS HOME	S	41 D2	34-03-21	118-27-20	345	23.50*
120	VINCENT PATROL STATION	S	183 A9	34-29-17	118-08-27	3135	14.10
122G	LEONA VALLEY-RACKETT RANCH	S	171 G3	34-37-52	118-19-22	3300	16.40*
125B	SAN FRANCISQUITO CYN P.H. 1	SP	(169)	34-35-25	118-27-15	2105	25.02
128B	ELIZABETH LAKE	A	(168)	34-36-28	118-33-40	2075	29.10
134C	PUDDINGSTONE DIVERSION	8.81	95A C5	34-07-52	117-46-55	1160	24.40
143B	AZUSA-CITY PARK	S	86 D5	34-08-03	117-54-17	610	23.79
144	SIERRA MADRE DAM	S	20A D3	34-10-34	118-02-32	1100	35.66
156B	LA MIRADA-STANDARD OIL CO.	A	83 A4	33-52-59	118-01-00	75	16.20
157C	EL SEGUNDO-CHEVRON OIL CO.	AP S	56 A6	33-54-57	118-25-05	150	14.60*
158	TANBARK FLATS	AP A	P D5	34-12-20	117-45-40	2750	35.90
167C	ARCADIA PUMPING PLANT #1	S	28 E2	34-09-31	118-02-02	611	27.08
169	SIERRA MADRE PUMPING PLANT	SP	28 D2	34-09-47	118-02-21	700	29.96
170F	POTRERO HEIGHTS	S	47 A4	34-02-32	118-04-44	285	18.42
172B	DUARTE	S	29 E4	34-08-26	117-58-02	548	22.95
174B	GLENDORA	S	87 E6	34-07-43	117-49-08	930	25.56
175B	LA CANADA IRRIGATION DIS.	S	19 A1	34-13-39	118-12-40	2020	41.53
176	ALTADENA-RUBIO CANYON	SP	20 B6	34-10-55	118-08-15	1125	35.22
191C	L.A.C.D.P.W.-WAREHOUSE	A	45 B1	34-03-48	118-11-58	400	24.06*
192C	BELL-FIRE STATION	8.81	53 C5	33-58-45	118-11-16	145	16.00*
193C	COVINA-NIGG	S	89 A5	34-04-55	117-52-25	575	23.76
196C	LA VERNE-FIRE STATION	S	90 D3	34-06-06	117-46-20	1050	23.04
200	SAUGUS-S. C. EDISON CO.	S	123 H8	34-25-21	118-34-26	1096	22.40
201D	HACIENDA HEIGHTS	A	85 C3	33-59-40	117-59-28	875	22.70
210C	BRAND PARK	A	18 B5	34-11-18	118-16-20	1250	30.00*
216B	GLENDALE-ANDREE	S	25 D2	34-09-54	118-15-01	615	29.58
222C	NORTH HOLLYWOOD P. P.	SP	16 C4	34-11-39	118-23-17	717	28.80*
223C	BIG DALTON DAM	S A	87 F2	34-10-06	117-48-36	1587	32.59
224D	LONG BEACH-ALAMITOS LAND CO.	S	76 B3	34-47-	118-08-	45	14.04*
225	MONTANA RANCH	S	71 C3	33-50-35	118-07-09	47	15.77
226B	BURBANK-FIRE STATION	S	17 E6	34-10-58	118-18-23	680	28.05*
227D	SAN GABRIEL-BRUINGTON-ORTON	S	37 D2	34-06-18	118-06-32	472	25.02
228C	BEVERLY HILLS CITY HALL	AP S	33 C6	34-06-00	118-23-40	245	22.39
235C	HENNIGER FLATS	A 8.81	20 F4	34-11-38	118-05-17	2550	44.88
237C	STONE CANYON RESERVOIR	SP	32 D2	34-06-21	118-27-13	865	28.10
238	HOLLYWOOD DAM	SP	34 C1	34-07-04	118-19-55	750	27.06
250D	ACTON CAMP	A	189 E5	34-27-02	118-11-55	2625	16.00
251C	LA CRESCENTA	S	18 D1	34-13-20	118-14-40	1440	36.76

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STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
252C	CASTAIC DAM	SP AP	(178)	34-29-53	118-36-53	1150	21.79
255F	MT. SAN ANTONIO COLLEGE	S	93 D4	34-02-41	117-50-19	720	21.78
256C	POMONA-FIRE STATION	S	94 E3	34-03-16	117-45-10	844	22.00*
257	GRIFFITH PARK NURSERY	S	35 A1	34-07-18	118-17-04	850	26.20*
261F	ACTON-ESCONDIDO CANYON	A	181 H9	34-29-42	118-16-22	2960	15.76*
269D	DIAMOND BAR FIRE STATION	SP AP	97 F2	33-59-50	117-48-55	870	19.45
277	SAWMILL MOUNTAIN	S	(155)	34-43-15	118-35-00	3700	23.20*
278B	L.A. CLARK MEMORIAL LIBRARY	S	43 D5	34-02-00	118-18-46	203	22.00*
280C	FLINTRIDGE-SACRED HEART	A	19 D6	34-10-54	118-11-08	1600	37.25
283C	CRYSTAL LAKE-EAST PINE FLAT	A	P B1	34-19-02	117-50-28	5370	53.10
287B	GLENDORA-CITY HALL	8.81	87 B5	34-08-09	117-51-52	785	27.27
289	LAGUNA-BELL-S.C.E. CO.	SP	54 A5	33-58-37	118-08-48	140	15.20*
290B	MONTEREY PARK-FIRE STATION	S	46 B4	34-02-27	118-07-42	305	21.46
291	LOS ANGELES-96th AND CENTRAL	A	58 C3	33-56-56	118-15-17	121	19.70
292D	ENCINO RESERVOIR	S A	21 D3	34-08-56	118-30-57	1075	35.53
293B	LAKE LOS ANGELES	SP	2 A4	34-17-18	118-28-54	1150	31.15
294B	SIERRA MADRE-MIRA MONTE P.P.	SP	28 C1	34-10-11	118-02-51	985	33.97
298C	GORMAN - SHERIFF	A	(141)	34-47-47	118-51-27	3835	17.00*
299F	LITTLE ROCK - SCHWAB	S	184 F5	34-32-12	117-58-43	2800	12.85
303F	PASADENA - CALTECH	A	27 C5	34-08-14	118-07-25	800	27.80*
306H	ZUMA BEACH	S	111 F6	34-01-15	118-49-42	15	20.72
321	PINE CANYON PATROL STATION	A	157 D7	34-40-24	118-25-45	3286	23.70
322	MUNZ VALLEY RANCH	S	158 A2	34-42-50	118-21-15	2600	18.07
334B	COGSWELL DAM	S A	N D4	34-14-37	117-57-35	2300	52.35
336	SILVER LAKE RESERVOIR	SP	35 B3	34-06-08	118-15-54	445	25.55
338C	MT. WILSON-OBSERVATORY	SP	20A C1	34-14-07	118-04-28	5709	47.83
341	ALISO CANYON-BLUM RANCH	S	189 J4	34-27-33	118-09-20	2900	18.00*
342C	UPLAND-CHAPPEL	AP	96 E6	34-07-33	117-40-52	1610	23.52
352B	LECHUZA PATROL STATION	AP S	105 B6	34-04-38	118-52-47	1620	29.53
355B	LOS ANGELES CITY COLLEGE	AP S	34 F4	34-05-14	118-17-28	310	24.62
356C	SPADRA-LANTERMAN HOSPITAL	S A	93 F4	34-02-31	117-48-35	690	20.96
372	SAN FRANCISQUITO P. H. NO.2	SP A	(179)	34-32-02	118-31-27	1580	28.91
373C	BRIGGS TERRACE	S A	11 F5	34-14-17	118-13-27	2200	42.78
377F	LAKE SHERWOOD ESTATES	SP AP	102A C4	34-08-26	118-52-31	960	20.75*
379B	SAN GABRIEL-EAST FORK	A	P C4	34-14-09	117-48-18	1600	32.30
387B	COVINA CITY YARD	SP	88 E5	34-05-02	117-53-57	508	22.42
388D	PARAMOUNT-COUNTY FIRE DEPT.	8.81	65 E3	33-53-50	118-10-02	80	17.25*
390B	MORRIS DAM	SP	P A6	34-10-53	117-52-43	1210	31.12
391C	MONTEBELLO-FIRE DEPARTMENT	8.81	54 E1	34-01-08	118-06-15	250	15.52
394	HIGHLAND PARK	S	36 D1	34-07-06	118-10-39	620	28.54

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STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
395B	OLIVE VIEW SANITARIUM	A	2 D1	34-19-29	118-26-55	1425	35.51
402F	CEDAR SPRINGS	A	(199)	34-21-21	117-52-34	6780	40.00*
405B	SOLEDAD CANYON	S	188 F6	34-26-23	118-17-33	2150	23.76
406C	WEST AZUSA	S	88 C2	34-06-53	117-54-56	505	21.07
409B	PYRAMID RESERVOIR	SP AP	(154)	34-40-34	118-46-47	2505	28.61
415	SIGNAL HILL-CITY HALL	S A	75 E2	33-47-49	118-10-03	140	14.93
423C	ANGELES FOREST-ALISO CYN	A	(190A)	34-24-57	118-05-26	3920	30.69
425B	SAN GABRIEL DAM	S A	P A5	34-12-19	117-51-38	1481	36.66
434	AGOURA	A	100A A5	34-08-08	118-45-08	800	28.80
435	MONTE NIDO	A	108 A6	34-04-41	118-41-35	600	35.10
436C	HANSEN DAM	AP	9 C2	34-16-08	118-23-59	1110	30.10
442C	MESCAL CREEK	S	(194)	34-29-05	117-44-10	3570	13.26
443B	LATIGO CANYON-BEACH RANCH	S	106 B4	34-05-35	118-48-52	1700	19.50*
446	ALISO CANYON-OAT MOUNTAIN	A	1 A2	34-18-53	118-33-25	2367	34.47*
447C	CARBON CANYON	S	114 E4	34-02-18	118-38-56	50	16.37
449B	EATON WASH DAM	S A	27 E1	34-10-06	118-05-33	880	30.62
453D	DEVILS GATE DAM	A	19 D6	34-10-53	118-10-27	980	28.42*
455B	LANCASTER-HWY MAINTENANCE	S	160 B6	34-40-57	118-08-02	2395	13.87
462B	HILLCREST COUNTRY CLUB	S	42 B3	34-02-54	118-24-06	185	22.27
465C	SEPULVEDA DAM	AP	22 B1	34-10-06	118-28-11	683	29.45
478	VALYERMO-U.S.F.S.	SP	192 H5	34-26-44	117-51-10	3710	18.00*
480B	TEMPLE CITY FIRE STATION	S	38 C2	34-06-31	118-03-25	404	21.08
482	LOS ANGELES-U.S.C.	S	43 F6	34-01-14	118-17-15	208	21.95
488B	KAGEL CANYON PATROL STATION	S	3 E4	34-17-45	118-22-30	1450	30.10
491D	PACIFIC PALISADES	S	40 C4	34-02-22	118-31-43	293	21.03
492A	CHILAO-HWY MAINTENANCE STA.	A	N C1	34-19-05	118-00-30	5275	31.21*
493D	SAND CANYON-MACMILLAN RANCH	A	128 D3	34-23-17	118-24-50	1805	34.00*
497	CLAREMONT-SLAUGHTER	8.81	91 A1	34-07-35	117-43-55	1350	25.20
517B	LEWIS RANCH	A	(192A)	34-25-12	117-53-11	4615	19.36
542	FAIRMONT	SP	(145)	34-42-15	118-25-40	3050	23.84
560A	LA VERNE HEIGHTS	S	90 E2	34-06-48	117-45-02	1210	23.90
564C	LLANO	S	185 J9	34-29-13	117-50-02	3390	13.47
591B	SANTA ANITA RESERVOIR	SP	20 E5	34-11-08	118-06-16	1205	22.62
598C	NEENACH-ERSTAD	S	(143)	34-46-28	118-35-55	3062	20.16
598D	NEENACH-CHECK 43-D.W.R.	SP	(143)	34-47-40	118-37-15	2965	19.26
610B	PASADENA-CITY HALL	SP	27 A4	34-08-54	118-08-36	864	30.61
612B	PASADENA-CHLORINE PLANT	SP	19 E3	34-12-04	118-09-49	1160	35.16
613C	PASADENA FIRE STATION	SP	27 B5	34-07-15	118-08-05	779	26.96
619	SAN ANTONIO CYN-SIERRA P. H.	A	P F5	34-12-29	117-40-26	3110	41.42
627	SAN GABRIEL CANYON-P. H.	SP A	86 D3	34-09-20	117-54-28	744	27.07

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STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
634C	SANTA MONICA	S	49 A1	34-00-43	118-29-27	94	18.19
662D	LONG BEACH AIRPORT	SP	71 A6	33-49-	118-09-	34	13.66
680B	WESTWOOD (U.C.L.A.)	SP	41 E1	34-04-10	118-26-30	430	23.16
683B	SUNSET RIDGE	S A	19 E4	34-12-53	118-08-47	2110	32.59
694G	BIG TUJUNGA CANYON-CAMP 15	A	N D6	34-17-22	118-17-17	1525	34.30
695B	TUJUNGA CANYON-VOGEL FLAT	S	N B2	34-17-12	118-13-32	1850	47.54
716	LOS ANGELES-DUCOMMUN ST.	SP A AP	44 E3	34-03-09	118-14-13	306	23.26
722C	BELLEVIEW	S	171 B3	34-37-23	118-13-55	2880	19.84*
726C	ANGELES CREST GUARD STATION	S	N D4	34-14-01	118-11-04	2300	43.67
734C	L. A. INTERNATIONAL AIRPORT	SP AP	56 C3	33-56-25	118-23-44	105	14.85
735H	BELL CANYON	A	5 D4	34-11-40	118-39-23	895	33.60
740B	SAN DIMAS CANYON-FERN NO.2	AP	P F6	34-11-48	117-41-45	5200	34.00*
741	SAN DIMAS CYN	AP	P E6	34-11-41	117-44-26	2675	35.05*
742C	SAN GABRIEL FIRE DEPARTMENT	SP	37 E3	34-06-11	118-05-56	445	23.19
747	SANDBERG-AIRWAYS STATION	SP AP	(142)	34-44-47	118-43-29	4517	17.70
749B	BURBANK VALLEY PUMP PLANT	SP AP	17 A5	34-11-11	118-20-54	655	30.78
750B	PALMDALE REGIONAL AIRPORT	S	172 F6	34-37-20	118-05-00	2528	12.47
771B	PACIFIC PALISADES-RIVIERA	S	40 F3	34-03-03	118-29-58	315	23.00*
794	LOWER FRANKLIN RESERVOIR	SP	33 B4	34-05-43	118-24-40	585	24.51
795	PASADENA	SP	27 F4	34-08-52	118-05-14	***	27.08
797	DE SOTO RESERVOIR	SP	6 D1	34-16-17	118-35-12	1127	30.20
801B	MAGIC MOUNTAIN	AP	(195)	34-23-18	118-19-27	4720	36.65
802C	EAGLE ROCK RESERVOIR	SP	26 C4	34-08-47	118-11-20	970	28.58
807	ASCOT RESERVOIR	SP AP	36 C5	34-04-46	118-11-14	620	24.26
1005B	MINT CANYON FIRE STATION	S	(180)	34-30-35	118-21-40	2300	18.65
1006	SAN PEDRO-CITY RESERVOIR	SP A	78 F2	33-44-37	118-17-47	150	17.25
1008	LA FRESA-S.C.E.CO.	S	63 C6	33-52-07	118-19-55	65	18.09
1011B	PALOS VERDES FIRE STATION	S	78 A1	33-45-25	118-21-11	1275	21.27
1012B	CASTAIC JUNCTION	S A	123 E6	34-26-18	118-36-43	1005	22.72
1017B	LITTLE ROCK CREEK ABOVE DAM	A	(191)	34-28-41	118-01-24	3280	17.80*
1020B	PADUA HILLS PATROL STATION	S	96 D4	34-08-52	117-41-55	1800	26.47
1025	MALIBU BEACH-DUNNE	S	113 E5	34-02-00	118-42-42	160	17.12
1029C	TUJUNGA-MILL CREEK SUMMIT	AP S	(197)	34-23-22	118-04-49	4990	31.83
1037	ARCADIA-ARBORETUM	S	28 C4	34-08-48	118-02-59	565	23.43
1040	POTRERO CYN-SUNRAY OIL CO.	S	126 C2	34-23-50	118-38-18	1150	24.00*
1041B	SANTA FE DAM	AP	39 D1	34-07-04	117-58-24	427	20.61
1046B	SANTA ANITA CYN-CHANTRY FLAT	S	20A F1	34-11-46	118-01-20	2175	42.08
1050F	OLD TOPANGA CANYON	S	108 F3	34-06-24	118-37-43	1000	44.41
1051B	CANOGA PARK-PIERCE COLLEGE	SP	12 E5	34-10-51	118-34-23	800	33.57
1052	CAMP JOSEPHO	S	30 D5	34-04-51	118-31-10	660	26.00*

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STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
1058B	PALMDALE	SP AP	172 E7	34-35-17	118-05-31	2595	12.69
1060B	LITTLE ROCK-SYCAMORE CAMP	A	(191)	34-25-02	117-58-13	4000	22.00*
1062	BUCKHORN FLAT	A	(199)	34-20-44	117-55-08	6760	34.40
1063	SOLEDAD PASS	S	183 E9	34-29-35	118-05-28	3520	18.50
1068	RATTLESNAKE CANYON	S	105 C5	34-05-00	118-51-55	1290	22.62
1070	MANHATTAN BEACH	S	62 D4	33-53-00	118-23-19	182	15.59
1071B	DESCANSO GARDENS	S	19 B2	34-12-07	118-12-46	1325	35.87
1072B	LITTLE TUJUNGA RANGER STA.	SP A	3 F5	34-17-37	118-21-38	1275	31.11
1074	LITTLE GLEASON	A	(197)	34-22-43	118-08-57	5600	32.00*
1075	UPPER WOLFSKILL	AP	96 B2	34-10-13	117-43-16	3625	31.54
1076B	MONTE CRISTO RANGER STATION	SP	M E1	34-19-42	118-07-20	3360	29.77
1077B	MONROVIA-FIVE POINTS	S	29 B1	34-09-58	117-59-37	962	31.49
1081B	GLENDALE-GREGG	SP	18 D4	34-11-45	118-14-30	1350	35.52
1087	GREEN-VERDUGO PUMPING PLANT	S	10 B3	34-15-25	118-20-11	1340	27.12
1088B	LA HABRA HEIGHTS	S A	84 E2	33-56-55	117-57-51	445	19.55
1090	LOS ALAMITOS	SP	81 B6	33-48-35	118-04-35	25	14.60*
1092B	BUENA PARK	3"P	OC10 C1	33-51-28	117-59-29	80	17.80*
1093	FULLERTON AIRPORT	SP AP	83 D5	33-52-23	117-58-24	100	19.00*
1095	ORANGE COUNTY RESERVOIR	SP AP	OC 2 F4	33-56-07	117-52-58	660	19.59
1104	BOUQUET CANYON AT TEXAS CYN	S	(180)	34-30-35	118-27-00	1760	23.20*
1107D	LA TUNA DEBRIS BASIN	A	10 C5	34-14-13	118-19-37	1160	29.80
1111C	DEVILS PUNCHBOWL	S	(192A)	34-24-48	117-51-25	4760	24.85
1113	DOMINGUEZ WATER CO.	A	69 F4	33-49-54	118-13-30	30	16.50
1114B	WHITTIER NARROWS DAM	AP	47 A6	34-01-29	118-05-02	239	17.41
1115	SAN ANTONIO DAM	AP SP	96 F3	34-09-24	117-40-20	2120	28.88
1126A	LOS ANGELES-EAST VALLEY	8.81	16 B3	34-12-30	118-24-35	780	28.28
1127	WEST BURBANK	S	17 B6	34-10-47	118-20-07	615	29.00*
1128	WRIGHTWOOD FIRE DEPARTMENT	SP	S.B.CO.	34-21-34	117-37-57	5960	21.77
1129B	NICHOLAS CANYON	S	110 D3	34-02-52	118-54-57	340	22.77
1132	OAK FLAT GUARD STATION	S	(166)	34-35-56	118-43-15	2800	29.20*
1135B	LUNADA BAY	SP	72 A4	33-46-37	118-25-01	250	16.00*
1140	ROSEMEAD	8.81	38 B5	34-04-53	118-03-55	305	16.54
1147	EL CABALLERO COUNTRY CLUB	S	21 C4	34-08-52	118-31-53	1000	44.17
1152	CLEAR CREEK RANGER STATION	S	M D3	34-16-15	118-09-11	3625	47.41
1157	CAL STATE UNIV. NORTHRIDGE	SP AP	7 C5	34-14-17	118-31-48	890	29.80*
1158	TORRANCE MUNICIPAL AIRPORT	S	73 B2	33-47-59	118-20-08	102	20.40
1166B	MILE HIGH RANCH	S	(193)	34-24-40	117-46-15	5280	26.00*
1167	FENNER CANYON	S	(200)	34-23-25	117-46-27	5380	32.00*
1169B	PIRU-TEMESCAL GUARD STATION	SP	V.CO.	34-28-22	118-45-21	1150	29.12
1170B	THOUSAND OAKS WEATHER STA.	AP	V.CO.	34-10-44	118-51-01	805	29.04

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STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
1171B	CAMULOS RANCH	SP AP	V.CO.	34-24-22	118-45-21	725	27.68
1172B	PIRU CANYON ABOVE PIRU LAKE	AP	(177)	34-30-48	118-45-24	1120	29.45
1173B	TAPO CANYON	AP	V.CO.	34-19-54	118-42-39	1525	27.56
1177B	BARD RESERVOIR	AP	V.CO.	34-14-32	118-49-41	1010	26.27
1183B	LA HABRA FIRE STATION	3*P	84 F4	33-55-53	117-57-17	315	19.70*
1190	PACOIMA CYN-NORTH FORK	S	(195)	34-23-17	118-15-06	4180	32.00*
1191	BEAR DIVIDE	S	128 F6	34-21-35	118-23-37	2700	35.34
1192	CARSON FIRE STATION	8.81	64 C6	33-52-04	118-15-45	92	18.00*
1193	WESTLAKE VILLAGE	S	102 A5	34-08-19	118-49-05	885	33.60
1194	SANTA YNEZ RESERVOIR	S	109 F6	34-04-23	118-33-59	735	29.80*
1195	CHINO FIRE STATION NO. 2	SP	S.B.CO.	33-59-00	117-43-20	655	20.17
1196	MONTCLAIR FIRE DEPARTMENT	SP	95 E2	34-03-41	117-41-16	965	22.36
1197	CAJON WEST SUMMIT	SP	S.B.CO.	34-23-30	117-34-35	4838	26.00*
1198	PHELAN FIRE CONTROL	SP	S.B.CO.	34-25-30	117-34-00	4160	16.49
1211	HACIENDA GOLF CLUB	S	98A A1	33-57-40	117-56-57	750	20.00*
1212	LANCASTER FSS/FAA	SP	147 C9	34-44-00	118-13-00	2340	12.60
1216	RANCHO PALOS VERDES	S	77 C1	33-45-10	118-23-32	780	16.95
1217	LOS ANGELES COUNTRY CLUB	S	42 A1	34-04-10	118-25-17	380	23.69
1222	NORTHRIDGE-GARLAND	8.81	7 E3	34-14-17	118-30-59	911	30.70
1223	WOODLAND HILLS-SHERMAN	8.81	100 E1	34-10-06	118-38-57	1035	32.10
1238	ACTON-MEARNS	S	189 G2	34-27-05	118-12-50	2775	16.00*
1239	MALIBU-BIG ROCK MESA	A	115 A4	34-02-34	118-37-16	725	21.00
1240	PEARBLOSSOM-CALIF.D.W.R.	SP AP	185 B7	34-30-32	117-55-15	3050	12.31
1242	ROCKY BUTTES	A	(162)	34-39-00	117-51-48	2540	10.60*
1243	REDMAN	A	(150)	34-45-52	117-55-30	2360	9.60*
1244	LANCASTER-ROPER	A	161 C6	34-40-27	118-00-37	2450	11.00*
1245	QUARTZ HILL-HALL	A	159 B7	34-40-28	118-14-40	2395	14.10
1246	SCOTT RANCH	A	(145)	34-46-59	118-28-10	2710	19.70*
1247	NORTH LANCASTER	A	148 D6	34-45-41	118-07-30	2310	11.30
1248	MESCAL-SMITH	A	(194)	34-28-03	117-42-40	3810	14.20
1249	RELAY	A	(150)	34-45-43	117-47-55	3140	8.80
1250	AVEK	A	185 B5	34-32-21	117-55-23	2825	11.50
1251	PALOS VERDES-WHITES POINT	SP	78 D6	33-42-50	118-19-02	100	13.47
1252	PALOS VERDES LANDFILL	SP	73 A4	33-45-40	118-20-03	400	18.85
1253	CARSON-COUNTY SANITATION	SP	74 A2	33-48-07	118-16-58	40	16.91
1254	LONG BEACH RECLAMATION PLANT	SP	76 F1	33-48-11	118-05-20	20	14.38
1255	LOS COYOTES RECLAMATION	SP	66 E4	33-53-05	118-06-24	70	15.99
1256	SOUTH GATE TRANSFER STATION	SP	59 E3	33-56-40	118-09-56	100	15.43
1257	SAN JOSE CREEK RECLAMATION	SP	47 F4	34-01-55	118-01-16	275	20.78
1258	PUENTE HILLS LANDFILL	SP	47 E5	34-01-35	118-01-49	300	20.09

ACTIVE RAINFALL STATIONS 1991-1992

STATION NO.	STATION NAME	TYPE OF GAGE	THOMAS GUIDE PAGE	NORTH LATITUDE	WEST LONGITUDE	GAGE ELEV. (feet)	SEASONAL TOTAL (inches)
1259	WHITTIER NARROWS RECLAMATION	SP	47 B1	34-03-59	118-03-54	225	16.39
1260	SPADRA LANDFILL	SP	93 E4	34-02-36	117-49-50	700	20.48
1261	LA CANADA RECLAMATION PLANT	SP	19 D2	34-13-00	118-11-14	1800	36.74
1262	SAUGUS RECLAMATION PLANT	SP	124 H9	34-24-48	118-32-23	1150	24.77
1263	VALENCIA RECLAMATION PLANT	SP	123 D7	34-25-55	118-37-13	1000	22.57
1264	CALABASAS LANDFILL	SP	100A E3	34-08-25	118-42-35	800	33.32
1265	SCHOLL CANYON LANDFILL	SP	26 C4	34-08-38	118-11-07	1000	32.44
1266	MISSION CANYON LANDFILL	SP	22 B6	34-08-40	118-28-45	1150	27.48
1267	LANCASTER RECLAMATION PLANT	SP	147 H4	34-46-38	118-09-11	2302	11.45
1268	PALMDALE RECLAMATION PLANT	SP	172 G6	34-35-30	118-05-10	2565	10.94
1271	POMONA WASTE RECLAMATION	SP	94 B3	34-03-18	117-47-34	786	21.78

LEGEND:

S	Standard 8 Inch Non-recording Gage Owned By L.A. County Public Works
8.81	8.81 Inch Diameter Non-recording Gage Owned By L.A. County Public Works
A	Automatic Recording Gage Owned By L.A. County Public Works
SP	Standard 8 Inch Diameter Non-recording Gage Owned By Outside Interest
AP	Automatic Recording Gage Owned By Outside Interest
3"P	Standard 3 Inch Gage Owned By Outside Interest
( )	Thomas Guide Page
O.CO.	Orange County Thomas Guide Page
V.CO.	Ventura County Thomas Guide Page
S.B.CO.	San Bernardino County Thomas Guide Page
*	Estimated Seasonal Total

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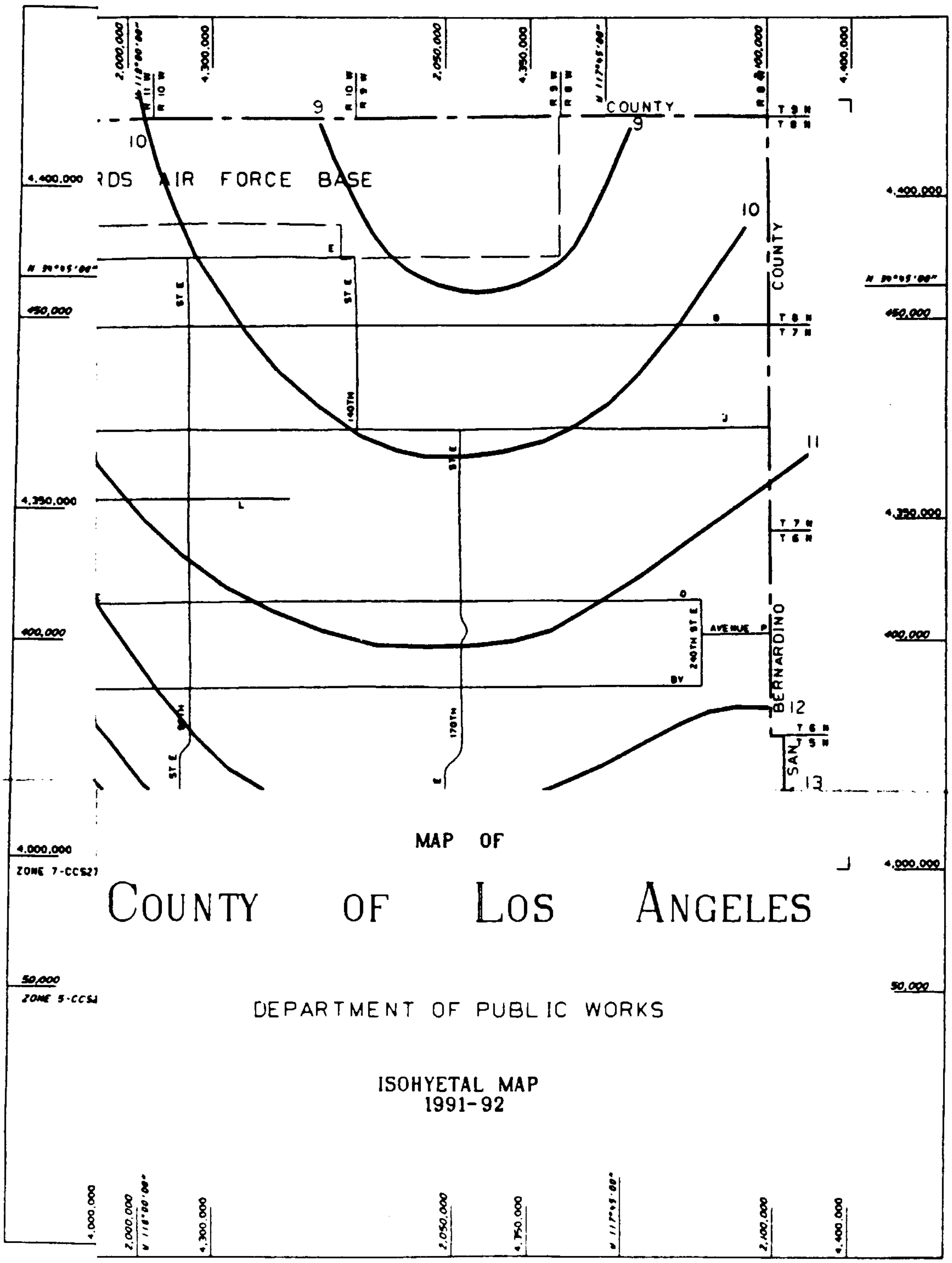

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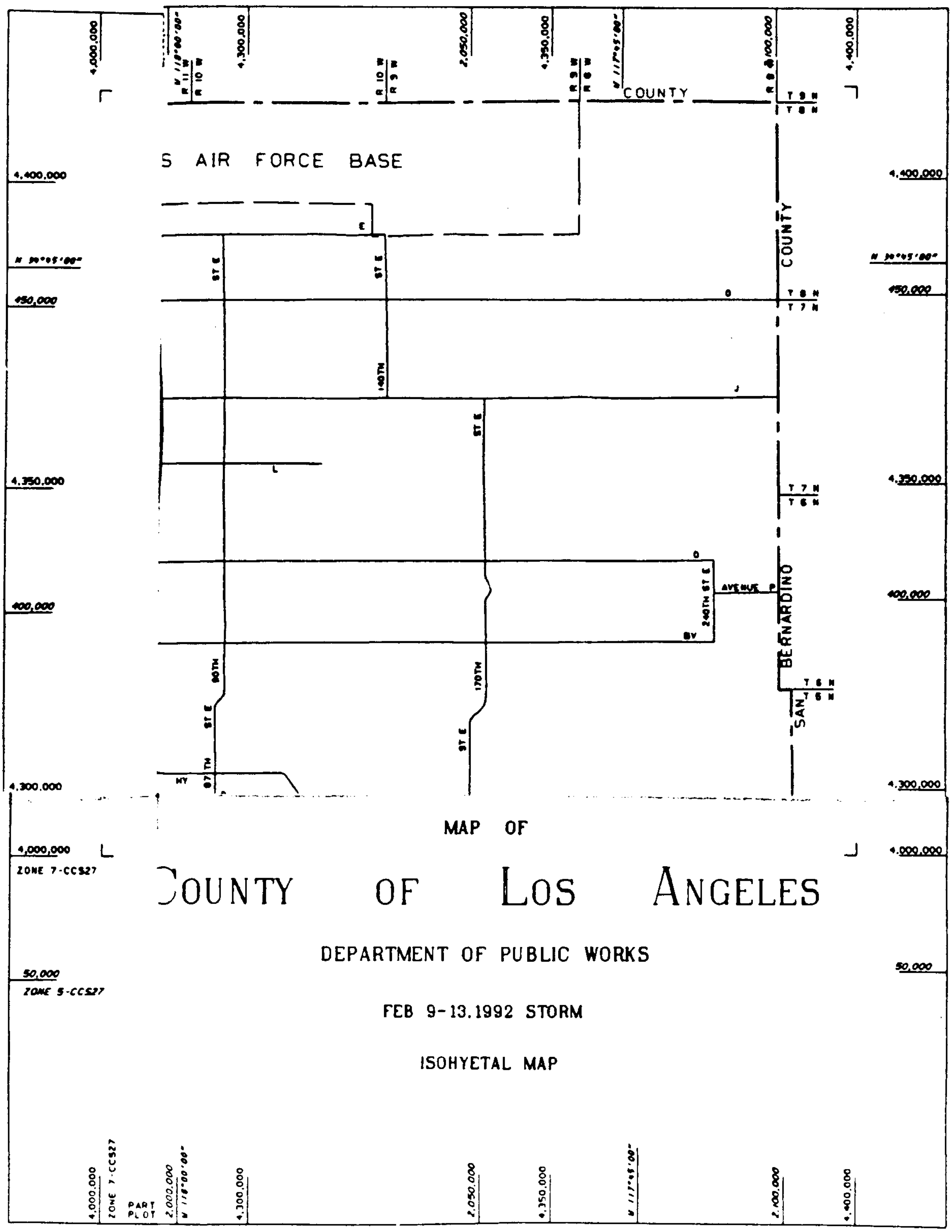

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EVAPORATION

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R0053405

EVAPORATION

Data for 14 active evaporation stations were reported to the Department during the 1991-92 water year. Daily records of active and inactive Department stations, as well as some stations of other agencies, are available in the Department's files. Monthly and seasonal evaporation has been published in the Department's Annual or Biennial Reports on Hydrologic Data since the 1931-32 season.

COOPERATION

The Department receives evaporation data from The Metropolitan Water District, Palmdale Water District, California Department of Water Resources, and Descanso Gardens.

LENGTH OF RECORD

The first land pan installed by this Department was at Santa Anita Dam in March 1929. There are 30 evaporation stations which have records of 15 seasons or more in the Department's files.

EVAPORATION STATION LIST 1991-92

STA. NO.	STATION NAME	EQUIPMENT	ELEVATION OF PAN	THOMAS GUIDE	NORTH LATITUDE	WEST LONGITUDE
33 A	Pacoima Dam	24X36 S	1500 ft.	145 F9	34-19-48	118-23-59
46 D	Big Tujunga Dam	24X36 S	2315 ft.	F C2	34-17-40	118-11-14
63 C3	Santa Anita Dam	24X36 S	1400 ft.	99 F2	34-11-03	118-01-12
89 B	San Dimas Dam	24X36 S	1350 ft.	95A C3	34-09-10	117-46-17
96 C	Puddingstone Dam	24X36 S	1030 ft.	89 F4	34-05-31	117-48-24
223 B	Big Dalton Dam	24X36 S	1587 ft.	87 F1	34-10-06	117-48-36
252 C	Castaic Reservoir	48X10 S	1150 ft.	(178)	34-29-53	118-36-53
334 B	Cogswell Dam	24X36 S	2300 ft.	G D4	34-14-37	117-57-35
390 B	Morris Dam	72X36 US	1210 ft.	86 F1	34-10-53	117-52-43
409 B	Pyramid Reservoir	48X10 S	2505 ft.	(154)	34-40-34	118-46-47
425 B	San Gabriel Dam	24X36 S	1481 ft.	H A5	34-12-19	117-51-38
1014 F	Rio Hondo S.G.	24X36 S	170 ft.	54 D3	33-59-57	118-06-04
1058 B	Palmdale	24X36 S	2595 ft.	172 F7	34-35-17	118-05-31
1071 B	Descanso Gardens	24X36 S	1325 ft.	19 B3	34-12-07	118-12-46

LEGEND

24X36 S = Screened land pan, 24 inches in diameter by 36 inches deep.
48X10 S = Screened land pan, 48 inches in diameter by 10 inches deep.
72X36 US = Unscreened land pan, 72 inches in diameter by 36 inches deep.
( ) = Thomas Guide future page assignment.

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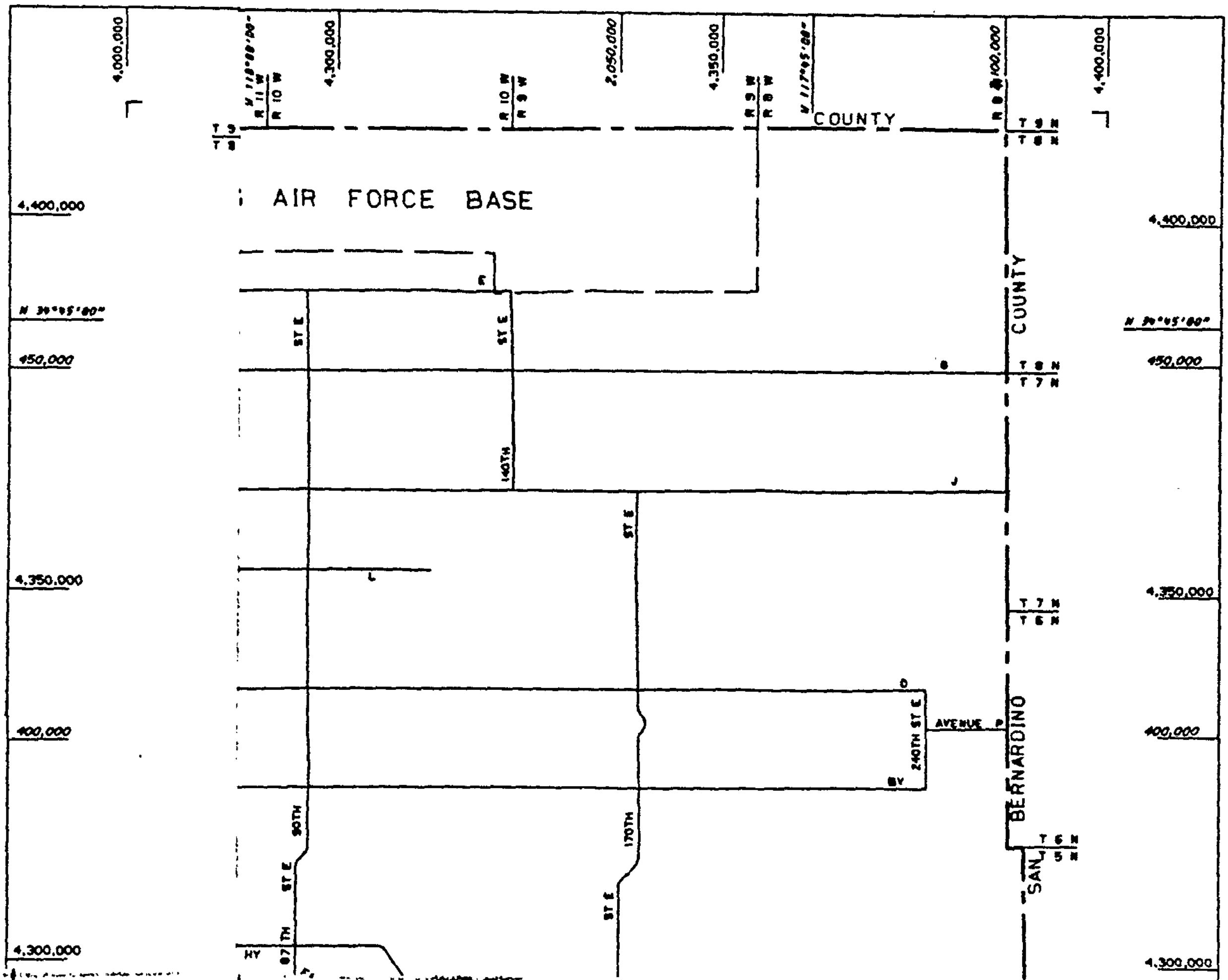
MONTHLY EVAPORATION SUMMARY FOR WATER YEAR 1991-92 (inches)

STA. NO		STATION NAME	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
33	A	Pacoima Dam	10.35	9.33	5.64	7.35	4.94	2.46	7.44	5.03	7.29	7.88	10.69	10.52	88.90
46	D	Big Tujunga Dam	9.30	6.89	4.99	4.66	4.08	3.31	6.06	5.95	7.91	9.10	11.20	9.86	83.29
63	D	Santa Anita Dam	6.51	5.17	3.58	3.31	2.47	1.94	3.37	3.51	4.87	5.05	6.77	6.56	53.09
89	B	San Dimas Dam	4.67	2.89	1.83	2.03	1.89	1.88	4.16	4.75	6.27	6.58	8.13	6.06	51.11
96	C	Puddingstone Dam	6.73	4.81	3.33	3.07	2.90	2.42	5.71	6.25	8.20	8.51	10.95	8.59	71.46
223	B	Big Dalton Dam	5.19	3.00	1.74	1.84	1.77	1.51	3.73	4.60	6.11	6.02	8.10	6.28	49.86
252	C	Castaic Reservoir	7.15	5.48	6.00	3.25	7.45	4.14	4.78	4.96	7.26	7.38	9.27	8.14	75.25
334	B	Cogswell Dam	5.18	2.71	1.50	1.28	1.64	1.48	3.89	5.54	7.15	7.57	8.69	6.50	53.11
390	B	Morris Dam	7.99	7.14	4.08	3.78	3.55	3.08	7.46	7.15	9.05	9.43	12.32	10.48	85.52
409	B	Pyramid Reservoir	6.20	5.44	6.43	5.69	9.59	7.55	5.15	6.71	8.97	8.03	9.72	10.88	90.36
425	B	San Gabriel Dam	8.38	6.26	3.90	3.70	3.08	2.66	6.07	5.99	7.80	8.05	9.74	9.02	74.61
1014	F	Rio Hondo S.G.	4.44	3.62	2.21	1.80	3.20	2.27	4.26	4.88	6.52	6.66	7.69	5.59	53.13
1058	B	Palmdale	6.01	2.88	2.19	1.30	1.56	2.82	8.88	13.53	16.40	15.49	15.62	11.55	98.21
1071	B	Descanso Gardens	4.98	2.78	2.08	1.63	1.77	1.58	3.24	3.88	4.71	5.44	7.07	5.69	44.83



MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

EVAPORATION STATIONS LOCATIONS MAP

1991-92

ZONE 7-CCS27

ZONE 5-CCS27

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R0053408

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0104

RUNOFF

R0053409

RUNOFF

The Department operated or received data from 65 water-stage recording stations during the 1991-92 water year. Data from 40 of those stations are summarized and published in this volume.

The above normal rainfall during this report period and especially the heavy storm activity during February have resulted in heavy runoff in the rivers, channels, and streams. The Los Angeles River in particular during February 10th, experienced flow rates at near-channel capacity at some locations.

RECORDS OF STREAMFLOW

Records published give the following information:

1. Station description which presents location, drainage area, type of channel, control, regulations, diversions, and available records.

2. Discharge tabulation which summarizes the maximum, minimum, and mean of the daily flow rates in second-feet for each month and the total monthly volumes in acre-feet.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorological conditions at 57 locations in the County. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The Department receives streamflow data from other agencies, or has access to the records for local stations. Data from 7 of the Department's stations are published in the United States Geological Survey's annual water supply papers.

Agencies with which the Department exchanges data are:

United States Geological Survey, Water Resource Division
United States Corps of Engineers
State Department of Water Resources
The Metropolitan Water District
San Gabriel River Water Committee

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LEGEND

Stations are designated by letters and numbers which indicate ownership, operation agency, and type of station. The letters used have the following connotations:

Prefix F - Indicates a station owned and operated by the Los Angeles County Department of Public Works.

Prefix E - Indicates a station owned by the Corps of Engineers, Department of the Army, but operated and maintained by the United States Geological Survey.

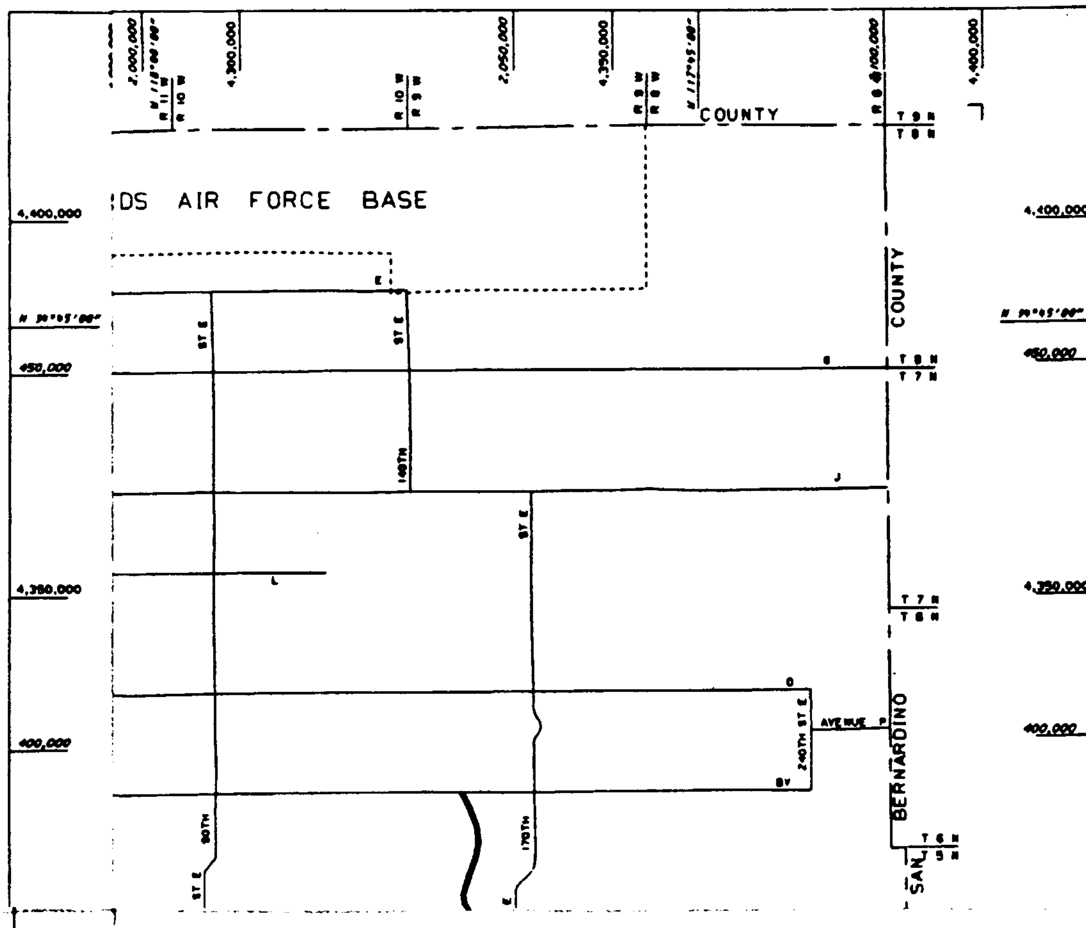
Prefix U - Indicates a station originally constructed and operated by the United States Geological Survey, Water Resources Division, now operated by the Department.

Prefix P - Indicates a station owned and operated by the Department, formerly operated by the Pasadena Water Department.

Prefix L - Indicates a station owned and operated by the Department, formerly owned by Little Rock Water District.

Suffix R - Indicates a recorder station.

Suffix B - Indicates that the station has been moved. B represents second location, C a third location, etc.



MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

STREAMFLOW GAGING STATION LOCATIONS

UPDATED MAY 11.1992

PC1

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01-07

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0108

INDEX OF STREAM GAGING STATIONS

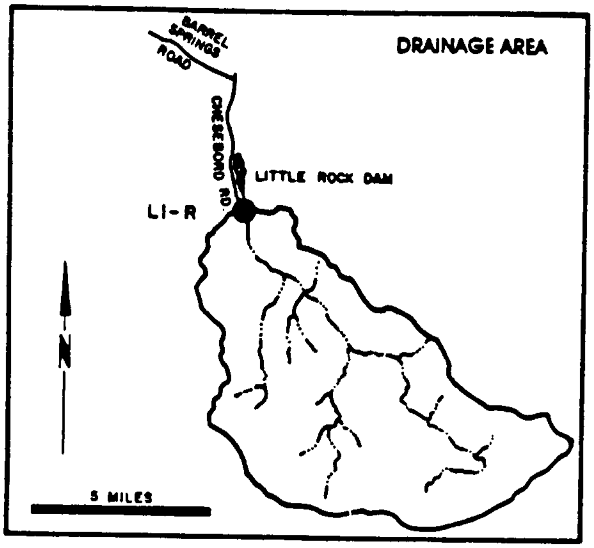
STATION	NAME	THOMAS GUIDE PG.	ALERT NO.	REGU-LATED	DRAINAGE AREA *
L1-R	LITTLE ROCK CREEK ABOVE LITTLE ROCK DAM	J		NO	49.20
F2WG	BROWNS CREEK AT VARIEL AVENUE	6 / D-2		NO	13.50
U7-R	FISH CREEK ABOVE MOUTH OF CANYON	86 / B-2		NO	6.36
U8-R	SAN GABRIEL RIVER BELOW MORRIS DAM	86 / F-1	415	YES	212.40
U14-R	BIG ROCK CREEK ABOVE MOUTH OF CANYON	J		NO	23.00
AAS(015)	VALYERMO S.G., BIG ROCK CK. D/S VALYERMO RD.	192/H-5			
F32B-R	THOMPSON CREEK BELOW THOMPSON CREEK DAM	96 / C-5	433	YES	3.70
F34D-R	LOS ANGELES RIVER BELOW FIRESTONE BLVD.	59 / E-3	315	YES	596.00
F37B-R	COMPTON CREEK NEAR GREENLEAF DRIVE	64 / F-4		NO	22.60
F38C-R	BALLONA CREEK ABOVE SAWTELLE BLVD.	50 / B-3	369	YES	88.60
F40-R	PUDDINGSTONE CREEK BELOW PUDDINSTONE DAM	89 / F-4	427	YES	33.20
F42B-R	SAN GABRIEL RIVER ABOVE SPRING STREET	76 / F-1	435	YES	231.00
F45B-R	RIO HONDO ABOVE STUART AND GRAY ROAD	59 / E-3	307	YES	140.00
F57C-R	LOS ANGELES RIVER ABOVE ARROYO SECO	35 / F-5		YES	511.00
F64-R	RIO HONDO ABOVE MISSION BRIDGE	47 / B-5		YES	115.00
F81D-R	ALHAMBRA WASH NEAR KLINGERMAN STREET	46 / F-2	347	NO	15.20
F82C-R	RUBIO WASH AT GLENDON WAY	38 / A-6	353	YES	10.90
F83	MISSION CREEK AT SAN GABRIEL BLVD.			YES	4.2
F92C-R	SANTA CLARA RIVER AT OLD ROAD BRIDGE	123 / G-7		YES	410.40
F93	SANTA CLARA RIVER AT LANG RAILROAD BRIDGE	125 / J-7		NO	157.30
F118B-R	PACOIMA CREEK FLUME BELOW PACOIMA DAM	3 / C-1	330	YES	28.20
F119C-R	SANTA ANITA CREEK BELOW SANTA ANITA DAM	20A / F-2	345	YES	10.80
F120B-R	BIG DALTON CREEK BELOW BIG DALTON DAM	87 / F-2	418	YES	4.80
F122-R	PALLETT CREEK AT VALYERMO HIGHWAY	199 / G-4		NO	15.80
F125-R	SANTIAGO CREEK ABOVE LITTLE ROCK CREEK	J		NO	11.20
F130B-R	MALIBU CREEK BELOW COLD CREEK	107 / F-6		YES	104.96
F168-R	BIG TUJUNGA CREEK BELOW BIG TUJUNGA DAM	M / C-2	333	YES	82.30
F181-R	MONTEBELLO STORM DRAIN OUTLET TO RIO HONDO	54 / E-3		NO	9.60
F190-R	SAN GABRIEL RIVER AT FOOTHILL BLVD.	86 / A-5		YES	230.00
F192B-R	RIO HONDO BELOW LOWER AZUSA ROAD	38 / E-4		YES	40.90
F193B-R	SANTA ANITA WASH AT LONGDEN AVENUE	38 / F-1		YES	18.80
F194B-R	SAWPIT WASH BELOW LIVE OAK AVENUE	39 / A-2		YES	16.10
F209-R	SAN GABRIEL RIVER - W. FORK BELOW COGSWELL DAM	N / D-4	410	YES	41.00
F218-R	SAN DIMAS WASH BELOW PUDD. DIVERSION DAM	95A / C-5	424	YES	19.90
F220B-R	SAN GABRIEL - AZUSA CONDUIT 10FT WEIR BELOW DAM	P / A-5		YES	0.00
F250-R	SAN GABRIEL - AZUSA CONDUIT 25FT WEIR BELOW DAM	P / A-5		YES	202.70
F251-R	SAN GABRIEL W. FORK AT TOE OF COGSWELL DAM	N / D-4		YES	39.20
F252-R	VERDUGO WASH AT ESTELLE AVENUE	25 / B-3		YES	26.80
F260C-R	SANTA ANITA WASH BELOW FOOTHILL BLVD.	28 / E-3		YES	17.20
F261C-R	SAN GABRIEL RIVER BELOW VALLEY BLVD.	48 / A-2	351	YES	118.00
F262B-R	SAN GABRIEL RIVER ABOVE FLORENCE AVE.	60 / E-4		YES	215.80
F263C-R	SAN GABRIEL RIVER BELOW S.G. RIVER PKWY	55 / C-1		YES	206.30
F267WG	SIERRA MADRE WASH AT HIGHLAND OAKS AVENUE	28 / E-3		YES	3.80
F271-R	EATON WASH BELOW EATON WASH DAM	27 / F-1	342	YES	12.40
F274B-R	DALTON WASH AT MERCED AVENUE	48 / F-1		YES	35.95
F277-R	ARROYO SECO BELOW DEVIL'S GATE DAM	19 / D-5	336	YES	32.50
F278-R	SAWPIT CREEK BELOW SAWPIT DAM	29 / C-1	339	YES	3.30
F280-R	SANTA FE DIVERSION CHANNEL BELOW SANTA FE DAM	39 / D-2		YES	CONTROLLED
E285-R	BURBANK WESTERN STORM DRAIN AT RIVERSIDE DR.	24 / E-2		YES	25.00
F300-R	LOS ANGELES RIVER AT TUJUNGA AVE.	23 / D-4		YES	401.00

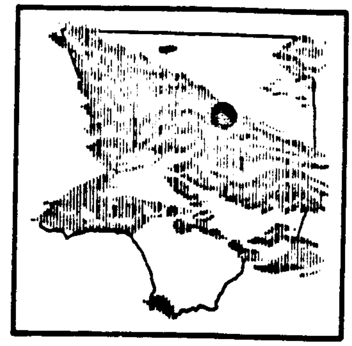
INDEX OF STREAM GAGING STATIONS

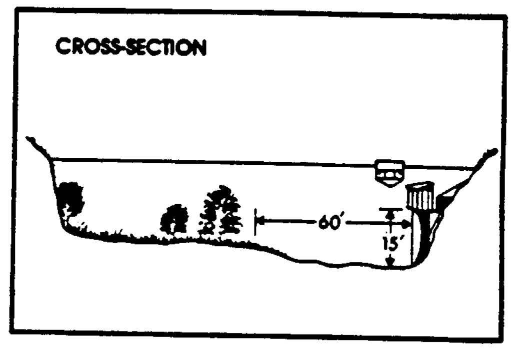
STATION	NAME	THOMAS GUIDE PG.	ALERT NO.	REGU-LATED	DRAINAGE AREA *
F303-R	SAN DIMAS CREEK BELOW SAN DIMAS DAM	95A / C-3	421	YES	16.20
F304-R	WALNUT CREEK ABOVE PUENTE AVENUE	48 / D-1		YES	57.60
F305-R	PACOIMA DIVERSION AT BRANFORD STREET	9 / A-5		YES	48.80
F312-R	SAN JOSE CHANNEL ABOVE WORKMAN MILL ROAD	47 / F-5	324	YES	83.40
F313B-R	RIO HONDO BYPASS CHANNEL ABOVE WHITTIER NAR	47 / B-5		YES	CONTROLLED
F317-R	ARCADIA WASH BELOW GRAND AVENUE	38 / E-3	355	YES	8.50
F318-R	EATON WASH AT LOFTUS DRIVE	34 / C-6		YES	22.80
F319-R	LOS ANGELES RIVER BELOW WARDLOW RIVER RD.	70 / B-5	313	YES	815.00
F328-R	MINT CANYON CREEK AT FITCH AVENUE	125 / C-5		NO	26.90
F329-R	BRADBURY CHANNEL BELOW CENTRAL AVENUE	29 / F-5		YES	3.30
F338-R	RUBIO DIV. CHANNEL BEL. GOOSEBERRY CYN INLET	20 / C-4		YES	2.10
F342-R	BRANFORD STREET CHANNEL BELOW SHARP AVE.	9 / B-5		YES	5.01
F354-R	COYOTE CREEK BELOW SPRING STREET	76 / F-1	437	YES	185.00
F356-R	LIVE OAK CREEK BELOW LIVE OAK DAM	95A / F-6	430	YES	2.28
F377-R	BOUQUET CANYON CREEK AT URBANDALE AVENUE	124 / F-5		YES	51.90
F378WG	DOMINGUEZ CHANNEL BELOW WESTERN AVENUE	63 / F-5		NO	37.10
F393-R	LITTLE ROCK AT HIGHWAY 138	184 / D-6		YES	70.00
F394-R	BIG ROCK CREEK UPSTREAM FROM PALLETT CREEK	192 / J-4		NO	34.30
F395-R	MESCAL CREEK AT MOUTH	J		NO	5.71
G44B-R	SAN GABRIEL RIVER ABOVE WHITTIER NAR. DAM	47 / C-6		NO	

* NOTE: All drainage areas in square miles.

LITTLE ROCK CREEK
above Little Rock Dam
STATION NO. L1-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 49.2 square miles.
LOCATION- 2.0 miles above Little Rock Dam, 5.0 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel, and boulders, natural in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1930 to date.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : L1–R

DRAINAGE AREA : 49.20 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.0	0.0	2.4	12.3	51.9			27.0	8.9	4.6	1.2	0.3
MAX.	0.0	0.0	16.5	66.1	109.0	NO	RECORDS	58.5	13.6	8.0	1.6	0.6
MIN.	0.0	0.0	0.0	5.9	9.5			10.1	5.9	1.4	0.7	0.0
TOTAL AF	0.0	0.0	145.0	757.0	2,987.0			1,662.0	532.0	281.0	73.4	17.5

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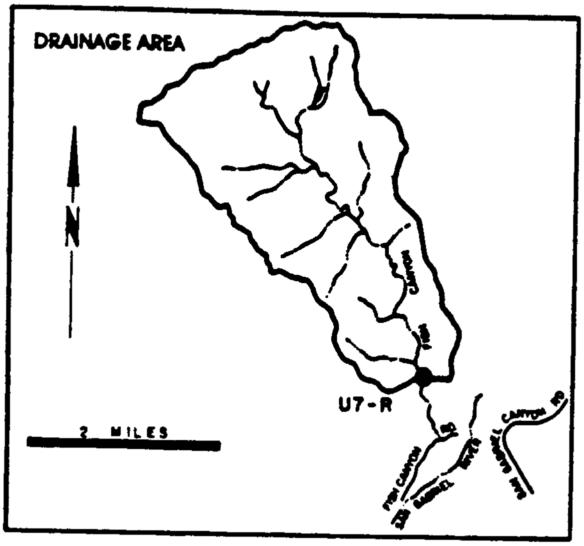
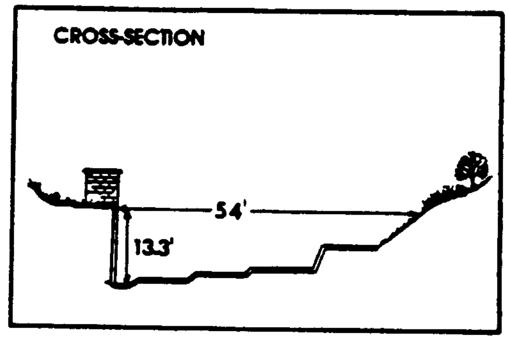
FISH CREEK
above Mouth of Canyon
STATION NO. U7-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 6.36 square miles.
LOCATION - 0.8 miles upstream at mouth of canyon and 3.0 miles northeast of Duarte.
REGULATION- none.
CHANNEL- natural, rock and gravel.
CONTROL- concrete control.
LENGTH OF RECORD- July to September 1916. July 1917 to date.
REMARKS- operated and maintained by USGS until October 1, 1971.

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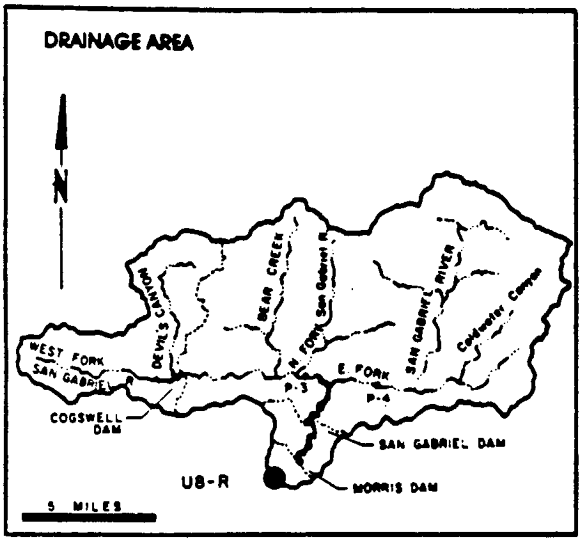
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

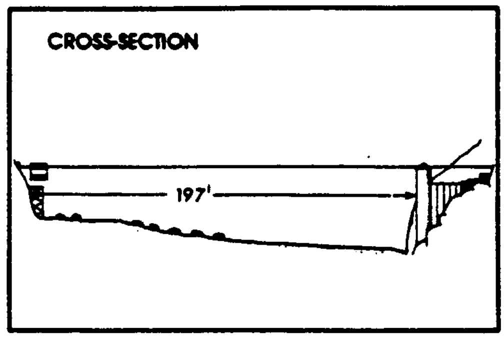
STATION NO. : U7–R DRAINAGE AREA : 6.36 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.1	0.1	5.0	7.2	32.6	52.7	13.6	8.4	2.4	1.1	0.8	0.4
MAX.	0.6	0.3	20.7	31.9	238.0	318.0	20.5	12.0	5.6	1.3	1.0	0.6
MIN.	0.0	0.0	0.4	2.0	0.7	12.6	12.0	5.0	1.6	0.8	0.6	0.3
TOTAL AF	3.8	3.4	305.0	444.0	1,874.0	3,241.0	808.0	515.0	144.0	66.4	51.8	24.4

R0053416

SAN GABRIEL RIVER
below Morris Dam
STATION NO.U8-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 212.4 square miles.
LOCATION- 1.1 miles downstream of Morris Dam, 2.7 miles northeast of Azusa.
REGULATION- all flows regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- gravel and boulders, natural section.
CONTROL- concrete control.
LENGTH OF RECORD- May 1894 to date.
REMARKS- flows up to 90 cfs are at times diverted past the station through the Azusa Conduit; flows at station may include imported water from the MWD outlet below Morris Dam.

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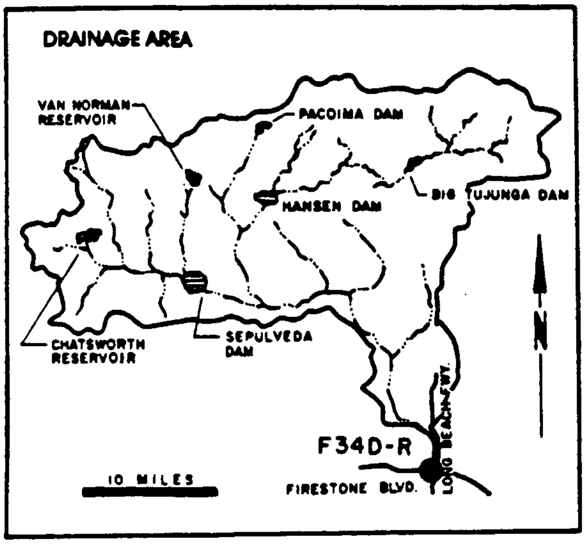
2 0112

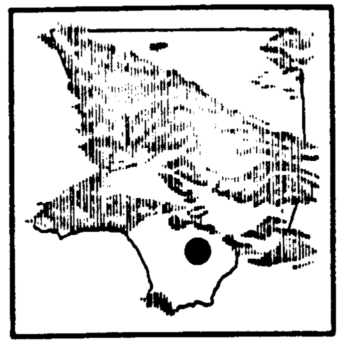
WATER YEAR 1991–1992
(DISCHARGE IN CFS)

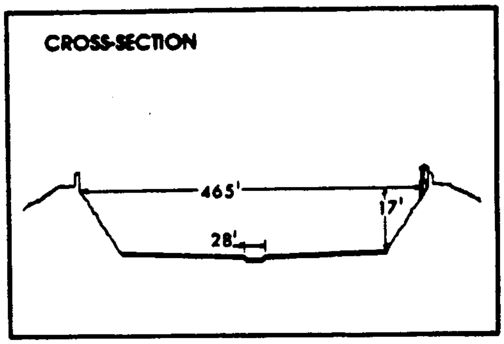
STATION NO. : U8–R DRAINAGE AREA : 212.40 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	61.6	4.9	3.9	219.0	354.0	332.0	407.0	326.0	372.0	258.0	9.0	138.0
MAX.	216.0	33.7	6.4	1,550.0	1,740.0	650.0	685.0	447.0	434.0	443.0	10.9	313.0
MIN.	1.2	1.6	2.3	0.8	4.6	21.9	342.0	140.0	209.0	10.9	7.0	9.1
TOTAL AF	3,788.0	289.0	241.0	13,461.0	20,340.0	20,409.0	24,224.0	20,045.0	22,134.0	15,835.0	552.0	8,190.0

LOS ANGELES RIVER
below Firestone Boulevard
STATION NO. F34D-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 596.0 square miles.
LOCATION- 472.0 feet downstream of Firestone Boulevard 3.0 miles west of Downey.
REGULATION- partially regulated by Sepulveda, Pacoima, Big Tujunga, Hansen, and Devil's Gate Dam; and by several spreading grounds, reservoirs, and debris basins.
CHANNEL- concrete, with rip-rap side slopes, trapezoidal in section, with trapezoidal low- flow channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F34-R March 1, 1928 to April 11, 1938. at Station F34B-R, April 11, 1938 to November 3, 1949. at Station F34C-R November 4, 1949, to December 11, 1956. at Station F34D-R December 11, 1956 to date.
REMARKS- subject to diversions from Big Tujunga Creek, Arroyo Seco, and other domestic and irrigation diversions.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

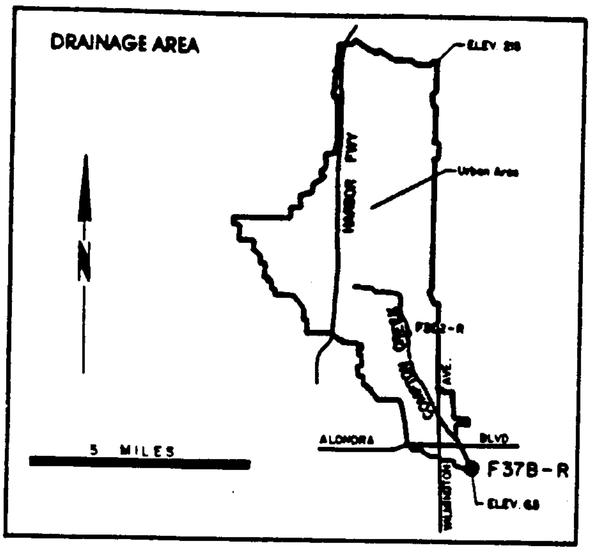
STATION NO. : F34D – R   DRAINAGE AREA : 596.00 SQ. MI.

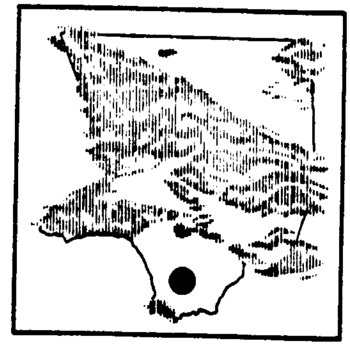
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	133.0	125.0	453.0	371.0	2,276.0	999.0	218.0	159.0	130.0	145.0	130.0	121.0
MAX.	377.0	144.0	7,040.0	5,020.0	16,500.0	5,280.0	1,120.0	200.0	136.0	208.0	139.0	124.0
MIN.	103.0	114.0	108.0	104.0	101.0	132.0	145.0	136.0	121.0	113.0	124.0	119.0
TOTAL AF	8,160.0	7,430.0	27,850.0	22,820.0	130,900.0	61,410.0	12,940.0	9,790.0	7,720.0	8,890.0	8,020.0	7,200.0

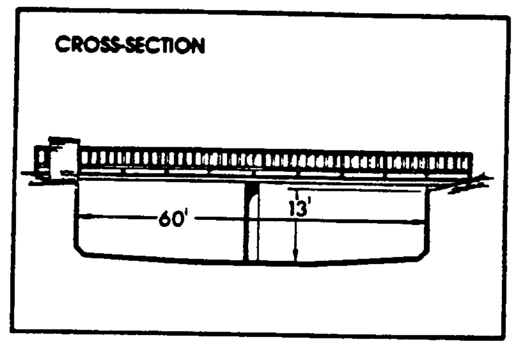
VOL 12

20113

COMPTON CREEK
near Greenleaf Drive
STATION NO. F37B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 22.6 square miles.
LOCATION- 120.0 feet above Greenleaf Boulevard, 1.5 miles south west of Compton.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 60 feet wide by 13 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F37-R January 22, 1928 to June 9, 1938. at Station F37B-R October 3, 1938 to date

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F37B – R   DRAINAGE AREA : 22.60 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	3.2	1.1	31.2	20.1	61.6	55.8	6.5	1.9	0.6	1.1	2.1	1.3
MAX.	19.3	4.1	510.0	339.0	493.0	403.0	114.0	6.6	0.9	1.5	5.6	4.3
MIN.	0.8	0.8	0.6	0.9	0.9	0.1	0.9	0.9	0.8	0.6	0.5	0.6
TOTAL AF	199.0	67.8	1 921.0	1 239.0	3 541.0	3 433.0	388.0	118.0	48.0	67.6	130.0	75.2

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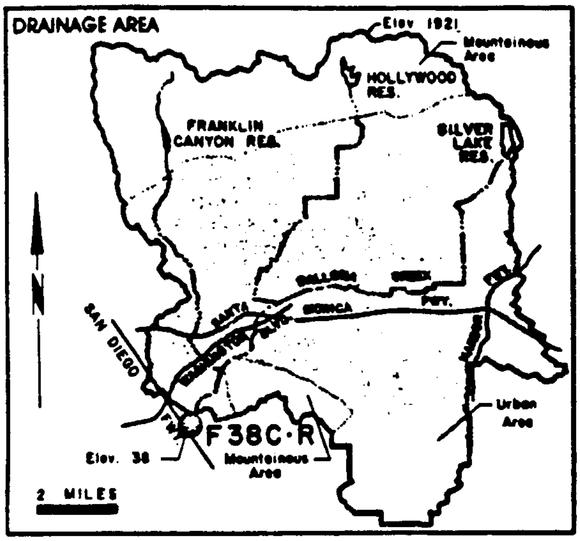
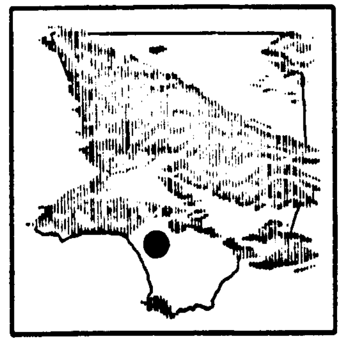
2 0114

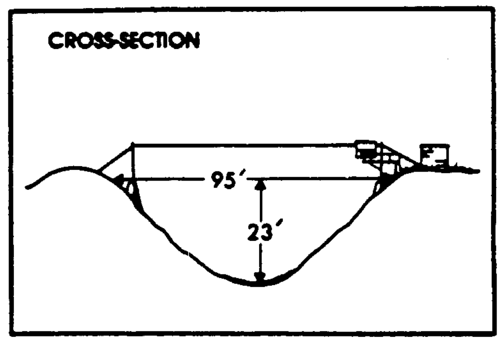
R0053419

BALLONA CREEK
above Sawtelle Boulevard
STATION NO. F38C-R

VOL 12







RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 88.6 square miles.

LOCATION- 530.0 feet above Sawtelle Boulevard, 1.5 miles southwest of Culver City.

REGULATION- Stone Canyon Reservoir prior to January, 1951. Upper and Lower Franklin Canyon Reservoir, Hollywood Reservoir, and Silverlake Reservoir.

CHANNEL- concrete rubble, trapezoidal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F38-R February 27,1928 to April 27, 1936. at Station F38B-R, May 14, 1936 to August 10, 1967. at Station F38C-R August 10, 1967, to date.

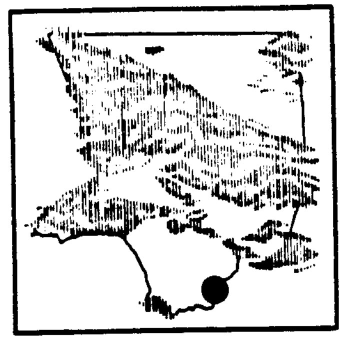
2 0 1 1 5

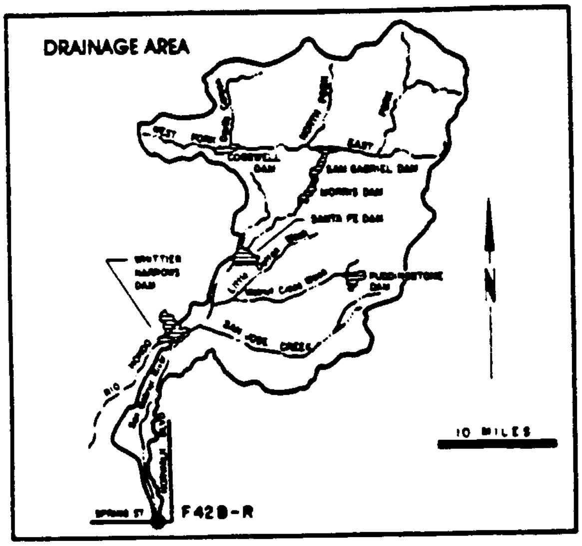
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

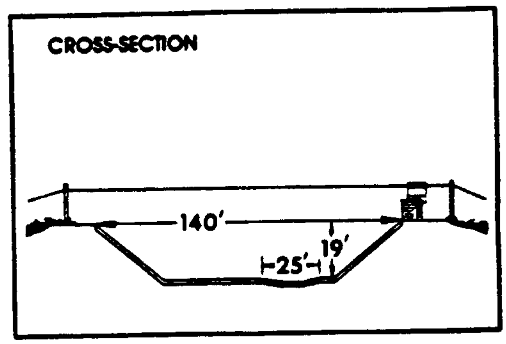
STATION NO. : F38C–R — DRAINAGE AREA : 88.60 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	17.3	9.5	119.0	92.8	309.0	125.0	22.8	12.5	13.7	12.7	11.2	12.2
MAX.	253.0	13.5	1,600.0	1,240.0	2,490.0	1,560.0	298.0	13.0	51.3	54.7	12.4	16.6
MIN.	7.0	8.2	12.4	8.2	7.6	8.7	10.6	11.4	11.1	8.7	10.9	9.9
TOTAL AF	1,067.0	567.0	7 309 0	5 705 0	17,750 0	7,655 0	1,358 0	768 0	817.0	778 0	690 0	727.0

SAN GABRIEL RIVER
above Spring Street
STATION NO. F42B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 231.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 455.0 feet north of Spring Street, 4.0 miles east of Signal Hill, Long Beach.
REGULATION- partially regulated by Cogswell, San Grabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek, and Whittier Narrows Dams, several debris basins, MWD outlet, and several spreading grounds.
CHANNEL- concrete, trapizoidal section with a low-flow channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F42-R February 6, 1928 to May 26, 1964. at Station F42B-R, November 16, 1964 to date.
REMARKS- high flows into Whittier Narrows Reservoir are partially diverted to the Rio Hondo.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F42B – R

DRAINAGE AREA : 231.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	60.6	71.5	129.0	119.0	278.0	203.0	134.0	60.2	76.3	60.9	48.9	49.7
MAX.	123.0	137.0	288.0	318.0	2,000.0	528.0	154.0	138.0	140.0	139.0	115.0	137.0
MIN.	33.4	30.2	107.0	42.2	40.8	109.0	72.9	32.8	31.7	33.5	30.4	28.4
TOTAL AF	3 724 0	4 254 0	7,926 0	7,337.0	15,979 0	12 498 0	7,969 0	3 702 0	4 542 0	3,747.0	3,009 0	2 960.0

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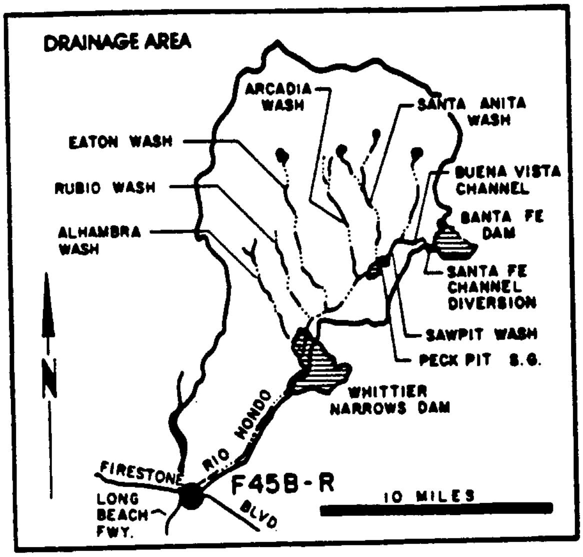
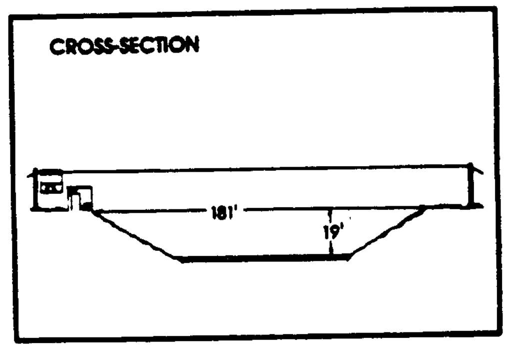
RIO HONDO
above Stewart and Gray Road
STATION NO. F45B-R





RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 140 square miles (excludes area above Santa Fe Dam).

LOCATION- 0.6 mile upstream of the confluence of Rio Hondo and Los Angeles River, 1.5 miles west of Downey.

REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, Santa Fe, and Whittier Narrows Dams, several debris basins, and spreading grounds.

CHANNEL- concrete with rip-rap side slopes. trapizodal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F45-R March 1, 1928 to April 18, 1951. at Station F45B-R October 31, 1951 to date.

REMARKS- subject to diversions from Eaton Creek, Monrovia Creek, Sawpit Creek, Little Santa Anita Canyon and other locations for irrigation and spreading. High flows from San Gabriel River may flow into Rio Hondo above Whittier Narrows Dam.

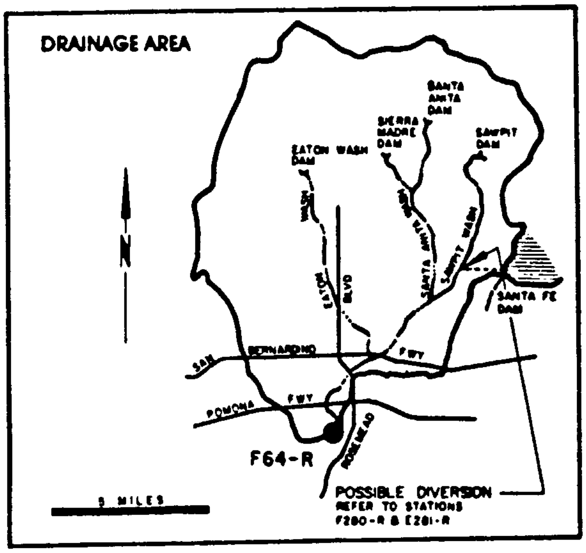
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

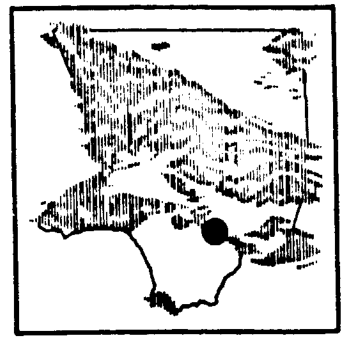
STATION NO. : F45B – R

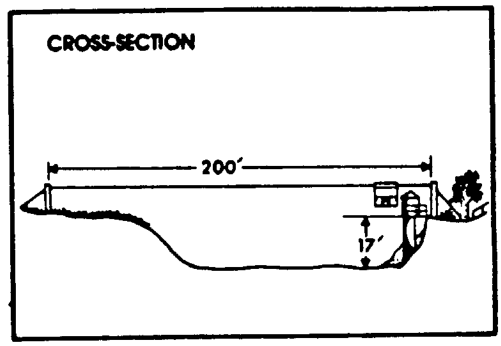
DRAINAGE AREA : 140.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.5	0.2	61.3	50.3	459.0	116.0	7.7	0.7	0.6	0.7	0.4	0.7
MAX.	32.2	0.5	1,260.0	1,470.0	6,930.0	1,830.0	26.4	1.3	1.2	7.2	1.7	1.4
MIN.	0.1	0.1	0.1	0.1	0.1	0.3	0.6	0.3	0.2	0.1	0.1	0.4
TOTAL AF	91.0	12.3	3 768 0	3 094 0	26 416 0	7 140 0	458 0	42 6	34 5	43 4	22 2	43 0

RIO HONDO
above Mission Bridge
STATION NO. F64-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 115 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,000 feet above San Gabriel Boulevard, west of Rosemead Boulevard, 2.0 miles northeast of Montebello.
REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, and Santa Fe Dams and several debris basins.
CHANNEL- sand and silt, natural in section.
CONTROL- none.
LENGTH OF RECORD- July 1, 1928 to date.
REMARKS- subject to diversions; water purchased from the MWD passes this station for spreading in the coastal basin.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F64–R — DRAINAGE AREA : 115.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	85.1	96.0	71.5	272.0	840.0	1386.0	57.7	100.0	165.0	165.0	47.6	32.7
MAX.	*	102.0	157.0	*	*	*	1220.0	197.0	256.0	343.0	70.7	53.2
MIN.	20.6	87.8	0.0	0.1	15.9	16.8	2.2	30.6	91.8	84.9	25.4	19.6
TOTAL AF	*	5711.0	*	*	*	*	3432.0	6146.0	9843.0	10150.0	2924.0	1943.0

LEGEND * – Data inaccurate due to back water condition.

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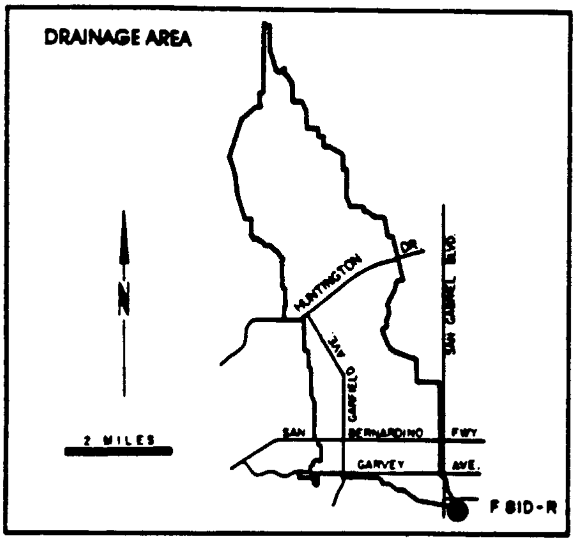
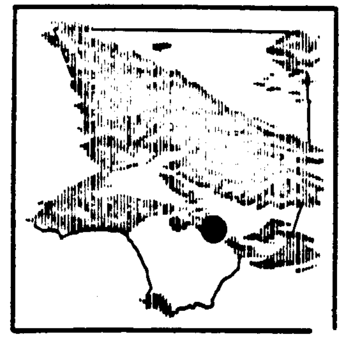
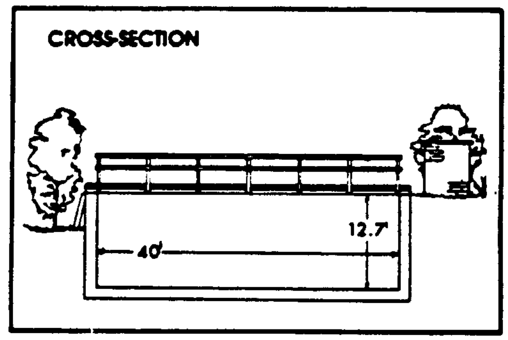
2 0118

R0053423

ALHAMBRA WASH
near Klingerman Street
STATION NO. F81D-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 15.2 square miles.
LOCATION- 250± feet above Klingerman Street and 2,650.0 feet below Garvey Avenue, South San Gabriel.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 40.0 feet wide by 12.7 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F81-R January 14, 1930 to September 30, 1934. at Station F81B-R October 1, 1934 to February 25, 1935. at Station F81C-R February 25, 1935 to April 27, 1936. at Station F81B-R April 27, 1936 to May 22, 1936. at Station F81D-R September 2, 1936 to date.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO.: F81D–R DRAINAGE AREA: 15.20 SQ. MI.

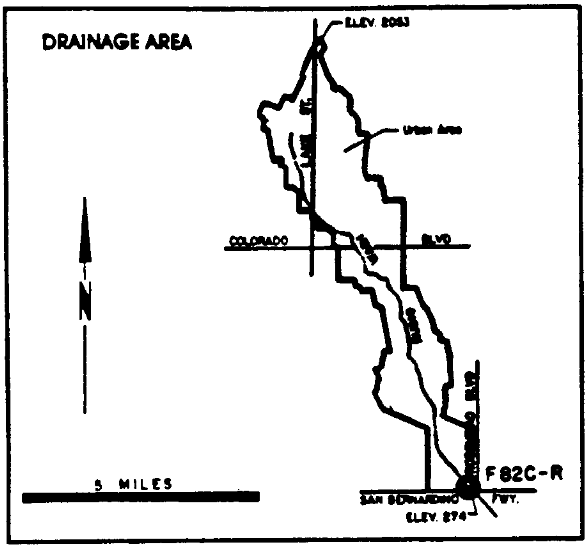
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	2.8	1.0	18.4	15.0	70.1	42.6	4.6	2.0	1.9	3.5	2.9	2.7
MAX.	54.5	1.5	381.0	284.0	570.0	291.0	84.6	2.5	2.2	29.0	3.7	3.2
MIN.	0.7	0.8	0.8	1.1	1.7	1.6	1.6	1.6	1.6	1.8	2.6	2.3
TOTAL AF	173 0	58 9	1,131.0	925 0	4 032 0	2 619 0	276 0	122 0	113.0	214 0	181 0	163.0

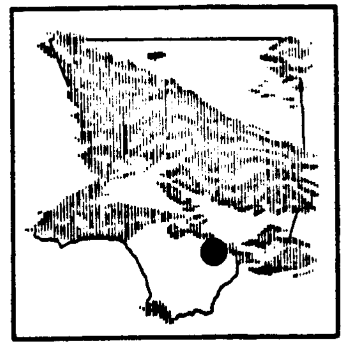
VOL 12

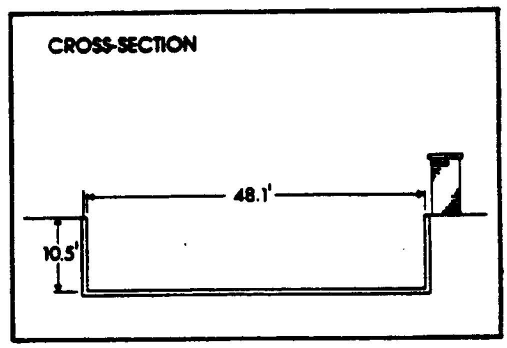
2 0119

R0053424

RUBIO WASH
at Glendon Wash
STATION NO. F82C-R







VOL 12

2 0120

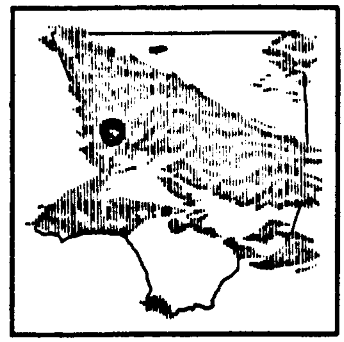
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge at station.
DRAINAGE AREA- 10.9 square miles.
LOCATION- on the east side of channel, 10 feet south of the westerly extension of Glendon Way, Rosemead.
REGULATION- flow partly regulated by Las Flores and Rubio debris basins.
CHANNEL- rectangular concrete.
CONTROL- channel forms control.
LENGTH OF RECORD- see station summary.

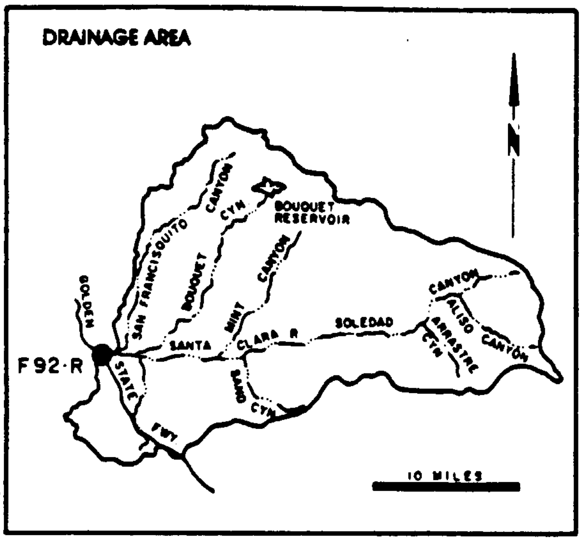
WATER YEAR 1991–1992
(DISCHARGE IN CFS)

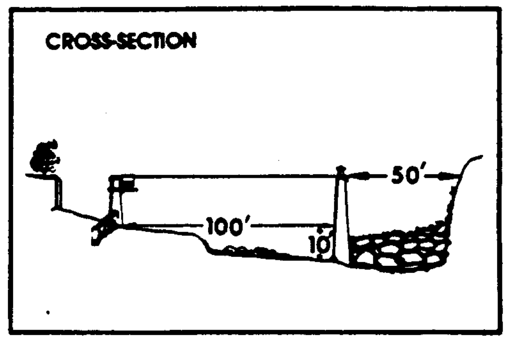
STATION NO.: F82C–R — DRAINAGE AREA: 10.90 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.1	0.3	6.2	4.4	35.0	19.8	1.5	0.0	0.0	0.8	0.1	0.1
MAX.	23.3	0.3	151.0	82.0	287.0	134.0	38.6	0.1	0.2	13.0	0.1	0.1
MIN.	0.2	0.3	0.0	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.1
TOTAL AF	68.6	17.9	383.0	272.0	2,011.0	1,215.0	89.7	1.6	0.6	46.2	3.2	6.0

SANTA CLARA RIVER
below Highway 5
STATION NO. F92C–R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 410.4 square miles.
LOCATION- downstream side of Old Highway bridge, 3.0 miles west of Saugus.
REGULATION- partially regulated by Bouquet Canyon and Dry Canyon Reservoirs.
CHANNEL- sand and gravel with brush, natural section.
CONTROL- none.
LENGTH OF RECORD- at Station F92-R January 18, 1930 to March 28, 1938, and September 24, 1956 to date. at Station F92B-R, October 1, 1938 to September 24, 1956.
REMARKS- subject to diversions for irrigation.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

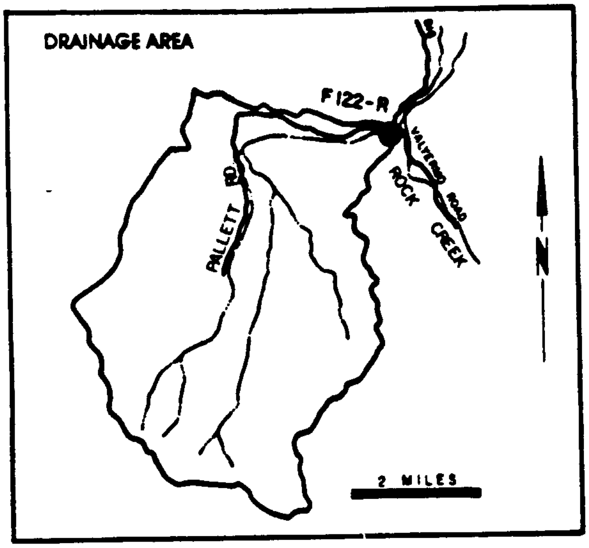
STATION NO. : F92C–R　　　　DRAINAGE AREA : 410.40 SQ. MI.

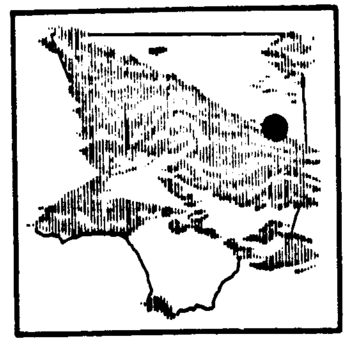
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	4.1	1.1										
MAX.	5.5	1.2		NO	RECORDS	DUE	TO	MISSING	RECORDER			
MIN.	2.4	1.0										
TOTAL AF	250.0	67.4										

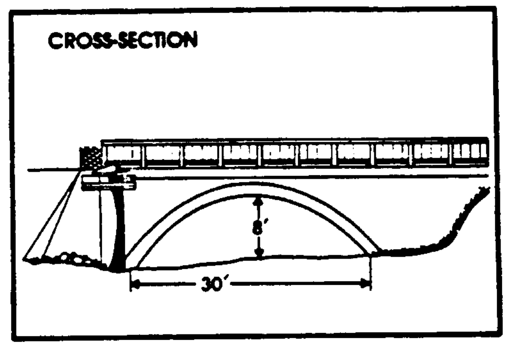
VOL 12
2 0121

R0053426

PALLETT CREEK
at Valyermo Highway
STATION NO. F122-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 15.8 square miles.
LOCATION- upstream side of Valyermo Highway bridge, 5.0 miles southeast of Pearblossom.
REGULATION- none.
CHANNEL- sand and gravel, natural section.
CONTROL- channel forms control for low flows; bridge culvert forms control for high flows.
LENGTH OF RECORD- at Station F122-S December 29, 1930 to October 31, 1961. at Station F122-R, October 31, 1961 to date.

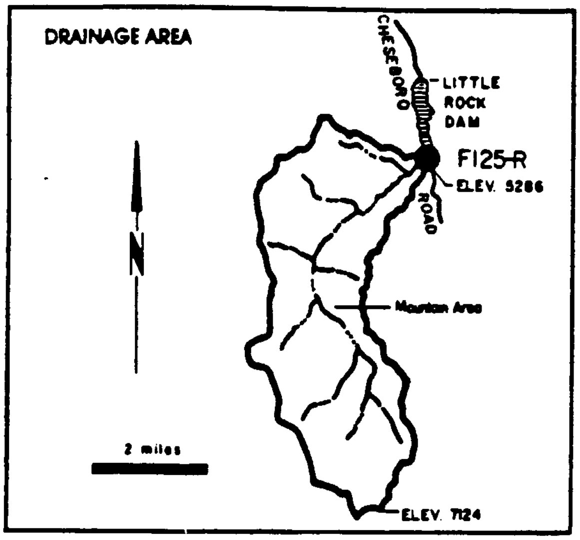
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

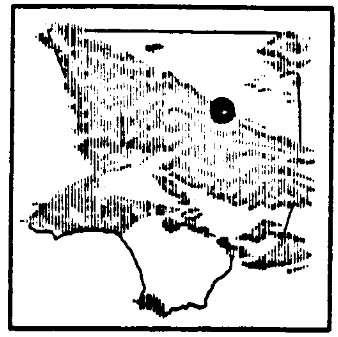
STATION NO. : F122–R DRAINAGE AREA : 15.80 SQ. MI.

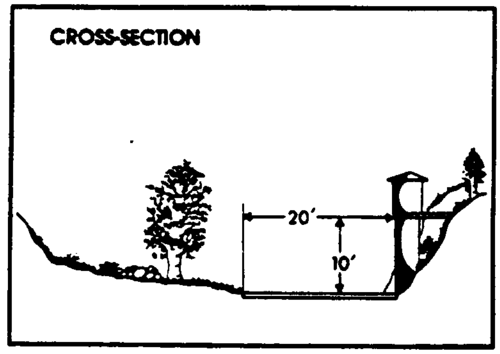
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.0	0.0	0.0	0.1	26.8	3.7	13.3	6.4	4.8	3.3	2.1	0.0
MAX.	0.0	0.0	0.0	0.4	240.0	27.0	23.7	12.8	6.1	5.4	3.1	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	0.1	2.7	3.3	3.5	1.9	1.2	0.0
TOTAL AF	0.0	0.0	0.0	5.5	1,540.0	226.0	792.0	392.0	285.0	203.0	130.0	0.0

VOL 12 2 0122

SANTIAGO CREEK
above Little Rock Creek
STATION NO. F125-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 11.2 square miles.
LOCATION- 1,000 feet above Little Creek and 4.5 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel and boulders.
CONTROL- concrete and rubble wall.
LENGTH OF RECORD- September 29, 1953 to date.
REMARKS- no high flow measurements.

VOL 12

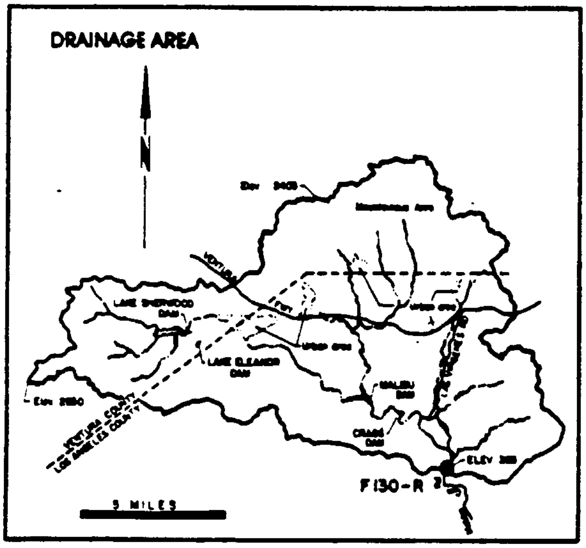
2 0123

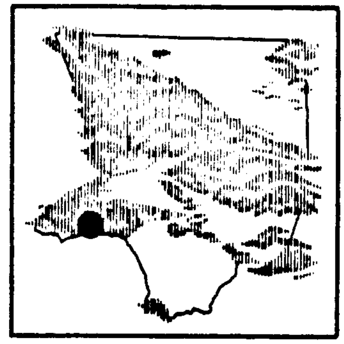
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

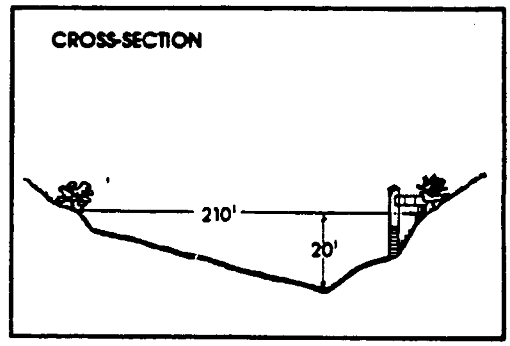
STATION NO. : F125 – R   DRAINAGE AREA : 11.20 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.0	0.0	0.0	0.0	6.0	2.7	1.3	0.6	0.0	0.0	0.0	0.0
MAX.	0.0	0.0	0.0	0.0	50.8	11.2	3.6	1.4	0.0	0.0	0.0	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.1	0.0	0.0	0.0	0.0
TOTAL AF	0.0	0.0	0.0	0.0	344.5	165.6	77.2	39.9	0.0	0.0	0.0	0.0

MALIBU CREEK
below Cold Creek
STATION NO. F130B-R







RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 104.96 square miles

LOCATION- 0.2± mile downstream of Cold Creek, 6.0 miles southwest of Calabasas.

REGULATION- Lake Sherwood Dam, Lake Eleanor Dam, Malibu Lake Dam, and Crag's Dam. Other small recreational dams affect low summer flows.

CHANNEL- coarse sand and gravel, lined with trees and brush, natural in section.

CONTROL- concrete stabilizer.

LENGTH OF RECORD- January 17, 1931 to date.

REMARKS- cableway washed out on January 25, 1969, no high flow measurements since that date.

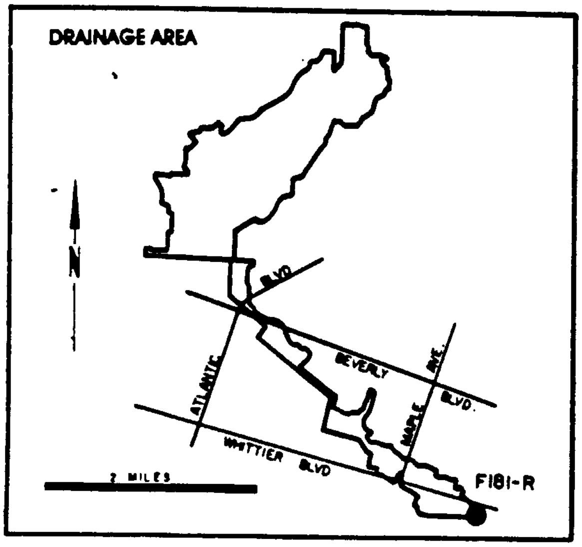
WATER YEAR 1991-1992
(DISCHARGE IN CFS)

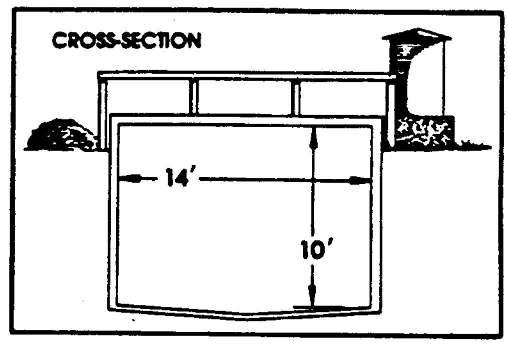
STATION NO. : F130B-R DRAINAGE AREA : 104.96 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	2.5	3.3	36.8	46.9	669.0	252.0	58.7	25.9	29.2	8.5	3.1	5.5
MAX.	3.8	4.2	616.0	395.0	5,850.0	1,060.0	112.0	33.9	52.0	18.7	3.8	16.3
MIN.	2.0	2.5	4.0	13.0	14.8	33.5	33.9	22.0	15.5	4.7	3.1	4.0
TOTAL AF	156.0	197.0	2,263.0	2,885.0	38,490.0	15,474.0	3,495.0	1,592.0	1,737.0	523.0	193.0	325.0

VOL 12 2 0124

MONTEBELLO STORM DRAIN
above Rio Hondo
STATION NO. F181-R





VOL 12 2 0125

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 9.6 square miles.
LOCATION- 150.0 feet east of Mines Avenue and 500.0 feet west of Rio Hondo.
REGULATION- none.
CHANNEL- 14.0-foot by 10.0-foot concrete, box section.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1932 to date.
REMARKS- may be affected by backwater during flood flows.

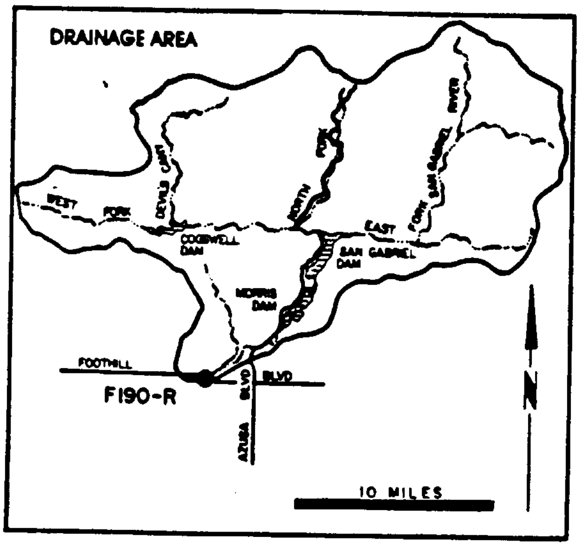
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

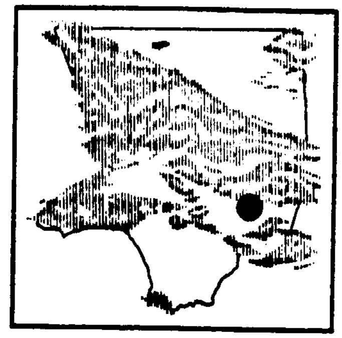
STATION NO. : F181 – R   DRAINAGE AREA : 9.60 SQ. MI.

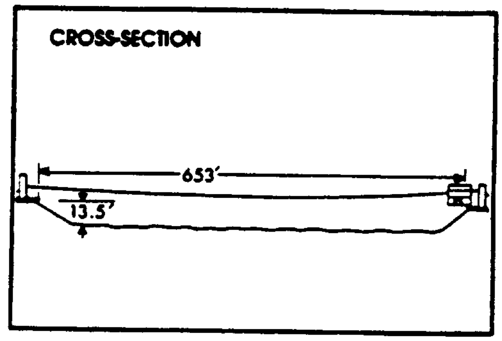
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.4	0.2	3.2	1.8	13.0	6.0	0.5	0.2	0.2	0.4	0.2	0.2
MAX	9.0	0.3	61.6	21.6	183.0	28.5	5.0	0.2	0.4	3.0	0.3	0.2
MIN.	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
TOTAL AF	27.6	9.9	197.0	112.0	750.0	367.0	27.0	12.3	12.7	24.2	12.9	11.9

SAN GABRIEL RIVER
at Foothill Boulevard
STATION NO. F190-R

VOL 12







2 0126

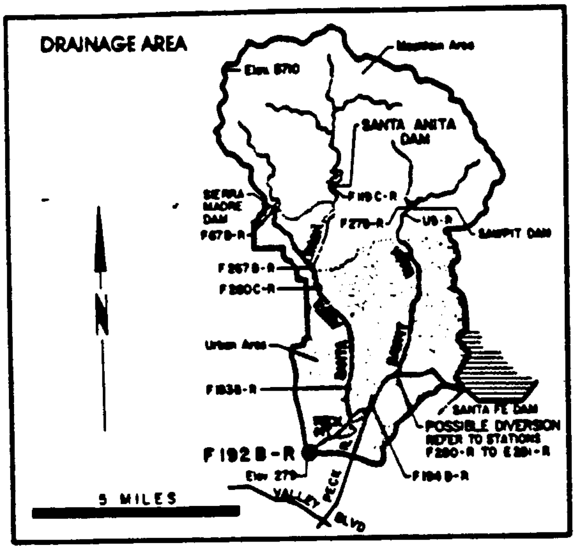
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 230.0 square miles.
LOCATION- downstream side of Foothill Boulevard bridge, 2.0 miles west of Azusa.
REGULATION- partially regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- sand, gravel and rock,trapezoidal section with soft bottom.
CONTROL- gunited rock stabilizers.
LENGTH OF RECORD- February 22, 1932 to date.
REMARKS- flows may include imported water originating at the Metropolitan Water District outlet below Morris Dam.

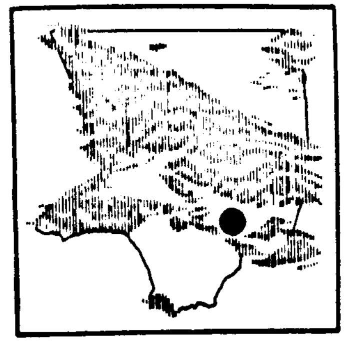
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

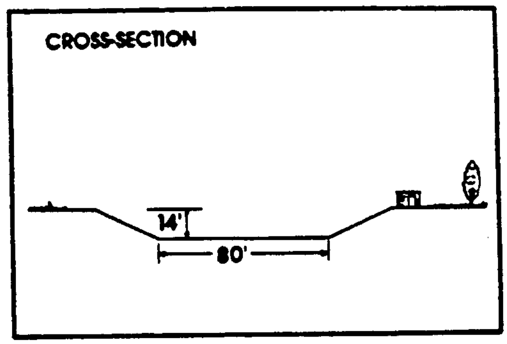
STATION NO. : F190-R   DRAINAGE AREA : 230.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	49.8	0.5	0.2	195.0	384.0	371.0	394.0	318.0	354.0	238.0	0.1	103.0
MAX.	235.0	12.8	6.7	1,330.0	1,580.0	774.0	792.0	475.0	415.0	442.0	2.8	233.0
MIN.	0.0	0.0	0.0	0.0	0.0	64.0	361.0	108.0	195.0	3.8	0.0	0.0
TOTAL AF	3 060 0	29 8	15.3	11,998 0	22 085 0	22 814 0	23 437.0	19 583 0	21 062 0	14,628 0	6.0	6,147.0

RIO HONDO
below Lower Azusa Road
STATION NO. F192B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 40.9 square miles (excludes area above Santa Fe Dam).
LOCATION- 300.0 feet downstream from Lower Azusa Road, 1.5 miles north of El Monte.
REGULATION- partially regulated by Sierra Madre Dam, Santa Anita Dam, Sawpit Dam, Santa Fe Dam, Peck Pit, Buena Vista Pit, and several debris basins.
CHANNEL- concrete, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F192-R February 22, 1932 to May 7, 1958. at Station F192B-R May 7, 1958 to date.
REMARKS- subject to diversions from Monrovia, Sawpit, and Little Santa Anita Creeks. Also from the San Gabriel River below Santa Fe Dam; and for irrigation and spreading.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

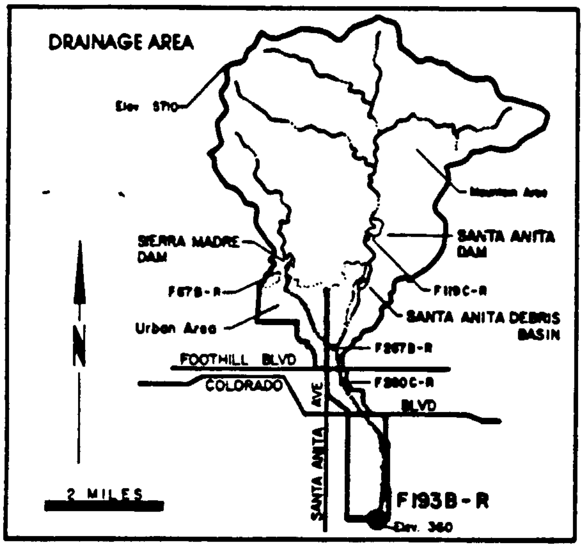
STATION NO. : F192B–R — DRAINAGE AREA : 40.90 SQ. MI.

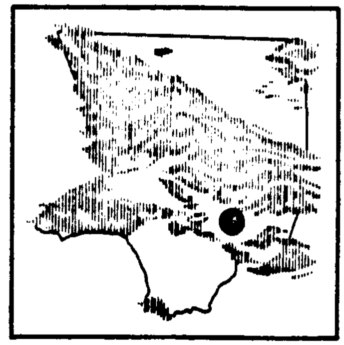
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.2	0.0	0.9	3.1	43.1	6.5	0.0	45.9	95.5	110.0	0.6	0.1
MAX.	4.5	0.2	18.2	16.2	809.0	56.9	1.1	114.0	170.0	180.0	8.2	0.2
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.3	19.5	0.0	0.0
TOTAL AF	9.9	0.4	54.9	194.0	2,481.0	402.0	2.2	2,823.0	5,682.0	6,742.0	33.9	3.4

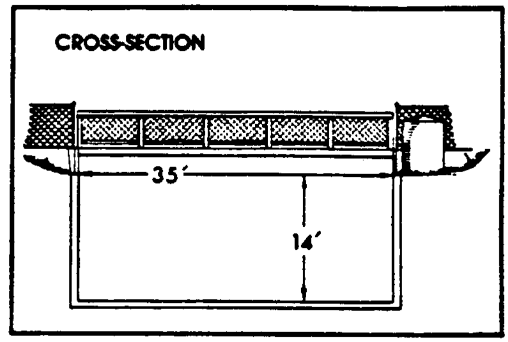
VOL 12

2 0127

SANTA ANITA WASH
at Longden Avenue
STATION NO. F193B-R







RECORDER - continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 18.8 square miles.
LOCATION - 30.0 feet above Longden Avenue, 1.5 miles south of Arcadia.
REGULATION - regulated by Santa Anita and Sierra Madre Dams, and Santa Anita Debris Basin.
CHANNEL - concrete rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F193-R, April 25, 1932 to March 1, 1938. at Station F193B-R, January 5, 1960 to date.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

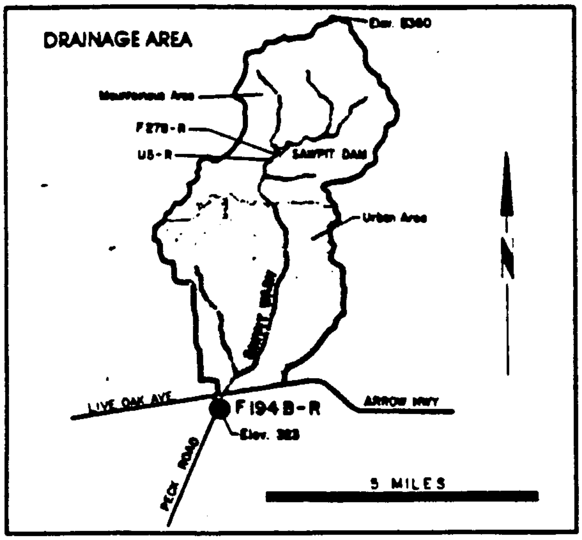
STATION NO. : F193B–R   DRAINAGE AREA : 18.80 SQ. MI.

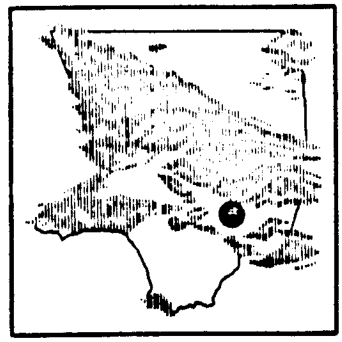
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.3	0.1	2.3	15.7	83.3	102.0	21.5	6.8	0.3	0.6	0.0	0.0
MAX.	9.9	0.4	44.4	426.0	498.0	238.0	78.5	13.2	0.3	12.3	0.1	0.0
MIN.	0.0	0.1	0.1	0.0	0.1	33.3	13.2	0.3	0.3	0.0	0.0	0.0
TOTAL AF	19.6	7.1	140.0	963.0	4,790.0	6,292.0	1,279.0	417.0	17.9	38.5	0.2	0.0

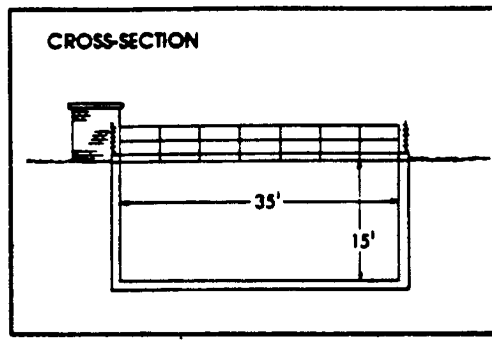
VOL 12

2 0128

SAWPIT WASH
below Live Oak Avenue
STATION NO. F194B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 16.1 square miles.
LOCATION- 1,500 feet below Arrow Highway, 3.0 miles south of Monrovia.
REGULATION- partially regulated by Sawpit and Santa Fe Dams, and by several debris basins.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F194-R February 22, 1932 to September 1, 1935 at Station F194B-R December 5, 1960 to date.

WATER YEAR 1991-1992
(DISCHARGE IN CFS)

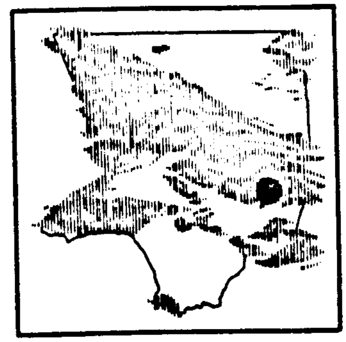
STATION NO.: F194B-R DRAINAGE AREA: 16.10 SQ. MI.

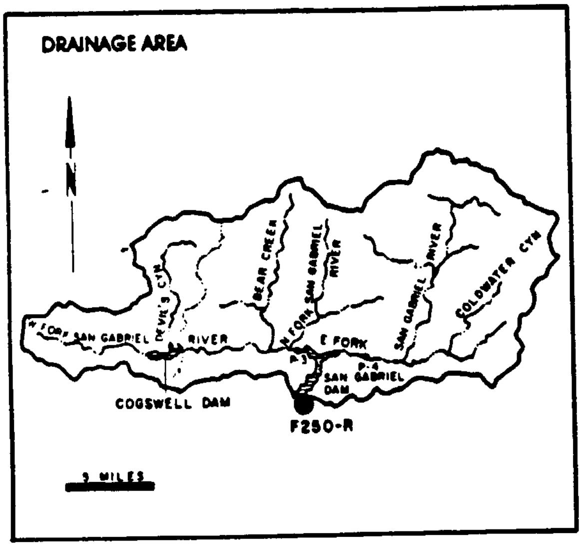
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	15.9	0.2	6.2	14.0	36.6	9.5	6.0	82.9	153.0	118.0	0.2	0.1
MAX.	57.4	0.2	119.0	77.1	259.0	93.1	38.3	179.0	325.0	180.0	0.6	0.1
MIN.	0.0	0.0	0.1	0.0	0.2	0.1	0.1	2.0	78.1	0.2	0.1	0.1
TOTAL AF	980.0	9.5	381.0	858.0	2,107.0	584.0	355.0	5,100.0	9,090.0	7,251.0	9.9	6.0

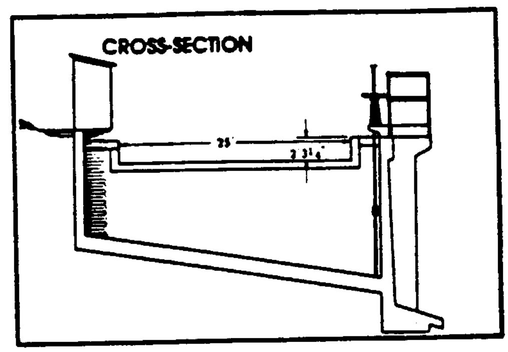
VOL 12
2 0129

R0053434

SAN GABRIEL-AZUSA CONDUIT
at 25 ft. Weir below San Gabriel Dam
STATION NO. F250-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- weir formula with gage height observation.
DRAINAGE AREA- none.
LOCATION- on the concrete conduit which diverts from San Gabriel Dam, 160 feet below the Dam.
REGULATION- regulated in section.
CONTROL- 25-foot concrete weir.
LENGTH OF RECORD- February 26, 1933, to date.
REMARKS- approximate capacity 95 second-feet.

VOL 12

2

0130

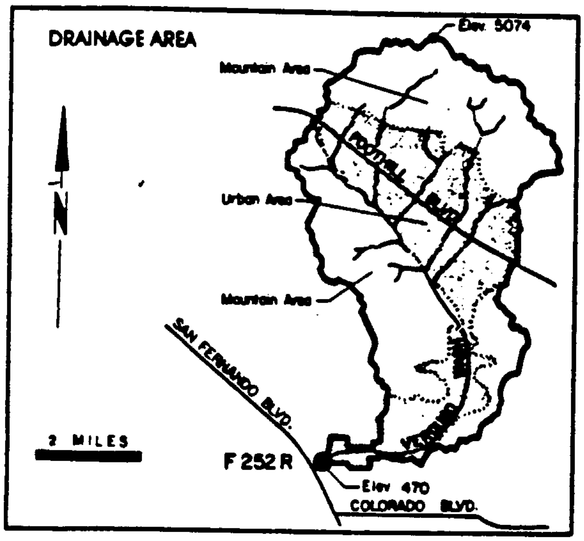
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

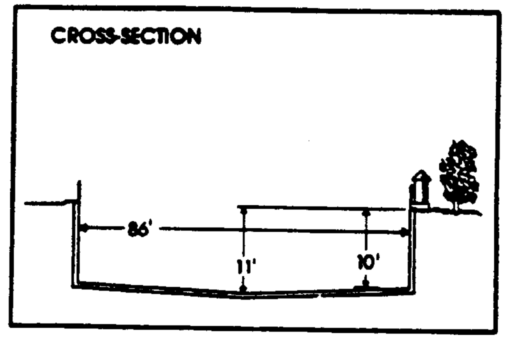
STATION NO. : F250–R

DRAINAGE AREA : NONE SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	72.8	77.9	39.7	39.2	43.0	53.8	63.9	77.2	77.2	75.6	3.9	0.0
MAX.	79.2	78.5	76.3	42.2	65.0	65.4	82.8	79.7	78.0	79.4	52.5	0.0
MIN.	47.7	76.0	31.1	38.1	12.6	0.7	21.6	75.2	76.2	52.2	0.0	0.0
TOTAL AF	4,474.0	4,634.0	2,441.0	2,411.0	2,471.0	3,309.0	3,801.0	4,747.0	4,591.0	4,648.0	237.0	0.0

VERDUGO WASH
at Estelle Avenue
STATION NO. F252-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from Concord Street Bridge.
DRAINAGE AREA- 26.8 square miles.
LOCATION- 800.0 feet east of San Fernando Road, 2.0 miles northwest of Glendale.
REGULATION- partially regulated by several debris basins.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- December 2, 1935 to date.

WATER YEAR 1991–1992
(DISCHARGE IN CFS)

STATION NO. : F252–R DRAINAGE AREA : 26.80 SQ. MI.

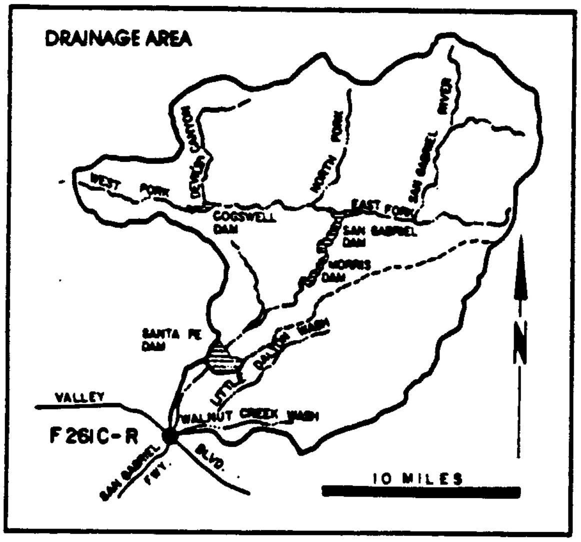
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	4.1	2.5	47.5	18.5	71.7	81.5	4.2	3.2	1.9	4.1	1.5	1.9
MAX.	43.9	3.9	314.0	316.0	636.0	405.0	18.6	7.2	2.8	69.2	2.8	[illegible]
MIN.	1.0	1.7	0.0	0.7	0.0	2.5	1.5	1.3	1.0	1.1	0.9	1.2
TOTAL AF	252.0	149.0	2,922.0	1,137.0	4,127.0	5,013.0	250.0	195.0	116.0	253.0	94.0	113.0

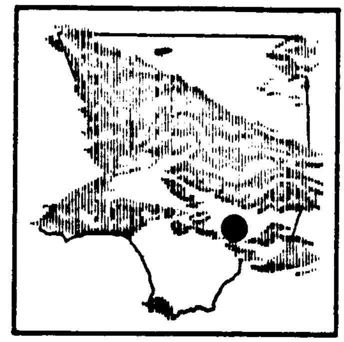
R0053436

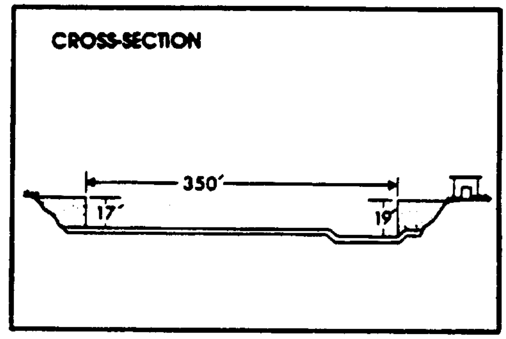
VOL 12

2 0131

SAN GABRIEL RIVER
below Valley Boulevard
STATION NO. F261C-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 118.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,150.0 feet below Valley Boulevard, 2.5 miles east of El Monte.
REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, and Puddingstone Dams.
CHANNEL- sand and gravel bottom with rip-rap side slopes; trapezoidal section.
CONTROL- concrete stabilizer with low-flow notch.
LENGTH OF RECORD- at Station F261-R March 11, 1937 to September 30, 1941. at Station F261B-R October 1, 1941 to April 23, 1946. at Station F261C-R November 29, 1960 to date.
REMARKS- flows may include imported water originating at Metropolitan Water District outlets at San Dimas Canyon and below San Bernardino Road.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F261C–R DRAINAGE AREA : 118.00 SQ. MI.

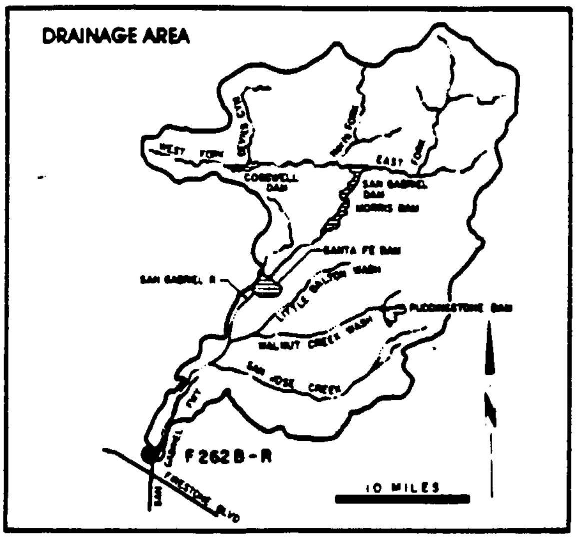
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	4.1	1.2	34.9	36.7	233.0	121.0	6.3	4.1	0.6	4.5	0.0	0.3
MAX.	113.0	11.0	796.0	691.0	2,150.0	572.0	35.6	75.4	7.4	33.8	0.1	3.1
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AF	251.0	69.0	2,148.0	2,256.0	13,374.0	7,413.0	374.0	254.0	49.4	278.0	0.4	16.9

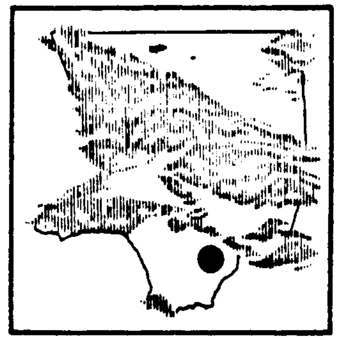
VOL 12

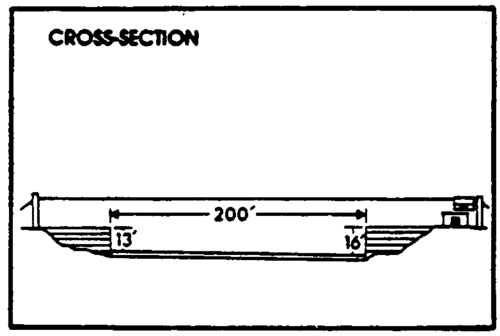
2 0132

R0053437

SAN GABRIEL RIVER
above Florence Avenue
STATION NO. F262C-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 215.8 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,400 feet above Florence Avenue, 2.0 miles east of Downey.
REGULATION- partially regulated by Cogswell, San Gabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek and Whittier Narrows Dams, several debris basins, MWD outlets, and several spreading grounds.
CHANNEL- sand bottom with rip-rap slopes, trapezoidal section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F267-R February 27, 1937 to September 30, 1967. at Station F262B-R August 6, 1968 to date.
REMARKS- no record during 1967-1968 season due to channel construction.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

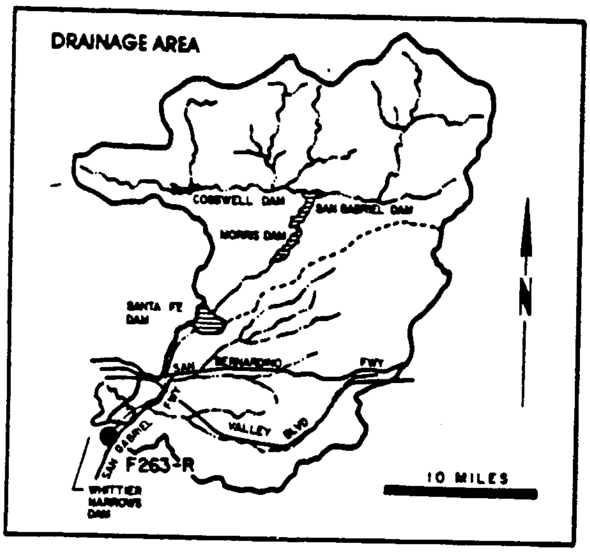
STATION NO. : F262C–R — DRAINAGE AREA : 215.8 SQ. MI.

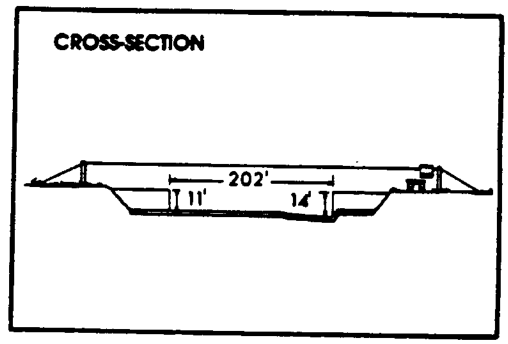
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.0	0.0	0.0	0.0	54.8	11.2	0.0	0.0	0.0	0.0	0.0	0.0
MAX.	0.0	0.0	0.0	0.1	673.0	126.0	0.0	0.0	0.0	0.0	0.0	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AF	0.0	0.0	0.0	0.3	3,150.0	692.0	0.0	0.0	0.0	0.0	0.0	0.0

VOL 12

2 0133

SAN GABRIEL RIVER
below San Gabriel River Parkway
STATION NO. F263C-R





RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 206.3 square miles (excludes area above Santa Fe Dam).

LOCATION- 462.0 feet below San Gabriel River Parkway, 1.4 miles northeast of Pico Rivera.

REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, Puddingstone, and Thompson Creek Dams. Flows may include imported water from several Metropolitan Water District outlets. Water is at times diverted to the Zone I ditch upstream of Whittier Narrows Dam.

CHANNEL- rip-rap slopes with sand bottom trapezoidal section.

CONTROL- concrete stabilizer.

LENGTH OF RECORD - at Station F263-R February 4, 1937 to March 6, 1952. at Station F263B-R March 6, 1952 to August 9, 1968. at Station F263C-R August 9, 1968 to date.

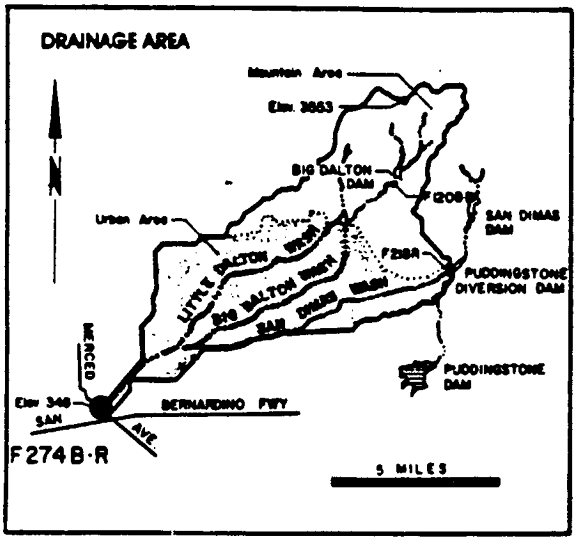
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

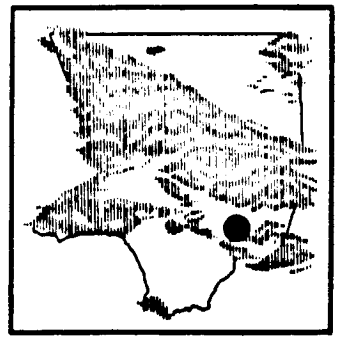
STATION NO. : F263C – R

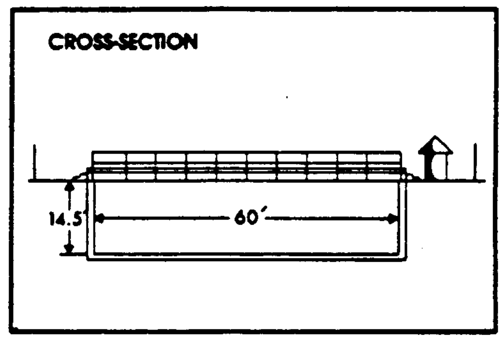
DRAINAGE AREA : 206.30 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	6.4	12.5	73.3	58.3	183.0	122.0	13.0	12.1	2.0	19.5	7.8	0.0
MAX.	116.0	83.8	330.0	441.0	1,320.0	481.0	97.6	49.8	2.1	66.6	71.6	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	0.0	0.0	0.0	0.0
TOTAL AF	392.0	745.0	4,506.0	3,587.0	10,551.0	7,477.0	775.0	741.0	11.3	1,197.0	478.0	0.0

DALTON WASH
at Merced Avenue
STATION NO. F274B-R







RECORDER- 15 minute punched tape.

METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge 100 feet upstream from station.

DRAINAGE AREA- 36.0 square miles, not including the area above Puddingstone Diversion Dam.

LOCATION- on the west bank and upstream of Merced Avenue about 150 feet, about one-half mile above the junction with Walnut Wash and about one mile south of Baldwin Park.

REGULATION- partly regulated by Big Dalton Dam, San Dimas Dam, Puddingstone Diversion Dam, Big Dalton Spreading Grounds, Little Dalton Spreading Grounds, Big Dalton Debris Basin, Little Dalton Debris Basin, and Irwindale Spreading Grounds.

REMARKS- flow may include imported water originating at San Dimas.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F274B – R | DRAINAGE AREA : 36.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	3.6	6.7	18.3	8.3	38.6	18.1	1.0	0.5	8.3	12.2	1.2	4.5
MAX.	80.2	38.0	427.0	190.0	529.0	128.0	3.9	3.9	36.7	32.9	6.8	14.7
MIN.	0.3	0.1	0.1	0.5	0.3	0.1	0.1	0.1	1.3	1.2	0.3	0.3
TOTAL AF	219.0	400.0	1,123.0	510.0	2,219.0	1,111.0	57.9	30.3	494.0	749.0	73.4	265.0

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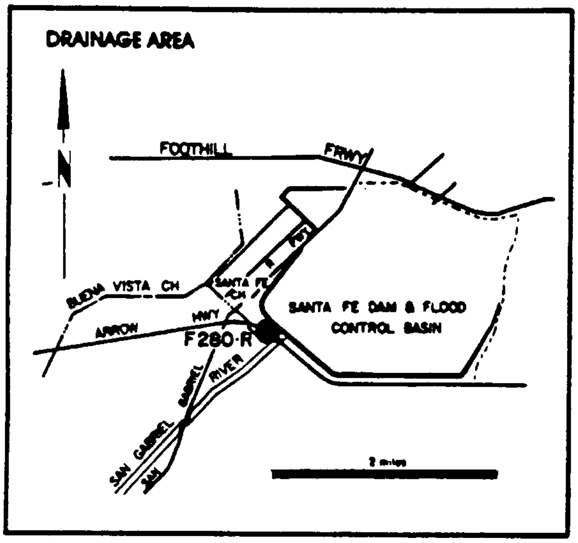
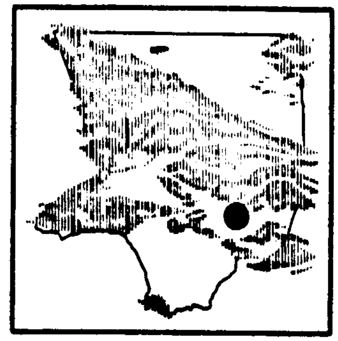
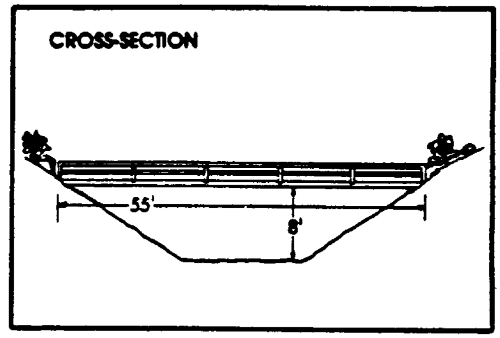
2 0135

SANTA FE CHANNEL
below Santa Fe Dam
STATION NO. F280-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- controlled.
LOCATION- 400.0 feet downstream of Santa Fe Dam outlet and 1.5 miles north of Baldwin Park.
REGULATION- flow regulated by five gates of stilling basin outlet of Santa Fe Dam.
CHANNEL- sand and gravel, natural section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F280-S October 1, 1942 to May 12, 1944. at Station F280-R May 12, 1944 to date.

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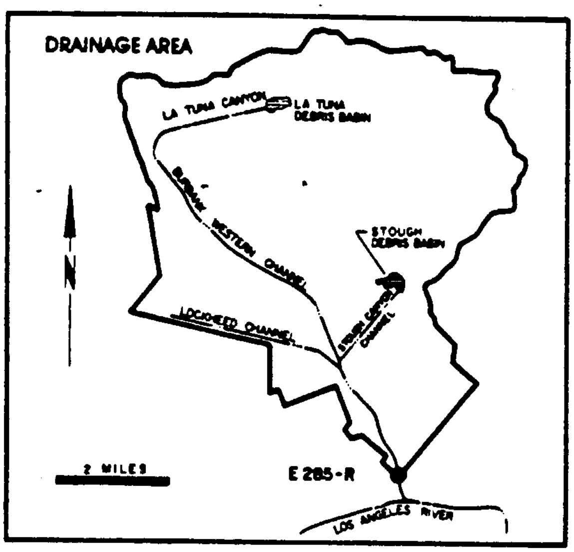
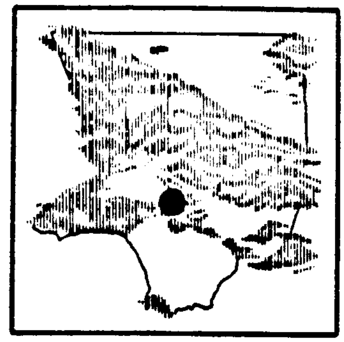
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

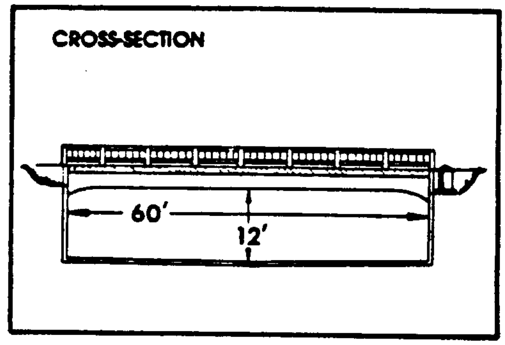
STATION NO. : F280–R DRAINAGE AREA : CONTROLLED

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	21.7	0.0	0.0	22.1	19.0	0.0	9.7	130.0	203.0	195.0	0.0	0.0
MAX.	75.2	0.0	0.2	118.0	276.0	0.0	84.2	271.0	428.0	305.0	0.0	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	88.9	0.1	0.0	0.0
TOTAL AF	1,333.0	0.0	0.4	1,360.0	1,095.0	0.0	577.0	7,988.0	12,056.0	11,996.0	0.0	0.0

BURBANK-WESTERN ST. DR.
at Riverside Drive
STATION NO. E 285-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading and from bridge.
DRAINAGE AREA- 25.0 square miles.
LOCATION- 20.0 feet upstream from Riverside Drive bridge, Glendale.
REGULATION- Several debris basins on tributaries.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1949 to date.
REMARKS- operated in cooperation with the USCE.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : E285–R DRAINAGE AREA : 25.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	13.0	11.6	41.0	56.1	185.0	72.7	13.9	7.4	5.5	7.9	7.8	11.6
MAX.	19.5	14.9	354.0	305.0	778.0	212.0	33.6	17.5	6.0	11.4	10.3	14.1
MIN.	9.6	6.6	9.0	12.8	6.9	6.7	4.1	3.0	4.6	4.6	6.2	7.2
TOTAL AF	802.0	688.0	2,522.0	3,449.0	10,616.0	4,470.0	829.0	453.0	324.0	487.0	479.0	693.0

VOL 12
2
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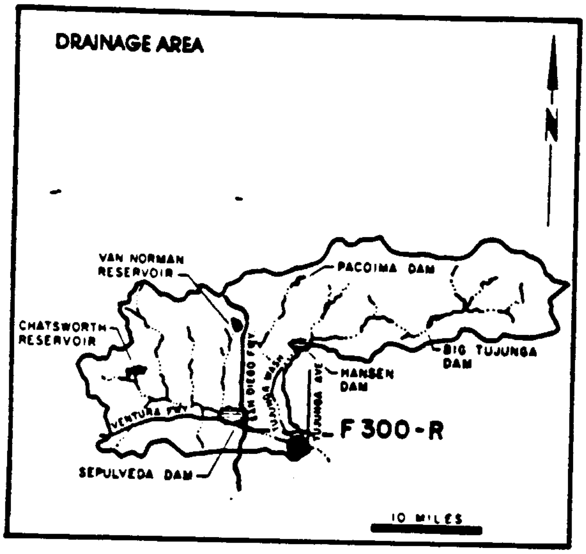
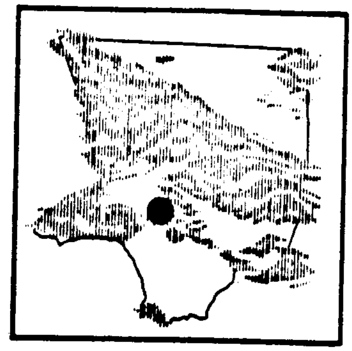
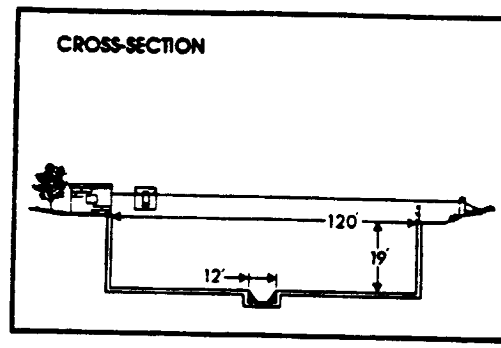
R0053442

LOS ANGELES RIVER
at Tujunga Avenue
STATION NO. F300-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 401.0 square miles.
LOCATION- 200.0 feet above Tujunga Avenue bridge, Studio City.
REGULATION- flow regulated by Sepulveda, Big Tujunga, Hansen, and Pacoima Dams, Lopez Debris Dam, and Project No. 85 Diversion.
CHANNEL- concrete, rectangular section, 120 feet wide by 19 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- May 8, 1950, to date.
REMARKS- subject to diversions at mouth of Big Tujunga and Pacoima Canyons for irrigation, at Big Tujunga, Branford, Hansen, and Pacoima Spreading Grounds.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

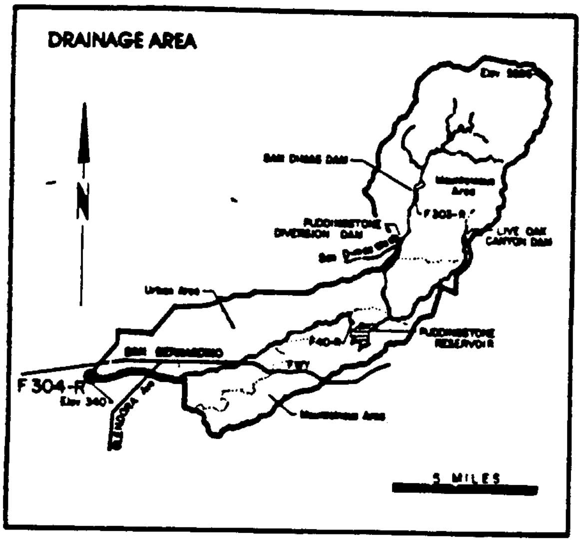
STATION NO. : F300-R DRAINAGE AREA : 401.00 SQ. MI.

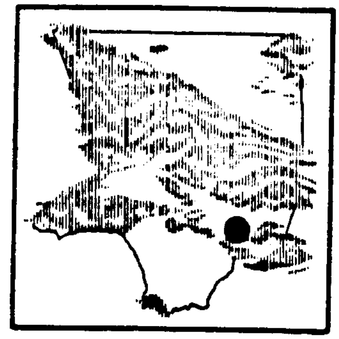
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	77.0	38.7	288.0	228.0	1,250.0	590.0	118.0	69.2	72.2	51.2	58.8	65.5
MAX.	543.0	42.3	4,440.0	2,070.0	10,800.0	2,690.0	337.0	86.1	132.0	74.1	69.1	77.8
MIN.	33.7	36.1	35.1	60.8	88.1	94.0	86.3	46.7	57.0	34.2	47.7	58.9
TOTAL AF	4,734.0	2,301.0	17,703.0	14,021.0	72,131.0	36,296.0	7,000.0	4,256.0	4,298.0	3,147.0	3,613.0	3,898.0

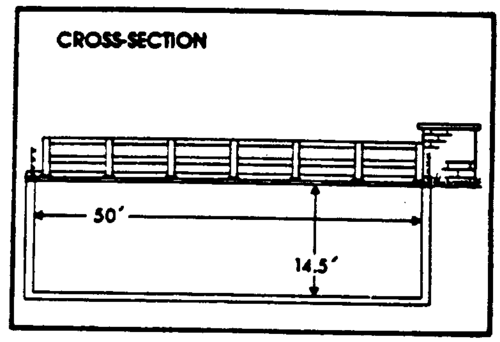
VOL 12
2
0138

R0053443

WALNUT CREEK
above Puente Avenue
STATION NO. F304-R







VOL 12

2 0139

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 57.6 square miles.
LOCATION- 845.0 feet upstream of Puente Avenue bridge, Baldwin Park.
REGULATION- partially regulated by San Dimas, Puddingstone Diversion, Puddingstone, and Live Oak Dams.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 14, 1952 to April 11, 1961, January 3, 1962 to date.
REMARKS- no record during April 11, 1961 to January 3, 1962 due to channel construction.

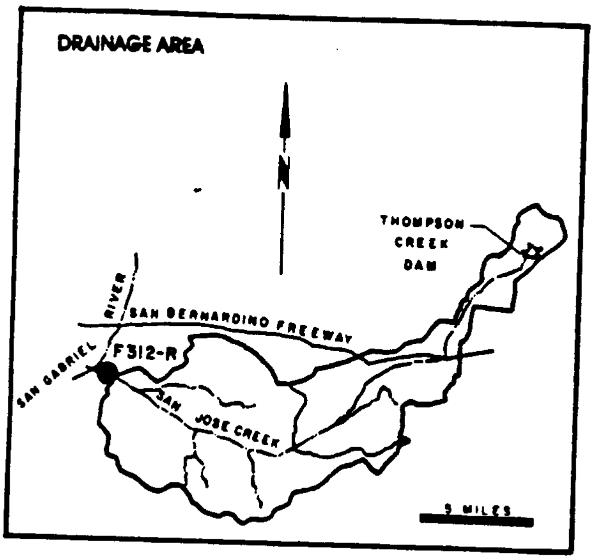
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

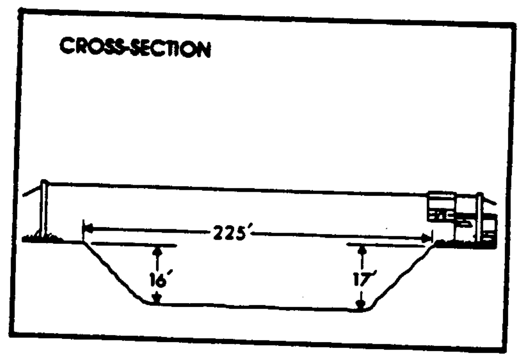
STATION NO. : F304–R DRAINAGE AREA : 57.60 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.5	0.6	20.1	19.8	103.0	190.0	0.0	0.2	0.3	1.6	0.7	0.2
MAX.	44.1	8.1	521.0	349.0	1,090.0	397.0	0.4	3.1	1.2	24.6	4.8	0.6
MIN.	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.1
TOTAL AF	90.2	32.7	1,237.0	1,218.0	5,913.0	11,704.0	2.8	14.3	15.5	97.6	43.8	14.1

R0053444

SAN JOSE CHANNEL
above Workman Mill Road
STATION NO. F312-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 83.4 square miles.
LOCATION- 1,650 feet above Workman Mill Road, 3.0 miles southeast of El Monte.
REGULATION- partially regulated by Thompson Creek Dam and Pomona Sewage Treatment Plant.
CHANNEL- grouted rip-rap side slopes with natural bottom, trapezoidal section.
CONTROL- rock stabilizer.
LENGTH OF RECORD- September 13, 1955 to date.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F312–R

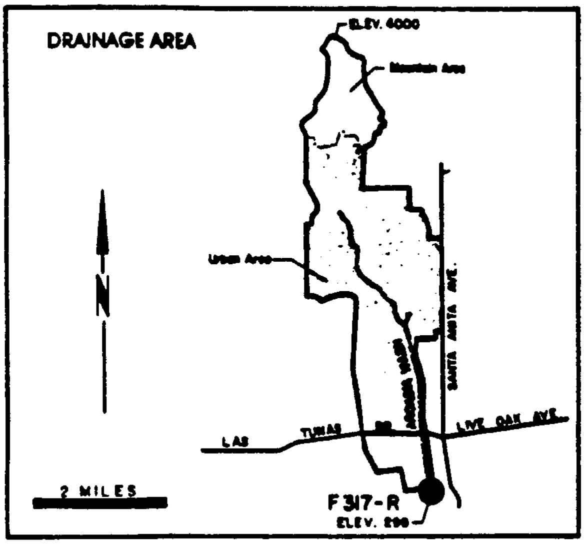
DRAINAGE AREA : 83.40 SQ. MI.

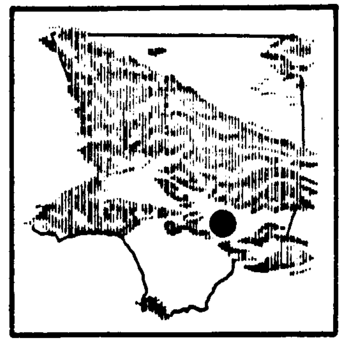
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	157.0	76.0	155.0	69.7	288.0	172.0	23.3	12.1	10.6	13.6	12.7	11.8
MAX.	357.0	158.0	1,920.0	1,450.0	2,370.0	956.0	135.0	12.6	11.8	46.0	14.9	13.2
MIN.	38.4	8.2	11.3	7.3	12.1	12.6	11.5	11.2	10.2	10.2	11.5	10.5
TOTAL AF	9,627.0	4,524.0	9,543.0	4,285.0	16,592.0	10,564.0	1,386.0	745.0	633.0	837.0	780.0	705.0

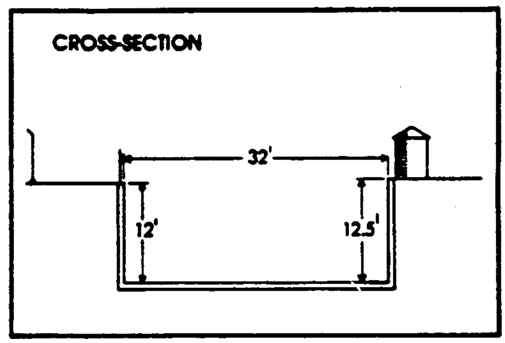
VOL 12 2

0140

ARCADIA WASH
below Grand Avenue
STATION NO. F 317-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of Grand Avenue bridge.
DRAINAGE AREA- 8.5 square miles.
LOCATION- on the west wall of Arcadia Wash about 75 feet downstream from centerline of Grand Avenue.
REGULATION- several debris basins located upstream.
CHANNEL- rectangular concrete.
LENGTH OF RECORD- December 12, 1955 to date.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F317–R DRAINAGE AREA : 8.50 SQ. MI.

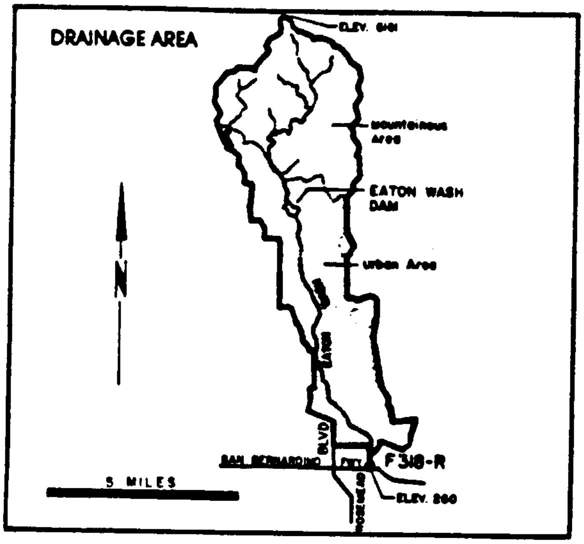
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.7	0.4	7.6	7.4	68.6	38.8	2.4	0.8	1.1	4.6	0.1	1.6
MAX.	6.9	0.6	147.0	127.0	301.0	150.0	46.9	1.3	1.7	49.6	0.1	4.6
MIN.	0.5	0.2	0.1	0.1	0.1	0.3	0.5	0.5	0.7	0.1	0.1	0.3
TOTAL AF	105.0	22.4	468.0	455.0	3 959.0	2 388.0	145.0	51.8	67.6	281.0	6.1	94.2

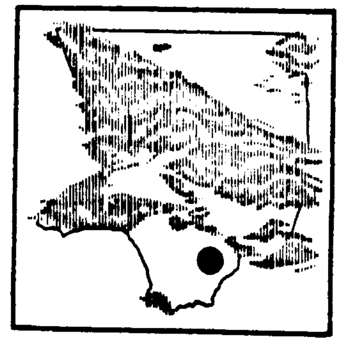
VOL 12

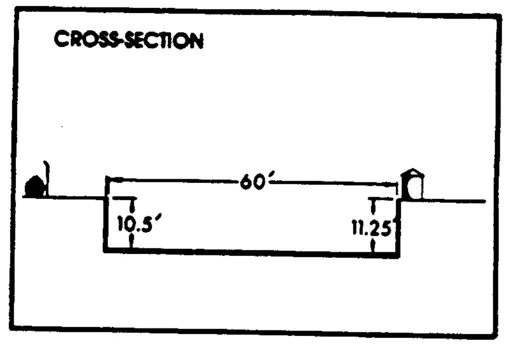
2

0141

EATON WASH
at Loftus Drive
STATION NO. F318-R







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2 0142

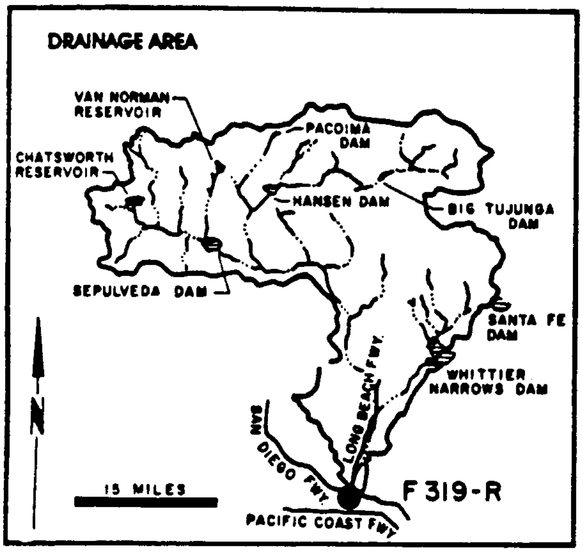
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of East Loftus Drive bridge.
DRAINAGE- 22.8 square miles.
LOCATION- on the west wall of the channel 52 feet above the centerline of East Loftus Drive bridge, 1.3 miles west of El Monte.
REGULATION- partly regulated by Eaton Dam.
DIVERSIONS- the Pasadena Water Department diverts some water just above the mouth of Eaton Canyon. The Flood Control District diverts water to spreading grounds below Eaton Dam and below Huntington Drive.
CHANNEL- rectangular concrete, 60 feet wide, 11.3 feet.
CONTROL- channel forms control.
LENGTH OF RECORD- 1956 to date.

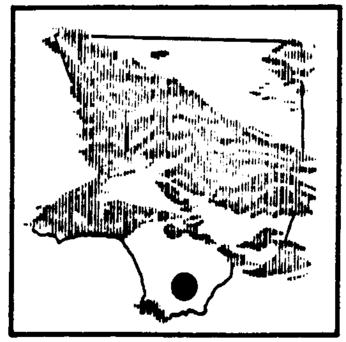
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

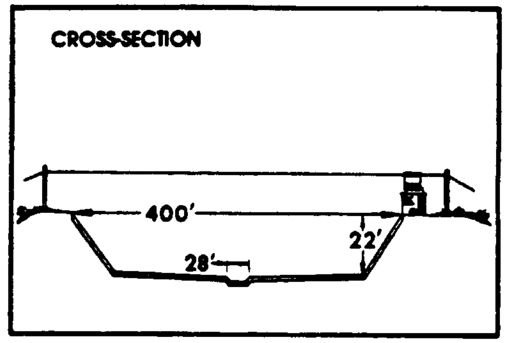
STATION NO. : F318–R DRAINAGE AREA : 22.80 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.6	0.1	10.8	8.2	79.9	60.1	9.0	1.5	0.2	1.4	0.2	0.1
MAX.	44.6	0.2	222.0	167.0	757.0	410.0	12.0	11.0	0.3	21.2	0.4	0.4
MIN.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
TOTAL AF	100.0	6.5	664.0	502.0	4,593.0	3,697.0	534.0	93.8	9.1	86.5	11.1	7.1

LOS ANGELES RIVER
below Wardlow Road
STATION NO. F319-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 815.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 900.0 feet below Wardlow Road, Long Beach.
REGULATION- flow is subject to the same regulation as Stations F34D-R and P458-R.
DIVERSIONS- flows diverted to Dominguez Gap Spreading Grounds.
CHANNEL- trapezoidal, concrete, 302.0 feet wide at bottom with 2.25:1 side slopes. Low flow channel 28.0 feet wide by 1.0 foot deep in center of channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F180-R October 31, 1931 to January 13, 1956. at Station F319-R January 13, 1956 to date.
REMARKS- prior to 1931, see Station F36-R.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F319-R DRAINAGE AREA : 815.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	159.0	137.0	695.0	604.0	3,580.0	1,730.0	345.0	208.0	168.0	206.0	164.0	145.0
MAX.	723.0	145.0	9,370.0	4,860.0	23,800.0	7,360.0	1,230.0	304.0	178.0	361.0	175.0	152.0
MIN.	110.0	121.0	128.0	312.0	459.0	361.0	239.0	167.0	157.0	174.0	154.0	138.0
TOTAL AF	9,759.0	8,126.0	42,748.0	37,135.0	206,140.0	106,302.0	20,523.0	12,791.0	9,973.0	12,666.0	10,058.0	8,628.0

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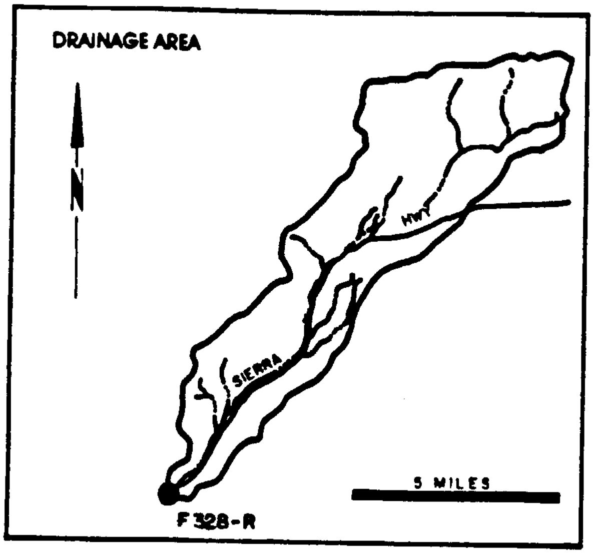
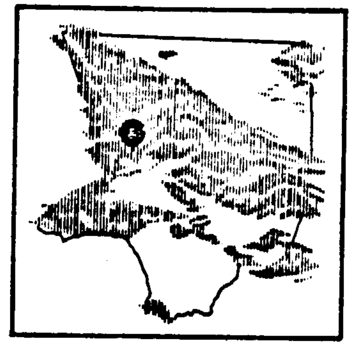
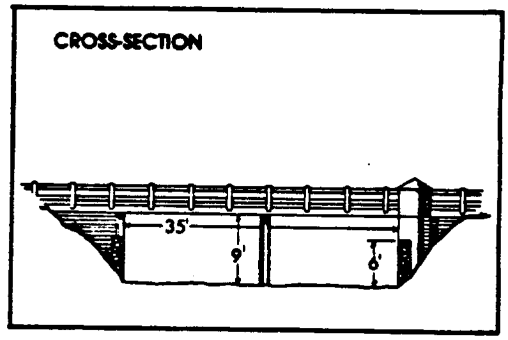
2-0143

R0053448

MINT CANYON CREEK
at Finch Avenue
STATION NO. F328-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 26.9 square miles.
LOCATION- 8.5 miles northeast of Saugus on west end of Fitch Avenue bridge.
REGULATION- none.
CHANNEL- natural, sand and gravel.
CONTROL- concrete control at downstream end of bridge.
LENGTH OF RECORD- October 26, 1956 to date.

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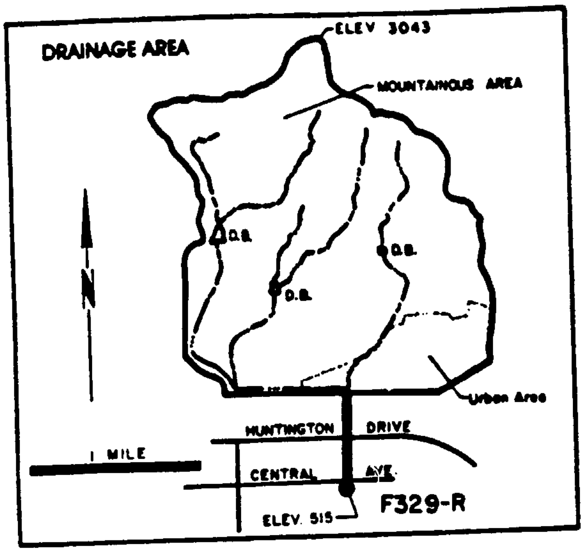
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

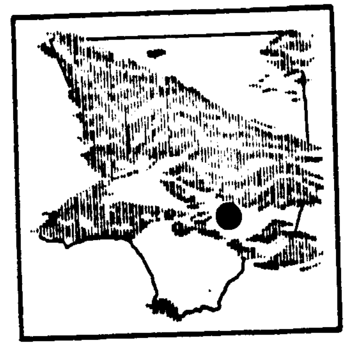
STATION NO. : F328 – R

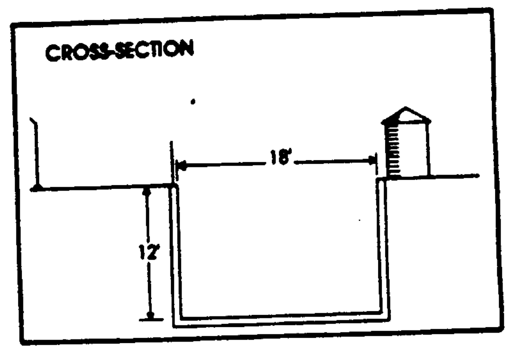
DRAINAGE AREA : 26.90 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN				0.0								
MAX.	RECORDER INOPERATIVE			0.0	RECORDER INOPERATIVE FOR THE REST OF THE YEAR							
MIN.				0.0								
TOTAL AF				0.0								

BRADBURY CHANNEL
below Central Avenue
STATION NO. F329-R







VCL 12

RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENT- low flows measured by wading. High flows measured from footbridge four feet downstream from recorder.
DRAINAGE AREA- 3.3 square miles.
LOCATION- on the east wall of Bradbury Channel, 200 feet downstream from the centerline of Central Avenue, one mile east of Duarte.
REGULATION- two debris basins located upstream.
CHANNEL- rectangular concrete, 18 feet wide, 12 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- June 14, 1957 to present.

2-0145

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F329–R

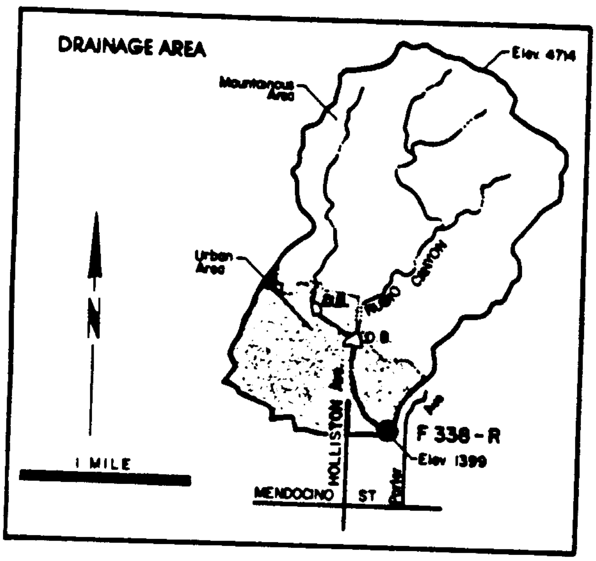
DRAINAGE AREA : 3.30 SQ. MI.

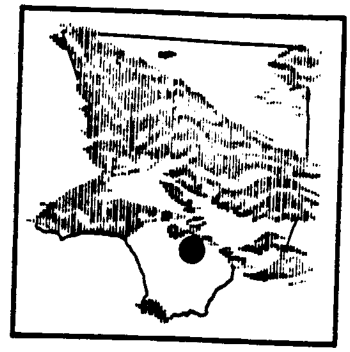
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.2	0.3	0.9	0.6	5.6	2.9	2.4	0.5	0.1	0.2	0.1	0.1
MAX.	5.5	1.0	13.4	11.5	50.9	19.2	3.8	5.5	0.5	3.3	0.3	0.6
MIN.	0.3	0.0	0.0	0.0	0.1	0.1	1.5	0.1	0.0	0.0	0.0	0.0
TOTAL AF	74.2	16.1	57.1	33.9	319.0	175.0	141.0	28.0	6.5	13.5	5.8	6.9

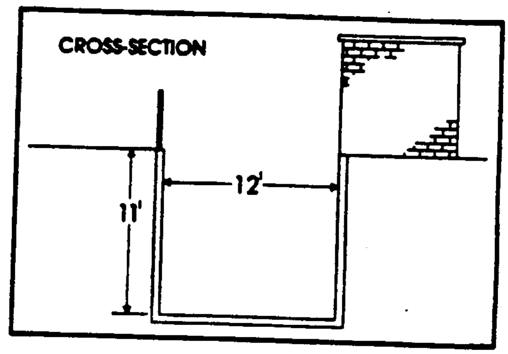
VOL 12

2 0146

RUBIO DIVERSION CHANNEL
below Goosebury Inlet
STATION NO. F338-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from steel footbridge 27 feet above station.
DRAINAGE AREA- 2.1 square miles.
LOCATION- on the north bank, 375 feet upstream of Crest Drive, three and one-half miles northeast of Pasadena.
REGULATION- flow partially regulated by Rubio and Gooseberry Debris Basins.
DIVERSIONS- Rubio Canyon Land and Water Association diverts low flows in Rubio Canyon.
CHANNEL- rectangular concrete, 12 feet wide and 11 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- December 16, 1959 to date.

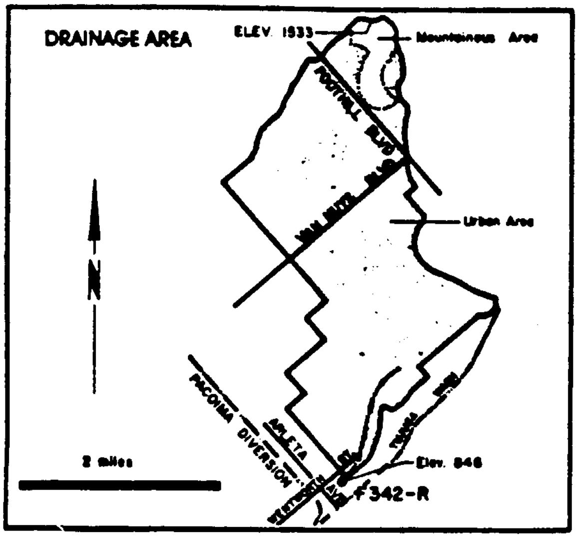
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

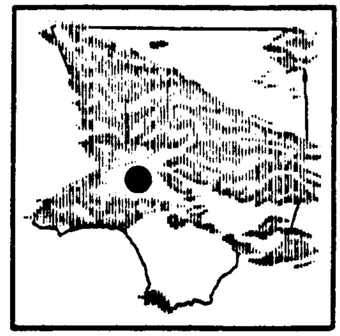
STATION NO. : F338–R

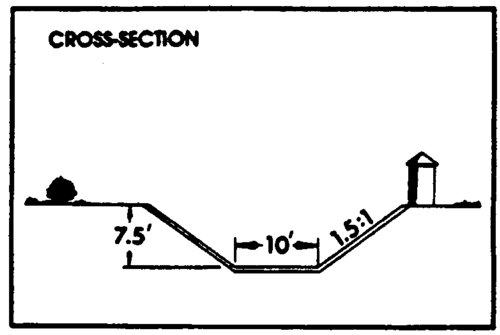
DRAINAGE AREA : 2.10 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.2	0.2	0.5	1.3	7.9	6.0	5.2	1.0	1.3	1.4	1.1	0.7
MAX.	2.1	0.5	5.2	6.5	45.4	9.4	8.5	1.6	2.3	4.0	1.4	1.0
MIN.	0.0	0.0	0.0	0.2	1.4	1.7	1.5	0.6	0.2	0.9	0.8	0.5
TOTAL AF	11.0	9.0	32.0	78.0	454.0	369.0	310.0	62.0	79.0	85.0	65.0	41.0

BRANFORD STREET CHANNEL
below Sharp Avenue
STATION NO. F342-R







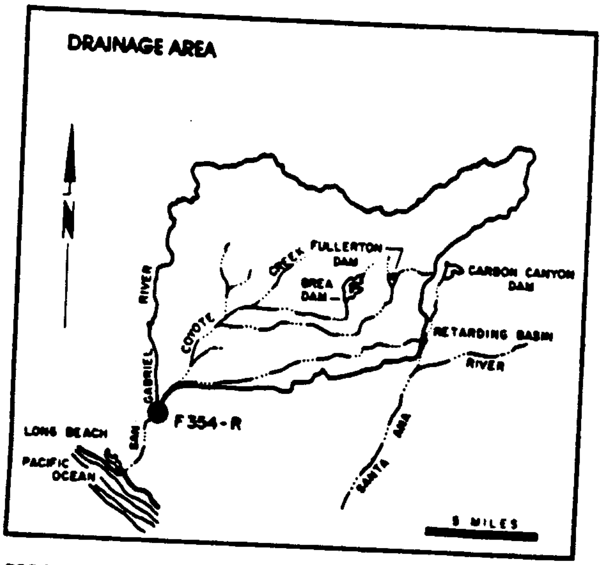
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured by floats.
DRAINAGE AREA- 5.01 square miles.
LOCATION- on the south bank of channel, 125 feet downstream from Sharp Avenue, about 3.6 miles south of San Fernando.
REGULATION- flow from Lopez Creek is diverted to Hansen Dam at the mouth of Lopez Canyon.
CHANNEL- trapezoidal, 10 feet wide at bottom and 7.5 feet deep with 1. 5 to 1 side slopes.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1962 to date.

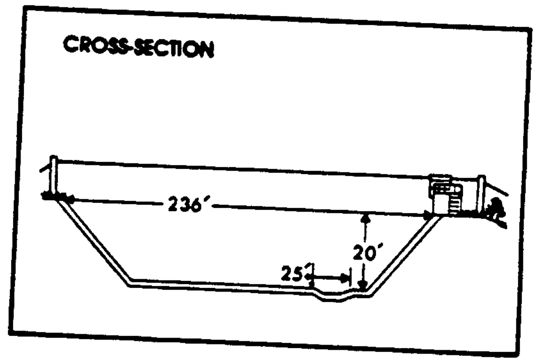
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F342–R DRAINAGE AREA : 5.01 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.5	0.0	4.1	2.3	18.9	7.5	0.2	0.2	0.0	0.1	0.0	0.0
MAX.	15.5	0.0	73.5	40.9	238.0	49.5	6.0	4.6	0.1	1.7	0.0	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AF	32.1	0.0	252.0	140.0	1,086.0	462.0	11.9	10.5	0.2	6.1	0.0	0.0

COYOTE CREEK
below Spring Street
STATION NO. F354-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 185.0 square miles.
LOCATION- 241.0 feet below Spring Street, 7.5 miles northeast of Long Beach.
REGULATION- partially regulated by Fullerton Dam, Brea Dam, and Carbon Canyon Dam.
CHANNEL- concrete, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD - December 17, 1963 to date.
REMARKS - previous gaging stations for record corelation: Station F41 - S December 1, 1928 to January 14, 1930. Station F41 - R January 14, 1930 to October 30, 1936. Station F41B - R October 30, 1936 to February 17, 1937. Station F41C - R February 18, 1937 to February 8, 1956. Station F320 - R February 9, 1956 to July 2, 1965.

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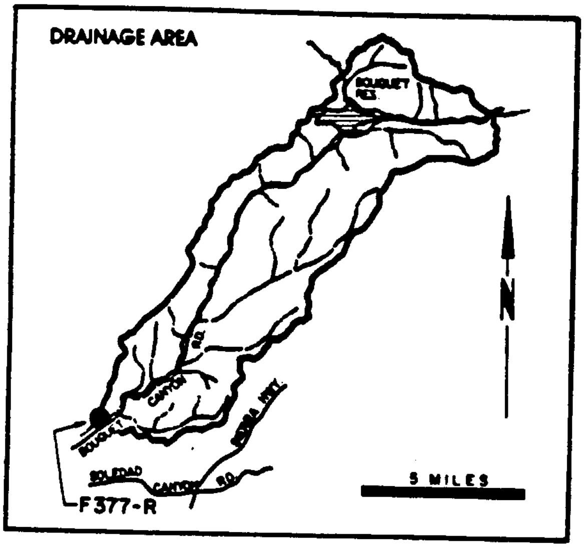
WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

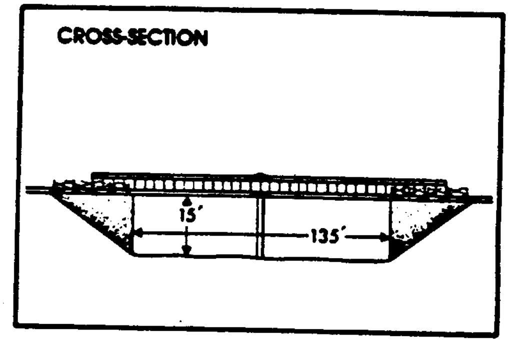
STATION NO. : F354–R

DRAINAGE AREA : 185.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	14.0	5.6	83.5	15.1	346.0	231.0	11.5	10.7	7.6	8.7	6.7	7.3
MAX.	142.0	15.3	1,350.0	228.0	3,120.0	1,620.0	44.0	43.2	10.7	37.8	12.6	10.4
MIN.	3.3	3.1	3.4	0.0	4.9	5.2	6.1	3.8	4.8	4.8	4.8	4.6
TOTAL AF	863.0	332.0	5,137.0	928.0	19,879.0	14,206.0	681.0	656.0	453.0	535.0	414.0	434.0

BOUQUET CANYON CREEK
at Urbandale Avenue
STATION NO. F377-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 51.9 square miles.
LOCATION- Bouquet Canyon Creek at Urbandale Avenue, 3.5 miles northeast of Saugus.
REGULATION- Bouquet Reservoir.
CHANNEL- concrete sides with natural bottom, trapezoidal in section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- October 11, 1967 to date.

WATER YEAR 1991 – 1992
(DISCHARGE IN CFS)

STATION NO. : F377 – R DRAINAGE AREA : 51.90 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	3.0	0.0	1.3	3.2	3.2	0.0	0.2	0.0	0.0	0.1	0.0	0.0
MAX.	72.3	0.0	34.0	33.3	42.5	1.3	0.2	0.0	0.0	0.3	0.0	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
TOTAL AF	184.1	0.0	82.5	194.8	185.1	2.6	11.9	0.0	0.0	8.9	0.0	0.0

VOL 12

2 0149

R0053454

RESERVOIRS

VOL 12

2

0150

VOL 12 2015-1

RESERVOIRS

Following the damaging flood of 1914 and creation of the Los Angeles County Flood Control District in 1915, a program of flood control and water conservation was initiated. Part of this program included the construction of 14 dams which were completed between 1920 and 1939. These dams were operated by the Department during the period covered by this report. In addition, five Corps of Engineers' dams, Lopez, Hansen, Santa Fe, Sepulveda and Whittier Narrows Dams, and Morris Dam owned by The Metropolitan Water District were operated in conjunction with the Department dams to achieve flood control and/or water conservation.

OPERATION

The reservoirs are operated to control flood waters during storm periods. Post storm releases are made, when feasible, in amounts which can be conserved in downstream spreading grounds and by channel percolation. Cleanouts are done to regain storage capacity in reservoirs (see Erosion Control for cleanout data).

RECORDS

The storage and flow records at the 14 Department reservoirs are summarized on the Dam Operation Record Sheets. The sheets show:

1. Daily reservoir water surface elevations. Elevations are obtained from water stage recorder graphs or interpolation from staff gage readings and recorded as of midnight of each day. Only maximum and minimum water surface elevations for each year are shown.

2. Available storage in acre-feet based on the most recent topographic surveys. Annual storage volumes are shown.

3. Stream inflow rates in cubic feet per second. This is usually calculated from storage change and known outflow.

4. Outflow in cubic feet per second. These values are determined from gaging station records, or when these are not available, from valve and spillway rating curves. Only the maximum and minimum of the daily outflow rates for the year and the instantaneous peak outflow rate are shown.

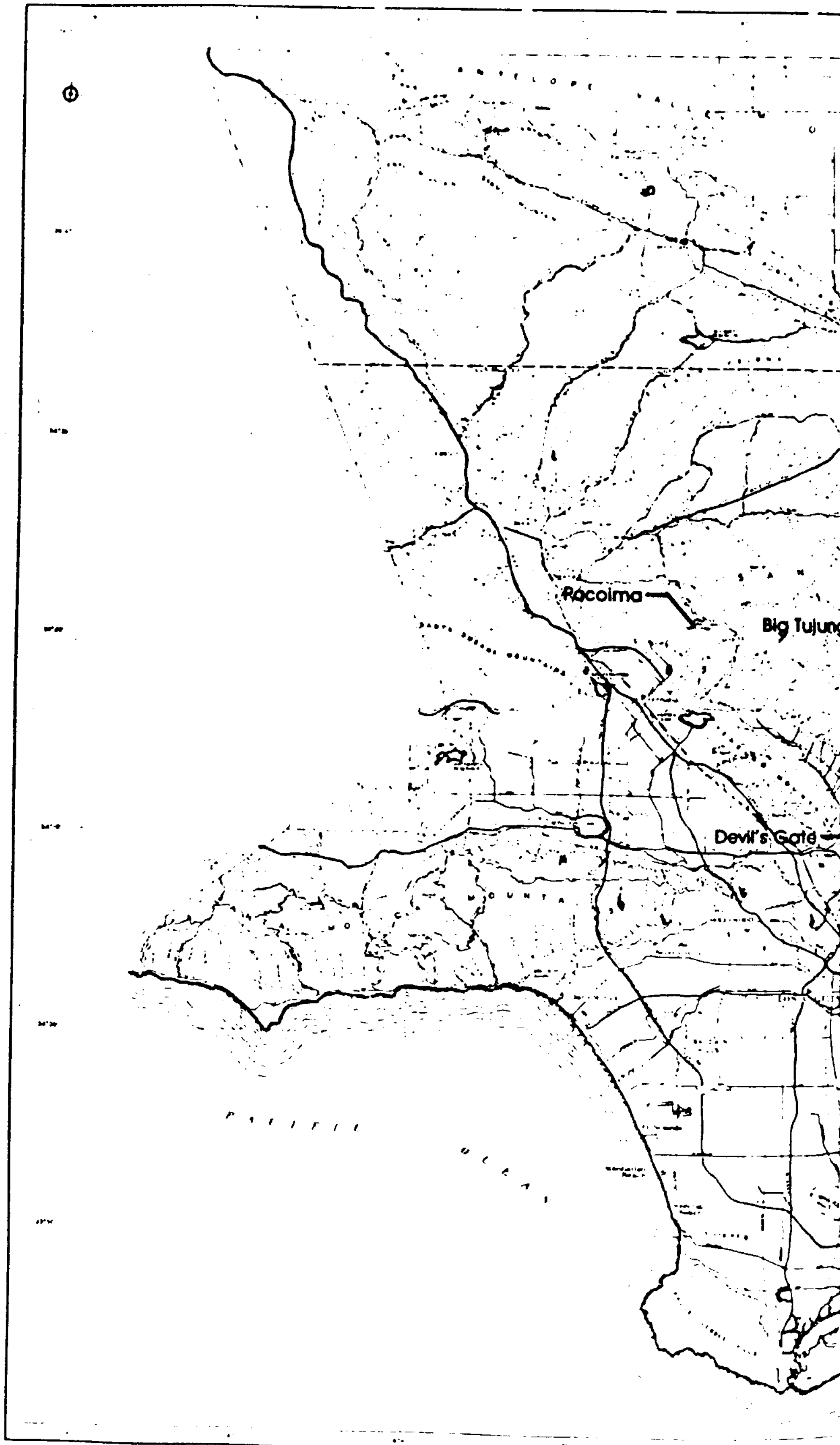
5. Discrepancies between outflow and storage losses at certain dams are attributable to evaporation and/or percolation losses. Total monthly evaporation losses are determined from the measurements made on land evaporation pans. In those cases where no allowances were made for evaporation, the amounts are necessarily included in the flow values. Accuracy of flow records computed from storage records is dependent on the frequency with which storage data are revised to keep in step with the physical change in reservoirs due to sediment deposition, accumulation and removal.

VOL 12

2

0152

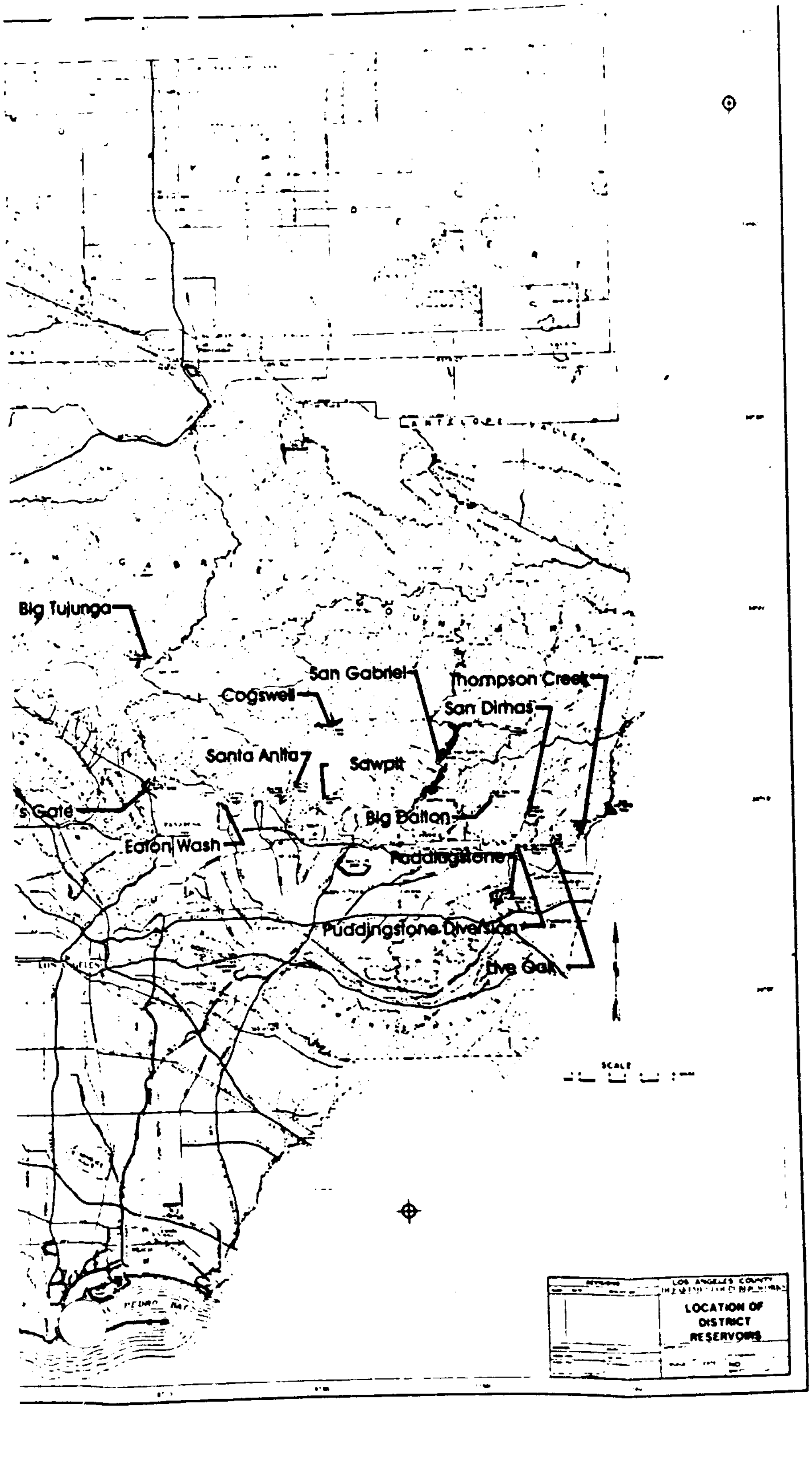
D2



VOL 12 2

0153

R0053458



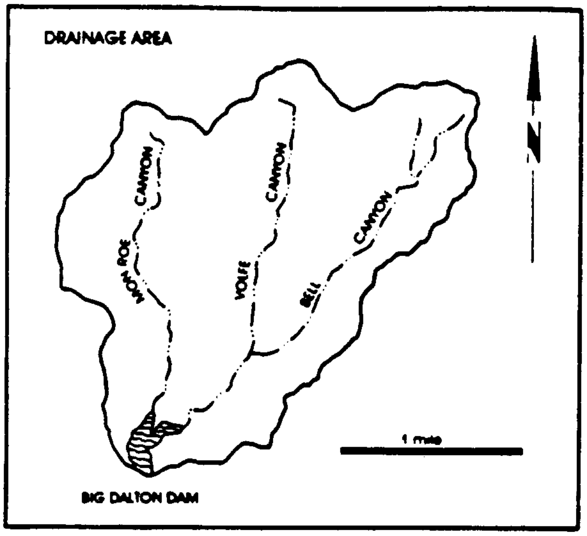
VOL 12

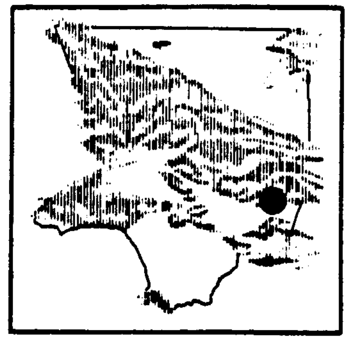
2 0154

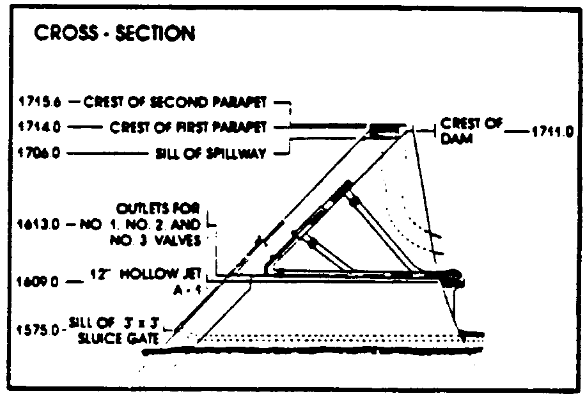
PD1

R0053459

BIG DALTON DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1927. Completed August 1929.
LOCATION - Big Dalton Canyon, 4.0 miles northeast of Glendora.
DRAINAGE AREA - 4.5 square miles.
CAPACITY - 963 acre - feet.
SPILLWAY ELEVATION - 1,706.0 feet.

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DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	121.08 CFS from 1500 on 02-12-92 to 1600 on 02-12-92
MAX. PEAK OUTFLOW	21.70 CFS from 1100 on 02-19-92 to 1130 on 02-19-92
MAX. W.S. ELEVATION	1655.50 feet on 02-13-92 STORAGE 168.70 ACRE-FEET
MIN. W.S. ELEVATION	1629.00 feet on 05-26-92 STORAGE 50.00 ACRE-FEET

BIG DALTON DAM OPERATION RECORD SUMMARY

WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	2.80	4.60	3.50	6.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	20.60	0.00	1.20
MAX. MEAN DAILY INFLOW (CFS)	0.30	0.50	0.30	0.50
TOTAL MONTHLY LOSSES (AF)	1.70	0.80	0.40	0.50
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	1.10	-16.80	3.10	4.50

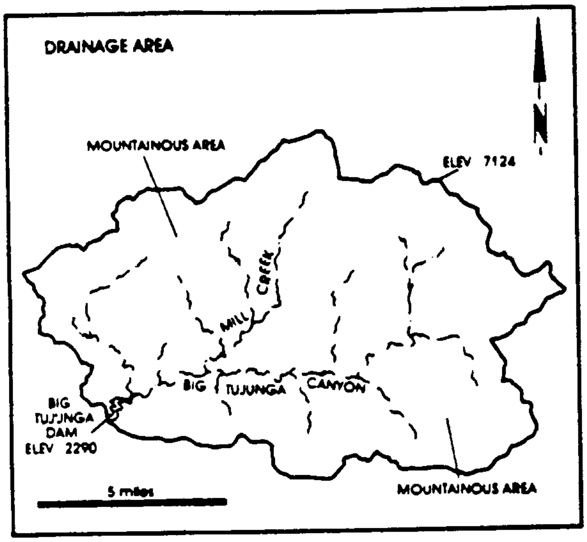
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	323.30	454.10	205.30	102.20
TOTAL MONTHLY OUTFLOW (AF)	327.30	424.30	235.20	110.50
MAX. MEAN DAILY INFLOW (CFS)	31.40	36.50	8.70	3.50
TOTAL MONTHLY LOSSES (AF)	0.60	0.50	1.10	1.30
MIN. MEAN DAILY INFLOW (CFS)	0.10	2.20	1.10	0.50
MONTHLY STORAGE CHANGE (AF)	-4.60	29.30	-31.00	-9.60

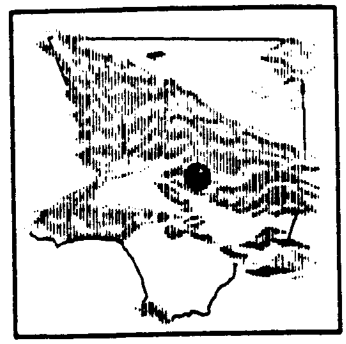
WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	94.50	44.50	11.00	7.00
TOTAL MONTHLY OUTFLOW (AF)	81.70	42.40	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	2.30	2.30	0.30	0.20
TOTAL MONTHLY LOSSES (AF)	1.80	1.60	2.40	2.00
MIN. MEAN DAILY INFLOW (CFS)	0.50	0.20	0.10	0.10
MONTHLY STORAGE CHANGE (AF)	11.00	0.50	8.60	5.00

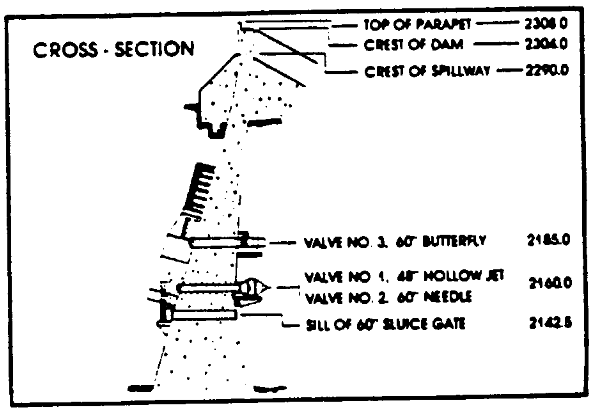
VOL 12

2 0156

BIG TUJUNGA DAM
AND RESERVOIR







PURPOSE - Flood Control Conservation.
DATE CONSTRUCTED - Started January 1930. Completed July 1931.
LOCATION - Big Tujunga Canyon, 10.0 miles northeast of Sunland.
DRAINAGE AREA - 82.3 square miles.
CAPACITY - 6,027 acre - feet.
SPILLWAY ELEVATION - 2,290.0 feet.

VOL 12 2 0157

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	5166.62 CFS from 1400 on 02-12-92 to 1500 on 02-12-92
MAX. PEAK OUTFLOW	1780.00 CFS from 2000 on 02-12-92 to 2015 on 02-12-92
MAX. W.S. ELEVATION	2283.20 feet on 02-19-92 STORAGE 5132.30 ACRE-FEET
MIN. W.S. ELEVATION	2205.20 feet on varies STORAGE 1058.30 ACRE-FEET

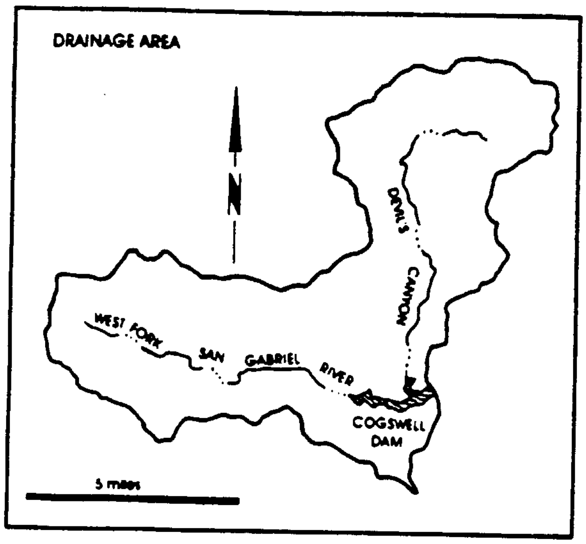
BIG TUJUNGA DAM OPERATION RECORD SUMMARY

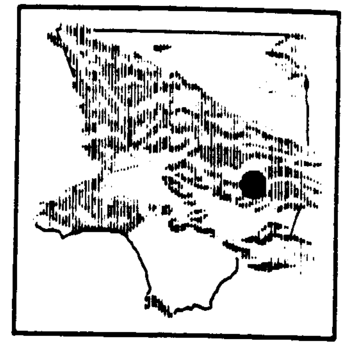
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	56.90	64.40	347.30	1,377.50
TOTAL MONTHLY OUTFLOW (AF)	11.50	92.40	337.40	1,384.10
MAX. MEAN DAILY INFLOW (CFS)	3.20	2.20	35.70	171.20
TOTAL MONTHLY LOSSES (AF)	20.70	15.50	11.00	10.30
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.20	1.40	5.30
MONTHLY STORAGE CHANGE (AF)	24.70	-43.50	-1.10	-16.90

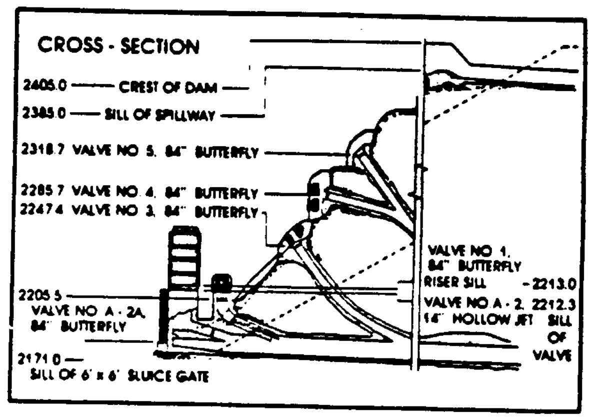
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	13,859.40	8,978.90	4,252.50	1,306.10
TOTAL MONTHLY OUTFLOW (AF)	13,561.00	8,756.40	3,936.80	1,266.00
MAX. MEAN DAILY INFLOW (CFS)	1,248.50	588.00	147.20	48.50
TOTAL MONTHLY LOSSES (AF)	11.90	8.70	17.90	19.60
MIN. MEAN DAILY INFLOW (CFS)	6.20	48.20	42.10	0.70
MONTHLY STORAGE CHANGE (AF)	286.50	213.80	297.80	20.50

WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	674.60	551.30	157.70	140.40
TOTAL MONTHLY OUTFLOW (AF)	1,328.30	549.20	122.20	68.40
MAX. MEAN DAILY INFLOW (CFS)	21.60	12.80	5.20	4.70
TOTAL MONTHLY LOSSES (AF)	19.70	19.60	25.80	22.80
MIN. MEAN DAILY INFLOW (CFS)	1.70	6.00	0.30	1.80
MONTHLY STORAGE CHANGE (AF)	-673.40	-17.50	9.70	49.20

COGSWELL DAM
AND RESERVOIR







PURPOSE - Flood Control, Conservation, and Recreation.
DATE CONSTRUCTED - Started March 1932. Completed April 1934.
LOCATION - 22.0 miles north of Azusa.
DRAINAGE AREA - 39.2 square miles.
CAPACITY - 9,339 acre - feet.
SPILLWAY ELEVATION - 2,385.0 feet.

VOL 12

2 0159

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	5231.21 CFS from	0400	on	02-11-92	to	0500	on	02-11-92
MAX. PEAK OUTFLOW	2300.00 CFS from	1230	on	02-12-92	to	1300	on	02-12-92
MAX. W.S. ELEVATION	2335.17 feet	on	04-08-92	STORAGE	3432.40 ACRE-FEET			
MIN. W.S. ELEVATION	2186.70 feet	on	varies	STORAGE	0.80 ACRE-FEET			

VOL 12

COGSWELL DAM OPERATION RECORD SUMMARY

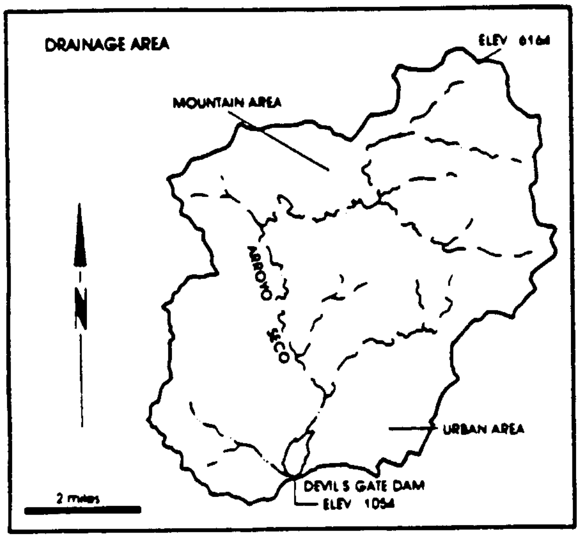
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	75.50	37.60	162.40	1,370.50
TOTAL MONTHLY OUTFLOW (AF)	75.40	29.00	137.50	1,370.40
MAX. MEAN DAILY INFLOW (CFS)	1.60	1.00	30.30	248.40
TOTAL MONTHLY LOSSES (AF)	0.20	0.10	0.20	0.20
MIN. MEAN DAILY INFLOW (CFS)	0.70	0.30	0.20	5.90
MONTHLY STORAGE CHANGE (AF)	0.10	8.50	24.70	-0.10

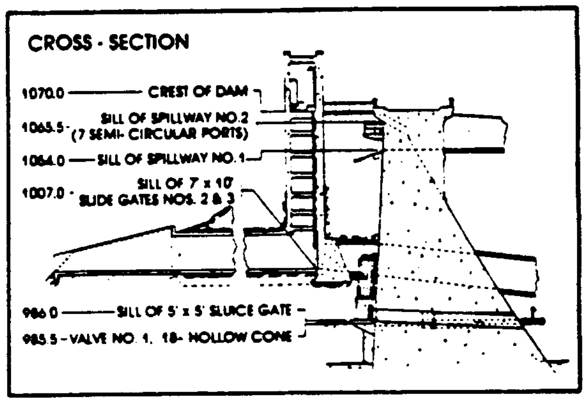
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	18,646.30	10,908.30	4,972.20	2,107.40
TOTAL MONTHLY OUTFLOW (AF)	17,692.20	8,895.10	7,439.60	2,345.10
MAX. MEAN DAILY INFLOW (CFS)	2,351.60	696.90	162.50	70.20
TOTAL MONTHLY LOSSES (AF)	2.30	5.30	15.50	6.90
MIN. MEAN DAILY INFLOW (CFS)	0.20	52.10	41.90	20.40
MONTHLY STORAGE CHANGE (AF)	951.80	2,007.90	-2,482.90	-244.60

WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	814.50	522.20	201.40	104.10
TOTAL MONTHLY OUTFLOW (AF)	814.20	518.30	195.40	110.70
MAX. MEAN DAILY INFLOW (CFS)	17.70	11.70	5.70	2.20
TOTAL MONTHLY LOSSES (AF)	5.40	7.10	9.10	6.30
MIN. MEAN DAILY INFLOW (CFS)	10.30	5.60	1.90	0.90
MONTHLY STORAGE CHANGE (AF)	-5.10	-3.20	-3.10	-12.90

2 0150

DEVIL'S GATE DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started May 1919. Completed June 1920.
LOCATION - On Arroyo Seco, northwest of Pasadena.
DRAINAGE AREA - 31.9 square miles.
CAPACITY - 1,928 acre - feet.
SPILLWAY ELEVATION - 1,054.0 feet.

VOL 12

DAM OPERATION RECORD SUMMARY †

MAX. PEAK INFLOW	3107.00 CFS from	1200	on	02-12-92	to	1300	on	02-12-92
MAX. PEAK OUTFLOW	1800.00 CFS from	1200	on	02-11-92	to	0600	on	02-12-92
MAX. W.S. ELEVATION	1045.20 feet on	02-11-92		STORAGE	1798.80 ACRE-FEET			
MIN. W.S. ELEVATION	992.00 feet on	varies		STORAGE	0.00 ACRE-FEET			

† - Values estimated due to incomplete records

2 0161

R0053466

VOL 12

DEVIL'S GATE DAM OPERATION RECORD SUMMARY

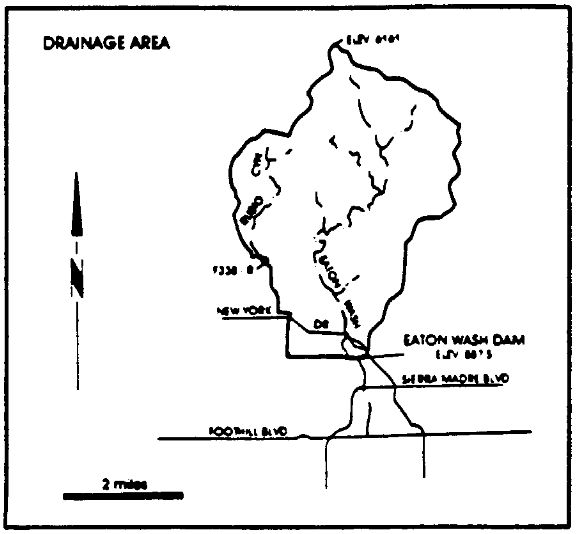
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	343.40	74.60
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	342.90	74.90
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	133.40	8.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.50	-0.30

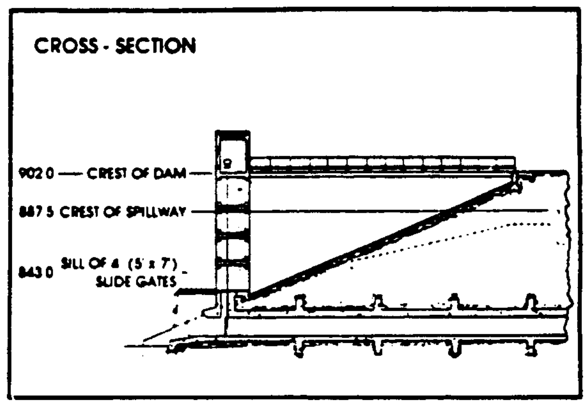
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	9,591.10	6,584.50	3,206.10	77.40
TOTAL MONTHLY OUTFLOW (AF)	9,591.10	6,514.70	3,275.90	77.40
MAX. MEAN DAILY INFLOW (CFS)	1,309.60	438.80	156.60	2.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	20.70	2.00	0.50
MONTHLY STORAGE CHANGE (AF)	0.00	69.80	-69.80	0.00

WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	7.90	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	7.90	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.50	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

2 0162

EATON WASH DAM
AND RESERVOIR





PURPOSE - Debris Storage and Conservation.
DATE CONSTRUCTED - Started January 1936. Completed February 1937.
LOCATION - Eaton Wash, northeast of Pasadena.
DRAINAGE AREA - 12.4 square miles.
CAPACITY - 879 acre - feet.
SPILLWAY ELEVATION - 887.5 feet.

VOL 12

20163

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	1068.04 CFS from	0400	on	02-11-92	to	0500	on	02-11-92
MAX. PEAK OUTFLOW	1240.00 CFS from	0445	on	02-11-92	to	1500	on	02-11-92
MAX. W.S. ELEVATION	885.00 feet on	02-11-92		STORAGE		654.60 ACRE-FEET		
MIN. W.S. ELEVATION	845.00 feet on	varies		STORAGE		0.00 ACRE-FEET		

VOL 12

EATON WASH DAM OPERATION RECORD SUMMARY

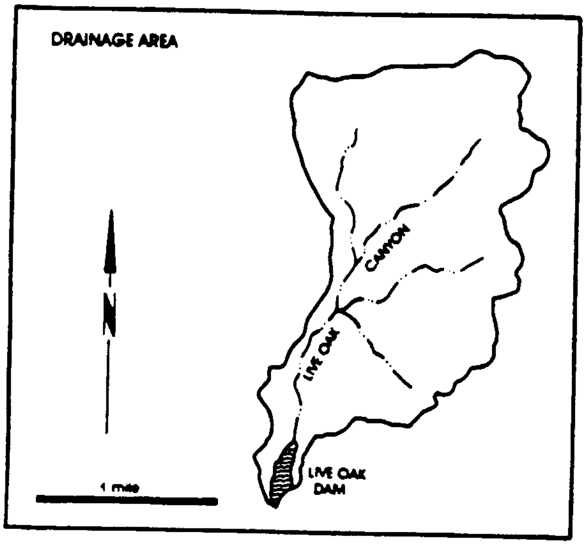
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	118.30	56.60
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	47.20	62.50
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	40.50	32.60
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	71.10	-5.90

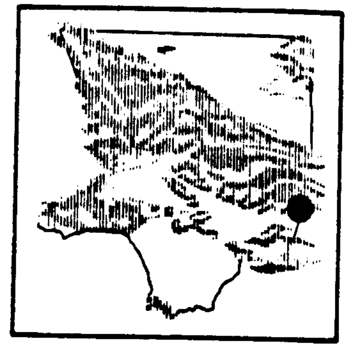
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1,723.90	2,537.60	911.70	213.70
TOTAL MONTHLY OUTFLOW (AF)	1,573.90	2,471.40	1,138.50	160.70
MAX. MEAN DAILY INFLOW (CFS)	295.40	197.80	31.90	8.50
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	6.30	3.00	0.60
MONTHLY STORAGE CHANGE (AF)	150.00	66.20	-226.80	53.00

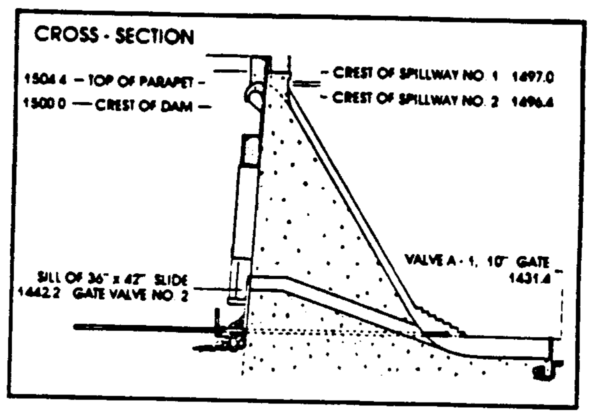
WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	120.10	5.70	5.40	0.00
TOTAL MONTHLY OUTFLOW (AF)	183.10	35.50	5.40	0.00
MAX. MEAN DAILY INFLOW (CFS)	9.90	4.60	0.30	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.40	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	-63.00	-29.80	0.00	0.00

2 0164

LIVE OAK DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started August 1921. Completed November 1922.
LOCATION - 2.5 miles northeast of La Verne.
DRAINAGE AREA - 2.3 square miles.
CAPACITY - 240 acre-feet.
SPILLWAY ELEVATION - 1,496.0 feet.

VOL 12

2 0165

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	111.92 CFS from	1300	on	02-12-92	to	1400	on	02-12-92
MAX. PEAK OUTFLOW	35.90 CFS from	1300	on	02-13-92	to	1315	on	02-13-92
MAX. W.S. ELEVATION	1477.80 feet on	02-13-92		STORAGE		88.90 ACRE-FEET		
MIN. W.S. ELEVATION	1440.00 feet on	varies		STORAGE		0.00 ACRE-FEET		

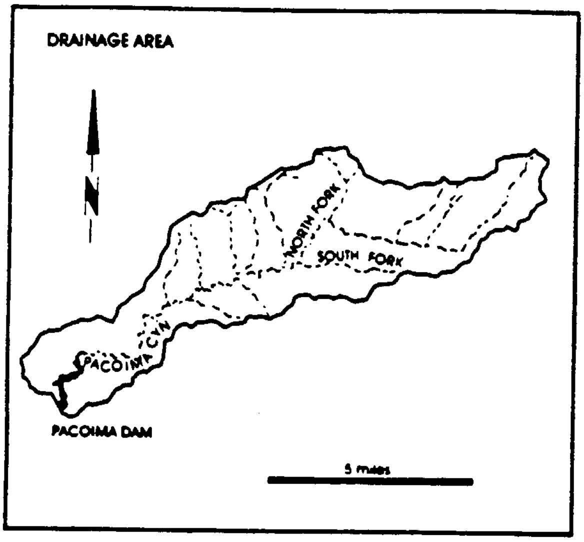
LIVE OAK DAM OPERATION RECORD SUMMARY

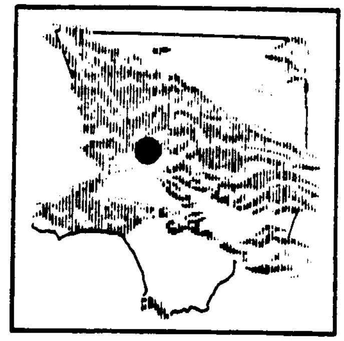
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	6.90
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	6.90
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.60
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

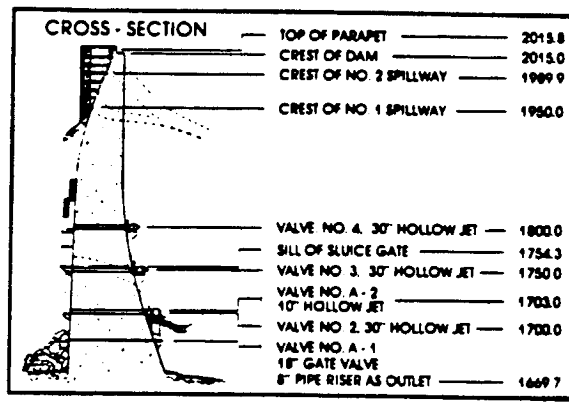
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	108.30	107.50	30.10	19.40
TOTAL MONTHLY OUTFLOW (AF)	108.30	107.50	30.10	19.40
MAX. MEAN DAILY INFLOW (CFS)	25.50	11.20	1.30	0.80
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.20	0.10
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	3.00	1.80	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	3.00	1.80	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.10	0.40	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

PACOIMA DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1925. Completed February 1929.
LOCATION - Pacoima Canyon, 4.0 miles northeast of San Fernando.
DRAINAGE AREA - 28.2 square miles.
CAPACITY - 3,929 acre - feet.
SPILLWAY ELEVATION - 1,950.0 feet.

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2 0167

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	1180.36 CFS from 2100 on 02-10-92 to 2200 on 02-10-92
MAX. PEAK OUTFLOW	917.00 CFS from 1400 on 02-12-92 to 1500 on 02-12-92
MAX. W.S. ELEVATION	1951.90 feet on 03-29-92 STORAGE 3851.20 ACRE-FEET
MIN. W.S. ELEVATION	1872.95 feet on 07-16-92 STORAGE 905.60 ACRE-FEET

R0053472

VOL 12

2

0168

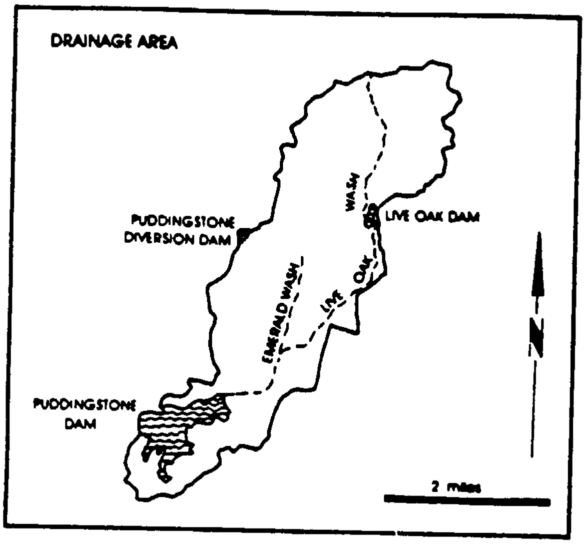
PACOIMA DAM OPERATION RECORD SUMMARY

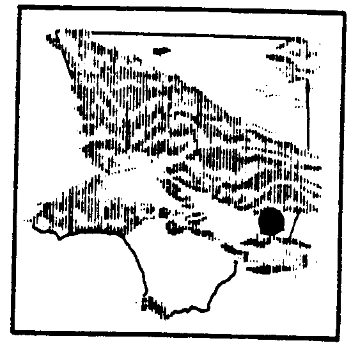
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	27.70	24.20	56.90	204.80
TOTAL MONTHLY OUTFLOW (AF)	4.40	0.00	176.50	239.80
MAX. MEAN DAILY INFLOW (CFS)	1.30	0.80	7.10	17.60
TOTAL MONTHLY LOSSES (AF)	21.30	19.20	10.50	14.40
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.00	0.20	0.10
MONTHLY STORAGE CHANGE (AF)	2.00	5.00	-130.10	-49.40

WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	6,878.30	5,155.90	3,523.10	1,037.20
TOTAL MONTHLY OUTFLOW (AF)	5,211.60	4,055.00	3,539.50	2,218.10
MAX. MEAN DAILY INFLOW (CFS)	708.40	207.10	101.90	26.90
TOTAL MONTHLY LOSSES (AF)	15.60	9.70	36.90	21.90
MIN. MEAN DAILY INFLOW (CFS)	1.40	36.20	15.60	12.30
MONTHLY STORAGE CHANGE (AF)	1,651.10	1,091.20	-53.30	-1,202.80

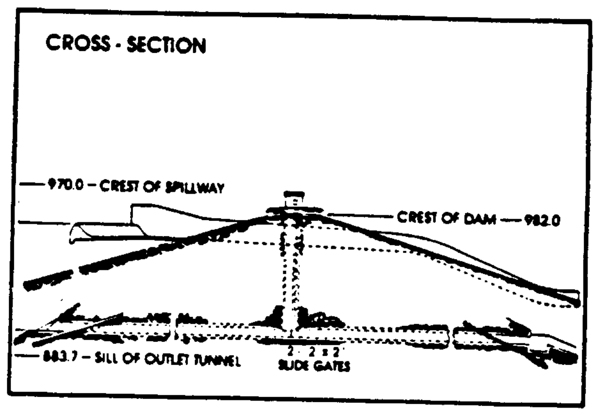
WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	532.70	INC	79.70	56.30
TOTAL MONTHLY OUTFLOW (AF)	2,059.40	INC	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	16.50	INC	1.90	1.10
TOTAL MONTHLY LOSSES (AF)	18.80	INC	18.00	18.90
MIN. MEAN DAILY INFLOW (CFS)	4.80	INC	0.80	0.70
MONTHLY STORAGE CHANGE (AF)	-1,545.50	INC	61.70	37.40

PUDDINGSTONE DAM
AND RESERVOIR





PURPOSE - Flood Control and Recreation.
DATE CONSTRUCTED - Started February 1925. Completed January 1928
LOCATION - 1.0 mile south of San Dimas.
DRAINAGE AREA - 11.0 square miles (uncontrolled)
22.1 square miles (controlled)
Total 33.1 square miles
CAPACITY - 16,856 acre - feet.
SPILLWAY ELEVATION - 970.0 feet.



DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	959.41 CFS from	1500	on	02-12-92	to	1600	on	02-12-92
MAX. PEAK OUTFLOW	580.00 CFS from	1130	on	02-12-92	to	1200	on	02-12-92
MAX. W.S. ELEVATION	945.36 feet on	03-23-92		STORAGE	7439.00 ACRE-FEET			
MIN. W.S. ELEVATION	940.16 feet on	varies		STORAGE	6108.80 ACRE-FEET			

VOL 12

PUDDINGSTONE DAM OPERATION RECORD SUMMARY

WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	118.70	61.20	494.00	508.40
TOTAL MONTHLY OUTFLOW (AF)	14.50	11.50	13.50	708.90
MAX. MEAN DAILY INFLOW (CFS)	17.80	2.80	146.50	110.90
TOTAL MONTHLY LOSSES (AF)	138.90	99.30	68.80	62.40
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.30	0.30	0.10
MONTHLY STORAGE CHANGE (AF)	-34.70	-49.60	411.70	-262.90

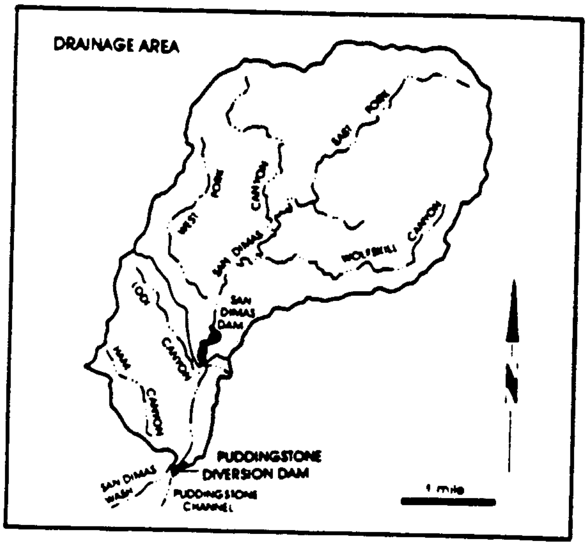
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	2,448.80	2,527.40	160.30	44.60
TOTAL MONTHLY OUTFLOW (AF)	2,076.50	2,103.30	143.40	192.60
MAX. MEAN DAILY INFLOW (CFS)	407.00	279.10	9.20	2.00
TOTAL MONTHLY LOSSES (AF)	59.70	51.30	122.70	139.20
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.80	0.40	0.00
MONTHLY STORAGE CHANGE (AF)	312.60	372.80	-105.80	-287.20

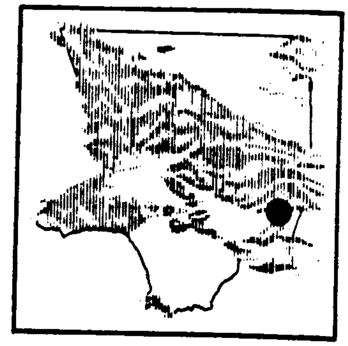
WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	81.90	106.90	125.30	103.40
TOTAL MONTHLY OUTFLOW (AF)	23.40	14.30	15.30	15.30
MAX. MEAN DAILY INFLOW (CFS)	2.90	3.00	4.40	3.10
TOTAL MONTHLY LOSSES (AF)	171.50	177.90	227.10	177.40
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.50	0.20	0.30
MONTHLY STORAGE CHANGE (AF)	-113.00	-85.30	-117.10	-89.30

2 0170

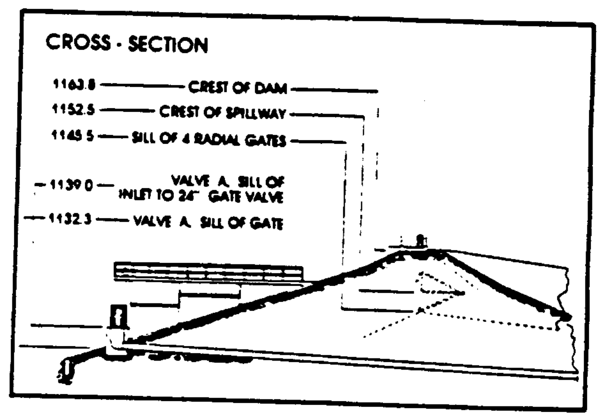
PUDDINGSTONE DIVERSION DAM
AND RESERVOIR

VOL 12





PURPOSE - Flood Control and Diversion of flow and Conservation.
DATE CONSTRUCTED - Started September 1927. Completed July 1928.
LOCATION - 2.0 miles northeast of San Dimas.
DRAINAGE AREA - 3.7 square miles (uncontrolled)
16.2 square miles (controlled)
Total 19.9 square miles
CAPACITY - 148 acre feet.
SPILLWAY ELEVATION - 1,152.0 feet.



2 0171

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	264.12 CFS from	1200	on	02-12-92	to	1300	on	02-12-92
MAX. PEAK OUTFLOW	174.20 CFS from	1200	on	02-12-92	to	1300	on	02-12-92
MAX. W.S. ELEVATION	1146.50 feet on	02-12-92		STORAGE	110.80 ACRE-FEET			
MIN. W.S. ELEVATION	1133.00 feet on	varies		STORAGE	0.00 ACRE-FEET			

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PUDDINGSTONE DIVERSION DAM OPERATION RECORD SUMMARY

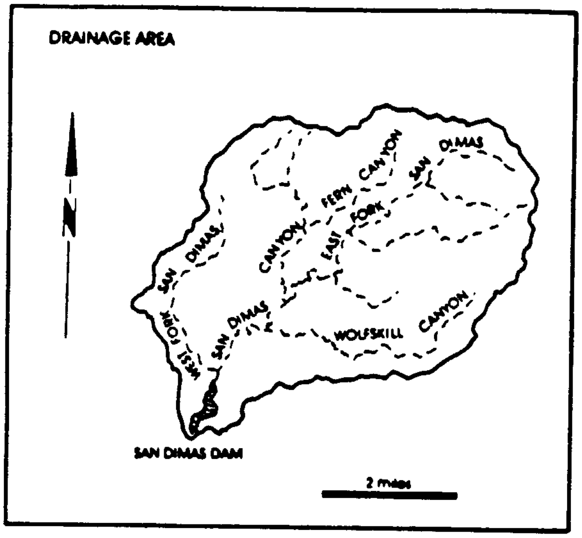
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	12.70	5.30
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	2.40	14.70
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	6.30	8.30
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	10.30	-9.40

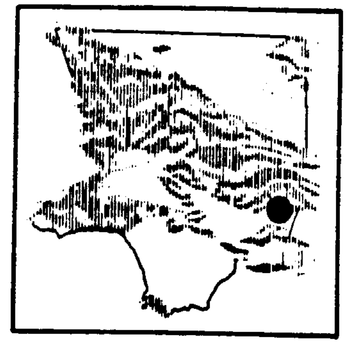
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	482.80	1,169.80	498.30	493.30
TOTAL MONTHLY OUTFLOW (AF)	435.80	1,176.80	494.10	516.10
MAX. MEAN DAILY INFLOW (CFS)	54.00	162.70	16.60	12.40
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	47.00	-7.00	4.20	-22.80

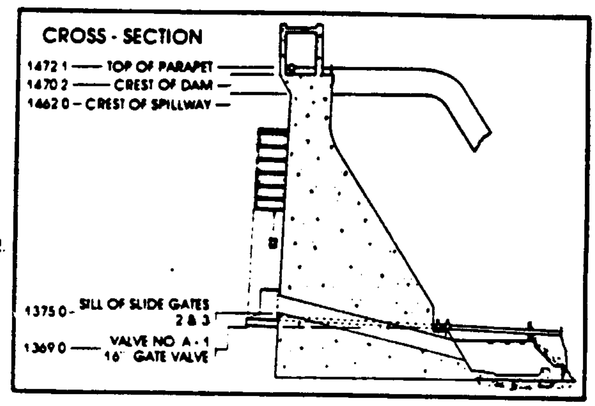
WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	158.40	338.40	128.60	1.40
TOTAL MONTHLY OUTFLOW (AF)	139.60	341.20	154.70	1.40
MAX. MEAN DAILY INFLOW (CFS)	11.40	6.80	6.90	0.20
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	11.70	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	3.70	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	18.80	-2.80	-37.80	0.00

2017 2

SAN DIMAS DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started November 1920. Completed September 1922.
LOCATION - 3.0 miles northeast of San Dimas.
DRAINAGE AREA - 16.2 square miles.
CAPACITY - 1,515 acre - feet.
SPILLWAY ELEVATION - 1,462.0 feet.

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2 0173

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	403.17 CFS from	1500	on	02-12-92	to	1600	on	02-12-92
MAX. PEAK OUTFLOW	150.00 CFS from	0900	on	03-24-92	to	0945	on	03-24-92
MAX. W.S. ELEVATION	1462.40 feet	on	04-14-92	STORAGE	1574.60 ACRE-FEET			
MIN. W.S. ELEVATION	1374.00 feet	on	varies	STORAGE	0.00 ACRE-FEET			

SAN DIMAS DAM OPERATION RECORD SUMMARY

WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	24.40	23.80	70.40	131.40
TOTAL MONTHLY OUTFLOW (AF)	24.40	23.80	39.30	5.60
MAX. MEAN DAILY INFLOW (CFS)	0.90	0.60	6.10	11.70
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	1.80
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.30	0.10	0.50
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	31.10	124.00

WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1,099.50	1,279.40	692.80	382.50
TOTAL MONTHLY OUTFLOW (AF)	233.70	994.70	652.20	720.60
MAX. MEAN DAILY INFLOW (CFS)	143.30	108.00	20.50	9.10
TOTAL MONTHLY LOSSES (AF)	3.70	6.50	12.30	12.00
MIN. MEAN DAILY INFLOW (CFS)	0.80	3.20	8.20	3.40
MONTHLY STORAGE CHANGE (AF)	862.10	278.20	28.30	-350.10

WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	133.70	111.50	64.30	23.30
TOTAL MONTHLY OUTFLOW (AF)	299.70	604.20	284.60	55.30
MAX. MEAN DAILY INFLOW (CFS)	3.60	3.60	2.60	1.10
TOTAL MONTHLY LOSSES (AF)	15.00	12.80	6.80	2.70
MIN. MEAN DAILY INFLOW (CFS)	1.20	0.40	0.00	0.10
MONTHLY STORAGE CHANGE (AF)	-181.00	-505.50	-227.10	-34.70

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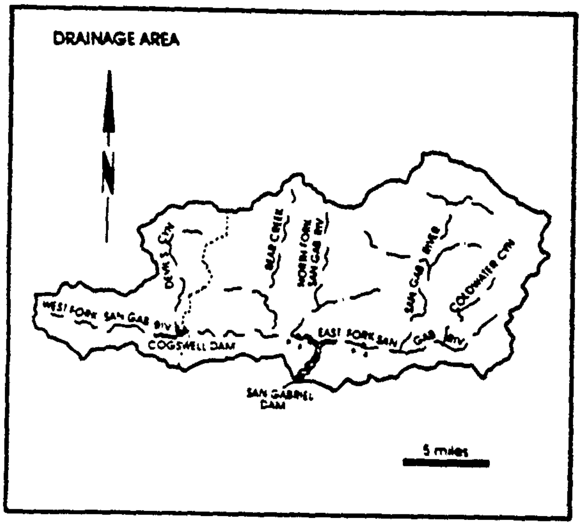
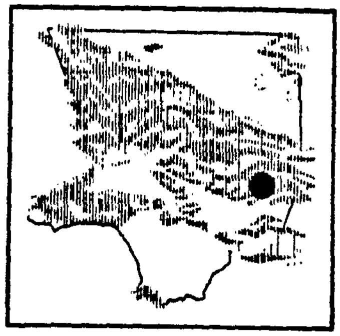
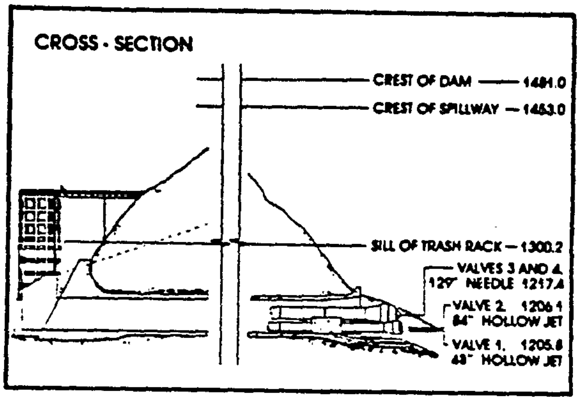
20174

SAN GABRIEL DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1932. Completed July 1939.
LOCATION - San Gabriel Canyon, 7.5 miles north of Azusa.
DRAINAGE AREA - 163.5 square miles (uncontrolled)
39.2 square miles (controlled)
Total 202.7 square miles
(Includes Cogswell drainage)
CAPACITY - 41,549 acre - feet.
SPILLWAY ELEVATION - 1,453 feet.

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	11425.86 CFS from	1300	on	02-12-92	to	1400	on	02-12-92
MAX. PEAK OUTFLOW	8258.50 CFS from	1400	on	02-11-92	to	1500	on	02-11-92
MAX. W.S. ELEVATION	1451.08 feet on	04-23-92		STORAGE	43161.00 ACRE-FEET			
MIN. W.S. ELEVATION	1279.00 feet on	varies		STORAGE	0.00 ACRE-FEET			

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20175

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SAN GABRIEL DAM OPERATION RECORD SUMMARY

WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	1,376.10	982.90	2,081.80	5,752.80
TOTAL MONTHLY OUTFLOW (AF)	5,049.70	7,034.00	9,708.70	4,670.10
MAX. MEAN DAILY INFLOW (CFS)	58.60	39.80	154.40	586.80
TOTAL MONTHLY LOSSES (AF)	246.90	164.20	75.10	70.20
MIN. MEAN DAILY INFLOW (CFS)	11.90	0.80	13.80	31.50
MONTHLY STORAGE CHANGE (AF)	-3,920.50	-6,215.30	-7,702.00	1,012.50

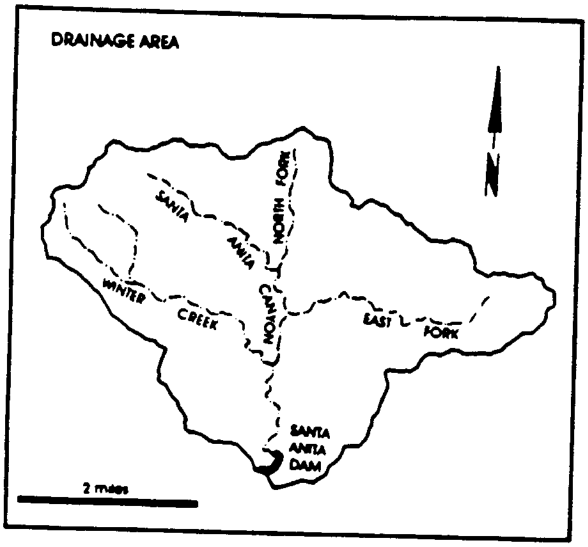
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	52,178.10	42,440.00	32,198.10	16,024.80
TOTAL MONTHLY OUTFLOW (AF)	36,284.00	27,628.20	26,557.10	18,649.20
MAX. MEAN DAILY INFLOW (CFS)	5,795.80	2,489.90	678.60	367.10
TOTAL MONTHLY LOSSES (AF)	81.80	90.00	259.90	254.40
MIN. MEAN DAILY INFLOW (CFS)	41.70	306.70	288.30	178.20
MONTHLY STORAGE CHANGE (AF)	15,812.30	14,721.80	5,381.10	-2,878.80

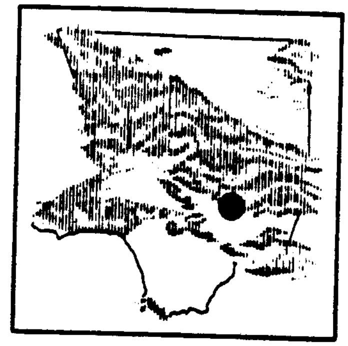
WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	7,844.20	6,426.40	2,499.10	1,812.90
TOTAL MONTHLY OUTFLOW (AF)	17,311.10	30,600.80	7,852.40	1,812.90
MAX. MEAN DAILY INFLOW (CFS)	171.50	181.20	75.60	40.80
TOTAL MONTHLY LOSSES (AF)	296.10	211.90	10.90	0.00
MIN. MEAN DAILY INFLOW (CFS)	92.50	50.50	0.00	24.90
MONTHLY STORAGE CHANGE (AF)	-9,763.00	-24,386.30	-5,364.20	0.00

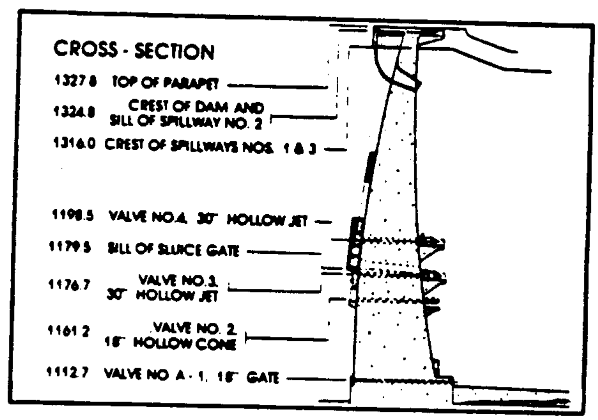
2 0176

VOL 12

SANTA ANITA DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started October 1924. Completed March 1927.
LOCATION - 2.5 miles north of Arcadia
DRAINAGE AREA - 10.8 square miles.
CAPACITY - 836 acre - feet.
SPILLWAY ELEVATION - 1,316.0 feet.

20177

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	863.20 CFS from	0300	on	02-11-92	to	0400	on	02-11-92
MAX. PEAK OUTFLOW	592.00 CFS from	0600	on	02-11-92	to	0645	on	02-11-92
MAX. W.S. ELEVATION	1297.08 feet	on	02-11-92	STORAGE	603.20 ACRE-FEET			
MIN. W.S. ELEVATION	1240.50 feet	on	07-22-92	STORAGE	153.10 ACRE-FEET			

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2018

SANTA ANITA DAM OPERATION RECORD SUMMARY

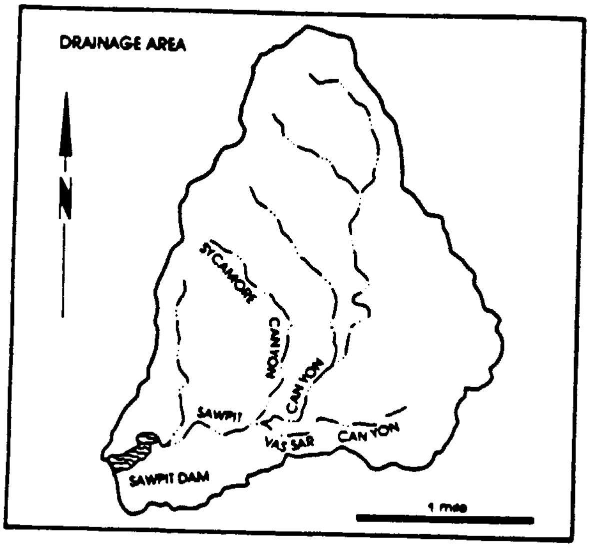
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	27.30	39.90	75.10	183.90
TOTAL MONTHLY OUTFLOW (AF)	0.00	94.00	0.00	280.70
MAX. MEAN DAILY INFLOW (CFS)	1.40	1.50	7.90	21.20
TOTAL MONTHLY LOSSES (AF)	3.40	2.70	1.70	1.60
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.20	0.60	0.20
MONTHLY STORAGE CHANGE (AF)	23.90	-56.80	73.40	-98.40

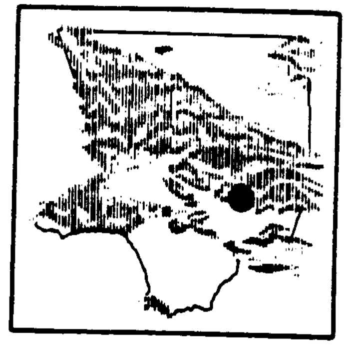
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	2,891.50	3,052.50	1,596.30	576.70
TOTAL MONTHLY OUTFLOW (AF)	2,694.00	3,048.00	1,566.10	737.90
MAX. MEAN DAILY INFLOW (CFS)	389.80	155.40	49.30	12.70
TOTAL MONTHLY LOSSES (AF)	1.70	1.50	2.30	2.30
MIN. MEAN DAILY INFLOW (CFS)	1.20	13.60	14.10	5.50
MONTHLY STORAGE CHANGE (AF)	195.80	3.00	27.90	-163.50

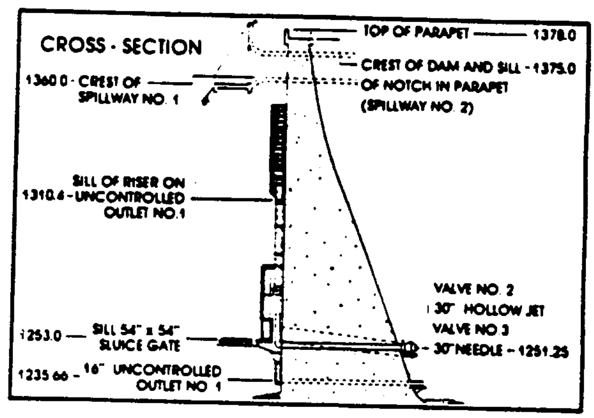
WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	363.40	301.90	136.10	94.10
TOTAL MONTHLY OUTFLOW (AF)	421.00	245.20	107.10	97.80
MAX. MEAN DAILY INFLOW (CFS)	9.70	8.50	3.30	2.10
TOTAL MONTHLY LOSSES (AF)	2.50	2.40	3.40	3.10
MIN. MEAN DAILY INFLOW (CFS)	3.90	3.20	0.80	0.80
MONTHLY STORAGE CHANGE (AF)	-60.10	54.30	25.60	-6.80

SAWPIT DAM
AND RESERVOIR

VOL 12







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1926. Completed June 1927.
LOCATION - 2.0 miles north of Monrovia.
DRAINAGE AREA - 3.2 square miles.
CAPACITY - 391 acre - feet.
SPILLWAY ELEVATION - 1,360.0 feet.

2 0179

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	123.22 CFS from	1300	on	02-12-92	to	1400	on	02-12-92
MAX. PEAK OUTFLOW	58.70 CFS from	0445	on	02-11-92	to	0500	on	02-11-92
MAX. W.S. ELEVATION	1316.10 feet	on	02-12-92	STORAGE	118.10 ACRE-FEET			
MIN. W.S. ELEVATION	1310.00 feet	on	10-24-91	STORAGE	94.80 ACRE-FEET			

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SAWPIT DAM OPERATION RECORD SUMMARY

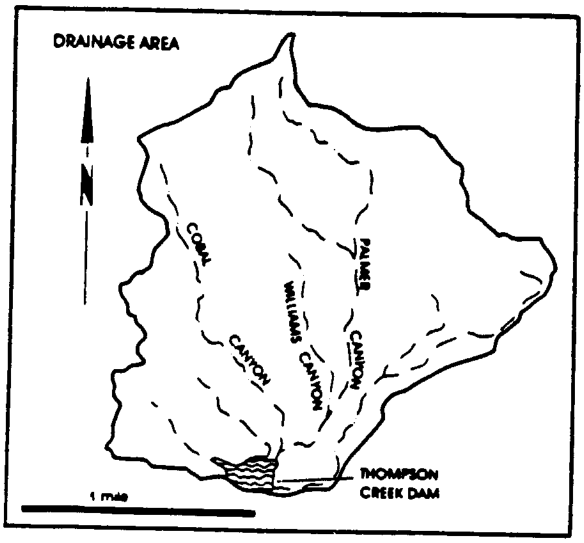
WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	49.90	61.60	80.50	103.90
TOTAL MONTHLY OUTFLOW (AF)	49.80	61.70	80.30	103.90
MAX. MEAN DAILY INFLOW (CFS)	1.50	1.30	2.60	3.80
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.40	0.80	1.00	1.20
MONTHLY STORAGE CHANGE (AF)	0.10	-0.10	0.20	0.00

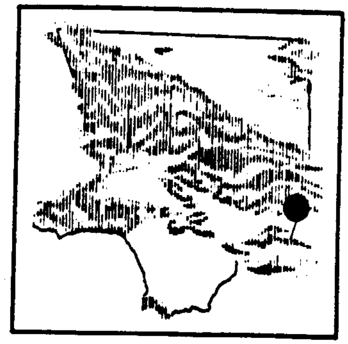
WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	375.40	394.80	258.60	187.40
TOTAL MONTHLY OUTFLOW (AF)	375.30	394.40	259.00	187.40
MAX. MEAN DAILY INFLOW (CFS)	41.20	24.40	5.80	3.80
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.40	2.60	3.30	2.60
MONTHLY STORAGE CHANGE (AF)	0.10	0.40	-0.40	0.00

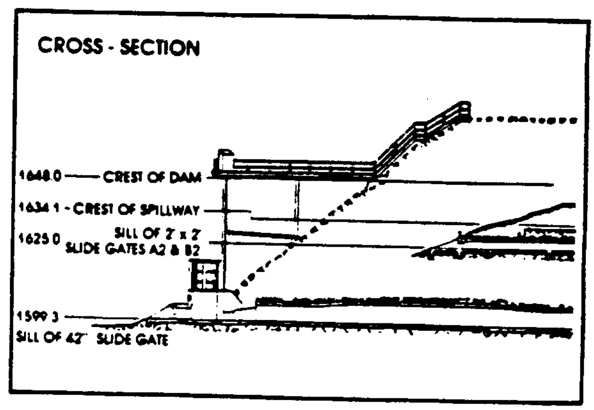
2 0180

WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	144.60	104.20	77.70	71.70
TOTAL MONTHLY OUTFLOW (AF)	144.80	104.10	77.80	71.80
MAX. MEAN DAILY INFLOW (CFS)	2.80	2.50	1.40	1.30
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.60	1.40	1.10	0.80
MONTHLY STORAGE CHANGE (AF)	-0.20	0.10	-0.10	-0.10

THOMPSON CREEK DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started September 1925 Completed March 1928
LOCATION - 3.0 miles north of Claremont.
DRAINAGE AREA - 3.5 square miles.
CAPACITY - 447.5 acre - feet.
SPILLWAY ELEVATION - 1,634 feet.

VOL 12

2 0181

DAM OPERATION RECORD SUMMARY

MAX. PEAK INFLOW	19.96 CFS from	1500	on	03-23-92	to	1600	on	03-23-92
MAX. PEAK OUTFLOW	6.30 CFS from	1500	on	02-10-92	to	1545	on	02-10-92
MAX. W.S. ELEVATION	1610.40 feet on	02-13-92		STORAGE		88.80 ACRE-FEET		
MIN. W.S. ELEVATION	1600.00 feet on	varies		STORAGE		0.00 ACRE-FEET		

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THOMPSON CREEK DAM OPERATION RECORD SUMMARY

WATER YEAR 1991-92	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

WATER YEAR 1991-92	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	85.20	93.10	11.60	0.00
TOTAL MONTHLY OUTFLOW (AF)	51.20	59.70	70.60	8.10
MAX. MEAN DAILY INFLOW (CFS)	14.80	15.60	0.60	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	34.00	33.40	-59.00	-8.10

WATER YEAR 1991-92	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE (AF)	0.00	0.00	0.00	0.00

2 0182

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2

0183

EROSION CONTROL

VOL 12

2 0184

EROSION CONTROL

Each year eroded material in various forms (trees, rock, sand, etc.) flows out of the mountain watersheds of Los Angeles County. In an effort to control this potentially disruptive force, the Department maintains a series of debris basins in canyon mouths and upstream stabilization structures in selected watersheds.

DEBRIS BASINS

The purpose of a debris basin is to entrap the debris flows emanating from the canyon and let the relatively desilted water pass into the flood control channels.

In the 1991-1992 water year, there were 114 debris basins. The total maximum capacity of the basins is approximately 7,573,050 cubic yards.

The Department cleaned out fifty debris basins and removed approximately 434,200 cubic yards of sediment.

Records of sediment inflow at individual debris basins and amounts excavated and removed are available in the Hydraulic/Water Conservation Division.

STABILIZATION STRUCTURES

Stabilization structures are constructed to control erosion in natural canyons. They serve to prevent downcutting by stabilizing alluvium deposits. In addition, they store debris generated by the watershed and serve to stabilize side banks, reducing side slope sloughing and bank erosion.

The Department maintains 225 stabilization structures in 47 major watersheds. No structures have been constructed since the 1973-74 water year.

EMERGENCY STRUCTURES

Emergency structures (rail and timber, and crib type) have been constructed to entrap the debris inflow from burned watersheds. They serve to protect improvements (road, channel, residence, etc.) located immediately downstream of the watersheds. Currently, 34 emergency structures exist with a total maximum capacity of 269,600 cubic yards. One major fire (over 500 acres) burned 1323 acres in this water year and is shown on the Burned Area Location Map on page PE2.

SEDIMENT REMOVAL FROM RESERVOIRS

Sediment deposition in reservoirs reduces the storage capacities and adversely affects flood control and water conservation efforts. Sediment removal is periodically necessary and is generally an expensive effort due to large quantities, the need to deal with water inflows, and in several cases, remote locations and limited accessibility for equipment.

Where practical, the Department encourages sediment removal by permittees at no cost to the Department such as at Eaton Wash and Devil's Gate Dams.

During the 1991-92 water year the Department completed cleanouts in Cogswell Reservoir and Morris Reservoir. These are two of three reservoirs in San Gabriel Canyon which collectively contain 36 million cubic yards (cy), about three-quarters of the cumulative volume of sediment currently behind all dams under the Department's control.

Morris reservoir's cleanout consisted of a Pilot Sluicing Project. This is the first debris removed from Morris Reservoir in its 57 year history. About 435,000 cy of material was removed with this year's cleanout.

The Department has also developed a Sediment Management Plan (SMP) with the goal of maintaining current flood control and water conservation capacities at the San Gabriel Canyon Reservoirs. The SMP identifies feasible alternatives for the removal, transport, and disposal of sediment from Cogswell, San Gabriel, and Morris Reservoirs. Sediment removal alternatives identified in the SMP include sluicing, flow assisted sediment transport, dredging, trucking, use of conveyor belts, and construction of a slurry pipeline. The Department is currently preparing an environmental document to evaluate the impacts of the various sediment removal concepts.

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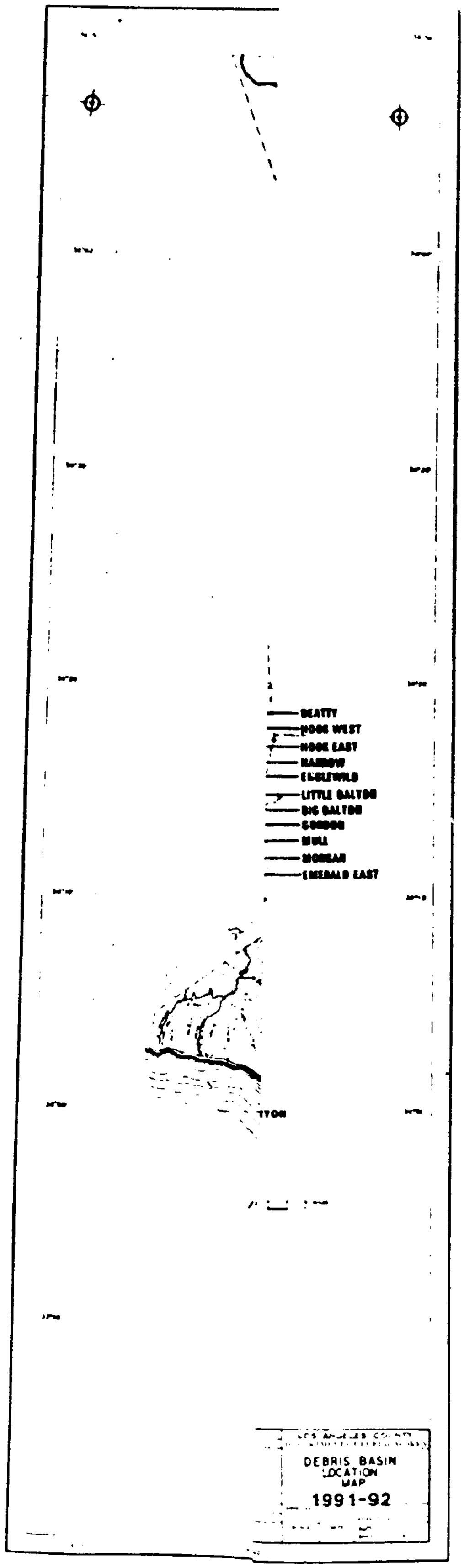

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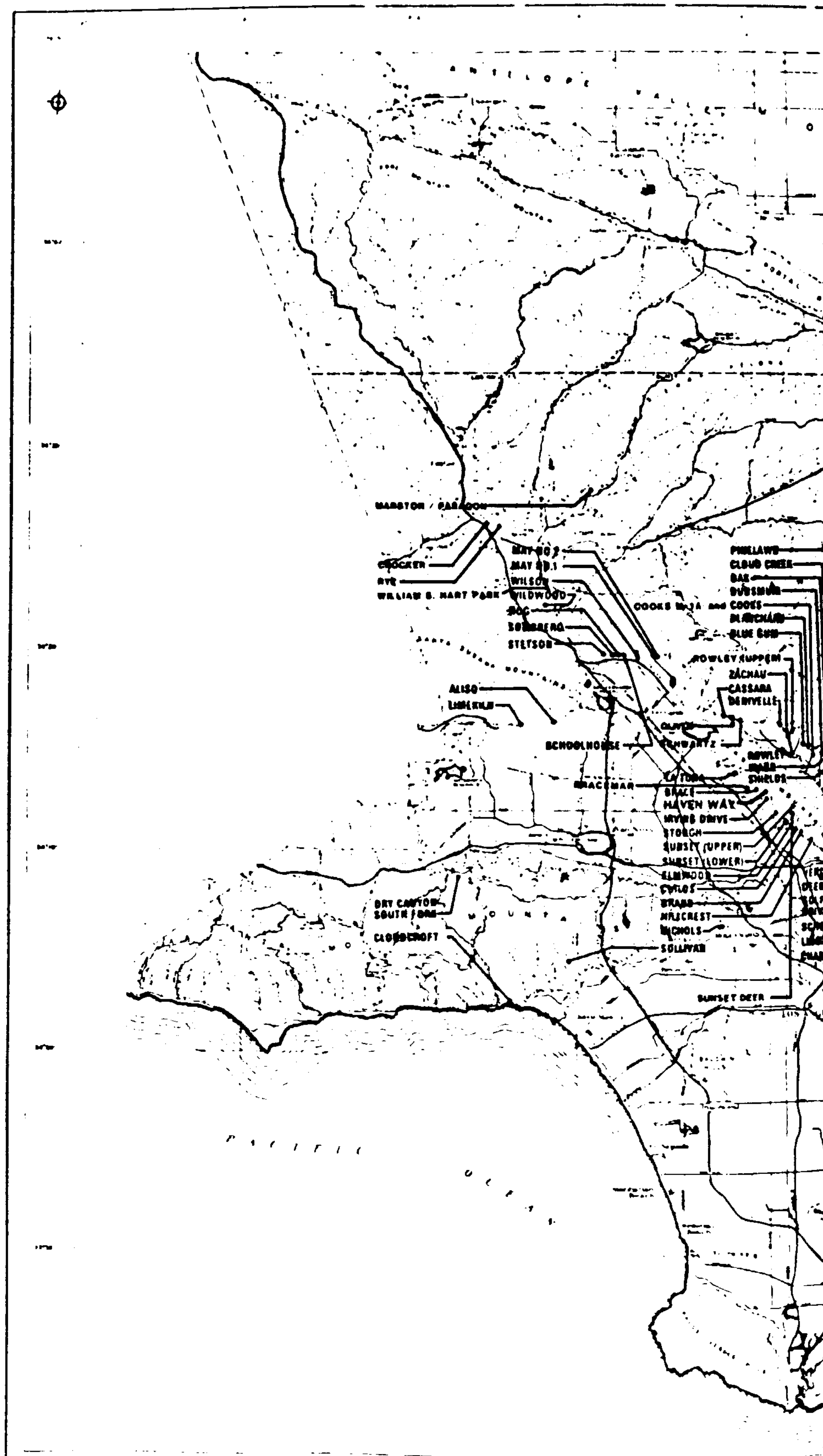

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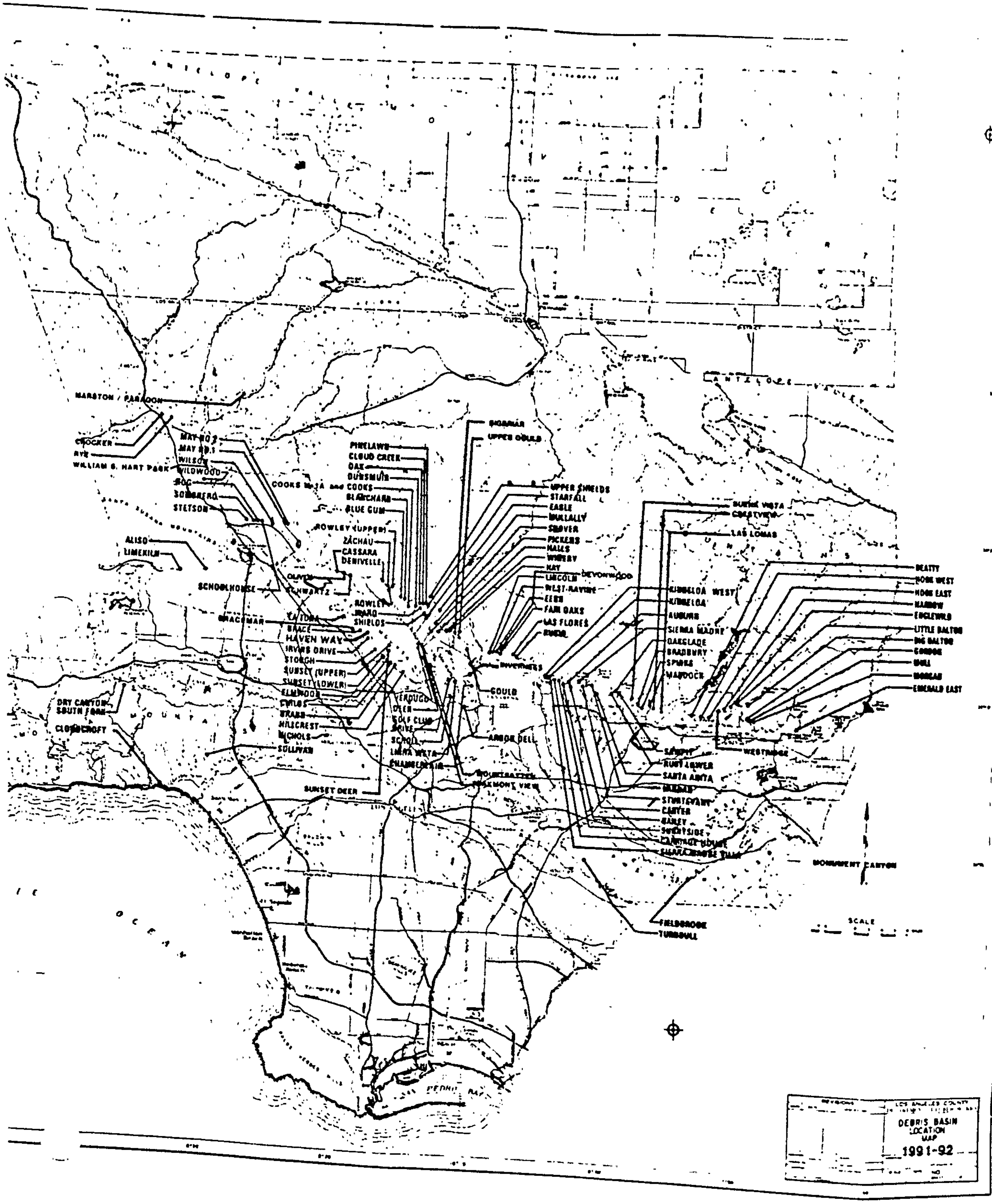

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DATA SHEET A

DEBRIS BASIN - DESIGN DATA

Including 1991-1992 Storm Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date: December 31, 1992
FILE: DSA92.WK4

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN (SQ. MI.)	BOTTOM ELEV. AT MAX. CAP. (FT.)	ELEV PORT INVERT (FT.)	ELEV. SPILLWAY CREST (FT.)	WIDTH SPILLWAY (FT.)	ELEV. CREST. OF DAM (FT.)	MAX. DEB. CAP. (CU. YDS.)
Aliso	1970 - 71	2.77	1108	1108.4	1120.0	70.0	1134.0	41,700 (8)
Arbor Dell	1971 - 72	0.11	898.7	898.4	913.0	22.9	919.6	12,400
Auburn	1954 - 55	0.19	1263.9	1263.0	1276.0	30.0	1283.0	31,600 (15)
Bailey	1945 - 46	0.60	1123	1123.1	1155.0	30.0	1166.0	128,800
Beatty	1970 - 71	0.27	800	800.0	807.0	32.0	815.5	43,000
Bigbriar	1971 - 72	0.02	1898.3	1896.0	1910.0	14.0	1910.9	2,600
Big Dalton	1959 - 60	2.94	1102	1101.9 (3)	1131.5	116.0	1148.7	517,800
Blanchard	1968 - 69	0.47	2026	2026.0	2053.5	40.0	2065.0	74,500
Blue Gum	1968 - 69	0.19	2020	2020.0	2042.0	25.0	2053.0	39,600
Brace	1971 - 72	0.29	1189.7	1189.7	1194.5	20.0	1203.3	27,500
Bracemar	1971 - 72	0.01	1140	1140.0	1145.5	8.0	1148.0	700
Bradbury	1954 - 55	0.68	912.5	913.1	920.0	58.0	928.0	89,800
Brand	1935 - 36	1.04	860	860.0	890.0	60.0	903.0	166,000
Buena Vista	1985 - 96	0.10	978.7	978.7	992.2	39.0	997.7	21,400
Carriage House	1970 - 71	0.03	1350.3	1350.0	1362.9	15.0	1366.8	6,100
Carter	1954 - 55	0.12	1222	1223.2	1238.2	30.0	1245.0	14,600
Cassara	1976 - 77	0.21	1271.5	1271.5	1291.7	66.0	1295.4	36,700
Chamberlain	1974 - 75	0.04	1084.6	1084.0	1097.5	20.0	1101.3	4,700
Childs	1963 - 64	0.30	1022	1022.0	1058.8	23.0	1071.0	50,400
Cloud Creek	1972 - 73	0.01	2350.5	2350.5	2360.0	(5)	2362.0	5,100 (14)
Cloudcroft	1973 - 74	0.21	313.9	315.0	329.5	36.0	329.5	34,700
Cooks	1951 - 52	0.58	2058	2058.0	2082.9	48.0	2092.0	51,900 (14)
Cooks M-1A	1975 - 76	(13)	2120.0	(10)	2142.4	(10)	(10)	33,700 (14)
Crestview	1983 - 84	0.03	864.4	864.0	886.2	20.0	891.7	5,900 (18)
Crocker	1983 - 84	0.67	1064.2	1064.2	1069.8	36.0	1077.0	19,300 (18)
Deer	1954 - 55	0.59	1185.4	1185.0	1201.0	56.0	1209.6	56,600
Denivelle	1976 - 77	0.18	1471	1471.0	1479.3	46.0	1483.3	8,200
Devonwood	1981 - 82	0.03	1899	1899.0	1915.8	22.0	1921.5	5,700
Dry Canyon-South Fork	1978 - 79	1.05	1062.8	1062.5	1074.8	32.0	1079.3	7,900
Dunsmuir	1935 - 36	0.84	2228	2227.7	2257.2	60.0	2272.2	102,700
Eagle	1936 - 37	0.48	1848.3	1848.3	1880.2	60.0	1895.2	62,400
Elmwood	1964 - 65	0.31	912	911.5	938.0	22.0	952.0	61,900
Emerald-East	1964 - 65	0.32	1185.1	1181.1	1192.0	30.0	1204.0	13,200
Englewild	1961 - 62	0.44	1274.9	1275.0	1297.0	50.0	1300.0	40,600
Fair Oaks	1935 - 36	0.21	1544	1544.0	1561.9	(6)	1566.5	23,800 (14)
Fern	1935 - 36	0.31	1438.7	1462.4 (1)	1470.2	25.0	1480.5	30,600
Fieldbrook	1974 - 75	0.35	712.7	713.0	718.0	28.0	722.3	2,800
Golf Club Drive	1970 - 71	0.32	880.7	880.7	902.0	36.7	915.0	14,700
Gordon	1973 - 74	0.18	1075.7	1075.0	1088.0	22.0	1096.0	18,800

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DATA SHEET A

DEBRIS BASIN - DESIGN DATA

Including 1991-1992 Storm Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date. December 31, 1992
FILE: DSA92.WK4

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN (SQ. MI.)	BOTTOM ELEV. AT MAX CAP. (FT.)	ELEV PORT INVERT (FT.)*	ELEV. SPILLWAY CREST (FT.)	WIDTH SPILLWAY (FT.)	ELEV. CREST. OF DAM (FT.)	MAX. DEB. CAP. (CU. YDS.)
Gould	1947 - 48	0.36	1529.5	1528.2	1548.0	55.0	1548.0	52,800 (14)
Gould (Upper)	1976 - 77	0.18	1883.9	1883.9	1897.7	32.0	1901.0	52,300
Halls	1935 - 36	0.86	1641.6	1641.8	1661.3	131.0	1664.0	89,400
Harrow	1958 - 59	0.43	1254.8	1255.0	1269.0	40.0	1277.8	68,000
Haven Way	1991 - 92	0.13	1323	1323.0	1329.0	20.0	1335.6	51,700 (16)
Hay	1936 - 37	0.20	1875.4	1901.0	1905.0	36.0	1915.0	34,400
Hillcrest	1962 - 63	0.35	883.5	883.5	895.0	18.0	901.0	57,800
Hog	1969 - 70	0.33	1520.1	1520.0	1535.0	32.0	1547.0	39,800
Hook East	1968 - 69	0.19	1197.5	1198.0	1210.8	37.0	1215.0	22,300
Hook West	1970 - 71	0.17	1144.9	1145.0	1159.8	40.0	1167.0	21,600
Inverness	1982 - 83	0.03	1253	1252.8	1256.7	20.0	1261.0	3,300
Irving Drive	1974 - 75	0.03	905.8	905.0	915.3	12.0	920.0	1,200
Kinneloa	1964 - 65	0.20	1370	1370.0	1388.0	40.0	1395.0	14,100
Kinneloa - West	1966 - 67	0.16	1384.9	1385.0	1400.0	22.0	1408.5	14,200
Lannan	1954 - 55	0.25	1016.0	1015.0	1035.9	14.0	1043.0	41,400 (14)
La Tuna	1955 - 56	5.34	1109.0	1110.0	1140.0	75.0	1157.0	482,300
Las Flores	1935 - 36	0.45	1685.1	(8)	1715.6	50.0	1726.4	55,600
Las Lomas	1983 - 84	0.07	895.4	896.0	906.6	24.0	911.0	5,400
Limekiln	1963 - 64	3.72	992.0	992.0	1003.0	77.0	1019.0	171,600
Lincoln	1935 - 36	0.50	1275.8	1276.0	1304.0	56.0	1322.5	39,400
Linda Vista	1970 - 71	0.37	979.5	979.5	989.8	40.0	995.7	3,200
Little Dalton	1959 - 60	3.31	1140.0	1139.5	1186.0	84.0	1200.2	660,500
Maddock	1954 - 55	0.26	888.6	891.9	901.0	36.0	904.0	45,000
Marston/Paragon	1988 - 89	0.20	1455.6	1455.6	1460.0	20.0	1466.0	6,000
May No. 1	1953 - 54	0.70	1665.9	1666.0	1684.0	60.0	1692.5	64,000
May No. 2	1953 - 54	0.09	1663.4	1663.5 (2)	1669.5	20.0	1674.0	10,000
Monument	1981 - 82	0.11	943.8	942.3	950.0	12.0	954.0	6,800
Morgan	1964 - 65	0.60	1135.0	1135.0	1158.0	45.0	1167.0	47,700
Mountbatten	1983 - 84	0.01	1136.2	1135.5	1140.9	20.0	1141.0	1,400
Mull	1973 - 74	0.15	1146.9	1147.0	1154.0	20.0	1165.0	12,500
Mullally (11)	1974 - 75	0.34	2420.0	2420.0	2435.4	42.0	2439.6	9,400
Nichols	1937 - 38	0.35	480.5	481.0	485.1	50.0	495.0	14,100 (14)
Oak	1975 - 76	0.05	2145.4	2145.7	2151.8	50.0	2156.2	8,700
Oakglade	1974 - 75	0.06	1274.6	1280.0	1290.0	20.0	1296.0	7,250
Oakmont View Drive	1984 - 85	0.02	1315.5	1315.5	1327.5	20.0	1327.5	3,400
Oliver	1989 - 90	0.18	1258.0	1258.0	1278.3	41.0	1283.3	32,100
Pickens	1935 - 36	1.50	1563.6	1564.0	1600.0	123.0	1613.0	125,100
Pinelawn	1973 - 74	0.02	2431.0	2430.5	2443.0	(7)	2448.5	3,200

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DATA SHEET A

DEBRIS BASIN - DESIGN DATA

Including 1991-1992 Storm Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date: December 31, 1992
FILE: DSA92.WK4

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN (SQ. MI.)	BOTTOM ELEV. AT MAX. CAP. (FT.)	ELEV PORT INVERT (FT.)	ELEV. SPILLWAY CREST (FT.)	WIDTH SPILLWAY (FT.)	ELEV. CREST. OF DAM (FT.)	MAX. DEB. CAP. (CU. YDS.)
Rowley	1953 - 54	0.21	1703.6	1703.6	1714.0	60.0	1722.0	43,100
Rowley (Upper)	1976 - 77	0.31	1926.0	1926.0	1946.0	42.0	1951.3	26,800
Rubio	1943 - 44	1.26	1582.1	1582.1	1608.3	59.0	1625.5	127,200
Ruby (Lower)	1955 - 56	0.28	810.8	809.6	828.0	45.0	833.0	28,600
Rye	1981 - 82	1.11	1073.9	1073.8	1077.7	58.2	1081.5	19,100
Saddleback	1988 89	0.04	1779.0	1779.3	1790.0	(10)	1796.0	27,000
Santa Anita	1959 - 60	1.70	748.5	748.5 (3)	774.7	160.0	786.0	394,600
Sawpit	1954 - 55	2.82	930.3	930.3	982.0	110.0	1000.0	635,700
Scholl	1945 - 46	0.16	950.0	950.0 (2)	956.0	76.0	966.0	9,300
Schoolhouse	1962 - 63	0.28	1459.6	1460.0	1478.5	20.0	1491.0	67,700
Schwartz	1976 - 77	0.25	1294.7	1294.7	1313.2	35.0	1319.0	45,400 (14)
Shields	1937 - 38	0.06	2030.0	2050.0	2058.1	30.0	2070.2	34,900
Sierra Madre Dam (12)	1927 - 28	2.39	1119.6	1119.5	1172.5	62.5	1175.0	136,400
Sierra Madre Villa	1957 - 58	1.46	1069.2	1069.2	1088.9	48.0	1102.5	402,700
Snover	1936 - 37	0.21	1862.8	1862.7	1879.0	40.0	1893.7	24,900
Sombrero	1969 - 70	1.06	1539.6	1540.0	1564.8	45.0	1580.0	87,900
Spinks	1958 - 59	0.42	750.0	750.0	761.5	40.0	765.9	56,000
Starfall	1973 - 74	0.13	2428.0	2428.0	2441.5	30.0	2446.5	14,900
Stetson	1969 - 70	0.29	1556.0	1555.0	1570.0	32.0	1570.0	41,300
Stough	1940 - 41	1.65	1006.0	1005.8	1031.5 (4	100.0	1043.5	180,600 (14)
Sturtevant	1967 - 68	0.03	975.0	971.0	983.6	8.0	990.0	1,400
Sullivan	1970 - 71	2.38	570.0	570.0	587.0	50.0	599.3	51,000
Sunnyside	1970 - 71	0.02	1290.0	1290.0	1299.5	15.0	1303.8	3,400
Sunset Canyon-Deer	1982 - 83	0.21	1382.4	1380.5	1401.8	24.0	1409.1	5,000
Sunset (Lower)	1963 - 64	0.45	1003.8	994.5	1040.0	40.0	1056.0	160,600
Sunset (Upper)	1928 - 29	0.44	1574.2	1574.0	1603.7	75.0	1610.1	15,900
Turnbull	1952 - 53	0.89	476.1	475.6	492.0	40.0	503.0	21,600
Upper Shields (11)	1976 - 77	0.20	2505	2502.0	2518.8	29.5	2524.0	5,600
Verdugo	1935 - 36	9.40	1109.5	1110.0	1119.7	145.0	1131.0	131,000
Ward	1956 - 57	0.12	2021.8	2022.0	2043.0	58.0	2035.3	26,400
West Ravine	1935 - 36	0.25	1468.8	1469.6 (1)	1501.9	20.0	1505.5	44,900
Westridge	1974 - 75	0.02	894	894.0	901.0	10.7	906.0	1,400
Wildwood	1967 - 68	0.65	1342.9	1342.9	1354.0	50.0	1360.0	20,700
William S. Hart Park	1983 - 84	0.09	1282.5	1280.0	1290.0	19.0	1293.0	2,400
Wilson	1962 - 63	2.58	1493.3	1493.0	1526.0	60.0	1543.0	313,100
Winery	1968 - 69	0.18	1920	1920.0	1935.0	20.0	1945.0	29,200
Zachau	1956 - 57	0.35	1803.4	1803.1	1820.5	44.0	1823.0	48,400
114 DEBRIS BASINS		74						7,674,060

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DATA SHEET A

DEBRIS BASIN - DESIGN DATA

Including 1991-1992 Storm Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date: December 31, 1992
FILE:DSAR92.WK4

(1) LOWEST CLEAR WATER OUTLET, NOT SPILLWAY.
(2) ELEVATION OF SPILLWAY NOTCH.
(3) FLOW LINE OF SLUICEWAY.
(4) ELEVATION OF SPILLWAY INTO OUTLET CHANNEL. ELEVATION OF OVERFLOW SPILLWAY 1036.9 FEET.
(5) ONE 30-INCH REINFORCED CONCRETE PIPE.
(6) FOUR 36-INCH CORRUGATED METAL PIPES.
(7) ONE 36-INCH REINFORCED CONCRETE PIPE. (ELEVATED INLET)
(8) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(9) PIT-TYPE BASIN.
(10) INFORMATION UNAVAILABLE.
(11) SPECIAL CLEANOUT REQUIRED DUE TO LIMITED STORAGE.
(12) CLEANOUT REQUIRED WHEN DEBRIS REACHES OR EXCEEDS ELEV. 1128.9 AGAINST FACE OF DAM.
(13) VALUES ARE COMBINED WITH COOKS DEBRIS BASIN
(14) VALUES ARE BASED ON RECENTLY APPROVED CUTPLANS OR NEW MAX. CAPACITY
(15) REDUCED CAPACITY BASED ON 5% MAX CONE SLOPE
(16) CAPACITY BASED ON "F" DRAWINGS AND IT WILL BE REVISED BASED ON A NEW TOPO MAP.
(17) BASIN BEING REPLACED WITH NEW DEBRIS BASIN DOWNSTREAM.
(18) SPILLWAY LEVEL STORAGE CAPACITY.
(19) MAXIMUM CAPACITY MAY BE MORE THAN SHOWN AND WILL BE REVIEWED.

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DATA SHEET B

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1991 - 1992 Storm Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date: December 31, 1992
FILE: DSB92.WK4

DEBRIS BASIN		NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED (CU. YDS.) (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION (CU. YDS.)	SEASON	ESTIMATED CONDITIONS DEBRIS STORED (CU. YDS.)	CAPACITY AVAILABLE (CU. YDS.)	PER CENT
Aliso	(11)	22	170,575	30,700	1982-83	-1483	43,183	104 (5)
Arbor Dell	(11)	21	1,929	800	1979-80	400	12,000	97
Auburn		38	84,889	20,100	1961-62	1523	30,077	95
Bailey		47	239,231	91,000	1979-80	8577	120,223	93
Beatty		22	13,920	7,600	1979-80	3659	39,141	91
Bigbriar		21	3,014	623	1987-88	-244	2,844	109
Big Dalton		33	833,003	296,700	1968-69	5200	512,600	99
Blanchard		24	70,881	36,600	1977-78	2811	71,689	96
Blue Gum		24	38,346	19,100	1977-78	-2913	42,513	107
Brace		21	39,855	12,000	1977-78	97	27,403	100
Braemar		21	664 (7)	283	1980-81	-200	900	129 (9)
Bradbury		38	268,262	70,200	1968-69	2098	87,702	98
Brand		57	266,632	53,100	1977-78	4951	161,049	97
Buena Vista		7	40	40	1987-88	40	21,360	100
Carriage House		22	4,742	3,400	1979-80	200	5,900	97
Carter		38	37,148	12,600	1979-80	1152	13,448	92
Cassara		16	28,798	16,800	1977-78	1611	35,089	96
Chamberlain (11)		18	556	300	1974-75	-100	4,800	102
Childs		29	45,220	10,700	1980-81	202	50,198	100
Cloud Creek		20	3,322	1,800	1977-78	-610	5,710	112
Cloudcroft		19	12,290	6,100	1973-74	1368	33,332	96
Cooks		41	175,472 (3)	61,200 (3)	1977-78	2451 (3)	83,149	97 (3)
Cooks M-1A		17	(13)	(13)	(13)	(13)	(13)	(13)
Crestview		9	(6)	(6)	(6)	5	5,895	100
Crocker		9	5,745	5745	1991-92	4046	15,254	79
Deer		38	161,857	44,200	1968-69	-251	56,851	100
Denivelle		16	9,626	5,500	1977-78	349	7,851	96
Devonwood		11	626	400	1991-92	200	5,500	96
Dry Canyon-South Fork		14	8,348	5,300	1979-80	400	7,500	95
Dunsmuir		57	361,512	86,200	1977-78	-3416	106,116	103
Eagle		58	194,910	41,700	1937-38	5447	56,953	91
Elmwood (11)		28	53,433	16,100	1980-81	22	61,878	100
Emerald-East (11)		28	10,561	1,800	1985-86	45	13,155	100
Englewild		31	85,640 (2)	60,200 (2)	1968-69	570	40,030	99
Fair Oaks		57	109,020	15,700	1935-36	-2462	26,262	110
Fern		57	164,359	23,900	1968-69	-1340	31,940	104
Fieldbrook		18	1,405	500	1977-78	408	2,392	85
Golf Club Drive		22	33,400	11,600	1979-80	642	14,058	96
Gordon		19	4,485	3,800	1977-78	-119	16,919	101

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DATA SHEET B

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1991 - 1992 Storm Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date: December 31, 1992
FILE: DSB92.WK4

DEBRIS BASIN	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED (CU. YDS.) (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION (CU. YDS.)	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS DEBRIS STORED (CU. YDS.)	ESTIMATED CONDITIONS CAPACITY AVAILABLE (CU. YDS.)	ESTIMATED CONDITIONS CAPACITY AVAILABLE PER CENT
Gould	45	121,394	18,000	1965-66	521	52,279	99
Gould (Upper)	16	36,621	11,177	1991-92	1108	51,192	98
Halls	57	597,961	102,100	1937-38	-1249	90,649	101
Harrow	34	78,297 (2)	63,400 (2)	1968-69	-5561	73,561	108
Haven Way	1	(8)	(8)	(8)	(8)	51,700	100
Hay	56	72,463	18,200	1937-38	5249	29,151	85
Hillcrest	30	52,349	11,700	1964-65	4462	53,338	92
Hog	23	6,500	3,900	1977-78	66	39,534	100
Hook East	24	45,709 (2)	40,200 (2)	1968-69	0	22,300	100
Hook West	22	7,139	3,600	1979-80	301	21,299	99
Inverness	10	281	252	1982-83	483	2,817	85
Irving Drive	18	1,584	600	1980-81	38	1,162	97
Kinneloa	28	54,484 (2)	17,600 (2)	1968-69	528	13,572	96
Kinneloa West	26	69,340 (2)	22,200 (2)	1968-69	976	13,224	93
Lannan	38	84,067	18,200	1969-70	0	41,400	100
La Tuna	37	632,474	172,100	1977-78	26115	456,185	95
Las Flores	57	214,754	36,000	1937-38	0	55,600	100
Las Lomas	9	(6)	(6)	(6)	35	5,365	99
Limekiln	29	308,861	42,300	1965-66	3613	167,987	98
Lincoln (11)	57	131,545	28,400	1968-69	688	37,712	98
Linda Vista (11)	22	12,546	3,400	1977-78	-240	3,440	108
Little Dalton	33	905,170	337,800	1968-69	16037	644,463	98
Maddock	38	56,979	16,200	1980-81	2045	42,955	95
Marston/Paragon	4	(8)	(8)	(8)	(8)	6,000	100
May No. 1 (11)	39	220,149	45,800	1968-69	562	63,438	99
May No. 2	39	27,937	6,200	1966-67	578	9,422	94
Monument	11	3,009	2,600	1981-82	292	6,508	96
Morgan	28	30,292	12,900	1968-69	651	47,049	99
Mountbatten	9	95	(6)	(6)	95	1,305	93
Mull	19	2,040	1,100	1979-80	146	12,354	99
Mullally (10)	18	62,990 (4)	24,400 (4)	1977-78	1309	8,091	86 (16)
Nichols	55	128,067	21,800	1951-52	471	13,629	97
Oak	17	13,258	6,900	1977-78	785	7,915	91
Oakglade	18	1,455	1,200	1977-78	538	6,712	93
Oakmont View Drive	8	221	221	1991-92	221	3,179	94
Oliver	3	30380 (14)	16255 (14)	1977-78	0	32,100	100
Pickens	57	729,000	140,600	1977-78	-107	125,207	100
Pinelawn	19	5,258	1,200	1976-77	79	3,121	98

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DATA SHEET B

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1991 - 1992 Storm Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date: December 31, 1992
FILE: DSB92.WK4

DEBRIS BASIN	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED (CU. YDS.) (1)	MAXIMUM SEASONAL DEBRIS PRODUCTION (CU. YDS.)	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS: DEBRIS STORED (CU. YDS.)	ESTIMATED CONDITIONS: CAPACITY AVAILABLE (CU. YDS.)	ESTIMATED CONDITIONS: CAPACITY AVAILABLE PER CENT
Rowley	39	77,618 (4)	13,000 (4)	1977-78	1383	41,717	97
Rowley (Upper)	16	50,306 (4)	31,900 (4)	1977-78	-2073	30,873	107
Rubio	49	285,876	133,000	1979-80	-1172	129,372	101
Ruby (Lower)	37	20,448	8,300	1968-69	1016	27,584	96
Rye	11	13,577	10,000	1981-82	-771	19,871	104
Saddleback	4	500	(6)	(6)	500	26,500	98
Santa Anita	33	701,789 (2,3)	132,000 (2,3)	1961-62	17942	376,658	95
Sawpit	38	688,846 (2,3)	232,200 (2,3)	1968-69	1849	633,851	100
Scholl	47	18,164	800	1968-69	670	8,630	93
Schoolhouse	30	34,331	21,600	1962-63	5076	62,624	93
Schwartz	16	49,165	21,600	1977-78	4106	41,294	91
Shields	55	173,612 (3)	7,800	1937-38	1800	33,000	95
Sierra Madre Dam (12)	65	365,888 (2)	95,200 (2)	1968-69	1015	135,385	99
Sierra Madre Villa	35	508,701	118,600	1961-62	-38674	441,374	110
Snover	56	109,280	19,300	1938-39	4883	19,917	80
Sombrero	23	6,030	3,300	1977-78	175	87,725	100
Spinks	34	67,086	15,600	1968-69	700	55,300	99
Starfall	19	29,030	14,200	1977-78	1857	13,043	88
Stetson (11)	23	19,196	1,500	1977-78	1962	39,338	95
Stough	52	162,766	44,100	1964-65	3447	177,153	98
Sturtevant	25	1,321	500	1977-78	120	1,280	91
Sullivan	22	93,952	35,300	1979-80	5178	45,822	90
Sunnyside	22	1,764	800	1978-79	35	3,365	99
Sunset Canyon-Deer	10	4,075	3,400	1982-83	100	4,900	98
Sunset (Lower)	29	144,350	20,200	1980-81	2581	158,019	98
Sunset (Upper)	64	146,427	27,000	1964-65	-1123	17,023	107
Turnbull (11)	40	54,372 (2)	15,900 (2)	1968-69	-957	22,557	104 (5)
Upper Shields (15)	16	43,217 (4)	16,900 (4)	1977-78	(15)	(15)	(15)
Verdugo	57	827,992	105,400	1937-38	13334	117,666	90
Ward	36	51,668	17,800	1977-78	230	26,170	99
West Ravine	57	149,160	29,900	1937-38	-463	45,363	101
Westridge	18	200	(6)	(6)	187	1,213	87
Wildwood	25	81,546	16,700	1977-78	171	20,529	99
William S. Hart Park	9	608	600	1983-84	-97	2,497	104
Wilson	30	215,634	55,500	1968-69	14671	298,429	95
Winery	24	27,215	9,400	1968-69	1659	27,541	94
Zachau	36	107,185 (4)	48,100 (4)	1977-78	1100	47,300	98
114 DEBRIS BASINS		13,621,280				7,429,662	

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R0053500

DATA SHEET B

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1991 - 1992 Storm Season

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date: December 31, 1992
FILE: DSB92.WK4.

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(1) VOLUME OF DEBRIS DEPOSITED IN BASINS DOES NOT INCLUDE DEBRIS SLUICED THROUGH OPEN PORTS OR NOTCH.

(2) VOLUME OF DEBRIS DEPOSITED DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1968-69 SEASON.

(3) INCLUDING DEBRIS FROM UPSTREAM BASIN OR DAM.

(4) VOLUME OF DEBRIS DEPOSITED DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1977-78 SEASON.

(5) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.

(6) NO SIGNIFICANT DEBRIS INFLOWS RECORDED.

(7) NO DEBRIS RECORDS EXIST FOR THE FIRST 9 SEASONS.

(8) INFORMATION UNAVAILABLE.

(9) MAXIMUM CAPACITY MAY BE MORE THAN SHOWN AND WILL BE REVIEWED.

(10) SPECIAL CLEANOUT REQUIRED DUE TO LIMITED STORAGE

(11) SPECIAL CLEANOUT REQUIRED DUE TO BURNED WATERSHED

(12) CLEANOUT REQUIRED WHEN DEBRIS REACHES OR EXCEEDS ELEV. 1128.9 AGAINST FACE OF DAM.

(13) VALUES ARE COMBINED WITH COOKS DEBRIS BASIN.

(14) INCLUDING DEBRIS DATA FROM PREVIOUS BASIN.

(15) BASIN BEING REPLACED WITH NEW DEBRIS BASIN DOWNSTREAM

(16) BASIN TO BE CLEANED.

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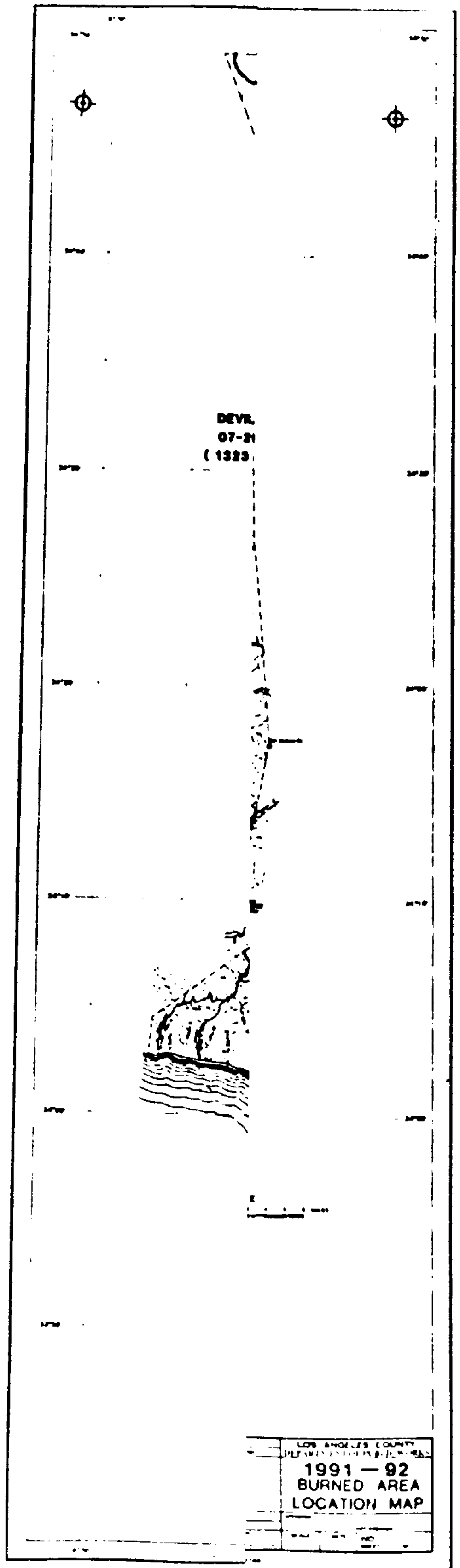

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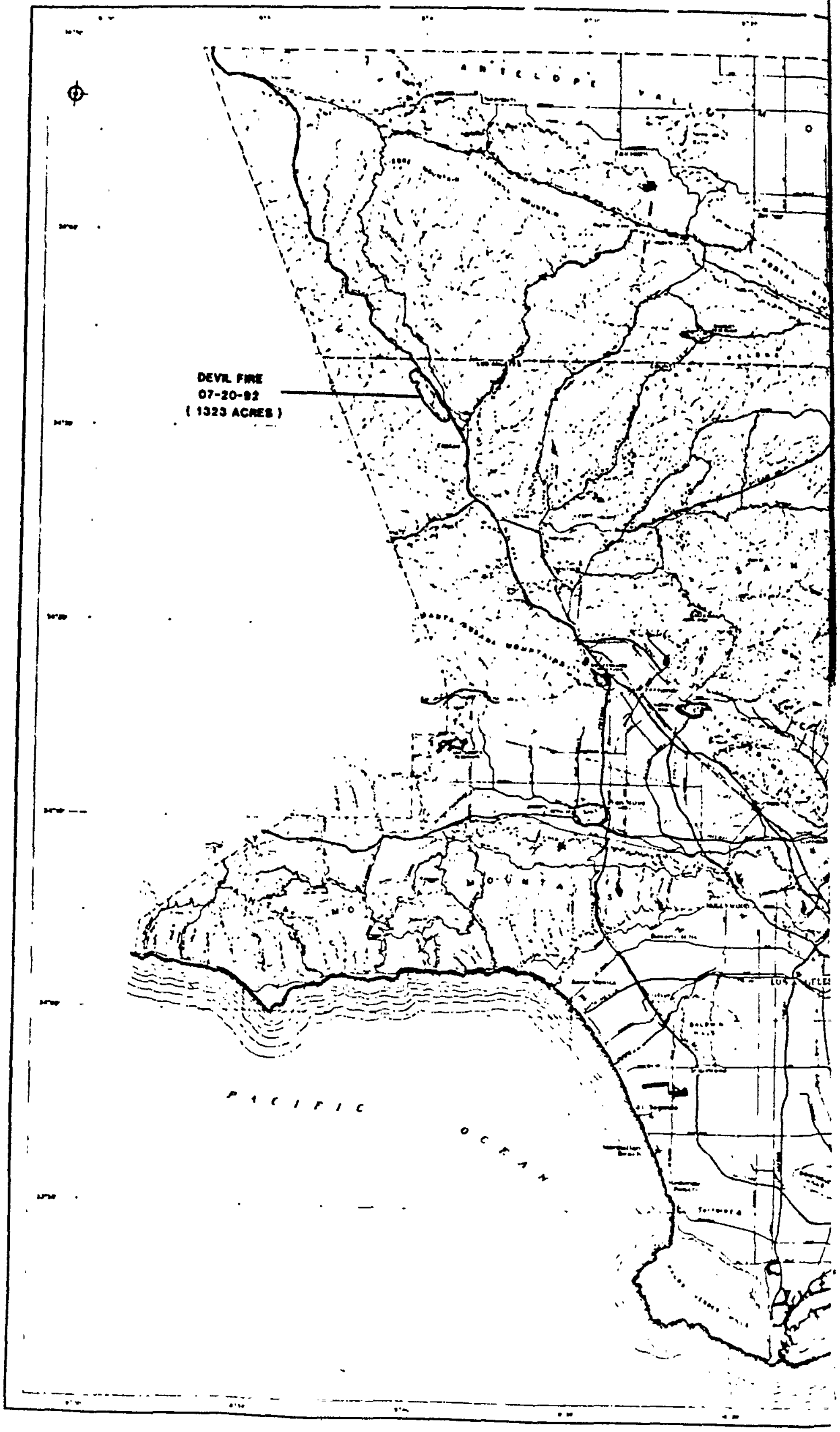

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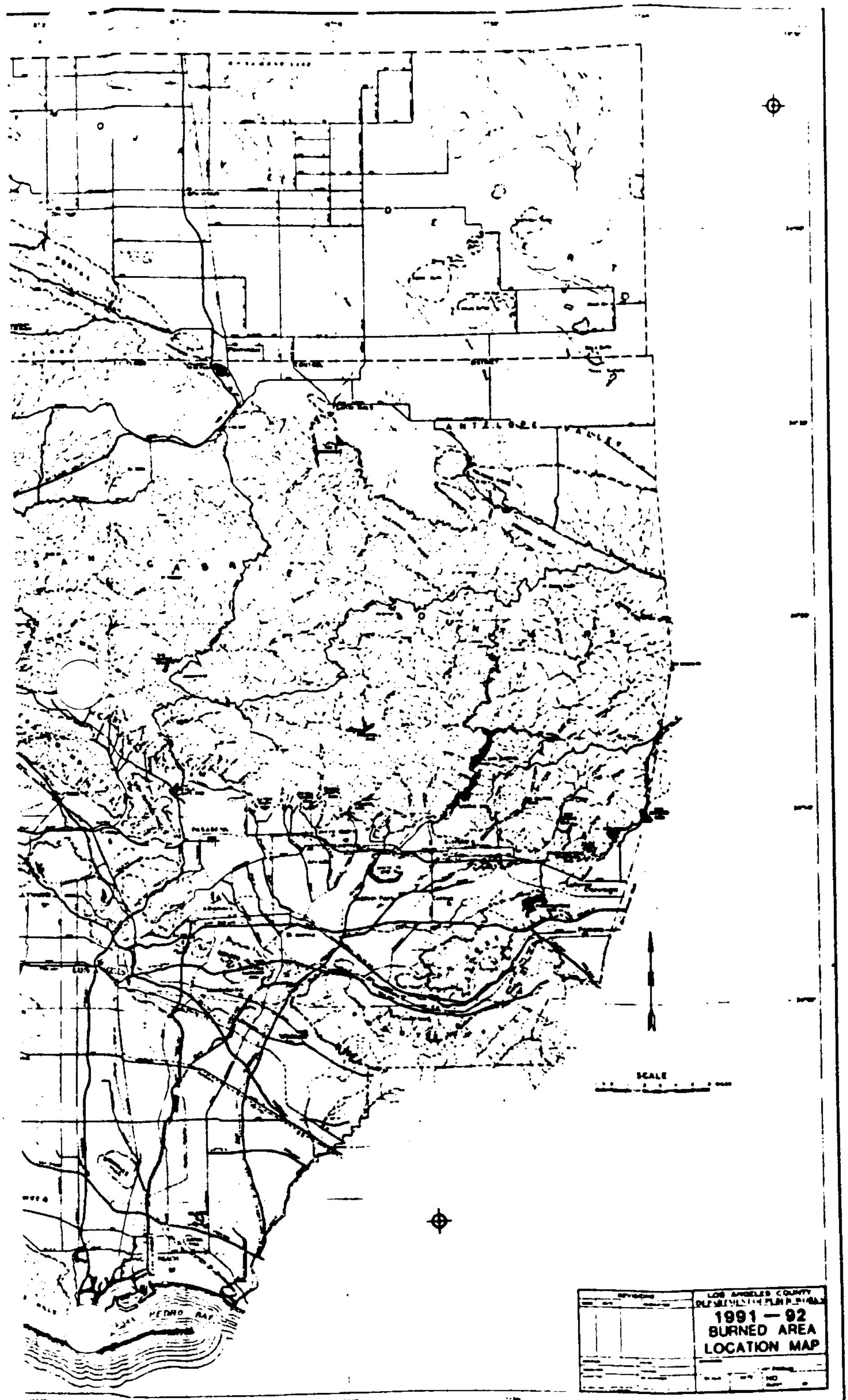
LOS ANGELES COUNTY
1991 — 92
BURNED AREA
LOCATION MAP
SCALE
PEDRO BAY

VOL 12

2

0200

WATER QUALITY

WATER QUALITY

Since its conception, the Flood Control District (now Department of Public Works) has actively engaged in operations which have proven indispensable in preserving the integrity of our water resources, both quantity and quality, and has aided in the establishment of regulations or controlling criteria by those agencies so empowered.

Prior to March 1986, monitoring activities in the field of water quality control were conducted by the Water Quality Section of Hydraulic/Water Conservation Division. In March 1986, the responsibilities of conducting such activities were transferred to Waste Management Division as a result of the consolidation. These activities include, among others, the collection of water quality samples, their analyses, and the interpretation and reporting of the resulting data.

Areas of involvement include the monitoring of all groundwater basins through the sampling of numerous wells, the monitoring of storm and low water flows at various strategic locations on the major streams or channels, and an assumed or obligated responsibility to monitor the quality effects and subsurface travel of recharge areas, specifically the Whittier Narrows Spreading Grounds area.

The Water Quality Section, together with personnel of other Departmental divisions, also conducts investigations into pollution problems relative to our facilities, particularly those from industrial discharges, vehicle accidents, ruptured pipelines, or the indiscriminate dumping of various waste products.

The principal objectives of these investigations are to determine the degree and apparent source or origin of the pollution and to take the necessary action that will immediately abate the existing problem and possibly provide a means to prevent or limit recurrence.

Since 1986, the Water Quality Section also has been conducting the screening of proposed connections to County storm drains, and developments over County right-of-ways, for the purpose of minimizing/eliminating potential of pollutants to the storm drain waters and, thereby, to the environment.

The above-mentioned activities of the Water Quality Section have recently been intensified, particularly in the areas of interfacing and coordinating with other municipalities/cities, environmental organizations, as well as Federal and State agencies, in an effort to comply with the regulations and requirements mandated under the 1987 Clean Water Act, whereby the Department's storm drain system is under the National Pollutant Discharge Elimination System (NPDES) permitting regulations of the California Regional Water Quality Control Board (CRWQCB).

The NPDES Permit (CA0061654) issued for the storm drain system in Los Angeles County requires the development of programs to improve the quality of stormwater/urban runoff discharges into the storm drain system. Los Angeles County, represented by the Department of Public Works, is the Principal Permittee and the cities within the County are

Co-Permittees. The drainage area covered by the Permit will become active in three phases, with Phase I, the Santa Monica Bay Drainage Basin, having begun July 1, 1990.

Phase II, which involves San Fernando and San Gabriel Drainage Basins, has begun in July 1992.

The Permit requires the County, together with the cities in the County, to (a.) develop and implement a stormwater/urban runoff monitoring program to gather data on the type and source of pollutants within the drainage basin, and (b.) develop and implement Best Management Practices (BMPs) to reduce the amount of pollutants that find their way into the storm drain system.

SURFACE WATER QUALITY

Prior to 1984, dry weather samples were collected from 30 sampling stations on a monthly basis for analysis such as general minerals, bacteria, pesticides, and heavy metals. In addition, storm samples were also collected and analyzed at least three times annually from the same 30 stations during storms season.

From 1984 to 1987, as a result of reorganization, the number of surface water monitoring stations was reduced to 21, while the parameters analyzed were reduced to include only total dissolved solids, pH, and dissolved oxygen. Storm sampling activities were also significantly curtailed.

In 1988, recognizing the inadequacy of the then existing monitoring program to meet the Department's need in dealing with the important issues in the areas of water quality, the Department Administration approved and implemented an expanded monitoring program effective May 1, 1988.

There are 28 monitoring stations in the Department's current Surface Water Quality Monitoring Program, from which dry weather samples are collected and analyzed on a monthly basis. These sampling stations are strategically located throughout the Department's major storm drains and water conservation facilities where the flows are representative of typical land uses as well as areas of significant water quality concerns. Of the 28 monitoring stations in the program, six are located at the outlets to Santa Monica Bay, while one is located in the mountain area where flow is considered to be natural and uncontaminated with the various pollutants associated with urbanization and developed land uses.

Monthly dry weather samples, thus collected, are analyzed for general minerals (pH, specific conductance, total dissolved solids, total hardness, potassium sulfate, calcium, magnesium, chloride, fluoride, nitrate-nitrogen, nitrite-nitrogen, ammonium-nitrogen, phosphate-P, boron, iron, and manganese), bacteria, pesticides, heavy metals (silver arsenic, barium, cadmium, chromium, mercury, lead, selenium, copper, nickel, zinc, and chromium [VI]), oil and grease, total organic carbon, total petroleum hydrocarbons, PCB's, biochemical oxygen demand, and volatile organic compounds (TCE, carbon tetrachloride, vinyl chloride, 1,2 dichlorethene, benzene, 1,1 dichloroethylene, 1,1,1 trichloroethane, p-dichlorobenzene). In addition, storm samples are collected for three to four storms annually from 21 stations, including San Gabriel Coastal and Rio Hondo Spreading Grounds for extensive analysis similar to those for dry weather samples, with additional testing of total suspended solids and volatile suspended solids to be included. For storm samples collected at San Gabriel Coastal and Rio Hondo Spreading Grounds, priority pollutant constituents are also analyzed under an agreement with the Central and West Basin Water Replenishment District.

A selective list of total dissolved solids is shown for some of the sampling locations on the streams and channels monitored under the Surface Water Quality Program. For a conception of the analysis performed on the surface flows, a yearly compilation of constituent determination is shown for one (Los Angeles River at Wardlow) of the sampling stations in the program.

GROUNDWATER QUALITY

The annual sampling of water wells, under a selected scheduling, in five major basins in Los Angeles County comprise the Groundwater Quality Program. The program, initiated in 1970, is coordinated with the State of California Department of Water Resources and the City of Los Angeles Department of Water and Power. These agencies participate in the obtainment and analysis of samples.

All the water well samples are from active production wells used either for municipal supply, irrigation, or for industrial purposes and are selected to represent a general portrayal of basin water quality conditions. The samples taken under this program are analyzed for major minerals, total dissolved solids, electrical conductivity, pH, and in specific cases, phosphate, iron, manganese, fluoride, or boron.

WATER QUALITY DATA ACCESSIBILITY

Data acquired from the various programs are on file in the Water Quality Section. In addition, all data is accessible to any user through STORET, an Environmental Protection Agency computer system that stores, retrieves, and manipulates data using agency code 21CALAFD.

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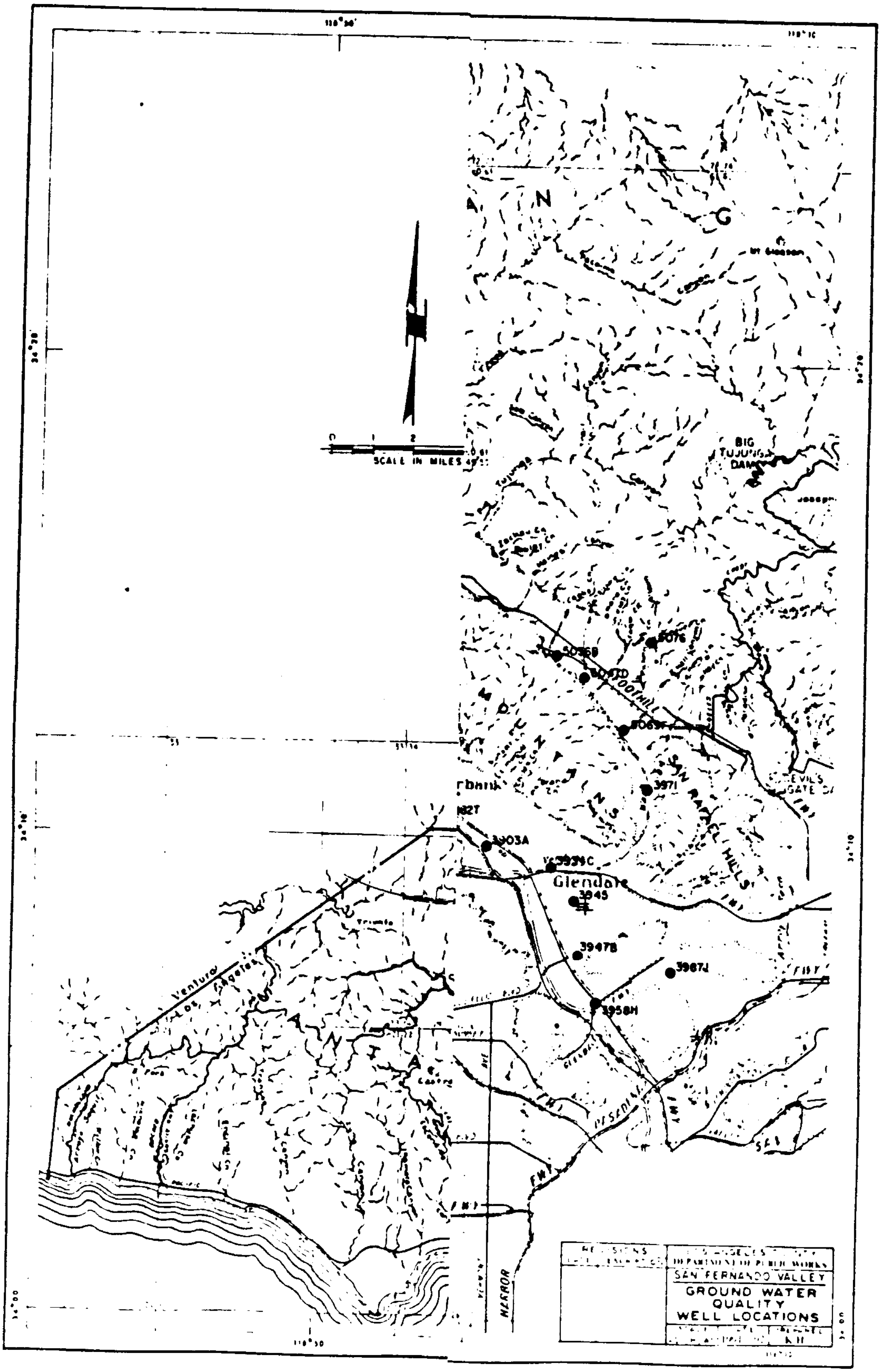
Surface Water Quality Monitoring Selected Surface Station
Table 1 Total Dissolved Solids - mg/l
1991-92 Season (Dry Weather Flow)

Sampling Location	Oct. 1991	Nov. 1991	Dec. 1991	Jan. 1992	Feb. 1992	Mar. 1992	Apr. 1992	May 1992	Jun. 1992	Jul. 1992	Aug. 1992	Sep. 1992	Average Value
Ballona Creek at Sawtelle Blvd.	642	772	952	972	856	988	884	570	602	700	752	638	777
Coyote Creek at Orangethorpe Avenue Willow Street	1028 686	1080 768	676 668	1070 680	1144 676	1164 920	1110 782	1150 1030	1060 788	1100 1140	926 818	886 698	1033 805
Dominguez Channel Above Vermont Avenue	649	748	564	736	-	472	770	-	908	630	170	838	649
Los Angeles River at Wardlow Road Firestone Boulevard	680 680	776 684	688 688	694 610	780 380	852 832	796 804	742 666	782 708	854 652	728 610	764 694	761 667
Los Cerritos Channel at Stearns Street	559	424	300	560	608	484	740	606	978	682	916	-	623
Rio Hondo River at Southern Avenue Spreading Grounds	705 660	692 604	352 -	500 480	- 460	932 648	1214 542	2020 246	660 352	- 256	- -	- 608	884 486
Santa Monica Cyn. Ch. at Short Street	949	788	880	1096	778	880	904	844	856	898	782	948	884
San Gabriel River at Spreading Grounds Willow Street	655 810	604 740	- 772	640 790	- 668	- 736	568 828	562 850	582 788	- 662	- 896	- 698	604 770
San Jose Creek at Workman Mill Road	677	664	596	860	912	888	966	788	880	874	874	890	822

Surface Water Quality Analysis (Partial Data)
Monthly Monitoring 1991-92 Season (Dry Weather)
Los Angeles River at Wardlow Road

Constituent mg/l	Oct. 1991	Nov. 1991	Dec. 1991	Jan. 1992	Feb. 1992	Mar. 1992	Apr. 1992	May 1992	Jun. 1992	Jul. 1992	Aug. 1992	Sep. 1992	Average
Hardness as $CaCO_3$	300	295	240	276	400	390	380	337	337	345	332	340	331
Calcium	96	48	76	75	114	112	104	83	75	81	77	78	85
Magnesium	15	43	12	21	28	27	29	31	36	35	34	35	29
Sodium	132	134	125	131	120	124	126	112	121	129	132	139	127
Potassium	13.7	16.5	16.3	19.0	14.6	13.9	10.9	14.2	14.3	16.6	15.1	13.0	14.8
Ammonium	2.0	9.2	8.0	9.7	9.7	3.0	7.0	8.2	0.5	1.7	2.2	0.7	5.2
Alkalinity as $CaCO_3$	189	200	139	198	209	192	230	192	214	193	184	194	195
Sulfate	144	158	161	195	287	274	283	239	170	225	222	307	222
Chloride	164	136	122	146	134	125	205	161	140	173	183	166	155
Nitrate-N	6.71	10.60	4.64	2.33	3.10	2.13	3.23	2.16	1.89	6.28	1.60	4.65	4.11
Phosphate	5.20	2.80	3.60	3.50	2.10	3.02	4.38	4.59	2.96	<0.03	2.62	3.72	3.50
Total Dissolved Solids	680	776	688	694	780	852	796	742	782	854	728	764	761
BOD	20.6	63.6	50.3	<1	55.0	<1	29.3	2.0	3.5	10.6	16.8	16.4	22.3
Total Organic Carbon	11.2	14.9	14.8	10.2	12.6	16.5	22.5	29.3	25.4	20.7	23.4	11.6	17.8
MPN/100ml													
Fecal Coliform	5,000	5,000	9,000	3,000	800	1,400	20	5,000	3,000	5,000	16,000	1,200	4,535
Total Coliform	>16,000	>16,000	>16,000	>16,000	16,000	>16,000	20	>16,000	>16,000	>16,000	>16,000	1,900	>16,000
Fecal Streptococcus	290	500	16,000	30	1,300	300	<20	700	2,200	3,000	5,000	3,000	2,693
Enterococcus	170	500	5,000	30	1,300	300	<20	700	2,200	2,400	5,000	3,000	1,717
pH	8.3	8.7	8.3	8.3	8.1	8.6	8.5	8.5	8.4	8.8	8.8	8.0	8.4
Temperature	60	64	52	50	58	60	66	68	70	70	70	68	63



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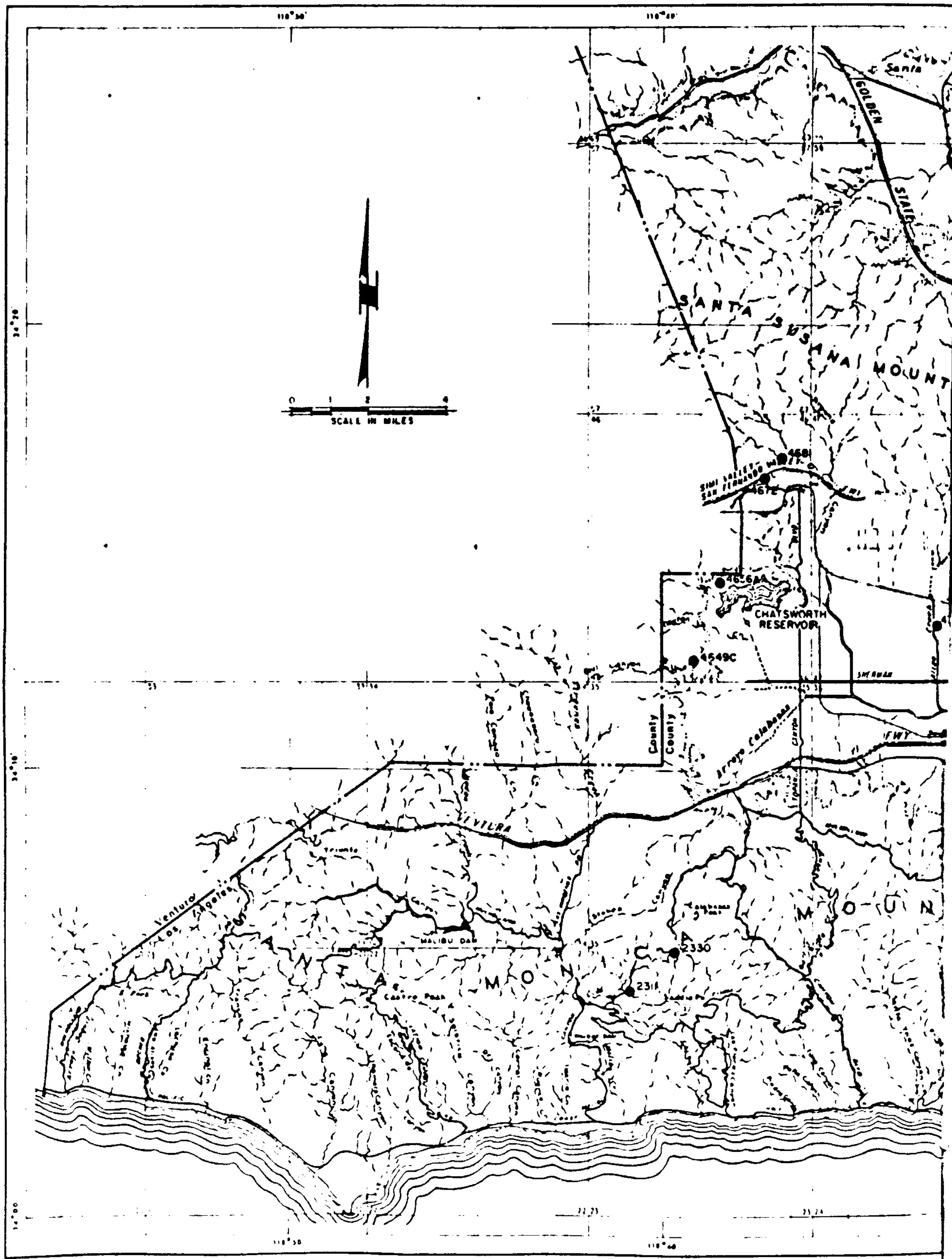

VOL 12

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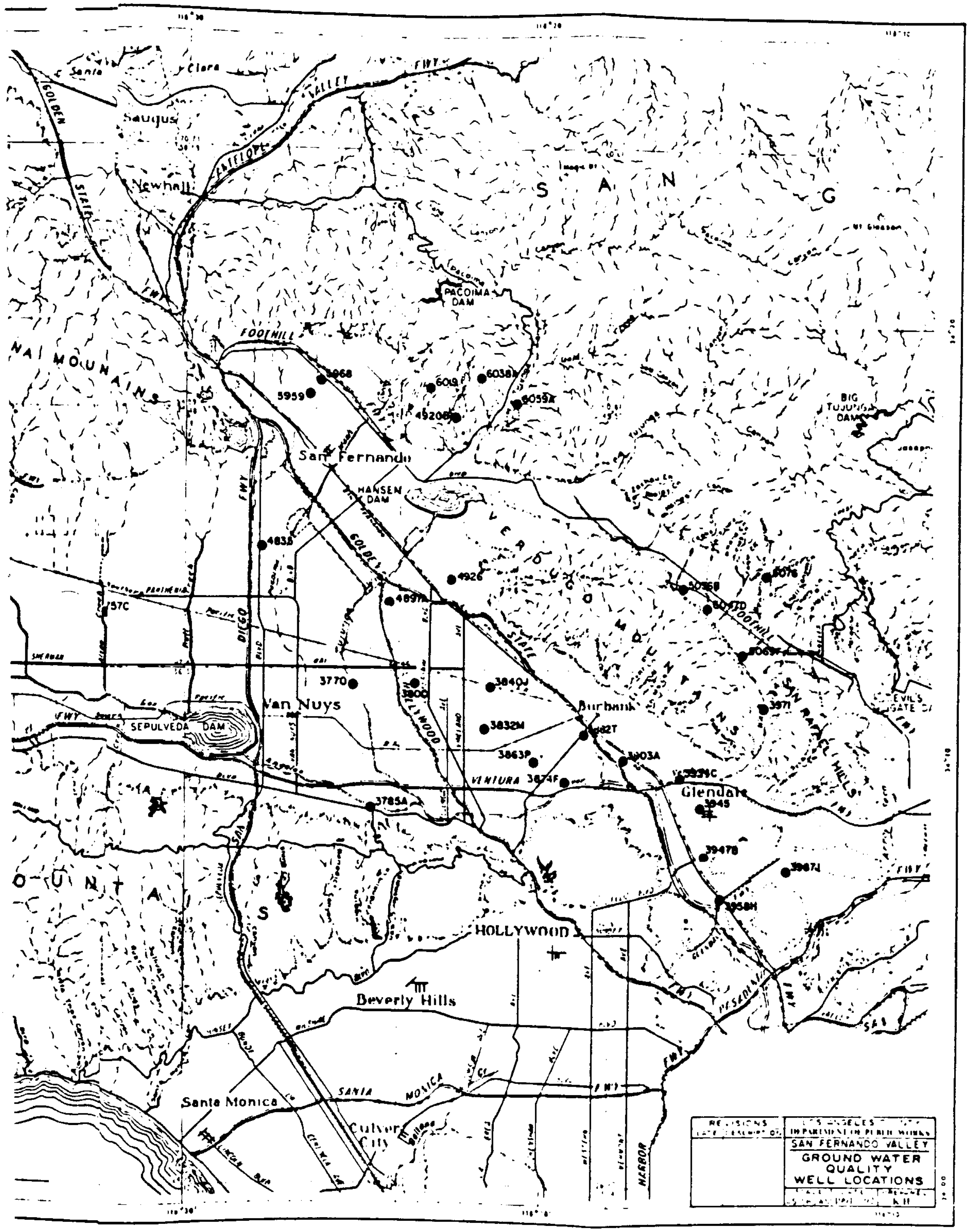

PF1

VOL 12

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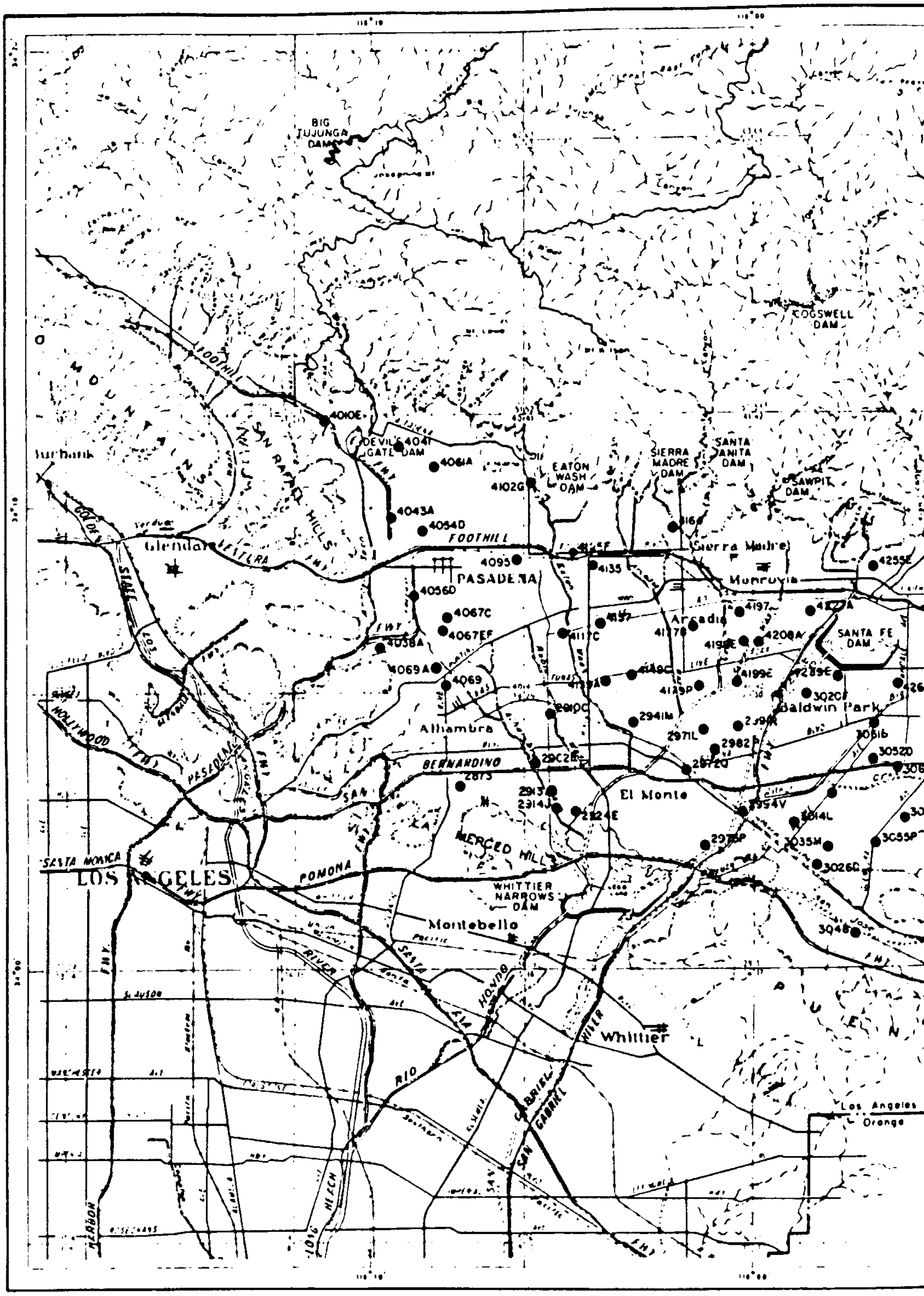

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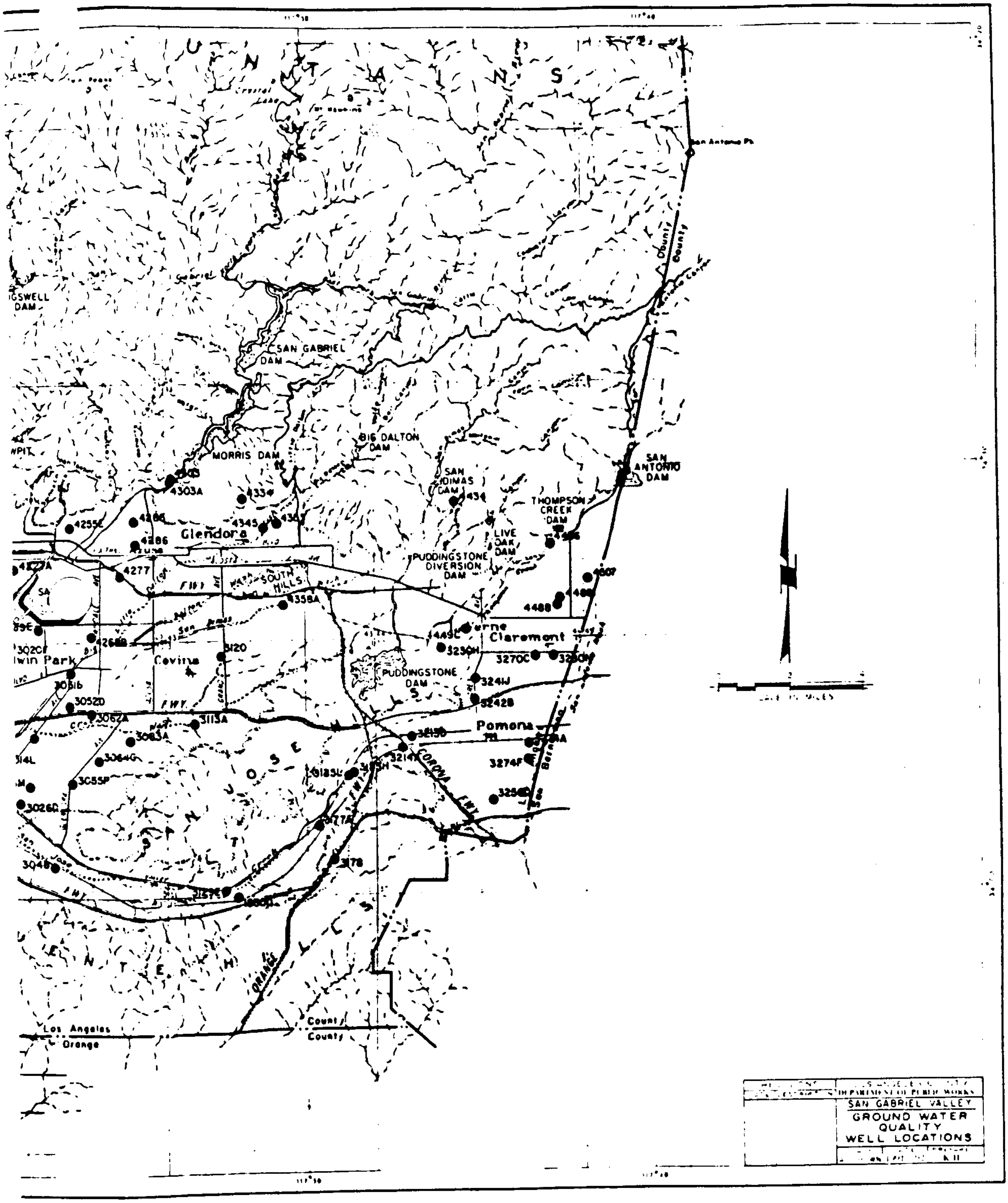
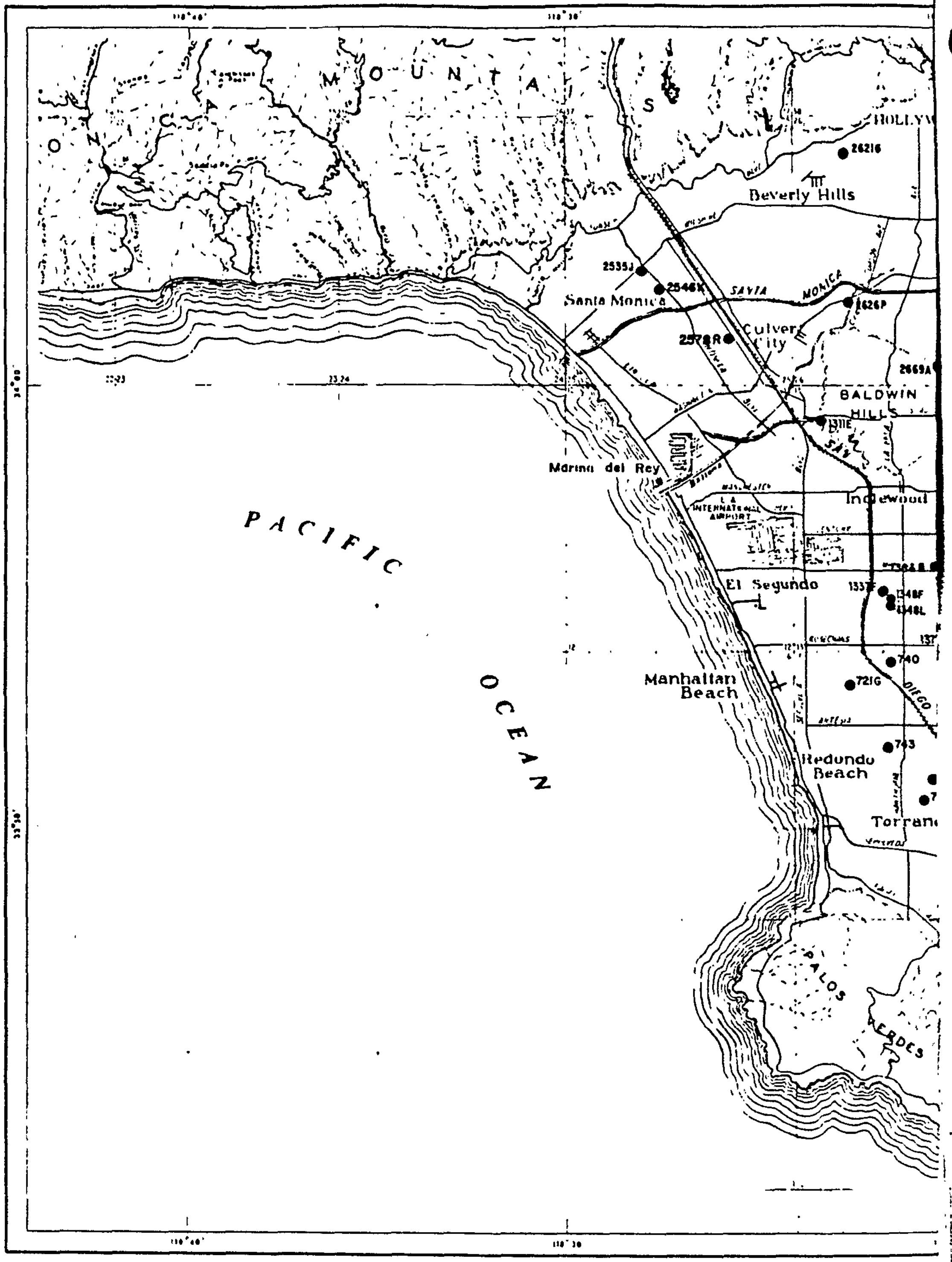


MORRIS DAM
SAN GABRIEL DAM
BIG DALTON DAM
SAN DIMAS DAM
LIVE OAK DAM
THOMPSON CREEK DAM
PUDDINGSTONE DIVERSION DAM
PUDDINGSTONE DAM
SAN ANTONIO DAM
Glendora
Covina
Claremont
Pomona
SOUTH HILLS
CORONA FWY
Los Angeles
Orange
County
County
4303A
4334
4255C
4286
4277
4345
4358A
3120
3270C
3241J
3242B
3113A
3062A
3052D
3083A
3064G
3055P
3026D
3048
3178
3274F
SAN GABRIEL VALLEY
GROUND WATER
QUALITY
WELL LOCATIONS

PF2



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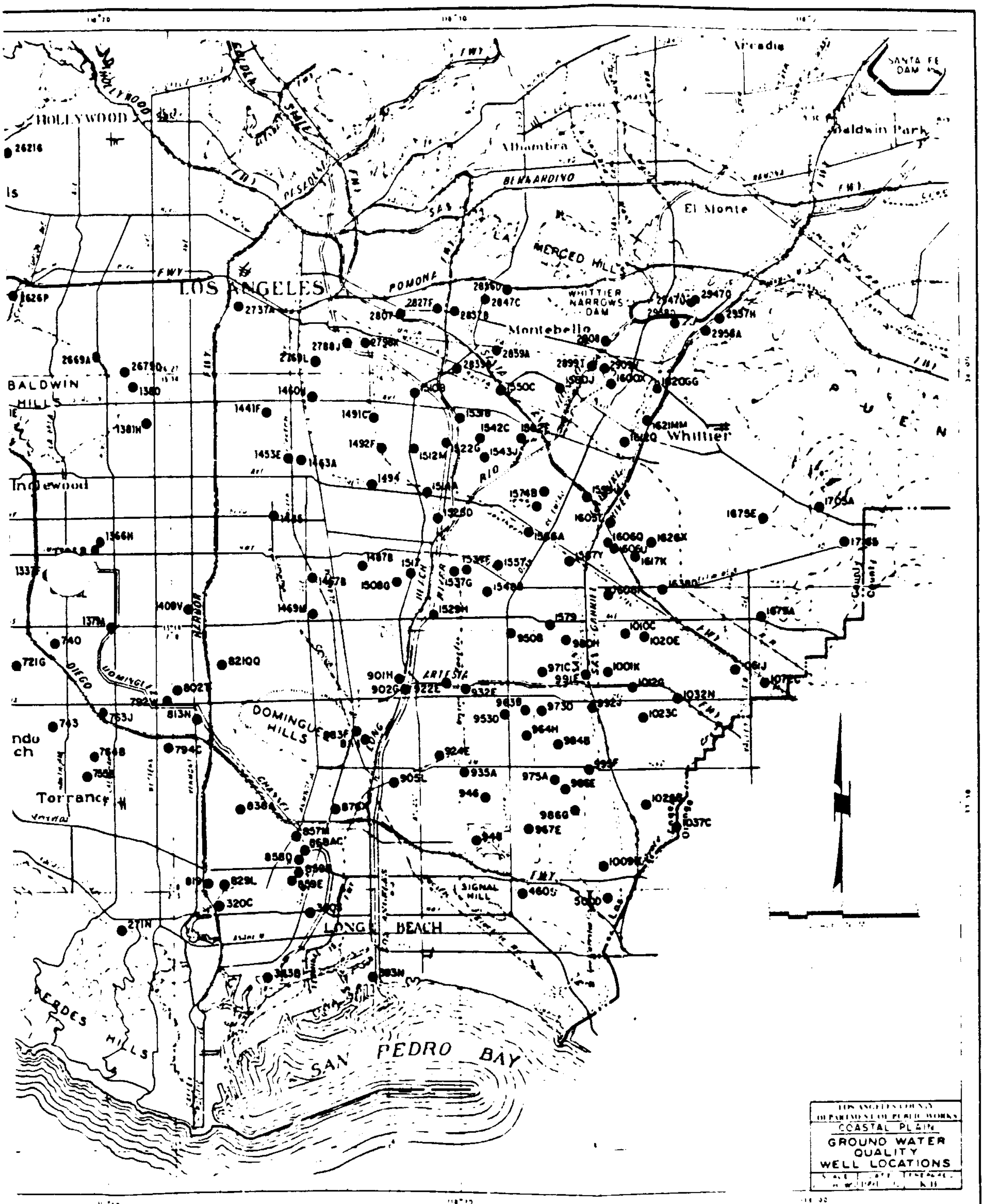

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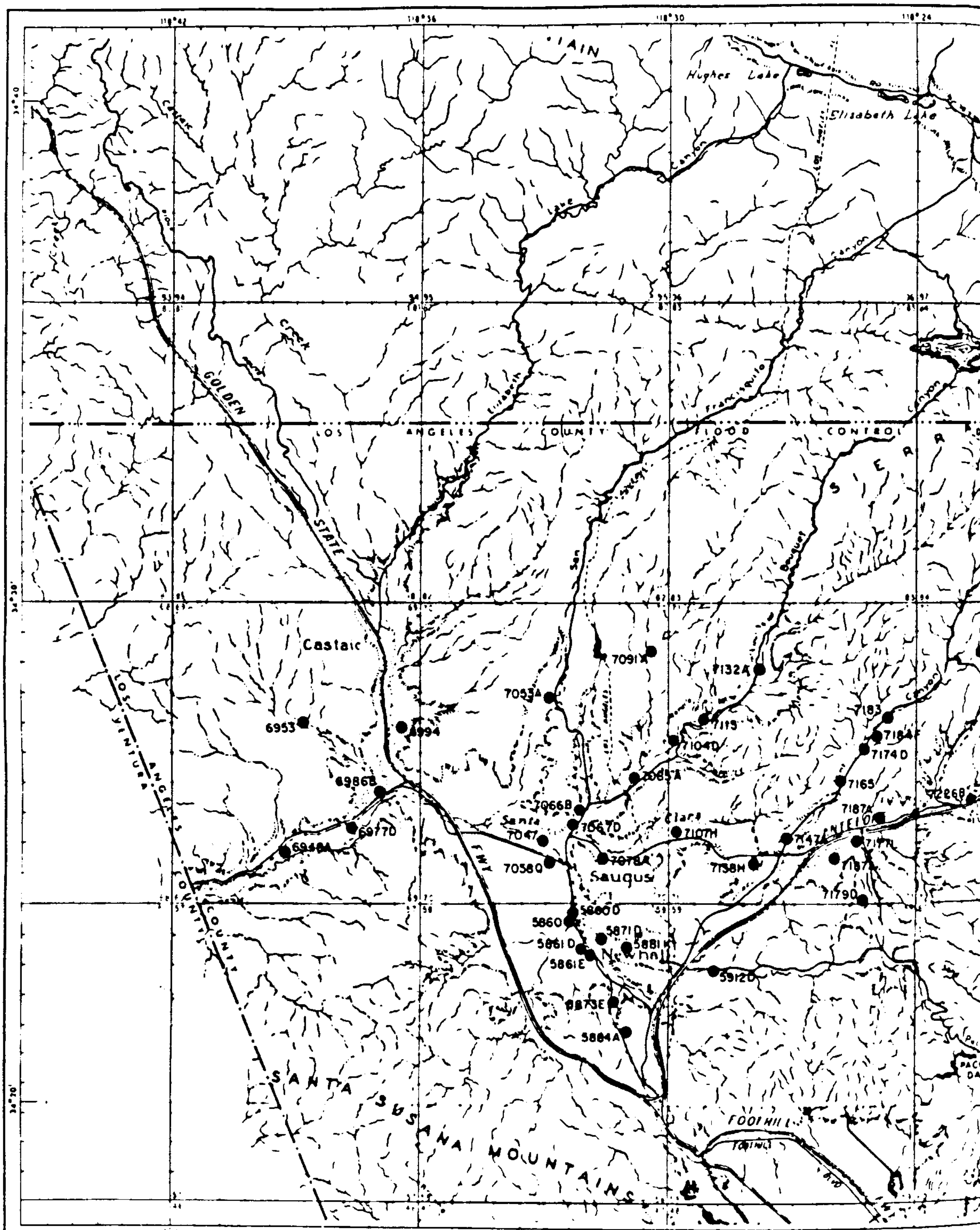
Castaic
Saugus
Newhall
Hughes Lake
Elisabeth Lake
GOLDEN STATE FWY
LOS ANGELES COUNTY FLOOD CONTROL
LOS ANGELES COUNTY
VENTURA
SANTA SUSANA MOUNTAINS
Santa Clara
San Francisquito Canyon
Bouquet Canyon
FOOTHILL
6953
6994
6986B
6977D
6948A
7091X
7132A
7053A
7115
7104D
7085A
7066B
7067D
7047
7058Q
7078A
7107H
7138H
7183
7184
7174D
7165
7187A
7226B
7147
7177
7187
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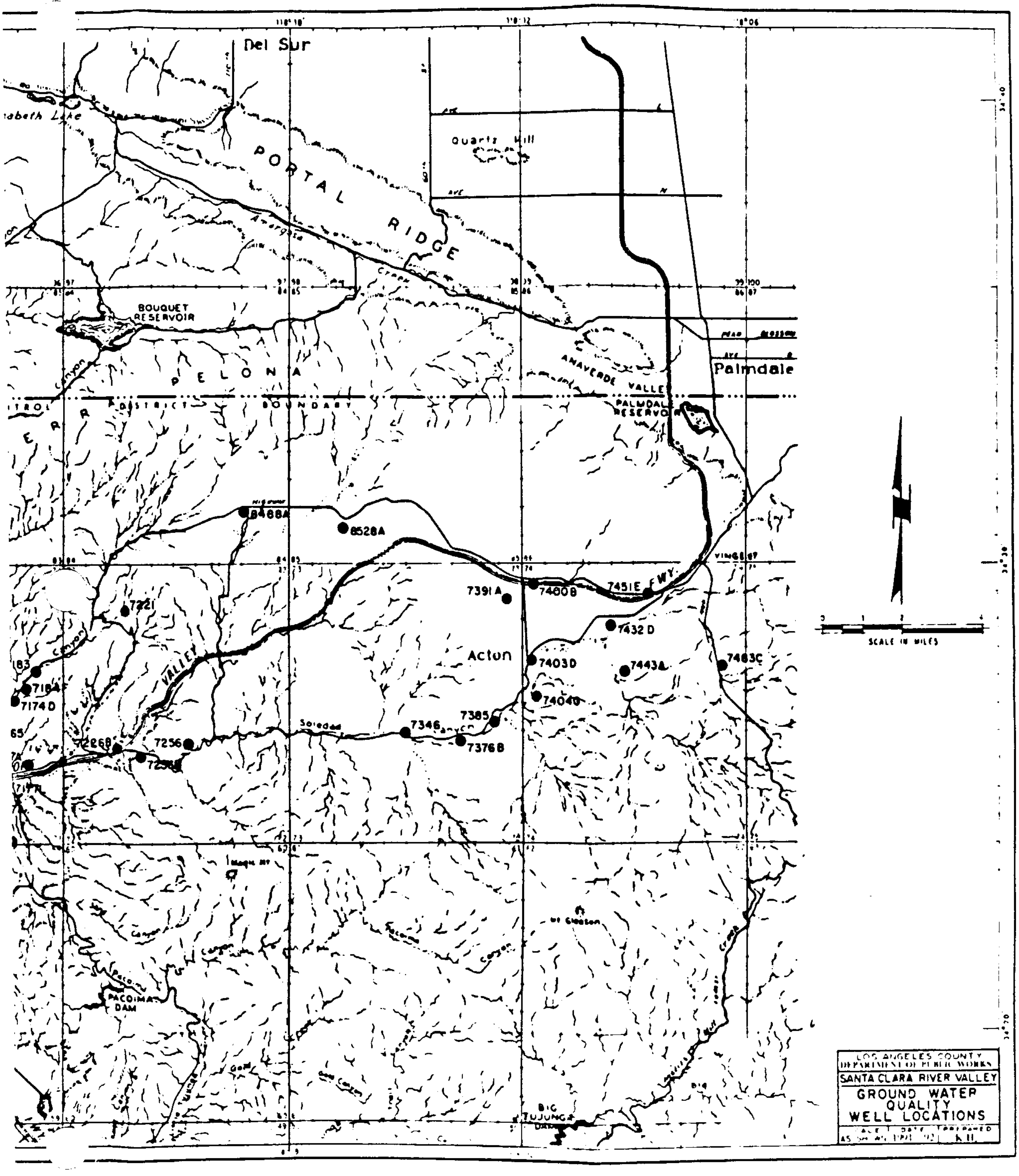

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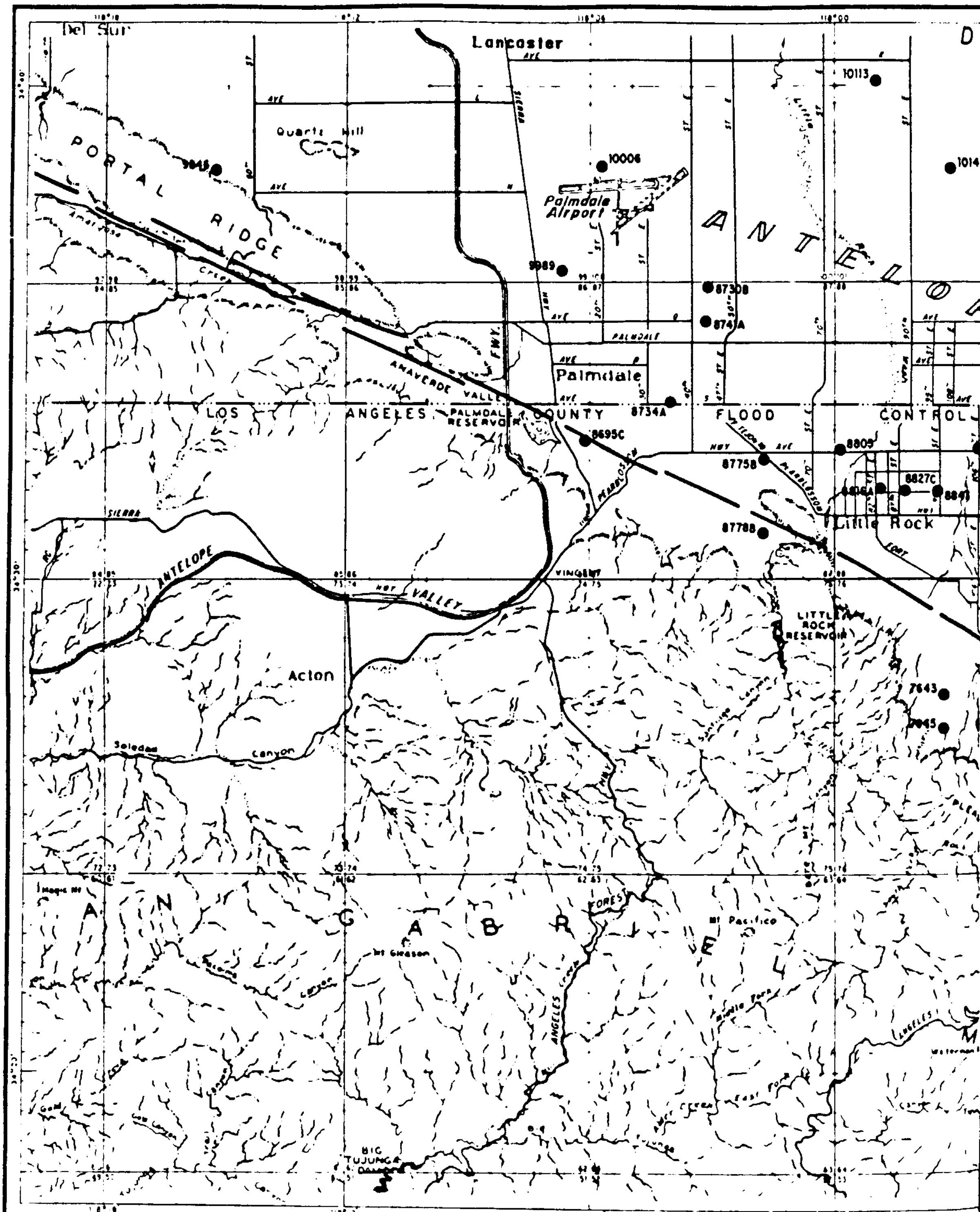

Del Sur
Lancaster
Quartz Hill
PORTAL RIDGE
Palmdale Airport
ANTELOPE
Palmdale
LOS ANGELES COUNTY FLOOD CONTROL
PALMDALE RESERVOIR
ANAVERDE VALLEY
FWY.
Little Rock
LITTLE ROCK RESERVOIR
SIERRA
ANTELOPE
HWY VALLEY
VINCENT
Acton
Soledad Canyon
SAN GABRIEL
ANGELES Crest
FOREST
Mt Gleason
Mt Pacifico
BIG TUJUNGA
10113
10006
10146
9945
9989
87308
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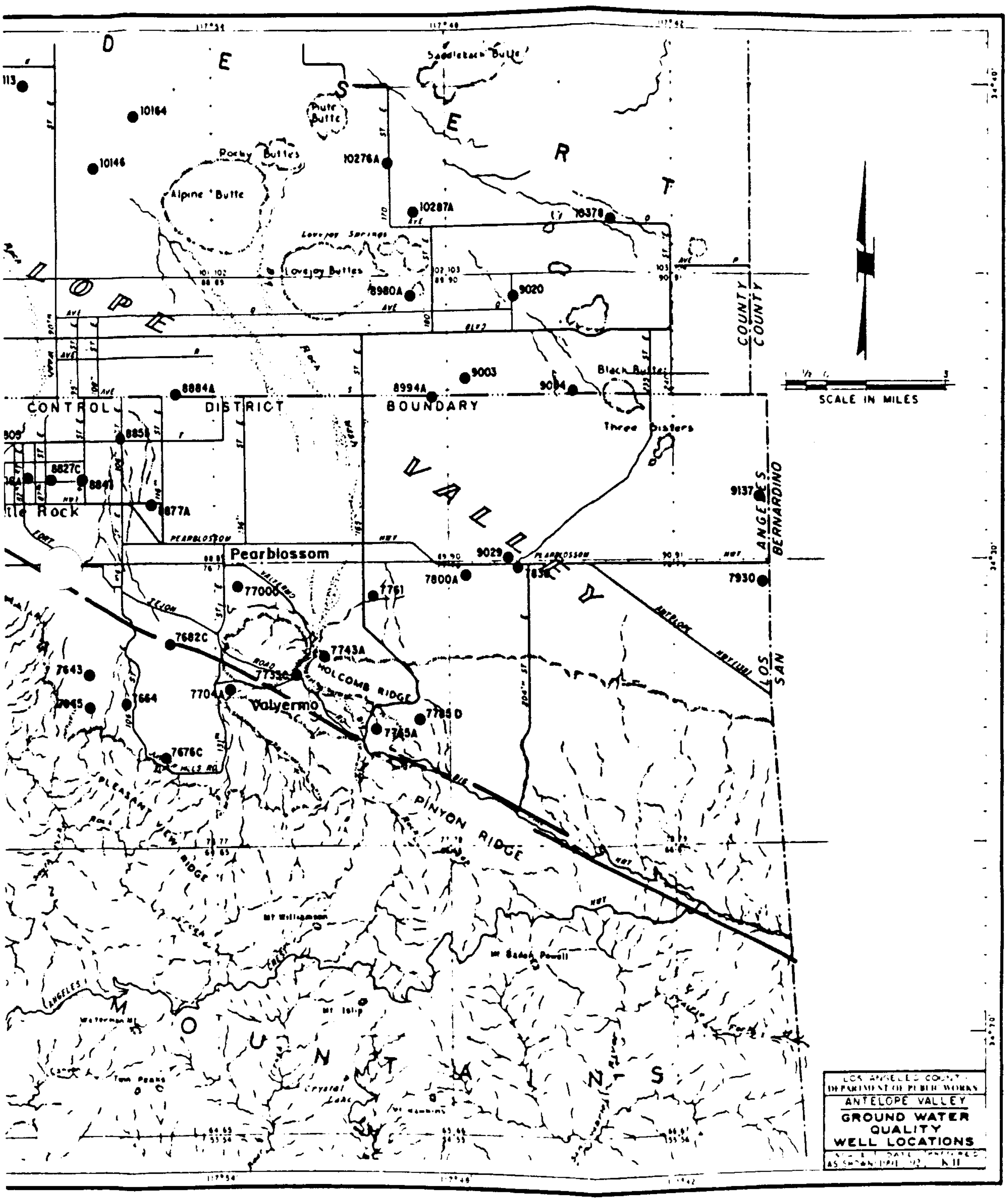

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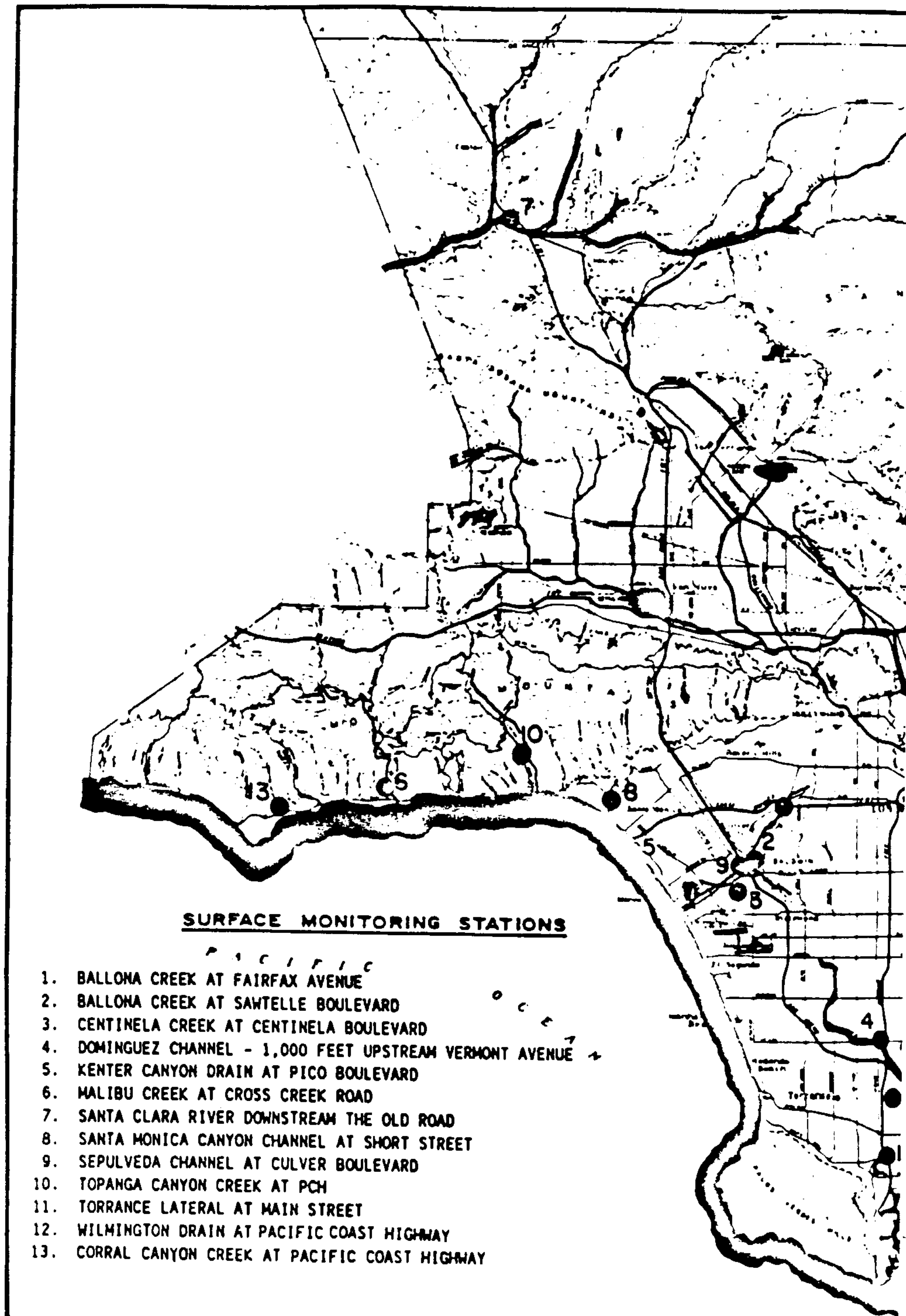
SURFACE MONITORING STATIONS
1. BALLONA CREEK AT FAIRFAX AVENUE
2. BALLONA CREEK AT SAWTELLE BOULEVARD
3. CENTINELA CREEK AT CENTINELA BOULEVARD
4. DOMINGUEZ CHANNEL - 1,000 FEET UPSTREAM VERMONT AVENUE
5. KENTER CANYON DRAIN AT PICO BOULEVARD
6. MALIBU CREEK AT CROSS CREEK ROAD
7. SANTA CLARA RIVER DOWNSTREAM THE OLD ROAD
8. SANTA MONICA CANYON CHANNEL AT SHORT STREET
9. SEPULVEDA CHANNEL AT CULVER BOULEVARD
10. TOPANGA CANYON CREEK AT PCH
11. TORRANCE LATERAL AT MAIN STREET
12. WILMINGTON DRAIN AT PACIFIC COAST HIGHWAY
13. CORRAL CANYON CREEK AT PACIFIC COAST HIGHWAY
PACIFIC
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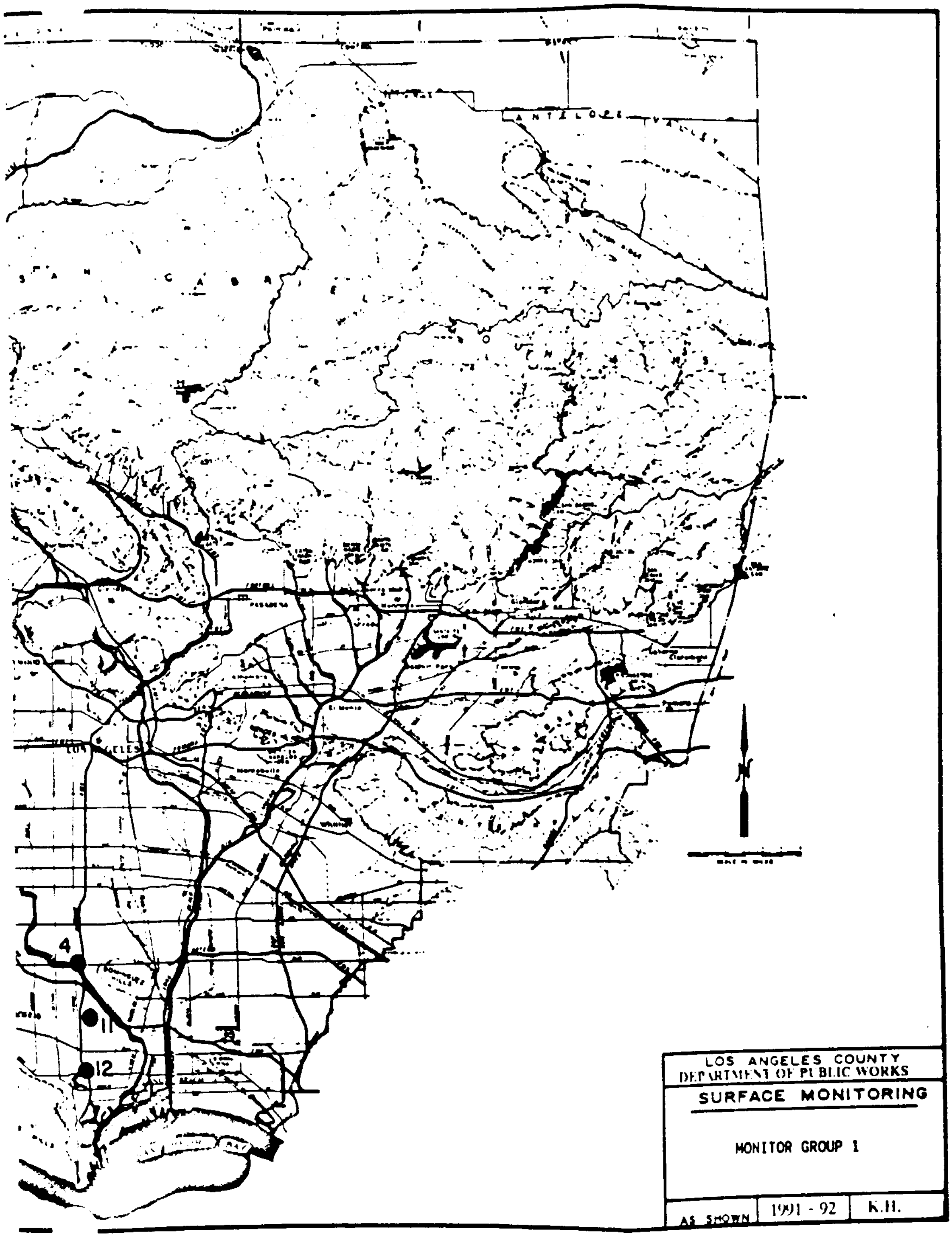

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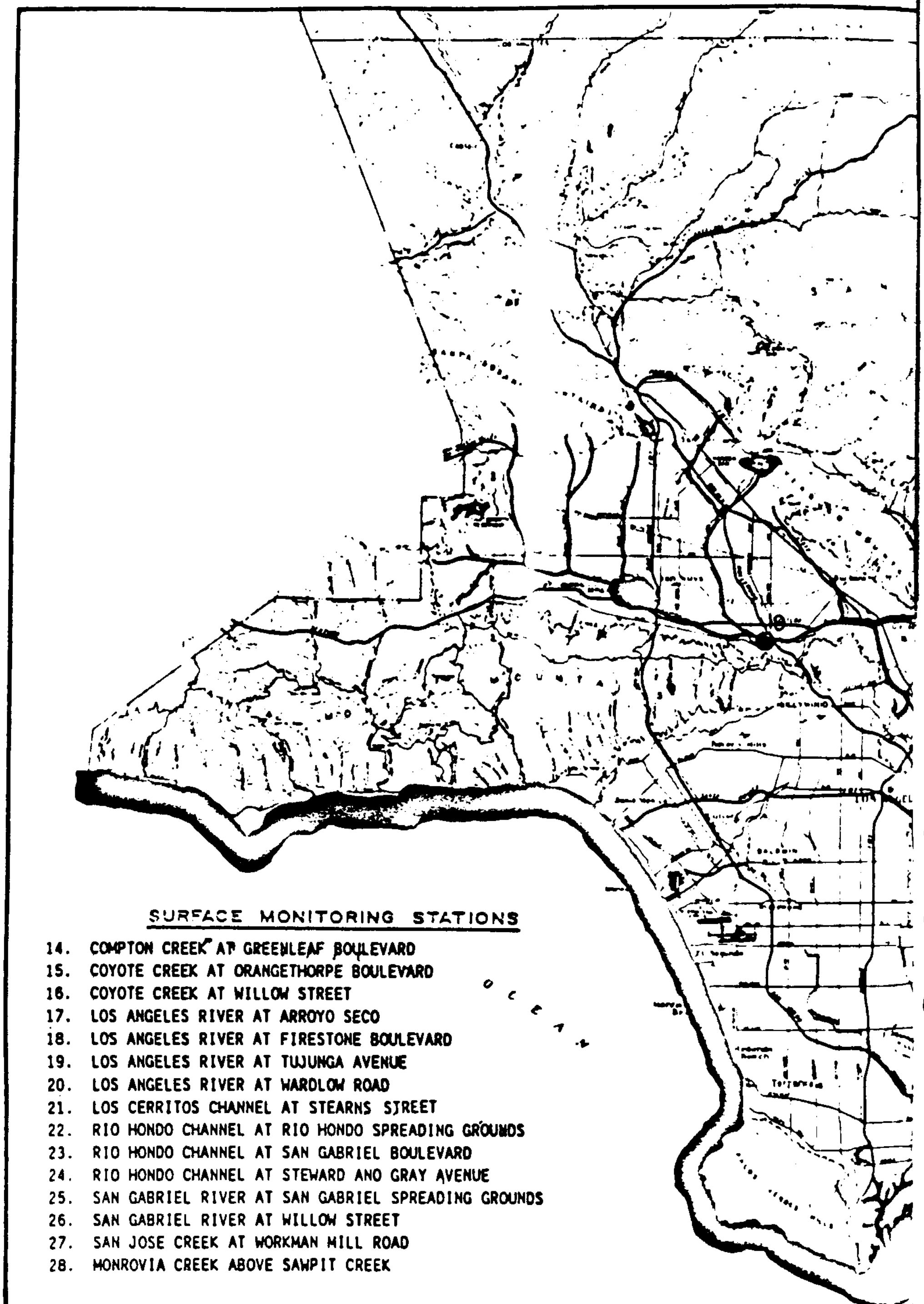
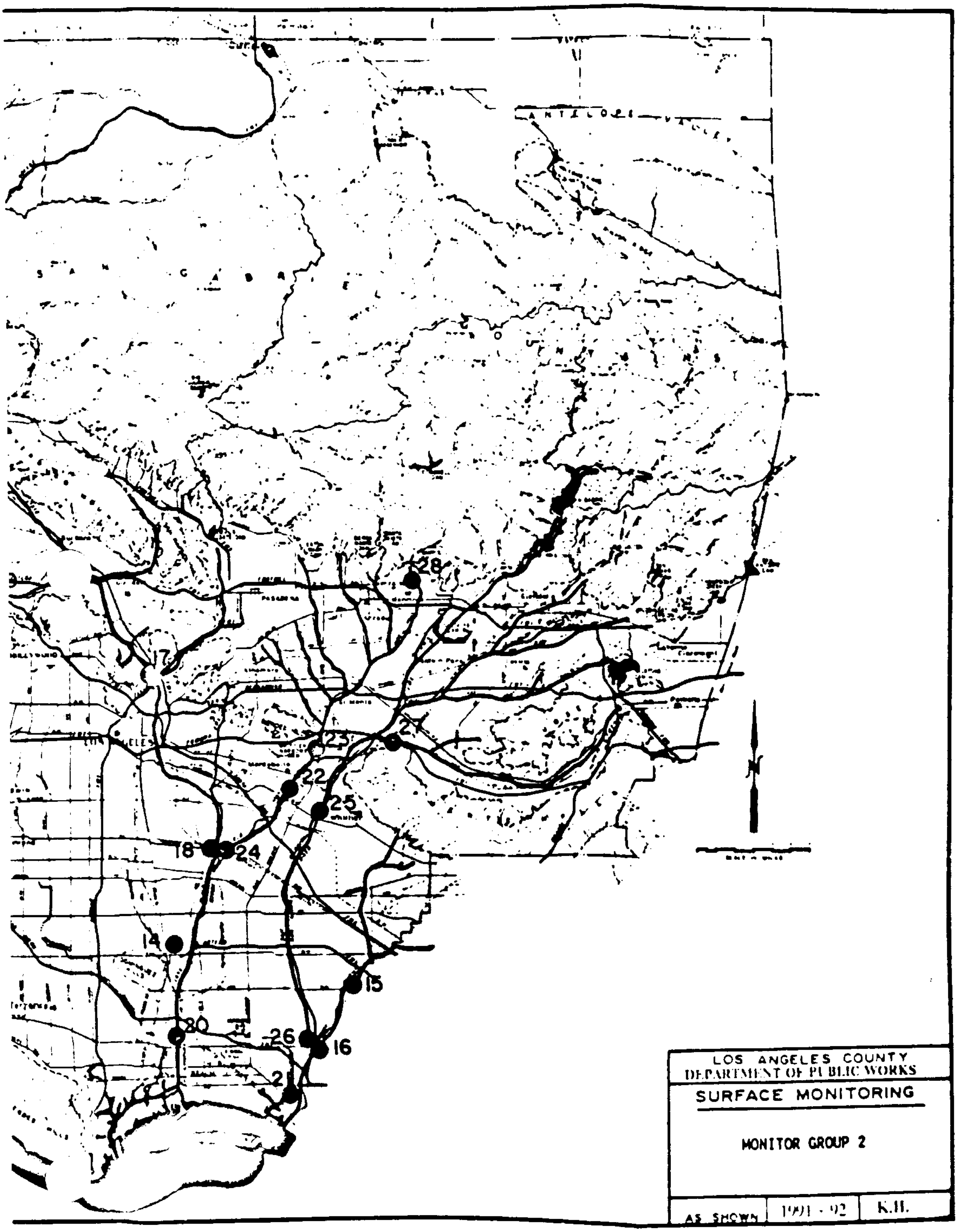


SURFACE MONITORING STATIONS
14. COMPTON CREEK AT GREENLEAF BOULEVARD
15. COYOTE CREEK AT ORANGETHORPE BOULEVARD
16. COYOTE CREEK AT WILLOW STREET
17. LOS ANGELES RIVER AT ARROYO SECO
18. LOS ANGELES RIVER AT FIRESTONE BOULEVARD
19. LOS ANGELES RIVER AT TUJUNGA AVENUE
20. LOS ANGELES RIVER AT WARDLOW ROAD
21. LOS CERRITOS CHANNEL AT STEARNS STREET
22. RIO HONDO CHANNEL AT RIO HONDO SPREADING GROUNDS
23. RIO HONDO CHANNEL AT SAN GABRIEL BOULEVARD
24. RIO HONDO CHANNEL AT STEWARD AND GRAY AVENUE
25. SAN GABRIEL RIVER AT SAN GABRIEL SPREADING GROUNDS
26. SAN GABRIEL RIVER AT WILLOW STREET
27. SAN JOSE CREEK AT WORKMAN MILL ROAD
28. MONROVIA CREEK ABOVE SAWPIT CREEK



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WATER CONSERVATION

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WATER CONSERVATION

Information presented in this section includes amounts of local, imported, and reclaimed water conserved in spreading areas and information on the seawater barrier projects which prevent saltwater intrusion to groundwater zones in the coastal areas. Pertinent data is presented regarding the locations and descriptions of Department water conservation facilities, a well as facilities owned by others. Also included are groundwater maps delineating static groundwater elevations recorded during the report period and hydrographs of selected key wells.

CONSERVING THE WATERS

In addition to the flood control program, the Department has the equally important task of conserving as much of the storm and other waters as practicable. The use of water conservation facilities adjacent to river channels, and in soft-bottom channels permits water to percolate into groundwater basins for later pumping. These water spreading facilities are located in areas where the underlying soils are composed of permeable formations.

The various types of water conserved, local, imported, and reclaimed, are construed to have the following meanings in this section: Local water is primarily runoff due to rainfall on the mountain and valley watersheds, dam releases, and rising water within the County. Imported water is water originating outside the County either from Northern California or from the Colorado River. Reclaimed water is the effluent produced by the Whittier Narrows Water Reclamation Plant, the San Jose Creek Water Reclamation Plant, and the Pomona Reclamation Plant, all operated by the Los Angeles County Sanitation District.

The importance of this activity is apparent when it is realized that about 30 to 40 percent of the water used in the County is pumped from ground supplies. The growth of the County, combined with periodic droughts, has seriously depleted these supplies on numerous occasions.

The Department's policy is to conserve the maximum amount of storm water possible consistent with considering runoff quantity and quality, capacities of the spreading facilities, and groundwater conditions.

IMPORTED WATER

During this report period, imported Colorado River and State Project water for spreading was received from the Metropolitan Water District (MWD). Imported water for groundwater recharge in the Coastal Plain was spread at the Department's facilities in the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds on behalf of the Water Replenishment District of Southern California. Imported water for groundwater recharge in the San Gabriel Valley was spread in Santa Fe Spreading Grounds, in the San Gabriel River, in Irwindale Spreading Basin/Manning Pit, and in Forbes Spreading Grounds on behalf of MWD, the Main San Gabriel Basin Watermaster, Three Valleys Municipal Water District, and the San Gabriel Valley Municipal Water District.

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RECLAIMED WATER

The County Sanitation District's Whittier Narrows Water Reclamation Plant effluent, purchased by the Water Replenishment District of Southern California, was transported to the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds for groundwater replenishment.

The County Sanitation District's San Jose Creek Water Reclamation Plant, activated in May 1972, made its first delivery of effluent in November 1972. The portion of the effluent that is spread is also purchased by the Water Replenishment District of Southern California.

Water from the Pomona Reclamation Plant is released down the San Jose Creek - San Gabriel River System to the Department's recharge facilities in the Rio Hondo and San Gabriel Coastal Basin spreading grounds.

The maximum amount of reclaimed water allowed for spreading in the Montebello Forebay, effective July 1991, is 60,000 acre-feet per year, but not to exceed 150,000 acre-feet over a three year period.

SEAWATER BARRIER PROJECTS

The Department operates three barrier projects to protect the groundwater in the West Coast and Central Basins against seawater intrusion by creating freshwater pressure ridges along the coastline. The pressure ridges are created by injecting fresh water through a series of injection wells. During the report period, 22,180 acre-feet of water was injected at the West Coast Basin Barrier Project, 6,893 acre-feet at the Dominguez Gap Barrier Project, and 4,172 acre-feet at the Los Angeles part of the Alamitos Barrier Project. On behalf of the Orange County Water District, 1,553 acre-feet of water was injected at the Orange County portion of the Alamitos Barrier Project.

The following seawater barrier improvements were completed during the 1991-92 water year:

1. Alamitos Barrier Project:

   No construction activity occurred during this period.

2. Dominguez Gap Barrier Project

   Construction began on ten multizone observation wells. The geohydrologic information gathered from this drilling contract will be used for determination of the required remedial improvements for mitigating intrusion around the North-South leg of the barrier.

3. West Coast Basin Barrier Project

During this period the construction of three injection wells and two observation wells was completed. In addition, construction commenced for three injection wells and two observation wells.

These wells were constructed as part of the Department's consultant study recommendations to mitigate barrier deficiencies in the Silverado and Lower San Pedro aquifers.

SEASONAL DATA AND MAPS

During this report period, weekly, monthly, and semi-annual measurements of groundwater levels in observation wells located throughout the groundwater basins in Los Angeles County were made and processed.

Hydrographs of selected key wells are included in this report.

GROUNDWATER BASINS AND GROUNDWATER RECHARGE

Groundwater in Los Angeles County is stored in basins underlying five major geographic areas. These groundwater basins are separated by geologic features which impede groundwater movement or sometimes by arbitrary political boundaries. The following is a background summary of the Department's groundwater recharge activities within each of these areas:

The Department operates 2,436 acres of spreading grounds and soft-bottom channel spreading areas for replenishment of local groundwater supplies. The Department also assisted in the operation and maintenance of 269 acres of spreading grounds owned by others. An additional 656 acres of spreading grounds are controlled, maintained, and operated by other agencies. The total gross acreage of spreading grounds in the county is 3,361 acres. During the report period, above normal rainfall allowed the Department to conserve approximately 389,270 acre-feet of storm runoff.

The conservation of local runoff is supplemented by spreading imported water and reclaimed water purchased by water agencies. During the period, 102,505 acre-feet of imported water and 46,900 acre-feet of reclaimed water were spread.

The Department is continuing its efforts to improve its water spreading facilities in order to maximize the amounts of water conserved and to simplify the spreading operations.

SAN GABRIEL VALLEY

The Department operates 20 spreading grounds in the San Gabriel Valley that receive direct valley runoff and flows from the San Gabriel Mountains. Some of these spreading grounds can also receive imported water. During the report period, the Department added approximately 214,275 acre-feet of local water and 59,100 acre-feet of imported water to the groundwater stored in the basins underlying the San Gabriel Valley and diverted 4,933 acre-feet of local water to grounds owned by others.

Main San Gabriel Basin

This is the largest basin underlying the San Gabriel Valley with an estimated storage capacity of 9.5 million acre-feet. It reacts quickly to artificial spreading in Santa Fe Reservoir Spreading Grounds and to infiltration in the San Gabriel River Downstream of Santa Fe Dam.

During the report period, the Department replenished the Main San Gabriel Basin with 178,533 acre-feet of local water and 53,573 acre-feet of imported water. Well 3030F in Baldwin Park recorded a high groundwater elevation for the report period of 238.7 ft on July 29, 1992.

Upper San Gabriel Canyon Basin

Approximately 25,718 acre-feet of local water and approximately 4,727 acre-feet of imported water were recharged by the Department through its San Gabriel Canyon Spreading Grounds and by percolation in the adjacent San Gabriel River. Also, 2,617 acre-feet of local water was routed to Fish Canyon Spreading Grounds which is operated by the Committee of Nine.

Lower San Gabriel Canyon Basin

The basin is located south of the Upper San Gabriel Canyon Basin and is separated from it by the underground Lohmon Dike. Groundwater cascades over the Lohmon Dike from the Upper San Gabriel Canyon Basin and recharges the Lower San Gabriel Canyon Basin. The Department spread 1,217 acre-feet of local water in Sawpit Spreading Grounds which is within the Lower Canyon Basin.

Wayhill Basin

The Department spread 175 acre-feet of local water and 800 acre-feet of imported water at Forbes spreading facility in the Wayhill Basin.

Foothill Basin

The Department spread 2,375 acre-feet of local water at its San Dimas Canyon Spreading Grounds facility in the Foothill Basin.

Glendora Basin

The Department spread 977 acre-feet of local water in its Big and Little Dalton facilities within the Glendora Basin.

Claremont Heights Basin

The Department has no spreading facilities in the Claremont Heights Basin.

Live Oak Basin

The Department has no spreading facilities in the Live Oak Basin.

Chino Basin

The basin is located in the most eastern part of the County. No Department recharge facilities are located within the Chino Basin.

San Dimas Basin

The basin is north of the San Jose Hills, east of the Main Basin, and south of the Wayhill Basin. The Department spread 13 acre-feet of local water in its Live Oak Spreading Grounds to recharge the basin.

Pomona Basin

The basin is located south of Claremont, Live Oak, and San Dimas Basins, and north of the Chino Basin and northeast of the San Jose Hills. The Department has no water spreading facilities within this basin.

Puente and Spadra Basins

No spreading occurs in this area.

Raymond Basin

The basin covering approximately 40 square miles is located in the northwest corner of the San Gabriel Valley and is separated from the Main San Gabriel Basin by the Raymond Fault. The Raymond Basin contains the Monk Hill Basin and the Pasadena and Santa Anita Subareas. The Department recharged 5,266 acre-feet of local water by its spreading facilities in the Raymond Basin and diverted 2,315 acre-feet to the City of Sierra Madre's spreading facility during the report period.

COASTAL PLAIN

The groundwater basins underlying the Coastal Plain are divided by geological features into the Central (includes the Montebello and Los Angeles Forebays), West Coast, Santa Monica, and Hollywood Basins. During the period of October 1, 1991 to September 30, 1992, the Department recharged 136,608 acre-feet of local water, 42,900 acre-feet of imported water, and 46,900 acre-feet of reclaimed water to the groundwater basins underlying the Coastal Plain. Most of the water was spread in the Montebello Forebay.

Central Basin

The Central Basin has the most storage capacity of the basins in the Coastal Plain. In addition to the water recharged in the Department's spreading facilities, water injected in the Alamitos Barrier Project also contributes to the replenishment of the pressure aquifers underlying the Central Basin.

West Coast Basin

The West Coast Basin is the second largest basin underlying the Coastal Plain and is separated from the Central Basin by the Newport-Inglewood Fault zone. Groundwater is primarily recharged by Central Basin subsurface flows and by water injected by the Department in the West Coast Basin and Dominguez Gap Barrier Projects. Groundwater elevations in the West Coast Basin are below sea level except in the area of the West Coast Basin Barrier injection mound.

James M. Montgomery Consulting Engineers and Camp, Dresser and McKee, Inc., completed the West Coast Basin Saline Water Plume Mitigation Study and their final report has been accepted.

The Department spread 46 acre-feet of water in the Dominguez Spreading Grounds.

Santa Monica and Hollywood Basins

The Department has no spreading facilities in either the Santa Monica or Hollywood groundwater basins.

SAN FERNANDO VALLEY

The San Fernando Valley is also called the Upper Los Angeles River Area (ULARA). Most of the runoff from the surrounding mountains flows to the Valley.

San Fernando Main Basin

The basin is the largest basin underlying the San Fernando Valley. During the report period, 38,386 acre-feet of local water and 505 acre-feet of imported water were spread by the Department. The County entered into an agreement with the City of Los Angeles to spread water at the newly renovated Tujunga Wash Spreading Grounds which is located approximately two miles downstream of Hansen Spreading Grounds. The City installed a rubber dam diversion and appurtenant facilities for County Spreading operations which started in March 1990.

Sylmar Basin

A much smaller basin underlying the San Fernando Valley is the Sylmar Basin; the Department has no spreading facility within this basin.

Verdugo and Eagle Rock Basins

The small Verdugo and Eagle Rock Basins comprise the remaining basins underlying the San Fernando Valley. The Department has no spreading facilities within either basin.

SANTA CLARITA VALLEY

The Department has no spreading facilities in the area. Most of the Valley is farmland, permitting substantial natural percolation.

The Upper Santa Clarita subunit comprises five basins.

ANTELOPE VALLEY

There are several groundwater subbasins underlying the Antelope Valley. Five of them are located within Los Angeles County.

The Department operates no spreading facilities in the Antelope Valley.

The hydrographs for well Nos. 9974 and 8825 are shown on page G25. They are located in the Lancaster and Little Rock subbasins respectively.

LOS ANGELES COUNTY DE
HYDRAULIC/WATER C

SUMMARY OF DATA ON
OWNED AND OPERATE
UPDATED THROUG

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES CHANNEL** (CFS)	CAPACITIES INTAKE (CFS)	CAPACITIES STORAGE (A.F.)	PERC (C
ARROYO SECO	SHALLOW BASINS	1948-49	24	15.1	-	75	30	
BEN LOMOND	SHALLOW BASINS	1958-59	24	17.0	-	25	25	
BIG DALTON	SHALLOW BASINS	1930-31	24	7.7	-	45	12	
BRANFORD	DEEP BASIN	1956-57	12	7	1,540	1,540	137	
BUENA VISTA	DEEP BASIN	1954-55	10	6	2,900	2,900	177	
CITRUS	MEDIUM DEPTH BASINS	1960-61	19	14.6	-	200	80	
DOMINGUEZ GAP	DEEP BASINS	1957-58	54	23.8	-	20	234	
EATON BASIN	DEEP BASIN	1956-57	16	10.5	9,600	400	284	

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS DO

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

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'WATER CONSERVATION DIVISION

DATA ON SPREADING FACILITIES
OPERATED BY THE DEPARTMENT
D THROUGH SEPTEMBER 1992

TES RAGE (.F.)	PERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
30	18	EASTERLY SIDE OF ARROYO SECO, 0.5 MILES ABOVE DEVIL'S GATE DAM.	CONTROLLED FLOW FROM CITY OF PASADENA. UNCONTROLLED FROM ARROYO SECO AND THE ALTADENA STORM DRAIN.	SPREADING GROUNDS ARE HELD UNDER EASEMENT FROM THE CITY OF PASADENA.
25	18	BOTH NORTH AND SOUTH SIDES OF SAN DIMAS WASH CHANNEL AT SOUTHWESTERLY CORNER OF INTERSECTION OF ARROW HIGH-WAY AND BARRANCA AVENUE.	COVINA IRRIGATING COMPANY.	SPREADING GROUNDS UTILIZED TO CONSERVE EXCESS COVINA IRRIGATION COMPANY WATER RELEASED FROM THE COMMITTEE OF NINE.
12	15	WESTERLY SIDE OF BIG DALTON WASH, ONE HALF MILE ABOVE SIERRA MADRE AVENUE.	CONTROLLED FLOWS FROM BIG DALTON DAM AND BIG DALTON DEBRIS BASIN.	
.37	1	SOUTHWESTERLY OF ARLETA AVENUE ABOVE CONFLUENCE OF TUJUNGA WASH AND PACOIMA DIVERSION CHANNEL.	UNCONTROLLED FLOWS FROM BRANFORD STREET DRAIN.	INSTREAM SPREADING FACILITY. OUTLET CAPACITY 1,540 CFS TO PACOIMA DIVERSION CHANNEL.
77	6	1.0 MILE EASTERLY OF SAWPIT WASH. 0.5 MILE NORTHERLY OF ARROW HIGHWAY, BETWEEN MERIDIAN STREET AND BUENA VISTA CHANNEL.	CONTROLLED FLOW FROM SANTA FE DAM AND UNCONTROLLED FLOW FROM BUENA VISTA CHANNEL.	INSTREAM SPREADING FACILITY. AN ADDITIONAL OUTLET CONSTRUCTED TO PROVIDE TOTAL OUTLET CAPACITY OF 270 CFS.
80	28	SOUTH SIDE OF BIG DALTON WASH BETWEEN CITRUS AND CERRITOS AVENUES.	CONTROLLED FLOWS FROM BIG DALTON DAM AND LITTLE DALTON DEBRIS DAMS. UNCONTROLLED FLOWS FROM BIG DALTON WASH.	THERE ARE 2 INTAKES, ONE IS A DROP INLET, THE OTHER AN AIR INFLATED RUBBER DAM.
34	1	SOUTH OF DEL AMO BOULEVARD AND BORDERS THE EASTERN AND WESTERN SIDES OF THE LOS ANGELES RIVER	CONTROLLED FLOW FROM LOS ANGELES RIVER LOW FLOW CHANNEL AND UNCONTROLLED FLOWS FROM STORM DRAINS.	EAST SIDE BASIN USED FOR FLOOD REGULATION WITH SOME CONSERVATION STORAGE. INTAKE CAPACITY IS 20 CFS FOR LOW FLOW DIVERSION FROM THE LOS ANGELES RIVER. THE WEST SIDE BASIN IS FED BY A 24-INCH CONCRETE PIPE FROM THE EAST SIDE BASIN.
84	10	EAST SIDE OF EATON WASH, NORTH OF DUARTE ROAD, 0.6 MILES SOUTH OF HUNTINGTON DRIVE.	CONTROLLED FLOW FROM EATON WASH DAM AND UNCONTROLLED FLOWS BETWEEN DAM AND SPREADING BASIN.	

'ILTRATION RATES WHICH MAY BE EXPECTED TO OCCUR
NUMBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

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LOS ANGELES COUNTY DEPA
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SUMMARY OF DATA ON S
OWNED AND OPERATED
UPDATED THROUGH

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES CHANNEL** (CFS)	CAPACITIES INTAKE (CFS)	CAPACITIES STORAGE (A.F.)	CAPACITIES PERCOLA (CFS
EATON WASH	DEEP & SHALLOW BASINS	1947-48	28	25.4	6,600	200	525	
FORBES	MEDIUM DEPTH BASINS	1964-65	21	10	-	100	87	
HANSEN	SHALLOW BASINS	1944-45	156	105.3	22,000	400	279	2
IRWINDALE/MANNING PIT	DEEP BASINS	1958-59	62	30	20,000	400	1133	
LITTLE DALTON	SHALLOW BASINS	1931-32	14	4.7	-	20	5	
LIVE OAK	SHALLOW BASINS	1961-62	5	1.2	-	15	2	
LOPEZ	SHALLOW BASINS	1956-57	18	11.9	-	25	23.6	
PACOIMA	MEDIUM DEPTH BASINS	1932-33	169	107.3	17,000	600	440	

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS DO N

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

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JNT :PARTMENT OF PUBLIC WORKS
NATE.. CONSERVATION DIVISION

DATA ON SPREADING FACILITIES
OPERATED BY THE DEPARTMENT
THROUGH SEPTEMBER 1992

...S AGE ...F.)	PERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
...25	17	EASTERLY SIDE OF EATON WASH FROM BELOW EATON DAM TO FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM EATON WASH DAM.	GROUND MODIFICATIONS COMPLETED IN DECEMBER 1991.
...87	5	SOUTH SIDE OF SAN DIMAS WASH BETWEEN LONE HILL AVENUE AND VALLEY CENTER AVENUE.	CONTROLLED RELEASES FROM PUDDINGSTONE DIVERSION DAM, AND UNCONTROLLED FLOWS FROM SAN DIMAS WASH; ALSO IMPORTED FROM SGVMWD AND CB48.	RECONSTRUCTION OF BASINS, FROM SHALLOW TO MEDIUM DEPTHS, WAS COMPLETED IN APRIL 1989.
...179	250	NORTHWESTERLY SIDE OF TUJUNGA WASH FROM ABOVE GLENOAKS BOULEVARD SOUTHWESTERLY TO SAN FERNANDO ROAD.	CONTROLLED FLOWS FROM HANSEN DAM AND BIG TUJUNGA DAM.	
...133	60	NORTHEASTERLY OF INTER-SECTION OF BIG DALTON CHANNEL AND IRWINDALE AVENUE; CONTINUES 1,300 FEET EAST OF IRWINDALE AVENUE	BIG DALTON CHANNEL CONTROLLED FLOWS FROM BIG AND LITTLE DALTON DEBRIS DAMS AND PUDDINGSTONE DIVERSION DAM; UNCONTROLLED FLOWS; ALSO IMPORTED WATER FROM CB48 AND SGVMWD.	MANNING PIT INTAKE COMPLETED MARCH 1991.
5	15	WESTERLY OF GLENDORA MT. ROAD, FROM LITTLE DALTON DEBRIS BASIN SOUTH TO EAST PALM DRIVE.	CONTROLLED FLOW FROM LITTLE DALTON DEBRIS BASIN.	
2	13	WESTERLY SIDE OF LIVE OAK WASH. NORTH OF BASE LINE ROAD (PROJECTED).	CONTROLLED FLOW FROM LIVE OAK DAM AND LIVE OAK DEBRIS BASIN.	
3.6	15	SOUTHEASTERLY SIDE OF PACOIMA WASH, NORTHEASTERLY OF FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM PACOIMA DAM AND LOPEZ FLOOD CONTROL BASIN.	
440	65	BOTH SIDES OF OLD PACOIMA WASH CHANNEL FROM ARLETA AVENUE SOUTHWESTERLY TO WOODMAN AVENUE.	CONTROLLED FLOW FROM PACOIMA DAM. PARTIALLY CONTROLLED FLOW FROM LOPEZ FLOOD CONTROL BASIN, UNCONTROLLED FLOW FROM EAST CANYON AND PACOIMA WASH. IMPORTED WATER FROM OWENS VALLEY DELIVERED BY CITY OF LOS ANGELES.	

...FILTRATION RATES WHICH MAY BE EXPECTED TO OCCUR
...NUMBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

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LOS ANGELES COUNTY DEPART
HYDRAULIC/WATER CONS

SUMMARY OF DATA ON SP
OWNED AND OPERATED B
UPDATED THROUGH S

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES CHANNEL** (CFS)	CAPACITIES INTAKE (CFS)	CAPACITIES STORAGE (A.F.)	CAPACITIES PERCOLATIO (CFS)
PECK ROAD	DEEP BASIN	1959-60	157	85	30,100	30,100	3,347	25
RIO HONDO COASTAL	MEDIUM DEPTH BASINS	1937-38	570	430.1	40,000	1,950	3,694	400
SAN DIMAS CANYON	SHALLOW BASINS	1965-66	22	10.8	-	25	22	12
SAN GABRIEL CANYON	DEEP BASINS	1917	165	-	-	40	-	35
SAN GABRIEL COASTAL	MEDIUM DEPTH BASINS	1938-39	128	95.9	-	350	575	75
SAN GABRIEL RIVER (MONTEBELLO FOREBAY)	MEDIUM DEPTH BASINS	1954-55	156	156	20,000	550	1,462***	100
SAN GABRIEL RIVER (SAN GABRIEL VALLEY)	TEMPORARY CHECK LEVEES	1965-66	196	196	-	-	-	100

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* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION RAT DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS DO NOT R

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

UNT :PARTMENT OF PUBLIC WORKS
WATE.. CONSERVATION DIVISION

DATA ON SPREADING FACILITIES
OPERATED BY THE DEPARTMENT
) THROUGH SEPTEMBER 1992

ES AGE F.)	PERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
47	25	CONFLUENCE OF SAWPIT AND SANTA ANITA WASHES.	CONTROLLED RELEASES FROM SANTA ANITA AND SAWPIT DEBRIS BASINS AND UNCONTROLLED FLOWS FROM LOCAL RUNOFF VIA SAWPIT AND SANTA ANITA WASHES.	INSTREAM SPREADING FACILITY.
94	400	EASTERLY SIDE OF RIO HONDO SOUTHERLY FROM S.P.R.R. (SOUTH OF WHITTIER BLVD.) TO SLAUSON AVENUE; WEST SIDE OF RIO HONDO CHANNEL FROM 0.2 MILE ABOVE WHITTIER BOULEVARD SOUTH TO FOSTER BRIDGE BOULEVARD.	CONTROLLED RELEASES FORM SAN GABRIEL CANYON DAMS, SANTA FE AND WHITTIER NARROWS DAMS. UNCONTROLLED RUNOFF VIA SAN GABRIEL RIVER, RIO HONDO CHANNEL AND THEIR TRIBUTARIES; ALSO IMPORTED AND RECLAIMED WATER.	IN COOPERATION WITH THE CORPS OF ENGINEERS. THE DISTRICT OPERATES 2,500 ACRE-FOOT POOL AT WHITTIER NARROWS DAM FOR RETENTION OF STORM WATER.
22	12	SOUTHEAST SIDE OF SAN DIMAS WASH BETWEEN PUDDINGSTONE DIVERSION AND SAN DIMAS CANYON ROAD.	CONTROLLED RELEASES FROM PUDDINGSTONE DIVERSION DAM; UNCONTROLLED FLOW FROM LOCAL STORM RUNOFF.	
-	35	EASTERLY SIDE OF SAN GABRIEL RIVER. BELOW MOUTH OF SAN GABRIEL CANYON. NORTH OF THE CITY OF AZUSA.	SAN GABRIEL RIVER CONTROLLED RELEASES FROM COGSWELL DAM, SAN GABRIEL DAM, AND MORRIS DAM. COMMITTEE OF NINE SURPLUS FLOWS.	
75	75	WESTERLY SIDE OF SAN GABRIEL RIVER, SOUTHERLY FROM WHITTIER BOULEVARD TO WASHINGTON BOULEVARD.	CONTROLLED RELEASES FROM SAN GABRIEL CANYON DAMS, SANTA FE AND WHITTIER NARROWS DAMS. ALSO IMPORTED AND RECLAIMED WATER.	IN COOPERATION WITH THE CORPS OF ENGINEERS. THE DISTRICT OPERATES 2,500 ACRE-FOOT POOL AT WHITTIER NARROWS DAM FOR RETENTION OF STORM WATERS.
62***	100	SAN GABRIEL RIVER FROM WHITTIER NARROWS DAM TO FLORENCE AVE. STORAGE BEHIND THE RUBBER DAMS.	SAME AS UPPER PORTION. ALSO RECLAIMED WATER.	FIVE RUBBER DAMS INSTALLED ON DROP STRUCTURES. WHEN INFLATED, CONVERTS RIVER BED TO SPREADING AREAS.
-	180	SAN GABRIEL RIVER FROM SANTA FE DAM TO WHITTIER NARROWS DAM.	CONTROLLED FLOW FROM DAMS IN SAN GABRIEL CANYON, SANTA FE DAM AND UNCONTROLLED VALLEY RUNOFF BELOW SANTA FE DAM; ALSO IMPORTED WATER.	CHECK LEVEES DEVELOPED IN RIVER TO SPREAD WATER.

FILTRATION RATES WHICH MAY BE EXPECTED TO OCCUR
UMBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

LOS ANGELES COUNTY DEP
HYDRAULIC/WATER CO

SUMMARY OF DATA ON
OWNED AND OPERATE
UPDATED THROUG

VOL 12

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA IN ACRES GROSS	AREA IN ACRES WETTED	CAPACITIES CHANNEL** (CFS)	CAPACITIES INTAKE (CFS)	CAPACITIES STORAGE (A.F.)	PERCO (CF
SANTA ANITA	SHALLOW BASINS	1944-45	20	8.5	-	20	25	
SANTA FE	SHALLOW AND MEDIUM DEPTH BASINS	1953-54	338	168	-	400	606	4
SAWPIT	SHALLOW BASINS	1946-47	12	3.8	-	30	13	
WALNUT	DEEP BASIN	1962-63	16	8.4	8,000	50	174	
TOTAL:			2,436	1,576	-	-	13,360	1,

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION
DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS DO N

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

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TY .RTMENT OF PUBLIC WORKS
TER CONSERVATION DIVISION

TA ON SPREADING FACILITIES
ERATED BY THE DEPARTMENT
HROUGH SEPTEMBER 1992

PERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
5	WESTERLY SIDE OF SANTA ANITA WASH 1.25 MILES ABOVE FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM SANTA ANITA DAM AND SANTA ANITA DEBRIS BASIN.	THE HEADWORKS LOCATED UPSTREAM OF THE DEBRIS BASIN DIVERTS WATER TO SANTA ANITA SPREADING GROUNDS AND CITY OF SIERRA MADRE SPREADING GROUNDS.
400	WITHIN SANTA FE DAM RESERVOIR AND SPILLWAY AREAS.	CONTROLLED FLOWS FROM SAN GABRIEL CANYON RESERVOIRS. UNCONTROLLED FLOWS FROM SAN GABRIEL RIVER BELOW MORRIS RESERVOIR; ALSO IMPORTED WATER FROM SGVMWD AND USG-3.	RIGHT OF WAY, HELD UNDER LICENSE FROM THE FEDERAL GOVERNMENT INCLUDES 30 ACRES IN SAN GABRIEL RIVER BED FOR EARTH DIVERSION LEVEE.
12	WESTERLY SIDE OF SAWPIT WASH BELOW MOUTH OF CANYON NEAR NORUMBEGA DRIVE, MONROVIA.	CONTROLLED FLOWS FROM SAWPIT DAM AND SAWPIT DEBRIS BASIN.	
	WEST SIDE OF WALNUT WASH, NORTH OF SAN BERNARDINO FREEWAY.	CONTROLLED FLOW FROM PUDDINGSTONE DAM AND UNCONTROLLED FLOWS FROM WALNUT WASH CHANNEL.	
1,756			

LATION RATES WHICH MAY BE EXPECTED TO OCCUR
S DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

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LOS ANGELES COUNTY DEPA
HYDRAULIC/WATER CON

SUMMARY OF DATA ON S
NOT OWNED BY T
UPDATED THROUGH

GROUNDS	TYPE	SEASON FIRST USED	AREA IN ACRES		CAPACITIES			
			GROSS	WETTED	CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCOLAT (CFS)
SIERRA MADRE**** (CITY OF SIERRA MADRE)	SHALLOW BASINS	ABOUT 1933	22	9	-	25	47	1
FISH CANYON (COMMITTEE OF NINE)	SHALLOW BASINS	ABOUT 1917	6	4	-	-	-	
THOMPSON CREEK **** POMONA VALLEY PROTECTIVE ASSOCIATION	DITCHES CHECKS AND DEEP BASIN	ABOUT 1928	53	37	-	35	-	1
TUJUNGA (L.A. CITY DEPT. OF WATER AND POWER) ***	SHALLOW BASINS	1931-32	188	83.2	22,000	400	-	39
	TOTALS:		269	133	-	-	-	4

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRA
DURING OPERATIONS FOR UP TO FIVE DAYS. NUMBERS

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

*** THE DEPARTMENT ENTERED INTO AN AGREEMENT WITH T
THIS FACILITY.

**** THE DEPARTMENT DIVERTS WATER TO THESE FACILITIES

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JNT :PARTMENT OF PUBLIC WORKS
VATER CONSERVATION DIVISION

)ATA ON SPREADING FACILITIES
VNED BY THE DEPARTMENT
THROUGH SEPTEMBER 1992

S AGE (.)	PERCOLATION* (CFS)	LOCATION	SOURCE OF WATER	REMARKS
47	15	CITY OF SIERRA MADRE, SOUTH SIDE OF GRANDVIEW AVENUE, ONE HALF MILE WEST OF SANTA ANITA AVENUE.	LITTLE SANTA ANITA CREEK AND STREET RUNOFF ALSO CONTROLLED FLOWS FROM SANTA ANITA DAM.	
-	7	WESTERLY SIDE OF SAN GABRIEL RIVER BELOW MOUTH OF FISH CANYON AND NORTH OF THE CITY OF AZUSA.	THE 'COMMITTEE OF NINE'.	OWNED AND OPERATED BY CAL-AMERICAN WATER COMPANY.
-	15	SOUTHERLY FROM, AND ADJACENT TO THOMPSON CREEK DAM, EAST SIDE OF CREEK. ELEVATION 1,625.	COBAL, WILLIAMS, PALMER, AND PADUA CREEKS, ALSO THOMPSON CREEK, WHEN RESERVOIR ABOVE	OPERATED BY POMONA VALLEY PROTECTIVE ASSOCIATION.
-	390	SAN FERNANDO VALLEY, EAST SIDE OF TUJUNGA WASH AT ROSCOE BOULEVARD.	LOS ANGELES CITY'S OWENS VALLEY AQUEDUCT AND CONTROLLED RELEASES FROM HANSEN DAM.	PRIOR TO 1938 FLOOD, USED 80 ACRES NET. TUJUNGA CHANNEL ON WESTERLY SIDE OF GROUNDS PAVED IN 1950.
-	427			

OF INFILTRATION RATES WHICH MAY BE EXPECTED TO OCCUR
YS. NUMBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

ANNEL.

EMENT WITH THE CITY OF LOS ANGELES TO OPERATE

SE FACILITIES.

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Los Angeles County, Department of Public Wor

WATER CONSERVED ALL FACILITIE

BASINS	SPREADING FACILITIES	OCT	NOV	DEC	JAN	FEB
SAN FERNANDO VALLEY	BRANFORD	32.1	0.0	103.7	48.2	140
	HANSEN	209.1	177.1	398.7	1,110.9	3,219
	LOPEZ	0.0	0.0	83.0	168.0	156
	PACOIMA	27.8	484.3	444.3	375.6	2,577
	TUJUNGA	0.0	0.0	179.5	367.8	2,700
	SUBTOTAL	269.0	661.4	1,209.2	2,070.5	8,793
SAN GABRIEL VALLEY	ARROYO SECO	2.9	6.1	101.0	168.0	550
	BEN LOMOND	52.0	64.0	46.0	146.0	258
	BIG DALTON	0.0	0.0	0.0	0.0	225
	BUENA VISTA	61.0	37.1	58.0	42.0	89
	CITRUS	12.0	6.5	34.0	42.0	80
	EATON BASIN	33.0	22.0	252.0	180.0	42[illegible]
	EATON GROUNDS	0.0	0.0	0.0	62.0	577
	FORBES	18.0	163.0	93.0	76.0	6[illegible]
	IRWINDALE	5,260.0	4,910.0	4,600.0	2,150.0	1,730
	LITTLE DALTON	0.0	0.7	0.1	0.5	16[illegible]
	LIVE OAK	0.0	0.0	0.0	0.0	13
	MORRIS TO STA. F190	851.0	375.8	631.7	2,101.0	1,511
	STA. F190 TO SANTA FE DAM	0.0	26.0	2.0	4,218.0	4,010
	PECK ROAD	969.7	16.2	466.1	1,627.0	4,416
	SAN DIMAS CANYON	0.0	0.0	2.4	9.3	304
	SAN GABRIEL CANYON	417.0	342.0	548.0	1,010.0	1,290
	SANTA ANITA	0.0	17.0	0.0	73.0	165
	SANTA FE SPRD. GROUNDS	0.0	0.0	0.0	2,690.0	6,730
	SANTA FE TO STA. F261	2,830.0	3.0	26.0	3,730.0	10,570
	SANTA FE DIVERSION	292.0	0.0	0.0	460.0	20[illegible]
	SAWPIT	0.0	0.0	27.0	65.0	221
	WALNUT	44.0	6.8	6.9	575.0	5[illegible]
	WALNUT,S.JOSE CRK TO 263	4,236.2	2,198.6	7,927.6	4,456.9	1,50[illegible]
	SUBTOTAL	15,098.8	8,194.8	14,824.0	23,901.7	35,14[illegible]
COASTAL PLAIN	RIO HONDO EAST FLUME	5,990.0	4,050.0	4,830.0	2,390.0	5,31[illegible]
	WEST FLUME	742.0	1,230.0	1,040.0	541.0	86[illegible]
	R/W FLUME	531.0	380.0	70.0	113.0	46[illegible]
	102" INTAKE	2,274.0	1,730.0	2,896.0	1,961.0	3,02[illegible]
	RIO HONDO SYSTEM	1,200.0	2,752.0	10,500.0	10,000.0	9,00[illegible]
	SAN GABRIEL SYSTEM	5,402.6	2,475.1	4,508.0	3,586.7	7,401
	DOMINGUEZ GAP	0.0	0.0	0.0	0.0	1[illegible]
	SUBTOTAL	17,139.6	12,617.1	23,844.0	18,591.7	26,092
ANTELOPE VALLEY	BIG ROCK	0.0	0.0	1.2	28.0	42[illegible]
OTHER FACILITIES	SIERRA MADRE	0.0	84.0	0.0	191.0	14[illegible]
	FISH CREEK	831.9	229.7	96.2	71.2	71
	SUBTOTAL	831.9	313.7	96.2	262.2	21[illegible]
TOTAL OF ALL WATER SPREAD &/OR DIVERTED		33,339.3	21,787.0	39,974.6	44,854.1	70,674

NOTES: *: SUBJECT TO ADJUSTMENT.

of Public Works, Hydraulic / Water Conservation Division

L FACIUTIES FOR WATER YEAR 1991–1992

	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ACC. TOT
2	140.0	300.1	11.9	10.5	0.2	6.1	0.0	0.0	652.8
9	3,219.7	2,804.0	2,733.1	1,120.9	1,709.1	1,217.9	732.0	28.7	15,461.2
.0	156.0	109.0	233.0	126.0	219.0	0.0	0.0	0.0	1,094.0
.6	2,577.7	3,570.1	2,233.4	1,775.2	767.2	150.1	5.7	0.0	12,411.4
.8	2,700.0	2,677.0	1,222.0	1,038.0	610.0	0.0	90.0	388.0	9,272.3
5	8,793.4	9,460.2	6,433.4	4,070.6	3,305.5	1,374.1	827.7	416.7	38,891.7
.0	550.0	734.0	744.0	355.0	34.0	17.0	0.0	2.0	2,714.0
.0	256.0	473.0	476.0	473.0	588.0	485.0	318.0	83.0	3,444.0
0	225.0	115.0	29.0	47.0	0.0	0.0	0.0	0.0	416.0
.0	89.0	86.0	2.0	18.0	0.0	0.0	0.0	0.0	393.1
.0	80.0	82.0	143.0	14.0	0.0	5.4	0.0	0.0	418.9
.0	426.0	775.0	294.0	34.0	49.0	61.0	7.4	0.0	2,133.4
.0	577.0	553.0	483.0	75.0	111.0	31.0	0.0	0.0	1,892.0
.0	64.0	63.0	81.0	80.0	118.0	16.0	142.0	61.0	975.0
0	1,730.0	2,560.0	3,980.0	3,770.0	3,290.0	3,230.0	3,880.0	1,770.0	41,110.0
5	166.0	195.0	150.0	40.0	8.5	0.0	0.0	0.0	560.8
0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0
0	1,511.0	3,047.0	1,962.0	1,247.0	1,511.0	1,536.0	763.4	2,282.0	17,818.9
0	4,010.0	6,304.0	4,510.0	1,185.0	0.0	0.0	6.0	67.0	20,328.0
0	[illegible]6.0	6,474.0	1,631.8	2,694.0	3,425.9	547.5	0.0	2.6	22,290.8
3	[illegible]4.0	462.0	458.0	512.0	134.0	341.0	151.0	1.4	2,375.1
0	1,290.0	1,630.0	1,670.0	1,460.0	1,170.0	1,360.0	1,190.0	539.0	12,626.0
0	165.0	117.0	72.0	38.0	82.0	23.0	5.5	67.0	659.5
0	6,730.0	10,790.0	13,310.0	6,000.0	4,710.0	3,150.0	0.0	2,100.0	49,480.0
0	10,570.0	5,720.0	5,040.0	4,410.0	8,890.0	3,370.0	0.0	3,980.0	48,369.0
0	200.0	0.0	220.0	2,670.0	2,966.0	4,745.0	0.0	0.0	11,753.0
0	221.0	316.0	331.0	96.0	48.0	65.0	28.0	0.0	1,217.0
0	53.0	282.0	176.0	189.0	115.0	112.0	86.0	46.0	1,671.7
9	1,500.0	1,600.0	1,203.6	981.5	1,131.2	2,698.2	1,512.4	1,268.0	30,714.4
7	35,148.0	42,378.0	36,946.4	26,588.5	28,181.8	21,773.1	8,069.7	12,269.0	273,373.6
0	5,310.0	6,130.0	759.0	2,810.0	4,660.0	3,760.0	2,440.0	3,870.0	47,999.0
0	868.0	837.0	131.0	599.0	1,230.0	1,210.0	583.0	45.0	9,056.0
0	468.0	499.0	64.0	2.1	153.0	268.0	393.0	275.0	3,216.1
0	3,026.0	3,295.0	537.0	1,285.0	1,568.0	773.0	0.0	569.0	19,914.0
0	9,000.0	50,126.0	2,038.3	2,171.4	3,452.3	4,838.5	4,273.1	2,256.6	102,610.3
7	7,401.0	6,785.0	863.8	4,730.3	3,257.6	3,410.0	476.0	870.1	43,566.2
0	19.1	19.4	6.9	0.1	0.0	0.0	0.0	0.0	45.5
7	26,092.1	67,693.4	4,400.0	11,597.9	14,318.9	14,259.6	8,167.1	7,685.7	226,407.1
0	428.0	536.0	813.0	912.0	799.0	711.0	192.0	101.0	4,521.2
0	142.0	243.0	480.0	601.0	293.0	186.0	86.0	9.4	2,315.4
2	71.2	116.8	164.1	252.7	226.8	277.8	238.4	40.8	2,617.4
2	213.2	359.8	644.1	853.7	519.8	463.6	324.4	50.2	4,932.8
1	70,674.7	120,427.4	49,236.9	44,022.7	47,124.8	38,581.4	17,580.9	20,522.6	548,126.4

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VOL 12

Los Angeles County,
Hydraulic Water

TOTAL WATER DEL
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MONTH	IMPORTED WATER OUTLET RELEASES								
	SAN DIMAS CB – 48	THOMPSON CREEK CB – 26	SAN GAB. RIVER CB – 37	ALHAMBRA CB – 36	OLDEN ST L.A. 699	USG 3 USGMWD	BEATTY CANYON SGVMWD	SAN DIMAS WH SGVMWD	MONTH TOTA SPRE
OCT	5,335.4	6,651.4	0.0	5,320.3	0.0	2,534.4	0.0	212.3	202
NOV	4,580.6	3,430.8	0.0	5,743.2	484.0	0.0	0.0	1,494.3	15
DEC	4,965.5	4,125.8	0.0	4,971.1	0.0	0.0	0.0	96.0	14
JAN	1,352.5	0.0	0.0	704.2	0.0	4,957.5	0.0	0.0	7
FEB	765.1	0.0	0.0	501.6	21.3	0.0	0.0	0.0	1
MAR	956.0	0.0	0.0	996.8	0.0	0.0	0.0	840.3	2
APR	3,305.9	0.0	0.0	566.1	0.0	0.0	279.7	1,021.8	5
MAY	2,491.3	0.0	0.0	1,778.7	0.0	0.0	520.0	1,497.0	6
JUN	3,186.0	0.0	0.0	1,687.2	0.0	0.0	0.0	1,103.0	5
JUL	3,106.0	0.0	0.0	1,900.2	0.0	0.0	0.0	1,228.0	6
AUG	3,152.8	0.0	0.0	2,619.2	0.0	0.0	0.0	1,079.0	6
SEP	1,041.6	0.0	0.0	1,906.7	0.0	6,635.1	0.0	1,121.0	10
TOTALS	34,260.7	14,408.0	0.0	28,695.3	505.3	14,127.0	799.7	9,692.7	102,5

NOTES :
- The Amounts of Reclaimed Water from Pomona Plant are estimated.
- Water delivered from CB–48 during October 1991 thru September 1992 were spread in San Gabriel

20242

County, Department of Public Works
lic Water Conservation Division

'ER DELIVERED IN ACRE-FEET
'ATER YEAR : 1991-1992

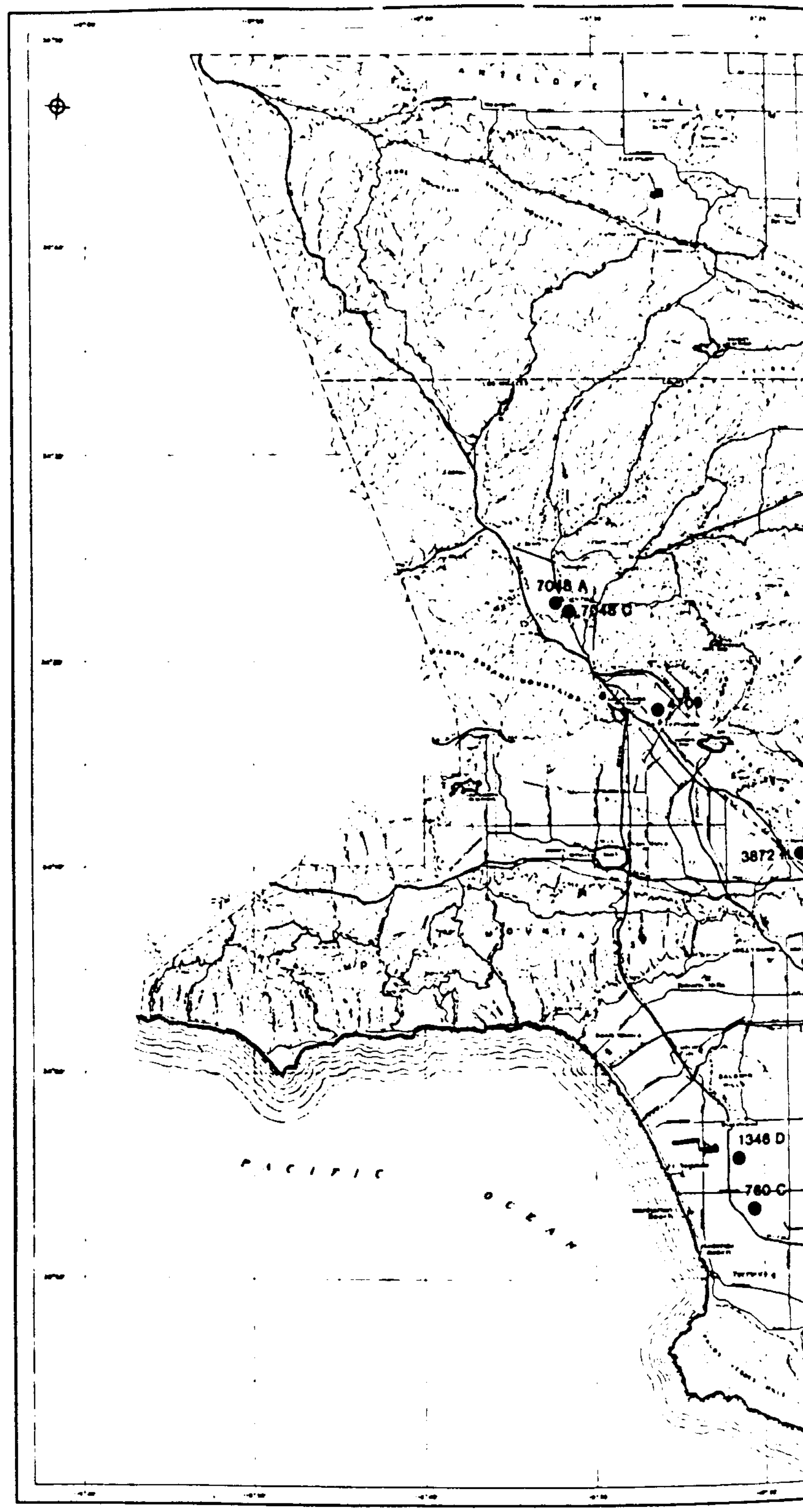
		RECLAIMED WATER DELIVERED									
DIMAS	MONTHLY	WHITTIER NARROWS PLANT				SAN JOSE PLANT				POMONA	MONTHLY
WH	TOTAL	DELIVERED		WASTED	MONTHLY	DELIVERED		WASTED	MONTHLY		TOTAL
/MWD	SPREAD	R.HONDO	S.GABRIEL		SPREAD	R.HONDO	S.GABRIEL		SPREAD	PLANT	SPREAD
212.3	20,253.8	1,385.5	0.0	0.0	1,385.5	0.0	5,010.6	0.0	5,010.6	130.8	6,526.9
1,494.3	15,732.9	1,296.0	0.0	0.0	1,296.0	1,072.1	1,759.9	0.0	2,832.0	239.6	4,367.6
96.0	14,178.4	508.6	927.8	0.0	1,436.4	0.0	0.0	0.0	0.0	200.7	1,637.1
0.[illegible]	7,014.2	334.7	1,089.0	0.0	1,423.7	0.0	946.7	0.0	946.7	235.8	2,606.2
0.0	1,306.0	998.9	0.0	154.3	844.6	0.0	848.8	110.0	738.8	353.6	1,637.0
640.3	2,793.1	595.6	564.6	210.5	949.7	0.0	37.1	0.2	36.9	340.2	1,326.8
1,021.8	5,173.5	459.3	572.0	459.3	572.0	0.0	88.8	0.0	88.8	333.6	994.4
1,497.0	6,287.0	100.8	620.7	0.0	721.5	0.0	4,301.5	0.0	4,301.5	200.6	5,223.6
1,103.0	5,976.2	1,218.3	0.0	0.0	1,218.3	0.0	3,246.3	0.0	3,246.3	154.7	4,619.3
1,226.0	6,236.2	586.9	112.6	0.0	699.7	0.0	4,311.8	0.0	4,311.8	268.6	5,280.1
1,079.0	6,851.0	826.1	0.0	0.0	826.1	4,416.5	615.8	0.0	5,032.3	245.1	6,103.5
1,121.0	10,704.4	1,246.6	0.0	0.0	1,246.6	4,109.9	670.1	0.0	4,780.0	251.1	6,277.7
,692.7	102,508.7	9,557.3	3,886.9	824.1	12,620.1	9,598.5	21,837.4	110.2	31,325.7	2,954.4	46,900.1

d in San Gabriel Valley.

VCI 12 20243

WELL HYDROGRAPHS INCLUDED IN THIS REPORT

GROUNDWATER BASIN	WELL NO.	APPROXIMATE LOCATION	PAGE NO.
WEST COAST	1346D 760C	11305 TRURO AVE., 250FT. N. OF IMPERIAL HWY., COMPTON 99 FT. S.W. OF INTERSECTION OF COMPTON BLVD. & DOTY AVE., LAWNDALE	G18
CENTRAL BASIN	460K 1601T 906D	2,600 FT. N.E. OF THE INTERSECTION OF LAKEWOOD BLVD. & PACIFIC COAST HWY., LONG BEACH 1,000 FT. S. OF THE INTERSECTION OF WASHINGTON BLVD. & ROSEMEAD BLVD., MONTEBELLO 1,300 FT. N.W. OF THE INTERSECTION OF LONG BEACH & SAN ANTONIO DR., LONG BEACH	G18 G19 G19
MAIN SAN GABRIEL	3030F 2965C	600 FT. N.W. OF THE INTERSECTION OF LOS ANGELES ST. & MAINE AVE., BALDWIN PARK 100 FT. S.W. OF THIENES AVE. & 180 FT. N.W. OF DURFEE AVE. (NOW PECK ROAD)	G20 G21
SAN GABRIEL CANYON	4284A 4285	5,600 FT. N.W. OF THE INTERSECTION OF SIERRA MADRE AVE. & SAN GABRIEL CANYON ROAD., AZUSA 2,700 FT. N.W. OF SAN GABRIEL CANYON RD. & SIERRA MADRE AVE.	G21
POMONA	3251E 3261P 4469A	2,200 FT. N. OF THE INTERSECTION OF SAN BERNARDINO FWY. & TOWNE AVE., POMONA 630 FT. N.E. FROM INTERSECTION OF LA VERNE AVE. & 50 FT. S.E. OF CENTERLINE OF TOWNE AVE. 739 FT. W. OF MOUNTAIN AVE., 1,025 FT. N. OF HARRISON AVE.	G22
CLAREMONT HEIGHTS	4508B 4508A	800 FT. S.E. OF THE INTERSECTION OF BASELINE RD. & PADUA AVE., CLAREMONT 270 FT. N.W. OF WELL 4508	G23
RAYMOND	4057H	LOS ROBLES & GLENARM STREETS, PASADENA	G23
SANTA CLARA	7048A 7048C	S.E. OF THE INTERSECTION OF NEWHALL AVE. & MAGIC MOUNTAIN PARKWAY, SAUGUS 544 FT. W. OF W. CURB OF VALENCIA BLVD., 56 FT. S. OF MAGIC MOUNTAIN PARKWAY, VALENCIA	G24
ANTELOPE VALLEY	9974 8825	8,976 FT. S. OF AVE. K & 200 FT. W. OF SIERRA HWY., LANCASTER 25 FT. N. OF AVE. T & 45 FT. E. OF 90TH ST., LITTLE ROCK	G25 G25
MAIN SAN FERNANDO	3872H 4709	CLARK AVE. & GRIFFITH PARK DR., BURBANK SHERMAN WAY & DEERING AVE., CANOGA PARK	G26 G26



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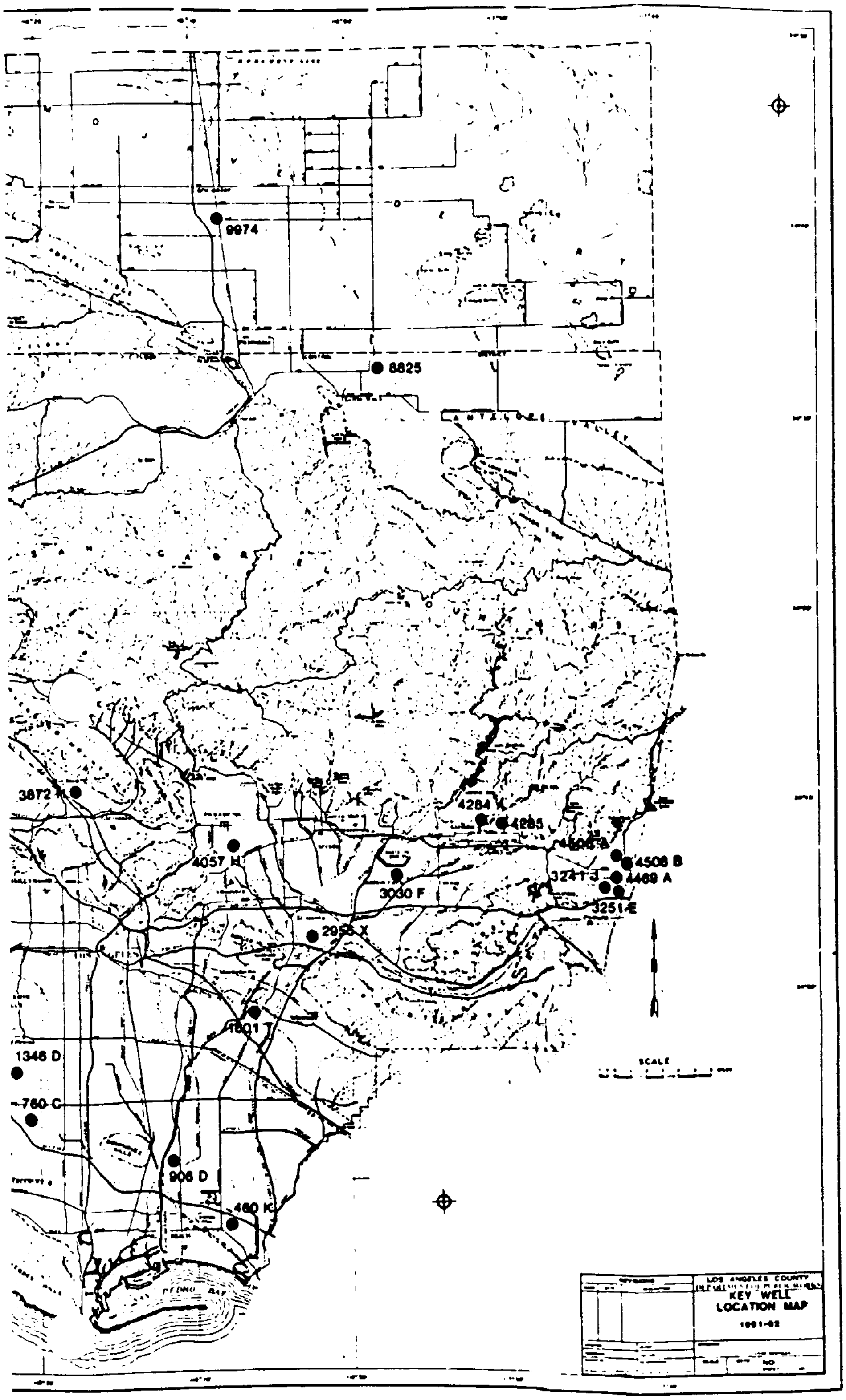

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G17

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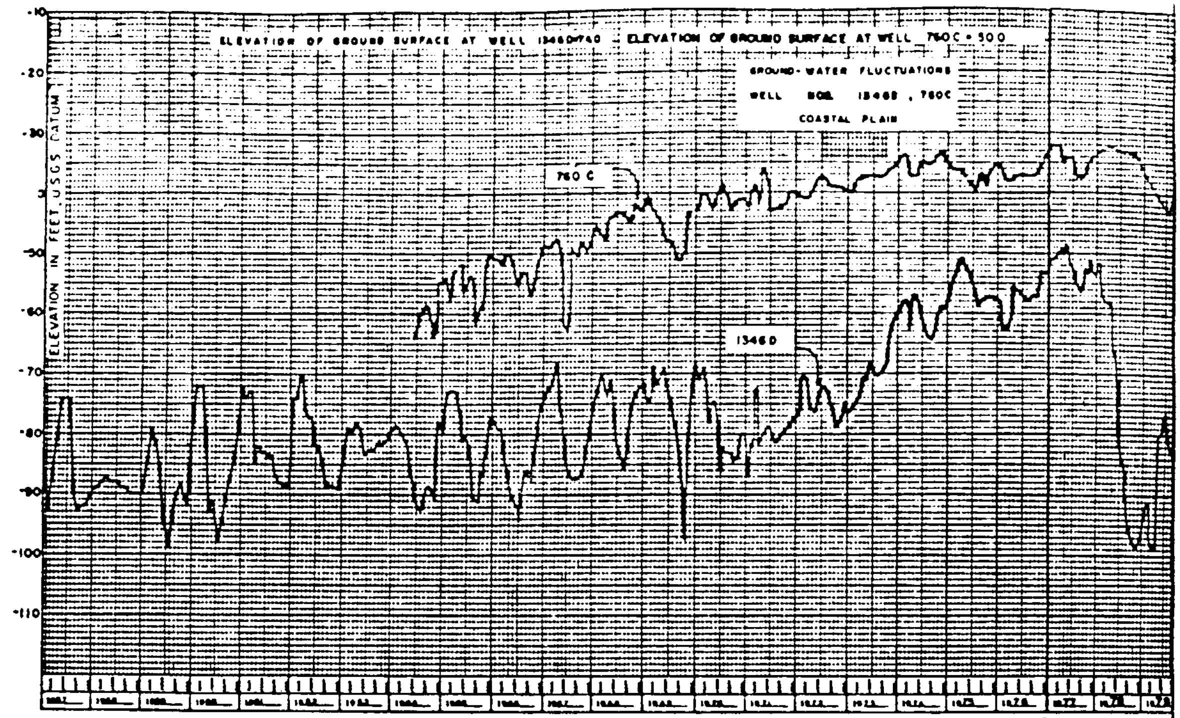
VCL 12



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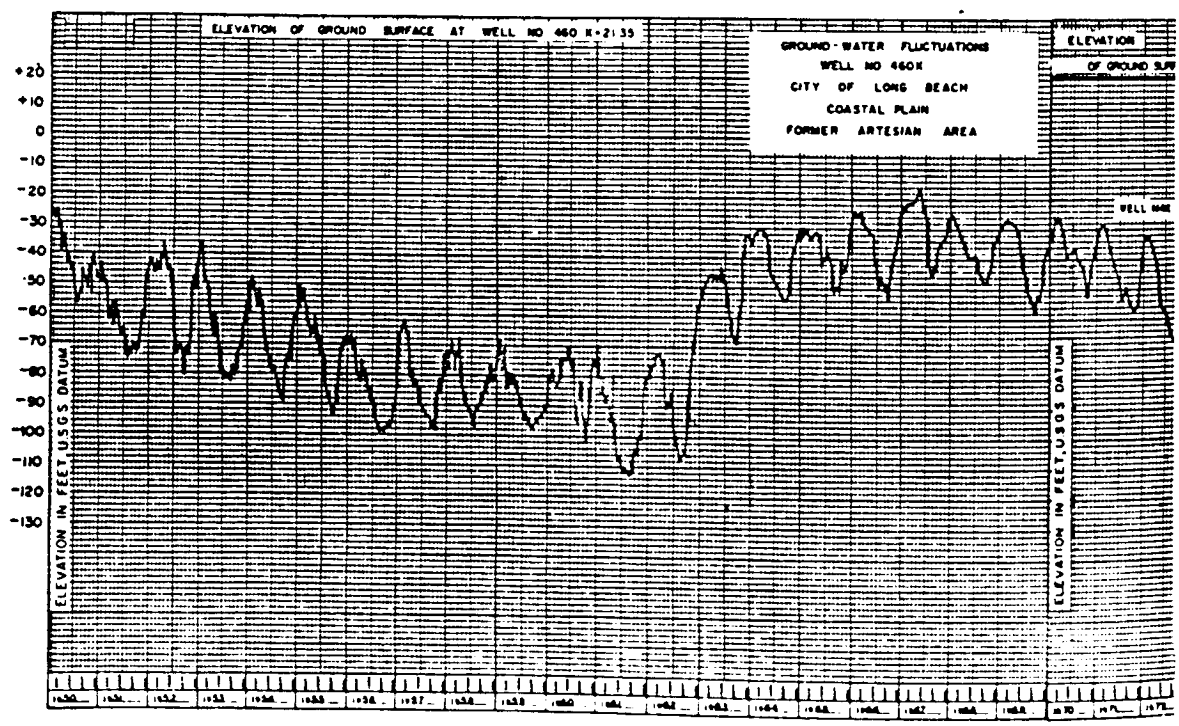

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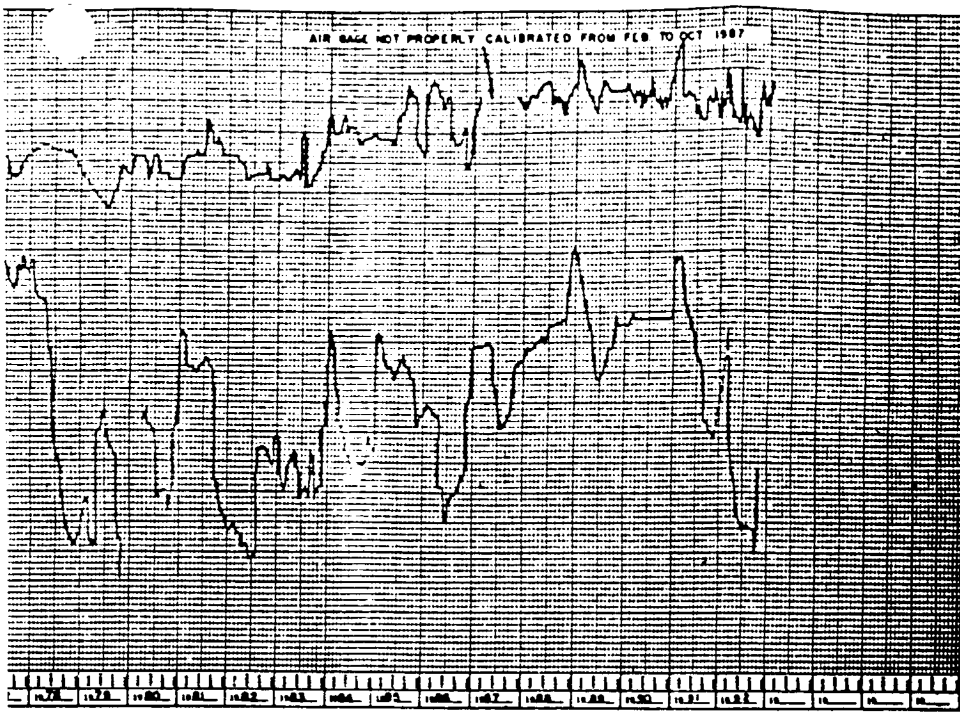

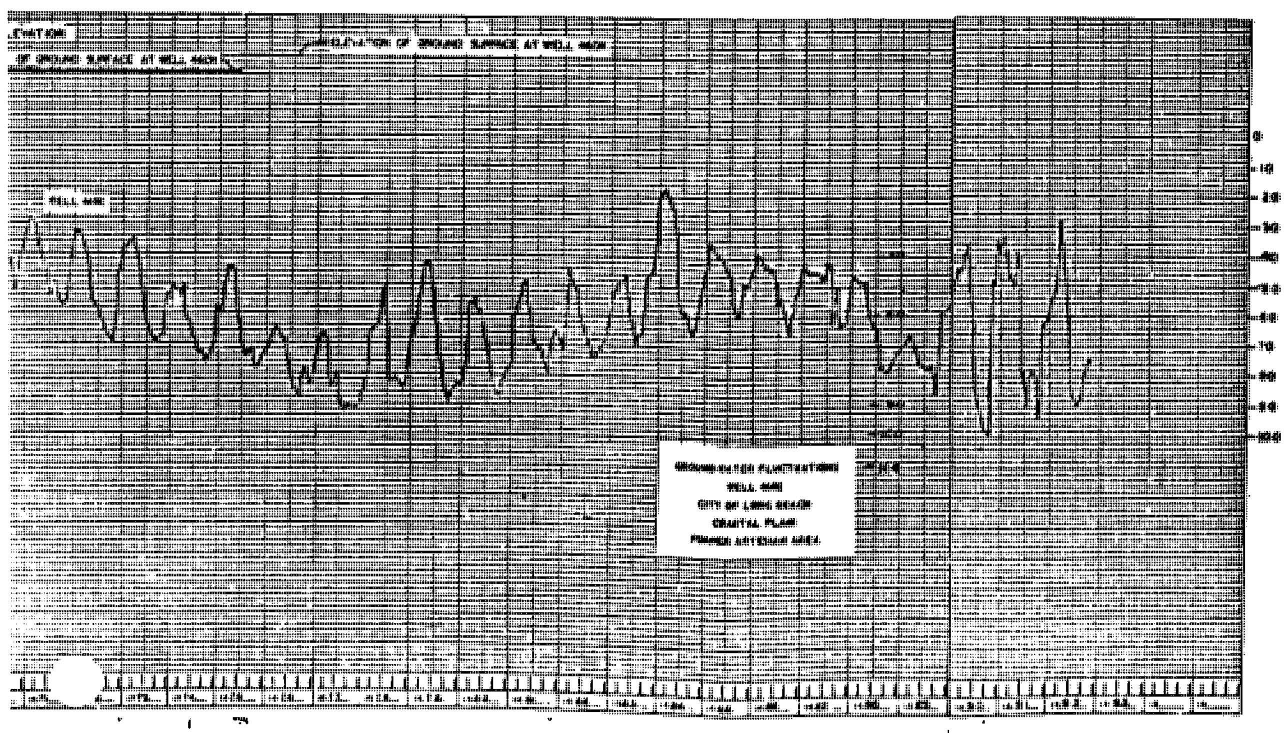

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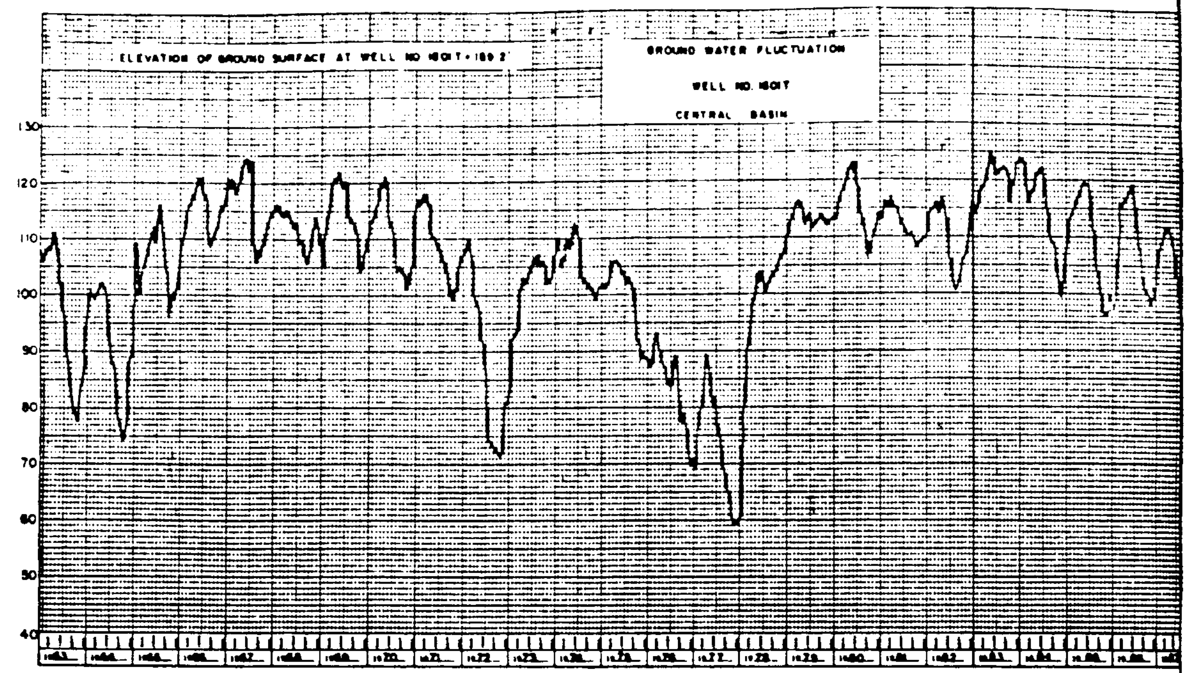

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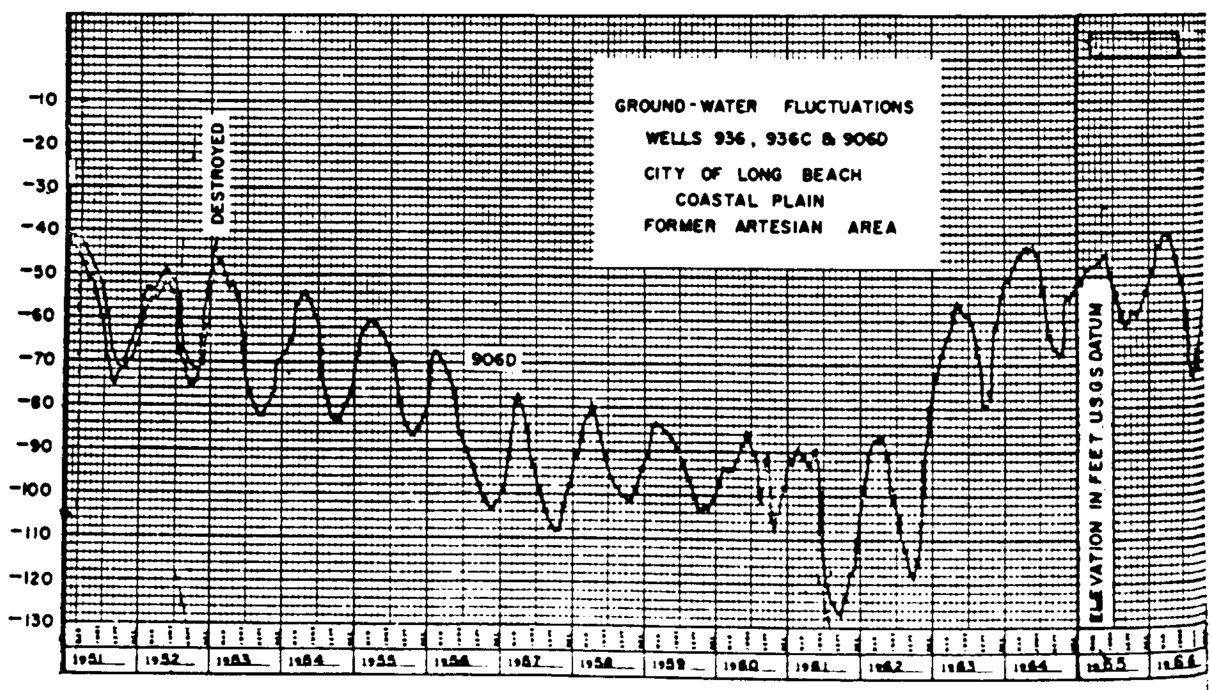

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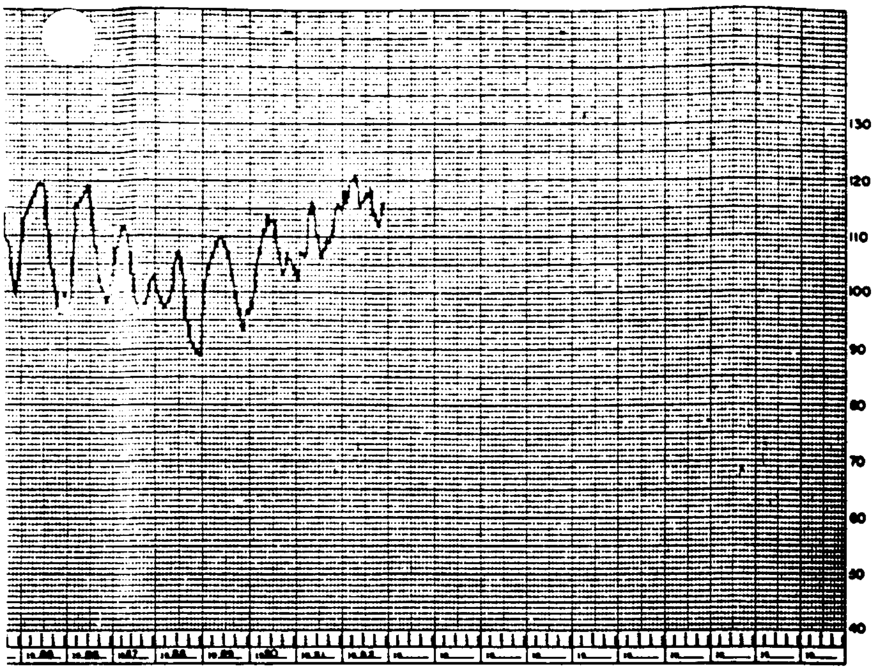

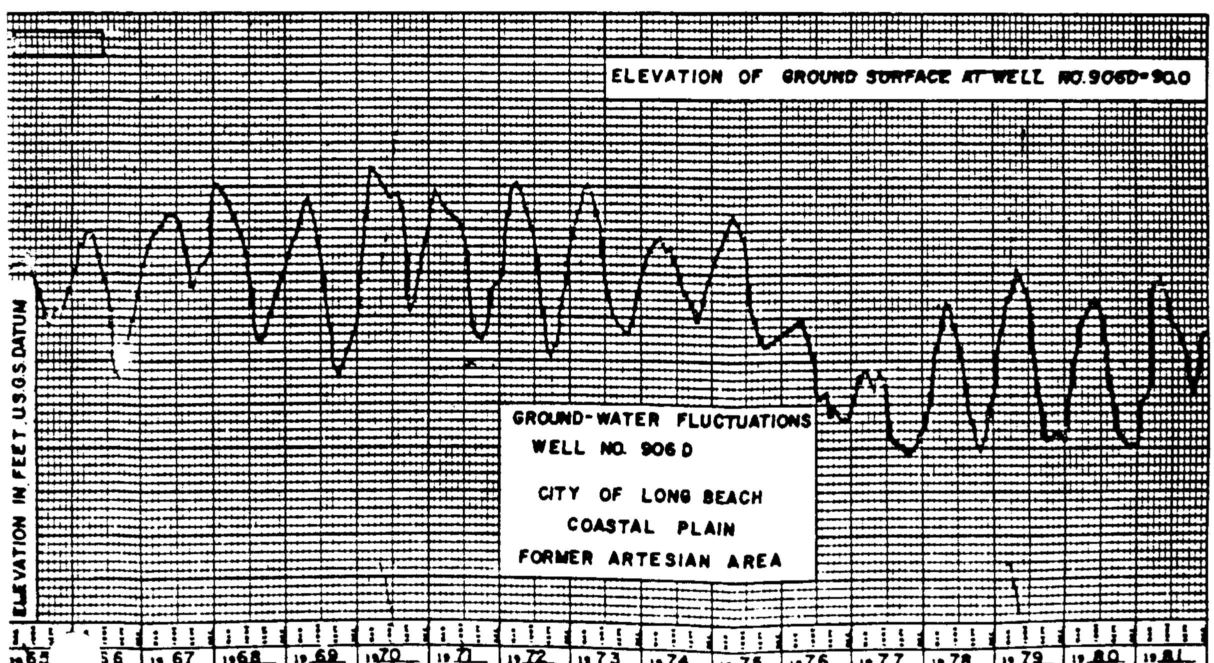

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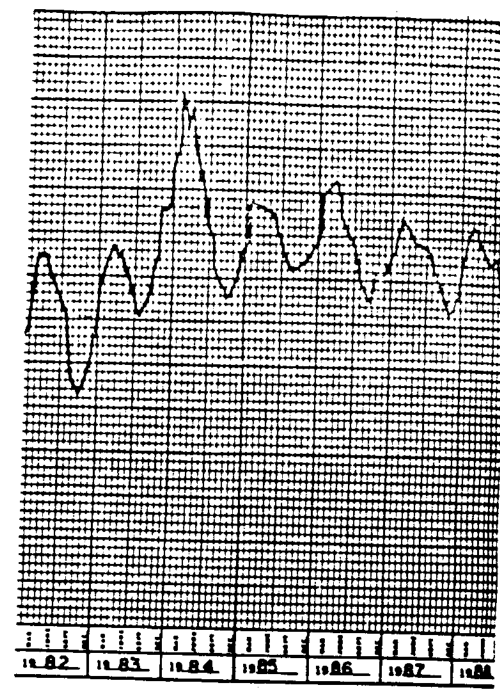
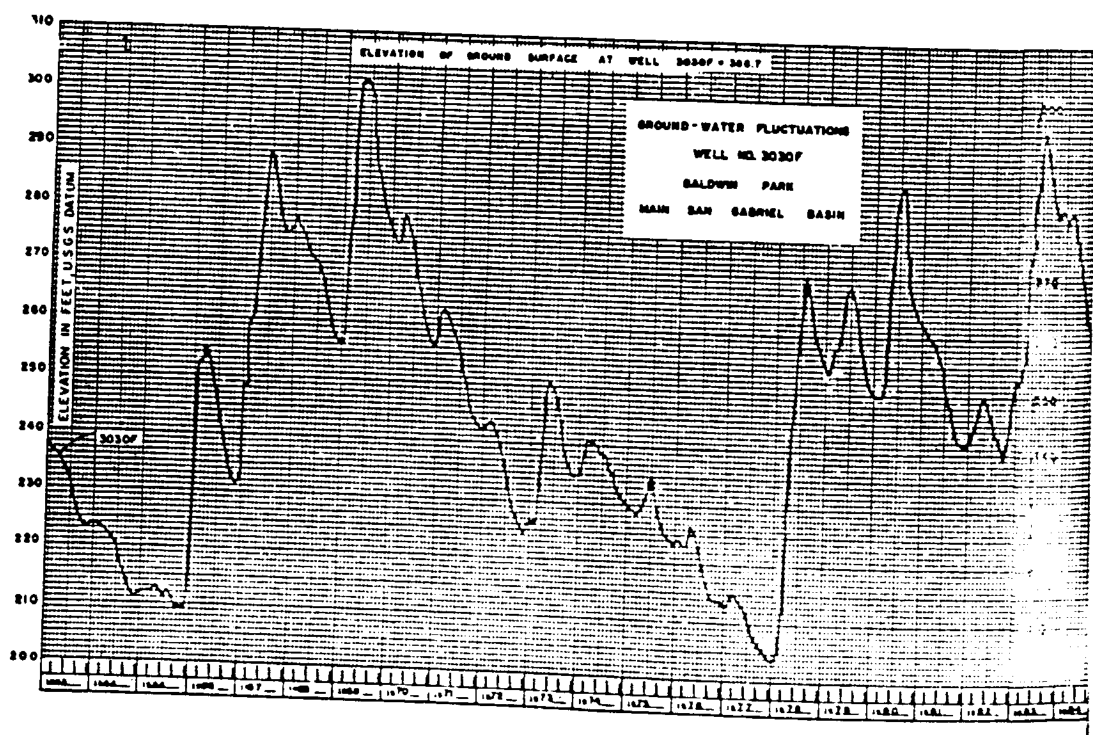
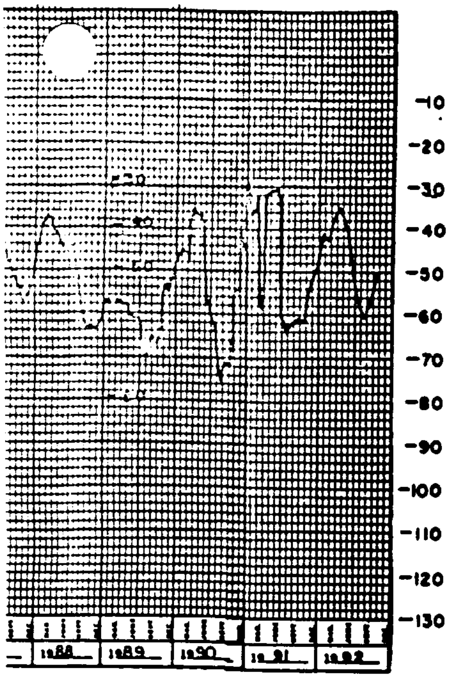
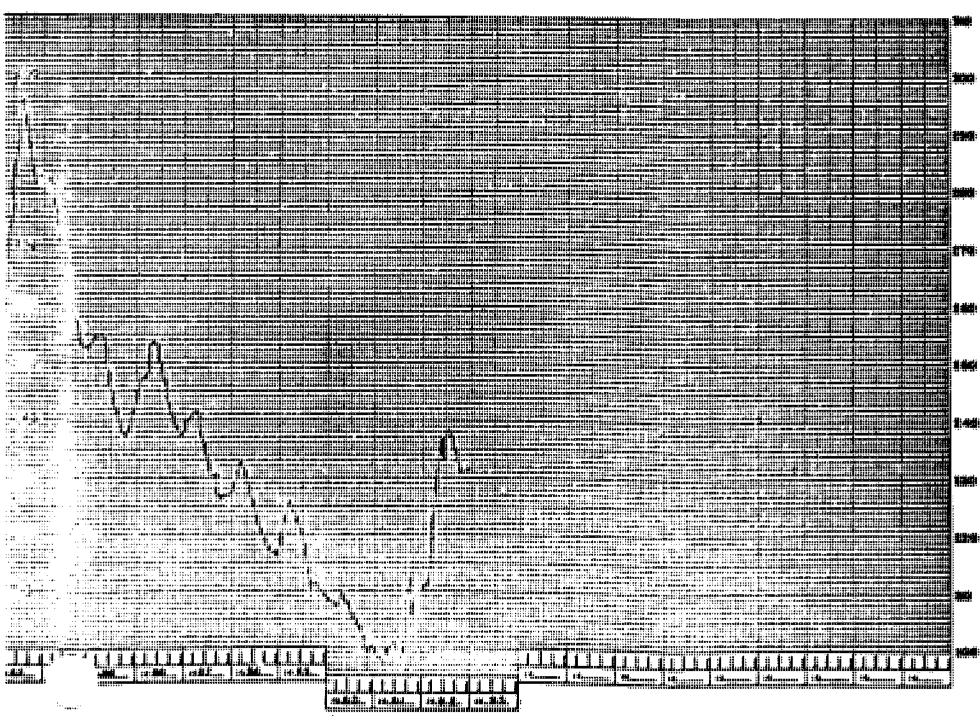
WELL NO. 906D

CONTINUED FROM PAGE G19









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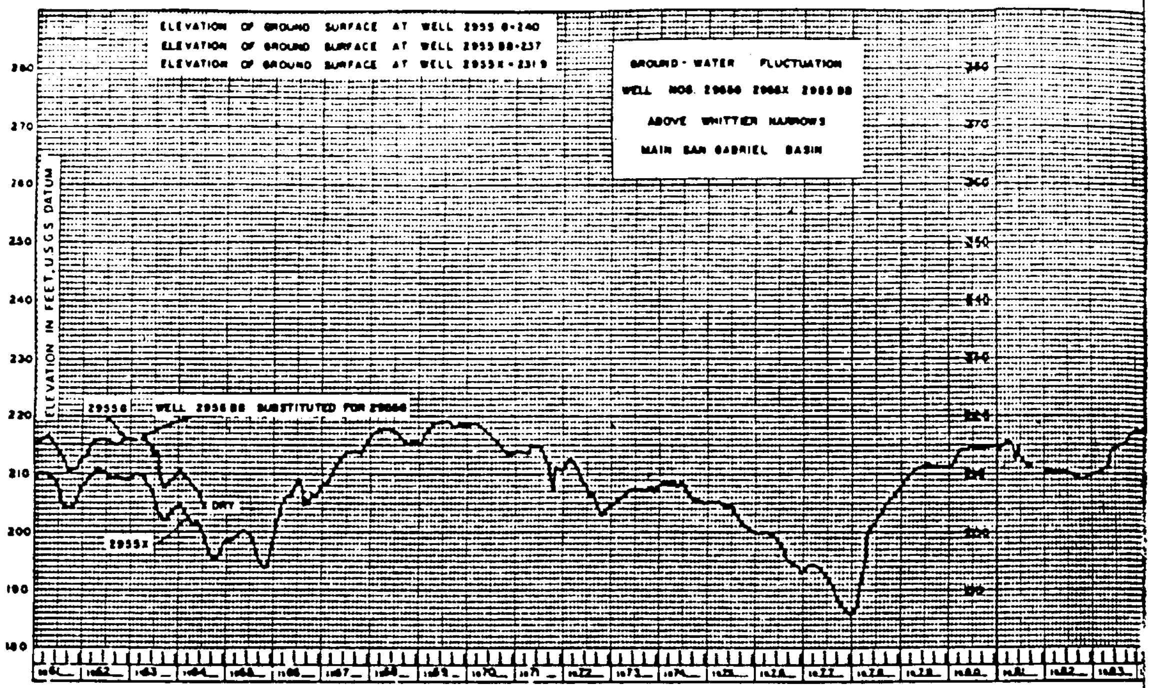
VOL 12 2

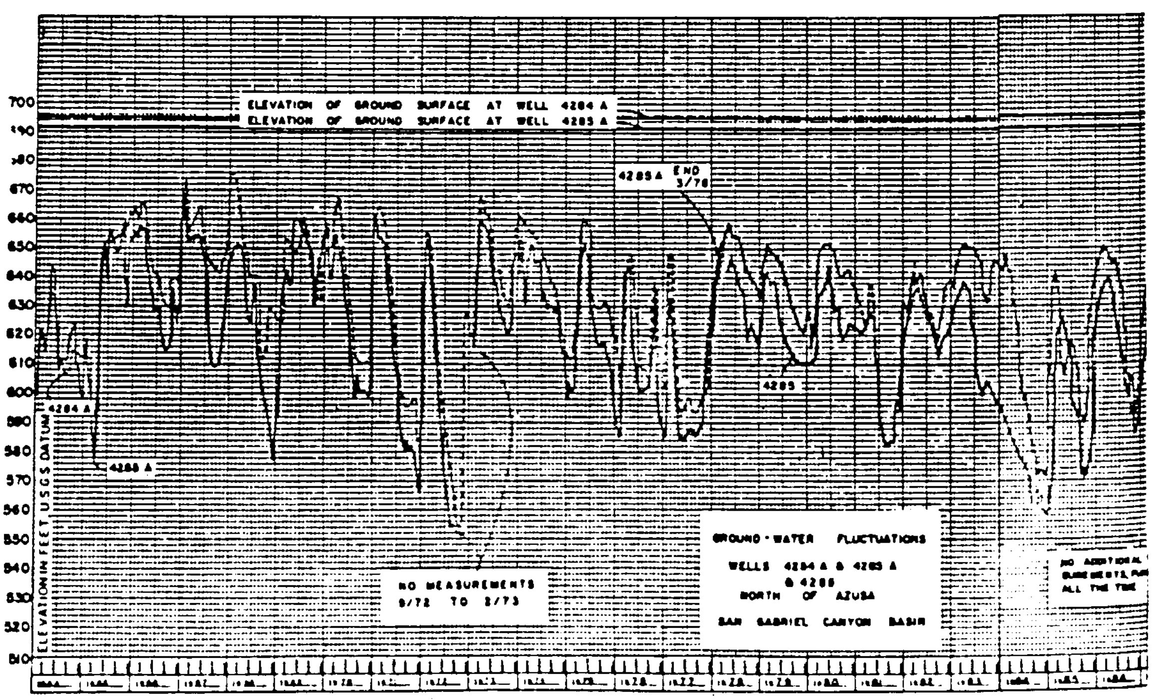
0252

R0053557

VOL 12 2

0253





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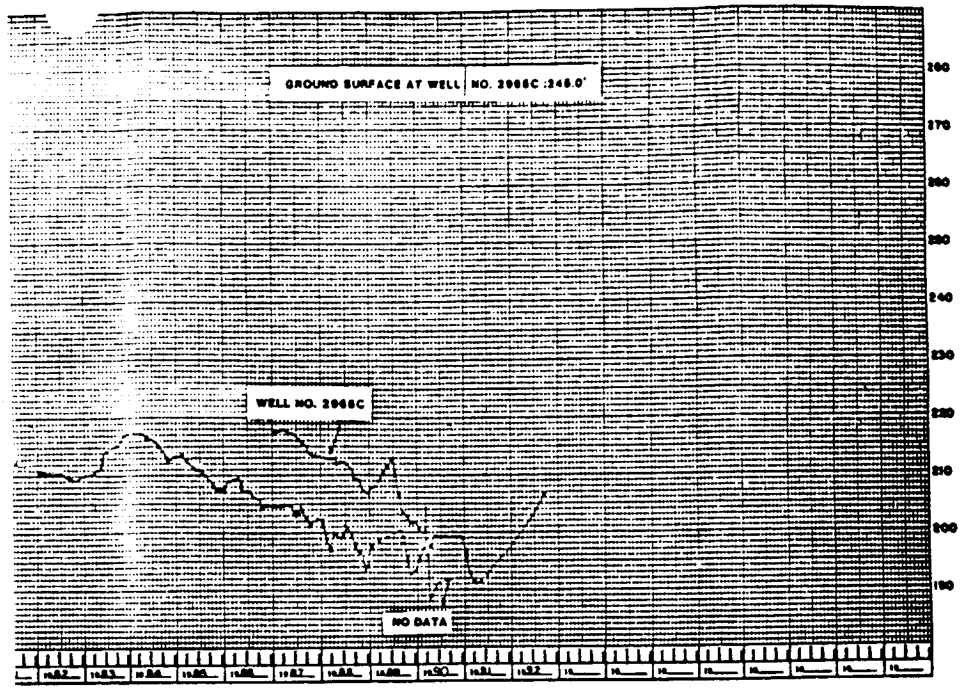

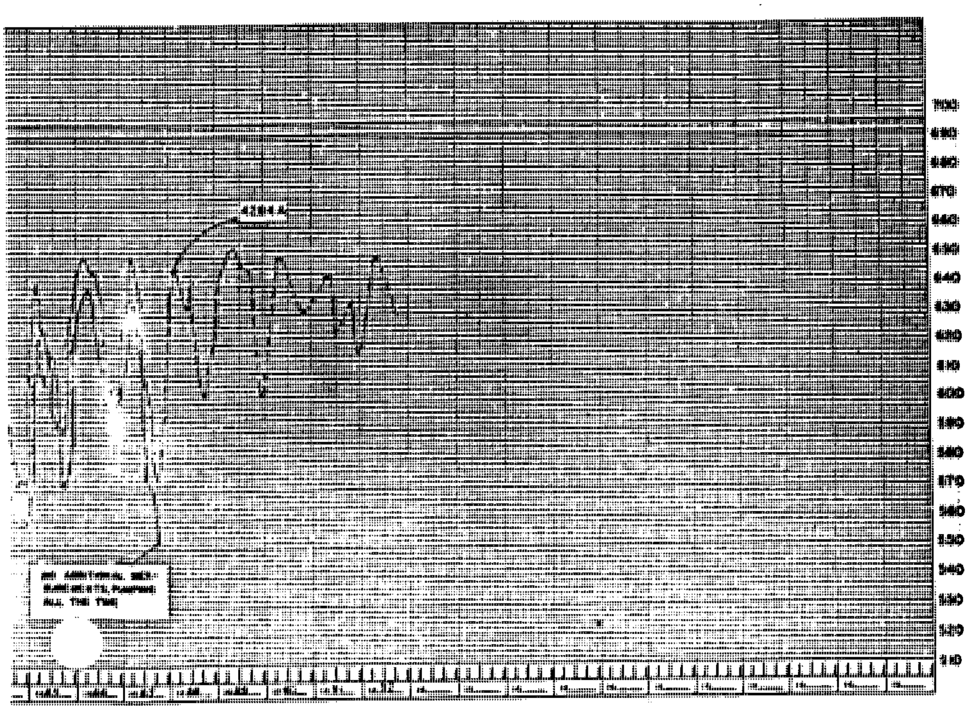

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R0053559

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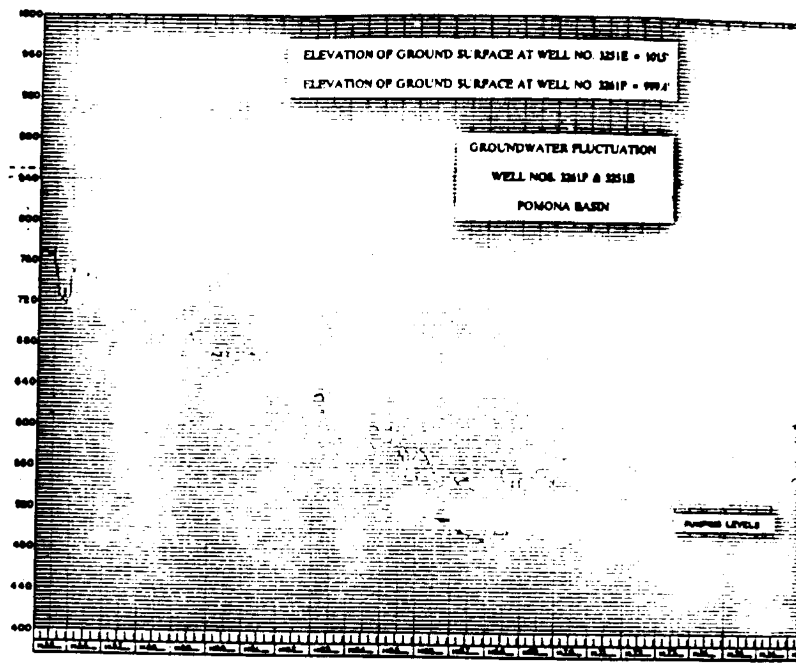

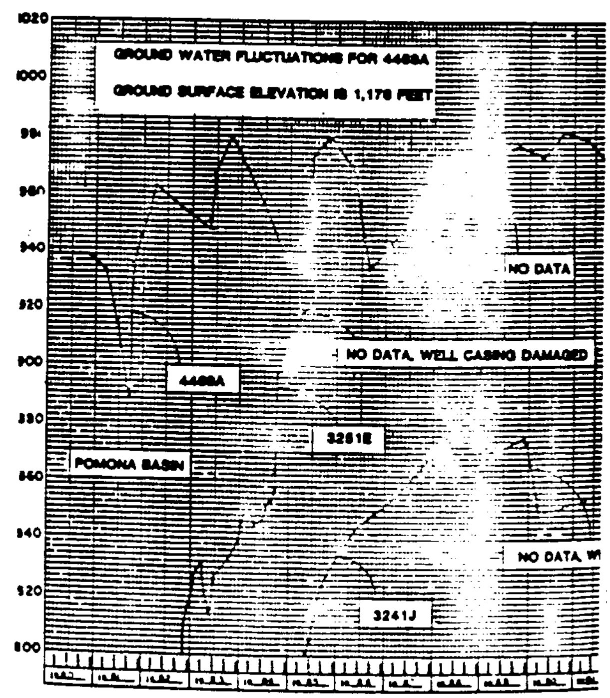

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VOL 12

2

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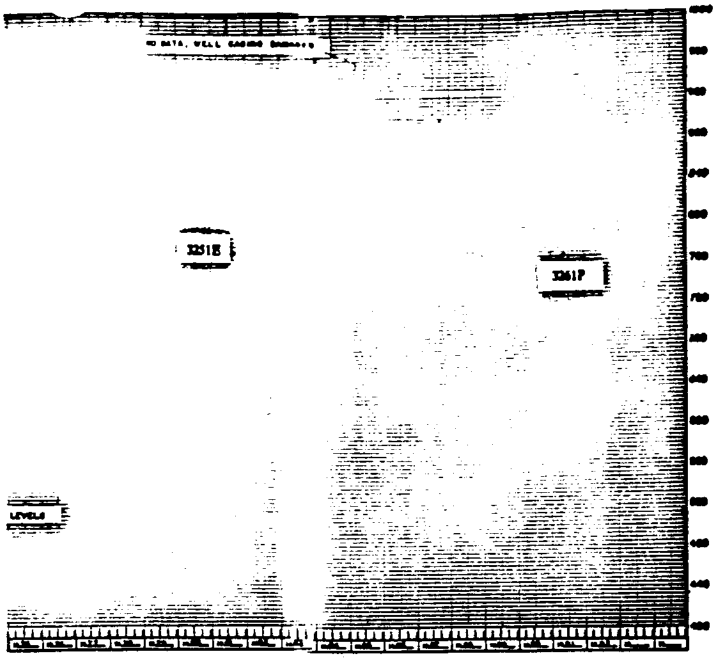

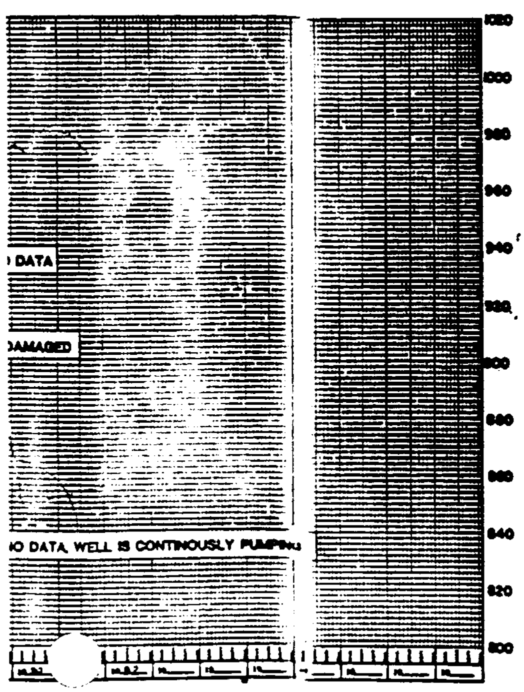

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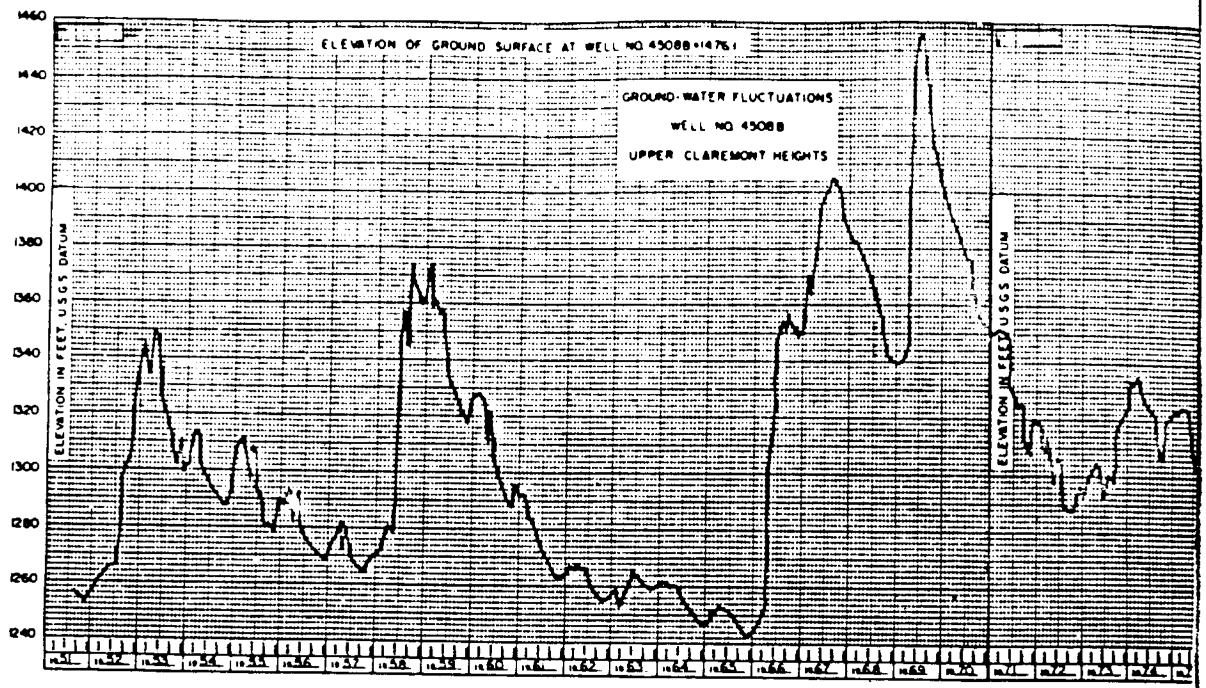

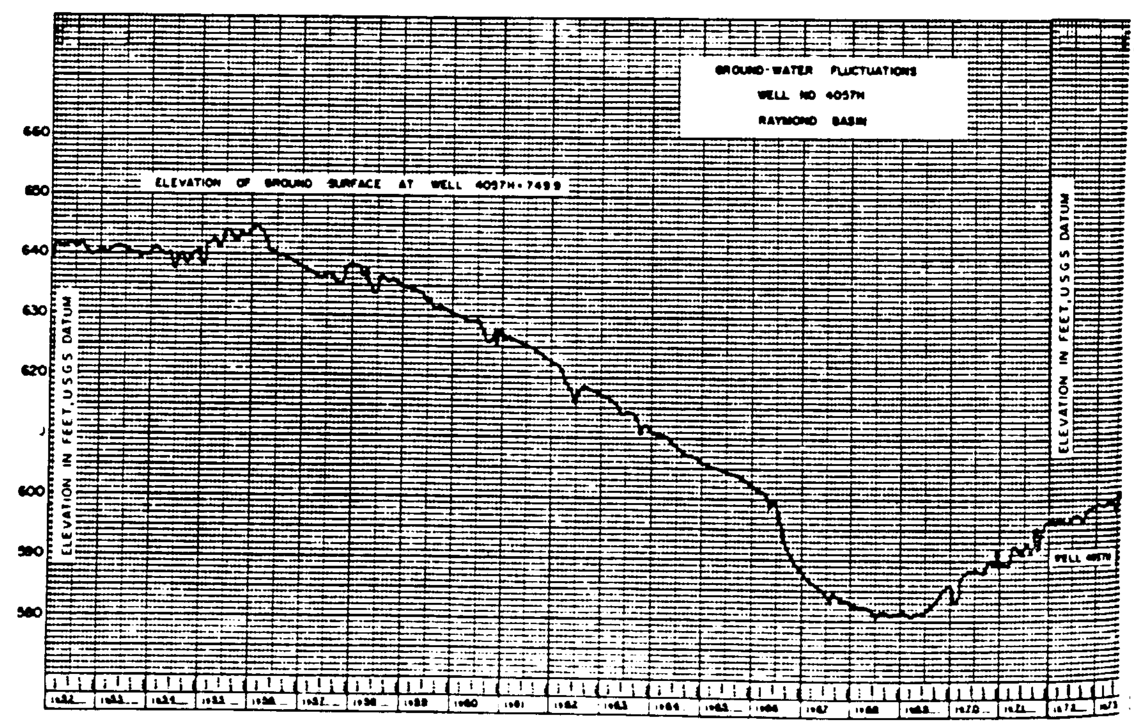

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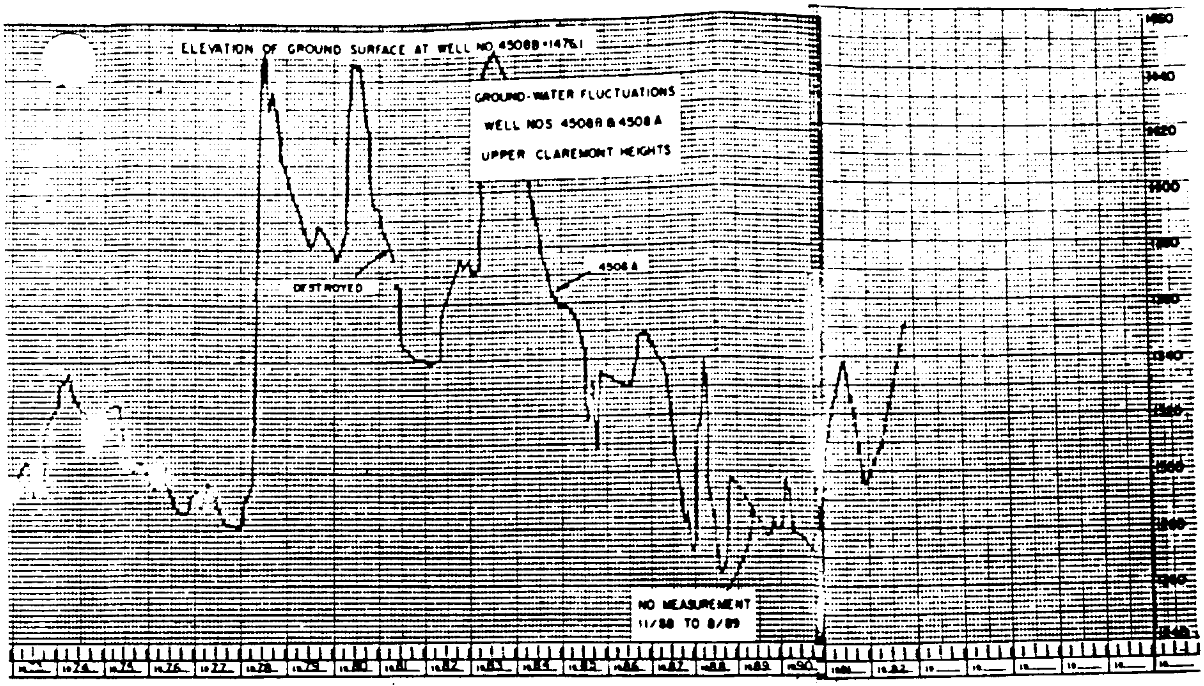
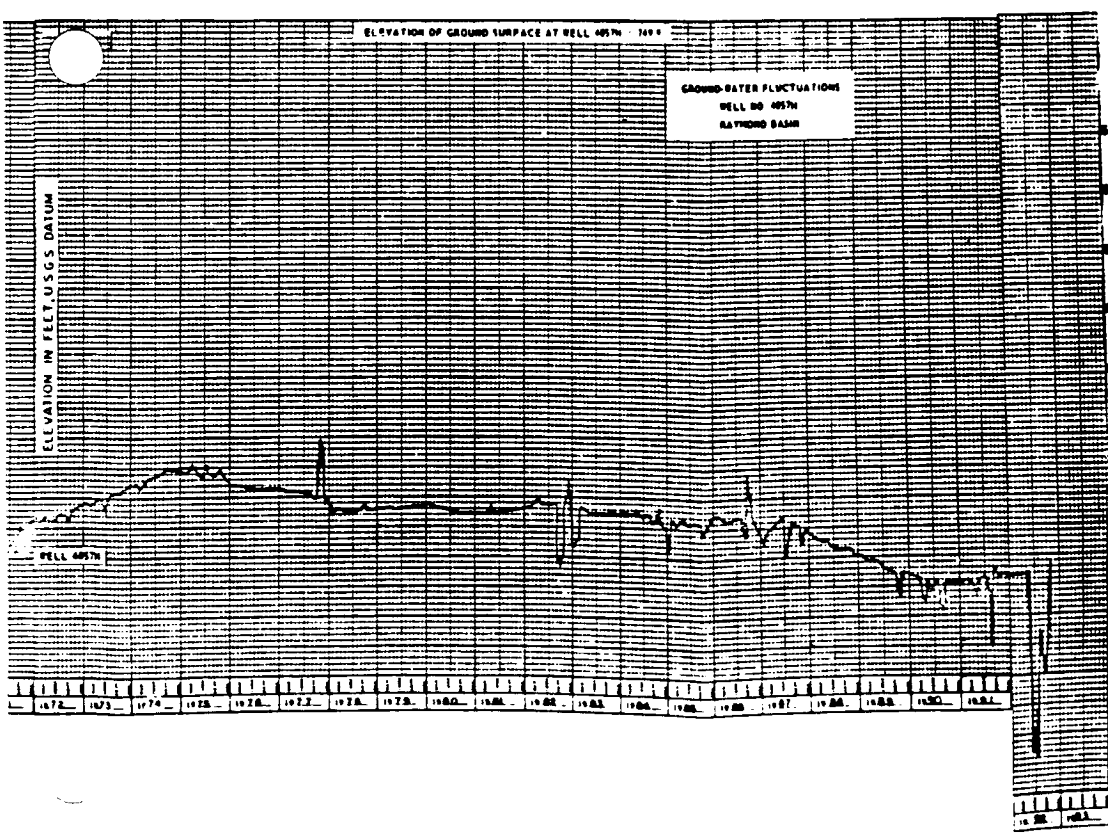
R0053562


ELEVATION OF GROUND SURFACE AT WELL NO 4508B
GROUND-WATER FLUCTUATIONS
WELL NOS 4508B & 4508A
UPPER CLAREMONT HEIGHTS
DESTROYED
4508A
NO MEASUREMENT
11/88 TO 8/89


ELEVATION OF GROUND SURFACE AT WELL
GROUND-WATER FLUCTUATIONS
RAYMOND BASIN
ELEVATION IN FEET, USGS DATUM
560
550
540
530
520
510
600
590
580
570
560
550

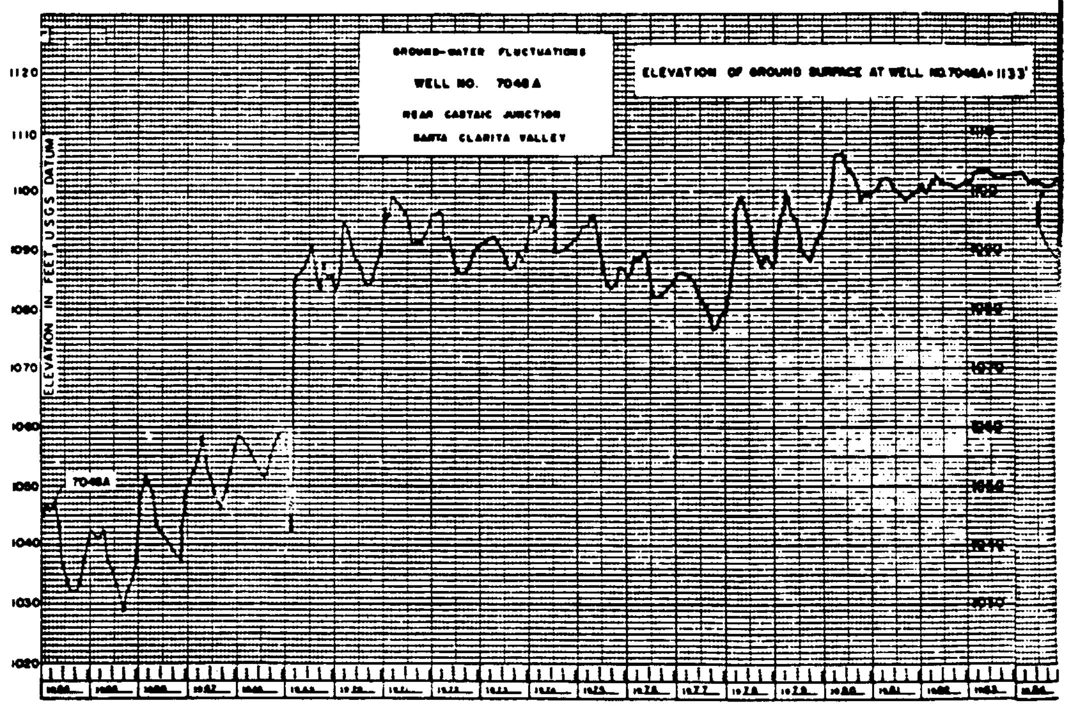
VOL 12

2

0258

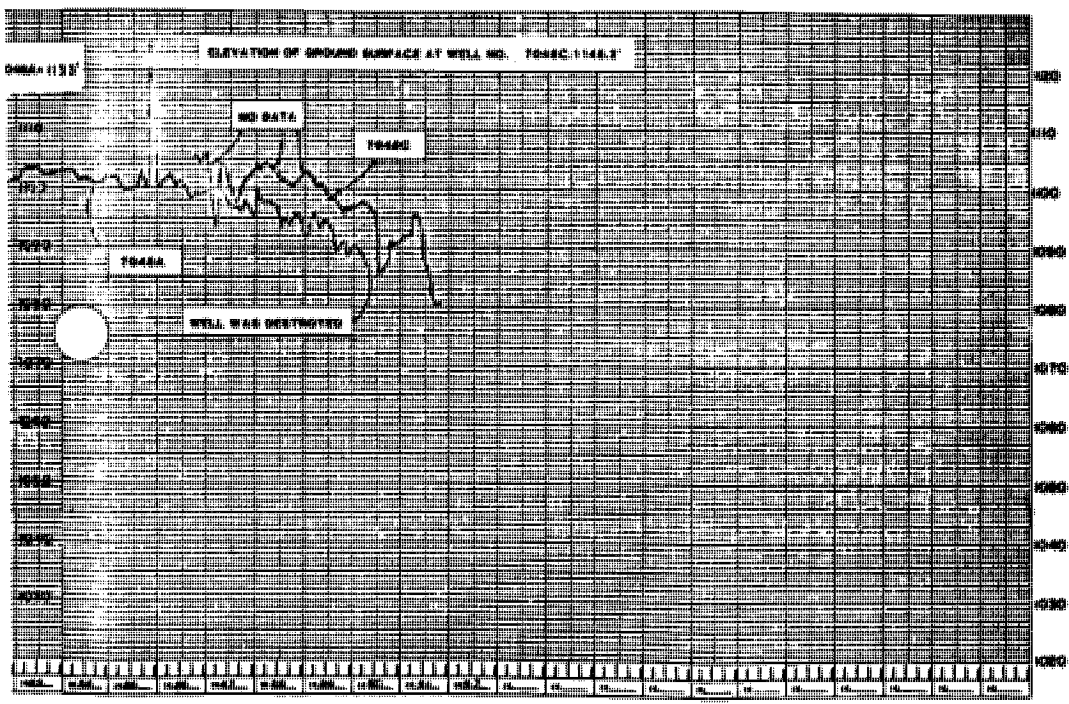
V
C
L

1
2



2
0
2
5
9

R0053564



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G24

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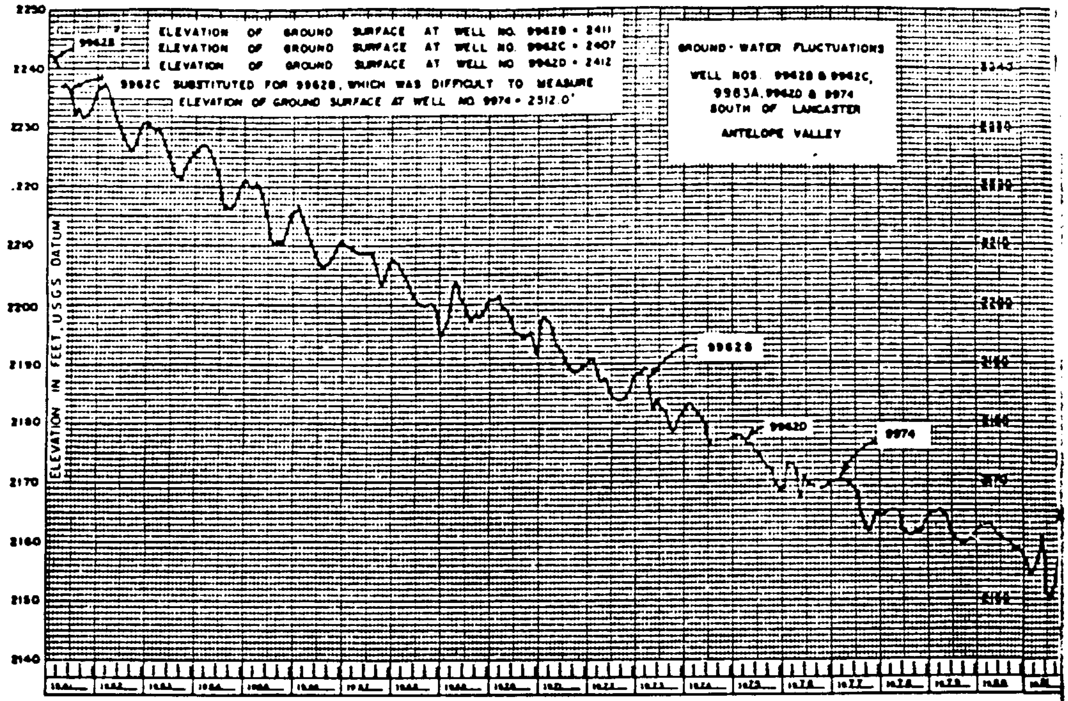
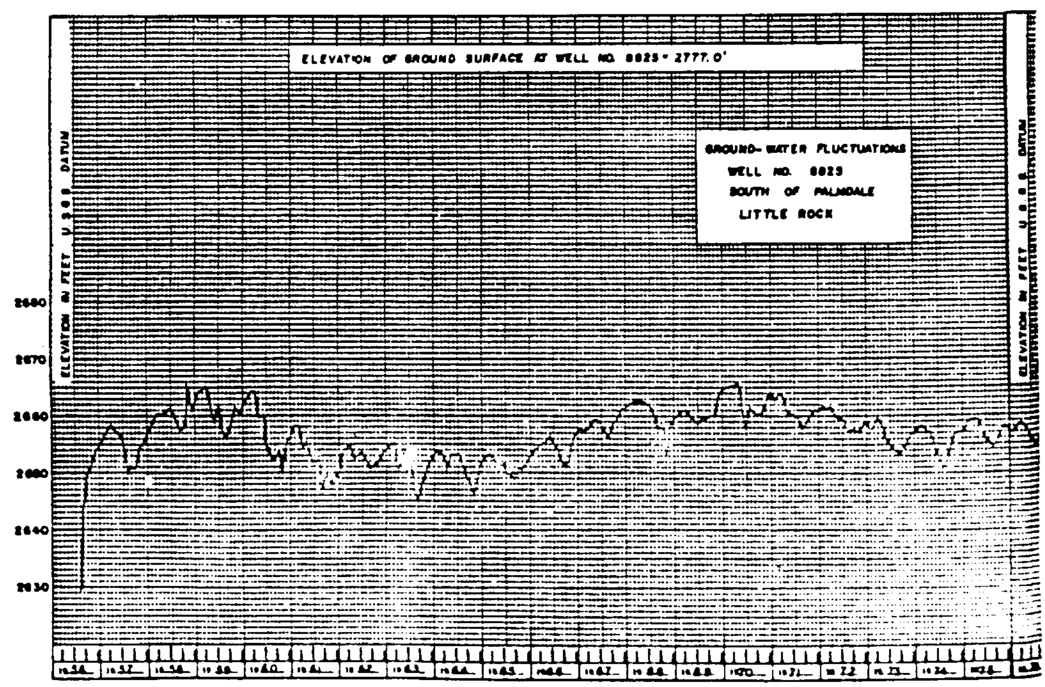
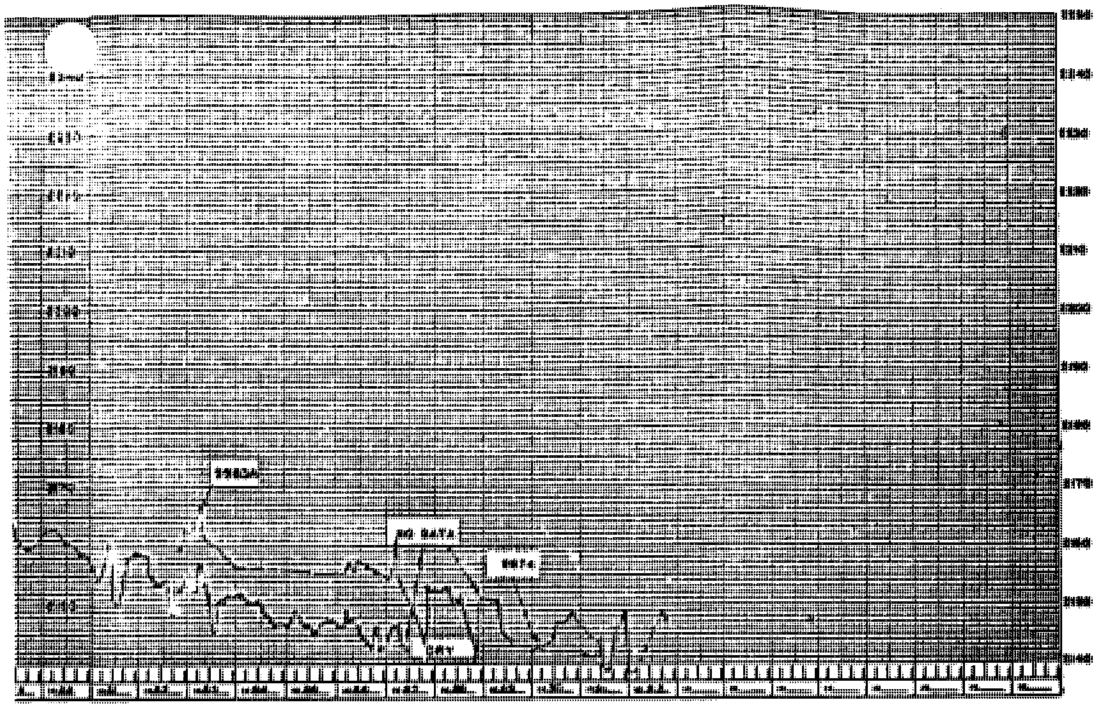
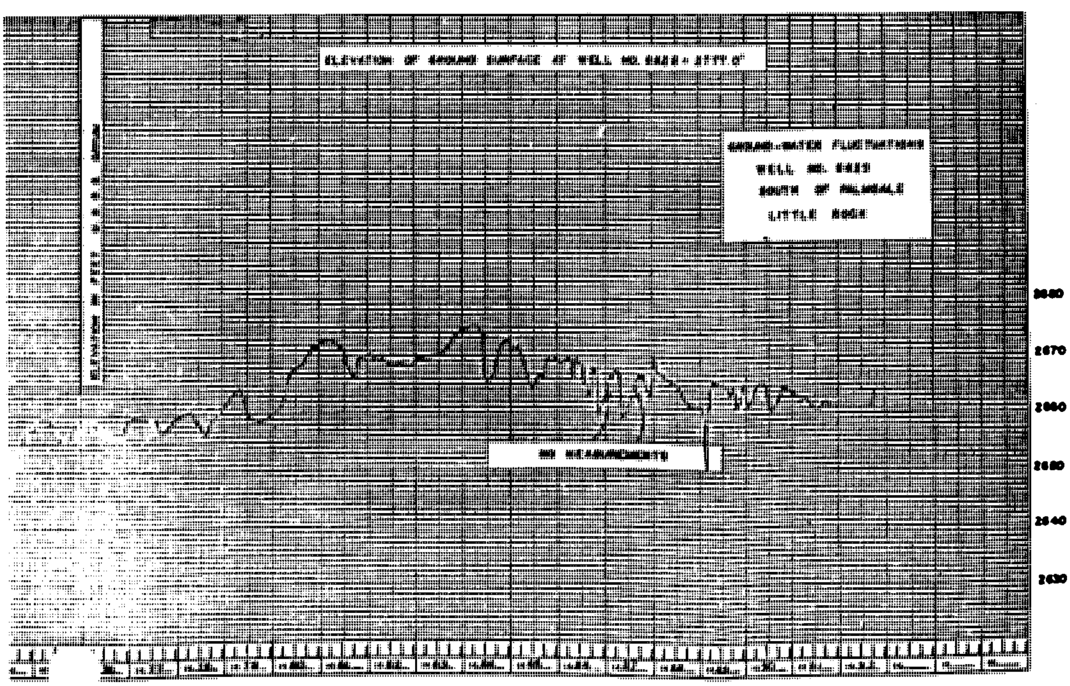
VCL 12 2 0261


ELEVATION OF GROUND SURFACE AT WELL NO. 9962B = 2411
ELEVATION OF GROUND SURFACE AT WELL NO. 9962C = 2407
ELEVATION OF GROUND SURFACE AT WELL NO. 9962D = 2412
9962C SUBSTITUTED FOR 9962B, WHICH WAS DIFFICULT TO MEASURE
ELEVATION OF GROUND SURFACE AT WELL NO. 9974 = 2312.0'
GROUND-WATER FLUCTUATIONS
WELL NOS. 9962B & 9962C, 9963A, 9962D & 9974
SOUTH OF LANCASTER
ANTELOPE VALLEY
ELEVATION IN FEET, USGS DATUM
9962B
9962D
9974
2250
2240
2230
2220
2210
2200
2190
2180
2170
2160
2150
2140


ELEVATION OF GROUND SURFACE AT WELL NO. 8823 = 2777.0'
GROUND-WATER FLUCTUATIONS
WELL NO. 8823
SOUTH OF PALMDALE
LITTLE ROCK
ELEVATION IN FEET, U.S.G.S. DATUM
2680
2670
2660
2650
2640
2630





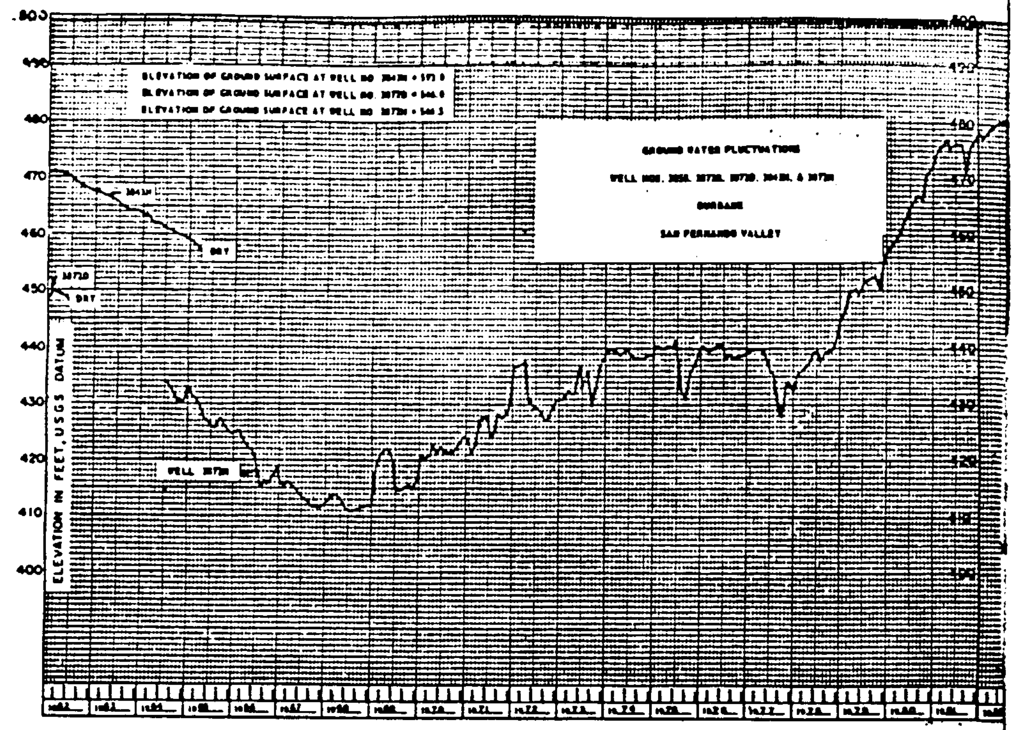
VOL 12

2 0262

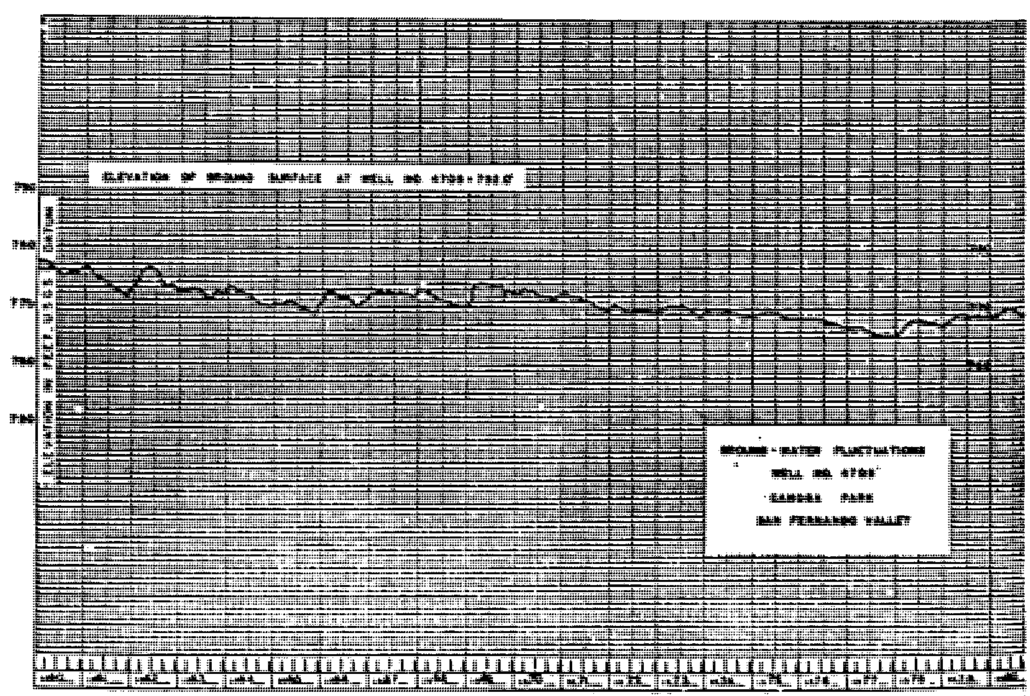
G25

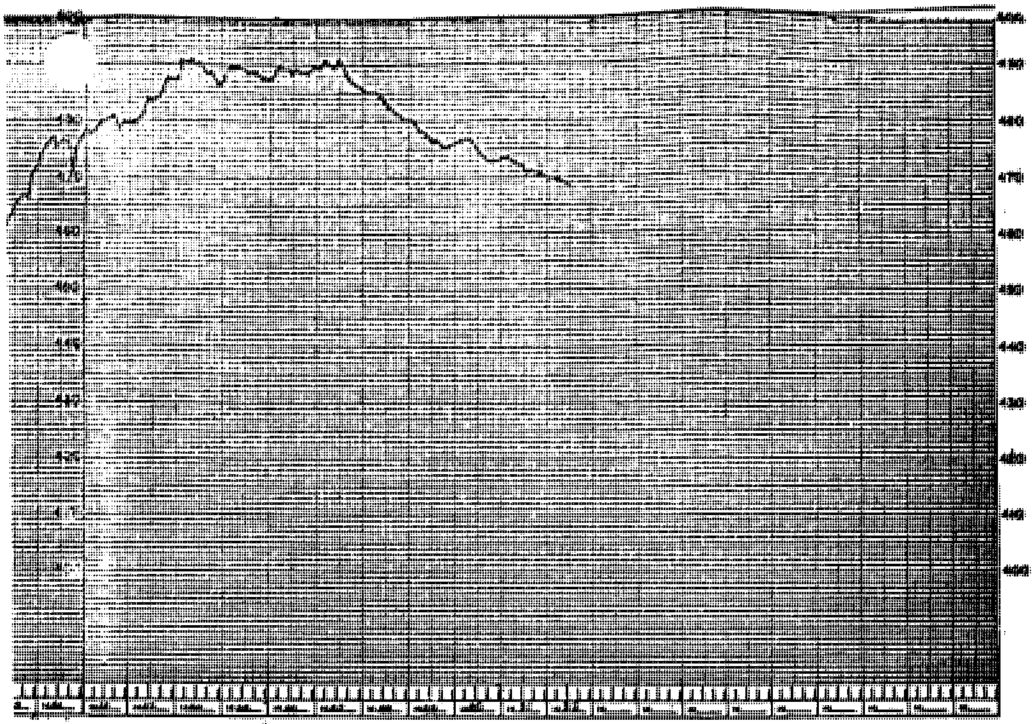
R0053567

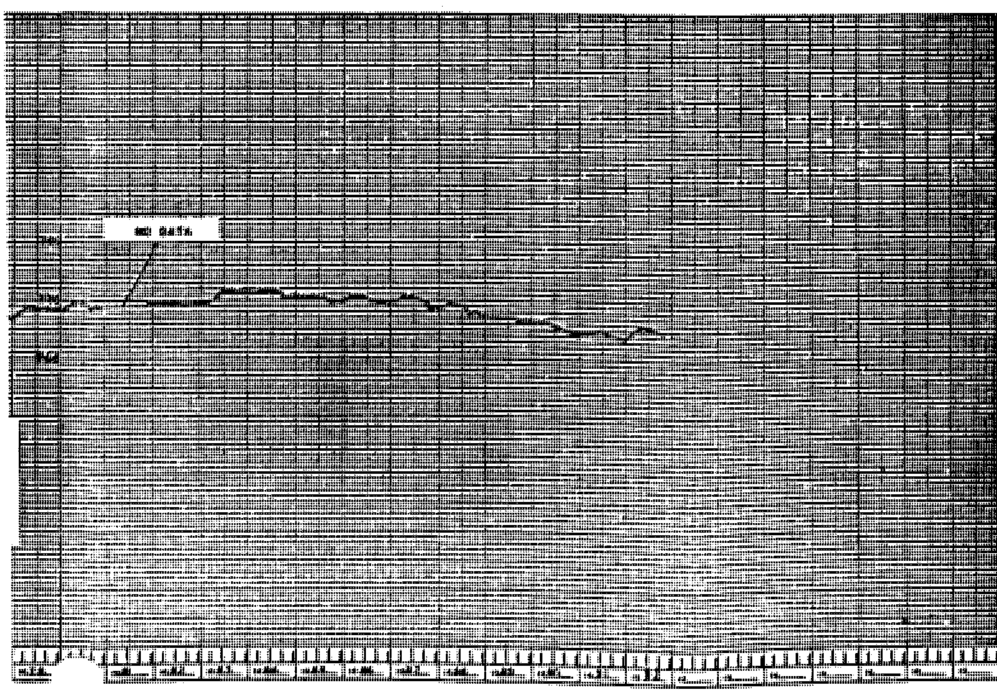
VOL 12


GROUND WATER FLUCTUATIONS
BURBANK
SAN FERNANDO VALLEY
ELEVATION IN FEET, U.S.G.S. DATUM
DRY
DRY

2 0263







G26

R0053569

NO 94

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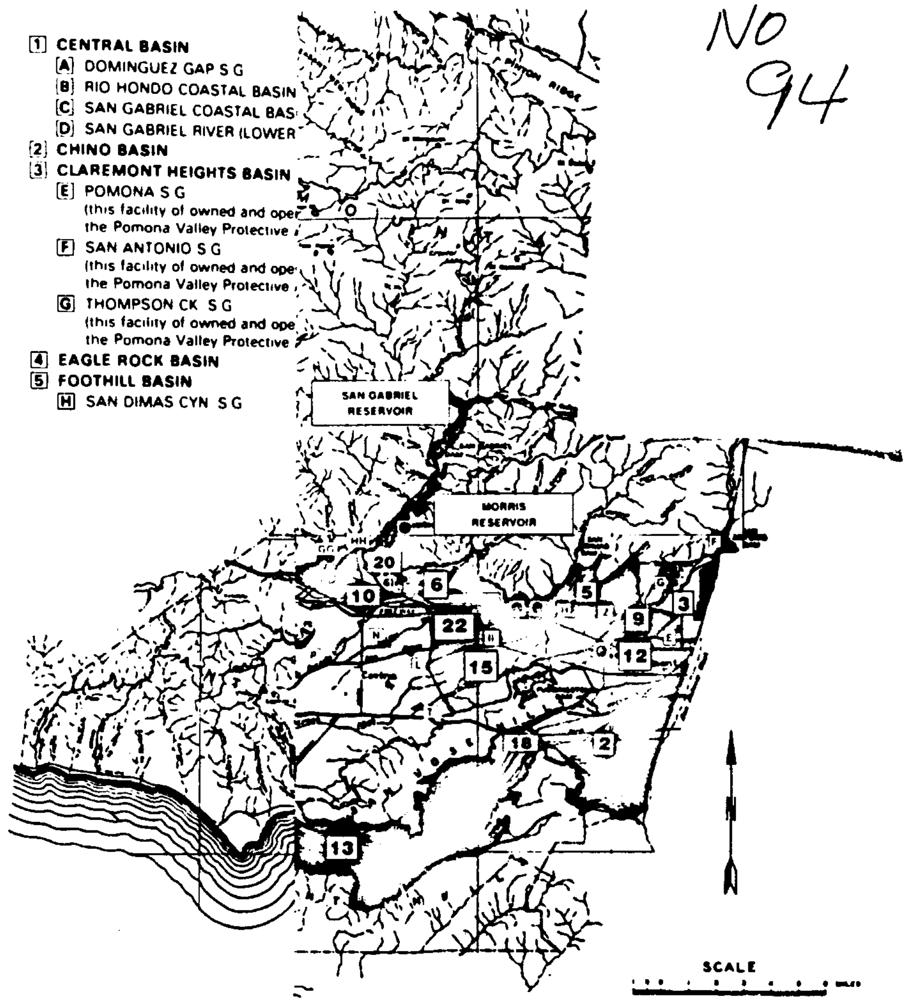
2-0265



[1] CENTRAL BASIN
- [A] DOMINGUEZ GAP S G
- [B] RIO HONDO COASTAL BASIN
- [C] SAN GABRIEL COASTAL BAS
- [D] SAN GABRIEL RIVER (LOWER

[2] CHINO BASIN

[3] CLAREMONT HEIGHTS BASIN
- [E] POMONA S G (this facility of owned and ope the Pomona Valley Protective
- [F] SAN ANTONIO S G (this facility of owned and ope the Pomona Valley Protective
- [G] THOMPSON CK S G (this facility of owned and ope the Pomona Valley Protective

[4] EAGLE ROCK BASIN

[5] FOOTHILL BASIN
- [H] SAN DIMAS CYN S G

[6] GLENDORA BASIN
- [I] BIG DALTON S G
- [J] LITTLE DALTON S G

[7] HOLLYWOOD BASIN

[8] LA HABRA BASIN

[9] LIVE OAK BASIN

[10] LOWER SAN GABRIEL CANYO
- [K] SAWPIT S G

[11] MAIN SAN GABRIEL BASIN
- [L] BEN LOMOND S G
- [M] BUENA VISTA S B
- [N] CITRUS S G
- [O] EATON S B
- [P] IRWINDALE S B MANNING P
- [Q] PECK RD S B
- [R] SAN GABRIEL RIVER (UPPER)
- [S] SANTA FE RESERVOIR S G
- [T] WALNUT S B
- [U] WHITTIER NARROWS W C DI CANAL (ZONE 1 DITCH)

[17] SANTA MONICA BASIN

[18] SPADRA BASIN

[19] SYLMAR BASIN

[20] UPPER SAN GABRIEL CANYON BASIN
- [GG] FISH CYN S G (this facility is owned and operated by Cal American Water Co.)
- [HH] SAN GABRIEL CANYON S G

[21] VERDUGO BASIN

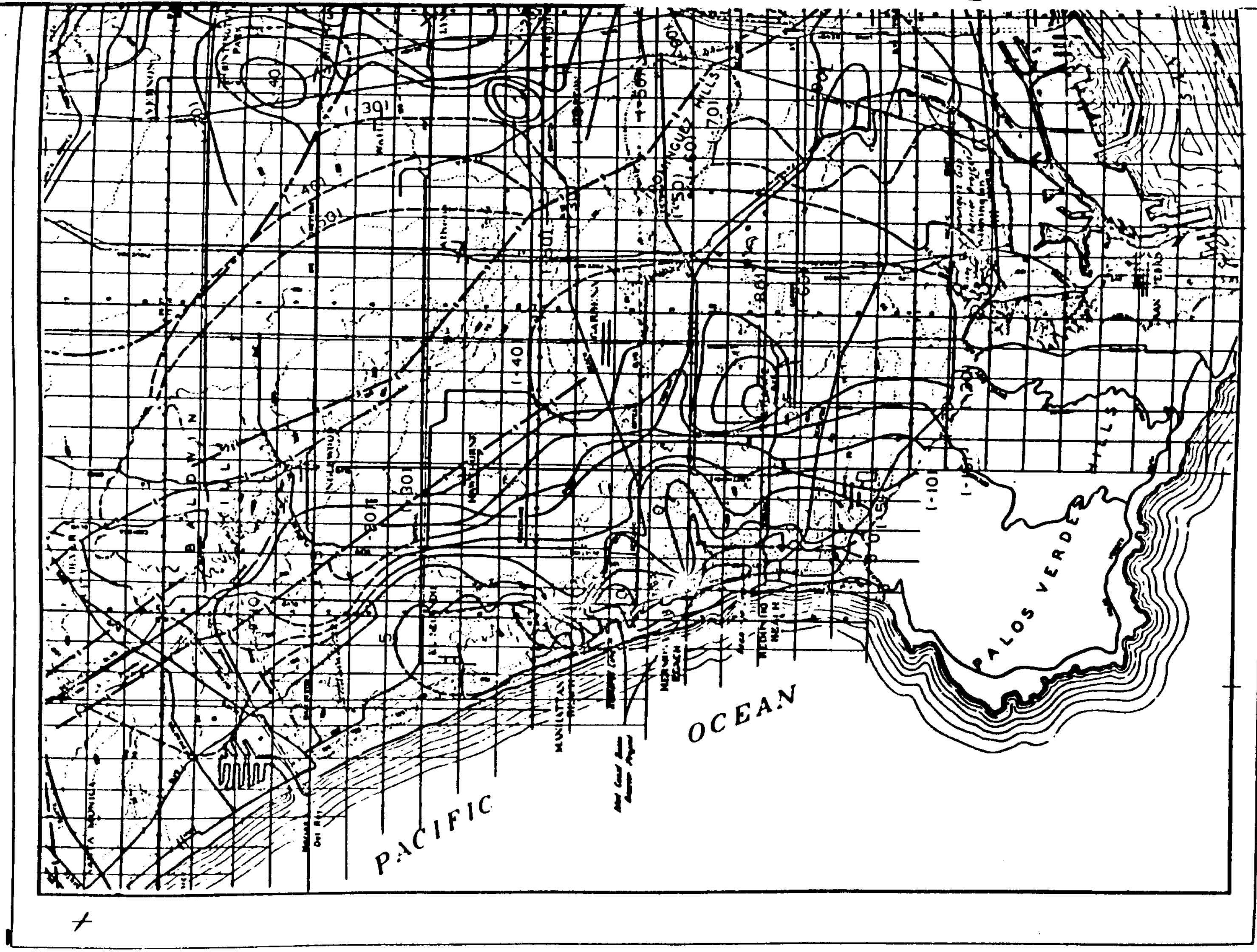
[22] WAY HILL BASIN
- [II] FORBES S G

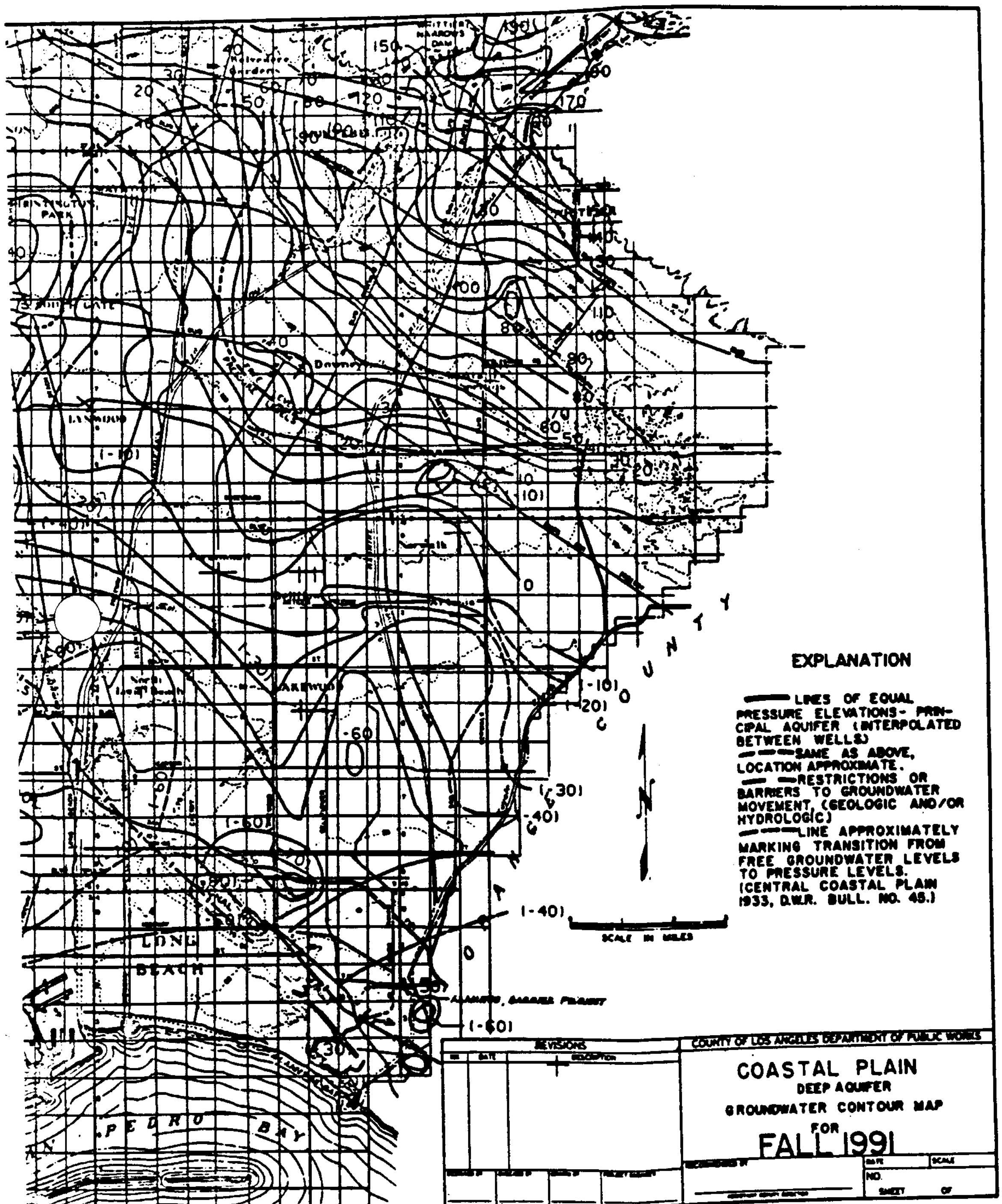
[23] WEST COAST BASIN

- ● SGVMWD
- ● OWENS VALLEY (LA)
- ● MWD OUTLETS

PG1

VCL 12 2


PACIFIC
OCEAN
PALOS VERDES
HILLS
BALDWIN
MANHATTAN
REDONDO BEACH



Plw. Deep Aquifer Wells

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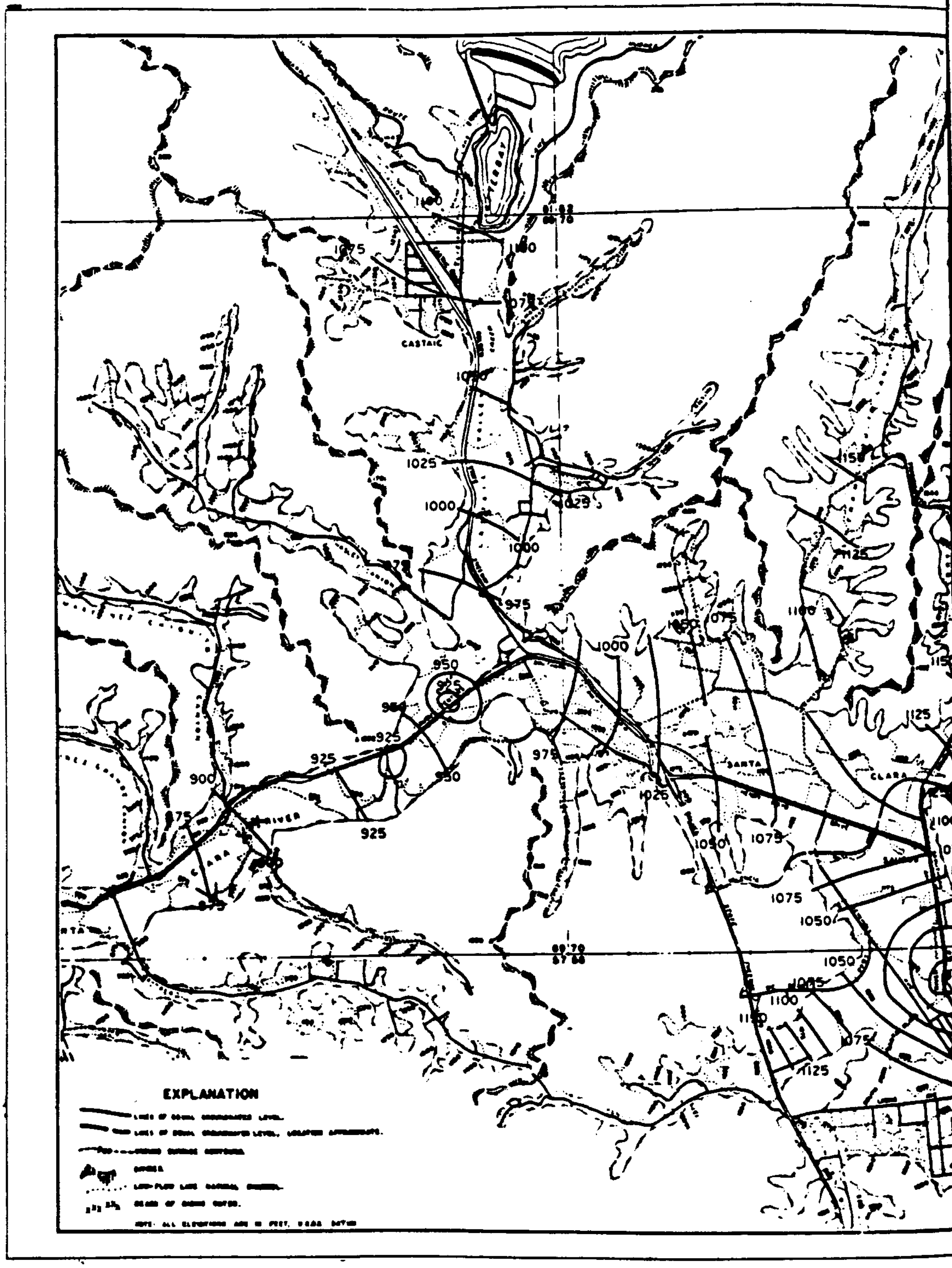
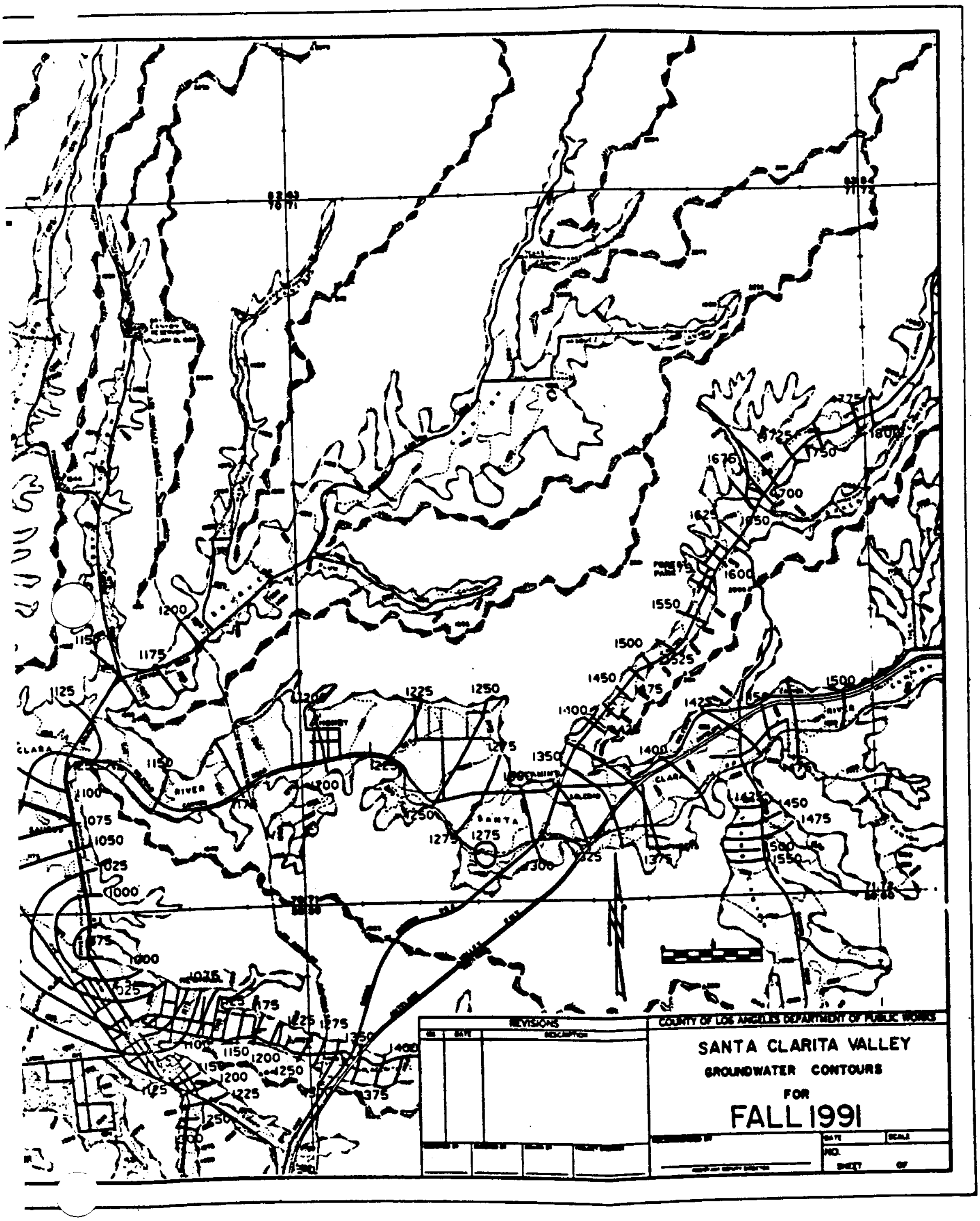
PG5

R0053572


CASTAIC
1075
1100
1050
1025
1000
975
950
925
900
1125
1150
RIVER
EXPLANATION



VOL 12

2-0269

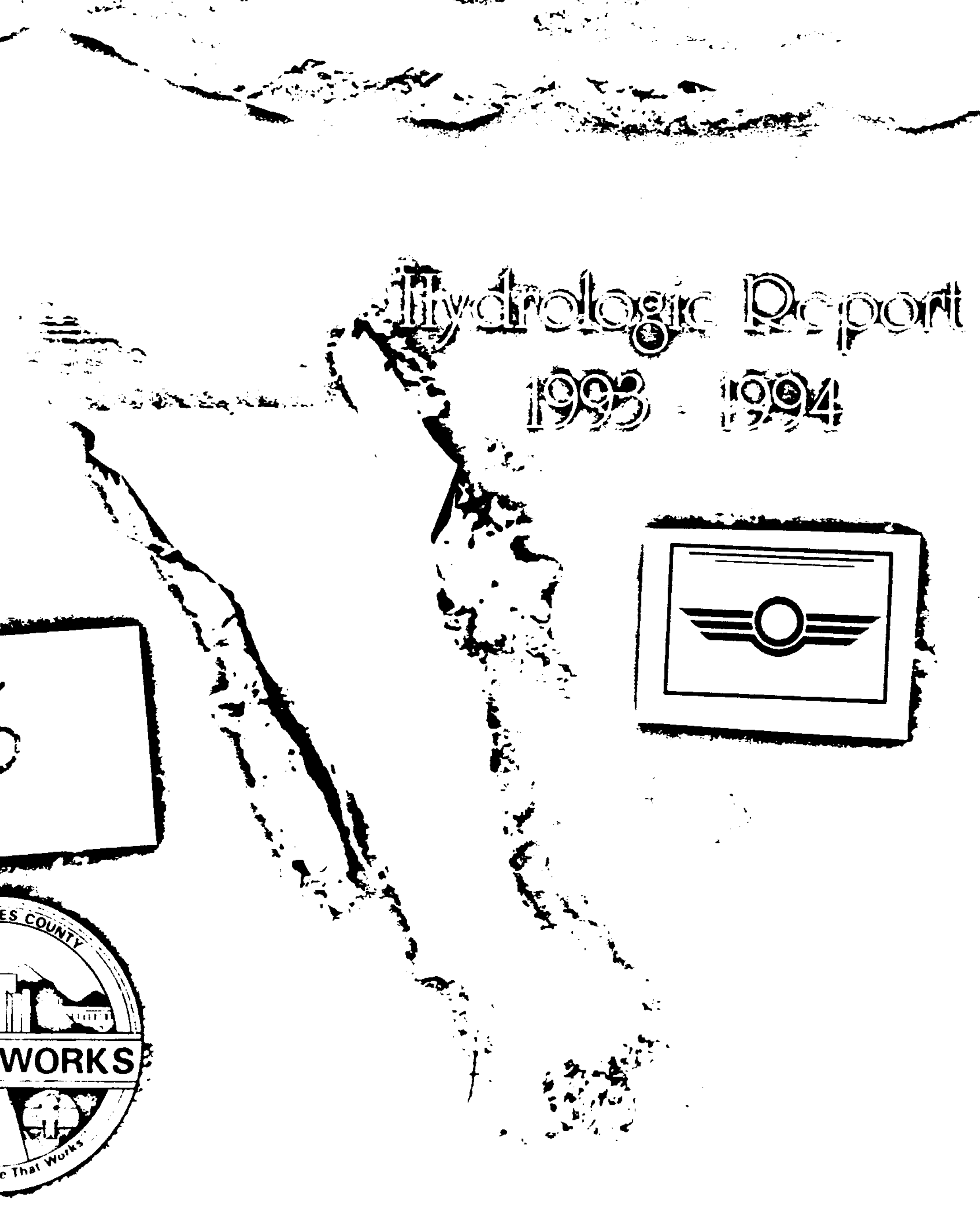
PG6

VOL 12

2

0270 L

VOL 12



Hydrologic Report 1993 - 1994

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LOS ANGELES COUNTY

PUBLIC WORKS

Public Service That Works

2 02771 F

R0053576

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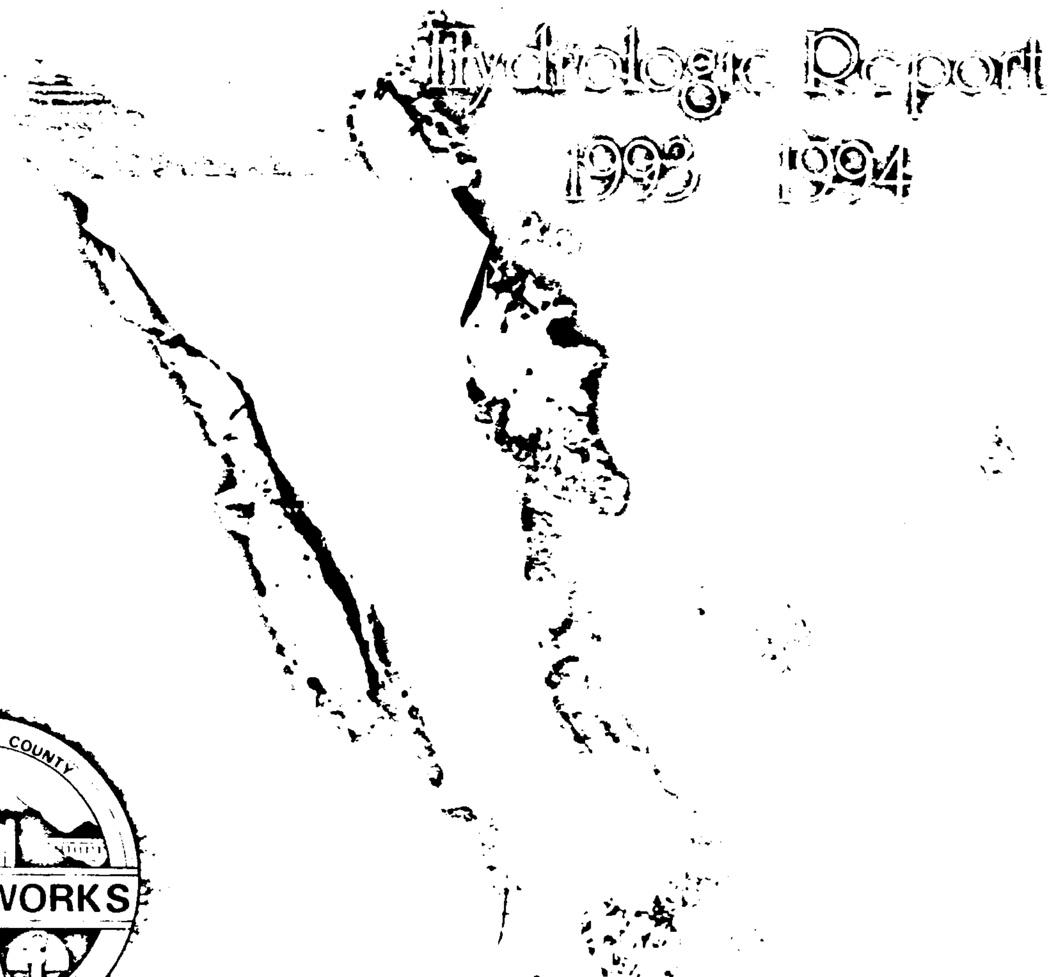
Hydrologic Report 1993 - 1994



LOS ANGELES COUNTY
PUBLIC WORKS
Public Service That Works

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02772

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COVER PHOTO: SAN GABRIEL DAM SPILLWAY

The Department of Public Works owns and maintains 14 operating dams for flood control and water conservation purposes. The largest of these is the San Gabriel Dam located in San Gabriel Canyon north of the City of Azusa. The dam was completed in 1939, drains 163.5 square miles of the San Gabriel Mountains and had an original capacity of 53,343 arce-feet. From August through December 1992, San Gabriel Reservoir, and while the dam was empty, the valve outlet tower was modified to bring up to current seismic standards. San Gabriel's sluice gate was closed on December 23, 1992 and it took about four months for the reservoir to fill and reach spillway flow in 1993. The cover photo shows the San Gabriel Dam at spillway flow of approximately 990 cfs. Snow-capped mountains in the background of the photo represent the source of the water collected by the reservoir. (Photo taken by Jim Camp, 3/24/95)

LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS

HYDROLOGIC REPORT

1993-94

PREPARED BY THE
HYDRAULIC/WATER CONSERVATION DIVISION
NOVEMBER 1995

VOL 12

2 0275

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Summary of Monthly Discharge Records at Selected Stations (cont.)

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RESERVOIRS

EROSION CONTROL

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2

0280

This report was prepared in the Hydraulic/Water Conservation Division under the direction of Robert D. Pedigo, Assistant Deputy Director. The following people contributed to the completion of this report:

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Supervision	T. Su	
Coordination	J. Keith G. Farag	
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Graphic Design, Layout, Art Production	R. Brown J. Garcia	

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INTRODUCTION

This report contains hydrologic data relative to Los Angeles County for the period beginning October 1, 1993 and ending September 30, 1994. The data are presented in seven sections.

Precipitation - lists 284 active rainfall stations and presents corresponding seasonal rainfall amounts.

Evaporation - lists all locations for which evaporation data is on file and provides monthly evaporation amounts at 14 locations.

Runoff - presents the maximum, minimum, and mean of the daily flow rates for each month and the monthly volumes for 40 streamflow stations.

Dam Operation - presents the maximum and minimum of the daily inflow and outflow rates for each month, the instantaneous peak inflow and outflow rates and storage volumes for 14 dams and reservoirs.

Erosion Control - lists debris basins and debris production amounts.

Water Quality Monitoring - presents maps of surface and groundwater sampling locations, and data at selected locations.

Conservation and Groundwater - presents records of water conserved at various facilities, water injected at seawater barrier projects, well hydrographs, and Fall, 1993 static groundwater contour maps.

Where practical, data which would satisfy immediate needs and serve as useful reference are published in these reports. Several tables appear listing locations for which unpublished data are available. Additional information may be obtained by writing to:

Los Angeles County Department of Public Works
Hydraulic/Water Conservation Division
P.O. Box 1460
Alhambra, CA 91802-1460

or telephone: **(818) 458-6112**

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LOS ANGELES COUNTY

TOPOGRAPHY

The County of Los Angeles covers an area of 4,083 square miles and measures approximately 66 miles in the east - west and 73 miles in the north - south directions.

The terrain within the County can be classified in broad terms as being 25 percent mountainous; 10 percent coastal plain; and 65 percent hills, valleys, or deserts. Relief of the terrain ranges from sea level to a maximum elevation of 10,000 feet. The coastal plain is generally of mild slope and contains relatively few depressions or natural ponding areas. The slopes of main river systems crossing the coastal plain, such as the San Gabriel River, Los Angeles River, and Ballona Creek, range from 4 to 14 feet per mile.

Topography in the mountainous area is generally rugged with deep, V-shaped canyons separated by sharp dividing ridges. Steepwalled canyons with side slopes of 70 percent or more are common. The gradient of principal canyons in the San Gabriel Mountains ranges from 150 to 850 feet per mile. Mountain ranges are aligned in a general east-west direction with the major range being the San Gabriel Mountains. The majority of mountain ridges lie below Elevation 5,000 feet. The total area above this level is approximately 210 square miles.

GEOLOGY - SOILS

Igneous, sedimentary, and metamorphic rock groups are all presented within the County. The San Gabriel Mountains and Verdugo Hills are composed primarily of highly fractured igneous rock, with large areas of granitic rock formation being exposed. Faulting and deep weathering have produced porous zones in the rock formation; however, rock masses have produced a comparatively shallow soil mantle due to the steepness of slopes which accelerates erosion of the fine material.

Other mountains and hilly reaches are composed primarily of folded and faulted sedimentary rocks, including shale, sandstone, and conglomerate. Residual soils in these areas are shallow and are generally less pervious than those of the San Gabriel Mountain range.

Valley and desert soils are alluvial and vary from coarse sand and gravel near canyon mouths to silty clay, clay and sand and gravel in lower valleys and the coastal plain. The alluvial fill has been built up by repeated deposition of debris to depths as great as several thousand feet. This fill is quite porous in areas of relatively low clay content. Geologic structures and irregularities in the underlying bedrock divide the alluvium into several groundwater basins. Valley soils are generally well drained but there are a few areas having perched water.

LAND USE

The principal vegetative cover of upper mountain areas consists of various species of brush and shrubs known as chaparral. Most trees found on mountain slopes are oak, with alder, willow, and sycamore found along streambeds at lower elevations. Pine, cedar, and juniper are found in ravines at higher elevations and along high mountain summits.

LOS ANGELES COUNTY

TOPOGRAPHY

The County of Los Angeles covers an area of 4,083 squar… …nd measures approximately 66 miles in the east - west and 73 miles in the north - south di…

Sta Clara Rvr 1030
LA Rvr 834.3
SMB 414.56
Dominguez 109.81
S. Gabriel Rvr 723.73
3112 sq miles

The terrain within the County can be classified in broad te… …inous; 10 percent coastal plain; and 65 percent hills, valleys, or de… …s from sea level to a maximum elevation of 10,000 feet. The coastal … …nd contains relatively few depressions or natural ponding areas. T… …crossing the coastal plain, such as the San Gabriel River, Los Angeles … …ge from 4 to 14 feet per mile.

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The chaparral is extremely flammable, and extensive burns of the mountain vegetation frequently occur during dry, low-humidity weather accompanied by high winds. Chaparral has the ability to sprout following fire and grows rapidly to re-establish the watershed cover within a period of 5 to 10 years.

Grasses are the principal natural vegetation on the hills. Much of the hill land and nearly all of the valley land in the densely populated portion of the County south of the San Gabriel Mountains has been converted to urban and suburban use. Development of the Santa Clarita Valley and desert areas to the north of the San Gabriel Mountains is sparse at present but is proceeding rapidly.

CLIMATE

The climate within the County varies between subtropical on the Pacific Ocean side of the San Gabriel Mountain range to arid in the Mojave Desert. Nearly all precipitation occurs during the months of December through March. Precipitation during summer months is infrequent, and rainless periods of several months are common. Snowfall at elevations above 5,000 feet is frequently experienced during the winter storms, but the snow melts rapidly except on higher peaks and the northern slopes. Snow is rarely experienced on the coastal plain.

January and July are the coldest and warmest months of the year, respectively. At Los Angeles, the 30-year average daily minimum temperature for January is 48 degrees above zero. The average daily maximum temperature for July is 84 degrees. At Mount Wilson (Elevation 5,850 feet), the 30-year average daily minimum temperature for January is 35 degrees above zero and the average daily maximum temperature for July is 80 degrees.

HYDROMETEOROLOGIC CHARACTERISTICS

Coastal and Mountain Areas

Precipitation in the Los Angeles area occurs primarily in the form of winter orographic rainfall associated with extratropical cyclones of North Pacific origin. Major storms consist of one or more frontal systems and occasionally last four days or longer. Air masses and frontal systems associated with major storms commonly extend for 500 to 1,000 miles in length and produce rainfall simultaneously throughout the County. Major storms approach Southern California from the west or southwest with southerly winds which continue until frontal passage. The mountain ranges lie directly across the path of the inflow of warm, moist air, and orographic effects greatly intensify precipitation.

The seasonal normal rainfall in Los Angeles County ranges from 27.50 inches in San Gabriel Mountains to 7.83 inches in the desert. The annual County average for the annual rainfall for Los Angeles County is 15.65 inches.

The effects of snowmelt upon flood runoff is of significance in the few cases when warm spring rains from southerly storms fall on a snowpack. During major storms, temperatures throughout the County may remain above freezing. Average individual storm rainfall amounts and intensities conform to a fairly definite aerial pattern which reflects general effects of topographic differences.

Desert Areas

Summer convective rainfall is principally experienced in the upper San Gabriel Mountains and the Mojave Desert regions. In many desert areas, the most serious flooding occurs as a result of summer convective storms.

RUNOFF CHARACTERISTICS

Mountain Areas

In mountain areas, the steep canyon slopes and channel gradients promote a rapid concentration of storm runoff quantities.. Depression storage and detention storage effects are minor in the rugged terrain. Soil moisture during a storm has a pronounced effect on runoff from the porous soils supporting a good growth of deeprooted vegetation such as chaparral. Soil moisture deficiency is greatest at the beginning of a rainy season, having been depleted by the evapotranspiration process during the dry summer months. Precipitation during periods of soil moisture deficiency is nearly entirely absorbed by soils, and except for periods of extremely intense rainfall, significant runoff does not occur until soils are wetted to field moisture capacity. Due to high infiltration rates and porosity of mountain soils, runoff occurs primarily as subsurface flow or interflow in addition to direct runoff. Spring or base flow is essentially limited to portions of the San Gabriel Mountain range. Consequently, most streams in the County are intermittent.

Runoff from a mountain watershed recently denuded by fire exceeds that for the unburned state due to greatly increased quantities of inorganic debris present in the flow and increased direct runoff resulting from lowered infiltration rates. Debris production from a major storm has amounted to as much as 223,000 cubic yards per square mile of watershed. Boulders up to eight feet in diameter have been deposited in valley areas a considerable distance from their source.

Debris quantities equal in volume to storm runoff, or in other words 100 percent bulking of runoff from a major storm, have been recorded. Where debris-laden flow traverses an alluvial fill unconfined by flood control works, flood discharges follow an unpredictable path across the debris cone formed at the canyon mouth.

Hill and Valley Areas

In hill areas, runoff concentrates rapidly from the generally steep slopes; however, runoff rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size. In those hill areas which have been developed for residential use, concentration times become considerably decreased due to drainage improvement, and runoff volumes and rates become increased due to increased imperviousness. On the other hand, erosion is controlled and debris is minimized from storm flows. Debris production rates from undeveloped hill areas are normally smaller than those from mountain areas of the same size.

In highly developed valley areas, local runoff volumes have increased as the soil surface has become covered by impervious materials. Peak runoff rates for valley areas have also increased due to elimination of natural ponding areas and improved hydraulic efficiency of water carriers such as streets and storm drain systems.

FLOOD CONTROL AND WATER CONSERVATION

FLOODS...AN OLD STORY

Floods in Los Angeles County have been recorded as far back as the days of the Mission Padres. For centuries waters have swept out of the San Gabriel Mountains causing extensive property damage and taking a great toll of lives.

Such a flood occurred in 1914 causing over $10 million in property damage and taking many lives. As a result, the State legislature in 1915 enacted the statute creating the Los Angeles County Flood Control District. The responsibilities and authority vested in the Flood Control District in 1985 were transferred to, and are now part of the Los Angeles County Department of Public Works.

The Department, under the Flood Control Act, has two tasks. . .control the floods and conserve the water.

CONTROLLING THE WATERS

Successful early bond issues financed construction of the 14 dams which the Department built in the San Gabriel Mountains and foothills to impound storm waters until they could be safely released. Debris basins were constructed to trap eroded materials which had caused terrible damage in the past. Flood channel improvements were undertaken to confine the waters and convey them safely through the urbanized areas to the ocean.

Department engineers prepared a Comprehensive Plan in the early 1930's which would control flooding and save as much of the water as practicable when fully implemented.

Federal legislation in 1936 brought the United States Army Corps of Engineers into the local flood control picture. Since that time, the two agencies have been jointly pursuing implementation of the Comprehensive Plan. The Department also cooperates with the United States Natural Resources Conservation Service and Forestry Service in erosion control.

CONSERVING THE WATERS

In addition to its flood control program, the Department has the equally important task of conserving as much of the storm and other waste waters as practicable. The use of water conservation facilities in or adjacent to river channels and their tributaries permits water to be percolated into groundwater reservoirs for later pumping and supply to consumers. These water conservation facilities are located in areas where the underlying soils are composed of porous sands and gravel formations. Some resemble rice paddies, while others are deep basins which were once gravel pits.

The importance of this activity is apparent when it is realized that about 30 to 40 percent of the water used in the County is pumped from ground supplies. The growth of the County, combined with periodic droughts, seriously depleted these supplies on numerous occasions throughout the history of the County.

Other major conservation efforts by the Department include combatting the serious salt water intrusion into groundwater supplies inland from the Pacific Ocean and utilizing imported water and reclaimed waters in groundwater recharge operations.

ORGANIZED TO DO THE JOB

Day-to-day administration of Department affairs is vested in the Director of Public Works who is appointed by and responsible to the Los Angeles County Board of Supervisors. A part of the Department's activities involve the planning, design and construction of flood control and water conservation facilities, and the operation and maintenance of dams, debris basins, spreading grounds, channels, and storm drains.

PRECIPITATION

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PRECIPITATION

This section contains annual precipitation data collected by the Department for the period beginning October 1, 1993 and ending September 30, 1994 Although the Department operates and maintains 271 rainfall stations, including 199 standard and 72 automatic gages which record amounts for durations ranging from 5 minutes to 24 hours, only annual amounts for the report period are listed herein. Additional data can be obtained by contacting the custodian of hydrologic records at the location shown in the front of the report.

RAINFALL AMOUNTS

For the year, rainfall recorded at the downtown Los Angeles station (No. 716) reached 9.07 inches, or 58 percent of the long-term average of 15.51 inches. The Cogswell Dam station (No. 334B) recorded 18.92 inches for the year which is 58 percent of the long-term average of 32.88 inches.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorological conditions in the County and Southern California in real time, i.e., as they occur. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system is also now automatically receiving rainfall data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

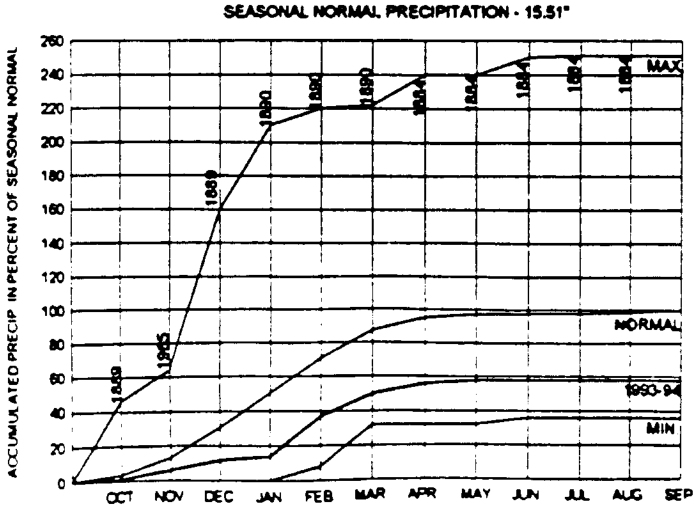
The cooperation of observers in furnishing rainfall data to the Department as a public service is appreciated. The effort of the many agencies and individuals who have so freely cooperated with us in the collection of this data have resulted in the large number of complete records for the period covered by this report.

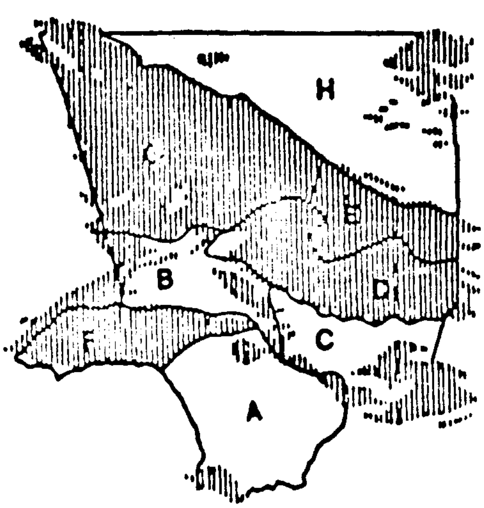
LOS ANGELES COUNTY RAINFALL INDICES
USING SELECTED STATIONS FOR THE PERIOD
OCTOBER 1, 1993 THROUGH SEPTEMBER 30, 1994

	PERCENT OF AREA	SEASONAL NORMAL PRECIP. (inches)	TOTAL PRECIP. TO DATE	PERCENT OF SEASONAL NORMAL	TOTAL PRECIP. LAST YR. TO DATE
A. COASTAL PLAIN	14.10	13.71	9.03	66	26.27
B. SAN FERNANDO VALLEY	7.90	17.62	11.27	64	35.96
C. SAN GABRIEL VALLEY	7.50	17.64	11.65	66	35.56
D. SAN GABRIEL MTS.	13.40	27.50	17.06	62	58.76
E. LITTLE ROCK, BIG ROCK	4.50	18.61	12.96	70	37.18
F. SANTA MONICA MTS.	5.70	19.96	12.50	63	38.33
G. SANTA CLARA	18.90	16.64	10.42	63	34.61
H. DESERT	28.00	7.83	5.15	66	19.89
COUNTY	100.00	15.65	10.02	64	33.05
LOS ANGELES (STATION #716)		15.51	9.07	58	30.89
COGSWELL DAM (STATION #334B)		32.88	18.92	58	77.02

MAX., MIN. & NORMAL CURVES

LOS ANGELES (STATION #716)
SEASONAL NORMAL PRECIPITATION - 15.51"





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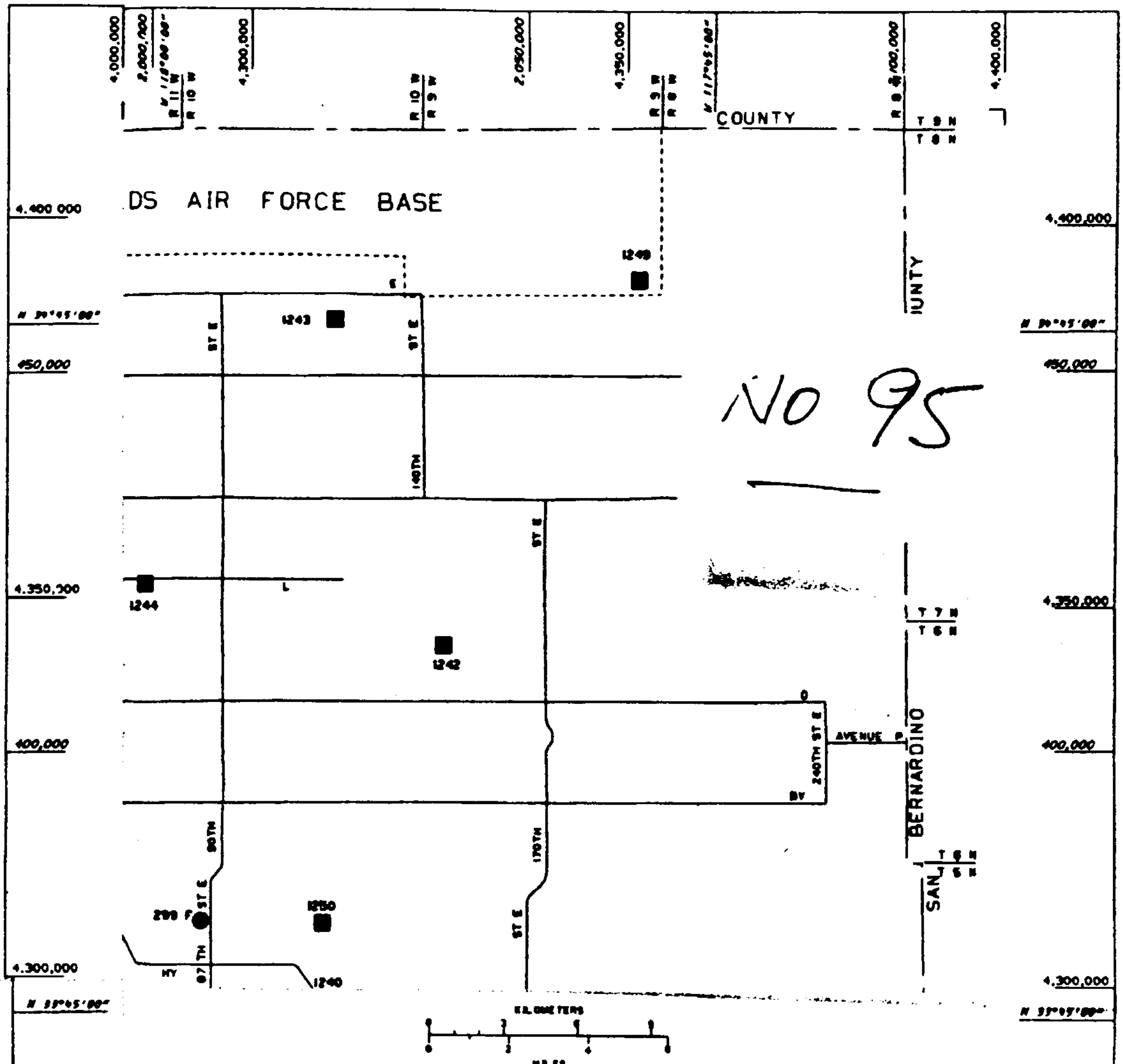

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MAP OF

County of Los Angeles

4,000,000
ZONE 7-CCS27

50,000
ZONE 5-CCS2.

DEPARTMENT OF PUBLIC WORKS

RAINFALL STATION LOCATIONS

UPDATED APRIL 21, 1994

PA1

Active Rainfall Stations 1993-94

Station No.	Station Name	Type of Gage	Thomas Guide Page	North Latitude	West Longitude	Gage Elev. (Feet)	Seasonal Total (Inches)
5B	CALABASAS	S	100 F3	34-09-24	118-38-14	924	12.30
6	TOPANGA PATROL STATION	A	109 C5	34-05-03	118-35-57	745	15.90*
9B	SEPULVEDA AND RAYEN	S	8 C6	34-13-52	118-28-04	828	10.97
10A	BEL AIR HOTEL	A	32 E5	34-05-11	118-26-45	540	10.80
11D	UPPER FRANKLIN CYN RES.	SP	33 B1	34-07-10	118-24-35	867	11.64*
13C	NORTH HOLLYWOOD-LAKESIDE	S	23 F4	34-08-46	118-21-13	550	11.83
14C	ROSCOE-MERRILL	S	9 F5	34-14-19	118-21-32	1050	8.19*
15A	VAN NUYS	S	15 D6	34-10-48	118-27-03	695	9.47
17	SEPULVEDA CYN AT MULHOLLAND	A	22 A5	34-07-51	118-29-26	1425	13.00*
20B	GIRARD RESERVOIR	S	13 B3	34-09-07	118-36-38	986	12.32
21B	WOODLAND HILLS	S	13 C1	34-10-14	118-35-33	875	11.20
23B	CHATSWORTH RESERVOIR	SP AP	6 A6	34-13-44	118-37-18	900	8.96*
25C	NORTHRIDGE-L.A.D.W.P.	SP	7 B6	34-13-52	118-32-28	810	8.98
32C	NEWHALL-SOLEDAD DIV. HDQTRS	AP S	127 C3	34-23-07	118-31-54	1243	10.38
33A	PACOIMA DAM	S A	128 F9	34-19-48	118-23-59	1500	11.56
42C	REDONDO BEACH-CITY HALL	S	67 D3	33-50-43	118-23-20	70	8.81*
43D	PALOS VERDES ESTATES	S	72 C2	33-47-58	118-23-29	216	7.13
44A	POINT VICENTE LIGHTHOUSE	A	77 B3	33-44-30	118-24-38	125	7.40
46D	BIG TUJUNGA DAM	S A	M C2	34-17-40	118-11-14	2315	15.50
47D	CLEAR CREEK-CITY SCHOOL	A	M D3	34-16-38	118-10-12	3150	16.10
53D	COLBY'S	A	M F2	34-18-05	118-06-39	3620	13.70
54C	LOOMIS RANCH-ALDER CREEK	S A	(197)	34-20-55	118-02-54	4325	12.10
57B	CAMP HI HILL (OPIDS)	A	M F3	34-15-18	118-05-41	4250	23.00
63C	SANTA ANITA DAM	S A	20A F2	34-11-03	118-01-12	1400	17.36
67G	MONROVIA-MOUNTAIN AVENUE	S	29 C4	34-08-46	117-59-05	602	12.68
68C	SAWPIT DAM	S A	20B C6	34-10-30	117-59-07	1375	16.31
82F	TABLE MOUNTAIN	S	(201)	34-22-56	117-40-39	7420	13.94
83B	BIG PINES RECREATION PARK	A	(201)	34-22-44	117-41-20	6860	15.90
89B	SAN DIMAS DAM	S A	95A C3	34-09-10	117-46-17	1350	15.13
91	CLAREMONT-INDIAN HILL	S	91 B1	34-07-22	117-43-11	1403	12.85
93C	CLAREMONT-POLICE STATION	8.81	91 B4	34-05-45	117-43-18	1170	11.83
95	SAN DIMAS-FIRE WARDEN	S	89 F3	34-06-26	117-46-19	955	13.81
96C	PUDDINGSTONE DAM	S A	89 F4	34-05-31	117-48-24	1030	12.44
102D	WALNUT-N.I. INDUSTRIES	S	97 B2	34-00-11	117-52-10	500	11.90
106F	WHITTIER CITY YARD	S	55 D4	33-58-57	118-02-50	300	8.82
107D	DOWNEY-FIRE DEPARTMENT	S	60 A5	33-55-48	118-08-47	110	9.26
108D	EL MONTE FIRE STATION	S	38 D6	34-04-30	118-02-30	275	9.91
109D	WEST ARCADIA	S	28 A6	34-07-42	118-04-22	547	10.91
110B	ALHAMBRA	S	37 B3	34-05-40	118-07-41	533	10.47
120	VINCENT PATROL STATION	S	183 A9	34-29-17	118-08-27	3135	5.52
125B	SAN FRANCISQUITO CYN P.H. 1	SP	(169)	34-35-25	118-27-15	2105	10.65
128B	ELIZABETH LAKE	A	(168)	34-36-28	118-33-40	2075	11.10
134C	PUDDINGSTONE DIVERSION	8.81	95A C5	34-07-52	117-46-55	1160	11.99
143B	AZUSA-CITY PARK	S	86 D5	34-08-03	117-54-17	610	12.73
144	SIERRA MADRE DAM	S	20A D3	34-10-34	118-02-32	1100	18.77
156B	LA MIRADA-STANDARD OIL CO.	A	83 A4	33-52-59	118-01-00	75	9.80
158	TANBARK FLATS	AP A	P D5	34-12-20	117-45-40	2750	17.00
167C	ARCADIA PUMPING PLANT #1	S	28 E2	34-09-31	118-02-02	611	13.54
169	SIERRA MADRE PUMPING PLANT	SP	28 D2	34-09-47	118-02-21	700	15.48
170F	POTRERO HEIGHTS	S	47 A4	34-02-32	118-04-44	285	10.28
172B	DUARTE	S	29 E4	34-08-26	117-58-02	548	9.51
174B	GLENDORA	S	87 E6	34-07-43	117-49-08	930	10.76
175B	LA CANADA IRRIGATION DIS.	S	19 A1	34-13-39	118-12-40	2020	14.71
176	ALTADENA-RUBIO CANYON	SP	20 B6	34-10-55	118-08-15	1125	13.80
191C	L.A.C.D.P.W.-WAREHOUSE	A	45 B1	34-03-48	118-11-58	400	10.40
192C	BELL-FIRE STATION	8 C1	53 C5	33-58-45	118-11-16	145	9.87*
193C	COVINA-NIGG	S	89 A5	34-04-55	117-52-25	575	10.80

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Active Rainfall Stations 1993-94

Station No.	Station Name	Type Gage	Thomas Guide Page	North Latitude	West Longitude	Gage Elev (Feet)	Seasonal Total (Inches)
196C	LA VERNE-FIRE STATION	S	90 D3	34-06-06	117-46-20	1050	11.78
200	SAUGUS-S. C. EDISON CO.	S	123 H8	34-25-21	118-34-26	1096	8.00*
201D	HACIENDA HEIGHTS	A	85 C3	33-59-40	117-59-28	875	11.80
210C	BRAND PARK	A	18 B5	34-11-18	118-18-20	1250	10.00
216B	GLENDALE-ANDREE	S	25 D2	34-09-54	118-15-01	615	10.70
222C	NORTH HOLLYWOOD P. P.	SP	16 C4	34-11-39	118-23-17	717	8.20*
223C	BIG DALTON DAM	S A	87 F2	34-10-06	117-48-36	1587	17.18
224D	LONG BEACH-ALAMITOS LAND CO.	S	76 B3	33-46-42	118-08-04	45	8.82*
225	MONTANA RANCH-LAKEWOOD	S	71 C3	33-50-35	118-07-09	47	10.57
226B	BURBANK-FIRE STATION	S	17 E6	34-10-58	118-18-23	680	10.29*
227D	SAN GABRIEL-BRUINGTON-ORTON	S	37 D2	34-06-18	118-06-32	472	11.37
228C	BEVERLY HILLS CITY HALL	AP S	33 C6	34-06-00	118-23-40	245	9.81
235C	HENNIGER FLATS	A 8.81	20 F4	34-11-38	118-05-17	2550	16.69
237C	STONE CANYON RESERVOIR	SP	32 D2	34-06-21	118-27-13	865	11.29*
238	HOLLYWOOD DAM	SP	34 C1	34-07-04	118-19-55	750	8.27
250D	ACTON CAMP	A	189 E5	34-27-02	118-11-55	2625	6.90
251C	LA CRESCENTA	S	18 D1	34-13-20	118-14-40	1440	12.21
252C	CASTAIC DAM	SP AP	(178)	34-29-53	118-36-53	1150	9.52
255F	MT. SAN ANTONIO COLLEGE	S	93 D4	34-02-41	117-50-19	720	8.86
256C	POMONA-FIRE STATION	S	94 E3	34-03-16	117-45-10	844	11.77*
261F	ACTON-ESCONDIDO CANYON	A	181 H9	34-29-42	118-16-22	2960	7.70
269D	DIAMOND BAR FIRE STATION	SP AP	97 F2	33-59-50	117-48-55	870	12.65
277	SAWMILL MOUNTAIN	S	(155)	34-43-15	118-35-00	3700	14.81
280C	FLINTRIDGE-SACRED HEART	A	19 D6	34-10-54	118-11-08	1600	13.60
283C	CRYSTAL LAKE-EAST PINE FLAT	A	P B1	34-19-02	117-50-28	5370	23.60
287B	GLENDORA-CITY HALL	8.81	87 B5	34-08-09	117-51-52	785	13.01
290B	MONTEREY PARK-FIRE STATION	S	46 B4	34-02-27	118-07-42	305	11.30
291	LOS ANGELES-96th AND CENTRAL	A	58 C3	33-56-56	118-15-17	121	9.90
292D	ENCINO RESERVOIR	S A	21 D3	34-08-56	118-30-57	1075	11.53
293B	LAKE LOS ANGELES	SP	2 A4	34-17-18	118-28-54	1150	11.32
294B	SIERRA MADRE-MIRA MONTE P.P.	SP	28 C1	34-10-11	118-02-51	985	16.27
298C	GORMAN - SHERIFF	A	(141)	34-47-47	118-51-27	3835	11.20
299F	LITTLE ROCK - SCHWAB	S	184 F5	34-32-12	117-58-43	2800	4.64
303F	PASADENA - CALTECH	S	27 C5	34-08-14	118-07-25	800	11.47*
306H	ZUMA BEACH	S	111 F6	34-01-15	118-49-42	15	11.28
321	PINE CANYON PATROL STATION	A	157 D7	34-40-24	118-25-45	3286	11.60
322	MUNZ VALLEY RANCH	S	158 A2	34-42-50	118-21-15	2600	7.57
334B	COGSWELL DAM	S A	N D4	34-14-37	117-57-35	2300	18.92
336	SILVER LAKE RESERVOIR	SP	35 B3	34-06-08	118-15-54	445	6.70
338C	MT. WILSON-OBSERVATORY	SP	20A C1	34-14-07	118-04-28	5709	20.03
342C	UPLAND-CHAPPEL	AP	96 E6	34-07-33	117-40-52	1610	12.44
352B	LECHUZA PATROL STATION	AP S	105 B6	34-04-38	118-52-47	1620	13.24
355B	LOS ANGELES CITY COLLEGE	AP S	34 F4	34-05-14	118-17-28	310	8.59*
356C	SPADRA-LANTERMAN HOSPITAL	S A	93 F4	34-02-31	117-48-35	690	10.89
372	SAN FRANCISQUITO P. H. NO.2	SP A	(179)	34-32-02	118-31-27	1580	9.01
373C	BRIGGS TERRACE	S A	11 F5	34-14-17	118-13-27	2200	15.69
377F	LAKE SHERWOOD ESTATES	SP AP	102A C4	34-08-26	118-52-31	960	13.36
379B	SAN GABRIEL-EAST FORK	A	P C4	34-14-09	117-48-18	1600	14.60
387B	COVINA CITY YARD	SP	88 E5	34-05-02	117-53-57	508	10.99
388D	PARAMOUNT-COUNTY FIRE DEPT.	8.81	65 E3	33-53-50	118-10-02	80	11.97
390B	MORRIS DAM	SP	P A6	34-10-53	117-52-43	1210	14.38
391C	MONTEBELLO-FIRE DEPARTMENT	8.81	54 E1	34-01-08	118-06-15	250	9.54
394	HIGHLAND PARK	S	36 D1	34-07-06	118-10-39	620	9.49
395B	OLIVE VIEW SANITARIUM	A	2 D1	34-19-29	118-26-55	1425	12.20
402F	CEDAR SPRINGS	A	(199)	34-21-21	117-52-34	6780	21.50
405B	SOLEDAD CANYON	S	188 F6	34-26-23	118-17-33	2150	8.38
406C	WEST AZUSA	S	88 C2	34-06-53	117-54-56	505	11.88

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Active Rainfall Stations 1993-94

Station No.	Station Name	Type of Gage	Thomas Guide Page	North Latitude	West Longitude	Gage Elev (Feet)	Seasonal Total (Inches)
409B	PYRAMID RESERVOIR	SP AP	(154)	34-40-34	118-46-47	2505	11.22
415	SIGNAL HILL-CITY HALL	S A	75 E2	33-47-49	118-10-03	140	9.61
423C	ANGELES FOREST-ALISO CYN	A	(190A)	34-24-57	118-05-26	3920	12.10
425B	SAN GABRIEL DAM	S A	P A5	34-12-19	117-51-38	1481	17.55
434	AGOURA	A	100A A5	34-08-08	118-45-08	800	11.50
435	MONTE NIDO	A	108 A6	34-04-41	118-41-35	600	14.00
436C	HANSEN DAM	AP	9 C2	34-16-08	118-23-59	1110	9.64
442C	MESCAL CREEK	S	(194)	34-29-05	117-44-10	3570	3.50
443B	LATIGO CANYON-BEACH RANCH	S	106 B4	34-05-35	118-48-52	1700	15.06
446	ALISO CANYON-OAT MOUNTAIN	A	1 A2	34-18-53	118-33-25	2367	13.70
447C	CARBON CANYON	S	114 E4	34-02-18	118-38-56	50	9.63
449B	EATON WASH DAM	S A	27 E1	34-10-06	118-05-33	880	12.00
453D	DEVILS GATE DAM	A	19 D6	34-10-53	118-10-27	980	9.70
455B	LANCASTER-HWY MAINTENANCE	S	160 B6	34-40-57	118-08-02	2395	4.23
462B	HILLCREST COUNTRY CLUB	S	42 B3	34-02-54	118-24-06	185	9.50
465C	SEPULVEDA DAM	AP	22 B1	34-10-06	118-28-11	683	9.59
480B	TEMPLE CITY FIRE STATION	S	38 C2	34-06-31	118-03-25	404	9.70
482	LOS ANGELES-U.S.C.	S	43 F6	34-01-14	118-17-15	208	8.19
488B	KAGEL CANYON PATROL STATION	S	3 E4	34-17-45	118-22-30	1450	10.53
491D	PACIFIC PALISADES	S	40 C4	34-02-22	118-31-43	293	10.13
492A	CHILAO-HWY MAINTENANCE STA.	A	N C1	34-19-05	118-00-30	5275	16.90
493D	SAND CANYON-MACMILLAN RANCH	A	128 D3	34-23-17	118-24-50	1805	12.84*
497	CLAREMONT-SLAUGHTER	B.81	91 A1	34-07-35	117-43-55	1350	13.71
517B	LEWIS RANCH	A	(192A)	34-25-12	117-53-11	4615	10.90
542	FAIRMONT	SP	(145)	34-42-15	118-25-40	3050	9.98
560A	LA VERNE HEIGHTS	S	90 E2	34-06-48	117-45-02	1210	13.17
564C	LLANO	S	185 J9	34-29-13	117-50-02	3390	3.78
591B	SANTA ANITA RESERVOIR	SP	20 E5	34-11-08	118-06-16	1205	14.87
598C	NEENACH-ERSTAD	S	(143)	34-46-28	118-35-55	3062	6.18
598D	NEENACH-CHECK 43-D.W.R.	SP	(143)	34-47-40	118-37-15	2985	9.30
610B	PASADENA-CITY HALL	SP	27 A4	34-08-54	118-08-36	864	10.95
612B	PASADENA-CHLORINE PLANT	SP	19 E3	34-12-04	118-09-49	1160	15.66
613C	PASADENA FIRE STATION	SP	27 B5	34-07-15	118-08-05	779	10.84
619	SAN ANTONIO CYN-SIERRA P. H.	A	P F5	34-12-29	117-40-26	3110	19.80
627	SAN GABRIEL CANYON-P. H.	SP A	86 D3	34-09-20	117-54-28	744	13.77
634C	SANTA MONICA	S	49 A1	34-00-43	118-29-27	94	8.81
662D	LONG BEACH AIRPORT	SP	71 A6	33-49-00	118-09-00	34	8.98
680B	WESTWOOD (U.C.L.A.)	SP	41 E1	34-04-10	118-26-30	430	9.73
683B	SUNSET RIDGE	S A	19 E4	34-12-53	118-08-47	2110	18.64
694G	BIG TUJUNGA CANYON-CAMP 15	A	M D6	34-17-22	118-17-17	1525	11.50
695B	TUJUNGA CANYON-VOGEL FLAT	S	M B2	34-17-12	118-13-32	1850	15.71
716	LOS ANGELES-DUCOMMUN ST.	SP A AP	44 E3	34-03-09	118-14-13	306	9.07
722C	BELLEVIEW	S	171 B3	34-37-23	118-13-55	2880	6.04
726C	ANGELES CREST GUARD STATION	S	M D4	34-14-01	118-11-04	2300	17.16
734C	L. A. INTERNATIONAL AIRPORT	SP AP	56 C3	33-56-25	118-23-44	105	8.21
735H	BELL CANYON	A	5 D4	34-11-40	118-39-23	895	11.60
740B	SAN DIMAS CANYON-FERN NO.2	AP	P F6	34-11-48	117-41-45	5200	19.30*
741	SAN DIMAS CYN	AP	P E6	34-11-41	117-44-26	2675	15.50*
742C	SAN GABRIEL FIRE DEPARTMENT	SP	37 E3	34-06-11	118-05-56	445	10.55
747	SANDBERG-AIRWAYS STATION	SP AP	(142)	34-44-47	118-43-29	4517	8.50*
749B	BURBANK VALLEY PUMP PLANT	SP AP	17 A5	34-11-11	118-20-54	655	9.24
750B	PALMDALE REGIONAL AIRPORT	S	172 F6	34-37-20	118-05-00	2528	4.35
771B	PACIFIC PALISADES-RIVIERA	S	40 F3	34-03-03	118-29-58	315	9.79*
794	LOWER FRANKLIN RESERVOIR	SP	33 B4	34-05-43	118-24-40	585	9.32*
795	PASADENA-JOURDAN	SP	27 F4	34-08-52	118-05-14	705	11.41
797	DE SOTO RESERVOIR	SP	6 D1	34-16-17	118-35-12	1127	11.92
801B	MAGIC MOUNTAIN	AP	(195)	34-23-18	118-19-27	4720	14.02

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Station No.	Station Name	Type of Gage	Thomas Guide Page	North Latitude	West Longitude	Gage Elev. (Feet)	Seasonal Total (Inches)
409B	PYRAMID RESERVOIR	SP AP	(154)	34-40-34	118-46-47	2505	11.22
415	SIGNAL HILL-CITY HALL	S A	75 E2	33-47-49	118-10-03	140	9.81
423C	ANGELES FOREST-ALISO CYN	A	(190A)	34-24-57	118-05-28	3920	12.10
425B	SAN GABRIEL DAM	S A	P A5	34-12-19	117-51-38	1481	17.55
434	AGOURA	A	100A A5	34-08-08	118-45-08	800	11.50
435	MONTE NIDO	A	108 A6	34-04-41	118-41-35	800	14.00
436C	HANSEN DAM	AP	9 C2	34-16-08	118-23-59	1110	9.64
442C	MESCAL CREEK	S	(194)	34-29-05	117-44-10	3570	3.50
443B	LATIGO CANYON-BEACH RANCH	S	108 B4	34-05-35	118-48-52	1700	15.06
446	ALISO CANYON-OAT MOUNTAIN	A	1 A2	34-18-53	118-33-25	2367	13.70
447C	CARBON CANYON	S	114 E4	34-02-18	118-38-56	50	9.63
449B	EATON WASH DAM	S A	27 E1	34-10-06	118-05-33	880	12.00
453D	DEVILS GATE DAM	A	19 D6	34-10-53	118-10-27	980	9.70
455B	LANCASTER-HWY MAINTENANCE	S	160 B6	34-40-57	118-08-02	2395	4.23
462B	HILLCREST COUNTRY CLUB	S	42 B3	34-02-54	118-24-08	185	9.50
465C	SEPULVEDA DAM	AP	22 B1	34-10-06	118-28-11	683	9.59
480B	TEMPLE CITY FIRE STATION	S	38 C2	34-06-31	118-03-25	404	9.70
482	LOS ANGELES-U.S.C.	S	43 F6	34-01-14	118-17-15	208	8.19
488B	KAGEL CANYON PATROL STATION	S	3 E4	34-17-45	118-22-30	1450	10.53
491D	PACIFIC PALISADES	S	40 C4	34-02-22	118-31-43	293	10.13
492A	CHILAO-HWY MAINTENANCE STA.	A	N C1	34-19-05	118-00-30	5275	16.90
493D	SAND CANYON-MACMILLAN RANCH	A	128 D3	34-23-17	118-24-50	1805	12.84*
497	CLAREMONT-SLAUGHTER	6.81	91 A1	34-07-35	117-43-55	1350	13.71
517B	LEWIS RANCH	A	(192A)	34-25-12	117-53-11	4615	10.90
542	FAIRMONT	SP	(145)	34-42-15	118-25-40	3050	9.98
560A	LA VERNE HEIGHTS	S	90 E2	34-06-48	117-45-02	1210	13.17
564C	LLANO	S	185 J9	34-29-13	117-50-02	3390	3.78
591B	SANTA ANITA RESERVOIR	SP	20 E5	34-11-08	118-06-16	1205	14.87
598C	NEENACH-ERSTAD	S	(143)	34-46-28	118-35-55	3062	8.18
598D	NEENACH-CHECK 43-D.W.R.	SP	(143)	34-47-40	118-37-15	2965	9.30
610B	PASADENA-CITY HALL	SP	27 A4	34-08-54	118-08-36	864	10.95
612B	PASADENA-CHLORINE PLANT	SP	19 E3	34-12-04	118-09-49	1160	15.66
613C	PASADENA FIRE STATION	SP	27 B5	34-07-15	118-08-05	779	10.84
619	SAN ANTONIO CYN-SIERRA P. H.	A	P F5	34-12-29	117-40-26	3110	19.80
627	SAN GABRIEL CANYON-P. H.	SP A	86 D3	34-09-20	117-54-28	744	13.77
634C	SANTA MONICA	S	49 A1	34-00-43	118-29-27	94	6.81
662D	LONG BEACH AIRPORT	SP	71 A6	33-49-00	118-09-00	34	6.98
680B	WESTWOOD (U.C.L.A.)	SP	41 E1	34-04-10	118-26-30	430	9.73
683B	SUNSET RIDGE	S A	19 E4	34-12-53	118-08-47	2110	16.64
694G	BIG TUJUNGA CANYON-CAMP 15	A	M D6	34-17-22	118-17-17	1525	11.50
695B	TUJUNGA CANYON-VOGEL FLAT	S	M B2	34-17-12	118-13-32	1850	15.71
716	LOS ANGELES-DUCOMMUN ST.	SP A AP	44 E3	34-03-09	118-14-13	306	9.07
722C	BELLEVIEW	S	171 B3	34-37-23	118-13-55	2880	6.04
726C	ANGELES CREST GUARD STATION	S	M D4	34-14-01	118-11-04	2300	17.16
734C	L. A. INTERNATIONAL AIRPORT	SP AP	56 C3	33-56-25	118-23-44	105	8.21
735H	BELL CANYON	A	5 D4	34-11-40	118-39-23	895	11.60
740B	SAN DIMAS CANYON-FERN NO.2	AP	P F6	34-11-48	117-41-45	5200	19.30*
741	SAN DIMAS CYN	AP	P E6	34-11-41	117-44-26	2675	15.50*
742C	SAN GABRIEL FIRE DEPARTMENT	SP	37 E3	34-06-11	118-05-56	445	10.55
747	SANDBERG-AIRWAYS STATION	SP AP	(142)	34-44-47	118-43-29	4517	8.50*
749B	BURBANK VALLEY PUMP PLANT	SP AP	17 A5	34-11-11	118-20-54	655	9.24
750B	PALMDALE REGIONAL AIRPORT	S	172 F6	34-37-20	118-05-00	2528	4.35
771B	PACIFIC PALISADES-RIVIERA	S	40 F3	34-03-03	118-29-58	315	9.79*
794	LOWER FRANKLIN RESERVOIR	SP	33 B4	34-05-43	118-24-40	585	9.32*
795	PASADENA-JOURDAN	SP	27 F4	34-08-52	118-05-14	705	11.41
797	DE SOTO RESERVOIR	SP	6 D1	34-16-17	118-35-12	1127	11.92
801B	MAGIC MOUNTAIN	AP	(195)	34-23-18	118-19-27	4720	14.02

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Station No.	Station Name	Type of Gage	Thomas Guide Page	North Latitude	West Longitude	Gage Elev. (Feet)	Seasonal Total (Inches)
802C	EAGLE ROCK RESERVOIR	SP	26 C4	34-08-47	118-11-20	970	10.68
807	ASCOT RESERVOIR	SP AP	36 C5	34-04-46	118-11-14	620	8.98
1005B	MINT CANYON FIRE STATION	S	(180)	34-30-35	118-21-40	2300	7.45
1006	SAN PEDRO-CITY RESERVOIR	SP A	78 F2	33-44-37	118-17-47	150	9.36
1011B	PALOS VERDES FIRE STATION	S	78 A1	33-45-25	118-21-11	1275	9.96
1012B	CASTAIC JUNCTION	S A	123 E6	34-26-18	118-36-43	1005	8.20
1017B	LITTLE ROCK CREEK ABOVE DAM	A	(191)	34-28-41	118-01-24	3280	6.50
1020B	PADUA HILLS PATROL STATION	S	96 D4	34-08-52	117-41-55	1800	14.47
1025	MALIBU BEACH-DUNNE	S	113 E5	34-02-00	118-42-42	160	8.54
1029C	TUJUNGA-MILL CREEK SUMMIT	AP S	(197)	34-23-22	118-04-49	4990	13.12
1037	ARCADIA-ARBORETUM	S	28 C4	34-08-48	118-02-59	565	12.67
1041B	SANTA FE DAM	AP	39 D1	34-07-04	117-58-24	427	10.54
1046B	SANTA ANITA CYN-CHANTRY FLAT	S	20A F1	34-11-46	118-01-20	2175	19.36
1050F	OLD TOPANGA CANYON	S	108 F3	34-06-24	118-37-43	1000	15.91
1051B	CANOGA PARK-PIERCE COLLEGE	SP	12 E5	34-10-51	118-34-23	800	10.90
1058B	PALMDALE	SP AP	172 E7	34-35-17	118-05-31	2595	4.34
1060B	LITTLE ROCK-SYCAMORE CAMP	A	(191)	34-25-02	117-58-13	4000	9.10
1062	BUCKHORN FLAT	A	(199)	34-20-44	117-55-08	6760	19.60*
1063	SOLEDAD PASS	S	183 E9	34-29-35	118-05-28	3520	7.92
1068	RATTLESNAKE CANYON	S	105 C5	34-05-00	118-51-55	1290	13.84*
1070	MANHATTAN BEACH	S	62 D4	33-53-00	118-23-19	182	7.67
1071B	DESCANSO GARDENS	S	19 B2	34-12-07	118-12-46	1325	12.74
1072B	LITTLE TUJUNGA RANGER STA.	SP A	3 F5	34-17-37	118-21-38	1275	11.82
1074	LITTLE GLEASON	A	(197)	34-22-43	118-08-57	5600	13.29
1075	UPPER WOLFSKILL	AP	96 B2	34-10-13	117-43-16	3625	18.78*
1076B	MONTE CRISTO RANGER STATION	SP	M E1	34-19-42	118-07-20	3360	11.62
1077B	MONROVIA-FIVE POINTS	S	29 B1	34-09-58	117-59-37	982	15.70
1081B	GLENDALE-GREGG	SP	18 D4	34-11-45	118-14-30	1350	12.07
1087	GREEN-VERDUGO PUMPING PLANT	S	10 B3	34-15-25	118-20-11	1340	9.52*
1088B	LA HABRA HEIGHTS	S A	84 E2	33-56-55	117-57-51	445	10.40
1090	LOS ALAMITOS	SP	81 B6	33-48-35	118-04-35	25	9.50*
1092B	BUENA PARK	S'P	OC10 C1	33-51-28	117-59-29	80	9.20*
1095	ORANGE COUNTY RESERVOIR	SP AP	OC 2 F4	33-56-07	117-52-58	660	10.00
1104	BOUQUET CANYON AT TEXAS CYN	S	(180)	34-30-35	118-27-00	1760	9.68*
1107D	LA TUNA DEBRIS BASIN	A	10 C5	34-14-13	118-19-37	1160	8.50
1111C	DEVILS PUNCHBOWL	S	(192A)	34-24-48	117-51-25	4760	10.70*
1113	DOMINGUEZ WATER CO.	A	69 F4	33-49-54	118-13-30	30	9.80
1114B	WHITTIER NARROWS DAM	AP	47 A6	34-01-29	118-05-02	239	10.53
1115	SAN ANTONIO DAM	AP SP	96 F3	34-09-24	117-40-20	2120	15.49
1126A	LOS ANGELES-EAST VALLEY	8.81	16 B3	34-12-30	118-24-35	780	9.61
1128	WRIGHTWOOD FIRE DEPARTMENT	SP	S.B.CO.	34-21-34	117-37-57	5960	9.20
1129B	NICHOLAS CANYON	S	110 D3	34-02-52	118-54-57	340	10.86
1132	OAK FLAT GUARD STATION	S	(166)	34-35-56	118-43-15	2800	15.00*
1140	ROSEMEAD	8.81	38 B5	34-04-53	118-03-55	305	12.01
1147	EL CABALLERO COUNTRY CLUB	S	21 C4	34-08-52	118-31-53	1000	11.08*
1152	CLEAR CREEK RANGER STATION	S	M D3	34-16-15	118-09-11	3625	16.20*
1158	TORRANCE MUNICIPAL AIRPORT	S	73 B2	33-47-59	118-20-08	102	9.01
1166B	MILE HIGH RANCH	S	(193)	34-24-40	117-46-15	5280	7.82
1169B	PIRU-TEMESCAL GUARD STATION	SP	V CO.	34-28-22	118-45-21	1150	11.92
1170B	THOUSAND OAKS WEATHER STA.	AP	V.CO.	34-10-44	118-51-01	805	10.59
1171B	CAMULOS RANCH	SP AP	V CO	34-24-22	118-45-21	725	11.37
1172B	PIRU CANYON ABOVE PIRU LAKE	AP	(177)	34-30-48	118-45-24	1120	11.54
1173B	TAPO CANYON	AP	V.CO.	34-19-54	118-42-39	1525	10.74
1177B	BARD RESERVOIR	AP	V.CO	34-14-32	118-49-41	1010	10.38
1183B	LA HABRA FIRE STATION	S'P	84 F4	33-55-53	117-57-17	315	10.20*
1190	PACOIMA CYN-NORTH FORK	S	(195)	34-23-17	118-15-06	4180	15.81
1191	BEAR DIVIDE	S	128 F6	34-21-35	118-23-37	2700	17.11

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Station No.	Station Name	Type Gage	Thomas Guide Page	North Latitude	West Longitude	Gage Elev (Feet)	Seasonal Total (Inches)
1192	CARSON FIRE STATION	8.81	64 C6	33-52-04	118-15-45	92	9.15
1193	WESTLAKE VILLAGE	S	102 A5	34-08-19	118-49-05	885	7.96*
1194	SANTA YNEZ RESERVOIR	S	109 F6	34-04-23	118-33-59	735	9.78*
1195	CHINO FIRE STATION NO. 2	SP	S.B.CO.	33-59-00	117-43-20	655	6.49
1196	MONTCLAIR FIRE DEPARTMENT	SP	95 E2	34-03-41	117-41-16	985	9.30
1197	CAJON WEST SUMMIT	SP	S.B.CO.	34-23-30	117-34-35	4838	4.30*
1198	PHELAN FIRE CONTROL	SP	S.B.CO.	34-25-30	117-34-00	4180	4.16
1211	HACIENDA GOLF CLUB	S	98A A1	33-57-40	117-56-57	750	11.00*
1212	LANCASTER FSS/FAA	SP	147 C9	34-44-00	118-13-00	2340	4.14
1216	RANCHO PALOS VERDES	S	77 C1	33-45-10	118-23-32	780	8.15
1217	LOS ANGELES COUNTRY CLUB	S	42 A1	34-04-10	118-25-17	380	9.72
1222	NORTHRIDGE-GARLAND	8.81	7 E3	34-14-17	118-30-59	911	10.14
1223	WOODLAND HILLS-SHERMAN	8.81	100 E1	34-10-06	118-38-57	1035	10.86
1239	MALIBU-BIG ROCK MESA	A	115 A4	34-02-34	118-37-16	725	11.50
1240	PEARBLOSSOM-CALIF.D.W.R.	SP AP	185 B7	34-30-32	117-55-15	3050	4.13
1242	ROCKY BUTTES	A	(162)	34-39-00	117-51-48	2540	3.60*
1243	REDMAN	A	(150)	34-45-52	117-55-30	2360	2.70
1244	LANCASTER-ROPER	A	161 C6	34-40-27	118-00-37	2450	3.90
1245	QUARTZ HILL-HALL	A	159 B7	34-40-28	118-14-40	2395	5.20
1246	SCOTT RANCH	A	(145)	34-46-59	118-28-10	2710	5.10
1247	NORTH LANCASTER	A	148 D6	34-45-41	118-07-30	2310	3.10
1248	MESCAL-SMITH	A	(194)	34-28-03	117-42-40	3810	3.60
1249	RELAY	A	(150)	34-45-43	117-47-55	3140	4.10
1250	AVEK	A	185 B5	34-32-21	117-55-23	2825	3.50
1251	PALOS VERDES-WHITES POINT	SP	78 D6	33-42-50	118-19-02	100	6.27
1252	PALOS VERDES LANDFILL	SP	73 A4	33-45-40	118-20-03	400	9.79
1253	CARSON-COUNTY SANITATION	SP	74 A2	33-48-07	118-16-58	40	6.86*
1254	LONG BEACH RECLAMATION PLANT	SP	76 F1	33-48-11	118-05-20	20	10.90
1255	LOS COYOTES RECLAMATION	SP	66 E4	33-53-05	118-06-24	70	9.49
1256	SOUTH GATE TRANSFER STATION	SP	59 E3	33-56-40	118-09-56	100	7.66
1257	SAN JOSE CREEK RECLAMATION	SP	47 F4	34-01-55	118-01-16	275	10.46
1258	PUENTE HILLS LANDFILL	SP	47 E5	34-01-35	118-01-49	300	10.85
1259	WHITTIER NARROWS RECLAMATION	SP	47 B1	34-03-59	118-03-54	225	10.53
1260	SPADRA LANDFILL	SP	93 E4	34-02-36	117-49-50	700	10.47
1261	LA CANADA RECLAMATION PLANT	SP	19 D2	34-13-00	118-11-14	1800	13.19
1262	SAUGUS RECLAMATION PLANT	SP	124 B9	34-24-48	118-32-23	1150	9.03
1263	VALENCIA RECLAMATION PLANT	SP	123 D7	34-25-55	118-37-13	1000	8.00
1264	CALABASAS LANDFILL	SP	100A E3	34-08-25	118-42-35	800	10.70
1265	SCHOLL CANYON LANDFILL	SP	26 C4	34-08-38	118-11-07	1000	11.59
1266	MISSION CANYON LANDFILL	SP	22 B6	34-08-40	118-28-45	1150	10.39
1267	LANCASTER RECLAMATION PLANT	SP	147 H4	34-46-38	118-09-11	2302	3.35
1268	PALMDALE RECLAMATION PLANT	SP	172 G6	34-35-30	118-05-10	2565	3.49
1271	POMONA WASTE RECLAMATION	SP	94 B3	34-03-18	117-47-34	786	10.56
1093	FULLERTON AIRPORT	SP AP	83 D5	33-52-23	117-58-24	100	9.80*

LEGEND:

S	Standard 8 inch diameter non-recording gage owned by the Department of Public Works
8.81	8.81 inch diameter non-recording gage owned by the Department of Public Works
A	Automatic recording gage owned by the Department of Public Works
ST	Storage type gage owned by the Department of Public Works
SP	Standard 8 inch diameter non-recording gage owned by outside interest
AP	Automatic recording gage owned by outside interest
( )	Thomas Guide future page
O.CO.	Orange County Thomas Guide page
V.CO.	Ventura County Thomas Guide page
S.B.CO.	San Bernardino County Thomas Guide page

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2 0300

Active Rainfall Stations 1993-94

Station No.	Station Name	Type Gage	Thomas Guide Page	North Latitude	West Longitude	Gage Elev (Feet)	Seasonal Total (Inches)

DSC. Discontinued
INC. Incomplete records
* Estimated Seasonal Total
N.R No Record(Data Not Available)

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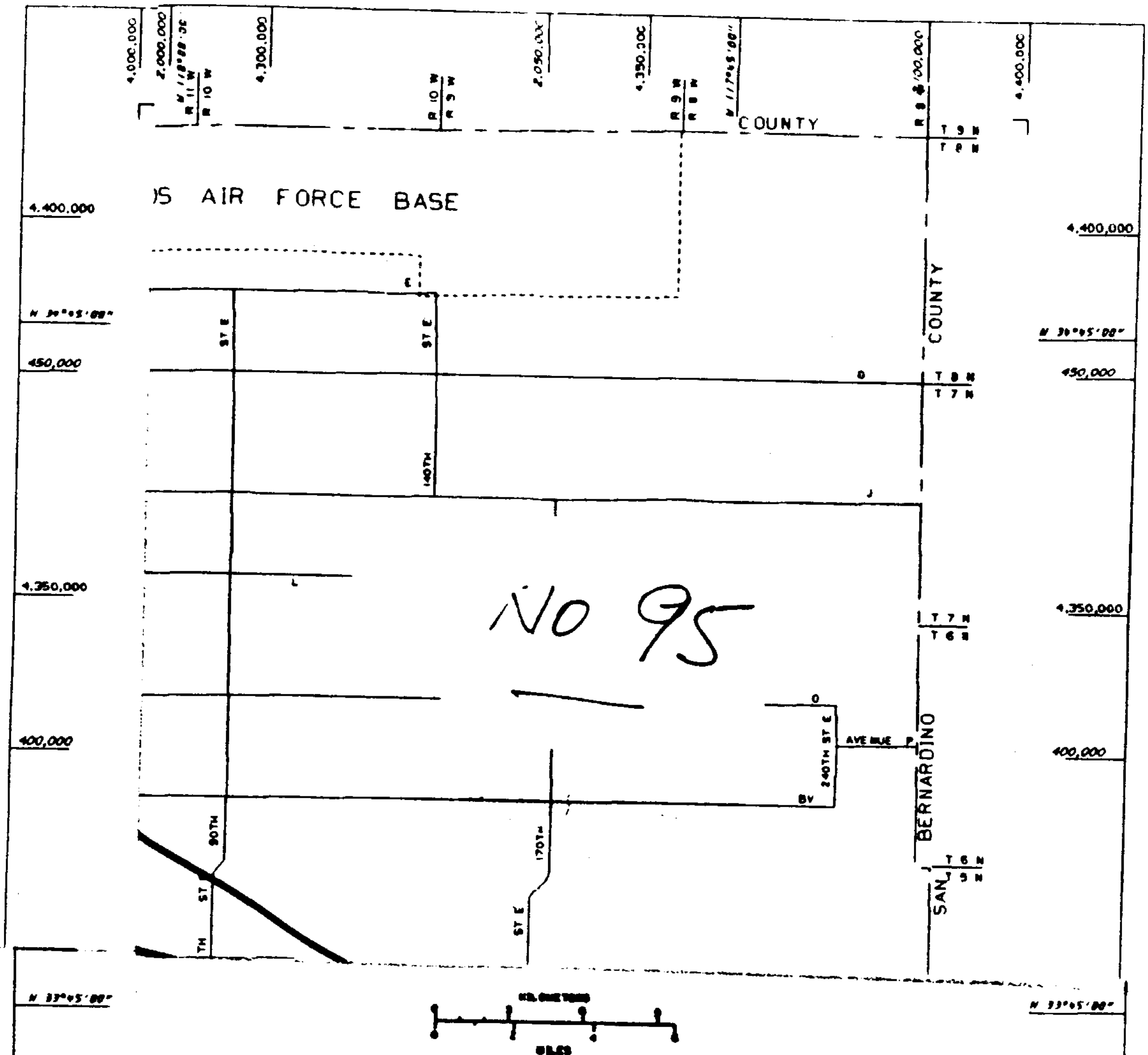

MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

ISOHYETAL MAP

1993-94

(ELEVATIONS ARE IN INCHES)

2 0301

PA2

R0053606

VOL 12

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03002

EVAPORATION

R0053607

EVAPORATION

Data for 14 active evaporation stations were reported to the Department during the 1993-94 water year. Daily records of active and inactive Department stations, as well as some stations of other agencies, are available in the Department's files. Monthly and seasonal evaporation has been published in the Department's Annual or Biennial Reports on Hydrologic Data since the 1931-32 season.

COOPERATION

The Department receives evaporation data from The Metropolitan Water District, Palmdale Water District, California Department of Water Resources, and Descanso Gardens.

LENGTH OF RECORD

The first land pan installed by this Department was at Santa Anita Dam in March 1929. There are 30 evaporation stations which have records of 15 seasons or more in the Department's files.

EVAPORATION STATION LIST 1993-94

STA. NO.	STATION NAME	EQUIPMENT	ELEVATION OF PAN	THOMAS GUIDE	NORTH LATITUDE	WEST LONGITUDE
33 A	Pacoima Dam	24X36 S	1500 ft.	482 F1	34-19-48	118-23-59
46 D	Big Tujunga Dam	24X36 S	2315 ft.	xi	34-17-40	118-11-14
63 C	Santa Anita Dam	24X36 S	1400 ft.	710 B2	34-11-03	118-01-12
89 B	San Dimas Dam	24X36 S	1350 ft.	470 F2	34-09-10	117-46-17
96 C	Puddingstone Dam	24X36 S	1030 ft.	600 A4	34-05-31	117-48-24
223 B	Big Dalton Dam	24X36 S	1587 ft.	570 B4	34-10-06	117-48-36
252 C	Castaic Reservoir	48X10 S	1150 ft.	4369 H6	34-29-53	118-36-53
334 B	Cogswell Dam	24X36 S	2300 ft.	ix	34-14-37	117-57-35
390 B	Morris Dam	72X36 US	1210 ft.	ix	34-10-53	117-52-43
409 B	Pyramid Reservoir	48X10 S	2505 ft.	593 E1	34-40-34	118-46-47
425 B	San Gabriel Dam	24X36 S	1481 ft.	ix	34-12-19	117-51-38
1014 F	Rio Hondo S.G.	24X36 S	170 ft.	676 D4	33-59-57	118-06-04
1058 B	Palmdale	24X36 S	2595 ft.	4196 E6	34-35-17	118-05-31
1071 B	Descanso Gardens	24X36 S	1325 ft.	535 B4	34-12-07	118-12-46

LEGEND

24X36 S = Screened land pan, 24 inches in diameter by 36 inches deep.
48X10 S = Screened land pan, 48 inches in diameter by 10 inches deep.
72X36 US = Unscreened land pan, 72 inches in diameter by 36 inches deep.
( ) = Thomas Guide future page assignment.

MONTHLY EVAPORATION SUMMARY FOR WATER YEAR 1993-94 (inches)

STA NO	STATION NAME	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
33 A	Pacoima Dam	8.39	7.96	6.73	7.71	5.02	5.87	5.69	4.30	9.05	8.16	11.19	9.25	89.32
46 D	Big Tujunga Dam	7.71	6.53	3.33	5.33	4.79	5.14	5.78	5.13	9.70	11.26	12.40	9.55	86.65
63 C	Santa Anita Dam	4.80	4.05	2.99	3.58	1.92	3.03	2.71	2.90	5.28	5.33	7.46	6.18	50.23
89 B	San Dimas Dam	3.66	2.38	1.66	2.10	1.57	2.82	3.50	3.41	6.68	7.17	8.35	6.10	49.40
96 C	Puddingstone Dam	5.75	4.30	2.80	3.42	2.38	3..97	4.94	4.84	9.00	9.35	10.27	7.90	68.92
223 C	Big Dalton Dam	3.73	2.74	1.52	1.87	2.95	2.22	3.23	3.31	6.86	7.43	9.59	6.60	52.05
252 C	Castaic Reservoir	6.37	4.47	3.06	4.03	2.59	4.49	4.00	4.58	9.75	10.58	11.06	8.45	73.43
334 B	Cogswell Dam	4.09	2.76	1.50	1.60	1.39	2.47	3.26	3.92	7.55	9.00	8.86	6.30	52.70
390 B	Morris Dam	7.42	6.52	4.67	4.61	3.18	5.40	5.44	5.65	11.03	10.72	12.76	10.00	87.40
409 B	Pyramid Reservoir	6.07	3.59	2.93	3.39	6.20	3.93	5.25	5.74	10.63	10.32	10.44	8.40	76.89
425 B	San Gabriel Dam	6.75	5.15	3.73	4.49	2.53	4.51	4.75	4.63	9.07	8.53	11.07	9.27	74.48
1014 F	Rio Hondo S.G.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	8.25	6.13	INC.
1058 B	Palmdale	6.69	4.29	2.82	2.96	2.67	5.41	8.11	9.30	14.95	16.88	15.18	10.25	99.51
1071 B	Descanso Gardens	3.53	2.30	1.56	1.83	1.45	2.73	3.24	2.66	6.01	6.37	7.22	5.32	44.22

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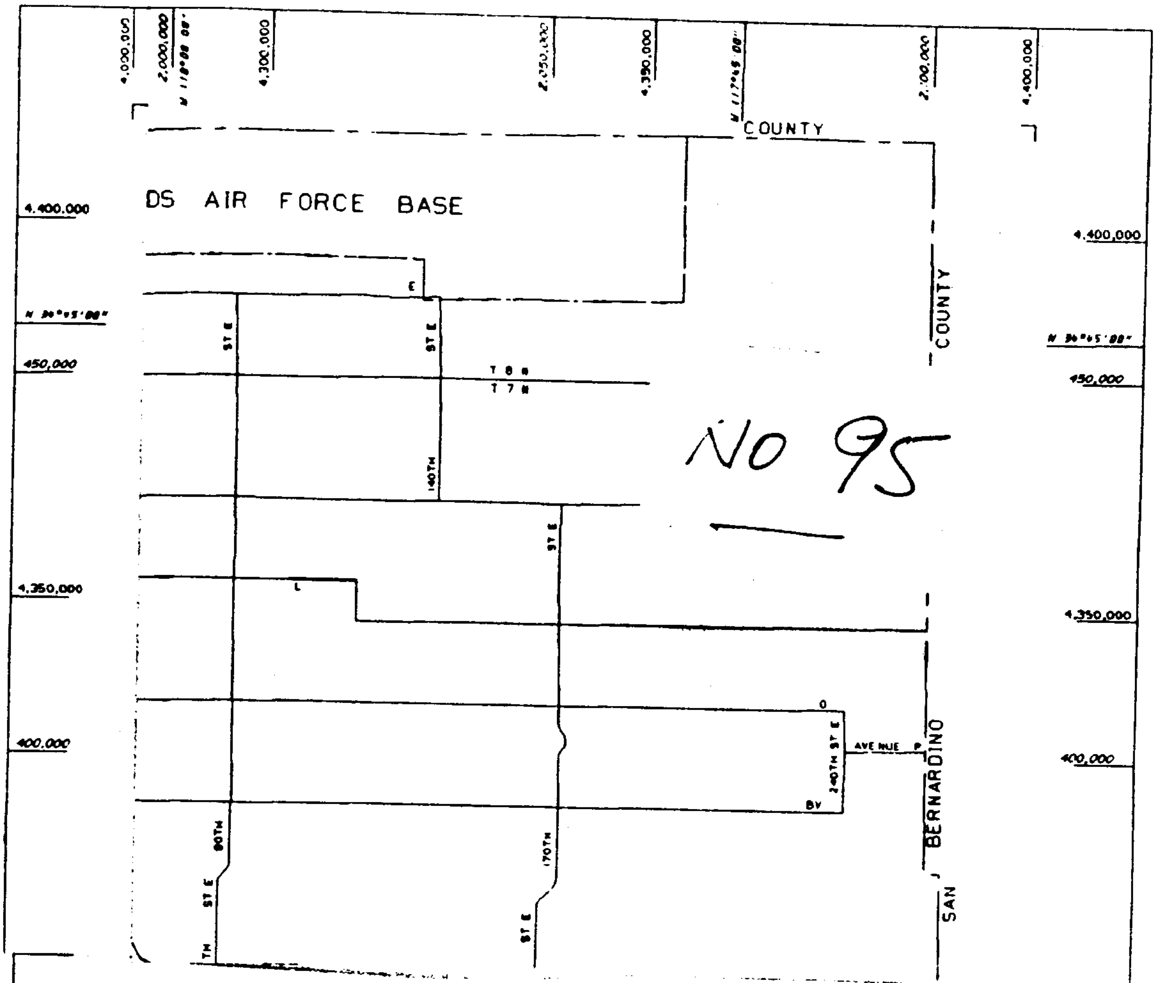

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MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

EVAPORATION STATIONS LOCATION

1994

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RUNOFF

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0306

RUNOFF

The Department operated 64 water-stage recording stations and 3 witness gages during the 1993-94 water year. Data from 40 of those stations are summarized and published in this volume.

RECORDS OF STREAMFLOW

Records published give the following information:

1. Station description which presents location, drainage area, type of channel, control, regulations, diversions, and available records.

2. Discharge tabulation which summarizes the maximum, minimum, and mean of the daily flow rates in second-feet for each month and the total monthly volumes in acre-feet.

ALERT SYSTEM (AUTOMATIC LOCAL EVALUATION IN REAL TIME)

The Department of Public Works has installed a state-of-the-art ALERT computer system to monitor meteorological conditions at 59 locations in the County. The system includes a network of field sensors that monitor precipitation amounts, river stages, and reservoir levels.

During the report period, the Department has continued to install and expand its ALERT System. The Department's ALERT system also receives rainfall, streamflow, and reservoir data from the Corps of Engineers' Los Angeles Telemetry System.

COOPERATION

The Department receives or has access to streamflow data from other agencies. Data from 5 of the Department's stations are published in the United States Geological Survey's annual water supply papers.

Agencies with which the Department exchanges data are:

United States Geological Survey, Water Resource Division
United States Corps of Engineers
State Department of Water Resources
The Metropolitan Water District
San Gabriel River Water Committee

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LEGEND

Stations are designated by letters and numbers which indicate ownership, operation agency, and type of station. The letters used have the following connotations:

Prefix F - Indicates a station owned and operated by the Los Angeles County Department of Public Works.

Prefix E - Indicates a station owned by the Corps of Engineers, Department of the Army, but operated and maintained by the United States Geological Survey.

Prefix U - Indicates a station originally constructed and operated by the United States Geological Survey, Water Resources Division, now operated by the Department.

Prefix P - Indicates a station owned and operated by the Department, formerly operated by the Pasadena Water Department.

Prefix L - Indicates a station owned and operated by the Department, formerly owned by Little Rock Water District.

Suffix R - Indicates a recorder station.

Suffix B - Indicates that the station has been moved. B represents second location, C a third location, etc.

INDEX OF STREAM GAGING STATIONS

STATION	NAME	THOMAS GUIDE PG.	ALERT NO.	REGU- LATED	DRAINAGE AREA *
L1-R	LITTLE ROCK CREEK ABOVE LITTLE ROCK DAM	J		NO	49.20
F2WG	BROWNS CREEK AT VARIEL AVENUE	6 / D-2		NO	13.50
U7-R	FISH CREEK ABOVE MOUTH OF CANYON	86 / B-2		NO	6.36
U8-R	SAN GABRIEL RIVER BELOW MORRIS DAM	86 / F-1	415	YES	212.40
AAS(015)	VALYERMO S.G.. BIG ROCK CK. D/S VALYERMO RD.	192/H-5			
F32B-R	THOMPSON CREEK BELOW THOMPSON CREEK DAM	96 / C-5	433	YES	3.70
F34D-R	LOS ANGELES RIVER BELOW FIRESTONE BLVD.	59 / E-3	315	YES	596.00
F37B-R	COMPTON CREEK NEAR GREENLEAF DRIVE	64 / F-4		NO	22.60
F38C-R	BALLONA CREEK ABOVE SAWTELLE BLVD.	50 / B-3	369	YES	88.60
F40-R	PUDDINGSTONE CREEK BELOW PUDDINSTONE DAM	89 / F-4	427	YES	33.20
F42B-R	SAN GABRIEL RIVER ABOVE SPRING STREET	76 / F-1	435	YES	231.00
F45B-R	RIO HONDO ABOVE STUART AND GRAY ROAD	59 / E-3	307	YES	140.00
F57C-R	LOS ANGELES RIVER ABOVE ARROYO SECO	35 / F-5		YES	511.00
F64-R	RIO HONDO ABOVE MISSION BRIDGE	47 / B-5		YES	115.00
F81D-R	ALHAMBRA WASH NEAR KLINGERMAN STREET	46 / F-2	347	NO	15.20
F82C-R	RUBIO WASH AT GLENDON WAY	38 / A-6	353	YES	10.90
F83	MISSION CREEK AT SAN GABRIEL BLVD.			YES	4.2
F92C-R	SANTA CLARA RIVER AT OLD ROAD BRIDGE	123 / G-7		YES	410.40
F93	SANTA CLARA RIVER AT LANG RAILROAD BRIDGE	125 / J-7		NO	157.30
F118B-R	PACOIMA CREEK FLUME BELOW PACOIMA DAM	3 / C-1	330	YES	28.20
F119C-R	SANTA ANITA CREEK BELOW SANTA ANITA DAM	20A / F-2	345	YES	10.80
F120B-R	BIG DALTON CREEK BELOW BIG DALTON DAM	87 / F-2	418	YES	4.80
F122-R	PALLETT CREEK AT VALYERMO HIGHWAY	199 / G-4		NO	15.80
F125-R	SANTIAGO CREEK ABOVE LITTLE ROCK CREEK	J		NO	11.20
F130-R	MALIBU CREEK BELOW COLD CREEK	107 / F-6		YES	104.96
F168-R	BIG TUJUNGA CREEK BELOW BIG TUJUNGA DAM	M / C-2	333	YES	82.30
F181-R	MONTEBELLO STORM DRAIN OUTLET TO RIO HONDO	54 / E-3		NO	9.60
F190-R	SAN GABRIEL RIVER AT FOOTHILL BLVD.	86 / A-5		YES	230.00
F192B-R	RIO HONDO BELOW LOWER AZUSA ROAD	38 / E-4		YES	40.90
F193B-R	SANTA ANITA WASH AT LONGDEN AVENUE	38 / F-1		YES	18.80
F194B-R	SAWPIT WASH BELOW LIVE OAK AVENUE	39 / A-2		YES	16.10
F209-R	SAN GABRIEL RIVER - W. FORK BELOW COGSWELL DAM	N / D-4	410	YES	41.00
F218-R	SAN DIMAS WASH BELOW PUDD. DIVERSION DAM	95A / C-5	424	YES	19.90
F220B-R	SAN GABRIEL - AZUSA CONDUIT 10FT WEIR BELOW DAM	P / A-5		YES	0.00
F250-R	SAN GABRIEL - AZUSA CONDUIT 25FT WEIR BELOW DAM	P / A-5		YES	202.70
F251-R	SAN GABRIEL W. FORK AT TOE OF COGSWELL DAM	N / D-4		YES	39.20
F252-R	VERDUGO WASH AT ESTELLE AVENUE	25 / B-3		YES	26.80
F260C-R	SANTA ANITA WASH BELOW FOOTHILL BLVD.	28 / E-3		YES	17.20
F261C-R	SAN GABRIEL RIVER BELOW VALLEY BLVD.	48 / A-2	351	YES	118.00
F262C-R	SAN GABRIEL RIVER ABOVE FLORENCE AVE.	60 / E-4		YES	215.80
F263C-R	SAN GABRIEL RIVER BELOW S.G. RIVER PKWY	55 / C-1		YES	206.30
F267WG	SIERRA MADRE WASH AT HIGHLAND OAKS AVENUE	28 / E-3		YES	3.80
F271-R	EATON WASH BELOW EATON WASH DAM	27 / F-1	342	YES	12.40
F274B-R	DALTON WASH AT MERCED AVENUE	48 / F-1		YES	35.95
F277-R	ARROYO SECO BELOW DEVIL'S GATE DAM	19 / D-5	336	YES	32.50
F278-R	SAWPIT CREEK BELOW SAWPIT DAM	29 / C-1	339	YES	3.30
F280-R	SANTA FE DIVERSION CHANNEL BELOW SANTA FE DAM	39 / D-2		YES	CONTROLLED
E285-R	BURBANK WESTERN STORM DRAIN AT RIVERSIDE DR.	24 / E-2		YES	25.00
F300-R	LOS ANGELES RIVER AT TUJUNGA AVE.	23 / D-4		YES	401.00

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INDEX OF STREAM GAGING STATIONS

STATION	NAME	THOMAS GUIDE PG.	ALERT NO.	REGU-LATED	DRAINAGE AREA *
F303-R	SAN DIMAS CREEK BELOW SAN DIMAS DAM	95A / C-3	421	YES	16.20
F304-R	WALNUT CREEK ABOVE PUENTE AVENUE	48 / D-1		YES	57.60
F305-R	PACOIMA DIVERSION AT BRANFORD STREET	9 / A-5		YES	48.80
F312B-R	SAN JOSE CHANNEL BELOW SEVENTH AVE.	47 / F-5	324	YES	83.40
F313B-R	RIO HONDO BYPASS CHANNEL ABOVE WHITTIER NAR.	47 / B-5		YES	CONTROLLED
F317-R	ARCADIA WASH BELOW GRAND AVENUE	38 / E-3	355	YES	8.50
F318-R	EATON WASH AT LOFTUS DRIVE	34 / C-6		YES	22.80
F319-R	LOS ANGELES RIVER BELOW WARDLOW RIVER RD.	70 / B-5	313	YES	815.00
F328-R	MINT CANYON CREEK AT FITCH AVENUE	125 / C-5		NO	26.90
F329-R	BRADBURY CHANNEL BELOW CENTRAL AVENUE	29 / F-5		YES	3.30
F338-R	RUBIO DIV. CHANNEL BEL. GOOSEBERRY CYN INLET	20 / C-4		YES	2.10
F342-R	BRANFORD STREET CHANNEL BELOW SHARP AVE.	9 / B-5		YES	5.01
F354-R	COYOTE CREEK BELOW SPRING STREET	76 / F-1	437	YES	185.00
F356-R	LIVE OAK CREEK BELOW LIVE OAK DAM	95A / F-6	430	YES	2.28
F377-R	BOUQUET CANYON CREEK AT URBANDALE AVENUE	124 / F-5		YES	51.90
F378WG	DOMINGUEZ CHANNEL BELOW WESTERN AVENUE	63 / F-5		NO	37.10
F393-R	LITTLE ROCK AT HIGHWAY 138	184 / D-6		YES	70.00
F394-R	BIG ROCK CREEK UPSTREAM FROM PALLETT CREEK	192 / J-4		NO	34.30
F395-R	MESCAL CREEK AT MOUTH	J		NO	5.71
G44B-R	SAN GABRIEL RIVER ABOVE WHITTIER NAR. DAM	47 / C-6		NO	

* NOTE: All drainage areas in square miles.

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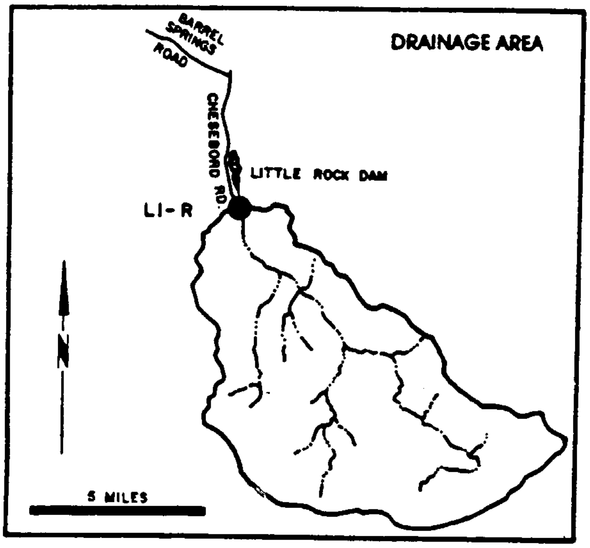
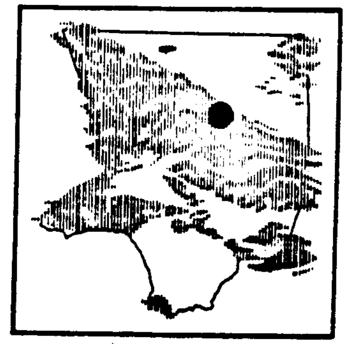
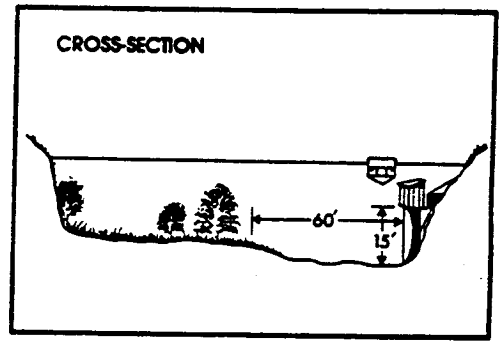
LITTLE ROCK CREEK
above Little Rock Dam
STATION NO. L1-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 49.2 square miles.
LOCATION- 2.0 miles above Little Rock Dam, 5.0 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel, and boulders, natural in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1930 to date.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO.: L1–R DRAINAGE AREA: 49.20 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	OUT	2.8	5.0	5.5	14.4	25.1	19.6	OUT	OUT	0.0	0.0	0.0
MAX.	OF	4.2	6.5	6.6	46.9	41.9	30.3	OF	OF	0.0	0.0	0.0
MIN.	SERVICE	1.3	3.9	4.8	6.6	17.3	9.4	SERVICE	SERVICE	0.0	0.0	0.0
TOTAL AF		164.0	306.0	341.0	801.0	1,544.0	1,165.0			0.0	0.0	0.0

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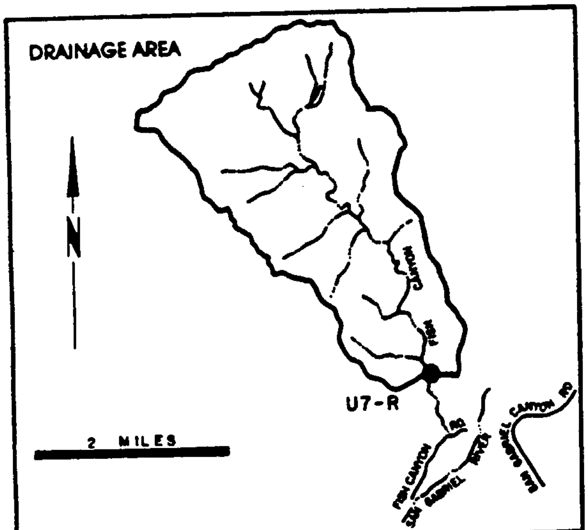
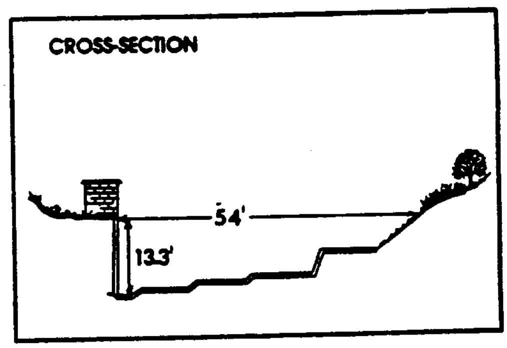
FISH CREEK
above Mouth of Canyon
STATION NO. U7-R





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0312

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 6.36 square miles.
LOCATION - 0.8 miles upstream of mouth of canyon and 3.0 miles northeast of Duarte.
REGULATION- none.
CHANNEL- natural, rock and gravel.
CONTROL- concrete control.
LENGTH OF RECORD- July to September 1916. July 1917 to date.
REMARKS- operated and maintained by USGS until October 1, 1971.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : U7–R

DRAINAGE AREA : 6.36 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.3	1.2	2.0	1.5	2.6	2.1	1.4	0.9	0.6	0.2	0.1	0.1
MAX	1.6	1.5	3.7	2.8	13.3	9.5	2.1	1.1	1.0	0.3	0.2	0.1
MIN	1.0	1.0	1.2	1.4	0 3	0.0	0.7	0.8	0.2	0.2	0.1	0.1
TOTAL AF	81.0	70.0	123.0	94 0	146 0	129 0	84 0	58 0	34.0	13 0	7.0	6.0

SAN GABRIEL RIVER
below Morris Dam
STATION NO.U8-R

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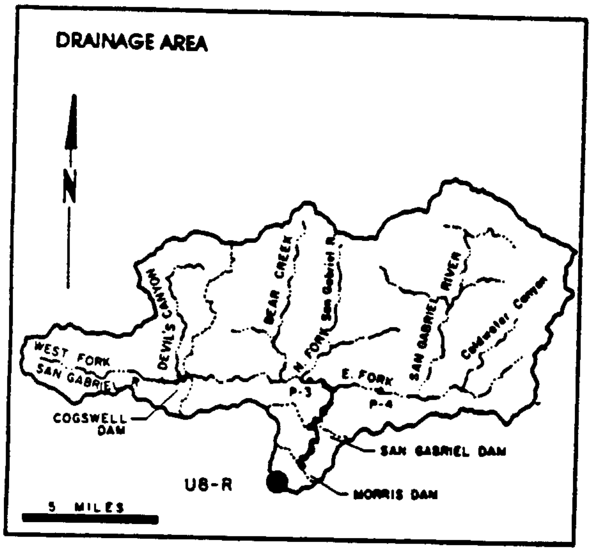

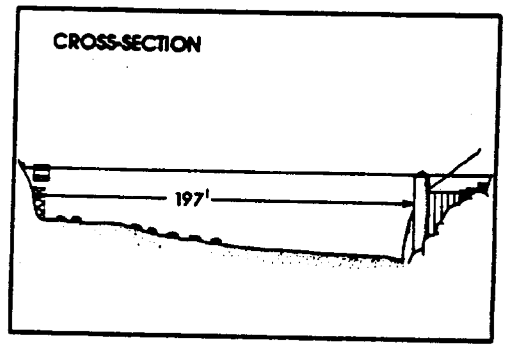

2 03/13

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 212.4 square miles.
LOCATION- 1.1 miles downstream of Morris Dam, 2.7 miles northeast of Azusa.
REGULATION- all flows regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- gravel and boulders, natural section.
CONTROL- concrete control.
LENGTH OF RECORD- May 1894 to date.
REMARKS- flows up to 90 cfs are at times diverted past the station through the Azusa Conduit; flows at station may include imported water from the MWD outlet below Morris Dam.

WATER YEAR 1993-1994
(DISCHARGE IN CFS)

STATION NO. : U8-R

DRAINAGE AREA : 212.40 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	172.0	47.7	32.6	4.2	19.3	0.7	69.0	226.0	105.0	6.3	6.1	0.7
MAX.	330.0	221.0	318.0	4.8	480.0	2.4	212.0	236.0	239.0	182.0	180.0	6.2
MIN	4.4	4.1	4.0	2.4	0.8	0.1	0.0	220.0	0.4	0.0	0.0	0.0
TOTAL AF	10,600.0	2,836.0	2,007.0	261.0	1,069.0	40.0	4,106.0	13,920.0	6,224.0	387.0	376.0	39.0

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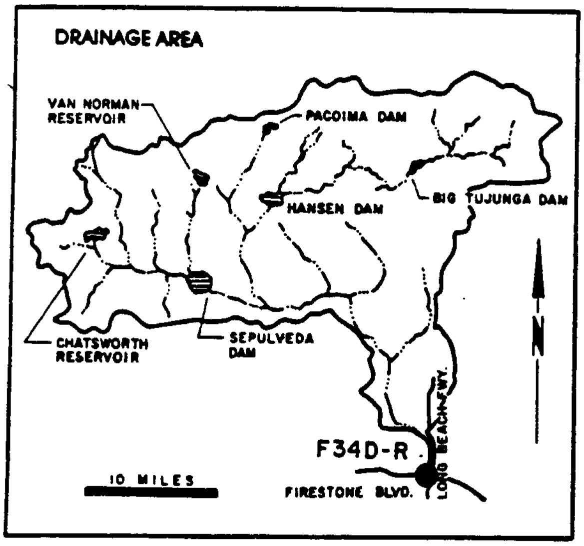
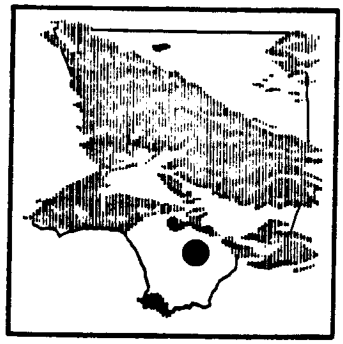
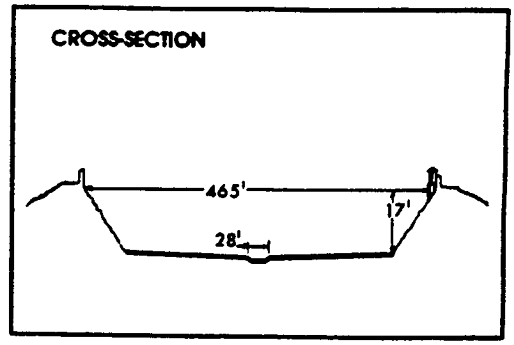
20314

LOS ANGELES RIVER
below Firestone Boulevard
STATION NO. F34D-R







RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from bridge.

DRAINAGE AREA- 596.0 square miles.

LOCATION- 472.0 feet downstream of Firestone Boulevard 3.0 miles west of Downey.

REGULATION- partially regulated by Sepulveda, Pacoima, Big Tujunga, Hansen, and Devil's Gate Dam; and by several spreading grounds, reservoirs, and debris basins.

CHANNEL- concrete, with rip-rap side slopes, trapezoidal in section, with trapezoidal low- flow channel.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F34-R March 1, 1928 to April 11, 1938. at Station F34B-R, April 11, 1938 to November 3, 1949. at Station F34C-R November 4, 1949, to December 11, 1956. at Station F34D-R December 11, 1956 to date.

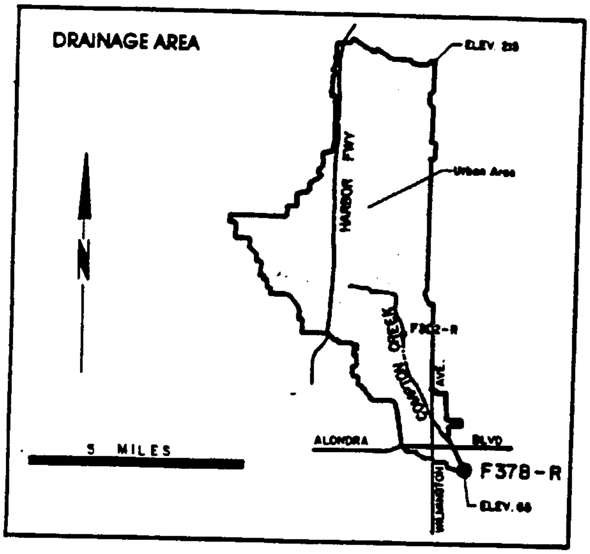
REMARKS- subject to diversions from Big Tujunga Creek, Arroyo Seco, and other domestic and irrigation diversions.

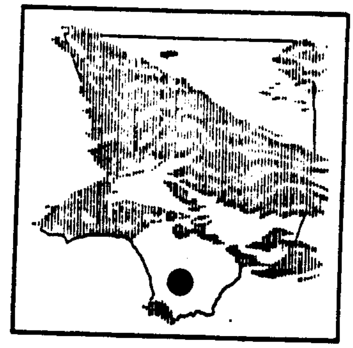
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

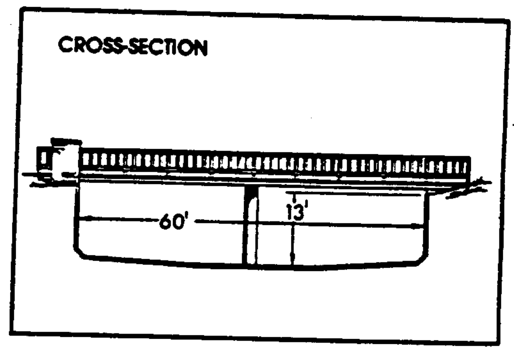
STATION NO. : F34D-R DRAINAGE AREA : 596.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	152.0	177.0	192.0	149.0	502.0	317.0	168.0	160.0	130.0	139.0	128.0	111.0
MAX.	442.0	1,200.0	1,720.0	727.0	3,870.0	2,800.0	451.0	219.0	150.0	147.0	136.0	120.0
MIN.	111.0	106.0	93.6	92.6	122.0	124.0	124.0	148.0	119.0	124.0	121.0	103.0
TOTAL AF	9,350.0	10,510.0	11,780.0	9,160.0	27,870.0	19,520.0	10,020.0	9,810.0	7,757.0	8,535.0	7,874.0	6,585.0

COMPTON CREEK
near Greenleaf Drive
STATION NO. F37B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 22.6 square miles.
LOCATION- 120.0 feet above Greenleaf Boulevard, 1.5 miles south west of Compton.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 60 feet wide by 13 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F37-R January 22, 1928 to June 9, 1938. at Station F37B-R October 3, 1938 to date

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F37B–R

DRAINAGE AREA : 22.60 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.7	7.8	5.3	2.3	34.3	14.1	3.6	1.3	0.7	0.9	1.1	0.9
MAX	15.0	143.0	57.1	40.2	290.0	219.0	55.8	6.1	0.9	0.9	1.5	0.9
MIN	0.6	0.7	0.2	0.5	0.6	0.8	0.6	0.8	0.5	0.9	0.8	0.7
TOTAL AF	104.0	463.0	327.0	143.0	1,903.0	866.0	212.0	83.0	41.0	55.0	66.0	51.0

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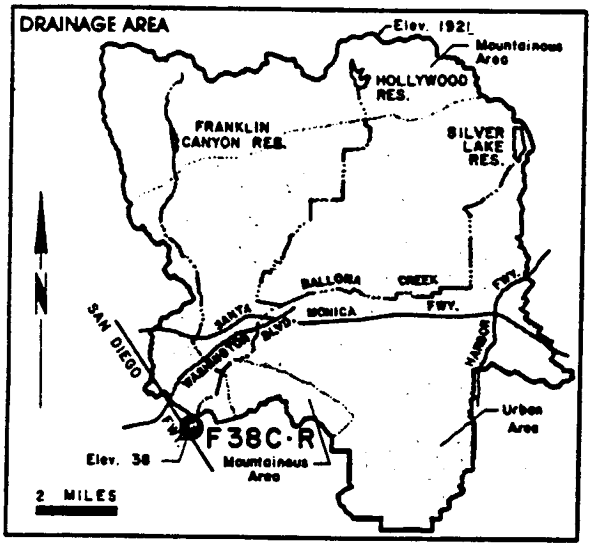
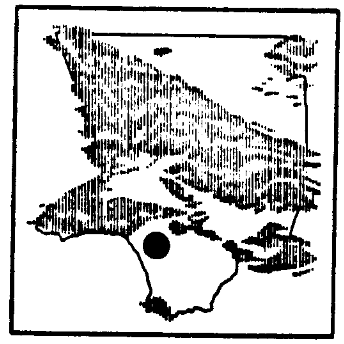
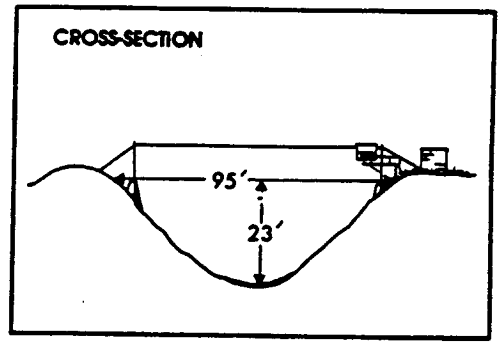
BALLONA CREEK
above Sawtelle Boulevard
STATION NO. F38C-R







VOL 12

2 03 16

RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 88.6 square miles.

LOCATION- 530.0 feet above Sawtelle Boulevard, 1.5 miles southwest of Culver City.

REGULATION- Stone Canyon Reservoir prior to January, 1951. Upper and Lower Franklin Canyon Reservoir, Hollywood Reservoir, and Silverlake Reservoir.

CHANNEL- concrete rubble, trapezoidal in section.

CONTROL- channel forms control.

LENGTH OF RECORD- at Station F38-R February 27,1928 to April 27, 1936. at Station F38B-R, May 14, 1936 to August 10, 1967. at Station F38C-R August 10, 1967, to date.

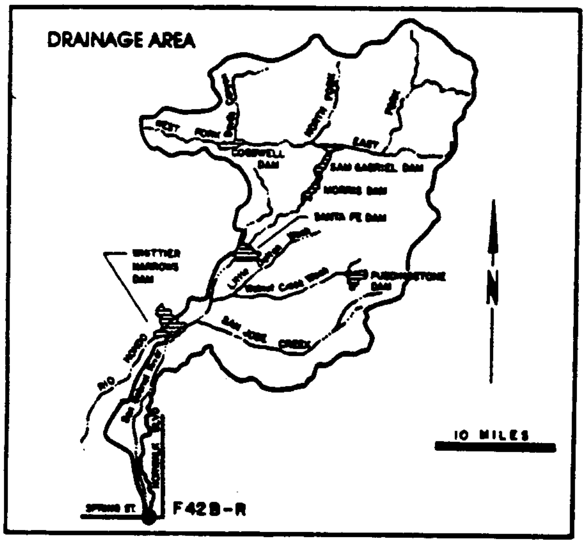
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

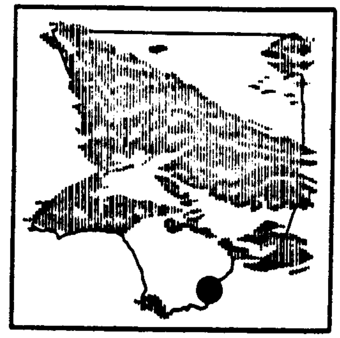
STATION NO. : F38C–R DRAINAGE AREA : 88.60 SQ. MI.

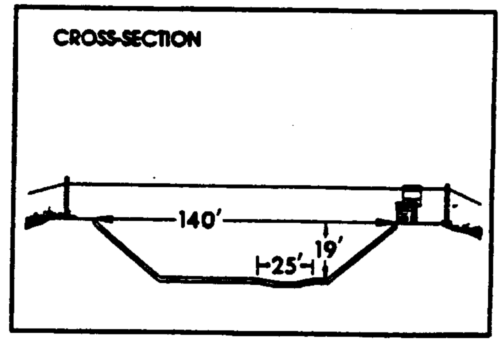
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	25.2	40.7	43.7	29.8	169.0	62.4	30.3	17.6	15.2	16.8	14.7	11.6
MAX.	149.0	531.0	450.0	229.0	1,450.0	771.0	365.0	59.1	17.5	21.7	18.4	13.8
MIN.	16.7	13.6	13.4	12.6	21.6	13.4	14.2	13.0	12.8	12.8	12.3	9.7
TOTAL AF	1,548.0	2,422.0	2,666.0	1,835.0	9,400.0	3,836.0	1,802.0	1,062.0	905.0	1,033.0	905.0	692.0

R0053621

SAN GABRIEL RIVER
above Spring Street
STATION NO. F42B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 231.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 455.0 feet north of Spring Street, 4.0 miles east of Signal Hill, Long Beach.
REGULATION- partially regulated by Cogswell, San Gabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek, and Whittier Narrows Dams, several debris basins, MWD outlet, and several spreading grounds.
CHANNEL- concrete, trapizoidal section with a low-flow channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F42-R February 6, 1928 to May 26, 1964. at Station F42B-R, November 16, 1964 to date.
REMARKS- high flows into Whittier Narrows Reservoir are partially diverted to the Rio Hondo.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO.: F42B–R   DRAINAGE AREA: 231.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	56.4	*	OUT	OUT	*115	78.7	66.3	81.0	84.1	*	OUT	OUT
MAX.	141.0	*	OF	OF	*270	159.0	123.0	99.2	106.0	*	OF	OF
MIN.	40.9	*	SERVICE	SERVICE	*83.6	28.6	24.3	24.1	34.5	*	SERVICE	SERVICE
TOTAL AF	3 467.0	*			*5939	4 836.0	3 947.0	4 981.0	5 002.0	*		

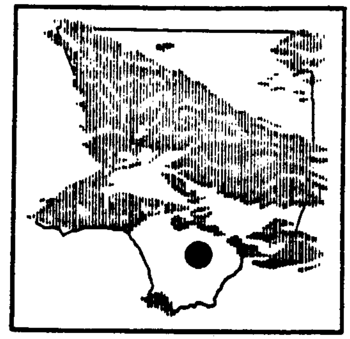
LEGEND * – Recorder malfunctioned during part of the month. Partial data is available

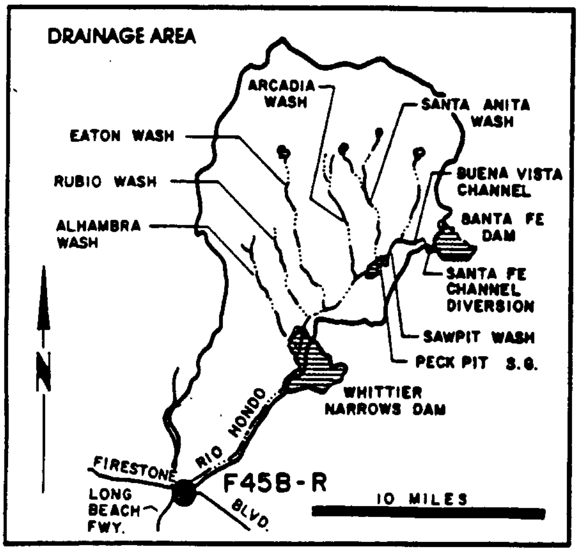
VOL 12

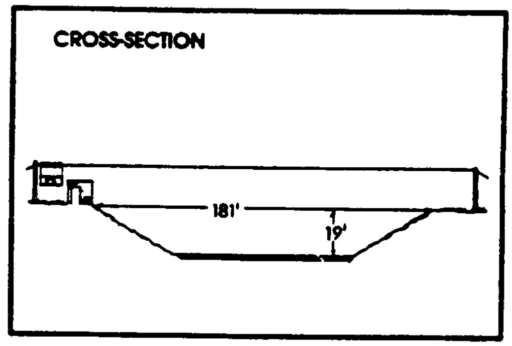
2 0317

R0053622

RIO HONDO
above Stewart and Gray Road
STATION NO. F45B-R







VOL 12

2 0 3 1 8

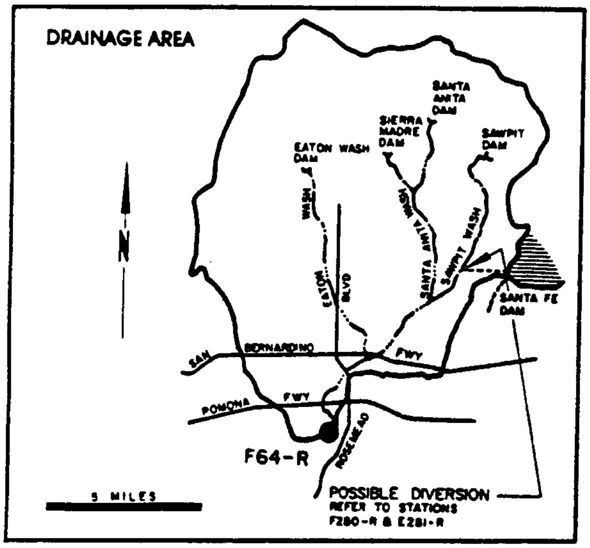
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 140 square miles (excludes area above Santa Fe Dam).
LOCATION- 0.6 mile upstream of the confluence of Rio Hondo and Los Angeles River, 1.5 miles west of Downey.
REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, Santa Fe, and Whittier Narrows Dams, several debris basins, and spreading grounds.
CHANNEL- concrete with rip-rap side slopes. trapizodal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F45-R March 1, 1928 to April 18, 1951. at Station F45B-R October 31, 1951 to date.
REMARKS- subject to diversions from Eaton Creek, Monrovia Creek, Sawpit Creek, Little Santo Anita Canyon and other locations for irrigation and spreading. High flows from San Gabriel River may flow into Rio Hondo above Whittier Narrows Dam.

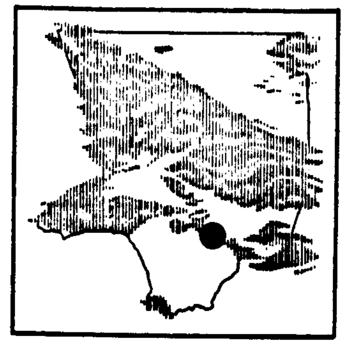
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

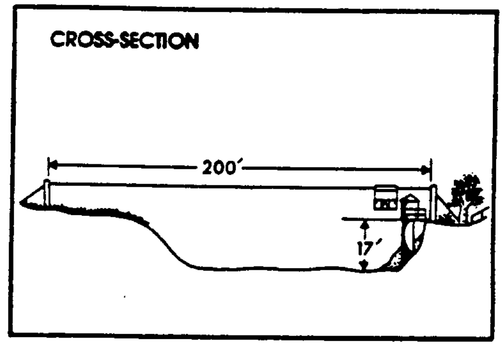
STATION NO. : F45B–R DRAINAGE AREA : 140.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.4	10.5	3.8	1.4	22.5	24.3	3.4	1.3	0.6	10.0	32.2	9.9
MAX.	3.2	167.0	46.9	25.8	179.0	260.0	54.9	12.7	1.4	36.8	45.9	30.0
MIN	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	1.3	0.4
TOTAL AF	27.0	625.0	233.0	88.0	1,252.0	1,496.0	20[illegible].0	79.0	35.0	612.0	1,980.0	590.0

RIO HONDO
above Mission Bridge
STATION NO. F64-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 115 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,000 feet above San Gabriel Boulevard, west of Rosemead Boulevard, 2.0 miles northeast of Montebello.
REGULATION- partially regulated by Sierra Madre, Santa Anita, Sawpit, Eaton, and Santa Fe Dams and several debris basins.
CHANNEL- sand and silt, natural in section.
CONTROL- none.
LENGTH OF RECORD- July 1, 1928 to date.
REMARKS- subject to diversions; water purchased from the MWD passes this station for spreading in the coastal basin.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F64–R DRAINAGE AREA : 115.00 SQ. MI.

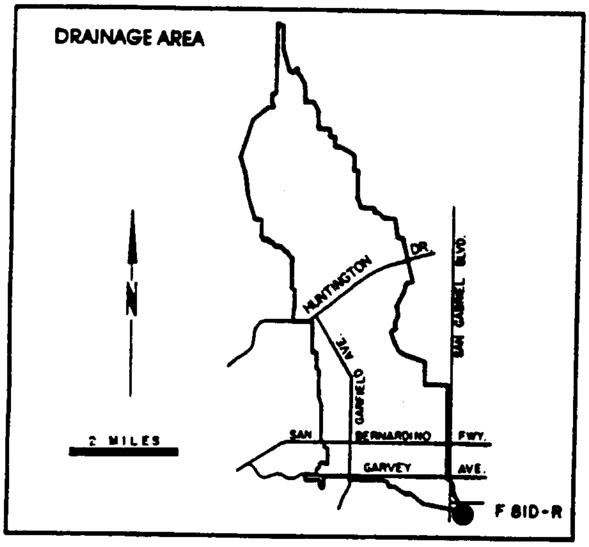
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	4.7	20.3	35.2	15.5	*	*	*	18.7	20.7	16.0	4.7	5.8
MAX.	10.0	171.0	482.0	182.0	*	*	*	38.9	29.9	25.6	7.5	23.8
MIN.	0.0	0.0	5.2	5.8	*	*	*	12.7	11.8	9.2	3.4	2.2
TOTAL AF	287.0	1,209.0	2,167.0	953.0	*	*	*	1,152.0	1,234.0	981.0	290.0	347.0

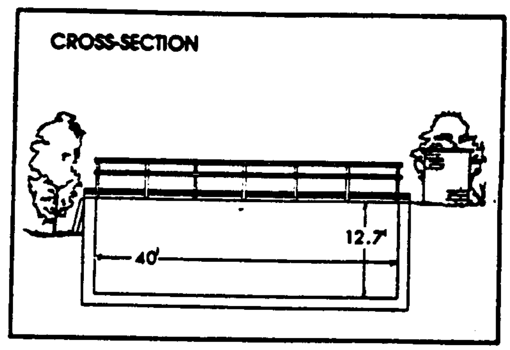
LEGEND * – Data inaccurate due to back water condition.

VOL 12 2 03/9

R0053624

ALHAMBRA WASH
near Klingerman Street
STATION NO. F81D-R





VOL 12 2

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 15.2 square miles.
LOCATION- 250± feet above Klingerman Street and 2,650.0 feet below Garvey Avenue, South San Gabriel.
REGULATION- none.
CHANNEL- concrete, rectangular in section, 40.0 feet wide by 12.7 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F81-R January 14, 1930 to September 30, 1934. at Station F81B-R October 1, 1934 to February 25, 1935. at Station F81C-R February 25, 1935 to April 27, 1936. at Station F81B-R April 27, 1936 to May 22, 1936. at Station F81D-R September 2, 1936 to date.

2

0320

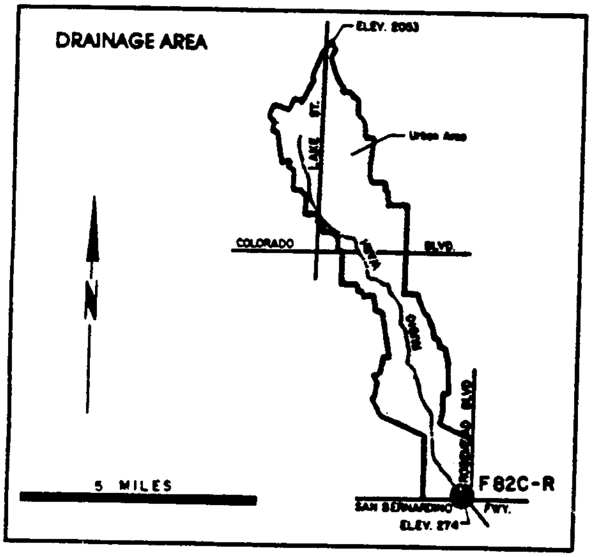
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

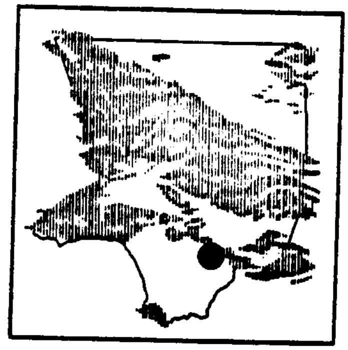
STATION NO.: F81D-R DRAINAGE AREA: 15.20 SQ. MI.

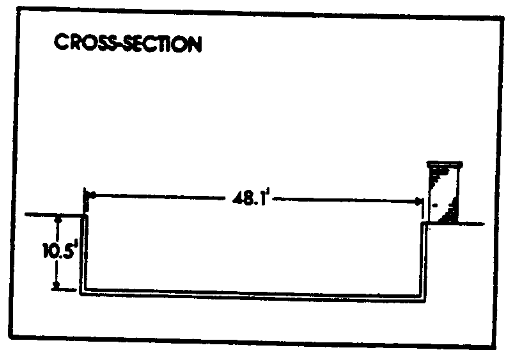
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	2.7	6.9	8.5	5.1	31.2	17.3	5.0	2.3	2.4	2.0	2.1	2.1
MAX	15.2	69.8	97.1	73.9	233.0	260.0	52.8	10.0	6.3	2.1	2.1	2.1
MIN	2.0	2.4	1.3	1.7	0.5	1.4	1.2	1.2	1.6	1.8	2.1	2.1
TOTAL AF	165.0	410.0	524.0	312.0	1,731.0	1,063.0	297.0	143.0	140.0	120.0	129.0	125.0

R0053625

RUBIO WASH
at Glendon Wash
STATION NO. F82C-R







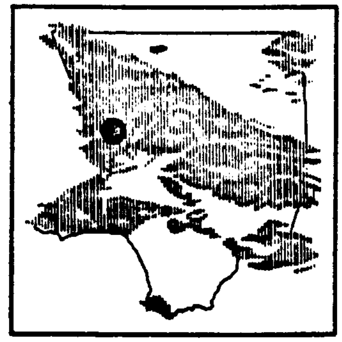
RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge at station.
DRAINAGE AREA- 10.9 square miles.
LOCATION- on the east side of channel, 10 feet south of the westerly extension of Glendon Way, Rosemead.
REGULATION- flow partly regulated by Las Flores and Rubio debris basins.
CHANNEL- rectangular concrete.
CONTROL- channel forms control.
LENGTH OF RECORD- see station summary.

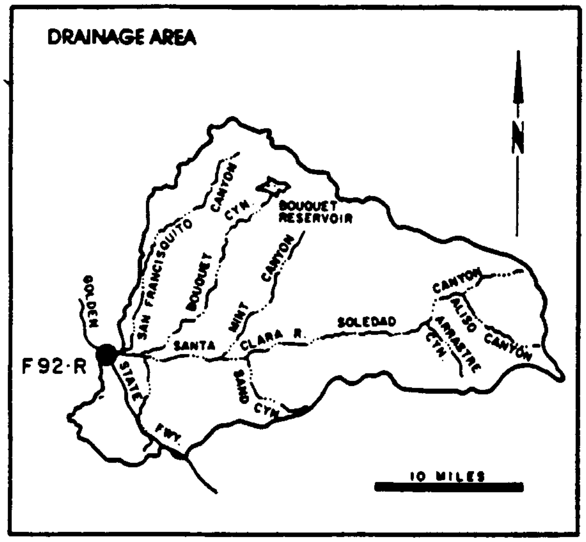
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

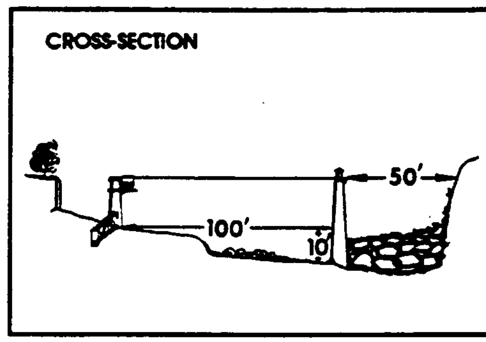
STATION NO. : F82C–R DRAINAGE AREA : 10.90 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.3	2.1	3.2	1.5	10.7	6.2	2.4	1.0	0.5	0.0	0.0	0.0
MAX.	4.4	32.7	50.8	34.4	98.2	105.0	20.8	9.7	2.6	0.0	0.1	0.1
MIN	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0
TOTAL AF	18.0	122.0	198.0	92.0	592.0	383.0	141.0	62.0	30.0	0.0	0.0	1.0

SANTA CLARA RIVER
below Highway 5
STATION NO. F92C–R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 410.4 square miles.
LOCATION- downstream side of Old Highway bridge, 3.0 miles west of Saugus.
REGULATION- partially regulated by Bouquet Canyon and Dry Canyon Reservoirs.
CHANNEL- sand and gravel with brush, natural section.
CONTROL- none.
LENGTH OF RECORD- at Station F92-R January 18, 1930 to March 28, 1938, and September 24, 1956 to date. at Station F92B-R, October 1, 1938 to September 24, 1956.
REMARKS- subject to diversions for irrigation.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F92C–R DRAINAGE AREA : 410.40 SQ. MI.

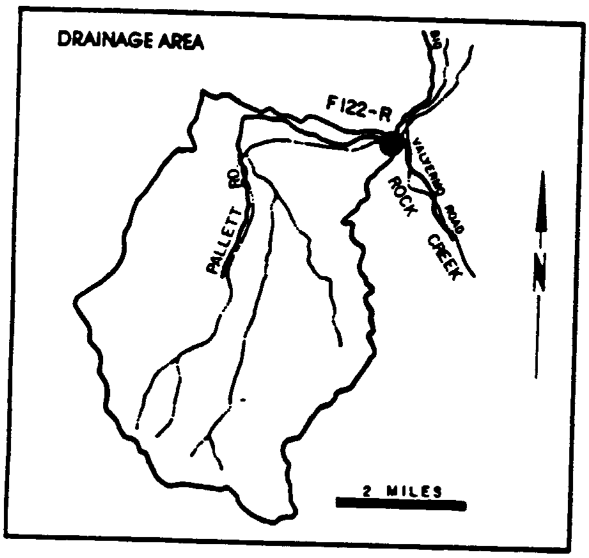
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	OUT	86.2	147.0	OUT	30.0	17.6	9.1	11.4	19.8	13.5	9.7	9.3
MAX	OF	1,150.0	233.0	OF	171.0	32.5	12.0	23.1	23.4	15.0	13.6	11.0
MIN	SERVICE	29.9	29.5	SERVICE	11.0	5.9	6.0	7.1	18.1	11.4	6.6	7.9
TOTAL AF		5,130.0	9,037.0		1,664.0	1,080.0	540.0	702.0	1,176.0	828.0	599.0	556.0

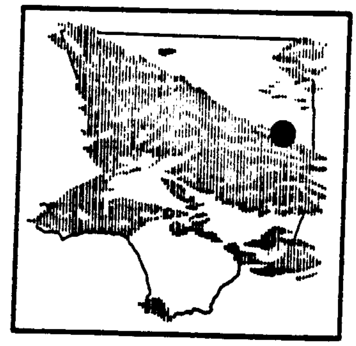
VOL 12

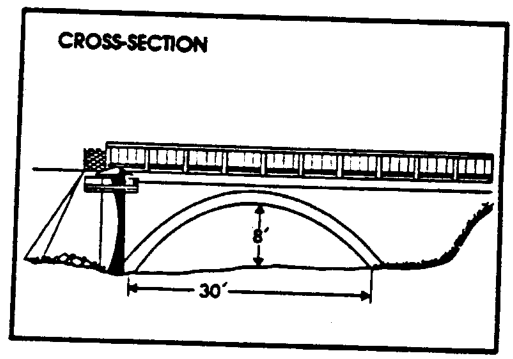
2 03222

R0053627

PALLETT CREEK
at Valyermo Highway
STATION NO. F122-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 15.8 square miles.
LOCATION- upstream side of Valyermo Highway bridge, 5.0 miles southeast of Pearblossom.
REGULATION- none.
CHANNEL- sand and gravel, natural section.
CONTROL- channel forms control for low flows; bridge culvert forms control for high flows.
LENGTH OF RECORD- at Station F122-S December 29, 1930 to October 31, 1961. at Station F122-R, October 31, 1961 to date.

VOL 12 2 03233

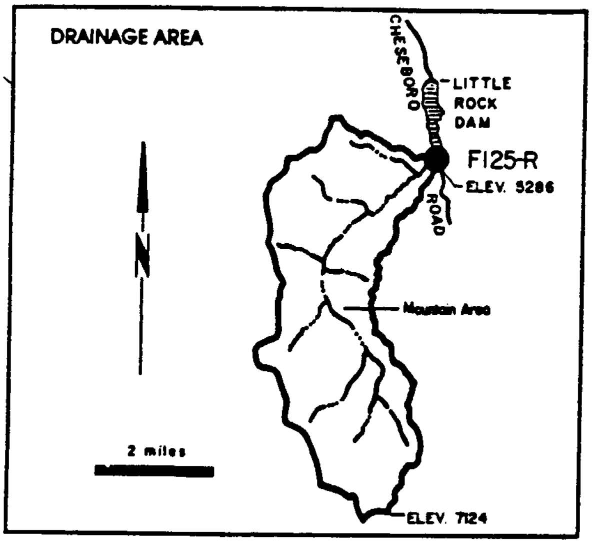
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

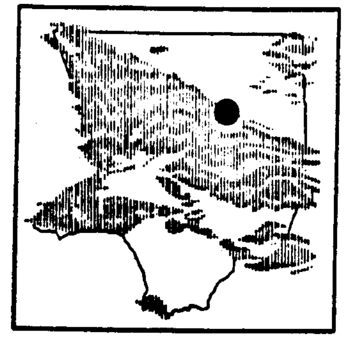
STATION NO. : F122-R

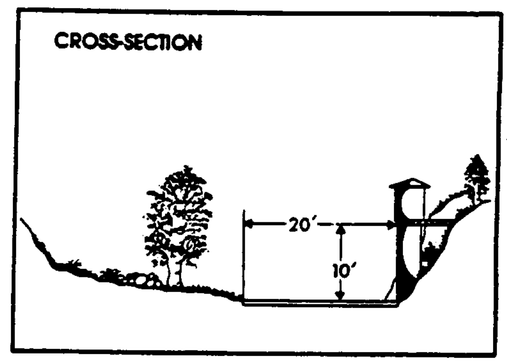
DRAINAGE AREA : 15.8 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.8	1.5	1.4	1.2	1.4	1.2	OUT	0.5	0.6	0.5	0.3	0.2
MAX	2.0	1.7	1.5	1.5	1.5	1.3	OF	0.6	0.6	0.6	0.4	0.3
MIN	1.4	1.2	1.3	1.1	1.2	1.1	SERVICE	0.5	0.5	0.3	0.3	0.2
TOTAL AF	111.0	88.0	88.0	77.0	78.0	74.0		32.0	34.0	29.0	20.0	12.0

SANTIAGO CREEK
above Little Rock Creek
STATION NO. F125-R







VOL 12 2 03224

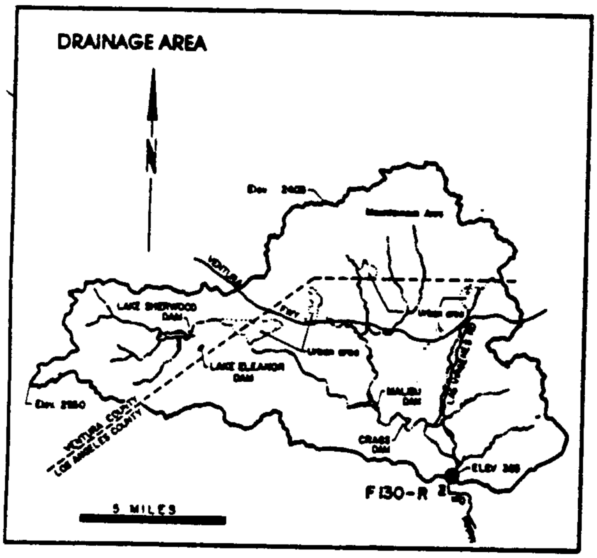
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 11.2 square miles.
LOCATION- 1,000 feet above Little Creek and 4.5 miles south of Little Rock.
REGULATION- none.
CHANNEL- sand, gravel and boulders.
CONTROL- concrete and rubble wall.
LENGTH OF RECORD- September 29, 1953 to date.
REMARKS- no high flow measurements.

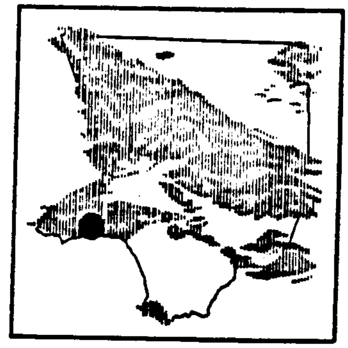
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

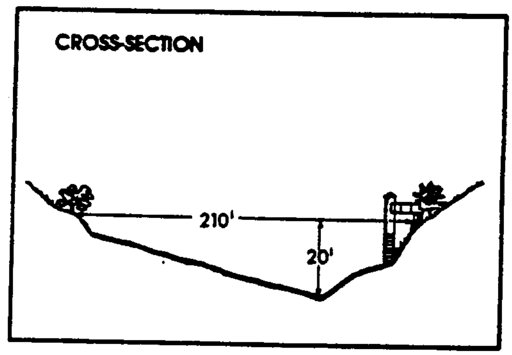
STATION NO. : F125–R DRAINAGE AREA : 11.20 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.1	0.2	0.7	0.3	1.0	1.2	0.5	0.1	0.0	0.0	0.0	0.0
MAX.	0.2	0.4	1.2	0.6	1.5	1.5	1.5	0.2	0.0	0.0	0.0	0.0
MIN.	0.1	0.1	0.5	0.2	0.5	0.7	0.1	0.0	0.0	0.0	0.0	0.0
TOTAL AF	6.0	10.0	45.0	19.0	57.0	73.0	31.0	6.0	0.0	0.0	0.0	0.0

MALIBU CREEK
below Cold Creek
STATION NO. F130B-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 104.96 square miles
LOCATION- 0.2± mile downstream of Cold Creek, 6.0 miles southwest of Calabasas.
REGULATION- Lake Sherwood Dam, Lake Eleanor Dam, Malibu Lake Dam, and Crag's Dam. Other small recreational dams affect low summer flows.
CHANNEL- coarse sand and gravel, lined with trees and brush, natural in section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- January 17, 1931 to date.
REMARKS- cableway washed out on January 25, 1969; no high flow measurements since that date.

WATER YEAR 1993-1994
(DISCHARGE IN CFS)

STATION NO.: F130-R

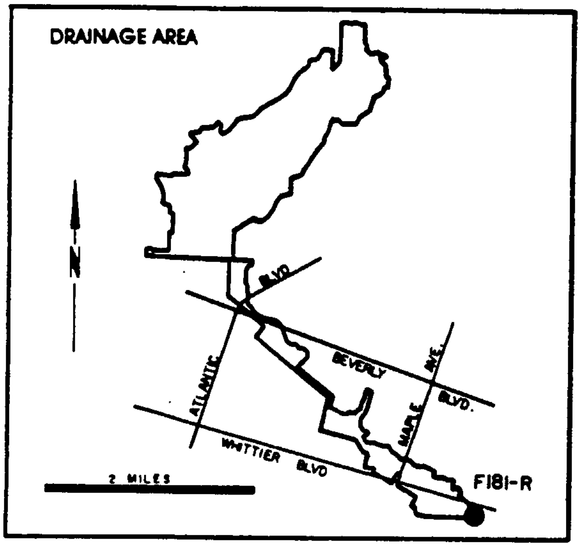
DRAINAGE AREA: 104.96 SQ. MI.

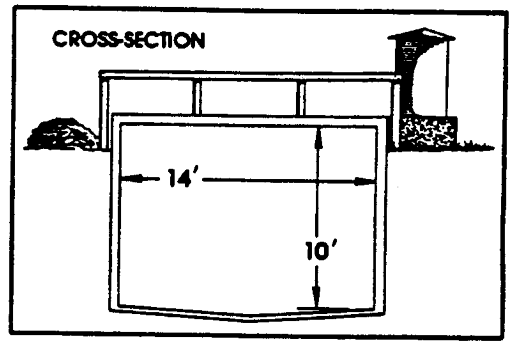
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	5.1	7.4	15.5	10.3	79.7	40.4	11.2	5.4	3.7	5.7	4.4	OUT
MAX.	5.3	14.3	53.4	21.7	880.0	191.0	17.3	8.6	7.2	7.4	6.4	OF
MIN.	5.1	5.0	7.9	6.3	8.1	16.7	6.9	1.5	0.9	4.8	3.4	SERVICE
TOTAL AF	315.0	443.0	952.0	633.0	4,428.0	2,483.0	665.0	332.0	222.0	350.0	270.0	

VOL 12

20325

MONTEBELLO STORM DRAIN
above Rio Hondo
STATION NO. F181-R





VOL 12

2 03226

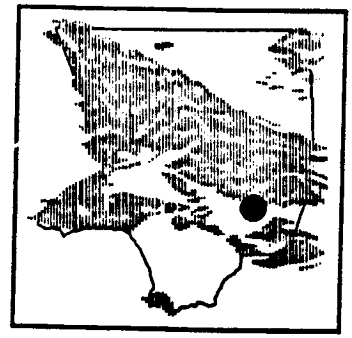
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 9.6 square miles.
LOCATION- 150.0 feet east of Mines Avenue and 500.0 feet west of Rio Hondo.
REGULATION- none.
CHANNEL- 14.0-foot by 10.0-foot concrete, box section.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1932 to date.
REMARKS- may be affected by backwater during flood flows.

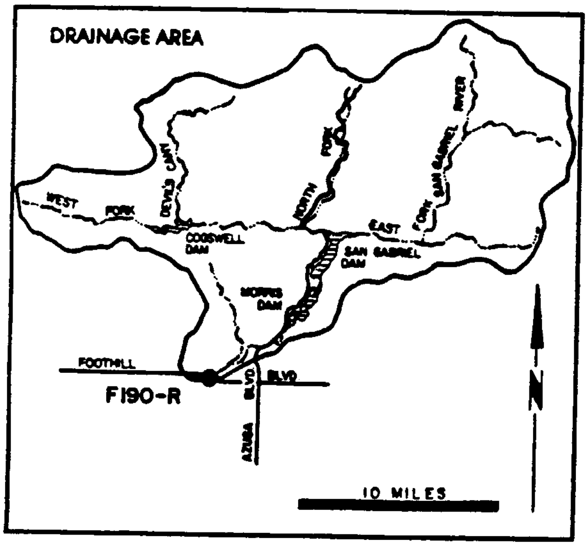
WATER YEAR 1993-1994
(DISCHARGE IN CFS)

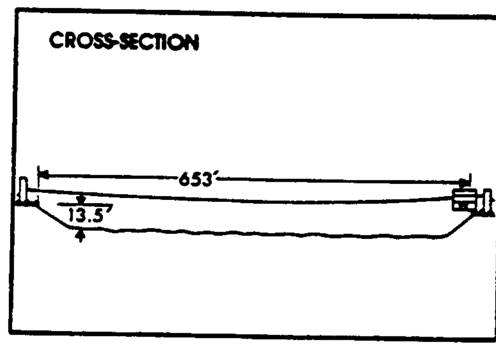
STATION NO. : F181-R DRAINAGE AREA : 9.60 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.2	0.6	0.7	0.4	3.1	2.4	0.5	0.2	0.3	0.3	0.2	0.3
MAX.	0.6	9.5	9.8	7.7	24.9	47.7	9.4	2.8	0.5	0.4	0.4	0.5
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2
TOTAL AF	10.0	34.0	44.0	22.0	173.0	147.0	28.0	13.0	20.0	18.0	12.0	17.0

SAN GABRIEL RIVER
at Foothill Boulevard
STATION NO. F190-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 230.0 square miles.
LOCATION- downstream side of Foothill Boulevard bridge, 2.0 miles west of Azusa.
REGULATION- partially regulated by Cogswell, San Gabriel, and Morris Dams.
CHANNEL- sand, gravel and rock,trapezoidal section with soft bottom.
CONTROL- gunited rock stabilizers.
LENGTH OF RECORD- February 22, 1932 to date.
REMARKS- flows may include imported water originating at the Metropolitan Water District outlet below Morris Dam.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F190–R

DRAINAGE AREA : 230.00 SQ. MI.

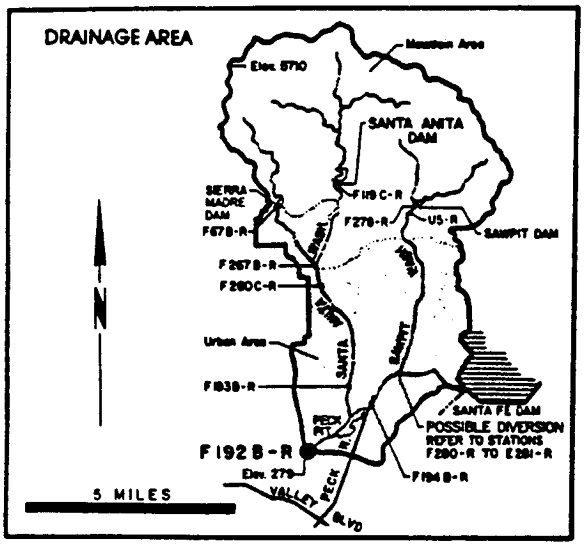
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	156.0	44.2	26.8	3.4	19.9	0.9	78.2	212.0	85.6	4.6	6.4	0.0
MAX.	314.0	243.0	268.0	7.4	393.0	3.6	225.0	223.0	254.0	141.0	196.0	0.0
MIN.	1.0	0.0	0.0	1.5	1.9	0.0	0.0	187.0	0.0	0.0	0.0	0.0
TOTAL AF	9,582.0	2,630.0	1,649.0	208.0	1,104.0	58.0	4,651.0	13,010.0	5,092.0	286.0	394.0	0.0

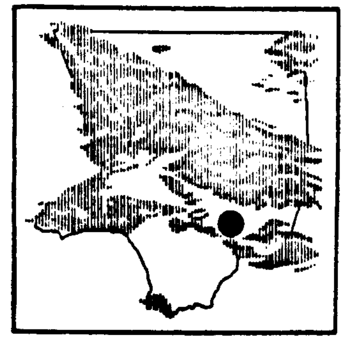
VOL 12

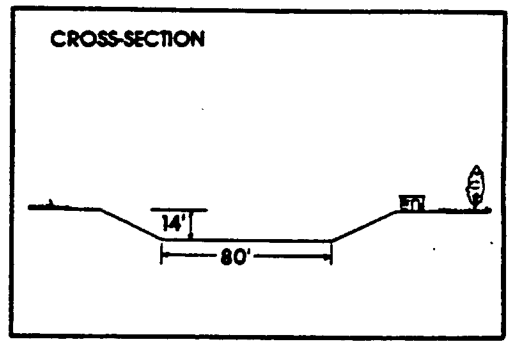
2 0327

R0053632

RIO HONDO
below Lower Azusa Road
STATION NO. F192B-R







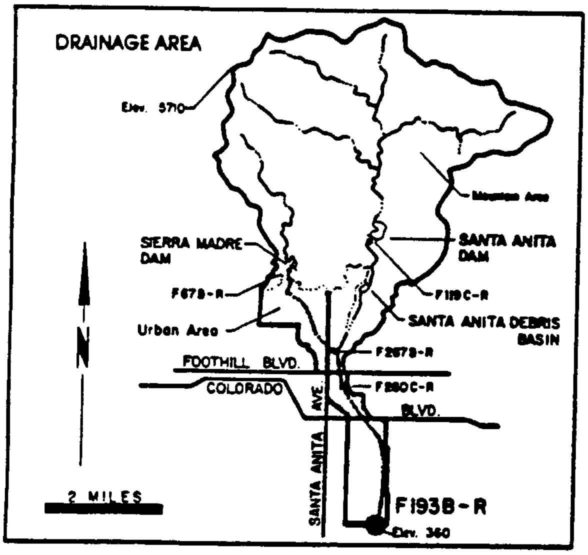
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 40.9 square miles (excludes area above Santa Fe Dam).
LOCATION- 300.0 feet downstream from Lower Azusa Road, 1.5 miles north of El Monte.
REGULATION- partially regulated by Sierra Madre Dam, Santa Anita Dam, Sawpit Dam, Santa Fe Dam, Peck Pit, Buena Vista Pit, and several debris basins.
CHANNEL- concrete, trapizoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F192-R February 22, 1932 to May 7, 1958. at Station F192B-R May 7, 1958 to date.
REMARKS- subject to diversions from Monrovia, Sawpit, and Little Santa Anita Creeks. Also from the San Gabriel River below Santa Fe Dam; and for irrigation and spreading.

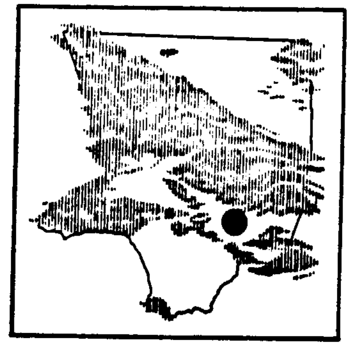
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

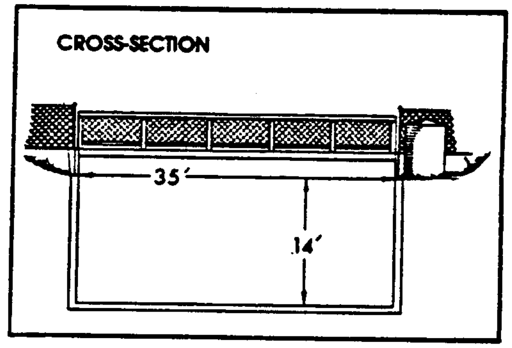
STATION NO.: F192B–R　　　DRAINAGE AREA: 40.90 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.2	7.6	12.0	0.4	7.5	1.4	0.3	0.1	0.0	0.0	0.0	0.0
MAX	0.4	47.0	43.1	7.3	31.5	23.3	2.8	1.1	0.0	0.1	0.0	0.1
MIN	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AF	14.0	451.0	738.0	23.0	417.0	87.0	16.0	3.0	0.0	0.0	0.0	0.0

SANTA ANITA WASH
at Longden Avenue
STATION NO. F193B-R







RECORDER - continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 18.8 square miles.
LOCATION - 30.0 feet above Longden Avenue, 1.5 miles south of Arcadia.
REGULATION - regulated by Santa Anita and Sierra Madre Dams, and Santa Anita Debris Basin.
CHANNEL - concrete rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F193-R, April 25, 1932 to March 1, 1938. at Station F193B-R, January 5, 1960 to date.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F193B–R DRAINAGE AREA : 18.80 SQ. MI.

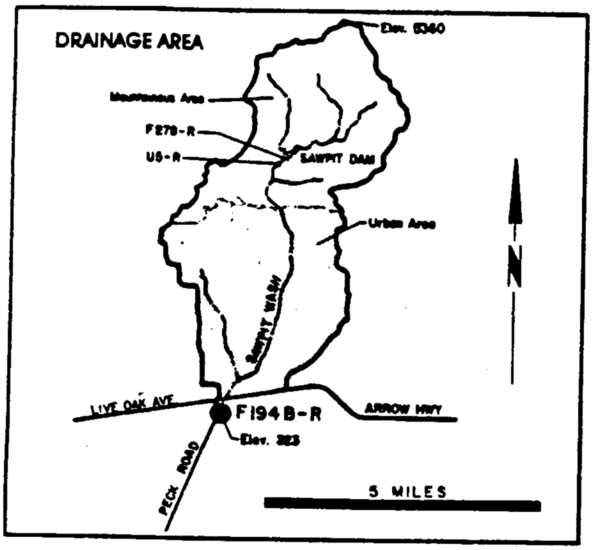
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.2	0.8	12.1	1.9	4.1	2.5	2.1	0.5	0.0	0.0	0.3	1.3
MAX.	2.6	7.8	354.0	14.5	29.3	19.1	28.4	7.9	0.1	0.1	1.2	2.5
MIN	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
TOTAL AF	75.0	48.0	747.0	116.0	227.0	154.0	124.0	28.0	1.0	2.0	20.0	80.0

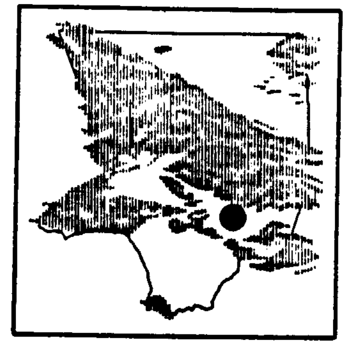
VOL 12

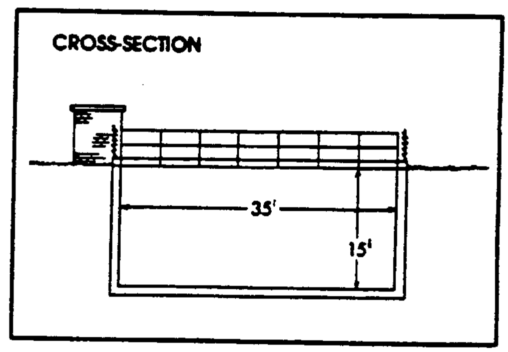
2 03229

R0053634

SAWPIT WASH
below Live Oak Avenue
STATION NO. F194B-R







VOL 12

2 0330

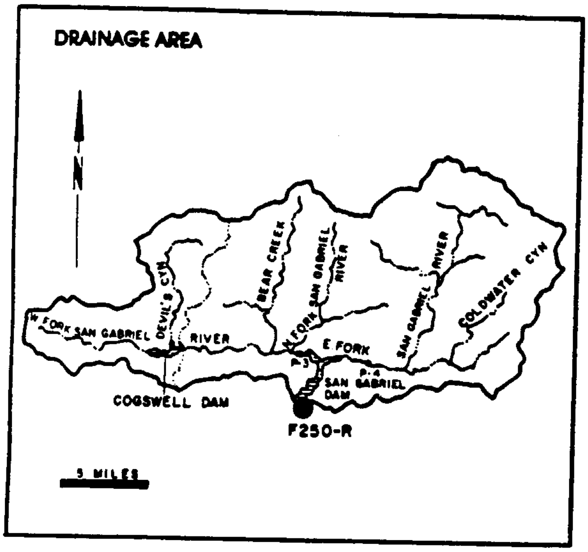
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 16.1 square miles.
LOCATION- 1,500 feet below Arrow Highway, 3.0 miles south of Monrovia.
REGULATION- partially regulated by Sawpit and Santa Fe Dams, and by several debris basins.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F194-R February 22, 1932 to September 1, 1935. at Station F194B-R December 5, 1960 to date.

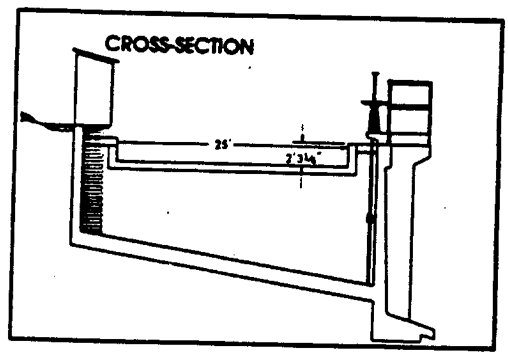
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO.: F194B–R DRAINAGE AREA: 16.10 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.0	13.8	8.4	1.2	10.4	5.2	2.5	0.4	0.1	0.6	1.3	0.1
MAX.	2.4	66.7	62.2	22.5	54.7	72.2	36.6	5.0	0.2	15.5	37.5	0.2
MIN	0.1	0.1	0.1	0.1	1.6	0.0	0.0	0.0	0.0	0.0	0.1	0.1
TOTAL AF	60.0	820.0	518.0	75.0	576.0	319.0	150.0	23.0	5.0	36.0	83.0	7.0

SAN GABRIEL-AZUSA CONDUIT
at 25 ft. Weir below San Gabriel Dam
STATION NO. F250-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- weir formula with gage height observation.
DRAINAGE AREA- none.
LOCATION- on the concrete conduit which diverts from San Gabriel Dam, 160 feet below the Dam.
REGULATION- regulated in section.
CONTROL- 25-foot concrete weir.
LENGTH OF RECORD- February 26, 1933, to date.
REMARKS- approximate capacity 95 second-feet.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F250–R

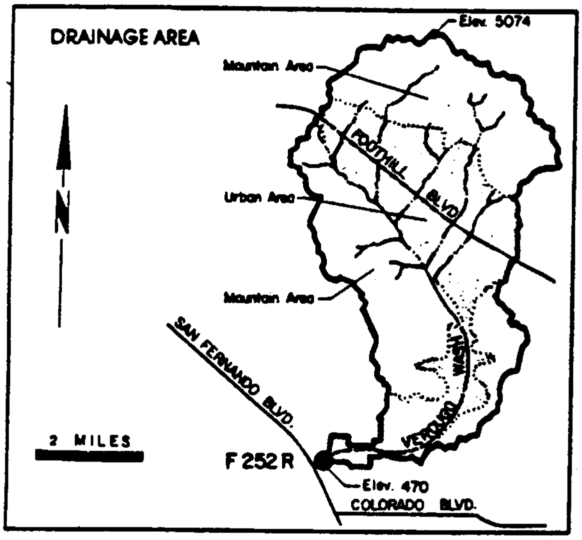
DRAINAGE AREA : NONE SQ. MI.

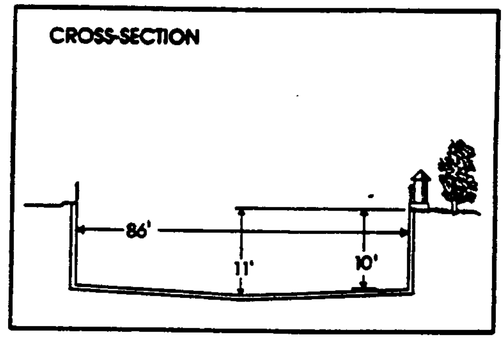
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	71.5	56.3	51.2	51.6	37.6	54.2	42.5	46.6	80.3	80.2	78.1	49.5
MAX.	82.2	72.0	52.3	52.4	52.3	70.2	47.7	47.0	81.7	80.8	80.9	76.0
MIN.	48.6	49.9	49.2	50.4	35.4	36.1	0.0	45.9	69.7	79.0	74.6	36.2
TOTAL AF	4 396.0	3 348.0	3 150.0	3 174.0	2 090.0	3 334.0	2 528.0	2 867.0	4 781.0	4 930.0	4 801.0	2 946.0

R0053636

VOL 12
20331

VERDUGO WASH
at Estelle Avenue
STATION NO. F252-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from Concord Street Bridge.
DRAINAGE AREA- 26.8 square miles.
LOCATION- 800.0 feet east of San Fernando Road, 2.0 miles northwest of Glendale.
REGULATION- partially regulated by several debris basins.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- December 2, 1935 to date.

VOL 12

2 0332

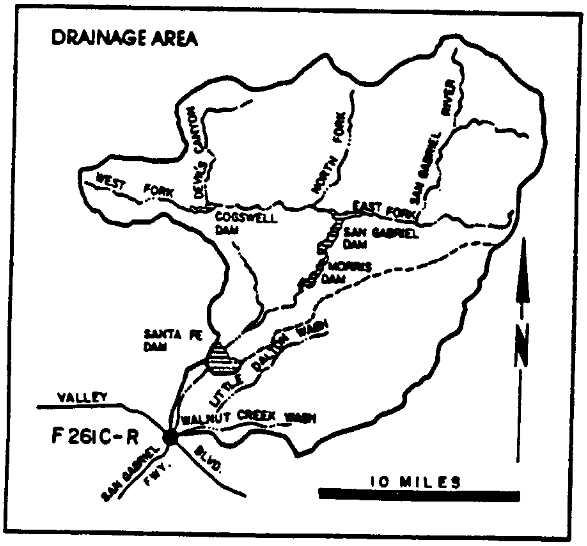
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

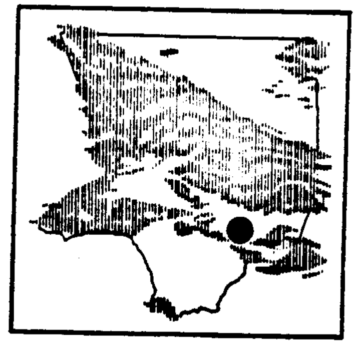
STATION NO. : F252–R DRAINAGE AREA : 26.80 SQ. MI.

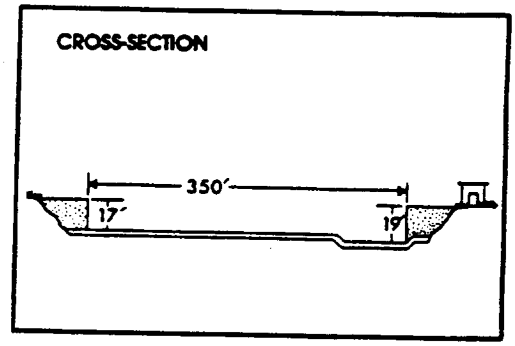
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	2.4	10.4	10.8	7.8	34.1	27.8	9.1	9.9	12.7	1.1	0.5	0.5
MAX.	9.2	130.0	163.0	83.6	265.0	225.0	47.4	74.4	18.7	4.7	0.5	0.5
MIN.	2.0	1.9	2.0	2.3	1.7	1.7	2.3	2.0	5.1	0.0	0.5	0.5
TOTAL AF	148.0	619.0	657.0	479.0	1,891.0	1,708.0	543.0	607.0	753.0	67.0	3.1	30.0

R0053637

SAN GABRIEL RIVER
below Valley Boulevard
STATION NO. F261C-R







VOL 12

2 0333

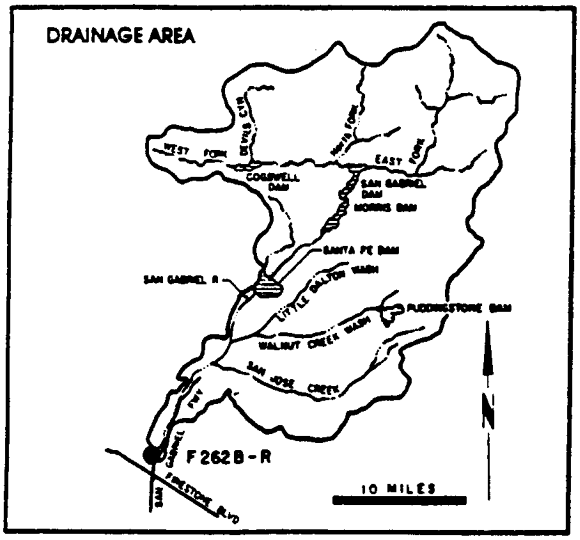
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading.
DRAINAGE AREA- 118.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,150.0 feet below Valley Boulevard, 2.5 miles east of El Monte.
REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, and Puddingstone Dams.
CHANNEL- sand and gravel bottom with rip-rap side slopes; trapezoidal section.
CONTROL- concrete stabilizer with low-flow notch.
LENGTH OF RECORD- at Station F261-R March 11, 1937 to September 30, 1941. at Station F261B-R October 1, 1941 to April 23, 1946. at Station F261C-R November 29, 1960 to date.
REMARKS- flows may include imported water originating at Metropolitan Water District outlets at San Dimas Canyon and below San Bernardino Road.

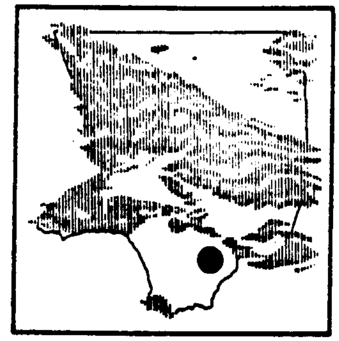
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

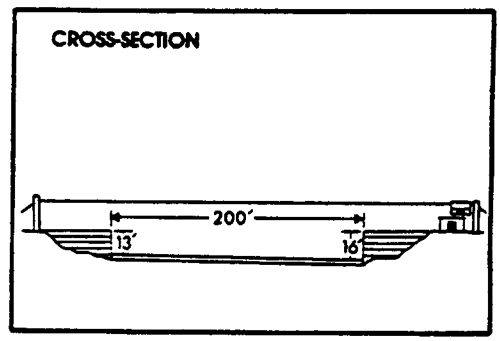
STATION NO.: F261C-R DRAINAGE AREA: 118.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.6	9.2	19.3	4.4	35.2	24.4	12.4	0.4	0.2	0.0	0.0	0.0
MAX.	6.8	127.0	256.0	69.1	280.0	379.0	251.0	5.9	2.5	0.0	0.0	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AF	36.0	548.0	1 186.0	271.0	1 954.0	1 503.0	738.0	27.0	12.0	0.0	0.0	0.0

SAN GABRIEL RIVER
above Florence Avenue
STATION NO. F262C–R







VOL 12

2

0334

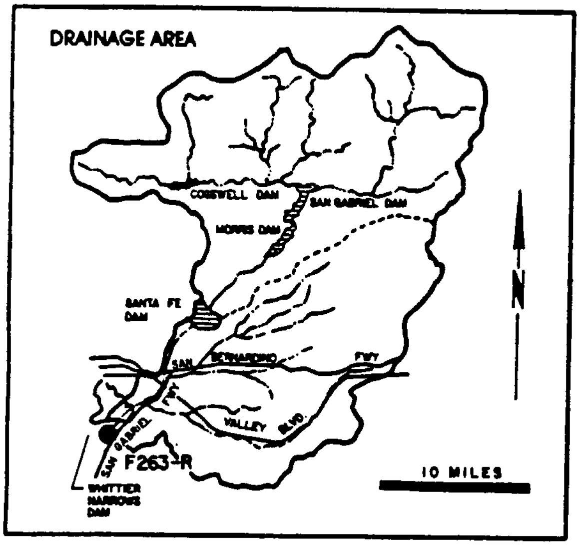
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 215.8 square miles (excludes area above Santa Fe Dam).
LOCATION- 1,400 feet above Florence Avenue, 2.0 miles east of Downey.
REGULATION- partially regulated by Cogswell, San Gabriel, Morris, Santa Fe, Big Dalton, San Dimas, Puddingstone Diversion, Puddingstone, Live Oak, Thompson Creek and Whittier Narrows Dams, several debris basins, MWD outlets, and several spreading grounds.
CHANNEL- sand bottom with rip-rap slopes, trapezoidal section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F267-R February 27, 1937 to September 30, 1967. at Station F262B-R August 6, 1968 to date.
REMARKS- no record during 1967-1968 season due to channel construction.

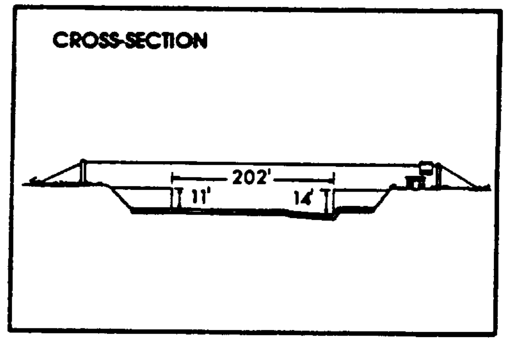
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F262C–R — DRAINAGE AREA : 215.8 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAX.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SAN GABRIEL RIVER
below San Gabriel River Parkway
STATION NO. F263C-R





VOL 12

2 0335

RECORDER- continuous water stage.

METHOD OF MEASUREMENTS- wading or from cable car.

DRAINAGE AREA- 206.3 square miles (excludes area above Santa Fe Dam).

LOCATION- 462.0 feet below San Gabriel River Parkway, 1.4 miles northeast of Pico Rivera.

REGULATION- partly regulated by Santa Fe, Big Dalton, Puddingstone Diversion, Puddingstone, and Thompson Creek Dams. Flows may include imported water from several Metropolitan Water District outlets. Water is at times diverted to the Zone I ditch upstream of Whittier Narrows Dam.

CHANNEL- rip-rap slopes with sand bottom trapezoidal section.

CONTROL- concrete stabilizer.

LENGTH OF RECORD - at Station F263-R February 4, 1937 to March 6, 1952. at Station F263B-R March 6, 1952 to August 9, 1968. at Station F263C-R August 9, 1968 to date.

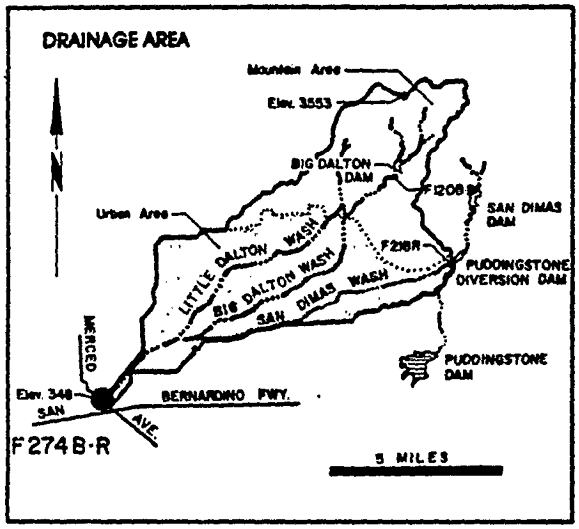
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

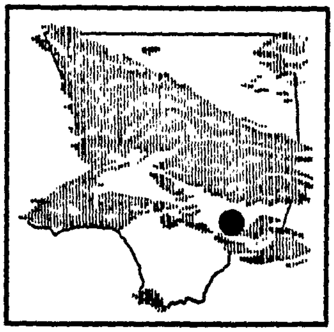
STATION NO. : F263C–R

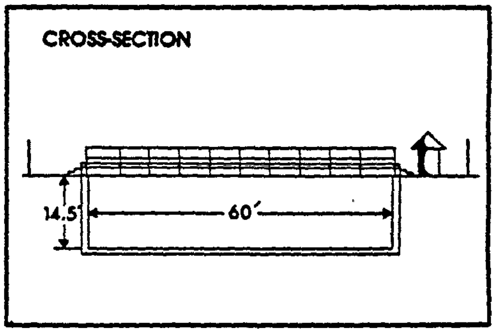
DRAINAGE AREA : 206.30 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	7.4	44.7	57.8	13.8	82.9	76.4	44.7	31.0	64.0	7.9	2.9	2.3
MAX.	41.8	387.0	327.0	232.0	218.0	193.0	77.5	65.1	91.6	63.2	3.9	7.1
MIN.	4.3	4.3	6.1	5.0	8.2	41.7	30.8	16.0	42.5	3.9	2.6	0.2
TOTAL AF	454.0	2,662.0	3,554.0	850.0	4,602.0	4,699.0	2,660.0	1,909.0	3,808.0	483.0	177.0	136.0

DALTON WASH
at Merced Avenue
STATION NO. F274B-R







VOL 12

2

0336

RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from footbridge 100 feet upstream from station.
DRAINAGE AREA- 36.0 square miles, not including the area above Puddingstone Diversion Dam.
LOCATION- on the west bank and upstream of Merced Avenue about 150 feet, about one-half mile above the junction with Walnut Wash and about one mile south of Baldwin Park.
REGULATION- partly regulated by Big Dalton Dam, San Dimas Dam, Puddingstone Diversion Dam, Big Dalton Spreading Grounds, Little Dalton Spreading Grounds, Big Dalton Debris Basin, Little Dalton Debris Basin, and Irwindale Spreading Grounds.
REMARKS- flow may include imported water originating at San Dimas.

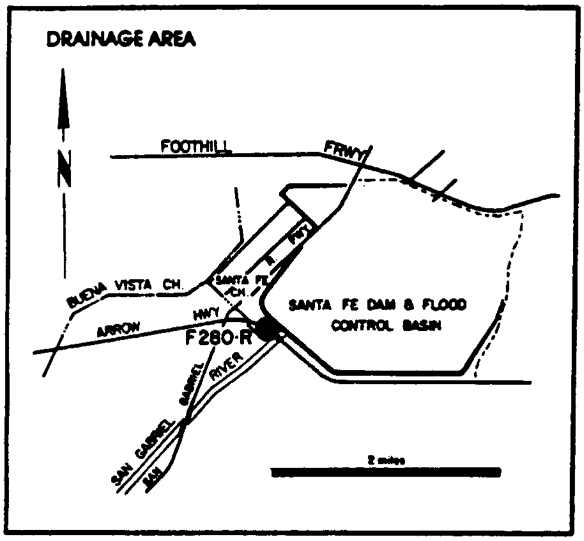
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

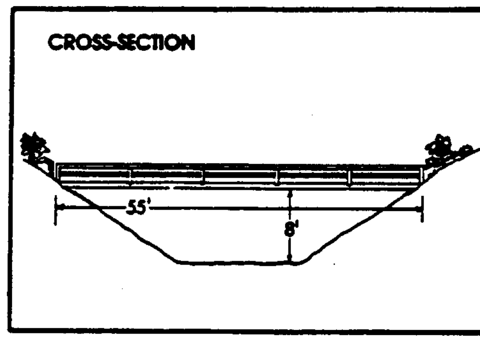
STATION NO.: F274B–R DRAINAGE AREA: 36.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	5.6	10.1	10.6	7.4	10.2	12.3	8.7	2.9	2.4	0.8	2.1	1.3
MAX.	16.9	50.2	162.0	35.7	79.2	169.0	131.0	11.5	11.0	2.5	8.1	2.4
MIN.	3.5	1.3	1.7	1.5	0.2	0.1	1.1	0.3	0.1	0.2	0.2	0.2
TOTAL AF	343.0	604.0	655.0	454.0	567.0	757.0	517.0	179.0	144.0	50.0	127.0	75.0

SANTA FE CHANNEL
below Santa Fe Dam
STATION NO. F280-R

VOL 12 2 0337





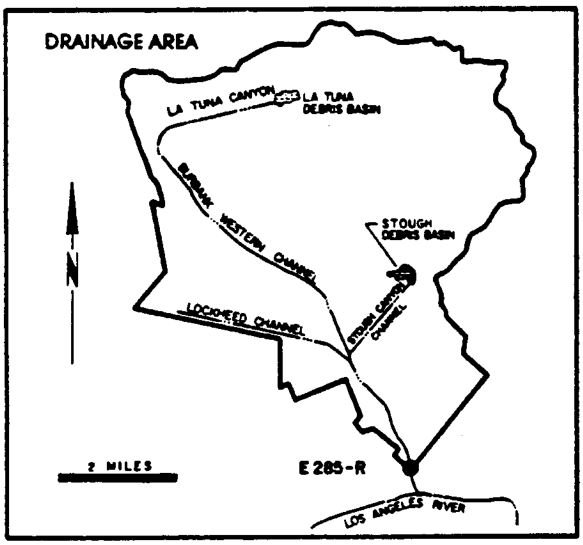
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- controlled.
LOCATION- 400.0 feet downstream of Santa Fe Dam outlet and 1.5 miles north of Baldwin Park.
REGULATION- flow regulated by five gates of stilling basin outlet of Santa Fe Dam.
CHANNEL- sand and gravel, natural section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- at Station F280-S October 1, 1942 to May 12, 1944. at Station F280-R May 12, 1944 to date.

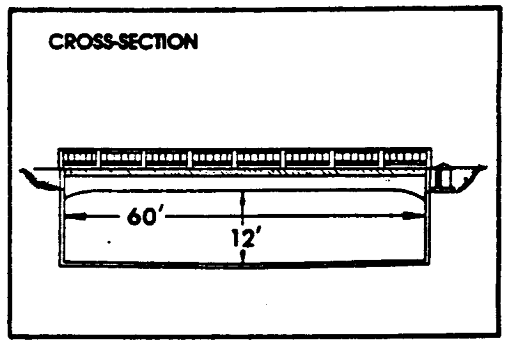
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO.: F280–R DRAINAGE AREA: CONTROLLED

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.0	17.3	6.1	0.0	0.0	0.0	0.2	0.0	0.0	0.5	1.1	0.0
MAX.	0.0	72.0	57.4	0.0	0.0	0.0	6.4	0.0	0.6	15.0	32.7	0.0
MIN.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL AF	0.0	1,030.0	372.0	0.0	0.0	0.0	13.0	0.0	1.0	30.0	65.0	0.0

BURBANK-WESTERN ST. DR.
at Riverside Drive
STATION NO. E 285-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading and from bridge.
DRAINAGE AREA- 25.0 square miles.
LOCATION- 20.0 feet upstream from Riverside Drive bridge, Glendale.
REGULATION- Several debris basins on tributaries.
CHANNEL- concrete, rectangular section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 1, 1949 to date.
REMARKS- operated in cooperation with the USCE.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : E285–R DRAINAGE AREA : 25.00 SQ. MI.

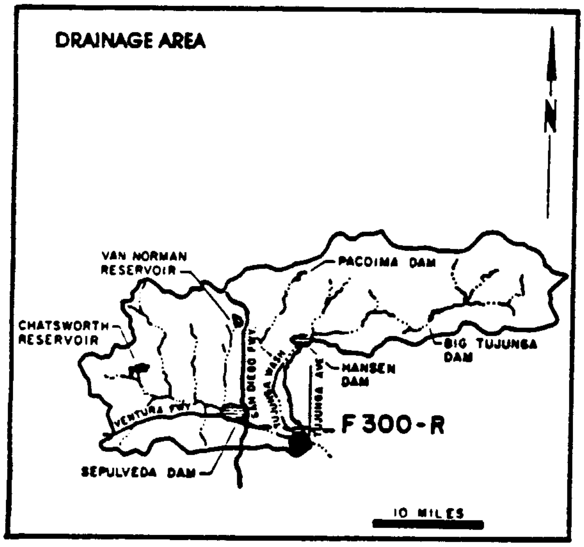
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	10.6	17.1	16.9	14.1	54.1	30.5	11.9	9.7	11.1	11.0	8.9	8.6
MAX.	32.2	165.0	115.0	73.0	355.0	290.0	15.4	11.5	14.6	12.0	10.2	9.0
MIN	6.8	5.7	7.9	9.3	8.0	9.2	9.8	6.7	9.1	10.2	7.0	7.9
TOTAL AF	654.0	1,018.0	1,038.0	865.0	3,007.0	1,875.0	709.0	596.0	662.0	674.0	545.0	512.0

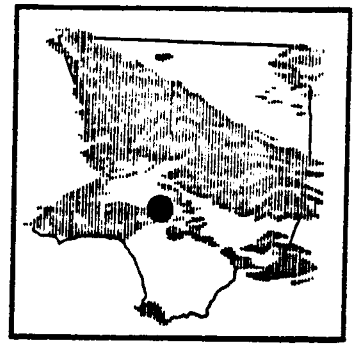
VOL 12

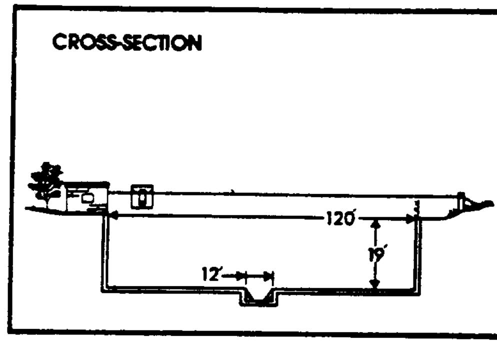
2 0338

R0053643

LOS ANGELES RIVER
at Tujunga Avenue
STATION NO. F300-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 401.0 square miles.
LOCATION- 200.0 feet above Tujunga Avenue bridge, Studio City.
REGULATION- flow regulated by Sepulveda, Big Tujunga, Hansen, and Pacoima Dams, Lopez Debris Dam, and Project No. 85 Diversion.
CHANNEL- concrete, rectangular section, 120 feet wide by 19 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- May 8, 1950, to date.
REMARKS- subject to diversions at mouth of Big Tujunga and Pacoima Canyons for irrigation, at Big Tujunga, Branford, Hansen, and Pacoima Spreading Grounds.

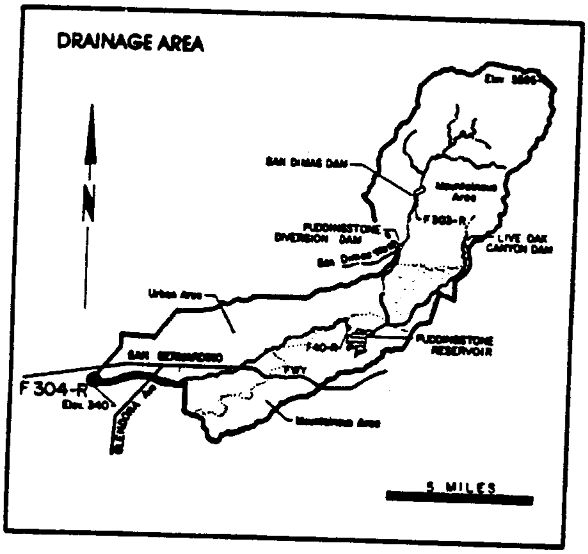
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

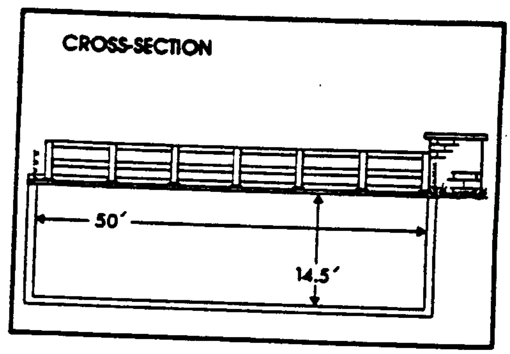
STATION NO. : F300-R DRAINAGE AREA : 401.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	87.4	98.5	117.0	70.3	491.0	209.0	115.0	97.7	92.3	83.2	81.7	78.1
MAX.	407.0	484.0	849.0	93.7	2,390.0	1,410.0	500.0	214.0	106.0	98.9	89.3	88.2
MIN.	54.7	56.9	57.7	55.8	91.0	82.3	81.2	73.3	77.1	73.5	71.3	67.5
TOTAL AF	5,377.0	5,860.0	7,196.0	4,320.0	27,260.0	12,880.0	6,834.0	6,007.0	5,492.0	5,117.0	5,025.0	4,650.0

VOL 12 2 0339

WALNUT CREEK
above Puente Avenue
STATION NO. F304-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from footbridge.
DRAINAGE AREA- 57.6 square miles.
LOCATION- 845.0 feet upstream of Puente Avenue bridge, Baldwin Park.
REGULATION- partially regulated by San Dimas, Puddingstone Diversion, Puddingstone, and Live Oak Dams.
CHANNEL- concrete, rectangular in section.
CONTROL- channel forms control.
LENGTH OF RECORD- October 14, 1952 to April 11, 1961, January 3, 1962 to date.
REMARKS- no record during April 11, 1961 to January 3, 1962 due to channel construction.

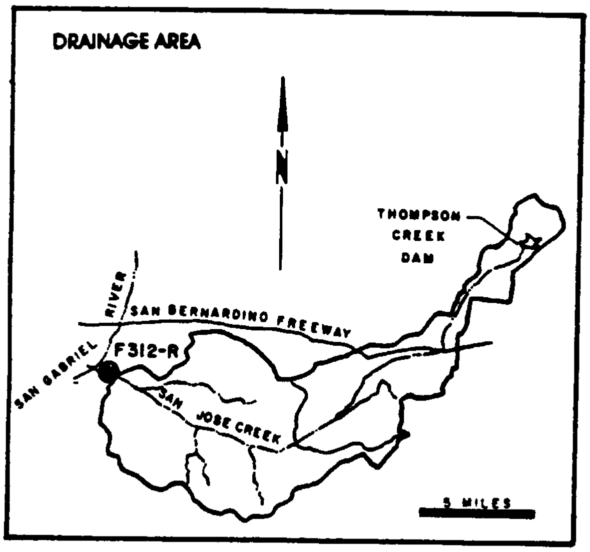
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

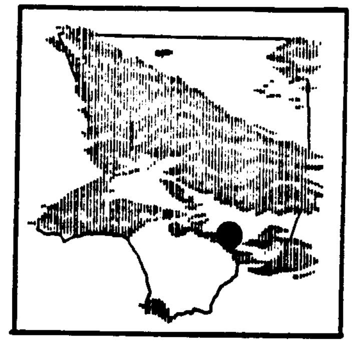
STATION NO.: F304–R

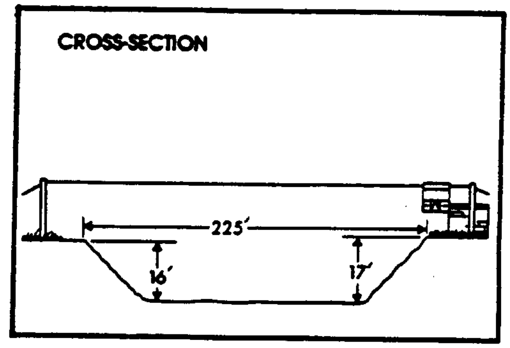
DRAINAGE AREA: 57.60 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	1.9	6.2	18.0	2.5	20.3	16.6	11.4	1.8	0.7	0.4	0.5	0.4
MAX.	8.0	57.0	147.0	22.3	190.0	249.0	208.0	7.1	1.5	1.2	1.4	1.5
MIN.	0.4	0.2	0.6	0.6	0.3	0.9	0.6	0.1	0.0	0.1	0.1	0.1
TOTAL AF	116.0	367.0	1,109.0	151.0	1,126.0	1,022.0	680.0	112.0	42.0	23.0	33.0	26.0

SAN JOSE CHANNEL
above Workman Mill Road
STATION NO. F312-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 83.4 square miles.
LOCATION- 1,650 feet above Workman Mill Road, 3.0 miles southeast of El Monte.
REGULATION- partially regulated by Thompson Creek Dam and Pomona Sewage Treatment Plant.
CHANNEL- grouted rip-rap side slopes with natural bottom, trapezoidal section.
CONTROL- rock stabilizer.
LENGTH OF RECORD- September 13, 1955 to date.

WATER YEAR 1993 – 1994
(DISCHARGE IN CFS)

STATION NO. : F312B – R DRAINAGE AREA : 83.40 SQ. MI.

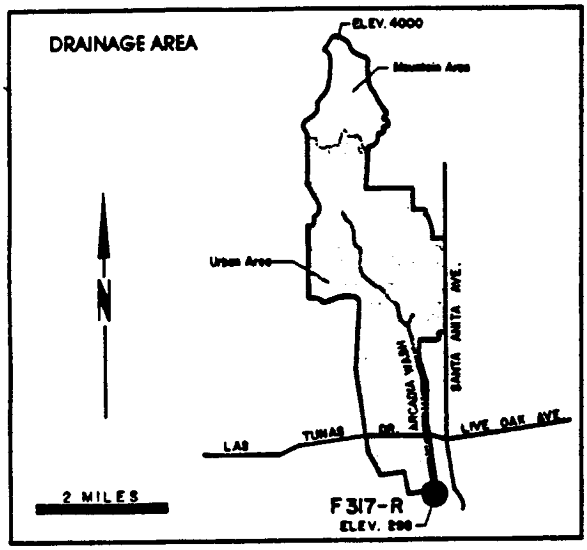
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	14.6	19.8	18.3	15.9	36.5	13.0	12.0	118.8	129.5	9.2	6.3	8.9
MAX.	46.0	136.0	127.0	131.0	149.0	16.0	52.0	136.0	136.0	13.6	9.1	13.6
MIN.	6.8	11.4	11.4	4.6	7.0	10.0	6.8	11.4	127.0	6.8	4.6	4.6
TOTAL AF	899.0	1,178.0	1,127.0	978.0	2,025.0	802.0	712.0	7,307.0	7,704.0	563.0	389.0	532.0

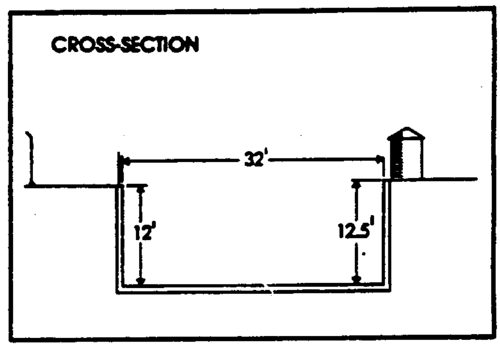
NOTE. DATA WAS ESTIMATED.

VOL 12 2 0341

R0053646

ARCADIA WASH
below Grand Avenue
STATION NO. F 317-R





RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of Grand Avenue bridge.
DRAINAGE AREA- 8.5 square miles.
LOCATION- on the west wall of Arcadia Wash about 75 feet downstream from centerline of Grand Avenue.
REGULATION- several debris basins located upstream.
CHANNEL- rectangular concrete.
LENGTH OF RECORD- December 12, 1955 to date.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

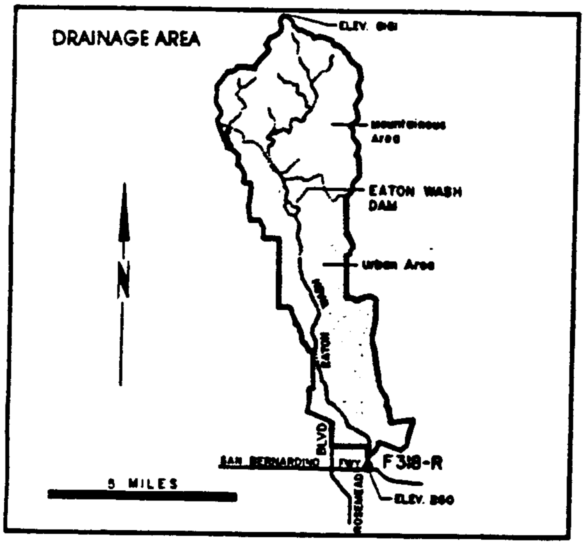
STATION NO. : F317–R DRAINAGE AREA : 8.50 SQ. MI.

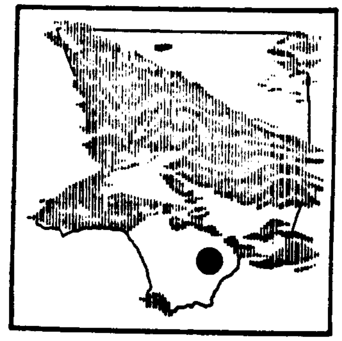
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	2.5	8.9	2.9	2.3	9.0	22.8	11.0	13.0	0.7	2.1	1.3	0.8
MAX.	7.6	162.0	55.2	33.1	57.0	239.0	95.2	125.0	1.4	4.3	3.9	1.3
MIN.	0.7	0.9	0.0	0.1	0.5	0.4	0.5	0.5	0.2	0.5	0.5	0.5
TOTAL AF	157.0	529.0	179.0	142.0	497.0	1,402.0	656.0	799.0	41.0	132.0	83.0	46.0

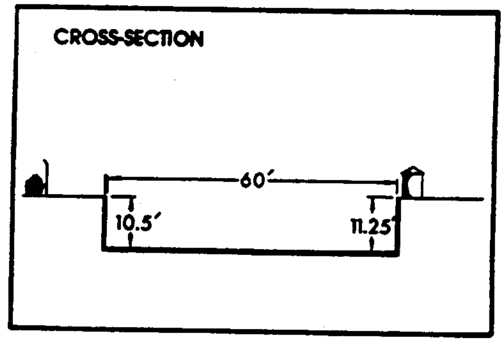
VOL 12
2 0342

R0053647

EATON WASH
at Loftus Drive
STATION NO. F318-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from upstream side of East Loftus Drive bridge.
DRAINAGE- 22.8 square miles.
LOCATION- on the west wall of the channel 52 feet above the centerline of East Loftus Drive bridge, 1.3 miles west of El Monte.
REGULATION- partly regulated by Eaton Dam.
DIVERSIONS- the Pasadena Water Department diverts some water just above the mouth of Eaton Canyon. The Flood Control District diverts water to spreading grounds below Eaton Dam and below Huntington Drive.
CHANNEL- rectangular concrete, 60 feet wide, 11.3 feet.
CONTROL- channel forms control.
LENGTH OF RECORD- 1956 to date.

VOL 12

2 0343

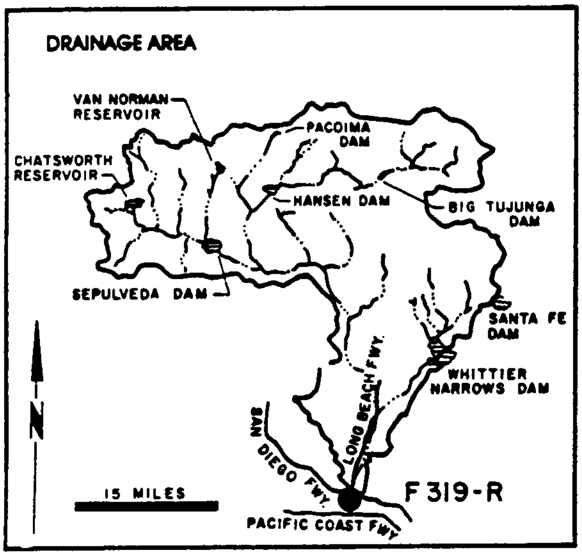
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

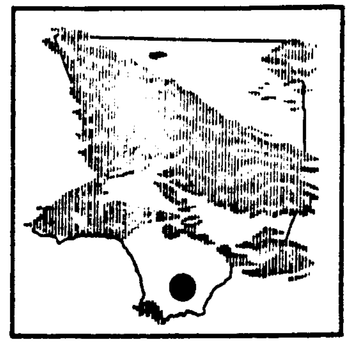
STATION NO. : F318–R DRAINAGE AREA : 22.80 SQ. MI.

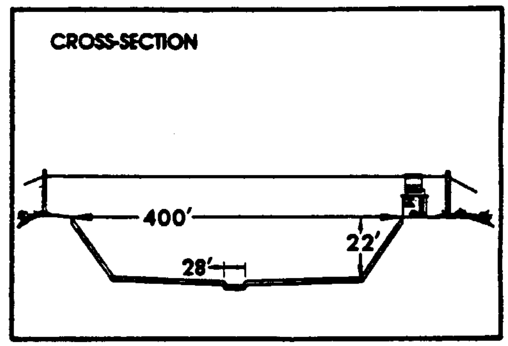
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.6	3.9	5.3	0.2	7.4	11.5	4.6	1.7	0.1	0.1	0.1	0.1
MAX.	4.9	64.1	77.4	0.5	159.0	146.0	40.5	14.3	0.3	0.1	0.2	0.3
MIN.	0.2	0.1	0.0	0.0	0.2	0.3	0.3	0.2	0.0	0.0	0.0	0.0
TOTAL AF	38.0	232.0	324.0	11.0	411.0	706.0	271.0	104.0	6.0	5.0	7.0	8.0

R0053648

LOS ANGELES RIVER
below Wardlow Road
STATION NO. F319-R







VOL 12 2 0344

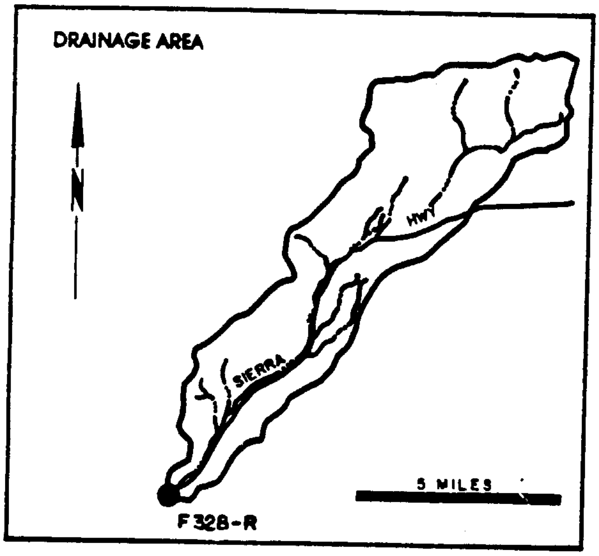
RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 815.0 square miles (excludes area above Santa Fe Dam).
LOCATION- 900.0 feet below Wardlow Road, Long Beach.
REGULATION- flow is subject to the same regulation as Stations F34D-R and P458-R.
DIVERSIONS- flows diverted to Dominguez Gap Spreading Grounds.
CHANNEL- trapezoidal, concrete, 302.0 feet wide at bottom with 2.25:1 side slopes. Low flow channel 28.0 feet wide by 1.0 foot deep in center of channel.
CONTROL- channel forms control.
LENGTH OF RECORD- at Station F180-R October 31, 1931 to January 13, 1956. at Station F319-R January 13, 1956 to date.
REMARKS- prior to 1931, see Station F36-R.

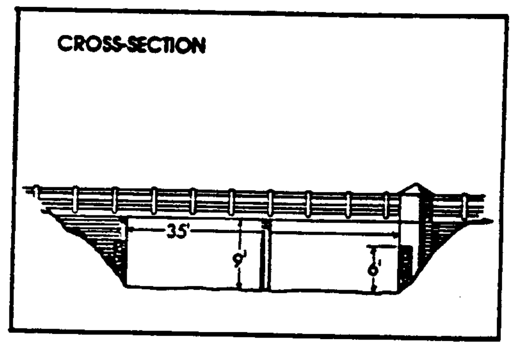
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO.: F319-R DRAINAGE AREA: 815.00 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	214.0	266.0	264.0	197.0	721.0	422.0	218.0	182.0	171.0	168.0	160.0	140.0
MAX	629.0	1,850.0	1,720.0	1,370.0	4,090.0	2,430.0	830.0	346.0	180.0	189.0	186.0	175.0
MIN	152.0	153.0	151.0	113.0	182.0	135.0	150.0	153.0	156.0	152.0	129.0	119.0
TOTAL AF	13,170.0	15,820.0	17,470.0	12,090.0	40,060.0	25,970.0	12,950.0	11,220.0	10,160.0	10,300.0	9,824.0	8,356.0

MINT CANYON CREEK
at Finch Avenue
STATION NO. F328-R





RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 26.9 square miles.
LOCATION- 8.5 miles northeast of Saugus on west end of Fitch Avenue bridge.
REGULATION- none.
CHANNEL- natural, sand and gravel.
CONTROL- concrete control at downstream end of bridge.
LENGTH OF RECORD- October 26, 1956 to date.

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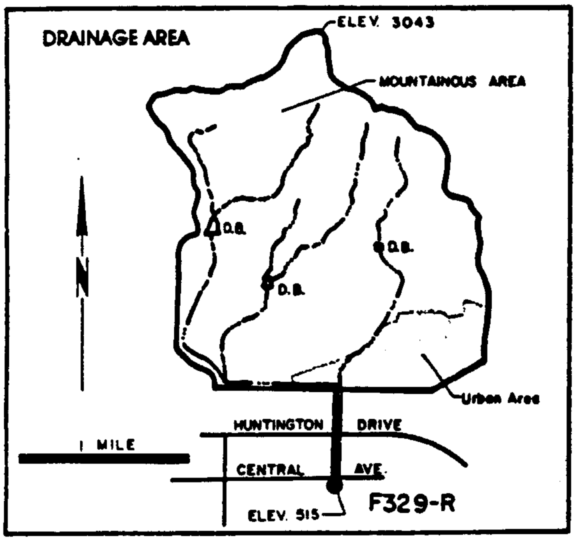
2 03345

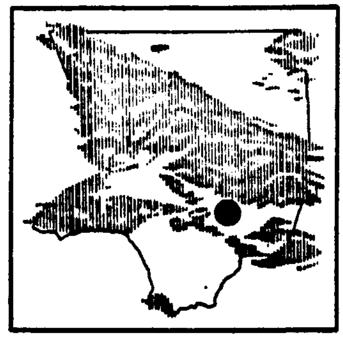
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

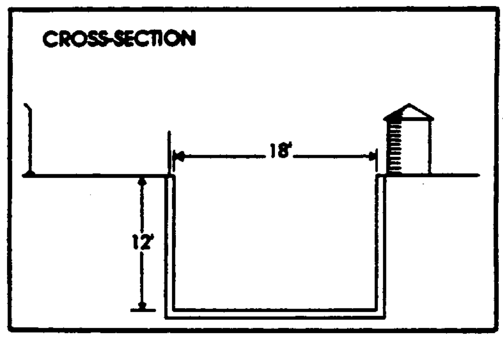
STATION NO. : F328–R DRAINAGE AREA : 26.90 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.7	1.1	0.7	0.5	0.9	0.6	0.5	0.7	0.3	0.2	0.2	0.0
MAX.	1.3	1.5	1.3	0.8	1.4	1.2	1.0	1.2	0.6	0.4	0.4	0.7
MIN.	0.3	0.7	0.4	0.1	0.5	0.3	0.1	0.1	0.1	0.1	0.1	0.0
TOTAL AF	44.0	65.0	46.0	33.0	51.0	39.0	27.0	46.0	18.0	11.0	10.0	2.0

BRADBURY CHANNEL
below Central Avenue
STATION NO. F329-R







RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENT- low flows measured by wading. High flows measured from footbridge four feet downstream from recorder.
DRAINAGE AREA- 3.3 square miles.
LOCATION- on the east wall of Bradbury Channel, 200 feet downstream from the centerline of Central Avenue, one mile east of Duarte.
REGULATION- two debris basins located upstream.
CHANNEL- rectangular concrete, 18 feet wide, 12 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- June 14, 1957 to present.

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2 0346

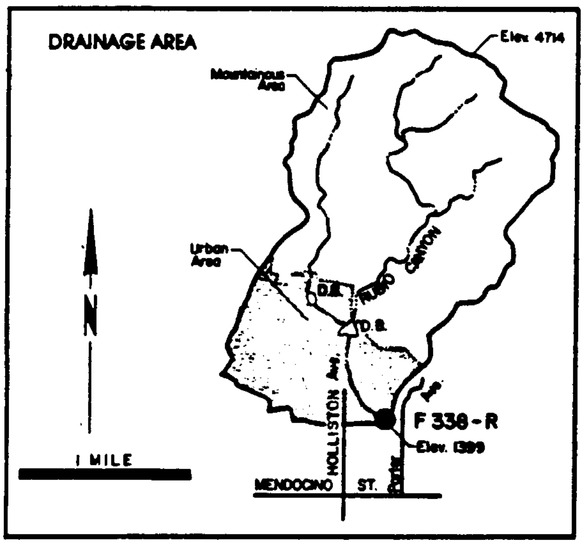
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

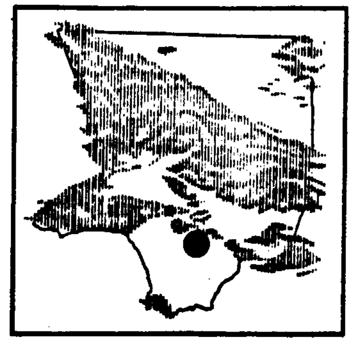
STATION NO. : F329–R DRAINAGE AREA : 3.30 SQ. MI.

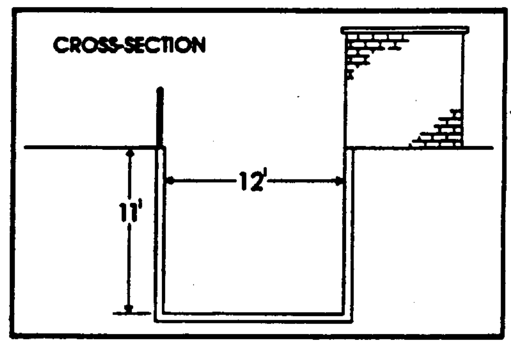
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.4	1.3	0.6	0.3	1.5	1.4	0.3	0.2	0.9	0.7	0.2	0.1
MAX.	1.3	5.6	7.8	3.4	8.8	14.6	4.2	1.4	2.0	2.1	0.6	0.2
MIN.	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0
TOTAL AF	26.0	75.0	37.0	18.0	84.0	87.0	15.0	12.0	54.0	42.0	12.0	6.0

R0053651

RUBIO DIVERSION CHANNEL
below Goosebury Inlet
STATION NO. F338-R







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0347

RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured from steel footbridge 27 feet above station.
DRAINAGE AREA- 2.1 square miles.
LOCATION- on the north bank, 375 feet upstream of Crest Drive, three and one-half miles northeast of Pasadena.
REGULATION- flow partially regulated by Rubio and Gooseberry Debris Basins.
DIVERSIONS- Rubio Canyon Land and Water Association diverts low flows in Rubio Canyon.
CHANNEL- rectangular concrete, 12 feet wide and 11 feet deep.
CONTROL- channel forms control.
LENGTH OF RECORD- December 16, 1959 to date.

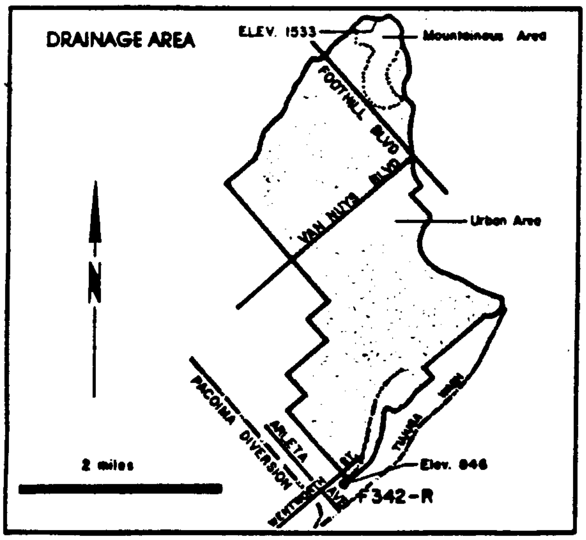
WATER YEAR 1993–1994
(DISCHARGE IN CFS)

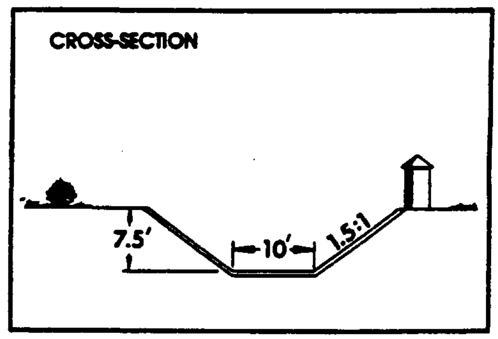
STATION NO. : F338–R — DRAINAGE AREA : 2.10 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.9	1.3	*	OUT	2.8	2.1	15.9	0.8	0.3	0.0	*	0.1
MAX.	1.8	7.0	*	OF	10.7	9.8	41.5	2.4	0.8	0.3	*	1.0
MIN.	0.2	0.0	*	SERVICE	0.0	0.4	0.3	0.0	0.0	0.0	*	0.0
TOTAL AF	56.0	75.0	*		154.0	129.0	947.0	52.0	17.0	2.0	*	8.0

LEGEND * – Recorder malfunctioned during part of the month. Partial data is available

BRANFORD STREET CHANNEL
below Sharp Avenue
STATION NO. F342-R





RECORDER- 15 minute punched tape.
METHOD OF MEASUREMENTS- low flows measured by wading. High flows measured by floats.
DRAINAGE AREA- 5.01 square miles.
LOCATION- on the south bank of channel, 125 feet downstream from Sharp Avenue, about 3.6 miles south of San Fernando.
REGULATION- flow from Lopez Creek is diverted to Hansen Dam at the mouth of Lopez Canyon.
CHANNEL- trapezoidal, 10 feet wide at bottom and 7.5 feet deep with 1. 5 to 1 side slopes.
CONTROL- channel forms control.
LENGTH OF RECORD- January 12, 1962 to date.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F342–R DRAINAGE AREA : 5.01 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.3	*	*	*	3.2	1.8	0.4	0.1	0.0	0.0	0.0	*
MAX.	8.4	*	*	*	35.3	34.7	6.3	3.3	0.0	0.5	0.0	*
MIN.	0.0	*	*	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
TOTAL AF	21.0	*	*	*	178.0	109.0	22.0	9.0	0.0	1.0	0.0	*

LEGEND * – Recorder malfunctioned during part of month. Partial data is available.

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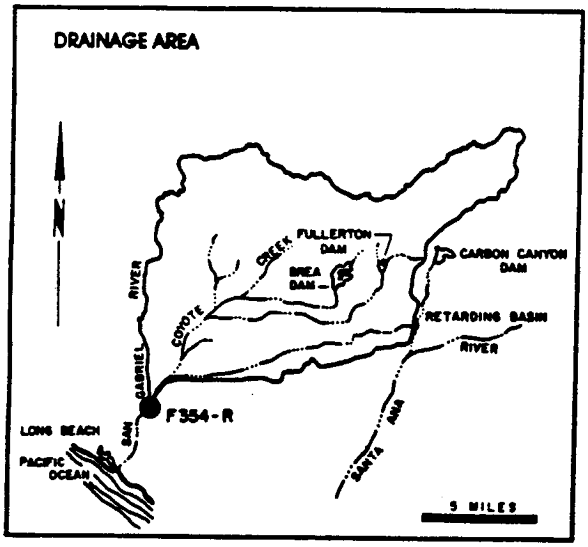
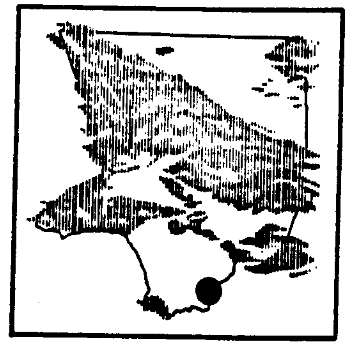
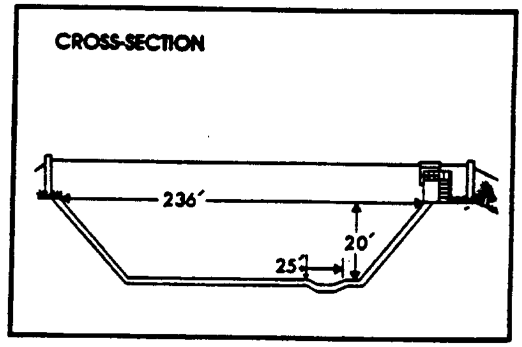
2
0348

R0053653

COYOTE CREEK
below Spring Street
STATION NO. F354-R







VOL 12

2 03449

RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from cable car.
DRAINAGE AREA- 185.0 square miles.
LOCATION- 241.0 feet below Spring Street, 7.5 miles northeast of Long Beach.
REGULATION- partially regulated by Fullerton Dam, Brea Dam, and Carbon Canyon Dam.
CHANNEL- concrete, trapezoidal in section.
CONTROL- channel forms control.
LENGTH OF RECORD - December 17, 1963 to date.
REMARKS - previous gaging stations for record corelation: Station F41 - S December 1, 1928 to January 14, 1930. Station F41 - R January 14, 1930 to October 30, 1936. Station F41B - R October 30, 1936 to February 17, 1937. Station F41C - R February 18, 1937 to February 8, 1956. Station F320 - R February 9, 1956 to July 2, 1965.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

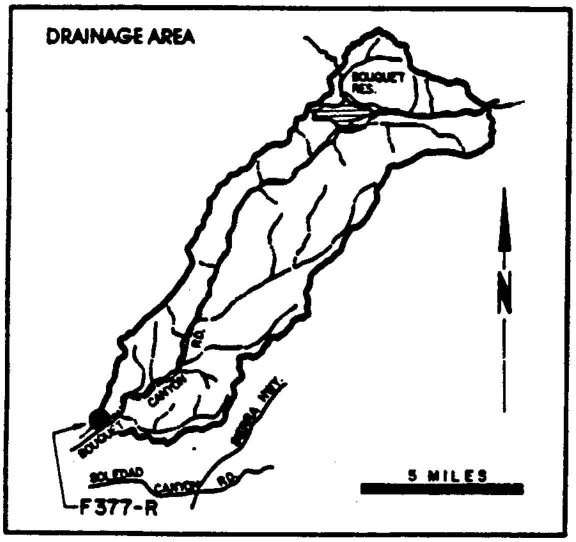
STATION NO. : F354–R DRAINAGE AREA : 185.00 SQ. MI.

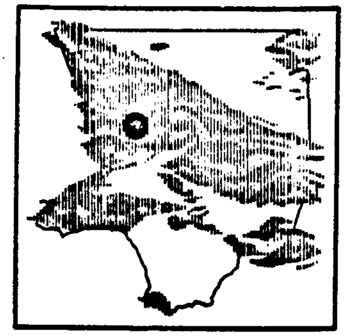
MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	15.9	OUT	*	*	210.0	110.0	*	*	OUT	*	OUT	OUT
MAX.	44.0	OF	*	*	1,510.0	1,230.0	*	*	OF	*	OF	OF
MIN.	5.0	SERVICE	*	*	7.2	20.6	*	*	SERVICE	*	SERVICE	SERVICE
TOTAL AF	979.0		*	*	11,660.0	6,765.0	*	*	-	*		

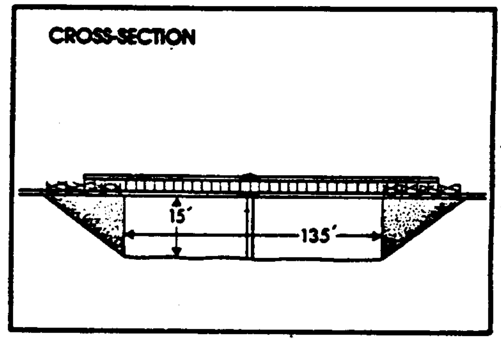
LEGEND * – Recorder malfunctioned during part of month. Partial data is available.

R0053654

BOUQUET CANYON CREEK
at Urbandale Avenue
STATION NO. F377-R







RECORDER- continuous water stage.
METHOD OF MEASUREMENTS- wading or from bridge.
DRAINAGE AREA- 51.9 square miles.
LOCATION- Bouquet Canyon Creek at Urbandale Avenue, 3.5 miles northeast of Saugus.
REGULATION- Bouquet Reservoir.
CHANNEL- concrete sides with natural bottom, trapezoidal in section.
CONTROL- concrete stabilizer.
LENGTH OF RECORD- October 11, 1967 to date.

WATER YEAR 1993–1994
(DISCHARGE IN CFS)

STATION NO. : F377–R DRAINAGE AREA : 51.90 SQ. MI.

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	0.1	0.2	*	*	0.0	0.1	0.1	0.8	0.0	0.0	OUT	*
MAX.	1.0	0.9	*	*	0.2	0.8	0.6	5.0	0.0	0.0	OF	*
MIN.	0.0	0.0	*	*	0.0	0.0	0.0	0.0	0.0	0.0	SERVICE	*
TOTAL AF	6.0	10.0	*	*	1.0	4.0	3.0	48.0	60.0	0.0		*

LEGEND * – Recorder malfunctioned during part of month. Partial data is available.

VOL 12

2 0350

R0053655

RESERVOIRS

VOL 12

2 0351

R0053656

RESERVOIRS

Following the damaging flood of 1914 and creation of the Los Angeles County Flood Control District in 1915, a program of flood control and water conservation was initiated. Part of this program included the construction of 14 dams which were completed between 1920 and 1939. These dams were operated by the Department during the period covered by this report. In addition, five Corps of Engineers' dams, Lopez, Hansen, Santa Fe, Sepulveda and Whittier Narrows Dams, and Morris Dam owned by The Metropolitan Water District were operated in conjunction with the Department dams to achieve flood control and/or water conservation.

OPERATION

The reservoirs are operated to control flood waters during storm periods. Post storm releases are made, when feasible, in amounts which can be conserved in downstream spreading grounds and by channel percolation. Cleanouts are done to regain storage capacity in reservoirs (see Erosion Control for cleanout data).

RECORDS

The storage and flow records at the 14 Department reservoirs are summarized on the Dam Operation Record Sheets. The sheets show:

1. Daily reservoir water surface elevations. Elevations are obtained from water stage recorder graphs or interpolation from staff gage readings and recorded as of midnight of each day. Only maximum and minimum water surface elevations for each year are shown.

2. Available storage in acre-feet based on the most recent topographic surveys. Annual storage volumes are shown.

3. Stream inflow rates in cubic feet per second. This is usually calculated from storage change and known outflow.

4. Outflow in cubic feet per second. These values are determined from gaging station records, or when these are not available, from valve and spillway rating curves. Only the maximum and minimum of the daily outflow rates for the year and the instantaneous peak outflow rate are shown.

5. Discrepancies between outflow and storage losses at certain dams are attributable to evaporation and/or percolation losses. Total monthly evaporation losses are determined from the measurements made on land evaporation pans. In those cases where no allowances were made for evaporation, the amounts are necessarily included in the flow values. Accuracy of flow records computed from storage records is dependent on the frequency with which storage data are revised to keep in step with the physical change in reservoirs due to sediment deposition, accumulation and removal.

VOL 12

2
0352

RESERVOIR CLEANOUTS

The periodical removal of Sediment is necessary in our reservoirs in order to maintain storage capacity. Sediment deposition adversely affects flood control and water conservation and storage activities in our reservoirs.

Between June 1993 and June 1994 the Department completed seven cleanouts. These cleanouts removed a total of 847,534 cyds of sediment from our reservoirs at the cost of $5.2 million. Eaton Wash Reservoir cleanout removed 314,000 CY of sediment. San Dimas Reservoir cleanout removed 87,400 CY of sediment. Santa Anita Reservoir cleanout removed 72,300 CY of sediment that was disposed of at Santa Anita SPS. Puddingstone Reservoir cleanout removed 113,600 CY of sediment. Big Dalton Sediment cleanout removed 43,000 CY of sediment that was disposed of at Dalton SPS. Live Oak removed 24,234 CY of sediment that was disposed of at Webb School. The Devil's Gate cleanout removed 193,000 CY of sediment that was disposed of at Scholl Canyon. Since the 1992 and 1993 storms were declared disaster events by the state and the federal government a portion of the total sediment inflow for these two seasons is eligible for Fema reimbursement. Currently, there are ongoing sediment removal projects at Big Tujunga, Cogswell (phase2), and Whittier Narrows. These cleanouts should restore an additional 4.9 mcy of capacity at these reservoirs at a cost of $23.2 million.

MORRIS RESERVOIR SEDIMENT TESTING

During the public review period for the San Gabriel Canyon Sediment Management Plan (SMP) Environmental Impact Statement Report/ Environmental Impact Statement a concern was raised about the possibility that the sediment within Morris Reservoir may have been contaminated by past naval activities at the facility. As a result, the Department hired a consultant to conduct a sediment testing program.

Our consultant Fugro-West, Inc. completed the Morris Reservoir sediment sampling program in October 1994. A total of 225 soil samples were collected throughout the reservoir for analytical chemistry analysis from 65 locations. Results of the analytical test data do not indicate the presence of any constituent that may be an environmental hazard. Fugro's report concludes that the sediments in the reservoir do not pose a threat to the groundwater and can be disposed of at an inert landfill.

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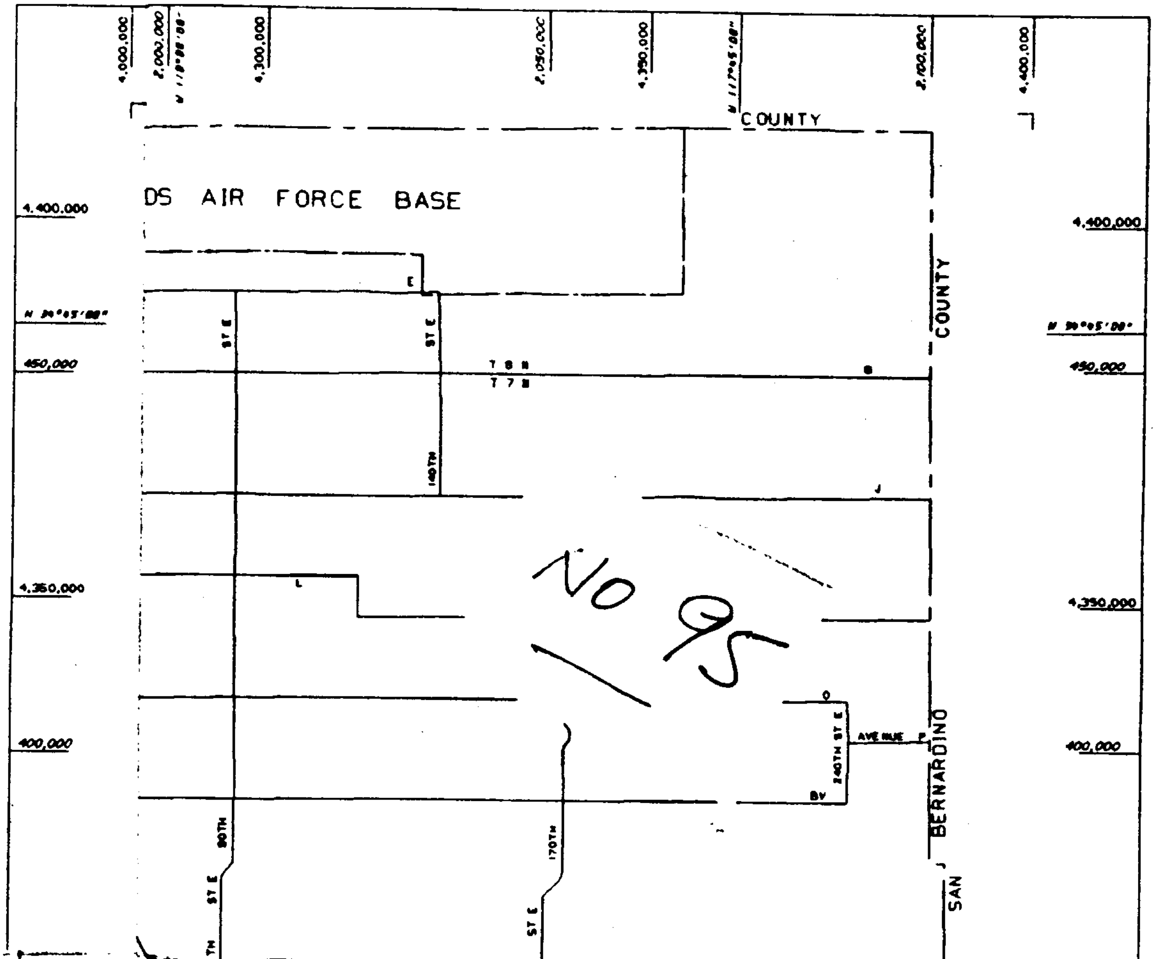
2 0354



MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

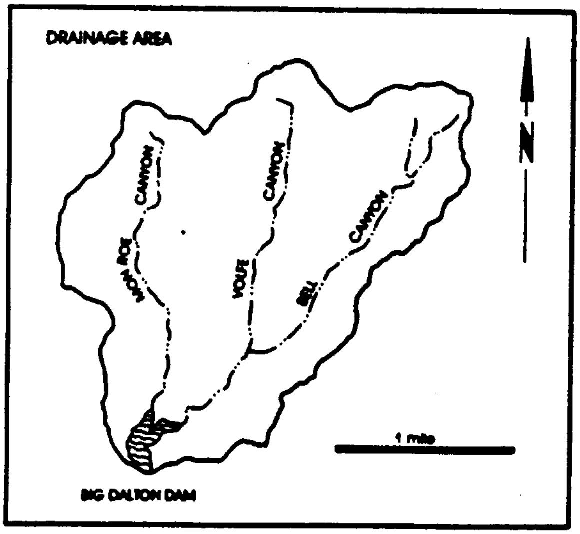
RESERVOIR LOCATIONS

1994

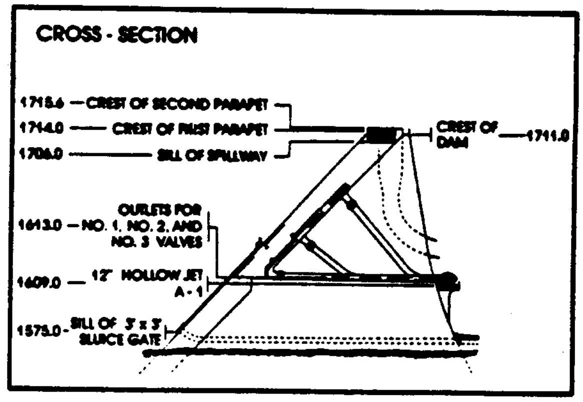
R0053659

PD1

BIG DALTON DAM
AND RESERVOIR



PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1927. Completed August 1929.
LOCATION - Big Dalton Canyon, 4.0 miles northeast of Glendora.
DRAINAGE AREA - 4.5 square miles.
CAPACITY - 963 acre - feet.
SPILLWAY ELEVATION - 1,706.0 feet.



DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	4.18 CFS from 1800 on 02-07-94 to 1900 on 02-07-94
Max. Peak Outflow	12.60 CFS from 0815 on 04-06-94 to 0830 on 04-06-94
Max. Water Surface Elev.	1,649.40 feet on 04-06-94 STORAGE 148.80 Acre-feet
Min. Water Surface Elev.	1,618.00 feet on varies STORAGE 35.60 Acre-feet

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2 0355

R0053660

VOL 12

BIG DALTON DAM OPERATION RECORD SUMMARY

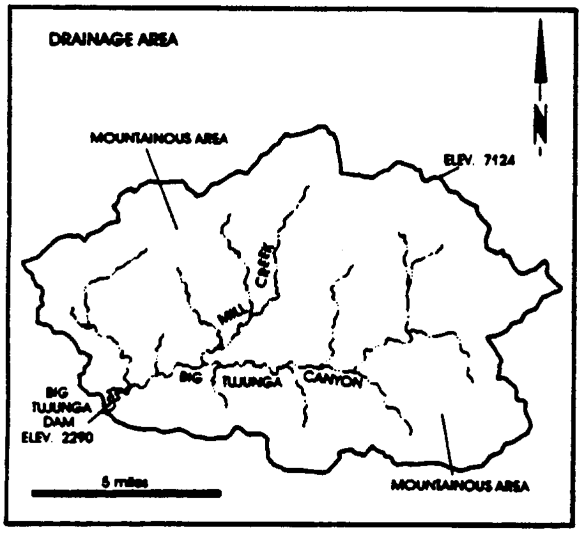
WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	18.50	13.10	18.50	19.70
TOTAL MONTHLY OUTFLOW (AF)	10.90	0.00	4.00	1.80
MAX. MEAN DAILY INFLOW (CFS)	0.50	0.80	0.40	0.60
TOTAL MONTHLY LOSSES (AF)	0.30	2.30	0.30	0.60
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.10	0.10	0.10
MONTHLY STORAGE CHANGE	7.30	10.80	14.20	17.30

WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	85.20	86.40	54.80	38.20
TOTAL MONTHLY OUTFLOW (AF)	62.10	42.80	122.40	22.00
MAX. MEAN DAILY INFLOW (CFS)	3.00	2.30	2.00	1.70
TOTAL MONTHLY LOSSES (AF)	1.20	1.40	1.30	1.30
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.90	0.10	0.20
MONTHLY STORAGE CHANGE	21.90	42.20	-68.90	14.90

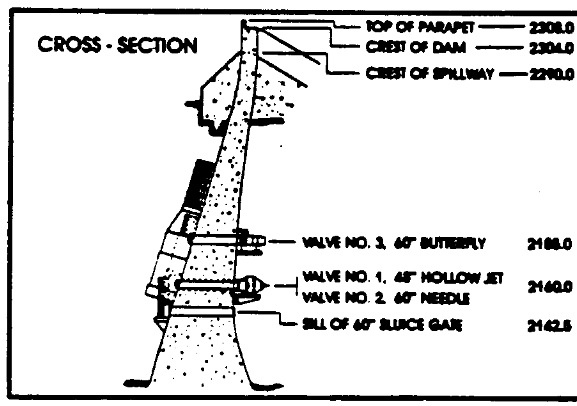
WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	15.90	8.20	6.40	3.60
TOTAL MONTHLY OUTFLOW (AF)	34.10	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.50	0.30	0.30	0.20
TOTAL MONTHLY LOSSES (AF)	2.20	2.70	3.00	2.50
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.00	0.00	0.00
MONTHLY STORAGE CHANGE	-20.40	5.50	3.40	1.10

2 0356

BIG TUJUNGA DAM
AND RESERVOIR



PURPOSE - Flood Control Conservation.
DATE CONSTRUCTED - Started January 1930. Completed July 1931.
LOCATION - Big Tujunga Canyon, 10.0 miles northeast of Sunland.
DRAINAGE AREA - 82.3 square miles.
CAPACITY - 6,027 acre - feet.
SPILLWAY ELEVATION - 2,290.0 feet.



DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	169.85 CFS	from 0100	on 02-08-94	to 0200	on 02-08-94				
Max. Peak Outflow	159.00 CFS	from 1515	on 02-08-94	to 1530	on 02-08-94				
Max. Water Surface Elev.	2,215.30	feet on	02-08-94	STORAGE	1,343.60 Acre-feet				
Min. Water Surface Elev.	2,140.00	feet on	varies	STORAGE	0.20 Acre-feet				

BIG TUJUNGA DAM OPERATION RECORD SUMMARY

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	728.20	896.00	942.70	1,012.50
TOTAL MONTHLY OUTFLOW (AF)	827.30	755.90	1,100.00	950.90
MAX. MEAN DAILY INFLOW (CFS)	14.10	23.90	22.00	26.90
TOTAL MONTHLY LOSSES (AF)	17.70	13.60	8.30	11.60
MIN. MEAN DAILY INFLOW (CFS)	10.00	11.40	9.80	13.00
MONTHLY STORAGE CHANGE	-116.80	126.50	-165.60	50.00

WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	2,186.30	1,364.00	1,159.00	110.50
TOTAL MONTHLY OUTFLOW (AF)	2,166.70	1,452.50	1,638.00	115.00
MAX. MEAN DAILY INFLOW (CFS)	79.80	39.70	44.00	5.00
TOTAL MONTHLY LOSSES (AF)	15.20	11.80	12.10	0.10
MIN. MEAN DAILY INFLOW (CFS)	17.00	3.50	4.80	0.00
MONTHLY STORAGE CHANGE	4.40	-100.30	-490.20	-4.60

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	125.10	32.10	42.40	35.30
TOTAL MONTHLY OUTFLOW (AF)	125.00	32.10	42.40	35.30
MAX. MEAN DAILY INFLOW (CFS)	2.10	0.90	1.00	1.00
TOTAL MONTHLY LOSSES (AF)	0.10	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	2.10	0.30	0.40	0.40
MONTHLY STORAGE CHANGE	0.00	0.00	0.00	0.00

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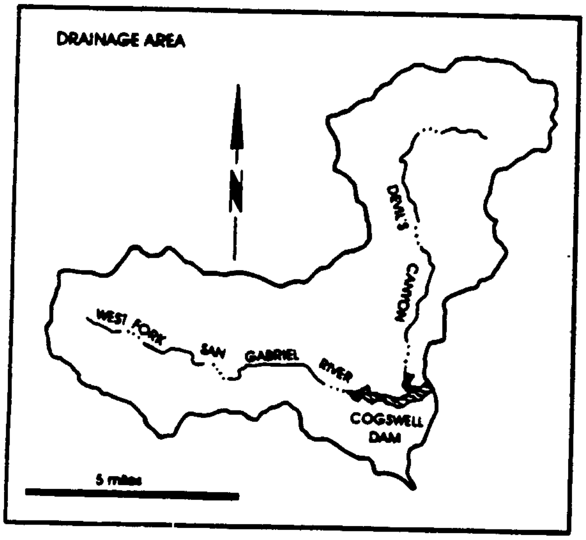
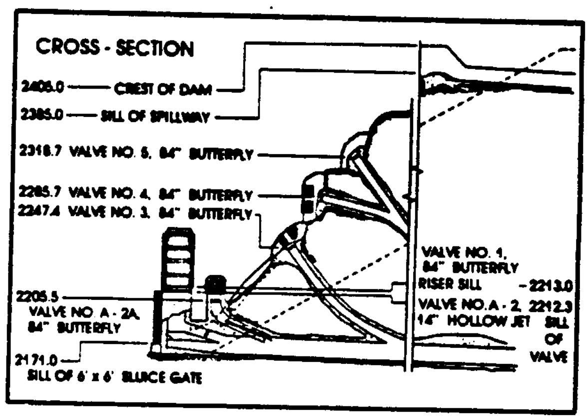
20358

COGSWELL DAM
AND RESERVOIR





PURPOSE - Flood Control, Conservation, and Recreation.
DATE CONSTRUCTED - Started March 1932. Completed April 1934.
LOCATION - 22.0 miles north of Azusa.
DRAINAGE AREA - 39.2 square miles.
CAPACITY - 9,339 acre - feet.
SPILLWAY ELEVATION - 2,385.0 feet.

VOL 12

2 0359

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	161.85 CFS	from	0700	on	02-08-94	to	0800 on	02-08-94
Max. Peak Outflow	85.50 CFS	from	0145	on	12-02-93	to	0200 on	12-02-93
Max. Water Surface Elev.	2,345.73	feet on	10-01-93	STORAGE		4,372.10		Acre-feet
Min. Water Surface Elev.	2,230.58	feet on	09-30-94	STORAGE		53.80		Acre-feet

VOL 12

2 0360

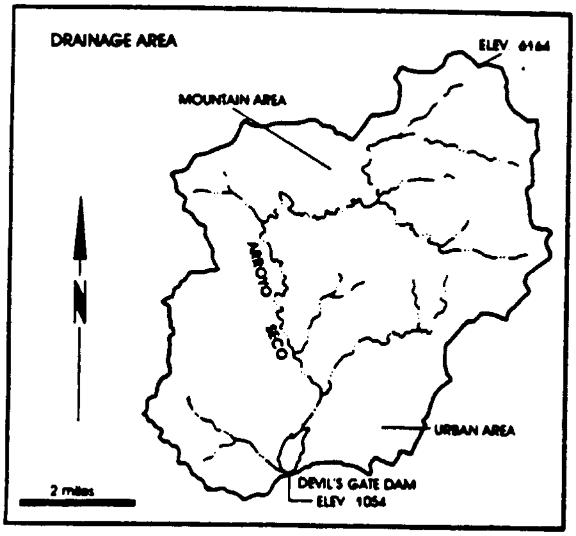
COGSWELL DAM OPERATION RECORD SUMMARY

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	754.70	402.00	592.10	409.20
TOTAL MONTHLY OUTFLOW (AF)	2,219.50	819.40	1,814.30	339.00
MAX. MEAN DAILY INFLOW (CFS)	14.30	11.00	15.70	10.60
TOTAL MONTHLY LOSSES (AF)	26.50	14.90	5.00	5.20
MIN. MEAN DAILY INFLOW (CFS)	10.60	4.10	4.10	5.10
MONTHLY STORAGE CHANGE	-1,491.30	-432.30	-1,227.20	65.00

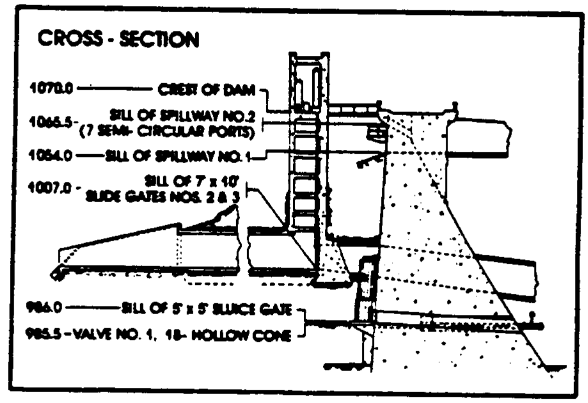
WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	1,249.70	1,604.30	904.90	529.50
TOTAL MONTHLY OUTFLOW (AF)	859.00	2,817.10	1,235.50	552.80
MAX. MEAN DAILY INFLOW (CFS)	105.10	56.90	29.50	13.00
TOTAL MONTHLY LOSSES (AF)	5.50	4.40	3.00	1.90
MIN. MEAN DAILY INFLOW (CFS)	7.60	16.20	6.50	2.40
MONTHLY STORAGE CHANGE	385.20	-1,217.20	-333.60	-25.20

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	198.10	146.10	64.80	40.30
TOTAL MONTHLY OUTFLOW (AF)	186.40	156.70	78.70	63.10
MAX. MEAN DAILY INFLOW (CFS)	5.90	4.50	1.90	1.30
TOTAL MONTHLY LOSSES (AF)	5.10	5.90	5.60	3.40
MIN. MEAN DAILY INFLOW (CFS)	1.70	1.10	0.50	0.20
MONTHLY STORAGE CHANGE	6.60	-16.50	-19.50	-26.20

DEVIL'S GATE DAM
AND RESERVOIR



PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started May 1919. Completed June 1920.
LOCATION - On Arroyo Seco, northwest of Pasadena.
DRAINAGE AREA - 31.9 square miles.
CAPACITY - 1,928 acre - feet.
SPILLWAY ELEVATION - 1,054.0 feet.



DAM OPERATION RECORD SUMMARY†

Max. Peak Inflow	25.30 CFS from 0800 on 02-17-94 to 0900 on 02-17-94
Max. Peak Outflow	25.00 CFS from 1030 on 02-17-94 to 1045 on 02-17-94
Max. Water Surface Elev.	997.80 feet on 04-26-94 STORAGE 2.80 Acre-feet
Min. Water Surface Elev.	987.00 feet on varies STORAGE 0.00 Acre-feet

† - Values estimated due to incomplete records.

DEVIL'S GATE DAM OPERATION RECORD SUMMARY†

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	82.90	93.20	172.80	140.60
TOTAL MONTHLY OUTFLOW (AF)	82.90	93.20	172.80	140.40
MAX. MEAN DAILY INFLOW (CFS)	1.50	6.20	21.30	8.10
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.30	0.00	1.30	1.30
MONTHLY STORAGE CHANGE	0.00	0.00	0.00	0.20

WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	264.20	222.00	165.20	122.20
TOTAL MONTHLY OUTFLOW (AF)	263.60	222.00	165.20	122.60
MAX. MEAN DAILY INFLOW (CFS)	20.00	12.00	10.30	4.40
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	2.10	1.90	0.00	1.80
MONTHLY STORAGE CHANGE	0.60	0.00	0.00	-0.40

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	126.10	46.80	12.20	8.10
TOTAL MONTHLY OUTFLOW (AF)	126.10	47.00	12.30	8.10
MAX. MEAN DAILY INFLOW (CFS)	5.30	1.90	0.20	0.20
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.10	0.10	0.00
MONTHLY STORAGE CHANGE	0.00	-0.20	-0.10	0.00

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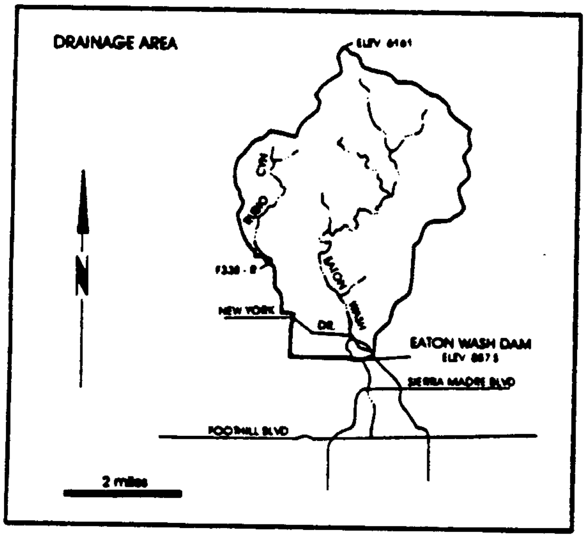
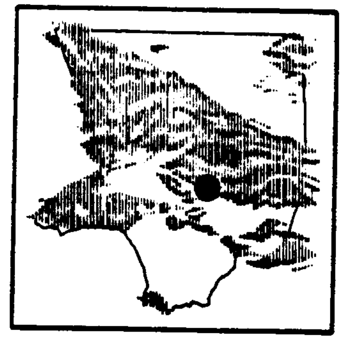
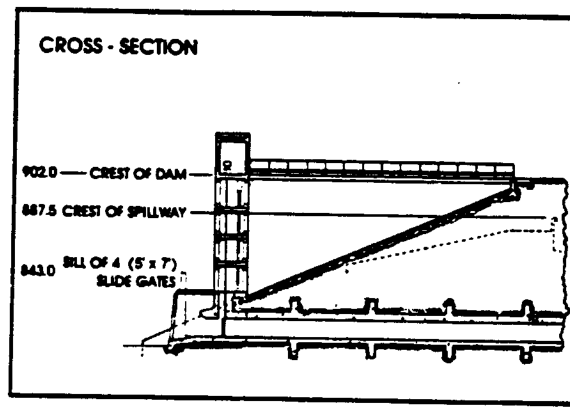
20362

EATON WASH DAM
AND RESERVOIR





PURPOSE - Debris Storage and Conservation.
DATE CONSTRUCTED - Started January 1936. Completed February 1937.
LOCATION - Eaton Wash, northeast of Pasadena.
DRAINAGE AREA - 12.4 square miles.
CAPACITY - 879 acre - feet.
SPILLWAY ELEVATION - 887.5 feet.



VOL 12

2 0363

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	50.58 CFS from 0600 on 02-08-94 to 0700 on 02-08-94
Max. Peak Outflow	17.00 CFS from 1300 on 03-07-94 to 1445 on 03-07-94
Max. Water Surface Elev.	873.16 feet on 03-27-94 STORAGE 384.90 Acre-feet
Min. Water Surface Elev.	842.00 feet on varies STORAGE 0.00 Acre-feet

R0053668

EATON WASH DAM OPERATION RECORD SUMMARY

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	61.50	75.80	139.30	155.50
TOTAL MONTHLY OUTFLOW (AF)	61.50	75.60	139.20	84.10
MAX. MEAN DAILY INFLOW (CFS)	1.00	3.00	13.20	6.90
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.00	1.00	1.30	1.40
MONTHLY STORAGE CHANGE	0.00	0.20	0.10	71.40

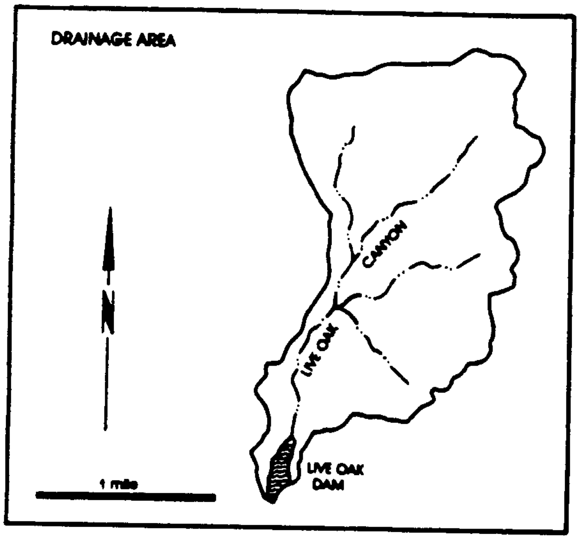
WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	264.00	176.40	127.00	75.30
TOTAL MONTHLY OUTFLOW (AF)	68.40	136.30	310.80	89.90
MAX. MEAN DAILY INFLOW (CFS)	25.90	17.90	10.60	3.70
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	3.20	45.20
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.00	0.00	0.10
MONTHLY STORAGE CHANGE	195.60	40.10	-187.00	-59.80

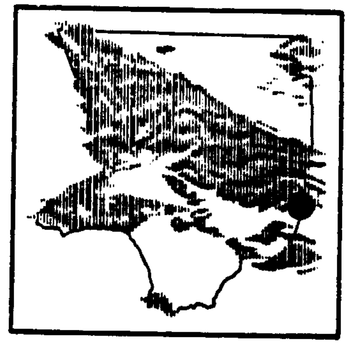
WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	25.60	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	17.90	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	1.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	68.40	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE	-60.70	0.00	0.00	0.00

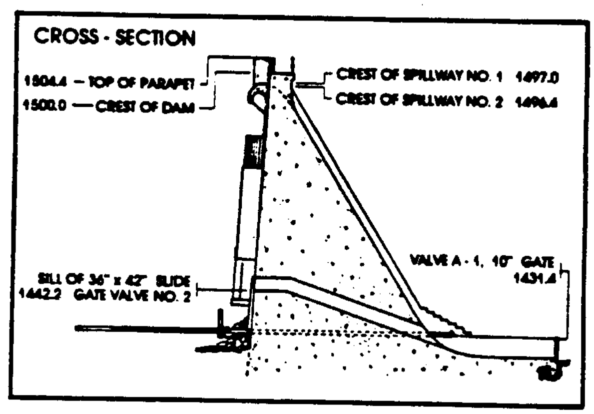
VOL 12

20364

LIVE OAK DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started August 1921. Completed November 1922.
LOCATION - 2.5 miles northeast of La Verne.
DRAINAGE AREA - 2.3 square miles.
CAPACITY - 240 acre-feet.
SPILLWAY ELEVATION - 1,496.0 feet.

VOL 12 2 0365

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	17.20 CFS from 1500 on 03-19-94 to 1600 on 03-19-94			
Max. Peak Outflow	6.30 CFS from 0500 on 05-10-94 to 0515 on 05-10-94			
Max. Water Surface Elev.	1,479.00 feet on 05-10-94	STORAGE	92.00	Acre-feet
Min. Water Surface Elev.	1,443.00 feet on varies	STORAGE	0.00	Acre-feet

VOL 12

LIVE OAK DAM OPERATION RECORD SUMMARY

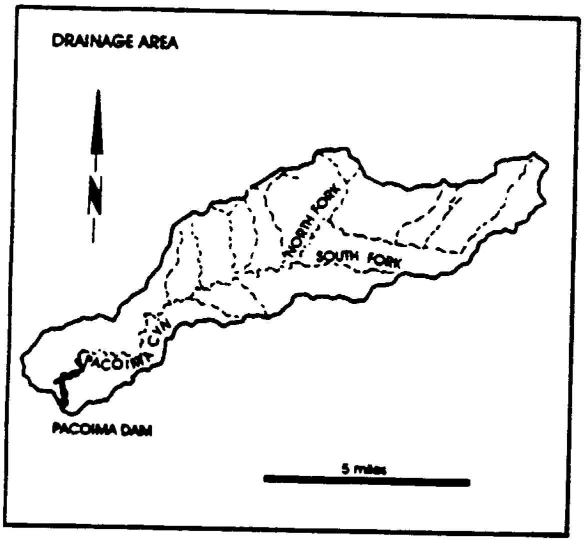
WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	24.40	17.80	19.20	16.10
TOTAL MONTHLY OUTFLOW (AF)	23.80	7.90	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.80	0.70	0.60	0.40
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.10	0.10	0.20
MONTHLY STORAGE CHANGE	0.60	9.90	19.20	16.10

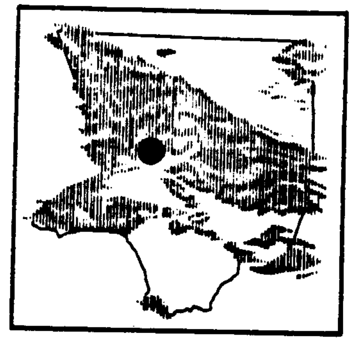
WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	27.90	37.00	27.80	29.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	33.30	17.90	120.40
MAX. MEAN DAILY INFLOW (CFS)	1.70	2.80	1.20	1.70
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.30	0.00
MONTHLY STORAGE CHANGE	27.90	3.70	9.90	-91.20

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	23.90	3.80	3.20	0.00
TOTAL MONTHLY OUTFLOW (AF)	24.40	3.80	3.20	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.60	0.20	0.10	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.10	0.00	0.00	0.00
MONTHLY STORAGE CHANGE	-0.50	0.00	0.00	0.00

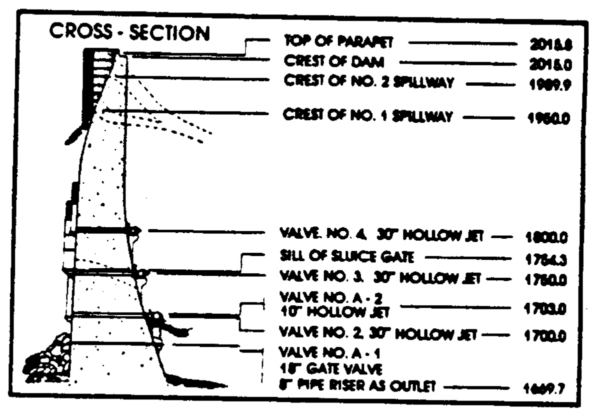
2 0366

PACOIMA DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1925. Completed February 1929.
LOCATION - Pacoima Canyon, 4.0 miles northeast of San Fernando.
DRAINAGE AREA - 28.2 square miles.
CAPACITY - 3,929 acre - feet.
SPILLWAY ELEVATION - 1,950.0 feet.



VOL 12

2 03671

DAM OPERATION RECORD SUMMARY†

Max. Peak Inflow	46.46 CFS from 0900 on 02-08-94 to 1000 on 02-08-94				
Max. Peak Outflow	82.00 CFS from 1700 on 03-25-94 to 0700 on 03-26-94				
Max. Water Surface Elev.	1,903.50 feet on	10-12-93	STORAGE	1,534.30 Acre-feet	
Min. Water Surface Elev.	1,850.00 feet on	06-30-94	STORAGE	432.30 Acre-feet	

† - Values estimated due to incomplete records.

R0053672

VOL 12

2

0368

PACOIMA DAM OPERATION RECORD SUMMARY†

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	164.10	88.20	185.60	201.20
TOTAL MONTHLY OUTFLOW (AF)	596.40	0.00	336.40	190.20
MAX. MEAN DAILY INFLOW (CFS)	5.80	2.40	8.80	10.20
TOTAL MONTHLY LOSSES (AF)	16.90	14.70	11.30	13.70
MIN. MEAN DAILY INFLOW (CFS)	0.90	1.00	0.90	1.10
MONTHLY STORAGE CHANGE	-449.20	73.50	-162.10	-2.70

WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	550.40	448.00	268.70	171.90
TOTAL MONTHLY OUTFLOW (AF)	674.40	275.10	253.70	155.30
MAX. MEAN DAILY INFLOW (CFS)	26.70	14.50	16.00	6.00
TOTAL MONTHLY LOSSES (AF)	8.60	9.40	16.30	7.50
MIN. MEAN DAILY INFLOW (CFS)	0.70	2.40	0.00	0.30
MONTHLY STORAGE CHANGE	-132.60	163.50	-1.30	9.10

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	170.00	97.20	68.70	51.10
TOTAL MONTHLY OUTFLOW (AF)	728.30	57.70	40.70	45.40
MAX. MEAN DAILY INFLOW (CFS)	13.90	4.70	6.20	2.10
TOTAL MONTHLY LOSSES (AF)	12.50	10.70	14.60	12.10
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.30	0.20	0.50
MONTHLY STORAGE CHANGE	-570.80	28.80	13.40	-6.40

PACOIMA DAM OPERATION RECORD SUMMARY†

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	164.10	88.20	185.60	201.20
TOTAL MONTHLY OUTFLOW (AF)	596.40	0.00	336.40	190.20
MAX. MEAN DAILY INFLOW (CFS)	5.80	2.40	8.80	10.20
TOTAL MONTHLY LOSSES (AF)	16.90	14.70	11.30	13.70
MIN. MEAN DAILY INFLOW (CFS)	0.90	1.00	0.90	1.10
MONTHLY STORAGE CHANGE	-449.20	73.50	-162.10	-2.70

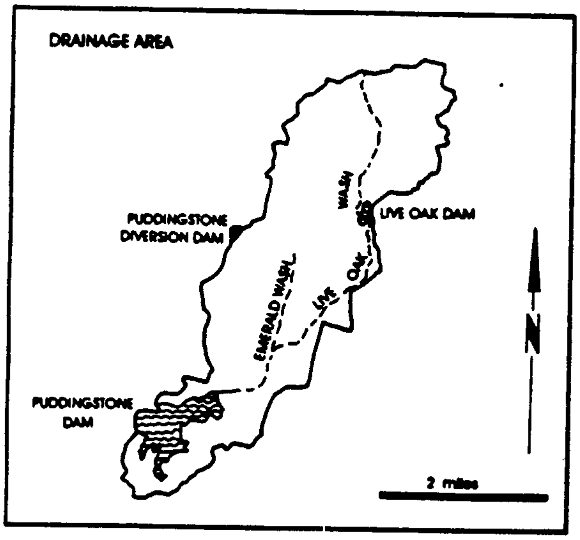
WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	550.40	448.00	268.70	171.90
TOTAL MONTHLY OUTFLOW (AF)	674.40	275.10	253.70	155.30
MAX. MEAN DAILY INFLOW (CFS)	26.70	14.50	16.00	6.00
TOTAL MONTHLY LOSSES (AF)	8.60	9.40	16.30	7.50
MIN. MEAN DAILY INFLOW (CFS)	0.70	2.40	0.00	0.30
MONTHLY STORAGE CHANGE	-132.60	163.50	-1.30	9.10

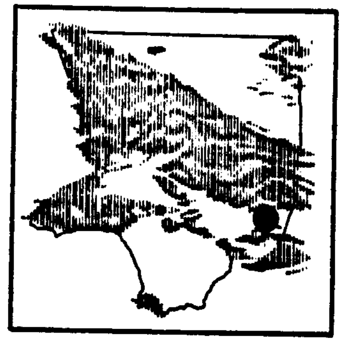
WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	170.00	97.20	68.70	51.10
TOTAL MONTHLY OUTFLOW (AF)	728.30	57.70	40.70	45.40
MAX. MEAN DAILY INFLOW (CFS)	13.90	4.70	6.20	2.10
TOTAL MONTHLY LOSSES (AF)	12.50	10.70	14.60	12.10
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.30	0.20	0.50
MONTHLY STORAGE CHANGE	-570.80	28.80	13.40	-6.40

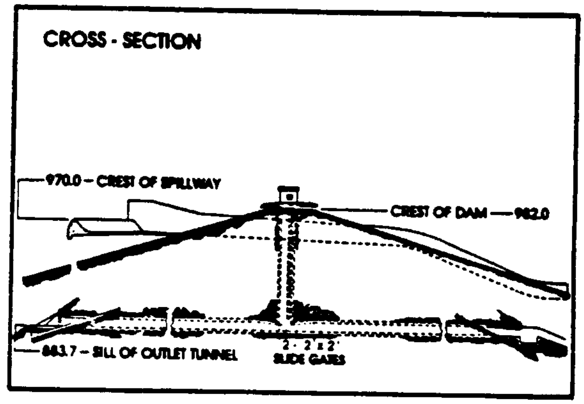
VOL 12

2 0369

PUDDINGSTONE DAM
AND RESERVOIR







PURPOSE - Flood Control and Recreation.
DATE CONSTRUCTED - Started February 1925. Completed January 1928.
LOCATION - 1.0 mile south of San Dimas.
DRAINAGE AREA - 11.0 square miles (uncontrolled)
22.1 square miles (controlled)
Total 33.1 square miles
CAPACITY - 16,856 acre - feet.
SPILLWAY ELEVATION - 970.0 feet.

VOL 12

2 0370

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	212.22 CFS from 1400 on 02-07-94 to 1500 on 02-07-94
Max. Peak Outflow	42.70 CFS from 0900 on 04-06-94 to 1000 on 04-06-94
Max. Water Surface Elev.	943.30 feet on 05-03-94 STORAGE 6,899.00 Acre-feet
Min. Water Surface Elev.	938 88 feet on varies STORAGE 5,795.30 Acre-feet

VOL 12

2 0371

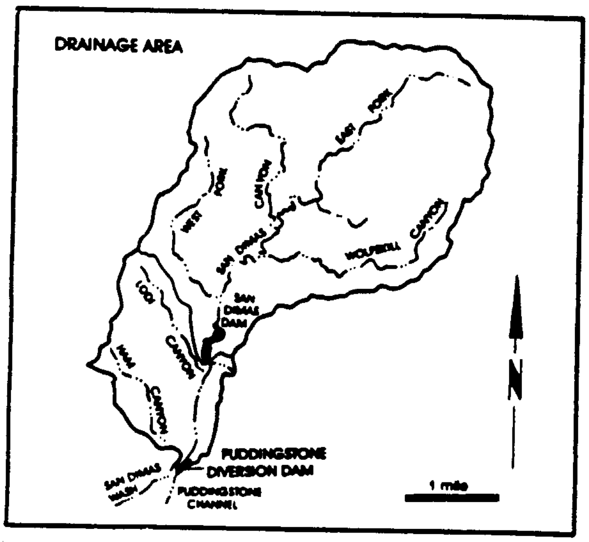
PUDDINGSTONE DAM OPERATION RECORD SUMMARY

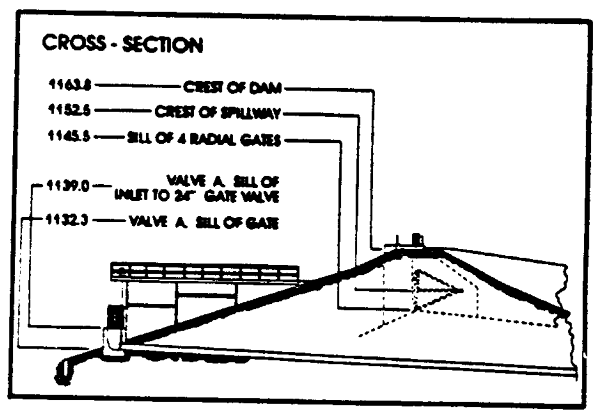
WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	84.80	119.30	278.30	136.30
TOTAL MONTHLY OUTFLOW (AF)	25.60	15.70	653.40	6.70
MAX. MEAN DAILY INFLOW (CFS)	3.40	7.20	27.50	12.60
TOTAL MONTHLY LOSSES (AF)	118.70	88.80	74.90	68.80
MIN. MEAN DAILY INFLOW (CFS)	0.40	0.10	0.60	0.50
MONTHLY STORAGE CHANGE	-59.50	14.80	-450.00	60.80

WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	645.70	567.20	435.50	160.70
TOTAL MONTHLY OUTFLOW (AF)	9.90	95.40	216.20	188.60
MAX. MEAN DAILY INFLOW (CFS)	77.60	60.70	63.40	13.70
TOTAL MONTHLY LOSSES (AF)	49.10	92.30	144.50	107.80
MIN. MEAN DAILY INFLOW (CFS)	0.60	0.90	0.10	0.50
MONTHLY STORAGE CHANGE	586.70	379.50	74.80	-135.70

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	111.10	115.70	115.30	113.70
TOTAL MONTHLY OUTFLOW (AF)	24.80	28.20	31.10	26.60
MAX. MEAN DAILY INFLOW (CFS)	3.60	4.10	4.10	5.20
TOTAL MONTHLY LOSSES (AF)	190.40	196.30	214.70	165.20
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.70	0.50	0.40
MONTHLY STORAGE CHANGE	-104.10	-108.80	-130.50	-78.10

PUDDINGSTONE DIVERSION DAM
AND RESERVOIR





PURPOSE - Flood Control and Diversion of flow and Conservation.
DATE CONSTRUCTED - Started September 1927. Completed July 1928.
LOCATION - 2.0 miles northeast of San Dimas.
DRAINAGE AREA - 3.7 square miles (uncontrolled)
16.2 square miles (controlled)
Total 19.9 square miles
CAPACITY - 148 acre feet.
SPILLWAY ELEVATION - 1,152.0 feet.

VOL 12 2 03772

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	23.41 CFS from 1300 on 02-07-94 to 1400 on 02-07-94				
Max. Peak Outflow	15.00 CFS from 1300 on 02-22-94 to 1400 on 02-07-94				
Max. Water Surface Elev.	1,140.80 feet on	11-02-93	STORAGE	54.50 Acre-feet	
Min. Water Surface Elev.	1,133.00 feet on	varies	STORAGE	0.00 Acre-feet	

VOL 12

PUDD. DIVERSION DAM OPERATION RECORD SUMMARY

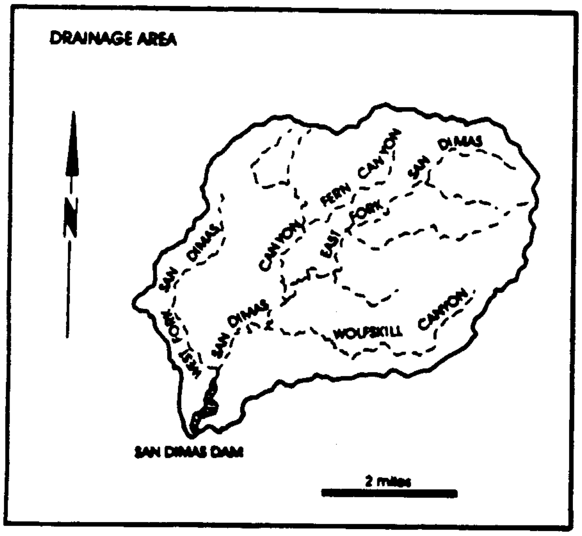
WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	22.60	125.10	157.90	46.20
TOTAL MONTHLY OUTFLOW (AF)	0.00	171.80	167.00	24.80
MAX. MEAN DAILY INFLOW (CFS)	2.60	7.20	10.50	2.70
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.80	0.80
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.10	0.10
MONTHLY STORAGE CHANGE	22.60	-46.70	-9.90	20.60

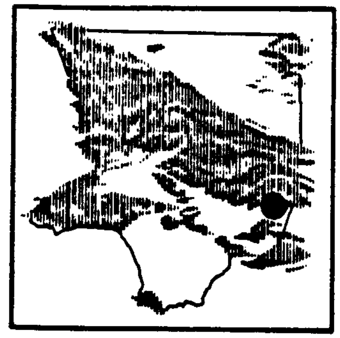
WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	450.00	139.40	19.20	10.00
TOTAL MONTHLY OUTFLOW (AF)	449.10	148.80	24.40	12.30
MAX. MEAN DAILY INFLOW (CFS)	13.70	10.70	1.20	0.90
TOTAL MONTHLY LOSSES (AF)	0.10	0.00	0.40	4.40
MIN. MEAN DAILY INFLOW (CFS)	0.20	0.00	0.00	0.00
MONTHLY STORAGE CHANGE	0.80	-6.40	-5.60	-6.70

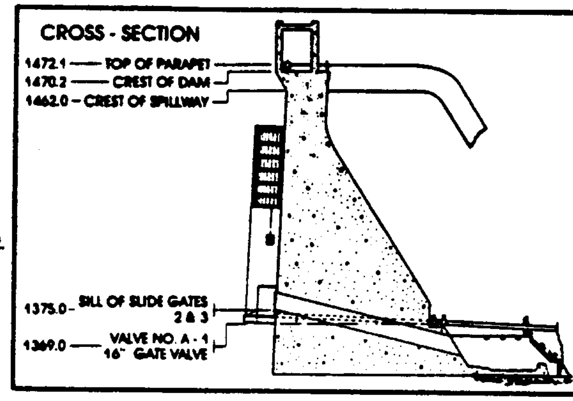
WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	365.20	123.60	13.80	1.80
TOTAL MONTHLY OUTFLOW (AF)	343.10	133.10	14.30	1.80
MAX. MEAN DAILY INFLOW (CFS)	11.90	13.10	0.60	0.70
TOTAL MONTHLY LOSSES (AF)	0.00	11.90	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.80	0.10	0.00	0.00
MONTHLY STORAGE CHANGE	22.10	-21.40	-0.50	0.00

2 0373

SAN DIMAS DAM
AND RESERVOIR







PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started November 1920. Completed September 1922.
LOCATION - 3.0 miles northeast of San Dimas.
DRAINAGE AREA - 16.2 square miles.
CAPACITY - 1,515 acre - feet.
SPILLWAY ELEVATION - 1,462.0 feet.

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	30.58 CFS from 1600 on 02-07-94 to 1700 on 02-07-94
Max. Peak Outflow	130.00 CFS from 0800 on 10-27-93 to 0815 on 10-27-93
Max. Water Surface Elev.	1,444.10 feet on 05-31-94 STORAGE 961.90 Acre-feet
Min. Water Surface Elev.	1,418.50 feet on 09-30-94 STORAGE 318.80 Acre-feet

VOL 12 2 0374

SAN DIMAS DAM OPERATION RECORD SUMMARY

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	199.60	199.10	242.60	224.40
TOTAL MONTHLY OUTFLOW (AF)	151.50	229.70	241.20	95.40
MAX. MEAN DAILY INFLOW (CFS)	4.40	4.60	7.90	6.00
TOTAL MONTHLY LOSSES (AF)	7.70	4.20	3.30	4.40
MIN. MEAN DAILY INFLOW (CFS)	2.10	1.90	1.60	2.80
MONTHLY STORAGE CHANGE	40.40	-34.80	-1.90	124.60

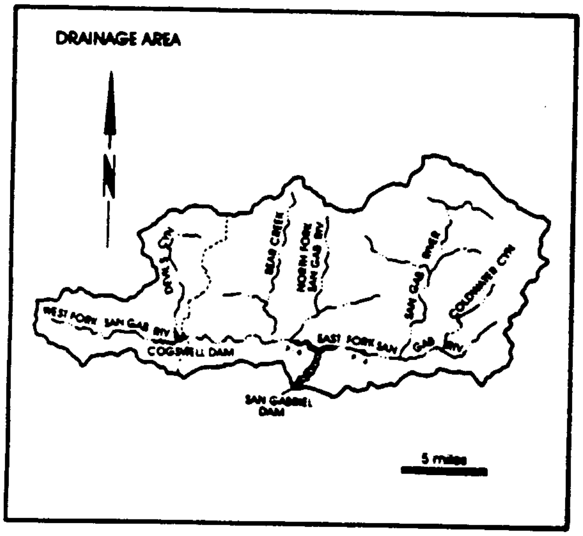
WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	332.30	312.60	250.80	212.50
TOTAL MONTHLY OUTFLOW (AF)	469.90	159.50	79.50	87.50
MAX. MEAN DAILY INFLOW (CFS)	17.30	10.30	7.70	4.60
TOTAL MONTHLY LOSSES (AF)	3.20	5.70	8.00	7.80
MIN. MEAN DAILY INFLOW (CFS)	2.80	3.60	3.20	2.20
MONTHLY STORAGE CHANGE	-140.80	147.40	163.30	117.20

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	141.20	99.00	34.00	46.60
TOTAL MONTHLY OUTFLOW (AF)	494.50	242.20	103.70	69.20
MAX. MEAN DAILY INFLOW (CFS)	3.40	5.20	1.20	1.20
TOTAL MONTHLY LOSSES (AF)	15.30	13.50	14.90	9.70
MIN. MEAN DAILY INFLOW (CFS)	1.10	0.20	0.20	0.30
MONTHLY STORAGE CHANGE	-368.60	-156 70	-84.60	-32.30

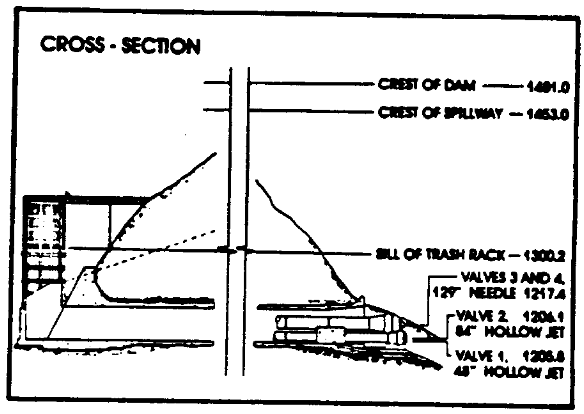
VOL 12

2 0375

SAN GABRIEL DAM
AND RESERVOIR



PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started December 1932. Completed July 1939.
LOCATION - San Gabriel Canyon, 7.5 miles north of Azusa.
DRAINAGE AREA - 163.5 square miles (uncontrolled)
39.2 square miles (controlled)
Total 202.7 square miles
(includes Cogswell drainage)
CAPACITY - 41,549 acre - feet.
SPILLWAY ELEVATION - 1,453 feet.



DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	433.41 CFS from 0500 on 02-08-94 to 0600 on 02-08-94
Max. Peak Outflow	387.30 CFS from 0800 on 12-01-93 to 1500 on 12-01-93
Max. Water Surface Elev.	1,391.67 feet on 05-29-94 STORAGE 19,389.00 Acre-feet
Min. Water Surface Elev.	1,336.54 feet on 09-30-94 STORAGE 5,083.00 Acre-feet

SAN GABRIEL DAM OPERATION RECORD SUMMARY

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	4,989.10	3,450.20	4,892.20	3,238.10
TOTAL MONTHLY OUTFLOW (AF)	9,418.70	3,526.60	4,710.70	3,281.30
MAX. MEAN DAILY INFLOW (CFS)	101.10	73.30	147.00	73.70
TOTAL MONTHLY LOSSES (AF)	135.10	97.40	70.60	86.20
MIN. MEAN DAILY INFLOW (CFS)	54.90	7.10	49.70	44.50
MONTHLY STORAGE CHANGE	-4,564.70	-173.80	110.90	-129.40

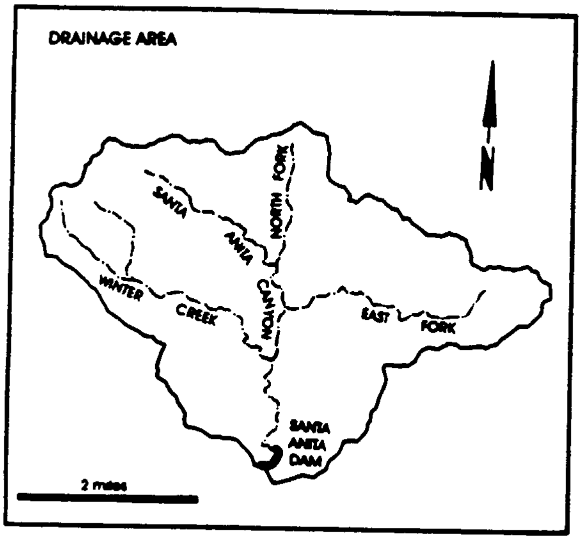
WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	6,421.90	8,052.50	5,206.90	3,729.20
TOTAL MONTHLY OUTFLOW (AF)	2,125.50	4,131.20	2,700.90	2,877.60
MAX. MEAN DAILY INFLOW (CFS)	312.30	173.10	144.60	96.90
TOTAL MONTHLY LOSSES (AF)	52.50	109.60	122.60	84.70
MIN. MEAN DAILY INFLOW (CFS)	54.60	88.20	62.20	38.40
MONTHLY STORAGE CHANGE	4,243.90	3,811.70	2,383.40	766.90

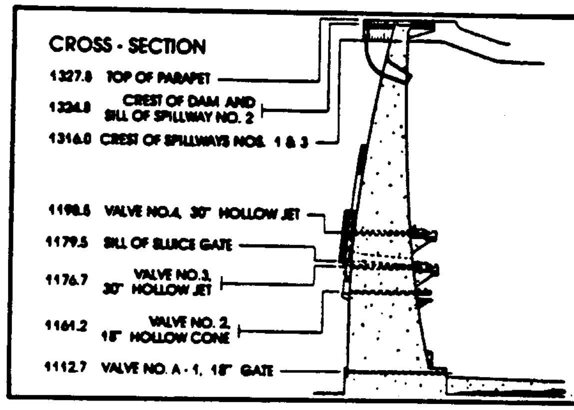
WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	1,872.80	1,181.50	617.70	616.90
TOTAL MONTHLY OUTFLOW (AF)	4,871.20	4,897.20	4,886.90	3,012.90
MAX. MEAN DAILY INFLOW (CFS)	45.20	25.30	18.50	16.20
TOTAL MONTHLY LOSSES (AF)	235.20	202.40	190.10	150.80
MIN. MEAN DAILY INFLOW (CFS)	20.10	14.20	0.60	5.40
MONTHLY STORAGE CHANGE	-3,233.60	-3,918.10	-4,459.30	-2,546.80

VOL 12

20377

SANTA ANITA DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started October 1924. Completed March 1927.
LOCATION - 2.5 miles north of Arcadia
DRAINAGE AREA - 10.8 square miles.
CAPACITY - 836 acre - feet.
SPILLWAY ELEVATION - 1,316.0 feet.

VOL 12
2
0378

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	19.07 CFS from 2000 on 03-24-94 to 2100 on 03-24-94
Max. Peak Outflow	146.00 CFS from 0845 on 05-26-94 to 0900 on 05-26-94
Max. Water Surface Elev.	1,277.90 feet on 04-18-94 STORAGE 388.30 Acre-feet
Min. Water Surface Elev	1,238 55 feet on 12-30-93 STORAGE 112.80 Acre-feet

VOL 12

SANTA ANITA DAM OPERATION RECORD SUMMARY

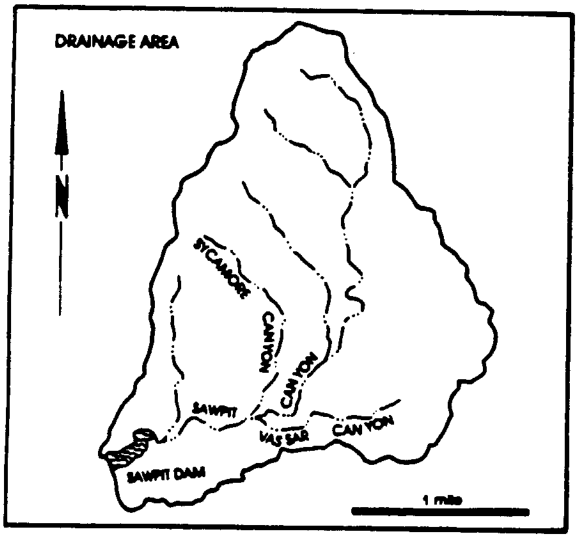
WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	125.30	130.50	150.70	146.30
TOTAL MONTHLY OUTFLOW (AF)	191.40	23.20	297.70	17.30
MAX. MEAN DAILY INFLOW (CFS)	3.20	3.20	4.30	4.00
TOTAL MONTHLY LOSSES (AF)	2.80	2.20	1.70	1.80
MIN. MEAN DAILY INFLOW (CFS)	0.20	1.70	0.80	1.90
MONTHLY STORAGE CHANGE	-68.90	105.10	-148.70	127.20

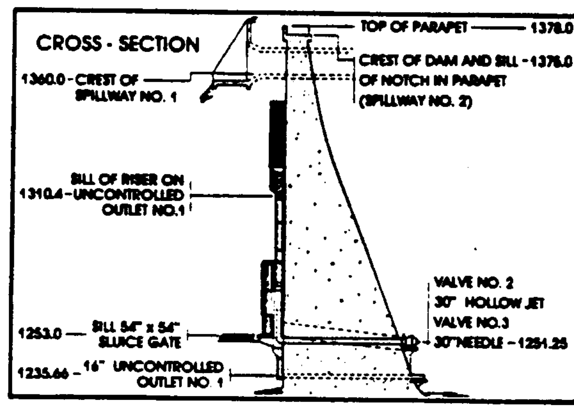
WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	283.80	232.90	143.20	172.00
TOTAL MONTHLY OUTFLOW (AF)	301.90	149.00	156.30	315.20
MAX. MEAN DAILY INFLOW (CFS)	15.10	8.20	4.10	5.10
TOTAL MONTHLY LOSSES (AF)	1.00	1.70	1.90	6.20
MIN. MEAN DAILY INFLOW (CFS)	0.80	2.10	1.60	1.60
MONTHLY STORAGE CHANGE	-19.10	82.20	-15.00	-149.40

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	51.50	21.30	11.60	5.90
TOTAL MONTHLY OUTFLOW (AF)	37.70	14.30	30.70	29.80
MAX. MEAN DAILY INFLOW (CFS)	1.90	0.60	0.60	0.20
TOTAL MONTHLY LOSSES (AF)	2.50	2.60	3.50	2.80
MIN. MEAN DAILY INFLOW (CFS)	0.30	0.00	0.00	0.00
MONTHLY STORAGE CHANGE	11.30	4.40	-22.60	-26.70

2 0379

SAWPIT DAM
AND RESERVOIR





PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started March 1926. Completed June 1927.
LOCATION - 2.0 miles north of Monrovia.
DRAINAGE AREA - 3.2 square miles.
CAPACITY - 391 acre - feet.
SPILLWAY ELEVATION - 1,360.0 feet.

VOL 12

2

0380

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	6.77 CFS from 0500 on 02-08-94 to 0600 on 02-08-94			
Max. Peak Outflow	29.70 CFS from 0815 on 06-22-94 to 0830 on 06-22-94			
Max. Water Surface Elev.	1,310.54 feet on	02-08-94	STORAGE	96.70 Acre-feet
Min. Water Surface Elev.	1,310.30 feet on	varies	STORAGE	95.90 Acre-feet

VOL 12

SAWPIT DAM OPERATION RECORD SUMMARY

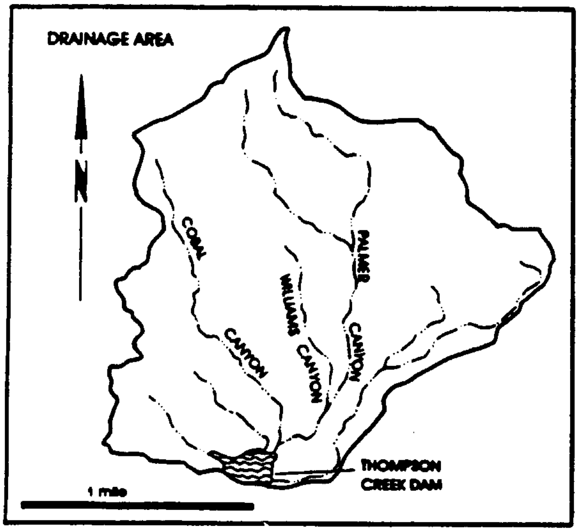
WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	149.00	142.70	147.80	145.20
TOTAL MONTHLY OUTFLOW (AF)	149.00	142.60	147.80	145.20
MAX. MEAN DAILY INFLOW (CFS)	2.60	3.00	2.90	3.10
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	2.20	2.30	2.30	2.20
MONTHLY STORAGE CHANGE	0.00	0.10	0.00	0.00

WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	144.80	149.60	133.30	130.80
TOTAL MONTHLY OUTFLOW (AF)	144.80	149.60	133.30	130.70
MAX. MEAN DAILY INFLOW (CFS)	4.10	3.40	2.60	2.60
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	2.30	2.10	2.10	1.90
MONTHLY STORAGE CHANGE	0.00	0.00	0.00	0.10

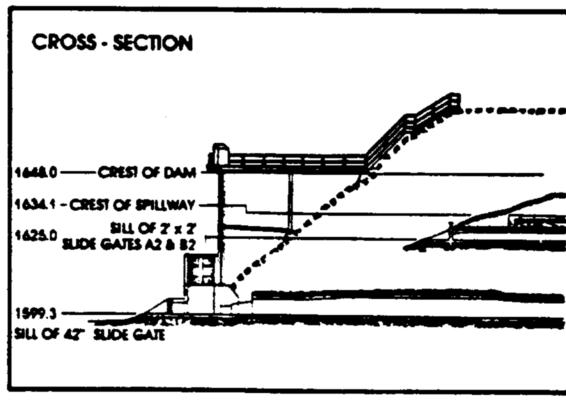
WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	108.40	108.10	97.40	98.20
TOTAL MONTHLY OUTFLOW (AF)	108.70	108.10	97.40	98.20
MAX. MEAN DAILY INFLOW (CFS)	2.20	1.80	1.70	1.80
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	1.60	1.70	1.50	1.40
MONTHLY STORAGE CHANGE	-0.30	0.00	0.00	0.00

2 0381

THOMPSON CREEK DAM
AND RESERVOIR



PURPOSE - Flood Control and Conservation.
DATE CONSTRUCTED - Started September 1925. Completed March 1928.
LOCATION - 3.0 miles north of Claremont.
DRAINAGE AREA - 3.5 square miles.
CAPACITY - 447.5 acre - feet.
SPILLWAY ELEVATION - 1,634 feet.



VOL 12

2 0382

DAM OPERATION RECORD SUMMARY

Max. Peak Inflow	1.20 CFS from 1300 on 03-19-94 to 1400 on 03-19-94
Max. Peak Outflow	1.20 CFS from 1400 on 03-19-94 to 1415 on 03-19-94
Max. Water Surface Elev.	1,600.00 feet on varies STORAGE 0.00 Acre-feet
Min. Water Surface Elev.	1,600.00 feet on varies STORAGE 0.00 Acre-feet

VOL 12

THOMPSON CREEK DAM OPERATION RECORD SUMMARY

WATER YEAR 1993-1994	OCTOBER	NOVEMBER	DECEMBER	JANUARY
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE	0.00	0.00	0.00	0.00

WATER YEAR 1993-1994	FEBRUARY	MARCH	APRIL	MAY
TOTAL MONTHLY INFLOW (AF)	0.20	0.20	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.20	0.20	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.10	0.10	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE	0.00	0.00	0.00	0.00

WATER YEAR 1993-1994	JUNE	JULY	AUGUST	SEPTEMBER
TOTAL MONTHLY INFLOW (AF)	0.00	0.00	0.00	0.00
TOTAL MONTHLY OUTFLOW (AF)	0.00	0.00	0.00	0.00
MAX. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
TOTAL MONTHLY LOSSES (AF)	0.00	0.00	0.00	0.00
MIN. MEAN DAILY INFLOW (CFS)	0.00	0.00	0.00	0.00
MONTHLY STORAGE CHANGE	0.00	0.00	0.00	0.00

2 0383

VOL 12

2

0384

EROSION CONTROL

EROSION CONTROL

Each year eroded material in various forms (trees, rock, sand, etc.) flows out of the mountain watersheds of Los Angeles County. In an effort to control this potentially disruptive force, the Department maintains a series of debris basins in canyon mouths and upstream stabilization structures in selected watersheds.

DEBRIS BASINS

The purpose of a debris basin is to entrap the sediment flows emanating from the canyon and let the relatively desilted water pass into the flood control channels.

In the 1993-1994 water year, the Department maintained 114 debris basins. The total maximum capacity of the basins is approximately 7,549,350 cubic yards.

The Department cleaned out 13 debris basins (Auburn, Bailey, Carriage House, Carter, Devonwood, Fair Oaks, Fern, Kinneloa West, Rubio, Sierra Madre Villa, Sunnyside, and West Ravine). The total amount of sediment removed was approximately 371,050 cubic yards.

Records of sediment inflow at individual debris basins and amounts removed from the debris basins are available in the Hydraulic/Water Conservation Division.

STABILIZATION STRUCTURES

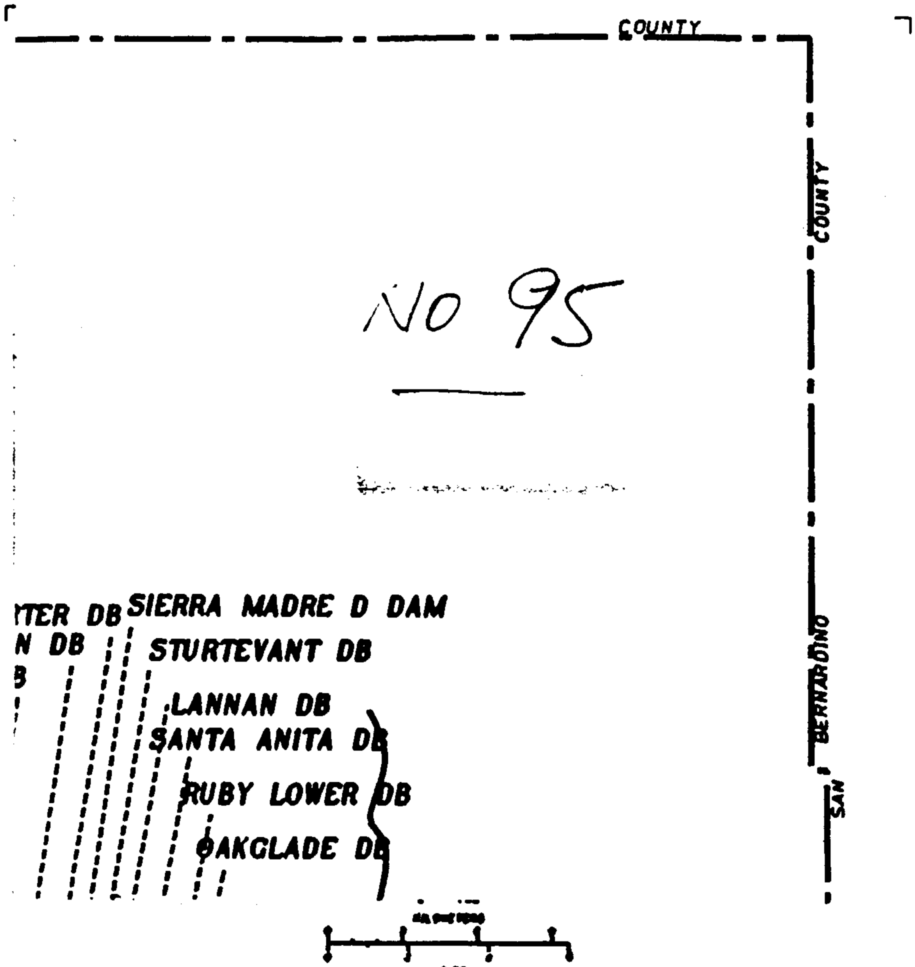
Stabilization structures are constructed to control erosion in natural canyons. They serve to prevent downcutting by stabilizing alluvium deposits. In addition, they store debris generated by the watershed and serve to stabilize side banks, reducing side slope sloughing and bank erosion.

The Department maintains 218 stabilization structures in 47 major watersheds. No structures have been constructed since the 1973-74 water year.

EMERGENCY STRUCTURES

Emergency structures (rail and timber, crib structures are not) have been constructed to entrap the debris inflow from burned watersheds. They serve to protect improvements (road, channel, residence, etc.) located immediately downstream of the watersheds. Currently, 33 emergency structures exist with a total maximum capacity of 266,400 cubic yards. Eight major fires (over 500 acres) burned 31,331 acres in this water year and are shown on the Burned Area Location Map on page PE2.

NO 95



MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN LOCATIONS ▲

UPDATED AUG. 28, 1995

VOL 12

2

03886

PE1

R0053691

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN - DESIGN DATA

Including 1993-1994 Storm Season

DATA SHEET A

Compiled by: Hydraulic and Water Conservation
Division - Sedimentation Management
Date: November 30, 1994
FILE: DBA94.xlw

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN (SQ. MI.)	BOTTOM ELEV. AT MAX CAP. (FT.)	ELEVATION PORT INVERT (FT.)	ELEVATION SPILLWAY CREST (FT.)	WIDTH SPILLWAY (FT.)	ELEVATION CREST OF DAM (FT.)	MAXIMUM DEBRIS CAPACITY (CU. YDS.)
Aliso	1970 - 71	2.77	1108	1108.4	1120.0	70.0	1134.0	41,700 (8)
Arbor Dell	1971 - 72	0.11	898.7	898.4	913.0	22.8	919.6	12,400
Auburn	1954 - 55	0.19	1263.9	1263.0	1275.0	30.0	1283.0	31,800
Bailey	1945 - 46	0.60	1123	1123.1	1155.0	30.0	1166.0	128,800
Beatty	1970 - 71	0.27	800	800.0	807.0	32.0	815.5	43,000
Bigbriar	1971 - 72	0.02	1898.3	1896.0	1910.0	14.0	1910.8	2,800
Big Dalton	1959 - 60	2.94	1102	1101.9 (3)	1131.5	116.0	1146.7	517,800
Blanchard	1968 - 69	0.47	2026	2026.0	2053.5	40.0	2065.0	74,500
Blue Gum	1968 - 69	0.19	2020	2020.0	2042.0	25.0	2053.0	39,800
Brace	1971 - 72	0.29	1189.7	1189.7	1198.0 (15)	20.0	1203.3	30,000 (15)
Bracemar	1971 - 72	0.01	1140	1140.0	1145.5	8.0	1148.0	700 (14)
Bradbury	1954 - 55	0.68	912.5	913.1	920.0	58.0	928.0	89,800
Brand	1935 - 36	1.04	860	860.0	890.0	60.0	903.0	166,000
Buena Vista	1985 - 86	0.10	978.7	978.7	992.2	39.0	997.7	21,800
Carriage House	1970 - 71	0.03	1350.2	1350.0	1362.9	15.0	1366.8	6,100
Carter	1954 - 55	0.12	1222	1223.2	1238.2	30.0	1245.0	14,500
Cassara	1976 - 77	0.21	1271.5	1271.5	1291.7	66.0	1295.4	36,700
Chamberlain	1974 - 75	0.04	1084.6	1084.0	1097.5	20.0	1101.3	4,700
Childs	1963 - 64	0.30	1022	1022.0	1058.8	23.0	1071.0	50,400
Cloud Creek	1972 - 73	0.01	2350.5	2350.5	2360.0	(5)	2362.0	5,100
Cloudcroft	1973 - 74	0.21	313.9	315.0	329.5	36.0	329.5	34,700
Cooks	1951 - 52	0.58	2058	2058.0	2082.9	46.0	2092.0	51,900
Cooks M-1A	1975 - 76	(13)	2120.0	(10)	2142.4	(10)	(10)	33,700
Crestview	1983 - 84	0.03	864.4	864.0	886.2	20.0	891.7	5,900 (14)
Crocker	1983 - 84	0.67	1064.2	1064.2	1069.8	36.0	1077.0	19,300 (14)
Deer	1954 - 55	0.59	1185.4	1185.0	1201.0	56.0	1209.6	56,600
Denivelle	1976 - 77	0.18	1471	1471.0	1479.3	46.0	1483.3	8,200
Devonwood	1981 - 82	0.03	1899	1899.0	1915.8	22.0	1921.5	5,800
Dry Canyon-South Fork	1978 - 79	0.49	1062.8	1062.5	1074.8	32.0	1079.3	7,900
Dunsmuir	1935 - 36	0.84	2228	2227.7	2257.2	60.0	2272.2	102,700
Eagle	1936 - 37	0.48	1848.3	1848.3	1880.2	60.0	1895.2	62,400
Elmwood	1964 - 65	0.31	912	911.5	938.0	22.0	952.0	66,400
Emerald-East	1964 - 65	0.32	1184.7	1181.1	1192.0	30.0	1204.0	13,600
Englewld	1961 - 62	0.44	1274.9	1275.0	1297.0	50.0	1300.0	40,600
Fair Oaks	1935 - 36	0.21	1544	1544.0	1561.9	(6)	1566.5	23,800
Fern	1935 - 36	0.31	1,440 (15)	1,440 (15)	1,476 (15)	25 (15)	1,482 (15)	43,200 (15)
Fieldbrook	1974 - 75	0.35	712.7	713.0	718.0	28.0	722.3	2,800
Golf Club Drive	1970 - 71	0.99	880.7	880.7	902.0	36.7	915.0	14,700

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN - DESIGN DATA

Including 1993-1994 Storm Season

DATA SHEET A

Compiled by: Hydraulic and Water Conservation
Division - Sedimentation Management
Date: November 30, 1994
FILE: DSA94.xlw

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN (SQ. MI.)	BOTTOM ELEV. AT MAX CAP. (FT.)	ELEVATION PORT INVERT (FT.)	ELEVATION SPILLWAY CREST (FT.)	WIDTH SPILLWAY (FT.)	ELEVATION CREST OF DAM (FT.)	MAXIMUM DEBRIS CAPACITY (CU. YDS.)
Gordon	1973 - 74	0.18	1075.7	1075.0	1096.0 (15)	22.0	1104.5 (15)	33,100 (15)
Gould	1947 - 48	0.36	1529.5	1528.2	1548.0	55.0	1548.0	52,800
Gould (Upper)	1976 - 77	0.18	1863.9	1863.9	1897.7	32.0	1901.0	52,300
Halls	1935 - 36	0.86	1641.6	1641.8	1661.3	131.0	1664.0	89,400
Harrow	1958 - 59	0.43	1254.8	1255.0	1269.0	40.0	1277.8	68,000
Haven Way	1991 - 92	0.13	1323	1323.0	1329.0	20.0	1335.6	38,200
Hay	1936 - 37	0.20	1875.4	1901.0	1905.0	36.0	1915.0	34,400
Hillcrest	1962 - 63	0.35	863.5	863.5	885.0	18.0	901.0	57,800
Hog	1969 - 70	0.33	1520.1	1520.0	1535.0	32.0	1547.0	39,600
Hook East	1968 - 69	0.18	1197.5	1198.0	1210.9	37.0	1215.0	22,300
Hook West	1970 - 71	0.17	1144.8	1145.0	1158.9	40.0	1167.0	21,600
Inverness	1982 - 83	0.03	1253	1252.9	1256.7	20.0	1261.0	3,300
Irving Drive	1974 - 75	0.03	905.8	905.0	915.3	12.0	920.0	1,200
Kinneloa	1964 - 65	0.20	1370	1370.0	1388.0	40.0	1395.0	14,100
Kinneloa - West	1966 - 67	0.19	1384.9	1385.0	1400.0	22.0	1408.5	14,200
Lannan	1954 - 55	0.25	1016.0	1015.0	1035.8	14.0	1043.0	41,400
La Tuna	1955 - 56	5.34	1109.0	1110.0	1140.0	75.0	1157.0	495,300
Las Flores	1935 - 36	0.45	1685.1	(9)	1715.6	50.0	1726.4	55,800
Las Lomas	1983 - 84	0.07	887.0 (15)	887.0 (15)	906.0 (15)	77.0 (15)	908.5 (15)	17,900 (15)
Limekiln	1963 - 64	3.72	992.0	992.0	1003.0	77.0	1019.0	171,600
Lincoln	1935 - 36	0.50	1275.8	1276.0	1304.0	56.0	1322.5	38,400
Linda Vista	1970 - 71	0.37	979.5	979.5	989.8	40.0	995.7	3,200
Little Dalton	1959 - 60	3.31	1140.0	1139.5	1186.0	84.0	1200.2	660,500
Maddock	1954 - 55	0.26	888.6	891.8	901.0	36.0	904.0	45,000
Marston/Paragon	1988 - 89	0.20	1455.6	1455.6	1460.0	20.0	1466.0	6,000
May No. 1	1953 - 54	0.70	1666.0	1666.0	1684.0	60.0	1692.5	64,000
May No. 2	1953 - 54	0.09	1663.4	1663.5 (2)	1669.5	20.0	1674.0	13,400 (17)
Monument	1981 - 82	0.11	943.8	942.3	950.0	12.0	954.0	6,800
Morgan	1964 - 65	0.60	1135.0	1135.0	1161.9 (15)	45.0	1171.5 (15)	76,800 (15)
Mountbatten	1983 - 84	0.01	1136.2	1135.5	1140.9	20.0	1141.0	1,400
Mull	1973 - 74	0.15	1146.9	1147.0	1154.0	20.0	1165.0	12,500
Mullally (11)	1974 - 75	0.34	2420.0	2420.0	2435.4	42.0	2439.6	9,400
Nichols	1937 - 38	0.94	480.5	481.0	485.1	50.0	495.0	14,100
Oak	1975 - 76	0.05	2145.4	2145.7	2151.8	50.0	2156.2	12,000 (15)
Oakglade	1974 - 75	0.06	1274.6	1280.0	1290.0	20.0	1296.0	7,250
Oakmont View Drive	1984 - 85	0.02	1315.5	1315.5	1327.5	20.0	1327.5	3,400
Oliver	1989 - 90	0.18	1258.0	1258.0	1278.3	41.0	1283.3	32,100
Pickens	1935 - 36	1.50	1563.6	1564.0	1600.0	123.0	1613.0	125,100

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN - DESIGN DATA

Including 1993-1994 Storm Season

DATA SHEET A

Compiled by: Hydraulic and Water Conservation
Division - Sedimentation Management
Date: November 30, 1994
FILE: DBA94.xlw

DEBRIS BASIN	FIRST DEBRIS SEASON	UNCONTROLLED DRAINAGE AREA ABOVE BASIN (SQ. MI.)	BOTTOM ELEV. AT MAX CAP. (FT.)	ELEVATION PORT INVERT (FT.)	ELEVATION SPILLWAY CREST (FT.)	WIDTH SPILLWAY (FT.)	ELEVATION CREST OF DAM (FT.)	MAXIMUM DEBRIS CAPACITY (CU. YDS.)
Pinelawn	1973 - 74	0.02	2431.0	2430.5	2443.0	(7)	2448.5	3,200
Rowley	1953 - 54	0.21	1703.6	1703.6	1714.0	60.0	1722.0	43,100
Rowley (Upper)	1976 - 77	0.31	1926.0	1926.0	1946.0	42.0	1951.3	28,800
Rubio	1943 - 44	1.26	1582.1	1582.1	1608.3	59.0	1625.5	127,200
Ruby (Lower)	1955 - 56	0.28	810.8	809.6	828.0	45.0	833.0	28,900
Rye	1961 - 82	1.11	1073.9	1073.8	1077.7	68.2	1081.5	19,100
Saddleback	1988 89	0.04	1779.0	1779.3	1790.0	(10)	1796.0	27,000
Santa Anita	1959 - 60	1.70	748.5	748.5 (3)	774.7	160.0	796.0	394,600
Sawpit	1954 - 55	2.82	930.3	930.3	982.0	110.0	1000.0	635,700
Scholl	1945 - 46	0.16	950.0	950.0 (2)	956.0	76.0	966.0	9,300
Schoolhouse	1962 - 63	0.28	1459.6	1460.0	1478.5	20.0	1491.0	67,700
Schwartz	1976 - 77	0.25	1294.7	1294.7	1313.2	35.0	1319.0	45,400
Shields	1937 - 38	0.06	2030.0	2050.0	2058.1	30.0	2070.2	34,800
Sierra Madre Dam (12)	1927 - 28	2.39	1119.6	1119.5	1172.5	82.5	1175.0	136,400
Sierra Madre Villa	1957 - 58	1.46	1069.2	1069.2	1088.9	48.0	1102.5	402,300
Snover	1936 - 37	0.21	1862.8	1862.7	1879.0	40.0	1893.7	24,800
Sombrero	1969 - 70	1.06	1539.6	1540.0	1564.8	45.0	1580.0	87,900
Spinks	1958 - 59	0.44	750.0	750.0	761.5	40.0	765.9	58,000
Starfall	1973 - 74	0.13	2428.0	2428.0	2441.5	30.0	2446.5	14,900
Stetson	1969 - 70	0.29	1556.0	1555.0	1570.0	32.0	1570.0	41,300
Stough	1940 - 41	1.65	1006.0	1005.8	1031.5 (4)	100.0	1043.5	180,600
Sturtevant	1967 - 68	0.03	975.0	971.0	983.6	8.0	990.0	1,400
Sullivan	1970 - 71	2.38	570.0	570.0	587.0	50.0	599.3	51,000
Sunnyside	1970 - 71	0.02	1290.0	1290.0	1299.5	15.0	1303.8	3,400
Sunset Canyon-Deer	1982 - 83	0.21	1382.4	1380.5	1401.8	24.0	1409.1	5,000
Sunset (Lower)	1963 - 64	0.45	1003.8	994.5	1040.0	40.0	1056.0	158,900
Sunset (Upper)	1928 - 29	0.44	1574.2	1574.0	1603.7	75.0	1610.1	15,900
Turnbull	1952 - 53	0.99	476.1	475.6	492.0	40.0	503.0	21,600
Upper Shields	1976 - 77	0.21	2498.0	2498.0	2530.0	33.3	2536.0	35,400
Verdugo	1935 - 36	9.40	1109.5	1110.0	1119.7	145.0	1131.0	131,000
Ward	1956 - 57	0.12	2021.8	2022.0	2043.0	58.0	2035.3	26,400
West Ravine	1935 - 36	0.25	1468.8	1469.6 (1)	1501.9	20.0	1505.5	44,900
Westridge	1974 - 75	0.02	894	894.0	901.0	10.7	906.0	1,400
Wildwood	1967 - 68	0.65	1342.9	1342.9	1354.0	50.0	1360.0	20,700
William S. Hart Park	1983 - 84	0.09	1282.5	1280.0	1290.0	19.0	1293.0	2,400
Wilson	1962 - 63	2.58	1493.0	1493.0	1526.0	60.0	1543.0	313,100
Winery	1968 - 69	0.18	1920	1920.0	1935.0	20.0	1945.0	29,200
Zachau	1956 - 57	0.35	1803.4	1803.1	1820.5	44.0	1823.0	47,900

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN - DESIGN DATA

Including 1993-1994 Storm Season

DATA SHEET A

Compiled by: Hydraulic and Water Conservation Division - Sedimentation Management
Date: November 30, 1994
FILE: DSAR94.xlw

(1) LOWEST CLEAR WATER OUTLET, NOT SPILLWAY.
(2) ELEVATION OF SPILLWAY NOTCH.
(3) FLOW LINE OF SLUICEWAY.
(4) ELEVATION OF SPILLWAY INTO OUTLET CHANNEL. ELEVATION OF OVERFLOW SPILLWAY 1036.9 FEET.
(5) ONE 30-INCH REINFORCED CONCRETE PIPE.
(6) FOUR 36-INCH CORRUGATED METAL PIPES.
(7) ONE 36-INCH REINFORCED CONCRETE PIPE. (ELEVATED INLET)
(8) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(9) PIT-TYPE BASIN.
(10) INFORMATION UNAVAILABLE.
(11) SPECIAL CLEANOUT REQUIRED TO LIMITED STORAGE.
(12) CLEANOUT REQUIRED WHEN DEBRIS REACHES OR EXCEEDS ELEV. 1128.9 FEET AGAINST FACE OF DAM.
(13) VALUES ARE COMBINED WITH COOKS DEBRIS BASIN.
(14) SPILLWAY LEVEL STORAGE CAPACITY.
(15) DATA TAKEN FROM DESIGN DRAWINGS USED FOR ENLARGING THE BASIN CAPACITY.
(16) DATA BASED ON AS-BUILT DRAWINGS.
(17) BASED ON AS-BUILT TOPOGRAPHIC MAP FOLLOWING ENLARGEMENT CONSTRUCTION.

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1993 -1994 Storm Season

DATA SHEET B

Compiled by: Hydraulic and Water Conservation
Division - Sedimentation Management
Date: November 30, 1994
File: DBB94.XLW

DEBRIS BASIN	DPA ZONE	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED (CU. YDS.)(1)	AVERAGE ANNUAL DEBRIS PRODUCTION (CU.YDS./YR)(15)	MAXIMUM SEASONAL DEBRIS PRODUCTION CU. YDS	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS: DEBRIS STORED CU. YDS. (17)	ESTIMATED CONDITIONS: CAPACITY AVAILABLE CU. YDS.	ESTIMATED CONDITIONS: CAPACITY AVAILABLE PERCENT
Aliso	4	24	191,511	7,980	32,296	1991-92	0	41,700	100 (5)
Arbor Dell	2	23	1,441	63	800	1979-80	480	11,940	96
Auburn (11)	1	40	97,364	2,434	20,100	1981-82	0	31,600	100
Bailey (11)	1	49	279,589	5,706	91,000	1979-80	810	127,990	98
Beatty	1	24	14,061	586	7,600	1979-80	4,000	38,000	91
Bigbriar	1	23	3,318	144	823	1987-88	60	2,540	98
Big Dalton	1	35	859,003	24,543	296,700	1968-69	31,200	486,600	94
Blanchard	1	26	78,368	3,014	36,600	1977-78	1,557	72,943	98
Blue Gum	1	26	38,386	1,476	19,100	1977-78	-2893	42,493	107
Brace	2	23	42,372	1,842	12,000	1977-78	0 (16)	30,000 (16)	100
Bracemar	2	23	671 (7)	29	283	1980-81	-193	893	128 (9)
Bradbury	1	40	268,864	6,722	70,200	1968-69	2,700	97,100	97
Brand	1	59	276,813	4,692	53,100	1977-78	6,501	159,499	96
Buena Vista	1	9	440	49	400	1992-93	440	21,360	98
Carriage House (11)	1	24	7,178	296	3,400	1979-80	0	6,100	100
Carter (11)	1	40	40,986	1,024	12,630	1979-80	0	14,500	100
Cassara	1	18	29,487	1,638	16,800	1977-78	2,300	34,400	94
Chamberlain (11)	2	20	710	36	300	1974-75	-673	6,273	112
Childs	1	31	46,518	1,501	10,700	1980-81	1,600	48,900	97
Cloud Creek	1	22	3,362	153	1,600	1977-78	-570	5,670	111
Cloudcroft	4	21	12,372	589	6,100	1973-74	1,450	33,250	96
Cooks	1	43	175,621 (3)	4,084 (3)	61,200 (3)	1977-78	2,900 (3)	83,000 (3)	97 (3)
Cooks M-1A	1	19	(13)	(13)	(13)	(13)	(13)	(13)	(13)
Crestview	1	11	(6)	(6)	(6)	(6)	0	5,900	100
Crocker	8	11	8,452	768	5,746	1991-92	2,336	16,964	88
Deer	1	40	168,108	4,203	44,200	1968-69	797	56,803	99
Denivelle	2	18	9,677	538	5,500	1977-78	400	7,800	95
Devonwood (11)	1	13	6,584	506	5,800	1993-94	0	5,800	100
Dry Canyon-South Fork	4	16	8,968	561	5,300	1979-80	480	7,420	94
Dunsmuir	1	59	372,685	6,317	86,200	1977-78	-3243	105,943	103
Eagle	1	58	194,940	3,361	41,700	1937-38	5,447	56,953	91
Elmwood	1	30	53,711	1,790	16,100	1980-81	300	86,100	100
Emerald-East	2	30	11,578	386	1,800	1985-86	1,062	12,538	92
Englewild	1	33	86,770 (2)	2,629	60,200 (2)	1968-69	1,700	38,900	96
Fair Oaks (11)	1	59	113,360	1,921	15,700	1935-36	0	23,800	100
Fern (11)	1	59	181,802	3,081	23,900	1968-69	0 (16)	43,200 (16)	100
Fieldbrook	6	20	1,894	95	500	1991-92	409	2,391	85
Golf Club Drive	2	24	33,400	1,392	11,600	1979-80	642	14,058	96
Gordon	1	21	5,604	267	3,800	1977-78	0 (16)	33,100 (16)	100

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1993 -1994 Storm Season

DATA SHEET B

Compiled by: Hydraulic and Water Conservation
Division - Sedimentation Management
Date: November 30, 1994
File: DBS94.XLW

DEBRIS BASIN	DPA ZONE	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED (CU YDS.)(1)	AVERAGE ANNUAL DEBRIS PRODUCTION (CU YDS./YR)(15)	MAXIMUM SEASONAL DEBRIS PRODUCTION CU YDS.	MAXIMUM SEASONAL DEBRIS PRODUCTION SEASON	ESTIMATED CONDITIONS DEBRIS STORED CU. YDS. (17)	ESTIMATED CONDITIONS CAPACITY AVAILABLE CU. YDS.	ESTIMATED CONDITIONS CAPACITY AVAILABLE PERCENT
Gould	1	47	133,110	2,832	18,000	1965-66	1,389	51,411	97
Gould (Upper)	1	18	37,013	2,056	11,177	1991-92	1,500	50,800	97
Halls	1	59	604,227	10,241	102,100	1937-38	-1950	91,350	102
Harrow	1	36	78,347 (2)	2,176	63,400 (2)	1968-69	-6611	73,511	108
Haven Way	2	3	(8)	(8)	(8)	(8)	0	38,200	100
Hay	1	59	75,782	1,306	18,200	1937-38	2,180	32,250	94
Hillcrest	1	32	52,649	1,645	11,700	1964-65	4,782	53,038	92
Hog	1	25	7,034	281	3,600	1977-78	800	38,000	98
Hook East	1	26	46,609 (2)	1,793	40,200 (2)	1968-69	0	22,300	100
Hook West	1	24	7,188	300	3,600	1979-80	350	21,250	98
Inverness	2	12	316	26	252	1982-83	618	2,782	94
Irving Drive	2	20	1,746	87	600	1980-81	200	1,000	83
Kinneloa (11)	1	30	93,316 (2)	3,111	36,386	1983-84	0	14,100	100
Kinneloa West (11)	1	28	107,876 (2)	3,853	34,754	1983-84	0	14,200	100
Lannan	1	40	84,767	2,119	18,200	1969-70	700	40,700	98
La Tuna	2	39	652,523	16,731	172,100	1977-78	89,164	436,137	98
Las Flores (11)	1	59	225,152	3,816	36,000	1937-38	-1649	57,249	103
Las Lomas	1	11	615	56	(6)	(6)	0 (16)	17,800 (16)	100
Limekiln	4	31	309,248	9,976	42,300	1965-66	4,000	167,600	98
Lincoln (11)	1	59	134,889	2,286	28,400	1968-69	1,028	37,372	97
Linda Vista	2	24	13,617	567	3,400	1977-78	302	2,898	91
Little Dalton	1	35	933,473	26,671	337,800	1968-69	44,340	616,160	93
Maddock	1	40	57,134	1,428	16,200	1980-81	2,200	42,600	95
Marston/Paragon	5	6	130	22	(6)	(6)	130	5,870	98
May No. 1 (11)	2	41	225,560	5,501	45,800	1968-69	0	84,000	100
May No. 2	2	41	28,016	683	8,200	1966-67	0	13,400 (18)	100
Monument	6	13	3,009	231	2,800	1981-82	292	6,508	96
Morgan	1	30	30,641	1,028	12,800	1968-69	0	78,800 (18)	100
Mountbatten	1	11	110	10	(6)	(6)	110	1,290	92
Mull	1	21	2,394	114	1,100	1979-80	500	12,000	96
Mullally (10)	1	20	65,074 (4)	3,254	24,400 (4)	1977-78	691	8,709	93
Nichols	4	57	131,304	2,304	21,800	1951-52	0	14,100	100
Oak	1	19	13,267	698	6,900	1977-78	0	12,000 (16)	100
Oakglade	1	20	1,567	78	1,200	1977-78	650	6,600	91
Oakmont View Drive	1	10	440	44	221	1991-92	-126	3,526	104
Oliver	1	5	31 580 (14)	6 316	16,255 (14)	1977-78	1,200	30,900	96
Pickens	1	59	730,027	12,373	140,600	1977-78	920	124,180	99
Pinetown	1	21	5,309	253	1,200	1976-77	130	3,070	96
Rowley	1&7	41	78,235 (4)	1,908	13,000 (4)	1977-78	2,000	41,100	95
Rowley (Upper)	1	18	51,805 (4)	2,878	31,900 (4)	1977-78	-574	29,374	102

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LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY

Including 1993 -1994 Storm Season

DATA SHEET B

Compiled by: Hydraulic and Water Conservation
Division - Sedimentation Management
Date: November 30, 1994
File: DBB94.XLW

DEBRIS BASIN	DPA ZONE	NUMBER OF SEASONS	TOTAL DEBRIS DEPOSITED (CU. YDS.)(1)	AVERAGE ANNUAL DEBRIS PRODUCTION (CU YDS./YR)(15)	MAXIMUM SEASONAL DEBRIS PRODUCTION: CU. YDS	MAXIMUM SEASONAL DEBRIS PRODUCTION: SEASON	ESTIMATED CONDITIONS: DEBRIS STORED CU. YDS. (17)	ESTIMATED CONDITIONS: CAPACITY AVAILABLE CU. YDS.	ESTIMATED CONDITIONS: CAPACITY AVAILABLE PERCENT
Rubio (11)	1	51	310,910	6,096	133,000	1979-80	0	127,200	100
Ruby (Lower)	1	39	21,432	550	8,300	1968-69	2,000	28,800	93
Rye	5	13	15,748	1,211	10,000	1981-82	-756	19,856	104
Saddleback	1	6	520	87	(6)	(6)	520	26,480	98
Santa Anita	1	35	755,383 (2,3)	21,582	132,000 (2,3)	1981-82	-3334	397,934	101
Sawpit	1	40	707,247 (2,3)	17,681	232,200 (2,3)	1968-69	20,250	615,450	97
Scholl	2	49	18,294	373	800	1968-69	800	8,900	91
Schoolhouse	1	32	34,481	1,078	21,600	1982-83	5,226	62,474	92
Schwartz	1	18	49,558	2,753	21,800	1977-78	4,600	40,900	90
Shields	1	57	173,622 (3)	3,046	7,600	1937-38	1,810	32,880	96
Sierra Madre Dam(11&12)	1	67	386,386 (2)	5,468	96,200 (2)	1968-69	-6485	141,885	104
Sierra Madre Villa (11)	1	37	719,756	19,453	171,775	1983-84	0	402,300	100
Snover	1	58	109,480	1,888	19,300	1938-39	0	24,800	100
Sombrero	1	25	11,856	474	3,300	1977-78	6,000	81,900	93
Spinks	1	39	67,486	1,875	15,800	1968-69	1,100	64,800	98
Starfall	1	21	29,110	1,386	14,200	1977-78	1,937	12,983	67
Stetson (11)	1	25	21,452	856	1,500	1977-78	100	41,300	99
Stough	2	54	162,819	3,015	44,100	1964-65	3,500	177,100	98
Sturtevant	1	27	1,356	50	500	1977-78	155	1,245	89
Sullivan	4	24	93,962	3,915	35,300	1979-80	0	51,000	100
Sunnyside (11)	1	24	3,450	144	1,621	1993-94	0	3,400	100
Sunset Canyon-Deer	1	12	4,156	346	3,400	1982-83	180	4,820	96
Sunset (Lower)	1	31	145,469	4,693	20,200	1980-81	3,700	156,200	98
Sunset (Upper)	1	66	149,660	2,268	27,000	1964-65	-1470	17,370	109
Turnbull (11)	6	42	69,646 (2)	1,658	15,800 (2)	1968-69	160	21,440	99
Upper Shields	1	18	43,217 (4,14)	2,401	16,900 (4,14)	1977-78	0 (8)	35,400	100
Verdugo	1	59	827,992	14,034	105,400	1937-38	13,334	117,866	90
Ward	1	38	52,671	1,386	17,800	1977-78	1,233	25,167	95
West Ravine (11)	1	59	159,887	2,710	29,900	1937-38	0	44,900	100
Westridge	1&7	20	223	11	(6)	(6)	210	1,190	85
Wildwood	3&5	27	86,252	3,195	16,700	1977-78	-1836	22,536	109
William S. Hart Park	5	11	658	60	600	1983-84	-97	2,497	104
Wilson	2	32	216,134	6,754	55,500	1968-69	15,171	297,929	95
Winery	1	26	27,215	1,047	9,400	1968-69	0	29,200	100
Zachau	1	38	110,636 (4)	2,911	48,100 (4)	1977-78	3,496	44,404	93
114 DEBRIS BASINS			14,349,361	363,802			288,999	7,431,752	

R0053698

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEBRIS BASIN-DEBRIS PRODUCTION HISTORY
Including 1993-1994 Storm Season

DATA SHEET B

Compiled by: Hydraulic and Water Conservation
Division - Sedimentatioon Management
Date: November 30, 1994
File:DSB94SHT.XLS

(1) VOLUME OF DEBRIS DEPOSITED IN BASINS DOES NOT INCLUDE DEBRIS SLUICED THROUGH OPEN PORTS OR NOTCH.
(2) VOLUME OF DEBRIS DEPOSITED IN BASINS DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1968-69 SEASON.
(3) INCLUDING DEBRIS FROM UPSTREAM BASIN OR DAM.
(4) VOLUME OF DEBRIS DEPOSITED IN BASINS DOES NOT INCLUDE DEBRIS WHICH PASSED OVER SPILLWAY DURING THE STORMS IN 1977-78 SEASON.
(5) DEBRIS CAPACITY AVAILABLE WITHIN RIGHT OF WAY LIMITS.
(6) NO SIGNIFICANT DEBRIS INFLOWS RECORDED.
(7) NO DEBRIS RECORDS EXIST FOR THE FIRST 9 SEASONS.
(8) INFORMATION UNAVAILABLE.
(9) MAXIMUM CAPACITY MAY BE MORE THAN SHOWN AND WILL BE REVIEWED.
(10) SPECIAL CLEANOUT REQUIRED DUE TO LIMITED STORAGE.
(11) SPECIAL CLEANOUT REQUIRED DUE TO BURNED WATERSHED.
(12) CLEANOUT REQUIRED WHEN DEBRIS REACHES OR EXCEEDS ELEV. 1128.9 FEET AGAINST FACE OF DAM.
(13) VALUES ARE COMBINED WITH COOKS DEBRIS BASIN.
(14) INCLUDING DEBRIS DATA FROM PREVIOUS BASIN.
(15) CALCULATED BASED ON THE TOTAL DEBRIS DEPOSITED IN THE BASIN DIVIDED BY THE NUMBER OF SEASONS.
(16) BASED ON DESIGN DRAWINGS USED FOR ENLARGING THE BASIN CAPACITY. THE DATA WILL BE REVISED BASED ON UPDATED TOPOGRAPHIC MAP.
(17) DEBRIS IN STORAGE DETERMINED BASED ON TOPOGRAPHIC SURVEY MAP OR FROM FIELD ESTIMATES.
(18) BASED ON AS-BUILT TOPOGRAPHIC MAP FOLLOWING ENLARGEMENT CONSTRUCTION.

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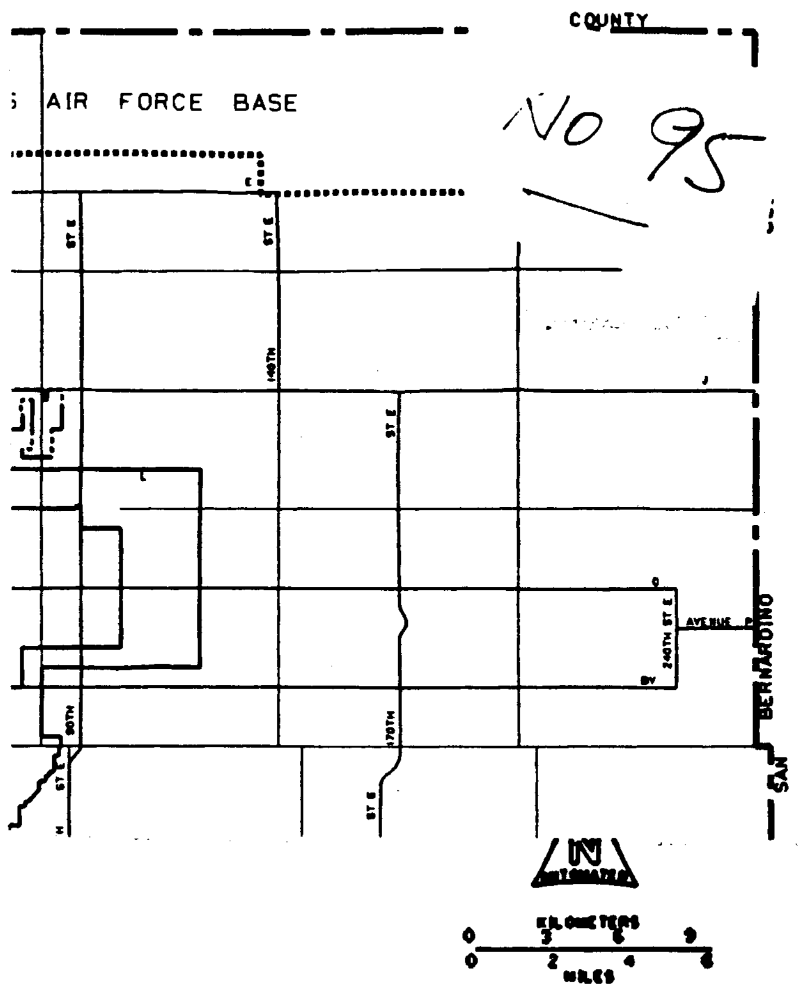

MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

OCT. 1, 1993 THRU
SEPT. 30, 1994 FIRES

<u>OVER 500 ACRES IN AREA</u>

BURNED AREA LOCATIONS

PE2

R0053700

WATER QUALITY

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WATER QUALITY

Since its conception, the Flood Control District (now Department of Public Works) has actively engaged in operations which have proven indispensable in preserving the integrity of our water resources, both quantity and quality, and has aided in the establishment of regulations or controlling criteria by those agencies so empowered.

Prior to March 1986, monitoring activities in the field of water quality control were conducted by the Water Quality Section of Hydraulic/Water Conservation Division. In March 1986, the responsibilities of conducting such activities were transferred to Waste Management Division as a result of the consolidation. These activities include, among others, the collection of water quality samples, their analyses, and the interpretation and reporting of the resulting data.

Areas of involvement include the monitoring of all groundwater basins through the sampling of numerous wells, the monitoring of storm and low water flows at various strategic locations on the major streams or channels, and an assumed or obligated responsibility to monitor the quality effects and subsurface travel of recharge areas, specifically the Whittier Narrows Spreading Grounds area.

The Water Quality Section, together with personnel of other Departmental divisions, also conducts investigations into pollution problems relative to our facilities, particularly those from industrial discharges, vehicle accidents, ruptured pipelines, or the indiscriminate dumping of various waste products.

The principal objectives of these investigations are to determine the degree and apparent source or origin of the pollution and to take the necessary action that will immediately abate the existing problem and possibly provide a means to prevent or limit recurrence.

Since 1986, the Water Quality Section also has been conducting the screening of proposed connections to County storm drains, and developments over County right-of-ways, for the purpose of minimizing/eliminating potential of pollutants to the storm drain waters and, thereby, to the environment.

The above-mentioned activities of the Water Quality Section have recently been expanded, particularly in the areas of interfacing and coordinating with other municipalities/cities, environmental organizations, as well as Federal and State agencies. In compliance with mandates under the 1987 Clean Water Act, the Department is implementing tasks required by the National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit.

The NPDES Permit (CA0061654) issued for the storm drain system in Los Angeles County requires the development and implementation of programs to improve the quality of stormwater/urban runoff discharges into the storm drain system. Los Angeles County, represented by the Department of Public Works, is the Principal Permittee and the cities within the County are Co-Permittees. The drainage area covered by the Permit is divided into three phases; with Phase I, the Santa Monica Bay Drainage Basin, having begun July 1, 1990, Phase II, which involves the Upper L.A. River and Upper San Gabriel River Drainage Basins, having begun in July 1992, and Phase III, which includes the

Lower L.A. River, Lower San Gabriel River, and Santa Clarita River Drainage Basins, initiated in July 1993.

The Permit requires the County, together with the cities to develop and implement a stormwater/urban runoff monitoring program to gather data on the type and source of pollutants within the drainage basins. The permit also requires the development and implementation of Best Management Practices (BMPs) to reduced the amount of pollutants that find their way into the storm drain system and to implement procedures to detect and eliminate illegal discharges.

SURFACE WATER QUALITY

Prior to 1984, dry weather samples were collected from 30 sampling stations on a monthly basis for analysis such as general minerals, bacteria, pesticides, and heavy metals. In addition, storm samples were also collected and analyzed at least three times annually from the same 30 stations during storms season.

From 1984 to 1987, as a result of reorganization, the number of surface water monitoring stations was reduced to 21, while the parameters analyzed were reduced to include only total dissolved solids, pH, and dissolved oxygen. Storm sampling activities were also significantly curtailed.

In 1988, recognizing the inadequacy of the then existing monitoring program to meet the Department's need in dealing with the important issues in the areas of water quality, the Department Administration approved and implemented an expanded monitoring program effective May 1, 1988.

There are 28 monitoring stations in the Department's current Surface Water Quality Monitoring Program, from which dry weather grab samples are collected and analyzed on a monthly basis. These sampling stations are strategically located throughout the Department's major storm drains and water conservation facilities where the flows are representative of typical land uses as well as areas of significant water quality concerns. Of the 28 monitoring stations in the program, six are located at the outlets to Santa Monica Bay, while one is located in the mountain area where flow is considered to be natural and uncontaminated with the various pollutants associated with urbanization and developed land uses.

Monthly dry weather grab samples, thus collected, are analyzed for general minerals (pH, Specific Conductance, Total Dissolved Solids, total Hardness, Potassium Sulfate, Calcium, Magnesium, Chloride, Fluoride, Nitrate-Nitrogen, Nitrite-Nitrogen, Ammonium-Nitrogen, Phosphate-P, Boron, Iron, and Manganese), bacteria, pesticides, heavy metals (Silver Arsenic, Barium, Cadmium, Chromium, Mercury, Lead, Selenium, Copper, Nickel, Zinc, and Chromium [VI]), Oil and Grease, Total Organic Carbon, Total Petroleum Hydrocarbons, PCB's, Biochemical Oxygen Demand, and Volatile Organic Compounds (TCE, Carbon Tetrachloride, Vinyl Chloride, 1,2 Dichloroethene, Benzene, 1,1 Dichloroethylene, 1,1,1 Trichloroethane, p-Dichlorobenzene). In addition, storm samples (also grab) are collected for three to four storms annually from 21 stations, including San Gabriel Coastal and Rio Hondo Spreading Grounds for extensive analysis similar to those for dry weather samples, with additional testing of Total suspended Solids and Volatile Suspended Solids to be included For storm samples collected at San Gabriel Coastal and Rio Hondo Spreading Grounds, priority pollutant constituents are also analyzed under an agreement with the Central and West Basin Water Replenishment District.

A selective list of total dissolved solids is shown for some of the sampling locations on the streams and channels monitored under the Surface Water Quality Program. For a conception of the analysis performed on the surface flows, a yearly compilation of constituent determination is shown for one (Los Angeles River at Wardlow) of the sampling stations in the program.

Beginning in early 1994, a more extensive Stormwater/Urban runoff Monitoring program utilizing automated sampling was established as required by the National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit. This program calls for installation of automated samplers within all major drainage basins, beginning with the Santa Monica Bay Drainage Basin, to collect flow-composite samples to better characterize sampling events. Nine (9) automated monitoring stations within the Santa Monica Bay Drainage Basin have been constructed from which data collection began in the 1994-95 storm season. While this new monitoring program is developing, the existing monitoring program will be maintained.

GROUNDWATER QUALITY

The Department's Groundwater Monitoring Program, which was initiated in the 1970's underwent thorough reevaluation in September 1993, and January 1994, to eliminate duplication of analyses among participating agencies. It was determined that the majority of the 314 wells in the program were already being sampled by the various watermasters within the County. The Department has discontinued its annual sampling activities for the program. However, we maintain the existing groundwater quality records and, upon request, provide the data to the public.

WATER, QUALITY DATA ACCESSIBILITY

Data acquired from the various programs are on file in the Water Quality Section. In addition, all data is accessible to any user through STORET, an Environmental Protection Agency computer system that stores, retrieves, and manipulates data using agency code 21CALAFD.

Surface Water Quality Monitoring Selected Surface Stations
Table I Total Dissolved Solids – ppm
1993–94 Season (Dry Weather Flow)

Sampling Locations	Oct. 1993	Nov. 1993	Dec. 1993	Jan. 1994	Feb. 1994	Mar. 1994	Apr. 1994	May 1994	Jun. 1994	Jul. 1994	Aug. 1994	Sep. 1994	Average
Ballona Creek at Sawtelle Blvd.	758	750	754	710	588	700	644	764	696	700	796	750	718
Coyote Creek at Orangethorpe Avenue	1108	1196	902	320	982	1050	1102	1334	848	1030	1102	1088	1005
Willow Street	832	884	1446	–	1278	916	734	758	824	820	992	734	929
Dominguez Channel Above Vermont Avenue	456	786	736	1068	1120	308	890	622	780	894	1012	900	798
Los Angeles River at Wardlow Road	718	786	678	–	802	744	820	652	726	692	672	630	720
Firestone Boulevard	712	792	680	–	764	720	800	702	680	688	622	724	717
Los Cerritos Channel at Stearns Street	802	422	1272	–	680	528	846	638	800	790	772	648	745
Rio Hondo River at Southern Avenue	1150	–	–	138	848	1006	760	948	1800	1212	692	554	911
Spreading Grounds	648	616	–	220	472	434	–	642	–	606	624	582	538
Santa Monica Cyn. Ch. at Short Street	–	890	952	988	1000	1020	954	1052	1030	900	920	820	957
San Gabriel River at Spreading Grounds	594	672	564	230	724	654	696	700	704	–	–	–	615
Willow Street	774	856	652	–	746	764	1456	680	734	754	724	722	806
San Jose Creek at Workman Mill Road	874	794	856	–	868	882	1120	730	734	910	800	984	868

HYD9394A

Surface Water Quality Analysis
Monthly Monitoring 1993–94 Season (Dry Weather)
Los Angeles River at Wardlow Road

Constituents ppm	Oct. 93	Nov. 93	Dec. 93	Jan. 94	Feb. 94	Mar. 94	Apr. 94	May 94	Jun. 94	Jul. 94	Aug. 94	Sep. 94	Average
Hardness as CaCO3	297	317	297	–	370	330	350	220	315	270	280	190	294
Ammonium	7.8	5.1	6.3	–	6.3	6.9	4.4	0.3	<0.1	0.4	0.1	0.2	3.8
Calcium	75.3	83.3	79.4	–	92.2	84.2	80.2	76.2	72.1	72.1	72.1	64.1	77.4
Magnesium	26.4	26.5	24.1	–	34.0	29.2	36.5	7.3	33.0	21.8	24.3	7.3	24.6
Potassium	10.2	10.5	11.9	–	6.6	6.3	9.7	10.0	7.0	8.1	9.6	9.3	9.0
Sodium	93.5	113.0	115.0	–	58.4	77.5	91.0	109.0	86.0	98.5	113.0	114.0	97.2
Alkalinity as CaCO3	152	134	168	–	179	188	172	104	146	151	146	79	147
Chloride	136.0	151.0	116.0	–	123.0	108.0	158.0	122.4	121.4	122.0	117.0	136.0	128.2
Flouride	0.4	0.4	0.3	–	0.3	0.3	0.3	0.4	0.4	0.8	0.5	0.4	0.4
Sulfate	215.0	238.0	208.0	–	233.0	227.0	252.0	201.2	186.3	184.0	201.0	182.0	211.6
Nitrate–N	8.1	5.1	3.5	–	6.4	3.7	9.6	<0.03	3.0	3.5	2.3	4.1	4.6
Nitrite–N	0.6	1.1	0.7	–	0.7	2.0	<0.03	1.1	<0.03	1.6	3.2	0.9	1.3
Phosphate	1.9	1.1	1.5	–	1.8	1.4	1.3	<0.05	0.8	0.4	0.9	0.3	1.0
Total Dissolved Solids	718	786	678	–	802	744	820	652	726	692	672	630	720
BOD	85.2	<1	59.3	–	121.2	43.9	78.0	NA	59.4	<2	45.2	24.7	64.6
Total Organic Carbon	9.0	9.7	11.6	–	13.8	3.6	14.7	NA	12.0	<1	14.1	12.6	11.2
Oil & Grease	<1	<1	<1	–	<1	<1	<1	<1	<1	<1	<1	<1	<1
TPH	<1	<1	<1	–	<1	<1	<1	<1	<1	<1	<1	<1	<1
pH	7.6	8.9	7.8	–	7.2	8.8	7.8	9.5	8.8	9.3	9.6	9.7	8.6
Temperature	65.0	70.0	58.0	–	58.0	65.0	60.0	82.0	75.0	80.0	82.0	74.0	69.9
MPN/100ml													
Total Coliform	16000	1700	2400	–	11000	>160,000	90000	<20	>160,000	<20	8000	80	NA
Fecal Coliform	500	170	1300	–	11000	>160,000	50000	<20	>160,000	<20	800	80	NA
Fecal Streptococcus	270	260	260	–	500	800	1700	300	300	<20	260	1100	NA
Enterococcus	270	260	170	–	500	800	1700	300	300	<20	260	330	NA

HYD93941

< = Less than > = Greater than NA = Not analyzed ppm = Parts per million ppb = Parts per billion

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R0053706

Surface Water Quality Analysis
Monthly Monitoring 1993–94 Season (Dry Weather)
Los Angeles River at Wardlow Road

Constituents (ppb)	Oct. 93	Nov. 93	Dec. 93	Jan. 94	Feb. 94	Mar. 94	Apr. 94	May 94	Jun. 94	Jul. 94	Aug. 94	Sep. 94	Average
Boron	685	622	495	–	640	645	440	436	<250	660	530	600	575.3
Heavy Metals:													
Arsenic	<10	<10	11	–	<10	<10	<10	<10	<10	<10	<10	<10	<10
Barium	<100	<100	178	–	<100	<100	110	106	<100	<100	<100	<100	<109
Cadmium	<10	<10	<10	–	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chromium	<10	<10	<10	–	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chromium (6)	<10	<10	<10	–	<10	<10	<10	<10	<10	<10	<10	<10	<10
Copper	24	<10	<10	–	11	<10	40	<10	<10	<10	18	<10	<15
Lead	<10	<10	<10	–	<10	<10	<10	<10	<10	<10	<10	<10	<10
Mercury	<1	<1	<1	–	<1	<1	<1	<1	<1	<1	<1	<1	<1
Nickel	<10	<10	<10	–	<10	<10	<10	<10	<10	<10	<10	<10	<10
Selenium	<5	<5	<5	–	<5	<5	<5	<5	<5	<5	<5	<5	<5
Silver	<10	<10	<10	–	<10	<10	<10	<10	<10	<10	<10	<10	<10
Zinc	<50	<50	<50	–	<50	<50	<50	<50	<50	<50	<50	<50	<50
Iron	<100	<100	<100	–	<100	100	<100	<100	<100	<100	200	<100	<109
Manganese	<30	<30	<30	–	<30	62	<30	<30	<30	<30	<30	<30	<33
Chlorinated Pesticides:													
Aldrin	<0.05	<0.05	<0.05	–	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lindane	<0.05	<0.05	<0.05	–	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Alpha–BHC	<0.05	<0.05	<0.05	–	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Beta–BHC	<0.05	<0.05	<0.05	–	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Delta–BHC	<0.05	<0.05	<0.05	–	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlordane	<0.05	<0.05	<0.05	–	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
pp'DDD	<0.10	<0.10	<0.10	–	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
pp'DDE	<0.10	<0.10	<0.10	–	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
pp'DDT	<0.10	<0.10	<0.10	–	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dieldrin	<0.10	<0.10	<0.10	–	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Endosulfan I	<0.10	<0.10	<0.10	–	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Endosulfan II	<0.10	<0.10	<0.10	–	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Endosulfan Sulfate	<0.10	<0.10	<0.10	–	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Endrin	<0.10	<0.10	<0.10	–	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Heptachlor	<0.05	<0.05	<0.05	–	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor Epoxide	<0.05	<0.05	<0.05	–	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Toxaphene	<1.0	<1.0	<1.0	–	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

HYD03942

< = Less than > = Greater than NA = Not analyzed ppm = Parts per million ppb = Parts per billion

Surface Water Quality Analysis
Monthly Monitoring 1993–94 Season (Dry Weather)
Los Angeles River at Wardlow Road

Constituents ppb	Oct. 93	Nov. 93	Dec. 93	Jan. 94	Feb. 94	Mar. 94	Apr. 94	May 94	Jun. 94	Jul. 94	Aug. 94	Sep. 94	Average
Polychlorinated biphenyls:													
PCB1016	<0.5	<0.5	<0.5	–	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PCB1221	<0.5	<0.5	<0.5	–	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PCB1232	<0.5	<0.5	<0.5	–	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PCB1242	<0.5	<0.5	<0.5	–	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PCB1248	<0.5	<0.5	<0.5	–	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PCB1254	<1.0	<0.5	<1.0	–	<1.0	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB1260	<0.5	<0.5	<0.5	–	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Volatile Organics:													
Benzene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Bromodichloromethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Bromoform	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Bromomethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Carbon Tetrachloride	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Chlorobenzene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Chloroethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
2-Chloroethylvinyl ether	NA	NA	NA	–	NA	NA	NA	NA	NA	<1.0	NA	NA	<1.0
Chloroform	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Chloromethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Dibromochloromethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
1,2 - Dichlorobenzene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
1,3 - Dichlorobenzene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
1,4 - Dichlorobenzene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Dichlorodifluoromethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
1,1 - Dichloroethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
1,2 - Dichloroethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
1,1 - Dichloroethene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
trans-1,2 Dichloroethene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
1,2-Dichloropropane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
cis-1,3-Dichloropropene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
trans-1,3-Dichloropropene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Ethyl benzene	NA	NA	NA	–	NA	NA	NA	NA	NA	<1.0	NA	NA	<1.0
Methylene chloride	NA	NA	NA	–	NA	NA	NA	NA	NA	<1.0	NA	NA	<1.0
1,1,2,2-Tetrachloroethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Tetrachloroethene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Toluene	NA	NA	NA	–	NA	NA	NA	NA	NA	<1.0	NA	NA	<1.0
1,1,1 Trichloroethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<1.0	NA	NA	<1.0
1,1,2-Trichloroethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<1.0	NA	NA	<1.0
Trichloroethene	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
Trichlorofluoromethane	NA	NA	NA	–	NA	NA	NA	NA	NA	<1.0	NA	NA	<1.0
Vinyl Chloride	NA	NA	NA	–	NA	NA	NA	NA	NA	<0.5	NA	NA	<0.5
p'-Dichlorobenzene	NA	NA	NA	–	NA	NA	NA	NA	NA	NA	NA	NA	NA

HYD0043

< = Less than > = Greater than NA = Not analyzed ppm = Parts per million ppb = Parts per billion

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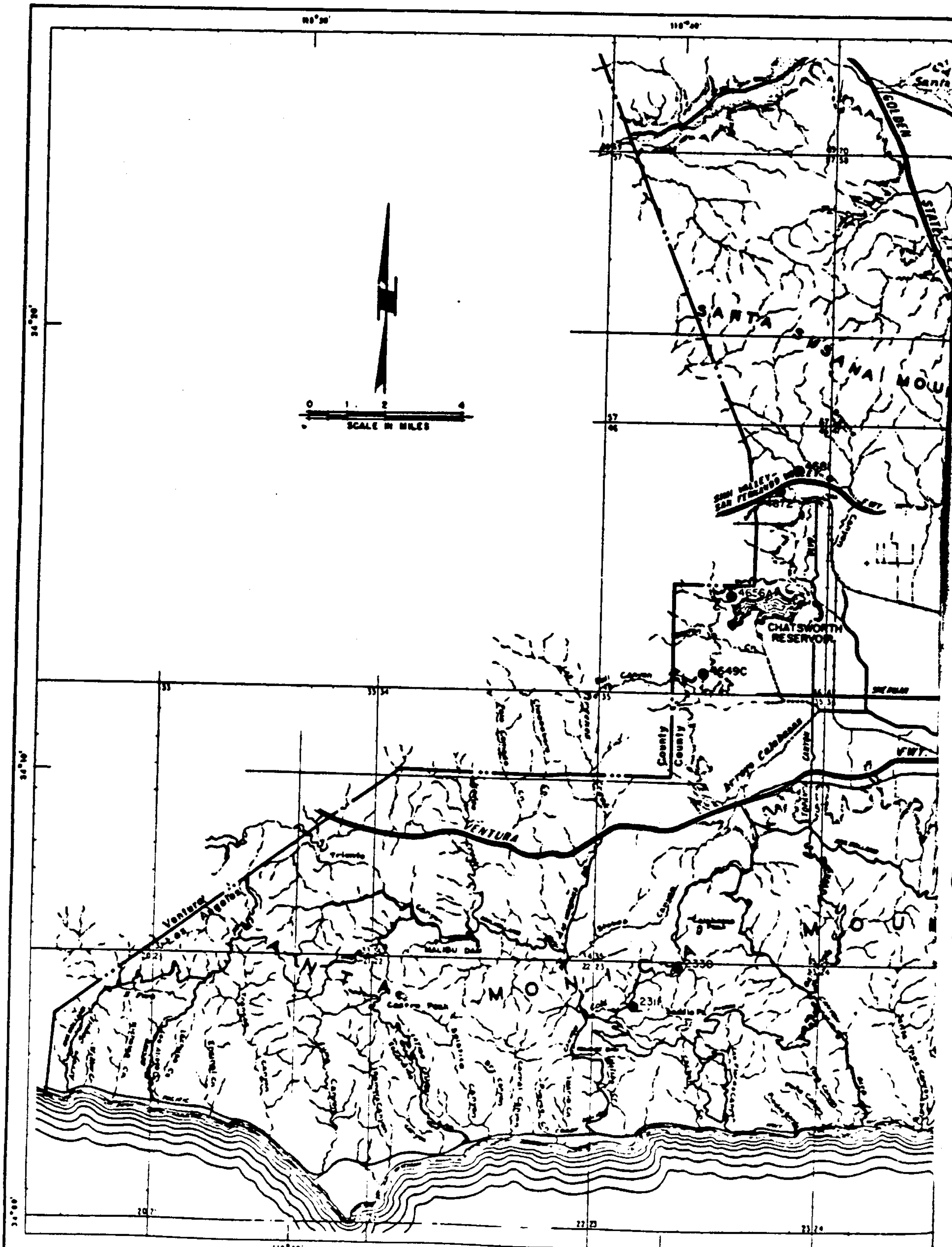
2 0403

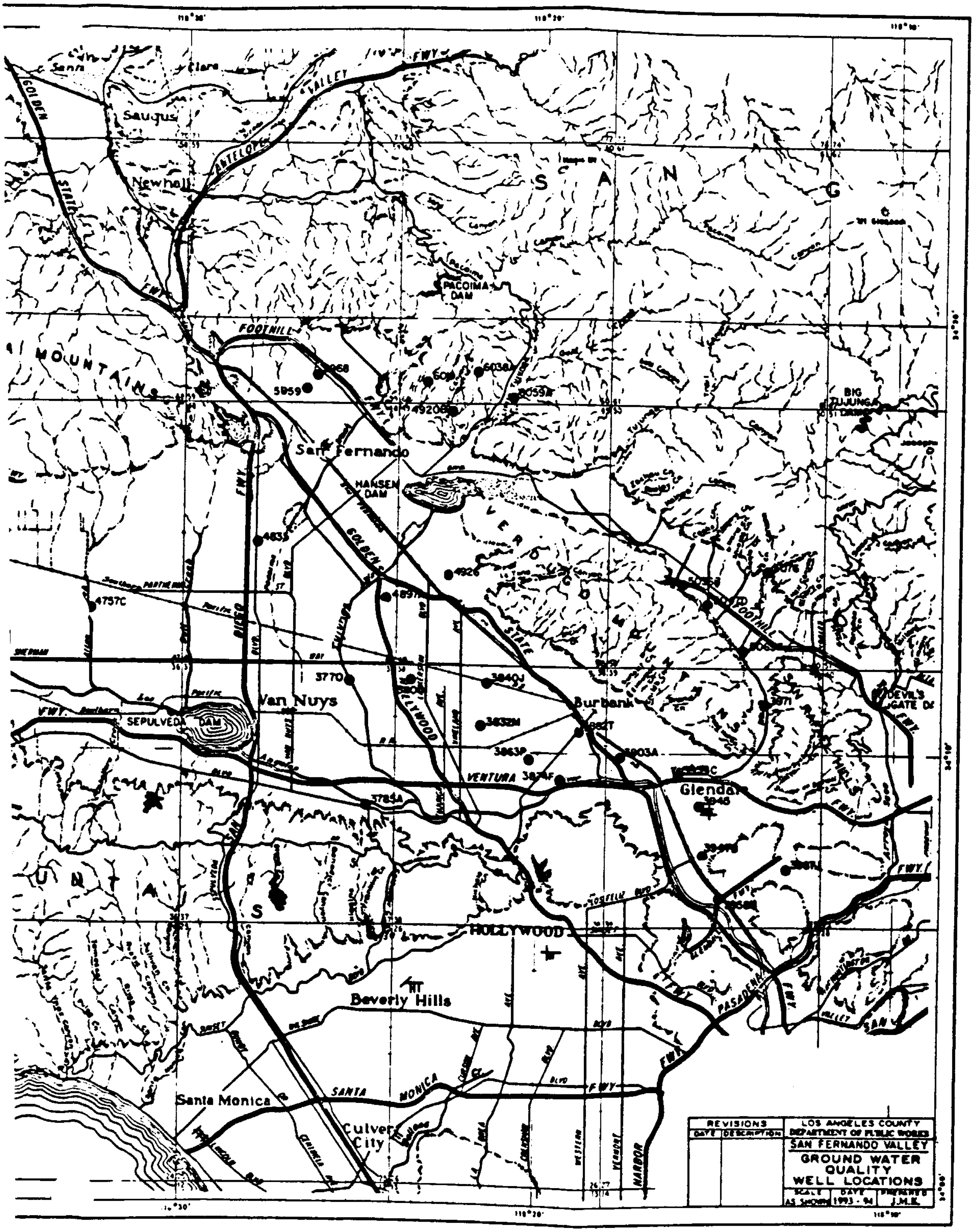
VOL 12 2 0404



R0053709

VOL 12

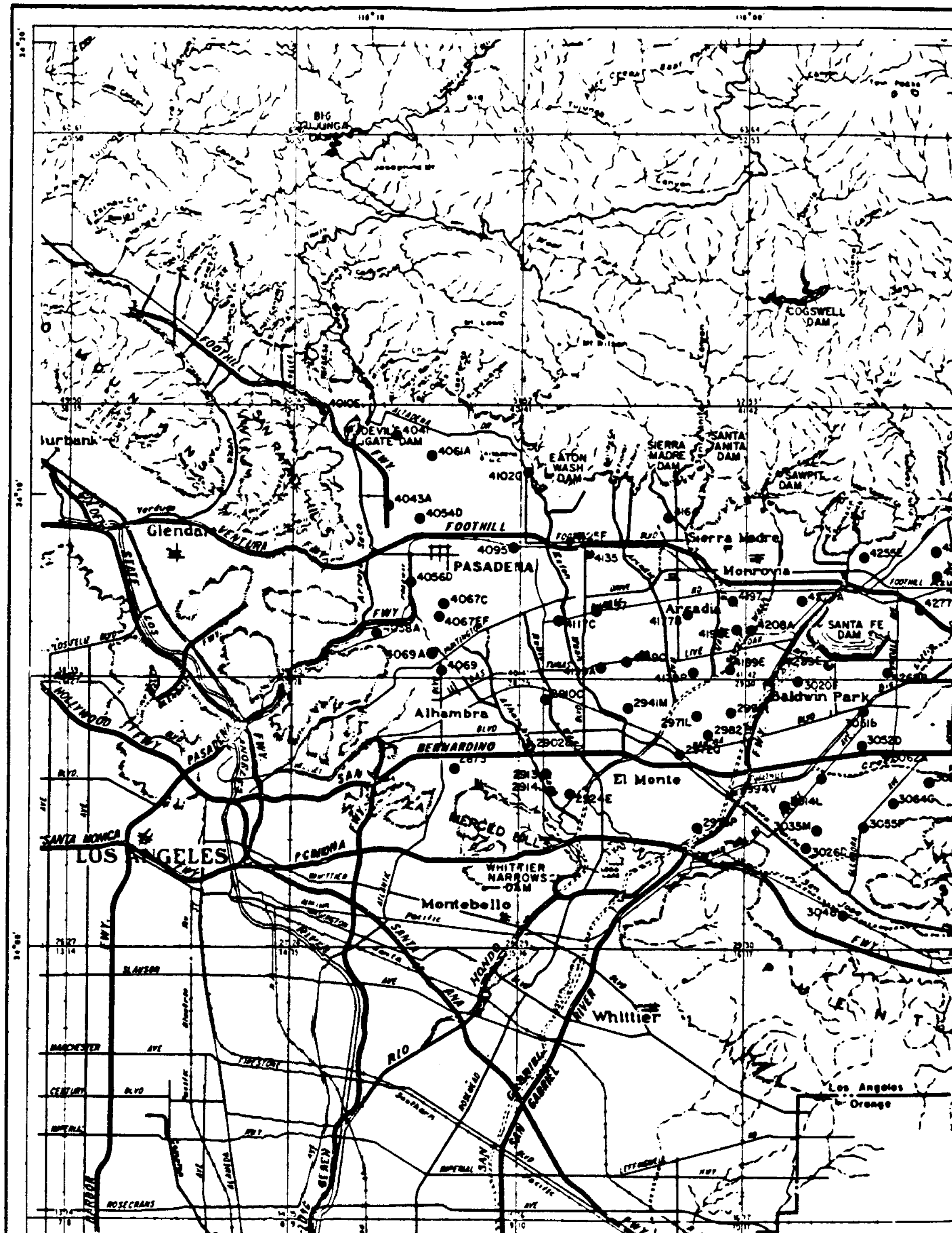
2 0405



REVISIONS		LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS		
DATE	DESCRIPTION	SAN FERNANDO VALLEY GROUND WATER QUALITY WELL LOCATIONS		
		SCALE	DATE	PREPARED
		AS SHOWN	1993 - 94	J.M.K.

PF1

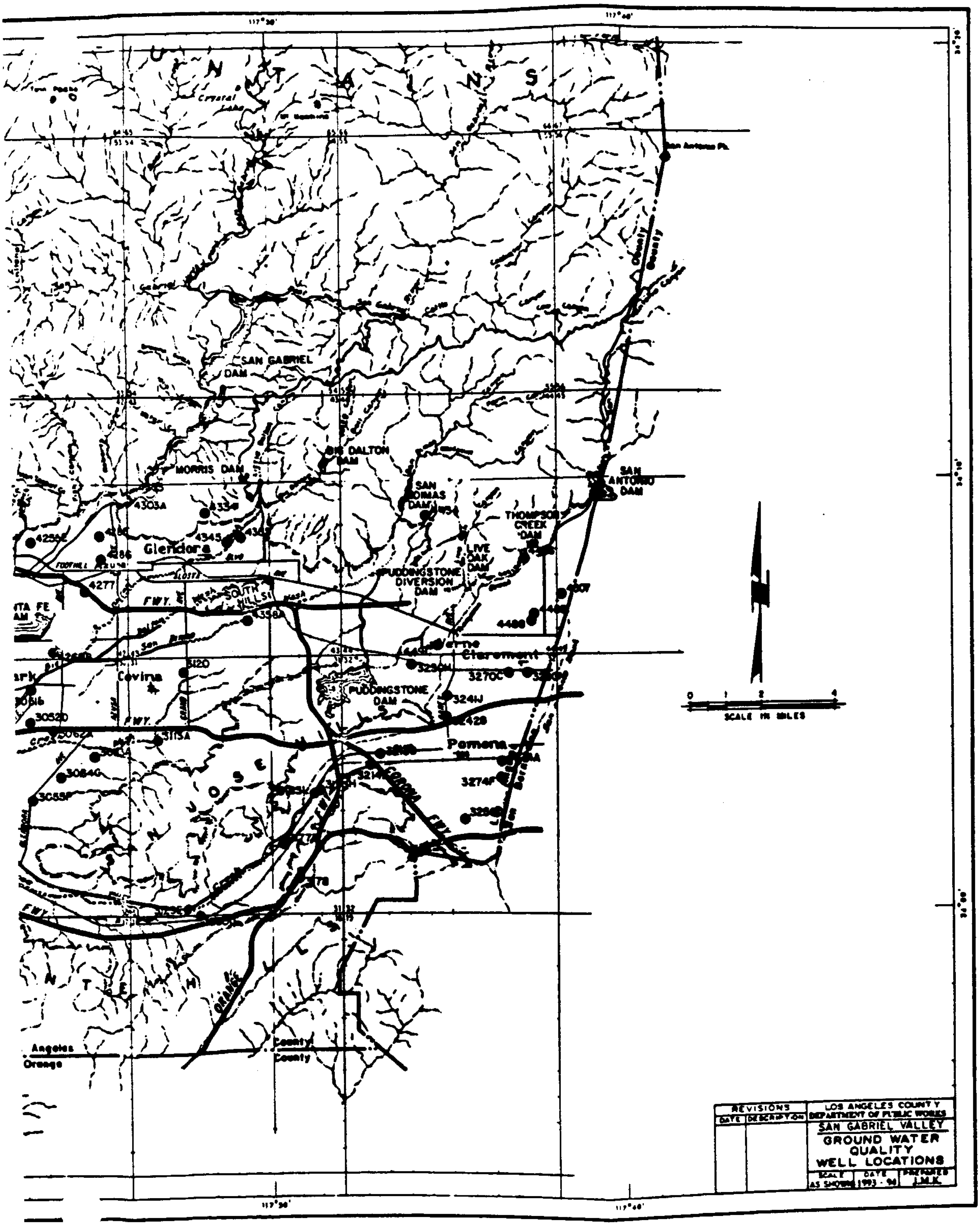
R0053710


BIG TUJUNGA DAM
COGSWELL DAM
FOOTHILL
DEVILS GATE DAM
EATON WASH DAM
SIERRA MADRE DAM
SANTA ANITA DAM
SAWPIT DAM
FOOTHILL
PASADENA
Sierra Madre
Monrovia
Arcadia
SANTA FE DAM
Baldwin Park
Alhambra
BERNARDINO
El Monte
SANTA MONICA
POMONA
WHITTIER NARROWS DAM
Montebello
Whittier
SAN GABRIEL RIVER
Los Angeles
Orange
HARBOR

VCL 122 04 06

VOL 12

20407



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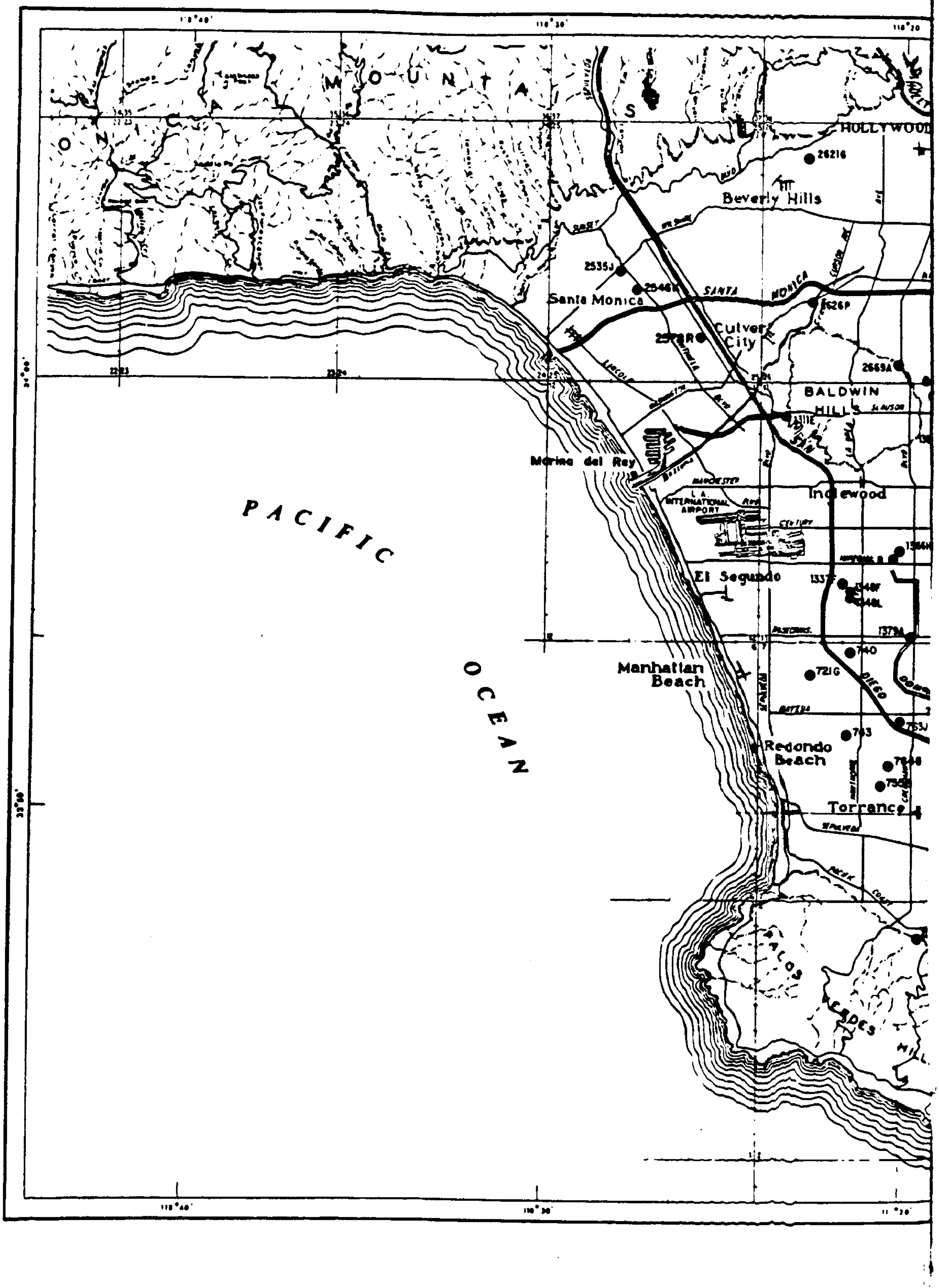
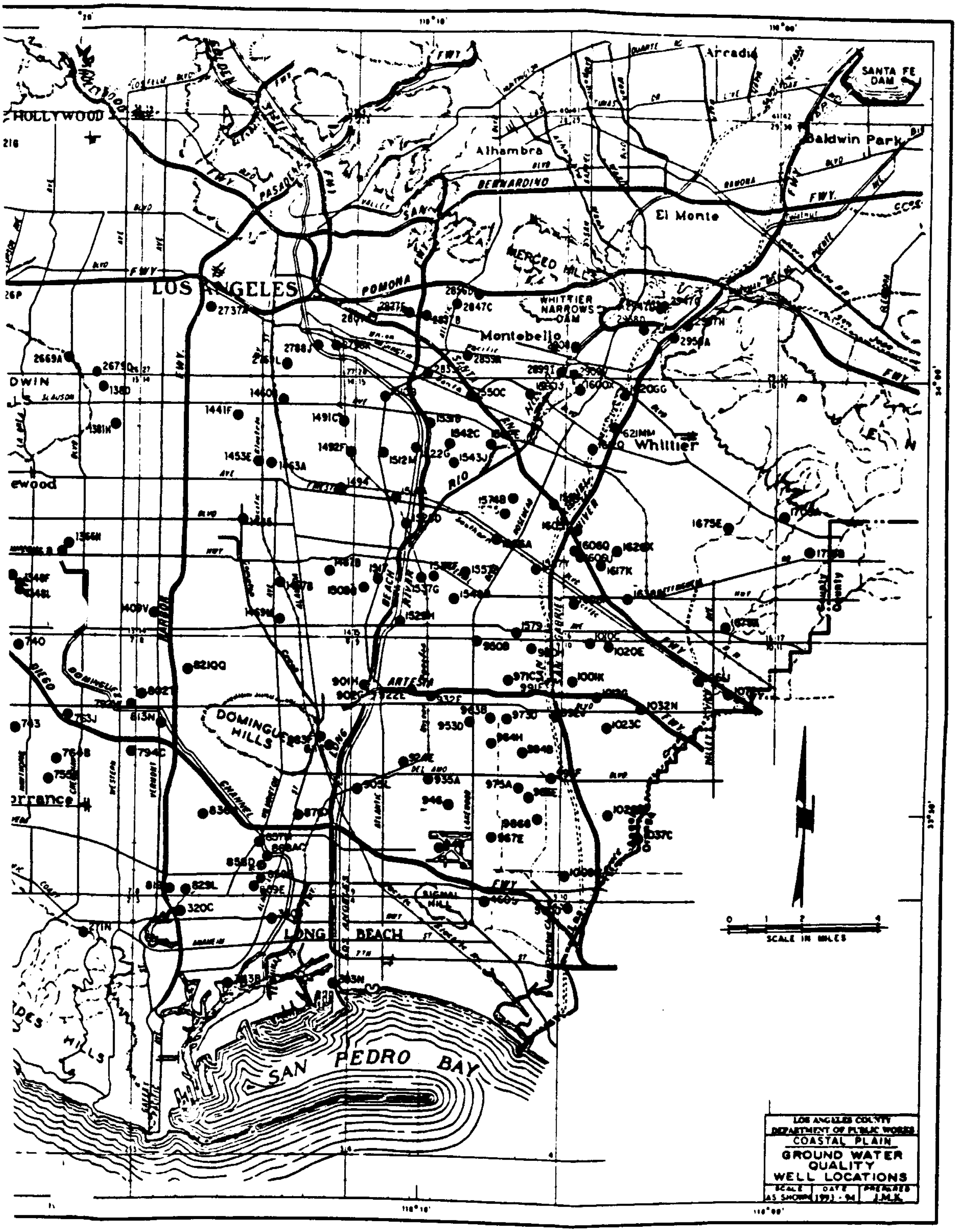
R0053712



MOUNTAINS
HOLLYWOOD
Beverly Hills
Santa Monica
Culver City
BALDWIN HILLS
Marina del Rey
Inglewood
L.A. INTERNATIONAL AIRPORT
PACIFIC
OCEAN
El Segundo
Manhattan Beach
Redondo Beach
Torrance
PALOS VERDES

VCL
12
2
0408



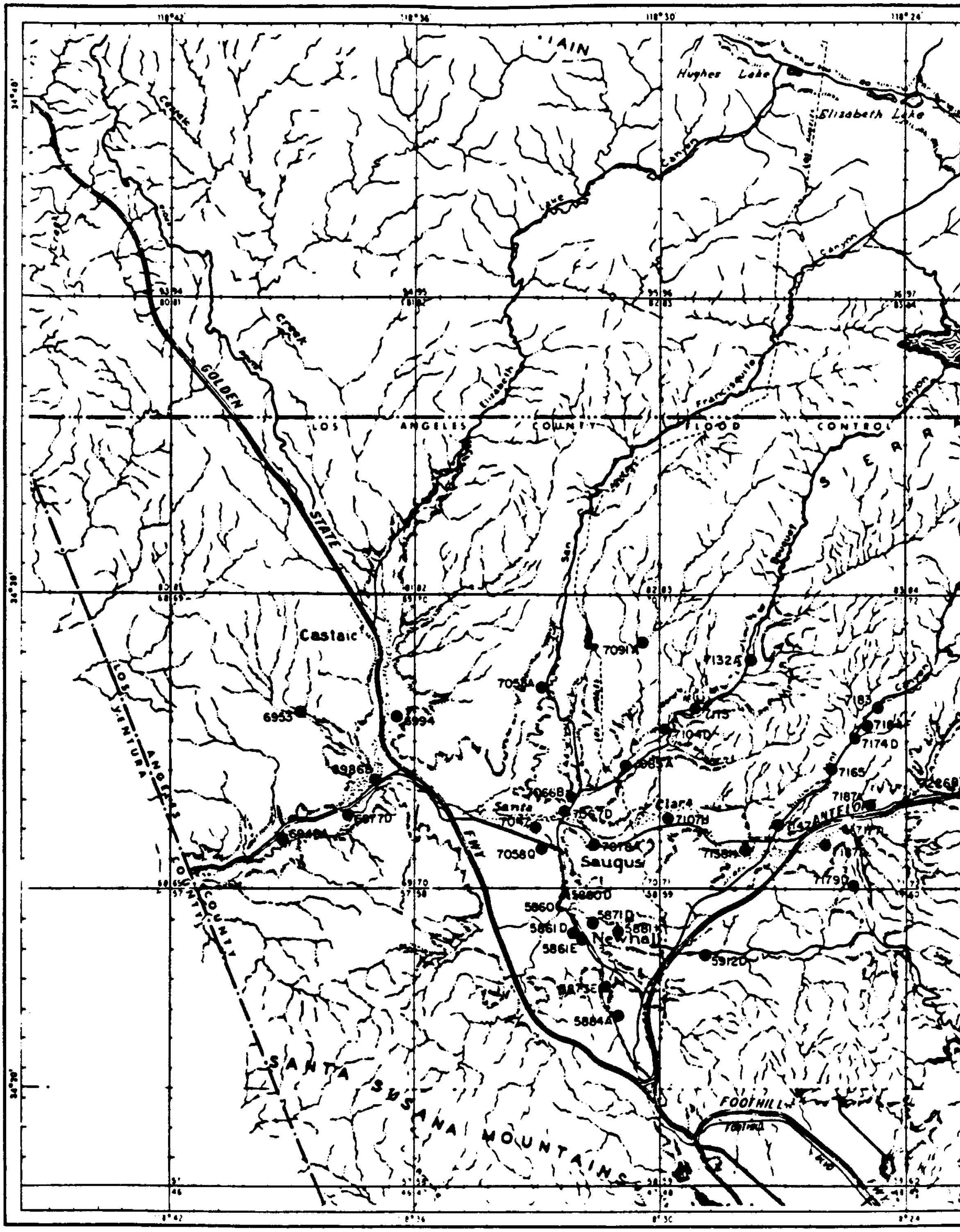
e-2

PF3

VOL 12

2 0409

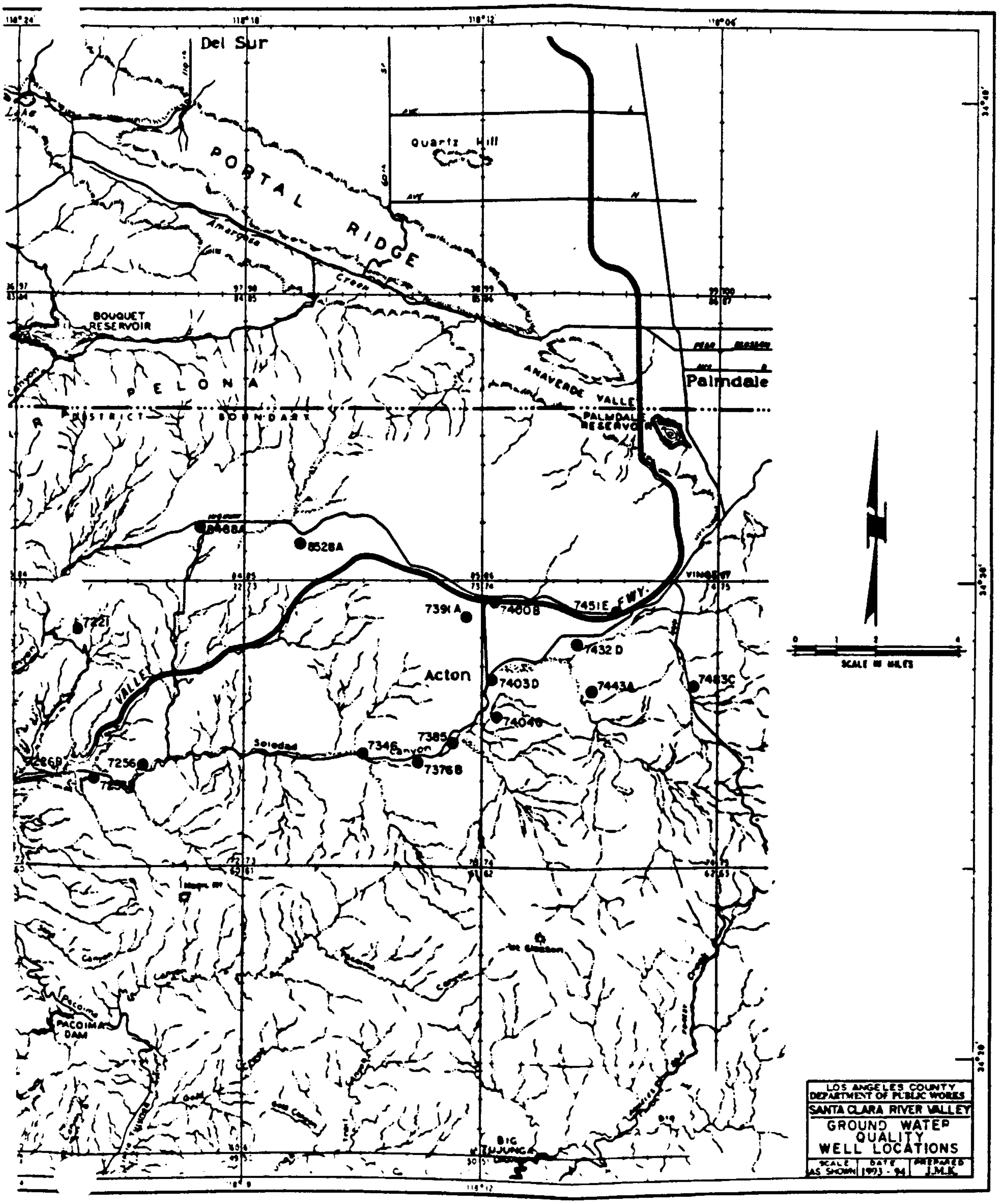
R0053714



VOL 12

2 0410

R0053715



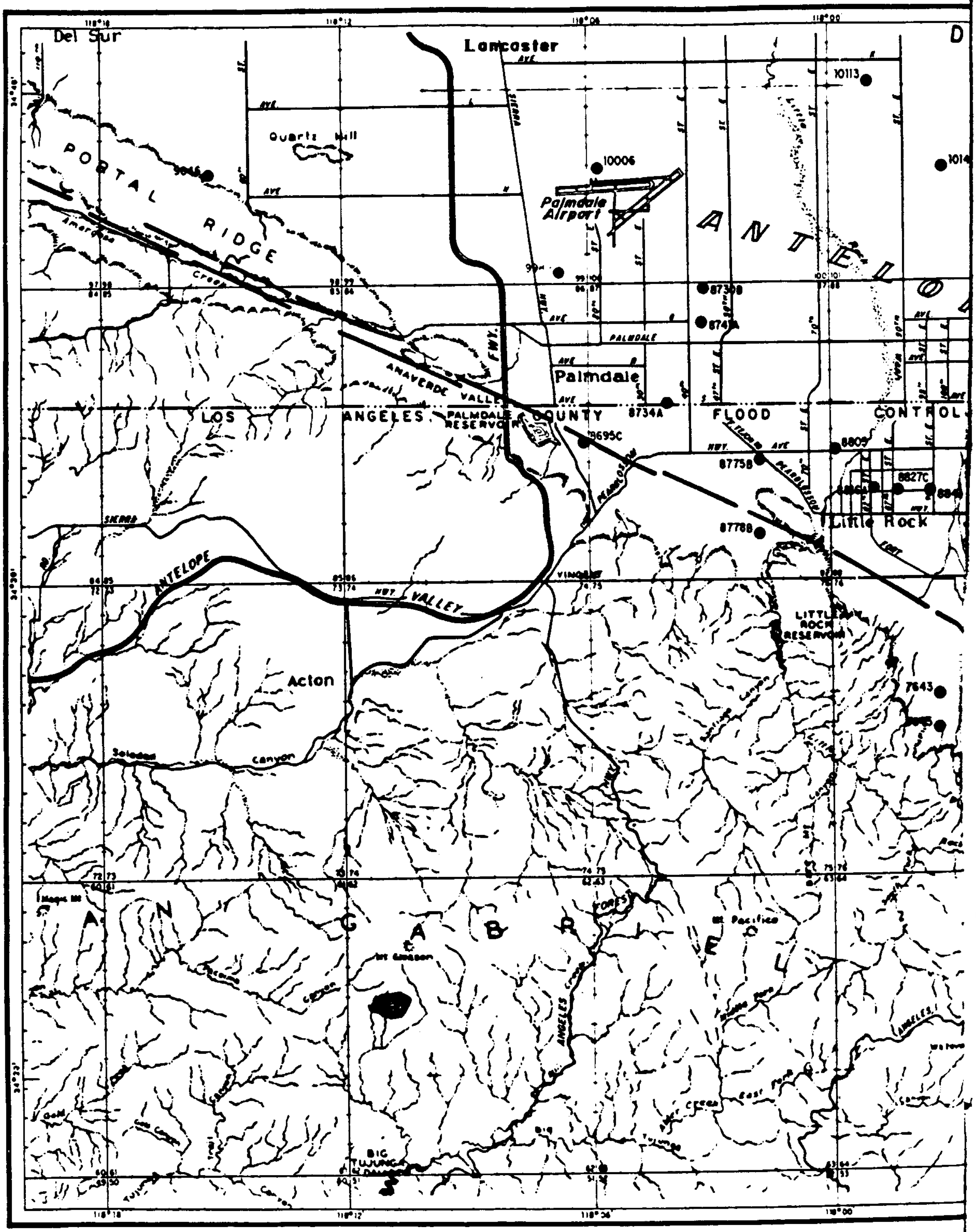
PF4

VOL 12

2

0411

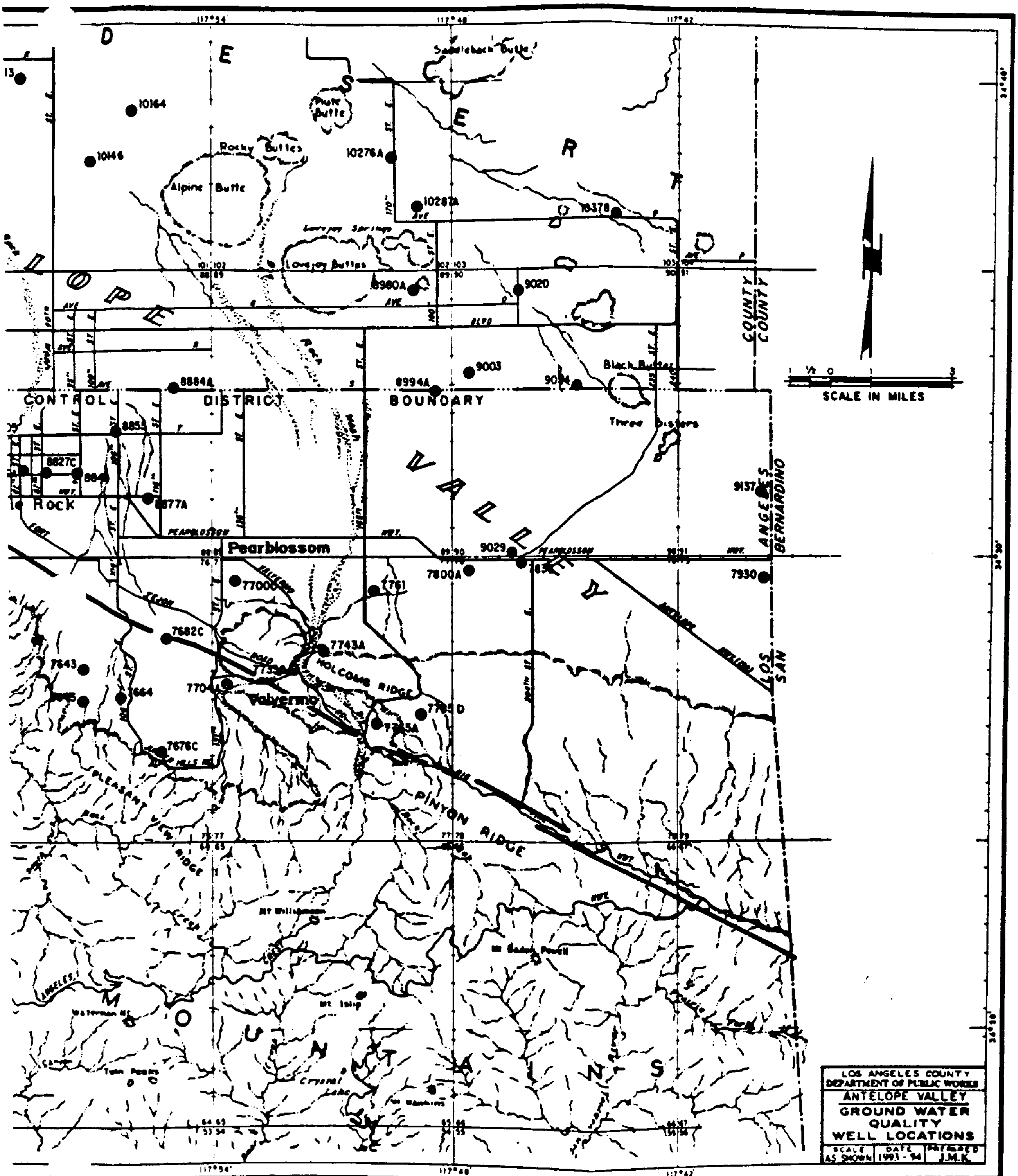
R0053716


Del Sur
Lancaster
Quartz Hill
PORTAL RIDGE
Palmdale Airport
10006
10113
ANTELOPE
Palmdale
LOS ANGELES COUNTY FLOOD CONTROL
PALMDALE RESERVOIR
8734A
8695C
87758
87788
8809
8827C
Little Rock
LITTLE ROCK RESERVOIR
7643
ANTELOPE VALLEY FWY.
Acton
Soledad Canyon
S A N G A B R I E L
BIG TUJUNGA DAM
D

VOL 12

2

0412



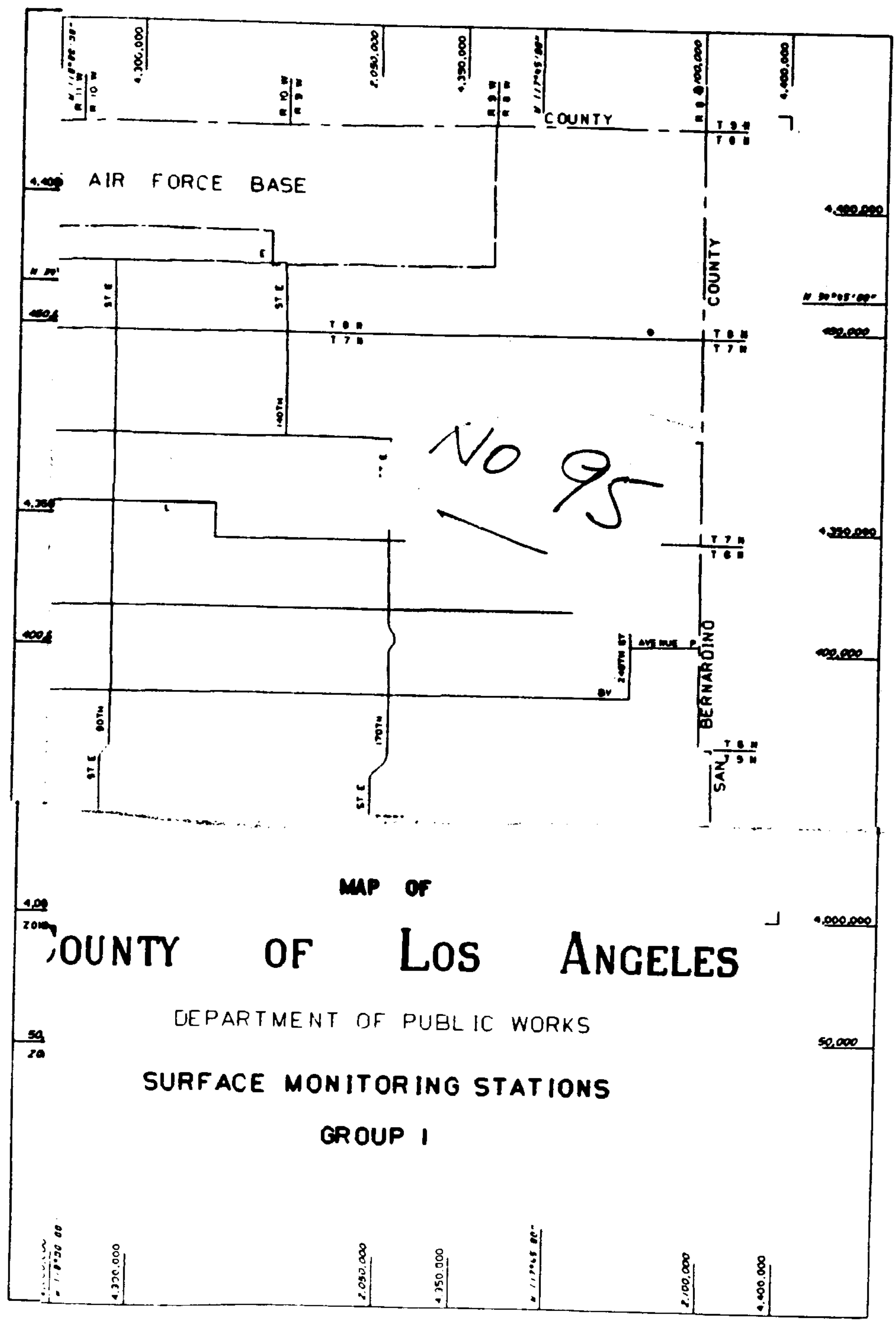
VOL 12

2 0413

D-1

PF5

R0053718



PF6

VOL 12

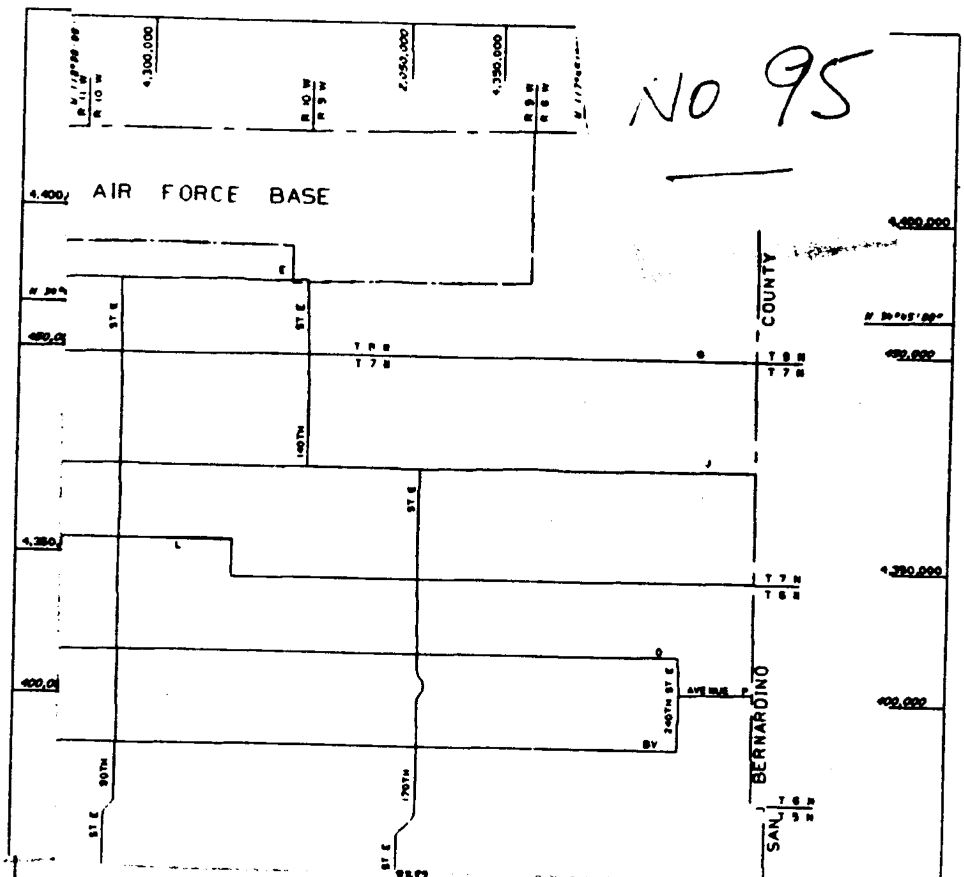
2 04-14

R0053719

NO 95

VOL 12

2 0415



MAP OF

OUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

SURFACE MONITORING STATIONS

GROUP 2

PF7

R0053720

VOL 12

2

0416

WATER CONSERVATION

WATER CONSERVATION

Information presented in this section includes amounts of local, imported, and reclaimed water conserved in spreading areas and information on the seawater barrier projects which prevent saltwater intrusion into groundwater zones in the coastal areas. Pertinent data is presented regarding the locations and descriptions of the Department's water conservation facilities, a well as facilities owned by others. Also included are groundwater maps delineating static groundwater elevations recorded during the report period and hydrographs of selected key wells.

CONSERVING THE WATERS

In addition to the flood control program, the Department has the equally important task of conserving as much of the storm and other waters as practicable. The use of water conservation facilities adjacent to river channels, and in soft-bottom channels permits water to percolate into groundwater basins for later pumping. These water spreading facilities are located in areas where the underlying soils are composed of permeable formations.

The various types of water conserved, local, imported, and reclaimed, are construed to have the following meanings in this section: Local water is primarily runoff due to rainfall on the mountain and valley watersheds, dam releases, and rising water within the County. Imported water is water originating outside the County either from Northern California or from the Colorado River. Reclaimed water is the effluent produced by the Whittier Narrows Water Reclamation Plant, the San Jose Creek Water Reclamation Plant, and the Pomona Reclamation Plant, all operated by the Los Angeles County Sanitation District.

The importance of this activity is apparent when it is realized that about 30 to 40 percent of the water used in the County is pumped from groundwater-supplies. The growth of the County, combined with periodic droughts, has seriously depleted these supplies on numerous occasions.

The Department's policy is to conserve the maximum possible amount of storm water consistent with runoff quantity and quality, capacities of the spreading facilities, and groundwater conditions.

IMPORTED WATER

During this report period, imported Colorado River and State Project water for spreading was received from the Metropolitan Water District (MWD) for spreading-Imported water in the Coastal Plain was spread at the Department's facilities in the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds on behalf of the Water Replenishment District of Southern California. Imported water in the San Gabriel Valley was spread in Santa Fe Spreading Grounds, in the San Gabriel River, in Irwindale Spreading Basin/Manning Pit, and in Forbes Spreading Grounds on behalf of the Upper San Gabriel Valley Municipal Water District, and the San Gabriel Valley Municipal Water District.

RECLAIMED WATER

The County Sanitation District's Whittier Narrows Water Reclamation Plant effluent, purchased by the Water Replenishment District of Southern California, is transported to the Rio Hondo and San Gabriel Coastal Basin Spreading Grounds for groundwater replenishment.

The County Sanitation District's San Jose Creek Water Reclamation Plant, made its first delivery of effluent in November 1972. The portion of the effluent that is spread is also purchased by the Water Replenishment District of Southern California.

Water from the Pomona Reclamation Plant is released down the San Jose Creek - San Gabriel River System to the Department's recharge facilities in the Rio Hondo and San Gabriel Coastal Basin spreading grounds.

The maximum amount of reclaimed water allowed for spreading in the Montebello Forebay, effective July 1991, is 60,000 acre-feet per year, but not to exceed 150,000 acre-feet over a three year period.

SEAWATER BARRIER PROJECTS

The Department operates three barrier projects to protect the groundwater in the West Coast and Central Basins against seawater intrusion by creating freshwater pressure ridges along the coastline. The pressure mound are created by injecting fresh water through a series of injection wells. During the report period, 15,482 acre-feet of water was injected at the West Coast Basin Barrier Project, 5,527 acre-feet at the Dominguez Gap Barrier Project, and 3,677 acre-feet at the Los Angeles part of the Alamitos Barrier Project. On behalf of the Orange County Water District, 1,309 acre-feet of water was injected at the Orange County portion of the Alamitos Barrier Project.

The following seawater barrier improvements were completed during the 1993-94 water year:

1. Alamitos Barrier Project:

   Orange County Water District drilled 4 new injection wells.

   Two injection wells were pressure-grouted to mitigate surface leakage problems.

   41 observation well manholes were modified by retrofitting them with 9-inch watertight vaults.

2. Dominguez Gap Barrier Project

   Construction was completed on ten multizone observation wells. The geohydrologic information gathered from this drilling contract will be used for determination of the required remedial improvements for mitigating intrusion around the North-South leg of the barrier.

   A consultant study based on strontium isotopes 86/87 ratios was conducted to eliminate oil field brines and other salt sources as contaminants. The study also identified and better defined seawater intrusion paths.

3. West Coast Basin Barrier Project

   During this period the construction of three injection wells and thirteen observation wells was completed.

These wells were constructed as part of the Department's consultant study recommendations to mitigate barrier deficiencies in the Silverado and Lower San Pedro aquifers.

SEASONAL DATA AND MAPS

During this report period, weekly, monthly, and semi-annual measurements of groundwater levels in observation wells located throughout the groundwater basins in Los Angeles County were made and processed.

Hydrographs of selected key wells are included in this report.

GROUNDWATER BASINS AND GROUNDWATER RECHARGE

Groundwater in Los Angeles County is stored in basins underlying five major geographic areas. These groundwater basins are separated by geologic features which impede groundwater movement or by political boundaries. The following is a background summary of the Department's groundwater recharge activities within each of these areas:

The Department operates 2,436 acres of spreading grounds and soft-bottom channel spreading areas for replenishment of local groundwater supplies. The Department also assisted in the operation and maintenance of 269 acres of spreading grounds owned by others. An additional 656 acres of spreading grounds are controlled, maintained, and operated by other agencies. The total gross acreage of spreading grounds in the County is 3,361 acres. During the report period, below normal rainfall allowed the Department to conserve approximately 117,260 acre-feet of storm runoff.

The conservation of local runoff is supplemented by spreading imported water and reclaimed water purchased by water agencies. During the report period, 56,041 acre-feet of imported water and 53,982 acre-feet of reclaimed water were spread.

The Department is continuing its efforts to improve its water spreading facilities in order to maximize the amounts of water conserved and to simplify the spreading operations.

SAN GABRIEL VALLEY

The Department operates 20 spreading facilities in the San Gabriel Valley that receive direct valley runoff and flows from the San Gabriel Mountains. Some of these spreading facilities can also receive imported water. During the report period, the Department added approximately 51,200 acre-feet of local water and 36,541 acre-feet of imported water to the groundwater stored in the basins underlying the San Gabriel Valley and diverted 2,618 acre-feet of local water to grounds owned by others.

Main San Gabriel Basin

This is the largest basin underlying the San Gabriel Valley with an estimated storage capacity of 9.5 million acre-feet. It reacts quickly to artificial spreading in Santa Fe Reservoir Spreading Grounds and to infiltration in the San Gabriel River downstream of Santa Fe Dam.

During the report period, the Department replenished the Main San Gabriel Basin with 37,883 acre-feet of local water and 30,981 acre-feet of imported water. Well 3030F in Baldwin Park recorded a high groundwater elevation for the report period of 259.6 ft on October 20, 1993.

The following improvements were constructed in the Upper San Gabriel Canyon Basin during 1993-94 water year:

San Gabriel Canyon Spreading Grounds - Improvements completed consisted of grading and lining of portions of the inlet canal, construction of an interbasin structure, a canal diversion structure into Basin 1, and the extension of the Basin 2 intake structure. These improvements increase flow capacity, reduced weed growth and erosion, minimized maintenance reqirements, and eliminated debris plugging the trashrack and the resulting washouts that have previously occurred.

Upper San Gabriel Canyon Basin

Approximately 6,931 acre-feet of local water and approximately 4,660 acre-feet of imported water were recharged by the Department through its San Gabriel Canyon Spreading Grounds and by percolation in the adjacent San Gabriel River. Also, 1,744 acre-feet of local water was routed to Fish Canyon Spreading Grounds, which is operated by the Committee of Nine.

Lower San Gabriel Canyon Basin

The basin is located south of the Upper San Gabriel Canyon Basin and is separated from it by the underground Lohmon Dike. Groundwater cascades over the Lohmon Dike from the Upper San Gabriel Canyon Basin and recharges the Lower San Gabriel Canyon Basin. The Department spread 995 acre-feet of local water in Sawpit Spreading Grounds which is within the Lower Canyon Basin.

Wayhill Basin

The Department spread 461 acre-feet of local water and 900 acre-feet of imported water at Forbes spreading facility in the Wayhill Basin.

Foothill Basin

The Department spread 3,034 acre-feet of local water at its San Dimas Canyon Spreading Grounds facility in the Foothill Basin.

Glendora Basin

The Department spread 198 acre-feet of local water in its Big and Little Dalton facilities within the Glendora Basin.

Claremont Heights Basin

The Department has no spreading facilities in the Claremont Heights Basin.

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Live Oak Basin

The Department has no spreading facilities in the Live Oak Basin.

Chino Basin

The basin is located in the most eastern part of the County. No Department recharge facilities are located within the Chino Basin.

San Dimas Basin

The basin is north of the San Jose Hills, east of the Main Basin, and south of the Wayhill Basin. The Department spread 136 acre-feet of local water in its Live Oak Spreading Grounds to recharge the basin.

Pomona Basin

The basin is located south of Claremont, Live Oak, and San Dimas Basins, and north of the Chino Basin and northeast of the San Jose Hills. The Department has no water spreading facilities within this basin.

Puente and Spadra Basins

No spreading occurs in this area.

Raymond Basin

The basin covering approximately 40 square miles is located in the northwest corner of the San Gabriel Valley and is separated from the Main San Gabriel Basin by the Raymond Fault. The Raymond Basin contains the Monk Hill Basin and the Pasadena and Santa Anita Subareas. The Department recharged 2,634 acre-feet of local water by its spreading facilities in the Raymond Basin and diverted 874 acre-feet to the City of Sierra Madre's spreading facility during the report period.

COASTAL PLAIN

The groundwater basins underlying the Coastal Plain are divided by geological features into the Central (includes the Montebello and Los Angeles Forebays), West Coast, Santa Monica, and Hollywood Basins. During this report period, the Department recharged 43,463 acre-feet of local water, 19,500 acre-feet of imported water, and 53,982 acre-feet of reclaimed water to the groundwater basins underlying the Coastal Plain. Most of the water was spread in the Montebello Forebay.

Central Basin

The Central Basin has the most storage capacity of the basins in the Coastal Plain. In addition to the water recharged in the Department's spreading facilities, water injected in the Alamitos Barrier Project also contributes to the replenishment of the pressure aquifers underlying the Central Basin.

The following project was constructed in the Central Basin during 1993-94 water year:

> Rio Hondo Coastal Basin Spreading Grounds - Replaced approximately 3,600 feet of open drainage ditch, which previously experienced severe erosion and seepage problems, with a 72-inch reinforced concrete pipe.

West Coast Basin

The West Coast Basin is the second largest basin underlying the Coastal Plain and is separated from the Central Basin by the Newport-Inglewood Fault zone. Groundwater is primarily recharged by Central Basin subsurface flows and by water injected by the Department in the West Coast Basin and Dominguez Gap Barrier Projects. Groundwater elevations in the West Coast Basin are below sea level except in the area of the West Coast Basin Barrier injection mound.

Santa Monica and Hollywood Basins

The Department has no spreading facilities in either the Santa Monica or Hollywood groundwater basins.

SAN FERNANDO VALLEY

The San Fernando Valley is also called the Upper Los Angeles River Area (ULARA). Most of the runoff from the surrounding mountains flows to the Valley.

San Fernando Main Basin

The basin is the largest basin underlying the San Fernando Valley. During the report period, 19,980 acre-feet of local water and no imported water were spread by the Department. The County entered into an agreement with the City of Los Angeles to spread water at the newly renovated Tujunga Wash Spreading Grounds which is located approximately two miles downstream of Hansen Spreading Grounds. The City installed a rubber dam diversion and appurtenant facilities for County Spreading operations which started in March 1990.

Sylmar Basin

A much smaller basin underlying the San Fernando Valley is the Sylmar Basin; the Department has no spreading facility within this basin.

Verdugo and Eagle Rock Basins

The small Verdugo and Eagle Rock Basins comprise the remaining basins underlying the San Fernando Valley. The Department has no spreading facilities within either basin.

SANTA CLARITA VALLEY

The Department has no spreading facilities in the area. Most of the Valley is farmland, permitting substantial natural percolation.

The Upper Santa Clarita subunit comprises five basins.

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ANTELOPE VALLEY

There are several groundwater subbasins underlying the Antelope Valley. Five of them are located within Los Angeles County.

The Department operates no spreading facilities in the Antelope Valley.

The hydrographs for well Nos. 9974 and 8825 are shown on pages G41 and G43. They are located in the Lancaster and Little Rock subbasins respectively.

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SPREADING FACILITY	TYPE	SEASON FIRST USED	ATER GR(	REMARKS
ARROYO SECO	SHALLOW BASINS	1948-49	ASADENA. D AND THE ALTADENA	SPREADING GROUNDS ARE HELD UNDER EASEMENT FROM THE CITY OF PASADENA.
BEN LOMOND	SHALLOW BASINS	1958-59	2	SPREADING GROUNDS UTILIZED TO CONSERVE EXCESS COVINA IRRIGATION COMPANY WATER RELEASED FROM THE COMMITTEE OF NINE.
BIG DALTON	SHALLOW BASINS	1930-31	2 ON DAM AND BIG	DIVIDED BASINS 2, 3, 4, AND 5, AND NOTCHED LEVEES TO ENABLE GROUNDS TO BE RUN IN BATTERY SYSTEM
BRANFORD	DEEP BASIN	1956-57	ORD STREET DRAIN.	INSTREAM SPREADING FACILITY. OUTLET CAPACITY 1,540 CFS TO PACOIMA DIVERSION CHANNEL.
BUENA VISTA	DEEP BASIN	1954-55	DAM AND VISTA CHANNEL.	INSTREAM SPREADING FACILITY. TOTAL OUTLET CAPACITY OF 270 CFS.
CITRUS	MEDIUM DEPTH BASINS	1960-61	ON DAM AND LITTLE .ED FLOWS FROM BIG	THERE ARE 2 INTAKES, ONE IS A DROP INLET, THE OTHER AN AIR INFLATED RUBBER DAM.
DOMINGUEZ GAP	DEEP BASINS	1957-58	LES RIVER LOW FLOW WS FROM STORM DRAINS.	EAST SIDE BASIN USED FOR FLOOD REGULATION WITH SOME CONSERVATION STORAGE. INTAKE CAPACITY IS 20 CFS FOR LOW FLOW DIVERSION FROM THE LOS ANGELES RIVER. THE WEST SIDE BASIN IS FED BY A 24-INCH CONCRETE PIPE FROM THE EAST SIDE BASIN.

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION R NUMBERS DO NOT REFLECT LONG TERM SPREADING OPER

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

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VOL 12

LOS ANGELES COUNTY DE
HYDRAULIC/WATER

SUMMARY OF DATA C
OWNED AND OPERAT
UPDATED THRO

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA (ACRES)		CAPACITIES				
			GROSS	WETTED	CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCOLATION* (CFS)	
ARROYO SECO	SHALLOW BASINS	1948-49	24	15.1	-	75	30	18	EASTERLY S GATE DAM
BEN LOMOND	SHALLOW BASINS	1958-59	24	17.0	-	25	25	18	BOTH NORT CHANNEL A INTERSECTIC AVENUE.
BIG DALTON	SHALLOW BASINS	1930-31	24	7.7	-	45	12	12	WESTERLY S ABOVE SIEF
BRANFORD	DEEP BASIN	1956-57	12	7.0	1,540	1,540	137	1	SOUTHWEST CONFLUEN DIVERSION
BUENA VISTA	DEEP BASIN	1954-55	10	6.0	2,900	2,900	177	6	1.0 MILE EA NORTHERLY MERIDIAN S
CITRUS	MEDIUM DEPTH BASINS	1960-61	19	14.6	-	200	80	28	SOUTH SIDE AND CERR
DOMINGUEZ GAP	DEEP BASINS	1957-58	54	23.8	-	20	234	1	SOUTH OF EASTERN A RIVER

2 0426

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION RATES. NUMBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

ɴTY DEPARTMENT OF PUBLIC WORKS
WATER CONSERVATION DIVISION

DATA ON SPREADING FACILITIES
OPERATED BY THE DEPARTMENT
) THROUGH SEPTEMBER 1994

LOCATION	SOURCE OF WATER	REMARKS
EASTERLY SIDE OF ARROYO SECO, 0.5 ABOVE DEVIL'S GATE DAM.	CONTROLLED FLOW FROM CITY OF PASADENA. UNCONTROLLED FROM ARROYO SECO AND THE ALTADENA STORM DRAIN.	SPREADING GROUNDS ARE HELD UNDER EASEMENT FROM THE CITY OF PASADENA.
BOTH NORTH AND SOUTH SIDES OF SAN DIMAS WASH CHANNEL AT SOUTHWESTERLY CORNER OF INTERSECTION OF ARROW HIGHWAY AND BARRANCA AVENUE.	COVINA IRRIGATING COMPANY.	SPREADING GROUNDS UTILIZED TO CONSERVE EXCESS COVINA IRRIGATION COMPANY WATER RELEASED FROM THE COMMITTEE OF NINE.
WESTERLY SIDE OF BIG DALTON WASH, ONE HALF MILE ABOVE SIERRA MADRE AVENUE.	CONTROLLED FLOWS FROM GIG DALTON DAM AND BIG DALTON DEBRIS BASIN.	DIVIDED BASINS 2, 3, 4, AND 5, AND NOTCHED LEVEES TO ENABLE GROUNDS TO BE RUN IN BATTERY SYSTEM
SOUT ERLY OF ARLETA AVENUE ABOVE CONF .CE OF TUJUNGA WASH AND PACOIMA DIVERSION CHANNEL.	UNCONTROLLED FLOWS FROM BRANFORD STREET DRAIN.	INSTREAM SPREADING FACILITY. OUTLET CAPACITY 1,540 CFS TO PACOIMA DIVERSION CHANNEL.
1.0 MILE EASTERLY OF SAWPIT WASH. 0.5 MILE NORTHERLY OF ARROW HIGHWAY, BETWEEN MERIDIAN STREET AND BUENA VISTA CHANNEL.	CONTROLLED FLOW FROM SANTA FE DAM AND UNCONTROLLED FLOW FROM BUENA VISTA CHANNEL.	INSTREAM SPREADING FACILITY. TOTAL OUTLET CAPACITY OF 270 CFS.
SOUTH SIDE OF BIG DALTON WASH BETWEEN CITRUS AND CERRITOS AVENUES.	CONTROLLED FLOWS FROM BIG DALTON DAM AND LITTLE DALTON DEBRIS DAMS. UNCONTROLLED FLOWS FROM BIG DALTON WASH.	THERE ARE 2 INTAKES, ONE IS A DROP INLET, THE OTHER AN AIR INFLATED RUBBER DAM.
SOUTH OF DEL AMO BOULEVARD AND BORDERS THE EASTERN AND WESTERN SIDES OF THE LOS ANGELES RIVER	CONTROLLED FLOW FROM LOS ANGELES RIVER LOW FLOW CHANNEL AND UNCONTROLLED FLOWS FROM STORM DRAINS.	EAST SIDE BASIN USED FOR FLOOD REGULATION WITH SOME CONSERVATION STORAGE. INTAKE CAPACITY IS 20 CFS FOR LOW FLOW DIVERSION FROM THE LOS ANGELES RIVER. THE WEST SIDE BASIN IS FED BY A 24-INCH CONCRETE PIPE FROM THE EAST SIDE BASIN.

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LOS ANGELES COUNTY DE
HYDRAULIC/WATER C

SUMMARY OF DATA O
OWNED AND OPERATE
UPDATED THROU

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA (ACRES)		CAPACITIES				
			GROSS	WETTED	CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCOLATION* (CFS)	
EATON BASIN	DEEP BASIN	1956-57	16	10.5	9,600	400	284	10	EAST SIDE OF ROAD, 0.6 MI
EATON WASH	DEEP & SHALLOW BASINS	1947-48	28	25.4	6,600	200	525	14	EASTERLY SIDE DAM TO FOOT
FORBES	MEDIUM DEPTH BASINS	1964-65	21	10	-	100	87	5	SOUTH SIDE OF AVENUE AND
HANSEN	SHALLOW BASINS	1944-45	156	105.3	22,000	400	279	150	NORTHWESTER ABOVE GLENO SAN FERNAND
IRWINDALE\MANNING PIT	DEEP BASINS	1958-59	62	30	20,000	400	1134	60	NORTHEASTER CHANNEL AND FEET EAST OF
LITTLE DALTON	SHALLOW BASINS	1931-32	14	4.7	-	20	5	15	WESTERLY OF DALTON DEBRIS
LIVE OAK	SHALLOW BASINS	1961-62	5	1.2	-	15	2	13	WESTERLY SIDE LINE ROAD (PR
LOPEZ	SHALLOW BASINS	1956-57	18	11.9	-	25	23.6	15	SOUTHEASTERLY NORTHEASTERLY

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION RATES.
NUMBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

2 0428

TY DEPARTMENT OF PUBLIC WORKS
ATER CONSERVATION DIVISION

ATA ON SPREADING FACILITIES
'ERATED BY THE DEPARTMENT
THROUGH SEPTEMBER 1994

LOCATION	SOURCE OF WATER	REMARKS
ST SIDE OF EATON WASH, NORTH OF DUARTE AD, 0.6 MILES SOUTH OF HUNTINGTON DRIVE.	CONTROLLED FLOW ROM EATON WASH DAM AND UNCONTROLLED FLOWS BETWEEN DAM AND SPREADING BASIN.	
STERLY SIDE OF EATON WASH FROM BELOW EATON M TO FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM EATON WASH DAM.	
JTH SIDE OF SAN DIMAS WASH BETWEEN LONE HILL ENUE AND VALLEY CENTER AVENUE.	CONTROLLED RELEASES FROM PUDDINGSTONE DIVERSION DAM, AND UNCONTROLLED FLOWS FROM SAN DIMAS WASH; ALSO IMPORTED RELEASES FROM SGVMWD.	
RTHWESTERLY SIDE OF TUJUNGA WASH FROM OVE GLENOAKS BOULEVARD SOUTHWESTERLY TO I FERNANDO ROAD.	CONTROLLED FLOWS FROM HANSEN DAM AND GIG TUJUNGA DAM.	
RTHEA OF INTERSECTION OF BIG DALTON ANNEL (WINDALE AVENUE; CONTINUES 1,300 ' EAST OF IRWINDALE VENUE	BIG DALTON CHANNEL CONTROLLED FLOWS FROM BIG AND LITTLE DALTON DEBRIS DAMS AND PUDDINGSTONE DIVERSION DAM; UNCONTROLLED FLOWS; ALSO IMPORTED RELEASES FROM SGVMWD.	
STERLY OF GLENDORA MT. ROAD FROM LITTLE TON DEBRIS BASIN SOUTH TO EAST PALM DRIVE.	CONTROLLED FLOW FROM LITTLE DALTON DEBRIS BASIN.	
TERLY SIDE OF LIVE OAK WASH. NORTH OF BASE ROAD (PROJECTED).	CONTROLLED FLOW FROM LIVE OAK DAM AND LIVE OAK DEBRIS BASIN.	
THEASTERLY SIDE OF PACOIMA WASH, THEASTERLY OF FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM PACOIMA DAM AND LOPEZ FLOOD CONTROL BASIN.	

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LOS ANGELES COUNTY DEPA
HYDRAULIC/WATER CO

SUMMARY OF DATA ON
OWNED AND OPERATE
UPDATED THROUG

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA (ACRES)		CAPACITIES				
			GROSS	WETTED	CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCOLATION* (CFS)	
PACOIMA	MEDIUM DEPTH BASINS	1932-33	169	107.3	17,000	600	440	65	BOTH SIDES OF ARLETA AVEN AVENUE.
PECK ROAD	DEEP BASIN	1959-60	157	105	30,100	30,100	3,347	25	CONFLUENCE
RIO HONDO COASTAL	MEDIUM DEPTH BASINS	1937-38	570	430.1	40,000	1,950	3,694	400	EASTERLY SIDE R. R. (SOUTHC AVENUE; WE 0.2 MILE ABO FOSTER BRID
SAN DIMAS CANYON	SHALLOW BASINS	1965-66	22	10.8	-	25	22	12	SOUTHEAST PUDDINGST CANYON RO
SAN GABRIEL CANYON	DEEP BASINS	1917	165	-	-	60	8170	35	EASTERLY SID OF SAN GA AZUSA.
SAN GABRIEL COASTAL	MEDIUM DEPTH BASINS	1938-39	128	95.9	-	350	575	75	WESTERLY SI FROM WHIT BOULEVARD

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION RATES. NUMBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

2 0430

ꞁNTY DEPARTMENT OF PUBLIC WORKS
WATER CONSERVATION DIVISION

' DATA ON SPREADING FACILITIES
OPERATED BY THE DEPARTMENT
ↄ THROUGH SEPTEMBER 1994

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LOCATION	SOURCE OF WATER	REMARKS
BOTH SIDES OF OLD PACOIMA WASH CHANNEL FROM ARLETA AVENUE SOUTHWESTERLY TO WOODMAN AVENUE.	CONTROLLED FLOW FROM PACOIMA DAM. PARTIALLY CONTROLLED FLOW FROM LOPEZ FLOOD CONTROL BASIN, UNCONTROLLED FLOW FROM EAST CANYON AND PACOIMA WASH. IMPORTED WATER FROM OWENS VALLEY DELIVERED BY CITY OF LOS ANGELES.	
CONFLUENCE OF SAWPIT AND SANTA ANITA WASHES.	CONTROLLED RELEASES FROM SANTA ANITA AND SAWPIT DEBRIS BASINS AND UNCONTROLLED FLOWS FROM LOCAL RUNOFF VIA SAWPIT AND SANTA ANITA WASHES.	INSTREAM SPREADING FACILITY.
EASTERLY SIDE OF RIO HONDO SOUTHERLY FROM S. P. R. R. (SOUTH OF WHITTIER BLVD.) TO SLAUSON AVENUE; WEST SIDE OF RIO HONDO CHANNEL FROM 0.2 MILE ABOVE WHITTIER BOULEVARD SOUTH TO FOSTER BRIDGE BOULEVARD.	CONTROLLED RELEASES FROM SAN GABRIEL CANYON DAMS, SANTA FE AND WHITTIER NARROWS DAMS. UNCONTROLLED RUNOFF VIA SAN GABRIEL RIVER, RIO HONDO CHANNEL AND THEIR TRIBUTARIES; ALSO IMPORTED AND RECLAIMED WATER.	IN COOPERATION WITH THE CORPS OF ENGINEERS. THE DISTRICT OPERATES 2,500 ACRE-FOOT POOL AT WHITTIER NARROWS DAM FOR RETENTION OF STORM WATER.
SOUTH SIDE OF SAN DIMAS WASH BETWEEN PUDDINGSTONE DIVERSION AND SAN DIMAS CANYON ROAD.	CONTROLLED RELEASES FROM PUDDINGSTONE DIVERSION DAM; UNCONTROLLED FLOW FROM LOCAL STORM RUNOFF.	
EASTERLY SIDE OF SAN GABRIEL RIVER. BELOW MOUTH OF SAN GABRIEL CANYON. NORTH OF THE CITY OF AZUSA.	SAN GABRIEL RIVER CONTROLLED RELEASES FROM COGSWELL DAM, SAN GABRIEL DAM, AND MORRIS DAM. COMMITTEE OF NINE SURPLUS FLOWS.	
WESTERLY SIDE OF SAN GABRIEL RIVER, SOUTHERLY FROM WHITTIER BOULEVARD TO WASHINGTON BOULEVARD.	CONTROLLED RELEASES FROM SAN GABRIEL CANYON DAMS. SANTA FE AND WHITTIER NARROWS DAMS. ALSO IMPORTED AND RECLAIMED WATER.	

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LOS ANGELES COUNTY DE
HYDRAULIC/WATER C

SUMMARY OF DATA O
OWNED AND OPERAT
UPDATED THROU

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA (ACRES)		CAPACITIES				
			GROSS	WETTED	CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCOLATION* (CFS)	
SAN GABRIEL RIVER (MONTEBELLO FOREBAY)	MEDIUM DEPTH BASINS	1954-55	156	156	20,000	550	1,462***	75	HEADWORK BEHIND THE
SAN GABRIEL RIVER (SAN GABRIEL VALLEY)	TEMPORARY CHECK LEVEES	1965-66	196	196	-	-	-	180	SAN GABRI
SANTA ANITA	SHALLOW BASINS	1944-45	20	8.5	-	20	25	5	WESTERLY S ABOVE FOO
SANTA FE	SHALLOW AND MEDIUM DEPTH BASINS	1953-54	338	168	-	400	540	400	WITHIN SAN AREAS.
SAWPIT	SHALLOW BASINS	1946-47	12	3.8	-	30	13	12	WESTERLY SI CANTON N
WALNUT	DEEP BASIN	1962-63	16	8.4	8,000	150	166	5	WEST SIDE C BERNARDIN

* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION RATES. NUMBERS DO NOT REFLECT LONG TERM SPREADING OPERATIONS.

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL

*** INCLUDES RUBBER DAMS STORAGE

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NTY DEPARTMENT OF PUBLIC WORKS
VATER CONSERVATION DIVISION

DATA ON SPREADING FACILITIES
)PERATED BY THE DEPARTMENT
THROUGH SEPTEMBER 1994

LOCATION	SOURCE OF WATER	REMARKS
HEADWORKS TO FIRESTONE AVE. ONLY. STORAGE BEHIND THE RUBBER DAMS.	SAME AS UPPER PORTION. ALSO RECLAIMED WATER.	FIVE RUBBER DAMS INSTALLED ON DROP STRUCTURES. WHEN INFLATED, CONVERTS RIVER AND TO SPREADING AREAS.
;AN GABRIEL RIVER FROM SANTA FE DAM.	CONTROLLED FLOW FROM DAMS IN SAN GABRIEL CANYON, SANTA FE DAM AND UNCONTROLLED VALLEY RUNOFF BELOW SANTA FE DAM; ALSO IMPORTED WATER.	
VESTERLY SIDE OF SANTA ANITA WASH 1.25 MILES ABOVE FOOTHILL BOULEVARD.	CONTROLLED FLOW FROM SANTA ANITA DAM AND SANTA ANITA DEBRIS BASIN.	THE HEADWORKS LOCATED UPSTREAM OF THE DEBRIS BASIN DIVERTS WATER TO SANTA ANITA SPREADING GROUNDS AND CITY OF SIERRA MADRE SPREADING GROUNDS
VITHIN SANTA FE DAM RESERVOIR AND SPILLWAY .REAS.	CONTROLLED FLOWS FROM SAN GABRIEL CANYON RESERVOIRS. UNCONTROLLED FLOWS FROM SAN GABRIEL RIVER BELOW MORRIS RESERVOIR; ALSO IMPORTED WATER FROM SGVMWD AND USG-3	
/ESTERLY SIDE OF SAWPIT WASH BELOW MOUTH OF :ANTON NEAR NORUMBEGA DRIVE, MONROVIA.	CONTROLLED FLOWS FROM SAWPIT DAM AND SAWPIT DEBRIS BASIN.	
/EST SIDE OF WALNUT WASH, NORTH OF SAN ERNARDINO FREEWAY.	CONTROLLED FLOW FROM PUDDINGSTONE DAM AND UNCONTROLLED FLOWS FROM WALNUT WASH CHANNEL.	

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HYDRAULIC/WATER C

SUMMARY OF DATA O
NOT OWNED BY
UPDATED THROU

SPREADING FACILITY	TYPE	SEASON FIRST USED	AREA (ACRES)		CAPACITIES				
			GROSS	WETTED	CHANNEL** (CFS)	INTAKE (CFS)	STORAGE (A.F.)	PERCOLATION* (CFS)	
SIERRA MADRE (CITY OF SIERRA MADRE)	SHALLOW BASINS	ABOUT 1933	22	9.0	-	25	47	15	CITY OF AVENUE AVENUE
FISH CANYON (COMMITTEE OF NINE)	SHALLOW BASINS	ABOUT 1917	6	4.0	-	-	-	7	WESTERL OF FISH
THOMPSON CREEK **** POMONA VALLEY PROTECTIVE ASSOCIATION	DITCHES CHECKS AND DEEP BASIN	ABOUT 1928	53	37.0	-	35	-	15	SOUTHE CREEK D
TUJUNGA (L.A. CITY DEPT. OF WATER AND POWER) ***	SHALLOW BASINS	ABOUT 1931-32	188	83.2	22,000	400	100	120	SAN FER WASH A
	TOTALS:		269	133.2	-	-	147	157	

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* THE CAPACITIES LISTED ARE ESTIMATES OF INFILTRATION RATES.

** DESIGN CAPACITY OF MAIN CONCRETE CHANNEL.

JNTY DEPARTMENT OF PUBLIC WORKS
WATER CONSERVATION DIVISION

' DATA ON SPREADING FACILITIES
VNED BY THE DEPARTMENT
) THROUGH SEPTEMBER 1994

)N°	LOCATION	SOURCE OF WATER	REMARKS
	CITY OF SIERRA MADRE, SOUTH SIDE OF GRANDVIEW AVENUE, ONE HALF MILE WEST OF SANTA ANITA AVENUE	LITTLE SANTA ANITA CREEK AND STREET RUNOFF ALSO CONTROLLED FLOWS FROM SANTA ANITA DAM.	THE DEPARTMENT DIVERTS WATER TO THIS FACILITY.
	WESTERLY SIDE OF SAN GABRIEL RIVER BELOW MOUTH OF FISH CANYON AND NORTH OF THE CITY OF AZUSA.	THE 'COMMITTEE OF NINE'.	OWNED AND OPERATED BY CAL-AMERICAN WATER COMPANY.
	SOUTHERLY FROM, AND ADJACENT TO THOMPSON CREEK DAM, EAST SIDE OF CREEK. ELEVATION 1,625.	COBAL, WILLIAMS, PALMER, AND PADUA CREEKS, ALSO THOMPSON CREEK WHEN RESERVOIR ABOVE	OPERATED BY POMONA VALLEY PROTECTIVE ASSOCIATION. THE DEPARTMENT DIVERTS WATER TO THIS FACILITY.
	SAN FERNANDO VALLEY, EAST SIDE OF TUJUNGA WASH AT ROSCOE BOULEVARD.	LOS ANGELES CITY'S OWENS VALLEY AQUEDUCT AND CONTROLLED RELEASES FROM HANSEN DAM.	THE DEPARTMENT ENTERED INTO AN AGREEMENT WITH THE CITY OF LOS ANGELES TO OPERATE THIS FACILITY.

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Hydraulic/Water

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TOTAL MONTHLY WATER CONS

AREA	SPREADING FACILITIES	OCT	NOV	DEC	JAN	FE
SAN FERNANDO VALLEY	BRANFORD	21	32	69	22	
	HANSEN	1,300	842	1,130	1,210	
	LOPEZ	0	0	0	0	
	PACOIMA	143	33	432	230	
	TUJUNGA	0	321	634	672	
	SUBTOTAL	1,464	1,228	2,265	2,134	
SAN GABRIEL VALLEY	ARROYO SECO	7	141	204	233	
	BEN LOMOND	562	498	725	539	
	BIG DALTON	0	0	0	0	
	BUENA VISTA	0	39	33	9	
	CITRUS	471	294	413	407	
	EATON BASIN	4	55	119	34	
	EATON GROUNDS	23	12	59	2	
	FORBES	21	145	147	190	
	IRWINDALE	1	1,500	951	555	
	LITTLE DALTON	0	0	0	3	
	LIVE OAK	0	0	0	0	
	MORRIS TO STA. F190	2,003	1,072	665	290	
	STA. F190 TO S.F. DAM OUTFLOW	1,837	1,036	562	226	
	PECK ROAD	121	417	527	168	
	SAN DIMAS CANYON	0	200	233	31	
	SAN GABRIEL CANYON	0	0	0	0	
	SANTA ANITA	51	97	161	78	
	SANTA FE SPRD. GROUNDS	7,110	0	0	0	
	SANTA FE TO STA. F261	423	425	1,328	501	
	SANTA FE DIVERSION	0	600	370	0	
	SAWPIT	61	153	143	150	
	WALNUT	56	65	160	0	
	WALNUT,S.JOSE CRK TO 263	456	650	597	510	
	SUBTOTAL	13,206	7,399	7,397	3,925	
COASTAL PLAIN	RIO HONDO EAST FLUME	1,940	4,370	3,190	2,790	
	WEST FLUME	1,260	1,660	1,480	903	
	R/W FLUME	155	166	345	221	
	102" INTAKE	1,162	161	1,037	2,045	
	WHITTIER NARROWS(Rio Hondo Side)	1,680	587	582	1,014	
	SAN GABRIEL SYSTEM	2,700	4,729	5,892	2,529	
	DOMINGUEZ GAP	2	5	19	30	
	SUBTOTAL	8,900	11,677	12,545	9,532	1
OTHER FACILITIES	SIERRA MADRE	0	0	72	15	
	FISH CREEK	294	104	127	123	
	SUBTOTAL	294	104	199	138	
TOTAL OF ALL WATER SPREAD &/OR DIVERTED		23,863	20,408	22,407	15,729	2

* Numbers include water infiltrated in the Rio Hondo Side of Whittier Narrows Reservoir, water infiltrated to the Rio Hondo via the cross-o

ounty Department of Public Works
lic/Water Conservation Division

ER CONSERVED DURING WATER YEAR 1993-94

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ACC. TOT
178	109	22	9	0	0	0	0	462
2,480	1,560	1,380	1,690	264	196	0	0	12,052
0	0	0	0	153	10	12	6	182
1,120	472	257	158	311	0	0	0	3,156
634	702	565	160	439	2	0	0	4,129
4,412	2,843	2,224	2,017	1,167	208	12	6	19,980
396	358	69	133	21	0	0	0	1,562
271	309	257	614	131	83	27	31	4,047
28	6	78	30	0	2	0	0	144
55	61	17	0	0	0	0	0	214
127	146	34	0	21	35	31	39	2,018
77	60	4	5	12	12	12	12	406
0	47	263	78	9	0	0	0	493
48	122	0	0	85	205	284	343	1,590
636	954	323	28	1,510	1,270	1,450	1,360	10,538
8	7	9	2	0	0	0	0	28
0	16	0	77	6	0	0	0	99
227	221	178	2,186	1,193	286	136	159	8,616
301	50	117	1,277	631	260	239	4	6,540
386	386	258	48	6	38	103	87	2,545
495	176	30	15	423	164	18	2	1,787
0	0	356	283	509	912	873	53	2,986
84	25	22	35	21	4	2	0	579
0	0	2,850	8,160	2,710	0	0	0	20,830
1,734	1,049	1,629	4,620	730	73	160	105	12,777
0	0	0	0	0	0	0	0	970
4	54	142	69	121	0	45	53	995
31	29	164	112	75	65	60	52	869
641	728	550	1,086	447	645	541	257	7,108
5,549	4,804	7,350	18,858	8,661	4,054	3,981	2,557	87,740
5,090	3,580	1,640	3,590	5,170	1,370	132	887	33,749
1,160	1,190	426	753	731	1,310	109	39	11,021
82	208	132	261	254	8	6	5	1,842
4,185	2,596	803	3,427	1,160	151	97	480	17,306
1,580	1,605	1,571	1,444	394	513	1,406	882	13,258
4,602	6,113	4,522	2,280	5,110	483	418	160	39,538
52	66	33	24	1	0	0	0	231
16,751	15,358	9,127	11,779	12,820	3,834	2,168	2,453	116,945
229	122	146	254	36	0	0	0	874
121	130	114	134	148	148	145	157	1,744
350	252	260	388	184	148	145	157	2,618
27,062	23,257	18,960	33,042	22,832	8,244	6,305	5,174	227,283

he cross-over channel, and infiltration within a portion of the zone 1 ditch.

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Los Angeles County, D
Hydraulic Water

Imported and Reclaimed
WATER YE

MONTH	IMPORTED WATER OUTLET RELEASES								
	SAN DIMAS CB - 48	THOMPSON CREEK CB - 28	SAN GAB. RIVER CB - 37	ALHAMBRA CB - 36	OLDEN ST L.A. 699	USG 3 USGMWD	BEATTY CANYON SGVMWD	SAN DIMAS WH SGVMWD	MONTHLY TOTAL SPREAD
OCT	0	0	0	745	0	0	0	59	80
NOV	0	0	0	1,899	0	0	0	1,992	3,89
DEC	0	0	0	1,348	0	0	0	1,242	2,59
JAN	0	0	0	859	0	0	0	929	1,78
FEB	0	0	0	3	0	0	0	0	[illegible]
MAR	0	0	0	0	0	0	0	793	79
APR	0	0	0	0	0	388	1,147	303	1,83
MAY	0	6,424	0	0	0	13,820	1,854	0	22,09
JUN	0	7,132	0	1,574	0	5,340	0	1,828	15,87
JUL	0	0	0	1,088	0	0	0	1,520	2,60
AUG	0	0	0	0	0	0	0	1,873	1,87
SEP	0	0	0	84	0	0	0	1,798	1,88
TOTALS	0	13,556	0	7,599	0	19,548	3,001	12,337	56,04

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ıty, Department of Public Works
ater Conservation Division

ned Water Delivered in Acre-Feet
R YEAR : 1993-1994

	RECLAIMED WATER DELIVERED									
MONTHLY TOTAL SPREAD	WHITTIER NARROWS PLANT DELIVERED R.HONDO	WHITTIER NARROWS PLANT DELIVERED S.GABRIEL	WHITTIER NARROWS PLANT WASTED	WHITTIER NARROWS PLANT MONTHLY SPREAD	SAN JOSE PLANT DELIVERED R.HONDO	SAN JOSE PLANT DELIVERED S.GABRIEL	SAN JOSE PLANT WASTED	SAN JOSE PLANT MONTHLY SPREAD	POMONA PLANT	MONTHLY TOTAL SPREAD
804	997	0	0	997	4,318	2,393	0	6,711	426	8,134
3,891	1,190	0	6	1,184	3,239	3,453	0	6,692	534	8,410
2	606	0	0	606	2,144	3,470	0	5,614	389	6,609
1,788	1,020	0	0	1,020	3,176	1,679	0	4,855	155	6,029
3	811	0	7	804	474	1,618	0	2,092	311	3,207
793	1,151	0	19	1,132	554	3,263	0	3,817	357	5,306
1,838	863	0	1	862	446	3,699	0	4,146	103	5,110
22,099	1,146	0	0	1,146	536	1,792	0	2,328	312	3,785
15,874	1,010	0	0	1,010	0	2,631	0	2,631	86	3,727
2,608	630	0	0	630	683	153	0	836	113	1,579
1,873	60	0	0	60	103	241	0	344	19	423
1,882	798	0	0	798	701	2	0	703	160	1,661
56,042	10,281	0	33	10,249	16,373	24,395	0	40,768	2,966	53,982

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2 0440

WELL HYDROGRAPHS INCLUDED IN THIS REPORT

GROUNDWATER BASIN	WELL NO.	APPROXIMATE LOCATION	PAGE NO.
WEST COAST	1346D 760C	11305 TRURO AVE., 250FT. N. OF IMPERIAL HWY., COMPTON 99 FT. S.W. OF INTERSECTION OF COMPTON BLVD. & DOTY AVE., LAWNDALE	G19
CENTRAL BASIN	460K	2,600 FT. N.E. OF THE INTERSECTION OF LAKEWOOD BLVD. & PACIFIC COAST HWY., LONG BEACH	G21
	1601T	1,000 FT. S. OF THE INTERSECTION OF WASHINGTON BLVD. & ROSEMEAD BLVD., MONTEBELLO	G23
	906D	1,300 FT. N.W. OF THE INTERSECTION OF LONG BEACH & SAN ANTONIO DR., LONG BEACH	G25
MAIN SAN GABRIEL	3030F	600 FT. N.W. OF THE INTERSECTION OF LOS ANGELES ST. & MAINE AVE., BALDWIN PARK	G27
	2965C	100 FT. S.W. OF THIENES AVE. & 180 FT. N.W. OF DURFEE AVE. (NOW PECK ROAD)	G29
SAN GABRIEL CANYON	4284A 4285	5,600 FT. N.W. OF THE INTERSECTION OF SIERRA MADRE AVE. & SAN GABRIEL CANYON ROAD., AZUSA 2,700 FT. N.W. OF SAN GABRIEL CANYON RD. & SIERRA MADRE AVE.	G31
POMONA	3251E 3261P 4469A	2,200 FT. N. OF THE INTERSECTION OF SAN BERNARDINO FWY. & TOWNE AVE., POMONA 630 FT. N.E. FROM INTERSECTION OF LA VERNE AVE. & 50 FT. S.E. OF CENTERLINE OF TOWNE AVE. 739 FT. W. OF MOUNTAIN AVE., 1,025 FT. N. OF HARRISON AVE.	G33
CLAREMONT HEIGHTS	4508B 4508A	800 FT. S.E. OF THE INTERSECTION OF BASELINE RD. & PADUA AVE., CLAREMONT 270 FT. N.W. OF WELL 4508	G35
RAYMOND	4057H	LOS ROBLES & GLENARM STREETS, PASADENA	G37
SANTA CLARA	7048A 7048C	S.E. OF THE INTERSECTION OF NEWHALL AVE. & MAGIC MOUNTAIN PARKWAY, SAUGUS 544 FT. W. OF W. CURB OF VALENCIA BLVD., 56 FT. S. OF MAGIC MOUNTAIN PARKWAY, VALENCIA	G39
ANTELOPE VALLEY	9974	8,976 FT. S. OF AVE. K & 200 FT. W. OF SIERRA HWY., LANCASTER	G41
	8825	25 FT. N. OF AVE. T & 45 FT. E. OF 90TH ST., LITTLE ROCK	G43
MAIN SAN FERNANDO	3872H	CLARK AVE. & GRIFFITH PARK DR., BURBANK	G45
	4709	SHERMAN WAY & DEERING AVE., CANOGA PARK	G47

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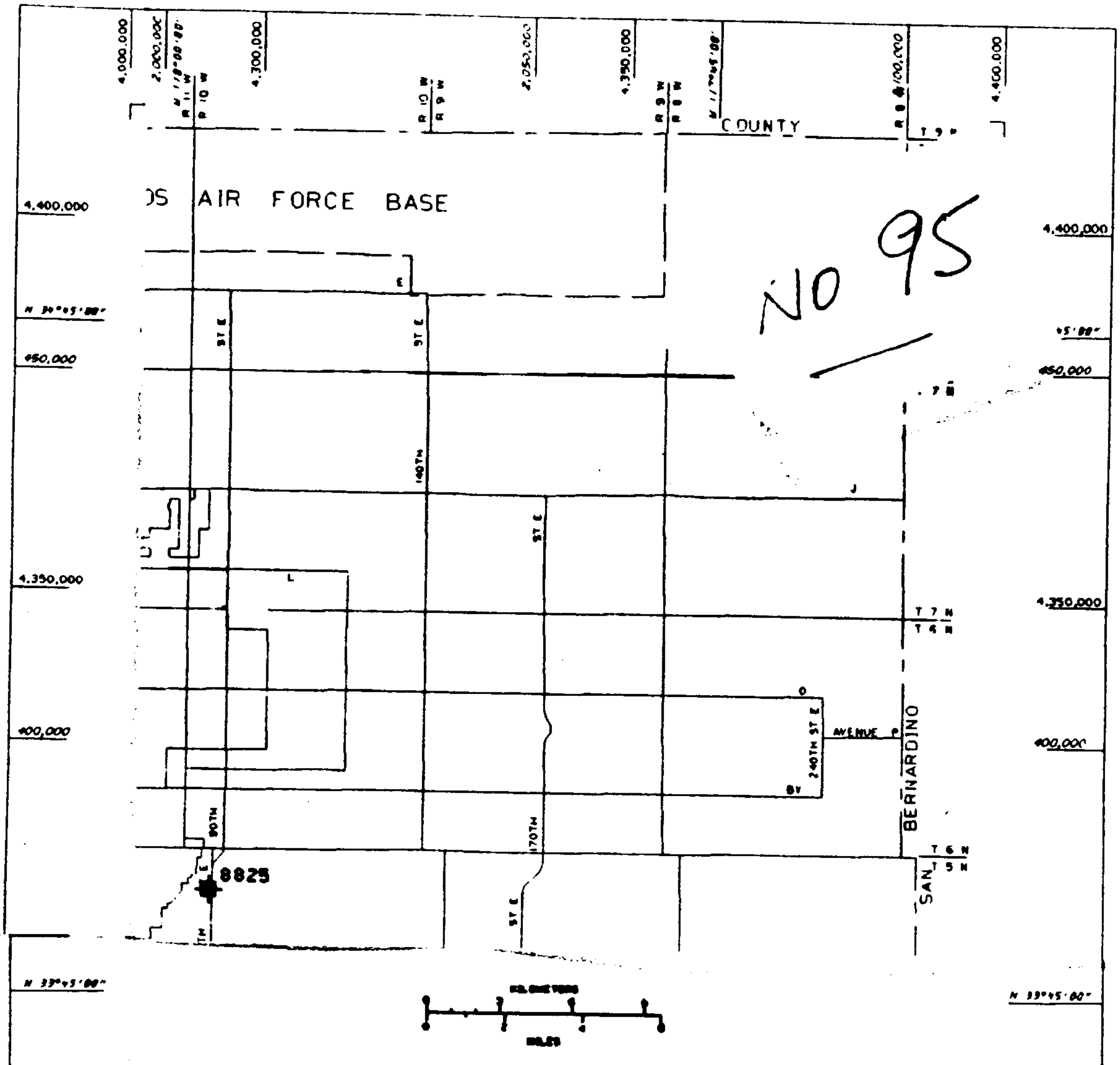


MAP OF

COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

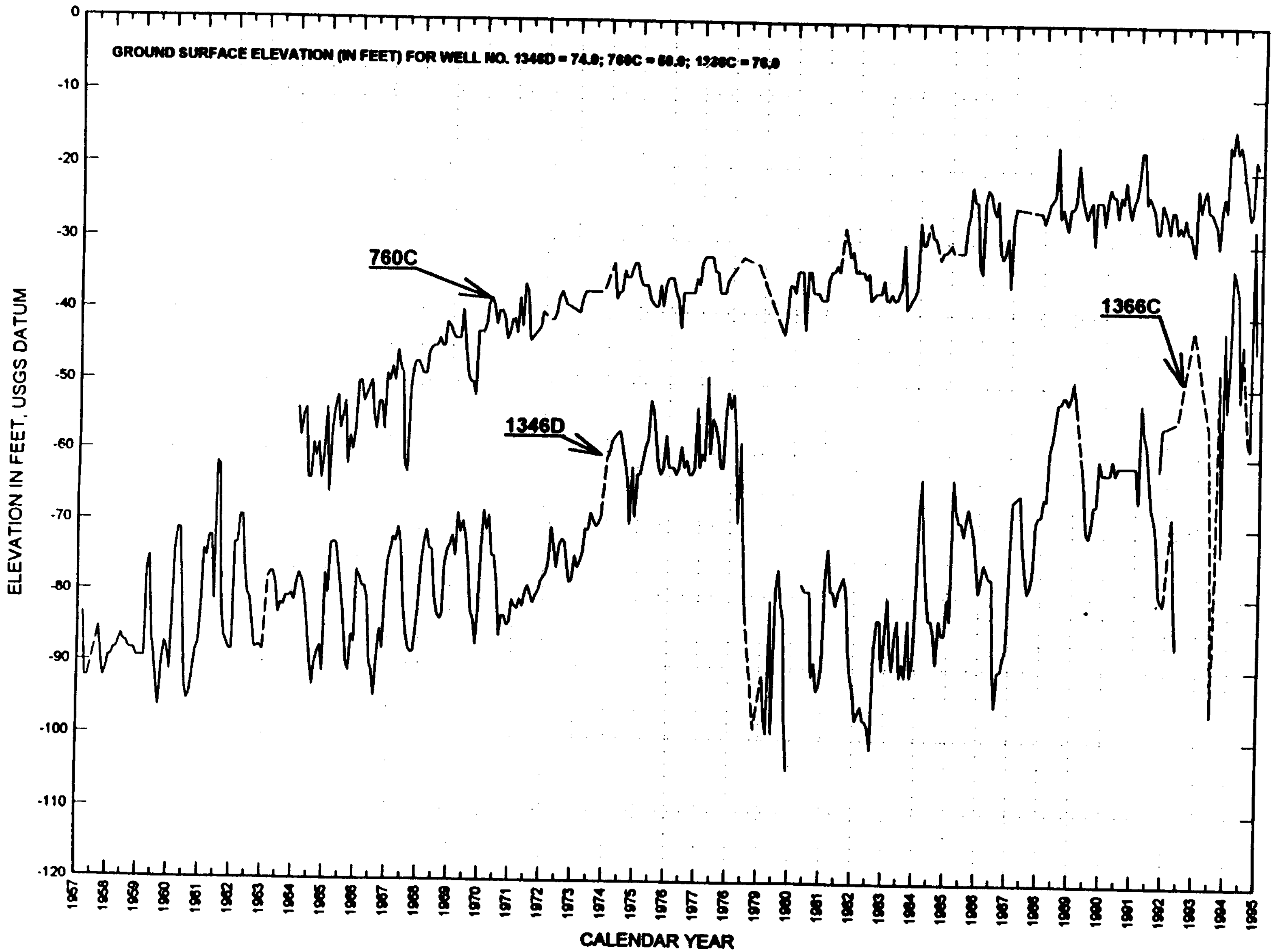
KEYWELL LOCATIONS

20441

R0053746

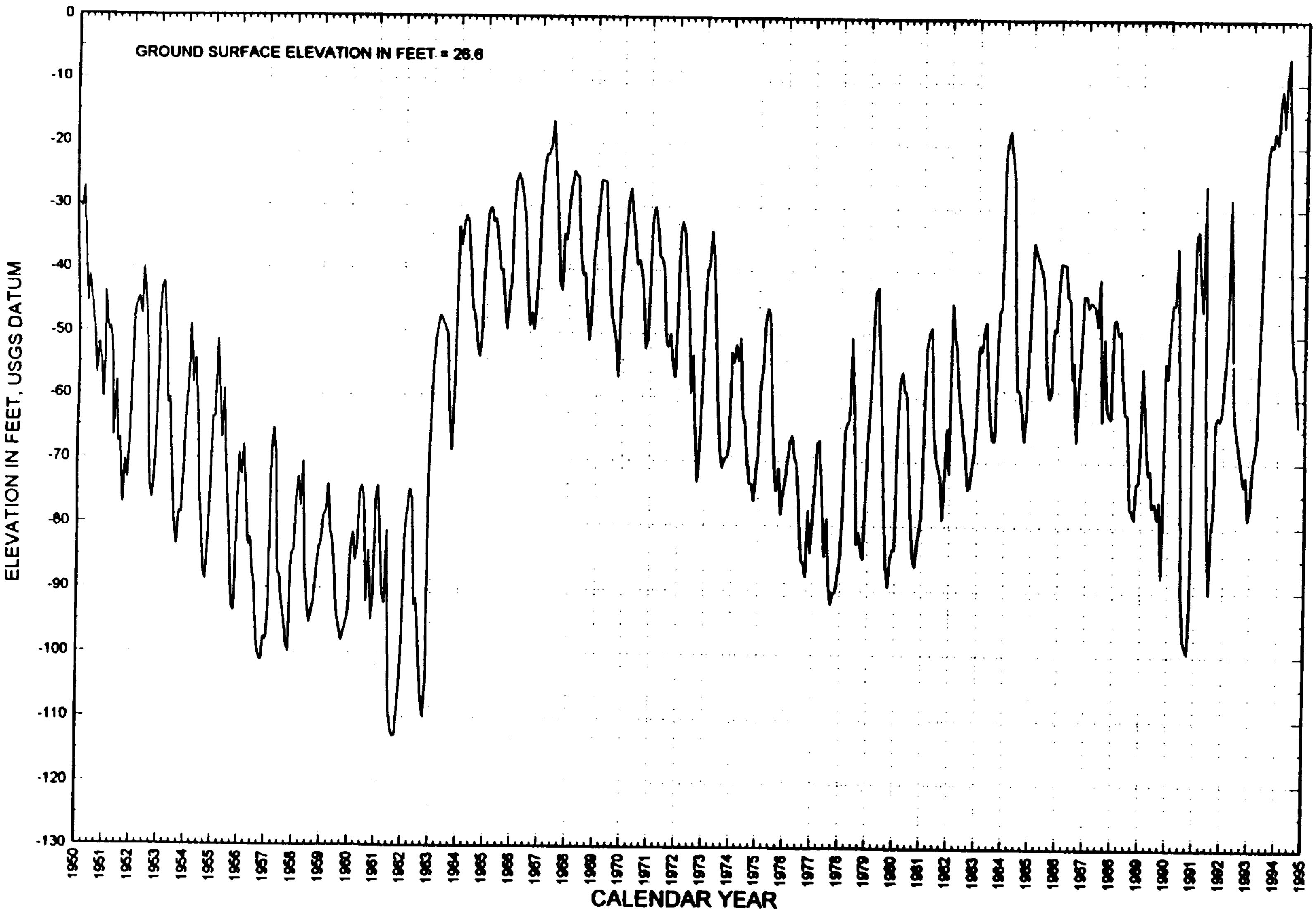
GROUNDWATER FLUCTUATIONS FOR WELL NOS. 1346D, 760C & 1366C

COASTAL PLAIN



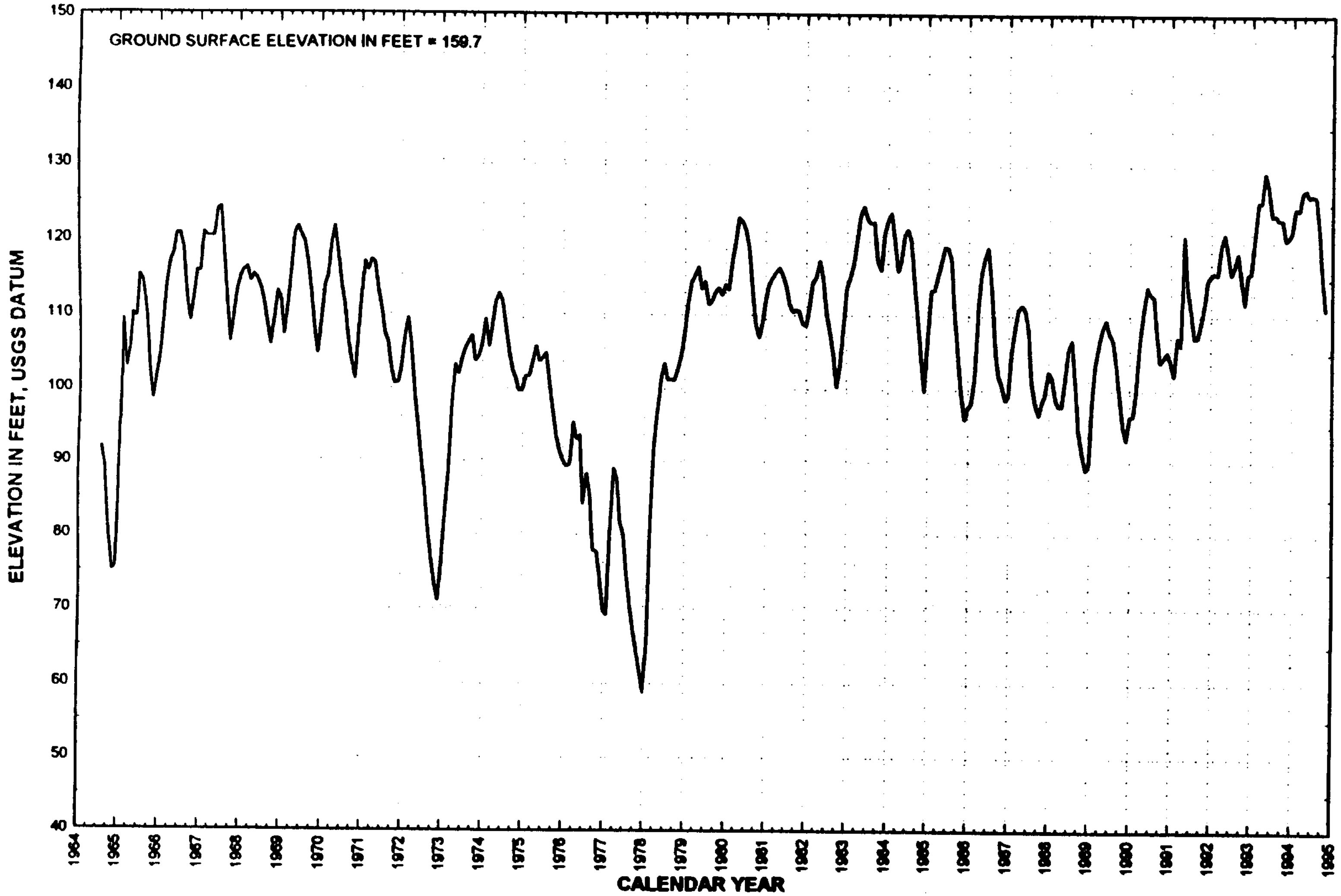
GROUNDWATER FLUCTUATIONS FOR WELL NO. 460K

CITY OF LONG BEACH, COASTAL PLAIN FORMER ARTESIAN AREA



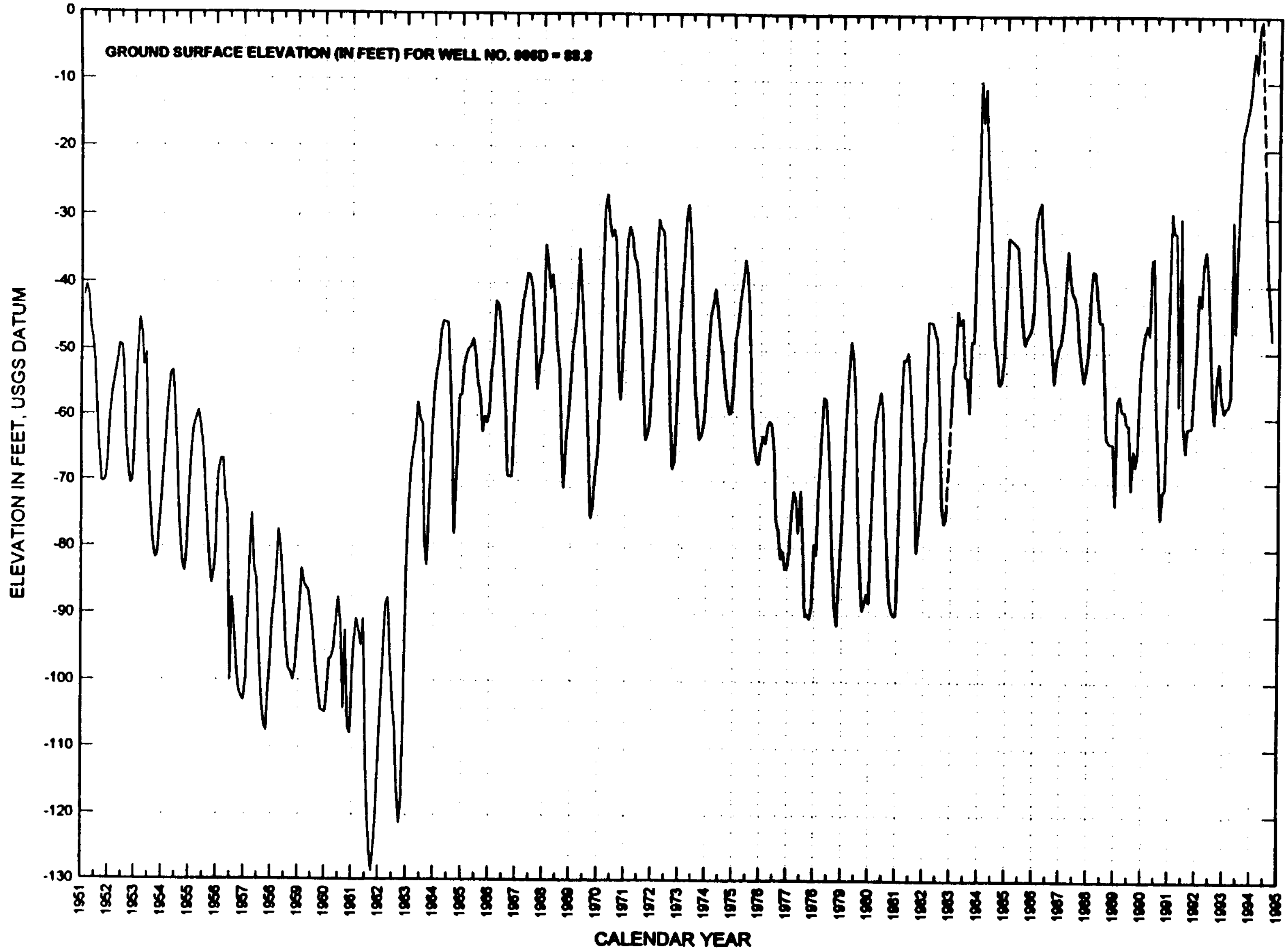
GROUNDWATER FLUCTUATIONS FOR WELL NO. 1601T

CENTRAL BASIN



GROUNDWATER FLUCTUATIONS FOR WELL NO. 906D

CITY OF LONG BEACH, COASTAL PLAIN, FORMER ARTESIAN AREA



G25

R0053750

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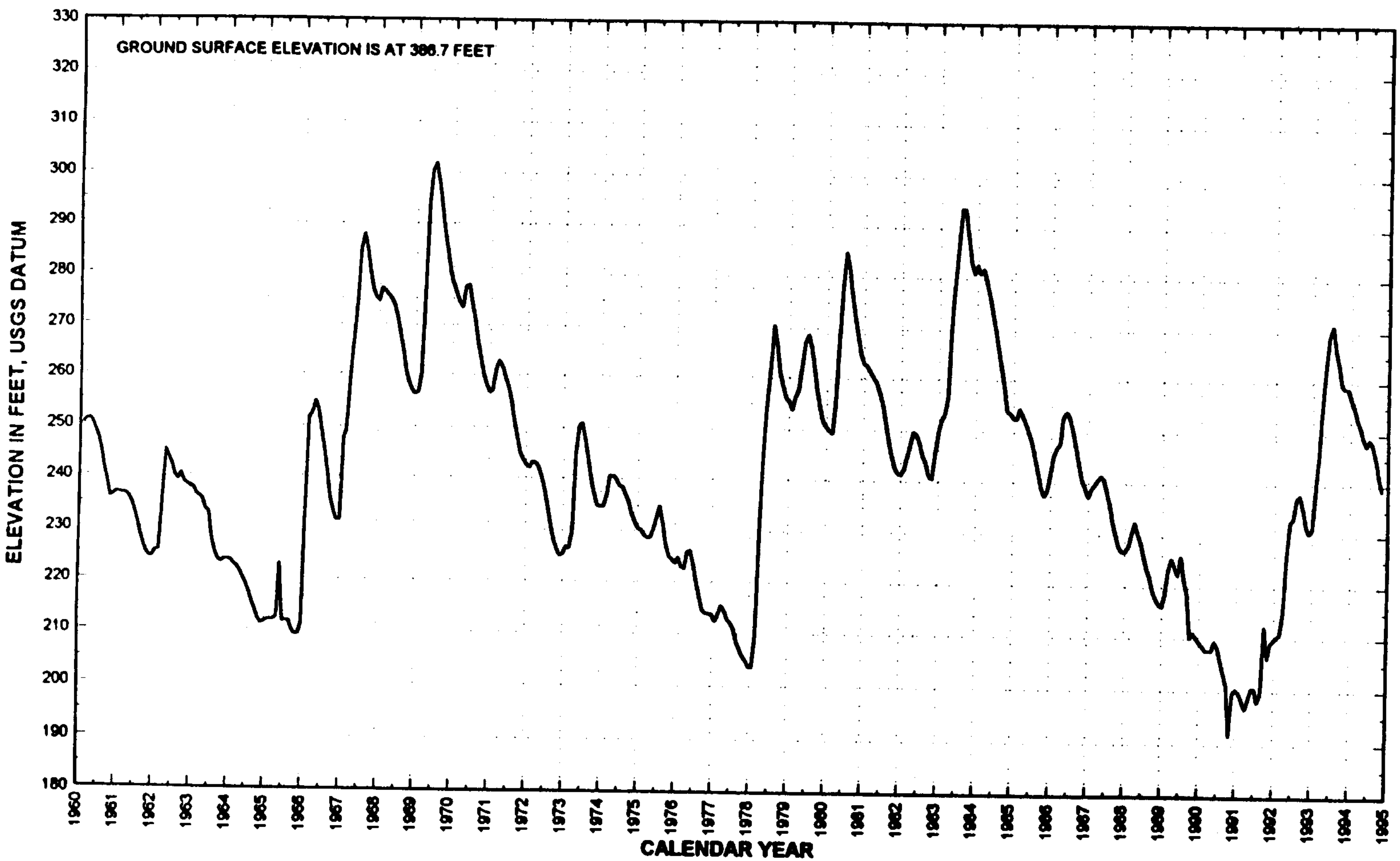
0446

GROUNDWATER FLUCTUATIONS FOR WELL NO. 3030F

BALDWIN PARK, MAIN SAN GABRIEL BASIN



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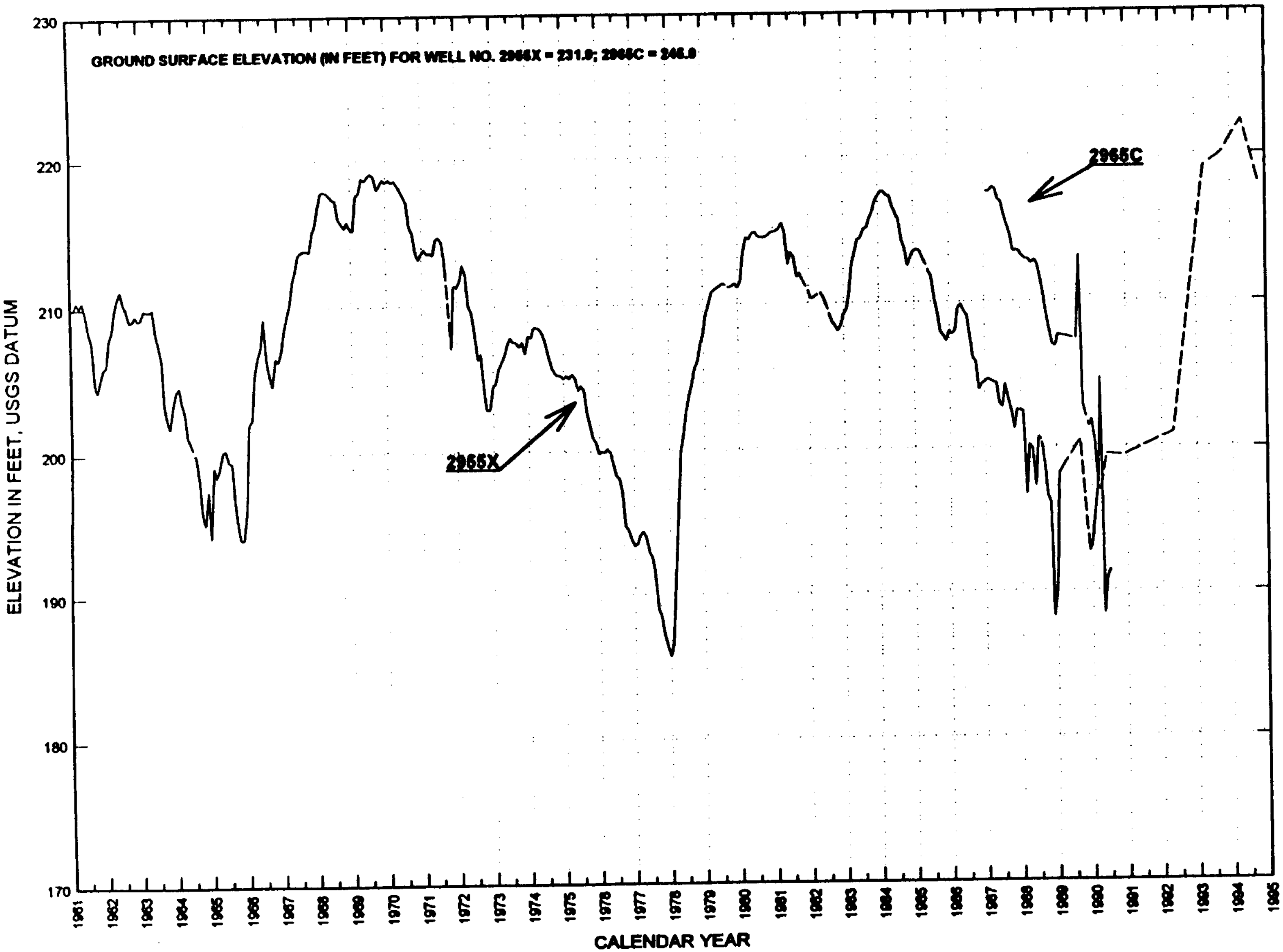
0448

GROUNDWATER FLUCTUATIONS FOR WELL NOS. 2955X & 2965C

MAIN SAN GABRIEL BASIN



G29

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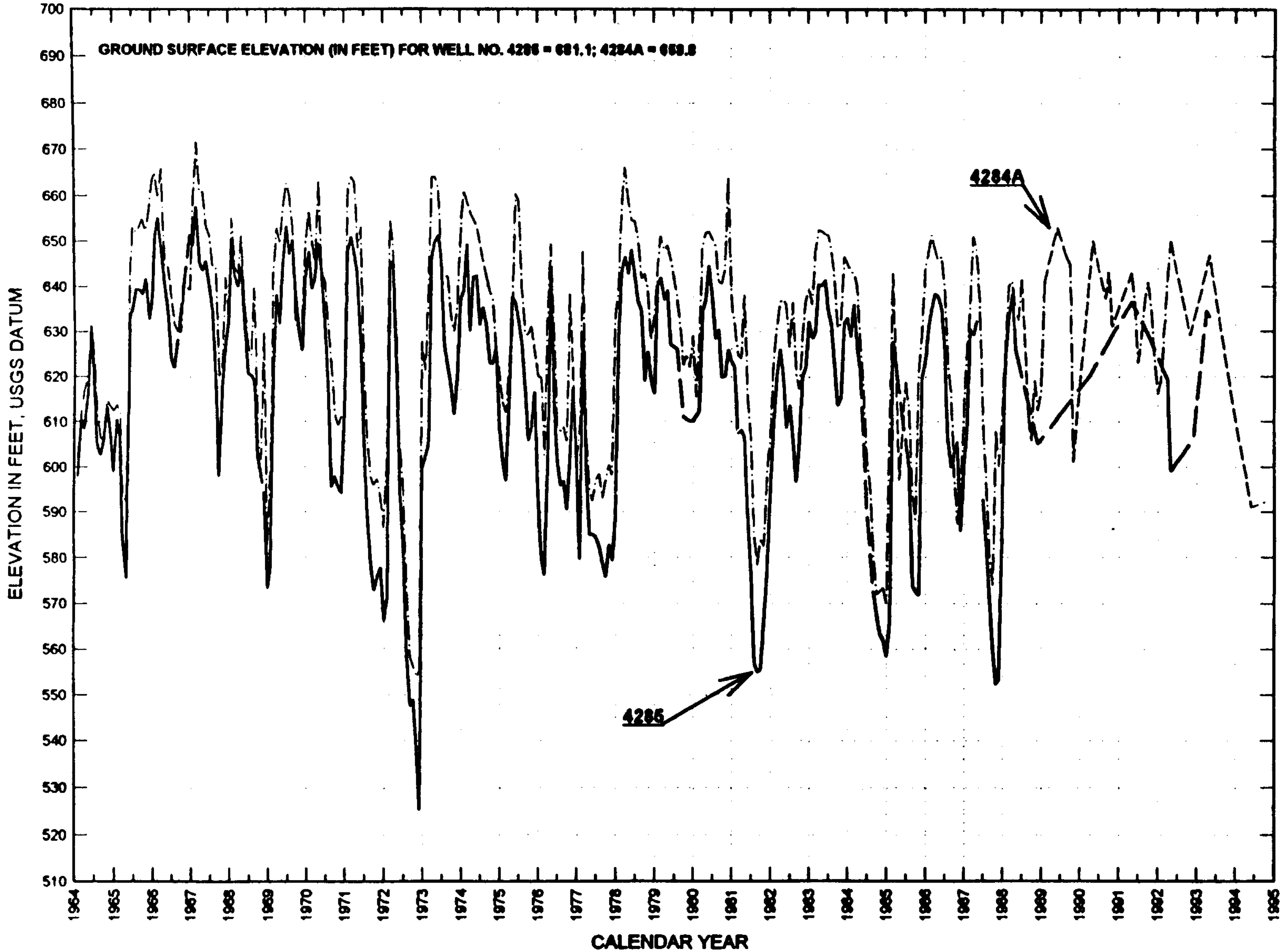
0450

GROUNDWATER FLUCTUATIONS FOR WELL NOS. 4285 & 4284A

NORTH OF AZUSA; SAN GABRIEL CANYON BASIN



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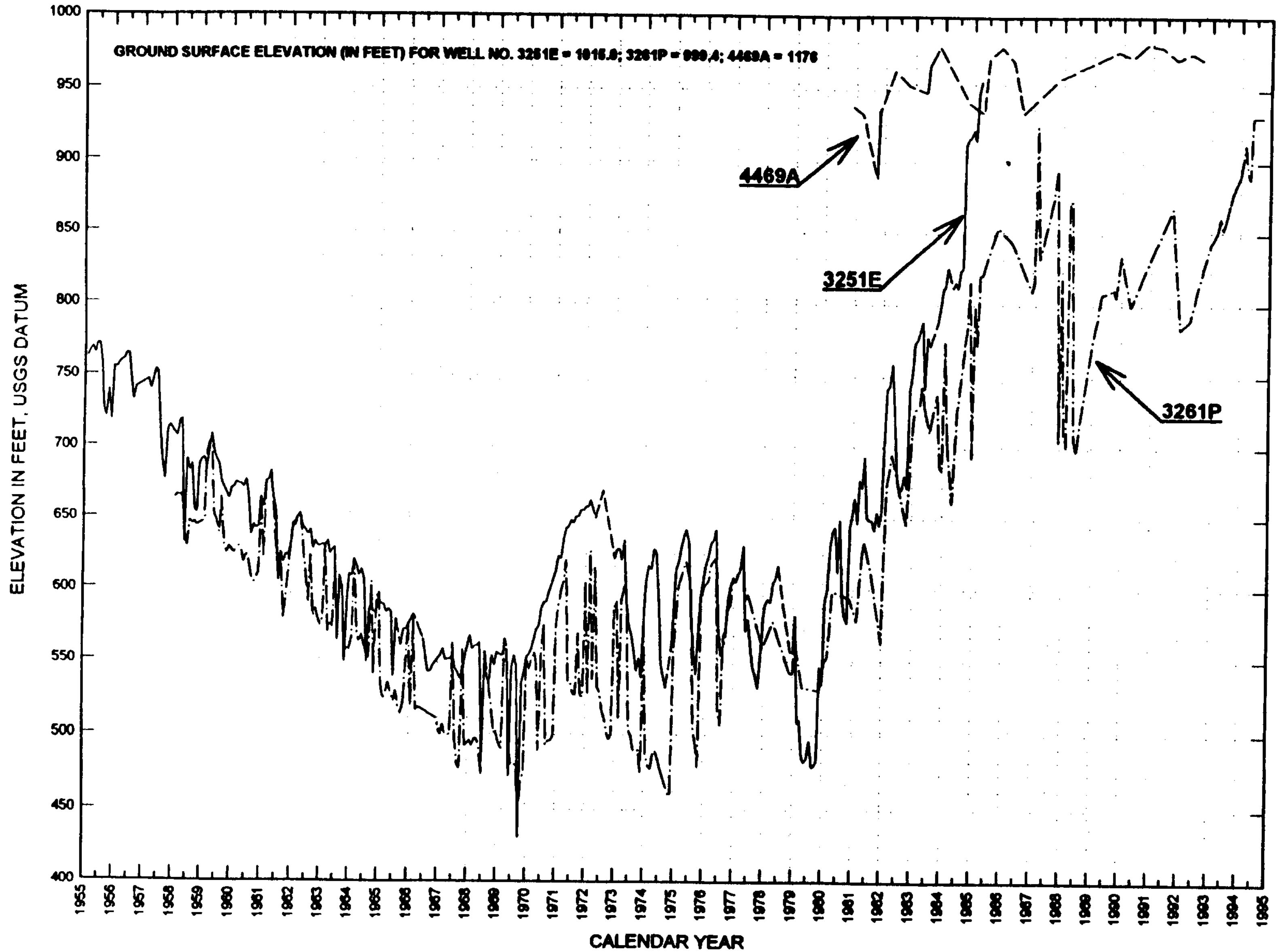
0452

G32

GROUNDWATER FLUCTUATIONS FOR WELL NOS. 3251E, 3261P & 4469A

POMONA BASIN



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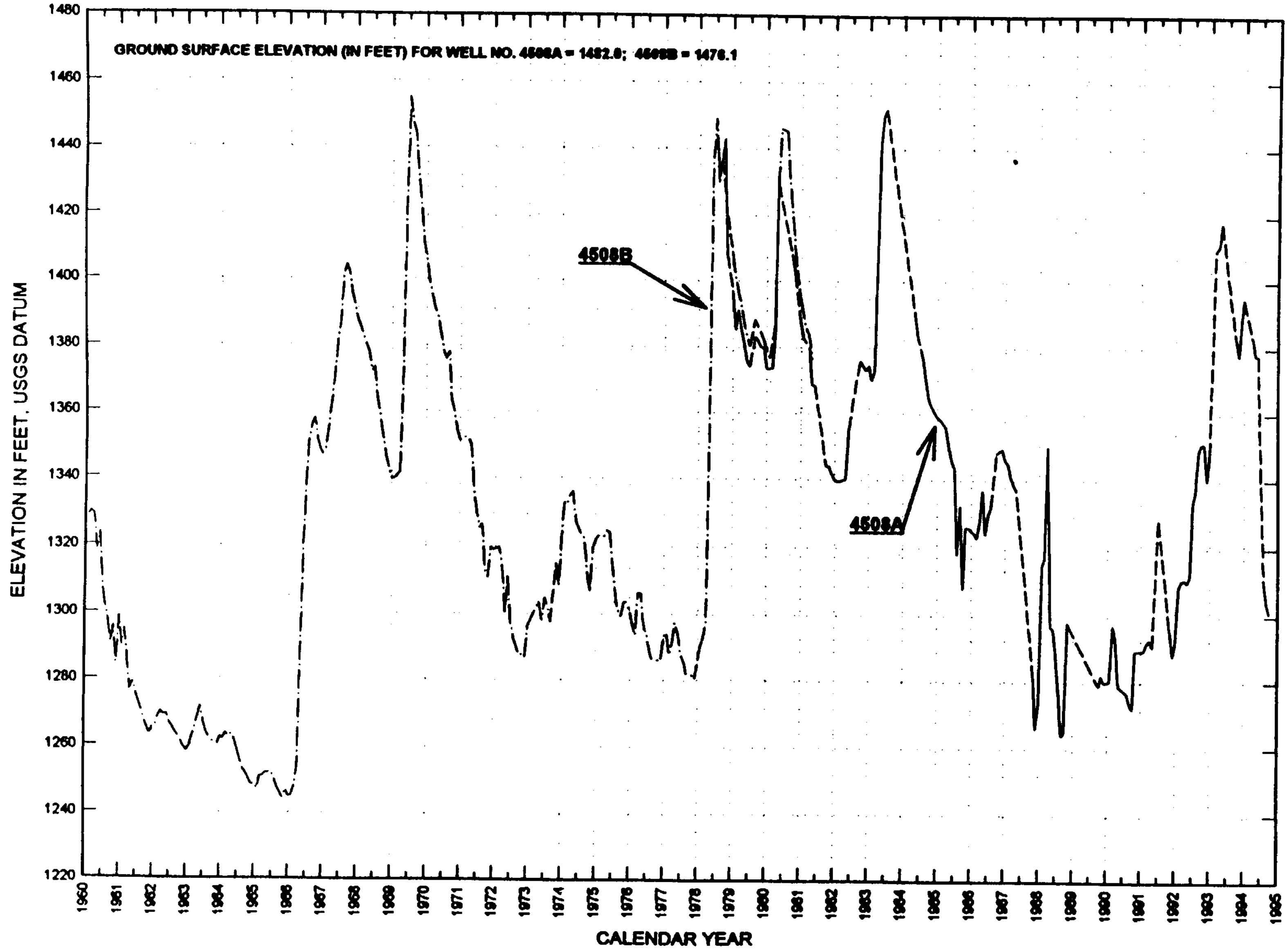
0454

GROUNDWATER FLUCTUATIONS FOR WELL NOS. 4508A & 4508B

UPPER CLAREMONT HEIGHTS



G35

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VOL 12

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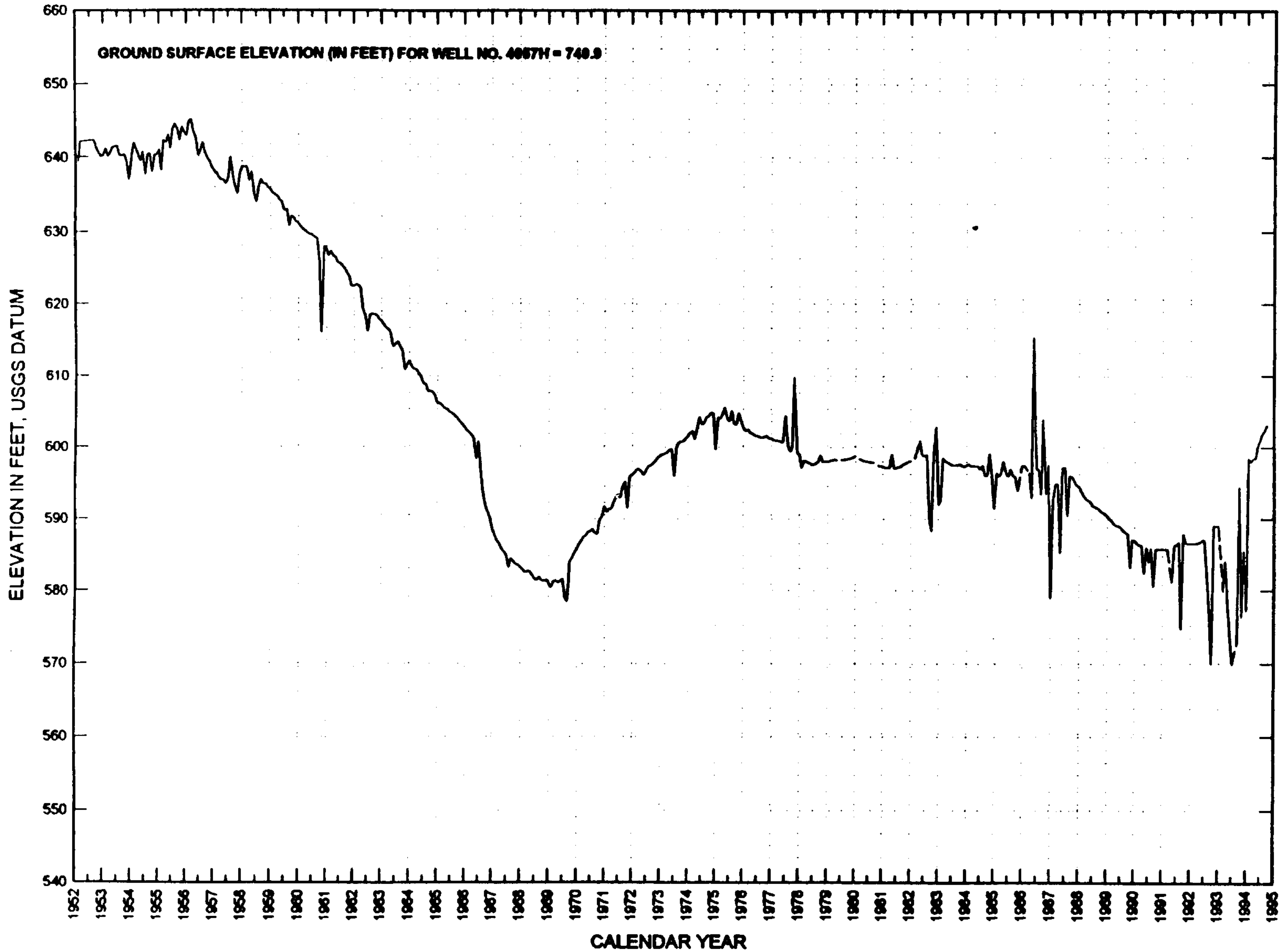
G36

GROUNDWATER FLUCTUATIONS FOR WELL NO. 4057H

RAYMOND BASIN



G37

R0053762

VOL 12 2

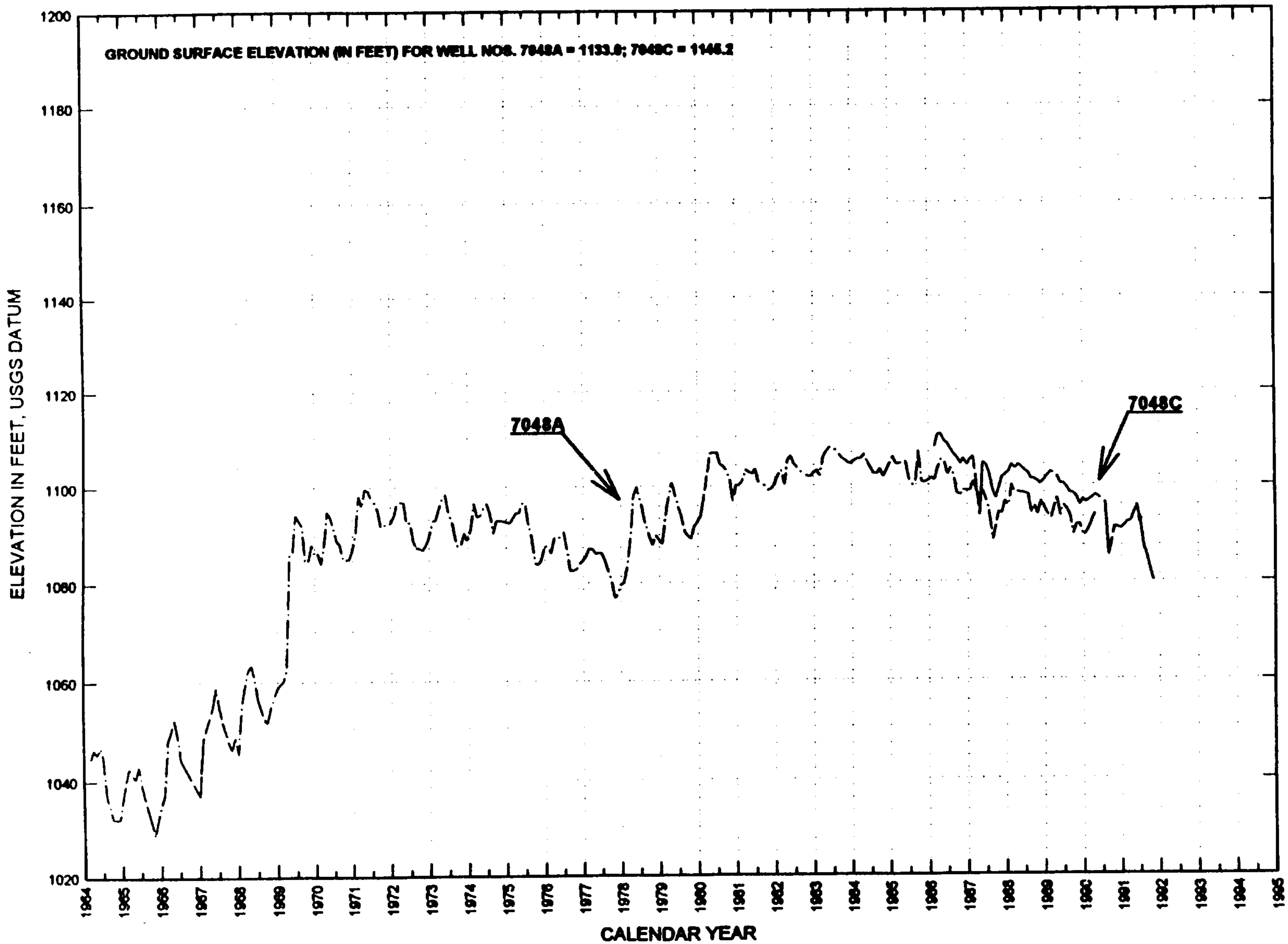
VOL 12

2

0458

GROUNDWATER FLUCTUATIONS FOR WELL NOS. 7048A & 7048C

NEAR CASTAIC JUNCTION, SANTA CLARITA VALLEY



G39

R0053764

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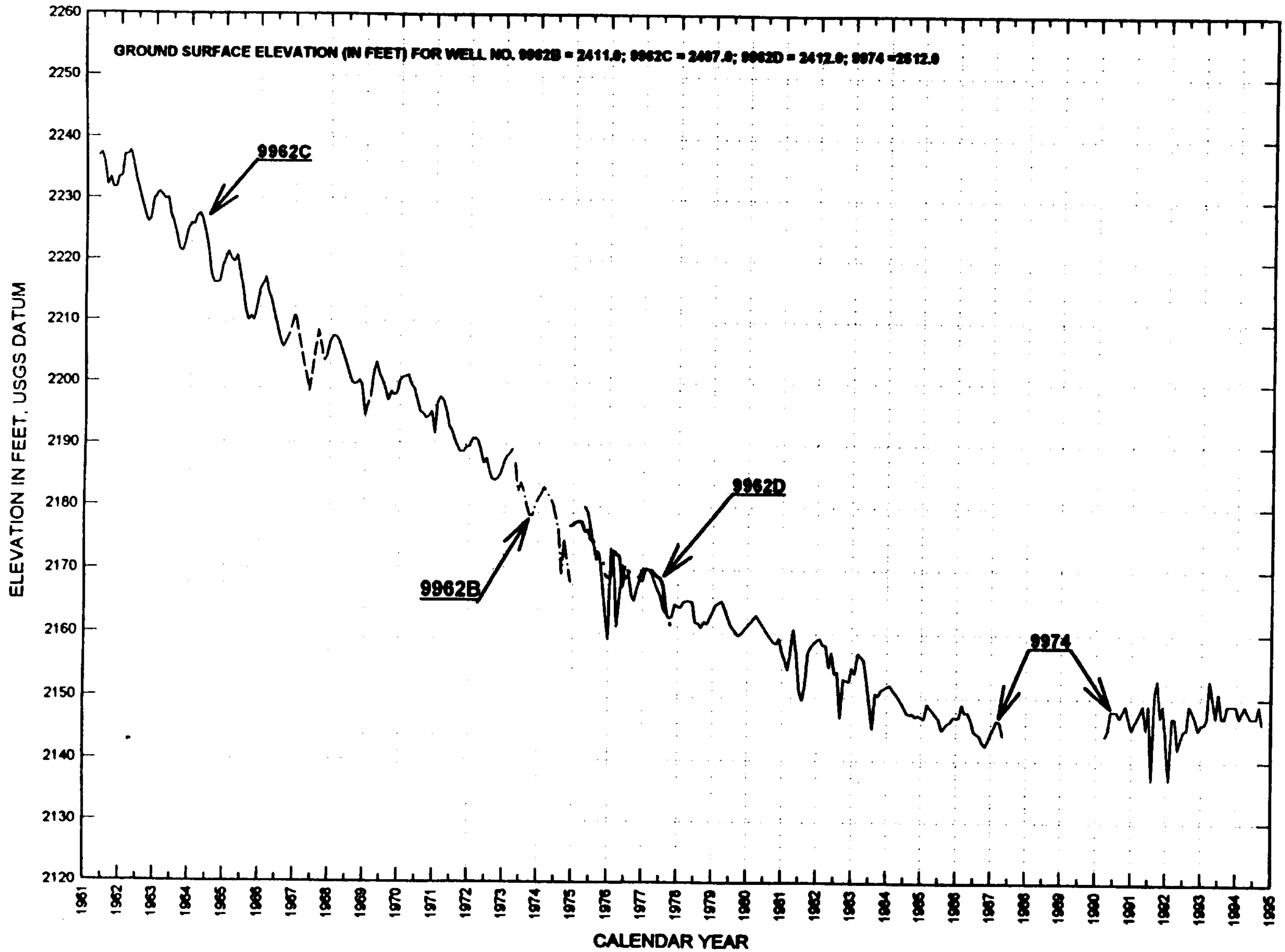
0460

G40

R0053765

GROUNDWATER FLUCTUATIONS FOR WELL NOS. 9962B, 9962C, 9962D & 9974

SOUTH OF LANCASTER, ANTELOPE VALLEY



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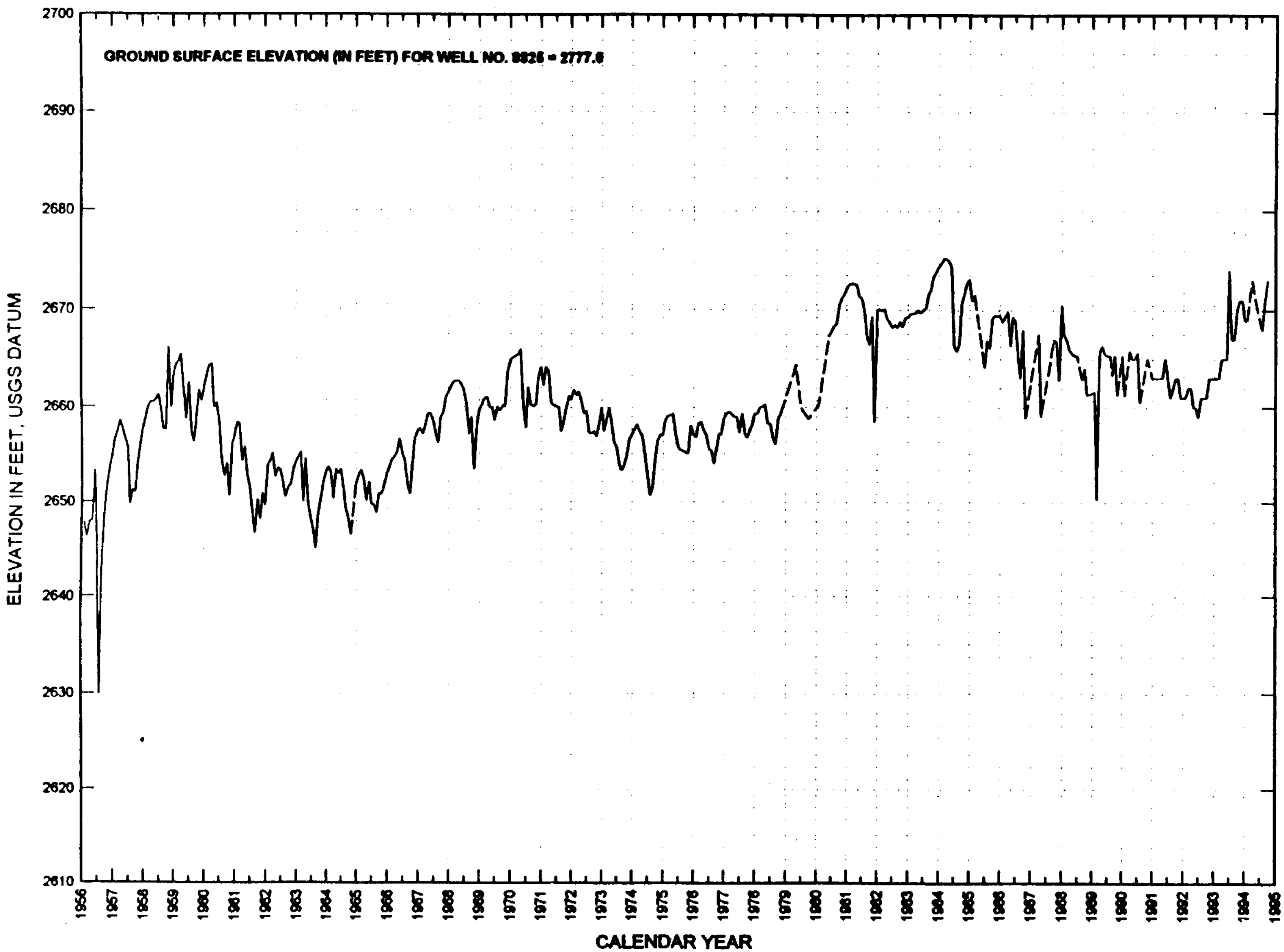
0462

GROUNDWATER FLUCTUATIONS FOR WELL NO. 8825

SOUTH OF PALMDALE, LITTLE ROCK



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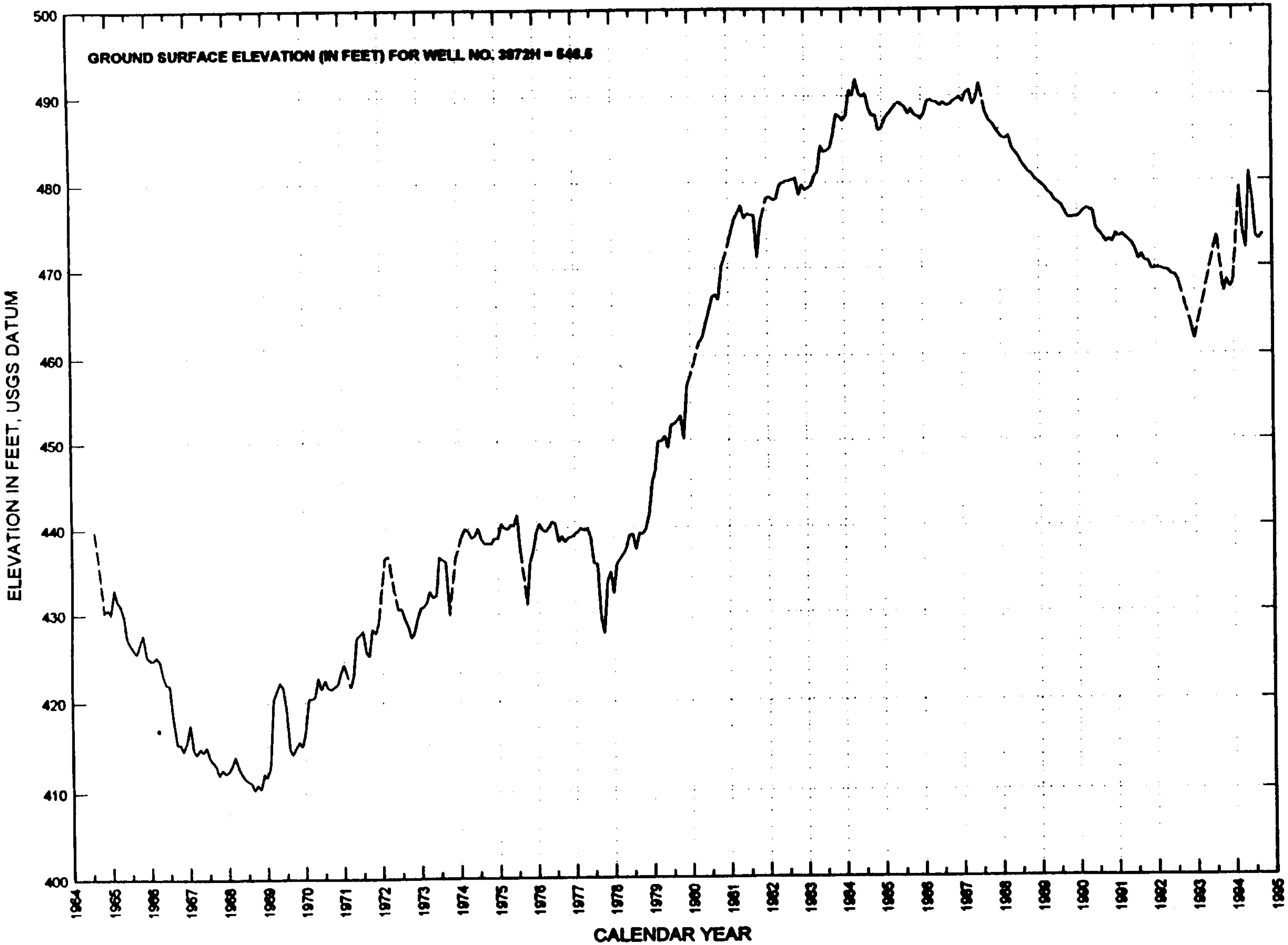
G44

R0053769

GROUNDWATER FLUCTUATIONS FOR WELL NO. 3872H

BURBANK, SAN FERNANDO VALLEY



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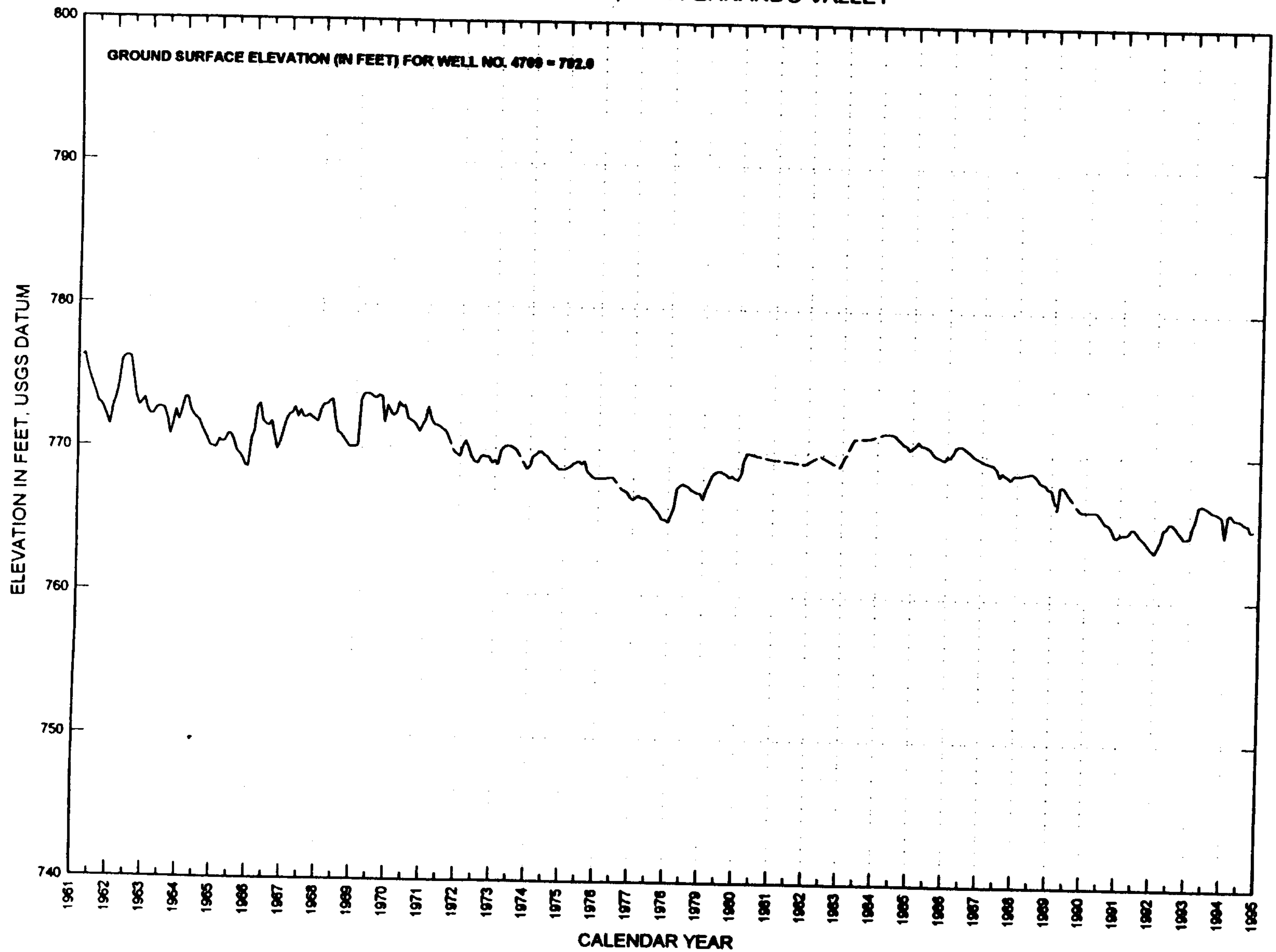
G46

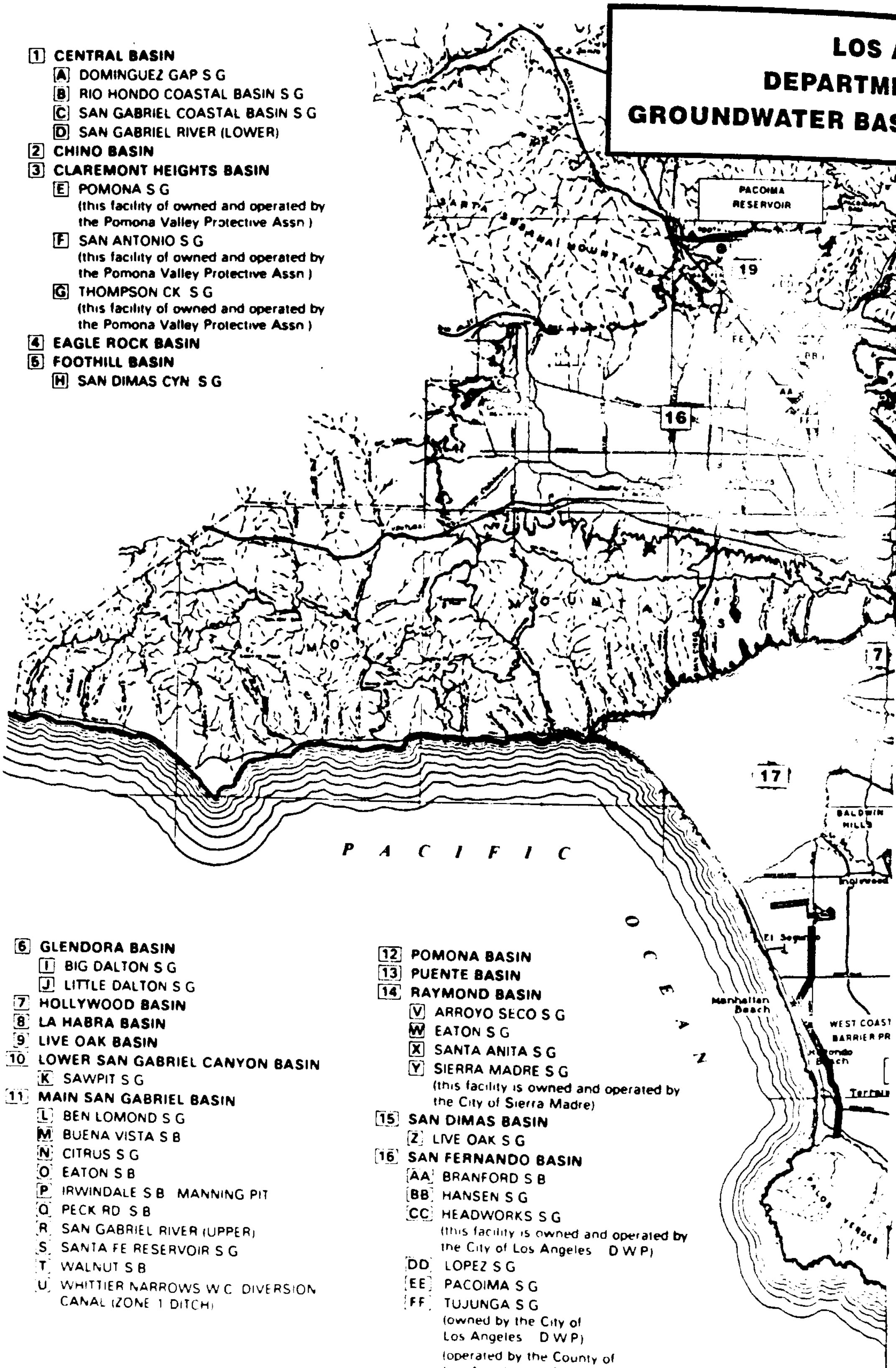
GROUNDWATER FLUCTUATIONS FOR WELL NO. 4709

CANOGA PARK, SAN FERNANDO VALLEY



G47

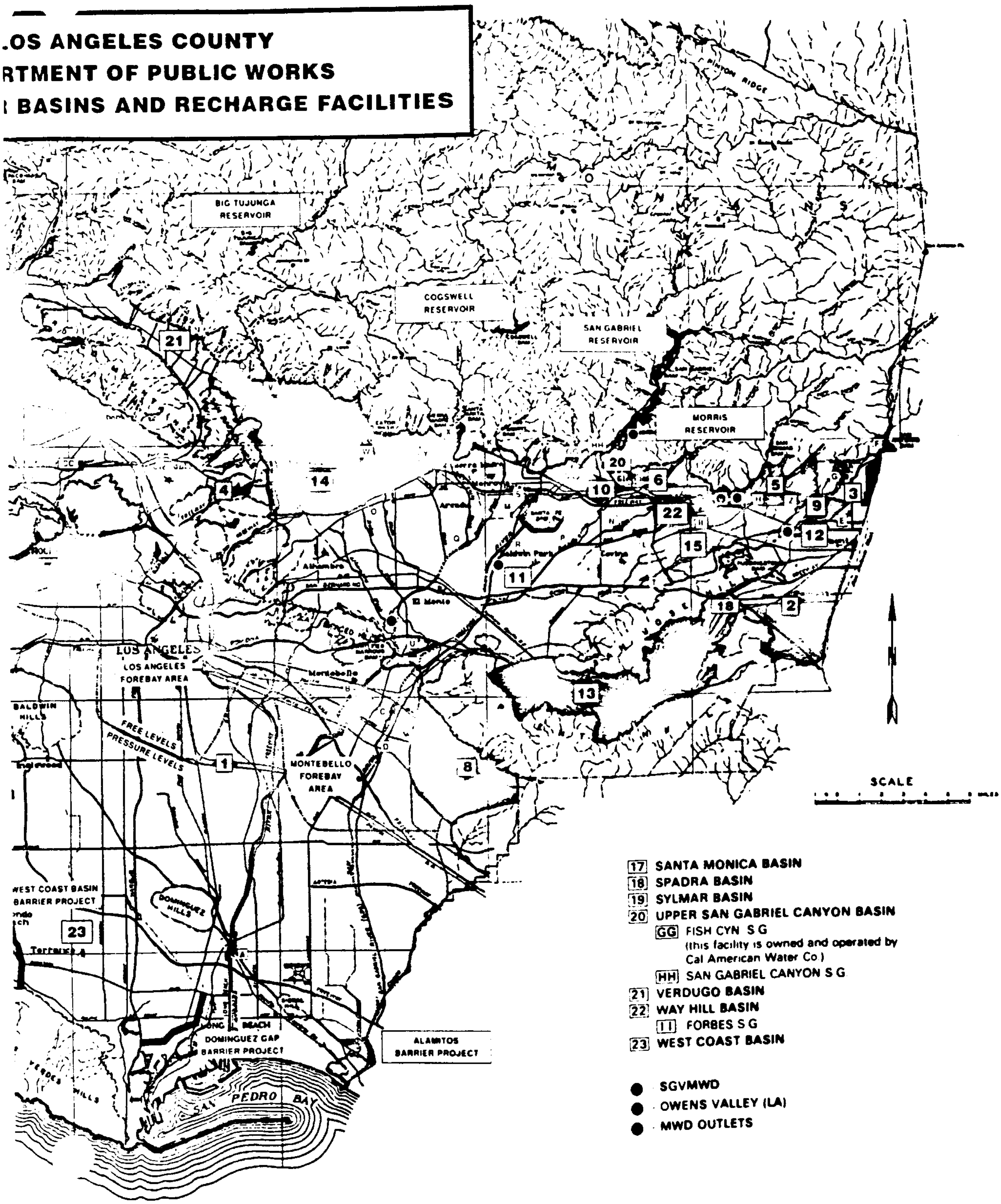
R0053772



VOL 12 2 04568

R0053773

VOL 12



2 0469

PG2

R0053774

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2 0470

No 95

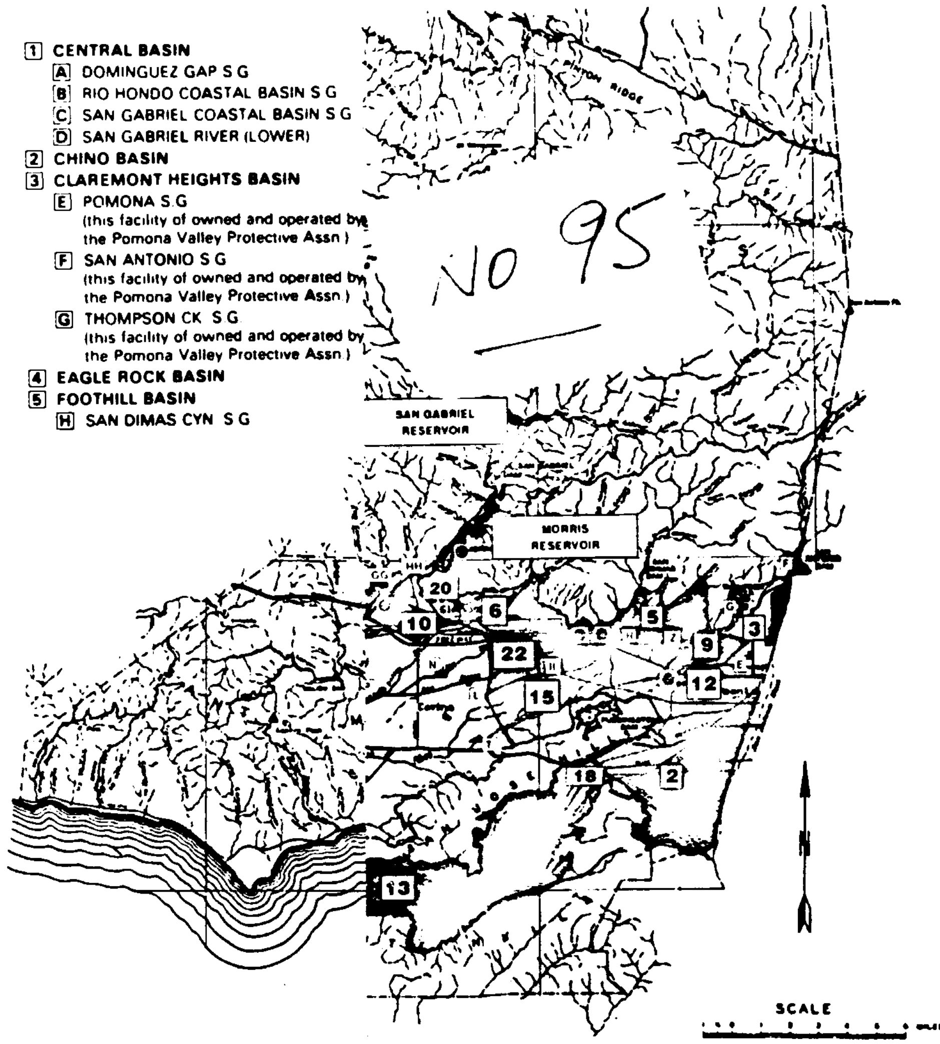
1 CENTRAL BASIN
- A DOMINGUEZ GAP S G
- B RIO HONDO COASTAL BASIN S G
- C SAN GABRIEL COASTAL BASIN S G
- D SAN GABRIEL RIVER (LOWER)

2 CHINO BASIN

3 CLAREMONT HEIGHTS BASIN
- E POMONA S G (this facility of owned and operated by the Pomona Valley Protective Assn.)
- F SAN ANTONIO S G (this facility of owned and operated by the Pomona Valley Protective Assn.)
- G THOMPSON CK S G (this facility of owned and operated by the Pomona Valley Protective Assn.)

4 EAGLE ROCK BASIN

5 FOOTHILL BASIN
- H SAN DIMAS CYN S G



6 GLENDORA BASIN
- I BIG DALTON S G
- J LITTLE DALTON S G

7 HOLLYWOOD BASIN

8 LA HABRA BASIN

9 LIVE OAK BASIN

10 LOWER SAN GABRIEL CANYON BASIN
- K SAWPIT S G

11 MAIN SAN GABRIEL BASIN
- L BEN LOMOND S G
- M BUENA VISTA S B
- N CITRUS S G
- O EATON S B
- P IRWINDALE S B /MANNING PIT
- Q PECK RD S B
- R SAN GABRIEL RIVER (UPPER)
- S SANTA FE RESERVOIR S G
- T WALNUT S B
- U WHITTIER NARROWS W C DIVERSION CANAL (ZONE 1 DITCH)

17 SANTA MONICA BASIN

18 SPADRA BASIN

19 SYLMAR BASIN

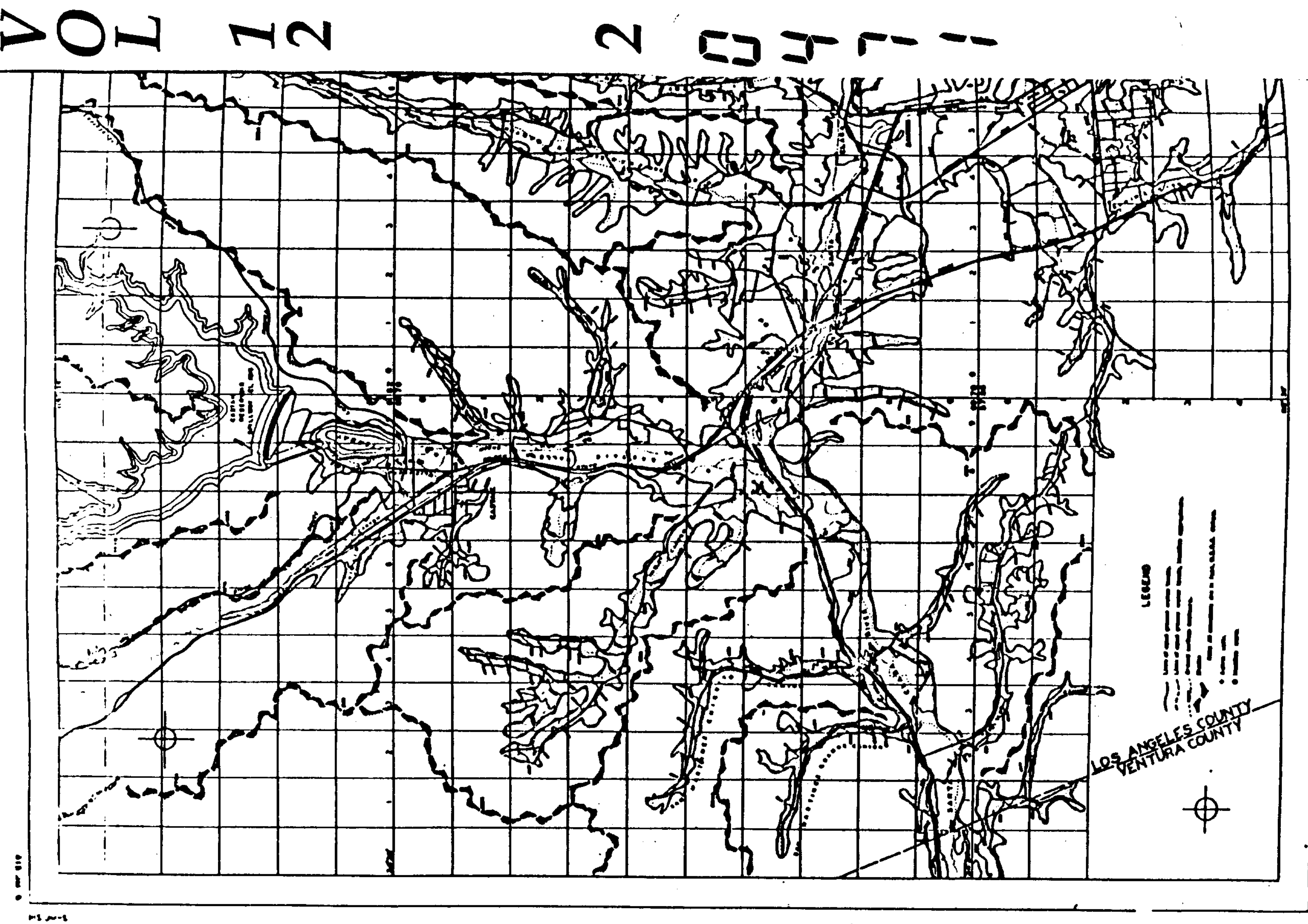
20 UPPER SAN GABRIEL CANYON BASIN
- GG FISH CYN S G. (this facility is owned and operated by Cal American Water Co.)
- HH SAN GABRIEL CANYON S G

21 VERDUGO BASIN

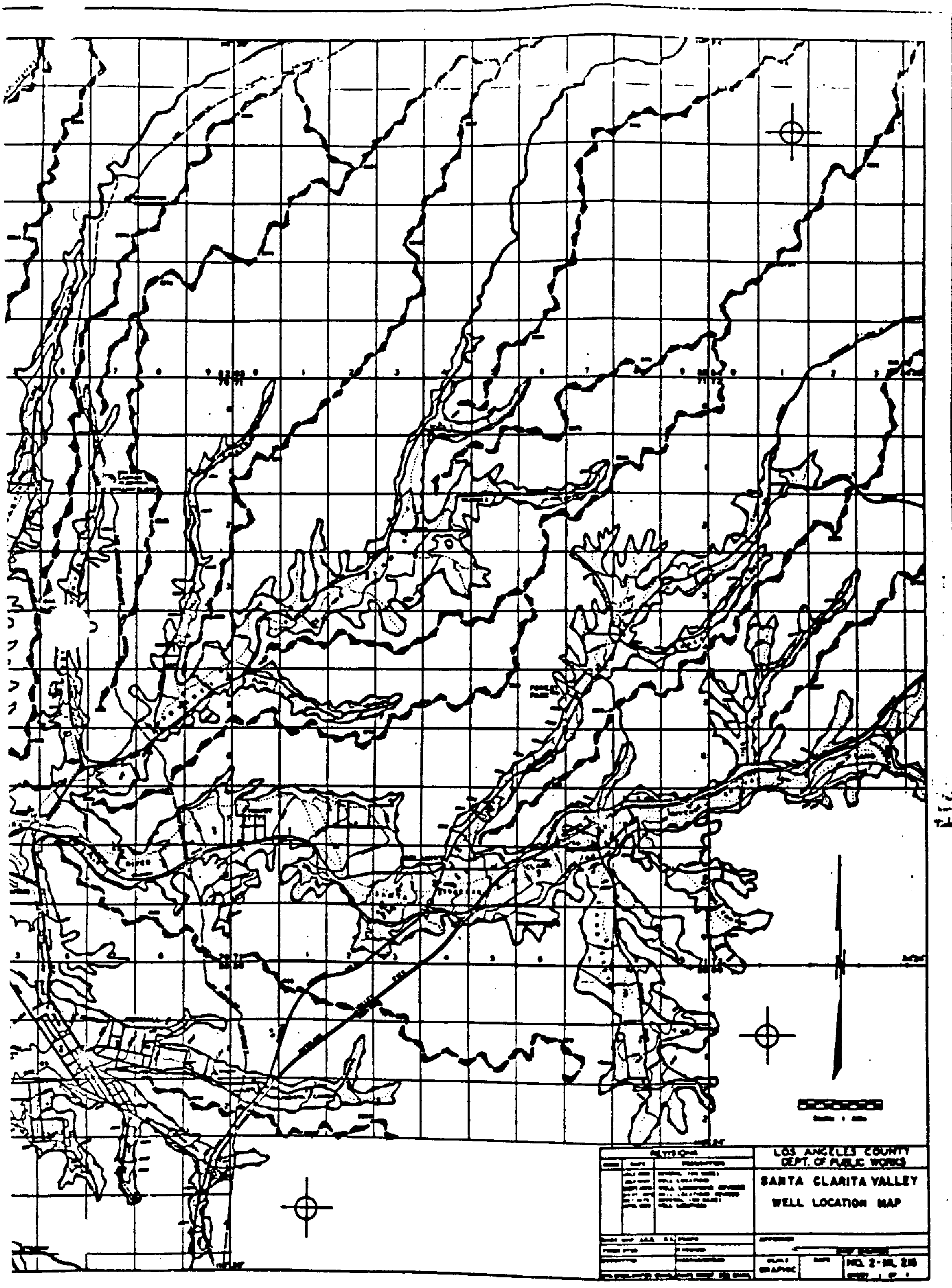
22 WAY HILL BASIN
- II FORBES S G

23 WEST COAST BASIN

- ● SGVMWD
- ● OWENS VALLEY (LA)
- ● MWD OUTLETS

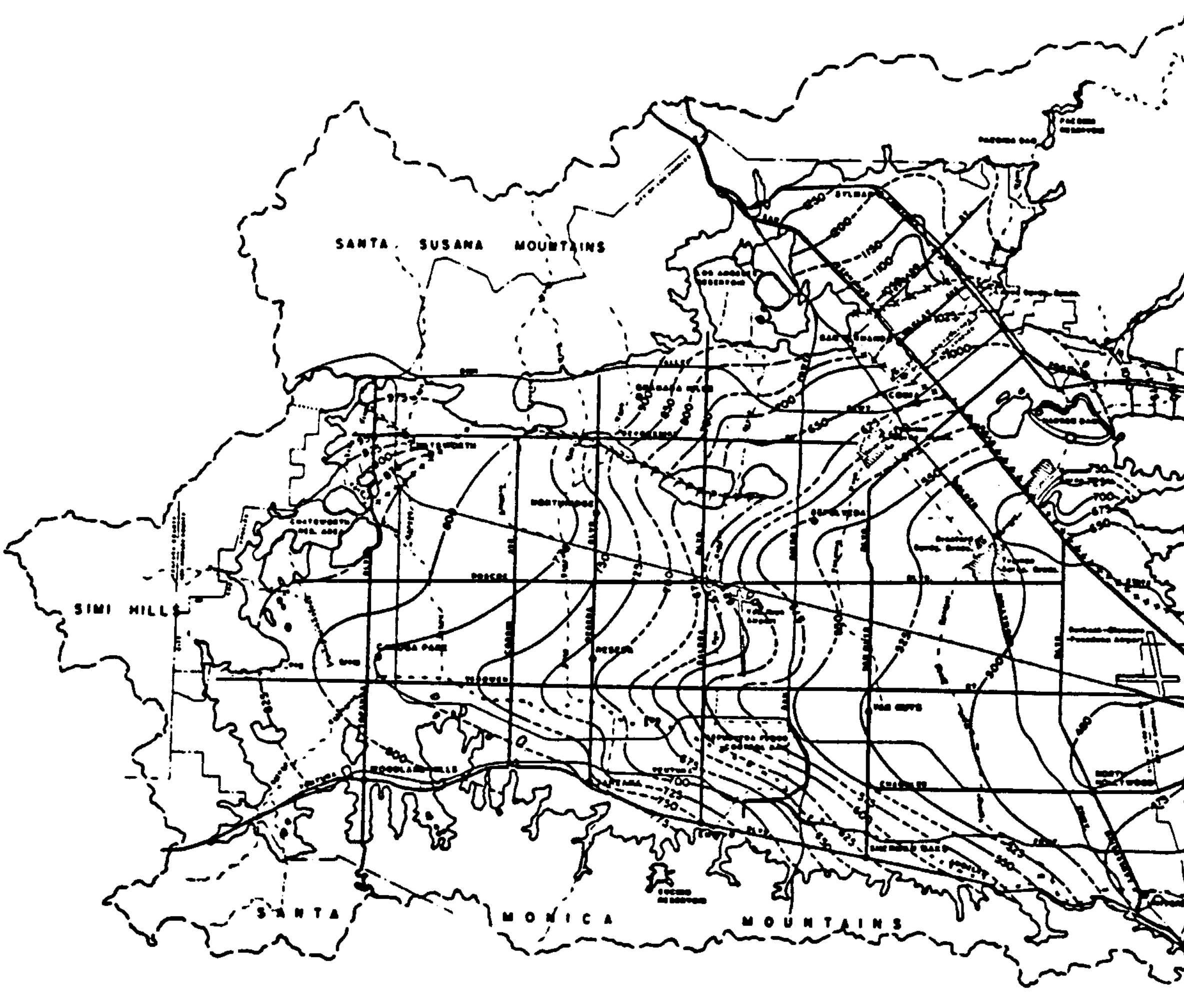


R0053776



Original Well Location Map

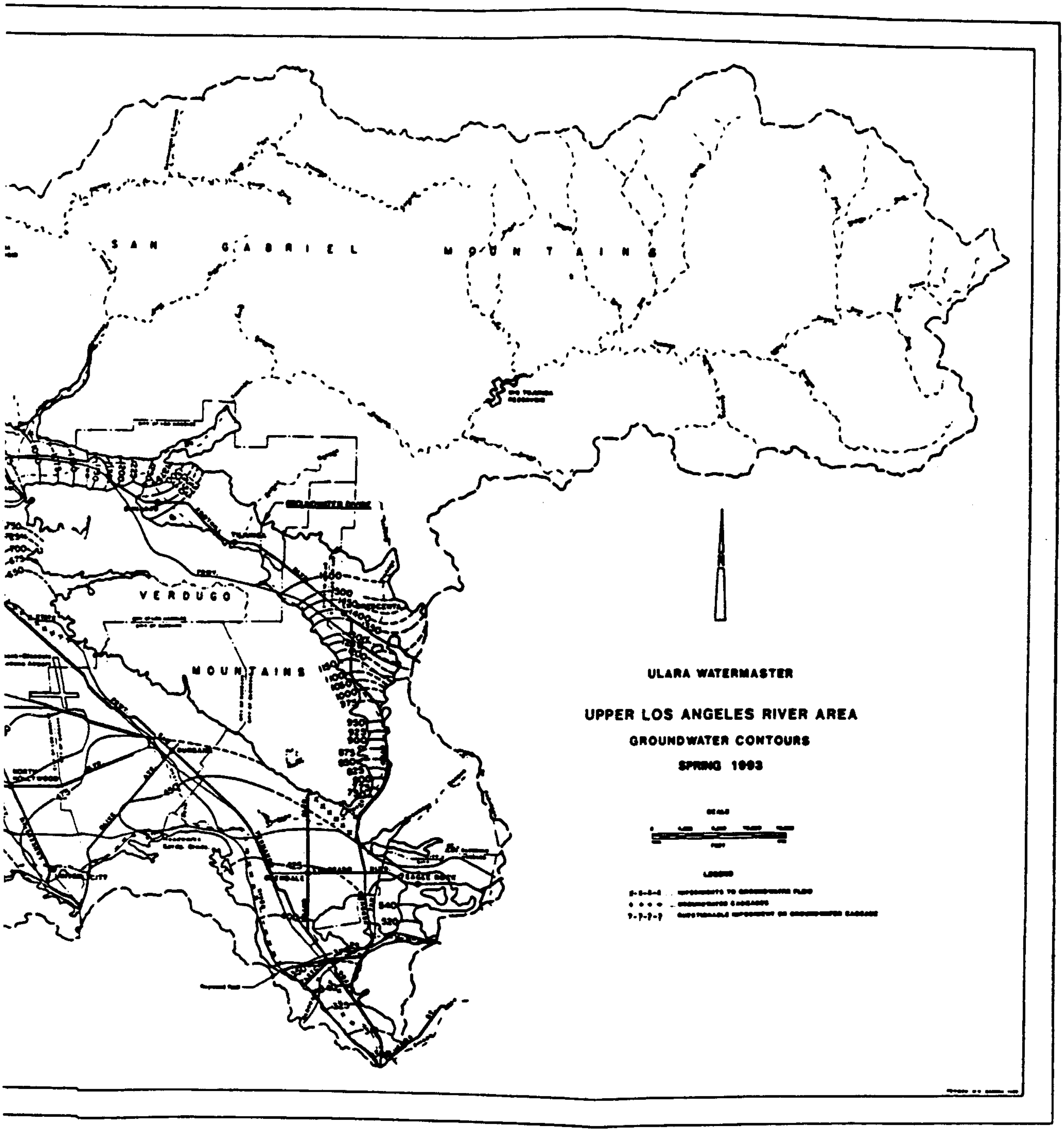
VOL 12



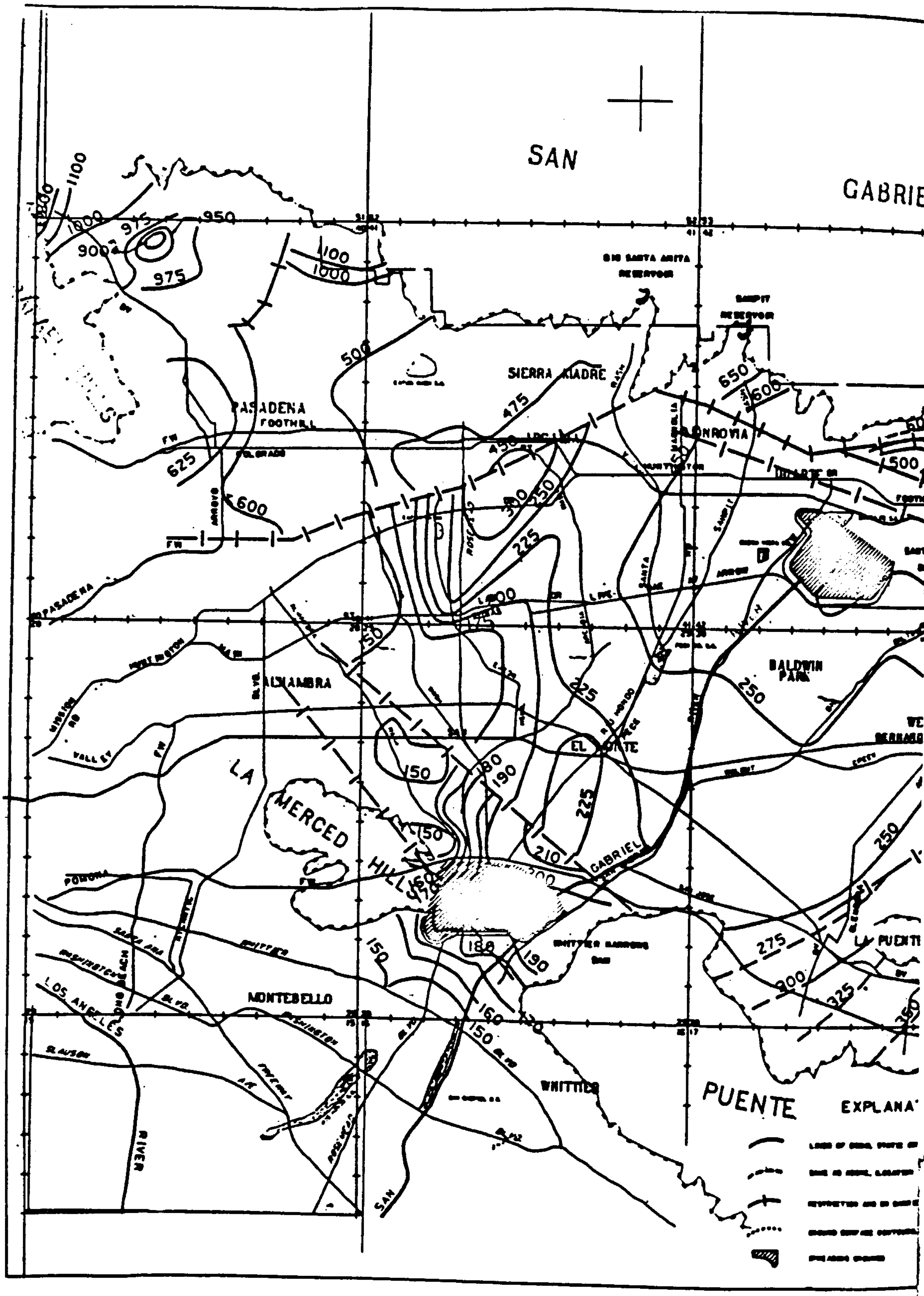
2 04773

VOL 12

2-0474



PG4



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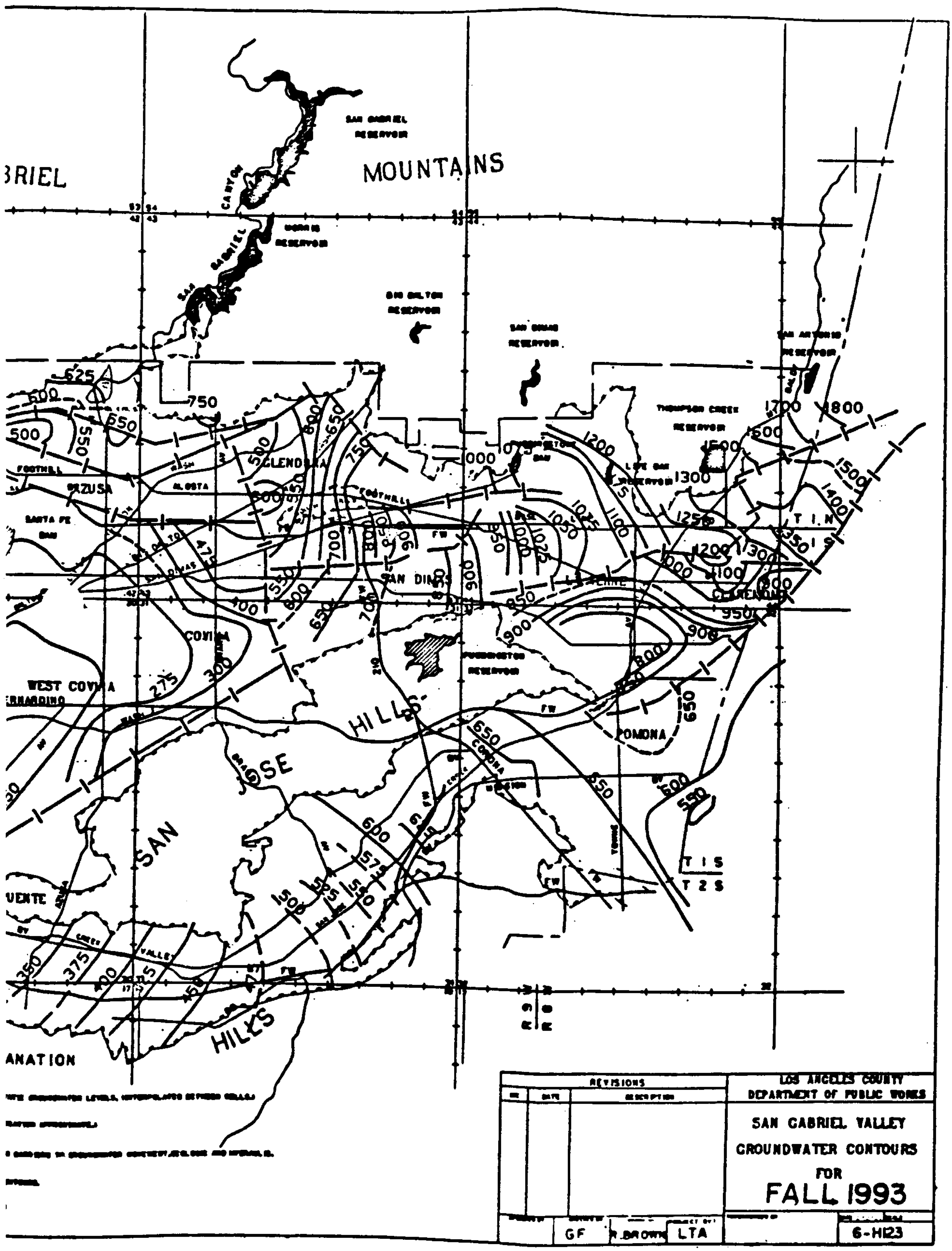
VOL 1 2

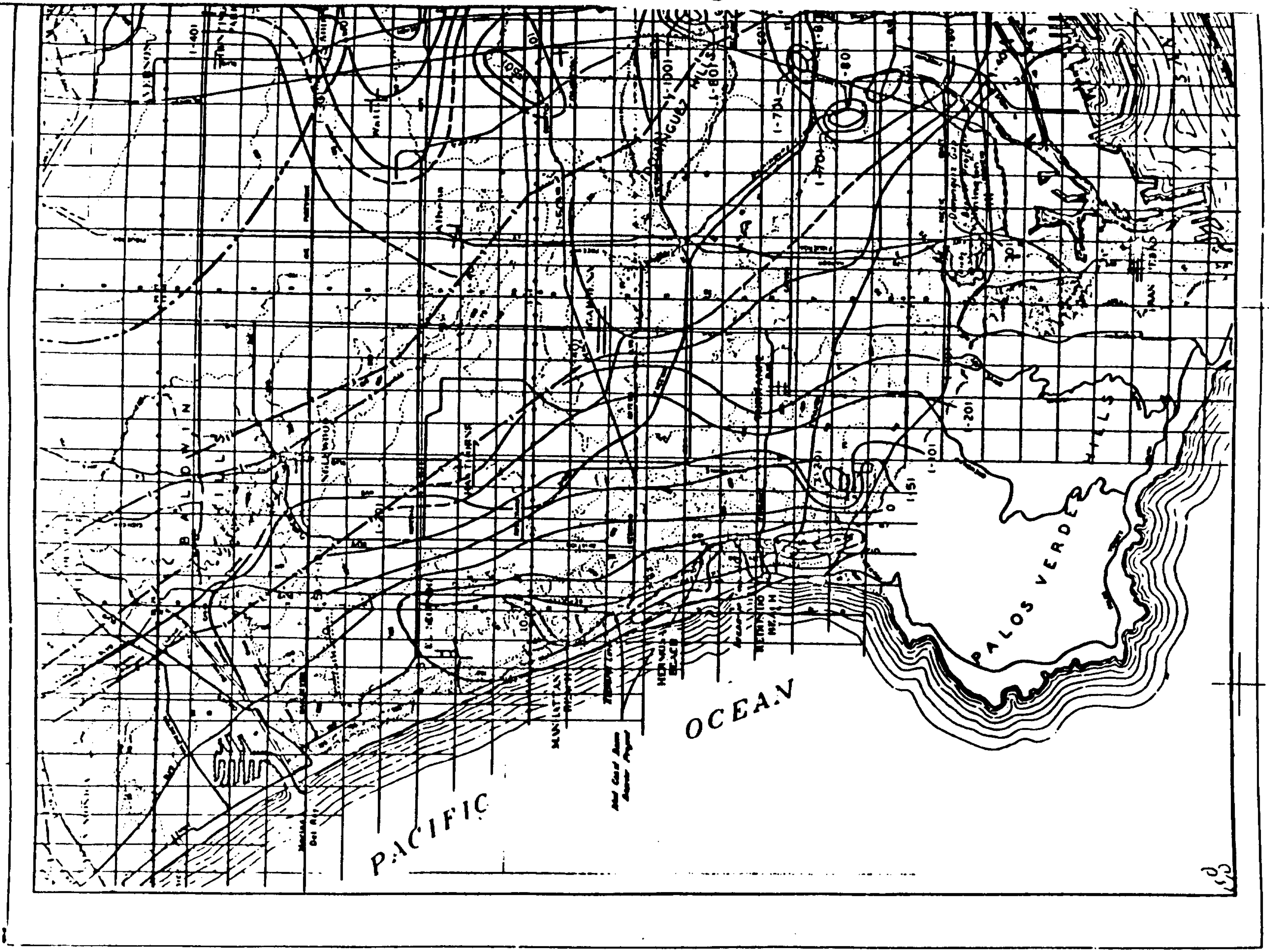


PG5

2 0476

R0053781

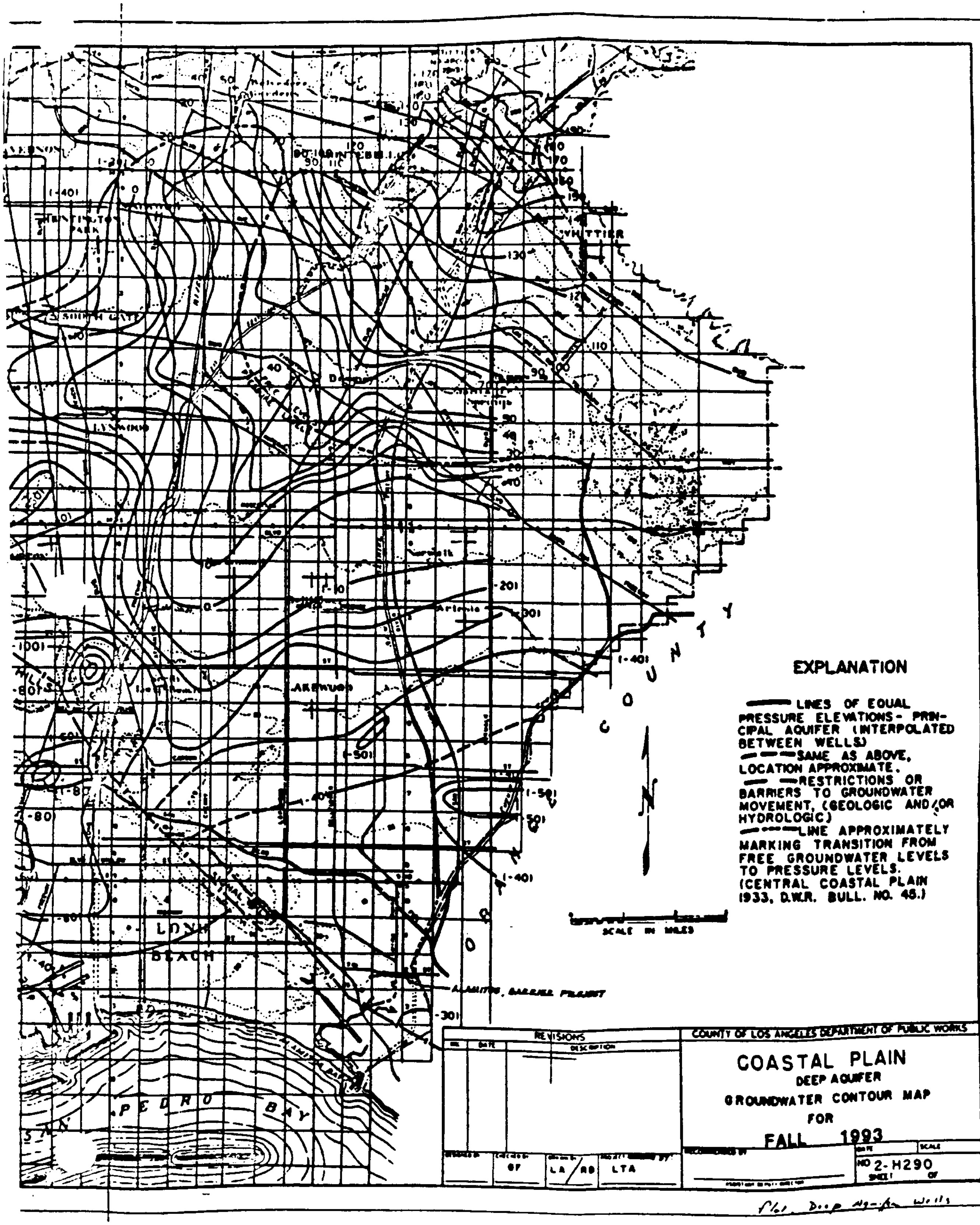
VOL 12 2



R0053782

VOL 12

2 0478



Plot Deep Aquifer Wells PG6

R0053783

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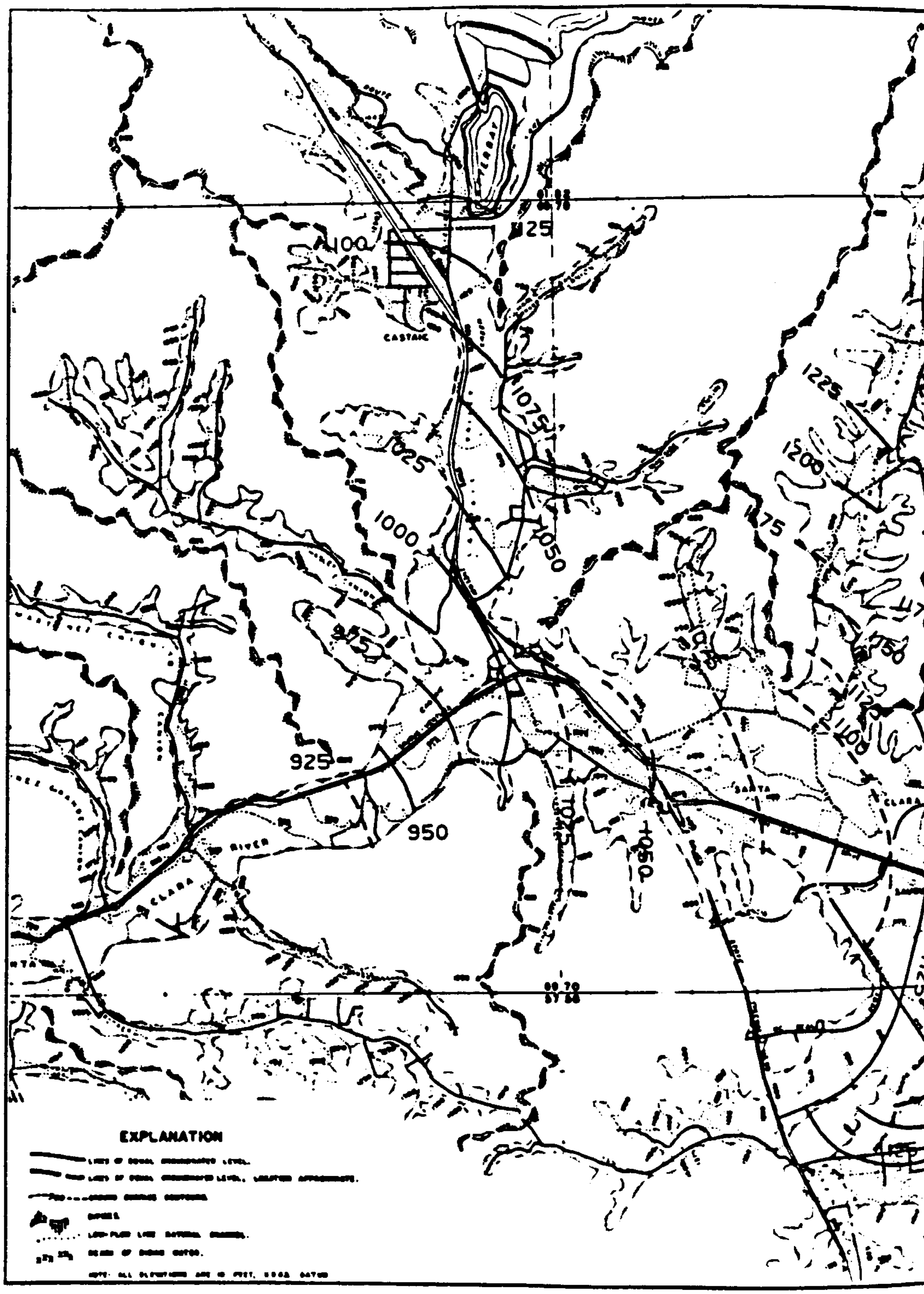

R0053784

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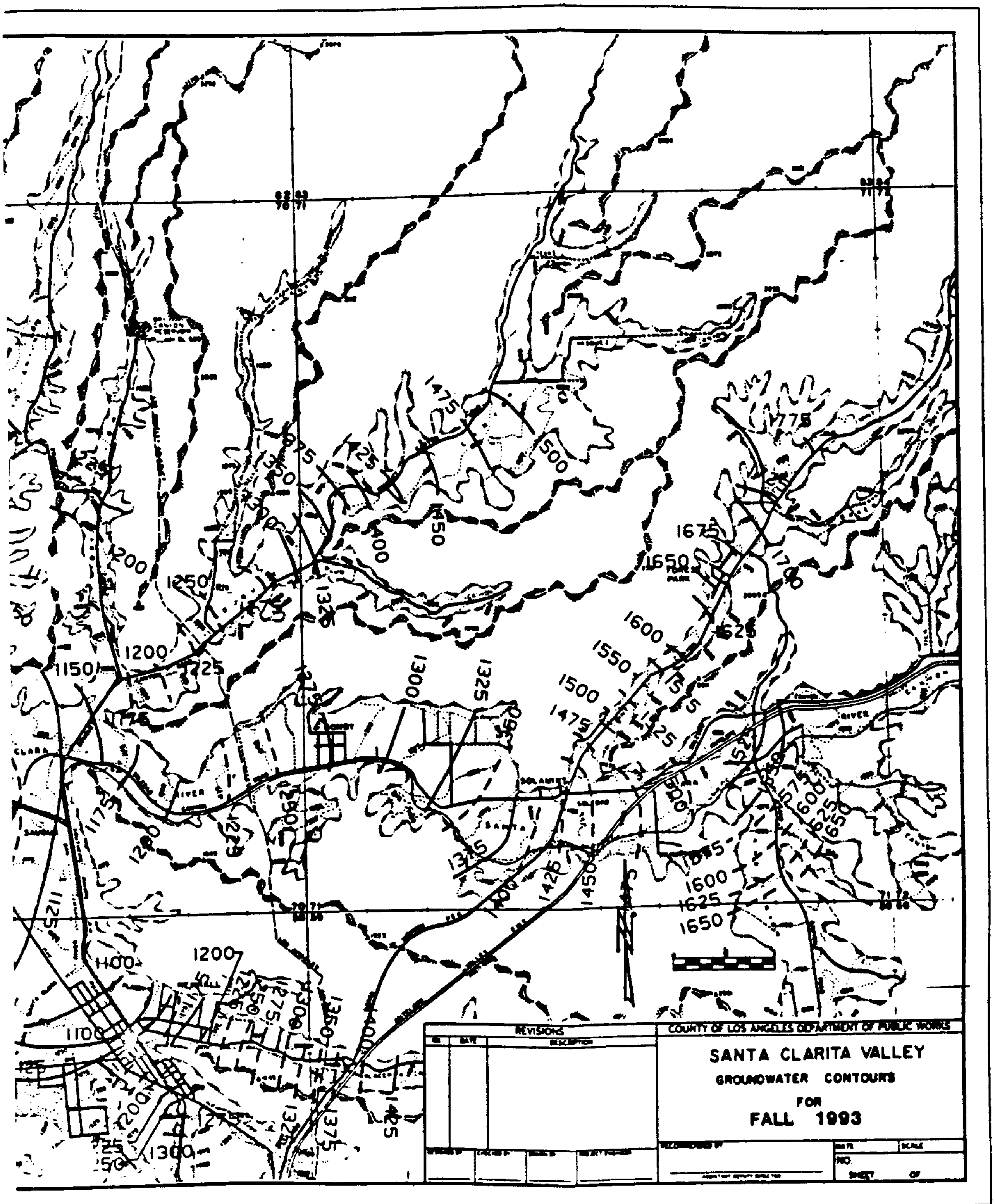
2 0480



PG7

R0053785

County of Los Angeles

BOARD OF SUPERVISORS

GLORIA MOLINA
First District

YVONNE BRATHWAITE BURKE
Second District

ZEV YAROSLAVSKY
Third District

DEANE DANA
Fourth District

MICHAEL D. ANTONOVICH
Fifth District

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Ventura Countywide
Stormwater Quality
Management Progra

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Participating Agencies

Camarillo

County of Ventura

Fillmore

Moorpark

Ojai

Oxnard

Port Hueneme

San Buenaventura

Santa Paula

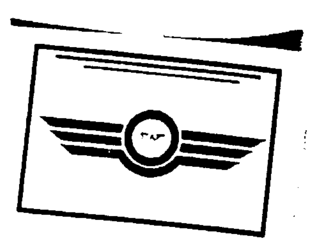
Simi Valley

Thousand Oaks

Ventura County
Flood Control
District

Illicit Discharge Investigation Approach

February 1995



0482 F

Ventura Countywide
Stormwater Quality
Management Program

Participating Agencies

Camarillo

County of Ventura

Fillmore

Moorpark

Ojai

Oxnard

Port Hueneme

San Buenaventura

Santa Paula

Simi Valley

Thousand Oaks

Ventura County
Flood Control
District

Illicit Discharge Investigation Approach

February 1995

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Contents

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List of Tables

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Illicit Discharge Investigations

Program Element

Illicit Discharge Investigations in Priority Area

Program Goal

An effective illicit discharge investigation program should detect the presence, identify the source, and plan the control of illicit discharges to co-permittee storm drain systems and/or receiving waters. Co-permittee programs that follow this Countywide approach to illicit discharge investigations should achieve the following objectives:

- Investigate locations where illicit discharges are commonly found.
- Thoroughly inspect these areas for evidence of illicit discharges.
- Accurately record observations and conduct sampling.
- Use appropriate efforts to identify sources of illicit discharges.
- Plan appropriate follow-up actions.

Background

Why Implement This Program?

Illicit discharges, as defined by the federal regulations are *any discharge to a municipal separate storm sewer that is not composed entirely of stormwater except discharges pursuant to a NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges relating to fire fighting activities.* Illicit discharges are caused by activities ranging from car washing and lawn watering to practices such as illicit connections of sanitary sewers to storm drains and dumping used oil into storm drains.

Illicit discharges are flows not composed entirely of storm water.

Under the Ventura County stormwater NPDES permit, certain discharges are prohibited outright, while others are prohibited if, in the judgment of the Regional Board or the municipality, they cause specific receiving water limit violations or constitute a significant pollutant discharge. The permit requires municipalities to detect, identify, and manage significant illicit discharges to their municipal storm drain systems.

The 1981 Nationwide Urban Runoff Program (NURP), an extensive survey of the nation's municipal storm drain systems, concluded that illicit discharges have the potential to adversely affect the quality of urban runoff. Since that time, further investigations into illicit discharges have shown that large amounts of wastes are improperly discarded into storm drains. Recent field inspection results verify that illicit discharges are not uncommon in Ventura County.

Table 1
Common Sources of Illicit Discharges

- Sanitary wastewater
- Septic tank effluent
- Household chemicals
- Gasoline filling stations
- Vehicle maintenance/repair
- Laundry wastewater
- Carpet cleaning wastewater
- Acid wash water
- Leaking tanks and pipes
- Miscellaneous process waters
- Loading docks
- Motor oil
- Wet sanding operation runoff
- Solvents
- Steam cleaning runoff
- Outside storage
- Landscape runoff
- Leaking air compressors

What Discharges are Illicit or Unacceptable?

The majority of observations of illicit discharges are found in older residential areas and areas used for industrial or commercial activities. Recent EPA guidance on illicit discharge investigations (1993), the California Storm Water BMP Handbook (1993) and the pilot illicit discharge control program conducted by Simi Valley have identified potential inappropriate entries into storm drainage systems from residential, commercial, and industrial areas. Table 1 summarizes common sources of illicit discharges.

What Illicit Discharges Are Conditionally Acceptable?

In general, illicit discharges are prohibited from entering storm drainage systems without an NPDES permit. This prohibition does not apply to the illicit discharges identified in the Ventura County permit (Table 2), unless the Regional Board determines that these discharges cause specific receiving water limit violations.

Table 2
Conditionally Acceptable Illicit Discharges

- water line flushing
- landscape irrigation
- diverted stream flows
- rising groundwater
- uncontaminated ground water infiltration to storm drains
- uncontaminated pumped groundwater
- discharges from potable water sources
- foundation drains
- air conditioning condensation
- irrigation water
- natural springs
- water from crawl space pumps
- footing drains
- lawn watering
- individual residential car washing
- riparian habitat/wetland flows
- dechlorinated swimming pool discharges
- discharges or flows from emergency fire fighting activities
- other types of illicit discharges identified in annual reports by the Countywide Program, as approved by the Regional Board

Table 3
Target Businesses for Illicit Discharge Investigations

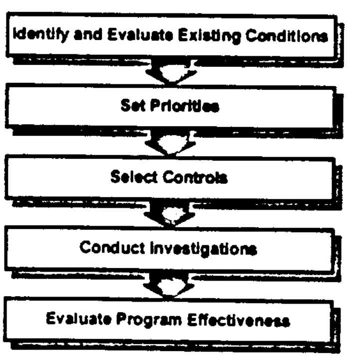
- gas stations
- automobile service facilities
- commercial laundries
- carpet cleaners
- painting contractors
- metal finishing facilities
- pool cleaning operations
- salvage yards
- recycling facilities
- restaurants
- machine shops
- facilities with outside storage

Who Is the Program Audience?

While investigations into illicit discharges must address the entire drainage system, initial investigations should target older residential areas and certain businesses where illicit discharges commonly occur. Illicit discharge investigations by Simi Valley and other communities found that the business categories listed in Table 3 are often sources of illicit discharges and should be targeted by an illicit discharge control program.

Countywide Program Approach

This section describes the suggested Countywide approach for the Illicit Discharge Investigation Program. The approach draws from USEPA's User's Guide; previous illicit discharge investigations by the Cities of Stockton, Oxnard, and Salinas; and the pilot Illicit Discharge Control Program conducted in Simi Valley. An overview of this approach appears next, followed by a detailed discussion of each step of the approach.



The figure on the left illustrates the Countywide Approach to illicit discharge investigations. This approach involves five steps:

1. *Identify and evaluate existing conditions.* Getting ready for an illicit discharge inspection program involves obtaining and reviewing available data about storm drains, land uses, and pollutant sources, and coordinating with other agencies responsible for investigating and regulating pollution.

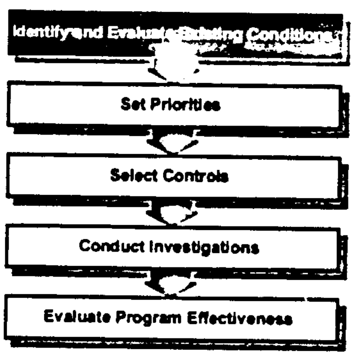
2. *Set Priorities.* Activities most likely to cause illicit discharges should be investigated first, and investigation and sampling procedures should be appropriate for these activities.

3. *Select Controls.* Illicit discharge control will begin with distribution of educational flyers to parties most likely to cause illicit discharges, with followup action based on field observations.

4. *Conduct Investigations.* Illicit discharge investigations involve field inspections, field testing, record keeping, tracking discharge sources, field data analysis, followup investigations, and control verification.

5. *Evaluate Program Effectiveness.* Evaluation and reporting of program effectiveness demonstrates permit compliance and improves future investigations.

Each co-permittee has already completed the first two steps of this approach and has selected priority targets for illicit discharge investigations during 1995. Volume 1 of the Ventura Countywide NPDES Stormwater Permit Application describes the selection process and priority targets. Findings are summarized below. Each co-permittee should follow the remaining steps to complete illicit discharge investigations within priority areas during 1995. The entire approach should then be repeated in subsequent years.



Identify and Evaluate Existing Conditions

This section describes information that should be reviewed before starting illicit discharge investigations. Much of this information is found in Volume 1 of the Countywide permit application. This volume contains information on established public agency programs, pollutant types and possible sources, business groups, land use, drainage patterns, and receiving waters. Volume 1 also identifies locations that the co-permittees will investigate for illicit discharges during FY 1994/95. The co-permittees should review and revise this information as needed to establish investigation priorities in subsequent years of the permit term.

Evaluation of Available Data

Illicit discharge investigations begin with review of available information about the drainage system and potential sources of pollution. The permit application contains maps of storm drains, land use, and significant known pollutant sources, lists of industries, and other types of information about stormwater pollution. Table 4 lists additional types of information that should be reviewed before field investigations begin. Using inadequate information may result in the inspection of areas less likely to produce illicit discharges or the omission of areas from inspection which have a high likelihood of illicit discharges. Some of the information in Table 4 may not be pertinent to a particular storm drain system or may be unavailable. Additional sources or types of information may be identified by each co-permittee.

The initial data collection effort should produce adequate information to perform an informed analysis and prioritization of areas most likely to contain illicit discharges.

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Several public agencies have jurisdiction over the dischargers that will be of concern to the co-permittees and should be contacted during the initial data collection effort.

Coordination with Established Programs

The public agencies listed in Table 4 often have jurisdiction over possible sources of illicit discharges and should be contacted during the initial data collection effort. For example, the Environmental Health Department may have data concerning spill control plans and hazardous materials inventories for local businesses. Local Fire Departments may also be a source of information on spill management and hazardous materials storage at local businesses. Wastewater industrial pretreatment programs will have wastewater monitoring data and information on facility operations from their industrial inspection program. They may also have information on smaller commercial businesses from their pollution prevention programs or their industrial user surveys. The Air Quality Management Control District conducts inspections of businesses looking for sources of air pollution and may have information that would be useful for identifying sources of illicit

Table 4
Potential Data Requirements for Illicit Discharge Control Program

Information Source	Type of Information Available
Ventura County Environmental Health Department	List of landfills List of hazardous waste TSDR facilities Hazardous Material Inventories for local businesses
Local Fire Departments	Fire Department chemical storage inspection records Spill reports
Pretreatment/Source Control Programs	Existing receiving water quality and urban runoff data List of industries, locations, and contacts Spill reports and spill prevention plans Process and chemical storage information
Air Pollution Control District	List of industries, locations, and contacts
Water Conservation Programs	Storm drain maintenance records Water use records Existing receiving water quality and urban runoff data
Public Works Department	Storm drain maintenance records Land use maps Storm drain system maps (including detention basins, if any) Topographic maps Maps of existing septic systems Current business licenses
Regional Water Quality Control Board	List of NPDES permittees discharging to the storm drain

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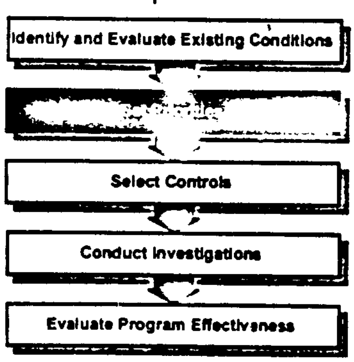
discharges. Water conservation programs may be able to provide water usage records and may be helpful in identifying and preventing discharges to the storm drains. Public Works Departments may be able to provide maintenance records that may describe evidence of illicit discharges.

There are distinct reasons to coordinate illicit discharge investigations and related activities of other agencies. Most businesses are inspected by several public agencies, each with its own set of requirements and regulations. As a result there are often contradictions between the various agencies' requirements that can make compliance difficult and confusing for a business. This issue was pointed out by several businesses that were inspected during the pilot program. There may be opportunities to work with other agencies to combine inspections or minimize any apparent inconsistencies between programs. Working with other agencies may also optimize the use of limited resources and allow a more unified message to be delivered to the community.



Set Priorities

To be most effective, initial investigations should be conducted in locations where illicit discharges are most likely to occur. This section describes how the data collected in the first step can be used to define priority locations for illicit discharge investigations. This approach was used by most co-permittees to define locations for illicit discharge investigations during 1995, as discussed in the permit application. Each year, the co-permittees should review and revise program priorities to select locations for subsequent illicit discharge investigations.

The prioritization process prescribed for Ventura County begins with organization of the data collected during the evaluation of existing conditions. The data are first organized by drainage basin (drainage basins are subunits of each city's watershed). Then basins are compared according to criteria about illicit discharges selected from available data and previous field experience. Basins are ranked from highest to lowest probability of containing illicit discharges using a matrix like the following one.

Basin	Criteria			Overall Score	Rank

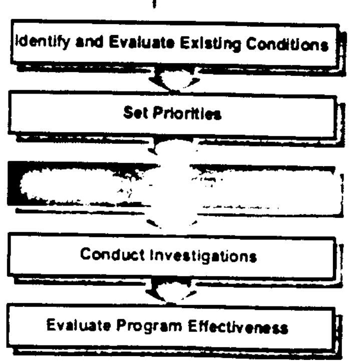
Criteria based on actual observations are given higher scores. Once scores are given, overall scores are tabulated for each basin. The basins are then ranked in order of highest overall score (sum of individual characteristics scores) to the lowest overall score. The highest ranked drainage basins are the first areas investigated for illicit discharges. This method is described in more detail in Attachment 1.

Ranking of drainage basins was conducted by the co-permittees at the end of 1993 using, for the most part, the matrix approach. The following criteria were used to rank basins:

- Industrial area fraction
- Commercial area fraction
- Density of residential areas
- Types of industry/commercial business (e.g., automotive related)
- Older areas (base date on changes to plumbing code, other factors)
- Areas with hazardous material storage
- Number of previously-observed illicit discharges
- Frequency of spill reports
- Density of septic systems

Table 5 lists locations selected by each co-permittee for illicit discharge investigations using this approach. In some cases, the co-permittees included additional criteria based on personal knowledge of activities undertaken in the watershed, or excluded some criteria, such as number of spills reported, due to lack of information. The City of Camarillo based their prioritization almost exclusively on land use and age of facilities, since no information was available on hazardous materials storage, illicit discharges, or spills. The City of Santa Paula had more information but decided to conduct illicit discharge investigations at certain high priority businesses (e.g., automotive businesses, transportation businesses, and hazardous materials handlers) regardless of location.

It is interesting to note which basin characteristics weighed prominently in determining the high priority drainage basins. Fraction of industrial area, age of facilities and infrastructure, and hazardous materials storage appear to be the common determining factors.



Select Controls

Once the high-priority basins have been identified, potential or existing sources of illicit discharges can be targeted for control. Some of the potential sources were listed earlier as the "target audience" and include automobile service facilities, painting contractors, carpet cleaners and pool cleaning operations. Appropriate best management practices (BMPs) are required to effectively control on-site pollutant generating

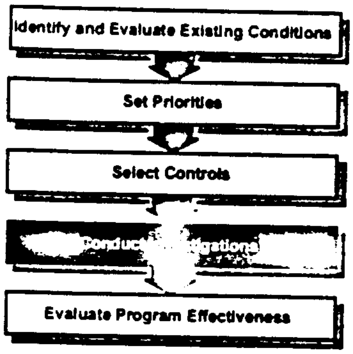
Table 5
Characteristics of the High Priority Drainage Basins

Co-permittee	Characteristics of the High Ranked Basins	Highest Priority Basin [1]
Camarillo	Older facilities and infrastructure, large number of automotive-related businesses	Basin 12
County of Ventura	Older facilities and presence of septic systems	Black Canyon
Fillmore	Older facilities and infrastructure	Between Ventura St. and Railroad
Moorpark	Large industrial area, large number of businesses of concern, known hazardous materials storage	Basin F
Ojai	Large number of businesses of concern, presence of older facilities and businesses, known hazardous materials storage	Basin I
Oxnard	Citywide illicit discharge investigations	All Basins
Port Hueneme	Larger industrial area located near waterfront	Basin 5
San Buenaventura	Larger industrial area, concentration of older facilities	Auto Center, older industrial areas
Santa Paula	Presence of older facilities and infrastructure, known hazardous materials storage	All areas
Simi Valley	Frequent spill reports, stored hazardous materials, many businesses of concern	N. Simi, Tapo
Thousand Oaks	High number of spill reports, large number of businesses of concern	Basin 10

[1] Rating matrices and maps locating priority basins can be found in Attachment 2.

activities at the targeted industries. For example, BMPs were developed for automobile service facilities for use during the pilot program.

The controls are selected with input from the business community in order to ensure compatibility with local practices and thus facilitate implementation. Developing a "Clean Business Program" may be one approach to implementing controls. Other controls are being developed as part of the countywide program and will be available to the co-permittees as they become available. In the interim, an initial set of BMPs for common activities generic to most residents and businesses may be appropriate. Handouts listing these BMPs that can be distributed during illicit discharge investigations are found in Attachment 3.



Conduct Investigations

The Countywide approach to illicit discharge investigations involves three types of investigations: field inspection and testing, illicit discharger identification, and followup planning. This section describes each type of investigations in detail.

Field Inspection and Testing

Field inspection involves visual observation of the storm drain system and visual observation of activities on the surface that may cause illicit discharges. A two to three person field inspection crew should thoroughly investigate the entire surface and subsurface drainage system for evidence of illicit discharge. On the surface, the inspection crew investigates accessible areas around residences and businesses, as well as nearby catch basins, for evidence of illegal dumping and other activities that could result in stormwater pollution. The surface inspections were shown during the pilot program to be the most successful in identifying illicit discharges. The crew should also inspect open channels near known and previously unidentified points of discharge, as well as manholes at strategic locations within the storm drain system. The crew may conduct field testing with probes, test kits, and water sample collection/analysis. Field testing helps detect illicit discharges and identify their sources, not quantify pollutants. Surface/storm drain field inspection and testing procedures follow.

Advance Planning. An effective field inspection program requires good advance planning. First, at least 4 people should be trained to conduct inspections so that qualified staff are available each day for the 2 to 3 person inspection crews. Inspections must be conducted during dry weather, usually in the summer when groundwater seepage is low. Before entering the field, the inspection crew should locate an initial set of inspection sites on a storm drain/street map:

- All known or suspected pollutant-generating activities
- Priority businesses
- Other locations representative of activities within the drainage basin.
- All locations where drains enter open channels
- Representative catch basins and storm drain manholes

In the field, other sites should also be inspected if suspicious conditions are observed. Finally when inspections are about to begin, obtain the equipment and store it in the vehicle used by the inspection crew. Table 6 lists equipment required for field inspections.

Table 6
Field Equipment for Illicit Discharge Investigations

Field Inspection Equipment
- Storm drain system map
- Field data log book
- Inspection checklists (Attachment 3)
- Tape measure
- First Aid kit
- Camera and film
- BMP Handouts

Field Testing Equipment
- Graduated container, stopwatch to measure flow
- Temperature/pH/conductivity (EC) probe
- Field test kits (e.g., Lamotte test kit)
- 12-1 liter amber glass sample bottles
- 12-1 liter HDPE sample bottles
- Cooler with ice for sample preservation
- Gloves
- Splash goggles/safety glasses

Visual Observation. Evidence of illicit discharges may only consist of visual observations because most illicit discharges are intermittent and will probably not be flowing when inspected. Table 7 lists the types of visual observations that should be recorded using the inspection checklists for drainage systems and business facilities located in Attachment 3. Also, take photos of visual observations to aid subsequent data analysis and followup planning.

Field Tests. If flow is observed at either surface or storm drain inspection sites, the field inspection crew should collect a sample, measure flow, and attempt to trace the flow to its source. This effort is coordinated between the storm drain crew and the surface crew. First, the storm drain crew uses the probe to measure the pH, temperature and conductivity (EC). If any of these parameters are abnormal or strong odors or flow discoloration are detected, the sample is analyzed with the field test kit. The test kit detects the presence of copper, phenols, detergents, and chlorine. Findings are recorded on the inspection checklist.

Table 7
Recommended Types of Visual Observations

All Inspection Locations
- General site description
- Amount, appearance, odor of debris
- Stains
- Structural cracking and corrosion
- Vegetative growth
- Poor outside housekeeping practices
- Pipes/hoses directed toward drainage system

Business Inspection Locations
- Vehicle and equipment fueling
- Vehicle and equipment washing and steam cleaning
- Outdoor loading/unloading areas
- Outdoor container storage of liquids
- Outdoor process equipment
- Outdoor storage areas
- Waste handling and disposal

Simi Valley field tested two types of field kits: DREL 2000 and Lamotte. The DREL 2000 is a portable spectrophotometer which yields very conclusive analytical results, but requires more time and auxiliary equipment to operate than the Lamotte system. The Lamotte system consists of field test kits which are simple to operate and yield quick results. However, the results are useful only for establishing an order of magnitude number.

Field Sampling. If visual observations are abnormal and/or the field tests detect high concentrations of any constituent, the field crew should collect samples for laboratory analysis. Two types of one liter containers are used: amber glass bottles to collect samples for organic, oil and grease,and TPH analysis, and plastic (HDPE) bottles to collect samples for metals analysis. If there is enough flow, the field crew should fill 2 amber glass sample bottles and 2 HDPE sample bottles to obtain enough sample volume for analysis of metals, organic and conventional pollutants. If there is a limited quantity or sampling is difficult, the field crew should collect as much sample as possible so that the laboratory can run a limited set of analyses. The samples are placed in a cooler filled with ice and transported to the lab(s) on the same day. Arrangements should be made prior to the field inspection with analytical laboratory(s) capable of performing the required analyses. Also, the laboratory can usually supply properly cleaned sample bottles.

Sample Analysis. The laboratory analyses run on each sample should be determined using the results of the field testing and visual observations. Given the potential high cost for laboratory work, it is prudent to limit the number of analytical parameters (or analytes) tested for each sample. First, general indicator analyses (e.g., total organic carbon (TOC), total organic halogens (TOX), oil and grease, biochemical oxygen demand (BOD), fecal coliform, and ammonia) should be run. Additional tests may be selected based on the findings of indicator analyses, visual observations, field tests, and information collected in Step 1 on the types of chemicals stored (and/or spilled) within each basin.

Illicit Discharger Identification

Typical illicit discharges are intermittent and may not be detected during the initial field inspection. Follow-up inspections may be warranted.

Many illicit dischargers will be identified by the field inspection procedures described above. Additional techniques may be needed to identify other sources of illicit discharges. These techniques include analysis of the field inspection data, and follow-up inspections of businesses, residences, and drainage systems.

Analysis of Field Inspection Data. When field inspections and sample analysis are complete, data analysis is performed to identify the most probable sources of illicit discharges. In some cases, field inspection crews may be able to conduct data analysis in the field, with immediate followup by the crew. In other cases, the discharge source may not be obvious and it may be more productive to analyze the data at the office. There, analytical results from field sampling can be compared with typical stormwater quality values (as defined by EPA's Nationwide Urban Runoff Program, NURP) to determine if the discharge is a concern. If the discharge poses a threat then records of chemical storage, use and spills should be reviewed for potential illicit dischargers. This data can be used to determine which businesses to investigate and to guide facility inspections. For example, if high levels of oil and grease are found (greater than 5.0 mg/L) in the discharge then restaurants or vehicle service facilities are likely candidates for followup inspections. Likewise, if the discharge has high BOD (greater than 20 mg/L) or fecal coliform counts greater than 100,000 MPN/100 mL then follow up inspections should focus on sanitary sewer cross connections.

Followup Investigations of Businesses and Residences. When evidence of illicit discharges is tracked to a source on private property, there are three approaches that can be taken depending on the experience and legal authority of the inspection team, the conclusiveness of the field inspection data, and the availability of background data on pollutant sources and drainage patterns:

Followup investigations may be referred to an agency with authority to enter the business or residence, deferred to a future date, or conducted immediately by the field inspection crew.

- The first approach is to refer the name and location of the business or resident suspected of illicit discharge to a program with the appropriate authority for follow-up. This may be the Stormwater Industrial/Commercial Business program, the Industrial Pretreatment Program, or the Environmental Health Department. The programs that should conduct this follow-up should be designated prior to conducting the illicit discharge investigations. Copies of the inspection reports should be sent to the appropriate program with a request for follow-up. Special attention should be given by those inspectors to the problems indicated by the field storm drain inspections. Examples of such special consideration include visual inspection of storm drains, roads, and ditches in each facility near or around chemical storage areas or areas in which these chemicals are used. Furthermore, these inspectors should record the results of all investigations prompted by field inspection data regardless of outcome. Businesses/residents should be notified of the impending inspection according to standard procedures of the agency conducting the followup.

- For the second approach, the illicit discharge inspection crew may have the authority to conduct the business investigation but may prefer to do this at a later date. In this case, a letter can be sent to the business describing the nature of the problem and advising them that an inspection will be conducted in the near future. The Business Inspection Checklist can be mailed along with this notification if desired.

- A third approach is to conduct the inspection at the time the illicit discharge is discovered. In this case, the storm drain crew is called to the surface for assistance in documenting the discharge and approaching the resident or owner/manager of the facility(s) under suspicion. One member of the crew meets with the resident or facility personnel and explains the potential stormwater contamination problem. Next, the inspection crew inspects the grounds for other sources of potential contamination and document the discharge by taking pictures, sampling and running the appropriate tests. These initial inspections should be viewed as opportunities to educate the public about the overall stormwater program and to provide the resident or business with information on how to eliminate illicit discharges.

Followup Storm Drain Investigations. Sources of remaining unexplained flows (after field inspection and followup investigation of residences and businesses) may be identified through the following alternative detection methods:

Followup storm drain investigations involving dye tests, smoke tests, and TV inspections are expensive and time-consuming, and thus will be used as a last resort.

- *Dye Tests.* Dye tests in areas where storm drain flows are unexplained may reveal illicit structural connections. Typical dye tests consist of the addition of fluorescent dye to a floor drain or waste line from a domestic, commercial or industrial process, followed by monitoring for the dye in downstream storm drains. Dye testing proceeds facility by facility (in each area where unexplained flow exists) until all facilities in the area are tested.

- *Smoke Tests.* Smoke testing in problem areas is another method of illicit discharge identification. Storm drains are sealed via sand bags or other sealing devices (plugs, etc.) and smoking incendiary devices are ignited upstream of the seal. Simultaneous inspections inside area facilities should reveal illicit connections even in the absence of flow. Since illicit discharges are intermittent, smoke tests offer real advantages over other types of illicit discharge source identification methods. However, since many legitimate connections to a storm drain may exist (roof drains, street drains, etc.) smoke may be observed extensively and some illicit connections may be missed.

- *T.V. Inspections.* Robotized or otherwise mobile television cameras allow visual inspection of storm drains (pipes) too small or dangerous for personnel to enter. Although an excellent method of identifying and documenting illicit connections, T.V. inspections have high costs. Some co-permittees may currently have T.V. equipment at their disposal.

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Since these methods are expensive and time consuming, their implementation is a last resort and will probably only be used once the more easily identifiable discharges are eliminated. A detailed description of these methods can be found in the California Stormwater BMP Handbook - Municipal .

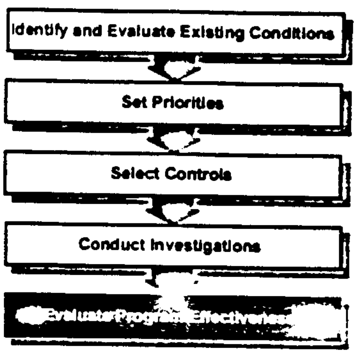
Illicit Discharge Control Planning

Once illicit dischargers are identified, actions to eliminate the discharges are initiated. The suggested strategy is to focus initial efforts on education, public outreach and technical assistance. These methods encourage voluntary compliance. Enforcement mechanisms are used only when voluntary techniques have been unsuccessful. Illicit discharge control programs are part of the Programs for Industrial and Commercial Businesses and Programs for Residents. These programs are summarized here and described in detail in separate Countywide program approaches developed for these programs.

Voluntary compliance is encouraged by focussing initial efforts on education, public outreach and technical assistance. Enforcement mechanisms are used only when voluntary techniques have been unsuccessful.

Community Education/Outreach Methods. Methods of communicating with businesses or residents with illicit discharges must be devised to ensure understanding of the program and proper implementation of the required BMPs. For retail businesses, a "Clean Business" outreach program was begun in 1995 for automobile service businesses and scheduled to be extended to restaurants and other businesses in subsequent years. The "Clean Business" concept merges facility inspections by municipalities, education of business owners and employees about appropriate controls, solicitation of their comments on the ability to implement the controls, and "awards" for implementing controls. Other types of business outreach (e.g., presentations to trade organizations, distribution of handouts/brochures with business license applications and renewals) may also be examined. For residents, the Countywide program has developed an inlet stenciling program, brochures about illicit discharges and proper refuse disposal, a display for community events, and presentation materials for speaking engagements. This material is being incorporated into residential outreach programs being implemented by each co-permittee.

Regulatory Procedures. If education and technical assistance efforts do not result in a business or resident eliminating its sources of illicit discharges, then enforcement may be necessary. During the initial implementation phase, the co-permittees will enforce illicit discharge control as allowed by existing ordinances. During the full implementation phase, additional ordinances/enforcement programs will be developed to supplement control achievable under voluntary programs and/or existing ordinances. In the event that an illicit discharger is uncooperative, legal authority must be in place and used to enforce stormwater ordinances. Recourse against uncooperative dischargers is similar to POTW pretreatment program authority with the exception of discharge permitting. Fines, compliance schedules, cease and desist orders, and legal action are all avenues available to co-permittees to require companies to comply. Ordinances should be reviewed to confirm that adequate legal authority is in place to carry out necessary enforcement actions.



Evaluate Program Effectiveness

Methods of data collection and record keeping are necessary to periodically assess program effectiveness and report results to the Ventura County Flood Control District and the Regional Board. Table 8 lists the type of information that can be tracked and how it can be used to assess program effectiveness. Included in Attachment 5 is a spreadsheet that may be used to compile the program results. By July 15, each co-permittee should complete the spreadsheet and submit it to the VCFCD for evaluation and compilation into the annual report to the Regional Board due September 1. At that time, an assessment of the Countywide program approach will be made.

Table 8
Possible Program Assessments

Type of Information	Program Results	Possible Assessments
Inspection Results	Number of facilities inspected	■ Inspector productivity ■ Number of problem facilities
	Number of illicit discharges detected	■ Stormwater quality from the applicable jurisdiction ■ Inspector effectiveness ■ Program effectiveness
	Number of illicit dischargers identified	■ Inspector effectiveness ■ Program effectiveness
	Number of illicit discharges abated	■ Success of inspection/education efforts
	Type of illicit discharges	■ Stormwater quality risks ■ Refocus of target efforts
Program Economics	Number of inspector-hrs per identified illicit discharger	■ Inspector efficiency ■ Effective staffing levels
	Number of personnel-hrs per identified illicit discharger	■ Effective staffing levels ■ Staffing projections
	Cost per identified illicit discharger	■ Cost per desired benefit ■ Budget projections
	Cost per illicit discharge abated	■ Cost per desired benefit ■ Budget projections

Periodically, it will be necessary to reassess the work effort including modifying the priority areas/analytes, determining effectiveness of outreach efforts, quantifying the removal of illicit discharges, and redirecting staff resources. The assessments listed in Table 8 are intended to define cost-effective approaches to future illicit discharge investigations. Some specific items to consider when conducting long range planning are:

- Follow-up inspections in priority drainage basins where outreach has been conducted
- Targeting new activities in the priority drainage basins
- Targeting additional drainage basins for inspections
- Modification of inspection program with regard to number of inspectors and tasks during inspections
- Frequency of inspections in one drainage basin to effectively identify illicit discharges
- Modification of existing handouts or development of new handouts

Program Administration Needs

Estimates of staff time, staffing levels, and other operating expenses were prepared as part of the pilot illicit discharge program conducted by Simi Valley. These estimates are discussed below and may be used as the basis for determining program staffing and budgets. Other factors to be considered in program development include the frequency with which field investigations are conducted and how much follow-up can be coordinated with other programs.. The pilot program concluded that field screening should be conducted more often than once per year due to the intermittent nature of many illicit discharges. As discussed earlier, there are other municipal programs that could aid in illicit discharge investigations.

The cost estimates were based on actual expenses incurred during the pilot program to conduct investigations of 33 separate occurrences of illicit discharges and contact 20 businesses regarding the source of the illicit discharges. To facilitate program preparation and budgeting by other co-permittees, the Simi Valley estimates were converted to convenient multipliers (amount per occurrence of illicit discharge and amount per business investigated) and are presented in Table 9.

Table 9
Level-of-Effort Multipliers

Budget Category	Total Amount for Drainage Basin[7]	Amount per Outfall	Amount per Investigated Business
Staff Hours:			
Inspector[1]	167	4.8 hrs	8.8 hrs
Lab Technician[2]	67	1.9 hrs	3.2 hrs
Supervisor[3]	84	2.4 hrs	4.2 hrs
Manager[4]	8	0.2 hrs	0.4 hrs
Total Hours	326	9	17
Vehicles[5]	$1,300	$37	$65
Field Analyses (by DREL 2000)[6]	$6,800	$194	$340
Field Analyses (by Lamotte)[6]	$830	$24	$42
Total Cost (DREL 2000)	$16,906	$482	$854
Total Cost (Lamotte)	$10,936	$312	$556

1 2 inspectors per investigation @ $26.79/hr
2 1 laboratory technician per investigations @ $23.59/hr
3 supervisor @ $28.98/hr
4 manager @ $39.66/hr
5 2 vehicles @ $6.50/hr, 1 vehicle @ $7.50/hr
6 analyses include temperature, dissolved oxygen, phenol, pH, chlorine, copper, detergents
7 drainage basin consists of 763 acres, 43% residential, 23% commercial, 9% industrial. There are 35 outfalls in the drainage basin. 33 sites were investigated, 4 in channel, 29 on surface.

The multipliers can be used to project staffing and equipment budgets by a particular co-permittee. However, the amounts are based on initial implementation of the program when the more obvious discharges are identified and when more time is spent with each discharger in explaining the program requirements. Amounts may decrease or increase in subsequent years as education yields widespread awareness or enforcement actions become necessary.

Estimated staff hours were based on using two inspectors and one lab technician to inspect outfalls within drainage channels and inspect facilities and residential areas, perform laboratory analyses, and document all activities. During inspections, approximately 70% of the staff time was spent investigating surface locations and 30% of the time was spent investigating the outfalls. For safety reasons, two persons were assigned to the channel investigations at all times. Although only one person was assigned to perform

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surface investigations, it was determined that using two persons at the surface would greatly increase investigation efficiency. When businesses were contacted regarding a potential problem, an average of 45 minutes to an hour was spent describing the program requirements, explaining identified problems, and prescribing corrective actions. Hours spent by the program manager were estimated based on any necessary enforcement actions. The two different costs for field analyses were based on the two types of analytical equipment used during the pilot program.

Implementation Schedule

The implementation schedule shown in Table 10 includes a period of initial implementation to test the program on priority businesses or areas and then a date for assessment and possible refocus of efforts. Additional dates and deliverables to be incorporated in the schedule will consist of a semiannual submittal to the county on program effectiveness.

Table 10
Proposed Implementation Schedule

Program Task	Annual Illicit Discharge Investigation Schedule
Identify and Evaluate Existing Conditions	September 1 - December 31
Set Priorities	January 1 - February 28
Select Controls	January 1 - February 28
Field Investigations	April 15 - July 15
Program Effectiveness Evaluation and Reporting	July 15 - September 1

Field Experience

In the fall of 1993, the City of Simi Valley conducted a pilot illicit discharge control program. It was designed to satisfy the requests of the Regional Board to begin early implementation of certain programs, and to evaluate the program work plan that was included in the permit application.

The North Simi Drain was chosen as the targeted high priority basin for the pilot program. The North Simi Drain is composed of 35 outfall/screening points within the drainage channel. During dry weather field screening in 1992, four of these screening points were identified with measurable flow and four additional screening points had unmeasurable flow and the remaining screening points had no flow. One discharge was clearly oil/petroleum product wastes. Surface inspection revealed 78% (15 of 19) of the pollution sources. The remaining 22% were identified from the channel, either with flow or by visual observation of stains. Only 10% (2 of 19) of all the identified pollution sources had actual flow at the time of the inspection whether found on the surface or in the channel. A total of 75% of the discharges identified during the pilot program were new since the previous year's dry weather field characterization which consisted of visual observation within the channel only.

The City of Simi Valley assigned two inspectors and one lab technician to the pilot program. The project was completed in approximately two weeks, including canvassing the North Simi Drain, inspection of facilities and residential areas, laboratory analyses and documentation.

Preparation and development of the pilot program field inspection presented many challenges and resulted in many interesting observations.

The handouts used in the pilot program were a key element in achieving the goal of voluntary compliance. The handouts were developed based on materials used in other jurisdictions and tailored to the Simi Valley project. The initial format chosen was a three-fold information sheet describing general housekeeping practices that reduce discharges. Separate, more detailed BMPs specific to the automotive industry were prepared for insertion into the three-fold depending on the specific issues identified at a facility. This proved cumbersome in the field and the BMPs were combined with the three-fold resulting in a booklet that was distributed as appropriate. If a facility had any potential to discharge or was on a common lot where discharge was an issue, the handouts were distributed. Businesses which had no evidence of discharge or potential to discharge did not receive handouts.

Organizing the inspection crew was a challenge initially. The initial format of two staff members in the channel and one staff member on the surface proved to be less efficient. The system was modified to emphasize surface inspections as discussed above in the section on inspection programs.

Personnel at the inspected facilities revealed a surprising appreciation for the advance notice of impending regulations. One service manager indicated that the handouts and BMP materials would be incorporated into safety meetings and copies would be distributed to all service personnel. The pilot program found that the solution to illicit discharges at most facilities involved improving housekeeping procedures. The most feasible BMPs included berming, covering and cleaning.

Based on the experiences during the pilot program, recommendations for future inspection programs included the following:

- Develop industry specific BMP handouts and technical assistance brochures to be used by all co-permittees.
- Provide English and Spanish translations of all handouts and brochures.
- Direct the drafting of a model ordinance to ensure consistent language and enforcement county wide.
- Define enforcement tools to be used to abate illicit discharges. Focus primarily on public education/outreach and voluntary compliance.
- Emphasize visual observation at the surface with observation in the channel as a support during the field inspection program.

References

- California Storm Water Best Management Practices (BMP) Handbook, March, 1993.
- Ventura Countywide Stormwater Quality Management Program, Ventura Countywide NPDES Stormwater Permit Application, Volume 1, January 1994, Volume 2, April 1994.
- Ventura Countywide Stormwater Quality Management Program, Pilot Illicit Discharge Control Subcommittee memorandum dated November 18, 1993.
- USEPA, Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems: A User's Guide, Office of Research and Development, Washington, DC, January, 1993.

Attachments

The following materials are attached to assist with program implementation:

1. Prioritization Process for Detection of Illicit Discharges
2. Locations of 1995 Co-permittee Illicit Discharge Investigations
3. Illicit discharge inspection checklists
4. Sample countywide BMP handout
5. Spreadsheet for compiling inspection results

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Preparation and development of the pilot program field inspection presented many challenges and resulted in many interesting observations.

The handouts used in the pilot program were a key element in achieving the goal of voluntary compliance. The handouts were developed based on materials used in other jurisdictions and tailored to the Simi Valley project. The initial format chosen was a three-fold information sheet describing general housekeeping practices that reduce discharges. Separate, more detailed BMPs specific to the automotive industry were prepared for insertion into the three-fold depending on the specific issues identified at a facility. This proved cumbersome in the field and the BMPs were combined with the three-fold resulting in a booklet that was distributed as appropriate. If a facility had any potential to discharge or was on a common lot where discharge was an issue, the handouts were distributed. Businesses which had no evidence of discharge or potential to discharge did not receive handouts.

Organizing the inspection crew was a challenge initially. The initial format of two staff members in the channel and one staff member on the surface proved to be less efficient. The system was modified to emphasize surface inspections as discussed above in the section on inspection programs.

Personnel at the inspected facilities revealed a surprising appreciation for the advance notice of impending regulations. One service manager indicated that the handouts and BMP materials would be incorporated into safety meetings and copies would be distributed to all service personnel. The pilot program found that the solution to illicit discharges at most facilities involved improving housekeeping procedures. The most feasible BMPs included berming, covering and cleaning.

Based on the experiences during the pilot program, recommendations for future inspection programs included the following:

- Develop industry specific BMP handouts and technical assistance brochures to be used by all co-permittees.
- Provide English and Spanish translations of all handouts and brochures.
- Direct the drafting of a model ordinance to ensure consistent language and enforcement county wide.
- Define enforcement tools to be used to abate illicit discharges. Focus primarily on public education/outreach and voluntary compliance.
- Emphasize visual observation at the surface with observation in the channel as a support during the field inspection program.

References

- California Storm Water Best Management Practices (BMP) Handbook, March, 1993.
- Ventura Countywide Stormwater Quality Management Program, Ventura Countywide NPDES Stormwater Permit Application, Volume 1, January 1994, Volume 2, April 1994.
- Ventura Countywide Stormwater Quality Management Program, Pilot Illicit Discharge Control Subcommittee memorandum dated November 18, 1993.
- USEPA, Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems: A User's Guide, Office of Research and Development, Washington, DC, January, 1993.

Attachments

The following materials are attached to assist with program implementation:

1. Prioritization Process for Detection of Illicit Discharges
2. Locations of 1995 Co-permittee Illicit Discharge Investigations
3. Illicit discharge inspection checklists
4. Sample countywide BMP handout
5. Spreadsheet for compiling inspection results

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ATTACHMENT 1
PRIORITIZATION PROCESS FOR DETECTION OF ILLICIT DISCHARGES

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ATTACHMENT 1

PRIORITIZATION PROCESS FOR DETECTION OF ILLICIT DISCHARGES

Prioritization of potential illicit discharge[1] areas is essential to effective illicit discharge detection and control programs. Past experience has shown the majority of observations of illicit discharges to occur in areas with characteristic land uses, age, history, and demography. The relationship between basin characteristics and frequency of illicit discharge detection allows the design of a more effective inspection program by focusing inspection efforts in priority areas. Prioritization of potential illicit discharge program basins will allow more efficient detection of illicit discharges.

Workplans developed by each co-permittee for detection and control of illicit discharges should include specific methods of prioritization of areas which select subject areas on the basis of past experience. Following a uniform prioritization process will enhance documentation of the area selection process and program reporting. This memo details a decision making method for basin prioritization known as the matrix method. This method basically consists of assigning numeric values (scores) to certain basin characteristics and summing the values to arrive at a ranking or prioritization of basins for further illicit discharge inspection.

Generic basin characteristics have been identified which signify greater risk of illicit discharge. The those characteristics are listed as follows:

Industrial area fraction
Commercial area fraction
Types of industry/commercial business (automotive related?)
Density of residential areas
Older areas (base date on changes to plumbing code, other factors)
Areas with hazardous material storage
Number of observed illicit discharges (maintenance personnel knowledge)
Frequency of spill reports
Density of septic systems

It is not expected that information will be available for all of these characteristics. Also, this list is not meant to be exclusive. Other characteristics which can be shown to indicate the existence of illicit discharges may be defined locally. The matrix technique works best when a relatively large number (> 3) of characteristics are used and the effects of the characteristics are weighted in proportion to the magnitude of the effect. The list presented above is meant to be a tool for beginning the data collection and prioritization process.

Basins are ranked from highest to lowest "probability" of containing illicit connections or illegal dumping in the matrix approach. Each basin is given a score with regard to each

[1]For our purposes, illicit discharges include both illicit connections (*e.g.* cross connections) and illegal dumping (*e.g.* oil dumping).

characteristic. Overall scores are then tabulated for each basin. The basins are then ranked in order of highest overall score (sum of individual characteristics scores) to lowest overall score. If the score or group of scores for a given characteristic seems to be disproportionately high or low when compared to the remaining characteristic scores, then the scoring system for that characteristic should be adjusted. Characteristics based on actual observations of illicit discharges should be given higher scores. The following table is an example of the matrix to be used in ranking the basins:

Table 1: Example Matrix of Basin Comparison

Basin	Characteristic——————→			Overall Score	Rank
A					
B					
C					

Methods of Scoring Basins on the Basis of Watershed Characteristics

Methods of scoring must be developed for each specific characteristic. The scoring should be consistent between characteristics so as not to bias the overall score toward a single or group of characteristics. A simple "1 to 5" approach usually works well and can be modified up or down for characteristics with extreme effects. Although the approach to developing characteristic scores is subjective, the matrix approach will work well even though the scores do not exactly reflect the actual probabilities of the basin containing illicit discharges. Scoring methods for each of the generic list of characteristics presented in the table above are developed using the "1 to 5" approach with a few of the characteristics slightly higher or lower. Some characteristics identified above exist only over a fraction of a basin area. In that case the scores are multiplied by the fractional area covered by the characteristic. Characteristics identified in addition to those presented here should be scored in a manner consistent with this technique (*i.e.* 1 to 5 and based on fractional coverage (area)).

<u>Industrial Area Fraction</u>

Since the probability of containing illicit discharges is directly proportional to the fraction of industrial area fraction, the scoring of this characteristic is fairly simple. The following scoring scale may be used:

Industrial Area Fraction	Score
0-20%	1
20-40%	2
40-60%	3
60-80%	4
80-100%	5

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Commercial Area Fraction

Commercial areas are nearly as likely to contain illicit discharges as industrial areas. Therefore, the scoring should be nearly the same as for industrial areas.

Commercial Area Fraction	Score
0-20%	1
20-40%	2
40-60%	3
60-80%	4
80-100%	5

Type of Business (Automotive)

Recently, observations of illicit discharges have correlated (subjectively) frequency of illicit discharge with certain types of industries, primarily automotive related. Recommended scoring for basins with automotive related industries is as follows:

Score	=	Major Automotive Related Business	-	5
		Average Automotive Related Business	-	3
		Minor Automotive Related Businesses	-	1
		No Automotive Related Businesses	-	0

Density of Residential Areas

Residential density is most often expressed in relative terms such as low, medium, and high. Some municipalities describe residential density based on the types of structures in the area, such as "multiple - single" family or the "detached - attached" designations or a combination of both. The recommended scoring methods to use are Low = 1, Medium = 2, and High = 3. In the case where information is available on the types of housing structures, the following scoring method is recommended:

Residential Density	Fraction of Area	Score
Low	p	p*1
Medium	p	p*2
High	p	p*3
Non-residential area	p	p*0
Characteristic Ranking Score = Sum of Scores	$\sum = 1$	$\sum$ Scores

Multiplying the density by the fraction of area occupied by the various residential densities allows for more than one type of housing within a given watershed area.

Older Areas

The age of an urban development within an area is probably as important as any other characteristics. When assessing the age of a development, care should be taken to determine whether or not improvements have been made to the storm drain system since the development was built since recent improvements may have disconnected many illegal connections. The recommended approach to scoring development age is as follows:

Age of Area	Fraction of Basin Area	Score
30+	p	p*4
20-30	p	p*3
10-20	p	p*2
0-10	p	p*1
Undeveloped area	p	p*0
Characteristic Ranking Score = Sum of Scores	$\sum p = 1$	$\sum$ Scores

Areas with Hazardous Material Storage

Although areas with hazardous material storage are no more likely to have illicit connections than areas without hazardous material storage, extra points should be given due to the serious nature of illicit discharge if one occurs. The recommended scoring methods for the hazardous material storage characteristic is as follows:

Score = 5 - Known Hazardous Material Storage
3 - Unknown Hazardous Material Storage
0 - No known Hazardous Material Storage

Number of Observed Illicit Discharges

Maintenance personnel may be the best source available of illicit discharge information. However, this information may be qualitative and not well documented or collected in a random manner which makes scoring areas based on this characteristics difficult. Therefore a general sense of the frequencies if illicit discharges to the storm drain system in each is probably the best type information to obtain from such observations. Observations should be given a high weighting factor values including negative observations (*i.e.* Low frequencies of illicit discharges) The recommended scoring for this type of information is as follows:

Illicit Discharge Frequency	Score
High Frequency	5
Moderately Frequent	3
Low Frequency	1

These scores may be weighted to account for the fact that this characteristic is the most important of all the basin characteristics. Such weighting may consist of multiplying the scores by two or three depending on the accuracy and comprehensive nature of the available information.

Spill Report Frequency

Similarly, the frequency of spill reporting is an observation based measure of illicit discharging and should be given high weighting factor values. The recommended scoring for spill report frequency information is as follows:

$$\text{Score} = \frac{\text{\# of Spills Reported Within Basin}}{\text{Total \#'s of Spill Reports}} * 10$$

Density of Septic Systems

Septic system density is an indicator of potential illicit connections to storm drain systems through infiltration or direct connection. Septic system density is usually expressed as a fraction of the total area served by septic systems. The recommended scoring for the septic system density characteristic is as follows:

Score = Septic System Density * 5

EXAMPLE

In the following example, two basins are compared using fictitious basin data. One basin is a residential and commercial area and one is a heavy industrial area. The resulting scores indicate that the industrial area is more likely to have evidence of illicit discharges. Therefore, the basin would be a higher priority for illicit discharge detection and control.

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Basin	Industrial Area	Commercial Area	Business Type	Residential Density	Age	Hazardous Material	Illicit Discharges	Spill Reports	Septic Tank Density	Total Score
A	1	2	1	1.2	2.2	0	1	0	0	8.4
B	4	1	3	0	3.6	5	5	2	0	23.6

Basin A Characteristics:

* 5% Industrial Area
* 25% Commercial
* Minor Automobile related activities
* Residential Area 30% low, 30% medium, 10% high, 30% non-residential
* 20% of the area built before 1965, 30% of the area built between 1965 and 1975, 20% built between 1975 and 1985, 10% built from 1985 to date, 20% undeveloped
* No Hazardous Material storage
* Poor records show occasional reports of illicit discharges
* No spills reported
* No septic systems in operation

Basin B Characteristics:

* 80% Industrial Area
* 20% Commercial Area
* Average number of automobile related activities
* No residential area
* 60% of the area built before 1965, 40% built between 1965 and 1975
* Known hazardous materia storage area
* High frequency of observed illicit discharges
* Of the 10 recent spill reports, 2 were from this basin
* No septic systems in operation

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ATTACHMENT 2
PRIORITY AREAS FOR ILLICIT DISCHARGE INVESTIGATIONS IN 1995

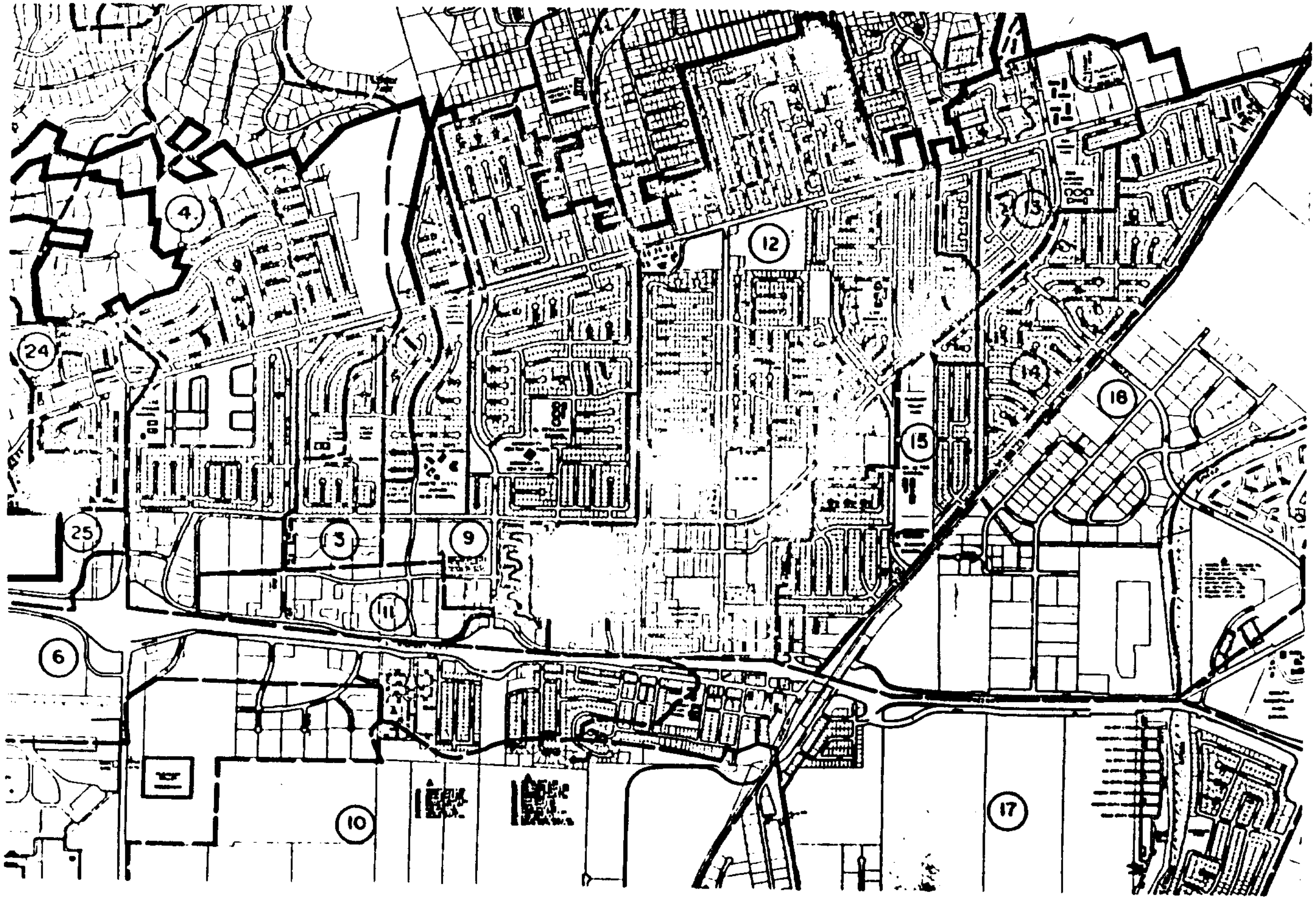
0515

CITY OF CAMARILLO

Potential Pollutant Source Rating Matrix

Basin	Industrial Area	Commercial Area	Auto Business	Residential Density	Age	Hazardous Material	Illicit Discharges	Spill Reports	Septic Tank Density	Total Score
12	1	2	5	2.1	3.5					13.6
16	5	1	1	0.0	3.0	1				11.0
4	1	1	2	3.2	2.9					10.1
11	1	3	3	0.3	2.2					9.5
15	1	1	2	1.5	4.0					9.5
9	1	1	2	1.9	3.2					9.1
14	1	1		2.0	3.9					7.8
22	1	1	2	2.2	1.6					7.7
18	3	1	2	0.0	1.1					7.1
13	1	1		1.8	3.3					7.1
3	1	1		2.8	2.3					7.1
6	2	1	2	0.6	1.5					7.1
17	1	1	3	0.9	1.0					6.9
24	1	1		1.8	3.0					6.8
8	3	1		0.0	2.0					6.0
25	1	1	1	0.8	2.0					5.8
20	1	1		2.0	1.7					5.7
7	2	1		0.0	2.5					5.5
21	1	1		0.7	1.2					3.9
5	1	1		1.0	0.8					3.8
23	1	1		0.8	0.5					3.3
1	1	1		1.0	0.1					3.1
19	1	1		0.6	0.5					3.0
10	1	1		0.2	0.4					2.5
2	1	1		0.0	0.0					2.0

[1] Individuals we spoke with reported no history of Illicit Discharges or Spill Reports



Drainage Basin for 1995 Illicit Discharge Investigations -- City of Camarillo

ILLICIT DISCHARGE CONTROL FOR THE UNINCORPORATED URBAN AREAS OF VENTURA COUNTY

There are eight distinct unincorporated urban areas of Ventura County. These areas have been rated in terms of their potential for illicit discharges to the storm drain system using the methodology described in Section 2.3.3 of the NPDES storm water permit application. These areas are shown on the enclosed Potential Pollutant Source Map. The prioritization of potential illicit discharge areas is instrumental in the detection of illicit discharges and implementation of control programs.

A prioritization process assigns numeric values based on area characteristics. The total of these values by area is used in a matrix format to rank areas for future illicit discharge monitoring and inspection. The rating matrix and ranking for each area is attached. The rating factors were evaluated based on physical characteristics, observations, and events that have occurred over the past five years. The following matrix was prepared in accordance with "Guidance on Prioritization Process for Detection of Illicit Discharges," by Larry Walker Associates, dated October 20, 1993.

The scores for the eight areas ranges from 2.2 to 8.3. The higher score means there is a greater potential for illicit discharges. The area with the highest score is the Black Canyon area near Simi Valley. This area rated the highest because of the age of the area and the number of septic systems there. The next higher rated areas, Ventura Avenue and El Rio, scored high because of their age and because they contain some commercial and industrial areas.

The two major land uses in the urbanized areas of the county are residential and agricultural. Residential land use comprises about 50% of the urbanized county and agricultural 39%. Industrial land use is about 5% and commercial land use is less than 1%. The remaining areas are divided among undeveloped and public open land. A rating of 1 in the industrial or commercial area fraction means that the area is 0-20% industrial or commercial.

There are no hazardous waste storage facilities in any of these areas. Spill reports are managed by numerous fire departments and the data was not readily available. To date, no programs have been implemented to report illicit discharges, therefore this category in the matrix was given a zero score for each area and was not considered to be a grading factor.

The County of Ventura is proposing to conduct an illicit discharge detection and inspection program, as outlined by the Management Committee. Illicit discharge activities will begin in (1) Black Canyon, as identified on the enclosed map.

Training will be given to personnel who will be participating in the illicit discharge detection and product control programs, and will include detection of potential violations and the reporting process and format.

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RATING MATRIX FOR UNINCORPORATED URBAN AREAS OF VENTURA COUNTY

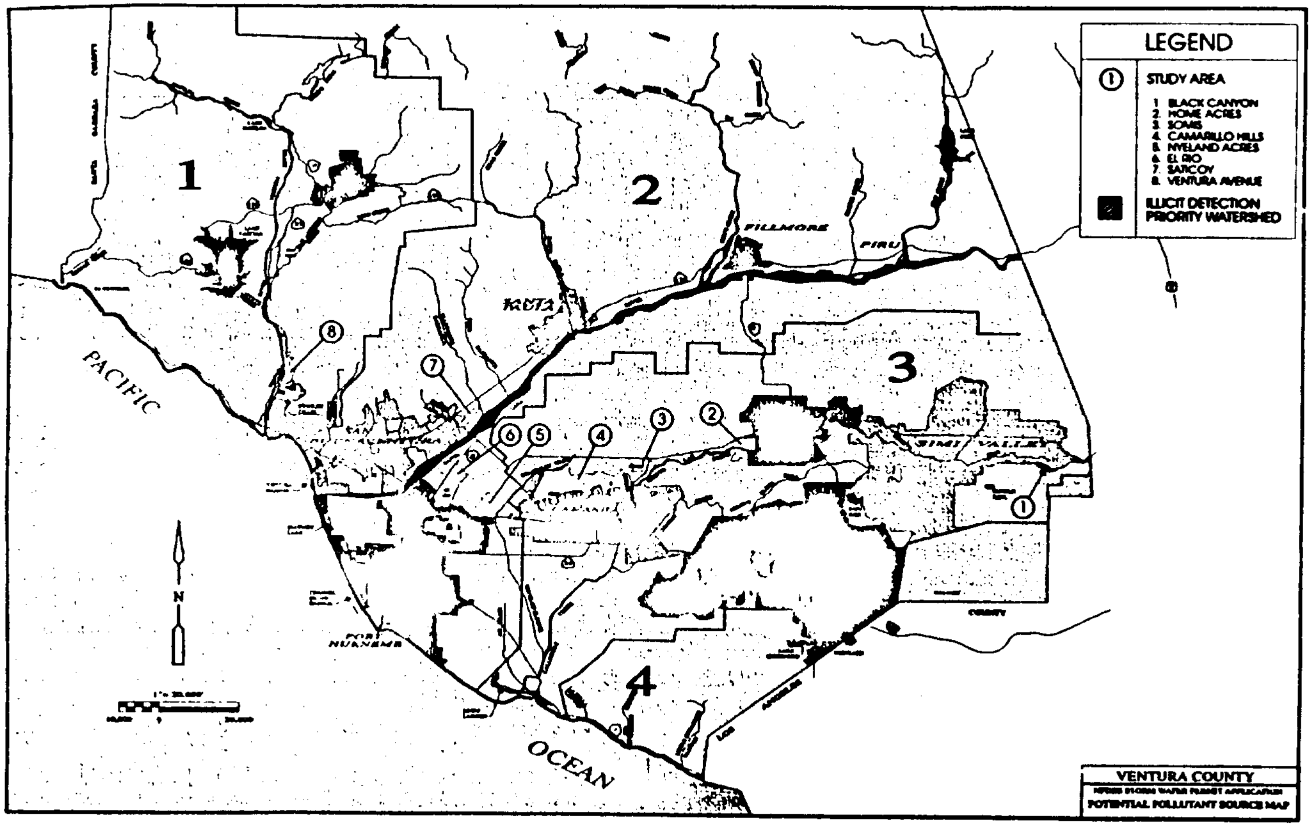
Area	Industrial Fraction	Commercial Area Fraction	Type of Business	Residential Density	Older Areas	HazMat Storage	Observed Illicit	Spill Reports	Septic Systems	Rank	TOTAL
1. Black Canyon	1	1	0	0.7	2.1	0	0	NA	3.5	1	8.3
2. Home Acres	1	1	0	0.4	1.1	0	0	NA	1.8	4	5.3
3. Somis	1	1	0	0.1	0.1	0	0	NA	0.0	8	2.2
4. Camarillo Hills	1	1	0	0.7	0.7	0	0	NA	0.4	6	3.8
5. Nyeland Acres	1	1	0	0.6	1.0	0	0	NA	0.5	5	4.1
6. El Rio	1	1	1	1.4	2.1	0	0	NA	0.0	3	6.5
7. Saticoy	1	1	0	0.1	0.2	0	0	NA	0.2	7	2.5
8. Ventura Avenue	2	1	0	0.8	2.3	0	0	NA	1.4	2	7.5

NA - Not Available

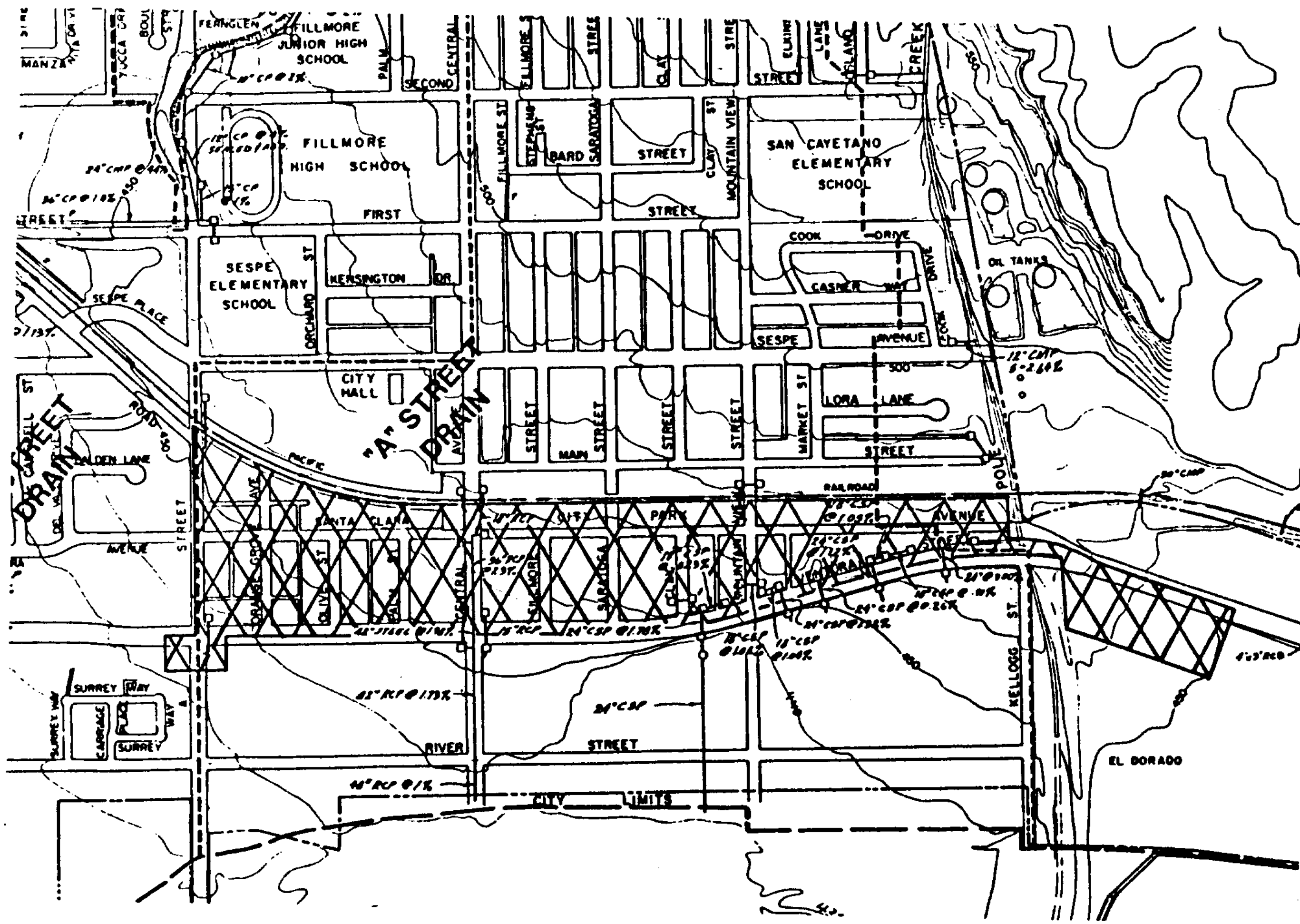
DRAINAGE AREA RATING BACKUP FOR
URBAN AREAS OF VENTURA COUNTY
POTENTIAL POLLUTANT SOURCES

Area	Total Area (acre)	Industrial			Commercial			Residential		Residential Density			Auto Business	Residential Age (years)	Septic Systems Fraction of Residences
		Area (acre)	Fraction	Rating	Area (acre)	Fraction	Rating	Area (acre)	Fraction	H	M	L			
1. Black Canyon	306.3	0.0	0.00	1	6.6	0.02	1	212.7	0.69			100%	0	20-30	1.0
2. Home Acres	619.6	0.0	0.00	1	0.0	0.00	1	225.4	0.36			100%	0	20-30	1.0
3. Somis	500.0	13.0	0.03	1	10.0	0.02	1	37.0	0.07			100%	0	0-10	0.1
4. Camarillo Hills	2,425.0	0.0	0.00	1	10.0	0.00	1	1,768.0	0.73			100%	0	0-10	0.1
5. Nyeland Acres	558.7	18.8	0.03	1	3.3	0.01	1	120.6	0.22	100%			0	30+	0.5
6. El Rio	925.5	6.8	0.01	1	51.6	0.06	1	434.4	0.47	100%			1	30+	0.0
7. Saticoy	764.0	95.3	0.12	1	3.3	0.00	1	63.9	0.08		50%	50%	0	0-10	0.5
8. Ventura Avenue	414.0	157.8	0.38	2	0.0	0.00	1	226.6	0.55		50%	50%	0	10-20/20-30	0.5

DRAINAGE AREA RATING BACKUP cont.									
Area	Residential Density Rating Fraction x Score = Rating			Age Rating Fraction x Score = Rating			Septic System Rating ResFr x SepFr x 5 =Rating		
1. Black Canyon	0.69	1	0.7	0.72	3	2.1	0.69	1.0	3.5
2. Home Acres	0.36	1	0.4	0.36	3	1.1	0.36	1.0	1.8
3. Somis	0.07	1	0.1	0.12	1	0.1	0.07	0.1	0.0
4. Camarillo Hills	0.73	1	0.7	0.73	1	0.7	0.73	0.1	0.4
5. Nyeland Acres	0.22	3	0.6	0.26	4	1.0	0.22	0.5	0.5
6. El Rio	0.47	3	1.4	0.53	4	2.1	0.47	0.0	0.0
7. Saticoy	0.04 0.04	2 1	0.1 0.0 0.1	0.21	1	0.2	0.08	0.5	0.2
8. Ventura Avenue	0.27 0.27	2 1	0.5 0.3 0.8	0.46 0.46	2 3	0.9 1.4 2.3	0.55	0.5	1.4



Drainage Basin for 1995 Illicit Discharge Investigations -- County of Ventura



Drainage Basin for 1995 Illicit Discharge Investigations – City of Fillmore

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CITY OF MOORPARK
PRIORITIZATION OF POTENTIAL ILLICIT DISCHARGE AREAS

Basin	Industrial Area	Commercial Area	Business Area	Residential Density	Age	Hazardous Material	Illicit Discharges	Spill Reports	Septic Tk Density	Total Score	Rank
A	1	2	1	2	4	3	1	0	0	14	3
B	1	1	1	2.5	4	3	1	0	0	13.5	4
C	1	1	3	2	4	3	1	0	0	15	2
D	1	1	0	2	4	0	1	0	0	9	8
E	1	1	0	3	2	3	1	0	0	11	6
F	5	1	3	0	1	5	1	0	0	16	1
G	1	1	0	0	0	0	1	0	0	3	12
H	1	1	0	0	1	0	1	0	0	4	11
I	1	1	0	2	1	0	1	0	0	6	10
J	1	1	0	0	0	0	1	0	0	3	14
K	1	1	0	0	0	0	1	0	0	3	13
L	1	1	0	1	2	0	1	0	0	6	9
M	1	1	1	2	1	3	1	0	0	10	7
N	5	1	0	0	1	5	1	0	0	13	5

* Basin locations are shown on Potential Pollutant Source Map.

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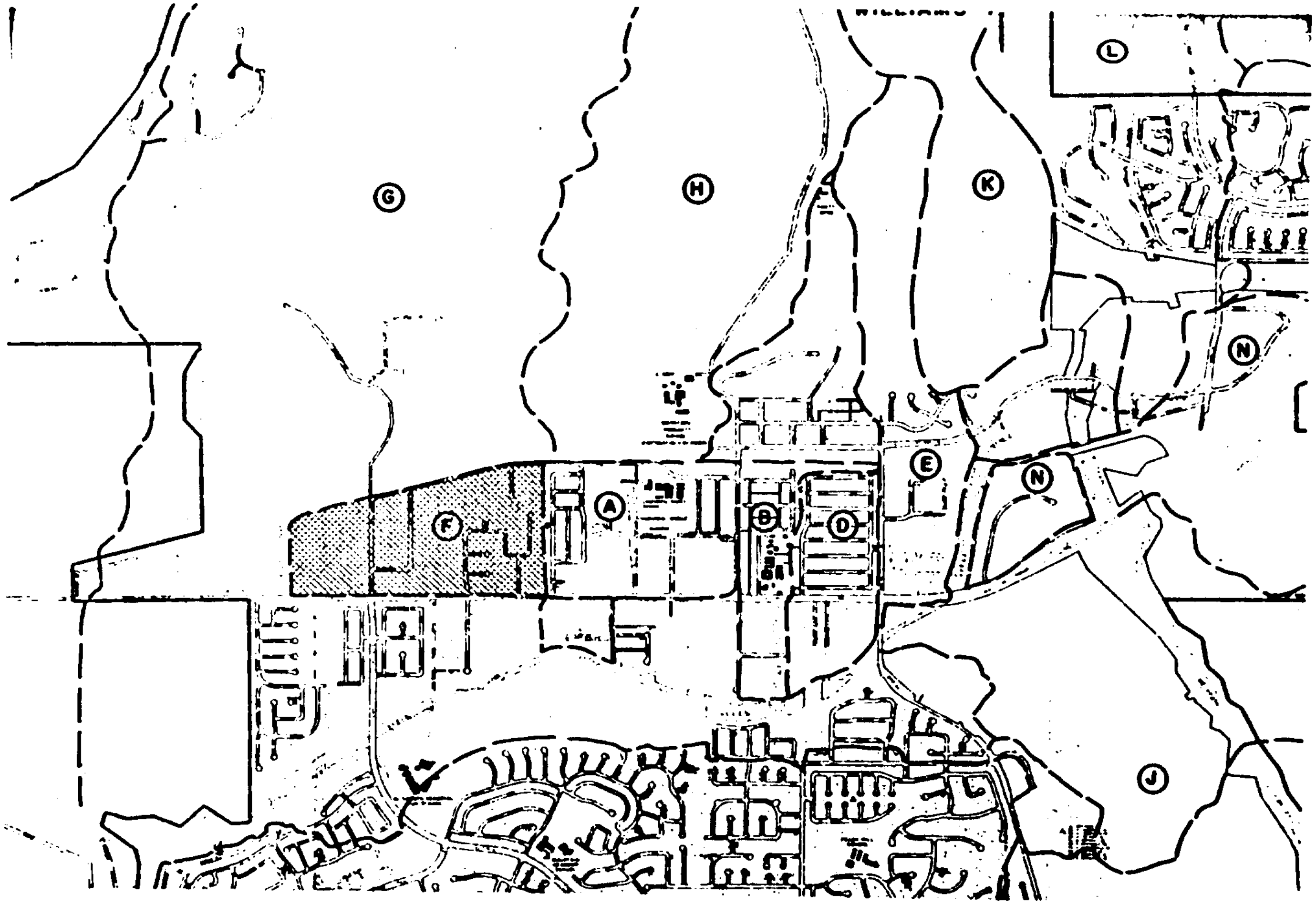

Drainage Basin for 1995 Illicit Discharge Investigations – City of Moorpark

November 11, 1993

CITY OF OJAI
PRIORITIZATION OF POTENTIAL ILLICIT DISCHARGE AREAS

Basin*	Industrial Area	Commercial Area	Business Area	Residential Density	Age	Hazardous Material	Illicit Discharges	Spill Reports	Septic Tk Density	Total Score	Rank
A	1	1	0	1.5	3	3	1	0	0	10.5	7
B	1	1	0	2	3	0	1	0	0	8	9
C	1	1	1	1	4	3	1	0	1	13	4
D	1	1	1	1	4	3	1	0	1	13	5
E	1	1	0	1	4	0	1	0	0	8	10
F	1	1	1	2	4	0	1	0	0	10	8
G	1	2	1	2	4	3	1	0	0	14	3
H	1	1	1	2	4	3	1	0	0	13	6
I	3	1	5	2	4	5	1	0	0	21	1
J	5	1	1	0	2	5	1	0	0	15	2
K	1	1	1	2	2	0	1	0	0	8	11

* Basin locations are shown on Potential Pollutant Source Map.

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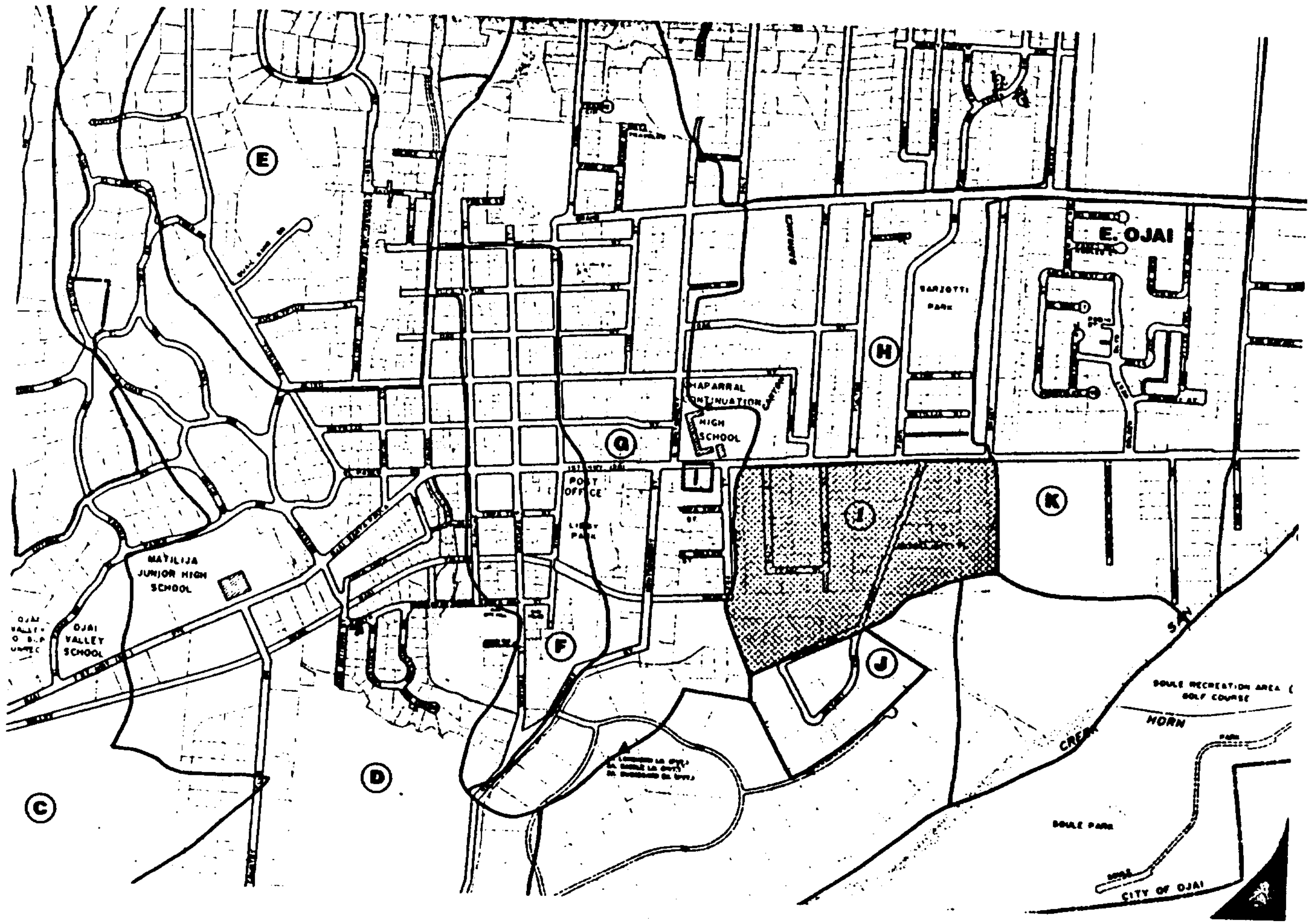

Drainage Basin for 1995 Illicit Discharge Investigations – City of Ojai

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Illicit Discharge Control for Port Hueneme

Using the guidelines prepared by the Storm Water Task Force, the City of Port Hueneme has been divided into five drainage areas. Each drainage area has been rated in terms of its priority for potential illicit discharges. The prioritization of potential illicit discharge areas is instrumental in the detection of illicit discharges and implementation of control programs. A prioritization process was developed which assigns numeric value to specific basin characteristics and sums the values. The total value is used to rank basins for future illicit discharge monitoring and inspection. This is known as the matrix method. The rating matrix and ranking for each basin is attached. Prioritized drainage areas are indicated on the land use map. The rating factors were evaluated based on experience and events that have occurred over the past five years. The following matrix was prepared in accordance with "Guidance on Prioritization Process for Detection of Illicit Discharges", by Larry Walker Associates, dated October 20, 1993.

The scores for the five drainage basins that were evaluated range from 4.5 to 6.7. In reviewing the existing land use map for Port Hueneme, it was determined that the majority of the drainage areas (approximately 80 percent) are residential. The remaining drainage areas are equally divided among commercial, industrial and undeveloped land. Drainage basin Nos. 1, 2 and 3 are mainly residential, with a very low concentration of commercial establishments. Basin Nos. 4 and 5 are mixed, with higher concentrations of industrial and commercial land uses.

To date, no programs have been implemented to report illicit discharges, therefore this category in the matrix was given a zero score for each basin and was not considered to be a grading factor. The city is proposing to conduct an illicit discharge detection and inspection program, as outlined by the Ventura County Storm Water Task Force. Illicit discharge activities will begin with the known locations and highest priority businesses located in Basin No. 5, as shown in the enclosed map.

All Port Hueneme wastewater flows are treated at the Oxnard Wastewater Treatment Facility. The City of Port Hueneme contracts with the City of Oxnard for the maintenance and operation of this facility. The Oxnard facility also conducts all source control operations. The City of Port Hueneme intends to extend the source control program to include illicit discharge detection and correction.

Training will be given to engineering personnel who will be participating in the illicit discharge detection and product control programs. The field personnel will be trained in the detection of potential violations and the reporting process and format.

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DRAINAGE AREA RATING MATRIX FOR PORT HUENEME

Area	Industrial Fraction	Commercial Area Fraction	Type of Business	Residential Density	Older Areas	HazMat Storage	Observed Illicit	Spill Reports	Septic Systems	No. Rank	TOTAL
1	0	1	0	2.3	1.2	0	0	0	0	5	4.5
2	0	1	1	2.8	1.8	0	0	0	0	2	6.6
3	0	1	1	1.7	1.7	0	0	0	0	3	5.4
4	1	1	0	1.3	1.8	0	0	0	0	4	5.1
5	1	1	0	2.0	2.7	0	0	0	0	1	6.7

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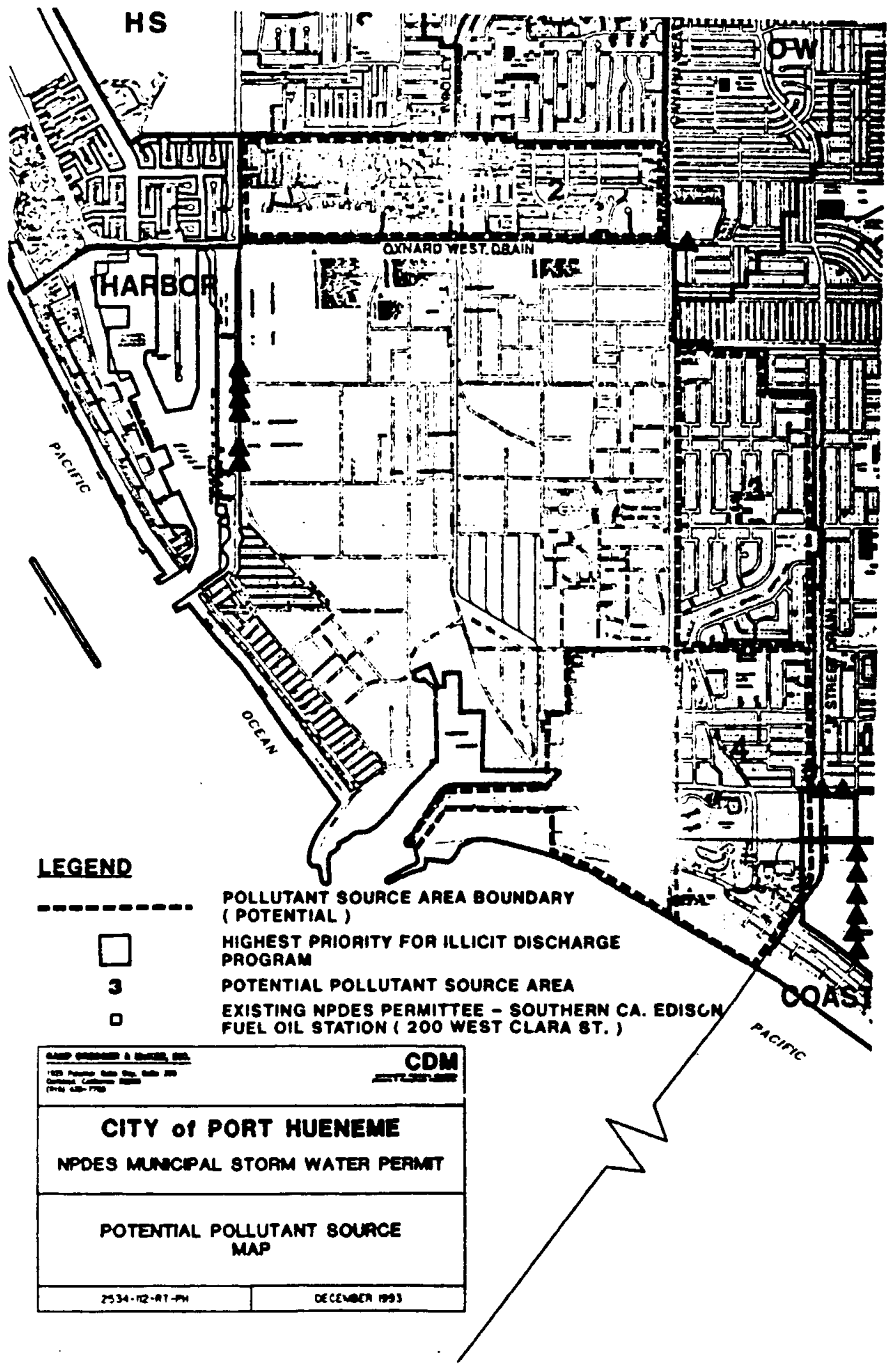

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R0053837

ILLICIT DISCHARGE CONTROL FOR THE CITY OF SAN BUENAVENTURA

Guidelines have been prepared by the Ventura County Storm Water Management Committee. The purpose of these guidelines is to assist the co-permittee is selecting an area of their jurisdiction to look for illicit discharges to the storm drain system. These areas are shown on the enclosed Potential Pollutant Source Maps.

The prioritization of potential illicit discharge areas is instrumental in the detection of illicit discharges and implementation of control programs. The rating factors were evaluated based on physical characteristics, observations, and events that have occurred over the past five years. The areas identified in San Buenaventura for the initial illicit discharge detection program are shown on the enclosed maps. These areas were selected using personal knowledge of the city. As such the rating matrix method was not used in the prioritization. Selection was based on the age of development and types of businesses. Older industrial areas and the Auto Center were selected as priority potential illicit discharge areas. These areas are currently involved in the city's pretreatment program. The illicit discharge detection program will be conducted in conjunction with the pretreatment program.

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Illicit Discharge Control

Using the guidelines prepared by the Storm Water Task Force, the City of Santa Paula has rated the sixteen drainage areas. The rating matrix and resulting prioritization is attached. The rating factors were developed by City staff based upon experience and events that have occurred over the past ten years.

The prioritization of the drainage areas has mixed results. Most of the results were anticipated; however, there are some factors that have clouded the results. In reviewing the existing land use map, staff has noted that most of the drainage areas have a varied mix of land uses. Commercial, industrial, and residential areas are intertwined to the extent that concentration on one top priority area will not be sufficient to achieve the level of inspection and enforcement that is needed.

The City is proposing to conduct illicit discharge activities in all areas at the same time. Illicit discharge activities will begin with the known locations and highest priority businesses. Activities will then proceed to the lower priority businesses.

Currently, the City of Santa Paula contracts with the Ventura Regional Sanitation District (VRSD) for the maintenance and operation of the Santa Paula Treatment Plant. VRSD also conducts all source control operations. The City proposes to use VRSD to extend the source control program to include illicit discharge detection and correction. The Santa Paula Fire Department will provide inspection and technical assistance at hazardous materials locations.

The illicit discharge program will implement using the business activity prioritization listed below:

1. Automotive & Transportation (experience indicates the most violations)
2. Hazardous Materials (extension of existing hazardous materials inspections)
3. General Industrial
4. Food Service
5. General Commercial

estimate 6 - 9 months per category

In addition to the VRSD, SPFD, and Public Works inspectors, all related field personnel will be trained to be aware of potential violation and the reporting format. This training will be given to building inspectors, fire personnel, public works maintenance, and refuse personnel.

CITY OF SANTA PAULA

POTENTIAL POLLUTANT SOURCE RATING MATRIX

Drainage Basin	Industrial Fraction	Commercial Fraction	Type of Business	Residential Density	Older Areas	Haz Mat Storage	Observed Illicit Discharges	Spill Reports	Septic Systems	TOTALS
A1	1	1	0	1	2	0	1	0	0	6
A2	2	2	1	1	2	3	1	0	0	12
A3	1	1	1	2	3	5	1	0	1	15
A4	1	1	0	1	3	0	1	0	0	7
A5	1	1	1	2	3	0	1	0	0	9
A6	2	2	3	2	3	3	1	1	0	17
A7	1	1	1	2	1	3	3	1	0	13
A8	1	1	1	1	4	5	1	1	0	15
A9	1	2	1	2	4	3	1	1	0	15
A10	1	2	3	2	4	3	3	0	0	18
A11	2	1	3	2	4	5	3	1	1	22
A12	2	1	1	1	3	5	1	0	0	14
A13	4	1	1	0	1	5	1	0	0	13
B1	1	1	0	1	2	0	1	0	0	6
B2	1	1	0	1	3	0	1	0	0	7
B3	1	1	0	1	3	0	1	0	0	7

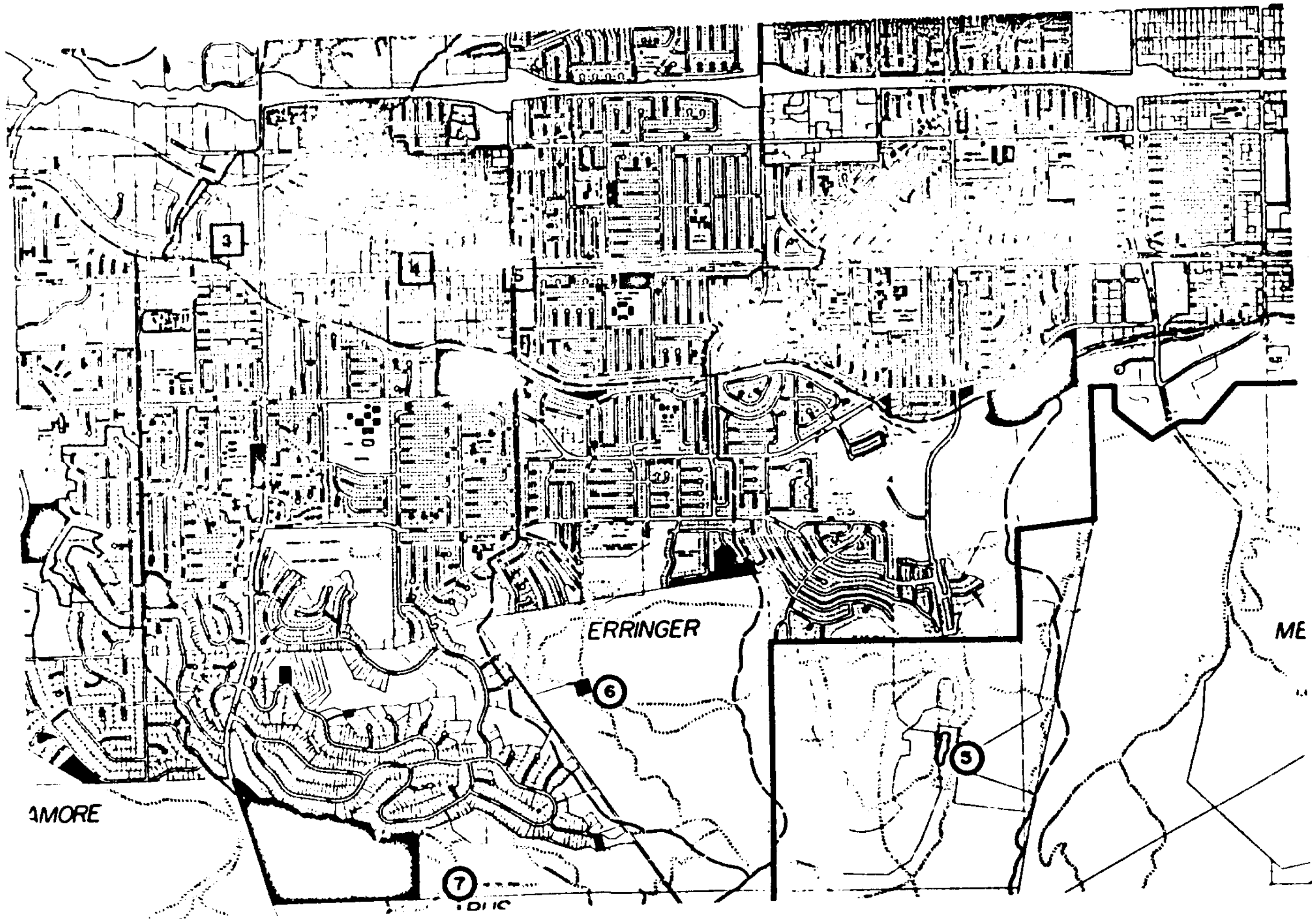
CITY OF SIMI VALLEY PRIORITIZATION OF DRAINAGE BASINS FOR ILLICIT DISCHARGE DETECTION

Watershed Basin	Industrial Area*	Commercial Area	Type of Business	Population Density by Basin	Hazmat Storage	Dry Weather Illicit Discharges Observed**	Number of Spill Reports ***	Density of Septic Systems	Total Score	Final Rank	Priority ***
ALAMOS	4	1	5	0	5	5	1	0	21	4/14	3
BREA	5	1	3	0	5	1	0	0	15	9/14	3
N. SIMI	2	3	5	1	5	5	5	5	31	1/14	5
DRY	1	2	3	5	3	3	0	0	17	6/14	3
TAPO	2	2	5	3	5	3	5	5	30	2/14	5
CHIVO	1	1	0	0	0	0	0	0	2	14/14	1
LAS LLAJAS	1	1	1	3	5	5	3	1	15	8/14	3
WHITE OAK	1	1	1	1	5	3	0	3	12	10/14	1
SANTA SUSANA	1	1	3	1	5	5	0	5	21	5/14	3
MEIER	1	1	0	0	0	1	0	0	3	13/14	1
RUNKLE	1	1	0	1	0	0	0	1	4	12/14	1
ERRINGER	1	1	1	1	5	3	1	1	12	11/14	1
BUS	1	1	3	1	5	5	1	3	15	7/14	3
SYCAMORE	1	1	5	1	5	5	1	5	24	3/14	3

*Scale revised to reflect all drainage basins that contain less than 40% industrial or commercial. City of Simi Valley scale: 1 = less than 5%; 2 = 5-15%; 3 = 16-25%; 4 = 26-35%; 5 = greater than 35%

**Scale reflects priority discharges identified in the Dry Weather Field Characterization, pages 4-21 and 4-24 of City of Simi Valley NPDES Storm Water Permit Application, July 1993 Draft Report by Camp Dresser & McKee: 0 = 0; 1 = 1-2; 3 = 3-5; 5 = 6 or greater

***Scale reflects storm water related complaints and reports received from 12/92 through 10/93.
****Priority scale (based on a possible total of 40 pts.): 1 = Low (1-12 pts.) 3 = Medium (13-26 pts.) 5 = High (27-40 pts.)



Drainage Basin for 1995 Illicit Discharge Investigations -- City of Simi Valley

CITY OF THOUSAND OAKS

Potential Pollutant Source Rating Matrix

Basin	Industrial Area	Commercial Area	Business Type	Residential Density	Age	Hazardous Material	Illicit Discharges	Spill Reports	Septic Tank Density	Total Score
10	1	1	5	1.40	1.90	0	0	7.14	0	17.44
23	1	2	3	1.20	2.25	0	0	1.43	0	10.88
6	1	1	1	1.90	3.00	0	0	0	0	7.90
26	1	2	1	1.60	1.95	0	0	0	0.25	7.80
14	1	1	0	0.30	2.50	0	0	1.43	0	6.23
24	1	1	0	1.50	2.55	0	0	0	0	6.05
25	1	1	0	1.40	2.20	0	0	0	0	5.60
3	1	1	0	1.10	2.50	0	0	0	0	5.60
21	3	1	0	0.00	1.50	0	0	0	0	5.50
8	1	1	0	1.00	1.90	0	0	0	0	4.90
27	1	1	0	1.20	1.55	0	0	0	0	4.75
4	1	1	0	0.60	1.95	0	0	0	0	4.55
22	1	1	0	0.60	1.50	0	0	0	0	4.10
11	1	1	0	0.90	1.10	0	0	0	0	4.00
28	1	1	0	0.05	0.80	1	0	0	0	3.85
7	1	1	0	1.05	0.65	0	0	0	0	3.70
12	1	1	0	0.70	0.75	0	0	0	0	3.45
13	1	1	0	0.70	0.60	0	0	0	0	3.30
15	1	1	0	0.10	1.15	0	0	0	0	3.25
16	1	1	0	0.30	0.40	0	0	0	0	2.70
19	1	1	0	0.00	0.10	0	0	0	0	2.10
20	1	1	0	0.00	0.10	0	0	0	0	2.10
1	1	1	0	0.00	0.00	0	0	0	0	2.00
17	1	1	0	0.00	0.00	0	0	0	0	2.00
2	1	1	0	0.00	0.00	0	0	0	0	2.00
29	1	1	0	0.00	0.00	0	0	0	0	2.00
30	1	1	0	0.00	0.00	0	0	0	0	2.00
31	1	1	0	0.00	0.00	0	0	0	0	2.00
32	1	1	0	0.00	0.00	0	0	0	0	2.00
33	1	1	0	0.00	0.00	0	0	0	0	2.00
5	1	1	0	0.00	0.00	0	0	0	0	2.00
18	1	0	0	0.00	0.00	0	0	0	0	1.00
9	1	1	0	0.90	1.20	0	0	0	0	0.00

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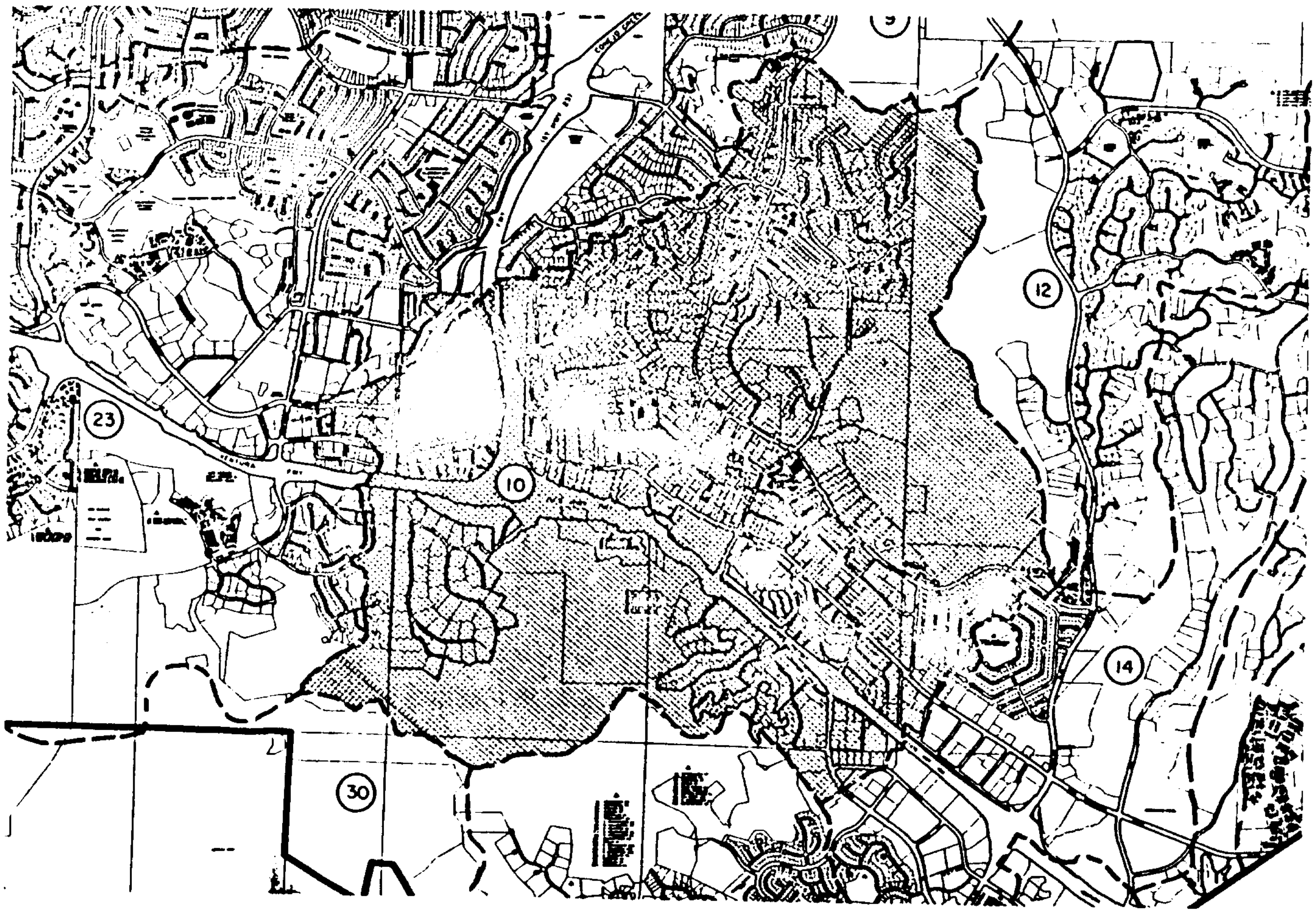

Drainage Basin for 1995 Illicit Discharge Investigations -- City of Thousand Oaks

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ATTACHMENT 3
ILLICIT DISCHARGE INSPECTION CHECKLISTS

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VENTURA COUNTY ILLICIT DISCHARGE INSPECTION CHECKLIST

	Date:

Site Description

Company: ____________	Contact Person:
Address: ____________	Phone:
____________	Business Category (Indust./Comm.)
City: ____________	SIC Code:
Storm Water Discharges to (receiving water or channel name):	
Site Area (acres):	Map of storm water collection available (Y/N)
Number of Drop Inlets and Catch Basins:	

Visual Observations (at each catch basin or drop inlet record the following)

Surface I.D.	Channel I.D.
Flow (Yes/No)	(If yes, how much flow)

If "yes" check:

Odor:	None ☐	Musty ☐	Sewage ☐	Rotten Eggs ☐	Sour Milk ☐	Oily ☐	Other ______
Color:	Clear ☐	Red ☐	Yellow ☐	Brown ☐	Green ☐	Grey ☐	Other ______
Turbidity:	Clear ☐	Cloudy ☐	Opaque ☐	Suspended Solids ☐	Other ______		

If "yes" or "no" check:

Deposits/Stains:	None ☐	Sediments ☐	Oily ☐	Garbage ☐	Other ______
Structural Condition:	Normal ☐	Concrete Cracking ☐	Metal ☐	Corrosion ☐	Other ______
Vegetation Conditions:	None ☐	Mosquito Larvae ☐	Algae ☐	Other ______	
Picture Taken:	Yes/No	Roll No. ______		Photo No. ______	

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Outfall Inspection(s) Observations (If possible, inspect site connections to City storm drain system & record here)

Surface I.D.	Channel I.D.
Flow (Yes/No)	(If yes, how much flow)

If "yes" check:

Odor:	None ☐	Musty ☐	Sewage ☐	Rotten Eggs ☐	Sour Milk ☐	Oily ☐	Other ______
Color:	Clear ☐	Red ☐	Yellow ☐	Brown ☐	Green ☐	Grey ☐	Other ______
Turbidity:	Clear ☐	Cloudy ☐	Opaque ☐	Suspended Solids ☐	Other ______		

If "yes" or "no" check:

Deposits/Stains:	None ☐	Sediments ☐	Oily ☐	Garbage ☐	Other ______
Structural Condition:	Normal ☐	Concrete Cracking ☐	Metal ☐	Corrosion ☐	Other ______
Vegetation Conditions:	None ☐	Mosquito Larvae ☐	Algae ☐	Other ______	
Picture Taken:	Yes/No	Roll No. ______		Photo No. ______	

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Handouts

Yes/No BMP's Discussed: ____________

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Activities On-Site

(Check the following on-site activities and describe site cover, slope, spill containment, floor drains, waste segregation, and other pertinent observations.)

Vehicle and Equipment Fueling:

Circle Items Present: Berm Slope Sumps Roof Vents Process Lines

Vehicle and Equipment Washing and Steam Cleaning:

Cirlce Items Present: Berm Slope Sumps Roof Vents Process Lines

Outdoor Loading and Unloading of Materials:

Circle Items Present: Berm Slope Sumps Roof Vents Process Lines

Outdoor Container Storage of Liquids:

Circle Items Present: Berm Slope Sumps Roof Vents Process Lines

Outdoor Process Equipment Operations and Maintenance:

Circle Items Present: Berm Slope Sumps Roof Vents Process Lines

Outdoor Storage of Raw Materials, Products, and By-Products:

Circle Items Present: Berm Slope Sumps Roof Vents Process Lines

Waste Handling and Disposal:

Circle Items Present: Berm Slope Sumps Roof Vents Process Lines

Other:

Circle Items Present: Berm Slope Sumps Roof Vents Process Lines

Field Site Description

Location (nearest cross streets):

Closed Conduit Open Channel Manhole Other ________ Size ________

Outfall Type: Major Minor

Dominant Watershed Land Uses:

Industrial Commercial Institutional Residential
Agricultural Open Space Unknown

Field Analysis

Water Temperature:	(C)	Chlorine (total):	(mg/L)
Dissolved Oxygen:	(mg/L)	Copper (total):	(mg/L)
Phenol (total):	(mg/L)	Detergents (surf):	(mg/L)
PH:			

Comments:

Possible Abatement:

Data Sheet filled out by (Signature):

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VENTURA COUNTY [illegible] DISCHARGE FIELD INVESTIGATION CHECKLIST

Field Site Description

Location (nearest cross streets):

Closed Conduit | Open Channel | Manhole | Other ________ | Size ________

Outfall Type: | Major | Minor

Dominant Watershed Land Uses:

	Industrial	Commercial	Institutional	Residential
	Agricultural	Open Space	Unknown	

Field Analysis

Water Temperature:	(C)	Chlorine (total):	(mg/L)
Dissolved Oxygen:	(mg/L)	Copper (total):	(mg/L)
Phenol (total):	(mg/L)	Detergents (surf):	(mg/L)
PH:			

Comments:

Possible Abatement:

Outfall Inspection(s) Observations

Surface I.D.	Channel I.D.
Flow (Yes/No)	(If yes, how much flow)

If "yes" check:

Odor:	None	Musty	Sewage	Rotten Eggs	Sour Milk	Oily	Other ________
Color:	Clear	Red	Yellow	Brown	Green	Grey	Other ________
Turbidity:	Clear	Cloudy	Opaque	Suspended Solids	Other ________		

If "yes" or "no" check:

Deposits/Stains:	None	Sediments	Oily	Garbage	Other ________
Structural Condition:	Normal	Concrete Cracking	Metal	Corrosion	Other ________
Vegetation Conditions:	None	Mosquito Larvae	Algae	Other ________	
Picture Taken:	Yes/No	Roll No. ________		Photo No. ________	

Outfall Inspector Data

Data Sheet filled out by (Signature):

Date:	Associated Surface (Business) Inspector: (names of business' inspected) ________ ________
Inspector:	

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VENTURA COUNTY ILLICIT DISCHARGE/BUSINESS INSPECTION CHECKLIST

Company: ______	Contact Person:
Address: ______	Phone:
______	Business Category (Indust./Comm.)
City: ______	SIC Code:
Storm Water Discharges to (receiving water or channel name):	
Site Area (acres):	Map of storm water collection available (Y/N)
Number of Drop Inlets and Catch Basins:	

Visual Observations (fill out one section for each catch basin or drop inlet, associated outfall)

Surface I.D.				Channel I.D.			
Flow (Yes/No)	Volume ______ (gal)			Time to fill ______ (sec)			
Odor:	None ☐	Musty ☐	Sewage ☐	Rotten Eggs ☐	Sour Milk ☐	Oily ☐	Other ______
Color:	Clear ☐	Red ☐	Yellow ☐	Brown ☐	Green ☐	Grey ☐	Other ______
Turbidity:	Clear ☐	Cloudy ☐	Opaque ☐	Suspended Solids ☐	Other ______		
Deposits/Stains:		None ☐	Sediments ☐	Oily ☐	Garbage ☐	Other ______	
Structural Condition:		Normal ☐	Concrete Cracking ☐	Metal ☐	Corrosion ☐	Other ______	
Vegetation Conditions:		None ☐	Mosquito Larvae ☐	Algae ☐	Other ______		
Picture Taken:		Yes/No	Roll No. ______		Photo No. ______		

Surface I.D.				Channel I.D.			
Flow (Yes/No)	Volume ______ (gal)			Time to fill ______ (sec)			
Odor:	None ☐	Musty ☐	Sewage ☐	Rotten Eggs ☐	Sour Milk ☐	Oily ☐	Other ______
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Turbidity:	Clear ☐	Cloudy ☐	Opaque ☐	Suspended Solids ☐	Other ______		
Deposits/Stains:		None ☐	Sediments ☐	Oily ☐	Garbage ☐	Other ______	
Structural Condition:		Normal ☐	Concrete Cracking ☐	Metal ☐	Corrosion ☐	Other ______	
Vegetation Conditions:		None ☐	Mosquito Larvae ☐	Algae ☐	Other ______		
Picture Taken:		Yes/No	Roll No. ______		Photo No. ______		

Surface I.D.				Channel I.D.			
Flow (Yes/No)	Volume ______ (gal)			Time to fill ______ (sec)			
Odor:	None ☐	Musty ☐	Sewage ☐	Rotten Eggs ☐	Sour Milk ☐	Oily ☐	Other ______
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Deposits/Stains:		None ☐	Sediments ☐	Oily ☐	Garbage ☐	Other ______	
Structural Condition:		Normal ☐	Concrete Cracking ☐	Metal ☐	Corrosion ☐	Other ______	
Vegetation Conditions:		None ☐	Mosquito Larvae ☐	Algae ☐	Other ______		
Picture Taken:		Yes/No	Roll No. ______		Photo No. ______		

Activities On-Site

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Waste Handling and Disposal:

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Other:

Circle Items Present: Berm Slope Sumps Roof Vents Process Lines

Handouts

Yes ☐ No ☐

BMPs Discussed:

Field Investigations Associated with this Business

(refer to appropriate Field Investigation Form)

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ATTACHEMENT 4
HANDOUTS FOR BUSINESSES AND RESIDENTS
ON ILLICIT DISCHARGE CONTROL

IS YOUR BUSINESS POLLUTING STORMWATER?

Even though you live miles from the ocean, you may be polluting waterways and the ocean without knowing it.

Storm drains and sanitary sewers are two separate systems that discharge to creeks, rivers, waterways, and the Pacific Ocean. Sanitary sewers are designed to collect most (but not all) liquid wastes and safely remove waste materials at treatment facilities. Storm drain channels that are located in neighborhoods, commercial developments, and industrial sites also receive wastes from clean-up activities that are washed down day after day into gutters, catch basins, and channels. Materials collected by storm drains receive no treatment, however! These materials collect until rainfall flushes pollutant materials to the nearest river or creek where they may harm wildlife, the environment, and recreational areas. The pollutants originating from our homes, businesses and a variety of sources contribute to stormwater pollution, a growing problem. This brochure briefly explains how you can the amounts of oil and grease, toxic materials, vegetation, floating materials, cleaning materials, and other substances you discharge into the storm drains.

Understanding and using this brochure will help you comply with local stormwater pollution requirements and wastewater discharge restrictions.

The Ventura Countywide Stormwater Quality Management Program has developed a seven step process for the selection of Best Management Practices (BMPs) to help you determine the best way to reduce potential stormwater pollutants. Please join us in our effort to protect the local waterways.

WHAT ARE BEST MANAGEMENT PRACTICES?

"Best Management Practices" is a term that embraces a variety of techniques used to reduce or eliminate potential stormwater pollutants at the source. Many BMPs are just good housekeeping. There are basically two types of BMPs: Source Control and Treatment Control. Source Control BMPs are operational practices, that prevent pollution by reducing potential pollutants at the source. Treatment Control BMPs are methods of treatment to remove pollutants from stormwater.

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Most BMPs target a specific activity that could add pollutants to stormwater. This pamphlet concentrates on a seven-step process allowing you to select BMPs based on the activities at your facility.

SEVEN STEPS FOR BMP SELECTION

1. Identify activities by type and location

Look around your facility and identify areas where waste liquids, operation rinse water and other non-domestic wastewater could reach a storm drain or floor drain. Look for activities that discharge water such as vehicle and equipment washing, repair, mopping or hosing down floors and pavement, and outdoor storage. Look for outdoor areas where rain water could wash pollutants into the storm drain.

2. Identify BMPs already in place and evaluate

It is possible that you will already have BMPs in place, but some may need "tightening up" to achieve their full effectiveness. Some examples include:

Plans to prevent or contain spills.
Separation of wastes to allow recycling.
Preventive maintenance procedures.
Vacuuming or sweeping before or instead of mopping.

3. Identify solutions to non-stormwater discharges.

Once you have identified pollutant generating activities, you can come up with ways to stop the discharge or move the activity inside or under a roof. Another possibility is to treat the wastewater and discharge it to the sanitary sewer.

4. Start with low cost, simple Source Control BMPs.

Begin by looking for ideas for reducing or eliminating discharges that are easy to implement and are inexpensive. Often improved housekeeping or a procedural change can go a long way to reducing the generation of wastes. The axiom of "80% of the problem can be solved with 20% of the effort" probably is true for most businesses.

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5. Consider other Source Control BMPs.

You may still have areas where the amount of pollution will be significant. The solution may involve a strategy that requires more effort. This could involve a change in equipment or material, sealing floor drains, finding a vendor who recycles spent materials, or covering a large exposed activity area.

6. Consider Treatment Control BMPs.

In a situation where a discharge can not be eliminated, the discharge should be treated. Treatment controls include oil/water separators, catch basin sumps, in-line treatment systems, filtration, or installing a diversion pipe to the sanitary sewer.

7. Prepare BMP list and priorities.

Decide which BMPs to implement first. Make sure the BMP list will meet the objective to reduce or eliminate the pollutant discharge.

2

TRAINING

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Another critical element to having a successful BMP program is training employees who will implement the BMPs. Training should be an integral part of your effort to reduce pollutants in stormwater. The Ventura Countywide Stormwater Quality Management Program is developing materials for various types of businesses that can be used in a training program. Materials for automotive service businesses will be ready soon, followed by materials for restaurants and other types of businesses.

STATE GENERAL PERMIT FOR INDUSTRIAL ACTIVITIES

If you are involved in certain industrial activities, you may be subject to a State General NPDES permit. Your community's stormwater program coordinator, listed below, local Ventura County representative can help you determine if you are subject to this permit.

For more information on developing and implementing BMPs, please call [include a list of contacts here].

Handout for Residents on Illicit Discharge Control (Front)

Have you seen this sign painted on the curb?

This sign on the curb is a reminder not to dispose of trash, motor oil, paint, cleaners, animal wastes, or other materials and substances into catch basins.

Stormwater will carry these substances through the storm drain system directly to our waterways and the ocean.

Storm drains are intended to carry only stormwater. Substances or materials dumped into storm drains may be harmful to fish, marine animals, birds, other wildlife and US!

You're the solution.

STOP STORMWATER POLLUTION!

- Never dispose of anything into gutters or down catch basins.
- Recycle used motor oil.
- Keep your vehicle in good working condition to prevent leaking oil, antifreeze and other fluids.
- Put trash in its proper place. Don't litter.
- Dispose of paint and other household harzardous wastes at local collection events.
- Use environmentally sound gardening practices.
- Compost or recycle yard and landscape clippings.
- Irrigate your landscape efficiently to avoid runoff.

For more ways to help protect the environment, contact one of the participating agencies.

Participating Agencies: Camarillo • County of Ventura • Fillmore • Moorpark • Ojai • Oxnard • Port Hueneme • Santa Paula • Simi Valley • Thousand Oaks • Ventura • Ventura County Flood Control District

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DON'T DUMP — DRAINS TO OCEAN

Este aviso en la banqueta le prohibe tirar basura, aceite de motor, pintura, detergentes, limpiadores, desechos de animales, materiales y substancias toxicas a la cuneta y a los alcantarillados.

El agua de la lluvia transporatara estas substancias por los alcantarillados directamente a nuestros rios y oceano.

La intension de los systemas de alcantarillado es especificamente para transportar agua de lluvia. Subtancias o materiales desechados en el alcantarillado pueden ser peligrosos para los seres humanos, la fuana marina, aves y toda vida salvaje.

Usted es la solución.

COOPERE Y EVITE LA CONTAMINACIÓN DE EL AGUA DE LAS LLUVIAS.

- Nunca tire basura a la cuneta o alcantarillados.
- Reciclar el aceite de motores usado en el lugar adecuado.
- Mantener el vehiculo en buen estado para prevenir fugas de aceite, anti-congelantes u otros fluidos.
- Poner las basura en el sitio apropiado.
- Deshacerse de pinturas o productos caseros toxicos en eventos de colección local.
- Usar metodos de jardineria que protejan el ambiente.
- Reciclar o deshacerse propiamente de rebabas de pasto y corte de ramas de arboles y arbustos.
- Riegue su jardin eficientemente para evitar que corra el agua.

Si necesita mas información para ayudar a proteger el medio ambiente, comuniquese con las siguientes agencias.

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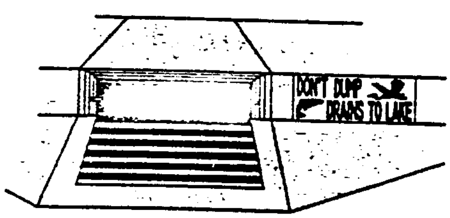
Door Hanger for Residents on Illicit Discharge Control

DON'T DUMP
DRAINS TO LAKE

This sign on the curb is a reminder not to dispose of trash, motor oil, paint, cleaners, animal wastes, or other materials and substances into gutters, curb inlets or catch basins.

Stormwater will carry these substances through the storm drain system directly to our waterways and the ocean.

Storm drains are intended to carry only stormwater. Substances or materials dumped into storm drains may be harmful to fish, marine animals, birds, other wildlife and US!



You're the solution.
STOP STORMWATER POLLUTION!

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You're the solution.
STOP STORMWATER POLLUTION!

- Never dispose of anything into the gutter or down curb inlets and catch basins.
- Recycle used motor oil.
- Keep your vehicle in good working condition to prevent leaking oil, antifreeze and other fluids.
- Put trash in its proper place. Don't litter.
- Dispose of paint and other household hazardous wastes at local collection events.
- Use environmentally sound gardening practices.
- Compost or recycle yard and landscape clippings.
- Irrigate your landscape efficiently to avoid runoff.

For more ways to help protect the environment, contact one of the participating agencies.

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ATTACHMENT 5
ILLICIT DISCHARGE INVESTIGATION SUMMARY

Illicit Discharge Inspection Program Summary

Outfall ID No.	Date of Inspection	Evidence of Discharge		Flow Observed?	Nature of Evidence				Picture Roll/Photo	Handouts	BMPs Recommended	Business Name/Comments
		Surface ID?	Channel ID?		Odor	Color	Turbidity	Other				

Co-permittee:________________

Reporting period:_____________

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R0053862

FINAL REPORT

SANTA MONICA BAY STORMWATER POLLUTANT REDUCTION STUDY

VOLUME I: STUDY RESULTS AND RECOMMENDATIONS

Prepared for

CITY OF LOS ANGELES

Wastewater Program Management Division

Contract No. C-67502

June 1994

Prepared by
ENGINEERING-SCIENCE
DESIGN • RESEARCH • PLANNING
199 SOUTH LOS ROBLES AVENUE • P.O. BOX 7056 • PASADENA, CALIFORNIA 91109
PSR158

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VOL 12

FINAL REPORT

SANTA MONICA BAY STORMWATER POLLUTANT REDUCTION STUDY

VOLUME I: STUDY RESULTS AND RECOMMENDATIONS

ES ENGINEERING-SCIENCE

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Prepared for

CITY OF LOS ANGELES

Wastewater Program Management Division

Contract No. C-67502

June 1994

Prepared by
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199 SOUTH LOS ROBLES AVENUE • P.O. BOX 7056 • PASADENA, CALIFORNIA 91109
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SEP 09 1994

Xavier Swamikannu
CRWQCB - L.A. Region
Stormwater
101 Centre Plaza Drive
Monterey Park, CA 91754-2156

SANTA MONICA BAY STORMWATER POLLUTANT REDUCTION STUDY

Enclosed is Volume I and Volume II (Data Appendix) of the final report for the Santa Monica Bay Stormwater Pollutant Reduction Study. This report, and the implementation of the recommended projects herein, is a result of an agreement the City of Los Angeles has with the EPA and the State of California (Amended Consent Decree).

The study assesses the nature and extent of discharges of pollutants from stormwater runoff. A large scale map of the "Drainage Basins and Sub-Basins in the Study Area", Exhibit 1, and "Land Use Distribution Within the Study Area", Exhibit 2 are included with this report (maps are located in rear pockets of Volume I of the report). The study is structured towards development of recommended pilot-size projects for control of stormwater runoff pollutants. A primary objective of the evaluation of such projects was to recommend projects that would be compatible with the long-term stormwater management plan being developed by the City.

Potential runoff pollution control measures that could be implemented in the study area were identified. Potential pollution control measures were categorized as structural (physical facilities) and non-structural (management approaches for controlling the discharge of pollutants). The primary criteria used to evaluate alternative runoff pollution control measures were costs, efficiency, community and environmental impacts, and regulatory and institutional aspects. Costs were defined in terms of Total Suspended Solids and Oil & Grease removal per thousand dollars of investment.

The four approved projects and their current status are:

<u>Enhanced Catch Basin Cleaning</u>

Enhanced catch basin cleaning was targeted for an area of about 17,000 catch basins. The debris is being assessed as an indication of the source of pollutants, first flush versus total runoff pollution discharge characteristics, and pollutant loadings from debris "stored" in the catch basins versus those pollutants resulting from "pass through" debris during a rainfall event.

Visual inspections and data recording, and debris accumulation are now in the 23rd month. Data is continuously being entered into the information management system and adjustments to the program are continuing as the need arises.

Both dry and wet weather water quality sampling and analysis have been completed for the purposes of this study. A draft report will then be prepared describing the monitoring results, the data on debris accumulation, and the general effectiveness of the program.

Parking Lot Strip Filters

This project constructed a rapid sand stormwater filter in a typical small parking lot. All of the runoff from the lot passes through the sand filter media prior to discharge into the storm drain system. A report describing the design and construction of this project is scheduled to be completed in September, 1994.

As part of the City's long term commitment to continually evaluate the effectiveness of Best Management Practices, this rapid sand filter is being monitored and refined as needed. The City has entered into an agreement with Loyola Marymount University to assist the City in studying the long term effectiveness of the rapid sand filter. This study will include wet weather monitoring, effectiveness evaluation and improvement/refinement recommendations.

The objective of the study is to evaluate the effectiveness of the strip filter design in removing the pollutants typically associated with urban parking lot runoff. Specific recommendations are to be made for any modifications, if necessary, to the design to enhance its performance, reliability, operation and maintenance. The design may become a typical design standard to be used at other locations.

Public Education Program

The status of the various programs within the Public Education Program is as follows:

The General Outreach Program

This program included the television, billboard and media outreach campaigns. The Ocean Safe Coalition was formed to bring the media in as partners to work on stormwater pollution problems. Appointments with television stations started in June 1994 with the goal of having a Public Service Announcement (PSA) on the air. Marketing the PSA for television is underway. The City is making appointments with each local media outlet to ask them to air the PSA and join the Ocean Safe Coalition. The PSA should be on the air in October, 1994.

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The Grass Roots Community Outreach Program

The main component is the catch basin stencil program. Over 14,000 catch basins have been stenciled around the City by the Los Angeles Conservation Corps and the Gutter Patrol volunteer program being administered by Heal the Bay. The second major component of the Grass Roots Program is the Ocean Safe Coalition (OSC) which is a forum for clean water issues. OSC is asking business, media, government, community and environmental groups to join together around the issue of stormwater pollution abatement as it relates to federal and state regulations as well as the quality of life in the community. Over 2,000 invitations to join the OSC have been sent and the first OSC event is planned to be held before the end of 1994.

The School Education Program

A classroom curriculum pilot program ended in August, 1994. In the pilot phase, the curriculum was presented to a dozen classrooms and approximately 400 students. Revisions are underway for the final draft of the curriculum. A report describing the highlights of the Program activities will be completed in September, 1994.

Household Hazardous Waste Collection

A total of four round-up events have been completed. This completes our Consent Decree obligation for this project. Data collected from these events is being assessed. This information will be used to extrapolate the amounts of various hazardous waste materials prevented from contributing to the pollution stream affecting the Santa Monica Bay, among other things.

In conclusion, if you desire additional information about any of the four stormwater projects, please call Mr. Wing Tam, Stormwater Management Division, Bureau of Engineering, at 213-847-5225. Calls regarding the study itself should be directed to Robert LaFrance, Wastewater Program Management Division, Bureau of Engineering, at 213-847-9576.

Sincerely,

Robert S. Horii
City Engineer

RSH/WMS:mdb/stormwtr.bay

Enclosure

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ACRONYMS AND ABBREVIATIONS

BHCs	benzene hexochlorides
BOD	biochemical oxygen demand
City	City of Los Angeles
COD	chemical oxygen demand
DDT	dichlorodiphenyltrichloroethene
EPA	U.S. Environmental Protection Agency
GIS	geographical information system
ha	hectare
HTP	Hyperion Treatment Plant
IASDTF	Inter-Agency Storm Drain Task Force
in	inch
JWPCP	Joint Water Pollution Control Plant
kg	kilogram
km	kilometer
L/s	liters per second
m	meters
m^3	cubic meters
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mgd	million gallons per day
mm	millimeter
NOS	North Outfall Sewer
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
O&G	oil and grease
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls

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RWQCB	Regional Water Quality Control Board, Los Angeles Region
Study	Santa Monica Bay Stormwater Pollution Reduction Study
SWRCB	California State Water Resources Control Board
TBT	tributyl tin
TSS	total suspended solids
ug/L	micrograms per liter
USCG	United States Coast Guard

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EXECUTIVE SUMMARY

This Santa Monica Bay Stormwater Pollutant Reduction Study (Study) was conducted for the City of Los Angeles (City) as a requirement of the Amended Consent Decree settlement regarding protection of water quality in Santa Monica Bay. The Study describes approaches and methods for development of pilot projects for reducing pollutants transported to Santa Monica Bay in runoff flows from rainfall and in unregulated anthropogenic flows during the dry season. The Study recommends pollutant control measures to be approved by the United States Environmental Protection Agency (EPA) and implemented by the City with a cost up to $3 million. Runoff sampling techniques and analysis procedures, development of loading models for targeted runoff pollutants, identification of feasible runoff pollutant control strategies, and recommendations for pilot control projects were discussed throughout the study with City staff, interested State agencies, EPA, and concerned public environmental groups.

The evaluations of potential runoff pollutant control projects were to be used to satisfy requirements of the Consent Decree and provide guidance for development of long-term control strategies. This Study can also be used to provide performance estimates and monitoring data to a stormwater runoff management plan by the City. Additional data would be needed to develop statistical information on stormwater runoff pollutant occurrence, levels, or distributions. Conclusions regarding the assimilative capacity of the receiving waters, and the extent of impact on the receiving waters from stormwater pollutant loading, would also require additional study.

THE STUDY AREA

The area included in this study represents the region of the Los Angeles Basin that drains into Santa Monica Bay and is served by the City's Hyperion Treatment Plant (HTP). This drainage area comprises 52,600 hectares (ha) (130,000 acres) of southwestern Los Angeles County, bounded on the north by the crest of the Santa Monica Mountains, on the southwest by the Pacific Ocean, and on the east by the downtown Los Angeles area. The highly-urbanized study area includes the cities of Los Angeles, Santa Monica, Beverly Hills, Culver City, and much of El Segundo, as well as portions of unincorporated Los Angeles County. Major land uses within the study area include residential, industrial, commercial, transportation, and dedicated open space.

The study area is served by an extensive network of stormwater drains separate from the sanitary sewer system. A total of 26 major storm drainage basins, some with distinct sub-basins, enter Santa Monica Bay from the study area (Exhibit 1). Runoff pollutants enter the Bay in the storm drain system both as a result of wet weather flows following rainfall events and in dry weather flows from a variety of primarily anthropogenic sources.

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EXISTING POLLUTANT SOURCES

Existing pollutant discharges to Santa Monica Bay have a variety of both regulated point sources and unregulated nonpoint sources. Regulated discharges include municipal wastewater treatment plants, electric power generating stations, an oil refinery, and numerous other smaller permitted discharges. Nonpoint sources include drainage channels, ocean dumping, marine vessels, and other sources. Municipal wastewater treatment plants and drainage channel runoff are the most significant sources of pollutant input.

Point source discharges to Santa Monica Bay are regulated through the National Pollutant Discharge Elimination System (NPDES) permit program administered by the California Regional Water Quality Control Board, Los Angeles Region. These discharges must meet the water quality objectives established to preserve the beneficial uses of Santa Monica Bay as set forth in the Water Quality Control Plan-Los Angeles River Basin (revised 11/27/78 and as amended 1992). Pollutant loading from drainage channels is partially controlled by structural (physical facilities) and non-structural (management approaches for controlling the discharge of pollutants) runoff control measures, including debris basins, settling basins, stormdrain system maintenance, streetsweeping, catch basin cleanings, and collection of household hazardous wastes. While design and operations of the drainage system is primarily designed for flood control, some components of the system, as well as some sanitation activities, indirectly provide a degree of runoff pollution control.

DETERMINATION OF RUNOFF POLLUTANT LOADING

The methodology used to determine runoff-associated pollutant loading into Santa Monica Bay included:

1. Identification of drainage basins and major land uses
2. Selection of important runoff pollution constituents
3. Selection of detailed land-use study areas
4. Runoff sample collection and constituent analysis
5. Analysis of rainfall records
6. Typical storm study
7. Calculation of estimated pollutant loads for a typical storm and a typical rainfall year

For each major storm drain outlet, drainage areas and sub-areas were developed using topographic and stormdrain network information. Land use was mapped for five major uses that are common over the entire study area: residential, commercial, light industrial, transportation, and dedicated open space (Exhibit 2). The distribution of land uses by drainage basin was then calculated.

Pollutants were selected for detailed study based on several criteria: their potential impact on beneficial uses of Santa Monica Bay, identification with adverse effects on human health through water contact activities, identification with adverse biological effects in Santa Monica Bay, identification with adverse aesthetic effects in Santa Monica Bay and on beaches, public concern, contribution of stormwater runoff pollutant loading versus total pollutant loading in Santa Monica Bay, and implementability of pollutant controls. The most persistent, nonvolatile constituents that accumulate in the environment were selected, including metals and inorganics (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) and certain pesticides and herbicides.

Selection of areas for detailed study was based on the need to characterize stormwater runoff on homogeneous land-use types that could be isolated for purposes of monitoring without interference from other activities. Candidate areas were identified for light industrial, commercial, residential, and transportation land uses. In addition, a monitoring location that provided integrated information was chosen. All of the areas were located within the Ballona Creek watershed.

Stormwater runoff samples were collected at each of the five chosen locations using automatic water collection pump samplers. Each sampler was coupled with a flow-monitoring device programmed to activate the sampler based on a preprogrammed increase in flow rate within the storm drain resulting from rainfall runoff. Dry-season flow samples were collected in the same land-use areas as those for which stormwater runoff flows were collected. For dry-season samples, a 24-hour composite sample was collected at each site by combining 24 discrete hourly samples collected over a 24-hour period. The volume of samples collected was sufficient to satisfy requirements of the analyzing laboratory to complete constituent testing.

Information from flowmeter data at the sampled study sites, data from rainfall recording stations, and historical storm data was used to develop runoff hydrographs for the sampling sites and the study area. Separate hydrographs were developed for coastal and mountain regions of the study area, and for storms occurring during the dry season and the wet season.

Estimates of pollutant loading into Santa Monica Bay from the study area were developed by calculating pollutant runoff from each land use type in each drainage area, and summing the contribution of each drainage basin. Dry weather runoff pollutant input was determined by calculating the volume of dry weather runoff flows from the study area and the concentrations of target pollutants in low-flow samples collected in Ballona Creek. Pollutant concentrations in both wet-weather and dry-weather runoff frequently exceeded California Ocean Plan instantaneous maximum concentration standards. While concentrations of target pollutants were frequently higher in stormwater runoff than those in municipal wastewater treatment plant discharges, the annual mass loading of runoff pollutants was approximately 25 percent of treatment plant loadings.

The analyses indicated that the control of total suspended solids (TSS) can effectively control the discharge of most toxic metals into Santa Monica Bay. Alternative measures, primarily based on controlling the sources, would be required for reducing the load of cadmium, silver, herbicides, and pesticides. Control measures suitable for removing oil and grease (O&G) from the runoff stream would also be effective in reducing herbicides and pesticides.

EVALUATION OF RUNOFF POLLUTANT CONTROL MEASURES

Potential runoff pollution control measures that could be implemented in the study area were identified to satisfy the requirements of the Consent Decree. Potential pollution control measures were categorized as structural (physical facilities) and nonstructural (management approaches for controlling the discharge of pollutants). The primary criteria used to evaluate alternative runoff pollution control measures were costs, efficiency, community and environmental impacts, and regulatory and institutional aspects. Costs were defined in terms of TSS and O&G removal per thousand dollars of investment.

The structural runoff pollution control measures that might be implemented in the study area were divided into four major groups: detention settling, treatment, transport, and infiltration pilot programs. The non-structural runoff pollution control measures that might be implemented in the study area were divided into three major groups: improved storm drain system maintenance practices, collection of household and other waste materials, and public awareness programs.

CONCLUSIONS AND RECOMMENDATIONS

In summary, the requirements of the Consent Decree can best be met by the following control practices:

1. infiltration pilot programs
2. collect household hazardous waste materials
3. "enhanced" catch basin cleaning program
4. public education program

A detailed analysis identifies specific areas within the Santa Monica Bay drainage area where implementation of the recommended measures would be most effective. The implementation of all of the above recommended pollution control measures at all of the recommended locations within the study area are estimated to reduce the annual TSS (and associated target metals) loading by approximately 8 percent, and the annual O&G (and associated herbicides and pesticides) loading by approximately 4 percent to Santa Monica Bay.

SECTION 1

INTRODUCTION

This report is the result of the Santa Monica Bay Stormwater Pollutant Reduction Study (Study), conducted for the City of Los Angeles (City) by Engineering-Science. The Study describes approaches and methods for development of pilot projects for reducing pollutants transported to Santa Monica Bay, a semi-enclosed coastal embayment included in the United States Environmental Protection Agency's (EPA) National Estuary Program, by storm runoff from urbanized areas served by the Hyperion Treatment Plant (HTP).

PURPOSE OF THE STUDY

On February 19, 1987, the City entered into an agreement with the EPA and the State of California in settlement of a lawsuit regarding alleged violations by the City of its National Pollutant Discharge Elimination System (NPDES) permit for wastewater discharges from the HTP. This agreement, as amended, was termed the Consent Decree (USA and State of California vs. City of Los Angeles, 1987). It placed several obligations on the City regarding wastewater treatment and waste disposal. One of the terms of the Consent Decree was Item XIV, Stormwater Control Project, which required that funds be obligated for a stormwater discharge control project. Specifications and schedules were set forth in Appendix C of the Consent Decree.

The City was directed to perform a study to "assess the nature and extent of discharges of pollutants from stormwater runoff from the HTP service area into Santa Monica Bay." The results of the study were to include recommended projects "to reduce effectively the discharge of such pollutants" into the Bay. The Consent Decree mandates that the City spend $3 million to implement control measures based on Study recommendations and EPA approval.

The study was structured to lead to the recommendation of pilot-size projects for control of stormwater runoff pollutants. In-place pilot projects were also to be evaluated for their effectiveness in reducing loading of such pollutants into Santa Monica Bay. The ultimate objective of evaluating such projects was to recommend projects that would be compatible with the long-term stormwater management plan being developed by the City to deal with pollutant runoff and loading.

RELATIONSHIP TO EPA STORMWATER REGULATIONS

On November 16, 1990, the EPA issued the final rule regarding discharge permitting procedures for stormwater runoff from certain industrial sites and from large and medium municipalities. The EPA authorized the California State Water Resources Control Board (SWRCB) to issue general or individual stormwater discharge permits. The new rules target individual cities and facilities, and allow stormwater pollutants to be controlled by several municipalities acting in conjunction within a watershed. The rules are directed at improving runoff water quality in separate storm sewer systems; they ban illicit connections between sanitary sewers and storm sewers and create new requirements for collection systems receiving stormwater separate from domestic sewage. One of these requirements is an extensive monitoring program, which requires permit holders to develop discharge characterization data for five to ten "representative" storm sewer outfalls, monitor facilities which contribute "substantial" pollutant loading to the system, and detect illicit discharges. Other requirements include a stormwater management plan which utilizes best management practices to reduce pollutant loadings, a demonstration of legal authority, and a fiscal and performance evaluation of controls proposed as part of the management plan.

The EPA also issued new rules for certain industrial facilities and for construction sites. As interpreted by the California State Water Resources Control Board, these rules require each facility or site to conduct a monitoring program to identify and monitor activities which contribute to pollutant loading to the stormwater system (especially illicit connections or disposals) and to determine the effectiveness of pollutant loading reduction efforts. A Stormwater Pollution Prevention Plan must also be prepared. This plan must include best management practices to reduce pollutant loading. In addition, worker training programs and spill prevention and response programs are required for industrial facilities. (As of this writing, the general construction activity stormwater permit applies only to sites larger than five acres, but this permit may be reopened as a result of a court case).

The City and County of Los Angeles both maintain separate stormwater control systems and are both significantly affected by the implications of the rule. This study addresses stormwater pollutant runoff control on a land-use and watershed basis, without regard to municipal boundary. Many of the recommendations contained in this report, although designed to reduce stormwater pollutant loading from targeted land-use areas and locations, would be applicable on a large scale to reduce stormwater pollutant loading from entire cities. In evaluating projects to reduce runoff pollutant loading, this study addresses one area considered by EPA to be a significant problem in attaining improved water quality in receiving water bodies: improper disposal of wastes. Information gathered from implementation of recommended runoff pollution control technologies in Section 5 of this study will help guide compliance by the City with the EPA regulations.

The new rules are of great concern to cities because of the increased responsibility for controlling stormwater pollutants, the complexity of the sampling and application requirements, and the potential financial burden imposed on affected cities. Many affected cities lack the authority to control discharges or raise revenue to conduct required programs. In addition, for most pollutants, the new regulations do not set numerical limits, but rather mandate (but do not define) best management practices.

PUBLIC PARTICIPATION PROGRAM

The results of this study, and subsequent cleanup and restoration activities in and around Santa Monica Bay, affect a large cross-section of interested public organizations. Consequently, a public participation program was developed to include public input and dissemination of information during each phase of the study.

The primary focus of the public participation program was to provide the interested agencies, environmental groups, and general public with information on the Study. The program provided information about the approaches, conduct, results, and recommendations of the Study to the Inter-Agency Storm Drain Task Force (IASDTF). Formerly known as the Pico-Kenter Task Force, this latter group was originally formed to deal with aesthetic and potential public health problems associated with dry weather runoff from the Pico-Kenter storm drain system, which discharges across a heavily-used public beach in Santa Monica.

Active participants in the IASDTF included the City of Santa Monica, the City of Los Angeles, the County of Los Angeles, the California Department of Fish and Game, the Los Angeles Regional Water Quality Control Board, the Sierra Club, Heal the Bay, UCLA, and representatives from several state and federal legislators' offices.

Primarily because of its experience and familiarity with stormwater technical and environmental issues, the IASDTF was chosen to act in an advisory role for the conduct of the Study. Monthly meetings (between 1988 and 1989) with the IASDTF were used to disseminate the information and recommendations resulting from the monitoring and evaluation phases of the Study. These meetings were open to any interested parties, and were used as a public forum to solicit and receive input from individuals and groups not directly affiliated with the IASDTF. The IASDTF was fully informed as to the scope and purpose of the study, the proposed sampling regime for the study, the proposed analytical procedures to be used, and the manner in which runoff loading and control projects would be evaluated. Additional public contacts and meetings were used to convey information regarding the study to interested City groups, environmental groups, and other interested parties. A presentation on the Preliminary Draft Report was made at the special AMICI briefing held on 11 May 1989. Additional meetings were held for the City Council staff, former Board of Public Works Commissioner Ed Avila, Heal the Bay, the Regional Water Quality Control Board, and the Santa Monica Bay Restoration Project.

CONTENT OF THIS DOCUMENT

Section 2 of this study reviews the current conditions in the study area and adjacent coastal waters relating to pollutant runoff and loading. Characteristics of the drainage area from which runoff enters Santa Monica Bay are discussed. Existing pollutant inputs into the Bay are identified and quantified in terms of annual loading. Stormwater and dry-weather runoff control practices in the study area are discussed with regard to their effectiveness on controlling pollutant loading to Santa Monica Bay.

Section 3 details the approach and methodology used in determining concentrations and total loading of runoff pollutants from the study area into Santa Monica Bay. Determination of drainage basin boundaries, land use distribution, and rainfall event characteristics in the study area are discussed. Descriptions of wet and dry weather runoff sample collections at selected land use sites are presented. A calculation of runoff loading is presented based on land use distribution and rainfall characteristics for each individual drainage basin.

Section 4 presents evaluations of the suitability of several structural and nonstructural runoff pollutant control measures in reducing pollutant loading to Santa Monica Bay. The evaluation of each measure includes consideration of cost, efficiency, environmental impact, and regulatory aspects in determining its suitability in relation to runoff characteristics described in Section 3. A final listing of implementable technologies that satisfy study requirements are developed.

Section 5 includes recommendations for runoff pollution control measures to reduce pollutant loading into Santa Monica Bay, and specifies areas in the drainage basin where the recommended measures would be most effective.

Section 6 provides references and personal communications used in the preparation of this Study.

Use of measurement units in this document will be mixed. In referring to locations of discharges and distances between points of interest, English units have been used to allow the public and other interested parties to easily refer to known locations (e.g., the 5-mile outfall of the Hyperion Treatment Plant). For consistency with scientific literature and comparison with other runoff pollutant studies, metric units have been used for measurements of area (hectare [ha]), flow (liter per second [L/s]), constituent concentrations (milligrams per liter [mg/L]), pollutant loading (kilograms [kg]), and associated quantities.

A data appendix, provided under separate cover (Volume II), includes complete descriptions and analytical results for studies conducted for this project, including analyses of areal rainfall variation during sampled storms in 1988, analysis of typical storms for use in calculation of runoff pollutant loading, and analytical results of runoff sample collections by land use.

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SECTION 2

STUDY APPROACH AND PRESENT CONDITIONS

CHARACTERISTICS OF THE SANTA MONICA BAY DRAINAGE AREA

The area included in this study comprises 52,600 ha (130,000 acres) of southwestern Los Angeles County. The curve of the southern California coast results in a roughly triangular-shaped region with fairly well-defined physical boundaries. The study area is bounded on the north by the crest of the Santa Monica Mountains, on the southwest by the Pacific Ocean, and on the east by the downtown area, the majority of which is not part of the drainage basin. This area represents the region of the Los Angeles Basin that drains into Santa Monica Bay and is served by the HTP (Exhibit 1).

The majority of the study area is highly urbanized. Most of the area lies in the City of Los Angeles; however, the area also includes the Cities of Santa Monica, Beverly Hills, Culver City, and much of El Segundo. These cities contract with the City of Los Angeles to provide sewage treatment services. They are, therefore, appropriate for inclusion in this investigation. Major land uses within the study area include residential, industrial, commercial, transportation, and dedicated open space. A more complete discussion of land-use distribution within the study area is included in Section 3.

The highly urbanized portions of the study area contain a high percentage of impervious surface: most of the rain falling on these surfaces quickly runs off to the storm-drain system. The northwestern portion of the study area includes the southern slopes of the Santa Monica Mountains. These slopes are primarily dedicated open space; existing residential sites generally include large lots. Some parts of this mountain area are classified residential-agricultural, and include lots zoned for equestrian use. These uses include locations with one or more animals. Areas zoned for dedicated open space generally have a very small percentage of impervious area; only a small fraction of rain falling on these surfaces escapes as runoff.

The study area is served by an extensive network of stormwater drains, separate from the sanitary sewer system. A total of 26 major storm drainage basins, some with distinct sub-basins, enter Santa Monica Bay from the study area (Exhibit 1; Table 2-1). Methodology for determining the extent of each drainage basin and sub-basins is described in Section 3. The storm-drain system was designed and constructed as a flood-control system, and acts to convey storm runoff to the ocean as quickly as possible. During the dry weather season, a significant percentage of the observed flows consist of regulated discharges, including cooling system blowdown waters, dewatering effluent, decorative fountain and pool backwash, water softener waste, commercial and industrial process water, and other effluents.

Table 2-1

Major Storm Drain Discharges Entering Santa Monica Bay[a]

Basin Number	Discharge Point
1	Chevron Refinery
1a	El Segundo Boulevard
2	Imperial Highway
3	North Westchester
4	Playa del Rey
5	Ballona Creek
6	Marina del Rey
7	Venice Canals
8	Venice Pavilion
9	Brooks Avenue
10	Thornton Avenue
11	Rose Avenue
12	Ashland Avenue
13	Pico-Kenter
14	Santa Monica Pier
15	Wilshire Boulevard
16	Montana Avenue
17	Santa Monica Canyon
18	Palisades Park
19	Temescal Canyon
20	Pulga Canyon
21	Balboa Bay Club
22	Marquez Avenue
23	Santa Ynez Canyon (Sunset Boulevard)
24	Parker Canyon
25	Castlerock
26	Topanga Canyon

Source: Engineering-Science
[a] Numbering corresponds to basins in Exhibit 1

Various parts of the storm system draining to Santa Monica Bay are owned and managed by a number of local government agencies, including the City of Los Angeles, the County of Los Angeles, and other cities. Each of these agencies has programs for safety and maintenance of the drain system, and most are also concerned with the quality of water within and passing through their jurisdictions. It is a peculiarity of the system that agencies frequently have no control over water quality entering their jurisdictions, but may be responsible for achieving certain water quality objectives as flows exit their jurisdictions. These agencies, although responsible for maintenance within the system, often have no authority to regulate discharges to the system, nor to raise funds to conduct enforcement, monitoring, and cleanup actions.

EXISTING POLLUTANT INPUTS INTO SANTA MONICA BAY

To provide perspective, an area much larger than the area addressed in this runoff study is included in the following description of pollutant inputs into Santa Monica Bay. Santa Monica Bay is defined for this study as extending from Point Dume to Point Fermin, rather than from Point Dume to Palos Verdes Point (the usual definition), because discharges on the Palos Verdes Shelf between Palos Verdes Point and Point Fermin affect the Bay (MBC, 1988). This wider definition reflects the impossibility of attempting to separate the Bay into distinct areas affected by pollutant inputs from adjacent land areas, as might be possible for land-based drainage systems. Data are provided for 1987, the baseline analysis year for this study.

Pollutants enter Santa Monica Bay through regulated discharge points and through unregulated nonpoint sources.

Regulated Discharges

Six facilities have NPDES permits to discharge directly into the Santa Monica Bay: two wastewater treatment plants, three power generating stations, and one oil refinery.

Wastewater Treatment Plants

Two municipal wastewater treatment plants discharge directly into Santa Monica Bay. These are the HTP of the City of Los Angeles and the Joint Water Pollution Control Plant (JWPCP) of the County Sanitation Districts of Los Angeles County. The two treatment plants treat most of the municipal sewage from the Los Angeles Basin portion of Los Angeles County.

Location. HTP is located on the coast of Santa Monica Bay at Playa del Rey. It routinely discharges wastewater undergoing primary treatment and partially secondary treatment (70 percent and 30 percent, respectively, in 1987) through an 8-kilometer (km) (5-mile) outfall, which discharges west of Playa del Rey at a depth of 60 meters (m) (Figure 2-1). A 1.6-km (1-mile) outfall, discharging at a depth of 15 m, is used during emergencies; the wastewater is required to receive secondary treatment and disinfection. HTP expects to provide a level of treatment so that the total plant's discharge meets secondary standards by 1998. From 1957 to 1987, sludge was discharged from an 11-km (7-mile) outfall (which terminated at the head of Santa Monica Canyon) at a depth of 100 m (MBC, 1988). This outfall was abandoned 1 December 1987

JWPCP, located in Carson, discharges wastewater undergoing advanced primary and partial secondary treatment through either of two outfalls that terminate about 3 km offshore at depths of 60 m (Figure 2-1). Two shorter outfalls, terminating at depths of 35 and 50 m, respectively, are sometimes used in addition to the two main outfalls (MBC, 1988).

Mean Annual Discharge Volume. The annual discharge volume of HTP and JWPCP was similar from 1974 to 1987. The mean annual discharge volume of the

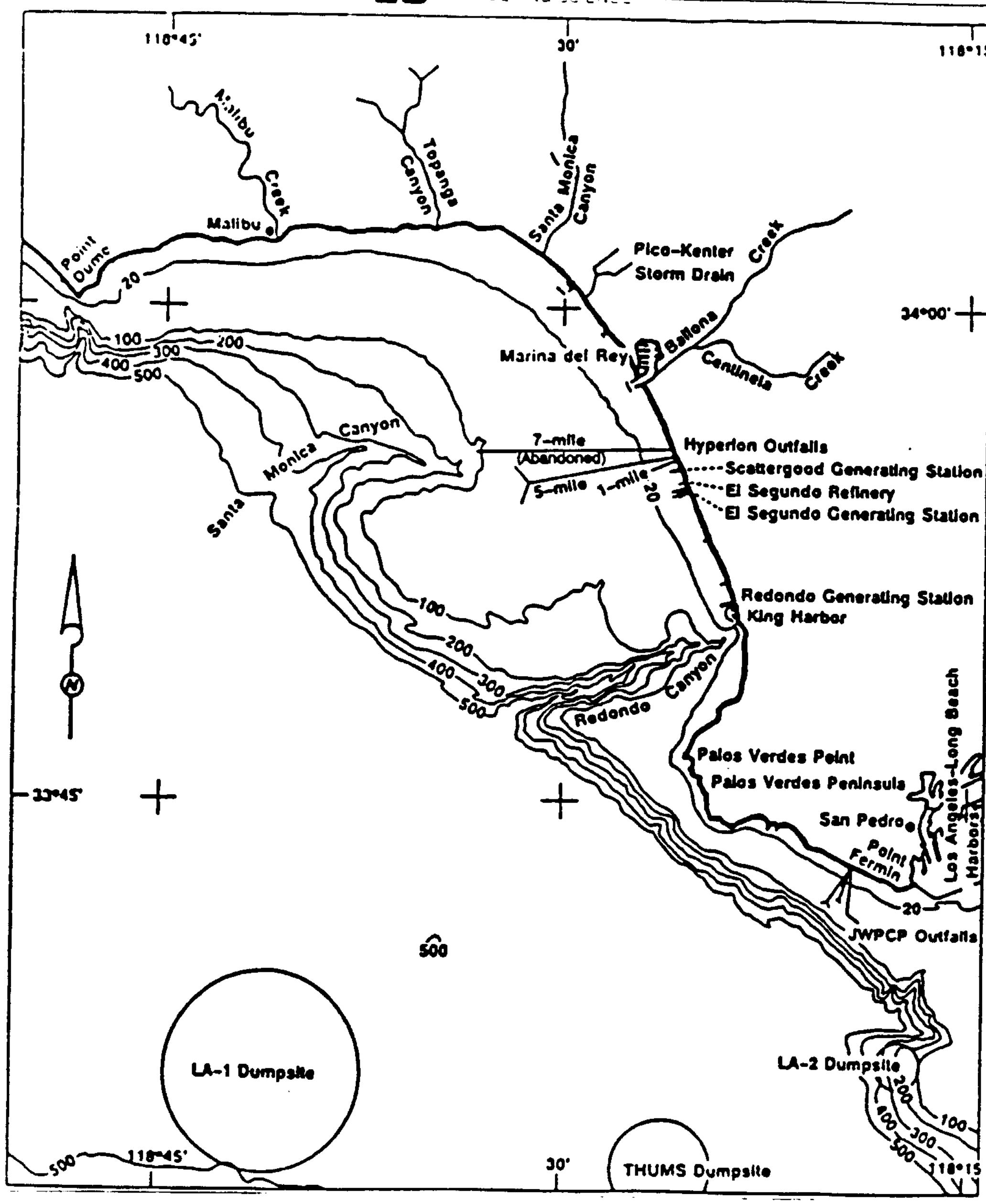

Figure 2-1 Major Discharges into Santa Monica Bay

SOURCE: MBC, 1988

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5-mile outfall of HTP was 507 x 10^9 liters. During the same period, the mean annual discharge volume of the 7-mile sludge outfall was 6 x 10^9 liters. Discharge from the 7-mile outfall was terminated late in 1987. The 1-mile outfall is used only in emergencies, with only a few periods of discharge per year. Hence, HTP had a mean annual discharge volume of about 513 x 10^9 liters. The discharge volume of the 5-mile pipe in 1987 was 518 x 10^9 liters. The mean annual discharge volume of the JWPCP outfalls from 1974 to 1987 was 492 x 10^9 liters. The discharge volume in 1987 was 507 x 10^9 liters (MBC, 1988).

Levels of Constituents of Concern. Levels of most constituents of concern have decreased in the effluent of HTP and JWPCP since 1974 because of improved treatment and source control; hence, recent levels are more representative than are mean levels (Table 2-2).

Several trends occurred at HTP during this period. HTP effluent concentrations and mass emissions of total suspended solids increased from 1974 to 1985 before decreasing to lower levels in 1987; a peak in 1985 resulted from construction at HTP, which temporarily reduced the number of holding tanks. Oil and grease levels remained relatively constant during this period. The levels of most metals was lower in 1987 than in 1974, but lead was higher; although most metals showed a relatively smooth decrease, levels of zinc and lead fluctuated greatly. In 1987, effluent from the 5-mile outfall had the highest concentrations of oil and grease and silver of the major regulated discharges to the Bay (Table 2-2). It had the lowest concentration of chromium. Because of the large flow volume, however, HTP was not only the major contributor (in terms of mass emissions) of oil and grease to the Bay but also of arsenic (along with JWPCP), cadmium, copper, nickel, and zinc. Total DDT was not detectable (MBC, 1988).

Most constituents at JWPCP showed a strong decreasing trend since 1974; however, silver and mercury were relatively constant. In 1987, the JWPCP effluent had the highest concentration of total suspended solids of the major discharges to the Bay (Table 2-2); however, suspended solids levels was not directly measured in storm water. The JWPCP effluent was the major contributor (excluding storm runoff) of total suspended solids to the Bay and also of arsenic (along with HTP), chromium, lead, silver, and mercury (MBC, 1988).

Regions Affected. The region most affected by the HTP and JWPCP outfalls lies offshore. In Santa Monica Bay proper, effects of the HTP outfalls occur near the ends of the outfalls, about 5 miles and 7 miles offshore and at depths of about 60 and 90 m, respectively. The disturbed area near the HTP 7-mile outfall has decreased in size since the termination of sludge discharge. The region most affected by the JWPCP outfall lies along the Palos Verdes Shelf at 60 m. Contaminants from this discharge are carried into Santa Monica Bay proper with greatest concentrations in the southern part of the Bay. The distribution of contaminated sediments and the effects on the benthic invertebrate and fish assemblages were extensive near the JWPCP outfall and somewhat less so near the HTP outfalls in the early 1970s. The affected area has decreased in both areas since then, however, apparently because of improved effluent quality (MBC, 1988).

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Table 2-2

Concentrations and Mass Emissions of Constituents From Existing Point and Nonpoint Sources to Santa Monica Bay[a]

ATTRIBUTES	MUNICIPAL WASTEWATER TREATMENT PLANTS HTP[c]	JWPCP	GENERATING STATIONS[b] Scattergood	El Segundo	Redondo	REFINERY El Segundo	DRAINAGE CHANNELS
Flow (L/yr x 10^9)	518.1	506.6	0.2	0.2	1.6	8.4	212.8
Concentrations							
Constituents (mg/l)							
TSS	58	73	15.6	5.9	1.8	12.5	-
O&G	15	11	1.2	4.1	6.6	7.5	3.1
Arsenic	0.008	0.007	0.018	ND	0.002	0.04	-
Cadmium	0.008	0.002	0.001	0.009	0.006	ND	<0.001
Chromium	0.017	0.052	0.060	0.136	0.121	0.040	0.031
Copper	0.058	0.042	0.120	0.136	0.120	0.005	0.028
Lead	0.043	0.050	0.001	0.045	0.060	ND	0.120
Nickel	0.056	0.051	0.120	0.090	0.060	0.010	0.054
Silver	0.010	0.008	ND	ND	0.002	0.001	0.002
Zinc	0.174	0.120	0.018	0.018	0.181	0.100	0.068
Trace Constituents (ug/l)							
Mercury	0.10	0.30	ND	-	-	1.67	< 1.00
Total DDT	ND	0.06	ND	-	-	ND	0.22
Mass Emissions							
Constituents (MT)							
TSS	29982	36900	2.6	1.3	3.0	105	-
O&G	7706	5560	0.2	0.9	11.0	63	664
Arsenic	4	4	0.003	ND	0.003	0.3	-
Cadmium	3	1	0.0002	0.002	0.01	ND	<0.2
Chromium	10	26	0.01	0.03	0.2	0.3	7
Copper	30	21	0.02	0.03	0.2	0.04	6
Lead	22	25	0.0002	0.01	0.1	ND	25
Nickel	29	26	0.02	0.02	0.1	0.1	11
Silver	5	< 10	ND	ND	0.003	0.01	0.4
Zinc	91	61	0.003	0.004	0.3	1	14
Trace Constituents (kg)							
Mercury	52	150	ND	-	-	14	<213
Total DDT	ND	30	ND	-	-	ND	47

Sources: HTP 1988; MBC 1988; Stull 1988, personal communication

[a] 1987 values except for drainage channels which are the mean of 1983 and 1984 values.

[b] These flows do not include once-through, noncontact cooling water flows, which was 419 x 10^9, 437 x 10^9, and 898 x 10^9 L/yr at Scattergood, El Segundo, and Redondo Generating Stations, respectively.

[c] 5-mile outfall; although 7-mile outfall was in operation during most of 1987, it is no longer used.

\- Not reported

HTP = Hyperion Treatment Plant; JWPCP = Joint Water Pollution Control Plant

ND = below detectable limits or no detectable difference between inlet and outlet samples (at generating stations).

TSS = Total suspended solids

O&G = Oil and Grease

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Industrial Discharges

The El Segundo Refinery of Chevron USA is the only industrial discharger with an outfall in the Bay. It manufactures various petroleum products from crude and refined oil.

Location. The El Segundo Refinery discharges wastewater undergoing primary and secondary treatment from a 0.2-km-long outfall at a depth of 6 m; all process water (about a third of the total volume) receives secondary treatment (Judson, 1989, personal communication). Surface runoff is also discharged through the outfall. The outfall lies between the intake and discharge conduits of the Scattergood and El Segundo Generating Stations at El Segundo (Figure 2-1).

Mean Annual Discharge Volume. The refinery generally discharges about 8.9×10^9 liters/year. In 1987, the discharge volume was 8.4×10^9 liters (MBC, 1988).

Levels of Constituents of Concern. Levels of most constituents in the effluent of the El Segundo Refinery have decreased since 1983 because of improved treatment; hence, recent levels are more representative than are mean levels. In 1987, the average concentration of copper was the lowest of any of the major discharges to the Bay and mercury was the highest (Table 2-2). Because of the relatively low discharge volume of the effluent, however, the refinery was not a major contributor of mercury to the Bay. Cadmium, lead, and DDT were not detected in the effluent (MBC, 1988).

Region Affected. The region affected by the El Segundo Refinery discharge is small, lying close to shore at El Segundo. Higher phytoplankton abundance associated with a plume of ammonia (possibly from the outfall) near the sea surface in the area before 1977 is the only known effect (Eppley, 1986; MBC, 1988).

Generating Stations

Three electrical power-generating stations circulate seawater from the Bay through their systems to cool condensers. These stations are the Scattergood Generating Station of the Department of Water and Power, City of Los Angeles, and the El Segundo and Redondo Generating Stations of the Southern California Edison Company.

Location. The Scattergood and El Segundo stations are near the City of El Segundo and the Redondo station is in the City of Redondo Beach (Figure 2-1). Intake and discharge conduits generally extend about 0.3 to 0.8 km offshore and have openings at depths of 5 to 6 m (MBC, 1988).

Mean Annual Discharge Volume. The volume of water circulated through the cooling system of the power-generating stations annually is very large (i.e., 444×10^9, 511×10^9, and $1{,}046 \times 10^9$ liters for Scattergood, El Segundo, and Redondo Generating Stations, respectively). In 1987, these volumes were 419×10^9, 437×10^9, and 898×10^9 liters. Because this cooling water is unfiltered seawater (with the contaminant levels of the sea offshore), it is unreasonable to use these flows in calculations of annual loadings. Wastes produced within the stations and surface runoff are held in settling basins before being discharged through the circulating seawater to the ocean. The mean volume of water discharged from the retention basins in 1987 was 166 x 10^6, 221 x 10^6, and 1,658 x 10^6 liters, or about 1,000 times less than cooling system flow volumes; these discharges contain most of the plant-generated contaminants (MBC, 1988).

Levels of Constituents of Concern. Levels of constituents for 1987 at the three generating stations were generally comparable to other discharges to the Bay in concentration, but were lower (because of lower flow volumes) in mass emissions (Table 2-2). The lowest concentrations of total suspended solids and oil and grease were found in the effluents of the Redondo and Scattergood Generating Stations, respectively. Copper concentrations were generally higher in these effluents than in other discharges to the Bay, with the highest concentration in the El Segundo Generating Station effluent. The highest concentration of nickel was found at Scattergood and the highest zinc concentration was found at Redondo.

Because of the low retention basin flow, mass emissions of all constituents were low (Table 2-2). The lowest emissions of oil and grease, chromium, copper, and zinc were those of Scattergood; the lowest emission of suspended solids occurred at El Segundo; and the lowest emission of nickel occurred at both Scattergood and El Segundo.

Silver was not detected at Scattergood and El Segundo; arsenic was not detected at El Segundo; and mercury and DDT were not detected at Scattergood.

Region Affected. The region affected by discharge from the three power-generating stations lies close to shore approximately from Playa del Rey to King Harbor. Effects have been studied in connection with NPDES permits, and appear to be minimal (EQA/MBC, 1973; IRC, 1979, 1981; MBC, 1982, 1986, 1988).

Nonpoint Sources

Nonpoint sources of contamination to Santa Monica Bay consist of unregulated and largely uncontrolled sources that are distributed broadly in the area. These include drainage channels, ocean dumping, marine vessels, aerial fallout, sediment reservoirs, seeps, and advection.

Drainage Channels

Drainage channels include the streams and stormdrains that discharge into the Bay. These have a low-volume flow throughout most of the year, but discharge high volumes during and following storms.

Location. At least 68 major storm drains are along the coast between Malibu and Point Fermin, with many additional smaller drains along the Malibu and Palos Verdes Coasts; four major channels (Santa Monica Canyon, Pico-Kenter Stormdrain, Ballona Creek, and Centinela Creek) are in the study area (Figure 2-1). The major streams in the area are Malibu Creek and Ballona Creek, with smaller streams reaching the ocean along the Malibu coast. Ballona Creek and Malibu Creek drain the largest areas (more than 250 km^2 each). The drainage of Malibu Creek includes a large segment of the Santa Monica Mountains, whereas the

Ballona Creek drainage includes much of Los Angeles and communities to the west; the natural drainage to Santa Monica Bay that lies south of Ballona Creek usually extends less than 2 km inland from the shore (MBC, 1988).

Mean Annual Discharge Volume. The mean annual discharge volume of surface runoff from the 68 drainage channels reaching Santa Monica Bay is about 213×10^9 liters (NRC/COWT, 1984; MBC, 1988); however, the daily average varies greatly with season and year. The annual flow of Ballona Creek ranges from about 27×10^9 liters in a dry year (1984) to 112×10^9 liters in a wet year (1983). In general, the flow from Ballona Creek is 2 to 10 times greater than that from Malibu Creek, but in 1969 (a wet year) the flow from Malibu Creek was 1.5 times greater than the Ballona flow (MBC, 1988). During a storm in 1986, the peak flow in Ballona Creek was 275 times the dry weather flow (Schafer and Gossett, 1988). Part of the flow in Ballona Creek is from regulated discharges; during dry-weather flow, this discharge may make up a significant percentage of the total flow (Mitchell, 1988, personal communication).

Levels of Constituents of Concern. The mean concentrations of constituents of concern for the calendar years 1983-1984 (the last years of frequent periodic sampling) were generally within the range of those of the point-source discharges to the Bay in 1987 (Table 2-2). Lead and total DDT concentrations, however, were higher in surface runoff than in the point-source discharges. Total suspended solids and arsenic were not reported for drainage channels; however, suspended solids are high during storms (MBC, 1988). Compared to other drainage channels in Southern California, Ballona Creek storm water had the highest levels of oil and grease, DDT, and trace metals in 1986 (Schafer and Gossett, 1988).

The mean annual loading (mass emissions) of the constituents of concern for the years 1983-1984 was generally within the range of the point-source discharges in 1987 (Table 2-2). Drainage channels, however, contributed more mercury and total DDT to the Bay than did the point sources (MBC, 1988). Annual loading of total pesticides in surface runoff was about 117 kg during this period.

Surface runoff from drainage channels is greatest during and following storms; hence, it is generally greater in the winter. Because of the large area drained, there is a lag time between the start of the storm and the discharge of runoff to the sea. During a storm in 1986, peak flows in Ballona Creek occurred 24 hours after the rainfall began, but concentrations of most constituents were greatest at 13 hours after the beginning of the storm (when flow was 40 percent of the peak flow). Maximum concentrations of the constituents (at 13 hours) were greater than the minimum levels (generally occurring at 24 to 42 hours after the storm began) by the following multipliers: DDT, 1360; lead, 261; total suspended solids, 192; total pesticides, 162; chromium, 110; copper, 31; cadmium, 29; zinc, 26; nickel, 19; and oil and grease, 17 (Schafer and Gossett, 1988).

Region Affected. The effects of surface runoff occur along the beach and inshore waters, throughout the Bay, but primarily off Malibu and from Pacific Palisades to Playa del Rey. The effects have not been well described.

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Ocean Dumping

Refuse, garbage, dredge spoils, drilling muds and cuttings, military explosives, and radioactive wastes have been dumped off Southern California in the past. At present, several EPA-regulated dumpsites are active in the area, and all limit dumping to certain materials within a prescribed region. Illegal dumping occurs, but is not well documented.

Location. All ocean dumpsites are outside Santa Monica Bay. The two nearest dumpsites with continuing or recent use include the LA-2 site and the THUMS dumpsite (Figure 2-1). Another (the LA-1) site was also used before 1973. Pollution from these sources enters the Bay by prevailing water currents. The LA-2 site is located about 10 km south of Point Fermin at 180 m depth, the THUMS site at 20 km southwest of Point Fermin at 900 m, and the LA-1 site at 30 km southwest of Long Point at 760 m (MBC, 1988).

Mean Annual Discharge Volume. A mean of 138,000 m^3 of dredged sediments from the Los Angeles-Long Beach Harbors is dumped at the LA-2 site each year (MBC, 1988; USEPA, 1988). The THUMS dumpsite was used during 1986-1987 to dump 10,378 m^3 of drilling muds and cuttings, but dumping there has been discontinued (MBC, 1988).

Levels of Constituents of Concern. Sediments dumped at the LA-2 site are required to be nontoxic (as determined by bioassay tests) (MBC, 1988). Drilling muds dumped at the THUMS site are required to be water-based and chromium-free; soybean oil must be used as a lubricant. Between 1947 and 1972, a mean of 19.4 x 10^6 liters/year of caustic and acid wastes from oil refineries and 3.45 x 10^6 liters/year of acid sludge from the Montrose Chemical Company were dumped at the LA-1 site. Between 348 and 696 metric tons of DDT were dumped at the site during these years (Chartrand, et al., 1985; MBC, 1988).

Region Affected. Advection of dumpsite materials to Santa Monica Bay may occur, but this has not been studied (MBC, 1988). Effects would most likely occur at the southwest corner of the Bay and off Palos Verdes Peninsula.

Marine Vessels

Recreational, commercial, and naval vessels using the Bay represent a nonpoint source of pollution. Contaminants enter the Bay as wastewater from toilets, wash water, and accidental (or unregulated) spills and leakages. Because recreational vessels concentrate in marinas, marine vessel contaminants also concentrate there.

Location. The two marinas in the Bay are Marina del Rey and King Harbor. Commercial and naval shipping lanes lie about 5.5 km offshore of the seaward boundary of Santa Monica Bay. Oil tankers enroute to moorings offshore of the El Segundo Refinery cross the Bay periodically each year (MBC, 1988).

Mean Annual Discharge Volume. Most discharges by marine vessels are undocumented, but some are documented. Of these, a mean of 505 liters/year of petroleum products were spilled into the Bay from 1973 to 1987. These spills consisted largely of fuel oil and crude oil (MBC, 1988).

Levels of Constituents of Concern. Levels of most constituents of concern to this study resulting from marine vessel contamination are not well described. High levels of tributyl tin (TBT), used as an antifouling agent in boat paints, occur in Marina del Rey (MBC, 1988). Sacrificial zinc anodes discarded by sail and power craft contribute about 30 to 38 metric tons of zinc to the Bay each year. The use of leaded fuel by recreational vessels contributes about 0.55 metric ton/year of lead. The amount of mercury contributed to the Southern California Bight in 1971 by marine vessels (primarily bottom paint) was greater than that from municipal wastewater discharge and surface runoff combined. Similarly, the amount of PCBs and copper emissions was about half the combined input of those sources (SCCWRP, 1973; MBC, 1988); however, the input of mercury and copper from marine vessels to Santa Monica Bay is unknown.

Region Affected. Most of the spills occurred in Marina del Rey, off El Segundo, or along the shipping lanes. TBT and zinc contamination occur primarily in Marina del Rey, although also to some extent in King Harbor (MBC, 1988). The effects of contaminants from these sources have not been described for the Bay.

Other Sources

Other sources of contamination to Santa Monica Bay include aerial fallout, sediment reservoirs, seeps, and advection. These sources introduce contaminants to the Bay through the air, sediments, and water currents, respectively.

Location. Aerial fallout occurs throughout the Bay; the distribution of fallout is poorly described, particularly over the open waters of the Bay. The accumulation of contaminants in sediments from past discharges provides a continuing source of contaminants through both natural and biological processes. Major sediment reservoirs of contaminants occur on the Palos Verdes Shelf near the JWPCP outfalls (DDT, PCBs, metals), in Santa Monica Canyon near the HTP sludge outfall (metals, chlorinated hydrocarbons), and in Marina del Rey (TBT). Natural oil seeps occur at the heads of Redondo Canyon offshore of Hermosa Beach. Advection of contaminants into the area through water currents occurs throughout the outer boundary of Santa Monica Bay (as defined). Currents transport contaminants into the area from the Los Angeles-Long Beach Harbors, the Santa Barbara Channel, and possibly from offshore dumpsites (MBC, 1988).

Tar from the natural oil seeps may drift to shore between Malibu and Redondo Beach (Marconsult, 1971; MBC, 1988); however, much of the tar reaching the beach may be advected in from the Santa Barbara Channel (Hartman and Hammond, 1981; MBC, 1988). Tar from Coal Oil Point (near Santa Barbara) probably travels west, south, and east from the Santa Barbara Channel in surface currents during the spring and summer. Drift tar takes about 10 to 14 days to reach Santa Monica Bay, but is retained in the Bay circulation for 1 to 3 weeks (Hartman and Hammond, 1981).

Mean Annual Discharge Volume. Gross discharge volumes for aerial fallout and sediment reservoirs are undescribed. The volume of water advected through the Bay is very large, but otherwise undescribed. The circulation patterns of the currents are variable and have yet to be adequately described. The residency time of the water mass in Santa Monica Bay is estimated to be about 3 to 4 days (Hickey, 1988, personal communication). The mean annual discharge from the natural oil seeps is about 670,000 liters/year (MBC, 1988).

Levels of Constituents of Concern. The importance of aerial fallout as a source of contaminants to Santa Monica Bay is not known; however, for the Southern California Bight as a whole, the amount of lead and mercury entering the sea from aerial fallout was greater than from discrete sources during the early 1970s. Copper, zinc, and nickel are also important in fallout (SCCWRP, 1973; MBC, 1988). During 1973-1974, about 113 kg/year of DDT entered Santa Monica Bay through aerial fallout (MBC, 1988).

Sediments in the vicinity of the HTP and JWPCP outfalls have accumulated contaminants for years. These sediments are reservoirs for many metals and chlorinated hydrocarbons, which are released into the Bay as the sediments are re-exposed by biological activities (e.g., burrowing and erosion). Near the JWPCP outfalls, levels of DDT in sediments 0.3 m below the surface reach 375 mg/kg (MBC, 1988; SDWG, 1988). Surface sediments with levels of 1 mg/kg occur over about 100 km^2 of bottom on the Palos Verdes Shelf (Word and Mearns, 1979; MBC, 1988). Sediments in this area and near the HTP outfalls (particularly the 11-km sludge outfall) also have high levels of all trace metals. Surface levels have generally decreased since the early 1970s because of the improved quality of the effluent (MBC, 1988).

Sediments near the JWPCP outfall had oil and grease levels up to 6,900 mg/kg in 1983 (Swartz, et al., 1986; MBC, 1988). Sediments in Marina del Rey have high levels of TBT, mercury, and oil and grease, presumably from marine vessel activity (MBC, 1988).

Region Affected. The effects of sediment reservoirs occur primarily in Marina del Rey and at the discharge depths of the HTP and JWPCP outfalls. The effects of aerial fallout occur at the sea surface and along the intertidal zone where the sea surface microlayer intersects with the land. Advection effects would occur throughout the Bay, but drifting tar accumulates along the beaches. Only the effects of the offshore sediment reservoirs have been well studied.

EXISTING STORMWATER RUNOFF CONTROL PRACTICES IN THE LOS ANGELES AREA

Until recently, stormwater runoff control was viewed strictly from the standpoint of flood control. During the past few years, however, national policies have been shifting away from the traditional approaches, and nonpoint-source (NPS) pollution control is becoming a major concern. The Clean Water Act Reauthorization of 1987 for the first time specifically addressed NPS pollution.

Historically, municipalities have not developed and implemented comprehensive stormwater management programs that included pollution control. Some structural components of the City's stormwater system, as well as some sanitation activities, indirectly provide a certain degree of runoff pollution control. Several stormwater control structures are being planned or constructed that will include some measures of stormwater runoff pollution control. In the study area, several nonstructural projects have been developed, or are under development, with the specific goal of controlling the discharge of pollutants into the stormwater system. Another important component of the existing stormwater runoff control program is the County's water quality monitoring system.

Structural Facilities

The structural facilities providing stormwater runoff pollution control in the study area are existing debris basins, several settling basins under construction, and the Pico-Kenter low flow diversion.

Existing Debris Basins

The existing debris basins are the most common structures in the stormwater system that have indirectly contributed to runoff pollution control. The main purpose of these structures is to control the entry of debris materials from undeveloped land into the stormwater system. Debris basins are generally built at the uppermost section of the system, thereby providing basically no control of materials originating in urbanized areas.

The City of Los Angeles operates and maintains about 70 debris basins. About 30 out of the 70 basins are in the foothills on the northern side of the study area. They are categorized as improved or unimproved, depending on whether they are built of concrete or earth surfaces.

The capacity of the debris basins varies widely, depending on the size of the catchment area. In general, debris basins are designed to catch runoff from the 50-year-magnitude storm. The design of the outlet works is such that, while debris is retained in the basin, water is discharged into the system as efficiently as possible.

Los Angeles County also operates a number of these debris structures; however, none of these are located in the study area.

Settling Basins Under Construction

Several settling basins are currently being developed in the study area. The proposed Stone Canyon project consists of converting an existing reservoir site to a runoff detention basin. In addition to providing pollution control for the area adjacent to Stone Canyon Road north of Sunset Boulevard, this project will also relieve the existing storm drain going into UCLA.

A 1.8-million-gallon settling facility was constructed at the Los Angeles International Airport in 1989. This basin collects stormwater flows from the central terminal area. The impounded stormwater is then discharged through a three-stage clarifier for additional solids removal, and oil and grease removal before it is sent for treatment at HTP (Wilson, 1991, personal communication).

The Potrero Canyon basin, under construction along the Pacific Palisades, is a small project operated by the Los Angeles Parks and Recreation Department. Although not specifically designed as a settling facility, it will provide some stormwater pollution control benefits in the adjacent area.

Nonstructural Measures

The nonstructural practices in the area that can have an effect on stormwater runoff pollution control are stormwater system maintenance practices, streetsweeping, and household hazardous waste collection programs.

Stormwater System Maintenance Practices

In general, the maintenance of the stormwater system in the study area is the responsibility of the various cities and Los Angeles County. The City of Los Angeles provides for the maintenance of the majority of the system in the study area. Maintenance practices are generally performed on an as-needed basis. The installation of a computerized system to help coordinate these activities is considered of primary importance by Bureau of Sanitation personnel.

In addition to the as-needed approach, the portion of the stormwater system maintained by the Los Angeles County Department of Public Works receives regular annual catch-basin cleaning. Pipe inspection routines are conducted once every 3 years to determine whether cleanups are necessary.

Streetsweeping Programs

Streetsweeping is one of the maintenance activities that has an indirect effect on the removal of stormwater runoff pollutants. The City of Los Angeles schedules street cleanings once every 3 to 4 weeks. In general, the impact of street sweeping on pollution removal is proportional to the accumulation period and the sweeping technique. According to Sartor and Boyd (1972), the rate of pollutant accumulation is most rapid during the first 2 or 3 days after a significant storm, and decreases after that period.

Solids loading curves from urban streets indicate that accumulated loadings in commercial and industrial areas peak after about 10 or 12 days. As explained in Section 3 of this report, the inter-event time of typical storms in the study area is about 10 days. Streetsweeping activities are, therefore, likely to have a minor impact on the removal of pollutants in the area, since accumulated materials are more likely to be removed by rainfall than by streetsweeping.

Household Hazardous Waste Collection Programs

The City of Los Angeles and Los Angeles County are currently engaged in the collection of household hazardous wastes. The main purpose of these programs is to prevent dumping of those materials into the stormwater system.

The previous program carried out by the City consisted of eight collection sites, distributed throughout the study area and beyond. During every roundup, only one site was operated. All kinds of substances considered to be hazardous wastes were received at each site, except ammunition and explosives. Up to 600 drums of a variety of wastes were collected per roundup and about 6,100 gallons of recyclable material (paint and oil) was collected and sent to recycling facilities. Other materials were disposed of at a Class 1 landfill.

The number of different types of wastes as well as the significant amounts collected during each roundup make hazardous waste collection programs quite expensive. The average cost of each roundup was about $250,000. Nevertheless, it was estimated that only a small portion of the actual volume of waste generated per household was collected through this program.

In addition to the hazardous waste roundups, the City conducted a pilot program by which hazardous materials were collected directly from households on a by-request basis from October 1988 to April 1989. The results of this program was that the cost per household was too high. A total of 313 drums of hazardous materials, and 9,100 gallons of recyclable material was collected at a cost of $485,000. The main problem with this program was the lack of public relations and public awareness associated with it. Only 1,435 households participated in this program. Future hazardous materials collection programs will include both mobile and permanent sites (Mofidi, 1991, personal communication).

Staring February, 1994, the City initiated a new mobile household hazardous waste collection program called HAZMOBILE, which replaces the single site Hazardous Waste Roundup program (David, 1994, personal communication). The HAZMOBILE program is a miniature hazardous waste roundup on wheels. It consists of several trailers and trucks that will move around to a total of 24 different geographic areas throughout the City each year. The trailers remain on-site for a period of two weeks and receive hazardous waste during the latter part of each week, usually Thursday, Friday, and Saturday. Hazardous waste is accepted on an appointment only basis. The HAZMOBILE program is advertised in local newspapers along with the appointment telephone number 1-800-98TOXIC. Operating costs for this program are not available at this time.

Water Quality Monitoring Programs

An important aspect of the control of stormwater runoff pollution is the water quality monitoring program carried out by the Water Quality Division of the Los Angeles County Department of Public Works. The program has been in operation for several years, but it was considerably expanded in 1988. Monthly samples from 28 sampling stations throughout the County's jurisdiction are analyzed for several constituents. Most stations collect both dry- and wet-weather samples; however, only one sample per storm event is collected. Seven stations are located within the area of interest of this study. Both dry- and wet-weather samples are collected in five of these seven stations. Results of this program was published by the County's staff, and were used on a comparative basis in evaluating the water quality results of this study.

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SECTION 3

DETERMINATION OF RUNOFF POLLUTANT LOADS

In order to determine runoff-associated pollutant loading into Santa Monica Bay, and to identify and prioritize pollutant sources, a methodology was developed to determine the magnitude of pollutant discharges by land-use category.

The methodology consisted of the following steps:

1. Identification of drainage basins and major land uses in the study area
2. Selection of important runoff pollution constituents
3. Selection of detailed land-use study areas for runoff sample collections
4. Collection of runoff samples and analysis of constituents
5. Analysis of rainfall records for the study area
6. Study of typical storm
7. Calculation of estimated pollutant loads for a typical storm and a typical rainfall year in the study area

The first three steps provided the framework for identifying the constituents of concern in the pollutant runoff study and the corresponding land uses where those substances originate. The concentrations of each pollutant by land-use category were determined by sampling identified areas with known land-use characteristics. The analysis of rainfall records was necessary to supplement the information provided by the sampling program.

The calculations leading to estimated pollutant loads were then based on the sampling results, estimates of runoff provided by the typical storm study, and flow information obtained from historical records. The step-wise process used for calculation of pollutant loading is illustrated in Figure 3-1. The following sections describe the methodology used to develop the data required for the calculation.

DRAINAGE BASINS AND MAJOR LAND USES IN THE STUDY AREA

Formulation of recommendations of selected control projects to achieve the objectives of this study were based on the approach of determining stormwater runoff pollutant loadings on a land-use basis. An initial step in this approach was to investigate drainage patterns within the study area in order to subdivide the area draining into Santa Monica Bay into smaller subareas. Individual control projects could then be more easily applied to these smaller areas. By determining the mix of land uses within these subareas, and relating loading ratios for each land-use type to the mix, pollutant loading for each subarea was estimated.

Twenty-six major storm-drain outlets were identified in the study area (Exhibit 1, Table 2-1). For each outlet, a drainage area was developed using topographic and

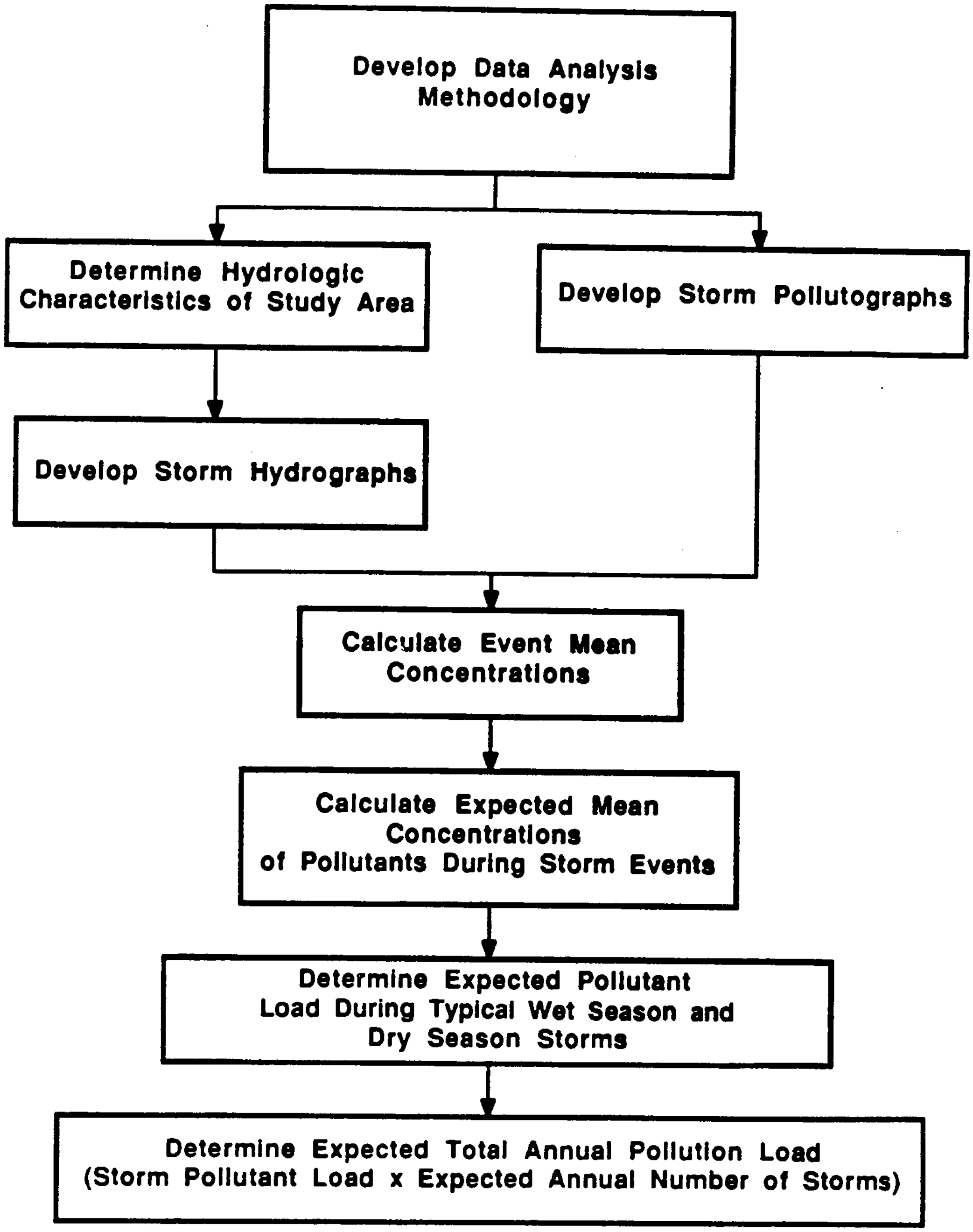

Figure 3-1 Data Analysis and Loading Calculation Methodology

SOURCE: Engineering-Science

storm-drain network information from the City of Los Angeles and the Los Angeles County Department of Public Works, along with other information on local runoff conditions. In drainage areas of substantial size, or where appropriate information was available, the drainage area for one outlet was subdivided into smaller units in order to permit the potential implementation of control projects at or within one or more of the smaller areas. As an example, the drainage area for Ballona Creek (Area 5) comprises more than 62 percent of the study area; drainage Area 5 was subdivided into 26 smaller areas that had the potential for applying individual control projects to each. This information on drainage areas and subareas was developed using a computerized geographic information system (GIS) to evaluate the spatial relationships between the storm drain system and area topography.

Land use was mapped for five major uses that are common over the entire study area: residential, commercial, light industrial, transportation, and dedicated open space (Exhibit 2). A description of these five major land uses are summarized in Appendix A. Information sources used for the development of the land-use map included:

- Los Angeles District Plan maps
- Los Angeles City zoning maps
- Los Angeles zoning consistency maps
- Culver City zoning and land-use maps
- Santa Monica zoning maps
- Beverly Hills zoning and land-use maps
- Thomas Guide Aerial Atlas

This land-use mapping information was also stored in the computerized GIS. When the two sets of mapped information (drainage area boundaries and land-use distribution) were combined, the resulting database provided an estimate of the percent occurrence of each land-use type within each drainage area and subarea. Table 3-1 shows the distributions of land uses by drainage basin. This information was used to develop information on potential target areas for applying stormwater runoff pollutant control projects, based on the results of the constituent sampling at each land-use collection site and models of runoff pollutant loading developed for the study area.

IDENTIFICATION OF IMPORTANT RUNOFF CONSTITUENTS

Selection Criteria

Development of criteria for the selection of pollutants for detailed study were based on a range of issues and concerns. The primary concern, resulting in the litigation between the City and the EPA, with active participation by a variety of citizen and environmental organizations, was that beneficial uses of Santa Monica Bay were threatened by pollutant input from stormwater and dry-season runoff flows. These uses included water-contact recreation (swimming, surfing, diving),

Table 3-1

Land Use Distribution By Drainage Basin

Drainage Basin	Residential Area (ha)	Residential Basin Area/Total Residential (%)	Commercial Area (ha)	Commercial Basin Area/Total Commercial (%)	Industrial Area (ha)	Industrial Basin Area/Total Industrial (%)	Transportation Area (ha)	Transportation Basin Area/Total Transportation (%)	Open Space Area (ha)	Open Space Basin Area/Total Open Space (%)
Area 1	28	0.11	0	0.00	404	14.45	18	0.57	6	0.04
Area 1A	53	0.20	16	0.37	160	5.72	10	0.31	7	0.05
Area 2	236	0.89	33	0.79	49	1.76	719	23.20	266	1.74
Area 3	418	1.58	32	0.76	3	0.12	8	0.25	186	1.22
Area 4	80	0.30	0	0.00	0	0.00	18	0.58	65	0.43
Area 5000	207	0.79	9	0.21	51	1.84	13	0.43	183	1.20
Area 5001	462	1.75	45	1.06	31	1.12	59	1.89	80	0.53
Area 5002	321	1.22	37	0.87	1	0.03	22	0.71	7	0.05
Area 5003	225	0.85	29	0.69	193	6.90	25	0.80	29	0.19
Area 5004	37	0.14	0	0.00	0	0.00	0	0.00	3	0.02
Area 5005	224	0.85	32	0.74	69	2.48	17	0.54	13	0.09
Area 5006	15	0.06	0	0.00	4	0.14	2	0.06	5	0.03
Area 5007	310	1.17	36	0.84	30	1.07	43	1.40	8	0.05
Area 5008	235	0.89	41	0.96	4	0.13	8	0.27	12	0.08
Area 5009	3025	11.45	895	21.04	82	2.92	288	9.29	630	4.13
Area 5-1-1	287	.09	6	0.14	41	1.46	25	0.80	3	0.02
Area 5-1-2	933	.53	91	2.13	208	7.45	137	4.42	79	0.52
Area 5100	352	.33	91	2.14	210	7.51	73	2.35	189	1.24
Total Area 5-1	1572	5.95	188	4.42	459	16.42	235	7.57	271	1.78

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Table 3-1 (Continued)

Land Use Distribution By Drainage Basin

Drainage Basin	Residential Area (ha)	Residential Basin Area/Total Residential (%)	Commercial Area (ha)	Commercial Basin Area/Total Commercial (%)	Industrial Area (ha)	Industrial Basin Area/Total Industrial (%)	Transportation Area (ha)	Transportation Basin Area/Total Transportation (%)	Open Space Area (ha)	Open Space Basin Area/Total Open Space (%)
Area 5-2-1	2406	9.10	384	9.04	46	1.64	195	6.30	1542	10.10
Area 5-2-2	668	2.53	176	4.13	113	4.04	82	2.66	36	0.24
Area 5200	267	1.01	2	0.05	0	0.00	25	0.80	6	0.04
Total Area 5-2	3340	12.64	562	13.23	159	5.68	303	9.76	1584	10.38
Area 5-3	263	0.99	32	0.74	25	0.89	8	0.26	28	0.18
Area 5-4-1	55	1.72	78	1.84	18	0.65	27	0.88	18	0.11
Area 5-4-2	525	1.99	0	0.00	0	0.00	35	1.12	399	2.62
Area 5-4-3	775	2.93	0	0.00	0	0.00	11	0.35	320	2.09
Area 5400	508	1.92	99	2.32	28	1.00	33	1.05	186	1.22
Total Area 5-4	2264	8.57	177	4.16	46	1.66	105	3.40	922	6.04
Area 5-5	2988	11.31	548	12.89	231	8.26	240	7.74	111	0.72
Area 5-6	1295	4.90	379	8.9	3401	14.33	181	5.84	83	0.54
Area 5-7	1150	4.35	185	4.36	8	0.28	82	2.63	42	0.28
Area 5-8	2446	9.26	466	10.96	138	4.93	188	6.06	638	4.18
Area 5-9	394	1.49	94	2.21	0	0.01	41	1.34	23	0.15
Total Area 5	20772	78.61	3755	88.32	1933	69.08	1860	59.98	4673	30.60
Area 6	399	1.51	19	0.44	66	2.34	29	0.94	77	0.51
Area 7	60	0.23	0	0.00	0	0.00	7	0.22	18	0.12
Area 8	35	0.13	4	0.10	1	0.03	7	0.24	18	0.12
Area 9	101	0.38	7	0.16	4	0.13	5	0.17	6	0.04

Table 3-1 (Continued)

Land Use Distribution By Drainage Basin

	Residential		Commercial		Industrial		Transportation		Open Space	
Drainage Basin	Area (ha)	Basin Area/ Total Residential (%)	Area (ha)	Basin Area/ Total Commercial (%)	Area (ha)	Basin Area/ Total Industrial (%)	Area (ha)	Basin Area/ Total Transportation (%)	Area (ha)	Basin Area/ Total Open Space (%)
Area 10	71	0.27	15	0.36	7	0.26	8	0.25	6	0.04
Area 11	636	2.41	93	2.18	16	0.57	74	2.40	38	0.25
Area 12	50	0.19	26	0.61	1	0.02	7	0.24	23	0.15
Area 13	965	3.65	126	2.97	154	5.50	81	2.60	353	2.31
Area 14	1	0.00	31	0.72			5	0.17	2	0.01
Area 15	218	0.82	80	1.89			33	1.05	45	0.29
Area 16	254	0.96	15	0.34			35	1.12	31	0.20
Area 1700	376	1.42					34	1.09	74	0.48
Area 17-1	268	1.01					18	0.57	1639	10.74
Area 17-2	242	0.92					0	0.00	723	4.73
Area 17-3	117	0.44					0	0.00	618	4.05
Total Area 17	1003	3.79					52	1.66	3054	20.00
Area 18	131	0.50					7	0.24	25	0.17
Area 19	109	0.41					8	0.25	555	3.63
Area 20	212	0.80					7	0.24	276	1.80
Area 21	49	0.19					7	0.24	3	0.02
Area 22	13	0.05					4	0.13	2	0.01
Area 23	389	1.47					13	0.411	374	9.00
Area 24	50	0.19					2	0.06	62	0.41
Area 25	25	0.10					3	0.09	1	0.01
Area 26	69	0.26					74	2.38	4098	26.83
TOTAL	26424	100.00	4252	100.00	2798	100.00	3101	100.00	15270	100.00

Source: Engineering-Science

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fishing, boating, and consumption of fish and shellfish. Concern for the future of the Bay as a viable habitat for marine flora and fauna was also a factor.

Criteria used for the final selection of pollutants to be addressed by the Study included:

- Identification with adverse effects on human health through water contact activities
- Identification with adverse biological effects in Santa Monica Bay
- Identification with adverse aesthetic effects in Santa Monica Bay and on beaches
- Public concern
- Contribution of stormwater runoff pollutant loading versus total pollutant loading in Santa Monica Bay
- Implementability of pollutant controls

Recommendations were taken from evaluation of the historical literature, input from meetings with the City staff and other interested groups, and discussions with the project's toxicologist, Dr. James Dahlgren, regarding exposure to potentially toxic materials through direct water contact.

Potential Pollutants of Concern

In previous studies in the Los Angeles area and elsewhere (Rimer, et al., 1978; Shelley and Gaboury, 1986; LACDPW, unpublished data), stormwater runoff samples have been analyzed for many conventional water quality parameters, as well as those known to be important in municipal wastewater treatment. In addition, other constituents have been suggested as being important; ultimately, a complete list of EPA priority pollutants could be examined. These include such major classes of pollutants as metals and inorganics, pesticides, PCBs and related compounds, halogenated aliphatics, ethers, monocyclic aromatics, phenols and cresols, phthalate esters, polycyclic (polynuclear) aromatic hydrocarbons (PAH-derived from petroleum and other chemical processes), nitrosamines, and other miscellaneous compounds.

All of these compounds are potentially present in runoff waters from heavily urbanized areas with diverse land uses and a wide variety of commercial and industrial practices and processes. These pollutants are highly compartmentalized between the water (suspended solids or dissolved), sediments (organic or inorganic fractions), and biota (phytoplankton, zooplankton, macrophytes, benthos, fish, birds, and mammals [Chapman, et al., 1982]). Some heavy metals and PAHs accumulate in the sea surface microlayer (i.e., upper 0.05 to 0.10 millimeter (mm) [Cross, et al., 1988]). PAHs are readily absorbed by particles and can be transported by stormwater runoff to receiving waters. PAHs can also accumulate in bottom sediments and they have the ability to bioaccumulate in marine organisms. Many PAHs are classified as carcinogens. Hence, different fractions of the stormwater runoff may need to be examined to obtain the greatest concentrations of these constituents. In addition, many of these pollutants vary in their volatility, ability to accumulate in the environment, and persistence (Chapman, et al., 1982).

Based on chemical properties and behavior, the most persistent, nonvolatile constituents that accumulate in the environment would be of most concern, and hence should be targeted in monitoring studies. These include many of the metals and inorganics (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc). Certain pesticides and PCB arochlors and PAHs also fall into this category. From the marine-life standpoint, those constituents that occur at acutely toxic concentrations would be of greater concern than those that cause sublethal effects, although these could also affect future generations of a species. From the human-health standpoint, human disease organisms and disease indicators, along with potential carcinogens, are important.

Human Disease Indicators

Human disease indicators - such as total coliform, fecal coliform, and enterococcus - are frequently examined in water quality samples. Coliform and fecal streptococcus (i.e., enterococcus) are common in fecal material and sewage, and are generally not pathogenic. These organisms are also frequently found at low levels in nonpoint-source runoff. Most bacteria causing infectious and enteric human diseases would be expected to enter the sea in municipal wastewater. Disease-causing enteric viruses (e.g., poliovirus, coxsackie virus, echovirus, and the virus that causes infectious hepatitis) have been found in sewage effluent, and these have been discovered in mussels in Marina del Rey and Ballona Creek. Recently, (1990) enteric viruses were demonstrated to exist in low-flow runoff entering Santa Monica Bay.

The nature of these indicators makes collections of samples difficult and rigorous. For example, such samples are not suitable for collection by automatic sampling devices left unattended for long periods. Also, collections need to be followed by almost immediate processing and analysis.

Carcinogens

Compounds considered carcinogens included dioxins, furans, and chlorophenols (Dahlgren, 1987, personal communication). Dioxins are produced as a byproduct of defoliants, by incineration of PCBs, and may occur in some waste oil (Dahlgren, 1987, personal communication; Sims, 1987, personal communication). Dioxins occur at parts per trillion levels in human fatty tissue. Other important contaminants are the organic compounds of mercury and other metals, as well as organophosphate, pyrethrate, and carbamate pesticides, phthalate esters (associated with plastics), and tetrachlorethane (a dry-cleaning solvent). Some of these compounds are highly volatile; the mechanical processes associated with stormwater runoff transport to locations where humans can be exposed are sufficiently severe to cause rapid volatilization in a very short time. The sampling method chosen for this study, although appropriate for addressing the requirements of the Consent Decree, was not suitable for collecting volatile organic materials; the unsealed head space in the collection device used would allow volatilization of these materials before the sample could be analyzed.

Selection of Target Pollutants for This Study

Target pollutants chosen for closer examination in storm-runoff and dry-season flows were selected by applying the criteria listed above to the range of potential pollutants. As discussed previously, effects on human health, whether through direct exposure or exposure to contaminated seafood, were the primary criteria. Pollutants chosen for more extensive analysis are presented on Table 3-2.

Several candidate constituents, examined in other stormwater studies, were not included in the analysis for this study. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were not considered health hazards in open Bay waters. The exposure paths of humans to phthalate esters and purgable organics are not through contact with marine waters. Chlorinated hydrocarbons are commonly found in soot, which is prevalent over wide areas, not lending toward straightforward determination of source. Also, total coliform and fecal coliform bacteria are common in runoff from a variety of sources, which does not lend toward straightforward determination of source.

Runoff pollutant reduction recommendations developed in this report may contain measures that will be effective in reducing the loading of chosen pollutants and cover additional pollutants not specifically sampled for this study. Limitations in the scope and purpose of this study, as defined previously, preclude a complete analytical treatment of runoff constituents. Additionally, control measures recommended for those constituents that were included on the analysis list will also be effective in controlling many of the substances not tested for, as many of the latter are contained in the same water-column pollutant fractions (particulate or lipid-soluble) that the control technologies recommended in this study are designed to reduce.

SELECTION OF DETAILED STUDY AREAS

Selection of areas for detailed study was based on the need to characterize stormwater runoff traits and identify candidate areas for control of key pollutants. The methodology developed anticipated the need to identify runoff pollutant loads by land-use types occurring within the study region, and to prescribe pollutant-reduction techniques that were specific to different land-use types.

The methodology for selection of areas for detailed study included development of information on land use, drainage patterns, and availability of access to drains to collect stormwater data. Selection of candidate areas for detailed study was based on the need to collect information on homogeneous land-use types that could be isolated for purposes of monitoring without interference from other activities. Characteristics included the need to identify a single location draining an area representative of the single land-use type to monitor runoff volumes and stormwater pollutant values. Land-use and drainage maps and aerial photographs of areas were analyzed for candidate sites satisfying the above criteria.

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Table 3-2

Pollutants Analyzed for Runoff Study

Pollutants Selected	Analytical Method Used	Source
Enterococcus bacteria	910	Standard Methods, 1985 [APHA]
Suspended solids	209C	Standard Methods, 1985 [APHA]
Oil and Grease	413.2	EPA, 1979
Particulate-Associated Pollutants		
Metals		
Arsenic	206.3	EPA, 1979
Cadmium	213.1	EPA, 1979
Chromium	218.1	EPA, 1979
Copper	220.1	EPA, 1979
Lead	239.1	EPA, 1979
Mercury	245.5	EPA, 1979
Nickel	249.1	EPA, 1979
Silver	272.1	EPA, 1979
Zinc	289.1	EPA, 1979
Organics		
Dioxins	613	EPA, 1982
Polynuclear Aromatic Hydrocarbons (PAHs)	610	EPA, 1982
Lipid Soluble-Associated Pollutants		
Pesticides and PCBs	608	EPA, 1982
Chlorophenoxy Acid Herbicides	8150	EPA, 1982

Source: Engineering-Science

Criteria used in choosing specific areas for study included:

- Land uses composing a significant percentage of the study area
- Land uses deemed to contribute significant pollutant loading based on historical information

Candidate areas were identified for each of the four land-use types to be evaluated by runoff sample collections (light industrial, commercial, residential, and transportation). In addition, a monitoring location that provided integrated information on the above land-use types was chosen. All of the areas were located within the Ballona Creek watershed. Each area was inspected to verify the land-use types within the area drained, to identify monitoring locations, and to isolate any potential problems in data collection not apparent from the evaluation of land-use and drainage maps and aerial photographs. The location of the monitoring station was verified in the field for each candidate area.

- Location of a land-use area of sufficient size to extrapolate to the overall study area
- Area "representative" of citywide land use
- Ability to sample a single land use from a single drain
- Location within the Santa Monica Bay drainage area
- Location within the City of Los Angeles, if possible

The candidate areas were screened against the selection criteria. Several of the candidate sites were deleted because of land-use types that were not representative of the mapped classification, drainage patterns that did not correspond with mapped information, and problems in gaining access for field monitoring. The field inspection also identified potential problems in collecting representative samples of areas upstream because of incomplete mixing or in monitoring flow volumes at the confluence of several flow streams where backwater conditions may interfere with the accuracy of flow readings.

To increase the effectiveness of any proposed pollutant-reduction measures or projects, the monitoring program focused on data collection, analysis, and control strategies that correlated these factors to specific land-use types that produce the highest loadings, and concentrations of key pollutants. For instance, studies have demonstrated that transportation facilities (e.g., highways) contribute high concentrations and a significant percentage of the loading of PAHs (Hoffman, et al., 1984). By evaluating areas used for transportation for both the percent contribution to this loading and for potential control strategies, the most effective control projects for this pollutant are likely to be identified.

The locations of study sampling locations are listed on Table 3-3. Detailed hydrographs of the areas are included as Appendix A-1.

RUNOFF SAMPLE COLLECTION AND CONSTITUENT ANALYSIS

Both stormwater runoff and dry weather runoff were sampled to develop estimates of pollutant concentrations during both wet and dry season runoff flows.

Stormwater Samples

Stormwater runoff samples were collected at each of the five chosen locations (Table 3-3) using automatic water collection pump samplers (ISCO Model 2700) to collect discrete samples at specified intervals. In examining stormwater runoff studies in the literature, the curve of runoff pollutant concentration versus time indicated that many of the major pollutants are mobilized early in the storm event (e.g. Hoffman, et al., 1984). Because a rainfall event could occur in the middle of the night or on very short notice, automated samplers left in place for extended

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Table 3-3

Locations of Land Use Sampling Stations

Land Use[a]	Drainage Area (N-E-S-W Boundaries)	Area (ha)	Sampling Access
Residential	West Adams (25th-Saint Andrews-Jefferson-Arlington)	38	Manhole on Cimmaron Street
Commercial	Los Angeles (Olympic-Grand 12th-Figueroa)	15	Manhole on 12th Street
Light Industrial	Los Angeles (22nd-Main-Adams-Hope)	23	Manhole on Adams Boulevard
Transportation	West Adams (I-10 Freeway between Western-Crenshaw)	11	Manhole on Bronson Avenue
Combined Use[b]	Ballona Creek	52,000	Bridge on Centinella Avenue

Source: Engineering-Science
[a] Using City of Los Angeles Land Use Criteria
[b] Location Collects from Several Land Use Types

periods were the only feasible means of capturing the leading edge of the runoff event. As discussed previously, this collection scheme restricted the number and type of runoff constituents that could be successfully sampled.

Each sampler was coupled with a flow-monitoring device programmed to activate the sampler based on a preprogrammed increase in flow rate within the storm drain resulting from rainfall runoff. The samplers themselves were time-programmable, allowing a fixed or variable time interval between sample collections. The sampling interval was determined by examining historical duration and intensity data for rainfall events in the study area. A 15- to 30-minute interval was used for collections during the first events sampled. A 1-hour interval was used during later events to provide a picture of runoff loading over more extended periods.

Collection of water samples from storm drains was initiated soon after the beginning of the rainfall event, as the flow meters monitoring runoff levels were triggered by the increase in flow and activated the samplers. Sample collection continued until runoff flows dropped to their pre-event levels, or until all sample bottles were filled. Bottles were replaced as necessary to collect samples over the duration of elevated flows.

The volume of samples collected was sufficient to satisfy requirements of the analyzing laboratory to complete testing, using EPA or APHA methodology (Table 3-2). Filling of multiple bottles was frequently necessary for each sample to satisfy analysis requirements. Strict adherence to preservation techniques, handling, holding times, and other analysis protocols was observed.

Collection and analysis of water samples for enterococcus group bacteria was complicated by the need for sterile equipment and methods during sampling. It was, therefore, impractical to collect enterococcus samples using the automatic samplers deployed in the study area. Bacterial samples were collected by hand, using appropriate sterile techniques, by technicians while servicing the samplers during the rainfall event. This restricted the number of samples at each location, and did not allow for time-synchronous collections. As a result of these factors, bacterial samples were considered less important than other constituents because of their frequent occurrence in runoff samples and their lower potential for effective control, and were not a significant factor in the eventual evaluation and development of runoff pollutant control measures.

Dry-Weather Flows

For the collection of dry-season flow samples, automated samplers equipped with recording flowmeters were deployed in the same land-use areas as those for which stormwater runoff flows were collected. A 24-hour composite sample was collected at each site by combining 24 discrete hourly samples collected over a 24-hour period. Analytical methods for constituent analyses were identical to those used for storm runoff samples.

Water Sample Analysis Methodology

Standard analytical methods from EPA and APHA Methods (Table 3-2) were used for constituent analysis. These methods were used to allow comparability with previous and future stormwater runoff constituent studies. All chemical analyses, except dioxin and enterococcus group bacteria, were performed by Global Geochemistry Consultants in Canoga Park. Dioxin analyses were performed by California Analytical Laboratories in Sacramento. Bacteria analyses were performed by Brown & Caldwell Laboratories in Pasadena.

ANALYSIS OF RAINFALL RECORDS

Determining the runoff flows associated with storm events is of particular importance in estimating total pollutant loads. The sampling program in this study included runoff flow measurements in the field in conjunction with water sampling for runoff pollutants (using ISCO Model 2870 flowmeters). The intermittent nature and wide variability of volume of runoff flows adversely affects flowmeter performance. The range of flows to be monitored requires the flowmeter record to be fairly coarse. To supplement the field information, an analysis of the areal and temporal distribution of the storm events sampled as part of this study was also performed. The objective of this analysis was to estimate more completely the actual rainfall causing the runoff from which water samples were taken for laboratory analysis. Four storm events occurring in 1988 were analyzed. Continuous rainfall data were obtained from recording stations within the drainage area. Rainfall records were provided by the City of Los Angeles and the Los Angeles County Department of Public Works. These agencies manage separate rainfall-monitoring networks that span the entire Los Angeles Basin. The recording stations used in the analysis are indicated on Table 3-4. Only automatic recording stations were selected, as continuous records of rainfall are required for temporal analysis. The Kriging interpolation technique (Tabios and Salas, 1985) was used to define regression equations representing rainfall estimates at each site based on the recording stations' data (Appendix B-1-1).

The total rainfall estimates for the detailed study areas during each of the storm events analyzed are indicated on Table 3-5. Except for the unusually heavy storm of 27 February through 2 March, rainfall was quite constant for all storms at all locations. An example of one of the rainfall hyetographs is shown in Figure 3-2. A complete description of the data and methodology used to develop these rainfall estimates is included in Appendix B-1-1.

TYPICAL STORM STUDY

Determination of the total wet-weather pollutant load into Santa Monica Bay was based on storm runoff flows and pollutant concentrations estimated from sample flowmeter records, analysis of areal rainfall data, and constituent analysis of collected samples. Pollutant concentrations were obtained from the sampling program results. Runoff flows, on the other hand, involved conducting an analysis of rainfall records.

Conventional hydrologic methods have been established to estimate intensity-duration-frequency relationships for infrequent events because of the emphasis placed in the past on rainfall studies aimed at flood-control practices. From the standpoint of pollution control, however, low-return-period storms are significantly more important because of their considerably higher pollution load per unit volume and the economic considerations regarding the design of structural pollution control facilities.

The concept of the "typical" storm was used to develop rainfall runoff and subsequent runoff pollutant loading estimates. Unlike the long-return-period case, for which data are selected to form a partial duration series for the analysis, the typical storm study required analyzing an entire period of record. Hourly rainfall records at the Los Angeles Airport National Weather Service station (No. 045114) for the years 1949 through 1987 were used in the analysis. The statistical analysis was carried out by using the Synoptic Rainfall Data Analysis Program (SYNOP)(EPA, n.d.). Table 3-6 is a summary of SYNOP statistics for the Los Angeles Airport data. Modifications of these results were made to represent the characteristics of the whole study area, based on annual average rainfall and 1-hour

Table 3-4

Automatic Rainfall Recording Stations

Location	ID Number County	ID Number City	Elevation (Feet)	Coordinates
Hancock Park	213G	---	200	34°03'52"N 118°21'17"W
Little Canyon	755	1A	900	34°07'32"N 118°16'58"W
Ferndell	757	6A	750	34°07'12"N 118°18'20"W
Silver Lake	---	51A	445	34°06'08"N 118°15'54"W
Elysian Heights School	772	28A	475	34°05'02"N 118°15'11"W
Irwin C. Technical Building	---	41A	329	34°03'20"N 118°13'44"W
Inglewood	116F	---	153	33°57'53"N 118°21'22"W
Culver City	1269	---	38	33°59'54"N 118°24'05"W
Los Angeles - 96th and Central Avenue	291	---	121	33°56'56"N 118°15'17"W

Source: City of Los Angeles, Los Angeles County Department of Public Works, 1988

peak-intensity contours at two identified geographical regions in the study area; the coastal plain and the mountain area. Figure 3-3 shows the geographical regions in the study area. The coastal plain comprises about two-thirds of the whole area. The peak intensity of the 50-year storm is relatively constant throughout this area and averages 34 mm/hour. The average annual rainfall varies between 305 and 460 mm. Events in the mountain area have widely varying peak intensities that range between 34 and 50 mm/hour. The annual rainfall varies between 430 and 610 mm.

Separate rainfall hyetograph patterns were developed for the wet (November through April) and dry seasons (May through October) for the two geographical regions. Figure 3-4, shows typical distributions of rainfall in the coastal plain of

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Table 3-5

Total Rainfall by Detailed Study Area

	Rainfall (millimeter)			
Storm Event (1988)	Residential	Commercial	Industrial	Transportation
February 27 through March 2	65	53	47	64
April 14 and 15	12	13	13	11
November 13 and 14	17	14	16	17
November 23 through 25	10	11	10	9

Source: Engineering-Science

the study area during a 24-hour period for a wet season and a dry season storm, respectively. From examination of the two hyetographs, it is reasonable to assume that the storm pattern is the same during both the wet-weather and the dry-weather storms.

POLLUTANT LOADING ANALYSIS

This section of the report includes an estimation of the magnitude of wet- and dry-weather runoff pollutant discharges from the study area into Santa Monica Bay. The large runoff volumes resulting from periodic rainfall events in the area are associated with large pollutant loads entering the Bay over a short time period. Lower-volume dry-weather runoff produces relatively small pollutant loads over equivalent time scales, but these discharges extend throughout the year. Because of the obvious hydrologic differences, wet- and dry-weather loading estimates are calculated separately.

For this study, wet weather is defined as any storm event occurring during the year. The commonly-accepted terms of wet season (November through April) and dry season (May through October) are used here in the same context. As displayed on Table 3-6, most storms occur during the wet season (an average of 12.2 per year), but some occur during the dry season (average of 1.3 per year). Wet weather loading is the result of these storm events during both wet and dry seasons. Dry weather loading occurs year-round (during both seasons) on days when storm events do not occur.

Discussions of the assimilative capacity of the receiving waters, and the extent of impact on the receiving environment by this loading, are beyond the scope of this study. The comparative loading rates for wet- and dry-weather runoffs developed in this study, however, will be an integral part of any such environmental or biological evaluation of pollutant inputs to Santa Monica Bay.

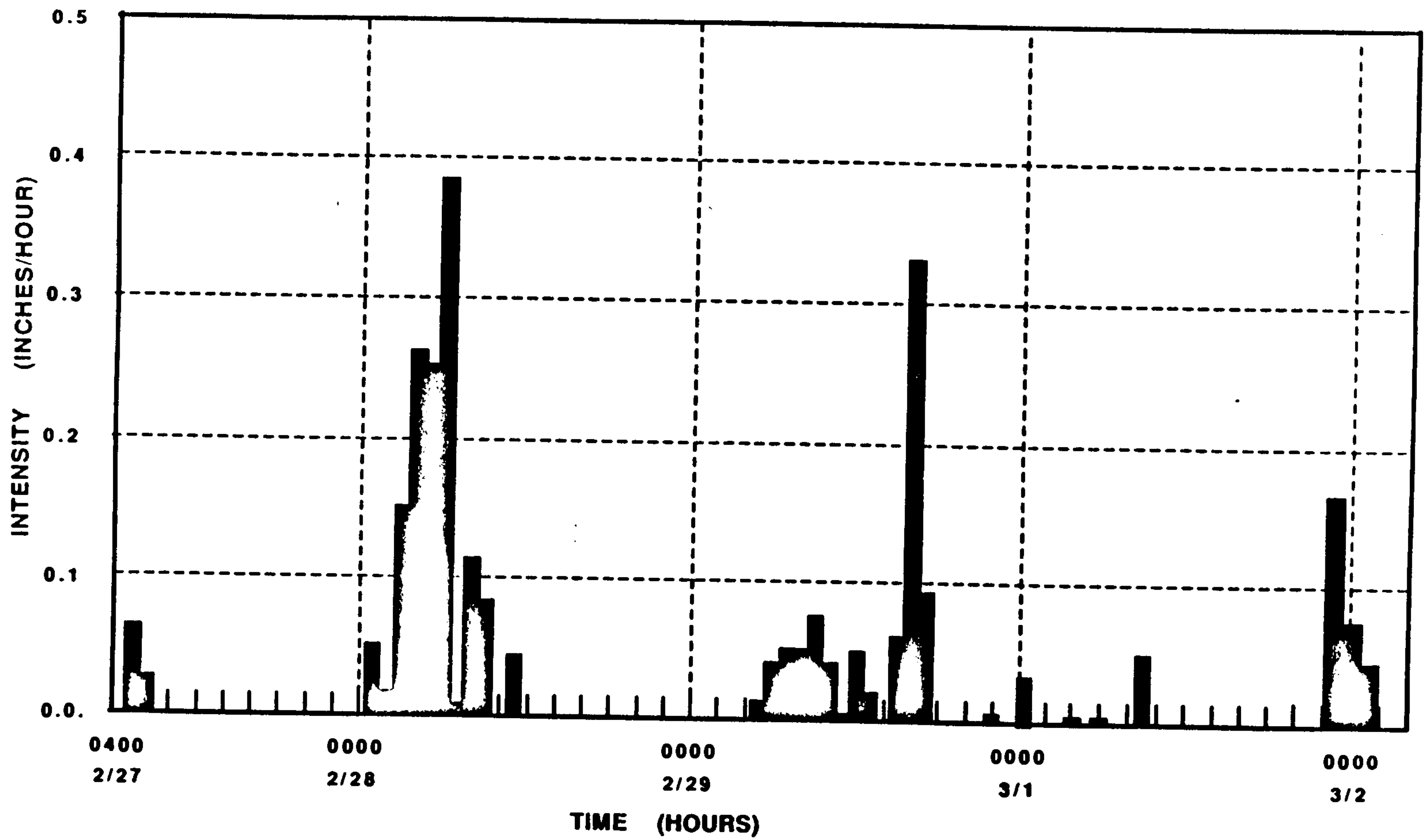

Figure 3-2 27 February - 2 March 1988 Storm - Rainfall Intensity in Transportation Area

SOURCE: City of Los Angeles and Los Angeles County Department of Public Works Rainfall Data, 1988

Table 3-6

Summary Table of SYNOP Statistics for Los Angeles International Airport (1949 to 1987)

Month	No. of Storms	Total Volume (inches)	Volume Average (inches)	Volume CV*	Duration Average (hours)	Duration CV	Intensity Average (in/hrs)	Intensity CV	Delta** Average (hours)	Delta** CV
<u>Wet Season</u>										
November	1.54	1.578	1.03	1.07	22.28	0.83	0.06	0.81	161	0.54
December	2.03	1.559	0.77	1.00	21.70	0.86	0.04	0.72	218	1.00
January	2.59	2.806	1.08	1.10	27.97	1.05	0.05	0.70	258	1.06
February	2.05	2.623	1.28	1.37	33.72	1.13	0.05	1.17	237	0.94
March	2.54	1.656	0.65	1.04	19.65	1.05	0.05	0.86	204	0.89
April	1.46	0.809	0.55	0.91	18.91	1.03	0.04	0.78	306	1.00
<u>Wet Season</u>										
November-April Summary	12.21	11.032	0.90	1.24	24.36	1.07	0.05	0.87	234	1.00
<u>Dry Season</u>										
May	0.26	0.116	0.45	1.53	51.60	0.88	0.02	1.23	232	0.62
June	0.08	0.020	0.26	0.14	16.00	0.44	0.02	0.54		1.00
July	0.03	0.004	0.15		8.00		0.01		1768	
August	0.15	0.111	0.72	1.28	26.17	1.32	0.08	1.01	1224	0.62
September	0.38	0.245	0.64	1.14	41.87	1.52	0.03	1.02	816	1.14
October	0.44	0.204	0.47	1.07	23.12	1.14	0.06	1.31	1132	1.07
<u>Dry Season</u>										
May-October Summary	1.33	0.701	0.53	1.22	33.65	1.32	0.04	1.36	967	0.98

Source: City of Los Angeles, 1988

* CV = Coefficient of variation = standard deviation / mean

** Delta = Time between storm midpoints

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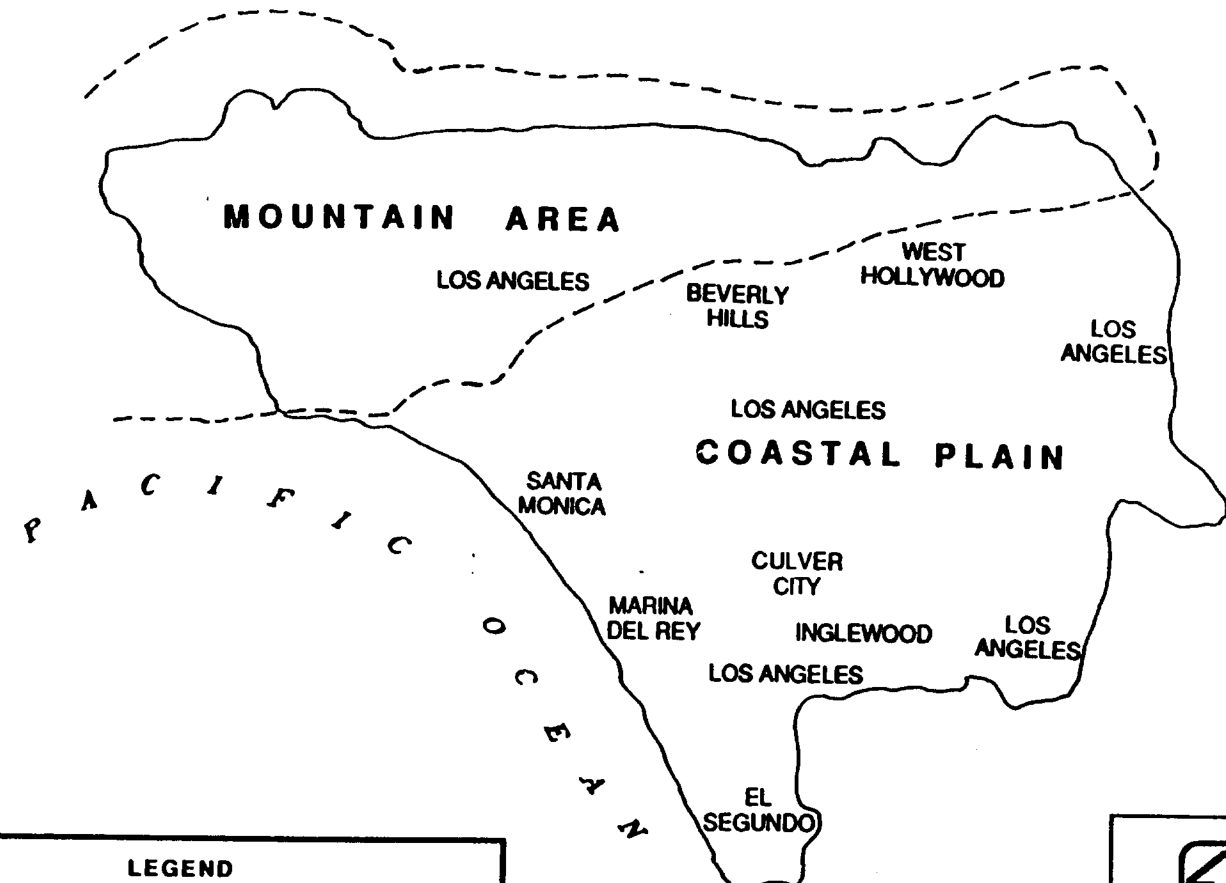

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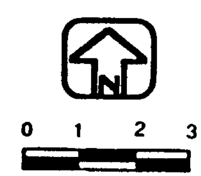
------- BOUNDARY OF SANTA MONICA MOUNTAINS FOR RAINFALL HYETOGRAPHS

SOURCE: Engineering-Science

Figure 3-3 Study Area Divided into Coastal Plain and Mountain Areas



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Wet-Weather Pollutant Loading Analysis

The expected stormwater-related annual pollutant load for the entire study area was developed by summing the contributions of runoff pollutants from each land-use category and drainage basin.

Data Analysis Methodology

The methodology for determining expected mean stormwater runoff pollutant concentrations was based primarily on the findings and recommendations indicated in the Final Report of the Nationwide Urban Runoff Program (NURP) conducted by EPA between 1977 and 1982 (EPA, 1983). The process takes into account the relationship between pollutant concentrations and the corresponding runoff volumes at several points in time during a given rainfall event. It permits the assessment of pollutant load from spatial and temporal points of view. In this study, the spatial analysis was used to determine the runoff quality from different land-use types and drainage basins within the study area. The objective of the temporal analysis was to determine the significance of the time response of pollutant washoff as compared to runoff occurrence.

A basic assumption incorporated into the NURP methodology is that urban runoff flow and urban runoff pollutant concentration can be treated as independent random variables. Pollutant concentrations are characterized by a parameter known as the event mean concentration (EMC). EPA defines EMC as the total mass of pollutant discharged during a storm event divided by the corresponding runoff volume. The calculation of the EMC value for a particular storm at a given site, therefore, requires correlating a storm's hydrograph and the corresponding pollutograph.

Storm Hydrographs. In the present study, runoff hydrographs were determined primarily by flow measurements in the field. When that information was not available, rainfall data were used to develop synthetic hydrographs for the particular sites and storms by using the SCS unit hydrograph method (McCuen, 1984). The 1988 rainfall events for which hydrographs were available for analysis occurred on 14 and 15 April, 13 November, and 25 November. As an example, Figure 3-5 shows plots of the hydrographs obtained at the commercial land-use study area. Plots of all other hydrographs developed from flow measurements in the field are included in Appendix A-1.

Synthetic storm hydrographs (a hydrograph for an entire storm) were obtained by aggregating unit hydrographs (a hydrograph for a specific area over a short period of time) over the storm duration. The values of the calculation variables were calibrated by using flow data from the study area collections. The SCS unit hydrograph method is particularly suited for local conditions because, as indicated above, the duration of a typical precipitation event in the study area is 24 hours. This method is based on the following main relationships:

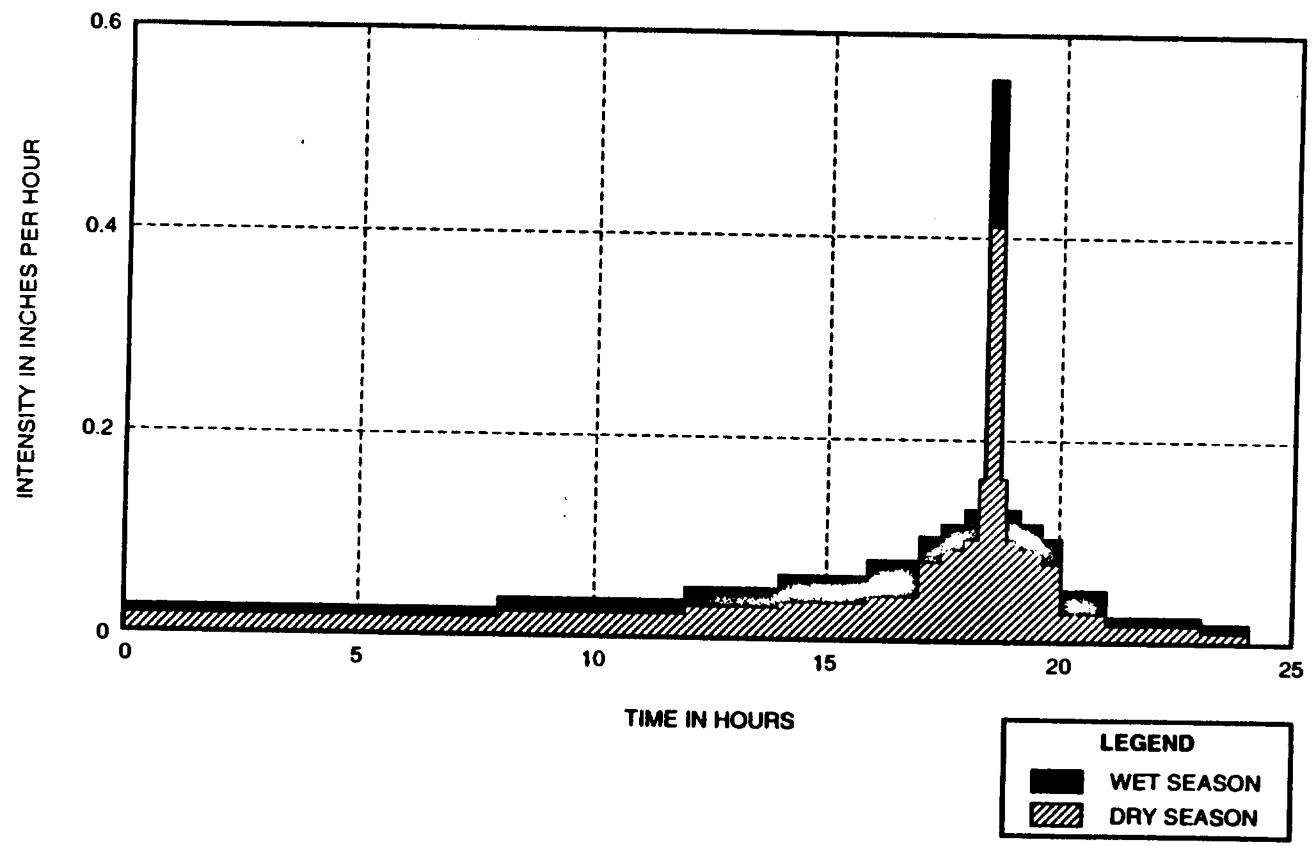

Figure 3-4
Coastal Plain Hyetographs for Typical Wet and Dry Season Storms in the Study Area

SOURCE: Los Angeles County Department of Public Works, 1988

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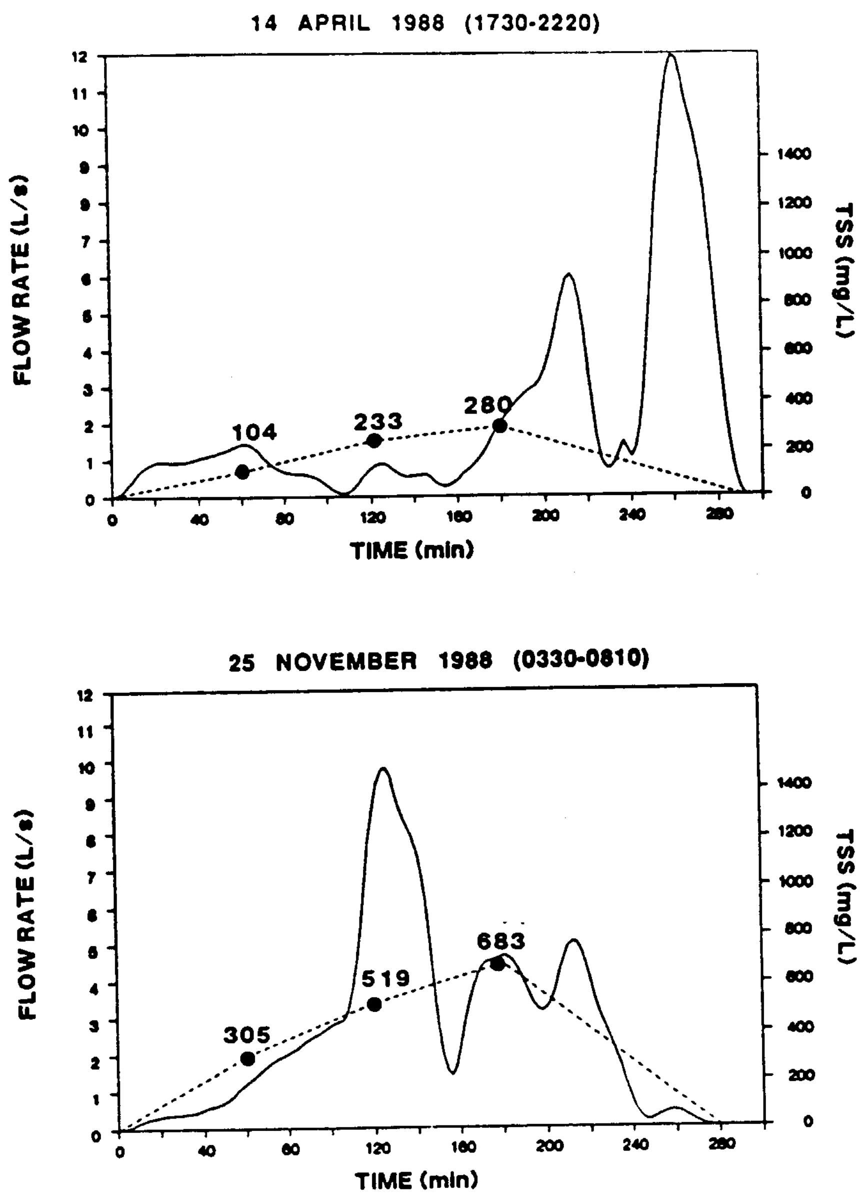

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min	MINUTES
TSS	TOTAL SUSPENDED SOLIDS
L/s	LITERS PER SECOND
mg/L	MILLIGRAMS PER LITER
———	FLOW RATE vs. TIME
- - - - -	TSS vs. TIME
104 ●	TSS CONCENTRATIONS

SOURCE: Engineering-Science

Figure 3-5 Commercial Area Hydrograph

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$$Q_p = \frac{KAR}{T_c}; \qquad R = \frac{(P - 0.2\,S)}{(P + 0.8\,S)}; \qquad S = \frac{1{,}000}{CN} - 10$$

where:

Q_p	=	Peak unit hydrograph discharge
K	=	Constant
A	=	Drainage area
R	=	Depth of excess precipitation (runoff)
T_c	=	Time of concentration
P	=	Depth of precipitation
S	=	Potential maximum retention
CN	=	SCS curve number

The calibration procedure was also used for defining runoff:rainfall relationships for the typical storms for each land-use category, as shown on Table 3-7. Because no data were available for the agricultural land use, a CN value of 80 was assumed, based on literature information (Colston, 1974).

Pollutant Concentrations. Data on runoff pollutant concentrations at each detailed study area site were obtained from analyses of samples collected during rainfall events. As an example, total suspended solids pollutographs for the commercial area are also shown in Figure 3-5 for two sampled storms. Concentrations at the beginning and end of each event were assumed to be zero. TSS pollutographs at the other sites sampled are included in Appendix A-1.

In some cases, pollutant concentrations in collected samples (if present at all) fell below laboratory detection limits for the analysis method used (i.e. they were reported as "not detected"). The detection limit is the minimum concentration of a substance that can be measured by the laboratory procedure used in the analysis of the samples. Consistent with EPA criteria, the pollution discharge analysis was carried out by assuming that the "notdetected" concentration values were equal to one-half the detection limits. The mass load of a given pollutant (mass load = flow x concentration) discharged in the period between two successive samples during a storm was assumed to be equal to the product of the samples' average pollutant concentration times the corresponding runoff volume passing the sampling station during that particular sampling period. The storm's total pollutant mass load was then calculated as the sum of the partial mass loads over the storm duration. The storm's EMC is equal to the storm's total pollutant load divided by the total runoff volume. An EMC was developed for each land use designation for each pollutant constituent.

In cases when only one pollutant concentration datum was obtained during the storm, it was assumed that this value represented the storm's mean concentration. This procedure was used in a total of five cases at three different land uses. Lack of pollutant concentration data are due to insufficient runoff flows during the time of sampling and sampler malfunctions.

Table 3-7

Rainfall and Runoff Characteristics
During Typical Wet-Season and Dry-Season Storms

Season	Region	Land Use	Rainfall (cm)	Runoff (cm)	Runoff as % of Rainfall
Wet	Coastal	Residential	2.87	0.78	0.27
		Commercial		1.29	0.45
		Industrial		0.86	0.30
		Transportation		2.32	0.81
		Open Space		0.55	0.19
	Mountain	Residential	3.99	1.48	0.37
		Commercial		2.19	0.55
		Industrial		1.60	0.40
		Transportation		3.43	0.86
		Open Space		1.16	0.29
Dry	Coastal	Residential	1.68	0.18	0.11
		Commercial		0.44	0.26
		Industrial		0.22	0.13
		Transportation		1.19	0.71
		Open Space		0.08	0.05
	Mountain	Residential	2.34	0.47	0.20
		Commercial		0.54	0.23
		Industrial		0.86	0.37
		Transportation		1.82	0.78
		Open Space		0.30	0.13

Source: Engineering-Science
cm = centimeters

In previous studies, including NURP, the log-normal distribution has been found to adequately represent the underlying probability density function of EMC values of all sampled storms for a given area, both from physical considerations (e.g., pollutant concentrations can never be negative) and through the multiplicative effects involved in stormwater runoff pollution processes. The small number of data points obtained in this study does not allow for the computation of all the statistical parameters of the underlying EMC probability density function. The most likely estimator of the concentration of a given pollutant per event can, however, be assumed equal to the geometric mean of the EMCs (EPA, 1983). The EMCs for measured constituents for each storm sampled during the study are shown on Tables 3-8 through 3-11. The geometric mean of the EMCs is expressed as the estimated mean concentration.

Table 3-11 shows two values of EMC geometric means for the transportation area. This resulted from the use of stormwater runoff pollution data collected by the Federal Highway Administration (FHwA). In 1981, the FHwA conducted several research programs throughout the United States to characterize stormwater runoff from highways. One of the sites analyzed was a 950-ft stretch of road surface on the San Diego Freeway, two miles from the Los Angeles Airport (Driscoll, et al., 1988). Table 3-12 shows the results from the FHwA study in terms of EMC values for several pollutants. The results from the FHwA research program have been included in the data analysis for this study because they represent information based on very similar land use designation and sampling methods. Inclusion of the FHwA information made the analysis more consistent with values reported in the literature, especially those resulting from the nationwide FHwA program. Table 3-11 shows the values obtained with the current data as well as those resulting from combining the FHwA and the current data. While the impact of the inclusion of this "outside" information on study results is significant, inclusion is reasonable since the sampling site and techniques meet all criteria set out for this study.

Significance of Pollutant Estimated Mean Concentrations. To identify stormwater pollutants exceeding water quality criteria established for California coastal waters, the estimated mean concentrations of pollutants shown on Tables 3-8 through 3-11 were compared with the instantaneous maximum concentration standards established in the California Ocean Plan (SWRCB, 1990). The results indicate that standards for many of the pollutants are often exceeded. TSS standards are exceeded at an average of approximately 3:1 for all land uses, with highest exceedance ratios in the commercial and transportation land uses. Lead is the heavy metal with highest ratios (average 12:1) in the residential, transportation, and commercial land uses. Its exceedance ratio in the light industrial land use is about 3:1. Concentrations of pesticides also exceeded standards in the residential and light industrial areas. The transportation area also shows high ratios for pesticides, possibly resulting from contamination from nearby residential areas. On an areawide basis, oil and grease in storm runoff appear not to pose significant pollution problems in the study area when compared to Ocean Plan standards.

Importance of Total Suspended Solids in Runoff. The objective of this study was to identify approaches for control of pollutants in stormwater runoff. Because many control measures concentrate on the removal of TSS, two relationships were investigated using information gathered during this study: the ratio of dissolved to total metals in the sampled runoff, and the correlation between TSS and the other target pollutants.

Table 3-13 shows the ratios of dissolved to total metals by land-use category. These ratios were obtained exclusively for those storms showing actual measured dissolved metal concentrations; that is, the two storms at the residential land-use site and one storm at each of the other three sites. The overall average ratio equals 38 percent. Because of the numerous nondetected values in the samples, the real value of the overall average ratio is probably lower than 38 percent.

Table 3-8

Residential Land-Use Runoff Pollutant Concentrations

Constituent		Event Mean Concentration			Estimated Mean Concentration	Ocean Plan Standards[a]	Estimated Mean Standards	Comparable Studies
		Event Date						
		4/15/88	11/14/88	11/25/88				
O&G	mg/L	12.5	57.7	0.9	8.8	75	0.12	
TSS	mg/L	69	1839	17	130	60	2.17	128-180 [b]
Arsenic (tot)	mg/L	0.0030	0.0390	0.0036	0.0075	0.0800	0.09	
Cadmium (tot)	mg/L	0.0200	0.0484	0.0113	0.0222	0.0100	2.22	0.01 [c]
Chromium (tot)	mg/L	0.0110	0.1233	0.0022	0.0145	0.0200	0.72	0.02 [c]
Copper (tot)	mg/L	0.0430	0.8950	0.0801	0.1456	0.0300	4.85	0.023 - 0.09 [b,c]
Lead (tot)	mg/L	0.2400	2.7780	0.0200	0.2371	0.0200	11.86	0.09 - 0.53 [b,c]
Nickel (tot)	mg/L	0.0250	0.1808	0.0025	0.0224	0.0500	0.45	0.02 - 0.03 [c]
Zinc (tot)	mg/L	0.5700	5.5547	0.7795	1.3514	0.2000	6.76	0.11 - 1.23 [b,c]
Silver (tot)	mg/L	0.0002	0.0023	0.0017	0.0009	0.0070	0.13	
Mercury (tot)	mg/L	0.0003	0.0044	0.0005	0.0008	0.0004	2.12	0.0002 [c]
Herbicides	ug/L	2.5000	4.4609	2.5000	3.0323	10.0000	0.30	
Pesticides	ug/L	0.4700	0.4514	0.0167	0.1524	0.0090	16.94	
Enterococcus	#/100ml	8300						

Source: Engineering-Science
[a] Instantaneous maximum concentrations, or 30-day average, as applicable (SWRCB, 1990)
[b] EPA, 1983
[c] Weeks, 1982
TSS = total suspended solids
O&G = oil and grease
tot = total
mg/L = milligrams per liter
ug/L = micrograms per liter
ml = milliliters

Table 3-9

Commercial Land Use Runoff Pollutant Concentrations

Constituent		Event Mean Concentration		Estimated Mean Concentration	Ocean Plan Standards[a]	Estimated Mean Standards	Comparable Studies
		Event Date					
		4/14/88	11/25/88				
O&G	mg/L	5.6	4.8	5.2	75	0.07	
TSS	mg/L	129	517	258	60	4.30	41 - 92[b]
Arsenic (tot)	mg/L	0.0020	0.0087	0.0042	0.0800	0.05	
Cadmium (tot)	mg/L	0.0101	0.0070	0.0084	0.0100	0.84	
Chromium (tot)	mg/L	0.0211	0.0714	0.0388	0.0200	1.94	
Copper (tot)	mg/L	0.0237	0.1692	0.0633	0.0300	2.11	0.019 - 0.045[b]
Lead (tot)	mg/L	0.1710	0.3427	0.2421	0.0200	12.10	0.075 - 0.15[b]
Nickel (tot)	mg/L	0.0250	0.0280	0.0265	0.0500	0.53	
Zinc (tot)	mg/L	0.4324	1.6119	0.8348	0.2000	4.17	0.15 - 0.335[b]
Silver (tot)	mg/L	0.0002	0.0022	0.0007	0.0070	0.10	
Mercury (tot)	mg/L	0.0005	0.0007	0.0006	0.0004	1.46	
Herbicides	ug/L	2.2018	3.7575	2.8763	10.0000	0.29	
Pesticides	ug/L	0.1379	0.0428	0.0768	0.0090	8.53	

Source: Engineering-Science

[a] Instantaneous maximum concentrations, or 30-day average, as applicable (SWRCB, 1990)

[b] EPA (1983)

TSS = total suspended solids

O&G = oil and grease

mg/L = milligrams per liter

ug/L = micrograms per liter

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Table 3-10

Light Industrial Land Use Runoff Pollutant Concentrations

Constituents		Event Mean Concentration (Event Date) 4/14/88	Event Mean Concentration (Event Date) 11/25/88	Estimated Mean Concentration	Ocean Plan Standards[a]	Estimated Mean Standards	Comparable Studies
O&G	mg/L	11.5	6.2	8.5	75	0.11	
TSS	mg/L	98	101	99	60	1.66	
Arsenic (tot)	mg/L	0.0043	0.0070	0.0055	0.0800	0.07	
Cadmium (tot)	mg/L	0.0222	0.0200	0.0211	0.0100	2.11	0 - 0.013 [b,c]
Chromium (tot)	mg/L	0.0142	0.0380	0.0232	0.0200	1.16	0 - 0.58 [b,c]
Copper (tot)	mg/L	0.0858	0.1230	0.1027	0.0300	3.42	0.019 - 0.48 [b,c]
Lead (tot)	mg/L	0.2109	0.0200	0.0650	0.0200	3.25	
Lead (diss)	mg/L	0.0374	0.0200	0.0273			0.075 - 0.49 [b,c]
Nickel (tot)	mg/L	0.0369	0.0250	0.0304	0.0500	0.61	
Zinc (tot)	mg/L	1.0287	1.1400	1.0829	0.2000	5.41	0.02 [c]
Zinc (diss)	mg/L	0.6287	0.0050	0.0561			0.15 - 5.8 [b,c]
Silver (tot)	mg/L	0.0014	0.0064	0.0030	0.0070	0.43	
Mercury (tot)	mg/L	0.0001	0.0018	0.0004	0.0004	1.06	0.0001 [c]
Mercury (diss)	mg/L	0.0001	0.0001	0.0001			
Herbicides	ug/L	4.2977	7.2700	5.5896	10.0000	0.56	
Pesticides	ug/L	0.1811	0.1800	0.1806	0.0090	20.06	

Source: Engineering-Science

[a] Instantaneous maximum concentrations, or 30-day average, as applicable (SWRCB, 1990)

[b] Weeks, 1982

[c] Randall, et al., 1982

TSS = total suspended solids

O&G = oil and grease

tot = total

mg/L = milligrams per liter

ug/L = micrograms per liter

Table 3-11

Transportation Land Use Runoff Pollutant Concentrations

Constituents		Event Mean Concentration		Estimated Mean Concentration		Ocean Plan Standards[b]	Estimated Mean Standards	Comparable Studies
		Event Date		Current Study	+FHwA Study[a]			
		4/15/88	11/25/88					
O&G	mg/L	10.5	1.7	4.2		75	0.06	172 [d]
TSS	mg/L	312	15.8	70.2	219	60	3.64	
Arsenic (tot)	mg/L	0.0090	0.0031	0.0053		0.0800	0.07	0.02 [c]
Cadmium (tot)	mg/L	0.0200	0.0050	0.0100	0.0064	0.0100	0.64	0.01 [c]
Chromium (tot)	mg/L	0.0300	0.0042	0.0112		0.0200	0.56	0.12 [c]
Copper (tot)	mg/L	0.1110	0.0156	0.0416		0.0300	1.39	0.69-0.99 [c,d]
Lead (tot)	mg/L	0.4600	0.0200	0.0959	0.4883	0.0200	24.41	0.03 [c]
Nickel (tot)	mg/L	0.0500	0.0250	0.0354		0.0500	0.71	0.65-1.10 [c,d]
Zinc (tot)	mg/L	1.2700	0.0946	0.3466	0.5757	0.2000	2.88	
Silver (tot)	mg/L	0.0005	0.0007	0.0006		0.0070	0.08	0.0002 [c]
Mercury (tot)	mg/L	0.0001	0.0001	0.0001		0.0004	0.25	
Herbicides	ug/L	2.5000	2.5000	2.5000		10.0000	0.25	
Pesticides	ug/L	0.7800	0.0509	0.1993		0.0090	22.14	
Enterococcus	#/100ml	11000						

Source: Engineering-Science
[a] Includes data from Santa Monica Bay Study and Driscoll, et al., 1988 (see Table 3-12)
[b] Instantaneous maximum concentrations, or 30-day average, as applicable (SWRCB, 1990)
[c] Weeks, 1982
[d] Shelley and Gaboury, 1986
TSS = total suspended solids
O&G = oil and grease
tot = total
mg/L = milligrams per liter
ug/L = micrograms per liter
ml = milliliters

Table 3-12

Federal Highway Administration Study - Runoff Pollutant Concentration Data

Sample Date	Event Mean Concentration (mg/L)			
	TSS	Cadmium	Lead	Zinc
1/11/81	166	0.020	0.710	2.200
1/23/81	200	0.003	0.510	0.950
1/27/81	8864	0.009	1.890	0.980
2/08/81	1630	0.010	1.780	1.090
2/25/81	70	0.003	1.930	0.380
3/04/81	81	0.002	1.020	0.220
3/19/81	85	0.000	0.380	0.310
Estimated Mean	302	0.006	0.987	0.666

Source: Driscoll, et al., 1988
TSS = total suspended solids
mg/L = milligrams per liter

The correlation between TSS and the other pollutants included in this study was tested by application of Spearman's rank correlation test. Table 3-14 shows the values of the Spearman r_s coefficients as well as the Z scores and the corresponding level of significance. The Z values were calculated as suggested by Champion (1980). The results indicate that significant correlations exist between TSS and all metals except cadmium and silver. Poor correlations are shown between TSS and herbicides and pesticides, which are lipid-soluble and associated with the oil and grease (O&G) fraction of runoff. The analysis results indicate that the control of TSS can effectively control the discharge of most toxic metals into Santa Monica Bay. Alternative measures, primarily based on controlling the sources, would be required for reducing the load of cadmium, silver, herbicides and pesticides. For the latter, control measures suitable for removing O&G from the runoff stream would also be effective in reducing herbicides and pesticides. Control measures for runoff pollutants, directed toward control of TSS and O&G, are evaluated in Section 4.

For purposes of comparison, Tables 3-8 through 3-11 also show the mean concentration of several stormwater EMCs as found in the literature. Some differences were found between the reported values for most pollutants and those reported herein. Specific conclusions cannot be derived because of the size of the data set; however, TSS, zinc, and lead concentrations in the commercial land use for this study appear to be consistently higher than the values reported in the literature.

The concentrations of copper, lead, and zinc in runoff from the residential and commercial sites in the study area appear to be higher than the reported values in the cited literature. Additionally, the average concentration of mercury from the residential area is higher than that found in the literature. The values of the estimated mean concentrations of pollutants for the residential site were strongly influenced by the result of the samples obtained during the 14 November 1988 storm. As indicated later in this section, these values appear to be a result of first-flush seasonal effects.

Pollutant Loading Estimates

The wet weather runoff pollution load from the study area was calculated by assuming that the estimated mean concentrations of pollutants obtained from the analysis described above are associated with the occurrence of typical storms. The spatial distribution of pollutant loads was developed by applying calculated runoff volumes and the pollutant loads associated with individual land uses to each drainage basin and sub-basin.

The pollutant loading calculation emphasized TSS and O&G control. O&G were included as runoff pollutants to be controlled in spite of the fact that they appear not to be present in significant concentrations on an areawide basis (comparison of estimated mean concentrations and Ocean Plan Standards; see Tables 3-8 through 3-11). O&G is likely to be important on a site-specific basis, such as runoff from parking lots. Also, control of the O&G fraction of runoff is the most direct technique of removing lipid-soluble pollutants from the runoff stream. Appendixes A-2 through A-5 show calculations of the TSS and O&G runoff load from a single wet season or dry season storm. These appendixes indicate land use area, estimated typical stormwater runoff volume, pollutant concentration, and total expected loads for each drainage area in both the coastal plain and mountain regions for the dry and wet seasons. TSS concentration values for open space and residential/agricultural land uses were obtained from the literature (EPA, 1974).

Research has shown that the pollution load from open space areas is negligible when compared to the load from other land uses, especially urban areas (Pitt, 1986). Furthermore, as suggested by Stenstrom, et al. (1985), the source and characteristics of any given hydrocarbon substance needs to be analyzed before it can be cataloged as a contaminant. For example, O&G from nonurbanized areas are likely to be the result of plant leaf degradation and microbial secretions. These products should not be subject to the same control approaches as O&G resulting from materials such as motor oil and diesel fuel discharges. Based on these considerations, it was determined appropriate not to include runoff from open space as a source of stormwater pollution.

Agricultural land uses, on the other hand, are often important sources of runoff pollution in terms of organic materials and nutrients. In the study area, however, agricultural land uses represent only 1.6 percent of the total area and are concentrated exclusively in the Topanga Canyon drainage basin (Basin 26, Exhibit 2). In addition, solids carried from undeveloped terrain present different characteristics from those carried from urbanized areas in terms of adsorbed materials. These solids are also an important source of replenishment material for area beaches. In this study it was determined that pollution load estimates from the agricultural land use could be excluded from the analysis, and that pollution control recommendations should be targeted to TSS and O&G from the residential, commercial, industrial, and transportation land uses in urbanized drainage basins (Basins 1 through 16, Exhibit 2).

Table 3-13

Ratio of Dissolved to Total Metals in Runoff Pollutant Sample Collections (%)

Metal	Land Uses: Residential	Land Uses: Commercial	Land Uses: Industrial	Land Uses: Transportation	Average of all Samples
Arsenic	18	50	58	56	45
Cadmium	44	50	30	25	37
Chromium	51	22	49	97	55
Copper	50	45	48	52	49
Lead	21	11	18	28	19
Nickel	14	ND	68	50	33
Zinc	41	34	61	64	50
Silver	9	85	14	40	37
Mercury	34	36	ND	18	29
OVERALL AVERAGE:		38%			

Source: Engineering-Science
ND = no data avaliable

Pollutant Loading Estimates by Drainage Basin. Tables 3-15 and 3-16 present summaries of wet-weather TSS and O&G annual pollution loads by drainage basin for the study area. Only estimated loads from the residential, commercial, light industrial, and transportation land-use areas are included; loading from open space areas is not included, as discussed previously. Annual loads were calculated by multiplying the wet- and dry-season storm loads by the number of expected rainfall events during each period, as obtained from the typical rainfall analysis: 12.21 events during the wet season and 1.33 events during the dry season, each event lasting an average of 24 hours. The loading ratios for each area are equal to the ratio of two partial ratios: basin load to total watershed load and basin area to total watershed area. Loading ratios, particularly the annual loading ratio, provide guidance for recommendation of pollutant removal strategies for each drainage and subdrainage basin; for example, O&G control would be more effective in reducing total load in drainage basin 1 (loading ratio = 1.42) than in drainage basin 4 (loading ratio = 0.87).

On Tables 3-17 and 3-18, the drainage basins in the study area are ranked based on the TSS and O&G loading ratios, respectively. All drainage basins were then ranked for total pollutant loading by summing the ranking numbers for TSS and O&G, with results as indicated on Table 3-19. In this case, equal weight was given to TSS and O&G. When considering the implementation of pollution

Table 3-14

Correlation Results Between TSS and Other Pollutants - Spearman's Rank Test

Constituent	r_s	Z	P
METALS (total)			
Arsenic	0.70	1.97	< 0.05
Cadmium	0.35	0.98	< 0.35
Chromium	0.93	2.63	< 0.01
Copper	0.78	2.21	< 0.02
Lead	0.78	2.21	< 0.02
Nickel	0.75	2.12	< 0.02
Zinc	0.82	2.31	< 0.02
Silver	0.31	0.88	< 0.40
Mercury	0.55	1.55	< 0.10
BIOCIDES			
Herbicides	0.25	0.71	< 0.50
Pesticides	0.32	0.92	< 0.40

Source: Engineering-Science
TSS = Total suspended solids
r_s = Spearman coefficient
Z = Z scores
P = Probability of significance

control measures, the relative significance of the TSS and O&G weighting for a drainage basin would depend on the characteristics of the proposed control measure to be applied: TSS removal would be the predominant factor in the design of settling facilities, whereas O&G removal would be important if oil-recycling programs are implemented. Appropriate basins would be selected based on their ranking for loading of each pollutant. Tables 3-17 and 3-18 also show the relationship between the accumulated percent area and the accumulated percent TSS and O&G loads. As an example, the Ballona Creek drainage basin (Basin 5) accounts for 63 percent of the total study area and 74 percent of the total wet-weather pollution load entering Santa Monica Bay from the study areas.

Table 3-20 shows the expected annual pollutant load of heavy metals, herbicides, and pesticides. The wet-weather estimates were calculated by averaging the weighted estimated mean concentration values from Tables 3-8 through 3-11, and multiplying by the expected annual runoff flow from the typical storms in the area.

Pollutant Loading Estimates by Land-use Category. Table 3-21 shows the ratios of total TSS and O&G loads to total area for all land-use categories. This table indicates that control measures should be directed primarily to the commercial

Table 3-15

Summary of Wet Weather Runoff Pollutant Loading - Total Suspended Solids

Drainage Basin	Area (ha)	Basin Area/ Total Area (%)	Dry Season Load: Load (kg)	Dry Season Load: Basin Load/ Total Load (%)	Wet Season Load: Load (kg)	Wet Season Load: Basin Load/ Total Load (%)	Annual Load: Load (kg)	Annual Load: Basin Load/ Total Load (%)	Loading Ratios: Dry	Loading Ratios: Wet	Loading Ratios: Annual
Area 1	457	0.87	1409	0.68	4649	0.77	58638	0.76	0.79	0.88	0.88
Area 1A	246	0.47	903	0.44	2921	0.48	36866	0.48	0.94	1.03	1.03
Area 2	1305	2.48	19952	9.67	41112	6.77	528514	6.88	3.91	2.74	2.78
Area 3	647	1.23	1645	0.80	6112	1.01	76815	1.00	0.65	0.82	0.81
Area 4	163	0.31	664	0.32	1721	0.28	21897	0.28	1.04	0.92	0.92
Area 5000	464	0.88	1057	0.51	3495	0.58	44080	0.57	0.58	0.65	0.65
Area 5001	677	1.29	3220	1.56	9400	1.55	119057	1.55	1.21	1.20	1.21
Area 5002	388	0.74	1770	0.86	5596	0.92	70681	0.92	1.16	1.25	1.25
Area 5003	501	0.95	1943	0.94	6157	1.01	77761	1.01	0.99	1.07	1.06
Area 5004	40	0.08	89	0.04	373	0.06	4673	0.06	0.57	0.82	0.81
Area 5005	355	0.67	1482	0.72	4751	0.78	59981	0.78	1.06	1.16	1.16
Area 5006	26	0.05	96	0.05	287	0.05	3632	0.05	0.95	0.97	0.97
Area 5007	427	0.81	2351	1.14	6777	1.12	85874	1.12	1.41	1.38	1.38
Area 5008	300	0.57	1252	0.61	4179	0.69	52691	0.69	1.06	1.21	1.20
Area 5009	4919	9.33	25080	12.15	75597	12.45	956396	12.44	1.30	1.33	1.33
Area 5-1-1	361	0.69	1500	0.73	4707	0.78	59467	0.77	1.06	1.13	1.13
Area 5-1-2	1448	2.75	7307	3.54	21171	3.49	268216	3.49	1.29	1.27	1.27
Area 5100	916	1.74	4232	2.05	12076	1.99	153077	1.99	1.18	1.14	1.15
Total 5-1	2725	5.17	13038	6.32	37952	6.25	480734	6.25	1.22	1.21	1.21
Area 5-2-1	4573	8.68	15336	7.43	47353	7.80	598577	7.79	0.86	0.90	0.90
Area 5-2-2	1075	2.04	5990	2.90	17734	2.92	224499	2.92	1.42	1.43	1.43
Area 5200	300	0.57	1319	0.64	4025	0.66	50900	0.66	1.12	1.17	1.16
Total 5-2	5949	11.29	22645	10.97	69115	11.38	874012	11.37	0.97	1.01	1.01

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Table 3-15 (Continued)

Summary of Wet Weather Runoff Pollutant Loading - Total Suspended Solids

Drainage Basin	Area (ha)	Basin Area/ Total Area (%)	Dry Season Load: Load (kg)	Dry Season Load: Basin Load/ Total Load (%)	Wet Season Load: Load (kg)	Wet Season Load: Basin Load/ Total Load (%)	Annual Load: Load (kg)	Annual Load: Basin Load/ Total Load (%)	Loading Ratios: Dry	Loading Ratios: Wet	Loading Ratios: Annual
Area 5-3	355	0.67	1255	0.61	4322	0.71	54441	0.71	0.90	1.06	1.05
Area 5-4-1	597	1.13	2733	1.32	8737	1.44	110314	1.44	1.17	1.27	1.27
Area 5-4-2	959	1.82	2172	1.05	7053	1.16	89006	1.16	0.58	0.64	0.64
Area 5-4-3	1106	2.10	2150	1.04	8355	1.38	104874	1.36	0.50	0.66	0.65
Area 5400	853	1.62	3253	1.58	10306	1.70	130163	1.69	0.97	1.05	1.05
Total 5-4	3515	6.67	10307	4.99	34451	5.67	434355	5.65	0.75	0.85	0.85
Area 5-5	4118	7.81	20159	9.77	62528	10.30	790278	10.28	1.25	1.32	1.32
Area 5-6	2339	4.44	12998	6.30	38305	6.31	484991	6.31	1.42	1.42	1.42
Area 5-7	1466	2.78	7006	3.39	21958	3.62	277425	3.61	1.22	1.30	1.30
Area 5-8	3876	7.35	16363	7.93	50898	8.38	643227	8.37	1.08	1.14	1.14
Area 5-9	552	1.05	3093	1.50	9206	1.52	116519	1.52	1.43	1.45	1.45
Total Area 5	32993	62.59	145202	70.34	445348	73.36	5630818	73.25	1.12	1.17	1.17
Area 6	589	1.12	2079	1.01	6683	1.10	84365	1.10	0.90	0.98	0.98
Area 7	84	0.16	323	0.16	949	0.16	12017	0.16	0.98	0.98	0.98
Area 8	65	0.12	325	0.16	873	0.14	11092	0.14	1.28	1.17	1.17
Area 9	123	0.23	468	0.23	1549	0.26	19536	0.25	0.97	1.09	1.09
Area 10	108	0.20	565	0.27	1688	0.28	21362	0.28	1.34	1.36	1.36
Area 11	857	1.63	4556	2.21	13410	2.21	169796	2.21	1.36	1.36	1.36
Area 12	107	0.20	604	0.29	1740	0.29	22049	0.29	1.44	1.41	1.41
Area 13	1679	3.19	6190	3.00	19343	3.19	244411	3.18	0.94	1.00	1.00
Area 14	38	0.07	485	0.23	1294	0.21	16445	0.21	3.23	2.93	2.94
Area 15	375	0.71	2282	1.11	6523	1.07	82681	1.08	1.55	1.51	1.51
Area 16	334	0.63	1682	0.81	4806	0.79	60918	0.79	1.29	1.25	1.25

Table 3-15 (Continued)

Summary of Wet Weather Runoff Pollutant Loading - Total Suspended Solids

			Dry Season Load		Wet Season Load		Annual Load				
		Basin Area/		Basin Load/		Basin Load/		Basin Load/			
Drainage	Area	Total Area	Load	Total Load	Load	Total Load	Load	Total Load		Loading Ratios	
Basin	(ha)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	Dry	Wet	Annual
Area 1700	483	0.92	1787	0.87	5498	0.91	69507	0.90	0.94	0.99	0.99
Area 17-1	1925	3.65	2338	1.13	5845	0.96	74477	0.97	0.31	0.26	0.27
Area 17-2	965	1.83	1470	0.71	4640	0.76	58610	0.76	0.39	0.42	0.42
Area 17-3	735	1.39	714	0.35	2254	0.37	28471	0.37	0.25	0.27	0.27
Total Area 17	4108	7.79	6302	3.03	18237	3.66	231055	3.64	0.39	0.47	0.47
Area 18	164	0.31	507	0.25	1694	0.28	21358	0.28	0.79	0.90	0.89
Area 19	672	1.27	973	0.47	2675	0.44	33956	0.44	0.37	0.35	0.35
Area 20	494	0.94	1578	0.76	4608	0.76	58362	0.76	0.81	0.81	0.81
Area 21	60	0.11	592	0.29	1494	0.25	19029	0.25	2.53	2.17	2.19
Area 22	19	0.04	243	0.12	555	0.09	7100	0.09	3.31	2.57	2.59
Area 23	1776	3.37	2873	1.39	8421	1.39	106642	1.39	0.41	0.41	0.41
Area 24	114	0.22	381	0.18	1102	0.18	13962	0.18	0.85	0.84	0.84
Area 25	30	0.06	271	0.13	705	0.12	8968	0.12	2.34	2.07	2.08
Area 26	5106	9.69	3367	1.63	6863	1.13	88275	1.15	0.17	0.12	0.12
BASIN TOTAL	52709	100.00	206432	100.00	607073	100.00	7686916	100.00			

Source: Engineering-Science
ha = hectare
kg = kilograms

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Table 3-16

Summary of Wet Weather Runoff Pollutant Loading - Oil and Grease

Drainage Basin	Area (ha)	Basin Area/ Total Area (%)	Dry Season Load: Load (kg)	Dry Season Load: Basin Load/ Total Load (%)	Wet Season Load: Load (kg)	Wet Season Load: Basin Load/ Total Load (%)	Annual Load: Load (kg)	Annual Load: Basin Load/ Total Load (%)	Loading Ratios: Dry	Loading Ratios: Wet	Loading Ratios: Annual
Area 1	457	0.87	89	1.15	332	1.23	4172	1.23	1.32	1.42	1.42
Area 1A	246	0.47	47	0.60	173	0.64	2175	0.64	1.30	1.38	1.38
Area 2	1305	2.48	416	5.35	922	3.42	11811	3.48	2.16	1.38	1.41
Area 3	647	1.23	80	1.03	317	1.18	3977	1.17	0.84	0.96	0.96
Area 4	163	0.31	22	0.28	72	0.27	908	0.27	0.92	0.87	0.87
Area 5000	464	0.88	53	0.68	198	0.73	2488	0.73	0.78	0.84	0.83
Area 5001	677	1.29	120	1.54	425	1.58	5349	1.58	1.20	1.23	1.23
Area 5002	388	0.74	71	0.91	266	0.99	3342	0.98	1.24	1.34	1.34
Area 5003	501	0.95	92	1.18	338	1.25	4249	1.25	1.25	1.32	1.32
Area 5004	40	0.08	6	0.08	25	0.09	313	0.09	1.03	1.23	1.23
Area 5005	355	0.67	65	0.84	241	0.89	3029	0.89	1.24	1.33	1.32
Area 5006	26	0.05	4	0.05	15	0.06	188	0.06	1.06	1.14	1.14
Area 5007	427	0.81	87	1.12	299	1.11	3767	1.11	1.38	1.37	1.37
Area 5008	300	0.57	52	0.67	198	0.73	2487	0.73	1.18	1.29	1.29
Area 5009	4919	9.33	856	11.02	3003	11.14	37805	11.14	1.18	1.19	1.19
Area 5-1-1	361	0.69	68	0.88	254	0.94	3192	0.94	1.28	1.38	1.37
Area 5-1-2	1448	2.75	281	3.62	984	3.65	12388	3.65	1.32	1.33	1.33
Area 5100	916	1.74	154	1.98	526	1.95	6627	1.95	1.14	1.12	1.12
Total 5-1	2725	5.17	503	6.47	1763	6.54	22195	6.54	1.25	1.27	1.27
Area 5-2-1	4573	8.68	587	7.56	2123	7.88	26703	7.87	0.87	0.91	0.91
Area 5-2-2	1075	2.04	211	2.72	736	2.73	9267	2.73	1.33	1.34	1.34
Area 5200	300	0.57	56	0.72	207	0.77	2602	0.77	1.27	1.35	1.35
Total 5-2	5949	11.29	855	11.01	3065	11.38	38561	11.36	0.98	1.01	1.01
Area 5-3	355	0.67	59	0.76	226	0.84	2838	0.84	1.13	1.24	1.24

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Table 3-16 (Continued)

Summary of Wet Weather Runoff Pollutant Loading - Oil and Grease

Drainage Basin	Area (ha)	Basin Area/ Total Area (%)	Dry Season Load: Load (kg)	Dry Season Load: Basin Load/ Total Load (%)	Wet Season Load: Load (kg)	Wet Season Load: Basin Load/ Total Load (%)	Annual Load: Load (kg)	Annual Load: Basin Load/ Total Load (%)	Loading Ratios: Dry	Loading Ratios: Wet	Loading Ratios: Annual
Area 5-4-1	597	1.13	109	1.40	403	1.50	5066	1.49	1.24	1.32	1.32
Area 5-4-2	959	1.82	103	1.33	392	1.45	4923	1.45	0.73	0.80	0.80
Area 5-4-3	1106	2.10	132	1.70	539	2.00	6757	1.99	0.81	0.95	0.95
Area 5400	853	1.62	126	1.62	465	1.73	5845	1.72	1.00	1.07	1.06
Total 5-4	3515	6.67	471	6.06	1799	6.68	22592	6.66	0.91	1.00	1.00
Area 5-5	4118	7.81	776	9.99	2808	10.42	35318	10.41	1.28	1.33	1.33
Area 5-6	2339	4.44	462	5.95	1608	5.97	20248	5.97	1.34	1.34	1.34
Area 5-7	1466	2.78	272	3.50	994	3.69	12499	3.68	1.26	1.33	1.32
Area 5-8	3876	7.35	625	8.04	2265	8.41	28487	8.40	1.09	1.14	1.14
Area 5-9	552	1.05	106	1.36	372	1.38	4683	1.38	1.30	1.32	1.32
Total Area 5	32993	62.59	5534	71.23	19911	73.89	250474	73.81	1.14	1.18	1.18
Area 6	589	1.12	96	1.24	362	1.34	4548	1.34	1.11	1.20	1.20
Area 7	84	0.16	13	0.17	48	0.18	603	0.18	1.05	1.12	1.11
Area 8	65	0.12	11	0.14	35	0.13	442	0.13	1.15	1.06	1.06
Area 9	123	0.23	23	0.30	81	0.30	1020	0.30	1.27	1.29	1.29
Area 10	108	0.20	21	0.27	71	0.26	895	0.26	1.32	1.29	1.29
Area 11	857	1.63	165	2.12	581	2.16	7313	2.16	1.31	1.33	1.33
Area 12	107	0.20	18	0.23	58	0.22	732	0.22	1.14	1.06	1.06
Area 13	1679	3.19	255	3.28	935	3.47	11756	3.46	1.03	1.09	1.09
Area 14	38	0.07	10	0.13	25	0.09	319	0.09	1.77	1.28	1.29
Area 15	375	0.71	69	0.89	234	0.87	2949	0.87	1.25	1.22	1.22
Area 16	334	0.63	61	0.79	217	0.81	2731	0.80	1.24	1.27	1.27

Table 3-16 (Continued)

Summary of Wet Weather Runoff Pollutant Loading - Oil and Grease

Drainage Basin	Area (ha)	Basin Area/ Total Area (%)	Dry Season Load: Load (kg)	Dry Season Load: Basin Load/ Total Load (%)	Wet Season Load: Load (kg)	Wet Season Load: Basin Load/ Total Load (%)	Annual Load: Load (kg)	Annual Load: Basin Load/ Total Load (%)	Loading Ratios: Dry	Loading Ratios: Wet	Loading Ratios: Annual
Area 1700	483	0.92	78	1.00	289	1.07	3632	1.07	1.10	1.17	1.17
Area 17-1	1925	3.65	124	1.60	367	1.34	4646	1.35	0.44	0.37	0.37
Area 17-2	965	1.83	99	1.27	317	1.17	4002	1.17	0.70	0.64	0.64
Area 17-3	735	1.39	48	0.62	155	0.57	1956	0.57	0.44	0.41	0.41
Total Area 17	4108	7.79	349	4.47	1128	5.05	14237	5.03	0.57	0.65	0.65
Area 18	164	0.31	25	0.32	96	0.36	1205	0.36	1.04	1.15	1.14
Area 19	672	1.27	51	0.66	152	0.56	1924	0.57	0.52	0.44	0.44
Area 20	494	0.94	93	1.20	286	1.06	3616	1.07	1.28	1.13	1.14
Area 21	60	0.11	26	0.33	75	0.28	950	0.28	2.95	2.46	2.47
Area 22	19	0.04	8	0.10	22	0.08	279	0.08	2.89	2.29	2.31
Area 23	1776	3.37	170	2.19	523	1.94	6612	1.95	0.65	0.58	0.58
Area 24	114	0.22	21	0.27	68	0.25	858	0.25	1.25	1.17	1.17
Area 25	30	0.06	12	0.15	37	0.14	468	0.14	2.76	2.45	2.46
Area 26	5106	9.69	85	1.09	196	0.73	2506	0.74	0.11	0.08	0.08
BASIN TOTAL	52713	100.00	7769	100.00	26956	100.00	339466	100.00			

Source: Engineering-Science
ha = hectare
kg = kilogram

Table 3-17

Ranking of Drainage Basins by Annual Wet-Weather Total Suspended Solids Runoff Loading Ratio

Rank	Drainage Basin	Annual Loading Ratio[a]	Basin Area (ha)	Accum. Area (%)	Basin Load (kg)	Accum. Load (kg)	Accum. Load (%)
1	14	2.94	38	0.1	16445	16445	0.2
2	2	2.78	1305	2.5	528514	544958	7.1
3	22	2.59	19	2.6	7100	552058	7.2
4	21	2.19	60	2.7	19029	571087	7.4
5	25	2.08	30	2.8	8968	580056	7.5
6	15	1.51	375	3.5	82681	662737	8.6
7	5-9	1.45	552	4.5	116519	779256	10.1
8	5-2-2	1.43	1075	6.6	224499	1003754	13.1
9	5-6	1.42	2339	11.0	484991	1488746	19.4
10	12	1.41	107	11.2	22049	1510795	19.7
11	5007	1.38	427	12.0	85874	1596669	20.8
12	11	1.36	857	13.6	169796	1766464	23.0
13	10	1.36	108	13.8	21362	1787826	23.3
14	5009	1.33	4919	23.2	956396	2744222	35.7
15	5-5	1.32	4118	31.0	790278	3534500	46.0
16	5-7	1.30	1466	33.8	277425	3811925	49.6
17	5-1-2	1.27	1448	36.5	268216	4080142	53.1
18	5-4-1	1.27	597	37.6	110314	4190455	54.5
19	16	1.25	334	38.3	60918	4251374	55.3
20	5002	1.25	388	39.0	70681	4322055	56.2
21	5001	1.21	677	40.3	119057	4441111	57.8
22	5008	1.20	300	40.9	52691	4493802	58.5
23	8	1.17	65	41.0	11092	4504894	58.6
24	5200	1.16	300	41.6	50900	4555793	59.3
25	5005	1.16	355	42.2	59981	4615774	60.0
26	5100	1.15	916	44.0	153077	4768851	62.0
27	5-8	1.14	3876	51.3	643227	5412078	70.4
28	5-1-1	1.13	361	52.0	59467	5471545	71.2
29	9	1.09	123	52.2	19536	5491081	71.4
30	5003	1.06	501	53.2	77761	5568842	72.4

Table 3-17 (Continued)

Ranking of Drainage Basins by Annual Wet-Weather Total Suspended Solids Runoff Loading Ratio

Rank	Drainage Basin	Annual Loading Ratio[a]	Basin Area (ha)	Accum. Area (%)	Basin Load (kg)	Accum. Load (kg)	Accum. Load (%)
31	5-3	1.05	355	53.9	54441	5623283	73.2
32	5400	1.05	853	55.5	130163	5753446	74.8
33	1A	1.03	246	55.9	36866	5790312	75.3
34	13	1.00	1679	59.1	244411	6034723	78.5
35	1700	0.99	483	60.1	69507	6104230	79.4
36	6	0.98	589	61.2	84365	6188595	80.5
37	7	0.98	84	61.3	12017	6200612	80.7
38	5006	0.97	26	61.4	3632	6204244	80.7
39	4	0.92	163	61.7	21897	6226140	81.0
40	5-2-1	0.90	4573	70.4	598577	6824717	88.8
41	18	0.89	164	70.7	21358	6846075	89.1
42	1	0.88	457	71.5	58638	6904713	89.8
43	24	0.84	114	71.8	13962	6918676	90.0
44	3	0.81	647	73.0	76815	6995491	91.0
45	20	0.81	494	73.9	58362	7053853	91.8
46	5004	0.81	40	74.0	4673	7058526	91.8
47	5000	0.65	464	74.9	44080	7102606	92.4
48	5-4-3	0.65	1106	77.0	104874	7207480	93.8
49	5-4-2	0.64	959	78.8	89006	7296486	94.9
50	17-2	0.42	965	80.6	58610	7355095	95.7
51	23	0.41	1776	84.0	106642	7461737	97.1
52	19	0.35	672	85.3	33956	7495693	97.5
53	17-3	0.27	735	86.7	28471	7524164	97.9
54	17-1	0.27	1925	90.3	74477	7598641	98.9
55	26	0.12	5106	100.0	88275	7686916	100.0

Source: Engineering-Science
[a] From Table 3-15
Accum. = accumulative
ha = hectare
kg = kilogram

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Table 3-18

Ranking of Drainage Basins by Annual Wet Weather Oil and Grease Runoff Loading Ratio

Rank	Drainage Basin	Annual Loading Ratio[a]	Basin Area (ha)	Accum. Area (%)	Basin Load (kg)	Accum. Load (kg)	Accum. Load (%)
1	21	2.47	60	0.1	950	950	0.3
2	25	2.46	30	0.2	468	1418	0.4
3	22	2.31	19	0.2	279	1697	0.5
4	1	1.42	457	1.1	4172	5869	1.7
5	2	1.41	1305	3.5	11811	17680	5.2
6	1A	1.38	246	4.0	2175	19855	5.9
7	5-1-1	1.37	361	4.7	3192	23047	6.8
8	5007	1.37	427	5.5	3767	26813	7.9
9	5200	1.35	300	6.1	2602	29415	8.7
10	5-6	1.34	2339	10.5	20248	49664	14.6
11	5-2-2	1.34	1075	12.6	9267	58931	17.4
12	5002	1.34	388	13.3	3342	62273	18.4
13	5-5	1.33	4118	21.1	35318	97591	28.8
14	5-1-2	1.33	1448	23.9	12388	109979	32.4
15	11	1.33	857	25.5	7313	117293	34.6
16	5-7	1.32	1466	28.3	12499	129791	38.2
17	5005	1.32	355	28.9	3029	132820	39.1
18	5-4-1	1.32	597	30.1	5066	137886	40.6
19	5003	1.32	501	31.0	4249	142135	41.9
20	5-9	1.32	552	32.1	4683	146818	43.3
21	14	1.29	38	32.1	319	147137	43.4
22	10	1.29	108	32.3	895	148032	43.6
23	9	1.29	123	32.6	1020	149051	43.9
24	5008	1.29	300	33.1	2487	151538	44.7
25	16	1.27	334	33.8	2731	154269	45.5
26	5-3	1.24	355	34.4	2838	157107	46.3
27	5001	1.23	677	35.7	5349	162455	47.9
28	5004	1.23	40	35.8	313	162769	48.0
29	15	1.22	375	36.5	2949	165718	48.8

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Table 3-18 (Continued)

Ranking of Drainage Basins by Annual Wet Weather Oil and Grease Runoff Loading Ratio

Rank	Drainage Basin	Annual Loading Ratio[a]	Basin Area (ha)	Accum. Area (%)	Basin Load (kg)	Accum. Load (kg)	Accum. Load (%)
30	6	1.20	589	37.6	4548	170265	50.2
31	5009	1.19	4919	47.0	37805	208070	61.3
32	24	1.17	114	47.2	858	208929	61.6
33	1700	1.17	483	48.1	3632	212561	62.6
34	18	1.14	164	48.4	1205	213766	63.0
35	5-8	1.14	3876	55.8	28487	242253	71.4
36	5006	1.14	26	55.8	188	242442	71.4
37	20	1.14	494	56.8	3616	246058	72.5
38	5100	1.12	916	58.5	6627	252685	74.5
39	7	1.11	84	58.7	603	253288	74.6
40	13	1.09	1679	61.8	11756	265044	78.1
41	12	1.06	107	62.0	732	265776	78.3
42	5400	1.06	853	63.7	5845	271621	80.0
43	8	1.06	65	63.8	442	272063	80.2
44	3	0.96	647	65.0	3977	276040	81.3
45	5-4-3	0.95	1106	67.1	6757	282797	83.3
46	5-2-1	0.91	4573	75.8	26703	309499	91.2
47	4	0.87	163	76.1	908	310408	91.5
48	5000	0.83	464	77.0	2488	312896	92.2
49	5-4-2	0.80	959	78.8	4923	317819	93.7
50	17-2	0.64	965	80.6	3966	321785	94.8
51	23	0.58	1776	84.0	6612	328397	9.8
52	19	0.44	672	85.3	1924	330320	97.3
53	17-3	0.41	735	86.7	1932	332252	97.9
54	17-1	0.37	1925	90.3	4573	336825	99.3
55	26	0.08	5106	100.0	2506	339331	100.0

Source: Engineering-Science
[a] from Table 3-16
Accum = accumulative
ha = hectare
kg = kilogram

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Table 3-19

Ranking of Drainage Basins by Annual TSS and O&G Runoff Loading Ratio

Overall Rank	Drainage Basin	Basin Area (ha)	Accum. Area (%)	TSS Load (kg)	TSS Accum. Load (kg)	TSS Accum. Load (%)	O&G Load (kg)	O&G Accum. Load (kg)	O&G Accum. Load (%)
1	21	60	0.1	19029	19029	0.2	950	950	0.3
2	22	19	0.1	7100	26129	0.3	279	1230	0.4
3	2	1305	2.6	528514	554643	7.2	11811	13040	3.8
4	25	30	2.7	8968	563611	7.3	468	13508	4.0
5	5007	427	3.5	85874	649485	8.4	3767	17275	5.1
6	5-2-2	1075	5.5	224499	873984	11.4	9267	26542	7.8
7	5-6	2339	10.0	484991	1358975	17.7	20248	46790	13.8
8	14	38	10.0	16445	1375420	17.9	319	47109	13.9
9	11	857	11.7	169796	1545216	20.1	7313	54422	16.0
10	5-9	552	12.7	116519	1661735	21.6	4683	59105	17.4
11	5-5	4118	20.5	790278	2452013	31.9	35318	94423	27.8
12	5-1-2	1448	23.3	268216	2720229	35.4	12388	106811	31.5
13	5002	388	24.0	70681	2790910	36.3	3342	110154	32.5
14	5-7	1466	26.8	277425	3068336	39.9	12499	122652	36.1
15	10	108	27.0	21362	3089697	40.2	895	123547	36.4
16	5200	300	27.6	50900	3140597	40.9	2602	126149	37.2
17	15	375	28.3	82681	3223278	41.9	2949	129098	38.0
18	5-4-1	597	29.4	110314	3333592	43.4	5066	134163	39.5
19	5-1-1	361	30.1	59467	3393059	44.1	3192	137355	40.5
20	1A	246	30.6	36866	3429925	44.6	2175	139530	41.1
21	16	334	31.2	60918	3490844	45.4	2731	142261	41.9
22	5005	355	31.9	59981	3550825	46.2	3029	145290	42.8
23	5009	4919	41.2	956396	4507220	58.6	37805	183095	54.0
24	5008	300	41.8	52691	4559911	59.3	2487	185582	54.7
25	1	457	42.6	58638	4618549	60.1	4172	189754	55.9
26	5001	677	43.9	119057	4737606	61.6	5349	195103	57.5
27	5003	501	44.9	77761	4815367	62.6	4249	199352	58.7
28	12	107	45.1	22049	4837416	62.9	732	200084	59.0
29	9	123	45.3	19536	4856951	63.2	1020	201104	59.3

Table 3-19 (Continued)

Ranking of Drainage Basins by Annual TSS and O&G Runoff Loading Ratio

Overall Rank	Drainage Basin	Basin Area (ha)	Accum. Area (%)	TSS Load (kg)	TSS Accum. Load (kg)	TSS Accum. Load (%)	O&G Load (kg)	O&G Accum. Load (kg)	O&G Accum. Load (%)
30	5-3	355	46.0	54441	4911392	63.9	2838	203942	60.1
31	5-8	3876	53.3	643227	5554620	72.3	28487	232428	68.5
32	5100	916	55.1	153077	5707696	74.3	6627	239056	70.4
33	8	65	55.2	11092	5718788	74.4	442	239498	70.6
34	6	589	56.3	84365	5803152	75.5	4548	244045	71.9
35	1700	483	57.2	69507	5872660	76.4	3632	247678	73.0
36	5400	853	58.8	130163	6002822	78.1	5845	253523	74.7
37	13	1679	62.0	244411	6247233	81.3	11756	265279	78.2
38	5004	40	62.1	4673	6251906	81.3	313	265592	78.3
39	5006	26	62.2	3632	6255538	81.4	188	265780	78.3
40	18	164	62.5	21358	6276896	81.7	1205	266986	78.7
41	24	114	62.7	13962	6290858	81.8	858	267844	78.9
42	7	84	62.8	12017	6302875	82.0	603	268447	79.1
43	20	494	63.8	58362	6361237	82.8	3616	272063	80.2
44	4	163	64.1	21897	6383134	83.0	908	272971	80.4
45	5-2-1	4573	72.8	598577	6981711	90.8	26703	299674	88.3
46	3	647	74.0	76815	7058526	91.8	3977	303651	89.5
47	5-4-3	1106	76.1	104874	7163400	93.2	6757	310408	91.5
48	5000	464	77.0	44080	7207480	93.8	2488	312896	92.2
49	5-4-2	959	78.8	89006	7296486	94.9	4923	317819	93.7
50	17-2	965	80.6	58610	7355095	95.7	3966	321785	94.8
51	23	1776	84.0	106642	7461737	97.1	6612	328397	96.8
52	19	672	85.3	33956	7495693	97.5	1924	330320	97.3
53	17-3	735	86.7	28471	7524164	97.9	1932	332252	97.9
54	17-1	1925	90.3	74477	7598641	98.9	4573	336825	99.3
55	26	5106	100.0	88275	7686916	100.0	2506	339331	100.0

Source: Engineering-Science
TSS = total suspended solids
O&G = oil and grease
Accum = accumulative
ha = hectare
kg = kilograms

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Table 3-20

Estimated Annual Runoff Pollutant Loading of Heavy Metals, Herbicides, and Pesticides into Santa Monica Bay from the Study Area

Pollutant	Wet Weather (kg)	Dry Weather (kg)	Total (kg)
Arsenic (total)	363	159	522
Arsenic(dissolved)	94	----	94
Cadmium (total)	939	N/D	939
Cadmium (dissolved)	378	----	378
Chromium (total)	1,419	125	1,543
Chromium (dissolved)	326	----	326
Copper (total)	5,712	334	6,046
Copper (dissolved)	748	----	748
Lead (total)	16,695	763	17,457
Lead (dissolved)	2,127	----	2,127
Nickel (total)	1,854	N/D	1,854
Nickel (dissolved)	1,617	----	1,617
Zinc (total)	62,172	1,919	64,091
Zinc (dissolved)	4,108	----	4,108
Silver (total)	85	N/D	85
Silver (dissolved)	13	----	13
Mercury (total)	32	N/D	32
Mercury (dissolved)	7	----	7
Herbicides	226	44	270
Pesticides	10	0.22	10

Source: Engineering-Science
N/D = Below detectable limits
---- = Not measured

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Table 3-21

Estimated Annual Wet Weather Runoff Pollutant Loading by Land Use Category - Total Suspended Solids and Oil and Grease

Land Use	Area (ha)	Percent Area	TSS Load (kg)	Percent Load	Loading Ratio[a]
Total Suspended Solids					
Residential	26,424	50.13	3,518,854	45.78	0.91
Commercial	4,252	8.07	1,794,903	23.35	2.89
Industrial	2,798	5.31	299,732	3.90	0.73
Transportation	3,101	5.88	2,073,437	26.97	4.59
Open Space	16,138	30.61	b	b	b
Total	52,713	100.00	7,686,925	100.00	
Oil and Grease					
Residential	26,424	50.13	237,891	70.08	1.40
Commercial	4,252	8.07	36,119	10.64	1.32
Industrial	2,798	5.31	25,746	7.58	1.43
Transportation	3,101	5.88	39,722	11.70	1.99
Open Space	16,138	30.61	b	b	
Total	52,713	100.00	339,479	100.00	

Source: Engineering-Science

[a] Loading ratio = (percent load/percent area)

[b] TSS load from open space (primarily Santa Monica Mountains) taken as beneficial loading, not a pollution input (see text). O&G load from open space (primarily Santa Monica Mountains) uncategorized, but assumed not significant as a pollution input.

TSS = total suspended solids

ha = hectare

kg = kilogram

and transportation land uses for most effective application of pollutant control measures. Again, TSS and O&G from the open space and residential/agricultural land uses have not been considered in the analysis.

Dry-Weather Pollution Analysis

Dry-weather contributions to total pollution loads into Santa Monica Bay may result primarily from effluents from permitted discharges within the drainage area (J. Mitchell, LACDPW, personal communication). Pollutant concentrations for dry-weather flow for this study were obtained by analyzing samples taken at a location on Ballona Creek near the discharge into the Bay. The sampling results are tabulated on Table 3-22. Additionally, this table shows a 6-month mean concentration of several target pollutants, as reported by the Waste Management Division of the Los Angeles County Department of Public Works. Those results were obtained from May through October 1988 as part of the County's ongoing sampling program.

As was displayed on Tables 3-8 through 3-11 for the wet-weather flow analysis, the dry-weather flow concentrations of target constituents were compared to effluent limitation values set by the California Ocean Plan standards (SWRCB, 1990). It was considered that the 6-month median value detailed in the Plan reflected adequately the relatively constant value of the discharged flows. For herbicides and pesticides, the 30-day average standard was used. Results indicate that, although the TSS and O&G concentration values are below those recommended by the standards, the 6-month median standards are exceeded by the concentration of several heavy metals, particularly lead, as well as pesticides. Table 3-22 indicates that the mean values obtained in this study are higher than those obtained by the County during the same period.

The calculation of expected dry-weather pollutant loads required estimating the corresponding flows. These were obtained from the analysis of 3 years of low-flow data at Ballona, Topanga, and Sawtelle-Westwood Creeks gauging stations (Los Angeles County, Department of Public works; unpublished data). A proportional relationship was found between drainage area and flow. Because the main interest of this study resides in the 16 drainage basin discharges from the urbanized portion of the study area, dry-weather flows for only those drainage basin discharges were estimated. The calculations were based on the assumption of a constant value throughout the study area of the flow-to-area ratio found for Ballona Creek.

Table 3-23 shows estimated flows and expected annual TSS and O&G loads from each drainage basin, based on a 365-day discharge. The dry-weather discharge at Ballona Creek represents more than 80 percent of the total estimated dry-weather flow in the 16-drainage-basin area. The expected dry-weather load of heavy metals, herbicides, and pesticides, as well as their total expected annual loads are indicated on Table 3-20.

Table 3-22

Dry Weather Runoff Pollutant Concentrations in the Study Area

	Sample Date 8/24/88 (mg/L)	Sample Date 9/27/88 (mg/L)	Estimated Mean Concentration (mg/L)	Ocean Plan Standards[a] (mg/L)	Estimated Mean Standards
Data From This Study					
O&G	12.5	0.5	2.5	25	0.10
TSS	29.0	31.0	30.0	60	0.50
Arsenic (tot)	0.011	0.019	0.014	0.008	1.81
Cadmium (tot)	ND	ND	ND	0.001	-
Chromium (tot)	0.032	0.004	0.011	0.002	5.66
Copper (tot)	0.184	0.005	0.030	0.003	10.11
Lead (tot)	0.020	0.240	0.069	0.002	34.64
Nickel (tot)	ND	ND	ND	0.005	-
Zinc (tot)	0.760	0.040	0.174	0.020	8.72
Herbicides	0.00643	0.0025	0.004	0.001	4.00
Pesticides	0.0001	ND	0.00002	0.000003	3.33

	Urbanized Basins (mg/L)	Nonurban Basins (mg/L)	Ocean Plan Standards[a] (mg/L)	Urbanized Basins Concentrations Standards
Los Angeles County, Department of Public Works[b]				
O&G	0.573	0.659	25	0.02
TSS	-	-	60	-
Arsenic (tot)	0.005	0.004	0.008	0.59
Cadmium (tot)	ND	ND	0.001	-
Chromium (tot)	0.007	ND	0.002	3.47
Copper (tot)	0.010	0.008	0.003	3.41
Lead (tot)	0.015	0.007	0.002	7.28
Nickel (tot)	ND	ND	0.005	-
Zinc (tot)	0.053	0.024	0.020	2.66
Herbicides	ND	ND	0.001	-
Pesticides	ND	ND	0.000003	-

Source: Engineering-Science; LACDPW Waste Management Division, 1988
[a] Six-month median toxic material limitations; 30-day average limitations for herbicides and pesticides.
[b] Study performed by Waste Management Division of the LACDPW between May & October, 1988.
TSS = total suspended solids
O&G = oil and grease
ND = Not detected
- = Not measured
mg/L = milligrams per liter
tot = total

Table 3-23

Dry Weather Runoff Flows by Drainage Basin

Drainage Area Basin	Area (ha)	Runoff Flow (L/s)	Annual TSS Load (kg)	Annual O&G Load (kg)
1	457	3.9	3,690	308
1A	246	2.1	1,987	166
2	1,305	11.2	10,596	883
3	647	5.6	5,298	442
4	163	1.4	1,323	110
5	32,993	283.4	268,153	22,346
6	589	5.1	4,789	399
7	84	0.7	684	57
8	65	0.6	527	44
9	123	1.1	1,000	83
10	108	0.9	877	73
11	857	11.3	10,726	894
12	107	0.9	869	72
13	1,679	14.4	13,645	1,137
14	38	0.3	311	26
15	375	3.2	3,050	254
16	334	2.9	2,712	226
17	4,108	nd	nd	nd
18	164	nd	nd	nd
19	672	nd	nd	nd
20	494	nd	nd	nd
21	60	nd	nd	nd
22	19	nd	nd	nd
23	1,776	nd	nd	nd
24	114	nd	nd	nd
25	30	nd	nd	nd
26	5,106	nd	nd	nd
WATERSHED	52,713	349	330,238	27,520

Source: Engineering-Science
TSS = total suspended solids
O&G = oil and grease
nd = not determined (see text)
ha = hectare
L/s = liters per second
kg = kilogram

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Temporal Analysis of Runoff Pollutant Discharges

As indicated previously, the temporal analysis of the data refers to determining the significance of pollutant washoff as compared to runoff occurrence. In stormwater runoff pollution studies, the main temporal processes are the so-called "first-flush" effects. For a given storm event, the first-flush effect is described by Colston (1974) as "an initially high pollutant concentration followed by decreasing concentrations as the storm proceeds." A similar effect is possible on a season-wide basis. The first storm occurring after a relatively long dry period could carry a larger pollutant concentration than a storm occurring after a short inter-event time. This condition is referred to as seasonal first-flush.

First-flush storm-related effects are usually important in stormwater pollution studies when considering small areas of study, on the order of a few acres. In the present study, this type of condition was difficult to identify because of the size of the areas where water samples were collected. In general, for regions such as the study area, routing processes are expected to take precedence over first-flush conditions; that is, the extensive storm drain system combines flows from many areas located far apart. The resulting mixture of runoff pollutants and volumes have varying concentrations and travel times, making identification of first-flush flows difficult on any basin larger than a few acres.

Seasonal first-flush effects, on the other hand, are likely to be important in the study area because of the frequent long periods with no rainfall that permit pollutant accumulation in the streets and structures such as catchment facilities. The wet season normally lasts from November through April, and the dry season lasts from May through October. During this study's sampling program, samples were taken at the residential site during the storm of November 13, 1988. This was the first storm after a 7-month dry period that affected Southern California in 1988. As shown on Table 3-8, the data show significantly larger concentrations of all pollutants during this storm than during the other two storms sampled at that site. This could be interpreted as a result of the presence of a seasonal first-flush. Additional sampling is necessary to conclusively demonstrate this phenomenon.

Another aspect usually considered in the estimation of stormwater pollution loads is that of upper threshold values. This threshold value is defined as a volume above which complete pollutant washoff occurs and contaminant loads experience dilution effects (Louks, et al., 1984). The direct relationship between runoff volume and contaminant load is lost. Dilution effects appear during high-intensity storms, with average intensities higher than 1.25 cm/hour (0.5 in/hour). From the 38 years of rainfall records at Los Angeles Airport, it can be seen that only about 8 percent of the recorded storms have intensities higher than 1.25 cm/hour (0.5 in/hour). Based on these data, upper threshold runoff effects are unlikely to have a significance in determining average pollution loads for the study area.

TOTAL ESTIMATED ANNUAL RUNOFF POLLUTANT LOAD

Table 3-24 is a summary of total annual wet- and dry-weather TSS and O&G loads into Santa Monica Bay. The results indicate that dry-weather contributions of TSS and O&G represent only about 4 and 8 percent, respectively, of the estimated total annual runoff pollution load being discharged into the Bay. Table 3-20 displayed the total estimated annual load of heavy metals, herbicides, and pesticides into Santa Monica Bay. More than 96 percent of the total load of these substances are caused by wet-weather discharges. Table 3-25 shows comparative percent ratios of the concentrations and total annual loads of several constituents as estimated in this study versus the 1988 discharge from the HTP. For most substances - particularly lead, zinc, and mercury - wet-weather pollutant concentrations exceed the HTP discharge concentrations. Concentrations of chromium and zinc from dry-weather flows also exceed those from the HTP discharge. In terms of total annual load, however, the HTP discharges exceed the runoff pollution load for all constituents.

Table 3-24

Total Estimated Annual Loads of Totals Suspended Solids and Oil and Grease

Drainage Basin	Area (ha)	TSS LOAD Wet Weather (kg)	TSS LOAD Dry Weather (kg)	TSS LOAD Total (kg)	O&G LOAD Wet Weather (kg)	O&G LOAD Dry Weather (kg)	O&G LOAD Total (kg)
1	457	58,638	3,690	62,328	4,172	308	4,480
1A	246	36866	1,987	38,853	2,175	166	2,341
2	1,305	528,514	10,596	539,110	11,811	883	12,694
3	647	76,815	5,298	82,113	3,977	442	4,419
4	163	21,897	1,323	23,220	908	110	1,019
5	32,993	5,630,818	268,153	5,898,971	250,474	22,346	272,820
6	589	84,365	4,789	89,153	4,548	399	4,947
7	84	12,017	684	12,701	603	57	660
8	65	11,092	527	11,619	442	44	486
9	123	19,536	1,000	20,536	1,020	83	1,103
10	108	21,362	877	22,239	895	73	968
11	857	169,796	10,726	180,522	7,313	894	8,207
12	107	22,049	869	22,917	732	72	805
13	1,679	244,411	13,645	258,056	11,756	1,137	12,893
14	38	16,445	311	16,756	319	26	345
15	375	82,681	3,050	85,731	2,949	254	3,203
16	334	60,918	2,712	63,631	2,731	226	2,957
17	4,108	231,055	279,808	14,237	17,067	nd	nd
18	164	21,358	21,358	1,205	1,205	nd	nd
19	672	33,956	33,956	1,924	1,924	nd	nd
20	494	58,362	58,362	3,616	3,616	nd	nd
21	60	19,029	19,029	950	950	nd	nd
22	19	7,100	7,100	279	279	nd	nd
23	1,776	106,642	106,642	6,612	6,612	nd	nd
24	114	13,962	13,962	858	858	nd	nd
25	30	8,968	8,968	468	468	nd	nd
26	5,106	88,275	88,275	2,506	2,506	nd	nd
TOTAL	52,713	7,686,925	330,238	8,017,163	339,479	27,520	366,999

Source: Engineering-Science
nd = not determined; dry-weather loading for drainage areas 1-16 only (see text)
TSS = total suspended solids
O&G = oil and grease
ha = hectare
kg = kilogram

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Table 3-25

Comparative Annual Runoff Pollutant Concentration and Loading - Runoff from the Study Area Versus HTP Discharge (1988)

	Concentration				Annual Mass Load Ratio	
	Wet-Weather Ratio		Dry-Weather Ratio			
Constituents	Runoff:HTP	JWPCP	Runoff:HTP	JWPCP	Runoff: HTP	JWPCP
TSS	2.05	1.06	0.52	0.23	0.27	0.12
O&G	0.35	0.03	0.16	0.10	0.05	0.03
Arsenic (total)	0.70	0.30	0.17	0.70	0.13	0.07
Cadmium (total)	1.82	1.50	0.52	ND	0.31	0.23
Chromium (total)	1.29	0.31	1.81	0.16	0.15	0.04
Copper (total)	1.52	0.88	ND	0.30	0.20	0.12
Lead (total)	6.00	1.78	0.67	0.77	0.79	0.37
Nickel (total)	0.51	0.26	0.52	ND	0.06	0.03
Zinc (total)	5.52	3.12	1.31	0.60	0.70	0.42
Silver (total)	0.13	0.07	ND	ND	0.02	0.02
Mercury (total)	4.88	1.25	1.00	ND	0.48	0.15

Source: Engineering-Science
HTP = Hyperion Treatment Plant
TSS = total suspended solids
O&G = oil and grease
ND = no data available

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SECTION 4

EVALUATION OF RUNOFF POLLUTANT CONTROL MEASURES

The purpose of the analysis in this section is to identify the potential runoff pollution control measures that could be implemented in the study area. Measures selected as a result of this evaluation will be used to satisfy the requirements of the Consent Decree. Potential pollution control measures are categorized as structural and nonstructural. Structural controls are associated with the construction of physical facilities; e.g., the construction of settling basins. Nonstructural measures are primarily based on management approaches for controlling the discharge of pollutants, and include maintenance practices, such as streetsweeping (Table 4-1).

CRITERIA FOR SELECTION OF CANDIDATE MEASURES

The alternative measures are described and analyzed in terms of their design characteristics as well as their efficiencies and effectiveness. Efficiency is defined as the ability of a given control measure to remove pollutants from the site (or flows) being treated. Effectiveness is the overall pollutant removal expected from the implementation of any given measure in the entire study area. For example, pollution-removal efficiencies of treatment of dry-weather flows are close to 100 percent, but because dry-weather flows represent only about 4 percent of the total expected load from the study area into Santa Monica Bay, the effectiveness of treating 50 percent of the dry-weather flows would be only about 2 percent.

The primary criteria included in this analysis to evaluate alternative runoff pollution control measures are costs, efficiency, effectiveness, community and environmental impacts, and regulatory and institutional aspects. Technical feasibility and time required for implementation are also addressed as evaluation criteria. Costs are defined in terms of TSS and O&G removal per thousand dollars of investment.

As was discussed in Section 3, control measures were evaluated based on removal of TSS and O&G from runoff loads. The percent removal of TSS and O&G is directly proportional to percent removal of metals, herbicides, and pesticides. Annual loading for these constituents was discussed on Table 3-20.

STRUCTURAL POLLUTION CONTROL MEASURES

The structural runoff pollution control measures that might be implemented in the study area were divided into four major groups: detention settling, treatment, transport, and infiltration pilot programs. Table 4-1 lists potential structural controls. Analytical and cost estimating procedures for structural measures were developed according to EPA recommendations (EPA, 1986; Weigand, et at., 1986).

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Table 4-1

Potential Runoff Pollution Control Options

Control Strategy	Control Measure
Structural Controls	
Detention	Use North Outfall Sewer structure Construct surface detention basins Construct underground detention
Treatment	Treat dry-weather flows at drainage discharges Divert dry-weather drainage into HTP interceptor Treat wet-weather flows Develop wetlands for runoff treatment
Transport	Construct dry-weather outfall Construct wet-weather outfalls
Infiltration Pilot programs	Build porous pavements Build green strip filters Build permeable inlet basins
Nonstructural Controls	
Waste collection and Recycling	Collect household hazardous waste materials Recycle waste oil
Maintenance Practices	Increase streetsweeping frequency Upgrade streetsweeping methods Increase catch basin cleaning
Public Education	Inform public of runoff pollutant problem Introduce concepts of pollutant runoff and control Emphasize need to implement solutions

Source: Engineering-Science

Detention Settling Facilities

Detention facilities analyzed in this study are the use of the North outfall sewer structure, the construction of surface detention basins in public lands (such as parks and highway medians), and the construction of underground detention systems.

North Outfall Sewer Structure Line Storage and Settling

Project Description. The North Outfall Sewer (NOS) was used by the City of Los Angeles to collect sewer flows from the northern part of the study area and carry them to HTP. The North Outfall Replacement Sewer has allowed the NOS to be taken out of service and rehabilitated. Dry-weather flows from an area of approximately 13,000 ha could be diverted to the NOS for temporary storage. The settling process associated with this storage would remove TSS from incoming flows. Subsequently, those flows would be pumped through the HTP ocean outfall.

Costs. The costs of implementing this alternative were not specifically determined because they are far greater than the requirements stated in the Consent Decree. There would be advantages in project implementation, however, because of the use of an existing structure for runoff pollution control.

Efficiency. The pollution-removal efficiency of this project would be on the order of 90 percent (for TSS). The effectiveness in total nonpoint-source pollution removal would be about 3 percent because of the low pollution load carried by the dry-weather flows, as compared to that resulting from wet-weather conditions.

Community and Environmental Impacts. The implementation of this alternative would have a very high community acceptance and a low environmental impact.

Regulatory Institutional Aspects. Regulatory institutional aspects are not expected to preclude project implementability. The NOS is not expected to be refurbished and available for this type of project until 1996.

Construction of Surface Detention Settling Basins

Project Description. Surface settling basins are common runoff pollution control facilities. Their main purpose is the removal of suspended solids. Their efficiency varies directly with the time that flows are detained within the basin. Detention time is a function of total volume; therefore, a direct relationship exists between removal efficiency and a basin's total area. The area of the basin, of course, translates into costs.

In general, detention times in basins designed for stormwater pollution control are relatively long because many of the pollutants are associated with very small particle sizes. For instance, Cobb (1982) reports that USGS studies have found that about half of the total recoverable lead is associated with particle sizes finer than 0.0039 mm. A detention time of more than 6 hours, however, would be required to remove particles of this size. Designing a detention-settling facility with a detention time of 6 hours would allow for collection of about 70 percent of the runoff resulting from a typical storm during peak-intensity periods.

In this study, estimated size of the settling facilities was based on the design procedure proposed by EPA (1986), assuming an 80 percent reduction in TSS concentration. Some reduction of oil and grease and pesticides would also be expected in these facilities. Other assumed design parameters were an average rainfall intensity of 1.27 mm/hour (0.05 in/hour) in the study area, an expected typical total rainfall of 28.70 mm (1.13 in) during a 24-hour rainfall, and an average runoff/rainfall ratio equal to 0.35 (see Table 3-7). The 1.27-mm/hour intensity is the average wet-season rainfall intensity, estimated from 38 years of rainfall analysis (EPA, n.d., and SYNOP historical data, Table 3-6). The 28.70-mm figure is the rainfall volume expected during a typical storm.

Settling basins would be on-line facilities. They would operate as dry ponds and the retention volume would be drawn down within 72 hours of the storm occurrence to reduce odor and insect problems. Although the basins could be designed to include percolation into the ground, this analysis considered that all flows would be returned to the stormwater system.

Costs. Although the characteristics of detention facilities are site-specific, Table 4-2 shows general basin characteristics associated with the 55 drainage basins in the study area. The drainage basins are ranked by TSS loading ratio as indicated on Table 3-17. Construction and O&M cost estimates were obtained from Weigand, et al. (1986). These costs were doubled in the calculations to account for 1989 costs, local cost conditions, and engineering plus contingencies. Capital costs include an estimated $750,000 per hectare of land.

Land availability is probably the main problem facing the development of settling basins in the study area. The O&M costs could increase significantly if the concentration of pesticides in the sediment makes frequent removal of accumulated sediments necessary. Estimation of total annual costs was based on a 20-year life and a 10 percent discount rate.

Efficiency. As indicated previously, these facilities were designed for a removal efficiency of about 80 percent TSS. The TSS removal-to-investment ratio varies from 488 kg/$1,000 at drainage basin 2 to 29 kg/$1,000 at drainage basin 26.

Community and Environmental Impacts. The construction of settling basins would have implications regarding public safety. Additionally, this type of project would not be acceptable if the facilities are built in public parks and recreation activities are disrupted. Environmental impacts caused by the presence and disposal of sediments would be moderate.

Regulatory Institutional Aspects. Some regulatory institutional issues are expected to arise if this alternative is implemented because of the required approvals by the City departments, the Regional Water Quality Control Board, Los Angeles Region (RWQCB), and EPA.

During this study, it was not possible to identify an appropriate site for the construction of a detention basin within the study area because of the numerous factors associated with land acquisition that would have to be resolved. Provided that a construction site is determined, the expected implementation time is estimated to be between 1 and 2 years.

Construction of Underground Detention Settling Facilities

Project Description. Underground settling facilities operate in a fashion similar to surface settling basins. Runoff flows are detained over a certain time period to accomplish pollutant removal by allowing suspended solids to settle under quiescent

Table 4-2

Detention Settling Basins: Sizing and Cost Estimates

Overall Rank[a]	Drainage Basin	Basin Area (ha)	Average Flow (m^3/hr)[b]	Pond Area (m^2)	Capital Costs ($000)[c]	Annual O&M Costs ($000)	Tot. Annual Cost($000) (10%, 20yr)	TSS Removal (kg/$000)	Removal Effectiveness (%)
1	14	38	222	1,456	157	8	26	483	0.2
2	2	1305	8692	57,020	4997	250	834	488	5.3
3	22	19	147	964	107	5	18	305	0.1
4	21	60	423	2,775	285	14	48	308	0.2
5	25	30	204	1,338	145	7	24	285	0.1
6	15	375	1552	10,181	966	48	161	395	0.8
7	5-9	552	2231	14,635	1362	68	227	394	1.2
8	5-2-2	1075	4387	28,779	2594	130	433	399	2.2
9	5-6	2339	9600	62,976	5498	275	918	407	4.9
10	12	107	426	2,795	287	14	48	354	0.2
11	5007	427	1738	11,401	1075	54	179	368	0.9
12	11	857	3414	22,396	2042	102	341	383	1.7
13	10	108	428	2,808	288	14	48	342	0.2
14	5009	4919	20696	135,766	11542	577	1,928	382	9.6
15	5-5	4118	15997	104,940	8997	450	1,502	405	7.9
16	5-7	1466	5619	36,861	3287	164	549	389	2.8
17	5-1-2	1448	5754	37,746	3363	168	562	368	2.7
18	5-4-1	597	2305	15,121	1405	70	235	362	1.1
19	16	334	1303	8,548	819	41	137	343	0.6
20	5002	388	1469	9,637	917	46	153	356	0.7
21	5001	677	2596	17,030	1573	79	263	349	1.2
22	5008	300	1100	7,216	698	35	117	348	0.5
23	8	65	249	1,633	174	9	29	293	0.1
24	5200	300	1127	7,393	714	36	119	329	0.5
25	5005	355	1335	8,758	837	42	140	330	0.6
26	5100	916	3517	23,072	2100	105	351	336	1.5
27	5-8	3876	15796	103,622	8888	444	1,484	334	6.4
28	5-1-1	361	1352	8,869	848	42	142	324	0.6
29	9	123	442	2,900	297	15	50	303	0.2
30	5003	501	1883	12,352	1160	58	194	309	0.8
31	5-3	355	1249	8,193	786	39	131	319	0.5

Table 4-2 (Continued)

Detention Settling Basins: Sizing and Cost Estimates

Overall Rank[a]	Drainage Basin	Basin Area (ha)	Average Flow (m^3/hr)[b]	Pond Area (m^2)	Capital Costs ($000)[c]	Annual O&M Costs ($000)	Tot. Annual Cost($000) (10%, 20yr)	TSS Removal (kg/$000)	Removal Effectiveness (%)
32	5400	853	3011	19,752	1811	91	302	331	1.3
33	1A	246	939	6,160	601	30	100	283	0.4
34	13	1679	5930	38,901	3461	173	578	326	2.4
35	1700	483	1707	11,198	1057	53	176	303	0.7
36	6	589	2081	13,651	1275	64	213	305	0.8
37	7	84	299	1,961	207	10	34	268	0.1
38	5006	26	93	610	71	4	12	237	0.0
39	4	163	580	3,805	383	19	64	264	0.2
40	5-2-1	4573	19330	126,805	10804	540	1,804	255	6.0
41	18	164	552	3,621	365	18	61	270	0.2
42	1	457	1728	11,336	1069	53	179	253	0.6
43	24	114	634	4,159	416	21	69	155	0.1
44	3	647	2031	13,323	1246	62	208	284	0.8
45	20	494	2735	17,942	1653	83	276	163	0.6
46	5004	40	126	827	93	5	16	231	0.0
47	5000	464	1446	9,486	903	45	151	225	0.4
48	5-4-3	1106	4149	27,217	2459	123	411	197	1.1
49	5-4-2	959	3958	25,964	2351	118	393	175	0.9
50	17-2	965	2405	15,777	1463	73	244	185	0.6
51	23	1776	9207	60,398	5281	264	882	93	1.1
52	19	672	3459	22,691	2067	103	345	76	0.3
53	17-3	735	1520	9,971	947	47	158	139	0.3
54	17-1	1925	3863	25,341	2297	115	384	149	0.7
55	26	5106	25430	166,821	14092	705	2,353	29	0.9

Source: Engineering Science
O&M = operation and maintenance
TSS = total suspended solids
[a] Rank based on annual pollutant loading ratio (Appendix A-2 through A-5)
[b] Based on basin area and typical storm (Table 3-6); average rainfall intensity I = 0.13 mm/hr (0.05 in./hr); runoff/rainfall = 0.35; depth = 1.2 m
[c] Cost estimates include land acquisition at $750,000 per hectare
ha = hectare
m^3/hr = cubic meter per hour
kg = kilogram

conditions. The design characteristics of these structures are indicated on Table 4-3. Design parameters used for sizing these structures were equal to those used for sizing surface settling basins. Removal efficiencies are expected to be about 80 percent.

Costs. The main advantage of underground detention facilities over settling basins is the availability of construction sites, which makes this alternative less site-specific. Underground settling facilities are generally more expensive than surface settling facilities in terms of capital and O&M costs. In this study, construction cost estimates were obtained from Weigand, et al. (1986). These costs were doubled in the calculations to account for 1989 costs, local cost conditions, and engineering and contingencies.

Efficiency. The main disadvantage of this alternative is the lower pollution removal-to-investment ratio as compared to surface settling basins. As shown on Table 4-3, the annual kilograms of TSS removal per $1,000 investment range from 361 at drainage basin 2 to 25 at drainage basin 26.

Community and Environmental Impacts. This type of facility would be more easily accepted by the community than surface settling basins. The environmental impact would probably be moderate because of the presence of sediments requiring removal and the perceived risk of groundwater contamination. Construction would result in extensive disruption of existing activities.

Regulatory Institutional Aspects. Some institutional regulatory issues are expected to arise because of O&M considerations. The estimated implementation time is between 3 and 5 years.

Treatment Facilities

Two main runoff pollution-control treatment alternatives were considered for analysis: treatment of dry-weather flows at drainage discharges and collection of dry-weather flows at drainage discharges for subsequent treatment at HTP. Additionally, facility site considerations are given for providing storage of wet-weather flows at the discharge sites for subsequent treatment in a Wastewater Treatment Plant, and development of wetland areas for runoff treatment is discussed.

Treatment of Dry-Weather Flows at Drainage Discharges

Project Description. Treatment of dry-weather flows consisting of primary sedimentation would be conducted at the discharge point of the receiving storm drain into the Bay. The addition of chemicals to the primary settling facilities may be necessary to remove heavy metals. The implementation of this alternative would require pumping the flows from the discharge site to the primary sedimentation units, which should be located in a site with adequate flood protection and as close to the discharge of the storm drain as possible.

Assuming that most dry-weather flows result from regulated discharges, removal of contaminants would be most effective if treatment takes place at the point of discharge. To be implemented, this measure would have to be added to existing NPDES permits by the RWQCB.

Table 4-3

Underground Detention Storage: Sizing and Cost Estimates

Overall Rank[a]	Drainage Basin	Area (ha)	Average Flow (m^3/hr)[b]	Pond Area (m^2)	Capital Costs ($000)[c]	Annual O&M Costs ($000)	Tot. Annual Cost($000) (10%, 20yr)	TSS Removal (kg/$000)	Removal Effectiveness (%)
1	14	38	222	1,456	384	12	56	224	0.2
2	2	1305	8692	57,020	7,663	230	1,126	361	5.3
3	22	19	147	964	275	8	40	135	0.1
4	21	60	423	2,775	650	20	96	153	0.2
5	25	30	204	1,338	359	11	53	131	0.1
6	15	375	1552	10,181	1,879	56	276	231	0.8
7	5-9	552	2231	14,635	2,526	76	371	242	1.2
8	5-2-2	1075	4387	28,779	4,386	132	645	268	2.2
9	5-6	2339	9600	62,976	8,310	249	1,222	306	4.9
10	12	107	426	2,795	654	20	96	177	0.2
11	5007	427	1738	11,401	2,060	62	303	218	0.9
12	11	857	3414	22,396	3,575	107	525	249	1.7
13	10	108	428	2,808	657	20	97	170	0.2
14	5009	4919	20696	135,766	15,554	467	2,286	322	9.6
15	5-5	4118	15997	104,940	12,606	378	1,853	328	7.9
16	5-7	1466	5619	36,861	5,368	161	789	271	2.8
17	5-1-2	1448	5754	37,746	5,473	164	805	257	2.7
18	5-4-1	597	2305	15,121	2,594	78	381	223	1.1
19	16	334	1303	8,548	1,629	49	239	196	0.6
20	5002	388	1469	9,637	1,796	54	264	206	0.7
21	5001	677	2596	17,030	2,859	86	420	218	1.2
22	5008	300	1100	7,216	1,419	43	209	195	0.5
23	8	65	249	1,633	422	13	62	138	0.1
24	5200	300	1127	7,393	1,447	43	213	184	0.5
25	5005	355	1335	8,758	1,661	50	244	189	0.6
26	5100	916	3517	23,072	3,662	110	538	219	1.5
27	5-8	3876	15796	103,622	12,477	374	1,834	270	6.4
28	5-1-1	361	1352	8,869	1,679	50	247	186	0.6
29	9	123	442	2,900	674	20	99	152	0.2
30	5003	501	1883	12,352	2,200	66	323	185	0.8
31	5-3	355	1249	8,193	1,574	47	231	181	0.5
32	5400	853	3011	19,752	3,226	97	474	211	1.3

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Table 4-3 (Continued)

Underground Detention Storage: Sizing and Cost Estimates

Overall Rank[a]	Drainage Basin	Area (ha)	Average Flow (m^3/hr)[b]	Pond Area (m^2)	Capital Costs ($000)[c]	Annual O&M Costs ($000)	Tot. Annual Cost($000) (10%, 20yr)	TSS Removal (kg/$000)	Removal Effectiveness (%)
33	1A	246	939	6,160	1,247	37	183	155	0.4
34	13	1679	5930	38,901	5,609	168	825	228	2.4
35	1700	483	1707	11,198	2,030	61	298	179	0.7
36	6	589	2081	13,651	2,387	72	351	185	0.8
37	7	84	299	1,961	490	15	72	128	0.1
38	5006	26	93	610	189	6	28	101	0.0
39	4	163	580	3,805	841	25	124	136	0.2
40	5-2-1	4573	19330	126,805	14,711	441	2,163	213	6.0
41	18	164	552	3,621	808	24	119	138	0.2
42	1	457	1728	11,336	2,051	62	301	150	0.6
43	24	114	634	4,159	905	27	133	81	0.1
44	3	647	2031	13,323	2,340	70	344	172	0.8
45	20	494	2735	17,942	2,983	89	438	102	0.6
46	5004	40	126	827	242	7	36	101	0.0
47	5000	464	1446	9,486	1,773	53	261	130	0.4
48	5-4-3	1106	4149	27,217	4,191	126	616	131	1.1
49	5-4-2	959	3958	25,964	4,033	121	593	116	0.9
50	17-2	965	2405	15,777	2,686	81	395	114	0.6
51	23	1776	9207	60,398	8,032	241	1,181	70	1.1
52	19	672	3459	22,691	3,613	108	531	49	0.3
53	17-3	735	1520	9,971	1,847	55	272	81	0.3
54	17-1	1925	3863	25,341	3,954	119	581	99	0.7
55	26	5106	25430	166,821	18,401	552	2,705	25	0.9

Source: Engineering-Science
O&M = operation and maintenance
TSS = total suspended solids
[a] Rank based on annual pollutant loading ratio (Appendix A-2 through A-5)
[b] Based on basin area and typical storm (Table 3-6); Average rainfall intensity I = 0.13 mm/hr (0.05 in./hr); runoff/rainfall = 0.35; Depth = 1.2 m
[c] Cost estimates include land acquisition at $750,000 per hectare
m^3/hr = cubic meter per hour
kg = kilogram

Costs. The removal costs associated with this alternative are indicated on Table 4-4. Costs were estimated by using factors developed by the U.S. Army, Corps of Engineers (1978), corrected for time, local conditions, and engineering and contingencies. The estimate of annual costs is based on a 20-year life and a 10 percent discount rate. A disadvantage of this alternative is the land requirements for construction of the facilities. This factor was not included in the cost estimates.

Efficiency. Treatment facilities are very efficient for removing a number of contaminants, including TSS and O&G. The annual TSS removal in kilograms per $1,000 invested is expected to vary from 226 at Ballona Creek and to 2 at drainage basin 14. The kilograms of O&G removed per $1,000 investment would vary from 18.8 to 1.3 in those same drainage basins. Removal effectiveness for low-flow treatment facilities would be quite low because of the very small dry-weather to wet-weather pollution ratio.

Community and Environmental Impacts. The environmental impact of developing this alternative would be high because of the presence of the treatment facilities in environmentally-sensitive areas. The community acceptance factor would be low because of the negative aesthetic impacts of the treatment plants and the perceived environmental risk.

Regulatory Institutional Aspects. Regulatory institutional issues are likely to be important because the treatment facilities would have to be operated under federal and state regulations. The period required for project implementation would be between 3 and 5 years.

Divert Dry-Weather Drainage into HTP Interceptor

Project Description. This alternative consists of constructing low-flow diversions from the drainage channels to the coastal sewer interceptor so that dry-weather flows could be treated at the HTP. Flow diversions would take place only during the dry season, which represents low-flow conditions at the treatment plant, and during periods between rainfall events when daily flows were at levels common during the dry season, and thus represents only "treatment by opportunity". The HTP has a treatment capacity of about 5.5×10^{11} liters per year (400 mgd). The average dry-weather flow for the urbanized basins (Basins 1-16) in the study area is about 349 L/s (8 mgd), which represents only about 2 percent of HTP capacity. From the standpoint of efficiency, diversion of Ballona Creek low flows alone would capture approximately 80 percent of the runoff from urbanized basins with the construction of a single diversion structure. Because of the small flows diverted, no major effects on the plant's capacity or performance would be expected.

The project would require constructing a diversion structure in the low-flow section of the Ballona Creek drainage channel. Automatic electrical operators would regulate flow diversion through a sluice gate valve so that no flow would be diverted during rainfall conditions or peak inflows at the treatment plant. The pipe carrying flows to the coastal interceptor is expected to operate entirely by gravity. The automatic operators could also be controlled by a flow-monitoring system installed at HTP.

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Table 4-4

Alternative: Treat Dry-Weather Runoff Flows at Drainage Discharges

Drainage Area	Area (Ha)	Flow (L/s)	Annual TSS Load (Kg)	Annual O&G Load (Kg)	Capital Costs ($000)[a]	Annual O&M Costs ($000)	Total Annual Cost($000)[a] (10%, 20yr)	TSS Removal (Kg/$000)	O&G Removal (Kg/$000)	Effectiveness TSS Rem. (%)	Effectiveness O&G Rem. (%)
1	457	3.9	3,690	308	1,393	12	175	21	1.8	0.05	0.08
1A	246	2.1	1,987	166	1,380	7	168	12	1.0	0.02	0.05
2	1,305	11.2	10,596	883	1,444	34	203	52	4.4	0.13	0.24
3	647	5.6	5,298	442	1,406	17	182	29	2.4	0.07	0.12
4	163	1.4	1,323	110	1,374	4	165	8	0.7	0.02	0.03
5	32,993	283.4	268,153	22,346	3,011	834	1,187	226	18.8	3.34	6.09
6	589	5.1	4,789	399	1,402	15	179	27	2.2	0.06	0.11
7	84	0.7	684	57	1,368	2	162	4	0.4	0.01	0.02
8	65	0.6	527	44	1,367	2	162	3	0.3	0.01	0.01
9	123	1.1	1,000	83	1,371	3	164	6	0.5	0.01	0.02
10	108	0.9	877	73	1,370	3	163	5	0.4	0.01	0.02
11	857	11.3	10,726	894	1,445	34	203	53	4.4	0.13	0.24
12	107	0.9	869	72	1,370	3	163	5	0.4	0.01	0.02
13	1,679	14.4	13,645	1,137	1,465	43	215	64	5.3	0.17	0.31
14	38	0.3	311	26	1,365	1	161	2	0.2	0.00	0.01
15	375	3.2	3,050	254	1,388	10	172	18	1.5	0.04	0.07
16	334	2.9	2,712	226	1,386	9	171	16	1.3	0.03	0.06

Source: Engineering-Science
[a] Cost does not include land acquisition
TSS = total suspended solids
O&G = oil and grease
O&M = operations and maintenance

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Costs. The cost factors associated with this alternative are indicated on Table 4-5. They include an estimated $100 per year per liter/second of flow volume. This value was obtained from Engineering-Science data for operation of wastewater treatment facilities. These estimates indicate a present-worth cost for diversion and treatment of Ballona Creek low flows to HTP of $536,000. The City Bureau of Sanitation has indicated that these costs may be substantially higher.

Efficiency. Comparison of effluent water quality at HTP (Table 2-2) and Ballona Creek low-flow runoff (Table 3-22) indicate that TSS and O&G concentrations in Ballona Creek runoff average 2 and 5 times lower, respectively, than in HTP effluent. Concentrations of metals in both systems are approximately equal. In terms of TSS and O&G removal, treatment would probably have no effects on the water quality of the incoming runoff flows to HTP. TSS and O&G would simply be discharged through HTP's outfall instead of draining directly onto the nearshore zone. On the other hand, some heavy metals would be removed from the discharged flows and incorporated into the excess sludge. Because of their relatively low loads and concentrations, no effects are expected on the plant's performance, specifically in the sludge treatment and disposal processes. A best-case estimate of the average annual kilograms of TSS removed from the drainage discharge per $1,000 investment would vary between 4285 and 31 (Table 4-5) at Ballona Creek and Santa Monica Pier drainage basins, respectively. Since the Ballona Creek flow represents 80 percent of the low-flow TSS and O&G entering the bay, removal effectiveness of treating this single outflow is much higher than treating any other drainage area.

Community and Environmental Impacts. The main advantage of this alternative is the increased public perception that the responsible agencies are taking steps toward solving the perceived pollution problem in the area. The negative environmental impacts of project implementation would be minimal, since Ballona Creek does not drain into the wetlands. Fresh water flows through the wetland area via Jefferson drain and the Centinela drain and into Ballona Creek.

Regulatory Institutional Aspects. Concern exists regarding the impact of implementing this alternative on the regulatory and financial requirements of the HTP. These will need to be resolved, including EPA approval to accept runoff flows other than domestic sewage. The Sewer Limitation Ordinance adopted by the City in 1988 regulates new sewer connections by both the City and contract agencies. Any diversion of low flows would need to be evaluated against criteria used for other connections.

Storage and Treatment of Wet-Weather Flows

This alternative would consist of collecting and storing stormwater runoff flows for treatment at a treatment facility. In terms of plant capacity, this alternative cannot be implemented because the expected volume resulting from a typical storm during the wet season would be about three times the existing treatment capacity at HTP. The size of storage requirements, flow conveyance facilities, and treatment units makes this alternative nonimplementable at this time or in the near future.

Table 4-5

Alternative: Divert Dry-Weather Drainage into HTP Interceptor

Drainage Basin	Basin Area (ha)	Flow (L/s)	Annual TSS Load (kg)	Annual O&G Load (kg)	Capital Costs ($000)	Annual O&M Costs ($000)	Total Annual Cost($000)[a] (10%, 20yr)	TSS Removal (kg/$000)	O&G Removal (kg/$000)	Effectiveness TSS Rem. (%)	Effectiveness O&G Rem. (%)
1	457	3.9	3,690	308	60	10	17	218	18.2	0.05	0.08
1A	246	2.1	1,987	166	48	7	13	159	13.2	0.02	0.05
2	1,305	11.2	10,596	883	68	18	26	410	34.2	0.13	0.24
3	647	5.6	5,298	442	63	12	19	275	22.9	0.07	0.12
4	163	1.4	1,323	110	50	6	12	109	9.1	0.02	0.03
5	32,993	283.4	268,153	22,346	204	39	63	4,285	357	3.34	6.09
6	589	5.1	4,789	399	63	11	19	256	21.3	0.06	0.11
7	84	0.7	684	57	48	6	11	61	5.1	0.01	0.02
8	65	0.6	527	44	48	5	11	48	4.0	0.01	0.01
9	123	1.1	1,000	83	47	6	11	90	7.5	0.01	0.02
10	108	0.9	877	73	48	6	11	77	6.4	0.01	0.02
11	857	11.3	10,726	894	68	18	26	413	34.4	0.13	0.24
12	107	0.9	869	72	48	6	11	77	6.4	0.01	0.02
13	1,679	14.4	13,645	1,137	72	22	30	454	37.8	0.17	0.31
14	38	0.3	311	26	45	5	10	31	2.6	0.00	0.01
15	375	3.2	3,050	254	60	9	16	188	15.6	0.04	0.07
16	334	2.9	2,712	226	57	9	15	178	14.8	0.03	0.06

Source: Engineering-Science
[a] Includes treatment costs estimated at $100/year per unit flow.
TSS = total suspended solids
O&G = oil and grease
O&M = operations and maintenance
ha = hectare
L/s = liter per second
kg = kilogram

A pollutant control technology that has been used widely in the Southeast is the detention of some first-flush volume of stormwater. After settling to remove pollutants, this volume is slowly released to the receiving body. In this way it operates in a similar manner to the settling basins discussed previously. This control technique may have applications in the Santa Monica Bay drainage areas in the City's long-term runoff management plan. ES estimates that capital costs required to implement this technology would be similar to those for detention basins.

Development of Wetlands for Runoff Treatment

Project Description. Treatment of stormwater runoff by routing the flows through wetland areas has proven effective in removing pollutant loads. Most studies reporting the results of the use of wetlands as a control measure indicate that they are most appropriate for removing nutrients and low levels of dissolved toxics (metals, etc.). They thereby function best as a "polishing" step at the end of a treatment series that uses other technologies to remove solids and some pollutants prior to reaching the wetlands. Because wetlands provide mostly nutrient and metals removal through biological uptake, careful studies are necessary to determine the effects of stormwaters in ecologically sensitive areas.

This study made an evaluation of the impact of using the Ballona Creek wetlands for treating stormwater runoff. A water quality objective for the Ballona Wetlands is to provide both storage and outflow for stormwater flow capacity for the 50-year storm event (Friends of Ballona Wetlands, 1990). By using wetlands only as a "polishing" step, pollutant removal efficiencies for this measure would be very low compared to other technologies. By treating the runoff flows before discharge, adequate uses of the water would be made; however, the purpose of using the wetlands as treatment units would be lost. Additionally, the treatment and flow conveyance costs would make this alternative not implementable at this time. Because of the high cost of land, the development of new wetlands in the area has also been considered infeasible.

Transport Facilities

The main alternative included under this category is the construction of dry weather outfalls. Additionally, some information is given regarding the construction of wet-weather outfalls. The outfalls would discharge into Santa Monica Bay at an undetermined distance from the beach, where dilution would decrease pollutant concentration below Ocean Plan Standards (SWRCB, 1990).

Construction of Dry-Weather Outfalls

Project Description. This alternative would consist of constructing outfalls similar to the proposed Pico-Kenter outfall system that would carry dry-weather flows for discharge at a certain distance from the beach. One problem with project implementation is the absence of pollutant-removal capabilities, which may not conform to the requirements of the Consent Decree.

Costs. The cost figures shown on Table 4-6 were developed at each discharge site using the estimated cost of the Pico-Kenter outfall as a basis point and sizing up or down as applicable. The cost estimate of the Pico-Kenter project was provided by the engineering staff of the Department of Public Works of Los Angeles County.

Efficiency. An important characteristic of this alternative is that pollutants are not actually removed from the Bay, but it is assumed that dilution effects would reduce pollutant concentrations to more acceptable levels.

Community and Environmental Impacts. The community acceptance factor of implementing this alternative is likely to be mixed. Some strong opposition would be expected from environmental groups. The actual environmental impacts are likely to be moderate. There may be a need to model the behavior and characteristics of the receiving water under the new discharge conditions.

Regulatory Institutional Aspects. Several regulatory institutional issues are expected from the development of this project because of the number of agencies and community groups involved in the decision-making process. The time period required for constructing an outfall similar to the Pico-Kenter system is estimated at about 5 years.

Construction of Wet-Weather Outfalls

As indicated previously, the expected volume resulting from a typical storm during the wet season is about three times the treatment capacity at HTP. The required size of the outfalls would, therefore, be substantially larger than the existing domestic sewage ocean outfall. Because of its high costs, it has been considered that this alternative cannot be implemented at this time.

Infiltration Pilot Programs

Project Description. Small pilot programs are recommended to assess the effectiveness of implementing site-specific runoff pollution-control measures in areas such as parking lots. Three examples of such programs are evaluated here: installation of small stormwater filters in parking lot green strips, use of porous pavements in low-traffic areas, and installation of permeable catch basins.

The proposed **stormwater filters** would be designed as slow sand filtration units with a filtration rate of about 4,000 $L/m^2 \cdot d$ (100 $gal/ft^2 \cdot d$). Figures 4-1 and 4-2 are schematic representations of one of these units, which would be installed as part of an existing green strip divider in a parking lot. During storms, runoff would be carried to these units by sloping the catchment surface toward the filter inlet. The filtered effluent would discharge into the stormwater system. Sampling and monitoring capabilities should be provided to test actual pollutant removal efficiencies. The only normal O&M procedure applied to this unit would be to replace the upper 1-inch layer of sand when water-head losses become excessive.

Porous pavement areas would consist of a coarse graded surface layer, containing at least 25 percent voids, laid on an impermeable underlayer. Colyer (1982) indicates that about 4 mm of rainfall could be retained in the voids. The retention time and the contacting surface would result in pollution reduction. The effluent from the porous pavement areas would be discharged into the stormwater system.

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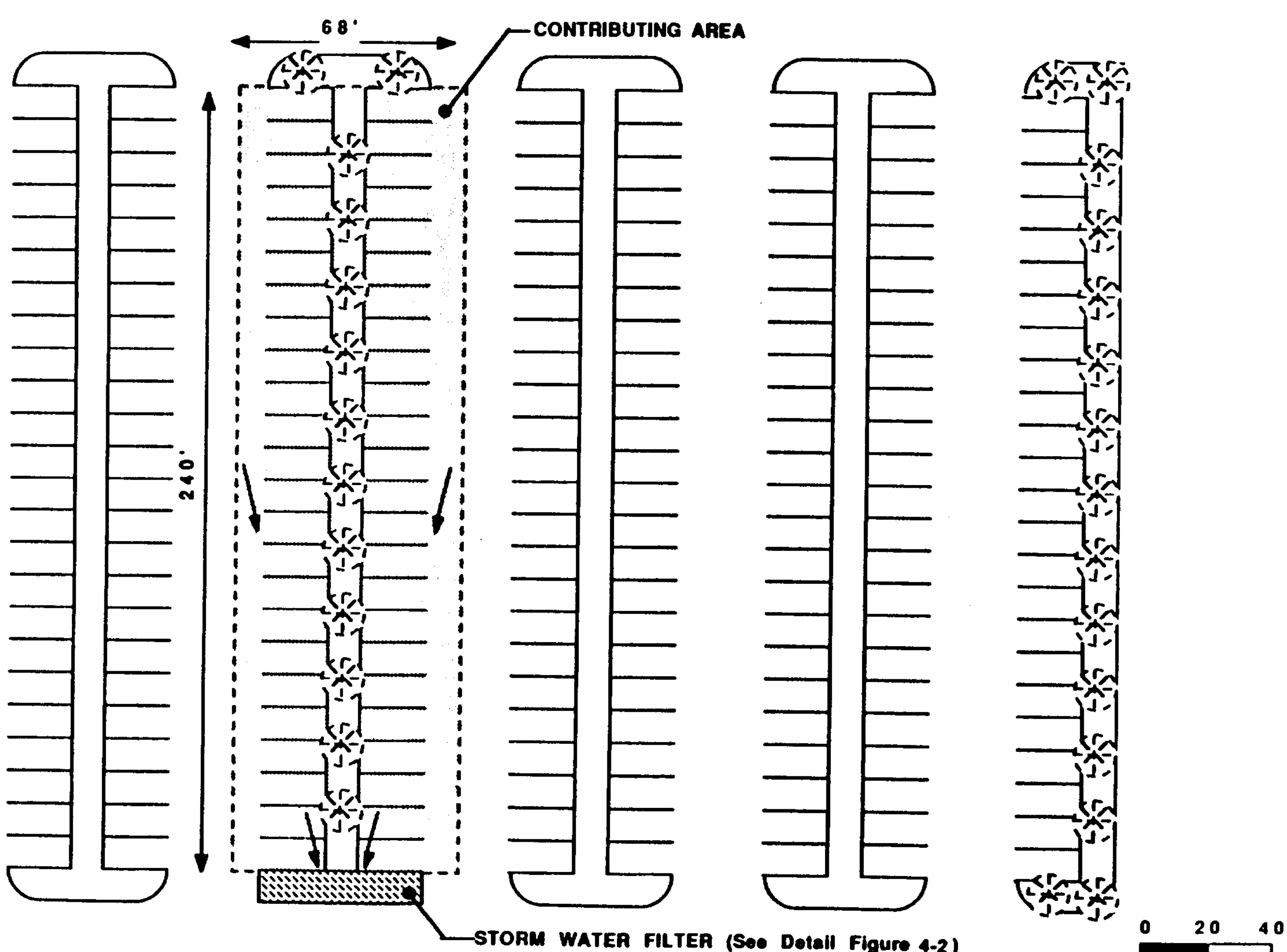
Table 4-6

Alternative: Construct Dry-Weather Runoff Outfalls

Drainage Basin	Area (ha)	Flow (L/s)	Annual TSS Load (kg)	Annual O&G Load (kg)	Capital Costs ($000)	Annual O&M Costs ($000)	Total Annual Cost ($000) (10%, 20yr)	Annual TSS Relocated (kg/$000)	Annual O&G Relocated (kg/$000)
Area 1	457[a]								
Area 1A	246	6.0	5,707	476	185	9	31	184	15
Area 2	1,305	6.8	6,448	537	198	10	33	195	16
Area 3	647	9.9	9,413	784	243	12	41	230	19
Area 4	163	1.4	1,323	110	83	4	14	95	8
Area 5	32,993	283.4	268,153	22,346	1,539	77	258	1,039	87
Area 6	589	5.1	4,789	399	169	8	28	171	14
Area 7	84	0.7	684	57	57	3	10	68	6
Area 8	65	0.6	527	44	52	3	9	59	5
Area 9	123	1.1	1,000	83	73	4	13	77	6
Area 10	108	0.9	877	73	65	3	11	80	7
Area 11	857	11.3	10,726	894	262	13	44	244	20
Area 12	107	0.9	869	72	65	3	11	79	7
Area 13	1,679	14.4	13,645	1,137	299	15	50	273	23
Area 14	38	0.3	311	26	36	2	6	52	4
Area 15	375	3.2	3,050	254	131	7	22	139	12
Area 16	334	2.9	2,712	226	124	6	21	129	11

Source: Engineering-Science
[a] Chevron El Segundo Refinery runoff collected, treated, and discharged through an existing ocean outfall.
TSS = total suspended solids
O&G = oil and grease
O&M = operations and maintenance
ha = hectare
L/s = liters per second
kg = kilogram



SOURCE: Engineering-Science

Figure 4-1 Pilot Greenstrip Filter - Conceptual View

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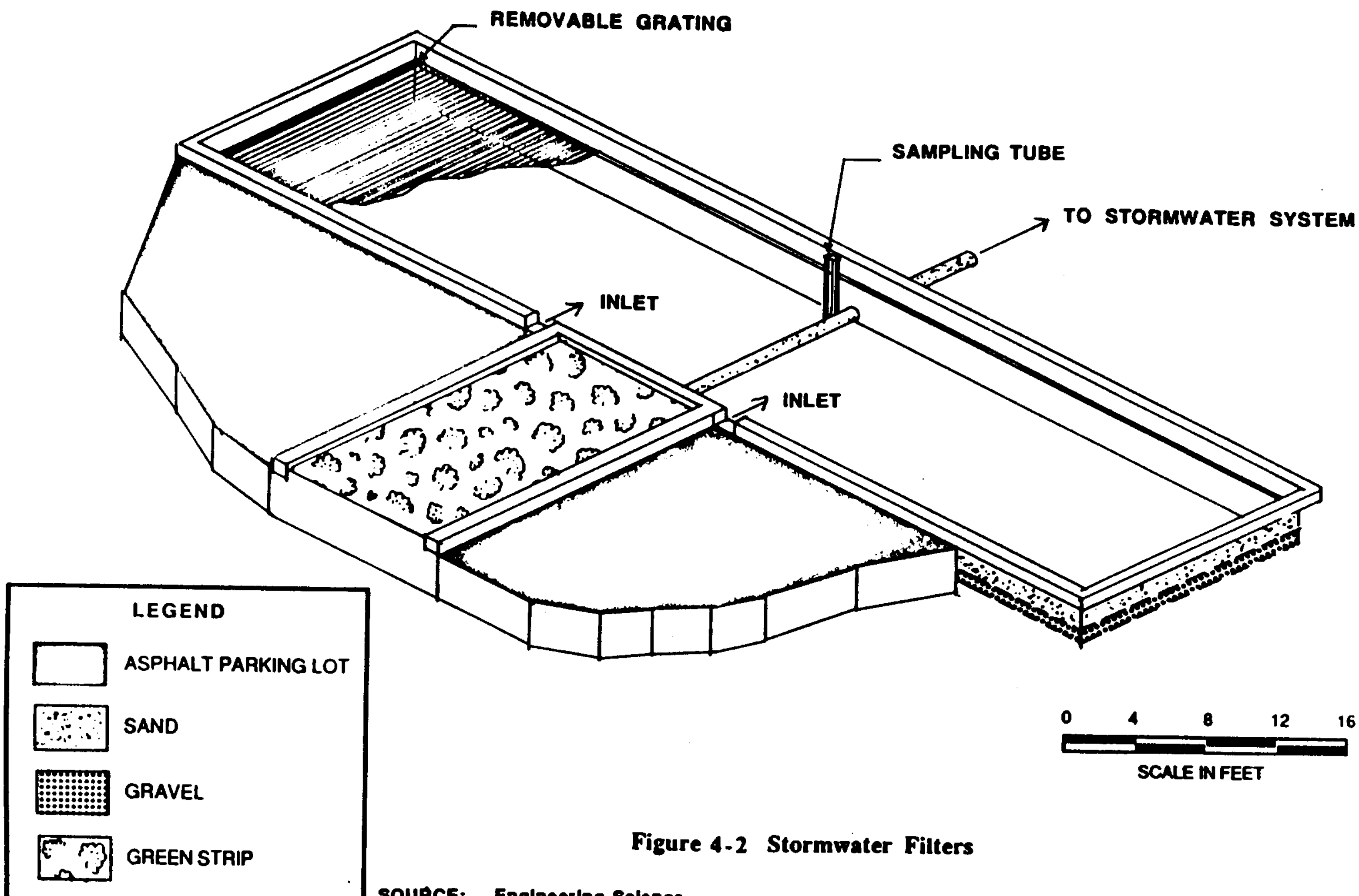

Figure 4-2 Stormwater Filters

SOURCE: Engineering-Science

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Problems encountered with these systems, as compared to regular asphalt pavement, are a faster wearing of the pavement surface and the need to apply special construction techniques. Control of construction would need to be more stringent than for normal road surfacings, and the costs are usually higher.

Permeable catch basins would be designed in a similar fashion to regular catch basins, except that the bottom would allow for the infiltration of runoff into the natural soil. These units could retain volumes of runoff from about 35 liters in a 300-mm chamber to 125 liters in a deep 450-mm chamber. Additional flows would be bypassed to the storm drain system. Installation of this type of catch basin should be considered as existing basins are repaired or replaced.

Pilot programs would require constant monitoring during an estimated three-year research period for determining actual pollutant-removal efficiencies. Porous pavements and green-strip filters allow easier access for these monitoring requirements than do permeable catch basins.

Costs. The construction cost of a green-strip filter collecting stormwater flows from an area of about 0.15 ha is approximately $14,000. The corresponding cost for a porous pavement area is approximately $24,000. The cost of a permeable catch basin is approximately $10,000.

Efficiency. The pollutant-removal efficiency of the filters and the porous pavement units would be about 80 percent for TSS and O&G removal. Because most of the soil in the study area is formed of clays or sandy loams with relatively low infiltration rates, the efficiency of permeable catch basins would be only about 10 percent during a typical storm event. Effectiveness of widespread implementation of these techniques has not been included in final project evaluations.

Community and Environmental Impacts. The implementation of the infiltration pilot program would result in positive community acceptance. No negative environmental impacts are expected from a pilot program or on areawide implementation of these control measures.

Regulatory Institutional Aspects. No regulatory institutional issues are expected from the implementation of a pilot program. Regulations would be necessary for implementing these measures on an areawide basis.

NONSTRUCTURAL POLLUTION CONTROL MEASURES

Modification to Existing Control Practices

Modifications to existing nonstructural control practices may be employed to reduce pollutant loadings. This can occur through changes in stormwater management techniques. As with structural controls, any changes in existing management practices must be carefully considered to ensure that meaningful pollutant-loading reductions are achieved within a reasonable cost when compared to other available control strategies.

Nonstructural controls may be either generally applicable throughout the study area or may be focused to a particular land-use or drainage area that has been identified as a source of high levels of pollutant loading. Four existing practices have been identified as feasible stormwater runoff pollution-control methods: household hazardous waste collection programs, improved street sweeping, sweeping of target areas, and increased frequency of catch basin cleaning.

Collect Household Hazardous Waste Materials

Project Description. Improper handling and disposal of hazardous waste materials can result in those materials reaching storm drains and being discharged to Santa Monica Bay and beach areas. Metals, pesticides, and oil and grease may be discharged through a variety of paths. Support of community efforts to periodically pick up household hazardous materials for proper disposal at approved sites is one way to reduce this potential contamination.

The most common method used by municipalities is to financially support a community-based pickup program of household hazardous waste materials and to publicize the availability and locations of these services. Continuing public education is required to ensure that the benefits of the program are continuous and not one-time. As indicated in Section 2, the City of Los Angeles and Los Angeles County are currently engaged in implementing this type of program in the study area.

Costs. The costs associated with the implementation of household hazardous waste collection programs vary widely, depending mainly on the amount and variety of wastes collected and the cost of waste disposal. According to City of Los Angeles estimates the cost per roundup event per year is about $250,000 (Table 4-7).

Efficiency. Experience from past roundups carried out by the City of Los Angeles indicate that the public response to this program varies widely from area to area. Similar programs in other parts of the nation have shown that the amount of hazardous waste collected is quite small as compared to the estimated availability. In terms of oil and grease removed, this program's efficiency has been estimated at 5 kilograms per $1,000 spent. Major assumptions are indicated on Table 4-7.

A recent program titled "Mobile Household Hazardous Waste Collection Program (HAZMOBILE)" was begun in February 1994. Operation details and costs have not been noted as yet. A brief description of this program is included in Section 2.

Community and Environmental Impacts. Hazardous waste pickup programs require safeguards for handling, transportation, and disposal of the material. The availability of hazardous material disposal areas must be assessed.

Regulatory Institutional Aspects. Coordination is necessary among the solid-waste handling agencies at the City and County level to gain an increased level of effectiveness of the program within the Santa Monica Bay drainage area.

Improved Streetsweeping

Project Description. This control strategy falls within the area of improved maintenance practices designed to reduce the level of TSS available to storm runoff.

Table 4-7

Household Hazardous Waste Collection Programs

Main assumptions:	
Radius of influence of collection site (km)	5
Area covered with one site (ha)	2,000
Number of additional collections per year	1
Program effectiveness	0.05
Collection cost per site (City information)	$250,000
Annual amount of O&G removed: (kg)/$1,000 investment	5

Source: Engineering-Science
O&G = oil and grease
km = kilometer
ha = hectare
kg = kilogram

Improved streetsweeping practices include acquisition of more efficient streetsweeping equipment and scheduling operations to coincide with the end of the dry season. Equipment includes vacuum streetsweepers capable of removing fine particulates from areas difficult to reach with conventional equipment.

Normal streetsweeping practices are designed to collect larger particulate matter that is generally less of a pollution problem than fine particles. Metals and other compounds resulting from tire and brake wear deposited on streets and highways, as well as pollutants from other sources, tend to be strongly associated with fine particulates.

A pilot program to demonstrate the efficiency of the equipment and frequency intervals necessary to achieve optimum system performance is recommended before proceeding with any large-scale implementation of this strategy. This could be implemented within a two-year period, including an assessment of the effectiveness of the program and assessment of the benefits of a wider-scale application. The pilot program should evaluate the quantity and type of material removed as well as the particle size distribution of the material to determine whether the goal of increasing the collection of fine particles and associated metals is satisfied.

Costs. To be an effective pollution control measure, streetcleaning frequency has to be related to pollutant accumulation and interstorm event times. Sartor and Boyd (1972) estimate that the solids loading accumulation curve in a commercial area tapers off after about 7 days after the previous cleaning. The inter-event time estimated from the typical storm study described in Section 3 of this report is about 10 days (1.3 weeks). Ten days, therefore, should be the optimum streetsweeping frequency for the area.

The City of Los Angeles operates 164 sweepers to cover a total of about 7,650 street miles. The cleaning frequency averages about once every 3.5 weeks; at that frequency, a sweeper would cover 18 miles of streets every 1.3 weeks (10 days). A total of 430 sweepers would be required to sweep 7,650 street miles every 10 days.

Assuming a similar efficiency for vacuum sweepers, a pilot program covering an impervious area of approximately 2,200 hectares could be accomplished in a high-density transportation area with eight streetsweepers. The annual cost of the pilot program would be approximately $900,000, including amortization of capital, labor, and operation and maintenance costs (Table 4-8).

Efficiency. One of the objectives of the NURP program was to establish the effects of streetsweeping on the loadings and concentrations of pollutants. The results indicated that pollutant-reduction efficiencies with conventional roller sweepers are very low - on the order of 10 percent. Occasionally, the street load after sweeping was greater than before. Novotny, et al. (1986) indicate that pollutant removal using high-efficiency equipment could be at most 25 percent. As shown on Table 4-8, in this study the efficiency of improved streetsweeping programs has been estimated at 20 percent with improved equipment such as vacuum streetsweepers. A removal rate of 70 kilograms total suspended solids per $1,000 invested has been estimated.

Community and Environmental Impacts. The increased frequency and intensity of improved streetsweeping may increase air emissions of fine particulate matter and would have associated noise impacts. The use of more efficient vacuum streetsweepers over conventional units, however, may compensate for the effect on air quality. If the operation is focused in a high-intensity transportation land use, the noise effects would be lessened. The material collected would require handling, transportation, and disposal in an appropriate landfill. Appropriate tests would have to be performed to determine the suitability of the material for disposal.

Regulatory Institutional Aspects. Coordination within City departments is desirable if the program is expanded beyond the pilot-scale demonstration. The effectiveness of improved streetsweeping may be increased if targeted areas are coordinated with cleaning of catch basins.

Sweep Target Areas

Project Description. Sweeping target areas with existing equipment to reduce particulate accumulation is another potential measure to reduce TSS loadings on storm-drainage systems. This measure is distinguished from improved streetsweeping because it does not supplement existing equipment.

Sweeping target areas entails improved scheduling designed according to criteria that consider the accumulation of material during the dry season (before the first seasonal storm) and between storm events. Target areas can be identified by identifying areas with higher pollutant loading ratios.

Costs. Assuming that a pilot program uses already programmed expenditures and existing equipment, there would be no increase in expenditures to focus streetsweeping activities in a target area, with the exception of monitoring the success of the project.

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Table 4-8

Improved Street Cleaning

Main assumptions:	The City of Los Angeles operates 164 sweepers to cover a total of about 7,650 street miles. The cleaning frequency is about once every 3.5 weeks. A vacuum truck having a similar efficiency would cover about 18 miles of streets if the frequency is reduced to 1.3 weeks (recurrence interval of a typical storm). In terms of area, 18 street miles is about 270 ha. The average load of TSS/ha is 145 kg. A total of 7,900 kg of TSS could be removed with a sweeper if the efficiency is assumed equal to 20 percent.
Cost of a vacuum sweeper ($)	120,000
Annual O&M ($)	84,000
Annual cost (10%, 6 year)	111,600
TSS removed: (kg)/$000	70

Source: Engineering-Science
TSS = total suspended solids
O&M = operations and maintenance

Efficiency. Any improvement in removal efficiency under this strategy is principally associated with choosing areas that have higher pollutant loading ratios. Assuming that the areas now swept have an average TSS annual loading of 145 kg/ha, sweeping target areas would reduce the pollutant load to about 130 kg/ha in those areas. Considering the annual cost of operating a streetsweeper equal to $100,000, and the same assumptions indicated on Table 4-8 (except for the lower efficiency), this would imply the additional removal of approximately 40 kilograms TSS/$1,000 invested. By reprogramming 40 (equivalent to 25 percent) of the existing streetsweepers to high pollutant-loading areas, the overall removal effectiveness would be less than 1 percent.

The actual effectiveness of this program could be determined by a pilot program that would compare conditions with and without the scheduling program in a target area. Because of the practical difficulties of isolating truly high-pollutant-loading areas, scheduling operations between storms, the high cost of operating and maintaining equipment, and the low marginal removal efficiency of improved scheduling using conventional streetsweeping equipment, the project would probably have an actual cost efficiency lower than that stated. Also, because existing equipment does little to remove the small particle fraction associated with high pollutant loads, the actual pollutant load reduction for metals and oil and grease may be much less than is implied by the TSS load reductions.

Community and Environmental Impacts. Sweeping target areas would have few if any environmental effects, except for changing the areas and frequency of streetsweeping activities.

Regulatory Institutional Aspects. There are no known regulatory or institutional problems in implementing this approach. The effectiveness of sweeping target areas may be severely limited because of practical considerations, such as the ability to operate between storm events during the rainy season. The intervals between storms are too short to allow a complete pattern of sweeping between runoff events. Furthermore, the use of existing equipment in target areas would require extending the cleaning frequency in other areas beyond the average 3.5 weeks. This might result in creating nuisance problems in some parts of the study area.

Catch Basin Cleaning

Project Description. Stormwater catch basins and debris basins provide the most practical opportunity for removal of accumulated particulates and debris from the storm drainage system as now configured. Increased frequency of maintenance of existing catch basins can remove accumulated material that would otherwise be uncontrolled without additional structures or treatment. Other existing storm-drainage components, such as storm drains and channels, provide sufficient velocities to keep particles suspended during all but the lowest flow conditions and do not provide for a convenient location for collection.

Periodic catch basin cleaning is currently being performed by the City. The present catch basin cleaning effort could be improved by:

- increasing the frequency of cleaning
- review of cleaning techniques and equipment efficiency
- modification of the present monitoring and tracking system to better direct cleaning routes and timing of cleaning

The scheduling of catch basin cleaning should consider the seasonality of hydrologic events in order to attempt a reduction in loading from the first seasonal flush. A pilot program should be initiated to determine the optimum scheduling and frequency of cleaning to gain the maximum advantage from these existing structures.

Costs. Assuming a schedule that permits a field crew to clean 10 catch basins per day at a daily cost of $500 provides an estimated unit cost of approximately $50 per catch basin cleaned (Table 4-9). Cost savings per unit may be able to be realized using modified or specialized equipment, and through scheduling practices that minimize on-site time by optimizing the servicing interval.

Efficiency. As indicated on Table 4-9, a removal ratio of about 600 kg TSS per $1,000 invested has been estimated for comparing the efficiency of this alternative with other pollution-removal methods. This assumes a 20 percent removal efficiency of TSS for an average of 1 ha drainage area per catch basin, using a cleaning interval sufficient to catch the first storm of the rainy season.

Community and Environmental Impacts. Increased cleaning of catch basins would generate additional solid waste, which would have to be transported for disposal or land reclamation. The effort would have a very positive aesthetic impact on areas where catch basins experience heavy debris and trash loading.

Table 4-9

Catch Basin Maintenance and Cleaning

Main Assumption:	Catch basins in identified drainage basins with annual loading ratios > 1 would be cleaned before the start of the rainy season. This is in addition to regular maintenance activities.
Estimated number of catch basins in the study area	50,000
Estimated number of catch basins per hectare	1
Estimated annual cost of maintenance per basin ($) (City and County information)	50
Total annual cost of maintenance ($000) assuming all catch basins are cleaned annually	2,500
Assumed pollutant-removal efficiency	0.2
Annual amount of TSS removed (kg)/$1,000	615
Annual amount of O&G removed (kg)/$1,000	27

Source: Engineering-Science
TSS = total suspended solids
O&G = oil and grease
kg = kilogram

Regulatory Institutional Aspects. Several entities have responsibility for maintaining existing catch basins. Coordination of the cleaning schedules for the various maintenance personnel and equipment may be necessary to implement this program on a pilot- or full-scale basis.

A disadvantage of this program is that, without design consideration for TSS removal in existing inlet structures, high stormwater velocities that occur during storm flows may allow only the larger particles to settle out. This means that smaller particles, which are more closely associated with the pollutants of concern in this study, may be readily transmitted through existing structures. If this occurs, the effectiveness of cleaning existing structures, in terms of pollutant removal, would be greatly reduced. The pilot program recommended with this type of project should include an assessment of the particle size distribution and association with other pollutant categories for the material removed from existing inlet structures. This would be conducted through measurement of the mass, particle size distribution, and distribution of types of material collected in catch basins.

This pilot program could also be combined with the construction of other types of inlet structures, such as permeable catch basins, as indicated previously in the description of structural pilot programs. Modifications to existing inlet structures would reduce velocities and would increase the removal effectiveness for smaller particles. This would have the same effect as constructing small area settling basins.

proposal could be implemented on a pilot scale with a voluntary recycling effort to demonstrate the recycling center concept, and document that proper controls for transport, handling, and disposal of waste oil are feasible. Currently, the hazardous waste collection programs in the area include oil collection and recycling.

Costs. Estimated costs for a pilot program, including a public education element, are in the range of $200,000 to $400,000 and could be implemented within a one-year period. If the pilot program proves successful, it would be possible to expand the program to include regulatory elements or as an expanded voluntary program within a three-year period.

Efficiency. The expected efficiency of this program is 65 kg O&G removed per $1,000 invested. This is based on an annual program cost of $400,000 and a 10 percent reduction in the amount of waste oil that enters the storm drainage system. This would result in the removal of approximately 26,000 kg of oil and grease per year.

Community and Environmental Impacts. Environmental constraints associated with air emissions and concerns over disposal of hazardous materials in waste oil products have limited existing recycling efforts.

Regulatory Institutional Aspects. If a regulatory approach were adopted, one possible method is to regulate the sale of motor-oil products to facilities that participate in a waste oil recycling program. This would require verification that a minimum percentage (for instance, 50 percent) of the oil product volume sold at the installation is accounted for through a recycling effort.

To be successful, a regulatory effort would need to be applicable to an area at least the scale of the study area and possibly to an even larger area. A voluntary program of waste-oil recovery could be conducted over a smaller geographic area, and would require a substantial public education effort as well as the potential need to financially support collection stations and waste-oil recycling centers.

Institutional considerations associated with this alternative are significant. The problems confronting the oil-recycling industry are both economic and regulatory. As additional regulations are imposed on these facilities because of air quality concerns and limitations on the transport and disposal of hazardous materials sometimes present in waste oil, many facilities have chosen to shut down.

To be successful, the program must have the support of regulatory agencies that have authority over these facilities with assurances that adequate environmental safeguards will be included at the recycling facilities in order to ensure that the recycled oil does not become an air quality or toxic waste disposal problem. The regulatory program envisioned by this alternative would require the adoption of similar local ordinances and the establishment of recycling centers involving cooperation with a number of local jurisdictions.

Public Education and Awareness

Project Description. Visible beach and ocean pollution discharged from storm drain outfalls is primarily due to the waste disposal practices of the average person. Most of the public are not aware that materials casually disposed of on the street (used motor oil, trash, animal waste, etc.) go directly into the ocean without treatment. An effective public education program must address this lack of awareness.

While some public education programs in other areas of the country with runoff pollutant problems have achieved highly productive, efficient, and positive results, any proposed public education program for the Santa Monica Bay Stormwater Pollutant Reduction Study must compete with other recommendations for the limited funding set aside for the implementation of control measures. A public education program should therefore complement other proposed control measures, and be structured in a manner that will promote the reduction of runoff pollutants while providing quantitative estimates of the effectiveness of both the control measures and the education program itself.

In the specific areas targeted for implementation of other runoff pollutant control measure pilot projects, a public education program should:

- heighten public awareness of the runoff pollutant problem
- introduce easily-understood technical concepts of pollutant runoff and control
- emphasize the need to expeditiously implement solutions

Constituent monitoring of runoff pollutant concentrations in an area where public education programs are conducted, and comparison to pollutant concentrations in an area where control measures were implemented without the benefit of a public education program, will provide a quantitative measure of the effectiveness of the education program in reducing runoff pollutants.

In the long term, this type of public education program will:

- encourage public participation in the evaluation and decision-making process
- solidify public support of solutions selected by public officials

Costs. The cost of this program can be flexible based on the Consent Decree funds available after the remaining pollutant control pilot projects are finalized. However, sufficient funding must be available to allow the program to be effective.

Efficiency. The efficiency of this type of pollutant control measure is uncertain; while there is general agreement that public education measures increase awareness of pollution control alternatives, quantification of this effectiveness is not always pursued. This type of control measure is difficult to evaluate against more traditional methods on a cost-benefit basis. A measure of the efficiency of this type of program is envisioned as part of the implementation of this measure.

Community and Environmental Impacts. This program should have only positive impacts on community awareness of the runoff pollutant problem.

Regulatory Institutional Aspects. This program will be closely coordinated with other runoff pollutant reduction techniques to maximize both the effectiveness of the entire reduction program and the awareness of the public of what is being accomplished. Similar to the efforts of the City's public awareness program regarding wastewater treatment, the stormwater runoff public awareness program

The success of design standards for stormwater pollutant load reduction is dependent on the rate of retrofitting and replacement of existing structures. Capital programming must consider whether the objective is to incorporate these measures only when upgrading storm-drainage facilities or to accelerate replacement.

Construction Standards. Improperly managed construction sites are known contributors to stormwater pollutant loading, especially TSS. Requiring temporary drainage and erosion control plans for construction activities, along with adequate enforcement of these measures, is a demonstrated control technique.

The primary elements of a control plan for runoff from construction sites include provisions for routing drainage away from graded and disturbed areas, providing measures to control soil loss on slopes, and eliminating soil tracking onto paved surfaces by construction vehicles. Long-term erosion controls include adequate soil cover materials and may require structural stabilization of erodible slopes with structural measures. Implementation of this measure requires inspection staff who have expertise in runoff control techniques and monitoring of construction sites for compliance. It could best be implemented along with the land-use controls discussed above.

Pesticides Use Control. The use of pesticides is subject to numerous federal and state regulations. From the standpoint of stormwater pollutant reduction in an urbanized area, however, the main concern is the regulation of pesticides used for lawn maintenance, primarily in residential neighborhoods. The extent of control regulations may range from prohibiting the use of certain types of pesticides to a total ban on the use of these substances.

The most common pesticides observed in sample collections during this study included DDT and benzene hexochlorides (BHCs), including lindane. DDT is illegal for use in any application (already prohibited) and BHCs cannot be sold for domestic use. DDT frequently appears in water samples due to extensive historical use and its persistence in the environment. The problem in controlling runoff of BHC materials is in controlling use. Given that the concentrations of pesticides in stormwater runoff from the local area appear to be on the average about 16 times higher than the recommended Ocean Plan standards, stringent pesticide control regulations are recommended in the study area, especially during the dry season when beach recreation use is high.

Product Restrictions. Among the materials runoff carries into the stormwater system are certain products that do not constitute sources of pollution, but rather create nuisance conditions at the points of discharge of the drainage channels. Most of these products are made of nonbiodegradable materials, such as Styrofoam containers.

Regulating the use of these products in the study area would result in significant economic as well as aesthetic benefits to the local area. Benefits would include reduced trash collection and disposal costs and more attractive beaches.

Solid-Waste Recycling. Economic incentives have resulted in extensive collection and recycling of aluminum cans, beverage bottles, and some plastics. Some of the components of household and everyday trash that find their way into stormwater drainage systems may be reusable, and are candidates for targeted recycling programs that could reduce the amount of improperly disposed solid waste in the

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Table 4-10

Summary of Preliminary Evaluation of Alternatives

Alternative	Evaluation Results
Structural Measures	
Use North Outfall Sewer structure	Eliminated based on cost and long-term implementation period
Construct surface settling basins	Eliminated based on cost and difficulty of implementation
Construct underground settling facilities	Eliminated based on cost and difficulty of implementation
Treat dry-weather flows at discharges	Eliminated based on cost and possible environmental impacts
Treat dry-weather flows at HTP	Eliminated based on institutional uncertainties
Treat wet-weather flows	Eliminated based on costs
Develop wetlands for stormwater treatment	Eliminated based on costs
Construct dry-weather outfalls	Eliminated based on nonreduction of runoff pollutant loading
Construct wet-weather outfalls	Eliminated based on costs
Infiltration pilot programs	Recommended
NONSTRUCTURAL MEASURES	
Collect household hazardous waste materials	Recommended
Sweep target areas	Eliminated because the project would negatively affect current streetcleaning practices
Improve streetsweeping	Eliminated due to high initial capital costs and uncertainty regarding debris removal
Improve catch basin cleaning efficiency	Recommended
Recycle waste oil	Eliminated because of regulatory complexities
Public education program	Recommended

Source: Engineering-Science

determine if water should be allowed to infiltrate beneath the filter, rather than being diverted to the storm drain. The buildup of filtered constituents at the surface of the filter and requirements for maintenance will also be monitored.

Collect Household Hazardous Waste Materials

The City and the County of Los Angeles have previously conducted household hazardous waste materials collection programs. The City completed eight "roundups" in 1989 at eight different locations. The funding set aside for collection activities for this program is $550,000, which is estimated to fund four roundups encompassing slightly smaller areas than those conducted previously.

Information from similar programs carried out in other areas of the country (e.g. cities in Florida and Texas) indicate that there is enthusiastic public response for programs such as this. With well-designed and implemented programs, there is the possibility of even greater participation and effectiveness in these kinds of programs in the future.

Specifically, there is a need to better determine the variables that trigger public participation in these collection programs. Additionally, as part of the public education and awareness program described below, it is important to assess changes in public awareness resulting from these collection activities.

The City has a unique opportunity to help determine the triggering mechanisms and effectiveness of the collection programs simply because there are identifiable areas where collection activities have been performed and other areas where they have not. The recommended project will be designed to help assess the impact of three major variables on public response:

- location of the collection site (proximity to users, travel time, etc.)
- frequency of publicity needed to stimulate participation
- effectiveness of specific roundups versus permanent collection sites

There are several ways to test the importance of these variables, and the program will be designed to complement past and current collection activities. The before, during, and after surveys will provide pertinent information regarding changes in public awareness and attitudes toward participation in these types of programs. The present value of a two-year targeted collection program has been estimated at $550,000. The amount of oil and grease removed per $1,000 invested has been estimated at about 80 kg.

Enhanced Catch Basin Cleaning

The recommended catch basin cleaning program is designed to begin with the existing program and significantly enhance its effectiveness, while simultaneously gathering data to be used in establishing modified ongoing programs in the future. The objective of the pilot study will be to evaluate and recommend changes to the existing program that can be expanded to the remainder of the City if successful.

Table 5-1

Areas Included in Recommended Catch Basin Cleaning Program

Basin Number	Watershed
5-9	Ballona Creek (Wilshire District)
5-2-2	Ballona Creek (Bel Air District)
5-6	Ballona Creek (Southwest, Southeast Districts)
12	Ashland Avenue
11	Rose Avenue
10	Thornton Avenue
5-5	Ballona Creek (Southwest District)
5-7	Ballona Creek (Wilshire District)
5-1-2	Ballona Creek (Inglewood)
5-4-1	Ballona Creek (Beverly Hills)
16	Montana Avenue
8	Venice Pavilion
5-8	Ballona Creek (Wilshire, West Hollywood Districts)
5-1-1	Ballona Creek (Westchester District)
9	Brooks Avenue

Source: Engineering-Science

City, and be comparable to other city tracking and routing programs, such as the City's sewer maintenance management program. This activity will result in immediate, measurable benefits for the City's targeted catch basin cleaning areas and will also provide a comparison of the "enhanced" versus existing cleaning efforts.

Furthermore, the computerized scheduling and routing program will increase the City's responsiveness and effectiveness in the overall stormwater management program. This computerized program will also enable inclusion of several technical factors such as pollutant loadings and water quality data into the management and scheduling activities.

Public Education Program

Based on the success of public information programs conducted in conjunction with the City's upgrading of wastewater treatment facilities, public education and awareness activities are necessary and vital components to the City of Los Angeles' Stormwater Management program. Specific public education and awareness activities will not be determined until the other pollutant reduction actions are officially decided upon. If the mix of projects detailed above are selected, a total of $500,000 is available for public education projects. This will allow the public education and awareness activities to be specifically tailored to support and enhance the other pilot project activities. For example, there will be "before" and "after" surveys conducted in association with the placement of strip filters, catch basin cleaning, and household hazardous waste collection activities. Once these activities

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are determined acceptable, the public education and awareness program will be finalized.

It is anticipated that the public education activities may include the actions listed below. These activities will be conducted in the same areas where the other runoff pollutant reduction activities are planned. They will complement the construction, clean up, and collection activities, including:

- before and after survey for awareness of runoff pollutant control measures
- public school campaign within the targeted implementation areas for runoff pollutant control measures
- business, civic, environmental, and industry campaign for the targeted implementation areas
- specific neighborhood or community event(s) to accompany the collection programs

RECOMMENDED RUNOFF POLLUTANT CONTROL PROJECTS

Table 5-2 provides a summary description of the pollution-control measures described above. This group of pollution-control measures was structured so that the total cost of the package amounts to approximately $3 million. Costs were calculated in terms of present worth of the equivalent annual cost of each pollutant-control measure. In general, the proposed programs would be implemented by departments within the Bureau of Sanitation and the Bureau of Engineering of the City of Los Angeles. The City, through its Stormwater Management Program, is also planning additional stormwater related projects.

Calculation of the removal effectiveness of each proposed measure was based on the actual amount of TSS and oil and grease loading in the drainage basins recommended for treatment and the total estimated amount of these pollutants in the study area. Efficiencies were assumed to be equal to those indicated in Section 4. For example, the annual amount of TSS load in the drainage basins recommended for catch basin cleaning can be calculated from the data on Table 3-17, and is equal to 3.3 million kg. The efficiency of implementing this measure has been assumed to be equal to 20 percent. The total annual estimated load of TSS discharged from the study area is about 8 million kg.

The estimated effectiveness in TSS removal for catch basin cleaning in the specified basins would be equal to:

$$\frac{3.3 \text{ million}}{8.0 \text{ million}} \times (0.2 \text{ TSS removal efficiency}) \times 100 = 8 \text{ percent}$$

A very valuable benefit that should be derived from the implementation of the proposed programs will be the collection of information that can be used for later development of permanent runoff pollution-control measures. The recommended packages, therefore, contain several individual measures that will be implemented on a pilot basis, instead of single-measure approaches that would be more effective for controlling pollution loads in the short term. An example of an effective single-

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Table 5-2

Detailed Description of Recommended Alternatives

Alternative	Recommended Action	Estimated Removal TSS (kg)/ $1,000[a]	Cost - Efficiency O&G (kg)/ $1,000[a]	Present Worth ($)
Structural Measures				
Construct stormwater filters	Construct one unit in each of two large parking areas (shopping centers) in the Venice and Hollywood districts drainage basins 5-2-2 and 5007; construct two additional filters in other areas	c	c	120,000
Nonstructural Measures				
Collect household hazardous waste materials	Set up additional 2-year collection program at the West Los Angeles area	b	77	550,000
Enhanced catch basin cleaning	Initiate program to upgrade cleaning efficiency in catch basins in the identified drainage areas with TSS loading ratio > 1 (Table 3-17, Table 5-1)	774	b	1,830,000
Public education program	Initiate public awareness program to enhance performance of other recommended actions, and to generate data on efficiency of public education programs in reducing runoff pollutant loading	c	c	500,000

Source: Engineering-Science
[a] Indicates $1,000 equivalent annual cost
[b] Benefit not calculated
[c] Benefit to be determined
TSS = total suspended solids
O&G = oil and grease

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measure approach is the cleaning of catch basins. This measure alone could cost more than $3 million per year if implemented on an areawide basis; however, the information obtained after the program is finished would be minimal. This approach, therefore, has not been included as one of the actions recommended for implementation.

Table 5-3 displays the effectiveness of the recommended control projects in removing pollutants from runoff into Santa Monica Bay. The total removal effectiveness for TSS of the group of measures recommended is 8 percent. Based on annual loading estimates of 8 million kg/year of TSS loading to Santa Monica Bay (see Section 3), the group of measures is estimated to remove 656,000 kg of TSS from runoff flows. This calculation presumes no benefit from strip filter pilot projects, which affect very small areas on an individual basis.

The estimate of oil and grease removal effectiveness of 4.5 percent results in a calculation of more than 16,000 kg O&G removed from runoff flows on an annual basis. Estimates of reduction in runoff pollutant loading of target constituents are also included on Table 5-3. For particulate-associated pollutants, removal estimates are based on TSS removal effectiveness of the recommended control projects and annual particulate loading of target constituents. For lipid soluble-associated pollutants, removal estimates are based on O&G removal effectiveness of the recommended control projects and annual total loading of target constituents.

Pollutant removal effectiveness of strip filters and public awareness programs will be determined as part of the conduct of the pilot projects themselves.

Table 5-3

Reductions in Annual Pollutant Loading to Santa Monica Bay from Recommended Control Projects

Proposed Control Measures	Cost ($)	Removal Effectiveness[a] TSS (%)	O&G (%)
Catch basin cleaning	1,830,000	8.2	3.9
Collect household hazardous waste materials	550,000	---	0.6
Public education program	500,000	---	---
Construction of stormwater filters	120,000	---	---
TOTAL	3,000,000	8.2	4.5

Constituents	Reduction In Annual Loading (Kg)
Total Suspended Solids	656,000
Oil and Grease	16,000
Particulate-associated Pollutants[b]	
Arsenic	35
Chromium	100
Copper	434
Lead	1,257
Nickel	19
Zinc	5,247
Mercury	2
Lipid Soluble-associated Pollutants[b]	
Herbicides	12
Pesticides	0.5
Pollutants Requiring Source Controls	
Cadmium	c
Silver	c

Source: Engineering-Science

[a] 1% TSS Removal = 80,000 kg; 8.2% Removal = 656,000 kg;
1% O&G Removal = 3,700 kg; 4.5% Removal = 16,000 kg

[b] see Section 3

[c] see Section 3; loading reductions for these constituents were not estimated

TSS = total suspended solids
O&G = oil and grease

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SECTION 6

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Exhibit 1

Drainage Basins and Sub-Basins in the Study Area

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Exhibit 2

Land Use Distribution in the Study Area

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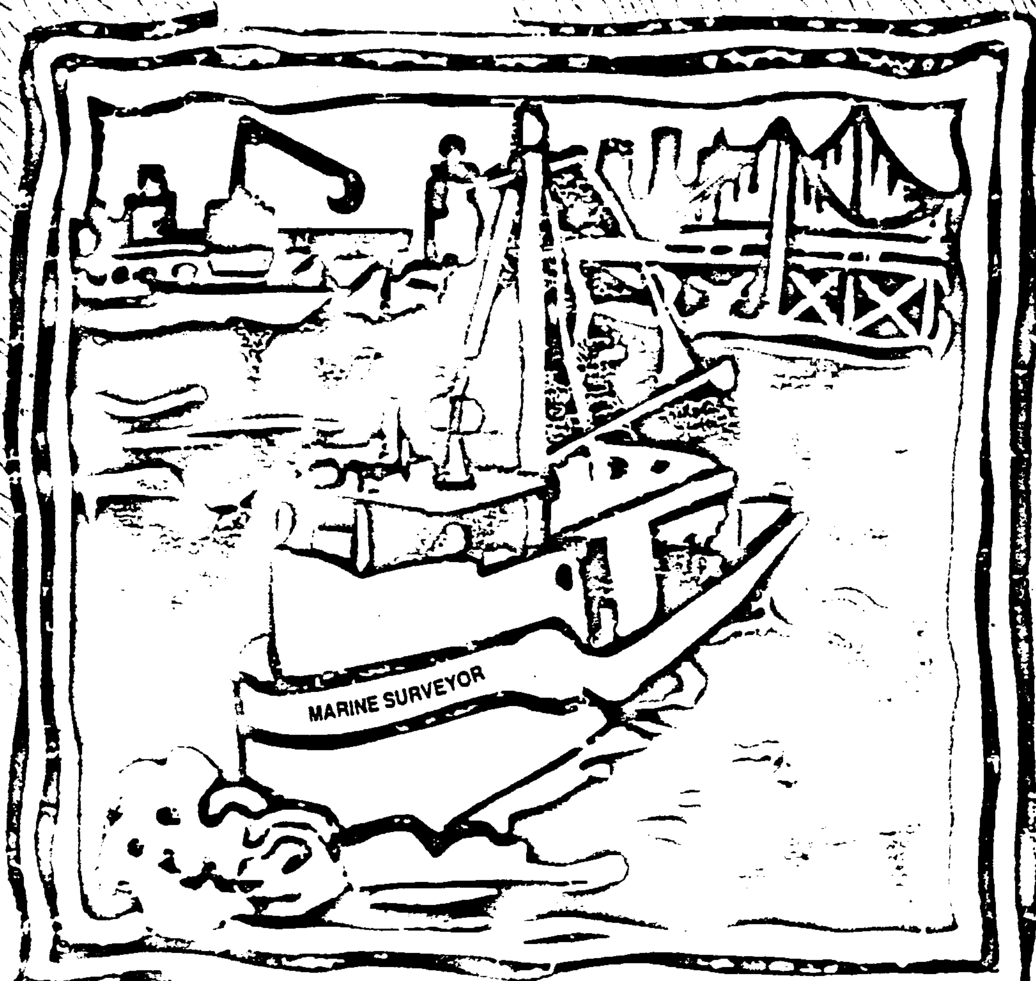

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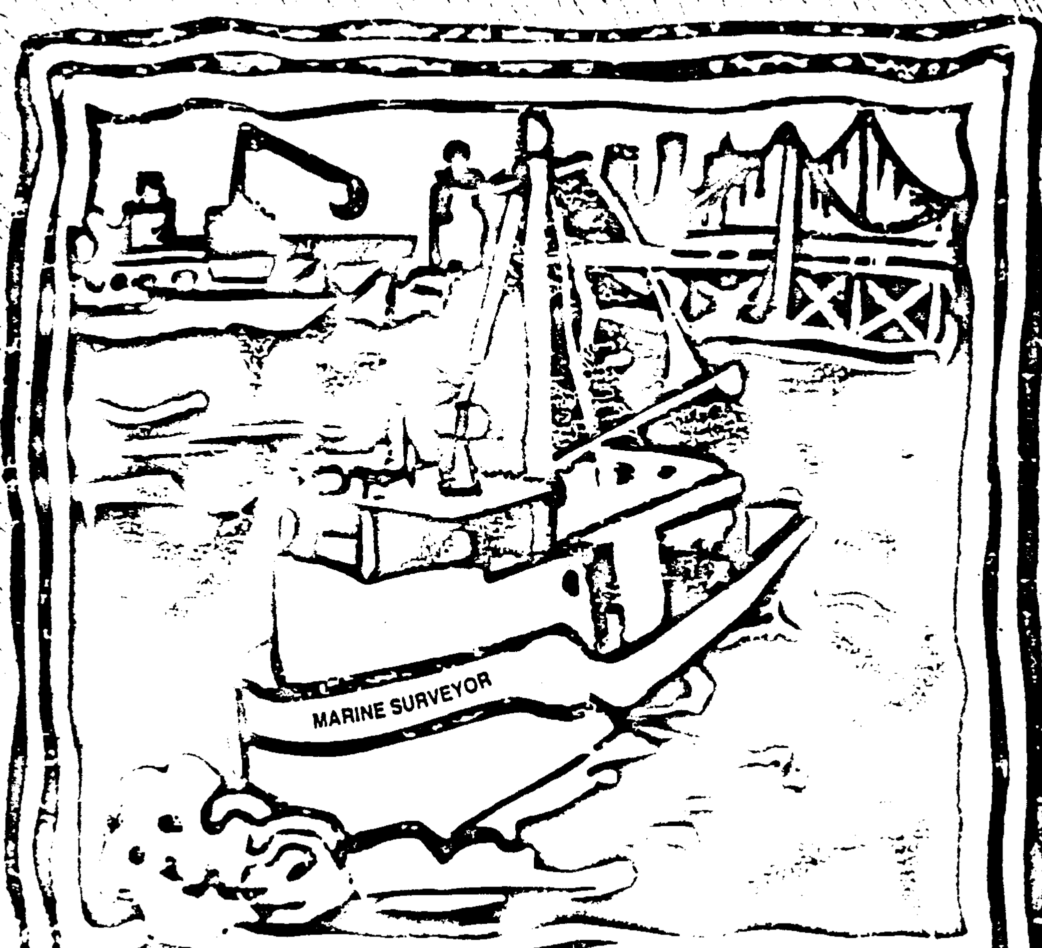

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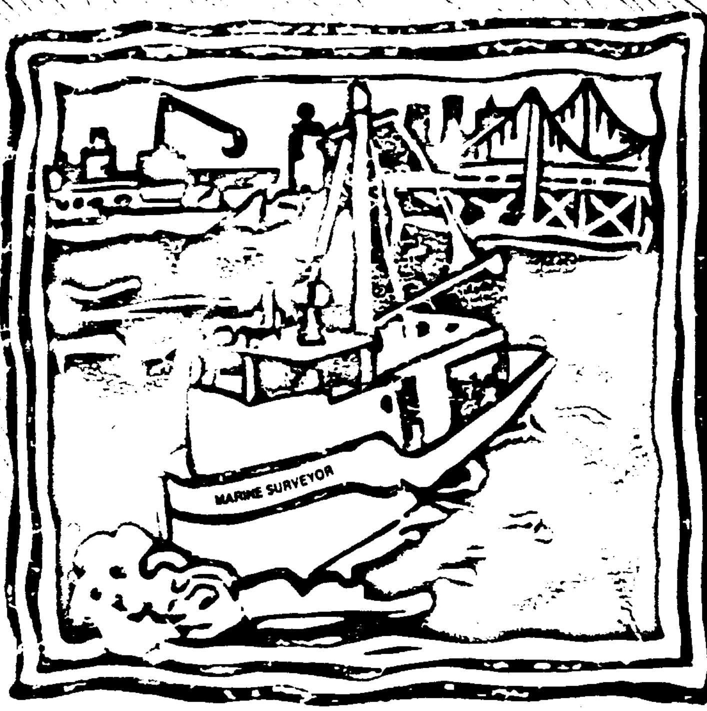

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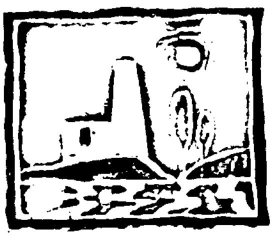

FATES

EFFECTS

ADDITIONAL ACTIVITIES

Director's Perspective

The past two years at SCCWRP have been eventful. Our Commission has expanded to nine members. It now includes, in addition to representatives from the City of Los Angeles, County Sanitation Districts of Los Angeles County, County Sanitation Districts of Orange County, and the City of San Diego, representatives from the U.S. Environmental Protection Agency Region IX, California State Water Resources Control Board, and the Los Angeles, Santa Ana, and San Diego Regional Water Quality Control Boards. This unique forum is bound by a common purpose — to better understand man's effects on the coastal marine environment.

We also have a new director. After 10 years on staff and one year as Assistant Director, I was given the opportunity to become Director. My goal is to continue the successful tradition that has made SCCWRP a leader in coastal marine environmental research since 1969. To do this, we will emphasize the elements that have made SCCWRP successful throughout its history: quality interdisciplinary research, regional scientific expertise, large-scale perspective, technical innovation, and effective communication.

There have been other changes in staffing as well. Old and new staff alike are rising to the challenge to make SCCWRP the premier problem-solving agency working on the fate and effects of anthropogenic wastes in the coastal marine environment off Southern California.

This report features the results of projects conducted over the past two years. These projects increase our understanding of the sources, fates, and effects of anthropogenic contaminants that find their way intentionally or unintentionally into the coastal marine environment. We continue to report on the biological changes in Santa Monica Bay following termination of sludge discharge. And we continue with our survey of contaminant inputs to the coastal ocean. One salient aspect of several reports is the attempt to distinguish between natural and anthropogenic perturbations.

This is an important time for SCCWRP. Approximately 15 million people live in Southern California and their impact on the shoreline and coastal marine environment has been profound. With each passing year, our research becomes more important to the well being of the coastal marine environment. As we head into our third decade, our mission, — to understand the effects of urban wastes on the marine environment — gives us purpose and direction.

Jeffrey N. Cross
Director
November 1992

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Executive Summary

SOURCES

Characteristics of effluents from large municipal wastewater treatment facilities in 1990 and 1991.

We summarize the concentrations of effluent constituents and estimates of effluent mass emissions for Hyperion Wastewater Treatment Plant, Joint Water Pollution Control Plant (JWPCP, County Sanitation Districts of Los Angeles County), County Sanitation Districts of Orange County (CSDOC) Wastewater Treatment Plants 1 and 2, and Point Loma Sewage Treatment Plant for 1990 and 1991. The trends in the mass emission of contaminants to the Southern California Bight over the past two decades are also examined.

The volume of effluent discharged from the four municipal wastewater treatment facilities declined by 12% from 1989 to 1991, perhaps as a result of water conservation efforts during the recent drought. The amount of effluent receiving secondary treatment increased from 43% of combined emissions in 1989 to 47% in 1991, while the concentrations of most effluent constituents declined. The combined emissions of suspended solids declined 5%, BOD declined 14%, and oil and grease declined 15%. The combined emissions of lead, cadmium, chromium, and mercury declined by more than 50%. Effluent concentrations of DDT and PCB were below method detection limits in 1991. Declines in constituent concentrations and mass emissions were the result of improved source control, improved primary treatment, and increased secondary treatment.

The combined flow from the four largest facilities increased 27% from 1971 to 1990 as a result of population increases. During that time, the volume of wastewater discharged by CSDOC and Point Loma doubled while the volume discharged by JWPCP and Hyperion increased only slightly. Population growth patterns, water reclamation, and inland discharge accounted for differences among the districts. Despite increases in the volume of wastewater discharged, the mass emissions of most effluent constituents have declined. The combined annual mass emission of suspended solids decreased 73%, BOD decreased 51%, and oil and grease decreased 69%. The combined mass emission of trace metals declined 94% and the combined emissions of chlorinated hydrocarbons declined more than 99% from 1971 to 1991.

Surface Runoff to the Southern California Bight

The concentrations of selected constituents were measured in dry and wet weather samples collected from the eight largest channels in Southern California between 1986 and 1988. We present estimates of the annual load of contaminants delivered to the ocean for the Santa Clara, Los Angeles, San Gabriel, Santa Ana, San Diego, and Tijuana rivers, and Calleguas and Ballona creeks. Most of the flows resulted from winter rains and discharge varied from year to year. The Santa Clara and Santa Ana rivers had no measurable flow during most of the study.

The eight channels sampled contributed about 80% of the total gauged runoff to the Southern California Bight. Annual discharges were, on average, 61% below their long-term means during 1986-87 and 31% below their long-term means in 1987-88. River discharge was a combination of surface and groundwater runoff, releases from control facilities, and inputs of domestic and industrial wastes.

The concentrations of trace metals and chlorinated hydrocarbons were generally correlated with suspended sediment and, to a lesser extent, with river discharge. The Tijuana River had the highest concentrations for most of the constituents measured. The Santa Clara River, a predominantly agricultural watershed, had the highest concentration of total DDT. The San Diego River, which drains a less developed basin, had the lowest concentrations for most of the constituents measured.

The Los Angeles, San Gabriel, and Tijuana rivers had the highest mass emissions, and the Santa Clara and San Diego rivers had the lowest. The mass emission of suspended sediment, trace metals, and chlorinated hydrocarbons increased from 1986-87 to 1987-88 in proportion to the increase in volume discharged. Most river discharge and contaminant transport in Southern California took place during winter storms that occur intermittently and unpredictably.

Hazardous Spills in the Southern California Bight

The existing data on hazardous material spills in the Southern California Bight were collected and are summarized in this report. The data were obtained from the U.S. Coast Guard's Pollution Response Branch in Washington, D.C. From 1985 through 1989, 327,115 L of hazardous materials were spilled in 1,102 separate incidents. The amount of hazardous material spilled varied by about an order of magnitude from year to year.

The majority of spills involved petroleum products, primarily diesel, fuel oil, jet fuel, and kerosene. The volume of individual spills was generally small; the median spill was 15 L for facilities and 19 L for vessels.

Spills from facilities accounted for 40% of the total number of spills and 60% of the total volume of material spilled. Most of the facility spills originated on land; a smaller proportion originated at offshore oil platforms and pipelines.

Spills from vessels accounted for 60% of the total number of spills and 40% of the total volume of material spilled. Most of the vessel spills originated with recreational boats, freighters, and tankers, although the largest volume of spills came from the U.S. Navy and towboats.

About 80% of the vessel spills and 50% of the facility spills occurred in harbors and bays. Los Angeles and Long Beach harbors were the site of more facility and vessel spills than any other waterbody.

Estimates of Ocean Disposal Inputs to the Southern California Bight

Currently, only approved dredged materials can be dumped at ocean disposal sites off Los Angeles (LA-2), Newport Beach (LA-3), and San Diego (LA-5). We estimated the total mass of dredge material and contaminants dumped at these sites between 1984 and 1991. The data were obtained from dredge permit files of the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency Region IX, and local port authorities.

Fifty-three projects disposed nearly 6,000,000 yd^3 of dredge materials in the bight between 1984 and 1991. The total annual volume of dredge materials dumped ranged from 72,000 to 2,354,000 yd^3; more than 80% of the material was dumped at LA-5 and LA-3. Most of the projects dumped small quantities of materials. The smallest projects dredged sand from private docks and marinas. Six projects accounted for 58% of all dredge materials dumped. The largest project was the deepening of Newport Harbor Back Bay completed in 1987. It contributed 70% of the material dumped at LA-3 and 22% of the volume dumped at all sites during the study.

Chemistry data were reported for 37 dredge projects that represented about 90% of the total volume dumped in the bight during the study. Dredge materials from the large industrialized harbors had the highest concentrations and largest concentration ranges. The annual mass input of most constituents to the bight was correlated with the annual mass input of solids.

Total Organic Carbon and Total Nitrogen in Marine Sediments, Sediment Trap Particles, Municipal Effluents, and Surface Runoff

We report on a method adopted in our laboratory for the analysis of total organic carbon (TOC) and total nitrogen (TN) in marine sediments, effluent particles, and similar matrices. Effluents were collected from the Joint Water Pollution Control Plant (JWPCP, County Sanitation Districts of Los Angeles County), the County Sanitation Districts of Orange County Wastewater Treatment Plant (CSDOC), and the City of San Diego Point Loma

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Treatment Plant (PLTP). Sediment trap particles were collected near each of their ocean outfalls. Surface sediments were collected near the CSDOC and PLTP outfalls.

There were no significant differences in concentrations of TOC (25-40%) and TN (2.5-6.0%) among effluent samples from the wastewater treatment plants. The C/N ratios of effluent particles (7.1-8.4) were comparable to C/N ratios of effluents from other treatment plants. The concentrations of organic carbon and nitrogen on effluent particles have not changed in nearly two decades, while the concentrations of suspended solids have declined 60-70% since 1978.

The organic content of sediment trap particles was about 5-10% of the organic content of effluent particles from the corresponding sites. The C/N ratios of sediment trap particles (9.1-10.3) were higher than the C/N ratios of effluent particles. The lower TOC and TN concentrations, and higher C/N ratios, of sediment trap material suggest that effluent particles undergo rapid biodegradation, and perhaps dilution with plankton and terrestrial particles, upon discharge to the marine environment.

The organic content of surface sediments off Orange County and Point Loma was 1-2% of the organic content of effluent particles from the same site. The organic content of sediments at both sites was at or below levels of TOC and TN in surface sediments at the 60-m Reference Survey stations. However, the TOC and TN concentrations in surficial sediments were generally higher at stations close to the outfall and lower at stations farther away.

Sediment Model Verification

We examined the ability of two models (DECAL and SED2D) to simulate the characteristics of sediments around ocean outfalls off Point Loma (City of San Diego), Huntington Beach (County Santitation Districts of Orange County), and the Palos Verdes Peninsula (County Santitation Districts of Los Angeles County). The study investigated the sensitivity of model predictions to the input data and the consistency of the predictions. It also provided site specific predictions based on the consequences of particle aggregation.

Both models predicted areas of high sedimentation rates near the ocean outfalls; these zones were surrounded by areas of lower rates of sedimentation. There were, however, substantial uncertainties in the predictions of the fates of wastewater particles. Interestingly, the models also predicted an increase in the sedimentation of natural particles as a result of particulate-free discharges.

Uncertainties in the predictions came from questions about the aggregation of particles in the water column, the lack of data on vertical mixing within the wastefield, a poor understanding of sediment resuspension processes, and the lack of estimates of the decay rate of organic material in the water column and sediments. Until these uncertainties are addressed, it will be difficult to assess the validity of the predictions of the two models and the process representations contained within them. However, the models provide qualitative insight into the dynamics of the interaction of a wastefield and natural waters, and the localized effects on sedimentation from the discharge of wastewater effluents.

Potential Extension of the Point Loma Outfall

The application of body contact standards for bacterial concentrations to kelp beds in 1983 doubled the depth of the protected waters off Point Loma, and decreased the distance between the outer boundary of the protected area and the outfall diffuser. These changes substantially reduced the isolation of the wastefield from areas where body contact standards must be met and resulted in violations of the standard. An extension of the existing outfall into deeper water offshore is one way to meet bacterial standards in the kelp bed.

We examined the characteristics of water column density stratification and the properties of currents with current meter and thermistor data collected by Engineering Science, Inc. between March and September 1990 near the Point Loma outfall. The results were incorporated into time-dependent models of initial dilution and transport of wastewater by ocean currents.

In simulations based only on density stratification of the water column, potential intrusions of the wastefield into the kelp beds were predicted for 18-38% of the time for an outfall in 83 m, and for 4-12% of the time for an outfall in 95 m. When ocean currents were added to the model, wastewater intrusions into the kelp bed peaked at 15% of the time 1-2 km upcoast from an outfall in 83 m of

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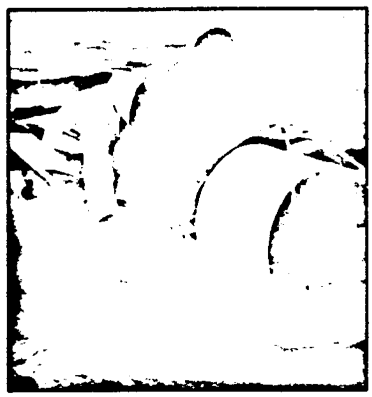
water; actual intrusions were predicted for about 40% of potential intrusions. Wastewater intrusions peaked at 7.5% of the time 4 km upcoast from an outfall in 95 m of water; actual intrusions were predicted for about 60% of potential intrusions. The increased upcoast displacement for the deeper discharge is the result of increased wastefield transport time from the diffuser to the kelp bed.

Response of Dover Sole to Termination of Sludge Discharge in Santa Monica Bay

We examined the response of Dover sole, a common deepwater flatfish, to the termination of sludge discharge by the Hyperion municipal wastewater treatment plant. The discharge of solid waste into the outer part of Santa Monica Bay ceased in November 1987 and resulted in changes in the biology of the macrofauna near the 7-mile sludge outfall.

Dover sole were most abundant in the contaminated zone near the outfall, and declined in abundance with increasing distance from the sludge outfall. The incidence of epidermal tumors and fin erosion decreased with distance from the outfall. There was little or no disease among fish collected in the reference area. The abundance of Dover sole and the incidence of disease in the contaminated zone declined after the termination of sludge discharge.

The decrease in Dover sole abundance and disease incidence after termination of solid waste discharge indicates that benthic conditions were improving near the outfall. The decline in abundance is probably related to the decreased organic content and prey abundance in the sediments. The organic content of surface sediment was significantly higher near the outfall and declined after termination of waste discharge. Sediments with high organic content support large populations of deposit feeders such as polychaetes, which are the primary prey items of Dover sole.



Temporal and Spatial Changes in Sediment Toxicity in Santa Monica Bay

We describe the temporal changes in sediment toxicity in the outer part of Santa Monica Bay following termination of sludge discharge by Hyperion wastewater treatment plant in 1987. The toxicity of sediments was tested in the laboratory with the amphipod, *Grandidierella japonica*.

The laboratory tests indicated that the toxicity of sediments in the sludge field decreased during a period of marked changes in animal species composition and abundance in the field. This suggests that the laboratory toxicity tests included the relevant sediment qualities that were important to organisms living in Santa Monica Bay.

Changes in the concentration of hydrogen sulfide, total organic carbon, and total nitrogen were related to the changes in toxicity. Low molecular weight petroleum aromatic hydrocarbons may have also played a role in the reductions in toxicity of sediments collected close to the 7-mile outfall.

By 1989, sediment quality at 100 m in the contaminated zones was similar to sediment quality in the reference zone. However, assemblages of benthic macrofauna in the contaminated zones were still adversely affected in 1990. Sediment toxicity tests with *G. japonica* were a less sensitive indicator of sediment quality in Santa Monica Bay than the composition of the benthic macrofauna in the field.

Long-Term Trends in Trawl-Caught Fishes Off Point Loma, San Diego

Information on long-term trends in demersal fish populations on the mainland shelf off Southern California is uncommon. This study examined temporal and spatial changes in trawl-caught fishes at six stations along the 60 m isobath off Point Loma from 1982 to 1991. Nearly 27,000 individuals from 57 species (28 families) were collected during a decade of semi-annual trawling.

The composition and abundance of trawl-caught fishes were similar among the six stations, although catches were lowest at the control station. Plainfin midshipman, longspine combfish, yellowchin sculpin, California tonguefish, and longfin sanddab occurred in over 90% of the trawls and accounted for 55% of the individuals collected. The 10 most abundant species accounted for 83% of the fish captured.

There were seasonal and long-term differences in trawl catches that were correlated with water temperature. Longfin sanddab, California lizardfish, and hornyhead turbot were more abundant in the winter, while Dover sole, Pacific sanddab, and rockfish were more abundant in the summer. The number of species, individuals, and biomass declined following the 1982-83 El Niño. In general, more species of fish were collected when bottom water temperatures were lower.

The similarity of trawl fish abundance and composition among the six stations, and the similarity in abundance and composition between this study and the 1990 Reference Survey, suggest that the effects of wastewater discharge on the structure of the fish assemblage off Point Loma are minimal.

1990 Reference Survey

We recently completed the third survey of chemical and biological conditions in reference areas on the mainland shelf off Southern California in the last 15 years. Seven stations along the 30, 60, and 150 m isobaths were sampled in summer 1990. We report estimates of sediment characteristics, contaminant concentrations, and biological conditions from the least impacted areas on the mainland shelf.

Shelf sediments were predominantly sandy silt. The sand content decreased, and the clay and organic content increased, with increasing water depth. Trace metal concentrations were low at all stations and were similar among depths. Sediment concentrations of DDT, PCB, and polynuclear aromatic hydrocarbons were higher at the northern stations.

The macrobenthic (>1 mm) organisms collected in grab samples were variations of the *Amphiodia urtica-Spiophanes missionensis* assemblage that inhabits the Southern California mainland shelf. Amphipods (*Amphideutopus oculatus* and *Ampelisca brevisimulata*) dominated the samples from 30 m. The brittlestar, *Amphiodia urtica*, and the polychaete, *Myriochele* sp. M., dominated samples collected at 60 m. The 150 m stations were dominated by polychaetes (*Spiophanes fimbriata* and *Myriochele* sp. M) and *Amphiodia urtica*.

Trawl catches of large, motile invertebrates (megabenthos) and fish increased with increasing depth. The asteroid, *Astropecten verrilli*, dominated collections at 30 m. The sea urchin, *Lytechinus pictus*, and the prawn, *Sicyonia ingentis* dominated collections at 60 m. The sea urchins, *Allocentrotus fragilis* and *Lytechinus pictus*, dominated the 150 m stations. Fish catches at 30 m were dominated by speckled sanddab and longfin sanddab. Pacific sanddab and longfin sanddab dominated trawl catches at the 60 m stations. Slender sole and plainfin midshipman dominated trawl catches at the 150 m stations.

The assemblages of macrobenthos, megabenthos, and demersal fishes collected in 1990 were similar to the assemblages collected in the 1977 and 1985 reference surveys.

Toxicity of Dry Weather Flow in Ballona Creek

Ballona Creek is one of the few flood control channels that flows throughout the year into Santa Monica Bay. During dry weather, it receives discharges from a variety of sources including groundwater pumping and decontamination, swimming pool drainage, and dehumidifier condensate. We determined the toxicity of dry weather flow in Ballona Creek to purple sea urchin gametes (fertilization) and embryos (development) and examined the variability in toxicity over different time scales.

Dilutions of Ballona Creek samples collected in winter 1990 and winter 1991 were toxic to sea urchin sperm and embryos, although the fertilization test was more strongly affected than the development test. There was little variability in toxicity among samples collected on the same day, but the 1991 samples were slightly more toxic than the 1990 samples. Most of the receiving water samples collected at the mouth of Ballona Creek were also toxic to sea urchin sperm.

Elevated pH was responsible for much of the toxicity, although other constituents could not be ruled out. The spatial pattern of toxicity suggested that there were upstream (dry weather flow) and downstream (Santa Monica Bay) sources. Sources contributing to the toxicity of the receiving water may be contamination from Marina del Rey or the release of toxicants from Ballona Creek sediments. ■

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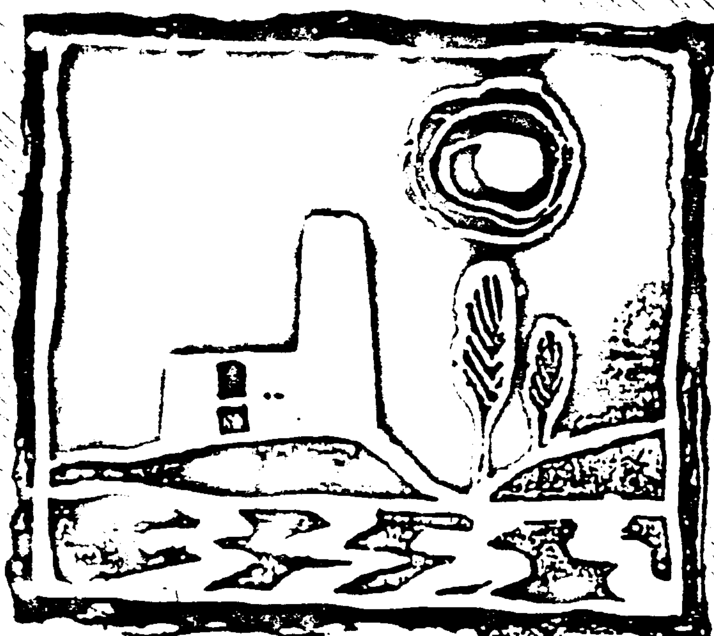

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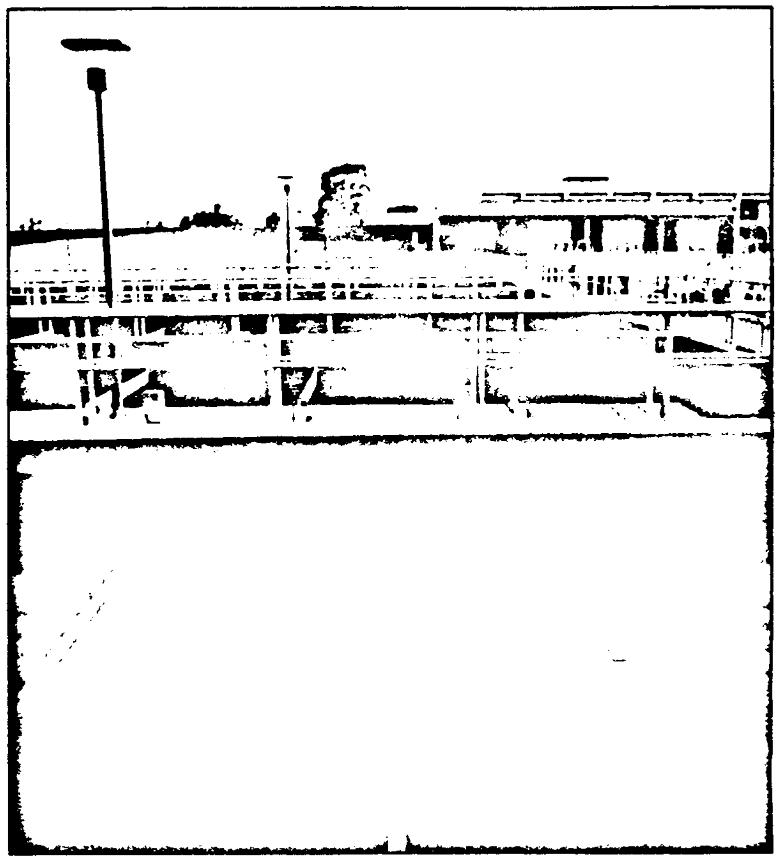
Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities in 1990 and 1991

In this report, we summarize concentrations of effluent constituents and estimates of effluent mass emissions for Hyperion Wastewater Treatment Plant (City of Los Angeles), Joint Water Pollution Control Plant (JWPCP, County Sanitation Districts of Los Angeles County), County Sanitation Districts of Orange County Wastewater (CSDOC) Treatment Plants 1 and 2, and Point Loma Sewage Treatment Plant (City of San Diego) for 1990 and 1991 (Figure 1). Effluents from these facilities composed 90% of municipal effluents discharged directly to the Southern California Bight.

The discharge agencies have measured the constituents featured in this report for at least two decades. Long-term trends in the mass emission of contaminants to the Southern California Bight (SCB) are also discussed.



County Sanitation Districts of Orange County Plant No.1

Materials and Methods

We obtained the effluent data that are reported monthly and annually by each discharge agency under National Pollution Discharge Elimination System permits from the Los Angeles, Santa Ana, and San Diego Regional Water Quality Control Boards.

Annual contaminant mass emissions were estimated from the product of mean daily flow in month *i*, constituent concentration in month *i*, and the number of days in the month; these were summed over all months to obtain the annual estimate (Appendix 1). This method differs from that used in previous SCCWRP reports where we estimated mass emissions by the product of total annual flow and mean annual constituent concentration (e.g., SCCWRP 1990). Estimates by the two methods differed by <1% (Appendix 1), so the historic mass emission data have not been recalculated. Constituent concentrations below detection limits were treated as zeros in both estimation methods.

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Results

The combined daily volume of effluent discharged from the four largest municipal wastewater treatment facilities in Southern California declined by 12% from 1989 to 1991 (Table 1; Figure 2); declines at individual treatment facilities ranged from 10-14%. Most of the declines occurred from 1990 to 1991. The amount of effluent receiving secondary treatment increased from 43% of the combined emissions in 1989 to 47% in 1991 (Table 1). The greatest increase occurred at Hyperion where 48% of the flow received secondary treatment in 1989 and 58% received secondary treatment in 1991.

The concentrations of effluent constituents generally varied by about a factor of two among the four municipal wastewater treatment plants; a few constituents, such as selenium, varied by an order of magnitude (Tables 2a,b).

Figure 1.
Map of the Southern California Bight showing the location of the four largest municipal wastewater dischargers: Hyperion Wastewater Treatment Plan (City of Los Angeles), Joint Water Pollution Control Plant (JWPCP; County Sanitation Districts of Los Angeles County), County Sanitation Districts of Orange County (CSDOC), and Point Loma Sewage Treatment Plant (City of San Diego).

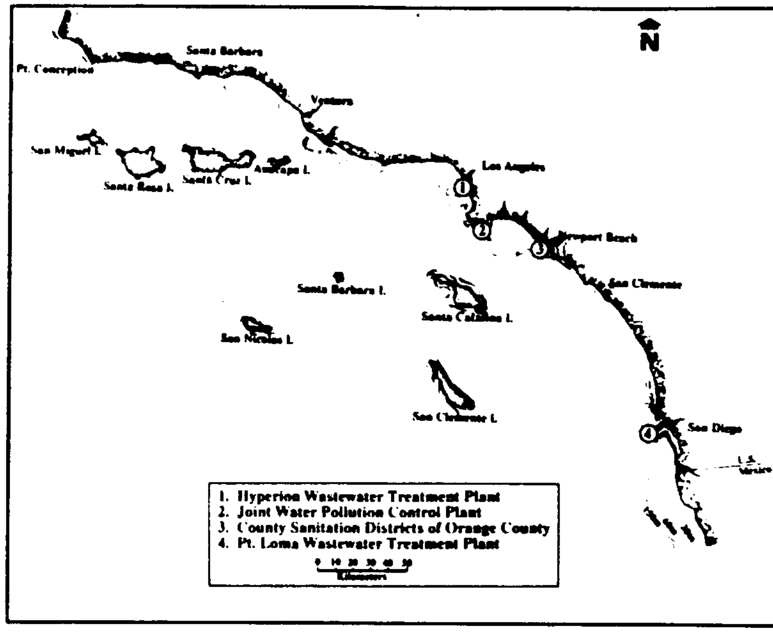

Table 1.
Volume of municipal wastewater discharged to the ocean from 1989 to 1991 from the largest treatment facilities in Southern California. Secondary is the volume of effluent receiving secondary treatment.

	1989		1990		1991			
	Secondary Flow (mgd[a])	Total Flow (mgd)	Secondary Flow (mgd)	Total Flow (mgd)	Secondary Flow (mgd)	Total Flow (mgd)	Distance of Discharge from Shore (m)	Depth of Discharge (m)
Hyperion[b]	177	365	185	354	182	315	8,300	57
JWPCP[c]	208	382	204	372	193	330	2,400/3,660	60
CSDOC[d]	134	261	128	266	116	235	7,250	60
Point Loma[e]	0	191	0	186	0	173	3,600	60
Total	519	1199	517	1178	491	1053		

[a]mgd=million gallons per day; 1 mgd = 3,785,000 L/day
[b]City of Los Angeles
[c]Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County
[d]County Sanitation Districts of Orange County
[e]City of San Diego

The differences among the effluents are due to the type of wastes (domestic and industrial), source control, volume of water removed for reclamation and inland discharge, and efficiency and degree of treatment (advanced primary or secondary).

The concentrations of some constituents varied substantially among months at individual treatment plants (Tables 2a,b). Nearly one-quarter of the mean monthly constituent concentrations had coefficients of variation greater than 50%. Coefficients of variation higher than 100% generally were due to a high

Table 2a.
Mean annual constituent concentrations in effluents from the largest municipal wastewater treatment facilities in Southern California in 1990. CV=coefficient of variation.

	Hyperion[a]		JWPCP[b]		CSDOC[c]		Point Loma[d]	
	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)
Flow (mgd)[e]	354	2	372	2	266	1	186	5
Suspended solids (mg/L)	30	11	63	8	44	5	65	14
Settlable solids (ml/L)	0.3	32	0.1	36	0.43	27	0.5	59
BOD (mg/L)	93	9	106	6	70	6	129	7
Oil and grease (mg/L)	11	12	11.8	6	13.7	10	19.2	11
NO_3-N (mg/L)	0.28	34	0.15	87	-	-	-	-
NO_2-N (mg/L)	-	-	0.56	154	-	-	-	-
NH_3-N (mg/L)	22	9	36.6	7	24	5	28.3	6
Organic N (mg/L)	5.4	17	7.4	12	-	-	-	-
PO_4-P[f] (mg/L)	-	-	-	-	-	-	3.8	44
Total phosphorus (mg/L)	5.0	13	7.2	13	-	-	-	-
MBAS[g] (mg/L)	-	-	3.9	14	-	-	5.8	19
Cyanide (mg/L)	0.013	79	0.01	80	<0.02	-	0.003	19
Phenols (µg/L)								
Non-chlorinated	4.0	86	-	-	4	92	5.8	25
Chlorinated	nd[k]	-	37	84	2.1	346	<2.7-<3.6	-
Turbidity NTU[h]	31	9	43	7	30	9	69	13
Toxicity TU[i]	0.88	57	1.41	21	0.57	49	1.25	17
Silver (µg/L)	6	39	8	13	7	18	<10	-
Arsenic (µg/L)	4	19	9	79	1.9	9	3.7	30
Cadmium (µg/L)	0.7	185	1	50	1.1	32	<5	-
Chromium (µg/L)	6	60	18	37	6.5	14	<50	-
Copper (µg/L)	38	25	31	14	45	8	32	17
Mercury (µg/L)	0.2	57	0.3	79	0.12	89	<0.5	-
Nickel (µg/L)	16	35	43	20	23	19	3.8	346
Lead (µg/L)	3	55	8	190	3.3	35	6.5	346
Selenium (µg/L)	nd	-	13	21	0.9	33	1.2	53
Zinc (µg/L)	69	15	87	22	55	18	67	26
Total DDT (µg/L)	<0.01-<0.05	-	0.02	57	<0.004-<0.05	-	0.021	275
Total PCB[j] (µg/L)	<0.02	-	<0.1-<0.9	-	<0.3-<0.5	-	nd	-

[a] City of Los Angeles
[b] Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County
[c] Plants 1 and 2, County Sanitation Districts of Orange County
[d] City of San Diego
[e] mgd=million gallons per day; 1 mgd=3,785,000 L/day
[f] soluble PO_4-P
[g] MBAS=methylene blue active substances
[h] NTU=nephelometric turbidity units
[i] TU=toxicity units acute = 100/(96 hr LC 50%)
[j] Total PCB=Aroclors 1016+1221+1232+1242+1248+1254+1260. JWPCP: Total PCB=Aroclors 1242+254+1260
[k] nd=not detectable and detection limit not reported

proportion of monthly contaminant concentrations below detection limits.

Effluent mass emissions from the four dischargers were generally related to flow (Tables 3a,b); the average rank correlation (r_s) among constituent mass emissions for the four treatment plants was 0.62 in 1990 and 0.44 in 1991. The JWPCP had the highest flow and generally the highest constituent mass emissions. It was followed by Hyperion, County Sanitation Districts of Orange County, and Point Loma.

From 1989 to 1991, the combined emissions of suspended

Table 2b.
Mean annual constituent concentrations in effluents from the largest municipal wastewater treatment facilities in Southern California in 1991. CV=coefficient of variation.

	Hyperion[a]		JWPCP[b]		CSDOC[c]		Point Loma[d]	
	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)
Flow (mgd)[e]	315	5	330	4	235	10	173	6
Suspended solids (mg/L)	33	10	70	9	44	5	81	8
Settlable solids (ml/L)	0.3	23	0.2	42	0.5	18	0.6	50
BOD (mg/L)	83	12	103	8	71	5	140	8
Oil and grease (mg/L)	10	17	13.4	7	13.8	15	18.4	12
NO_3-N (mg/L)	0.328	63	0.22	51	-	-	-	-
NO_2-N (mg/L)	-	-	0.25	47	-	-	-	-
NH_3-N (mg/L)	25.8	6	37.8	8	25	4	30.0	9
Organic N (mg/L)	5.5	10	7.87	10	-	-	-	-
PO_4-P (mg/L)[f]	-	-	-	-	-	-	4.3	50
Total phosphorus (mg/L)	4.75	12	7.87	13	-	-	-	-
MBAS[g] (mg/L)	-	-	4.4	25	-	-	6.5	22
Cyanide (mg/L)	0.022	76	0.01	62	<0.02	-	0.006	59
Phenols (µg/L)								
Non-chlorinated	2.11	151	-	-	6.0	67	4.6	55
Chlorinated	<1-<3	-	24	99	<0.2-<3	-	<2.7-<3.6	-
Turbidity NTU[h]	37	26	43	9	37	8	80	15
Toxicity TU[i]	1.40	23	1.58	15	0.61	48	1.38	10
Silver (µg/L)	5.7	53	8	18	6	29	<10	-
Arsenic (µg/L)	5	17	4	11	2	21	3.2	31
Cadmium (µg/L)	<1	-	<1	-	1.2	71	<5	-
Chromium (µg/L)	4	57	15	44	6	34	<50	-
Copper (µg/L)	31	24	29	22	38	18	30	17
Mercury (µg/L)	0.2	74	<0.5	-	0.3	216	<0.5	-
Nickel (µg/L)	17	42	38	17	24	10	<40	-
Lead (µg/L)	2	83	<8	-	2	35	<50	-
Selenium (µg/L)	<1	-	14.2	15	<1	-	1.4	21
Zinc (µg/L)	113	110	92	26	48	22	79	35
Total DDT (µg/L)	<0.03	-	<0.01-<0.03	-	<0.02	-	<0.02-<0.04	-
Total PCB[j] (µg/L)	<0.02	-	<0.01-<0.9	-	<0.5	-	nd[k]	-

[a] City of Los Angeles
[b] Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County
[c] County Sanitation Districts of Orange County
[d] City of San Diego
[e] mgd=million gallons per day; 1 mgd=3,785,000 L/day
[f] soluble PO_4-P
[g] MBAS=methylene blue active substances
[h] NTU=nephelometric turbidity units
[i] TU=toxicity units acute = 100/(96 hr LC 50%)
[j] Total PCB=Aroclors 1016+1221+1232+1242+1248+1254+1260; JWPCP Total PCB=Aroclors 1242+254+1260
[k] nd=not detectable and detection limit not reported

solids declined 5%, BOD declined 14%, and oil and grease declined 15% (Table 4). The discharge of suspended solids decreased 15% at Hyperion and CSDOC, and 8% at JWPCP, but it increased 22% at Point Loma. The discharge of BOD decreased 21% at Hyperion, 19% at JWPCP, and 14% at CSDOC, but it increased 7% at Point Loma. The discharge of oil and grease decreased by 33% at Hyperion, 10% at Point Loma, 6% at CSDOC, and 5% at JWPCP. [Data for 1989 are from SCCWRP (1990).]

From 1989 to 1991, their were substantial declines in the combined emissions of several trace metals (Table 4). The combined emissions of lead declined 95%, cadmium declined 79%, chromium declined 55%, and mercury declined 50%. The combined emissions of nickel declined 39%, copper declined 31%, and silver and arsenic declined 27%. The combined emissions of zinc declined 14% and selenium declined 11%. [Data for 1989 are from SCCWRP (1990).]

Effluent concentrations of DDT and PCB were below

Table 3a.

Estimated mass emissions from the largest municipal wastewater treatment facilities in Southern California in 1990.

	Hyperion[a]	JWPCP[b]	CSDOC[c]	Point Loma[d]
Flow (L x 10^9)	489	513	367	256
Suspended solids (mt[e])	14,435	32,578	16,001	16,700
BOD (mt)	45,520	54,434	25,616	33,147
Oil and grease (mt)	5,418	6,076	5,027	4,937
NO_3-N (mt)	137	76	-	-
NO_2-N (mt)	-	288	-	-
NH_3-N (mt)	10,911	18,799	8,711	7,264
Organic N (mt)	2,635	3,773	-	-
PO_4-P (mt)	-	-	-	962
Total phosphorus (mt)	2,456	3,706	-	-
MBAS[f] (mt)	-	2,017	-	1,485
Cyanide (mt)	6.6	6.0	-	0.84
Phenols (mt)				
Non-chlorinated	1.9	-	1.6	1.5
Chlorinated	-	19	0.75	-
Silver (mt)	3.0	3.9	2.5	-
Arsenic (mt)	2.0	4.6	0.66	0.94
Cadmium (mt)	0.34	0.64	0.41	-
Chromium (mt)	3.1	9.0	2.4	-
Copper (mt)	19	16	16	8.2
Mercury (mt)	0.077	0.13	0.043	-
Nickel (mt)	8.0	22	8.5	1.1
Lead (mt)	1.2	4.0	1.2	1.6
Selenium (mt)	-	6.6	0.34	0.32
Zinc (mt)	34	44	20	17
Total DDT (kg)	-	12	-	5.4
Total PCB[g] (kg)	-	-	-	-

[a]City of Los Angeles
[b]Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County
[c]County Sanitation Districts of Orange County
[d]City of San Diego
[e]mt=metric tons
[f]MBAS=methylene blue active substances
[g]Total PCB=Aroclors 1016+1221+1232+1242+1248+1254+1260; JWPCP Total PCB=Aroclors 1242+1254+1260

method detection limits in 1991. Based on detectable concentrations, the estimated mass emission of DDT declined 40% from 1989 to 1990.

Discussion

The annual combined volume of effluent discharged has declined only five times since 1971 (Table 4). The lower volumes discharged in 1990 and 1991 may be the result of water conservation efforts during the drought. The concentrations of most effluent constituents declined from 1989 to 1991. The greatest change was in lead — effluent concentrations declined 92% at Hyperion and 86% at CSDOC.

Declines in constituent concentrations and mass emissions are the result of improved primary treatment, increased secondary treatment, and improved source control (the most important factor). As a consequence, the number of reported analyses with masses below detection limits (BDL) continues to increase. Some contaminant measurements are consistently below detection limits. If detection limits of the recommended techniques are

Table 3b.
Estimated mass emissions from the largest municipal wastewater treatment facilities in Southern California in 1991.

	Hyperion[a]	JWPCP[b]	CSDOC[c]	Point Loma[d]
Flow (L x 10^9)	435	455	325	239
Suspended solids (mt[e])	14,170	31,715	14,120	19,353
BOD (mt)	36,037	46,683	23,090	33,464
Oil and grease (mt)	4,390	6,076	4,481	4,393
NO_3-N (mt)	144	99	-	-
NO_2-N (mt)	-	113	-	-
NH_3-N (mt)	11,229	17,190	8,025	7,189
Organic N (mt)	2,394	3,578	-	-
PO_4-P (mt)	-	-	-	1,025
Total phosphorus (mt)	2,065	3,585	-	-
MBAS[f] (mt)	-	1,991	-	1,546
Cyanide (mt)	9.4	5.0	-	1.43
Phenols (mt)				
Non-chlorinated	0.95	-	2.0	1.1
Chlorinated	-	11	-	-
Silver (mt)	2.5	3.6	1.8	-
Arsenic (mt)	2.0	1.8	0.79	0.77
Cadmium (mt)	-	-	0.40	-
Chromium (mt)	1.8	6.6	2.0	-
Copper (mt)	13	13	13	7.3
Mercury (mt)	0.076	-	0.082	-
Nickel (mt)	7.6	17	7.7	-
Lead (mt)	0.70	-	0.68	-
Selenium (mt)	-	6.5	-	0.33
Zinc (mt)	49	42	16	19
Total DDT (kg)	-	-	-	-
Total PCB[g] (kg)	-	-	-	-

[a]City of Los Angeles
[b]Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County
[c]County Sanitation Districts of Orange County
[d]City of San Diego
[e]mt=metric tons
[f]MBAS=methylene blue active substances
[g]Total PCB=Aroclors 1016+1221+1232+1242+1248+1254+1260, JWPCP: Total PCB=Aroclors 1242+1254+1260

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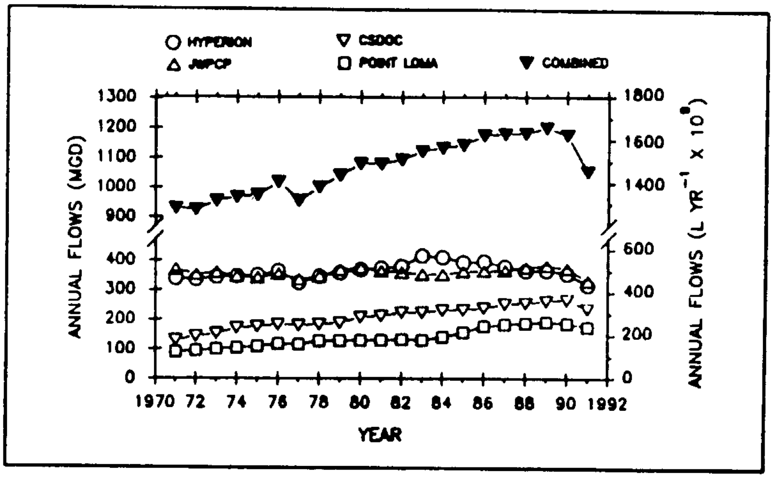
Figure 2.

Combined effluent flow and individual effluent flows from the four largest municipal wastewater treatment facilities in Southern California (MGD = millions of gallons per day, L = liters).



below discharge permit requirements, then BDL results are in compliance. However, BDL results complicate mass emissions estimates. We reported detection limits in the table of concentrations (Tables 2a,b) and treated BDL results as zeros for the estimates of mass emissions (Tables 3a,b).

The combined flow from the four largest facilities increased 27% between 1971 and 1990 as a result of population increases (Figure 2). This is a mean annual increase of 1.3% (sd=2.5, n=19). During this time, the volume of wastewater discharged by CSDOC and Point Loma doubled while the volume discharged by

Table 4.

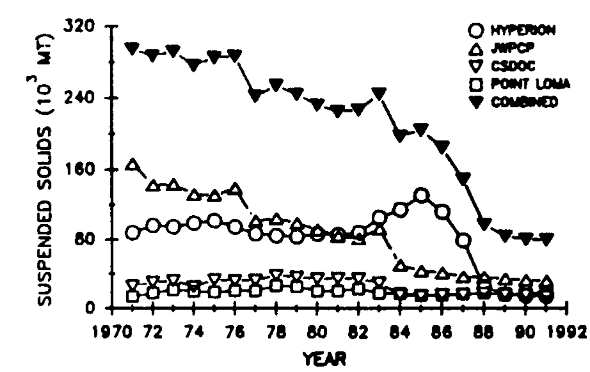
Combined mass emissions from City of Los Angeles Hyperion Treatment Plant, County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant, County Sanitation Districts of Orange County Wastewater Treatment Plants 1 and 2, and City of San Diego Point Loma Sewage Treatment Plant from 1971 through 1991.

	1971	1972	1973	1974	1975	1976	1977	1978	1979
Flow (L x 10^9)	1,284	1,278	1,319	1,336	1,346	1,406	1,319	1,382	1,438
Flow (mgd[a])	930	922	954	967	975	1,015	955	1,001	1,041
Suspended solids[b](mt[c])	294,000	286,500	291,700	270,900	284,900	286,400	241,800	253,800	243,900
BOD (mt)	283,100	250,300	226,800	233,900	233,500	255,900	241,500	234,200	241,900
Oil and grease (mt)	62,312	60,700	60,700	54,800	56,500	58,800	49,200	48,500	45,400
NH_3-N (mt)	54,500	40,100	45,900	38,900	36,300	37,000	40,000	38,900	41,100
Total P[d](mt)	33,500	36,300	39,200	37,700	11,000	22,800	10,600	10,100	10,000
MBAS[e] (mt)	6,500	6,300	5,900	6,800	6,100	6,100	5,400	5,800	6,300
Cyanide (mt)	188	238	244	303	251	401	213	176	145
Silver (mt)	15	22	29	22	25	20	34	32	43
Arsenic (mt)	3[f]	18	16	18	12	11	12	15	15
Cadmium (mt)	52	34	49	55	51	44	41	44	43
Chromium (mt)	667	675	694	690	579	592	368	279	239
Copper (mt)	535	486	508	576	510	506	402	416	361
Mercury (mt)	2.9	2.6	3.1	1.8	2.2	2.5	2.6	1.9	2.6
Nickel (mt)	326	262	318	315	282	302	262	318	256
Lead (mt)	226	252	180	199	198	189	150	216	224
Selenium (mt)	12	11	16	18	11	22	22	23	7.9
Zinc (mt)	1,834	1,201	1,189	1,324	1,087	1,061	834	833	728
DDT[g] (kg)	21,527	6,558	3,818	1,562	1,158	1,633	855	1,121	839
PCB[g] (kg)	8,730	9,830	3,389	5,421	3,065	3,492	2,183	2,540	1,170

[a]mgd=million gallons per day; 1 mgd=3,785,000 L/day
[b]solids for Hyperion 7-mile outfall are total solids
[c]mt=metric tons
[d]City of San Diego measures only soluble PO_4P

JWPCP and Hyperion increased only slightly (Figure 2). Population growth patterns, water reclamation, and inland discharge account for differences among the districts. Orange and San Diego counties have grown faster than Los Angeles County. Los Angeles County and the City of Los Angeles expanded their upstream treatment and reclamation facilities. The County reclaimed 155 mgd of water in 1990 — double the amount reclaimed 10 years ago. The volume of effluent discharged to the Los Angeles River by the Los Angeles-Glendale and Donald C. Tillman water reclamation plants

Figure 3.
Combined suspended solids emissions and individual suspended solids from the four largest municipal wastewater treatment facilities (MT = metric tons).



1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1,493	1,492	1,511	1,549	1,565	1,579	1,623	1,629	1,632	1,656	1,627	1,455
1,078	1,080	1,094	1,122	1,129	1,143	1,175	1,179	1,178	1,199	1,178	1,053
232,100	224,900	226,800	244,600	197,700	204,500	184,900	149,100	97,000	83,400	79,700	79,400
255,100	260,900	266,100	251,800	230,100	253,500	181,900	166,500	168,800	161,100	159,000	139,300
38,400	36,700	37,300	35,700	30,000	34,300	29,000	25,800	25,300	22,600	21,500	19,300
41,200	40,500	41,500	39,800	40,400	42,500	45,000	44,300	44,300	45,100	45,700	43,600
10,000	9,500	9,000	9,000	9,200	8,500	10,900	9,000	7,100	6,900	7,100	6,700
6,400	5,600	5,700	5,200	4,600	4,300	4,800	4,600	3,400	3,300	3,500	3,500
116	98	77	46	39	26	22	27	26	10	13	16
30	28	25	26	24	26	22	15	11	11	9	8
11	12	8	10	18	16	12	12	8.9	7.4	8.2	5.4
39	32	21	23	16	16	14	9.0	3.4	1.9	1.0	0.4
275	187	203	163	140	110	88	57	29	22	14	10
335	337	284	272	251	239	202	125	76	68	59	47
1.8	1.8	1.2	1.1	0.9	0.9	0.7	0.4	0.4	0.4	0.2	0.2
224	167	168	163	133	118	127	76	63	54	40	33
175	130	122	98	87	118	105	61	50	27	6.4	1.4
11	15	6.4	6.5	6.5	5.8	8.2	7.2	6.7	7.6	7.3	6.8
729	538	545	497	369	375	336	261	151	146	115	125
671	480	290	223	310	48	51	53	26	20	12	-[b]
1,127	1,252	785	628	1,209	46	37	5	-[b]	-[b]	-[b]	-

[a]Hyperion 7-mile outfall not included
[f]only Hyperion data were available
[e]estimates for 1971-75 are based on SCCWRP analyses of effluents; estimates estimates for 1976-91 are based on discharger data
[b]concentrations were below detection limits

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increased from 25 mgd in 1985 to 55 mgd in 1990.

Despite increases in population and the volume of wastewater discharged over the past two decades, the mass emissions of most effluent constituents have declined (Table 4). The combined annual mass emission of suspended solids has decreased 73%, BOD has decreased 51%, and oil and grease has decreased 69% (Figures 3, 4, and 5). The decline in JWPCP solids emissions between 1971 and 1989 accounts for 65% of the reduction. Termination of sludge discharge from the Hyperion 7-mile outfall (October 1987) accounts for a 40% reduction in combined emissions from 1987 to 1988. Most of the decline in BOD occurred after 1985. Reductions by JWPCP account for about 75% of the decline in oil and grease.

The combined mass emission of trace metals declined 94% from 1971 to 1991 (Table 4; Figure 6). Declines of individual metals averaged 84% (sd=19%, n=10). The greatest reductions were for chromium (99%), cadmium (99%), lead (99%), zinc (93%), mercury (93%), copper (91%), nickel (90%), and selenium (43%). From 1972 to 1990, arsenic declined 70% and silver declined 64%. The combined mass emissions of trace metals declined 36% from 1987 to 1988; termination of sludge discharge from the Hyperion 7-mile outfall accounted for about 60% of this decline.

The combined emissions of chlorinated hydrocarbons declined more than 99% from 1971 to 1990 (Table 4; Figure 7). Montrose Chemical Corporation, the largest manufacturer of DDT in the world and the only manufacturer in California, discharged DDT wastes into the Los Angeles County sewer system from 1947 to 1971. Residual waste in the sanitation system was the principal source of DDT in JWPCP effluent after that time. Concentrations of DDT in JWPCP effluent are now below detection limits (tens of pg/l).

The interpretation of long-term trends is hindered somewhat by the reliability of trace contaminant analyses, especially trace organic analyses, in early monitoring programs. Analytical methods for quantifying chlorinated hydrocarbons evolved during the 1970s and techniques were not standardized among laboratories. The older data reported herein are the best available for past discharges, but the old methods are unacceptable today. The accuracy and precision of contaminant analyses have improved over the years because of advancements in methods and instruments, and because of intercalibration among laboratories.

Figure 4.
Combined mass emission of biological oxygen demand from the four largest municipal wastewater treatment facilities (MT = metric tons).

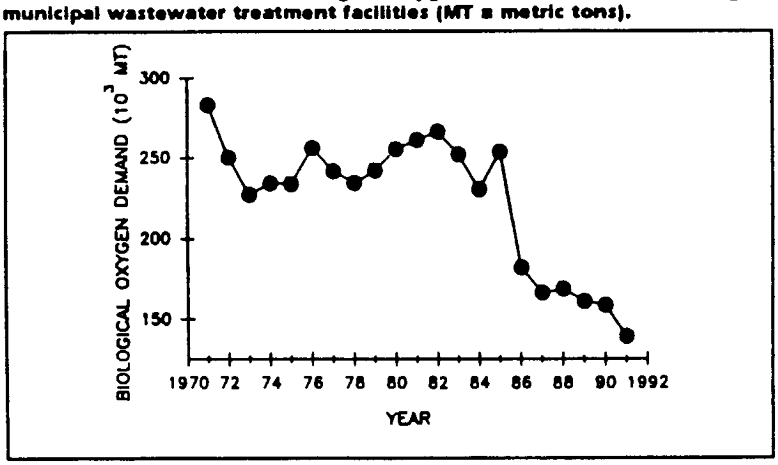

Figure 5.
Combined oil and grease emissions and individual oil and grease from the four largest municipal wastewater treatment facilities (MT = metric tons).

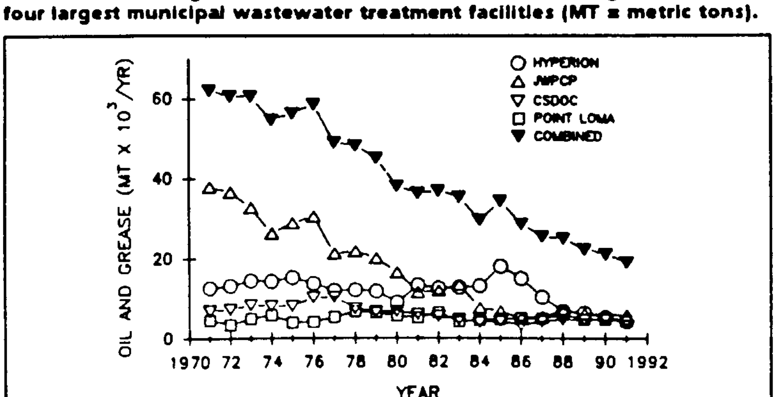

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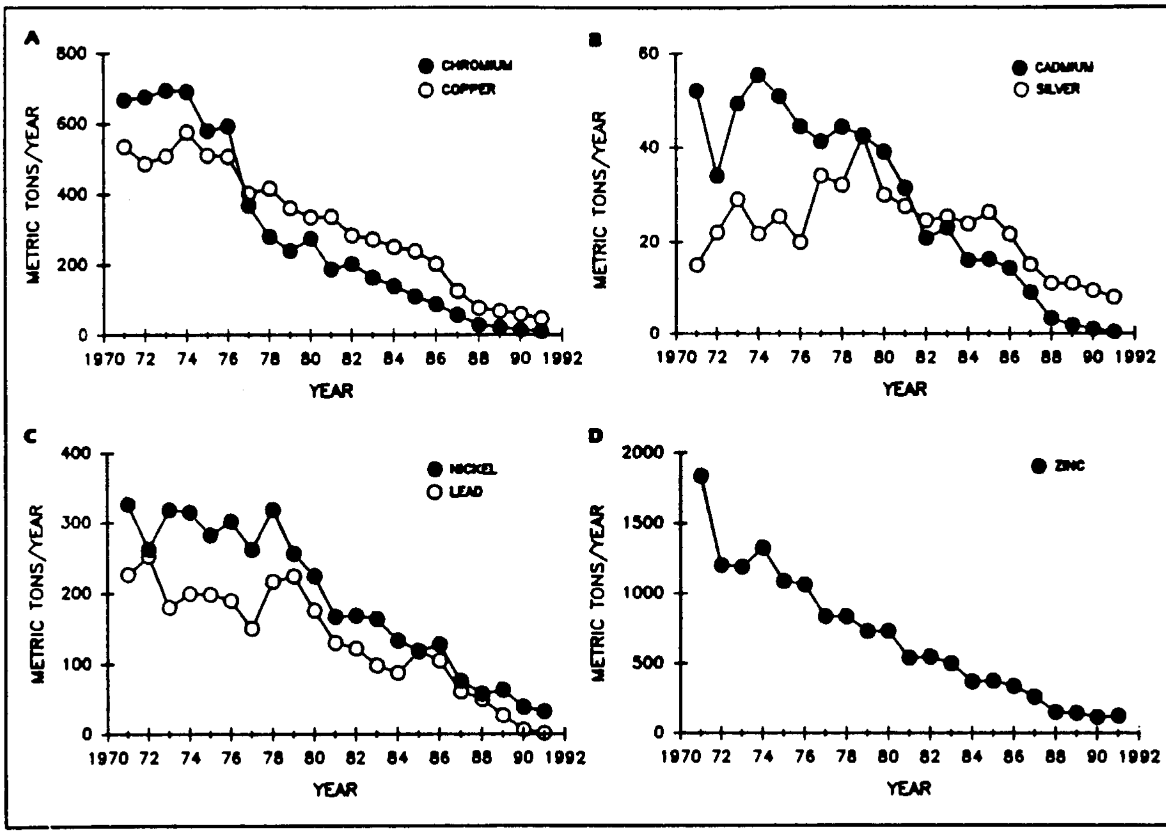
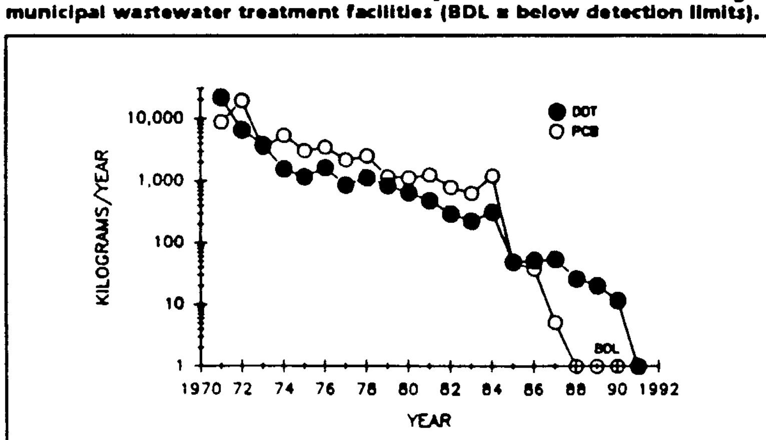
Figure 6.
Combined mass emissions of trace metals from the four largest municipal wastewater treatment facilities.



Conclusions

The quality of municipal wastewaters discharged to the Southern California Bight today is significantly better than the quality of wastewaters discharged in 1971. Decreases in contaminant mass emissions are due to increased source control and land disposal of sludge, improved sludge and primary treatment, and increased secondary treatment. Further reductions in mass emissions on a comparable scale are not possible. Nominal reductions

Figure 7.
Combined mass emissions of chlorinated hydrocarbons from the four largest municipal wastewater treatment facilities (BDL = below detection limits).



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will occur due to planned increases in the volume of wastewater receiving secondary treatment, increased inland reclamation of water, and more effective source control ■

Literature Cited

•SCCWRP. 1990. Characteristics of effluents from large municipal wastewater treatment plants in 1989. pp. 8-15, *In:* Southern California Coastal Water Research Project. Annual Report 1989-90. J.N. Cross (ed.). Southern California Coastal Water Research Project, Long Beach.

Appendix 1.

Annual mass emissions (ME) of contaminants were estimated from:

$$ME=\sum_{i=1}^{12}(F_i C_i D_i) \qquad (1)$$

where:
F_i = mean daily flow in month *i*;
C_i = constituent concentration in month *i*; and
D_i = number of days in month *i*.

Historically, mass emissions were estimated from:

$$ME=\sum F_i C_m \qquad (2)$$

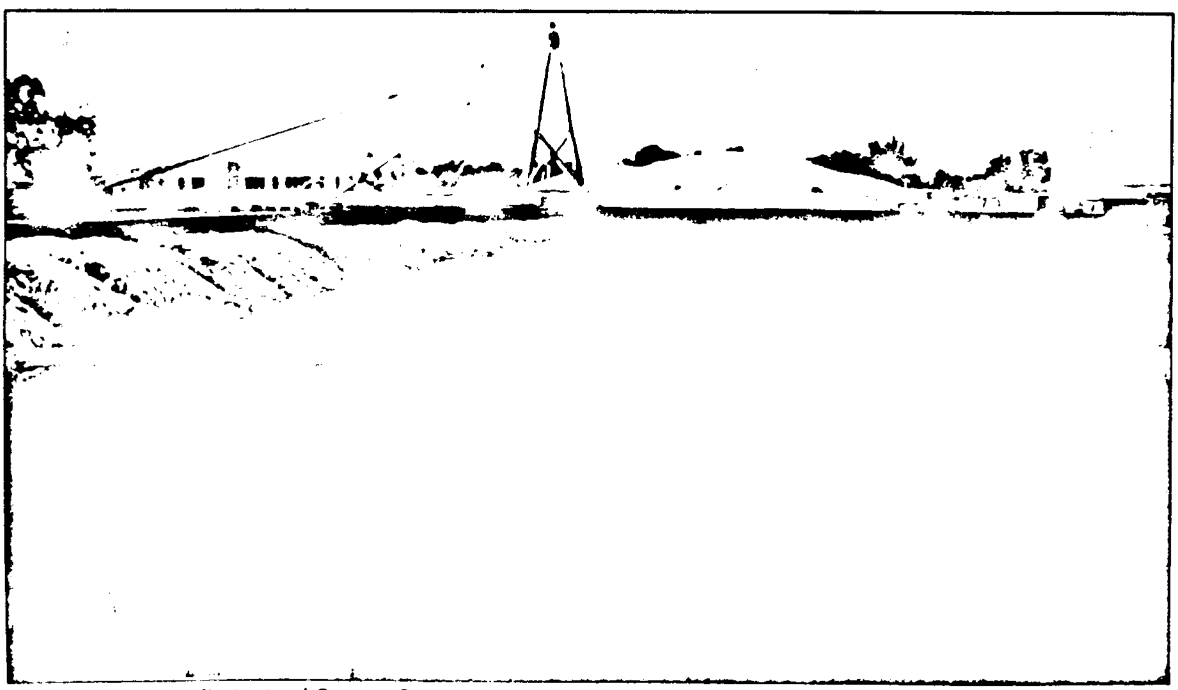
where:
$\sum F_i$ = total annual flow, and
C_m = mean monthly constituent concentration.

We estimated mass emissions for 1990 and 1991 by both methods. Estimates by (2) were similar to estimates by (1); the mean difference in 1990 was -0.09% (sd=1.55, n=71, min=0%, max=-10.5%) and the median difference was 0.08%. The maximum difference occurred for estimates of nickel emissions from Point Loma. Without this datum, the mean difference was 0.06% (sd=0.61, n=70, min=0%, max=-3.0%) and the median difference was 0.10%.

Method (2) was slightly, but significantly, positively biased. Nearly 70% of the 1990 estimates were higher by (2) than by (1), more than would be expected by chance alone (normal approximation to binomial test, Z=3.04, 0.002<p<0.005). Estimates by (1) were more accurate, and therefore less biased, than (2). Method (1) also allowed us to examine monthly variability in constituent concentrations (Tables 2a,b).

Acknowledgements

Authors Jeffrey Cross and Valerie Raco thank the Los Angeles, Santa Ana, and San Diego Regional Water Quality Control Boards; Hyperion Wastewater Treatment Plant; County Sanitation Districts of Los Angeles County; County Sanitation Districts of Orange County; and Point Loma Sewage Treatment Plant for their cooperation.



County Sanitation Districts of Orange County Plant No.1

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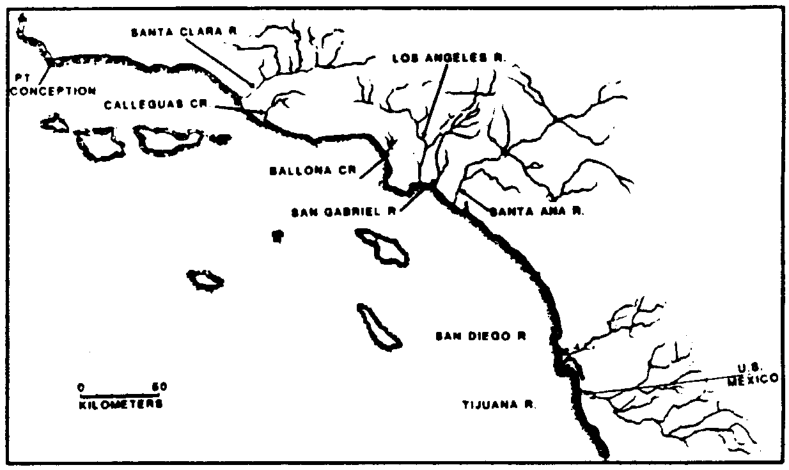
Surface Runoff to the Southern California Bight

Twenty creeks and rivers drain the coastal mountains, valleys and plains between Point Conception and the U.S./Mexican border and discharge into the Southern California Bight (SCB). A large portion of this discharge is urban runoff. Although a significant amount of data have been collected on contaminant concentrations in surface runoff, there are few published estimates of the mass of contaminants delivered to the ocean (e.g., SCCWRP 1973, Eganhouse and Kaplan 1982, SCAG 1988).

The objective of this study was to measure the concentration of selected constituents in runoff samples from the largest channels in Southern California and to estimate the mass carried to the ocean. We collected samples from eight channels during storms and low flows, and estimated the annual load of contaminants delivered to the ocean.

Figure 1.
Runoff samples were collected from the eight largest rivers and creeks that discharge to the ocean off Southern California.



Materials and Methods

Sampling Method and Locations.
Samples were collected between September 1986 and April 1988 with a sampling device patterned after the U.S. Geological Survey suspended sediment pint sampler that has been in use in Southern California for two decades (Young and Bodeen 1991). About 10 samples were collected during each storm and were distributed over rising and declining flows. Samples were collected in the middle of each channel at the same location throughout the study. The sampling device and sampling method are described in SCCWRP (1990). The sampling locations were (Figure 1):

- *Santa Clara River:* Highway 101 8 km from the ocean.
- *Calleguas Creek:* above the tidal prism at Highway 1.
- *Ballona Creek:* Inglewood Boulevard 4 km from the ocean.
- *Los Angeles River:* above the tidal prism at the Willow Street bridge in Long Beach.
- *San Gabriel River:* College Park Drive bridge 4 km above the tidal prism and below confluence of the San Gabriel River and Coyote Creek.
- *Santa Ana River:* Hamilton Street on the border between Huntington Beach and Costa Mesa.
- *San Diego River:* 4 km above the tidal prism east of Fashion Valley Road in San Diego.
- *Tijuana River:* 6 km above the ocean at Dairy Mart Road.

Analytical Methods.
The samples were analyzed for suspended solids, selected trace metals, and selected trace organics. Sampling handling and analytical methods are described in SCCWRP (1990).

Load estimates.
The load of a particular constituent in a river is the total mass of the constituent passing the point of measurement over some period of time. We estimated the load of selected constituents transported by the eight rivers with a flow-weighted ratio estimator. Where sufficient contaminant data existed, we stratified the estimates into low and high flows. The inflexion point on the flow duration curve was the cutoff between low and high flow days (SCCWRP, unpublished data). Contaminant data from the two

years were pooled to increase sample sizes.

The flow-weighted ratio estimator is based on the relation between flows and loads:

$$L = QT\frac{\sum_{i=1}^{n} c_i q_i}{\sum_{i=1}^{n} q_i}$$

where L is the load of the constituent, Q is the mean period flow, T is the total time in the period, c_i is the ith concentration, and q_i is the corresponding flow rate. The method assumes that flows are continuously monitored, mean flow can be determined accurately, concentrations are related to flows, and the underlying distributions are approximately normal. The estimation method and its assumptions and shortcomings are described in more detail in SCCWRP (1990).

River flow data were obtained from the U.S. Geological Survey, the Ventura and Los Angeles County Departments of Public Works, and the International Boundary Water Commission. Flow data are reported by water year (October 1 to the following September 30). We modified the

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Table 1.
Flow-weighted mean constituent concentrations for runoff samples collected between 1986 and 1988 from rivers and creeks that discharge into the Southern California Bight. SS=suspended solids in dry weight.

	SS	Cd	Cr	Cu	Ni	Pb	Zn	ΣDDT[1]	ΣPCB[2]
	(mg/L)	(μg/L)						(ng/L)	
Santa Clara River	995	1.4	60	55	34	90	264	248	51
Calleguas Creek	667	3.0	111	80	62	28	195	176	187
Ballona Creek									
High Flow	402	3.3	38	138	39	286	766	183	166
Low Flow	136	1.3	12	60	19	52	206	25	75
Los Angeles River									
High Flow	1194	3.3	43	138	49	242	618	155	308
Low Flow	71	4.2	11	17	13	23	81	8	21
San Gabriel River	820	3.6	54	87	36	124	408	50	133
Santa Ana River	3,298	2.6	99	141	91	103	719	57	78
San Diego River	283	0.02	10	15	2.4	27	85	90	26
Tijuana River	4,313	5.1	184	416	116	988	1,150	243	634

[1]o,p'-DDT + p,p'-DDT+ o,p'-DDE + p,p'-DDE+ o,p'-DDD + p,p'-DDD
[2]Aroclor 1242 + Aroclor 1254

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Table 2.
Spearman rank correlation coefficients (r_s) among constituent concentrations and instantaneous flow in runoff samples collected between September 1986 and January 1987 from rivers and creeks that discharge into the Southern California Bight. Only r_s significant at p<0.05 (*) and p<0.01 (**) are shown. SS=suspended solids.

	Santa Clara River Flow	Santa Clara River SS	Calleguas Creek Flow	Calleguas Creek SS	Ballona Creek Flow	Ballona Creek SS
SS	.732**					
Cd	.637*	.782**		.940**		.855**
Cr	.684*	.976**		.966**		.722**
Cu	.653*	.988**		.862**		.946**
Ni	.578*	.802**		.904**		.809**
Pb	.639*	.888**		.944**		.793**
Zn	.615*	.939**		.962**	.556*	.862**
DDT[1]		.834**	.794**	.821**		.695**
PCB[2]			.638*			.840**

[1]o, p'-DDT + p, p'-DDT + o, p'-DDE + p, p'-DDE + o, p'-DDD + p, p'-DDD
[2]Aroclor 1242 + Aroclor 1254

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water year to run from September 1 to August 31 because the first storm of the study occurred in September 1986 after five months of no precipitation.

Results

Santa Clara River

The Santa Clara River is 155 km long, drains an area of 4,219 km^2, and empties into the ocean south of Ventura. The drainage basin is moderately developed with large reservoirs, extensive levees, and agricultural diversions along the coastal plain. In the last 50 km, the river flows over a permeable, sandy, alluvial plain and flow rarely reaches the ocean except during storms. Annual rainfall ranges from 35 cm at the mouth of the river to 90 cm in the mountains (Brownlie and Taylor 1981).

Discharge from the Santa Clara River during the 1987 water year (0.9×10^6 m^3) was 0.2% of the total gauged runoff to the SCB; discharge during the 1988 water year (28.4×10^6 m^3) was 4.2% of the total discharge to the SCB. Discharge during the 2-year study was <1% and 19% of the long-term annual mean (1950-88: 146.2×10^6 m^3). The flow gauge on the lower river registered flow on only 18 days in 1987 and 22 days in 1988. Runoff from one storm in February 1988 was 72% of the gauged flow for that year. Most of the discharge from the river occurred from January through March.

Eleven runoff samples were collected from storms that occurred in September 1986 and January 1987. The flow increase during the September 1986 storm was small and not recorded by the flow gauge. Discharge during the January 1987 storm (3.6×10^6 m^3) was 13% of the annual discharge. One non-storm sample was collected in October 1986. Eleven samples were analyzed for suspended solids and chlorinated hydrocarbons and 10 samples were analyzed for trace metals (Table 1). Most constituents were correlated with flow and suspended solids (Table 2). The volume of discharge from the Santa Clara River increased by nearly 3200% from the first study year to the second. Estimates of constituent mass emissions increased by a similar amount (Tables 3a,b).

Calleguas Creek.

Calleguas Creek drains 837 km^2, including the rapidly growing Simi Valley, Thousand Oaks, and Camarillo, and empties into the ocean through Mugu Lagoon. The channel is moderately developed due to levees, agriculture, and urban and suburban development. Five municipal wastewater treatment plants discharged 87,000 m^3/day (23 mgd) into the creek during the study.

Discharge from Calleguas Creek during the 1987 water year (21.7×10^6 m^3) and the 1988 water year (31.3×10^6 m^3) was 5% of the total gauged runoff to the SCB. Discharge during the 2-year study was 59% and 93% of the long-term annual mean (1969-89: 35.2×10^6 m^3). High flows (>0.8 m^3/s) occurred 12% of the days during 1987 and 17% of the days during 1988, and accounted for 29% and 51% of the the annual discharge. Most of the discharge from Calleguas Creek occurred from December through March.

Nine runoff samples were collected from Calleguas Creek

Los Angeles River		San Gabriel River		Santa Ana River		San Diego River		Tijuana River	
Flow	SS	Flow	SS	Flow	SS	Flow	SS	Flow	SS
.720**		.797**		.830**		.656**		.600**	
				.604**	.730**			.761**	.547**
.507**	.787**	.514*	.787**	.872**	.891**		.811**	.560**	.642**
.659**	.829**			.934**	.910**		.730**	.664**	.606**
.481**	.813**			.872**	.926**		.508**	.544**	.652**
.691**	.736**			.905**	.883**		.734**	.509**	.428*
.671**	.845**			.908**	.914**		.648**	.572**	.471**
.764**	.697**	.673**	.533*	.527*	.690**	.674**	.692**	.557**	.397*
.492**	.408**							.611**	.407*

during storms in September 1986 and January 1987. These storms accounted for 1.4% of the discharge volume in 1986-87 and 1.8% of the discharge volume in 1987-88. One non-storm sample was taken in October 1986. Ten runoff samples were analyzed for suspended solids and chlorinated hydrocarbons, and nine samples were analyzed for trace metals (Table 1). The concentrations of most constituents were correlated with suspended solids, but not with flow (Table 2). The total volume discharged from Calleguas Creek increased 44% from 1987 to 1988 and so did the mass emission estimates (Tables 3a,b).

Ballona Creek.
Ballona Creek drains 232 km^2 of urbanized, predominantly residential, Los Angeles. The creek originates northeast of Baldwin Hills and empties into the ocean through Ballona Wetlands. The creek was once the outlet of the Los Angeles River. The channel is extensively developed as a result of urbanization and concrete channelization.

Discharge from Ballona Creek during the 1987 water year (21.8 x 10^6 m^3) was 4% of the total guaged runoff to the SCB; discharge during the 1988 water year (51.5 x 10^6 m^3) was 8% of the total guaged runoff to the SCB. Ballona Creek contributed 58% of the total runoff to Santa Monica Bay in 1987 and 71% in 1988. Discharge during the 2-year study was 48% and 133% of the long-term annual mean (1928-89: 38.7 x 10^6 m^3). High flows (>0.06 m^3/s) occurred 5% of the days during 1987 and 11% of the days during 1988, and accounted for 54% and 82% of the annual discharge. Most of the discharge from the creek occurred from November through March.

Fifteen runoff samples were collected from Ballona Creek during storms in September 1986, January 1987, and March 1987. Discharge during the storms averaged 2.4 x 10^6 m^3 (range: 0.7-4.5 x 10^6 m^3). The three storms accounted for 3.4%, 9.1%, and 20.5% of the total annual discharge volume. Two non-storm samples were collected in October 1986 and September 1987. Seventeen samples were analyzed for suspended solids, 16 samples were analyzed for trace metals, and 15 samples were analyzed for chlorinated hydrocarbons (Table 1). The concentrations of most constituents were correlated with suspended solids, but not with flow (Table 2). Flow-weighted mean concentrations at high flow were two to seven times greater than flow-weighted mean concentrations at low flow (Table 1).

High flow discharge accounted

Table 3a

Estimates of the mass emission of selected contaminants from rivers and creeks that discharged into the Southern California Bight between September 1, 1986 and August 31, 1987. VOL=annual discharge volume; SS=suspended solids in dry weight.

	VOL	SS	Cd	Cr	Cu	Ni	Pb	Zn	ΣDDT[1]	ΣPCB[2]
	(x 10^6 m^3)	(x 10^3 kg)	(kg)							
Santa Clara River	0.87	862	1	52	48	29	78	227	0.2	0.04
Calleguas Creek	21.7	14,452	65	2,407	1,735	1,344	607	4,228	3.8	4.1
Ballona Creek										
High Flow	11.8	4,708	39	440	1,632	462	3,354	8,976	2.1	2.0
Low Flow	10.0	1,390	13	117	604	194	518	2,067	0.3	0.7
Los Angeles River										
High Flow	61.0	72,437	202	2,609	8,372	2,973	14,682	37,492	9.7	18.8
Low Flow	95.4	6,799	402	1,053	1,628	1,245	2,202	7,756	1.0	1.9
San Gabriel River	139.2	114,127	501	7,516	12,109	5,010	17,258	56,785	7.0	18.5
Santa Ana River	17.6	58,060	46	1,742	2,481	1,601	1,812	12,650	1.0	1.4
San Diego River	20.0	5,667	<1	192	300	48	541	1,702	1.8	0.5
Tijuana River	10.2	43,883	52	1,870	4,231	1,178	10,051	11,706	2.5	6.4

[1]o, p'-DDT + p,p'-DDT + o, p'-DDE + p, p'-DDE + o, p'-DDD + p, p'-DDD
[2]Aroclor 1242 + Aroclor 1254

for 70-97% of the estimated annual constituent loads (Tables 3a,b). Total runoff volume increased 137% from 1987 to 1988 and high flow runoff volume increased 259%. Mass emissions estimates increased 100% to 300%. Low flow volume and estimates of the constituent mass emissions were similar in both years.

Los Angeles River.
The Los Angeles River is the largest single source of gauged runoff to the SCB. It originates in the Santa Susana and Santa Monica mountains in the western part of the San Fernando Valley and also receives runoff from the western San Gabriel Mountains and the Santa Monica Mountains. The river enters the ocean in San Pedro Bay, but historically it has changed course several times and entered the ocean as far north as Ballona Creek and as far south as the San Gabriel River (Brownlie and Taylor 1981).

The Los Angeles River drains 2,155 km^2 and, for its size, is one of the most extensively controlled rivers in the world. All of the river has been channelized below the upland catchments (Brownlie and Taylor 1981). In 1982, nearly 60% of the river basin was urban and suburban, 40% was native vegetation, and 1% was agriculture (Department of Water Resources 1982).

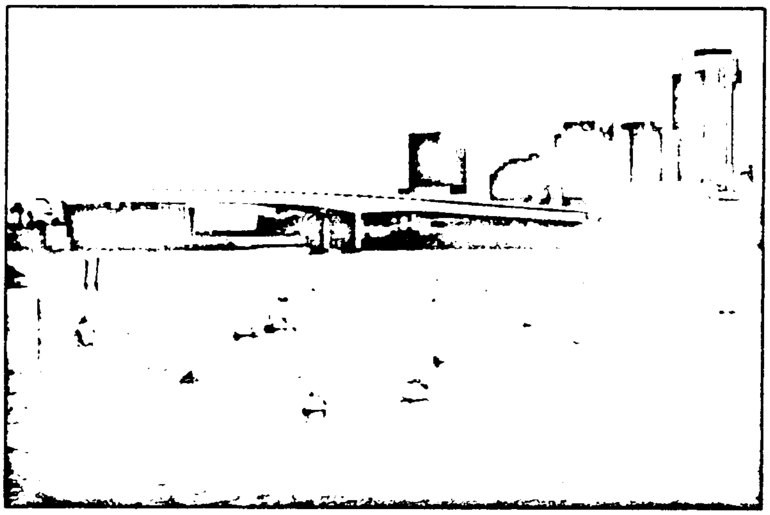
Discharge from the Los Angeles River during the 1987 (156.4 x 10^6 m^3) and 1988 (217.3 x 10^6 m^3) water years was 33% of the total gauged runoff to the SCB. Discharge during the 2-year study was 83% and 115% of the long-term annual mean (1929-88: 189 x 10^6 m^3). High flows (>5 m^3/s) occurred 8% of the days during 1987 and 9% of the days during 1988, and accounted for 39% and 57% of the annual discharge.Most of the discharge occurred from November through March.

Fifty-three runoff samples were collected from the Los Angeles River during six storms that occurred in September 1986, January 1987, March 1987, October 1987, December 1987, and January 1988. Mean discharge during the storms was 12.9 x 10^6 m^3 (range: 2.9-21.3 x 10^6 m^3) was 6-8% of the annual discharge. One non-storm sample was collected in October 1986. Fifty-four samples were analyzed for suspended solids, trace metals, and chlorinated hydrocarbons (Table 1). The concentrations of all constituents except cadmium were correlated with flow and suspended solids (Table 2). Concentrations at high flow were three to 17 times greater than concentrations at low flow for all constituents except cadmium (Table 1).

Table 3b.
Estimates of the mass emission of selected contaminants from rivers and creeks that discharged into the Southern California Bight between September 1, 1987 and August 31, 1988. VOL=annual discharge volume; SS=suspended solids in dry weight.

	VOL	SS	Cd	Cr	Cu	Ni	Pb	Zn	ΣDDT[1]	ΣPCB[2]
	(x 10^6 m^3)	(x 10^3 kg)	(kg)							
Santa Clara River	28.4	28,236	40	1,702	1,560	965	2,554	7,490	7.0	1.4
Calleguas Creek	31.3	20,893	94	3,408	2,508	1,944	878	6,113	5.5	5.9
Ballona Creek										
High Flow	42.2	16,971	140	1,584	5,850	1,667	12,093	32,356	7.7	7.0
Low Flow	9.3	1,305	12	110	567	182	486	1,940	0.2	0.7
Los Angeles River										
High Flow	123.9	148,011	409	5,330	17,107	6,074	29,998	76,609	19.8	38.4
Low Flow	93.4	6,628	392	1,027	1,587	1,213	2,147	7,560	0.9	1.9
San Gabriel River	138.6	113,671	499	7,486	12,060	4,990	17,189	56,558	6.9	18.4
Santa Ana River	25.8	85,294	67	2,559	3,644	2,352	2,662	18,584	1.5	2.0
San Diego River	30.5	8,620	<1	292	457	73	822	2,589	2.7	0.8
Tijuana River	40.2	173,270	205	7,385	16,706	4,653	39,684	46,221	9.8	25.5

[1]o,p'-DDT + p,p'-DDT + o,p'-DDE + p,p'-DDE + o,p'-DDD + p,p'-DDD
[2]Aroclor 1242 + Aroclor 1254



Mouth of the Los Angeles River in Queensway Bay, Long Beach

Except for cadmium, 66-95% of the estimated annual constituent loads was discharged during high flow days (Tables 3a,b). One third to one half of the estimated annual load of cadmium went out during high flow days. Total high flow volume increased 104% from 1987 to 1988. Consequently, the mass of solids and contaminants discharged during high flow days more than doubled (Tables 3a,b). Low flow volume and constituent mass emission estimates were similar in both years.

The Los Angeles-Glendale, Tillman, and Burbank water reclamation plants discharge tertiary effluent (disinfected) into the Los Angeles River. Their effluents constituted 69% of low flow, 9% of high flow, and 45% of total river discharge in the 1987 water year and 85% of low flow, 6% of high flow, and 39% of total river discharge in 1988 (SCCWRP 1990). Except for cadmium and nickel, the combined mass emissions from the three water reclamation plants accounted for less than 30% of the estimated loads delivered to the SCB by the Los Angeles River.

San Gabriel River.

The San Gabriel River drains 1,663 km^2 between the San Gabriel Mountains and the ocean and is the second largest single source of gauged runoff to the SCB. The river travels nearly 90 km from the junction of the East and West forks in the San Gabriel Valley to its mouth east of Long Beach. Annual rainfall ranges from 35 to 50 cm in the valleys and coastal plain, to 50 to 120 cm in the mountains (Brownlie and Taylor 1981). The San Gabriel River basin is extensively developed and the river is the second most controlled river in Southern California. Most of the river below the upland catchments has been channelized (Brownlie and Taylor 1981). The river receives tertiary treated wastewater from four water reclamation plants.

Discharge from the San Gabriel River was 30% of the total gauged runoff to the SCB during the 1987 water year (139.2 x 10^6 m^3) and 21% of the total gauged runoff to the SCB in 1988 (138.6 x 10^6 m^3). In both years, discharge was 115% of the long-term mean annual (1964-88: 120.9 x 10^6 m^3). Most of the discharge occurred from November through March. High flows (>5 m^3/s) occurred 10% of the days during 1987 and 11% of the days during 1988, and accounted for 31% and 39% of the annual discharge.

Sixteen runoff samples were collected from the San Gabriel river during storms in September 1986 and January 1987. These storms accounted for 5% and 9% of the flow for the year. Two non-storm samples were collected in October and November 1986. Sixteen samples were analyzed for suspended solids and chlorinated hydrocarbons, and 13 samples were analyzed for trace metals (Table 1). The concentrations of few constituents were correlated with flow or suspended solids (Table 2).

The San Gabriel River was the only channel where discharge did not increase from 1987 to 1988. Mass emission estimates for all nine constituents in 1988 declined by an amount proportional to the decline in discharge (Tables 3a,b).

Santa Ana River.

The Santa Ana River drains 4,406 km^2 and receives runoff from the San Bernardino, San Jacinto, and San Gabriel mountains. The river travels over 250 km before it empties into the ocean north of Newport Bay. Annual rainfall ranges from 30 to 45 cm in the plains and valleys to 50 to 120 cm in the mountains (Brownlie and

Taylor 1981). The Santa Ana River basin is extensively developed with water diversions for municipal and agricultural uses, flood control, and hydroelectric plants. Inputs from four municipal wastewater treatment plants (5.7 x 10^5 m^3/day, 150 mgd) augment the flow. Approximately 33% of the basin is urban and suburban, 10% is agriculture, and 57% is native vegetation (Department of Water Resources 1982, 1985).

Discharge from the Santa Ana River was 3% of the total gauged runoff to the SCB during the 1987 water year (17.6 x 10^6 m^3) and 4% of the total gauged runoff in 1988 (25.8 x 10^6 m^3). Discharge during the 2-year study was 36% and 63% of the long-term annual mean (1924-88: 40.7 x 10^6 m^3). Control facilities, spreading grounds, and the sandy river channel prevent everything but storm flow from reaching the ocean. There were no low flow days during the 2-year study; all of the flow went out in about 30% of the year. Most of the discharge from the river occurred from January through April.

Nineteen runoff samples were collected from two storms in January and April 1988. The January storm was 17%, and the April storm was 2%, of the annual flow. One non-storm sample was collected in December 1987. Twenty samples were analyzed for suspended solids and trace metals, and 19 samples were analyzed for total DDT and total PCB (Table 1). The concentrations of all constituents except total PCB were correlated with flow and suspended solids (Table 2). Total runoff volume increased nearly 50% from 1987 to 1988; annual mass emission estimates increased by a proportional amount (Tables 3a,b).

San Diego River

The San Diego River drains 1,119 km^2 extending from the Laguna Mountains in east San Diego County to the ocean near Mission Bay. The San Diego River is moderately developed. Only the last few kilometers of the channel are lined with concrete. Annual rainfall varies from 23 cm on the coastal plain to 81 cm in the mountains (Brownlie and Taylor 1981). Approximately 21% of the basin is urban and suburban, 2% is agriculture, and the remaining 77% is native vegetation (Department of Water Resources 1987).

Discharge from the San Diego River during the 1987 water year (20.0 x 10^6 m^3) and the 1988 water year (30.5 x 10^6 m^3) was 4% of total gauged runoff to the SCB. Discharge during the 2-year study was 48% and 23% of the annual mean (1982-86: 36.5 x 10^6 m^3). Most of the discharge from the river occurred from November through April. Unlike the other seven channels, the flow duration curve had no inflexion point so flows were not stratified.

Twenty-nine runoff samples were collected from storms that occurred in October 1987, January 1988, and April 1988. Discharge during the storms averaged 1.1 x 10^6 m^3 (range: 0.04-2.4

Table 4a

Constituent mass emissions as percent of total for channels that discharged into the Southern California Bight between September 1, 1986 and August 31, 1987. Vol=volume of discharge, SS=suspended solids in dry weight. Total is the volume (m^3) discharged and the estimated mass emission (kg).

	Vol	SS	Cd	Cr	Cu	Ni	Pb	Zn	ΣDDT[1]	ΣPCB[2]
Santa Clara River	0.2	0.1	0.1	0.3	0.1	0.2	0.2	0.2	0.7	<0.1
Calleguas Creek	5.6	2.4	4.9	13.4	5.2	9.5	1.2	2.9	12.9	7.6
Ballona Creek	5.6	14.8	3.9	3.1	6.7	4.7	7.6	7.7	8.2	5.0
Los Angeles River	40.3	23.4	45.6	20.3	30.2	29.9	33.0	31.5	36.4	38.1
San Gabriel River	35.9	45.0	38.0	41.8	36.5	35.6	33.8	39.5	23.8	34.1
Santa Ana River	4.5	2.9	3.5	9.7	7.5	11.4	3.5	8.8	3.4	2.6
San Diego River	5.2	1.8	<0.1	1.1	0.9	0.3	1.1	1.2	6.1	0.9
Tijuana River	2.6	9.6	3.9	10.4	12.8	8.4	19.7	8.2	8.5	11.8
Total	387.8x10^6	1.33x10^6	1,319	17,997	33,131	14,084	51,103	143,590	29.4	54.3

[1]o, p'-DDT + p, p'-DDT + o, p'-DDE + p, p'-DDE + o, p'-DDD + p, p'-DDD
[2]Aroclor 1242 + Aroclor 1254

x 10^6 m^3). The three storms accounted for 0.1%, 2.6%, and 7.9% of the total annual discharge. Two low-flow samples were collected in September and December 1987. Thirty-one samples were analyzed for suspended solids, 30 samples for trace metals, and 29 samples for chlorinated hydrocarbons (Table 1). The concentrations of most constituents were correlated with suspended solids, but not with flow (Table 2). Concentrations of cadmium, nickel, and total PCB were especially low because of the high proportion of non-detectable measurements. Runoff volume increased by 53% in 1988 and mass emission estimates increased by a proportional amount (Tables 3a;b).

Tijuana River.
The Tijuana River straddles the border between the United States and Mexico. Twenty-seven percent of the drainage basin (4,483 km^2) lies in Mexico and 73% lies in the United States. The channel is moderately developed and water is diverted to San Diego and Tijuana on its way to the ocean through Tijuana Slough. On the U.S. side, 3% of the land is urban and suburban, 2% is agriculture, and 95% is native vegetation (Brownlie and Taylor 1981).

Approximately 16.6 x 10^6 m^3/yr (12 mgd) of raw sewage and industrial and agricultural wastes are discharged into the Tijuana River south of the International Border (International Boundary and Water Commission, personal communication, October 16, 1990). This was 163% of the total discharge from the river in 1987 and 41% of the total discharge in 1988.

Discharge from the Tijuana River was 2% of total gauged runoff to the SCB during the 1987 water year (10.2 x 10^6 m^3) and 6% of total gauged runoff during the 1988 water year (40.2 x 10^6 m^3). Discharge during the 2-year study was 24% and 94% of long-term annual mean (1950-88: 42.9 x 10^6 m^3). Discharge during high flows (>0.5 m^3/s) occurred 7% of the days in 1987 and 24% of the days in 1988, and accounted for 48% and 82% of the annual river discharge. Most of the discharge from the river occurred from January through April.

Twenty-seven runoff samples were collected from storms in October 1987, January 1988, and April 1988. Discharge during these storms was 1-15% (0.4-6.0 x 10^6 m^3) of the annual discharge volume. Two non-storm samples were collected in September and December 1987. Twenty-nine samples were analyzed for suspended solids, 28 samples for trace metals, and 27 samples for chlorinated hydrocarbons (Table 1). The concentrations of all constituents were positively correlated with flow and suspended solids (Table 2). The volume of discharge from the Tijuana River increased by 300% from 1987 to 1988; mass emission estimates increased by the same amount (Tables 3a,b).

Table 4b

Constituent mass emissions as percent of total for channels that discharged into the Southern California Bight between September 1, 1987 and August 31, 1988. Vol=volume of discharge, SS=suspended solids in dry weight. Total is the volume (m^3) discharged and the estimated mass emission (kg).

	Vol	SS	Cd	Cr	Cu	Ni	Pb	Zn	ΣDDT[1]	ΣPCB[2]
Santa Clara River	5.0	1.5	2.2	5.5	2.5	4.0	2.4	2.9	11.3	1.4
Calleguas Creek	5.6	2.0	5.1	11.2	4.0	8.1	0.8	2.4	8.9	5.8
Ballona Creek	9.1	25.3	8.2	5.5	10.3	7.7	11.6	13.4	12.7	7.5
Los Angeles River	38.6	21.8	43.1	20.5	30.2	30.2	29.6	32.9	33.5	39.5
San Gabriel River	24.6	24.7	26.8	24.2	19.4	20.7	15.8	22.1	11.1	18.0
Santa Ana River	4.6	2.4	3.6	8.3	5.9	9.8	2.5	7.3	2.4	2.0
San Diego River	5.4	1.5	<0.1	0.9	0.7	0.3	0.8	1.0	4.3	0.8
Tijuana River	7.1	20.8	11.0	23.9	26.9	19.3	36.6	18.1	15.8	25.0
Total	563.6x10^6	2.41x10^8	1,859	30,955	62,046	24,144	108,514	256,020	62.1	102.0

[1] o, p'-DDT + p, p'-DDT + o, p'-DDE + p, p'-DDE + o, p'-DDD + p, p'-DDD
[2] Aroclor 1242 + Aroclor 1254

Discussion

Hydrography.

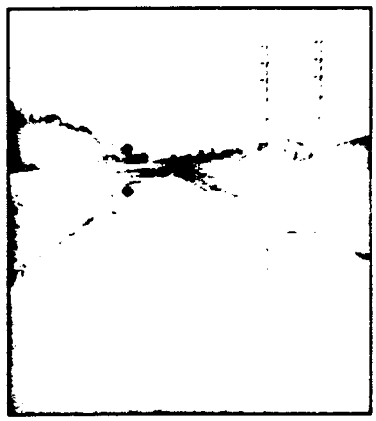
The rivers in this study occupy basins that are either moderately developed (Santa Clara, San Diego, and Tijuana rivers and Calleguas Creek) or extensively developed (Los Angeles, San Gabriel, and Santa Ana rivers and Ballona Creek) (Brownlie and Taylor 1981). In the most developed and manipulated basins, river discharge was extremely variable. The Santa Clara and Santa Ana rivers had no measurable flow for most of the year. River discharge was a combination of surface and groundwater runoff, releases from control facilities, and inputs of domestic and industrial wastes. Most of the flows resulted from winter rains; storms are short and intense, and discharge is variable from year to year.

The eight channels sampled during this 2-year study contributed about 80% of the total gauged runoff to the SCB. Annual river discharge during the study ranged from 0.9×10^6 m^3 for the Santa Clara River to 217×10^6 m^3 for the Los Angeles River. Annual discharges were, on average, 61% below their long-term means during the 1987 water year (range: 17-99% below), and 31% below their long-term means in 1988 (range: 75% below to 33% above). Rainfall in Los Angeles was 48% below its long-term average (1877-1988: 37.5 cm) during 1987 and 15% below average during 1988.

Constituent Concentrations.

Between September 1986 and April 1988, 191 runoff samples were collected from eight channels and analyzed for nine constituents; 179 samples were collected during storms and 12 samples were collected during non-storm periods. Constituent concentrations varied from one to two orders of magnitude among the channels (Table 1).

The Tijuana River, which is dominated by raw sewage, had the highest concentrations for eight of the nine constituents, and the second highest concentration for the remaining constituent. The



Storm channel in Orange County

Santa Clara River, a predominantly agricultural watershed, had the highest concentration of total DDT. The San Diego River, which drains a less developed basin, had the lowest concentrations for four of the nine constituents, and the second lowest concentrations for three of the remaining constituents. Low flow in the Los Angeles River had the lowest concentrations for five constituents and the second lowest concentrations for three of the remaining constituents. Interestingly, most of the water in the Los Angeles River at low flow is tertiary effluent from water reclamation plants.

The concentrations of most constituents were correlated with suspended sediment, and to a lesser extent with river discharge (Table 2). The average rank correlation among constituent concentrations was 0.53. The average rank correlation among constituent mass emissions was 0.86 in 1987 and 0.80 in 1988 indicating that within a channel, conditions that result in high concentrations and mass emissions for one constituent hold for the other constituents. As river discharge rises, sediment mobilization increases. Suspended sediment, usually the constituent present in the greatest amount, comes from soil erosion and, in urban areas, particles produced by automobiles, industry, and commercial activities. Contaminant concentrations and mass emissions increase with increasing sediment loads because the surface area available for adsorption increases (Williams *et al.* 1966, Bradley and Lewin 1982).

Constituent Mass Emissions.

Mass emissions varied from one to three orders of magnitude among the channels (Tables 4a,b). The Los Angeles, San Gabriel, and Tijuana rivers had the highest mass emissions, and the Santa Clara and San Diego rivers had the lowest. Mass emission estimates generally increased from 1987 to 1988 in proportion to the increase in volume discharged. For Ballona Creek and the Los Angeles River, most of the increase was associated with the increased frequency of high flows; low flow volumes and constituent mass emissions estimates were similar between years.

Not all of the channels sampled discharge directly into the ocean. Several channels discharge into harbors and lagoons; it is possible to calculate the load delivered by the river to the harbor or lagoon, but because of modifications due to processes in the receiving body of water, this is not necessarily the load delivered to the ocean. Harbors and lagoons can be a partial trap for many substances, especially sediment.

Conclusions

Urbanization has had a dramatic impact on the landscape of southern California during the past century. Rivers and streams have been extensively modified to conserve water for a growing population and to control floods (Brownlie and Taylor 1981). Urbanization increases the quantities of pollutants that reach rivers and streams. The type and concentrations of pollutants in runoff are determined by the degree of urbanization, types of land use, densities and types of vehicle traffic and animal populations, atmospheric quality, municipal cleaning practices, and specific storm characteristics (Randall and Grizzard 1983, Ellis 1986). Most river discharge and contaminant transport in southern California happens during winter storms that occur intermittently and unpredictably. ■

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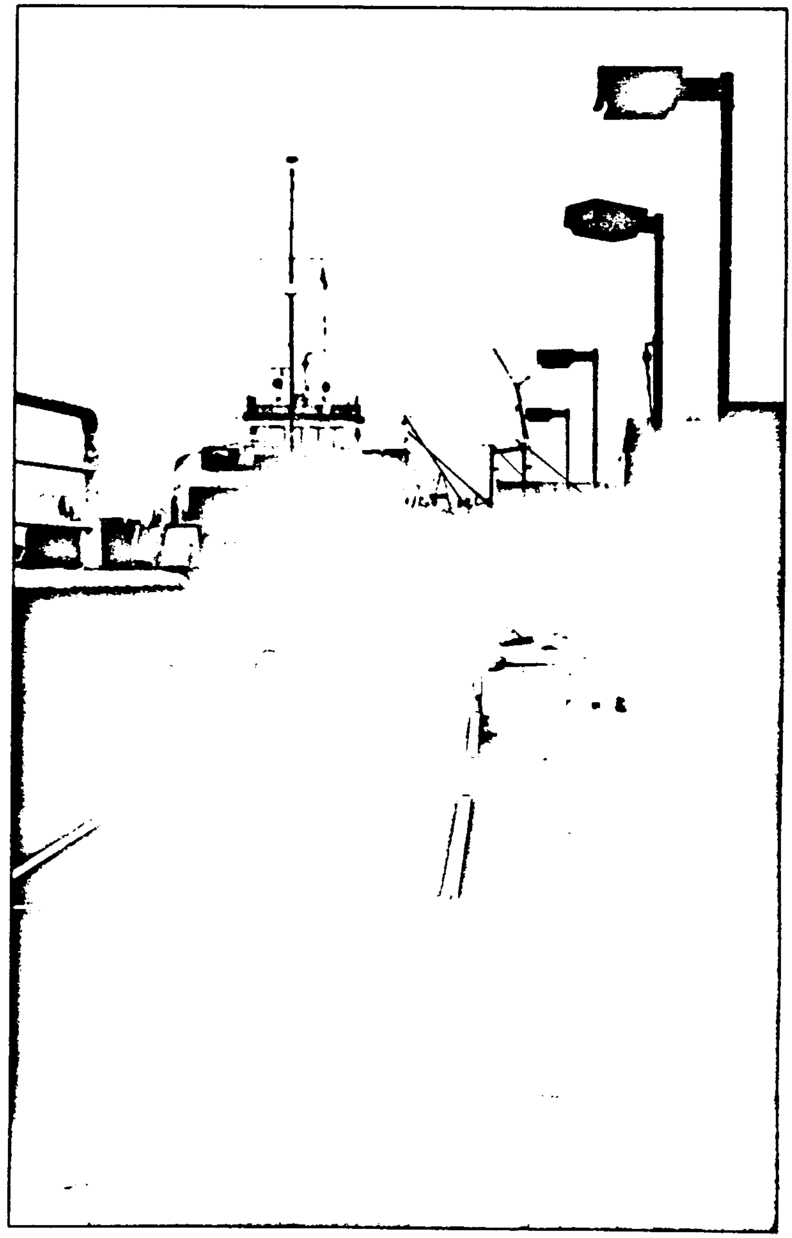
Hazardous Spills in the Southern California Bight

Pollution of the marine environment occurs through inadvertent losses of hazardous materials during production, transportation, refining, and utilization. In the past 25 years, there have been several significant hazardous material spills in the Southern California Bight (SCB). The blowout of Platform A in the Santa Barbara Channel in January 1969 released an estimated 12.3 x 10^6 L (3.25 x 10^6 gal) of oil in the first 100 days. The 70,000 t tanker *Sansinena* exploded and burned in December 1976 while it was docked in Los Angeles Harbor releasing about 5.1 x 10^6 L (32,000 bbl) of Bunker C fuel oil. In January 1990, the tanker *American Trader* ran aground and was punctured by its anchor spilling about 1.5 x 10^6 L (400,000 gal) of crude oil off Huntington Beach.

In this report, we summarize the existing data on hazardous material spills in the Southern California Bight between 1985 and 1990. The objective of this effort was to develop baseline information to provide insight into inadvertent spills in the SCB.



Fuel dock in Los Angeles Harbor

Methods

Data on hazardous material spills were obtained from the U.S. Coast Guard (Pollution Response Branch, Washington, D.C.) for 1985 through 1989. The Coast Guard categorizes the data by source (facility or vessel), type of material, and waterbody. They report the net amount spilled

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(amount spilled minus amount recovered). The number of material and source categories were reduced for the tables and figures in this report. A complete list is provided in Appendix A and category definitions are provided in Appendix B.

We made several modifications to the classifications presented in the original data. We reclassified small harbors to "Pacific coastal harbors" and removed them from coastal and unclassified categories. Bays were reclassified with harbors. Turning basins in Los Angeles and Long Beach harbors were reclassified as Los Angeles/Long Beach Harbor. From 1986 on, inland spills were removed from the unclassified category and placed in an inland category. All U.S. ship spills were reclassified as "Navy vessels."

Results and Discussion

From 1985 through 1989, 327,115 L (86,424 gal or 2,058 bbl) of hazardous materials were spilled in 1,102 separate incidents in the SCB. The majority of spills (99% by volume and 96% by number) involved petroleum products (Table 1; Figure 1). Middle distillate fuels (diesel, fuel oil, jet fuel, and kerosene) were the largest class of materials spilled (50% by volume). The volume of individual spills was generally small; the median spill for all facilities was 15 L and the median spill for all vessels was 19 L (Table 1).

Spills from facilities accounted for 40% of the total number of spills and 60% of the total volume of material spilled. The greatest number and volume of facility spills involved crude oil (Table 1; Figure 1). About 60% by number and 80% by volume of the classified facility spills originated on land (Table 2; Figure 2). About 40% of the classified facility spills by number and 20% by volume originated with offshore oil pipelines and platforms.

Spills from vessels accounted for 60% of the total number of spills and 40% of the total volume of material spilled. The greatest number and volume of vessel spills involved fuel oil (Table 1; Figure 1). About 60% of the classified vessel spills by number were evenly divided among recreational boats, freighters, and

Table 1
Number and size of hazardous material spills from facilities and vessels in the Southern California Bight* from 1985 through 1989. Measurements are in liters except where noted.

Material	N	Median	Mean	Min	Max	Total
FACILITY SPILLS						
Petroleum Products						
Gas oil: cracked	4	13	15	4	30	61
Gasoline: other	4	6	6	4	8	23
Gasoline: automotive	16	28	1,040	4	15,140	16,646
Gasoline: aviation	8	87	1,061	4	7,949	8,486
Jet fuel/kerosene	4	66	76	11	159	303
Naptha	6	38	50	11	114	299
Oil: crude	138	19	840	4	33,459	115,885
Oil: diesel	79	19	161	4	7,002	12,706
Oil: fuel	77	8	465	4	23,054	35,783
Oil: lubricating	31	4	11	4	76	344
Oil: mineral	12	6	23	4	159	273
Oil: miscellaneous	10	13	27	4	79	273
Oil: motor	16	6	9	4	19	144
Oil: spray	8	28	307	4	1,893	2,453
Oil: waste/lubricants	10	11	30	4	189	303
Total	423					193,982
Non-Petroleum Products						
Chromic anhydride	1	341	341	341	341	341
Dichloromethane	1	34	34	34	34	34
Ethylene glycol	1	4	4	4	4	4
Hydrochloric acid	1	38	38	38	38	38
Hydrofluoric acid	1	19	19	19	19	19
Latex	1	4	4	4	4	4
Phosphoric acid	1	19	19	19	19	19
Sodium hypochlorite (kg)	2	537	537	53	1,020	1,073
Sodium hypochlorite (soln)	1	38	38	38	38	38
Solvents: mixed waste	8	11	108	4	757	867
Trichloroethylene	1	11	11	11	11	11
o-Xylene	1	4	4	4	4	4
Total	18					1,379
Total dry (kg)	2					1,073
Grand total	441					195,361
Grand total dry (kg)	2					1,073

tankers (Table 2). Most of the classified vessel spills by volume originated with the U.S. Navy and towboats (Table 2; Figure 2).

About 80% of the classified spills from vessels and 50% of the classified spills from facilities occurred in harbors and bays in the SCB (Figure 3; Table 3). Los Angeles and Long Beach harbors received more facility spills (45% by volume) and vessel spills (29% by volume) than any other classified waterbody (Table 3). Within Los Angeles and Long Beach harbors, facilities spilled primarily crude oil from land facilities and vessels spilled mainly middle distillate fuels from Navy and freight vessels (Figure 4).

The amount of hazardous material spilled varied from year to year (Figures 5, 6, and 7). Annual volumes spilled by facilities varied by a factor of 21 and annual volumes spilled by vessels varied by a factor of nine. Spills from land facilities varied by a factor of 33 and spills from vessels varied by a factor of 16. Annual volumes spilled in Los Angeles and Long Beach harbors varied by a a factor of 43 for facility spills and 9 for vessel spills (Figure 8).

Material	N	Median	Mean	Min	Max	Total
VESSEL SPILLS						
Petroleum Products						
Gas oil: cracked	3	8	130	4	379	390
Gasoline: other	6	19	20	4	38	121
Gasoline: automotive	41	11	83	4	1,908	3,391
Gasoline: aviation	3	95	208	57	473	625
Jet fuel	4	814	2,011	57	6,359	8,043
Naptha	2	28	28	4	53	57
Oil: crude	42	9	174	4	1,590	7,313
Oil: diesel	179	19	206	4	18,925	36,862
Oil: fuel	225	19	301	4	11,355	67,646
Oil: lubricating	46	6	64	4	2,385	2,922
Oil: mineral	5	4	51	4	189	257
Oil: miscellaneous	9	76	204	4	757	1,832
Oil: motor	33	8	19	4	83	628
Oil: spray	2	4	4	4	4	8
Oil: waste/lubricants	37	8	23	4	189	859
Total	637					130,954
Non-Petroleum Products						
Cumene	1	4	4	4	4	4
Solvents: mixed waste	19	15	35	4	358	791
Styrene	1	4	4	4	4	4
Tallow	1	4	4	4	4	4
Total	22					803
Grand total	659					131,757

*Between 32°30'N and 34°28'N, 117°00'W and 120°30'W

Conclusions

Petroleum products accounted for the majority of unintentional releases of pollutants to the Southern California Bight. Petroleum products also accounted for the majority of the volume of pollutants spilled, even in years without major accidents.

The volume of most spills was relatively small; a few spills, even in a period lacking a major spill, accounted for most of the inadvertent discharge. Since a few locations and facility types accounted for the majority of reported spills, the data assembled in this report may provide the basis for prioritizing and targeting improvements in oil spill prevention.■

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Figure 1

Types of hazardous material spilled in the Southern California Bight from A) facilities and B) vessels from 1985 through 1989. Proportion is by volume.

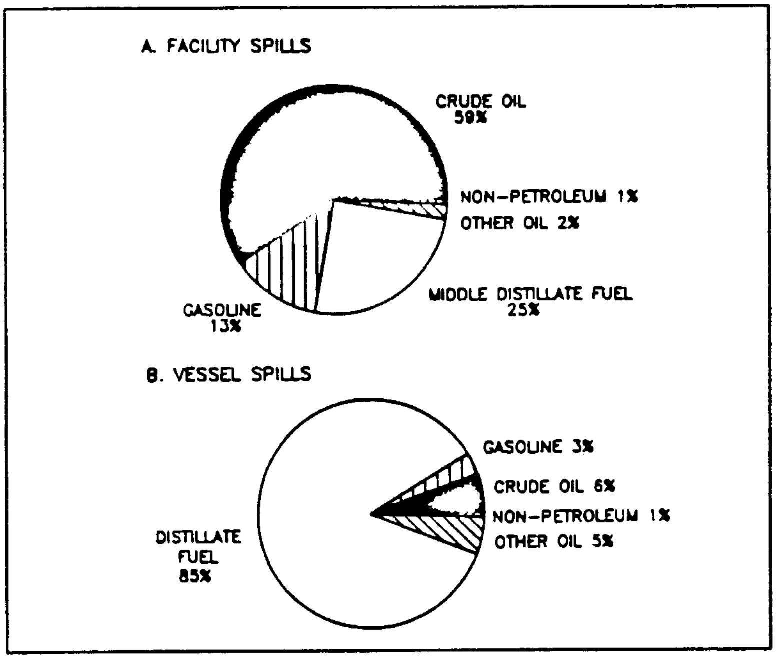
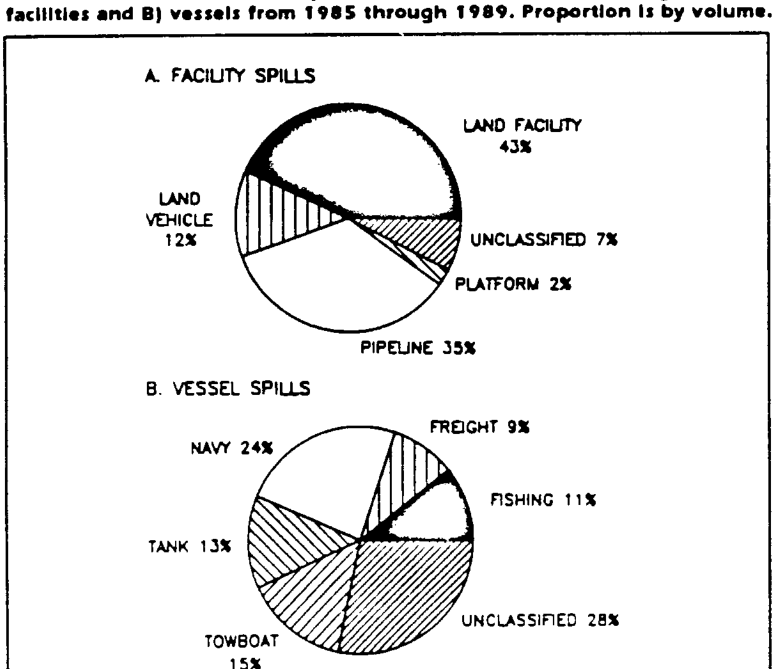


Figure 2

Source of hazardous material spilled in the Southern California Bight from A) facilities and B) vessels from 1985 through 1989. Proportion is by volume.



Appendix A—

Category Constituents

- *MATERIAL* (classifications refer to figures)
  Middle distillate fuel: Diesel oil, fuel oil, jet fuel, kerosene.
  Gasoline: Alkylates, automobile, aviation, casinghead, polymer, reformates, straight run.
  Non Petroleum: see Table 1.
  Other oil: Absorption oil, clarified oil, cracked gas oil, lubricating oil, mineral oil, motor oil, naptha, penetration oil, range oil, spindle oil, spray oil, turbine oil, waste oil.
- *SOURCE—Facility* (classifications refer to figures)
  Miscellaneous and unclassified: Aircraft, railroad tank car, unclassified spills.
- *SOURCE—Vessel* (classifications refer to figures)
  Miscellaneous and unclassified: Commercial, government owned, industrial, mobile offshore drilling unit, offshore supply vessel, passenger, recreation, research, unclassified spills.
- *WATERBODY* (classifications refer to figures)
  Harbors: Alamitos Bay, Channel Islands Harbor, Huntington Harbor, Los Angeles/Long Beach harbors, Marina Del Rey, Newport Bay, Port Hueneme, San Diego Harbor/ Mission Bay, Santa Barbara Harbor Ventura Marina.
  Inland: Inland spills, rivers (facility spills).
  Miscellaneous and unclassified: Rivers (vessel spills), unclassified spills.
- *MATERIAL* (classifications refer to tables)
  Gasoline: Alkylates, casinghead, polymer, reformates, straight run.
  Jet fuel: JP-1, JP-4, JP-5.
  Naptha: Mineral spirits, naptha.
  Fuel oil: No. 1, 1-D, 2, 2-D, 4, 5, 6.
  Miscellaneous oil: Absorption oil, clarified oil, penetration oil, range oil, spindle oil, turbine oil.
- *SOURCES* (classifications refer to tables)
  Unclassified spills: Known source, not elsewhere classified, unknown source.

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Appendix B—
Definitions

- *PETROLEUM REFINING*
  Catalytic cracking: Cracking process in the presence of a catalyst.
  Cracking: Process by which large molecules are broken into smaller molecules with lower boiling points.
  Straight run: Products from distillation rather than the cracking process.
- *PETROLEUM MATERIALS*
  Gas oil: Liquid petroleum distillate with viscosity and boiling range between kerosene and lubricating oil. A mixture of straight chain, cyclic and aromatic compounds C15 to C25 hydrocarbons. Used to make distillate-type fuel oils and diesel fuels.
  Gas oil, cracked: Gas oil in which the large molecules have been broken into smaller, lower-boiling hydrocarbon molecules.

Table 2

Number and size of hazardous material spills from facilities and vessels in the Southern California Bight[a] from 1985 through 1989. Measurements are in liters except where noted.

Source	N	Median	Mean	Min	Max	Total
Facility Spills						
Aircraft	3	114	486	19	1,325	1,457
Designated waterfront facility[b]	29	19	920	4	23,846	26,680
Land facility	56	23	886	4	33,459	49,599
Dry (kg)	2	537	537	53	1,020	1,073
Land vehicle	18	28	1,192	4	15,140	21,453
North offshore oil platform[c]	85	4	37	4	636	3,179
South offshore oil platform[c]	32	8	48	4	636	1,525
Offshore pipeline	13	8	2,302	4	23,054	29,932
Onshore pipeline	22	17	1,713	4	15,897	37,691
Onshore marine facility	30	19	273	4	3,179	8,183
Railroad tank car	1	379	379	379	379	379
Tank truck	11	19	233	4	1,136	2,562
Unclassified	141	15	90	4	7,002	12,718
Total	441					195,358
Total dry (kg)	2					1,073
Vessel Spills						
Combatant/Navy	52	76	601	4	9,463	31,226
Commercial, industrial, research	10	8	16	4	76	163
Fishing (commercial)	36	19	392	4	11,355	14,099
Freight	88	19	139	4	3,179	12,203
Government owned	8	15	317	4	2,385	2,540
Mobile offshore drilling unit	1	76	76	76	76	76
Offshore supply	12	8	26	4	95	307
Passenger	34	11	56	4	757	1,908
Recreation	91	15	54	4	1,325	4,943
Tank	67	8	257	4	6,359	17,241
Towboat/tugboat	17	19	1,160	4	18,925	19,716
Unclassified	243	19	112	4	11,355	27,335
Total	659					131,757

[a]Between 32°30'N and 34°28'N, 117°00'W and 120°30'W
[b]Meet federal requirements to handle dangerous cargo
[c]North = offshore platforms above 34° N latitude; South = below 34° N latitude

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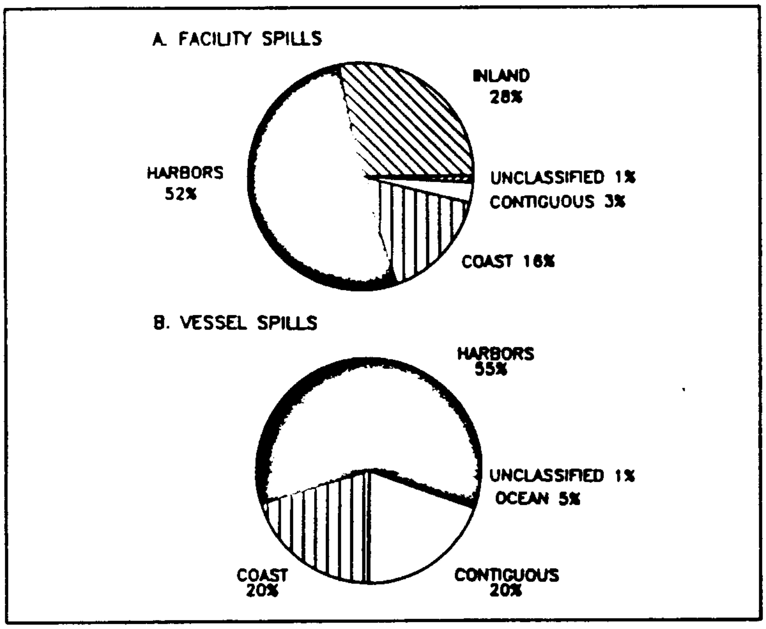
Figure 3

Location of waterbody receiving hazardous material spilled in the Southern California Bight from A) facilities and B) vessels from 1985 through 1989. Proportion is by volume.



Gasoline: C7 to C11 hydrocarbons; 10-60% straight chain paraffin content. Aromatics vary from 5-30% by weight of gasoline fraction; branched paraffins are 13-32% and cycloparaffins are 8-14%. Suitable for fuel in internal-combustion engines.
Gasoline, Automotive (4.23 g Pb/gal): Gasoline with a research octane number approximately 90 used in automobiles.
Gasoline, Aviation (4.86 g Pb/gal): Gasoline with a research octane number of 100 or more used in piston - engined aircraft.
Gasoline, Casinghead: Gasoline obtained by recovering butane, pentane, and hexane hydrocarbons present in small amounts in certain natural gases. Used in blending to produce a finished gasoline with adjusted volatility but low octane number.
Gasoline, Polymer: Gasoline produced by polymerization of low molecular weight hydrocarbons

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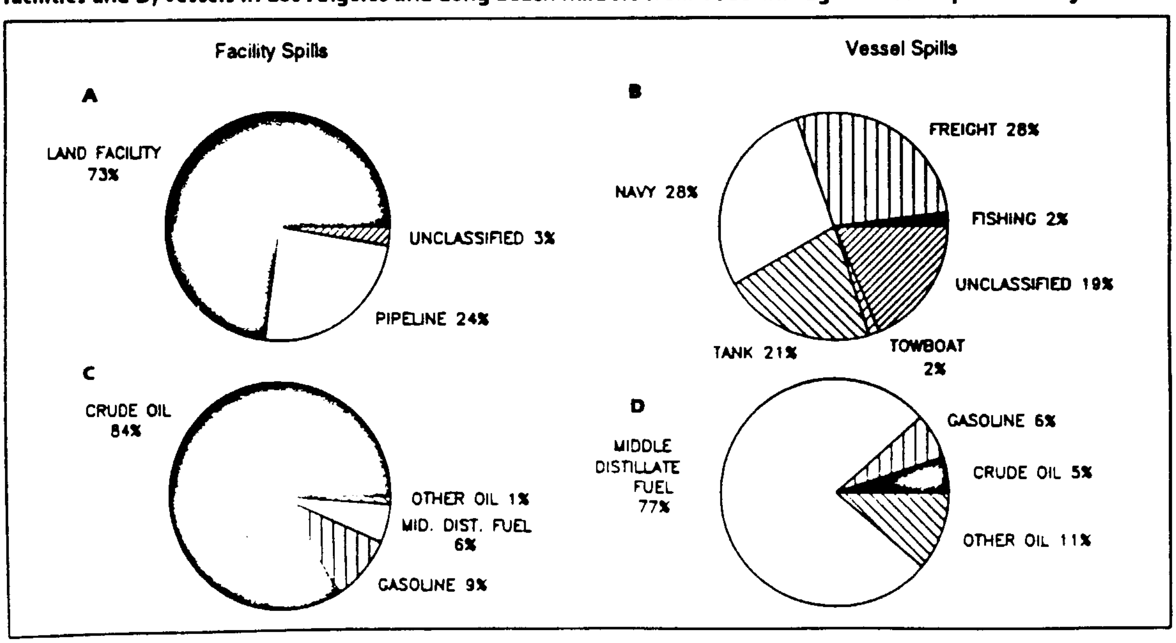
Figure 4

Source of hazardous material spilled from A) facilities and B) vessels and type of hazardous material spilled from C) facilities and D) vessels in Los Angeles and Long Beach harbors from 1985 through 1989. Proportion is by volume.



such as ethylene, propene, and butenes. Used in small amounts for blending with other gasolines to improve octane number.
Gasoline, Straight run: Gasoline produced by distillation without cracking or other chemical conversion processes; contains high percentage of straight chain paraffins. Octane number is low.
Gasoline blending stocks, Alkylates: High-octane product produced by petroleum refining and blended into premium motor gasoline and aviation gasoline.
Gasoline blending stocks, Reformates: High octane product obtained from low octane gasoline by heating vapors to high temperature or by passing vapors through catalyst. Blended into regular and premium gasoline.
Jet fuel: Material in kerosene boiling range used in gas-turbine jet engines.
Kerosene: Straight run fraction from crude oil; boiling range 150 to 250°C; aromatics range from 10-40%. More condensed naphtheno-aromatics and multi-ring cycloparaffins than in gasoline.
Mineral spirits: A grade of naptha.
Naphtha solvent: General term applied to refined, partly refined, or unrefined petroleum products and liquid products of natural gas. Used as solvents, dry-cleaning agents, and charge stocks to reforming (mild thermal cracking or catalytic conversion) units to make high octane gasoline.
Oil, Clarified: Heavy oil product from catalytic cracking process from which catalyst has been removed.
Oil, Crude: Liquid hydrocarbon

Figure 5
Amount of hazardous material spilled in the Southern California Bight from A) facilities and B) vessels from 1985 through 1989.

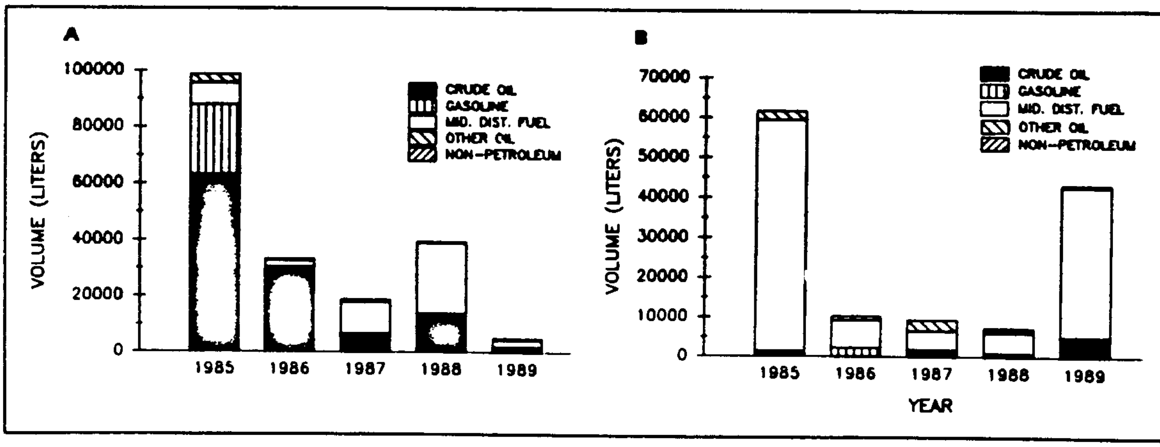


Figure 6
Source of hazardous material spilled in the Southern California Bight from A) facilities and B) vessels from 1985 through 1989.

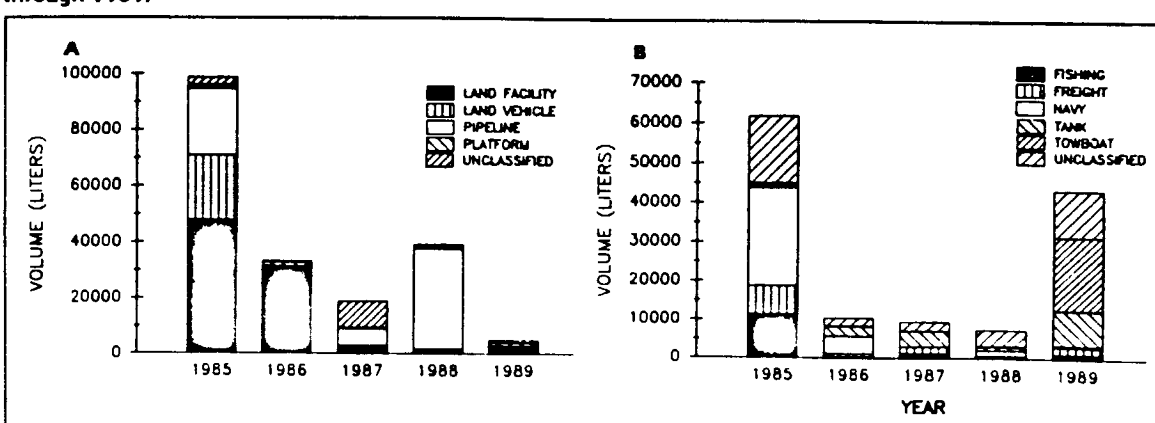


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Table 3

Number and size of hazardous material spills from facilities and vessels in the Southern California Bight[a] from 1985 through 1989. Measurements are in liters except where noted.

Waterbody	N	Median	Mean	Min	Max	Total
Facility Spills						
Contiguous zone (3-12 mi)	91	4	63	4	2,385	5,727
Coastal zone (0-3 mi)	72	8	433	4	23,054	31,143
Dry (kg)[b]	1	53	53	53	53	53
Los Angeles/Long Beach harbors	138	11	645	4	33,459	89,053
San Diego Bay/Mission Bay	56	11	75	4	1,325	4,220
Small harbors[c]	29	19	294	4	7,002	8,512
Rivers	4	38	43	19	76	170
Inland[d]	36	114	1,518	4	15,897	54,640
Dry (kg)[b]	1	1,020	1,020	1,020	1,020	1,020
Unclassified	15	19	126	4	795	1,893
Total	441					195,358
Total dry (kg)	2					1,073
Vessel Spills						
Ocean (12-200 mi)	8	189	765	4	4,164	6,117
Contiguous zone (3-12 mi)	43	19	603	4	18,925	25,912
Coastal zone (0-3 mi)	72	19	367	4	11,355	26,393
Los Angeles/Long Beach harbors	273	19	141	4	7,570	38,418
San Diego Bay/Mission Bay	131	15	129	4	9,463	16,892
Small harbors[c]	106	11	161	4	11,355	17,112
Rivers	3	76	66	8	114	197
Unclassified	23	19	31	4	144	715
Total	659					131,756

[a] Between 32° 30'N and 34° 28'N, 117° 00'W and 120° 30'W

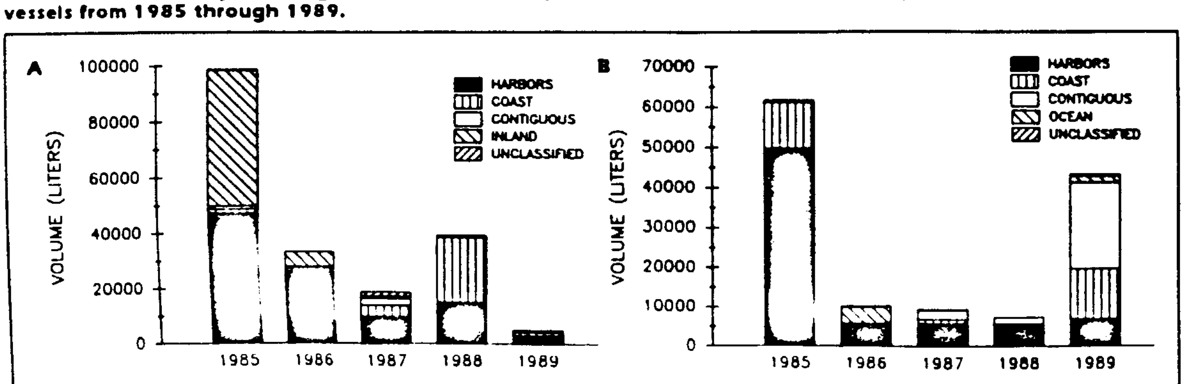
[b] Sodium hypochlorite

[c] Alamitos Bay, Channel Islands Harbor, Huntington Harbour, Marina del Rey, Newport Bay, Port Hueneme, Santa Barbara Harbor, and Ventura Marina

[d] Spills washed into street gutters that lead into storm drains and channels

Figure 7

Location of waterbody receiving hazardous material spilled in the Southern California Bight from A) facilities and B) vessels from 1985 through 1989.



mixture occurring naturally in the earth; may be treated to render it suitable for transportation. Includes crude oil from which certain distillate fractions have been removed and crude oil to which certain distillate fractions may have been added.

Oil, Diesel: Composed chiefly of unbranched paraffins; volatility is similar to that of gas oil. No. 2 fuel oil with additives.

Oil, Fuel No. 1: Straight run distillate, heavier than kerosene, used almost exclusively for domestic heating

Oil, Fuel No. 1-D: Type of diesel fuel oil. Used in engines with low fuel temperatures and in high-speed engines that have frequent and wide variations in loads and speeds.

Oil, Fuel No. 2: Straight-run or cracked distillates used as general purpose domestic or commercial fuel in atomizing-type burners.

Oil, Fuel No. 2-D: Type of diesel fuel oil. Used in high-speed engines with relatively high loads and uniform speeds.

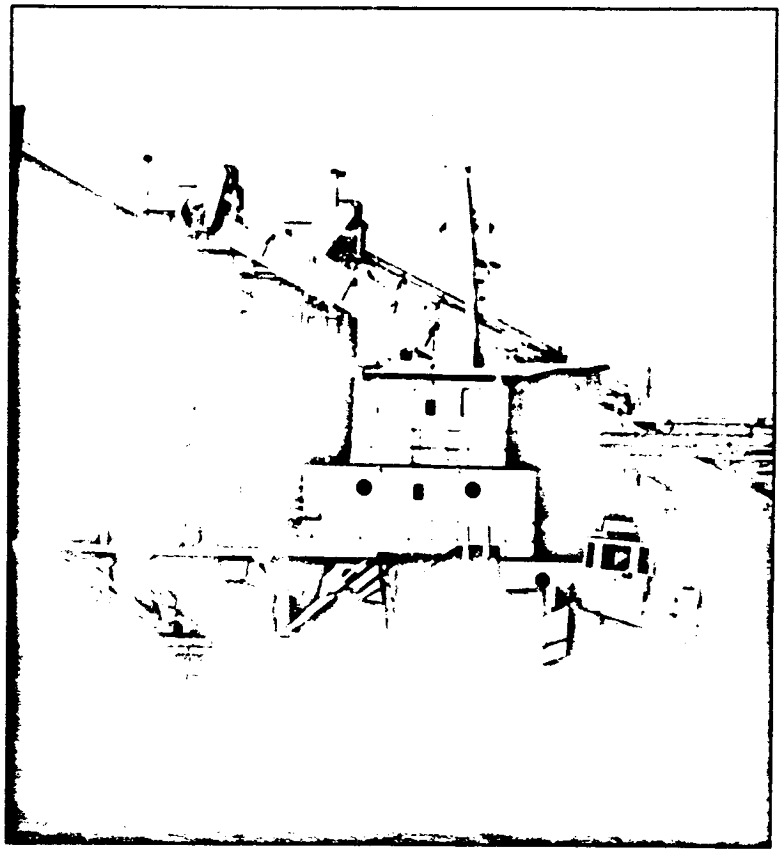
Oil, Fuel No. 4: Heavier straight run or cracked distillates used in commercial or industrial burner installations not equipped with preheating facilities.

Oil, Fuel No. 5: Bunker fuel used in furnaces and boilers of utility power plants, ships, locomotives, metallurgical operations, and industrial power plants.

Oil, Fuel No. 6: Bunker fuel (see Fuel Oil No. 5.).

Oil, Miscellaneous absorption: Miscellaneous hydrocarbon mixture; oil that extracts heavier components from a vapor mixture.

Oil, Miscellaneous lubricating: C20 to C50 compounds that include straight chain, branched, cycloparaffins, and aromatics similar to those in gas oil, but with a higher molecular weight. Usually have small amounts of additives to impart special properties such as viscosity index and detergency.



Boats unloading in Los Angeles Harbor

Oil, Miscellaneous mineral: Oil derived from mineral substances.

Oil, Miscellaneous motor: Oils used to lubricate automotive, aircraft, and diesel engines.

Oil, Miscellaneous penetrating: Used to aid a bath or liquid penetrate a material.

Oil, Miscellaneous range: Type of kerosene used for space heating.

Oil, Miscellaneous spindle: Low viscosity lubricating oil for textile and other high speed machinery.

Oil, Miscellaneous spray: Low viscosity oil used as a pesticide for trees and shrubbery.

Oil, Miscellaneous turbine: Oil used to lubricate, cool, and inhibit rusting of turbines.

- *WATERBODYS*

  Inland: Spills washed into street gutters that lead into storm drains and channels.

  Coastal: 0-3 mi from shore.

  Contiguous: 3-12 mi from shore.

  Ocean: 12-200 mi from shore.

- *SOURCES—Facility Spills*

  Designated water facility: Land facility that meets federal requirements to handle dangerous cargo.

  Land facility: Land facility other than a designated water facility or onshore marine facility.

  Onshore marine facility: Any facility that deals with marine related transportation.

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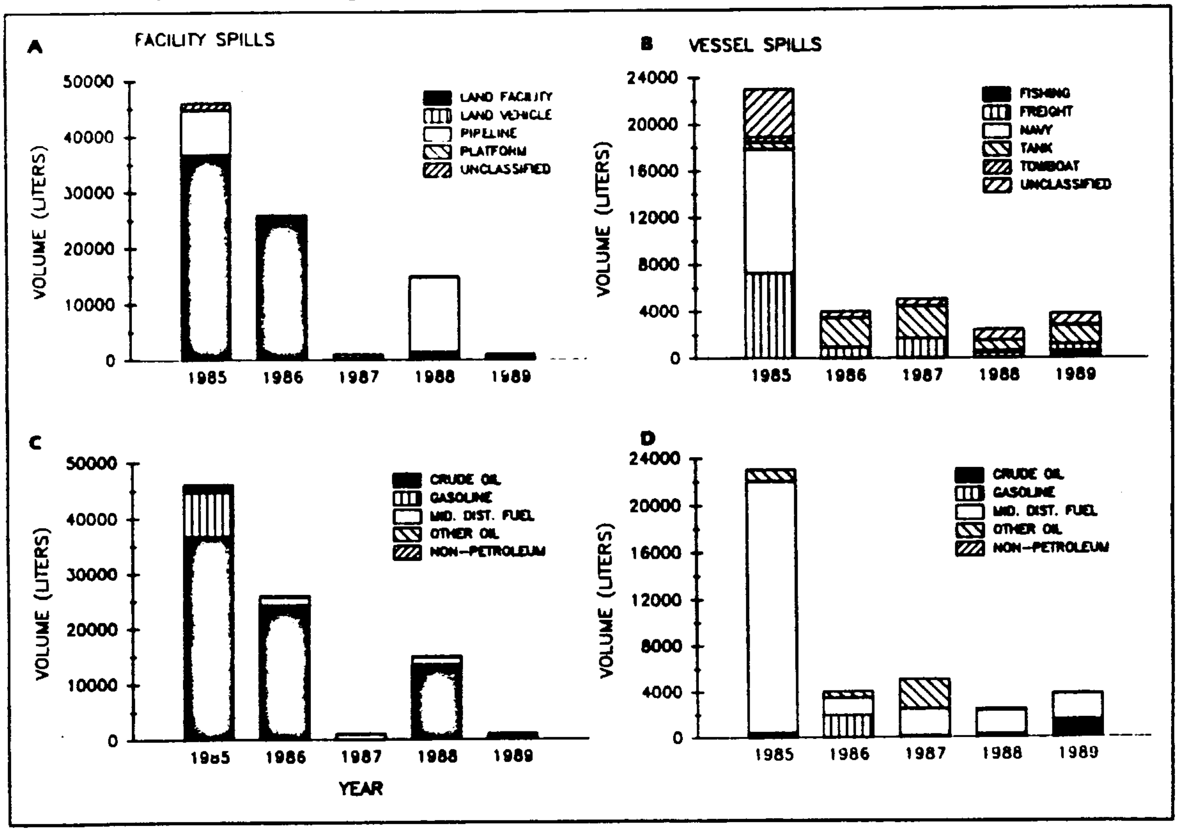
Figure 8

Source of hazardous material spilled from A) facilities and B) vessels and type of hazardous material spilled from C) facilities and D) vessels in Los Angeles and Long Beach harbors from 1985 through 1989.



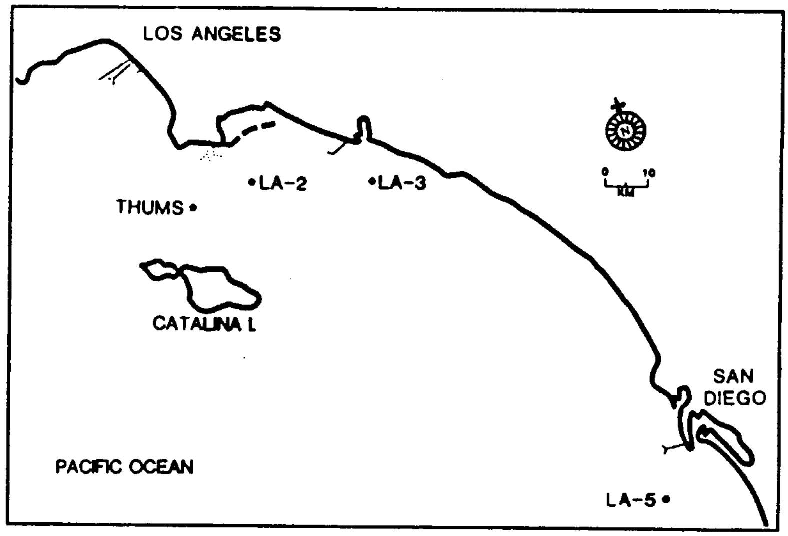
- *SOURCES—Vessel Spills*
  Combatant: U.S. Navy.
  Commercial: Any trade or business involving transportation of goods or individuals, except service performed by a combatant vessel.
  Fishing: Vessel that commercially engages in catching, taking, or harvesting fish or activity expected to result in catching, taking, or harvesting fish.
  Freight: Barge or motor vessel of more than 15 gross tons that carries freight for hire, except an oceanographic research vessel or an offshore supply vessel.
  Government owned: Vessel owned or demise chartered and operated by U.S. Government or government of a foreign country and not engaged in commercial service.
- *SOURCES—Industrial*
  Mobile offshore drilling unit: Vessel capable of drilling for the exploration or exploitation of subsea resources.
  Offshore supply: Motor vessel of more than 15 gross tons, but less than 500 gross tons, that regularly carries goods, supplies, or equipment in support of exploration, exploitation, or production of offshore mineral or energy resources and is not a small passenger vessel.
  Passenger: Vessel of at least 100 gross tons carrying at least one passenger for hire.
  Recreation: Vessel manufactured or operated primarily for pleasure or leased, rented, or chartered to another for pleasure.
  Research: Vessel that is employed in instruction of or research in oceanography or limnology.
  Tank: Vessel of the barge or motor vessel that carries oil or hazardous material in bulk as cargo or cargo residue.
  Towboat/tugboat: Commercial vessel engaged in, or intending to engage in, service of pulling along side, or any combination of pulling, pushing, pushing, or hauling along side.

Estimates of Ocean Disposal Inputs to the Southern California Bight

Fourteen designated ocean disposal sites have been used in the Southern California Bight (SCB) since 1931 for disposal of refinery wastes, chemical wastes, filter cake, oil drilling wastes, refuse and garbage, radioactive wastes, military explosives, and miscellaneous wastes (SCCWRP 1973, Chartrand *et al.* 1985). Currently, only approved dredged materials can be released at two designated ocean disposal sites off Los Angeles (LA-2) and San Diego (LA-5), and one interim ocean disposal site off Newport Beach (LA-3) (Figure 1).

Millions of cubic yards of sediments have been removed from harbors and bays to expand coastal areas and improve navigable waters in the last decade. These harbors and bays receive inputs of stormwater runoff, and support industrial and military activities. Because they are generally poorly flushed, the sediments often have high concentrations of contaminants (Anderson *et al.* 1988, National Oceanic and Atmospheric Administration 1991). Much of the material dredged from harbors and bays is dumped at offshore sites in the SCB, yet little has been published on the magnitude of dredge inputs for the region. The objective of this study was to estimate the total mass of dredge material and associated contaminants dumped in the SCB between 1984 and 1991.

Figure 1.
Location of the dredge material disposal sites in the Southern California Bight.



Materials and Methods

Permit Data

All permit applications for projects that disposed any material at sea in the SCB from January 1984 to June 1991 were examined. We obtained data from the dredge permit files of the U.S. Army Corps of Engineers (ACOE) Los Angeles District Office, the Dredge Material Tracking System (DMATS) of the U.S. Environmental Protection Agency Region IX, dredge permittees and local port authorities.

We collected data on dredging location, disposal site, completion date, volume of material disposed, and contaminant concentrations. Sediment chemistry data were obtained from technical reports, environmental impact statements, and reports for each permitted project. The trace metals included Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn. The pesticides included DDT, DDE, total DDT, total identifiable chlorinated hydrocarbons (TICH), chlorinated hydrocarbons (CHC), and total organic halogens (TOH). The PCBs included individual Aroclors and total PCBs (sum of

Aroclor mixtures). There were too few measurements of organotins, oil and grease, and polycyclic aromatic hydrocarbons to estimate mass inputs.

The start and completion dates, and the actual volume of material dredged, were not available for all projects. When completion dates were not reported, the year the permit was issued was assumed to be the year of completion. When actual dredge volumes were not reported, the maximum volume estimated for the permit application was assumed to be the actual volume dredged, unless other documentation (individual dredging reports or communication with port authorities, permittees, and dredging engineers) was available.

Mass Emission Estimates

Constituent mass emissions were estimated from:

$$M = \sum_{i=1}^{n} (C_i V_i D)$$

where:
M = mass of constituent,
C_i = mean constituent concentration for i[th] permit,
V_i = volume of material dredged for i[th] permit,
D = density conversion factor from cubic yards to metric tons (mt), and
n = number of permits

The density conversion factor varied with the type of material dredged (i.e., sand, silt, clay). Density measurements for dredged materials were obtained for 17 projects in Southern California bays and harbors from 1976 to 1978 (U.S. Army Corps of Engineers 1977, 1978, 1979). Densities ranged from 0.969 to 1.361 mt/yd^3; the mean density (1.087 mt/yd^3; sd = 0.140) was used as the conversion factor.

Not all constituents were measured for each project. Chemical analyses and biological testing were not required for dredge material that was predominantly sand. When concentration data were missing for a constituent for a particular project, the mean concentration of that constituent for all projects in the same harbor was used to estimate mass emissions. Constituent concentrations for sand and concentrations below detection limits were set to zero to estimate mass emissions.

Statistical Analyses

Dredge material constituent concentrations were tested for differences among harbors by nonparametric analysis of variance (Kruskal-Wallis test; Zar 1984). Data from Los Angeles and Long Beach harbors, Huntington Harbor and Anaheim Bay, and northern and southern San Diego Bay were pooled to increase sample size. The relation between dredge mass and contaminant mass was determined by Spearman rank correlation (Zar 1984).

Results

Fifty-three projects disposed 5,971,197 yd^3 (4,565,577 m^3) of

Table 1.
Constituent concentrations (dry weight) from sediment chemistry analyses from 37 dredging permits in Southern California bays and harbors from 1984 through 1991. ΣPCB=total PCB, ΣPest=total pesticides, N=number samples, SD=one standard deviation.

	Los Angeles Harbor			Long Beach Harbor		
	Mean	SD	N	Mean	SD	N
Ag (μg/g)	0.75	0.24	4	0.52	0.12	15
As (μg/g)	2.3	0.38	4	0.81	3.47	23
Cd (μg/g)	1.68	3.20	27	1.07	0.21	23
Cr (μg/g)	38	14	4	32	7	23
Cu (μg/g)	44	57	27	47	39	23
Hg (μg/g)	0.32	0.34	27	0.09	0.06	23
Ni (μg/g)	17	7.1	4	13	1.6	22
Pb (μg/g)	42	38	27	27	16	23
Zn (μg/g)	75	38	4	27	41	23
ΣPCB (ng/g)	107	129	3	22	103	21
ΣPest (ng/g)	44	47	7	582	389	22

[1] includes Huntington Harbor
*Only 4 of 42 samples had detectable mass (1-11 ng/g); detection limits ranged from <1 to <50 ng/g

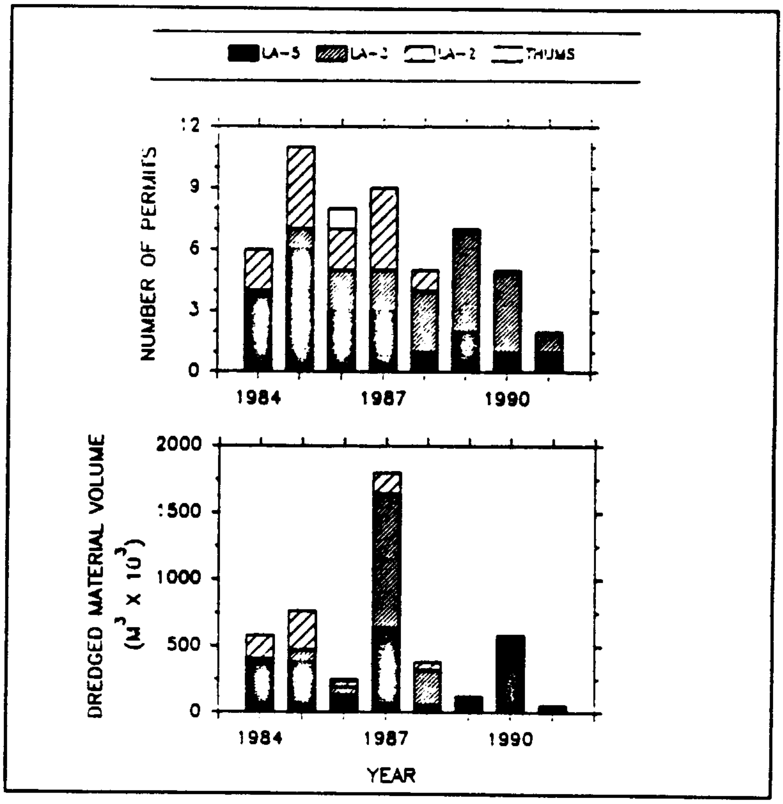
dredged materials in the Southern California Bight between January 1984 and June 1991. Thirty-seven permits reported constituent concentrations for 120 dredge material samples.

Dredging Volumes

The total annual volume of materials dumped at the disposal sites ranged from 72,000 to 2,353,800 yd³ (55,000-1,800,000 m³) (Figure 2); the average annual volume was 746,400 yd³ (570,700 m³). Most of the material was dumped at LA-5 (51%) and LA-3 (32%); lesser amounts were dumped at LA-2 (16%) and THUMS (<1%). The number of permitted projects varied from year to year and dumpsite to dumpsite (Figure 2); 21 projects dumped at LA-5, 18 projects dumped at LA-3, 13 projects dumped at LA-2, and one project dumped at THUMS. The total number of projects per year ranged from two to 11 (mean = 6.6; sd = 2.8).

Disposal sites LA-2 and LA-5 were closed from 1/89 to 2/91,

Figure 2.
The number of permits (above) and the volume of dredge materials disposed (below) by site in the Southern California Bight between January 1984 and June 1981.



Anaheim Bay[1]			Newport Bay			Dana Point Harbor			San Diego Bay		
Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
1.0	0.14	2	1.15	0.92	8	0.43	0.14	9	0.71	1.00	30
4.7	0.35	2	<0.1	0.2	10	7.0	3.4	9	9.0	13	25
1.1	0.85	6	0.40	0.88	11	0.38	0.24	10	1.5	2.3	43
34	2.8	2	33	10	10	34	10	9	67	93	43
24	19	6	24	5	10	42	54	9	90	74	43
0.11	0.11	6	0.38	0.43	11	0.044	0.034	10	0.55	1.00	43
35	2.1	2	-	-	-	14	4.5	9	14	3.2	4
43	32	6	38	19	11	26	33	9	47	42	25
145	6	2	117	65	11	61	32	9	175	199	25
11	18	6	<100	-	10	<50	-	9	75	113	43
61	66	6	63	18	8	<20	-	10	•	-	42

Figure 3.
Frequency distribution of the volume of material dredged by permit (n=53).

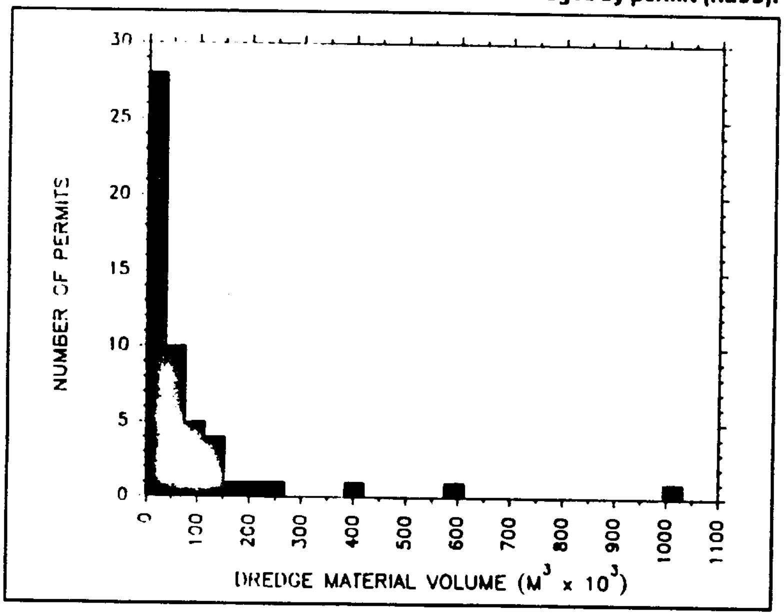


Table 2.
Estimated mass loads of selected constituents in materials disposed in the Southern California Bight from 1984 through 1991. mt=metric tons; bdl=below detection limits; ΣPCB=total PCB; ΣPesticides=total pesticides.

	DUMPSITE				
	LA-2	LA-3	LA-5	THUMS	Total
Solids (mt x 10^3)	1,035.8	2,099.1	3,338.8	16.6	6,490.7
Ag (mt)	0.6	0.5	3.6	bdl	4.7
As (mt)	1.6	2.1	22.7	bdl	26.4
Cd (mt)	4.2	3.5	2.7	0.01	10.4
Cr (mt)	34.0	43.4	160.9	0.26	238.5
Cu (mt)	63.2	45.6	309.5	0.17	418.1
Hg (mt)	0.2	1.4	1.0	bdl	2.6
Ni (mt)	14.0	9.8	45.4	0.16	69.4
Pb (mt)	46.7	93.7	142.7	0.13	283.2
Zn (mt)	38.6	340.7	473.6	1.62	854.5
ΣPCB (kg)	90.4	9.2	102.3	bdl	201.9
ΣPesticides (kg)	341.6	33.4	7.1	0.96	383.1

although projects with sand waivers continued to dump. LA-5 received material from the largest number of projects in one year (six in 1985). The THUMS Company of Long Beach was the only company permitted to dump at the THUMS disposal site northwest of Catalina Island. They dumped a relatively small amount of drilling muds and cuttings from oil and gas exploration at the site in 1985, which is no longer in use.

Most of the dredging projects dumped small quantities of dredge materials (Figure 3). The smallest projects were predominantly sand removed from private docks and marinas in Newport Harbor. These projects ranged from 195 to 1,200 yd^3 (149-918 m^3) and disposed of their materials at LA-3 in 1989 and 1990. Six projects dumped volumes greater than 200,000 yd^3 (153,000 m^3) and composed 58% of all dredge materials dumped (four at LA-5 and two at LA-3). The largest project was the deepening of Newport Harbor Back Bay that was completed in 1987. More than 1,313,000 yd^3 (1,004,000 m^3) were dumped at LA-3, which represented 70% of the total volume dumped at that site and 22% of the total volume dumped at all sites.

Contaminant Concentrations

Chemistry data were reported for 70% of the dredge projects representing about 90% of the total volume dumped in the SCB during the study. Seventeen percent of the projects dredged sand for which chemical analyses were not required; these projects accounted for less than 0.1% of

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the total volume disposed. Thirteen percent of the projects did not report chemistry data, although the dredge material was submitted for biological testing; these projects represented 11% of the total volume disposed.

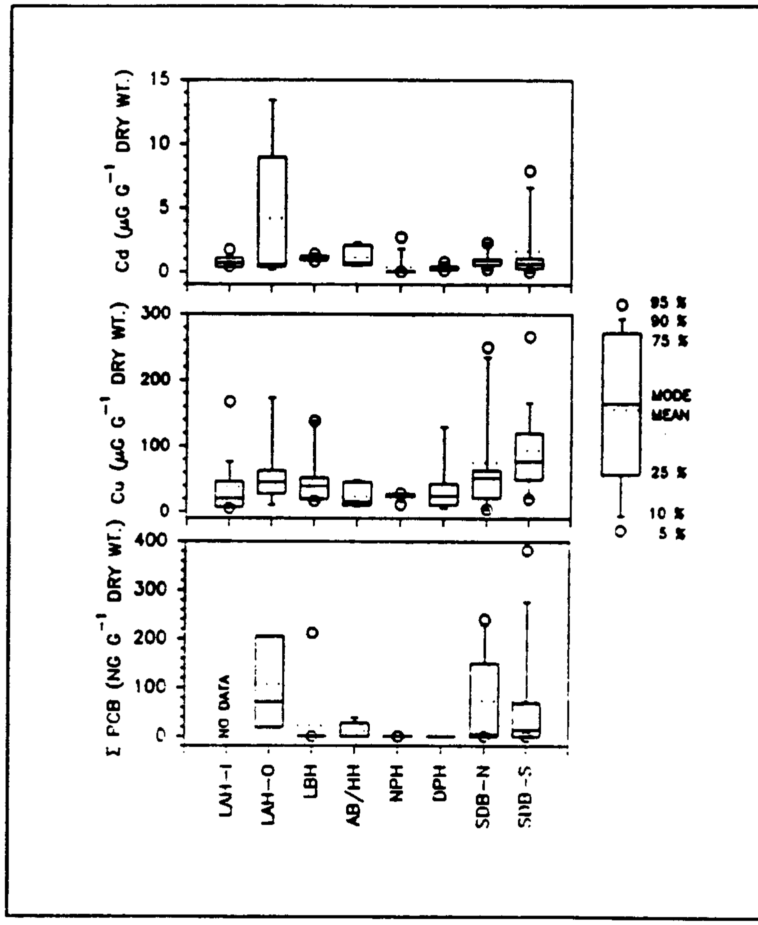
The number of chemical analyses ranged from 41 for nickel to 120 for cadmium and mercury (Table 1). Dredge materials from the larger, more industrialized harbors had the highest concentrations and largest concentration range (Figure 4). There were no significant differences among the harbors in the concentrations of Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, or total PCB (Kruskal-Wallis test, $p>0.05$). The concentrations of pesticides were significantly higher (Kruskal-Wallis test, $H=23.35$, $p=0.001$).

Mass Emissions Estimates

Nearly 6.5 x 10^6 mt of solids were dumped in the SCB during the study (Table 2). Most of this material was dumped at LA-5 and LA-3; lesser amounts were dumped at LA-2 and THUMS (Table 2). The LA-5 site received 86% of the arsenic, 77% of the silver, and 74% of the copper. The LA-3 site received 55% of the mercury. The LA-2 site received 89% of the pesticides, 45% of the total PCB, and 40% of the cadmium.

The annual mass input of dredge materials varied two orders of magnitude and the annual mass input of contaminants varied from one to three orders of magnitude (Table 3). The mass input of solids and seven of the 11 constituents was highest in 1987. The annual mass inputs of all constituents except Ag and total PCBs were positively correlated with the annual mass inputs of solids (Spearman r_s, $p<0.05$).

Figure 4.
Box plots of the concentrations of cadmium, copper, and total PCBs in dredge materials by harbor. LAH-I = Inner Los Angeles Harbor; LAH-O = Outer Los Angeles Harbor; LBH = Long Beach Harbor; AB/HH = Anaheim Bay and Huntington Harbor; NPH = Newport Harbor; DPH = Dana Point Harbor; SDB-N = North San Diego Bay; SDB-S = South San Diego Bay.



Discussion

On average, 746,400 yd^3 (811,300 mt) of sediments were removed from harbors and bays and dumped at offshore sites in the Southern California Bight from 1984 to 1991. Over 70% of the dredge projects were small and disposed less than 100,000 yd^3 (109,000 mt) of material. The disposal sites off San Diego (LA-5) and Newport Beach (LA-3) received more than 80% of the material.

Constituent inputs to each disposal site were not always proportional to the mass of solids received. Proportionally more arsenic, silver and copper was dumped at LA-5, proportionally more mercury was dumped at LA-3, and proportionally more cadmium, total PCB, and pesticides were dumped at LA-2. The disproportionate share of contaminant mass dumped at these sites is due to sources of contaminants peculiar to the harbors and bays from which the sediment was removed.

For example, copper has been used as an antifouling agent in bottom paints of Navy ships. Dredge materials from Navy berths in San Diego Bay composed 73% of the material disposed at LA-5 and accounted for 74% of the copper dumped in the SCB. In the past, mercury mines were located along San Diego Creek just above Newport Back Bay (Orange County Environmental Management Agency, personal communication). Dredge material from Newport Harbor and Newport Back Bay composed 77% of the material dumped at LA-3 and accounted for 54% of the mercury dumped in the SCB. The disproportionate share of pesticides dumped at LA-2 can be traced to Dominguez channel, which empties into Consolidated Slip in Los Angeles Harbor. Dominguez Channel received runoff from the Montrose Chemical Corporation, the largest manufacturer of DDT in the world and the only manufacturer in California (Chartrand *et al.* 1985). Dredge material from Los Angeles and Long Beach harbors composed all of the material dumped at LA-2 and accounted for 89% of the pesticides dumped in the SCB.

The concentrations of Cu and total PCB in dredge materials removed from Los Angeles and Long Beach harbors and San Diego Bay were compared to sediment concentrations measured by National Oceanic and Atmospheric Administration (NOAA) Mussel Watch and Benthic Surveillance Program (National Oceanic and Atmospheric Administration 1991) and by SCCWRP (Anderson *et al.* 1988). Mean Cu concentrations varied by about a factor of three in both harbors (Figure 5). The differences were not significant in San Diego Bay (Kruskal-Wallis test, H=8.83, p=0.066), but they were significant in Los Angeles and Long Beach harbors (H=17.67, p=0.001).

Mean total PCB concentrations varied by about a factor of five in both harbors (Figure 6). The differences were significant in San Diego Bay (H=26.25, p<0.001) and in Los Angeles and Long Beach harbors (H=22.76, p<0.001). In Los Angeles and Long Beach harbors, NOAA Mussel Watch, NOAA Benthic Surveillance, and SCCWRP data were not significantly different. In

Table 3.
Estimated annual mass emissions of material dumped in the Southern California Bight from 1984 through 1991. mt=metric tons; bdl=concentrations below detection limit; ΣPCB=total PCB; ΣPesticides=total pesticides.

	1984	1985	1986	1987	1988	1989	1990	1991
Solids (mt x 10^3)	824.7	1,083.1	352.8	2,557.8	539.5	175.6	879.0	78.3
Ag (mt)**	0.52	0.63	0.26	0.67	0.32	0.11	2.1	0.03
As (mt)	7.1	4.8	1.6	10.2	1.4	0.22	0.35	0.66
Cd (mt)*	3.6	0.96	0.44	4.1	0.90	0.09	0.29	0.03
Cr (mt)**	27.1	80.7	13.7	67.0	12.5	4.1	29.7	3.7
Cu (mt)**	76.2	77.1	16.6	126.4	41.2	3.6	70.1	7.0
Hg (mt)**	0.25	0.24	0.09	1.6	0.07	0.02	0.27	0.04
Ni (mt)**	11.2	12.9	3.9	15.5	10.5	2.4	12.0	1.2
Pb (mt)**	36.1	57.2	14.3	113.1	33.7	2.3	22.9	3.6
Zn (mt)**	99.4	122.2	42.4	449.1	45.2	9.6	67.0	19.6
ΣPCB (kg)	64.2	40.3	11.6	61.0	9.2	1.3	bdl	14.4
ΣPesticides (kg)*	24.7	235.4	27.7	72.3	21.7	bdl	0.79	0.55

* constituent load correlated (r_s) to annual solids mass emissions at p≤0.05.
** constituent load correlated (r_s) to annual solids mass emissions at p≤0.01.

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San Diego Harbor, NOAA Benthic Surveillance and SCCWRP data were not significantly different. Differences in Cu and PCB concentrations could be due to differences in sampling methods, analytical techniques, or methods of quantification. For example, each group differs in the number and type of Aroclors quantified. There is also substantial heterogeneity in the distribution of PCBs within harbor sediments (SCCWRP 1990).

The estimates of mass inputs from dredge material disposal presented in this study suffer from missing data, lack of standardized chemical characterization, and inconsistent reporting. Mass inputs were calculated for each permit, although some permits lacked chemical data. Chemical characterization was not consistent among permits and detection limits varied widely. Information on project start and completion dates, dredge material density, and the total volume dumped was often missing from Army Corps of Engineers permit files and was not included in the Dredged Material Tracking System.

Inconsistent analytical techniques and reporting are illustrated by the trace organic hydrocarbon data. Various projects reported pesticides as DDT, DDE, total DDT, chlorinated hydrocarbons, total identifiable chlorinated hydrocarbons, and total organic halogens. Different projects quantified different PCB Aroclor mixtures, and some projects summed the different Aroclor mixtures and reported only total PCBs. There were too few measurements of polycyclic aromatic hydrocarbons to estimate mass inputs, although harbor and bay sediments are often significantly

Figure 5.
Box plots of the concentration of copper in dredge material and sediments in Los Angeles and Long Beach harbors and in San Diego Bay. Data are from the dredging permits, the Mussel Watch Program (NOAA-MW; NOAA 1991), the Benthic Surveillance Program (NOAA-BS; NOAA 1991), and SCCWRP (Anderson and Gossett 1987). NOAA-BS sampled two stations in San Diego Harbor.

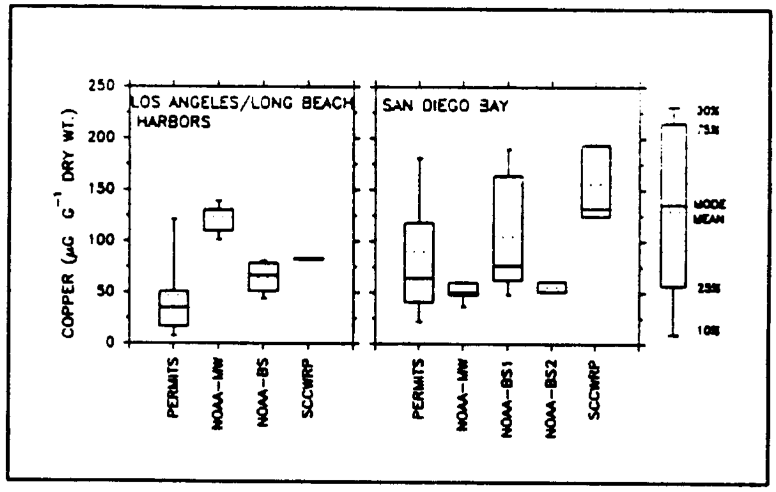
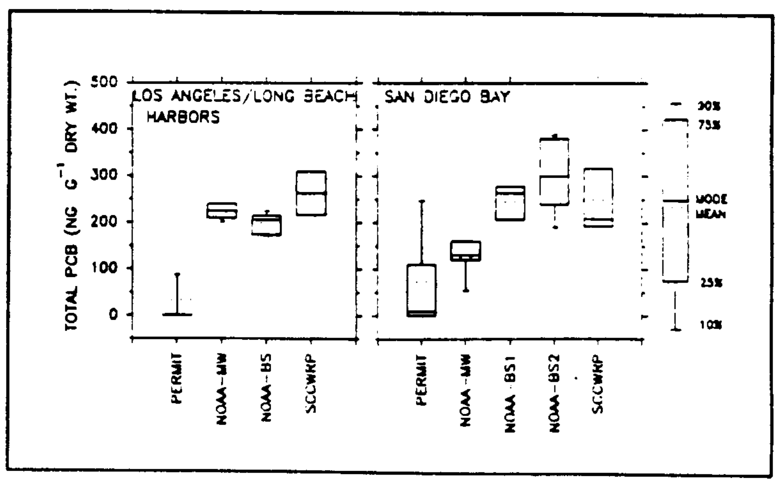


Figure 6.
Box plots of the concentration of total PCBs in dredge material and sediments in Los Angeles and Long Beach harbors and in San Diego Bay. Data are from the dredging permits, the Mussel Watch Program (NOAA-MW; NOAA 1991), the Benthic Surveillance Program (NOAA-BS; NOAA 1991), and SCCWRP (Anderson and Gossett 1987). NOAA-BS sampled two stations in San Diego Harbor.



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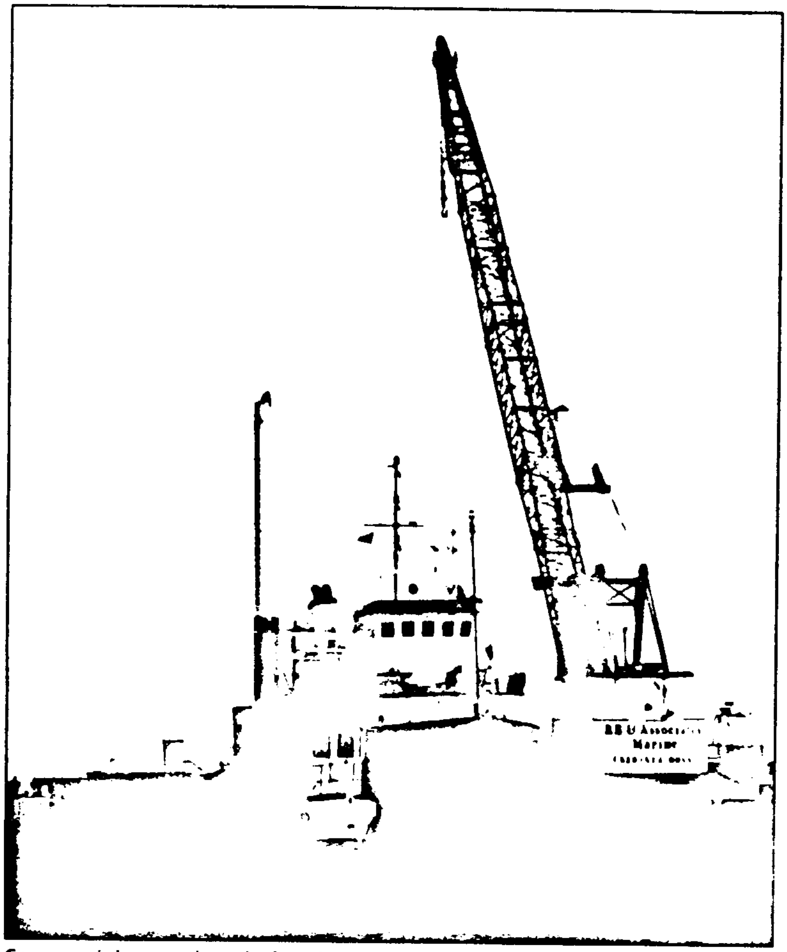

Commercial operations in Los Angeles Harbor

contaminated (Anderson and Gossett 1987). Improved characterization of dredge materials is needed before we will be able to accurately estimate the mass emissions from dredge material disposal.

Acknowledgements

Authors Kenneth Schiff and Jeffrey Cross would like to thank Mo Chang and Sherry Stevens (U.S. Army Corps of Engineers, Los Angeles District), Shelley Clarke and Patrick Cotter (U.S. Environmental Protection Agency, Region IX), Michael Salazar (Naval Ocean Systems Center, San Diego), Tom Rossmiller (Orange County Dept. of Harbors, Parks, and Beaches), Robert Kanter (Port of Long Beach), Larry Smith and Bob Smuda (Port of Los Angeles), Christine Stein (San Diego Unified Port Districts), Mark Shemaria (THUMS Company, Long Beach), and Karen Engelhardt, Valerie Raco, and Henry Schafer (Southern California Coastal Water Research Project). This project could not have been completed without their assistance.■

Appendices

Appendix 1: Permit Process

The Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972, also known as the Ocean Dumping Act, regulates ocean dumping and phased out the disposal of certain types of wastes at sea (e.g., industrial wastes, sludges, etc.). This act established a permit process for ocean disposal that evaluates the environmental impacts of materials dumped at sea, allows enforcement of permit conditions, and establishes a process to designate and manage ocean disposal sites. Dredge material disposal in the SCB requires a federal permit from the Army Corps of Engineers (ACOE).

Ocean dumping permits are evaluated on a project-by-project basis. The Army Corps of Engineers administers all permits under the Dredged Material Disposal permit process of the MPRSA, Section 103. Permit approval is contingent upon guidelines established by the U.S. Environmental Protection Agency (EPA) Ocean Dumping Regulations (40 CFR 220-229). In the SCB, all permit applications are submitted to the ACOE Los Angeles District Office and reviewed by EPA Region IX, San Francisco. The ACOE releases

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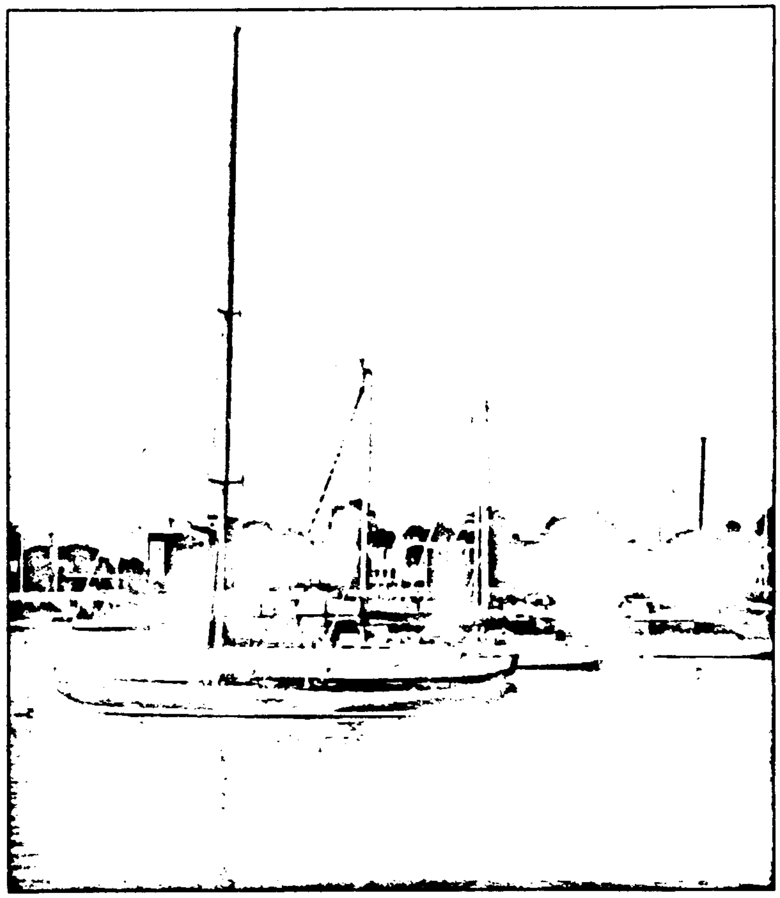
each application for public comment and solicits opinions from federal, state, and local government agencies. The California Coastal Commission must also approve the dredging permit under a Coastal Consistency Determination.

The EPA criteria for disposal of dredged materials are based on environmental acceptability, chemical analyses, and biological tests. Permits to dredge rock, gravel, shell fragments, or sand are generally approved without extensive chemical or biological testing. Coarse grained materials, characteristic of high energy environments, generally have low organic content and low contaminant concentrations. They are used for beach replenishment if grain size is compatible with the receiving environment.

If the dredge material does not meet the exclusion criterion [40 CFR 227.13 (b)], it is submitted for chemical analyses, liquid/suspended particulate and solid phase bioassays, and bioaccumulation tests with approved species (U.S. EPA/U.S. Army Corps of Engineers 1991). Testing determines the potential for adverse biological effects resulting from disposal. If contaminant concentrations are low and bioassay and bioaccumulation results are not significant, then a permit for ocean disposal may be issued.

Dredge material that does not meet the chemical, toxicity, or bioaccumulation standards may still be dredged. Alternative disposal sites, such as sanitary landfills or diked disposal areas, must be found. Diked disposal areas, where dredge material is used for fill, are planned for the 2020 Los Angeles/Long Beach Harbor Expansion Project.



Early morning in Newport Bay

Appendix 2: Designated Dumpsites

The LA-2 disposal site is located 6.7 nm south of the breakwater at San Pedro; it has a radius of 915 m and ranges from 118 to 320 m in depth (U.S. Environmental Protection Agency 1988). The LA-5 disposal site is located 10 nm southwest of San Diego; it has a radius of 915 m and ranges from 145 to 200 m in depth (U.S. Environmental Protection Agency 1987). The LA-3 disposal site is located 9 nm south of Newport Harbor; it has a radius of 915 m and averages 457 m deep (U.S. Army Corps of Engineers, Los Angeles District, personal communication). The THUMS site, which is not currently in use, was designated in 1985 for the disposal of drilling muds and cuttings from oil and gas development in Long Beach Harbor. It is located 16 nm southwest of the Long Beach Harbor breakwater; it has a radius of 2.8 km and is approximately 890 m deep (U.S. Environmental Protection Agency 1985).

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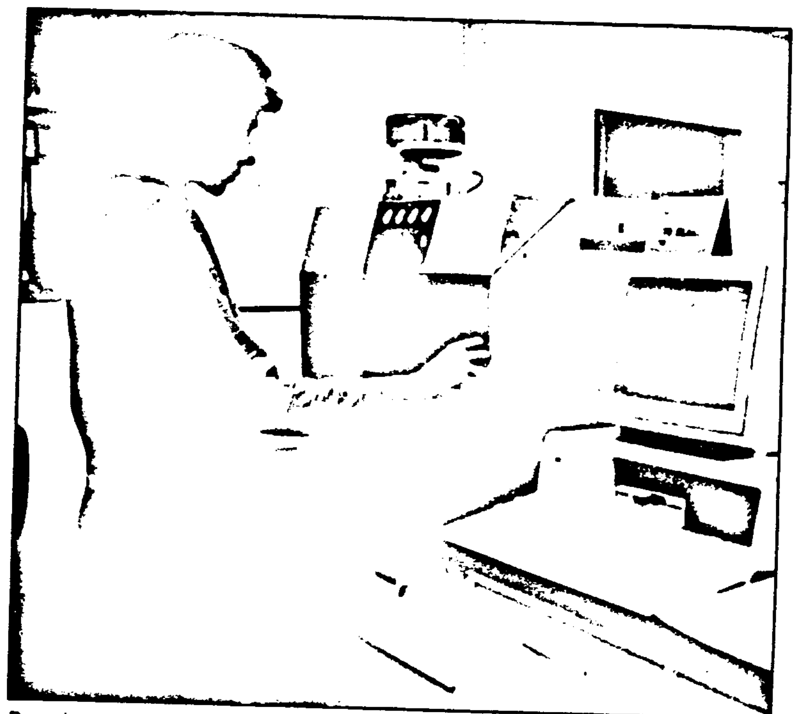
Total Organic Carbon and Total Nitrogen in Marine Sediments, Sediment Trap Particles, Municipal Effluents, and Surface Runoff

Elemental carbon and nitrogen are the basic components of organic matter entering the marine environment. Their measurement may provide a gross assessment of the origin and accumulation of organic material in marine sediments, and possibly the transport and fate of contaminants. The ratio of carbon to nitrogen (C/N) is used to identify the source of organic material. Humic substances originating from marine organisms are rich in nitrogen, hence their C/N ratios are lower than those derived from terrestrial vegetation. Typical C/N ratio of marine humic material ranges from 10 to 15, although ratios of 5 to 10 are not unusual, especially for compounds originating from algal sources. Coastal environments also have high C/N ratios as a result of microbial mineralization of organic nitrogen. Terrestrial materials generally have C/N ratios between 10 and 35 (Rashid 1985).


Running samples on the CHN analyzer

Organic carbon and nitrogen can be measured in sediments by wet chemistry or instrumental methods. The latter is the more prevalent technique because of better accuracy and precision, and shorter analysis time. The objectives of this study were: 1) to develop instrumental methods to measure organic carbon and nitrogen in wastewater effluent, marine sediment, sediment trap particles, and surface runoff, and 2) to examine the usefulness of the C/N ratio for distinguishing among sources of organic material in the marine environment.

Materials and Methods

Effluents were collected from the County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant (JWPCP), the County Sanitation Districts of Orange County Wastewater Treatment Plant (CSDOC), and the City of San Diego Point Loma Treatment Plant (PLTP). Sediment trap particles were collected near each of the three ocean outfalls. Surface sediments were collected near the CSDOC and PLTP ocean outfalls. Sample collection and analysis was conducted over a 12-month period. Water samples were collected from the Los Angeles River in Long Beach during a winter storm.

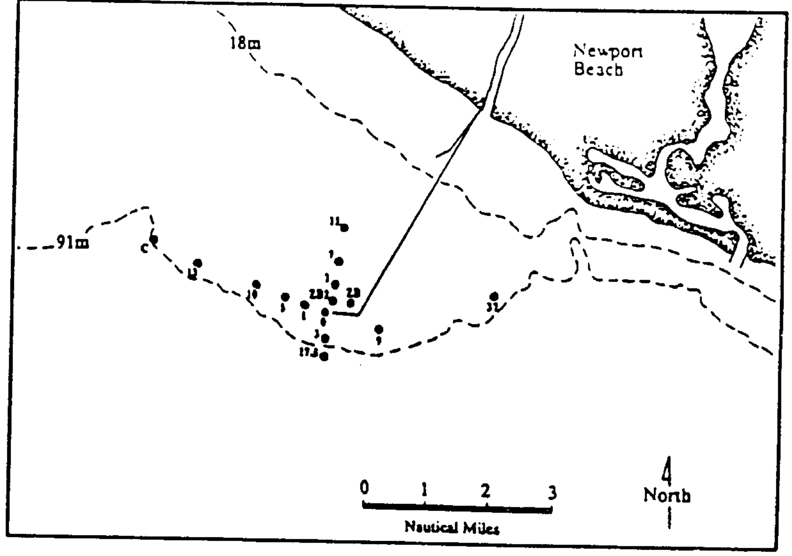
Effluents

Final effluents were collected from JWPCP, CSDOC, and PLTP every other month from January to November 1990. Twenty-four- hour composite samples were collected by treatment plant personnel in two bottles: 1) an amber glass bottle (for determination of total suspended solids), and 2) an acid-rinsed 2 L polyethylene bottle sealed with Teflon-lined cap (for determination of TOC and TN). The samples were placed on ice, returned to the laboratory within 12 hr of collection, and analyzed immediately.

About 100 ml of the effluent from the glass bottle was measured using a graduated cylinder, and filtered in an all-glass filtration assembly using pre-combusted, pre-weighed 25 mm or 47 mm Whatman GF/C glass fiber filter. The filter was washed with distilled water and transferred to a previously kilned Petri dish and dried in a vacuum desiccator for two days. Total suspended solids were determined by reweighing the dry filter on a Cahn 31 microbalance.

About 100 ml of the effluent were removed from the polyethylene bottle, filtered, dried as described above, and exposed to hydrochloric acid vapor for 18 hr to remove inorganic carbon. This is a modification of the acid vaporization technique described by Hedges and Stern (1984). The filter was then dried in an oven at 60°C for 4-6 hr to remove excess acid and water, crimped in a tin combustion boat (Carlo Erba), and analyzed for TOC and TN. We calculated particulate organic carbon (POC) and particulate nitrogen (PN) based on the amount of total suspended solids measured in the effluent.

Figure 1.
Surface sediment sampling sites near the County Sanitation Districts of Orange County municipal wastewater outfall.



Sediment Trap Particles

Sediment traps were deployed off the Palos Verdes Peninsula, Orange County (Huntington Beach), and Point Loma from October 1989 to November 1990 at elevations of 0.5, 2.0, and 5.0 m above the sea floor in 60 m of water and 1 km downcurrent from each of the outfalls (JWPCP, CSDOC, PLTP). The traps were retrieved monthly, although some moorings were lost. Particles were collected in glass centrifuge bottles in the trap. The bottles were transported to the laboratory and stored at -20°C until the particles were analyzed.

The frozen sediment trap particles were thawed at room temperature and homogenized with a glass rod. The wet sample was transferred in an acid-rinsed glass jar and dried at 60°C overnight. A 20-30 mg aliquot of the dry sample was weighed into a silver boat (Carlo Erba) using a Cahn 31 microbalance, placed in a Teflon plate, exposed to acid for 18 hr, and dried as described above. The silver boat was crimped and loaded in a tin combustion boat for analysis.

Sediments

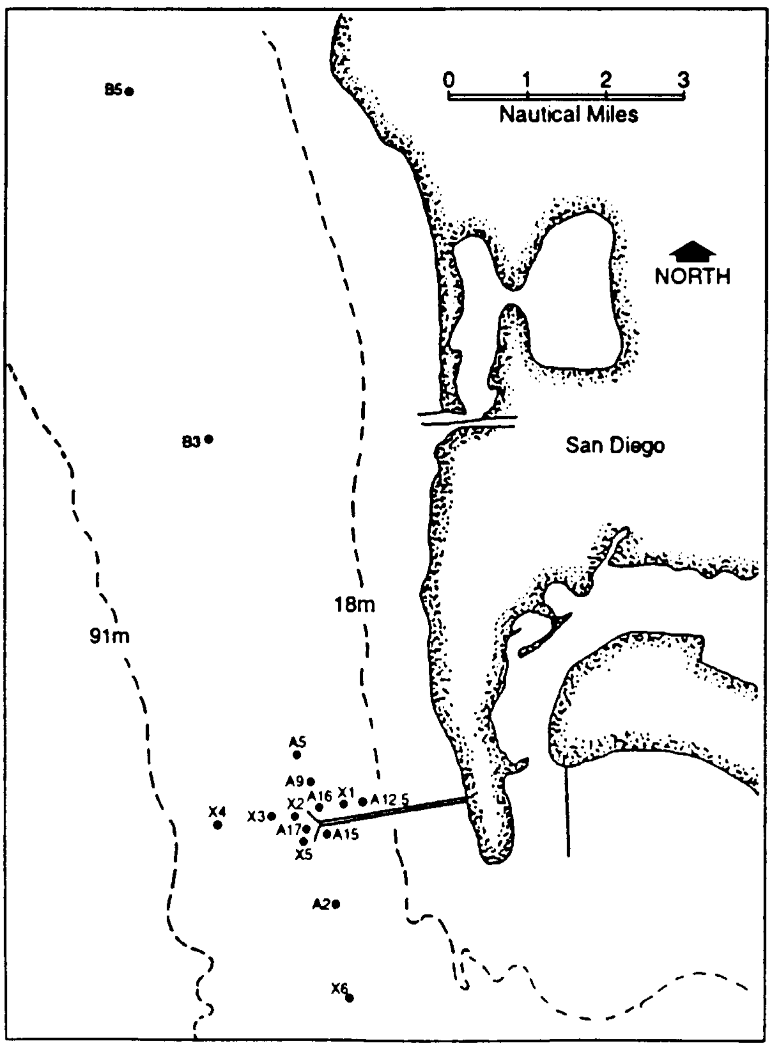
Surficial sediments were collected near the CSDOC outfall in May 1989 (Figure 1) and near the Point Loma outfall (Figure 2) in April 1989 by Van Veen grab (Stubbs *et al.* 1987). Subsamples of the upper 2 cm of the sediments were collected in precombusted glass jars covered with Teflon-lined caps, transported on ice to the laboratory, and stored at -20°C until analyzed.

The frozen sediments were thawed at room temperature and homogenized with a glass rod. The wet sediment sample was dried in an aluminum pan at 60°C overnight and stored in a glass vial. An aliquot of the dry sample was weighed and the carbonate removed as described for the sediment trap samples.

River Runoff

Water samples were collected from the Los Angeles River at Willow Street in Long Beach during a storm in January 1990. Samples were collected at 15-30 min intervals for 6 hr. Flow measurements at the time of sampling were obtained from the Los Angeles Department of Public Works. The sampler and sampling method are described in SCCWRP (1990a). Water samples were stored in polyethylene bottles and refrigerated at 5°C until analyzed. Subsamples of 15-25 ml were filtered in the same way as effluent samples and the carbonate was removed as described for sediment trap samples.

Figure 2.
Surface sediment sampling sites near the Point Loma Treatment Plant municipal wastewater outfall.



Instrumental Analysis

Carbon, hydrogen and nitrogen (CHN) were determined by flash combustion on a Carlo Erba EA 1108 CHN Elemental Analyzer equipped with an AS/23 autosampler, Porapak QS column, and a thermal conductivity detector. The sample was crimped in a tin combustion boat, placed in a quartz combustion tube packed with chromium oxide and silvered cobaltous-cobaltic oxide catalyst, and combusted at 1050°C with oxygen as the oxidizing agent. The oxides pass through a reduction tube filled with copper to convert nitrogen oxides to elemental nitrogen. The resulting compounds are separated and eluted as CO_2, N_2, and H_2O by gas chromatography. Helium was used as a carrier gas at a flow rate of 100 ml/min. Total analysis time was 10 min per sample.

The instrument was calibrated daily with standard acetanilide using a three-point calibration curve. The same standard was also processed daily as a sample to determine TOC and TN recovery. Data were acquired and processed with a DP 110 integrator and later with a Carlo Erba 100 data system that uses an IBM-compatible computer. Quality control and quality assurance data are presented in the Appendix.

Results

Effluent Particles

There were no significant differences in TOC concentrations (ANOVA, $F_{2,16}=0.346$, $p=0.71$) and TN concentrations

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Table 1

Elemental composition of effluent particles from County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant (JWPCP), County Sanitation Districts of Orange County (CSDOC), and City of San Diego Point Loma Treatment Plant (PLTP). TOC = total organic carbon, TN = total nitrogen, TSS = total suspended solids, POC = particulate organic carbon, PN = particulate nitrogen, SD = standard deviation, and CV = coefficient of variation.

	Collection Date	TOC (%)	TN (%)	C/N	TSS[a] (mg/L)	POC (mg/L)	PN (mg/L)
JWPCP	1/17/90	30.7	3.29	9.33	82.9	25.4	2.73
	3/17/90	28.7	4.02	7.14	76.1	21.8	3.06
	4/12/90	31.6	4.16	7.6	70.7	22.3	2.94
	7/6/90	35.0	4.32	8.10	61.8	21.6	2.67
	10/1/90	39.4	4.68	8.42	49.4	19.5	2.32
	11/1/90	37.2	3.90	9.54	71.6	26.6	2.79
	11/21/90	25.3	2.96	8.55	89.7	22.7	2.66
	Mean	32.6	3.90	8.38	71.7	22.8	2.74
	SD	4.9	0.59	0.86	13.3	2.4	0.24
	CV(%)	15	15	10	18	11	9
CSDOC	1/17/90	30.1	3.80	7.92	56.0	16.8	2.13
	3/9/90	28.7	4.04	7.11	60.8b	17.4	2.46
	5/17/90	38.5	5.79	6.65	49.8b	19.2	2.88
	7/5/90	39.9	5.75	6.94	54.5	21.7	3.13
	9/24/90	41.4	5.47	7.57	42.4	17.6	2.32
	11/21/90	22.2	3.38	6.57	79.0	17.5	2.67
	Mean	33.5	4.71	7.12	57.1	18.4	2.60
	SD	7.6	1.08	0.53	12.4	1.8	0.37
	CV (%)	23	23	7	22	10	14
PLTP	1/18/90	24.8	3.19	7.77	81.7	20.3	2.61
	3/12/90	32.9	5.06	6.5	94.8b	31.2	4.8
	5/24/90	35.3	3.55	9.94	100.9b	35.6	3.58
	7/6/90	32.3	5.13	6.3	101.9	32.9	5.23
	9/17/90	35.5	4.07	8.72	117.2	41.6	4.77
	11/19/90	23.0	2.45	9.39	120.3b	27.7	2.95
	Mean	30.6	3.91	8.10	102.8	31.6	3.99
	SD	5.4	1.06	1.51	14.3	7.2	1.09
	CV (%)	18	27	19	14	23	27

[a] TSS measured on 47 mm Whatman GF/C glass fiber filter
[b] TSS measured on 25 mm Whatman GF/C glass fiber filter

(ANOVA, $F_{2,16}=1.540$, $p=0.25$) among effluent samples from the three municipal wastewater treatment plants (Table 1). The variability of TOC and TN measurements was moderate; coefficients of variation (CV) ranged from 15 to 30%.

Total suspended solids were significantly different among the three effluents (ANOVA on log-transformed data, $F_{2,16}=15.94$, $p<0.001$). The CSDOC effluent had the lowest concentration; PLTP effluent had the highest concentration, and hence the highest concentrations of POC and PN. The average POC concentration in the PLTP effluent was about 40% greater than the JWPCP effluent and 70% higher than the CSDOC effluent.

Sediment Trap Particles

The concentrations of TOC and TN in sediment trap particles generally increased with trap elevation above the sea floor (Figure 3). Particles collected 5 m above the bottom had 5-20% higher average TOC concentrations, and 4-30% higher average TN concentrations, than particles collected 0.5 m above the bottom. Particles collected 2 m above the bottom had 1-12% higher average TOC concentrations, and 0-10% higher average TN concentrations, than particles collected 0.5 m off the bottom.

Sediment trap particles collected 5 m above the bottom off Palos Verdes had a 70% higher average TOC concentration, and a 60% higher average TN concentration, than particles collected 5 m above the bottom off Orange County and Point Loma.

The variability of TOC and TN concentrations was greater for particles collected off Orange County and Point Loma (CV_{TOC}=9-34%, CV_{TN}=10-53%) than particles collected off Palos Verdes (CV_{TOC}=5-8%, CV_{TN}=8-9%) (Figure 3). The coefficients of variation were about twice as large for the 5 m traps compared to the 0.5 m traps at Orange County and Point Loma.

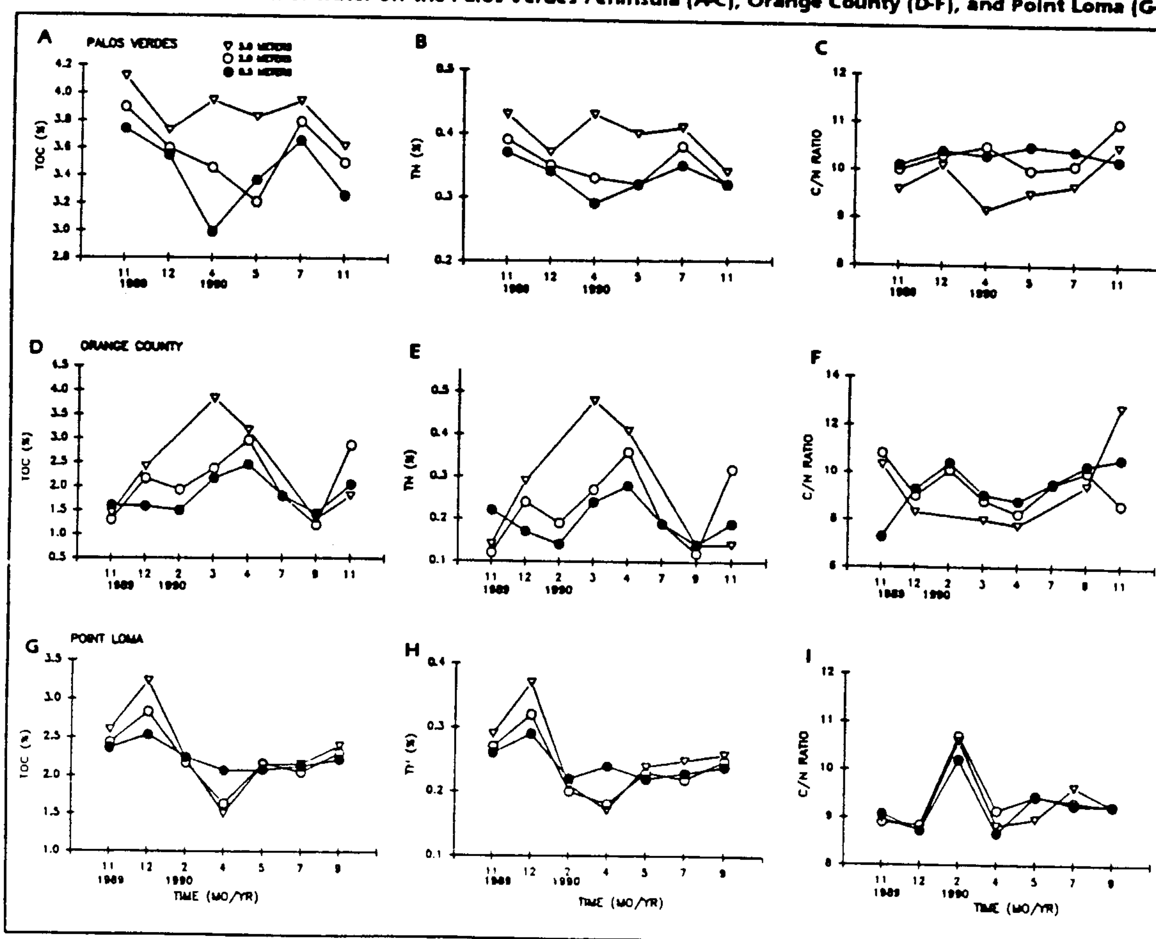
The C/N ratios were consistent (CV range 1-3%) across all trap elevations at the three sites (Figure 3).

Sediments

Off Orange County, TOC and TN concentrations in surficial

Figure 3.

Total organic carbon (TOC), total nitrogen (TN), and C/N ratios of sediment trap particles collected at three elevations above the seafloor in 60 m of water off the Palos Verdes Peninsula (A-C), Orange County (D-F), and Point Loma (G-I).



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sediments were highest at the station closest to the end of the outfall and lowest at the station farthest downcoast (Table 2, Figure 1). The C/N ratio had a substantial range (4.7), but the variability was low (CV=11%).

The TOC and TN concentrations in surficial sediments off Point Loma were about twice those off Orange County (Table 2). The concentrations were highest at several stations upcoast and downcoast from the outfall, and lowest at two stations farthest upcoast (Figure 2). The C/N ratio had a narrow range (1.9) and low variability (CV=6%).

River Runoff

The organic content of suspended particles collected in the Los Angeles River declined as the storm progressed (Figure 4). River flow was inversely correlated with the concentrations of TOC (Spearman r_s= -0.83, p<0.002) and TN (r_s= -0.85, p<0.001), but was not correlated with the C/N ratio. During the early part of the storm when flows were less than 10 m^3/s, the TOC concentration averaged 12%, the TN concentration averaged 1.2%, and the C/N ratio was 10.8. During the storm when flows were greater than 20 m^3/s, the TOC concentration averaged 6%, the TN concentration averaged 0.5%, and the C/N ratio was 12.1.

Table 2

Concentration of total organic carbon (TOC) and total nitrogen (TN), and the C/N ratio in surficial sediments (0-2 cm) near the County Sanitation Districts of Orange County (Figure 1) and Point Loma Treatment Plant (Figure 2) outfalls.

	Station	TOC (%)	TN (%)	C/N
Orange County	OC-0	0.54	0.058	9.3
	OC-1	0.33	0.031	10.6
	OC-2	0.31	0.033	9.4
	OC-3	0.32	0.033	9.7
	OC-5	0.37	0.041	9.0
	OC-7	0.34	0.036	9.4
	OC-9	0.26	0.026	10.0
	OC-10	0.38	0.039	9.7
	OC-11	0.29	0.027	10.7
	OC-13	0.33	0.034	9.7
	OC-17.5	0.32	0.031	10.3
	OC-37	0.17	0.013	13.1
	OC-ZB	0.32	0.031	10.3
	OC-ZB2	0.38	0.045	8.4
	OC-control	0.31	0.033	9.4
Point Loma	SD A-2	0.70	0.100	7.0
	SD A-5	0.70	0.083	8.4
	SD A-9	0.60	0.070	8.6
	SD A-12.5	0.54	0.065	8.3
	SD A-15	0.63	0.072	8.8
	SD A-16	0.57	0.066	8.6
	SD A-17	0.54	0.061	8.8
	SD B-3	0.46	0.058	7.9
	SD B-5	0.48	0.057	8.4
	SD X-1	0.55	0.067	8.2
	SD X-2	0.65	0.073	8.9
	SD X-3	0.65	0.079	8.2
	SD X-4	0.57	0.067	8.5
	SD X-5	0.57	0.067	8.5
	SD X-6	0.62	0.076	8.2

Discussion

Effluents

Effluent particles from the three municipal wastewater treatment plants had similar TOC and TN concentrations, but because of differences in level of treatment, TSS (and POC and PN) concentrations were significantly different. Effluent at PLTP received advanced primary treatment and had the highest TSS concentration. More than 50% of the effluents from JWPCP and CSDOC receive secondary treatment (SCCWRP 1990b).

Our measurements of effluent TSS were significantly higher than effluent TSS measurements reported by CSDOC (Mann-Whitney U test, p<0.02) and PLTP (U test, p<0.001), but not by JWPCP (U test, p>0.10) (see *Characteristics of Effluents from Large Municipal Wastewater Treatment Plants in 1990* in this report). This may be a function of differences in filter pore sizes used by the laboratories. SCCWRP and JWPCP use Whatman GF/C filters with a particle retention size of 1.2 µm; CSDOC and PLTP use Whatman 934-AH filters with a particle retention size of 1.5 µm. Filters with smaller pore diameter may retain more of the suspended particles and have higher TSS concentrations[1].

Because of improved wastewater treatment practices and increased source control, effluent concentrations of suspended solids are 60-70% lower today than in 1978 (Schafer 1980, SCCWRP 1990b). Effluent particle concentrations of organic carbon and nitrogen, however, have not changed in nearly two decades. The concentration of TOC in present-day JWPCP effluent particles (25-39%) is similar to concentrations measured by Myers (1974; 28-42%), Sweeney and Kaplan (1980; 31-32%), and Venkatesan and Kaplan (1990; 25%). The range of TN concentrations measured in the present study (2.5-5.8%) was higher than concentrations measured by Sweeney and Kaplan (1980; 2.4%).

The C/N ratios of effluent particles (7.1-8.4) from the three municipal wastewater treatment plants are comparable to the C/N ratios of effluent (8.3) from South Essex District in Massachusetts (Eganhouse 1986) and the combined sewer overflow effluent (6.5-8.9) discharged to Boston Harbor (Eganhouse and Sherblom 1991).

Sediment Traps

The organic content of sediment trap particles collected off Palos Verdes, Orange County, and Point Loma was substantially less than the organic content of effluent particles from the corresponding sites. Sediment trap particles had 6-11% of the TOC concentration, and 4-9% of the TN concentration, of effluent particles. The C/N ratios of sediment trap particles (9.1-10.3) were 13-34% higher than the C/N ratios of effluent particles (7.1-8.4) from the corresponding sites.

The lower TOC and TN concentrations, and higher C/N ratios, of sediment trap material suggest that effluent particles undergo rapid biodegradation upon discharge to the marine environment (Myers 1974, Eganhouse and Kaplan 1988), and perhaps dilution with plankton and terrestrial lithogenic particles transported into the area. The higher TOC and TN concentrations of particles at the higher trap elevations suggest accumulation of sinking sewage material.

The TOC concentrations of sediment trap particles collected off the Palos Verdes Peninsula during the present study (3.0-4.1%) are comparable to TOC concentrations of flocculent material collected in shallow water off Palos Verdes by Myers (1974; 1.8-3.2%) and Sweeney and Kaplan (1980; 0.8-5.2%). The C/N ratios of their samples (8-12) are comparable with present data.

Sediments

The concentrations of TOC and TN in surface sediments off Orange County and Point Loma were at or below levels of TOC (mean=0.72% dry weight, sd=0.22, n=11) and TN (mean=0.04% dry weight, sd=0.02, n=11) in surface sediments at the 60 m Reference Survey stations (SCCWRP 1992). There was some evidence, however, for the effect of effluent discharge on sediments near the outfalls. Sediment concentrations of TOC and TN near the CSDOC outfall were 200-300% higher than concentrations at the most distant stations. Sediment concentrations of TOC and TN near the PLTP outfall were about 50% higher than concentrations at the most distant stations.

The organic content of sediments collected off Orange

Table 3

The average concentration of total organic carbon (TOC) and total nitrogen (TN), and the average C/N ratio of municipal wastewater effluents, surface runoff, sediment trap particulates, and sediments.

	Effluent[a]	Runoff[b]	Sediment trap[c]	Sediments[d]
TOC (%)	32	8.4	2.7	0.46
TN (%)	4	0.75	0.28	0.05
C/N	8	11	10	9

[a]from County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant (JWPCP), County Sanitation Districts of Orange County Wastewater Treatment Plant (CSDOC), and City of San Diego Point Loma Treatment Plant (PLTP)
[b]from the Los Angeles River
[c]from sediment traps deployed near JWPCP, CSDOC, and PLTP outfalls
[d]from sediment samples collected near CSDOC and PLTP outfalls

[1] County Sanitation Districts of Los Angeles County compared the GF/C and 934AH filters in 1992 and found no significant difference in estimates of TSS concentrations (J. Stull, County Sanitation Districts of Los Angeles County, personal communication, September 1992).

County and Point Loma was substantially less than the organic content of effluent particles from the corresponding sites. Sediments off Orange County had 10-30% of the TOC and TN concentration of sediment trap particles and <1-2% of the TOC and TN concentration of effluent particles from the same site. Sediments off Point Loma had 20-30% of the TOC and TN concentration of sediment trap particles and 1-2% of the TOC and TN concentration of effluent particles from the same site.

The patterns of C/N ratios of sediments around the outfalls were not consistent between the two sites. The high C/N ratio at station OC-37, which is located near Newport Canyon, is probably due to dilution of the sediment with terrigenous debris low in nitrogen.

No current TOC data by this method are available for sediments off Palos Verdes. A decade ago, the TOC concentration in the upper 1 cm of sediment was 6.8-8.7% (Kettenring 1981). Background levels for sediments near the JWPCP outfalls are about 1% TOC and 0.1% TN (Eganhouse and Kaplan 1988).

River Runoff

The concentrations of TOC and TN in particles collected from the Los Angeles River during a storm declined as flow increased. The C/N ratio was variable and did not correlate with flow. This was not unexpected since the source of organic material, and its removal by scouring, is probably not consistent throughout a storm. At low flow, sand-filtered, secondary effluents from three water reclamation plants make up 80-90% of stream flow (SCCWRP 1990a). The decline in the organic content and the increase in C/N ratio as river discharge increased suggests that the municipal effluents were being diluted by surface runoff.

Particles collected in the Los Angeles River during low flow had, on average, about 40% of the TOC concentration and 30% of the TN concentration of effluent particles. Particles collected in the river during high flow had, on average, about 20% of the TOC and 10% of the TN concentration of effluent

Figure 4.
Total organic carbon (A), total nitrogen (B), and C/N ratios (C) of surface runoff particles collected in the Los Angeles River (D).

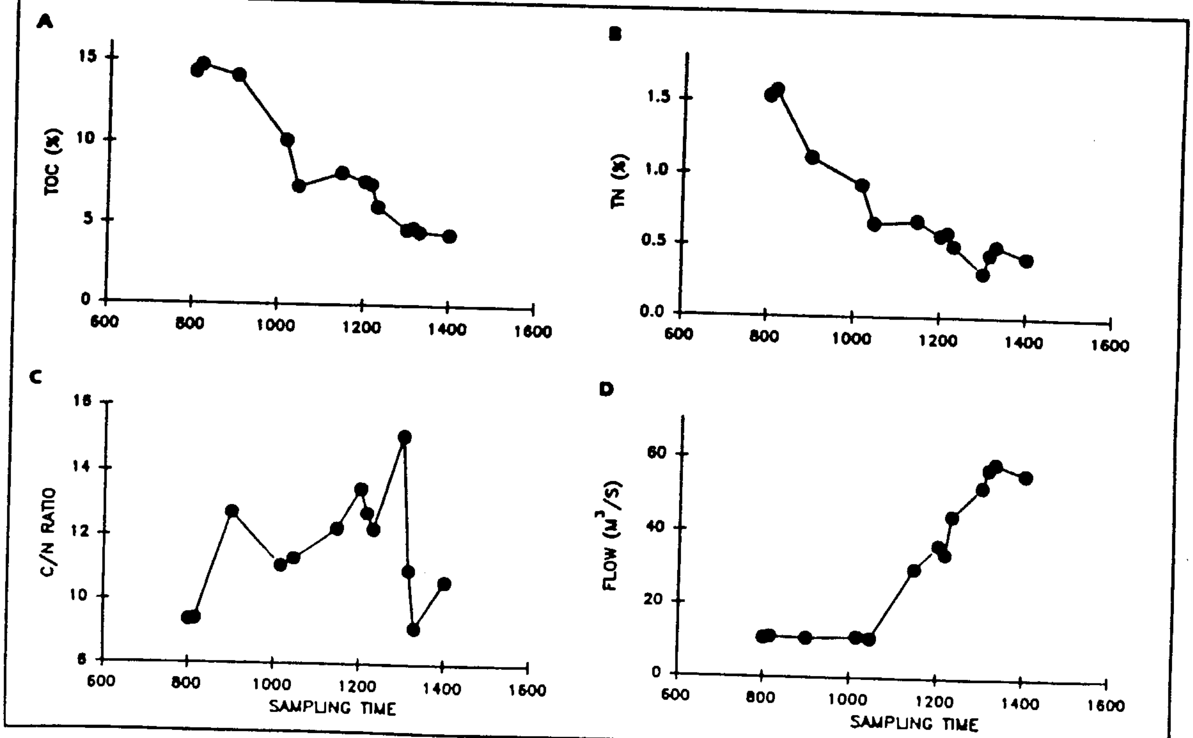

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Table 4
Precision and accuracy of elemental analyses of effluent particles, sediments, and sludge. CV = coefficient of variation.

	N	Carbon (%) mean	Carbon (%) CV	Nitrogen (%) mean	Nitrogen (%) CV	Hydrogen (%) mean	Hydrogen (%) CV
Effluent[a]	5	41.2	4	4.79	2	7.31	3
Sediment-1[b]	10	11.4	2	0.42	29	1.85	2
Sediment-2[c]	10	1.1	4	-	-	0.37	10
Sludge-1[d]	5	35.0	1	3.09	3	-	-
Sludge-2	5	40.0	3	3.62	2	7.38	2
PACS-1a[e]	5	3.59	1	0.28	1	0.88	3
PACS-1b	3	3.48	1				
PACS-1c	3	3.61	1				
Certified value		3.69	3.0				

[a] from County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant
[b] from Station HR 51-1 in Santa Monica Bay
[c] from Station HR 6-1 in Santa Monica Bay
[d] from County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant
[e] sediment reference material from Canadian Research Council

Table 5.
Recovery of standards.

	N	Recovery (%) Carbon	Recovery (%) Nitrogen	Recovery (%) Hydrogen
Acetanilide-1	3	100	99	103
Acetanilide-2	3	101	98	100
Cyclohexanone-1[a]	3	101	100	96
Cyclohexanone-2	6	101	101	103
Phenanthrene-1	3	101	-	100
Phenanthrene-2	6	100	-	99
PACS-1a[b]	3	98		
PACS-1b	3	95		

[a] cyclohexanone-2,4-dinitrophenylhydrazone
[b] sediment reference material from Canadian Research Council

particles. The average C/N ratio of particles in runoff was about 30% higher than effluent at low flow and 40% higher than effluent at high flow.

Conclusions

We compared the organic material associated with effluent, sediment, sediment trap, and surface runoff particles by elemental analysis of organic carbon and nitrogen. Effluents had the highest organic carbon and nitrogen content and sediments had the lowest (Table 3). The results for sediment trap material and sediments suggest that effluent particles undergo rapid biodegradation, and perhaps dilution with plankton and terrestrial particles, in the marine environment.

The C/N ratio data collected in this study were not very helpful for differentiating sources of the particles, but offered some insight into areas enriched by municipal wastewater discharge. Marine organic matter is rich in N and has a C/N ratio of 5-9; terrestrial organic matter is poor in N and has a C/N ratio of at least five or six times that of terrestrial organic matter (e.g., Macdonald *et al.* 1991). Other indicators such as stable isotopes or molecular markers need to be examined to draw more definitive conclusions.■

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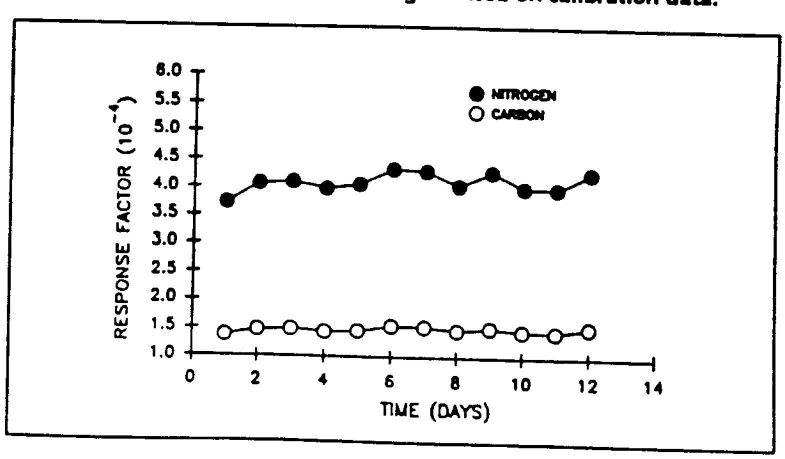
Appendix:

Quality Control/Quality Assurance

Samples of final effluent particles, sediments, and raw sludge were used to bring the method online. Analytical standards used were acetanilide, cyclohexanone, phenanthrene, and a sediment reference material (PACS-1) obtained from the Canadian Research Council.

The final effluent sample was a 24-hr composite obtained from JWPCP. A 100 ml subsample was homogenized and filtered on a 25

Figure 5.
Response factors for carbon and nitrogen based on calibration data.



mm Whatman GF/C glass fiber filter; suspended particles on the filter were transferred to a glass Petri dish and dried under vacuum for two days. The filter was then exposed to hydrochloric acid vapor for 18 hr in a desiccator to remove inorganic carbon, dried, crimped in a tin boat, and loaded in the CHN analyzer. Five replicate subsamples were analyzed to determine the variability of TOC and TN measurements.

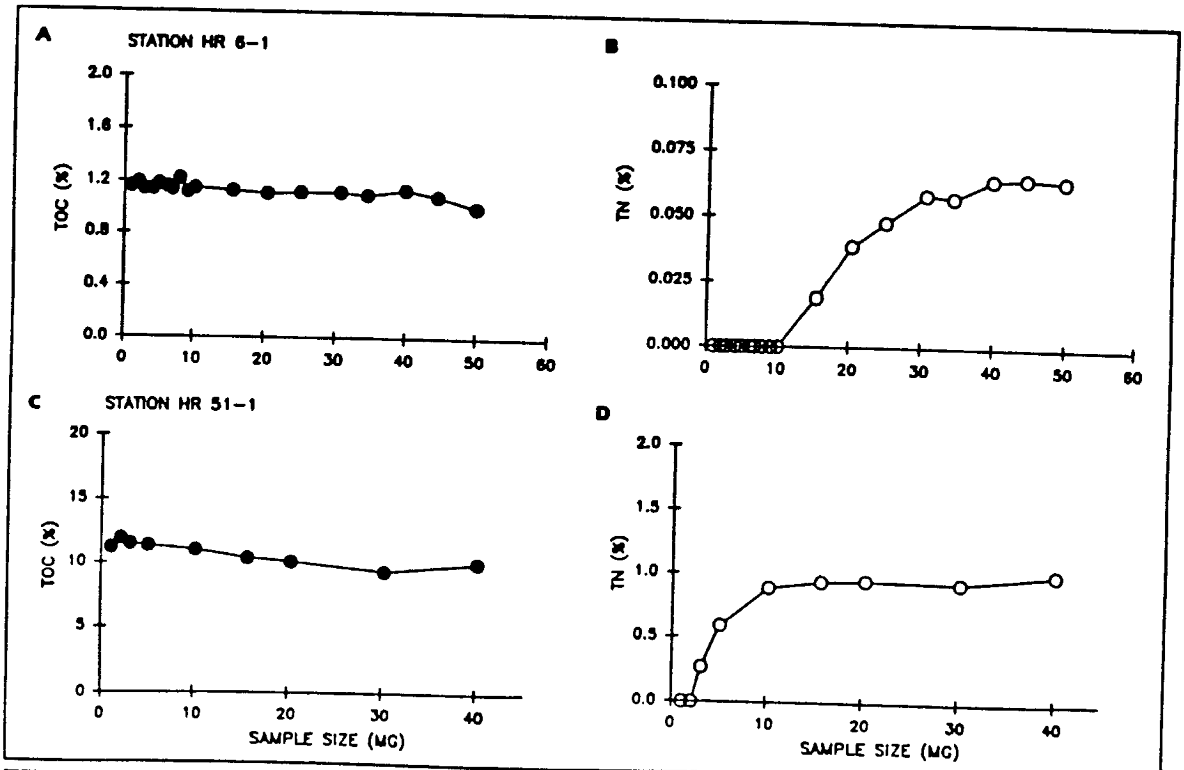
Primary sludge was also obtained from JWPCP. The sample was thoroughly mixed in a polytron homogenizer. A 75 µl subsample was pipetted directly into a silver boat, dried at 60°C, and weighed to obtain 2-3 mg of sample. The boat was placed in a Teflon plate and acid-exposed in a desiccator for 24-48 hr, dried at 60°C, and crimped into a tin boat. Five replicate samples were prepared.

Surface sediment samples were collected from Station HR 51-1 and HR 6-1 in Santa Monica Bay. A 50 g wet subsample was dried and pulverized, and an aliquot was ground in an agate mortar and pestle, and stored in glass vials. The optimum sample size required for TOC and TN analysis was determined from 10 replicate analyses of sediments (1-50 mg) from each station.

The glass fiber filters used to filter effluents and surface runoff samples were kilned at 425°C for 4 hr and stored in glass jars sealed with Teflon-lined caps. For effluent particle analysis, blanks of kilned filter paper were processed as samples at a rate of two per eight samples. Empty silver boats were processed as blanks for the sediments and sediment trap particles. Duplicate analyses were run every 10 samples.

The precision of TOC and TN measurements was high for all sample types (Table 4). Carbon and nitrogen recoveries were consistently high for standards and sediment reference material (Table 5) The response factors, calculated daily from the standard data, was constant over time for carbon and nitrogen (Figure 5) The minimum sample size required to quantitate total nitrogen and carbon simultaneously in sediments varied with TOC content. For sediment from HR 51-1 with TOC of 11%, optimum sample size was 10-15 mg; for sediment from HR 6-1 with a TOC of 1%, optimum sample size was 35-40 mg (Figure 6).

Figure 6.
Effect of sample size on carbon (A,C) and nitrogen (B,D) concentrations in sediment samples collected in Santa Monica Bay.



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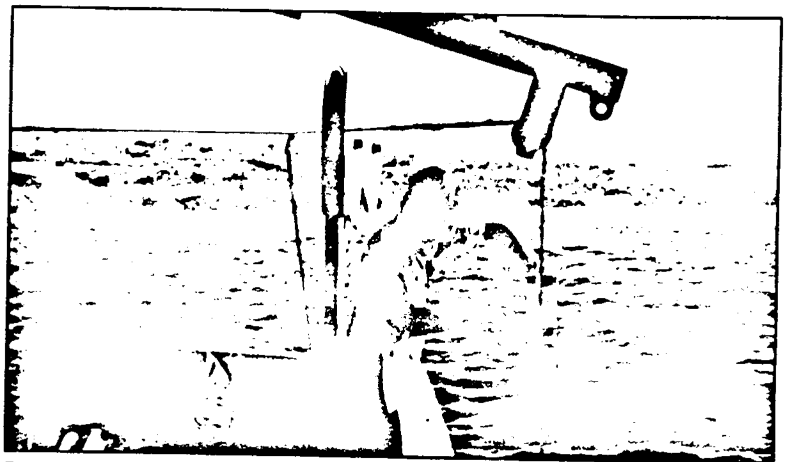
Sediment Model Verification

The characteristics of sediments surrounding an ocean outfall can be altered by the accumulation of organically enriched particles from municipal wastewater discharge. The composition and abundance of animals that live in and on the sediments can also be affected. Several numerical models have been developed to relate changes in sediments and bottom-dwelling organisms to the characteristics of wastewater discharge and the receiving environment.

Prior efforts by SCCWRP to model the fates of particles discharged from ocean outfalls focused on transport and sedimentation of discrete effluent particles, and their subsequent resuspension, transport, redeposition, and accumulation in the sediments. Sedimentation patterns predicted by these models correspond reasonably well with observed patterns (e.g., Hendricks 1984, 1987). However, predicted rates of sediment accumulation are less than observed rates.

Settling column measurements on County Sanitation Districts of Los Angeles and County Sanitation Districts of Orange County final effluents in the early 1970s suggested that most of the particle mass was associated with very small, slow-settling particles. Only about 10% of the mass of suspended solids was associated with particles with settling speeds >13 m/day; approximately one-half of the particle mass was associated with settling speeds <0.25 m/day (Myers 1974, Herring and Abati 1978, Hendricks 1983). The slow-settling particles would require two months or more to settle 15 m from a wastefield to the bottom. Fast-settling particles contribute the most to sedimentation predicted by early SCCWRP deposition simulation models—about 90% of the particle mass is predicted to be carried beyond the outfall area before reaching the bottom.


Recovering sediment traps

Particles entering the ocean may not remain as individual particles, but may coalesce among themselves or with natural particles to form larger "aggregate" particles with higher settling speeds. If the smaller particles aggregate after discharge, the sedimentation rate in the ocean will be greater than the sedimentation rate predicted from settling column measurements. The aggregation of natural particles has been observed in the ocean and the aggregation of effluent particles is suggested by laboratory and theoretical studies.

As part of a contract from the California State Water Resources Control Board, we examined the ability of two models (DECAL and SED2D) to simulate the characteristics of sediments around ocean outfalls off Point Loma (San Diego), Huntington Beach (Orange County), and the Palos Verdes Peninsula (Los Angeles County) (Hendricks and Eganhouse 1992). The model DECAL was developed by Dr. Kevin Farley of Clemson University and the set of submodels SED2D were developed by Dr. Tareah Hendricks of SCCWRP.

Methods

The modeling study: 1) examined the sensitivity of model predictions to input data and the self-consistency of the predictions, and 2) provided site specific predictions based on the consequences of particle aggregation at the three outfall sites. The DECAL and SED2D models had to be modified and expanded to accomplish this. The modeling study was supported by field and laboratory studies that provided input data for the simulations and characterized the sediments for comparison with model predictions.

The simulation of the wastefield in the water column in DECAL (ODES Tool #61; Tetra Tech 1987) was not representative of the discharge and receiving waters in Southern California (i.e., distinct subsurface wastefield isolated from the bottom by an underlying layer of receiving water). We subcontracted with Dr. Farley to conduct new studies of the aggregation process under receiving water conditions present in Southern California. A generalization of the results for a wastefield of arbitrary thickness is found in Hendricks and Eganhouse (1990).

The most important conclusions of the aggregation process studies by Castro (1990, Farley and Castro 1990) are:

1) differential particle settling was the dominant aggregation mechanism for typical ocean and discharge conditions (i.e., larger, faster settling particles falling through smaller, slower settling particles resulted in collisions and aggregation);
2) the rate of production of aggregate particles was approximately proportional to the square of the concentration of suspended solids (2.3-power) and to the thickness of the wastefield (1.2-power);
3) the settling speed of aggregate particles was approximately proportional to the squares of the suspended solids concentration (1.8-power) and wastefield thickness (1.7-power); and
4) the production of aggregate particles in the layer of receiving water beneath the wastefield could be neglected.

These results were incorporated into a new version of the DECAL model by Dr. Farley and into a new set of SED2D submodels by Dr. Hendricks. The revised models were used for sensitivity and self-consistency studies, and for site-specific simulations.

A large number of complex processes determine the fate of natural and effluent particles in the ocean (Figure 1). The following processes, which are only a subset of all the processes involved, were represented in the two simulation models:

1) initial dilution (initial concentration of effluent particles in the wastefield),
2) concentration, flux, and production rate of natural particles in the water column,
3) aggregation of particles into larger particles with faster settling speeds,
4) settling of aggregate particles as they are transported by ocean currents,
5) decay of organic material in the water column and in the sediments,
6) mobilization and demobilization of trace constituents on the particles (DECAL),
7) resuspension (DECAL and SED2D), transport, and redeposition (SED2D) of sediment particles, and
8) accumulation rate and concentration of organic material (DECAL and SED2D) and trace constituents (DECAL) in the sediments.

Although the two models had similar goals and generally incorporated representations of the same processes, the assumptions, representations, and approaches for some of the processes were substantially different (e.g., Hendricks and Eganhouse 1992).

Results and Discussion

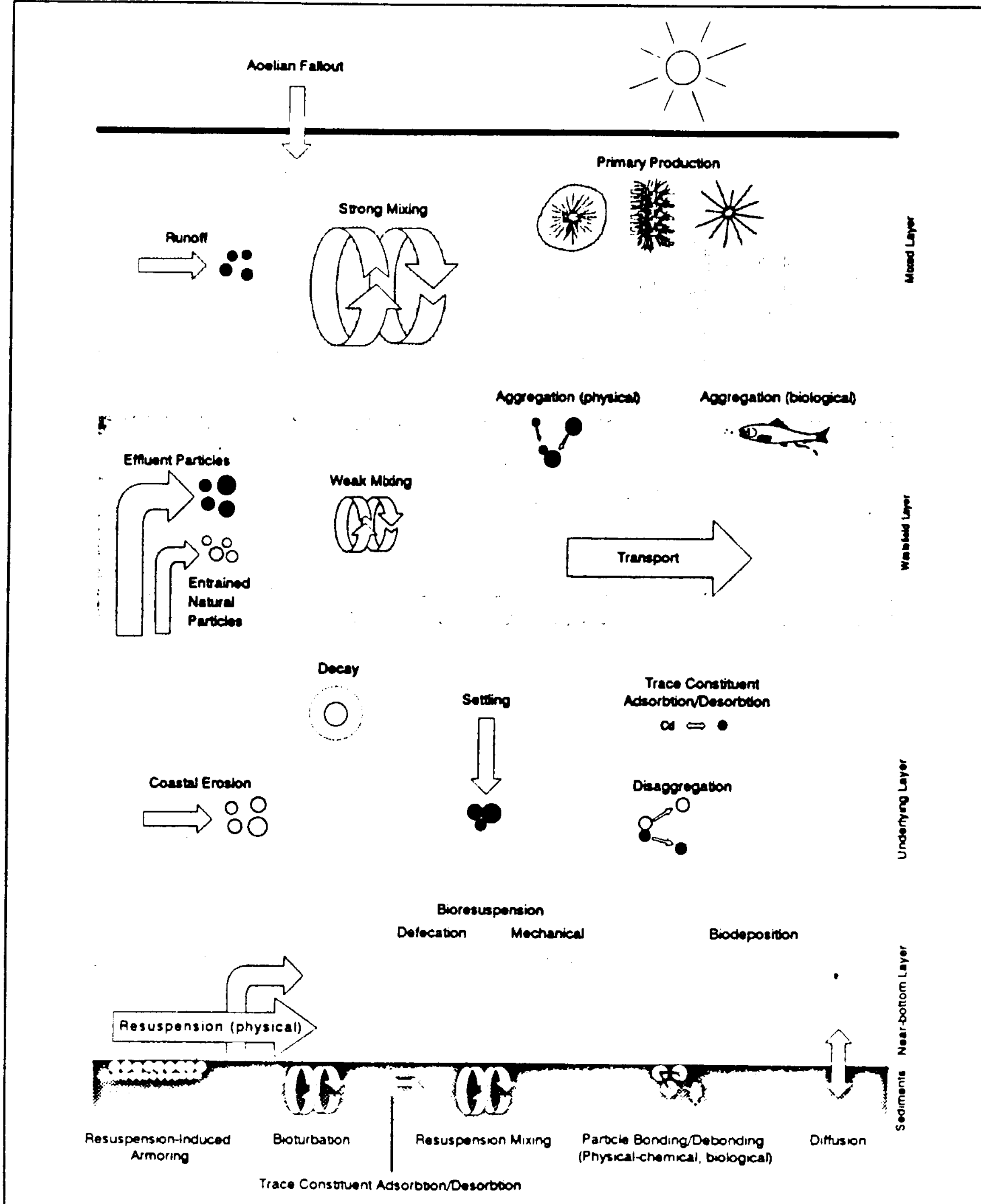
The sensitivity and self-consistency studies brought out several fundamental problems in assessing the importance of particle aggregation to the fate of particles discharged from outfalls. These uncertainties fall into four categories: 1) assumptions used to develop the aggregation rate and particle settling speed equations, 2) aggregation characteristics of natural suspended solids, 3) decay rates or fluxes of effluent and natural particles in Southern California coastal waters and sediments, and 4) quantitative representation of resuspension, transport, and redeposition of sediment particles. We discuss some of the predicted consequences and implications of particle aggregation for wastewater discharge, and the sensitivity of the predictions to those uncertainties.

Effects of Natural Suspended Solids in the Ocean

Natural and effluent particles can aggregate in the simulations generated by DECAL and SED2D. The aggregation of phytoplankton cells produced in the surface waters above the wastefield can generate particles that settle into the wastefield. Natural suspended solids entrained into the wastefield during initial dilution are another source of particles.

Both models included sedimentation of aggregate phytoplankton cells from the overlying water. The DECAL simulations assumed that the concentration of natural suspended solids in the layer of receiving water beneath the wastefield (i.e., entrainment

Figure 1
Processes that determine the fate of natural and wastewater effluent particles in the ocean.



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region during initial dilution) was negligible (Farley and Castro 1990). The SED2D simulations used measurements of natural suspended solids in the water column as the concentration of natural suspended solids entrained into the wastefield. Concentrations measured off White Point, Dana Point (Myers 1974), Encinitas (Kinnetic Laboratories, Inc. 1989), and San Diego (Point Loma Laboratory, City of San Diego, unpublished data) were about 2 mg/L at representative entrainment depths.

The two models estimated initial dilution and the initial concentration of suspended solids in the water column by different methods. Dilutions predicted by SED2D simulations were substantially greater than those predicted by DECAL simulations. For example, SED2D simulations for the Point Loma outfall (San Diego) predicted an average initial dilution of 281:1, while DECAL predicted an initial dilution of 116:1. If we assume an initial dilution of 150:1 and an effluent suspended solids concentration of 70 mg/L (1988 effluent), the initial concentration of effluent suspended solids in the wastefield will be about 0.5 mg/L, or about 25% of the initial concentration of natural suspended solids in the wastefield.

If all natural particles can aggregate, their predominance in wastefield total suspended solids has important consequences for wastewater discharge. In the presence of effluent-natural and natural-natural particle aggregation in our example above, 80% of the mass of wastefield particles that settled to the bottom were natural particles and 20% were effluent particles. Analyses of sediment cores collected in 1981 at 60 m near the outfalls on the Palos Verdes Shelf (Stull *et al.* 1986) provide support for aggregation of wastefield and natural particles. The background natural flux was about 200 mg/cm^2/yr, and each unit mass of effluent particles that accumulated in the sediments was accompanied by approximately one unit mass of natural particles over and above the background flux (Figure 2).

The magnitude of the background flux, and the ratio between the additional flux of natural particles and effluent particles, depend on assumptions about the effects of bioturbation on the distribution of effluent particles in the core horizon influenced by effluent discharge. Background fluxes ranged from about 100 to 300 mg/cm^2/yr in limiting cases, and the ratio of natural flux to effluent flux ranged between 1 and 3. A background natural flux of 200 mg/cm^2/yr is 7 to 20 times greater than published estimates for natural particle accumulation in this region (Emery 1960, Schwalbach and Gorsline 1985).

We examined the predicted change in peak sedimentation of wastefield particulates if treatment removed all suspended solids from the effluent. The initial concentration of total suspended solids in the San Diego wastefield example would decrease from 2.5 mg/L (2.0 mg/L natural + 0.5 mg/L effluent) to 2.0 mg/L. For discharges into Southern California coastal waters, the peak sedimentation rate of wastefield suspended solids on the bottom varies roughly with the square of the initial wastefield concentration (Hendricks and Eganhouse 1990). Total removal of suspended solids from the San Diego effluent (i.e., discharge of distilled water) only reduced the peak sedimentation rate near the outfall diffuser by about one-third. The remaining flux of natural particles from the wastefield was predicted, however, to remain roughly an order-of-magnitude greater than the flux of natural particles in the absence of the discharge.

Why did the model predict such a large enhancement of the sedimentation rate of natural particles in the presence of a particle-free discharge? One possibility is that most of the natural particle mass was associated with particles that did not aggregate. The concentration associated with this mass should not be included in the particle aggregation computations. However, we do not know if cohesive and non-cohesive natural particles exist, or what partitioning may occur. An alternate explanation is that enhanced vertical mixing within the wastefield increased the flux of particles.

Vertical Mixing within the Wastefield

The development of the aggregation equations assumed that all size classes of aggregate particles were uniformly distributed throughout a fully mixed wastefield. Particles undergoing aggregation by settling through the wastefield could be recycled to the top of the wastefield by mixing, allowing them to fall through the wastefield many times. During each fall, they could collide with smaller, slower settling particles, thus increasing aggregate particle mass and settling speed. As particle settling speed increased, the likelihood of the particle settling from the wastefield increased. Ultimately, the settling speed of aggregate particles became so large that turbulence could not carry them upward in the wastefield and they settled to the bottom. In the absence of discharge, the reduced turbulence in the water column did not permit vertical recycling of large, fast-settling particles, so the rate of particle production and settling speed decreased.

We assumed that the 2 mg/L ambient concentration of natural particles in the water column was the steady-state condition in the absence of discharge. The flux of aggregate phytoplankton cells settling from the surface layer into the "wastefield" region of the water column matched the loss of particles from the wastefield region due to aggregation and sedimentation. We did not assume that the wastefield region was fully mixed. Instead, we estimated the thickness of the mixing layer in the aggregation equations that would produce the steady-state.

The results depended on the rate of production of phytoplankton mass in the surface layer. We used 600 mg/m²/day as the typical production rate, and 2400 mg/m²/day as the maximum production rate, for Southern California coastal waters (Tetra Tech 1987). The "effective" mixing layer thickness for the aggregation equations was 0.4 m for the typical rate and 1.9 m for the maximum rate. These values are an order of magnitude smaller than normal wastefield thickness (15-30 m). Because aggregate particle production rate varied as the 1.2-power of wastefield thickness (i.e., effective mixing layer thickness) and particle settling speeds varied as the 1.7-power, greatly enhanced production rates and increased settling speeds were predicted in the presence of discharge.

The assumption that complete vertical mixing occurred within the wastefield may be inappropriate. Temperature, salinity, dissolved oxygen, and light transmissivity are generally not uniform between the upper and lower boundaries within wastefields (Hendricks and Harding 1974, Hendricks 1977, 1987, Thompson 1992). Laboratory studies of vertical mixing for conditions analogous to wastewater discharge into a stratified water column indicate a rapid dissipation of vertical turbulence (Lin and Pao 1979). Stratification in these studies, however, was greater than in the ocean.

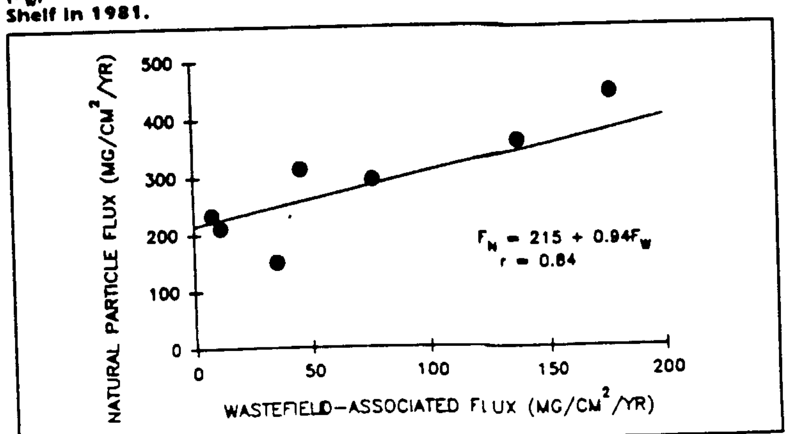
We also compared the density structure within the wastefield to the structure in the surrounding ambient water. Despite uncertainties introduced by internal waves and tides, density gradients existed within the wastefield that may be comparable to the density gradient in the ambient water. This suggests that using the full thickness of the wastefield in the aggregation equations may substantially overestimate the rate of aggregate particle production and their settling speeds.

The effective mixing layer thickness in the absence of discharge provides a lower bound for the effective mixing layer thickness within a wastefield. Simulations based on this assumption predicted a substantial increase in the time between particle discharge from the outfall and particle arrival on the sediments (from about one hour to about six days; Hendricks and Eganhouse 1992). The reduced production rate of aggregate particles, and the dispersion of settling particles by currents during longer water column residence times, greatly reduced the sedimentation flux to the bottom. It also minimized or eliminated the normal local enhancement of sedimentation rate near outfalls.

Sediment Resuspension

Once particles settle to the bottom, they can be mixed with sediments, buried, and resuspended; the organic material can decay; and trace constituents can be mobilized. Both models pro-

Figure 2
The relation between natural particle flux (F_N) and wastefield particle flux (F_W) estimated from sediment cores collected at 60 m from the Palos Verdes Shelf in 1981.



turbulence could not carry them upward in the wastefield and they settled to the bottom. In the absence of discharge, the reduced turbulence in the water column did not permit vertical recycling of large, fast-settling particles, so the rate of particle production and settling speed decreased.

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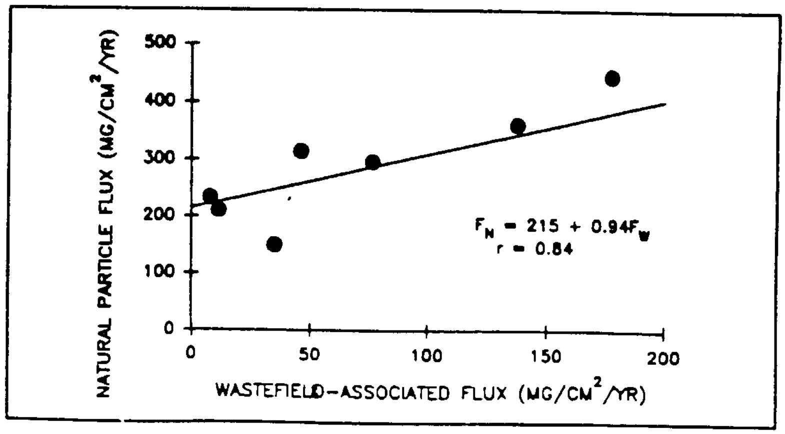


vided only primitive representations of these processes. The processes were combined into two first-order rate equations in DECAL (one for organic material and one for a trace constituent). Under steady-state conditions, the rate of loss (or gain) of these processes was proportional to the mass of organic material (or trace constituent) deposited on the sediment surface. The magnitude of this parameter was determined either by choosing a value that minimized the difference between the predicted and observed sediment characteristics, or a value estimated from previous simulations for similar ocean environments.

The SED2D simulations used a different representation for sediment decay processes and did not simulate trace constituent concentrations. The simulations estimated fluxes of material into and out of the sediments as a result of resuspension, transport by near-bottom currents, and redeposition. Observations with sediment traps deployed off Southern California at 0.5, 2.0, 5.0 m above the bottom formed the conceptual framework of the resuspension submodels.

The material collected in sediment traps is primarily resuspended sediments (Hendricks and Eganhouse 1992, unpublished data). Most of the resuspended material is found within 3 m of the bottom and is transported out of the immediate area by near-bottom ocean currents (Hendricks 1987). In the absence of discharge, fluxes of resuspended sediments into the sediment traps are one to two orders of magnitude greater than the rate of accumulation of particle mass in the sediments (SCCWRP 1986, 1987, Hendricks 1987, Hendricks and Eganhouse 1992).

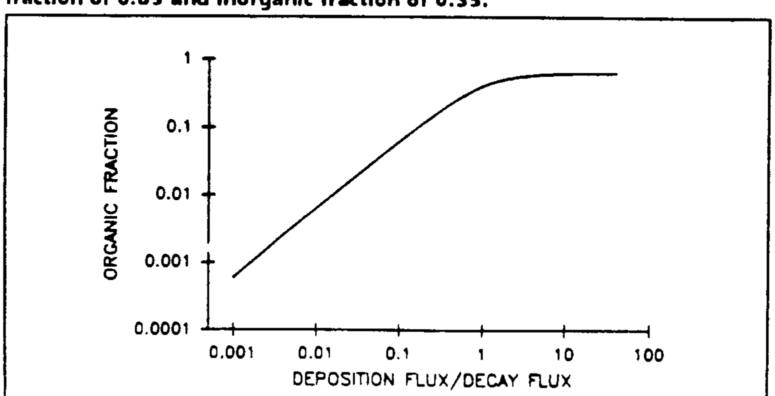
Knowledge of the ocean conditions leading to sediment resuspension and redeposition are required to conduct SED2D simulations of sediment resuspension, transport, and redeposition. These conditions are not well known for the three test sites. However, studies by Washburn *et al.* (1991) near the outfalls on the Palos Verdes Shelf provide some empirical data.

Resuspension begins at current speeds of about 10 cm/sec and no material is resuspended at current speeds of a few cm/sec. (Resuspension also occurs under the combined stress of waves and currents.) We used a threshold resuspension speed of 9 cm/sec and a threshold deposition speed of 4.5 cm/sec for the simulations.

The other required piece of information for SED2D is the average number of resuspensions a particle undergoes before it is buried in the sediments. In the absence of wastewater discharge, this is approximately equal to the deposition flux of mass into a near-bottom sediment trap divided by the accumulation flux of mass into the sediments (approximately 10 to 100 resuspensions). However, changes in the composition of the sediments associated with wastewater discharge, or alterations of the sediments by benthic and epibenthic biota, may affect this number in a way that cannot now be determined *a priori*. For example, SED2D simulations suggested that the average number of resuspensions was lower in the area affected by the Los Angeles County discharge than in the other two test areas. (This could explain the high rate of accumulation of natural particles estimated from the Palos Verdes Shelf cores.)

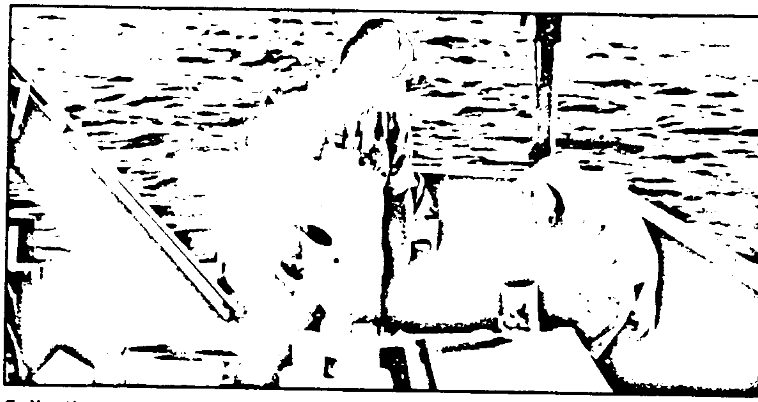
We used sensitivity simulations to examine the ratio between the peak sedimentation flux of wastefield particles to the bottom and the net deposition of wastefield particles in sediments at that location after resuspension. As used herein, "sedimentation" is the initial deposition of particles from the water column; "deposition" is the deposition of particles after resuspension. This ratio was approximately inversely proportional to the average

Figure 3
The relation between the organic content of sediments and the ratio of the deposition flux to the limiting decay flux for particles with an initial organic fraction of 0.65 and inorganic fraction of 0.35.



number of resuspensions experienced by a particle—provided that the number of resuspensions was in excess of about 10. Estimates of the peak accumulation rate of sediments were sensitive to errors in estimates of the average number of resuspensions of sedimenting particles. Sensitivity varies away from the area of peak sedimentation, where effects of the deposition of sediments resuspended from adjacent areas are more important.

Other simulations suggested that the average distance a resuspended particle traveled before redeposition was sensitive to threshold resuspension and redeposition speeds. Changes in transport distance had only minor effects on peak deposition rates around outfalls, but influenced deposition fluxes in areas on the fringes of wastefield sedimentation. Uncertainties in the effects of sediment resuspension in areas most heavily impacted by discharge were more sensitive to the average number of resuspensions and less sensitive to the threshold speed.



Collecting sediment trap material

Decay of Organic Material

The discussion so far has implicitly assumed that particle mass is inert. If the particle contains labile organic material, loss due to decay can affect the initial deposition flux to the bottom, the rate of accumulation of particle mass in the sediments, and sediment composition. Approximately 70% of effluent particle mass is organic material (Hendricks and Eganhouse 1992); effects of decay may alter particle fate predictions. We examined the sensitivity of the results to uncertainties in the decay rate of organic material in the water column and in the sediments.

The decay of organic material as a particle settles through the water column reduces the organic content, total mass, and deposition flux of material to surface sediments. Loss of mass reduces particle settling speed, increases residence time in the water column, and magnifies the effects of decay. The decay of organic material has the potential to produce large changes in particle composition and sedimentation fluxes if settling time becomes comparable to, or greater than, the characteristic decay time (inverse of the decay rate). Unfortunately, the decay rate of organic material in the ocean is not well known. Estimates based on treatment plant observations are about 0.1/day (Tetra Tech 1987). Laboratory and *in situ* studies suggest 0.52/day (Myers 1974). Simulations were carried out for values of 0.1 and 0.52/day.

When the decay rate was reduced from 0.52 to 0.1/day in DECAL, the predicted peak fluxes of total suspended solids to the sediments increased by about two (Los Angeles County) to four (Orange County). The effects were smaller in the SED2D simulations for two reasons. First, entrainment of natural suspended solids during initial dilution increased the wastefield concentration and particle settling speeds, thus reducing residence time in the water column. Second, particles consist of inorganic as well as organic material, so all of the particle mass was not subject to decay and the change in particle settling speed was less than in similar DECAL simulations.

Decay can continue after particles settle to the ocean bottom. In the SED2D model, decay was assumed to be confined to a layer of surface sediments. Hence there is a limit to the rate of loss of organic material (per unit area)—even if the sediments consist entirely of organic matter. For sediments with reduced concentrations of organic material, the rate of loss was correspondingly reduced below the limiting value. The decay flux can determine the rate of accumulation of mass in sediments, the organic content of sediments, and the rate at which sediment composition changes in response to changes in treatment method or changes in the ocean environment. No estimates of the "limiting" decay flux were available for sediments at the three test sites. Estimates from offshore basins and other geographical areas vary over several orders of magnitude.

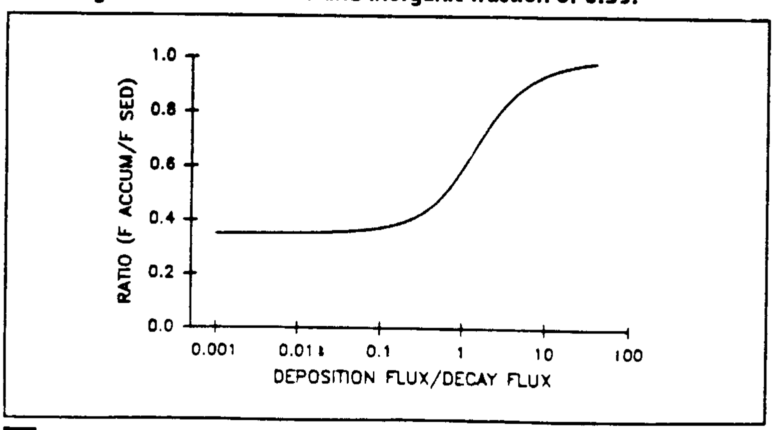
The organic content of sediments was related to the ratio of the deposition flux to the limiting decay flux (Figure 3). Once the deposition flux exceeded the limiting decay flux ($F_{depos}/F_{decay} > 1$), the composition of the sediments became nearly the same as the settling particles (because particles only spent a short time in the sediment layer where decay occurred). At lower deposition rates however, the organic fraction of the sediments was proportional to the deposition flux.

The material remaining after decay contributed to the accumulation of particle mass in the sediments and to sediment burial. The ratio of accumulation flux to deposition flux was less than unity ($F_{accum}/F_{depos} < 1$) and depended on the ratio of the deposition flux to the limiting decay flux (Figure 4). For deposition fluxes that were ten or more times the limiting decay flux ($F_{depos}/F_{decay} > 10$), the accumulation flux was virtually equal to the deposition flux (because little decay occurred before the particles were buried below the decay layer). Conversely, if the limiting decay flux was ten or more times greater than the deposition flux ($F_{depos}/F_{decay} < 0.1$), nearly all of the organic material was lost to decay and accumulation was due primarily to particle inorganic material. At intermediate deposition fluxes, the ratio between accumulation flux and deposition flux varied between these limits. Our best estimate for the decay flux was 180 mg/cm^2/yr, so the region of variability in the accumulation-deposition flux ratio corresponded to deposition fluxes of 18 to 1800 mg/cm^2/yr. This roughly corresponds to the range of accumulation rates (natural + effluent) estimated from cores taken on the Palos Verdes Shelf (Figure 2).

Large uncertainties in estimates of deposition flux were due to uncertainties in: 1) the contribution of natural particles to the aggregation process, 2) the effective mixing layer thickness for particle aggregation, 3) the rate of loss of organic material in the water column due to decay, and 4) the average number of resuspensions of a particle settling to the bottom. Similarly, the limiting decay flux of organic material in the sediments is unknown. These uncertainties magnify the potential for error in estimates of the composition of sediments and their rate of accumulation (i.e., burial).

Figure 4

The relation between the ratio of accumulation flux to deposition flux and the ratio of deposition flux to the limiting decay flux for particles with an initial organic fraction of 0.65 and inorganic fraction of 0.35.



Conclusion

There are substantial uncertainties in the predictions of the fates of wastewater effluent particles based on the DECAL and SED2D simulation models. Both models predicted areas of high rates of sedimentation near outfalls that were surrounded by areas of lower rates of sedimentation. The models predicted an increase in sedimentation of natural particles as a result of a discharge lacking particulate matter.

Uncertainties in the predictions arise from: 1) questions about the validity of aggregation equation assumptions, 2) lack of data on vertical mixing within the wastefield, 3) lack of knowledge about the aggregation characteristics of natural suspended solids, 4) poor understanding of sediment resuspension processes, and 5) lack of estimates of the decay rate of organic material in the water column and sediments. Until these uncertainties are addressed, it will be difficult to assess the validity of the predictions of the two models and the process representations contained in them. However, the models provide qualitative insight into the dynamics of the interaction of a wastefield and natural waters and the localized effects on sedimentation from the discharge of wastewater effluent. ■

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EXTENSION OF POINT LOMA OUTFALL

In 1983, the State revised the California Ocean Plan and applied body contact standards for bacterial concentrations to beds of giant kelp *(Macrocystis pyrifera)*. This doubled the depth of protected inshore waters from 35 ft (10.7 m) to 70 ft (21.3 m) near the Point Loma ocean outfall (City of San Diego). At the same time, the distance between the outer boundary of the protected area (historical extent of the kelp bed) and the outfall diffuser was reduced from 2.6 km to 1.6 km.

These changes substantially reduced the isolation of the wastefield from areas where the body contact standard must be met and resulted in violations of the standard. An extension of the existing outfall offshore and into deeper water (85-105 m) is a potential way of meeting the bacterial standards in the kelp bed. Increased isolation is achieved by the greater depth of the wastefield in the water column, and by the increased distance between the outfall diffuser and the kelp beds.

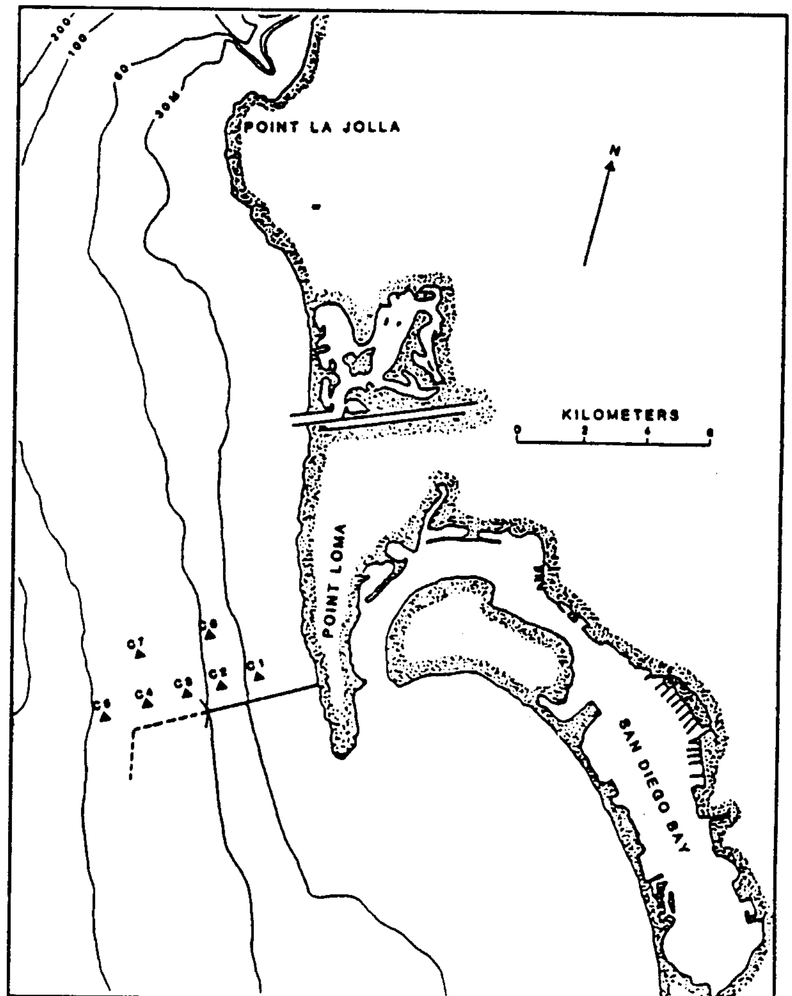


Figure 1
Location of current meter and thermistor moorings (C1-C7) off Point Loma (adapted from Engineering Science, Inc. 1991). Dashed line is potential outfall extension.

Methods

Engineering Science, Inc. subcontracted with SCCWRP to study the feasibility of the proposed extension. We examined the characteristics of water column density stratification and the properties of currents with current meter and thermistor data collected by Engineering Science. The data were collected between March and September 1990 near the Point Loma outfall (Figure 1) by 17 current meters on seven moorings and 51 thermistors on 5 moorings (Figure 2; Appendix 1). The results were incorporated into time-dependent models of initial dilution and transport of wastewater by ocean currents (Appendix 2). Analyses of the oceanographic data and formulation of the simulation models are discussed in Hendricks (1990) and Engineering Science (1991).

Two approaches were used in the simulations. The first approach considered isolation provided solely by density stratification of the water column. Density stratification suppresses vertical diffusion and advection, and "traps" the diluted wastewater in the water column. If the submerged wastefield is formed sufficiently deep so that its upper boundary always lies below the bottom of the outer edge of the kelp bed, the wastefield will not intrude into the kelp bed. However, because the ocean is a dynamic environment, it is not sufficient to simply ensure that the top of the wastefield lies below the kelp bed depth at the time of formation. Internal tides, internal waves, and slowly varying changes in density structure of the water column can change the depth of the wastefield after its formation. For example, during simulations of a discharge in deep water, vertical excursions of the wastefield of 10 m were common and occasional excursions of 30 m were observed.

The temperature of ambient water at the top of the wastefield at the time of formation was used as a surrogate indicator of water density. This temperature was compared with water temperature measured at the bottom of the outer edge of the kelp bed at later times. If the kelp bed temperature was warmer than the wastefield indicator temperature, the wastefield would not intrude into the kelp bed. If the kelp bed temperature was colder than the wastefield indicator temperature, density stratification of the water column would not prevent an intrusion. The occurrence of an *actual* intrusion, however, depended on ocean currents between the time the wastewater was discharged and when the *potential* intrusion could occur.

Results and Discussion

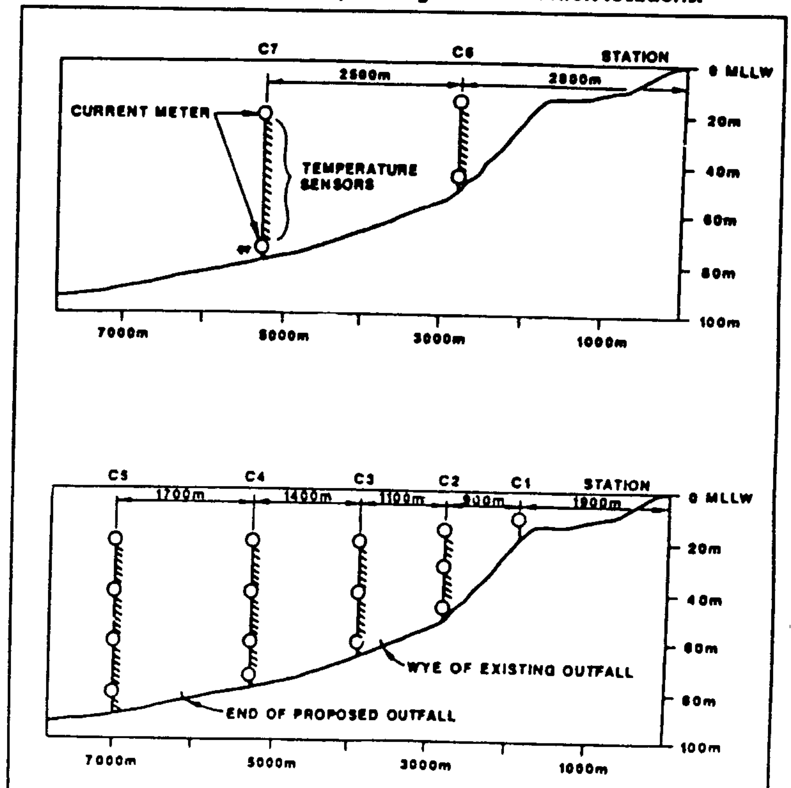
The fraction of time that a "density window" was "open" for potential intrusions was simulated for seven periods for discharge from a line source (0.05 mgd/ft, or 0.007 m^3/sec-m, of diffuser) in 83 and 95 m of water. We assumed that only wastewater discharged within the preceding five days could result in potential intrusions and that wastewater discharged earlier had been carried out of the area.

The density window was open from 18 to 38% of the time in 83 m, and from 4 to 12% of the time in 95 m (Figure 3). We assumed that data from individual moorings could be used to estimate intrusions at locations between, or offshore from, current meter and thermistor moorings. This assumption is supported by the similarity of the curves for the fraction of time the density window was open as a function of discharge depth (Figure 4).

The actual occurrence of an intrusion during an open density window also depends on ocean currents. During the second phase of the modeling effort, we added time-series measurements of ocean currents and water temperature to a data-driven, time-dependent, three-dimensional model of wastewater transport.

Figure 2

Location of current meters and thermistors on the moorings (adapted from Engineering Science, Inc. 1991). See figure 1 for station locations.



The model predicted that wastewater intrusions into the kelp bed would peak at 15% of the time 1 to 2 km upcoast from an outfall in 83 m of water (Figure 5a). Actual intrusions were predicted for about 40% of potential intrusions. The peak probability was reduced to 7.5% of the time 4 km upcoast from an outfall in 95 m of water (Figure 5b). The increased upcoast displacement for the deeper discharge is the result of increased wastefield transport time from the diffuser to the kelp bed. Actual intrusions were predicted for about 60% of potential intrusions.

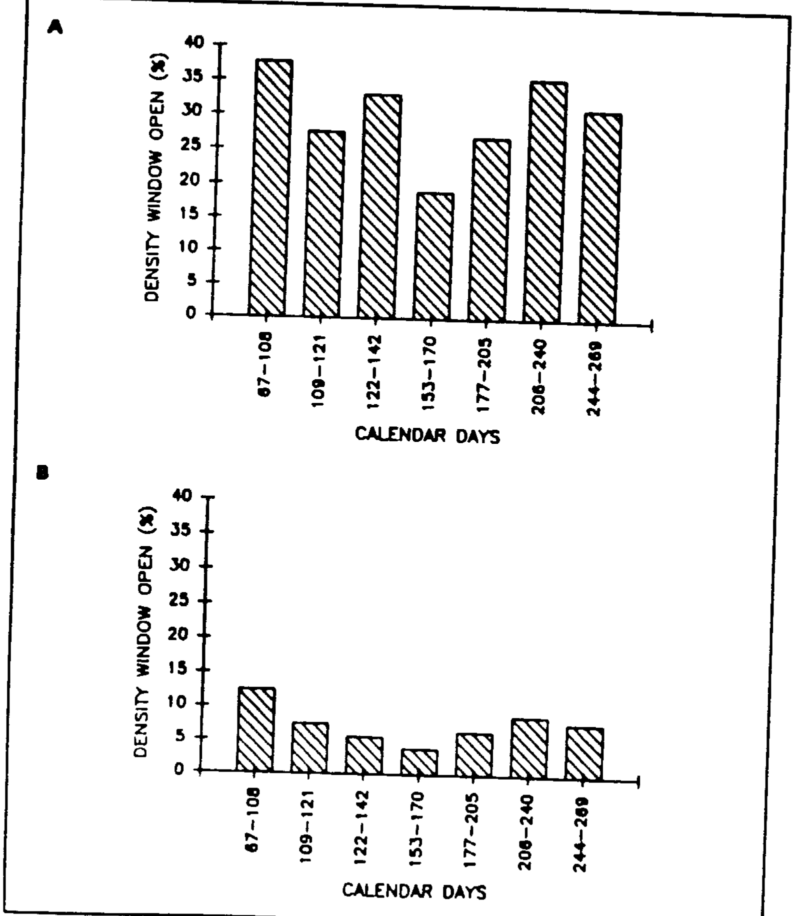
The probability of a potential intrusion leading to an actual intrusion was 50% greater for the deeper discharge, i.e., the effectiveness of transport alone in isolating the wastefield from the kelp bed was *reduced* by extending the outfall farther offshore and into deeper water. This somewhat surprising result is probably due to the formation of a deeper wastefield, which leads to an increase in onshore transport by ocean currents at deeper depths (Appendix 1). However, despite increased onshore transport, extending the outfall farther offshore into deeper water reduced the number of actual intrusions.

Intrusion probabilities are not directly convertible into probabilities of regulatory violations. Bathing water standards for total coliform (TC) bacteria require that concentrations not exceed 1000 TC/100 ml more than 20% of the time within a 30-day period. The probability of exceeding the standard depends on the intrusion probability, the distribution of intrusions in a 30-day period, the concentration of TC within the wastefield, and the number of samples collected during the period. For example, let us assume that intrusions occur randomly with a probability of 0.05 in a 30-day period, and that TC concentrations exceed 1000 TC/100 ml when the wastefield is present. If only four samples are collected during a 30-day period, the probability of exceeding the regulatory standard is 0.18 (roughly one out of every five 30-day periods). If 10 samples are collected, the probability falls to about 0.01 (one out of every 100 30-day periods).

These probability estimates may possess considerable uncertainty, particularly for predictions based on the combination of density stratification and wastewater transport. Results of simulated transport were sensitive to the details of cross-shore transport during upwelling and downwelling, including the details associated with internal tides. These processes are not well understood. For example, a shallower isotherm (an indicator

Figure 3

Percent of time the density window was open for discharges in (a) 83 m and (b) 95 m of water from March to September 1990.



of upwelling) was not always accompanied by onshore flow in waters below that isotherm. This suggests more complex flow patterns for ocean currents than could be resolved from the field measurements.

Similarly, the simulated cross-shore transport associated with a "gravitational collapse" of the wastefield (Wu 1969, Roberts *et al.* 1989a) contributed significantly to onshore transport of wastewater. Gravitational collapse results from relaxation of imbalances between density structures in the wastefield and in the adjacent ambient water, even though average densities in the two regions are equal. However, the measured density stratification in the ocean was much less than in laboratory studies. As a result, frictional effects may be important and the rate of collapse may be much lower than computed in the simulations (e.g., Amen and Maxworthy 1980). In this case, cross-shore transport would be substantially overestimated in the simulation, leading to an overestimate of the intrusion probability.

Estimates based on density considerations are more straight forward and provide an upper bound for intrusion probabilities. The primary uncertainties associated with estimates of potential intrusion probabilities are: 1) changes in the height-of-rise during initial dilution associated with differences between the simulated line-source and the final configuration of the outfall diffuser, 2) lack of oceanographic data for late fall and winter conditions, 3) interannual variability in the oceanographic environment, and 4) neglect of the opposing mechanisms of gravitational collapse of the wastefield and vertical mixing.■

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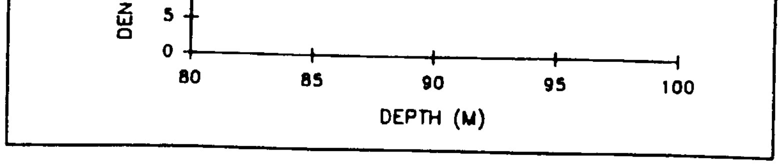
Figure 4
Percent of time the density window was open as a function of the discharge depth for the period of greatest potential for intrusions (3/8/90 to 4/8/90). M4 is the prediction for 83 m (Station C4; Figure 1); M5 is the prediction for 95 m (Station C5).



Appendix 1:

Receiving Water Characteristics

Current meter and thermistor data were collected at 30 min intervals between March and October 1990. Fluctuations in the currents and temperature structure of the water column were separated by their temporal properties. A 24.75 hr running-average filter was used to divide the time-series into: 1) net current and current fluctuations that vary more slowly than tidal changes ("subtidal" component) and 2) tidal and higher frequency fluctuations ("tidal" component). Flows associated with subtidal fluctuations were predominantly longshore; the principal axis averaged 351-359° magnetic. Transport associated with tidal fluctuations was roughly isotropic (independent of direction), but with a small longshore enhancement. Transport distances characterizing tidal fluctuations were 1-3 km; distances characterizing subtidal fluctuations were tens of kilometers in the longshore direction.

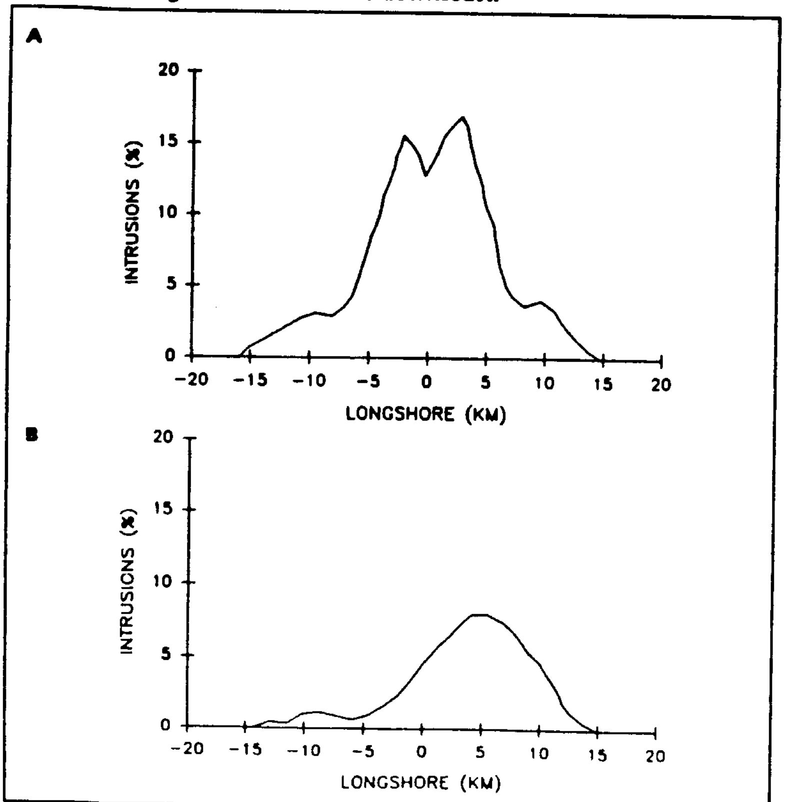
Net flows at depths greater than 40 m were upcoast and ranged from 1.3 to 4.0 cm/sec depending on the distance offshore. The net flow at 20 m had weaker upcoast transport and ranged from 1.4 to 2.4 cm/sec. Net flows in the cross-shore direction were weakly onshore at a depth of 20 m (-0.1 to 0.8 cm/sec). The tendency for onshore flow increased with depth and peaked at 60 m (0.7 to 1.9 cm/sec). Within a few meters of the bottom, net cross-shore movement was offshore (-0.1 to -1.1 cm/sec).

Although data were collected from a large number of current meters and thermistors, the instruments covered only a fraction of the area around the Point Loma outfall. Previous measurements off San Diego (Hendricks 1977) and 30-80 km upcoast (Winant 1983) indicate coherence length-scales of 30-50 km for the subtidal longshore component of the currents. In this study, the coefficient of determination (r^2) for the subtidal longshore component for moorings 2 km apart ranged from 0.42 to 0.85 (increasing offshore). For vertical separations of 20 m on one mooring, r^2 ranged from 0.35 to 0.79 (increasing offshore). For the longshore component of tidal fluctuations, r^2 ranged from 0.14 to 0.72 for horizontal separations of 2 km, and 0.11 to 0.42 for vertical separations of 20 m on one mooring; r^2 generally increased offshore. The dominant pattern for fluctuations in both frequency ranges was a mode in which changes occurred in the same direction at all depths (barotropic mode).

Correlation length-scales for cross-shore motions were shorter than for longshore motions. In the tidal band, r^2 for horizontal separations of about 2 km typically ranged from 0.16 to 0.66, but fell to 0.003 between the innermost pair of moorings (Figure 1). Cross-shore motions are dominated by top and bottom currents in the opposite direction (baroclinic mode). Coefficients of determination between currents at 20 m and currents near the bottom ranged from 0.07 to 0.23. For fluctuations in the subtidal band, r^2 ranged between 0.13 and 0.62 for cross-shore motions at horizontal separations of about 2 km. For the tidal band, r^2 between the innermost two moorings was 0.03. Coefficients of determination between subtidal fluctuations for a vertical separation of 20 m were 0.01 to 0.14 and the flow tended to be barotropic. The

Figure 5

Probability of intrusion as a function of distance away from an outfall discharging in (a) 83 m of water and (b) 95 m of water. Positive distances are upcoast and negative distances are downcoast.



short correlation length-scales for cross-shore motions illustrate the difficulty and uncertainty in estimating cross-shore transport from the current meter data, especially in view of vertical wastefield excursions associated with internal tides and internal waves.

Fluctuations in water temperatures had longer correlation length-scales than did currents, especially for vertical separations (Figure 6). As a result, we could estimate the position of a segment of the wastefield in the water column from temperature data better than we could estimate the cross-shore transport of the same segment from current measurements.

Appendix 2:

Model Formulation

The first stage of modeling simulated formation of a wastefield in the water column after initial dilution. Simultaneous measurements of water column temperature structure and ocean currents in the entrainment region were used to compute characteristics of the wastefield at 30 min intervals. Of particular significance for the intrusion analysis was estimation of ambient water temperature at the depth of the top of the wastefield.

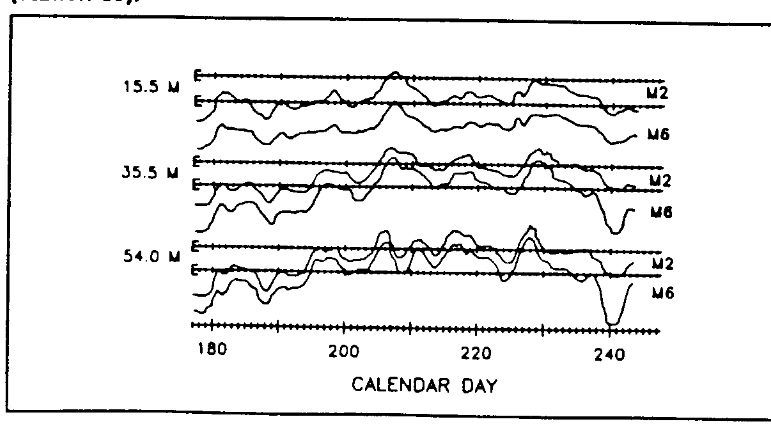
The initial dilution model (TSLINE) was developed from physical model studies by Roberts *et al.* (1989a,b,c), which used a constant density gradient ("linear density profile") in the receiving water. The density gradient in the ocean, however, generally increased with decreasing depth until reaching the pycnocline. The equilibrium depth of the wastefield in the water column was calculated iteratively by assuming a linear density gradient between diffuser port depth and equilibrium depth. The density at each depth was estimated by interpolation from thermistor measurements. Temperature was converted into density using temperature-salinity-density relationships from CTD (conductivity-temperature-depth) data collected on monthly hydrocast surveys.

Once the equilibrium depth of the wastefield was determined, the ambient water temperature at the top of the wastefield ("wastefield temperature") was computed from the average temperature gradient. The depth of the top of the wastefield was estimated using relations in Roberts *et al.* (1989a,b,c) for a line source discharge. In the presence of an increasing temperature gradient with decreasing water depth, the approximations tended to overestimate height-of-rise of the plume, but may have underestimated wastefield temperature.

Ambient water temperature was used as a surrogate indicator of the location of the top of the wastefield in the intrusion analysis and was stored in a time-series (along with other wastefield indicators such as length of each wastefield segment). The wastefield was represented by a collection of individual segments, each of which had a temperature, and hence a position in the water column. At each time step during the *potential* intrusion simulations, the temperature at the bottom of the kelp bed was compared with the temperature of each wastefield segment formed earlier during the simulation. In practice, the comparison was limited to segments formed within the preceding 5 days (earlier segments were assumed to have been carried out of the area). Since the wastefield was either present or absent at a given time, the comparison with wastefield segments for a specific time during the simulation was terminated as soon as a potential intrusion was detected. The probability of a potential intrusion occurring within the simulation area was the total number of potential intrusions during the simulation period divided by the number of time steps during the period.

In the second stage of modeling, the transport of each segment of the wastefield was simulated as it moved away from the diffuser. The first step was to establish the position of each segment in the water column. The cross-shore position at each time step was used to determine the pair of thermistor moorings that bracketed the position. Water temperatures recorded at the two closest thermistor moorings were examined to find the depths that corresponded to wastefield temperature. These depths were used to determine the pair of current meters on each of the two closest moorings that bracketed the depth associated with the wastefield

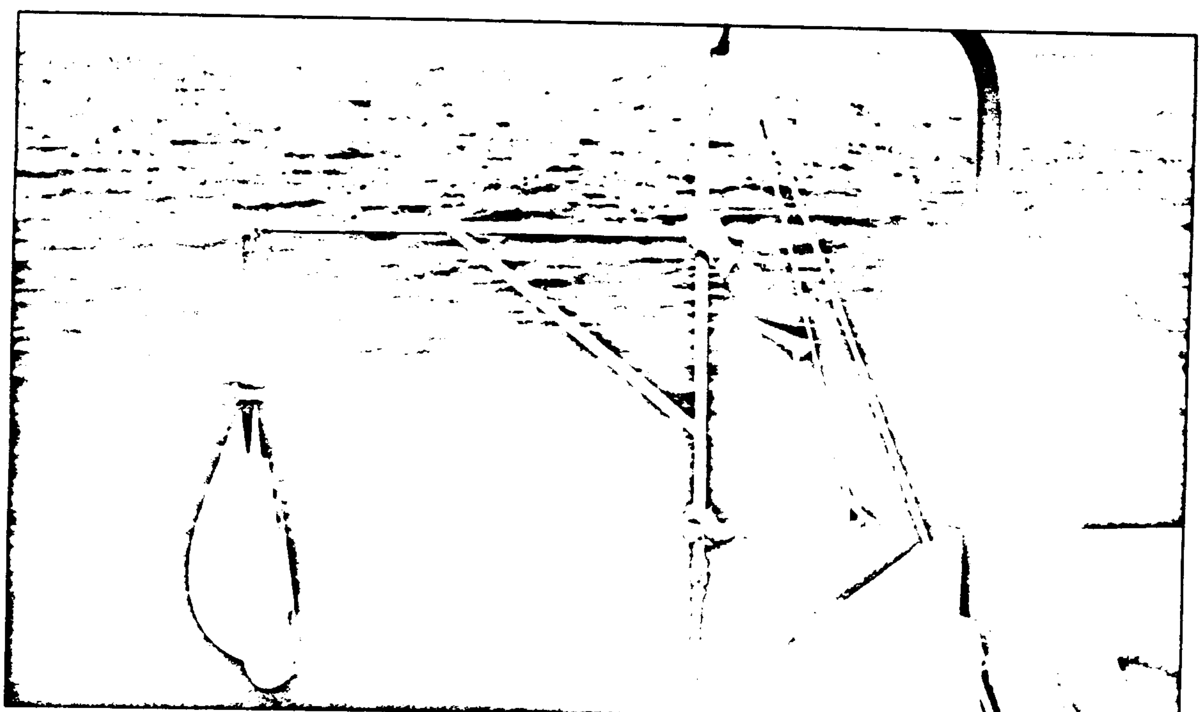
Figure 6
Temperature fluctuations in the subtidal frequency mode from June to August 1990 at three depths on moorings M2 (Station C2; Figure1) and M6 (Station C6).



temperature. Velocities measured at the pair of moorings were used to estimate the velocity components at the wastefield depth at each mooring. These were interpolated to estimate the velocity at the location of the wastefield segment. This velocity was used to estimate the position of the segment at the beginning of the next time step. This process was repeated for each wastefield segment at each time-step until the segment moved beyond the boundaries of the simulation area (16 km upcoast and downcoast from the diffuser), or the current meter data were exhausted. If the segment was transported out of the simulation area, it was removed from further computations.

Since measured flows generally had a net onshore movement, the simulated transport eventually moved a wastefield segment onshore. This cannot occur in the real ocean. To prevent this, the depth and position of each wastefield segment was checked at the end of each time step. If the depth of the segment was greater than the water depth at its predicted location, the segment was in deeper water farther offshore. Therefore, the predicted position of the wastefield segment was moved offshore until its depth was equal to the water depth.

An *actual* intrusion occurred whenever a wastewater segment moved inshore of the 25 m isobath (although kelp beds are absent from some sections of the coast). To calculate intrusion probabilities, the coast was divided into 1 km intervals. The fraction of each coastal interval affected by the intrusion was determined from the longshore position of the segment and segment length. For example, if a 1 km coastal interval was included within a wastefield segment, the probability of an intrusion was unity. If the segment only spanned one-quarter of the coastal interval, the intrusion probability was 0.25. The probability of an intrusion within a coastal interval at any given time in the simulation was equal to the sum of the probabilities associated with each wastefield segment at that time. The intrusion probability for the coastal interval for an entire simulation period was equal to the sum of the probabilities for each computation time divided by the number of these times during the period.



Deploying tilt current meter

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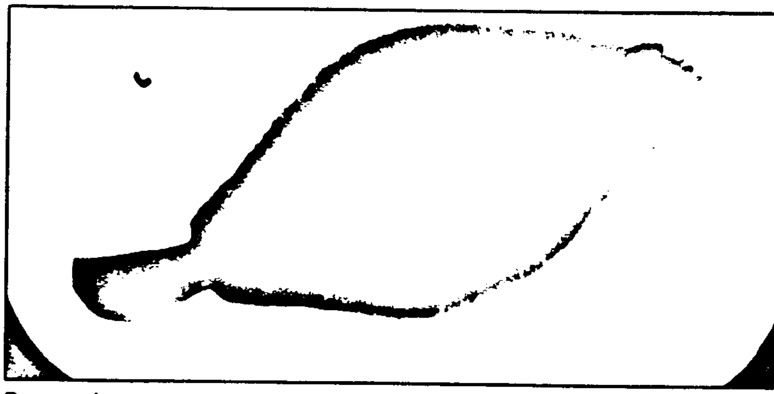
Response of Dover Sole to Termination of Sludge Discharge in Santa Monica Bay

Dover sole *(Microstomus pacificus)* commonly occur on the upper slope off Southern California at depths to about 1000 m (Allen and Mearns 1976). Most of the fish migrate into shallow water in summer related to feeding and back into deep water in the winter for reproduction (Hagerman 1952).

Dover sole are more abundant near municipal wastewater outfalls and the incidence of fin erosion and epidermal tumors is also higher in these areas (Cross 1985, 1986). Fish in contaminated areas may be more susceptible to these diseases due to elevated body burdens of contaminants, which may interfere with the immune system of the fish.

A major dietary component of Dover sole is polychaetes, especially *Capitella* spp. (Pearcy and Hancock 1978). The high levels of total organic carbon (TOC) in the sediments near the Joint Water Pollution Control Plant (Los Angeles County) outfall support high abundances of deposit feeding polychaetes like *Capitella*, and this probably supports the higher abundance of Dover sole in these areas (Cross *et al.* 1985).

The Hyperion sewage treatment plant terminated discharge of solid waste into the Santa Monica Bay in November 1987. Termination of sludge discharge caused changes in the biology of the macrofauna in the area near the outfall (Thompson 1991). The objective of this study was to examine changes in the abundance of Dover sole as a result of termination of sludge discharge.



Dover sole

Materials and Methods

Biologists from the Environmental Monitoring Division (City of Los Angeles) and SCCWRP collected fish at 12 stations in Santa Monica Bay from July 1986 to August 1990. Fish were collected by dragging a 7.6 m otter trawl for 10 min along a depth isobath at approximately 2 knots. Trawls were made during the summer (Jul-Aug) and winter (Jan-Feb) at two stations at 100 m and two stations at 200 m in each of three zones; there were no trawl collections in winter 1987. Fish were counted, measured (standard length) to the nearest centimeter, and examined for diseases (fin erosion and tumors). The catch was weighed to the nearest 0.1 kg by species.

Raw abundance data were not normally distributed and variances increased with increased means. Log transformation of abundance produced a normal distribution with homogeneous variances. The transformed data were analyzed by analysis of variance for effects of depth (100 and 200 m), season (winter and summer), location relative to the outfall (reference, transition, and contaminated zones), and pre- and post-sludge discharge. Disease incidence and sediment TOC data were transformed with the arcsin. The transformed TOC data were analyzed by analysis of variance for effects of depth, season, location relative to the outfall, and pre- and post-sludge discharge.

Three zones differing in the effect of sludge discharge were identified by benthic macrofauna assemblages: contaminated, transition, and reference. Sediment and infauna samples were collected using a modified Van Veen grab with an area of 0.1 m^2 along the 100 m and 200 m isobaths; two stations at each depth were located in each zone (Thompson 1991).

Results

The abundance of Dover sole in the trawls was significantly affected by season, distance of collection from the outfall (zone), and termination of sludge discharge (Table 1). Dover sole were generally more abundant in the summer (Table 2). Dover sole were most abundant in the contaminated zone near the outfall, least abundant in the reference zone, and intermediate in abundance in the transition zone. The abundance of Dover sole declined after the termination of sludge discharge. There was no significant difference in abundance of fish at 100 m and 200 m.

Epidermal tumors and fin erosion occurred in 5% of all Dover sole collected and the proportion of disease decreased with distance from the sludge outfall (Table 3). The highest incidence of disease occurred among fish collected on the 100 m isobath in the contaminated zone. There was little or no disease among fish collected in the reference and transition zones, although they were significantly different from each other.

Discussion

The seasonal patterns of Dover sole abundance observed in this study are consistent with the seasonal migration patterns of Dover sole reported by others (Hagerman 1952, Cross 1985, Hunter *et al.* 1990). The higher abundance of Dover sole, and the increased prevalence of fin erosion and epidermal tumors, in the contaminated zone near the sludge outfall is similar to the pattern observed among fish collected near the municipal wastewater outfalls on the Palos Verdes Shelf (Cross 1985, 1986). Of the nearly 60 species collected on the Palos Verdes Shelf, Dover sole were the most susceptible to tumors and fin erosion (Cross 1985).

The decrease in Dover sole abundance and disease prevalence after termination of solid waste discharge indicates that benthic conditions are improving near the outfall. The decline in fish abundance may be related to decreased organic content and prey abundance in the sediments. The abundance of Dover sole was correlated with the organic carbon content of the sediments. The concentrations of TOC in surface sediment was significantly higher near the outfall and declined somewhat after termination of solid waste discharge (Table 4). The abundance of polychaetes in grab samples was also correlated with TOC ($r=0.214$, $n=95$, $0.02<p<0.05$). Sediments with high organic content support large populations of deposit feeders such as polychaetes, which are the main prey item of Dover sole (Gabriel and Pearcy 1981, Cross *et al.* 1985).

Further evidence for the link between Dover sole abundance, sediment organic content, and polychaete abundance was observed during an anomalous incident. During the summer of 1989, the abundance of fish at the contaminated stations declined well below abundances recorded in previous summers. By the summer of 1990, abundances had returned to pre-1989 levels. In the summer of 1989, sediment TOC levels and polychaete abundances decreased, and the sand content of the sediments increased, at canyon stations close to the sludge outfall. High down-canyon currents were also measured during this period. These currents may have been responsible for increased levels of sand and decreased levels of TOC in the contaminated zone. Burial of the high organic sediments by shelf sediments entrained in the high currents, or resuspension of the organic material, may have increased the amount of sand and decreased the number of

Table 1

Analysis of variance of Dover sole abundance (log transformed number per 10 min trawl). Main effects are before and after termination of sludge discharge (pre/post), season (winter and summer), zone (contaminated, transition, and reference), and depth of collection (100 and 200 m). Interactions were not significant ($p>0.05$); N = 108, R^2 = 0.585. SS = sum of squares, DF = degrees of freedom, MS = mean square, F = MS main effect/MS error, P = probability.

Source	SS	DF	MS	F	P
Pre/Post	0.676	1	0.676	4.108	0.046
Season	0.773	1	0.773	4.696	0.033
Zone	11.373	2	5.686	34.552	0.000
Depth	0.241	1	0.241	1.466	0.229
Error	13.824	84	0.165		

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polychaetes. Reduced prey availability may account for the decline in the number of Dover sole collected. By the winter of 1990, the characteristics of the sediments had returned to pre-1989 conditions and the relative abundances of Dover sole and their prey species increased to former levels.

Conclusions

Termination of sludge discharge has significantly changed the marine environment in the area of the sludge outfall in Santa Monica Bay. The decreased incidence of disease in the Dover sole population is a positive sign of improving conditions. This trend of improvement will likely continue in the future. ■

Table 2
Dover sole abundance (number/10 min trawl) in the contaminated, transition, and reference zones in winter and summer collections before and after sludge discharge termination (pre and post) in Santa Monica Bay. Data from the 100 and 200 m stations combined. N = number of trawls in each zone, SD = standard deviation.

			Contaminated		Transition		Reference	
		N	Mean	SD	Mean	SD	Mean	SD
Pre	Winter	4	62.5	70.1	48.3	40.4	10.8	11.8
	Summer	8	101.6	66.7	41.1	31.5	6.3	4.6
Post	Winter	12	36.2	29.0	21.2	23.4	4.8	5.1
	Summer	12	83.7	74.6	25.8	24.6	13.3	10.8

Table 3
Summary of incidence of epidermal tumors and fin erosion in the contaminated, transition, and reference zones, during winter and summer, before (pre) and after (post) termination of sludge discharge in Santa Monica Bay. Data from the 100 and 200 m stations combined. N = number of trawls in each zone, SD = standard deviation.

			Contaminated		Transition		Reference	
		N	Mean	SD	Mean	SD	Mean	SD
Pre	Winter	4	12.8	20.9	0.5	1.0	0	
	Summer	8	10.1	9.0	0.3	0.7	0	
Post	Winter	12	2.5	3.6	0.1	0.3	0.1	0.3
	Summer	12	2.4	3.7	0.3	0.6	0.3	0.6

Table 4
Summary of sediment total organic carbon (%TOC) content in the contaminated, transition, and reference zones, during winter and summer, before (pre) and after (post) termination of sludge discharge in Santa Monica Bay. Data from the 100 and 200 m stations combined. N = number of trawls in each zone, SD = standard deviation.

			Contaminated		Transition		Reference	
		N	Mean	SD	Mean	SD	Mean	SD
Pre	Winter	4	2.9	1.4	1.9	1.1	1.2	0.3
	Summer	8	2.7	1.1	1.9	1.2	1.2	0.2
Post	Winter	12	2.8	1.4	1.8	1.1	1.1	0.4
	Summer	12	2.2	1.2	1.7	1.2	1.2	0.2

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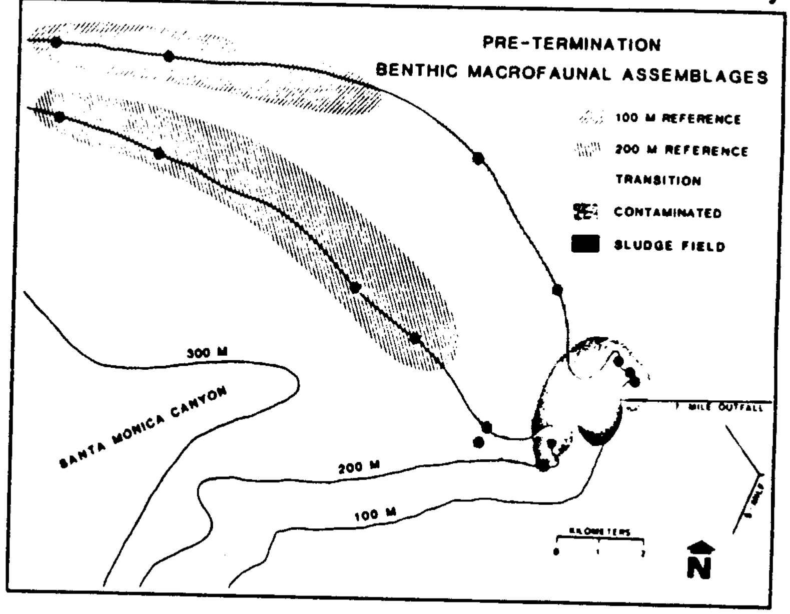
Temporal and Spatial Changes in Sediment Toxicity in Santa Monica Bay

The City of Los Angeles stopped discharging sludge into Santa Monica Bay in November 1987. As a result, the mass emissions of solids and contaminants into the bay have declined substantially (SCCWRP 1989). The effect of this event on the sediment quality and marine life in Santa Monica Bay was examined by SCCWRP from 1986 to 1990 (Thompson 1991).

This report describes the results of one component of the study, sediment toxicity in Santa Monica Bay. The objectives were to document temporal changes in sediment toxicity at the sludge discharge site, and to compare the relative sediment toxicity with the chemical characteristics of the sediments.

Figure 1.
Locations of sampling stations and the Hyperion sludge outfall in Santa Monica Bay.



Methods

Sediment samples were collected from eight stations in Santa Monica Bay (Figure 1). A pair of stations was located in each of four zones characterized by different benthic macrofaunal assemblages: reference (Stations 5 and 6), transition (3 and 4), contaminated (1 and 2), and canyon (sludge field; 50 and 51) (Thompson 1991). All stations, except those in the canyon, were located at a depth of 100 m.

Temporal changes in the toxicity of canyon zone sediments were determined by laboratory tests on samples collected five times between November 1987 and August 1990. Spatial changes in toxicity among the four zones were investigated by laboratory tests with sediments collected in August 1989 and August 1990.

Surface sediment (upper 2 cm) was removed from the Van Veen grab sample, placed in a plastic jar, and stored refrigerated for up to two weeks before the toxicity tests. Short-term (10 days) and long-term (28 days) tests were conducted with the amphipod, *Grandidierella japonica*, using methods described in Nipper *et al.* (1989). Survival was measured in the short-term test, while survival and growth (change in body length per 28 days) were measured in the long-term test. Sediment from the amphipod collection site in Newport Bay was included in each test as a laboratory control.

The stations sampled and the number of replicates varied between collections because of sampling difficulties and limited availability of amphipods. Three replicates of one composite sediment sample from station 50 were tested in 1987 and 1988.

Single grab samples (not replicated) from Stations 1, 2, 4, 5, 6, 50, and 51 were tested in August 1989. Replicate grab samples from stations 50 and 51 were tested in February 1990. Replicate grab samples from stations 1, 2, 3, 4, 5, 6, 50, and 51 were tested in August 1990.

The sediment samples were analyzed for grain size (sand, silt, and clay), total organic carbon (TOC), total nitrogen (TN), dissolved sulfides, cadmium, copper, zinc, silver, DDT, DDE, DDD, Aroclor 1242, Aroclor 1254, hexachlorobenzene, and 22 polynuclear aromatic hydrocarbons (PAHs). Sediment analyses and toxicity tests were conducted on subsamples of sediment from the same grab sample. The chemistry data and analytical methods are found in Anderson *et al.* (1988) for the 1987-88 samples and Thompson (1991) for the 1989-90 samples.

Data for chlorinated hydrocarbons and polynuclear aromatic hydrocarbons were normalized to sediment organic carbon content prior to statistical analyses. Nonionic hydrocarbon concentration data are more highly correlated with biological effects when normalized to organic carbon than when expressed on a dry weight basis (Di Toro *et al.* 1991). Trace metal concentrations, grain size, TOC, and TN were expressed on a dry weight basis.

The data were tested for differences among zones and the laboratory control by single factor analysis of variance and Dunnett's multiple comparison test. The relations between changes in sediment characteristics and toxicity were examined with Spearman rank correlation coefficients.

Results

Temporal Changes in Toxicity

The 10-day survival of amphipods in laboratory control sediment (Newport Bay) varied between experiments, especially in February 1990 (Table 1).

Table 1.
Survival of Grandidierella japonica following 10-day exposure to sediments from the Canyon Zone (Stations 50 and 51) in Santa Monica Bay. Data are mean and one standard deviation (in parentheses). Three samples from each station were analyzed in 1987 and 1988, two samples were analyzed in 1989, and four samples were analyzed in 1990.

	10-Day Survival (%)				Adjusted survival % of control
	Canyon Zone		Lab Control		
Nov. 1987	35	(35)*	92	(7)	38
Apr. 1988	8	(14)*	88	(7)	9
Aug. 1989	90	(0)	98	(4)	92
Feb. 1990	53	(10)	65	(6)	82
Aug. 1990	72	(21)*	94	(6)	76

*Means significantly different from lab control (ANOVA and Dunnett's test, $p<0.05$).

Survival was expressed as percent of the laboratory control to compensate for variability in control survival. The adjusted survival of *G. japonica* doubled between 1988 and 1989 suggesting a dramatic reduction in the toxicity of canyon zone sediment (Table 1). Survival in canyon sediment remained high in subsequent experiments, although survival in the August 1990 experiment was significantly less than the laboratory control.

Spatial Changes in Toxicity

Amphipod growth rates were similar between the 28-day exposures in 1989 and 1990 (Table 2) and were not significantly different among the zones (ANOVA, $p>0.05$). Growth rates in 1990 were less variable among zones than growth rates in 1989. Growth rates were expressed as percent of the laboratory control to compensate for variations between experiments.

Amphipod survival during the 28-day tests was variable and not significantly different among the zones (Table 2). Animals exposed to reference zone sediment in 1990 had the lowest survival, while amphipods exposed to contaminated zone sediment had the highest survival.

Toxicity and Sediment Characteristics

The relation between toxicity and sediment characteristics was examined with the data from five experiments with canyon zone sediments. Correlations and *post hoc* hypotheses were used to identify which of the measured sediment variables corresponded with reductions in toxicity during the course of the study.

Spearman rank correlations were calculated between amphipod toxicity and sediment characteristics (Table 3). We assumed that sediment constituents exerting toxic effects would have negative coefficients; a correlation of -1.0 is the strongest possible relation (i.e., reduced concentration accompanied by increased survival). Organic carbon, organic nitrogen, naphthalene, C1 substituted naphthalenes, and sulfide had high negative correlations. Hexachlorobenzene was the only chlorinated hydrocarbon that was negatively correlated with survival. Correlation coefficients for DDTs and PCBs were positive, indicating that amphipods had higher survival at higher concentrations. Zinc had the largest negative correlation among the trace metals.

In the second analysis, sediment data for the canyon zone were divided into low toxicity samples (1989 and 1990 tests) and high toxicity samples (1987 and 1988 tests) (Table 3). Mean chemical concentrations in the low toxicity group were compared to those in the high toxicity group (hydrocarbons were TOC normalized). We assumed that only contaminants with a substantial concentration reduction from 1987/88 to 1989/90 would have played a role in temporal toxicity changes.

The greatest change between the high and low toxicity groups was the reduction in sulfide concentration (Table 3). Concentrations of anthracene, C2 and C3 substituted phenanthrenes, and perylene declined by more than 50%. Concentrations of 29 of the 36 measured constituents declined

Figure 2.
Scatterplot of Spearman rank correlations and relative concentration change for canyon zone sediments in the 10-day amphipod survival test. The correlations were calculated between toxicity and sediment chemistry. The concentration change compared sediments collected in 1989/90 to sediments collected in 1987/88. Labelled points in the lower left quadrant are the sediment characteristics that had the greatest relation to temporal toxicity changes. C1NAPH = C1 substituted naphthalenes, C1-C3PHEN = C1-C3 substituted phenanthrenes, HCB = hexachlorobenzene, NAPH = naphthalene, PCB42 = Aroclor 1242, PCB54 = Aroclor 1254, PERY = perylene, PPDDD = p,p'DDD, S = dissolved sulfide, TN = total nitrogen, TOC = total organic carbon.

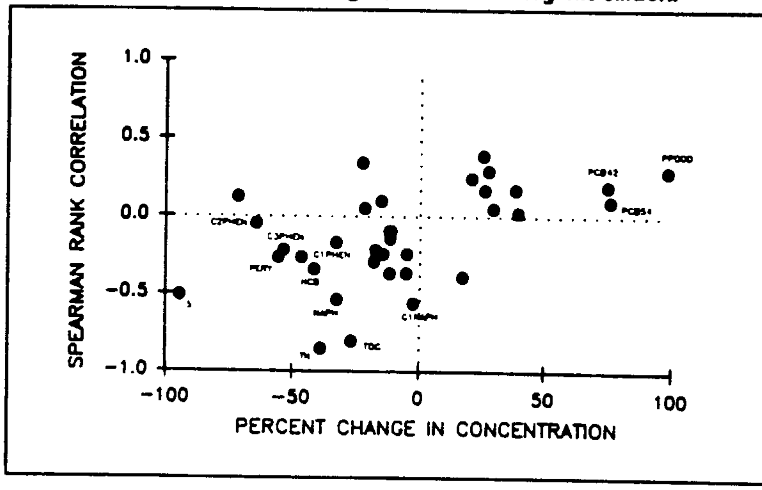


Table 2
Mean growth (mm/28 days) and survival (percent) of Grandidierella japonica following 28-day exposure to sediments from Santa Monica Bay and Newport Bay (laboratory control). N = 2 for each zone in 1989; N = 4 for each zone in 1990 (except transition where N = 2). Data are mean and one standard deviation (in parentheses).

	Growth				Survival			
	mm/28 day		% of control		Percent		% of control	
	1989	1990	1989	1990	1989	1990	1989	1990
Lab control	3.4 (0.1)	2.8 (0.3)	100	100	42 (12)	74 (6)	100	100
Reference	2.2 (0.5)	2.0 (0.8)	65	71	50 (8)	26 (21)	119	35
Transition	2.3 (0.7)	1.6 (0.4)	68	57	20 (19)	31 (29)	48	42
Contaminated	2.9 (0.2)	1.8 (0.4)	85	68	22 (8)	47 (13)	52	64
Canyon	1.8 (0.3)	1.8 (0.4)	53	64	25 (4)	44 (50)	60	59

by less than 25%. The mean concentrations of 16 contaminants, including DDTs, PCBs, and silver, increased.

Ten contaminants had the greatest expected responses (negative correlation and reduced concentration): sulfide, TOC, TN, hexachlorobenzene, naphthalene, C1 substituted naphthalenes, phenanthrene, C2 and C3 substituted phenanthrenes, and perylene (Figure 2). The patterns of change in sulfide and organic enrichment (TOC) at Station 50 matched the temporal change in toxicity (mortality) most closely (Figure 3). The change in TN was similar to that of TOC (data not shown). The concentrations of the hexachlorobenzene, naphthalenes, phenanthrenes, and perylene declined between 1987 and 1988, a period during which amphipod toxicity remained high (Figures 4 and 5).

Figure 3.
Temporal changes in 10-day amphipod (*Grandidierella japonica*) mortality, dissolved sulfide, and sediment TOC for Station 50 (canyon zone).

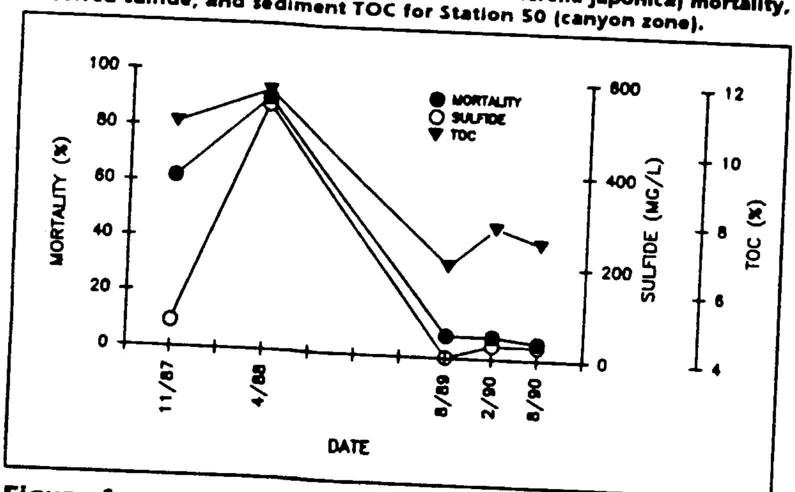
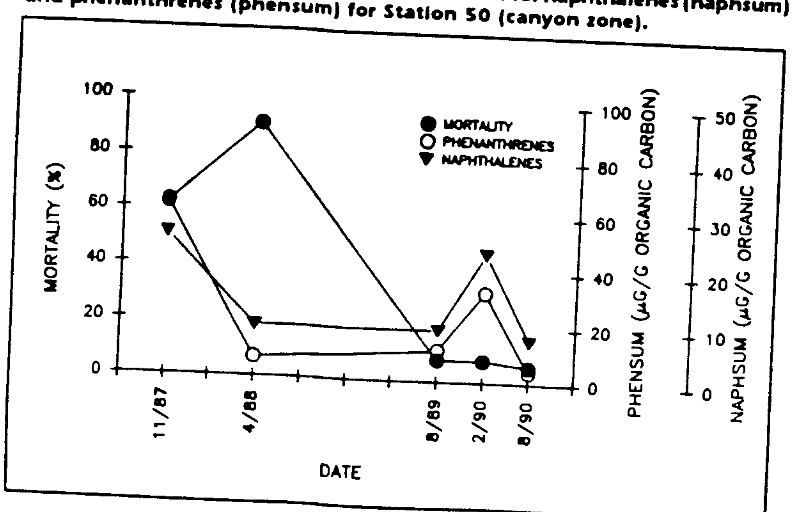


Figure 4.
Temporal changes in 10-day amphipod (*Grandidierella japonica*) mortality and the TOC-normalized sediment concentrations for naphthalenes (naphsum) and phenanthrenes (phensum) for Station 50 (canyon zone).



Discussion

Laboratory tests with *Grandidierella japonica* documented: 1) a decrease in the toxicity of sediments in the canyon zone (sludge field) between April 1988 and August 1989, and 2) sediment quality at 100 m in the transition, contaminated, and canyon zones in 1989 and 1990 was similar to sediment quality in the reference zone. The reduction in toxicity of sediments in the sludge field occurred during a period of marked changes in animal species composition and abundance (Thompson 1991). This indicates that laboratory toxicity tests with *G. japonica* included relevant sediment qualities that were important to organisms living in Santa Monica Bay.

Changes in the concentration of hydrogen sulfide, TOC, and TN (sediment characteristics associated with organic enrichment) were strongly related to the changes in toxicity (Table 3). Sea urchins exposed to sulfide at concentrations comparable to those measured in canyon zone sediments suffer reduced growth and increased mortality (Thompson *et al.* 1991).

Naphthalenes, phenanthrenes, perylene, and hexachlorobenzene were identified as potential

Table 3

Changes in Santa Monica Bay canyon sediment characteristics and their correlation (Spearman rank correlation coefficient, r_s) to 10-day amphipod survival. Percent change in sediment concentration is the difference between means of the high toxicity group (Station 50 in 1987 and 1988) and the low toxicity group (Station 50 in 1989 and 1990). Negative change indicates a reduction in concentration from the high to the low toxicity group. Reference concentrations are means for Stations 5 and 6 between 1987 and 1990. Hydrocarbon concentrations are expressed relative to the organic carbon (oc) content of the sediment; remaining sediment constituents are expressed on a dry weight basis.

	r_s	% Change	Concentration 1987/88	Concentration 1988/89	Concentration Reference
TN (%)	-0.85	-39	1.16	0.70	0.01
TOC (%)	-0.80	-27	10.99	8.02	0.95
C1-Naphthalenes (μg/g_{oc})	-0.56	-3	7.24	7.05	0.28
Naphthalene (μg/g_{oc})	-0.53	-33	2.72	1.83	0.24
Sulfide (mg/L)	-0.51	-94	293.75	16.07	0.06
Benzo(b)fluoranthene (μg/g_{oc})	-0.39	17	4.39	5.14	1.12
Benzo(e)pyrene (μg/g_{oc})	-0.36	-6	1.96	1.85	0.49
Benzo(a)pyrene (μg/g_{oc})	-0.36	-13	2.42	2.12	0.43
Hexachlorobenzene (μg/g_{oc})	-0.34	-42	0.04	0.02	0.03
Clay (%)	-0.29	-18	9.45	7.71	7.36
C1-Phenanthrenes (μg/g_{oc})	-0.26	-47	6.78	3.60	0.36
Perylene (μg/g_{oc})	-0.26	-56	1.99	0.88	0.98
Benz(a)anthracene (μg/g_{oc})	-0.24	-5	2.41	2.29	0.26
Chrysene (μg/g_{oc})	-0.24	-15	3.13	2.66	0.54
Zinc (mg/kg)	-0.22	-18	491.00	403.33	60.70
C3-Phenanthrenes (μg/g_{oc})	-0.22	-54	15.94	7.35	0.26
Biphenyl (μg/g_{oc})	-0.17	-33	15.32	10.24	0.53
C3-Naphthalenes (μg/g_{oc})	-0.14	-12	2.59	2.28	0.16
Copper (mg/kg)	-0.09	-12	389.95	341.83	22.53
Benzo(ghi)perylene (μg/g_{oc})	-0.09	-12	1.24	1.09	0.39
C2-Phenanthrenes (μg/g_{oc})	-0.04	-65	9.66	3.43	0.27
Sand (%)	0.02	39	35.75	49.73	42.44
Silt (%)	0.04	-22	54.75	42.53	50.12
Silver (mg/kg)	0.04	29	24.78	32.01	1.18
Cadmium (mg/kg)	0.09	-16	22.07	18.60	0.27
Aroclor 1254 (μg/g_{oc})	0.09	76	4.55	7.99	5.85
Anthracene (μg/g_{oc})	0.12	-72	0.88	0.25	0.06
9,10-Diphenylanthracene (μg/g_{oc})	0.12	290	0.03	0.14	0.06
p,p'-DDT (μg/g_{oc})	0.17	327	0.03	0.14	0.09
C2-Naphthalenes (μg/g_{oc})	0.17	38	4.72	6.52	0.35
Dibenz(ah)anthracene (μg/g_{oc})	0.17	25	0.37	0.46	0.08
Aroclor 1242 (μg/g_{oc})	0.19	74	1.59	2.78	1.03
Pyrene (μg/g_{oc})	0.19	107	3.58	7.42	1.37
Fluoranthene (μg/g_{oc})	0.24	20	3.80	4.57	0.74
Benzo(k)fluoranthene (μg/g_{oc})	0.26	648	0.03	0.24	0.07
p,p'-DDE (μg/g_{oc})	0.29	26	1.63	2.07	7.88
p,p'-DDD (μg/g_{oc})	0.29	97	0.22	0.43	0.98
Phenanthrene (μg/g_{oc})	0.34	-23	2.24	1.72	0.41
o,p'-DDE (μg/g_{oc})	0.39	24	0.13	0.17	1.30
o,p'-DDT (μg/g_{oc})	0.53	334	0.06	0.28	0.12
2,3-Benzofluorene (μg/g_{oc})	0.56	100	0.44	0.89	0.74

contributors to reductions in the toxicity of canyon zone sediments. Hexachlorobenzene concentrations, however, were similar in all four zones (Table 3) and were unlikely to have a significant influence on toxicity.

Draft sediment quality criteria have been proposed for phenanthrene based on equilibrium partitioning theory. Concentrations less than 120 μg/g organic carbon (95% confidence limits: 74-340 $\mu g/g_{oc}$) are "protective" of marine benthic organisms. Phenanthrene concentrations in excess of 3,000 $\mu g/g_{oc}$ produce 50% amphipod mortality in spiked sediment experiments (U.S. E.P.A. 1992). The mean phenanthrene sediment concentration in the high toxicity group in this study was 2.2 $\mu g/g_{oc}$, three orders of magnitude below the toxic levels in spiked sediment tests. The combined concentrations of naphthalenes and phenanthrenes in the high toxicity group was 52 $\mu g/g_{oc}$, approximately half of the draft E.P.A. criterion.

It is unlikely that the low molecular weight PAH compounds were the principal factor in the temporal toxicity changes in Santa Monica Bay sediments. These compounds may have contributed to the reductions, but additional laboratory testing with pure chemicals is needed before conclusions can be drawn. Insufficient data were available to evaluate the influence of perylene on toxicity in this study.

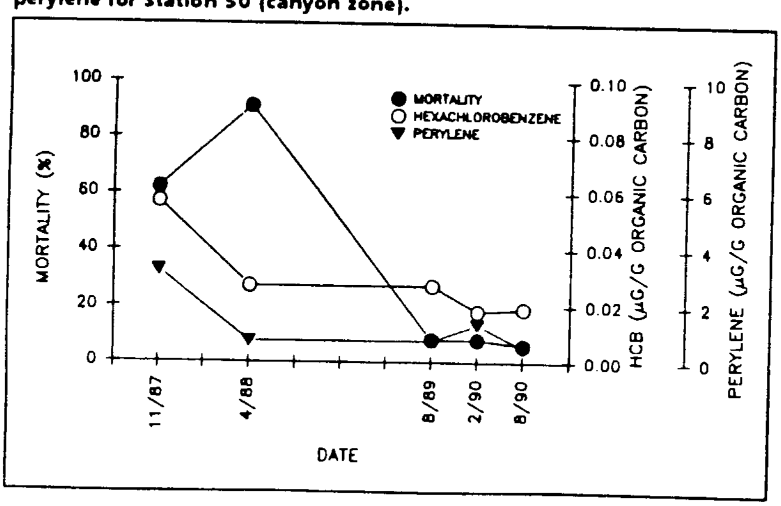
The lack of negative correlations between toxicity and DDT and PCB concentrations was not surprising; TOC-normalized concentrations in the canyon zone were similar to concentrations in the reference area (Table 3).

Conclusions

The reductions in sediment toxicity in 1989 and 1990 did not indicate that the effects of sludge discharge had disappeared in Santa Monica Bay. The assemblages of benthic macrofauna in the canyon, contaminated, and transition zones were still adversely affected in 1990 (Thompson 1991) and the concentrations of many contaminants in the canyon zone were 5-10 times higher than in reference areas (Table 3). We do not know if the differences in composition of macrofauna among the zones were caused by toxic sediments, or if they were the product of variables not represented in the toxicity test (e.g., sediment preferences, interactions among species, etc.). In any case, sediment toxicity tests with *G. japonica* were a less sensitive indicator of sediment quality in Santa Monica Bay than the composition of the benthic macrofauna.

Results based on chemical analyses of field sediments are not definitive, but can guide the selection of contaminants for laboratory research. Additional laboratory tests with sediments from Santa Monica Bay are planned to complement the data reported herein. We will use longer exposures to examine effects on reproduction of *G. japonica* and we will examine the effects of organic enrichment and grain size on benthic organisms. This research will provide some of the data needed to determine the relative influence of the various sediment characteristics on the benthic macrofauna in Santa Monica Bay. ■

Figure 5.
Temporal changes in 10-day amphipod (*Grandidierella japonica*) mortality and the TOC-normalized sediment concentrations of hexachlorobenzene and perylene for Station 50 (canyon zone).



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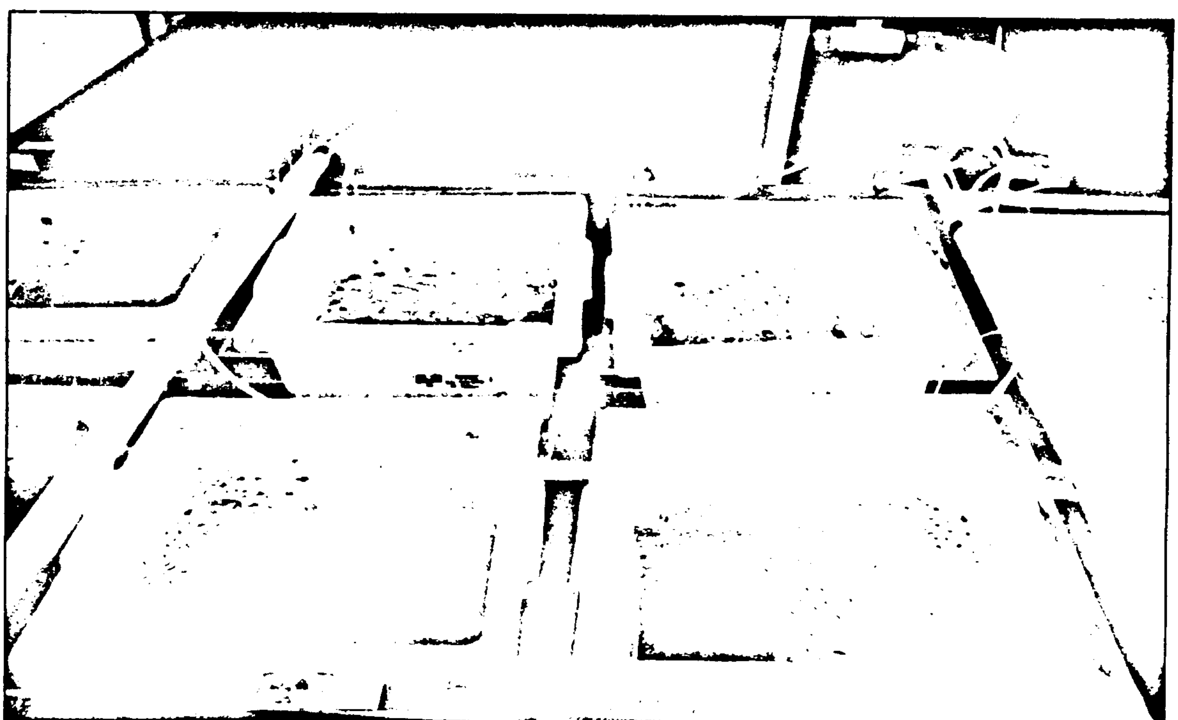

Sediment toxicity tests

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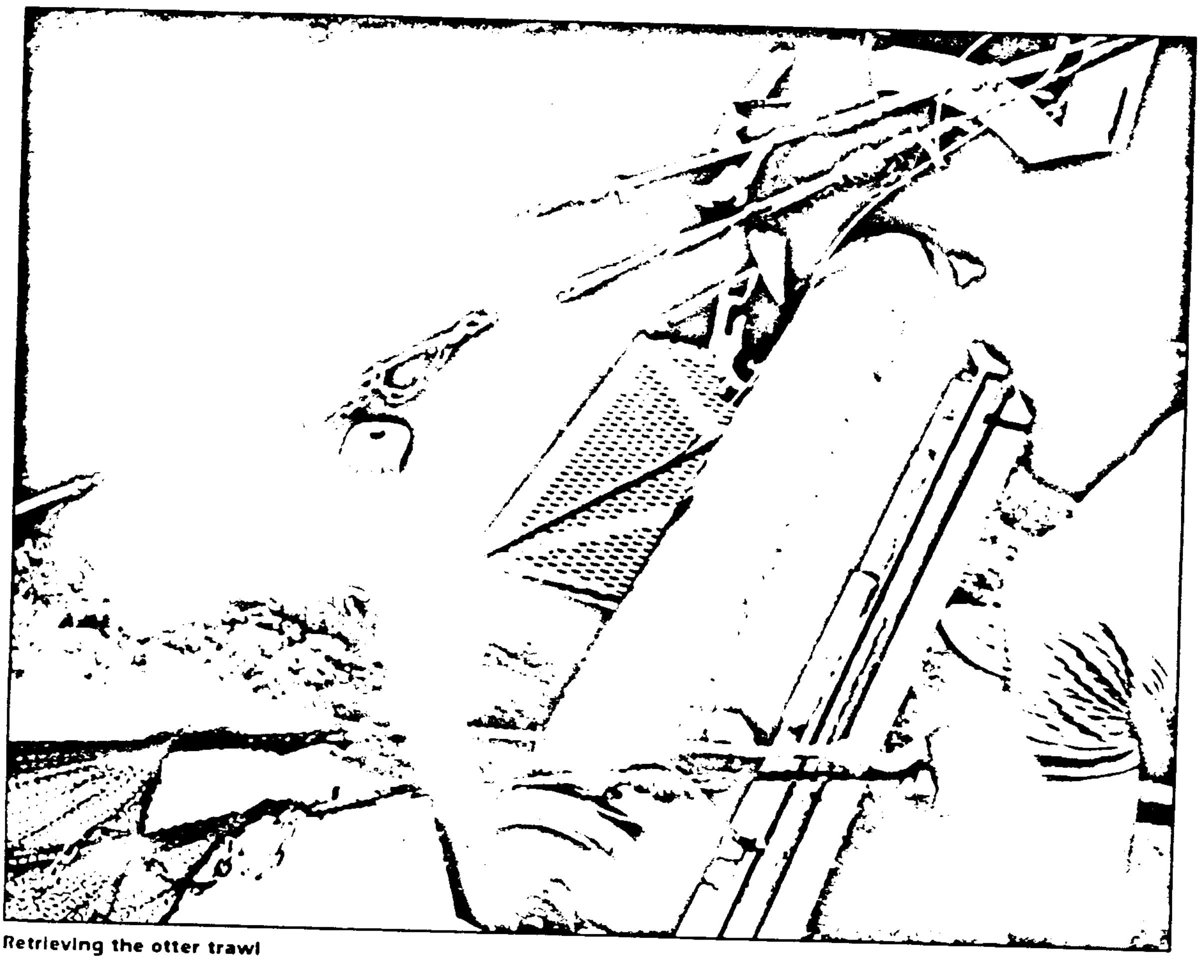
Long-Term Trends in Trawl-Caught Fishes Off Point Loma, San Diego



Retrieving the otter trawl

The mainland shelf off Point Loma is narrow; at roughly 140 m, it drops away into the San Diego Trough. The municipal wastewater outfall for the City of San Diego extends 4 km across the shelf and discharges approximately 256×10^9 L annually (186 mgd) into 60 m of water. Shelf sediments range from sand to sandy-silt; the sand content of the sediments ranges from 37% near the outfall to 52% off Mission Bay (Word and Mearns 1979). Water temperatures are generally cool during the winter and the water column is characterized by weak thermal stratification. Water temperatures are generally warm during the summer and the water column is characterized by strong thermal stratification. Major oceanographic events like El Niño significantly affect water characteristics.

Pacific sanddab, pink surfperch, stripetail rockfish, and longspine combfish were the most abundant fishes collected off Point Loma in the early 1970s (Voglin 1975). Pacific sanddab, English sole, and Dover sole occurred at most stations. Pacific sanddab, white croaker, longfin sanddab, and calico rockfish were the most abundant species at two reference sites near San Diego in 1985 and 1990 (Thompson *et al.* 1987, 1992).

Information on long-term trends in demersal fish populations on the mainland shelf off Southern California is uncommon. Most studies last less then three years (Cross and Allen 1992). The objective of this study was to examine temporal and spatial changes in trawl-caught fishes on the 60 m isobath off Point Loma over a 10-year period. Fish catches were examined in relation to water temperatures.

Materials and Methods

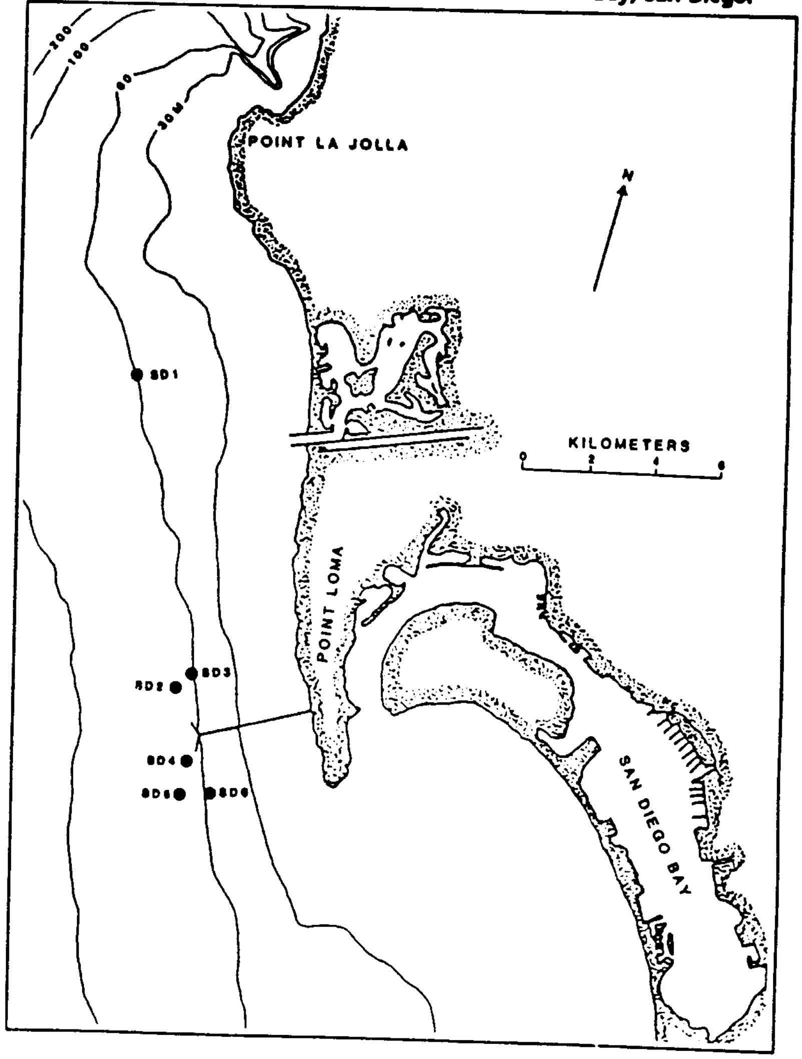
Biologists from the Point Loma Wastewater Treatment Laboratory and SCCWRP collected fishes by otter trawl at six stations off Point Loma near the municipal wastewater outfall for the city of San Diego (Figure 1). Station depths ranged from 55 to 70 m. Sampling began in the summer of 1982 and usually occurred in January (winter) and June (summer). From 1982 and 1992, 120 trawls were made.

One 10-min tow using a 7.6 m (headrope length) otter trawl was made at each station at a scope ratio (towing cable length versus water depth) of 3:1 (Word and Mearns 1979). When more then one trawl was made, the first one was used in the analyses. Vessel speed was approximately 2 knots and roughly 0.7 km were trawled at each station.

All fish in the trawl were identified, counted, measured to the nearest millimeter, and weighed aboard ship. If more than 20 fish of one species were collected, all fish were measured to the nearest centimeter. Unknown fish were returned to the lab and identified to genus and species whenever possible. Fish length data were converted to 1 cm size classes for the analyses.

Temperature data were averaged from four to five Point Loma water quality stations along the 60 m contour. From January 1980 to July 1987, water temperature was measured with a Martec

Figure 1.
Location of trawl stations off Point Loma and Mission Bay, San Diego.



XMS Mark 7. From 1988 on, the water column was profiled with a Seabird CTD (conductivity, temperature, and depth).

The similarity of trawl catches among stations was examined by cluster analysis of abundances standardized to Z-scores. Species occurring in less than 10% of the collections were eliminated. The similarity measure was Euclidean distance and the clustering method was single linkage (nearest neighbor) (Wilkinson 1990). The similarity in species lists was examined with average rank correlations (Mosteller and Rourke 1973) and the relation between trawl catch parameters and temperature was examined with Spearman rank correlations (Zar 1974).

Figure 2.
Mean monthly surface water temperature for 1980 to 1992, and annual deviations from the mean, along the 60 m isobath off Point Loma.

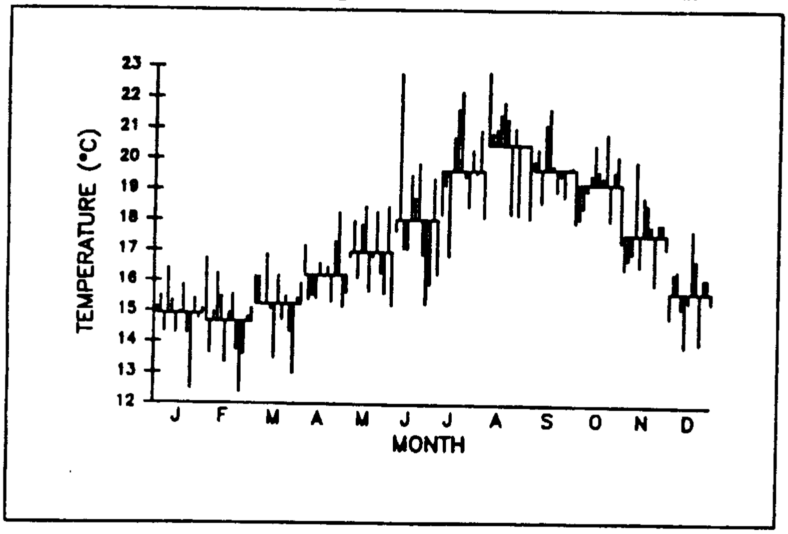
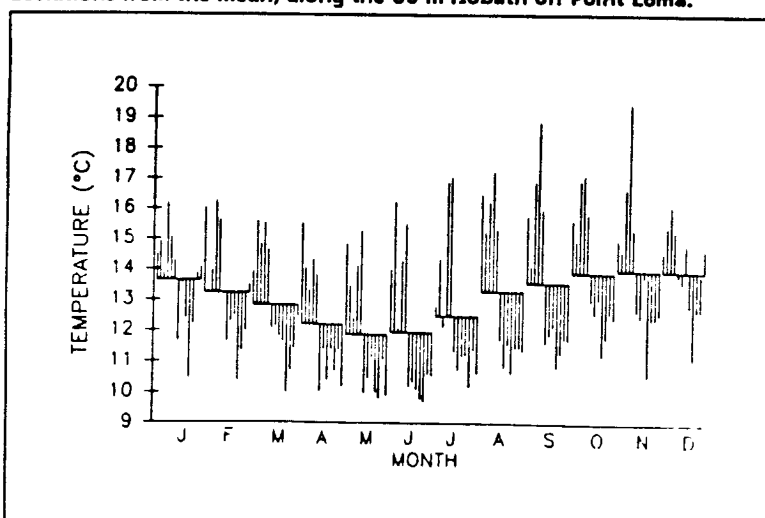


Figure 3.
Mean monthly bottom water temperature for 1980 to 1992, and annual deviations from the mean, along the 60 m isobath off Point Loma.



Results

Water temperature

Surface water temperatures were warm during the summer months (June to September) and cool during the winter months (December to February) (Figure 2). During some years, cool temperatures that occurred in May and June were related to upwelling. The water column was weakly stratified in the winter and strongly stratified in the summer. Average bottom temperatures declined after 1984 (Figure 3). The difference between surface and bottom temperatures increased from 1980-84 (0-6.5°C) to 1985-92 (1-11°C).

Trawl catch

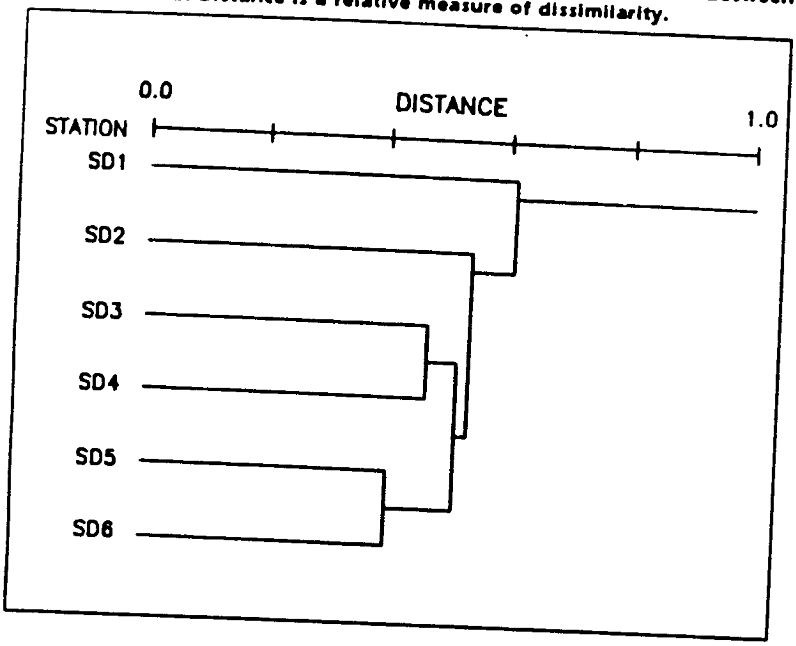
Ten years of semi-annual trawling at six stations off Point Loma produced 57 species from 28 families and 26,839 individuals (Table 1). Plainfin midshipman, longspine combfish, yellowchin sculpin, California tonguefish, and longfin sanddab occurred in over 90% of the trawls and accounted for 55% of the individuals collected. The 10 most abundant species accounted for 83% of the fish captured. Two rare fishes were collected in January 1988: spotted batfish and slender snipefish (Miller and Lea 1972).

Table 1

List of fish species and numbers collected and percent occurrence (PO) in 120 trawls off Point Loma, San Diego between 1982 and 1992.

Family	Common Name	Scientific Name	Number	PO
Myxinidae	Pacific hagfish	*Eptatretus stoutii*	1	< 1
Squalidae	spiny dogfish	*Squalus acanthias*	6	3
Torpedinidae	Pacific electric ray	*Torpedo californica*	2	2
Rajidae	big skate	*Raja binoculata*	2	2
	California skate	*Raja inornata*	23	17
	longnose skate	*Raja rhina*	3	< 1
	unidentified skate	*Raja* spp.	1	< 1
Myliobatididae	bat ray	*Myliobatus californica*	1	< 1
Chimaeridae	ratfish	*Hydrolagus colliei*	15	7
Engraulididae	northern anchovy	*Engraulis mordax*	4	3
Argentinidae	Pacific argentine	*Argentina sialis*	647	34
Synodontidae	California lizardfish	*Synodus lucioceps*	1,012	68
Batrachoididae	specklefin midshipman	*Porichthys myriaster*	6	2
	plainfin midshipman	*Porichthys notatus*	3,962	92
Ophidiidae	spotted cuskeel	*Chilara taylori*	44	14
Merlucciidae	Pacific hake (whiting)	*Merluccius productus*	1	< 1
Ogcocephalidae	spotted batfish	*Zalieutes elater*	1	< 1
Centriscidae	slender snipefish	*Macrorhamphosus gracilis*	1	< 1
Syngnathidae	kelp pipefish	*Sygnathus californiensis*	1	< 1
Scorpaenidae	scorpionfish	*Scorpaena guttata*	274	48
	bocaccio	*Sebastes paucispinis*	1	< 1
	calico rockfish	*Sebastes dallii*	1,118	63
	cowcod	*Sebastes levis*	1	< 1
	greenblotched rockfish	*Sebastes rosenblatti*	10	6
	greenspotted rockfish	*Sebastes chlorostictus*	1	< 1
	halfbanded rockfish	*Sebastes semicinctus*	42	8
	unidentified rockfish	*Sebastes* spp.	40	17
	splitnose rockfish	*Sebastes diploproa*	1	< 1
	stripetail rockfish	*Sebastes saxicola*	1,444	48
	vermilion rockfish	*Sebastes miniatus*	24	13
Zaniolepididae	longspine combfish	*Zaniolepis latipinnis*	2,701	93
	shortspine combfish	*Zaniolepis frenata*	1	< 1
Hexagrammidae	lingcod	*Ophiodon elongatus*	1	< 1
Cottidae	roughback sculpin	*Chitonotus pugetensis*	106	31
	yellowchin sculpin	*Icelinus quadriseriatus*	2,829	93
Agonidae	pigmy poacher	*Odontopyxis trispinosa*	48	15
Sciaenidae	queenfish	*Seriphus politus*	62	5
	white croaker	*Genyonemus lineatus*	803	33
Embiotocidae	pile surfperch	*Damalichthys vacca*	1	< 1
	pink surfperch	*Zalembius rosaceus*	2,267	74
	shiner surfperch	*Cymatogaster aggregata*	4	3
Uranoscopidae	smooth stargazer	*Kathetostoma averruncus*	8	6
Gobiidae	bay goby	*Lepidogobius lepidus*	354	51
	blackeye goby	*Coryphopterus nicholsii*	1	< 1
	unidentified goby	Gobiidae spp.	1	< 1
Stromateidae	Pacific butterfish	*Peprilus simillimus*	2	2
Cynoglossidae	California tonguefish	*Symphyrus atricauda*	1,670	93
Bothidae	bigmouth sole	*Hippoglossina stomata*	341	76
	fantail sole	*Xystreurys liolepis*	54	26
	gulf sanddab	*Citharichthys fragilis*	63	14
	longfin sanddab	*Citharichthys xanthostigma*	3,687	97
	Pacific sanddab	*Citharichthys sordidus*	1,489	64
	unidentified sanddab	*Citharichthys* spp.	341	8
Pleuronectidae	Dover sole	*Microstomus pacificus*	845	71
	English sole	*Pleuronectes (=Parophrys) vetulus*	149	43
	hornyhead turbot	*Pleuronichthys verticalis*	313	78
	slender sole	*Eopsetta (=Lyopsetta) exilis*	9	4
			26,839	

Figure 4.
Tree diagram of relations among trawl stations off Point Loma (SD1 to SD6) based on the composition and abundance of fishes in trawl catches between 1982 and 1992. Distance is a relative measure of dissimilarity.



The composition and rank order of abundance of trawl-caught fishes were similar among the six stations (Table 2). The average rank correlation among the species in Table 2 was 0.64 ($p<0.01$) indicating that the conditions that resulted in their dominance were similar among the stations. The control station (SD1) was the most dissimilar of all the stations, while the downcoast stations (SD5 and SD6) were the most similar (Figure 4). Eliminating SD1 from the calculations only raised the average rank correlation to 0.69.

Trawl catches were the smallest at SD1 (Figure 5). The mean number of species per trawl was 12% lower, the mean number of individuals was 39% lower, and the mean biomass was 60% lower at SD1 compared to the mean for the five remaining stations. The abundance of yellowchin sculpin,

Table 2.
Rank order of the 10 most abundant species caught in trawls (20 per station) off Point Loma (stations SD1 to SD6) from 1982 to 1992, and the most abundant species for the periods 1982-84 (30 trawls) and 1985-92 (90 trawls).

	1982-92						All Stations	
	SD1	SD2	SD3	SD4	SD5	SD6	82-84	85-92
Longfin sanddab	1	2	2	7	1	3	6	2
Pink surfperch	2	3	6	5	6	5	9	5
Pacific sanddab	3	13	11	6	4	8	11	6
Longspine combfish	4	5	3	4	5	2	4	4
California tonguefish	5	8	7	8	8	4	1	9
Plainfin midshipman	6	1	1	1	2	6	3	1
Yellowchin sculpin	7	4	4	3	3	1	5	3
California lizardfish	8	9	10	11	10	12	7	10
Bigmouth sole	9	17	16	18	17	13	16	15
Stripetail rockfish	10	11	12	2	7	9	10	7
Dover sole	11	10	9	10	14	11	8	11
White croaker	12	12	5	12	15	10	2	16
Calico rockfish	13	7	8	9	9	7	12	8
Pacific argentine	15	6	13	15	12	16	30	12

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Table 1

List of fish species and numbers collected and percent occurrence (PO) in 120 trawls off Point Loma, San Diego between 1982 and 1992.

Family	Common Name	Scientific Name	Number	PO
Myxinidae	Pacific hagfish	*Eptatretus stoutii*	1	< 1
Squalidae	spiny dogfish	*Squalus acanthias*	6	3
Torpedinidae	Pacific electric ray	*Torpedo californica*	2	2
Rajidae	big skate	*Raja binoculata*	2	2
	California skate	*Raja inornata*	23	17
	longnose skate	*Raja rhina*	3	< 1
	unidentified skate	*Raja* spp.	1	< 1
Myliobatididae	bat ray	*Myliobatus californica*	1	< 1
Chimaeridae	ratfish	*Hydrolagus colliei*	15	7
Engraulididae	northern anchovy	*Engraulis mordax*	4	3
Argentinidae	Pacific argentine	*Argentina sialis*	647	34
Synodontidae	California lizardfish	*Synodus lucioceps*	1,012	68
Batrachoididae	specklefin midshipman	*Porichthys myriaster*	6	2
	plainfin midshipman	*Porichthys notatus*	3,962	92
Ophidiidae	spotted cuskeel	*Chilara taylori*	44	14
Merlucciidae	Pacific hake (whiting)	*Merluccius productus*	1	< 1
Ogcocephalidae	spotted batfish	*Zalieutes elater*	1	< 1
Centriscidae	slender snipefish	*Macrorhamphosus gracilis*	1	< 1
Syngnathidae	kelp pipefish	*Sygnathus californiensis*	1	< 1
Scorpaenidae	scorpionfish	*Scorpaena guttata*	274	48
	bocaccio	*Sebastes paucispinis*	1	< 1
	calico rockfish	*Sebastes dallii*	1,118	63
	cowcod	*Sebastes levis*	1	< 1
	greenblotched rockfish	*Sebastes rosenblatti*	10	6
	greenspotted rockfish	*Sebastes chlorostictus*	1	< 1
	halfbanded rockfish	*Sebastes semicinctus*	42	8
	unidentified rockfish	*Sebastes* spp.	40	17
	splitnose rockfish	*Sebastes diploproa*	1	< 1
	stripetail rockfish	*Sebastes saxicola*	1,444	48
	vermilion rockfish	*Sebastes miniatus*	24	13
Zaniolepididae	longspine combfish	*Zaniolepis latipinnis*	2,701	93
	shortspine combfish	*Zaniolepis frenata*	1	< 1
Hexagrammidae	lingcod	*Ophiodon elongatus*	1	< 1
Cottidae	roughback sculpin	*Chitonotus pugetensis*	106	31
	yellowchin sculpin	*Icelinus quadriseriatus*	2,829	93
Agonidae	pigmy poacher	*Odontopyxis trispinosa*	48	15
Sciaenidae	queenfish	*Seriphus politus*	62	5
	white croaker	*Genyonemus lineatus*	803	33
Embiotocidae	pile surfperch	*Damalichthys vacca*	1	< 1
	pink surfperch	*Zalembius rosaceus*	2,267	74
	shiner surfperch	*Cymatogaster aggregata*	4	3
Uranoscopidae	smooth stargazer	*Kathetostoma averruncus*	8	6
Gobiidae	bay goby	*Lepidogobius lepidus*	354	51
	blackeye goby	*Coryphopterus nicholsii*	1	< 1
	unidentified goby	Gobiidae spp.	1	< 1
Stromateidae	Pacific butterfish	*Peprilus simillimus*	2	2
Cynoglossidae	California tonguefish	*Symphyrus atricauda*	1,670	93
Bothidae	bigmouth sole	*Hippoglossina stomata*	341	76
	fantail sole	*Xystreurys liolepis*	54	26
	gulf sanddab	*Citharichthys fragilis*	63	14
	longfin sanddab	*Citharichthys xanthostigma*	3,687	97
	Pacific sanddab	*Citharichthys sordidus*	1,489	64
	unidentified sanddab	*Citharichthys* spp.	341	8
Pleuronectidae	Dover sole	*Microstomus pacificus*	845	71
	English sole	*Pleuronectes (=Parophrys) vetulus*	149	43
	hornyhead turbot	*Pleuronichthys verticalis*	313	78
	slender sole	*Eopsetta (=Lyopsetta) exilis*	9	4
			26,839	

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in the 1985 Reference Survey, but common thereafter; 3) English sole, which were abundant in 1975, were rare in both Reference Surveys and the present study; and 4) Pacific argentine were not collected before 1985.

Changes in dominance among trawl-caught fishes are not uncommon in the Southern California Bight. Stripetail rockfish dominated rockfish catches on the mainland shelf throughout the SCB from 1971 to 1975. Significant recruitment occurred in 1971, 1973, and 1975 when average annual water temperatures were 16°C or less. Significant recruitment of calico rockfish occurred in 1975 and 1977 when average annual water temperatures were 17°C or higher. Calico rockfish dominated rockfish catches from 1975 to 1978 (Mearns *et al.* 1980). The ranges of both species extend south to central Baja California, but calico rockfish are rare north of Santa Barbara and sripetail rockfish occur as far north as Alaska (Eschmeyer *et al.* 1983). The switch in dominance from stripetail rockfish to calico rockfish spanned 100 km of coast south of Point Dume and was linked to changing oceanographic conditions.

Bottom water temperatures off San Diego were above the 12 year mean (13.1°C) from 1980 to the end of 1984. The greatest deviations occurred in summer of 1983 coincident with the 1982-1983 El Niño. Trawl catches declined during the El Niño. The mean number of species per trawl declined 16-32% and the mean number of individuals and mean catch weight declined 57-65% over the periods immediately before and after the El Niño (Cross and Allen 1992). Immediately following the El Niño, catches of longfin sanddab, yellowchin sculpin, Dover sole, California lizardfish, and plainfin midshipman increased by 50-75%, while catches of longspine combfish, pink surfperch, calico rockfish, and stripetail rockfish increased by 80-99%. More species of fish were collected when bottom water temperatures were lower. Mearns (1978),

Figure 7

Relation between the mean number of species caught by trawl at all stations on one sampling date (n=6 trawls/date) and bottom water temperature. r_s is Spearman rank correlation.

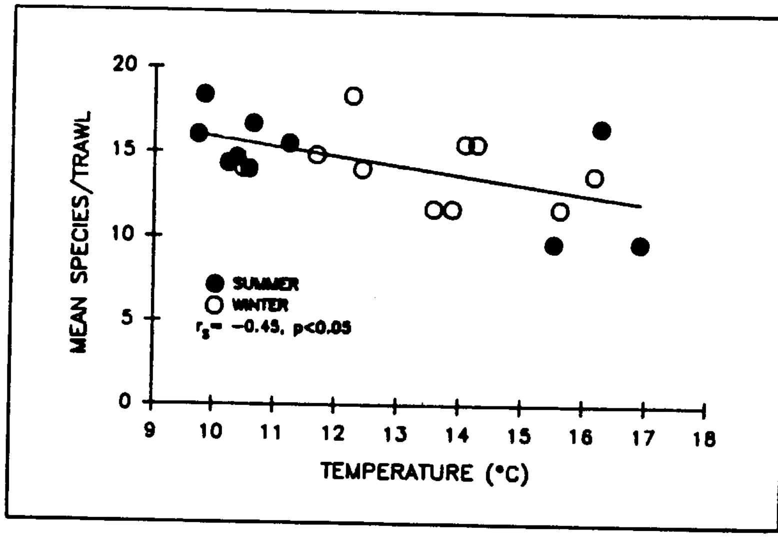
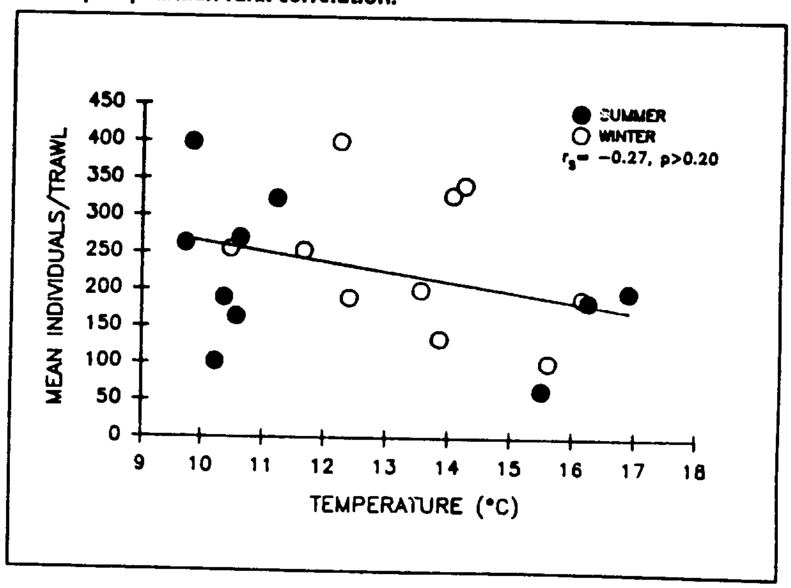
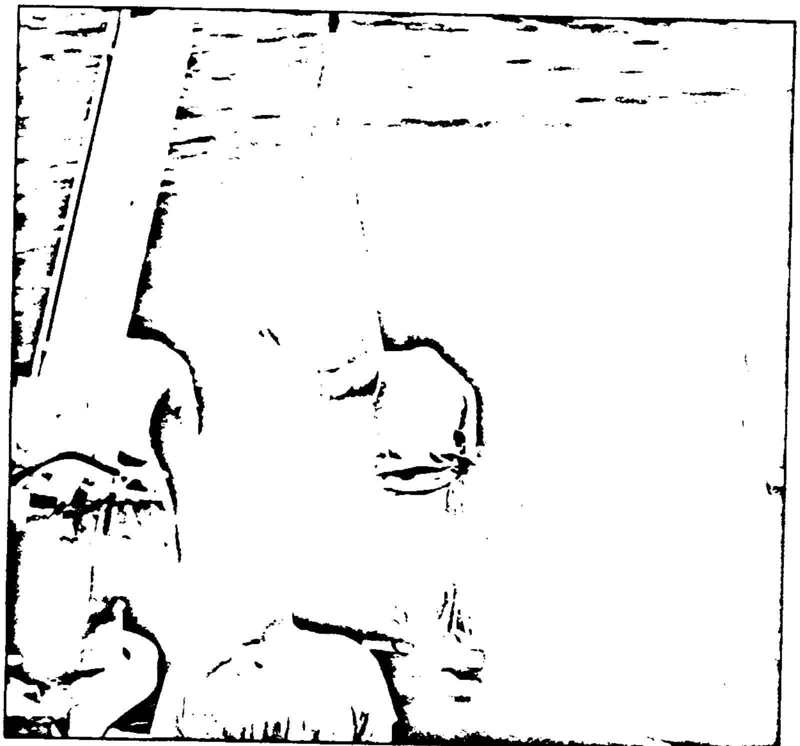


Figure 8

Relation between the mean number of individuals caught by trawl at all stations on one sampling date (n=6 trawls/date) and bottom water temperature. r_s is Spearman rank correlation.





Cod end of otter trawl containing the catch

using surface water temperature, found a similar correlation between trawl catches and water temperature. Many demersal species had poor recruitment during the warm-water years of 1957 to 1959 (Carlisle 1969) and 1974 to 1975 (Allen and Voglin 1976).

Cluster analysis separated the control station (SD1) from the remaining stations based on the composition and abundance of the trawl catches. The control station had the lowest catches of the six stations and lower catches than the 60 m stations in the 1990 Reference Survey (Figure 5). The organic content of sediments off Mission Bay (0.45% total organic carbon) is lower than the organic content of sediments close to the Point Loma outfall (0.54-0.65%) (see *Total Organic Carbon and Total Nitrogen in Marine Sediments, Sediment Trap Particles, Municipal Effluents, and Surface Runoff* in this report). The organic content of sediments close to the outfall was similar to the organic content of sediments collected at 60 m in the 1990 Reference Survey (0.57%; Thompson *et al.* 1992).

Changes in the composition of fish assemblages around some outfalls may be the result of alterations in the sediments caused by the discharge of wastewater solids. Changes in sediment properties, particularly increases in organic content, lead to alteration in benthic invertebrate assemblages. As the infauna changes, so does the assemblage of demersal fishes that prey on them (Cross *et al.* 1985).

Conclusions

The abundance and composition of the trawl catches, as well as the sediment organic content, at stations close to the Point Loma outfall were similar to the values obtained for the 60 m stations in the 1990 Reference Survey (Thompson *et al.* 1992). The control station (SD1) had the lowest trawl catches and sediment organic content. Either the control station is located in an area that is not typical of mainland shelf conditions, or the shelf off San Diego is similar to SD1 and there are not enough data to verify it. The similarity of trawl fish abundance and composition among the six stations, and the similarity in abundance and composition between this study and the 1990 Reference Survey, suggest that the effects of wastewater discharge on the fish assemblage off Point Loma are minimal.

It is not surprising that the fish assemblage off Point Loma responds to oceanographic events such as El Niño. The coupling of environmental changes and biological responses underscores the importance of long-term data collection (Wolfe *et al.* 1987). The data generated by monitoring programs should be adequate to differentiate between the natural variability of the biota and anthropogenic impacts on the biota (e.g., Stull *et al.* 1987). ■

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1990 Reference Survey

Longspine combfish

We recently completed the third survey of chemical and biological conditions in reference areas on the mainland shelf off Southern California. Seven stations from the 60 m Survey (Word and Mearns 1979) and 1985 Reference Survey (Thompson *et al.* 1987) were sampled in July and August 1990. The objective was to provide estimates of sediment characteristics, contaminant levels, and biological conditions from the least impacted areas on the mainland shelf. A detailed account of sampling protocols, analytical methods, and the results are available as a SCCWRP Technical Report (Thompson *et al.* 1992).

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Materials and Methods

Field Collections

Sediments, invertebrates, and fish were sampled at 30, 60, and 150 m at each of the seven stations; however, one 30 m station (R61 off La Jolla) had to be abandoned due to the presence of kelp. Water column salinity, temperature, and dissolved oxygen were measured at each station by hydrocast with a SeaBird CTD.

Sediment samples were collected with a 0.10 m^2 chain-rigged Van Veen grab sampler. Subsamples from the top 2 cm of the grab sample were taken with a 26 mm diameter syringe and immediately frozen for laboratory analyses. Macrobenthic infauna were collected from a separate Van Veen grab sample sieved through a 1.0 mm screen. The animals and debris were fixed in 10% borax buffered formalin in seawater, returned to the lab, and transferred to 70% ethanol. The samples were sorted to major taxa and identified to the lowest taxon practical. Megafaunal invertebrates and fish were collected at each station with a 7.6 m otter trawl towed for 10 min along an isobath at approximately 2 knots.

Laboratory Analyses

Total Organic Carbon and Nitrogen.

Sediments were analyzed for total organic carbon (TOC) and total nitrogen (TN) by high temperature (flash) combustion using a Carlo Erba EA1108 elemental analyzer (methods are detailed in *Total Organic Carbon and Total Nitrogen in Marine Sediments, Sediment Trap Particles, Municipal Effluents, and Surface Runoff* in this report).

Sand, Silt, Clay.

Sediment samples were homogenized, organic material was digested with 10% hydrogen peroxide, and the sample was wet sieved through a 63 µm stainless steel sieve. The sand fraction retained on the screen was dried and the sieving repeated. Particles that passed through the sieve were dried and added to the silt fraction. The sand fraction was weighed.

The silt/clay fraction that passed through the sieve was transferred to a 1000 ml graduated cylinder. After 24 hr, the water was decanted into 500 ml polypropylene bottles and centrifuged for 20 min at 1000 RPM. The water was siphoned from the centrifuge bottles and the residue was washed back into the graduated cylinder. Twenty-five ml of 1% Calgon solution were added to the silt/clay fraction to prevent flocculates and the sample was adjusted to 1000 ml with distilled H_2O and vigorously mixed. A 25 ml sample was drawn 20 cm from the top 20 sec after mixing (=silt fraction). The sample and pipet were rinsed with distilled water into an aluminum dish. A 25 ml sample was taken from a depth of 5 cm at the times tabulated by Plumb (1981) and transferred to an aluminum dish (=clay fraction). The samples were dried and weighed, and the weights were corrected for the addition of Calgon.

Trace Metals.

Sediments were analyzed for silver, cadmium, chromium, copper, nickel, lead, zinc, iron, and manganese by Global Geochemistry Corp. of Canoga Park, California. Wet sediment was digested in nitric acid and hydrogen peroxide. The digestate was then refluxed with either nitric acid or hydrochloric acid and then diluted to a volume of 50 ml (EPA procedure SW 846 3050). Percent moisture was determined on a separate sample. Digestates were analyzed on an inductively coupled plasma emission spectrometer (Baird simultaneous PST installed with 27 element channels). Concentrations were determined by comparison with standards. Samples were spiked after digestion and recoveries were used to correct data affected by the sample matrix.

Trace Organics.

Polynuclear aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons (CHCs) were analyzed by Global Geochemistry Corp. Extraction and clean up of sediment samples were conducted according to modified SCCWRP methods (Eganhouse *et al.* 1990). Wet sediment was extracted three times with methylene chloride by sonication for 30 min. The combined extracts were concentrated and cleaned up on a silica gel column. The PAHs were analyzed on an Incos 50 GC-MS by a modified EPA 8270 method. The CHCs were analyzed on a Varian 3700 GC with an ECD. The DDT compounds (o, p'-DDE, p,p'-DDE, o. p'-DDT, and p, p'-DDT) and the Arochlors (1242 and 1254) were quantified by the internal standard method with PCB congener 207 (Ballschmiter and Zell 1980). One peak was used for quantitation of 1242 and two peaks for 1254 (Eganhouse and Gossett 1991).

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Statistical Analyses

The contaminant concentrations and biological variables (species, individuals, and biomass) were tested for differences among groups of stations, depths, and surveys by one-way analysis of variance (ANOVA) and the HSD multiple comparisons test (Tukey 1951). The patterns in species composition among the stations were examined using classification analysis of species abundance data (Clifford and Stephenson 1975). Proportion data were arcsine transformed and abundance data were $\log_{10}$ transformed. A value of 0.5 times the detection limit was used to calculate sample statistics for contaminants with masses below detection limit.

Table 1.
Means and 95% confidence intervals (CI) of near-bottom water and sediment parameters by depth at the reference sites in July-August 1990.

	Stations					
	30 m (n=6)		60 m (n=7)		150 m (n=7)	
	mean	CI	mean	CI	mean	CI
Near-bottom water						
Temperature (°C)	13.2	(0.5)	11.8	(0.6)	10.1	(0.2)
Salinity (°/oo)	33.4	(0.1)	33.4	(0.1)	33.7	(0.1)
Dissolved oxygen (mg/L)	7.4	(1.9)	6.2	(1.6)	4.4	(1.2)
Sediment (% dry weight)						
Sand	65	(30)	48	(32)	38	(23)
Silt	32	(29)	47	(30)	52	(19)
Clay	3	(2)	6	(2)	10	(5)
Dry weight	69	(3)	65	(6)	60	(7)
Total organic carbon	0.47	(0.19)	0.57	(0.24)	0.82	(0.44)
Total nitrogen	0.04	(0.01)	0.04	(0.02)	0.07	(0.04)
Trace metals (ppm)						
Silver	0.10	(0.10)	0.25	(0.43)	0.05	(0.00)
Cadmium	0.26	(0.23)	0.24	(0.27)	0.37	(0.23)
Chromium	17	(4)	26	(14)	31	(10)
Copper	5.3	(2.3)	9.2	(5.5)	14	(5.6)
Nickel	8.0	(4.0)	11	(8.2)	14	(5.9)
Lead	4.4	(1.4)	6.9	(3.3)	8.2	(3.6)
Zinc	29	(11)	45	(21)	55	(18)
Iron	10,998	(3,667)	17,964	(7,746)	21,311	(6,037)
Manganese	99	(44)	133	(63)	156	(58)
Trace organics (ppb)						
Total PCB[1]	7	(4)	12	(11)	12	(10)
Total DDT[2]	5	(5)	13	(13)	15	(14)
Total PAH[3]	24	(20)	26	(14)	39	(20)

[1] Aroclor 1254 + Aroclor 1260
[2] o,p'-DDE + p,p'-DDE + p,p'-DDT + o,p'-DDT
[3] 30 compounds

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Results

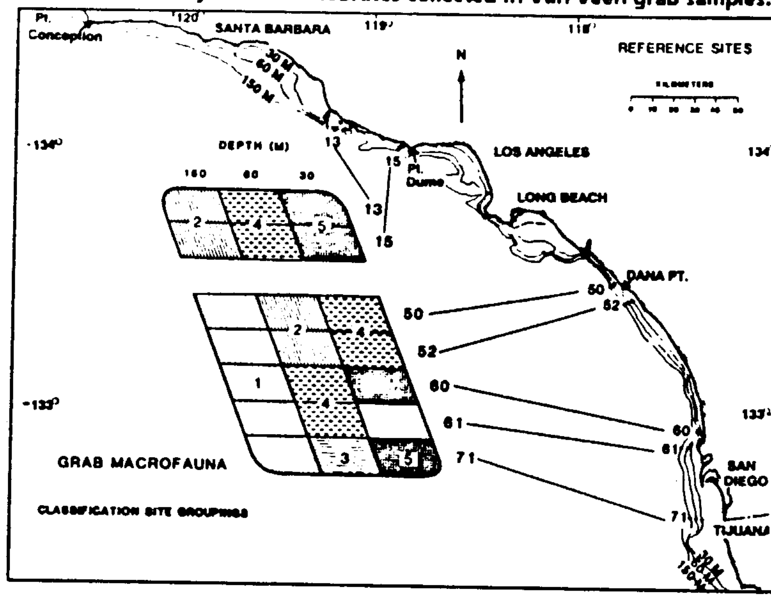
Water column and sediments

Temperatures near the bottom ranged between 9.9° and 13.8°C. Salinities ranged between 33.2 and 33.8 ppt. The lowest salinities were measured at the head of the La Jolla submarine canyon. Dissolved oxygen concentrations ranged between 3.1 and 9.0 mg/L. Temperature and dissolved oxygen were generally lowest at the 150 m stations and highest at the 30 m stations.

Shelf sediments were predominantly sandy-silt. As water depth increased, the amount of sand in the sediments decreased and the amount of clay increased, except off Imperial Beach where sand increased in deep water. Total organic carbon (TOC) ranged from 0.15% to 1.52% and was highly correlated with clay content ($r = 0.786$).

Sediment trace metal concentrations were generally low at all stations (Table 1) and were not significantly different among depths. Total DDT ranged between <0.5 to 39 ppb; concentrations were highest at the northern 60 and 150 m sites. Total PCBs ranged from <5 to 31 ppb; concentrations were highest off Point Dume and Dana Point. Total PAHs ranged from <0.09 to 69 ppb; concentrations were highest off Oxnard. The mean concentrations of trace organic contaminants were not significantly different among depths.

Figure 1.
Distribution of benthic macrofaunal assemblages (site groups) determined by classification analysis of invertebrates collected in Van Veen grab samples.



Macrobenthos

Classification analysis of the macrobenthos (>1 mm) identified five groups of stations (Figure 1; Table 2). Groups 1, 2, and 5 were variations of the *Amphiodia urtica-Spiophanes missionensis* assemblage (Group 4) that inhabits the entire Southern California mainland shelf. The benthos at station R71-60 formed a distinct assemblage. The number of species, number of individuals, and biomass were not significantly different among depths (Table 2).

Two species of amphipods, *Amphideutopus oculatus* and *Ampelisca brevisimulata*, dominated most of the grab samples collected at the 30 m stations. *Amphiodia urtica*, and to a lesser extent the polychaete, *Myriochele* sp. M., dominated samples collected at 60 m. The 150 m stations were dominated by the polychaetes, *Spiophanes fimbriata* and *Myriochele* sp. M, and *Amphiodia urtica*. The station in 60 m of water off Imperial Beach (R71) was dominated by the gastropod, *Micranellum crebricinctum*, and the ostracod, *Euphilomedes carcharodonta*.

Megabenthos

Classification analysis of the large, motile invertebrates (megabenthos) in otter trawl samples identified four groups of stations (Figure 2; Table 3). The asteroid, *Astropecten verrilli*, dominated trawl collections at 30 m, but decreased in abundance with increasing depth. The sea urchin, *Lytechinus pictus*, and the prawn, *Sicyonia ingentis* dominated collections at 60 m. The sea urchins, *Allocentrotus fragilis*, a common slope species, and *Lytechinus pictus* dominated the 150 m stations.

The number of species, individuals, and biomass per trawl were significantly higher at the 60 and 150 m stations compared to the 30 m stations (Table 3). The 60 m stations (Group 2) were inhabited by typical southern California mainland shelf megabenthos. The number of species was similar among the sites. Group 4a resulted from a small trawl catch at Station R52-30.

Demersal Fishes

Classification analysis of the demersal fishes identified three groups of stations (Figure 3; Table 4). The speckled sanddab *(Citharichthys stigmaeus)* and longfin sanddab *(Citharichthys xanthostigma)* dominated trawl catches at the 30 m stations. Pacific sanddab *(Citharichthys sordidus)* and longfin sanddab dominated trawl catches at the 60 m stations. Slender sole *(Eopsetta exilis)* and plainfin midshipman *(Porichthys notatus)* dominated trawl catches at the 150 m stations.

The number of fish species, individuals, and biomass increased with increasing depth

Table 2.
Mean abundance per 0.1 m² grab of the five most abundance macrofauna in each site group (determined by classification analysis) and the ten most common species. FO=frequency of occurrence (N=20); P=polychaete; Os=ostracod; Op=ophiuroid; Pe=pelecypod; G=gastropod; A=amphipod; Ph=phoronid.

			Mean number/grab by site group				
			1	2	3	4	5
Species	Taxon	FO	150m n=5	60-150m n=4	R71-60 n=1	30-60m n=6	30m n=4
Euphilomedes producta	Os	9	8.4	20.8	0	1.2	.0
Spiophanes fimbriata	P	12	29.6	6.5	0	3.0	2.0
Maldane sarsi	P	15	11.8	1.0	1	1.3	1.5
Pectinaria californiensis	P	18	10.4	25.0	5	7.5	1.2
Amphiodia urtica	Op	16	19.4	120.2	0	77.3	4.2
Spiophanes berkeleyorum	P	16	6.8	2.5	0	6.0	1.8
Tellina carpenteri	Pe	17	2.0	2.2	0	5.7	2.0
Myriochele sp. M	P	6	0	386.5	1	6.8	0
Mediomastus sp.	P	19	9.2	5.2	4	7.0	2.8
Parvilucina tenuisculpta	Pe	19	13.2	1.2	8	5.2	2.8
Spiophanes missionensis	P	20	5.0	13.2	24	32.7	11.5
Rhepoxynius bicuspidatus	A	15	1.6	5.0	0	5.7	8.5
Prionospio sp. A	P	16	2.4	1.5	12	10.5	7.8
Paraprionospio pinnata	P	11	0.6	2.2	0	2.3	8.5
Chloeia pinnata	P	7	0.2	1.0	24	2.5	0
Micranellum crebricinctum	G	1	0	0	40	0	0
Euclymeninae sp. A	P	11	0.2	0.2	6	7.2	5.0
Euphilomedes carcharodonta	Os	13	0.2	2.8	40	4.8	5.2
Phoronis sp.	Ph	10	0	0.5	28	3.8	3.0
Ampelisca brevisimulata	A	11	0	1.5	0	3.8	12.5
Amphideutopus oculatus	A	7	0	0.2	0	0.3	16.8
Spiophanes bombyx	P	7	0	0	10	0.3	9.5
Mean number species/grab			62.2	58.8	76.0	90.3	78
Mean number individivids/grab			247	691.5	356.0	375	273
Mean biomass (wet g)/grab			8.9	7.9	4.1	15	6.3

(Table 4). However, due to the variability among stations, there were no significant differences in species or biomass among the depths. The number of individuals was significantly greater at the 150 m stations compared to the 30 m sites.

Discussion

The mainland shelf (30-150 m) was composed primarily of sandy-silt sediments with an average TOC content of about 0.6%. The benthic invertebrates and demersal fishes collected at the 20 stations were typical of Southern California reference areas. Sediments at Station R71-60 contained about 94% sand and the macrofauna was distinct from the remaining stations (Table 2). Water depth and sediment type contribute to the differences among the assemblages identified by classification analysis.

The data from the 1977 60 m Survey (Word and Mearns 1979), the 1985 Reference Survey (Thompson *et al.* 1987), and the present study provide information about long-term temporal variation at reference sites. The chemical methods (sediment extraction and instrumental analysis) differed among the surveys. The number of DDT isomers and PAH compounds quantified changed between surveys. Nevertheless, silver was the only sediment characteristic measured that was significantly different among the three surveys (Table 5).

The same grab and trawl gear and methods were used in the 1977, 1985, and 1990 surveys. The assemblages of macrobenthic

Figure 2.
Distribution of benthic megafaunal assemblages (site groups) determined by classification analysis of invertebrates collected in trawl samples.

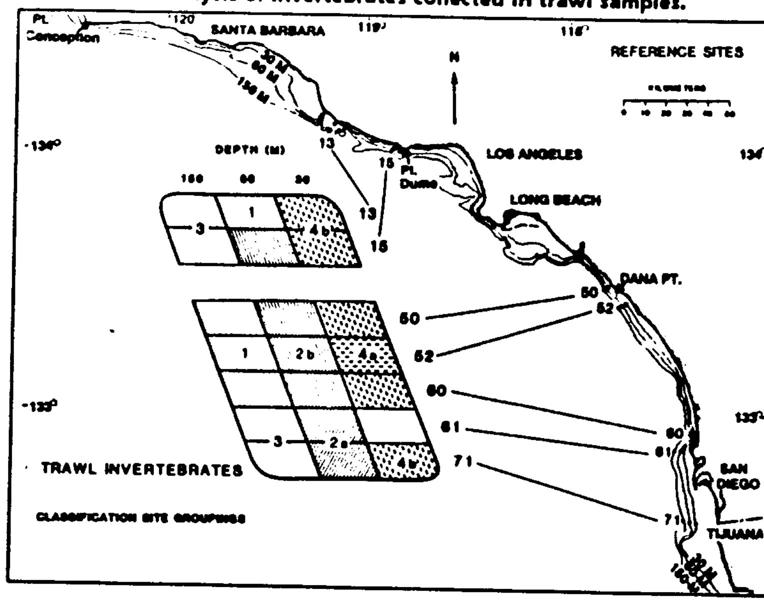
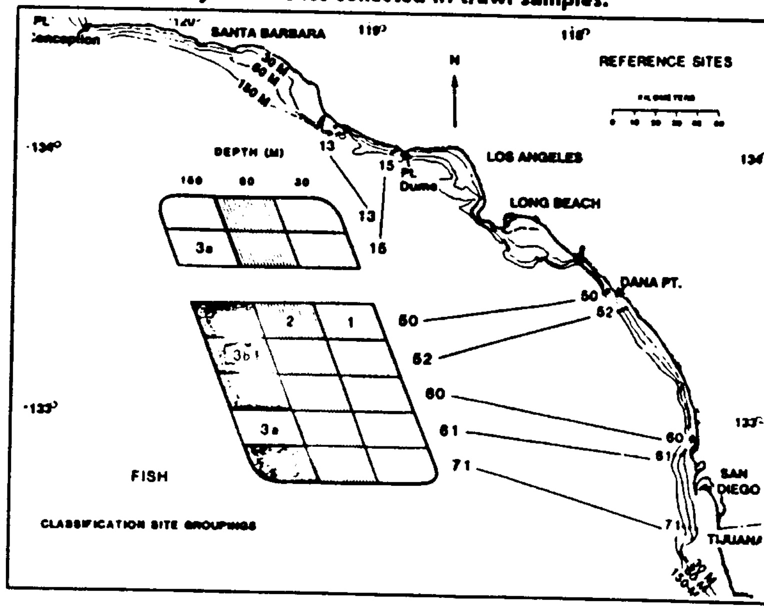


Figure 3.
Distribution of demersal fish assemblages (site groups) determined by classification analysis of fishes collected in trawl samples.



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and megabenthic invertebrates sampled in 1990 were similar to the assemblages sampled in 1977 and 1985. The macrobenthic grab and megabenthic trawl statistics were highest in 1990, but there were no significant difference among surveys (Table 5). Megabenthic individuals were two orders of magnitude lower in 1985 than in 1977 and 1990. However, due to the large variation within years, the difference was not significant.

The assemblage of demersal fishes sampled in 1990 was similar to assemblages sampled in 1977 and 1985; seven of the ten most frequently occurring species were common to all three surveys. In contrast to the invertebrate data, fish trawl statistics were significantly lower in 1985 (Table 5). This may have resulted from altered environmental conditions following the 1982-83 El Niño and the severe storms in the winter of 1983.

Conclusions

The data collected during this survey complement the 1977 60 m Survey (Word and Mearns 1979) and the 1985 Reference Survey (Thompson *et al.* 1987). The seven reference areas (20 stations) sampled in 1990 were comparable to the major shelf habitats off Southern California and bracketed the major ocean municipal wastewater discharges. This is probably the minimum number of stations needed to describe reference conditions on the mainland shelf. With the renewed interest in bight-wide monitoring (National Research Council 1990), these reference stations could be incorporated into a regional monitoring program for the Southern California Bight. ■

Table 3.

Mean abundance of the megabenthos per 10-minute trawl in each site group (determined by classification analysis) and the ten most common species. FO=frequency of occurrence (N=20); C=crustacean; E=echinoderm; M=molluscan.

			Mean number/trawl by site group					
			1	2a	2b	3	4a	4b
Species	Taxon	FO	60-150m n=4	60m n=2	60m n=4	150m n=4	R52-30 n=1	30m n=5
Pandalus platyceros	C	3	29.8	0	0	0	0	0
Pleurobranchaea californica	M	7	2.8	0	0.2	1.4	0	0
Parastichopus californicus	E	11	25.8	13.0	12.8	0.6	0	0.4
Sicyonia ingentis	C	12	64.0	1.5	45.0	1.6	0	0
Luidia foliolata	E	15	29.8	4.0	2.2	13.4	0	2.8
Brissopsis pacifica	E	4	0.5	0	0	41.0	0	0
Allocentrotus fragilis	E	6	29.8	0	0	303.6	0	0
Octopus rubescens	M	6	0.2	3.0	0.5	1.2	0	0
Lytechinus pictus	E	13	23.2	11391.5	350.2	212.2	8	1.0
Luidia asthenosoma	E	1	0	6.0	0	0	0	0
Ophiothrix spiculata	E	7	0	6.0	3.0	0	0	0.2
Crangon alaskensis	C	3	0	0	6.5	0	0	0
Loxorhynchus grandis	C	8	0.5	0	2.2	0	0	0.2
Astropecten verrilli	E	17	0.8	40.0	11.2	8.8	9	110.4
Lovenia cordiformis	E	4	0	0	0	0.6	2	3.0
Heterocrypta occidentalis	C	3	0	0	0.2	0	0	1.0
Mean number species/trawl			16.8	14.5	10.8	11.0	5.0	7.2
Mean number individuals/trawl			249.5	11,478.0	440.0	739.3	21.0	122.
Mean biomass (wet kg)/trawl			17.4	21.1	8.4	17.0	0.2	1.2

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Table 4.
Mean abundance of five most abundant species of demersal fish per 10-minute trawl in each site group (determined by classification analysis) and the ten most common species. FO=frequency of occurrence (N=20).

		Mean number/trawl by site group			
		1	2	3a	3b
Species	FO	30m n=6	60m n=7	150m n=3	150m n=4
Speckled sanddab	6	52.2	1.7	0	0
Hornyhead turbot	13	9.7	6.1	0	0
California lizardfish	14	4.7	2.4	0.3	0.8
Longfin sanddab	13	32.7	73.0	0	0.2
California tonguefish	10	0.7	12.6	0	0.2
Yellowchin sculpin	10	0.3	46.6	0.3	0.2
Longspine combfish	6	0.3	19.7	0.3	0
Bigmouth sole	16	6.0	3.3	0.3	4.2
Pink surfperch	9	0	4.0	0	4.8
Pacific sanddab	16	10.2	91.0	99.3	40.5
Slender sole	7	0	0	18.7	188.2
Dover sole	9	0	1.1	8.7	57.0
Stripetail rockfish	9	0	1.7	41.7	38.2
Plainfin midshipman	10	0	1.0	40.7	115.8
Gulf sanddab	7	0	0.4	81.0	16.5
Mean number species/trawl		11.2	14.1	10.7	18.8
Mean number individuals/trawl		129.7	278.9	296.7	553.8
Mean biomass (wet kg)/trawl		8.0	8.2	10.9	18.7

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Hauling the net aboard

Quick and dirty methods in statistics. pp. 189-197. *In:* Simple analysis for standard designs. Part II. Proc. 5th Ann. Conv. Amer. Soc. Qty. Ctrl.

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Author Bruce Thompson thanks the City of Los Angeles, County Sanitation Districts of Los Angeles County, and the City of San Diego for providing ship time, and the captains and crews of the R/V *La Mer*, R/V *Ocean Sentinel*, and R/V *Monitor III* for their assistance. Global Geochemistry (Canoga Park, CA) performed the sediment trace metal and organic hydrocarbon analyses. Dr. Robert Smith (EcoAnalysis, Ojai, CA) performed the classification analyses. Harold Stubbs (SCCWRP) directed the field collections and was ably assisted by David Tsukada, Diane O'Donohue, Andrew Jirik, Dario Diehl, Azra Khan, Marilyn Castillo, Larry Cooper, and Valerie Raco (SCCWRP).

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Table 5.

Sediment and biological variables measured in the 60 m Survey (Word and Mearns 1977), the 1985 Reference Survey (Thompson et al. 1986), and the 1990 Reference Survey (Thompson et al. 1992). Means and confidence limits 95% CI (in parentheses) were calculated from the seven 60 m sites common to each survey. Total DDT and total PCB were only measured at three sites in 1977 common to the 1985 and 1990 surveys. Total PAH was not measured in 1977. ANOVA = one-way analysis of variance; P = probability.

	1977		1985		1990		ANOVA
	mean	95% CI	mean	95% CI	mean	95% CI	P
Sediments							
TOC (%)	0.53[1]	(0.15)	0.57	(0.36)	0.57	(0.24)	0.982
TVS (%)	2.7	(0.8)	3.3	(1.8)	2.9[1]	(1.3)	0.888
Sand (%)	46.4	(26.1)	49.7	(38.2)	47.8	(32.4)	0.984
Silver (ppm)	0.30	(0.25)	0.04	(0.05)	0.25	(0.43)	0.001**
Cadium (ppm)	0.30	(0.21)	0.13	(0.11)	0.24	(0.27)	0.165
Chromium (ppm)	19.8	(9.4)	21.8	(11.1)	25.6	(13.8)	0.753
Copper (ppm)	6.3	(2.9)	11.0	(6.4)	9.2	(5.5)	0.538
Nickle (ppm)	10.1	(8.4)	11.6	(8.7)	11.4	(8.2)	0.870
Lead (ppm)	6.3	(1.9)	5.4	(3.4)	6.9	(3.3)	0.412
Zinc (ppm)	36.1	(12.2)	44.5	(25.7)	45.1	(21.2)	0.913
ΣPCB (ppb)	9.7	(13.6)	18.9	(11.3)	10.6	(11.0)	0.235
ΣDDT (ppb)	28.0	(63.2)	23.5	(35.5)	12.6	(12.7)	NT[2]
ΣPAH (ppb)	—		26.3	(44.7)	25.9	(14.0)	NT[2]
Biology							
Infaunal species (no/grab)	68	(23)	56	(19)	83	(21)	0.070
Infaunal individuals (no/grab)	418	(88)	332	(138)	626	(573)	0.136
Infaunal biomass (no/grab)	6.7	(3.1)	10.0	(6.4)	15.2	(15.4)	0.354
Megafaunal species[3] (no/trawl)	10.7	(5.0)	11.8	(6.0)	13.3	(4.0)	0.495
Megafaunal individuals (no/trawl)	1043	(1490)	85	(45)	3556	(5627)	0.078[4]
Megafaunal biomass (no/trawl)	7 0	(6.1)	3.5	(4.4)	12.4	(10.2)	0.075[4]
Fish species[3] (no/trawl)	15.6	(3.2)	11.4	(3.8)	14.1	(3.0)	0.087
Fish individuals (no/trawl)	375	(246)	146	(73)	279	(118)	0.026*
Fish biomass (no/trawl)	8.4	(7.1)	3.9	(1.5)	8.2	(3.9)	0.029*

*significant at 0.05
**significant at 0.01
[1]Value calculated from regression of TOC on TVS
[2]Not tested because different components were measured in different years.
[3]Names of organisms not standardized among surveys
[4]Variances heterogeneous

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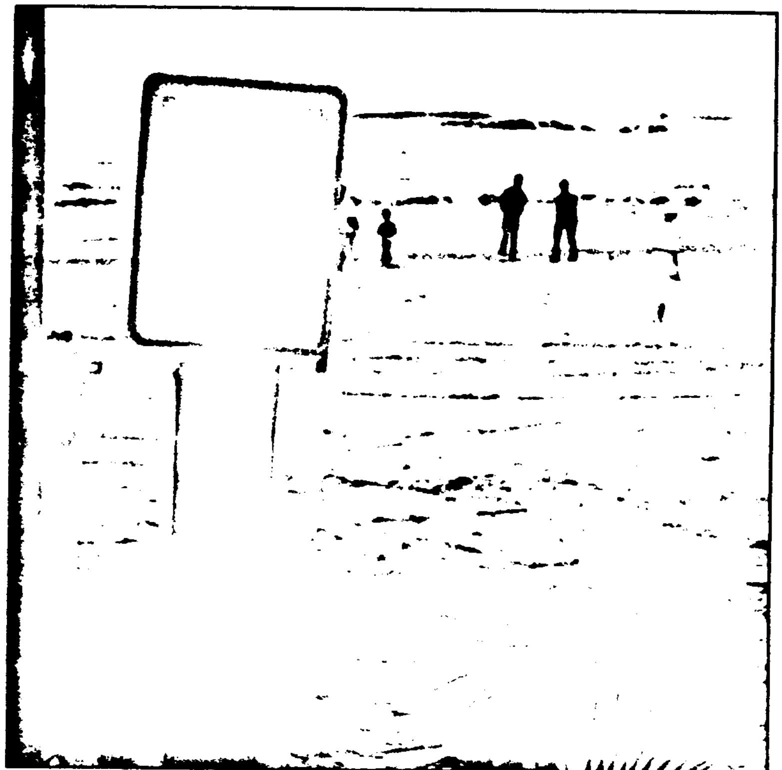
R0054109

Toxcity of Dry Weather Flow in Ballona Creek

Ballona Creek is one of the few flood control channels that flows throughout the year into Santa Monica Bay. In addition to receiving surface runoff from streets and commercial and industrial properties during storms, Ballona Creek receives discharges from a variety of sources throughout the year (e.g., groundwater pumping and decontamination, swimming pool drainage, and dehumidifier condensate).

Previous studies by SCCWRP measured the chemical composition and toxicity of samples collected from Ballona Creek during storms. The concentrations of oil and grease, cadmium, chromium, copper, and nickel in stormwater samples from Ballona Creek are higher than concentrations in stormwater samples from several other channels in southern California (Schafer and Gossett 1988), and are comparable to concentrations in sewage effluents discharged into Santa Monica Bay. The concentrations of lead, zinc, total DDT, and total PCB in stormwater samples from Ballona Creek are greater than concentrations in sewage effluents discharged into the bay. The toxicity of Ballona Creek stormwater samples is similar to the toxicity of stormwater samples from the Los Angeles River, the largest source of gauged runoff in Southern California (SCCWRP 1989).

Elevated levels of contaminants are also present in Ballona Creek dry weather flow (SCCWRP, unpublished data), but we have not measured the toxicity of dry weather discharge to marine animals. The object of this study was to determine the toxicity of dry weather flow in Ballona Creek to sea urchin gametes and embryos. We compared the sensitivity of the two toxicity tests and examined the variability in toxicity over different temporal scales (hours and months). Sea urchin toxicity tests provide data useful for assessing impacts in the environment because sea urchins inhabit rocky intertidal areas of Santa Monica Bay and their larvae are found in the water column.



Storm drain warning

Materials and Methods Sampling

Three water samples were collected at hourly intervals on the afternoon of December 10, 1990 below the Inglewood Street overpass of Ballona Creek (Figure 1). Samples were collected

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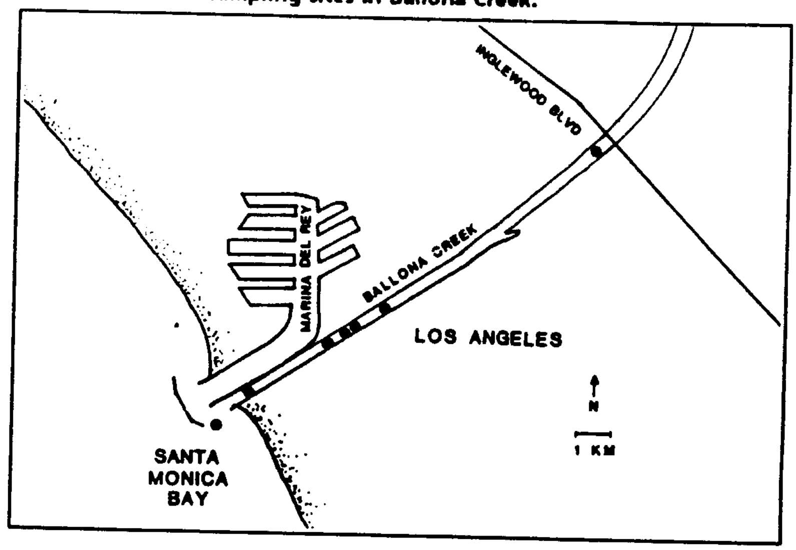
from the center of the channel with a glass bottle. The collection site was above the tidal prism and contained undiluted dry weather flow; samples from this site had a salinity of 0 mg/g. Two additional water samples were collected from this location on February 25, 1991. Sampling in December was preceded by 21 days of dry weather, while sampling in February was preceded by 47 days of dry weather.

Surface water samples from six areas near the mouth of Ballona Creek were also collected on February 25 (Figure 1). These stations were within the mixing zone of Ballona Creek discharge with ocean water. Conductivity measurements indicated that the water samples contained 0-22% creek water.

Figure 1
Location of water sampling sites in Ballona Creek.



Sample preparation

The water samples were stored at 5°C and tested for toxicity within 24 h. Each of the Inglewood Street samples was diluted with filtered natural seawater (34 ppt salinity) to produce concentrations of 2-32% dry weather flow. Dilutions of distilled water with natural seawater were used to test the effects of variable salinities. Receiving water samples from the mouth of Ballona Creek were tested at full strength.

Seawater controls were used to document the health of the test organisms and to provide a reference for identifying toxic effects. We also used a series of reference toxicant dilutions ($CuCl_2 \cdot 2H_2O$ in seawater) in each toxicity test to document relative sensitivity between test dates. The pH of some Ballona Creek samples was adjusted by adding either 0.1 N HCl or 0.1 N NaOH.

Test procedures

Purple sea urchins *(Strongylocentrotus purpuratus)* were collected from the intertidal near Point Dume in northern Santa Monica Bay. The urchins were held in recirculating seawater aquaria at 13-15°C until the tests were performed.

Three or four replicates of each sample were tested for toxicity at 15°C. All samples were tested with the sea urchin fertilization test; one sample from December was also tested with the embryo development test. The fertilization test followed the procedures of Dinnel *et al.* (1987) and consisted of a 60 min exposure of sperm to the test samples. Eggs were then added to the samples and allowed 20 min for fertilization to occur. Preserved samples were examined under a microscope and the percent of eggs fertilized was determined. Reduced fertilization is an indicator of toxic effects.

The embryo development test consisted of a 48 h exposure and followed the procedures described in Long *et al.* (1990). Preserved embryo samples were examined under a microscope to detect developmental abnormalities, indicators of toxic effects. Normal embryos have a pyramid shape, differentiated gut, and well-developed skeletal rods. Abnormal embryos exhibit either a delayed rate of development, or pathological conditions such as aberrant cleavage and cell death.

Statistical significance was determined by analysis of variance and Dunnett's multiple comparison test of the toxicity data (relative to controls). Raw proportion data were transformed by the arcsine for the analyses. The concentration of sample producing the median toxic response (EC50) was estimated using probit analysis.

Results

Relative sensitivity

Dilutions of the December 1990 Ballona Creek sample were toxic to both sea urchin sperm and embryos (Figure 2). The fertilization test was more strongly affected than the development test by sample concentrations of 10% and greater.

Control percent fertilization was high in the December and February sea urchin sperm tests (95-98%; Table 1). There was little variability in toxicity among the Inglewood Street samples, or among samples collected on the same day (Table 1). The February Ballona Creek samples were slightly more toxic (EC50 = 6%) than the December samples (EC50 = 10%).

Results of the copper reference toxicant were similar between experiments (Table 1). The fertilization test in February was slightly more sensitive to copper (EC50 = 13 µg/L) than the fertilization test in December (EC50 = 19 µg/L).

The fertilization test results were unaffected by salinity changes over the range of 28-34 mg/g (Table 1). Large reductions in fertilization were produced by Ballona Creek dry weather flow dilutions with salinities of 30-32 mg/g, well within the range tolerated by the sperm.

The pH of undiluted dry weather flow was unexpectedly high in both sets of samples (pH 10.1). Consequently, the pH of test samples containing more than 5% Ballona Creek effluent was greater than the control (pH = 8.1; Table 1). The effect of pH on fertilization was tested on dilutions of a dry weather flow sample collected in February. The sample pH was adjusted to 8.1, the pH of the dilution seawater. Both the pH-adjusted and non-adjusted samples were toxic (Figure 3). However, the non-adjusted sample produced stronger effects on the sperm. At a concentration of 5.6%, fertilization in the non-adjusted sample was 53%. Fertilization in the adjusted sample was 89%, which was not significantly different from the control (Dunnett's test, $p>0.05$).

Figure 2

Response of sea urchin sperm (fertilization test) and embryos (development test) to various concentrations of Ballona Creek dry weather flow collected in December 1990. Data are mean ± 1 standard error.

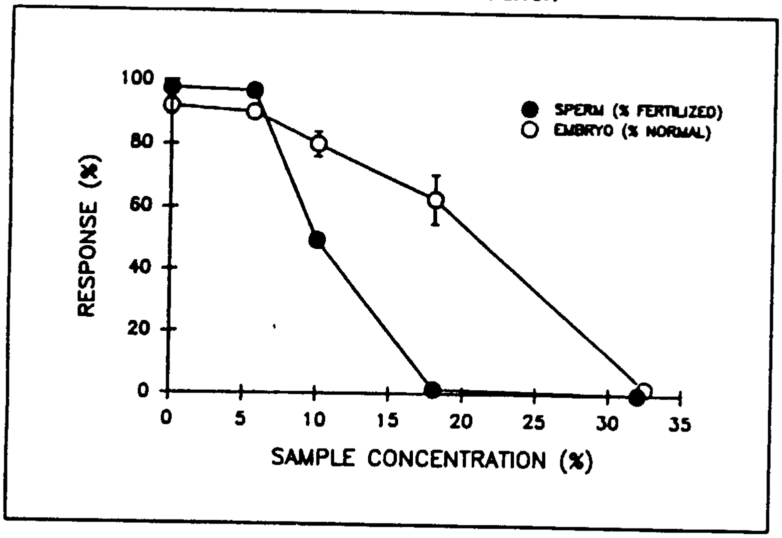
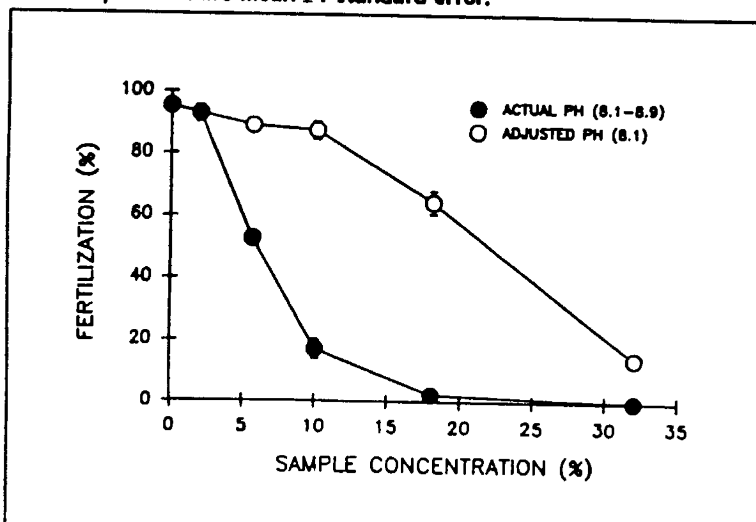


Figure 3

Influence of pH on fertilization test results of a February 1991 dry weather flow sample. Data are mean ± 1 standard error.



Most of the receiving water samples from the mouth of Ballona Creek were toxic to sea urchin sperm (Table 2). High toxicity was present in samples from the upstream and downstream ends of the mixing zone. Samples from the middle of the mixing zone were the least toxic. The pattern of toxicity in Ballona Creek did not correspond to the amount of creek water in the sample; the greatest effects were produced by water samples containing no dry weather flow.

Discussion

Ballona Creek dry weather flow was toxic to sea urchin sperm and embryos at low concentrations. The level of toxicity was similar among samples taken the same day and among samples taken several months apart. The greater toxic effects of the February samples may have been the result of variations in test sensitivity, rather than changes in dry weather flow toxicity. This conclusion is supported by the reference toxicant and salinity control data; tests conducted in February were more sensitive than tests conducted in December.

Variation in sensitivity among tests is an inherent characteristic of most biological test methods. The acceptability of test results is based on the magnitude of sensitivity changes measured by reference toxicants. Results of reference toxicant tests should be interpreted cautiously, however. Variations in sensitivity to one reference toxicant may not be an accurate indicator of overall test performance, unless the reference material possesses the same mode of toxic action and chemical characteristics (e.g., changes in speciation with pH) as the unknown material(s) exerting toxicity in the samples. The differences in sperm sensitivity to copper in this study were relatively small in comparison to other data (SCCWRP 1990) and unlikely to have had a large influence on the results for the Ballona Creek water samples.

Sea urchin fertilization was more sensitive to Ballona Creek water samples than embryo development. The relative sensitivity of these toxicity tests depends on the toxicant(s) present. In this study, elevated pH was responsible for much of the toxicity. Sea urchin sperm are sensitive to pH; fluctuations as small as 0.2 units (e.g., pH 8.2 to 8.4) produce declines in percent fertilization (Bay *et al.* 1992). The embryo development test is similar in sensitivity to the fertilization test for other toxicants (e.g., copper) and is more sensitive in some cases (e.g., ammonia; Bay *et al.* 1992).

Table 1

Water quality characteristics and results of sea urchin fertilization tests of dry weather flow from Ballona Creek at Inglewood Street. Results are also presented for diluted seawater (salinity control) and dissolved copper (reference toxicant) tests. Fertilization (Fert) is mean ± 1SE (N = 3-4). Conc = percent of dry weather flow or distilled water in test sample; Sal = salinity; Rep = replicate sample.

	Ballona Creek						Salinity control			Reference toxicant	
	Conc (%)	Sal (mg/g)	pH	Fertilization (%) Rep1	Rep2	Rep3	Conc (%)	Sal (mg/g)	Fert (%)	Copper (µg/l)	Fert (%)
Dec 1990											
										3.2	99±1
	5.6	32	8.2	97±1	97±1	97±1	5.6	32	97±1	5.6	98±1
	10	30	8.3	50±2			10	30	97±1	10	97±1
	18	28	8.6	1±1			18	28	95±1	18	56±2
	32	24	9.0	0±0	0±0	0±0	32	23	73±1	32	2±1
Feb 1991											
	2	32	8.1	93±3						3.2	95±3
	5.6	32	8.2	53±1	61±7					5.6	88±4
	10	30	8.4	17±3	22±5		10	30	88±2	10	70±5
	18	28	8.5	2±1	14±2		18	28	84±3	18	20±11
	32	24	8.9	0±0			32	23	27±5	32	0±0

The toxicity detected in Ballona Creek dry weather flow is the result of toxic constituents in addition to altered pH. Salinity variations of 28-34 mg/g did not exert a major influence on test results.

The cause of high pH in Ballona Creek is unknown. None of the NPDES-permitted discharges to the creek has a high pH (S. Birosik, Los Angeles Regional Water Quality Control Board, personal communication). Altered pH may be the result of the normal metabolic activity of algae (uptake of dissolved CO_2 during photosynthesis) lining the concrete channels of the Ballona Creek drainage system. Algal metabolism raises pH in other waterbodies (Lee and Jones-Lee 1991).

The results of the receiving water tests indicated that water quality was reduced near the mouth of Ballona Creek. The spatial pattern of toxicity results suggested that there were upstream (dry weather flow) and downstream (Santa Monica Bay) sources of toxicity. Sources contributing to the toxicity of the receiving water may be contamination from nearby Marina del Rey or the release of toxicants from Ballona Creek sediments into the water.

This is the first of our efforts to understand the biological effects of nonpoint source pollutants on the marine environment. The toxicity of Ballona Creek dry weather flow and the receiving water was comparable to the toxicity of Southern California sewage effluents (SCCWRP 1990), yet much less effort has been expended to study the composition and toxicity of this and other urban drainages. In the future, more intensive studies of the potential effects of discharge from channels like Ballona Creek will be conducted by agencies such as the Santa Monica Bay Restoration Project. ■

Acknowledgements

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Table 2

Toxicity test results for samples of Ballona Creek dry weather flow and Santa Monica Bay receiving water (bay) in the sea urchin fertilization test. The amount of dry weather flow in each sample was based on conductivity measurements.

	Bay	Distance from Santa Monica Bay (km) 0.5	3.3	3.8	4.3	5.3
Fertilization (%)	16	16	54	90	62	21
Dry weather flow (%)	0	0	4	6	9	22

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ADDITIONAL ACTIVITIES

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Additional Activities

Sampling at Sea in 1990-91

DATE	VESSEL	ACTIVITY	LOCATION
July 1990			
11	Ocean Sentinel	CTD and sediment samples	Palos Verdes
13	Marine Surveyor	Sediment toxicity	Santa Monica Bay
17	Monitor III	Sediment toxicity and sediment samples	San Diego
25	Enchanter IV	CTD and sediment samples	Orange County
27	Enchanter IV	CTD and current meters	Orange County
30-31	Monitor III	Reference survey south	San Diego
August 1990			
1	Monitor III	Reference survey south	San Diego
2-3	Marine Surveyor	Reference survey north	Ventura
6-7	Ocean Sentinel	Reference survey middle	Orange County
8-14	Marine Surveyor	Hyperion recovery	Santa Monica Bay
17	Monitor III	Toxicity grabs, CTD, and sediment samples	San Diego
28	Ocean Sentinel	CTD and sediment samples	Palos Verdes
29	Enchanter IV	CTD and sediment samples	Orange County
30	Enchanter IV	CTD and current meters	Orange County
September 1990			
4-10	Early Bird	Collect white croaker	Santa Monica Bay
12	Monitor III	Sediment samples, toxicity, and CTD	San Diego
13-14	Marine Surveyor	Hyperion recovery, sediment samples and current meters	Santa Monica Bay
19-21	Marine Surveyor	Microlayer	Santa Monica Bay
26	Ocean Sentinel	Sediment samples and CTD	Palos Verdes
27-28	Enchanter IV	CTD, sediment samples and current meters	Orange County
October 1990			
4	Marine Surveyor	Current meters and sediment samples	Santa Monica Bay
5	Phaon	CTD and sediment samples	Palos Verdes
10-11	Monitor III	Sediment samples, toxicity, and CTD	San Diego
25	Ocean Sentinel	Grabs	Palos Verdes
28-29	Westwind	Cores	Orange County
November 1990			
1-2	Enchanter IV	CTD, sediment samples and current meters	Orange County
8	Marine Surveyor	Sediment toxicity grabs	Santa Monica Bay
13	Ocean Sentinel	Sediment model coring and grabs	Palos Verdes
14	Monitor III	Sediment toxicity and CTD	San Diego
29	Dingy	Hook and line fishing	Seal Beach
December 1990			
4	Enchanter IV	Spar recovery and sediment samples	Orange County
6	Marine Surveyor	Toxicity grabs	Santa Monica Bay
11	Monitor III	Toxicity grabs	San Diego
12-14	Marine Surveyor	Microlayer sampling	Santa Monica Bay
January 1991			
3	Enchanter IV	Hornyhead trawls	Orange County
23-25	Monitor III	Toxicity grabs	San Diego
February 1991			
12	Marine Surveyor	Toxicity grabs	Santa Monica Bay
19	Marine Surveyor	Hyperion recovery	Santa Monica Bay
March 1991			
13-15	Marine Surveyor	Hyperion microlayer and current meters	Santa Monica Bay
18	La Mer	Equipment testing	Palos Verdes
June 1991			
19-21	La Mer	Microlayer	Santa Monica Bay
26-28	Monitor III	Trawls	San Diego

SCCWRP Contributions in 1990-91 and 1991-92

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- Thompson, B.E. 1992. Recovery of Santa Monica Bay from Sludge Discharge. Report to Bureau of Sanitation, Los Angeles, CA. 111 pp.
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Sampling at Sea in 1991-92

DATE	VESSEL	ACTIVITY	LOCATION
August 1991			
19-23	Marine Surveyor	Cores	Santa Monica Bay
September 1991			
10	Enchanter IV	Spar deployment	Orange County
18-20	Marine Surveyor	Microlayer and sediment collectors	Santa Monica Bay
October 1991			
21	Marine Surveyor	Sediment collectors	Santa Monica Bay
24	Enchanter IV	Trawls	Orange County
29-30	Monitor III	Trawls	San Diego
November 1991			
5	Enchanter IV	Current meters and sediment collectors	Orange County
18	La Mer	Sediment collectors	Santa Monica Bay
Decemberr 1991			
5	Enchanter IV	Current meters and sediment collectors	Orange County
11-13	La Mer	Microlayer sampling	Santa Monica Bay
20	Enchanter IV	Current meters and sediment collectors	Orange County
January 1992			
15	Enchanter IV	Trawls	Orange County
21, 24	Enchanter IV	Current meters and sediment collectors	Orange County
27-30	Monitor III	Trawls	San Diego
February 1992			
18-20	Ocean Sentinel	Trawls	Palos Verdes
25	Enchanter IV	Current meters and sediment collectors	Orange County
27	La Mer	Trawls	Santa Monica
March 1992			
12	Enchanter IV	Trawls	Orange County
23	La Mer	Grabs	Santa Monica Bay
26	Enchanter IV	Current meters and sediment collectors	Orange County
April 1992			
2	Enchanter IV	Current meters	Orange County
16	ConSuerte	Grabs	Dana Point
20	Ocean Sentinel	Box corer	Palos Verdes
27-29	Monitor III	Trawls	San Diego
May 1992			
11	La Mer	Box corer	Santa Monica Bay
19	Enchanter IV	Trawls	Orange County
June 1992			
9-10	Marine Surveyor	Cores	Santa Monica Bay

We would like to thank the following individuals who provide invaluable field sampling expertise:

Scott Johnson, Steven Kmeth, Peter Christie, and William Schafer of the *Marine Surveyor*, City of Los Angeles;

Joe Meistrell, Steve Gregson, and John Gavran of the *Ocean Sentinel*, County Sanitation Districts of Los Angeles County;

Fred O'Brien and Tom Pesich of the *Enchanter IV*, County Sanitation Districts of Orange County;

Kenny Neilsen and Robert Lorman of the *Con Suerte and Early Bird*, Sea Ventures, Inc.;

Mike Gunnels and Randy Driskill of the *Lo-Ann*, MEC Analytical Systems Inc.;

Tim Rothans, Jack Russell, and Richard Mange of the *Monitor III*, City of San Diego.

SCCWRP Presentations in 1990-91 and 1991-92

Steven M. Bay

Effects of H_2S in Sediment on the Urchin *Lytechinus pictus*. 11th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Arlington, VA. November 1990.

Status and Applications of Echinoderm Toxicity Test Methods. 1st ASTM symposium on Environmental Toxicology and Risk Assessment, Atlantic City, NJ. April 1991.

Assessment of Sediment Toxicity near Sewage Outfalls. Annual Conference of the California Water Pollution Control Association, Pasadena, CA. April 1991.

The Toxicity of Ballona Creek Runoff to Marine Animals. Annual Meeting of the Southern California Academy of Sciences, Los Angeles, CA. May 1991.

Evaluation of Chronic Sediment Toxicology Test Methods Using the Brittlestar, *Amphiodia urtica*. 12th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Seattle, WA. November 1991.

Seasonality and Relative Sensitivity of the Purple Sea Urchin Sperm Test. 12th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Seattle, WA. November 1991.

Priorities for Improvement of Aquatic Toxicity Assessment Methods. 2nd Annual Meeting of the Northern California Regional Chapter of the Society of Environmental Toxicology and Chemistry, Oakland, CA. May 1992.

Jeffrey N. Cross

Estimates of Contaminant Inputs to the Southern California Bight from surface runoff. 11th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Arlington, VA. November 1990.

Urban Wastes in the Marine Environment. Young Scholars Ocean Science Institute, California State University, Long Beach, CA. July 1991.

Sources and Fates of Anthropogenic Wastes in the Coastal Marine Ecosystem. Graduate Center for Public Policy and Administration, California State University, Long Beach, CA.
October 1991.

Contaminant Levels in Fishes in the Southern California Bight. Pacific Fisheries Legislative Task Force, Los Angeles, CA. March 1992.

Earth Day, Cabrillo Marine Museum, San Pedro, CA. April 1992.

Bruce E. Thompson

Understanding Sediment Toxicity off Southern California. 17th Annual Aquatic Toxicity Workshop, Vancouver, B.C., Canada. November 1990.

Understanding Sediment Toxicity off Southern California. Scripps Institution of Oceanography, Marine Biology Seminar, La Jolla, CA. April 1991.

Assessment of Monitoring and Data Management Needs in Santa Monica Bay. U.S. Environmental Protection Agency, 3rd National Coastal Programs Conference, San Diego, CA. May 1991.

Recovery of Santa Monica Bay from Sludge Discharge. Civil Engineering Department Seminar, University of California, Irvine, CA. October 1991.

Financial Statements

STATEMENT OF REVENUES, EXPENDITURES AND CHANGES IN FUND BALANCE FOR THE YEAR ENDED JUNE 30, 1991

	Budget	Actual	Variance Favorable (Unfavorable)
Revenues:			
Member contributions	1,032,500	1,500,000	467,500
Contracts and grants	447,000	158,004	(288,996)
Use of money and property	28,000	12,659	(15,341)
Total Revenues	1,507,500	1,670,663	163,163
Expenditures:			
Salaries and employee benefits	945,400	830,190	115,210
Contract services	129,348	235,408	(106,060)
Materials and supplies	144,500	126,514	17,986
Rent	77,852	108,494	(30,642)
Insurance	36,000	30,558	5,442
Office expenses	85,800	73,667	12,133
Capital outlay	20,000	6,179	13,821
Other	68,600	22,151	46,449
Total Expenditures	1,507,500	1,433,161	74,339
Excess of Revenues Over Expenditures		237,502	
Fund balance at beginning of year		(338,132)	
Fund balance at end of year		(100,630)	

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Financial Statements

STATEMENT OF REVENUES, EXPENDITURES AND CHANGES IN FUND BALANCE FOR THE YEAR ENDED JUNE 30, 1992

	Budget	Actual	Variance Favorable (Unfavorable)
Revenues:			
Member contributions	1,200,000	1,200,000	0
Contracts and grants	285,280	92,208	(193,072)
Use of money and property	13,190	31,028	17,838
Total Revenues	1,498,470	1,323,236	(175,234)
Expenditures:			
Salaries and employee benefits	882,850	709,288	173,562
Operations	100,980	71,614	29,366
Office Supplies	56,250	39,162	17,088
Lab supplies	60,000	39,921	23,079
Rent	63,600	63,222	378
Lease obligations	84,400	70,956	13,444
Capital outlay	26,270	14,460	11,810
Transportation/travel	28,800	14,955	13,845
Professional Services	37,690	19,576	18,114
Sub-contract	143,230	33,359	109,871
Miscellaneous	14,400	4,304	10,096
Total Expenditures	1,498,470	1,077,817	420,653
Excess of Revenues Over Expenditures		245,419	
Fund balance at beginning of year		(100,630)	
Fund balance at end of year		144,789	

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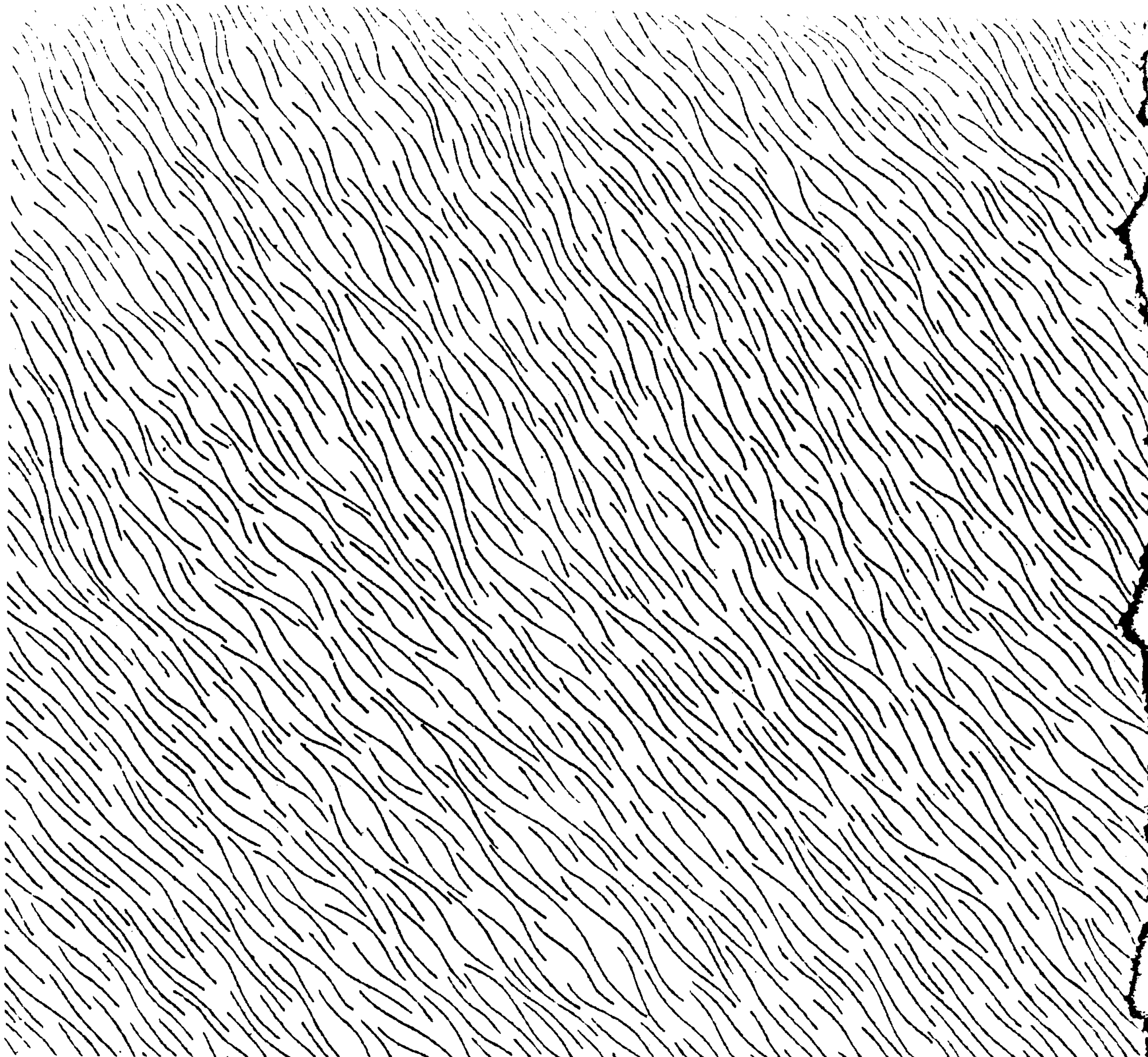

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Southern California Coastal Water Research Project Authority

646 W. Pacific Coast Highway

Long Beach, California 90806

Phone (310) 435-7071, FAX (310) 432-2171

Final Report

STORM RUNOFF IN LOS ANGELES AND VENTURA COUNTIES

TO

California Regional Water Quality Control Board
Los Angeles Region
107 South Broadway, Suite 4027
Los Angeles, California 90012

FROM

Henry Schafer and Richard Gossett
Southern California Coastal Water Research Project
646 W. Pacific Coast Highway
Long Beach, California 90806

June 1988

SCCWRP Contribution C292

VOL 12

2 0823

Final Report

STORM RUNOFF IN LOS ANGELES AND VENTURA COUNTIES

TO

California Regional Water Quality Control Board
Los Angeles Region
107 South Broadway, Suite 4027
Los Angeles, California 90012

FROM

Henry Schafer and Richard Gossett
Southern California Coastal Water Research Project
646 W. Pacific Coast Highway
Long Beach, California 90806

June 1988

SCCWRP Contribution C292

VOL 12

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0824

Final Report

STORM RUNOFF IN LOS ANGELES AND VENTURA COUNTIES

TO

California Regional Water Quality Control Board
Los Angeles Region
107 South Broadway, Suite 4027
Los Angeles, California 90012

FROM

Henry Schafer and Richard Gossett
Southern California Coastal Water Research Project
646 W. Pacific Coast Highway
Long Beach, California 90806

June 1988

SCCWRP Contribution C292

VOL 12 20825

State of California

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

Resolution No. 89-002

Regional Board Acceptance of Storm Runoff Report

WHEREAS:

1. The Los Angeles Regional Water Quality Control Board and the Southern California Coastal Water Research Project conducted a cooperative study of storm runoff in Los Angeles and Ventura Counties.

2. Pursuant to terms of the cooperative agreement, the Southern California Water Research Project has completed and submitted a final report entitled Storm Runoff in Los Angeles and Ventura Counties.

3. The study provides new information on the contaminant load that enters the coastal waters off Los Angeles and Ventura Counties.

4. A significant reduction in pollutant discharge to coastal waters can be achieved through better management and control of urban runoff.

NOW, THEREFORE, BE IT RESOLVED:

1. That the Regional Board accepts the report, Storm Runoff in Los Angeles and Ventura Counties; and

2. That the report be distributed to all affected agencies and interested parties; and

3. That staff be directed to work with all appropriate agencies to develop an urban runoff management strategy to control pollutant discharges to coastal waters.

I, Robert P. Ghirelli, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of a resolution adopted by the California Regional Water Quality Control Board, Los Angeles Region, on February 27, 1989.

Robert P. Ghirelli

ROBERT P. GHIRELLI, D.Env.
Executive Officer

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SUMMARY

Forty-nine samples of runoff were collected from eight sites in Los Angeles and Ventura Counties on September 23-25, 1986, during the first rain after the dry season. Six sites were near the mouths of major storm channels and three were spread along the Los Angeles River, the largest source of gaged runoff in Southern California. Suspended solids, oil and grease, total extractable organics (TEO), trace metals, DDT, polychlorinated biphenyl compounds (PCBs), polycyclic aromatic hydrocarbons (PAHs), and n-alkanes were measured. Fifteen-minute flow data were obtained for most sites from the county flood control districts. Because the storm was unpredicted and so early in the rain season, samples were not taken as regularly as planned, but low-flow, high-flow, and post high-flow samples were taken at each site.

In general the highest contaminant concentrations occurred near the peak flows and not at the first increase in flow. With few exceptions the highest concentrations appeared at the channels with the greatest flows also making them the greatest sources of contaminant mass emissions.

The two Ventura sites showed minimal increases in flows, probably due to a limited amount of impermeable surface area and the dry status of the soils. The Santa Clara River samples had the highest suspended solids concentrations and DDT levels of any site, but the low volumes produced very low mass emissions.

Accurate flow measurements at the four Los Angeles County sites were obtained only for Ballona Creek and the three sites on the Los Angeles River. There was no gage on the Dominguez Channel and one of two gages required to determine the total flow for the San Gabriel River failed during the storm.

Flows from the Los Angeles River, Ballona Creek and the San Gabriel River were large; each exceeded the daily flow of the largest municipal wastewater treatment plant in the county. The runoff of the Los Angeles River at Willow Street and Ballona Creek had the highest mean concentrations of almost all contaminants. Concentrations of oil and grease, cadmium, chromium, copper, and nickel were similar to Hyperion 1985 five-mile effluent values, while lead, zinc, DDT, and PCB concentrations were higher.

Within the Los Angeles River system, runoff contaminant concentrations increased from the headwaters at Tujunga Wash through the mid-river site at the San Fernando Valley to the mouth near Long Beach. Most contaminants were below detectable limits at Tujunga Wash above any land development.

Downtown Los Angeles and the commercial and industrial area of south Los Angeles County added less than one-half the flow of the upstream drainage but three to five times the mass of contaminants.

Petroleum hydrocarbon characteristics in runoff were not very consistent within or between channels. However gas chromatograms for most samples contained unresolved complex mixtures (UCMs) humps characteristic of crankcase oil inputs. The relative abundances of polycyclic aromatic hydrocarbons (PAHs) in runoff samples at several sites indicated the input of unweathered petroleum and combustion by-products with the latter in greater amounts.

Previous studies found that the mean concentrations of contaminants in the Los Angeles River did not change much between 1971/72 and 1979/80, except for lead and PCBs. Our preliminary results for the Los Angeles River do not indicate much change since 1979 with the exception of a fourfold decrease in DDT concentrations.

INTRODUCTION

This report is the result of a cooperative study with the Los Angeles Regional Water Quality Control Board to measure runoff contaminant concentrations and to estimate mass emissions during storm flow conditions at several important channels in Los Angeles and Ventura Counties. Three to ten samples were taken at each of seven sites (49 samples total) during a 48-h period in order to sample peak and decreasing flow stages. We measured concentrations of suspended solids, percent volatile solids, oil and grease, TEO, cadmium, chromium, copper, nickel, lead, zinc, DDT, DDD, DDE, PCBs, n-alkanes and PAHs in whole water samples. A subset of samples was analyzed for triterpanes and steranes by UCLA. Rainfall and flow data were obtained from the County Flood Control Districts.

Results from a second storm sampled in January 1987 at these sites are not included in this report but will be reported when complete data become available. This study is part of a long-term Southern California Coastal Water Research Project (SCCWRP) program to update and improve past estimates of contaminant inputs to the Southern California Bight. By the summer of 1988 we will have sampled storm runoff from the largest storm channels in four of the coastal counties of Southern California.

Background Studies

Southern California Bight

Beach closures, pelican reproduction failures, fin rot, contaminated fish seizures, and kelp bed disappearances off the Southern California coast have stimulated interest in anthropogenic inputs of contaminants to Southern California coastal waters since the 1960's. Extensive monitoring of trace metals and chlorinated organics in municipal wastewater effluents, the principal source of most anthropogenic contaminants to the Southern California Bight (20, 26), began around 1970 and has expanded through the 1970's and 1980's. By 1985, source control, improved sludge handling, and increased treatment (additional advanced primary and secondary treatment) combined to reduce wastewater emissions significantly. Silver, cadmium, chromium, copper, mercury, nickel, lead, and zinc discharges were an average of 65% lower than peak (mid-1970's) emissions. DDT and PCB discharges were 99 and 90% lower, respectively. These reductions occurred despite increases in population and effluent flows (21). Recently, completed and planned municipal wastewater effluent improvements should continue to reduce outfall inputs while continued population growth and land development have made and will continue to make runoff a more important pollutant source of contaminants than it was 10 years ago.

Studies of contaminants in Southern California runoff are scarce compared with those available for municipal wastewater outfalls. Among possible reasons are (1) no agency has been responsible for storm drain water quality; (2) storm flow (which is responsible for most runoff volume and contaminant emissions) is unpredictable, highly variable and limited to a few months of the year; and (3) representative samples of storm flow are not easily obtained.

One of the first studies to measure runoff impacts in Southern California was conducted by Chen in the early 1970's at Marina del Rey (4). Water and sediment samples were taken from the marina near two storm drains and Ballona Creek over several stormy periods. It was determined that storm runoff had little direct effect on trace metal and pesticide levels in the water column within the marina. In contrast, sediments near the runoff channels were highly contaminated; sediments near the storm drains with DDE levels up to 5.5 mg/dry kg were 60 times more contaminated than sediments near the Hyperion five-mile outfall.

The most detailed and complete study of runoff emissions was conducted by SCCWRP during 1971/72, an unusually dry year (43% of average annual runoff). Wet and dry weather flows were sampled at four major rivers, and dry flow was sampled at an additional 11 streams in Southern California (20). Based on this limited survey it was concluded that the contribution of contaminants via runoff was less than 10% of that discharged by municipal outfalls in southern California. Exceptions to this generalization included suspended solids, nitrate, nitrogen, iron, manganese, lead, and cobalt. Two contaminants of note were suspended solids (274,000 metric tons, 99% of effluent emissions) and lead (90 metric tons, 43% of effluent emissions). DDT (0.12 metric tons) and PCB (0.25 metric tons) emissions were about 1 and 3%, respectively, of the combined outfall values.

Using the same sampling technique, Young et al. (25) repeated a similar study of three storms at the largest source of runoff in Southern California, the Los Angeles River (30% of the total average annual gaged flow from Southern California) in 1979/80. In that year low flow was responsible for only 5% of the annual discharge, and low-flow contaminant concentrations were approximately one-half of the storm concentrations. This indicates that storm runoff was by far the most important source of mass emissions. The 1979/80 study and the 1971/72 study also showed that with the exception of nickel, 88-99% of the trace metal and chlorinated hydrocarbons were associated with particulates (>0.4 m). A comparison of flow-proportioned mean concentrations of 10 trace metals, DDT, and PCBs between two storms in 1971/72 and three storms in 1979/80 showed that the standard error of 10 of the 12 contaminants was less than 50% (six of the twelve were less than 20%). This suggests that there was not a large difference in mean concentration values between years. Differences in lead and PCB concentrations were much larger than those of the other contaminants, and mean concentrations (between 1971/72 and 1979/80) showed a six- and eightfold reduction, respectively. These reductions were most likely due to legal restrictions on the industrial use of both compounds.

The Los Angeles County Flood Control District (now called the Department of Public Works) has conducted detailed monitoring of storm channel contaminants since the late 1960's. Monthly samples from 30 channel sites were collected from 1967 through 1984 (5). Biochemical oxygen demand (BOD) and levels of oil and grease, nutrients, trace metals, pesticides, and bacteria were measured (5). In 1985, the monthly monitoring program was reduced to 7 stations plus 14 additional stations monitored bimonthly or quarterly and 15 stations sampled twice annually during storm flows (6). Although this is the largest storm channel data base for Southern California and may reveal trends in low flow concentrations, it was not designed for the estimation of mass emissions because corresponding flows have not been recorded. In addition, runoff was rarely sampled during peak flows when

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concentrations are most variable and emissions are most significant. Despite limitations of this data set, Garber (12) has made some preliminary estimates of long-term emissions rates to Santa Monica Bay. He used the annual average concentrations from Flood Control contaminant data and annual flow measurements from four gaged channels and assumed individual storm drains contribute about 40% of the gaged runoff. The single greatest cause of variation in annual emissions is variation in annual water discharge volume.

Figures 1 and 2 show the annual flow and lead emissions between 1967 and 1982 for the Los Angeles River, the total runoff to Santa Monica Bay, and the Hyperion combined outfalls. From the available data, Garber (12) estimated that Santa Monica Bay runoff inputs (1967-1982) of lead, selenium, nickel, copper, mercury, chromium, and total identifiable hydrocarbons to be 40%, 17%, 14%, 6%, 52%, 9%, and 7%, respectively, of the 1987 emissions from Hyperion's two outfalls. These estimates are probably low because storm conditions (which normally lead to much higher contaminant concentrations) were not proportionally sampled. As of the end of 1987 the sludge outfall discharges have been terminated reducing many outfall contaminant inputs by 50% and further increasing the importance of runoff as a source of contaminants.

The Pico-Kenter storm drain in Santa Monica delivered a small but regular flow that accumulated on the beach. This site has been the focus of attention because of petroleum-like discharges that have closed the beach and because of high incidences of cancer in lifeguards who have worked in the area (7). The linkage of storm drain constituents to the incidences of cancer has been investigated (and discounted) and chemical values (nutrients, BOD, chemical oxygen demand (COD), oil and grease, phenols, cyanide, and 14 metals) have been reported (7). Estimates of mass emissions have been made by using Pico-Kenter contaminant data and County Flood Control flow data for all of Santa Monica Bay (18). These calculations estimate that runoff to the bay is responsible for 10% of the oil and grease and 10-50% of the trace metals that the seven-mile sludge line discharged in 1981.

Studies of water and sediment quality in Marina del Rey, the adjacent mouth of Ballona Creek, and storm drains entering the harbor (13) have shown higher levels of contaminants at sites near the storm drains and creek mouth than in the harbor. Elevated contaminant concentrations and reduced dissolved oxygen were detected at most stations after storm runoff. Interestingly, measurements of oil and grease in runoff to Marina del Rey showed no decrease in the concentration ranges through three consecutive storms indicating a large reserve.

Eganhouse and Kaplan (9-11) characterized organics in Los Angeles River water from an early season storm in 1978 and compared constituents and masses of runoff inputs with municipal emissions. They found that 60% of the extractables were petroleum derived, whereas the non-hydrocarbons were mostly biogenic. Although runoff inputs of hydrocarbons were estimated to be one-half of municipal outfall inputs to Southern California, they were estimated to represent 2% of the global inputs from all sources to the ocean.

In 1986 Anderson and Gossett (1) reported on PAHs in marine sediments from the outfall and harbor areas between San Diego and Los Angeles. They found some of the highest levels near the mouths of the Los Angeles River, and the Dominguez Channel and near storm drains in San Diego Bay.

Background Outside Southern California

In comparison to Southern California runoff, the east coast of the United States has been extensively studied (2, 15, 16, 17, 23). There is also considerably more information about sources of contaminants. However, these studies were carried out in areas that receive much more frequent rain than Southern California does, and in most cases rainfall occurs throughout the year with short intervals between runoff events.

In a three-year study of contaminant sources and mass emissions to Narragansett Bay, Hoffman and Quinn (15) determined that runoff was the largest source of petroleum hydrocarbons, high molecular weight PAHs, lead, and zinc to the bay. Municipal outfalls were the major source of low-molecular-weight PAHs. Although highways and industrial areas occupied a relatively small portion of the drainage basin they were important sources because of their very high concentrations. Highways and industrial runoff contained, respectively, 40 and 80 times the petroleum hydrocarbons, 40 and 12 times the copper, 100 and 7 times the lead, and 160 and 15 times the zinc as residential runoff concentrations.

In Richmond, California, Stenstrom et al. (22) measured oil and grease emissions from five different land use areas in a basin that drains into San Francisco Bay. The authors concluded that runoff emissions were an important and growing problem and that 50% of the oil and grease emissions from the studied basin could be eliminated if emissions from industrial and parking facilities (11% of land in the basin) were controlled.

Ebbert and Wagner (8) examined 35 collection sites from eight urban areas throughout the United States, compared rain concentrations of contaminants with runoff concentrations, and found that rain could be a significant source of contaminants. The mean contributions of rain to runoff emissions were 74% for nitrate plus nitrite, 12% for COD, 12% for copper, 6% for lead, and 2% for suspended solids.

Richards and Holloway (19) used Monte Carlo techniques to evaluate the accuracy and precision of tributary load estimates using a 4000 data point sampling set. Hypothetical annual sampling programs with 12 to 600 samples were examined. The results showed that the bias and precision of loading estimates were influenced not only by the frequency and pattern of the sampling plan but also by the size of the drainage basin (smaller channels need more frequent sampling) and the behavior of the constituent measured. Stratified sampling with the bulk of the samples taken during the highest flow will produce the most accurate estimates. Estimates within 20% accuracy are suggested with only a few low flow measurements and careful concentrated sampling during the 2 or 3 greatest flows of the year (24).

OBJECTIVES

The primary objective of this study was to determine the concentrations of contaminants from major runoff sources and to estimate their mass emission rates to the ocean. These data are compared to past estimates of runoff emissions as well as other sources of contamination to the Southern California Bight.

We also determined how the concentration and mass of contaminants varied throughout the storm events to see if significant portions of the mass emissions were concentrated in a small part of the flow. We sampled sites to see how contaminant levels varied with land use. In addition, we measured polycyclic aromatic hydrocarbons (PAH) concentrations for the first time for several channels to determine which compounds were present in Southern California runoff.

METHODS

Six large runoff sources in Ventura and Los Angeles Counties were sampled (Figure 3). Each channel has a unique drainage basin, and most of the channels (Santa Clara River, Calleguas Creek, Los Angeles River, and San Gabriel River) receive wastewater effluent from one or more municipal wastewater treatment plants. This contributes significantly to dry weather flows.

Sampling locations on each channel were selected for the following reasons: (1) to provide safe sampling; (2) to be used under adverse weather conditions; (3) to provide access to the center channel of the flow; and (4) to be downstream from the major sources of runoff contaminants. In an attempt to sample downstream from potential major sources we located three of our stations (Calleguas Creek, Dominguez Channel, and San Gabriel River) in the upper reaches of the tidal prism.

Santa Clara River

The Santa Clara River drains the second largest basin in Southern California (4,200 km^2) and has produced some of the largest peak flows (165,000 cfs) in Southern California's history. However, the flow near the mouth is poorly correlated with natural weather conditions because water is imported from the California Water Project and flow in the upper and middle river is regulated by releases from the dams at Lake Piru, Lake Pyramid, and Lake Casitas. Diversions and groundwater recharge prevent upstream flows from reaching the ocean except during large storms. Even below the last water diversion the dry sandy riverbed is capable of absorbing most of the flow from early season and small storms.

We sampled on the north side of the channel where Highway 101 crosses the river (H on Figure 3). This site is located about 8 km above the mouth of the river, which is at McGrath State Beach. Our site is the last accessible, safe location to sample moderate or high flow conditions. The channel is over 300 ft wide, and the bed is unlined.

Calleguas Creek

Calleguas Creek drains 650 km^2, including the southern part of the Hueneme Plain, and receives secondary effluent discharge from several treatment plants. This sampling site on Highway 1 is in the middle of the tidal prism and above Mugu Lagoon (I on Figure 3). We decided to sample here because it would allow us to obtain runoff from Calleguas Creek as well as Revlon Slough, which also drains a large portion of the Hueneme Plain that is used intensively to grow vegetables and other cash crops. Unfortunately, between the time we selected this site and when it was sampled, the channels were separated and the junction point moved below our site location. Therefore we collected separate samples from only

Calleguas Creek. Flow data were obtained from the Ventura Department of Public Works from their station at Camarillo, which is about 6 km above the sampling site.

Ballona Creek

Ballona Creek drains 232 km^2 of highly urbanized land in West Los Angeles. The main channel is concrete lined. Oil and tar lines on the banks of the channel are evidence of the occasional discharge of petroleum from freeway tanker spills and other sources. Our sampling station (D on Figure 3) is located 4 km above the mouth of the creek, between the entrance to Marina del Rey and the beach at Playa del Rey. The station on the Inglewood Avenue bridge is above tidal influence except during the highest tides; however, we saw no visual or chemical evidence of saltwater intrusion during any sampling period. Flow data were obtained from the Los Angeles County Department of Public Works recording gauge F 38C-R, which is located near Sawtelle Avenue about 1 km above the sampling site.

Dominguez Channel

The Dominguez Channel drains about 100 km^2 of industrial and urban land in south Los Angeles. In the past, the upper reaches received runoff from the Montrose Chemical Plant. This plant was the source of most of the DDT discharged from municipal outfalls or dumped into Southern California marine waters between the late 1940's and mid-1970's (3). The sides of the Dominguez Channel are covered with riprap, and the lower 10 miles are within the tidal prism and continuously filled with water. There is no recording flow gage in the lower reaches of the channel. The sampling site (C on Figure 3) is located on the railroad bridge just south of Anaheim Street, which was as close to the channel's termination in Los Angeles/Long Beach Harbor as possible. Although this sampling site lacked adequate flow data and was in the lowest section of the tidal prism, we decided to sample here because the 5-6 km of channel immediately above this site is lined with oil refineries. In addition, the harbor sediment just below our sampling site has been shown to have very high levels of petroleum hydrocarbons and pesticides (1). Justification for selecting this site comes from its high potential for producing environmentally significant concentrations of contaminants under rapid flow conditions.

Los Angeles River

The Los Angeles river was sampled because it is responsible for about 30% of the total annual gaged runoff from Southern California and it has been studied twice before by using similar techniques. Three sites were selected in an attempt to separate sources of contaminants to the river. The upper river basin is slightly developed, the middle portion drains the San Fernando Valley and is largely residential, while the lower half of the river drainage is more commercial and industrial. The three sites sampled were Big Tujunga Wash (F on Figure 3), Fletcher Avenue Bridge (E on Figure 3), and the Willow Street Bridge (B on Figure 3).

Big Tujunga Wash is one of three major tributaries draining the foothills above Los Angeles. Our sampling site was located below the Big Tujunga Dam which collects runoff from undeveloped steep-sloped hills. Although the flow in this area is small, we decided to sample here because anthropogenic contaminants in this area could only have been deposited by aerial fallout.

The Fletcher Avenue Bridge crosses the Los Angeles River about halfway between the headwaters and the mouth. Drainage above this site is mostly from the suburban San Fernando Valley and the less developed foothills. The Los Angeles County Public Works Department maintains a recording gage that records flow at 15-min intervals at this site.

The Willow Street sampling site is located in Long Beach at the end of the concrete-lined channel about 2 km above the river mouth in Long Beach Harbor. The total area drained above this site is about 3200 km^2. Past flows at this site have reached over 100,000 cfs. This section of the channel receives runoff from downtown Los Angeles and the commercial/industrial developments of east and southeast Los Angeles. The Rio Hondo Channel is approximately 16 km above this site and is capable of transferring water from the San Gabriel River to the Los Angeles River at the discretion of the Public Works Department.

Flow data for the three sites were obtained from the Los Angeles County Department of Public Works for stations F168-R, F57C-R, and F319-R (Figure 3). These are within 1 km of their respective sampling sites.

San Gabriel River

The San Gabriel River drains approximately 1600 km^2, but its discharge to the ocean is relatively small. During low flow and small storm flows much of the upper river water is retained for groundwater recharge. Most of the dry weather flow in the lower river is from advanced wastewater effluents.

We intended to sample two sites on the San Gabriel River; however, the first storm occurred so early in the season that we missed sampling the upper station at San Gabriel Parkway.

The lower San Gabriel River was sampled at College Park, (A on Figure 3), which is about 3 km above the river mouth in Long Beach Harbor. Unfortunately, this site was also located about 1 km below the upper end of the tidal prism. The site was selected because it was the nearest point of access below the confluence of the San Gabriel River and Coyote Creek. Storm flows from Coyote Creek to the San Gabriel River can constitute more than one-half of the total flow. We selected this site under the assumption that any significant flow would flush saltwater out even at the highest tides. However, salinity measurements of a few low flow samples taken at high tide indicated the presence of marine water. Consequently, trace metals were not measured for those samples nor were they included in emission estimates. Two Los Angeles County Department of Public Works flow gages were required to measure the total flow from both channels for our site. Gage F428-R on the San Gabriel River malfunctioned during the storm and no data were collected. Gage F354-R, below Spring Street, measured Coyote Creek flow about 3 km above the sampling site. Mass emission estimates are based only on the Coyote Creek flow.

Samples were collected from the center of flow for each channel by lowering an acid-washed kilned 1-gallon bottle in an epoxy covered metal sampler that was equipped with a horizontal and vertical tail stabilizer that kept the bottle opening facing upstream. The bottles passed through the surface layer uncapped. The sampler was submerged about 0.5 meter below the surface, and was filled in about 90 seconds. The sampler was deployed twice for each sampling period, and the sample was proportionally divided into the sample containers for organics (4 liters), trace metals (1 liter), suspended solids (1 liter), oil and grease (1 liter), and toxicity (20 ml).

Cumulative rainfall data from 17 sites (Table 1) located within the drainage basins that we were studying were collected from Los Angeles County Department of Public Works files.

River Flow Data

Figure 3 shows gaging stations for Los Angeles County. The gages on Ballona Creek, the Los Angeles River, the San Gabriel River, and Coyote Creek can provide flow data at 15-min intervals. Continuous flow data for Calleguas Creek were provided by the Ventura County Department of Public Works. Data for the Santa Clara River flow are based on field crews observations, which we believe to be acceptable since the flow was low and did not change much during the storm.

RESULTS AND DISCUSSION

A complete listing of flow rates, flow volume, interval volume, contaminant concentrations, and mass emissions for each sample is listed in Appendix A.

Differences Between Sites

Mean concentrations

Flow-proportioned mean contaminant concentrations and ranges for eight sites are summarized in Table 2. Histograms of mean concentrations at the sampling sites are shown in Figure 4, A-N.

Suspended solids mean concentrations for seven sites are shown in Figure 4, C. The highest (1250 mg/liter at the Santa Clara River) and lowest (30 mg/liter at Calleguas Creek) concentrations were found in Ventura County. The sites in Los Angeles County ranged between 200 and 750 mg/liter.

The Los Angeles River at the Willow Street site (Figure 4; B, D-H). generally had the highest concentrations of hydrophobic (oil and grease, total extractable organics, PAH, n-alkanes, PCBs, and DDT) contaminants. Exceptions occurred at Ballona Creek, which had 50% more oil and grease and a DDT concentration 4 times that of the Willow Street site, and Santa Clara, which had a DDT concentration 11 times that of the Willow Street site.

The trace metals concentrations (cadmium, chromium, copper, nickel, lead, and zinc) were all highest at Ballona Creek followed by the LA River at Willow (Figure 4, I-N). Concentrations at Tujunga Wash were consistently below detection, while the other sites had roughly equal levels.

Within the LA River system contaminants increased between upper and lower stations. The Willow runoff had about twice the amount of suspended solids as the upper two stations did. Oil and grease and TEO concentrations quadrupled between Tujunga and Fletcher and again between Fletcher and Willow. Metal concentrations were below detection limits at Tujunga, but metal concentrations at Willow were two to four times higher than those at Fletcher (Figure 4, I-N).

Mean concentrations per gram of suspended solid

Past studies have shown that most of the contaminants are associated with suspended particulates (9, 21). We have calculated contaminant concentrations per gram of suspended solid in Table 3 assuming that all of the contaminants are particulate bound. This could be a misleading supposition if contaminant levels are very low and dissolved contaminants constitute a significant percent of the total concentration. However, with this caution in mind Table 3 (and Figure 5, A-L) gives an indication of quality of particulates that may accumulate in sediments or be spread in near-shore waters.

Oil and grease measurements at Tujunga and Santa Clara were an order of magnitude less than at the other sites (Figure 5, A). The four sites with moderate to high flows (Willow, Fletcher, Ballona, and San Gabriel) had similar values between 10.5 and 23.6 mg/g. The very high concentrations at Calleguas Creek were a result of the very low concentrations of suspended solids.

DDT and PCBs had two different patterns (Figure 5, E-F). Santa Clara River and Ballona Creek particulates were more contaminated with DDT than were particulates at the other sites, while PCBs were more uniformly distributed at all sites except Tujunga Wash.

The Los Angeles River and Ballona Creek had much higher concentrations of PAHs and n-alkanes than the other sites.

The trace metals concentrations on suspended solids (Figure 5, G-L) were reasonably uniform at four stations (Willow, Fletcher, Ballona, and San Gabriel), while concentrations of metals at Tujunga and the Santa Clara River were much lower.

Los Angeles River System

Within the Los Angeles River stations, the Tujunga samples had the lowest contaminant concentrations but moderately high suspended solids levels. This resulted in very low concentrations per gram of suspended solid. The trace metals, pesticides, PCBs and PAHs were below detection limits while oil and grease and n-alkanes were 4 and 9 times higher than at mid-river. Concentrations of metals, pesticides and PCB on suspended solids are similar for samples from mid-river (Fletcher) and lower river (Willow). However, the lower river samples are 2 to 9 times high in TEO, PAHs and n-alkanes.

Mass Emissions

Calculated flow-proportioned mass emissions are listed in Table 4 and shown in Figure 6, A-N.

The Los Angeles River is the largest source of runoff to the Southern California Bight. The highest flows combined with the high concentrations caused the Willow Street site to have the highest mass emissions of all constituents except DDT.

For all constituents except DDT there is a consistent pattern of greatest emissions coming from the Los Angeles River, then Ballona Creek followed by Fletcher and San Gabriel. The remaining stations have minimal inputs.

Within the LA River stations, Tujunga emits a miniscule volume of runoff and contaminants. The flow at the Willow site is about 30% greater than that at Fletcher, but contaminant emissions are 3 to 10 times greater, indicating a much greater source, in the lower basin.

The Ballona Creek drainage is only about 10% of the Los Angeles drainage basin, but during this storm its flow was about 40% of the LA River flow. The emissions of most contaminants were approximately 40% of the LA River emissions. Exceptions were lead and zinc, which were about equal to Willow emissions, and DDT and n-alkanes which were twice and one-sixth of the Willow emissions.

We have underestimated the emissions from the San Gabriel River because we only have flow data from Coyote Creek, so our estimates could be low by a factor of 2 or more. The measured flow is three-fourths the size of the Ballona Creek flow, but emissions of oil and suspended solids, oil and grease, TEO, trace metals, and chlorinated hydrocarbons are between 3 and 20% of Ballona's emissions, while PAH and n-alkane emissions are 1 and 3%, respectively.

Trends in flow and contaminant concentrations with time

Figure 7, A-H, shows the flow and concentrations of suspended solids, oil and grease, TEO, lead, total PAHs, total PCBs, and volatile solids for the Los Angeles River during the 48-h of sampling.

There were two peaks in flow about 6 h apart; the first peak exceeded 10,000 cfs, whereas the second peak returned to 9,000 cfs after dropping to 5,000 cfs.

The peak contaminant concentrations (except percent volatile solids) occurred in either sample 6 or 7 before the first peak in flow. Although sample 8 had the highest flow, the concentrations of all contaminants dropped. This may be due to a washout of contaminants.

Trends in Cumulative Emissions

As an example of when contaminant emissions occur, Figure 8, A-D, shows the cumulative percent flow with cumulative percent emissions of suspended solids, oil and grease, combined trace metals, and chlorinated hydrocarbons for the Willow station, and Figure 9, A-D, shows that approximately 80% of the flow and suspended solids were discharged within a 10-h period. Contaminant emissions lagged during the first 5% of flow but rapidly increased after 10% of the flow occurred. In general the first 25% of flow produced 50% of the contaminant emissions, and when 50% of the flow had occurred, 75% of the contaminant emissions had occurred. This pattern is representative of the other sites studied.

Petroleum hydrocarbon characterization

Aliphatic hydrocarbons

Figure 10a represents a typical chromatogram of the aliphatic fraction from our stormwater runoff samples. Generally, most of the samples contained a single hump of varying size (known as the unresolved complex mixture-UCM) and numerous resolved peaks which represent simple alkanes containing from 10 to 30 carbons. The presence of a UCM maximizing at n-C21-C35 is indicative of crankcase oil in the runoff. The n-alkanes, which are the resolved peaks labelled with their respective number of carbons, showed maxima at n-C17 as well as the higher molecular weight n-alkanes with odd numbers of carbons (i.e., n-C27, C29 and C31). The odd-even carbon chain length predominance of these higher molecular weight species indicates the presence of waxes characteristically associated with the cuticles of higher plants.

There were two notable exceptions to the pattern illustrated in Figure 10a. First, samples taken from Ballona Creek at 6 and 47 hours contained two UCM humps, the first hump being larger and maximizing at n-C18 (Figure 10b). It has been suggested by some researchers that this pattern may be representative of bacterial degradation products. Second, the 31 hour sample taken from the Los Angeles River at Willow Street contained no UCM at all. It did, however, exhibit the highest concentrations of n-alkanes (mostly from the C23-C39 range) with little apparent odd-even predominance. This sample was taken during the second peak in flow at approximately 8500 cubic feet/second (Figure 7a). The distribution we observed is not consistent with a recent biogenic origin, but may be related to dewaxing of petroleum. Similar distributions were not observed in samples taken before or after this one. Therefore, it is unclear whether these results are anomalous, representing the inclusion of a small particle of pure wax, or an indication of a short-term input to the river.

Aromatic hydrocarbons

Figure 11 presents a relative abundance plot for the 26 PAHs measured in this study (see Appendix A for a list of the compounds and their individual concentrations). This sample was taken from the Los Angeles River at Willow Street after 30.8 hours and is indicative of the most common distributional pattern. Most of the samples contained some naphthalenes (compounds 1-4) and phenanthrenes (compounds 9-12) which are the dominant PAHs in unweathered petroleum. However, the compounds with four or more rings (fluoranthene through benzo[g,hi,i]perylene; compound 14-26), which are combustion products, were frequently present at higher concentrations. Therefore, results of this study showed a mixture of both types of hydrocarbons being discharged during this storm with a larger amount of combustion products present.

The PAH composition was variable throughout the storm at a single point on the channel and in samples taken contemporaneously during a storm at different sites in the channel. However, the plot from the Los Angeles River station at Willow Street (Figure 8) is comparable to those obtained by Anderson and Gossett (1) for bottom sediments collected at the mouth of the Los Angeles River as well as those for sediments from the vicinity of Los Angeles County's outfall, suggesting that stormwater runoff and municipal effluent may contain PAHs of similar composition.

CONCLUSION

As the emissions of contaminants from outfalls continue to decrease, runoff emissions become a more important source of marine inputs. Outfall emissions have been steadily reduced over the last 10 years (21), but little has been done to reduce contaminants. Young et al. (25) concluded that variations in runoff concentrations were not significantly different in the Los Angeles River between 1971 and 1979 except for lead and PCBs, which were reduced by factors of 6 and 8, respectively. There do not appear to be many major changes in concentration since

1979. Table 5 shows concentrations for the five storms measured in 1971 and 1979 and the present 1986 results. Between 1979 and 1986 copper and lead concentrations increased by about a factor of 2, while suspended solids and chromium were reduced by two-thirds and one-half, respectively. The rest of the trace metals and PCBs varied by less than one-third. DDT had the largest change and was reduced by a factor of 4.

How the volume of runoff affects contaminant emissions is not clear. Los Angeles River runoff in 1971/72 was about one-half of normal runoff, while 1979/80 produced runoff five times the 15-year average; yet Young and his co-workers found most contaminant concentrations to be similar. Five of the twelve highest concentrations in the year did not occur in the first storm of 1979, and the third storm had cadmium and lead concentrations higher than those of the first storm. Data from the storm we sampled in January 1987 should allow us to determine the changes between storms within a year.

We did have some indication of a washout of contaminants in the Los Angeles River in this year's study because almost all of the contaminant concentrations peaked before our highest flow sample was taken. If the distribution of rain on land use areas did not change significantly there may have been a reduction in available contaminants. Hoffman et al. (14) found that residential, highway, commercial, and industrial areas had different rates of washout during a storm with residential concentrations of petroleum hydrocarbon approaching zero after less than 2 cm of rain, while industrial sites showed no reductions in concentrations after 2 cm of rain.

Large flows from Ballona Creek, Los Angeles River Willow, Los Angeles River Fletcher, and the San Gabriel River exceeded 3.5×10^9 liters (920 million gallons) during the storm, while flows of less than 0.32×10^9 liters (84 million gallons) occurred at the Santa Clara, Tujunga, and Calleguas sites.

During the storm, flows changed very little at Big Tujunga Wash, the Santa Clara River, and Dominguez Channel, while at Ballona Creek, Los Angeles River Willow, and San Gabriel flows varied by about 100x.

The highest concentrations of contaminants are associated with peak flows. Because we sampled the two Ventura sites while they had relatively low flow, this data may be less representative annual emissions of contaminants.

The two channels with the highest flows, Los Angeles River Willow and Ballona Creek, had the highest mean contaminant concentrations and consequently had the highest emissions of oil and grease, TEOs, cadmium, chromium, copper, nickel, lead, zinc, PCBs, PAHs, resolved hydrocarbons, and n-alkanes.

Annual estimate of runoff should be viewed with the awareness of certain limitations, some relevant to all runoff studies and others relevant only to this study. Factors that need further examination include annual variations in total rainfall within a drainage basin, the intentional retention of runoff for groundwater recharge, and diversions between drainage basins. The factors can combine to make each storm and year difficult to compare with other storms and years.

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APPENDIX A
Chemical Data

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	2.67
Location:	Willow Street	Time Interval:	00:00-03:30
Date:	23 Sep 86	IntervalVol(M**3):	37'0
Time:	17:55	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	46mG/L	1.753 T	Naphthalene	<21nG/L	0 G
TVS	65%	***	C1-Naphthalenes	<21nG/L	0 G
Total Solids	627mG/L	23.89 T	C2-Naphthalenes	<21nG/L	0 G
Dissolved Solids	581mG/L	22.14 T	C3-Naphthalenes	<45nG/L	0 G
Oil & Grease	.7mG/L	.0267 T	Biphenyl	<21nG/L	0 G
Chloroform Extr.	1.4mG/L	.0533 T	Acenaphthylene	<21nG/L	0 G
Salinity	.5ppt	***	Acenaphthene	<45nG/L	0 G
pH	7	***	Fluorene	<20nG/L	0 G
			Phenanthrene	<20nG/L	0 G
Cadmium	3uG/L	.1143kG	C1-Phenanthrenes	<20nG/L	0 G
Chromium	3uG/L	0kG	C2-Phenanthrenes	<20nG/L	0 G
Copper	12uG/L	.4572kG	C3-Phenenthrenes	<20nG/L	0 G
Nickel	16uG/L	.6096kG	Anthracene	<20nG/L	0 G
Lead	55uG/L	2.096kG	Fluoranthene	<16nG/L	0 G
Zinc	21uG/L	.8001kG	Pyrene	<16nG/L	0 G
Silver	<1uG/L	0kG	2,3-Benzofluorene	<48nG/L	0 G
			Benz(a)anthracene	<17nG/L	0 G
o,p'-DDE	1nG/L	.0381 G	Chrysene	<17nG/L	0 G
p,p'-DDE	5nG/L	.1905 G	Benzo(b)fluoranth	<14nG/L	0 G
o,p'-DDD	<1nG/L	0 G	Benzo(k)fluoranth	<14nG/L	0 G
p,p'-DDD	<1nG/L	0 G	Benzo(e)pyrene	<14nG/L	0 G
o,p'-DDT	<1nG/L	0 G	Benzo(a)pyrene	<14nG/L	0 G
p,p'-DDT	<1nG/L	0 G	Perylene	<14nG/L	0 G
TOTAL DDT	6nG/L	.2286 G	9,10-Diphenylanth	<14nG/L	0 G
			Dibenz(a,h)anthra	<12nG/L	0 G
Aroclor 1242	44nG/L	1.676 G	Benzo(g,h,i)peryl	<12nG/L	0 G
Aroclor 1254	<1nG/L	0 G	TOTAL PAH	0nG/L	0 G
TOTAL PCB	44nG/L	1.676 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	4nG/L	.1524 G	d8-Naphthalene	41%	***
Lindane	<1nG/L	0 G	d10-Acenaphthene	71%	***
			d10-Phenanthrene	84%	***
Toxicity	NoTest	***	d12-Chrysene	118%	***
			d12-Perylene	122%	***
			Resolved HCs	0nG/L	0 G
			n-alkanes c10-c39	2234nG/L	85.12 G
			Pristane	348nG/L	13.26 G
			Phystane	420nG/L	16.00 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
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Time:	17:55

Flow (M**3/Sec):	2.67
Time Interval:	00:00-03:30
IntervalVol (M**3):	3710
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	46mG/L	1.753 T	Naphthalene	<21nG/L	0 G
TVS	65%	***	C1-Naphthalenes	<21nG/L	0 G
Total Solids	627mG/L	23.89 T	C2-Naphthalenes	<21nG/L	0 G
Dissolved Solids	581mG/L	22.14 T	C3-Naphthalenes	<45nG/L	0 G
Oil & Grease	.7mG/L	.0267 T	Biphenyl	<21nG/L	0 G
Chloroform Extr.	1.4mG/L	.0533 T	Acenaphthylene	<21nG/L	0 G
Salinity	.5ppt	***	Acenaphthene	<45nG/L	0 G
pH	7	***	Fluorene	<20nG/L	0 G
			Phenanthrene	<20nG/L	0 G
Cadmium	3uG/L	.1143kG	C1-Phenanthrenes	<20nG/L	0 G
Chromium	<3uG/L	0kG	C2-Phenanthrenes	<20nG/L	0 G
Copper	12uG/L	.4572kG	C3-Phenenthrenes	<20nG/L	0 G
Nickel	16uG/L	.6096kG	Anthracene	<20nG/L	0 G
Lead	55uG/L	2.096kG	Fluoranthene	<16nG/L	0 G
Zinc	21uG/L	.8001kG	Pyrene	<16nG/L	0 G
Silver	<1uG/L	0kG	2,3-Benzofluorene	<48nG/L	0 G
			Benz(a)anthracene	<17nG/L	0 G
o,p'-DDE	1nG/L	.0381 G	Chrysene	<17nG/L	0 G
p,p'-DDE	5nG/L	.1905 G	Benzo(b)fluoranth	<14nG/L	0 G
o,p'-DDD	<1nG/L	0 G	Benzo(k)fluoranth	<14nG/L	0 G
p,p'-DDD	<1nG/L	0 G	Benzo(e)pyrene	<14nG/L	0 G
o,p'-DDT	<1nG/L	0 G	Benzo(a)pyrene	<14nG/L	0 G
p,p'-DDT	<1nG/L	0 G	Perylene	<14nG/L	0 G
TOTAL DDT	6nG/L	.2286 G	9,10-Diphenylanth	<14nG/L	0 G
			Dibenz(a,h)anthra	<12nG/L	0 G
Aroclor 1242	44nG/L	1.676 G	Benzo(g,h,i)peryl	<12nG/L	0 G
Aroclor 1254	<1nG/L	0 G	TOTAL PAH	0nG/L	0 G
TOTAL PCB	44nG/L	1.676 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	4nG/L	.1524 G	d8-Naphthalene	41%	***
Lindane	<1nG/L	0 G	d10-Acenaphthene	71%	***
			d10-Phenanthrene	84%	***
Toxicity	NoTest	***	d12-Chrysene	118%	***
			d12-Perylene	122%	***
			Resolved HCs	0nG/L	0 G
			n-alkanes c10-c39	2234nG/L	85.12 G
			Pristane	348nG/L	13.26 G
			Phystane	420nG/L	16.00 G

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0848

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	23 Sep 86
Time:	21:05

Flow (M**3/Sec):	2.78
Time Interval:	03:30-05:45
IntervalVol(M**3):	22,500
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	35mG/L	.896 T
TVS	69%	***
Total Solids	662mG/L	16.95 T
Dissolved Solids	627mG/L	16.05 T
Oil & Grease	2.3mG/L	.0589 T
Chloroform Extr.	1.7mG/L	.0435 T
Salinity	ppt	***
pH		***
Cadmium	2uG/L	.0512 kG
Chromium	<3uG/L	0 kG
Copper	15uG/L	.384 kG
Nickel	13uG/L	.3328 kG
Lead	[illegible]	0 kG
Zinc	49uG/L	1.254 kG
Silver	[illegible]	[illegible]
o,p'-DDE	<1nG/L	0 G
p,p'-DDE	<1nG/L	0 G
o,p'-DDD	<1nG/L	0 G
p,p'-DDD	<1nG/L	0 G
o,p'-DDT	<1nG/L	0 G
p,p'-DDT	<1nG/L	0 G
TOTAL DDT	0nG/L	0 G
Aroclor 1242	<1nG/L	0 G
Aroclor 1254	11nG/L	.2816 G
TOTAL PCB	11nG/L	.2816 G
Hexachlorobenzene	<1nG/L	0 G
Lindane	<1nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<15nG/L	0 G
C1-Naphthalenes	<15nG/L	0 G
C2-Naphthalenes	<15nG/L	0 G
C3-Naphthalenes	<32nG/L	0 G
Biphenyl	<15nG/L	0 G
Acenaphthylene	<15nG/L	0 G
Acenaphthene	<32nG/L	0 G
Fluorene	<14nG/L	0 G
Phenanthrene	<14nG/L	0 G
C1-Phenanthrenes	<14nG/L	0 G
C2-Phenanthrenes	<14nG/L	0 G
C3-Phenenthrenes	<14nG/L	0 G
Anthracene	<14nG/L	0 G
Fluoranthene	<12nG/L	0 G
Pyrene	<12nG/L	0 G
2,3-Benzofluorene	<34nG/L	0 G
Benz(a)anthracene	<12nG/L	[illegible]
Chrysene	<12nG/L	0 G
Benzo(b)fluoranth	<10nG/L	0 G
Benzo(k)fluoranth	<10nG/L	0 G
Benzo(e)pyrene	<10nG/L	0 G
Benzo(a)pyrene	<10nG/L	0 G
Perylene	<10nG/L	0 G
9,10-Diphenylanth	<10nG/L	0 G
Dibenz(a,h)anthra	<9nG/L	0 G
Benzo(g,h,i)peryl	<9nG/L	0 G
TOTAL PAH	0nG/L	0 G
SURROGATE RECOVERY		
d8-Naphthalene	0%	***
d10-Acenaphthene	0%	***
d10-Phenanthrene	0%	***
d12-Chrysene	6%	***
d12-Perylene	2%	***
Resolved HCs	0nG/L	0 G
n-alkanes c10-c39	750nG/L	19.2 G
Pristane	375nG/L	9.6 G
Phytane	0nG/L	0 G

VOL 12

20849

R0054149

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	5.21
Location:	Willow Street	Time Interval:	12:15-18:45
Date:	24 Sep 86	IntervalVol (M**3):	154.000
Time:	09:30	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	106 mG/L	16.75 T	Naphthalene	<18 nG/L	0 G
TVS	55 %	***	C1-Naphthalenes	<18 nG/L	0 G
Total Solids	669 mG/L	105.7 T	C2-Naphthalenes	<18 nG/L	0 G
Dissolved Solids	563 mG/L	88.95 T	C3-Naphthalenes	<38 nG/L	0 G
Oil & Grease	3.5 mG/L	.553 T	Biphenyl	<16 nG/L	0 G
Chloroform Extr.	5.1 mG/L	.8058 T	Acenaphthylene	<18 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<38 nG/L	0 G
pH	5.5	***	Fluorene	<17 nG/L	0 G
			Phenanthrene	<17 nG/L	0 G
Cadmium	3 uG/L	.474kG	C1-Phenanthrenes	<17 nG/L	0 G
Chromium	9 uG/L	1.422kG	C2-Phenanthrenes	<17 nG/L	0 G
Copper	40 uG/L	6.32kG	C3-Phenenthrenes	<17 nG/L	0 G
Nickel	33 uG/L	5.214kG	Anthracene	<17 nG/L	0 G
Lead	42 uG/L	6.636kG	Fluoranthene	<14 nG/L	0 G
Zinc	157 uG/L	24.81kG	Pyrene	<14 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<41 nG/L	0 G
			Benz(a)anthracene	<14 nG/L	0 G
o,p'-DDE	2 nG/L	.316 G	Chrysene	<14 nG/L	0 G
p,p'-DDE	3 nG/L	.474 G	Benzo(b)fluoranth	<12 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<12 nG/L	0 G
p,p'-DDD	2 nG/L	.316 G	Benzo(e)pyrene	<12 nG/L	0 G
o,p'-DDT	1 nG/L	.158 G	Benzo(a)pyrene	<12 nG/L	0 G
p,p'-DDT	2 nG/L	.316 G	Perylene	<12 nG/L	0 G
TOTAL DDT	10 nG/L	1.58 G	9,10-Diphenylanth	<12 nG/L	0 G
			Dibenz(a,h)antnra	<10 nG/L	0 G
Aroclor 1242	5 nG/L	.79 G	Benzo(g,h,i)peryl	<10 nG/L	0 G
Aroclor 1254	24 nG/L	3.792 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	29 nG/L	4.582 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	1 nG/L	.158 G	d8-Naphthalene	83 %	***
Lindane	4 nG/L	.632 G	d10-Acenaphthene	103 %	***
			d10-Phenanthrene	114 %	***
Toxicity	NoTest	***	d12-Chrysene	157 %	***
			d12-Perylene	141 %	***
			Resolved HCs	15844 nG/L	2503. G
			n-alkanes c10-c39	12410 nG/L	1961. G
			Pristane	1292 nG/L	204.1 G
			Phytane	1495 nG/L	236.2 G

VOL 12

2 0850

R0054150

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	23 Sep 86
Time:	22:40

Flow (M**3/Sec):	2.83
Time Interval:	06:00-12:00
IntervalVol(M**3):	156,000
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	31mG/L	4.96 T	Naphthalene	<18nG/L	0 G
TVS	39%	***	C1-Naphthalenes	<18nG/L	0 G
Total Solids	661mG/L	105.8 T	C2-Naphthalenes	<18nG/L	0 G
Dissolved Solids	630mG/L	100.8 T	C3-Naphthalenes	<38nG/L	0 G
Oil & Grease	1.7mG/L	.272 T	Biphenyl	<18nG/L	0 G
Chloroform Extr.	4.1mG/L	.656 T	Acenaphthylene	<18nG/L	0 G
Salinity	ppt	***	Acenaphthene	<38nG/L	0 G
pH		***	Fluorene	<17nG/L	0 G
			Phenanthrene	<17nG/L	0 G
Cadmium	3uG/L	.48kG	C1-Phenanthrenes	<17nG/L	0 G
Chromium	<3uG/L	0kG	C2-Phenanthrenes	<17nG/L	0 G
Copper	16uG/L	2.56kG	C3-Phenenthrenes	<17nG/L	0 G
Nickel	18uG/L	2.88kG	Anthracene	<17nG/L	0 G
Lead	<10uG/L	0kG	Fluoranthene	<14nG/L	0 G
Zinc	46uG/L	7.36kG	Pyrene	<14nG/L	0 G
Silver	<1uG/L	0kG	2,3-Benzofluorene	<41nG/L	0 G
			Benz(a)anthracene	<14nG/L	0 G
o,p'-DDE	<1nG/L	0 G	Chrysene	<14nG/L	0 G
p,p'-DDE	<1nG/L	0 G	Benzo(b)fluoranth	<12nG/L	0 G
o,p'-DDD	<1nG/L	0 G	Benzo(k)fluoranth	<12nG/L	0 G
p,p'-DDD	<1nG/L	0 G	Benzo(e)pyrene	<12nG/L	0 G
o,p'-DDT	<1nG/L	0 G	Benzo(a)pyrene	<12nG/L	0 G
p,p'-DDT	<1nG/L	0 G	Perylene	<12nG/L	0 G
TOTAL DDT	0nG/L	0 G	9,10-Diphenylanth	<10nG/L	0 G
			Dibenz(a,h)anthra	<10nG/L	0 G
Aroclor 1242	<1nG/L	0 G	Benzo(g,h,i)peryl	<10nG/L	0 G
Aroclor 1254	7nG/L	1.12 G	TOTAL PAH	0nG/L	0 G
TOTAL PCB	7nG/L	1.12 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	<1nG/L	0 G	d8-Naphthalene	82%	***
Lindane	<1nG/L	0 G	d10-Acenaphthene	112%	***
			d10-Phenanthrene	99%	***
Toxicity	NoTest	***	d12-Chrysene	102%	***
			d12-Perylene	127%	***
			Resolved HCs	0nG/L	0 G
			n-alkanes c10-c39	901nG/L	144.2 G
			Pristane	386nG/L	61.76 G
			Phytane	398nG/L	63.68 G

2 0851

R0054151

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	24 Sep 86
Time:	22:50

Flow (M**3/Sec):	240
Time Interval:	28:00-35:30
IntervalVol(M**3):	4.84x10^6
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	458mG/L	2290 T	Naphthalene	106nG/L	530 G
TVS	25%	***	C1-Naphthalenes	106nG/L	530 G
Total Solids	692mG/L	3460 T	C2-Naphthalenes	64nG/L	320 G
Dissolved Solids	234mG/L	1170 T	C3-Naphthalenes	60nG/L	300 G
Oil & Grease	8mG/L	40 T	Biphenyl	<15nG/L	0 G
Chloroform Extr.	6.1mG/L	30.5 T	Acenaphthylene	<15nG/L	0 G
Salinity	0ppt	***	Acenaphthene	<32nG/L	0 G
pH	6	***	Fluorene	<14nG/L	0 G
			Phenanthrene	274nG/L	1370 G
Cadmium	3uG/L	15kG	C1-Phenanthrenes	230nG/L	1150 G
Chromium	18uG/L	90kG	C2-Phenanthrenes	217nG/L	1085 G
Copper	144uG/L	720kG	C3-Phenenthrenes	80nG/L	400 G
Nickel	26uG/L	130kG	Anthracene	<15nG/L	0 G
Lead	139uG/L	695kG	Fluoranthene	301nG/L	1505 G
Zinc	348uG/L	1740kG	Pyrene	253nG/L	1265 G
Silver	<1uG/L	0kG	2,3-Benzofluorene	<34nG/L	0 G
			Benz(a)anthracene	71nG/L	355 G
o,p'-DDE	12nG/L	60 G	Chrysene	163nG/L	815 G
p,p'-DDE	18nG/L	90 G	Benzo(b)fluoranth	169nG/L	845 G
o,p'-DDD	1nG/L	0 G	Benzo(k)fluoranth	39nG/L	195 G
p,p'-DDD	8nG/L	40 G	Benzo(e)pyrene	90nG/L	450 G
o,p'-DDT	12nG/L	60 G	Benzo(a)pyrene	42nG/L	210 G
p,p'-DDT	10nG/L	50 G	Perylene	10nG/L	0 G
TOTAL DDT	60nG/L	300 G	9,10-Diphenylanth	10nG/L	0 G
			[illegible]	9nG/L	[illegible] G
Aroclor 1242	[illegible]	[illegible] G	Benzo(g,h,i)peryl	15nG/L	575 G
Aroclor 1254	76nG/L	[illegible]	TOTAL [illegible]	[illegible]	[illegible] G
TOTAL PCB	138nG/L	690 G			
			SURROGATE RECOVERY		
Hexachlorobenzene	2nG/L	10 G	d6-Naphthalene	79%	***
Lindane	17nG/L	85 G	d10-Acenaphthene	136%	***
			d10-Phenanthrene	122%	***
Toxicity	NoTest	***	d12-Chrysene	147%	***
			d12-Perylene	116%	***
			Resolved HCs	1.6e6nG/L	7.8e6 G
			n-alkanes c10-c39	1.0e6nG/L	5.0e6 G
			Pristane	9328nG/L	46640 G
			Phytane	11333nG/L	56665 G

: B : : D : : E : : F : : G : : H : : J : : I : : L

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2 0852

R0054152

VOL 12

2 0853

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Willow Street
Date:	24 Sep 86
Time:	17:00

Flow (M**3/Sec):	146
Time Interval:	23:45-27:45
IntervalVol (M**3):	2.93×10^6
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	927mG/L	2781 T
TVS	21%	***
Total Solids	1220mG/L	3660 T
Dissolved Solids	293mG/L	879 T
Oil & Grease	14mG/L	42 T
Chloroform Extr.	103mG/L	309 T
Salinity	0ppt	***
pH	5.5	***
Cadmium	10uG/L	30kG
Chromium	88uG/L	264kG
Copper	273uG/L	819kG
Nickel	75uG/L	225kG
Lead	531uG/L	1593kG
Zinc	1400uG/L	4200kG
Silver	<1uG/L	0kG
o,p'-DDE	39nG/L	117 G
p,p'-DDE	42nG/L	126 G
o,p'-DDD	<1nG/L	0 G
p,p'-DDD	30nG/L	90 G
o,p'-DDT	31nG/L	93 G
p,p'-DDT	27nG/L	81 G
TOTAL DDT	169nG/L	507 G
Aroclor 1242	267nG/L	801 G
Aroclor 1254	428nG/L	1284 G
TOTAL PCB	695nG/L	2085 G
Hexachlorobenzene	9nG/L	27 G
Lindane	25nG/L	75 G
Toxicity	Notest	***

CONSTITUENT	CON	MASS
Naphthalene	598nG/L	1794 G
C1-Naphthalenes	1460nG/L	4380 G
C2-Naphthalenes	2270nG/L	6810 G
C3-Naphthalenes	6570nG/L	19710 G
Biphenyl	84nG/L	252 G
Acenaphthylene	104nG/L	312 G
Acenapnthene	141nG/L	423 G
Fluorene	255nG/L	765 G
Phenanthrene	5230nG/L	15690 G
C1-Phenanthrenes	5200nG/L	15600 G
C2-Phenanthrenes	5280nG/L	15840 G
C3-Phenenthrenes	4550nG/L	13650 G
Anthracene	999nG/L	2997 G
Fluoranthene	16900nG/L	50700 G
Pyrene	15100nG/L	45300 G
2,3-Benzofluorene	2380nG/L	7140 G
Benz(a)anthracene	6310nG/L	18930 G
Chrysene	23900nG/L	71700 G
Benzo(b)fluoranth	10200nG/L	30600 G
Benzo(k)fluoranth	6150nG/L	18450 G
Benzo(e)pyrene	4980nG/L	14940 G
Benzo(a)pyrene	1740nG/L	5220 G
Perylene	582nG/L	1746 G
9,10-Diphenylanth	53nG/L	159 G
Dibenz(a,h)anthra	261nG/L	783 G
Benzo(g,h,i)peryl	984nG/L	2952 G
TOTAL PAH	1.2e5nG/L	3.6e5 G
SURROGATE RECOVERY		
d8-Naphthalene	86%	***
d10-Acenaphthene	140%	***
d10-Phenanthrene	134%	***
d12-Chrysene	184%	***
d12-Perylene	190%	***
Resolved HCs	6.0e6nG/L	1.8e7 G
n-alkanes c10-c39	3.7e5nG/L	1.1e6 G
Pristane	37119nG/L	1.1e5 G
Phytane	48395nG/L	1.5e5 G

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Dominguez Channel
Location:	Ford Street
Date:	24 Sep 86
Time:	20:35

Flow (M**3/Sec):	
Time Interval:	26:30-34:15
IntervalVol (M**3):	
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	43 mG/L	0 T
TVS	35 %	***
Total Solids	14400 mG/L	0 T
Dissolved Solids	14400 mG/L	0 T
Oil & Grease	2.9 mG/L	0 T
Chloroform Extr.	1.6 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	Salty uG/L	0kG
Chromium	Salty uG/L	0kG
Copper	Salty uG/L	0kG
Nickel	Salty uG/L	0kG
Lead	salty uG/L	0kG
Zinc	Salty uG/L	0kG
Silver	Salty uG/L	0kG
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	4 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	2 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	2 nG/L	0 G
TOTAL DDT	9 nG/L	0 G
Aroclor 1242	13 nG/L	0 G
Aroclor 1254	21 nG/L	0 G
TOTAL PCB	34 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	4 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<9 nG/L	0 G
C1-Naphthalenes	<9 nG/L	0 G
C2-Naphthalenes	<9 nG/L	0 G
C3-Naphthalenes	<19 nG/L	0 G
Biphenyl	<9 nG/L	0 G
Acenaphthylene	<9 nG/L	0 G
Acenaphthene	<19 nG/L	0 G
Fluorene	<9 nG/L	0 G
Phenanthrene	30 nG/L	0 G
C1-Phenanthrenes	23 nG/L	0 G
C2-Phenanthrenes	33 nG/L	0 G
C3-Phenenthrenes	<9 nG/L	0 G
Anthracene	<9 nG/L	0 G
Fluoranthene	72 nG/L	0 G
Pyrene	79 nG/L	0 G
2,3-Benzofluorene	<20 nG/L	0 G
Benz(a)anthracene	<7 nG/L	0 G
Chrysene	33 nG/L	0 G
Benzo(b)fluoranth	<6 nG/L	0 G
Benzo(k)fluoranth	<6 nG/L	0 G
Benzo(e)pyrene	12 nG/L	0 G
Benzo(a)pyrene	<6 nG/L	0 G
Perylene	<6 nG/L	0 G
9,10-Diphenylanth	<6 nG/L	0 G
Dibenz(a,h)anthra	<5 nG/L	0 G
Benzo(g,h,i)peryl	<5 nG/L	0 G
TOTAL PAH	282 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	51 %	***
d10-Acenaphthene	85 %	***
d10-Phenanthrene	92 %	***
d12-Chrysene	116 %	***
d12-Perylene	111 %	***
Resolved HCs	13400 nG/L	0 G
n-alkanes c10-c39	8538 nG/L	0 G
Pristane	1867 nG/L	0 G
Phytane	2046 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Dominguez Channel	Flow (M**3/Sec):	
Location:	Ford Street	Time Interval:	34:15-56:00
Date:	25 Sep 86	IntervalVol(M**3):	
Time:	07:50	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	76 mG/L	0 T	Naphthalene	137 nG/L	0 G
TVS	28 %	***	C1-Naphthalenes	220 nG/L	0 G
Total Solids	1360 mG/L	0 T	C2-Naphthalenes	<16 nG/L	0 G
Dissolved Solids	1280 mG/L	0 T	C3-Naphthalenes	<33 nG/L	0 G
Oil & Grease	2.8 mG/L	0 T	Biphenyl	<16 nG/L	0 G
Chloroform Extr.	1.4 mG/L	0 T	Acenaphthylene	<16 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<33 nG/L	0 G
pH		***	Fluorene	<15 nG/L	0 G
			Phenanthrene	76 nG/L	0 G
Cadmium	Salty uG/L	0KG	C1-Phenanthrenes	<15 nG/L	0 G
Chromium	Salty uG/L	0KG	C2-Phenanthrenes	<15 nG/L	0 G
Copper	Salty uG/L	0KG	C3-Phenenthrenes	<15 nG/L	0 G
Nickel	Salty uG/L	0KG	Anthracene	<15 nG/L	0 G
Lead	Salty uG/L	0KG	Fluoranthene	22 nG/L	0 G
Zinc	Salty uG/L	0KG	Pyrene	<12 nG/L	0 G
Silver	Salty uG/L	0KG	2,3-Benzofluorene	<36 nG/L	0 G
			Benz(a)anthracene	<12 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	<12 nG/L	0 G
p,p'-DDE	2 nG/L	0 G	Benzo(b)fluoranth	<10 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<10 nG/L	0 G
p,p'-DDD	3 nG/L	0 G	Benzo(e)pyrene	<10 nG/L	0 G
o,p'-DDT	1 nG/L	0 G	Benzo(a)pyrene	<10 nG/L	0 G
p,p'-DDT	2 nG/L	0 G	Perylene	<10 nG/L	0 G
TOTAL DDT	8 nG/L	0 G	9,10-Diphenylanth	<10 nG/L	0 G
			Dibenz(a,h)anthra	<9 nG/L	0 G
Aroclor 1242	14 nG/L	0 G	Benzo(g,h,i)peryl	<9 nG/L	0 G
Aroclor 1254	14 nG/L	0 G	TOTAL PAH	455 nG/L	0 G
TOTAL PCB	28 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	59 %	***
Lindane	5 nG/L	0 G	d10-Acenaphthene	101 %	***
			d10-Phenanthrene	109 %	***
Toxicity	NoTest	***	d12-Chrysene	113 %	***
			d12-Perylene	98 %	***
			Resolved HCs	5.5e5 nG/L	0 G
			n-alkanes c10-c39	2.4e5 nG/L	0 G
			Pristane	338 nG/L	0 G
			Phytane	449 nG/L	0 G

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VOL 12

2 0856

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Dominquez Channel	Flow (M**3/Sec):	
Location:	Ford Street	Time Interval:	00:00-22:00
Date:	24 Sep 86	IntervalVol (M**3):	
Time:	11:45	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	32 mG/L	0 T	Naphthalene	<18 nG/L	0 G
TVS	50 %	***	C1-Naphthalenes	<18 nG/L	0 G
Total Solids	35900 mG/L	0 T	C2-Naphthalenes	<18 nG/L	0 G
Dissolved Solids	35900 mG/L	0 T	C3-Naphthalenes	<38 nG/L	0 G
Oil & Grease	.2 mG/L	0 T	Biphenyl	<18 nG/L	0 G
Chloroform Extr.	.73 mG/L	0 T	Acenaphthylene	<18 nG/L	0 G
Salinity	32 ppt	***	Acenaphthene	<38 nG/L	0 G
pH	6.5	***	Fluorene	<17 nG/L	0 G
			Phenanthrene	<17 nG/L	0 G
Cadmium	Salty uG/L	0kG	C1-Phenanthrenes	<17 nG/L	0 G
Chromium	Salty uG/L	0kG	C2-Phenanthrenes	<17 nG/L	0 G
Copper	Salty uG/L	0kG	C3-Phenenthrenes	<17 nG/L	0 G
Nickel	Salty uG/L	0kG	Anthracene	<17 nG/L	0 G
Lead	Salty uG/L	0kG	Fluoranthene	<14 nG/L	0 G
Zinc	Salty uG/L	0kG	Pyrene	<14 nG/L	0 G
Silver	Salty uG/L	0kG	2,3-Benzofluorene	<41 nG/L	0 G
			Benz(a)anthracene	<14 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	<14 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G	Benzo(b)fluoranth	<12 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<12 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<12 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<12 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	<12 nG/L	0 G
TOTAL DDT	0 nG/L	0 G	9,10-Diphenylanth	<12 nG/L	0 G
			Dibenz(a,h)anthra	<10 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<10 nG/L	0 G
Aroclor 1254	15 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	15 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	38 %	***
Lindane	2 nG/L	0 G	d10-Acenaphthene	77 %	***
			d10-Phenanthrene	79 %	***
Toxicity	Notest	***	d12-Chrysene	112 %	***
			d12-Perylene	122 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	0 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

R0054156

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Dominguez Channel
Location:	Ford Street
Date:	24 Sep 86
Time:	16:35

Flow (M**3/Sec):
Time Interval: 22:00-26:30
IntervalVol (M**3):
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	11 mG/L	0 T
TVS	54 %	***
Total Solids	30600 mG/L	0 T
Dissolved Solids	30600 mG/L	0 T
Oil & Grease	1.8 mG/L	0 T
Chloroform Extr.	5.1 mG/L	0 T
Salinity	28 ppt	***
pH	5.5	***
Cadmium	Salty uG/L	0kG
Chromium	Salty uG/L	0kG
Copper	Salty uG/L	0kG
Nickel	Salty uG/L	0kG
Lead	Salty uG/L	0kG
Zinc	Salty uG/L	0kG
Silver	Salty uG/L	0kG
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	3 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	4 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	11 nG/L	0 G
TOTAL PCB	11 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	<1 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	14 nG/L	0 G
C1-Naphthalenes	<14 nG/L	0 G
C2-Naphthalenes	<14 nG/L	0 G
C3-Naphthalenes	<28 nG/L	0 G
Biphenyl	<14 nG/L	0 G
Acenaphthylene	14 nG/L	0 G
Acenaphthene	<28 nG/L	0 G
Fluorene	<13 nG/L	0 G
Phenanthrene	75 nG/L	0 G
C1-Phenanthrenes	31 nG/L	0 G
C2-Phenanthrenes	<13 nG/L	0 G
C3-Phenenthrenes	<13 nG/L	0 G
Anthracene	<13 nG/L	0 G
Fluoranthene	157 nG/L	0 G
Pyrene	89 nG/L	0 G
2,3-Benzofluorene	<31 nG/L	0 G
Benz(a)anthracene	<11 nG/L	0 G
Chrysene	76 nG/L	0 G
Benzo(b)fluoranth	<9 nG/L	0 G
Benzo(k)fluoranth	<9 nG/L	0 G
Benzo(e)pyrene	<9 nG/L	0 G
Benzo(a)pyrene	<9 nG/L	0 G
Perylene	<9 nG/L	0 G
9,10-Diphenylanth	<9 nG/L	0 G
Dibenz(a,h)anthra	<8 nG/L	0 G
Benzo(g,h,i)peryl	<8 nG/L	0 G
TOTAL PAH	442 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	69 %	***
d10-Acenaphthene	102 %	***
d10-Phenantnrene	101 %	***
d12-Chrysene	135 %	***
d12-Perylene	129 %	***
Resolved HCs	88051 nG/L	0 G
n-alkanes c10-c39	7517 nG/L	0 G
Pristane	1079 nG/L	0 G
Phytane	1170 nG/L	0 G

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2 0857

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
SURVEY
SAMPLE DATA SHEET

Channel:	San Gabriel River
Location:	College Pk Bridge
Date:	25 Sep 86
Time:	07:00

Flow (M**3/Sec):	10.6
Time Interval:	34:45-43:15
IntervalVol(M**3):	345,000
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1080 mG/L	0 T	Naphthalene	94 nG/L	0 G
TVS	6.5 %	***	C1-Naphthalenes	69 nG/L	0 G
Total Solids	1300 mG/L	0 T	C2-Naphthalenes	46 nG/L	0 G
Dissolved Solids	220 mG/L	0 T	C3-Naphthalenes	<14 nG/L	0 G
Oil & Grease	2.8 mG/L	0 T	Biphenyl	<7 nG/L	0 G
Chloroform Extr.	11.9 mG/L	0 T	Acenaphthylene	<7 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<14 nG/L	0 G
pH	6	***	Fluorene	<7 nG/L	0 G
			Phenanthrene	167 nG/L	0 G
Cadmium	4 uG/L	0kG	C1-Phenanthrenes	33 nG/L	0 G
Chromium	68 uG/L	0kG	C2-Phenanthrenes	35 nG/L	0 G
Copper	143 uG/L	0kG	C3-Phenenthrenes	<7 nG/L	0 G
Nickel	67 uG/L	0kG	Anthracene	<7 nG/L	0 G
Lead	200 uG/L	0kG	Fluoranthene	218 nG/L	0 G
Zinc	385 uG/L	0kG	Pyrene	214 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<16 nG/L	0 G
			Benz(a)anthracene	54 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	176 nG/L	0 G
p,p'-DDE	3 nG/L	0 G	Benzo(b)fluoranth	223 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<4 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	90 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	73 nG/L	0 G
p,p'-DDT	4 nG/L	0 G	Perylene	12 nG/L	0 G
TOTAL DDT	7 nG/L	0 G	9,10-Diphenylanth	<4 nG/L	0 G
			Dibenz(a,h)anthra	7 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	106 nG/L	0 G
Aroclor 1254	68 nG/L	0 G	TOTAL PAH	1617 nG/L	0 G
TOTAL PCB	68 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	2 nG/L	0 G	d8-Naphthalene	75 %	***
Lindane	9 nG/L	0 G	d10-Acenaphthene	138 %	***
			d10-Phenanthrene	122 %	***
Toxicity	Notest	***	d12-Chrysene	124 %	***
			d12-Perylene	102 %	***
			Resolved HCs	60992 nG/L	0 G
			n-alkanes c10-c39	35793 nG/L	0 G
			Pristane	3483 nG/L	0 G
			Phytane	4149 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: San Gabriel River
Location: College Pk Bridge
Date: 25 Sep 86
Time: 15:30

Flow (M**3/Sec): 2.11
Time Interval: 43:15-56:00
IntervalVol (M**3): 25,406
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	158 mG/L	0 T	Naphthalene	152 nG/L	0 G
TVS	17 %	***	C1-Naphthalenes	<17 nG/L	0 G
Total Solids	462 mG/L	0 T	C2-Naphthalenes	<17 nG/L	0 G
Dissolved Solids	304 mG/L	0 T	C3-Naphthalenes	<35 nG/L	0 G
Oil & Grease	1.5 mG/L	0 T	Biphenyl	<17 nG/L	0 G
Chloroform Extr.	2.5 mG/L	0 T	Acenaphthylene	<17 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<35 nG/L	0 G
pH	6	***	Fluorene	<16 nG/L	0 G
			Phenanthrene	<16 nG/L	0 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<16 nG/L	0 G
Chromium	6 uG/L	0kG	C2-Phenanthrenes	<16 nG/L	0 G
Copper	17 uG/L	0kG	C3-Phenenthrenes	<16 nG/L	0 G
Nickel	13 uG/L	0kG	Anthracene	<16 nG/L	0 G
Lead	23 uG/L	0kG	Fluoranthene	<13 nG/L	0 G
Zinc	80 uG/L	0kG	Pyrene	<13 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<37 nG/L	0 G
			Benz(a)anthracene	<13 nG/L	0 G
o,p'-DDE	4 nG/L	0 G	Chrysene	<13 nG/L	0 G
p,p'-DDE	12 nG/L	0 G	Benzo(b)fluoranth	<11 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<11 nG/L	0 G
p,p'-DDD	7 nG/L	0 G	Benzo(e)pyrene	<11 nG/L	0 G
o,p'-DDT	3 nG/L	0 G	Benzo(a)pyrene	<11 nG/L	0 G
p,p'-DDT	9 nG/L	0 G	Perylene	<11 nG/L	0 G
TOTAL DDT	35 nG/L	0 G	9,10-Diphenylanth	<11 nG/L	0 G
			Dibenz(a,h)anthra	<9 nG/L	0 G
Aroclor 1242	8 nG/L	0 G	Benzo(g,h,i)peryl	<9 nG/L	0 G
Aroclor 1254	30 nG/L	0 G	TOTAL PAH	152 nG/L	0 G
TOTAL PCB	38 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	83 %	***
Lindane	16 nG/L	0 G	d10-Acenaphthene	105 %	***
			d10-Phenanthrene	113 %	***
Toxicity	Notest	***	d12-Chrysene	144 %	***
			d12-Perylene	113 %	***
			Resolved HCs	3727 nG/L	0 G
			n-alkanes c10-c39	8830 nG/L	0 G
			Pristane	1273 nG/L	0 G
			Phytane	1167 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	San Gabriel River
Location:	College Park Bridg
Date:	24 Sep 86
Time:	17:45

Flow (M**3/Sec):	40.5
Time Interval:	24:15-28:00
IntervalVol(M**3):	489,500
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	484 mG/L	0 T
TVS	30 %	***
Total Solids	534 mG/L	0 T
Dissolved Solids	50 mG/L	0 T
Oil & Grease	7.8 mG/L	0 T
Chloroform Extr.	5 mG/L	0 T
Salinity	0 ppt	***
pH	5.5	***
Cadmium	4 uG/L	0kG
Chromium	40 uG/L	0kG
Copper	158 uG/L	0kG
Nickel	61 uG/L	0kG
Lead	201 uG/L	0kG
Zinc	744 uG/L	0kG
Silver	<1 uG/L	0kG
o,p'-DDE	6 nG/L	0 G
p,p'-DDE	6 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	2 nG/L	0 G
o,p'-DDT	4 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	18 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	22 nG/L	0 G
TOTAL PCB	22 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	<1 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	51 nG/L	0 G
C1-Naphthalenes	<21 nG/L	0 G
C2-Naphthalenes	<21 nG/L	0 G
C3-Naphthalenes	<45 nG/L	0 G
Biphenyl	<21 nG/L	0 G
Acenaphthylene	<21 nG/L	0 G
Acenaphthene	<45 nG/L	0 G
Fluorene	<20 nG/L	0 G
Phenanthrene	127 nG/L	0 G
C1-Phenanthrenes	<20 nG/L	0 G
C2-Phenanthrenes	<20 nG/L	0 G
C3-Phenenthrenes	<20 nG/L	0 G
Anthracene	<20 nG/L	0 G
Fluoranthene	176 nG/L	0 G
Pyrene	110 nG/L	0 G
2,3-Benzofluorene	<48 nG/L	0 G
Benz(a)anthracene	<17 nG/L	0 G
Chrysene	64 nG/L	0 G
Benzo(b)fluoranth	37 nG/L	0 G
Benzo(k)fluoranth	<14 nG/L	0 G
Benzo(e)pyrene	<14 nG/L	0 G
Benzo(a)pyrene	<14 nG/L	0 G
Perylene	<14 nG/L	0 G
9,10-Diphenylanth	<14 nG/L	0 G
Dibenz(a,h)anthra	<12 nG/L	0 G
Benzo(g,h,i)peryl	<12 nG/L	0 G
TOTAL PAH	565 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	64 %	***
d10-Acenaphthene	126 %	***
d10-Phenanthrene	125 %	***
d12-Chrysene	101 %	***
d12-Perylene	81 %	***
Resolved HCs	72117 nG/L	0 G
n-alkanes c10-c39	42489 nG/L	0 G
Pristane	3925 nG/L	0 G
Phytane	4072 nG/L	0 G

2 0860

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
SURVEY
SAMPLE DATA SHEET

Channel:	San Gabriel River	Flow (M**3/Sec):	122
Location:	College Pk Bridge	Time Interval:	28:00-34:45
Date:	24 Sep 86	IntervalVol (M**3):	2 x10^6
Time:	22:20	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	mG/L	0 T	Naphthalene	62 nG/L	0 G
TVS	18 %	***	C1-Naphthalenes	35 nG/L	0 G
Total Solids	1160 mG/L	0 T	C2-Naphthalenes	<13 nG/L	0 G
Dissolved Solids	mG/L	0 T	C3-Naphthalenes	<27 nG/L	0 G
Oil & Grease	5 mG/L	0 T	Biphenyl	<13 nG/L	0 G
Chloroform Extr.	1.8 mG/L	0 T	Acenaphthylene	<13 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<27 nG/L	0 G
pH	.	***	Fluorene	<12 nG/L	0 G
			Phenanthrene	130 nG/L	0 G
Cadmium	2 uG/L	0kG	C1-Phenanthrenes	61 nG/L	0 G
Chromium	30 uG/L	0kG	C2-Phenanthrenes	42 nG/L	0 G
Copper	78 uG/L	0kG	C3-Phenenthrenes	<12 nG/L	0 G
Nickel	26 uG/L	0kG	Anthracene	<12 nG/L	0 G
Lead	111 uG/L	0kG	Fluoranthene	247 nG/L	0 G
Zinc	477 uG/L	0kG	Pyrene	233 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<29 nG/L	0 G
			Benz(a)anthracene	42 nG/L	0 G
o,p'-DDE	6 nG/L	0 G	Chrysene	149 nG/L	0 G
p,p'-DDE	6 nG/L	0 G	Benzo(b)fluoranth	114 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	74 nG/L	0 G
p,p'-DDD	2 nG/L	0 G	Benzo(e)pyrene	80 nG/L	0 G
o,p'-DDT	4 nG/L	0 G	Benzo(a)pyrene	31 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	<8 nG/L	0 G
TOTAL DDT	19 nG/L	0 G	9,10-Diphenylanth	<8 nG/L	0 G
			Dibenz(a,h)anthra	<7 nG/L	0 G
Aroclor 1242	42 nG/L	0 G	Benzo(g,h,i)peryl	89 nG/L	0 G
Aroclor 1254	33 nG/L	0 G	TOTAL PAH	1389 nG/L	0 G
TOTAL PCB	75 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	2 nG/L	0 G	d8-Naphthalene	63 %	***
Lindane	6 nG/L	0 G	d10-Acenaphthene	120 %	***
			d10-Phenanthrene	119 %	***
Toxicity	NoTest	***	d12-Chrysene	125 %	***
			d12-Perylene	100 %	***
			Resolved HCs	52786 nG/L	0 G
			n-alkanes c10-c39	28740 nG/L	0 G
			Pristane	2348 nG/L	0 G
			Phytane	3256 nG/L	0 G

VOL 12

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	San Gabriel River
Location:	College Pk Bridge
Date:	23 Sep 86
Time:	19:45

Flow (M**3/Sec):	.564
Time Interval:	00:00-11:00
IntervalVol (M**3):	252,000
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	16 mG/L	0 T	Naphthalene	<10 nG/L	0 G
TVS	31 %	***	C1-Naphthalenes	<10 nG/L	0 G
Total Solids	6180 mG/L	0 T	C2-Naphthalenes	<10 nG/L	0 G
Dissolved Solids	6160 mG/L	0 T	C3-Naphthalenes	<22 nG/L	0 G
Oil & Grease	3.2 mG/L	0 T	Biphenyl	<10 nG/L	0 G
Chloroform Extr.	1.43 mG/L	0 T	Acenaphthylene	<10 nG/L	0 G
Salinity	6 ppt	***	Acenaphthene	<22 nG/L	0 G
pH	5.5	***	Fluorene	<10 nG/L	0 G
			Phenanthrene	<10 nG/L	0 G
Cadmium	salty uG/L	0kG	C1-Phenanthrenes	<10 nG/L	0 G
Chromium	salty uG/L	0kG	C2-Phenanthrenes	<10 nG/L	0 G
Copper	salty uG/L	0kG	C3-Phenenthrenes	<10 nG/L	0 G
Nickel	salty uG/L	0kG	Anthracene	<10 nG/L	0 G
Lead	salty uG/L	0kG	Fluoranthene	<8 nG/L	0 G
Zinc	salty uG/L	0kG	Pyrene	<8 nG/L	0 G
Silver	salty uG/L	0kG	2,3-Benzofluorene	<24 nG/L	0 G
			Benz(a)anthracene	<8 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<8 nG/L	0 G
p,p'-DDE	1 nG/L	0 G	Benzo(b)fluoranth	<7 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<7 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<7 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<7 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	<7 nG/L	0 G
TOTAL DDT	2 nG/L	0 G	9,10-Diphenylanth	<7 nG/L	0 G
			Dibenz(a,h)anthra	<6 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<6 nG/L	0 G
Aroclor 1254	13 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	13 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	16 nG/L	0 G	d8-Naphthalene	0 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	0 %	***
			d10-Phenanthrene	0 %	***
Toxicity	Notest	***	d12-Chrysene	7 %	***
			d12-Perylene	6 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	993 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

VOL 12

2 0862

R0054162

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: San Gabriel River
Location: College Park Bridg
Date: 24 Sep 86
Time: 14:50

Flow (M**3/Sec): 26.2
Time Interval: 21:45-24:15
IntervalVol (M**3): [illegible]
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	222 mG/L	0 T
TVS	26 %	***
Total Solids	9060 mG/L	0 T
Dissolved Solids	8840 mG/L	0 T
Oil & Grease	6.2 mG/L	0 T
Chloroform Extr.	8.1 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	3 uG/L	0kG
Chromium	15 uG/L	0kG
Copper	65 uG/L	0kG
Nickel	39 uG/L	0kG
Lead	104 uG/L	0kG
Zinc	364 uG/L	0kG
Silver	<1 uG/L	0kG
o,p'-DDE	6 nG/L	0 G
p,p'-DDE	7 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	4 nG/L	0 G
o,p'-DDT	7 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	24 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	57 nG/L	0 G
TOTAL PCB	57 nG/L	0 G
Hexachlorobenzene	2 nG/L	0 G
Lindane	22 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	214 nG/L	0 G
C1-Naphthalenes	251 nG/L	0 G
C2-Naphthalenes	35 nG/L	0 G
C3-Naphthalenes	<33 nG/L	0 G
Biphenyl	<16 nG/L	0 G
Acenaphthylene	<16 nG/L	0 G
Acenaphthene	<33 nG/L	0 G
Fluorene	<15 nG/L	0 G
Phenanthrene	132 nG/L	0 G
C1-Phenanthrenes	<15 nG/L	0 G
C2-Phenanthrenes	<15 nG/L	0 G
C3-Phenenthrenes	<15 nG/L	0 G
Anthracene	<15 nG/L	0 G
Fluoranthene	177 nG/L	0 G
Pyrene	163 nG/L	0 G
2,3-Benzofluorene	<35 nG/L	0 G
Benz(a)anthracene	<12 nG/L	0 G
Chrysene	155 nG/L	0 G
Benzo(b)fluoranth	89 nG/L	0 G
Benzo(k)fluoranth	<10 nG/L	0 G
Benzo(e)pyrene	130 nG/L	0 G
Benzo(a)pyrene	76 nG/L	0 G
Perylene	<10 nG/L	0 G
9,10-Diphenylanth	<10 nG/L	0 G
Dibenz(a,h)anthra	<9 nG/L	0 G
Benzo(g,h,i)peryl	109 nG/L	0 G
TOTAL PAH	1531 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	71 %	***
d10-Acenaphthene	104 %	***
d10-Phenanthrene	105 %	***
d12-Chrysene	163 %	***
d12-Perylene	157 %	***
Resolved HCs	56412 nG/L	0 G
n-alkanes c10-c39	37536 nG/L	0 G
Pristane	3846 nG/L	0 G
Phytane	4683 nG/L	0 G

VOL 12

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0863

R0054163

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	San Gabriel River	Flow (M**3/Sec):	.564
Location:	College P. Bridge	Time Interv:	[illegible]
Date:	23 Sep 86	IntervalVol (M**3):	2,126
Time:	19:45	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	16 mG/L	0 T	Naphthalene	<10 nG/L	0 G
TVS	31 %	***	C1-Naphthalenes	<10 nG/L	0 G
Total Solids	6180 mG/L	0 T	C2-Naphthalenes	<10 nG/L	0 G
Dissolved Solids	6160 mG/L	0 T	C3-Naphthalenes	<22 nG/L	0 G
Oil & Grease	3.2 mG/L	0 T	Biphenyl	<10 nG/L	0 G
Chloroform Extr.	1.43 mG/L	0 T	Acenaphthylene	<10 nG/L	0 G
Salinity	6 ppt	***	Acenaphthene	<22 nG/L	0 G
pH	5.5	***	Fluorene	<10 nG/L	0 G
			Phenanthrene	<10 nG/L	0 G
Cadmium	salty uG/L	0kG	C1-Phenanthrenes	<10 nG/L	0 G
Chromium	salty uG/L	0kG	C2-Phenanthrenes	<10 nG/L	0 G
Copper	salty uG/L	0kG	C3-Phenenthrenes	<10 nG/L	0 G
Nickel	salty uG/L	0kG	Anthracene	<10 nG/L	0 G
Lead	salty uG/L	0kG	Fluoranthene	<8 nG/L	0 G
Zinc	salty uG/L	0kG	Pyrene	<8 nG/L	0 G
Silver	salty uG/L	0kG	2,3-Benzofluorene	<24 nG/L	0 G
			Benz(a)anthracene	<8 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<8 nG/L	0 G
p,p'-DDE	1 nG/L	0 G	Benzo(b)fluoranth	<7 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<7 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<7 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<7 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	<7 nG/L	0 G
TOTAL DDT	2 nG/L	0 G	9,10-Diphenylanth	<7 nG/L	0 G
			Dibenz(a,h)anthra	<6 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<6 nG/L	0 G
Aroclor 1254	13 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	13 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	16 nG/L	0 G	d8-Naphthalene	0 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	0 %	***
			d10-Phenanthrene	0 %	***
Toxicity	Notest	***	d12-Chrysene	7 %	***
			d12-Perylene	6 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	993 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

VOL 12

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	San Gabriel River
Location:	College Pk Bridge
Date:	24 Sep 86
Time:	10:00

Flow (M**3/Sec): 4.92
Time Interval: 11:00-19:30
IntervalVol (M**3): 95,000
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	5 mG/L	0 T	Naphthalene	<22 nG/L	0 G
TVS	100 %	***	C1-Naphthalenes	<22 nG/L	0 G
Total Solids	27300 mG/L	0 T	C2-Naphthalenes	<22 nG/L	0 G
Dissolved Solids	27300 mG/L	0 T	C3-Naphthalenes	<46 nG/L	0 G
Oil & Grease	.2 mG/L	0 T	Biphenyl	<22 nG/L	0 G
Chloroform Extr.	1.83 mG/L	0 T	Acenaphthylene	<22 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<46 nG/L	0 G
pH		***	Fluorene	<21 nG/L	0 G
			Phenanthrene	<21 nG/L	0 G
Cadmium	Salty uG/L	0kG	C1-Phenanthrenes	<21 nG/L	0 G
Chromium	Salty uG/L	0kG	C2-Phenanthrenes	<21 nG/L	0 G
Copper	Salty uG/L	0kG	C3-Phenenthrenes	<21 nG/L	0 G
Nickel	Salty uG/L	0kG	Anthracene	<21 nG/L	0 G
Lead	Salty uG/L	0kG	Fluoranthene	<17 nG/L	0 G
Zinc	Salty uG/L	0kG	Pyrene	<17 nG/L	0 G
Silver	Salty uG/L	0kG	2,3-Benzofluorene	<50 nG/L	0 G
			Benz(a)anthracene	<17 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	<17 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G	Benzo(b)fluoranth	<14 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<14 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<14 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<14 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G	Perylene	<14 nG/L	0 G
TOTAL DDT	0 nG/L	0 G	9,10-Diphenylanth	<14 nG/L	0 G
			Dibenz(a,h)anthra	<12 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<12 nG/L	0 G
Aroclor 1254	7 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	7 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	62 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	111 %	***
			d10-Phenanthrene	99 %	***
Toxicity	NoTest	***	d12-Chrysene	120 %	***
			d12-Perylene	110 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	921 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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VOL 12

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Calleguas Creek
Location: Highway 1
Date: 24 Sep 86
Time: 15:10

Flow (M**3/Sec): 1.53
Time Interval: 21:45-34:15
IntervalVol (M**3): 168,000
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	2 mG/L	0 T
TVS	60 %	***
Total Solids	1820 mG/L	- -
Dissolved Solids	1820 mG/L	0 T
Oil & Grease	1.6 mG/L	0 T
Chloroform Extr.	1.3 mG/L	0 T
Salinity	ppt	***
p-		***
Cadmium	<1 uG/L	0kG
Chromium	<3 uG/L	0kG
Copper	4 uG/L	0kG
Nickel	3 uG/L	0kG
Lead	9 uG/L	0kG
Zinc	8 uG/L	0kG
Silver	<1 uG/L	0kG
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	2 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	1 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	1 nG/L	0 G
TOTAL DDT	5 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	11 nG/L	0 G
TOTAL PCB	11 nG/L	0 G
Hexachlorobenzene	<1 nG/L	0 G
Lindane	1 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<7 nG/L	0 G
C1-Naphthalenes	<7 nG/L	0 G
C2-Naphthalenes	<7 nG/L	0 G
C3-Naphthalenes	<14 nG/L	0 G
Biphenyl	<7 nG/L	0 G
Acenaphthylene	<7 nG/L	0 G
Acenaphthene	<14 nG/L	0 G
Fluorene	<6 nG/L	0 G
Phenanthrene	6 nG/L	0 G
C1-Phenanthrenes	<6 nG/L	0 G
C2-Phenanthrenes	6 nG/L	0 G
C3-Phenanthrenes	<6 nG/L	0 G
Anthracene	<6 nG/L	0 G
Fluoranthene	<5 nG/L	0 G
Pyrene	<5 nG/L	0 G
2,3-Benzofluorene	<15 nG/L	0 G
Benz(a)anthracene	<5 nG/L	0 G
Chrysene	<5 nG/L	0 G
Benzo(b)fluoranth	<4 nG/L	0 G
Benzo(k)fluoranth	<4 nG/L	0 G
Benzo(e)pyrene	<4 nG/L	0 G
Benzo(a)pyrene	<4 nG/L	0 G
Perylene	<4 nG/L	0 G
9,10-Diphenylanth	<4 nG/L	0 G
Dibenz(a,h)anthra	<4 nG/L	0 G
Benzo(g,h,i)peryl	<4 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	18 %	***
d10-Acenaphthene	33 %	***
d10-Phenanthrene	31 %	***
d12-Chrysene	38 %	***
d12-Perylene	33 %	***
Resolved HCs	0 nG/L	0 G
n-alkanes c10-c39	24 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

R0054166

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Callequas Creek
Location:	Highway 1
Date:	25 Sep 86
Time:	13:22

Flow (M**3/Sec):	2.41
Time Interval:	34:15-45:00
IntervalVol (M**3):	109,000
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	85 mG/L	0 T	Naphthalene	<14 nG/L	0 G
TVS	28 %	***	C1-Naphthalenes	<14 nG/L	0 G
Total Solids	931 mG/L	0 T	C2-Naphthalenes	<14 nG/L	0 G
Dissolved Solids	846 mG/L	0 T	C3-Naphthalenes	<30 nG/L	0 G
Oil & Grease	1.7 mG/L	0 T	Biphenyl	<14 nG/L	0 G
Chloroform Extr.	1.6 mG/L	0 T	Acenaphthylene	<14 nG/L	0 G
Salinity	2 ppt	***	Acenaphthene	<30 nG/L	0 G
pH	5.5	***	Fluorene	<13 nG/L	0 G
			Phenanthrene	<13 nG/L	0 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<13 nG/L	0 G
Chromium	5 uG/L	0kG	C2-Phenanthrenes	<13 nG/L	0 G
Copper	46 uG/L	0kG	C3-Phenenthrenes	<13 nG/L	0 G
Nickel	12 uG/L	0kG	Anthracene	<14 nG/L	0 G
Lead	<9 uG/L	0kG	Fluoranthene	<11 nG/L	0 G
Zinc	14 uG/L	0kG	Pyrene	<11 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<32 nG/L	0 G
			Benz(a)anthracene	<11 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<11 nG/L	0 G
p,p'-DDE	5 nG/L	0 G	Benzo(b)fluoranth	<9 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<9 nG/L	0 G
p,p'-DDD	3 nG/L	0 G	Benzo(e)pyrene	<9 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<9 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	<9 nG/L	0 G
TOTAL DDT	10 nG/L	0 G	9,10-Diphenylanth	<9 nG/L	0 G
			Dibenz(a,h)anthra	<8 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<8 nG/L	0 G
Aroclor 1254	19 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	19 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	0 %	***
Lindane	6 nG/L	0 G	d10-Acenaphthene	17 %	***
			d10-Phenanthrene	58 %	***
Toxicity	Notest	***	d12-Chrysene	101 %	***
			d12-Perylene	104 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	0 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

2 0867

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Santa Clara River
Location:	Highway 101
Date:	25 Sep 86
Time:	12:15

Flow (M**3/Sec): 0.14
Time Interval: 34:15-4?:00
IntervalVol(M**3): 11,970
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	16 mG/L	0 T	Naphthalene	<26 nG/L	0 G
TVS	88 %	***	C1-Naphthalenes	<26 nG/L	0 G
Total Solids	2780 mG/L	0 T	C2-Naphthalenes	<26 nG/L	0 G
Dissolved Solids	2760 mG/L	0 T	C3-Naphthalenes	<54 nG/L	0 G
Oil & Grease	1 mG/L	0 T	Biphenyl	<26 nG/L	0 G
Chloroform Extr.	2.1 mG/L	0 T	Acenaphthylene	<26 nG/L	0 G
Salinity	3 ppt	***	Acenaphthene	<54 nG/L	0 G
pH	6	***	Fluorene	<24 nG/L	0 G
			Phenanthrene	<24 nG/L	0 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<24 nG/L	0 G
Chromium	<2 uG/L	0kG	C2-Phenanthrenes	<24 nG/L	0 G
Copper	<2 uG/L	0kG	C3-Phenenthrenes	<24 nG/L	0 G
Nickel	4 uG/L	0kG	Anthracene	<25 nG/L	0 G
Lead	<8 uG/L	0kG	Fluoranthene	<20 nG/L	0 G
Zinc	7 uG/L	0kG	Pyrene	<20 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<58 nG/L	0 G
			Benz(a)anthracene	<20 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<20 nG/L	0 G
p,p'-DDE	3 nG/L	0 G	Benzo(b)fluoranth	<17 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<17 nG/L	0 G
p,p'-DDD	3 nG/L	0 G	Benzo(e)pyrene	<17 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<17 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	<17 nG/L	0 G
TOTAL DDT	8 nG/L	0 G	9,10-Diphenylanth	<17 nG/L	0 G
			Dibenz(a,h)anthra	<14 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<14 nG/L	0 G
Aroclor 1254	12 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	12 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	67 %	***
Lindane	2 nG/L	0 G	d10-Acenaphthene	111 %	***
			d10-Phenanthrene	97 %	***
Toxicity	Notest	***	d12-Chrysene	127 %	***
			d12-Perylene	117 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	0 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Callequas Creek	Flow (M**3/Sec):	.82
Location:	Highway 1	Time Interval:	00:00-21:45
Date:	24 Sep 86	IntervalVol (M**3):	41,515
Time:	12:20	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	2 mG/L	0 T	Naphthalene	<11 nG/L	0 G
TVS	60 %	***	C1-Naphthalenes	<11 nG/L	0 G
Total Solids	1251 mG/L	0 T	C2-Naphthalenes	<11 nG/L	0 G
Dissolved Solids	1249 mG/L	0 T	C3-Naphthalenes	<23 nG/L	0 G
Oil & Grease	6.8 mG/L	0 T	Biphenyl	<11 nG/L	0 G
Chloroform Extr.	1.1 mG/L	0 T	Acenaphthylene	<11 nG/L	0 G
Salinity	.5 ppt	***	Acenaphthene	<23 nG/L	0 G
pH	6.5	***	Fluorene	<10 nG/L	0 G
			Phenanthrene	<10 nG/L	0 G
Cadmium	<1 uG/L	0KG	C1-Phenanthrenes	<10 nG/L	0 G
Chromium	<3 uG/L	0KG	C2-Phenanthrenes	<10 nG/L	0 G
Copper	3 uG/L	0KG	C3-Phenenthrenes	<10 nG/L	0 G
Nickel	9 uG/L	0KG	Anthracene	<10 nG/L	0 G
Lead	<9 uG/L	0KG	Fluoranthene	<8 nG/L	0 G
Zinc	6 uG/L	0KG	Pyrene	<8 nG/L	0 G
Silver	<1 uG/L	0KG	2,3-Benzofluorene	<25 nG/L	0 G
			Benz(a)anthracene	23 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	112 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G	Benzo(b)fluoranth	<7 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<7 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<7 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<7 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	<7 nG/L	0 G
TOTAL DDT	1 nG/L	0 G	9,10-Diphenylanth	<7 nG/L	0 G
			Dibenz(a,h)anthra	<6 nG/L	0 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	<6 nG/L	0 G
Aroclor 1254	13 nG/L	0 G	TOTAL PAH	135 nG/L	0 G
TOTAL PCB	13 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	66 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	88 %	***
			d10-Phenanthrene	82 %	***
Toxicity	Notest	***	d12-Chrysene	92 %	***
			d12-Perylene	87 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c39	0 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Santa Clara River
Location:	Highway 101
Date:	24 Sep 86
Time:	13:10

Flow (M**3/Sec):	0.15
Time Interval:	00:00-21:45
IntervalVol(M**3):	1979
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1090 mG/L	0 T	Naphthalene	106 nG/L	0 G
TVS	12 %	***	C1-Naphthalenes	78 nG/L	0 G
Total Solids	1420 mG/L	0 T	C2-Naphthalenes	124 nG/L	0 G
Dissolved Solids	330 mG/L	0 T	C3-Naphthalenes	<31 nG/L	0 G
Oil & Grease	6.8 mG/L	0 T	Biphenyl	<15 nG/L	0 G
Chloroform Extr.	1.1 mG/L	0 T	Acenaphthylene	<15 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<31 nG/L	0 G
pH	5.5	***	Fluorene	<14 nG/L	0 G
			Phenanthrene	193 nG/L	0 G
Cadmium	2 uG/L	0kG	C1-Phenanthrenes	286 nG/L	0 G
Chromium	68 uG/L	0kG	C2-Phenanthrenes	226 nG/L	0 G
Copper	74 uG/L	0kG	C3-Phenenthrenes	50 nG/L	0 G
Nickel	48 uG/L	0kG	Anthracene	<14 nG/L	0 G
Lead	134 uG/L	0kG	Fluoranthene	178 nG/L	0 G
Zinc	391 uG/L	0kG	Pyrene	214 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<34 nG/L	0 G
			Benz(a)anthracene	<12 nG/L	0 G
o,p'-DDE	13 nG/L	0 G	Chrysene	232 nG/L	0 G
p,p'-DDE	177 nG/L	0 G	Benzo(b)fluoranth	66 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	30 nG/L	0 G
p,p'-DDD	25 nG/L	0 G	Benzo(e)pyrene	76 nG/L	0 G
o,p'-DDT	21 nG/L	0 G	Benzo(a)pyrene	25 nG/L	0 G
p,p'-DDT	60 nG/L	0 G	Perylene	<10 nG/L	0 G
TOTAL DDT	296 nG/L	0 G	9,10-Diphenylanth	<10 nG/L	0 G
			Dibenz(a,h)anthra	<8 nG/L	0 G
Aroclor 1242	70 nG/L	0 G	Benzo(g,h,i)peryl	67 nG/L	0 G
Aroclor 1254	86 nG/L	0 G	TOTAL PAH	1951 nG/L	0 G
TOTAL PCB	156 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	62 %	***
Lindane	7 nG/L	0 G	d10-Acenaphthene	125 %	***
			d10-Phenanthrene	131 %	***
Toxicity	NoTest	***	d12-Chrysene	157 %	***
			d12-Perylene	134 %	***
			Resolved HCs	1.2e5 nG/L	0 G
			n-alkanes c10-c39	51516 nG/L	0 G
			Pristane	36160 nG/L	0 G
			Phytane	4516 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Santa Clara River
Location:	Highway 101
Date:	24 Sep 86
Time:	14:30

Flow (M**3/Sec): 0.28
Time Interval: 21:45-34:15
IntervalVol(M**3): 9030
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	1920 mG/L	0 T
TVS	8.4 %	***
Total Solids	2470 mG/L	0 T
Dissolved Solids	550 mG/L	0 T
Oil & Grease	3 mG/L	0 T
Chloroform Extr.	7.5 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	1 uG/L	OkG
Chromium	80 uG/L	OkG
Copper	106 uG/L	OkG
Nickel	18 uG/L	OkG
Lead	124 uG/L	OkG
Zinc	337 uG/L	OkG
Silver	<1 uG/L	OkG
o,p'-DDE	22 nG/L	0 G
p,p'-DDE	879 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	151 nG/L	0 G
o,p'-DDT	103 nG/L	0 G
p,p'-DDT	417 nG/L	0 G
TOTAL DDT	1572 nG/L	0 G
Aroclor 1242	47 nG/L	0 G
Aroclor 1254	203 nG/L	0 G
TOTAL PCB	250 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	38 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	125 nG/L	0 G
C1-Naphthalenes	45 nG/L	0 G
C2-Naphthalenes	22 nG/L	0 G
C3-Naphthalenes	<25 nG/L	0 G
Biphenyl	<12 nG/L	0 G
Acenaphthylene	<12 nG/L	0 G
Acenaphthene	112 nG/L	0 G
Fluorene	44 nG/L	0 G
Phenanthrene	375 nG/L	0 G
C1-Phenanthrenes	62 nG/L	0 G
C2-Phenanthrenes	46 nG/L	0 G
C3-Phenenthrenes	<11 nG/L	0 G
Anthracene	<11 nG/L	0 G
Fluoranthene	237 nG/L	0 G
Pyrene	182 nG/L	0 G
2,3-Benzofluorene	<27 nG/L	0 G
Benz(a)anthracene	<9 nG/L	0 G
Chrysene	150 nG/L	0 G
Benzo(b)fluoranth	64 nG/L	0 G
Benzo(k)fluoranth	21 nG/L	0 G
Benzo(e)pyrene	37 nG/L	0 G
Benzo(a)pyrene	<8 nG/L	0 G
Perylene	<8 nG/L	0 G
9,10-Diphenylanth	<8 nG/L	0 G
Dibenz(a,h)anthra	<7 nG/L	0 G
Benzo(g,h,i)peryl	35 nG/L	0 G
TOTAL PAH	1557 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	74 %	***
d10-Acenaphthene	123 %	***
d10-Phenanthrene	126 %	***
d12-Chrysene	100 %	***
d12-Perylene	74 %	***
Resolved HCs	70900 nG/L	0 G
n-alkanes c10-c39	33965 nG/L	0 G
Pristane	2349 nG/L	0 G
Phytane	3246 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Ballona Creek
Location: Inglewood Avenue
Date: 25 Sep 86
Time: 15:15

Flow (M**3/Sec): .538
Time Interval: 43:45-45:00
IntervalVol (M**3): 9770
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	184 mG/L	4.250 T
TVS	18 %	***
Total Solids	1760 mG/L	40.66 T
Dissolved Solids	1580 mG/L	36.50 T
Oil & Grease	2.9 mG/L	.0670 T
Chloroform Extr.	2.4 mG/L	.0554 T
Salinity	2 ppt	***
pH	6	***
Cadmium	2 uG/L	.0462kG
Chromium	19 uG/L	.4389kG
Copper	44 uG/L	1.016kG
Nickel	19 uG/L	.4389kG
Lead	27 uG/L	.6237kG
Zinc	172 uG/L	3.973kG
Silver	<1 uG/L	0kG
o,p'-DDE	6 nG/L	.1386 G
p,p'-DDE	8 nG/L	.1848 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	2 nG/L	.0462 G
o,p'-DDT	5 nG/L	.1155 G
p,p'-DDT	3 nG/L	.0693 G
TOTAL DDT	24 nG/L	.5544 G
Aroclor 1242	22 nG/L	.5082 G
Aroclor 1254	45 nG/L	1.040 G
TOTAL PCB	67 nG/L	1.548 G
Hexachlorobenzene	1 nG/L	.0231 G
Lindane	5 nG/L	.1155 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<14 nG/L	0 G
C1-Naphthalenes	<14 nG/L	0 G
C2-Naphthalenes	<14 nG/L	0 G
C3-Naphthalenes	<28 nG/L	0 G
Biphenyl	<14 nG/L	0 G
Acenaphthylene	<14 nG/L	0 G
Acenaphthene	<28 nG/L	0 G
Fluorene	<13 nG/L	0 G
Phenanthrene	156 nG/L	3.604 G
C1-Phenanthrenes	<13 nG/L	0 G
C2-Phenanthrenes	29 nG/L	.6699 G
C3-Phenenthrenes	<13 nG/L	0 G
Anthracene	<13 nG/L	0 G
Fluoranthene	138 nG/L	3.188 G
Pyrene	81 nG/L	1.871 G
2,3-Benzofluorene	<31 nG/L	0 G
Benz(a)anthracene	<11 nG/L	0 G
Chrysene	79 nG/L	1.825 G
Benzo(b)fluoranth	<9 nG/L	0 G
Benzo(k)fluoranth	<9 nG/L	0 G
Benzo(e)pyrene	<9 nG/L	0 G
Benzo(a)pyrene	<9 nG/L	0 G
Perylene	<9 nG/L	0 G
9,10-Diphenylanth	<9 nG/L	0 G
Dibenz(a,h)anthra	<8 nG/L	0 G
Benzo(g,h,i)peryl	<8 nG/L	0 G
TOTAL PAH	483 nG/L	11.16 G
SURROGATE RECOV.		
d8-Naphthalene	68 %	***
d10-Acenaphthene	99 %	***
d10-Phenanthrene	111 %	***
d12-Chrysene	121 %	***
d12-Perylene	92 %	***
Resolved HCs	93659 nG/L	2164. G
n-alkanes c10-c39	42711 nG/L	986.6 G
Pristane	5341 nG/L	123.4 G
Phytane	4300 nG/L	99.33 G

2 0872

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Santa Clara River
Location: Highway 101
Date: 24 Sep 86
Time: 13:10

Flow (M**3/Sec): 0.15
Time Interval: 00:00-21:45
IntervalVol (M**3): 1970
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1090 mG/L	0 T	Naphthalene	106 nG/L	0 G
TVS	12 %	***	C1-Naphthalenes	78 nG/L	0 G
Total Solids	1420 mG/L	0 T	C2-Naphthalenes	124 nG/L	0 G
Dissolved Solids	330 mG/L	0 T	C3-Naphthalenes	<31 nG/L	0 G
Oil & Grease	0.8 mG/L	0 T	Biphenyl	<15 nG/L	0 G
Chloroform Extr.	1.1 mG/L	0 T	Acenaphthylene	<15 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<31 nG/L	0 G
pH	5.5	***	Fluorene	<14 nG/L	0 G
			Phenanthrene	193 nG/L	0 G
Cadmium	2 uG/L	0kG	C1-Phenanthrenes	286 nG/L	0 G
Chromium	68 uG/L	0kG	C2-Phenanthrenes	226 nG/L	0 G
Copper	74 uG/L	0kG	C3-Phenenthrenes	50 nG/L	0 G
Nickel	48 uG/L	0kG	Anthracene	<14 nG/L	0 G
Lead	134 uG/L	0kG	Fluoranthene	178 nG/L	0 G
Zinc	391 uG/L	0kG	Pyrene	214 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<34 nG/L	0 G
			Benz(a)anthracene	<12 nG/L	0 G
o,p'-DDE	13 nG/L	0 G	Chrysene	232 nG/L	0 G
p,p'-DDE	177 nG/L	0 G	Benzo(b)fluoranth	66 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	30 nG/L	0 G
p,p'-DDD	25 nG/L	0 G	Benzo(e)pyrene	76 nG/L	0 G
o,p'-DDT	21 nG/L	0 G	Benzo(a)pyrene	25 nG/L	0 G
p,p'-DDT	60 nG/L	0 G	Perylene	<10 nG/L	0 G
TOTAL DDT	296 nG/L	0 G	9,10-Diphenylanth	<10 nG/L	0 G
			Dibenz(a,h)anthra	<8 nG/L	0 G
Aroclor 1242	70 nG/L	0 G	Benzo(g,h,i)peryl	67 nG/L	0 G
Aroclor 1254	86 nG/L	0 G	TOTAL PAH	1951 nG/L	0 G
TOTAL PCB	156 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	62 %	***
Lindane	7 nG/L	0 G	d10-Acenaphthene	125 %	***
			d10-Phenanthrene	131 %	***
Toxicity	NoTest	***	d12-Chrysene	157 %	***
			d12-Perylene	134 %	***
			Resolved HCs	1.2e5 nG/L	0 G
			n-alkanes c10-c39	51516 nG/L	0 G
			Pristane	36160 nG/L	0 G
			Phytane	4516 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Ballona Creek
Location:	Inglewood Avenue
Date:	24 Sep 86
Time:	21:30

Flow (M**3/Sec): 140
Time Interval: 27:15-34:45
IntervalVol (M**3): 1.57 x 10^6
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	112 mG/L	180.3 T
TVS	17 %	***
Total Solids	165 mG/L	265.7 T
Dissolved Solids	53 mG/L	85.33 T
Oil & Grease	6.3 mG/L	10.14 T
Chloroform Extr.	1.6 mG/L	2.576 T
Salinity	0 ppt	***
pH	5.5	***
Cadmium	<1 uG/L	0kG
Chromium	5 uG/L	8.05kG
Copper	43 uG/L	69.23kG
Nickel	14 uG/L	22.54kG
Lead	68 uG/L	109.5kG
Zinc	237 uG/L	381.6kG
Silver	<1 uG/L	0kG
o,p'-DDE	6 nG/L	9.66 G
p,p'-DDE	6 nG/L	9.66 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	1 nG/L	1.61 G
o,p'-DDT	5 nG/L	8.05 G
p,p'-DDT	7 nG/L	11.27 G
TOTAL DDT	25 nG/L	40.25 G
Aroclor 1242	44 nG/L	70.84 G
Aroclor 1254	31 nG/L	49.91 G
TOTAL PCB	75 nG/L	120.8 G
Hexachlorobenzene	1 nG/L	1.61 G
Lindane	8 nG/L	12.88 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<15 nG/L	0 G
C1-Naphthalenes	<15 nG/L	0 G
C2-Naphthalenes	<15 nG/L	0 G
C3-Naphthalenes	<32 nG/L	0 G
Biphenyl	<15 nG/L	0 G
Acenaphthylene	<15 nG/L	0 G
Acenaphthene	<32 nG/L	0 G
Fluorene	<15 nG/L	0 G
Phenanthrene	79 nG/L	127.2 G
C1-Phenanthrenes	<15 nG/L	0 G
C2-Phenanthrenes	<15 nG/L	0 G
C3-Phenenthrenes	<15 nG/L	0 G
Anthracene	<15 nG/L	0 G
Fluoranthene	203 nG/L	326.8 G
Pyrene	179 nG/L	288.2 G
2,3-Benzofluorene	<35 nG/L	0 G
Benz(a)anthracene	21 nG/L	33.81 G
Chrysene	101 nG/L	162.6 G
Benzo(b)fluoranth	55 nG/L	88.55 G
Benzo(k)fluoranth	<10 nG/L	0 G
Benzo(e)pyrene	34 nG/L	54.74 G
Benzo(a)pyrene	<10 nG/L	0 G
Perylene	<10 nG/L	0 G
9,10-Diphenylanth	<10 nG/L	0 G
Dibenz(a,h)anthra	<9 nG/L	0 G
Benzo(g,h,i)peryl	<9 nG/L	0 G
TOTAL PAH	672 nG/L	1082. G
SURROGATE RECOV.		
d8-Naphthalene	0 %	***
d10-Acenaphthene	57 %	***
d10-Phenanthrene	98 %	***
d12-Chrysene	142 %	***
d12-Perylene	128 %	***
Resolved HCs	7.8e5 nG/L	1.3e6 G
n-alkanes c10-c39	2.6e5 nG/L	4.1e5 G
Pristane	15381 nG/L	24763 G
Phytane	29166 nG/L	46957 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Ballona Creek
Location: Inglewood Avenue
Date: 25 Sep 86
Time: 08:06

Flow (M**3/Sec): 1.09
Time Interval: 35:00-43:30
IntervalVol(M**3): 57 960
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	13 mG/L	.7059 T
TVS	46 %	***
Total Solids	284 mG/L	15.42 T
Dissolved Solids	271 mG/L	14.72 T
Oil & Grease	2.2 mG/L	.1195 T
Chloroform Extr.	5.7 mG/L	.3095 T
Salinity	ppt	***
pH		***
Cadmium	<1 uG/L	0kG
Chromium	<3 uG/L	0kG
Copper	28 uG/L	1.520kG
Nickel	7 uG/L	.3801kG
Lead	23 uG/L	1.249kG
Zinc	187 uG/L	10.15kG
Silver	<1 uG/L	0kG
o,p'-DDE	<1 nG/L	0 G
p,p'-DDE	<1 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	1 nG/L	.0543 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	[illegible]	.0543 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	18 nG/L	.9774 G
TOTAL PCB	18 nG/L	.9774 G
Hexachlorobenzene	<1 nG/L	0 G
Lindane	7 nG/L	.3801 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	140 nG/L	7.602 G
C1-Naphthalenes	80 nG/L	4.344 G
C2-Naphthalenes	<15 nG/L	0 G
C3-Naphthalenes	<32 nG/L	0 G
Biphenyl	<15 nG/L	0 G
Acenaphthylene	<15 nG/L	0 G
Acenaphthene	<32 nG/L	0 G
Fluorene	<14 nG/L	0 G
Phenanthrene	120 nG/L	6.516 G
C1-Phenanthrenes	<14 nG/L	0 G
C2-Phenanthrenes	<14 nG/L	0 G
C3-Phenenthrenes	<14 nG/L	0 G
Anthracene	<15 nG/L	0 G
Fluoranthene	33 nG/L	1.792 G
Pyrene	27 nG/L	1.466 G
2,3-Benzofluorene	<34 nG/L	0 G
Benz(a)anthracene	<12 nG/L	0 G
Chrysene	<12 nG/L	0 G
Benzo(b)fluoranth	10 nG/L	0 G
Benzo(k)fluoranth	10 nG/L	0 G
Benzo(e)pyrene	10 nG/L	0 G
Benzo(a)pyrene	10 nG/L	0 G
Perylene	10 nG/L	0 G
9,10-Diphenylanth	10 nG/L	0 G
Dibenz(a,h)anthra	<9 nG/L	[illegible]
Benzo(g,h,i)peryl	<9 nG/L	0 G
TOTAL PAH	400 nG/L	21.72 G
SURROGATE RECOV.		
d8-Naphthalene	71 %	***
d10-Acenaphthene	103 %	***
d10-Phenanthrene	105 %	***
d12-Chrysene	114 %	***
d12-Perylene	100 %	***
Resolved HCs	17727 nG/L	962.6 G
n-alkanes c10-c39	8910 nG/L	483.8 G
Pristane	1889 nG/L	102.6 G
Phytane	2033 nG/L	110.4 G

2 0875

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Ballona Creek
Location:	Inglewood Avenue
Date:	24 Sep 86
Time:	10:50

Flow (M**3/Sec):	56.6
Time Interval:	12:30-21:45
IntervalVol(M**3):	7.14 x10⁶
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	2500 mG/L	17.58 T	Naphthalene	815 nG/L	5.729 G
TVS	20 %	***	C1-Naphthalenes	1298 nG/L	9.125 G
Total Solids	5250 mG/L	36.91 T	C2-Naphthalenes	1451 nG/L	10.20 G
Dissolved Solids	2750 mG/L	19.33 T	C3-Naphthalenes	4447 nG/L	31.26 G
Oil & Grease	36.4 mG/L	.2559 T	Biphenyl	86 nG/L	.6046 G
Chloroform Extr.	76.6 mG/L	.5385 T	Acenaphthylene	<15 nG/L	0 G
Salinity	.25 ppt	***	Acenaphthene	195 nG/L	1.371 G
pH	5.5	***	Fluorene	352 nG/L	2.475 G
			Phenanthrene	4635 nG/L	32.58 G
Cadmium	22 uG/L	.1547kG	C1-Phenanthrenes	4426 nG/L	31.11 G
Chromium	248 uG/L	1.743kG	C2-Phenanthrenes	6754 nG/L	47.48 G
Copper	860 uG/L	6.046kG	C3-Phenenthrenes	7675 nG/L	53.96 G
Nickel	261 uG/L	1.835kG	Anthracene	765 nG/L	5.378 G
Lead	1829 uG/L	12.86kG	Fluoranthene	7731 nG/L	54.35 G
Zinc	4398 uG/L	30.92kG	Pyrene	8064 nG/L	56.69 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	2596 nG/L	18.25 G
			Benz(a)anthracene	3768 nG/L	26.49 G
o,p'-DDE	346 nG/L	2.432 G	Chrysene	6671 nG/L	46.90 G
p,p'-DDE	354 nG/L	2.489 G	Benzo(b)fluoranth	<9 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	8375 nG/L	58.88 G
p,p'-DDD	151 nG/L	1.062 G	Benzo(e)pyrene	<9 nG/L	0 G
o,p'-DDT	330 nG/L	2.320 G	Benzo(a)pyrene	4088 nG/L	28.74 G
p,p'-DDT	179 nG/L	1.258 G	Perylene	70 nG/L	.4921 G
TOTAL DDT	1360 nG/L	9.561 G	9,10-Diphenylanth	248 nG/L	1.743 G
			Dibenz(a,h)anthra	395 nG/L	2.777 G
Aroclor 1242	4 nG/L	.0281 G	Benzo(g,h,i)peryl	789 nG/L	5.547 G
Aroclor 1254	628 nG/L	4.415 G	TOTAL PAH	75694 nG/L	532.1 G
TOTAL PCB	632 nG/L	4.443 G			
			SURROGATE RECOV.		
Hexachlorobenzene	9 nG/L	.0633 G	d8-Naphthalene	77 %	***
Lindane	49 nG/L	.3445 G	d10-Acenaphthene	126 %	***
			d10-Phenanthrene	126 %	***
Toxicity	NoTest	***	d12-Chrysene	201 %	***
			d12-Perylene	164 %	***
			Resolved HCs	7.7e6 nG/L	54123 G
			n-alkanes c10-c39	4.4e5 nG/L	3104. G
			Pristane	39421 nG/L	277.1 G
			Phytane	47000 nG/L	330.4 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Ballona Creek
Location:	Inglewood Avenue
Date:	24 Sep 86
Time:	16:55

Flow (M**3/Sec):	63.7
Time Interval:	22:00-27:15
IntervalVol (M**3):	1.67 x 10^6
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	234 mG/L	395.5 T	Naphthalene	264 nG/L	446.2 G
TVS	15 %	***	C1-Naphthalenes	748 nG/L	1264. G
Total Solids	306 mG/L	517.1 T	C2-Naphthalenes	659 nG/L	1114. G
Dissolved Solids	72 mG/L	121.7 T	C3-Naphthalenes	738 nG/L	1247. G
Oil & Grease	9.3 mG/L	15.72 T	Biphenyl	<21 nG/L	0 G
Chloroform Extr.	16.5 mG/L	27.89 T	Acenaphthylene	<21 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<43 nG/L	0 G
pH		***	Fluorene	46 nG/L	77.74 G
			Phenanthrene	857 nG/L	1448. G
Cadmium	3 uG/L	5.07kG	C1-Phenanthrenes	1160 nG/L	1960. G
Chromium	13 uG/L	21.97kG	C2-Phenanthrenes	1326 nG/L	2241. G
Copper	86 uG/L	145.3kG	C3-Phenenthrenes	741 nG/L	1252. G
Nickel	23 uG/L	38.87kG	Anthracene	<20 nG/L	0 G
Lead	96 uG/L	162.2kG	Fluoranthene	980 nG/L	1656. G
Zinc	613 uG/L	1036.kG	Pyrene	991 nG/L	1675. G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	227 nG/L	383.6 G
			Benz(a)anthracene	314 nG/L	530.7 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	673 nG/L	1137. G
p,p'-DDE	13 nG/L	21.97 G	Benzo(b)fluoranth	636 nG/L	1075. G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<13 nG/L	0 G
p,p'-DDD	9 nG/L	15.21 G	Benzo(e)pyrene	354 nG/L	598.3 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	174 nG/L	294.1 G
p,p'-DDT	22 nG/L	37.18 G	Perylene	<13 nG/L	0 G
TOTAL DDT	44 nG/L	74.36 G	9,10-Diphenylanth	<13 nG/L	0 G
			Dibenz(a,h)anthra	41 nG/L	69.29 G
Aroclor 1242	<1 nG/L	0 G	Benzo(g,h,i)peryl	443 nG/L	748.7 G
Aroclor 1254	220 nG/L	371.8 G	TOTAL PAH	11372 nG/L	19219 G
TOTAL PCB	220 nG/L	371.8 G			
			SURROGATE RECOV.		
Hexachlorobenzene	2 nG/L	3.38 G	d8-Naphthalene	46 %	***
Lindane	10 nG/L	16.9 G	d10-Acenaphthene	137 %	***
			d10-Phenanthrene	125 %	***
Toxicity	NoTest	***	d12-Chrysene	148 %	***
			d12-Perylene	124 %	***
			Resolved HCs	3.1e5 nG/L	5.2e5 G
			n-alkanes c10-c39	1.2e5 nG/L	2.1e5 G
			Pristane	11238 nG/L	18992 G
			Phytane	12621 nG/L	21329 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Big Tujunga Wash
Date:	25 Sep 86
Time:	08:30

Flow (M**3/Sec):	0.07
Time Interval:	34:30-36:00
IntervalVol (M**3):	382
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MAS
Suspended Solids	826 mG/L	0 T	Naphthalene	<33 nG/L	
TVS	9 %	***	C1-Naphthalenes	<33 nG/L	
Total Solids	345 mG/L	0 T	C2-Naphthalenes	<33 nG/L	
Dissolved Solids	-481 mG/L	0 T	C3-Naphthalenes	<69 nG/L	
Oil & Grease	.1 mG/L	0 T	Biphenyl	<33 nG/L	
Chloroform Extr.	2.12 mG/L	0 T	Acenaphthylene	<33 nG/L	
Salinity	ppt	***	Acenaphthene	<69 nG/L	
pH		***	Fluorene	<31 nG/L	
			Phenanthrene	<31 nG/L	
Cadmium	<1 uG/L	0KG	C1-Phenanthrenes	<31 nG/L	
Chromium	8 uG/L	0KG	C2-Phenanthrenes	<31 nG/L	
Copper	28 uG/L	0KG	C3-Phenenthrenes	<31 nG/L	
Nickel	5 uG/L	0KG	Anthracene	<32 nG/L	
Lead	<7 uG/L	0KG	Fluoranthene	<25 nG/L	
inc	47 uG/L	0KG	Pyrene	<25 nG/L	
Silver	<1 uG/L	0KG	2,3-Benzofluorene	<75 nG/L	
			Benz(a)anthracene	<26 nG/L	
o,p'-DDE	1 nG/L	0 G	Chrysene	<26 nG/L	
p,p'-DDE	2 nG/L	0 G	Benzo(b)fluoranth	<21 nG/L	
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<21 nG/L	
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	<21 nG/L	
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<21 nG/L	
p,p'-DDT	2 nG/L	0 G	Perylene	<21 nG/L	
TOTAL DDT	5 nG/L	0 G	9,10-Diphenylanth	<21 nG/L	
			Dibenz(a,h)anthra	<19 nG/L	
Aroclor 1242	12 nG/L	0 G	Benzo(g,h,i)peryl	<19 nG/L	
Aroclor 1254	23 nG/L	0 G	TOTAL PAH	0 nG/L	
TOTAL PCB	35 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	34 %	***
Lindane	2 nG/L	0 G	d10-Acenaphthene	73 %	***
			d10-Phenanthrene	96 %	***
Toxicity	Notest	***	d12-Chrysene	177 %	***
			d12-Perylene	163 %	***
			Resolved HCs	5310 nG/L	
			n-alkanes c10-c39	1442 nG/L	
			Pristane	0 nG/L	
			Phytane	0 nG/L	

VOL 12

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Ballona Creek
Location: Inglewood Avenue
Date: 23 Sep 86
Time: 21:55

Flow (M**3/Sec): .51
Time Interval: 00:00-12:15
IntervalVol (M**3): 19 400
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	331 mG/L	.2274 T
TVS	30 %	***
Total Solids	6070 mG/L	4.170 T
Dissolved Solids	5741 mG/L	3.944 T
Oil & Grease	4.5 mG/L	.0031 T
Chloroform Extr.	59.6 mG/L	.0409 T
Salinity	6 ppt	***
pH	6	***
Cadmium	2 uG/L	.0014kG
Chromium	12 uG/L	.0082kG
Copper	112 uG/L	.0769kG
Nickel	33 uG/L	.0227kG
Lead	113 uG/L	.0776kG
Zinc	376 uG/L	.2583kG
Silver	<1 uG/L	0kG
o,p'-DDE	14 nG/L	.0096 G
p,p'-DDE	11 nG/L	.0076 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	6 nG/L	.0041 G
o,p'-DDT	10 nG/L	.0069 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	41 nG/L	.0282 G
Aroclor 1242	<1 nG/L	0 G
Aroclor 1254	116 nG/L	.0797 G
TOTAL PCB	116 nG/L	.0797 G
Hexachlorobenzene	5 nG/L	.0034 G
Lindane	<1 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	62 nG/L	.0426 G
C1-Naphthalenes	48 nG/L	.0330 G
C2-Naphthalenes	125 nG/L	.0859 G
C3-Naphthalenes	632 nG/L	.4342 G
Biphenyl	<6 nG/L	0 G
Acenaphthylene	<6 nG/L	0 G
Acenaphthene	<12 nG/L	0 G
Fluorene	58 nG/L	.0398 G
Phenanthrene	228 nG/L	.1566 G
C1-Phenanthrenes	1222 nG/L	.8395 G
C2-Phenanthrenes	1411 nG/L	.9694 G
C3-Phenenthrenes	1480 nG/L	1.017 G
Anthracene	34 nG/L	.0234 G
Fluoranthene	626 nG/L	.4301 G
Pyrene	685 nG/L	.4706 G
2,3-Benzofluorene	273 nG/L	.1876 G
Benz(a)anthracene	177 nG/L	.1216 G
Chrysene	387 nG/L	.2659 G
Benzo(b)fluoranth	419 nG/L	.2879 G
Benzo(k)fluoranth	<4 nG/L	0 G
Benzo(e)pyrene	239 nG/L	.1642 G
Benzo(a)pyrene	100 nG/L	.0687 G
Perylene	65 nG/L	.0447 G
9,10-Diphenylanth	17 nG/L	.0117 G
Dibenz(a,h)anthra	41 nG/L	.0282 G
Benzo(g,h,i)peryl	303 nG/L	.2082 G
TOTAL PAH	8632 nG/L	5.930 G
SURROGATE RECOV.		
d8-Naphthalene	86 %	***
d10-Acenaphthene	125 %	***
d10-Phenanthrene	114 %	***
d12-Chrysene	99 %	***
d12-Perylene	93 %	***
Resolved HCs	4.2e5 nG/L	285.9 G
n-alkanes [illegible]	177254 nG/L	0 G
Pristane	33237 nG/L	22.87 G
[illegible]tane	41442 nG/L	28.47 G

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY

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R0054179

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Los Angeles River
Location: Big Tujunga Wash
Date: 24 Sep 86
Time: 18:30

Flow (M**3/Sec): 0.011 m³/s
Time Interval: 24:15-27:45
IntervalVol(M**3): 99.6
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	4 mG/L	0 T
TVS	%	***
Total Solids	300 mG/L	0 T
Dissolved Solids	296 mG/L	0 T
Oil & Grease	<.1 mG/L	0 T
Chloroform Extr.	1.85 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	<1 uG/L	0kG
Chromium	<3 uG/L	0kG
Copper	4 uG/L	0kG
Nickel	<2 uG/L	0kG
Lead	<7 uG/L	0kG
Zinc	4 uG/L	0kG
Silver	<1 uG/L	0kG
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	2 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G
o,p'-DDT	2 nG/L	0 G
p,p'-DDT	2 nG/L	0 G
TOTAL DDT	7 nG/L	0 G
Aroclor 1242	6 nG/L	0 G
Aroclor 1254	16 nG/L	0 G
TOTAL PCB	22 nG/L	0 G
Hexachlorobenzene	<1 nG/L	0 G
Lindane	2 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<32 nG/L	0 G
C1-Naphthalenes	<32 nG/L	0 G
C2-Naphthalenes	<32 nG/L	0 G
C3-Naphthalenes	<67 nG/L	0 G
Biphenyl	<32 nG/L	0 G
Acenaphthylene	<32 nG/L	0 G
Acenaphthene	<67 nG/L	0 G
Fluorene	<31 nG/L	0 G
Phenanthrene	<31 nG/L	0 G
C1-Phenanthrenes	<31 nG/L	0 G
C2-Phenanthrenes	<31 nG/L	0 G
C3-Phenenthrenes	<31 nG/L	0 G
Anthracene	<31 nG/L	0 G
Fluoranthene	<25 nG/L	0 G
Pyrene	<25 nG/L	0 G
2,3-Benzofluorene	<73 nG/L	0 G
Benz(a)anthracene	<25 nG/L	0 G
Chrysene	<25 nG/L	0 G
Benzo(b)fluoranth	<21 nG/L	0 G
Benzo(k)fluoranth	<21 nG/L	0 G
Benzo(e)pyrene	<21 nG/L	0 G
Benzo(a)pyrene	<21 nG/L	0 G
Perylene	<21 nG/L	0 G
9,10-Diphenylanth	<21 nG/L	0 G
Dibenz(a,h)anthra	<18 nG/L	0 G
Benzo(g,h,i)peryl	<18 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	0 %	***
d10-Acenaphthene	0 %	***
d10-Phenanthrene	0 %	***
d12-Chrysene	2 %	***
d12-Perylene	8 %	***
Resolved HCs	3045 nG/L	0 G
n-alkanes c10-c39	2304 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River	Flow (M**3/Sec):	0.011
Location:	Big Tujunga Wash	Time Interval:	27:45-34:30
Date:	24 Sep 86	IntervalVol (M**3):	151
Time:	20:45	Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	7 mG/L	0 T	Naphthalene	41 nG/L	0 G
TVS	50 %	***	C1-Naphthalenes	41 nG/L	0 G
Total Solids	1260 mG/L	0 T	C2-Naphthalenes	41 nG/L	0 G
Dissolved Solids	1250 mG/L	0 T	C3-Naphthalenes	86 nG/L	0 G
Oil & Grease	<.1 mG/L	0 T	Biphenyl	41 nG/L	0 G
Chloroform Extr.	3.87 mG/L	0 T	Acenaphthylene	41 nG/L	0 G
Salinity	ppt	***	Acenaphthene	86 nG/L	0 G
pH		***	Fluorene	39 nG/L	0 G
			Phenanthrene	39 nG/L	0 G
Cadmium	<1 uG/L	0KG	C1-Phenanthrenes	39 nG/L	0 G
Chromium	<3 uG/L	0KG	C2-Phenanthrenes	39 nG/L	0 G
Copper	4 uG/L	0KG	C3-Phenenthrenes	39 nG/L	0 G
Nickel	2 uG/L	0KG	Anthracene	39 nG/L	0 G
Lead	<8 uG/L	0KG	Fluoranthene	31 nG/L	0 G
Zinc	2 uG/L	0KG	Pyrene	31 nG/L	0 G
Silver	<1 uG/L	0KG	2,3-Benzofluorene	93 nG/L	0 G
			Benz(a)anthracene	32 nG/L	0 G
o,p'-DDE	<1 nG/L	0 G	Chrysene	32 nG/L	0 G
p,p'-DDE	1 nG/L	0 G	Benzo(b)fluoranth	26 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	26 nG/L	0 G
p,p'-DDD	<1 nG/L	0 G	Benzo(e)pyrene	26 nG/L	0 G
o,p'-DDT	1 nG/L	0 G	Benzo(a)pyrene	26 nG/L	0 G
p,p'-DDT	2 nG/L	0 G	Perylene	27 nG/L	0 G
TOTAL DDT	3 nG/L	0 G	9,10-Diphenylanth	27 nG/L	0 G
			Dibenz(a,h)anthra	23 nG/L	0 G
Aroclor 1242	<2 nG/L	0 G	Benzo(g,h,i)peryl	23 nG/L	0 G
Aroclor 1254	2 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	2 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	0 %	***
Lindane	2 nG/L	0 G	d10-Acenaphthene	0 %	***
			d10-Phenanthrene	0 %	***
Toxicity	Notest	***	d12-Chrysene	0 %	***
			d12-Perylene	5 %	***
			Resolved HCs	4587 nG/L	0 G
			n-alkanes c10-c39	4270 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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VCL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Big Tujunga Wash
Date:	24 Sep 86
Time:	11:30

Flow (M**3/Sec):	0.011 m^3/s
Time Interval:	00:00-21:00
IntervalVol (M**3):	596
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	3 mG/L	0 T
TVS	%	***
Total Solids	398 mG/L	0 T
Dissolved Solids	395 mG/L	0 T
Oil & Grease	1.3 mG/L	0 T
Chloroform Extr.	.05 mG/L	0 T
Salinity	2 ppt	***
pH	5.5	***
Cadmium	<1 uG/L	0kG
Chromium	<2 uG/L	0kG
Copper	3 uG/L	0kG
Nickel	<2 uG/L	0kG
Lead	<6 uG/L	0kG
Zinc	3 uG/L	0kG
Silver	<1 uG/L	0kG
o,p'-DDE	1 nG/L	0 G
p,p'-DDE	4 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	1 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G
p,p'-DDT	<1 nG/L	0 G
TOTAL DDT	6 nG/L	0 G
Aroclor 1242	16 nG/L	0 G
Aroclor 1254	15 nG/L	0 G
TOTAL PCB	31 nG/L	0 G
Hexachlorobenzene	<1 nG/L	0 G
Lindane	4 nG/L	0 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<33 nG/L	0 G
C1-Naphthalenes	<33 nG/L	0 G
C2-Naphthalenes	<33 nG/L	0 G
C3-Naphthalenes	<68 nG/L	0 G
Biphenyl	<33 nG/L	0 G
Acenaphthylene	<33 nG/L	0 G
Acenaphthene	<68 nG/L	0 G
Fluorene	<31 nG/L	0 G
Phenanthrene	<31 nG/L	0 G
C1-Phenanthrenes	<31 nG/L	0 G
C2-Phenanthrenes	<31 nG/L	0 G
C3-Phenenthrenes	<31 nG/L	0 G
Anthracene	<31 nG/L	0 G
Fluoranthene	<25 nG/L	0 G
Pyrene	<25 nG/L	0 G
2,3-Benzofluorene	<74 nG/L	0 G
Benz(a)anthracene	<25 nG/L	0 G
Chrysene	<25 nG/L	0 G
Benzo(b)fluoranth	<21 nG/L	0 G
Benzo(k)fluoranth	<21 nG/L	0 G
Benzo(e)pyrene	<21 nG/L	0 G
Benzo(a)pyrene	<21 nG/L	0 G
Perylene	<21 nG/L	0 G
9,10-Diphenylanth	<21 nG/L	0 G
Dibenz(a,h)anthra	<18 nG/L	0 G
Benzo(g,h,i)peryl	<18 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	49 %	***
d10-Acenaphthene	92 %	***
d10-Phenanthrene	102 %	***
d12-Chrysene	115 %	***
d12-Perylene	116 %	***
Resolved HCs	7990 nG/L	0 G
n-alkanes c10-c39	6349 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

2 0882

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Big Tujunga Wash
Date:	24 Sep 86
Time:	14:45

Flow (M**3/Sec): 0.011
Time Interval: 21:00-24:15
IntervalVol (M**3): 92.4
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	4 mG/L	0 T	Naphthalene	<42 nG/L	0 G
TVS	16 %	***	C1-Naphthalenes	<42 nG/L	0 G
Total Solids	350 mG/L	0 T	C2-Naphthalenes	<42 nG/L	0 G
Dissolved Solids	346 mG/L	0 T	C3-Naphthalenes	<88 nG/L	0 G
Oil & Grease	.7 mG/L	0 T	Biphenyl	<42 nG/L	0 G
Chloroform Extr.	0 mG/L	0 T	Acenaphthylene	<42 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<88 nG/L	0 G
pH	6	***	Fluorene	<40 nG/L	0 G
			Phenanthrene	<40 nG/L	0 G
Cadmium	<1 uG/L	0kG	C1-Phenanthrenes	<40 nG/L	0 G
Chromium	<3 uG/L	0kG	C2-Phenanthrenes	<40 nG/L	0 G
Copper	3 uG/L	0kG	C3-Phenenthrenes	<40 nG/L	0 G
Nickel	<2 uG/L	0kG	Anthracene	<40 nG/L	0 G
Lead	<8 uG/L	0kG	Fluoranthene	<32 nG/L	0 G
Zinc	22 uG/L	0kG	Pyrene	<32 nG/L	0 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<95 nG/L	0 G
			Benz(a)anthracene	<33 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	<33 nG/L	0 G
p,p'-DDE	5 nG/L	0 G	Benzo(b)fluoranth	<27 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<27 nG/L	0 G
p,p'-DDD	4 nG/L	0 G	Benzo(e)pyrene	<27 nG/L	0 G
o,p'-DDT	<1 nG/L	0 G	Benzo(a)pyrene	<27 nG/L	0 G
p,p'-DDT	2 nG/L	0 G	Perylene	<27 nG/L	0 G
TOTAL DDT	12 nG/L	0 G	9,10-Diphenylanth	<27 nG/L	0 G
			Dibenz(a,h)anthra	<24 nG/L	0 G
Aroclor 1242	22 nG/L	0 G	Benzo(g,h,i)peryl	<24 nG/L	0 G
Aroclor 1254	19 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	41 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	<1 nG/L	0 G	d8-Naphthalene	54 %	***
Lindane	<1 nG/L	0 G	d10-Acenaphthene	96 %	***
			d10-Phenanthrene	91 %	***
Toxicity	Notest	***	d12-Chrysene	85 %	***
			d12-Perylene	89 %	***
			Resolved HCs	3474 nG/L	0 G
			n-alkanes c10-c39	3392 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	24 Sep 86
Time:	20:00

Flow (M**3/Sec): 58.3
Time Interval: 26:45-35:00
IntervalVol (M**3): 2.33x10⁶
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	257 mG/L	616.8 T
TVS	22 %	***
Total Solids	398 mG/L	955.2 T
Dissolved Solids	141 mG/L	338.4 T
Oil & Grease	3.8 mG/L	9.12 T
Chloroform Extr.	7.8 mG/L	18.72 T
Salinity	ppt	***
pH		***
Cadmium	1 uG/L	2.4kG
Chromium	12 uG/L	28.8kG
Copper	84 uG/L	201.6kG
Nickel	21 uG/L	50.4kG
Lead	80 uG/L	192kG
Zinc	302 uG/L	724.8kG
Silver	<1 uG/L	0kG
o,p'-DDE	18 nG/L	43.2 G
p,p'-DDE	23 nG/L	55.2 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	11 nG/L	26.4 G
o,p'-DDT	13 nG/L	31.2 G
p,p'-DDT	10 nG/L	24 G
TOTAL DDT	75 nG/L	180 G
Aroclor 1242	<2 nG/L	0 G
Aroclor 1254	93 nG/L	223.2 G
TOTAL PCB	93 nG/L	223.2 G
Hexachlorobenzene	2 nG/L	4.8 G
Lindane	38 nG/L	91.2 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<39 nG/L	0 G
C1-Naphthalenes	<39 nG/L	0 G
C2-Naphthalenes	<39 nG/L	0 G
C3-Naphthalenes	<81 nG/L	0 G
Biphenyl	<39 nG/L	0 G
Acenaphthylene	<39 nG/L	0 G
Acenaphthene	<81 nG/L	0 G
Fluorene	<37 nG/L	0 G
Phenanthrene	127 nG/L	304.8 G
C1-Phenanthrenes	<37 nG/L	0 G
C2-Phenanthrenes	<37 nG/L	0 G
C3-Phenenthrenes	<37 nG/L	0 G
Anthracene	<37 nG/L	0 G
Fluoranthene	265 nG/L	636 G
Pyrene	198 nG/L	475.2 G
2,3-Benzofluorene	<87 nG/L	0 G
Benz(a)anthracene	<30 nG/L	0 G
Chrysene	123 nG/L	295.2 G
Benzo(b)fluoranth	41 nG/L	98.4 G
Benzo(k)fluoranth	<25 nG/L	0 G
Benzo(e)pyrene	33 nG/L	79.2 G
Benzo(a)pyrene	<25 nG/L	0 G
Perylene	<25 nG/L	0 G
9,10-Diphenylanth	<25 nG/L	0 G
Dibenz(a,h)anthra	<22 nG/L	0 G
Benzo(g,h,i)peryl	<22 nG/L	0 G
TOTAL PAH	787 nG/L	1889. G
SURROGATE RECOV.		
d8-Naphthalene	73 %	***
d10-Acenaphthene	107 %	***
d10-Phenanthrene	105 %	***
d12-Chrysene	126 %	***
d12-Perylene	112 %	***
Resolved HCs	1.2e5 nG/L	3.0e5 G
n-alkanes c10-c39	58169 nG/L	1.4e5 G
Pristane	6210 nG/L	14904 G
Phytane	6272 nG/L	15053 G

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0884

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	25 Sep 86
Time:	10:00

Flow (M**3/Sec): 4.44
Time Interval: 35: – 600
IntervalVol (M**3): 5.47 x10^6
Storm #: 1

CONSTITUENT	CONC.	MASS
Suspended Solids	126 mG/L	89.96 T
TVS	29 %	***
otal Solids	313 mG/L	223.5 T
ssolved Solids	187 mG/L	133.5 T
Oil & Grease	1.2 mG/L	.8568 T
Chloroform Extr.	2.6 mG/L	1.856 T
alinity	ppt	***
pH		***
Cadmium	<1 uG/L	0kG
Chromium	4 uG/L	2.856kG
Copper	26 uG/L	18.56kG
Nickel	12 uG/L	8.568kG
Lead	24 uG/L	17.14kG
Zinc	116 uG/L	82.82kG
Silver	<1 uG/L	0kG
o,p'-DDE	4 nG/L	2.856 G
p,p'-DDE	8 nG/L	5.712 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	3 nG/L	2.142 G
o,p'-DDT	2 nG/L	1.428 G
p,p'-DDT	4 nG/L	2.856 G
TOTAL DDT	21 nG/L	14.99 G
Aroclor 1242	38 nG/L	27.13 G
Aroclor 1254	32 nG/L	22.85 G
TOTAL PCB	70 nG/L	49.98 G
Hexachlorobenzene	1 nG/L	.714 G
Lindane	21 nG/L	14.99 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<20 nG/L	0 G
C1-Naphthalenes	<20 nG/L	0 G
C2-Naphthalenes	<20 nG/L	0 G
C3-Naphthalenes	<42 nG/L	0 G
Biphenyl	<20 nG/L	0 G
Acenaphthylene	<20 nG/L	0 G
Acenaphthene	<42 nG/L	0 G
Fluorene	<19 nG/L	0 G
Phenanthrene	<19 nG/L	0 G
C1-Phenanthrenes	<19 nG/L	0 G
C2-Phenanthrenes	<19 nG/L	0 G
C3-Phenenthrenes	<19 nG/L	0 G
Anthracene	<19 nG/L	0 G
Fluoranthene	25 nG/L	17.85 G
Pyrene	<15 nG/L	0 G
2,3-Benzofluorene	<46 nG/L	0 G
Benz(a)anthracene	<16 nG/L	0 G
Chrysene	<16 nG/L	0 G
Benzo(b)fluoranth	<13 nG/L	0 G
Benzo(k)fluoranth	<13 nG/L	0 G
Benzo(e)pyrene	<13 nG/L	0 G
Benzo(a)pyrene	<13 nG/L	0 G
Perylene	<13 nG/L	0 G
9,10-Diphenylanth	<13 nG/L	0 G
Dibenz(a,h)anthra	<11 nG/L	0 G
Benzo(g,h,i)peryl	<11 nG/L	0 G
TOTAL PAH	25 nG/L	17.85 G
SURROGATE RECOV.		
d8-Naphthalene	16 %	***
d10-Acenaphthene	60 %	***
d10-Phenanthrene	94 %	***
d12-Chrysene	126 %	***
d12-Perylene	117 %	***
Resolved HCs	8963 nG/L	6400. G
n-alkanes c10-c39	10932 nG/L	7805. G
Pristane	1775 nG/L	1267. G
Phytane	1882 nG/L	1344. G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	24 Sep 86
Time:	15:30

Flow (M**3/Sec):	64.6
Time Interval:	2[illegible]:[illegible]-24:15
IntervalVol(M**3):	364 000
Storm #:	1

CONSTITUENT	CC.	MASS
Suspended Solids	553 mG/L	199.1 T
TVS	30 %	***
Total Solids	935 mG/L	336.6 T
Dissolved Solids	382 mG/L	137.5 T
Oil & Grease	7.5 mG/L	2.7 T
Chloroform Extr.	18.7 mG/L	6.732 T
Salinity	0 ppt	***
pH	5.5	***
Cadmium	7 uG/L	2.52kG
Chromium	34 uG/L	12.24kG
Copper	179 uG/L	64.44kG
Nickel	56 uG/L	20.16kG
Lead	248 uG/L	89.28kG
Zinc	733 uG/L	263.9kG
Silver	<1 uG/L	0kG
o,p'-DDE	23 nG/L	8.28 G
p,p'-DDE	24 nG/L	8.64 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	10 nG/L	3.6 G
o,p'-DDT	23 nG/L	8.28 G
p,p'-DDT	10 nG/L	3.6 G
TOTAL DDT	90 nG/L	32.4 G
Aroclor 1242	108 nG/L	38.88 G
Aroclor 1254	190 nG/L	68.4 G
TOTAL PCB	298 nG/L	107.3 G
Hexachlorobenzene	3 nG/L	1.08 G
Lindane	23 nG/L	8.28 G
Toxicity	Notest	***

CONSTITUENT	CONC.	MASS
Naphthalene	91 nG/L	32.76 G
C1-Naphthalenes	142 nG/L	51.12 G
C2-Naphthalenes	213 nG/L	76.68 G
C3-Naphthalenes	778 nG/L	280.1 G
Biphenyl	<14 nG/L	0 G
Acenaphthylene	<14 nG/L	0 G
Acenaphthene	<29 nG/L	0 G
Fluorene	23 nG/L	8.28 G
Phenanthrene	681 nG/L	245.2 G
C1-Phenanthrenes	744 nG/L	267.8 G
C2-Phenanthrenes	941 nG/L	338.8 G
C3-Phenenthrenes	574 nG/L	206.6 G
Anthracene	<13 nG/L	0 G
Fluoranthene	678 nG/L	244.1 G
Pyrene	710 nG/L	255.6 G
2,3-Benzofluorene	224 nG/L	80.64 G
Benz(a)anthracene	160 nG/L	57.6 G
Chrysene	432 nG/L	155.5 G
Benzo(b)fluoranth	467 nG/L	168.1 G
Benzo(k)fluoranth	<9 nG/L	0 G
Benzo(e)pyrene	260 nG/L	93.6 G
Benzo(a)pyrene	143 nG/L	51.48 G
Perylene	<9 nG/L	0 G
9,10-Diphenylanth	<9 nG/L	0 G
Dibenz(a,h)anthra	<8 nG/L	0 G
Benzo(g,h,i)peryl	292 nG/L	105.1 G
TOTAL PAH	7553 nG/L	2719. G
SURROGATE RECOV.		
d8-Naphthalene	72 %	***
d10-Acenaphthene	124 %	***
d10-Phenanthrene	129 %	***
d12-Chrysene	115 %	***
d12-Perylene	89 %	***
Resolved HCs	2.6e5 nG/L	95325 G
n-alkanes c10-c39	1.3e5 nG/L	46450 G
Pristane	10979 nG/L	3952. G
Phytane	14529 nG/L	5230. G

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VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Los Angeles River
Location: Fletcher avenue
Date: 24 Sep 86
Time: 17:00

Flow (M**3/Sec): 76.5
Time Interval: 24:?? -26:30
Interval Vol (M**3): 619,000
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	1190 mG/L	761.6 T	Naphthalene	152 nG/L	97.28 G
TVS	22 %	***	C1-Naphthalenes	413 nG/L	264.3 G
Total Solids	823 mG/L	526.7 T	C2-Naphthalenes	375 nG/L	240 G
Dissolved Solids	-367 mG/L	-235. T	C3-Naphthalenes	1956 nG/L	1252. G
Oil & Grease	10.9 mG/L	6.976 T	Biphenyl	<37 nG/L	0 G
Chloroform Extr.	29 mG/L	18.56 T	Acenaphthylene	<37 nG/L	0 G
Salinity	0 ppt	***	Acenaphthene	<78 nG/L	0 G
pH	5.5	***	Fluorene	<35 nG/L	0 G
			Phenanthrene	1259 nG/L	805.8 G
Cadmium	9 uG/L	5.76kG	C1-Phenanthrenes	1703 nG/L	1090. G
Chromium	46 uG/L	29.44kG	C2-Phenanthrenes	1528 nG/L	977.9 G
Copper	667 uG/L	426.9kG	C3-Phenenthrenes	1189 nG/L	761.0 G
Nickel	67 uG/L	42.88kG	Anthracene	<36 nG/L	0 G
Lead	347 uG/L	222.1kG	Fluoranthene	1720 nG/L	1101. G
Zinc	1365 uG/L	873.6kG	Pyrene	1727 nG/L	1105. G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	304 nG/L	194.6 G
			Benz(a)anthracene	572 nG/L	366.1 G
o,p'-DDE	60 nG/L	38.4 G	Chrysene	1316 nG/L	842.2 G
p,p'-DDE	78 nG/L	49.92 G	Benzo(b)fluoranth	1513 nG/L	968.3 G
o,p'-DDD	<1 nG/L	0 G	Benzo(k)fluoranth	<24 nG/L	0 G
p,p'-DDD	33 nG/L	21.12 G	Benzo(e)pyrene	810 nG/L	518.4 G
o,p'-DDT	59 nG/L	37.76 G	Benzo(a)pyrene	458 nG/L	293.1 G
p,p'-DDT	19 nG/L	12.16 G	Perylene	78 nG/L	49.92 G
TOTAL DDT	249 nG/L	159.4 G	9,10-Diphenylanth	<24 nG/L	0 G
			Dibenz(a,h)anthra	87 nG/L	55.68 G
Aroclor 1242	<2 nG/L	0 G	Benzo(g,h,i)peryl	1108 nG/L	709.1 G
Aroclor 1254	352 nG/L	225.3 G	TOTAL PAH	18268 nG/L	11692 G
TOTAL PCB	352 nG/L	225.3 G			
			SURROGATE RECOV.		
Hexachlorobenzene	9 nG/L	5.76 G	d8-Naphthalene	79 %	***
Lindane	29 nG/L	18.56 G	d10-Acenaphthene	109 %	***
			d10-Phenanthrene	130 %	***
Toxicity	Notest	***	d12-Chrysene	142 %	***
			d12-Perylene	135 %	***
			Resolved HCs	5.7e5 nG/L	3.6e5 G
			n-alkanes c10-c39	2.8e5 nG/L	1.8e5 G
			Pristane	24090 nG/L	15418 G
			Phytane	32347 nG/L	20702 G

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY

2 0887

VOL 12

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	24 Sep 86
Time:	11:50

Flow (M**3/Sec):	13.4
Time Interval:	1[illegible]:00-20:45
IntervalVol(M**3):	1.08 x10^6
Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	469 mG/L	52.06 T
TVS	31 %	***
Total Solids	796 mG/L	88.36 T
Dissolved Solids	327 mG/L	36.30 T
Oil & Grease	7.1 mG/L	.7881 T
Chloroform Extr.	0 mG/L	0 T
Salinity	2 ppt	***
pH	5.5	***
Cadmium	10 uG/L	1.11kG
Chromium	55 uG/L	6.105kG
Copper	213 uG/L	23.64kG
Nickel	46 uG/L	5.106kG
Lead	165 uG/L	18.32kG
Zinc	791 uG/L	87.80kG
Silver	<1 uG/L	0kG
o,p'-DDE	22 nG/L	2.442 G
p,p'-DDE	26 nG/L	2.886 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	8 nG/L	.888 G
o,p'-DDT	13 nG/L	1.443 G
p,p'-DDT	14 nG/L	1.554 G
TOTAL DDT	83 nG/L	9.213 G
Aroclor 1242	74 nG/L	8.214 G
Aroclor 1254	188 nG/L	[illegible].67 G
TOTAL PCB	262 nG/L	29.08 G
Hexachlorobenzene	7 nG/L	.777 G
Lindane	15 nG/L	1.665 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	175 nG/L	19.43 G
C1-Naphthalenes	80 nG/L	8.88 G
C2-Naphthalenes	<29 nG/L	0 G
C3-Naphthalenes	<60 nG/L	0 G
Biphenyl	<29 nG/L	0 G
Acenaphthylene	<29 nG/L	0 G
Acenaphthene	<60 nG/L	0 G
Fluorene	<27 nG/L	0 G
Phenanthrene	323 nG/L	35.85 G
C1-Phenanthrenes	205 nG/L	22.76 G
C2-Phenanthrenes	237 nG/L	26.31 G
C3-Phenenthrenes	102 nG/L	11.32 G
Anthracene	<27 nG/L	0 G
Fluoranthene	502 nG/L	55.72 G
Pyrene	542 nG/L	60.16 G
2,3-Benzofluorene	<65 nG/L	0 G
Benz(a)anthracene	237 nG/L	26.31 G
Chrysene	470 nG/L	52.17 G
Benzo(b)fluoranth	309 nG/L	34.30 G
Benzo(k)fluoranth	119 nG/L	13.21 G
Benzo(e)pyrene	237 nG/L	26.31 G
Benzo(a)pyrene	143 nG/L	15.87 G
Perylene	<19 nG/L	0 G
9,10-Diphenylanth	<19 nG/L	0 G
Dibenz(a,h)anthra	<16 nG/L	0 G
Benzo(g,h,i)peryl	186 nG/L	20.65 G
TOTAL PAH	3867 nG/L	429.2 G
SURROGATE RECOV.		
d8-Naphthalene	75 %	***
d10-Acenaphthene	[illegible] %	***
d10-Phenanthrene	112 %	***
d12-Chrysene	[illegible] %	***
d12-Perylene	112 %	***
Resolved HCs	65179 nG/L	7235. G
n-alkanes c10-c39	21524 nG/L	2389. G
Pristane	1313 nG/L	145.7 G
Phytane	1985 nG/L	220.3 G

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Los Angeles River
Location:	Fletcher Avenue
Date:	24 Sep 86
Time:	14:00

Flow (M**3/Sec):	22.8
Time Interval:	21:00-22:45
IntervalVol (M**3):	1[illegible],000
Storm #:	1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	193 mG/L	33.97 T	Naphthalene	76 nG/L	13.38 G
TVS	24 %	***	C1-Naphthalenes	<23 nG/L	0 G
Total Solids	536 mG/L	94.34 T	C2-Naphthalenes	<23 nG/L	0 G
Dissolved Solids	343 mG/L	60.37 T	C3-Naphthalenes	<47 nG/L	0 G
Oil & Grease	5.7 mG/L	1.003 T	Biphenyl	<23 nG/L	0 G
Chloroform Extr.	Lost mG/L	0 T	Acenaphthylene	<23 nG/L	0 G
Salinity	ppt	***	Acenaphthene	<47 nG/L	0 G
pH		***	Fluorene	<21 nG/L	0 G
			Phenanthrene	123 nG/L	21.65 G
Cadmium	5 uG/L	.88kG	C1-Phenanthrenes	<21 nG/L	0 G
Chromium	18 uG/L	3.168kG	C2-Phenanthrenes	<21 nG/L	0 G
Copper	146 uG/L	25.70kG	C3-Phenenthrenes	<21 nG/L	0 G
Nickel	49 uG/L	8.624kG	Anthracene	<22 nG/L	0 G
Lead	144 uG/L	25.34kG	Fluoranthene	161 nG/L	28.34 G
Zinc	1358 uG/L	239.0kG	Pyrene	162 nG/L	28.51 G
Silver	<1 uG/L	0kG	2,3-Benzofluorene	<51 nG/L	0 G
			Benz(a)anthracene	44 nG/L	7.744 G
o,p'-DDE	Lost nG/L	0 G	Chrysene	200 nG/L	35.2 G
p,p'-DDE	Lost nG/L	0 G	Benzo(b)fluoranth	44 nG/L	7.744 G
o,p'-DDD	Lost nG/L	0 G	Benzo(k)fluoranth	<14 nG/L	0 G
p,p'-DDD	Lost nG/L	0 G	Benzo(e)pyrene	34 nG/L	5.984 G
o,p'-DDT	Lost nG/L	0 G	Benzo(a)pyrene	<14 nG/L	0 G
p,p'-DDT	Lost nG/L	0 G	Perylene	<15 nG/L	0 G
TOTAL DDT	Lost nG/L	0 G	9,10-Diphenylanth	<15 nG/L	0 G
			Dibenz(a,h)anthra	<13 nG/L	0 G
Aroclor 1242	Lost nG/L	0 G	Benzo(g,h,i)peryl	<13 nG/L	0 G
Aroclor 1254	Lost nG/L	0 G	TOTAL PAH	844 nG/L	148.5 G
TOTAL PCB	Lost nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	Lost nG/L	0 G	d8-Naphthalene	73 %	***
Lindane	Lost nG/L	0 G	d10-Acenaphthene	103 %	***
			d10-Phenanthrene	108 %	***
Toxicity	NoTest	***	d12-Chrysene	99 %	***
			d12-Perylene	83 %	***
			Resolved HCs	98906 nG/L	17407 G
			n-alkanes c10-c39	41550 nG/L	7313. G
			Pristane	3552 nG/L	625.2 G
			Phytane	4099 nG/L	721.4 G

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TABLES

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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel:	Revlon Slough	Flow (M**3/Sec):	
Location:	Highway 1	Time Interval:	[illegible]
Date:	25 Sep 86	IntervalVol (M**3):	
Time:	13:40	Storm #:	1

CONSTITUENT	CONC.	MASS
Suspended Solids	58 mG/L	0 T
TVS	52 %	***
Total Solids	[illegible] mG/L	0 T
Dissolved Solids	1270 mG/L	0 T
Oil & Grease	1.2 mG/L	0 T
Chloroform Extr.	1.2 mG/L	0 T
Salinity	ppt	***
pH		***
Cadmium	<1 uG/L	0 G
Chromium	4 uG/L	0 G
Copper	4 uG/L	0 G
Nickel	6 uG/L	0 G
Lead	<8 uG/L	0 G
Zinc	12 uG/L	0 G
Silver	<1 uG/L	0 G
o,p'-DDE	2 nG/L	0 G
p,p'-DDE	11 nG/L	0 G
o,p'-DDD	<1 nG/L	0 G
p,p'-DDD	6 nG/L	0 G
o,p'-DDT	1 nG/L	0 G
p,p'-DDT	1 nG/L	0 G
TOTAL DDT	21 nG/L	0 G
Aroclor 1242	9 nG/L	0 G
Aroclor 1254	35 nG/L	0 G
TOTAL PCB	44 nG/L	0 G
Hexachlorobenzene	1 nG/L	0 G
Lindane	1 nG/L	0 G
Toxicity	NoTest	***

CONSTITUENT	CONC.	MASS
Naphthalene	<5 nG/L	0 G
C1-Naphthalenes	<9 nG/L	0 G
C2-Naphthalenes	<9 nG/L	0 G
C3-Naphthalenes	15 nG/L	0 G
Biphenyl	<5 nG/L	0 G
Acenaphthylene	<5 nG/L	0 G
Acenaphthene	15 nG/L	0 G
Fluorene	9 nG/L	0 G
Phenanthrene	<9 nG/L	0 G
C1-Phenanthrenes	<5 nG/L	0 G
C2-Phenanthrenes	<9 nG/L	0 G
C3-Phenanthrenes	<9 nG/L	0 G
Anthracene	<5 nG/L	0 G
Fluoranthene	<7 nG/L	0 G
Pyrene	<7 nG/L	0 G
2,3-Benzofluorene	<21 nG/L	0 G
Benz(a)anthracene	<7 nG/L	0 G
Chrysene	<7 nG/L	0 G
Benzo(b)fluoranth	<6 nG/L	0 G
Benzo(k)fluoranth	<6 nG/L	0 G
Benzo(e)pyrene	<6 nG/L	0 G
Benzo(a)pyrene	<6 nG/L	0 G
Perylene	<6 nG/L	0 G
9,10-Diphenylanth	<6 nG/L	0 G
Dibenz(a,h)anthra	<5 nG/L	0 G
Benzo(g,h,i)peryl	<5 nG/L	0 G
TOTAL PAH	0 nG/L	0 G
SURROGATE RECOV.		
d8-Naphthalene	[illegible] %	***
d10-Acenaphthene	84 %	***
d10-Phenanthrene	100 %	***
d12-Chrysene	123 %	***
d12-Perylene	121 %	***
Resolved HCs	0 nG/L	0 G
n-alkanes c10-c39	0 nG/L	0 G
Pristane	0 nG/L	0 G
Phytane	0 nG/L	0 G

ASH WF

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
LOS ANGELES/VENTURA RUNOFF SURVEY
SAMPLE DATA SHEET

Channel: Revlon Slough
Location: Highway 1
Date: 24 Sep 86
Time: 15:25

Flow (M**3/Sec):
Time Interval: 00:00-24:00
IntervalVol (M**3):
Storm #: 1

CONSTITUENT	CONC.	MASS	CONSTITUENT	CONC.	MASS
Suspended Solids	2 mG/L	0 T	Naphthalene	21 nG/L	0 G
TVS	100 %	***	C1-Naphthalenes	21 nG/L	0 G
Total Solids	3840 mG/L	0 T	C2-Naphthalenes	21 nG/L	0 G
Dissolved Solids	3840 mG/L	0 T	C3-Naphthalenes	45 nG/L	0 G
Oil & Grease	.3 mG/L	0 T	Biphenyl	21 nG/L	0 G
Chloroform Extr.	2.3 mG/L	0 T	Acenaphthylene	21 nG/L	0 G
Salinity	3 ppt	***	Acenaphthene	45 nG/L	0 G
pH	6	***	Fluorene	20 nG/L	0 G
			Phenanthrene	20 nG/L	0 G
Cadmium	N/A uG/L	N/A G	C1-Phenanthrenes	20 nG/L	0 G
Chromium	N/A uG/L	N/A G	C2-Phenanthrenes	20 nG/L	0 G
Copper	N/A uG/L	N/A G	C3-Phenanthrenes	20 nG/L	0 G
Nickel	N/A uG/L	N/A G	Anthracene	21 nG/L	0 G
Lead	N/A uG/L	N/A G	Fluoranthene	16 nG/L	0 G
Zinc	N/A uG/L	N/A G	Pyrene	16 nG/L	0 G
Silver	N/A uG/L	N/A G	2,3-Benzofluorene	48 nG/L	0 G
			Benz(a)anthracene	17 nG/L	0 G
o,p'-DDE	1 nG/L	0 G	Chrysene	17 nG/L	0 G
p,p'-DDE	2 nG/L	0 G	Benzo(b)fluoranth	14 nG/L	0 G
o,p'-DDD	1 nG/L	0 G	Benzo([illegible])fluoranth	14 nG/L	0 G
p,p'-DDD	4 nG/L	0 G	Benzo(e)pyrene	14 nG/L	0 G
o,p'-DDT	1 nG/L	0 G	Benzo(a)pyrene	14 nG/L	0 G
p,p'-DDT	1 nG/L	0 G	Perylene	14 nG/L	0 G
TOTAL DDT	[illegible] nG/L	0 G	9,10-Diphenylanth	14 nG/L	0 G
			Dibenz(a,h)anthra	12 nG/L	0 G
Aroclor 1242	1 nG/L	0 G	Benzo(g,h,i)peryl	12 nG/L	0 G
Aroclor 1254	21 nG/L	0 G	TOTAL PAH	0 nG/L	0 G
TOTAL PCB	21 nG/L	0 G			
			SURROGATE RECOV.		
Hexachlorobenzene	1 nG/L	0 G	d8-Naphthalene	72 %	***
Lindane	3 nG/L	0 G	d10-Acenaphthene	93 %	***
			d10-Phenanthrene	100 %	***
Toxicity	NoTest	***	d12-Chrysene	137 %	***
			d12-Perylene	148 %	***
			Resolved HCs	0 nG/L	0 G
			n-alkanes c10-c30	1667 nG/L	0 G
			Pristane	0 nG/L	0 G
			Phytane	0 nG/L	0 G

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Table 1. Rainfall total for selected stations during the storm of September 24, 1986.

Station	Rain in Centimeters
1. La Mirada- Standard Oil	2.9
2. Signal Hill	2.9
3. San Pedro - City Reservoir	2.9
4. Inglewood Fire Station	4.8
5. Baldwin Park Station	2.9*
6. Cloudcroft Debris Station	5.7
7. Encino Reservoir	1.9
8. Chatsworth- Twin Lakes	2.0
9. La Tuna Canyon	2.2*
10. Big Tujuga Canyon	---
11. Big Tujunga Dam	3.3
12. Brand Park	3.3
13. Los Angeles, Alcazar	3.6
14. Rio Hondo Spreading Grounds	3.7*
15. San Gabriel Canyon	7.3*
16. La Fresa	3.7
17. Crystal Lake	5.1

All data are from the Los Angeles Department of Public Works.
* measurable rain fell the following day.

Table 4. Mass emission rates (Metric Tons) for several runoff constituents in the 23-25 September, 1986 storm.

STATION	LA RIVER WILLOW	LA RIVER FLETCHER	LA RIVER TUJUNGA	BALLONA CREEK	SANTA CLARA	CALLEGUAS CREEK	SAN GABRIEL	HYPERION 5-MILE	OXNARD PLANT
Total Volume ($L \times 10^9$)	11	7.7	0.0014	4.5	0.016	0.32	3.5	1.47	0.070
Sus. Solids	7100	1900	0.32	3400	20	9.7	720	238	2.3
Total Solids	10000	3200	0.67	6900	39	460	8400	*	*
Oil & Grease	110	20	0.0009	67	0.045	0.74	17	43	0.030
TEOs	380	44	0.0018	120	0.080	0.44	13	*	*
Cadmium	.064	.013	ND	0.030	ND	ND	0.0082	0.016	0.0009
Chromium	0.50	0.088	ND	0.31	0.0009	0.0005	0.11	0.088	0.0008
Copper	2.0	0.74	ND	1.2	0.0011	0.0058	0.30	0.29	0.004
Nickel	0.52	0.16	ND	0.36	0.0003	0.0022	0.12	0.12	0.004
Lead	2.9	0.55	ND	2.4	0.0014	ND	0.42	0.13	0.002
Zinc	7.9	2.3	ND	6.4	0.0038	0.0031	1.6	0.41	0.005
Total DDTs (kG)	0.93	0.35	ND	1.7	0.015	0.002	0.056	0.030	*
Total PCBs (kG)	3.2	0.83	ND	1.2	0.0026	0.0045	0.20	0.15	<0.07
HCB (kG)	0.044	0.015	ND	0.015	ND	0.0001	0.0060	*	*
Lindane (kG)	0.18	0.16	ND	0.086	0.0004	0.0008	0.022	*	*
Total PAHs (kG)	400	15	ND	110	0.018	0.0056	4.0	*	*
n-Alkanes (kG)	6300	320	0.0057	1100	0.41	0.0040	100	*	*

Daily emissions based on 1985 monitoring data ble 5. Flow weighted mean concentrations of trace metals and chlorinate drocarbons in Los Angeles River storm runoff.

Constituent	1971/72		1979/80			1986/87
	Storm 1	Storm 2	Storm 1	Storm 2	Storm 3	Storm 1
(ug/liter)						
Silver	1.9	2.6	1.3	0.7	0.4	--
Cadmium	16	9.3	1.6	8.7	1.8	5.8
Chromium	86	80	140	120	52	45.4
Copper	120	140	110	110	44	182
Mercury	-	-	1.8	0.4	0.2	-
Nickel	83	72	73	77	34	47.3
Lead	910	980	74	210	180	164
Zinc	940	1100	760	450	230	718
Iron mg/l	10	25	68	57	28	-
Maganese	450	500	640	860	450	-
DDT	-	0.93 -	0.51	0.38	0.10	0.08
PCB	-	2.6 -	0.35	0.47	0.12	0.29
Volume 10^9 liters	1.4	7.2	2.8	21.8	14.5	11
Sus Solids mg/l	-	-	2700	1900	1500	645

rom Young, et al (25)

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Table 2. Flow proportioned average concentrations and ranges of actual concentrations for storm runoff samples collected from the 23-25 September storm.

CONSTITUENT	STATION LA RIVER WILLOW	LA RIVER FLETCHER	LA RIVER TUJUNGA	BALLONA CREEK	SANTA CLARA	CALLEGUAS CREEK	SAN GABRIEL	DOMINGUEZ CHANNEL	HYPERION 5-MILE [1]	OXNARD PLANT [1]
	10	8	5	6	3	3	8	4	1985 AVE	1985 AV
Flow(CF/S)	•	•	•	•	•	•	•	•	•	•
Min	95	157	•	19	•	2	75	•	•	•
Max	8400	2200	•	4960	•	85	4300	•	•	•
SS(mG/L)	645	246	229	755	1250	30	206	206	•	•
Min	31	17	3	13	16	3	5	11	•	•
Max	1850	1190	826	2500	1920	85	1000	76	•	•
% Vol. Solids	•	•	•	•	•	•	•	•	•	•
Min	5.4	21.6	9.0	15.0	8.4	27.6	6.5	27.6	•	•
Max	68.6	30.6	50.0	46.2	87.5	60.0	100	54.5	•	•
O & G(mG/L)	10.0	2.6	0.6	14.9	2.8	2.3	4.9	•	29.3	4.3
Min	0.7	1.2	<0.1	2.2	1.0	0.2	0.2	0.2	•	•
Max	21.8	10.9	1.3	36.4	6.8	1.7	7.8	2.9	•	•
TEOs(mG/L)	34.5	5.7	1.3	26.7	5.0	1.4	3.7	•	•	•
Min	1.4	1.6	<0.1	1.6	1.1	0.4	0.4	0.7	•	•
Max	103	29.0	3.9	59.6	7.5	1.6	11.9	5.1	•	•
Cadmium(G/L)	5.8	1.7	•	6.7	•	•	2.3	•	10.9	12.8
Min	<1	<1	<1	<1	<1	<1	<1	•	•	•
Max	21	28	•	22	1	•	4	•	•	•
Chromium(G/L)	45.4	11.4	•	67	56.2	1.6	31.4	•	59.9	11.4
Min	<3	<2	<2	<3	<2	<3	6	•	•	•
Max	147	107	8	248	80	5	68	•	•	•
Copper(G/L)	182	96.1	•	267	68.7	18.1	85.7	•	197	57
Min	12	26	3	43	<2	3	17	•	•	•
Max	512	667	28	860	106	46		•	•	•
Nickel(G/L)	47.3	20.8	•	80.0	18.8	6.3	34.3	•	81.6	57.0
Min	13	12	<2	7	4	3	13	•	•	•
Max	131	92	5	261	48	12	61	•	•	•
Lead(G/L)	264	71.4	•	530	87.5	•	120	•	88.4	285
Min	<8	24	<6	23	8	<9	23	•	•	•
Max	607	345	•	1830	134	•	201	•	•	•
Zinc(G/L)	718	299	•	1420	238	10	457	•	279	71
Min	21	116	2	172	7	6	80	•	•	•
Max	1970	1360	47	4400	391	14	744	•	•	•
DDTs(nG/L)	84.5	45.5	•	378	938	6.2	16.0	•	20.4	•
Min	<1	21	3	1	8	1	<1	<1	•	•
Max	169	249	12	1360	1570	10	'5	9	•	•
PCBs(nG/L)	291	108	•	267	162	14	57	•	102	<1000
Min	11	58	2	18	12	11	<1	15	•	•
Max	695	352	41	632	250	19	75	34	•	•
PAHs(G/L)	36.4	1.9	•	24.4	1.1	0.02	1.1	•	•	•
Min	<0.01	<0.01	<0.02	0.4	<0.01	<0.01	<0.01	•	•	•
Max	120	18	•	76	1.9	0.14	0.5	•	•	•
Alkanes(G/L)	572	41.5	4.1	244	5.9	0.01	28.6	•	•	•
Min	0.8	8.0	1.4	8.9	<0.01	<0.01	0.9	<0.01	•	•
Max	1000	200	6.4	440	51.5	•	42.5	240	•	•

1 Based on 1985 monitoring data

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Table 3. Calculated concentrations of contaminants per dry gram of suspended solids using the flow-weighted mean data from Table 2

CONSTITUENT	LA RIVER WILLOW	LA RIVER FLETCHER	LA RIVER TUJUNGA	BALLONA CREEK	SANTA CLARA	CALLEGUAS CREEK	SAN GABRIEL	HYPERION 5-Mile *	OXNARD PLANT *
Total Solids (mG/G)	1410	1680	2090	2030	1950	47400	11670	•	•
Oil & Grease (mG/G)	15.5	10.5	2.8	19.7	2.2	76.3	23.6	181	130
TEOs (mG/G)	53.5	23.2	5.6	35.3	4.0	45.4	18.0	•	•
Cadmium (mG/G)	.009	.007	•	.009	0	0	.011	.067	.391
Chromium (mG/G)	.070	.046	•	.003	.045	.052	.153	.370	.348
Copper (mG/G)	.282	.389	•	.353	.055	.598	.417	1.22	1.74
Nickel (mG/G)	.073	.084	•	.106	.015	.227	.167	.504	1.74
Lead (mG/G)	.408	.289	•	.706	.070	0	.583	.546	.870
Zinc (mG/G)	1.11	1.21	•	1.88	.19	.32	2.22	1.72	2.17
Total DDTs (uG/G)	.131	.184	•	.500	.750	.206	.078	.126	•
Total PCBs (uG/G)	.451	.437	•	.353	.130	.464	.278	.630	•
HCB (uG/G)	.006	.008	•	.004	0	.010	.008	•	•
Lindane (uG/G)	.025	.084	•	.025	.020	.082	.031	•	•
Total PAHs (uG/G)	56.3	7.9	•	32.3	.9	.6	5.6	•	•
n-Alkanes (uG/G)	887	168	18	324	20	<1	139	•	•

* Daily emissions based on 1985 monitoring data

FIGURES

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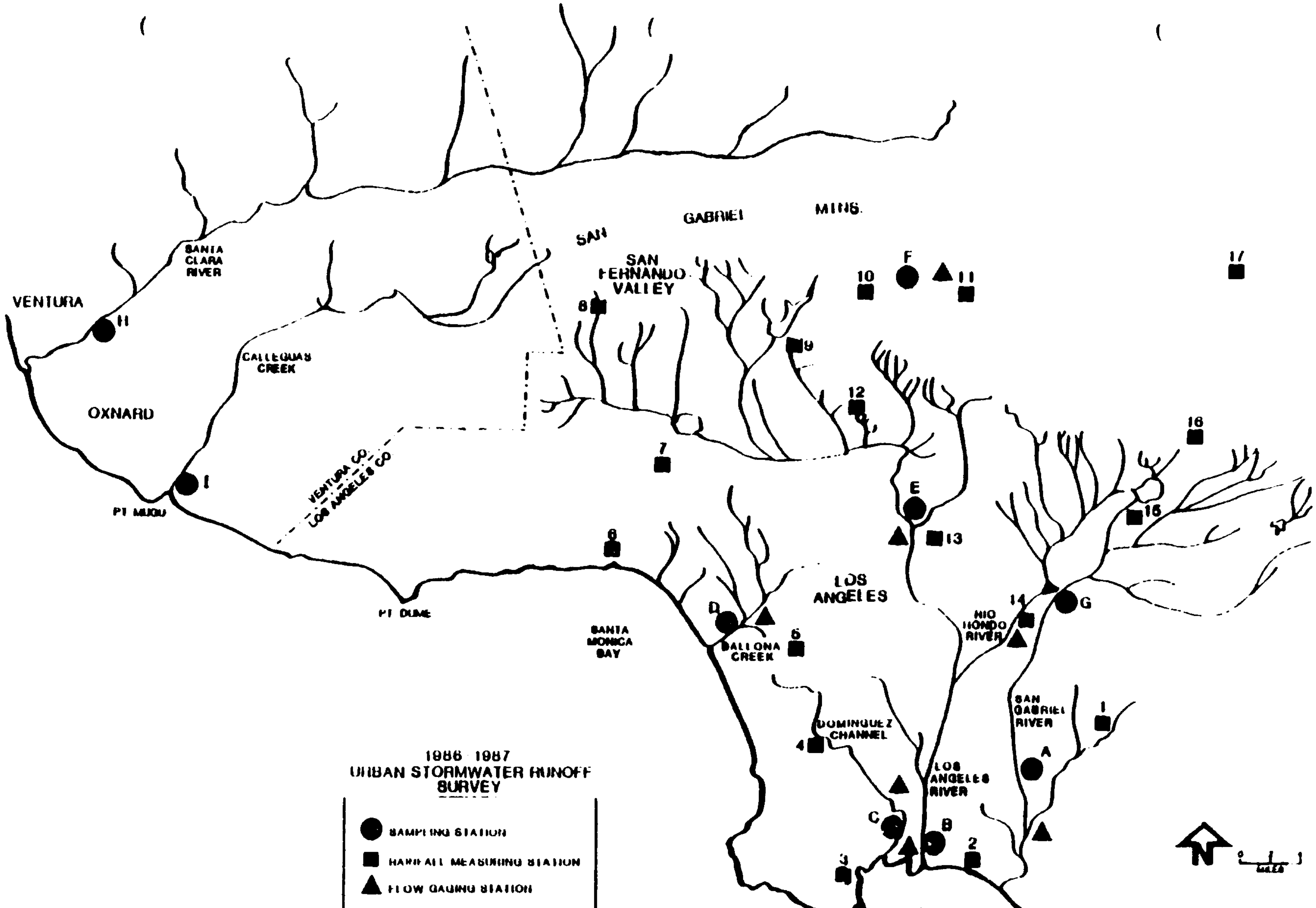

Figure 3. 1986/87 runoff study station locations

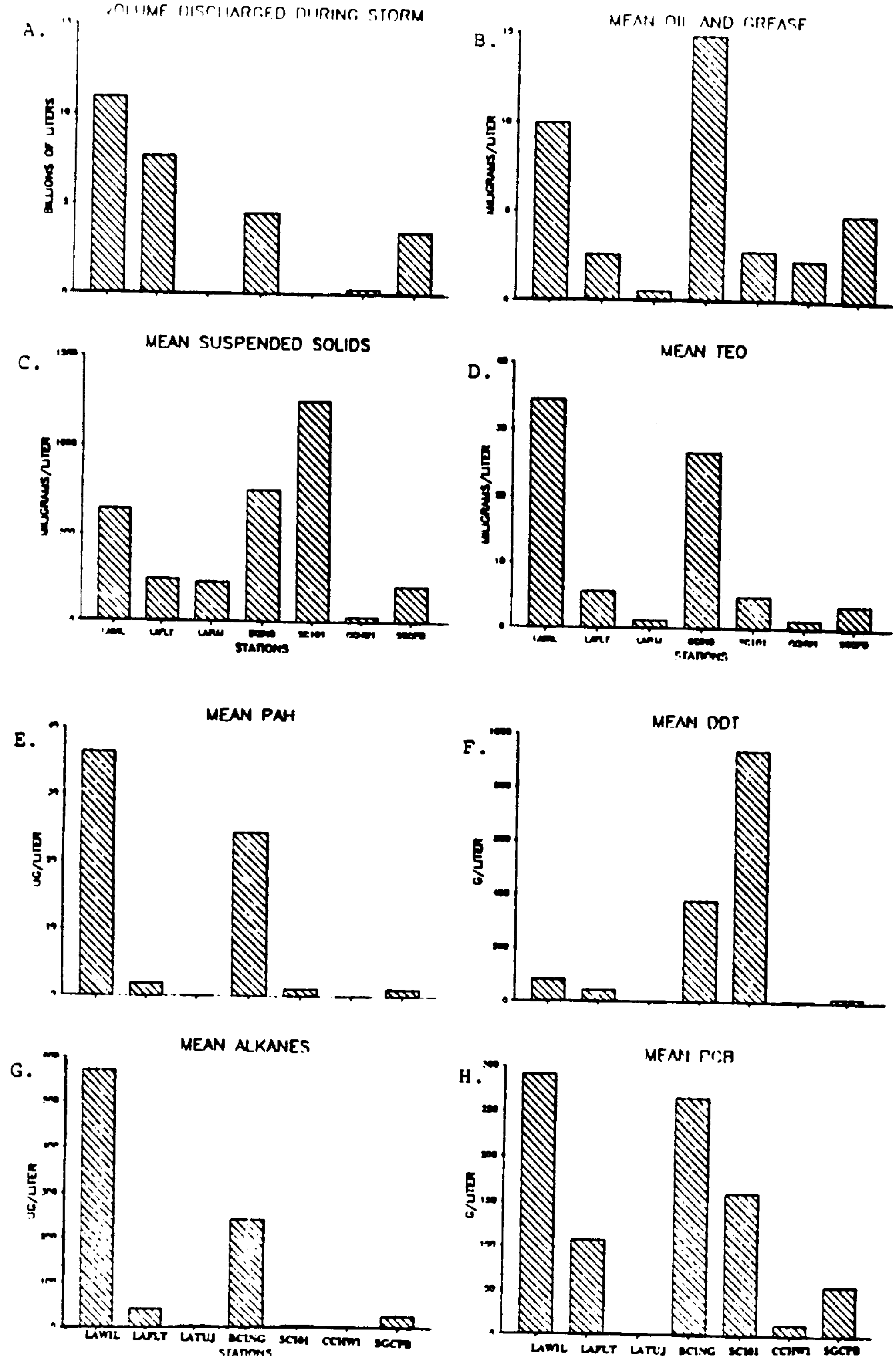

Figure 4. a-n Flow weighted mean concentrations of contaminants at the LA River at Willow (LAWIL), FLETCHER (LAFLT), TUNJUNGA Wash (LATUJ), Ballona Creek (BCING),Santa Clara River (SC101),Calleguas Creek (CCHW1) and the San Gabriel River (SGCPB).

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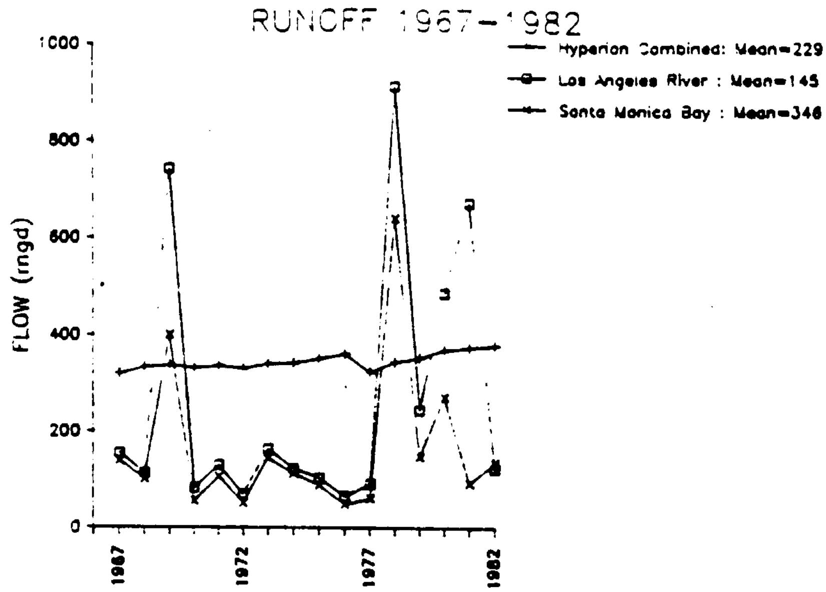

Figure 1. Annual flows from the Los Angeles River, storm channels around Santa Monica Bay (assumes ungaged flows are equal to 40% of gaged flows) and the combined Hyperion outfalls (from Garber (12)).

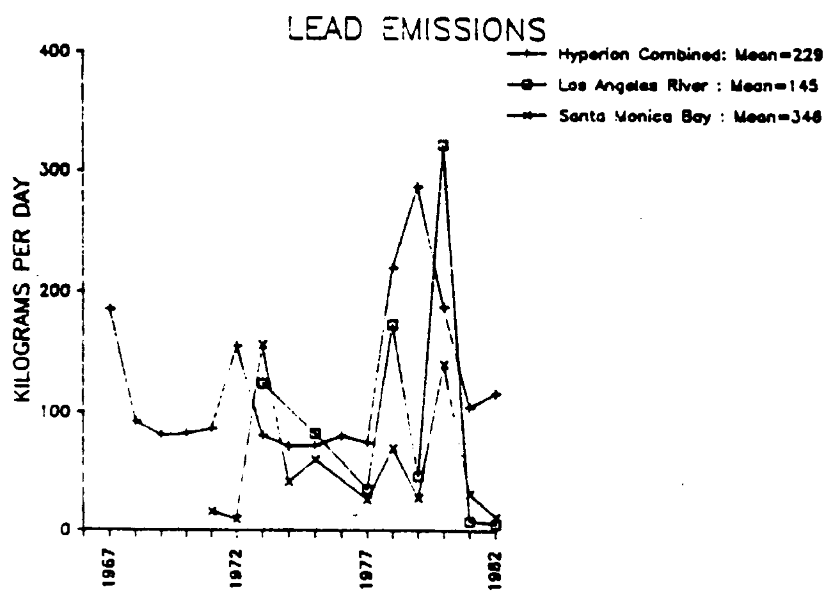

Figure 2. Average daily emissions of lead from the Los Angeles River, storm drains around Santa Monica Bay and combined Hyperion outfalls (from Garber (12)).

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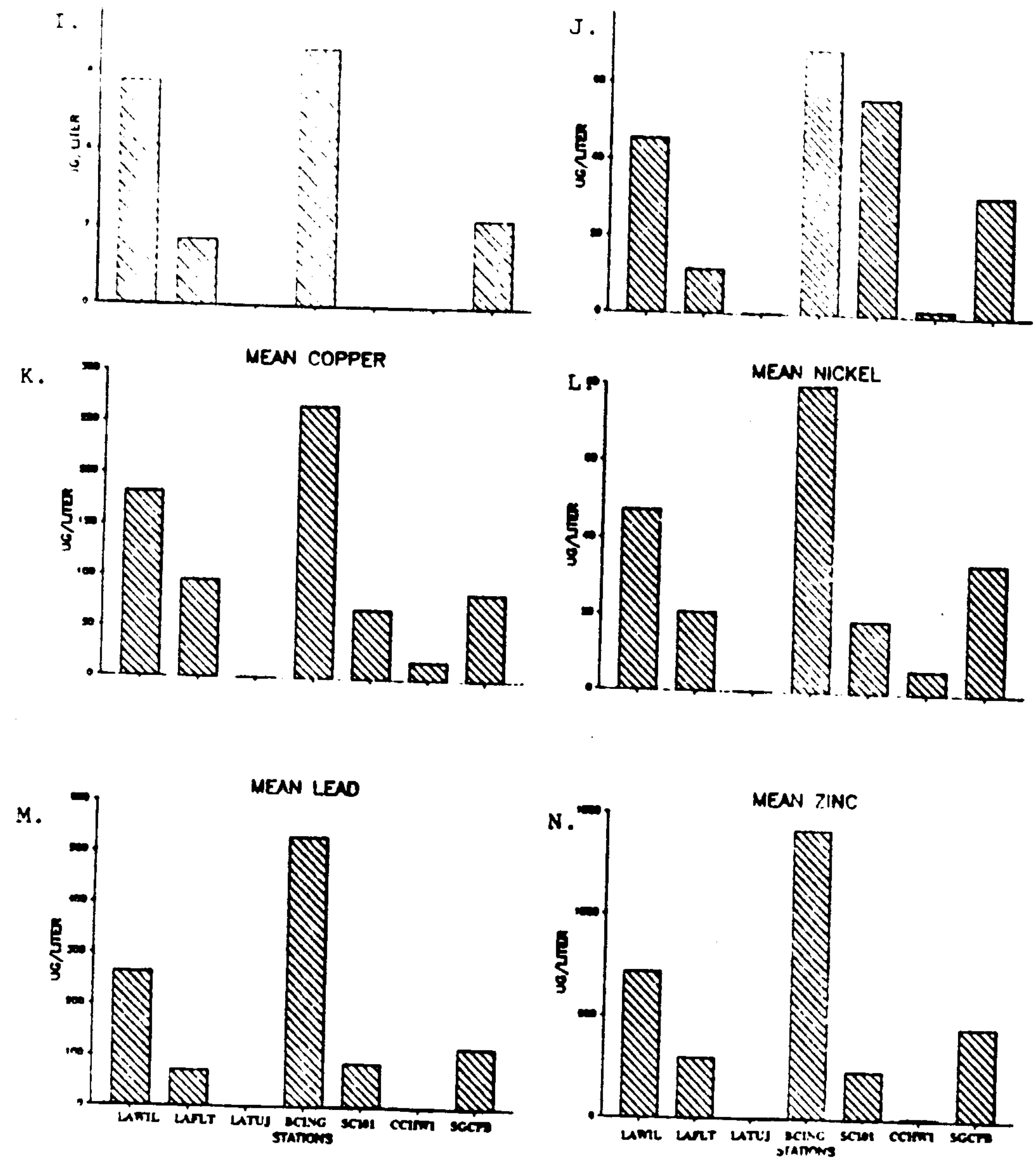

Figure. 4 I-N

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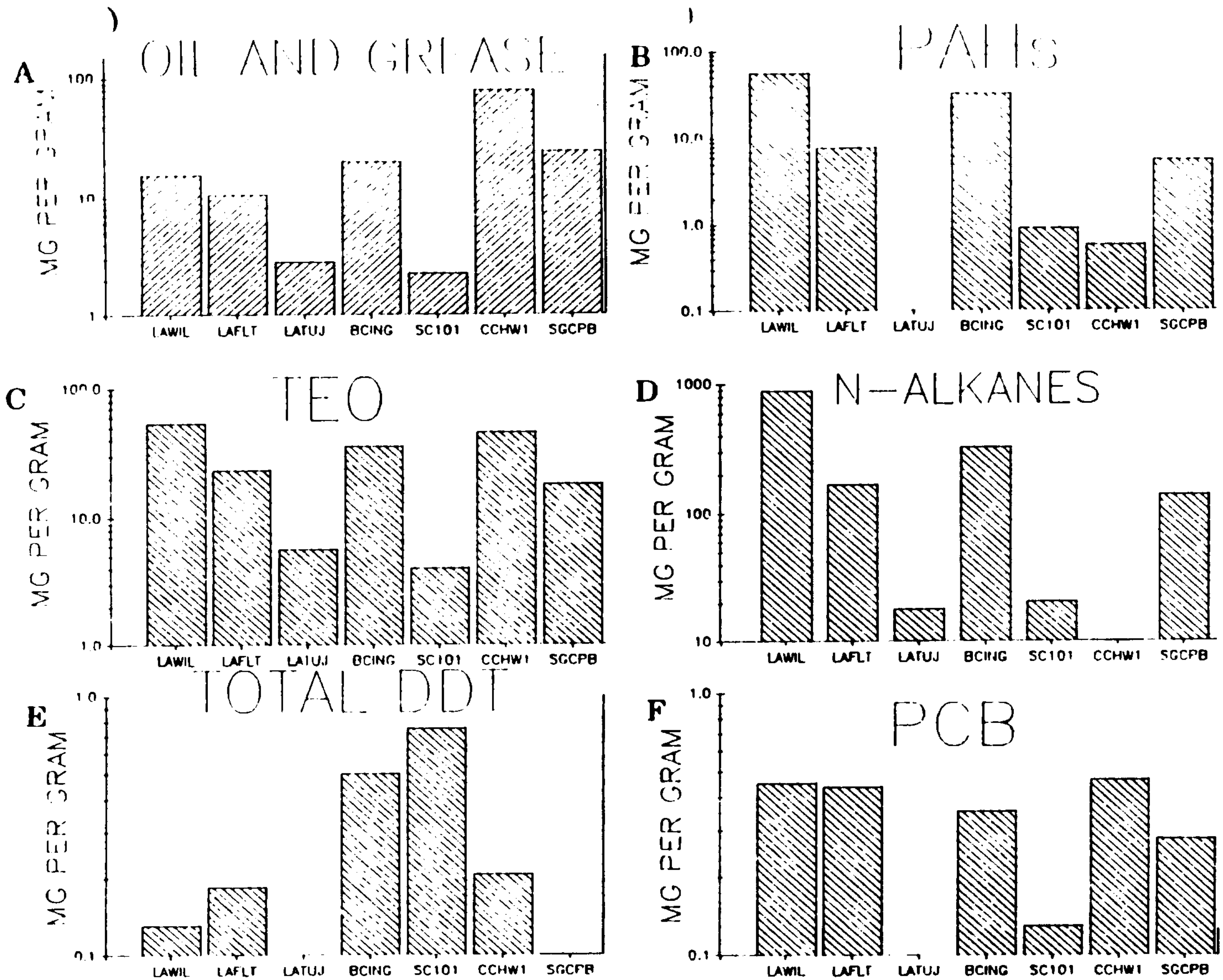


Figure 5 A-L. Concentrations of contaminants calculated on a per gram of suspended solids basis at the Los Angeles River at Willow (LAWIL), Fletcher (LAFLT), Tujunga Wash (LATUJ), Ballona Creek (BCING), Santa Clara River (SC101), Calleguas Creek (CCHW1) and San Gabriel River (SGCPB).

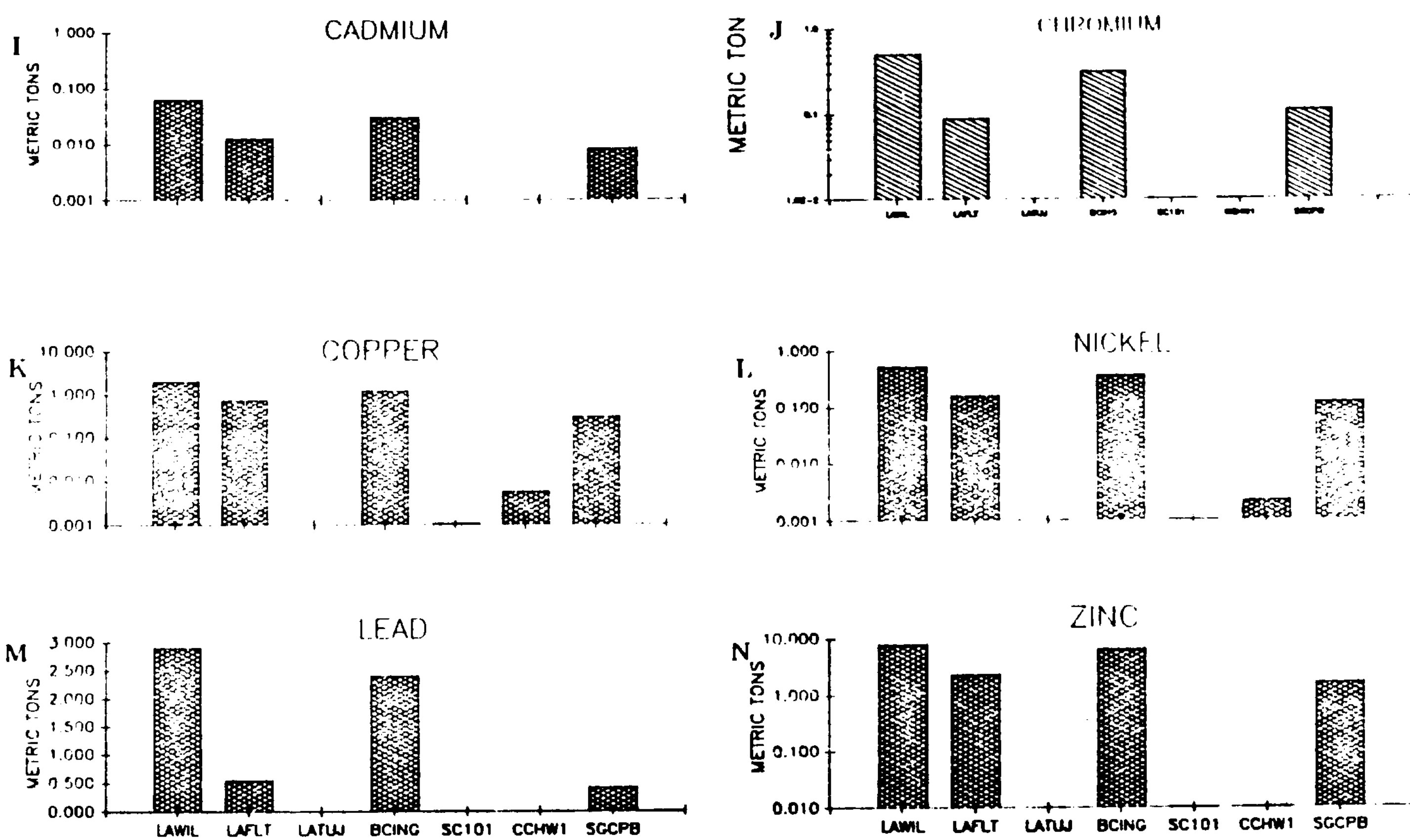


Figure 6. continued

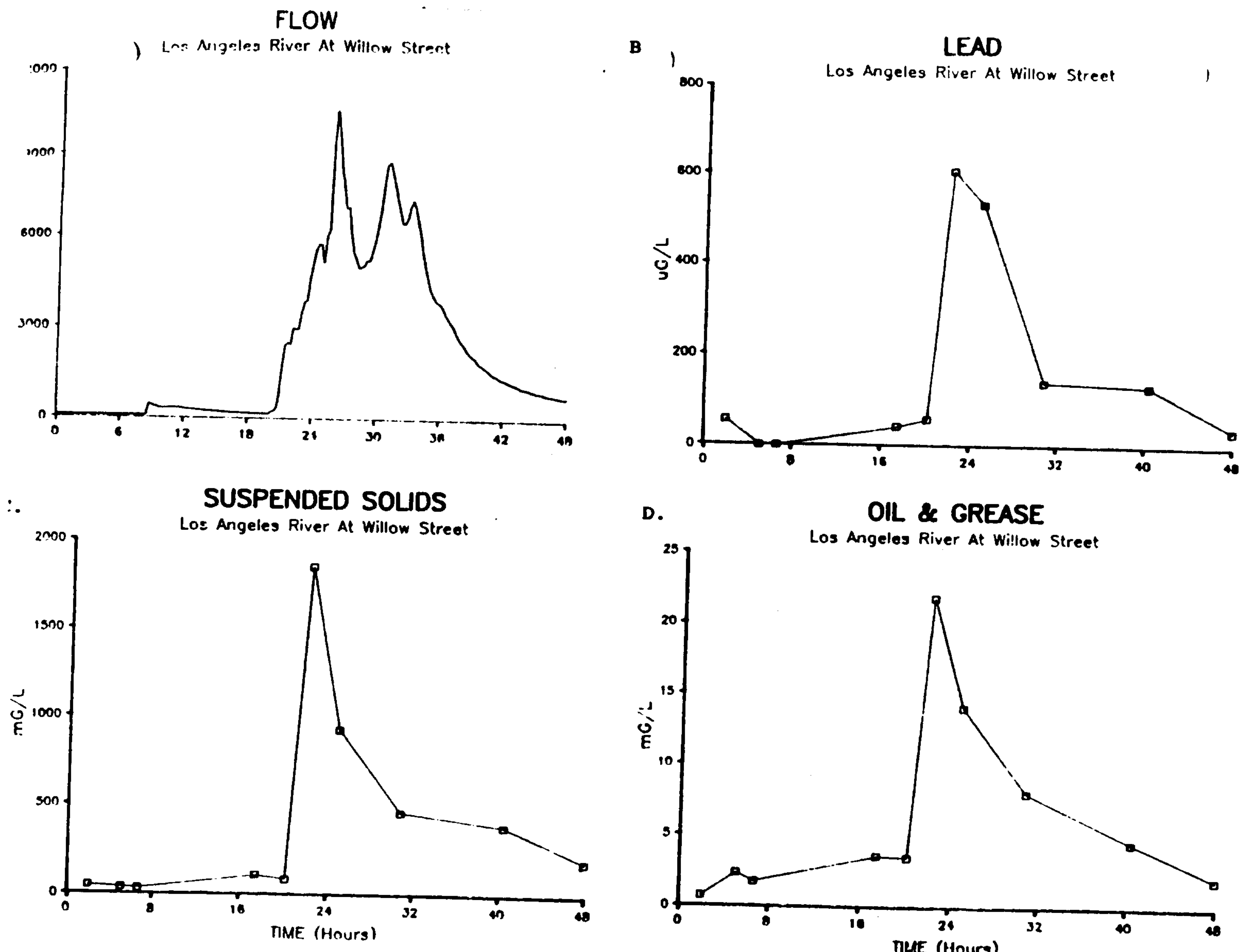


Figure 7. A-H Flow and contaminant concentrations at the Los Angeles River at Willow Street during the September 23-25, 1986 storm.

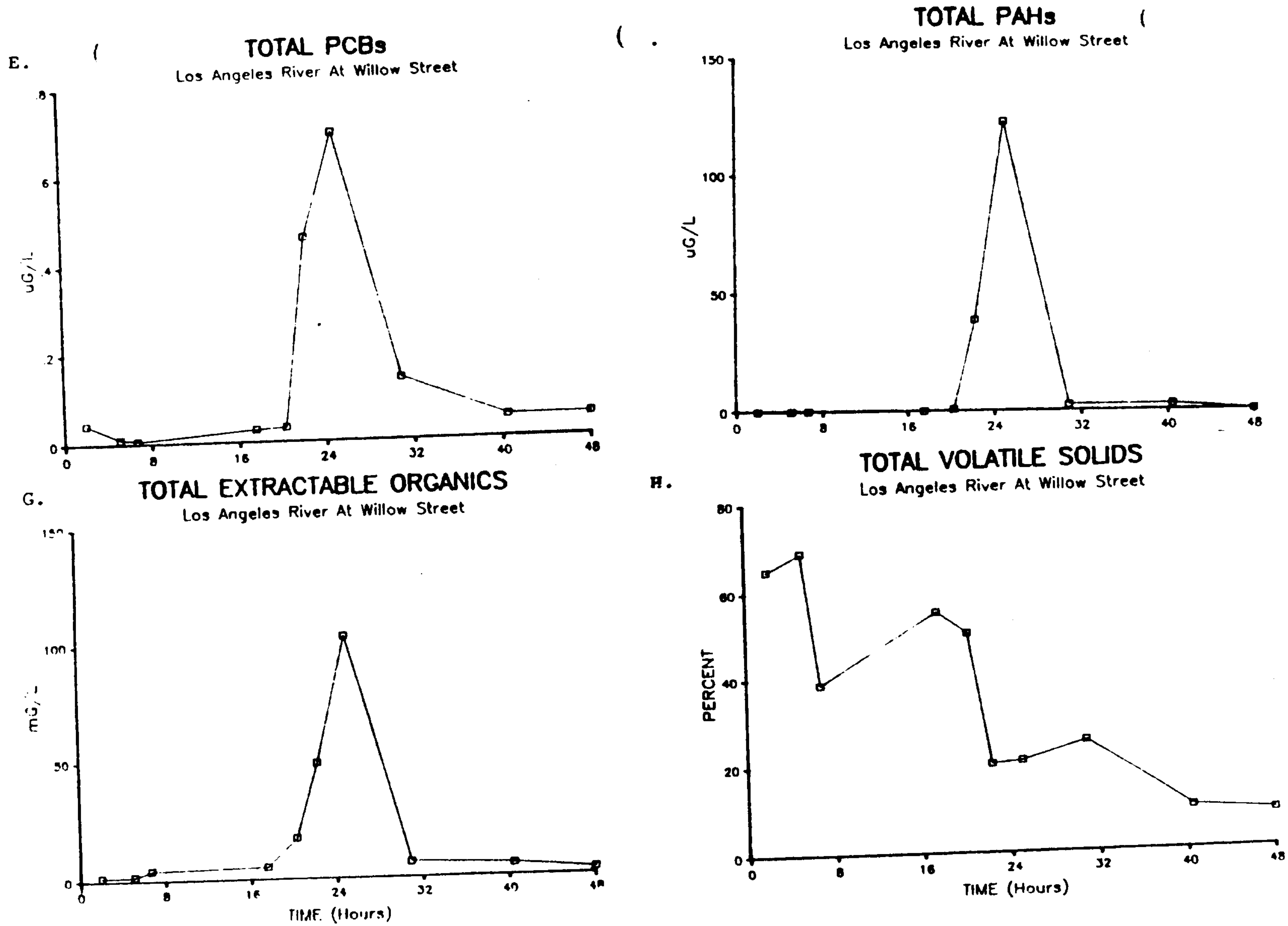


Figure 7 continued

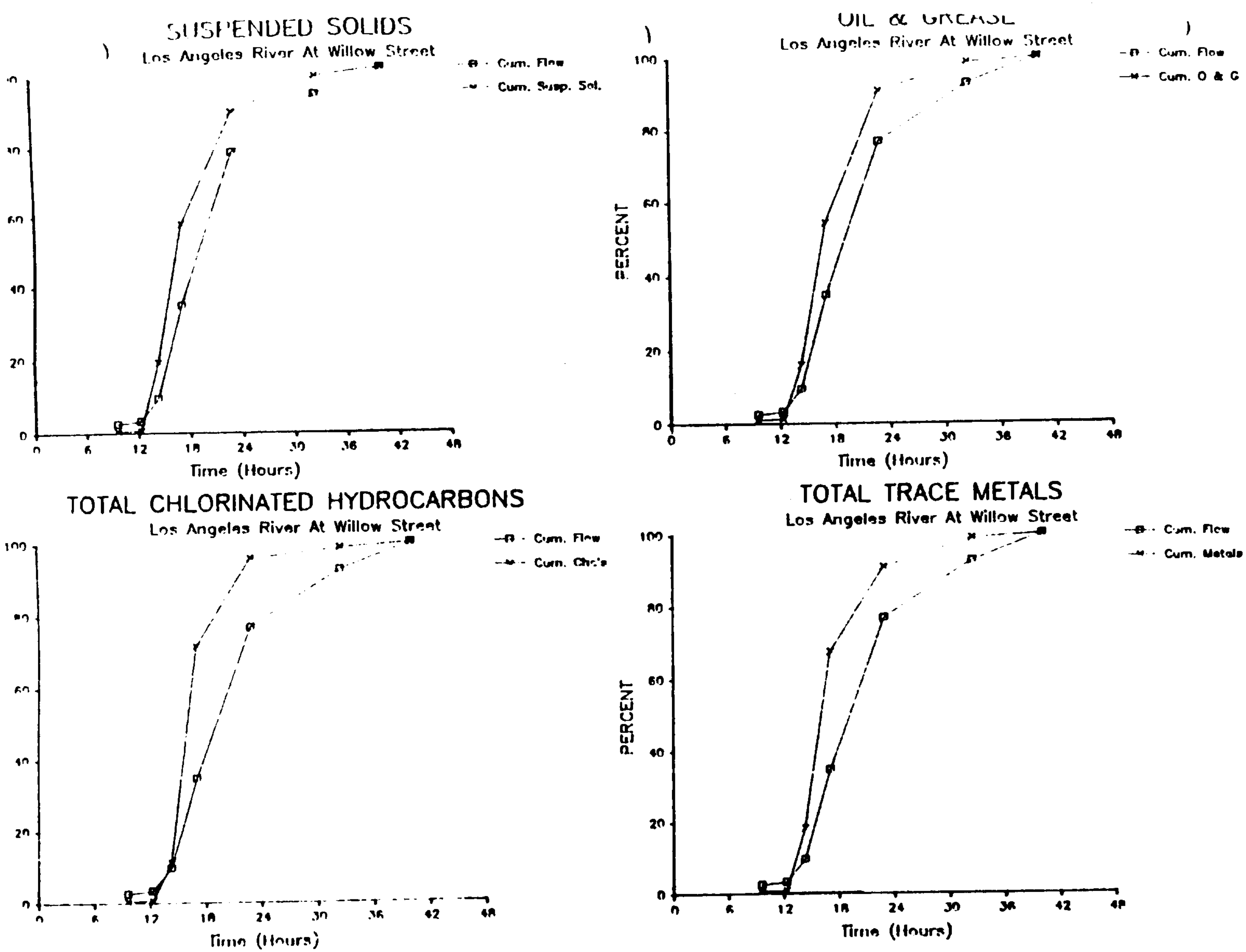


Figure 8 A-D Cummulative percentage of flow and contaminants for the Willow station

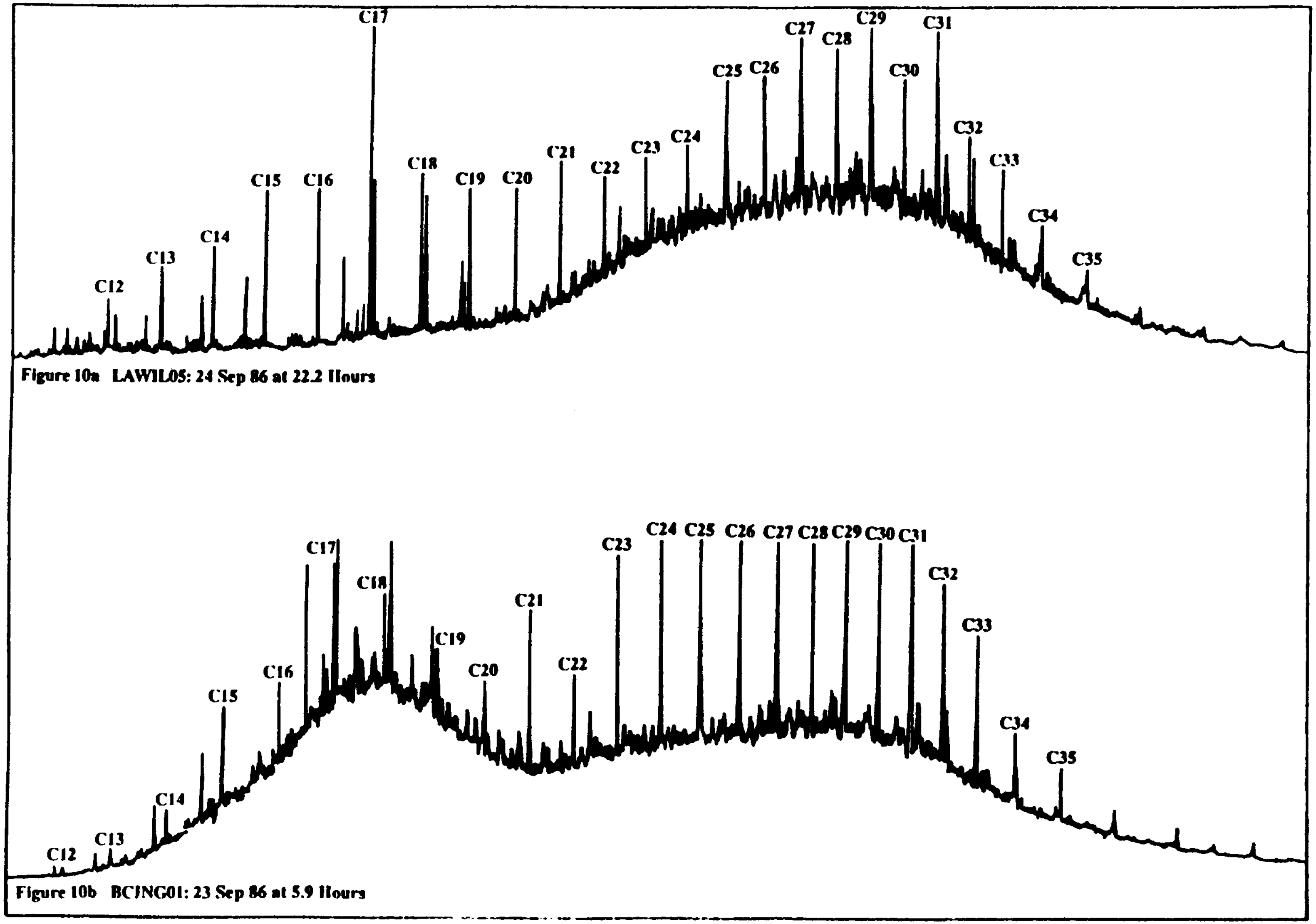


Figure 10a and 10b. Aliphatic hydrocarbon chromatograms of stormwater runoff samples.

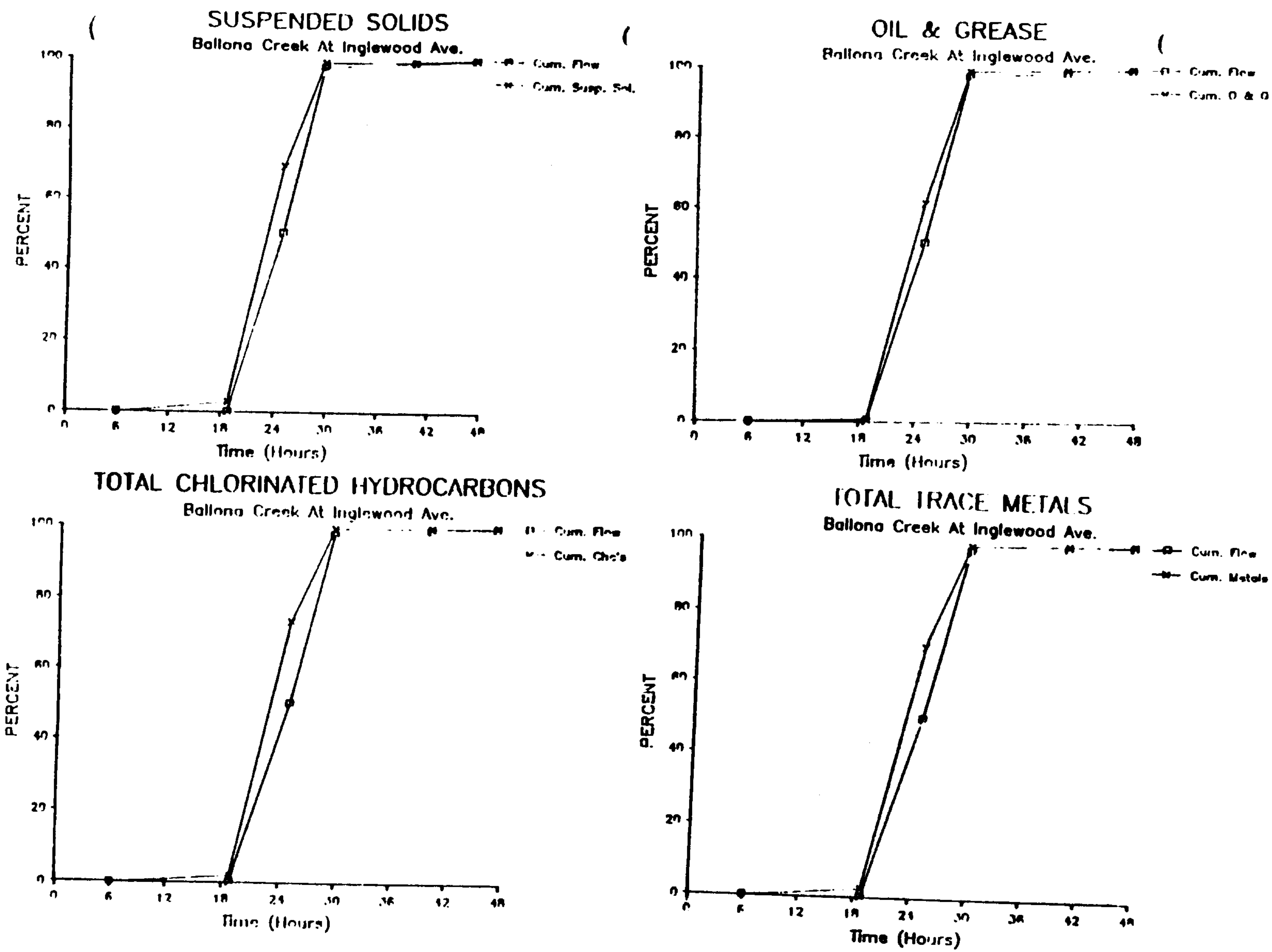
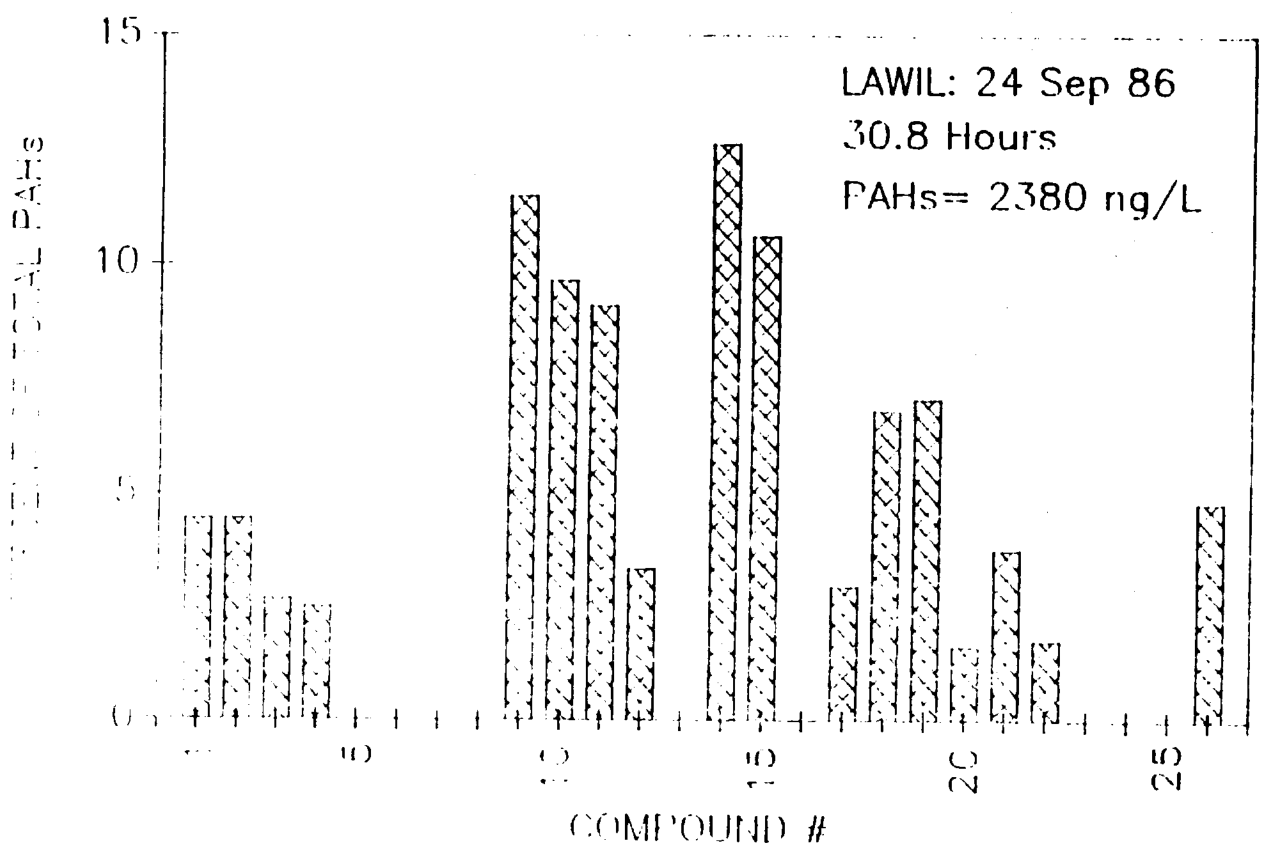


Figure 9 A-D Cummulative percentage of flow and contaminants at the Ballona Creek station



igure 11. Relative abundances of 26 PAH compounds in runoff sampled at Willow Street on the Los Angeles River. (Compounds listed in Appendix A)

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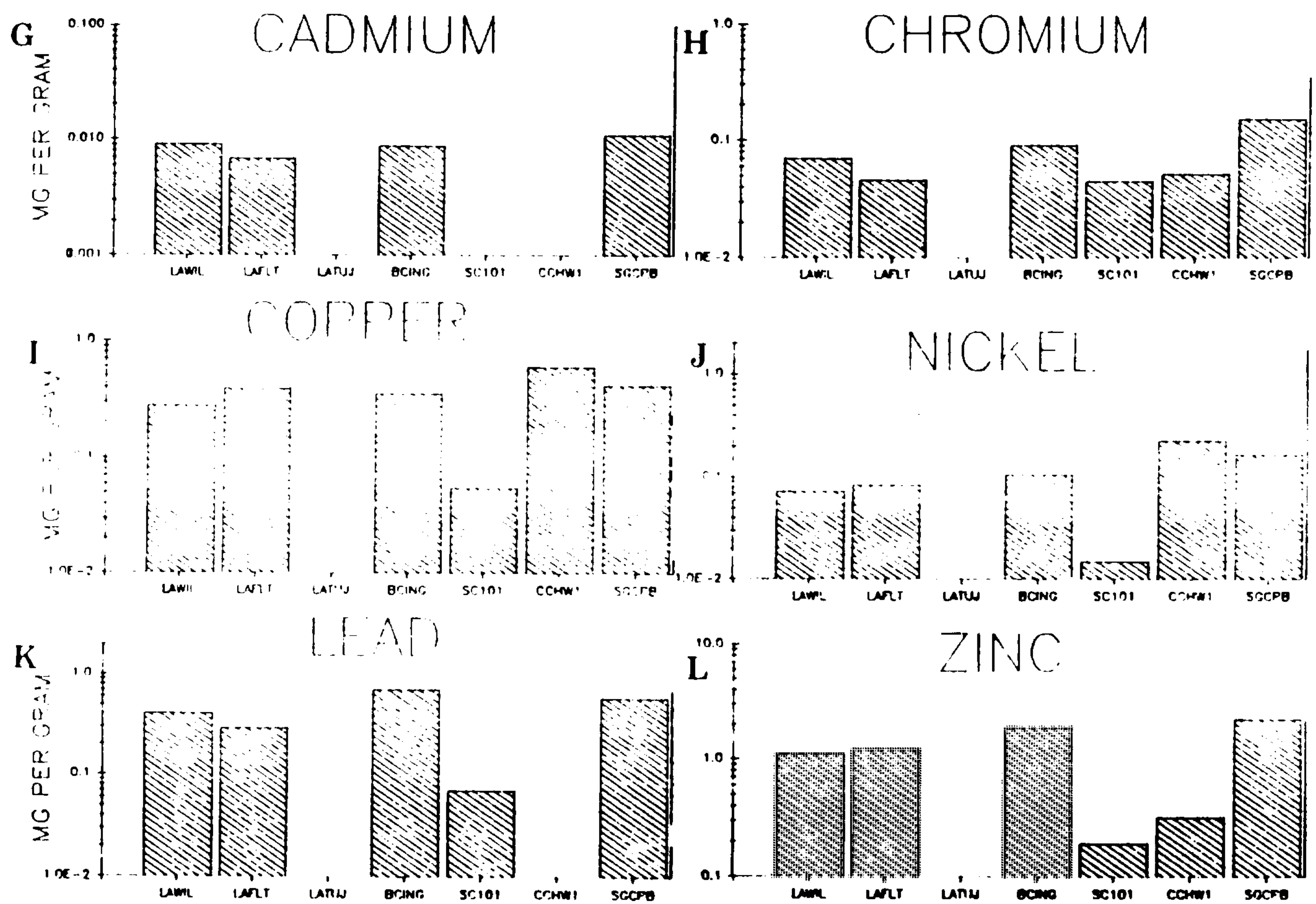

Figure 5. continued

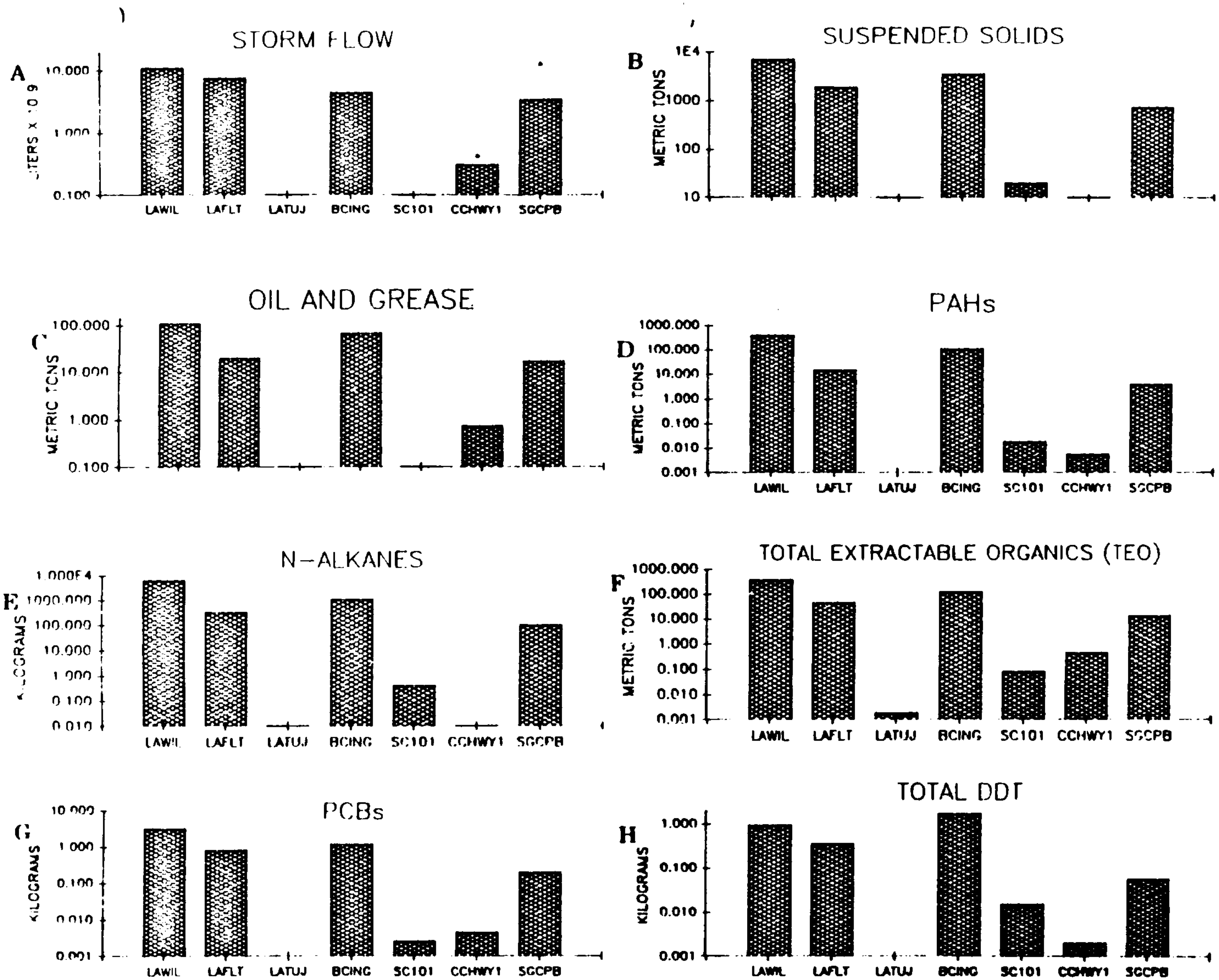

Figure 6 A-M. Calculated contaminant mass emissions from September 23-24, 1986 storm.

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BEST MANAGEMENT PRACTICES PLAN FOR SEDIMENT CONTROL

NOVEMBER 1981

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FINAL

TASK 8015.03

TECHNICAL MEMORANDUM

NEWPORT BAY WATERSHED: CONSTRUCTION ACTIVITIES BEST MANAGEMENT PRACTICES PLAN FOR SEDIMENT CONTROL

2

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Boyle Engineering Corporation

PREPARED FOR THE
CITY OF IRVINE AND THE
SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS

NOVEMBER 1981

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Water Resources Division
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CITY OF IRVINE
Attention Ed Moore
P.O. Box 19575
Irvine, CA 92713

November 6, 1981

Newport Bay Watershed: Construction Activities Best Management Practices Plan for Sedimentation Control

Enclosed is the Final Technical Memorandum for Task 8015.03, Newport Bay Watershed: Construction Activities Best Management Practices Plan for Sediment Control.

This technical memorandum describes the best management practices that are suitable for construction sites within the watershed. The report also compares the grading ordinances, and administrative and enforcement practices of five jurisdictions in the watershed. The study concludes that in general the present system is working effectively to reduce erosion and sediment at construction sites, but recommends some modifications in the ordinances and their administration.

We appreciate your cooperation during the course of this project.

BOYLE ENGINEERING CORPORATION
Water Resources Division

J.G. Polifka, PE
Project Manager

M.K. Cordill
Project Engineer

jer

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ACKNOWLEDGMENT

Many agencies and individuals contributed to this study, including

City of Irvine

City of Newport Beach

City of Orange

City of Tustin

Orange County

California Regional Water Quality Control Board

California State Water Resources Control Board

California Department of Fish and Game

Soil Conservation Service

The Irvine Company

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SUMMARY

The rapid sedimentation of Upper Newport Bay has become the concern of many agencies and individuals. The bay is currently the focus for a series of studies to develop sedimentation control plans. This study investigates the reduction of sediment produced at construction sites by the application of best management practices (BMPs). These BMPs consist of structural measures used at the site and nonstructural measures involving administrative and regulatory processes.

Construction site BMPs are described in section 3.0 of the report. Twenty-seven of the practices are found to be appropriate for occasional-to-frequent use within the watershed. No single set of measures is recommended because selection must be site specific.

Section 4.0 of the report describes the procedures used by local governments to promote erosion and sediment control measures at construction sites. Five jurisdictions in the watershed were studied: Irvine, Newport Beach, Orange, Tustin, and Orange County. The five grading ordinances were compared with each other and with model ordinances. The administrative and enforcement procedures used by Irvine were studied in detail and compared with those of Newport Beach and Orange County. The study concludes that generally the present system is working effectively to reduce erosion and sediment produced from construction sites. Nevertheless, some modifications in the ordinances and in administration are recommended.

Section 5.0 describes the institutional arrangements used to achieve water quality goals relating to construction sites. The emphasis is on land use regulation by local governments, with supervisory review by the Regional Water Quality Control Board.

The conclusions and recommendations of the study appear in detail in sections 3.0, 4.0 and 5.0, and are summarized in section 2.0. Sections 1.0 and 2.0 will serve as the basis for the 208 plan amendment.

1.0 INTRODUCTION

1.1 Background

Sediment that is eroded from a watershed and deposited downstream reduces water quality and impairs the beneficial use of natural habitats and man-made facilities. All watersheds produce sediment under natural conditions. However, sediment production may increase temporarily by several thousand times if the natural vegetation is disturbed and the soil exposed. This temporary increase in sediment may have serious, longterm impacts if it is deposited in sensitive areas such as Upper Newport Bay.

1.2 Study Objective and Scope

The objective of this study is to develop a sedimentation control plan for construction activities in the Upper Newport Bay watershed employing best management practices. This plan defines and recommends specific practices to be used on construction sites, suggests changes in existing grading ordinances and administrative procedures, and describes the framework for regulating the erosion and sedimentation aspects of construction activities. The report is to be used in conjunction with current studies of other sediment sources in the watershed.

The information presented in the study is based on published materials and personal interviews. The grading ordinances and administrative procedures of five juisdictions within the watershed were studied: Irvine, Newport Beach, Orange, Tustin, and Orange County. Construction site best management practices applied throughout the country were examined, and those appropriate to conditions in the watershed were recommended.

This study updates and expands earlier work conducted as part of the areawide 208 planning process. (See Pomeroy, Johnston & Bailey, July 1978: and J.B. Gilbert & Assocs., Aug. 1978.)

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2.0 FINDINGS, CONCLUSIONS & RECOMMENDATIONS

Public officials, developers and contractors in the Upper Newport Bay watershed are well aware of the problems caused by increased sediment runoff from construction sites. This concern for sedimentation in Upper Newport Bay has led to regulation of construction sites that is among the most strict in the state. Based on conversations with knowledgeable people in the public and private sectors, it appears that the present system is working effectively. Major reasons are the close communication between local governments and developers/contractors, and the voluntary cooperation shown by local developers such as The Irvine Company.

Conclusions

1. Erosion control plans specifying appropriate best management practices can lead to a reduction in accelerated sediment production from construction sites.
2. The three major jurisdictions in the watershed--Irvine, Newport Beach and Orange County--maintain relatively uniform ordinances, standards and procedures.
3. The city of Tustin currently does not have an erosion/sedimentation control policy.
4. The city of Orange is applying an extensive set of standards in its approach to erosion/sedimentation control. The success or failure of this approach will have little effect on Upper Newport Bay because the drainage area within the city is small compared to the total watershed.
5. None of the jurisdictions studied specifies water quality protection as a goal of its grading ordinance.

Recommendations

1. Best Management Practices. Twenty-seven BMPs are recommended as appropriate for occasional-to-frequent use in the watershed (Table 2). Four of these practices are now rarely used.

2. Grading Ordinances. It is recommended that the jurisdictions in the watershed adopt water quality protection as a goal of their grading ordinances. Additional changes in the ordinances are not recommended because it appears that changes can be more easily incorporated into existing administrative standards and procedures.

3. Administrative Standards and Procedures. The following actions are recommended:

- that the present uniformity in standards be maintained among Irvine, Newport Beach and Orange County;
- that the present positive working relationship with developers and contractors be maintained;
- that the jurisdictions actively promote and participate in erosion control training programs for their staff;
- that efforts be made to improve communication between plan checkers and site inspectors;
- that Irvine and Orange County institute collection of a debris deposit similar to that of Newport Beach, and
- that the city of Tustin begin developing an erosion/sediment control program at the earliest possible time.

4. Regulatory Process. It is recommended that the local governments continue to take the lead responsibility for erosion and sediment control at construction sites. The Regional Water Quality Control Board should maintain an active supervisory role by performing periodic site inspections and by requesting annual reports from local governments when water quality goals are not being met.

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3.0 BEST MANAGEMENT PRACTICES

3.1 Definition

Best management practices (BMPs) are defined broadly in the Code of Federal Regulations.

> BMPs are those methods, measures, or practices to prevent or reduce water pollution and include but are not limited to structural and nonstructural controls, and operation and maintenance procedures. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters. (40 CFR 35.1521-4(c))

BMPs therefore include many responses to erosion and sedimentation ranging from regulations and enforcement (section 4.0 of this report), to specific measures applied at construction sites as part of a sediment control plan. This section discusses the latter category of BMPs.

BMPs that reduce sediment produced from construction sites can be divided generally between temporary and permanent measures. The expected life of temporary measures can vary from one day to eighteen months. After that time, substantial maintenance or reconstruction is required to retain the efficiency of most temporary measures. Permanent measures have a longer expected life, usually dependent on construction materials. Both temporary and permanent measures require some degree of design and construction expertise. Even placing gravel bags on a graded roadway requires an estimate of flow rate to determine optimum placement.

The goal of BMPs should be to obtain a significant reduction of sediment at a reasonable cost. The definition of "significant" and "reasonable" will vary depending on the source--public agency or private developer. However, disagreements may be reduced by keeping in mind the following principles.

1. Use land according to its capability and treat it according to its needs.

2. Leave soil bare for the shortest time possible.

3. Reduce the velocity and control the flow of runoff.

4. Detain runoff at the site to trap sediment.

5. Release runoff safely to downstream areas.
(John Muir Institute, June 1979, p. 27)

These principles illustrate the need to develop control measures on a site-by-site basis. There is no single BMP or combination of BMPs that will always be effective.

Even the best planned erosion and sediment control measures will not totally eliminate the temporary increase in sediment runoff from construction sites. Nevertheless, those measures that reduce erosion, such as diversions or vegetation, are important in preventing silts and clays from entering the stream system. These fine-grained particles are the most difficult to trap in downstream sediment-control devices. Therefore, any site plan should concentrate first on erosion control within the site, and then second on trapping sediment before it leaves the site.

3.2 Description of Practices

This section describes 36 best management practices that could be applied to the Newport Bay watershed. Sources for the information are cited in the text. When no page number appears, the previous citation applies. Sample drawings and specifications are included for information only, and are not intended for use in formal design.

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BEST MANAGEMENT PRACTICES

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TEMPORARY GRAVEL CONSTRUCTION ENTRANCE

Definition. A stabilized pad of crushed stone located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area. (USDA, SCS, July 1975, p. 16.01)

Purpose. To reduce or eliminate mud and sediment transported onto public rights-of-way by vehicles or runoff. (USDA, SCS, July 1975, p. 16.01)

Conditions Where Practice Applies. Wherever traffic will be leaving a construction site and moving directly onto a paved surface. Should be used in conjunction with other practices to stabilize construction site roadways, and prevent offsite movement of sediment. Standard applies where the entrance will be removed or paved within 12 months after construction. (ABAG, Aug. 1980, p. I-107)

Design and Maintenance Considerations.

1. Two to three-inch stone, at least 6 inches thick (Virginia, 1980, p. III-2), or

   1-1/2 to 2-1/2-inch stone at least 8 inches thick (ABAG, Aug. 1980, p. I-107; also USDA, SCS, July 1975).

2. The width shall extend the full width of all points of ingress and egress. (ABAG, Aug. 1980, and Virginia, 1980)

3. The length of the pad shall be as required, but not less than 50 feet. (ABAG, Aug. 1980, and Virginia, 1980)

4. The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spilled, dropped, washed or tracked onto public rights-of-way must be removed immediately. (ABAG, Aug. 1980)

5. When necessary, wheels must be cleaned to remove sediment prior to entrance onto public rights-of-way. When washing is required, it shall be done on an area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch or watercourse through use of sand bags, gravel, or other approved methods. (ABAG, Aug. 1980)

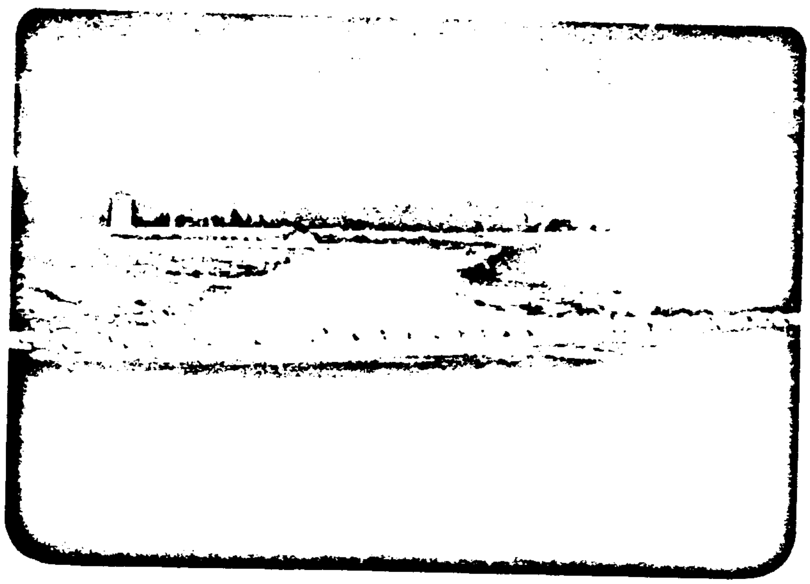

FIGURE 1. A temporary gravel construction entrance with filter berm in place when entrance is not being used. (Courtesy The Irvine Company)

CONSTRUCTION SITE ROAD STABILIZATION

Definition. The temporary stabilization of access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes with stone or asphalt immediately after grading. (Virginia, 1980, p. III-5)

Purposes.

1. To reduce the erosion of temporary roadbeds by construction traffic during wet weather, and to reduce dust during dry weather.

2. To reduce the erosion and therefore regrading of permanent roadbeds between the time of initial grading and final stabilization. (Virginia, 1980, p. III-5)

Conditions Where Practice Applies. Wherever stone-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic. Associated practices are vegetation establishment and protection, and dust control.

Paved areas should be constructed immediately after completion of building foundations and all subsequent motorized travel on the site should be limited to these areas except for completion of roadwork. Materials delivery should also be conducted on these stabilized areas. (Panhandle Area Council, April 1978, p. I-4)

Design Considerations.

1. Temporary roads and parking areas shall follow the contour of the natural terrain to the extent possible. A 6-inch course of 2-to-3-inch aggregate shall be applied immediately after grading or completion of utility installation within the right-of-way. Filter fabric may be applied to the roadbed for additional stability in accordance with fabric manufacturer's specifications. (Virginia, 1980, p. III-6)

2. Permanent roads and parking areas shall be designed and constructed in accordance with applicable standards. If areas are not paved immediately after grading, additional gravel base may be required. (Virginia, 1980)

Maintenance. Both temporary and permanent roads and parking areas may require periodic top dressing with new gravel. (Virginia, 1980, p. III-7)

SANDBAG, GRAVEL BAG, OR STRAW BALE BARRIERS

Definition. A temporary sediment barrier consisting of a row of entrenched and anchored straw bales, or stable, interlocking sand- or gravel-filled bags. (Virginia, 1980, p. III-9; and Panhandle, Apr. 1978, p. VI-7)

Purpose. To intercept and detain small amounts of sediment from disturbed areas of limited extent, and to decrease the velocity of sheet flow and low-to-moderate channel flows (bags only). (Virginia, 1980)

Conditions Where Practice Applies. Below disturbed areas subject to sheet and rill erosion where size of drainage is no greater than one-half acre. (ABAG, Aug. 1980, p. I-109; and USDA SCS, Dec. 1970, p. 13.01) Straw bale barriers can be used on slopes that do not exceed 50 percent (2:1) or around drainage inlets. Filtering capabilities are improved when used in conjunction with filter fabric. Sandbags or gravel bags can be used on slopes (not exceeding 50 percent), around drainage inlets, and in small swales or ditches subject to low-to-moderate-level flows. Sandbags do not provide sediment filtration, but cause deposition by detaining and diverting flows. (Panhandle, April 1978, p. VI-7) Gravel bags provide some filtration, and also detain flows.

The maximum life expectancy of bale or bag barriers is one rainy season. Because maintenance can be a problem, this measure should not be used where other sediment control practices are feasible. (ABAG, Aug. 1980, p. I-109)

Design Considerations.

1. Dikes of bags or bales constructed across a right-of-way or immediately below the site of construction activities should have a low spillway-embankment section of sand and gravel that serves as a filter outlet. (Amimoto, May 1978, p. 151)

2. The gravel bags should contain 1/4-inch aggregate, or pea gravel.

3. The barriers must be installed so that runoff cannot escape freely under the straw bales or sand/gravel bags. (Amimoto, May 1978)

4. Straw bales bound with nylon or wire are more durable than twine-bound bales. (Amimoto, May 1978)

5. Straw bales should be anchored to the ground with steel rods, fence posts, rebars, or wood pickets. Two anchors per bale are required. (Amimoto, May 1978)

6. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. After the bales are staked, the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier. (Virginia, 1980, p. III-12)

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7. Sandbags exceeding two bags in height must be pyramided and may require anchoring with steel rods, rebars, or similar supports. (Amimoto, May 1978, p. 152)

Maintenance Considerations.

1. Straw bale barriers shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. (Virginia, 1980, p. III-12)
2. Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales. (Virginia, 1980)
3. Sediment deposits should be removed after each major rainfall. (Virginia, 1980, p. III-15; also Panhandle, April 1978, p. VI-7)

FIGURE 2. A filter berm of gravel bags showing sediment deposition on the upstream (right) side. (Courtesy The Irvine Company)

FIGURE 3. A filter berm of straw bales at construction entrance. To prevent washouts, bales should be entrenched and secured by stakes or rebar. (Courtesy The Irvine Company)

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FIGURE 4. A series of gravel-bag filter berms on graded right-of-way. Note berm used for slope protection and berms at base of gradient to reduce runoff velocity. (Courtesy The Irvine Company)

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FIGURE 4. A series of gravel-bag filter berms on graded right-of-way. Note berm used for slope protection and berms at base of gradient to reduce runoff velocity. (Courtesy The Irvine Company)

SILT FENCE

Definition. A temporary sediment barrier consisting of a filter fabric (either burlap or synthetic filter fabric) stretched across and attached to supporting posts and entrenched.

Purpose. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site; and to decrease the velocity of sheet flows, and low-to-moderate channel flows.

Conditions Where Practice Applies. Below disturbed areas where erosion would occur in the form of sheet and rill erosion, and where the size of drainage area is no more than one-half acre. (ABAG, Aug. 1980, p. I-112) Maximum slope above the barrier should not exceed 50 percent (2:1). (Virginia, 1980, p. III-18) Barriers should not be used where flow rate is expected to exceed one cubic foot per second (1 cfs). (Virginia, 1980) Maximum life expectancy is six months. (Virginia, 1980, III-19) This measure should be used only where no other practices, except a straw bale dike, are feasible. (ABAG, Aug. 1980, p. I-112)

Design Considerations.

FLOW RATES AND FILTERING EFFICIENCIES OF
VARIOUS SEDIMENT FILTER MATERIALS

Material	Flow Rate (gal./sq.ft./min.)	Filter Efficiency (%)
Straw	5.6	67
Burlap (10 oz. fabric)	2.4	84
Synthetic Fabric	0.3 (Avg.)	97 (Avg.)

Source: Virginia, 1980, p. III-18.

1. The fence posts shall be spaced a maximum distance of 10 feet center-to-center.

2. Woven wire fence shall be fastened securely to the upstream side of the fence posts by staples or wire ties.

3. A trench at least 6 inches deep shall be excavated on the upstream side of the fence.

4. The filter cloth shall be stapled or securely fastened to the upstream side of the woven wire. Sufficient filter cloth shall be allowed to extend to the bottom of the trench and back up to the upstream side of trench.

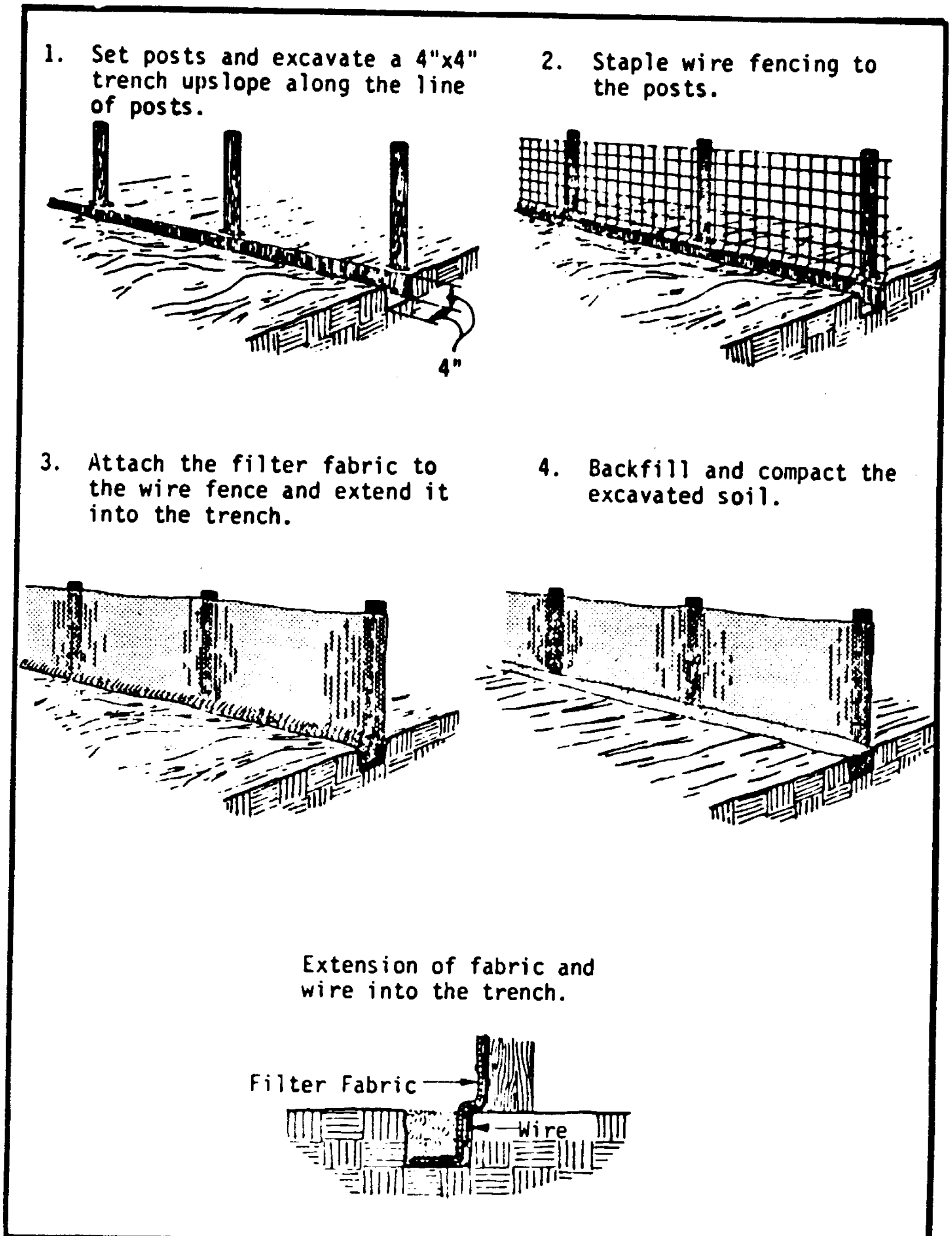
5. The trench shall be backfilled with soil and compacted to the original ground level. (ABAG, Aug. 1980, p. I-114)

Maintenance Considerations.

1. The fence shall be inspected during each storm and the filter cloth shall be replaced promptly as needed if it is torn.

2. Silt shall be removed periodically to keep the silt level from reaching halfway to the top of the fence. (ABAG, Aug. 1980, p. I-114)

SAMPLE DRAWING: SILT FENCE



Source: Virginia, 1980.

FIGURE 5

FILTER BERMS

Definition. A temporary sediment trap consisting of a ridge of gravel or crushed rock placed across a graded right-of-way, or at the point of discharge from a perimeter berm or other diversion device. (Amimoto, May 1978, p. 151)

Purpose. To retain sediment on-site by retarding and filtering runoff while at the same time allowing construction traffic to proceed along the right-of-way. (Amimoto, May 1978)

Conditions Where Practice Applies. Any graded right-of-way with slope greater than two percent; or an outlet from a diversion device with drainage area less than five acres. (Amimoto, May 1978, p. 157, and USDA SCS, July 1975, p. 17.01) Filtering capabilities can be enhanced by using a sand core or filter fabric. (White and Franks, 1978, p. 161) Maximum design life, with continuous maintenance, is one rainy season. (White and Franks, 1978, p. 148)

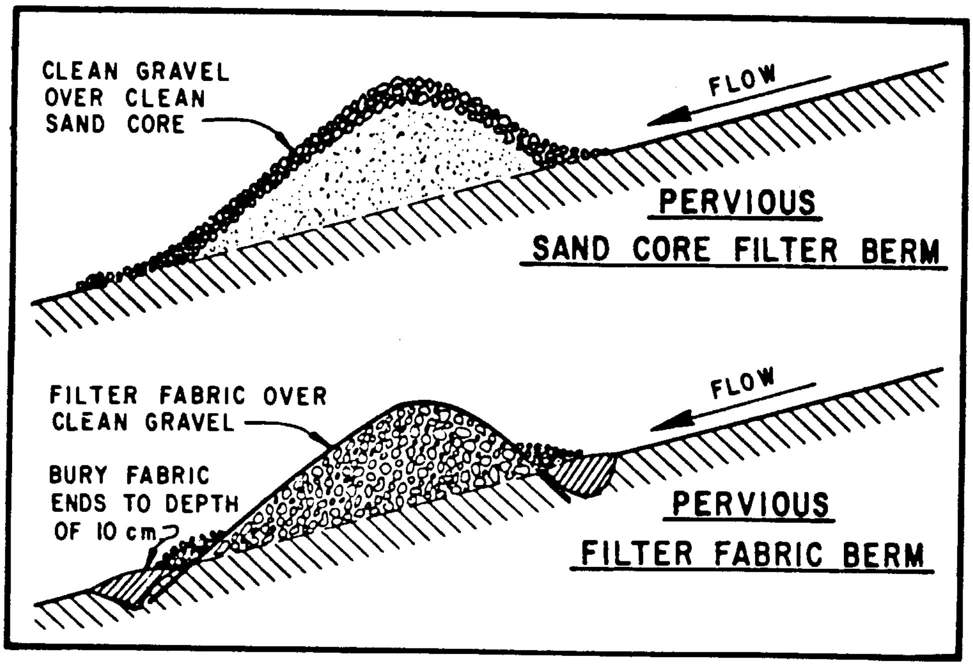
Design and Maintenance Considerations. Sample design standards (Amimoto, May 1978, p. 151):

1. Height: 1.5 - 2.0 feet;
2. Top width: 3 - 5 feet;
3. Side slopes: 3:1 or flatter;
4. Spacing: maximum distance 200 - 300 feet apart (when placed on right-of-way);
5. Material: 3/4 - 3-inch, well-graded gravel or crushed rock.

Where berm will be subjected to concentrated flows, gravel should be embedded at least four inches in the ground. (USDA SCS, July 1975, p. 17.03)

After each storm remove trapped sediment and clean out or replace clogged filter material. During dry weather inspect regularly and repair as needed when berm is damaged by vehicular traffic. (Panhandle, Apr. 1978, p. VI-9)

SAMPLE DRAWING: FILTER BERMS



Source: White and Franks, 1978.

FIGURE 6

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BRUSH BARRIER

Definition. A temporary sediment barrier constructed at the perimeter of a disturbed area from the residue materials available from clearing and grubbing the site.

Purpose. To intercept and retain sediment from disturbed areas of limited extent, preventing sediment from leaving the site.

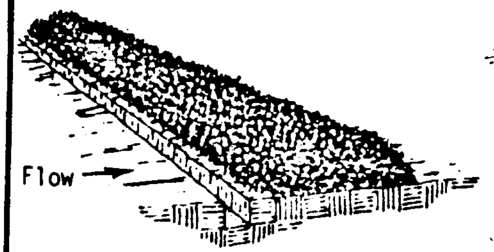
Conditions Where Practice Applies. Below disturbed areas subject to sheet and rill erosion, where enough residue material is available for construction of such a barrier.

Construction and Maintenance Considerations.

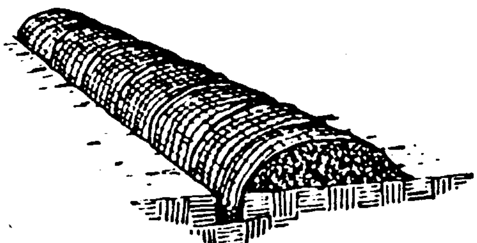
1. The height of a brush barrier shall be a minimum of 3 feet.
2. The width of a brush barrier shall be a minimum of 5 feet at its base. (The sizes of brush barriers may vary considerably based upon the amount of material available and the judgment of the design engineer).
3. The barrier shall be constructed by piling brush, stone, root mat and other material from the clearing process into a mounded row on the contour.
4. The mound slab shall be completely covered by filter fabric entrenched on the uphill side and secured with stakes on the downhill side.
5. Brush barriers shall be inspected after each rainfall and necessary repairs shall be made promptly.
6. Sediment deposits must be removed when they reach approximately one-half the height of the barrier. (Virginia, 1980, pp. III-25-27)

2 0946

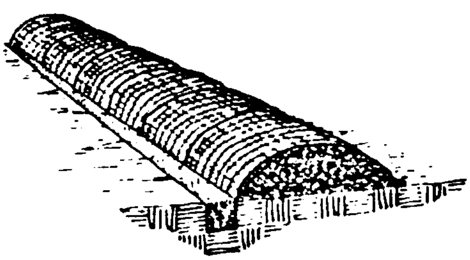
SAMPLE DRAWING: BRUSH BARRIERS



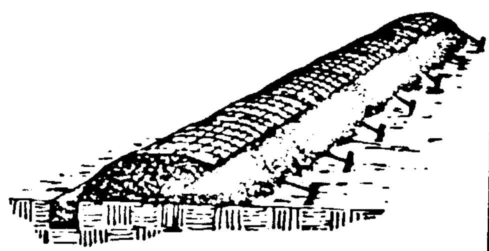
1. Excavate a 4" x 4" trench along the uphill edge of the brush barrier.



2. Drape filter fabric over the brush barrier and into the trench. Fabric should be secured in the trench with stakes set approximately 36" o.c.



3. Backfill and compact the excavated soil.



4. Set stakes along the downhill edge of the brush barrier, and anchor by tying twine from the fabric to the stakes.

Source: Virginia, 1980.

FIGURE 7

FILTER INLET

Definition. A temporary sediment filter or an impounding area around a stormdrain drop inlet or curb inlet. (Virginia, 1980, p. III-29)

Purpose. To prevent sediment from entering stormdrainage systems prior to permanent stabilization of the disturbed area. (Virginia, 1980)

Conditions Where Practice Applies. Where stormdrain inlets are operating before permanent stabilization of drainage area. The actual type of structure will vary with site conditions. (Virginia, 1980)

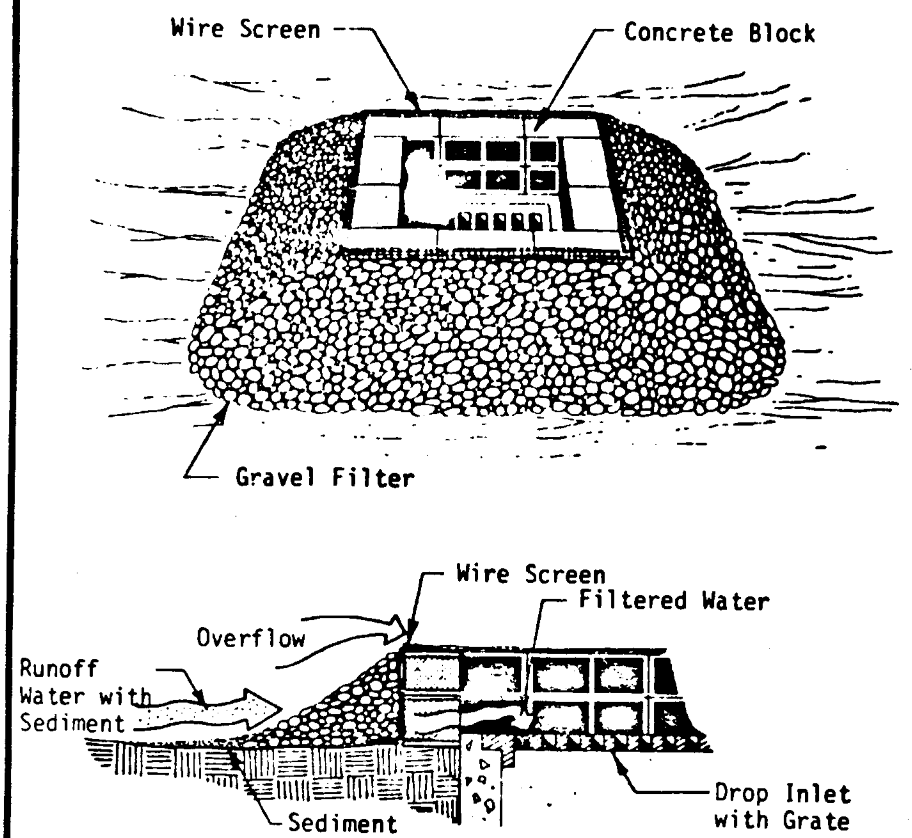
Design Considerations.

1. The contributing drainage area shall not exceed one acre.
2. Design should facilitate inspection and cleaning of filter material.
3. Do not use in streets where impounded water will create a safety hazard or endanger fill slopes.
4. Types of filter inlet designs:
   a. straw bale drop inlet structure -- bales must be anchored and staked; filtering ability enhanced by using filter fabric.
   b. burlap drop inlet sediment filter -- use 10-ounce-per-square-yard fabric; attach to stakes spaced a maximum of 3 feet apart, and entrench lower edge of fabric.
   c. gravel-and-wire-mesh drop inlet (or curb inlet) sediment filter -- place coarse gravel 12 inches deep over wire mesh covering inlet structure.
   d. block-and-gravel drop inlet (or curb inlet) sediment filter -- surround inlet with concrete block covered by wire mesh; pile gravel against wire mesh on the outside of the block barrier.
   e. excavated drop inlet sediment trap -- size to provide sufficient storage capacity and prevent overflow into inlet. (See Sediment Traps.)
   f. sod drop inlet sediment filter -- place sod to cover soil for a distance of four feet an each side of the inlet. (Virginia, 1980, pp. II-30-38)

Maintenance Considerations. Trapped sediment should be removed and the clogged filter material cleaned out or replaced after each storm. (Amimoto, May 1978, p. 152; also Panhandle, Apr. 1978, p. VI-13)

FIGURE 8. Inlet protection provided by gravel-bag berms. These are recommended only where ponding on the road will not cause a public hazard. (Courtesy The Irvine Company)

SAMPLE DRAWING: DROP INLET PROTECTION



Specific Application

This method of inlet protection is applicable where heavy flows are expected and where an overflow capacity is necessary to prevent excessive ponding around the structure.

Source: Virginia, 1980.

FIGURE 9

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INTERCEPTOR DITCH

Definition. A permanent structure located at the top of a cut slope. Also known as a brow ditch.

Purpose. To divert water away from a cut slope.

Conditions Where Practice Applies. Wherever a cut slope is to be part of the final project design.

Design Considerations.

1. The interceptor ditches should be designed to convey the design flood from the contributing area above the cut.
2. The interceptor ditches should be protected against erosion by lining and also protected against clogging by vegetative debris.
3. The discharge area should be non-erodible or have energy dissipating structures.
4. The interceptor ditch should be completed before the cut is made to the final grade.

Maintenance Considerations. A permanent inspection and maintenance program should be established and followed. (Amimoto, May 1978, p. 90)

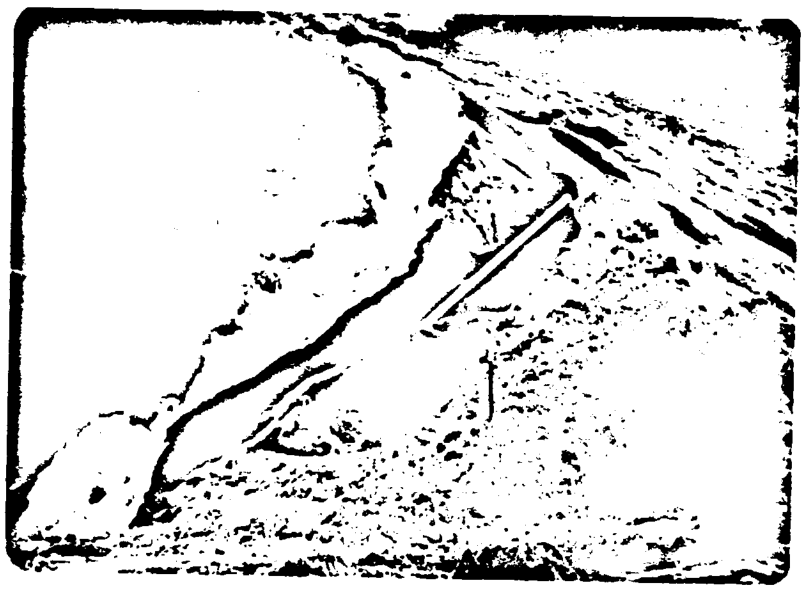

FIGURE 10. Permanent interceptor ditch. Improper design and/or maintenance of control measures can actually accelerate erosion. (Courtesy Dept. of Fish and Game)

DIVERSION DIKES

Definition. A ridge designed to redirect sheet flow, especially away from a slope. A temporary diversion dike is usually composed of compacted soil, whereas a permanent diversion dike is made of erosion-resistant material such as asphalt. (Virginia, 1980, p. III-39; and Amimoto, May 1978, p. 89)

Purpose. To divert storm runoff from higher drainage areas away from slopes to a stabilized outlet; or to divert sediment-laden runoff from a disturbed area to a sediment-trapping facility. (Virginia, 1980)

Conditions Where Practice Applies. Wherever stormwater runoff must be diverted to protect slopes or to retain sediments on site during construction. Temporary structures have a life expectancy of 18 months. (Virginia, 1980) Permanent diversions are used in rural areas where curbs and gutters are not required. An alternative measure may be an interceptor ditch or swale.

Design Considerations.

1. Sample design standards (Virginia, 1980, pp. III-40 & 41):

   - drainage area: less than five acres
   - minimum height: 18 inches
   - side slopes: 1.5:1 or flatter
   - grade: area upslope of dike must have positive grade to stabilized outlet. If slope is greater than two percent, stabilization of the drainage path with grouted rock or asphalt may be required.
   - outlet: diverted runoff, if free from sediment, must be released through a stabilized outlet; or if sediment laden, must be released through a sediment trapping facility.

2. Whenever feasible, the dike should be built before construction begins on the project.

3. The dike should be adequately compacted to prevent failure.

4. Temporary or permanent seeding and mulch shall be applied to the dike within 15 days of construction.

5. The dike should be located to minimize damages by construction operations and traffic. (Virginia, 1980, p. III-41)

Maintenance Considerations. The measure shall be inspected after every storm and repairs made to the dike, flow channel and outlet, as necessary. Approximately once every week, whether a storm has occurred or not, the measure shall be inspected and repairs made if needed. Damages caused by construction traffic or other activity must be repaired before the end of each working day. (Virginia, 1980, p. III-42)

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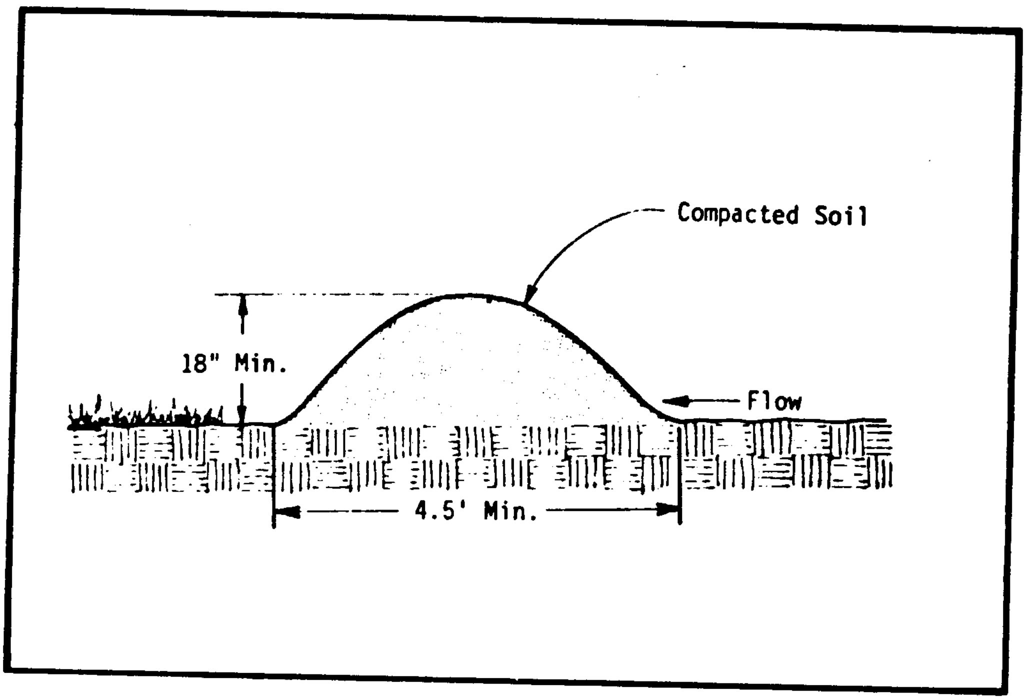
SAMPLE DRAWING: TEMPORARY DIVERSION DIKE



Source: Virginia, 1980.

FIGURE 11

ACTIVE FILL DIVERSION

Definition. A temporary channel with a supporting ridge on the downhill side, cut along the top of an active earth fill.

Purpose. To divert storm runoff away from the unprotected slope of an active fill to a stabilized outlet or sediment-trapping facility.

Conditions Where Practice Applies.

Where the drainage area at the top of an active earth fill slopes toward the exposed slope and where continuous fill operations make the use of a diversion dike unfeasible. This temporary structure should remain in place for less than one week.

Design Considerations.

1. Drainage area: less than five acres.

2. Height: minimum height of ridge will be nine inches.

3. Grade: the channel will have a positive grade to a stabilized outlet or sediment-trapping device, if needed.

4. The diversion shall be constructed at the top of the fill at the end of each work day as needed.

5. The diversion shall be located at least 2 feet inside the top edge of the fill.

6. The supporting ridge of the lower side shall be constructed with a uniform height along its entire length.

Maintenance Considerations. Because the practice is temporary and under most situations will be covered the next work day, the maintenance required should be low. If the practice is to remain in use for more than one day, an inspection will be made at the end of each work day and repairs made to the measure if needed. The contractor should avoid the placement of any material over the structure while it is in use. Construction traffic should not be permitted to cross the diversion. (Virginia, 1980, pp. III-43 - 45)

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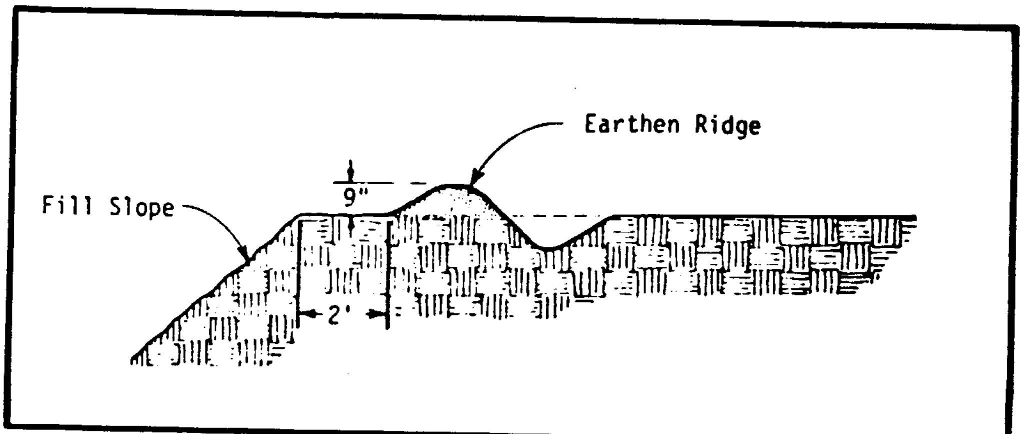
SAMPLE DRAWING: ACTIVE FILL DIVERSIONS



Source: Virginia, 1980.

FIGURE 12

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PERMANENT DIVERSION

Definition. A channel constructed across a slope with a supporting ridge on the lower side. (Virginia, 1980, p. III-51)

Purpose. To reduce slope length and to intercept and divert stormwater runoff to stabilized outlets at non-erosive velocities. (Virginia, 1980)

Conditions Where Practice Applies.

1. Where runoff from higher areas may damage property, cause erosion, or interfere with the establishment of vegetation on lower areas.
2. Where surface and/or shallow subsurface flow is damaging sloping upland.
3. Where the slope length needs to be reduced to minimize soil loss. (Virginia, 1980)

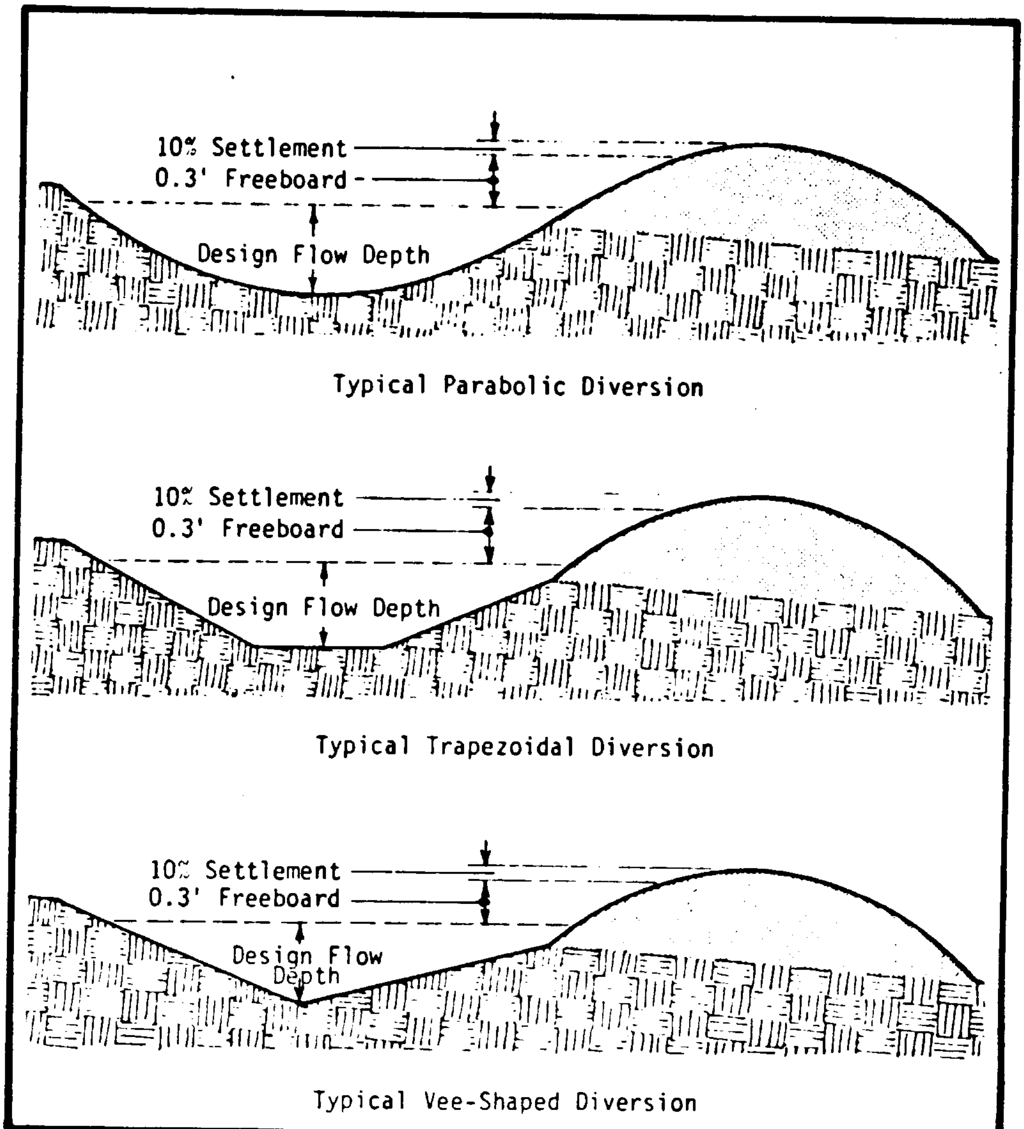
Design Considerations.

1. Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, seepage planes (where seepage is a problem) and the development layout.
2. The channel may be parabolic, trapezoidal or vee-shaped, but must be able to carry the design storm with 0.3 feet of freeboard.
3. The supporting ridge shall incorporate the following design features:
    a. the side slopes shall be no steeper than 2:1;
    b. the width at the design water elevation shall be a minimum of 4 feet;
    c. the minimum freeboard shall be 0.3 foot; and
    d. the design shall include a 10 percent settlement factor.
4. Diversions shall have adequate outlets which will convey concentrated runoff without erosion.
5. Unless otherwise stabilized, the ridge and channel shall be mulched and seeded within 15 days of installation.
6. Disturbed areas draining into the diversion shall be mulched and seeded before or at the time the diversion is constructed. (Virginia, 1980, III-52 & 54)

Maintenance Considerations.

Before final stabilization, the diversion should be inspected after every rainfall. Sediment shall be removed from the ditchline and repairs made as necessary. Seeded areas which fail to establish a vegetative cover shall be reseeded as necessary. Thereafter, a permanent inspection and maintenance program should be followed. (Virginia, 1980)

SAMPLE DRAWING: PERMANENT DIVERSIONS



Source: Virginia, 1980.

FIGURE 13

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PERIMETER BERM OR SWALE

Definition. A temporary dike (berm) or excavated drainageway (swale) along the perimeter of a construction site or disturbed area. (USDA SCS, July 1975, p. 15.01; and Tahoe, Jan. 1978, p. VII-20)

Purpose. To prevent offsite stormwater runoff from entering disturbed areas, and to direct runoff from the sites to sediment-trapping devices. (USDA SCS, July 1975; and Tahoe, Jan. 1978)

Conditions Where Practice Applies. Throughout the entire construction period, from rough grading through permanent stabilization. (USDA SCS, July 1975)

Design Considerations.

1. Berms (Tahoe, Jan. 1978, pp. VII-20 & 21):

   a. .75 - 1.5-inch gravel, covered by plastic sheeting, 6 mils thick;

   b. side slopes not to exceed 2:1 (horizontal to vertical).

2. Swales (USDA SCS, July 1975, pp. 15.01 & 15.02)

   a. drainage area less than five acres.

   b. bottom width: seven feet minimum.

   c. side slopes: 2:1 (horizontal to vertical) or flatter.

   d. stabilization may be required when grade exceeds two percent or where regular traffic crossings occur.

3. Experience in Colorado has shown that hand-dug diversion ditches have less negative impacts on soil stability than machine-dug ditches, and that they are easier to maintain than berms. (Johnson & Fifer, undated, p. 41)

Maintenance Considerations. Periodic inspections should be made and repairs made as needed. More frequent inspections should occur during the wet season.

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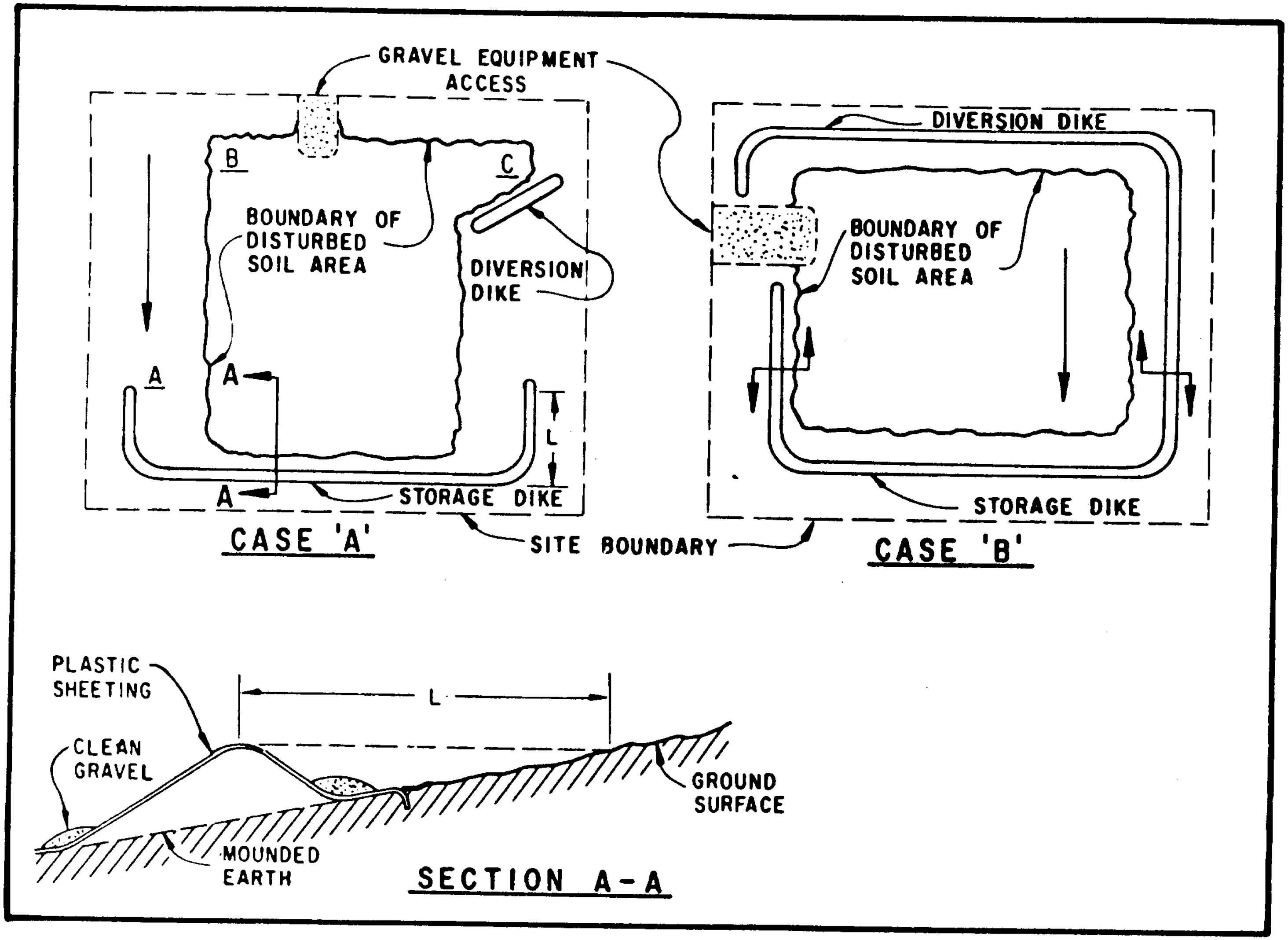
SAMPLE DRAWING: PERIMETER BERMS



Source: White and Franks, 1978.

FIGURE 14

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RIGHT-OF-WAY DIVERSIONS

Definition. Temporary berms or swales located across disturbed areas or graded rights-of-way.

Purposes. To shorten the length of exposed slopes, thereby reducing the potential for erosion, by intercepting stormwater runoff and diverting it to a stabilized outlet or sediment-trapping device. (USDA SCS, July 1975, p. 14.01)

Conditions Where Practice Applies. Across disturbed rights-of-way, such as for roads or pipelines, or disturbed areas such as graded parking lots or earth fills. Drainage swales, or dips, are not recommended when the slope exceeds 10 percent (1:10). (Amimoto, May 1978, p. 108) The berms, also known as interceptor dikes or water bars, may be composed of compacted soil and stabilized with asphalt. (Amimoto, May 1978, pp. 105 & 106) An alternative measure is a filter berm.

Design Considerations.

1. Berms (Amimoto, May 1978, p. 105):

   a. minimum height: 1.5 feet;

   b. minimum top width: 2 feet;

   c. maximum side slopes: 2:1 (horizontal to vertical); and

   d. spacing: to vary with erosion hazard and uphill slope (White & Franks, 1978, p. 170).

2. Swales (USDA, July 1975, p. 14.01):

   a. minimum bottom width: 7 feet;

   b. minimum depth: 1 foot;

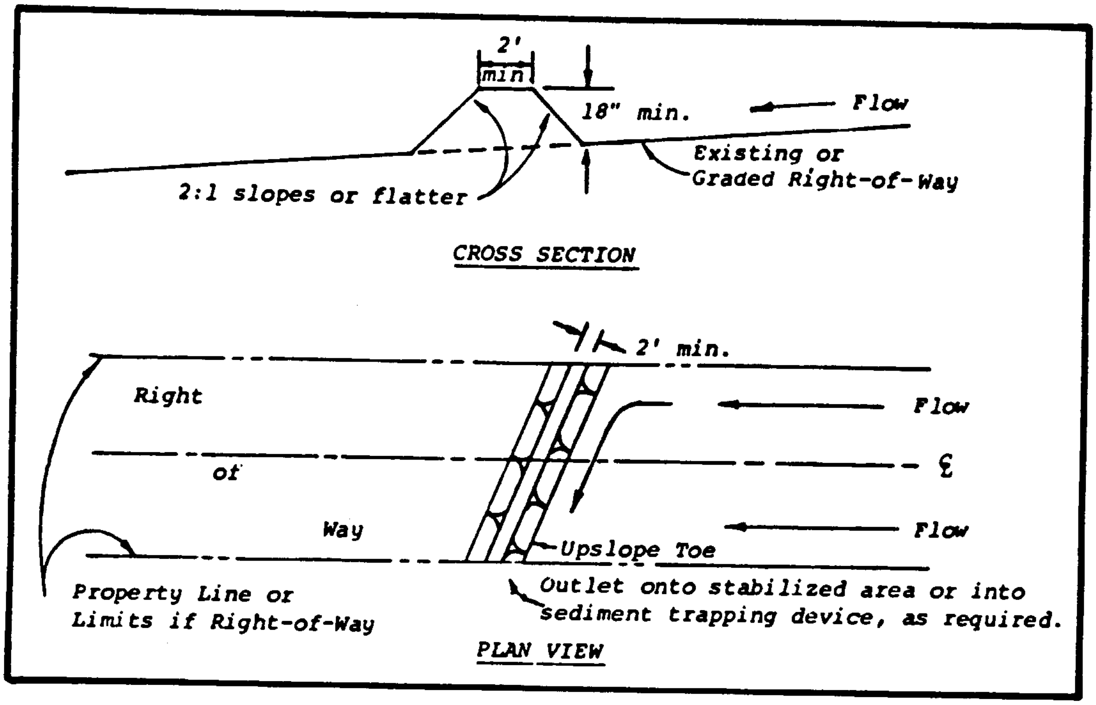
   c. maximum side slopes: 2:1; and

   d. stabilization: gravel or grass may be required.

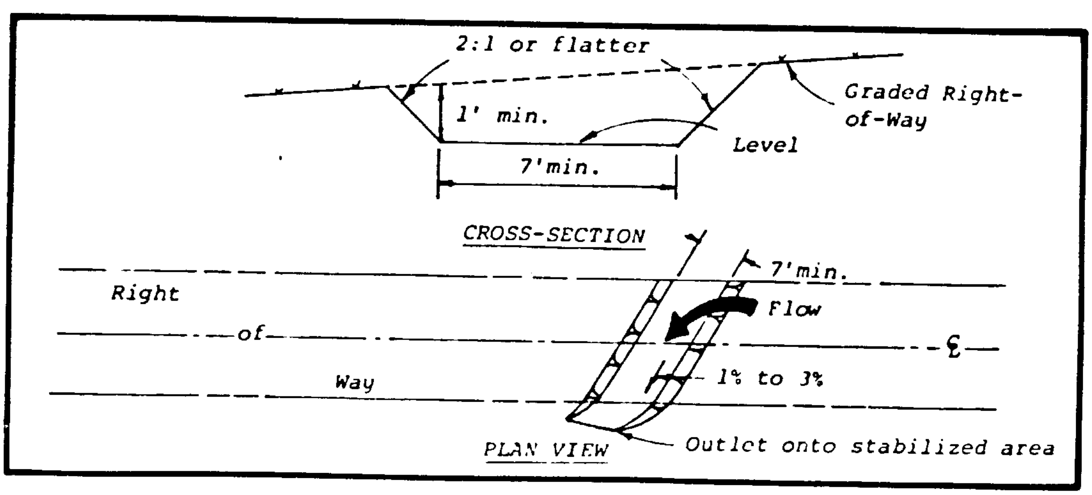
3. All measures shall have a positive grade to a stabilized outlet or to a sediment-trapping device.

Maintenance Considerations. Periodic inspection shall be made as needed. More frequent inspections should be made during the rainy season.

SAMPLE DRAWING: INTERCEPTOR DIKE



SAMPLE DRAWING: INTERCEPTOR SWALE



Source: USDA SCS, July 1975.

FIGURE 15

ROADSIDE DITCHES

Definition. A permanent side ditch adjoining the shoulder of a road.

Purpose. To carry excess road runoff and to prevent erosion from uncontrolled surface flows along roadway.

Conditions Where Practice Applies. To be used only in limited locations where surface runoff from the adjacent roadway surface exceeds the gutter capacity or where gutters are inappropriate or not required. This method of drainage control is not be used as a major drainage channel. Associated practices are right-of-way diversions, and check dams.

Design Considerations. Ditch sections should be designed in conformance with applicable standards. Depending on expected velocity of flow, the ditch can be unlined (less than 2 cfs) or lined (greater than 2 cfs) with riprap, grouted stone, asphalt, concrete or vegetation, as appropriate.

Maintenance Considerations. Periodic inspections should be made as needed. (Tahoe, Jan. 1978, p. IX-17)

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STORMWATER CHANNELS

Definition. A permanent, designed waterway, shaped and lined with appropriate vegetation or structural material to safely convey excess stormwater runoff away from a developing area. (Virginia, 1980, p. III-101)

Purpose. To provide for the disposal of concentrated surface runoff without damage from erosion. (Virginia, 1980)

Conditions Where Practice Applies. Generally applicable to man-made channels, including roadside ditches, and intermittent natural channels that are modified to accomodate increased flows generated by land development. This practice is not generally applicable to major natural streams. (Virginia, 1980)

Planning Considerations. The design of a channel cross section and lining is based primarily upon the volume and velocity of flow expected in the channel. If conditions are appropriate, grass, other vegetative linings or riprap channels may be used. Where high velocities cannot be avoided, structural stabilization with concrete will be required.

Besides the primary design considerations of capacity and velocity, a number of other important factors should be taken into account when selecting a cross section and lining. These factors include land availability, compatibility with land use and surrounding environment, safety, maintenance requirements, and outlet conditions.

1. Vee-shaped ditches are generally used where the quantity of water to be handled is relatively small, such as along roadsides. A grass or sod lining will suffice where velocities in the ditch are low. For steeper slopes where high velocities are encountered, a concrete or asphaltic concrete lining may be appropriate.

2. Parabolic channels are often used where the quantity of water to be handled is larger and where space is available for a wide, shallow channel with low velocity flow. Riprap should be used where higher velocities are expected and where some dissipation of energy (velocity) is desired. Combinations of grass and riprap are also useful where there is a continuous low flow in the channel.

3. Trapezoidal channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity. Trapezoidal ditches are generally lined with concrete or riprap.

4. Outlet conditions for all channels should be considered. This is particularly important for the transition from a man-made lining such as concrete to a vegetative lining. Appropriate measures must be taken to dissipate the energy of the flow to prevent scour of the receiving channel. (Virginia, 1980, p. III-102) (See Outlet Protection.)

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Maintenance Considerations.

Grass-lined Channels

During the initial establishment, grass-lined channels should be repaired immediately and grass re-established if necessary. After grass has become established, the channel should be checked periodically to determine if the grass is staying in place. If the channel is to be mowed, it should be done in a manner that will not damage the grass.

Riprap-lined Channels

Riprap-lined channels should be checked periodically to ensure that scour does not occur beneath the riprap layer. The channel should also be checked to determine that the stones are not dislodged by the flow.

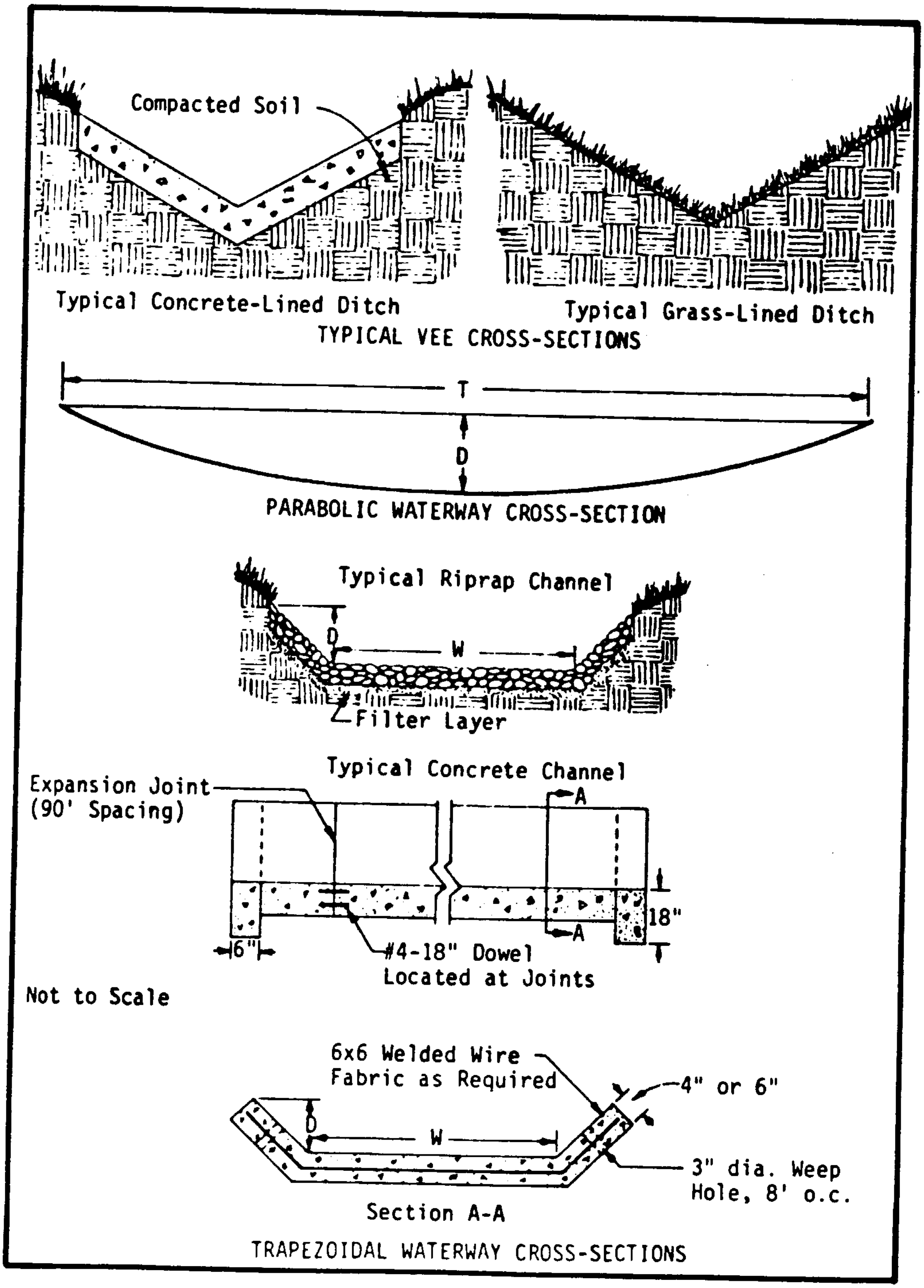
Concrete-lined Channels

Concrete-lined channels should be checked periodically to ensure that there is no undermining of the channel or erosion adjacent to the side walls. Particular attention should be paid to the outlet of the channel. If scour is occurring at the outlet, appropriate energy dissipation measures should be taken.

Sediment Deposition

If the channel is below a high sediment-producing area, sediment should be trapped before it enters the channel. If sediment is deposited in grass-lined channels, it should be removed promptly to prevent damage to the grass. Sediment deposited in riprap and concrete-lined channels should be removed when it reduces the capacity of the channel. (Virginia, 1980, pp. III-109 & 110)

SAMPLE DRAWING: STORMWATER CHANNELS



Source: Virginia, 1980.

FIGURE 16

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INFILTRATION TRENCHES

Definition. A permanent ditch filled with gravel and rock used to increase infiltration of runoff from impervious surfaces.

Purpose. Increases infiltration and thereby reduces runoff volume and velocity from impervious surfaces.

Conditions Where Practice Applies. Where any extensive area of impervious surfaces is used, such as paved parking lots. The trench should be designed to operate as part of a total stormwater management system on a project. Not recommended for sediment trapping alone.

Design and Maintenance Considerations.

1. Provision should be made for overflow into a stormdrain system in case of failure of the trench because of clogging by deposited sediments, or storm intensities greater than the design storm.

2. Use of sediment traps upstream can increase life expectancy of the trench.

3. Provision should be made for periodic removal of gravel-rock backfill and sediment. (White and Franks, 1978, pp. 170 & 171)

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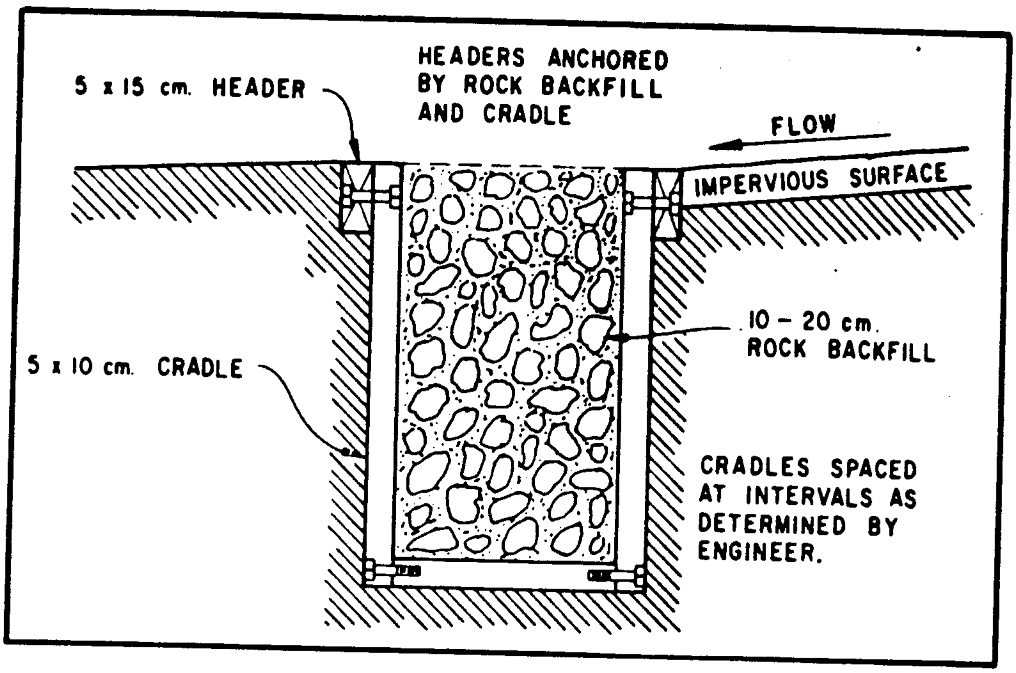
SAMPLE DRAWING: INFILTRATION TRENCH



Source: White and Franks, 1978.

FIGURE 17

SLOPE DRAIN

Definition. A temporary installation of conduit or flexible tubing extending from the top to the bottom of a cut or fill slope. (Virginia, 1980, III-89)

Purpose. To conduct concentrated stormwater runoff safely down the face of a slope without causing erosion problems on or below the slope. (Virginia, 1980)

Conditions Where Practice Applies. On cut or fill slopes before permanent stormwater drainage structures are installed. Can be used in association with diversion dikes above the slope, and outlet protection at the base. (Virginia, 1980)

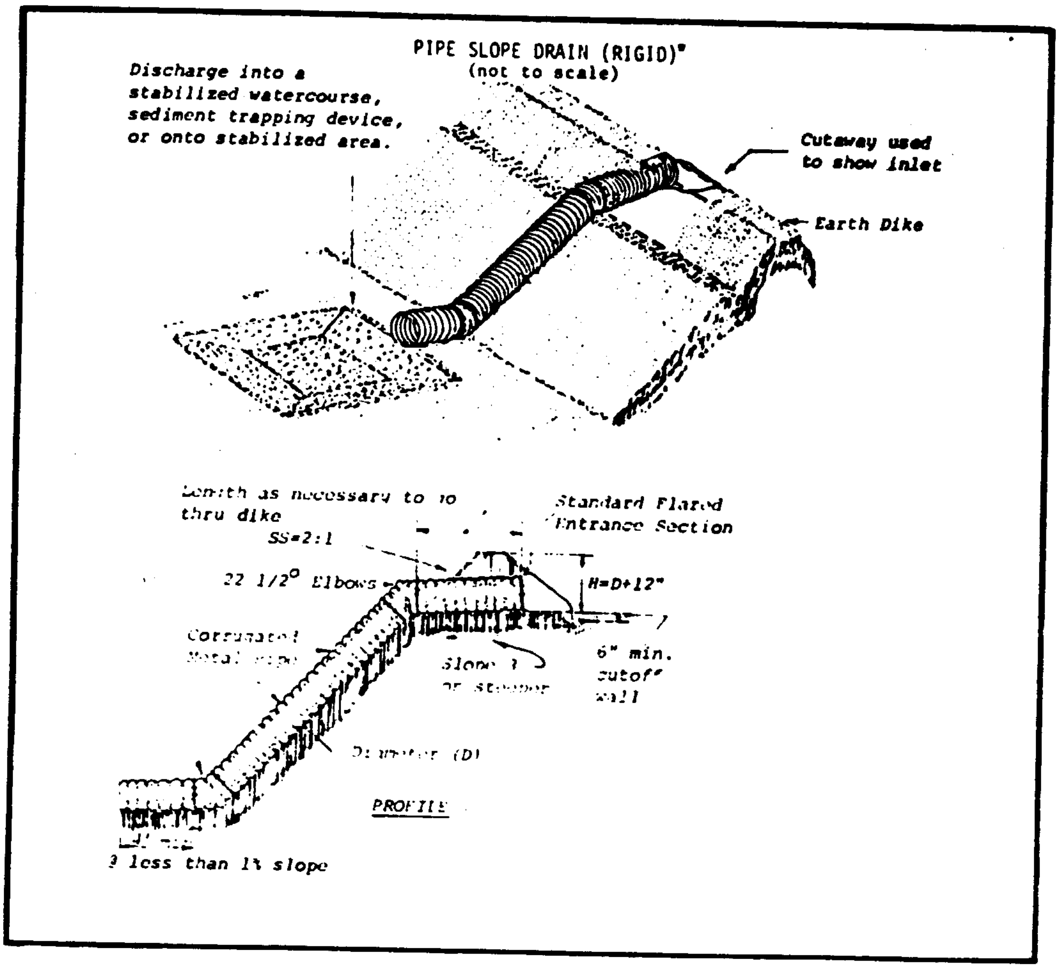
Design and Maintenance Considerations.

1. It is important that these temporary structures be installed properly and maintained since their failure will often result in severe gully erosion. The entrance section must be securely entrenched, all connections must be watertight, and the conduit must be staked securely. (Virginia, 1980, p. III-90)

2. The outlet of the slope drain must be protected from erosion. Often an energy dissipating device is required. (The Irvine Company, 1975, p. 19)

3. Slope drains can be made of flexible tubing or corrugated metal pipe. The flexible tubing must be securely anchored to the slope at regular intervals not to exceed 10 feet, and must be inspected regularly to ensure that it has not been torn or twisted. (Virginia, 1980, III-90)

SAMPLE DRAWING: PIPE SLOPE DRAIN



Source: USDA SCS, July 1975.

FIGURE 18

(See pp. 23-25 and 83 for examples of inlets, and pp. 48 and 49 for examples of outlets.)

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R0054270

CHUTES AND FLUMES

Definition. A temporary or permanent open, lined channel constructed on a slope. (Virginia, 1980, p. III-95)

Purpose. To conduct concentrated stormwater runoff safely down the face of a slope without causing erosion problems on or below the slope. (Virginia, 1980)

Conditions Where Practice Applies. Where flow must be conveyed down a cut or fill slope. The maximum recommended drainage area is 36 acres. (USDA SCS, July 1975, p. 18.01)

Design Considerations.

1. The width and depth of the chute or flume will depend on the contributing drainage area. (USDA SCS, July 1975, p. 18.02)

2. The outlet must be protected and an energy dissipating device installed if necessary to prevent downstream erosion. (USDA SCS, July 1975)

3. The channel must be lined with non-erosive material such as concrete. (USDA SCS, July 1975)

4. The structure shall be placed on a firm foundation such as undisturbed soil or compacted fill. It must be tied in with the appropriate diversion and outlet facilities. (USDA SCS, July 1975)

Maintenance Considerations. A permanent schedule for inspection and maintenance should be required for a permanent structure. Periodic inspections of temporary structures is also necessary.

FIGURE 19. Concrete chute. Proper design and maintenance of diversion facilities at chute entrance reduces the chance of undermining the structure. (Courtesy Dept. of Fish and Game)

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OUTLET PROTECTION

Definition. Temporary or permanent structurally lined aprons or other acceptable energy dissipating devices placed at the outlets of pipes or paved channel sections. (Virginia, 1980, III-127)

Purpose. To prevent scour at stormwater outlets and to minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows. (Virginia, 1980)

Conditions Where Practice Applies. Applicable to the outlets of all pipes and paved channel sections where the velocity of flow at design capacity of the outlet will exceed the permissible velocity of the receiving channel or area. (Virginia, 1980)

Planning Considerations.

1. The most commonly used device for outlet protection is a structurally lined apron. These aprons are generally lined with riprap, grouted riprap, or concrete. They are constructed at a zero grade for a distance which is related to the outlet flow rate and the tailwater level. (Virginia, 1980, III-128)

2. Experience in Colorado has shown that straw bales and silt fences were adequate protection below 8-inch pipes, but rock riprap was required even for temporary outlet protection below larger diameter culverts. (Johnson and Fifer, undated, p. 46)

3. If the outlet discharges into a well-defined channel, the side slopes of the channel should not be steeper than 2:1. (Virginia, 1980, III-130)

4. The apron should be located so that there are no bends in the horizontal alignment. (Virginia, 1980)

Maintenance Considerations. Inspection and repair requirements will vary depending on construction material.

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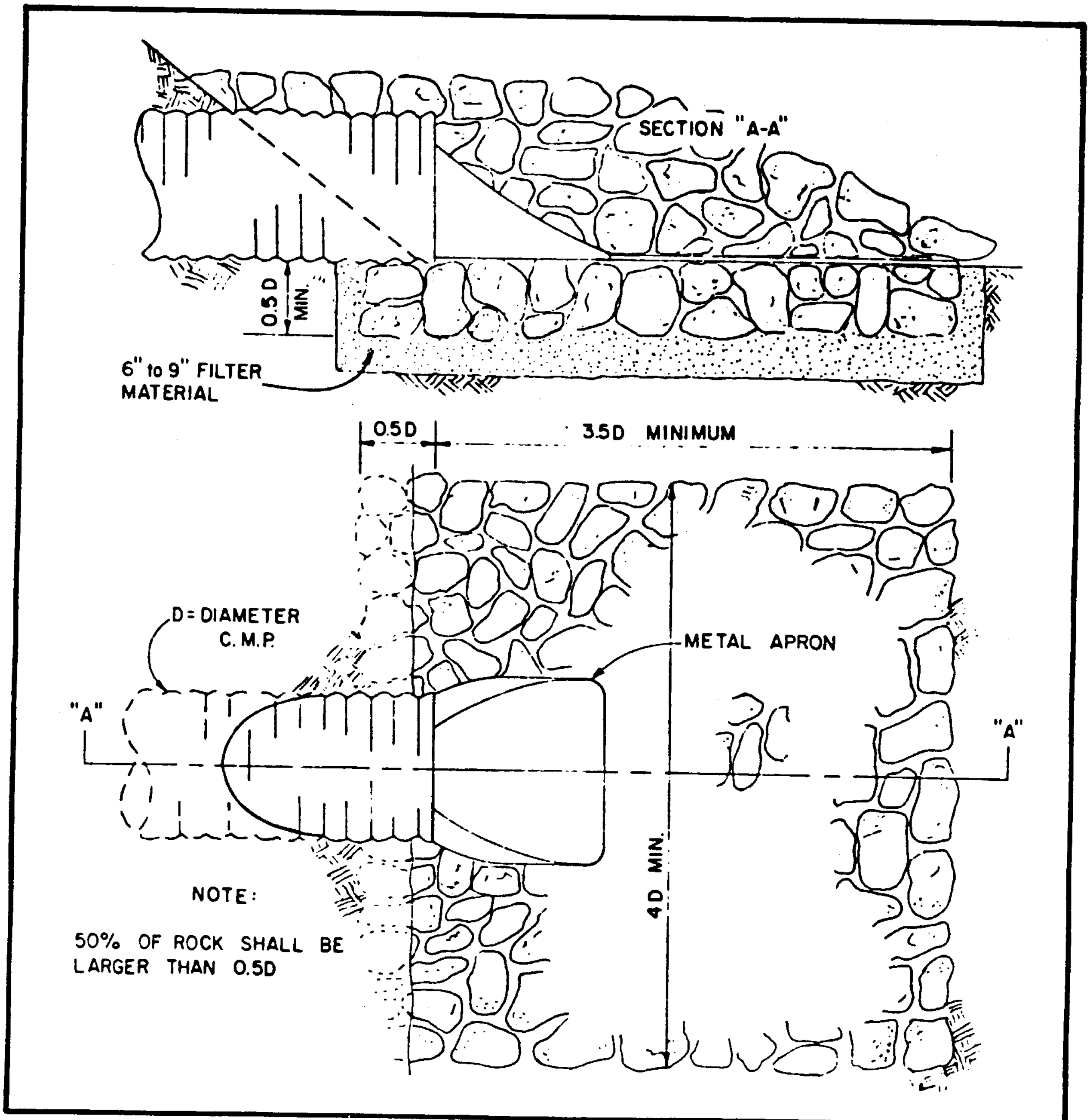
SAMPLE DRAWING: ROCK APRON OUTLET



Source: Tahoe, Jan. 1978.

FIGURE 20

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LEVEL SPREADER

Definition. A temporary or permanent stable outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope. (Virginia, 1980, p. III-161)

Purpose. To convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation. (Virginia, 1980)

Conditions Where Practice Applies. Where sediment-free storm runoff is intercepted and diverted away from graded areas onto undisturbed stabilized areas. This practice applies only in those situations where the spreader can be constructed on undisturbed soil and the area below the level lip is stabilized by natural vegetation. The water should not be allowed to reconcentrate after release. (Virginia, 1980) Usually used in association with a temporary diversion dike or a temporary right-of-way diversion. Can also be used at outlet of stabilized area such as a paved parking area. Can be used in conjunction with stormwater management practices to increase infiltration, thereby reducing runoff volume and velocity.

Design Considerations.

1. Length is determined on the basis of expected flow (in cfs) from the design storm. (Virginia, 1980, III-162)
2. Minimum width is six feet, and minimum depth is six inches. (Virginia, 1980)
3. The grade of the channel entering the spreader shall be less than or equal to 1 percent for the last 20 feet before discharge. (Virginia, 1980)
4. The spreader should not be constructed on fill material. (Virginia, 1980, p. III-163; also USDA SCS, July 1975, p. 37.02)
5. Runoff should not be allowed to reconcentrate below the spreader. (Virginia, 1980, p. III-164)
6. Spreaders should not be constructed on slopes exceeding 3:1 (horizontal to vertical). (Tahoe, Jan. 1978, p. VIII-6)

Maintenance Considerations.

The measure shall be inspected after every rainfall and repairs made if required. The contractor should avoid the placement of any material on and prevent construction traffic across the structure. If the measure is damaged by construction traffic, it shall be repaired immediately. (Virginia, 1980, p. III-164)

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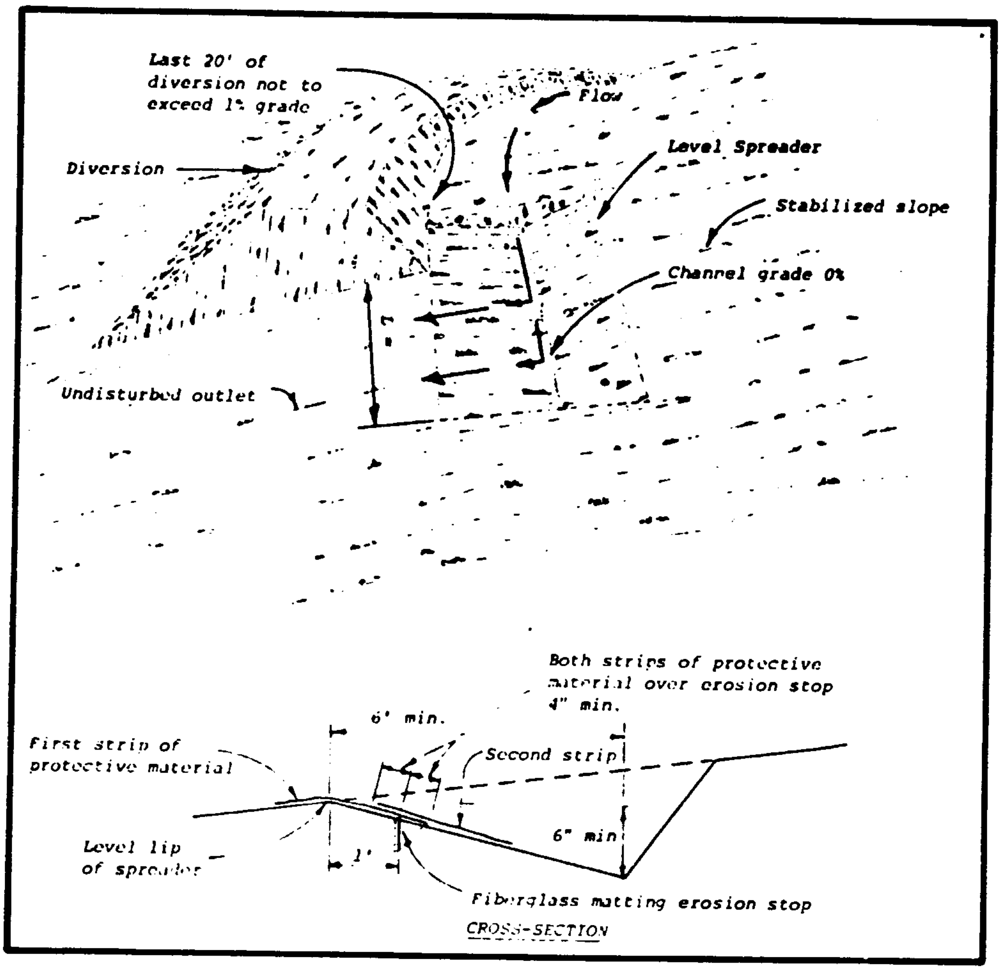
SAMPLE DRAWING: LEVEL SPREADER



Source: USDA SCS, July 1975.

FIGURE 21

RIPRAP

Definition. A permanent, erosion-resistant ground cover of large, loose, angular stone. (Virginia, 1980, p. III-137)

Purposes.

1. To protect the soil surface from the erosive forces of concentrated runoff.

2. To slow the velocity of concentrated runoff while enhancing the potential for infiltration.

3. To stabilize slopes with seepage problems and/or non-cohesive soils. (Virginia, 1980)

Conditions Where Practice Applies.

To soil-water interfaces where the soil conditions, water turbulence and velocity, or expected vegetative cover are such that the soil may erode under the design flow conditions. Riprap may be used, as appropriate, at stormdrain outlets, on channel banks and/or bottoms, roadside ditches, drop structures, and at the toe of slopes. (Virginia, 1980)

Design Considerations.

1. Graded vs. Uniform Riprap. Riprap is classified as either graded or uniform. A sample of graded riprap would contain a mixture of stones which vary in size from small to large. A sample of uniform riprap would contain stones which are all fairly close in size.

   For most applications, graded riprap is preferred to uniform riprap. Graded riprap forms a flexible self-healing cover, while uniform riprap is more rigid and cannot withstand movement of the stones. Graded riprap is cheaper to install, requiring only that the stones be dumped so that they remain in a well-graded mass. Hand or mechanical placement of individual stones is limited to that necessary to achieve the proper thickness and line. Uniform riprap requires placement in a more or less uniform pattern, requiring more hand or mechanical labor. (Virginia, 1980, p. III-138)

2. Sequence. Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate. (Virginia, 1980, p. III-139)

3. Filter Blankets. A filter blanket is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. A filter blanket can be of two general forms:

a gravel layer or a plastic filter cloth. No filter blanket is necessary for riprap used as stormdrain outlet protection. (Virginia, 1980, pp. III-141 & 142)

Maintenance Considerations. Properly installed riprap should require very little maintenance. It should be inspected periodically, and repaired if needed. (Virginia, 1980, p. III-143)

STREAMBANK STABILIZATION

Definition. Methods of stabilizing the banks of streams using structural or vegetative measures, or a combination of both. (Virginia, 1980, p. III-175)

Purpose. To protect streambanks from erosion. (Virginia, 1980)

Conditions Where Practice Applies. Use in streambank sections that are subject to erosion because of disturbance during construction or increased flows after construction. (Virginia, 1980)

Design Considerations.

1. Types of structural measures:

   Riprap - heavy, angular stone placed or dumped onto the streambank to provide armor protection against erosion.

   Gabions - these rectangular rock-filled wire baskets are pervious, semi-flexible building blocks which can be used to armor the bed and/or banks of channels or to divert flow away from eroding channel sections.

   Deflectors (groins or jetties) - Structural barriers which project into the stream to divert flow away from eroding streambank sections.

   Reinforced Concrete - may be used to armor eroding sections of the streambank by constructing retaining walls or bulk heads. Positive drainage behind these structures must be provided. Reinforced concrete may also be used as a channel lining.

   Log Cribbing - a retaining structure built of logs to protect streambanks from erosion. Log cribbing is normally built on the outside of stream bends to protect the streambank from the impinging flow of the stream.

   Grid Pavers - modular concrete units with interspersed void areas which can be used to armor the streambank while maintaining porosity and allowing the establishment of vegetation. These structures may be obtained in precast blocks or mats, or they may be formed and poured in place. Design and installation should be in accordance with manufacturer's instructions. (Virginia, 1980, III-177)

   Revetments - a wall of stone or concrete, or a fence of flexible material, such as wire mesh, along the outside of stream bends; used to protect the bank from high velocity flows.

2. Types of vegetative measures:

   Sod Walls - sod blocks are piled, tilting slightly toward bank, and backfilled with soil. Used to stabilize terraces.

   Woven Willow (Wattling) - live willow branches are interwoven with anchored willow poles and sticks, forming short fences along the bank parallel to the streambed.

Brush Layers - live branches are planted in ditches dug parallel to stream. (Tourbier & Westmacott, Apr. 1974, pp. 107 and 108)

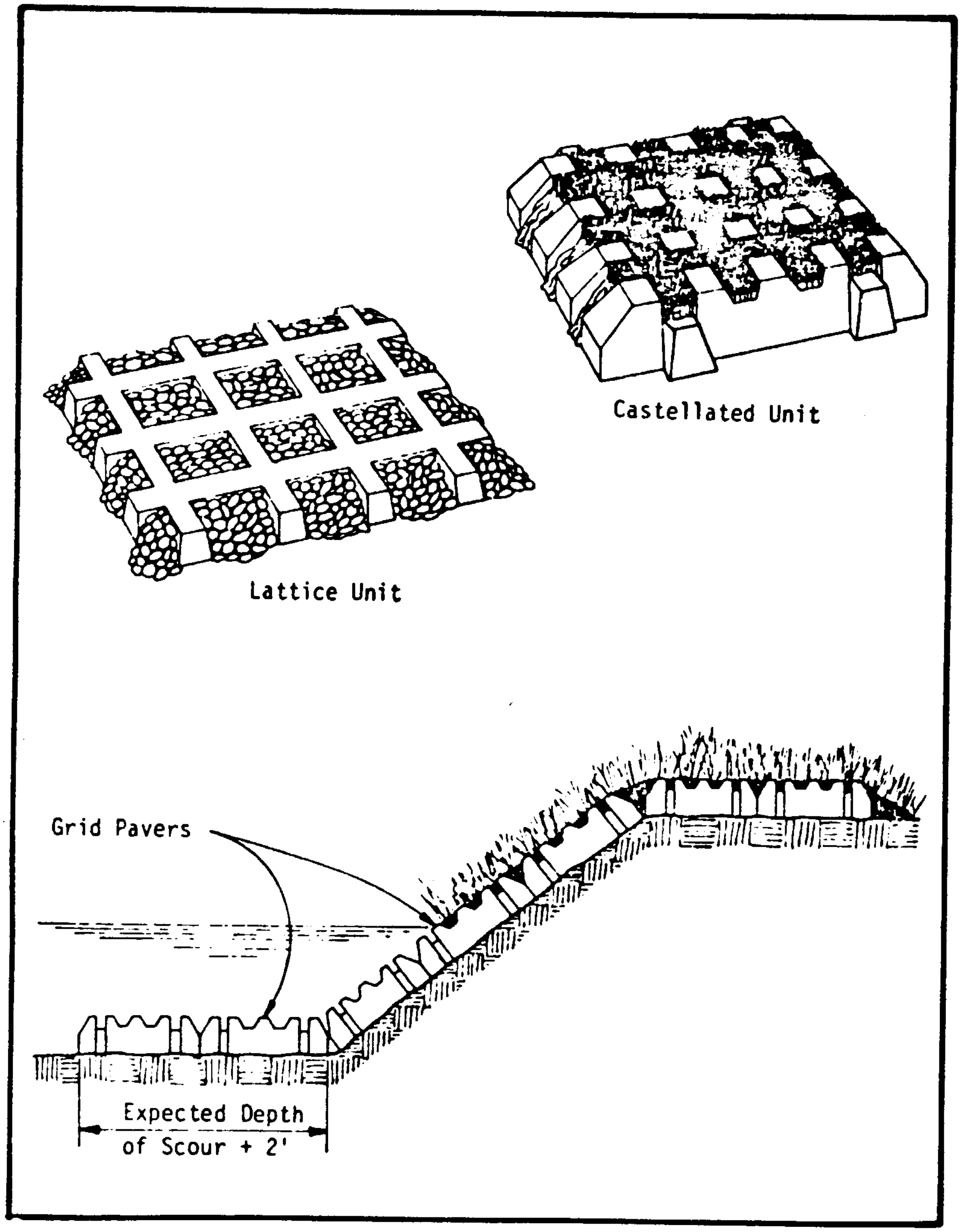
Sprigging - planting runners of mat-type grass, such as bermuda grass.

Maintenance Considerations. All structures should be maintained in an "as-built" condition. Structural damage caused by storm events should be repaired as soon as possible to prevent further damage to the structure or erosion of the streambank. Vegetation should be re-established if damaged during high flows or by other causes. (Virginia, 1980, p. III-177)

FIGURE 22. An unstabilized stormwater channel. Note over-steepened banks. (Courtesy Dept. of Fish and Game)

FIGURE 23. Stormwater channel with right bank stabilized by vegetation. (Courtesy Dept. of Fish and Game)

SAMPLE DRAWING: GRID PAVERS



Source: Virginia, 1980.

FIGURE 24

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GRADE CONTROL STRUCTURES

Definition. Structures which reduce and maintain the channel gradient. Examples include drop structures, check dams, and erosion checks. (Amimoto, May 1978, p. 125)

Purpose. By reducing the channel gradient, the runoff velocities decrease, thus preventing erosion at higher flows. (Amimoto, May 1978)

Conditions Where Practice Applies.

1. Drop Structures - In man-made channels which must traverse long, relatively steep slopes without large increases in the flow velocity. In natural channels which have long or relatively steep sections and which, as a result of construction activities, are expected to experience channel erosion problems. (Virginia, 1980, p. III-155)

2. Check Dams - This practice is limited to use in small open channels which drain 10 acres or less. It should not be used in a live stream. Some specific applications are illustrated by the following examples.

   a. Temporary ditches or swales which, because of their short length of service, cannot receive a nonerodible lining but still need some protection to reduce erosion.

   b. Permanent ditches or swales which for some reason cannot receive a permanent nonerodible lining for an extended period of time.

   c. Either temporary or permanent ditches or swales which need protection during the establishment of grass linings. (Virginia, 1980, pp. III-151 and 152)

   Alternative measures in small drainageways are silt fences and sediment barriers such as sand or gravel bags.

3. Erosion Checks - Used in areas that are susceptible to rill erosion, such as swales or shallow ditches, or on critical slopes subject to severe sheetflow. They are generally located at stress joints in swales and ditches where the gradient changes or tributary inflow occurs. (The Irvine Company, 1975, pp. 20 & 21)

Design and Maintenance Considerations.

1. Drop Structures - Waterway drop structures are expensive, permanent structures and consequently should be designed by a qualified engineer. When locating the structure, attention should be given to changed water elevations which will result and their effect upon adjacent areas. Waterway drop structures of this type are most cost effective where the design flow is 100 cfs or greater and the drop in elevation across the structure is less than 10 feet. (Virginia, 1980, p. III-156)

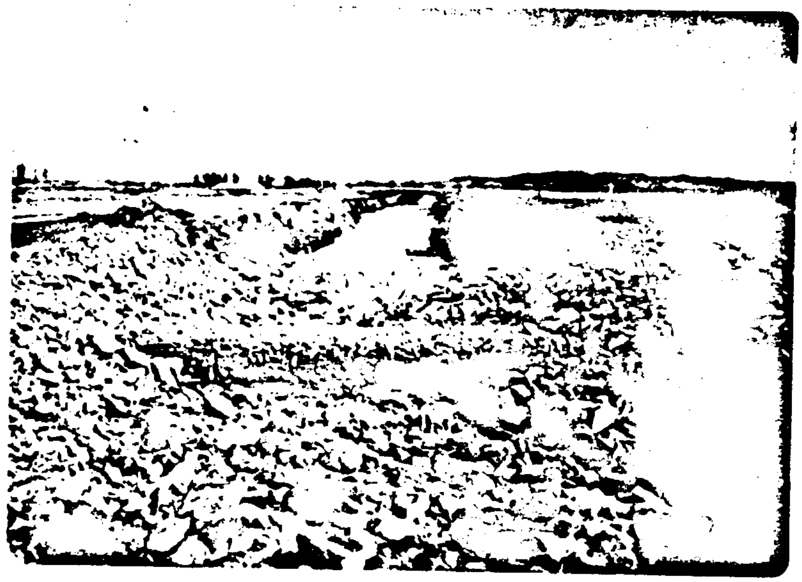
   Once the drop structure is built and the area around it stabilized, maintenance should be minimal. Immediately after construction, the channel should be checked for scour above and below the structure. Periodic inspections should be made to check for cracking of the concrete, uneven settlement, and piping around the structure. (Virginia, 1980, p. III-160)

2. Check Dams - Check dams can be constructed of either stone or logs. Stone generally must be purchased, but is cheaper to install because it requires little hand labor. Stones should be a minimum 2 - 3-inch diameter. The cross section of the ditch or swale should be covered completely, with the center of the dam lower than the edges. (Virginia, 1980, p. III-152)

   Provision must be made for removal of the dam if it is used as a temporary structure. Regular inspections should be made of the dams during the rainy season, and sediment removed when it reaches half the height of the dam. (Virginia, 1980, p. III-154)

3. Erosion Checks - Composed of flexible, porous, long-lived mats of fiberglass, plastic or jute buried in vertical slit trenches. A cap strip should extend two feet upstream and downstream of the erosion check. They should be installed immediately after final grading and before seeding. The checks should be inspected for erosion, and replaced or repaired as necessary. (Amimoto, May 1978, p. 128; also The Irvine Company, 1975, pp. 20 & 21)

FIGURE 25. Grade control structures composed of gravel bags and plastic pipe. (Courtesy The Irvine Company)



FIGURES 26 AND 27. Gabions used as grade control structures. (Courtesy Dept. of Fish and Game)

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STREAM CROSSINGS

Definition. Temporary, nonerodible road crossings used by construction traffic. Structures may include bridges, culverts, pipe arches or paved fords. (Virginia, 1980, p. III-183; Amimoto, May 1978, p. 146)

Purpose. To provide a means for construction traffic to cross flowing streams without damaging the channel or banks; and to keep sediment generated by construction traffic out of a stream. (Virginia, 1980)

Conditions Where Practice Applies. Bridges, culverts and spans are generally applicable to small, flowing streams. (Virginia, 1980). Paved fords are frequently used at crossings subject to flash floods, seasonal storm runoff peaks, or frequent heavy passage of debris. This type of structure is less expensive than raising the grade of the road and installing a bridge or culvert. (Amimoto, May 1978, p. 146) However if a permanent bridge will be part of the completed project, it should be constructed as soon as possible, avoiding the need for a temporary stream crossing.

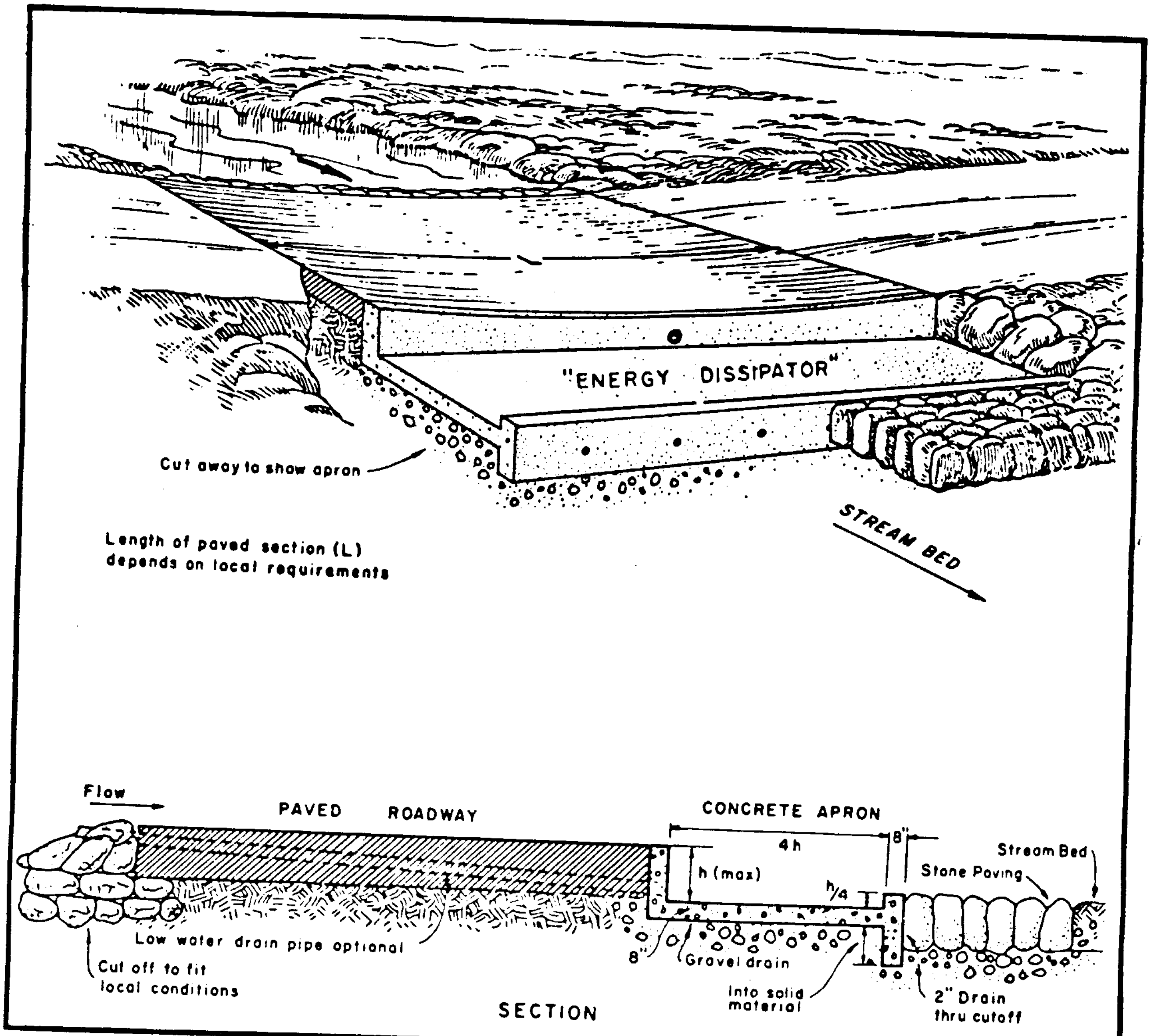
Design and Maintenance Considerations.

1. Bridges and culverts are channel constrictions which can cause flow backups or washouts during periods of high flow. For this reason, the temporary nature of stream crossings is stressed. They should be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed. The structures should be designed by a qualified civil engineer based on best available estimates of hydrology and sediment or debris hazard, and on adequate geotechnical information. (Virginia, 1980, p. III-184) Structures should be inspected after every rainfall and at least once a week, whether it has rained or not, and all damages repaired immediately. (Virginia, 1980, III-186)

2. A paved ford may cause less disturbance of stream flow regime, but it cannot be removed easily after construction. Because the roadbed is not raised above the channel, care must be taken to avoid the tracking or washing of sediment onto the paved ford. Associated practices could include gravelled approaches and filter berms. After construction, little maintenance of the ford should be required.

3. Permits to install stream crossings may be required by the Corps of Engineers and California Fish and Game.

SAMPLE DRAWING: PAVED FORD



Source: Amimoto, May 1978.

FIGURE 28

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FIGURE 29. A temporary stream crossing using conduit and fill. Fill slopes should be stabilized with riprap. (Courtesy Dept. of Fish and Game)

VEGETATION PROTECTION

Definition. Temporary methods of preventing disruption by construction activities of natural or planted vegetation.

Purpose. To minimize the extent of land disturbance and retain natural sediment control.

Conditions Where Practice Applies. Any area where construction activity disturbs the land to the extent of reducing protective vegetation, compacting soil, or otherwise causing deterioration of the environment. (Tahoe, Jan. 1978, p. I-21) Vegetation protection can be especially important along streamcourses and drainage ways.

Design Considerations.

1. Trees can be protected from traffic with temporary measures such as fences. They can be protected from cut and fill activities by using dry wells, retaining walls or drain tiles as appropriate. (USDA SCS, July 1975, pp. 58.04 & 58.05)

2. Buffer strips, or vegetative filter strips, can act as a natural sediment trap. Filter strips can be either natural or planted. Tall, dense stands of grass are the most effective sediment traps. Minimum width of strips should be 15 feet plus 1/2 of channel width above diversions, and 100 feet along flowing streams. (Amimoto, May 1978, p. 152)

3. Traffic control is the restriction of construction traffic to predetermined routes according to types and numbers of vehicles anticipated. Associated practices are road stabilization and stream crossings. (Tahoe, Jan. 1978, p. I-21)

VOL 12

VEGETATION ESTABLISHMENT

Definition. The selection and use of appropriate plants as a temporary or permanent erosion control measure.

Purpose. To provide protection to slopes, drainageways or other disturbed areas that are subject to sheetflows or low-velocity flows.

Conditions Where Practice Applies.

1. Temporary plantings are used where grading operations are not completed and will be resumed within five years, or where grading operations are complete but a rapid-growing ground cover is needed before permanent vegetation can be established. (The Irvine Company, 1975, p. 32)

2. Permanent plantings are generally made after construction is completed. Irrigation may be required for establishing and sustaining vegetation.

3. If used alone, vegetative erosion control methods can be expected to achieve a considerable degree of success on less than severe slopes (less than 2:1) where drainage control is not a problem. However, on steeper slopes (greater than 2:1) or areas with drainage problems, permanent vegetative erosion control must be combined with drainage control and mechanical stabilization techniques. (White and Franks, 1978, pp. 148 & 149)

4. The associated practices of mulching, fertilizing, and slope preparation are usually necessary to establish successful plantings. At some sites, irrigation may also be required.

Design and Maintenance Considerations.

1. Selection of appropriate plants should be made by an experienced professional who is knowledgeable in vegetative erosion control measures. Periodic inspections should be made by the designer to ensure that plantings are installed, maintained, and are operating as conceived.

2. Guidelines for selection of appropriate plant materials are contained in Tahoe, Jan. 1978, Chapter XI and in Chan & Burgess, Jan. 1981. Advice on local planting conditions may also be available from the Soil Conservation Service and Caltrans district offices.

3. Methods of revegetation include:

   a. manual broadcasting,
   b. drilling,
   c. hydroseeding,
   d. spot seeding of shrubs,
   e. wattling (see also Streambank Stabilization),
   f. sodding, and
   g. sprigging.

   (Amimoto, May 1978, pp. 47-51, Virginia, 1980, pp. III-231-233)

2 0991

VOL 12

MULCHES

<u>Definition.</u> A temporary medium used to cover exposed soil in order to conserve soil moisture and reduce the erosive force of raindrops.

<u>Purpose.</u> To improve seed germination and plant establishment.

<u>Conditions Where Practice Applies.</u> Any construction area where temporary or permanent plantings will be made. It should be noted that a light application of mulch does not reduce erosion. (U.S. EPA, Dec. 1976, p. 17) Therefore, mulching should be looked on as an associated practice of vegetation establishment, not necessarily as an erosion control measure in itself.

<u>Design and Maintenance Considerations.</u>

1. Types of Mulches

   a. hydromulching (usually done at same time as hydroseeding),

   b. wood chips,

   c. fiberglass roving,

   d. straw,

   e. crushed stone or gravel,

   f. jute matting,

   g. wood excelsior matting

   h. plastic netting.
   (Tahoe, Jan. 1978, pp. V-i & ii; Amimoto, May 1978, p. 66)

   Chemicals and tackifiers are often considered mulches although they may inhibit plant growth by reducing soil porosity.

2. Mulches may have to be reapplied or repaired if vegetation is not successfully established.

2 0992

VOL 12

TOPSOILING

Definition. Methods of preserving and using topsoil to enhance final site stabilization with vegetation.

Purpose. To provide a suitable growth medium for final site stabilization with vegetation.

Conditions Where Practice Applies.

1. Where the preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium.

2. Where the subsoil or existing soil presents the following problems:

   a. the texture, pH, or nutrient balance of the available soil cannot be modified by reasonable means to provide an adequate growth medium.

   b. the soil material is too shallow to provide an adequate root zone and to supply necessary moisture and nutrients for plant growth.

   c. the soil contains substances potentially toxic to plant growth.

3. Where high-quality turf is desirable to withstand intense use or meet aesthetic requirements.

4. Where ornamental plants will be established.

5. Only on slopes that are 2:1 or flatter.

6. Topsoiling, like mulching, should be viewed as an associated practice of vegetation establishment, not as a sediment control measure by itself.

Design Considerations. Topsoil is the surface layer of the soil profile, generally characterized as being darker than the subsoil due to the presence of organic matter. It is the major zone of root development, carrying much of the nutrients available to plants, and supplying a large share of the water used by plants.

Although topsoil provides an excellent growth medium, there are disadvantages to its use. Stripping, stockpiling, and reapplying topsoil, or importing topsoil, may not always be cost-effective. Topsoiling can delay seeding or sodding operations, increasing the exposure time of denuded areas. Most topsoil contains weed seeds, and weeds may compete with desirable species.

Advantages of topsoil include its high organic matter content and friable consistence, water-holding capacity, and nutrient content. (Virginia, 1980, pp. III-207 & 208)

2 0993

VOL 12

SLOPE PREPARATION--SCARIFYING

Definition. Providing a rough soil surface with horizontal depressions created by operating a tillage or other suitable implement on the contour. (Virginia, 1980, p. III-201) Also known as "grooving." (Virginia, 1980, p. III-204)

Purposes. To aid in establishment of vegetative cover with seed, and to reduce runoff velocity and increase infiltration. (Virginia, 1980)

Conditions Where Practice Applies. Slopes with grades less than 2:1 that are to be mulched and/or seeded. (Tahoe, Jan. 1978, p. VI-24) Scarifying alone does not significantly reduce erosion, and if improperly done, can even increase it. (U.S. EPA, Dec. 1976, p. 17) To be successful, the measure must be used in conjunction with other practices such as mulching, seeding and brow ditches or berms.

Design Considerations.

1. Scarifying shall be applied on cuts in cohensive soil or in soft rock which can be excavated without ripping. (Amimoto, May 1978, p. 53)
2. The steps shall be approximately square with horizontal dimensions of 8-10 inches. (Amimoto, May 1978)
3. Steps should be approximately horizontal, with a gradient not to exceed two percent. (Amimoto, May 1978)
4. Excavation of each step shall be in the opposite direction from the preceding one to minimize build-up of loose material at ends of steps. (Amimoto, May 1978)
5. Loose material which collects at the ends of steps shall be removed and ends blended into the natural ground. (Amimoto, May 1978)
6. Scarifying shall not be allowed in the lowest zone of the slope because loose material tends to slough onto toe. (Amimoto, May 1978)

2 0994

SLOPE PREPARATION - STAIR STEPPING

Definition. Construction of a continuous series of large horizontal steps on slopes by operating a tillage or other suitable implement on the contour. (Amimoto, May 1978, p. 54, and Virginia, 1980, p. III-201). Also known as "serrating." (Amimoto, May 1978, p. 54)

Purposes. To aid in establishment of vegetation, and to reduce runoff velocity and increase infiltration. (Virginia, 1980)

Conditions Where Practice Applies. Stair stepping applies to slopes greater than 2:1 (horizontal to vertical) composed of soft, rippable rock. (Amimoto, May 1978, p. 54) It creates benches partially filled with loose material (colluvium) which can support vegetation. To be successful, the measure must be used in conjunction with other practices such as mulching, seeding, and brow ditches or berms.

Design Considerations.

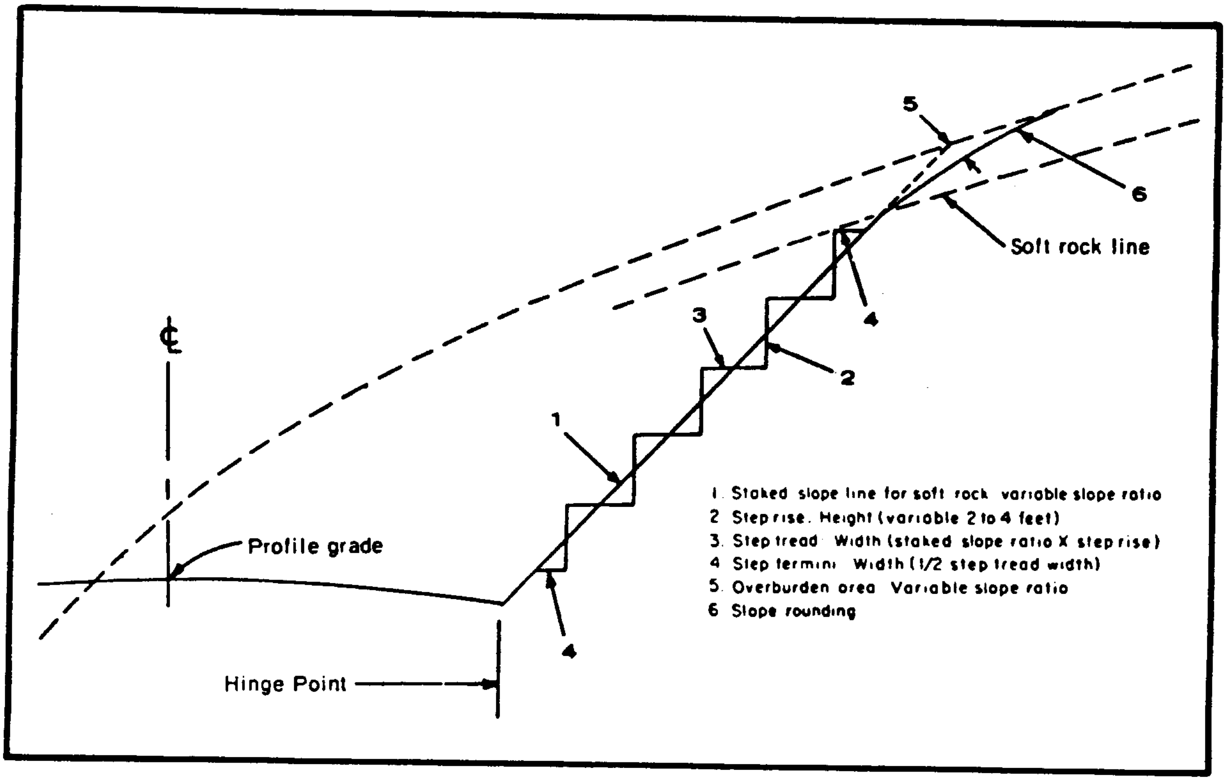
1. The steps may vary from 2-4 feet vertically, with the horizontal dimensions being a function of the staked slope ratio. (Amimoto, May 1978, p. 54) In no case should the percentage slope of the steps exceed the natural angle of repose for the colluvial material.

2. Steps shall be approximately horizontal, with a gradient not to exceed two percent. (Amimoto, May 1978)

3. Excavation of each step shall be in the opposite direction from the preceding one to minimize build-up of loose material at the ends of steps. (Amimoto, May 1978)

4. Loose material which collects at the ends of steps shall be removed and the ends blended into the natural ground. (Amimoto, May 1978)

SAMPLE DRAWING: STAIR-STEPPED SLOPE



Source: Amimoto, May 1978.

FIGURE 30

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SEDIMENT TRAPS

Definition. A small temporary ponding area, formed by constructing an earthen embankment with a gravel outlet, across a drainage swale.

Purpose. To detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the coarse sediment to settle out.

Conditions Where Practice Applies.

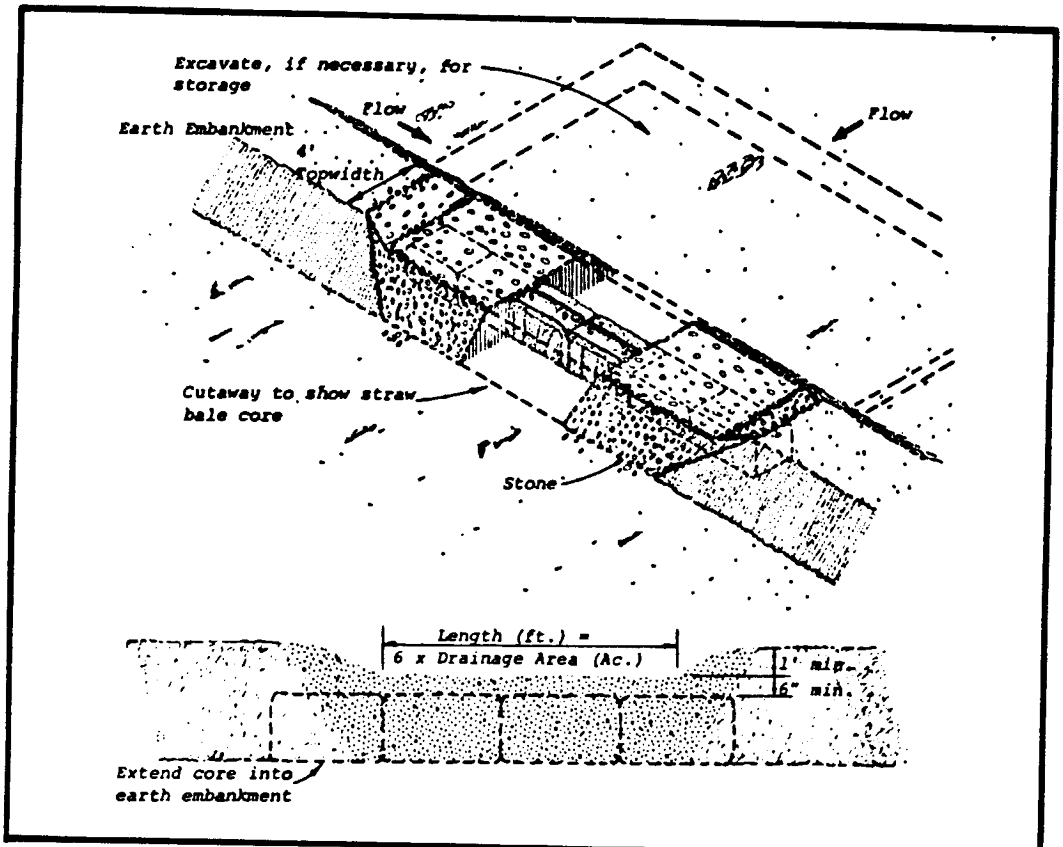
1. Below drainage areas of 5 acres or less.
2. Where the sediment trap will be used no longer than 18 months. (The maximum useful life is 18 months.)
3. The sediment trap may be constructed either independently or in conjunction with a temporary diversion dike.

Design and Maintenance Considerations.

1. Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than five acres, then a sediment basin should be used.
2. Sediment must be periodically removed from the trap. Plans should detail how this sediment is to be disposed of, such as by use in fill areas on site or removal to an approved off-site dump.
3. Sediment traps, along with perimeter controls, should be installed before any land disturbance takes place in the drainage area.
4. If excavation is necessary to attain the required storage volume, side slopes should be no steeper than 2:1.
5. The outlet for the sediment trap should consist of a crushed stone section of the embankment located at the low point in the basin. The crest of the outlet should be at least one foot below the top of the embankment.
6. The structure should be checked regularly to ensure that it is structurally sound. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to half the design volume of the trap.
7. Sediment traps must be removed after the contributing drainage area is stabilized. Erosion control plans should show how the site of the trap is to be graded and stabilized after removal.

(Virginia, 1980, pp. III-55-58; also USDA SCS, July 1975, pp. 20.01 - 20.08)

SAMPLE DRAWING: SEDIMENT TRAP



Source: USDA SCS, July 1975.

FIGURE 32

FIGURE 32. A temporary sediment trap composed of gravel bags and plastic sheeting with a plastic pipe outlet discharging onto a paved street. (Courtesy The Irvine Company)

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TEMPORARY SEDIMENT BASIN

Definition. A temporary basin with a controlled stormwater release structure, formed by constructing an embankment of compacted soil across a drainageway. (Virginia, 1980, p. III-59; also USDA SCS, July 1975, p. 19.01)

Purpose. To detain sediment-laden runoff from disturbed areas long enough for the majority of the sediment to settle out. A sediment basin will not necessarily reduce the peak rate of runoff. (Virginia, 1980)

Conditions Where Practice Applies. Below disturbed areas greater than 5 acres but less than 150 acres. There must be sufficient space and appropriate topography for the construction of a temporary impoundment. These structures are limited to a useful life of 18 months; otherwise they must be designed as permanent debris basins. (Virginia, 1980)

Design Considerations.

1. Effectiveness. Sediment basins are at best only 70-80 percent effective in trapping sediment which flows into them. Therefore, they should be used in conjunction with erosion control practices such as temporary seeding, mulching, diversion dikes, to reduce the amount of sediment flowing into the basin. (Virginia, 1980, p. III-60)

2. Location. To improve the effectiveness of the basin, it should be located so as to intercept the largest possible amount of runoff from the disturbed area. The best locations are generally low areas and natural drainageways below disturbed areas. Drainage into the basin can be improved by the use of diversion dikes and ditches. The basin should not be located where its failure would result in the loss of life or interruption of the use or service of public utilities or roads. (Virginia, 1980)

3. Design Elements.

   a. design capacity,

   b. embankment and/or excavation specifications,

   c. principal spillway,

   d. emergency spillway,

   e. soil erodibility and trap efficiency, and

   f. controlled access for safety. (ABAG, Aug. 1980, pp. I-87)

4. Stabilization. Stabilize embankment and emergency spillway using structural and vegetative stabilization, as appropriate. Stabilize inlet to the basin if velocities are high. (Tahoe, Jan. 1978, p. IX-43)

5. Permits should be obtained as necessary from the Army Corps of Engineers, California Department of Fish and Game, and California Department of

Water Resources (DWR). Dams within the jurisdiction of DWR are those having a height greater than 6 feet and storage exceeding 50 acre-feet, and those having a storage exceeding 15 acre-feet if the dam height is greater than 25 feet. (Dept. of Water Resources, Dec. 1979, p. xvii)

6. Methods of basin removal and site stabilization should be specified in the design plans.

Maintenance Considerations. Cleanout intervals should be specified in the initial plans. Sediment disposal shall not create a potential additional sediment source. All-weather access to the basin must be provided.

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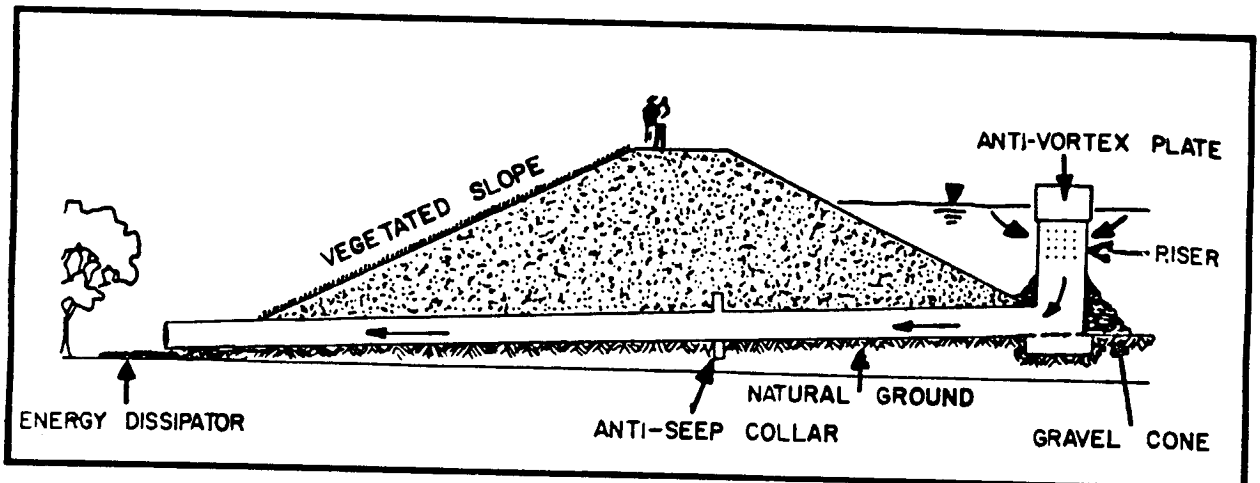
SCHEMATIC DRAWING: SEDIMENT/DEBRIS BASIN



Source: Amimoto, May 1978.

FIGURE 33

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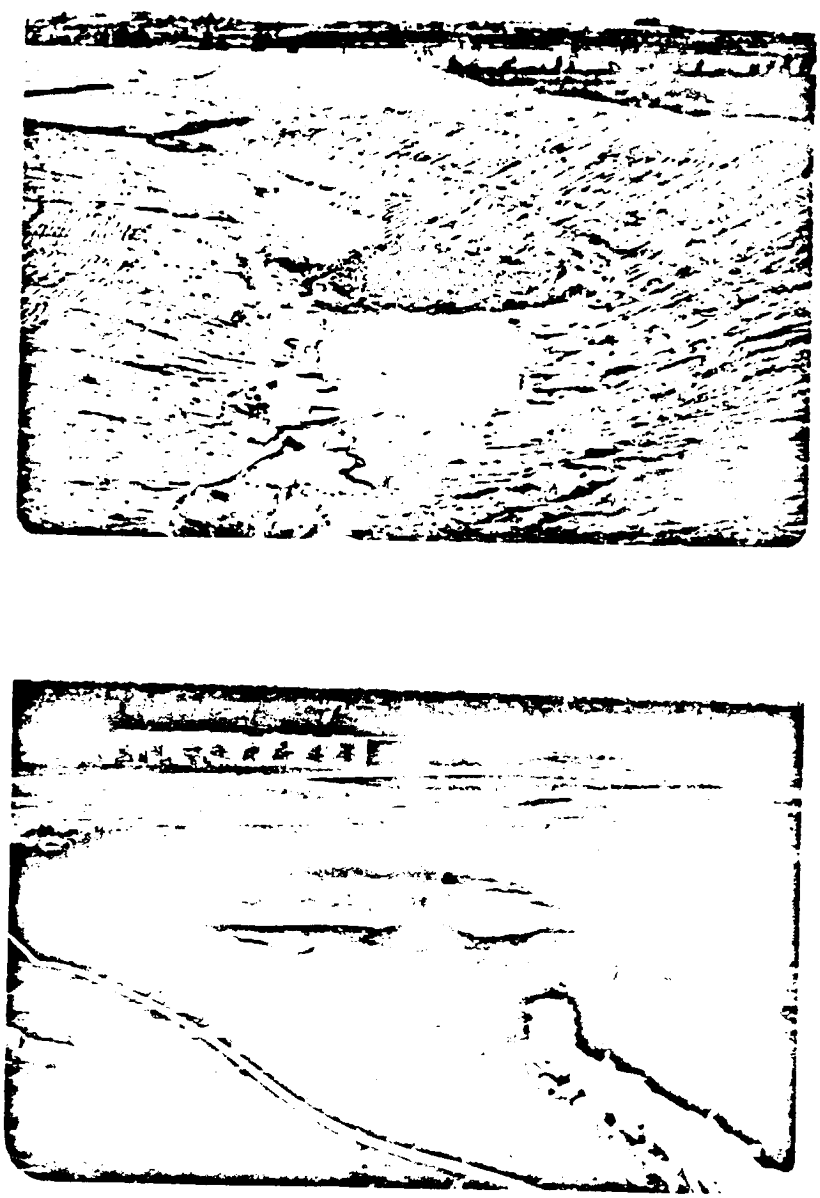

FIGURES 34 AND 35. Two sediment basins showing perforated riser and gravel filter. (Courtesy The Irvine Company)

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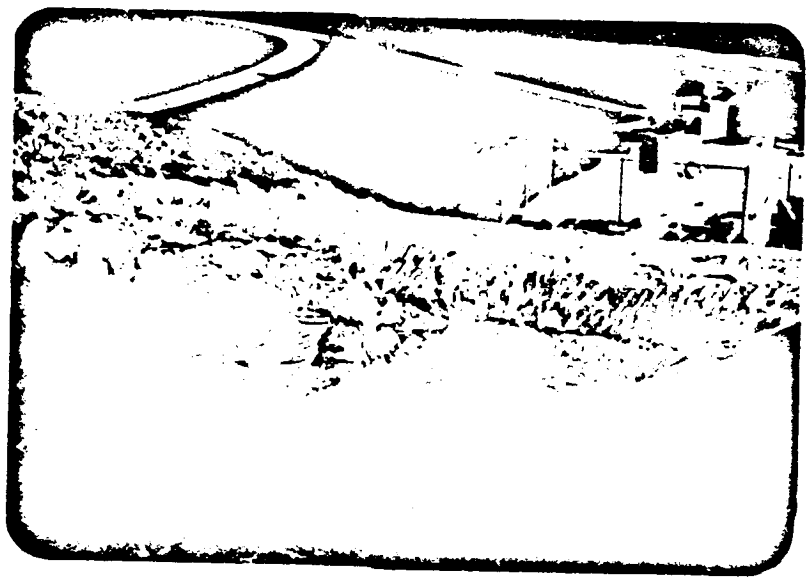

FIGURE 36. Temporary sediment basin after deposition of sediment. Note vegetative side slope protection, and stabilized outlet at discharge point. (Courtesy The Irvine Company)

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PERMANENT DEBRIS BASINS

Definition. A permanent earth dam designed for impounding and controlled release of water.

Purpose. To detain sediment-laden runoff from disturbed areas long enough for most of the sediment to settle out. A debris basin may also cause some flood-peak reduction.

Conditions Where Practice Applies. In disturbed watersheds, below areas greater than 150 acres, and wherever permanent sediment control is necessary and a major structure is economically feasible.

Design Considerations. Design elements are the same as those listed for temporary sediment basins. However, the level of design effort is greater. Safety considerations are of primary importance. Therefore, detailed analyses of hydrology and geology are necessary to ensure a properly designed structure. An example of design criteria appears in USDA SCS, June 1976.

Maintenance Considerations. Methods of and responsibility for maintenance sould be determined during initial design. The question of public safety will generally require some degree of public agency participation.

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FIGURE 37. Permanent debris basin. Vegetation should be removed immediately prior to the rainy season as a part of regular maintenance. (Courtesy Dept. of Fish and Game)

SUBSURFACE DRAINS

Definition. A perforated conduit such as pipe, tubing or tile installed beneath the ground to intercept and convey groundwater.

Purposes.

1. To prevent sloping soils from becoming excessively wet and subject to sloughing.

2. To improve the quality of the growth medium in excessively wet areas by lowering the water table.

3. To drain stormwater detention areas or structures.

Conditions Where Practice Applies. Wherever excess water must be removed from the soil. The soil must be deep and permeable enough to allow an effective system to be installed. Either a gravity outlet must be available or pumping must be provided. These standards do not apply to foundation drains.

Design Considerations. Subsurface drainage systems are of two types, relief drains and interceptor drains. Relief drains are used either to lower the water table in order to improve the growth of vegetation, or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random pattern.

Interceptor drains are used to remove water as it seeps down a slope, to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout. (Virginia, 1980, pp. III-187 & 188; also USDA SCS, July 1975, pp. 40.01 - A40.14)

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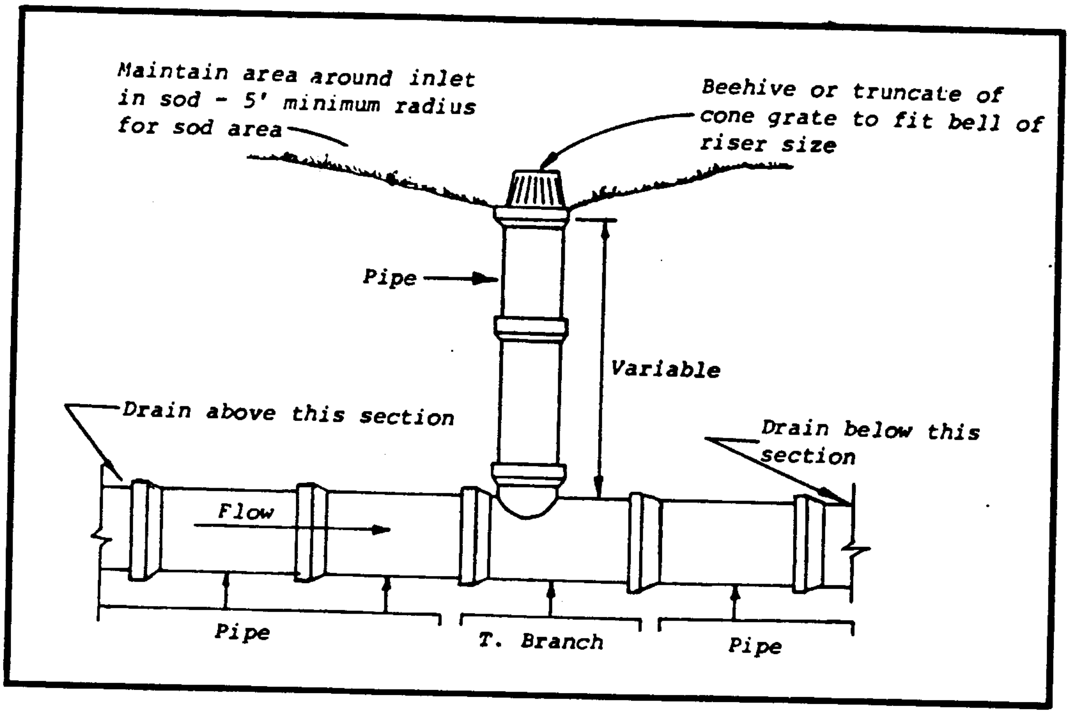
SAMPLE DRAWING: SUBSURFACE DRAIN AND INLET



Source: USDA SCS, July 1975.

FIGURE 38

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DUST CONTROL

Definition. Reducing surface and air movement of dust during land disturbing, demolition and construction activities.

Purpose. To prevent surface and air movement of dust from exposed soil surfaces and reduce the presence of airborne substances which may be harmful or injurious to human health, welfare, or safety, or to animal or plant life.

Conditions Where Practice Applies. In areas subject to surface and air movement of dust where on-site and off-site damage is likely to occur if preventive measures are not taken.

Design Considerations. Construction activities inevitably result in the exposure and disturbance of soil. Fugitive dust is emitted both during the activities (i.e., excavation, demolition, vehicle traffic, human activity) and as a result of wind erosion over the exposed earth surfaces. Large quantities of dust are typically generated in "heavy" construction activities, such as road and street construction and subdivision, commercial or industrial development, which involve disturbance of significant areas of soil surface. Research at construction sites has established an average dust emission rate of 1.2 tons/acre/month for active construction. Earth-moving activities comprise the major source of construction dust emissions, but traffic and general disturbance of the soil also generate significant dust emissions. Most of this dust will be redeposited and eventually washed into the storm-drain or stream system.

Methods to reduce dust include:

1. Temporary measures:
   - mulches, especially tackifiers,
   - vegetative cover,
   - tillage,
   - irrigation,
   - barriers, and
   - calcium chloride.
2. Permanent measures:
   - permanent vegetation,
   - topsoiling, and
   - stone.

(Virginia, 1980, pp. III-299-301)

Maintenance Considerations. Dust control measures should be reapplied or repaired, as needed.

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STOCKPILE STABILIZATION

Definition. Temporary methods to prevent erosion of materials that are being stored at a construction site.

Purpose. To reduce sediment and dust that may be produced by temporary stockpiles.

Conditions Where Practice Applies. Whenever loose, unconsolidated material, such as topsoil, sand, or sediment that has removed from traps or basins, is being stored at a construction site. Associated practices are temporary diversion dikes, traffic control, and dust control.

Design and Maintenance Considerations. Stockpiles should not be placed on sloping ground, drainage ways, or areas subject to rapid sheetflow. Stockpiles should be placed on level terrain away from areas subject to ponding from sediment control or other devices. Temporary diversions made of compacted soil berms or sandbags may be required around the stockpile. Traffic should be diverted away from stockpiles. Stockpiles should not be disturbed unnecessarily after placement. Plastic netting or tackifiers may be required to stabilize fine materials. Stockpiles should be inspected frequently during the rainy season to ensure stability.

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3.3 Findings, Conclusions and Recommendations

Table 1 shows the frequency of BMPs used in the watershed. The table was compiled from six responses to a questionnaire. The respondents were

- Irvine,
- Newport Beach,
- Orange,
- Orange County,
- Soil Conservation Service, and
- The Irvine Company.

In written and verbal comments, all respondents stressed the need for proper design, installation and maintenance. They pointed out that even a well-conceived practice will be ineffective, or actually worsen erosion, if not installed or maintained properly. They also stressed that good design and placement is required for even the most simple or temporary measure. Clearly there is a need for a continuing erosion control training program to educate everyone involved--designers, builders, plan-checkers, and inspectors--about BMPs. The program recently instituted by the Soil Conservation Service is a good beginning in this education process. It should be supported and supplemented by the jurisdictions within the watershed.

TABLE 1

USE OF BMPs IN THE NEWPORT BAY WATERSHED

Practice	Frequent	Occasional	Rare
Temporary gravel construction entrance		X	
Construction site road stabilization			X
Sandbag, gravel bag or straw bale barriers	X		
Silt fence			X
Filter berms		X	
Brush barriers			X
Filter inlet	X		
Interceptor ditch	X		
Diversion dikes		X	
Active fill diversion		X	
Permanent diversion		X	
Perimeter berm or swale		X	
Right-of-way diversions		X	
Roadside ditches		X	
Stormwater channels		X	
Slope drains	X		
Chutes and flumes			X
Outlet protection	X		
Level spreader			X
Riprap		X	
Streambank stabilization		X	
Grade control structures		X	

TABLE 1 (CONTINUED)

Practice	Frequent	Occasional	Rare
Stream crossings		X	
Vegetative protection			X
Vegetation establishment	X		
Mulches	X		
Topsoiling			X
Slope preparation--scarifying			X
Slope preparation--stair stepping			X
Subsurface drain		X	
Dust control	X		
Stockpile stabilization		X	
Sediment traps	X		
Sediment basins	X		
Permanent debris basins		X	

Based on a review of applicable BMPs and their present use, the following practices are recommended for occasional-to-frequent use:

1. temporary gravel construction entrance,
2. sandbag, gravel bag or straw bale barriers,
3. silt fences,
4. filter berms,
5. filter inlets,
6. interceptor ditches,
7. diversion dikes,
8. active fill diversions,
9. permanent diversions,
10. perimeter berms or swales,
11. right-of-way diversions,
12. stormwater channels,
13. slope drains,
14. outlet protection,
15. level spreader,
16. riprap,
17. streambank stabilization,
18. grade control structures,
19. vegetation protection,
20. vegetation establishment,
21. mulches,
22. temporary sediment traps,
23. temporary sediment basins,
24. permanent debris basins,
25. topsoiling,
26. dust control, and
27. stockpile stabilization.

Four of the practices are now used only rarely in the watershed: silt fences, level spreaders, vegetation protection, and topsoiling. The Soil Conservation Service also recommends that the use of vegetation protection and topsoiling be encouraged.

It is difficult to recommend more frequent use of practices now used only occasionally because of the site-specific nature of erosion and sediment control plans. However, a review of the responses to our questionnaire indicates that diversion structures may be underused at present. These structures include diversion dikes, active fill diversions, permanent diversions, perimeter berms or swales, and right-of-way diversions.

The lands currently under development in the cities of Orange and Tustin generally have gentle slopes. Future development in Tustin is expected to extend into the foothills as recently annexed land is urbanized. Lands under development in Newport Beach, Irvine and the areas under county jurisdiction vary in topography from gentle slopes to hilly areas. The BMPs recommended above can be used in all jurisdictions for those projects that have the conditions where the practice applies. These conditions are specified for each BMP in section 3.2. Table 2 summarizes the recommended best management practices and the control objectives to which they are applied.

The remaining BMPs not listed above may be useful under special circumstances. The following BMPs may be used rarely, but effectively, at appropriate sites:

1. construction site road stabilization,
2. brush barriers,
3. roadside ditches,
4. infiltration trenches,
5. chutes and flumes,
6. temporary stream crossings,
7. scarifying,
8. stair stepping, and
9. subsurface drains.

TABLE 2

RECOMMENDED BEST MANAGEMENT PRACTICES

Name	Description	Level of Design Effort[1]: Low to Moderate	Level of Design Effort[1]: Moderate to Extensive	Management Objective: Perimeter Control	Slope Protection	Drainageway Protection	Erosion Reduction	Sediment Trapping	Temporary Stabilization	Permanent Stabilization
1. Temporary gravel construction entrance	A gravel pad, located at points of vehicular exit from a construction site, to reduce mud and sediment tracked onto public roads.	X		X				X	X	
2. Sandbag, gravel bag or straw bale barriers	A sediment barrier to intercept and detain small amounts of sediment from disturbed areas of limited extent.	X		X	X			X	X	
3. Silt fence	A sediment barrier of filter fabric to intercept and detain small amounts of sediment from disturbed areas of limited extent.	X		X	X			X	X	
4. Filter Berms	A sediment trap that retards and filters runoff while allowing passage of construction traffic	X		X	X			X	X	

TABLE 2

RECOMMENDED BEST MANAGEMENT PRACTICES

Name	Description	Level of Design Effort (1): Low to Moderate	Level of Design Effort (1): Moderate to Extensive	Management Objective: Perimeter Control	Slope Protection	Drainageway Protection	Erosion Reduction	Sediment Trapping	Temporary Stabilization	Permanent Stabilization
5. Filter inlet	A sediment barrier around a stormdrain drop or curb inlet	X						X	X	
6. Interceptor ditch	A ditch located at top of cut slope to divert water from slope	X			X		X			X
7. Diversion dikes	A ridge used to divert water from a slope, or to direct sediment-laden water to a sediment-trapping facility	X			X		X		X	X
8. Active fill diversion	A channel with supporting ridge to divert water from a fill slope that is under construction	X			X		X		X	
9. Permanent diversion	A channel with supporting ridge constructed across a slope to reduce slope length and divert runoff to stabilized outlets	X			X		X			X

TABLE 2

RECOMMENDED BEST MANAGEMENT PRACTICES

Name	Description	Level of Design Effort (1): Low to Moderate	Level of Design Effort (1): Moderate to Extensive	Management Objective: Perimeter Control	Slope Protection	Drainageway Protection	Erosion Reduction	Sediment Trapping	Temporary Stabilization	Permanent Stabilization
10. Perimeter berm or swale	A dike or drainageway around the perimeter of a disturbed area that prevents runoff from the site to a sediment-trapping device	X		X			X		X	
11. Right-of-way diversions	Dikes or drainageways located across disturbed rights-of-way to shorten length of exposed slopes, and directing runoff to stabilized outlet or sediment-trapping device	X			X		X		X	
12. Stormwater channel	A drainageway to convey excess runoff away from developing area		X			X	X			X
13. Slope drain	Conduit or tubing to conduct concentrated runoff from top to bottom of cut or fill slope	X			X		X		X	

TABLE 2

RECOMMENDED BEST MANAGEMENT PRACTICES

Name	Description	Level of Design Effort (1): Low to Moderate	Level of Design Effort (1): Moderate to Extensive	Management Objective: Perimeter Control	Slope Protection	Drainageway Protection	Erosion Reduction	Sediment Trapping	Temporary Stabilization	Permanent Stabilization
14. Outlet protection	Structural devices at outlets of pipes or paved channels to prevent scour by reducing velocity of runoff		X	X		X	X		X	X
15. Level spreader	An outlet for dikes or diversions to transform concentrated runoff to sheetflow		X	X			X		X	X
16. Riprap	Erosion-resistant ground cover of large, loose, angular stone		X		X	X	X			X
17. Streambank stabilization	Vegetative or structural measures used to protect streams from erosion		X			X	X			X
18. Grade control structures	Methods to reduce and maintain channel gradient, preventing erosion at higher flows		X			X	X			X

TABLE 2

RECOMMENDED BEST MANAGEMENT PRACTICES

Name	Description	Level of Design Effort (1): Low to Moderate	Level of Design Effort (1): Moderate to Extensive	Management Objective: Perimeter Control	Slope Protection	Drainageway Protection	Erosion Reduction	Sediment Trapping	Temporary Stabilization	Permanent Stabilization
19. Vegetation protection	Measures such as buffer strips and traffic control used to minimize extent of land disturbance	X			X	X	X		X	
20. Vegetation establishment	The selection and use of appropriate plants to protect slopes, drainageways or other disturbed areas from low-velocity flows		X		X	X	X		X	X
21. Mulches	A medium for covering exposed soil and improving seed germination and plant establishment	X							X	
22. Topsoiling	Methods to preserve and use topsoil to enhance final site stabilization with vegetation	X							X	X
23. Dust control	Methods to reduce dust movement	X					X		X	

TABLE 2

RECOMMENDED BEST MANAGEMENT PRACTICES

Name	Description	Level of Design Effort (1): Low to Moderate	Level of Design Effort (1): Moderate to Extensive	Management Objective: Perimeter Control	Slope Protection	Drainageway Protection	Erosion Reduction	Sediment Trapping	Temporary Stabilization	Permanent Stabilization
24. Stockpile stabilization	Methods to prevent erosion of materials being stored on a construction site	X					X		X	
25. Sediment traps	Ponding areas formed by an earthen embankment with a gravel outlet to detain runoff from disturbed areas less than 5 acres		X	X				X	X	
26. Temporary sediment basin	A basin with controlled release to detain runoff from disturbed areas up to 150 acres		X	X				X	X	
27. Debris basin	An earth dam designed to detain runoff from large areas		X	X				X		X

(1) Varies depending on site characteristics. Expertise in erosion control is assumed.

4.0 GRADING ORDINANCES

4.1 Comparison of Ordinances

Five grading ordinances currently applied in the Newport Bay drainage area were compared. The five jurisdictions considered were Irvine, Newport Beach, Orange, Tustin and Orange County. In importance of effect on sedimentation of the Upper Bay, the cities of Irvine and Newport Beach rank highest. Irvine is critical because the city covers nearly 30 percent of the watershed. Approximately 10 to 15 percent of the city's area is disturbed by construction every year (personal communication, Bob Storchheim, city of Irvine, July 27, 1981). This figure will probably remain high for some time as The Irvine Company continues to develop its land. Newport Beach is important to the Upper Bay because the city surrounds it. Sediment is transported from construction sites almost directly into the bay. The remaining jurisdictions produce less sediment from construction sites largely because there is less continuing construction activity within their boundaries. Only a small portion of the city of Orange lies within the watershed. The topography of the city of Tustin is relatively flat and construction sites are less susceptible to erosion. The intensity of development activites within the area under the jurisdiction of Orange County is much less than that within the cities of Irvine and Newport Beach. Nevertheless, erosion rates from Orange County sites may be high when construction occurs in the foothills.

Table 3 is a matrix comparing the grading ordinances of the five jurisdictions. Three ordinances are nearly identical in their major provisions: Irvine, Newport Beach, and Orange County. These three ordinances are based on the model grading ordinance in the Uniform Building Code (UBC) (Int'l Conf. of Bldg. Officials, 1979), but with an added emphasis on erosion and sediment control.

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TABLE 3

COMPARISON OF GRADING ORDINANCES

Ordinance Provisions	Irvine Grading and Excavation Code	Newport Beach Excavation and Grading Ordinance	Orange County Grading and Excavation Code	Tustin Grading Ordinance (Model Grading Ordinance Ch. 70, Uni. Bldg. Code)	Orange Proposed Grading Ordinance	208 Plan Model Ordinance	Model Erosion Control Ordinance Ca. Dept. of Cons.
1. Ordinance not applicable when:							
Cut is less than							
Quantity, cu yd	50 and	50 and	50 and	-		50 or	-
Depth, ft	2 or	2 or	2 or	2		3	-
Slope, H:V	1.5:1 and	2:1	1.5:1	1.5:1		-	-
Height, ft	5	-	and 5	5		-	4 and
Area, sq ft	-	-	-	-		-	200
Fill is less than							
Quantity, cu yd	50 and	50 and	50 and	50		50 or	-
Depth, ft	3*	3 or	3*	3		3	3 and
Slope, H:V	-	5:1	-	-		-	-
Area sq ft	-	-	-	-		-	200
Grading is in isolated areas	-	-	-	+		-	-
2. Responsible agency may require:							
Soils engineer report	+	+	+	+	+	+	-
Engineering geologist report	+	+	+	+	+	+	+
3. Bond or similar surety required	+	+	+	+	+	+	+
4. Cut							
Maximum slope, H:V	2:1	2:1	2:1	2:1	**	2:1	2:1
5. Fill							
Maximum slope, H:V	2:1	2:1	2:1	2:1	**	2:1	2:1
Bench if depth, ft	>5 or slopes>5:1	>5 & slopes>5:1	same	>5		>5 & slopes>5:1	-
6. Runoff diversion							
Drainage of cuts and fill slopes required	+	+	+	+	**	+	+
Protected discharge areas required	+	+	+	+		+	-
Terraces/benches for vertical distance, ft	>30	>30	>30	>30		> 25	-
7. Erosion control							
Vegetative slope stabilization	+	+	+	-	+	+	+
Other BMPs required	+	+	+	+	+	+	+
Omit if erosion resistant	+	+	+	-	-	-	-
Special conditions during rainy season	+	+	+	-	+	+	-
8. Exolicit purpose - water quality protection	-	-	-	-	-	+	-
9. Construction schedule specified	-	-	-	-	-	-	+
10. Erosion and sediment control plan required unless explicitly waived	-	+	-	-	+	+	+
11. Sizing criteria for desilting basins specified	-	+	-	-	-	+	-

\+ ordinance contains provision
\- ordinance does not contain provision
* or less than 1 ft deep on natural slope <5:1
** no arbitrary limits established; decided for each site based on the natural topography, good engineering practices, and the recommendations of a geologist and soils engineer.

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Tustin has adopted the UBC ordinance directly, without any modifications. The UBC ordinance as written does not address erosion/sediment control on construction sites. Rather, it is directed at reducing hazards of cut and fill operations to adjacent property and to the public. However, many jurisdictions use the ordinance as the authority to require erosion/sediment control measures when they appear necessary. Other jurisdictions, such as Irvine, Newport Beach and Orange County, amend the ordinance to reflect local needs and concerns. In either case, however, the authority of the ordinance is sufficient to regulate erosion/sediment control practices at construction sites.

A detailed comparison of the ordinances for Irvine, Newport Beach, Orange County and Tustin reveals that the Tustin ordinance does not contain specific requirements for erosion control measures. Historically such controls were not required because the city occupies flat terrain which is not subject to severe erosion, even when disturbed. However, Tustin has recently annexed land which is owned by The Irvine Company and extends into the foothills. This land is in agricultural reserve. However, the city expects that it will be developed eventually. When The Irvine Company begins conceptual planning of its development, the city will review the need for requiring erosion control measures (personal communication, Alan Warren, city of Tustin, July 31, 1981). The absence of other major developments in the meantime and present staffing shortages may delay this review for a considerable period.

Comparison of the ordinances of Irvine, Newport Beach and Orange County indicates uniformity in their requirements. This uniformity is desirable from the developers' viewpoint because it facilitates preparation of grading and erosion control plans. The thresholds of the ordinances are described in item 1 of the matrix (Table 3). These thresholds, which determine the projects that are exempt from the ordinance requirements, are among the lowest in the state (Fitting, Nov. 1979; J.B. Gilbert & Assocs., Aug. 1978). This means that nearly all clearing or grading operations are subject to erosion control standards.

Item 2 of the matrix compares the authority of the agencies to require reports by a soils engineer and/or an engineering geologist. These reports may be required at the discretion of the responsible agency in every jurisdiction reviewed. However, such reports are not required for every grading project. In the case of the Newport Beach ordinance, all projects within the Newport Bay watershed must submit an erosion control plan, even if a soils or engineering report is not required.

All the ordinances require a bond or similar surety to cover the cost of repairing the contractor's grading work (item 3). In the cases of Irvine and Newport Beach, this bond is usually not released until the project site is ready for occupance and final landscaping is established. Retention of the bond for this entire period is desirable because erosion problems can occur at all stages of construction, not only during grading.

Items 5 and 6 show the final slope requirements for cuts and fills. The requirements are important for erosion control because certain practices, such as slope vegetation, are not effective on gradients steeper than 50 percent (2:1) (White and Franks, 1978).

All three ordinances require that runoff be diverted before reaching cut or fill slopes (item 6). Diversion swales must be paved to prevent erosion, have a minimum gradient of six percent, and drain an area not exceeding one-third acre. All diversion outlets must be protected from erosion by resistant material such as riprap.

Item 7 of the matrix lists the provisions for on-site erosion/sediment control. The three ordinances require vegetative slope stabilization and other best management practices (BMPs) where appropriate. The BMPs to be employed are chosen on a site-by-site basis, and are specified in an erosion and sediment control plan. No single BMP or group of BMPs is appropriate in all situations. Therefore, erosion and sediment control plans will vary among sites. The ordinances also specify that additional BMPs may be required during the rainy season. This provision improves the effectiveness of erosion control measures, and encourages land developers to perform a detailed project review prior to grading during the rainy season.

None of the existing ordinances specifically states that water quality protection is a purpose (item 8). However Irvine, Newport Beach and Orange County use their ordinances to implement 208 planning goals. Section 208(b)(2)(H), 86 Stat. 841, requires this planning process to "set forth procedures and methods (including land use requirements) to control to the extent feasible" water pollution related to construction activity. The existing grading ordinances have been a convenient way to require and enforce installation of best management practices. This reality could be reflected in the present grading ordinances by a minor amendment: "It is the intent of this code to safeguard life, limb, property, <u>water resources</u>, and the public welfare by regulating grading . . . ." (City of Irvine Grading Regulations) Although not necessary for enforcement, more elaborate wording could be borrowed from ordinances such as Solano County's.

> The purpose of this ordinance is to provide the means for controlling soil erosion, sedimentation, increased rates of surface runoff and related environmental damage by establishing minimum standards and providing regulations for the construction and maintenance of fills, excavations, cuts and clearing of vegetation, revegetation of cleared areas, drainage control, and the protection of exposed soil surfaces in order to protect downstream waterways and wetlands and to promote the safety, public health, convenience and general welfare of the community.

None of the three ordinances specifically requires a construction schedule (item 9). However, as a matter of practice all project schedules are filed with the reviewing agency so that those expected to extend into the rainy season can be closely monitored. Sites that are graded during the dry season, but left exposed during the rainy season, are thereby subject to the additional rainy-season requirements noted in item 7.

Item 10 indicates that the Newport Beach ordinance specifically requires an erosion and sediment control plan for projects subject to the ordinance. As a matter of policy, however, Irvine and Orange County also require erosion and sediment control plans for any proposed construction during the rainy season. The format of erosion and sediment control plans is similar in the three jurisdictions. Appendix C is a copy of Orange County's requirements for an erosion control plan. A typical plan would include:

1. a 24-hour telephone number of someone responsible for the construction site;
2. paved areas and drainage devices that will be completed by October 15 (the beginning of the rainy season);
3. type and placement of on-site erosion control devices; and
4. location of and access to desilting basins, if any.

As noted above, the specific best management practices included in the plan would vary depending on the site and the extent of grading.

Item 11 shows that only Newport Beach includes sizing criteria for desilting basins in its ordinance. The criteria used by Irvine and Orange County are specified in their standard plans, not in their ordinances. The advantage of omitting design criteria from the ordinance is that they can be easily modified and updated as conditions change, or technology and new information develop. A discussion of the design criteria for desilting basins and other BMPs appears in section 3.2.

Methods of enforcement are specified in the three ordinances. These methods include warnings by inspectors, stop-work orders, or withholding of building permits. However, the goal of all jurisdictions is to obtain voluntary cooperation from contractors without resorting to compulsory alternatives. The administrative and enforcement procedures used by Irvine, Newport Beach and Orange County are discussed in section 4.2.

The city of Orange is in the process of adopting a grading ordinance which contrasts sharply with those of the other four jurisdictions. The proposed ordinance is a series of brief resolutions which define the general scope and purpose of grading regulations. In addition to minimizing hazards to life and property, the purpose is to

> assure the proper development of the City in level and hillside terrain so as not to destroy the natural character and amenities of such land or deplete the scenic resources of the City. (Undated draft, Proposed Grading Ordinance, City of Orange.)

The resolutions refer to "Standards for Grading." The standards are contained in a 75-page document that is similar to other cities' grading ordinances.

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The advantage of this arrangement is flexibility: old standards can be modified and new ones adopted quickly in response to changing conditions and technologies. City Council approval is not required for these revisions. A Design Review Board is responsible for ensuring that the principles of the grading ordinances are applied to specific projects. The Board, which has been operating for three years, consists of representatives from various city agencies and private firms. The Board works with developers at the conceptual planning stage, leaving final plan checking and approval to qualified city staff. As with the other jurisdictions reviewed, the effectiveness of this approach depends on how the standards are applied to and enforced for specific projects.

An additional comparison was made among the five ordinances and two model ordinances (SCAG, April 1979; Amimoto, May 1978). Table 3 includes the major provisions of the South Coast 208-plan model ordinance and of the California Department of Conservation (CDC) model ordinance. The most notable differences between the existing ordinances (except Tustin's) and the CDC model ordinance are that the model does not require 1.) special rainy-season control measures and 2.) outlet protection where diverted runoff is discharged. Both are key elements in reducing erosion and sedimentation at construction sites, and should be retained in the existing ordinances. On the other hand, the CDC model calls for a construction schedule to be filed with a grading permit application. Although this is done for projects in the jurisdictions reviewed, except Tustin, it is not specifically required by the existing grading ordinances.

The 208-plan model ordinance is similar to the existing ordinances in Irvine, Newport Beach and Orange County in its erosion control elements. The exception is that the model ordinance does not specifically exempt erosion-resistant areas. Another difference is that the model ordinance specifies sizing criteria for desilting basins. As discussed above, a grading ordinance may not be the best place to specify design criteria because the requirement limits the agency's response to unique situations or new technologies.

Comparison was also made with the modifications of the UBC model code suggested by Pomeroy, Johnston & Bailey (July 28, 1978). These changes include:

1. adding the purpose of protecting water resources;
2. extending the scope of the ordinance to erosion control;
3. making erosion/sediment control plans mandatory unless specifically waived by the responsible agency;
4. adding special requirements for rainy-season operations; and
5. deleting the exemption from erosion control measures for erosion-resistant cut slopes.

Except for items 1 and 5, Irvine, Newport Beach and Orange County have made these changes, either in their ordinances or in administrative policy. It is suggested that these modifications would be appropriate for Tustin to consider.

The jurisdications in the Upper Newport Bay watershed have approached erosion and sediment problems through their grading ordinances and permit process. Some jurisdictions elsewhere in California have chosen to adopt a separate erosion control ordinance. Resource conservation districts in California are proposing county erosion and sediment control ordinances that address the problems of accelerated erosion on all categories of land use, including construction areas.

One example of this type of ordinance is the one amending the Santa Cruz County Code. The purpose of this ordinance "is to eliminate and prevent conditions of accelerated erosion that have led to, or could lead to, degradation of water quality, loss of fish habitat, damage to property, loss of topsoil and vegetation cover, disruption of water supply, and increased danger from flooding." It includes provisions that no person shall cause or allow to be continued a condition on any site that is causing or is likely to cause accelerated erosion as determined by the Planning Director. Such a condition shall be controlled and/or prevented by using appropriate measures as outlined in the code or by additional measures as specified by the Planning Director. Property owners will be given a reasonable amount of time, as determined by the Planning Director, to control the specified erosion problems.

The ordinance requires the development of erosion control plans; provides for the setting of fees for plan checking, inspection, violations, variance requests and for land clearing permits; provides for inspection and compliance; and provides for determination of violations, work stoppage, and the assessment and enforcement of penalties.

4.2 Administration and Enforcement

The following discussion concentrates on the city of Irvine. As noted in section 4.1, Irvine contains the largest area of land that will be developed in the near future, and has the potential to increase sediment from the watershed during the construction phase of development. The regulatory procedures used by Newport Beach and Orange County are discussed in relation to Irvine. Omitted from the report are Tustin, which does not currently have an erosion control program, and Orange, which has insignificant jurisdictional authority in the watershed (less than one-half square mile). Sources of information for this section include state and local government personnel, and local developers.

In the city of Irvine, an erosion control plan is required for every grading project covered by a grading permit if that project will extend into the rainy season (October 15 to April 15). No grading permit will be issued unless an erosion control plan has been approved, or the requirement specifically waived by the city. The permit is valid for one year, and a new plan must be submitted and approved if grading operations extend into subsequent rainy seasons. Every plan submitted to Community Development is checked for sufficiency by staff at the Regional Water Quality Control Board in Riverside. Review by city staff is minimal. The Regional Board may ask the city to have a specific control plan modified, or the city may require modification on its own.

After a permit is issued and grading begins, site inspections are made by city staff. At minimum, the following inspections occur:

1. pregrading inspection,
2. toe inspection,
3. excavation inspection,
4. fill inspection,
5. drainage device inspection,
6. rough grading, and
7. final grading.

None of these relates directly to the erosion control plan, but the condition of the site with respect to erosion control measures is checked on each visit. In addition, all sites are inspected for adequacy of erosion control during the month immediately preceding the rainy season. Spot checks are made during periods of heavy rain whenever they occur. Enforcement action is taken by the city to correct any deficiencies or inadequate maintenance observed on continuing basis during the rainy season. Yearly on August 15 and September 15, the city advises contractors with active grading permits about rainy-season requirements for erosion control. Measures and enforcement policies are discussed at open meetings held quarterly for contractors.

The same inspector follows a project through all grading stages. If the inspector finds the erosion control measures to be inadequate, then a 24-hour notice is issued. If the contractor does not make an effort to solve the problem in that time, then a stop-work order is issued by the city. The order can be enforced by city police, but such enforcement has not been necessary in the past. Another alternative open to the city is to do remedial work on a site and recover the cost from the bond all contractors must post. This alternative is used only in extreme emergencies because of time involved in recovering the cost. Nevertheless, the existence of the bonds is important in assisting enforcement of erosion control even after grading is completed. The bond is held until final project improvements are made. The period between final grading and project completion allows additional time to determine whether all required erosion control measures are operating as designed.

Finally, the city has a Standards Committee which regularly reviews city regulations and standards, including the grading ordinance and erosion controls. The committee consists of the managers of Inspection, Final Engineering, and Maintenance Services. This procedure indicates effective communication, and allows for the updating of standards and requirements, making them more responsive to actual field conditions. Standard reviews are initiated regularly by committee members, and additional reviews are made upon the request of developers and contractors.

The Newport Beach and Orange County systems are similar to Irvine's. Plan checking and inspections are divided between departments. However, Newport Beach and Orange County do not request routine plan checking from the Regional Board. Instead, only major projects are sent to the Board for review.

Newport Beach has an additional enforcement tool--the debris deposit. This deposit, usually made in cash, is required from a contractor before any building or grading permit is issued. The amount may range from $100 to $15,000, depending on either the value of proposed construction or the amount of proposed grading. If construction does not conform to permit requirements or the erosion control plan, the city issues a notice to the contractor giving a time limit for correction. If the problem is not corrected within the specified time, the deposit is forfeited and the permit is suspended until the problem is corrected and a new deposit is made. When the city issues its final project approval, the full remaining deposit is refunded to the contractor.

The major land developer in the Irvine-Newport Beach area is The Irvine Company (TIC). The company produces an annual erosion control program that complies with the cities' ordinances. The program serves to advise contractors on TIC projects about their erosion-control responsibilities during the rainy season. TIC takes an active part in site inspections, emergency service, and city-contractor liaison during the rainy season. Part of the success of erosion control in the Upper Newport Bay watershed is due to this active interest by TIC.

4.3 Conclusions and Recommendations

Conclusions

1. The jurisdictions of Irvine, Newport Beach and Orange County cover most of the area within the Newport Bay watershed.
2. These three jurisdictions maintain an excellent uniformity in the requirements of their grading ordinances, standards and procedures.
3. These requirements equal or exceed the model ordinances studied in terms of erosion control.
4. The city of Tustin has not incorporated erosion control requirements into its grading ordinance or administrative policy.
5. The city of Orange is approaching erosion control by using extensive standards that are separate from the grading ordinance. The success or failure of this new approach will have little effect on Upper Newport Bay because the drainage area within the city of Orange is small compared to the rest of the basin.
6. None of the jurisdictions specifies water quality protection as a goal of their grading ordinances. However, all but Tustin apply their ordinances to 208-planning goals.
7. Voluntary cooperation by developers and contractors is preferred. However, compulsory compliance is enforced when needed.
8. Irvine, Newport Beach and Orange County generally have good communication with developers. Notices sent to contractors prior to the rainy season help them comply with special erosion control requirements. Quarterly meetings, such as those held by Irvine, also improve contractors' understanding of city requirements.

9. According to developers' comments, lack of communication among the departments and staff within the jurisdictions appears to be an occasional problem. The source of the problem is generally a difference in interpretation between the plan checker and the site inspector.

10. There is an occasional shortage of qualified personnel for plan checking or site inspections because of the cyclical nature of erosion control measures. All plans must be approved and sites inspected during the month preceding October 15. During the winter, inspections must be made whenever there is significant rainfall. This shortage can be acute for Orange County because its jurisdiction is fragmented and scattered over a large area.

11. Enforcement measures available to Irvine, Newport Beach and Orange County are stop-work orders and contractor's bonds. In addition, Newport Beach requires a debris deposit.

Recommendations

1. That Irvine, Newport Beach and Orange County continue to maintain uniform ordinances, standards, and procedures. Regional training classes and occasional meetings of field supervisors from each jurisdiction would probably accomplish the necessary coordination.
2. That Tustin begin reviewing its grading ordinance and developing erosion control standards at the earliest possible time, but not later than proposed development of foothill land.
3. That the existing ordinances of Irvine, Newport Beach, Orange County and Orange be modified to include water quality protection as a goal.
4. That all jurisdictions continue to maintain positive working relationships with developers and contractors to encourage voluntary compliance with erosion control standards.

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5. That regular meetings be held with plan checkers and inspectors in attendance to improve communication and to ensure that standards remain consistent. Feedback on field conditions and actual effectiveness of BMPs would be especially useful for the plan checkers. Another way to increase communication is simply to place plan checkers and inspectors in adjacent or nearby offices, as is currently done in Irvine.

6. That temporary staff be partly offset by training other inspection personnel, such as building inspectors, in erosion control methods. These inspectors would supplement the regular staff during peak periods, as is currently done in Irvine. An added benefit is that the inspectors are then able to recognize and report erosion problems on any site they visit while performing their normal duties.

7. That, in order to increase knowledge among agency personnel, all jurisdictions support and participate in the Soil Conservation Service's local erosion control training program. Each jursidiction may also decide to organize supplementary in-house training, emphasizing field applications.

8. That the filing time for complete erosion control plans be modified in some cases. For example, a grading application may be filed in April or May, with the operation planned to extend into the rainy season. The initial erosion control plan should be required for permanent measures, or measures such as sediment basins, that will be constructed before or during rough grading. However, rainy-weather measures should not be filed with the agency until August or September. At that time, the contractor will have a more precise construction schedule and can make his erosion control plan more specific.

9. That permanent erosion control measures be carefully inspected before the release of the grading bond. A permanent maintenance schedule should be established and the responsible party should be designated. In addition,

all temporary measures and sediment should be removed and stabilized in accordance with the erosion control plan.

10. That Irvine and Orange County collect a debris deposit similar to that of Newport Beach.

5.0 REGULATORY PROCESS

5.1 Present Agency Responsibilities

The Federal Water Pollution Control Act is administered by the Environmental Protection Agency. Section 208 of the act applies to nonpoint sources of pollution, such as sediment. EPA has designated the State Water Resources Control Board as the state planning agency under section 208. California's Porter-Cologne Water Quality Control Act enables the board to carry out its designated functions. These functions include guiding the statewide planning process to identify nonpoint sources of pollution and methods of control. In addition, the Porter-Cologne Act authorizes the board to establish water quality policy for the state.

The state board acts through the Regional Water Quality Control Boards. These regional boards are directly involved in applying statewide water quality goals through the development of water quality plans and the use of waste discharge requirements. These requirements set water quality standards. For example, land use activities cannot reduce water quality beyond the established limits. However, the regional boards cannot specify the methods by which the standards are to be met. It, therefore, falls to cities and counties to regulate land use activities and promote best management practices that reduce sediment production. However, if local governments fail to regulate land use activities, the regional boards may step in and take necessary enforcement actions to prevent pollution. For instance, regional boards may order remedial work to be done directly, and then recover the cost from the polluter. (John Muir Institute, 1979, pp. 83-93.)

5.2 Revised Implementation Framework

The attached flowchart shows recommended changes in the 208 Construction BMPs Implementation Framework. The original framework is given in Appendix A. The chart emphasizes the role of the responsible local agencies and shows the Water Quality Board as having review responsibility. It is recommended that the regional board not become involved in individual plan preparation and approval, but that it concern itself with general policy, coordination among local agencies, and enforcement problems when they occur. The monitoring of agency performance would be by report from the jurisdictions, and/or by independent verification by board staff. Site inspections are the best way to ensure that the management agencies are fulfilling their duties. It is recommended, however, that all jurisdictions continue to advise the regional board and other appropriate agencies of major grading projects by sending them a copy of the proposed erosion control plans.

This change in emphasis is most likely to affect the present working relationship between Irvine and the regional board. The board currently reviews all erosion control plans submitted to the city. However, expected state budget cuts will likely prevent the regional board from maintaining this high level of involvement. Therefore, Irvine eventually will need to reduce its reliance on the regional board for review of all erosion control plans. The resulting increased costs to the city may have to be partially offset by additional charges to developers.

The regional board should also take an active part in the erosion control training program. The board's guidance would be helpful in developing a program consistent with water quality goals, and one which encourages uniform enforcement among jurisdictions.

In the revised implementation framework, the board may request periodic reports from the management agencies in accordance with the Porter-Cologne Act, section 13225(c). One such report may be requested in October and would list the locations of grading operations, divided between regular grading and engineered grading (greater than 5,000 cubic yards). This list would assist the board in making site inspections during the winter. Another report may be requested by the board in May or June, assessing the agency's enforcement procedures during the preceding rainy season. The following items may be included in the report:

1. type and location of regulated grading projects, divided between regular and engineered grading;
2. types and design standards of erosion and sediment control measures;
3. number of inspections for each site; and
4. any enforcement actions taken by agency.

The board may wish to forego this detailed report if independent site inspections during the winter indicate that the management agency is rigorously enforcing its grading ordinance.

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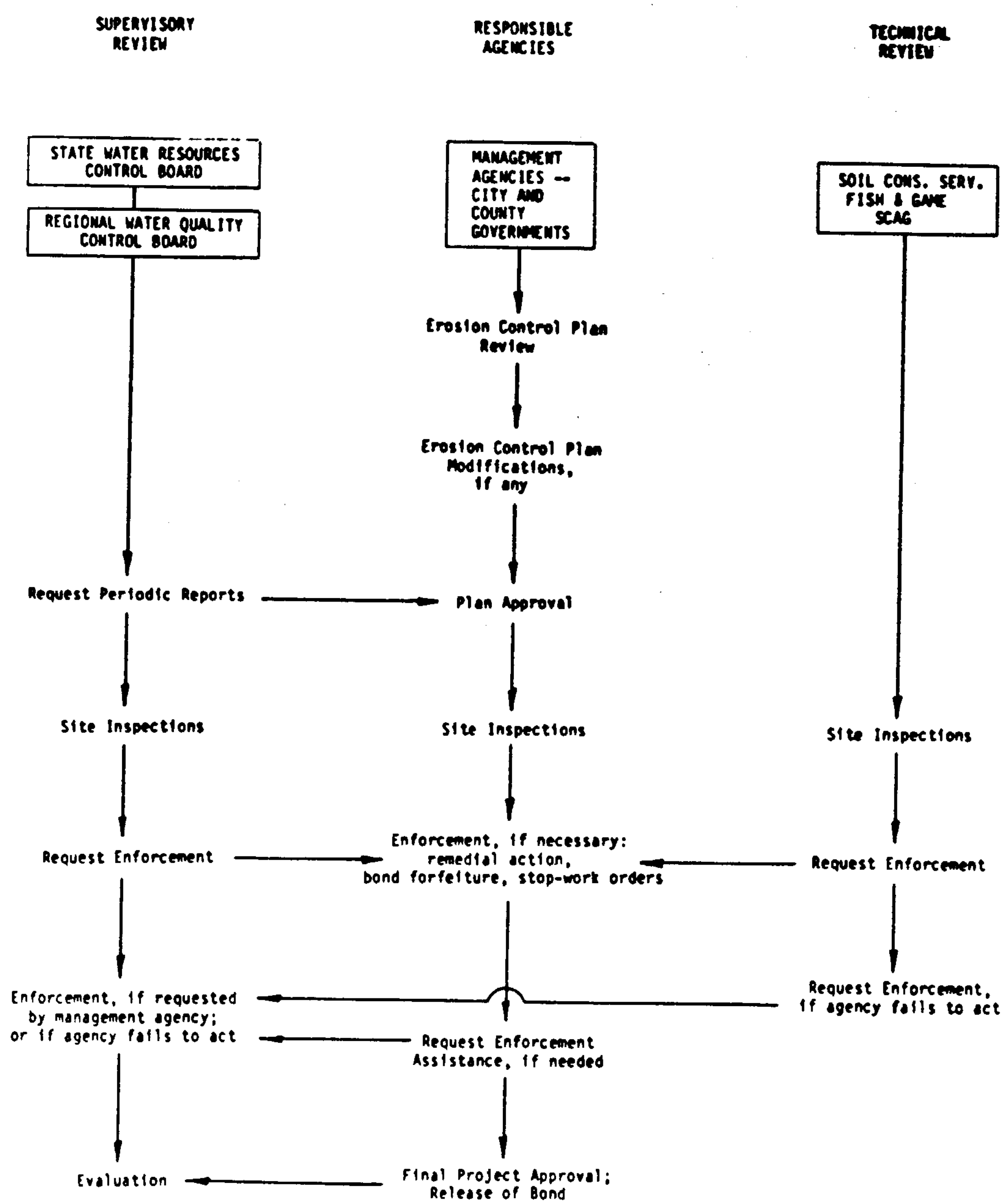
FIGURE 39
REVISED IMPLEMENTATION FRAMEWORK



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Irvine, CA
Montgomery County, MD
Newport Beach, CA
Orange, CA
Orange County, CA
San Diego, CA
San Diego County, CA
Santa Cruz County, CA
Solano County, CA
Tustin, CA

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BRASH INDUSTRIES

30 December 1995

Santa Monica Bay Restoration Project
101 Centre Plaza Drive
Monterey Park, CA 91754

Attention: Ms. Stephanie McDonald
Contract Manager

Subject: BRASH Industries PIE 94-015

Dear Ms. McDonald:

It is with a sense of sadness that I compose this last Official correspondence on the BRASH PIE Project. The project and all of its relevant forms Exhibit E, Deliverables, text, and general outline information is included. Much useful stormwater information was gathered from the various Santa Monica Watershed cities and cities in other states.

In summary, the program was finished on time and delivered a good product. Our hope is that the information presented at the workshops will be useable for subsequent programs and that we all have had an opportunity to make positive steps in storm(-)water pollution prevention.

This program evolved to a "Grander" reality then was originally anticipated in its conception. This was made possible through the efforts of those who supported this project: Liz Allen-PS Enterprises, Donna Toy-Chen, HTM Office, EAD City of LA, and of course Stephanie McDonald of SMBRP. Stephanie, I enjoyed working with you and appreciate your timely assistance and support. There are numerous agency representative, trade associations, and professional people whose assistance also made our workshops successful.

I hope this project will be regarded by those who judge progress and success as a worthwhile model for supporting industry efforts to implement pollution prevention programs, in a business friendly environment.

Sincerely,

M. H. Sachse

Marvin H. Sachse, P.E.
President

Enc:

2 1047 F

P.O. BOX 957 • VENICE, CALIFORNIA 90294 • TELEPHONE: 310-305-8637

STORMWATER 2000

EDUCATION BEFORE REGULATION

15 NOVEMBER 1995

WORKSHOP I

INDUSTRIAL FACILITY COST EFFECTIVE NPDES COMPLIANCE

9:00 - 9:15 Opening
Marvin Sachse, P.E. BRASH Industries

9:15 - 9:35 The Real Results of Stormwater Pollution
Dean Smith, Los Angeles County Department of Beaches and Harbors

This section addressed the incontrovertible evidence of pollution and its financial impact on the community. The cost of clean-up plus qualitative and quantitative information dramatically emphasized the need for Stormwater Management Programs.

9:35 - 10:05 Trends, Techniques, and Facility Trouble Spots
Dan Radulescu, Santa Monica Bay Restoration Project

This section focussed on the regulatory aspects of Stormwater Management. It also placed a human face on the regulators. It provided insights into the regulatory process, established that every-body is in the process together, and the their are some very bad operators that make it difficult for those who are striving for compliance.

10:05 - 10:20 Stormwater Management Assistance Sources
Donna Toy-Chen, R.E.A., Hazardous and Toxic Material Program, City of L.A. Environmental Affairs Dept.

The availability of free or low cost assistance is an encouraging sign for industry, and lets industry know that their tax dollars are being utilized for their assistance, not just their regulation.

10:20 - 10:50 Do It Yourself Compliance-NOI, SWPPP, Reports, Sampling: **Marvin Sachse**, P.E. BRASH Industries

A brief explanation of the NOI/SWPPP process, providing self help information on the completion of the SWM paperwork and sampling. Forms were presented to assist in SWPPP and Annual Report completion. Between-the-lines insights on sampling and how to reduce its cost were presented. Locations and sources of testings labs were offered along with pricing and sample collection and preservation guidelines. Information on Annual report completion was also presented.

10:50 - 11:00 Questions and Answers

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WORKSHOP II

COMMERCIAL/RETAIL STORMWATER COMPLIANCE

2:00 - 2:15 Opening
Honorable Ruth Galanter: City of Los Angeles Council District Six

2:15 - 2:35 Stormwater Pollution Impacts
Dr. James Fawcett, Los Angeles County Department of Beaches and Harbors

This section addressed the incontrovertible evidence of pollution and its financial impact on the community. The cost of clean-up plus qualitative and quantitative information dramatically emphasized the need for Stormwater Management Programs.

2:35 - 2:50 Santa Monica Bay Progress
Marianne Yamaguchi, Santa Monica Bay Restoration *Project*

The overview of the S M B R P provided perspectives on the magnitude of the bay pollution challenge, and more importantly, indication that progress was being made -- in a reasonable time frame.

2:50 - 3:10 Restaurant Perspectives
***Gerry Breitbart**, California Restaurant Association*

The importance of proper restaurant training and procedures to reduce stormwater pollution. Specific areas of concern were parking log maintenance, proper facilities maintenance procedures, floor mat washing. Points were brought up that much pollution originates from the purchaser not the food provider.

3:10 - 3:30 Fast Food Industry Compliance Experiences
Dan Milojevich, In-N-Out Burger

First-hand experience in working with different municipalities and regulatory agencies. The difficulties that were encountered as well as some of the cost effective solutions found in the working with regulators. The importance of stakeholder involvement cannot be overlooked.

3:30 - 3:50 Auto Services Compliance
Ron Wilkniss, Western States Petroleum Association

The automotive service industry has distinct stormwater concerns. This presentation was to assist gasoline and service station operators understand the regulatory environment as well as pollution prevention alternatives. Data was presented indicating that service stations contamination levels were at, or near, background levels.

3:50 - 4:00 Self Regulation and Education Before Mandatory Regulation
Marvin Sachse, P.E., BRASH Industries

The importance of self inspections and networking within an industry was emphasized as a means of reducing regulatory scrutiny. A present day, business sensitive, attitude exists with many regulatory agencies and municipalities. The importance of dialog was stressed.

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BRASH INDUSTRIES

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DELIVERABLE CHECK LIST

1) Summary report of watershed city interviews and copy of survey form:

Submitted: July 1995 Copy Available upon request:

2) Technical Information Package: Copies of applicable workshop information publications.

Enclosed.

3) Module-Script of general presentation, in presentation form.

To achieve maximum audience interest regulatory experts, industry spokespeople, and company representatives with first hand compliance experience, were utilized as - featured speakers. They were all asked to provide a copy of their presentation for our records. One did, it is enclosed. A detailed agenda is enclosed to define the subject area that were addressed. This should provide the form for subsequent forums.

Comments Enclosed.

3a) Text of press release for module user to submit to media.

See 3b).

3b) Text of two, one minute public service radio announcements for module user to submit to radio stations.

Stephanie McDonald has same in her possession. The same item was used for PSA as well Print media.

4) Two Work shops, list of attendees:

Enclosed.

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5) Summary of:

1) Work shop evaluation and copy of survey form.

Reviewed by Stephanie McDonald, SMB Project Manager, at work shop. Blank form included. Completed forms are available.

2) Summary of test City's reactions to using the module.

Enclosed.

Three cities provided evaluations. The cities that were in attendance were: Culver City, Hawthorne*, Los Angeles*, and Manhattan Beach*, Santa Monica. (Many more cities were invited to attend, but were unable to participate.) The summary of three polled cities (*) were:

The following points were considered very positively:

- **The presentation was well put together.**
- **The mix of speakers.**
- **The quality of speakers.**
- **The information presented.**
- **First hand experiences as related to storm water compliance.**
- **Representation by the different impacted industries.**

Deficiencies were:

- **The total number of industry representatives in attendance.**
- **How does one secure attendance by the key audience?**

The three cities polled expressed an interest in utilizing the module for their city's Stormwater program.

DISTRIBUTION OF FLYERS

WORKSHOP

Group/Agency	NPDES	COMMERCIAL/RETAIL
Restaurant Assns:		1,500
Auto Repair		1,000
City of L.A.	1,900	
El Segundo	10	72
Santa Monica	60	600
Manhattan Beach		110
Culver City		250
Hawthorne		250
Various Stormwater Agencies		50

DELIVERABLE: ITEM 4

ATTENDEE LIST - INDUSTRIAL WORKSHOP

Name	Title	Company
Dick Anderson	Owner	Anderson Yacht Maintenance
Jim Lee	Captain	Sapphire Sea II
George M. Payba	Inspector	City of LA, Stormwater
Ching W. Peng	Inspector	City of LA, Stormwater
Tri N. Tran	Inspector	City of LA, Stormwater
Dean Smith	Chief Admin. Servs.	Beaches and Harbors, LA County
Don Light	President	Liberty Metal Co.
David Conlin	President	Breakthrough Environmental Technologies
Harlan Christianson	Consultant	Breakthrough Environmental Technologies

ATTENDEE LIST - COMMERCIAL/RETAIL INDUSTRIAL WORKSHOP

Tami Davidson	Service Admin.	WI Simonson, Mercedes Benz
Dale W. Ma	Franchisee	Burger King
Michael Kissel	Enviro. Specialist	Carl's Jr.
Steve A. Heinze	President	Vallen Enterprises
Lee Guenveur	Owner	Lee's Unocal Service
Mort Farberow	Owner	Mort's Palisades Deli
Carrie Hayashida	Enviro. Intern	City of Manhattan Beach
Dina Khadavi	Enviro. Inspector	City of Santa Monica
Malek Taweil	Asst. Engineer	City of Ha+.wthorne
Jeff S. Ross	Shop Foreman	Sheridan Toyota
Bill Thornborough	Vice President	Sheridan Toyota
Ron Wilkniss	South Coast Issues	Western States Petroleum Association
Charles D. Herbertson	Pub. Works Director	City of Hawthorne
Pamela Keyes	Civil Engineer	City of Culver City
Billi Romain	Environmental	City Of Santa Monica
Mark Sands	Owner	Overland Cafe
John	Owner	Johnny's Auto Repair
Mike Madan	Owner	Golden State Fuels

Appendices

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Santa Clara Valley Nonpoint Source Study

Volume I: Loads Assessment Report

2

Submitted to

Santa Clara Valley Water District

10 5 4 F F

February 22, 1991

Submitted by

Woodward-Clyde Consultants

in associated with

Kinnetic Laboratory, Inc.

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Appendices

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Santa Clara Valley Nonpoint Source Study

Volume I: Loads Assessment Report

Submitted to

Santa Clara Valley Water District

February 22, 1991

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Submitted by

Woodward-Clyde Consultants

in associated with

Kinnetic Laboratory, Inc.

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APPENDIX A

APPENDIX A
FIELD MONITORING PROGRAM

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APPENDIX A
FIELD MONITORING PROGRAM

A.1 INTRODUCTION

The field monitoring program was designed to provide data to characterize runoff concentrations and to estimate nonpoint source pollutant loads entering the Lower South Bay from Santa Clara County. Monitoring during storm events was conducted to provide data to calibrate and verify the hydrologic and pollutant simulation model. Hydrological and water quality data associated with base dry-weather streamflows were also collected to estimate dry-weather annual pollutant loads. A secondary objective was to obtain initial information on the toxicity of both storm-related and dry-weather flows in streams entering the Bay.

The field monitoring program utilized three types of stations, as follows:

- Land use stations - Small, relatively homogenous land use catchments were selected to represent major land use categories. Data from these catchments were used as input to the loading model.
- Stream stations - Stations that were located in the lower portions of watersheds and which received a composite of storm runoff waters from multiple land use categories. Stream stations were monitored to provide data to verify the loading model.
- Reservoir stations - Stations located immediately below the water supply reservoirs. These were utilized to provide data to establish upstream background water quality conditions and to estimate loads associated with reservoir releases.

The field program can be conveniently described in terms of the following elements:

- The hydrology monitoring element consisted of continuously monitoring flows at stream and land use stations at hourly intervals throughout the duration of the monitoring program in order to estimate the hydrological component of the load.

- Water quality monitoring was conducted in three program elements: wet weather, dry weather, and reservoir release. Wet-weather water quality monitoring consisted of monitoring water quality at land use and stream stations for seven storm events. Storm composite samples were collected. The purpose of this sampling was to provide a basis for estimating pollutant loads during winter storm events. In order to estimate loads during winter base flow periods and summer dry-weather periods, dry-weather water quality monitoring was conducted by obtaining grab samples at the stream stations eight times through the program. To provide information on the water quality of water released from reservoirs, one round of reservoir release water quality monitoring was conducted at six stations immediately downstream of reservoirs.

- Bottom sediment sampling was conducted at the four stream stations. This sampling was conducted quarterly throughout the first year of the study. The purpose of this monitoring was to evaluate the role of bottom sediments as both a source and sink of pollutants associated with nonpoint source runoff.

- The bioassay testing program was designed as an initial screening of toxicity exerted by wet-weather samples obtained from land use and stream stations and dry-weather samples from stream stations.

In addition to the above, a number of special studies were conducted to address specific concerns. These studies examined: (1) dissolved oxygen concentrations during storm events at selected stream stations, (2) dissolved metal concentrations in runoff, (3) settling rates of suspended particulates in stormwater collected from stream stations, and (4) concentrations of fecal streptococci bacteria in stormwaters.

A.2 SAMPLING STATIONS

The selection of appropriate sites for the field monitoring program was critical to characterize stormwater runoff pollutants. The following sections discuss the selection criteria and the characteristics of the selected catchments and stations.

A.2.1 Selection Criteria

Specific site selection criteria followed the general guidelines provided by Shelley (1979). Criteria used to select specific monitoring sites were (1) catchment characteristics, (2) hydraulic factors, and (3) accessibility and safety.

Catchment characteristics of primary concern in selection of land use stations were representativeness of land use, overall size of the catchment, and uniformity of land use. In practice, the latter two concerns tend to operate in an opposite fashion, thus constraining the suitability of many catchments for siting of monitoring stations. With increasing size of the catchment, it becomes more unlikely that the requirement for uniformity of land use can be met. In the case of stream stations, it was desirable that the stations be located as far downstream in the watershed as possible, yet upstream of any tidal influences that would adversely affect the rating curve.

Hydraulic factors were important considerations in selection of both land use and stream stations. In the case of open-channel stations, it was necessary that eath be located at a site with an existing stage-discharge rating or at a site where adequate stage-discharge ratings could be established. Similarly, it was essential that manhole stations have suitable hydraulic characteristics for installation (and calibration) of the weirs. Thus, the following hydraulic factors were important considerations in the site selection process:

- Location at a site with an existing stage-discharge rating or at a site having a suitable control where a reliable rating curve could be developed

- Uniform and stable channel conditions for a distance equal to at least six channel widths upstream of the station

- Lack of tidal influence or backwater effects caused by downstream obstructions

- No evidence of surcharging or submergence over the normal range of precipitation (manhole installations)

- Adequate distance from major tributaries in order to allow for complete mixing

Safety and accessibility were important considerations, primarily to avoid accidents and injury, but also to ensure that field crews felt sufficiently safe so they exercised due care in conducting the field effort. Considerations included avoiding heavily trafficked areas or areas where light and/or visibility created conditions conducive to an accident with passing cars or trucks. Choice of station locations was also influenced by accessibility and security, and wherever possible, stations were located on SCVWD right-of-way which was secured.

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A.2.2 Catchment and Station Characteristics

The following describes the catchment and station characteristics for land use and stream stations. For reference, Table A-1 summarizes general information and Table A-2 gives estimates of the land use mix of each catchment.

A.2.2.1 Land Use Catchments. The land use catchments were selected to represent the following major land use categories: light and heavy industry, commercial, single- and multi-family residential, and open.

Station L1 was a light industrial site located on Junction Avenue. The catchment drains a 22-acre industrial park bordered by Charcot Avenue, Dado Avenue, and Coyote Creek (in San Jose). The station was located in a manhole on Junction Avenue near the Southern Pacific Railroad (SPRR) lines. The storm drain diameter was 30 inches, and a sharp-crested weir was placed in the manhole to facilitate flow measurements. Truck traffic on Junction Avenue was often heavy and on one occasion was sufficient to create vibrations that broke the 10-liter glass bottle in the automatic sampler suspended below the manhole.

Station L2 was a heavy-industrial site on a catchment that drains Walsh Avenue between the SPRR lines and Lafayette Street (in Santa Clara). This 28-acre catchment included warehouse distribution centers involving heavy truck traffic, a used-car parts distributor, a commercial carpet cleaning service, a printing shop, and small miscellaneous manufacturing and office facilities. Initially there was an open drum storage area that was associated with a carpet cleaning facility; however, the drums were found to have been removed on a field reconnaissance conducted on December 5, 1988. The station was located in the right-of-way east of the SPRR lines in a manhole with a 20-inch-diameter storm drain. A weir was installed in the manhole for flow measurements. There was evidence of an illicit discharge at this station in August 1988 that was analyzed and shown to be strongly caustic.

Table A-1. STATION DESCRIPTION

Designation	Type of Station	Location	Location	Jurisdiction	Principal Land Use	Drainage Area (acres)	Conveyance	Remarks
L1	Land Use	Junction Avenue, between Charcot and Dado Streets	San Jose	San Jose	industrial park	22	30" R.C.P.	Manhole station, with weir installed
L2	Land Use	Walsh Avenue, near SPRR	Santa Clara	Santa Clara	heavy industry	28	27" R.C.P.	Manhole station, with weir installed
L3	Land Use	Frances and Beemer streets, north of Sunny-vale Caltrans RR Station	Sunnyvale	Sunnyvale	commercial	265	42" R.C.P.	Manhole station, with weir installed
L4	Land Use	Hale Creek, near Magdalena Rd.	Santa Clara County	SCVWD	low-density single-family residential (hillside)	1,633	open channel	SCVWD gaging station No. 33
L5	Land Use	Sunnyvale East Channel, near Fremont Avenue	Sunnyvale	SCVWD	single-family residential (valley)	2,080	channelized	Highly-erodable channel, rating developed
L6	Land Use	Pasetta and Williams, near San Tomas Expressway and SPRR	Santa Clara	Santa Clara	multi-family residential	85	33" R.C.P.	Manhole station, with weir installed

Table A-1. STATION DESCRIPTION (continued)

Designation	Type of Station	Location	Location	Jurisdiction	Principal Land Use	Drainage Area (acres)	Conveyance	Remarks
L7	Land Use	Stevens Creek, above Stevens Creek Reservoir	Santa Clara County	SCVWD	open (forest)	8,410	natural	Rating developed but not considered reliable because of backwater effects
L8	Land Use	Packwood Creek, at Jackson Ranch (east of Anderson Reservoir)	Santa Clara County	SCVWD	open (ranchland)	6,464	natural	SCVWD gaging station No. 57
S1	Stream	Calabazas Creek, at Wilcox School	Santa Clara	SCVWD	mixed	9,216	natural	SCVWD gaging station No. 26A
S2	Stream	Sunnyvale East Channel, at Bayshore Frontage Road (A.P. Sta 2)	Sunnyvale	SCVWD	mixed	3,437	channelized	SCVWD gaging station No. 74
S3	Stream	Guadalupe River, at San Jose	San Jose	SCVWD	mixed	15,904	natural	USGS gaging station No. 169000
S4	Stream	Coyote Creek, at Montague	San Jose	SCVWD	mixed	79,552	natural	SCVWD high-flow gaging station No. 2060
R1	Reservoir Release	Below Stevens Creek Reservoir (A.P. Sta 14)	Santa Clara County	SCVWD	open	10,924	natural	SCVWD gaging station No. 44

Table A-1. STATION DESCRIPTION (concluded)

Designation	Type of Station	Location	Location	Jurisdiction	Principal Land Use	Drainage Area (acres)	Conveyance	Remarks
R2	Reservoir Release	Below Lexington Reservoir	Santa Clara County	SCVWD	open	23,859	natural	SCVWD gaging station No. 67
R3	Reservoir Release	Below Guadalupe Reservoir	Santa Clara County	SCVWD	open	3,808	natural	SCVWD gaging station No. 17
R4	Reservoir Release	Below Almaden Reservoir	Santa Clara County	SCVWD	open	7,667	natural	SCVWD gaging station No. 16
R5	Reservoir Release	Below Calero Reservoir	Santa Clara County	SCVWD	open	4,621	natural	SCVWD gaging station No. 13
R6	Reservoir Release	Below Anderson Reservoir	Santa Clara County	SCVWD	open	124,787	natural	SCVWD gaging station No. 9

Station		Area (Acres)	Open (%)	Residential[c] Low Density (%)	Residential[c] Medium Density (%)	Residential[c] High Density (%)	Commercial (%)	Industrial[d] Light (%)	Industrial[d] Heavy (%)	Other (%)	Remarks
L1	Junction Ave.	2						100			
L2	Walsh Ave.	28							100		
L3	Frances and Beamer	265			58		42				resid. density ~ 6-7 d.u./acre
L4	Hale Creek	1633	20	80							resid. density ~ 1-2 d.u./acre
L5	Sunnyvale East, at Fremont Ave.	2,080	6	49	30		21				
L6	Passetta and Williams	85			30	53				17	medium density resid. ~ 6-7 d.u./acre, other land use includes church (5 acres) and school (9 acres)
L7	Stevens Creek, at Camp Castanoan	8,410	100								
L8	Packwood Creek	6,464	100								
S1	Calabazas Creek	9,216[b]	21	35	36		7				
S2	Sunnyvale East at Bayshore	3,437[b]		47	18	3	32				
S3	Guadalupe River	55,904[b]	30	23	34	4	5	3	1		
S4	Coyote Creek	79,552[b]	64	4	24	2	1	4	1		

a Based on county and city general land use plans as compiled by SCVWD (projections generally ranged between 1989 and 2000), field reconnaissances, and aerial photos.

b Does not include areas above upland reservoirs.

c Definition of low-, medium-, and high-density residential differed amongst municipalities, but generally was as follows: Low--1 to 5 dwelling units/acre; Medium--6 to 12 dwelling units per acre; High--greater than 12 dwelling units per acre.

d Light-industrial land use refers to industrial parks and high technology manufacturing. Heavy industry refers to more traditional manufacturing and distribution centers.

Station L3 was a manhole station located at the intersection of Frances and Beamer Streets, north of the Sunnyvale Caltrans Station. The 300-acre catchment represented commercial and single-family residential land use and included the Sunnyvale Town Center and the Caltrans station. The drainage area was approximately bounded by the SPRR lines (north), Mathilde Avenue (west), Bayview Avenue (east), and Olive Avenue (south). A weir was also installed at this station.

Station L4 was located on Hale Creek near Magdalena Road. It drains a 1633-acre, low-density (1-2 dwelling units/acre), single-family residential area in Los Altos Hills. The station corresponded to SCVWD gaging station No. 33, which employs a sloping concrete weir as a hydraulic control for flow measurement.

Land use Station L5 was located on Sunnyvale East Channel at Fremont Avenue. It drains a 2080-acre predominantly single-family residential area. The monitoring station, located in a short earthen reach between Fremont Avenue and Ashbourne Drive, was just upstream of a concrete apron and box culvert which pass under Fremont Avenue. The channel was subject to extensive bank and bottom erosion, especially in the area downstream of the box culvert below Ashbourne Drive.

Station L6 was a 85-acre catchment consisting of a multi-family residential area bounded by Passetta, Williams, and Monroe streets, and Deborah Drive, and a single-family residential area located along Sheraton Drive and El Capitan Avenue. This catchment also included a church and school. The station was located in a manhole near the San Tomas Expressway and the SPRR. The second manhole upstream of the station was located at the junction of Passetta and Williams streets. The storm drain in the manhole was 33 inches in diameter. A weir was installed at this station to better estimate flows.

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Station L7 was on Stevens Creek, just upstream of Camp Castanoan Bridge, above Stevens Creek Reservoir. The 8410-acre drainage area consisted primarily of steep, heavily forested land in the Santa Cruz Mountains.

Station L8 was a second open land use catchment (6464 acres in area) located in the Diablo Range and draining primarily open ranchland. The station corresponded to the SCVWD gaging station No. 57 on Packwood Creek, upstream of Anderson Reservoir.

A.2.2.2 Stream Stations. Four stream stations were selected at locations near the Bay, but above the zone of tidal influence. The purpose of the stream stations was to provide a means of making loading estimates from large catchments solely with measured flow and water quality data. Such estimates could then be used as a check by comparing findings with the model predictions (based on the upstream land use characteristics). The following is a description of the stream stations.

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Station S1 was located at the SCVWD gaging station No. 26A, located on Calabazas Creek near Wilcox school. The drainage area is 14 square miles and consists of approximately 80 percent residential/commercial and 20 percent open (Table A-2), the latter of which is located mostly in the upland portions of the catchment in the foothills of the Santa Cruz Mountains. The control is a sloping concrete weir.

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Station S2 was located on Sunnyvale East Channel, just upstream of Awhanee Avenue (a frontage road along Bayshore Freeway). This catchment has an area of 5.2 square miles and is wholly urbanized, consisting of residential (68 percent) and commercial (32 percent) land use on the valley floor. The station corresponds to the SCVWD gaging station No. 74. The control is a sloping concrete weir.

These two stations were selected to be representative of the smaller more urbanized watersheds on the west side of the Study Area.

Station S3 was the USGS station No. 1119000 on the Guadalupe River, located downstream of the confluence with Los Gatos Creek. This station has a total drainage area of 146 square miles and includes Los Gatos Creek and Lexington Reservoir, Guadalupe Creek and Guadalupe Reservoir, Ross Creek, Alamitos Creek and Almaden Reservoir, and Calero Creek and Calero Reservoir. This station was selected because it drains a large urbanized area that is accurately gaged. The area of the catchment below the reservoirs is approximately 85 square miles. The land use in this area is 30 percent open, 61 percent residential, 5 percent commercial, and 4 percent industrial (Table A-2).

Station S4 was located on Coyote Creek at Montague Expressway at the SCVWD high-flow gaging station No. 2060. This catchment includes Upper Penitencia and Silver and Thompson creeks, and Anderson and Coyote reservoirs. The catchment area below Anderson Reservoir is approximately 120 square miles, 64 percent of which is open ranch land located in the foothills of the Diablo Range. The remaining land use consists of 30 percent residential, 1 percent commercial, and 5 percent industrial (Table A-2). The SCVWD gaging station at this location was designed to record only flood stages, so this station had to be rated for more typical lower storm-event flows.

A.2.2.3 Reservoir Stations. The reservoir stations were located at SCVWD gaging stations below Stevens Creek, Lexington, Guadalupe, Almaden, Calero, and Anderson Reservoirs (Table A-1).

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A.3 SAMPLING AND ANALYSIS PROGRAM

A.3.1 Hydrology

The field study was designed to collect accurate hydrological information at each station to quantify discharges throughout the year and to collect flow-weighted composite samples. Thus, monitoring of stage (water depth) was performed continuously throughout the year, at all stations that had year-round flow.

The majority of open-channel stations were located at sites which had previously-established stage-discharge curves. Two of the open-channel stations (L5 and L7) required establishment of new stage-discharge curves. A third station (S4) required establishment of the low-flow portion of the rating curve.

Flow ratings at all four manhole installations were initially calculated using a standard weir-rating formula. These ratings were later calibrated at manhole installations L2, L3, and L6 using dye-dilution methods.

A.3.2 Water Quality

Water quality constituents included in the field monitoring program were selected based on the following factors:

- Constituents previously identified to be a major concern in Lower South Bay and its tributaries
- Constituents previously identified as prevalent in urban runoff studies conducted as part of EPA's National Urban Runoff Program
- Pollutants expected to be present in surface runoff waters from the Study Area, based upon industrial sources, or other specific local knowledge

- Pollutants identified historically in nonpoint source runoff samples collected within the Study Area

The overall approach of the water quality studies was to examine a wide range (or "full suite") of potential pollutants in the early phases of the study and then develop a more refined list (or "reduced suite") of pollutants based upon results of the initial surveys (Table A-3). One analysis, organophosphate pesticides, was added to the reduced suite but was later eliminated, because none were detected.

A.3.3 Sediment Quality

The overall approach and list of sediment quality constituents (Table A-4) were similar to those described for the water quality testing program. The primary difference in the sediment quality program was that the reduced suite of constituents was originally expected to retain the broader scan of organic contaminants provided by the semi-volatile (EPA 625) GC/MS analysis. It was originally expected that a number of priority pollutant compounds would be detected in sediments, due to their low solubilities and their tendency to associate with fine particles. Due to low levels of these compounds detected, the final suite of constituents focused more directly on polynuclear aromatic hydrocarbons (PNA) that are produced as by-products of internal combustion engines.

Organophosphate pesticides were analyzed in the sediments on only one occasion. Since none were detected in the samples, this group of compounds was not included in later analyses.

A.4 SCHEDULE

The field monitoring program was initiated in February 1988 and completed in April 1989. Figure A-1 shows the schedule and Table A-5 gives specific sampling dates. A single survey was conducted to assess the quality of water discharged from six major reservoirs in the Santa Clara able A-3. SUITES FOR CHEMICAL ANALYSIS OF WATER QUALITY SAMPLES

lass	Complete Suite	Reduced Suite
rganics	Total Organic Halogens	Total Organic Halogens
	TOC	TOC
	Volatiles (624-GC/MS)	
	Semi-volatiles (625-GC/MS)	PNA (610)
608)	Organochlorine pesticides (608)	Organochlorine pesticides (608)
	Chlorinated herbicides (8150)	
letals, Total	Arsenic	Arsenic
	Cadmium	Cadmium
	Chromium (total)	Chromium (total)
		Chromium (hexavalent)
	Copper	Copper
	Lead	Lead
	Mercury	Mercury
	Nickel	Nickel
	Selenium	Selenium
	Silver	Silver
	Zinc	Zinc
lutrients	TKN	TKN
	NH_3-N	
	NO_2 and NO_3	
	Total Phosphate	
3acteria	Total and fecal coliform	Total and fecal coliform
Jther	BOD_5	BOD_5
	Temperature	Temperature
	pH	pH
	TSS	TSS
		Total hardness
		Turbidity

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Table A-4. SUITES FOR CHEMICAL ANALYSIS OF SEDIMENT QUALITY SAMPLES

Class	Complete Suite	Reduced Suite
Organics	TOC Volatiles (8240-GC/MS) Semi-volatiles Organochlorine pesticides (8080) Chlorinated herbicides (8150)	PNA (83[illegible]) (8270-GC/MS) Organochlorine pesticides (8080)
Metals, Total	Arsenic Cadmium Chromium (total) Copper Lead Mercury Nickel Selenium Silver Zinc	Arsenic Cadmium Chromium (total) Chromium (hexavalent) Copper Lead Mercury Nickel Selenium Silver Zinc
Nutrients	TKN NH_3-N	
Other		Sediment particle size

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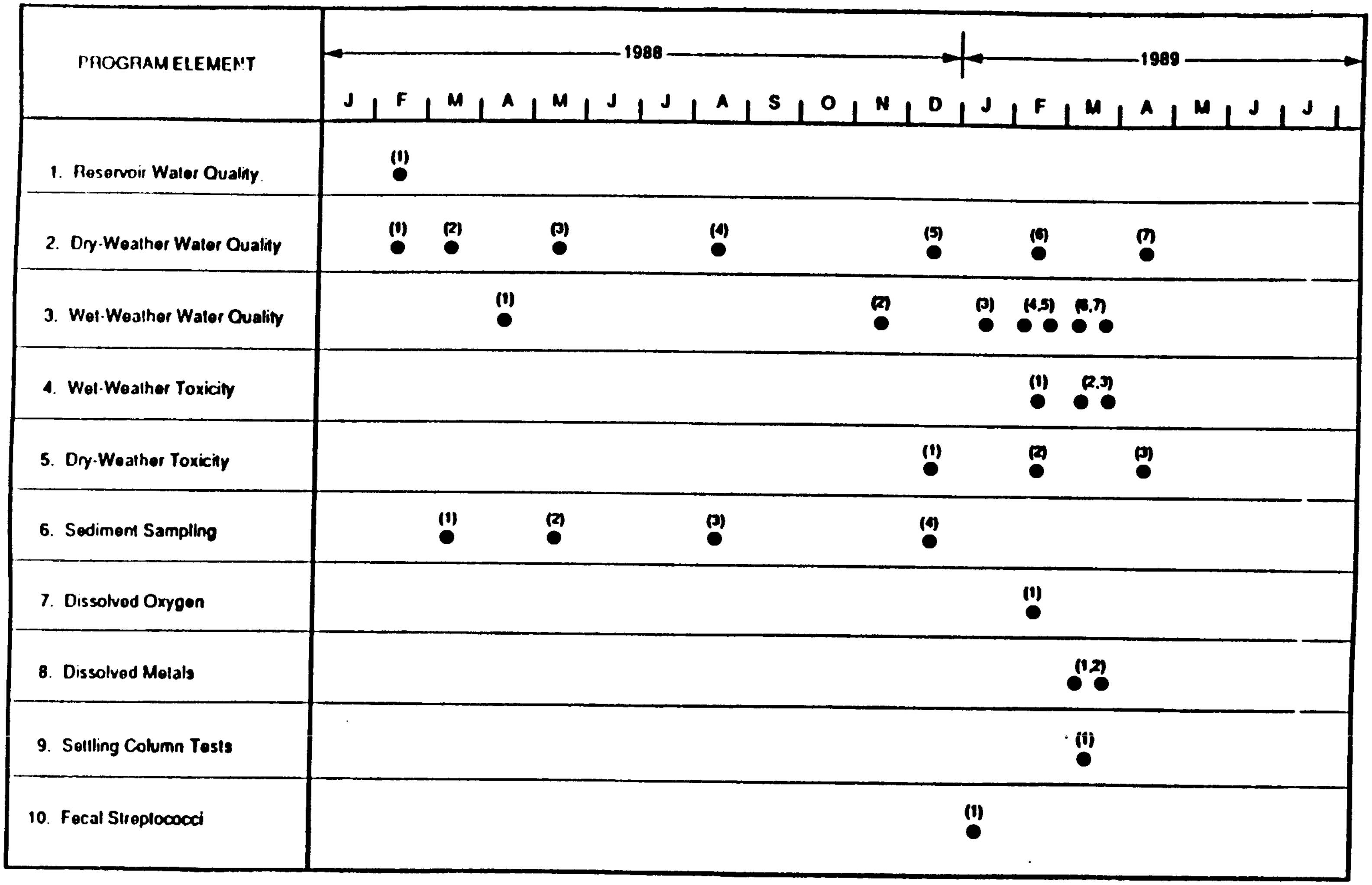

Figure A-1. SAMPLING SCHEDULE

Table A-5. SAMPLING DATES

Program Element	Round	Sampling Date[a] Month	Day	Year
(1) Reservoir Water Quality	1	February	26	1988
(2) Dry-Weather Water Quality	1	February	26	1988
	2	March	30	1988
	3	May	11	1988
	4	August	22	1988
	5	December	12	1988
	6	February	1	1989
	7	April	6	1989
(3) Wet-Weather Water Quality	1	April	20	1988
	2	November	23	1988
	3	January	23	1989
	4	February	4	1989
	5	February	9	1989
	6	March	2	1989
	7	March	25	1989
(4) Wet-Weather Toxicity	1	February	9	1989
	2	March	2	1989
	3	March	25	1989
(5) Dry-Weather Toxicity	1	December	12	1988
	2	February	1	1989
	3	April	6	1989
(6) Sediment Sampling	1	March	30	1988
	2	May	11	1988
	3	August	22	1988
	4	December	12	1988
(7) Dissolved Oxygen	1	February	9	1989
(8) Dissolved Metals	1	March	25	1989
	2	April	6	1989
(9) Settling Column Tests	1	March	25	1989
(10) Fecal Streptococci Bacteria	1	January	23	1989

[a] Initial date only; sampling often continued for one or two additional days.

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Valley. The reservoir water quality survey was conducted on February 26, 1988, concurrently with the first dry-weather water quality survey.

A total of seven dry-weather water quality surveys were conducted during the 15-month field program. Four of these studies were conducted during winter months, two during the spring, and one in the autumn following a lengthy dry period.

Seven wet-weather (i.e., storm) events were sampled to obtain water quality data. The first and only storm event sampled in the 1987-88 wet-weather season occurred on April 20, 1988. The six remaining storm events that were sampled occurred in the 1988-89 wet-weather season. The first significant rainfall of the 1988-89 wet-weather season was sampled on November 23, 1988. The remaining five storm events monitored were in January, February, and March 1989.

Three wet-weather toxicity tests were conducted in February and March 1989. Dry-weather toxicity testing was coordinated with the December 12, 1988, and the February 1 and April 6, 1989, dry-weather water quality surveys.

The sediment sampling was fully completed during the first year of the study. The final quarterly sediment survey was completed on December 12, 1988.

A number of other program elements classified as "special studies" were completed in association with storm events sampled in early 1989. Detailed monitoring of dissolved-oxygen levels was performed at the four stream stations on February 9. Concentrations of dissolved metals were added to the suite of constituents measured in storm runoff during the March 25 and April 6 storm events. Experiments on settling rates of suspended particulates were conducted on samples collected on May 25. A special survey of concentrations of fecal streptococci bacteria was conducted in association with the January 23 storm event.

A.5 EQUIPMENT

A.5.1 Station Design

Two generalized station designs were employed in the field study. The most common design was for monitoring flow and water quality in open channels. This configuration varied slightly among the several stations, depending upon specific site characteristics. The second type of station was designed for monitoring flow and water quality within storm sewers.

The following design considerations were common to both station configurations:

- Intakes must be protected from large objects transported by the stormwater runoff.
- Intakes must be located in a well mixed area not subject to burial or emergence.
- Water velocity in the intake hose during sampling must be maximized to maintain particulate material in suspension.
- Intake hose material must be appropriate to avoid metals and organic contamination of samples.
- Sample container material must be compatible with holding samples to be analyzed for both trace metals and organic compounds.
- The peristaltic pumps must be capable of delivering consistent sample volumes, regardless of intake hose length and changes in head associated with the rise and fall of stage in the water body being sampled.

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- Automatic samplers should not exceed a head difference of 20 feet above the water in order to prevent deterioration in water velocities within the intake and decreasing precision in sample volume.

All intakes were placed in cages constructed of quarter-inch stainless rod. These cages were designed to deflect moderate-sized objects around the intakes and the pressure sensors. Coarse stainless steel intake screens were used to reduce the likelihood of blockage within the sample tubing.

In most installations, intakes were positioned between 2 and 4 inches above the bottom, as recommended by Shelley (1979). This range was believed to be a reasonable compromise between avoidance of bedload transport and keeping the intake submerged. When base flow conditions allowed, the intake was positioned higher in the water column. For example, the base stage in Coyote Creek was typically around 3 feet, so the intake at this station was positioned 1.5 feet off the bottom.

The 3/8-inch (i.d.) intake hose was constructed of polyethylene on the outside and Teflon on the inside. The polyethylene provided the required physical strength while the Teflon provided a suitable material for handling samples which would be analyzed for either metals or organic compounds. The bore diameter of the intake hose was selected to maximize the velocity of flow within the hose (in order to prevent settling of suspended solids). An internal diameter of 3/8 inch was calculated to maintain the minimum velocities of 1 to 2 fps at head differences of up to 20 feet.

Consistent sample volumes were obtained over a wide range of head differences by development and use of an algorithm which could compensate for changes in head pressures. This algorithm was part of the specialized software developed to control the automatic samplers. The number of pump rotations necessary to obtain a sample volume of 500 ml was calculated as a function of intake hose length and an instantaneous measure of head pressure between the pump and surface of the water. This value could be calibrated in the field to compensate for specific station configurations.

The composite sample containers provided commercially by ISCO were inappropriate for collection of water for analysis of both trace metals and organic compounds. Borosilicate glass provided the best alternative for collection of water to be submitted for metals and organics. Thus 10-liter, borosilicate media bottles were used to replace the standard containers.

Although the open-channel and manhole installations shared common design criteria, the manhole installations were unique in that they required installation of a primary control device to increase accuracy of flow measurements, particularly at lower flows. Rectangular sharp-crested weirs were used, because they were found to be the most cost-effective primary control device to fabricate and install in this application.

A.5.2 Weirs

All weirs utilized in the manhole installations were rectangular weirs made from quarter-inch steel plate. The heights of the weirs were generally about one-half the diameter of each pipe. A rectangular cutout with a width equal to one-quarter of the pipe diameter and a depth equal to one-sixth of the diameter was placed in the center top portion of the weir to facilitate accurate measurement of lower flows (see Figure A-2).

Each weir was secured by stainless steel cable to eyebolts set in the wall of the manhole. This both prevented the weirs from becoming lodged in the pipe if they were to break loose during a storm event, and it allowed for quick removal of the weirs, if upstream flooding were to occur. Hoses were attached to the back of the weirs to aerate the nappe.

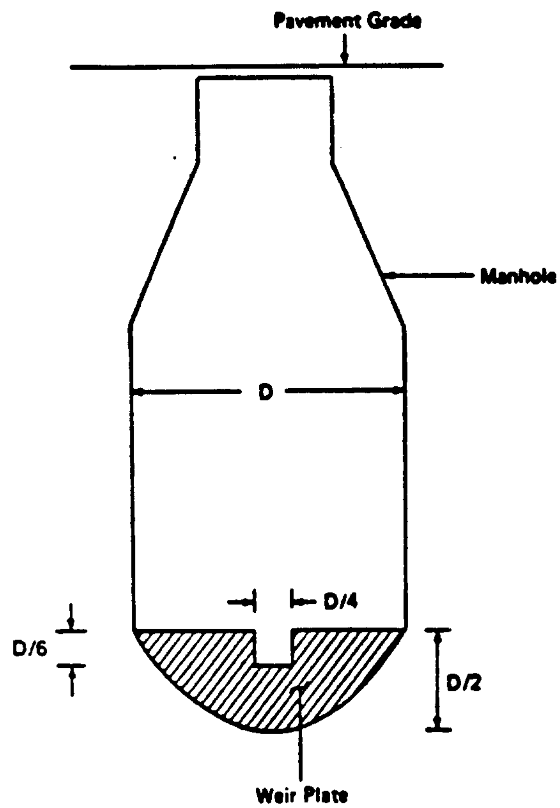

Figure A-2. WEIR SCHEMATIC

A.5.3 Automatic Samplers and Stage Recorders

Automatic samplers and stage recorders were deployed in all of the open-channel and manhole installations. Each system consisted of an ISCO Model 2700 composite sampler, a Campbell Scientific Model CR-10 Data Logger and Control Module, and a pressure sensor. GeoKon Model AVW-1 Vibrating Wire pressure/temperature sensors were initially installed at all stations. These sensors were selected for the study on the basis of their extreme durability and accuracy. Nevertheless, a number of these sensors were observed to drift out of specifications in the early stages of the study. These sensors were then replaced with the newly available Druck Model PDCR-830 titanium pressure sensors. These Druck sensors proved to have both excellent accuracy and stability characteristics under a variety of field conditions.

The ISCO composite samplers were used to pump, cool, and store water samples during storm events. The standard programmable read-only memory (PROM) units which contain the instruction set for the samplers were specially modified to allow full external control via the sampler's flowmeter input data port. All pumping functions could then be controlled externally by the Campbell Scientific CR-10.

A.5.4 Data Logger

Campbell Scientific CR-10s were used at each station to provide overall system control functions and to serve as a central data processor and data storage module. Two types of data, high-resolution storm data and continuous (dry- and wet-weather) hydrology data, were recorded by the data logger. Data were nondestructively retrieved by use of a standard, portable tape deck. The tapes were then read by an IBM-compatible microcomputer with a Campbell Scientific PC-201 card. If the data dump was defective, the station could be revisited and the data retrieved again.

The storm data memory register stored detailed information on the storm events, including the time the storm mode was initiated, the time each

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sample was taken, and the storm runoff volume represented by each sample. After completely filling a 10-liter sample container, 15-minute-averaged values for temperature, stage, and flow were stored in the storm memory register until the station was visited by the field crews to change sample containers.

The continuous hydrology memory register maintained hourly-averaged temperature and stage data. These data were continuously recorded during storm events and base flow conditions.

A.5.5 Software to Initiate and Terminate Flow Composite Sampling

Software installed in each CR-10 was designed to continuously monitor stage at each monitoring station and then automatically initiate flow-weighted composite sampling. Pressure sensors were interrogated every 15 seconds to determine stage. Fifteen-minute averages of the stage data were then stored and later used to evaluate whether storm sampling should be initiated.

The software enabled storm sampling to be initiated, based upon both relative and absolute criteria. At the end of every 15-minute interval, stage or flow data (using stage-discharge equations) were compared to those obtained during the prior 15-minute interval. Storm sampling was initiated, if percentage increases in one of these parameters exceeded a given criterion, typically 20 percent. This criterion could be modified to adjust sensitivity of the "trigger," based upon the specific hydrological characteristics of each station.

In addition to comparing relative increases in either stage or flow, storm sampling could be automatically initiated if the 15-minute average stage measurement exceeded a set value. This trigger was particularly useful for stations that, under certain conditions, did not increase rapidly enough in stage to exceed the relative criteria or where no base flows were present.

Flow-weighted composite sampling could also be terminated by software control of the system. The data loggers were programmed to terminate the storm sampling mode once the stage dropped below a level 20 percent greater than the storm initiation or trigger stage. Sampling would not terminate automatically without first filling a sample container.

A.5.6 Equipment and Installation

Instrumentation for all open channel installations was contained in custom-built 2-ft x 4-ft x 30-inch steel enclosures mounted on concrete pads. In natural channels, conduits for containment of pressure sensor leads and water intake tubing were installed through the concrete pad and led underground to the channel. In some cases, a short conduit (approximately 0.5 to 1.0 feet) was installed between the instrument enclosure and adjacent stilling wells. The pressure sensor could then be installed in the stilling well where it was well protected from potential vandalism. For installations where both stilling wells and concrete channels existed, both the pressure transducer and intake hose were run into the stilling well. The intake tubing was then fished through the lower communication port and mounted at the bottom of the channel.

Each storm sewer installation was completely contained within the existing manhole chambers. All equipment was suspended by metal cable slings from eyebolts installed in the concrete wall just under the manhole cover. A two-person field crew was required to conduct routine monitoring involving removal of the sampling equipment from the manhole. Data dumps and routine monitoring of station operation could be performed by one person, since the systems communication port was located immediately below the manhole cover.

A.6 SAMPLING METHODS

A.6.1 Field Procedures and Training

A detailed set of Standard Operating Procedures (SOP) were developed for all phases of the field monitoring program. The SOP contained the following procedural instructions:

- Standard Observations
- Initial setup of the composite samplers
- Storm monitoring station software initiation
- Battery replacement
- Data retrieval
- Sample removal and handling
- Grab sampling
- Sample transfer and tracking

Field training sessions were held prior to each storm season for personnel expected to participate in storm monitoring. The training sessions involved review of the SOP and hands-on experience in interrogating a model storm monitoring station.

Additional training was provided in the field during station maintenance visits. Less experienced field personnel were routinely deployed with key project personnel. This enabled greater dissemination of important station-specific knowledge (e.g., location and special handling needs) and provided an opportunity to practice station interrogation skills that would be needed during the intensive storm monitoring events.

A.6.2 Grab Samples

Grab samples were taken for all water samples that were not appropriate for analysis from the pumped composite sample. Grab samples were necessary for bacteria, volatile organics, pH, and dissolved oxygen.

Two methods were used to obtain grab samples of water. The primary method involved direct collection of the water sample in the sample container. The open container was attached to a stainless steel rod. This enabled the open container to be fully immersed as near as possible to the centroid of flow and eliminated potential contamination of the sample. This method was applied to samples collected for bacteria, volatile organics, and pH. Van Dorn (1.5-liter) bottle samplers were used for collection of samples for measurement of dissolved oxygen.

The guidelines followed by Kinnetic Laboratories field personnel for grab sampling during storm events calls for collection of samples in the early phase of the storm, certainly during the rising limb of the hydrograph. Most of the grab samples collected in this program were performed in the early phase of the storm.

Sediment grab samples were collected either by use of clean stainless steel scoops or by scraping the sediments directly into the sample containers. Four to five different scrapes were taken to comprise a single sample. A conscious effort was made to sample finer-grained sediments in depositional areas of the stream bed. In several cases, appropriate sediments were difficult to locate. In such cases, professional judgement was used to locate the most appropriate sediments along a given reach.

A.6.3 Automatic Samplers

Sampling of stormwater runoff was accomplished primarily by use of modified ISCO composite samplers. The automatic samplers were designed to take 500-ml aliquots of runoff water at time intervals corresponding to a given volume of water flowing by the monitoring station. The volume of runoff represented by each 500-ml sample was a user-specified value. The default setting for each site was 1/20 of the expected runoff volume for a 0.25-inch storm. The sampling rate at a given station could be altered in the field by increasing or decreasing this value. It was necessary to adjust this variable based upon both sample volume requirements (e.g., additional analytical and bioassay water requirements) and anticipated rainfall in excess of 0.25 inches.

The percentage of the total storm represented by each composite sample varied widely among storm events and stations (Table A-6). The precipitation, runoff, and required sample volumes were important factors in determining the percentage of the storm from which flow-weighted composites were attained. After depositing 19 samples (9.5 liters) into the composite sample container, the monitoring system would go into standby mode until visited by the field crew. High sampling rates or brief, intense periods of rainfall occasionally caused the composite samplers to fill too rapidly and enter the standby mode. This would cause loss of storm coverage until the station was revisited by the field crew. Low sampling rates or lower than anticipated rainfall would result in good storm coverage but inadequate sample volumes.

A.6.4 <u>Effects of Partial Storm Capture on Load Estimates</u>

In the field monitoring efforts, it was not always possible to secure samples over the entire runoff period, for use in the flow-weighted composites that were analyzed. In some cases, this was due to the inability of field crews to reach all stations before runoff began. In most cases, it resulted from the sample collection container filling before runoff from the event had terminated. A record was maintained of the fraction of the total runoff volume that was sampled and incorporated in the samples for water quality analysis. This information is summarized in Table A-6 which lists, for each event at each station, the ratio of the sampled volume to the total volume of runoff.

As the listing indicates, the storm fraction sampled varied from event to event at any site, and the pattern was not consistent from site to site for a specific storm event. Fifty-seven (57) of a possible 70 station-events produced composite samples that were analyzed for water quality. Four station-events were missed due to equipment malfunction (SM). The

Table A-6. PERCENT OF STORM EVENT RUNOFF SAMPLED[a]

Event No.	Date of Storm Event	L1	L2	L3	L4	L5	L6	S1	S2	S3	S4
		Stations[b]									
1	4-20-88	21	95	98	NS	SM	33	SM	40	57	100
2	11-23-88	100	90	97	NS	75	95	17	33	61	50
3	1-23-89	NS	NS	NS	NS	73	NS	3[c]	50	57	NS
4	2-1-89	35	3[c]	85	70	73	SM	40*	29*	66	40
5	2-8-89	33	56	100	100	58	36	40	53	46*	63
6	3-2-89	32	79	100	50	100	100	51	99	65	74
7	3-23-89	NS	NS	78	60	100	95	36	50	SM	67

a The ratio of the volume sampled to the total volume of runoff is the percentage of the runoff sampled.

b Samples were not obtained at Station L8 because of lack of runoff; samples were obtained at Station L7, but the rating curve was affected by downstream activities.

c The percent sampled was considered too small for the data to be considered representative.

NS Not sampled (often because of lack of runoff).

SM Sampling equipment malfunctioned.

* Volume sampled did not include the storm peak.

remaining nine (NS) produced no water quality samples, often due to lack of runoff.

An evaluation of the potential effect of the percentage of an event sampled on the estimate of the site median concentration (SMC) which was used in developing pollutant load estimates was structured on the basis of the following considerations.

- The data set as a whole covers a wide range of sampled fractions, and a significant spread in percent sampled also applies generally to individual stations.
- The quality data exhibit significant variability, with each station having a different mean or median.
- Concentrations of different pollutants have different orders of magnitude.
- Working separately with individual pollutants at individual sites provides too small a sample for reliable analysis.

To evaluate the effect of the fraction of the storm sampled, each EMC (event mean concentration for the site-event for each pollutant) was first normalized by computing the ratio of the individual concentration value to the SMC for the corresponding pollutant and site. Individual EMCs are tabulated in the Volume I Appendix document. The SMC values used are those presented in report Tables 6-2 and 6-3. Pollutants used in this analysis were those for which nearly all measurements were above detection limits. This set included six metals (Cd, Cr, Cu, Pb, Ni and Zn), plus TSS, BOD and Total Hardness (TH), to have several different basic pollutant types represented. The normalization procedure reduced all the data to a common basis, and provides a sample size of about 500 values for analysis.

A comparison of the normalized pollutant concentrations in relation to the percentage of the storm event that was sampled is displayed by Figure A-3 for the Land Use Sites, and by Figure A-4 for the Stream Stations.

Pollutant concentrations for the Land Use Sites provided the primary basis for the load estimates. A good basis for comparison exists here, because 42 percent of the site-events captured 90 to 100 percent of the runoff (65 percent captured more than 70 percent). The display indicates that the variability in measured concentrations of the nine different pollutants is unrelated to the fraction of total runoff volume captured. There are a small number of individual values that deviate substantially from the median, but the bulk of the results (all pollutants, all sites, all percent captures) fall into a relatively narrow band either side of the site median (Ratio = 1). Note that each SMC reflects a series of events with an appreciable range of percent captures.

On this basis, we conclude that the pollutant site median concentrations, which provided the principal basis for load estimates, are not distorted by the lower percentages of total runoff that were sampled for some events. This situation, therefore, has not influenced the load estimates that were developed.

Results for the Stream Stations are generally similar, but with the difference that less than 10 percent of the values apply to events where more than 90 percent of the runoff was captured. For these stations, 85 percent of the values apply to events which captured between 30 and 70 percent of the storm flow. There is no trend indicated either within this range, or compared with the limited data at 100 percent runoff capture. The single set at 3 percent capture (event 3 at station S-1) would be appropriate to exclude, although this single set of values will not have a significant effect on the overall study results.

Fig. A-3. Effect of Percentage of Total Storm Sampled on Event Mean Concentration Land Use Sites

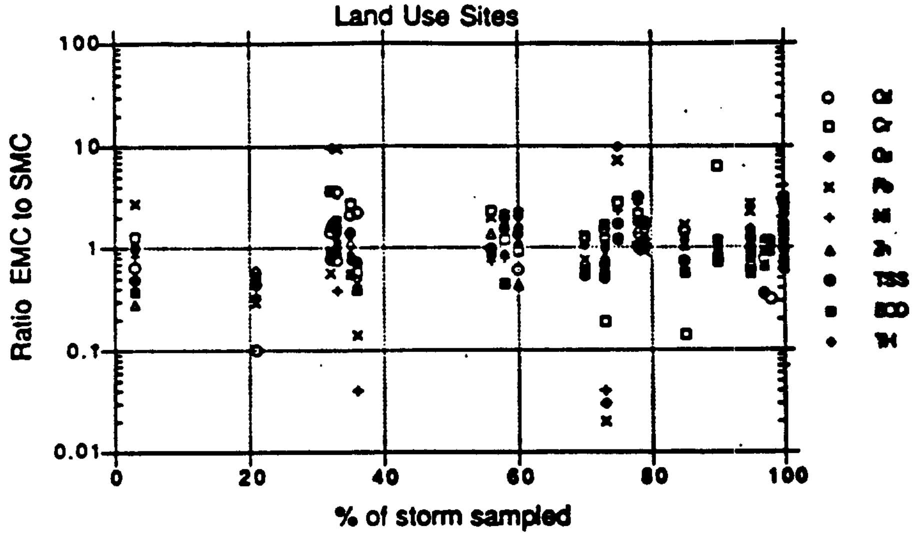
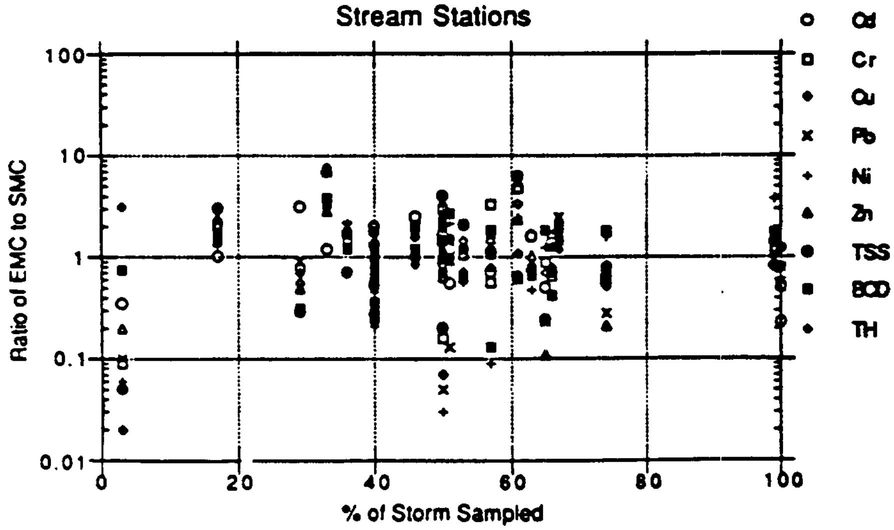


Fig. A-4. Effect of Percentage of Storm Sampled on Event Mean Concentration Stream Stations



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The stream concentrations were utilized in the study for comparison with projected in-stream concentrations computed from the land use runoff. The differences (measured concentrations were consistently greater than projections based on land runoff) provided the basis for a correction factor. The variation in percent capture of event runoff is not indicated to influence estimates of stream concentrations. However, because the bulk of this data is based on 30 to 70 percent capture of the total event values, there is a somewhat greater uncertainty in the concentration estimates for the Stream Stations, than is the case for the Land Use Sites.

A.6.5 Flow-Rating

Development of new stage-discharge relationships was required at three open channel stations and three manhole stations. In manhole stations, rectangular notched weirs were installed. Flow was then estimated based on the theoretical sharp-crested contracted weir equation (ISCO 1979):

$$Q = 3.33\ (L - 0.2H)H^{1.5}$$

where

Q = flow (cfs)
L = width of the weir crest (ft)
H = stage (feet)

This equation was verified by performing low-flow dye dilution measurements at the manhole stations. These tests indicated that some calibration of the weir equation was required for flow within the weir notch at stations L2 and L3. As a result, the following rating curves were used for low flows in these weirs:

$Q = 1.73H^{.85}$ (Station L2)
$Q = 1.83H^{1.79}$ (Station L3)

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Rating curves for stations L5, L7, and S4 were developed from discharge measurements. Rating curves were developed only for low flows at station S4, since a high flow rating curve had previously been developed by the SCVWD. Figures A-5, A-6, and A-7 show the rating curves for these three stations. Discharge measurements for these stations were generally good. For station S4, the rating curve was developed from 10 flow measurements, and a good fit was obtained to these data. However, the rating curves for stations L5 and L7 are at best of fair quality, given the low number (three) of discharge measurements used at each station.

Current-meter surveys were conducted to develop stage-discharge data at the three open-channel stations. Discharge methods were made using standard USGS methods (USGS 1970). It was desired that at least six discharge measurements be taken over a full range of stages in order to obtain reliable rating information at each site.

Dye-dilution methods were used to verify weir equations at three of the four manhole stations. (At these stations, provisions for a water supply could be arranged with the local water supplier.) Intra-acid Rhodamine WT was used as the tracer. Rhodamine WT is a nontoxic, fluorescent tracer dye that is commonly used in applications such as this. This dye is stable and is not easily adsorbed to particulates.

Flow was established at each station by use of upstream fire hydrants. Dye of a known concentration was injected into the turbulent flow at an upstream manhole by use of FMI constant displacement piston pumps. Stage, temperature, and dye concentration were then measured just upstream of the weir at the subject station. Periodic water samples were obtained for later laboratory verification of dye concentrations in order to provide backup to the field fluorometer and to make certain that concentrations were in the linear response range of the fluorometer. Due to the limited flow capacity of fire hydrants, verification of the theoretical weir equations was only possible for low-flow conditions.

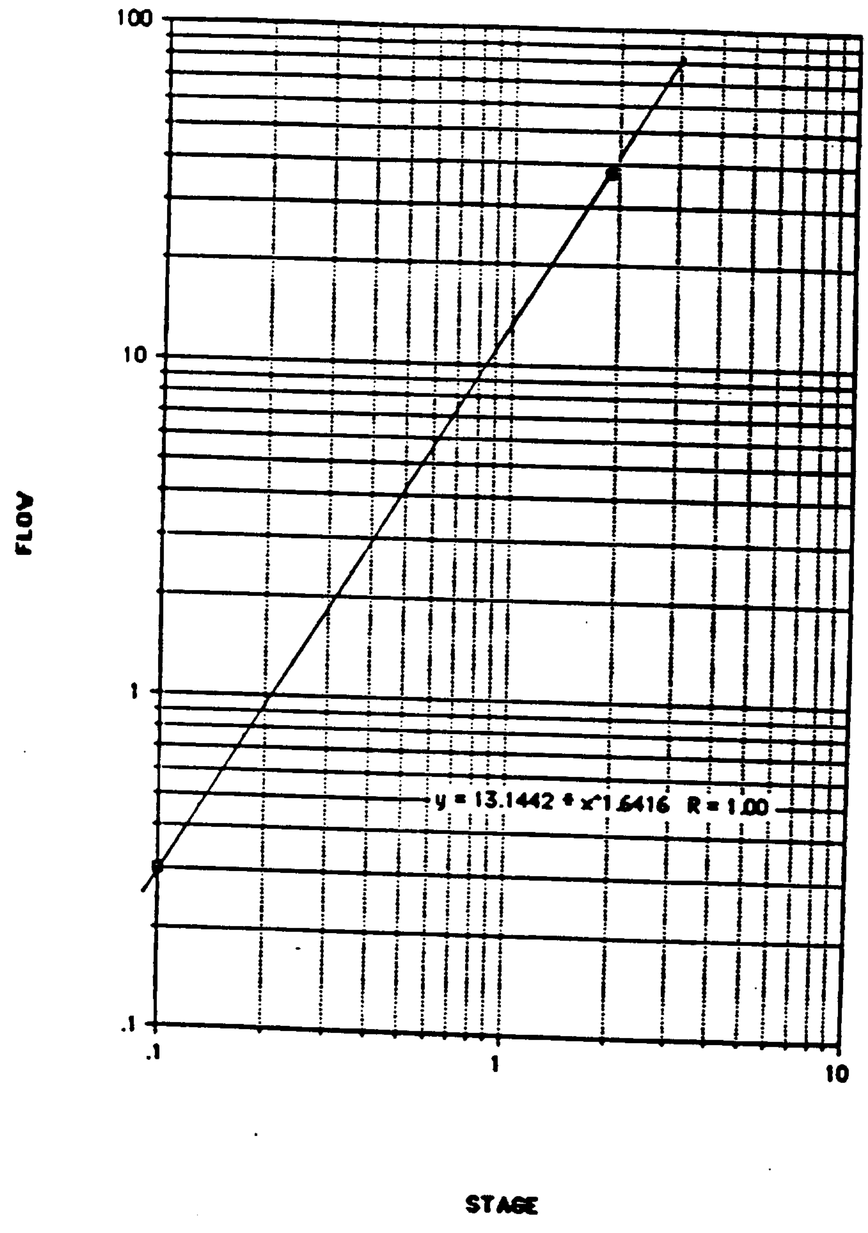

Figure A-5. Rating Curve for Station L5

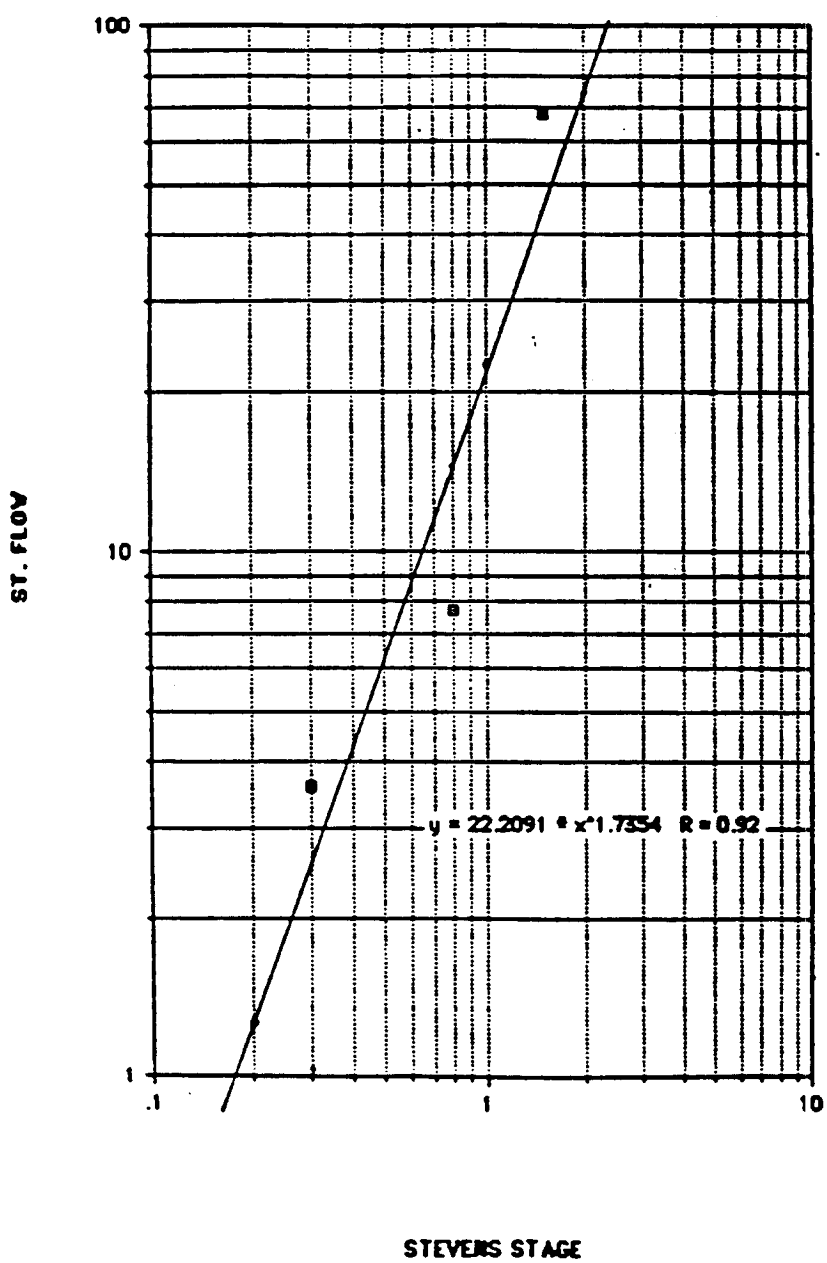

Figure A-6. Rating Curve for Station L7

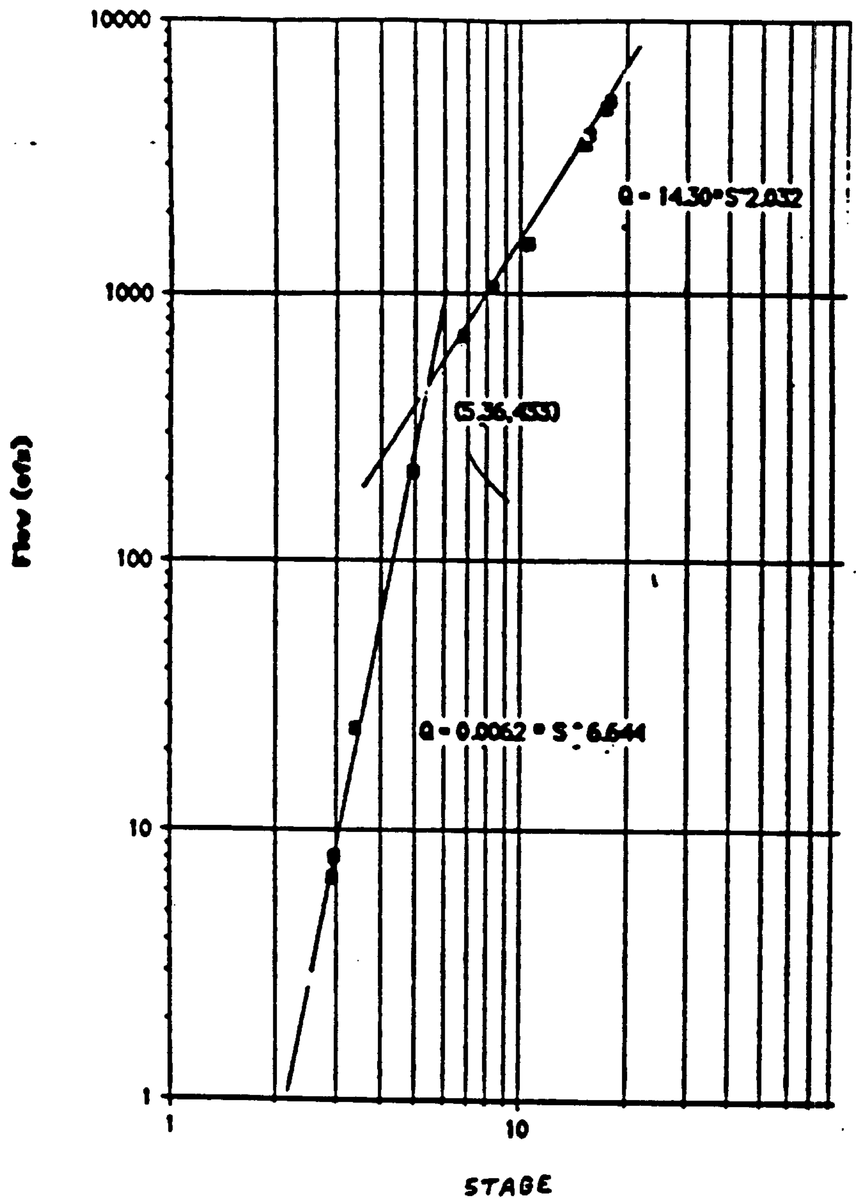

Figure A-7. Rating Curve for Station S4

A modification of the channel occurred at one station, L7 (Stevens Creek at Camp Castanoan Bridge), midway through the study. That alteration required establishment of a second rating curve. A small rock dam was constructed just below the station in order to enhance the water supply system for Camp Castanoan. This dam was breached during a storm in early March, at which time the initial flow rating was reinstated.

A.6.6 Special Studies - Dissolved Oxygen

Many of the previous studies involving nonpoint source water quality have been concerned about depression of dissolved oxygen levels in the receiving waters. A single intensive study was conducted at each of the four stream stations to measure dissolved oxygen concentrations during and after stormwater discharges.

Dissolved oxygen was measured for a period of approximately 35 hours using duplicate Winkler titrations in lieu of polarographic membrane probe techniques. The titrations provide a much more accurate estimate of dissolved oxygen, particularly in the presence of oil and grease. Polarographic oxygen probes can become rapidly desensitized if contaminated with oil and grease.

Dissolved oxygen results did not show any signs of depression for all four stations studied. The DO results are summarized here and shown in Appendix D.8. For station S-1, DO ranged from 8.9 to 11.8 mg/L, and DO levels ranged from 8.6 to 12.2 for station S-2. The DO concentrations were similar for stations S-3 (9.7 to 10.4 mg/L) and S-4 (8.5 to 9.6 mg/L).

A.6.7 Special Studies - Dissolved Metals

Two sampling rounds were conducted to evaluate the relative contributions of dissolved metals and particulate-associated metals in stormwater runoff. Both dissolved and total metal concentrations were measured in all stormwater samples obtained during each storm event.

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Dissolved metal samples were subsampled from the composite storm samples in the same manner as the total metal samples. Prior to fixation, the dissolved metal samples were filtered through 0.45-micron polycarbonate filters. The filtrate was subsequently acidified with HNO_3 to a pH of less than 2.

A.6.8 Special Studies - Settling Column Tests

A preliminary screening of the settling characteristics of particulates present in the NPS discharges from the study area was made by conducting settling tests on samples taken from each of the stream stations (S-1, S-2, S-3, and S-4) during the storm runoff event in March 1989.

This effort was designed to provide information on settleability, for reference and potential use in the consideration of issues such as detention basin controls, sediment accumulation and scour in stream beds, and pollutant accumulations in bay sediments.

Because of the nature of the test procedure and the variability expected of particle size distributions in stormwater runoff, the results obtained should only be considered to provide a general approximation of the settling characteristics of particulates that are introduced to the South San Francisco Bay by nonpoint sources in the study area.

The tests were performed using a settling column constructed from an 8-inch in diameter by 5-foot, 1-inch-long lucite tube. Four sample ports are located at 1-foot intervals.

The column is filled to the top with a sample of the water to be tested, and then stirred to distribute the settleable solids uniformly throughout the column.

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A sample at time zero is analyzed to establish initial conditions. Total suspended solids (TSS) was selected as the pollutant analyzed for these tests.

Samples are then withdrawn from each port at selected time intervals after the start of the test. They are analyzed to determine the concentration of TSS that remains at the sample location after the elapsed time interval.

The difference between each such concentration and the amount present initially is used to compute a percent removal.

Since each combination of depth to a sample port and elapsed time to the sample reflects a specific distance settled in a specific interval of time, each sample corresponds to a settling velocity (feet per hour). Each such value corresponds to a percent removed value computed from the measured concentration.

The results can be interpreted as the percentage of the TSS in the sample that have settling velocities equal to or greater than the value represented by the port depth and sample time. The results are then plotted to provide an indication of the frequency distribution of pollutant settling velocities in the sample.

Test results are summarized in Table A-7. This table lists both the measured concentration and also the percentage of the initial concentration that each value represents. It also lists the set of settling velocities (in feet per hour) that are computed from the various combinations of depth and sample time. Note that the combinations employed result in multiple measurements for some settling velocities. In the table, the settling velocities are listed in increasing rank order, and for each of these the corresponding removal percentage is tabulated for each of the four samples.

Table A-7. Settling Column Test Results

STA	initial TSS (mg/l)	sample port	MEASURED TSS CONCENTRATIONS 2	6	12	24	48	settling distance feet	PERCENT TSS REMOVED (settling time <--hours-->) 2	6	12	24	48
S-1	85 mg/l = initial TSS	1	53	34	25	8	14	1	38	60	71	91	84
		2	59	40	30	13	9	2	31	53	65	85	89
		3	63	39	23	13	10	3	26	54	73	85	88
		4	76	43	26	25	23	4	11	49	69	71	73
S-2	28 mg/l = initial TSS							sett dist FT					
		1	12	9	14	9	10	1	57	68	50	68	64
		2	15	16	19	9	8	2	46	43	32	68	71
		3	30	24	14	5	13	3	-7	14	50	82	54
		4	31	22	17	12	3	4	-11	21	39	57	89
S-3	22 mg/l = initial TSS	1	19	5	8	12	12	1	14	77	64	45	45
		2	24	9	9	5	4	2	-9	59	59	77	82
		3	17	15	18	9	5	3	23	32	18	59	77
		4	19	17	9	7	3	4	14	23	59	68	86
S-4	69 mg/l = initial TSS	1	58	43	32	28	10	1	16	38	54	59	86
		2	60	37	32	23	16	2	13	46	54	67	77
		3	73	53	31	25	22	3	-6	23	55	64	68
		4	69	55	31	22	17	4	0	20	55	68	75

Vs ft/hr	% Greater than S-1	S-2	S-3	S-4
0.021	84	64	45	86
0.042	91	68	45	59
0.042	89	71	82	77
0.063	88	54	77	68
0.083	71	50	64	54
0.083	85	68	77	67
0.083	73	89	86	75
0.125	85	82	59	64
0.167	60	68	77	38
0.167	65	32	59	54
0.167	71	57	68	68
0.250	73	50	18	55
0.333	53	43	59	46
0.333	69	39	59	55
0.500	38	57	14	16
0.500	54	14	32	23
0.667	49	21	23	20
1.000	31	46	-9	13
1.500	26	-7	23	-6
2.000	11	-11	14	0

Table A-8. Distribution of Settling Velocities - Pooled Test Results

SETT VELOC Vs ft/hr	% Greater Than S-1	S-2	S-3	S-4	Average % Removal 4 sites	Average % Removal for Vs	SETT VELOC Vs ft/hr
0.021	84	64	45	86	70	70	0.021
0.042	91	68	45	59	66		0.042
0.042	89	71	82	77	80	73	0.042
0.063	88	54	77	68	72	72	0.063
0.083	71	50	64	54	59		0.083
0.083	85	68	77	67	74		0.083
0.083	73	89	86	75	81	72	0.083
0.125	85	82	59	64	72	72	0.125
0.167	60	68	77	38	61		0.167
0.167	65	32	59	54	52		0.167
0.167	71	57	68	68	66	60	0.167
0.250	73	50	18	55	49	49	0.250
0.333	53	43	59	46	50		0.333
0.333	69	39	59	55	56	53	0.333
0.500	38	57	14	16	31		0.500
0.500	54	14	32	23	31	31	0.500
0.667	49	21	23	20	28	28	0.667
1.000	31	46	-9	13	20	20	1.000
1.500	26	-7	23	-6	9	9	1.500
2.000	11	-11	14	0	3	3	2.000

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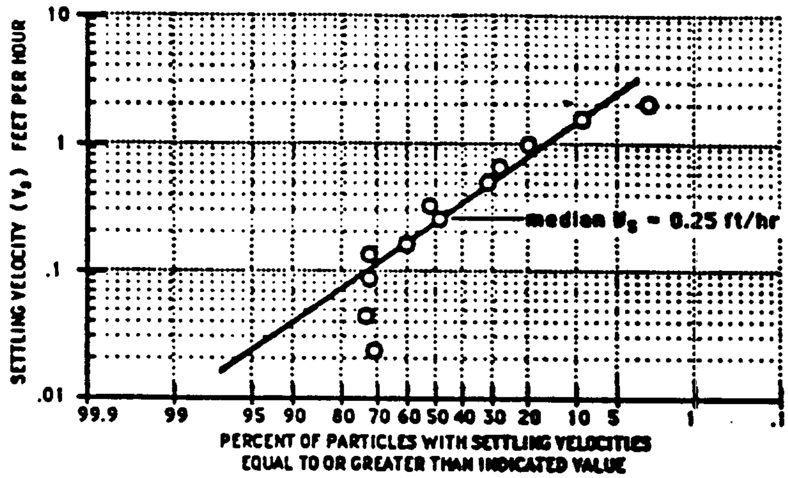

Figure A-9. Distribution of Settling Velocities of Pooled Data for Stream Stations

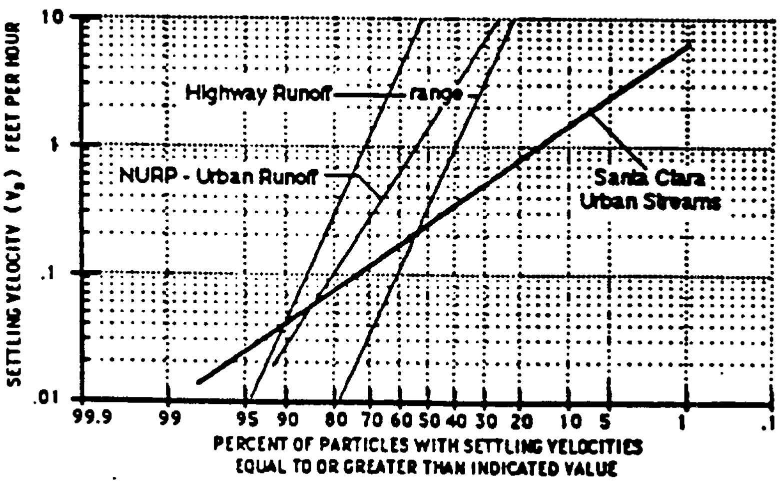

Figure A-10. Comparison of Settling Velocity Distribution from Different Sources

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Each of the samples shows a difference in particle sizes, reflected by the median settling velocities for the test, which range between 0.15 and 0.45 ft/hr. Because of the variability and the nature of the test, it would be inappropriate at this point to simply observe that the stream samples tested indicate a median settling velocity on the order of approximately 0.25 ft/hr, and having a distribution approximately as shown by Figure A-9.

These results are compared with the results of similar tests reported in other studies in Figure A-10. The principal indication is that the particulates in the Santa Clara wet weather stream samples are appreciably smaller in size (lower settling velocities) than those measured in direct runoff from urban or highway sites. This type of relationship can be expected if one considers that most of the bigger particles will have settled out rapidly in the stream, and as a result do not show up in these samples.

A.6.9 Special Studies - Fecal Streptococci

Analysis of fecal streptococci, together with fecal coliform, provide insight on possible sources of fecal contamination. Ratios of fecal coliform to fecal streptococci provide some indication as to whether the contamination was of human or nonhuman origin. Ratios in excess of 4.1 are sometimes considered to be primarily of human origin, whereas ratios less than 0.7 are considered to be of nonhuman origin. Ratios between 0.7 and 4.1 may be indicative of mixed human and nonhuman fecal contamination (Standard Methods 1980).

A survey of fecal streptococci and coliform bacteria was conducted at the four stream sites in order to assess possible sources of fecal contamination in nonpoint source runoff during storm events. Grab samples were taken at stream sites S1 through S4 during the third Wet-Weather Water Quality event in January 23, 1989. The analyses for both types of bacteria were conducted in accordance with Standard Methods for the Examination of Water and Wastewater (1980).

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Results of the fecal streptococci are presented in Appendix D.2-1. Ratios of fecal coliform to fecal streptococci show values ranging from about 1 (S3 and S4) to 10 (S1 and S2).

A.6.10 Subsampling Procedures, Sample Containers, and Preservatives

The 10-liter composite samples collected from the autosamplers during storm events were sealed with Teflon-lined polyethylene caps, packed in ice, and transported to Kinnetic Laboratories, Inc., in Santa Cruz for further processing. When multiple 10-liter bottles were collected for a single station, it was first necessary to thoroughly blend the samples. Blending of the composite samples was accomplished by use of a peristaltic pump and Teflon hose.

The peristaltic pump was also used to draw samples for each set of analyses. Samples for each analyses were placed in prelabeled containers with appropriate preservatives (see Table A-9). Whenever possible, analyses requiring common containers and preservation were placed in the same container in order to minimize sample handling.

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Grab samples for analysis of sediment were placed directly into appropriate sample containers (see Table A-10). In most situations, common containers were used for collection and holding of sediments to be analyzed for (1) trace metals and inorganics and (2) volatile and semi-volatile organics. Single containers were utilized for organochlorine pesticides, chlorinated herbicides, and polynuclear aromatic hydrocarbons.

A.6.11 Field QA/QC

Several external or field quality control procedures were used to evaluate potential errors which could have been introduced during sample collection and subsequent analytical procedures. These external quality control checks were performed by blind submission of blanks and duplicates.

le A-9. CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR AQUEOUS SAMPLES

ss	Min. Volume Utilized (ml)	Container	Preservation	Holding Time
ganics				
otal Organic Halogen (TOX)	250	G (amber) Teflon cap	Cool, 4°C H_2SO_4 to pH<2	7 days
otal Organic Carbon (TOC)	125	G (amber) Teflon cap	Cool, 4°C H_2SO_4 to pH<2	28 days
olatiles, GC/MS	125	G (amber) Teflon cap	Cool, 4°C	14 days
emi-volatiles, GC/MS	1000	G (amber) CH_3Cl rinse	Cool, 4°C 40 d(anal.)	7 d(extract)
rganochlorine pesticides	1000	G (amber) CH_3Cl rinse	Cool, 4°C 40 d(anal.)	7 d(extract)
hlorinated herbicides	1000	G (amber) CH_3Cl rinse	Cool, 4°C 40 d(anal.)	7 d(extract)
A	1000	G (amber) CH_3Cl rinse	Cool, 4°C 40 d(anal.)	7 d(extract)
rganophosphate pesticides	1000	G (amber) CH_3Cl rinse	Cool, 4°C 40 d(anal.)	7 d(extract)
tals				
otal	500	P	Cool, 4°C HNO_3 to pH<2	6 months
• Chromium, hexavalent	200	P	Cool, 4°C	24 hours
• Mercury	100	P	Cool, 4°C HNO_3 to pH<2	28 days

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Table A-9. CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR AQUEOUS SAMPLES (concluded)

Class	Min. Volume Utilized (ml)	Container	Preservation	Holding Time
Metals (continued)				
Dissolved	500	P	Cool, 4°C Filter, HNO_3 to pH<2	6 months
• Chromium, Hexavalent	200	P	Cool, 4°C	24 hours
• Mercury	100	P	Cool, 4°C HNO_3 to pH<2	28 days
Nutrients				
Total Kjeldahl Nitrogen (TKN)	200	P	Cool, 4°C H_2SO_4 to pH<2	28 days
Ammonia (NH_3-N)	200	P		
Nitrite (NO_2^--N)	15	P		
Nitrate (NO_3^--N)	15	P		
Total Phosphate	50	P		
Bacteria				
Total and fecal coliform	100	P	Cool, 4°C	6 hours
Fecal streptococcus	100	P	Cool, 4°C	6 hours
Others				
BOD_5	300	G	Cool, 4°C	6 hours
COD	100	P	H_2SO_4 to pH<2	7 days
Total Suspended Solids (TSS)	100	P	Cool, 4°C	7 days
Total hardness	100	P	HNO_3 to pH<2	6 months

P = Plastic laboratory container
G = Glass laboratory container

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ble A-10. CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR SEDIMENT SAMPLES

ass	Min. Volume Utilized (ml)	Container	Preservation	Holding Time
ganics				
Total Organic Carbon (TOC)	125	G (amber) Teflon septum	Cool, 4°C H_2SO_4 to pH<2	28 days
Volatiles, GC/MS	500	G (amber) wide-mouth Teflon lid	Cool, 4°C	14 d(extract) 40 d(anal.)
Semi-volatiles, GC/MS	500	G (amber) wide-mouth Teflon lid	Cool, 4°C	14 d(extract 40 d(anal.)
Organochlorine pesticides	125	G (amber) Teflon septum	Cool, 4°C	14 d(extract) 40 d(anal.)
Chlorinated herbicides	370	G (amber) wide-mouth Teflon lid	Cool, 4°C	14 d(extract) 40 d(anal.)
PNA	250	G (amber) wide-mouth Teflon lid	Cool, 4°C	7 d(extract) 40 d(anal.)
Organophosphate pesticides	250	G (amber) wide-mouth Teflon lid	Cool, 4°C	7 d(extract) 40 d(anal.)
letals				
Total	250	P HNO_3 to pH<2	Cool, 4°C	6 months
lutrients				
Total Kjeldahl Nitrogen (TKN)	200	P	Cool, 4°C	28 days
Ammonia (NH_3-N)	200	P	Cool, 4°C	28 days

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Table A-10. CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR SEDIMENT SAMPLES (concluded)

Class	Min. Volume Utilized (ml)	Container	Preservation	Holding Time
Others				
BOD_5	300	G	Cool, 4°C	
COD	100	P	H_2SO_4 to pH<2	7 days
Grain size distribution	50	P	Cool, 4°C	

P = Plastic laboratory container
G = Glass laboratory container

Blanks used in the field QA/QC procedures consisted of both field blanks and trip blanks. Field blanks were used to assess errors due to bottle contamination and field sampling procedures. Field blanks were obtained by sampling contaminant-free waters (furnished by the laboratory) using procedures identical to those used for collection of field samples. The field blanks for samples taken from the composite samplers were obtained by pumping contaminant-free waters into sample containers. This same procedure was used to extract field samples from the composite sample. Field blanks for grab samples were obtained by pouring blank water into a sample container. Trip blanks were utilized to assess potential contamination from both sample containers and coolers used for sample transportation. These blanks consisted of contaminant-free water provided in a standard sample container by the laboratory. These blanks remained unopened in the coolers and were returned to the laboratory for analysis.

Field duplicates were utilized to evaluate data precision. Analysis of these types of control samples provide a measure of the variability due to natural factors in the water body, sampling procedures and analytical procedures. Field duplicates were collected in the same manner as the primary samples and submitted blind to the laboratory.

A third quality control check conducted as part of the field program was quarterly analysis of external spike samples. Samples containing certified levels of contaminants were purchased from ERA laboratories in Colorado and the National Bureau of Standards (PNAs only). These samples were received by the project QA/QC officer. The QA/QC officer then removed certification information and submitted the samples to each laboratory under chain-of-custody.

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A.7 LABORATORY ANALYSIS

A.7.1 Constituents and Methods

All analytical methods were either EPA or Standard Methods approved. All constituents and analytical methodologies used in this study are listed in Tables A-11 (water) and A-12 (sediments). All analytical method numbers cited in these tables refer to the following standard laboratory references:

- "SM":

  APHA-AWWA-WPCF. 1985. Standard Methods for the Examination of Water and Wastewater - 16th Edition.

- "Plumb":

  Plumb, Jr., R.H. 1981. Procedures for Handling and Chemical Analysis of Sediment and Water Samples. Prepared by Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material 81-4. Environmental Laboratory U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

- "EPA":

  U.S. Environmental Protection Agency. 1979 (Revised 1983). Methods for the Chemical Analysis of Water and Wastes. (EPA 600/4-79-020).

  U.S. Environmental Protection Agency. 1986. Test Methods for Evaluating Solid Waste, U.S. EPA SW-846, September 1986.

  U.S. Environmental Protection Agency. 1982. Methods for Organic Chemical Analysis for Municipal and Industrial Wastewater, (EPA 600/4-82-057).

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Table A-11. WATER QUALITY CONSTITUENTS AND TEST METHODS

Class	Constituent	Test Method
Organics	Total Organic Halogen (TOX)	EPA 9020
	Total Organic Carbon (TOC)	EPA 9060
	Volatiles (Purgeables), GC/MS	EPA 624
	Semi-volatiles (Base/Neutrals), GC/MS	EPA 625
	Organochlorine pesticides	EPA 608
	Chlorinated herbicides	EPA 8150
	Polynuclear Aromatic Hydrocarbons (PNA)	EPA 8100/610
	Organophosphate pesticides	EPA 614
Metals	Arsenic	EPA 206.2
	Cadmium	EPA 213.2
	Chromium, total	EPA 218.2
	Chromium, hexavalent	EPA 218.5
	Copper	EPA 220.2
	Lead	EPA 239.2
	Mercury	EPA 245.1
	Nickel	EPA 249.2
	Selenium	EPA 270.3
	Silver	EPA 272.2
	Zinc	EPA 289.2
Nutrients	Total Kjeldahl Nitrogen (TKN)	SM 420A
	Ammonia (NH_3-N)	SM 417D
	Nitrite (NO_2-N)	SM 419
	Nitrate (NO_3-N)	SM 418C
	Total Phosphate	SM 424F
Bacteria	Total coliform	SM 908A
	Fecal coliform	SM 908C
	Fecal streptococcus	SM 910A
Others	Five-day Biochemical Oxygen Demand (BOD_5)	SM 507
	Chemical Oxygen Demand	SM 508A
	Total Suspended Solids (TSS)	SM 209C
	Total hardness	EPA 130.2

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Table A-12. SEDIMENT QUALITY CONSTITUENTS AND TEST METHODS

Class	Constituent	Test Method
Organics	Total Organic Carbon (TOC)	EPA 9060
	Volatiles (Purgeables), GC/MS	EPA 8240
	Semi-volatiles (Base/Neutrals), GC/MS	EPA 8270
	Organochlorine pesticides	EPA 8080
	Chlorinated herbicides	EPA 8150
	Polynuclear Aromatic Hydrocarbons (PNA)	EPA 8100/610
	Organophosphate pesticides	EPA 8140
Metals	Arsenic	EPA 206.2
	Cadmium	EPA 213.2
	Chromium, total	EPA 218.2
	Chromium, hexavalent	EPA 218.5
	Copper	EPA 220.2
	Lead	EPA 239.2
	Mercury	EPA 245.1
	Nickel	EPA 245.1
	Selenium	EPA 270.3
	Silver	EPA 272.2
	Zinc	EPA 289.2
Nutrients	Total Kjeldahl Nitrogen (TKN)	SM 417D
	Ammonia (NH_3-N)	SM 417D
Others	Five-day Biochemical Oxygen Demand (BOD_5)	SM 507
	Chemical Oxygen Demand	SM 508A
	Sediment grain size distribution	Plumb

A.7.2 Laboratory QA/QC

Laboratory procedures used to monitor bias and precision in analytical measurements included the following:

- Use of full-range internal calibration standards
- Analysis of laboratory blank water for every 10 samples analyzed by each methodology
- Analysis of a laboratory spike for every 10 samples
- Laboratory splits on 10 percent of the field samples submitted to the laboratory

Spikes were intended to evaluate the overall accuracy of the data set. Although spiking of either field samples or contaminant-free blank water was permitted by the project QA/QC plan, all spikes were performed using field samples in order to account for possible matrix interferences.

The laboratory blanks were conducted as part of each participating laboratories quality assurance plans. These blanks provided a measure of potential sources of contamination to the samples.

Laboratory splits were utilized to evaluate the precision of the analytical measurements. The duplicate data were used to calculate relative percent difference (RPD) values for each constituent. Upper and lower control limits based upon 95 percent confidence limits of historical laboratory splits were used to evaluate analytical precision and acceptability of the data.

A.8 DATA MANAGEMENT

Hardcopies of analytical chemistry results received from each contract laboratory were entered into a spreadsheet database using Lotus 1-2-3. Separate spreadsheets were maintained for each major chemical analysis (e.g., PNAs, organochlorine pesticides) or class of analyses (e.g., physical data-TSS, pH).

Each spreadsheet contained information on the type of sample (e.g., dry-weather, wet-weather), station identification, a sequential event number, date of sampling, analytical laboratory sample identifier, and target detection limits for each analyte. Reported values and actual detection limit on the laboratory report were recorded for each analyte.

Copies of the individual laboratory reports (hardcopy), chain-of-custody documents, and the complete Lotus 1-2-3 database were provided to Woodward-Clyde Consultants by Kinnetic Laboratories, Inc.

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APPENDIX B

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APPENDIX B
HYDROLOGIC MODEL CALIBRATION AND VERIFICATION

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APPENDIX B
HYDROLOGIC MODEL CALIBRATION AND VERIFICATION

Stormwater quality loads for 11 watersheds were estimated by first determining the loads from each land use in each watershed, and then summing loads from all land uses to produce loads to the bay. Because land use loads were calculated as the product of flow volume and concentration, this methodology required estimates of 1) the volume of runoff from each land use category, and 2) the average concentration of pollutants from each land use category.

This Appendix describes the procedures used to estimate flow volumes. Section B.1 provides an overview of the Stormwater Management Model (SWMM), the rainfall-runoff model used to estimate flow volumes. Section B.2 describes the model setup for the Santa Clara Valley, Section B.3 discusses model calibration and verification, and Section B.4 presents estimates of stormwater runoff volumes for the Santa Clara Valley.

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B.1 OVERVIEW OF SWMM

The review of hydrologic data presented in Section 5.0 provides insight into the historical magnitude and variability of rainfall and runoff in the Santa Clara Valley. However, to estimate nonpoint source loads, knowledge of the sources of storm runoff is required. Runoff from undeveloped areas will differ in terms of water quality from runoff in urban areas on the valley floor, and little can be learned about the apportionment of runoff between developed and undeveloped areas through analysis of existing streamflow records alone. Unless one is willing to install and operate many more stream gages for several years, the preferred way to estimate runoff from individual land uses and from ungaged areas is by using a rainfall-runoff model.

Rainfall-runoff models use physical and land use information about a catchment to calculate storm runoff from a given rainfall record. Rainfall-runoff models vary in complexity from relatively simple models such as the Rational Method (Linsley et al. 1982), to models which attempt to represent in detail the physical mechanisms through which rainfall is converted to runoff.

In this study, the U.S. EPA Stormwater Management Model Version IV (Huber et al. 1988) was used to estimate runoff volumes from land use areas for loads calculations. This model, referred to as SWMM, contains a detailed mathematical description of the hydrologic cycle, including runoff from impervious and pervious areas, infiltration, percolation to the water table, groundwater flow into channels, losses due to evapotranspiration, interception, and depression storage, and routing of runoff down stream channels. The model also has water quality and treatment components which are useful in evaluating the effects of control measures. Thus, SWMM is sufficiently detailed and general in scope to model the processes which are relevant to the estimation of nonpoint source loads.

SWMM represents a watershed as a set of hydrologic units referred to as subcatchments. Each subcatchment is assumed to have a unique set of runoff properties, including rainfall, area, width, slope, infiltration characteristics, and percent of impervious areas. The model simulates runoff over time using time steps determined by the interval at which rainfall data are available. For accurate simulation of storm hydrographs, this time step is typically on the order of 15 to 60 minutes. At each time step, the model performs a water balance on all subcatchments, as illustrated in Figure B-1. The volume of water available for surface runoff is determined by first subtracting losses for depression storage, infiltration, and evaporation from rainfall. The remaining water is routed

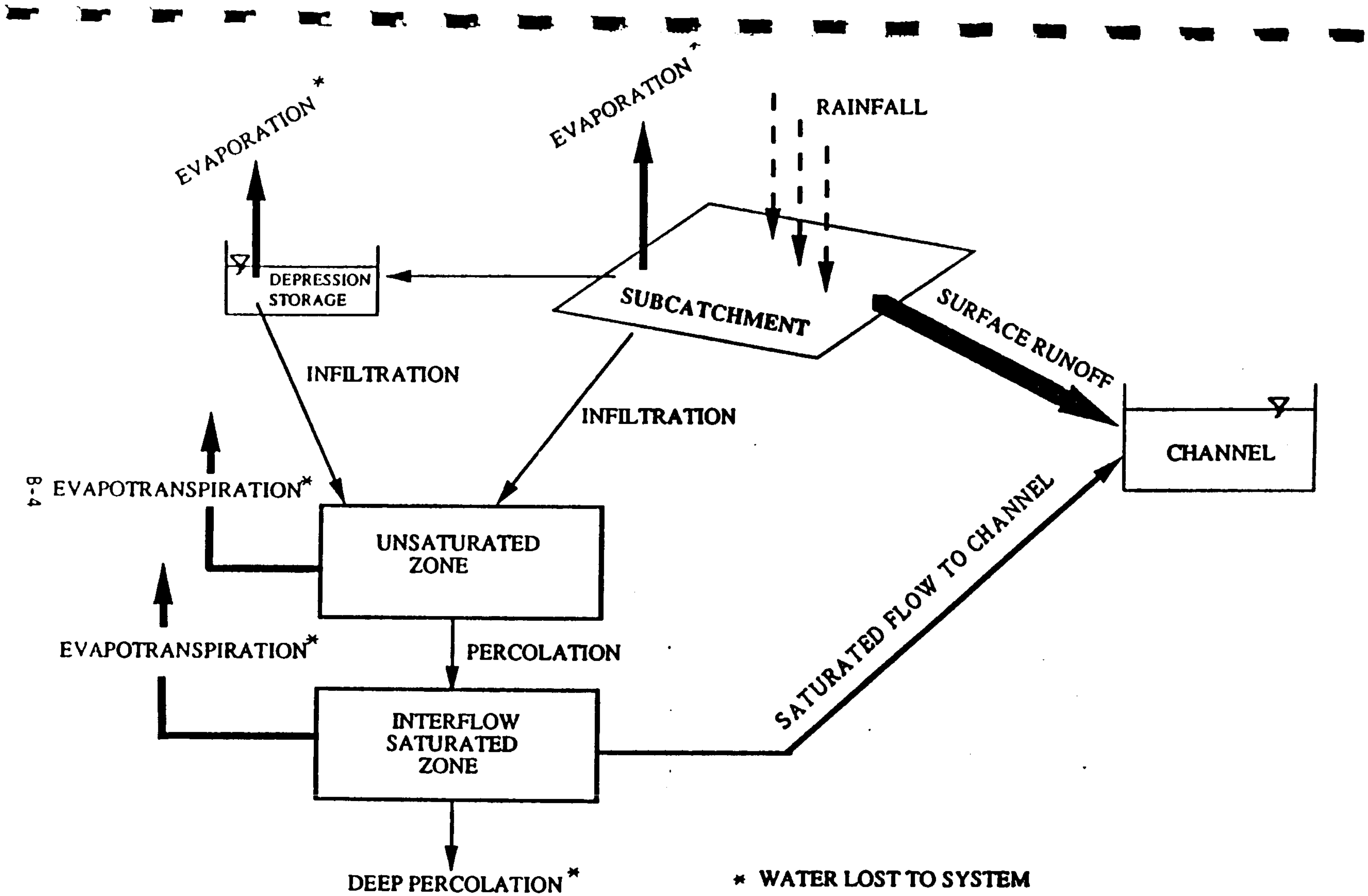

FIGURE B-1. SWMM Water Balance For a Subcatchment as runoff from the subcatchments into channels using a non-linear reservoir routing scheme, with the outflow rate determined by Manning's equation. Each subcatchment contains both pervious and impervious areas; runoff is more rapid from impervious areas because rainfall on these areas is not subject to infiltration losses. Water in depression storage, used to simulate storage in depressions on the ground surface, may either infiltrate or evaporate.

The subsurface component of the hydrologic cycle is represented in SWMM by two storage reservoirs, one for the unsaturated zone and one for the saturated zone. The volume of infiltration is determined using either a Horton or a Green-Ampt infiltration model. Infiltrated water then moves into the unsaturated zone, where it may either remain in storage, evapotranspirate, or percolate into the saturated zone. Water in the saturated zone may either remain in storage, flow into channels, or percolate out of the system. Flow from the saturated zone to channels is determined based on the difference in elevation between the water table and the channel water surface; the water table elevation is recalculated each time step based on the current volume of water in the saturated zone and the porosity of the saturated zone.

B.2 MODEL SETUP FOR THE SANTA CLARA VALLEY

The goal of this study was to estimate total nonpoint source loads from the Santa Clara Valley. Thus, SWMM was used to model runoff from the entire valley. For data management and calibration purposes, the valley was subdivided into the 11 major watersheds shown in Figure B-2. Streamflow data for calibration were available at the downstream ends of six of these watersheds; runoff from the remaining watersheds was estimated using SWMM without calibration.

Prior to using SWMM, a conceptual model of the important runoff processes occurring in the valley was developed. Based on the analysis of

	AREA* (sq miles)	% of TOTAL
	124	33
	106	28
uinas	28	7
	17	4
	21	6
st Channel	7	2
st Channel	5	2
k	12	3
reek	17	4
ro Barron	34	9
uito (Santa Clara County)	7	2
	380	100

* Does not include areas above reservoirs

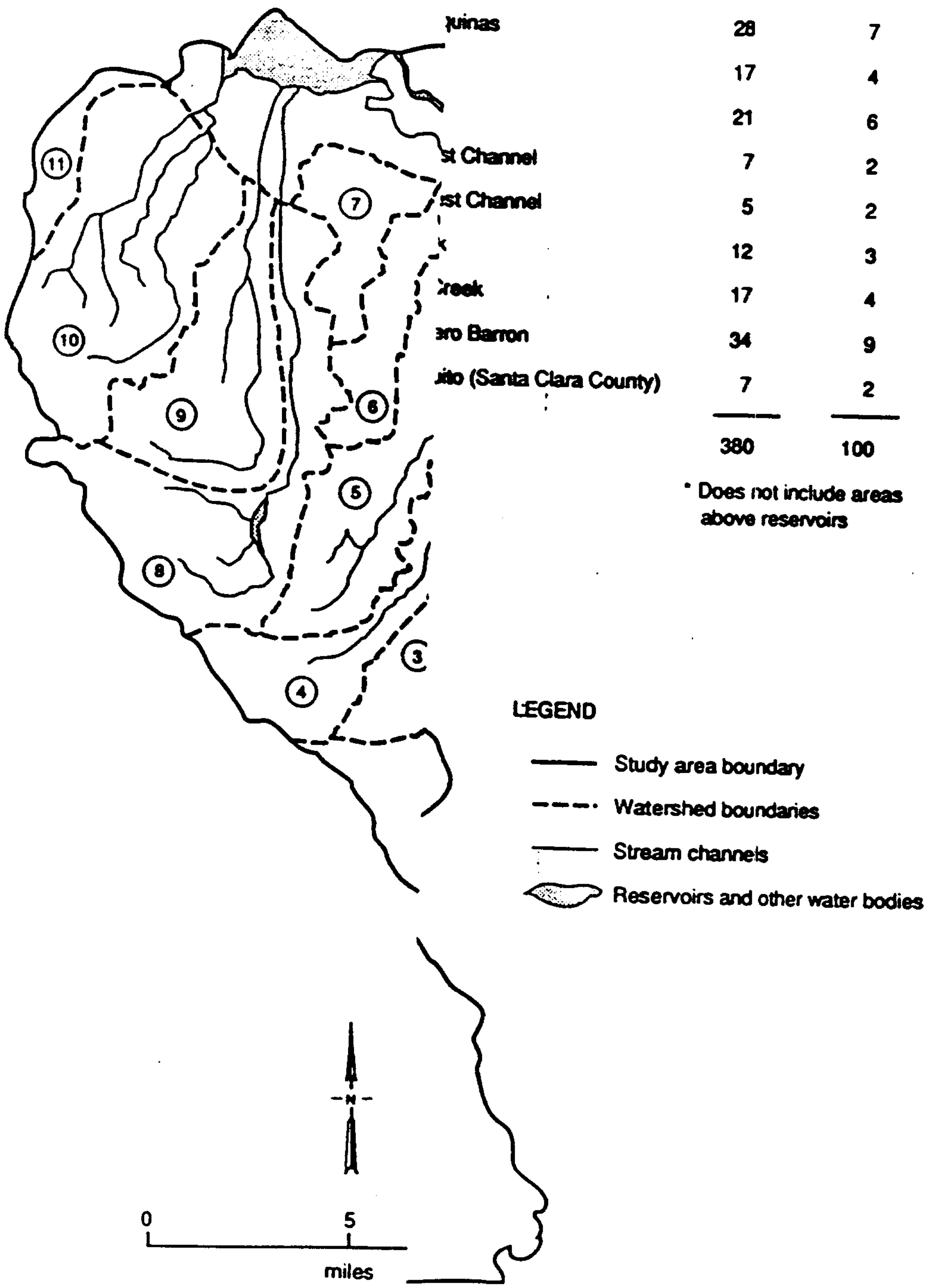

Figure B-2. WATERSHEDS IN STUDY AREA

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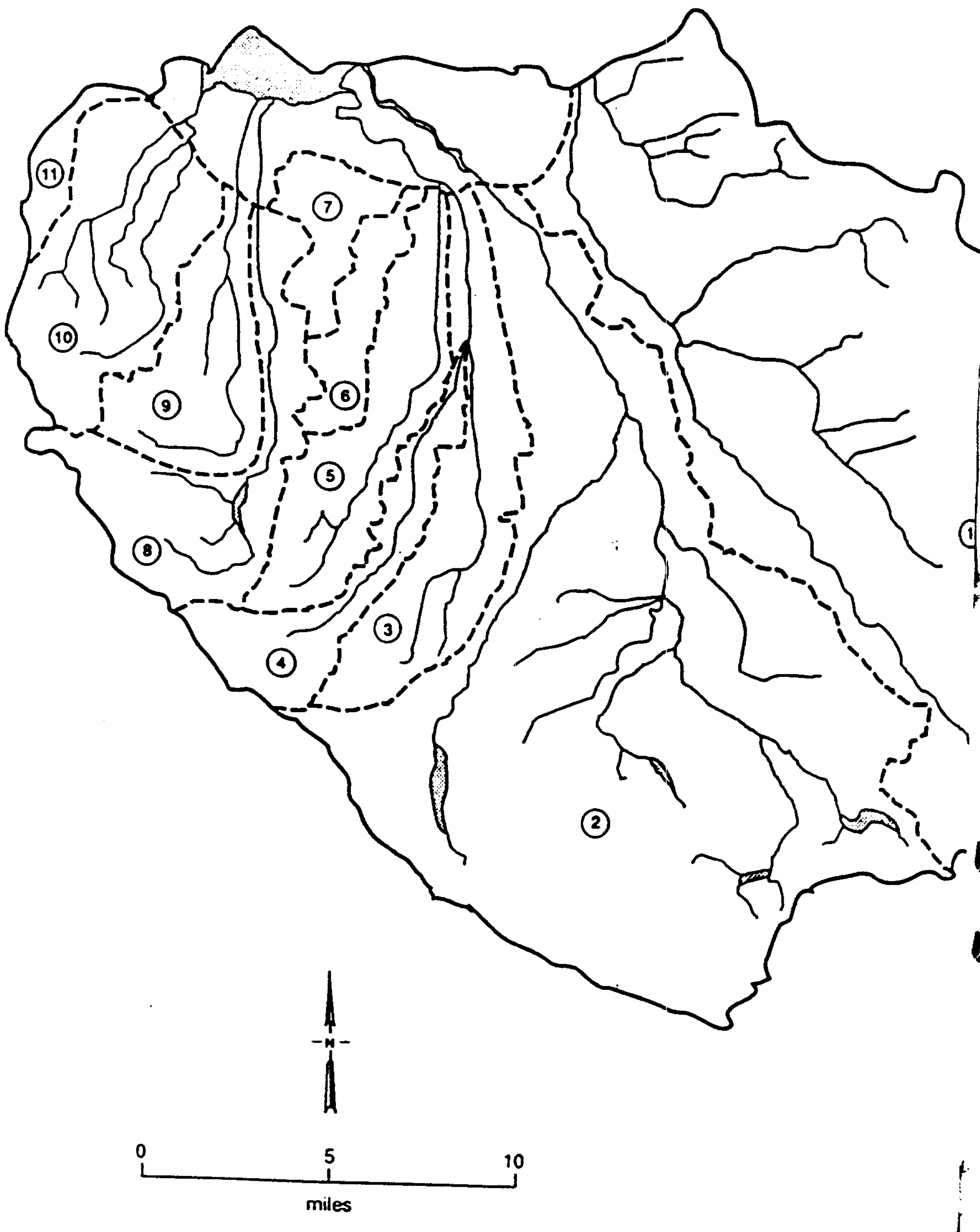
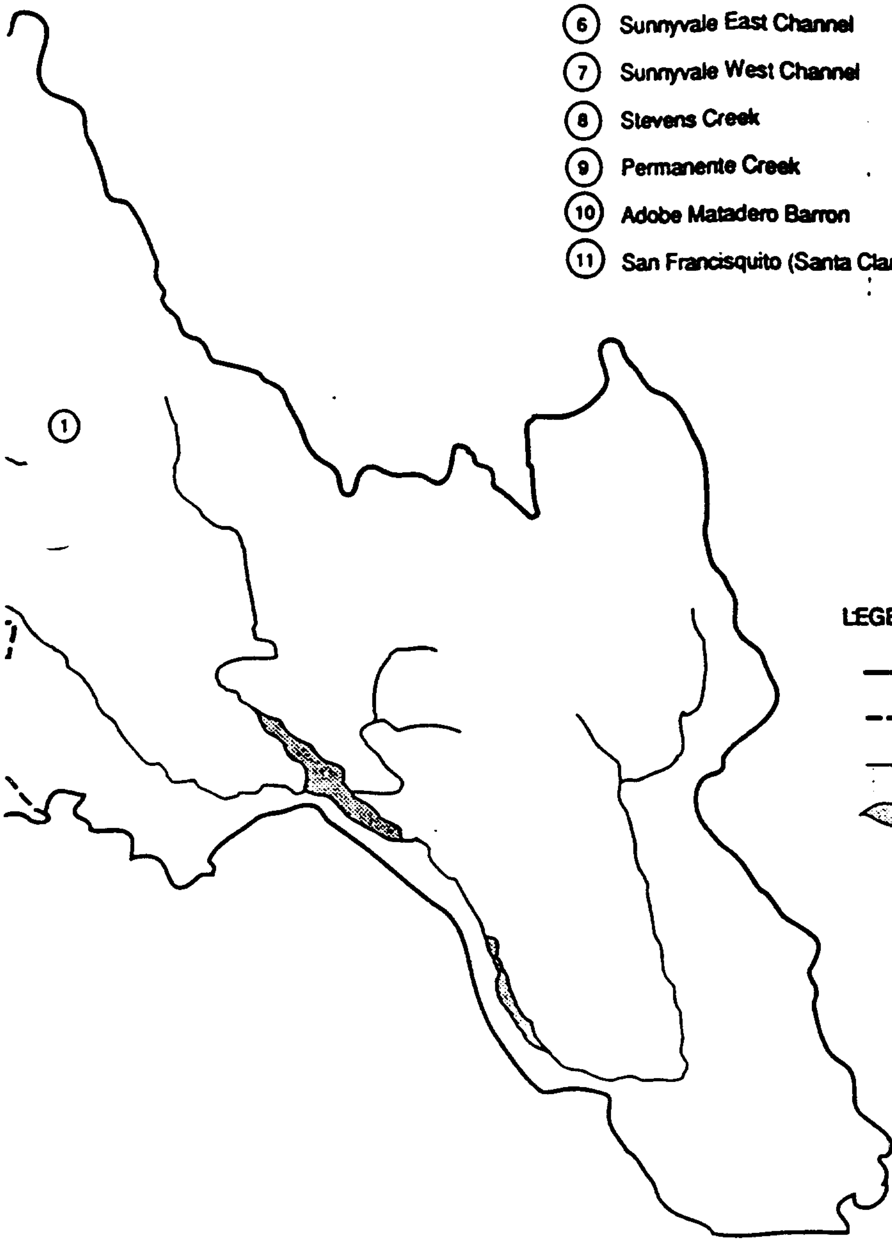

11
10
9
8
7
6
5
4
3
2
1
N
0
5
10
miles

WATERSHED	AREA* (sq miles)	% of TOTAL
(1) Coyote	124	33
(2) Guadalupe	108	28
(3) San Tomas Aquinas	28	7
(4) Saratoga	17	4
(5) Calabazas	21	6
(6) Sunnyvale East Channel	7	2
(7) Sunnyvale West Channel	5	2
(8) Stevens Creek	12	3
(9) Permanente Creek	17	4
(10) Adobe Matadero Barron	34	9
(11) San Francisquito (Santa Clara County)	7	2
	380	100

* Does not include areas above reservoirs



LEGEND

- Study area boundary
- Watershed boundaries
- Stream channels
- Reservoirs and other water bodies

Figure B-2. WATERSHEDS IN STUDY AREA

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measured flow and precipitation data presented in Section 5.0, the following concepts were used to guide the application of SWMM to the study area:

1) Orographic effects on rainfall are strong, especially in the Santa Cruz Mountains.

2) Runoff on the valley floor occurs primarily from impervious areas associated with urban development.

3) Runoff from pervious areas occurs primarily in the Santa Cruz Mountains where rainfall intensities are sufficient to exceed soil infiltration capacities.

4) Runoff from pervious areas has a seasonal component, with the strongest runoff response occurring in the late wet season when antecedent soil moisture levels are highest.

5) Storm hydrographs typically have a 2- to 3-day recession component derived from subsurface flow rather than from surface runoff. This subsurface flow is probably interflow through temporarily saturated areas and perched groundwater in the unsaturated zone.

These concepts were used in determining how the SWMM runoff, infiltration, and groundwater algorithms were configured for this study, and will be referred to in terms of specific model parameters in the following sections. Section B.2.1 discusses how watersheds were subdivided into SWMM subcatchments, and Section B.2.2 describes procedures used to estimate model input parameters.

B.2.1 Watershed Discretization

The number and size of subcatchments used by SWMM should be determined by (1) the level of detail required in the model results, and (2) the level of detail at which data are available. For this study, complete data were available for relatively small subcatchments used by the Santa Clara Valley Water District (SCVWD) for their flood hydrograph modeling. However, this level of detail, while important for flood modeling, is not necessary for estimating annual-scale runoff and water quality loads. Huber and Dickenson (1988) present data and examples showing that small subcatchments can be lumped into larger SWMM subcatchments with little loss of information, as long as input parameters are scaled appropriately.

Because orographic effects on rainfall are so important in the Study Area, the first step in setting up subcatchments for this study was to divide each watershed into subareas over which rainfall was assumed to be uniformly distributed. The number of subareas were selected such that the variability of rainfall within watersheds was adequately represented. Figure 8-3 illustrates the subarea breakdown for the Calabazas Creek watershed. The subareas shown are typical of those used in the smaller watersheds in the western part of the valley, with three subareas representing rainfall on 1) the lower valley floor, 2) the upper valley floor, and 3) the Santa Cruz Mountain foothills. Table 8-1 summarizes the rain gages used to model runoff for all of the watersheds in the Study Area.

SWMM performs water balance calculations and estimates flows for areas represented by subcatchments. Thus, to estimate flows from individual land uses each rain gage subarea was divided into subcatchments for up to six land use categories (open, low density residential, medium density residential, high density residential, commercial, and industrial). These land use subcatchments represented "lumped areas" in that all of the areas of a given land use were modeled as a single contiguous subcatchment. In the example shown in Figure 8-3, rain gage subarea 100 was subdivided into an open subcatchment, a low residential subcatchment, and a medium residential subcatchment. Because the land use breakdown for the area was 43 percent open, the open subcatchment had an area equal to 43 percent of

Table B-1. RAIN GAGES USED TO MODEL RUNOFF IN EACH WATERSHED

Watershed	Rain Gages[a]	Calibrated?
Coyote Creek	NWS, 37, 123, 23, 99	yes
Guadalupe River	NWS, 1, 36, 123, 128	yes
San Tomas Aquinas Creek	NWS, 79, 108	yes
Saratoga Creek	77, 108	yes
Calabazos Creek	100, 108, 121	yes
Sunnyvale East	48	yes
Sunnyvale West	121	no
Stevens Creek	48, 100, 121	yes
Permanente Creek	48, 53, 100, 121	no
Adobe - Matadero - Barron	24, 48, 53	no
San Francisquito Creek	24, 53	no

[a] Rain gage numbers are based on the SCVWD numbering system. NWS refers to the San Jose National Weather Service gage.

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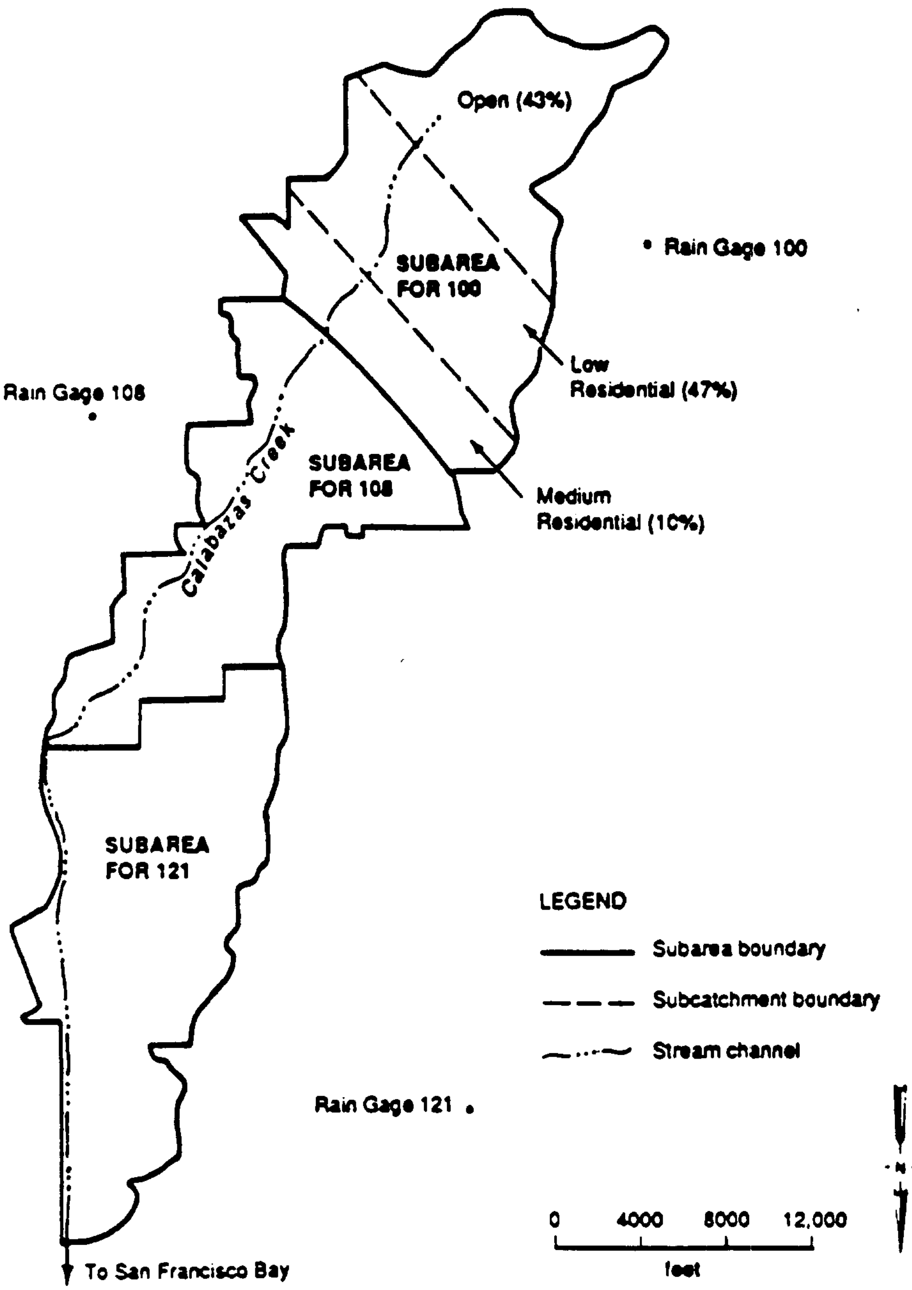

Figure B-3. SUBCATCHMENT BREAKDOWN FOR CALABAZAS CREEK the total area represented by rain gage 100. In general, physical properties such as rainfall, subcatchment width, and soil infiltration parameters were identical for all land use subcatchments in a given rain gage subarea. Land use properties such as impervious area were allowed to vary between land use subcatchments to reflect different levels of development.

B.2.2 Model Parameter Estimation

SWMM requires a number of parameters describing meteorology, catchment geometry, and runoff characteristics. The accuracy at which parameters can be estimated without model calibration varies. Thus, parameters can be grouped as follows:

1) Parameters which can be accurately estimated with no calibration (i.e., catchment area)

2) Parameters which can be estimated with reasonable accuracy, but must be refined through calibration (i.e., infiltration parameters)

3) Parameters which can be estimated only through model calibration (i.e., interflow outflow coefficients)

Table B-2 summarizes the important model input parameters and the corresponding estimation procedures; these are discussed in detail in the following paragraphs.

B.2.2.1 Rainfall. Rainfall is the driving force in the model, and is by far the most important input parameter. SWMM in this case was run continuously for multiple-year simulations, and required continuous records of 15-minute or hourly rainfall. Therefore, the continuous rainfall records available for SCVWD and NWS gages in the valley were used as inputs to the model. The SCVWD gages are weighing gages which record at 15-minute intervals with a precision of 0.1 inch. The one NWS gage, located in San

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Table 8-2. SUMMARY OF SWMM RUNOFF INPUT PARAMETERS

Parameters	Estimation Procedure	Varies by Land Use?	Calibration Parameter?
Rainfall (in.)	NWS hourly and SCVWD 15-minute recording weighing gages (1974-1989). To correct for orographic effects, rainfall records were multiplied by isohyetal correction factors based on the ratio of average annual rainfall for subareas to the average at the gage.		
Potential Evapotranspiration Rate (in./day)	Average monthly pan evaporation data at the Alamitos Recharge facilities, multiplied by monthly pan coefficients provided by the SCVWD.		
Area (acres)	Drainage areas were measured from drainage maps provided by the SCVWD.		
Slope (fraction)	Slopes were determined by area-weighting slopes for those SCVWD catchments contained in model subcatchment.	•	
Land Use (%)	Land use percentages were determined by area-weighting values for SCVWD catchments contained within each SWMM subcatchment.	•	
Catchment Width (feet)	Drainage area divided by the maximum length of overland flow.		•
Impervious Area (%)	Derived from calibration of SWMM for monitored land use catchments (Station L1-L7) for the 1988-89 season.	•	•
Surface Roughness	Values for each land use were derived from tables for grassy, paved, and forested surfaces in the SWMM User's Manual.	•	
Depression Storage (in.)	Values for each land use were derived from tables for grassy and paved surfaces in the SWMM User's Manual.	•	•
Infiltration Parameters	Hydrologic soil groups were mapped from Soil Conservation Service (SCS).	•	•
Interflow Parameters	Soil surveys (1941). Typical values for each soil group were then selected from tables in the SWMM User's Manual. The average for a SWMM subarea was determined by area-weighted averaging.		
Unsaturated zone	From typical values tabulated in SWMM user's manual for soil types surveyed by the SCS (1941).		•
Saturated zone	From typical values tabulated in SWMM user's manual for soil types surveyed by the SCS (1941).		•
Outflow coefficients	By calibration to match measured hydrographic recessions.	•	•

Jose, is an hourly gage with a precision of 0.01 inch. A detailed description of these data is provided in Section 5.1.

The rainfall record for each subcatchment was selected by first identifying the rain gage located nearest to the centroid of the subcatchment area. The record for this rain gage then became the base rainfall record for the subcatchment. In selecting a base rainfall record, we also compared the elevation of the rain gage to that of the subcatchment (i.e., if the nearest gage were on a high ridge above the subcatchment, another gage at an elevation closer to that of the subcatchment was sometimes selected as a more representative record).

Once a base record was established for the subcatchment, the rainfall record was adjusted for the average difference between rainfall volumes in the subcatchment and at the rain gage. To accomplish this, rainfall records were multiplied by correction factors based on the ratio of average annual precipitation in the subcatchment to average annual precipitation in the rain gage:

$$R_{sc} = R_g * (P_{sc}/P_g) \qquad \text{(B-1)}$$

where

R_{sc} = 15-minute rainfall values used in modeling the sub catchment (in)

R_g = the corresponding 15-minute rainfall in the rain gage (in)

P_{sc} = the mean annual rainfall in the subcatchment (in)

P_g = the mean annual rainfall in the rain gage (in)

The mean annual rainfall for the catchment was estimated from annual average rainfall isohyets. Rainfall isohyets were derived from isohyetal maps provided by the SCVWD.

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Storm patterns within a year can be highly variable, and this correction of rainfall records based on long-term annual average rainfall totals will certainly not capture all of the spatial variability within an individual storm. However, the method does ensure that, on average, the rainfall record used in modeling runoff will have the correct cumulative volume. This method should therefore be sufficiently accurate for estimating annual flow volumes and loads.

8.2.2.2 Potential Evapotranspiration Rate. The potential evapotranspiration rate determines how much water could be lost to evaporation and transpiration. SWMM uses an average rate for each month of the year; for this study, these rates were estimated using the average monthly pan evaporation rates measured by the SCVWD at the Alamitos Recharge Facility. These pan evaporation rates were corrected by pan coefficients provided by the SCVWD.

8.2.2.3 Catchment Area, Slope, and Land Use. These data were available for catchments used by the SCVWD in their flood modeling. These catchments were smaller than the SWMM subcatchments used in this study. Consequently, model subcatchment areas were determined from the SCVWD catchment maps by summing the areas for the appropriate SCVWD catchments. Similarly, slopes and land use breakdown were determined by area-weighting the values for the SCVWD catchments comprising a SWMM subcatchment.

8.2.2.4 Catchment Width. SWMM represents each subcatchment as a rectangle defined by an area and width; the length of overland flow is then the area divided by the width. Catchment width is therefore an important parameter in determining the timing of runoff. This width is difficult to measure, since the actual shapes of subcatchments are rarely rectangular. As recommended in the SWMM Users Manual (Huber and Dickensen 1988), a first estimate of this parameter was obtained by dividing the subcatchment area by the maximum distance from catchment boundary to the main channel.

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B.2.2.5 Impervious Area. This parameter is defined as the percentage of an area that has no infiltration, i.e., paved areas, rooftops, etc. Impervious areas must also be connected, and paved areas that drain onto pervious areas should not be considered impervious. This parameter could conceivably be measured directly from aerial photos, but this would be extremely costly and of questionable accuracy for an area as large as the Santa Clara Valley.

The approach used here was to determine representative impervious areas for each land use by calibrating SWMM on storm data at the single land use catchments sampled in this study. These values were then adjusted during calibration of the larger watersheds to match observed runoff volumes.

B.2.2.6 Surface Roughness Coefficients and Depression Storages. These were estimated for pervious and impervious areas using values tabulated in the SWMM user's manual for various types of surfaces. Values tabulated for either paved, grassy, or forested surfaces were selected based on land use. Depression storages were also calibrated in forested areas to represent interception on vegetation.

B.2.2.7 Infiltration Parameters. For this study, the Green-Ampt option in SWMM was selected for modeling infiltration during storm events. The Green-Ampt infiltration model, while certainly idealized, is mechanistically rather than empirically based and has input parameters that can easily be related to known soil properties. For infiltration during storms, the model uses three parameters: 1) the saturated hydraulic conductivity, 2) a suction parameter, and 3) the maximum soil moisture deficit. The saturated hydraulic conductivity represents the infiltration rate at saturation. The suction parameter is used to model the effects of capillary suction in the soil. The maximum moisture deficit is analogous to porosity and determines the storage capacity of the soil layer that controls infiltration. Values of these parameters are tabulated for each of the four Soil Conservation Service (SCS) hydrologic soil groups in the SWMM User's Manual. Therefore,

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values for this study were determined by overlaying SCS soil survey maps (SCS 1941) onto maps of the SWMM subcatchments. The area of soils in each SCS hydrologic group were measured, and the average parameters for the watershed were determined by area weighting. The following calculation illustrates the method for the saturated hydraulic conductivity:

$$K = (\%A)(KA) + (\%B)(KB) + (\%C)(KC) + (\%D)(KD) \qquad \text{(B-2)}$$

where:

K = the average saturated hydraulic conductivity for a subcatchment
A, B, C, D = the four SCS hydrologic soil groups
%A = the percentage of the total area that are A soils
KA = the value of saturated hydraulic conductivity for A soils

In general, soils in the area ranged from B to D, where D soils have the lowest infiltration rates.

Between storms, SWMM uses a simple empirical algorithm to determine how dry soils are at the start of the next storm. As previously discussed, the antecedent soil moisture level is an important factor in determining runoff response in the Study Area, especially in the later months of the rainy season. Initial calibration of SWMM indicated that the empirical SWMM soil moisture depletion algorithm was not adequately reproducing the seasonality of soil moisture levels; soils were generally saturating during every storm and then drying out to the maximum moisture deficit within a few days. Thus, the model predicted that storms in February responded the same to rainfall as storms in November. The SWMM soil moisture depletion algorithm was therefore modified so that the depletion rate and storage capacity of the soil layer controlling infiltration could be adjusted during calibration. The depletion rate was defined as a fraction of the potential evapotranspiration rate:

$$R_i = (F_d)(PET_i) \quad \text{(B-3)}$$

where:

R_i = the soil moisture depletion rate for month i
PET_i = the potential evapotranspiration rate for month i
F_d = the soil moisture depletion factor

This modification allowed depletion rates to vary seasonally, and F_d was added as a calibration parameter for the model. To control the storage capacity of the soil, the thickness of the soil layer controlling infiltration was also added as a calibration parameter. This storage parameter could then be adjusted along with the depletion factor to match the observed seasonality in runoff.

B.2.2.8 Interflow Parameters. To model the interflow recession observed in many storm hydrographs in the Study Area, the SWMM groundwater model was configured as shown in Figure B-4. The bottom of the saturated zone was set at a relatively shallow depth (10 to 15 feet) so that the saturated zone rose rapidly during storm events and released stored water into channels within 1 to 7 days. This interflow system was modeled only in steep areas with high rainfall volumes; interflow was generally not observed in valley floor catchments.

Model input parameters in the unsaturated zone include storage parameters such as field capacity and wilting point, and parameters describing hydraulic conductivity as a function of soil moisture. These were generally estimated from tables of typical values for the appropriate SCS soil types. Similarly, the saturated zone is defined by storage parameters such as porosity and rate parameters such the saturated zone outflow coefficients. Flow from the saturated zone into the channel was calculated using the following model based on head differences between the channel and the saturated zone:

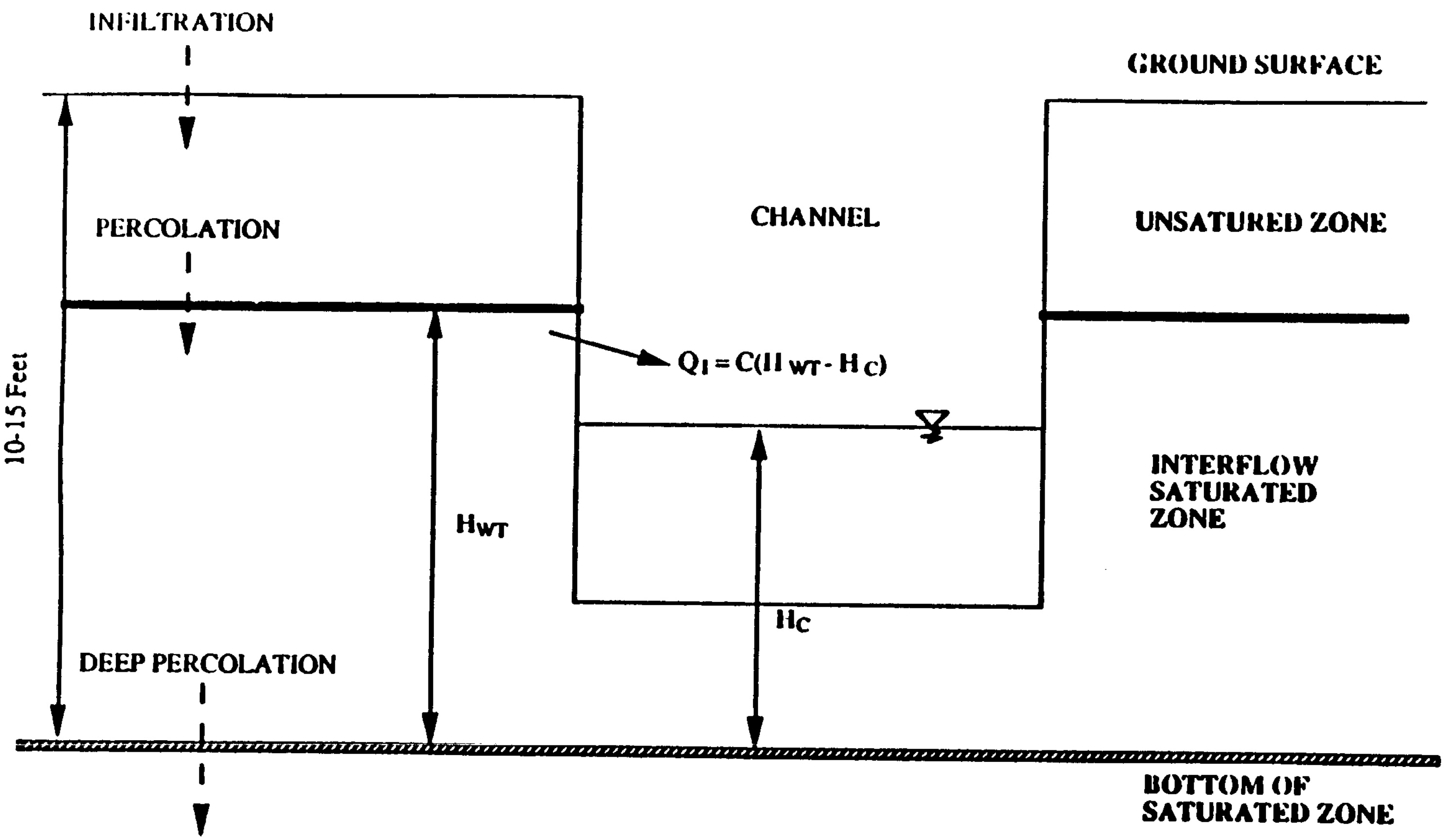

FIGURE B-4. SWMM Interflow Model

$$Q_I = C(H_{wt} - H_c) \quad (B\text{-}4)$$

where:

Q_I = interflow rate into the channel (cfs)
H_{wt} = elevation of the water table (ft)
H_c = elevation of water in the channel (ft)
C = interflow coefficient (ft^2/sec)

The interflow coefficient C is a calibration parameter which was primarily used to determine the magnitude of interflow into the channel. An additional calibration parameter, representing deep percolation out of the saturated zone, was used to steepen predicted hydrograph recessions to match observed recession curves.

B.2.2.9 Channel Data. Runoff and interflow from SWMM subcatchments were routed down channels using the SWMM non-linear routing algorithm. For this study, one channel was defined for each rain gage subarea, and input data were required specifying the slope, Manning's roughness coefficient, and cross section of each channel reach. Cross-sectional data for all streams were provided by the SCVWD in the form of HEC-2 input files used in flood modeling. From these, representative cross sections were selected and approximated as trapezoids for SWMM (defined by a bottom width and two side slopes). Manning's roughness coefficients and slopes were averaged for each channel reach modeled.

B.3 SWMM CALIBRATION AND VERIFICATION

Although SWMM is a state of the art model of rainfall-runoff processes, it, like all runoff models, represents an idealization of the actual processes occurring in a catchment. In addition, the spatial variability of model input parameters is difficult to account for in large catchments with many types of geology and land uses. Therefore, the model must be calibrated against measured streamflow data to produce reliable results. The calibration consists of running the model, comparing model prediction to measured streamflows, and adjusting the model calibration parameters to better match the observed flows. The process is repeated until the comparison between measured and predicted flows is deemed adequate. Calibration is then followed by verification, in which the calibrated model is run and compared to streamflow records for a period not included in the calibration period.

The following sections describe 1) calibration criteria, 2) selection of calibration periods, 3) calibration parameters, and 4) results for individual watersheds.

B.3.1 Calibration Goals and Criteria

To capture the year to year variability of runoff, SWMM was run continuously over several years during calibration and verification. Since the emphasis of this study was on annual loads from storm runoff, the primary goal of calibration was to match measured wet-season total runoff volumes. The runoff volume for a season consists primarily of runoff from relatively few storm events (typically less than 15), and matching wet-season runoff volumes required accurate simulation of individual storm events.

For calibration purposes, predicted flows were compared to measured flows at SCVWD and USGS stream gages. See Section 5.2 for a discussion of stream gages in the Study Area. A number of parameters were calculated to measure the quality of calibration. For comparing predicted versus measured wet-season totals, the following statistics were calculated:

$$\text{RMSE} = \frac{100\left(\sum_{i=1}^{n}(P_i - M_i)^2/n\right)^{1/2}}{M} \qquad \text{(B-5)}$$

$$\text{BIAS} = 100(P - M)/M \qquad \text{(B-6)}$$

where:

P_i = predicted wet-season runoff volume for year i (in.)

M_i = measured wet-season runoff volume for year i (in.)

n = the number of years in the calibration period.

M = the mean measured wet-season runoff volume (in.)

P = the mean predicted wet-season runoff volume (in.)

The RMSE, or root mean square error, is a measure of the absolute magnitude of calibration errors expressed as a percentage of mean runoff. The BIAS indicates whether the model is on average over- or under-predicting runoff volumes, and is also expressed as a percentage of the mean wet-season runoff volume. The goal of calibration was to minimize both the RMSE and the BIAS.

Results of calibrations performed for comparable studies were consulted to derive specific calibration acceptance criteria. Alley (1986) summarizes calibration results from the USGS rainfall-runoff model DR3M for 37 catchments nationwide. In this study, calibration errors were measured by the mean absolute deviation (MAD) between predicted and observed flow volumes. On average, the MAD was on the order of 20 percent for the 37 simulated catchments. In a modeling study of three small urban catchments, Guay and Smith (1988) calibrated the USGS model DR3M to runoff data for 10 to 13 storms in one season. Prediction errors in total annual runoff volume for these three single land use catchments ranged from 10 to 25 percent. In a study performed on Permanente Creek in Santa Clara County, Nolan and Hill (1989) obtained calibration errors in total annual flow volume of 3 to 33 percent.

These studies indicate that calibration errors are generally on the order of 20 percent, but may range as high as 30 or 40 percent. The studies cited above generally focused on small (less than 100 acre) urban catchments with a single well-defined land use. None of these studies

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calibrated using more than 3 years of flow data. Thus, one would expect that the calibration errors obtained in modeling the large watersheds in the Santa Clara Valley for up to 10 years of flow data would be somewhat higher. Nonetheless, for this study a relatively ambitious calibration goal of 15 percent RMSE was used for annual flow predictions. Given the difficulties inherent in simulating large open areas, this goal was often not achieved. However, the RMSEs summarized in Table B-3 range from 1 to 40 percent, and are consistent with calibration errors obtained in other studies. More importantly, the biases in the model predictions are small, and range from 1 to 16 percent.

Daily predicted flows were compared to measured flows in two ways. First, daily predicted flows and measured flows were plotted together over time and visually compared. These plots were used for detailed analyses of the sources of calibration errors, particularly in terms of matching seasonal runoff patterns and hydrograph recessions. Finally, a Kolmogorov-Smirnov hypothesis test was used to compare the frequency distributions of measured and predicted daily flows. This test first calculates the maximum difference between measured and predicted cumulative probabilities. This difference is then compared to a test statistic based on the number of daily flows and the confidence level. If the maximum difference is less than the test statistic, the hypothesis that the predicted and measured flows are from the same population is accepted. This test, while it does not check that the flow on a given day is accurately predicted, does measure how well the model is reproducing the day to day variability of flows.

B.3.2 Selection of Calibration and Verification Periods

Runoff in the Study Area varies greatly from year to year, and the annual runoff volume for a wet year can be ten times greater than in a dry year. A calibration based on only one dry year would therefore not accurately represent runoff in wet years. Therefore, SWMM was calibrated and verified against as many years of streamflow data as were available,

Table B-3. SUMMARY OF SWMM CALIBRATION/VERIFICATION

Watershed	Calibration Period	Verification Period	Calibration: Mean Wet-Season Runoff (in.)	Calibration: RMSE (%)	Calibration: Bias (%)	Verification: Mean Wet-Season Runoff (in.)	Verification: RMSE (%)	Verification: Bias (%)	Combined Calibration and Verification Period: Mean Wet-Season Runoff (in.)	Combined: RMSE[a] (%)	Combined: Bias[b] (%)
Calabazas Creek	1976-80, 86-88	1980-83, 1984-85, 1988-1989	4.00	8	-5	5.51	13	6	4.73	11	1
Stevens Creek	1977-1981	1975-77, 1981-83	1.96	15	1	2.15	45	1	2.06	34	1
Sunnyvale East	1974-1982	1984-1989	5.66	6	3	3.31	3	-9	4.59	9	-1
Saratoga Creek	1974-1982	1982-1986	6.57	30	-8	11.90	13	10	8.19	22	0.1
San Tomas Aquinas Creek	1975-1981	1983-1987	6.50	17	-7	6.93	25	5	6.73	21	-2
Coyote Creek	1988-1 89	None	0.73	1	-1	None	None	None	0.73	1	-1
Berryessa Creek	1974-1979	1980-1982	1.39	19	-12	4.69	25	16	2.09	29	6
Guadalupe River	1977-1981	1981-82, 1987-89	2.92	30	-2	1.73	40	-3	2.4	40	-2
STUDY AREA			2.80	25	-4	2.90	22	5	2.8	25	-1

[a] RMSE measures the average error in predicted wet-season runoff, as a percentage of the mean wet-season runoff volume.

[b] BIAS measures the average bias (tendency to under- or over-predict) in predicted wet-season runoff, as a percentage of the mean wet-season runoff volume.

with approximately two thirds of the record used for calibration and one third for verification. As discussed in Section 5.0, concurrent streamflow and rainfall data are generally available for the period 1974 through 1989, with occasional gaps due to gaging errors, data storage problems, and damage to stream gages. Table B-3 summarizes the calibration and verification periods for the various watersheds; calibration periods were typically 4 to 9 years in length, while verification periods were 3 to 5 years long. Both calibration and verification periods were selected to contain a mix of wet, dry, and average years. Note that there was only one year of data available for calibration of the Coyote Creek watershed.

B.3.3 Calibration Parameters

Table B-4 summarizes the values of parameters derived from calibration of SWMM for each watershed. For adjustment of runoff volumes in urban areas, the most important parameters were the percent of impervious area and depression storages. These parameters were especially important in dry years when almost all runoff was from impervious areas; the percent impervious area for each of the various land uses was therefore determined primarily through calibration on dry years. In open and low-residential areas, the most important parameters were the Green-Ampt infiltration and soil depletion parameters. The saturated hydraulic conductivity was used to determine the overall rate of infiltration (and therefore reduction in runoff). The soil moisture depletion parameters L and F_d were used to model the seasonality of infiltration (and runoff) by adjusting the rate at which soils dried out between storms. The interflow coefficient A1 and deep percolation factor DF were used to match hydrograph recessions, while CET, POR, and GRELEV defined the storage characteristics of the saturated zone.

B.3.3.1 Calibration of the Percent Imperviousness. One of the most sensitive model parameters in urban areas is the percent imperviousness. Runoff volumes are often directly proportional to the value of the percent imperviousness, meaning that if this parameter is doubled, runoff volumes

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Table B-4. PARAMETER VALUES USED IN THE CALIBRATION OF SWMM FOR EACH WATERSHED

Watershed	Sub Catchment	Rain Gage	Land Use Type	Area (acre)	% Imp.	Manning's n Imp.	Manning's n Perv.	Depression Storage Imp. (in.)	Depression Storage Perv. (in.)	Infiltration Parameters Suction Pres. (in.)	Infiltration Parameters Hyd. Con. (in./hr)	Initial Moist. Deficit	Soil Moist. Depletion Factor	Infil. Layer Thickness (in.)
Coyote	Upper Penitentia	99	Open	142.4	0	0.013	0.4	0.03	0.1	10	0.05	0.26	0.8	20
			Med. Res.	849.3	25	0.013	0.4	0.03	0.1	10	0.1	0.26	0.8	20
			High Res.	173.8	35	0.013	0.2	0.03	0.1	10	0.1	0.26	0.8	20
			Comm.	31.4	45	0.013	0.2	0.03	0.1	10	0.1	0.26	0.8	20
	Silver Thompson	90	Open	10559	0	0.013	0.4	0.03	0.1	10	0.05	0.26	0.8	20
			Low Res.	4432	15	0.013	0.2	0.03	0.1	10	0.1	0.26	0.8	20
			Med. Res.	4709	25	0.013	0.2	0.03	0.1	10	0.1	0.26	0.8	20
		86	Open	5201	0	0.013	0.4	0.03	0.1	10	0.1	0.26	0.8	20
			Med. Res.	4186	25	0.013	0.2	0.03	0.1	10	0.1	0.26	0.8	20
			High Res.	254	35	0.013	0.2	0.03	0.1	10	0.1	0.26	0.8	20
			Comm.	1903	60	0.013	0.2	0.03	0.1	10	0.1	0.26	0.8	20
			Industrial	1142	70	0.013	0.2	0.03	0.1	10	0.1	0.26	0.8	20
	Berryessa	323	Open	17860	0	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
			Low Res.	952	10	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
			Med. Res.	1452	20	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
			Comm.	541	40	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
			Industrial	465	50	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
		123	Low Res.	203.2	5	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
			Med. Res.	1579.3	13	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
		223	Open	2163.5	0	0.013	0.24	0.03	0.1	10	0.08	0.26	0.2	7
			Low Res.	961.5	5	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
			Med. Res.	80.1	20	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
			High Res.	40.1	30	0.013	0.2	0.03	0.1	10	0.16	0.26	0.2	7
San Tomas	79	79	Open	1479	0	0.03	0.4	0.03	0.1	10	0.1	0.26	0.4	10
			Low Res.	5100	10	0.03	0.2	0.03	0.1	10	0.1	0.26	0.4	10
			Med. Res.	739	20	0.03	0.2	0.03	0.1	10	0.1	0.26	0.4	10
			Comm.	74	50	0.03	0.2	0.03	0.1	10	0.1	0.26	0.4	10
	108	108	Open	331	0	0.03	0.2	0.05	0.15	10	0.2	0.26	0.4	10
			Low Res.	3576	10	0.03	0.2	0.05	0.15	10	0.2	0.26	0.4	10
			Med. Res.	667	20	0.03	0.2	0.05	0.15	10	0.2	0.26	0.4	10
			High Res.	551	30	0.03	0.2	0.05	0.15	10	0.2	0.26	0.4	10
			Comm.	441	40	0.03	0.2	0.05	0.15	10	0.2	0.26	0.4	10
	86	86	Low Res.	1020	10	0.03	0.2	0.05	0.15	10	0.2	0.26	0.4	10
			Med. Res.	373	20	0.03	0.2	0.05	0.15	10	0.2	0.26	0.4	10
			Industrial	2473	60	0.03	0.2	0.05	0.15	10	0.2	0.26	0.4	10

Table B-4. PARAMETER VALUES USED IN THE CALIBRATION OF SWMM FOR EACH WATERSHED (continued)

Watershed	Sub Catchment	Rain Gage	Land Use Type	Area (acre)	% Imp.	Manning's n Imp.	Manning's n Perv.	Depression Storage Imp. (in.)	Depression Storage Perv. (in.)	Infiltration Parameters Suction Pres. (in.)	Infiltration Parameters Hyd. Con. (in./hr)	Initial Moist. Deficit	Soil Moist. Depletion Factor	Infil. Layer Thickness (in.)
Saratoga	77	77	Open	5535	0	0.013	0.4	0.1	0.3	10	0.1	0.26	0.2	7
			Low Res.	554	5	0.013	0.2	0.1	0.3	10	0.1	0.26	0.2	7
	100	100	Open	109	0	0.013	0.2	0.1	0.3	10	0.3	0.26	0.2	7
			Low Res.	1755	5	0.013	0.2	0.1	0.3	10	0.3	0.26	0.2	7
			Med. Res.	2443	8	0.013	0.2	0.1	0.3	10	0.3	0.26	0.2	7
			High Res.	69	30	0.013	0.2	0.1	0.3	10	0.3	0.26	0.2	7
			Comm.	482	20	0.013	0.2	0.1	0.3	10	0.3	0.26	0.2	7
Sunnyvale East Channel	40	40	Low Res.	2048	10	0.013	0.2	0.03	0.1	9	0.12	0.26	0.7	7
			Med. Res.	637	20	0.013	0.2	0.03	0.1	9	0.12	0.26	0.7	7
			High Res.	106	30	0.013	0.2	0.03	0.1	9	0.12	0.26	0.7	7
			Comm.	1632	60	0.013	0.2	0.03	0.1	9	0.12	0.26	0.7	7
Guadelupe	Calero	220	Open	2057	0	0.013	0.4	0.2	0.3	8	0.05	0.25	0.0	10
			Low Res.	1316	5	0.013	0.2	0.2	0.3	8	0.05	0.25	0.0	10
	Alamitos	120	Open	1609	0	0.013	0.4	0.2	0.3	0.0	0.05	0.20	0.0	10
			Low Res.	909	5	0.013	0.2	0.06	0.2	0.0	0.05	0.20	0.0	10
		123	Open	4313	0	0.013	0.4	0.2	0.3	9	0.05	0.20	0.0	10
		401	Open	2259	0	0.013	0.4	0.1	0.3	8	0.05	0.25	0.0	15
			Low Res.	3175	5	0.013	0.2	0.03	0.2	8	0.05	0.25	0.0	15
			Med. Res.	672	15	0.013	0.2	0.03	0.2	8	0.05	0.25	0.0	15
		301	Open	566	0	0.013	0.4	0.1	0.3	7.4	0.12	0.25	0.0	15
			Low Res.	840	5	0.013	0.2	0.03	0.2	7.4	0.12	0.25	0.0	15
		201	Low Res.	347	5	0.013	0.2	0.03	0.2	8	0.12	0.3	0.0	14
			Med. Res.	3124	15	0.013	0.2	0.03	0.2	8	0.12	0.3	0.0	14
			High Res.	347	30	0.013	0.2	0.03	0.2	8	0.12	0.3	0.0	14
			Comm.	521	50	0.013	0.1	0.03	0.2	8	0.12	0.3	0.0	14
		86	Open	1538	0	0.013	0.2	0.03	0.2	8.3	0.12	0.20	0.0	14
			Low Res.	1878	5	0.013	0.2	0.03	0.2	8.3	0.12	0.20	0.0	14
			Med. Res.	4951	15	0.013	0.2	0.03	0.2	8.3	0.12	0.20	0.0	14
			High Res.	1194	30	0.013	0.2	0.03	0.2	8.3	0.12	0.20	0.0	14
			Comm.	4440	50	0.013	0.1	0.03	0.2	8.3	0.12	0.20	0.0	14
			Industrial	3072	60	0.013	0.1	0.03	0.2	8.3	0.12	0.20	0.0	14
	Canoas	401	Open	2504	0	0.013	0.2	0.03	0.2	7.6	0.12	0.26	0.0	14
			Low Res.	477	5	0.013	0.2	0.03	0.2	7.6	0.12	0.26	0.0	14
			Med. Res.	6200	15	0.013	0.2	0.03	0.2	7.6	0.12	0.26	0.0	14
			High Res.	715	30	0.013	0.2	0.03	0.2	7.6	0.12	0.26	0.0	14
			Comm.	596	50	0.013	0.1	0.03	0.2	7.6	0.12	0.26	0.0	14
			Industrial	1431	60	0.013	0.1	0.03	0.2	7.6	0.12	0.26	0.0	14

Table B-4. PARAMETER VALUES USED IN THE CALIBRATION OF SWMM FOR EACH WATERSHED (continued)

Watershed	Sub Catchment	Rain Gage	Land Use Type	Area (acre)	% Imp.	Manning's n Imp.	Manning's n Perv.	Depression Storage Imp. (in.)	Depression Storage Perv. (in.)	Infiltration Parameters Suction Pres. (in.)	Infiltration Parameters Hyd. Con. (in./hr)	Initial Moist. Deficit	Soil Moist. Depletion Factor	Infil. Layer Thickness (in.)
Guadalupe	Ross	136	Open	1575	0	0.015	0.4	0.1	0.3	0.1	0.12	0.26	0.0	14
			Low Res.	1462	5	0.015	0.2	0.03	0.2	0.1	0.12	0.26	0.0	14
			Med. Res.	2973	15	0.015	0.2	0.03	0.2	0.1	0.12	0.26	0.0	14
			High Res.	254	30	0.015	0.2	0.03	0.2	0.1	0.12	0.26	0.0	14
			Comm.	191	50	0.015	0.1	0.03	0.2	0.1	0.12	0.26	0.0	14
	Los Gatos	125	Low Res.	2675	5	0.015	0.2	0.03	0.2	10	0.12	0.26	0.0	14
			Med. Res.	3000	15	0.015	0.2	0.03	0.2	10	0.12	0.26	0.0	14
			High Res.	600	30	0.015	0.2	0.03	0.2	10	0.12	0.26	0.0	14
			Comm.	1275	50	0.015	0.1	0.03	0.2	10	0.12	0.26	0.0	14
		36	Open	1935	0	0.015	0.4	0.1	0.3	10	0.12	0.26	0.0	10
			Low Res.	1290	5	0.015	0.2	0.06	0.2	10	0.12	0.26	0.0	10
			Med. Res.	645	15	0.015	0.2	0.03	0.2	10	0.12	0.26	0.0	10
			Comm.	161	50	0.015	0.1	0.03	0.2	10	0.12	0.26	0.0	10
Calabazas	100	100	Open	1965	0	0.015	0.4	0.1	0.3	9.1	0.03	0.24	0.0	10
			Low Res.	2150	6	0.015	0.2	0.1	0.3	9.1	0.025	0.24	0.0	10
			Med. Res.	457	15	0.015	0.2	0.1	0.3	9.1	0.025	0.24	0.0	10
	100	100	Low Res.	1133	10	0.015	0.2	0.06	0.1	7.9	0.025	0.3	0.6	7
			Med. Res.	2520	20	0.015	0.2	0.06	0.1	7.9	0.025	0.3	0.6	7
			Comm.	697	70	0.015	0.1	0.06	0.1	2.9	0.025	0.3	0.6	7
	121	121	Open	236	0	0.015	0.15	0.06	0.1	9.4	0.025	0.20	0.6	6
			Low Res.	1650	10	0.015	0.2	0.06	0.1	9.4	0.025	0.20	0.6	6
			Med. Res.	1085	20	0.015	0.2	0.06	0.1	9.4	0.025	0.20	0.6	6
			High Res.	330	30	0.015	0.2	0.06	0.1	9.4	0.025	0.20	0.6	6
			Comm.	1415	80	0.015	0.1	0.06	0.1	9.4	0.025	0.20	0.6	6
Stevens	100	100	Open	1022	0	0.015	0.4	0.1	0.3	10	0.07	0.20	0.0	10
			Low Res.	1750	6	0.015	0.2	0.1	0.3	10	0.07	0.20	0.0	10
	40	40	Low Res.	3068	8	0.015	0.2	0.06	0.1	10	0.1	0.20	0.7	8
			Med. Res.	90	20	0.015	0.2	0.06	0.1	10	0.1	0.20	0.7	8
			Comm.	90	50	0.015	0.1	0.06	0.1	10	0.1	0.20	0.7	8
	121	121	Open	44	0	0.015	0.16	0.06	0.1	10	0.1	0.20	0.7	8
			Low Res.	256	8	0.015	0.2	0.06	0.1	10	0.1	0.20	0.7	8
			Med. Res.	222	20	0.015	0.2	0.06	0.1	10	0.1	0.20	0.7	8
			High Res.	200	30	0.015	0.2	0.06	0.1	10	0.1	0.20	0.7	8
			Comm.	300	80	0.015	0.1	0.06	0.1	10	0.1	0.20	0.7	8

Table B-4. PARAMETER VALUES USED IN THE CALIBRATION OF SWMM FOR EACH WATERSHED (continued)

Watershed	Sub Catchment	Rain Gage	Land Use Type	Area (acre)	% Imp.	Manning's n Imp.	Manning's n Perv.	Depression Storage Imp. (in.)	Depression Storage Perv. (in.)	Infiltration Parameters Suction Pres. (in.)	Infiltration Parameters Hyd. Con. (in./hr)	Initial Moist. Deficit	Soil Moist. Depletion Factor	Infil. Layer Thickness (in.)
Sunnyvale West	48	48	Open	100	0	0.013	0.2	0.05	0.1	9	0.1	0.26	0.7	7
			Low Res.	451	10	0.013	0.2	0.05	0.1	9	0.1	0.26	0.7	7
			Med. Res.	311	20	0.013	0.2	0.05	0.1	9	0.1	0.26	0.7	7
			High Res.	165	30	0.013	0.1	0.05	0.1	9	0.1	0.26	0.7	7
			Comm.	33	60	0.013	0.1	0.05	0.1	9	0.1	0.26	0.7	7
San Francisquito	24	24	Open	2339	0	0.013	0.2	0.1	0.3	9	0.07	0.26	0.8	10
			Low Res.	349	6	0.013	0.2	0.1	0.3	9	0.07	0.26	0.8	10
	53	53	Open	1425	0	0.013	0.2	0.1	0.3	9	0.07	0.26	0.8	10
			Low Res.	403	0	0.013	0.2	0.1	0.3	9	0.07	0.26	0.8	10
			Med. Res.	45	20	0.013	0.2	0.08	0.2	9	0.07	0.26	0.8	10
			Comm.	345	50	0.013	0.1	0.08	0.1	9	0.07	0.26	0.8	10
Adobe	24	24	Open	2546	0	0.013	0.2	0.1	0.3	9	0.07	0.26	0.8	10
			Low Res.	315	6	0.013	0.2	0.1	0.3	9	0.07	0.26	0.8	10
	53	53	Open	557	0	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Low Res.	6192	0	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Comm.	209	50	0.013	0.1	0.08	0.1	9	0.05	0.26	0.6	7
	48	48	Low Res.	753	0	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Comm.	502	50	0.013	0.1	0.08	0.1	9	0.05	0.26	0.6	7
Barron	53	53	Open	48	0	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Low Res.	1450	6	0.013	0.2	0.1	0.5	9	0.07	0.26	0.8	10
			Med. Res.	48	20	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Comm.	48	50	0.013	0.1	0.08	0.1	9	0.05	0.26	0.6	7
	48	48	Low Res.	266	0	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Med. Res.	17	20	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Comm.	50	50	0.015	0.1	0.08	0.1	9	0.05	0.26	0.6	7
Matadero	53	53	Open	1933	0	0.013	0.2	0.1	0.3	9	0.07	0.36	0.8	10
			Low Res.	1933	6	0.013	0.2	0.1	0.3	9	0.07	0.26	0.8	10
			Med. Res.	145	15	0.013	0.2	0.08	0.2	9	0.07	0.26	0.8	10
			Comm.	821	50	0.013	0.1	0.08	0.1	9	0.07	0.26	0.8	10
	48	48	Open	505	0	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Low Res.	2175	0	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Med. Res.	410	20	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Comm.	1003	50	0.015	0.1	0.08	0.1	9	0.05	0.26	0.6	7

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Table H 4. PARAMETER VALUES USED IN THE CALIBRATION OF SWMM FOR EACH WATERSHED (concluded)

Watershed	Sub Catchment	Rain Gage	Land Use Type	Area (acre)	% Imp.	Manning's n Imp.	Manning's n Perv.	Depression Storage Imp. (in.)	Depression Storage Perv. (in.)	Infiltration Parameters Suction Pres. (in.)	Infiltration Parameters Hyd. Con. (in./hr)	Initial Moist. Deficit	Soil Moist. Depletion Factor	Infil. Layer Thickness (in.)
Permanente	Hale	53	Open	323	0	0.013	0.4	0.1	0.3	9	0.07	0.26	0.8	10
			Low Res.	2704	6	0.013	0.2	0.1	0.3	9	0.07	0.26	0.8	10
			High Res.	100	30	0.013	0.2	0.08	0.1	9	0.07	0.26	0.8	10
			Comm.	54	50	0.013	0.1	0.08	0.1	9	0.07	0.26	0.8	10
	40	40	Open	290	0	0.013	0.4	0.1	0.3	9	0.05	0.26	0.6	7
			Low Res.	1101	8	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Comm.	58	50	0.013	0.1	0.08	0.1	9	0.05	0.26	0.6	7
	121	121	Open	150	0	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Low Res.	702	8	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Med. Res.	266	70	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			High Res.	309	30	0.013	0.2	0.08	0.1	9	0.05	0.26	0.6	7
			Comm.	67	80	0.013	0.1	0.08	0.1	9	0.08	0.26	0.6	7

will nearly double. This is especially true in urban areas with low rainfall intensities.

Estimation of the percent imperviousness can conceivably be performed by direct measurement from areal photographs. However, this is usually impractical for large areas such as the Santa Clara Valley. The usual practice is therefore to derive general values of this parameter for each land use category. However, even values tabulated in the literature for individual land uses may vary by as much as 100 percent. For instance, Table B-5 compares values tabulated for Santa Clara County by (1) the SCVWD, and (2) the U.S. Geological Survey (1977). In general, the USGS values are considerably lower than the SCVWD values. The USGS data also indicate considerable variability within land use categories, with values ranging from 6 percent in hillside residential areas to 10 percent in valley floor low-density residential areas. An important conclusion that can be drawn from this is that no one value can be realistically used to represent all low-density residential areas, since not all areas within the low-density category are paved or developed to the same extent.

For our calibration of SWMM, we initially used the percent imperviousness values developed by the SCVWD (shown in Table B-5). However, use of these values resulted in consistent overestimation of runoff. That this overestimation was derived from the imperviousness estimate became apparent when examining predicted runoff from small early season storms. Runoff from these storms comes primarily from paved areas, and the model consistently overpredicted runoff from these storms even when infiltration parameters were adjusted to prevent any pervious area runoff from occurring. We therefore adjusted the percent impervious values downward to match storm volumes for these types of events.

Clearly, percent imperviousness is a very sensitive calibration parameter, and should not be adjusted to account for processes that may be better represented by the pervious area infiltration parameters. To ensure

Table B-5. COMPARISON OF CALIBRATED PERCENT IMPERVIOUSNESS VALUES TO VALUES SUPPLIED BY SCVWD

Land Use	SCVWD Percent Imperviousness	USGS (1977) Percent Imperviousness*	Calibrated Percent Imperviousness
Open	0	2	0
Low Residential	35	6, Hillsides 10, Valley Floor	3-10, Hillsides 8-10, Valley Floor 10-15, Eastern Valley Floor
Medium Residential	65	20	15-25
High Residential	75	32	30-35
Commercial	90	50	50-80
Industrial	90	40-50	50-70

* Values tabluated for Santa Clara County.

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that we were not adjusting percent imperviousness when calibration of infiltration parameters would have been more appropriate, calibration of this parameter was performed only to match runoff volumes from small storms where little runoff was occurring from pervious areas. The resulting calibrated percent imperviousness values are shown in Table B-4 for each watershed, and are summarized in Table B-5. As shown in Table B-5, the calibrated values are much lower than the original SCVWD values, but are consistent with percent imperviousness values tabulated by the USGS for Santa Clara County.

B.3.3.2 Sensitivity of the Model to Green-Ampt Infiltration Parameters. An important component of the SWMM rainfall-runoff calibration was the calibration of the Green-Ampt infiltration parameters. These parameters control infiltration of water on pervious surfaces, and thus play a critical role in predicting runoff from open areas. The Green-Ampt infiltration algorithm has three parameters: the saturated hydraulic conductivity, a capillary suction parameter, and the maximum soil moisture deficit. Sensitivity analyses of the model indicated that the controlling infiltration parameter was the saturated hydraulic conductivity, defined as the infiltration rate at saturation. Our calibration efforts therefore focused on this parameter, while leaving the values of the suction parameter and soil moisture deficit constant. As a result, occasionally the final calibrated value of the hydraulic conductivity was not consistent with the values of the suction parameter and maximum soil moisture deficit.

To test whether this inconsistency had a significant effect on the model results, a model run for Calabazas Creek was performed to demonstrate SWMM's insensitivity to the suction parameter and maximum soil moisture deficit. In this run, the values of these two parameters (which formerly corresponded to a moderately permeable "C" soil) were forced to be consistent with the calibrated hydraulic conductivity value (which corresponded to a low permeability "D" soil). Table B-6 summarizes the results of this analysis. In general, annual flow volumes were insensitive

Table B-6. SENSITIVITY OF ANNUAL LOADINGS TO THE SUCTION AND INITIAL MOISTURE DEFICIT PARAMETERS

	Percent Difference from Original Model Results		
Year	Mixed	Open	Total
77-78	-3.29	-0.87	-3.00
78-79	-4.55	-2.21	-4.24
79-80	-4.14	-2.61	-3.93
80-81	-1.00	-0.65	-0.95
81-82	-2.17	-0.81	-1.99
82-83	-3.70	-1.40	-3.39
83-84	-3.70	-2.91	-3.61
84-85	-1.54	-4.33	-1.67
85-86	-2.09	-1.78	-2.06
86-87	-1.10	-2.80	-1.15
87-88	-0.98	-0.65	-0.96
88-89	0.00	-8.39	-0.02
Total	-2.93	-1.60	-2.78

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to these parameters. Annual loading results between the new run and the original run differed by as little as .02 percent in 1988-89, and by as much as 4 percent in 1978-79. Total loadings for the 1977-1989 period change by about 3 percent.

B.3.3.3 Sensitivity of the Model to Time Series Potential Evapotranspiration Data. Potential evapotranspiration (PE) was represented in the model by average pan evaporation rates for each month of the year. Evaporation data are used in the model to simulate (1) changes in depression storage between storms and (2) seasonal changes in soil moisture storages. These processes primarily affect the antecedent soil moisture levels before storms, and therefore are most important in nonurban areas. Soil moisture levels change on a monthly or seasonal time scale, indicating that predicted annual runoff volumes are not sensitive to day to day changes in evaporation rates.

Table B-7 summarizes the mean monthly evaporation rates used in the model, and also shows the standard deviation and range of observed monthly values for the period 1976 to 1988. Note that the standard deviation of monthly values is on the order of 20 percent or less of the mean, indicating that monthly evaporation shows little year to year variation. To test the sensitivity of the annual loading predictions to the use of monthly average PE data, a model simulation was performed for Calabazas Creek using time series PE data. Table B-8 compares the resulting flow predictions to those obtained using monthly average evaporation data. Annual loads predicted from the two data sets differed by 1 to 6 percent, while the mean annual load differed by only 1.6 percent. Thus, it is reasonable to conclude that monthly average PE data are adequate for annual loads prediction.

B.3.4 Calibration and Verification Results

Table B-3 summarizes the calibration and verification statistics for all of the watersheds for which flow data were available. Figures B-5

Table B-7. MONTHLY AVERAGE POTENTIAL EVAPOTRANSPIRATION VALUES USED IN FLOW CALIBRATION

Month	Mean Evaporation (in.)	Standard Deviation (in.)	Range (in.)
October	2.93	.30	2.4 - 3.4
November	1.36	.26	0.8 - 1.8
December	0.79	.17	0.6 - 1.1
January	0.79	.13	0.6 - 1.0
February	1.45	.27	1.0 - 1.8
March	2.35	.53	1.9 - 3.3
April	3.95	.51	3.2 - 4.3
May	5.25	.73	4.3 - 6.7
June	6.69	.65	5.8 - 8.0
July	7.02	.88	6.0 - 9.0
August	5.96	.53	4.8 - 6.8
September	4.48	.83	3.0 - 6.1

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Table 8-8. SENSITIVITY OF ANNUAL FLOW PREDICTIONS TO THE USE OF AVERAGE VS TIME SERIES POTENTIAL EVAPOTRANSPIRATION DATA

Year	% Difference In Annual Flow Volume		
	Mixed Land Use	Open Land Use	Total
77-78	1.5	0.9	1.4
78-79	3.9	7.0	4.3
79-80	0.6	2.6	0.9
80-81	0.5	0.7	0.5
81-82	1.6	1.6	1.6
82-83	0.7	-0.5	0.6
83-84	2.6	4.8	2.9
84-85	4.6	23.7	5.5
85-86	2.1	3.1	2.2
86-87	1.1	2.8	1.1
TOTAL	1.6	2.0	1.6

through B-11 plot predicted wet-season volumes against measured volumes. These statistics and plots measure how well the model was able to predict total wet-season runoff volumes. During calibration, RMSEs ranged from 1 to 38 percent, and the BIAS ranged from ±1 to ±12 percent. During verification, RMSEs ranged from 3 to 45 percent, and the BIAS ranged from ±1 to ±16 percent. For the combined period, RMSEs ranged from 1 to 40 percent of mean wet-season runoff, while the BIAS ranged from ±0.1 to ±6 percent. The flow-weighted average RMSEs for the Study Area were 25, 22, and 25 percent for the calibration, verification, and combined periods, respectively. Average BIASes were -4, 5, and -1 percent for these three periods. Details on the calibration and verification process for individual watersheds are presented below.

B.3.4.1 <u>Calabazas Creek</u>. Calabazas Creek originates in the foothills of the Santa Cruz Mountains and drains into Guadalupe Slough. Mean annual rainfall ranges from 12 inches near the Bay to 32 inches in the foothills. For SWMM, the catchment was divided into three rain gage subareas corresponding to SCVWD rain gages 100, 108, and 121. Model calibration was performed primarily against streamflow data for SCVWD streamgage 26a, located on the valley floor and representing about three-fourths of the total watershed area. In addition, streamflow data at SCVWD streamgage 31 were used to refine estimates of pervious runoff parameters in the upper portion of the watershed.

Calibration and verification results for Calabazas Creek, in terms of wet-season runoff, are illustrated in Figure B-5. The calibration for Calabazas Creek was generally accurate and unbiased, with a RMSE for the combined calibration/verification period of 11 percent of the mean volume and a BIAS of 1 percent. The predicted daily flow distribution passed the Kolmogorov-Smirnov distribution test at the 95 percent confidence level. The most important calibration parameters were the Green-Ampt infiltration parameters, used to model seasonal runoff. Matching the seasonal patterns of runoff required an infiltration layer with a thickness of 8 to 10

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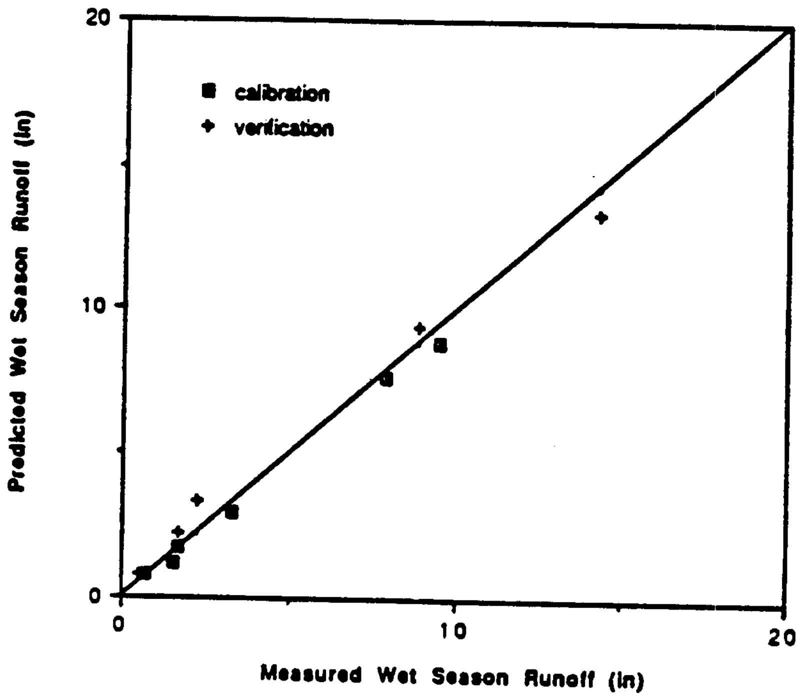

Figure B-5. Predicted versus Measured Wet Season Runoff for Calabazas Creek

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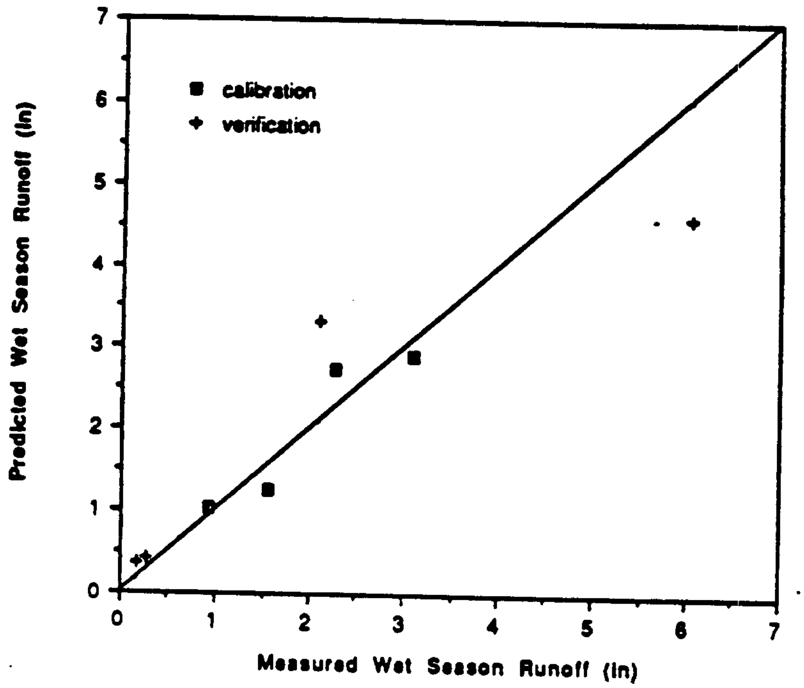

Figure B-6. Predicted versus Measured Wet Season Runoff
for Stevens Creek

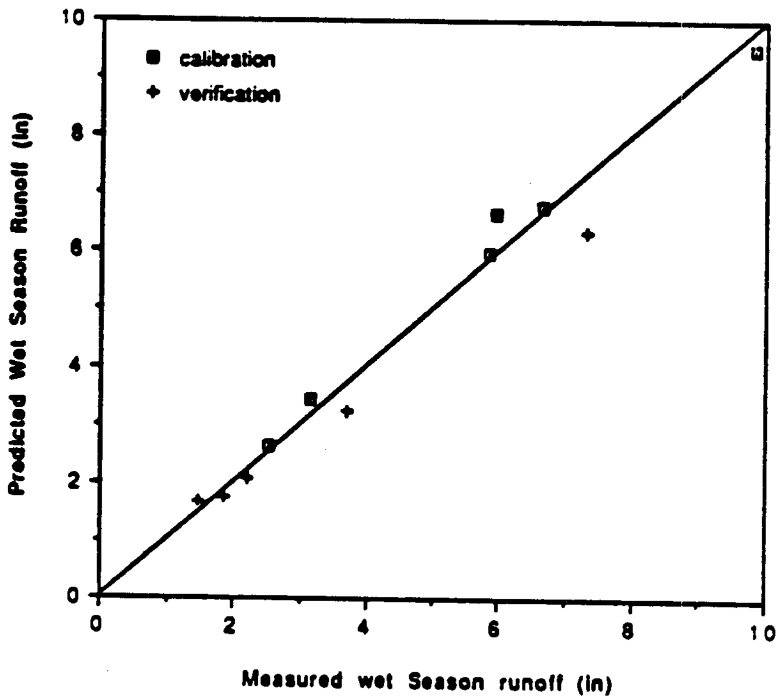

Figure B-7. Predicted versus Measured Wet Season Runoff for Sunnyvale East Channel

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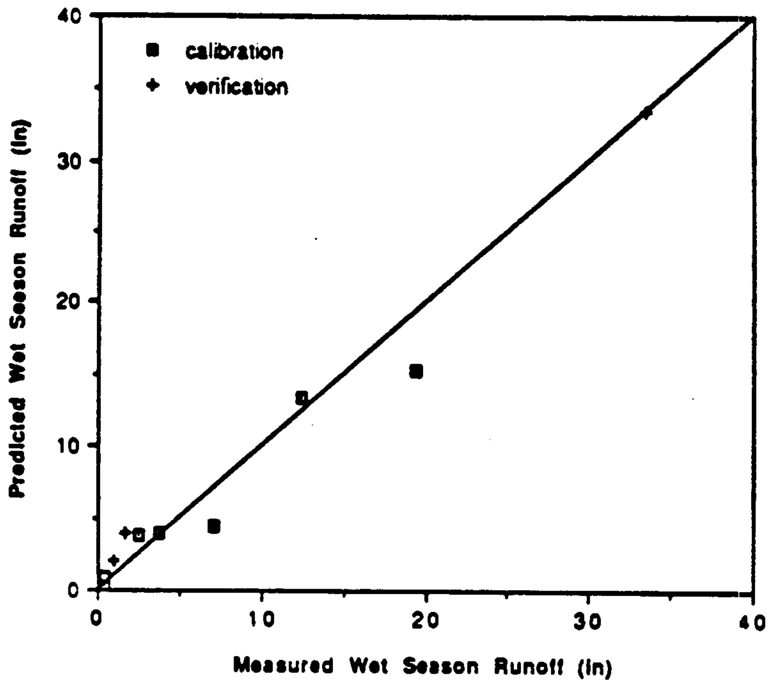

Figure B-8. Predicted versus Measured Wet Season Runoff for Saratoga Creek

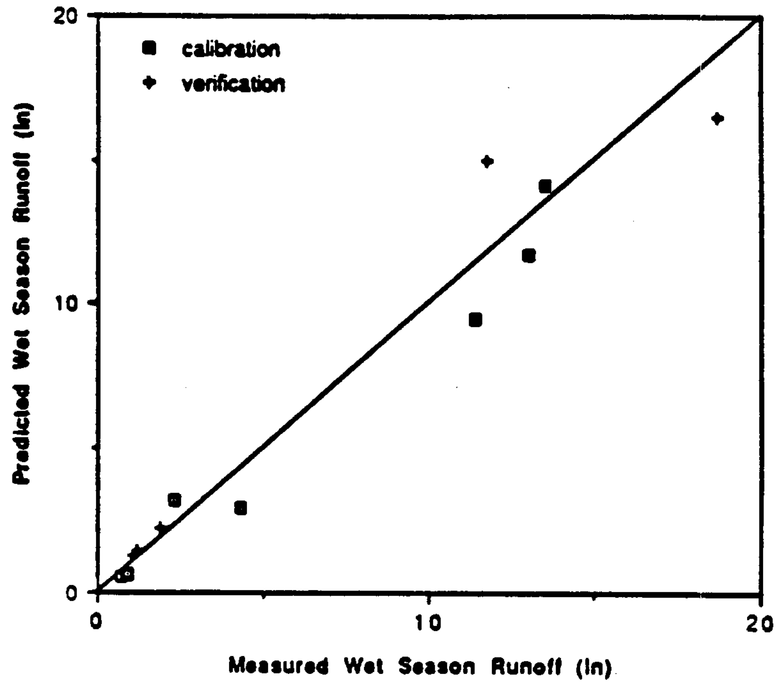

Figure B-9. Predicted versus Measured Wet Season Runoff for San Tomas Aquinas Creek

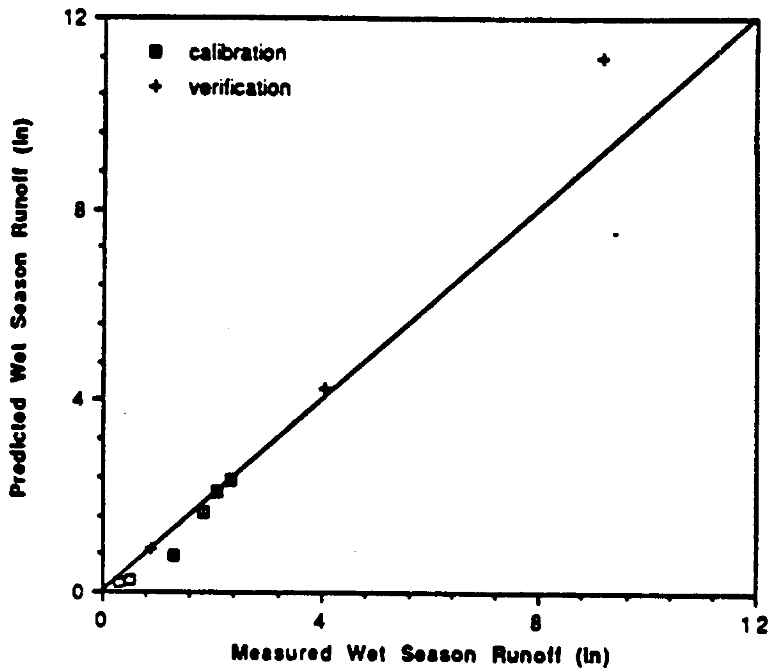

Figure B-10. Predicted versus Measured Wet Season Runoff for Berryessa Creek

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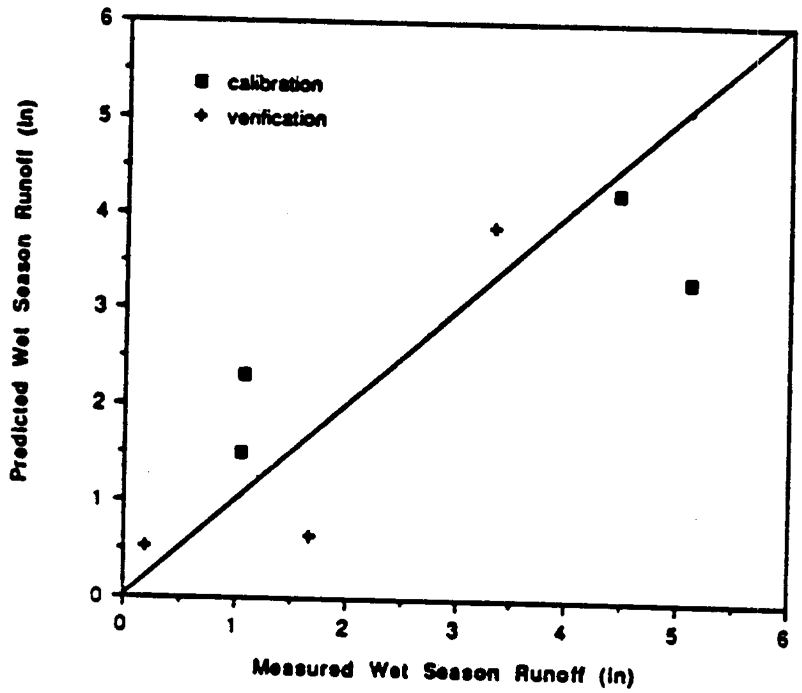

Figure B-11. Predicted versus Measured Wet Season Runoff for the Guadalupe River

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inches, so that the soil did not saturate until after the first or second major storm of the season.

B.3.4.2 Stevens Creek. Stevens Creek is in the western part of the valley, and extends from the county boundary in the Santa Cruz Mountains down to the Bay. Most of the undeveloped portion of the watershed flows into Stevens Creek Reservoir. This reservoir, while designed to store flows in the winter for release in the summer, does commonly release stormwater during wet years. Mean annual rainfall ranges from 12 inches near the Bay to 24 inches just below the reservoir, and is as high as 60 inches above Stevens Creek Reservoir.

Calibration of SWMM was performed only for the portion of the watershed below Stevens Creek Reservoir; flows out of the reservoir were represented by the record for SCVWD gage 44. Rain gage subareas were designated for SCVWD rain gages 100,48, and 121. The model was calibrated against measured flows at SCVWD gage 35, just north of the Central Expressway. To determine the amount of runoff occurring below the reservoir, flows from gage 44 (immediately below the reservoir) were subtracted from flows at gage 35. Also subtracted from the gage 35 record were diversion flows from Permanente Creek into Stevens Creek (measured by the difference between SCVWD gages 32a and 37). Calibration was limited to the period 1975 to 1983, when the diversion gage 37 was discontinued.

Figure B-6 shows the calibration results for Stevens Creek (areas downstream of Stevens Creek Reservoir). The RMSE for the combined calibration/verification period was 34 percent of the mean annual flow, and the BIAS was 1 percent. The model generally performed well, except in the 1981-82 season, when the model overpredicted runoff by about 60 percent. The predicted daily flow distribution passed the Kolmogorov-Smirnov distribution test at the 95 percent confidence level. Because the area downstream of the reservoir is mostly urbanized, the percent impervious area was the most important calibration parameter, although the Green-Ampt

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infiltration parameters were also important in modeling seasonal effects on runoff.

8.3.4.3 Sunnyvale East Channel. This watershed is a small urban area extending from the City of Cupertino down to the Bay. Mean annual rainfall in the basin ranges from 12 to 16 inches. The entire area was modeled using SCVWD rain gage 48. Calibration and verification were performed for the 1977 to 1989 record at SCVWD streamgage 74.

Calibration results are shown in Figure B-7. The RMSE in this case was 9 percent of the mean wet-season volume, while the BIAS was -1 percent. The predicted daily flow distribution passed the Kolmogorov distribution test at the 95 percent confidence level. The most important calibration parameters in this mostly urban, low rainfall catchment was the percent of impervious area; little or no seasonality was observed in runoff response to rainfall.

8.3.4.4 Saratoga Creek. Saratoga Creek extends from the county boundary in the Santa Cruz Mountains to its confluence with San Tomas Aquinas Creek. Mean annual rainfall ranges from 50 inches in the uplands to 12 inches near the Bay. For SWMM modeling, SCVWD rain gage 77 was used to represent the undeveloped upland areas, while rain gage 108 was used in the urban valley floor areas. Calibration and verification were performed on the record for SCVWD gage 25. The 1984-85 season was not included in the calibration or verification periods because the measured flow data for this year indicated an annual runoff coefficient of 0.95, which is unreasonable for a watershed which includes significant open and low-density residential areas.

Calibration and verification results for Saratoga Creek are shown in Figure B-8. The RMSE for the combined calibration/verification period was 22 percent of the mean wet-season volume, while the BIAS was .1 percent. The calibration of this watershed was complicated due to 1) the strong

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infiltration parameters were also important in modeling seasonal effects on runoff.

8.3.4.3 Sunnyvale East Channel. This watershed is a small urban area extending from the City of Cupertino down to the Bay. Mean annual rainfall in the basin ranges from 12 to 16 inches. The entire area was modeled using SCVWD rain gage 48. Calibration and verification were performed for the 1977 to 1989 record at SCVWD streamgage 74.

Calibration results are shown in Figure 8-7. The RMSE in this case was 9 percent of the mean wet-season volume, while the BIAS was -1 percent. The predicted daily flow distribution passed the Kolmogorov distribution test at the 95 percent confidence level. The most important calibration parameters in this mostly urban, low rainfall catchment was the percent of impervious area; little or no seasonality was observed in runoff response to rainfall.

8.3.4.4 Saratoga Creek. Saratoga Creek extends from the county boundary in the Santa Cruz Mountains to its confluence with San Tomas Aquinas Creek. Mean annual rainfall ranges from 50 inches in the uplands to 12 inches near the Bay. For SWMM modeling, SCVWD rain gage 77 was used to represent the undeveloped upland areas, while rain gage 108 was used in the urban valley floor areas. Calibration and verification were performed on the record for SCVWD gage 25. The 1984-85 season was not included in the calibration or verification periods because the measured flow data for this year indicated an annual runoff coefficient of 0.95, which is unreasonable for a watershed which includes significant open and low-density residential areas.

Calibration and verification results for Saratoga Creek are shown in Figure 8-8. The RMSE for the combined calibration/verification period was 22 percent of the mean wet-season volume, while the BIAS was .1 percent. The calibration of this watershed was complicated due to 1) the strong interflow recession component observed in many storms, and 2) the extremely strong response to runoff in wet years. To match observed storm response, it was necessary at times to force the model to shut off infiltration through saturation of the soil profile from below. Thus, the important model parameters were 1) the interflow recession constants, and 2) the soil and groundwater storage parameters.

B.3.4.5 San Tomas Aquinas Creek. This watershed is adjacent to Saratoga Creek and extends from the Santa Cruz Mountain foothills to its discharge point into Guadalupe Slough. Rainfall ranges from 12 to 40 inches per year on average. SCVWD rain gage 79 was used to represent the foothills and upper valley, gage 108 was used on the central valley floor, and the San Jose National Weather Service gage was used in the lower valley floor. Calibration was performed primarily at SCVWD streamgage 24, although data at SCVWD streamgage 29 were used to refine estimates of parameters in the upper portion of the catchment.

Calibration and verification results are shown in Figure B-9. The RMSE for wet-season volumes was 21 percent, while the BIAS was -2 percent. San Tomas Aquinas Creek was very similar to Saratoga Creek in terms of runoff, with storm hydrographs exhibiting a very strong interflow recession component and unusually strong response to rainfall. Again, the most important parameters were (1) interflow recession constants, and (2) soil and groundwater storage coefficients. An additional problem encountered here was the very different behavior of runoff between post-1983 and pre-1983 data. Measured flow data at gage 24 generally indicated less response to rainfall (i.e., lower runoff coefficients) after 1983, and we were unable to arrive at a calibration which could match both periods. One possible explanation for this is a change in the rating curve at gage 24 after the floods of the 1982-83 season.

B 3.4.6 Coyote Creek. This is the largest watershed in the valley, and drains the entire eastern side of the valley. Included are large

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undeveloped areas above Anderson Reservoir, Silver-Thompson Creek, Upper Penitencia Creek, and Berryessa Creek. For SWMM, Coyote Creek was modeled only between SCVWD streamgage 58 (below Anderson Reservoir) and the Bay; most of the area upstream of gage 58 either drain into reservoirs or are undeveloped areas. Storm runoff from these areas was therefore represented by the actual record for streamgage 58. The drainage area below this point is mixed urban and non-urban, with most of the non-urban areas located in the upper portions of Silver-Thompson and Upper Penitencia Creek.

The only streamgage on Coyote Creek below gage 58 is a high-flow gage which records only when stage is above 8.5 feet; the record here is consequently of limited usefulness. However, a continuous stage recorder was installed at this location for the 1988-89 sampling period as part of this study. Thus, Coyote Creek was calibrated for one year only (1988-89). This period was relatively dry, and use of the model for wetter years should be less reliable than if it had been calibrated over a variety of hydrologic conditions. The predicted wet-season volume for this period was 1 percent lower than measured. Because of the dryness of the calibration period, the most important calibration parameter was the percent of impervious area.

B.3.4.7 Berryessa Creek. The Berryessa Creek watershed is located on the eastern side of the valley on the slopes of the Diablo Range, and flows into Coyote Creek near the Bay. Rainfall in this area is much lower than in the Santa Cruz Mountains, and ranges from 14 to 20 inches on average per year. SCVWD rain gage 23 was used to model the upper parts of the catchment, and the San Jose National Weather Service gage was used to model the lower portions of the catchment. Calibration and verification were performed at SCVWD streamgage 64.

Figure B-10 show the calibration and verification results for this watershed. The overall RMSE was 29 percent of the mean annual flow, and the BIAS was 6 percent. The calibration was adequate in most years, with most of the RMSE resulting from the 2-inch overprediction of runoff in 1982-83.

B.3.4.8 Guadalupe River. The Guadalupe River is the second largest watershed in the valley, and extends from the Santa Cruz Mountains to the Bay. Major tributaries include Los Gatos Creek, Ross Creek, Calero Creek, Alamitos Creek, and Canoas Creek. Mean annual rainfall in the basin ranges from 12 inches near the Bay to about 50 inches on the Santa Cruz Mountain ridgeline. Rain gages used to model the watershed are shown in Table B-1.

The SCVWD operates an extensive reservoir and recharge system on the Guadalupe River. Most of the areas in the Santa Cruz Mountains drain into Lexington, Guadalupe, Almaden, and Calero reservoirs. Water released from Lexington Reservoir is also stored in Vasona Reservoir. For the most part, these reservoirs are designed to store runoff in the winter and release in the summer for groundwater recharge. However, during wet years the reservoirs do release significant volumes of winter storm runoff. Outflows from each reservoir are measured by stream gages located immediately below the reservoir spillways. Much of the water released by reservoirs during dry weather is diverted downstream into groundwater recharge ponds. Water can also be diverted into the watershed from Coyote Creek through the Coyote-Alamitos Canal.

Calibration and verification of SWMM on the Guadalupe River was performed using the flow record for the U.S. Geological Survey (USGS) gage immediately below the confluence with Los Gatos Creek. This gage is downstream of the recharge ponds, and represents all of the major Guadalupe tributaries. It does not measure runoff from much of the urban San Jose portion of the watershed. Calibration was performed for runoff from areas downstream of reservoirs; runoff above the reservoirs was represented in loads calculations by the actual reservoir release records. To determine the volume of runoff occurring downstream of reservoirs, reservoir releases were subtracted from the USGS gage record using the following rules:

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1) During storms, all of the water released from reservoirs reaches the USGS gage.

2) Between storms, all of the flow recorded by the USGS gage consists of reservoir releases minus diversions to recharge ponds.

These rules basically assume that released water is not diverted during storms, and that dry-weather reservoir releases are much larger than natural baseflow.

Calibration efforts on the Guadalupe River were less successful than at other watersheds, primarily because the Guadalupe River watershed is a highly managed system with numerous storage reservoirs and diversions. Because there were insufficient data to account for all of the stored and diverted water in the watershed, it was difficult to differentiate between storm runoff and water released from other sources. In several years, these data indicated storm runoff coefficients (runoff/rainfall) greater than 1.0 in February and March. As a results, SWMM was calibrated only during periods in which the measured flow data appeared to be reasonable (i.e., had reasonable runoff coefficients). Even focusing on these periods, the calibration/verification resulted in a wet-season RMSE of 40 percent and a BIAS of -2 percent. Calibration and verification results are plotted on Figure B-11. The predicted daily flow distribution passed the Kolmogorov-Smirnov test at the 95 percent confidence level. This calibration could have been improved by using parameter values which were completely inconsistent with those used in other basins. For instance, to match observed dry year totals (when all runoff is from impervious areas), the model would require percent impervious areas ranging from 1 to 20 percent in urban areas. In other simiiar basins, this parameter generally ranged from 10 to 80 percent. Given the mass balance problems observed in the measured flow data, the final calibration was determined using the best combination of parameters that was consistent with values used on Calabazas, Saratoga, San Tomas Aquinas, and Stevens Creek.

B.3.4.9 Comparisons of Predictions with Observed Flows for Selected Storms. An important component of any calibration is visual comparison of predicted hydrographs with measured hydrographs. Analysis of calibration statistics alone is not sufficient; visual comparison must also be made to ensure that the model predictions are consistent with our understanding of the relevant physical processes. In this section, selected predicted and measured hydrographs are presented to give the reader some idea of how well we were able to simulate storm hydrographs.

Figures B-12, B-13, and B-14 are examples of the range of hydrograph comparisons we were able to obtain. Figure B-12 shows the measured and predicted daily average flows for February 1980 storms in Calabazas Creek, and is an example of an excellent match between the model and the observed flows. Both the peak and storm recession are accurately predicted by the model. Figure B-13 illustrates a poor match between predicted and observed flows for a December 1977 storm on San Tomas Aquinas Creek. In this case, the model significantly overpredicted the peak flow rate and total storm volume. Figure B-14 shows a perhaps more typical hydrograph comparison for a March 1979 storm on San Tomas Aquinas Creek. Here, the model overpredicts the peak flow rate by about 20 percent, but is able to accurately simulate the total storm volume.

B.4 WATERSHED RUNOFF PREDICTIONS

The goal of the SWMM calibration discussed in the previous section was to produce a model which could 1) estimate runoff in ungaged areas, and 2) estimate the contributions of various land uses to runoff. This section summarizes storm runoff predictions for the Santa Clara Valley. These predictions were made for all watersheds for water years 1977-78 through 1988-89, the period for which rainfall data are available for all catchments.

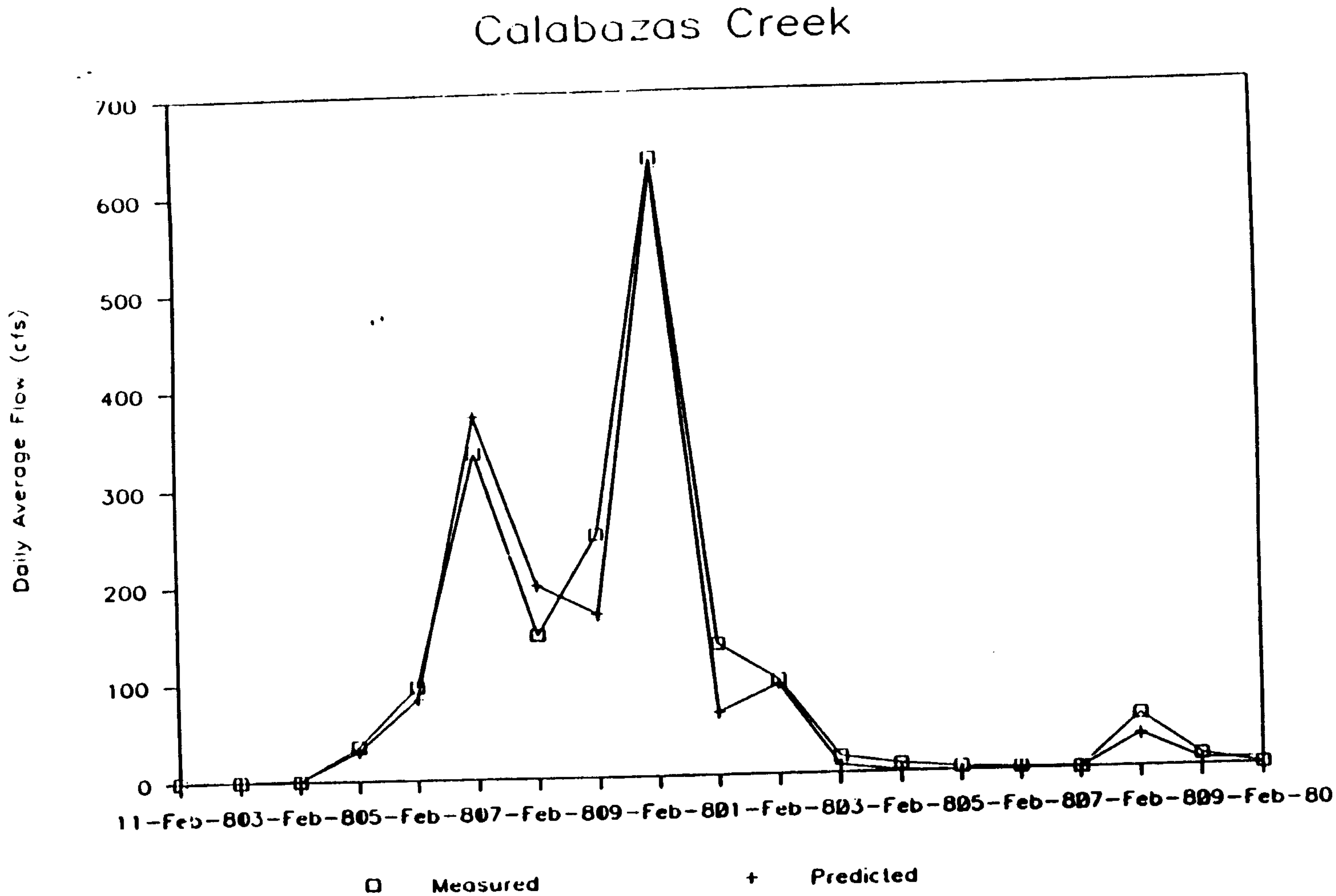

Figure B-12. Comparison of Predicted and Measured Hydrographs for Calabazas Creek, February 1980

San Tomas Aquinas Creek

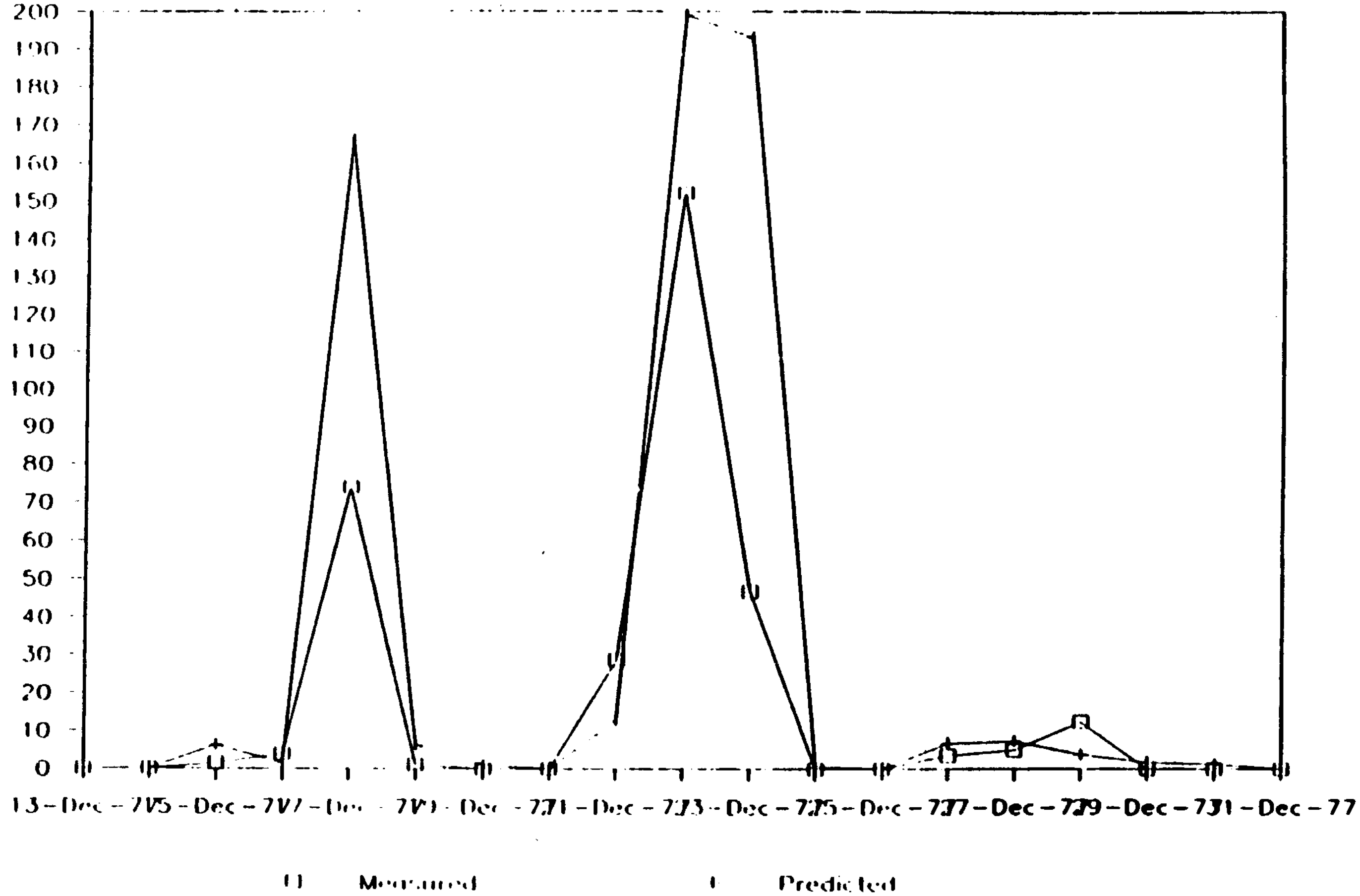

Figure B-13. Comparison of Predicted and Measured Hydrographs for San Tomas Aquinas Creek, December 1977

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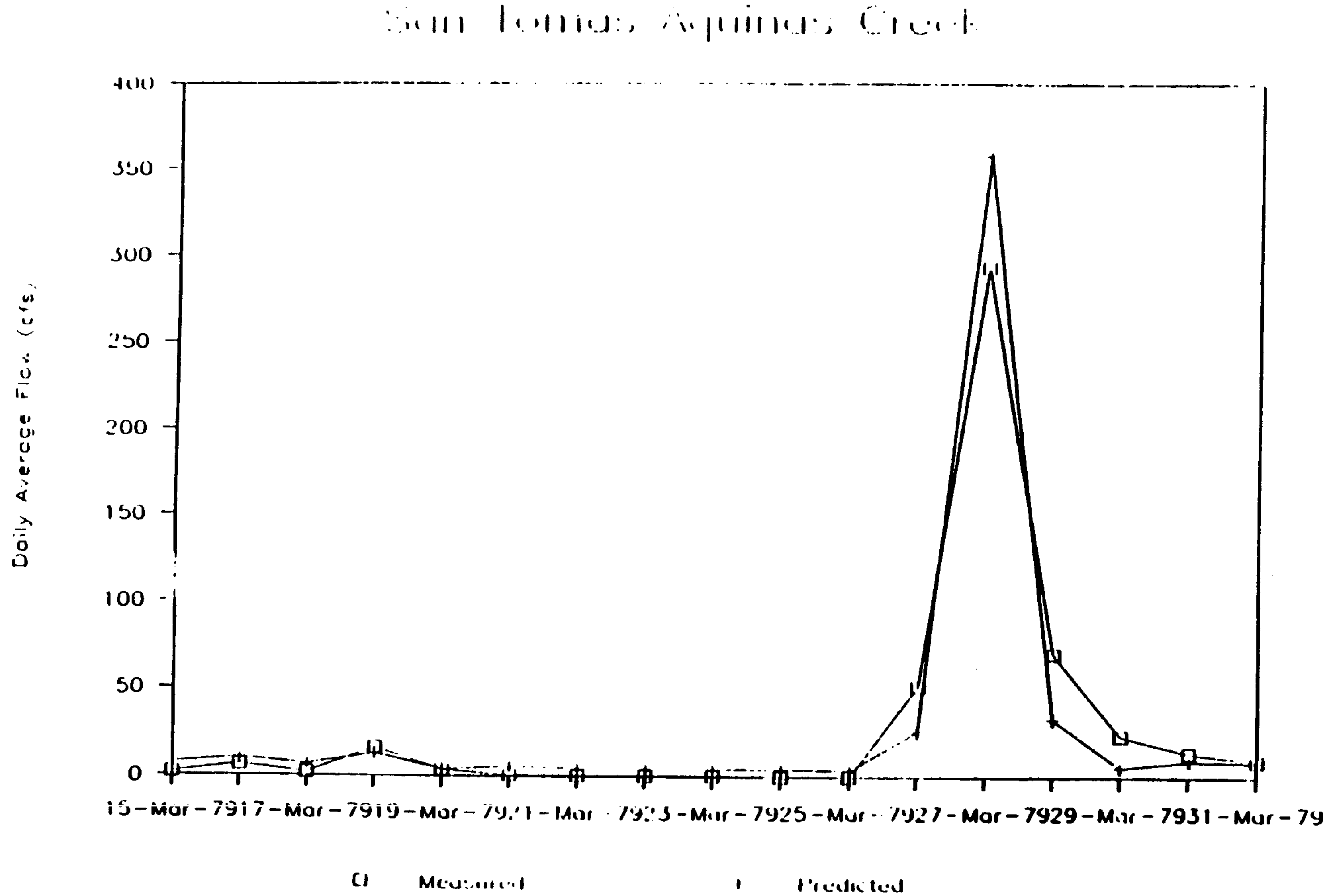

Figure B-14. Comparison of Predicted and Measured Hydrographs for San Tomas Aquinas Creek, March 1979

SWMM was used to predict runoff in three types of areas:

1) Areas for which the model was calibrated against measured streamflow data

2) Areas in calibrated watersheds that are downstream of the calibration gage

3) Watersheds for which no flow data are available for calibration

For areas in which the model was calibrated, flow predictions were made by simply running the calibrated version of the model for the projection period. To account for model errors in calibration/verification years, the predicted flows for each land use were then multiplied by the ratio of wet-season measured runoff to predicted runoff for that year. This correction scaled the predicted flows to match measured totals exactly, and assumed that the correction factor was the same for all land uses.

For watersheds with streamflow data for calibration, there were usually uncalibrated urban areas in the lower portions of the watersheds. This applies to the following watersheds: Coyote Creek, Guadalupe River, Calabazas Creek, Saratoga Creek, San Tomas Aquinas Creek, Sunnyvale East Channel, and Stevens Creek. Because Sunnyvale East Channel best represents typical northern valley urban areas, parameters calibrated for this watershed were used in other uncalibrated urban areas. Soils parameters were estimated based on soil type and calibration in areas with similar soils.

Most of the western portion of the valley has little or no flow data for calibration. This includes Permanente Creek, Adobe, Matadero, and Barron creeks, and Sunnyvale West Channel. In addition, as only the portion of the San Francisquito Creek watershed in Santa Clara County was modeled, flow data could not be used for calibration. In these areas, parameters were estimated from similar calibrated watersheds. In urban

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areas on the lower valley floor, parameters were estimated based on the calibration for Sunnyvale East Channel. In areas on the upper valley floor, parameters were estimated from the calibrations for Stevens Creek and Calabazas Creek. Finally, in upland areas calibration results for Stevens, Calabazas, and San Tomas Aquinas creeks were used to estimate parameters.

Table 8-9 summarizes the predicted annual storm runoff volumes for each watershed in the valley. As would be expected based on the relative drainage areas, 50 percent of storm runoff on average comes from Coyote Creek and the Guadalupe River. The highest runoff volume occurred during the 1982-83 season, while the lowest occurred in the 1988-89 season.

8.5 DETERMINISTIC WATER QUALITY MODELING OF CALABAZAS CREEK

As described in Section 8, loads in this study were derived as the product of annual runoff volume (from SWMM modeling) and annual mean concentration for each constituent and land use. These mean concentrations were obtained from statistical analysis of the water quality data collected at the land use and stream sampling stations. An alternative approach to estimate loads is to use the semi-empirical buildup-washoff models included in SWMM to predict runoff water quality. While these models are highly empirical and largely unverified, they do attempt to represent a number of the physical processes that are thought to determine runoff water quality. To compare this approach to the statistical mean concentration approach used in this study, the SWMM buildup washoff model was applied to estimate annual load from the Calabazas Creek watershed. A description of the model, calibration results, and predicted loads are provided in this section, as well as a comparison of the buildup-washoff load predictions to those derived from the statistical mean concentration model.

8.5.1 Model Description

The SWMM runoff water quality model is based on the concept of pollutant buildup and washoff. The concept behind this model is that a

Table B-9. Storm Runoff Predictions for the Study Area

TOTAL WET WEATHER FLOWS (ac-ft)

Year	Coyote	Guadalupe	San Tomas	Saratoga	Calabazas	Sunnyvale East	Sunnyvale West	Stevens	Permanante	ABM	San Francisquito	Total
77-78	15255	47158	14145	5110	9652	2192	1746	1632	5986	9357	1834	114066
78-79	11374	7431	5058	1630	3800	1160	1011	1204	1443	4082	755	39008
79-80	22384	26979	12414	6922	8136	2191	1510	1979	6685	9352	1973	100523
80-81	6089	6946	3646	1408	2297	925	694	676	982	2967	330	26960
81-82	16827	46421	14022	10786	9539	2526	2038	1645	9066	11845	2634	127348
82-83	42636	97976	20866	21380	15557	3698	2874	4787	17934	17617	3801	249125
83-84	8054	6372	4893	3483	4282	1190	1003	896	832	4441	992	36439
84-85	6609	8927	2539	814	2044	1383	1011	845	1176	3407	655	29411
85-86	18857	78009	12902	13197	8308	2792	1980	2167	8972	11678	1599	160462
86-87	5400	5709	1584	704	1856	689	577	445	452	3303	1521	22238
87-88	6799	8625	2141	977	2138	828	783	652	722	2317	366	26348
88-89	3507	1287	1877	506	1154	553	613	456	347	1293	200	11792
Average	13649	28492	8007	5577	5730	1677	1320	1449	4550	6805	1388	78643

TOTAL WET WEATHER FLOWS (%)

Year	Coyote	Guadalupe	San Tomas	Saratoga	Calabazas	Sunnyvale East	Sunnyvale West	Stevens	Permanante	ABM	San Francisquito	Total
77-78	13.4	41.3	12.4	4.5	8.5	1.9	1.5	1.4	5.2	8.2	1.6	100
78-79	29.2	19.2	13.0	4.2	9.7	3.0	2.6	3.1	3.7	10.5	1.9	100
79-80	22.3	26.8	12.3	6.9	8.1	2.2	1.5	2.0	6.6	9.3	2.0	100
80-81	22.6	25.8	13.5	5.2	8.5	3.4	2.6	2.5	3.6	11.0	1.2	100
81-82	13.2	36.5	11.0	8.5	7.5	2.0	1.6	1.3	7.1	9.3	2.1	100
82-83	17.1	39.3	8.4	8.6	6.2	1.5	1.2	1.9	7.2	7.1	1.5	100
83-84	22.1	17.5	13.4	9.6	11.8	3.3	2.8	2.5	2.3	12.2	2.7	100
84-85	22.5	30.4	8.6	2.8	6.9	4.7	3.4	2.9	4.0	11.6	2.2	100
85-86	11.8	48.6	8.0	8.2	5.2	1.7	1.2	1.4	5.6	7.3	1.0	100
86-87	24.3	25.7	7.1	3.2	8.3	3.1	2.6	2.0	2.0	14.9	6.8	100
87-88	25.8	32.7	8.1	3.7	8.1	3.1	3.0	2.5	2.7	8.8	1.4	100
88-89	29.7	10.9	15.9	4.3	9.8	4.7	5.2	3.9	2.9	11.0	1.7	100
Average (%)	21.2	29.6	11.0	5.8	8.2	2.9	2.4	2.3	4.4	10.1	2.2	100

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supply of constituents builds up on the land surface during dry periods and is subsequently washed off during a storm. Pollutant buildup is assumed to occur as a function of time between storms. During a storm, washoff is assumed to occur as a function of the available mass of pollutants on the land surface and the rate of runoff. While the buildup-washoff concept does explain some of the mechanisms thought to produce runoff water quality, the model itself is highly empirical and requires substantial calibration to produce reasonable results.

Many studies have been conducted to determine rates of buildup on city streets. Sartor and Boyd (1972), among others, found that buildup appears to be non-linear, developing rapidly at first and then leveling off to a limit. This form of buildup is implemented in SWMM using an exponential buildup function:

$$P_{Shed} = P_{lim}*(1-\exp(-K_b*t)) \qquad (8\text{-}7)$$

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where

P_{Shed} = mass of constituent in watershed at time t (lbs/acre)
P_{lim} = upper limit on constituent mass that can accumulate (lbs/acre)
K_b = buildup rate constant ($days^{-1}$)
t = time between storms (days)

Washoff is the process that mobilizes the accumulated constituents into runoff and streamflow. In stream channels and other areas of significant flow, this process is described by sediment transport theory, where flow rate and bottom shear stress are important factors. For thin overland flows (sheet flows) common during storms in urban environments, rainfall energy can also mobilize particles. Therefore, more intense storms are able to washoff more of a constituent than a less intense storm. Whatever mechanisms are involved, it is obvious that as rainfall and washoff continue the amount of constituen. remaining in the watershed diminishes.

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This observation, combined with the results of several empirical studies leads to the washoff formula used in SWMM:

$$Poff(t) = K_w * r^c * P_{shed} \qquad (B-8)$$

where

Poff = amount washed off at time t (lbs/acre)
K_w = washoff coefficient
r = runoff rate (in/hr)
c = empirical washoff exponent

Thus, the model has four input parameters: the limiting buildup rate (P_{lim}), the buildup rate constant (K_b), the washoff coefficient (K_w), and the washoff exponent (c). The buildup limit sets an upper limit on the availability of the constituents, and has a linear effect on the total mass load. The buildup rate constant sets the time scale of buildup between storms and thus attempts to capture the effects of "antecedent conditions." It can therefore be used to match observed water quality variations between sequential storm events. The washoff coefficient has a linear effect on the total mass that washes off during a storm. The washoff exponent primarily controls how load varies with time during a storm.

B.5.2 Model Calibration

None of the buildup-washoff model parameters can be measured directly, and all must be estimated by calibrating the model against measured water quality data. Few data on initial estimates of the buildup parameters are available in the literature for the types of constituents of concern in this study, although there are data on buildup rates of "dust and dirt" on parking lots and streets. The SWMM manual suggests an initial estimate of the washoff coefficient K_w of 4.6 in_{-1}, although other studies have used values ranging from .052 to 6.6 in_{-1}. The washoff exponent is suggested to range from 1.0 to 2.0, with a median value of 1.5.

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8.5.2.1 Data Used for Calibration. The buildup washoff model was calibrated against water quality data collected at the Calabazas Creek monitoring station (S1) for five storms in the 1988-89 season. The available water quality data consisted of Event Mean Concentrations (EMCs) derived from composite samples; no data on the time-dependence of concentrations within a storm were available. Three constituents, Total Suspended Solids (TSS), copper and lead, were chosen for this test of the water quality model portion of SWMM. Measured EMCs used in calibration are listed in Table B-10.

8.5.2.2 Calibration Methods. The goal of calibration was to match to the extent possible the observed EMCs for the five storms for each constituent. Calibration was performed by systematically changing the values of the four buildup washoff parameters to minimize the difference between the simulated and observed EMCs. A number of parameters were used to measure the accuracy of the calibration. The root mean square error (RMSE) of predicted vs. observed EMCs was used to quantify the magnitude of model calibration errors. This was reported as a percentage of the mean measured concentration. The BIAS, or sum of errors, was used to indicate if the model was systematically under or overpredicting EMCs. To verify that the model was reproducing the statistics of the measured data, the predicted mean and coefficient of variation of the EMCs for the five storms were compared to the mean and coefficient of variation of the observed data. Finally, the data for each storm were tabulated and plotted as a function of time to verify whether or not the model was reproducing the observed trends in the data.

8.5.2.3 Calibration Results. Table B-10 compares the calibrated model to the measured data, and lists the calibration statistics for each constituent. Final calibrated values of the model input parameters are shown in Table B-11. RMSEs for the calibrations ranged from 19 percent for copper to 25 percent for TSS, and were relatively unbiased. The model was able to accurately reproduce the means of the observed data, but consistently underestimated the coefficient of variation of the data.

Table B-10. MEASURED AND CALIBRATED EMCs

STORM	TSS mg/l Measured	TSS mg/l Calib.	Copper ug/l Measured	Copper ug/l Calib.	Lead ug/l Measured	Lead ug/l Calib.
11/23/89	360	230	95	67	99	92
2/3/90	34	170	30	50	60	68
2/8/90	63	186	31	55	36	74
3/2/90	180	192	44	56	5	77
3/23/90	205	116	58	34	80	47
Mean	195	180	53	53	80	72
CV	1.22	0.26	0.51	0.26	1.80	0.26
% RMSE		25		19		22
% BIAS		18		9		28

CV = Coefficient of Variation

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Table B-11. CALIBRATED VALUES OF WATER QUALITY MODEL INPUT PARAMETERS

Constituent	Plim	Kb	Kw	a
TSS	82000	0.04	2.3	1.3
Copper	24	0.04	2.3	1.3
Lead	33	0.04	2.3	1.3

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Figure B-15 compares the predicted and observed EMCs as a function of time for Copper. The model was able to reproduce the relatively high concentrations observed in the first November storm, but was unable to simulate the low concentrations found in the January and February storms. Much of the rainfall in 1988-89 occurred in the last week of December 1988, and the low concentrations observed in January may be a result of heavy washoff of constituents from street surfaces in December. However, the model did not reproduce this effect. The model also could not reproduce the rapid drop in concentration that was measured in the second of the two March storms. Overall, although the model was on average able to match observed concentrations with an RMSE of about 20 percent, it was not particularly successful at matching the observed sequence and timing of storm concentrations.

B.5.3 Comparison of Annual Load Estimates for Deterministic and Constant Concentration Water Quality Models

The calibrated water quality model was used to estimate annual loads for the 12 year simulation period (water years 1977-78 to 1988-89). Table B-12 compares these results to the annual load predictions obtained from the statistical mean concentration model. In dry years such as the 1988-89 calibration period the two models give comparable estimates of annual load. However, the deterministic water quality model predicts loads that are 2-3 times lower in wet years such as 1982-83. Overall, the deterministic water quality model predicts significantly lower concentrations than does the mean concentration model.

The reasons behind this difference between the two methods lie primarily in the assumptions behind the buildup-washoff model. During wet years, the buildup-washoff model assumes that the increased number of storms will reduce the mass of pollutant available on the street surfaces for washoff. Thus, although flow volumes may be an order of magnitude higher in wet years than in dry years, predicted concentrations in runoff are lower due to this source limitation effect. On the other hand, the

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Figure B-15. Observed vs. Predicted Concentrations for Copper

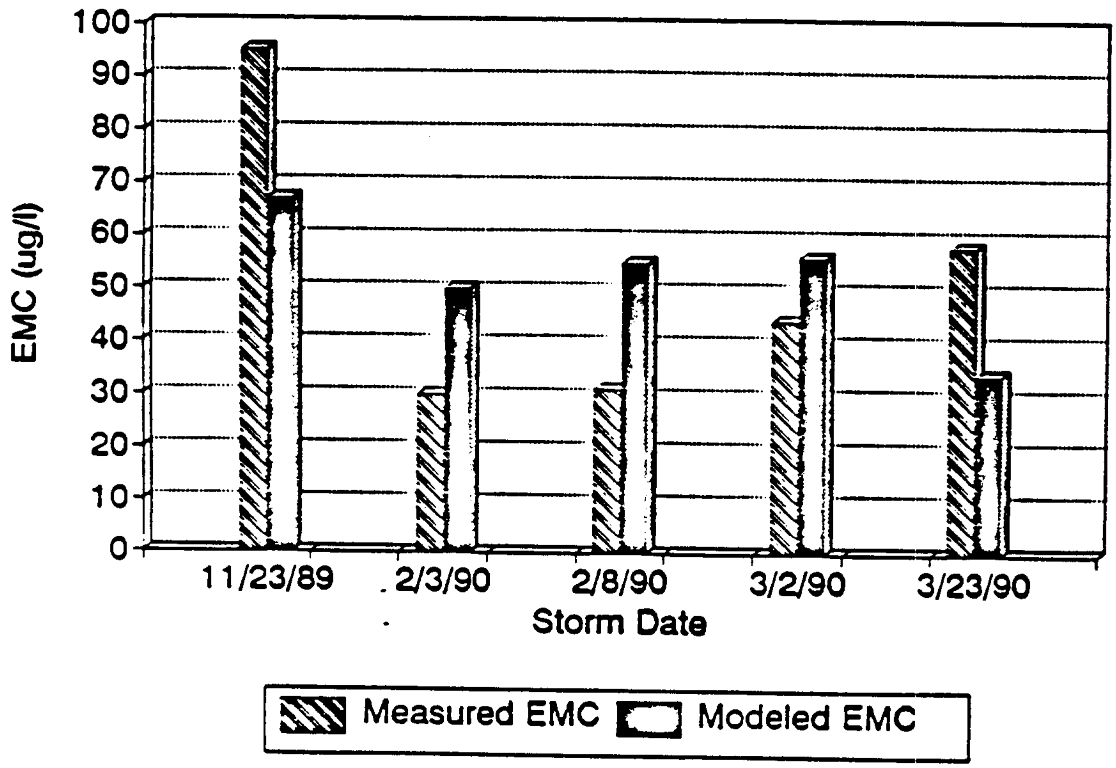

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Table B-12. COMPARISON OF ESTIMATED LOADS FOR CALABAZAS CREEK

WATER YEAR	TSS Buildup-Washoff	TSS Mean Conc.	COPPER Buildup-Washoff	COPPER Mean Conc.	LEAD Buildup-Washoff	LEAD Mean Conc.
	LOAD IN POUNDS					
1978	2,000,000	7,400,000	559	1,798	798	1,791
1979	1,210,000	2,900,000	338	700	483	696
1980	1,980,000	6,200,000	555	1,485	793	1,475
1981	1,180,000	1,800,000	330	422	472	420
1982	2,860,000	7,300,000	800	1,760	1,140	1,751
1983	2,980,000	11,900,000	834	2,850	1,190	2,831
1984	1,460,000	3,300,000	407	797	582	794
1985	1,260,000	1,600,000	352	405	503	407
1986	1,980,000	6,300,000	554	1,601	791	1,604
1987	724,000	1,400,000	203	375	289	378
1988	1,060,000	1,600,000	296	426	423	428
1989	580,000	870,000	162	238	232	240
Mean	1,630,000	4,380,833	457	1,071	652	1,068
Mean w/o 1982-83	1,481,273	3,697,273	414	910	591	908

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mean concentration method assumes no difference in average water quality between wet and dry years. There is of course no direct evidence that the "dilution" effect predicted by the buildup-washoff model actually occurs. In this study, little or no correlation was found between the time between storms and runoff concentration, implying that the number of storms in a year should have little effect on water quality concentrations.

In summary, the deterministic water quality model predicts significantly lower loads and concentrations in wet years. The model does account for a number of mechanisms that one would intuitively believe to occur during and between storms. However, the model requires substantial calibration, and was not able to accurately simulate observed patterns in water quality during the 1988-89 monitoring period. The mean concentration model used in loads estimation in the remainder of this study makes direct use of the observed water quality data, and requires little calibration. The mean concentration model, however, is unable to account for possible differences in water quality during wet and dry years. Currently, there are no data available to determine which (if either) of these models is best able to simulate water quality in wet years.

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APPENDIX C

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APPENDIX C
SUMMARY OF LABORATORY QA/QC

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APPENDIX C
SUMMARY OF LABORATORY QA/QC

Evaluation of the quality of the analytical data included:

1) Precision of laboratory duplicates (Table C.1)
2) Precision of field duplicates (Table C.2)
3) Precision of matrix spike and matrix spike duplicate recoveries (Table C.3)
4) Potential contamination of field and laboratory (method or reagent) blanks (Table C.4)
5) Laboratories performance on Environmental Resources Associates (ERA) quality control samples (Table C.5)

C.1 WATER SAMPLES

C.1.1 Laboratory Duplicates

Laboratory duplicates were routinely performed by the laboratory for a reduced suite of parameters. The only exception was for dry-weather 3 (May 12, 1989) and wet-weather 1 sampling events (May 5, 1989), where laboratory duplicate analyses were not generated. Results of laboratory duplicate analyses are presented in Tables C.1-1 to C.1-12. The precision of the laboratory duplicates is an indication of the variability in the extraction and analytical procedures in the laboratory. This precision is commonly expressed as a relative percent difference (RPD). The RPD was calculated by the following equation:

$$|Conc\ (A) - Conc\ (B)| / \{[Conc\ (A) + Conc\ (B)]/2\}$$

where

Conc (A) = Concentration of primary duplicate sample

Conc (B) = Concentration of secondary duplicate sample

|Conc (A) - Conc (B)| = Difference between concentrations of primary and secondary duplicates expressed as absolute values

For the dry-weather sampling events 1, 2, 4, 5, 6, and 7, the RPD ranged from 0 to 29%, with a mean value of 6%. The RPDs for all wet-weather sampling events (2 to 7) were between 0 to 40% (mean of 16%), with the exception of two elevated RPDs for lead (55%) and mercury (100%) analyses for wet-weather 2 duplicate samples. Thus the reported RPDs for both dry and wet-weather samples are considered to be within laboratory acceptable limits.

C.1.2 Field Duplicates

Results of field duplicate samples are an indication of overall field variability, precision of field sampling and laboratory analyses. As such, the results of field duplicates have more variability than laboratory duplicates, which measure only laboratory performance. Field duplicate samples were collected and analyzed for a reduced parameter suite for all dry and wet-weather sampling events, with the exception of wet-weather 1 (May 5, 1989). The results of field duplicate analyses are presented in Tables C.2-1 to C.2-13. For all dry-weather field duplicate samples, the RPD ranged from 0 to 100%, with a mean of 23%. The RPD ranged from 0 to 94% for all wet-weather field duplicate samples; the mean value was 31%. These mean field duplicate RPDs are higher than the laboratory duplicate RPDs by about a factor of two to three, and likely represent the additional variability from field sampling.

C.1.3 Matrix Spike and Matrix Spike Duplicates

Matrix spike (MS) and matrix spike duplicate (MSD) recovery data are performed to evaluate accuracy and precision of each individual analytical method. The results of MS and MSD recoveries and also the RPD of these matrix spikes are summarized in Tables C.3-1 to C.3-10. Matrix spike recoveries for specific compounds analyzed under each method evaluated in this program were within acceptable limits according to the current EPA guidance for laboratory analyses (EPA, Test Methods for Evaluating Solid Waste, SW846, Third Edition). The RPD between MS and MSD recoveries were generally less than 30%, and therefore considered to be within EPA acceptable limits.

C.1.4 Laboratory (Method or Reagent) and Field Blanks

The purpose of laboratory and field blank analysis is to detect potential contamination from the laboratory and/or field sampling. All laboratory method blanks and field blanks were generally free of contaminants, with the exception of the detections of some organic compounds and metals.

C.1.4.1 Metals. It is important to note that the collection of field blanks in this sampling program was different for the dry- and wet-weather sampling events. Field blanks were obtained using procedures identical to those for collection of field samples. Dry-weather samples were collected by dipping sample containers in the sampling stream. Correspondingly, field blanks were collected by pouring laboratory reagent water (Milli-Q purified) into sample containers at each sampling station. Wet-weather composite samples were collected in the ISCO samplers in 10-liter borosilicate bottles, which were then taken to the laboratory. In the laboratory, a peristaltic pump with Teflon hose was used to fill individual sample bottles required for the various analyses (e.g., metals, pesticides, etc.). The Teflon hose was flushed with laboratory reagent water every time a new 10-liter sample bottle from each of the sampling stations was to be drained. At the end of this process, the Teflon hose was flushed and then laboratory reagent water was used to fill sample bottles for the blank analysis. This method of blank collection is commonly known as an

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equipment blank. Hereinafter, all "field blanks" collected in the wet-weather period will be referred to as equipment blanks.

For the dry-weather samples, field blanks showed low levels of zinc contamination in dry-weather 4 (0.011 mg/L), dry-weather 5 (0.014 mg/L), dry-weather 6 (0.010 mg/L), and dry-weather 7 (0.006 mg/L). These levels of zinc were generally equal to or lower than the actual zinc levels found in the stream samples (Stations S1 to S4). No zinc contamination was found in the method blank analyses for the above-listed dry-weather sampling rounds. Because the method blanks were free of contamination, the source of the zinc contamination in the field blank is not the laboratory reagent water or the acid-preservative.

In addition, mercury and lead were detected at 0.0003 mg/L and 0.003 mg/L in dry-weather 4 and 6, respectively. The impact of mercury and lead contamination on the actual concentrations found in water samples is minimal because of the following reasons:

1) Mercury and lead were not detected in method blanks.

2) Mercury and lead concentrations in the field blank are close to the detection limit of 0.0001 mg/L and 0.001 mg/L, respectively.

3) Mercury levels detected in actual water samples are about 10 times higher than those found in the field blank.

4) Lead was not detected in actual water samples except for a lead concentration of 0.004 mg/L detected in one stream sample.

For the wet-weather samples, low levels of some metals were detected in the equipment blanks from wet-weather 2 (Table C.4-8), wet-weather 3 (Table C.4-10), wet-weather 5 (Table C.4-12), and wet-weather 7 (Table C.4-14). The source of contamination is potentially from carryover of residual metals found in the hose used with the peristaltic pump. The concentrations found in the actual water samples were not corrected for these metal contaminants because all method blanks were generally free of metal contamination for the above-listed wet-weather sampling events with the exception of wet-weather 2, in which cadmium was detected in the method blank at the detection limit of 0.0002 mg/L.

For wet-weather 6, five metals--chromium (0.052 mg/L), copper (0.011 mg/L), lead (0.001 mg/L), nickel (0.06 mg/L), and zinc (0.018 mg/L)--were detected in the equipment blank. The source of these elevated metals is probably from the laboratory water. Because the Milli-Q purification system was broken during this sampling event, laboratory water was obtained from the solar still, which probably contained the elevated metals. Although the equipment blank was contaminated, the metals results for the actual water samples should not be affected because the samples did not come in contact with the solar still water except perhaps for a very small volume that may have adhered to the tubing from the flushing operation. The method blank analysis generally did not detect any metals concentrations that were comparable to those found in the equipment blank. For wet-weather 6, the only metal detected above the detection limit in the method blank was chromium. Chromium was detected at 0.002 mg/L in the first method blank and at a lower level of 0.001 mg/L in the second method blank.

C.1.4.2 Organics. Two volatile organics, methylene chloride and acetone, were detected in method blanks. Methylene chloride was detected at 6, 11, and 7 μg/L in method blanks for dry-weather 1 and 2, and wet-weather 1, respectively. Acetone was detected twice at 27 and 20 μg/L for dry-weather 2 and wet-weather 1, respectively. These volatile organics are commonly used solvents in the laboratory for sample extractions. Therefore, the detections of methylene chloride and acetone in storm runoff samples during dry-weather 1 and 2, and wet-weather 2, are suspect and most probably due to laboratory contamination.

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A semi-volatile organic, bis(2-ethylhexyl)phthalate (BEHP), was detected in method blanks from dry-weather 1 and 2, and wet-weather 1 and 2. The concentrations of BEHP ranged from 11 to 800 µg/L. The presence of BEHP is common in plastic material such as gloves and tubing. According to the current guidance from EPA on evaluation of phthalate data (EPA 1988), phthalates are common laboratory contaminants at levels of less than 100 µg/L. Based on evidence of BEHP contamination in the laboratory and EPA's current position on phthalate compounds, the detections of BEHP in storm runoff samples from L1, L2, and L6 are therefore suspect and most probably due to laboratory contamination.

A detection of 4,4'-DDE at 0.077 µg/L was found in a field blank from wet-weather 3. Since this organochlorine compound, 4,4'-DDE, was not detected in any of the storm runoff samples for wet-weather 3, this one-time detection of 4,4'-DDE in a field blank is likely due to field or laboratory contamination, and does not impact the results of organochlorine analyses of water samples collected from wet-weather 3.

C.2 SEDIMENT SAMPLES

Results of QC analyses for sediment samples are presented in Tables C.1-13, C.2-14 to C.2-16, and C.3-11 to C.3-14. Generally, the RPDs for laboratory and field duplicates were similar to those reported for the water samples. Matrix spike recoveries and RPDs of these matrix spike recoveries were also within acceptable limits.

As with the water samples, BEHP was detected in method blanks in the second and third sampling rounds. BEHP concentrations ranged from 940 to 2400 µg/kg The ubiquitous presence of BEHP in both laboratory and field environments is discussed earlier in Section C.1.4. Detections of BEHP in actual sediment samples from sampling events 2 and 3 are therefore suspect and likely due to laboratory artifacts.

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C.3 EXTERNAL REFERENCE SAMPLES

External reference samples were submitted to the laboratories by the Project Quality Control Officer. These samples were supplied by Environmental Resource Associates (ERA), Arvada, Colorado, with certified analyses of target parameters. External reference samples were selected by the project quality control officer to match specific method analyses, expected concentration ranges, and sample matrices as closely as possible. The analytical results supplied with the reference samples were not disclosed to the individual laboratories. Samples were submitted a total of five times on a quarterly basis throughout the study. A summary of the results of comparisons between laboratory performance and ERA results for selected constituents is presented in Table C.5.1. Results of each quarter are presented in Tables C.5.2 through C.5.6.

C.3.1 First Quarter ERA Quality Control Samples, 1988

All laboratory reported concentrations were within the advisory ranges of the external reference samples except for arsenic, semi-volatiles (1,2,3-trichlorobenzene), and pesticides (gamma-BHC and PCBs, Aroclor 1242). The advisory range is the range of values that an experienced laboratory can expect to attain using the most precise methods and equipment. In determining advisory ranges, ERA considers both the parameter and the most commonly used method of analysis for the parameter. The arsenic value was outside the advisory range, but was determined to be an acceptable level of performance by the individual laboratory. True and advisory values for ERA organic quality control samples (volatiles, semi-volatiles, pesticides and PCBs, and herbicides) are based on analytical results from applicable EPA reference methods. True values represent 100% recoveries for the analyses. Since many organic analytical methods do not yield 100% recoveries, ERA advisory ranges reflect typical recoveries from water samples for the applicable EPA methodologies. The semi-volatile and pesticides and PCBs values were within an acceptable level of performance by the laboratory.

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C.3.2 Second Quarter ERA Quality Control Samples

Laboratory reported values were within the advisory ranges except for the conventional constituents (BOD and TKN), and organic quality control samples such as volatiles (chloroform) and semi-volatiles (acenaphthene, benzo(a)pyrene, 2-chloronaphthalene, 1,3-dichlorobenzene and hexachlorobutadiene). The conventional constituent values were within acceptable levels of performance. The organic sample values were low due to laboratory contamination problems experienced during sample preparation.

C.3.3 Third Quarter ERA Quality Control Samples

Laboratory reported values outside the advisory ranges were for conventional constituents (TKN, ammonia, and phosphate) and organic quality control samples including:

1) Semi-volatiles (hexachloroethane, 1,2,4-trichlorobenzene, 2-chloronaphthalene, acenaphthylene)
2) Pesticides (aldrin and heptachlor epoxide)
3) PCBs (Aroclor 1242)

The pesticides and PCBs true values were near or below the detection limits for the laboratory, which caused recovery values to be unattainable by the laboratory.

C.3.4 Fourth Quarter ERA Quality Control Samples

Laboratory reported values were within the advisory ranges except for trace metals (arsenic, mercury, selenium, and silver), conventional constituents (ammonia, nitrate, phosphate), and organic quality control samples including semi-volatiles (1,4-dichlorobenzene and bis(2-chloroisopropyl)ether), PCBs (Aroclor 1221), and herbicides (2,4-D and 2,4,5-TP). The true values for PCBs and herbicides were below the detection limits for the laboratory and recovery values were unattainable. The herbicides ERA sample was no longer analyzed because the concentration levels of the analyte were always below laboratory detection limits. Due to complications during sample preparation for the metals analysis, low recoveries were reported by the laboratory. The conventional constituent values were acceptable levels of performance.

C.3.5 First Quarter ERA Quality Control Samples, 1989

Laboratory reported values were within the advisory ranges except for trace metals (lead and cadmium), and the organic quality control samples: pesticides (endrin aldehyde) and PCBs (Aroclor 1221). The concentration of endrin aldehyde and Aroclor 1221 were below the laboratory detection limits. The conventional constituent values and the trace metal values were acceptable levels of performance.

C.4 CONCLUSIONS

In summary, the QA/QC data are of acceptable quality according to the current EPA guidelines for laboratory analyses. Based on this QA/QC evaluation, the chemical data (water and sediment) collected in this program are therefore considered of good and reliable quality.

The precision of the data, represented by the relative percent difference (RPD), was evaluated for both field and laboratory duplicates. For field duplicates collected during wet and dry weather periods, the RPD ranged from 0 to 100 percent with an associated mean of 27 percent. For laboratory duplicates, the RPD ranged from 0 to 29 percent (mean of 6 percent) for dry weather samples, and 0 to 40 percent (mean of 16 percent) for wet weather samples. Results of field duplicate samples are an indication of overall field variability, and precision of field sampling techniques and laboratory analyses. As such, the results of field duplicates show more variability than laboratory duplicates, which measure only the precision of laboratory methods.

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The accuracy of the data is represented by the results of (1) matrix spike recoveries, and (2) external reference standards. Matrix spike recoveries for all constituents were within acceptable limits. Based on the results of five rounds of external reference standards, most of the metals concentrations (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) and other conventional pollutants (TKN, nitrate, phosphate, BOD, and total suspended solids) were within the "true" concentrations, therefore indicating that they are reliable values. It is important to note that cadmium, chromium, copper, lead, nickel, and zinc are the five metals used for estimates of metals loads to the Bay. For selenium and silver, however, the actual measured concentrations appear to underestimate the "true" concentrations by about 10 to 30 percent. These two metals were not used in the loading estimates, and were consistently found at low levels with a few values above the detection limit.

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APPENDIX C.1

PRECISION OF LABORATORY DUPLICATES

Table C.1.1. Dry Weather 1

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID DUPLICATE	STATION No.	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
Chlorinated Herbicides	SW8150	03-137-1	03-137-11	S1	DW#1	2,4-D	WATER	ug/L	13	13	0	27-Aug-88
						Dicamba			5.1	4.9	4	
TOX	SW9020	03-137-1	03-137-12	S1	DW#1	TOX	WATER	mg/L	0.08	0.08	0	27-Aug-88

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Table C 1 2 Dry Weather 2

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
METALS	SW6010	2274-5	2274-5	S1	DW#2	Copper	WATER	mg/L	0.051	0.052	2	31-Mar-88
						Lead		mg/L	0.0008	0.0006	29	
						Mercury		mg/L	0.0003	ND	-	
						Silver		mg/L	0.0013	0.0012	8	
						Zinc		mg/L	0.003	0.003	0	
Organophos. Pesticides	SW8140	88-04-002-04	88-04-002-04	S1	DW#2	Organophos. Pesticides	WATER	mg/L	ND	ND	-	31-Mar-88
NH3N	350.1	2274-4	2274-5	S4	DW#2	NH3N	WATER	ug/L	110	115	4	31-Mar-88
TKN	351.2	2274-4	2274-5	S4	DW#2	TKN	WATER	ug/L	690	720	4	31-Mar-88
TOC	415.1	2274-4	2274-5	S4	DW#2	TOC	WATER	ug/L	11400	11100	3	31-Mar-88
TKN	351.2	2274-5	2274-5	S4	DW#2	TKN	WATER	mg/L	2.2	2.2	0	31-Mar-88
BOD	405.1	2274-5	2274-5	S4	DW#2	BOD	WATER	mg/L	>15	>15	-	31-Mar-88
TSS	160.2	2274-5	2274-5	S4	DW#2	TSS	WATER	mg/L	20	22	10	31-Mar-88
pH	E150.1	2274-5	2274-5	S4	DW#2	pH	WATER	-	8.1	8.1	0	31-Mar-88
Pesticides & PCBs	E608	2274-5	2274-5	S4	DW#2	Pesticides/PCBs	WATER	ug/L	ND	ND	-	31-Mar-88
Chlorinated Herbicides	SW8150	84-020-8	84-020-8	S1	DW#2	Chlorinated Herbicides	WATER	ug/L	ND	ND	-	31-Mar-88

Table C 1 3 Dry Weather 4

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
												*
Chlorinated Herbicides	SW8150	88-610-08	88-610-11	S1	DW#4	Chlorinated Herbicides	WATER	ug/L	ND	ND	-	23-Aug-88
Chlorinated Herbicides	SW8150	88-610-06	88-610-13	S1	DW#4	Chlorinated Herbicides	WATER	ug/L	ND	ND	-	23-Aug-88
Polynuclear Aromatic Hydrocarbons (PAH)	E610	S8-88-261-03A	S8-88-261-03AD	S5	DW#4	PAH Compounds	WATER	ug/L	ND	ND	-	23-Aug-88

Table C 1 4 Dry Weather 5

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
TOX	9020	12-322-4	12-322-14	S3	DW#5	TOX	WATER	mg/L	ND	ND	-	24-Dec-88
Chlorinated Herbicides	SW8150	12-322-4	12-322-14	S3	DW#5	Chlorinated Herbicides	WATER	ug/L	ND	ND	-	24-Dec-88

Table C.1.5 Dry Weather 6

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No.	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
TOC	E415.2	02-059-3	02-059-6	S3	DW#6	TOC	WATER	mg/L	1.7	1.8	6	2-Feb-89
TOX	9020	02-059-3	02-059-6	S3	DW#6	TOX	WATER	mg/L	<0.025	<0.025	-	2-Feb-89
METALS	SW6010	T-3531	T-3531	S3	DW#6	Arsenic	WATER	mg/L	ND	ND	-	2-Feb-89
						Cadmium		mg/L	ND	0.0006	-	
						Chromium, Total		mg/L	0.003	0.003	0	
						Chromium, Hex		mg/L	ND	ND	-	
						Copper		mg/L	ND	ND	-	
						Lead		mg/L	ND	ND	-	
						Mercury		mg/L	ND	ND	-	
						Nickel		mg/L	ND	0.002	-	
						Selenium		mg/L	0.0008	0.0009	12	
						Silver		mg/L	ND	ND	-	
						Zinc		mg/L	0.008	0.006	29	
BOD	405.1	T-3531	T-3531	S3	DW#6	BOD	WATER	mg/L	2.6	2.4	8	2-Feb-89
Turbidity	180.1	T-3531	T-3531	S3	DW#6	Turbidity	WATER	mg/L	4.6	4.8	4	2-Feb-89
Hardness	200.7	T-3531	T-3531	S3	DW#6	Hardness	WATER	mg/L	389	378	3	2-Feb-89
TKN	351.2	T-3531	T-3531	S3	DW#6	TKN	WATER	mg/L	ND	ND	-	2-Feb-89
TSS	160.2	T-3531	T-3531	S3	DW#6	TSS	WATER	mg/L	ND	ND	-	2-Feb-89

Table C-1.8 Dry Weather 7

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No.	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
TOC	415.2	04-195-3	04-195-6	S3	DW#7	TOC	WATER	mg/L	2.3	2.3	0	7-Apr-89
TOX	9020	04-195-3	04-195-6	S3	DW#7	TOX	WATER	mg/L	<0.025	<0.025	-	

Table C-1-7 Wet Weather 2

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
METALS	SW6010	T88-3284	T88-3264	S3	WW#2	Arsenic	WATER	mg/L	ND	ND	-	24-Nov-88
						Cadmium		mg/L	0.001	0.0007	35	
						Chromium, Total		mg/L	0.12	0.11	9	
						Chromium, Hex		mg/L	IS	IS	-	
						Copper		mg/L	0.17	0.15	13	
						Lead		mg/L	0.35	0.2	55	
						Mercury		mg/L	0.008	0.002	100	
						Nickel		mg/L	0.22	0.1	75	
						Selenium		mg/L	ND	ND	-	
						Silver		mg/L	0.0002	0.0002	0	
						Zinc		mg/L	0.45	0.4	12	
TKN	351.2	T88-3284	T88-3264	S3	WW#2	TKN	WATER	mg/L	5	5.3	6	24-Nov-88
Ammonia (as N)	350.1	T88-3284	T88-3264	S3	WW#2	Ammonia (as N)	WATER	mg/L	ND	ND	-	24-Nov-88
Nitrate (as N)	353.2	T88-3264	T88-3284	S3	WW#2	Nitrate (as N)	WATER	mg/L	0.82	0.85	5	24-Nov-88
Nitrite (as N)	354.1	T88-3284	T88-3264	S3	WW#2	Nitrite (as N)	WATER	mg/L	0.025	0.024	4	24-Nov-88
Hardness	200.7	T88-3284	T88-3284	S3	WW#2	Hardness	WATER	mg/L	180	180	0	24-Nov-88
Turbidity	180.1	T88-3284	T88-3284	S3	WW#2	Turbidity	WATER	mg/L	910	890	2	24-Nov-88
BOD	405.1	T88-3284	T88-3284	S3	WW#2	BOD	WATER	mg/L	4	IS	-	24-Nov-88
TSS	160.2	T88-3284	T88-3264	S3	WW#2	TSS	WATER	mg/L	1700	1700	0	24-Nov-88
Phosphorus	365.3	T88-3284	T88-3264	S3	WW#2	Phosphorus	WATER	mg/L	1.15	1.04	10	24-Nov-88
Pesticides & PCBs	E608	T88-3284	T88-3264	S3	WW#2	Pesticides & PCBs	WATER	ug/L	ND	ND	-	24-Nov-88

Table C-1-8 Wet Weather 3

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No.	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
TOC	415.2	01-530-5	01-530-6	S3	WW#3	TOC	WATER	mg/L	20	15	29	23-Jan-89
TOX	9020	01-530-5	01-530-6	S3	WW#3	TOX	WATER	mg/L	<0.02	<0.02	-	23-Jan-89

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Table C.1.9 Wet Weather 4

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
Polynuclear Aromatic Hydrocarbons (PAH)	E610	045598 0005	045596 0005DU	LS	WW#4	Benzo(b)fluoranthene	WATER	ug/L	0.20	0.26	7	5-Feb-89
TOC	E415.2	02-154-5	02-154-13	LS	WW#4	TOC	WATER	mg/L	1.1	1.1	0	5-Feb-89
TOX	9020	02-154-5	02-154-13	LS	WW#4	TOX	WATER	mg/L	ND	ND	-	5-Feb-89

Table C 1-10 Wet Weather 5

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
Polynuclear Aromatic Hydrocarbons (PAH)	E610	045688-0001	045688 0001DU	L1	WW#5	Fluoranthene	WATER	ug/L	2.4	2.6	8	10-Feb-89
						Pyrene		ug/L	2	2.2	10	
						Benzo(a)anthracene		ug/L	0.56	0.6	7	
						Benzo(b)fluoranthene		ug/L	0.78	0.86	10	
						Benzo(k)fluoranthene		ug/L	0.34	0.37	8	
						Benzo(a)pyrene		ug/L	0.91	1	9	
						Benzo(ghi)perylene		ug/L	1.3	1.5	14	
						Indeno(1,2,3-c,d)pyrene		ug/L	1.4	1.2	15	
TOC	E415.2	02-388-1	02-388-14	L1	WW#5	TOC	WATER	mg/L	44	44	0	10-Feb-89
TOX	9020	02-388-1	02-388-14	L1	WW#5	TOX	WATER	mg/L	0.06	0.04	40	10-Feb-89

Table C 1 11 Wet Weather 6

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
Polynuclear Aromatic Hydrocarbons (PAH)	E610	46005 0006-SA	46005 0006 DU	S1	WW06	PNA	WATER	ug/L	0.36	0.31	15	2-Mar-89
TOC	415 2	03 115-1	03 115-12	L1	WW06	TOC	WATER	mg/L	260	260	0	2-Mar-89

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Table C-1-12 Wet Weather 7

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
TOC	415.2	03-665-7	03-665-11	S1	WW#7	TOC	WATER	mg/L	8.3	8.4	1	25-Mar-89

Table C.1.13. Sediment 1

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No.	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	RPD (%)	DATE SAMPLED
TOC	415.2	2274-5	2274-5	S4	Sed#1	TOC	SOIL	ug/g	11400	11100	3	31-Mar-89
Ammonia	351.2	2274-5	2274-5	S4	Sed#1	Ammonia	SOIL	ug/g	110	115	4	31-Mar-89
TKN	350.1	2274-5	2274-5	S4	Sed#1	TKN	SOIL	ug/g	690	720	4	31-Mar-89
Metals	SW6010	2274-5	2274-5	S4	Sed#1	Arsenic	SOIL	ug/g	7.9	8.8	11	31-Mar-89
						Cadmium		ug/g	0.37	0.32	14	
						Chromium, Total		ug/g	80	83	4	
						Copper		ug/g	35	33	6	
						Lead		ug/g	28	28	0	
						Mercury		ug/g	0.14	0.16	13	
						Nickel		ug/g	85	82	4	
						Selenium		ug/g	0.59	0.49	19	
						Silver		ug/g	1.2	1.1	9	
						Zinc		ug/g	100	110	10	
Pesticides & PCBs	SW8080	2274-5	2274-5	S4	Sed#1	gamma Chlordane	SOIL	ug/g	13	ND	NA	31-Mar-89
						alpha Chlordane			8.4	3.5	82	
						4,4' DDD			24	7	110	
						4,4' DDE			14	8.5	49	
						4,4' DDT			8.9	11	21	
						PCBs			80	44	58	

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APPENDIX C.2
PRECISION OF FIELD DUPLICATES

Table C.2.1 Dry Weather 1

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
TOX	9020	03-137-1	03-137-11	S1	DW#1	TOX	WATER	mg/L	0.08	0.08	0	27-Feb-88
Chlorinated Herbicides	SW8150	03-137-1	03-137-11	S1	DW#1	2,4-D	WATER	ug/L	13	13	0	
						DICAMBA		ug/L	5.1	4.9	4	
TOX	9020	03-137-2	03-137-12	S2	DW#1	TOX	WATER	mg/L	<0.025	0.08	NA	27-Feb-88
Chlorinated Herbicides	SW8150	03-137-2	03-137-12	S2	DW#1	2,4-D	WATER	ug/L	ND	11	NA	
						DICAMBA		ug/L	ND	4.2	NA	
Chlorinated Herbicides	SW8150	E88-04-029	E88-04-029	S1	DW#1	Chlor. Herbicides	WATER	ug/L	ND	ND	NA	27-Feb-88

Table C 2 2 Dry Weather 2

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Metals	SW6010	2274-5	2274-5	S1	DW#2	Copper	WATER	mg/L	0.051	0.052	2	31-Mar-88
						Lead			0.0006	0.0008	29	
						Mercury			0.0003	ND	NA	
						Selenium			ND	ND	NA	
						Silver			0.0013	0.0012	8	
						Zinc			0.003	0.003	0	
Polynuclear Aromatic Hydrocarbons (PAH)	SW8100	S8-04-002-04	88-04-002-04	S1	DW#2	PAH Compounds	WATER	ug/L	ND	ND	NA	31-Mar-88
Organo Pesticides	SW8140	88-04-002-02	88-04-002-02	S1	DW#2	Organo Pesticides	WATER	ug/L	ND	ND	NA	31-Mar-88
Chlorinated Herbicides	SW8150	84-020-8	84-020-88	S1	DW#2	Chlorinated Herbicides	WATER	ug/L	ND	ND	NA	31-Mar-88

Table C 2 3 Dry Weather 3

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Chlorinated Herbicides	SW8150	05-399-04	05-399-05	S4	DW#3	2,4-D	WATER	ug/L	61	56	9	12-May-88
						Dicamba			47	48	2	
Metals	SW6010	2376	2376	S4	DW#3	Copper	WATER	mg/L	0.008	0.01	22	12-May-88
						Lead			0.0076	0.0078	7	
						Mercury			ND	ND	NA	
						Selenium			ND	ND	NA	
						Silver			0.0034	0.0033	3	
						Zinc			0.023	0.026	12	
BOD	05.1	2376	2376	S4	DW#3	BOD	WATER	mg/L	8	8	0	12-May-88
TKN	351.2	2376	2376	S4	DW#3	TKN	WATER	mg/L	1.7	1.7	0	12-May-88
TSS	160.2	2376	2376	S4	DW#3	TSS	WATER	mg/L	38	30	26	12-May-88
pH	E150.1	2376	2376	S4	DW#3	pH	WATER	mg/L	7.5	7.7	3	12-May-88
Total Coliform	909C	2376	2376	S4	DW#3	Total Coliform	WATER	mg/L	900000	>1600000	NA	12-May-88
Fecal Coliform	909A	2376	2376	S4	DW#3	Fecal Coliform	WATER	mg/L	4000	7000	55	12-May-88
TOC	415.1	2376	2376	S4	DW#3	TOC	WATER	mg/L	33	22	40	12-May-88
Polynuclear Aromatic	E610	88-06-165-04	88-06-165-04D	S4	DW#3	Polynuclear Aromatic	WATER	ug/L	ND	ND	NA	12-May-88

Table C 2 4 Dry Weather 4

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
TOX	8020	88-610-1	88-610-3	S3	DW#4	TOX	WATER	mg/L	ND	ND	NA	23-Aug-88
Chlorinated Herbicides	SW8150	88-610-1	88-610-3	S3	DW#4	Chlorinated Herbicides	WATER	ug/L	ND	ND	NA	23-Aug-88
Total Coliform	909C	S3	S5	S3	DW#4	Total Coliform	WATER	MPN/100	>2400	>2400	NA	23-Aug-88
Fecal Coliform	909A	S3	S5	S3	DW#4	Fecal Coliform	WATER	MPN/100	70	70	0	23-Aug-88
Pesticides & PCBs	E608	S3	S5	S3	DW#4	Pesticides & PCBs	WATER	ug/L	ND	ND	NA	23-Aug-88
Metals	SW6010	S3	S5	S3	DW#4	Copper	WATER	mg/L	0.011	0.007	44	23-Aug-88
						Lead			ND	0.014	NA	
						Mercury			0.0027	0.0025	8	
						Selenium			0.0023	0.0018	24	
						Silver			0.0024	0.003	22	
						Zinc			0.080	0.014	43	
Nitrite	354.1	S3	S5	S3	DW#4	Nitrite	WATER	mg/L	2	1.8	11	23-Aug-88
Nitrate	353.2	S3	S5	S3	DW#4	Nitrate	WATER	mg/L	ND	ND	NA	23-Aug-88
TKN	351.2	S3	S5	S3	DW#4	TKN	WATER	mg/L	1	3	100	23-Aug-88
TSS	160.2	S3	S5	S3	DW#4	TSS	WATER	mg/L	8.5	5.5	43	23-Aug-88
BOD	405.1	S3	S5	S3	DW#4	BOD	WATER	mg/L	7	5	33	23-Aug-88
Polynuclear Aromatic Hydrocarbons (PAH)	E61[illegible]	S3	S5	S3	DW#4	PAH Compounds	WATER	ug/L	ND	ND	NA	23-Aug-88

Table C 2 5 Dry Weather 5

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID. DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Polynuclear Aromatic Hydrocarbons (PAH)	E610	44880 0003	44880 0003DU	S3	DW#5	PAH Compounds	WATER	ug/L	ND	ND	NA	13-Dec-88
TX	9020	12-322-3	12-322-4	S3	DW#5	TX	WATER	mg/L	ND	ND	NA	13-Dec-88
Chlorinated Herbicides	SW8150	12-322-3	12-322-4	S3	DW#5	Chlorinated Herbicides	WATER	mg/L	ND	ND	NA	13-Dec-88
Total Coliform	909C	S3	S5	S3	DW#5	Total Coliform	WATER	MPN/100	>2400	>2400	NA	13-Dec-88
Fecal Coliform	909A	S3	S5	S3	DW#5	Fecal Coliform	WATER	MPN/100	1100	400	92	13-Dec-88
Pesticides & PCBs	E608	T88-3340	T88-3340	S3	DW#5	Pesticides & PCBs	WATER	ug/L	ND	ND	NA	13-Dec-88
Metals	SW6010	T88-3340	T88-3340	S3	DW#5	Chromium, Hex	WATER	mg/L	ND	ND	NA	13-Dec-88
						Copper			0.003	ND	NA	
						Land			ND	ND	NA	
						Mercury			ND	ND	NA	
						Selenium			0.0003	ND	NA	
						Silver			ND	ND	NA	
						Zinc			0.020	0.014	60	
TKN	351.2	T88-3340	T88-3340	S3	DW#5	TKN	WATER	mg/L	ND	ND	NA	13-Dec-88
ROD	405.1	T88-3340	T88-3340	S3	DW#5	ROD	WATER	mg/L	ND	2	NA	13-Dec-88
TSS	160.2	T88-3340	T88-3340	S3	DW#5	TSS	WATER	mg/L	ND	ND	NA	13-Dec-88
Hardness	200.7	T88-3340	T88-3340	S3	DW#5	Hardness	WATER	mg/L	340	320	6	13-Dec-88
Turbidity	180.1	T88-3340	T88-3340	S3	DW#5	Turbidity	WATER	mg/L	8	5	10	13-Dec-88

Table C 2 6 Dry Weather 6

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Polynuclear Aromatic Hydrocarbons (PAH)	E610	045559-0003	045559-0005	S3	DW#6	PAH Compounds	WATER	ug/L	ND	ND	NA	2-Feb-89
Total Coliform	908C	S3	S5	S3	DW#6	Total Coliform	WATER	MPN/100	24000	11000	74	2-Feb-89
Fecal Coliform	909A	S3	S5	S3	DW#6	Fecal Coliform	WATER	MPN/100	43	23	61	2-Feb-89
TOC	415.1	02-059-3	02-059-5	S3	DW#6	TOC	WATER	mg/L	1.7	1.7	0	2-Feb-89
TOX	9020	02-059-3	02-059-5	S3	DW#6	TOX	WATER	mg/L	<0.025	<0.025	NA	2-Feb-89
Pesticides & PCBs	E608	T-3531	T-3531	S3	DW#6	Pesticides & PCBs	WATER	mg/L	ND	ND	NA	2-Feb-89
Metals	SW6010	T-3531	T-3531	S3	DW#6	Arsenic	WATER	mg/L	ND	ND	NA	2-Feb-89
						Cadmium			ND	0.0002	NA	
						Chromium, Total			0.003	0.003	0	
						Chromium, Hex			ND	ND	NA	
						Copper			ND	0.004	NA	
						Lead			ND	0.004	NA	
						Mercury			ND	ND	NA	
						Nickel			ND	ND	NA	
						Selenium			0.0008	0.0005	46	
						Silver			ND	ND	NA	
						Zinc			0.008	0.01	22	
BOD	405.1	T-3531	T-3531	S3	DW#6	BOD	WATER	mg/L	2.8	1.9	31	2-Feb-89
Turbidity	180.1	T-3531	T-3531	S3	DW#6	Turbidity	WATER	mg/L	4.8	3	42	2-Feb-89
Hardness	200.7	T-3531	T-3531	S3	DW#6	Hardness	WATER	mg/L	380	380	0	2-Feb-89
TKN	351.2	T-3531	T-3531	S3	DW#6	TKN	WATER	mg/L	ND	ND	NA	2-Feb-89
TSS	160.2	T-3531	T-3531	S3	DW#6	TSS	WATER	mg/L	ND	ND	NA	2-Feb-89

Table C 2 7 Dry Weather 7

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Total Coliform	909C	S3	S5	S3	DW#7	Total Coliform	WATER	MPN/100	4000	2400	63	7-Apr-89
Fecal Coliform	909A	S3	S5	S3	DW#7	Fecal Coliform	WATER	MPN/100	400	460	14	7-Apr-89
Pesticides & PCBs	E608	T-3839	T-3839	S3	DW#7	Pesticides & PCBs	WATER	mg/L	ND	ND	NA	7-Apr-89
Metals	SW6010	T-3839	T-3839	S3	DW#7	Arsenic	WATER	mg/L	0.001	0.001	0	7-Apr-89
						Cadmium			ND	0.0031	NA	
						Chromium,Total			0.003	ND	NA	
						Chromium, Hex			ND	ND	NA	
						Copper			0.004	0.003	29	
						Lead			ND	ND	NA	
						Mercury			ND	ND	NA	
						Nickel			0.002	ND	NA	
						Selenium			ND	ND	NA	
						Silver			0.002	ND	NA	
						Zinc			0.01	0.015	40	
TKN	351.2	T-3839	T-3839	S3	DW#7	TKN	WATER	mg/L	ND	ND	NA	7-Apr-89
TSS	160.2	T-3839	T-3839	S3	DW#7	TSS	WATER	mg/L	2.4	2.0	18	7-Apr-89
BOD	405.1	T-3839	T-3839	S3	DW#7	BOD	WATER	mg/L	1.0	1.0	0	7-Apr-89
Hardness	200.7	T-3839	T-3839	S3	DW#7	Hardness	WATER	mg/L	200	200	0	7-Apr-89
Turbidity	180.1	T-3839	T-3839	S3	DW#7	Turbidity	WATER	mg/L	4.8	3.8	33	7-Apr-89
TOC	415.1	04-195-3	04-195-5	S3	DW#7	TOC	WATER	mg/L	2.3	2.4	4	7-Apr-89
TOX	9020	04-195-3	04-195-5	S3	DW#7	TOX	WATER	mg/L	ND	ND	NA	7-Apr-89
Polynuclear Aromatic Hydrocarbons (PAH)	E610	048590-0003	048590-0005	S3	DW#7	PAH Compounds	WATER	ug/L	ND	ND	NA	7-Apr-89

Table C 2 8 Wet Weather 2

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID. DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Volatile Organics	E624	8811103-08	8811103-11	S3	WW#2	Volatile Organics	WATER	ug/L	ND	ND	NA	24-Nov-88
Semivolatile Organics	E 625	8811103-08	8811103-11	S3	WW#2	Semivolatile Organics	WATER	ug/L	ND	ND	NA	24-Nov-88
METALS	SW6010			S3	WW#2	Arsenic	WATER	mg/L	ND	ND	NA	24-Nov-88
						Cadmium		mg/L	0.004	0.002	67	
						Chromium,Total		mg/L	0.14	0.065	73	
						Chromium, Hex		mg/L	IS	IS	NA	
						Copper		mg/L	0.18	0.072	80	
						Lead		mg/L	0.25	0.13	63	
						Mercury		mg/L	0.004	0.003	28	
						Nickel		mg/L	0.24	0.1	82	
						Selenium		mg/L	ND	ND	NA	
						Silver		mg/L	0.0004	ND	NA	
						Zinc		mg/L	0.81	0.20	84	
TOC	415.1	11-030-8	11-035-11	S3	WW#2	TOC	WATER	mg/L	23	9	88	24-Nov-88
TOX	802?	11-035-8	11-035-11	S3	WW#2	TOX	WATER	mg/L	0.020	0.058	82	24-Nov-88
Chlorinated Herbicides	SW8150	11-035-8	11-035-11	S3	WW#2	Chlorinated Herbicides	WATER	ug/L	ND	ND	NA	24-Nov-88
Pesticides & PCB's	E 608	S4	S5	S4	WW#2	4,4'-DDE	WATER	ug/L	0.07	0.08	33	24-Nov-88
						4,4' DDT		ug/L	0.18	0.15	24	
						gamma chlordane		ug/L	0.1	ND	NA	
						Endosulfan I		ug/L	0.13	ND	NA	
						Endosulfan II		ug/L	0.08	ND	NA	
						Arochlor 1254		ug/L	ND	1.4	NA	
TKN	351.2	T88-3284	T88-3264	S4	WW#2	TKN	WATER	mg/L	1.0	1.0	12	24-Nov-88
Ammonia	350.1	T88-3284	T88-3264	S4	WW#2	Ammonia	WATER	mg/L	ND	ND	NA	24-Nov-88
Nitrite	354.1	T88-3284	T88-3264	S4	WW#2	Nitrite	WATER	mg/L	0.67	0.02	8	24-Nov-88
Nitrate	353.2	T88-3284	T88-3284	S4	WW#2	Nitrate	WATER	mg/L	0.045	0.032	34	24-Nov-88
Hardness	200.7	T88-3284	T88-3264	S4	WW#2	Hardness	WATER	mg/L	236	156	42	24-Nov-88
Turbidity	180.1	T88-3284	T88-3284	S4	WW#2	Turbidity	WATER	mg/L	300	650	52	24-Nov-88
BOD	405.1	T88-3284	T88-3284	S4	WW#2	BOD	WATER	mg/L	12	20	50	24-Nov-88
TSS	160.2	T88-3284	T88 3284	S4	WW#2	TSS	WATER	mg/L	430	1200	84	24-Nov-88
Phosphorus		T88-3284	T88-3264	S4	WW#2	Phosphorus	WATER	mg/L	0.55	0.88	44	24-Nov-88

Table C.2.9 Wet Weather 3

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Polynuclear Aromatic Hydrocarbons (PAH)	E 610	045459-0004	045459-0005	S3	WW#3	Fluoranthene	WATER	ug/L	0.29	0.26	11	24-Jan-89
						Pyrene		ug/L	0.33	0.32	3	
TOC	415.1	01-539-3	01-539-4	S2	WW#3	TOC	WATER	mg/L	19	19	0	24-Jan-89
TOX	9020	01-539-3	01-539-4	S2	WW#3	TOX	WATER	mg/L	0.04	0.04	0	24-Jan-89
Metals	SW6010	T-3497	T-3497	S2	WW#3	Arsenic	WATER	mg/L	ND	ND	NA	24-Jan-89
						Cadmium		mg/L	0.0006	0.0004	40	
						Chromium, Total		mg/L	0.004	0.003	29	
						Chromium, Hex		mg/L	ND	ND	NA	
						Copper		mg/L	0.003	0.002	40	
						Lead		mg/L	0.001	0.002	67	
						Mercury		mg/L	ND	ND	NA	
						Nickel		mg/L	ND	ND	NA	
						Selenium		mg/L	ND	ND	NA	
						Silver		mg/L	ND	ND	NA	
						Zinc		mg/L	0.14	0.22	44	
TKN	351.2	T-3497	T-3497	S2	WW#3	TKN	WATER	mg/L	1.7	1.5	13	24-Jan-89
BOD	405.1	T-3497	T-3497	S2	WW#3	BOD	WATER	mg/L	13	12	8	24-Jan-89
Pesticides & PCBs	E608	T-3497	T-3497	S2	WW#3	gamma-BHC (Lindane)	WATER	ug/L	0.032	ND	NA	24-Jan-89

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Table C 2 10 Wet Weather 4

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Polynuclear Aromatic Hydrocarbons (PAH)	E 610	045596-0005	045596-0011	L5	WW#4	Benzo(b)fluoranthene	WATER	ug/L	0.28	0.33	16	6-Feb-89
TOC	E 415.2	02-154-5	02-154-11	L5	WW#4	TOC	WATER	mg/L	11	11	0	6-Feb-89
TOX	E 415.2	02-154-5	02-154-11	L5	WW#4	TOX	WATER	mg/L	ND	ND	NA	6-Feb-89
Metals	SW6010	T-3553	T-3553	L5	WW#4	Arsenic	WATER	mg/L	ND	ND	NA	6-Feb-89
						Cadmium		mg/L	0.0028	0.0028	7	
						Chromium, Total		mg/L	0.028	0.011	87	
						Chromium, Hex		mg/L	ND	ND	NA	
						Copper		mg/L	0.032	0.019	51	
						Lead		mg/L	0.05	0.042	17	
						Mercury		mg/L	0.004	0.006	40	
						Nickel		mg/L	0.025	0.021	17	
						Selenium		mg/L	ND	ND	NA	
						Silver		mg/L	ND	ND	NA	
						Zinc		mg/L	0.2	0.18	11	
TKN	351.2	T-3553	T-3553	L5	WW#4	TKN	WATER	mg/L	1.2	1.7	34	6-Feb-89
BOD	405.1	T-3553	T-3553	L5	WW#4	BOD	WATER	mg/L	4.4	4.1	7	6-Feb-89
TSS	160.1	T-3553	T-3553	L5	WW#4	TSS	WATER	mg/L	52	46	12	6-Feb-89
Hardness	200.7	T-3553	T-3553	L5	WW#4	Hardness	WATER	mg/L	45	47	4	6-Feb-89
Turbidity	180.1	T-3553	T-3553	L5	WW#4	Turbidity	WATER	mg/L	73	87	18	6-Feb-89
Pesticides & PCBs	E608	T-3553	T-3553	L5	WW#4	Pesticides & PCBs	WATER	ug/L	0.05	0.05	0	6-Feb-89

Table C 2 11 Wet Weather 5

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Pesticides & PCBs	E608	T-3573	T-3573	S1	WW#5	Pesticides & PCBs	WATER	ug/L	ND	ND	NA	10-Feb-89
Total Coliform	909C	S1	SS	S1	WW#5	Total Coliform	WATER	MPN/100	>240000	>240000	NA	10-Feb-89
Fecal Coliform	909A	S1	SS	S1	WW#5	Fecal Coliform	WATER	MPN/100	>240000	11000	NA	10-Feb-89
Metals	SW6010	T-3573	T-3573	S1	WW#5	Arsenic	WATER	mg/L	ND	ND	NA	10-Feb-89
						Cadmium		mg/L	0.0035	0.0035	0	
						Chromium, Total		mg/L	0.019	0.019	0	
						Chromium, Hex		mg/L	ND	ND	NA	
						Copper		mg/L	0.032	0.03	6	
						Lead		mg/L	0.032	0.039	20	
						Mercury		mg/L	ND	ND	NA	
						Nickel		mg/L	ND	0.018	NA	
						Selenium		mg/L	ND	ND	NA	
						Silver		mg/L	ND	ND	NA	
						Zinc		mg/L	0.12	0.18	40	
TKN	51.2	T-3573	T-3573	S1	WW#5	TKN	WATER	mg/L	ND	1.8	NA	10-Feb-89
BOD	15.1	T-3573	T-3573	S1	WW#5	BOD	WATER	mg/L	6.7	4	50	10-Feb-89
TSS	160.2	T-3573	T-3573	S1	WW#5	TSS	WATER	mg/L	78	50	41	10-Feb-89
Hardness	200.7	T-3573	T-3573	S1	WW#5	Hardness	WATER	mg/L	60	50	18	10-Feb-89
Turbidity	180.1	T-3573	T-3573	S1	WW#5	Turbidity	WATER	mg/L	69	95	32	10-Feb-89
TOC	415.1	02-380-8	02-380-12	S1	WW#5	TOC	WATER	MPN/100	12	9.8	20	10-Feb-89
TOX	9020	02-380-8	02-380-12	S1	WW#5	TOX	WATER	MPN/100	ND	0.03	NA	10-Feb-89
Polynuclear Aromatic Hydrocarbons (PAH)	E610	45888-0008	45888-0012	S1	WW#5	Benzo(b) fluoranthene	WATER	ug/L	0.18	ND	NA	10-Feb-89

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Table C 2 12 Wet Weather 8

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID. PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Pesticides & PCBs	E608	T-3650	T-3650	LS	WW#6	Pesticides & PCBs	WATER	ug/L	ND	ND	NA	3-Mar-89
Metals	SW6010	T-3650	T-3650	LS	WW#6	Arsenic	WATER	mg/L	ND	ND	NA	3-Mar-89
						Cadmium		mg/L	0.0013	0.0012	8	
						Chromium,Total		mg/L	0.017	0.017	0	
						Chromium, Hex		mg/L	ND	ND	NA	
						Copper		mg/L	0.05	0.05	0	
						Lead		mg/L	0.045	0.05	11	
						Mercury		mg/L	ND	0.0002	NA	
						Nickel		mg/L	0.06	0.05	18	
						Selenium		mg/L	ND	ND	NA	
						Silver		mg/L	ND	ND	NA	
						Zinc		mg/L	0.31	0.32	3	
TKN	351.2	T-3650	T-3650	LS	WW#6	TKN	WATER	mg/L	1.0	2.0	67	3-Mar-89
BOD	405.1	T-3650	T-3650	LS	WW#6	BOD	WATER	mg/L	13	15	14	3-Mar-89
TSS	160.2	T-3650	T-3650	LS	WW#6	TSS	WATER	mg/L	88	84	4	3-Mar-89
Hardness	200.7	T-3650	T-3650	LS	WW#6	Hardness	WATER	mg/L	35	60	61	3-Mar-89
Turbidity	180.1	T-3650	T-3650	LS	WW#6	Turbidity	WATER	mg/L	83	88	18	3-Mar-89
Total Coliform	909C	03-115-1	03-115-0	LS	WW#6	Total Coliform	WATER	MPN/100	46000	110000	82	3-Mar-89
Fecal Coliform	909A	03-115-1	03-115-0	LS	WW#6	Fecal Coliform	WATER	MPN/100	2400	4300	57	3-Mar-89

Table C 2 13 Wet Weather 7

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Metals	SW6010	T-3769	T-3769	S1	WW07	Arsenic	WATER	mg/L	0.004	0.002	67	20-Mar-09
						Cadmium		mg/L	0.0013	0.0015	14	
						Chromium,Total		mg/L	0.027	0.030	29	
						Chromium, Hex		mg/L	ND	ND	NA	
						Copper		mg/L	0.055	0.061	10	
						Lead		mg/L	0.06	0.1	50	
						Mercury		mg/L	0.0002	ND	NA	
						Nickel		mg/L	0.09	0.11	20	
						Selenium		mg/L	ND	ND	NA	
						Silver		mg/L	0.0002	0.0003	40	
						Zinc		mg/L	0.24	0.37	43	
TSS	160.2	T-3769	T-3769	S1	WW07	TSS	WATER	mg/L	190	220	15	20-Mar-09
BOD	405.1	T-3769	T-3769	S1	WW07	BOD	WATER	mg/L	10	9.2	8	20-Mar-09
Hardness	200.7	T-3769	T-3769	S1	WW07	Hardness	WATER	mg/L	40	64	29	20-Mar-09
Turbidity	180.1	T-3769	T-3769	S1	WW07	Turbidity	WATER	mg/L	97	120	21	20-Mar-09
TOC	415.2	03-665-7	03-665-10	S1	WW07	TOC	WATER	mg/L	0.3	0.1	2	20-Mar-09

Table C 2 14 Sediment 1

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%) RPD	DATE SAMPLED
Chlorinated Herbicides	SW8150	08-300-9	08-300-10	S4	Sed#1	Chlorinated Herbicides	SOIL	mg/kg	ND	ND	NA	31-Mar-88

Table C.2.15. Sediment 3

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No.	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)	DATE SAMPLED
Chlorinated Herbicides	SW8150	88-610-8	88-610-10	S4	Sed#3	Chlorinated Herbicides	SOIL	mg/kg	ND	ND	NA	23-Aug-88
Pesticides & PCBs	E608	T88-2797	T88-2797	S4	Sed#3	gamma BHC (lindane)	SOIL	ug/kg	ND	7.8	NA	23-Aug-88
						alpha Chlordane			10	10	0	
						gamma chlordane			13	13	0	
						4,4'-DDD			27	55	68	
						4,4'-DDE			8.1	8.6	6	
						4,4'-DDT			37	27	31	
Semivolatile Organics	E625	8808209-03	8808209-05	F1	Sed#3	Semivolatile Organics	SOIL	ug/kg	ND	ND	NA	23-Aug-88
Organophosphorus Pesticides	SW8140	S8-88-281-01	S8-88-281-03	S4	Sed#3	Organophosphorus Pesticides	SOIL	mg/kg	ND	ND	NA	23-Aug-88

Table C.2.16 Sediment 4

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLE ID PRIMARY	SAMPLE ID DUPLICATE	STATION No	SAMPLING EVENT	ANALYTES	MATRIX	UNITS	CONCENTRATION PRIMARY	CONCENTRATION DUPLICATE	(%)
Polynuclear Aromatic Hydrocarbons (PAH)	E610	44880-0009	44880-0011	S3	Sed#4	Phenanthrene	SOIL	ug/kg	ND	380	NA
						Fluoranthene			460	780	52
						Pyrene			420	460	9
						Benzo(a)anthracene			130	ND	NA
						Benzo(b)fluoranthene			250	410	48
						Benzo(k)fluoranthene			1:0	190	53
						Benzo(a)pyrene			230	360	44
Chlorinated Herbicides	SW8150	12-322-8	12-322-11	S3	Sed#4	Chlorinated Herbicides	SOIL	mg/kg	ND	ND	NA
Pesticides & PCBs	E608	T88-3330	T88-3330	S3	Sed#4	alpha-Chlordane	SOIL	ug/kg	13	9.8	28
						gamma chlordane			20	16	22
						4,4'-DDD			24	17	34
						4,4'-DDE			13	11	17
						4,4'-DDT			25	ND	NA
						PCBs			240	125	63
Metals	SW6010	T88-3330	T88-3330	S3	Sed#4	Copper	SOIL	mg/kg	45	45	0
						Lead			64	86	29
						Mercury			3.8	2.8	32
						Selenium			1	1	0
						Silver			ND	ND	NA
						Zinc			160	150	6

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APPENDIX C.3
PRECISION OF MATRIX SPIKE AND MATRIX SPIKE DUPLICATES

Table C 3 1 Dry Weather 1

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE: MS CONC	MATRIX SPIKE: MS REC CONC	MATRIX SPIKE: MS REC (%)	MATRIX SPIKE DUPLICATE: MSD CONC	MATRIX SPIKE DUPLICATE: MSD REC CONC	MATRIX SPIKE DUPLICATE: MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Volatile Organics	WATER	DW#1	51-2192	Phenol	ug/L	100	34	34	100	30	30	10--43	-14	Anametrix 8-Mar-89
				2 Chlorophenol	ug/L	100	83	83	100	75	75	13-84	--17	
				1,4 Dichlorobenzene	ug/L	50	23	46	50	31	62	12--88	-30	
				Nitrosodipropylamine	ug/L	50	32	64	50	36	72	25--88	-12	
				1,2,4 Trichlorobenzene	ug/L	50	26	52	50	32	64	17--78	-21	
				4 Chloro 3 methylphenol	ug/L	100	87	87	100	85	85	10--127	2	
				Acenaphthene	ug/L	50	39	78	50	39	78	27--123	0	
				4 Nitrophenol	ug/L	100	21	21	100	17	17	10--80	21	
				2,4 Dinitrotoluene	ug/L	50	43	86	50	39	78	43--117	10	
				Pentachlorophenol	ug/L	100	67	67	100	51	51	10--151	27	
				Pyrene	ug/L	50	45	90	50	39	78	47-146	14	
METALS	WATER	DW#1	2274-5	Arsenic		-	-	NA	-	-	92	-	10	TerScan 25-May-89
				Cadmium		-	-	112	-	-	81	-	14	
				Chromium		-	-	113	-	-	75	-	4	
				Copper		-	-	112	-	-	89	-	0	
				Lead		-	-	107	-	-	88	-	8	
				Mercury		-	-	92	-	-	125	-	13	
				Nickel		-	-	73	-	-	87	-	4	
				Selenium		-	-	82	-	-	78	-	10	
				Silver		-	-	114	-	-	NA	-	2	
				Zinc		-	-	85	-	-	83	-	4	

* RPD values were calculated by the laboratory.

Table C 3 2 Dry Weather 2

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE: MS CONC	MATRIX SPIKE: MS REC CONC	MATRIX SPIKE: MS REC (%)	MATRIX SPIKE DUPLICATE: MSD CONC	MATRIX SPIKE DUPLICATE: MSD REC CONC	MATRIX SPIKE DUPLICATE: MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
METALS	WATER	DW#2	2274-5	Copper		-	-	100	-	-	104	-	2	ToxScan
				Lead		-	-	99	-	-	89	-	20	25-May-88
				Mercury		-	-	111	-	-	104	-	NA	
				Selenium		-	-	110	-	-	92	-	NA	
				Silver		-	-	85	-	-	NA	-	8	
				Zinc		-	-	86	-	-	86	-	0	
Pesticides & PCB's	WATER	DW#2	2274-5	Aldrin		-	-	48	-	-	NA	-	NA	
				Gamma BHC		-	-	67	-	-	NA	-	NA	ToxScan
				4,4'-DDT		-	-	78	-	-	NA	-	NA	25-May-88
				Dieldrin		-	-	84	-	-	NA	-	NA	
				Endrin		-	-	81	-	-	NA	-	NA	
				Heptachlor		-	-	65	-	-	NA	-	NA	
Pesticides & PCB's	WATER	DW#2	2274-5	Aldrin		-	-	89	-	-	NA	-	NA	ToxScan
				Gamma BHC		-	-	88	-	-	NA	-	NA	25-May-88
				4,4'-DDT		-	-	112	-	-	NA	-	NA	
				Dieldrin		-	-	98	-	-	NA	-	NA	
				Endrin		-	-	121	-	-	NA	-	NA	
				Heptachlor		-	-	101	-	-	NA	-	NA	

Table C 3 3 Dry Weather 4

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE MS CONC.	MATRIX SPIKE MS REC CONC.	MATRIX SPIKE MS REC (%)	MATRIX SPIKE DUPLICATE MSD CONC.	MATRIX SPIKE DUPLICATE MSD REC CONC.	MATRIX SPIKE DUPLICATE MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Chlorinated Herbicides	WATER	DW#4	88-010 12	2,4,5-T		-	-	-	-	-	127	-	-	BSC
				2,4,5 TP		-	-	-	-	-	127	-	-	23-Aug-88
				2,4 D		-	-	-	-	-	-	-	-	
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	DW#4	88-08 261 01A	Dibenz(a,h)anthracene	ug/L	50	16	32	-	-	-	-	-	IT
				Anthracene	ug/L	50	38	76	-	-	-	-	-	
				Benzo(a)pyrene	ug/L	50	31	63	-	-	-	-	-	
				Acenaphthene	ug/L	50	30	61	-	-	-	-	-	
Metals	WATER	DW#4	2797	Copper		-	-	101	-	-	-	-	-	TerScan
				Lead		-	-	135	-	-	-	-	-	20-Oct-88
				Mercury		-	-	82	-	-	-	-	-	
				Selenium		-	-	102	-	-	-	-	-	
				Silver		-	-	100	-	-	-	-	-	
				Zinc		-	-	117	-	-	-	-	-	

* RPD values were calculated by the laboratory.

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Table C 3-4 Dry Weather 5

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE: MS CONC	MS REC CONC	MS REC (%)	MATRIX SPIKE DUPLICATE: MSD CONC	MSD REC CONC	MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	DW#5	44880-0003 MS	Naphthalene	ug/L	5	2.7	54	5	2.94	59	-	-	CAL 21-Dec-88
				Fluorene	ug/L	1	0.649	65	1	0.682	68	-	-	
				Pyrene	ug/L	1	0.819	82	1	0.804	80	-	-	
				Benzo(a)pyrene	ug/L	0.5	0.402	80	0.5	0.398	80	-	-	
				Indeno(1,2,3-c,d)pyrene	ug/L	0.5	0.391	78	0.5	0.368	74	-	-	
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	DW#5	44880-0009 MS	Naphthalene	ug/L	1000	ND	--	-	-	-	-	-	CAL 21-Dec-88
				Fluorene	ug/L	200	ND	--	-	-	-	-	-	
				Pyrene	ug/L	208	252	--	-	-	-	-	-	
				Benzo(a)pyrene	ug/L	100	149	--	-	-	-	-	-	
				Indeno(1,2,3-c,d)pyrene	ug/L	100	ND	--	-	-	-	-	-	
TOC Chlorinated Herbicides	WATER	DW#5	12-322-15	TOC		-	-	114	-	-	-	-	-	B&C 5-Jan-89
				2,4,5-T		-	-	120	-	-	-	-	-	
				2,4,5-TP		-	-	94	-	-	-	-	-	
				2,4-D		-	-	110	-	-	-	-	-	
				2,4-DB		-	-	110	-	-	-	-	-	
				Dicamba		-	-	90	-	-	-	-	-	
				Dinoseb		-	-	100	-	-	-	-	-	
Volatile Organics	WATER	DW#5	8811183-09	1,1 dichloroethene	ug/L	50	60	120	50	54	108	61--157	11	Anametrix 5-Dec-88
				Freon 113	ug/L	50	44	88	50	41	82	61--150	7	
				Methylene chloride	ug/L	50	57	114	50	55	110	81--141	4	
				Chloroform	ug/L	50	55	110	50	52	104	70--127	6	
				1,1,1 trichloroethane	ug/L	50	60	120	50	56	112	60--147	7	
				Benzene	ug/L	50	63	126	50	60	120	60--137	5	
				1,2 dichloroethane	ug/L	50	61	122	50	59	118	82--121	3	
				Trichloroethene	ug/L	50	46	92	50	43	86	64--131	7	
				4 methyl 2 pentanone	ug/L	50	57	114	50	65	130	50--132	-13	
				Toluene	ug/L	50	58	116	50	56	112	80--125	4	
				Tetrachloroethene	ug/L	50	55	110	50	52	104	85--125	6	
				Chlorobenzene	ug/L	50	55	110	50	53	106	87--124	4	
				1,2 dichlorobenzene	ug/L	50	56	112	50	54	108	83--132	4	
Semivolatile Organics	WATER	DW#5	88111183-10	Phenol	ug/L	100	19	19	-	-	-	10--43		Anametrix 7-Dec-88
				2 chlorophenol	ug/L	100	32	32	-	-	-	13--64		
				1,4 dichlorobenzene	ug/L	50	10	20	-	-	-	12--68		
				Nitrosodipropylamine	ug/L	50	19	38	-	-	-	25--86		
				1,2,4 trichlorobenzene	ug/L	50	12	24	-	-	-	17--70		
				4 chloro 3 methylphenol	ug/L	100	74	74	-	-	-	10--127		
				Acenaphthene	ug/L	50	29	58	-	-	-	27--123		
				4 nitrophenol	ug/L	100	34	34	-	-	-	10--88		
				2,4 dinitrotoluene	ug/L	50	35	70	-	-	-	43--117		
				Pentachlorophenol	ug/L	100	83	83	-	-	-	10--151		
				Pyrene	ug/L	50	39	78	-	-	--	47--148		

Table C.3.5 Dry Weather 8

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE: MS CONC	MATRIX SPIKE: MS REC. CONC	MATRIX SPIKE: MS REC. (%)	MATRIX SPIKE DUPLICATE: MSD CONC.	MATRIX SPIKE DUPLICATE: MSD REC. CONC.	MATRIX SPIKE DUPLICATE: MSD REC (%)	LAB REC. LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	DW#8	045559-0003MS	Naphthalene	ug/L	5	3.1	62	5	2.1	42	-	38	CAL 14-Feb-89
				Fluorene	ug/L	1	0.88	88	1	0.67	67	-	25	
				Pyrene	ug/L	1	1.1	110	1	0.91	91	-	19	
				Benzo(a)pyrene	ug/L	0.5	0.56	112	0.5	0.47	94	-	17	
				Indeno(1,2,3-c,d)pyrene	ug/L	0.5	0.56	112	0.5	0.48	96	-	15	
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	DW#8	045558-0003MS	Naphthalene	ug/L	5	3.08	62	5	2.14	43	-	36	CAL 15-Feb-89
				Acenaphthalene	ug/L	5	3.46	69	5	2.66	53	-	26	
				Acenaphthene	ug/L	10	7.01	70	10	6.49	65	-	10	
				Fluorene	ug/L	1	0.883	88	1	0.673	67	-	25	
				Phenanthrene	ug/L	0.4	0.393	98	0.4	0.323	81	-	20	
				Anthracene	ug/L	0.2	0.196	98	0.2	0.171	86	-	14	
				Fluoranthene	ug/L	0.5	0.539	108	0.5	0.463	93	-	15	
				Pyrene	ug/L	1	1.06	106	1	0.913	91	-	15	
				Benzo(a)anthracene	ug/L	0.5	0.526	105	0.5	0.440	88	-	15	
				Chrysene	ug/L	0.5	0.54	108	0.5	0.466	93	-	15	
				Benzo(b)fluoranthene	ug/L	0.25	0.213	85	0.25	0.185	74	-	14	
				Benzo(k)fluoranthene	ug/L	0.25	0.214	86	0.25	0.183	73	-	16	
				Benzo(a)pyrene	ug/L	0.5	0.56	112	0.5	0.47	94	-	17	
				Dibenzo(a,h)anthracene	ug/L	2	2.12	106	2	1.8	90	-	16	
				Benzo(g,h,i)perylene	ug/L	1	0.937	94	1	0.784	78	-	18	
				Indeno(1,2,3-cd)pyrene	ug/L	0.5	0.565	113	0.5	0.477	95	-	17	

* RPD values were calculated by the laboratory.

Table C 3 8 Wet Weather 1

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE: MS CONC	MATRIX SPIKE: MS REC CONC	MATRIX SPIKE: MS REC (%)	MATRIX SPIKE DUPLICATE: MSD CONC	MATRIX SPIKE DUPLICATE: MSD REC CONC	MATRIX SPIKE DUPLICATE: MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Volatile Organics	WATER	WW#1	55300 L3	Phenol	ug/L	100	25	25	-	-	-	10--43	-	Anametrix 5-May-88
				2 Chlorophenol	ug/L	100	60	60	-	-	-	13--84	-	
				1,4 Dichlorobenzene	ug/L	50	28	56	-	-	-	12--60	-	
				Nitrosodipropylamine	ug/L	50	35	70	-	-	-	25--88	-	
				1,2,4 Trichlorobenzene	ug/L	50	30	60	-	-	-	17--70	-	
				4 Chloro-3-methylphenol	ug/L	100	85	85	-	-	-	10--127	-	
				Acenaphtene	ug/L	50	38	78	-	-	-	27--123	-	
				4 Nitrophenol	ug/L	100	32	32	-	-	-	10--86	-	
				2,4 Dinitrotoluene	ug/L	50	41	82	-	-	-	43--117	-	
				Pentachlorophenol	ug/L	100	100	100	-	-	-	10--151	-	
				Pyrene	ug/L	50	43	86	-	-	-	47--148	-	
METALS	WATER	WW#1	2330	Arsenic		-	-	120	-	-	120	-	0	ToxScan 27-May-88
				Cadmium		-	-	117	-	-	70	-	0	
				Chromium		-	-	86	-	-	102	-	25	
				Copper		-	-	114	-	-	88	-	3.2	
				Lead		-	-	134	-	-	100	-	0	
				Mercury		-	-	104	-	-	100	-	0	
				Nickel		-	-	103	-	-	106	-	4.3	
				Selenium		-	-	118	-	-	97	-		
				Silver		-	-	80	-	-	NA	-	10.2	
				Zinc		-	-	85	-	-	100	-	0	

Table C.3.7 Wet Weather 2

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No.	ANALYTES	UNITS	MATRIX SPIKE: MS CONC.	MATRIX SPIKE: MS REC. CONC.	MATRIX SPIKE: MS REC. (%)	MATRIX SPIKE DUPLICATE: MSD CONC.	MATRIX SPIKE DUPLICATE: MSD REC. CONC.	MATRIX SPIKE DUPLICATE: MSD REC. (%)	LAB REC. LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
METALS	WATER	WW#2	3264	Arsenic		-	-	72	-	-	78	-	NA	ToxScan
				Cadmium		-	-	102	-	-	92	-	9	29-Nov-88
				Chromium		-	-	127	-	-	121	-	2	
				Copper		-	-	126	-	-	130	-	3	
				Lead		-	-	250	-	-	125	-	13	
				Mercury		-	-	98	-	-	80	-	25	
				Selenium		-	-	149	-	-	131	-	18	
				Silver		-	-	87	-	-	72	-	NA	
				Zinc		-	-	78	-	-	NA	-	8	
TOC	WATER	WW#2	11-635-13	TOC		-	-	80	-	-	-	-	-	B&C 24-Nov-88
Chlorinated Herbicides	WATER	WW#2	11-635-15	2,4,5-T		-	-	140	-	-	28	-	-	B&C
				2,4,5-TP Silvex		-	-	110	-	-	18	-	-	24-Nov-88
				2,4-D		-	-	130	-	-	22	-	-	
				2,4-DB		-	-	190	-	-	88	-	-	
				Dicamba		-	-	100	-	-	32	-	-	
				Dinoseb		-	-	71	-	-	12	-	-	

* RPD values were calculated by the laboratory.

Table C 3 8 Wet Weather 3

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS				C	QIC	[illegible] (%)	QC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	WW#3	45459-0004	Naphthalene	ug/L	5	1 4	.	5	1 5	30	-	7	CAL 4-Feb-89
				Fluorene	ug/L	1	0 75	75	1	0.78	78	-	4	
				Pyrene	ug/L	1	1 3	97	1	1 4	107	-	10	
				Benzo(a)pyrene	ug/L	0 5	0 65	130	0 5	0 65	130	-	0	
				Indeno(1,2,3 c,d)pyrene	ug/L	0.5	0 65	130	0 5	0 64	128	-	2	
Polynuclear Aromatic Hydrocarbons (PAH)	WA ER	WW#3	045459-4MS/MSD	Naphthalene	ug/L	5	1 37	27	5	1 53	31	-	14	CAL 4-Feb-89
				Acenaphthylene	ug/L	5	3 5	70	5	3 46	69	-	1	
				Acenaphthene	ug/L	10	7 64	76	10	6 78	68	-	1	
				Fluorene	ug/L	1	0 752	75	1	0 779	78	-	4	
				Phenanthrene	ug/L	0.4	0 582	146	0.4	0 572	143	-	2	
				Anthracene	ug/L	0 2	0 158	79	0 2	0 173	87	-	10	
				Fluoranthene	ug/L	0.5	0 631	129	0.5	0 685	119	-	8	
				Pyrene	ug/L	1	1 34	101	1	1 38	105	-	4	
				Benzo(a)anthracene	ug/L	0 5	0 493	99	0 5	0 513	103	-	4	
				Chrysene	ug/L	0 5	0 588	118	0 5	0 608	122	-	3	
				Benzo(b)fluoranthene	ug/L	0 25	0 395	158	0 25	0 398	159	-	0.8	
				Benzo(k)fluoranthene	ug/L	0 25	0 256	102	0 25	0 26	104	-	2	
				Benzo(a)pyrene	ug/L	0 5	0 65	130	0 5	0 648	130	-	0	
				Dibenzo(a,h)anthracene	ug/L	2	1 62	81	2	1 58	78	-	3	
				Benzo(g,h,i)perylene	ug/L	1	0 761	76	1	0 823	82	-	7	
				Indeno(1,2,3 cd)pyrene	ug/L	0 5	0 648	130	0 5	0 644	129	-	1	

Table C 3 9 Wet Weather 4

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE MS CONC	MS REC CONC	MS REC (%)	MATRIX SPIKE DUPLICATE MSD CONC	MSD REC CONC	MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	WW#4	045598 0005MS	Naphthalene	ug/L	5	ND	NC	-	-	-	-	-	CAL 17-Feb-89
				Fluorene	ug/L	1	0 50	50	-	-	-	-	-	
				Pyrene	ug/L	1	1.2	120	-	-	-	-	-	
				Benzo(a)pyrene	ug/L	0 5	0 5	100	-	-	-	-	-	
				Indeno(1,2,3 c,d)pyrene	ug/L	0 5	0 66	132	-	-	-	-	-	
TCC	WATER	WW#4	02-154-14	TCC		-	-	110	-	-	-	-	-	B&C
TCX				TCX		-	-	107	-	-	-	-	-	

* RPD values were calculated by the laboratory

Table C 3 10 Wet Weather 5

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE MS CONC	MATRIX SPIKE MS REC CONC	MATRIX SPIKE MS REC (%)	MATRIX SPIKE DUPLICATE MSD CONC	MATRIX SPIKE DUPLICATE MSD REC CONC	MATRIX SPIKE DUPLICATE MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
TOC	WATER	WW#5	02-380-015	TOC		-	-	120	-	-	-	-	-	B&C
TOX				TOX		-	-	105	-	-	-	-	-	
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	WW#5	045550-0003MS	Naphthalene	ug/L	5	ND	NC	-	-	-	-	-	CAL 22-Feb-88
				Fluorene	ug/L	1	0.53	53	-	-	-	-	-	
				Pyrene	ug/L	1	2.0	90	-	-	-	-	-	
				Benzo(a)pyrene	ug/L	0.5	1.2	58	-	-	-	-	-	
				Indeno(1,2,3 c,d)pyrene	ug/L	0.5	1.6	NC	-	-	-	-	-	
									SAMPLE					
Polynuclear Aromatic Hydrocarbons (PAH)	WATER	WW#5	045888-0001	Naphthalene	ug/L	-	-	-	ND	ND	-	-	NC	CAL 16-Feb-88
				Acenaphthalene	ug/L	-	-	-	ND	ND	-	-	NC	
				Acenaphthene	ug/L	-	-	-	ND	ND	-	-	NC	
				Fluorene	ug/L	-	-	-	ND	ND	-	-	NC	
				Phenanthrene	ug/L	-	-	-	ND	ND	-	-	NC	
				Anthracene	ug/L	-	-	-	ND	ND	-	-	NC	
				Fluoranthene	ug/L	-	-	-	2.4	2.6	-	-	8	
				Pyrene	ug/L	-	-	-	2	2.2	-	-	9.5	
				Benzo(a)anthracene	ug/L	-	-	-	0.56	0.6	-	-	6.9	
				Chrysene	ug/L	-	-	-	ND	ND	-	-	NC	
				Benzo(b)fluoranthene	ug/L	-	-	-	0.70	0.86	-	-	9.8	
				Benzo(k)fluoranthene	ug/l	-	-	-	0.34	0.37	-	-	8.5	
				Benzo(a)pyrene	ug/L	-	-	-	0.91	1	-	-	9.4	
				Dibenzo(a,h)anthracene	ug/L	-	-	-	ND	ND	-	-	NC	
				Benzo(g,h,i)perylene	ug/L	-	-	-	1.3	1.5	-	-	14	
				Indeno(1,2,3 cd)pyrene	ug/L	-	-	-	1.4	1.2	-	-	15	

Table C 3 11 Sediment 1

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE MS CONC	MATRIX SPIKE MS REC CONC	MATRIX SPIKE MS REC (%)	MATRIX SPIKE DUPLICATE MSD CONC	MATRIX SPIKE DUPLICATE MSD REC CONC	MATRIX SPIKE DUPLICATE MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Volatile Organics	SOIL	Sed#1	55304 R 3	Phenol	mg/kg	3300	2300	70	3300	2500	76	10--85	8	Anametrix 13-Apr-88
				2 Chlorophenol	mg/kg	3300	2200	67	3300	2900	88	18--70	4	
				1,4 Dichlorobenzene	mg/kg	1700	1000	59	1700	1100	65	10--70	10	
				Nitrosodipropylamine	mg/kg	1700	1200	71	1700	1200	70	10--83	0	
				1,2,4 Trichlorobenzene	mg/kg	1700	1100	65	1700	1200	71	12--70	0	
				4 Chloro 3 methylphenol	mg/kg	3300	2900	88	3300	3100	94	30--80	7	
				Acenaphthene	mg/kg	1700	1400	82	1700	1500	88	10--110	7	
				4 Nitrophenol	mg/kg	3300	3000	91	3300	3000	91	20--110	0	
				2,4 Dinitrotoluene	mg/kg	1700	1400	82	1700	1500	88	27--104	7	
				Pentachlorophenol	mg/kg	3300	2300	70	3300	2400	73	10--128	4	
				Pyrene	mg/kg	1700	1500	88	1700	1700	100	33--120	13	

* RPD values were calculated by the laboratory.

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Table C 3 12 Sediment 2

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE MS CONC	MS REC CONC	MS REC (%)	MATRIX SPIKE DUPLICATE MSD CONC	MSD REC CONC	MSD REC (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Pesticides & PCBs	SOIL	Sed#2	2376	Lindane		-	-	82	-	-	88	-	4.6	TexScan 8-Jun-88
				Heptchlor		-	-	104	-	-	110	-	2.8	
				Aldrin		-	-	60	-	-	60	-	0	
				Dieldrin		-	-	86	-	-	96	-	4.1	
				Endrin		-	-	108	-	-	112	-	1.8	
				4,4'-DDT		-	-	150	-	-	130	-	14	

Table C 3.13 Sediment 3

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No.	ANALYTES	UNITS	MATRIX SPIKE: MS CONC.	MATRIX SPIKE: MS REC. CONC.	MATRIX SPIKE: MS REC. (%)	MATRIX SPIKE DUPLICATE: MSD CONC.	MATRIX SPIKE DUPLICATE: MSD REC. CONC.	MATRIX SPIKE DUPLICATE: MSD REC. (%)	LAB REC LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Organophosphorus Pesticides	SOIL	Sed#3	S8-08-261-02B	Ethoprop	mg/kg	-	-	0.99	-	0.8	81	-	-	TexScan 6-Oct-88
				Ethion	mg/kg	-	-	0.99	-	0.87	88	-	-	
Chlorinated Herbicides	SOIL	Sed#3	08-610-14	2,4,5-T		-	-	-	-	-	86	-	-	BAC 23-Aug-88
				2,4,5-TP		-	-	-	-	-	75	-	-	
				2,4-D		-	-	-	-	-	56	-	-	

* RPD values were calculated by the laboratory.

Table C 3-14 Sediment 4

CHEMICAL GROUP	SAMPLE MATRIX	SAMPLING EVENT	SAMPLE ID No	ANALYTES	UNITS	MATRIX SPIKE: MS CONC	MATRIX SPIKE: MS REC. CONC	MATRIX SPIKE: MS REC. (%)	MATRIX SPIKE DUPLICATE: MSD CONC	MATRIX SPIKE DUPLICATE: MSD REC. CONC	MATRIX SPIKE DUPLICATE: MSD REC (%)	LAB REC. LIMITS (%)	RPD* (%)	LAB/ ANALYSIS DATE
Chlorinated Herbicides	SOIL	Sed#4	12-322-17	2,4,5-T		-	-	120	-	-	92	-	-	B&C 24-Dec-88
				2,4,5-TP		-	-	93	-	-	65	-	-	
				2,4-D		-	-	100	-	-	76	-	-	
				2,4-DB		-	-	120	-	-	88	-	-	
				Dicamba		-	-	98	-	-	84	-	-	

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APPENDIX C.4
RESULTS OF METHOD, FIELD, AND TRIP BLANKS

MB	Method Blank
TB	Trip Blank
FB	Field Blank
EB	Equipment Blank - collected only during the wet weather sampling rounds; see QA/QC discussion on blank contamination for details

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Table C 4-1 Dry Weather 1

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No	ANALYTES	CONC.	UNITS	SAMPLING DATE	REMARKS
Volatile Organics	EPA 624	DW#1	MB	Methylene Chloride	6	ug/L	8-Mar-88	
Semivolatile Organics	EPA 625	DW#1	MB	BEHP*	18	ug/L	8-Mar-88	

* bis(2-ethylhexyl)phthalate

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Table C 4-2 Dry Weather 2

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No	ANALYTES	CONC	UNITS	SAMPLING DATE	REMARKS
Volatile Organics	EPA 624	DW#2	MB	Acetone	27	ug/L	8-Apr-88	
				Methylene Chloride	11	ug/L		
Semivolatile Organics	EPA 625	DW#2	MB	BEHP*	800	ug/L	9-Apr-88	
Semivolatile Organics	EPA 625	DW#2	MB	BEHP*	410	ug/L	10-Apr-88	

* bis(2-ethylhexyl)phthalate

Table C.4-3. Dry Weather 4

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Chlor. Herbicides	SW8150	DW#4	FB	Chlor. Herbicides	ND	ug/l	23-Aug-88
TOX	9020	DW#4	FB	TOX	ND	mg/L	23-Aug-88
Chlor. Herbicides	SW8150	DW#4	TB	Chlor. Herbicides	ND	ug/L	23-Aug-88
TOX	9020	DW#4	TB	TOX	ND	mg/L	23-Aug-88
Total Coliform	909C	DW#4	FB	Total Coliform	ND	MPN/100 ml	1-Sep-88
Fecal Coliform	909A	DW#4	FB	Fecal Coliform	ND	MPN/100 ml	1-Sep-88
Metals	SW6010	DW#4	FB/ T88-2797	Mercury Zinc	0.0003 0.011	mg/L mg/L	26-Aug-88
Metals	SW6010	DW#4	MB	Metals	ND		26-Aug-88
Nitrite	354.1	DW#4	FB/ T88-2797	Nitrite	ND	mg/L	26-Aug-88
Nitrate	353.2	DW#4	FB/ T88-2797	Nitrate	ND	mg/L	26-Aug-88
TKN	351.2	DW#4	FB/ T88-2797	TKN	ND	mg/L	26-Aug-88
TSS	160.3	DW#4	FB/ T88-2797	TSS	2.5	mg/L	26-Aug-88
BOD	405.1	DW#4	FB/ T88-2797	BOD	8	mg/L	26-Aug-88
Polynuclear Aromati Hydrocarbons (PAH)	EPA 610	DW#4	FB/ S8-08-281 -04A	PAH Compounds	ND	ug/L	26-Aug-88

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Table C.4-4. Dry Weather 5

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	DW#5	MB	PAH	ND	ug/L	•
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	DW#5	FB	PAH	ND	ug/L	13-Dec-88
TOX	9020	DW#5	FB/ 12-322-5	TOX	0.03	mg/L	13-Dec-88
TOX	9020	DW#5	MB/ 12-322-12	TOX	ND	mg/L	13-Dec-88
Chlor. Herbicides	SW8150	DW#5	FB/ 12-322-5	Chlor. Herbicides	ND	ug/L	13-Dec-88
Chlor. Herbicides	SW8150	DW#5	MB/ 12-322-19	Chlor. Herbicides	ND	ug/L	13-Dec-88
Total Coliform	909C	DW#5	FB	Total Coliform	ND	MPN/100 ml	24-Dec-88
Fecal Coliform	909A	DW#5	FB	Fecal Coliform	ND	MPN/100 ml	24-Dec-88
Pesticides & PCBs	E608	DW#5	FB/ T88-3340	Pest. & PCBs	ND	ug/L	24-Dec-88
Metals	SW6010	DW#5	FB/ T88-3340	Zinc	0.014	mg/L	24-Dec-88
Metals	SW6010	DW#5	MB	Metals	ND	mg/L	24-Dec-88
TKN	351.2	DW#5	FB/ T88-3340	TKN	ND	mg/L	24-Dec-88
TSS	160.3	DW#5	FB/ T88-3340	TSS	ND	mg/L	24-Dec-88
BOD	405.1	DW#5	FB/ T88-3340	BOD	ND	mg/L	24-Dec-88
Hardness	200.7	DW#5	FB/ T88-3340	Hardness	ND	mg/L	24-Dec-88
Turbidity	180.1	DW#5	FB/ T88-3340	Turbidity	ND	NTU	24-Dec-88
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	DW#5	MB/ 44880-MB	PAH Compounds	ND	ug/L	24-Dec-88

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Table C.4-5. Dry Weather 6

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Total Coliform	909C	DW#6	FB	Total Coliform	ND	MPN/100 ml	14-Feb-89
Fecal Coliform	909A	DW#6	FB	Fecal Coliform	ND	MPN/100 ml	14-Feb-89
Pesticides & PCBs	E608	DW#6	FB/ T-3531	Pesticides & PCBs	ND	ug/L	14-Feb-89
Metals	SW6010	DW#6	FB/ T-3531	Lead Zinc	0.003 0.010	mg/L	14-Feb-89
Metals	SW6010	DW#6	MB	Metals	ND	mg/L	14-Feb-89
TKN	351.2	DW#6	FB/ T-3531	TKN	ND	mg/L	14-Feb-89
TSS	160.3	DW#6	FB/ T-3531	TSS	ND	mg/L	14-Feb-89
BOD	405.1	DW#6	FB/ T-3531	BOD	ND	mg/L	14-Feb-89
Hardness	200.7	DW#6	FB/ T-3531	Hardness	ND	mg/L	14-Feb-89
Turbidity	180.1	DW#6	FB/ T-3531	Turbidity	ND	NTU	14-Feb-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	DW#6	MB/ 45559-0006SA	PAH Compounds	ND	ug/L	14-Feb-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	DW#6	MB/ 45559-0006SA	PAH Compounds	ND	ug/L	14-Feb-89

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Table C.4-6. Dry Weather 7

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Total Coliform	909C	DW#7	FB	Total Coliform	ND	MPN/100 ml	19-Apr-89
Fecal Coliform	909A	DW#7	FB	Fecal Coliform	ND	MPN/100 ml	19-Apr-89
TOC	415.1	DW#7	FB/ 04-195-8	TOC	ND	mg/L	19-Apr-89
Pesticides & PCBs	E608	DW#7	FB/ T-3839	Pest. & PCBs	ND	ug/L	19-Apr-89
Metals	SW6010	DW#7	FB/ T-3839	Zinc	0.006	mg/L mg/L	19-Apr-89
Metals	SW6010	DW#7	MB	Metals	ND	mg/L	19-Apr-89
TKN	351.2	DW#7	FB/ T-3839	TKN	ND	mg/L	19-Apr-89
TSS	160.3	DW#7	FB/ T-3839	TSS	ND	mg/L	19-Apr-89
BOD	405.1	DW#7	FB/ T-3839	BOD	ND	mg/L	19-Apr-89
Hardness	200.7	DW#7	FB/ T-3839	Hardness	ND	mg/L	19-Apr-89
Turbidity	180.1	DW#7	FB/ T-3839	Turbidity	ND	NTU	19-Apr-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	DW#7	FB 45559-0006SA	PAH Compounds	ND	ug/L	19-Apr-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	DW#7	MB	PAH Compounds	ND	ug/L	19-Apr-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	DW#7	FB 45559-0006SA	PAH Compounds	ND	ug/L	19-Apr-89

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Table C 4-7 Wet Weather 1

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE	REMARKS
Volatile Organics	EPA 624	WW#1	MB	Acetone	20	ug/L	23-Apr-89	
				Methylene Chloride	7	ug/L		
Volatile Organics	EPA 624	WW#1	MB	Methylene Chloride	9	ug/L	26-Apr-89	
				1,1,1-trichloroethane	9	ug/L		
Semivolatile Organics	EPA 625	WW#1	MB	BEHP*	11	ug/L	4-May-89	

* bis(2-ethylhexyl)phthalate

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Table C 4-8 Wet Weather 2

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No	ANALYTES	CONC	UNITS	SAMPLING DATE
TOC	415.1	WW#2	MB 11-635-17	TOC	0.7	mg/L	24-Nov-88
TOX	9020	WW#2	MB 11-635-17	TOX	ND	mg/L	24-Nov-88
Chlorinated Herbicides	SW8150	WW#2	MB 11-635-17	Chlorinated Herb	ND	ug/L	24-Nov-88
Volatile Organics	EPA 624	WW#2	MB	Volatile Organics	ND	ug/L	2-Dec-88
Volatile Organics	EPA 624	WW#2	MB	Volatile Organics	ND	ug/L	3-Dec-88
Volatile Organics	EPA 624	WW#2	MB	Volatile Organics	ND	ug/L	5-Dec-88
Semivolatile Organics	EPA 625	WW#2	MB	BEHP	120	ug/L	6-Dec-88
Semivolatile Organics	EPA 625	WW#2	MB	BEHP	50	ug/L	7-Dec-88
Metals	SW6010	WW#2	EB/ T88-3264	Cadmium Chromium, Total Mercury Silver	0.0002 0.002 0.0004 0.0002	mg/L mg/L mg/L mg/L	29-Nov-88
Metals	SW6010	WW#2	MB	Cadmium Chromium, Total Mercury Silver	0.0002 ND ND ND	mg/L mg/L mg/L mg/L	29-Nov-88
TKN	351.2	WW#2	EB T88-3264	TKN	ND	mg/L	29-Nov-88
Ammonia (as N)	350.1	WW#2	EB/ T88-3264	Ammonia (as N)	ND	mg/L	
Nitrate (as N)	353.2	WW#2	EB/ T88-3264	Nitrate (as N)	ND	mg/L	
Nitrite (as N)	354.1	WW#2	EB/ T88-3264	Nitrite (as N)	ND	mg/L	
Hardness	200.7	WW#2	EB/ T88-3264	Hardness	ND	mg/L	

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Table C 4-9 Wet Weather 2 (Continued)

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
TOX	9020	WW#2	EB/ 11-635-12	TOX	ND	mg/L	24-Nov-88
TOX	9020	WW#2	MB/ 11-635-17	TOX	ND	mg/L	24-Nov-88
TOC	415.1	WW#2	MB/ 11-635-17	TOC	0.7	mg/L	24-Nov-88
Chlor. Herbicides	SW8150	WW#2	EB/ 11-635-12	Chlor. Herbicides	ND	ug/L	24-Nov-88
Chlor. Herbicides	SW8150	WW#2	MB/ 11-635-12	Chlor. Herbicides	ND	ug/L	24-Nov-88
Volatile Organics	EPA 624	WW#2	EB 8811183-12	Volatile Organics	ND	ug/L	3-Dec-88
Semivolatile Organics	EPA 625	WW#2	EB 8811183-12	Semivolatile Organics	ND	ug/L	8-Dec-88
Pesticides & PCB's	EPA 608	WW#2	EB	Pesticides & PCB	ND	ug/L	24-Nov-88
Total Coliform	909C	WW#2	EB	Total Coliform	ND	MPN/100 ml	24-Nov-88
Fecal Coliform	909A	WW#2	EB	Fecal Coliform	ND	MPN/100 ml	24-Nov-88

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Table C.4-10 Wet Weather 3

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No	ANALYTES	CONC.	UNITS	SAMPLING DATE
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#3	MB	PAH Compounds	ND		2-Feb-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#3	EB	PAH Compounds	ND		4-Feb-89
TOX	9020	WW#3	EB 01-539-8	TOX	ND	mg/L	24-Jan-88
Metals	SW6010	WW#3	EB T-3497	Cadmium Zinc	0.0019 0.01	mg/L	14-Apr-88
Metals	SW6010	WW#3	MB	Metals	ND	mg/L	14-Apr-88
TKN	351.2	WW#3	EB T-3497	TKN	ND	mg/L	14-Apr-88
TSS	160.3	WW#3	EB T-3497	TSS	ND	mg/L	14-Apr-88
BOD	405.1	WW#3	EB T-3497	BOD	ND	mg/L	14-Apr-88
Hardness	200.7	WW#3	EB T-3497	Hardness	ND	mg/L	14-Apr-88
Turbidity	180.1	WW#3	EB T-3497	Turbidity	ND	NTU	14-Apr-88
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#3	EB 45559-0006SA	PAH Compounds	ND	ug/L	2-Feb-88
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#3	MB 45559-MB	PAH Compounds	ND	ug/L	2-Feb-88
Total Coliform	909C	WW#3	EB	Total Coliform	ND	MPN/100 ml	2-Feb-88
Fecal Coliform	909A	WW#3	EB	Fecal Coliform	ND	MPN/100 ml	2-Feb-88
Fecal Strep		WW#3	EB	Fecal Strep	ND	MPN/100 ml	2-Feb-88
Pesticides & PCB s	EPA 608	WW#3	EB T-3497	4,4'-DDE	0.077	ug/L	14-Apr-88

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Table C.4-11 Wet Weather 4

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
TOX	9020	WW#4	EB 02-154-12	TOX	ND	mg/L	5-Feb-89
Metals	SW6010	WW#4	EB T-3553	Metals	ND	mg/L	18-Apr-89
Metals	SW6010	WW#4	MB	Metals	ND	mg/L	18-Apr-89
TKN	351.2	WW#4	EB T-3553	TKN	ND	mg/L	18-Apr-89
TSS	160.3	WW#4	EB T-3553	TSS	ND	mg/L	18-Apr-89
BOD	405.1	WW#4	EB T-3553	BOD	ND	mg/L	18-Apr-89
Hardness	200.7	WW#4	EB T-3553	Hardness	ND	mg/L	18-Apr-89
Turbidity	180.1	WW#4	EB T-3553	Turbidity	ND	NTU	18-Apr-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#4	EB 45556-0012	PAH Compounds	ND	ug/L	17-Feb-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#4	MB 45556-MB	PAH Compounds	ND	ug/L	17-Feb-89
Pesticides & PCB's	EPA 608	WW#4	EB T-3553	Pesticides & PCB	ND	ug/L	18-Apr-89

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Table C.4-12 Wet Weather 5

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
TOX	9020	WW#5	EB 02-358-13	TOX	ND	mg/L	10-Feb-89
Metals	SW6010	WW#5	EB T-3572	Copper	0.004	mg/L	10-Feb-89
Metals	SW6010	WW#5	MB	Metals	ND	mg/L	10-Feb-89
TKN	351.2	WW#5	EB T-3572	TKN	ND	mg/L	10-Feb-89
TSS	160.3	WW#5	EB T-3572	TSS	ND	mg/L	10-Feb-89
BOD	405.1	WW#5	EB T-3572	BOD	ND	mg/L	10-Feb-89
Hardness	200.7	WW#5	EB T-3572	Hardness	ND	mg/L	10-Feb-89
Turbidity	180.1	WW#5	EB T-3572	Turbidity	ND	NTU	10-Feb-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#5	EB 45688-0013	PAH Compounds	ND	ug/L	22-Feb-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#5	MB 45688-MB	PAH Compounds	ND	ug/L	22-Feb-89
Pesticides & PCB's	EPA 608	WW#5	EB T-3572	Pesticides & PCB	ND	ug/L	10-Feb-89
Total Coliform	909C	WW#5	EB	Total Coliform	ND	MPN/100 ml	10-Feb-89
Fecal Coliform	909A	WW#5	EB	Fecal Coliform	ND	MPN/100 ml	10-Feb-89

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Table C.4-13 Wet Weather 6

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Pesticides & PCB's	EPA 608	WW#6	EB T-3659	Pesticides & PCB	ND	ug/L	3-Mar-89
Total Coliform	909C	WW#6	EB	Total Coliform	ND	MPN/100 ml	3-Mar-89
Fecal Coliform	909A	WW#6	EB	Fecal Coliform	ND	MPN/100 ml	3-Mar-89
Metals* (Total)	SW6010	WW#6	EB T-3659	Chromium Copper Lead Nickel Zinc	0.052 0.011 0.001 0.06 0.018	mg/L	3-Mar-89
Metals* (Dissolved)	SW6010	WW#6	EB T-3659	Chromium Copper Nickel Zinc	0.001 0.008 0.004 0.015	mg/L	3-Mar-89
Metals (Total)	SW6010	WW#6	MB	Chromium Chromium	0.002 0.001	mg/L	3-Mar-89
TKN	351.2	WW#6	EB T-3659	TKN	ND	mg/L	3-Mar-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#6	EB 46005-0009	PAH Compounds	ND	ug/L	10-Mar-89
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	WW#6	MB 46005-MB	PAH Compounds	ND	ug/L	10-Mar-89
TOX	9020	WW#6	EB 03-115-11	TOX	ND	mg/L	3-Mar-89

* Blank water was taken directly from the solar still; see QA/QC discussion on blank contamination

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Table C.4-14 Wet Weather 7

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Metals	SW6010	WW#7	EB T-3769	Arsenic Chromium Zinc	0.001 0.001 0.003	mg/L	29-Mar-89
Metals	SW6010	WW#7	MB	Metals	ND	mg/L	29-Mar-89

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Table C.4-15 Sediment 2

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Volatile Organics	EPA 624	Sed#2	MB	Volatile Organics	ND	ug/kg	3-Jun-88
Semivolatile Organics	EPA 625	Sed#2	MB	BEHP*	940	ug/kg	3-Jun-88

* bis(2-ethylhexyl)phthalate

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Table C.4-16 Sediment 3

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Semivolatile Organics	EPA 625	Sed#3	MB	BEHP*	2400	ug/kg	13-Sep-88
Semivolatile Organics	EPA 625	Sed#3	MB	BEHP*	1400	ug/kg	13-Sep-88

* bis(2-ethylhexyl)phthalate

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Table C.4-17 Sediment 4

CHEMICAL GROUP	ANALYSIS METHOD	SAMPLING EVENT	SAMPLE/ ID No.	ANALYTES	CONC.	UNITS	SAMPLING DATE
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	Sed#4	MB1	PAH Compounds	ND	ug/kg	-
Polynuclear Aromatic Hydrocarbons (PAH)	EPA 610	Sed#4	MB2	PAH Compounds	ND	ug/kg	-
Chlorinated Herbicides	SW8150	Sed#4	MB 12-322-12	Chlorinated Herb	ND	mg/kg	13-Dec-88

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APPENDIX C.5
RESULTS OF ERA QUALITY CONTROL SAMPLES

Table C.5.1. SUMMARY OF RELATIVE PERCENT DIFFERENCES (RPD) BETWEEN ACTUAL AND ERA CERTIFIED CONCENTRATIONS

CONSTITUENT	1st Quarter '88			2nd Quarter '88			3rd Quarter '88			4th Quarter '88			1st Quarter '89			
	ACTUAL CONC. (µg/L)	ERA * CERT. VALUE (µg/L)	RPD (%)	ACTUAL CONC. (µg/L)	ERA CERT. VALUE (µg/L)	RPD (%)	ACTUAL CONC. (µg/L)	ERA CERT. VALUE (µg/L)	RPD (%)	ACTUAL CONC. (µg/L)	ERA CERT. VALUE (µg/L)	RPD (%)	ACTUAL CONC. (µg/L)	ERA CERT. VALUE (µg/L)	RPD (%)	AVG.† (%)
ARSENIC	165	133	11	130	152	-8	55	75.8	-16	70	43.6	23	124	131	-3	2
CADMIUM	78	78	0	105	102	1	96	97.9	-1	280	230	10	80	54.1	19	6
CHROMIUM	87	91	-2	175	181	4	100	99	1	200	172	8	300	257	8	4
COPPER	70	68	3	99	91	4	135	110	10	230	200	7	90	99.5	-5	4
LEAD	95	89	3	115	141	-10	175	169	2	200	180	11	140	154	-5	0
MERCURY	10	11	-5	11.2	9.8	8	4.6	3.8	10	4.5	3.4	14	4.4	3.4	13	6
NICKEL	74	77	-2	87	83	2	140	141	0	60	74.1	-11	80	131	-24	-7
SELENIUM	72	79	-5	134	137	-1	60	68	-6	28	49.1	-31	70	81.6	-8	-10
SILVER	75	79	-3	-	80	NC	-	-	NC	60	170	-55	20	40	-33	-30
ZINC	180	134	8	192	183	8	185	183	1	300	280	7	220	188	8	7
TKN	5	5.0	0	4.8	3	21	2.8	4	-18	3.7	4.8	-11	3.7	4.8	-11	-4
NITRATE as N	6.4	6.7	-2	4.4	4.5	-1	7	6.5	4	3.72	5.8	-20	-	-	NC	-6
PHOSPHATE as P	7.4	7.4	0	4.1	3.8	2	4.8	4.4	4	6.14	7.1	-7	-	-	NC	0
TSS	-	-	NC	85	71	-4	36.8	35	3	-	-	NC	78	85	-4	-2
BOD	-	-	NC	58	41	17	50	53	-3	80.2	82	13	32	43	-15	3

ERA = External Reference Standards provided by Environmental Resource Associates, Arvada, Colorado
\- = Analysis Not Performed
NC = Not Calculated
AVG.† = Average of RPDs for All Available Quarterly Results

Table C.5.2 First Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	ERA Certified Value	ERA Target Range	Comments
Oil and Grease	30 mg/bottle	35 mg/bottle	28-42 mg/bottle	
TRACE METALS	(ug/L)	(ug/L)	(ug/L)	
Arsenic	165	133	133-160	Conc. out of target range.
Cadium	78	78	62-94	
Chromium	87	91	73-109	
Copper	70	66	53-79	
Lead	95	89	71-107	
Mercury	10	11.0	8.8-13.0	
Nickel	74	77	62-92	
Selenium	72	79	63-95	
Silver	75	79	63-95	
Zinc	160	134	107-161	
Conventional Constituents				
pH	Value not reported.	9.1	8.9-9.3	
	(mg/L)	(mg/L)	(mg/L)	
BOD(5 day)	Value not reported.	65	49-81	
TOC	Value not reported.	43	34-52	
Kjeldahl nitrogen as N	5	5.0	3.9-6.1	
	(mg/L)	(mg	(mg/L)	
Ammonia as N	6.6	6.[illegible]	5.7-7.3	
Nitrate as N	6.4	6.7	5.9-7.5	
Phosphate as P	7.4	7.4	6.6-8.2	

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Table C.5.2 First Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	ERA Certified Value	ERA Target Range	Comments
VOLATILES (GC/MS)	(ug/L)	(ug/L)	(ug/L)	
chlorobenzene	74	73.1	27-100	
chloroform	15	13.9	10-17	
1,2-dichloroethane	46	46.3	31-66	
ethylbenzene	30	32.1	12-43	
methylene chloride	110	112	39-230	
1,1,1-trichloroethane	140	143	74-220	
trichloroethene	56	54.3	39-75	
SEMIVOLATILE (GC/MS)	(ug/L)	(ug/L)	(ug/L)	
acenaphthene	50	65.1	21-94	
bis(2-chloroethyl)ether	[illegible]6	136	16-212	
4-chlorophenyl phenyl ether	55	64.8	28-102	
di-n-butyl phthalate	87	97.5	15-115	
diethyl phthalate	70	70.5	17-80	
naphthalene	100	173	66-230	
n-nitroso-di-n-propylamine	14	22.8	9-52	
1,2,4-trichlorobenzene	24	62.9	28-89	Conc. out of target range.
PESTICIDES (GC)	(ug/L)	(ug/L)	(ug/L)	
beta-BHC	0.76	0.88	0.31-1.3	
gamma-BHC (Lindane)	0.58	0.39	0.21-0.56	Conc. out of target range.
heptchlor	2.7	2.85	1.9-3.8	
endrin	1.0	1.44	0.6-2.2	
PCB'S (GC)				
Aroclor 1242	0.35	0.219	0.085-0.33	Conc. out of target range.
Toxaphene	0.47	0.263	0.11-0.33	Conc. out of target range.

Table C.5.2 First Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	ERA Certified Value	ERA Target Range	Comments
HERBICIDES (GC)	(mg/L)	(mg/L)	(mg/L)	
2,4-D	0.31	0.540	0.14-0.66	
2,4,5-TP	0.35	0.320	0.11-0.45	

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Table C.5.3 Second Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	ERA Certified Value	ERA Target Range	Comments
Oil and Grease	35 mg/bottle	45 mg/bottle	35-55 mg/bottle	
TRACE METALS	(ug/L)	(ug/L)	(ug/L)	
Arsenic	130	152	122-182	
Cadium	105	102	82-122	
Chromium	175	161	129-193	
Copper	99	91	73-109	
Lead	115	141	113-169	
Mercury	11.2	9.6	7.7-12.0	
Nickel	87	83	66-100	
Selenium	134	137	110-164	
Silver	Conc. not reported	80	64-96	
Zinc	132	163	134-202	
Conventional Constituents				
pH	8.9	9.1	8.9-9.3	
	(mg/L)	(mg/L)	(mg/L)	
BOD(5 day)	58	41	31-51	Conc. out of target range.
TOC	Conc. not reported	27	21-33	
Kjeldahl nitrogen as N	4.6	3	2.4-3.6	Conc. out of target range.
	(mg/L)	(mg/L)		
Total Suspended Soilds	65	71	[illegible]	
	(mg/L)	(mg/L)	(mg/L)	
Ammonia as N	5.7	5.7	5.0-6.4	
Nitrate as N	4.4	4.5	4.0-5.0	
Phosphate as P	4.1	3.9	3.5-4.3	

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Table C.5.3 Second Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	ERA Certified Value	ERA Target Range	Comments
VOLATILES (GC/MS)	(ug/L)	(ug/L)	(ug/L)	
chloroform	35	23.7	16-29	Conc. out of target range.
1,2-dichloroethane	92	78.8	39-108	
bromodichloromethane	11	8.9	4-12	
trans-1,3-dichloropropene	42	26.3	10-43	
toluene	180	160	75-214	
ethylbenzene	101	96.5	36-129	
SEMIVOLATILE (GC/MS)	(ug/L)	(ug/L)	(ug/L)	
acenaphthene	31	75.1	35-109	Conc. out of target range.
benzo(b)fluoranthene	23	45.5	11-72	
benzo(a)pyrene	Not detected	15.9	3-26	Conc. out of target range.
bis(2-ethylhexyl)phthalate	43	102	29-161	
2-chloronapthalene	Not detected	21.1	13-25	Conc. out of target range.
1,3-dichlorobenzene	24	98	25-169	Conc. out of target range.
2,4-dinitrotoluene	54	130	51-181	
hexachlorobutadiene	12	62.9	15-73	Conc. out of target range.
nitrobenzene	49	88	31-158	
HERBICIDES (GC)	(mg/L)	(mg/L)	(mg/L)	
2,4-D	0.11	0.111	0.030-0.135	
2,4,5-TP		0.185	0.065-0.259	

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Table C.5.4 Third Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	EPA Certified Value	ERA Target Range	Comments
Oil and Grease	15 mg/bottle	20 mg/bottle	16-24 mg/bottle	Conc. out of target range.
TRACE METALS	(ug/L)	(ug/L)	(ug/L)	
Arsenic	55	75.8	55-95	
Cadium	96	97.9	73-122	
Chromium	100	99	74-124	
Copper	135	110	83-138	
Lead	175	169	127-211	
Mercury	4.6	3.8	2.8-4.8	
Nickel	140	141	106-176	
Selenium	60	68	57-85	
Zinc	185	183	137-229	
Conventional Constituents				
pH	9.2	8.8	8.6-9.0	
	(mg/L)	(mg/L)	(mg/L)	
BOD(5 day)	50	53	40-66	
TOC	30	35	27-43	
Kjeldahl nitrogen as N	2.8	4	3.2-4.8	Conc. out of target range.
Total Suspended Solids	36.8	35	29-41	
	(mg/L)	(mg/L)	(mg/L)	
Ammc 'a as N	4.6	3.8	3.3-4.3	Conc. out of target range.
Nitrate as N	7	6.5	5.8-7.2	
Phosphate as P	4.8	4.4	3.6-5.2	

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Table C.5.4 Third Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	EPA Certified Value	ERA Target Range	Comments
VOLATILES (GC/MS)	(ug/L)	(ug/L)	(ug/L)	
Methylene Chloride	85	77	27-160	
1,1-Dichloroethane	25	23.3	11-33	
Carbon Tetrachloride	15	12.3	8.8-76	
Benzene	70	58.3	22-76	
Chlorobenzene	19	15.5	5.7-21	
1,1,2,2-Tetrachloroethane	140	132	60-179	
SEMI-VOLATILE (GC/MS)	(ug/L)	(ug/L)	(ug/L)	
1,4-Dichlorobenzene	Not detected	9.65	4.1-12	
Hexachloroethane	Not detected	24.2	9.7-27	Conc. out of target range.
1,2,4-Trichlorobenzene	14	62.6	27-89	Conc. out of target range.
2-Chloronaphthalene	Not detected	13	7.8-15	Conc. out of target range.
Acenaphthylene	Not detected	44.8	15-65	Conc. out of target range.
Acenphthene	20	Not reported		Not in ERA sample.
2,4-dinitrotoluene	91	143	56-199	
Butylbenzylphthalate	63	93.7	14-142	
Bis(2-ethylhexyl)phthalate	33	79.3	22-125	
PESTICIDES (GC)	(ug/L)	(ug/L)	(ug/L)	
Aldrin	0.11	1.42	0.62--1.7	Conc. out of target range.
Heptachlor epoxide	ND	0.385	0.17--0.55	Conc. below laboratory detection limit.
4,4'-DDD	0.095	0.135	0.06--0.16	
4,4'-DDE	0.08	0.26	0.08--0.37	
4,4'-DDT	0.23	Not reported		Not in ERA sample.
Dieldrin	0.083	Not reported		Not in ERA sample.
Endrin	0.06	Not reported		Not in ERA sample.
PCB'S (GC)	(ug/L)	(ug/L)	(ug/L)	
Aroclor 1242	ND	0.219	0.085-0.33	Conc. below laboratory detection limit.

Table C.5.4 Third Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	EPA Certified Value	ERA Target Range	Comments
Toxaphene	ND	0.263	0.11-0.33	Conc. below laboratory detection limit.
HERBICIDES (GC)	(mg/L)	(mg/L)	(mg/L)	
2,4-D	0.3	0.540	0.14-0.66	
2,4,5-TP	0.33	0.320	0.11-0.45	

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Table C.5.5 Fourth Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	ERA Certified Value	ERA Target Range	COMMENTS
Oil and Grease	38 mg/bottle	37 mg/bottle	29-45 mg/bottle	
TRACE METALS	(mg/L)	(mg/L)	(mg/L)	
Arsenic	70	43.6	33-54	Conc. out of target range.
Cadium	280	230	172-288	
Chromium	200	172	129-215	
Copper	230	200	150-250	
Lead	200	160	121-200	
Mercury	4.5	3.4	2.6-4.2	Conc. out of target range.
Nickel	60	74.1	56-93	
Selenium	26	49.1	37-61	Conc. out of target range.
Silver	50	170	110-210	Conc. out of target range.
Zinc	300	260	195-325	
Conventional Constituents				
pH	9.17	9	8.8-9.2	
	(mg/L)	(mg/L)	(mg/L)	
BOD(5 day)	80.2	62	46-78	Conc. out of target range.
TOC				
Kjeldahl nitrogen as N	3.7	4.6	3.7-5.5	
	(mg/L)		(mg/L)	
Ammonia as N	3.65	5.3	4.6-6.0	Conc. out of target range.
Nitrate as N	3.72	5.6	5.0-6.2	Conc. out of target range.
Phosphate as P	6.14	7.1	5.8-8.4	

Table C.5.5 Fourth Quarter ERA Quality Control Samples for 1988

Analyte	Reported Concentration	ERA Certified Value	ERA Target Range	COMMENTS
VOLATILES (GC/MS)	(ug/L)	(ug/L)	(ug/L)	
1,1-dichloroethene	130	112	21-230	
Methylene chloride	87	85.5	30-170	
Trans-1,2-dichloroethene	16	15.3	10-20	
Toluene	19	13.5	7-22	
1,1,2-trichloroethane	98	100	52-140	
Tetrachloroethene	25	22.1	14-29	
SEMI-VOLATILE (GC/MS)	(ug/L)	(ug/L)	(ug/L)	
1,4-dichlorobenzene	31	237	60-390	Conc. out of target range.
bis(2-chloroisopropyl)Ether	14	68.7	25-110	Conc. out of target range.
Diethylphthalate	27	59.4	14-68	
Phenanthrene	12	23.6	12-28	
Fluoranthene	28	43.7	26-60	
Butylbenzyphthalate	41	139	21-210	
PESTICIDES (GC)	(ug/L)	(ug/L)	(ug/L)	
Aldrin	0.12	0.143	0.063-0.17	
Dieldrin	0.52	0.574	0.23-0.81	
Endrin	0.26	0.357	0.11-0.53	
PCB'S (GC)	(ug/L)	(ug/L)	(ug/L)	
Aroclor 1221	X Detected	0.148	0.035-0.26	Conc. below laboratory detection limit.
HERBICIDES (GC)	(mg/L)	(mg/L)	(mg/L)	
2,4-D	Not Detected	0.625	0.17-0.79	Conc. below laboratory detection limit.
2,4,5-TP	Not Detected	0.173	0.061-0.24	Conc. below laboratory detection limit.

Table C.5.6 First Quarter ERA Quality Control Samples for 1989

Analyte	Reported Concentration	ERA Certified Value	ERA Target Range	Comments
Oil and Grease	64 mg/bottle	55 mg/bottle	46-66 mg/bottle	
TRACE METALS	(ug/L)	(ug/L)	(ug/L)	
Arsenic	124	131	98-164	
Cadium	80	54.1	40-68	Conc. out of target range.
Chromium	300	257	192-321	
Copper	90	98.5	74-123	
Lead	140	154	115-192	
Mercury	4.4	3.4	2.6-4.2	Conc. out of target range.
Nickel	80	131	98-164	
Selenium	70	81.6	61-102	
Silver	20	40	21-65	
Zinc	220	188	141-235	
Conventional Constituents				
pH	9.1	8.9	8.7-9.1	
	(mg/L)	(mg/L)	(mg/L)	
BOD(5 day)	32	43	30-68	
TOC	23	28	22-34	
Kjeldahl nitrogen as N	3.7	4.6	3.7-5.5	
Total Suspended Solids	78	85	71-99	
PESTICIDES (GC)	(ug/L)	(ug/L)	(ug/L)	
gamma-BHC (lindane)	0.1	0.098	0.028-0.14	
Dieldrin	0.084	0.073	0.029-0.1	
Endrin	0.1	0.12	0.037-0.18	
Endrin aldehyde	ND	0.064	0.022-0.094	Conc. below laboratory detection limit.
PCB'S (GC)	(ug/L)	(ug/L)	(ug/L)	
Aroclor 1221	ND	0.967	0.14-1.3	Conc. below laboratory detection limit.

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APPENDIX D

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APPENDIX D
SANTA CLARA NONPOINT SOURCE WATER
AND SEDIMENT QUALITY DATA

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APPENDIX D
SANTA CLARA NONPOINT SOURCE WATER AND SEDIMENT QUALITY DATA

The following section presents the water and sediment quality data collected for the Santa Clara Valley Nonpoint Source study. The data are organized by parameter type (e.g., metals, conventional, etc.) and are titled D.1 through D.7. Under each parameter type the data are further subdivided into water samples and sediment samples. In addition, the metals include subgroups for total and dissolved concentrations in the wat r column. Following is a list of the parameter types and the corresponding appendix section:

- D.6 Polynuclear aromatic hydrocarbons
  - D.6-1 Polynuclear aromatic hydrocarbons in water column
  - D.6-2 Polynuclear aromatic hydrocarbons in sediment
- D.7 Volatiles and semi-volatiles
  - D.7-1 Volatiles and semi-volatiles in water column
  - D.7-2 Volatiles and semi-volatiles in sediment
- D.8 Dissolved oxygen data from stream stations and settling data

Within each parameter subgroup, the data are further organized by sample I.D. along rows and with the parameters sampled along columns. The sample I.D. corresponds to the sampling station identification number (e.g., L1 through L7 for land use stations, S1 through S4 for stream stations, and R1 through R6 for reservoir release stations). Under each sample I.D. the data are again subdivided into samples collected during dry (DRY) and wet (WET) weather, when appropriate. Also shown under sample I.D. are field duplicate (FD), lab replicates (LR), and field blanks (FB).

Under each parameter type are the measured concentrations (or ND if non-detected) and the value of the detection limit for the sample collected. Blanks in the data set mean that an analysis was not performed for certain parameters (such as hexavalent chromium) during a particular sampling event.

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D.1 Metals

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D.1-1 Total metals in water column

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Arsenic actual mg/l	D.L. mg/l	Cadmium actual mg/l	D.L. mg/l	Chromium actual mg/l	D.L. mg/l	Hexav Cr actual mg/l	D.L. mg/l	Copper actual mg/l	D.L. mg/l	Lead actual mg/l	D.L. mg/l
STANDARD REPORTING OBJECTIVES							0.001		0.0001		0.001				0.001		0.001
L1	4	20	1988	WET	1	0.001	0.001	ND	0.0002	0.006	0.001			0.021	0.001	0.010	0.001
L1	11	23	1988	WET	2	ND	0.001	0.001	0.0002	0.009	0.001			0.020	0.001	0.045	0.001
L1	2	4	1988	WET	4	ND	0.001	0.0021	0.0002	0.035	0.001	ND	0.01	0.026	0.001	0.050	0.001
L1	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.010	0.001	ND	0.01	0.065	0.001	0.505	0.001
L1	3	2	1988	WET	6	ND	0.001	0.0014	0.0002	0.012	0.001	ND	0.01	0.055	0.001	0.035	0.001
L2	4	20	1988	WET	1	0.002	0.001	0.0052	0.0002	0.010	0.001			0.051	0.001	0.085	0.001
L2	11	23	1988	WET	2	ND	0.001	0.004	0.0002	0.21	0.001			0.051	0.001	0.14	0.001
L2	2	4	1988	WET	4	ND	0.001	0.0035	0.0002	0.042	0.001	ND	0.01	0.046	0.001	0.33	0.001
L2	2	8	1988	WET	5	ND	0.001	0.0052	0.0002	0.075	0.001	ND	0.01	0.047	0.001	0.238	0.001
L2	3	2	1988	WET	6	ND	0.001	0.0085	0.0002	0.030	0.001	ND	0.01	0.060	0.001	0.11	0.001
L2	3	25	1988	WET	7	0.001	0.001	0.0047	0.0002	0.030	0.001	NR	0.01	0.030	0.001	0.075	0.001
L3	4	20	1988	WET	1	0.001	0.001	0.0004	0.0002	0.007	0.001			0.026	0.001	0.053	0.001
L3	11	23	1988	WET	2	ND	0.001	0.001	0.0002	0.007	0.001			0.014	0.001	0.03	0.001
L3	2	4	1988	WET	4	ND	0.001	0.0010	0.0002	0.001	0.001	ND	0.01	0.016	0.001	0.077	0.001
L3	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.016	0.001	ND	0.01	0.025	0.001	0.045	0.001
L3	3	2	1988	WET	6	ND	0.001	0.0012	0.0002	0.008	0.001	ND	0.01	0.033	0.001	0.035	0.001
L3	3	25	1988	WET	7	ND	0.001	0.0013	0.0002	0.015	0.001	ND	0.01	0.022	0.001	0.055	0.001
L4	2	4	1988	WET	4	ND	0.001	0.0012	0.0002	0.032	0.001	ND	0.01	0.012	0.001	0.003	0.001
L4	2	8	1988	WET	5	ND	0.001	0.0017	0.0002	0.021	0.001	ND	0.01	0.020	0.001	0.004	0.001
L4	3	25	1988	WET	7	ND	0.001	0.0006	0.0002	0.023	0.001	ND	0.01	0.033	0.001	0.007	0.001
L5	11	23	1988	WET	2	ND	0.001	0.003	0.0002	0.044	0.001			0.32	0.001	0.316	0.001
L5	1	23	1988	WET	3	ND	0.001	0.0008	0.0002	0.003	0.001	ND	0.01	ND	0.001	ND	0.001
L5	2	4	1988	WET	4	ND	0.001	0.0020	0.0002	0.020	0.001	ND	0.01	0.032	0.001	0.05	0.001
L5FD	2	4	1988	WET	4	ND	0.001	0.0026	0.0002	0.011	0.001	ND	0.01	0.010	0.001	0.042	0.001
L5	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.010	0.001	ND	0.01	0.070	0.001	0.081	0.001
L5	3	2	1988	WET	6	ND	0.001	0.0013	0.0002	0.017	0.001	ND	0.01	0.050	0.001	0.045	0.001
L5FD	3	2	1988	WET	6	ND	0.001	0.0012	0.0002	0.017	0.001	ND	0.01	0.050	0.001	0.050	0.001
L5	3	25	1988	WET	7	ND	0.001	0.0011	0.0002	0.010	0.001	ND	0.01	0.044	0.001	0.11	0.001
L6	4	20	1988	WET	1	0.003	0.001	0.0012	0.0002	0.021	0.001			0.080	0.001	0.09	0.001
L6	11	23	1988	WET	2	ND	0.001	0.001	0.0002	0.016	0.001			0.054	0.001	0.11	0.001
L6	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.014	0.001	ND	0.01	0.023	0.001	0.007	0.001
L6	3	2	1988	WET	6	0.002	0.001	0.0015	0.0002	0.074	0.001	ND	0.01	0.030	0.001	0.030	0.001
L6	3	25	1988	WET	7	0.002	0.001	0.0014	0.0002	0.023	0.001	ND	0.01	0.055	0.001	0.13	0.001
~~L7~~	~~11~~	~~23~~	~~1988~~	~~WET~~	~~2~~	~~ND~~	~~0.001~~	~~0.0004~~	~~0.0002~~	~~0.008~~	~~0.001~~			~~0.011~~	~~0.001~~	~~0.016~~	~~0.001~~
L7	2	4	1988	WET	4	ND	0.001	0.0007	0.0002	0.002	0.001	ND	0.01	ND	0.001	ND	0.001
L7	2	8	1988	WET	5	ND	0.001	0.0017	0.0002	0.012	0.001	ND	0.01	0.010	0.001	ND	0.001
L7	3	2	1988	WET	6	0.004	0.001	ND	0.0002	0.005	0.001	ND	0.01	0.004	0.001	0.001	0.001
L7	3	25	1988	WET	7	ND	0.001	-0.0002	0.0002	0.022	0.001	NR	0.01	0.011	0.001	0.003	0.001
R1	2	27	1988	RES	1	0.003	0.001	ND	0.0002	0.006	0.001			0.006	0.001	0.002	0.001
R2	2	28	1988	RES	1	0.002	0.001	ND	0.0002	0.003	0.001			0.007	0.001	0.002	0.001
R3	2	27	1988	RES	1	0.002	0.001	ND	0.0002	0.003	0.001			0.005	0.001	0.002	0.001
R4	2	27	1988	RES	1	0.007	0.001	ND	0.0002	0.10	0.001			0.007	0.001	0.002	0.001
R5	2	27	1988	RES	1	0.004	0.001	ND	0.0002	0.0044	0.001			0.004	0.001	ND	0.001
R6	2	27	1988	RES	1	0.001	0.001	0.0007	0.0002	0.005	0.001			0.007	0.001	0.002	0.001

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Arsenic actual mg/l	D.L. mg/l	Cadmium actual mg/l	D.L. mg/l	Chromium actual mg/l	D.L. mg/l	Hexav Cr actual mg/l	D.L. mg/l	Copper actual mg/l	D.L. mg/l	Lead actual mg/l	D.L. mg/l
STANDARD REPORTING OBJECTIVES							0.001		0.0001		0.001				0.001		0.001
S1	2	26	1988	DRY	1	0.001	0.001	ND	0.0002	0.005	0.001			0.011	0.001	ND	0.001
S1	3	30	1988	DRY	2									0.051	0.001	0.0006	0.0005
S1LR	3	30	1988	DRY	2									0.052	0.001	0.0008	0.0005
S1	6	11	1988	DRY	3									0.007	0.001	0.0010	0.0002
S1	12	12	1988	DRY	5							ND	0.01	0.007	0.001	ND	0.001
S1	2	1	1988	DRY	6	ND	0.001	0.0003	0.0002	0.001	0.001	ND	0.01	ND	0.001	ND	0.001
S1	4	8	1988	DRY	7	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.006	0.001	ND	0.001
S1	11	23	1988	WET	2	ND	0.001	0.002	0.0002	0.046	0.001			0.005	0.001	0.008	0.001
S1	1	23	1988	WET	3	ND	0.001	0.0007	0.0002	0.002	0.001	ND	0.01	ND	0.001	0.004	0.001
S1	2	4	1988	WET	4	ND	0.001	0.0026	0.0002	0.007	0.001	ND	0.01	0.03	0.001	0.08	0.001
S1	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.010	0.001	ND	0.01	0.032	0.001	0.032	0.001
S1FD	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.018	0.001	ND	0.01	0.030	0.001	0.030	0.001
S1	3	2	1988	WET	6	0.003	0.001	0.0011	0.0002	0.026	0.001	ND	0.01	0.044	0.001	0.005	0.001
S1	3	25	1988	WET	7	0.004	0.001	0.0013	0.0002	0.027	0.001	ND	0.01	0.055	0.001	0.080	0.001
S1FD	3	25	1988	WET	7	0.002	0.001	0.0015	0.0002	0.030	0.001	ND	0.01	0.061	0.001	0.10	0.001
S2	2	20	1988	DRY	1	0.002	0.001	ND	0.0002	0.008	0.001			0.008	0.001	0.002	0.001
S2	3	30	1988	DRY	2									0.01	0.001	0.0010	0.0005
S2	5	11	1988	DRY	3									0.008	0.001	0.0012	0.0002
S2	12	12	1988	DRY	5							ND	0.01	ND	0.001	ND	0.001
S2	2	1	1988	DRY	6	ND	0.001	0.0004	0.0002	0.002	0.001	ND	0.01	ND	0.001	ND	0.001
S2	4	8	1988	DRY	7	ND	0.001	0.0008	0.0002	0.003	0.001	ND	0.01	0.003	0.001	ND	0.001
S2	4	20	1988	WET	1	0.003	0.001	0.0008	0.0002	0.03	0.001			0.072	0.001	0.072	0.031
S2	11	23	1988	WET	2	ND	0.001	0.002	0.0002	0.003	0.001			0.32	0.001	0.27	0.001
S2	1	23	1988	WET	3	ND	0.001	0.006	0.0002	0.004	0.001	ND	0.01	0.003	0.001	0.001	0.001
S2FD	1	23	1988	WET	3	ND	0.001	0.0004	0.0002	0.003	0.001	ND	0.01	0.002	0.001	0.002	0.001
S2	2	4	1988	WET	4	ND	0.001	0.0053	0.0002	0.010	0.001	ND	0.01	0.023	0.001	0.035	0.001
S2	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.020	0.001	ND	0.01	0.060	0.001	0.081	0.001
S2	3	2	1988	WET	6	0.003	0.001	0.0014	0.0002	0.020	0.001	ND	0.01	0.050	0.001	0.036	0.001
S2	3	25	1988	WET	7	ND	0.001	0.0015	0.0002	0.050	0.001	ND	0.01	0.060	0.001	0.050	0.001
S3	2	20	1988	DRY	1	0.001	0.001	ND	0.0002	0.006	0.001			0.003	0.001	0.002	0.001
S3	3	30	1988	DRY	2									0.004	0.001	0.0023	0.0005
S3	5	11	1988	DRY	3									0.005	0.001	0.0020	0.0002
S3	8	26	1988	DRY	4									0.011	0.001	ND	0.001
S3FD	8	26	1988	DRY	4									0.007	0.001	0.014	0.001
S3	12	12	1988	DRY	5							ND	0.01	0.003	0.001	ND	0.001
S3FD	12	12	1988	DRY	5							ND	0.01	ND	0.001	ND	0.001
S3	2	1	1988	DRY	6	ND	0.001	ND	0.0002	0.003	0.001	ND	0.01	ND	0.001	ND	0.001
S3LR	2	1	1988	DRY	6	ND	0.001	0.0006	0.0002	0.003	0.001	ND	0.01	ND	0.001	ND	0.001
S3FD	2	1	1988	DRY	6	ND	0.001	0.0002	0.0002	0.003	0.001	ND	0.01	0.004	0.001	0.004	0.001
S3	4	8	1988	DRY	7	0.001	0.001	ND	0.0002	0.002	0.001	ND	0.01	0.004	0.001	ND	0.001
S3FD	4	8	1988	DRY	7	0.001	0.001	0.0031	0.0002	ND	0.001	ND	0.01	0.003	0.001	ND	0.001
S3	4	20	1988	WET	1	0.005	0.001	0.0016	0.0002	0.062	0.001			0.080	0.001	0.080	0.001
S3	11	23	1988	WET	2	ND	0.001	0.001	0.0002	0.12	0.001			0.17	0.001	0.35	0.001
S3LR	11	23	1988	WET	2	ND	0.001	0.0007	0.0002	0.11	0.001			0.15	0.001	0.2	0.001
S3	1	23	1988	WET	3	ND	0.001	0.0010	0.0002	0.014	0.001	ND	0.01	0.008	0.001	0.007	0.001
S3	2	4	1988	WET	4	ND	0.001	0.0010	0.0002	0.016	0.001	ND	0.01	0.06	0.001	0.001	0.001
S3	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.051	0.001	ND	0.01	0.075	0.001	0.11	0.001
				WET	6	ND	0.001	0.0007	0.0002	0.022	0.001	ND	0.01	0.033	0.001	0.012	0.001

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Mercury actual mg/l	D.L. mg/l	Nickel actual mg/l	D.L. mg/l	Selenium actual mg/l	D.L. mg/l	Silver actual mg/l	D.L. mg/l	Zinc actual mg/l	D.L. mg/l
STANDARD REPORTING OBJECTIVES							0.0002		0.001		0.0002		0.0001		0.001
L1	4	20	1988	WET	1	ND	0.0002	0.016	0.001	ND	0.002	0.0003	0.0001	0.12	0.0(
L1	11	23	1988	WET	2	0.0012	0.0002	0.047	0.001	ND	0.0003	0.0002	0.0002	0.15	0.001
L1	2	4	1988	WET	4	ND	0.0002	0.030	0.002	ND	0.0002	0.0002	0.0002	0.26	0.001
L1	2	8	1988	WET	5	ND	0.0002	0.018	0.002	ND	0.0002	0.002	0.0002	0.35	0.001
L1	3	2	1988	WET	6	0.0002	0.0002	0.45	0.002	ND	0.0002	0.0013	0.0002	0.40	0.001
L2	4	20	1988	WET	1	0.0002	0.0002	0.020	0.001	ND	0.002	0.0003	0.0001	1.7	0.01
L2	11	23	1988	WET	2	0.0044	0.0002	0.04	0.001	ND	0.0003	0.0004	0.0002	0.05	0.001
L2	2	4	1988	WET	4	0.0007	0.0002	0.04	0.002	ND	0.0002	0.0005	0.0002	0.37	0.001
L2	2	8	1988	WET	5	ND	0.0002	0.035	0.002	ND	0.0002	0.007	0.0002	1.8	0.001
L2	3	2	1988	WET	6	ND	0.0002	0.08	0.002	ND	0.0002	0.0018	0.0002	2.0	0.001
L2	3	25	1988	WET	7	ND	0.0002	0.08	0.002	ND	0.0002	0.0028	0.0002	0.78	0.001
L3	4	20	1988	WET	1	ND	0.0002	0.015	0.001	ND	0.002	0.0004	0.0001	0.2	0.01
L3	11	23	1988	WET	2	ND	0.0002	0.010	0.001	ND	0.0003	ND	0.0002	0.14	0.001
L3	2	4	1988	WET	4	0.0005	0.0002	0.010	0.002	ND	0.0002	ND	0.0002	0.22	0.001
L3	2	8	1988	WET	5	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.10	0.001
L3	3	2	1988	WET	6	0.0002	0.0002	0.03	0.002	ND	0.0002	ND	0.0002	0.20	0.001
L3	3	25	1988	WET	7	0.0002	0.0002	0.04	0.002	ND	0.0002	0.0001	0.0002	0.32	0.001
L4	2	4	1988	WET	4	0.0005	0.0002	0.014	0.002	0.0004	0.0002	0.0005	0.0002	0.08	0.001
L4	2	8	1988	WET	5	ND	0.0002	0.010	0.002	0.0005	0.0002	0.0005	0.0002	0.080	0.001
L4	3	25	1988	WET	7	ND	0.0002	0.06	0.002	0.001	0.0002	0.0030	0.0002	0.020	0.001
L5	11	23	1988	WET	2	0.003	0.0002	0.053	0.001	ND	0.0003	ND	0.0002	0.30	0.001
L5	1	23	1988	WET	3	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.24	0.001
L5	2	4	1988	WET	4	0.0004	0.0002	0.025	0.002	ND	0.0002	ND	0.0002	0.2	0.001
L5FD	2	4	1988	WET	4	0.0008	0.0002	0.021	0.002	ND	0.0002	ND	0.0002	0.10	0.001
L5	2	8	1988	WET	5	ND	0.0002	0.010	0.002	ND	0.0002	ND	0.0002	0.53	0.001
L5	3	2	1988	WET	6	ND	0.0002	0.08	0.002	ND	0.0002	ND	0.0002	0.31	0.001
L5FD	3	2	1988	WET	6	0.0002	0.0002	0.05	0.002	ND	0.0002	ND	0.0002	0.32	0.001
L5	3	25	1988	WET	7	ND	0.0002	0.06	0.002	ND	0.0002	0.0002	0.0002	0.24	0.001
L6	4	20	1988	WET	1	0.0008	0.0002	0.031	0.001	ND	0.002	0.0003	0.0001	0.3	0.01
L6	11	23	1988	WET	2	0.002	0.0002	0.028	0.001	ND	0.0003	ND	0.0002	0.24	0.001
L6	2	8	1988	WET	5	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.10	0.001
L6	3	2	1988	WET	6	ND	0.0002	0.11	0.002	ND	0.0002	ND	0.0002	0.20	0.001
L6	3	25	1988	WET	7	ND	0.0002	0.07	0.002	ND	0.0002	0.0002	0.0002	0.30	0.001
L7	11	23	1988	WET	2	0.002	0.0002	0.004	0.001	ND	0.0003	ND	0.0002	0.011	0.001
L7	2	4	1988	WET	4	0.0011	0.0002	0.009	0.002	ND	0.0002	ND	0.0002	0.021	0.001
L7	2	8	1988	WET	5	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	ND	0.001
L7	3	2	1988	WET	6	0.0002	0.0002	0.008	0.002	0.001	0.0002	0.0002	0.0002	0.005	0.001
L7	3	25	1988	WET	7	ND	0.0002	0.08	0.002	ND	0.0002	0.0003	0.0002	0.012	0.001
R1	2	27	1988	RES	1	ND	0.0002	0.005	0.001	ND	0.0005	0.0004	0.0002	0.008	0.001
R2	2	28	1988	RES	1	ND	0.0002	0.003	0.001	ND	0.0005	0.0012	0.0002	0.005	0.001
R3	2	27	1988	RES	1	ND	0.0002	0.008	0.001	ND	0.0005	0.0002	0.0002	0.007	0.001
R4	2	27	1988	RES	1	ND	0.0002	0.027	0.001	ND	0.0005	ND	0.0002	0.01	0.001
R5	2	27	1988	RES	1	ND	0.0002	0.004	0.001	ND	0.0005	0.0003	0.0002	0.001	0.001
R6	2	27	1988	RES	1	ND	0.0002	0.003	0.001	ND	0.0005	0.0008	0.0002	0.010	0.001

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	Mercury actual mg/l	D.L. mg/l	Nickel actual mg/l	D.L. mg/l	Selenium actual mg/l	D.L. mg/l	Silver actual mg/l	D.L. mg/l	Zinc actual mg/l	D.L. mg/l
STANDARD REPORTING OBJECTIVES							0.0002		0.001		0.0002		0.0001		0.001
S1	2	26	1988	DRY	1	ND	0.0002	ND	0.002	ND	0.0002	0.0007	0.0002	0.076	0.001
S1	3	30	1988	DRY	2	0.0003	0.0002			ND	0.01	0.0013	0.0005	0.003	0.001
S1LR	3	30	1988	DRY	2	ND	0.0002			ND	0.01	0.0012	0.0005	0.003	0.001
S1	5	11	1988	DRY	3	ND	0.0002			ND	0.002	0.0024	0.0002	0.012	0.002
S1	12	12	1988	DRY	5	ND	0.0002			ND	0.0002	ND	0.0002	0.012	0.001
S1	2	1	1988	DRY	6	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.014	0.001
S1	4	6	1988	DRY	7	ND	0.0002	0.002	0.002	ND	0.0002	ND	0.0002	0.006	0.001
S1	11	23	1988	WET	2	0.002	0.0002	0.08	0.001	ND	0.0003	0.0002	0.0002	0.35	0.001
S1	1	23	1988	WET	3	ND	0.0002	0.003	0.002	ND	0.0002	ND	0.0002	0.05	0.001
S1	2	4	1988	WET	4	0.0008	0.0002	0.021	0.002	ND	0.0002	ND	0.0002	0.20	0.001
S1	2	8	1988	WET	5	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.12	0.001
S1FD	2	8	1988	WET	5	ND	0.0002	0.010	0.002	ND	0.0002	ND	0.0002	0.10	0.001
S1	3	2	1988	WET	6	0.0002	0.0002	0.10	0.002	0.001	0.0002	0.0002	0.0002	0.23	0.001
S1	3	25	1988	WET	7	0.0002	0.0002	0.08	0.002	ND	0.0002	0.0002	0.0002	0.24	0.001
S1FD	3	25	1988	WET	7	ND	0.0002	0.11	0.002	ND	0.0002	0.0003	0.0002	0.37	0.001
S2	2	26	1988	DRY	1	ND	0.0002	ND	0.002	ND	0.0002	0.0024	0.0002	0.008	0.001
S2	3	30	1988	DRY	2	ND	0.0002			0.01	0.01	0.0076	0.0005	0.007	0.001
S2	5	11	1988	DRY	3	ND	0.0002			0.005	0.002	0.0047	0.0002	0.0075	0.002
S2	12	12	1988	DRY	5	ND	0.0002			ND	0.0002	ND	0.0002	0.006	0.001
S2	2	1	1988	DRY	6	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.020	
S2	4	8	1988	DRY	7	ND	0.0002	0.003	0.002	0.004	0.0002	0.0007	0.0002	0.010	0.001
S2	4	20	1988	WET	1	0.0003	0.0002	0.020	0.001	ND	0.002	0.0007	0.0001	0.33	0.01
S2	11	23	1988	WET	2	0.003	0.0002	0.12	0.001	ND	0.0003	0.0004	0.0002	0.02	0.001
S2	1	23	1988	WET	3	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.14	0.001
S2FD	1	23	1988	WET	3	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.22	0.001
S2	2	4	1988	WET	4	0.0005	0.0002	0.023	0.002	ND	0.0002	ND	0.0002	0.14	0.001
S2	2	8	1988	WET	5	ND	0.0002	0.010	0.002	ND	0.0002	ND	0.0002	0.35	0.001
S2	3	2	1988	WET	6	ND	0.0002	0.12	0.002	ND	0.0002	0.0003	0.0002	0.25	0.001
S2	3	25	1988	WET	7	ND	0.0002	0.08	0.002	ND	0.0002	0.0004	0.0002	0.27	0.001
S3	2	26	1988	DRY	1	ND	0.0002	ND	0.002	ND	0.0002	0.0008	0.0002	0.008	0.001
S3	3	30	1988	DRY	2	ND	0.0002			ND	0.01	0.0015	0.0005	0.002	0.001
S3	5	11	1988	DRY	3	ND	0.0002			ND	0.002	0.003	0.0002	0.0075	0.002
S3	8	25	1988	DRY	4	0.0027	0.0002			0.0023	0.0002	0.0023	0.0005	0.008	0.001
S3FD	8	25	1988	DRY	4	0.0023	0.0002			0.0010	0.0002	0.0018	0.0005	0.014	0.001
S3	12	12	1988	DRY	5	ND	0.0002			0.0003	0.0002	ND	0.0002	0.020	0.001
S3FD	12	12	1988	DRY	5	ND	0.0002			ND	0.0002	ND	0.0002	0.014	0.001
S3	2	1	1988	DRY	6	ND	0.0002	ND	0.002	0.0008	0.0002	ND	0.0002	0.008	0.001
S3LR	2	1	1988	DRY	6	ND	0.0002	0.002	0.002	0.0008	0.0002	ND	0.0002	0.008	0.001
S3FD	2	1	1988	DRY	6	ND	0.0002	ND	0.002	0.0005	0.0002	ND	0.0002	0.010	0.001
S3	4	8	1988	DRY	7	ND	0.0002	0.002	0.002	ND	0.0002	0.0002	0.0002	0.010	0.001
S3FD	4	8	1988	DRY	7	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.015	0.001
S3	4	20	1988	WET	1	0.0018	0.0002	0.11	0.001	ND	0.002	0.0006	0.0001	0.27	0.01
S3	11	23	1988	WET	2	0.008	0.0002	0.22	0.001	ND	0.0003	0.0002	0.0002	0.45	0.001
S3LR	11	23	1988	WET	2	0.002	0.0002	0.1	0.001	ND	0.0003	0.0002	0.0002	0.4	0.001
S3	1	23	1988	WET	3	ND	0.0002	0.006	0.002	ND	0.0002	ND	0.0002	0.10	0.001
S3	2	4	1988	WET	4	0.0004	0.0002	0.004	0.002	ND	0.0002	ND	0.0002	0.23	0.001
S3	2	8	1988	WET	5	ND	0.0002	0.11	0.002	ND	0.0002	ND	0.0002	0.35	0.001
S3	3	2	1988	WET	6	ND	0.0002	0.08	0.002	0.001	0.0002	0.0004	0.0002	0.010	0.001

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Mercury actual mg/l	D.L. mg/l	Nickel actual mg/l	D.L. mg/l	Selenium actual mg/l	D.L. mg/l	Silver actual mg/l	D.L. mg/l	Zinc actual mg/l	D.L. mg/l
STANDARD REPORTING OBJECTIVES							0.0002		0.001		0.0002		0.0001		0.001
S4	2	28	1988	DRY	1	ND	0.0002	ND	0.002	0.005	0.0002	0.0022	0.0002	0.016	0.001
S4	3	30	1988	DRY	2	ND	0.0002			ND	0.01	0.0033	0.0005	0.008	0.001
S4	5	11	1988	DRY	3	ND	0.0002			ND	0.002	0.0034	0.0002	0.023	0.002
S4LR	5	11	1988	DRY	3	ND	0.0002			ND	0.002	0.0033	0.0002	0.020	0.002
S4	8	25	1988	DRY	4	0.0023	0.0002			0.0010	0.0002	0.0018	0.0005	0.011	0.001
S4	12	12	1988	DRY	5	ND	0.0002			ND	0.0002	ND	0.0002	0.010	0.001
S4	2	1	1988	DRY	6	ND	0.0002	ND	0.002	0.0004	0.0002	ND	0.0002	0.012	0.001
S4	4	8	1988	DRY	7	ND	0.0002	0.005	0.002	0.001	0.0002	0.0002	0.0002	0.020	0.001
S4	4	28	1988	WET	1	0.0003	0.0002	0.040	0.001	ND	0.002	0.001	0.0001	0.14	0.01
S4	11	23	1988	WET	2	0.004	0.0002	0.24	0.001	ND	0.0003	0.0004	0.0002	0.01	0.001
S4FD	11	23	1988	WET	2	0.003	0.0002	0.1	0.001	ND	0.0003	ND	0.0002	0.25	0.001
S4	2	4	1988	WET	4	0.0005	0.0002	0.037	0.002	ND	0.0002	ND	0.0002	0.17	0.001
S4	2	8	1988	WET	5	ND	0.0002	0.035	0.002	ND	0.0002	ND	0.0002	0.10	0.001
S4	3	2	1988	WET	6	ND	0.0002	0.12	0.002	0.001	0.0002	0.0003	0.0002	0.030	0.001
S4	3	25	1988	WET	7	ND	0.0002	0.15	0.002	ND	0.0002	0.0020	0.0002	0.42	0.001
FB	8	25	1988	DRY	4	0.0003	0.0002			ND	0.0002	ND	0.0005	0.011	0.001
FB	12	12	1988	DRY	5	ND	0.0002			ND	0.0002	ND	0.0002	0.014	0.001
FB	2	1	1988	DRY	6	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.010	0.001
FB	4	8	1988	DRY	7	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.006	0.001
FB	11	23	1988	WET	2	0.0004	0.0002	ND	0.001	ND	0.0003	0.0002	0.0002	ND	0.001
FB	1	23	1988	WET	3	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.01	0.001
FB	2	8	1988	WET	5	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	ND	0.001
FB	3	2	1988	WET	6	ND	0.0002	0.08	0.002	ND	0.0002	ND	0.0002	0.010	0.001
FB	3	25	1988	WET	7	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002	0.003	0.001

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Arsenic actual mg/l	D.L. mg/l	Cadmium actual mg/l	D.L. mg/l	Chromium actual mg/l	D.L. mg/l	Hexav Cr actual mg/l	D.L. mg/l	Copper actual mg/l	D.L. mg/l	Lead actual mg/l	D.L. mg/l
STANDARD REPORTING OBJECTIVES							0.001		0.0001		0.001				0.001		0.001
S4	2	26	1988	DRY	1	0.002	0.001	ND	0.0002	0.005	0.001			0.01	0.001	0.001	0.001
S4	3	30	1988	DRY.	2									0.008	0.001	0.0026	0.0005
S4	5	11	1988	DRY	3									0.008	0.001	0.0026	0.0002
S4LR	5	11	1988	DRY	3									0.01	0.001	0.0028	0.0002
S4	8	25	1988	DRY	4									0.012	0.001	ND	0.001
S4	12	12	1988	DRY	5							ND	0.01	0.003	0.001	ND	0.001
S4	2	1	1988	DRY	6	ND	0.001	0.0006	0.0002	0.004	0.001	ND	0.01	0.001	0.001	ND	0.001
S4	4	6	1988	DRY	7	0.002	0.001	ND	0.0002	0.003	0.001	ND	0.01	0.006	0.001	ND	0.001
S4	4	20	1988	WET	1	0.003	0.001	0.0005	0.0002	0.018	0.001			0.042	0.001	0.042	0.001
S4	11	23	1988	WET	2	ND	0.001	0.004	0.0002	0.14	0.001			0.10	0.001	0.25	0.001
S4FD	11	23	1988	WET	2	ND	0.001	0.002	0.0002	0.065	0.001			0.072	0.001	0.13	0.001
S4	2	4	1988	WET	4	ND	0.001	0.0044	0.0002	0.021	0.001	ND	0.01	0.038	0.001	0.042	0.001
S4	2	8	1988	WET	5	ND	0.001	0.0035	0.0002	0.023	0.001	ND	0.01	0.035	0.001	0.035	0.001
S4	3	2	1988	WET	6	ND	0.001	0.0012	0.0002	0.027	0.001	ND	0.01	0.027	0.001	0.016	0.001
S4	3	25	1988	WET	7	0.008	0.001	0.0048	0.0002	0.073	0.001	ND	0.01	0.11	0.001	0.13	0.001
FB	8	25	1988	DRY	4									ND	0.001	ND	0.001
FB	12	12	1988	DRY	5							ND	0.01	ND	0.001	ND	0.001
FB	2	1	1988	DRY	6	ND	0.001	ND	0.0002	ND	0.001	ND	0.01	ND	0.001	0.003	0.001
FB	4	8	1988	DRY	7	ND	0.001	ND	0.0002	ND	0.001	ND	0.01	ND	0.001	ND	0.001
FB	11	23	1988	WET	2	ND	0.001	0.0002	0.0002	0.002	0.001			ND	0.001	ND	0.001
FB	1	23	1988	WET	3	ND	0.001	0.0010	0.0002	ND	0.001	ND	0.01	ND	0.001	ND	0.001
FB	2	8	1988	WET	5	ND	0.001	ND	0.0002	ND	0.001	ND	0.01	0.004	0.001	ND	0.001
FB	3	2	1988	WET	6	ND	0.001	ND	0.0002	0.052	0.001	ND	0.01	0.011	0.001	0.001	0.001
FB	3	25	1988	WET	7	0.001	0.001	ND	0.0002	0.001	0.001	ND	0.01	ND	0.001	ND	0.001

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Arsenic actual mg/l	Arsenic DL mg/l	Cadmium actual mg/l	Cadmium DL mg/l	Chromium actual mg/l	Chromium DL mg/l	Hexav Cr actual mg/l	Hexav Cr DL mg/l	Copper actual mg/l	Copper DL mg/l
STANDARD REPORTING OBJECTIVES															
L1	3	2	1989	WET	6	ND	0.001	0.005	0.0002	0.008	0.001	ND	0.01	0.010	0.001
L2	3	2	1989	WET	6	ND	0.001	0.001	0.0002	0.006	0.001	ND	0.01	0.013	0.001
L2	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.006	0.001	ND	0.01	0.010	0.001
L3	3	2	1989	WET	6	ND	0.001	0.0003	0.0002	0.001	0.001	ND	0.01	0.008	0.001
L3	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.006	0.001
L4	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.004	0.001	ND	0.01	0.002	0.001
L5	3	2	1989	WET	6	ND	0.001	0.0003	0.0002	0.001	0.001	ND	0.01	0.012	0.001
L5 FIELD DUP	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.010	0.001
L5	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.002	0.001	ND	0.01	0.007	0.001
L6	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.009	0.001
L6	3	25	1989	WET	7	ND	0.001	0.0003	0.0002	0.002	0.001	ND	0.01	0.009	0.001
L7	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.004	0.001
L7	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.009	0.001
S1	3	2	1989	WET	6	ND	0.001	0.0002	0.0002	0.001	0.001	ND	0.01	0.010	0.001
S1	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.007	0.001
S5	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.008	0.001
S2	3	2	1989	WET	6	ND	0.001	0.0003	0.0002	0.001	0.001	ND	0.01	0.011	0.001
S2	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.008	0.001
S3	3	2	1989	WET	6	ND	0.001	0.0002	0.0002	0.003	0.001	ND	0.01	0.006	0.001
S4	3	2	1989	WET	6	ND	0.001	0.0002	0.0002	0.001	0.001	ND	0.01	0.007	0.001
S4	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.006	0.001
FB	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.001	0.001	ND	0.01	0.006	0.001
FB	3	25	1989	WET	7	ND	0.001	ND	0.0002	ND	0.001	ND	0.01	0.001	0.001

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Lead actual mg/l	Lead DL mg/l	Mercury actual mg/l	Mercury DL mg/l	Nickel actual mg/l	Nickel DL mg/l	Selenium actual mg/l	Selenium DL mg/l	Silver actual mg/l	Silver DL mg/l
STANDARD REPORTING OBJECTIVES															
L1	3	2	1989	WET	6	0.005	0.001	ND	0.0002	0.017	0.002	ND	0.0002	0.006	0.0002
L2	3	2	1989	WET	6	0.002	0.001	ND	0.0002	0.006	0.002	ND	0.0002	ND	0.0002
L2	3	25	1989	WET	7	0.003	0.001	ND	0.0002	0.008	0.002	ND	0.0002	0.0005	0.0002
L3	3	2	1989	WET	6	ND	0.001	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002
L3	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.004	0.002	ND	0.0002	ND	0.0002
L4	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.008	0.002	0.001	0.0002	0.002	0.0002
L5	3	2	1989	WET	6	ND	0.001	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002
L5 FIELD DUP	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.005	0.002	ND	0.0002	ND	0.0002
L5	3	25	1989	WET	7	0.002	0.001	ND	0.0002	0.005	0.002	ND	0.0002	ND	0.0002
L6	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.004	0.002	ND	0.0002	ND	0.0002
L6	3	25	1989	WET	7	0.003	0.001	ND	0.0002	0.008	0.002	ND	0.0002	ND	0.0002
L7	3	2	1989	WET	6	ND	0.001	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002
L7	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.006	0.002	ND	0.0002	0.0002	0.0002
S1	3	2	1989	WET	6	ND	0.001	ND	0.0002	ND	0.002	0.001	0.0002	ND	0.0002
S1	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.005	0.002	ND	0.0002	ND	0.0002
S5	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.005	0.002	ND	0.0002	ND	0.0002
S2	3	2	1989	WET	6	ND	0.001	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002
S2	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.005	0.002	ND	0.0002	ND	0.0002
S3	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.006	0.002	0.001	0.0002	0.0002	0.0002
S4	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.008	0.002	0.001	0.0002	0.0002	0.0002
S4	3	25	1989	WET	7	ND	0.001	ND	0.0002	0.006	0.002	ND	0.0002	0.0004	0.0002
FB	3	2	1989	WET	6	ND	0.001	ND	0.0002	0.004	0.002	ND	0.0002	ND	0.0002
FB	3	25	1989	WET	7	ND	0.001	ND	0.0002	ND	0.002	ND	0.0002	ND	0.0002

D.1-2 Dissolved metals in water column

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D.1-3 Total metals in sediment

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Zinc actual mg/l	Zinc DL mg/l
STANDARD REPORTING OBJECTIVES							
L1	3	2	1989	WET	6	0.3	0.001
L2	3	2	1989	WET	6	0.8	0.001
L2	3	25	1989	WET	7	0.20	0.001
L3	3	2	1989	WET	6	0.1	0.001
L3	3	25	1989	WET	7	0.10	0.001
L4	3	25	1989	WET	7	0.005	0.001
L5	3	2	1989	WET	6	0.1	0.001
L5 FIELD DUP	3	2	1989	WET	6	0.09	0.001
L5	3	25	1989	WET	7	0.10	0.001
L6	3	2	1989	WET	6	0.1	0.001
L6	3	25	1989	WET	7	0.10	0.001
L7	3	2	1989	WET	6	0.003	0.001
L7	3	25	1989	WET	7	0.007	0.001
S1	3	2	1989	WET	6	0.1	0.001
S1	3	25	1989	WET	7	0.040	0.001
S5	3	25	1989	WET	7	0.040	0.001
S2	3	2	1989	WET	6	0.1	0.001
S2	3	25	1989	WET	7	0.040	0.001
S3	3	2	1989	WET	6	0.017	0.001
S4	3	2	1989	WET	6	ND	0.001
S4	3	25	1989	WET	7	0.016	0.001
FB	3	2	1989	WET	6	0.015	0.001
FB	3	25	1989	WET	7	0.015	0.001

D.2 Conventional parameters

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Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	Arsenic actual mg/kg	Arsenic D.L. mg/kg	Cadmium actual mg/kg	Cadmium D.L. mg/kg	Chromium actual mg/kg	Chromium D.L. mg/kg	Copper actual mg/kg	Copper D.L. mg/kg	Lead actual mg/kg	Lead D.L. mg/kg
STANDARD REPORTING OBJECTIVES							0.1		0.1		1		1		1
S1	3	30	1988	DRY	1	3.7	0.1	0.1	0.1	77	1	23	1	9	1
S1	5	11	1988	DRY	2	4.5	0.1	0.1	0.1	70	0.1	25	0.1	44	0.1
S1	8	22	1988	DRY	3		0.1		0.1		0.1	27	0.1	16	0.1
S1	12	12	1988	DRY	4							63	1	45	1
S2	3	30	1988	DRY	1	2.9	0.1	0.5	0.1	78	1	76	1	93	1
S2	5	11	1988	DRY	2	4.3	0.1	2	0.1	84	0.1	48	0.1	98	0.1
S2	8	22	1988	DRY	3		0.1		0.1		0.1	40	0.1	40	0.1
S2	12	12	1988	DRY	4							32	1	32	1
S3	3	30	1988	DRY	1	6.7	0.1	1.4	0.1	170	1	100	1	150	1
S3	5	11	1988	DRY	2	4.1	0.1	0.1	0.1	80	0.1	37	0.1	25	0.1
S3	8	22	1988	DRY	3		0.1		0.1		0.1	97	0.1	160	0.1
S3FD	8	22	1988	DRY	3		0.1		0.1		0.1	95	0.1	150	0.1
S3	12	12	1988	DRY	4							45	1	64	1
S3FD	12	12	1988	DRY	4							45	1	66	1
S3LR	12	12	1988	DRY	4							43	1	55	1
S4	3	30	1988	DRY	1	7.8	0.1	0.4	0.1	80	1	35	1	20	1
S4LR	3	30	1988	DRY	1	8.8	0.1	0.3	0.1	83	1	33	1	20	1
S4	5	11	1988	DRY	2	6.6	0.1	1.3	0.1	110	0.1	87	0.1	120	0.1
S4FD	5	11	1988	DRY	2	5.6	0.1	0.7	0.1	87	0.1	53	0.1	87	0.1
S4	8	22	1988	DRY	3		0.1		0.1		0.1	65	0.1	77	0.1
S4	12	12	1988	DRY	4							28	1	33	1

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	Mercury actual mg/kg	Mercury D.L. mg/kg	Nickel actual mg/kg	Nickel D.L. mg/kg	Selenium actual mg/kg	Selenium D.L. mg/kg	Silver actual mg/kg	Silver D.L. mg/kg	Zinc actual mg/kg	Zinc D.L. mg/kg
STANDARD REPORTING OBJECTIVES							0.1		1		0.1		0.1		1
S1	3	30	1988	DRY	1	0.1	0.1	49	1	ND	0.1	1	0.1	70	1
S1	5	11	1988	DRY	2	0.05	0.02	68	0.1	ND	0.2	0.7	0.1	84	1
S1	8	22	1988	DRY	3	ND	0.02	68	0.1	0.3	0.1	0.8	0.1	68	1
S1	12	12	1988	DRY	4	0.38	0.1			0.27	0.1	ND	0.1	180	1
S2	3	30	1988	DRY	1	0.2	0.1	41	1	3.3	0.1	1.3	0.1	150	1
S2	5	11	1988	DRY	2	0.14	0.02	76	0.1	0.2	0.2	0.9	0.1	100	1
S2	8	22	1988	DRY	3	ND	0.02	76	0.1	1	0.1	1.5	0.1	88	1
S2	12	12	1988	DRY	4	0.15	0.1			1.2	0.1	ND	0.1	110	1
S3	3	30	1988	DRY	1	4.1	0.1	160	1	1.4	0.1	2	0.1	280	1
S3	5	11	1988	DRY	2	0.74	0.02	87	0.1	ND	0.2	0.7	0.1	88	1
S3	8	22	1988	DRY	3	4.7	0.02	97	0.1	0.8	0.1	2	0.1	340	1
S3FD	8	22	1988	DRY	3	4.4	0.02	110	0.1	1	0.1	1.8	0.1	330	1
S3	12	12	1988	DRY	4	3.6	0.1			1	0.1	ND	0.1	160	1
S3FD	12	12	1988	DRY	4	2.6	0.1			1	0.1	ND	0.1	150	1
S3LR	12	12	1988	DRY	4	2.7	0.1			0.85	0.1	ND	0.1	140	1
S4	3	30	1988	DRY	1	0.1	0.1	85	1	0.59	0.1	1.2	0.1	100	1
S4LR	3	30	1988	DRY	1	0.2	0.1	82	1	0.49	0.1	1.1	0.1	110	1
S4	5	11	1988	DRY	2	0.49	0.02	140	0.1	0.5	0.2	1.9	0.1	360	1
S4FD	5	11	1988	DRY	2	0.23	0.02	110	0.1	0.3	0.2	1	0.1	210	1
S4	8	22	1988	DRY	3	0.17	0.02	140	0.1	0.4	0.1	1.3	0.1	190	1
S4	12	12	1988	DRY	4	0.45	0.1			0.58	0.1	ND	0.1	89	1

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	TSS actual mg/L	TSS D.L. mg/L	NO3-N actual mg/L	NO3-N D.L. mg/L	NO2-N actual mg/L	NO2-N D.L. mg/L	NH3-N actual mg/L	NH3-N D.L. mg/L	TKN actual mg/L	TKN D.L. mg/L	PO4-P actual mg/L	PO4-P D.L. mg/L	pH
S2	2	26	1988	DRY	1	ND	10	2.5	0.1	0.012	0.005	ND	1	1	1	ND	0.1	8.8
S2	3	30	1988	DRY	2	5	1							0.8	0.1			8.7
S2	5	11	1988	DRY	3	0.5	0.1							4.8	0.1			8.4
S2	12	12	1988	DRY	5	ND	10							ND	1.0			
S2	2	1	1989	DRY	6	ND	10							ND	1			
S2	4	6	1989	DRY	7	ND	1.0							ND	1.0			
S2	4	20	19 8	WET	1													
S2	11	23	1988	WET	2	990	10	0.51	0.1	0.051	0.01	ND	1	2.5	1	0.8	0.1	
S2	1	23	1989	WET	3	40	1.0							1.7	1.0			
S2FD	1	23	1989	WET	3	18	1.0							1.5	1.0			
S2	2	4	1989	WET	4	38	1							1.8	1			
S2FD	2	4	1989	WET	4	48	1							1.7	1			
S2	2	9	1989	WET	5	170	1							1.8	1			
S2	3	2	1989	WET	6	200	1.0							1.7	1.0			
S2	3	25	1989	WET	7	210	1.0											
S3	2	26	1988	DRY	1	ND	10	2.4	0.1	0.008	0.005	ND	1	ND	1	0.1	0.1	8.4
S3	3	30	1988	DRY	2	11	1							1.4	0.1			8.5
S3	5	11	1988	DRY	3	7	0.1							1.4	0.1			8.4
S3	8	22	1988	DRY	4	8.5	1	2	0.1	ND	0.1			1	0.5			
S3FD	8	22	1988	DRY	4	5.5	1	1.8	0.1	ND	0.1			3	0.5			
S3FD	8	22	1988	DRY	4													
S3	12	12	1C 8	DRY	5	ND	10							ND	1.0			
S3FD	12	12	1988	DRY	5	ND	10							ND	1.0			
S3	2	1	1989	DRY	6	ND	10							ND	1			
S3LR	2	1	1989	DRY	6	ND	10							ND	1			
S3FD	2	1	1989	DRY	6	ND	10							ND	1			
S3	4	6	1989	DRY	7	2.4	1.0							ND	1.0			
S3LR	4	6	1989	DRY	7													
S3FD	4	6	1989	DRY	7	2.8	1.0							ND	1.0			
S3	4	20	1988	WET	1													
S3	11	23	1988	WET	2	1700	10	0.62	0.1	0.025	0.01	ND	1	5	1	1.15	0.1	
S3FD	11	23	1988	WET	2													
S3LR	11	23	1988	WET	2	1700	10	0.65	0.1	0.024	0.01	ND	1	5.3	1	1.04	0.1	
S3	1	23	1989	WET	3	290	1.0							1.9	1.0			
S3FD	1	23	1988	WET	3													
S3LR	1	23	1989	WET	3													
S3	2	4	1989	WET	4	190	1							1.9	1			
S3	2	9	1989	WET	5	270	1							1.4	1			
S3	3	2	1989	WET	6	84	1.0							1.5	1.0			

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	TSS actual mg/L	TSS D.L. mg/L	NO3-N actual mg/L	NO3-N D.L. mg/L	NO2-N actual mg/L	NO2-N D.L. mg/L	NH3-N actual mg/L	NH3-N D.L. mg/L	TKN actual mg/L	TKN D.L. mg/L	PO4-P actual mg/L	PO4-P D.L. mg/L	pH
S4	2	26	1988	DRY	1	25	10	3.5	0.1	0.018	0.005	ND	1	2	1	0.1	0.1	8.4
S4	3	30	1988	DRY	2	20	1							2.2	0.1			8.1
S4	5	11	1988	DRY	3	30	0.1							1.7	0.1			7.5
S4FD	5	11	1988	DRY	3	38	0.1							1.7	0.1			7.7
S4	8	22	1988	DRY	4	18	1	2	0.1	ND	0.1			5	0.5			
S4	12	12	1988	DRY	5	13	10							ND	1.0			
S4	2	1	1988	DRY	6													
S4	2	1	1988	DRY	6	52	10							1.2	1			
S4	4	6	1988	DRY	7	5.2	1.0							ND	1.0			
S4D	3	30	1988	DRY	2	22	1							2.2	0.1			8.1
S4	4	20	1988	WET	1	250	1	1.2	0.1	0.03	0.01	0.2	0.1	2.5	0.1	0.8	0.1	7.6
S4	11	23	1988	WET	2	430	10	0.57	0.1	0.045	0.01	ND	1	1.8	1	0.55	0.1	
S4FD	11	23	1988	WET	2	1200	10	0.62	0.1	0.032	0.01	ND	1	1.6	1	0.86	0.1	
S4	1	23	1988	WET	3													
S4	2	4	1988	WET	4	120	1							1.2	1			
S4	2	8	1988	WET	5	150	1							1.1	1			
S4	3	2	1988	WET	6	130	1.0							ND	1.0			
S4	3	25	1988	WET	7	370	1.0											
FB	8	22	1988	DRY	4	2.5	1	ND	0.1	ND	0.1			ND	0.5			
FB	8	22	1988	DRY	4													
FB	12	12	1988	DRY	5													
FB	12	12	1988	DRY	5	ND	10							ND	1.0			
FB	2	1	1988	DRY	6													
FB	2	1	1988	DRY	6	ND	10							ND	1			
FB	4	6	1988	DRY	7													
FB	4	6	1988	DRY	7	ND	1.0							ND	1.0			
FB	11	23	1988	WET	2													
FB	11	23	1988	WET	2													
FB	11	23	1988	WET	2	IS	10	ND	0.1	ND	0.01	ND	1	ND	1	IS	0.1	
FB	1	23	1989	WET	3													
FB	1	23	1988	WET	3	ND	1.0							ND	1.0			
FB	2	8	1988	WET	5													
FB	2	8	1988	WET	5	NA	1							ND	1			
FB	3	2	1988	WET	6													
FB	3	2	1988	WET	6		1.0							ND	1.0			
FB	3	25	1988	WET	7		1.0											

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	TSS actual mg/L	TSS D.L. mg/L	NO3 N actual mg/L	NO3 N D.L. mg/L	NO2-N actual mg/L	NO2-N D.L. mg/L	NH3-N actual mg/L	NH3-N D.L. mg/L	TKN actual mg/L	TKN D.L. mg/L	PO4-P actual mg/L	PO4-P D.L. mg/L	pH
L1	4	20	1988	WET	1	23	1	1	0.1	0.02	0.01	0.2	0.1	2.8	0.1	0.3	0.1	7.5
L1	11	23	1988	WET	2	60	10	0.31	0.1	0.016	0.01	ND	1	1.1	1	0.23	0.1	
L1	2	4	1989	WET	4	72	1							4.3	1			
L1	2	9	1989	WET	5	82	1							2.7	1			
L1LR	2	9	1989	WET	5													
L1	3	2	1989	WET	6	40	1.0							3.0	1.0			
L1LR	3	2	1989	WET	6													
L2	4	20	1988	WET	1	76	1	0.7	0.1	0.05	0.01	0.6	0.1	2.2	0.1	0.8	0.1	7.5
L2	11	23	1988	WET	2	110	10	0.4	0.1	0.095	0.01	ND	1	1.7	1	0.56	0.1	
L2	2	4	1989	WET	4	64	1							2.8	1			
L2	2	9	1989	WET	5	130	1							1.0	1			
L2	3	2	1989	WET	6													
L2	3	2	1989	WET	6	130	1.0							ND	1.0			
L2	3	25	1989	WET	7	300	1.0											
L3	4	20	1988	WET	1	82	1	0.6	0.1	0.04	0.01	0.2	0.1	1.7	0.1	0.4	0.1	7.2
L3	11	23	1988	WET	2	19	10	0.65	0.1	0.049	0.01	ND	1	ND	1	0.15	0.1	
L3	2	4	1989	WET	4	40	1							5.5	1			
L3	2	9	1989	WET	5	62	1							2.4	1			
L3	3	2	1989	WET	6	58	1.0							ND	1.0			
L3	3	25	1989	WET	7	170	1.0											
L4	4	20	1988	WET	1													
L4	11	23	1988	WET	2													
L4	2	4	1989	WET	4	32	1							ND	1			
L4	2	9	1989	WET	5	94	1							1.1	1			
L4	3	2	1989	WET	6													
L4	3	25	1989	WET	7	80	1.0											
L5	4	20	1988	WET	1													
L5	11	23	1988	WET	2	110	10	0.7	0.1	0.028	0.01	ND	1	1.6	1	0.34	0.1	
L5	1	23	1989	WET	3	62	1.0							2.0	1.0			
L5	2	4	1989	WET	4	52	1							1.2	1			
L5LR	2	4	1989	WET	4													
L5	2	9	1989	WET	5	140	1							4.5	1			
L5	3	2	1989	WET	6	90	1.0							1.4	1.0			
L5FD	3	2	1989	WET	6	94	1.0							2.6	1.0			
L5	3	25	1989	WET	7	130	1.0											
L6	4	20	1988	WET	1													
L6	11	23	1988	WET	2	80	10	0.69	0.1	0.066	0.01	ND	1	1.8	1	0.24	0.1	
L6	2	9	1989	WET	5	54	1							ND	1			
L6	3	2	1989	WET	6	110	1.0							ND	1.0			
L6	3	25	1989	WET	7	92	1.0											

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	TSS actual mg/L	TSS D.L. mg/L	NO3-N actual mg/L	NO3-N D.L. mg/L	NO2-N actual mg/L	NO2-N D.L. mg/L	NH3-N actual mg/L	NH3-N D.L. mg/L	TKN actual mg/L	TKN D.L. mg/L	PO4-P actual mg/L	PO4-P D.L. mg/L	pH
L7	4	20	1988	WET	1													
L7	11	23	1988	WET	2	38	10	0.18	0.1	ND	0.01	ND	1	ND	1	0.10	0.1	
L7	2	4	1989	WET	4	26	1							1.5	1			
L7	2	9	1989	WET	5	12	1							ND	1			
L7	3	2	1989	WET	6	22	1.0							ND	1.0			
L7	3	25	1989	WET	7	420	1.0											
R1	2	27	1988	RES	1	24	10	0.1	0.1	0.006	0.005	ND	1	ND	1	ND	0.1	6
R2	2	26	1988	RES	1	11	10	0.8	0.1	0.009	0.005	ND	1	1	1	ND	0.1	8
R3	2	27	1988	RES	1	ND	10	0.2	0.1	0.005	0.005	ND	1	ND	1	ND	0.1	8.2
H4	2	27	1988	RES	1	84	10	0.1	0.1	0.006	0.005	ND	1	ND	1	0.2	0.1	8
R5	2	27	1988	RES	1	ND	10	ND	0.1	0.007	0.005	ND	1	1	1	0.1	0.1	8.5
R6	2	27	1988	RES	1	ND	10	0.2	0.1	0.006	0.005	ND	1	1	1	ND	0.1	8.8
S1	2	26	1988	DRY	1	ND	10	ND	0.1	ND	0.005	ND	1	2	1	0.1	0.1	8.2
S1	3	30	1988	DRY	2	3	1							1.1	0.1			8
S1	5	11	1988	DRY	3	1	0.1							1.4	0.1			8.7
S1	12	12	1988	DRY	5	ND	10							ND	1.0			
S1	2	1	1989	DRY	6	ND	10							ND	1			
S1	4	6	1989	DRY	7	1.6	1.0							ND	1.0			
S1	4	20	1988	WET	1													
S1	11	23	1988	WET	2	360	10	0.5	0.1	0.032	0.01	ND	1	2	1	0.56	0.1	
S1	1	23	1989	WET	3	5.5	1.0							ND	1.0			
S1	2	4	1989	WET	4	34	1							2	1			
S1	2	9	1989	WET	5	76	1							ND	1			
S1FD	2	9	1989	WET	5	50	1							1.8	1			
S1	3	2	1989	WET	6	180	1.0							1.4	1.0			
S1	3	25	1989	WET	7	190	1.0											
S1LR	3	25	1989	WET	7													
S1FD	3	25	1989	WET	7	220	1.0											

D.2-1 Conventional parameters in water column

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Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	TOC actual mg/L	D.L. mg/L	BOD actual mg/L	D.L. mg/L	COD actual mg/L	D.L. mg/L	Total Coliform MPN per 100ml of sample	D.L. MPN/100	Fecal Coliform MPN per 100ml of sample	D.L. MPN/100
S2	2	26	1988	DRY	1	5	1			31	5	35000	2	4600	2
S2	3	30	1988	DRY	2			4	1			1300	2	1300	2
S2	5	11	1988	DRY	3	5.3	1	ND	1			30000	2	2000	2
S2	12	12	1988	DRY	5			3	1			>2400	3	>2400	3
S2	2	1	1989	DRY	6	2.1	1	2.7	1			11000	3	93	3
S2	4	6	1989	DRY	7	1.9	1	2 5	1.0			2400	3	460	3
S2	4	20	1988	WET	1	13	1					54000	2	7000	2
S2	11	23	1988	WET	2	14	0.1	45	1			>240000	3	<240000	3
S2	1	23	1989	WET	3	19	1	13	1			24000	3	11000	3
S2FD	1	23	1989	WET	3	19	1	12	1						
S2	2	4	1989	WET	4	14	1	3 3	1						
S2FD	2	4	1989	WET	4	11	1	4.1	1						
S2	2	9	1989	WET	5	10	1	7 3	1			>240000	3	11000	3
S2	3	2	1989	WET	6	14	1	21	1.0			15000	3	4600	3
S2	3	25	1989	WET	7	7.3	1	8.4	1.0						
S3	2	26	1988	DRY	1	2	1			47	5	5400	2	2400	2
S3	3	30	1988	DRY	2			6	1			7900	2	4900	2
S3	5	11	1988	DRY	3	8.4	1	2	1			110000	2	2000	2
S3	8	22	1988	DRY	4			7	1			>2400	2	70	2
S3FD	8	22	1988	DRY	4			5	1						
S3FD	8	22	1988	DRY	4							>2400	2	70	2
S3	12	12	1988	DRY	5			ND	1			>2400	3	1100	3
S3FD	12	12	1988	DRY	5			2	1			>2400	3	460	3
S3	2	1	1989	DRY	6	1.7	1	2.6	1			24000	3	43	3
S3LR	2	1	1989	DRY	6	1.6	1	2.4	1						
S3FD	2	1	1989	DRY	6	1.7	1	1.9	1			11000	3	23	3
S3	4	6	1989	DRY	7	2.3	1	1.9	1.0			4600	3	1100	3
S3LR	4	6	1989	DRY	7	2.3	1								
S3FD	4	6	1989	DRY	7	2.4	1	1.6	1.0			2400	3	460	3
S3	4	20	1988	WET	1	13	1					240000	2	17000	2
S3	11	23	1988	WET	2	23	0.1	4	1			>240000	3	<240000	3
S3FD	11	23	1988	WET	2	9	0.1					>240000	3	46000	3
S3LR	11	23	1988	WET	2	8.4	0.1	IS	1						
S3	1	23	1989	WET	3	20	1	12	1			24000	3	4600	3
S3FD	1	23	1989	WET	3							110000	3	24000	3
S3LR	1	23	1989	WET	3	15	1								
S3	2	4	1989	WET	4	8.9	1	2 8	1						
S3	2	9	1989	WET	5	8.6	1	7.9	1			24000	3	4600	3
S3	3	2	1989	WET	6			12	1.0			46000	3	46000	3

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	TOC actual mg/L	D.L. mg/L	BOD actual mg/L	D.L. mg/L	COD actual mg/L	D.L. mg/L	Total Coliform MPN per 100ml of sample	D.L. MPN/100	Fecal Coliform MPN per 100ml of sample	D.L. MPN/100
L1	4	20	1988	WET	1	13	1	5				2300	2	2300	2
L1	11	23	1988	WET	2	6.8	0.1	9	1			110000	3	24000	3
L1	2	4	1989	WET	4	18	1	5.3	1						
L1	2	9	1989	WET	5	44	1	10	1			110000	3	15000	3
L1LR	2	9	1989	WET	5	44	1								
L1	3	2	1989	WET	6	260	1	35	1.0			9300	3	150	3
L1LR	3	2	1989	WET	6	260	1								
L2	4	20	1988	WET	1	23	1	13				7900	2	2300	2
L2	11	23	1988	WET	2	9.9	0.1	10	1			4600	3	2400	3
L2	2	4	1989	WET	4	11	1	3.6	1						
L2	2	9	1989	WET	5	13	1	8.4	1			4600	3	2400	3
L2	3	2	1989	WET	6							7500	3	93	3
L2	3	2	1989	WET	6			16	1.0						
L2	3	25	1989	WET	7	8.3	1	13	1.0						
L3	4	20	1988	WET	1	16	1	7				350000	2	7900	2
L3	11	23	1988	WET	2	9.2	0.1	7	1			46000	3	11000	3
L3	2	4	1989	WET	4	9.5	1	4.3	1						
L3	2	9	1989	WET	5	'9.2	1	5.9	1			11000	3	4600	3
L3	3	2	1989	WET	6	12	1	12	1.0			24000	3	930	3
L3	3	25	1989	WET	7	8.9	1	14	1.0						
L4	4	20	1988	WET	1			7				24000	2	4900	2
L4	11	23	1988	WET	2							>240000	3	110000	3
L4	2	4	1989	WET	4	9.7	1	3.1	1						
L4	2	9	1989	WET	5	8.7	1	4.2	1			24000	3	2400	3
L4	3	2	1989	WET	6							15000	3	2400	3
L4	3	25	1989	WET	7	9.4	1	11	1.0						
L5	4	20	1988	WET	1							170000	2	4900	2
L5	11	23	1988	WET	2	12	0.1	10	1			4600	3	400	3
L5	1	23	1989	WET	3	21	1	14	1			24000	3	2400	3
L5	2	4	1989	WET	4	11	1	4.4	1						
L5LR	2	4	1989	WET	4	11	1								
L5	2	9	1989	WET	5	7.7	1	3.7	1			46000	3	2400	3
L5	3	2	1989	WET	6	12	1	13	1.0			46000	3	2400	3
L5FD	3	2	1989	WET	6	12	1	15	1.0			110000	3	4300	3
L5	3	25	1989	WET	7	6.7	1	12	1.0						
L6	4	20	1988	WET	1	17	1					70000	2	500	2
L6	11	23	1988	WET	2	14	0.1	13	1			46000	3	1500	3
L6	2	9	1989	WET	5	6.5	1	4.2	1			46000	3	15000	3
L6	3	2	1989	WET	6	18	1	25	1.0			2100	3	240	3
L6	3	25	1989	WET	7	8.3	1	10	1.0						

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	TOC actual mg/L	TOC D.L. mg/L	BOD actual mg/L	BOD D.L. mg/L	COD actual mg/L	COD D.L. mg/L	Total Coliform MPN per 100ml of sample	D.L. MPN/100	Fecal Coliform MPN per 100ml of sample	D.L. MPN/100
L7	4	20	1988	WET	1							17000	2	800	2
L7	11	23	1988	WET	2	7.1	0.1	5	1			110000	3	11000	3
L7	2	4	1989	WET	4	4.8	1	2.1	1						
L7	2	8	1988	WET	5	3.1	1	3.1	1			750	3	76	3
L7	3	2	1989	WET	6	3.7	1	7.2	1.0			93	3	93	3
L7	3	28	1989	WET	7	6.1	1	7.3	1.0						
R1	2	27	1988	REB	1	5	1			31	5	7.8	2	<2	2
R2	2	28	1988	REB	1	4	1			31	5	49	2	33	2
R3	2	27	1988	REB	1	4	1			16	5	2	2	<2	2
R4	2	27	1988	REB	1	4	1			16	5	7.8	2	4.5	2
R5	2	27	1988	REB	1	7	1			16	5	540	2	13	2
R8	2	27	1988	REB	1	6	1			ND	5	2	2	<2	2
S1	2	28	1988	DRY	1	9	1			63	5	2400	2	2400	2
S1	3	30	1988	DRY	2			8	1			4800	2	2300	2
S1	5	11	1988	DRY	3	0.4	1	1	1			130000	2	8000	2
S1	12	12	1988	DRY	5			3	1			>2400	3	>2400	3
S1	2	1	1989	DRY	6	3.0	1	3.6	1			4600	3	43	3
S1	4	6	1989	DRY	7	3.0	1	1.5	1.0			11000	3	1500	3
S1	4	20	1988	WET	1							350000	2	3300	2
S1	11	23	1988	WET	2	10	0.1	13	1			>240000	3	110000	3
S1	1	23	1989	WET	3	9.0	1	5.8	1			110000	3	46000	3
S1	2	4	1989	WET	4	14	1	2.8	1						
S1	2	9	1989	WET	5	12	1	6.7	1			>240000	3	>240000	3
S1FD	2	9	1989	WET	5	12	1	4.9	1			>240000	3	11000	3
S1	3	2	1989	WET	6	14	1	21	1.0			46000	3	24000	3
S1	3	25	1989	WET	7	8.3	1	10	1.0						
S1LR	3	25	1989	WET	7	8.4	1								
S1FD	3	25	1989	WET	7	8.1	1	9.2	1.0						

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Fecal Strep MPN per 100ml of sample	D.L. MPN/100	Hardness actual mg/L	D.L. mg/L	Turbidity actual NTU	D.L. NTU
L1	4	20	1988	WET	1			31	1	39	
L1	11	23	1988	WET	2			32	1	170	1
L1	2	4	1989	WET	4						
L1	2	9	1989	WET	5			36	1	82	1
L1LR	2	9	1989	WET	5			80	1.0	60	1.0
L1	3	2	1989	WET	6						
L1LR	3	2	1989	WET	6						
L2	4	20	1988	WET	1			47	1	77	
L2	11	23	1988	WET	2			42	1	170	1
L2	2	4	1989	WET	4			33	1	120	1
L2	2	9	1989	WET	5						
L2	3	2	1989	WET	6			47	1.0	140	1.0
L2	3	2	1989	WET	6			35	1.0	140	1.0
L2	3	25	1989	WET	7						
L3	4	20	1988	WET	1			33	1	21	
L3	11	23	1988	WET	2			32	1	66	1
L3	2	4	1989	WET	4			26	1	30	1
L3	2	9	1989	WET	5			25	1.0	51	1.0
L3	3	2	1989	WET	6			26	1.0	50	1.0
L3	3	25	1989	WET	7						
L4	4	20	1988	WET	1						
L4	11	23	1988	WET	2			530	1	37	1
L4	2	4	1989	WET	4			470	1	66	1
L4	2	9	1989	WET	5						
L4	3	2	1989	WET	6			550	1.0	64	1.0
L4	3	25	1989	WET	7						
L5	4	20	1988	WET	1			70	1	69	
L5	11	23	1988	WET	2	2400	3	51	1.0	59	1.0
L5	1	23	1989	WET	3			45	1	73	1
L5	2	4	1989	WET	4						
L5LR	2	4	1989	WET	4			41	1	110	1
L5	2	9	1989	WET	5			35	1.0	83	1.0
L5	3	2	1989	WET	6			59	1.0	69	1.0
L5FD	3	2	1989	WET	6			36	1.0	79	1.0
L5	3	25	1989	WET	7						
L6	4	20	1988	WET	1			56	1	36	
L6	11	23	1988	WET	2			25	1	30	1
L6	2	9	1989	WET	5			35	1.0	66	1.0
L6	3	2	1989	WET	6			37	1.0	100	1.0
L6	3	25	1989	WET	7						

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	Fecal Strep MPN per 100ml of sample	D.L. MPN/100	Hardness actual mg/L	D.L. mg/L	Turbidity actual NTU	D.L. NTU
L7	4	20	1000	WET	1						
L7	11	23	1088	WET	2			260	1	25	
L7	2	4	1080	WET	4			250	1	30	1
L7	2	0	1000	WET	5			250	1	11	1
L7	3	2	1080	WET	6			250	1.0	10	1.0
L7	3	25	1000	WET	7			170	1.0	360	1.0
R1	2	27	1008	RES	1						
R2	2	26	1080	RES	1						
R3	2	27	1000	RES	1						
R4	2	27	1000	RES	1						
R5	2	27	1000	RES	1						
R6	2	27	1000	RES	1						
S1	2	26	1010	DRY	1						
S1	3	30	1040	DRY	2						
S1	5	11	1630	DRY	3						
S1	12	12	1008	DRY	5			230	1.0	4	1 0
S1	2	1	1080	DRY	6			190	1	5.2	1
S1	4	6	1000	DRY	7			220	1.0	1.6	1.0
S1	4	20	1000	WET	1						
S1	11	23	1000	WET	2			110	1	240	
S1	1	23	1080	WET	3	4660	3	240	1.0	5 1	1.0
S1	2	4	1000	WET	4			110	1	60	1
S1	2	0	1000	WET	5			60	1	60	1
S1FD	2	0	1000	WET	5			50	1	05	1
S1	3	2	1000	WET	6			76	1.0	120	1.0
S1	3	25	1000	WET	7			40	1.0	07	1.0
S1LR	3	25	1000	WET	7						
S1FD	3	25	1060	WET	7			64	1.0	120	1.0

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D.2-2 Conventional parameters in sediment

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	Fecal Strep MPN per 100ml of sample	D.L. MPN/100	Hardness actual mg/L	D.L. mg/L	Turbidity actual NTU	D.L. NTU
S2	2	26	1988	DRY	1						
S2	3	30	1988	DRY	2						
S2	5	11	1988	DRY	3						
S2	12	12	1988	DRY	5			500	1.0	3	1.0
S2	2	1	1989	DRY	6			530	1	2.5	1
S2	4	6	1989	DRY	7			500	1.0	3.2	1.0
S2	4	20	1988	WET	1						
S2	11	23	1988	WET	2			330	1	480	
S2	1	23	1989	WET	3	1100	3	120	1.0	39	1.0
S2FD	1	23	1989	WET	3			86	1.0	27	1.0
S2	2	4	1989	WET	4			100	1	83	1
S2FD	2	4	1989	WET	4			47	1	87	1
S2	2	9	1989	WET	5			76	1	79	1
S2	3	2	1989	WET	6			88	1.0	110	1.0
S2	3	25	1989	WET	7			77	1.0	120	1.0
S3	2	26	1988	DRY	1						
S3	3	30	1988	DRY	2						
S3	5	11	1988	DRY	3						
S3	8	22	1988	DRY	4						
S3FD	8	22	1988	DRY	4						
S3FD	8	22	1988	DRY	4						
S3	12	12	1988	DRY	5			340	1.0	6	1.0
S3FD	12	12	1988	DRY	5			320	1.0	5	1.0
S3	2	1	1989	DRY	6			360	1	4.6	1
S3LR	2	1	1989	DRY	6			370	1	4.8	1
S3FD	2	1	1989	DRY	6			360	1	3.0	1
S3	4	6	1989	DRY	7			290	1.0	4.9	1.0
S3LR	4	6	1989	DRY	7						
S3FD	4	6	1989	DRY	7			300	1.0	3.5	1.0
S3	4	20	1988	WET	1						
S3	11	23	1988	WET	2			180	1	910	
S3FD	11	23	1988	WET	2						
S3LR	11	23	1988	WET	2			180	1	890	
S3	1	23	1989	WET	3			130	1.0	200	1.0
S3FD	1	23	1989	WET	3	4600	3				
S3LR	1	23	1989	WET	3						
S3	2	4	1989	WET	4			130	1	180	1
S3	2	9	1989	WET	5			140	1	150	1
S3	3	2	1989	WET	6			300	1.0	34	1.0

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Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	Fecal Strep MPN per 100ml of sample	D.L. MPN/100	Hardness actual mg/L	Hardness D.L. mg/L	Turbidity actual NTU	Turbidity D.L. NTU
S4	2	26	1988	DRY	1						
S4	3	30	1988	DRY	2						
S4	5	11	1988	DRY	3						
S4FD	5	11	1988	DRY	3						
S4	8	22	1988	DRY	4						
S4	12	12	1988	DRY	5			460	1.0	15	1.0
S4	2	1	1989	DRY	6						
S4	2	1	1989	DRY	6			420	1	36	1
S4	4	8	1989	DRY	7			420	1.0	7.0	1.0
S4D	3	30	1988	DRY	2						
S4	4	20	1988	WET	1						
S4	11	23	1988	WET	2			230	1	380	
S4FD	11	23	1988	WET	2			150	1	650	
S4	1	23	1989	WET	3	>240000	3				
S4	2	4	1989	WET	4			160	1	120	1
S4	2	8	1989	WET	5			140	1	100	1
S4	3	2	1989	WET	6			140	1.0	86	1.0
S4	3	25	1989	WET	7			200	1.0	220	1.0
FB	8	22	1988	DRY	4						
FB	8	22	1988	DRY	4						
FB	12	12	1988	DRY	5						
FB	12	12	1988	DRY	5			ND	1.0	ND	1.0
FB	2	1	1989	DRY	6						
FB	2	1	1989	DRY	6			ND	1	ND	1
FB	4	6	1989	DRY	7						
FB	4	6	1989	DRY	7			ND	1.0	ND	1.0
FB	11	23	1988	WET	2						
FB	11	23	1988	WET	2						
FB	11	23	1988	WET	2			ND	1	IS	
FB	1	23	1989	WET	3	<3	3				
FB	1	23	1989	WET	3			ND	1.0	ND	1.0
FB	2	8	1989	WET	5						
FB	2	8	1989	WET	5			ND	1	ND	1
FB	3	2	1989	WET	6						
FB	3	2	1989	WET	6				1.0		1.0
FB	3	25	1989	WET	7				1.0		1.0

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	PARTICLE SIZE % SAND 0 4 PHI %	% SILT 5 8 PHI %	% CLAY <<9 PHI %	NH3 N actual mg/kg	NH3 N D L mg/kg	TKN actual mg/kg	TKN D L mg/kg	TOC actual mg/kg	TOC D L mg/kg	BOD actual mg/kg	BOD D L mg/kg
STANDARD LIMITS										1		1		100		25
S1	3	30	1988	DRY	1				82	1	210	1	ND	100		
S1	8	22	1988	DRY	3	76 9	9 3	0								
S1	12	12	1988	DRY	4	94 1	5 1	0 8								
S2	3	30	1988	DRY	1				130	1	830	1	16500	100		
S2	8	22	1988	DRY	3	83 3	11 4	1 1								
S2	12	12	1988	DRY	4	81.7	16	2 3								
S3	3	30	1988	DRY	1				150	1	920	1	33700	100		
S3	8	22	1988	DRY	3	26 4	64 3	9 3								
S3	12	12	1988	DRY	4	90 1	8 4	1 3								
S3LR	12	12	1988	DRY	4	94	4 4	1 7								
S4	3	30	1988	DRY	1				110	1	690	1	11400	100		
S4LR	3	30	1988	DRY	1				115	1	720	1	11100	100		
S4	8	22	1988	DRY	3	67 1	26	6 9								
S4FD	8	22	1988	DRY	3	22 3	68 1	9 7								
S4	12	12	1988	DRY	4	84 5	14	1 4								
S4FD	12	12	1988	DRY	4	89 5	8 9	1 5								

VOL 12

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D.3 Organochlorine pesticides

VOL 12

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D.3-1 Organochlorine pesticides in water column

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ORGANOCHLORINE PESTICIDES

Abbreviated Name	Actual Name
6CL-CHX-A	Alpha-BHC (hexachlorocyclohexane
6CL-CHX-B	Beta-BHC (hexachlorocyclohexane)
6CL-CHX-D	Delta-BHC (hexachlorocyclohexane)
6CL-CHX-G	Gamma-BHC (hexachlorocyclohexane)
G-CHLORDANE	Gamma-chlordane
ENDOSULFAN-A	Endosulfan I
ENDOSULFAN-B	Endosulfan II
ENDOSULFAN-S	Endosulfan sulfate
ENDRIN-ALD	Endrin aldehyde
HEPCL EPOX	Heptachlor epoxide
METHOXYCL	Methoxychlor
tPCB	Total polychlorinated biphenyls
DDD	4,4'-DDD
DDE	4,4'-DDE
DDT	4,4'-DDT

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ALDRIN actual ug/l	ALDRIN DL ug/l	6CL CHX-A actual ug/l	6CL CHX-A DL ug/l	6CL CHX-B actual ug/l	6CL CHX-B DL ug/l	6CL CHX-D actual ug/l	6CL CHX-D DL ug/l	6CL CHX-G actual ug/l	6CL CHX-G DL ug/l	G-CHLORDANE actual ug/l	G-CHLORDANE DL ug/l
STANDARD REPORTING OBJECTIVES							0.05		0.05		0.05		0.05		0.05		0.1
S4	2	26	1988	DRY	1	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	3	30	1988	DRY	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	5	11	1988	DRY	3	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	8	25	1988	DRY	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	12	12	1988	DRY	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	2	1	1989	DRY	6	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	4	6	1989	DRY	7	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	4	20	1988	WET	1	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	11	23	1988	WET	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	0.1	0.1
S4FD	11	23	1988	WET	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	2	4	1989	WET	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S4	2	9	1989	WET	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
SB	8	25	1988	DRY	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
FB	8	25	1988	DRY	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
FB	12	12	1988	DRY	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
FB	2	1	1989	DRY	6	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
FB	4	6	1989	DRY	7	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
FB	11	23	1988	WET	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
FB	1	23	1989	WET	3	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
FB	2	9	1989	WET	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
FB	3	2	1989	WET	6	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	A CHLORDANE actual ug/l	DL ug/l	DDD actual ug/l	DL ug/l	DDE actual ug/l	DL ug/l	DDT actual ug/l	DL ug/l	DIELDRIN actual ug/l	DL ug/l	ENDOSLFN A actual ug/l	DL ug/l
STANDARD REPORTING OBJECTIVES							0.1		0.1		0.05		0.1		0.05		0.05
L1	4	20	1988	WET	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L1	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
L1	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L1	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L1	3	2	1989	WET	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L2	4	20	1988	WET	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L2	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.05	0.16	0.1	ND	0.1	ND	0.05
L2	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L2	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L3	4	20	1988	WET	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L3	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
L3	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L3	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L3	3	2	1989	WET	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L4	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L4	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L5	11	23	1988	WET	2	ND	0.1	ND	0.1	0.05	0.05	0.13	0.1	ND	0.1	ND	0.05
L5	1	23	1989	WET	3	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L5	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L5	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L5	3	2	1989	WET	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L5FD	3	2	1989	WET	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L6	4	20	1988	WET	1	0.3	0.1	ND	0.1	0.1	0.05	ND	0.1	ND	0.05	ND	0.05
L6	11	23	1988	WET	2	ND	0.1	ND	0.1	0.074	0.05	ND	0.1	ND	0.1	ND	0.05
L6	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L6	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L7	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
L7	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L7	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
L7	3	2	1989	WET	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
R1	2	27	1989	RES	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
R2	2	26	1989	RES	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
R3	2	27	1989	RES	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
R4	2	27	1989	RES	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
R5	2	27	1989	RES	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
R6	2	27	1989	RES	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ALDRIN actual ug/l	ALDRIN DL ug/l	6CL CHX A actual ug/l	6CL CHX A DL ug/l	6CL CHX B actual ug/l	6CL CHX B DL ug/l	6CL CHX D actual ug/l	6CL CHX D DL ug/l	6CL CHX G actual ug/l	6CL CHX G DL ug/l	G-CHLORDANE actual ug/l	G-CHLORDANE DL ug/l
STANDARD REPORTING OBJECTIVES							0 05		0 05		0 05		0 05		0 05		0 1
L1	4	20	1988	WET	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L1	11	23	1988	WET	2	ND	0 05	0 077	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L1	2	4	1989	WET	4	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L1	2	9	1989	WET	5	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L1	3	2	1989	WET	6	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L2	4	20	1988	WET	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L2	11	23	1988	WET	2	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L2	2	4	1989	WET	4	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L2	2	9	1988	WET	5	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L3	4	20	1988	WET	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L3	11	23	1988	WET	2	ND	0 05	0 053	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L3	2	4	1989	WET	4	ND	0 05	ND	0 05	ND	0 05	ND	0 05	0.18	0 05	ND	0 1
L3	2	9	1989	WET	5	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L3	3	2	1989	WET	6	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L4	2	4	1989	WET	4	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L4	2	9	1988	WET	5	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L5	11	23	1988	WET	2	ND	0 05	0 07	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L5	1	23	1989	WET	3	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L5	2	4	1988	WET	4	ND	0 05	ND	0 05	ND	0 05	ND	0 05	0 05	0 05	ND	0 1
L5	2	9	1989	WET	5	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L5	3	2	1989	WET	6	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L5FD	3	2	1989	WET	6	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L6	4	20	1988	WET	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	0 2	0 1
L6	11	23	1988	WET	2	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L6	2	4	1989	WET	4	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L6	2	9	1989	WET	5	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L7	11	23	1988	WET	2	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L7	2	4	1989	WET	4	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L7	2	9	1989	WET	5	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
L7	3	2	1989	WET	6	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
R1	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
R2	2	26	1988	RES	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
R3	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
R4	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
R5	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1
R6	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 05	ND	0 1

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ALDRIN actual ug/l	DL ug/l	6CL CHX-A actual ug/l	DL ug/l	6Cl actu ug					g/l		DL ug/l
STANDARD REPORTING OBJECTIVES							0.05		0.05						0 (		0.1
S1	2	26	1988	DRY	1	ND	0.05	ND	0.05	ND					(		0.1
S1	3	30	1988	DRY	2	ND	0.05	ND	0.05	ND						)	0.1
S1	5	11	1988	DRY	3	ND	0.05	ND	0.05	ND	(			D		D	0.1
S1	12	12	1988	DRY	5	ND	0.05	ND	0.05	ND	0			ND		ND	0.1
S1	2	1	1989	DRY	6	ND	0.05	ND	0.05	ND	0			ND		ND	0.1
S1	4	6	1989	DRY	7	ND	0.05	ND	0.05	ND	0	D		ND	0	ND	0.1
S1	11	23	1988	WET	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S1	1	23	1989	WET	3	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S1	2	4	1989	WET	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S1	2	8	1989	WET	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S1FD	2	8	1989	WET	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S1	3	2	1989	WET	6	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	2	26	1988	DRY	1	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	3	30	1988	DRY	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	5	11	1988	DRY	3	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	12	12	1988	DRY	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	2	1	1989	DRY	6	ND	0.05	ND	0.05	ND	0.05	ND	0.06	ND	0.05	ND	0.1
S2	4	6	1989	DRY	7	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	11	23	1988	WET	2	ND	0.05	0.05	0.05	ND	0.05	ND	0.05	ND	0.05	0.1	0.1
S2	1	23	1989	WET	3	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S5	1	23	1989	WET	3	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	2	4	1989	WET	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	2	8	1989	WET	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S2	3	2	1989	WET	6	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	2	26	1988	DRY	1	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	3	30	1988	DRY	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	5	11	1988	DRY	3	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	8	25	1988	DRY	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3FD	8	25	1988	DRY	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	12	12	1988	DRY	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S5	12	12	1988	DRY	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	2	1	1989	DRY	6	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S5	2	1	1989	DRY	6	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	4	6	1989	DRY	7	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S5	4	6	1989	DRY	7	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	11	23	1988	WET	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3LR	11	23	1988	WET	2	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	1	23	1989	WET	3	ND	0.05	ND	0.05	ND	0.05	ND	0.05	0.032	0.05	ND	0.1
S3	2	4	1989	WET	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	2	4	1589	WET	4	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1
S3	2	8	11.30	WET	5	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.1

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ENDOSULFN B actual ug/l	ENDOSULFN B DL ug/l	ENDOSULFN S actual ug/l	ENDOSULFN S DL ug/l	ENDRIN actual ug/l	ENDRIN DL ug/l	ENDRIN-ALD actual ug/l	ENDRIN-ALD DL ug/l	HEPTACHLOR actual ug/l	HEPTACHLOR DL ug/l
STANDARD REPORTING OBJECTIVES							0.05		0.1		0.1		0.1		0.05
L1	4	20	1988	WET	1	ND	0.05	0.12	0.1	ND	0.1	ND	0.1	ND	0.05
L1	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L1	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L1	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L1	3	2	1989	WET	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L2	4	20	1988	WET	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L2	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L2	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L2	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L3	4	20	1988	WET	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L3	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L3	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L3	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L3	3	2	1989	WET	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L4	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L4	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L5	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L5	1	23	1989	WET	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L5	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L5	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L5	3	2	1989	WET	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L5FD	3	2	1989	WET	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L6	4	20	1988	WET	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L6	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L6	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L6	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L7	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L7	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L7	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
L7	3	2	1989	WET	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
R1	2	27	1988	RES	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
R2	2	26	1988	RES	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
R3	2	27	1988	RES	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
R4	2	27	1988	RES	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
R5	2	27	1988	RES	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
R6	2	27	1988	RES	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ENDOSLFN-B actual ug/l	DL ug/l	ENDOSLFN-S actual ug/l	DL ug/l	ENDRIN actual ug/l	DL ug/l	ENDRIN-ALD actual ug/l	DL ug/l	HEPTACHLOR actual ug/l	DL ug/l
STANDARD REPORTING OBJECTIVES							0.05		0.1		0.1		0.1		0.05
S1	2	26	1988	DRY	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	3	30	1988	DRY	2	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	5	11	1988	DRY	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	12	12	1988	DRY	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	2	1	1989	DRY	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	4	6	1989	DRY	7	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	1	23	1989	WET	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	2	8	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1FD	2	8	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S1	3	2	1989	WET	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	2	26	1988	DRY	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	3	30	1988	DRY	2	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	5	11	1988	DRY	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	12	12	1988	DRY	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	2	1	1989	DRY	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	4	6	1989	DRY	7	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	1	23	1989	WET	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S5	1	23	1989	WET	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S2	3	2	1989	WET	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	2	26	1988	DRY	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	3	30	1988	DRY	2	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	5	11	1988	DRY	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	8	25	1988	DRY	4	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3FD	8	25	1988	DRY	4	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	12	12	1988	DRY	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S5	12	12	1988	DRY	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	2	1	1989	DRY	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S5	2	1	1989	DRY	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	4	6	1989	DRY	7	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S5	4	6	1989	DRY	7	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3LR	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	1	23	1989	WET	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S3	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	A CHLORDANE actual ug/l	DL ug/l	DDD actual ug/l	DL ug/l	DDE actual ug/l	DL ug/l	DDT actual ug/l	DL ug/l	DIELDRIN actual ug/l	DL ug/l	ENDOSLFN A actual ug/l	DL ug/l
STANDARD REPORTING OBJECTIVES							0.1		0.1		0.05		0.1		0.05		0.05
S1	2	26	1988	DRY	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1	3	30	1988	DRY	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1	5	11	1988	DRY	3	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1	12	12	1988	DRY	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1	2	1	1989	DRY	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1	4	6	1989	DRY	7	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S1	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S1	1	23	1989	WET	3	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1FD	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S1	3	2	1989	WET	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	2	26	1988	DRY	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	3	30	1988	DRY	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	5	11	1988	DRY	3	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	12	12	1988	DRY	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	2	1	1989	DRY	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	4	6	1989	DRY	7	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S2	11	23	1988	WET	2	ND	0.1	0.13	0.1	0.08	0.05	0.25	0.1	ND	0.1	ND	0.05
S2	1	23	1989	WET	3	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S5	1	23	1989	WET	3	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S2	3	2	1989	WET	6	0.1	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	2	26	1988	DRY	1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	3	30	1988	DRY	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	5	11	1988	DRY	3	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	8	25	1988	DRY	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S3FD	8	25	1988	DRY	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S3	12	12	1988	DRY	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S5	12	12	1988	DRY	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	2	1	1989	DRY	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S5	2	1	1989	DRY	6	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	4	6	1989	DRY	7	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S5	4	6	1989	DRY	7	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S3	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S3LR	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
S3	1	23	1989	WET	3	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	2	4	1989	WET	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
S3	2	9	1989	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05

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Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	A CHLORDANE actual ug/l	A CHLORDANE DL ug/l	DDD actual ug/l	DDD DL ug/l	DDE actual ug/l	DDE DL ug/l	DDT actual ug/l	DDT DL ug/l	DIELDRIN actual ug/l	DIELDRIN DL ug/l	ENDOSLFN A actual ug/l	ENDOSLFN A DL ug/l
STANDARD REPORTING OBJECTIVES							0 1		0.1		0.05		0.1		0.05		0.05
S4	2	26	1988	DRY	1	ND	0 1	ND	0 1	ND	0 05	ND	0.1	ND	0.05	ND	0 05
S4	3	30	1988	DRY	2	ND	0 1	ND	0 1	ND	0 05	ND	0.1	ND	0 05	ND	0 05
S4	5	11	1988	DRY	3	ND	0 1	ND	0.1	ND	0.05	ND	6.1	ND	0.05	ND	0 05
S4	8	25	1988	DRY	4	ND	0 1	ND	0.1	ND	0 05	ND	0.1	ND	0.1	ND	0 05
S4	12	12	1988	DRY	5	ND	0 1	ND	0 1	ND	0 05	ND	0.1	ND	0.05	ND	0 05
S4	2	1	1988	DRY	6	ND	0.1	ND	0 1	ND	0 05	ND	0.1	ND	0.05	ND	0 05
S4	4	6	1988	DRY	7	ND	0 1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0 05
S4	4	20	1988	WET	1	ND	0 1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0 05
S4	11	23	1988	WET	2	ND	0 1	ND	0 1	0.07	0 05	0.19	0.1	ND	0.1	0.13	0.05
S4FD	11	23	1988	WET	2	ND	0 1	ND	0.1	0.05	0 05	0.15	0.1	ND	0.1	ND	0 05
S4	2	4	1988	WET	4	ND	0.1	ND	0.1	0 05	0 05	0 05	0.1	ND	0.05	ND	0 05
S4	2	8	1988	WET	5	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0.05
SB	8	25	1988	DRY	4	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
FB	8	25	1988	DRY	4	ND	0.1	ND	0 1	ND	0 05	ND	0.1	ND	0.1	ND	0 05
FB	12	12	1988	DRY	5	ND	0 1	ND	0.1	ND	0.05	ND	0.1	ND	0.05	ND	0 05
FB	2	1	1988	DRY	6	ND	0 1	ND	0.1	ND	0 05	ND	0.1	ND	0 05	ND	0 05
FB	4	6	1988	DRY	7	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
FB	11	23	1988	WET	2	ND	0 1	ND	0 1	ND	0.05	ND	0.1	ND	0.1	ND	0.05
FB	1	23	1989	WET	3	ND	0 1	ND	0.1	0 077	0.05	ND	0.1	ND	0.05	ND	0 05
FB	2	9	1989	WET	5	ND	0 1	ND	0 1	ND	0 05	ND	0.1	ND	0.05	ND	0.05
FB	3	2	1988	WET	6	ND	0 1	ND	0 1	ND	0.05	ND	0.1	ND	0.05	ND	0.05

R0054620

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	HEPCL EPOX actual ug/l	DL ug/l	METHOXYCL actual ug/l	DL ug/l	TOXAPHENE actual ug/l	DL ug/l	tPCB actual ug/l	DL ug/l
STANDARD REPORTING OBJECTIVES							0.05		0.05		1		1
S1	2	26	1988	DRY	1	ND	0.05	ND	0.05	ND	1	ND	1
S1	3	30	1988	DRY	2	ND	0.05	ND	0.05	ND	1	ND	1
S1	5	11	1988	DRY	3	ND	0.05	ND	0.05	ND	1	ND	1
S1	12	12	1988	DRY	5	ND	0.05	ND	0.5	ND	1	ND	1
S1	2	1	1989	DRY	6	ND	0.05	ND	0.5	ND	1	ND	1
S1	4	6	1989	DRY	7	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S1	11	23	1988	WET	2	ND	0.05	ND	0.5	ND	1	ND	1
S1	1	23	1989	WET	3	ND	0.05	ND	0.5	ND	1	ND	1
S1	2	4	1989	WET	4	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S1	2	9	1989	WET	5	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S1FD	2	9	1989	WET	5	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S1	3	2	1989	WET	6	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S2	2	26	1988	DRY	1	ND	0.05	ND	0.05	ND	1	ND	1
S2	3	30	1988	DRY	2	ND	0.05	ND	0.05	ND	1	ND	1
S2	5	11	1988	DRY	3	ND	0.05	ND	0.05	ND	1	ND	1
S2	12	12	1988	DRY	5	ND	0.05	ND	0.5	ND	1	ND	1
S2	2	1	1989	DRY	6	ND	0.05	ND	0.5	ND	1	ND	1
S2	4	6	1989	DRY	7	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S2	11	23	1988	WET	2	ND	0.05	ND	0.5	ND	1	ND	1
S2	1	23	1989	WET	3	ND	0.05	ND	0.5	ND	1	ND	1
S5	1	23	1989	WET	3	ND	0.05	ND	0.5	ND	1	ND	1
S2	2	4	1989	WET	4	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S2	2	9	1989	WET	5	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S2	3	2	1989	WET	6	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S3	2	26	1988	DRY	1	ND	0.05	ND	0.05	ND	1	ND	1
S3	3	30	1988	DRY	2	ND	0.05	ND	0.05	ND	1	ND	1
S3	5	11	1988	DRY	3	ND	0.05	ND	0.05	ND	1	ND	1
S3	8	25	1988	DRY	4	ND	0.05	ND	0.5	ND	1	ND	1
S3FD	8	25	1988	DRY	4	ND	0.05	ND	0.5	ND	1	ND	1
S3	12	12	1988	DRY	5	ND	0.05	ND	0.5	ND	1	ND	1
S5	12	12	1988	DRY	5	ND	0.05	ND	0.5	ND	1	ND	1
S3	2	1	1989	DRY	6	ND	0.05	ND	0.5	ND	1	ND	1
S5	2	1	1989	DRY	6	ND	0.05	ND	0.5	ND	1	ND	1
S3	4	6	1989	DRY	7	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S5	4	6	1989	DRY	7	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S3	11	23	1988	WET	2	ND	0.05	ND	0.5	ND	1	ND	1
S3LR	11	23	1988	WET	2	ND	0.05	ND	0.5	ND	1	ND	1
S3	1	23	1989	WET	3	ND	0.05	ND	0.5	ND	1	ND	1
S3	2	4	1989	WET	4	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S3	2	4	1989	WET	4	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S3	2	9	1989	WET	5	ND	0.05	ND	0.5	ND	1.0	ND	1.0

R0054621

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	HEPCL EPOX actual ug/l	DL ug/l	METHOXYCL actual ug/l	DL ug/l	TOXAPHENE actual ug/l	DL ug/l	IPCB actual ug/l	DL ug/l
STANDARD REPORTING OBJECTIVES							0.05		0.05		1		1
S4	2	26	1988	DRY	1	ND	0.05	ND	0.05	ND	1	ND	1
S4	3	30	1988	DRY	2	ND	0.05	ND	0.05	ND	1	ND	1
S4	5	11	1988	DRY	3	ND	0.05	ND	0.05	ND	1	ND	1
S4	8	25	1988	DRY	4	ND	0.05	ND	0.05	ND	1	1.3	1
S4	12	12	1988	DRY	5	ND	0.05	ND	0.5	ND	1	ND	1
S4	2	1	1988	DRY	6	ND	0.05	ND	0.5	ND	1	ND	1
S4	4	6	1988	DRY	7	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S4	4	20	1988	WET	1	ND	0.05	ND	0.05	ND	1	ND	1
S4	11	23	1988	WET	2	ND	0.05	ND	0.5	ND	1	ND	1
S4FD	11	23	1988	WET	2	ND	0.05	ND	0.5	ND	1	1.4	1
S4	2	4	1988	WET	4	ND	0.05	ND	0.5	ND	1.0	ND	1.0
S4	2	8	1988	WET	5	ND	0.05	ND	0.5	ND	1.0	ND	1.0
SB	8	25	1988	DRY	4	ND	0.05	ND	0.5	ND	1	1.3	1
FB	8	25	1988	DRY	4	ND	0.05	ND	0.5	ND	1	1.3	1
FB	12	12	1988	DRY	5	ND	0.05	ND	0.5	ND	1	ND	1
FB	2	1	1989	DRY	6	ND	0.05	ND	0.5	ND	1	ND	1
FB	4	6	1988	DRY	7	ND	0.05	ND	0.5	ND	1.0	ND	1.0
FB	11	23	1988	WET	2	ND	0.05	ND	0.5	ND	1	ND	1
FB	1	23	1988	WET	3	ND	0.05	ND	0.5	ND	1	ND	1
FB	2	8	1988	WET	5	ND	0.05	ND	0.5	ND	1.0	ND	1.0
FB	3	2	1988	WET	6	ND	0.05	ND	0.5	ND	1.0	ND	1.0

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ENDOSLFN B actual ug/l	DL ug/l	ENDOSLFN S actual ug/l	DL ug/l	ENORIN actual ug/l	DL ug/l	ENORIN ALD actual ug/l	DL ug/l	HEPTACHLOR actual ug/l	DL ug/l
STANDARD REPORTING OBJEC IVES							0.05		0.1		0.1		0.1		0.05
S4	2	26	1988	DRY	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	3	30	1988	DRY	2	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	5	11	1988	DRY	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	8	25	1988	DRY	4	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	12	12	1988	DRY	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	2	1	1989	DRY	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	4	6	1989	DRY	7	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	4	20	1988	WET	1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	11	23	1988	WET	2	0.06	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4FD	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	2	4	1989	WET	4	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
S4	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
SB	8	25	1988	DRY	4	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
FB	8	25	1988	DRY	4	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
FB	12	12	1988	DRY	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
FB	2	1	1989	DRY	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
FB	4	6	1989	DRY	7	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
FB	11	23	1988	WET	2	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05
FB	1	23	1989	WET	3	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
FB	2	9	1989	WET	5	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05
FB	3	2	1989	WET	6	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND	0.05

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	HEPCL EPOX actual ug/l	HEPCL EPOX DL ug/l	METHOXYCL actual ug/l	METHOXYCL DL ug/l	TOXAPHENE actual ug/l	TOXAPHENE DL ug/l	1PCB actual ug/l	1PCB DL ug/l
STANDARD REPORTING OBJECTIVES							0 05		0 05		1		1
L1	4	20	1988	WET	1	ND	0 05	ND	0 05	ND	1	ND	1
L1	11	23	1988	WET	2	ND	0 05	ND	0 5	ND	1	ND	1
L1	2	4	1989	WET	4	ND	0 05	ND	0 5	ND	1 0	ND	1 0
L1	2	9	1989	WET	5	ND	0 05	ND	0 5	ND	1.0	ND	1 0
L1	3	2	1989	WET	6	ND	0 05	ND	0 5	ND	1 0	ND	1.0
L2	4	20	1988	WET	1	ND	0 05	ND	0 05	ND	1	ND	1
L2	11	23	1988	WET	2	ND	0 05	ND	0 5	ND	1	ND	1
L2	2	4	1989	WET	4	ND	0 05	ND	0 5	ND	1.0	ND	1.0
L2	2	9	989	WET	5	ND	0 05	ND	0.5	ND	1.0	ND	1.0
L3	4	20	1988	WET	1	ND	0 05	ND	0 05	ND	1	ND	1
L3	11	23	1988	WET	2	ND	0 05	ND	0 5	ND	1	ND	1
L3	2	4	1989	WET	4	ND	0 05	ND	0 5	ND	1 0	ND	1.0
L3	2	9	1989	WET	5	ND	0 05	ND	0 5	ND	1 0	ND	1 0
L3	3	2	1989	WET	6	ND	0 05	ND	0 5	ND	1.0	ND	1.0
L4	2	4	1989	WET	4	ND	0 05	ND	0 5	ND	1 0	ND	1.0
L4	2	9	1989	WET	5	ND	0 05	ND	0 5	ND	1.0	ND	1.0
L5	11	23	1988	WET	2	ND	0 05	ND	0 5	ND	1	ND	1
L5	1	23	1989	WET	3	ND	0 05	ND	0 5	ND	1	ND	1
L5	2	4	1989	WET	4	ND	0 05	ND	0 5	ND	1.0	ND	1.0
L5	2	9	1989	WET	5	ND	0 05	ND	0 5	ND	1 0	ND	1 0
L5	3	2	1989	WET	6	ND	0 05	ND	0 5	ND	1.0	ND	1 0
L5FD	3	2	1989	WET	6	ND	0 05	ND	0 5	ND	1.0	ND	1.0
L6	4	20	1988	WET	1	ND	0 05	ND	0 05	ND	1	1.4	1
L6	11	23	1988	WET	2	ND	0 05	ND	0.5	ND	1	ND	1
L6	2	4	1989	WET	4	ND	0.05	ND	0 5	ND	1.0	ND	1.0
L6	2	9	1989	WET	5	ND	0 05	ND	0.5	ND	1.0	ND	1 0
L7	11	23	1888	WET	2	ND	0 05	ND	0 5	ND	1	ND	1
L7	2	4	1989	WET	4	ND	0 05	ND	0.5	ND	1.0	ND	1.0
L7	2	9	1989	WET	5	ND	0.05	ND	0.5	ND	1.0	ND	1.0
L7	3	2	1989	WET	6	ND	0.05	ND	0.5	ND	1.0	ND	1.0
R1	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	1	ND	1
R2	2	26	1988	RES	1	ND	0 05	ND	0 05	ND	1	ND	1
R3	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	1	ND	1
R4	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	1	ND	1
R5	2	27	1988	RES	1	ND	0 05	ND	0 05	ND	1	ND	1
R6	2	27	1988	RES	1	ND	0.05	ND	0.05	ND	1	ND	1

D.3-2 Organochlorine pesticides in sediment

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Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	ALDRIN actual µg/kg	ALDRIN D.L. µg/kg	6CL-CHX-A actual µg/kg	6CL-CHX-A D.L. µg/kg	6CL-CHX-B actual µg/kg	6CL-CHX-B D.L. µg/kg	6CL-CHX-D actual µg/kg	6CL-CHX-D D.L. µg/kg	6CL-CHX-G actual µg/kg	6CL-CHX-G D.L. µg/kg
STANDARD REPORTING OBJECTIVES							2		2		2		2		2
S1	3	30	1988	DRY	1	ND	2	ND	2	ND	2	ND	2	ND	2
S1	5	11	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5
S1	8	22	1988	DRY	3	ND	5	ND	5	ND	5	ND	5	5	5
S1	12	12	1988	DRY	4	ND	4	ND	4	ND	4	ND	4	ND	4
S2	3	30	1988	DRY	1	ND	2	ND	2	ND	2	ND	2	ND	2
S2	5	11	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5
S2	8	22	1988	DRY	3	ND	5	ND	5	ND	5	ND	5	ND	5
S2	12	12	1988	DRY	4	ND	4	ND	4	ND	4	ND	4	ND	4
S3	3	30	1988	DRY	1	ND	2	ND	2	ND	2	ND	2	ND	2
S3	5	11	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5
S3	8	22	1988	DRY	3	ND	5	ND	5	ND	5	ND	5	ND	5
S3	12	12	1988	DRY	4	ND	4	ND	4	ND	4	ND	4	ND	4
S3FD	8	22	1988	DRY	3	ND	5	ND	5	ND	5	ND	5	7.8	5
S3FD	12	12	1988	DRY	4	ND	4	ND	4	ND	4	ND	4	ND	4
S4	3	30	1988	DRY	1	ND	2	ND	2	ND	2	ND	2	ND	2
S4	5	11	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5
S4	8	22	1988	DRY	3	ND	5	ND	5	ND	5	ND	5	ND	5
S4	12	12	1988	DRY	4	ND	4	ND	4	ND	4	ND	4	ND	4
S4LR	3	30	1988	DRY	1	ND	2	ND	2	ND	2	ND	2	ND	2

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	G-CHLORDANE actual µg/kg	G-CHLORDANE D L. µg/kg	A-CHLORDANE actual µg/kg	A-CHLORDANE D L. µg/kg	DDD actual µg/kg	DDD D L. µg/kg	DDE actual µg/kg	DDE D L. µg/kg	DDT actual µg/kg	DDT D L. µg/kg	DIELDRIN actual µg/kg	DIELDRIN D L. µg/kg
STANDARD REPORTING OBJECTIVES							4		3		2		2		4		2
S1	3	30	1988	DRY	1	ND	4	ND	3	2	2	2.4	2	ND	4	ND	2
S1	5	11	1988	DRY	2	6	6	8	6	ND	10	ND	5	ND	10	ND	5
S1	8	22	1988	DRY	3	ND	10	ND	10	ND	10	7	5	ND	10	ND	10
S1	12	12	1988	DRY	4	11	8	8.3	8	13	8	14	4	13	8	ND	4
S2	3	30	1989	DRY	1	7.4	4	6.4	3	12	2	7.8	2	6.4	4	ND	2
S2	5	11	1988	DRY	2	ND	6	ND	6	ND	10	ND	5	13	10	ND	5
S2	8	22	1988	DRY	3	ND	10	ND	10	ND	10	ND	5	ND	10	ND	10
S2	12	12	1988	DRY	4	ND	8	ND	8	ND	8	8.4	4	ND	8	ND	4
S3	3	30	1988	DRY	1	ND	4	28	3	22	2	26	2	26	4	ND	2
S3	5	11	1988	DRY	2	ND	6	ND	6	ND	10	ND	5	11	10	ND	5
S3	8	22	1988	DRY	3	13	10	10	10	27	10	8.1	5	37	10	ND	10
S3	12	12	1988	DRY	4	20	8	13	8	24	8	13	4	25	8	ND	4
S3FD	8	22	1988	DRY	3	13	10	10	10	22	10	8.6	5	27	10	ND	10
S3FD	12	12	1988	DRY	4	16	8	9.8	8	17	8	11	4	ND	8	ND	4
S4	3	30	1988	DRY	1	13	4	8.4	3	24	2	14	2	8.8	4	ND	2
S4	5	11	1988	DRY	2	ND	6	ND	6	ND	10	ND	5	ND	10	ND	5
S4	8	22	1988	DRY	3	13	10	10	10	31	10	12	5	28	10	ND	10
S4	12	12	1988	DRY	4	28	8	14	8	34	8	26	4	ND	8	ND	4
S4LR	3	30	1888	DRY	1	ND	4	3.5	3	7	2	8.5	2	11	4	ND	2

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ENDOSLFN-A actual µg/kg	D.L. µg/kg	ENDOSLFN B actual µg/kg	D.L. µg/kg	ENDOSLFN S actual µg/kg	D.L. µg/kg	ENDRIN actual µg/kg	D.L. µg/kg	ENDRIN-ALD actual µg/kg	D.L. µg/kg
STANDARD REPORTING OBJECTIVES							2		2		4		4		4
S1	3	30	1988	DRY	1	ND	2	ND	2	ND	4	ND	4	ND	4
S1	5	11	1988	DRY	2	ND	5	ND	5	ND	10	ND	10	ND	10
S1	8	22	1988	DRY	3	ND	5	ND	10	ND	10	ND	10	ND	10
S1	12	12	1988	DRY	4	ND	4	ND	4	ND	8	ND	8	ND	8
S2	3	30	1988	DRY	1	ND	2	3.4	2	ND	4	ND	4	ND	4
S2	5	11	1988	DRY	2	ND	5	ND	5	ND	10	ND	10	ND	10
S2	8	22	1988	DRY	3	ND	5	ND	10	ND	10	ND	10	ND	10
S2	12	12	1988	DRY	4	ND	4	ND	4	ND	8	ND	8	ND	8
S3	3	30	1988	DRY	1	ND	2	9	2	ND	4	ND	4	ND	4
S3	5	11	1988	DRY	2	ND	5	ND	5	ND	10	ND	10	ND	10
S3	8	22	1988	DRY	3	ND	5	ND	10	ND	10	ND	10	ND	10
S3	12	12	1988	DRY	4	ND	4	ND	4	ND	8	ND	8	ND	8
S3FD	8	22	1988	DRY	3	ND	5	ND	10	ND	10	ND	10	ND	10
S3FD	12	12	1988	DRY	4	ND	4	ND	4	ND	8	ND	8	ND	8
S4	3	30	1988	DRY	1	ND	2	ND	2	ND	4	ND	4	ND	4
S4	5	11	1988	DRY	2	ND	5	ND	5	ND	10	ND	10	ND	10
S4	8	22	1988	DRY	3	ND	5	ND	10	ND	10	ND	10	ND	10
S4	12	12	1988	DRY	4	ND	4	ND	4	ND	8	ND	8	ND	8
S4LR	3	30	1988	DRY	1	ND	2	ND	2	ND	4	ND	4	ND	4

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	HEPTACHLOR actual µg/kg	HEPTACHLOR D.L. µg/kg	HEPOL EPOX actual µg/kg	HEPOL EPOX D.L. µg/kg	METHOXYCL actual µg/kg	METHOXYCL D.L. µg/kg	TOXAPHENE actual µg/kg	TOXAPHENE D.L. µg/kg	PCB actual µg/kg	PCB D.L. µg/kg
STANDARD REPORTING OBJECTIVES							2		22		2		20		20
S1	3	30	1988	DRY	1	ND	2	ND	22	ND	2	ND	20	ND	20
S1	5	11	1988	DRY	2	ND	5	ND	5	ND	5	ND	100	ND	100
S1	8	22	1988	DRY	3	ND	5	ND	5	ND	50	ND	100	ND	100
S1	12	12	1988	DRY	4	ND	4	ND	4	ND	40	ND	80	140	80
S2	3	30	1988	DRY	1	ND	2	ND	22	ND	2	ND	20	ND	20
S2	5	11	1988	DRY	2	ND	5	ND	5	ND	5	ND	100	ND	100
S2	8	22	1988	DRY	3	ND	5	ND	5	ND	50	ND	100	ND	100
S2	12	12	1988	DRY	4	ND	4	ND	4	ND	40	ND	80	ND	80
S3	3	30	1988	DRY	1	ND	2	ND	22	ND	2	ND	20	390	20
S3	5	11	1988	DRY	2	ND	5	ND	5	ND	5	ND	100	ND	100
S3	8	22	1988	DRY	3	ND	5	ND	5	ND	50	ND	100	ND	100
S3	12	12	1988	DRY	4	ND	4	ND	4	ND	40	ND	80	240	80
S3FD	8	22	1988	DRY	3	ND	5	ND	5	ND	50	ND	100	ND	100
S3FD	12	12	1988	DRY	4	ND	4	ND	4	ND	40	ND	80	125	80
S4	3	30	1988	DRY	1	ND	2	ND	22	ND	2	ND	20	80	20
S4	5	11	1988	DRY	2	ND	5	ND	5	ND	5	ND	100	ND	100
S4	8	22	1988	DRY	3	ND	5	ND	5	ND	50	ND	100	ND	100
S4	12	12	1988	DRY	4	ND	4	ND	4	ND	40	ND	80	ND	80
S4LR	3	30	1988	DRY	1	ND	2	ND	22	ND	2	ND	20	44	20

D.4 Chlorinated herbicides

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D.4-1 Chlorinated herbicides and TOX in water column

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	TOX actual mg/l	TOX DL mg/l	2,4,5 T actual ug/l	2,4,5 T DL ug/l	SILVEX actual ug/l	SILVEX DL ug/l	2,4,D actual ug/l	2,4,D DL ug/l	2,4,DB actual ug/l	2,4,DB DL ug/l	DALAPON actual ug/l	DALAPON DL ug/l
STANDARD REPORTING LIMITS							0.025		1		1		5		10		500
L1	4	20	1988	WET	1	0.058	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L1	11	23	1988	WET	2	0.065	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L1	2	4	1989	WET	4	0.08	0.025										
L1	2	9	1989	WET	5	0.08	0.025										
L1LR	2	9	1989	WET	5	0.04	0.025										
L1	3	2	1989	WET	6		0.025										
L1LR	3	2	1989	WET	6	ND	0.025										
L2	4	20	1988	WET	1	0.048	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L2	11	23	1988	WET	2	0.033	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L2	2	4	1989	WET	4	ND	0.025										
L2	2	9	1989	WET	5	ND	0.025										
L3	4	20	1988	WET	1	0.042	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L3	11	23	1988	WET	2	0.038	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L3	2	4	1989	WET	4	ND	0.025										
L3	2	9	1989	WET	5	ND	0.025										
L3	3	2	1989	WET	6	ND	0.025										
L4	2	4	1989	WET	4	0.04	0.025										
L4	2	9	1989	WET	5	0.04	0.025										
L5	11	23	1988	WET	2	0.045	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L5	1	23	1989	WET	3	0.03	0.025										
L5	2	4	1989	WET	4	ND	0.025										
L5LR	2	4	1989	WET	4	ND	0.025										
L5FD	2	4	1989	WET	4	ND	0.025										
L5	2	9	1989	WET	5	0.03	0.025										
L5	3	2	1989	WET	6	ND	0.025										
L5FD	3	2	1989	WET	6	ND	0.025										
L6	4	20	1988	WET	1	0.051	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L6	11	23	1988	WET	2	0.028	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L6	2	9	1989	WET	5	ND	0.025										
L7	11	23	1988	WET	2	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
L7	2	4	1989	WET	4	ND	0.025										
L7	2	9	1989	WET	5	ND	0.025										
L7	3	2	1989	WET	6	ND	0.025										
R1	2	27	1988	RES	1	ND	0.025	ND	0.5	ND	0.5	ND	3	ND	5	ND	250
R2	2	28	1988	RES	1	ND	0.025	ND	0.5	ND	0.5	ND	3	ND	5	ND	250
R3	2	27	1988	RES	1	ND	0.025	ND	0.5	ND	0.5	ND	3	ND	5	ND	250
R4	2	27	1988	RES	1	ND	0.025	ND	0.5	ND	0.5	ND	3	ND	5	ND	250
R5	2	27	1988	RES	1	ND	0.025	ND	0.5	ND	0.5	ND	3	ND	5	ND	250
R6	2	27	1988	RES	1	ND	0.025	ND	0.5	ND	0.5	ND	3	ND	5	ND	250

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	TOX actual mg/l	TOX DL mg/l	2,4,5-T actual ug/l	2,4,5-T DL ug/l	SILVEX actual ug/l	SILVEX DL ug/l	2,4,D actual ug/l	2,4,D DL ug/l	2,4,DB actual ug/l	2,4,DB DL ug/l	DALAPON actual ug/l	DALAPON DL ug/l
S1	2	26	1988	DRY	1	0.08	0.025	ND	0.5	ND	0.5	13	3	ND	5	ND	250
S1FD1	2	26	1988	DRY	1	0.08	0.025	ND	0.5	ND	0.5	13	3	ND	5	ND	250
S1FD2	2	26	1988	DRY	1	0.08	0.025	ND	0.5	ND	0.5	11	3	ND	5	ND	250
S1	3	30	1988	DRY	2			ND	0.1	ND	0.1	ND	0.5	ND	1	ND	50
S1FD	3	30	1988	DRY	2			ND	0.1	ND	0.1	ND	0.5	ND	1	ND	50
S1	5	11	1988	DRY	3			ND	2	ND	2	ND	10	ND	20	ND	1000
S1	12	12	1988	DRY	5	0.12	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S1	2	1	1989	DRY	6	0.11	0.025										
S1	4	6	1989	DRY	7	0.09	0.025										
S1	11	23	1988	WET	2	0.042	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S1	1	23	1989	WET	3	0.10	0.025										
S1	2	4	1989	WET	4	0.03	0.025										
S1	2	9	1989	WET	5	ND	0.025										
S1FD	2	9	1989	WET	5	ND	0.025										
S1	3	2	1989	WET	6	ND	0.025										
S2	2	26	1988	DRY	1	ND	0.025	ND	0.5	ND	0.5	ND	3	ND	5	ND	250
S2	3	30	1988	DRY	2			ND	0.1	ND	0.1	ND	0.5	ND	1	ND	50
S2	5	11	1988	DRY	3			ND	1	ND	1	ND	5	ND	10	ND	500
S2	12	12	1988	DRY	5	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S2	2	1	1989	DRY	6	ND	0.025										
S2	4	6	1989	DRY	7	ND	0.025										
S2	11	23	1988	WET	2	0.053	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S2	1	23	1989	WET	3	0.04	0.025										
S2FD	1	23	1989	WET	3	0.04	0.025										
S2	2	4	1989	WET	4	0.03	0.025										
S2	2	9	1989	WET	5	ND	0.025										
S2	3	2	1989	WET	6	ND	0.025										
S3	2	26	1988	DRY	1	ND	0.025	ND	0.5	ND	0.5	ND	3	ND	5	ND	250
S3	3	30	1988	DRY	2			ND	0.1	ND	0.1	ND	0.5	ND	1	ND	50
S3	5	11	1988	DRY	3			ND	1	ND	1	ND	5	ND	10	ND	500
S3	8	22	1988	DRY	4	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S3FD	8	22	1988	DRY	4	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S3	12	12	1988	DRY	5	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S3	2	1	1989	DRY	6	ND	0.025										
S3LR	2	1	1989	DRY	6	ND	0.025										
S3FD	2	1	1989	DRY	6	ND	0.025										
S3	4	6	1989	DRY	7	ND	0.025										
S3LR	4	6	1989	DRY	7	ND	0.025										
S3FD	4	6	1989	DRY	7	ND	0.025										
S3	4	20	1988	WET	1			ND	1	ND	1	ND	5	ND	10	ND	500
S3	11	23	1988	WET	2	0.029	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S3FD	11	23	1988	WET	2	0.055	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S3LR	11	23	1988	WET	2	0.036	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S3	1	23	1989	WET	3	ND	0.025										

Sample ID	Month	Day	Year	Sample Type	Sample Event	TOX actual mg/l	TOX DL mg/l											
S3LR	1	23	1989	WET	3	ND	0.025											
S3	2	4	1989	WET	4	ND	0.025											
S3	2	9	1989	WET	5	ND	0.025											
S3	3	2	1989	WET	6	ND	0.025											

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	TOX actual mg/l	TOX DL. mg/l	2,4,5-T actual ug/l	2,4,5-T DL. ug/l	SILVEX actual ug/l	SILVEX DL. ug/l	2,4,D actual ug/l	2,4,D DL. ug/l	2,4,DB actual ug/l	2,4,DB DL. ug/l	DALAPON actual ug/l	DALAPON DL. ug/l
STANDARD REPORTING LIMITS							0.025		1		1		5		10		500
S4	2	26	1988	DRY	1	0.03	0.025	ND	0.5	ND	0.5	0.5	3	ND	5	ND	250
S4	3	30	1988	DRY	2			ND	0.1	ND	0.1	ND	0.5	ND	1	ND	50
S4	5	11	1988	DRY	3			ND	1	ND	1	61	5	ND	10	ND	500
S4	8	22	1988	DRY	4	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S4	12	12	1988	DRY	5	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S4FD	12	12	1988	DRY	5	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S4FDLR	12	12	1988	DRY	5	ND	0.025	ND	1	ND	1	ND	5				
S4	2	1	1989	DRY	6	0.03	0.025										
S4	4	6	1989	DRY	7	0.05	0.025										
S4D	5	11	1988	DRY	3			ND	1	ND	1	58	5	ND	10	ND	500
S4	4	20	1988	WET	1	0.029	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S4	11	23	1988	WET	2	0.028	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
S4	2	4	1989	WET	4	ND	0.025										
S4	2	9	1989	WET	5	0.03	0.025										
SB	2	1	1989	DRY	6	ND	0.025										
SB	1	23	1989	WET	3	0.04	0.025										
SB	2	4	1989	WET	4	ND	0.025										
SB	2	9	1989	WET	5	0.05	0.025										
FB	8	22	1988	DRY	4	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
FB	12	12	1988	DRY	5	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
FB	4	6	1989	DRY	7	ND	0.025										
FB	11	23	1988	WET	2	ND	0.025	ND	1	ND	1	ND	5	ND	10	ND	500
FB	3	2	1989	WET	6	ND	0.025										

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	DICAMBA actual ug/l	DICAMBA DL ug/l	DICHLOROPHOP actual ug/l	DICHLOROPHOP DL ug/l	DINOSEB actual ug/l	DINOSEB DL ug/l	MCPA actual ug/l	MCPA DL ug/l	MCPP actual ug/l	MCPP DL ug/l
STANDARD REPORTING LIMITS							5		5		5		2000		2000
L1	4	20	1988	WET	1	ND	5	ND	5	ND	5	ND	2000	ND	2000
L1	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
L1	2	4	1989	WET	4										
L1	2	9	1989	WET	5										
L1LR	2	9	1989	WET	5										
L1	3	2	1989	WET	6										
L1LR	3	2	1989	WET	6										
L2	4	20	1988	WET	1	ND	5	ND	5	ND	5	ND	2000	ND	2000
L2	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
L2	2	4	1989	WET	4										
L2	2	9	1989	WET	5										
L3	4	20	1988	WET	1	ND	5	ND	5	ND	5	ND	2000	ND	2000
L3	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
L3	2	4	1989	WET	4										
L3	2	9	1989	WET	5										
L3	3	2	1989	WET	6										
L4	2	4	1989	WET	4										
L4	2	9	1989	WET	5										
L5	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
L5	1	23	1989	WET	3										
L5	2	4	1989	WET	4										
L5LR	2	4	1989	WET	4										
L5FD	2	4	1989	WET	4										
L5	2	9	1989	WET	5										
L5	3	2	1989	WET	6										
L5FD	3	2	1989	WET	6										
L6	4	20	1988	WET	1	ND	5	ND	5	ND	5	ND	2000	ND	2000
L6	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
L6	2	9	1989	WET	5										
L7	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
L7	2	4	1989	WET	4										
L7	2	9	1989	WET	5										
L7	3	2	1989	WET	6										
R1	2	27	1989	RES	1	ND	3	ND	3	ND	3	ND	1000	ND	1000
R2	2	28	1989	RES	1	ND	3	ND	3	ND	3	ND	1000	ND	1000
R3	2	27	1989	RES	1	ND	3	ND	3	ND	3	ND	1000	ND	1000
R4	2	27	1989	RES	1	ND	3	ND	3	ND	3	ND	1000	ND	1000
R5	2	27	1989	RES	1	ND	3	ND	3	ND	3	ND	1000	ND	1000
R6	2	27	1989	RES	1	ND	3	ND	3	ND	3	ND	1000	ND	1000

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	DICAMBA actual ug/l	DICAMBA DL ug/l	DICHLOROPROP actual ug/l	DICHLOROPROP DL ug/l	DINOSEB actual ug/l	DINOSEB DL ug/l	MCPA actual ug/l	MCPA DL ug/l	MCPP actual ug/l	MCPP DL ug/l
S1	2	26	1988	DRY	1	5.1	3	ND	3	ND	3	ND	1000	ND	1000
S1FD1	2	26	1988	DRY	1	4.9	3	ND	3	ND	3	ND	1000	ND	1000
S1FD2	2	26	1988	DRY	1	4.2	3	ND	3	ND	3	ND	1000	ND	1000
S1	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	200	ND	200
S1FD	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	200	ND	200
S1	5	11	1988	DRY	3	ND	10	ND	10	ND	10	ND	4000	ND	4000
S1	12	12	1988	DRY	5	ND	5	ND	5	ND	5	ND	2000	ND	2000
S1	2	1	1989	DRY	6										
S1	4	6	1989	DRY	7										
S1	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
S1	1	23	1989	WET	3										
S1	2	4	1989	WET	4										
S1	2	9	1989	WET	5										
S1FD	2	9	1989	WET	5										
S1	3	2	1989	WET	6										
S2	2	26	1988	DRY	1	ND	3	ND	3	ND	3	ND	1000	ND	1000
S2	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	200	ND	200
S2	5	11	1988	DRY	3	ND	5	ND	5	ND	5	ND	2000	ND	2000
S2	12	12	1988	DRY	5	ND	5	ND	5	ND	5	ND	2000	ND	2000
S2	2	1	1989	DRY	6										
S2	4	6	1989	DRY	7										
S2	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
S2	1	23	1989	WET	3										
S2FD	1	23	1989	WET	3										
S2	2	4	1989	WET	4										
S2	2	9	1989	WET	5										
S2	3	2	1989	WET	6										
S3	2	26	1988	DRY	1	ND	3	ND	3	ND	3	ND	1000	ND	1000
S3	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	200	ND	200
S3	5	11	1988	DRY	3	ND	5	ND	5	ND	5	ND	2000	ND	2000
S3	8	22	1988	DRY	4	ND	5	ND	5	ND	5	ND	2000	ND	2000
S3FD	8	22	1988	DRY	4	ND	5	ND	5	ND	5	ND	2000	ND	2000
S3	12	12	1988	DRY	5	ND	5	ND	5	ND	5	ND	2000	ND	2000
S3	2	1	1989	DRY	6										
S3LR	2	1	1989	DRY	6										
S3FD	2	1	1989	DRY	6										
S3	4	6	1989	DRY	7										
S3LR	4	6	1989	DRY	7										
S3FD	4	6	1989	DRY	7										
S3	4	28	1988	WET	1	ND	5	ND	5	ND	5	ND	2000	ND	2000
S3	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
S3FD	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
S3LR	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
S3	1	23	1989	WET	3										

S3LR	1	23	1989	WET	3
S3	2	4	1989	WET	4
S3	2	9	1989	WET	5
S3	3	2	1989	WET	6

						DICAMBA		DICHLOROPROP		DINOSEB		MCPA		MCPP	
Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	actual ug/l	DL ug/l	actual ug/l	DL ug/l	actual ug/l	DL ug/l	actual ug/l	DL ug/l	actual ug/l	DL ug/l
STANDARD REPORTING LIMITS							5		5		5		2000		2000
S4	2	26	1988	DRY	1	ND	3	ND	3	ND	3	ND	1000	ND	1000
S4	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	200	ND	200
S4	5	11	1988	DRY	3	47	5	ND	5	ND	5	ND	2000	ND	2000
S4	8	22	1988	DRY	4	ND	5	ND	5	ND	5	ND	2000	ND	2000
S4	12	12	1988	DRY	5	ND	5	ND	5	ND	5	ND	2000	ND	2000
S4FD	12	12	1988	DRY	5	ND	5	ND	5	ND	5	ND	2000	ND	2000
S4FDLR	12	12	1988	DRY	5	ND	5	ND	5	ND	5	ND	2000	ND	2000
S4	2	1	1989	DRY	6										
S4	4	6	1989	DRY	7										
S4D	5	11	1988	DRY	3	40	5	ND	5	ND	5	ND	2000	ND	2000
S4	4	20	1988	WET	1	ND	5	ND	5	ND	5	ND	2000	ND	2000
S4	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
S4	2	4	1989	WET	4										
S4	2	9	1989	WET	5										
SB	2	1	1989	DRY	6										
SB	1	23	1989	WET	3										
SB	2	4	1989	WET	4										
SB	2	9	1989	WET	5										
FB	8	22	1988	DRY	4	ND	5	ND	5	ND	5	ND	2000	ND	2000
FB	12	12	1988	DRY	5	ND	5	ND	5	ND	5	ND	2000	ND	2000
FB	4	6	1989	DRY	7										
FB	11	23	1988	WET	2	ND	5	ND	5	ND	5	ND	2000	ND	2000
FB	3	2	1989	WET	6										

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Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	2,4,5-T actual mg/kg	2,4,5-T D.L. mg/kg	SILVEX actual mg/kg	SILVEX D.L. mg/kg	2,4,D actual mg/kg	2,4,D D.L. mg/kg	2,4,DB actual mg/kg	2,4,DB D.L. mg/kg	DALAPON actual mg/kg	DALAPON D.L. mg/kg
STANDARD REPORTING OBJECTIVES							0.1		0.1		0.6		1		1
S1	3	30	1988	DRY	1	ND	0.05	ND	0.05	ND	0.3	ND	0.5		
S1	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S1	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1		
S1LR	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S1	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
													1	ND	50
S2	3	30	1988	DRY	1	ND	0.05	ND	0.05	ND	0.3	ND	0.5		
S2	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S2	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S2	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50
S3	3	30	1988	DRY	1	ND	0.05	ND	0.05	ND	0.3	ND	0.5		
S3	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S3	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S3FD	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S3	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50
S3FD	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50
S4	3	30	1988	DRY	1	ND	0.05	ND	0.05	ND	0.3	ND	0.5		
S4	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S4FD	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S4	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S4	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	2,4,5-T actual mg/kg	2,4,5-T D L. mg/kg	SILVEX actual mg/kg	SILVEX D L. mg/kg	2,4,D actual mg/kg	2,4,D D.L. mg/kg	2,4,DB actual mg/kg	2,4,DB D.L. mg/kg	DALAPON actual mg/kg	DALAPON D.L. mg/kg
STANDARD REPORTING OBJECTIVES							0.1		0.1		0.6		1		1
S1	3	30	1988	DRY	1	ND	0.05	ND	0.05	ND	0.3	ND	0.5		
S1	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S1	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S1LR	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S1	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50
S2	3	30	1988	DRY	1	ND	0.05	ND	0.05	ND	0.3	ND	0.5		
S2	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S2	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S2	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50
S3	3	30	1988	DRY	1	ND	0.05	ND	0.05	ND	0.3	ND	0.5		
S3	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S3	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S3FD	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S3	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50
S3FD	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50
S4	3	30	1988	DRY	1	ND	0.05	ND	0.05	ND	0.3	ND	0.5		
S4	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S4FD	5	11	1988	DRY	2	ND	0.1	ND	0.1	ND	0.6	ND	1		
S4	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	1
S4	12	12	1988	DRY	4	ND	0.1	ND	0.1	ND	0.6	ND	1	ND	50

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	DICHLOROPROP actual mg/kg	DICHLOROPROP D.L. mg/kg	DINOSEB actual mg/kg	DINOSEB D.L. mg/kg	MCPA actual mg/kg	MCPA D.L. mg/kg	MCPP actual mg/kg	MCPP D.L. mg/kg
STANDARD REPORTING OBJECTIVES							0.6		0.6		200		200
S1	3	30	1988	DRY	1	ND	0.3	ND	0.3	ND	100	ND	100
S1	5	11	1988	DRY	2	ND	0.6	ND	0.6	ND	200	ND	200
S1	8	22	1988	DRY	3	ND	0.6	ND	0.6	ND	200	ND	200
S1LR	8	22	1988	DRY	3	ND	0.6	ND	0.6	ND	200	ND	200
S1	12	12	1988	DRY	4	ND	0.6	ND	0.6	ND	200	ND	200
S2	3	30	1988	DRY	1	ND	0.3	ND	0.3	ND	100	ND	100
S2	5	11	1988	DRY	2	ND	0.6	ND	0.6	ND	200	ND	200
S2	8	22	1988	DRY	3	ND	0.6	ND	0.6	ND	200	ND	200
S2	12	12	1988	DRY	4	ND	0.6	ND	0.6	ND	200	ND	200
S3	3	30	1988	DRY	1	ND	0.3	ND	0.3	ND	100	ND	100
S3	5	11	1988	DRY	2	ND	0.6	ND	0.6	ND	200	ND	200
S3	8	22	1988	DRY	3	ND	0.6	ND	0.6	ND	200	ND	200
S3FD	8	22	1988	DRY	3	ND	0.6	ND	0.6	ND	200	ND	200
S3	12	12	1988	DRY	4	ND	0.6	ND	0.6	ND	200	ND	200
S3FD	12	12	1988	DRY	4	ND	0.6	ND	0.6	ND	200	ND	200
S4	3	30	1988	DRY	1	ND	0.3	ND	0.3	ND	100	ND	100
S4	5	11	1988	DRY	2	ND	0.6	ND	0.6	ND	200	ND	200
S4FD	5	11	1988	DRY	2	ND	0.6	ND	0.6	ND	200	ND	200
S4	8	22	1988	DRY	3	ND	0.6	ND	0.6	ND	200	ND	200
S4	12	12	1988	DRY	4	ND	0.6	ND	0.6	ND	200	ND	200

D5 Organophosphate pesticides

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D.5-1 Organophosphate pesticides in water column

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	AZINPHOS-METHYL actual ug/l	D.L. ug/l	CHLORPYRIFOS actual ug/l	D.L. ug/l	COUMAPHOS actual ug/l	D.L. ug/l	DDVP actual ug/l	D.L. ug/l	DEMETON actual ug/l	D.L. ug/l
STANDARD REPORTING LIMITS							0.5		0.05		0.5		0.05		0.05
S1	3	30	1988	DRY	2	ND	2	ND	0.5	ND	2	ND	1	ND	1
S1LR	3	30	1988	DRY	2	ND	2	ND	0.5	ND	2	ND	1	ND	1
S2	3	30	1988	DRY	2	ND	2	ND	0.5	ND	2	ND	1	ND	1
S3	3	30	1988	DRY	2	ND	2	ND	0.5	ND	2	ND	1	ND	1
S4	3	30	1988	DRY	2	ND	2	ND	0.5	ND	2	ND	1	ND	1

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	DIAZINON actual ug/l	DIAZINON D.L. ug/l	DIMETHOATE actual ug/l	DIMETHOATE D.L. ug/l	DISULFOTON actual ug/l	DISULFOTON D.L. ug/l	EPN actual ug/l	EPN D.L. ug/l	ETHOPROP actual ug/l	ETHOPROP D.L. ug/l	FENSUL-FOTHION actual ug/l	FENSUL-FOTHION D.L. ug/l
STANDARD REPORTING LIMITS							0.05		0.05		0.05		0.05		0.05		0.05
S1	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	1
S1LR	3	30	188(	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	1
S2	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	1
S3	3	30	1998	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	1
S4	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	1

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Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	FENTHION actual ug/l	FENTHION D.L. ug/l	MALATHION actual ug/l	MALATHION D.L. ug/l	MERPHOS actual ug/l	MERPHOS D.L. ug/l	MEVINPHOS actual ug/l	MEVINPHOS D.L. ug/l	MONOCROTOPHOS actual ug/l	MONOCROTOPHOS D.L. ug/l
STANDARD REPORTING LIMITS							0.1		0.05		0.05		0.05		0.05
S1	3	30	1988	DRY	2	ND	0.5	ND	1	NA	0.05	ND	1	ND	1
S1LR	3	30	1988	DRY	2	ND	0.5	ND	1	NA	0.05	ND	1	ND	1
S2	3	30	1988	DRY	2	ND	0.5	ND	1	NA	0.05	ND	1	ND	1
S3	3	30	1988	DRY	2	ND	0.5	ND	1	NA	0.05	ND	1	ND	1
S4	3	30	1988	DRY	2	ND	0.5	ND	1	NA	0.05	ND	1	ND	1

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	NALED actual ug/l	NALED D.L. ug/l	PARATHION, ETH actual ug/l	PARATHION, ETH D.L. ug/l	PARATHION, METH actual ug/l	PARATHION, METH D.L. ug/l	PHORATE actual ug/l	PHORATE D.L. ug/l	RONNEL actual ug/l	RONNEL D.L. ug/l
STANDARD REPORTING LIMITS							0.05		0.2		0.1		0.05		0.05
S1	3	30	1988	DRY	2	ND	5	ND	0.5	ND	0.5	ND	0.5	NA	1
S1LR	3	30	1988	DRY	2	ND	5	ND	0.5	ND	0.5	ND	0.5	NA	1
S2	3	30	·988	DRY	2	ND	5	ND	0.5	ND	0.5	ND	0.5	NA	1
S3	3	30	'988	DRY	2	ND	6	ND	0.5	ND	0.5	ND	0.5	NA	1
S4	3	30	1988	DRY	2	ND	5	ND	0.5	ND	0.5	ND	0.5	NA	1

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	SULFOTEPP actual ug/l	D.L. ug/l	SULPROFOS actual ug/l	D.L. ug/l	TEPP actual ug/l	D.L. ug/l	TETRACHLORVINPHOS actual ug/l	D.L. ug/l
STANDARD REPORTING LIMITS							0.05		0.05		0.1		0.02
S1	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	10	ND	2
S1LR	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	10	ND	2
S2	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	10	ND	2
S3	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	10	ND	2
S4	3	30	1988	DRY	2	ND	0.5	ND	0.5	ND	10	ND	2

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	TRICHLORONATE actual ug/l	D.L. ug/l
STANDARD REPORTING LIMITS							0.05
S1	3	30	1988	DRY	2	NA	0.5
S1LR	3	30	1988	DRY	2	NA	0.5
S2	3	30	1988	DRY	2	NA	0.5
S3	3	30	1988	DRY	2	NA	0.5
S4	3	30	1988	DRY	2	NA	0.5

D.5-2 Organophosphate pesticides in sediment

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Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	AZINPHOS-METHYL actual mg/kg	AZINPHOS-METHYL D.L. mg/kg	CHLORPYRIFOS actual mg/kg	CHLORPYRIFOS D.L. mg/kg	COUMAPHOS actual mg/kg	COUMAPHOS D.L. mg/kg	DDVP actual mg/kg	DDVP D.L. mg/kg	DEMETON actual mg/kg	DEMETON D.L. mg/kg	DIAZINON actual mg/kg	DIAZINON D.L. mg/kg
							0.1		0.01		0.1		0.01		0.01		0.01
STANDARD REPORTING OBJECTIVES																	
S1	8	22	1988	DRY	3												
S2	8	22	1988	DRY	3	ND	2.5	ND	0.25	ND	1.25	ND	0.25	ND	0.25	ND	0.25
S3	8	22	1988	DRY	3	ND	1	ND	0.1	ND	0.5	ND	0.1	ND	0.1	ND	0.1
S3LR	8	22	1988	DRY	3	ND	1	ND	0.1	ND	0.5	ND	0.1	ND	0.1	ND	0.1
S4	8	22	1988	DRY	3	ND	1	ND	0.1	ND	0.5	ND	0.1	ND	0.1	ND	0.1
S3FD	8	22	1988	DRY	3	ND	1	ND	0.1	ND	0.5	ND	0.1	ND	0.1	ND	0.1

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	DIMETHOATE actual mg/kg	DIMETHOATE D.L. mg/kg	DISULFOTON actual mg/kg	DISULFOTON D.L. mg/kg	EPN actual mg/kg	EPN D.L. mg/kg	ETHOPROP actual mg/kg	ETHOPROP D.L. mg/kg	FENSUL-FOTHION actual mg/kg	FENSUL-FOTHION D.L. mg/kg	FENTHION actual mg/kg	FENTHION D.L. mg/kg
							0.01		0.01		0.01		0.01		0.01		0
STANDARD REPORTING OBJECTIVES																	
S1	8	22	1988	DRY	3												
S2	8	22	1988	DRY	3	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.5	ND	0
S3	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.2	ND	0
S3LR	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.2	ND	0
S4	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.2	ND	0
S3FD	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.2	ND	0

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	MALATHION actual mg/kg	MALATHION D.L. mg/kg	MERPHOS actual mg/kg	MERPHOS D.L. mg/kg	MEVINPHOS actual mg/kg	MEVINPHOS D.L. mg/kg	MONOCROTOPHOS actual mg/kg	MONOCROTOPHOS D.L. mg/kg	NALED actual mg/kg	NALED D.L. mg/kg
							0.01		0.01		0.01		0.01		0.01
STANDARD REPORTING OBJECTIVES					3										
S1	8	22	1988	DRY	3	ND	0.25			ND	0.25	ND	1	ND	1.25
S2	8	22	1988	DRY	3	ND	0.1			ND	0.1	ND	0.4	ND	0.5
S3	8	22	1988	DRY	3	ND	0 1			ND	0.1	ND	0.4	ND	0.5
S3LR	8	22	1988	DRY	3	ND	0 1			ND	0.1	ND	0.4	ND	0.5
S4	8	22	1988	DRY	3	ND	0.1			ND	0.1	ND	0.4	ND	0.5
S3FD	8	22	1988	DRY	3	ND									

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	PARATHION, ETH actual mg/kg	PARATHION, ETH D.L. mg/kg	PARATHION, METH actual mg/kg	PARATHION, METH D.L. mg/kg	PHORATE actual mg/kg	PHORATE D.L. mg/kg	RONNEL actual mg/kg	RONNEL D.L. mg/kg	SULFOTEPP actual mg/kg	SULFOTEPP D.L. mg/kg
							0.01		0.01		0.01		0.01		0.01
STANDARD REPORTING OBJECTIVES															
S1	8	22	1988	DRY	3										
S2	8	22	1988	DRY	3	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25
S3	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1
S3LR	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1
S4	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1
S3FD	8	22	1988	DRY	3	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	SULPROFOS actual mg/kg	SULPROFOS D.L. mg/kg	TEPP actual mg/kg	TEPP D.L. mg/kg	TETRACHLORVINPHOS actual mg/kg	TETRACHLORVINPHOS D.L. mg/kg	TRICHLORONATE actual mg/kg	TRICHLORONATE D.L. mg/kg
							0.01		0.1		0.01		0.01
STANDARD REPORTING OBJECTIVES													
S1	8	22	1988	DRY	3								
S2	8	22	1988	DRY	3	ND	0.25	ND	2	ND	0.5	ND	ND
S3	8	22	1988	DRY	3	ND	0.1	ND	0.8	ND	0.2	ND	0.1
S3LR	8	22	1988	DRY	3	ND	0.1	ND	0.8	ND	0.2	ND	0.1
S4	8	22	1988	DRY	3	ND	0.1	ND	0.8	ND	0.2	ND	0.1
S3FD	8	22	1988	DRY	3	ND	0.1	ND	0.8	ND	0.2	ND	0.1

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D.6 Polynuclear Aromatic Hydrocarbons

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POLYNUCLEAR AROMATIC HYDROCARBONS

Abbreviated Name	Actual Name
ACENAPE	Acenaphthene
ACENAPTYLE	Acenapthylene
BAA	Benzo(a)anthracene
BAP	Benzo(a)pyrene
BBF	Benzo(b)fluoranthene
BGHIP	Benzo(ghi)perylene
BKF	Benzo(k)fluoranthene
DBAHA	Dibenzo(a,h)anthracene
FLUORANTHN	Fluoranthene
ICDP	Indeno(1,2,3-cd)pyrene
PHENANTHRN	Phenanthrene

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D.6-1 Polynuclear Aromatic Hydrocarbons in water column

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	ACENAPE actual ug/l	ACENAPE DL ug/l	ACENAPTYLE actual ug/l	ACENAPTYLE DL ug/l	ANTHRACENE actual ug/l	ANTHRACENE DL ug/l	BAA actual ug/l	BAA DL ug/l	BAP actual ug/l	BAP DL ug/l	BBF actual ug/l	BBF DL ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2		2		2
L1	2	4	1989	WET	4	ND	200	ND	200	ND	7.0	ND	8.0	ND	5.0	ND	2.0
L1	2	9	1989	WET	5	ND	10	ND	10	ND	3.5	0.56	0.40	0.91	0.25	0.78	0.10
L1LR	2	9	1989	WET	5	ND	10	ND	10	ND	3.5	0.60	0.40	1.0	0.25	0.86	0.10
L1	3	2	1989	WET	6	ND	20	ND	200	ND	7.0	ND	0.80	ND	0.50	0.49	0.20
L2	2	4	1989	WET	4	ND	20	ND	200	ND	7.0	ND	0.80	ND	0.50	ND	0.20
L2	2	9	1989	WET	5	ND	10	ND	10	ND	0.70	ND	0.40	ND	0.25	0.10	0.10
L3	2	4	1989	WET	4	ND	20	ND	200	ND	7.0	ND	0.80	ND	0.50	ND	0.20
L3	2	9	1989	WET	5	ND	10	ND	20	ND	3.5	ND	0.40	ND	0.25	ND	0.10
L3	3	2	1989	WET	6	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	ND	0.20
L4	2	4	1989	WET	4	ND	20	ND	20	ND	0.70	ND	0.080	ND	0.50	ND	0.20
L4	2	9	1989	WET	5	ND	10	ND	10	ND	3.5	ND	0.40	ND	0.25	ND	0.10
L5	1	23	1989	WET	3	ND	20	ND	20	ND	0.70	ND	0.080	ND	0.50	ND	0.20
L5	2	4	1989	WET	4	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	0.28	0.20
L5	2	9	1989	WET	5	ND	10	ND	20	ND	3.5	ND	0.40	ND	0.50	0.32	0.10
L5	3	2	1989	WET	6	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	0.27	0.20
L5LR	2	4	1989	WET	4	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	0.26	0.20
L5FD	2	4	1989	WET	4	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	0.33	0.20
L6	2	9	1989	WET	5	ND	10	ND	20	ND	3.5	ND	0.40	ND	0.50	ND	0.20
L7	2	4	1989	WET	4	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
L7	2	9	1989	WET	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
L7	3	2	1989	WET	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S1	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S1LR	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S1	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S1	12	12	1988	DRY	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S1	2	1	1989	DRY	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S1	4	6	1989	DRY	7	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S1	1	23	1989	WET	3	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	0.037	0.020
S1	2	4	1989	WET	4	ND	20	ND	20	ND	7.0	ND	0.80	0.52	0.50	0.46	0.20
S1	2	9	1989	WET	5	ND	10	ND	10	ND	3.5	ND	0.40	ND	0.25	0.16	0.10
S1FD	2	9	1989	WET	5	ND	10	ND	20	ND	3.5	ND	0.40	ND	0.25	ND	0.10
S1	3	2	1989	WET	6	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	0.36	0.20
S1LR	3	2	1989	WET	6	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	0.31	0.20

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ACENAPE actual ug/l	ACENAPE DL ug/l	ACENAPTYLE actual ug/l	ACENAPTYLE DL ug/l	ANTHRACENE actual ug/l	ANTHRACENE DL ug/l	BAA actual ug/l	BAA DL ug/l	BAP actual ug/l	BAP DL ug/l	BBF actual ug/l	BBF DL ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2		2		2
S2	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S2	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S2	12	12	1988	DRY	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S2	2	1	1989	DRY	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S2	4	6	1989	DRY	7	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S2	1	23	1989	WET	3	ND	20	ND	20	ND	0.70	ND	0.080	0.081	0.050	0.089	0.020
S2	2	4	1988	WET	4	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	ND	0.20
S2	2	8	1989	WET	5	ND	20	ND	200	ND	3.5	ND	0.80	ND	0.50	0.67	0.20
S2	3	2	198P	WET	6	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	ND	0.20
S3	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S3	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S3	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	1	ND	10
S3FD	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1
S3FDLR	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1
S3	12	12	1988	DRY	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S3FD	12	12	1988	DRY	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S3LR	12	12	1988	DRY	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S3	2	1	1989	DRY	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S3FD	2	1	1988	DRY	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S3LR	2	1	1989	DRY	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S3	4	6	1989	DRY	7	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S3FD	4	6	1989	DRY	7	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S3	1	23	1989	WET	3	ND	20	ND	20	ND	0.70	ND	0.080	ND	0.50	ND	0.20
S3FD	1	23	1989	WET	3	ND	20	ND	20	ND	0.70	ND	0.080	ND	0.50	ND	0.20
S3	2	4	1989	WET	4	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	ND	0.20
S3	2	9	1888	WET	5	ND	10	ND	20	ND	3.5	ND	0.40	ND	0.25	ND	0.10
S4	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S4	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S4LR	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S4	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	50	ND	1
S4	12	12	1988	DRY	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	0.11	0.050	0.083	0.020
S4	2	1	1988	DRY	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S4	4	6	1C38	DRY	7	ND	2.0	ND	20	ND	0.70	ND	0.080	ND	0.050	ND	0.020
S4	2	4	[illegible]	WET	4	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	ND	0.20
S4	2	9	1989	WET	5	ND	10	ND	20	ND	3.5	ND	0.40	ND	0.25	ND	0.10
S4	3	2	1989	WET	6	ND	20	ND	20	ND	7.0	ND	0.80	ND	0.50	ND	0.20

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ACENAPE actual ug/l	ACENAPE DL ug/l	ACENAPTYLE actual ug/l	ACENAPTYLE DL ug/l	ANTHRACENE actual ug/l	ANTHRACENE DL ug/l	BAA actual ug/l	BAA DL ug/l	BAP actual ug/l	BAP DL ug/l	BBF actual ug/l	BBF DL ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2		2		2
5B	1	23	1989	WET	3	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
5B	2	4	1989	WET	4	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
5B	2	9	1989	WET	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
5B	3	2	1989	WET	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
FB	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1
FB	12	12	1988	DRY	5	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
FB	2	1	1989	DRY	6	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020
FB	4	6	1989	DRY	7	ND	2.0	ND	2.0	ND	0.70	ND	0.080	ND	0.050	ND	0.020

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	BGHIP actual ug/l	BGHIP DL ug/l	BKF actual ug/l	BKF DL ug/l	CHRYSENE actual ug/l	CHRYSENE DL ug/l	DBAHA actual ug/l	DBAHA DL ug/l	FLUORANTHN actual ug/l	FLUORANTHN DL ug/l	FLUORENE actual ug/l	FLUORENE DL ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2		2		2
L1	2	4	1989	WET	4	ND	8.0	ND	2.0	ND	20	ND	20	3.3	2.0	ND	2.0
L1	2	9	1989	WET	5	1.3	0.40	0.34	0.10	ND	1.0	ND	1.0	2.4	1.0	ND	1.0
L1LR	2	9	1989	WET	5	1.5	0.40	0.37	0.10	ND	1.0	ND	1.0	2.6	1.0	ND	1.0
L1	3	2	1989	WET	6	ND	0.80	0.22	0.20	ND	20	ND	2.0	ND	2.0	ND	2.0
L2	2	4	1989	WET	4	ND	0.80	ND	0.20	ND	20	ND	2.0	ND	2.0	ND	2.0
L2	2	9	1989	WET	5	ND	0.40	ND	0.10	ND	1.0	ND	1.0	ND	0.20	ND	1.0
L3	2	4	1989	WET	4	ND	0.80	ND	0.20	ND	20	ND	2.0	ND	2.0	ND	2.0
L3	2	9	1989	WET	5	ND	0.40	ND	0.10	ND	2.0	ND	1.0	ND	1.0	ND	1.0
L3	3	2	1989	WET	6	ND	0.80	ND	0.20	ND	2.0	ND	2.0	ND	2.0	ND	2.0
L4	2	4	1989	WET	4	ND	0.080	ND	0.20	ND	2.0	ND	2.0	ND	0.20	ND	2.0
L4	2	9	1989	WET	5	ND	0.40	ND	0.10	ND	1.0	ND	1.0	ND	1.0	ND	1.0
L5	1	23	1989	WET	3	ND	0.80	ND	0.20	ND	2.0	ND	2.0	0.26	0.20	ND	2.0
L5	2	4	1989	WET	4	ND	0.80	ND	0.20	ND	20	ND	2.0	ND	2.0	ND	2.0
L5	2	9	1989	WET	5	ND	0.40	0.14	0.10	ND	2.0	ND	1.0	ND	1.0	ND	1.0
L5	3	2	1989	WET	6	ND	0.80	ND	0.20	ND	2.0	ND	2.0	ND	2.0	ND	2.0
L5LR	2	4	1989	WET	4	ND	0.80	ND	0.20	ND	2.0	ND	2.0	ND	2.0	ND	2.0
L5FD	2	4	1989	WET	4	ND	0.80	ND	0.20	ND	2.0	ND	2.0	ND	2.0	ND	2.0
L6	2	9	1989	WET	5	ND	0.40	ND	0.20	ND	2.0	ND	2.0	ND	1.0	ND	1.0
L7	2	4	1989	WET	4	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
L7	2	9	1989	WET	5	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
L7	3	2	1989	WET	6	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
S1	3	30	1989	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S1LR	3	30	1989	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S1	5	11	1989	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S1	12	12	1988	DRY	5	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
S1	2	1	1989	DRY	6	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
S1	4	6	1989	DRY	7	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.50
S1	1	23	1989	WET	3	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
S1	2	4	1989	WET	4	ND	0.80	ND	0.20	ND	2.0	ND	2.0	ND	2.0	ND	2.0
S1	2	9	1989	WET	5	ND	0.40	ND	0.10	ND	1.0	ND	1.0	ND	1.0	ND	1.0
S1FD	2	9	1989	WET	5	ND	0.40	ND	0.10	ND	1.0	ND	1.0	ND	1.0	ND	1.0
S1	3	2	1989	WET	6	ND	0.80	ND	0.20	ND	2.0	ND	2.0	ND	2.0	ND	2.0
S1LR	3	2	1989	WET	6	ND	0.80	ND	0.20	ND	2.0	ND	2.0	ND	2.0	ND	2.0

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	BGHIP actual ug/l	BGHIP DL ug/l	BKF actual ug/l	BKF DL ug/l	CHRYSENE actual ug/l	CHRYSENE DL ug/l	DBAHA actual ug/l	DBAHA DL ug/l	FLUORANTHN actual ug/l	FLUORANTHN DL ug/l	FLUORENE actual ug/l	FLUORENE DL ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2		2		2
S2	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S2	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S2	12	12	1988	DRY	5	ND	0 080	ND	0 020	ND	0 20	ND	0 20	ND	0.20	ND	0 20
S2	2	1	1989	DRY	6	ND	0 080	ND	0 020	ND	0 20	ND	0 20	ND	0.20	ND	0 20
S2	4	6	1989	DRY	7	ND	0 080	ND	0 020	ND	0.20	ND	0 20	ND	0.20	ND	0.50
S2	1	23	1989	WET	3	ND	0 080	0 041	0 020	ND	2 0	ND	0 20	0.21	0.20	ND	2 0
S2	2	4	1989	WET	4	ND	0 80	ND	0 20	ND	2 0	ND	2 0	ND	2 0	ND	2 0
S2	2	9	1989	WET	5	ND	0 80	0 29	0 20	ND	20	ND	2 0	1.1	1 0	ND	2 0
S2	3	2	1989	WET	6	ND	0.80	ND	0 20	ND	2 0	ND	2 0	ND	2 0	ND	2 0
S3	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S3	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S3	8	22	1988	DRY	4	ND	2	ND	1	ND	1	ND	2	ND	1	ND	1
S3FD	8	22	1988	DRY	4	ND	2	ND	1	ND	1	ND	2	ND	1	ND	1
S3FDLR	8	22	1988	DRY	4	ND	2	ND	1	ND	1	ND	2	ND	1	ND	1
S3	12	12	1988	DRY	5	ND	0 080	ND	0 020	ND	0 20	ND	0.20	ND	0.20	ND	0.20
S3FD	12	12	1988	DRY	5	ND	0 080	ND	0 020	ND	0 20	ND	0 20	ND	0 20	ND	0.20
S3LR	12	12	1988	DRY	5	ND	0 080	ND	0 020	ND	0 20	ND	0 20	ND	0 20	ND	0 20
S3	2	1	1989	DRY	6	ND	0 080	ND	0 020	ND	0 20	ND	0.20	ND	0.20	ND	0.20
S3FD	2	1	1989	DRY	6	ND	0 080	ND	0 020	ND	0 20	ND	0.20	ND	0.20	ND	0 20
S3LR	2	1	1989	DRY	6	ND	0 080	ND	0 020	ND	0 20	ND	0.20	ND	0 20	ND	0.50
S3	4	6	1989	DRY	7	ND	0 080	ND	0 020	ND	0 20	ND	0 20	ND	0 20	ND	0.50
S3FD	4	6	1989	DRY	7	ND	0 080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.50
S3	1	23	1989	WET	3	ND	0.80	ND	0 20	ND	2 0	ND	2.0	0.29	0 20	ND	2 0
S3FD	1	23	1989	WET	3	ND	0 80	ND	0 20	ND	2 0	ND	2 0	0 26	0.20	ND	2 0
S3	2	4	1989	WET	4	ND	0 80	ND	0 20	ND	2 0	ND	2 0	ND	2.0	ND	2.0
S3	2	9	1989	WET	5	ND	0 40	ND	0 10	ND	1 0	ND	1.0	ND	1.0	ND	1 0
S4	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
S4	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S4LR	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2	ND	2	ND	2
S4	8	22	1988	DRY	4	ND	50	ND	1	ND	1	ND	50	ND	1	ND	1
S4	12	12	1988	DRY	5	ND	0 080	0 04	0 020	ND	0 20	ND	0 20	ND	0 20	ND	0 20
S4	2	1	1989	DRY	6	ND	0 080	ND	0 020	ND	0 20	ND	0 20	ND	0.20	ND	0 20
S4	4	6	1989	DRY	7	ND	0.080	ND	0 020	ND	0.20	ND	0 20	ND	0 20	ND	0.50
S4	2	4	1989	WET	4	ND	0 80	ND	0 20	ND	2.0	ND	2 0	ND	2 0	ND	2 0
S4	2	9	1989	WET	5	ND	0 40	ND	0 10	ND	1 0	ND	1.0	ND	1 0	ND	1 0
S4	3	2	1989	WET	6	ND	0.80	ND	0.20	ND	2.0	ND	2 0	ND	2 0	ND	2 0

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	BGHIP actual ug/l	BGHIP DL ug/l	BKF actual ug/l	BKF DL ug/l	CHRYSENE actual ug/l	CHRYSENE DL ug/l	DBAHA actual ug/l	DBAHA DL ug/l	FLUORANTHN actual ug/l	FLUORANTHN DL ug/l	FLUORENE actual ug/l	FLUORENE DL ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2		2		2
5B	1	23	1989	WET	3	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
5B	2	4	1989	WET	4	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
5B	2	9	1989	WET	5	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
5B	3	2	1989	WET	6	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
FB	8	22	1988	DRY	4	ND	2	ND	1	ND	1	ND	2	ND	1	ND	1
FB	12	12	1988	DRY	5	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
FB	2	1	1989	DRY	6	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.20
FB	4	6	1989	DRY	7	ND	0.080	ND	0.020	ND	0.20	ND	0.20	ND	0.20	ND	0.50

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ICDP actual ug/l	ICDP DL ug/l	NAPTHALENE actual ug/l	NAPTHALENE DL ug/l	PHENANTHRN actual ug/l	PHENANTHRN DL ug/l	PYRENE actual ug/l	PYRENE DL ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2
L1	2	4	1989	WET	4	ND	20	ND	200	ND	6.0	ND	3.0
L1	2	9	1989	WET	5	1.4	1.0	ND	10	ND	3.0	2.0	1.5
L1LR	2	9	1989	WET	5	1.2	1.0	ND	10	ND	3.0	2.2	1.5
L1	3	2	1989	WET	6	ND	2.0	ND	200	ND	6.0	ND	3.0
L2	2	4	1989	WET	4	ND	2.0	ND	200	ND	6.0	ND	3.0
L2	2	9	1989	WET	5	ND	1.0	ND	10	ND	3.0	ND	0.30
L3	2	4	1989	WET	4	ND	2.0	ND	200	ND	6.0	ND	3.0
L3	2	9	1989	WET	5	ND	1.0	ND	20	ND	3.0	ND	1.5
L3	3	2	1989	WET	6	ND	2.0	ND	200	ND	6.0	ND	3.0
L4	2	4	1989	WET	4	ND	0.20	ND	20	ND	6.0	ND	0.30
L4	2	9	1989	WET	5	ND	1.0	ND	10	ND	3.0	ND	1.5
L5	1	23	1989	WET	3	ND	2.0	ND	20	ND	6.0	ND	0.30
L5	2	4	1989	WET	4	ND	2.0	ND	200	ND	6.0	ND	3.0
L5	2	9	1989	WET	5	ND	1.0	ND	20	ND	3.0	ND	1.5
L5	3	2	1989	WET	6	ND	2.0	ND	200	ND	6.0	ND	3.0
L5LR	2	4	1989	WET	4	ND	2.0	ND	200	ND	6.0	ND	3.0
L5FD	2	4	1989	WET	4	ND	2.0	ND	20	ND	6.0	ND	3.0
L6	2	9	1989	WET	5	ND	1.0	ND	20	ND	3.0	ND	1.5
L7	2	4	1989	WET	4	ND	0.20	ND	2.0	ND	0.60	ND	0.30
L7	2	9	1989	WET	5	ND	0.20	ND	2.0	ND	0.60	ND	0.30
L7	3	2	1989	WET	6	ND	0.20	ND	20	ND	0.60	ND	0.30
S1	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5
S1LR	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5
S1	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2
S1	12	12	1988	DRY	5	ND	0.20	ND	2.0	ND	0.60	ND	0.30
S1	2	1	1989	DRY	6	ND	0.20	ND	2.0	ND	0.60	ND	0.30
S1	4	6	1989	DRY	7	ND	0.20	ND	20	ND	0.60	ND	0.30
S1	1	23	1989	WET	3	ND	0.20	ND	2.0	ND	0.60	ND	0.30
S1	2	4	1989	WET	4	ND	2.0	ND	20	ND	6.0	ND	3.0
S1	2	9	1989	WET	5	ND	1.0	ND	20	ND	3.0	ND	1.5
S1FD	2	9	1989	WET	5	ND	1.0	ND	20	ND	3.0	ND	1.5
S1	3	2	1989	WET	6	ND	2.0	ND	200	ND	6.0	ND	3.0
S1LR	3	2	1989	WET	6	ND	2.0	ND	200	ND	6.0	ND	3.0

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Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ICDP actual ug/l	ICDP DL ug/l	NAPTHALENE actual ug/l	NAPTHALENE DL ug/l	PHENANTHRN actual ug/l	PHENANTHRN DL ug/l	PYRENE actual ug/l	PYRENE DL ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2
S2	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5
S2	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2
S2	12	12	1988	DRY	5	ND	0 20	ND	2 0	ND	0 60	ND	0.30
S2	2	1	1989	DRY	6	ND	0 20	ND	2 0	ND	0 60	ND	0 30
S2	4	6	1988	DRY	7	ND	0.20	ND	2.0	ND	0 60	ND	0.30
S2	1	23	1989	WET	3	ND	0 20	ND	20	ND	6 0	ND	0.30
S2	2	4	1988	WET	4	ND	2 0	ND	20	ND	6 0	ND	3 0
S2	2	8	1989	WET	5	ND	2 0	ND	200	ND	6 0	ND	1 5
S2	3	2	1989	WET	6	ND	2 0	ND	200	ND	6 0	ND	3.0
S3	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5
S3	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2
S3	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1
S3FD	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1
S3FDLR	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1
S3	12	12	1988	DRY	5	ND	0 20	ND	20 0	ND	0 60	ND	0 30
S3FD	12	12	1988	DRY	5	ND	0.20	ND	2 0	ND	0 60	ND	0 30
S3LR	12	12	1988	DRY	5	ND	0 20	ND	2 0	ND	0 60	ND	0 30
S3	2	1	1989	DRY	6	ND	0 20	ND	2 0	ND	0 60	ND	0 30
S3FD	2	1	1989	DRY	6	ND	0 20	ND	2 0	ND	0 60	ND	0 30
S3LR	2	1	1988	DRY	6	ND	0 20	ND	2 0	ND	0 60	ND	0 30
S3	4	6	1988	DRY	7	ND	0 20	ND	20	ND	0 60	ND	0 30
S3FD	4	6	1988	DRY	7	ND	0.20	ND	20	ND	0 60	ND	0.30
S3	1	23	1989	WET	3	ND	2 0	ND	20	ND	6 0	0 33	0 30
S3FD	1	23	1989	WET	3	ND	2 0	ND	20	ND	6 0	0.32	0.30
S3	2	4	1988	WET	4	ND	2 0	ND	20	ND	6 0	ND	3 0
S3	2	8	1989	WET	5	ND	1.0	ND	20	ND	3 0	ND	1.5
S4	3	30	1988	DRY	2	ND	5	ND	5	ND	5	ND	5
S4	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2
S4LR	5	11	1988	DRY	3	ND	2	ND	2	ND	2	ND	2
S4	8	22	1988	DRY	4	ND	50	ND	1	ND	1	ND	1
S4	12	12	1988	DRY	5	ND	0 20	ND	2 0	ND	0 60	ND	0 30
S4	2	1	1989	DRY	6	ND	0 20	ND	2 0	ND	0 60	ND	0.30
S4	4	6	1988	DRY	7	ND	0.20	ND	20	ND	0 60	ND	0.30
S4	2	4	1988	WET	4	ND	2 0	ND	20	ND	6 0	ND	3 0
S4	2	8	1988	WET	5	ND	1.0	ND	20	ND	3 0	ND	1.5
S4	3	2	1988	WET	6	ND	2.0	ND	200	ND	6.0	ND	3.0

Sample ID	Date Sampled Month	Day	Year	Sample Type	Sample Event	ICDP actual ug/l	ICDP DL. ug/l	NAPTHALENE actual ug/l	NAPTHALENE DL ug/l	PHENANTHRN actual ug/l	PHENANTHRN DL. ug/l	PYRENE actual ug/l	PYRENE DL. ug/l
STANDARD REPORTING OBJECTIVES							2		2		2		2
5B	1	23	1989	WET	3	ND	0.20	ND	2.0	ND	0.60	ND	0.30
5B	2	4	1989	WET	4	ND	0.20	ND	2.0	ND	0.60	ND	0.30
5B	2	9	1989	WET	5	ND	0.20	ND	2.0	ND	0.60	ND	0.30
5B	3	2	1989	WET	6	ND	0.20	ND	2.0	ND	0.60	ND	0.30
FB	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1
FB	12	12	1988	DRY	5	ND	0.20	ND	2.0	ND	0.60	ND	0.30
FB	2	1	1989	DRY	6	ND	0.20	ND	2.0	ND	0.60	ND	0.30
FB	4	6	1989	DRY	7	ND	0.20	ND	2.0	ND	0.60	ND	0.30

D.6-2 Polynuclear Aromatic Hydrocarbons in sediment

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Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	ACENAPE actual mg/kg	ACENAPE D.L. mg/kg	ACENAPTYLE actual mg/kg	ACENAPTYLE D.L. mg/kg	ANTHRACENE actual mg/kg	ANTHRACENE D.L. mg/kg	BAA actual mg/kg	BAA D.L. mg/kg	BAP actual mg/kg	BAP D.L. mg/kg	BBF actual mg/kg	BBF D.L. mg/kg
STANDARD REPORTING LIMITS							0.2		0.2		0.2		0.2		0.2		0.2
S1	12	12	1988	DRY	5	ND	1.100	ND	1.100	ND	0.400	0.230	0.045	0.490	0.280	0.540	0.110
S2	12	12	1988	DRY	5	ND	0.660	ND	0 660	ND	0.230	0.100	0.026	0.200	0.160	0.190	0.066
S3	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	1	ND	10
S3	12	12	1988	DRY	5	ND	0.650	ND	0.650	ND	0.230	0.130	0.028	0.230	0.160	0.250	0.065
S3FD	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1
S3FD	12	12	1989	DRY	5	ND	0.910	ND	0.910	ND	0.320	ND	0.360	0.360	0.230	0.410	0.091
S4	8	22	1989	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	50	ND	1
S4	12	12	1988	DRY	5	ND	0.710	ND	0.710	ND	0.250	0.270	0.180	0.270	0.180	0.360	0.071

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	BGHIP actual mg/kg	BGHIP D L. mg/kg	BKF actual mg/kg	BKF D L. mg/kg	CHRYSENE actual mg/kg	CHRYSENE D L. mg/kg	DBAHA actual mg/kg	DBAHA D L. mg/kg	FLUORANTHN actual mg/kg	FLUORANTHN D L. mg/kg
STANDARD REPORTING LIMITS							0.2		0.2		0.2		0.2		0.2
S1	12	12	1988	DRY	5	ND	0.450	0.270	0.110	ND	1.100	ND	0.110	0.910	0.110
S2	12	12	1988	DRY	5	ND	0.260	0.100	0.066	ND	0.660	ND	0.660	0.400	0.068
S3	8	22	1988	DRY	4	ND	2	ND	1	ND	1	ND	2	ND	1
S3	12	12	1988	DRY	5	ND	0.260	0 110	0.065	ND	0.650	ND	0.650	0 460	0.065
S3FD	8	22	1988	DRY	4	ND	2	ND	1	ND	1	ND	2	ND	1
S3FD	12	12	1988	DRY	5	ND	0.360	0.190	0.081	ND	0.810	ND	0.810	0.780	0.081
S4	8	22	1988	DRY	4	ND	50	ND	1	ND	1	ND	50	ND	1
S4	12	12	1988	DRY	5	ND	0.280	0.160	0.071	ND	0.710	ND	0.710	0.650	0.071

Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	FLUORENE actual mg/kg	FLUORENE D.L. mg/kg	ICDP actual mg/kg	ICDP D.L. mg/kg	NAPTHALENE actual mg/kg	NAPTHALENE D.L. mg/kg	PHENANTHRN actual mg/kg	PHENANTHRN D.L. mg/kg	PYRENE actual mg/kg	PYRENE D.L. mg/kg
STANDARD REPORTING LIMITS							0.2		0.2		0.2		0.2		0.2
S1	12	12	1988	DRY	5	ND	0.110	ND	1.100	ND	1.100	0.350	0.340	0.650	0.170
S2	12	12	1988	DRY	5	ND	0.068	ND	0.660	ND	0.660	ND	0.200	0.350	0.098
S3	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	1
S3	12	12	1988	DRY	5	ND	0.065	ND	0.650	ND	0.650	ND	0.190	0.420	0.097
S3FD	8	22	1988	DRY	4	ND	1	ND	1	ND	1	ND	1	ND	1
S3FD	12	12	1988	DRY	5	ND	0.091	ND	0.910	ND	0.910	0.380	0.270	0.480	0.140
S4	8	22	1988	DRY	4	ND	1	ND	50	ND	1	ND	1	ND	1
S4	12	12	1988	DRY	5	ND	0.071	ND	0.710	ND	0.710	0.260	0.210	0.570	0.110

D.7 Volatiles and semi-volatiles

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VOLATILES AND SEMI-VOLATILES

Abbreviated Name	Actual Name
3CLETHENE	Trichlorethene
METHYLECL	Methylene Chloride
B2ETHXPHTH	Bis(2-ethylhexyl) phthalate
2NOCTP	Di-n-octylphthalate

D.7-1 Volatiles and semi-volatiles in water column

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Sample I.D.	Date Sampled Month	Day	Year	Sample Type	Sample Event	EPA 624 3CLETHE actual ug/l	D.L. ug/l	ACETONE actual ug/l	D.L. ug/l	2 BUTANONE actual ug/l	D.L. ug/l	METHYLE CL actual ug/l	D.L. ug/l	EPA 624 XYLENE-T actual ug/l	D.L. ug/l	TOLUENE actual ug/l	D.L. ug/l
STANDARD REPORTING OBJECTIVES																	
W AVE	2	17	1988					80	20							13	5
L1	4	20	1988	WWWQ	1									9	5		
L1	11	23	1988	WWWQ	2							54	5				
L2	4	20	1988	WWWQ	1			45	20								
L2	11	23	1988	WWWQ	2			30	20	130	20			55	5		
L3	4	20	1988	WWWQ	1												
L3	11	23	1988	WWWQ	2												
L5	11	23	1988	WWWQ	2												
L6	4	20	1988	WWWQ	1												
L6	11	23	1988	WWWQ	2												
L7	11	23	1988	WWWQ	2												
R1	2	26	1988	RRWQ	1												
R2	2	26	1988	RRWQ	1												
R3	2	26	1988	RRWQ	1												
R4	2	26	1988	RRWQ	1												
R5	2	26	1988	RRWQ	1												
R6	2	26	1988	RRWQ	1												
S1	2	26	1988	DWWQ	1												
S1	11	23	1988	WWWQ	2												
S2	2	26	1988	DWWQ	1	6	5										
S2	4	20	1988	WWWQ	1												
S2	11	23	1988	WWWQ	2												
S3	2	26	1988	DWWQ	1												
S3	4	20	1988	WWWQ	1												
S3	11	23	1988	WWWQ	2												
S3LR	11	23	1988	WWWQ	2												
S4	2	26	1988	DWWQ	1												
S4	4	20	1988	WWWQ	1												
S4	11	23	1988	WWWQ	2												
S4LR	11	23	1988	WWWQ	2												

Sample I D	Date Sampled Month	Day	Year	Sample Type	Sample Event	EPA 625 B2ETHXPHTH actual ug/l	D.L. ug/l	2NOCTP actual ug/l	D.L. ug/l	BENZOIC AC actual ug/l	D.L. ug/l	4-METHPHN actual ug/l	D.L. ug/l
STANDARD REPORTING OBJECTIVES													
W AVE	2	17	1988			320	10			430	50	20	10
L1	4	20	1988	WWWQ	1	41	10						
L1	11	23	1988	WWWQ	2								
L2	4	20	1988	WWWQ	1	49	10						
L2	11	23	1988	WWWQ	2								
L3	4	20	1988	WWWQ	1								
L3	11	23	1988	WWWQ	2								
L5	11	23	1988	WWWQ	2								
L6	4	20	1988	WWWQ	1	43	10						
L6	11	23	1988	WWWQ	2								
L7	11	23	1988	WWWQ	2								
R1	2	26	1988	RFWQ	1								
R2	2	26	1988	RFWQ	1								
R3	2	26	1988	RFWQ	1								
R4	2	26	1988	RFWQ	1								
R5	2	26	1988	RFWQ	1								
R6	2	26	1988	RFWQ	1								
S1	2	26	1988	DWWQ	1								
S1	11	23	1988	WWWQ	2								
S2	2	26	1988	DWWQ	1								
S2	4	20	1988	WWWQ	1								
S2	11	23	1988	WWWQ	2								
S3	2	26	1988	DWWQ	1								
S3	4	20	1988	WWWQ	1								
S3	11	23	1988	WWWQ	2								
S3LR	11	23	1988	WWWQ	2								
S4	2	26	1988	DWWQ	1	82	10	38	10				
S4	4	20	1988	WWWQ	1								
S4	11	23	1988	WWWQ	2								
S4LR	11	23	1988	WWWQ	2								

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D.7-2 Volatiles and semi-volatiles in sediment

CHEMICAL	GROUP	STATION	SAMPLING DATE	CONCENTRATION (ug/kg)
Toluene	Volatile	S3	3/30/88	5
Acetone	Volatile	S3	3/30/88	63
BEHP	Semi-Volatile	S3	3/30/88	2700
		S3	5/11/88	970
		S4	5/11/88	4400
		S4.duplicate	5/11/88	1400
Butylbenzyl-phthalate	Semi-Volatile	S3	3/30/88	490
Fluoranthene	Semi-Volatile	S3	3/30/88	330
		S4	5/11/88	400
Pyrene	Semi-Volatile	S3	3/30/88	330

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D.8 Dissolved Oxygen Data from Stream Stations and Settling Data

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SANTA CLARA URBAN RUNOFF STUDY

10-11 February 89
Assessment of Discrete and Persistent Dissolved Oxygen

The following data are from samples collected at four stations in the Santa Clara Urban Runoff study area, at five-to-seven hour intervals.

STATION	LOCATION	DATE	TIME COLLECTED	x (mg/L) CONCENTRATION	STANDARD DEVIATION
S-1	Wilcox	10FEB89	04:40	11.83	0.042
S-1	Wilcox	10FEB89	10:30	11.66	0.071
S-1	Wilcox	10FEB89	17:30	10.81	0.127
S-1	Wilcox	10FEB89	23:00	10.03	0.028
S-1	Wilcox	11FEB89	04:00	8.94	0.106
S-1	Wilcox	11FEB89	09:00	10.31	0.014
S-1	Wilcox	11FEB89	15:00	10.01	0.071

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10-11 February 89
Assessment of Discrete and Persistent Dissolved Oxygen

The following data are from samples collected at four stations in the Santa Clara Urban Runoff study area at five-to-seven hour intervals.

STATION	LOCATION	DATE	TIME COLLECTED	x (mg/L) CONCENTRATION	STANDARD DEVIATION
S-2	Bayshore	10FEB89	04:13	11.33	0.106
S-2	Bayshore	10FEB89	09:50	10.81	0.170
S-2	Bayshore	10FEB89	16:50	10.59	0.078
S-2	Bayshore	10FEB89	22:05	9.27	0.028
S-2	Bayshore	11FEB89	03:30	8.51	0.035
S-2	Bayshore	11FEB89	08:30	9.19	0.049
S-2	Bayshore	11FEB89	14:30	12.18	0.042

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SANTA CLARA URBAN RUNOFF STUDY
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Assessment of Discrete and Persistent Dissolved Oxygen

The following data are from samples collected at four stations in the Santa Clara Urban Runoff study area, at five-to-seven hour intervals.

STATION	LOCATION	DATE	TIME COLLECTED	x (mg/L) CONCENTRATION	STANDARD DEVIATION
S-3	Guadalupe	10FEB89	05:40	10.26	0.028
S-3	Guadalupe	10FEB89	12:10	10.04	0.028
S-3	Guadalupe	10FEB89	15:17	9.81	0.064
S-3	Guadalupe	10FEB89	20:25	9.85	0.0
S-3	Guadalupe	11FEB89	01:30	9.83	0.049
S-3	Guadalupe	11FEB89	06:30	9.65	0.014
S-3	Guadalupe	11FEB89	12:45	10.42	0.735

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SANTA CLARA URBAN RUNOFF STUDY
10-11 February 89
Assessment of Discrete and Persistent Dissolved Oxygen

The following data are from samples collected at four stations in the Santa Clara Urban Runoff study area at two-to-seven hour intervals.

STATION	LOCATION	DATE	TIME COLLECTED	x (mg/L) CONCENTRATION	STANDARD DEVIATION
S-4	Coyote	10FEB89	01:15	9.44	N/A*
S-4	Coyote	10FEB89	03:10	8.70	0.042
S-4	Coyote	10FEB89	08:57	9.03	0.049
S-4	Coyote	10FEB89	16:05	8.47	0.021
S-4	Coyote	10FEB89	21:30	8.89	0.071
S-4	Coyote	11FEB89	03:00	8.84	0.057
S-4	Coyote	11FEB89	08:00	8.83	0.049
S-4	Coyote	11FEB89	14:05	9.57	0.134

*Only one sample was collected at this site.

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Dane D. Hardin
Regional Manager

R0054683

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TABLE 2

CERIODAPHNIA REPRODUCTION AND SURVIVAL

Santa Clara Valley NPS Sample #3334

Sample	Day #	Replicate a	b	c	d	e	f	g	h	i	j	Total Young	# Live Adults
Control	4	5	4	0	4	5	4	4	2	6	2	36	10
	5	5	0	4	3	0	0	0	8	0	8	28	10
	6	0	8	5	8	10	8	6	0	8	0	53	10
	7	12	10	11	12	12	12	10	10	12	12	113	10
S-1	4	X	X	X	X	X	X	X	X	X	X	X	0
	5	-	-	-	-	-	-	-	-	-	-	-	0
	6	-	-	-	-	-	-	-	-	-	-	-	0
	7	-	-	-	-	-	-	-	-	-	-	-	0
S-2	4	4	4	4	5	0	0	3	3	2	4	29	40
	5	0	0	0	0	5	0	4	5	7	10	31	10
	6	8	10	8	12	10	10	0	1	0	0	59	10
	7	5	0	0	0	0	0	12	12	10	2	41	10
S-3	4	4	3	4	5	5	4	6	4	4	4	43	10
	5	0	0	0	10	8	12	9	10	10	10	69	10
	6	12	10	12	1	0	0	0	0	0	8	43	10
	7	16	2	8	2	16	16	18	16	18	X	112	9
L-1	4	0	0	0	0	0	0	0	0	0	0	0	10
	5	0	0	0	0	X	0	0	0	0	X	0	8
	6	0	0	0	0	-	0	0	0	0	-	0	8
	7	0	0	0	0	-	0	0	0	0	-	0	8
L-2	4	4	5	4	5	5	4	5	6	5	6	49	10
	5	10	8	10	10	0	0	0	0	0	0	38	10
	6	14	0	0	0	12	10	12	8	10	13	79	10
	7	0	10	10	12	6	14	17	18	18	18	123	10

X = Adult Died

TABLE 2 -cont. CERIODAPHNIA REPRODUCTION AND SURVIVAL

Santa Clara Valley NPS Sample #3334

Sample	Day #	Replicate a	b	c	d	e	f	g	h	i	j	Total Young	# Live Adults
Control	4	5	4	0	4	5	4	4	2	6	2	36	10
	5	5	0	4	3	0	0	0	8	0	8	28	10
	6	0	8	5	8	10	8	6	0	8	0	53	10
	7	12	10	11	12	12	12	10	10	12	12	113	10
L-3	4	5	4	4	X	5	5	4	5	4	4	40	9
	5	0	0	0	-	0	0	0	0	0	0	0	9
	6	0	12	0	-	0	0	0	0	4	0	16	9
	7	X	X	X	-	X	X	X	X	X	X	0	0
L-4	4	0	0	6	5	6	5	4	2	0	X	28	9
	5	5	8	0	0	0	0	0	8	8	-	29	9
	6	0	10	10	11	10	12	8	0	8	-	69	9
	7	0	2	12	0	12	8	8	3	0	-	45	9
L-5	4	2	X	4	5	5	3	5	4	6	7	41	9
	5	2	-	6	6	8	0	0	0	0	9	29	9
	6	5	-	0	3	0	5	8	9	6	0	36	9
	7	10	-	12	10	12	11	1	16	6	4	82	9
L-6	4	4	4	5	5	6	2	5	6	6	6	49	10
	5	0	0	0	0	0	0	0	0	0	0	0	10
	6	7	11	9	10	8	10	12	8	10	13	98	10
	7	18	18	18	20	20	18	16	18	14	20	180	10
L-7	4	6	4	6	5	4	5	3	6	5	6	50	10
	5	9	6	0	0	0	8	0	0	9	12	44	10
	6	0	0	8	8	10	3	10	11	0	0	50	10
	7	15	14	16	12	16	17	16	15	16	14	151	10

X = Male Died

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TABLE 3

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3334

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	8.2	6.6	8.2	7.2	8.2	7.4	8.2	7.9	8.1	7.8	8.2	7.8	8.1	7.8
S-1	9.4	6.4	8.7	7.3	9.0	7.1	8.5	7.6	8.8	7.7	8.4	7.8	8.4	7.7
S-2	9.0	6.4	8.9	7.7	9.0	7.0	8.1	8.0	9.0	7.9	8.8	7.8	8.7	7.8
S-3	8.3	6.5	8.0	7.3	8.5	7.4	8.5	8.0	8.2	7.8	8.2	7.8	8.0	7.8
L-1	9.4	6.4	9.6	7.0	10.0	6.7	10.2	7.8	9.8	7.8	9.2	7.8	10.0	7.8
L-2	9.0	6.5	8.8	7.7	9.0	7.2	9.2	7.9	8.6	7.9	8.6	7.8	8.5	7.8
L-3	9.0	6.3	9.2	7.3	9.0	7.3	10.0	7.9	9.4	7.8	9.2	7.7	8.0	7.8
L-4	9.4	6.8	9.2	7.4	9.4	7.5	9.6	8.0	9.4	7.9	9.8	7.7	9.4	7.8
L-5	9.0	6.6	9.0	7.4	9.0	7.7	7.9	7.9	8.6	7.8	8.2	7.9	8.0	7.8
L-6	9.1	6.7	8.6	7.4	9.1	7.5	9.2	7.9	8.5	7.8	8.0	7.8	8.0	7.9
L-7	9.2	6.7	9.0	7.3	9.2	7.4	10.3	8.0	9.0	7.8	9.8	7.8	9.4	7.6

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	8.0	8.1	7.9	7.7	8.0	7.9	7.9
S-1	6.6	7.1	6.7	7.0	6.9	6.6	6.5
S-2	7.5	7.4	7.1	7.2	7.2	7.0	7.0
S-3	7.9	7.7	7.4	7.5	7.4	7.3	7.3
L-1	10.5	10.4	10.4	10.4	10.2	10.1	10.4
L-2	7.3	7.1	6.8	6.5	6.7	6.7	6.7
L-3	7.3	7.4	7.0	6.6	6.8	6.7	6.7
L-4	8.0	8.0	7.6	7.8	7.6	7.6	7.6
L-5	7.4	7.4	6.9	7.1	7.0	6.9	6.9
L-6	7.4	7.5	7.3	7.1	7.1	7.1	7.0
L-7	8.2	8.3	8.0	8.1	8.0	7.8	7.9

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TABLE 3 - continued **CERIODAPHNIA - ENVIRONMENTAL MONITORING**
Santa Clara Valley NPS Sample #3334

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	270	270	270	270	270	270	270
S-1	115	120	120	120	120	120	120
S-2	168	165	165	165	165	165	165
S-3	290	290	290	290	290	290	290
L-1	750	775	775	775	775	775	775
L-2	78	80	80	80	80	80	80
L-3	58	70	70	70	70	70	70
L-4	1100	1100	1100	1100	1100	1100	1100
L-5	175	180	180	180	180	180	180
L-6	60	75	75	75	75	75	75
L-7	600	600	600	600	600	600	600

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	25.5	25.5	24.0	25.0	25.0	25.0
S-1	25.0	25.5	25.5	23.9	25.5	25.0	25.0
S-2	25.0	25.5	25.5	25.0	25.5	25.0	25.0
S-3	25.0	25.5	25.5	25.0	25.5	25.0	25.0
L-1	25.0	25.5	25.5	23.9	25.5	25.0	25.0
L-2	25.0	25.5	25.5	25.0	25.5	25.0	25.0
L-3	25.0	25.5	25.5	25.0	25.5	25.0	25.0
L-4	25.0	25.5	25.5	24.0	25.5	25.0	25.0
L-5	25.0	25.5	25.5	24.1	25.5	25.0	25.0
L-6	25.0	25.5	25.5	25.3	25.5	25.0	25.0
L-7	25.0	25.5	25.5	24.4	25.5	25.0	25.0

Alkalinity/Hardness (as mg/l CaCO3)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	68/104	68/104	68/104	68/104	68/104	68/104	68/104
S-1	44/36	44/36	44/36	44/36	44/36	44/36	44/36
S-2	62/68	62/68	62/68	62/68	62/68	62/68	62/68
S-3	129/136	129/136	129/136	129/136	129/136	129/136	129/136
L-1	258/32	258/32	258/32	258/32	258/32	258/32	258/32
L-2	34/28	34/28	34/28	34/28	34/28	34/28	34/28
L-3	26/26	26/26	26/26	26/26	26/26	26/26	26/26
L-4	210/440	210/440	210/440	210/440	210/440	210/440	210/440
L-5	45/56	45/56	45/56	45/56	45/56	45/56	45/56
L-6	38/32	38/32	38/32	38/32	38/32	38/32	38/32
L-7	212/230	212/230	212/230	212/230	212/230	212/230	212/230

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TABLE 4

FATHEAD MINNOW LARVAE
MEAN PERCENT SURVIVAL (n=30) AND MEAN LARVAL DRY WEIGHT

Santa Clara Valley NPS Sample #3334

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	(mg) Mean Larval Dry Weight
Control	100	100	100	97	97	93	93	0.5407
S-1	100	100	100	100	100	97	97	0.3570
S-2	100	100	100	100	100	100	100	0.4200
L-1	37	33	29	0	0	0	0	------
L-2	0	0	0	0	0	0	0	------
L-4	100	100	97	97	97	97	97	0.5411
L-5	100	100	100	100	100	100	100	0.4100
L-7	100	100	100	100	97	97	97	0.4700

For Larval Weight Data (excludes L1 and L2)

Bartlett's B (calculated) = 22.42
Tabled X^2 value (p=0.01, 5 df) = 15.09
Bartlett's B (square root transformed data) = 17.64

ANOVA F (calculated) = 6.13
ANOVA F (tabled) = 3.11

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TABLE 5

FATHEAD MINNOW LARVAE
SURVIVAL AND LARVAL DRY WEIGHT DATA

Santa Clara Valley NPS Sample #3334

Sample	Replicate	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Mean Larval Dry Weight (mg)
		Number of Survivors								
Control	1	10	10	10	10	9	9	9	9	0.5222
	2	10	10	10	10	10	10	9	9	0.5000
	3	10	10	10	10	10	10	10	10	0.6000
S-1	1	10	10	10	10	10	10	9	9	0.4111
	2	10	10	10	10	10	10	10	10	0.4200
	3	10	10	10	10	10	10	10	10	0.3300
S-2	1	10	10	10	10	10	10	10	10	0.4400
	2	10	10	10	10	10	10	10	10	0.3800
	3	10	10	10	10	10	10	10	10	0.4400
L-1	1	10	1	1	1	1	0	0	0	------
	2	10	4	2	2	'	0	0	0	------
	3	10	6	6	5		0	0	0	------
L-2	1	10	0	0	0	0	0	0	0	------
	2	10	0	0	0	0	0	0	0	------
	3	10	0	0	0	0	0	0	0	------
L-4	1	10	10	10	10	10	10	10	10	0.4700
	2	10	10	10	9	9	9	9	9	0.6333
	3	10	10	10	10	10	10	10	10	0.5200
L-5	1	10	10	10	10	10	10	10	10	0.4300
	2	10	10	10	10	10	10	10	10	0.4100
	3	10	10	10	10	10	10	10	10	0.3900
L-7	1	10	10	10	10	10	10	10	10	0.4700
	2	10	10	10	10	10	10	10	10	0.4700
	3	10	10	10	10	10	9	9	9	0.4700

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TABLE 6

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3334

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	8.2	6.3	8.2	6.8	8.2	6.9	8.2	7.1	8.1	7.0	8.2	7.0	8.1	6.6
S-1	9.4	5.5	8.7	6.0	9.0	5.5	8.5	6.4	8.8	6.1	8.4	6.2	8.4	6.0
S-2	9.0	5.6	8.9	5.7	9.0	5.4	8.1	6.2	9.0	5.4	8.8	5.1	8.7	5.9
L-1	9.4	5.6	9.6	5.2	10.0	5.0	10.2	4.2	9.8	4.5	9.2	---	10.0	---
L-2	9.0	5.4	8.8	---	9.0	---	9.2	---	8.6	---	8.6	---	8.5	---
L-4	9.4	6.0	9.2	6.6	9.4	6.4	9.6	6.7	9.4	6.3	9.8	6.0	9.4	6.2
L-5	9.0	5.6	9.0	6.2	9.0	6.1	7.9	6.7	8.6	6.5	8.2	6.3	8.0	6.3
L-7	9.2	6.3	9.0	6.9	9.2	6.5	10.3	6.8	9.0	6.7	9.8	6.5	9.4	6.5

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	8.0	8.1	7.9	7.7	8.0	7.9	7.9
S-1	6.6	7.1	6.7	7.0	6.9	6.6	6.5
S-2	7.5	7.4	7.1	7.2	7.2	7.0	7.0
L-1	10.5	10.4	10.4	10.4	10.2	10.1	10.4
L-2	7.3	7.1	6.8	6.5	6.7	6.7	6.7
L-4	8.0	8.0	7.6	7.8	7.6	7.6	7.6
L-5	7.4	7.4	6.9	7.1	7.0	6.9	6.9
L-7	8.2	8.3	8.0	8.1	8.0	7.8	7.9

TABLE 6 - continued

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3334

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	270	270	270	270	270	270	270
S-1	115	120	120	120	120	120	120
S-2	168	165	165	165	165	165	165
L-1	750	775	775	775	775	775	775
L-2	78	80	80	80	80	80	80
L-4	1100	1100	1100	1100	1100	1100	1100
L-5	175	180	180	180	180	180	180
L-7	600	600	600	600	600	600	600

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Lay 4	Day 5	Day 6	Day 7
Control	25.0	25.5	25.5	24.0	25.0	25.0	25.0
S-1	25.0	25.5	25.5	23.9	25.5	25.0	25.0
S-2	25.0	25.5	25.5	25.0	25.5	25.0	25.0
L-1	25.0	25.5	25.5	23.9	25.5	25.0	25.0
L-2	25.0	25.5	25.5	25.0	25.5	25.0	25.0
L-4	25.0	25.5	25.5	24.0	25.5	25.0	25.0
L-5	25.0	25.5	25.5	24.1	25.5	25.0	25.0
L-7	25.0	25.5	25.5	24.4	25.5	25.0	25.0

Alkalinity/Hardness (as mg/l CaCO3)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	68/104	68/104	68/104	68/104	68/104	68/104	68/104
S-1	44/36	44/36	44/36	44/36	44/36	44/36	44/36
S-2	62/68	62/68	62/68	62/68	62/68	62/68	62/68
L-1	258/32	258/32	258/32	258/32	258/32	258/32	258/32
L-2	34/28	34/28	34/28	34/28	34/28	34/28	34/28
L-4	210/440	210/440	210/440	210/440	210/440	210/440	210/440
L-5	45/56	45/56	45/56	45/56	45/56	45/56	45/56
L-7	212/230	212/230	212/230	212/230	212/230	212/230	212/230

TABLE 7

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3334 - Run #1

Sample	Replicate 1	Replicate 2	Replicate 3	Mean
		Cells/ml X 10^6 after 96 hours		
Control	3.17	3.17	3.37	3.24
L-3	3.39	3.22	3.43	3.35
L-4	3.13	3.20	3.43	3.25
L-5	1.22	1.28	1.15	1.22
L-6	2.73	2.21	2.39	2.44
L-7	1.92	2.30	2.23	2.15

Bartlett's B (calculated) = 3.653
Tabled X^2 value (p=0.01, df=5) = 15.01

ANOVA F (calculated) = 76.98
ANOVA F (tabled) = 3.11

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	23.8	24.2	24.0	24.7
L-3	23.8	24.2	24.0	24.7
L-4	23.8	24.2	24.0	24.7
L-5	23.8	24.2	24.0	24.7
L-6	23.8	24.2	24.0	24.7
L-7	23.8	24.2	24.0	24.7

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	8.0	270
L-3	7.3	58
L-4	8.0	1100
L-5	7.4	175
L-6	7.4	60
L-7	8.2	600

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TABLE 8

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3334 - Run #2

Sample	Cells/ml X 10^6 after 96 hours			
	Replicate 1	Replicate 2	Replicate 3	Mean
Control	3.66	3.76	3.63	3.68
S-1	2.09	2.94	3.37	3.80
S-2	2.38	3.02	3.10	2.83
S-3	4.03	3.60	3.79	3.81
L-1	0.033	0.043	0.038	0.038
L-2	0.0022	0	0.010	0.0061

Bartlett's B (calculated) = 31.22 ANOVA F (calculated) = 121.4
Tabled X^2 value (p=0.01, df=5) = 15.01 ANOVA F (tabled) = 3.11
Bartlett's B (square root transformed data) = 14.88

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	24.3	24.4	24.8	24.5
S-1	24.3	24.4	24.8	24.5
S-2	24.3	24.4	24.8	24.5
S-3	24.3	24.4	24.8	24.5
L-1	24.3	24.4	24.8	24.5
L-2	24.3	24.4	24.8	24.5

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	8.0	270
S-1	7.1	120
S-2	7.4	165
S-3	7.7	290
L-1	10.4	775
L-2	7.1	80

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APPENDIX A

Summary of Test Conditions

square root transformed weight data. There was no significant decrease in mean larval weight in samples L-4 and L-7 when compared with the weight of laboratory water controls. There was significantly decreased larval weight in samples S1, S2 and L5.

Environmental monitoring data for fathead minnow larvae are summarized in Table 6.

<u>Selenastrum</u>

Growth and environmental monitoring data are summarized in Table 7.

Because of the large number of samples, the test was run in two batches. Run #1 included samples L3, L4, L5, L6 and L7. Run #2 included samples S1, S2, S3, L1 and L2. Each sample set had its own control.

For Run #1, cell number data were normally distributed (Shapiro-Wilkes) and homogeneous (Bartletts B = 3.653 vs tabled χ^2 value at p=0.01 and 5 d.f. = 15.09). ANOVA and Dunnetts analyses were done on the untransformed data. There was no significant decrease in mean cell numbers in samples L3 and L4 when compared with growth in lab water controls. There were significantly decreased cell numbers in sample L5, L6 and L7.

For Run #2, cell number data were normally distributed (Shapiro-Wilkes), but were not homogeneous. Square root transformation corrected the homogeneity (Bartlett's B = 14.88 vs tabled critical value for p=0.01 and df=5 of 15.09). ANOVA and Dunnett's tests were done on the square root-transformed data. There was no significant decrease in mean cell numbers in samples S1, S2 and S3 when compared with growth in lab water controls. There were significantly decreased cell numbers in samples L1 and L2.

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TABLE 1

SUMMARY OF REPRODUCTION AND SURVIVAL FOR CERIODAPHNIA
Santa Clara Valley NPS Sample #3334

Sample	Total Young Produced/Replicate a	b	c	d	e	f	g	h	i	j	% Survival (n = 10)
Control	22	22	20	27	27	24	20	20	26	22	100
**S-1	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
**S-2	17	14	12	17	15	10	19	21	19	16	100
**S-3	32	15	24	18	29	32	33	30	32	22	100
L-1	0	0	0	0	0*	0	0	0	0	0*	80
**L-2	18	23	33	24	23	28	34	32	33	37	100
**L-3	5*	16*	4*	0*	5*	5*	4*	5*	8*	4*	0
**L-4	5	24	28	16	28	25	20	13	22	0*	90
**L-5	15	0*	22	24	25	19	14	29	18	20	90
**L-6	29	33	32	35	34	30	33	32	30	39	100
L-7	30	24	30	25	30	33	29	32	30	32	100

* Adult died
** Sample was tested at 10% dilution

For Reproductive Data (excludes S1, L1 and L3)

Bartlett's B (calculated) = 19.86***
Tabled X^2 value (p=0.05, dF=7) = 18.48

Steel's Rank Sum, Sample S2 = 55
Steel's Rank Sum, Sample L3 = 55
Steel's Rank Sum, All others = >73

*** Data were not homogeneous and could not be corrected by transformation. Data were analyzed by Steel's Many-One Rank Test.

All algal counts were made manually with a hemacytometer and microscope. Treatment groups and controls were set up with a minimum of three replicates. Testing was conducted in an environmental chamber with continuous illumination of 400 ft/candles at 24 + 2°C for 96 hours. All test flasks were innoculated with apprcximately Γ X 10^4 cells/ml from a 4 day old stock culture. Cultures were shaken twice daily by hand. Upon conclusion of testing, statistical analyses were made of final cell densities to determine EC50 concentrations using the Probit Method. Bartlett's test was used to confirm homogeneity of variance after which Dunnett's test was used.

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Results and Conclusions

Ceriodaphnia

On 14 February, testing was initiated on all samples. Within 8 hours, all daphnids in samples S1, S2, S3, L2, L3, L4, L5 and L6 had died. Ten percent dilutions of those samples were prepared using laboratory water, and the entire test was re-started on 15 February. The reproduction and survival data summarized in Tables 1 and 2 are the results of testing 100% concentrations of samples L1 and L7, and 10% concentrations of the samples listed above. Data were statistically analyzed using the laboratory water controls as the comparative data.

Analysis of survival data by Fisher's Exact Test showed that samples S1, L1 and L3 produced statisticelly significant mortality when compared with laboratory water controls. Following protocol guidelines, reproduction data for those samples was excluded from subsequent statistical analysis.

Reproduction data were found to be non-homogeneous, with a Bartlett's B value of 19.86 (tabled Bartletts value at P = 0.01 for 7 df = 18.48). This non-homogeneity could not be corrected by data transformation (square root, log, arcsin), and subsequent analysis was done by Steel's Many-One Rank Test. The tabulated critical rank sum value for n= 10 and K=8 at P=0.05 is 73. Rank sums for samples S-2 (55) and L3 (55) were less than 73, indicating that reproduction in these samples was significantly lower than in the laboratory control water.

Environmental monitoring data are tabulated and presented in Table 3.

Fathead Minnow Larvae

Survival and growth (dry weight) data are summarized in Table 4, and data for individual replicate test containers are presented in Table 5.

Mortality in samples L1 and L2 was significantly higher than in control water, and these data were excluded from further statistical analysis.

Larval weight data were normally distributed (Shapiro-Wilkes) but were not homogeneous (Bartletts B = 22.42). Data transformation (square root, log, arcsin) did not correct the non-homogeneity. Protocol guidance suggests that Steel's Many-One Rank Test be used to analyze growth data, but Steel's cannot be used when there are less than 4 replicates. Telephone guidance from EPA Cincinnati directed us to transform the data to produce the Bartletts B value closest to the critical number, and use that transformed data set to perform Dunnett's test. Square root transformation produced a Bartlett's B value of 17.64, compared with a critical B at 0.05 with 5 df of 15.09. Dunnett's analysis was done on the

Introduction

As part of the Santa Clara Valley Non-Point Source Program, toxicity testing must be carried out on water samples collected during both dry weather (four times) and wet weather (three times). Dry weather tests require daily collection of water samples at the four stream stations (S1-S4). Wet weather tests are conducted using a single composite sample of runoff water for the daily renewals. This test is the first of three wet weather tests. Three toxicity tests are conducted, utilizing Ceriodaphnia dubia (invertebrate), Pimephales promelas (fish) and Selenastrum capricornutum (plant).

The Ceriodaphnia and Pimephales tests are seven days in duration, and are static-renewal protocols, requiring daily replacement of test solutions. Collections of runoff water are made by MBL personnel and stored at 4°C. Aliquots of this stored water are used for daily renewals.

The three bioassays were performed concurrently. Daphnids and fish were run on 15-21 February, 1989. Algae were tested in two batches, 14-18 February and 15-19 February, 1989. Methods, results and data are presented in the following pages.

The samples were collected and delivered to MBL by Kinnetic Laboratories Inc. personnel. The experimental design called testing only undiluted (100%) stream water. A lab water control (EPA moderately-hard) was run to provide quality assurance data. The lab water results were also used as the comparative data for statistical comparisons.

Most of the runoff samples proved to be acutely toxic to Ceriodaphnia, producing 100% mortality within 8 hours of test initiation. Those acutely toxic samples were S1, S2, S3, L2, L3, L4, L5 AND L6. After consultation with our client, we prepared 1:10 dilutions of each of those samples and started the Ceriodaphnia test again using 10% concentrations.

Fathead minnow and Selenastrum bioassays were done with undiluted runoff samples.

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Methods

Ceriodaphnia

Test organisms were neonates derived from in-house cultures. Original broodstock was from EPA Duluth, received 11 May, 1988 and cultured in EPA moderately hard water prepared with Milli-Q water. Samples of stream test water were collected daily during the test, and lab control water was EPA moderately hard (Milli-Q).

The test was initiated with 4-8 hour old neonates derived from third broods of individually maintained broodstock. Testing was conducted with 10 individuals per treatment, each in individual plastic cups containing 15 ml of test solution. Test temperature was 25 $\pm$ 1°C and photoperiod was 16 hour light:8 hour dark. Test solutions were renewed daily, concurrent with transfers, water quality measurements and assessment of survival and reproduction. At each daily transfer, new media were inoculated with food (2 drops of *Ceriodaphnia* chow and 1 drop of *Selenastrum* culture, density approximately 2.5 X 10^6 cells/ml). Following the 7-day test period, survival data was statistically evaluated using the probit method to calculate the 96-hour LC50. Reproductive data was evaluated using ANOVA and Dunnett's Test after confirming data homogeneity by Bartlett's Test. Test conditions and organism data are summarized in Appendix Table A-1.

Fathead Minnow Larvae

Test organisms were larvae, less than 24 hours old, obtained from in-house culture. All larvae were from the same spawning substrate, but probably from multiple spawns. Original broodstock was purchased from Thomas Fish Farms, San Rafael, California, approximately March of 1988. Stream test water samples were collected fresh each day. Control water was EPA moderately hard (Milli-Q). Ten larvae were used in each test container and there were three replicate containers per concentration. Each larval container was fed three times daily with 750-1000 newly-hatched *Artemia* nauplii. Test temperature was 25 $\pm$ 1°C, and photoperiod was 16:8. Daily renewal of 80% of the test volume coincided with daily environmental monitoring and assessment of survival. After seven days of exposure, the test was terminated by addition of formalin to each container. Surviving larvae were dried and weighed, and weight data were statistically evaluated using Bartlett's Test followed by ANOVA and Dunnett's Test. Probit analysis of survival data was used to calculate the 96-hour LC_1. Test conditions and organism data are summarized in appendix Table A-2.

Selenastrum

Algal assays were conducted in sterile 250 ml Erlenmeyer flasks. Preparation of the nutrient medium followed guidelines set forth in EPA-600/9-78-018.

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3 SPECIES BIOASSAY RESULTS:

SANTA CLARA VALLEY NON-POINT SOURCE PROGRAM

WET WEATHER TEST #1

SAMPLES RECEIVED 13 FEBRUARY, 1989 AND THEREAFTER

DRAFT

Prepared for

KINNETIC LABORATORIES, INC.
Santa Cruz, California

Prepared by

MARINE BIOASSAY LABORATORIES DIVISION
TOXSCAN, INC.
Watsonville, California

APRIL, 1989

MBL
A DIVISION OF TOXSCAN, INC.

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APPENDIX E

APPENDIX E
SANTA CLARA TOXICITY DATA

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E.1
WET-WEATHER TOXICITY DATA

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Santa Clara Settling Column Test Results

STA	SAMP PORT	MEASURED TSS CONCENTRATIONS 2 hr	6 hr	12 hr	24 hr	48 hr	sett time <-hours-> / sett dist (feet)	PERCENT TSS REMOVED 2	6	12	24	48
S-1	85 mg/l = Initial TSS											
	1	53	34	25	8	14	1	38	60	71	91	84
	2	59	40	30	13	9	2	31	53	65	85	89
	3	63	39	23	13	10	3	26	54	73	85	88
	4	76	43	26	25	23	4	11	49	69	71	73
S-2	28 mg/l = Initial TSS											
	1	12	9	14	9	10	1	86	89	84	89	88
	2	15	16	19	9	8	2	82	81	78	89	91
	3	30	24	14	5	13	3	65	72	84	94	85
	4	31	22	17	12	3	4	64	74	80	86	96
S-3	22 mg/l = Initial T:											
	1	19	5	8	12	12	1	78	94	91	86	86
	2	24	9	9	5	4	2	72	89	89	94	95
	3	17	15	18	9	5	3	80	82	79	89	94
	4	19	17	[illegible]	[illegible]	3	4	78	80	89	92	96
S-4	69 mg/l = Initial TSS											
	1	58	43	32	28	10	1	32	49	62	67	88
	2	60	37	32	23	16	2	29	56	62	73	81
	3	73	53	31	25	22	3	14	38	64	71	74
	4	69	55	31	22	17	4	19	35	64	74	80

Distribution of Settling velocities

Vs ft/hr	% Greater Than S-1	S-2	S-3	S-4
0.021	84	64	45	86
0.042	91	68	45	59
0.042	89	71	82	77
0.063	88	54	77	68
0.083	71	50	64	54
0.083	85	68	77	67
0.083	73	89	86	75
0.125	85	82	59	64
0.167	60	68	77	38
0.167	65	32	59	54
0.167	71	57	68	68
0.250	73	50	18	55
0.333	53	43	59	46
0.333	69	39	59	55
0.500	38	57	14	16
0.500	54	14	32	23
0.667	49	21	23	20
1.000	31	46	-9	13
1.500	26	-7	23	-6
2.000	11	-11	14	0

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Distribution of Settling Velocities - Pooled Test Results

Vs ft/hr	S-1	% Greater Than S-2	S-3	S-4	Avg % Remov 4 tests	Avg % Remov for Vs	Vs ft/hr
0.021	84	64	45	86	70	70	0.021
0.042	91	68	45	59	68		
0.042	89	71	82	77	80	73	0.042
0.063	88	54	77	68	72	72	0.063
0.083	71	50	64	54	59		
0.083	85	68	77	67	74		
0.083	73	89	86	75	81	72	0.083
0.125	85	82	59	64	72	72	0.125
0.167	60	68	77	38	61		
0.167	65	32	59	54	52		
0.167	71	57	68	68	66	60	0.167
0.250	73	50	18	55	49	49	0.250
0.333	53	43	59	46	50		
0.333	69	39	59	55	56	53	0.333
0.500	38	57	14	16	31		
0.500	54	14	32	23	31	31	0.500
0.667	49	21	23	20	28	28	0.667
1.000	31	46	-9	13	20	20	1.000
1.500	26	-7	23	-6	9	9	1.500
2.000	11	-11	14	0	3	3	2.000

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TABLE A-1

Ceriodaphnia Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Reproduction
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	14 February, 1989, 11:00 hours
Finish:	21 February, 1989, 11:00 hours
Test Containers:	1 oz plastic cups
Test Volume:	15 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #1
Test Concentrations:	100%, controls
# Replicates:	10
Organisms per replicate:	1
Test Species:	Ceriodaphnia dubia
Source:	in-house culture
Age:	4-8 hours
Acclimation/Culture Water:	EPA Moderately Hard (Milli-Q)
Diet:	Selenastrum, Ceriodaphnia chow

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TABLE A-2

Fathead Minnow Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Growth
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	14 February, 1989, 12:30 hours
Finish:	21 February, 1989, 12:30 hours
Test Containers:	1 liter glass jars
Test Volume:	500 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #1
Test Concentrations:	100%, control
# Replicates:	3
Organisms per replicate:	10
Test Species:	*Pimephales promelas* (Fathead minnow)
Source:	in-house culture
Age:	<24 hours
Culture Water:	Dechlorinated Tap
Diet:	*Artemia* nauplii

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TABLE A-3

Selenastrum Bioassay

Test Type:	Static
Test Endpoints:	Growth, (cell number)
Test Duration:	4 days, 96 hours
Temperature:	24 ± 2°C
Photoperiod:	Continuous light
Light Intensity:	400 ± 40 FC
Start:	14 & 15 February, 1989, 14:00 hours
Finish:	18 & 19 February, 1989, 14:00 hours
Test Containers:	250 ml Erlenmeyer flasks
Test Volume:	100 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #1
Test Concentrations:	100%, Control
# Replicates:	3
Organisms per replicate:	10,000/ml innoculated
Test Species:	*Selenastrum capricornutum*
Source:	In-house culture
Age:	4 days
Culture Water:	EPA Moderately Hard

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3 SPECIES BIOASSAY RESULTS:

SANTA CLARA VALLEY NON-POINT SOURCE PROGRAM

WET WEATHER TEST #2

SAMPLES RECEIVED 11 MARCH, 1989 AND THEREAFTER

Prepared for

KINNETIC LABORATORIES, INC.
Santa Cruz, California

Prepared by

MARINE BIOASSAY LABORATORIES DIVISION
TOXSCAN, INC.
Watsonville, California

MAY, 1989

MBL

A DIVISION OF TOXSCAN, INC.

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Introduction

As part of the Santa Clara Valley Non-Point Source Program, toxicity testing must be carried out on water samples collected during both dry weather (four times) and wet weather (three times). Dry weather tests require daily collection of water samples at the four stream stations (S1-S4). Wet weather tests are conducted using a single composite sample of runoff water for the daily renewals. This test is the second of three wet weather tests. Three toxicity tests are conducted, utilizing Ceriodaphnia dubia (invertebrate), Pimephales promelas (fish) and Selenastrum capricornutum (plant).

The Ceriodaphnia and Pimephales tests are seven days in duration, and are static-renewal protocols, requiring daily replacement of test solutions. Collections of runoff water are made by MBL personnel and stored at 4°C. Aliquots of this stored water are used for daily renewals.

The three bioassays were performed concurrently. Daphnids and fish were run on 14-21 March, 1989. Algae were tested in two batches, 11-15 March and 12-16 March, 1989. Methods, results and date are presented in the following pages.

The samples were collected and delivered to MBL by Kinnetic Laboratories Inc. personnel. The experimental design called for testing only undiluted (100%) stream water. A lab water control (EPA moderately-hard) was run to provide quality assurance data. The lab water results were also used as the comparative data for statistical comparisons.

Some of the runoff samples proved to be acutely toxic to Ceriodaphnia, producing 100% mortality within 8 hours of test initiation. Those acutely toxic samples were S1, S2, L5 and L6. We prepared dilutions of each of those samples and started the Ceriodaphnia test again using 25% or 50% concentrations.

Fathead minnow and Selenastrum bioassays were done with undiluted runoff samples.

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Methods

Ceriodaphnia

Test organisms were neonates derived from in-house cultures. Original broodstock was from EPA Duluth, received 11 May, 1988 and cultured in EPA moderately hard water prepared with Milli-Q water. Samples of stream test water were collected daily during the test, and lab control water was EPA moderately hard (Milli-Q).

The test was initiated with 4-8 hour old neonates derived from third broods of individually maintained broodstock. Testing was conducted with 10 individuals per treatment, each in individual plastic cups containing 15 ml of test solution. Test temperature was 25 ± 1°C and photoperiod was 16 hour light:8 hour dark. Test solutions were renewed daily, concurrent with transfers, water quality measurements and assessment of survival and reproduction. At each daily transfer, new media were inoculated with food (2 drops of Ceriodaphnia chow and 1 drop of Selenastrum culture, density approximately 2.5×10^6 cells/ml). Following the 7-day test period, survival data was statistically evaluated using the probit method to calculate the 96-hour LC50. Reproductive data was evaluated using ANOVA and Dunnett's Test after confirming data homogeneity by Bartlett's Test. Test conditions and organism data are summarized in Appendix Table A-1.

Fathead Minnow Larvae

Test organisms were larvae, less than 24 hours old, obtained from in-house culture. All larvae were from the same spawning substrate, but probably from multiple spawns. Original broodstock was purchased from Thomas Fish Farms, San Rafael, California, approximately March of 1988. Stream test water samples were collected fresh each day. Control water was EPA moderately hard (Milli-Q). Ten larvae were used in each test container and there were three replicate containers per concentration. Each larval container was fed three times daily with 750-1000 newly-hatched Artemia nauplii. Test temperature was 25 ± 1°C, and photoperiod was 16:8. Daily renewal of 80% of the test volume coincided with daily environmental monitoring and assessment of survival. After seven days of exposure, the test was terminated by addition of formalin to each container. Surviving larvae were dried and weighed, and weight data were statistically evaluated using Bartlett's Test followed by ANOVA and Dunnett's Test. Probit analysis of survival data was used to calculate the 96-hour LC_1. Test conditions and organism data are summarized in appendix Table A-2.

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Selenastrum

Algal assays were conducted in sterile 250 ml Erlenmeyer flasks. Preparation of the nutrient medium followed guidelines set forth in EPA-600/9-78-018.

All algal counts were made manually with a hemacytometer and microscope. Treatment groups and controls were set up with a minimum of three replicates. Testing was conducted in an environmental chamber with continuous illumination of 400 ft/candles at 24 $\pm$ 2°C for 96 hours. All test flasks were innoculated with approximately 1 X 10^4 cells/ml from a 4 day old stock culture. Cultures were shaken twice daily by hand. Upon conclusion of testing, statistical analyses were made of final cell densities to determine EC50 concentrations using the Probit Method. Bartlett's test was used to confirm homogeneity of variance after which Dunnett's test was used.

Results and Conclusions

Ceriodaphnia

On 13 March, rangefinder acute testing was initiated on all samples. Within 8 hours, all daphnids in samples S1, S2, L5 and L6 had died. Dilutions of those samples were prepared using laboratory water, and the entire test was re-started on 14 February. The reproduction and survival data summarized in Tables 1 and 2 are the results of testing 100% concentrations of samples L1, L3, L4 and L7, 50% concentrations of samples S1 and L5 and 25% concentrations of samples S2 and L6. Data were statistically analyzed using the laboratory water controls as the comparative data.

Analysis of survival data by Fisher's Exact Test showed that all samples except L7 produced statistically significant mortality when compared with laboratory water controls. Following protocol guidelines, reproduction data for those samples was excluded from subsequent statistical analysis.

Mean young production for Sample L7 was higher (25.8 per adult) than laboratory water controls (17.3 per adult). No statistical analysis was necessary to determine that Sample L7 did not inhibit reproduction when compared with controls.

Environmental monitoring data are tabulated and presented in Table 3.

Fathead Minnow Larvae

Survival and growth (dry weight) data are summarized in Table 4, and data for individual replicate test containers are presented in Table 5.

Mortality in sample L1 was significantly higher than in control water, and these data were excluded from further statistical analysis.

Larval weight data were normally distributed (Shapiro-Wilkes) and homogeneous (Bartletts B = 7.324). Dunnett's analysis was done on the untransformed weight data. There was no significant decrease in mean larval weight in samples S1, S2, L5, and L7 when compared with the weight of laboratory water controls.

Environmental monitoring data for fathead minnow larvae are summarized in Table 6.

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Selenastrum

Growth and environmental monitoring data are summarized in Table 7.

Because of the large number of samples, the test was run in two batches. Run #1 included samples S1, S2, S3, S4 and L1. Run #2 included samples L3, L4, L5, L6 and L7. Each sample set had its own control.

For Run #1, cell number data were normally distributed (Shapiro-Wilkes) and homogeneous (Bartletts B = 8.606 vs tabled X^2 value at p=0.01 and 4 d.f. = 13.28). There were no visible cells in sample L1 after four days of incubation, so these data were excluded from further statistical analysis. There were significantly decreased cell numbers in sample S1, S2, S3 and S4 when compared with growth in lab water controls.

For Run #2, cell number data were normally distributed (Shapiro-Wilkes) and homogeneous. (Bartlett's B = 9.736 vs tabled critical value for p=0.01 and df=5 of 15.09). ANOVA and Dunnett's tests were done on the untransformed data. There was no significant decrease in mean cell numbers in samples L3, L6 and L7 when compared with growth in lab water controls. There were significantly decreased cell numbers in samples L4 and L5.

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TABLE 1

SUMMARY OF REPRODUCTION AND SURVIVAL FOR CERIODAPHNIA
Santa Clara Valley NPS Sample #3658

Sample	Total Young Produced/Replicate a	b	c	d	e	f	g	h	i	j	% Survival (n = 10)
Control	21	17	6	19	17	18	17	20	18	20	100
S-1(50%)	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
S-2(25%)	0*	0*	3*	0*	4*	5*	0*	3*	0*	0*	0
L-1	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
L-3	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
L-4	22*	6*	3*	10*	9*	10*	14*	23	8*	11*	10
L-5(50%)	0*	4*	0*	4*	0*	2*	4*	1*	3*	4*	0
L-6(25%)	4*	2*	2*	0*	0*	4*	5*	0*	2*	4*	0
L-7	25	26	21	18	31	27	25	27	29	29	100

* Organism died prior to test completion.

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TABLE 2 **CERIODAPHNIA REPRODUCTION AND SURVIVAL**

Santa Clara Valley NPS Sample #3658

Sample	Day #	a	b	c	d	e	f	g	h	i	j	Total Young	# Live Adults
		Replicate											
Control	4	5	3	2	4	1	4	3	3	4	4	33	10
	5	0	0	1	0	0	0	0	0	0	0	1	10
	6	6	6	3	7	8	6	6	8	6	8	64	10
	7	10	8	0	8	8	8	8	9	8	8	75	10
S-1 (50%)	4	X	X	X	X	X	X	X	X	X	X	0	0
	5	-	-	-	-	-	-	-	-	-	-	0	0
	6	-	-	-	-	-	-	-	-	-	-	0	0
	7	-	-	-	-	-	-	-	-	-	-	0	0
S-2 (25%)	4	X	X	3	X	4	5	X	3	X	X	15	4
	5	-	-	-	-	-	-	-	-	-	-	0	0
	6	-	-	-	-	-	-	-	-	-	-	0	0
	7	-	-	-	-	-	-	-	-	-	-	0	0
L-1 (100%)	4	X	X	X	X	X	X	X	X	X	X	0	0
	5	-	-	-	-	-	-	-	-	-	-	0	0
	6	-	-	-	-	-	-	-	-	-	-	0	0
	7	-	-	-	-	-	-	-	-	-	-	0	0
L-3 (100%)	4	X	X	X	X	X	X	X	X	X	X	0	0
	5	-	-	-	-	-	-	-	-	-	-	0	0
	6	-	-	-	-	-	-	-	-	-	-	0	0
	7	-	-	-	-	-	-	-	-	-	-	0	0
L-4 (100%)	4	4	0	3	4	3	4	5	4	5	4	36	10
	5	0	2	0	0	0	0	2	7	0	2	13	10
	6	9	4	X	6X	6X	6X	7	X	3X	5X	46	3
	7	9X	0X	-	-	-	-	-	12	-	-	21	1

X= Organism died prior to test completion

TABLE 2 (cont.) **CERIODAPHNIA REPRODUCTION AND SURVIVAL**

Santa Clara Valley NPS Sample #3658

Sample	Day #	a	b	c	d	e	f	g	h	i	j	Total Young	# Live Adults
Control	4	5	3	2	4	1	4	3	3	4	4	33	10
	5	0	0	1	0	0	0	0	0	0	0	1	10
	6	6	6	3	7	8	6	6	8	6	8	64	10
	7	10	8	0	8	8	8	8	9	8	8	75	10
L-5 (50%)	4	X	4X	X	4X	X	2X	4X	1X	3X	4X	22	0
	5	-	-	-	-	-	-	-	-	-	-	0	0
	6	-	-	-	-	-	-	-	-	-	-	0	0
	7	-	-	-	-	-	-	-	-	-	-	0	0
L-6 (50%)	4	4X	2	2X	X	X	4X	5X	X	2X	4X	23	1
	5	-	X	-	-	-	-	-	-	-	-	0	0
	6	-	-	-	-	-	-	-	-	-	-	0	0
	7	-	-	-	-	-	-	-	-	-	-	0	0
L-7 (100%)	4	4	4	4	4	6	5	4	5	6	4	46	10
	5	0	0	0	0	0	0	7	0	0	9	16	10
	6	8	10	7	7	8	9	0	10	9	0	68	10
	7	13	12	10	7	17	13	14	12	14	16	128	10

X= Organism died prior to test completion.

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TABLE 3

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3658

Dissolved Oxygen (mg/1)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	7.8	7.7	7.8	7.6	7.6	7.5	7.7	7.7	7.7	7.7	8.1	7.6	8.1	7.2
S-1(50%)	7.7	7.5	8.5	7.5	8.3	7.5	-	-	-	-	-	-	-	-
S-2(25%)	8.7	7.5	10.0	7.5	9.1	7.5	9.8	7.5	9.4	-	-	-	-	-
L-1	6.5	502	707	706	707	705	-	-	-	-	-	-	-	-
L-3	9.6	7.2	9.4	7.6	-	-	-	-	-	-	-	-	-	-
L-4	9.5	7.6	9.2	7.6	8.9	7.5	9.2	7.7	9.2	7.7	9.4	7.6	9.3	5.6
L-5(50%)	9.2	7.4	9.2	7.6	9.6	7.5	10.1	7.6	10.3	-	-	-	-	-
L-6(50%)	8.6	7.2	10.0	7.5	8.6	7.5	8.4	7.1	-	-	-	-	-	-
L-7	9.6	7.6	10.2	7.6	9.8	7.6	10.0	7.7	10.4	7.5	10.2	7.6	10.1	6.4

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	7.8	8.0	7.9	7.9	7.8	7.8	7.9
S-1(50%)	6.5	6.5	6.6	-	-	-	-
S-2(25%)	6.7	6.8	6.9	6.8	6.9	-	-
L-1	5.6	5.7	5.9	-	-	-	-
L-3	6.4	6.6	-	-	-	-	-
L-4	7.7	7.9	8.0	7.9	7.9	7.9	7.9
L-5(50%)	6.4	6.5	6.7	6.7	6.4	-	-
L-6(50%)	6.7	6.8	7.2	7.2	-	-	-
L-7	7.8	7.9	7.9	7.8	7.8	7.9	7.8

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TABLE 3 - continued

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3658

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	275	275	275	275	275	275	275
S-1	140	140	140	140	140	140	140
S-2	140	140	140	140	140	140	140
L-1	2700	2700	2700	2700	2700	2700	2700
L-3	110	110	110	110	110	110	110
L-4	1100	1100	1100	1100	1100	1100	1100
L-5	90	90	90	90	90	90	90
L-6	100	100	100	100	100	100	100
L-7	600	600	600	600	600	600	600

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	25.0	25.5	25.5	25.2	23.2	25.0
S-1	25.0	25.0	25.5	-	-	-	-
S-2	25.0	25.0	25.5	25.0	-	-	-
L-1	25.0	25.0	25.5	-	-	-	-
L-3	25.0	25.0	-	-	-	-	-
L-4	25.0	25.0	25.5	25.0	25.5	25.2	25.0
L-5	25.0	25.0	25.5	25.0	26.0	-	-
L-6	25.0	25.0	25.5	25.0	25.5	-	-
L-7	25.0	25.0	25.5	25.0	25.5	25.2	25.0

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TABLE 3 - continued

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3658

Alkalinity/Hardness (as mg/l CaCO3)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	78/102	78/102	78/102	78/102	78/102	78/102	78/102
S-1	57/56	57/56	57/56	57/56	57/56	57/56	57/56
S-2	58/66	58/66	58/66	58/66	58/66	58/66	58/66
L-1	274/88	274/88	274/88	274/88	274/88	274/88	274/88
L-3	28/32	28/32	28/32	28/32	28/32	28/32	28/32
L-4	214/508	214/508	214/508	214/508	214/508	214/508	214/508
L-5	32/44	32/44	32/44	32/44	32/44	32/44	32/44
L-6	32/44	32/44	32/44	32/44	32/44	32/44	32/44
L-7	222/272	222/272	222/272	222/272	222/272	222/272	222/272

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TABLE 4

FATHEAD MINNOW LARVAE
MEAN PERCENT SURVIVAL (n=30) AND MEAN LARVAL DRY WEIGHT

Santa Clara Valley NPS Sample #3658

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	(mg) Mean Larval Dry Weight
Control	100	100	100	100	100	100	100	0.2566
S-1	100	100	100	100	100	100	100	0.3666
S-2	100	100	100	100	100	100	97	0.2907
L-1	0	0	0	0	0	0	0	—
L-5	100	100	100	100	100	100	100	0.3533
L-7	100	100	100	93	90	90	90	0.4214

For Larval Weight Data

Bartlett's B = 7.324
Tabled X^2 value (p=0.05, 4 df) = 13.28

ANOVA F (calculated) = 8.648
ANOVA F (tabled) = 3.48

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TABLE 5

FATHEAD MINNOW LARVAE
SURVIVAL AND LARVAL DRY WEIGHT DATA

Santa Clara Valley NPS Sample #3658

Sample	Replicate	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Mean Larval Dry Weight (mg)
		Number of Survivors								
Control	1	10	10	10	10	10	10	10	10	0.210
	2	10	10	10	10	10	10	10	10	0.300
	3	10	10	10	10	10	10	10	10	0.260
S-1	1	10	10	10	10	10	10	10	10	0.370
	2	10	10	10	10	10	10	10	10	0.400
	3	10	10	10	10	10	10	10	9	0.330
S-2	1	10	10	10	10	9	9	9	9	0.310
	2	10	10	10	10	10	9	8	8	0.340
	3	10	10	10	10	8	8	8	8	0.222
L-1	1	10	0	0	0	0	0	0	0	---
	2	10	0	0	0	0	0	0	0	---
	3	10	0	0	0	0	0	0	0	---
L-5	1	10	10	10	10	10	10	10	10	0.350
	2	10	10	10	10	10	10	10	10	0.360
	3	10	10	10	10	10	10	10	10	0.350
L-7	1	10	10	10	10	10	10	10	10	0.440
	2	10	10	10	10	10	10	10	10	0.410
	3	10	10	10	10	8	7	7	7	0.4142

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TABLE 6

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3658

Dissolved Oxygen (mg/l)

Sample	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7	
	i*	f*	i	f	i	f	i	f	i	f	i	f	i	f
Control	7.8	7.1	7.8	6.9	7.6	6.5	7.7	6.7	7.7	7.0	8.1	6.8	8.1	6.6
S-1	7.7	6.1	8.5	5.5	8.3	5.8	-	6.1	-	6.5	-	6.0	-	5.6
S-2	8.7	6.4	10.0	5.9	9.1	5.9	9.8	6.4	9.4	6.5	-	6.1	-	5.5
L-1	6.5	7.0	7.7	-	7.7	-	-	-	-	-	-	-	-	-
L-5	9.2	6.4	9.2	5.6	9.6	5.7	10.1	6.3	10.3	7.0	-	6.5	-	6.1
L-7	9.6	6.4	10.2	6.1	9.8	6.1	10.0	6.6	10.4	7.0	10.2	6.5	10.1	6.1

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	7.8	8.0	7.9	7.9	7.8	7.8	7.9
S-1	6.5	6.5	6.6	-	-	-	-
S-2	6.7	6.8	6.9	6.8	6.9	-	-
L-1	5.6	5.7	5.9	-	-	-	-
L-5	6.4	6.5	6.7	6.7	6.4	-	-
L-7	7.8	7.9	7.9	7.8	7.8	7.9	7.8

TABLE 6 - continued

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3658

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	275	275	275	275	275	275	275
S-1	140	140	140	140	140	140	140
S-2	140	140	140	140	140	140	140
L-1	2700	2700	2700	2700	2700	2700	2700
L-5	90	90	90	90	90	90	90
L-7	600	600	600	600	600	600	600

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	25.0	25.5	25.5	25.2	23.2	25.0
S-1	25.0	25.0	25.5	-	-	-	-
S-2	25.0	25.0	25.5	25.0	-	-	-
L-1	25.0	25.0	25.5	-	-	-	-
L-5	25.0	25.0	25.5	25.0	26.0	-	-
L-7	25.0	25.0	25.5	25.0	25.5	25.2	25.0

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TABLE 6 - continued

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3658

Alkalinity/Hardness (as mg/l CaCO3)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	78/102	78/102	78/102	78/102	78/102	78/102	78/102
S-1	57/56	57/56	57/56	57/56	57/56	57/56	57/56
S-2	58/66	58/66	58/66	58/66	58/66	58/66	58/66
L-1	274/88	274/88	274/88	274/88	274/88	274/88	274/88
L-5	32/44	32/44	32/44	32/44	32/44	32/44	32/44
L-7	222/272	222/272	222/272	222/272	222/272	222/272	222/272

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TABLE 7

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3658

Sample	Replicate 1	Replicate 2	Replicate 3	Mean
	Cells/ml X 10^6 after 96 hours			
Control	2.54	2.56	2.49	2.53
S-1	2.03	1.91	1.99	1.98
S-2	1.86	1.69	1.78	1.78
S-3	1.71	1.93	2.29	1.98
S-4	1.79	1.82	1.96	1.86
L-1	0	0	0	0

Bartlett's B (calculated) = 8.606
Tabled X^2 value (p=0.05, df=4) = 13.28

ANOVA F (calculated) = 12.34
ANOVA F (tabled) = 3.48

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	25.0	26.5	25.9	25.3
S-1	25.0	26.5	25.9	25.3
S-2	25.0	26.5	25.9	25.3
S-3	25.0	26.5	25.9	25.3
S-4	25.0	26.5	25.9	25.3
L-1	25.0	26.5	25.9	25.3

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	7.6	275
S-1	7.2	140
S-2	7.4	140
S-3	7.9	-
S-4	8.0	-
L-1	6.1	2700

TABLE 8

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3658

Sample	Replicate 1	Cells/ml X 10^6 after 96 hours Replicate 2	Replicate 3	Mean
Control	1.51	2.10	2.13	1.91
L-3	2.06	2.28	2.09	2.14
L-4	0.44	0.48	0.53	0.48
L-5	1.12	1.02	0.98	1.04
L-6	2.72	2.82	2.92	2.82
L-7	2.04	2.19	2.13	2.12

Bartlett's B (calculated) = 9.736
Tabled X^2 value (p=0.05, df=4) = 15.09

ANOVA F (calculated) = 80.66
ANOVA F (tabled) = 3.11

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	24.2	24.0	23.8	24.4
L-3	24.2	24.0	23.8	24.4
L-4	24.2	24.0	23.8	24.4
L-5	24.2	24.0	23.8	24.4
L-6	24.2	24.0	23.8	24.4
L-7	24.2	24.0	23.8	24.4

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	7.5	275
L-3	6.9	110
L-4	8.0	1100
L-5	6.9	90
L-6	7.0	100
L-7	8.2	600

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APPENDIX A

Summary of Test Conditions

TABLE A-1

Ceriodaphnia Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Reproduction
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	14 March, 1989, 13:00 hours
Finish:	21 March, 1989, 13:00 hours
Test Containers:	1 oz plastic cups
Test Volume:	15 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #2
Test Concentrations:	100%, 50%, 25%, controls
# Replicates:	10
Organisms per replicate:	1
Test Species:	Ceriodaphnia dubia
Source:	in-house culture
Age:	4-8 hours
Acclimation/Culture Water:	EPA Moderately Hard (Milli-Q)
Diet:	Selenastrum, Ceriodaphnia chow

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TABLE A-2

Fathead Minnow Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Growth
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	14 March, 1989, 10:00 hours
Finish:	21 March, 1989, 10:00 hours
Test Containers:	1 liter glass jars
Test Volume:	500 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #2
Test Concentrations:	100%, control
# Replicates:	3
Organisms per replicate:	10
Test Species:	*Pimephales promelas* (Fathead minnow)
Source:	in-house culture
Age:	<24 hours
Culture Water:	Dechlorinated Tap
Diet:	*Artemia* nauplii

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TABLE A-3

Selenastrum Bioassay

Test Type:	Static
Test Endpoints:	Growth, (cell number)
Test Duration:	4 days, 96 hours
Temperature:	24 ± 2°C
Photoperiod:	Continuous light
Light Intensity:	400 ± 40 FC
Start:	11 & 12 March, 1989, 14:00 hours
Finish:	15 & 16 March, 1989, 14:00 houre
Test Containers:	250 ml Erlenmeyer flasks
Test Volume:	100 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #2
Test Concentrations:	100%, Control
# Replicates:	3
Organisms per replicate:	10,000/ml innoculated
Test Species:	*Selenastrum capricornutum*
Source:	In-house culture
Age:	4 days
Culture Water:	EPA Moderately Hard

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3 SPECIES BIOASSAY RESULTS:

SANTA CLARA VALLEY NON-POINT SOURCE PROGRAM

WET WEATHER TEST #3

SAMPLES RECEIVED 28 MARCH, 1989 AND THEREAFTER

Prepared for

KINNETIC LABORATORIES, INC.
Santa Cruz, California

Prepared by

MARINE BIOASSAY LABORATORIES DIVISION
TOXSCAN, INC.
Watsonville, California

MAY, 1989

MBL

A DIVISION OF TOXSCAN, INC.

R0054733

Introduction

As part of the Santa Clara Valley Non-Point Source Program, toxicity testing must be carried out on water samples collected during both dry weather (four times) and wet weather (three times). Dry weather tests require daily collection of water samples at the four stream stations (S1-S4). Wet weather tests are conducted using a single composite sample of runoff water for the daily renewals. This test is the third of three wet weather tests. Three toxicity tests are conducted, utilizing Ceriodaphnia dubia (invertebrate), Pimephales promelas (fish) and Selenastrum capricornutum (plant).

The Ceriodaphnia and Pimephales tests are seven days in duration, and are static-renewal protocols, requiring daily replacement of test solutions. Collections of runoff water are made by MBL personnel and stored at 4°C. Aliquots of this stored water are used for daily renewals.

The three bioassays were performed concurrently. Daphnids and fish were run on 28 March - 4 April, 1989. Algae were tested in two batches, both run on 30 March - 4 April, 1989. Methods, results and data are presented in the following pages.

The samples were collected and delivered to MBL by Kinnetic Laboratories Inc. personnel. The experimental design called for testing only undiluted (100%) stream water. A lab water control (EPA moderately-hard) was run to provide quality assurance data. The lab water results were also used as the comparative data for statistical comparisons.

Based upon previous wet weather test results, we expected many of the runoff samples to produce rapid and complete mortality in Ceriodaphnia tests. After one day of exposure in this test, however, most Ceriodaphnia were still alive, so we did not prepare dilutions of any of the test samples. All species were tested with undiluted runoff samples.

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Methods

Ceriodaphnia

Test organisms were neonates derived from in-house cultures. Original broodstock was from EPA Duluth, received 11 May, 1988 and cultured in EPA moderately hard water prepared with Milli-Q water. Samples of stream test water were collected daily during the test, and lab control water was EPA moderately hard (Milli-Q).

The test was initiated with 4-8 hour old neonates derived from third broods of individually maintained broodstock. Testing was conducted with 10 individuals per treatment, each in individual plastic cups containing 15 ml of test solution. Test temperature was 25 ± 1°C and photoperiod was 16 hour light:8 hour dark. Test solutions were renewed daily, concurrent with transfers, water quality measurements and assessment of survival and reproduction. At each daily transfer, new media were inoculated with food (2 drops of <u>Ceriodaphnia</u> chow and 1 drop of <u>Selenastrum</u> culture, density approximately 2.5 X 10^6 cells/ml). Following the 7-day test period, survival data was statistically evaluated using the probit method to calculate the 96-hour LC50. Reproductive data was evaluated using ANOVA and Dunnett's Test after con' ing data homogeneity by Bartlett's Test. Test conditions and org. sm data are summarized in Appendix Table A-1.

Fathead Minnow Larvae

Test organisms were larvae, less than 24 hours old, obtained from in-house culture. All larvae were from the same spawning substrate, but probably from multiple spawns. Original broodstock was purchased from Thomas Fish Farms, San Rafael, California, approximately March of 1988. Stream test water samples were collected fresh each day. Control water was EPA moderately hard (Milli-Q). T.. larvae were used in each test container and there were three replicate containers per concentration. Each larval container was fed three times daily with 750-1000 newly-hatched <u>Artemia</u> nauplii. Test temperature was 25 ± 1°C, and photoperiod was 16:8. Daily renewal of 80% of the test volume coincided with daily environmental monitoring and assessment of survival. After seven days of exposure, the test was terminated by addition of formalin to each container. Surviving larvae were dried and weighed, and weight data were statistically evaluated using Bartlett's Test followed by ANOVA and Dunnett's Test. Probit analysis of survival data was used to calculate the 96-hour LC_1. Test conditions and organism data are summarized in appendix Ta'le A-2.

Selenastrum

Algal assays were conducted in sterile 250 ml Erlenmeyer flasks. Preparation of the nutrient medium followed guidelines set forth in EPA-600/9-78-018.

All algal counts were made manually with a hemacytometer and microscope. Treatment groups and controls were set up with a minimum of three replicates. Testing was conducted in an environmental chamber with continuous illumination of 400 ft/candles at 24 ± 2°C for 96 hours. All test flasks were innoculated with approximately 1 X 10^4 cells/ml from a 4 day old stock culture. Cultures were shaken twice daily by hand. Upon conclusion of testing, statistical analyses were made of final cell densities to determine EC50 concentrations using the Probit method. Bartlett's test was used to confirm homogeneity of variance after which Dunnett's test was used.

Results and Conclusions

Ceriodaphnia

Testing was initiated on 28 March, 1989. Reproduction and survival data are summarized in Table 1 and are presented in full in Table 2. Data was statistically analysed using the laboratory water as the comparitive dictum ("control").

Analysis of survival data by Fisher's Exact Test showed that all samples except L-2 and L-7 produced statistically significant mortality when compared with laboratory water controls. Following protocol guidelines, reproduction data for those samples was excluded from subsequent statistical analysis.

Reproduction data for control, L-2 and L-7 samples were found to be normally distributed (Shapiro-Wilkes test) and homogeneous (Bartlett's B = 2.760). Subsequent ANOVA and Dunnett's tests showed that there was significantly decreased young production in sample L-2 when compared with lab water controls. Sample L-7 was not significantly diferent from controls.

Environmental monitoring data are tabulated and presented in Table 3.

Fathead Minnow Larvae

Survival and growth (dry weight) data are summarized in Table 4, and data for individual replicate test containers are presented in Table 5.

Larval weight data were normally distributed (Shapiro-Wilkes) and homogeneous (Bartletts B = 11.89). Dunnett's analysis was done on the untransformed weight data. Mean larval weight in all samples tested was significantly decreased in comparison with larval weight of laboratory controls. For this data set, the minimum significant difference was 0.145 grams, representing a 17.9% reduction in larval weight from the control.

Environmental monitoring data for fathead minnow larvae are summarized in Table 6.

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Selenastrum

Growth and environmental monitoring data are summarized in Table 7.

Because of the large number of samples, the test was run in two batches. Run #1 included samples L4, L5, L6 and L7. Run #2 included samples S1,S2,S4,L2,and L3. Each sample set had its own control.

For Run #1, cell number data were normally distributed (Shapiro-Wilkes) and homogeneous (Bartletts B = 8.941 vs tabled X^2 value at p=0.01 and 4 d.f. = 13.28). There were significantly decreased cell numbers in samples L4, L5, L6 and L7 when compared with growth in lab water controls.

For Run #2, cell number data were normally distributed (Shapiro-Wilkes) but were not homgeneous (Bartletts B = 16.84). Data transformation (square root, log, arcsin) did not correct the non-homogenity. Protocol guidance suggests that Steel's Many-One Rank Test be used to analyze growth data, but Steel's cannot be used when there are less than 4 replicates. Telephone guidance from EPA Cincinnati directed us to transform the data to produce the Bartletts B value closest to the critical number, and use that transformed data set to perform Dunnett's test. Square root transformation produced a Bartlett's B value of 15.58, compared with a critical B at 0.05 with a 5df of 15.09. Dunnett's analysis was done on the square root trasformed data. There was no significant decrease in cell number in samples S1, S2, and L3 when compared with laboratory water controls. There were significantly decreased cell numbers in samples S4 and L2.

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TABLE 1

SUMMARY OF REPRODUCTION AND SURVIVAL FOR CERIODAPHNIA
Santa Clara Valley NPS Sample #3774

	Total Young Produced/Replicate										
	a	b	c	d	e	f	g	h	i	j (n = 10)	% Survival
Control	16	14	16	18	19	0*	19	20	18	16	90
S-1	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
S-2	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
S-4	2*	0*	0*	0*	4*	0*	0*	0*	1*	0*	0
L-2	17	2	0*	5	14	6	6	11	9	10	90
L-3	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
L-4	0*	0*	0*	0*	0*	0*	2*	2*	0*	0*	0
L-5	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
L-6	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0
L-7	20	10	17	21	18	20	19	19	20	15	100

* Organism died prior to test completion.

For Reproductive Data

Bartlett's B = 2.760
Tabled X^2 value (p=0.01, 2 df) = 9.210

ANOVA F (calculated) = 11.23
ANOVA F (tabled) = 3.35

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TABLE 2 CERIODAPHNIA REPRODUCTION AND SURVIVAL

Santa Clara Valley NPS Sample #3774

Sample	Day #	Replicate a	b	c	d	e	f	g	h	i	j	Total Young	# Live Adults
Control	4	4	0	0	0	0	0	0	4	2	2	12	10
	5	0	3	0	2	7	X	6	0	0	0	18	9
	6	5	4	7	6	5	-	6	6	6	6	51	9
	7	7	7	9	10	7	-	7	10	10	8	75	9
L-2	4	1	0	X	0	0	2	2	3	0	1	9	9
	5	0	2	-	0	2	0	0	0	2	0	6	9
	6	10	0	-	1	4	0	0	5	1	4	26	9
	7	6	0	-	4	8	4	4	3	5	5	39	9
L-7	4	3	2	3	2	3	2	2	1	2	2	22	10
	5	0	0	0	0	0	0	2	0	8	6	16	10
	6	8	5	5	9	7	9	5	8	0	5	61	10
	7	9	3	9	10	8	9	10	10	10	2	80	10

X= Organism died prior to test completion

TABLE 3

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3774

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	7.6	7.6	7.4	7.7	7.5	7.9	7.5	7.6	7.6	7.5	7.7	7.6	7.6	7.1
S-1	9.1	7.5	8.6	7.6	-	-	-	-	-	-	-	-	-	-
S-2	8.9	7.4	8.2	7.6	7.9	7.6	-	-	-	-	-	-	-	-
S-4	8.6	7.5	7.5	7.6	8.0	7.7	9.1	7.6	-	-	-	-	-	-
L-2	8.7	7.4	8.0	7.4	7.9	7.7	8.7	7.6	8.1	7.5	7.4	7.7	8.0	7.0
L-3	8.4	7.4	8.0	7.4	8.3	7.6	9.0	7.6	-	-	-	-	-	-
L-4	8.7	7.5	8.6	7.5	8.7	7.8	9.7	7.5	-	-	-	-	-	-
L-5	9.7	7.4	18.8	7.5	8.9	7.7	9.5	7.6	-	-	-	-	-	-
L-6	7.4	7.4	-	-	-	-	-	-	-	-	-	-	-	-
L-7	9.8	7.4	9.3	7.4	9.6	7.9	9.4	7.6	9.4	7.5	9.8	7.7	9.8	6.7

*i= initial
f= final (just before renewal)

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TABLE 3 - continued

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3774

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	7.9	8.0	8.2	8.0	7.9	8.0	8.0
S-1	7.1	7.0	-	-	-	-	-
S-2	7.3	7.3	7.3	-	-	-	-
S-4	5.6	7.9	7.9	7.7	-	-	-
L-2	7.0	6.9	6.8	6.8	6.6	6.7	6.6
L-3	6.7	6.8	6.5	6.4	-	-	-
L-4	8.0	8.0	8.1	8.0	-	-	-
L-5	6.8	6.7	6.8	6.7	-	-	-
L-6	6.7	-	-	-	-	-	-
L-7	7.8	7.8	8.0	7.8	7.8	7.6	7.6

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	330	-	-	-	-	-	-
S-1	145	-	-	-	-	-	-
S-2	140	140	145	-	-	-	-
S-4	825	-	-	-	-	-	-
L-2	80	80	80	82	80	80	80
L-3	55	55	58	58	-	-	-
L-4	1500	1500	1400	1400	-	-	-
L-5	90	90	80	80	-	-	-
L-6	70	-	-	-	-	-	-
L-7	360	360	350	360	340	360	360

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TABLE 3 - continued

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3774

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.5	26	26	26	26	26	26
S-1	26	26	-	-	-	-	-
S-2	26	26	26	-	-	-	-
S-4	26	26	26.5	25.5	-	-	-
L-2	26	26	26	24.8	25.5	25	25.5
L-3	26	26	26.5	25	-	-	-
L-4	26	26	26	25	-	-	-
L-5	26	26	26.5	25	-	-	-
L-6	26	-	-	-	-	-	-
L-7	26	26	26.5	24	25.5	25	25.5

Alkalinity/Hardness (as mg/1 CaCO3)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	87/120	87/120	87/120	87/120	87/120	87/120	87/120
S-1	48/46	48/46	48/46	48/46	48/46	48/46	48/46
S-2	52/60	52/60	52/60	50/60	52/60	52/60	52/60
S-4	200/165	200/165	200/165	200/165	200/165	200/165	200/165
L-2	35/40	35/40	35/40	35/40	35/40	35/40	35/40
L-3	35/24	35/24	35/24	35/24	35/24	35/24	35/24
L-4	295/583	295/583	295/583	295/583	295/583	295/583	295/583
L-5	42/32	42/32	42/32	42/32	42/32	42/32	42/32
L-6	47/28	47/28	47/28	47/28	47/28	47/28	47/28
L-7	155/176	155/176	155/176	155/176	155/176	1[illegible]76	155/176

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APPENDIX A

<u>Summary of Test Conditions</u>

TABLE A-1

Ceriodaphnia Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Reproduction
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	12 December, 1988, 14:30 hours
Finish:	19 December, 1988, 14:30 hours
Test Containers:	1 oz plastic cups
Test Volume:	15 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #1
Test Concentrations:	100%, controls
# Replicates:	10
Organisms per replicate:	1
Test Species:	*Ceriodaphnia dubia*
Source:	in-house culture
Age:	4-8 hours
Acclimation/Culture Water:	EPA Moderately Hard (Milli-Q)
Diet:	Selenastrum, *Ceriodaphnia* chow

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TABLE A-2

Fathead Minnow Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Growth
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	12 December, 1988, 11:00 hours
Finish:	19 December, 1988, 11:00 hours
Test Containers:	1 liter glass jars
Test Volume:	500 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #1
Test Concentrations:	100%, control
# Replicates:	3
Organisms per replicate:	10
Test Species:	Pimephales promelas (Fathead minnow)
Source:	in-house culture
Age:	<24 hours
Culture Water:	Dechlorinated Tap
Diet:	Artemia nauplii

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TABLE A-3

Selenastrum Bioassay

Test Type:	Static
Test Endpoints:	Growth, (cell number)
Test Duration:	4 days, 96 hours
Temperature:	24 ± 2°C
Photoperiod:	Continuous light
Light Intensity:	400 ± 40 FC
Start:	13 December, 1988, 16:00 hours
Finish:	17 December, 1988, 16:00 hours
Test Containers:	250 ml Erlenmeyer flasks
Test Volume:	100 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #1
Test Concentrations:	100%, Control
# Replicates:	3
Organisms per replicate:	10,000/ml innoculated
Test Species:	*Selenastrum capricornutum*
Source:	In-house culture
Age:	4 days
Culture Water:	EPA Moderately Hard

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TABLE 4

FATHEAD MINNOW LARVAE
MEAN PERCENT SURVIVAL (n=30) AND MEAN LARVAL DRY WEIGHT
Santa Clara Valley NPS Sample #3774

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	(mg) Mean Larval Dry Weight
Control	100	100	100	100	100	100	100	0.4065
S-1	100	100	100	100	100	97	97	0.2630
S-2	100	100	100	100	100	100	97	0.2730
L-2	100	100	93	93	90	90	90	0.1750
L-3	100	97	97	97	97	97	97	0.2550
L-5	100	100	100	100	97	97	97	0.2650
L-6	100	100	97	97	93	93	93	0.2580
L-7	100	100	100	100	100	100	100	0.3317

For Larval Weight Data

Bartlett's B = 11.89
Tabled X^2 value (p=0.05, 7 df) = 18.48

ANOVA F (calculated) = 11.05
ANOVA F (tabled) = 2.66

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TABLE 5

FATHEAD MINNOW LARVAE
SURVIVAL AND LARVAL DRY WEIGHT DATA
Santa Clara Valley NPS Sample #3774

Sample	Replicate	Number of Survivors Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Mean Larval Weight (mg
Control	1	10	10	10	10	10	10	10	10	0.400
	2	10	10	10	10	10	10	10	10	0.465
	3	10	10	10	10	10	10	10	10	0.355
S-1	1	10	10	10	10	10	10	10	10	0.235
	2	10	10	10	10	10	10	9	9	0.265
	3	10	10	10	10	10	10	10	10	0.290
S-2	1	10	10	10	10	10	10	10	10	0.275
	2	10	10	10	10	10	10	10	10	0.235
	3	10	10	10	10	10	10	10	10	0.310
L-2	1	10	10	10	10	10	10	10	10	0.175
	2	10	10	10	10	10	10	10	10	0.165
	3	10	10	10	8	8	7	7	7	0.185
L-3	1	10	10	9	9	9	9	9	9	0.270
	2	10	10	10	10	10	10	10	10	0.275
	3	10	10	10	10	10	10	10	10	0.230
L-5	1	10	10	10	10	10	10	10	10	0.245
	2	10	10	10	10	10	10	10	10	0.330
	3	10	10	10	10	10	9	9	9	0.230
L-6		10	10	10	9	9	8	8	8	0.255
	[illegible]	10	10	10	10	10	10	10	10	0.260
	3	10	10	10	10	10	10	10	10	0.260
L-7	1	10	10	10	10	10	10	10	10	0.340
	[illegible]	10	10	10	10	10	10	10	10	0.355
	3	10	10	10	10	10	10	10	10	0.300

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TABLE 6

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3774

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	7.6	6.7	7.4	5.9	7.5	6.3	7.5	6.7	7.6	6.4	7.7	5.2	7.6	5.1
S-1	9.1	6.6	8.6	5.5	8.6	5.8	9.0	6.5	9.0	6.0	8.5	4.9	9.4	5.0
S-2	8.9	6.4	18.2	4.5	7.9	5.6	8.4	6.5	8.3	5.9	7.5	4.5	8.2	5.1
L-2	8.7	6.7	8.0	5.5	7.9	5.3	8.7	6.3	8.1	6.2	7.4	5.4	8.0	5.0
L-3	8.4	6.6	8.0	5.4	8.3	5.6	9.0	6.5	8.8	5.8	8.1	4.6	9.3	4.8
L-5	9.7	6.5	8.8	5.2	8.9	5.3	9.5	6.4	9.4	5.9	8.7	4.9	9.3	4.9
L-6	7.4	6.4	7.4	4.9	7.1	5.4	7.5	6.3	7.3	5.7	7.2	4.5	7.8	5.0
L-7	9.8	6.7	8.3	5.5	9.6	6.1	9.4	6.8	9.4	6.2	9.8	5.1	9.8	5.7

i = initial f = final (just before renewal)

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pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	7.9	8.0	8.2	8.0	7.9	8.0	8.0
S-1	7.1	7.0	7.1	6.8	6.9	6.9	6.7
S-2	7.3	7.3	7.3	7.1	7.0	7.2	7.1
L-2	7.0	6.9	6.8	6.8	6.6	6.7	6.6
L-3	6.7	6.8	6.5	6.4	6.4	6.3	6.3
L-5	6.8	6.7	6.8	6.7	6.8	6.5	6.4
L-6	6.7	6.7	6.7	6.6	6.7	6.6	6.5
L-7	7.8	7.8	8.0	7.8	7.8	7.6	7.6

TABLE 6 - continued

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3774

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	330	300	300	305	300	310	305
S-1	145	145	147	145	146	148	146
S-2	140	140	145	140	142	140	145
L-2	80	80	80	82	80	80	80
L-3	55	55	58	58	57	55	58
L-5	90	90	80	80	85	80	85
L-6	70	70	72	73	70	72	70
L-7	360	360	350	360	340	360	360

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.5	26	26	26	26	25	25.5
S-1	26	26	26	25	25.5	25	25.5
S-2	26	26	26	24.8	25.5	25	25.5
L-2	26	26	26	24.8	25.5	25	25.5
L-3	26	26	26.5	25	25.5	25	25.5
L-5	26	26	26.5	25	25.5	25	25.5
L-6	26	26	26.5	24.5	25.5	25	25.5
L-7	26	26	26.5	24	25.5	25	25.5

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TABLE 6 - continued

FATHEAD MINNOW LARVAL ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3774

Alkalinity/Hardness (as mg/l CaCO3)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	87/120	87/120	87/120	87/120	87/120	87/120	87/120
S-1	48/46	48/46	48/46	48/46	48/46	48/46	48/46
S-2	52/60	52/60	52/60	52/60	52/60	52/60	52/60
L-2	35/40	35/40	35/40	35/40	35/40	35/40	35/40
L-3	35/24	35/24	35/24	35/24	35/24	35/24	35/24
L-5	42/32	42/32	42/32	42/32	42/32	42/32	42/32
L-6	47/28	47/28	47/28	47/28	47/28	47/28	47/28
L-7	155/176	155/176	155/176	155/176	155/176	155/176	155/176

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TABLE 7

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS sample # 774- Run #1

Sample	Cells/ml X 10^6 after 96 hours Replicate 1	Replicate 2	Replicate 3	Mean
Control	2.46	2.59	2.34	2.46
L-4	1.43	1.59	1.67	1.56
L-5	1.17	1.07	0.95	1.06
L-6	0.0066	0.0178	0.0089	0.0111
L-7	2.12	2.23	2.17	2.17

Bartlett's B (calculated) = 8.941
Tabled X^2 value (p=0.01, df=4) = 13.28

ANOVA F (calculated) = 3.0
ANOVA F (tabled) = 3.48

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	24.4	24.8	24.6	23.9
L-4	24.4	24.8	24.6	23.9
L-5	24.4	24.8	24.6	23.9
L-6	24.4	24.8	24.6	23.9

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	7.5	300
L-4	8.0	1500
L-5	7.0	90
L-6	6.9	70
L-7	8.0	360

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TABLE 8

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3774

Sample	Replicate 1	Replicate 2	Replicate 3	Mean
	Cells/ml X 10^6 after 96 hours			
Control	2.93	2.93	2.89	2.92
S-1	2.56	2.57	2.53	2.55
S-2	2.28	2.12	2.85	2.42
S-4	1.47	0.99	1.23	1.23
L-2	1.06	1.21	1.19	1.15
L-3	3.83	4.47	3.80	4.03

Bartlett's B (calculated) = 15.58 ANOVA F (calculated) = 65.5
Tabled X^2 value (p=0.01, df=5) = 15.01 ANOVA F (tabled) = 3.11

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	25.1	24.1	25.5	25.4
S-1	25.1	24.1	25.5	25.4
S-2	25.1	24.1	25.5	25.4
S-4	25.1	24.1	25.5	25.4
L-2	25.1	24.1	25.5	25.4
L-3	25.1	24.1	25.5	25.4

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TABLE 8 - continued

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3774 Run #2

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	7.5	300
S-1	7.1	145
S-2	7.4	140
S-4	7.7	650
L-2	7.1	80
L-3	6.8	55

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APPENDIX A

<u>Summary of Test Conditions</u>

TABLE A-1

Ceriodaphnia Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Reproduction
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	28 March, 1989, 10:00 hours
Finish:	4 April, 1989, 10:00 hours
Test Containers:	1 oz plastic cups
Test Volume:	15 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #3
Test Concentrations:	100%, 50%, 25%, controls
# Replicates:	10
Organisms per replicate:	1
Test Species:	Ceriodaphnia dubia
Source:	in-house culture
Age:	4-8 hours
Acclimation/Culture Water:	EPA Moderately Hard (Milli-Q)
Diet:	Selenastrum, Ceriodaphnia chow

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TABLE A-2

Fathead Minnow Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Growth
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	28 March, 1989, 11:00 hours
Finish:	4 April, 1989, 11:00 hours
Test Containers:	1 liter glass jars
Test Volume:	500 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #3
Test Concentrations:	100%, control
# Replicates:	3
Organisms per replicate:	10
Test Species:	*Pimephales promelas* (Fathead minnow)
Source:	in-house culture
Age:	<24 hours
Culture Water:	Dechlorinated Tap
Diet:	*Artemia* nauplii

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TABLE A-3

Selenastrum Bioassay

Test Type:	Static
Test Endpoints:	Growth, (cell number)
Test Duration:	4 days, 96 hours
Temperature:	24 ± 2°C
Photoperiod:	Continuous light
Light Intensity:	400 ± 40 FC
Start:	30 March, 1989, 10:00 and 14:00 hours
Finish:	3 April, 1989, 10:00 and 14:00 hours
Test Containers:	250 ml Erlenmeyer flasks
Test Volume:	100 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Wet Weather #3
Test Concentrations:	100%, Control
# Replicates:	3
Organisms per replicate:	10,000/ml innoculated
Test Species:	*Selenastrum capricornutum*
Source:	In-house culture
Age:	4 days
Culture Water:	EPA Moderately Hard

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E.2
DRY-WEATHER TOXICITY DATA

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3 SPECIES BIOASSAY RESULTS:

SANTA CLARA VALLEY NON-POINT SOURCE PROGRAM

DRY WEATHER TEST #1

SAMPLES RECEIVED 12 DECEMBER, 1988 AND THEREAFTER

Prepared for

KINNETIC LABORATORIES, INC.
Santa Cruz, California

Prepared by

MARINE BIOASSAY LABORATORIES DIVISION
TOXSCAN, INC.
Watsonville, California

JANUARY 9, 1989

MBL

A DIVISION OF TOXSCAN, INC.

R0054761

Introduction

As part of the Santa Clara Valley Non-Point Source Program, toxicity testing must be carried out on water samples collected during both dry weather (four times) and wet weather (twice). Dry weather tests require daily collection of water samples at the four stream stations (S1-S4). Wet weather tests will be conducted using a single composite sample of runoff water for the daily renewals. This test is the first of four dry weather tests. Three toxicity tests are conducted, utilizing Ceriodaphnia dubia (invertebrate), Pimephales promelas (fish) and Selenastrum capricornutum (plant).

The Ceriodaphnia and Pimephales tests are seven days in duration, and are static-renewal protocols, requiring daily replacement of test solutions with newly-collected test water samples. Daily collections of stream water are made by MBL personnel.

The three bioassays were performed concurrently. Daphnids and fish were run on 13-20 December,1988 while algae were tested on 13-17 December, 1988. Methods, results and data are presented in the following pages.

The samples were collected and delivered to MBL by MBL personnel. The experimental design called testing only undiluted (100%) stream water. A lab water control (EPA moderately-hard) was run to provide quality assurance data. The lab water results were also used as the comparative data for statistical comparisons.

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Methods

Ceriodaphnia

Test organisms were neonates derived from in-house cultures. Original broodstock was from EPA Duluth, received 11 May, 1988 and cultured in EPA moderately hard water prepared with Milli-Q water. Samples of stream test water were collected daily during the test, and lab control water was EPA moderately hard (Milli-Q).

The test was initiated with 4-8 hour old neonates derived from third broods of individually maintained broodstock. Testing was conducted with 10 individuals per treatment, each in individual plastic cups containing 15 ml of test solution. Test temperature was 25 ± 1°C and photoperiod was 16 hour light:8 hour dark. Test solutions were renewed daily, concurrent with transfers, water quality measurements and assessment of survival and reproduction. At each daily transfer, new media were inoculated with food (2 drops of Ceriodaphnia chow and 1 drop of Selenastrum culture, density approximately 2.5 X 10^6 cells/ml). Following the 7-day test period, survival data was statistically evaluated using the probit method to calculate the 96-hour LC50. Reproductive data was evaluated using ANOVA and Dunnett's Test after confirming data homogeneity by Bartlett's Test. Test conditions and organism data are summarized in Appendix Table A-1.

Fathead Minnow Larvae

Test organisms were larvae, less than 24 hours old, obtained from in-house culture. All larvae were from the same spawning substrate, but probably from multiple spawns. Original broodstock was purchased from Thomas Fish Farms, San Rafael, California, approximately March of 1988. Stream test water samples were collected fresh each day. Control water was EPA moderately hard (Milli-Q). Ten larvae were used in each test container and there were three replicate containers per concentration. Each larval container was fed three times daily with 750-1000 newly-hatched Artemia nauplii. Test temperature was 25 ± 1°C, and photoperiod was 16:8. Daily renewal of 80% of the test volume coincided with daily environmental monitoring and assessment of survival. After seven days of exposure, the test was terminated by addition of formalin to each container. Surviving larvae were dried and weighed, and weight data were statistically evaluated using Bartlett's Test followed by ANOVA and Dunnett's Test. Probit analysis of survival data was used to calculate the 96-hour LC_1. Test conditions and organism data are summarized in appendix Table A-2.

Selenastrum

Algal assays were conducted in sterile 250 ml Erlenmeyer flasks. Preparation of the nutrient medium followed guidelines set forth in EPA-600/9-78-018.

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All algal counts were made manually with a hemacytometer and microscope. Treatment groups and controls were set up with a minimum of three replicates. Testing was conducted in an environmental chamber with continuous illumination of 400 ft/candles at 24 ± 2°C for 96 hours. All test flasks were innoculated with approximately 1 X 10^4 cells/ml from a 4 day old stock culture. Cultures were shaken twice daily by hand. Upon conclusion of testing, statistical analyses were made of final cell densities to determine EC50 concentrations using the Probit Method. Bartlett's test was used to confirm homogeneity of variance after which Dunnett's test was used.

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Results and Conclusions

Ceriodaphnia

Reproduction and survival data for *Ceriodaphnia* are summarized in Table 1, and are presented in full in Table 2. Data were statistically analyzed using the laboratory water as the comparative datum ("control").

No stream sample produced ≥ 50% mortality of *Ceriodaphnia* after 96 hours exposure. The 96-hour LC_{50} for *Ceriodaphnia* is >100% for all samples.

Reproduction data were determined to be homogeneous by Bartlett's test, with a B value of 0.5476. Tabled X^2 value for 4 d.f. at p=0.05 was 9.488. ANOVA and Dunnett's test were performed on the untransformed reproduction data. For these data, the minimum significant difference is 8.15 young per adult, representing a 45.3% reduction of mean young production from control levels. There was no significant reduction in young produced between any stream water and the lab water controls.

Environmental monitoring data are tabulated and presented in Table 3.

Fathead Minnow Larvae

Survival and growth (dry weight) data are summarized in Table 4, and data for individual replicate test containers are presented in Table 5.

There was no effluent concentration tested in which survival was less than 83%. The 96-hour LC_{50} values, therefore, are >100% for all samples.

Larval weight data were determined to be homogeneous, with a Bartlett's B value of 4.674. The tabled X^2 value for 4 d.f. at p=0.05 is 9.488. Subsequent ANOVA and Dunnetts analyses were done on the untransformed weight data. There was no significant decrease in mean larval weight in samples S-1, S-2 and S-3 when compared with the weight of dilution water controls. There was significantly decreased larval weight in the S-4 sample.

Environmental monitoring data for fathead minnow larvae are summarized in Table 6.

Selenastrum

Growth and environmental monitoring data are summarized in Table 7.

The lab water growth (cell number) data were set equal to 100% growth, and cell numbers in each stream sample were transformed to

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percentage of the lab water values. The 96-hour EC_{50} was calculated to be >100% of all stream samples.

Cell number data were homogeneous (Bartletts B = 0.9274 vs tabled X^2 value at p=0.05 and 4 d.f. = 9.488). ANOVA and Dunnetts analyses were done on the untransformed data. There was no signficant decrease in mean cell numbers in any of the stream samples when compared with growth in lab water controls.

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TABLE 1

SUMMARY OF REPRODUCTION AND SURVIVAL FOR *CERIODAPHNIA*
Santa Clara Valley NPS Sample #3334

Sample	Total Young Produced/Replicate a	b	c	d	e	f	g	h	i	j	% Survival (n = 10)
Control	M	14	25	11	13	M	27	M	16	20	100
S-1	M	14	11	30	16	14	M	25	24	15	100
S-2	14	30	14	15	13	28	20	M	26	21	100
S-3	26	14	31	31	M	M	24	13	12	18	100
S-4	14	25	M	11	M	13	27	16	20	M	100

M = Male

For Reproductive Data

Bartlett's B (calculated) = 0.5476
Tabled X^2 value (p=0.05, df=4) = 9.488

ANOVA F (calculated) = 0.326
ANOVA F (table) = 2.65

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TABLE 2 **CERIODAPHNIA REPRODUCTION AND SURVIVAL**

Santa Clara Valley NPS Sample #3334

Sample	Day #	a	b	c	d	e	f	g	h	i	j	Total Young	# Live Adults
		Replicate											
Control	4	M	0	4	0	3	M	4	M	0	2	13	10
	5	-	4	10	2	0	-	0	-	6	8	30	10
	6	-	0	0	0	4	-	9	-	4	0	17	10
	7	-	10	11	9	6	-	14	-	6	10	66	10
S-1	4	M	0	0	4	0	0	M	4	6	0	14	10
	5	-	4	3	0	4	4	-	0	2	5	22	10
	6	-	10	8	10	12	1	-	10	10	10	71	10
	7	-	0	0	16	0	9	-	11	6	0	42	10
S-2	4	0	4	0	0	0	0	4	M	4	0	12	10
	5	4	0	4	4	4	4	0	-	6	4	30	10
	6	10	12	10	11	9	10	6	-	6	7	83	10
	7	0	14	0	0	0	14	10	-	10	10	58	10
S-3	4	4	0	4	4	M	M	4	0	0	0	16	10
	5	0	6	0	0	-	-	0	4	4	6	20	10
	6	8	8	10	12	-	-	7	0	8	8	61	10
	7	14	0	17	15	-	-	13	9	0	4	72	10
S-4	4	0	4	M	0	M	0	0	0	0	M	4	10
	5	4	0	-	4	-	4	4	4	4	-	24	10
	6	10	10	-	0	-	9	10	9	9	-	56	10
	7	0	11	-	7	-	0	13	3	7	-	41	10

M = Male

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TABLE 3

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3334

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	8.1	7.9	8.2	8.2	8.0	8.0	8.3	8.0	8.4	8.3	8.2	8.0	8.6	7.1
S-1	9.4	7.9	9.3	8.2	8.6	8.1	9.4	8.0	9.5	8.4	9.0	7.9	9.8	6.9
S-2	9.4	7.9	9.7	8.0	8.8	8.0	9.4	8.0	9.4	8.4	9.5	7.9	9.4	7.2
S-3	8.6	7.9	9.0	8.0	8.6	8.0	9.2	8.0	9.3	8.4	9.5	7.9	9.3	7.1
S-4	8.5	7.9	9.1	8.2	8.6	8.1	9.0	8.1	9.3	8.4	8.5	8.0	8.6	7.1

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	8.1	7.9	8.0	7.9	8.0	7.8	8.1
S-1	8.6	7.9	8.1	8.2	8.2	8.2	8.2
S-2	8.6	8.0	8.2	8.4	8.5	8.1	8.2
S-3	8.4	8.1	8.2	8.2	8.2	8.1	8.2
S-4	8.3	7.9	8.2	8.1	8.0	8.1	8.1

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TABLE 3 - continued

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3334

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	340	335	320	350	345	340	330
S-1	750	775	800	800	790	790	790
S-2	1100	1150	1100	1100	1100	1250	1250
S-3	800	800	700	800	800	900	900
S-3	1425	1400	1500	1450	1450	1425	1425

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	25.5	24.5	24.5	24.0	25.0	24.0
S-1	25.0	25.5	24.5	24.5	24.0	25.0	24.0
S-2	25.0	25.5	24.5	24.5	24.0	25.0	24.0
S-3	25.0	25.5	24.5	24.5	24.0	25.0	24.0
S-4	25.0	25.5	24.5	24.5	24.0	25.0	24.0

Alkalinity/Hardness (as mg/l $CaCO_3$)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	82/114	80/110	75/110	68/105	70/108	70/110	72/110
S-1	192/238	200/210	165/215	220/255	210/245	210/245	210/245
S-2	392/572	390/525	350/518	360/520	350/520	355/525	360/518
S-3	308/390	300/350	210/305	275/328	290/335	300/320	300/338
S-4	532/495	520/440	505/445	450/460	465/455	455/450	470/465

TABLE 4

FATHEAD MINNOW LARVAE
MEAN PERCENT SURVIVAL (n=30) AND MEAN LARVAL DRY WEIGHT

Santa Clara Valley NPS Sample #3334

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	(mg) Mean Larval Dry Weight
Control	100	100	100	100	100	100	100	0.4067
S-1	100	100	100	100	100	100	97	0.4037
S-2	100	100	100	90	87	83	83	0.3606
S-3	100	100	100	100	100	100	97	0.4022
S-4	100	100	100	97	93	93	90	0.3428

For Larval Weight Data

Bartlett's B = 4.674
Tabled X^2 value (p=0.05, 4 df) = 9.488

ANOVA F (calculated) = 4.955
ANOVA F (tabled) = 3.48

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TABLE 5

FATHEAD MINNOW LARVAE
SURVIVAL AND LARVAL DRY WEIGHT DATA

Santa Clara Valley NPS Sample #3334

Sample	Replicate	Number of Survivors Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Mean Larval Dry Weight (mg)
Control	1	10	10	10	10	10	10	10	10	0.4100
	2	10	10	10	10	10	10	10	10	0.4100
	3	10	10	10	10	10	10	10	10	0.4000
S-1	1	10	10	10	10	10	10	10	10	0.3800
	2	10	10	10	10	10	10	10	10	0.4200
	3	10	10	10	10	10	10	10	9	0.4111
S-2	1	10	10	10	10	9	9	9	9	0.3444
	2	10	10	10	10	10	9	8	8	0.3750
	3	10	10	10	10	8	8	8	8	0.3625
S-3	1	10	10	10	10	10	10	10	9	0.3667
	2	10	10	10	10	10	10	10	10	0.4000
	3	10	10	10	10	10	10	10	10	0.4400
S-4	1	10	10	10	10	9	8	8	8	0.3250
	2	10	10	10	10	10	10	10	10	0.3700
	3	10	10	10	10	10	10	10	10	0.3333

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TABLE 6

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3334

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	8.1	6.8	8.2	7.2	8.0	6.5	8.3	6.7	8.4	6.8	8.2	6.2	8.6	6.8
S-1	9.4	7.1	9.3	7.1	8.6	6.6	9.4	6.5	9.5	7.0	9.0	5.8	9.8	6.5
S-2	9.4	7.3	9.7	7.2	8.8	6.6	9.4	7.1	9.4	7.3	9.5	6.9	9.4	7.1
S-3	8.6	7.2	9.0	7.0	8.6	6.7	9.2	6.9	9.3	7.0	9.5	6.3	9.3	7.1
S-4	8.5	7.0	9.1	7.1	8.6	6.6	9.0	6.9	9.3	7.1	8.5	6.0	8.6	6.6

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	8.1	7.9	8.0	7.9	8.0	7.8	8.1
S-1	8.6	7.9	8.1	8.2	8.2	8.2	8.2
S-2	8.6	8.0	8.2	8.4	8.5	8.1	8.2
S-3	8.4	8.1	8.2	8.2	8.2	8.1	8.2
S-4	8.3	7.9	8.2	8.1	8.0	8.1	8.1

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TABLE 6

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3334

Dissolved Oxygen (mg/l)

Sample	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7	
	i*	f*	i	f	i	f	i	f	i	f	i	f	i	f
Control	8.1	6.8	8.2	7.2	8.0	6.5	8.3	6.7	8.4	6.8	8.2	6.2	8.6	6.8
S-1	9.4	7.1	9.3	7.1	8.6	6.6	9.4	6.5	9.5	7.0	9.0	5.8	9.8	6.5
S-2	9.4	7.3	9.7	7.2	8.8	6.6	9.4	7.1	9.4	7.3	9.5	6.9	9.4	7.1
S-3	8.6	7.2	9.0	7.0	8.6	6.7	9.2	6.9	9.3	7.0	9.5	6.3	9.3	7.1
S-4	8.5	7.0	9.1	7.1	8.6	6.6	9.0	6.9	9.3	7.1	8.5	6.0	8.6	6.6

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	8.1	7.9	8.0	7.9	8.0	7.8	8.1
S-1	8.6	7.9	8.1	8.2	8.2	8.2	8.2
S-2	8.6	8.0	8.2	8.4	8.5	8.1	8.2
S-3	8.4	8.1	8.2	8.2	8.2	8.1	8.2
S-4	8.3	7.9	8.2	8.1	8.0	8.1	8.1

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TABLE 6 - continued

PATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3334

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	340	335	320	350	345	340	330
S-1	750	775	800	800	790	790	790
S-2	1100	1150	1100	1100	1100	1250	1250
S-3	800	800	700	800	800	900	900
S-3	1425	1400	1500	1450	1450	1425	1425

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	25.5	24.5	24.5	24.0	25.0	24.0
S-1	25.0	25.5	24.5	24.5	24.0	25.0	24.0
S-2	25.0	25.5	24.5	24.5	24.0	25.0	24.0
S-3	25.0	25.5	24.5	24.5	24.0	25.0	24.0
S-4	25.0	25.5	24.5	24.5	24.0	25.0	24.0

Alkalinity/Hardness (as mg/l $CaCO_3$)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	82/114	80/110	75/110	68/105	70/108	70/110	72/110
S-1	192/238	200/210	165/215	220/255	210/245	210/245	210/245
S-2	392/572	390/525	350/518	360/520	350/520	355/525	360/518
S-3	308/290	300/350	210/305	275/328	290/335	300/320	300/338
S-4	532/495	520/440	505/445	450/460	465/455	455/450	470/465

TABLE 7

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3334

Sample	Cells/ml X 10^6 after 96 hours Replicate 1	Replicate 2	Replicate 3	Mean
Control	1.703	2.013	2.277	1.998
S-1	3.530	3.645	3.275	3.483
S-2	4.260	4.180	3.935	4.125
S-3	2.510	2.950	2.880	2.780
S-4	2.195	1.970	1.910	2.025

Bartlett's B (calculated) = 0.9274
Tabled X^2 value (p=0.05, df=4) = 9.488

ANOVA F (calculated) = 57.08
ANOVA F (tabled) = 3.48

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	25.0	25.5	24.3	24.5
S-1	25.0	25.5	24.3	24.5
S-2	25.0	25.5	24.3	24.5
S-3	25.0	25.5	24.3	24.5
S-4	25.0	25.5	24.3	24.5

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	8.1	340
S-1	8.6	750
S-2	8.6	1100
S-3	8.4	800
S-4	8.3	1425

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3 SPECIES BIOASSAY RESULTS:

SANTA CLARA VALLEY NON-POINT SOURCE PROGRAM

DRY WEATHER TEST #2

SAMPLES RECEIVED 1 FEBRUARY, 1989 AND THEREAFTER

DRAFT

Prepared for

KINNETIC LABORATORIES, INC.
Santa Cruz, California

Prepared by

MARINE BIOASSAY LABORATORIES DIVISION
TOXSCAN, INC.
Watsonville, California

APRIL, 1989

MBL

A DIVISION OF TOXSCAN, INC

R0054777

All algal counts were made manually with a hemacytometer and microscope. Treatment groups and controls were set up with a minimum of three replicates. Testing was conducted in an environmental chamber with continuous illumination of 400 ft/candles at 24 $\pm$ 2°C for 96 hours. All test flasks were innoculated with approximately 1×10^4 cells/ml from a 4 day old stock culture. Cultures were shaken twice daily by hand. Upon conclusion of testing, statistical analyses were made of final cell densities to determine EC50 concentrations using the Probit Method. Bartlett's test was used to confirm homogeneity of variance after which Dunnett's test was used.

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Results and Conclusions

Ceriodaphnia

Reproduction and survival data for *Ceriodaphnia* are summarized in Table 1, and are presented in full in Table 2. Data were statistically analyzed using the laboratory water as the comparative datum ("control").

Analysis of mortality data by Fisher's Exact Test showed that sample S-2 produced statistically significant mortality when compared with laboratory water controls (Fishers b value = 3). Following protocol guidance, reproduction data from S-2 were not included in subsequent statistical analyses.

Reproduction data were found to be not normally distributed (D'Agostino's D value = 0.2397). Critical D values are 0.2655 to 0.2874. Data could not be normalized by any transformation (Square root, log, or arcsin $\sqrt{x}$), and subsequent analysis was done by the non-parametric Steel's Many-One Rank Test. The tabulated critical rank sum value for n=10 and k=4 is 76. Rank sums for S-1, S-3, S-4 and S-5 all exceeded 76, indicating that reproduction in these samples was not significantly lower than in the laboratory control water.

Environmental monitoring data are tabulated and presented in Table 3.

Fathead Minnow Larvae

Survival and growth (dry weight) data are summarized in Table 4, and data for individual replicate test containers are presented in Table 5. There was not enough sample from S-5 to do the fathead minnow bioassay, and only S-1 through S-4 were included.

Larval weight data were determined to be normally distributed (Shpiro-Wilkes test), and homogeneous, with a Bartlett's B value of 0.979. The tabled X^2 value for 4 d.f. at p=0.01 is 13.28. Subsequent ANOVA and Dunnetts analyses were done on the untransformed weight data. There was no significant decrease in mean larval weight in samples S-1, S-2, S-3 and S-4 when compared with the weight of dilution water controls.

Environmental monitoring data for fathead minnow larvae are summarized in Table 6.

Selenastrum

Growth and environmental monitoring data are summarized in Table 7.

Cell number data were normally distributed (Shapiro-Wilkes) and homogeneous (Bartletts B = 0.9274 vs tabled X^2 value at p=0.01 and 5 d.f.

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Introduction

As part of the Santa Clara Valley Non-Point Source Program, toxicity testing must be carried out on water samples collected during both dry weather (four times) and wet weather (twice). Dry weather tests require daily collection of water samples at stream stations. Wet weather tests will be conducted using a single composite sample of runoff water for the daily renewals. This test is the second of four dry weather tests. Three toxicity tests are conducted, utilizing Ceriodaphnia dubia (invertebrate), Pimephales promelas (fish) and Selenastrum capricornutum (plant).

The Ceriodaphnia and Pimephales tests are seven days in duration, and are static-renewal protocols, requiring daily replacement of test solutions with newly-collected test water samples. Daily collections of stream water were made only during the first two days of the test period. On the second day it became clear that an unexpected rainstorm was imminent, and the inclusion of storm runoff in our "dry weather" samples was not appropriate in terms of the study objectives. The decision was made, therefore, to collect enough sample on Day 2 (our last dry day) to perform daily renewals for the remainder of the 7-day test period. In summary, water collections were made only on Days 1 and 2 of the test period. Water collected on Day 2 was stored at 4°C for the remainder of the 7-day test period, and daily renewals on days 2-7 were done using this stored water.

The three bioassays were performed concurrently. Daphnids and fish were run on 3-10 February, 1989 while algae were tested on 3-7 February, 1989. Methods, results and data are presented in the following pages.

The samples were collected and delivered to MBL by MBL personnel. The experimental design called testing only undiluted (100%) stream water. A lab water control (EPA moderately-hard) was run to provide quality assurance data. The lab water results were also used as the comparative data for statistical comparisons.

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Methods

Ceriodaphnia

Test organisms were neonates derived from in-house cultures. Original broodstock was from EPA Duluth, received 11 May, 1988 and cultured in EPA moderately hard water prepared with Milli-Q water. Samples of stream test water were collected daily during the test, and lab control water was EPA moderately hard (Milli-Q).

The test was initiated with 4-8 hour old neonates derived from third broods of individually maintained broodstock. Testing was conducted with 10 individuals per treatment, each in individual plastic cups containing 15 ml of test solution. Test temperature was 25 ± 1°C and photoperiod was 16 hour light:8 hour dark. Test solutions were renewed daily, concurrent with transfers, water quality measurements and assessment of survival and reproduction. At each daily transfer, new media were inoculated with food (2 drops of *Ceriodaphnia* chow and 1 drop of *Selenastrum* culture, density approximately 2.5×10^6 cells/ml). Following the 7-day test period, survival data was statistically evaluated using the probit method to calculate the 96-hour LC50. Reproductive data was evaluated using ANOVA and Dunnett's Test after confirming data homogeneity by Bartlett's Test. Test conditions and organism data are summarized in Appendix Table A-1.

Fathead Minnow Larvae

Test organisms were larvae, less than 24 hours old, obtained from in-house culture. All larvae were from the same spawning substrate, but probably from multiple spawns. Original broodstock was purchased from Thomas Fish Farms, San Rafael, California, approximately March of 1988. Stream test water samples were collected fresh each day. Control water was EPA moderately hard (Milli-Q). Ten larvae were used in each test container and there were three replicate containers per concentration. Each larval container was fed three times daily with 750-1000 newly-hatched *Artemia* nauplii. Test temperature was 25 ± 1°C, and photoperiod was 16:8. Daily renewal of 80% of the test volume coincided with daily environmental monitoring and assessment of survival. After seven days of exposure, the test was terminated by addition of formalin to each container. Surviving larvae were dried and weighed, and weight data were statistically evaluated using Bartlett's Test followed by ANOVA and Dunnett's Test. Probit analysis of survival data was used to calculate the 96-hour LC_1. Test conditions and organism data are summarized in appendix Table A-2.

Selenastrum

Algal assays were conducted in sterile 250 ml Erlenmeyer flasks. Preparation of the nutrient medium followed guidelines set forth in EPA-600/9-78-018.

TABLE 2 CERIODAPHNIA REPRODUCTION AND SURVIVAL

Santa Clara Valley NPS Sample #3533

Sample	Day #	Replicate a	b	c	d	e	f	g	h	i	j	Total Young	# Live Adults
Control	4	0	0	0	3	3	0	2	4	0	0	12	10
	5	6	5	5	0	3	6	0	7	4	3	39	10
	6	0	5	8	7	6	6	6	0	0	2	40	10
	7	12	7	10	9	6	7	10	9	8	9	87	10
S-1	4	6	7	7	7	7	6	6	5	2	5	58	10
	5	0	0	0	0	0	0	0	0	0	0	0	10
	6	13	10	12	10	11	15	13	11	11	11	117	10
	7	16	17	20	17	16	20	20	18	15	17	176	10
S-2	4	6	X	0	X	0	0	4	X	3	2	15	7
	5	0	-	0	-	4	X	0	-	0	0	4	6
	6	0	-	0	-	4	-	2	-	0	2	8	6
	7	X	-	0	-	X	-	0	-	0	X	0	3
S-3	4	5	6	6	6	1	6	4	5	4	1	44	10
	5	0	0	0	0	3	0	0	0	0	3	6	10
	6	10	8	10	10	8	11	10	11	9	9	96	10
	7	14	15	14	16	0	15	15	16	15	12	132	10
S-4	4	6	5	0	6	0	5	5	6	5	6	44	10
	5	0	0	0	0	0	0	0	0	0	0	0	10
	6	12	15	11	11	3	9	10	11	9	11	102	10
	7	19	21	17	18	0	15	17	15	13	16	151	10
S-5	4	6	4	6	0	6	4	5	4	5	0	40	10
	5	0	0	0	6	0	0	0	0	0	4	10	10
	6	9	12	9	10	11	8	10	9	8	8	94	10
	7	14	0	13	0	9	7	10	15	13	15	96	10

X = Adult Died

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TABLE 3

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3533

Dissolved Oxygen (mg/l)

Sample	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7	
	i*	f*	i	f	i	f	i	f	i	f	i	f	i	f
Control	7.7	7.5	8.5	7.9	8.3	8.0	8.0	7.8	8.8	8.2	8.0	8.1	8.8	7.2
S-1	9.3	7.4	9.4	7.8	7.2	7.9	9.4	7.8	9.1	.8	9.9	7.1	9.9	6.7
S-2	10.0	7.4	10.4	7.9	9.8	7.9	10.1	7.8	10.2	8.0	10.6	7.4	10.8	6.4
S-3	8.2	7.4	10.4	7.8	10.0	7.9	9.6	7.7	9.6	7.9	10.6	7.5	10.6	6.8
S-4	7.8	7.4	8.9	7.8	8.8	7.9	8.9	7.6	9.4	7.9	10.2	7.4	10.2	7.2
S-5	8.5	7.4	10.4	7.8	10.0	7.9	9.6	7.7	9.6	7.9	10.6	7.5	10.6	6.8

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	7.8	7.4	7.9	.99	8.0	7.9	8.0
S-1	9.0	8.6	8.8	8.8	8.8	8.6	8.4
S-2	8.3	8.3	8.5	8.5	8.5	8.4	8.2
S-3	8.2	8.3	8.4	8.4	8.4	8.4	8.1
S-4	8.0	8.0	8.0	8.0	8.1	8.0	7.7
S-5	8.2	8.3	8.4	8.4	8.4	8.4	8.1

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= 15.09). ANOVA and Dunnetts analyses were done on the untransformed data. There was no signficant decrease in mean cell numbers in any of the stream samples when compared with growth in lab water controls. There were significantly increased cell numbers in samples S-2, S-3 and S-5.

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TABLE 1

SUMMARY OF REPRODUCTION AND SURVIVAL FOR CERIODAPHNIA
Santa Clara Valley NPS Sample #3533

Sample	Total Young Produced/Replicate a	b	c	d	e	f	g	h	i	j	% Survival (n = 10)
Control	18	17	23	19	18	19	18	20	12	14	100
S-1	35	34	39	34	34	41	39	34	28	33	100
S-2	6*	0*	0	0*	8*	0*	6	0*	3	4*	30
S-3	29	29	30	32	12	32	29	32	28	25	100
S-4	37	41	28	35	3	29	32	32	27	33	100
S-5	29	16	28	16	26	19	25	28	26	27	100

* = Adult died prior to test completion

For Survival Data

Fisher's Exact Test - Critical b value = 6
- b value for sample S-2 = 3

For Reproductive Data

D'Agostino's D (calculated) = 0.2397*
Critical D interval (tabled) = 0.2655-0.2874

Steel's Critical Rank Sum = 76
Steel's Rank Sum for all samples =

* Data were not normally distributed and could not be normalized by transformation. Data were analyzed by Steel's Many-One Rank Test.

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TABLE 5

FATHEAD MINNOW LARVAE
SURVIVAL AND LARVAL DRY WEIGHT DATA

Santa Clara Valley NPS Sample #3533

Sample	Replicate	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Mean Larval Dry Weight (mg)
		Number of Survivors								
Control	1	10	10	10	10	10	10	10	9	0.4000
	2	10	10	10	10	10	10	9	9	0.4440
	3	10	10	10	10	10	10	10	10	0.4000
S-1	1	10	10	10	10	10	10	10	9	0.3770
	2	10	10	10	10	10	10	10	10	0.3540
	3	10	10	10	10	10	10	10	10	0.3300
S-2	1	10	10	10	10	10	10	10	10	0.3900
	2	10	10	10	10	9	9	8	8	0.4370
	3	10	10	10	10	8	8	8	8	0.3500
S-3	1	10	10	10	10	10	10	10	9	0.4110
	2	10	10	10	10	10	10	9	9	0.4550
	3	10	10	10	10	10	10	7	7	0.4000
S-4	1	10	10	10	10	10	10	10	9	0.4770
	2	10	10	10	10	10	10	9	9	0.4330
	3	10	10	10	10	10	10	10	9	0.4330

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TABLE 6

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3533

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	7.7	7.4	8.5	7.5	8.3	7.6	8.0	7.0	8.8	7.0	8.0	6.7	8.8	6.6
S-1	9.3	7.3	9.4	7.3	7.2	7.2	9.4	6.7	9.1	7.1	9.9	7.3	9.9	6.8
S-2	10.0	7.6	10.4	7.5	9.8	7.4	10.1	7.1	10.2	7.5	10.6	7.0	10.8	7.1
S-3	8.2	7.5	10.4	7.3	10.0	7.2	9.6	6.4	9.6	7.1	10.6	6.9	10.6	7.0
S-4	7.8	7.2	8.9	7.2	8.8	7.0	8.9	6.4	9.4	7.0	10.2	6.6	10.2	6.5

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	7.8	7.4	7.9	.99	8.0	7.9	8.0
S-1	9.0	8.6	8.8	8.8	8.8	8.6	8.4
S-2	8.3	8.3	8.5	8.5	8.5	8.4	8.2
S-3	8.2	8.3	8.4	8.4	8.4	8.4	8.1
S-4	8.0	8.0	8.0	8.0	8.1	8.0	7.7
S-5	8.2	8.3	8.4	8.4	8.4	8.4	8.1

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TABLE 3 - continued

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3533

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	280	280	---	---	---	---	---
S-1	530	1180	---	---	---	---	---
S-2	1090	1060	---	---	---	---	---
S-3	775	795	---	---	---	---	---
S-4	1320	1100	---	---	---	---	---
S-5	750	795	---	---	---	---	---

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	24.0	24.0	24.0	24.0	24.0	24.0
S-1	24.0	24.5	24.5	24.5	25.0	25.0	25.0
S-2	24.0	24.5	24.5	24.5	25.0	25.0	25.0
S-3	24.0	24.5	24.5	24.5	25.0	25.0	25.0
S-4	24.0	24.5	24.5	24.5	25.0	25.0	25.0
S-5	24.0	24.5	24.5	24.5	25.0	25.0	25.0

Alkalinity/Hardness (as mg/l $CaCO_3$)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	76/102	76/102	---	---	---	---	---
S-1	180/224	---	---	---	---	---	---
S-2	368/530	---	---	---	---	---	---
S-3	280/370	---	---	---	---	---	---
S-4	472/454	---	---	---	---	---	---
S-5	280/370	---	---	---	---	---	---

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TABLE 4

FATHEAD MINNOW LARVAE
MEAN PERCENT SURVIVAL (n=30) AND MEAN LARVAL DRY WEIGHT

Santa Clara Valley NPS Sample #3533

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	(mg) Mean Larval Dry Weight
Control	100	100	100	100	100	97	93	0.4147
S-1	100	100	100	100	100	100	97	0.3537
S-2	100	100	100	97	97	87	87	0.3923
S-3	100	100	100	100	100	87	83	0.4220
S-4	100	100	100	100	100	97	90	0.4477

For Larval Weight Data

Bartlett's B = 0.979
Tabled X^2 value (p=0.01, 4 df) = 13.28

ANOVA F (calculated) = 4.08
ANOVA F (tabled) = 3.48

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APPENDIX A

Summary of Test Conditions

TABLE 6 - continued

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3533

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	280	280	---	---	---	---	---
S-1	530	1180	---	---	---	---	---
S-2	1090	1060	---	---	---	---	---
S-3	775	795	---	---	---	---	---
S-4	1320	1100	---	---	---	---	---
S-5	750	795	---	---	---	---	---

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	24.0	24.0	24.0	24.0	24.0	24.0
S-1	24.0	24.5	24.5	24.5	25.0	25.0	25.0
S-2	24.0	24.5	24.5	24.5	25.0	25.0	25.0
S-3	24.0	24.5	24.5	24.5	25.0	25.0	25.0
S-4	24.0	24.5	24.5	24.5	25.0	25.0	25.0
S-5	24.0	24.5	24.5	24.5	25.0	25.0	25.0

Alkalinity/Hardness (as mg/l $CaCO_3$)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	76/102	76/102	---	---	---	---	---
S-1	180/224	---	---	---	---	---	---
S-2	368/530	---	---	---	---	---	---
S-3	280/370	---	---	---	---	---	---
S-4	472/454	---	---	---	---	---	---
S-5	280/370	---	---	---	---	---	---

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TABLE 7

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3533

Sample	Cells/ml X 10^6 after 96 hours Replicate 1	Replicate 2	Replicate 3	Mean
Control	2.59	2.66	2.61	2.62
S-1	2.41	2.67	2.66	2.58
S-2	5.06	5.04	5.40	5.17
S-3	2.90	3.33	3.68	3.30
S-4	2.13	2.17	2.08	2.13
S-5	3.20	3.58	4.40	3.73

Bartlett's B (calculated) = 14.83
Tabled X^2 value (p=0.01, df=5) = 15.09
ANOVA F (calculated) = 36.39
ANOVA F (tabled) = 3.11

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	25.6	25.1	25.0	25.8
S-1	25.6	25.1	25.0	25.8
S-2	25.6	25.1	25.0	25.8
S-3	25.6	25.1	25.0	25.8
S-4	25.6	25.1	25.0	25.8
S-5	25.6	25.1	25.0	25.8

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	7.9	280
S-1	8.8	480
S-2	8.5	1060
S-3	8.4	795
S-4	8.0	1100
S-5	8.5	795

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TABLE A-3

Selenastrum Bioassay

Test Type:	Static
Test Endpoints:	Growth, (cell number)
Test Duration:	4 days, 96 hours
Temperature:	24 ± 2°C
Photoperiod:	Continuous light
Light Intensity:	400 ± 40 FC
Start:	3 February, 1989, 13:00 hours
Finish:	7 February, 1989, 13:00 hours
Test Containers:	250 ml Erlenmeyer flasks
Test Volume:	100 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #2
Test Concentrations:	100%, Control
# Replicates:	3
Organisms per replicate:	10,000/ml innoculated
Test Species:	*Selenastrum capricornutum*
Source:	In-house culture
Age:	4 days
Culture Water:	EPA Moderately Hard

TABLE A-1

Ceriodaphnia Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Reproduction
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	3 February, 1989, 10:00 hours
Finish:	10 February, 1989, 10:00 hours
Test Containers:	1 oz plastic cups
Test Volume:	15 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #2
Test Concentrations:	100%, controls
# Replicates:	10
Organisms per replicate:	1
Test Species:	Ceriodaphnia dubia
Source:	in-house culture
Age:	4-8 hours
Acclimation/Culture Water:	EPA Moderately Hard (Milli-Q)
Diet:	Selenastrum, Ceriodaphnia chow

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TABLE A-2

Fathead Minnow Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Growth
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	3 February, 1989, 12:00 hours
Finish:	10 February, 1989, 12:00 hours
Test Containers:	1 liter glass jars
Test Volume:	500 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #2
Test Concentrations:	100%, control
# Replicates:	3
Organisms per replicate:	10
Test Species:	*Pimephales promelas* (Fathead minnow)
Source:	in-house culture
Age:	<24 hours
Culture Water:	Dechlorinated Tap
Diet:	*Artemia* nauplii

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Introduction

As part of the Santa Clara Valley Non-Point Source Program, toxicity testing must be carried out on water samples collected during both dry weather (four times) and wet weather (twice). Dry weather tests require daily collection of water samples at stream stations. Wet weather tests will be conducted using a single composite sample of runoff water for the daily renewals. This test is the third of four dry weather tests. Three toxicity tests are conducted, utilizing *Ceriodaphnia dubia* (invertebrate), *Pimephales promelas* (fish) and *Selenastrum capricornutum* (plant).

The *Ceriodaphnia* and *Pimephales* tests are seven days in duration, and are static-renewal protocols, requiring daily replacement of test solutions with newly-collected test water samples. Daily collections of stream water were made by Kinnetic Laboratories (KLI) personnel.

The three bioassays were performed concurrently. Daphnids and fish were run on 9-16 April, 1989 while algae were tested on 8-12 April, 1989. Methods, results and data are presented in the following pages.

The experimental design called for testing only undiluted (100%) stream water. A lab water control (EPA moderately-hard) was run to provide quality assurance data. The lab water results were also used as the comparative data for statistical comparisons.

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Methods

Ceriodaphnia

Test organisms were neonates derived from in-house cultures. Original broodstock was from EPA Duluth, received 11 May, 1988 and cultured in EPA moderately hard water prepared with Milli-Q water. Samples of stream test water were collected daily during the test, and lab control water was EPA moderately hard (Milli-Q).

The test was initiated with 4-8 hour old neonates derived from third broods of individually maintained broodstock. Testing was conducted with 10 individuals per treatment, each in individual plastic cups containing 15 ml of test solution. Test temperature was 25 ± 1°C and photoperiod was 16 hour light:8 hour dark. Test solutions were renewed daily, concurrent with transfers, water quality measurements and assessment of survival and reproduction. At each daily transfer, new media were inoculated with food (2 drops of Ceriodaphnia chow and 1 drop of Selenastrum culture, density approximately 2.5 X 10^6 cells/ml). Following the 7-day test period, survival data was statistically evaluated using the probit method to calculate the 96-hour LC50. Reproductive data was evaluated using ANOVA and Dunnett's Test after confirming data homogeneity by Bartlett's Test. Test conditions and organism data are summarized in Appendix Table A-1.

Fathead Minnow Larvae

Test organisms were larvae, less than 24 hours old, obtained from in-house culture. All larvae were from the same spawning substrate, but probably from multiple spawns. Original broodstock was purchased from Thomas Fish Farms, San Rafael, California, approximately March of 1988. Stream test water samples were collected fresh each day. Control water was EPA moderately hard (Milli-Q). Ten larvae were used in each test container and there were three replicate containers per concentration. Each larval container was fed three times daily with 750-1000 newly-hatched Artemia nauplii. Test temperature was 25 ± 1°C, and photoperiod was 16:8. Daily renewal of 80% of the test volume coincided with daily environmental monitoring and assessment of survival. After seven days of exposure, the test was terminated by addition of formalin to each container. Surviving larvae were dried and weighed, and weight data were statistically evaluated using Bartlett's Test followed by ANOVA and Dunnett's Test. Probit analysis of survival data was used to calculate the 96-hour LC_1. Test conditions and organism data are summarized in appendix Table A-2.

Selenastrum

Algal assays were conducted in sterile 250 ml Erlenmeyer flasks. Preparation of the nutrient medium followed guidelines set forth in EPA-600/9-78-018.

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3 SPECIES BIOASSAY RESULTS:
SANTA CLARA VALLEY NON-POINT SOURCE PROGRAM
DRY WEATHER TEST #3
SAMPLES RECEIVED 7 APRIL, 1989 AND THEREAFTER

DRAFT

Prepared for

KINNETIC LABORATORIES, INC.
Santa Cruz, California

Prepared by

MARINE BIOASSAY LABORATORIES DIVISION
TOXSCAN, INC.
Watsonville, California

APRIL, 1989

All algal counts were made manually with a hemacytometer and microscope. Treatment groups and controls were set up with a minimum of three replicates. Testing was conducted in an environmental chamber with continuous illumination of 400 ft/candles at 24 $\pm$ 2°C for 96 hours. All test flasks were innoculated with approximately 1 X 10^4 cells/ml from a 4 day old stock culture. Cultures were shaken twice daily by hand. Upon conclusion of testing, statistical analyses were made of final cell densities to determine EC50 concentrations using the Probit Method. Bartlett's test was used to confirm homogeneity of variance after which Dunnett's test was used.

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All algal counts were made manually with a hemacytometer and microscope. Treatment groups and controls were set up with a minimum of three replicates. Testing was conducted in an environmental chamber with continuous illumination of 400 ft/candles at 24 ± 2°C for 96 hours. All test flasks were innoculated with approximately 1 X 10^4 cells/ml from a 4 day old stock culture. Cultures were shaken twice daily by hand. Upon conclusion of testing, statistical analyses were made of final cell densities to determine EC50 concentrations using the Probit Method. Bartlett's test was used to confirm homogeneity of variance after which Dunnett's test was used.

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All algal counts were made manually with a hemacytometer and microscope. Treatment groups and controls were set up with a minimum of three replicates. Testing was conducted in an environmental chamber with continuous illumination of 400 ft/candles at 24 $\pm$ 2°C for 96 hours. All test flasks were innoculated with approximately 1 X 10^4 cells/ml from a 4 day old stock culture. Cultures were shaken twice daily by hand. Upon conclusion of testing, statistical analyses were made of final cell densities to determine EC50 concentrations using the Probit Mathod. Bartlett's test was used to confirm homogeneity of variance after which Dunnett's test was used.

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Results and Conclusions

Ceriodaphnia

Reproduction and survival data for Ceriodaphnia are summarized in Table 1, and are presented in full in Table 2. Data were statistically analyzed using the laboratory water as the comparative datum ("control").

Analysis of mortality data by Fisher's Exact Test showed that sample S-4 produced statistically significant mortality when compared with laboratory water controls (Fishers b value = 3). Following protocol guidance, reproduction data from S-4 were not included in subsequent statistical analyses.

Reproduction data were found to be normally distributed (D'Agostino's D test) and homogeneous (Bartlett's B = 9.81).

None of the samples produced significantly decreased young production when compared with laboratory water controls.

Environmental monitoring data are tabulated and presented in Table 3.

Fathead Minnow Larvae

Survival and growth (dry weight) data are summarized in Table 4, and data for individual replicate test containers are presented in Table 5. There was not enough sample from S-5 to do the fathead minnow bioassay, and only S-1 through S-4 were included.

Larval weight data were determined to be normally distributed (Shapiro-Wilkes test), and homogeneous, with a Bartlett's B value of 3.85. The tabled X^2 value for 4 d.f. at p=0.01 is 13.28. Subsequent ANOVA and Dunnetts analyses were done on the untransformed weight data. There was no significant decrease in mean larval weight in samples S-1, S-2, and S-4 when compared with the weight of dilution water controls. There was significantly decreased larval weight in sample S-3.

Environmental monitoring data for fathead minnow larvae are summarized in Table 6.

Selenastrum

Growth and environmental monitoring data are summarized in Table 7.

Cell number data were normally distributed (Shapiro-Wilkes) and homogeneous (Bartletts B = 5.86 vs tabled X^2 value at p=0.01 and 4 d.f. = 13.28). ANOVA and Dunnetts analyses were done on the untransformed data. There was no signficant decrease in mean cell numbers in samples S1, S2 and S3 when compared with growth in lab water controls. There were significantly decreased cell numbers in sample S-4.

TABLE 3

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3838

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	7.6	7.7	7.9	7.8	8.0	7.5	8.1	7.8	8.0	7.9	8.2	7.8	8.0	7.1
S-1	9.2	7.7	9.2	7.5	10.0	7.4	9.5	7.6	9.4	8.0	9.7	7.5	7.8	7.0
S-2	10.0	7.7	10.5	7.2	9.8	7.5	10.4	7.8	10.4	7.8	10.0	7.7	8.7	7.0
S-3	9.1	7.8	9.4	7.4	9.7	7.4	8.9	7.7	9.4	7.9	8.8	7.7	7.7	7.1
S-4	8.2	7.8	9.5	7.5	8.8	7.4	8.7	7.8	8.4	7.8	7.2	7.6	7.2	7.3

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	8.0	7.9	7.9	8.0	7.9	7.7	7.9
S-1	8.2	7.9	8.0	8.7	8.1	8.1	7.9
S-2	8.2	8.2	8.0	8.4	8.2	8.2	8.1
S-3	8.1	8.1	7.8	8.1	8.0	7.8	7.9
S-4	8.0	7.9	7.8	8.1	7.8	7.7	7.9

TABLE 3 - continued

CERIODAPHNIA - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3838

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	275	250	285	310	300	270	285
S-1	700	7000	700	600	600	700	700
S-2	1100	1075	1110	1100	1100	1100	1150
S-3	780	780	790	810	740	800	840
S-4	1500	1580	1500	1550	1460	1560	1580

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	25.5	25.0	26.0	23.0	25.5	26.0
S-1	25.0	25.5	25.0	26.0	24.0	25.0	26.0
S-2	25.0	25.5	25.0	26.0	24.0	25.5	26.0
S-3	25.0	25 5	25.0	26.0	23.5	24.5	26.0
S-4	25.0	25.5	24.0	26.0	25.0	25.0	24.0

Alkalinity/Hardness (as mg/l $CaCO_3$)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	60/100	65/100	67/100	67/100	65/100	67/102	65/102
S-1	125/215	115/218	204/218	142/184	190/190	195/210	212/208
S-2	275/475	300/485	359/550	366/590	352/625	352/584	420/580
S-3	200/320	210/320	275/330	252/344	350/304	275/336	330/294
S-4	390/425	390/435	505/450	512/432	482/440	525/460	550/440

TABLE 1

SUMMARY OF REPRODUCTION AND SURVIVAL FOR CERIODAPHNIA
Santa Clara Valley NPS Sample #3838

Sample	Total Young Produced/Replicate										% Survival
	a	b	c	d	e	f	g	h	i	j	(n = 10)
Control	16	19	20	19	22	15	14	17	18	17	100
S-1	28	28	9	11*	29	34	34	24	28	30	90
S-2	13	0*	18	12	15	25	23	18	11	15	80
S-3	29	31	25	28	26	31	40	14	29	19	100
S-4	28*	18	15*	15*	15*	16*	19*	15*	17*	27*	10

* = Adult died prior to test completion

For Reproductive Data

Bartlett's B (calculated) = 9.81
Tabled x^2 value (p=0.01, dF=3) = 11.35

ANOVA F (calculated) = 9.95
ANOVA F (Tabled) = 2.86

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TABLE 2

CERIODAPHNIA REPRODUCTION AND SURVIVAL

Santa Clara Valley NPS Sample #3838

Sample	Day #	a	b	c	d	e	f	g	h	i	j	Total Young	# Live Adults
		Replicate											
Control	4	3	4	3	0	3	4	4	0	4	2	27	10
	5	0	0	2	5	4	0	1	4	0	4	20	10
	6	4	6	6	4	7	3	4	2	5	3	44	10
	7	9	9	9	10	8	8	5	11	9	8	86	10
S-1	4	3	3	4	4	5	5	4	4	3	4	39	10
	5	1	10	0	7	8	11	13	5	11	0	66	10
	6	9	0	10	X	0	0	0	0	0	13	32	9
	7	15	15	15	-	16	18	17	15	14	13	138	9
S-2	4	3	X	4	5	5	4	4	3	5	5	38	9
	5	0	-	8	5	0	11	10	7	6	0	47	9
	6	7	-	0	0	4	0	0	0	X	6	17	8
	7	3	-	6	2	6	10	9	8	-	4	48	8
S-3	4	4	4	4	4	4	4	5	3	3	4	39	10
	5	0	11	0	12	10	12	10	0	0	0	55	10
	6	10	0	10	0	0	0	10	11	12	10	63	10
	7	15	16	11	12	12	15	15	0	14	15	120	10
S-4	4	2	5	3	5	5	3	4	4	4	4	39	10
	5	11	10	12	10	10	0	0	11	13	8	85	10
	6	15	0	X	0	0	13	0	X	X	15	43	7
	7	X	3	-	X	X	X	X	-	-	X	3	1

X = Adult Died

TABLE 4

FATHEAD MINNOW LARVAE
MEAN PERCENT SURVIVAL (n=30) AND MEAN LARVAL DRY WEIGHT

Santa Clara Valley NPS Sample #3838

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	(mg) Mean Larval Dry Weight
Control	100	100	100	97	97	97	97	0.5200
S-1	100	97	97	97	97	97	97	0.4833
S-2	100	97	97	97	97	97	97	0.5100
S-3	100	100	97	97	97	97	97	0.4400
S-4	100	100	100	100	100	100	100	0.4500

For Larval Weight Data

Bartlett's B = 3.85
Tabled X^2 value (p=0.01, 4 df) = 13.28

ANOVA F (calculated) = 2.56
ANOVA F (tabled) = 3.48

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TABLE 5

FATHEAD MINNOW LARVAE
SURVIVAL AND LARVAL DRY WEIGHT DATA

Santa Clara Valley NPS Sample #3838

Sample	Replicate	Number of Survivors Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Mean Larval Dr Weight (mg)
Control	1	10	10	10	10	10	10	10	10	0[illegible]00
	2	10	10	10	10	10	10	10	10	0.[illegible]00
	3	10	10	10	10	9	9	9	9	0.[illegible]00
S-1	1	10	10	10	10	10	10	10	10	0.4600
	2	10	10	9	9	9	9	9	9	0.4500
	3	10	10	10	10	10	10	10	10	0.5400
S-2	1	10	10	9	9	9	9	9	9	0.5[illegible]00
	2	10	10	10	10	10	10	10	10	0.4800
	3	10	10	10	10	10	10	10	10	0.5300
S-3	1	10	10	10	9	9	9	9	9	0.4400
	2	10	10	10	10	10	10	10	10	0.4900
	3	10	10	10	10	10	10	10	10	0.3900
S-4	1	10	10	10	10	10	10	10	10	0.4900
	2	10	10	10	10	10	10	10	10	0.4500
	3	10	10	10	10	10	10	10	10	0.4100

TABLE 7

SELENASTRUM CAPRICORNUTUM
GROWTH AND ENVIRONMENTAL MONITORING DATA
Santa Clara Valley NPS Sample #3838

Sample	Replicate 1	Cells/ml X 10^6 after 96 hours Replicate 2	Replicate 3	Mean
Control	3.10	3.02	3.11	3.08
S-1	3.13	3.47	3.10	3.23
S-2	3.82	3.62	3.76	3.73
S-3	3.03	2.96	3.97	2.99
S-4	1.49	1.34	1.44	1.42

Bartlett's B (calculated) = 5.86
Tabled X^2 value (p=0.01, df=4) = 13.28

ANOVA F (calculated) = 181.6
ANOVA F (tabled) = 3.48

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4
Control	26.2	25.3	24.8	25.4
S-1	26.2	25.3	24.8	25.4
S-2	26.2	25.3	24.8	25.4
S-3	26.2	25.3	24.8	25.4
S-4	26.2	25.3	24.8	25.4

Initial pH Value and Conductivity

Sample	pH value	Conductivity (umhos/cm)
Control	8.0	275
S-1	8.2	700
S-2	8.2	1100
S-3	8.1	780
S-4	8.0	1500

TABLE 6

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3838

Dissolved Oxygen (mg/l)

Sample	Day 1 i*	Day 1 f*	Day 2 i	Day 2 f	Day 3 i	Day 3 f	Day 4 i	Day 4 f	Day 5 i	Day 5 f	Day 6 i	Day 6 f	Day 7 i	Day 7 f
Control	7.6	6.5	7.9	5.5	8.0	6.2	8.1	6.5	8.0	6.3	8.2	5.3	8.0	4.8
S-1	9.2	6.3	9.2	5.3	10.0	5.8	9.5	5.8	9.4	5.9	9.7	5.2	7.8	5.0
S-2	10.0	6.1	10.5	5.0	9.8	5.7	10.4	6.5	10.4	6.3	10.0	5.0	8.7	5.6
S-3	9.1	6.2	9.4	5.2	9.7	4.9	8.9	5.7	9.4	6.0	8.8	4.9	7.7	5.9
S-4	8.2	6.3	9.5	5.2	8.8	5.6	8.7	5.9	8.4	5.6	7.2	4.7	7.2	5.1

*i = initial
f = final (just before renewal)

pH Value (units)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	8.0	7.9	7.9	8.0	7.9	7.7	7.9
S-1	8.2	7.9	8.0	8.7	8.1	8.1	7.9
S-2	8.2	8.2	8.0	8.4	8.2	8.2	8.1
S-3	8.1	8.1	7.8	8.1	8.0	7.8	7.9
S-4	8.0	7.9	7.8	8.1	7.8	7.7	7.9

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TABLE 6 - continued

FATHEAD MINNOW LARVAE - ENVIRONMENTAL MONITORING
Santa Clara Valley NPS Sample #3838

Conductivity (umhos/cm)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	275	250	285	310	300	270	285
S-1	700	7000	700	600	600	700	700
S-2	1100	1075	1110	1100	1100	1100	1150
S-3	780	780	790	810	740	800	840
S-4	1500	1580	1500	1550	1460	1560	1580

Temperature (°C)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	25.0	25.5	25.0	26.0	23.0	25.5	26.0
S-1	25.0	25.5	25.0	26.0	24.0	25.0	26.0
S-2	25.0	25.5	25.0	26.0	24.0	25.5	26.0
S-3	25.0	25.5	25.0	26.0	23.5	24.5	26.0
S-4	25.0	25.5	24.0	26.0	25.0	25.0	24.0

Alkalinity/Hardness (as mg/l $CaCO_3$)

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Control	60/100	65/100	67/100	67/10C	65/100	67/102	65/102
S-1	125/215	115/218	204/218	142/184	190/190	195/210	212/208
S-2	275/475	300/485	359/550	366/590	352/625	352/584	420/580
S-3	200/320	210/320	275/330	252/344	350/304	275/336	330/294
S-4	390/425	390/435	505/450	512/432	482/440	525/460	550/440

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APPENDIX A

Summary of Test Conditions

TABLE A-1

Ceriodaphnia Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Reproduction
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	9 April, 1989, 11:00 hours
Finish:	16 April, 1989, 11:00 hours
Test Containers:	1 oz plastic cups
Test Volume:	15 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #3
Test Concentrations:	100%, controls
# Replicates:	10
Organisms per replicate:	1
Test Species:	Ceriodaphnia dubia
Source:	in-house culture
Age:	4-8 hours
Acclimation/Culture Water:	EPA Moderately Hard (Milli-Q)
Diet:	Selenastrum, Ceriodaphnia chow

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TABLE A-2

Fathead Minnow Bioassay

Test Type:	Static Daily Renewal
Test Endpoints:	Survival, Growth
Test Duration:	7 days - 168 hours
Temperature:	25 ± 1°C
Photoperiod:	16 L: 8 D
Start:	9 April, 1989, 12:00 hours
Finish:	16 April, 1989, 12:00 hours
Test Containers:	1 liter glass jars
Test Volume:	500 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #3
Test Concentrations:	100%, control
# Replicates:	3
Organisms per replicate:	10
Test Species:	*Pimephales promelas* (Fathead minnow)
Source:	in-house culture
Age:	<24 hours
Culture Water:	Dechlorinated Tap
Diet:	*Artemia* nauplii

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TABLE A-3

Selenastrum Bioassay

Test Type:	Static
Test Endpoints:	Growth, (cell number)
Test Duration:	4 days, 96 hours
Temperature:	24 ± 2°C
Photoperiod:	Continuous light
Light Intensity:	400 ± 40 FC
Start:	8 April, 1989, 13:00 hours
Finish:	12 April, 1989, 13:00 hours
Test Containers:	250 ml Erlenmeyer flasks
Test Volume:	100 ml
Dilution Water:	Not Applicable
Test Material:	Santa Clara Valley NPS - Dry Weather #3
Test Concentrations:	100%, Control
# Replicates:	3
Organisms per replicate:	10,000/ml innoculated
Test Species:	*Selenastrum capricornutum*
Source:	In-house culture
Age:	4 days
Culture Water:	EPA Moderately Hard

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APPENDIX F

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APPENDIX F
USGS/SCVWD WATER AND SEDIMENT QUALITY DATA

8720115A-F CON-2

USGS STATION NO. 11168800
LOS GATOS CREEK AT
LINCOLN AVENUE AT SAN JOSE, CA

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11168800 · LOS GATOS C AT LINCOLN AVE AT SAN JOSE CALIF

DATE	Flow (cfs)	Cond (µmohs)	pH	Temp (deg C)	TDS (mg/l)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
01/12/1980	110.0	315.0	7.1	14.0	190.0	34.0	9.8		6.7	130.0	94.0
01/29/1981	39.0	256.0	7.5	11.5	150.0	44.0	10.4	96	6.9	99.0	78.0
01/05/1982	41.0	204.0	7.8	11.0	120.0	180.0	10.5	95	6.2	87.0	74.0
01/21/1982	1.7	225.0	7.9	7.5	120.0	8.8	11.3	95	4.3	81.0	72.0
01/19/1893	9.7	245.0	8.2	9.5	140.0	5.7	11.3	99	4.0	100.0	84.0
01/27/1983	400.0	188.0	7.8	11.5	120.0	440.0	10.6	99	5.6	80.0	72.0
02/20/1980	202.0	192.0	7.0	12.0	120.0	580.0	10.4		6.2	79.0	67.0
02/17/1982	9.4	321.0	8.6	14.0	190.0	9.2	10.7	103	5.5	140.0	110.0
02/08/1983	561.0	236.0	8.0	11.0	140.0	130.0	11.2	102	4.2	100.0	90.0
02/28/1984	5.0	359.0	9.1	14.0	200.0	1.9	12.6	123	2.5	150.0	124.0
02/13/1986	45.0	420.0	8.2	12.0	260.0	19.0	10.5	97		190.0	137.0
02/24/1986	59.0	160.0	8.1	13.0	120.0	500.0	10.7	101		85.0	69.0
03/06/1980	32.0	272.0	7.8	12.5	160.0	99.0	10.3		6.9	110.0	89.0
03/30/1982	251.0	296.0	8.2	11.0	180.0	32.0	11.2	102	3.4	130.0	108.0
03/01/1983	2600.0	217.0	8.0	12.0	140.0	460.0	11.0		4.5	96.0	84.0
03/17/1984	3.4	307.0	8.6	14.0	180.0	3.0	12.1	116	4.1	140.0	113.0
03/10/1985	128.0	86.0	8.2	14.0	49.0	55.0	10.0	97		31.0	25.0
03/11/1986	551.0	228.0	8.2	14.0	140.0	130.0	10.7	104		97.0	83.0
04/12/1983	18.0	317.0	9.6	14.5	180.0	2.2	16.6	163	2.3	130.0	110.0
05/06/1980	1.0	323.0	8.2	15.0	190.0	1.3	10.1	100	4.2	110.0	73.0
05/17/1983	52.0	275.0	8.8	16.5	170.0	8.7	12.5	128	1.8	130.0	110.0
08/30/1983	1.6	286.0	8.5	23.0	180.0	0.8	11.4	133	2.0	130.0	110.0
09/08/1982	1.0	295.0	7.6	23.5	180.0	1.5	8.3	98	3.0	130.0	104.0
11/20/1979	0.7	407.0	8.2	11.5	240.0	6.6	11.1		6.5	150.0	110.0
11/17/1981	2.2	259.0	7.8	15.5	150.0	2.2	9.0	89	14.0	73.0	58.0
12/30/1981	3.9	408.0	8.4	14.5	240.0	1.0	11.2	110	3.5	120.0	86.0

11168800 - LOS GATOS C AT LINCOLN AVE AT SAN JOSE CALIF

Period	Flow (cfs)	Cond (µmohs)	pH	Temp (deg C)	TDS (mg/l)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
All											
Mean	197.3	273.0	8.1	13.6	163.4	106 0	11.0	107	4.9	111.5	89.8
CV	2.62	0.29	0.07	0.26	0.28	1.67	0.13	0.16	0.53	0.29	0.26
n	26	26	26	26	26	26	26	21	22	26	26
Month											
Nov	1.5	333.0	8.0	13.5	195.0	4.4	10.1	89	10.3	111.5	84.0
Jan	86.5	263.0	7.8	11.4	154.3	101.9	10.7	99	5.3	99.6	80.0
Feb	146.9	281.3	8.2	12.7	171.7	206.7	11.0	105	4.6	124.0	99.5
March	511.9	246.1	8.4	13.1	147.0	111.6	11.7	116	4.2	104.9	87.4
May	26.5	299.0	8.5	15.8	180.0	5.0	11.3	114	3.0	120.0	91.5
Sept	1.3	290.5	8.1	23.3	180.0	1.2	9.9	116	2.5	130.0	107.0
Winter											
Nov-April	230.6	269.0	8.1	12.5	160.4	124.7	11.1	105.4	5.4	109.0	88.0
n	22	22	22	22	22	22	22	17	18	22	22
Summer											
May-Sept	13.9	294.8	8.3	19.5	180.0	3.1	10.6	114.8	2.8	125.0	99.3
n	4	4	4	4	4	4	4	4	4	4	4

C V = Coefficent of Variation
n = Sample number

11168800 - LOS GATOS C AT LINCOLN AVE AT SAN JOSE CALIF

DATE	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO2+NO3 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic N (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
01/12/1980	110.0	0.14	0.08	70.0	40.00	0.85	0.07	1.20	1.30	2.20
01/29/1981	39.0	0.12	0.06	40.0	40.00	0.81	0.10			
01/05/1982	41.0	0.16	0.09	40.0	59.00	1.20	0.11	0.65	0.78	2.00
01/21/1982	1.7	0.08	0.06	60.0	52.00	0.60	0.13	0.55	0.73	1.30
01/19/1893	9.7	0.05	0.01	50.0	30.00	0.33	0.06		1.10	1.40
01/27/1983	400.0	0.75	0.08	40.0	150.00	0.67	0.06	1.10	1.30	2.00
02/20/1980	202.0	0.50	0.06	50.0	160.00	1.10	0.04	1.50	1.70	2.80
02/17/1982	9.4	0.04	0.02	60.0	75.00	0.65	0.09	0.58	0.67	1.30
02/08/1983	561.0	0.16	0.07	40.0	19.00	0.32	0.10	0.92	1.00	1.30
02/28/1984	5.0	0.01	0.01	70.0	33.00	0.10	0.04	0.35	0.40	
02/13/1986	45.0	0.12	0.07	80.0	49.00		0.12	0.59	0.70	1.60
02/24/1986	59.0	0.24	0.02	30.0	84.00		0.05	1.10	1.20	2.00
03/06/1980	32.0	0.12	0.04	60.0	20.00	0.51	0.01	0.70	0.77	1.30
03/30/1982	251.0	0.02	0.03	60.0	10.00	0.40	0.12	0.42	0.52	0.92
03/01/1983	2600.0	0.66	0.03	40.0	130.00	0.30	0.12	1.70	1.80	2.10
03/17/1984	3.4	0.04	0.04	50.0	14.00	0.14	0.02	0.26	0.30	0.50
03/10/1985	128.0	0.38	0.18	20.0	44.00	0.34	0.15	1.40	1.60	1.90
03/11/1986	551.0	0.23	0.02	50.0	96.00		0.02	0.43	0.50	1.20
04/12/1983	18.0	0.03	0.02	70.0	17.00	0.10	0.06	0.61	0.70	
05/06/1980	1.0	0.01	0.00	160.0	10.00	0.02	0.03	0.83	0.93	0.97
05/17/1983	52.0	0.04	0.01	50.0	16.00	0.10	0.07	0.19	0.30	
08/30/1983	1.6	0.01	0.01	50.0	7.00	0.10	0.03		0.20	
09/08/1982	1.0	0.03	0.01	70.0	10.00	0.13	0.14	0.78	1.00	1.10
11/20/1979	0.7	0.02	0.02	110.0	10.00	0.33	0.07	0.34	0.43	0.76
11/17/1981	2.2	0.08	0.08	60.0	49.00	0.46	0.15	0.46	0.57	1.00
12/30/1981	3.9	0.07	0.05	130.0	10.00	0.98	0.07	0.54	0.66	1.70

11168800 - LOS GATOS C AT LINCOLN AVE AT SAN JOSE CALIF

Period	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis. Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO2+NO3 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic N (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
All										
Mean	197.3	0.16	0.05	61.9	47.46	0.46	0.08	0.75	0.85	1.49
CV	2.62	1.26	0.86	0.49	0.93	0.75	0.54	0.55	0.52	0.38
n	26	26	26	26	26	23	26	23	25	21
Month										
Nov	1.5	0.05	0.05	85.0	29.50	0.40	0.11	0.40	0.50	0.88
Jan	86.5	0.20	0.06	61.4	54.43	0.78	0.09	0.81	0.98	1.77
Feb	146.9	0.18	0.04	55.0	70.00	0.54	0.07	0.84	0.95	1.80
March	511.9	0.21	0.05	50.0	47.29	0.30	0.07	0.79	0.88	1.32
May	26.5	0.03	0.01	105.0	13.00	0.06	0.05	0.51	0.62	0.97
Sept	1.3	0.02	0.01	60.0	8.50	0.12	0.09	0.78	0.60	1.10
Winter										
Nov-April	230.6	0.18	0.05	58.2	54.1	0.54	0.08	0.77	0.89	1.54
n	22	22	22	22	22	19	22	20	21	19
Summer										
May-Sept	13.9	0.02	0.01	82.5	10.8	0.09	0.07	0.80	0.61	1.04
n	4	4	4	4	4	4	4	3	4	2

C V = Coefficent of Variation
n = Sample number

Station # 11168800 - LOS GATOS CREEK AT LINCOLN AVE. AT SAN JOSE CALIF

DATE	Flow (cfs)	Zn Dissolved (µg/l)	Zn Sediment (µg/gm)	Pb Dissolved (µg/l)	Pb Sediment (µg/gm)	Cu Dissolved (µg/l)	Cu Sediment (µg/gm)	As Dissolved (µg/l)	As Sediment (µg/gm)
01/05/1982	41	10	80	6	60	2	20	1	5
01/27/1983	400	4	60	1	50	3	10	1	4
02/20/1980	202	20	100	6	150	2	30	1	5
02/13/1986	45	18		2		2		1	
02/24/1986	59	10		1		1		1	
08/30/1983	1.6	6	30	1	20	2	10	1	3
09/08/1982	1	10	30	1	20	2	9	1	15
All									
Mean	107.1	11.1	60.0	2.6	60.0	2.0	15.8	1.0	6.4
CV	1.36	0.53	0.51	0.92	0.89	0.29	0.58	0.00	0.76
n	7	7	5	7	5	7	5	7	5
Winter									
Mean	149.4	12.4	80.0	3.2	86.7	2.0	20.0	1.0	4.7
n	5	5	3	5	3	5	3	5	3
Summer									
Mean	1.3	8.0	30.0	1.0	20.0	2.0	9.5	1.0	9.0
n	2	2	2	2	2	2	2	2	2

Station # 11 68800 - LOS GATOS CREEK AT LINCOLN AVE. AT SAN JOSE CALIF

DATE	Flow (cfs)	Fe Sediment (µg/l)	Mn Dissolved (µg/l)	Mn Sediment (µg/gm)	Al Dissolved (µg/l)	Al Sediment (µg/gm)	Co Sediment (µg/gm)
01/05/1982	41	13000	10	270	30	6500	10
01/27/1983	400	8500	11	200	130	5000	10
02/20/1980	202	6200	0	240	170	60	20
02/13/1986	45		6		20		
02/24/1986	59		10		30		
08/30/1983	1.6	5500	1	170	10	3200	10
09/08/1982	1	3200	10	110	10	1900	10
All							
Mean	107.1	7280.0	6.9	198.0	57.1	3332.0	12.0
CV	1.36	0.51	0.68	0.31	1.14	0.76	0.37
n	7	5	7	5	7	5	5
Winter							
Mean	149.4	9233.3	7.4	236.7	76.0	3853.3	13.3
n	5	3	5	3	5	3	3
Summer							
Mean	1.3	4350.0	5.5	140.0	10.0	2550.0	10.0
n	2	2	2	2	2	2	2

Station # 11168800 - LOS GATOS CREEK AT LINCOLN AVE. AT SAN JOSE CALIF

DATE	Flow (cfs)	Cd Dissolved (µg/l)	Cd Sediment (µg/gm)	Cr Dissolved (µg/l)	Cr Sediment (µg/gm)	Hg Dissolved (µg/l)	Hg Sediment (µg/gm)	Ni AS NI) (01065)	Se Sediment (µg/gm)
01/05/1982	41	1	1	<10	30	<0.1	0.07	<100	<1
01/27/1983	400	<1	<1	<10	20	<0.1	0.06	<100	<1
02/20/1980	202	0	1	0	20	0.1	0.03	0	0
02/13/1986	45	<1		<10		<0.1		<100	
02/24/1986	59	<1		<10		<0.1		<100	
08/30/1983	1.6	<1	<1	<10	10	<0.1	0.04	<100	<1
09/08/1982	1	<1	<1	<10	6	<0.1	0.03	<100	<1

11168000 - LOS GATOS C AT LINCOLN AVE AT SAN JOSE CALIF

DATE	Total Diazinon (µg/l)	Total 2,4-D, (µg/l)	Total Lindane (µg/l)	Total Malathion (µg/l)	Total Chlordane (µg/l)	Total DDD (µg/l)	Total DDE (µg/l)	Total DDT (µg/l)	Total Dieldrin (µg/l)	Total Heptachlor (µg/l)
02/20/1980	0.02		0.01	0	0	0	0	0.01	0	0
01/05/1982	0.03	0.02	0.01	0.13	0	0	0	0	0	0
09/08/1982	<0.01	0.02	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
01/27/1983	0.03	0.01	0.02	0.01	0.1	<0.010	0.01	<0.010	<0.010	<0.010
04/12/1983	0.01	0.03	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
08/30/1983	0.01	0.02	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
02/13/1986	0.1	0.03	<0.010	0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010

11168800 · LOS GATOS C AT LINCOLN AVE AT SAN JOSE CALIF

DATE	Naphthalenes Polychlor (µg/l)	Total PCB (µg/l)	Total Aldrin (µg/l)	Total Endosulfan (µg/l)	Total Endrin (µg/l)	Total Ethion (µg/l)	Total Chlor Epoxide (µg/l)	Total Oxychlor (µg/l)	Total Methyl Parathion (µg/l)
02/20/1980	0	0	0	0	0	0	0	0	0
01/05/1982	0	0	0	0	0	0	0	0	0
09/08/1982	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
01/27/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
04/12/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
08/30/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
02/13/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01

11160800 - LOS GATOS C AT LINCOLN AVE AT SAN JOSE CALIF

DATE	Total Methyl Trithion (µg/l)	Total Mirex (µg/l)	Total Perthane (µg/l)	Total Toxaphene (µg/l)	Total Trithion (µg/l)	Total 2,4,5-T (µg/l)	Total Silvex (µg/l)
02/20/1980	0	0	0	0	0		
01/05/1982	0	0	0	0	0	0	0
09/08/1982	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
01/27/1983	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
04/12/1983	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
08/30/1983	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
02/13/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01

8720115A-F CON-3

USGS STATION NO. 11168660

LOS GATOS CREEK AT

LARK AVENUE AT LOS GATOS, CA

VOL 12

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11168660 - LOS GATOS C AT LARK A AT LOS GATOS CALIF

DATE	Flow (cfs)	Cond (µmohs)	pH	Temp (deg C)	TDS (mg/l)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
01/17/1979	34.0	339.0	7.5	10.0	200.0		8.9			150.0	110.0
01/12/1980	211.0	347.0	7.2	12.5	230.0	37.0	10.2		5.9	170.0	130.0
01/29/1981	68.0	343.0	7.2	11.0	190.0	46.0	10.5	96.0	8.2	140.0	110.0
01/05/1982	192.0	182.0	7.8	10.0	110.0	240.0	10.8	97.0	6.3	84.0	74.0
01/21/1982	16.0	366.0	7.8	8.5	210.0	24.0	10.8	93.0	4.2	170.0	143.0
01/19/1983	33.0	308.0	7.7	8.5	180.0	22.0	10.9	94.0	3.8	140.0	110.0
01/27/1983	108.0	177.0	7.7	10.5	130.0	340.0	10.4	95.0	5.6	81.0	74.0
01/15/1985	2.2	608.0	8.0	8.5	370.0	25.0	9.2	79.0	2.1	290.0	246.0
01/29/1985	2.7	588.0	7.9	9.0	350.0	20.0	9.2	80.0	3.6	270.0	236.0
01/29/1986	2.7	556.0	8.0	11.5	340.0	1.5	8.0	74.0		270.0	185.0
02/14/1979	24.0	388.0	8.4	12.5	240.0		7.6			180.0	120.0
02/19/1980	294.0	170.0	7.6	12.5	100.0	730.0	10.2		7.1	73.0	63.0
02/17/1982	43.0	303.0	8.0	13.0	170.0	56.0	10.2	96.0	5.2	140.0	112.0
02/08/1983	656.0	232.0	7.9	11.0	140.0	140.0	10.9	100.0	4.6	100.0	88.0
02/28/1984	24.0	355.0	8.5	12.0	210.0	3.2	10.6	99.0	2.9	160.0	133.0
02/08/1985	159.0	178.0	7.7	11.0	110.0	43.0	9.7	89.0		77.0	60.0
02/13/1986	47.0	443.0	8.2	11.5	270.0	20.0	9.8	90.0		210.0	153.0
02/24/1986	485.0	156.0	8.0	13.0	120.0	400.0	10.2	98.0		86.0	67.0
03/16/1979	17.0	410.0	8.3	13.5	250.0		11.5			190.0	140.0
03/27/1979	68.0	372.0	8.0	14.5	230.0		9.8			170.0	130.0
03/06/1980	369.0	271.0	7.3	12.0	160.0	110.0	10.6		11.0	120.0	89.0
03/05/1981	17.0	394.0	7.3	11.0	240.0	7.4	9.9	91.0	6.2	180.0	140.0
03/27/1981	18.0	396.0	8.1	13.0	240.0	12.0	9.6	91.0	6.5	180.0	140.0
03/30/1982	388.0	297.0	8.0	10.5	180.0	33.0	11.0	99.0	3.6	130.0	107.0
03/01/1983	1240.0	204.0	7.9	12.0	130.0	380.0	10.6	99.0	4.1	90.0	82.0
03/17/1984	29.0	346.0	8.3	13.5	210.0	8.0	9.0	86.0	5.6	160.0	129.0
03/10/1985	10.0	436.0	8.4	13.0	260.0	7.8	11.4	109.0		200.0	145.0
03/11/1986	649.0	228.0	8.2	14.0	130.0	120.0	10.1	99.0		97.0	74.0
04/12/1983	66.0	288.0	8.4	12.5	180.0	17.0	10.6	100.0	1.8	130.0	120.0
04/26/1979	21.0	387.0	8.1	15.5	230.0		9.8			170.0	120.0
05/23/1979	1.3	397.0	8.4	25.5	250.0		12.1			200.0	130.0
05/06/1980	23.0	316.0	8.2	16.5	200.0	9.0	9.9	102.0	7.2	150.0	120.0
05/19/1981	2.1	413.0	7.7	16.0	270.0	0.8	6.0	61.0	7.3	190.0	150.0
05/18/1982	31.0	293.0	8.2	15.0	190.0	8.6	9.7	97.0	2.2	140.0	118.0
05/17/1983	96.0	273.0	8.3	14.5	170.0	15.0	9.9	97.0	1.7	130.0	110.0

05/13/1986	29.0	279.0	8.3	16.0	180.0	20.0	8.9	91.0		130.0	108.0
06/12/1984	21.0	353.0	8.3	19.0	210.0	1.5	8.2	89.0	2.8	160.0	133.0
06/13/1985	43.0	506.0	8.3	21.5	310.0	6.1	8.0	92.0		240.0	169.0
07/31/1979	13.0	387.0	7.7	21.0	240.0		8.9			160.0	130.0
07/16/1980	30.0	298.0	7.4	16.5	190.0	13.0	9.2	95.0	2.7	140.0	120.0
07/14/1981	12.0	437.0	8.0	22.5	280.0	1.5	6.9	81.0	5.0	200.0	150.0
07/20/1982	32.0	289.0	8.1	20.0	180.0	4.1	8.5	94.0	2.8	140.0	116.0
07/12/1983	60.0	301.0	8.2	17.5	170.0	5.0	8.9	94.0	1.9	130.0	110.0
07/10/1984	23.0	366.0	8.3	21.5	210.0	3.9	7.7	88.0	2.8	160.0	131.0
07/24/1985	13.0	563.0	8.1	24.0	340.0	1.6	6.7	81.0		260.0	198.0
07/22/1986	27.0	299.0	8.4	20.5	180.0	2.9	8.5	95.0		130.0	117.0
08/30/1983	46.0	292.0	8.1	19.0	180.0	3.3	8.4	91.0	2.0	140.0	110.0
08/27/1984	43.0	363.0	7.7	19.5	210.0	5.0	8.3	91.0	3.3	170.0	130.0
09/04/1979	28.0	399.0	8.2	21.0	240.0		8.4			180.0	120.0
09/10/1980	74.0	318.0	7.8	19.0	200.0	4.4	8.8		4.1	150.0	120.0
09/01/1981	11.0	488.0	7.6	22.0	300.0	1.5	6.8	79.0	3.4	220.0	160.0
09/08/1982	63.0	279.0	7.8	17.5	170.0	3.0	9.2	97.0	2.5	130.0	106.0
09/11/1985	2.2	554.0	8.0	17.0	330.0	3.5	6.4	67.0		250.0	194.0
09/23/1986	5.5	365.0	8.1	18.0	210.0	1.3	7.1	76.0		160.0	144.0
11/20/1979	10.0	446.0	7.5	13.5	300.0	1.8	9.5		11.0	230.0	160.0
11/18/1980	16.0	392.0	8.3	13.0	220.0	2.5	11.0	104.0	6.2	170.0	150.0
11/17/1981	31.0	377.0	7.9	15.5	240.0	15.0	9.0	91.0	15.0	170.0	130.0
11/16/1982	53.0	341.0	8.3	13.0	210.0	3.3	9.5	91.0	2.9	150.0	130.0
12/30/1981	0.6	459.0	7.7	12.0	270.0	3.0	7.0	66.0	5.9	210.0	180.0

11168660 - LOS GATOS C AT LARK A AT LOS GATOS CALIF

Period	Flow (cfs)	Cond (µmohs)	pH	Temp (deg C)	TDS (mg/l)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Dis Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
All											
Mean	104.0	354.4	8.0	14.9	216.3	58.5	9.3	90.5	4.9	162.7	128.4
CV	2.01	0.29	0.04	0.28	0.29	2.29	0.15	0.11	0.58	0.31	0.29
n	59	59	59	59	59	51	59	46	39	59	59
Month											
Nov	27.5	389.0	8.0	13.8	242.5	5.7	9.8	95.3	8.8	180.0	142.5
Jan	60.9	388.5	7.7	10.2	234.5	75.9	9.6	86.0	5.1	179.5	145.3
Feb	216.5	278.1	8.0	12.1	170.0	198.9	9.9	95.3	5.0	128.3	99.5
March	261.0	331.1	8.0	12.7	200.9	77.2	10.4	96.8	5.5	149.7	117.8
May	29.7	357.4	8.2	17.7	223.3	8.7	9.2	89.9	4.2	167.8	128.7
July	26.3	367.5	8.0	20.4	223.8	4.6	8.2	89.7	3.0	165.0	134.0
Sept	34.1	382.3	7.9	19.1	230.0	3.1	7.9	83.5	3.1	175.0	135.5
Winter											
Nov - April	154.4	346.7	7.9	12.2	212.0	89.4	9.9	93.4	6.1	159.4	126.3
n	35	35	35	35	35	30	35	26	24	35	35
Summer											
May - Sept	30.4	369.1	8.0	19.1	225.7	5.5	8.4	87.7	3.4	169.3	132.7
n	24	24	24	24	24	21	24	20	15	24	24

C V = Coefficent of Variation
n = Sample number

flow	tds	turb	th	tp	no2+no3	tn
27.50	242.50	5.65	180.00	0.03	0.31	1.20
60.93	234.55	75.85	179.55	0.17	0.79	1.64
216.50	170.00	198.89	128.25	0.26	0.54	2.33
261.00	200.91	77.24	149.73	0.10	0.39	1.13
29.71	223.33	8.71	167.78	0.04	0.20	0.96
26.25	223.75	4.57	165.00	0.03	0.09	0.81
34.09	230.00	3.14	175.00	0.04	0.10	0.89

flow	tds	turb	th	tp	no2+no3	tn
27.50	242.50	5.65	180.00	0.03	0.31	1.20
60.93	234.55	75.85	179.55	0.17	0.79	1.64
216.50	170.00	198.89	128.25	0.26	0.54	2.33
261.00	200.91	77.24	149.73	0.10	0.39	1.13
29.71	223.33	8.71	167.78	0.04	0.20	0.96
26.25	223.75	4.57	165.00	0.03	0.09	0.81
34.09	230.00	3.14	175.00	0.04	0.10	0.89

11168660 - LOS GATOS C AT LARK A AT LOS GATOS CALIF

DATE	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis. Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO2+NO3 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic N (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
01/17/1979	34.0	0.12	0.01	60.0	30.00	0.83	0.06	0.58	0.66	1.50
01/12/1980	211.0	0.12	0.04	60.0	50.00	0.77	0.14	1.20	1.30	2.10
01/29/1981	68.0	0.11	0.04	40.0	60.00	0.84	0.10	1.20	1.30	2.20
01/05/1982	192.0	0.18	0.10	40.0	85.00	1.10	0.10	0.84	0.96	2.10
01/21/1982	16.0	0.07	0.06	50.0	52.00	1.30	0.15	0.62	0.76	2.10
01/19/1983	33.0	0.08	0.01	50.0	15.00	0.29	0.06		0.40	0.70
01/27/1983	108.0	0.75	0.07	30.0	170.00	0.67	0.13	1.00	1.20	1.80
01/15/1985	2.2	0.13	0.04	80.0	6.00	0.72	0.44	0.47	0.90	1.60
01/29/1985	2.7	0.09	0.02	80.0	5.00	0.41	0.21	0.48	0.70	1.10
01/29/1986	2.7	0.05	0.02	80.0	5.00		0.12	0.57	0.70	1.20
02/14/1979	24.0	0.06	0.01	90.0	20.00	0.45	0.02	0.42	0.50	0.92
02/19/1980	294.0	0.63	0.08	50.0	160.00	1.00	0.06	2.70	3.00	4.10
02/17/1982	43.0	0.07	0.04	50.0	74.00	0.72	0.09	0.64	0.74	1.50
02/08/1983	656.0	0.15	0.07	40.0	16.00	0.32	0.12	1.10	1.20	1.50
02/28/1984	24.0	0.04	0.01	50.0	33.00	0.10	0.03	0.25	0.30	
02/08/1985	159.0	0.80	0.02	30.0	500.00	0.63	0.33	4.10	4.50	5.10
02/13/1986	47.0	0.07	0.06	90.0	32.00		0.15	0.56	0.70	1.40
02/24/1986	485.0	0.23	0.02	30.0	16.00		0.05	1.00	1.10	1.80
03/16/1979	17.0	0.03	0.01	80.0	30.00	0.54	0.04	0.39	0.46	1.00
03/27/1979	68.0	0.04	0.01	80.0	20.00	0.51	0.12	0.48	0.57	1.10
03/06/1980	369.0	0.11	0.03	50.0	70.00	0.44	0.01	1.20	1.20	1.70
03/05/1981	17.0	0.07	0.00	50.0	20.00	0.54	0.05	0.81	0.86	1.40
03/27/1981	18.0	0.05	0.00	40.0	10.00	0.32	0.04	0.64	0.67	0.99
03/30/1982	388.0	0.07	0.04	50.0	14.00	0.40	0.11	0.33	0.48	0.88
03/01/1983	1240.0	0.44	0.03	40.0	86.00	0.31	0.08	1.30	1.40	1.70
03/17/1984	29.0	0.05	0.02	50.0	9.00	0.18	0.05	0.67	0.70	0.90
03/10/1985	10.0	0.05	0.01	70.0	18.00	0.33	0.01	0.45	0.50	0.80
03/11/1986	649.0	0.12	0.02	40.0	110.00		0.04	0.33	0.40	1.00
04/12/1983	66.0	0.05	0.03	40.0	13.00	0.30	0.06	0.58	0.70	1.00
04/26/1979	21.0	0.03	0.02	90.0	20.00	0.38	0.01	0.35	0.43	0.83
05/23/1979	1.3	0.03	0.01	80.0	10.00	0.27	0.01	0.36	0.41	0.83
05/06/1980	23.0	0.03	0.00	50.0	10.00	0.20	0.06	1.40	1.50	1.70
05/19/1981	2.1	0.05	0.03	40.0	10.00	0.26	0.16	0.49	0.66	0.93
05/18/1982	31.0	0.07	0.01	40.0	9.00	0.16	0.11	0.47	0.57	0.73
05/17/1983	96.0	0.04	0.01	40.0	15.00	0.14	0.07	0.80	0.90	1.00

05/13/1986	29.0	0.06	0.01	40.0	4.00		0.05	0.45	0.50	0.70
06/12/1984	21.0	0.01	0.01	50.0	9.00	0.10	0.03	0.36	0.40	
06/13/1985	43.0	0.05	0.01	70.0	3.00	0.10	0.05	0.32	0.40	
07/31/1979	13.0	0.01	0.01	90.0	10.00	0.03	0.04	0.34	0.36	0.41
07/16/1980	30.0	0.06	0.00	70.0	10.00	0.25	0.04	0.75	0.83	1.10
07/14/1981	12.0	0.05	0.02	60.0	10.00	0.04	0.11	0.48	0.73	0.82
07/20/1982	32.0	0.01	0.01	50.0	8.00	0.10	0.11	0.98	1.10	1.20
07/12/1983	60.0	0.04	0.01	40.0	11.00	0.10	0.06	0.46	0.50	
07/10/1984	23.0	0.01	0.01	50.0	3.00	0.10	0.01	0.26	0.30	
07/24/1985	13.0	0.04	0.04	70.0	10.00	0.01	0.06	0.35	0.40	
07/22/1986	27.0	0.01	0.01	50.0	11.00		0.04	0.26	0.30	0.50
08/30/1983	46.0	0.01	0.01	40.0	10.00	0.10	0.03	0.20	0.30	
08/27/1984	43.0	0.02	0.01	50.0	4.00	0.10	0.03	0.27	0.30	
09/04/1979	28.0	0.04		70.0	10.00		0.11	0.61	0.70	0.79
09/10/1980	74.0	0 04	0.04	70.0	10.00	0.08	0.04	0.54	0.56	0.66
09/01/1981	11.0	0.07	0.02	80.0	10.00	0.08	0.15	0.79	0.98	1.00
09/08/1982	63.0	0.04	0.01	50.0	3.00	0.15	0.10	0.68	0.90	1.10
09/11/1985	2.2	0.08	0.03	90.0	8.00	0.11	0.08	0.71	0.80	0.90
09/23/1986	5.5	0.05	0.01	60.0	5.00		0.05	0.32	0.40	
11/20/1979	10.0	0.02	0.02	80.0	10.00	0.18	0.12	0.45	0.61	0.79
11/18/1980	16.0	0.02	0.01	80.0	10.00	0.07	0.05			
11/17/1981	31.0	0.06	0.06	50.0	40.00	0.88	0.26	0.52	0.75	1.60
11/16/1982	53.0	0.01	0.01	50.0	5.00	0.10	0.08		1.20	
12/30/1981	0.6	0.12	0.09	60.0	26.00	0.99	0.11	0.52	0.66	1.60

11168660 - LOS GATOS C AT LARK A AT LOS GATOS CALIF

Period	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO2+NO3 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic N (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
All										
Mean	104.0	0.10	0.03	57.6	34.63	0.37	0.09	0.70	0.82	1.34
CV	2.01	1.58	0.92	0.31	2.05	0.86	0.86	0.87	0.80	0.62
	59	59	58	59	59	51	59	56	58	48
Month										
Nov	27.5	0.03	0.03	65.0	16.25	0.31	0.13	0.49	0.85	1.20
Jan	60.9	0.17	0.05	57.3	45.82	0.79	0.15	0.75	0.87	1.64
Feb	216.5	0.26	0.04	53.8	106.38	0.54	0.11	1.35	1.51	2.33
March	261.0	0.10	0.02	53.6	36.36	0.39	0.06	0.65	0.72	1.13
May	29.7	0.04	0.01	55.6	10.00	0.20	0.06	0.56	0.64	0.96
July	26.3	0.03	0.01	60.0	9.13	0.09	0.06	0.49	0.57	0.61
Sept	34.1	0.04	0.02	63.8	7.50	0.10	0.07	0.52	0.62	0.89
Winter										
Nov - April	141.5	0.14	0.03	57.4	51.20	0.51	0.11	0.81	0.99	1.57
n	35	35	35	35	35	31	35	32	34	32
Summer										
May - Sept	30.0	0.04	0.01	59.8	8.88	0.13	0.06	0.52	0.61	0.89
n	24	24	23	24	24	20	24	24	24	16

C V = Coefficent of Variation
n = Sample number

Station # 11168660 - LOS GATOS CREEK AT LARK AVE. AT LOS GATOS CALIF

DATE	Flow (cfs)	Zn Dissolved (µg/l)	Zn Sediment (µg/gm)	Pb Dissolved (µg/l)	Pb Sediment (µg/gm)	Cu Dissolved (µg/l)	Cu Sediment (µg/gm)	As Dissolved (µg/l)	As Sediment (µg/gm)
01/17/1979	34	3		7		3		1	
01/05/1982	192	10	60	6	30	2	20	1	7
01/27/1983	108	7	60	1	20	2	20	1	4
02/19/1980	294	10	60	ND	90	1	20	1	5
02/08/1985	159	16	70	2	40	2	30	1	7
02/13/1986	47	51		3		1		1	
02/24/1986	185	10		1		2		1	
03/27/1981	18	10	40	ND	40	4	8	2	9
07/31/1979	13	3		ND		ND		1	
08/30/1983	46	6	30	1	10	1	20	1	3
08/27/1984	43	17	80	1	20	1	30	1	1
09/10/1980	74	10	50	4	40		20	2	4
09/01/1981	11	10	60	2	10	9	20	2	4
09/08/1982	63	10	50	1	20	1	20	1	4
09/11/1985	2.2	10	120	1	60	4	50	2	6
All									
Mean	105.9	12.2	61.8	2.5	34.5	2.5	23.5	1.3	4.9
CV	1.25	0.93	0.38	0.84	0.69	0.88	0.45	0.36	0.45
n	15	15	11	12	11	13	11	15	11
Winter									
Mean	167.1	14.6	58.0	3.3	44.0	2.1	19.6	1.1	6.4
CV	0.95	1.04	0.19	0.77	0.61	0.47	0.40	0.31	0.30
n	8	8	5	6	5	8	5	8	5
Summer									
Mean	36.0	9.4	65.0	1.7	26.7	3.2	26.7	1.4	3.7
CV	0.77	0.46	0.48	0.73	0.74	1.09	0.45	0.37	0.45
n	7	7	6	6	6	5	6	7	6

Station # 11168660 - LOS GATOS CREEK AT LARK AVE. AT LOS GATOS CALIF

DATE	Flow (cfs)	Fe Sediment (µg/l)	Mn Dissolved (µg/l)	Mn Sediment (µg/gm)	Al Dissolved (µg/l)	Al Sediment (µg/gm)	Cb Sediment (µg/gm)
01/17/1979	34		10		10		
01/05/1982	192	14000	10	460	40	7500	10
01/27/1983	108	10000	30	410	150	6000	10
02/19/1980	294	7300	ND	190	50	640	10
02/08/1985	159	36000	400	780	50	16000	30
02/13/1986	47		41		10		
02/24/1986	485		10		40		
03/27/1981	18	7000	50	480	10	4200	10
07/31/1979	13		100		100		
08/30/1983	46	4800	24	300	10	2300	10
08/27/1984	43	18000	75	860	10	9300	10
09/10/1980	74	10000	130	350	ND	3400	20
09/01/1981	11	16000	10	600	ND	4000	10
09/08/1982	63	8000	20	310	10	3300	10
09/11/1985	2.2	22000	130	2100	10	13000	20
All							
Mean	105.9	13918.2	74.3	621.8	38.5	6330.9	13.6
CV	1.25	0.65	1.39	0.85	1.12	0.75	0.49
n	15	11	14	11	13	11	11
Winter							
Mean	167.1	14860.0	78.7	464.0	45.0	6868.0	14.0
CV	0.95	0.82	1.81	0.45	1.02	0.83	0.64
n	8	5	7	5	8	5	5
Summer							
Mean	36.0	13133.3	69.9	753.3	28.0	5883.3	13.3
CV	0.77	0.50	0.75	0.92	1.44	0.73	0.39
n	7	6	7	6	5	6	6

Station # 11168660 - LOS GATOS CREEK AT LARK AVE. AT LOS GATOS CALIF

DATE	Flow (cfs)	Cd Dissolved (µg/l)	Cd Sediment (µg/gm)	Cr Dissolved (µg/l)	Cr Sediment (µg/gm)	Hg Dissolved (µg/l)	Hg Sediment (µg/gm)	Ni Dissolved (µg/l)	Se Dissolved (µg/l)	Se Sediment (µg/gm)
01/17/1979	34	<2		<20		<0.1		ND		
01/05/1982	192	1	1	<10	30	<0.1	0.08	<100		<1
01/27/1983	108	<1	<1	<10	20	<0.1	0.05	<100		<1
02/19/1980	294	0	0	0	20	0	0.03	0		0
02/08/1985	159	<1	<1	<10	160	<0.1	1.5	<100	<1	<1
02/13/1986	47	<1		<10		<0.1		<100		
02/24/1986	485	<1		<10		<0.1		<100		
03/27/1981	18	0	0	10	14	0	0.9	0		0
07/31/1979	13	2		<20		<0.1		ND		
08/30/1983	46	<1	<1	<10	9	<0.1	0.06	<100		<1
08/27/1984	43	<1	<1	<10	40	<0.1	1.1	<100		<1
09/10/1980	74	0	2	0	21	0	0.04	0		0
09/01/1981	1	1	<1	0	30	0	0.06	0		0
09/08/1982	63	<1	<1	<10	20	<0.1	0.05	<100		<1
09/11/1985	2.2	1	0		680	<0.1	0.2	<100		<1

Station #11168660 - LOS GATOS CREEK AT LARK AVE. AT LOS GATOS CALIF

DATE	Total Diazinon (µg/l)	Total 2,4-D, (µg/l)	Total Lindane (µg/l)	Total Malathion (µg/l)	Total Chlordane (µg/l)	Total DDD (µg/l)	Total DDE (µg/l)	Total DDT (µg/l)	Total Dieldrin (µg/l)	Total Heptachlor (µg/l)
02/19/1980	0.01	0.02	0.01	0	0	0	0.01	0.02	0	0
09/10/1980	0	0	0	0	0	0	0	0	0	0
03/27/1981	0.01	0	0	0	0	0	0	0	0	0
09/01/1981	0	0.01	0	0.61	0	0	0	0	0	0
01/05/1982	0.01	0.02	0	0.1	0	0	0	0	0	0
09/08/1982	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
01/27/1983	0.02		0.01	0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
04/12/1983	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
08/30/1983	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
08/27/1984	<0.01	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
02/08/1985	0.16	0.04	0.01	0.01	0.1	0.01	0.01	0.01	<0.010	<0.010
09/11/1985	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
01/29/1986	0.06	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
02/13/1986	0.1	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
02/24/1986	<0.01		<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
07/22/1986	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
07/23/1986	<0.01	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010

Station #11168660 - LOS GATOS CREEK AT LARK AVE. AT LOS GATOS CALIF

DATE	Naphthalenes Polychlor (µg/l)	Total PCB (µg/l)	Total Aldrin (µg/l)	Total Endosulfan (µg/l)	Total Endrin (µg/l)	Total Ethion (µg/l)	Total Chlor Epoxide (µg/l)	Total Oxychlor (µg/l)	Total Methyl Parathion (µg/l)
02/19/1980	0	0	0	0	0	0	0	0	0
09/10/1980	0	0	0	0	0	0	0	0	0
03/27/1981	0	0	0	0	0	0	0	0	0
09/01/1981	0	0	0	0	0	0	0	0	0
01/05/1982	0	0	0	0	0	0	0	0	0
09/08/1982	<0.10	<0.1	<0.010	<0.010	0	0	0	0	0
01/27/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
04/12/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
08/30/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
08/27/1984	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
02/08/1985	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
09/11/1985	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
01/29/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
02/13/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
02/24/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
07/22/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
07/23/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01

Station #11168660 - LOS GATOS CREEK AT LARK AVE. AT LOS GATOS CALIF

DATE	Total Methyl Trithion (µg/l)	Total Mirex (µg/l)	Total Perthane (µg/l)	Total Toxaphene (µg/l)	Total Trithion (µg/l)	Total 2,4,5-T (µg/l)	Total Silvex (µg/l)
02/19/1980	0	0	0	0	0	0	0.01
09/10/1980	0	0	0	0	0	0	0
03/27/1981	0	0	0	0	0	0	0
09/01/1981	0	0	0	0	0	0	0
01/05/1982	0	0	0	0	0	0	0.01
09/08/1982	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
01/27/1983	<0.01	<0.01	<0.1	<1	<0.01		
04/12/1983	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
08/30/1983	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
08/27/1984	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
02/08/1985	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
09/11/1985	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
01/29/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
02/13/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
02/24/1986	<0.01	<0.01	<0.1	<1	<0.01		
07/22/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
07/23/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01

USGS STATION NO. 11168000

LOS GATOS CREEK AT

LOS GATOS, CA

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Station #11168000 -LOS GATOS CREEK AT LOS GATOS, CALIF.

DATE	Flow (cfs)	Cond (µmohs)	TDS (mg/l)	pH	Temp (deg C)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
1/12/80	62.0	217.0	125.0		13.0	100.0	10.1		7.6	94.0	79.0
1/29/81		340.0	191.2			160.0				140.0	
1/4/82		156.0	102.9			570.0				76.0	
1/20/82		341.0	191.2			22.0				160.0	
1/19/83	28.0	321.0	198.5	7.9	8.0	29.0	11.2	96	3.5	150.0	120.0
1/26/83		180.0	110.3			370.0				80.0	
1/15/85	0.4	530.0	323.5	8.1	7.5	0.5	13.4	112	1.6	270.0	222.0
1/29/85	0.3	539.0	323.5	7.8	7.5	0.3	12.4	104	2.5	260.0	222.0
1/26/86	4.1	488.0	294.1	8.0	11.0	24.0	10.8	99		230.0	148.0
2/19/80	99.0	186.0	117.6	7.4	12.0	550.0	10.1		5.0	81.0	75.0
2/16/82		286.0	169.1			120.0				130.0	
2/7/83		241.0	154.4			150.0				110.0	
2/27/84		343.0	205.9			16.0				150.0	
2/8/85	34.0	231.0	125.0	8.0	9.5	64.0	11.0	97		110.0	72.0
2/13/86	2.0	327.0	191.2	8.2	12.0	130.0	9.2	86		150.0	131.0
2/24/86	181.0	146.0	117.6	7.9		350.0	10.4			80.0	66.0
3/5/80		262.0	161.8			110.0				110.0	87.0
3/4/81		413.0	235.3			54.0				180.0	
3/25/81		414.0	235.3			70.0				180.0	
3/30/82	259.0	301.0	183.8	8.0	10.5	21.0	11.0	100	3.0	130.0	106.0
3/1/83			132.3			220.0				98.0	
3/17/84	22.0	340.0	198.5	8.1	11.0	7.6	10.9	99	2.9	150.0	126.0
3/10/85	16.0	400.0	235.3	8.2	11.0	28.0	11.4	104		170.0	
3/4/86	113.0	208.0	117.6	8.0	13.0	170.0	10.2	98		87.0	70.0
3/11/86	324.0	220.0	125.0	8.2	14.0	88.0	9.6	94		95.0	79.0
4/11/83			169.1			1.4				120.0	
4/15/86	47.0	244.0	139.7	8.1	13.0	53.0	10.2	98		100.0	89.0
5/6/80	19.0	281.0	176.5	8.0	13.0	36.0	10.9	104	6.1	130.0	98.0
5/18/81		421.0	250.0			19.0				180.0	
5/17/82		266.0	161.8			17.0				120.0	
5/16/83		271.0	169.1			19.0				120.0	
5/13/86	30.0	246.0	154.4	8.1	13.0	2.0	10.2	98		110.0	92.0
6/11/84			205.9			5.1				180.0	
6/11/85	46.0	515.0	330.9	8.3	19.0	6.5	9.0	99	3.7	250.0	176.0
6/10/86	52.0	252.0	154.4	8.3	15.0	1.5	10.8	108		110.0	98.0
7/16/80		292.0	176.5			12.0				130.0	100.0
7/13/81		455.0	279.4			6.1				210.0	
7/19/82		274.0	169.1			15.0				120.0	

7/12/83	60.0	281.0	169.1	8.0	13.5	8.4	10.3	101	1.9	120.0	110.0
7/10/84	23.0	355.0	205.9	8.3	14.0	2.2	10.7	106		160.0	125.0
7/24/85	5.3	711.0	441.1	8.3	22.5	7.0	8.5	100		360.0	285.0
7/22/86	37.0	283.0	176.5	8.2	15.0	2.0	11.0	110		110.0	110.0
8/1/81		532.0	323.5			11.0				250.0	
8/29/83		285.0	176.5			4.0				140.0	
8/27/84	46.0	365.0	220.6	8.1	20.0	2.1	9.3	103	3.0	170.0	137.0
8/20/86	58.0	291.0	169.1	8.0	17.0	4.4	10.6	111		120.0	107.0
9/10/80		331.0	191.2			11.0				150.0	110.0
9/8/82	67.0	270.0	169.1	7.5	13.5	2.7	10.3	100	2.2	120.0	102.0
9/11/85	4.8	550.0	352.9	8.0	12.0	43.0	10.0	94		280.0	236.0
9/23/86	0.2	380.0	242.6	8.1	15.0	0.7	10.0	100		180.0	167.0
11/20/79	9.2	445.0	308.8	8.2	13.0	12.0	10.3		7.2	220.0	160.0
11/18/80		385.0	213.2			16.0				160.0	
11/16/81		347.0	205.9			15.0				160.0	
11/16/82	59.0	337.0	205.9	8.2	14.0	3.5	10.0	99	3.4	150.0	130.0
12/30/81	5.9	380.0	213.2	8.1	11.5	4.2	10.7	99	5.2	180.0	166.0
12/18/85	2.9	664.0	441.1	8.3	8.0	3.5	11.6	98		320.0	199.0

Station #11168000 -LOS GATOS CREEK AT LOS GATOS, CALIF.

Period	Flow (cfs)	Cond (µmohs)	TDS (mg/l)	pH	Temp (deg C)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Organic C (mg/l as C)	TH (mg/l as $CaCO_3$)	Alkalinity (mg/l as $CaCO_3$)
All											
Mean	53.7	342.2	205.9	8.1	13.0	67.3	10.5	101	3.9	155.0	129.4
CV	1.38	0.35	0.37	0.03	0.26	1.84	0.09	0.05	0.48	0.40	0.41
n	32	53	56	31	31	56	32	28	15	56	34
Month											
Nov	34.1	378.5	233.4	8.2	13.5	11.6	10.2	99	5.3	172.5	145.0
Jan	14.8	377.8	228.6	8.0	9.5	116.7	11.5	101	4.1	178.2	165.1
Feb	79.0	251.4	154.4	7.9	11.2	197.1	10.2	92	5.0	115.9	86.0
Mar	130.2	311.3	175.8	8.1	12.1	74.8	10.6	99	3.0	129.1	92.8
May	24.5	297.0	182.3	8.1	13.0	18.6	10.6	101	6.1	132.0	95.0
Jun	49.0	383.5	230.4	8.3	17.0	4.4	9.9	104	3.7	173.3	137.0
July	31.3	378.7	231.1	8.2	16.3	7.5	10.1	104	1.9	172.9	146.0
August	52.0	368.3	222.4	8.1	18.5	5.4	10.0	107	3.0	170.0	122.0
Sept	24.0	382.8	239.0	7.9	13.5	14.4	10.1	98	2.2	182.5	153.8
Winter											
Nov-Apr	66.8	330.1	195.8	8.0	11.1	107.1	10.8	98.9	4.2	147.9	123.5
n	19	31	33	18	18	33	19	15	10	33	19
Summer											
May-Oct	34.5	359.4	220.3	8.1	15.6	10.3	10.1	102.6	3.4	165.2	136.9
n	13	22	23	13	13	23	13	13	5	23	15

C V = Coefficent of Variation
n = Sample number

Station #11168000 -LOS GATOS CREEK AT LOS GATOS, CALIF.

DATE	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis. Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO2+NO3 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic N (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
1/12/80	62.0	0.19	0.03	60.0	40.00	0.66	0.04	1.70	1.80	2.50
1/29/81		0.12	0.01	50.0	60.00	0.89	0.07			
1/4/82		0.16	0.05	30.0	970.00	0.83	0.08	0.70	0.81	1.70
1/20/82		0.06	0.03	50.0	110.00	0.48	0.17	0.45	0.65	1.10
1/19/83	28.0	0.05	0.02	50.0	17.00	0.26	0.06		0.70	1.00
1/26/83		0.38	0.03	30.0	110.00	0.31	0.06	1.20	1.50	1.80
1/15/85	0.4	0.01	0.01	100.0	17.00	0.10	0.01		0.20	
1/29/85	0.3	0.01	0.01	100.0	11.00	0.10	0.02		0.30	
1/26/86	4.1	0.12	0.03	80.0	22.00		0.10	0.68	0.80	1.80
2/19/80	99.0	0.72	0.02	40.0	50.00	0.78	0.04	2.20	2.40	3.20
2/16/82		0.06	0.02	50.0	22.00	0.38	0.08	0.37	0.47	0.88
2/7/83		0.12	0.06	40.0	9.00	0.23	0.12	0.84	0.90	1.10
2/27/84		0.06	0.02	50.0	14.00	0.10	0.03	0.78	0.80	0.90
2/8/85	34.0	0.14	0.03	40.0	170.00	1.10	0.01	1.30	1.30	2.40
2/13/86	2.0	0.08	0.04	70.0			0.05	0.82	0.90	1.70
2/24/86	181.0	0.20	0.02	40.0	130.00		0.07	0.74	0.90	1.60
3/5/80		0.14	0.03	60.0	110.00	0.41	0.03	0.84	0.90	1.30
3/4/81		0.11	0.01	50.0	20.00	0.69	0.03	0.71	0.77	1.50
3/26/81		0.12	0.00	40.0	20.00	0.48	0.00	1.50	1.50	2.00
3/30/82	259.0	0.03	0.03	50.0	15.00	0.33	0.12	0.26	0.41	0.74
3/1/83		0.18	0.01	30.0	40.00	0.22	0.14	0.66	0.80	1.00
3/17/84	22.0	0.03	0.03	50.0	12.00	0.18	0.02	0.27	0.30	0.50
3/10/85	16.0	0.04	0.01	60.0	30.00	0.35	0.01	0.57	0.60	1.00
3/4/86	113.0	0.17	0.02	40.0	47.00		0.03	0.44	0.50	1.20
3/11/86	324.0	0.13	0.02	40.0	110.00		0.02	0.32	0.40	1.00
4/11/83		0.06	0.03	40.0	19.00	0.21	0.08	0.28	0.40	0.60
4/15/86	47.0	0.06	0.03	40.0	15.00		0.02	0.26	0.30	0.90
5/6/80	19.0	0.05	0.01	50.0	30.00	0.32	0.01	0.53	0.63	0.91
5/18/81		0.08	0.03	30.0	20.00	0.51	0.08	1.00	1.20	1.70
5/17/82		0.07	0.03	40.0	13.00	0.19	0.12	0.52	0.64	0.84
5/16/83		0.04	0.01	40.0	20.00	0.15	0.08	0.08	0.20	0.40
5/13/86	30.0	0.05	0.02	50.0	9.00		0.02	0.28	0.30	0.80
6/11/84		0.04	0.02	50.0	10.00	0.20	0.01	0.28	0.30	0.50
6/11/85	46.0	0.03	0.01	80.0	3.00	0.10	0.03	0.46	0.50	
6/10/86	52.0	0.05	0.03	50.0	37.00		0.01	0.26	0.30	0.80
7/16/80		0.06	0.01	70.0	10.00	0.46	0.01	0.49	0.50	0.96
7/13/81		0.10	0.02	60.0	10.00	0.25	0.10	0.81	1.00	1.30
7/19/82		0.04	0.02	50.0	7.00	0.29	0.08			

7/12/83	60.0	0.05	0.02	40.0	17.00	0.13	0.04	0.36	0.40	0.50
7/10/84	23.0	0.01	0.02	50.0	5.00	0.13	0.01	0.27	0.30	0.40
7/24/85	5.3			70.0	9.00					
7/22/86	37.0	0.04	0.01	50.0	5.00		0.02	0.39	0.40	0.80
8/1/81		0.07	0.00	70.0	10.00	0.16	0.06	0.85	0.71	0.84
8/29/83		0.03	0.02	40.0	5.00	0.16	0.08	0.61	0.70	0.90
8/27/84	46.0	0.04	0.03	50.0	31.00	0.10	0.01	0.24	0.30	
8/20/86	58.0	0.02	0.01	40.0	7.00		0.04		0.20	
9/10/80		0.07	0.03	70.0	10.00	0.11	0.04	0.46	0.49	0.62
9/8/82	67.0	0.04	0.01	50.0	4.00	0.27	0.08	0.34	0.60	0.90
9/11/85	4.8	0.35	0.02	110.0	36.00	0.16	0.51	2.00	2.50	2.70
9/23/86	0.2	0.02	0.01	70.0	16.00		0.03		0.20	
11/20/79	9.2	0.01	0.01	80.0	10.00	0.12	0.04	0.41	0.48	0.57
11/18/80		0.03	0.01	60.0	10.00	0.12	0.02			
11/16/81		0.05	0.05	60.0	97.00	0.85	0.14	0.44	0.59	1.50
11/16/82	59.0	0.01	0.01	50.0	5.00	0.10	0.10	0.99	1.10	
12/30/81	5.9	0.04	0.03	70.0	68.00	0.49	0.08	0.45	0.57	1.10
12/18/85	2.9	0.02	0.01	90.0	8.00		0.05	0.45	0.50	1.60

Station #11168000 -LOS GATOS CREEK AT LOS GATOS, CALIF.

Period	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis. Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO2+NO3 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic N (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
All										
Mean	53.7	0.09	0.02	54.8	49.31	0.34	0.06	0.66	0.71	1.20
CV	1.38	1.24	0.57	0.33	2.67	0.76	1.19	0.70	0.70	0.53
n	32	55	55	56	55	43	55	47	52	45
Month										
Nov	34.1	0.03	0.02	62.5	30.50	0.30	0.08	0.61	0.72	1.04
Jan	14.8	0.11	0.02	64.5	130.27	0.46	0.07	0.80	0.78	1.58
Feb	79.0	0.20	0.03	47.1	65.83	0.52	0.06	1.01	1.10	1.68
Mar	130.2	0.10	0.02	45.5	39.82	0.36	0.05	0.56	.0.63	1.07
May	24.5	0.06	0.02	42.0	18.40	0.29	0.06	0.48	0.59	0.93
Jun	49.0	0.04	0.02	60.0	16.67	0.15	0.02	0.33	0.37	0.65
July	31.3	0.05	0.02	55.7	9.00	0.25	0.04	0.46	0.52	0.79
August	52.0	0.04	0.02	50.0	13.25	0.14	0.05	0.57	0.48	0.87
Sept	24.0	0.12	0.02	75.0	16.50	0.18	0.17	0.93	0.95	1.41
Winter										
Nov-Apr	66.8	0.11	0.02	54.2	74.6	0.41	0.06	0.74	0.79	1.36
n	19	33	33	33	32	26	33	28	31	28
Summer										
May-Oct	34.5	0.06	0.02	55.7	14.1	0.22	0.07	0.54	0.59	0.93
n	13	22	22	23	23	17	22	19	21	17

C V = Coefficent of Variation
n = Sample number

Station #11168000 - LOS GATOS CREEK AT LOS GATOS, CALIF.

DATE	Flow (cfs)	Zn Dissolved (µg/l)	Zn Sediment (µg/gm)	Pb Dissolved (µg/l)	Pb Sediment (µg/gm)	Cu Dissolved (µg/l)	Cu Sediment (µg/gm)	As Dissolved (µg/l)	As Sediment (µg/gm)
1/4/82		10	--	6	--	4	--	1	--
1/26/83		28	20	1	30	3	10	1	2
2/19/80	99	10	--	5	--	1	--	1	--
2/8/85	34	3	50	1	50	2	30	1	2
2/24/86	181	20	--	1	--	1	--	1	--
3/26/81		50	--	3	--	2	--	2	--
6/11/85	46	10	--	4	--	1	--	1	--
8/1/81		20	--	2	--	4	--	2	--
8/29/83		9	--	1	--	2	--	1	--
8/27/84	46	9	40	1	50	1	30	1	1
9/10/80		60	--	3	--	1	--	2	--
9/8/82	67	3	--	1	--	1	--	1	--
9/11/85	5	10	120	1	30	1	70	3	7
All									
Mean	68	19	58	2	40	2	35	1	3
CV	0.8	0.9	0.7	0.7	0.3	0.6	0.6	0.5	0.8
n	7	13	4	13	4	13	4	13	4
Winter									
Mean	105	20	35	3	40	2	20	1	2
CV	0.6	0.8	0.4	0.7	0.3	0.5	0.5	0.3	0.0
n	3	6	2	6	2	6	2	6	2
Summer									
Mean	41	17	80	2	40	2	50	2	4
CV	0.5	1.0	0.5	0.6	0.3	0.7	0.4	0.5	0.8
n	4	7	2	7	2	7	2	7	2

CV = Coefficent of Variation
n = Sample number

Station #11168000 - LOS GATOS CREEK AT LOS GATOS, CALIF.

DATE	Flow (cfs)	Fe Sediment (µg/l)	Mn Dissolved (µg/l)	Mn Sediment (µg/gm)	Al Dissolved (µg/l)	Al Sediment (µg/gm)	Cb Sediment (µg/gm)
1/4/82		--	50	--	90	--	--
1/26/82		4500	3	240	20	3300	10
2/19/80	99	--	0	--	80	--	--
2/8/85	34	23000	22	660	120	15000	20
2/24/86	181	--	10	--	70	--	--
3/26/81		--	20	--	10	--	--
6/11/85	46	--	30	--	10	--	--
8/1/81		--	40	--	10	--	--
8/29/83		--	1	--	10	--	--
8/27/84	46	13000	280	640	10	9300	10
9/10/80		--	230	--	10	--	--
9/8/82	67	--	2	--	10	--	--
9/11/85	5	22000	420	270	150	11000	20
All							
Mean	68	15625	85	453	46	9650	15
CV	0.8	0.5	1.5	0.4	1.0	0.4	0.3
n	7	4	13	4	13	4	4
Winter							
Mean	105	13750	18	450	65	9150	15
CV	0.6	0.7	0.9	0.5	0.6	0.6	0.3
n	3	2	6	2	6	2	2
Summer							
Mean	41	17500	143	455	30	10150	15
CV	0.5	0.3	1.1	0.4	1.6	0.1	0.3
n	4	2	7	2	7	2	2

C V = Coefficent of Variation
n = Sample number

Station #11168000 - LOS GATOS CREEK AT LOS GATOS, CALIF.

DATE	Flow (cfs)	Cd Dissolved (µg/l)	Cd Sediment (µg/gm)	Cr Dissolved (µg/l)	Cr Sediment (µg/gm)	Hg Dissolved (µg/l)	Hg Sediment (µg/gm)	Ni AS NI) (01065)	Sn Dissolved (µg/l)	Sn Sediment (µg/gm)
1/4/82		1	--	<10	--	<0.1	--	<100	--	--
1/26/83		<1	<1	<10	20	<0.1	0.05	<100	--	<1
2/19/80	99	0	--	0	--	0.00	--	0	--	--
2/8/85	34	<1	<1	<10	70	<0.1	0.05	<100	<1	<1
2/24/86	181	<1	--	<10	--	<0.1	--	<100	--	--
3/26/81		2	--	10	--	0.00	--	100	--	--
6/11/85	46	1	--	<10	--	<0.1	--	<100	--	--
8/1/81		0	--	10	--	0.00	--	0	--	--
8/29/83		<1	--	<10	--	<0.1	--	<100	--	--
8/27/84	46	<1	<1	10	50	<0.1	0.69	<100	--	<1
9/10/80		0	--	0	--	0.00	--	0	--	--
9/8/82	67	<1	--	<10	--	<0.1	--	<100	--	--
9/11/85	5	1	1	<10	380	<0.1	0.20	<100	--	1

Station #11168000 - LOS GATOS CREEK AT LOS GATOS, CALIF.

DATE	Total Diazinon (µg/l)	Total 2,4-D, (µg/l)	Total Lindane (µg/l)	Total Malathion (µg/l)	Total Chlordane (µg/l)	Total DDD (µg/l)	Total DDE (µg/l)	Total DDT (µg/l)	Total Dieldrin (µg/l)	Total Heptachlor (µg/l)
2/19/80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/10/80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/27/81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/1/81	0.00	0.01	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
1/5/82	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/8/82	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
4/12/83	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
8/30/83	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
8/27/84	<0.01	--	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
2/8/85	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
9/11/85	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
1/29/86	0.03	0.02	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010

Station #11168000 - LOS GATOS CREEK AT LOS GATOS, CALIF.

DATE	Total Naphthalenes Polychlor (µg/l)	Total PCB (µg/l)	Total Aldrin (µg/l)	Total Endosulfan (µg/l)	Total Endrin (µg/l)	Total Ethion (µg/l)	Total Chlor Epoxide (µg/l)	Total Oxychlor (µg/l)	Total Methyl Parathion (µg/l)
2/19/80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/10/80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/27/81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/1/81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/5/82	0.00	0.00	0.00	0.00	0.00	0.00	--	0.00	0.00
9/8/82	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
4/12/83	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
8/30/83	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
8/27/84	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
2/8/85	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
9/11/85	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
1/29/86	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01

Station #11168000 - LOS GATOS CREEK AT LOS GATOS, CALIF.

DATE	Total Methyl Trithion (µg/l)	Total Mirex (µg/l)	Total Perthane (µg/l)	Total Toxaphene (µg/l)	Total Trithion (µg/l)	Total 2,4,5-T (µg/l)	Total Silvex (µg/l)
2/19/80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/10/80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/27/81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/1/81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/5/82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/8/82	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
4/12/83	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
8/30/83	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
8/27/84	<0.01	<0.01	<0.1	<1	<0.01	--	--
2/8/85	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
9/11/85	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
1/29/86	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01

USGS STATION NO. 11171500
COYOTE CREEK NEAR
EDENVALE, CA

VOL 12

2

1557

Station #11171500 - COYOTE C NR EDENVALE CALIF

Date	Flow (cfs)	Cond (µmohs)	TDS (mg/l)	pH	Temp (deg C)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Dis. Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
1/17/79	5.1	560.0	316.2	7.4	9.5		8.9			240.0	170.0
1/11/80		146.0	95.6			620.0				69.0	70.0
1/29/81		525.0	279.4			110.0				220.0	
1/5/82		195.0	102.9			270.0				83.0	
1/21/82		363.0	205.9			130.0				160.0	
1/19/83		526.0	301.4			44.0				230.0	
1/28/83	841.0	294.0	176.5	7.8	10.5	320.0	10.0	91	5.6	130.0	118.0
1/30/86	1.8	79.0	44.1	7.7	11.5	65.0	8.0	74		28.0	31.0
2/14/79	0.0	73.0	36.8	7.0	15.5		9.7			26.0	21.0
2/20/80	331.0	270.0	169.1	7.2	13.5	210.0	9.0		12.0	120.0	100.0
2/18/82	22.0	570.0	308.8	8.0	13.5	8.8	8.4	80	6.6	250.0	204.0
2/9/83	3300.0	311.0	183.8	8.0	10.5	210.0	10.6	95	5.3	140.0	124.0
2/28/84			382.3							300.0	
2/9/85	16.0	621.0	360.3	8.0	10.0	24.0	10.2	90		290.0	216.0
2/14/86	32.0	344.0	191.2	8.3	13.5	42.0	8.9	86		150.0	125.0
2/25/86	42.0	515.0	308.8	8.1	15.0	25.0	10.1	101		230.0	198.0
3/16/79	0.4	391.0	213.2	7.8	16.5		8.2			170.0	110.0
3/27/79	1.4	66.0	36.8	7.5	14.5		9.0			23.0	16.0
3/7/80	41.0	513.0	301.4	7.4	12.0	28.0	8.8		12.0	230.0	200.0
3/5/81		541.0	316.2			81.0				240.0	
3/28/81	3.8	605.0	345.6	8.2	13.5	3.5	7.8	75	7.8	270.0	210.0
3/31/82	486.0	239.0	125.0	7.9	10.5	48.0	10.0	90	4.9	100.0	92.0
3/2/83	5900.0	273.0	176.5	8.1	11.5	370.0	10.0	95	5.0	130.0	114.0
3/12/86	89.0	475.0	272.0	8.2	13.5	25.0	9.4	91		210.0	185.0
4/13/83	502.0	381.0	198.5	8.1	11.0	35.0	10.6	96	3.4	150.0	130.0
4/26/79	0.4	213.0	110.3	7.1	19.0		3.9			88.0	80.0
5/23/79	0.4	435.0	279.4	7.6	20.5		7.4			210.0	180.0
5/18/82	3.0	618.0	360.3	8.2	20.5	0.5	9.3	104	2.1	280.0	228.0
5/17/83		366.0	213.2			45.0				150.0	
5/14/86	5.2	463.0	272.0	8.2	17.5	2.1	7.2	76		200.0	176.0
7/31/79	0.3	431.0	250.0	7.6	28.0		5.5			170.0	170.0
7/17/80		406.0	227.9			4.4				170.0	150.0
7/15/81	1.9	383.0	242.6	8.0	20.5	0.8	5.8	65	6.1	170.0	150.0
7/20/82		457.0	264.7			76.0				200.0	
7/12/83		426.0	257.3			180.0				190.0	
7/11/84	4.6	488.0	286.7	8.2	22.0	1.6	6.0	69		230.0	179.0
8/30/83		556.0	294.1			150.0				220.0	
9/10/80	0.5	403.0	242.6	7.4	19.0	0.5	6.0		4.5	180.0	160.0

9/2/81	0.9	380.0	220.6	7.8	18.0	0.7	5.6	60	3.3	160.0	150.0
9/7/82	5.5	442.0	250.0	7.7	20.5	0.8	6.8	76	3.3	190.0	158.0
9/24/86	2.1	357.0	220.6	7.9	16.5	0.5	6.8	71		160.0	141.0
11/17/81		527.0	294.1			30.0				230.0	
11/16/82		512.0	286.7			30.0				220.0	
12/31/81	0.6	[illegible]89.0	279.4	7.4	11.0	5.6	5.5	50	3.7	210.0	164.0

Station #11171500 - COYOTE C NR EDENVALE CALIF

Period	Flow (cfs)	Cond (umohs)	TDS (mg/l)	pH	Temp (deg C)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Dis. Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
All											
Mean	388.0	400.7	234.1	7.8	15.3	88.8	8.1	82	5.7	177.7	141.3
CV	3.12	0.37	0.37	0.05	0.29	1.49	0.23	0.18	0.52	0.38	0.39
n	30	43	44	30	30	36	30	20	15	44	32
Month											
Nov		519.5	290.4			30.0				225.0	
Jan	212.1	353.0	200.1	7.6	10.6	195.6	8.1	72	4.7	152.2	110.6
Feb	534.7	386.3	242.6	7.8	13.1	86.0	9.6	90	8.0	188.3	141.1
Mar	878.0	387.1	220.6	7.9	12.9	84.4	9.2	89	6.6	169.2	132.1
May	2.3	419.0	247.0	7.8	19.4	15.9	7.0	90	2.1	185.6	166.0
July	2.3	431.8	254.9	7.9	23.5	52.6	5.8	67	6.1	188.3	162.3
Sept	2.3	395.5	233.4	7.7	18.5	0.6	6.3	69	3.7	172.5	152.3
Winter											
Nov-Apr	611.3	385	225	7.8	12.5	118.9	9.1	85.7	6.6	173.2	129.9
CV	2.44	0.45	0.45	0.05	0.16	1.28	0.13	0.16	0.47	0.46	0.49
n	19	27	28	19	19	23	19	13	10	28	20
Summer											
May-Oct	2.3	427	250	7.8	20.2	35.6	6.4	74.4	3.9	185.5	160.2
CV	0.90	0.21	0.21	0.05	0.15	1.74	0.21	0.19	0.39	0.22	0.21
n	11	16	16	11	11	13	11	7	5	16	12

Station #11171500 - COYOTE C NR EDENVALE CALIF

Date	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO3+NO2 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
1/17/79	5.1	0.19	0.07	130.0	60.0	4.90	0.04	1.10	1.20	5.90
1/11/80		0.65	0.13	50.0	70.0	0.95	0.03	2.40	2.50	3.50
1/29/81		0.25	0.04	100.0	20.0	4.00	0.04			
1/5/82		0.41	0.24	50.0	230.0	1.20	0.09	1.30	1.50	2.70
1/21/82		0.23	0.16	70.0	350.0	2.00	0.22	1.10	1.30	3.30
1/19/83		0.19	0.08	100.0	19.0	4.00	0.06	1.20	1.30	5.30
1/28/83	841.0	0.34	0.10	70.0	75.0	0.93	0.06	1.50	1.70	2.60
1/30/86	1.8	0.22	0.14	40.0	120.0	0.40	0.18	0.15	1.40	1.80
2/14/79	0.0	0.22	0.09	20.0	40.0	0.31	0.08	0.46	0.54	0.82
2/20/80	331.0	0.59	0.23	90.0	130.0	1.70	0.09	1.70	1.90	3.60
2/18/82	22.0	0.08	0.05	130.0	53.0	3.50	0.07	1.20	1.30	4.80
2/9/83	3300.0	0.31	0.06	70.0	28.0	0.34	0.12		1.60	1.90
2/28/84		0.26	0.01	130.0	37.0	5.90	0.03	2.20	2.30	8.10
2/9/85	16.0	0.02	0.02	130.0	3.0	5.60	0.01	0.01	1.80	7.40
2/14/86	32.0	0.08	0.03	100.0	21.0	1.80	0.05	0.06	0.60	2.40
2/25/86	42.0	0.15	0.11	110.0	36.0	2.70	0.08	0.07	0.80	3.50
3/16/79	0.4	0.19	0.09	110.0	20.0	2.80	0.01	0.92	0.94	3.50
3/27/79	1.4	0.12	0.08	50.0	40.0	0.19	0.06	0.37	0.43	0.62
3/7/80	41.0	0.15	0.12	120.0	20.0	3.10	0.04	1.20	1.20	4.30
3/5/81		0.28	0.01	120.0	10.0	1.80	0.03	1.80	1.90	5.70
3/28/81	3.8	0.04	0.00	100.0	20.0	4.20	0.04	1.20	1.30	5.40
3/31/82	486.0	0.18	0.08	60.0	66.0	0.51	0.11	0.66	0.82	1.30
3/2/83	5900.0	0.45	0.02	70.0	100.0	0.34	0.14	2.30	2.40	2.80
3/12/86	89.0	0.14	0.08	100.0	65.0	2.00	0.14	0.10	0.80	2.80
4/13/83	502.0	0.05	0.02	70.0	18.0	0.88	0.08	0.60	0.70	1.60
4/26/79	0.4	0.37	0.13	100.0	600.0	0.06	0.03	1.20	1.40	1.50
5/23/79	0.4	0.05	0.05	210.0	10.0	0.12	0.01	0.42	0.49	0.59
5/18/82	3.0	0.03	0.02	120.0	9.0	4.40	0.10	0.65	0.78	5.30
5/17/83		0.11	0.02	80.0	11.0	0.93	0.06	1.00	1.10	2.00
5/14/86	5.2	0.01	0.01	100.0	7.0	2.00	0.03	0.03	0.50	2.50
7/31/79	0.3	0.02	0.03	130.0	20.0	0.02	0.03	0.24	0.24	0.29
7/17/80		0.08	0.01	120.0	10.0	1.00	0.01	2.20	2.20	3.20
7/15/81	1.9	0.05	0.02	90.0	30.0	0.20	0.12	0.63	0.85	1.10
7/20/82		0.08	0.03	100.0	3.0	1.70	0.09	1.80	1.90	3.50
7/12/83		0.35	0.03	90.0	5.0	1.90	0.07	1.80	1.90	3.80
7/11/84	4.6	0.01	0.02	110.0	3.0	1.00	0.05	0.01	0.50	1.50
8/30/83		0.28	0.01	100.0	9.0	2.50	0.05	2.20	2.30	4.80
9/10/80	0.5	0.03	0.00	110.0	30.0	0.95	0.05	0.45	0.48	1.40

9/2/81	0.9	0.04	0.00	90.0	31.0	0.04	0.12	0.57	0.68	0.70
9/7/82	5.5	0.03	0.01	110.0	3.0	2.00	0.13	0.77	1.00	3.00
9/24/86	2.1	0.03	0.02	100.0	23.0	1.20	0.03	0.04	0.50	1.70
11/17/81		0.11	0.09	100.0	23.0	3.70	0.08	0.82	1.00	4.80
11/16/82		0.11	0.01	100.0	3.0	3.40	0.06	1.90	2.00	5.40
12/31/81	0.6	0.09	0.06	90.0	36.0	4.30	0.09	0.99	1.10	5.40

Station #11171500 - COYOTE C NR EDENVALE CALIF

Period	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO3+NO2 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
All										
Mean	388.0	0.17	0.06	96.4	57.2	1.99	0.07	0.98	1.24	3.21
CV	3.12	0.88	0.97	0.33	1.84	0.82	0.65	0.74	0.50	0.59
n	30	44	44	44	44	44	44	42	43	43
Month										
Nov	0.0	0.11	0.05	100.0	13.0	3.55	0.07	1.36	1.50	5.10
Jan	212.1	0.29	0.11	77.8	108.9	2.52	0.09	1.22	1.50	3.81
Feb	534.7	0.21	0.08	97.5	43.5	2.73	0.07	0.81	1.36	4.07
Mar	878.0	0.18	0.06	88.9	39.9	1.76	0.07	1.02	1.17	3.11
May	2.3	0.11	0.05	122.0	127.4	1.50	0.05	0.66	0.85	2.38
July	2.3	0.10	0.02	106.7	11.8	0.97	0.06	1.11	1.27	2.23
Sept	2.3	0.03	0.01	102.5	21.8	1.05	0.08	0.48	0.67	1.70
Winter										
Nov-Apr	611.3	0.22	0.08	88.6	61.2	2.41	0.08	1.05	1.35	3.75
CV	2.44	0.71	0.77	0.34	1.21	0.72	0.65	0.68	0.43	0.51
n	19	28	28	28	28	28	28	26	27	27
Summer										
May-Oct	2.3	0.10	0.03	110.0	50.3	1.25	0.08	0.88	1.05	2.31
CV	0.90	1.23	1.19	0.27	2.92	0.93	0.85	0.86	0.65	0.65
n	11	16	16	16	16	16	16	16	16	16

Station # 11171500 - COYOTE CREEK NEAR EDENVALE CALIF.

DATE	Flow (cfs)	Zn dissolved (µg/l)	Zn sediment (µg/l)	PB dissolved (µg/l)	PB sediment (µg/l)	Cu dissolved (µg/l)	Cu sediment (µg/l)	As dissolved (µg/l)	As sediment (µg/l)
1/17/79	5	3	--	3	--	4	--	2	--
1/5/82		10	--	6	--	4	--	3	--
1/28/83	841	3	60	--	50	2	10	1	6
2/20/80	331	10	8	ND	5	3	4	3	8
2/9/85	16	3	60	1	210	1	20	1	3
2/14/86	32	20	--	3	--	1	--	1	--
2/25/86	42	10	--	4	--	1	--	3	--
3/28/81	4	10	110	6	80	2	8	1	7
7/31/79	89	3	--	ND	--	ND	--	1	--
8/30/83		100	--	1	--	2	--	1	--
9/10/80	1	50	100	2	150	1	20	1	6
9/2/81	1	10	90	3	50	1	10	1	10
9/7/82	6	30	30	1	20	9	7	1	7
All									
Mean	124	20	65	3	81	3	11	2	7
CV	2.0	1.3	0.5	0.6	0.8	0.9	0.5	0.5	0.3
n	11	13	7	10	7	12	7	13	7
Winter									
Mean	182	9	60	4	86	2	11	2	6
CV	1.6	0.6	0.6	0.5	0.9	0.5	0.6	0.5	0.3
n	7	8	4	6	4	8	4	8	4
Summer									
Mean	24	39	73	2	73	3	12	1	8
CV	1.5	0.9	0.4	0.5	0.8	1.0	0.5	0.0	0.2
n	4	5	3	4	3	4	3	5	3

Station # 11171500 - COYOTE CREEK NEAR EDENVALE CALIF.

DATE	Flow (cfs)	Fe sediment (µg/l)	Mn dissolved (µg/l)	Mn sediment (µg/l)	Al dissolved (µg/l)	Al sediment (µg/l)	Co sediment (µg/l)
1/17/79	5	--	6	--	10	--	--
1/5/82		--	10	--	40	--	--
1/28/83	841	9500	3	280	60	3900	20
2/20/80	331	150	10	190	60	ND	5
2/9/85	16	26000	--	580	10	9400	30
2/14/86	32	--	10	--	30	--	--
2/25/86	42	--	10	--	20	--	--
3/28/81	4	6000	10	190	10	1800	30
7/31/79	89	--	10	--	100	--	--
8/30/83		--	91	--	10	--	--
9/10/80	1	6100	10	290	10	1600	40
9/2/81	1	14000	ND	230	10	1000	20
9/7/82	6	4300	10	290	10	1500	10
All							
Mean	124	9436	16	293	29	3200	22
CV	2.0	0.8	1.4	0.4	0.9	0.9	0.5
n	11	7	11	7	13	6	7
Winter							
Mean	182	10413	8	310	30	5033	21
CV	1.8	0.9	0.3	0.5	0.7	0.6	0.5
n	7	4	7	4	8	3	4
Summer							
Mean	24	8133	30	270	28	1367	23
CV	1.5	0.5	1.2	0.1	1.3	0.2	0.5
n	4	3	4	3	5	3	3

Station # 11171500 - COYOTE CREEK NEAR EDENVALE CALIF.

DATE	Flow (cfs)	Cd dissolved (µg/l)	Cd sediment (µg/l)	Cr dissolved (µg/l)	Cr sediment (µg/l)	Hg dissolved (µg/l)	Hg sediment (µg/l)	Ni sediment (µg/l)	Se dissolved (µg/l)	Se sediment (µg/l)
1/17/79	5	5	--	ND	--	<0.1	--	ND	--	--
1/5/82		1	--	<10	--	<0.1	--	<100	--	--
1/28/83	841	<1	1	<10	50	<0.1	0.10	<100	--	<1
2/20/80	331	0	0	0	10	0.10	0.08	0	--	0
2/9/85	16	<1	<1	<10	160	<0.1	0.06	<100	<1	<1
2/14/86	[illegible]2	1	--	<10	--	<0.1	--	<100	--	--
2/25/86	[illegible]2	<1	--	<10	--	<0.1	--	<100	--	--
3/28/81	4	0	0	10	58	0.00	1.00	0	--	0
7/31/79	89	<2	--	ND	--	<0.1	--	ND	--	--
8/30/83		<1	--	10	--	<0.1	--	<100	--	--
9/10/80	1	1	1	0	58	0.00	0.14	0	--	--
9/2/81	1	0	<1	0	100	1.70	0.05	0	--	0
9/7/82	6	<1	<1	<10	20	<0.1	0.05	<100	--	<1

Station #11171500 - COYOTE C NR EDENVALE CALIF

DATE	Total Diazinon (μg/l)	Total 2,4-D, (μg/l)	Total Lindane (μg/l)	Total Malathion (μg/l)	Total Chlordane (μg/l)	Total DDD (μg/l)	Total DDE (μg/l)	Total DDT (μg/l)	Total Dieldrin (μg/l)	Total Heptachlor (μg/l)
2/20/80	0.05	0.98	0	0	0	0.01	0.04	0.04	0	0
9/10/80	0	0	0	0	0	0	0	0	0	0
3/28/81	0.07	0.08	0	0	0	0	0	0	0	0
9/2/81	<0.01	0.01	0	0.24	0	0	0	0	0	0
1/6/82	0.06	0.02	0	0.03	0	0.02	0.03	0	0.01	0
9/7/82	0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
1/28/83	0.03	<0.01	<0.020	<0.01	<0.2	<0.020	0.01	0.01	0.01	<0.020
4/13/83	0.02	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
8/31/83	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
2/9/85	0.04	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
1/30/86	0.41	0.08	0.01	1.3	0.2	<0.010	0.01	<0.010	<0.010	<0.010
2/14/86	0.1	0.03	<0.010	0.03	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
2/25/86	0.02	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
9/24/86	0.02	0.02	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010

Station #11171500 - COYOTE C NR EDENVALE CALIF

DATE	Total Naphthalenes Polychlor (µg/l)	Total PCB (µg/l)	Total Aldrin (µg/l)	Total Endosulfan (µg/l)	Total Endrin (µg/l)	Total Ethion (µg/l)	Total Chlor Epoxide (µg/l)	Total Oxychlor (µg/l)	Total Methyl Parathion (µg/l)
2/20/80	0	0	0	0	0.02	0	0	0	0
9/10/80	0	0	0	0	0	0	0	0	0
3/28/81	0	0	0	0	0	0	0	0	0
9/2/81	0	0	0	0	0	0	0	0	0
1/6/82	0	0	0	0	0.01	0	0	0	0
9/7/82	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
1/28/83	<0.20	<0.2	<0.020	<0.020	<0.020	0.01	<0.020	<0.02	<0.01
4/13/83	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
8/31/83	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
2/9/85	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
1/30/86	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
2/14/86	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
2/25/86	<0.10	<0.1	<0.010	<0.010	<0.010	0.01	<0.010	<0.01	<0.01
9/24/86	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01

Station #11171500 - COYOTE C NR EDENVALE CALIF

DATE	Total Methyl Trithion (µg/l)	Total Mirex (µg/l)	Total Perthane (µg/l)	Total Toxaphene (µg/l)	Total Trithion (µg/l)	Total 2,4,5-T (µg/l)	Total Silvex (µg/l)
2/20/80	0	0	0	0	0	0	0
9/10/80	0	0	0	0	0	0	0
3/28/81	0	0	0	0	0	0	0
9/2/81	0	0	0	0	0	0	0
1/6/82	0	0	0	0	0	0	0
9/7/82	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
1/28/83	<0.01	<0.02	<0.2	<2	<0.01	<0.01	<0.01
4/13/83	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
8/31/83	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
2/9/85	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
1/30/86	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
2/14/86	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
2/25/86	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
9/24/86	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01

8720115A-F CON-6

VOL 12

USGS STATION NO. 11169970
COYOTE CREEK BELOW
LEROY ANDERSON DAM NEAR MADRONE, CA

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1570

STA 11 169 970 Coyote Creek - below Leroy Anderson dam - near Madrone CA

DATE	FLOW (inst) (CFS)	COND (US/CM)	TDS (mg/l)	pH	TEMP DEGC	TURBIDITY (NTU)	DO (mg/l)	DO (% sat)	DIS. ORGC (mg/l C)	TH mg/l CaCO3	ALK mg/l CaCO3
11/21/79	12	382	240	8.4	15.0	6	10.0	--	6.3	170	150
11/19/80	17	296	170	7.6	13.0	34	10.4	99	5.5	120	120
11/18/81	7.2	349	220	8.0	13.5	3	10.1	97	9.8	150	146
11/17/82	58	313	190	7.9	12.0	15	10.4	98	4.1	140	120
1/11/80	159	419	260	7.8	11.5	17	10.8	--	7.3	190	180
1/30/81	29	301	180	7.7	11.0	290	10.7	97	9.4	120	110
12/31/81	8.4	358	220	8.2	13.0	25	10.4	100	4.5	160	148
1/6/82	8.8	308	180	8.1	11.0	160	10.7	97	5.6	140	122
1/22/82	8	343	210	8.1	10.0	44	11.2	99	4.9	160	136
1/20/83	27	336	200	8.1	9.0	51	11.1	98	4.0	150	130
1/28/83	570	276	170	8.0	10.5	260	10.9	100	5.2	120	110
1/16/85	35	454	280	8.4	10.0	5	10.8	96	--	200	172
1/16/85	35	454	280	8.4	10.0	5	10.8	96	2.5	200	172
1/30/85	29	448	280	8.4	10.0	7	11.2	100	4.0	210	178
1/30/86	6.7	554	340	8.2	11.0	20	9.9	91	--	250	221
2/21/80	3.3	342	220	7.0	11.5	410	10.0	--	8.6	150	98
2/18/82	5.5	297	170	8.2	10.0	120	11.0	98	5.7	130	112
2/9/83	413	277	170	8.0	10.5	160	11.1	100	5.5	120	110
2/29/84	14	422	260	8.4	11.5	23	11.0	102	2.8	190	162
2/9/85	9.4	461	290	8.2	10.0	6	12.0	107	--	210	181
2/14/86	6.7	562	340	8.2	11.0	21	10.1	93	--	250	221
3/7/80	4.3	296	180	7.5	11.5	120	10.5	--	14.0	120	94
3/6/81	29	313	200	7.9	11.0	100	10.6	98	6.2	140	130
3/28/81	19	316	200	8.2	11.0	42	10.6	97	4.8	140	130
3/31/82	350	327	190	8.1	10.5	16	11.0	100	4.8	140	130
3/2/83	1000	250	160	8.2	11.0	310	10.4	96	5.4	110	100
3/16/84	24	428	250	8.2	11.5	12	11.2	103	2.7	180	164
3/11/85	9	463	280	8.3	10.5	4	13.5	122	--	210	170
3/12/86	20	291	160	8.2	13.5	78	10.1	98	--	120	102
4/13/83	432	324	170	8.1	11.5	43	10.9	101	3.9	120	110
5/7/80	40	271	170	7.6	12.0	20	10.7	100	9.8	120	98
5/20/81	52	325	200	8.0	12.0	26	10.6	99	7.8	140	130
5/18/82	21	314	170	8.1	11.0	14	11.0	101	4.1	130	122
5/18/83	371	305	190	8.1	12.0	20	10.8	101	3.2	130	120
5/14/86	46	264	150	8.1	13.0	28	10.0	96	--	99	98

6/13/84	64	--	250	8.3	13.5	3	10.2	--	--	190	--
6/14/85	77	472	280	8.3	12.5	6	10.8	103	--	210	172
7/17/80	59	281	170	7.4	12.0	18	10.4	97	5.2	120	100
7/15/81	65	337	210	8.1	13.0	14	10.2	98	7.8	140	130
7/21/82	63	312	190	8.0	12.0	20	10.7	100	4.6	130	122
7/13/83	62	321	200	8.1	13.5	18	10.5	102	3.1	140	120
7/11/84	70	423	260	8.2	15.0	7	10.5	106	--	190	162
7/25/85	59	472	280	8.2	14.5	14	10.0	100	--	210	179
7/24/86	64	253	170	8.1	13.5	20	10.9	105	--	120	104
8/31/83	62	396	210	8.1	14.0	20	9.9	98	2.8	150	130
8/28/84	71	435	260	8.0	15.0	8	9.8	98	3.8	190	166
9/9/80	60	289	170	7.5	13.0	24	10.2	97	6.8	120	110
9/2/81	73	334	200	8.0	13.0	8	10.2	98	3.4	140	130
9/7/82	68	314	180	7.7	12.0	11	10.6	100	4.4	130	114
9/12/85	70	498	300	8.2	18.5	7	9.4	101	--	230	189
9/24/86	60	272	170	7.7	14.5	27	9.8	98	--	120	105

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STA 11 169 970 Coyote Creek - below Leroy Anderson dam - near Madrone CA

MONTHLY AND SEASONAL AVERAGES

PERIOD	FLOW (inst) (CFS)	COND (US/CM)	TDS (mg/l)	pH	TEMP DEGC	TURBIDITY (NTU)	DO (mg/l)	DO (% sat)	DIS. ORGC (mg/l C)	TH mg/l CaCO3	ALK mg/l CaCO3
ALL											
average	97	357	216	8.0	12.1	54	10.6	100	5.5	156	137
cov	1.84	0.22	0.23	0.04	0.15	1.63	0.06	0.04	0.44	0.25	0.24
MONTH											
NOV	24	335	205	8.0	13.4	14	10.2	98	6.4	145	134
JAN	83	386	236	8.1	10.6	80	10.8	97	5.3	173	153
FEB	75	394	242	8.0	10.8	123	10.9	100	5.7	175	147
MAR	182	336	203	8.1	11.3	85	11.0	102	6.3	145	128
APR	432	324	170	8.1	11.5	43	10.9	101	3.9	120	110
MAY	106	296	176	8.0	12.0	22	10.6	99	6.2	124	114
JUN	71	472	265	8.3	13.0	4	10.5	103	-	200	172
JULY	63	343	211	8.0	13.4	16	10.5	101	5.2	150	131
SEPT	67	357	213	7.9	14.3	14	10.0	99	4.6	155	136
NOV - APR	112	365	222	8.1	11.2	80	10.8	99	5.7	160	141
MAY - OCT	75	344	209	8.0	13.3	16	10.3	100	5.1	150	130

STA 11 169 970 Coyote Creek - below Leroy Anderson dam - near Madrone CA

DATE	FLOW (inst) (CFS)	DIS. BORON (ug/l B)	DIS. IRON (ug/l Fe)	TOTAL P (mg/l P)	DIS. ORTHO P (mg/l P)	NO2+NO3 (mg/l N)	DIS. AMMONIA (mg/l N)	TOTAL ORGANIC (mg/l N)	TOTAL ORG+NH3 (mg/l N)	TOTAL N (mg/l N)
11/21/79	12	120	70	0.01	0.01	0.11	0.04	0.99	1.10	1.20
11/19/80	17	80	20	0.05	0.02	0.52	0.04	0.65	0.69	1.20
11/18/81	7.2	80	10	0.03		0.24	0.29	0.35	0.65	0.89
11/17/82	58	80	16	0.02	0.01	0.30	0.13	1.30	1.40	1.70
1/11/80	159	100	10	0.04	0.01	0.16	0.01	0.91	0.91	1.10
1/30/81	29	70	40	0.13	0.02	0.54	0.05			
12/31/81	8.4	100	10	0.05	0.02	0.13	0.09	0.54	0.67	0.80
1/6/82	8.8	80	24	0.10	0.04	0.42	0.08	0.69	0.80	1.20
1/22/82	8	90	28	0.05	0.03	0.23	0.11	0.50	0.64	0.87
1/20/83	27	80	8	0.05	0.01	0.20	0.06		0.30	0.50
1/28/83	570	80	69	0.18	0.03	0.20	0.06	0.98	1.10	1.30
1/16/85	35	120	12							
1/16/85	35	100	8	0.01	0.01	0.10	0.01		0.30	
1/30/85	29	100	7	0.01	0.01	0.10	0.01	0.38	0.40	
1/30/86	6.7	130	13	0.03	0.01	0.10	0.07	0.35	0.40	
2/21/80	3.3	90	170	0.64	0.04	0.67	0.07	2.70	2.90	3.60
2/18/82	5.5	90	30	0.05	0.02	0.26	0.10	0.56	0.68	0.94
2/9/83	413	70	33	0.12	0.06	0.20	0.09	0.74	0.80	1.00
2/29/84	14	90	11	0.02	0.01	0.20	0.02	0.29	0.30	0.50
2/9/85	9.4	100	3	0.01	0.01	0.10	0.01		0.70	
2/14/86	6.7	130	4	0.02	0.01	0.10	0.14	0.55	0.70	0.80
3/7/80	4.3	90	20	0.09	0.04	0.46	0.01	0.65	0.72	1.20
3/6/81	29	80	390	0.09	0.02	0.26	0.04	0.75	0.82	1.10
3/28/81	19	70	10	0.06	0.01	0.27	0.02	0.46	0.49	0.76
3/31/82	350	100	30	0.03	0.02	0.25	0.08	0.45	0.54	0.79
3/2/83	1000	70	120	0.26	0.02	0.20	0.09	0.95	1.10	1.30
3/16/84	24	80	5	0.02	0.02	0.30	0.05	0.38	0.40	0.70
3/11/85	9	100	6	0.01	0.01	0.10	0.01	0.25	0.30	
3/12/86	20	90	110	0.09	0.02	0.50	0.02	0.26	0.30	0.80
4/13/83	432	60	9	0.07	0.04	0.30	0.12	0.61	0.70	1.00
5/7/80	40	110	50	0.04	0.03	0.36	0.03	0.82	0.90	1.30
5/20/81	52	70	10	0.06	0.02	0.29	0.12	0.49	0.66	0.95
5/18/82	21	70	23	0.04	0.03	0.22	0.09	0.57	0.70	0.92
5/18/83	371	70	23	0.06	0.02	0.20	0.06	0.70	0.80	1.00

6/13/84	64	80	[illegible]	0.01	0.01	0.20	0.01	[illegible]	[illegible]	[illegible]
6/14/85	77	100	17	0.01	0.01	0.10	0.05	0.25	0.30	
7/17/80	59	110	50	0.08	0.02	0.56	0.01	0.93	0.96	1.50
7/15/81	65	80	20	0.06	0.01	0.34	0.10	0.50	0.70	1.00
7/21/82	63	80	15	0.03	0.02	0.31	0.08	1.30	1.40	1.70
7/13/83	62	70	15	0.05	0.02	0.30	0.05	0.43	0.50	0.80
7/11/84	70	80	3	0.01	0.02	0.20	0.01	0.17	0.20	0.40
7/25/85	59	60	12	0.01	0.01	0.10	0.03	0.28	0.30	
7/24/86	64	80	11	0.05	0.04	0.50	0.05	0.47	0.50	1.00
8/31/83	62	60	18	0.02	0.02	0.30	0.01	0.60	0.70	1.00
8/28/84	71	80	3	0.05	0.01	0.20	0.01	0.59	0.60	0.80
9/9/80	60	140	40	0.07	0.05	0.51	0.02	0.50	0.50	1.00
9/2/81	73	80	10	0.04	0.01	0.27	0.06	0.94	1.00	1.30
9/7/82	68	80	3	0.11	0.01	0.30	0.10	0.35	0.60	0.90
9/12/85	70	120	3	0.02	0.01	0.10	0.09	0.31	0.40	
9/24/86	60	80	15	0.04	0.01	0.50	0.03	0.58	0.60	1.10

STA 11 169 970 Coyote Creek - below Leroy Anderson dam - near Madrone CA

MONTHLY AND SEASONAL AVERAGES

MONTHLY AND SEASONAL AVERAGES

PERIOD	FLOW (inst) (CFS)	DIS. BORON (ug/l B)	DIS. IRON (ug/l Fe)	TOTAL P (mg/l P)	DIS. ORTHO P (mg/l P)	NO2+NO3 (mg/l N)	DIS. AMMONIA (mg/l N)	TOTAL ORGANIC (mg/l N)	TOTAL ORG+NH3 (mg/l N)	TOTAL N (mg/l N)
ALL average	97	88	33	0.06	0.02	0.28	0.06	0.64	0.70	1.07
cov	1.84	0.21	1.83	1.47	0.60	0.53	0.85	0.64	0.60	0.46
NOV	24	90	29	0.03	0.01	0.29	0.13	0.82	0.96	1.25
JAN	83	95	21	0.07	0.02	0.22	0.06	0.62	0.61	0.96
FEB	75	95	42	0.14	0.03	0.26	0.07	0.97	1.01	1.37
MAR	182	85	86	0.08	0.02	0.29	0.04	0.52	0.58	0.95
APR	432	60	9	0.07	0.04	0.30	0.12	0.61	0.70	1.00
MAY	106	80	28	0.05	0.02	0.29	0.06	0.59	0.69	0.99
JUN	71	90	12	0.01	0.01	0.15	0.03	0.62	0.65	1.20
JULY	63	80	18	0.04	0.02	0.33	0.05	0.58	0.65	1.07
SEPT	67	97	12	0.06	0.02	0.31	0.05	0.55	0.62	1.02
NOV - APR	112	91	43	0.08	0.02	0.26	0.07	0.69	0.74	1.10
MAY - OCT	75	85	18	0.04	0.02	0.30	0.05	0.58	0.65	1.04

Station #11169970 - COYOTE CREEK BELOW LEROY ANDERSON DAM NEAR MADRONE CALIF.

DATE	Flow (cfs)	Zn Dissolved (µg/l)	Zn Sediment (µg/gm)	Pb Dissolved (µg/l)	Pb Sediment (µg/gm)	Cu Dissolved (µg/l)	Cu Sediment (µg/gm)	As Dissolved (µg/l)	As Sediment (µg/gm)
1/6/82	9	10	20	1	10	2	20	2	8
1/28/83	570	3	50	1	20	2	260	1	3
2/21/80	3	10	40	ND	40	2	20	1	10
2/9/85	9	9	80	1	70	1	50	1	9
2/14/86	7	20		1		3		1	
2/25/86		10		2		1		2	
3/28/81	19	20	30	4	10	3	20	1	12
8/31/83	62	41	40	1	20	2	20	1	8
8/28/84	71	6	60	1	10	1	30	1	
9/9/80	60	10	20	2	10	2	20	2	6
9/2/81	73	10	40	2	10	1	20	1	14
9/7/82	68	10	20	1	10	3	10	1	4
9/12/85	70	10	70	1	10	1	70	2	12
All									
Mean	85	13	43	2	20	2	49	1	9
CV	1.7	0.7	0.5	0.6	0.9	0.4	1.4	0.4	0.4
n	12	13	11	12	11	13	11	13	10
Winter									
Mean	103	12	44	2	30	2	74	1	8
CV	2.0	0.5	0.5	0.7	0.8	0.4	1.3	0.4	0.4
n	6	7	5	6	5	7	5	7	5
Summer									
Mean	67	15	42	1	12	2	28	1	9
CV	0.1	0.8	0.4	0.4	0.3	0.4	0.7	0.4	0.4
n	6	6	6	6	6	6	6	6	5

Station #11169970 - COYOTE CREEK BELOW LEROY ANDERSON DAM NEAR MADRONE CALIF.

DATE	Flow (cfs)	Fe Sediment (µg/gm)	Mn Dissolved (µg/l)	Mn Sediment (µg/gm)	Al Dissolved (µg/l)	Al Sediment (µg/gm)	Cb Sediment (µg/gm)
1/6/82	9	8500	10	850	10	5000	20
1/28/83	570	9500	3	310	80	3900	10
2/21/80	3	9500	10	610	170	90	30
2/9/85	9	53000	6	1700	10	23000	40
2/14/86	7		100		10		
2/25/86			790		10		
3/28/81	19	10000	20	1700	10	4200	30
8/31/83	62	6000	11	240	10	2100	20
8/28/84	71	23000	9	1100	10	9800	30
9/9/80	60	8000	30	700	20	3000	20
9/2/81	73	19000	ND	1800	ND	4000	20
9/7/82	68	6500	10	1200	10	2600	20
9/12/85	70	28000	350	1900	10	14000	30
All							
Mean	85	16455	112	1101	30	6517	25
CV	1.7	0.8	2.0	0.5	1.5	1.0	0.3
n	12	11	12	11	12	11	11
Winter							
Mean	103	18100	134	1034	43	7238	26
CV	2.0	1.0	2.0	0.6	1.3	1.1	0.4
n	6	5	7	5	7	5	5
Summer							
Mean	67	15083	82	1157	12	5917	23
CV	0.1	0.6	1.6	0.5	0.3	0.8	0.2
n	6	6	5	6	5	6	6

Station #11169970 - COYOTE CREEK BELOW LEROY ANDERSON DAM NEAR MADRONE CALIF.

DATE	Flow (cfs)	Cd Dissolved (µg/l)	Cd Sediment (µg/gm)	Cr Dissolved (µg/l)	Cr Sediment (µg/gm)	Hg Dissolved (µg/l)	Hg Sediment (µg/gm)	Ni Sediment (µg/gm)	Se Dissolved (µg/l)	Se Sediment (µg/gm)
1/6/82	9	<1	<1	<10	20	<0.1	0.07	<100	--	<1
1/28/83	570	<1	1	<10	30	<0.1	0.11	<100	--	<1
2/21/80	3	0	0	0	30	0.00	0.13	0	--	0
2/9/85	9	<1	<1	<10	130	<0.1	0.07	<100	<1	<1
2/14/86	7	1	--	<10	--	<0.1	--	<100	--	--
2/25/86	--	<1	--	<10	--	--	--	<100	--	--
3/28/81	19	0	0	10	34	0.00	0.60	0	--	0
8/31/83	62	<1	<1	<10	20	<0.1	0.06	<100	--	<1
8/28/84	71	<1	<1	<10	70	<0.1	0.65	<100	--	<1
9/9/80	60	0	2	0	13	0.00	0.04	0	--	0
9/2/81	73	0	<1	0	60	1.90	0.04	0	--	0
9/7/82	68	<1	<1	<10	20	<0.1	0.06	<100	--	<1
9/12/85	70	2	<1	<10	950	<0.1	0.08	<100	--	<1

Station #11169970 - COYOTE C BL LEROY ANDERSON DM NR MADRONE CALIF

DATE	Total Diazinon (µg/l)	Total 2,4-D. (µg/l)	Total Lindane (µg/l)	Total Malathion (µg/l)	Total Chlordane (µg/l)	Total DDD (µg/l)	Total DDE (µg/l)	Total DDT (µg/l)	Total Dieldrin (µg/l)	Total Heptachlor (µg/l)
2/21/80	0	0	0	0	0	0	0	0	0	0
9/9/80	0	0	0	0	0	0	0	0	0	0
3/28/81	0	0	0	0	0	0	0	0	0	0
9/2/81	0	--	0	0.01	0	0	0	0	0	0
1/6/82	<0.01	0.02	0	<0.01	0	0	0	0	0	0
9/7/82	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
1/28/83	<0.01	0.01	<0.020	<0.01	<0.2	<0.020	<0.020	<0.020	<0.020	<0.020
4/13/83	<0.01	0.02	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
8/31/83	<0.01	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
8/28/84	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
2/9/85	<0.01	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
9/12/85	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
1/30/86	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010

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Station #11169970 - COYOTE C BL LEROY ANDERSON DM NR MADRONE CALIF

DATE	Total Naphthalenes Polychlor (µg/l)	Total PCB (µg/l)	Total Aldrin (µg/l)	Total Endosulfan (µg/l)	Total Endrin (µg/l)	Total Ethion (µg/l)	Total Chlor Epoxide (µg/l)	Total Oxychlor (µg/l)	Total ethyl Parathio (µg/l)	Total ethyl Trithion (µg/l)
2/21/80	0	0	0	0	0	0	0	0	0	0
9/9/80	0	0	0	0	0	0	0	0	0	0
3/28/81	0	0	0	0	0	0	0	0	0	0
9/2/81	0	0	0	0	0	0	0	0	0	0
1/6/82	0	0	0	0	0	0	0	0	0	0
9/7/82	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0 01	<0.01
1/28/83	<0.20	<0.2	<0.020	<0.020	<0.020	<0.01	<0.020	<0.02	<0.01	<0.01
4/13/83	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
8/31/83	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
8/28/84	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
2/9/85	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
9/12/85	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
1/30/86	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01

Station #11169970 - COYOTE C BL LEROY ANDERSON DM NR MADRONE CALIF

DATE	Total Naphthalenes Polychlor (µg/l)	Total PCB (µg/l)	Total Aldrin (µg/l)	Total Endosulfan (µg/l)	Total Endrin (µg/l)	Total Ethion (µg/l)	Total Chlor Epoxide (µg/l)	Total Oxychlor (µg/l)	Total ethyl Parathion (µg/l)	Total Methyl Trithion (µg/l)
2/21/80	0	0	0	0	0	0	0	0	0	0
9/9/80	0	0	0	0	0	0	0	0	0	0
3/28/81	0	0	0	0	0	0	0	0	0	0
9/2/81	0	0	0	0	0	0	0	0	0	0
1/6/82	0	0	0	0	0	0	0	0	0	0
9/7/82	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
1/28/83	<0.20	<0.2	<0.020	<0.020	<0.020	<0.01	<0.020	<0.02	<0.01	<0.01
4/13/83	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
8/31/83	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
8/28/84	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
2/9/85	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
9/12/85	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01
1/30/86	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01

Station #11169970 - COYOTE C BL LEROY ANDERSON DM NR MADRONE CALIF

DATE	Total Mirex (μg/l)	Total Perthane (μg/l)	Total Toxaphene (μg/l)	Total Trithion (μg/l)	Total 2,4,5-T (μg/l)	Total Silvex (μg/l)
2/21/80	0	0	0	0	0	0
9/9/80	0	0	0	0	0	0
3/28/81	0	0	0	0	0	0
9/2/81	0	0	0	0	--	--
1/6/82	0	0	0	0	0	0
9/7/82	<0.01	<0.1	<1	<0.01	<0.01	<0.01
1/28/83	<0.02	<0.2	<2	<0.01	<0.01	<0.01
4/13/83	<0.01	<0.1	<1	<0.01	<0.01	<0.01
8/31/83	<0.01	<0.1	<1	<0.01	<0.01	<0.01
8/28/84	<0.01	<0.1	<1	<0.01	<0.01	<0.01
2/9/85	<0.01	<0.1	<1	<0.01	<0.01	<0.01
9/12/85	<0.01	<0.1	<1	<0.01	<0.01	<0.01
1/30/86	<0.01	<0.1	<1	<0.01	<0.01	<0.01

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USGS STATION NO. 11167572
GUADALUPE RIVER AT
ALAMITOS RECHARGE FACILITY AT SAN JOSE, CA

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Station #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

Period	Flow (cfs)	Cond (µmohs)	TDS (mg/l)	pH	Temp (deg C)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Dis. Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
01/18/1979	18.0	439	250	8.2	10.5	.	9.2			200	160
01/11/1980	-	477	270			30.0				220	170
01/29/1981	-	326	180			200.0				140	
01/04/1982	-	215	130			190.0				100	
01/20/1982	-	481	270			3.5				230	
01/18/1983	-	485	270			44.0				220	
01/26/1983	-	196	120			480.0				93	
01/15/1985	14.0	462	260	7.9	10.0	3.0	11.7	104	3.3	180	141
01/29/1985	7.2	466	270	8.3	11.0	2.3	13.0	118	3.0	180	137
01/29/1986	3.6	630	370	8.5	12.0	1.7	11.6	109		300	239
02/14/1979	68.0	415	240	7.8	13.5	.	10.7			170	130
02/18/1980	-	266	160			220.0				120	99
02/16/1982	-	391	210			46.0				190	
02/07/1983	-		180			100.0				140	
02/28/1983	-		130			190.0				98	
02/27/1984	-		320			.				260	
02/09/1985	40.0	428	240	7.9	10.0	39.0	9.4	83		180	134
02/13/1986	74.0	450		8.1	13.0	39.0	10.0	95		210	169
02/25/1986	247.0		200	8.0		40.0	10.2			170	133
03/16/1979	12 J	504	300	8.4	14.5	.	12.2			230	190
03/27/1979	86.0	372	220	7.9	14.5	.	9.3			180	140
03/05/1980	-	363	210			39.0				170	150
03/04/1981	-	512	290			16.0				220	
03/26/1981	-	498	280			54.0				200	
03/29/1982	-	355	210			32.0				180	
03/17/1984	13.0	530	300	8.4	16.0	2.0	9.4	94	3.0	250	
03/11/1985	14.0	477	270	8.0	13.0	12.0	9.6	91		210	160
03/11/1986	512.0	278	170	8.2	14.0	61.0	10.3	100		130	121
04/11/1983	-		300			20.0				250	
04/26/1979	15.0	557	330	8.2	18.0	.	9.7			280	220
05/23/1979	18.0	463	290	8.3	23.0	.	11.1			250	210
05/06/1980	-	451	280			18.0				240	200
05/18/1981	-	494	280			10.0				230	
05/17/1982	-	564	310			5.0				260	
05/16/1983	-	467	270			78.0				220	
05/13/1986	15.0	514	300	8.4	21.5	5.5	10.8	121		240	208
06/11/1984	-		300			7.3				250	218

06/13/1985	11.0	583	340	8.4	25.0	1.5	9.8	120		290	240
07/31/1979	13.0	475	280	8.4	25.5	-	12.2			230	210
07/16/1980	-	493	280			1.3				220	200
07/13/1981	-	638	310			11.0				260	
07/19/1982	-	518	300			13.0				260	
07/12/1983	11.0	502	280	8.6	23.5	2.0	9.9	118	1.9	230	200
07/10/1984	17.0	495	290	8.6	26.0	4.4	10.1	126		250	215
07/22/1986	7.9	517	300	8.6	25.5	1.0	8.3	102		230	215
08/31/1981	-	439	240			-				210	
08/29/1983	-	527	300			15.0				260	
08/27/1984	1.8	550	310	8.0	23.0	1.1	6.9	81	3.9	260	234
09/04/1979	13.0	433	250	8.6	24.5	-	12.1			220	190
09/10/1980	-		330			12.0				270	220
09/07/1982	-	480	270			7.4				220	
09/11/1985	5.8	612	360	8.4	21.5	1.3	10.7	122		290	244
09/23/1986	13.0	456	270	8.2	20.0	1.5	9.3	103		220	190
11/20/1979	10.0	470	290	8.4	16.5	2.2	11.6		3.9	210	180
11/18/1980	-	448	250			18.0				210	
11/16/1981	-	429	240			42.0				190	
11/15/1982	-	509	290			15.0				240	
12/30/1981	25.0	551	320	7.8	13.5	7.8	8.6	83	3.8	250	204

Station #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

Period	Flow (cfs)	Cond (µmohs)	TDS (mg/l)	pH	Temp (deg C)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Dis. Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
All											
Mean	47.6	464	265	8.2	17.7	44.7	10.3	104	3.3	214	184
CV	2.20	0.20	0.21	0.03	0.32	1.89	0.13	0.14	0.22	0.22	0.21
n	27	51	57	27	26	48	27	17	7	58	33
Month											
Nov	10.0	464	268	8.4	16.5	19.3	11.6		3.9	213	180
Jan	13.6	430	246	8.1	11.4	96.2	10.8	104	3.4	192	175
Feb	107.3	390	210	8.0	12.2	96.3	10.1	89		171	133
Mar	127.4	432	255	8.2	14.4	29.5	10.2	95	3.0	202	152
May	14.8	512	300	8.3	21.9	17.9	10.3	121		251	216
July	12.2	520	291	8.6	25.1	5.5	10.1	115	1.9	240	208
Sept	8.4	500	291	8.3	22.3	6.4	9.8	102	3.9	244	216
Winter											
Nov-Apr	76.3	428	243	8.1	13.0	67.2	10.5	97	3.4	192	156
n	15	29	33	15	14	29	15	9	5	34	17
Summer											
May-Sept	11.8	510	295	8.4	23.1	10.3	10.1	112	2.9	245	213
n	12	22	24	12	12	19	12	8	2	24	16

Station #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

Period	Flow (cfs)	Total Phosphorous (mg/l as P)	Ortho P (mg/l as P)	Total Boron (mg/l as B)	Dis Iron (mg/l as Fe)	Nitrogen NO3+NO2 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
01/18/1979	18	0.18	0.08	110	10	1.90	0.06	0.74	0.84	2.70
01/11/1980		0.15	0.11	120	60	1.60	0.04	1.10	1.10	2.70
01/29/1981		0.27	0.16	80	80	1.80	0.15			
01/04/1982		0.28	0.20	60	240	1.60	0.11	1.10	1.20	2.80
01/20/1982		0.10	0.09	100	46	2.60	0.21	0.53	0.76	3.40
01/18/1983		0.16	0.08	100	16	2.20	0.12	1.00	1.10	3.30
01/26/1983		0.33	0.10	50	150	0.63	0.08	1.30	1.60	2.20
01/15/1985	14	0.05	0.04	130	16	1.60	0.06	0.64	0.70	2.40
01/29/1985	7.2	0.04	0.02	130	12	1.50	0.04	0.48	0.50	2.10
01/29/1986	3.6	0.03	0.01	140	8		0.05	0.63	0.70	2.30
02/14/1979	68	0.11	0.04	160	60	1.40	0.02	0.63	0.72	2.10
02/18/1980		0.57	0.16	110	30	1.30	0.10	1.50	1.70	3.00
02/16/1982		0.07	0.04	80	13	1.20	0.11	0.59	0.71	1.70
02/07/1983		0.20	0.09	70	92	0.74	0.13	0.80	0.90	1.70
02/28/1983		0.25	0.09	50	160	0.45	0.14	1.30	1.50	2.00
02/27/1984		0.15	0.01	130	3	1.80	0.04	1.40	1.40	3.10
02/09/1985	40	0.13	0.04	110	37	0.87	0.04	1.20	1.30	3.00
02/13/1986	74	0.14	0.06	100	63		0.11	0.71	0.80	2.20
02/25/1986	247	0.06	0.03	80	43		0.04	0.36	0.40	2.00
03/16/1979	12	0.04	0.01	150	10	1.70	0.01	0.46	0.51	2.10
03/27/1979	86	0.11	0.03	130	30	1.10	0.06	0.45	0.51	1.50
03/05/1980		0.09	0.08	90	30	1.10	0.07	0.75	0.82	1.90
03/04/1981		0.13	0.02	130	20	2.30	0.04	1.20	1.30	3.40
03/26/1981		0.18	0.00	130	20	1.30	0.05	1.70	1.80	3.10
03/29/1982		0.05	0.05	100	10	1.10	0.10	0.54	0.68	1.80
03/17/1984	13	0.02	0.05	110	3	1.70	0.08	0.36	0.40	2.10
03/11/1985	14	0.07	0.05	120	34	1.60	0.06	0.41	0.50	2.10
03/11/1986	512	0.11	0.04	70	96		0.03	0.43	0.50	1.10
04/11/1983		0.06	0.03	110	3	1.80	0.10	1.50	1.60	3.40
04/26/1979	15	0.04	0.02	160	10	1.90	0.01	0.47	0.53	2.40
05/23/1979	18	0.03	0.01	130	10	0.83	0.01	0.32	0.40	1.30
05/06/1980		0.05	0.00	110	10	1.40	0.04	0.98	1.10	
05/18/1981		0.08	0.01	100	10	1.00	0.11	1.50	1.70	2.70
05/17/1982		0.05	0.02	110	9	2.10	0.10	0.85	0.98	3.00
05/16/1983		0.05	0.01	110	6	1.10	0.07	0.39	0.50	1.60
05/13/1986	15	0.03	0.01	130	3		0.02	0.39	0.40	1.70
06/11/1984		0.04	0.01	180	13	0.60	0.04	0.77	0.80	1.40

06/13/1985	11	0.01	0.01	150	8	0.66	0.04	0.43	0.50	1.10
07/31/1979	13	0.01	0.01	130	10	0.64	0.04	0.37	0.38	1.00
07/16/1980		0.03	0.00	140	10	1.30	0.04	0.60	0.64	1.90
07/13/1981		0.08	0.02	120	10	0.78	0.12	1.00	1.20	2.00
07/19/1982		0.02	0.01	130	3	1.30	0.07	3.00	3.10	4.40
07/12/1983	11	0.02	0.01	140	6	0.90	0.04	0.76	0.80	1.70
07/10/1984	17	0.01	0.02	160	4	0.51	0.01	0.45	0.50	1.00
07/22/1986	7.9	0.02	0.01	130	7		0.02	0.37	0.40	1.10
08/31/1981		0.04	0.00	120	10	0.35		0.90	1.00	1.30
08/29/1983		0.05	0.01	130	3	0.92	0.03	1.00	1.10	2.00
08/27/1984	1.8	0.01	0.01	130	7	0.25	0.01	0.38	0.40	0.70
09/04/1979	13	0.02	0.01	140	10	0.29	0.03	0.55	0.58	0.87
09/10/1980		0.07	0.01	150	20	1.50	0.01	0.68	0.71	2.30
09/07/1982		0.04	0.01	120	6	0.82	0.14	0.69	0.90	1.70
09/11/1985	5.8	0.02	0.01	140	9	0.47	0.06	0.44	0.50	1.00
09/23/1986	13	0.02	0.01	130	5		0.05	0.34	0.40	1.00
11/20/1979	10	0.00	0.01	150	10	0.69	0.05	0.34	0.43	1.10
11/18/1980		0.03	0.01	130	10	0.84	0.05	0.49	0.54	1.40
11/16/1981		0.15	0.12	100	56	1.50	0.21	0.64	0.82	2.30
11/15/1982		0.05	0.01	140	4	0.97	0.15	1.50	1.60	2.60
12/30/1981	25	0.08	0.04	130	12	1.90	0.07	1.20	1.30	3.10

Station #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

Period	Flow (cfs)	Phosphorous (mg/l as P)	Ortho P (mg/l as P)	Total Boron (mg/l as B)	Dis Iron (mg/l as Fe)	Nitrogen NO3+NO2 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic (mg/l as N)	Total ORG+NH3 (mg/l as N)	Total Nitrogen (mg/l as N)
All										
Mean	47.6	0.09	0.04	119	29	1.22	0.07	0.80	0.89	2.09
CV	2.20	1.08	1.14	0.23	1.50	0.46	0.70	0.60	0.57	0.39
n	27	58	58	58	58	51	57	57	57	56
Month										
Nov	10.0	0.06	0.04	130	20	1.00	0.12	0.74	0.85	1.85
Jan	13.6	0.15	0.08	105	59	1.73	0.09	0.87	0.98	2.70
Feb	107.3	0.19	0.06	99	56	1.11	0.08	0.94	1.05	2.31
Mar	127.4	0.09	0.04	114	26	1.52	0.06	0.78	0.86	2.25
May	14.8	0.04	0.01	131	9	1.20	0.05	0.68	0.77	1.90
July	12.2	0.03	0.01	136	7	0.91	0.05	0.94	1.00	1.87
Sept	8.4	0.03	0.01	133	9	0.66	0.05	0.62	0.70	1.36
Winter										
Nov-Apr	76.3	0.13	0.06	109	44	1.43	0.08	0.85	0.95	2.35
n	15	34	34	34	34	30	34	33	33	33
Summer										
May-Sept	11.8	0.04	0.01	133	8	0.93	0.05	0.73	0.81	1.70
n	12	24	24	24	24	21	23	24	24	23

Station #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

DATE	Flow (cfs)	Zn dissolved (µg/l)	Zn sediment (µg/l)	PB dissolved (µg/l)	PB sediment (µg/l)	Cu dissolved (µg/l)	Cu sediment (µg/l)	As dissolved (µg/l)	As sediment (µg/l)
01/04/1982		20		4		6		2	
01/18/1979		3		4		3		2	
01/26/1983		3	30	1	10	4	20	1	9
02/09/1985	40	3	140	1	110	4	60	1	6
02/13/1986	74	14		2		1		1	
02/18/1980		50		3		3		1	
02/25/1986	247	10		3		1		1	
02/27/1984				1		2		1	
03/26/1981		80		3		4		2	
07/31/1979	13	3		ND		ND		1	
08/27/1984	1.8	30	50	1	10	1	30	1	1
08/29/1983		43		1		3		1	
08/31/1981		80		5		3		1	
09/07/1982		76		1		6		2	
09/10/1980		50		4		ND		2	
09/11/1985	6	10	90	1	10	1	70	1	9
All Data									
Mean	64	32	78	2	35	3	45	1	6
CV	1.48	0.93	0.63	0.62	1.43	0.57	0.53	0.36	0.60
n	6	15	4	15	4	14	4	16	4
Winter									
Mean	120	23	85	2	60	3	40	1	8
CV	0.92	1.22	0.92	0.51	1.18	0.52	0.71	0.36	0.28
n	3	8	2	9	2	9	2	9	2
Summer									
Mean	7	42	70	2	10	3	50	1	5
CV	0.83	0.72	0.40	0.85	0.00	0.73	0.57	0.38	1.13
n	3	7	2	6	2	5	2	7	2

Station #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

DATE	Flow (cfs)	Fe sediment (µg/l)	Mn dissolved (µg/l)	Mn sediment (µg/l)	Al dissolved (µg/l)	Al sediment (µg/l)	Cb sediment (µg/l)
01/04/1982			20		20		
01/18/1979			8		10		
01/26/1983		11000	4	330	120	6400	20
02/09/1985	40	36000	15	2100	40	20000	30
02/13/1986	74		17		30		
02/18/1980			20		50		
02/25/1986	247		10		20		
02/27/1984							
03/26/1981			5		20		
07/31/1979	13		3		100		
08/27/1984	1.8	19000	8	360	10	9000	20
08/29/1983			2		10		
08/31/1981			ND		10		
09/07/1982			2		10		
09/10/1980			10		0		
09/11/1985	6	21000	10	630	10	12000	30
All Data							
Mean	64	21750	10	855	31	11850	25
CV	1.48	0.48	0.66	0.98	1.14	0.50	0.23
n	6	4	14	4	15	4	4
Winter							
Mean	120	23500	12	1215	39	13200	25
CV	0.92	0.75	0.52	1.03	0.91	0.73	0.28
n	3	2	8	2	8	2	2
Summer							
Mean	7	20000	6	495	21	10500	25
CV	0.83	0.07	0.67	0.39	1.63	0.20	0.28
n	3	2	6	2	7	2	2

Station #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

DATE	Flow (cfs)	Cd dissolved (µg/l)	Cd sediment (µg/l)	Cr dissolved (µg/l)	Cr sediment (µg/l)	Hg dissolved (µg/l)	Hg sediment (µg/l)	Ni sediment (µg/l)	Se dissolved (µg/l)	Se sediment (µg/l)
01/04/1982		<1		<10		<0.1				
01/18/1979		<2		<20		<0.1		<200		
01/26/1983		<1	<1	<10	40	<0.1	4	<100		<1
02/09/1985	40	<1	<1	<10	100	<0.1	0	<100	<1	<1
02/13/1986	74	<1		<10		<0.1		<100		
02/18/1980		0		0		0		0		
02/25/1986	247	<1		<10		<0.1		<100		
02/27/1984		<1		<10		<0.1				
03/26/1981		2		10		0		100		
07/31/1979	13	<2		ND		<0.1		ND		
08/27/1984	1.8	<1	<1	10	80	<0.1	2	<100		<1
08/29/1983		<1		10		<0.1		<100		
08/31/1981		1		0		0		0		
09/07/1982		<1		10		<0.1		<100		
09/10/1980		1		0		0		0		
09/11/1985	6	<1	<1		1100	<0.1	4	<100		<1

STATION #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

DATE	Total Diazinon (μg/l)	Total 2,4-D, (μg/l)	Total Lindane (μg/l)	Total Malathion (μg/l)	Total Chlordane (μg/l)	Total DDD (μg/l)	Total DDE (μg/l)	Total DDT (μg/l)	Total Dieldrin (μg/l)	Total Heptachlor (μg/l)
01/05/1982	0.05	0.03	0.01	0.09	0	0.01	0.01	0	0	0
01/26/1983	0.01	0.01	<0.010	<0.01	<0.1	<0.010	0.01	<0.010	0.01	<0.010
01/29/1986	0.11	0.04	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
02/09/1985	0.12	0.03	0.03	0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
02/13/1986	0.1	0.17	<0.010	0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
02/19/1980	0.03	0	0	0	0.1	0	0	0	0	0
02/25/1986	<0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
03/27/1981	0.03	0.06	0.01	0	0	0	0	0	0	0
04/12/1983	0.01	0.02	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
07/22/1986	0.02	0.02	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
08/27/1984	0.01	0.03	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
08/30/1983	0.01	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
09/01/1981	0.01	0.02	0	0.16	0	0	0	0	0	0
09/08/1982	0.01	<0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
09/10/1980	0	0	0	0	0	0	0	0	0	0
09/11/1985	0.01	0.03	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
09/23/1986	0.01	0.01	<0.010	<0.01	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010

STATION #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

DATE	Naphthalenes Polychlor (µg/l)	Total PCB (µg/l)	Total Aldrin (µg/l)	Total Endosulfan (µg/l)	Total Endrin (µg/l)	Total Ethion (µg/l)	Total Chlor Epoxide (µg/l)	Total Oxychlor (µg/l)	Total Methyl Parathion (µg/l)
01/05/1982	0	0	0	0	0	0	0	0	0
01/26/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
01/29/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
02/09/1985	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
02/13/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
02/19/1980	0	0	0	0	0	0	0	0	0
02/25/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
03/27/1981	0	0	0	0	0	0	0	0	0
04/12/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
07/22/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
08/27/1984	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
08/30/1983	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
09/01/1981	0	0	0	0	0	0	0	0	0
09/08/1982	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
09/10/1980	0	0	0	0	0	0	0	0	0
09/11/1985	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01
09/23/1986	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01

STATION #11167572 GUADALUPE RIVER AT ALAMITOS RECHARGE FACILITY AT SAN JOSE CALIF.

DATE	Total Methyl Trithion (µg/l)	Total Mirex (µg/l)	Total Perthane (µg/l)	Total Toxaphene (µg/l)	Total Trithion (µg/l)	Total 2,4,5-T (µg/l)	Total Silvex (µg/l)
01/05/1982	0	0	0	0	0	0	0
01/26/1983	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
01/29/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
02/09/1985	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
02/13/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
02/19/1980	0	0	0	0	0	0	0
02/25/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
03/27/1981	0	0	0	0	0	0	0
04/12/1983	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
07/22/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
08/27/1984	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
08/30/1983	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
09/01/1981	0	0	0	0	0	0	0
09/08/1982	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
09/10/1980	0	0	0	0	0	0	0
09/11/1985	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01
09/23/1986	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01

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SAN JOSE, CA

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STATION #11169000 GAUDALUPE RIVER AT SAN JOSE, CALIF.

Period	Flow (cfs)	Cond (µmohs)	TDS (mg/l)	pH	Temp (deg C)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Dis. Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
1/17/79	52.0	405	230	7.6	9.0	--	11.0	--	5.1	180	140
1/12/80	221.0	300	180	7.4	15.0	28	9.1	--	--	130	97
1/29/81	293.0	282	150	7.4	11.0	130	10.2	93	--	110	90
1/5/82	943.0	242	140	7.9	11.0	270	10.5	95	--	110	100
1/21/82	137.0	369	210	8.0	9.0	6	11.0	95	--	170	144
1/19/83	68.0	454	260	8.1	10.0	27	10.7	95	--	200	170
1/27/83	1540.0	235	150	7.9	12.0	350	10.6	99	--	99	104
1/29/85	22.0	681	410	8.3	13.5	6.5	10.8	103	42.0	320	269
1/29/86	25.0	652	400	8.3	15.0	28	8.8	88	10.0	310	266
1/28/87	24.0	393	246	8.1	13.0	17	9.7	92	5.1	180	147
1/15/85	23.0	715	440	8.5	13.0	1.4	11.6	110	5.0	350	302
2/14/79	135.0	177	140	7.2	12.5	--	10.0	--	--	95	67
2/19/80	7900.0	172	100	6.8	12.5	800	9.7	--	--	68	62
2/17/82	348.0	362	200	8.6	12.0	50	10.0	92	--	170	160
2/8/83	934.0	270	150	8.0	12.0	150	10.7	100	--	120	84
2/28/84	28.0	695	200	8.6	15.0	5.7	12.0	120	18.0	310	128
2/9/85	116.0	496	290	8.2	10.0	30	10.8	95	30.0	220	178
2/13/86	124.0	466	280	8.3	14.0	81	10.0	97	42.0	220	171
2/24/86	925.0	202	150	8.2	11.0	330	11.1	100	98.0	110	94
2/11/87	31.0	605	362	8.4	16.0	6.8	11.4	116	3.3	270	230
3/16/79	27.0	288	160	7.7	13.5	--	8.5	--	--	100	71
3/27/79	453.0	176	100	7.5	13.5	--	9.5	--	--	73	52
3/6/80	302.0	336	190	7.8	13.0	57	10.0	--	--	150	130
3/5/81	21.0	394	230	7.7	12.0	19	10.0	94	--	160	120
3/27/81	3.7	332	190	8.0	15.5	16	8.4	84	--	130	120
3/30/82	480.0	323	190	8.1	11.0	48	10.4	94	--	150	122
3/1/83	4240.0	200	130	8.0	13.0	330	10.0	--	--	93	88
3/17/84	29.0	350	440	7.9	15.0	54	8.8	86	3.0	140	289
3/11/85	69.0	252	150	8.0	14.5	23	8.8	86	40.0	110	92
3/11/86	1480.0	258	150	8.2	13.5	110	10.2	98	39.0	110	100
3/5/87	200.0	342	198	7.9	14.0	24	9.3	91	12.0	140	117
4/12/83	61.0	554	250	9.0	14.0	15	13.1	128	16.0	250	170
4/26/79	31.0	259	150	7.2	18.5	--	6.8	--	19.0	88	62
5/23/79	0.7	895	520	8.1	18.5	--	7.8	--	--	360	290
5/6/80	0.7	826	490	8.2	16.5	5.2	7.4	76	--	370	310
5/19/81	0.5	866	510	8.1	16.0	2.1	6.3	64	--	370	340
5/18/82	3.7	918	570	8.3	17.5	0.5	12.1	127	--	430	384
5/17/83	103.0	411	420	8.5	18.0	6.5	10.0	105	6.0	190	270

5/13/86	25.0	690	430	8.4	20.0	4	10.5	116	<3	320	272
6/12/84	24.0	817	420	8.5	20.0	1.1	11.8	131	5.0	340	283
6/13/85	20.0	736	450	8.4	22.0	4	8.9	102	4.0	350	295
6/2/87	20.0	712	461	8.4	22.0	4.5	10.4	119	--	340	294
7/16/80	0.2	750	440	8.3	21.5	6.9	15.6	176	--	320	280
7/14/81	0.3	702	440	8.5	23.0	5.2	13.2	155	--	290	250
7/20/82	3.2	864	540	8.4	21.5	4.2	12.7	144	--	360	300
7/12/83	18.0	743	440	8.6	23.0	1	9.6	113	4.0	330	290
7/10/84	25.0	614	430	8.5	21.5	6.4	12.0	137	<3	320	283
7/24/85	22.0	748	430	8.0	22.0	23	10.9	127	6.0	340	288
7/22/86	22.0	765	460	8.4	21.5	8.6	11.5	131	4.0	340	310
7/7/87	17.0	722	450	8.4	23.0	32	8.7	102	2.8	340	305
8/1/79	0.3	735	460	8.2	26.0	--	10.9	--	15.0	310	270
8/30/83	20.0	713	400	8.3	23.0	4.5	10.6	124	11.0	350	277
8/27/84	22.0	721		8.3	21.0	16	9.7	109		330	
8/11/87	15.0	724	434	8.4	22.0	8	10.4	120	2.5	340	292
9/4/79	0.0	859	520	8.0	21.0	--	7.0	--	19.0	350	290
9/10/80	0.5	869	500	7.8	18.0	4	6.2	--	--	350	310
9/1/81	0.3	728	440	8.0	19.5	2.6	9.8	107	--	300	250
9/8/82	2.8	498	280	7.5	23.0	1.5	9.9	118	--	200	138
9/11/85	20.0	712	430	8.4	17.5	24	9.4	98	3.0	340	289
9/23/86	23.0	701	450	8.3	18.0	100	7.6	81	3.0	350	295
11/18/80	0.2	724	400	7.2	10.5	4.9	1.0	9	--	260	240
11/17/81	128.0	289	150	7.8	15.5	70	8.6	85	--	120	102
11/16/82	14.0	606	360	8.4	12.5	20	10.0	94	--	260	230
12/6/86	27.0	496	291	8.1	14.0	13	8.8	85	8.9	230	187
12/30/81	27.0	375	210	8.0	13.0	52	9.5	90	--	160	130

STATION #11169000 GAUDALUPE RIVER AT SAN JOSE, CALIF.

Period	Flow (cf)	Cond (µmohs)	TDS (mg/l)	pH	Temp (deg C)	Turbidity (NTU)	DO (mg/l)	DO (% sat)	Dis. Organic C (mg/l as C)	TH (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)
All											
Mean	341.6	537	321	8.1	16.2	60.7	9.9	104	16.1	238	202
CV	3.32	0.42	0.44	0.05	0.27	2.16	0.20	0.24	1.25	0.43	0.45
n	64	64	63	64	64	56	64	51	30	64	63
Month											
Nov	42.3	529	300	7.9	13.1	27.0	7.1	68	8.9	218	190
Jan	281.3	425	252	8.0	12.0	83.3	10.3	96	13.4	193	163
Feb	1171.2	383	208	8.0	12.8	181.7	10.6	103	38.3	176	130
Mar	613.8	317	198	8.0	13.5	69.6	9.8	95	22.0	134	123
May	22.9	713	442	8.2	18.9	3.5	9.2	105	8.5	316	280
July	12.0	738	454	8.4	22.6	10.9	11.7	136	6.4	328	286
August	14.3	723	431	8.3	23.0	9.5	10.4	118	9.5	333	280
Sept	7.8	728	437	8.0	19.5	26.4	8.3	101	8.3	315	262
Winter											
Nov-Apr	579.8	391	229	8.0	12.8	96.2	9.9	94	23.8	172	145
n	37	37	37	37	37	33	37	29	16	37	37
Summer											
May-Sept	15.7	725	443	8.2	20.5	11.5	9.9	117	7.5	322	278
n	28	28	27	28	28	24	28	23	14	28	27

STATION #11169000 GAUDALUPE RIVER AT SAN JOSE, CALIF.

Period	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO3+NO2 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic (mg/l as N)	Total Nitrogen (mg/l as N)
1/17/79	52.0	0.16	0.04	110	20	1.50	0.06	0.58	2.20
1/12/80	221.0	0.23	0.09	100	80	0.99	0.06	1.20	2.30
1/29/81	293.0	0.26	0.15	60	30	1.50	0.10	--	--
1/5/82	943.0	0.25	0.16	60	150	1.80	0.13	1.20	3.20
1/21/82	137.0	0.15	0.12	80	22	1.70	0.15	0.61	2.60
1/19/83	68.0	0.47	0.31	100	17	1.90	0.07	0.93	2.90
1/27/83	1540.0	0.60	0.08	50	150	0.80	0.09	1.10	2.10
1/29/85	22.0	0.07	--	0.04	150	3.50	0.60	0.55	4.20
1/29/86	25.0	0.17	0.07	0.06	150	--	1.10	0.98	4.30
1/28/87	24.0	0.10	0.05	90	19	1.70	0.05	1.20	2.90
1/15/85	23.0	0.02	--	0.02	160	3.60	0.30	- -	4.10
2/14/79	135.0	0.17	0.07	80	80	0.76	0.13	0.81	1.60
2/19/80	7900.0	2.80	0.20	70	190	0.93	0.09	4.50	5.60
2/17/82	348.0	0.06	0.04	80	38	0.80	0.08	0.57	1.50
2/8/83	934.0	0.21	0.09	50	40	0.60	0.09	1.00	1.70
2/28/84	28.0	0.14	--	0.05	80	1.40	0.60	0.47	2.00
2/9/85	116.0	0.10	--	0.03	130	1.20	1.00	0.97	3.10
2/13/86	124.0	0.09	0.06	0.02	90	--	1.10	1.00	2.60
2/24/86	925.0	0.21	0.04	0.02	70	--	1.10	1.00	2.10
2/11/87	31.0	0.04	0.02	160	5	- -	0.01	0.70	2.70
3/16/79	27.0	0.27	0.13	130	30	1.30	0.06	1.40	2.60
3/27/79	453.0	0.67	0.13	70	100	0.63	--	1.50	2.20
3/6/80	302.0	0.10	0.05	80	30	0.56	0.04	0.83	1.70
3/5/81	21.0	0.15	0.06	120	50	1.40	0.06	1.00	2.50
3/27/81	3.7	0.21	0.05	80	20	0.81	0.08	1.20	2.00
3/30/82	480.0	0.08	0.05	80	34	0.56	0.12	0.42	1.10
3/1/83	4240.0	0.79	0.07	50	240	0.43	0.12	1.90	2.50
3/17/84	29.0	0.02	--	0.01	160	3.30	1.00	0.55	4.20
3/11/85	69.0	0.18	--	0.1	60	0.88	0.70	0.61	1.60
3/11/86	1480.0	0.17	0.05	0.04	50	--	0.60	0.52	1.30
3/5/87	200.0	0.20	0.09	100	41	- -	0.03	1.80	3.10
4/12/83	61.0	0.04	--	0.01	80	1.10	0.60	1.00	1.70
4/26/79	31.0	0.21	0.07	160	70	0.82	0.06	1.00	1.90
5/23/79	0.7	0.13	0.09	450	10	0.79	0.01	0.82	1.70
5/6/80	0.7	0.13	0.04	220	20	1.40	0.03	1.40	3.00
5/19/81	0.5	0.24	0.14	190	10	1.70	0.21	0.86	2.80
5/18/82	3.7	0.15	0.09	210	9	2.60	0.12	0.95	3.50
5/17/83	103.0	0.05	--	0.04	160	3.20	1.00	0.47	4.20

5/13/86	25.0	0.11	0.01	0.01	160	..	0.40	0.38	2.90
6/12/84	24.0	0.04	..	0.02	150	3.20	0.80	0.98	4.00
6/13/85	20.0	0.04	..	0.01	170	3.00	0.50	0.43	3.50
6/2/87	20.0	0.02	0.01	160	3	- -	0.04	1.00	3.60
7/16/80	0.2	0.22	0.05	220	30	0.31	0.01	1.30	1.70
7/14/81	0.3	0.24	0.15	150	10	1.00	0.17	0.86	2.10
7/20/82	3.2	0.20	0.19	180	3	1.20	0.06	1.80	3.10
7/12/83	18.0	0.05	..	0.03	150	2.70	0.90	0.96	3.80
7/10/84	25.0	0.04	..	0.01	150	3.30	0.60	0.74	3.90
7/24/85	22.0	0.05	..	0.02	100	3.20	0.90	0.84	4.10
7/22/86	22.0	0.03	0.02	0.01	160	- -	0.40	0.37	3.30
7/7/87	17.0	0.58	0.02	150	3	- -	0.04	0.80	3.30
8/1/79	0.3	0.07	0.10	210	20	1.40	0.07	0.72	2.10
8/30/83	20.0	0.03	..	0.02	160	3.20	0.50	0.78	3.60
8/27/84	22.0							0.58	
8/11/87	15.0	0.09	0.01	160	3	2.20	0.02	0.40	2.70
9/4/79	0.0	0.14	0.10	270	10	0.54	0.10	0.68	1.30
9/10/80	0.5	0.22	0.16	240	10	1.20	0.03	0.90	2.10
9/1/81	0.3	0.24	0.09	180	10	1.40	0.09	0.93	2.40
9/8/82	2.8	0.09	0.08	100	40	0.35	0.13	0.77	1.40
9/11/85	20.0	0.05	..	0.02	150	3.20	0.70	0.65	3.90
9/23/86	23.0	0.08	0.05	0.02	170	- -	0.40	- -	3.50
11/18/80	0.2	0.30	0.20	150	90	1.20	0.02	0.95	2.20
11/17/81	128.0	0.20	0.14	60	34	0.98	0.16	0.53	1.70
11/16/82	14.0	0.28	0.17	110	7	1.60	0.06	1.30	3.10
12/6/86	27.0	0.15	- -	120	51	- -	0.03	1.00	3.20
12/30/81	27.0	0.21	0.11	90	20	1.20	0.10	0.69	2.00

STATION #11169000 GAUDALUPE RIVER AT SAN JOSE, CALIF.

Period	Flow (cfs)	Total Phosphorous (mg/l as P)	Dis Ortho P (mg/l as P)	Boron (mg/l as B)	Iron (mg/l as Fe)	Nitrogen NO3+NO2 (mg/l as N)	Dis. Ammonia (mg/l as N)	Total Organic (mg/l as N)	Total Nitrogen (mg/l as N)
All									
Mean	341.6	0.22	0.09	87.2	74	1.59	0.30	0.95	2.74
CV	J.32	1.69	0.68	1.03	0.86	0.61	1.14	0.60	0.35
n	64	63	47	63	63	51	62	61	62
Month									
Nov	42.3	0.23	0.17	110.0	46	1.26	0.07	0.95	2.55
Jan	281.3	0.22	0.12	61.7	81	1.84	0.23	0.90	2.98
Feb	1171.2	0.42	0.07	48.9	80	0.95	0.47	1.22	2.54
Mar	613.8	0.24	0.08	59.2	75	1.10	0.31	1.08	2.21
May	22.9	0.11	0.06	139.0	76	2.09	0.32	0.83	3.11
July	12.0	0.16	0.09	101.1	70	1.87	0.35	0.93	3.04
August	14.3	0.06	0.06	123.3	61	2.27	0.20	0.62	2.80
Sept	7.8	0.14	0.10	131.7	65	1.34	0.24	0.79	2.43
Winter									
Nov-Apr	579.8	0.28	0.10	63.0	75	1.35	0.30	1.04	2.57
n	37	37	29	37	37	30	36	35	36
Summer									
May-Sept	15.7	0.13	0.08	120.4	72	1.91	0.31	0.83	2.94
n	28	27	19	27	27	22	27	27	27

STATION 11 169000 - GUADALUPE RIVER AT SAN JOSE, CALIF.

GROUP A - PRESENT IN STREAM

DATE	FLOW	DIAZINON TOTAL (UG/L)	2,4-D TOTAL (UG/L)	LINDANE TOTAL (UG/L)	MALATHION TOTAL (UG/L)
1/17/79	52.00	0.07	0.07	0.02	0.00
8/1/79	0.33	0.20	0.11	0.01	0.00
2/19/80	7900.00	0.07	0.07	0.02	0.01
9/10/80	0.53	0.03	0.00	0.01	0.00
3/27/81	3.70	0.34	0.17	0.02	0.22
9/1/81	0.33	0.02	0.02	0.00	0.96
1/5/82	943.00	0.07	0.02	0.01	0.09
9/8/82	2.80	0.16	0.02	<0.010	<0.01
1/27/83	1540.00	< 0.01	< 0.01	<0.010	<0.01
4/12/83	61.00	0.01	0.03	<0.010	<0.01
8/30/83	20.00	0.02	0.05	<0.010	<0.01
8/27/84	22.00	0.01	0.04	<0.010	<0.01
2/9/85	116.00	0.09	0.07	0.04	0.01
9/11/85	20.00	0.04	< 0.01	<0.010	<0.01
1/29/86	25.00	0.18	0.01	<0.010	0.03
2/13/86	124.00	0.10	0.10	<0.010	0.01
2/24/86	925.00	< 0.01	< 0.01	<0.010	<0.01
7/22/86	22.00	0.01	0.11	<0.010	<0.01
9/23/86	23.00	0.02	0.03	<0.010	<0.01
ALL - AVG		0.08	0.05		
COV		1.14	0.92		
mid 82 - 86					
winter		0.08	0.04	see data	see data
summer		0.04	0.04	all < 0.010	all < 0.01
79 - mid 82					
winter		0.14	0.08	0.02	0.08
summer		0.08	0.04	0.01	0.32

STATION 11 169000 - GUADALUPE RIVER AT SAN JOSE, CALIF.

GROUP B - SOME POSITIVE BEFORE MID 1982 - NONE > D.L. AFTER

DATE	FLOW	CHLORODANE TOTAL (UG/L)	DDD TOTAL (UG/L)	DDE TOTAL (UG/L)	DDT TOTAL (UG/L)	DIELDRIN TOTAL (UG/L)	HEPTACHLOR TOTAL (UG/L)
1/17/79	52.00	0.00	0.00	0.00	0.00	0.00	0.00
8/1/79	0.33	0.00	0.00	0.00	0.00	0.00	0.00
2/19/80	7900.00	0.60	0.04	0.04	0.11	0.02	0.02
9/10/80	0.53	0.10	0.01	0.00	0.00	0.00	0.00
3/27/81	3.70	0.10	0.00	0.00	0.00	0.00	0.00
9/1/81	0.33	0.00	0.00	0.00	0.00	0.00	0.00
1/5/82	943.00	0.00	0.01	0.01	0.00	0.00	0.00
9/8/82	2.80	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
1/27/83	1540.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
4/12/83	61.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
8/30/83	20.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
8/27/84	22.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
2/9/85	116.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
9/11/85	20.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
1/29/86	25.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
2/13/86	124.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
2/24/86	925.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
7/22/86	22.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010
9/23/86	23.00	<0.1	<0.010	<0.010	<0.010	<0.010	<0.010

STATION 11 169000 - GUADALUPE RIVER AT SAN JOSE, CALIF.

GROUP C - NEVER DETECTED

DATE	ENDO-SULFAN TOTAL (UG/L)	ENDRIN TOTAL (UG/L)	ETHION TOTAL (UG/L)	CHLOR EPOXIDE TOTAL (UG/L)	OXY-CHLOR TOTAL (UG/L)	METHYL PARA-THION TOTAL (UG/L)	METHYL TRI-THION TOTAL (UG/L)	MIREX TOTAL (UG/L)	PER-THANE TOTAL (UG/L)	TOXA-PHENE TOTAL (UG/L)	TOTAL TRI-THION (UG/L)	245-T TOTAL (UG/L)	SILVEX TOTAL (UG/L)	NAPHTH-ALENES POLYCHL TOTAL (UG/L)	PCB TOTAL (UG/L)
Jan-79	0.00	0.00	0.00	0.00	--	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	--	0.00
Aug-79	0.00	0.00	0.00	0.00	--	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	--	0.00
Feb-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Sep-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Mar-81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep-81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan-82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep-82	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Jan-83	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Apr-83	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Aug-83	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Aug-84	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Feb-85	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Sep-85	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Jan-86	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Feb-86	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Feb-86	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Jul-86	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1
Sep-86	<0.010	<0.010	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01	<0.01	<0.01	<0.10	<0.1

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GROUP #1

DATE	FLOW CFS	Zn dissolved ug/l	Zn sediment ug/gm	PB dissolved ug/l	PB sediment ug/gm	Cu dissolved ug/l	Cu sediment ug/gm	As dissolved ug/l	As sediment ug/gm
1/17/79	52.0	20	--	26	--	3	--	1	--
1/5/82	943.0	10	100	6	60	2	30	2	8
1/27/83	1540.0	6	70	1	80	2	20	1	4
1/28/88	24.0	8	- -	5	- -	2	- -	2	- -
2/19/80	7900.0	190	810	0	1000	2	40	2	8
2/9/85	116.0	3	110	2	80	3	180	1	4
2/13/86	124.0	28	--	1	--	3	--	1	--
2/24/86	925.0	20	--	1	--	1	--	1	--
3/27/81	3.7	20	70	3	20	6	20	3	10
8/1/79	0.3	6	--	ND	--	2	--	2	--
8/30/83	20.0	9	50	1	40	1	10	1	2
8/27/84	22.0	6	120	1	50	1	60	1	1
8/11/88	15.0	3	100	5	40	1	30	1	5
9/10/80	0.5	10	40	2	40	2	20	4	16
9/1/81	0.3	40	120	5	110	2	100	2	7
9/8/82	2.8	30	70	1	60	5	10	2	3
9/11/85	20.0	10	190	1	300	1	100	1	7
ALL DATA									
AVG	688.7	25	154	3.8	157	2.3	52	1.6	6.3
COV	2.78	1.78	1.36	1.63	1.76	0.61	0.99	0.52	0.65
WINTER									
AVG	1292.0	34	232	5.0	248	2.7	58	1.6	6.8
COV	1.96	1.74	1.39	1.62	1.70	0.53	1.18	0.47	0.39
SUMMER									
AVG	10.1	14	99	2.3	91	1.9	47	1.8	5.9
COV	0.99	0.93	0.52	0.83	1.04	0.72	0.85	0.59	0.86

STATION 11 169000 GUADALUPE RIVER

GROUP #2 - NOT ENVIRONMENTALLY SIGNIFICANT

DATE	FLOW CFS	FE sediment ug/gm	Mn dissolved ug/l	Mn sediment ug/gm	Al dissolved ug/l	Al sediment ug/gm	Cb sediment ug/gm
1/17/79	52.0	--	4	--	10	--	--
1/5/82	943.0	16000	20	330	40	9500	20
1/27/83	1540.0	7000	10	350	120	3900	20
1/28/88	24.0	- -	10	- -	10		- -
2/19/80	7900.0	13000	10	400	60	700	30
2/9/85	116.0	30000	8	500	20	12000	20
2/13/86	124.0	--	5	--	10	--	--
2/24/86	925.0	--	10	--	40	--	--
3/27/81	3.7	7500	20	190	20	4200	20
8/1/79	0.3	--	30	--	50	--	--
8/30/83	20.0	6500	12	200	10	3500	10
8/27/84	22.0	22000	10	390	10	9300	20
8/11/88	15.0	13000	9	370	10		<50
9/10/80	0.5	10000	0	540	10	3100	30
9/1/81	0.3	16000	0	310	10	5000	20
9/8/82	2.8	4500	20	150	10	49000	<10
9/11/85	20.0	21000	20	660	10	12000	20
ALL DATA							
AVG	688.7	13,875	12	366	26	10,200	21
COV	2.78	0.55	0.69	0.41	1.10	1.32	0.27
WINTER							
AVG	1292.0	14,700	11	354	37	6,060	22
COV	1.96	0.64	0.53	0.32	0.97	0.76	0.20
SUMMER							
AVG	10.1	13,286	13	374	15	13,650	20
COV	0.99	0.51	0.82	0.48	0.94	1.29	0.35

STATION 11 169000 GUADALUPE RIVER

GROUP #3 - BELOW DETECTION LIMIT

DATE	FLOW CFS	Ni dissolved ug/l	Cr dissolved ug/l	Cr sediment ug/gm	Cd dissolved ug/l	Cd sediment ug/gm	Hg dissolved ug/l	Hg sediment ug/gm	Se dissolved ug/l	Se sediment ug/gm
1/17/79	52.0	ND	ND	--	2	--	<0.1	--	--	--
1/5/82	943.0	<100	<10	60	1	1	<0.1	1.7	--	<1
1/27/83	1540.0	<100	<10	30	<1	1	<0.1	3.5	--	<1
1/28/88	24.0	<1	<1	- -	<1	- -	<.1	- -	1	- -
2/19/80	7900.0	0	0	50	0	2	0	1.7	--	0
2/9/85	116.0	<100	<10	90	<1	<1	<0.1	0.3	<1	<1
2/13/86	124.0	<100	<10	--	<1	--	<0.1	--	--	--
2/24/86	925.0	<100	<10	--	<1	--	<0.1	--	--	--
3/27/81	3.7	0	10	21	1	0	0	0.4	--	0
8/1/79	0.3	ND	ND	--	<2	--	<0.1	--	--	--
8/30/83	20.0	<100	<10	20	<1	<1	<0.1	0.03	--	<1
8/27/84	22.0	<100	<10	80	<1	<1	<0.1	0.9	--	<1
8/11/88	15.0	<1	2	50	<1	1	<.1	1.7	3	<1
9/10/80	0.5	0	0	43	0	2	0	10	--	<1
9/1/81	0.3	0	0	50	0	2	0	10	--	0
9/8/82	2.8	<100	<10	10	<1	<1	<0.1	0.08	--	<1
9/11/85	20.0	<100	--	740	1	0	<0.1	1.7	--	1

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APPENDIX G

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APPENDIX G
POINT SOURCE LOADS

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APPENDIX G
POINT SOURCE LOADS

G.1 WASTEWATER TREATMENT PLANT LOADS

Annual loads were estimated for the three Lower South Bay wastewater treatment plants (San Jose/Santa Clara, Sunnyvale, Palo Alto) based on self-monitoring data provided by the Regional Board for 1987 and 1988. The data, shown in Table G-1, give for each year the number of samples, the number of samples below the detection limit, the average concentration, and the load for each plant. The total annual load is then computed in the right-hand column. Loads were estimated using synoptic rather than average flow measurements. The mean annual flows for each treatment plant are also provided at the top of each table.

When the majority of samples are below detection, the estimated load is uncertain and conservative because the concentration was assumed to equal the detection limit, whereas the actual concentration is between zero and the detection limit. Comparisons with nonpoint source loads were made only for those constituents which were consistently measured at levels well above detection limits.

G.2 OTHER POINT SOURCES

There are a number of point source discharges to the area streams, operating under NPDES Permits. These are facilities which pump contaminated groundwater from the aquifer, subject it to treatment to remove contaminants, and then discharge to a stream, often via a storm drain. All of the identified discharges are upstream of the stream

Table G-1. ESTIMATED ANNUAL LOADS FOR WASTEWATER TREATMENT PLANTS FOR 1987 AND 1988

	PALO ALTO WWTP Qave=25.7MGD				1987 SAN JOSE SANTA CLARA WWTP Qave=121MGD				SUNNYVALE WWTP Qave=17.6MGD				
CONTAMINANT	NO. OF DATA POINTS	NO. OF BDL VALUES	AVE. CONC. (ug/l)	TOTAL ANNUAL LOAD (LB)	NO. OF DATA POINTS	NO. OF BDL VALUES	AVE. CONC. (ug/l)	TOTAL ANNUAL LOAD (LB)	NO. OF DATA POINTS	NO. OF BDL VALUES	AVE. CONC. (ug/l)	TOTAL ANNUAL LOAD (LB)	TOTAL LOAD (all plants LB)
ARSENIC	12	11	5	378	4	0	3	995	1	0	4	214	1,585*
CADMIUM	12	11	6	454	4	0	3	921	3	2	0	21	1,397*
CHROMIUM	12	4	7	532	4	0	4	1,401	48	2	6	252	2,185
COPPER	12	1	38	2,990	4	0	13	4,718	50	0	21	1,110	8,818
LEAD	10	2	12	918**	4	0	16	5,897	47	5	3	177	6,990**
MERCURY	12	8	1	39	4	4	0	111	-	-	-	0	++
NICKEL	12	1	20	1,509	4	0	25	8,906	49	0	25	1,335	11,810
SELENIUM	2	1	3	235	2	2	1	359	-	-	-	0	++
SILVER	11	1	11	630	4	0	2	553	49	5	1	70	1,452
ZINC	12	0	85	5,104	4	0	51	18,813	50	0	40	2,139	[illegible]5,656
AMMONIA	12	0	1,800	140,911	12	0	1,800	589,720	12	0	3,300	176,916	907,547
CYANIDE	7	5	23	1,001	6	6	100	+	3	2	10	538	+
OIL & GREASE	12	0	800	62,627	12	0	700	258,002	12	0	1,700	91,138	411,768
PHENOLS	4	4	17	1,315	4	0	2	811	-	-	-	0	++

Note: For the estimation of the total annual loads, if the concentration was BDL (Below Detection limit), the value used to estimate the load was the detection limit, therefore the load estimate is a maximum.

* Load estimates subject to much uncertainty because most concentrations were BDL

** Total annual load for Palo Alto WWTP based on conc. from Jan-Oct (Nov and Dec were 100 ug/l, which appear to be unusually high

+ Load estimate not made because of unusually high detection limit (100 ug/l), at San Jose Santa Clara WWTP, and most concentrations were BDL

++ Total load for all plants not calculated because no data was reported from Sunnyvale WWTP

Table G-1(continued). ESTIMATED ANNUAL LOADS FOR WASTEWATER TREATMENT PLANTS FOR 1987 AND 1988

1988

CONTAMINANT	PALO ALTO WWTP Qave=23.5 MGD NO OF DATA POINTS	NO OF BDL VALUES	AVE CONC (µg/l)	TOTAL ANNUAL LOAD (LB)	SAN JOSE SANTA CLARA WWTP Qave=118MGD NO OF DATA POINTS	NO OF BDL VALUES	AVE CONC (µg/l)	TOTAL ANNUAL LOAD (LB)	SUNNYVALE WWTP Qave=16.8MGD NO OF DATA POINTS	NO OF BDL VALUES	AVE CONC (µg/l)	TOTAL ANNUAL LOAD (LB)	TOTAL LOAD (all plants LB)
ARSENIC	12	3	3	222	12	0	2	719	52	52	1	51	992*
CADMIUM	12	12	5	358	12	0	3	899	52	52	1	51	1,308*
CHROMIUM	12	2	7	501	12	0	4	1,330	52	52	3	138	1,969*
COPPER	12	1	31	2,219	12	0	13	4,601	52	0	17	870	7,690
LEAD	12	4	17	1,217	12	0	19	6,829	52	0	7	358	8,408
MERCURY	12	10	1	36	12	12	0	72	52	52	1	51	159*
NICKEL	12	6	15	1,074	12	0	29	10,424	52	0	24	1,228	12,728
SILVER	12	6	5	379	12	0	2	719	52	52	2	102	1,201*
ZINC	12	0	71	5,082	12	0	62	22,249	52	52	36	1,842	29,174*
NITRATE	12	0	15,000	1,073,741	12	0	19,700	7,090,900	49	0	9,900	501,505	8,656,146
TKN	12	0	2,200	157,482	12	0	2,700	970,479	25	0	7,600	388,923	1,516,983
PHOSPHATE	12	0	18,300	1,309,964	12	0	17,400	6,254,196	25	0	21,500	1,100,241	8,664,401
TSS	12	0	4,700	336,439	12	0	1,200	431,324	164	0	11,000	562,914	1,330,677
BOD	12	0	3,100	221,906	12	0	4,000	1,437,746	164	0	5,780	295,788	1,955,438
AMMONIA	12	0	1,400	100,216	12	0	1,500	539,155	54	0	3,500	179,109	818,480
CYANIDE	4	0	20	1,432	12	12	100	+	52	52	10	512	++
OIL & GREASE	11	0	700	50,108	12	0	700	251,606	50	9	3,090	158,128	459,841
PHENOLS	4	0	46	3,314	4	0	1	467	52	0	40	2,047	5,829

Note: For the estimation of the total annual loads, if the concentration was BDL (Below Detection limit), the value used to estimate the load was the detection limit, therefore the load estimate is a maximum.

* Load estimates subject to much uncertainty because most concentrations were BDL.

\+ Load estimate not made because of unusually high detection limit (100 ug/l), at San Jose Santa Clara WWTP, and most concentrations were BDL.

\++ Total load for all plants not calculated because no data was reported from Sunnyvale WWTP.

monitoring stations used in the study, and would therefore influence the conditions at the station, primarily during dry weather periods.

As part of their permit requirements, these plants submit regular reports providing information on discharge quantity and quality. For this study, WCC obtained and reviewed these reports for each of the facilities which discharge, covering a substantial portion of 1987. This source was useful in establishing the approximate rate and total volume of discharge by these point sources. There are usually a large number of flow observations reported, and the degree of fluctuation between observations is nominal, so that the average that was computed for use in the load estimates is considered to provide a suitable indicator of the quantity of treated groundwater discharged to the streams.

Characterization of the quality of these discharges is a different matter. The principal constraint imposed by the data in the Permit reports is that the laboratory analyses performed examined only organic compounds (the pollutants of concern at these sites), and, following treatment, all concentrations reported (with isolated occasional exceptions) were below detection levels.

To address this limitation, the RWQCB requested the facilities involved to conduct a special supplementary survey to provide information on heavy metal levels in the discharge. Heavy metals are a normal component of urban runoff and this information would provide a common element to use for comparisons of sources. Results from the single sample analyzed by these special studies were reviewed, and the concentrations observed were combined with the discharge flows from the more comprehensive flow records, to compute estimates of the pollutant loads from the point sources.

These results are summarized by Table G-2. Facilities are organized by stream, and the discharge rate and concentrations of observed pollutants are listed. Copper and zinc are selected for load computations because

TABLE G-2 SUMMARY OF POINT SOURCE POLLUTANT DISCHARGES

Wet Seas - days= 212 Oct - Apr
Dry Seas - days= 153 May-Sept

CALABAZAS STA S-1

PS Facility	Disch Q (gpm)	Disch Q (cfs)	Pollutant Conc µg/l Cu	Zn	other rep'td	Season Pollutant Load (lbs) WET (212 da) Cu	Zn	dry (153 da) Cu	Zn
1 Unocal	4	0.009		170	As 6 ; Se 9	0	1.7	0	1.2
2 Hewlett Packard	1.5	0.003			Se 5	0	0	0	0
3 Nat'l Semicond	75	0.167			org - approx 10	0	0	0	0
4 Intersil	0.64	0.001		134	-	0	0.2	0	0.2
5 Siemens	18.8	0.042	152	331	-	7.2	15.8	5.2	11.4
6 Signetics	201	0.448		60	-	0	30.5	0	22.0
PS Total	301	0.670	9.5	63		7.2	48.2	5.2	34.8

SUNNYVALE EAST STA S-2

PS Facility	Disch Q (gpm)	Disch Q (cfs)	Pollutant Conc µg/l Cu	Zn	other rep'td	Season Pollutant Load (lbs) WET (212 da) Cu	Zn	dry (153 da) Cu	Zn
1 Signetics	75	0.167		30		0	5.7	0	4.1
2 Signetics	85	0.189		60		0	12.9	0	9.3
3 Adv Micro	98	0.218			Pb 55; Ag 19; 245	0	0	0	0
4 TRW	26	0.058	5.5	35	-	0.4	2.3	0.3	1.7
PS Total	284	0.633	0.5	29		0.4	20.9	0.3	15.1

GUADALUPE STA S-3

PS Facility	Disch Q (gpm)	Disch Q (cfs)	Pollutant Conc µg/l Cu	Zn	other rep'td	Season Pollutant Load (lbs) WET (212 da) Cu	Zn	dry (153 da) Cu	Zn
1 IBM	1406	3.133		33	Se 6; org 1 to 30	0	117.5	0	84.8
2 Fairchild	1054	2.348			TCE 1.2	0	0	0	0
3 Lincoln Prop	250	0.557	21	39	Se 4 ; As 1	13.3	24.7	9.6	17.8
PS Total	2710	6.038	2	21		13.3	142.2	9.6	102.6

COYOTE STA S-4

PS Facility	Disch Q (gpm)	Disch Q (cfs)	Pollutant Conc µg/l Ni	Zn	other rep'td	Season Pollutant Load (lbs) WET (212 da) Ni	Zn	dry (153 da) Ni	Zn
1 So Pacific Pipe	2400	5.347	130		Cd 13	790	0	570	0
2 SC Co Transit	0.1	0.000		90		0	0.023	0	0.016
PS Total	2400	5.347	130	0.004		790	0.023	570	0.016

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they are the only metals that appear to be present often enough to include in a watershed summary. Coyote Creek is a partial exception, in that nickel, rather than copper is present. Zinc appears to be the only heavy metal that is observed in most of the discharges.

The flows are assumed to be uniform throughout the year, and the mass loads computed from the listed flows and concentrations are shown for the wet and dry seasons. These results are presented for each discharge, as is the total for all the discharges upstream of each stream monitoring station. The concentrations shown for the PS total for the watershed are the flow weighted concentrations for the composite point source discharges above each station, which could be compared with the measured concentrations at the station. Chapter 8 of the report discusses the influence of the presence of pollutants from upstream point sources on the projections of loads from watersheds that do not contain such facilities.

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APPENDIX H

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APPENDIX H
ANALYSIS OF UNCERTAINTY IN LOAD ESTIMATES

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APPENDIX H
ANALYSIS OF UNCERTAINTY IN LOAD ESTIMATES

The annual nonpoint source load estimates presented in Section 8 were derived from simulated flows and measured concentration data. Because the exact values of flows and concentrations are not known, annual load estimates have some degree of uncertainty associated with them. In this appendix we describe and quantify this uncertainty, so that future decisions and analyses can be based on both the loads estimates and their associated confidence levels.

The sources of uncertainty in loads estimates are summarized and discussed in Section H.1. Section H.2 then presents the procedures used to quantify uncertainty. Section H.3 discusses the results of the quantitative uncertainty analysis in terms of confidence bounds on annual load estimates for the entire valley.

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H.1 SOURCES OF UNCERTAINTY

For the purposes of this study, annual loads are estimated as the product of annual flow volume and mean concentrations for each land use. Thus, uncertainty in the load arises from (1) uncertainty in the estimate of flow from each watershed and land use, and (2) uncertainty in the estimate of mean concentrations for each land use.

H.1.1 Uncertainty in Flow Estimates

Storm runoff flow volumes were estimated in this study using the rainfall-runoff model SWMM, as described in Appendix B. In watersheds where flow data were available, the model was calibrated to match observed flow volumes. In watersheds where no flow data were available, the model was applied using input data from similar calibrated watersheds. The following factors contribute to uncertainty in flow estimates:

1. Model input parameters are not known exactly,
2. The model itself is an inexact representation of the actual hydrologic processes,
3. The measured flows used in calibration of the model are not exact.

Calibration of the model against observed flows attempts to minimize the first two components of flow uncertainty. However, as described in Appendix B it is not possible to arrive at a perfect calibration for any one watershed. Root Mean Square Errors (RMSEs) in annual load estimates generally ranged from 15 to 25 percent, but were as high as 40 percent in some watersheds. Errors in uncalibrated watersheds would be expected to be higher.

Even if the calibration resulted in a perfect match with observed flows, there would be some uncertainty associated with errors in flow measurements. The magnitude of these errors is currently unknown, but is assumed to be small relative to calibration errors in most watersheds. A possible exception to this is the Guadalupe River, where flow measurements were found to be inconsistent with reservoir release data (see Section 5.3.2 for a detailed discussion).

H.1.2 Uncertainty in the Mean Concentration

The annual mean concentrations for each land use and constituent were estimated from the sampling data collected during the 1987-88 and 1988-89 monitoring periods. The following factors contribute to the uncertainty in the estimated mean concentrations:

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1. Mean concentrations for each land use were estimated from a finite number of water quality samples (generally less than 25). Statistically, the degree of uncertainty in the mean decreases with large samples sizes, and increases as the sample variance increases. For industrial and open land uses, mean concentrations were estimated based on 5 or fewer samples.

2. Measured concentrations are subject to laboratory and field sampling errors. As discussed in Section C.4, laboratory QA/QC data indicated the data collected in this study are of good and reliable quality. Relative percent differences (RPDs) between field duplicates were on average 29 percent, and ranged from 0 to 100 percent. For laboratory duplicates, relative percent differences were on average 16 percent, and ranged from 0 to 40 percent.

3. Data collected during the 1987-88 and 1988-89 monitoring periods may not be representative of other years with higher rainfall. The monitoring period for this study unfortunately coincided with several years of drought in California. Thus, there is the concern that water quality in wet and normal years might differ significantly from data collected during dry years. As discussed in Section 8.6.4, dry years differ from wet years primarily in terms of the number of storms, not the volume of storms. Data collected during the monitoring period suggest little relationship between runoff volume, storm frequency, and concentration. However, buildup-washoff, water quality modeling results for Calabazas Creek (Appendix B) suggest that water quality is significantly different in wet years such as 1982-83 than in dry years such as the monitoring period. This component of uncertainty cannot be quantified until monitoring data are collected in wet years.

4. Land use concentrations were corrected by loads correction factors to compensate for differences between land use and stream station concentrations. As discussed in Section 8.6.2, the processes that might be explained by these loads correction factors are currently unknown. We

believe that these factors probably account for processes occurring within the stream bed. This component of uncertainty cannot be quantified until more data are collected on stream processes and stream bed water quality.

H.2 PROCEDURES USED TO QUANTIFY UNCERTAINTY

For this analysis, uncertainty is quantified by deriving confidence bounds on annual loads estimates, given the uncertainty in flow and concentration. A first-order, second moment approach is used, assuming that the distribution of load estimates for a given year can be described completely by the mean and variance of the estimates. Alternative methods for uncertainty analysis (e.g., Monte Carlo simulation) can give a more precise evaluation of uncertainty, but generally require more data and computational time than is practical for a modeling study of this scale.

The following sections describe the procedures and equations used in the analysis. Key assumptions include:

- Flow and concentration are assumed to be independent of each other.
- Uncertainty due to differences between water quality during the dry monitoring period and wetter years is not quantified, due to the lack of data. This component of uncertainty should be evaluated when wet-year water quality data are collected.
- Uncertainty due to stream bed processes is not evaluated, again due to lack of quantitative data on the effects of these processes.
- The mean and variance in flow estimates can be quantified using the model calibration errors, expressed as the ratio of observed to predicted annual flow volumes.

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- The distribution of load estimates can be described completely by the mean estimate and the variance in estimates.

- In deriving confidence bounds, the distribution of errors in loads estimates is assumed to be Log Normal.

H.2.1 Uncertainty in Loads from a Single Land Use in a Watershed

The estimate of annual load from a single land use within a watershed is computed from the following model:

$$L_{ij} = Q_{ij}\, C_j \qquad \text{(H-1)}$$

where

L_{ij} = the estimated load for a given year from watershed i, land use j

Q_{ij} = the estimated flow volume from watershed i, land use j

C_j = the estimated mean concentration for land use j

Because Q_{ij} and Cm_j are not precisely known, the expected value (or mean estimate) of L_{ij} is estimated by correcting the estimated flow by the mean calibration error:

$$E[L_{ij}] = E[Q_{ij}]\, E[C_j] = (Q_{ij}\bar{e}_i)C_j \qquad \text{(H-2)}$$

where

E[ ] = expected value (or mean) of [ ]

$\bar{e}_i$ = the mean flow model calibration error for watershed i, expressed as the mean ratio of observed to predicted flows

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The variance of load estimates about this mean has two components. The first component, referred to as the intrinsic variance, accounts for the variability of flow and concentration estimates, assuming that the mean estimates of flow and concentration are known exactly:

$$Var[L_{ij}]_{int} = (Q_{ij}\bar{e}_i)^2 Var[C_j] + \bar{C}_j^2 Var[Q_{ij}] + Var[Q_{ij}] Var[C_j] \qquad (H\text{-}3)$$

where

$$Var[\,] = \text{variance of } [\,] \qquad (H\text{-}4)$$

The variance in C_j is simply the variance in the measured water quality samples for land use j, and accounts for both natural storm to storm variability and variability due to measurement (QA/QC) errors. The variance in Q_{ij} can be derived from the model calibration errors as follows:

$$Var[Q_{ij}] = Q_{ij}^2 \; Var[e_i] \qquad (H\text{-}5)$$

where e_i is the ratio of observed to predicted flows for watershed i.

The second component of the uncertainty in load estimates is the parametric variance. The parametric variance accounts for the fact that the mean estimates of flow and concentration are derived from limited data sets, and are therefore uncertain:

$$Var[L_{ij}]_{par} = Var[\; E[Q_{ij}] \; E[C_j] \;] \qquad (H\text{-}6)$$

$$= (Q_{ij}\bar{e}_i)^2 Var[C_j]/n_c + \bar{C}m_j^2 Q_{ij}^2 Var[e_i]/n_e + Q_{ij}^2 Var[e_i] \; Var[C_j]/(n_e n_c)$$

where

n_c = number of concentration data
n_e = number of years of data used to estimate the mean model error

The total variance in load estimates for a given year is then given by the sum of the intrinsic and parametric variances:

$$Var[L_{ij}] = Var[L_{ij}]_{int} + Var[L_{ij}]_{par} \tag{H-7}$$

H.2.2 Uncertainty in Annual Loads Estimates for the Entire Study Area

The expected value of annual load estimates for the study area in year t is the sum of the mean load estimates for each watershed and land use in year t:

$$E[L_t] = \Sigma_i \Sigma_j E[L_{ij}] \tag{H-8}$$

where
$E[L_t]$ = the expected value of the load estimate for the study area in year t

Similarly, the variance in the estimate of the total annual load is the sum of the variances of load from each watershed and land use:

$$Var[L_t] = \Sigma_i \Sigma_j Var[L_{ij}] \tag{H-9}$$

H.2.3 Uncertainty in the Mean Annual Load Estimate

The mean annual load is the mean of the annual loads for the 12 year simulation period, and is estimated as follows:

$$E[L] = \Sigma_t E[L_t] / n_t \tag{H-10}$$

where

n_t = the number of years in the simulation period

The estimated mean is uncertain due to (1) the limited number of years of data used to estimate E[L], and (2) the parametric uncertainty in the mean estimates of flow and concentration. As a result, the variance in the mean annual load estimate is the sum of the sample variance of annual loads and the parametric variance:

$$Var[\ E[L]\ ] = \Sigma_t[(L_t - E[L])^2/(n_t-1) + Var[L_t]_{par}]/n_t \qquad (H-11)$$

H.2.4 Estimation of Confidence Bounds

The equations given above allow for the estimation of the mean estimate and the variance in estimates for (1) study area loads for any year t, and (2) the mean annual study area load. The next step in the analysis is to derive confidence bounds by assuming a distribution of estimates about the mean estimate. For this study, a log normal distribution of loads estimates was assumed. While there is no direct evidence that load estimates should be log normally distributed, this distribution is commonly observed in environmental data, and has the advantage of being bound by zero. Log normal distributions are described completely by the mean and variance.

H.2.5 Data Used in the Uncertainty Analysis

The uncertainty analysis described above requires (1) estimates of the flow model calibration errors, and (2) estimates of the mean and variance of concentrations for each land use and constituent.

Table H-1 summarizes the mean and variance of the model calibration error ratios (e_i) for each calibrated watershed. These were derived directly as the ratio of observed to predicted annual flow volumes for each calibration period. To quantify error ratios for uncalibrated watersheds, simulation experiments were conducted in which data from one calibrated

Table H-1. SUMMARY OF FLOW CALIBRATION ERROR RATIOS FOR EACH WATERSHED

Watershed	Mean Error (em_1)	Variance of Errors	Number of Values
Coyote Creek	1.01	0.20*	6*
Guadalupe River	1.22	1.11	9
San Tomas Aq. Cr.	1.20	0.09	12
Saratoga Creek	1.02	0.20	10
Calabazas Creek	1.02	0.04	11
Sunnyvale East Ch.	1.10	0.03	11
Stevens Creek	1.28	0.27	8
Ungaged Areas**	1.19	0.28	22

*Since only 1 year of calibration was available for Coyote Creek, the variance in error was estimated as the mean of the variances from the 6 other calibrated watersheds.

**Derived from simulation experiments on Sunnyvale East and San Tomas Aquinas Creek.

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watershed were used to simulate runoff from a second calibrated watershed. Thus, the second watershed was treated as if it were uncalibrated. For these experiments, Sunnyvale East Channel was simulated using Calabazas Creek model data, and San Tomas Aquinas Creek was simulated using Saratoga Creek data. The resulting error ratios are summarized in Table H-1.

The means and variances of concentrations for each land use were obtained from statistical analysis of the sampling data, as described in Section 6. Table H-2 summarizes these for each land use and constituent.

H.3 RESULTS OF THE UNCERTAINTY ANALYSIS

Results of the uncertainty analysis for total loads from the study area are presented here as confidence bounds about the estimated load. Confidence bounds define the region in which one believes the true estimate of load lies, at a given level of confidence. Thus, 90 percent confidence bounds define the bounds between which one is 90 percent certain that the true value lies. Narrow confidence bounds imply a low level of uncertainty in an estimate, while wide confidence bounds imply high uncertainty.

Table H-3 summarizes the 90 percent confidence bounds for the mean annual total load estimate for each chemical parameter. In general, the 90 percent bounds are about plus or minus 50 to 60 percent away from the mean estimate. The relative widths of the bounds vary little among the different chemical parameters.

Note that these confidence bounds account only for uncertainty in flow estimates and in mecn concentration estimates for land uses. Thev do not account for possible differences in water quality between wet and dry years, nor do they account for possible stream bed processes.

Table H-2 SUMMARY OF CONCENTRATION STATISTICS

LANDUSE TYPE	STATIONS	SEASON	Cadmium MEAN µg/l	median	CV	N	Chromium MEAN µg/l	median	CV	N
INDUSTRIAL	L2	WET	5.0	5.45	0.4	5	38.1	33.73	0.62	5
RESIDENTIAL/ COMMERCIAL	L1,L3,L4, L5,L8	WET	1.7	1.32	0.84	25	21.1	14.30	1.08	25
OPEN	L7	WET	0.6	0.43	0.90	5	10.0	7.92	0.77	5
RESERVOIRS	R 1,6	DRY	0.3	0.24	0.72	6	6.7	4.90	0.01	6
STREAM	S1	WET	2.2	1.85	0.49	5	28.3	21.91	0.82	5
	S2	WET	2.3	1.90	0.84	7	41.7	25.44	1.3	7
	S3	WET	1.8	1.38	0.90	6	40.8	24.98	1.3	6
	S4	WET	3.2	2.18	1.05	6	45.2	34.81	0.83	6
STREAM	S1,S2, S3,S4	DRY	0.3	0.28	0.48	17	3.5	2.06	0.72	12

LANDUSE TYPE	STATIONS	SEASON	Copper MEAN µg/l	median	CV	N	Lead MEAN µg/l	median	CV	N	Nickel MEAN µg/l	median	CV	N	ZINC MEAN µg/l	median	CV	N
INDUSTRIAL	L2	WET	52.0	49.11	0.4	5	133.5	121.78	0.48	5	54.0	48.10	0.51	5	1471.3	1328	0.48	5
RESIDENTIAL/ COMMERCIAL	L1,L3,L4, L5,L8	WET	50.5	30.93	1.79	25	80.8	37.08	1.3	25	40.0	24.88	1.3	25	251.3	200	0.78	25
OPEN	L7	WET	8.8	7.37	0.7	5	4.0	2.45	1.3	5	10.4	11.21	1.3	5	10.0	7.88	0.78	5
RESERVOIRS	R 1,6	DRY	6.3	5.07	0.4	6	1.8	1.78	0.4	6	6.3	5.53	1.12	6	8.8	6.77	0.63	6
STREAM	S1	WET	52.5	46.80	0.51	5	63.4	38.67	1.3	5	90.2	47.50	0.97	5	288.5	249	0.4	5
	S2	WET	60.1	42.15	1.3	7	64.5	38.33	1.3	7	81.0	31.57	1.3	7	336.0	200	0.81	7
	S3	WET	70.1	48.22	1.3	6	85.6	52.18	1.3	6	107.4	65.48	1.3	6	283.7	179	1.3	6
	S4	WET	65.6	53.01	0.73	6	82.8	53.28	1.17	6	88.5	75.45	0.84	6	283.8	174	1.13	6
STREAM	S1,S2, S3,S4	DRY	7.4	4.80	1.25	28	1.4	1.24	0.47	28	2.8	2.00	-	12	13.4	10	0.81	28

Table H-2. SUMMARY OF CONCENTRATION STATISTICS (Concluded)

LANDUSE TYPE	STATIONS	SEASON	BOD MEAN mg/L	median	CV	N	NO3 N MEAN mg/L	median	CV	N	PO4-P MEAN mg/L	median	CV	N	TKN MEAN mg/L	median	CV	N	TSS MEAN mg/L	median	CV	N
INDUSTRIAL	L2	WET	12.7	11.8	0.4	5	0.8	0.5	0.41	2	1.0	0.7	0.4	2	1.9	1.8	0.4	4	181.7	134.1	0.53	5
RESIDENTIAL/ COMMERCIAL	L1,L3,L4, L5,L6	WET	10.0	8.3	0.67	25	0.7	0.6	0.4	6	0.7	0.3	0.4	6	2.1	1.8	0.61	20	78.1	65.8	0.58	24
OPEN	L7	WET	5.1	4.4	0.60	5	0.18			1	0.10			1	1.1	1.0	0.4	4	84.8	51.8	1.3	5
RESERVOIRS	R-1,8	DRY	5.1	4.4	0.30	5	0.3	0.2	1.00	5	0.3	0.1	0.4	6	1.8		-	1	48.7	20.6	1.3	3
STREAM	S1	WET	11.3	8.3	0.82	5	0.30		-	1	0.58		-	1	1.8	1.8	0.4	4	180.1	121.7	1.2	5
	S2	WET	17.3	11.8	1.07	6	0.51		-	1	0.80		-	1	2.1	1.8	0.4	3	234.2	142.8	1.3	6
	S3	WET	8.2	6.6	0.74	5	0.43		-	1	1.10		-	1	2.4	2.1	0.56	6	464.2	277.0	1.3	6
	S4	WET	10.8	7.8	0.85	5	0.30		-	2	0.73		-	2	1.5	1.4	0.4	5	240.3	208.3	0.67	5
STREAM	S1,S2, S3,S4	DRY	3.0	2.0	0.80	22	2.3	1.4	1.3	6	0.10		-	4	1.4	1.3	0.51	28	12.0	7.8	1.3	20

Table H-3. SUMMARY OF 90 PERCENT CONFIDENCE BOUNDS FOR MEAN ANNUAL LOAD ESTIMATES

CHEMICAL PARAMETER	MEAN ANNUAL LOAD (1000 lbs)	90 PERCENT BOUNDS LOWER (1000 lbs)	UPPER (1000 lbs)
Cadmium	0.51	0.3	0.77
Chromium	9.7	5.3	17.7
Copper	14.6	8.4	24
Lead	14.6	8.6	23.7
Nickel	20.6	11.5	35.6
Zinc	50	31.2	77
BOD	2,110	1,500	3,840
NO3-N	206	102	360
PO4-P	161	147	216
TKN	378	294	744
TSS	68,600	43,400	133,000

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As an example of how this information can be interpreted, the estimated mean annual copper loading is 14,600 lbs. Uncertainty results indicate that we can be 50 percent certain the actual mean annual load is between 11,500 and 17,600 lbs. We can be 90 percent certain the actual mean annual load is between 8400 and 24,000 lbs.

As an indication of how uncertainty varies year to year, Figure H-1 presents the confidence bounds about the estimated annual copper load for each of the twelve simulated years. As would be expected, confidence bounds tend to be wider for individual years than they are for the mean (i.e., we are more certain about the mean of the 12 annual load estimates than we are of any one year's load). 90 percent bounds are about plus or minus 95 percent away from the estimated value.

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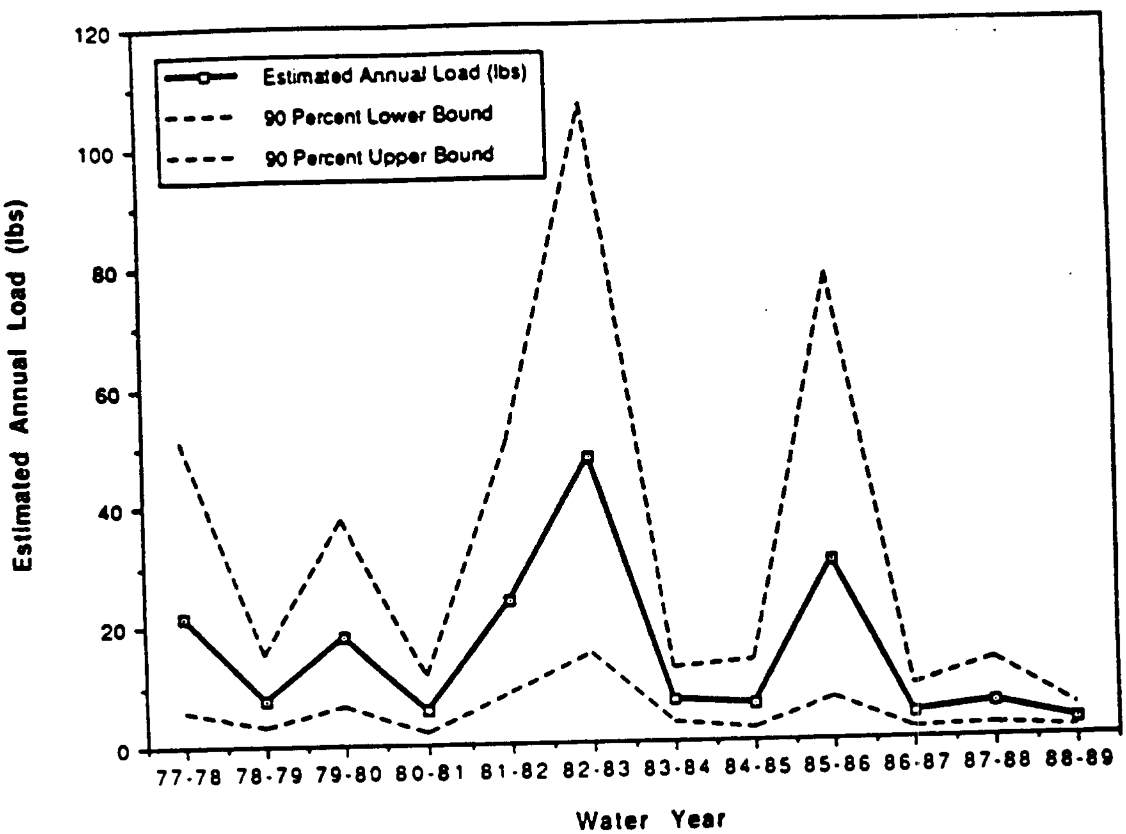

Figure H-1. 90 Percent Confidence Bounds on Annual Copper Loads

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